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(54) Title: METHOD AND APPARATUS FOR ELIMINATING BLIND DETECTION AMBIGUITY

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Partitioning a sequence of encoded control information bits into a plurality of sub-blocks, wherein the sequence of encoded control information bits comprises K originally-encoded control information bits and at least M repetition bits of the originally-encoded control information bits

110

Interleaving the sub-blocks to form interleaved encoded control information bits, wherein the interleaved encoded control information bits are to be placed on physical resources corresponding to control channel elements at a first aggregation-level, and wherein K interleaved encoded control information bits placed on the physical resources corresponding to a beginning of each blind detection control channel elements group according to a second aggregation-level are different from the K originally-encoded control information bits

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(57) Abstract: A method and apparatus for eliminating blind detection ambiguity. The method is performed at a transmitter and comprises a step of partitioning a sequence of encoded control information bits into a plurality of sub-blocks, wherein the sequence of encoded control information bits comprises K originally-encoded control information bits and at least M repetition bits of the originally-encoded control information bits; and a step of interleaving the sub-blocks to form interleaved encoded control information bits, wherein the interleaved encoded control information bits are to be placed on physical resources corresponding to control channel elements at a first aggregation-level, and wherein K interleaved encoded control information bits placed on the physical resources corresponding to a beginning of each blind detection control channel elements group according to a second aggregation-level are different from the K originally-encoded control information bits, where K is an integer no less than 1, and M is an integer no less than 1.

FIG.1

METHOD AND APPARATUS FOR ELIMINATING BLIND DETECTION AMBIGUITY

TECHNICAL FIELD

[0001] The present disclosure generally relates to a cellular radio communication system,
5 and specifically to a method and apparatus for eliminating blind detection ambiguity.

BACKGROUND

[0002] The problem of ambiguity between aggregation-levels (AL) 8 and 16 Physical
Downlink Control Channel (PDCCH) candidates has been identified for 5G new radio (NR)
system. This issue has been discussed earlier in the context of downlink (DL) control and rate
10 matching. No agreement was reached to address this issue for enhanced Mobile Broadband
(eMBB) within 3GPP.

[0003] The ambiguity issue under current 3GPP Rel-15 specification generally means, that
when for example a gNodeB (gNB) intends to transmit a number of Downlink Control
Information (DCI) bits on a PDCCH with a payload size (including Cyclic Redundancy Check
15 (CRC) bits) equal or less than 108 bits using an AL8, there is a possibility that a user equipment
(UE) could succeed with the blind detection using a hypothetical aggregation-level of 16 , or vice
versa, due to the rate matching rule and nested property of Rel-15 Polar codes.

[0004] Since Ultra-Reliable Low-Latency Communication (URLLC) has imposed more
stringent service requirements differentiating from eMBB, a higher AL is most likely used in
20 order to ensure an ultra-high reliability even under good channel conditions. Therefore, the
probability of encountering an ambiguity is high. With the existence of current ambiguity issue,
the gNB and the UE will have a different understanding about the Physical Downlink Shared
Channel (PDSCH) rate matching pattern, which results in catastrophic decoding at the receiver
side.

[0005] For instance, in R1-1802898, an example of PDCCH transmitting 40 DCI bits with
AL16 is given. According to the rate matching defined in the 3GPP Rel-15 specification, the 40
DCI bits are first Polar-encoded then repeated several times in order to fit into the physical
resource size of 16 control channel elements (CCE), equivalently 1728 bits. Therefore, if a UE
decodes these encoded and rate matched (repeated) DCI bits with the assumption of AL8, there
30 is a chance that the attempted decoding could be successful (including passing a CRC) when a
Signal to Noise Ratio (SNR) is sufficiently high. This might further lead to unfavorable results,
for example erroneous rate matching pattern and wrong understanding on the partitioning of
PDSCH resources.

[0006] Furthermore, this issue is expected to cause more trouble when even higher aggregation-levels are introduced in the future, e.g. AL32, AL64, unless a valid solution is proposed.

[0007] In order to address the above ambiguity, the existing solution prefers to pretend that AL16 is used at the receiver (Rx) side for the blind detection no matter AL8 or AL16 is employed at the transmitter (Tx) side. This solution is straightforward, but leads to unsatisfactory results, especially for URLLC. If URLLC always use AL8 and AL16 for transmissions, it might have a significant loss in the resource utilization. The reason is explained as follows.

[0008] The latest Rel-15 specifications allow unoccupied PDCCH CORESET resources to be used for the PDSCH. Since URLLC is extremely latency-sensitive, it would be beneficial to start the PDSCH as soon as possible after the PDCCH or even at the same time. With the existence of ambiguity issue, if the UE thinks that it is AL8, it might think there are data symbols around PDCCH resources, which may be not the case if AL16 is actually employed at the transmitter side. Hence, an assumption of AL16 used at the receiver side could avoid the ambiguity only temporarily, but at the cost of sacrificing the chance of CORESET re-use for PDSCH. As a consequence, it might compromise a low latency, which is crucial for URLLC.

[0009] Therefore, it is urgent and imperative to provide a more effective solution for resolving this ambiguity issue.

SUMMARY

[0010] The present disclosure is going to solve the aforementioned problems by proposing method and apparatus for eliminating blind detection ambiguity, in order to distinguish from AL configurations, and to ensure the correct detection and decoding of data channel accordingly. Other features and advantages of embodiments of the present disclosure will also be understood from the following description of specific embodiments when read in conjunction with the accompanying drawings, which illustrate, by way of example, the principles of embodiments of the present disclosure.

[0011] In a first aspect of the disclosure, there is provided a method for eliminating blind detection ambiguity. The method is performed at a transmitter. The method comprises partitioning a sequence of encoded control information bits into a plurality of sub-blocks, wherein the sequence of encoded control information bits comprises K originally-encoded control information bits and at least M repetition bits of the originally-encoded control information bits. The method further comprises interleaving the sub-blocks to form interleaved encoded control information bits, wherein the interleaved encoded control information bits are to

be placed on physical resources corresponding to control channel elements at a first aggregation-level, and wherein K interleaved encoded control information bits placed on the physical resources corresponding to a beginning of each blind detection control channel elements group according to a second aggregation-level are different from the K originally-encoded control information bits, where K is an integer no less than 1, and M is an integer no less than 1.

[0012] In one embodiment, the method may further comprise determining the number of sub-blocks based on a ratio between a total number of bits placed on the physical resources corresponding to the control channel elements at the first aggregation-level and the number of the originally-encoded control information bits, i.e. K .

[0013] In one embodiment, in a case that the ratio is an integer, the partitioning may comprise partitioning the sequence of encoded control information bits to form at least one sub-block that spans two adjacent blind detection control channel elements groups according to the second aggregation-level.

[0014] In one embodiment, the partitioning may comprise partitioning the sequence of encoded control information bits resulting in each of the plurality of sub-blocks comprises partial bits of the originally-encoded control information bits and/or partial bits of one of the repetition bits.

[0015] In one embodiment, the partitioning may comprise equally partitioning the sequence of encoded control information bits into the plurality of sub-blocks.

[0016] In one embodiment, the partitioning may comprise unequally partitioning the sequence of encoded control information bits into the plurality of sub-blocks.

[0017] In one embodiment, the first aggregation-level may comprise 2^n , and the second aggregation-level may comprise 2^{n-i} , wherein n is an integer larger than 0, and i is an integer with $0 < i \leq n$.

[0018] In one embodiment, the first aggregation-level may comprise 16, and the second aggregation-level may comprise 8.

[0019] In one embodiment, the first aggregation-level may comprise 32, and the second aggregation-level may comprise 8 and/or 16.

[0020] In one embodiment, the control information bits may comprise downlink control information bits transmitted on a physical downlink control channel.

[0021] In one embodiment, the control information bits may comprise uplink control information bits transmitted on a physical uplink control channel.

[0022] In a second aspect of the disclosure, there is provided a computer readable storage medium, on which stored computer-executable instructions. When the computer-executable

instructions are executed on at least one processor, the at least one processor is caused to carry out the method according to the first aspect of the disclosure.

[0023] In a third aspect of the disclosure, there is provided an apparatus for eliminating blind detection ambiguity. The apparatus comprises at least one processor and at least one memory including computer-executable instructions. The at least one memory and the computer-executable instructions configured to, with the at least one processor, cause the apparatus at least to partition a sequence of encoded control information bits into a plurality of sub-blocks, wherein the sequence of encoded control information bits comprises K originally-encoded control information bits and at least M repetition bits of the originally-encoded control information bits. The at least one memory and the computer-executable instructions configured to, with the at least one processor, further cause the apparatus at least to interleave the sub-blocks to form interleaved encoded control information bits, wherein the interleaved encoded control information bits are to be placed on physical resources corresponding to control channel elements at a first aggregation-level, and wherein K interleaved encoded control information bits placed on the physical resources corresponding to a beginning of each blind detection control channel elements group according to a second aggregation-level are different from the K originally-encoded control information bits, where K is an integer no less than 1, and M is an integer no less than 1.

[0024] In one embodiment, the at least one memory and the computer program code may be configured to, with the at least one processor, cause the apparatus at least to determine the number of sub-blocks based on a ratio between a total number of bits placed on the physical resources corresponding to the control channel elements at the first aggregation-level and the number of the originally-encoded control information bits, i.e. K .

[0025] In one embodiment, the at least one memory and the computer program code may be configured to, with the at least one processor, cause the apparatus at least to in a case that the ratio is an integer, partition the sequence of encoded control information bits to form at least one sub-block that spans two adjacent blind detection control channel elements groups according to the second aggregation-level.

[0026] In one embodiment, the at least one memory and the computer program code may be configured to, with the at least one processor, cause the apparatus at least to partition the sequence of encoded control information bits resulting in each of the plurality of sub-blocks comprises partial bits of the originally-encoded control information bits and/or partial bits of the repetition bits.

[0027] In one embodiment, the at least one memory and the computer program code may be configured to, with the at least one processor, cause the apparatus at least to equally partition the sequence of encoded control information bits into the plurality of sub-blocks.

[0028] In one embodiment, the at least one memory and the computer program code may be configured to, with the at least one processor, cause the apparatus at least to unequally partition the sequence of encoded control information bits into the plurality of sub-blocks.

[0029] In one embodiment, the first aggregation-level may comprise 2^n , and the second aggregation-level may comprise 2^{n-i} , wherein n is an integer larger than 0, and i is an integer with $0 < i \leq n$.

[0030] In one embodiment, the first aggregation-level may comprise 16, and the second aggregation-level may comprise 8.

[0031] In one embodiment, the first aggregation-level may comprise 32, and the second aggregation-level, AL_2 , may comprise 8 and/or 16.

[0032] In one embodiment, the control information bits may comprise downlink control information bits transmitted on a physical downlink control channel.

[0033] In one embodiment, the control information bits may comprise uplink control information bits transmitted on a physical uplink control channel.

[0034] In a fourth aspect of the disclosure, there is provided an apparatus for eliminating blind detection ambiguity. The apparatus comprises means for partitioning a sequence of encoded control information bits into a plurality of sub-blocks, wherein the sequence of encoded control information bits comprises K originally-encoded control information bits and at least M repetition bits of the originally-encoded control information bits. The apparatus further comprises means for interleaving the sub-blocks to form interleaved encoded control information bits, wherein the interleaved encoded control information bits are to be placed on physical resources corresponding to control channel elements at a first aggregation-level, and wherein K interleaved encoded control information bits placed on the physical resources corresponding to a beginning of each blind detection control channel elements group according to a second aggregation-level are different from the K originally-encoded control information bits, where K is an integer no less than 1, and M is an integer no less than 1.

[0035] According to the various aspects and embodiments as mentioned above, an ambiguity issue for blind detection can be resolved.

BRIEF DESCRIPTION OF THE DRAWINGS

[0036] The above and other aspects, features, and benefits of various embodiments of the present disclosure will become more fully apparent, by way of example, from the following detailed description with reference to the accompanying drawings, in which like reference
5 numerals or letters are used to designate like or equivalent elements. The drawings are illustrated for facilitating better understanding of the embodiments of the disclosure and not necessarily drawn to scale, in which:

[0037] FIG. 1 illustrates a flowchart of a method 100 for eliminating blind detection ambiguity according to embodiments of the present disclosure;

10 [0038] FIG. 2 schematically illustrates a sequence of encoded control information bits according to embodiments of the present disclosure;

[0039] FIG. 3 schematically illustrates a scheme for eliminating blind detection ambiguity for the AL16 configuration shown in FIG. 2;

15 [0040] FIG. 4 schematically illustrates another sequence of encoded control information bits according to embodiments of the present disclosure; and

[0041] FIG. 5 illustrates a simplified block diagram of an apparatus according to embodiments of the present disclosure.

DETAILED DESCRIPTION

20 [0042] Hereinafter, the principle of the present disclosure will be described with reference to illustrative embodiments. It should be understood, all these embodiments are given merely for one skilled in the art to better understand and further practice the present disclosure, but not for limiting the scope of the present disclosure. For example, features illustrated or described as part of one embodiment may be used with another embodiment to yield still a further embodiment. In the interest of clarity, not all features of an actual implementation are described in this
25 specification.

[0043] Throughout the specification, the words with similar meaning, such as “interleave”, “interleaving”, “disperse”, “dispersion”, “reorder”, “change the order of”, “map”, “mapping” and different combinations of these words, can be used interchangeably.

30 [0044] References in the specification to “one embodiment,” “an embodiment,” “an example embodiment,” etc. indicate that the embodiment described may include a particular feature, structure, or characteristic, but it is not necessary that every embodiment includes the particular feature, structure, or characteristic. Moreover, such phrases are not necessarily referring to the same embodiment. Further, when a particular feature, structure, or characteristic is described in connection with an embodiment, it is submitted that it is within the knowledge of

one skilled in the art to affect such feature, structure, or characteristic in connection with other embodiments whether or not explicitly described.

[0045] In the following description and claims, unless defined otherwise, all technical and scientific terms used herein have the same meaning as commonly understood by one of ordinary skills in the art to which this disclosure belongs. For example, the term “transmitting apparatus” or the like used herein may refer to any apparatus having wireless communication capabilities, including but not limited to, a base-station. The term “receiving apparatus” or the like used herein may refer to any apparatus having wireless communication capabilities, including but not limited to, a terminal device or UE. The terminal device or UE may be mobile phones, cellular phones, smart phones, or personal digital assistants (PDAs), portable computers, and the like. Furthermore, user equipment that is not mobile may also readily employ embodiments of the present invention. In the following description, the terms “user equipment”, “UE” and “terminal device” may be used interchangeably. Similarly, the term “base-station” may represent a base station (BS), a node B (NodeB or NB), an evolved NodeB (eNodeB or eNB), a gNodeB (gNB) and a relay node (RN) and so forth.

[0046] For illustrative purposes, several embodiments of the present disclosure will be described in the context of a 5G NR system. Those skilled in the art will appreciate, however, that the concept and principle of the several embodiments of the present disclosure may be more generally applicable to other wireless networks, for example a second generation (2G) radio access network (RAN), a third generation Long Term Evolution (3G-LTE) network, a fifth generation (4G) network, 4.5G LTE, or a future network (e.g. 5G network), cellular Internet of things (IoT) RAN, cellular radio HW.

[0047] As used herein, the term “circuitry” may refer to one or more or all of the following:

- (a) hardware-only circuit implementations (such as implementations in only analog and/or digital circuitry); and
- (b) combinations of hardware circuits and software, such as (as applicable): (i) a combination of analog and/or digital hardware circuit(s) with software/firmware and (ii) any portions of hardware processor(s) with software (including digital signal processor(s)), software, and memory(ies) that work together to cause an apparatus, such as a mobile phone or server, to perform various functions); and
- (c) hardware circuit(s) and or processor(s), such as a microprocessor(s) or a portion of a microprocessor(s), that requires software (e.g., firmware) for operation, but the software may not be present when it is not needed for operation.

[0048] This definition of circuitry applies to all uses of this term in this application, including in any claims. As a further example, as used in this application, the term circuitry also

covers an implementation of merely a hardware circuit or processor (or multiple processors) or portion of a hardware circuit or processor and its (or their) accompanying software and/or firmware. The term circuitry also covers, for example and if applicable to the particular claim element, a baseband integrated circuit or processor integrated circuit for a mobile device or a similar integrated circuit in server, a cellular network device, or other computing or network device.

[0049] As used herein, the singular forms “a”, “an”, and “the” are intended to include the plural forms as well, unless the context clearly indicates otherwise. The term “includes” and its variants are to be read as open terms that mean “includes, but is not limited to”. The term “based on” is to be read as “based at least in part on”. The term “one embodiment” and “an embodiment” are to be read as “at least one embodiment”. The term “another embodiment” is to be read as “at least one other embodiment”. Other definitions, explicit and implicit, may be included below.

[0050] The present disclosure relates to a scheme for eliminating blind detection ambiguity. As discussed above, the ambiguity issue is associated with the rate matching and nested property of Rel-15 Polar codes. Since the fundamental Polar encoding and rate matching procedures have been standardized and now fixed, a simple yet robust mechanism is conceived from coding chain perspective to distinguish from AL configurations, and to ensure the correct detection and decoding of PDSCH accordingly.

[0051] In general, when it comes to AL8/16 ambiguity, it generally means UE could detect an AL8 configuration mistakenly as AL16, or vice versa. Thus this problem is actually two-fold: AL8 mis-detected as AL16 and AL16 mis-detected as AL8. A study of 4 cases that could lead to such ambiguity is summarized as follows:

- 1) Tx transmits with AL=8, and a blind detection is performed at Rx side from the smallest AL. If an ambiguity is caused, a detection with AL8 would be failed but a detection with AL16 would be succeed later. However, this is impossible to happen.
- 2) Tx transmits with AL=8, and a blind detection is performed at Rx side from the highest AL. If an ambiguity is caused, a detection with AL16 would be successful and the blind detection is therefore terminated. This is possible, for example when a SNR at Rx side is high for the first 8CCEs of 16CCEs, and the SNR is low for the second 8CCEs of 16CCEs. Therefore, these 16CCEs would be decoded with AL=16. However, this scenario is rare.
- 3) Tx transmits with AL=16, and a blind detection is performed at Rx side from the smallest AL. If an ambiguity is caused, a detection with AL8 would be successful and the blind

detection is therefore terminated. This is possible, for example when the channel condition is good.

- 4) Tx transmits with AL=16, and a blind detection is performed at Rx side from the highest AL. If an ambiguity is caused, a detection with AL16 would be failed but a detection with AL8 would be succeed later. This is possible, for example when the second 8CCEs of 16CCEs suffers from chaotic channel conditions. In this case, if a decoder carries out a decoding with an assumption of AL=16, the decoding would be failed.

[0052] According to an analysis from a perspective of Polar coding, a scenario in which transmission with an AL8 configuration is mistakenly detected as transmission with an AL16 configuration is very rare to happen. Thus, the two-fold problem can be simplified to one-fold, i.e. how to make sure AL16 is not going to be mis-detected as AL8, and also to ensure that a similar ambiguity is not going to happen again when AL32 or a higher AL is introduced. As pointed out previously, the rate matching rule for Polar code is repetition when an ambiguity happens, therefore this invention attempts to solve the ambiguity from Layer1 physical coding chain.

[0053] In order to guarantee that transmitting of control information on a control channel is detected and decoded correctly with no confusion on the aggregation-level, the present disclosure introduces a partitioning and interleaving mechanism to manipulate the encoded control information bits in order to achieve the elimination of blind detection ambiguity. Figure 1 illustrates a flowchart of a method 100 for eliminating blind detection ambiguity according to embodiments of the present disclosure. As shown in step 110 in Figure 1, a sequence of encoded control information bits may be partitioned into a plurality of sub-blocks. The sequence of encoded control information bits may comprise K originally-encoded control information bits and at least M repetition bits of the originally-encoded control information bits, where K is an integer no less than 1 and M is an integer no less than 1. In an embodiment, the control information bits may be downlink control information bits transmitted on a physical downlink control channel. As an alternative, the control information bits may be uplink control information bits transmitted on a physical uplink control channel. As another alternative, the control information bits may comprise other control information bits available currently or in future transmitted on a physical control channel available currently or in future.

[0054] As shown in step 120 in Figure 1, the sub-blocks may be interleaved to form interleaved encoded control information bits, wherein the interleaved encoded control information bits are to be placed on physical resources corresponding to control channel elements at a first aggregation-level, and wherein K interleaved encoded control information bits placed on the physical resources corresponding to a beginning of each blind detection control

channel elements group according to a second aggregation-level, are different from the K originally-encoded control information bits. As mentioned above, the words “interleave”, “interleaving”, “disperse”, “dispersion”, “reorder”, “change the order of”, “map”, “mapping” and different combinations of these words can indiscriminately indicate changing the order of the plurality of sub-blocks. In an embodiment, the order of the K interleaved encoded control information bits may be different from the order of the K originally-encoded control information bits.

[0055] Moreover, blind detection control channel elements group is a group of control channel elements, and the size of each group is determined by the second aggregation-level. The control channel elements in each group may be processed together according to a second aggregation-level during each blind detection attempt. For example, in an embodiment, a first aggregation-level defined at Tx side may comprise aggregation of 2^n control channel elements, i.e., the first aggregation-level equals to 2^n , and a second aggregation-level for blind detection attempt at Rx side may comprise aggregation of 2^{n-i} control channel elements, i.e., the second aggregation-level equals to 2^{n-i} , wherein n is an integer larger than 0, and i is an integer with $0 < i \leq n$.

[0056] For example, a first aggregation-level may be AL16, and a second aggregation-level may be AL8. Accordingly, the size of each blind detection control channel elements group according to AL8 is 8 control channel elements. In this case, according to AL8, blind detection attempt would be executed to recover the control information carried by every group of 8 control channel elements.

[0057] As another example, a first aggregation-level may be AL32, and a second aggregation-level may comprise AL8 and AL16. Accordingly, the blind detection attempt would be executed to recover the control information carried by every group of 8 control channel elements, and every group of 16 control channel elements.

[0058] In an embodiment, the number of sub-blocks may be determined based on a ratio between a total number of bits placed on the physical resources corresponding to the control channel elements at the first aggregation-level and the number of the originally-encoded control information bits, i.e. K . In this regard, the length of the originally-encoded control information bits is K bits. For example, a ratio between a total number of bits placed on the resources corresponding to, for example, 16CCEs at an aggregation-level of 16 and the number of the encoded DCI payload (including CRC) bits (prior to rate-matching) can be derived. Then the number of sub-blocks may be considered and decided based on this ratio. For example, if this ratio is an integer, one of the sub-blocks should span the first half and second half of the

16CCEs. For another example, if this ratio is NOT an integer, the number of sub-blocks may be larger than 2. More details will be described below relative to Figures 2 and 4.

[0059] In an embodiment, the sequence of encoded control information bits may be partitioned such that each of the plurality of sub-blocks comprises partial bits of the originally-encoded control information bits and/or partial bits of the repetition bits. With this partitioning pattern, during subsequent processing, it is easy to ensure that the K interleaved encoded control information bits placed on the physical resources corresponding to the beginning of each blind detection control channel elements group according to a second aggregation-level are different from the K originally-encoded control information bits. Therefore this partitioning pattern is available for blind detection in various AL configurations.

[0060] In an embodiment, the sequence of encoded control information bits may be partitioned equally into the plurality of sub-blocks (i.e., a plurality of equal-sized sub-blocks obtained). The number of resultant sub-blocks may vary, depending on the number of bits chosen for each sub-block during equal-partitioning. Actually a number greater than 2 would generally work. For example, if the sequence of encoded control information bits is quartered, the total number of resultant sub-blocks will be 4 sub-blocks. The partitioning may depend on the first aggregation-level. For example, when the first aggregation-level is AL16, the number of resultant sub-blocks can be 4. When the first aggregation-level is AL32, the number of resultant sub-blocks can be 8. Alternatively, the sequence of encoded control information bits may be partitioned unequally into the plurality of sub-blocks (i.e., a plurality of unequal-sized sub-blocks obtained).

[0061] Embodiments as discussed above can avoid a blind detection ambiguity which mistakes a second aggregation-level as a first aggregation-level. A blind detection may be performed in a granularity of one control channel element. In an embodiment, when a first aggregation-level is 16, a blind detection attempt at a second aggregation-level can span 8 control channel elements. That is, at a receiver side, if a blind detection attempt is executed on every 8 control channel elements, the blind detection will not be successful. In another embodiment, when a first aggregation-level is 32, a blind detection attempt at a second aggregation-level executed on every 8 control channel elements and/or every 16 control channel elements will not be successful.

[0062] It should be appreciated that, in addition to or alternative to the above implementation solutions, the sequence of encoded control information bits can be partitioned based on other procedures in a similar way. In this regard, the number and size of sub-blocks may be configured as any suitable value. Moreover, the plurality of sub-blocks can be

interleaved in any suitable way. In other words, the proposed solution can be designed based on other similar, available operations and steps.

[0063] Now, details of these steps will be described with respect to some particular embodiments. The following elaborates solutions in two kinds of typical scenarios.

5 Scenario 1

[0064] Figure 2 schematically illustrates a sequence of encoded control information bits according to embodiments of the present disclosure. In this embodiment, it is considered that payload size of control information bits (including CRC bits) is less than 108 bits, and the payload size of control information bits (including CRC bits) is not dividable number of 108.

10 The transmitter employs an AL16 configuration for transmitting the control information bits, such as DCI bits or other control information bits available currently or in future. Then the ratio between the total number of bits placed on physical resources corresponding to 16CCEs at AL16 and the number of originally-encoded DCI (prior to rate-matching) bits is NOT an integer. In this case, it is assumed that the originally-encoded DCI bits are repeated twice. The number of repetitions may vary in a communication system in practice. In this embodiment, repeating the originally-encoded DCI bits twice is just for a demonstration purpose. As shown in Figure 2, the originally-encoded DCI bits 201 are represented by a blank gray portion, whose length may be K bits, where K is an integer no less than 1. The 1st rate-matched repetition 202 of the originally-encoded control information bits is represented by a left oblique portion. A part of the 20 2nd rate-matched repetition 203 of the originally-encoded control information bits is represented by a right oblique portion. The originally-encoded control information bits 201, the 1st rate-matched repetition 202 and the 2nd rate-matched repetition 203 may be completely identical to each other. Note that, only an incomplete part of the 2nd repetition fits in 16CCEs owing to the restriction of total number of bits can be accommodated by the physical resources corresponding to 16CCEs.

[0065] As shown in Figure 3, in order to tackle the ambiguity issue, the sequence of encoded control information bits including the K originally-encoded control information bits 201, the 1st rate-matched repetition 202 and partial of the 2nd rate-matched repetition 203 are equal-partitioned into 4 sub-blocks labeled as [0 1 2 3], for simplicity in this example. Then, the resultant sub-blocks are interleaved to form interleaved encoded control information bits. Bits of the interleaved sub-blocks are to be placed on the physical resources corresponding to 16CCEs at an aggregation-level of 16. For example, the total 4 sub-blocks can be interleaved in the order of, for example [3 0 2 1]. It can be seen from Figure 3, before the interleaving, the sub-block 1 comprises partial bits of the K originally-encoded control information bits 201 and partial bits of

the 1st rate-matched repetition 202. The sub-block 3 comprises partial bits of the 1st rate-matched repetition 202 and partial bits of the 2nd rate-matched repetition 203. These interleaved encoded control information bits can be utilized to achieve discrimination of AL8/AL16 configuration, because after the interleaving, neither the first 8CCEs nor the second 8CCEs of the formed 16CCEs can be decoded correctly using the assumption of AL8 configuration. On the other hand, these interleaved encoded control information bits can be decoded correctly using the assumption of AL16 configuration, since the order of these interleaved encoded control information bits can be inversed via corresponding de-interleaving when making blind detection attempt under AL16 configuration. It is noted that the order of such interleaving is not unique, but may depend on the AL configuration, as long as the K interleaved encoded control information bits placed on the physical resources corresponding to a beginning of each blind detection control channel elements group according to AL8 are different from the K originally-encoded control information bits 201. That is, the first K bits placed on the physical resources corresponding to the first and second 8CCEs of the total 16CCEs are different from the K originally-encoded control information bits 201.

[0066] It should be noted that the way to perform partitioning of the sequence of encoded control information bits may be relevant to the AL configuration. Furthermore, the way to perform interleaving of the resultant sub-blocks may be also AL-dependent.

Scenario 2

[0067] In this embodiment, it is considered that a case that the payload size of DCI bits (including CRC bits) is exactly 108 bits or dividable number of 108 and smaller than 108. The transmitter employs AL16 configuration. In this case, it is assumed that the originally-encoded DCI bits are repeated three times, and again, this is just for a demonstration purpose only. As shown in Figure 4, the first portion is the originally-encoded control information bits 401 (the length of which may also be K bits, where K is an integer no less than 1), for example DCI bits or other control information bits available currently or in future, followed by the 1st rate-matched repetition 402, the 2nd rate-matched repetition 403 and the 3rd rate-matched repetition 404 (i.e., $M = 3K$). Then the ratio between the total number of bits placed on the physical resources corresponding to 16CCEs at AL16 and the number of the originally-encoded DCI bits (i.e., the K bits) is an integer. Based on the idea of the present disclosure, the solution to avoid the ambiguity issue shown in Figure 4 is immediate. For example, the issue can be easily rectified by partitioning the sequence of encoded control information bits including the originally-encoded control information bits 401, the 1st rate-matched repetition 402, the 2nd rate-matched repetition 403 and the 3rd rate-matched repetition 404 to ensure that one of the

resultant sub-blocks in the middle spans the first and second 8CCEs of the total 16CCEs. Therefore, after partitioning and interleaving, the K interleaved encoded control information bits placed on the physical resources corresponding to each blind detection control channel elements group starting at the positions of '0' and '8', are also different from the K originally-encoded control information bits 401. In this example, the control channel elements are indexed from '0'.

[0068] Based on the above description, it should be easily appreciated that, the proposed mechanism can also be applied to the case of AL32 or a higher AL. The corresponding procedures for the partitioning and interleaving patterns are the same to that of the above embodiments described in relation to AL16. A general idea can be generalized as follows: from a perspective of partitioning, the number of sub-blocks may be determined based on a ratio between a total number of bits placed on the physical resources corresponding to the control channel elements at the first aggregation-level and the number of the originally-encoded control information bits. From a perspective of interleaving, K interleaved encoded control information bits placed on the physical resources corresponding to a beginning of each blind detection control channel elements group according to a second aggregation-level are different from the K originally-encoded control information bits. In an embodiment, in an instance where the second aggregation-level is AL8, the beginning of each blind detection control channel elements group may start from the j -th control channel element, where $\text{mod}(j, 8) = 0$, when indexes of the control channel elements are started from '0' and 'mod' represents the modulo operation, i.e., the remainder after division.

[0069] In summary, the present disclosure introduces a partitioning and interleaving mechanism to manipulate the encoded control information bits in order to achieve the elimination of blind detection ambiguity. The introduced mechanism can ensure transmitting of control information on a control channel is detected and decoded correctly with no confusion on the aggregation-level, and further ensure correct detection and decoding of data channel accordingly.

[0070] Reference is now made to Figure 5, which illustrates a simplified block diagram of an apparatus 500 according to some embodiments of the present disclosure. The apparatus may be embodied in/as a base station in a radio communication system, which can communicate with multiple UEs simultaneously. For example, the base station may be a gNB operating in a 5G NR system. The apparatus 500 is operable to carry out the methods as described with reference to Figures 1, 2, 3 and/or 4, and possibly any other processes or methods. It is also to be understood that any one of the above methods are not necessarily carried out completely by the apparatus 500. Some steps of the above methods may be performed by one or more other entities.

[0071] The apparatus 500 may comprise at least one processor 501, such as a data processor (DP) and at least one memory (MEM) 502 coupled to the processor 501. The apparatus 500 may further comprise a transmitter TX and receiver RX (or a transceiver) 503 coupled to the processor 501. The MEM 502 stores a program (PROG) 504. The PROG 504 may include instructions that, when executed on the associated processor 501, enable the apparatus 500 to operate in accordance with the embodiments of the present disclosure, for example to perform the above methods. A combination of the at least one processor 501 and the at least one MEM 502 may form processing means 505 adapted to implement various embodiments of the present disclosure.

[0072] Various embodiments of the present disclosure may be implemented by computer program executable by the processor 501, circuitry, software, firmware, hardware or in a combination thereof. The processors 501 may be of any type suitable to the local technical environment, and may include one or more of general purpose computers, special purpose computers, microprocessors, digital signal processors DSPs and processors based on multicore processor architecture, as non-limiting examples.

[0073] The MEMs 502 may be of any type suitable to the local technical environment and may be implemented using any suitable data storage technology, such as semiconductor-based memory devices, magnetic memory devices and systems, optical memory devices and systems, fixed memory and removable memory, as non-limiting examples.

[0074] The transmitter TX and receiver RX 503 can have multiple antennas that utilize various transmission diversity schemes, for example for supporting the 5G NR technology. For example, the apparatus 500 can comprise two transmit antennas, or four or more transmit antennas that support beamforming.

[0075] In addition, the present disclosure may also provide a carrier containing the computer program as mentioned above, wherein the carrier is one of an electronic signal, optical signal, radio signal, or computer readable storage medium. The computer readable storage medium can be, for example, an optical compact disk or an electronic memory device like a RAM (random access memory), a ROM (read only memory), Flash memory, magnetic tape, CD-ROM, DVD, Blue-ray disc and the like.

[0076] The techniques described herein may be implemented by various means so that an apparatus implementing one or more functions of a corresponding apparatus described with an embodiment comprises not only prior art means, but also means for implementing the one or more functions of the corresponding apparatus described with the embodiment and it may comprise separate means for each separate function, or means that may be configured to perform two or more functions. For example, these techniques may be implemented in hardware (one or

more apparatuses), firmware (one or more apparatuses), circuitry, software (one or more modules), or combinations thereof. For a firmware, circuitry, or software, implementation may be made through modules (e.g., procedures, functions, and so on) that perform the functions described herein.

5 **[0077]** Embodiments herein have been described above with reference to block diagrams and flowchart illustrations of methods and apparatuses. It will be understood that each block of the block diagrams and flowchart illustrations, and combinations of blocks in the block diagrams and flowchart illustrations, respectively, can be implemented by various means including computer program instructions. These computer program instructions may be loaded onto a
10 general purpose computer, special purpose computer, or other programmable data processing apparatus to produce a machine, such that the instructions which execute on the computer or other programmable data processing apparatus create means for implementing the functions specified in the flowchart block or blocks.

15 **[0078]** Further, while operations are depicted in a particular order, this should not be understood as requiring that such operations be performed in the particular order shown or in sequential order, or that all illustrated operations be performed, to achieve desirable results. In certain circumstances, multitasking and parallel processing may be advantageous. Likewise, while several specific implementation details are contained in the above discussions, these should not be construed as limitations on the scope of the subject matter described herein, but
20 rather as descriptions of features that may be specific to particular embodiments. Certain features that are described in the context of separate embodiments may also be implemented in combination in a single embodiment. Conversely, various features that are described in the context of a single embodiment may also be implemented in multiple embodiments separately or in any suitable sub-combination.

25 **[0079]** It will be obvious to a person skilled in the art that, as the technology advances, the inventive concept can be implemented in various ways. The above described embodiments are given for describing rather than limiting the disclosure, and it is to be understood that modifications and variations may be resorted to without departing from the spirit and scope of the disclosure as those skilled in the art readily understand. Such modifications and variations
30 are considered to be within the scope of the disclosure and the appended claims. The protection scope of the disclosure is defined by the accompanying claims.

WHAT IS CLAIMED IS:

1. A method comprising:

partitioning a sequence of encoded control information bits into a plurality of sub-blocks,
5 wherein the sequence of encoded control information bits comprises K originally-encoded control information bits and at least M repetition bits of the originally-encoded control information bits; and

interleaving the sub-blocks to form interleaved encoded control information bits, wherein
the interleaved encoded control information bits are to be placed on physical resources
10 corresponding to control channel elements at a first aggregation-level, and wherein K interleaved encoded control information bits placed on the physical resources corresponding to a beginning of each blind detection control channel elements group according to a second aggregation-level are different from the K originally-encoded control information bits, where K is an integer no less than 1, and M is an integer no less than 1.

2. The method according to Claim 1, further comprises:

determining the number of sub-blocks based on a ratio between a total number of bits
placed on the physical resources corresponding to the control channel elements at the first
aggregation-level and K .

3. The method according to Claim 2, wherein in a case that the ratio is an integer, the
partitioning comprises:

partitioning the sequence of encoded control information bits to form at least one sub-block
that spans two adjacent blind detection control channel elements groups according to the second
25 aggregation-level.

4. The method according to any of Claims 1 to 3, wherein the partitioning comprises:

partitioning the sequence of encoded control information bits resulting in each of the
plurality of sub-blocks comprises partial bits of the originally-encoded control information bits
30 and/or partial bits of the repetition bits.

5. The method according to any of Claims 1 to 4, wherein the partitioning comprises:

equally partitioning the sequence of encoded control information bits into the plurality of
sub-blocks.

6. The method according to any of Claims 1 to 4, wherein the partitioning comprises:
unequally partitioning the sequence of encoded control information bits into the plurality of sub-blocks.

7. The method according to any of Claims 1 to 6, wherein the first aggregation-level comprises 2^n , and the second aggregation-level comprises 2^{n-i} , wherein n is an integer larger than 0, and i is an integer with $0 < i \leq n$.

8. The method according to Claim 7, wherein the first aggregation-level comprises 16, and the second aggregation-level comprises 8.

9. The method according to Claim 7, wherein the first aggregation-level comprises 32, and the second aggregation-level comprises 8 and/or 16.

10. The method according to any of Claims 1 to 9, wherein the control information bits comprise downlink control information bits transmitted on a physical downlink control channel.

11. The method according to any of Claims 1 to 9, wherein the control information bits comprise uplink control information bits transmitted on a physical uplink control channel.

12. A computer readable storage medium storing thereon computer-executable instructions which, when executed by at least one processor, causing perform the method according to any of Claims 1-11.

13. An apparatus, comprising:
at least one processor; and
at least one memory including computer-executable instructions;
the at least one memory and the computer-executable instructions configured to, with the at least one processor, cause the apparatus at a transmitter, at least to:

partition a sequence of encoded control information bits into a plurality of sub-blocks, wherein the sequence of encoded control information bits comprises K originally-encoded control information bits and at least M repetition bits of the originally-encoded control information bits; and

interleave the sub-blocks to form interleaved encoded control information bits, wherein the interleaved encoded control information bits are to be placed on physical resources

corresponding to control channel elements at a first aggregation-level, and wherein K interleaved encoded control information bits placed on the physical resources corresponding to a beginning of each blind detection control channel elements group according to a second aggregation-level are different from the K originally-encoded control information bits, where K is an integer no less than 1, and M is an integer no less than 1.

14. The apparatus according to Claim 13, wherein the at least one memory and the computer program code configured to, with the at least one processor, cause the apparatus to further:

determine the number of sub-blocks based on a ratio between a total number of bits placed on the physical resources corresponding to the control channel elements at the first aggregation-level and K .

15. The apparatus according to Claim 14, wherein the at least one memory and the computer program code configured to, with the at least one processor, cause the apparatus at least to:

in a case that the ratio is an integer, partition the sequence of encoded control information bits to form at least one sub-block that spans two adjacent blind detection control channel elements groups according to the second aggregation-level.

16. The apparatus according to any of Claims 13 to 15, wherein the at least one memory and the computer program code configured to, with the at least one processor, cause the apparatus at least to:

partition the sequence of encoded control information bits resulting in each of the plurality of sub-blocks comprises partial bits of the originally-encoded control information bits and/or partial bits of the repetition bits.

17. The apparatus according to any of Claims 13 to 16, wherein the at least one memory and the computer program code configured to, with the at least one processor, cause the apparatus at least to:

equally partition the sequence of encoded control information bits into the plurality of sub-blocks.

18. The apparatus according to any of Claims 13 to 16, wherein the at least one memory and the computer program code configured to, with the at least one processor, cause the apparatus at least to:

5 unequally partition the sequence of encoded control information bits into the plurality of sub-blocks.

19. The apparatus according to any of Claims 13 to 18, wherein the first aggregation-level comprises 2^n , and the second aggregation-level comprises 2^{n-i} , wherein n is an integer larger than 0, and i is an integer with $0 < i \leq n$.

10 20. The apparatus according to Claim 19, wherein the first aggregation-level comprises 16, and the second aggregation-level comprises 8.

15 21. The apparatus according to Claim 19, wherein the first aggregation-level comprises 32, and the second aggregation-level comprises 8 and/or 16.

22. The apparatus according to any of Claims 13 to 21, wherein the control information bits comprise downlink control information bit transmitted on a physical downlink control channel.

20 23. The apparatus according to any of Claims 13 to 21, wherein the control information bits comprise uplink control information bit transmitted on a physical uplink control channel.

24. An apparatus, comprising:
25 means for partitioning a sequence of encoded control information bits into a plurality of sub-blocks, wherein the sequence of encoded control information bits comprises K originally-encoded control information bits and at least M repetition bits of the originally-encoded control information bits; and

means for interleaving the sub-blocks to form interleaved encoded control information bits,
30 wherein the interleaved encoded control information bits are to be placed on physical resources corresponding to control channel elements at a first aggregation-level, and wherein K interleaved encoded control information bits placed on the physical resources corresponding to a beginning of each blind detection control channel elements group according to a second aggregation-level are different from the K originally-encoded control information bits, where K is an integer no
35 less than 1, and M is an integer no less than 1.

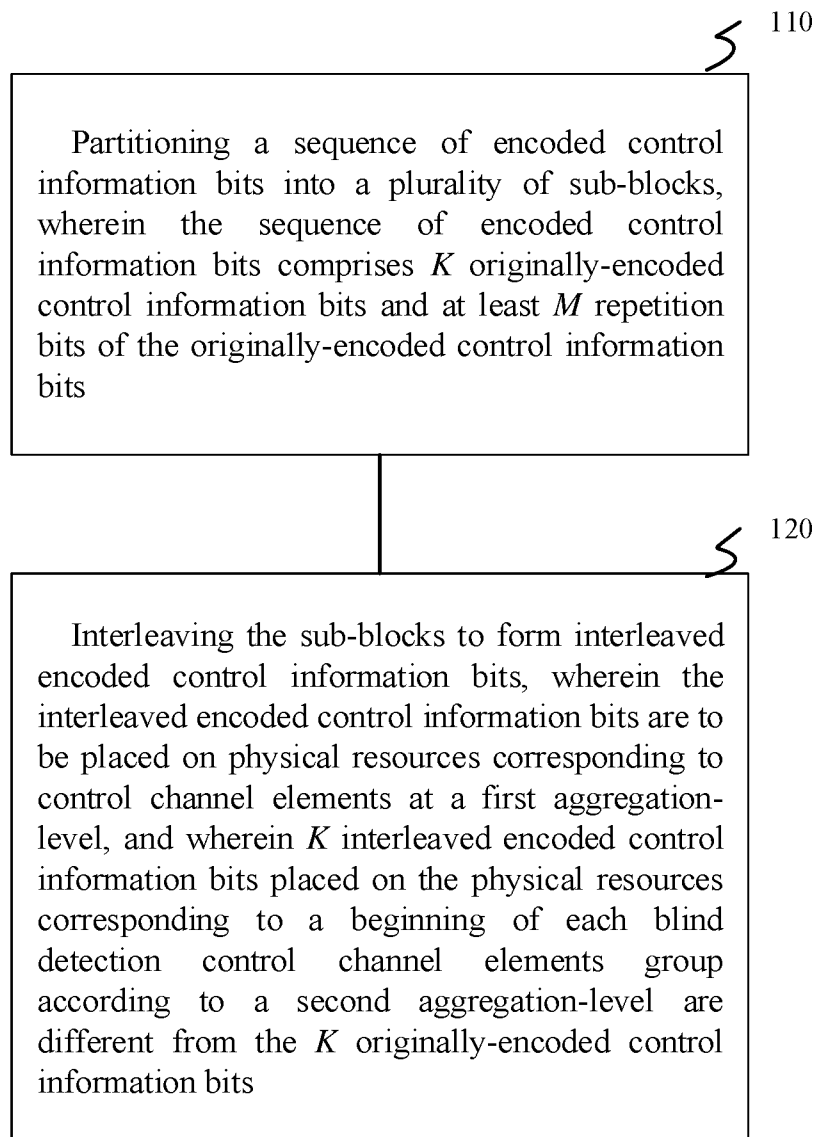
100

FIG.1

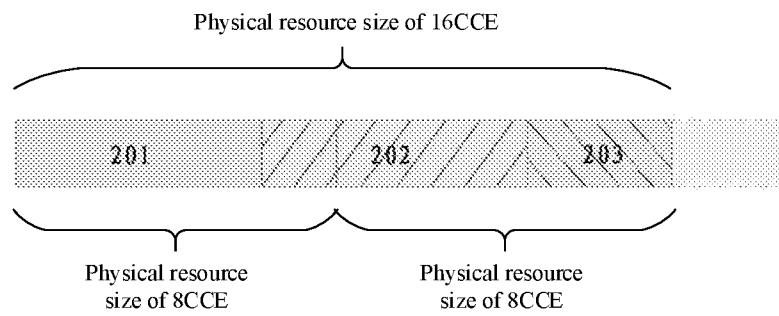


FIG.2

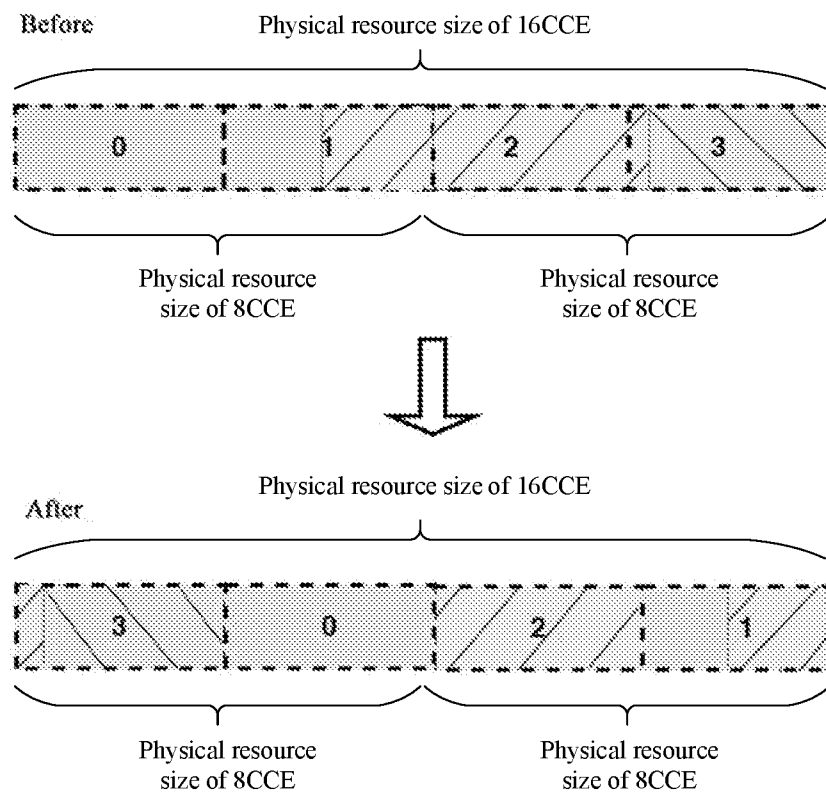


FIG.3

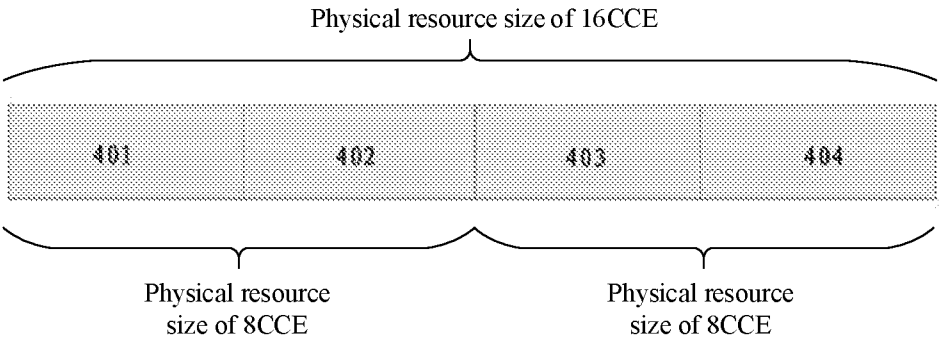


FIG.4

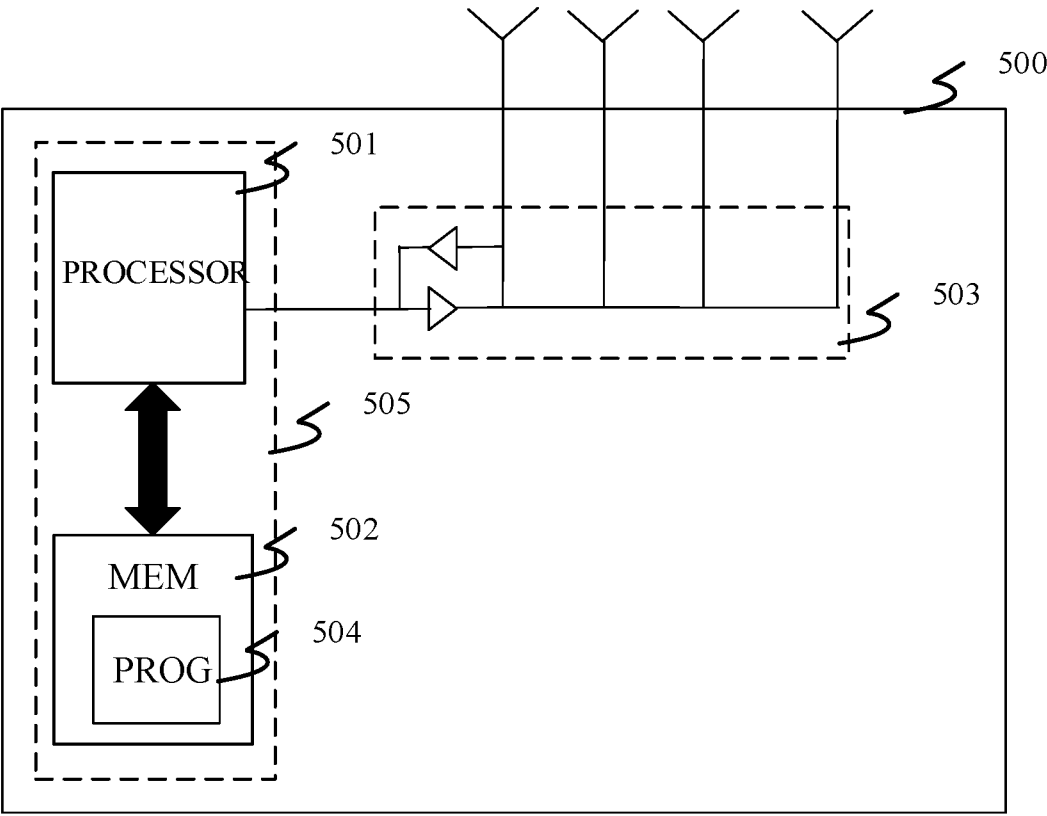


FIG.5

INTERNATIONAL SEARCH REPORT

International application No.

PCT/CN2018/122490

A. CLASSIFICATION OF SUBJECT MATTER

H04L 1/00(2006.01)i

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

H04L

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

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

WPI, EPODOC, CNPAT, CNKI: h04l, encod+, block?, interleav+, aggregat+, original+, ambiguity, blind

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	CN 104618068 A (SHANGHAI ADVANCED RESEARCH INSTITUTE, CHINESE ACADEMY OF SCIENCE) 13 May 2015 (2015-05-13) the abstract	1-24
A	CN 101860412 A (ZTE CORPORATION) 13 October 2010 (2010-10-13) the whole document	1-24
A	CN 105612706 A (QUALCOMM INCORPORATED) 25 May 2016 (2016-05-25) the whole document	1-24
A	US 7729389 B1 (MARVELL INTERNATIONAL LTD.) 01 June 2010 (2010-06-01) the whole document	1-24
A	US 2013091398 A1 (NEC LABORATORIES AMERICA, INC.) 11 April 2013 (2013-04-11) the whole document	1-24

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

* Special categories of cited documents:

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

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

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

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

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

“&” document member of the same patent family

Date of the actual completion of the international search

30 August 2019

Date of mailing of the international search report

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INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.

PCT/CN2018/122490

Patent document cited in search report			Publication date (day/month/year)	Patent family member(s)			Publication date (day/month/year)
CN	104618068	A	13 May 2015	None			
CN	101860412	A	13 October 2010	WO	2010118591	A1	21 October 2010
CN	105612706	A	25 May 2016	US	2015098420	A1	09 April 2015
				EP	3055940	A1	17 August 2016
				KR	20160067862	A	14 June 2016
				JP	2019118110	A	18 July 2019
				JP	2016539534	A	15 December 2016
				WO	2015054268	A1	16 April 2015
				BR	112016007897	A2	01 August 2017
				IN	201647007486	A	01 July 2016
US	7729389	B1	01 June 2010	US	8451869	B1	28 May 2013
				US	8233507	B1	31 July 2012
				US	8982915	B1	17 March 2015
US	2013091398	A1	11 April 2013	None			