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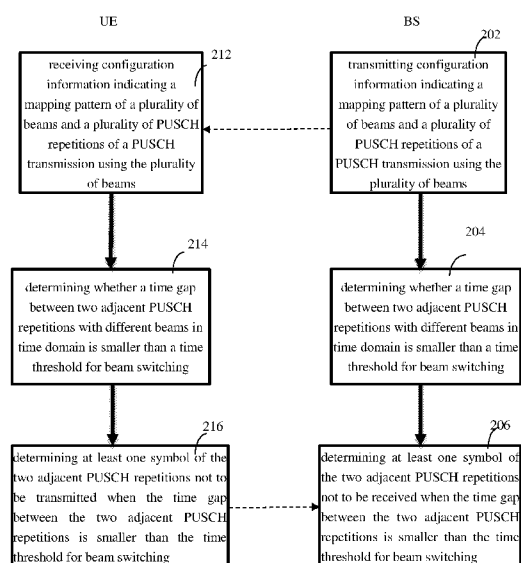


FIG. 2

(57) Abstract: Embodiments of the present application are related to a method and apparatus for physical uplink shared channel (PUSCH) transmission with repetition. According an embodiment of the present application, an exemplary method includes: receiving configuration information indicating a mapping pattern of a plurality of beams and a plurality of PUSCH repetitions of a PUSCH transmission using the plurality of beams, wherein each of the plurality of beams is represent by spatial relation information; determining whether a time gap between two adjacent PUSCH repetitions with different beams in time domain is smaller than a time threshold for beam switching; and determining at least one symbol of the two adjacent PUSCH repetitions not to be transmitted when the time gap between the two adjacent PUSCH repetitions is smaller than the time threshold for beam switching.

METHOD AND APPARATUS FOR PUSCH TRANSMISSION WITH REPETITION

TECHNICAL FIELD

[0001] Embodiments of the present application relate to wireless communication technology, especially to a method and an apparatus for physical uplink shared channel (PUSCH) transmission with repetition.

BACKGROUND OF THE INVENTION

[0002] In new radio (NR) R17, it is proposed to identify and specify features to improve reliability and robustness for channels other than physical downlink shared channel (PDSCH) using multiple transmission reception points (TRP) and/or multi-panel, with R16 reliability features. The concerned channels other than PDSCH are: physical downlink control channel (PDCCH), PUSCH, and physical uplink control channel (PUCCH). Specifically, regarding PUSCH, PUSCH repetitions with multiple beams or multiple TRPs can utilize the spatial diversity of multiple beams (a beam may be represented by spatial relation information) or TRPs of PUSCH transmission to increase the reliability and robustness. However, only one panel can be used for uplink transmission in R17 considering the power limitation of user equipment (UE), which means that additional time is needed for switching beams between two adjacent PUSCH repetitions with different beams from different panels when the time gap between the two adjacent PUSCH repetitions is not sufficient for beam switching.

[0003] Therefore, how to handle two adjacent PUSCH repetitions with different beams in time domain should be further studied. The industry needs to improve PUSCH transmission with repetition in view of multi-beams or multi-TRP.

[0004] One objective of the embodiments of the present application is to provide a technical solution for PUSCH transmission with repetition, especially for PUSCH transmission with repetition using different beams.

[0005] An embodiment of the present application provides a method, which includes: receiving configuration information indicating a mapping pattern of a plurality of beams and a plurality of PUSCH repetitions of a PUSCH transmission using the plurality of beams, wherein each of the plurality of beams is represented by spatial relation information; determining whether a time gap between two adjacent PUSCH repetitions with different beams in time domain is smaller than a time threshold for beam switching; and determining at least one symbol of the two adjacent PUSCH repetitions not to be transmitted when the time gap between the two adjacent PUSCH repetitions is smaller than the time threshold for beam switching.

[0006] According to some embodiments of the present application, the time threshold for beam switching is predefined in specification(s), or is specifically determined for a user equipment (UE) based on capability of the UE.

[0007] In some embodiments of the present application, determining the at least one symbol not to be transmitted is only based on a former repetition of the two adjacent PUSCH repetitions starting earlier in the time domain. In the case that both the two adjacent PUSCH repetitions are repetitions of PUSCH repetition type A or are actual repetitions of PUSCH repetition type B, the method includes: determining last T symbol(s) of the former repetition not to be transmitted when the time gap between the two adjacent PUSCH repetitions is smaller than the time threshold for beam switching, wherein, $T = \min(L1, M-N)$, L1 is a total symbol number of the former repetition, N symbol(s) represents the time gap between the two adjacent PUSCH repetitions, M symbol(s) represents the time threshold for beam switching, and all of L1, M and N are nature number; and counting a number of the plurality of PUSCH repetitions by including the former repetition. In the case that both the two adjacent PUSCH repetitions are actual repetitions of PUSCH repetition type B, the method includes: determining last T symbol(s) of the former repetition to be invalid and not to be transmitted when the time gap between the two adjacent PUSCH repetitions is smaller than the time threshold for beam switching, wherein, $T = \min(L1, M-N)$, L1 is

a total symbol number of the former repetition, N symbol(s) represents the time gap between the two adjacent PUSCH repetitions, M symbol(s) represents the time threshold for beam switching, and all of $L1$, M and N are nature number; and counting a number of the plurality of PUSCH repetitions by including the former repetition only when remaining valid symbol(s) of the former repetition is still qualified for an actual repetition of PUSCH repetition type B after excluding the last T symbols from the former repetition.

[0008] In some other embodiments of the present application, determining the at least one symbol not to be transmitted is only based on a later repetition of the two adjacent PUSCH repetitions starting later in the time domain. In the case that both the two adjacent PUSCH repetitions are repetitions of PUSCH repetition type A or are actual repetitions of PUSCH repetition type B, the method includes: determining first T symbol(s) of the later repetition not to be transmitted when the time gap between the two adjacent PUSCH repetitions is smaller than the time threshold for beam switching, wherein, $T = \min(L2, M - N)$, $L2$ is a total symbol number of the later repetition, N symbol(s) represents the time gap between the two adjacent PUSCH repetitions, M symbol(s) represents the time threshold for beam switching, and all of $L2$, M and N are nature number; and counting a number of the plurality of PUSCH repetitions by including the later repetition. In the case that both the two adjacent PUSCH repetitions are actual repetitions of PUSCH repetition type B, the method includes: determining first T symbol(s) of the later repetition to be invalid and not to be transmitted when the time gap between the two adjacent PUSCH repetitions is smaller than the time threshold for beam switching, wherein, $T = \min(L2, M - N)$, $L2$ is a total symbol number of the later repetition, N symbol(s) represents the time gap between the two adjacent PUSCH repetitions, M symbol(s) represents the time threshold for beam switching, and all of $L2$, M and N are nature number; and counting a number of the plurality of PUSCH repetitions by including the later repetition only when the remaining valid symbol(s) of the later repetition is still qualified for an actual repetition of PUSCH repetition type B after excluding the first T symbols from the later repetition.

[0009] In some yet other embodiments of the present application, determining the at least one symbol not to be transmitted is based on both a former repetition of the two

adjacent PUSCH repetitions starting earlier in the time domain and a later repetition of the two adjacent PUSCH repetitions starting later in the time domain. In the case that both the two adjacent PUSCH repetitions are repetitions of PUSCH repetition type A or are actual repetitions of PUSCH repetition type B, the method includes: determining last T1 symbol(s) of the former repetition and first T2 symbol(s) of the later repetition not to be transmitted when the time gap between the two adjacent PUSCH repetitions is smaller than the time threshold for beam switching, wherein, $T1 = \min(L1, \text{ceil}((M-N)/2))$, $T2 = \min(L2, \text{floor}((M-N)/2))$, L1 is a total symbol number of the former repetition, L2 is a total symbol number of the later repetition, N symbol(s) represents the time gap between the two adjacent PUSCH repetitions, M symbol(s) represents the time threshold for beam switching, and all of L1, L2, M and N are nature number; and counting a number of the plurality of PUSCH repetitions by including the former repetition and the later repetition. In the case that both the two adjacent PUSCH repetitions are actual repetitions of PUSCH repetition type B, the method includes: determining last T1 symbol(s) of the former repetition and first T2 symbol(s) of the later repetition to be invalid and not to be transmitted when the time gap between the two adjacent PUSCH repetitions is smaller than the time threshold for beam switching, wherein, $T1 = \min(L1, \text{ceil}((M-N)/2))$, $T2 = \min(L2, \text{floor}((M-N)/2))$, L1 is a total symbol number of the former repetition, L2 is a total symbol number of the later repetition, N symbol(s) represent the time gap between the two adjacent PUSCH repetitions, M symbol(s) represent the time threshold for beam switching, and all of L1, L2, M and N are nature number; counting a number of the plurality of PUSCH repetitions by including the former repetition only when remaining valid symbol(s) of the former repetition is still qualified for an actual repetition of PUSCH repetition type B after excluding the last T1 symbols from the former repetition; and counting a number of the plurality of PUSCH repetitions by including the later repetition only when remaining valid symbol(s) of the later repetition is still qualified for an actual repetition of PUSCH repetition type B after excluding the first T2 symbols from the later repetition. In the case that both the two adjacent PUSCH repetitions are repetitions of PUSCH repetition type A or are actual repetitions of PUSCH repetition type B, the method includes: determining last T1 symbol(s) of the former repetition and first T2 symbol(s) of the later repetition not to be transmitted when the time gap between the two adjacent PUSCH repetitions is smaller than the time threshold for beam switching, wherein, $T1 = \min(L1,$

$\text{floor}((M-N)/2)$), $T2 = \min(L2, \text{ceil}((M-N)/2))$, $L1$ is a total symbol number of the former repetition, $L2$ is a total symbol number of the later repetition, N symbol(s) represents the time gap between the two adjacent PUSCH repetitions, M symbol(s) represents the time threshold for beam switching, and all of $L1$, $L2$, M and N are nature number; and counting a number of the plurality of PUSCH repetitions by including the former repetition and the later repetition. In the case that both the two adjacent PUSCH repetitions are actual repetitions of PUSCH repetition type B, the method includes: determining last $T1$ symbol(s) of the former repetition and first $T2$ symbol(s) of the later repetition to be invalid and not to be transmitted when the time gap between the two adjacent PUSCH repetitions is smaller than the time threshold for beam switching, wherein, $T1 = \min(L1, \text{floor}((M-N)/2))$, $T2 = \min(L2, \text{ceil}((M-N)/2))$, $L1$ is a total symbol number of the former repetition, $L2$ is a total symbol number of the later repetition, N symbol(s) represents the time gap between the two adjacent PUSCH repetitions, M symbol(s) represents the time threshold for beam switching, and all of $L1$, $L2$, M and N are nature number; counting a number of the plurality of PUSCH repetitions by including the former repetition only when remaining valid symbol(s) of the former repetition is still qualified for an actual repetition of PUSCH repetition type B after excluding the last $T1$ symbols from the former repetition; and counting the number of the plurality of PUSCH repetitions by including the later repetition only when remaining valid symbol(s) of the later repetition is still qualified for an actual repetition of PUSCH repetition type B after excluding the first $T2$ symbols from the later repetition.

[0010] Another embodiment of the present application provides a method, which includes: transmitting configuration information indicating a mapping pattern of a plurality of beams and a plurality of PUSCH repetitions of a PUSCH transmission using the plurality of beams, wherein each of the plurality of beams is represented by spatial relation information; determining whether a time gap between two adjacent PUSCH repetitions with different beams in time domain is smaller than a time threshold for beam switching; and determining at least one symbol of the two adjacent PUSCH repetitions not to be received when the time gap between the two adjacent PUSCH repetitions is smaller than the time threshold for beam switching.

[0011] In some embodiments of the present application, determining the at least one

symbol not to be received is only based on a former repetition of the two adjacent PUSCH repetitions starting earlier in the time domain. In the case that both the two adjacent PUSCH repetitions are repetitions of PUSCH repetition type A or are actual repetitions of PUSCH repetition type B, the method includes: determining last T symbol(s) of the former repetition not to be received when the time gap between the two adjacent PUSCH repetitions is smaller than the time threshold for beam switching, wherein, $T = \min(L1, M-N)$, L1 is a total symbol number of the former repetition, N symbol(s) represents the time gap between the two adjacent PUSCH repetitions, M symbol(s) represents the time threshold for beam switching, and all of L1, M and N are nature number; and counting a number of the plurality of PUSCH repetitions by including the former repetition. In the case that both the two adjacent PUSCH repetitions are actual repetitions of PUSCH repetition type B, the method includes: determining last T symbol(s) of the former repetition to be invalid and not to be received when the time gap between the two adjacent PUSCH repetitions is smaller than the time threshold for beam switching, wherein, $T = \min(L1, M-N)$, L1 is a total symbol number of the former repetition, N symbol(s) represents the time gap between the two adjacent PUSCH repetitions, M symbol(s) represents the time threshold for beam switching, and all of L1, M and N are nature number; and counting a number of the plurality of PUSCH repetitions by including the former repetition only when remaining valid symbol(s) of the former repetition is still qualified for an actual repetition of PUSCH repetition type B after excluding the last T symbols from the former repetition.

[0012] In some other embodiments of the present application, determining the at least one symbol not to be received is only based on a later repetition of the two adjacent PUSCH repetitions starting later in the time domain. In the case that both the two adjacent PUSCH repetitions are repetitions of PUSCH repetition type A or are actual repetitions of PUSCH repetition type B, the method includes: determining first T symbol(s) of the later repetition not to be received when the time gap between the two adjacent PUSCH repetitions is smaller than the time threshold for beam switching, wherein, $T = \min(L2, M-N)$, L2 is a total symbol number of the later repetition, N symbol(s) represents the time gap between the two adjacent PUSCH repetitions, M symbol(s) represents the time threshold for beam switching, and all of L2, M and N are nature number; and counting a number of the plurality of PUSCH repetitions by

including the later repetition. In the case that both the two adjacent PUSCH repetitions are actual repetitions of PUSCH repetition type B, the method includes: determining first T symbol(s) of the later repetition to be invalid and not to be received when the time gap between the two adjacent PUSCH repetitions is smaller than the time threshold for beam switching, wherein, $T = \min(L2, M-N)$, L2 is a total symbol number of the later repetition, N symbol(s) represents the time gap between the two adjacent PUSCH repetitions, M symbol(s) represents the time threshold for beam switching, and all of L2, M and N are nature number; and counting a number of the plurality of PUSCH repetitions by including the later repetition only when the remaining valid symbol(s) of the later repetition is still qualified for an actual repetition of PUSCH repetition type B after excluding the first T symbols from the later repetition.

[0013] In some yet other embodiments of the present application, determining the at least one symbol not to be received is based on both a former repetition of the two adjacent PUSCH repetitions starting earlier in the time domain and a later repetition of the two adjacent PUSCH repetitions starting later in the time domain. In the case that both the two adjacent PUSCH repetitions are repetitions of PUSCH repetition type A or are actual repetitions of PUSCH repetition type B, the method includes: determining last T1 symbol(s) of the former repetition and first T2 symbol(s) of the later repetition not to be received when the time gap between the two adjacent PUSCH repetitions is smaller than the time threshold for beam switching, wherein, $T1 = \min(L1, \text{ceil}((M-N)/2))$, $T2 = \min(L2, \text{floor}((M-N)/2))$, L1 is a total symbol number of the former repetition, L2 is a total symbol number of the later repetition, N symbol(s) represents the time gap between the two adjacent PUSCH repetitions, M symbol(s) represents the time threshold for beam switching, and all of L1, L2, M and N are nature number; and counting a number of the plurality of PUSCH repetitions by including the former repetition and the later repetition. In the case that both the two adjacent PUSCH repetitions are actual repetitions of PUSCH repetition type B, the method includes: determining last T1 symbol(s) of the former repetition and first T2 symbol(s) of the later repetition to be invalid and not to be received when the time gap between the two adjacent PUSCH repetitions is smaller than the time threshold for beam switching, wherein, $T1 = \min(L1, \text{ceil}((M-N)/2))$, $T2 = \min(L2, \text{floor}((M-N)/2))$, L1 is a total symbol number of the former repetition, L2 is a total symbol number of

the later repetition, N symbol(s) represent the time gap between the two adjacent PUSCH repetitions, M symbol(s) represent the time threshold for beam switching, and all of $L1$, $L2$, M and N are nature number; counting a number of the plurality of PUSCH repetitions by including the former repetition only when remaining valid symbol(s) of the former repetition is still qualified for an actual repetition of PUSCH repetition type B after excluding the last $T1$ symbols from the former repetition; and counting a number of the plurality of PUSCH repetitions by including the later repetition only when remaining valid symbol(s) of the later repetition is still qualified for an actual repetition of PUSCH repetition type B after excluding the first $T2$ symbols from the later repetition. In the case that both the two adjacent PUSCH repetitions are repetitions of PUSCH repetition type A or are actual repetitions of PUSCH repetition type B, the method includes: determining last $T1$ symbol(s) of the former repetition and first $T2$ symbol(s) of the later repetition not to be received when the time gap between the two adjacent PUSCH repetitions is smaller than the time threshold for beam switching, wherein, $T1 = \min(L1, \text{floor}((M-N)/2))$, $T2 = \min(L2, \text{ceil}((M-N)/2))$, $L1$ is a total symbol number of the former repetition, $L2$ is a total symbol number of the later repetition, N symbol(s) represents the time gap between the two adjacent PUSCH repetitions, M symbol(s) represents the time threshold for beam switching, and all of $L1$, $L2$, M and N are nature number; and counting a number of the plurality of PUSCH repetitions by including the former repetition and the later repetition. In the case that both the two adjacent PUSCH repetitions are actual repetitions of PUSCH repetition type B, the method includes: determining last $T1$ symbol(s) of the former repetition and first $T2$ symbol(s) of the later repetition to be invalid and not to be received when the time gap between the two adjacent PUSCH repetitions is smaller than the time threshold for beam switching, wherein, $T1 = \min(L1, \text{floor}((M-N)/2))$, $T2 = \min(L2, \text{ceil}((M-N)/2))$, $L1$ is a total symbol number of the former repetition, $L2$ is a total symbol number of the later repetition, N symbol(s) represents the time gap between the two adjacent PUSCH repetitions, M symbol(s) represents the time threshold for beam switching, and all of $L1$, $L2$, M and N are nature number; counting a number of the plurality of PUSCH repetitions by including the former repetition only when remaining valid symbol(s) of the former repetition is still qualified for an actual repetition of PUSCH repetition type B after excluding the last $T1$ symbols from the former repetition; and counting the number of the plurality of PUSCH repetitions by including the later repetition only when remaining valid

symbol(s) of the later repetition is still qualified for an actual repetition of PUSCH repetition type B after excluding the first T2 symbols from the later repetition.

[0014] Yet another embodiment of the present application provides an apparatus, including: at least one non-transitory computer-readable medium having stored thereon computer-executable instructions; at least one receiving circuitry; at least one transmitting circuitry; and at least one processor coupled to the at least one non-transitory computer-readable medium, the at least one receiving circuitry and the at least one transmitting circuitry. The computer-executable instructions cause the at least one processor to implement any method according to an embodiment of the present application with the at least one receiving circuitry and the at least one transmitting circuitry.

[0015] Embodiments of the present application can improve reliability and robustness for uplink transmissions, especially for PUSCH with repetition using different beams, and will facilitate the deployment and implementation of the NR.

BRIEF DESCRIPTION OF THE DRAWINGS

[0016] In order to describe the manner in which advantages and features of the present disclosure can be obtained, a description of the present disclosure is rendered by reference to specific embodiments thereof which are illustrated in the appended drawings. These drawings depict only exemplary embodiments of the present disclosure and are not therefore intended to limit the scope of the present disclosure.

[0017] FIG. 1 is a schematic diagram illustrating an exemplary wireless communication system according to some embodiments of the present application;

[0018] FIG. 2 illustrates a flow chart of a method for PUSCH transmission with repetition according to some embodiments of the present application;

[0019] FIG. 3 illustrates an exemplary diagram of two repetitions of a PUSCH

transmission with different beams by Solution 1-1 according to some other embodiments of the present application;

[0020] FIG. 4 illustrates an exemplary diagram of two repetitions of a PUSCH transmission with different beams by Solution 1-2 according to some other embodiments of the present application;

[0021] FIG. 5 illustrates an exemplary diagram of two repetitions of a PUSCH transmission with different beams by Solution 2-1 according to some other embodiments of the present application;

[0022] FIG. 6 illustrates an exemplary diagram of two repetitions of a PUSCH transmission with different beams by Solution 2-2 according to some other embodiments of the present application;

[0023] FIG. 7 illustrates an exemplary diagram of two repetitions of a PUSCH transmission with different beams by Solution 3-1 according to some other embodiments of the present application;

[0024] FIG. 8 illustrates an exemplary diagram of two repetitions of a PUSCH transmission with different beams by Solution 3-2 according to some other embodiments of the present application; and

[0025] FIG. 9 illustrates a simplified block diagram of an apparatus for multiplexing uplink resources according to some embodiments of the present application.

DETAILED DESCRIPTION

[0026] The detailed description of the appended drawings is intended as a description of the currently preferred embodiments of the present disclosure and is not intended to represent the only form in which the present disclosure may be practiced. It is to be understood that the same or equivalent functions may be accomplished by different embodiments that are intended to be encompassed within the spirit and scope of the present disclosure.

[0027] Reference will now be made in detail to some embodiments of the present disclosure, examples of which are illustrated in the accompanying drawings. To facilitate understanding, embodiments are provided under specific network architecture and new service scenarios, such as 3rd generation partnership project (3GPP) 5G, 3GPP long term evolution (LTE) Release 8 and so on. Persons skilled in the art know very well that, with the development of network architecture and new service scenarios, the embodiments in the present disclosure are also applicable to similar technical problems.

[0028] FIG. 1 illustrates a schematic diagram of an exemplary wireless communication system 100 according to some embodiments of the present application.

[0029] As shown in FIG. 1, the wireless communication system 100 includes a UE 102 and a BS 101. Although merely one BS is illustrated in FIG. 1 for simplicity, it is contemplated that the wireless communication system 100 may include more BSs in some other embodiments of the present application. Similarly, although merely one UE is illustrated in FIG. 1 for simplicity, it is contemplated that the wireless communication system 100 may include more UEs in some other embodiments of the present application.

[0030] The BS 101 may also be referred to as an access point, an access terminal, a base, a macro cell, a node-B, an enhanced node B (eNB), a gNB, a home node-B, a relay node, or a device, or described using other terminology used in the art. The BS 101 is generally part of a radio access network that may include a controller communicably coupled to the BS 101.

[0031] The UE 102 may include computing devices, such as desktop computers, laptop computers, personal digital assistants (PDAs), tablet computers, smart televisions (e.g., televisions connected to the Internet), set-top boxes, game consoles, security systems (including security cameras), vehicle on-board computers, network devices (e.g., routers, switches, and modems), or the like. According to an embodiment of the present application, the UE 102 may include a portable wireless communication device, a smart phone, a cellular telephone, a flip phone, a device having a subscriber identity module, a personal computer, a selective call receiver, or

any other device that is capable of sending and receiving communication signals on a wireless network. In some embodiments, the UE 102 may include wearable devices, such as smart watches, fitness bands, optical head-mounted displays, or the like. Moreover, the UE 102 may be referred to as a subscriber unit, a mobile, a mobile station, a user, a terminal, a mobile terminal, a wireless terminal, a fixed terminal, a subscriber station, a user terminal, or a device, or described using other terminology used in the art.

[0032] The wireless communication system 100 is compatible with any type of network that is capable of sending and receiving wireless communication signals. For example, the wireless communication system 100 is compatible with a wireless communication network, a cellular telephone network, a time division multiple access (TDMA)-based network, a code division multiple access (CDMA)-based network, an orthogonal frequency division multiple access (OFDMA)-based network, an LTE network, a 3GPP-based network, a 3GPP 5G network, a satellite communications network, a high altitude platform network, and/or other communications networks.

[0033] For PUSCH (or PUSCH transmission), PUSCH repetitions with multiple beams or TRPs can utilize the spatial diversity of multiple beams or TRPs of PUSCH transmission, and thus can greatly increase the reliability and robustness of uplink data transmissions. Currently, there are two types of PUSCH repetition, i.e., PUSCH repetition Type A and PUSCH repetition Type B. For PUSCH repetition Type A, a PUSCH transmission in a slot of a multi-slot PUSCH transmission is omitted according to the conditions in Clause 11.1 of [6, TS38.213], and the time allocation of each repetition is same and is indicated by the corresponding DCI. Different from PUSCH repetition Type A, in PUSCH repetition Type B, concepts "nominal repetition" and "actual repetition" are introduced so that multiple repetitions within one slot will be identified. The time allocation of each actual repetition of a PUSCH repetition Type B is not the same and is determined by the slot segment and invalid symbols in a nominal repetition.

[0034] Specifically, according to TS 38.214, for PUSCH repetition Type B, the number of nominal repetitions is given by the parameter *numberofrepetitions*, for the n^{th} nominal repetition, wherein the value of n ranges from 0 to *numberofrepetitions*-1,

the starting slot, starting symbol, ending slot, and ending symbol of the n^{th} nominal repetition are calculated as follows:

- i. the slot where the nominal repetition starts:

$$K_s + \left\lfloor \frac{S + n \cdot L}{N_{\text{ymb}}^{\text{slot}}} \right\rfloor \quad (1)$$

- ii. the starting symbol relative to the start of the slot:

$$\text{mod}(S + n \cdot L, N_{\text{ymb}}^{\text{slot}}) \quad (2)$$

- iii. the slot where the nominal repetition ends:

$$K_s + \left\lfloor \frac{S + (n + 1) \cdot L - 1}{N_{\text{ymb}}^{\text{slot}}} \right\rfloor \quad (3)$$

- iv. the ending symbol relative to the start of the slot:

$$\text{mod}(S + (n + 1) \cdot L - 1, N_{\text{ymb}}^{\text{slot}}) \quad (4)$$

Wherein K_s is the slot where the PUSCH transmission starts, and $N_{\text{ymb}}^{\text{slot}}$ is the number of symbols per slot, S is the starting symbol S relative to the start of the slot, and L is the number of consecutive symbols L counting from the symbol S allocated for each nominal repetition of a PUSCH repetition Type B transmission. S and L are respectively provided by the parameters: *startSymbol* and *length* of the indexed row of the resource allocation table.

[0035] Meanwhile, for PUSCH repetition Type B, among the starting symbol to the ending symbol, there might be one or more invalid symbols. The UE determines these invalid symbols for PUSCH repetition Type B transmission based on the following rules:

- i. A symbol that is indicated as downlink by *tdd-UL-DL-ConfigurationCommon* or *tdd-UL-DL-ConfigurationDedicated*. Since the symbol is indicated to be used for downlink transmission, the UE considers that the symbol cannot be used for uplink transmission. Thus, the symbol is an invalid symbol for PUSCH repetition Type B transmission.

- ii. The UE may be configured with the high layer parameter *InvalidSymbolPattern*, which provides a symbol level bitmap spanning one or two slots, e.g., high layer parameter *symbols* given by *InvalidSymbolPattern*. A bit value equal to 1 in the symbol level bitmap *symbols* indicates that the corresponding symbol is an invalid symbol for PUSCH repetition Type B transmission. The UE may be additionally configured with a time-domain pattern, e.g., high layer parameter *periodicityAndPattern* given by *InvalidSymbolPattern*, where each bit of *periodicityAndPattern* corresponds to a unit equal to a duration of the symbol level bitmap *symbols*, and a bit value equal to 1 indicates that the symbol level bitmap *symbols* is present in the unit. The *periodicityAndPattern* can be {1, 2, 4, 5, 8, 10, 20 or 40} units long, but maximum of 40ms. The first symbol of *periodicityAndPattern* every $40\text{ms}/P$ periods is a first symbol in frame $nf \bmod 4 = 0$, where P is the duration of *periodicityAndPattern* in units of ms. When the parameter *periodicityAndPattern* is not configured, for a symbol level bitmap spanning two slots, the bits of the first and second slots correspond respectively to even and odd slots of a radio frame, and for a symbol level bitmap spanning one slot, the bits of the slot correspond to every slot of a radio frame. If the parameter *InvalidSymbolPattern* is configured, when the UE applies the invalid symbol pattern is determined as follows:

- a) if the PUSCH is scheduled by downlink control information (DCI) format 0_1, or corresponds to a Type 2 configured grant activated by DCI format 0_1, and if *InvalidSymbolPatternIndicator-ForDCIFormat0_1* is configured, if invalid symbol pattern indicator field is set 1, the UE applies the invalid symbol pattern; otherwise, the UE does not apply the invalid symbol pattern;
- b) if the PUSCH is scheduled by DCI format 0_2, or corresponds to a Type 2 configured grant activated by DCI format 0_2, and if *InvalidSymbolPatternIndicator-ForDCIFormat0_2* is configured, if invalid symbol pattern indicator field is set 1, the UE applies the invalid symbol pattern; otherwise, the UE does not apply the invalid symbol pattern;

- c) otherwise, the UE applies the invalid symbol pattern.

[0036] After determining the invalid symbol(s) for PUSCH repetition Type B transmission for each nominal repetition, the remaining symbols are considered as potentially valid symbols for PUSCH repetition Type B transmission. If the number of potentially valid symbols for PUSCH repetition Type B transmission is greater than zero for a nominal repetition, the nominal repetition consists of one or more actual repetitions, where each actual repetition consists of a consecutive set of potentially valid symbols that can be used for PUSCH repetition Type B transmission within a slot. An actual repetition with a single symbol is omitted except for the case of the number of consecutive symbols L is one, e.g., $L=1$. An actual repetition is omitted according to the conditions in Clause 11.1 of [6, TS38.213]. The redundancy version to be applied on the n th actual repetition (with the counting including the actual repetitions that are omitted) is determined according to table 6.1.2.1-2.

[0037] Although the above descriptions on nominal repetition and actual repetition are provided according to TS 38.214, they may be changed or updated as the evolution of 3GPP specifications or other related specifications/protocols, and thus should not be limited to the above.

[0038] On the other hand, according to NR R17, multiple beams will be used for PUSCH repetitions with multiple TRP's reception to further improve the reliability and robustness. For example, as discussed in RAN1 #102e, up to 2 beams will be used to transmit PUSCH repetition where 2 TRPs will be used to receive multiple repetitions in the scenario of single downlink control information (DCI) based multiple TRPs. However, only one panel in the UE side can be used to transmit UL transmission simultaneously in R17. The beam switching time (or switching gap, or switching latency) between two adjacent PUSCH repetitions in time domain using different beams should be considered. Accordingly, when the time gap between the two adjacent PUSCH repetitions is not sufficient for beam switching, how to handle the two adjacent PUSCH repetitions needs to be solved.

[0039] At least to deal with the technical problem caused by beam switching time between two PUSCH repetitions with different beams during a PUSCH transmission, embodiments of the present application propose an improved technical solution for

PUSCH transmission with repetition.

[0040] FIG. 2 illustrates a flow chart of a method for PUSCH transmission with repetition according to some embodiments of the present application. Although the method is illustrated in a system level by a UE in a remote side (or UE side) and a BS in a network side (or BS side), persons skilled in the art can understand that the method implemented in the remote side and that implemented in the network side can be separately implemented and incorporated by other apparatus with the like functions.

[0041] In the exemplary method shown in FIG. 2, in step 202, the network side, e.g., a BS 101 as shown in FIG. 1 may transmit configuration information to the remote side, e.g., a UE 102, e.g., by at least one radio resource control (RRC) signaling and/or downlink control information (DCI). Correspondingly, in step 212, the remote side may receive the configuration information from the network side. The configuration information may indicate a mapping pattern of a plurality of beams and a plurality of PUSCH repetitions of a PUSCH transmission using the plurality of beams. Each of the plurality of beams may be represented by spatial relation information. According to the mapping pattern, a beam of the plurality of beams can be associated with (or mapped to) one or more corresponding PUSCH repetitions of the plurality of PUSCH repetitions.

[0042] The mapping pattern of the plurality of beams may be any beam mapping pattern, e.g., cyclical mapping pattern, or sequential mapping pattern, which have been agreed by 3GPP. The PUSCH transmission may be a PUSCH repetition Type A transmission in some embodiments of the present application. In some other embodiments of the present application, the PUSCH transmission may be a PUSCH repetition Type B transmission.

[0043] In the UE side, for a PUSCH transmission with repetition using different beams to be transmitted, whether a time gap between two adjacent PUSCH repetitions with different beams in time domain is smaller than a time threshold for beam switching will be determined in step 214. According to some embodiments of the present application, the time threshold for beam switching is predefined in specification(s) (or protocol(s)). For example, 3GPP specification(s) may define the

time threshold for beam switching as a number of symbols in the future, which is different in view of different subcarrier spacing (SCS). That is, the time threshold for beam switching may be predefined as a different number of symbols in different SCS. According to some other embodiments of the present application, the time threshold for beam switching may be specifically determined for a UE based on the capability of the UE. For example, the time threshold for beam switching may be similar to a threshold *timeDurationForQCL* for transmission configuration indication (TCI) state determination of PDSCH. A UE may report its capability under beam switching of UL transmission, and the network side will determine the time threshold for beam switching for the UE based on the UE's capability. In some other embodiments of the present application, the UE may determine its time threshold for beam switching by itself based on its capability and report the determined time threshold for beam switching to the network side.

[0044] In step 216, how to handle the two adjacent PUSCH repetitions with different beams will be determined according to various manners in the UE side, e.g., determining at least one symbol of the two adjacent PUSCH repetitions not to be transmitted when the time gap between the two adjacent PUSCH repetitions is smaller than the time threshold for beam switching. For example, according to some embodiments of the present application, determining the at least one symbol not to be transmitted is only based on a former repetition of the two adjacent PUSCH repetitions starting earlier in the time domain. According to some other embodiments of the present application, determining the at least one symbol not to be transmitted is only based on a later repetition of the two adjacent PUSCH repetitions starting later in the time domain. According to some yet other embodiments of the present application, determining the at least one symbol not to be transmitted is based on both a former repetition of the two adjacent PUSCH repetitions starting earlier in the time domain and a later repetition of the two adjacent PUSCH repetitions starting later in the time domain. Details on the determination are omitted here and will be illustrated in the following text in view of various exemplary scenarios and embodiments.

[0045] Similarly, in the network side, for a PUSCH transmission with repetition using different beams to be received, operation consistent with the remote side will be

performed.

[0046] For example, whether a time gap between two adjacent PUSCH repetitions with different beams in time domain is smaller than a time threshold for beam switching will be determined in step 204. The time threshold for beam switching is predefined in specification(s), or is specifically determined for a UE based on capability of the UE, which is consistent with the remote side and will not be repeated.

[0047] In step 206, how to handle the two adjacent PUSCH repetitions with different beams will be determined according to various manners in the network side, e.g., determining at least one symbol of the two adjacent PUSCH repetitions not to be received when the time gap between the two adjacent PUSCH repetitions is smaller than the time threshold for beam switching. For example, according to some embodiments of the present application, when the UE side adopts the measure of determining the at least one symbol not to be transmitted only based on a former repetition of the two adjacent PUSCH repetitions starting earlier in the time domain, the network side will determine the at least one symbol not to be received only based on the former repetition of the two adjacent PUSCH repetitions starting earlier in the time domain. According to some other embodiments of the present application, when the UE side adopts the measure of determining the at least one symbol not to be transmitted only based on a later repetition of the two adjacent PUSCH repetitions starting later in the time domain, the network side will determine the at least one symbol not to be received only based on the later repetition of the two adjacent PUSCH repetitions starting later in the time domain. According to some yet other embodiments of the present application, when the UE side adopts the measure of determining the at least one symbol not to be transmitted based on both a former repetition of the two adjacent PUSCH repetitions and a later repetition of the two adjacent PUSCH repetitions, the network side will determine the at least one symbol not to be received based on both the former repetition and the later repetition.

[0048] Based on the above basic solutions, more details will be illustrated in various embodiments hereafter. Considering the consistency between the remote side and network side, although the following demonstrations are provided mainly in the

remote side, persons skilled in the art should clearly understand how to apply them in the network side.

Scheme 1: the at least one symbol not to be transmitted (or received in the network side) is only based on a former repetition of the two adjacent PUSCH repetitions starting earlier in the time domain.

[0049] Solution 1-1: According to some embodiment of the present application, an exemplary solution according to Scheme 1 may include: determining last T symbol(s) of the former repetition not to be transmitted when the time gap between the two adjacent PUSCH repetitions is smaller than the time threshold for beam switching, wherein, $T = \min(L1, M-N)$, L1 is a total symbol number of the former repetition, N symbol(s) represents the time gap between the two adjacent PUSCH repetitions, M symbol(s) represents the time threshold for beam switching, and all of L1, M and N are nature number. That is, the last T symbol(s) of the former repetition not to be transmitted is the minimum of the total symbol number (L1) of the former repetition and the symbol number difference (M-N) between the time threshold (M) for beam switching and the time gap (N) between the two adjacent PUSCH repetitions. In some embodiments of the present application, for example, the two adjacent repetitions may be relatively close, the former repetition may be relatively short and/or the time threshold may be relative large, which may cause all the symbols of the former repetition will not be transmitted.

[0050] The T symbol(s) not to be transmitted will be dropped but will not affect the counting of the repetition number of the PUSCH transmission. The number of the plurality of PUSCH repetitions will be counted by including the former repetition even in the case of all symbols of the repetition not to be transmitted.

[0051] This exemplary solution can be applicable to the scenario that both the two adjacent PUSCH repetitions are repetitions of PUSCH repetition Type A or are actual repetitions of PUSCH repetition Type B, that is, in spite that the two adjacent repetitions of PUSCH transmission are PUSCH repetition Type A or are PUSCH repetition Type B, Solution 1-1 according to Scheme 1 is applicable.

[0052] FIG. 3 illustrates an exemplary diagram of two repetitions of a PUSCH

transmission with different beams by Solution 1-1 according to some embodiments of the present application.

[0053] Referring to FIG. 3, there are two adjacent PUSCH repetitions in time domain, e.g., repetition 0 and repetition 1 of PUSCH repetition Type A with different beams, e.g., beam 1 and beam 2 respectively. Repetition 0, i.e., the former repetition in time domain, has 12 symbols (each symbol represented by each block) to be transmitted in slot n , starting from the second symbol and ending in the 13th symbol. Repetition 1, i.e., the later repetition in time domain, has 12 symbols to be transmitted in slot $n+1$, starting from the second symbol and ending in the 13th symbol. There is a two-symbol gap between repetition 0 and repetition 1. That is, $L1$ is 12, and N is 2. Assuming that the time threshold for beam switching is 4 symbols, i.e., $M=4$, $T=\min(12, 4-2)=2$. Therefore, the last 2 symbols of repetition 0 in FIG. 3, i.e., 12th symbol and 13th symbol in slot n will be dropped and will not be transmitted in the remote side (or received in the network side) according to Solution 1-1. The dropped symbols do not affect counting repetition 0, and the repetition number of the PUSCH transmission will still count repetition 0.

[0054] Although only one pair of adjacent repetitions are illustrated in FIG. 3, persons skilled in the art can clearly understand that for a PUSCH transmission, there may be more pairs of adjacent repetitions, and each of them should be handled based on the same solution from repetitions starting earlier to repetitions starting later.

[0055] Solution 1-2: According to some other embodiment of the present application, another exemplary solution for PUSCH repetition Type B according to Scheme 1 is proposed, which may include: determining last T symbol(s) of the former repetition to be invalid and not to be transmitted when the time gap between the two adjacent PUSCH repetitions is smaller than the time threshold for beam switching. Similarly, $T=\min(L1, M-N)$, $L1$ is a total symbol number of the former repetition, N symbol(s) represents the time gap between the two adjacent PUSCH repetitions, M symbol(s) represents the time threshold for beam switching, and all of $L1$, M and N are nature number. That is, the last T symbol(s) of the former repetition not to be transmitted is the minimum of the total symbol number ($L1$) of the former repetition and the symbol number difference ($M-N$) between the time threshold (M) for beam switching and the

time gap (N) between the two adjacent PUSCH repetitions. In some embodiments of the present application, for example, the two adjacent repetitions may be relatively close, the former repetition may be relatively short and/or the time threshold may be relative large, which may cause all the symbols of the former repetition will be invalid and not be transmitted.

[0056] As stated above, for PUSCH repetition Type B, whether an actual repetition will be counted is determined based on the invalid symbols of the repetition. Thus, the invalid T symbol(s) not to be transmitted will affect the counting of the repetition number of the PUSCH transmission. The number of the plurality of PUSCH repetitions will be counted by including the former repetition only when remaining valid symbol(s) of the former repetition is still qualified for an actual repetition of PUSCH repetition Type B after excluding the last T symbols from the former repetition. Whether the remaining valid symbol(s) of the former repetition is still qualified for actual repetition of PUSCH repetition Type B after excluding the last T symbols from the former repetition can be determined according to that defined in TS 38.214 or other required standards.

[0057] FIG. 4 illustrates an exemplary diagram of two repetitions of a PUSCH transmission with different beams by Solution 1-2 according to some other embodiments of the present application.

[0058] Referring to FIG. 4, according to configuration information without considering beam switching time, there are two adjacent PUSCH actual repetitions in time domain, e.g., original actual repetition 0 using beam 1 in nominal repetition 0 of PUSCH repetition Type B in slot n, and original repetition 1 using beam 2 in nominal repetition 1 of PUSCH repetition Type B in slot n+1. Original actual repetition 0, i.e., the former repetition in time domain, has 5 symbols (each symbol represented by each block) in slot n, starting from the 9th symbol and ending in the 13th symbol. Original actual repetition 1, i.e., the later repetition in time domain, has 4 symbols, starting from the second symbol and ending in the 5th symbol in slot n+1. There is a two-symbol gap between original actual repetition 0 and original actual repetition 1. That is, L1 is 5, and N is 2. Assuming that the time threshold for beam switching is 4 symbols, i.e., M=4, $T = \min(5, 4-2)=2$. Thus, the last 2 symbols of original actual

repetition 0, i.e., 12th symbol and 13th symbol in slot n are invalid symbols and will not be transmitted, and only first 3 symbols of original actual repetition 0, i.e., 9th symbol, 10th symbol and 11th symbol in slot n are valid symbols. According to the above description on PUSCH repetition Type B in TS38.214, the 3 valid symbols can be an actual repetition of PUSCH repetition Type B. That is, the remaining valid symbols of the former repetition are still qualified for actual repetition of PUSCH repetition Type B after excluding the last 2 symbols from the former repetition. Thus, the actual repetition number of the PUSCH transmission will be counted by including the former actual repetition, i.e., including actual repetition 0 as original configured.

[0059] Although only one pair of adjacent repetitions are illustrated in FIG. 4, persons skilled in the art can clearly understand that for a PUSCH transmission, there may be more pairs of adjacent repetitions, and each of them should be handled based on the same solution from repetitions starting earlier to repetitions starting later.

Scheme 2: determining the at least one symbol not to be transmitted (or received in the network side) is only based on a later repetition of the two adjacent PUSCH repetitions starting later in the time domain.

[0060] Solution 2-1, according to some embodiment of the present application, an exemplary solution according to Scheme 2 may include: determining first T symbol(s) of the later repetition not to be transmitted when the time gap between the two adjacent PUSCH repetitions is smaller than the time threshold for beam switching, wherein, $T = \min(L2, M-N)$, L2 is a total symbol number of the later repetition, N symbol(s) represents the time gap between the two adjacent PUSCH repetitions, M symbol(s) represents the time threshold for beam switching, and all of L2, M and N are nature number. That is, the first T symbol(s) of the later repetition not to be transmitted is the minimum of the total symbol number (L2) of the later repetition and the symbol number difference (M-N) between the time threshold (M) for beam switching and the time gap (N) between the two adjacent PUSCH repetitions. In some embodiments of the present application, for example, the two adjacent repetitions may be relatively close, the later repetition may be relatively short and/or the time threshold may be relative large, which may cause all the symbols of the later

repetition will not be transmitted.

[0061] The T symbol(s) not to be transmitted will be dropped but will not affect the counting of the repetition number of the PUSCH transmission. The number of the plurality of PUSCH repetitions will be counted by including the later repetition even in the case of all symbols of the repetition not to be transmitted.

[0062] Solution 2-1 can be applicable to the scenario that both the two adjacent PUSCH repetitions are PUSCH repetition Type A or are actual repetition of PUSCH repetition Type B, that is, in spite that the PUSCH transmission is PUSCH repetition Type A or PUSCH repetition Type B, Solution 2-1 according to Scheme 2 is applicable.

[0063] FIG. 5 illustrates an exemplary diagram of two repetitions of a PUSCH transmission with different beams by Solution 2-1 according to some embodiments of the present application.

[0064] Referring to FIG. 5, there are two adjacent PUSCH repetitions in time domain, e.g., repetition 0 and repetition 1 of PUSCH repetition Type A with different beams, e.g., beam 1 and beam 2 respectively. Repetition 0, i.e., the former repetition in time domain, starts from the second symbol and ends in the 13th symbol in slot n, and thus has 12 symbols (each symbol represented by each block) to be transmitted in slot n. Repetition 1, i.e., the later repetition in time domain, starts from the second symbol and ends in the 13th symbol in slot n+1, and thus has 12 symbols to be transmitted in slot n+1. There is a two-symbol gap between repetition 0 and repetition 1. That is, L2 is 12, and N is 2. Assuming that the time threshold for beam switching is 4 symbols, i.e., $M=4$, $T = \min(12, 4-2)=2$. Therefore, the first 2 symbols of repetition 1 in FIG. 5, i.e., the second and third symbols in slot n+1 will be dropped and will not be transmitted in the remote side (or received in the network side) according to Solution 2-1. The dropped symbols do not affect counting repetition 1, and the repetition number of the PUSCH transmission will still count repetition 1.

[0065] Although only one pair of adjacent repetitions are illustrated in FIG. 5, persons skilled in the art can clearly understand that for a PUSCH transmission, there may be more pairs of adjacent repetitions, and each of them should be handled based

on the same solution from repetitions starting earlier to repetitions starting later.

[0066] Solution 2-2: According to some other embodiment of the present application, another exemplary solution for PUSCH repetition Type B according to Scheme 2 is proposed, which may include: determining first T symbol(s) of the later repetition to be invalid and not to be transmitted when the time gap between the two adjacent PUSCH repetitions is smaller than the time threshold for beam switching. Similarly, $T = \min(L2, M-N)$, L2 is a total symbol number of the later repetition, N symbol(s) represents the time gap between the two adjacent PUSCH repetitions, M symbol(s) represents the time threshold for beam switching, and all of L2, M and N are nature number. That is, the first T symbol(s) of the later repetition not to be transmitted is the minimum of the total symbol number (L2) of the later repetition and the symbol number difference (M-N) between the time threshold (M) for beam switching and the time gap (N) between the two adjacent PUSCH repetitions. In some embodiments of the present application, for example, the two adjacent repetitions may be relatively close, the former repetition may be relatively short and/or the time threshold may be relative large, which may cause all the symbols of the later repetition will be invalid and not be transmitted.

[0067] As stated above, for PUSCH repetition Type B, whether an actual repetition will be counted is determined based on the invalid symbols of the repetition. Thus, the invalid T symbol(s) not to be transmitted will affect the counting of the repetition number of the PUSCH transmission. The number of the plurality of PUSCH repetitions will be counted by including the later repetition only when remaining valid symbol(s) of the later repetition is still qualified for an actual repetition of PUSCH repetition Type B after excluding the first T symbols from the later repetition.

[0068] FIG. 6 illustrates an exemplary diagram of two repetitions of a PUSCH transmission with different beams by Solution 2-2 according to some other embodiments of the present application.

[0069] Referring to FIG. 6, according to configuration information without considering beam switching time, there are two adjacent PUSCH actual repetitions in time domain e.g., original actual repetition 0 using beam 1 in nominal repetition 0 of PUSCH repetition Type B in slot n, and original repetition 1 using beam 2 in nominal

repetition 1 of PUSCH repetition Type B in slot $n+1$. Original actual repetition 0, i.e., the former repetition in time domain, has 5 symbols (each symbol represented by each block) in slot n , starting from the 9th symbol and ending in the 13th symbol. Original actual repetition 1, i.e., the later repetition in time domain, has 3 symbols, starting from the second symbol and ending in the 4th symbol in slot $n+1$. There is a two-symbol gap between original actual repetition 0 and original actual repetition 1. That is, L_2 is 3, and N is 2. Assuming that the time threshold for beam switching is 4 symbols, i.e., $M=4$, $T = \min(3, 4-2)=2$. Thus, the first 2 symbols of original actual repetition 1, i.e., the second and third symbols in slot $N=1$ are invalid symbols and not to be transmitted, and only last 1 symbol of original actual repetition 1, i.e., the fourth symbol in slot $n+1$ is a valid symbol. According to the above description on PUSCH repetition Type B in TS38.214, the only one valid symbol cannot be qualified for an actual repetition any more. Thus, the actual repetition number of the PUSCH transmission will not include the later actual repetition, i.e., not including original actual repetition 1. The corresponding repetition serial number, actual repetition 1 of the PUSCH transmission will be assigned to another qualified actual repetition starting later, e.g., original actual repetition 2.

[0070] Although only one pair of adjacent repetitions are illustrated in FIG. 6, persons skilled in the art can clearly understand that for a PUSCH transmission, there may be more pairs of adjacent repetitions, and each of them should be handled based on the same solution from repetitions starting earlier to repetitions starting later.

Scheme 3: determining the at least one symbol not to be transmitted is based on both a former repetition of the two adjacent PUSCH repetitions starting earlier in the time domain and a later repetition of the two adjacent PUSCH repetitions starting later in the time domain.

[0071] Solution 3-1: According to some embodiment of the present application, an exemplary solution according to Scheme 3 may include: determining last T_1 symbol(s) of the former repetition and first T_2 symbol(s) of the later repetition not to be transmitted when the time gap between the two adjacent PUSCH repetitions is smaller than the time threshold for beam switching. In some embodiments of the present application, $T_1 = \min(L_1, \text{ceil}((M-N)/2))$, $T_2 = \min(L_2, \text{floor}((M-N)/2))$. L_1 is a total

symbol number of the former repetition, $L2$ is a total symbol number of the later repetition, N symbol(s) represents the time gap between the two adjacent PUSCH repetitions, M symbol(s) represents the time threshold for beam switching, and all of $L1$, $L2$, M and N are nature number. That is, the last $T1$ symbol(s) of the former repetition not to be transmitted is the minimum of the total symbol number ($L1$) of the former repetition and a value ($\text{ceil}(M-N)/2$) computed by a ceil operation on a half of the symbol number difference ($M-N$) between the time threshold (M) for beam switching and the time gap (N) between the two adjacent PUSCH repetitions; and the first $T2$ symbol(s) of the later repetition not to be transmitted is the minimum of the total symbol number ($L2$) of the later repetition and a value ($\text{floor}(M-N)/2$) computed by a floor operation on a half of the symbol number difference ($M-N$) between the time threshold (M) for beam switching and the time gap (N) between the two adjacent PUSCH repetitions. In some other embodiments of the present application, $T1 = \min(L1, \text{floor}((M-N)/2))$, $T2 = \min(L2, \text{ceil}((M-N)/2))$. That is, the last $T1$ symbol(s) of the former repetition not to be transmitted is the minimum of the total symbol number ($L1$) of the former repetition and a value ($\text{floor}(M-N)/2$) computed by a floor operation on a half of the symbol number difference ($M-N$) between the time threshold (M) for beam switching and the time gap (N) between the two adjacent PUSCH repetitions; and the first $T2$ symbol(s) of the later repetition not to be transmitted is the minimum of the total symbol number ($L2$) of the later repetition and a value ($\text{ceil}(M-N)/2$) computed by a ceil operation on a half of the symbol number difference ($M-N$) between the time threshold (M) for beam switching and the time gap (N) between the two adjacent PUSCH repetitions.

[0072] In some embodiments of the present application, for example, the two adjacent repetitions may be relatively close, the former repetition may be relatively short and/or the time threshold may be relative large, which may cause all the symbols of the former repetition will be invalid and not be transmitted. That is the same for the later repetition.

[0073] The $T1$ and $T2$ symbol(s) not to be transmitted will be dropped but will not affect the counting of the repetition number of the PUSCH transmission. The number of the plurality of PUSCH repetitions will be counted by including the former repetition even in the case of all symbols of the former repetition not to be transmitted.

That is also the same for the later repetition.

[0074] This exemplary solution can be applicable to the scenario that both the two adjacent PUSCH repetitions are repetitions of PUSCH repetition Type A or are actual repetitions of PUSCH repetition Type B, that is, in spite that the PUSCH transmission is PUSCH repetition Type A or PUSCH repetition Type B, Solution 3-1 according to Scheme 3 is applicable.

[0075] FIG. 7 illustrates an exemplary diagram of two repetitions of a PUSCH transmission with different beams by Solution 3-1 according to some embodiments of the present application.

[0076] Referring to FIG. 7, there are two adjacent PUSCH repetitions in time domain, e.g., repetition 0 and repetition 1 of PUSCH repetition Type A with different beams, e.g., beam 1 and beam 2 respectively. Repetition 0, i.e., the former repetition in time domain, has 12 symbols (each symbol represented by each block) to be transmitted in slot n, starting from the second symbol and ending in the 13th symbol. Repetition 1, i.e., the later repetition in time domain, has 12 symbols to be transmitted in slot n+1, starting from the second symbol and ending in the 13th symbol. There is a two-symbol gap between repetition 0 and repetition 1. That is, L1 is 12, L2 is 12, and N is 2.

[0077] Assuming that the time threshold for beam switching is 4 symbols, i.e., $M=4$, according to some embodiments of the present application, $T1 = \min(L1, \text{ceil}((M-N)/2)) = \min(12, \text{ceil}((4-2)/2)) = 1$, $T2 = \min(L2, \text{floor}((M-N)/2)) = \min(12, \text{floor}((4-2)/2)) = 1$. According to some other embodiments of the present application, $T1 = \min(L1, \text{floor}((M-N)/2)) = \min(12, \text{floor}((4-2)/2)) = 1$, $T2 = \min(L2, \text{ceil}((M-N)/2)) = \min(12, \text{ceil}((4-2)/2)) = 1$. Therefore, the last 1 symbol of repetition 0, i.e., the 13th symbol in slot n will be dropped and not be transmitted, and meanwhile the first 1 symbol of repetition 1, i.e., the second symbol in slot n+1 will be dropped and not be transmitted according to Solution 3-1. The dropped symbols do not affect counting repetition 0 and repetition 1, and the repetition number of the PUSCH transmission will still count repetition 0 and repetition 1.

[0078] Although only one pair of adjacent repetitions are illustrated in FIG. 7,

persons skilled in the art can clearly understand that for a PUSCH transmission, there may be more pairs of adjacent repetitions, and each of them should be handled based on the same solution from repetitions starting earlier to repetitions starting later.

[0079] Solution 3-2: According to some other embodiment of the present application, another exemplary solution for PUSCH repetition Type B according to Scheme 3 is proposed, which may include: determining last T1 symbol(s) of the former repetition and first T2 symbol(s) of the later repetition to be invalid and not to be transmitted when the time gap between the two adjacent PUSCH repetitions is smaller than the time threshold for beam switching. In some embodiments of the present application, $T1 = \min(L1, \text{ceil}((M-N)/2))$, $T2 = \min(L2, \text{floor}((M-N)/2))$. L1 is a total symbol number of the former repetition, L2 is a total symbol number of the later repetition, N symbol(s) represents the time gap between the two adjacent PUSCH repetitions, M symbol(s) represents the time threshold for beam switching, and all of L1, L2, M and N are nature number. That is, the last T1 symbol(s) of the former repetition not to be transmitted is the minimum of the total symbol number (L1) of the former repetition and a value $(\text{ceil}(M-N)/2)$ computed by a ceil operation on a half of the symbol number difference (M-N) between the time threshold (M) for beam switching and the time gap (N) between the two adjacent PUSCH repetitions; and the first T2 symbol(s) of the later repetition not to be transmitted is the minimum of the total symbol number (L2) of the later repetition and a value $(\text{floor}(M-N)/2)$ computed by a floor operation on a half of the symbol number difference (M-N) between the time threshold (M) for beam switching and the time gap (N) between the two adjacent PUSCH repetitions. In some other embodiments of the present application, $T1 = \min(L1, \text{floor}((M-N)/2))$, $T2 = \min(L2, \text{ceil}((M-N)/2))$. That is, the last T1 symbol(s) of the former repetition not to be transmitted is the minimum of the total symbol number (L1) of the former repetition and a value $(\text{floor}(M-N)/2)$ computed by a floor operation on a half of the symbol number difference (M-N) between the time threshold (M) for beam switching and the time gap (N) between the two adjacent PUSCH repetitions; and the first T2 symbol(s) of the later repetition not to be transmitted is the minimum of the total symbol number (L2) of the later repetition and a value $(\text{ceil}(M-N)/2)$ computed by a ceil operation on a half of the symbol number difference (M-N) between the time threshold (M) for beam switching and the time gap (N) between the two adjacent PUSCH repetitions.

[0080] In some embodiments of the present application, for example, the two adjacent repetitions may be relatively close, the former repetition may be relatively short and/or the time threshold may be relative large, which may cause all the symbols of the former repetition will be invalid and not be transmitted. That is the same for the later repetition.

[0081] In addition, as stated above, for PUSCH repetition Type B, whether an actual repetition will be counted is determined based on the invalid symbols of the repetition. Thus, the invalid T symbol(s) not to be transmitted will affect the counting of the repetition number of the PUSCH transmission. The number of the plurality of PUSCH repetitions will be counted by including the former repetition only when remaining valid symbol(s) of the former repetition is still qualified for an actual repetition of PUSCH repetition Type B after excluding the last T1 symbols from the former repetition. Similarly, the number of the plurality of PUSCH repetitions will be counted by including the later repetition only when remaining valid symbol(s) of the later repetition is still qualified for an actual repetition of PUSCH repetition Type B after excluding the first T2 symbols from the later repetition. Whether the remaining valid symbol(s) of the former repetition is still qualified for an actual repetition of PUSCH repetition Type B after excluding the last T1 symbols from the former repetition can be determined according to that defined in TS 38.214 or other required standards. A similar mechanism is also adaptive to the later repetition.

[0082] FIG. 8 illustrates an exemplary diagram of two repetitions of a PUSCH transmission with different beams by Solution 3-2 according to some other embodiments of the present application.

[0083] Referring to FIG. 8, according to configuration information without considering beam switching time, there are two adjacent PUSCH actual repetitions in time domain e.g., original actual repetition 0 using beam 1 in nominal repetition 0 of PUSCH repetition Type B in slot n, and original repetition 1 using beam 2 in nominal repetition 1 of PUSCH repetition Type B in slot n+1. Original actual repetition 0, i.e., the former repetition in time domain, has 5 symbols in slot n, starting from the 9th symbol and ending in the 13th symbol. Original actual repetition 1, i.e., the later repetition in time domain, has 4 symbols, starting from the second symbol and ending

in the 5th symbol in slot $n+1$. There is a two-symbol gap between original actual repetition 0 and original actual repetition 1. That is, L_1 is 5, L_2 is 4 and N is 2.

[0084] Assuming that the time threshold for beam switching is 4 symbols, i.e., $M=4$, according to some embodiments of the present application, $T_1 = \min(L_1, \text{ceil}((M-N)/2)) = \min(5, \text{ceil}((4-2)/2)) = 1$, $T_2 = \min(L_2, \text{floor}((M-N)/2)) = \min(4, \text{floor}((4-2)/2)) = 1$. According to some other embodiments of the present application, $T_1 = \min(L_1, \text{floor}((M-N)/2)) = \min(5, \text{floor}((4-2)/2)) = 1$, $T_2 = \min(L_2, \text{ceil}((M-N)/2)) = \min(4, \text{ceil}((4-2)/2)) = 1$. Therefore, the last 1 symbol of repetition 0, i.e., the 13th symbol in slot n will be invalid and not be transmitted, and meanwhile the first 1 symbol of repetition 1, i.e., the second symbol in slot $n+1$ will be invalid and not be transmitted according to Solution 3-2. Accordingly, the first 4 symbols of original actual repetition 0 are valid symbols, and the last 3 symbols of original actual repetition 1 are valid symbols.

[0085] According to the above description on PUSCH repetition Type B in TS38.214, the remaining 4 valid symbols of repetition 0 and the remaining 3 valid symbols of repetition 1 are still qualified for actual repetitions of PUSCH repetition Type B. Thus, the actual repetition number of the PUSCH transmission will be counted by including the former actual repetition and the later actual repetition, i.e., including actual repetition 0 and actual repetition 1 as original configured.

[0086] Although only one pair of adjacent repetitions are illustrated in FIG. 8, persons skilled in the art can clearly understand that for a PUSCH transmission, there may be more pairs of adjacent repetitions, and each of them can be handled based on the same solution from repetitions starting earlier to repetitions starting later.

[0087] Embodiments of the present application also propose an apparatus for PUSCH transmission with repetition. For example, FIG. 9 illustrates a block diagram of an apparatus 900 for multiplexing uplink resources according to some embodiments of the present application.

[0088] As shown in FIG. 9, the apparatus 900 may include at least one non-transitory computer-readable medium 901, at least one receiving circuitry 902, at least one transmitting circuitry 904, and at least one processor 906 coupled to the

non-transitory computer-readable medium 901, the receiving circuitry 902 and the transmitting circuitry 904. The apparatus 900 may be a network side apparatus (e.g., a BS) configured to perform a method illustrated in FIG. 2 and the like, or a remote unit (e.g., a UE) configured to perform a method illustrated in FIG. 2 or the like.

[0089] Although in this figure, elements such as the at least one processor 906, transmitting circuitry 904, and receiving circuitry 902 are described in the singular, the plural is contemplated unless a limitation to the singular is explicitly stated. In some embodiments of the present application, the receiving circuitry 902 and the transmitting circuitry 904 can be combined into a single device, such as a transceiver. In certain embodiments of the present application, the apparatus 900 may further include an input device, a memory, and/or other components.

[0090] For example, in some embodiments of the present application, the non-transitory computer-readable medium 901 may have stored thereon computer-executable instructions to cause a processor to implement the method with respect to the UE as described above. For example, the computer-executable instructions, when executed, cause the processor 906 interacting with receiving circuitry 902 and transmitting circuitry 904, so as to perform the steps with respect to the UE depicted in FIG. 2.

[0091] In some embodiments of the present application, the non-transitory computer-readable medium 901 may have stored thereon computer-executable instructions to cause a processor to implement the method with respect to the BS as described above. For example, the computer-executable instructions, when executed, cause the processor 906 interacting with receiving circuitry 902 and transmitting circuitry 904, so as to perform the steps with respect to the BS depicted in FIG. 2.

[0092] The method according to embodiments of the present application can also be implemented on a programmed processor. However, the controllers, flowcharts, and modules may also be implemented on a general purpose or special purpose computer, a programmed microprocessor or microcontroller and peripheral integrated circuit elements, an integrated circuit, a hardware electronic or logic circuit such as a discrete element circuit, a programmable logic device, or the like. In general, any device on which resides a finite state machine capable of implementing the flowcharts shown in

the figures may be used to implement the processor functions of this application. For example, an embodiment of the present application provides an apparatus for PUSCH transmission with repetition, including a processor and a memory. Computer programmable instructions for implementing a method are stored in the memory, and the processor is configured to perform the computer programmable instructions to implement the method. The method may be a method as stated above or other method according to an embodiment of the present application.

[0093] An alternative embodiment preferably implements the methods according to embodiments of the present application in a non-transitory, computer-readable storage medium storing computer programmable instructions. The instructions are preferably executed by computer-executable components preferably integrated with a network security system. The non-transitory, computer-readable storage medium may be stored on any suitable computer readable media such as RAMs, ROMs, flash memory, EEPROMs, optical storage devices (CD or DVD), hard drives, floppy drives, or any suitable device. The computer-executable component is preferably a processor but the instructions may alternatively or additionally be executed by any suitable dedicated hardware device. For example, an embodiment of the present application provides a non-transitory, computer-readable storage medium having computer programmable instructions stored therein. The computer programmable instructions are configured to implement a method as stated above or other method according to an embodiment of the present application.

[0094] In addition, in this disclosure, relational terms such as "first," "second," and the like may be used solely to distinguish one entity or action from another entity or action without necessarily requiring or implying any actual such relationship or order between such entities or actions. The terms "comprises," "comprising," or any other variation thereof, are intended to cover a non-exclusive inclusion, such that a process, method, article, or apparatus that comprises a list of elements does not include only those elements but may include other elements not expressly listed or inherent to such process, method, article, or apparatus. An element preceded by "a," "an," or the like does not, without more constraints, preclude the existence of additional identical elements in the process, method, article, or apparatus that comprises the element. Also, the term "another" is defined as at least a second or more. The terms

"including," "having," and the like, as used herein, are defined as "comprising."

WHAT IS CLAIMED:

1. A method, comprising:

receiving configuration information indicating a mapping pattern of a plurality of beams and a plurality of physical uplink shared channel (PUSCH) repetitions of a PUSCH transmission using the plurality of beams, wherein each of the plurality of beams is represented by spatial relation information;

determining whether a time gap between two adjacent PUSCH repetitions with different beams in time domain is smaller than a time threshold for beam switching; and

determining at least one symbol of the two adjacent PUSCH repetitions not to be transmitted when the time gap between the two adjacent PUSCH repetitions is smaller than the time threshold for beam switching.

2. The method of claim 1, wherein the time threshold for beam switching is predefined in specification(s), or is specifically determined for a user equipment (UE) based on capability of the UE.

3. The method of claim 1, wherein, determining the at least one symbol not to be transmitted is only based on a former repetition of the two adjacent PUSCH repetitions starting earlier in the time domain.

4. The method of claim 3, in the case that both the two adjacent PUSCH repetitions are repetitions of PUSCH repetition type A or are actual repetitions of PUSCH repetition type B, comprising:

determining last T symbol(s) of the former repetition not to be transmitted when the time gap between the two adjacent PUSCH repetitions is smaller than the time threshold for beam switching,

wherein, $T = \min(L1, M-N)$, L1 is a total symbol number of the former repetition, N symbol(s) represents the time gap between the two adjacent PUSCH

repetitions, M symbol(s) represents the time threshold for beam switching, and all of $L1$, M and N are nature number; and

counting a number of the plurality of PUSCH repetitions by including the former repetition.

5. The method of claim 3, in the case that both the two adjacent PUSCH repetitions are actual repetitions of PUSCH repetition type B, comprising:

determining last T symbol(s) of the former repetition to be invalid and not to be transmitted when the time gap between the two adjacent PUSCH repetitions is smaller than the time threshold for beam switching,

wherein, $T = \min(L1, M-N)$, $L1$ is a total symbol number of the former repetition, N symbol(s) represents the time gap between the two adjacent PUSCH repetitions, M symbol(s) represents the time threshold for beam switching, and all of $L1$, M and N are nature number; and

counting a number of the plurality of PUSCH repetitions by including the former repetition only when remaining valid symbol(s) of the former repetition is still qualified for an actual repetition of PUSCH repetition type B after excluding the last T symbols from the former repetition.

6. The method of claim 1, wherein determining the at least one symbol not to be transmitted is only based on a later repetition of the two adjacent PUSCH repetitions starting later in the time domain.

7. The method of claim 6, in the case that both the two adjacent PUSCH repetitions are repetitions of PUSCH repetition type A or are actual repetitions of PUSCH repetition type B, comprising:

determining first T symbol(s) of the later repetition not to be transmitted when the time gap between the two adjacent PUSCH repetitions is smaller than the time threshold for beam switching,

wherein, $T = \min(L2, M-N)$, $L2$ is a total symbol number of the later repetition, N symbol(s) represents the time gap between the two adjacent PUSCH repetitions, M symbol(s) represents the time threshold for beam switching, and all of $L2$, M and N are nature number; and

counting a number of the plurality of PUSCH repetitions by including the later repetition.

8. The method of claim 6, in the case that both the two adjacent PUSCH repetitions are actual repetitions of PUSCH repetition type B, comprising:

determining first T symbol(s) of the later repetition to be invalid and not to be transmitted when the time gap between the two adjacent PUSCH repetitions is smaller than the time threshold for beam switching,

wherein, $T = \min(L2, M-N)$, $L2$ is a total symbol number of the later repetition, N symbol(s) represents the time gap between the two adjacent PUSCH repetitions, M symbol(s) represents the time threshold for beam switching, and all of $L2$, M and N are nature number; and

counting a number of the plurality of PUSCH repetitions by including the later repetition only when the remaining valid symbol(s) of the later repetition is still qualified for an actual repetition of PUSCH repetition type B after excluding the first T symbols from the later repetition.

9. The method of claim 1, wherein determining the at least one symbol not to be transmitted is based on both a former repetition of the two adjacent PUSCH repetitions starting earlier in the time domain and a later repetition of the two adjacent PUSCH repetitions starting later in the time domain.

10. The method of claim 9, in the case that both the two adjacent PUSCH repetitions are repetitions of PUSCH repetition type A or are actual repetitions of PUSCH repetition type B, comprising:

determining last T1 symbol(s) of the former repetition and first T2 symbol(s) of the later repetition not to be transmitted when the time gap between the two adjacent PUSCH repetitions is smaller than the time threshold for beam switching,

wherein, $T1 = \min(L1, \text{ceil}((M-N)/2))$, $T2 = \min(L2, \text{floor}((M-N)/2))$, L1 is a total symbol number of the former repetition, L2 is a total symbol number of the later repetition, N symbol(s) represents the time gap between the two adjacent PUSCH repetitions, M symbol(s) represents the time threshold for beam switching, and all of L1, L2, M and N are nature number; and

counting a number of the plurality of PUSCH repetitions by including the former repetition and the later repetition.

11. The method of claim 9, in the case that both the two adjacent PUSCH repetitions are actual repetitions of PUSCH repetition type B, comprising:

determining last T1 symbol(s) of the former repetition and first T2 symbol(s) of the later repetition to be invalid and not to be transmitted when the time gap between the two adjacent PUSCH repetitions is smaller than the time threshold for beam switching,

wherein, $T1 = \min(L1, \text{ceil}((M-N)/2))$, $T2 = \min(L2, \text{floor}((M-N)/2))$, L1 is a total symbol number of the former repetition, L2 is a total symbol number of the later repetition, N symbol(s) represent the time gap between the two adjacent PUSCH repetitions, M symbol(s) represent the time threshold for beam switching, and all of L1, L2, M and N are nature number;

counting a number of the plurality of PUSCH repetitions by including the former repetition only when remaining valid symbol(s) of the former repetition is still qualified for an actual repetition of PUSCH repetition type B after excluding the last T1 symbols from the former repetition; and

counting a number of the plurality of PUSCH repetitions by including the later repetition only when remaining valid symbol(s) of the later repetition is still qualified

for an actual repetition of PUSCH repetition type B after excluding the first T2 symbols from the later repetition.

12. The method of claim 9, in the case that both the two adjacent PUSCH repetitions are repetitions of PUSCH repetition type A or are actual repetitions of PUSCH repetition type B, comprising:

determining last T1 symbol(s) of the former repetition and first T2 symbol(s) of the later repetition not to be transmitted when the time gap between the two adjacent PUSCH repetitions is smaller than the time threshold for beam switching,

wherein, $T1 = \min(L1, \text{floor}((M-N)/2))$, $T2 = \min(L2, \text{ceil}((M-N)/2))$, L1 is a total symbol number of the former repetition, L2 is a total symbol number of the later repetition, N symbol(s) represents the time gap between the two adjacent PUSCH repetitions, M symbol(s) represents the time threshold for beam switching, and all of L1, L2, M and N are nature number; and

counting a number of the plurality of PUSCH repetitions by including the former repetition and the later repetition.

13. The method of claim 9, in the case that both the two adjacent PUSCH repetitions are actual repetitions of PUSCH repetition type B, comprising:

determining last T1 symbol(s) of the former repetition and first T2 symbol(s) of the later repetition to be invalid and not to be transmitted when the time gap between the two adjacent PUSCH repetitions is smaller than the time threshold for beam switching,

wherein, $T1 = \min(L1, \text{floor}((M-N)/2))$, $T2 = \min(L2, \text{ceil}((M-N)/2))$, L1 is a total symbol number of the former repetition, L2 is a total symbol number of the later repetition, N symbol(s) represents the time gap between the two adjacent PUSCH repetitions, M symbol(s) represents the time threshold for beam switching, and all of L1, L2, M and N are nature number;

counting a number of the plurality of PUSCH repetitions by including the former repetition only when remaining valid symbol(s) of the former repetition is still qualified for an actual repetition of PUSCH repetition type B after excluding the last T1 symbols from the former repetition; and

counting the number of the plurality of PUSCH repetitions by including the later repetition only when remaining valid symbol(s) of the later repetition is still qualified for an actual repetition of PUSCH repetition type B after excluding the first T2 symbols from the later repetition.

14. A method, comprising:

transmitting configuration information indicating a mapping pattern of a plurality of beams and a plurality of physical uplink shared channel (PUSCH) repetitions of a PUSCH transmission using the plurality of beams, wherein each of the plurality of beams is represented by spatial relation information;

determining whether a time gap between two adjacent PUSCH repetitions with different beams in time domain is smaller than a time threshold for beam switching; and

determining at least one symbol of the two adjacent PUSCH repetitions not to be received when the time gap between the two adjacent PUSCH repetitions is smaller than the time threshold for beam switching.

15. An apparatus, comprising:

at least one non-transitory computer-readable medium having stored thereon computer-executable instructions;

at least one receiving circuitry;

at least one transmitting circuitry; and

at least one processor coupled to the at least one non-transitory computer-readable medium, the at least one receiving circuitry and the at least one transmitting circuitry,

wherein the computer-executable instructions cause the at least one processor to implement the method of any of Claims 1-14 with the at least one receiving circuitry and the at least one transmitting circuitry.

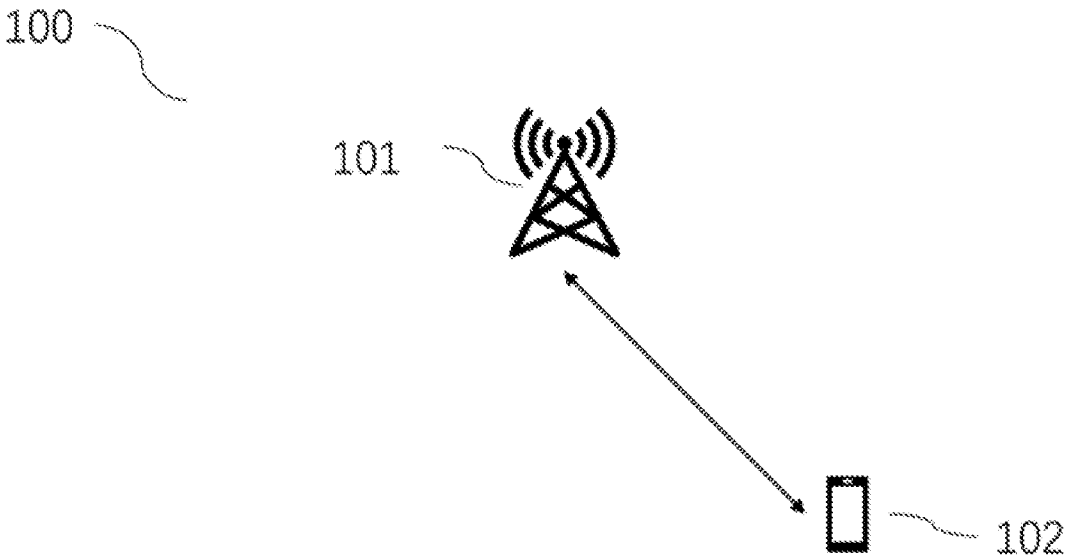


FIG. 1

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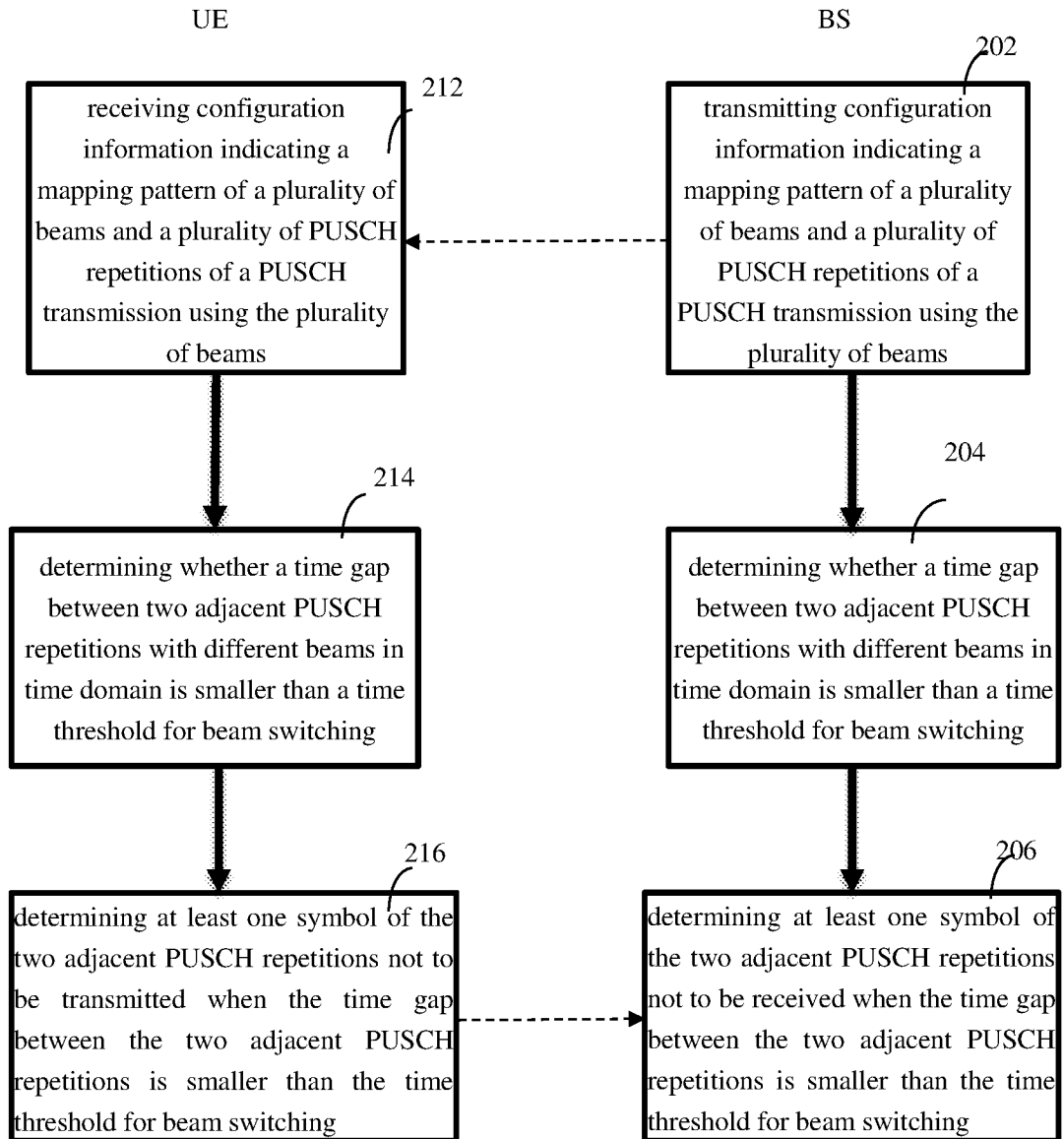


FIG. 2

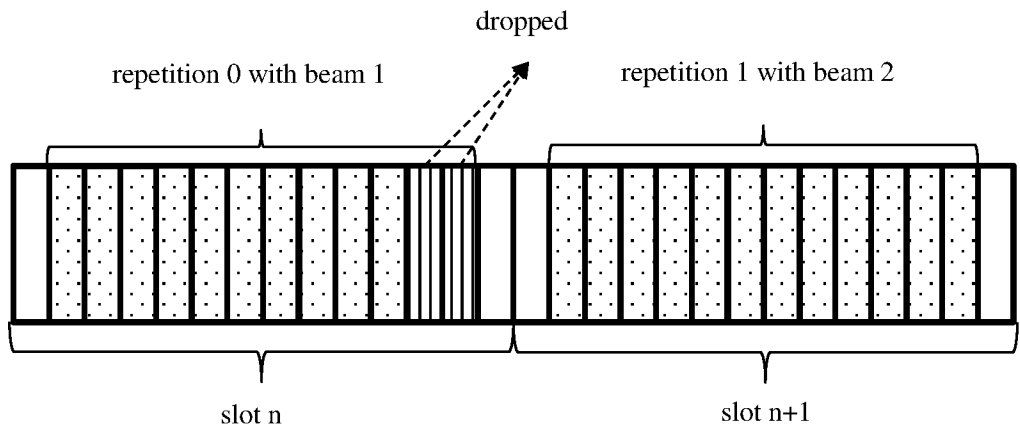


FIG. 3

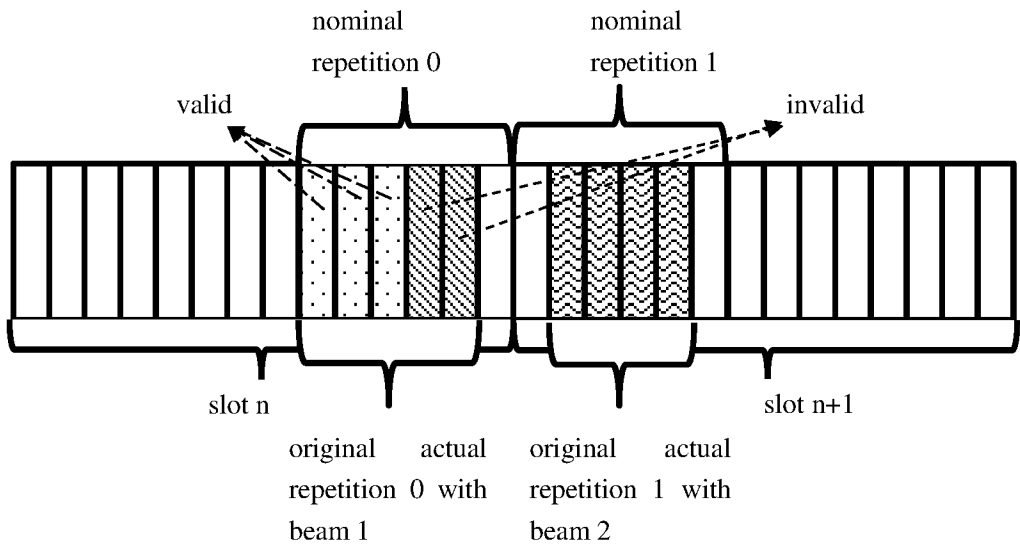


FIG. 4

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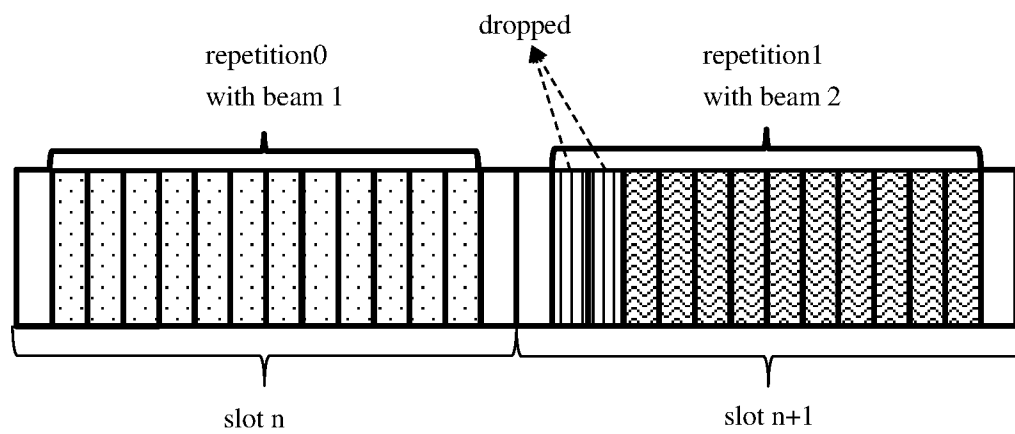


FIG. 5

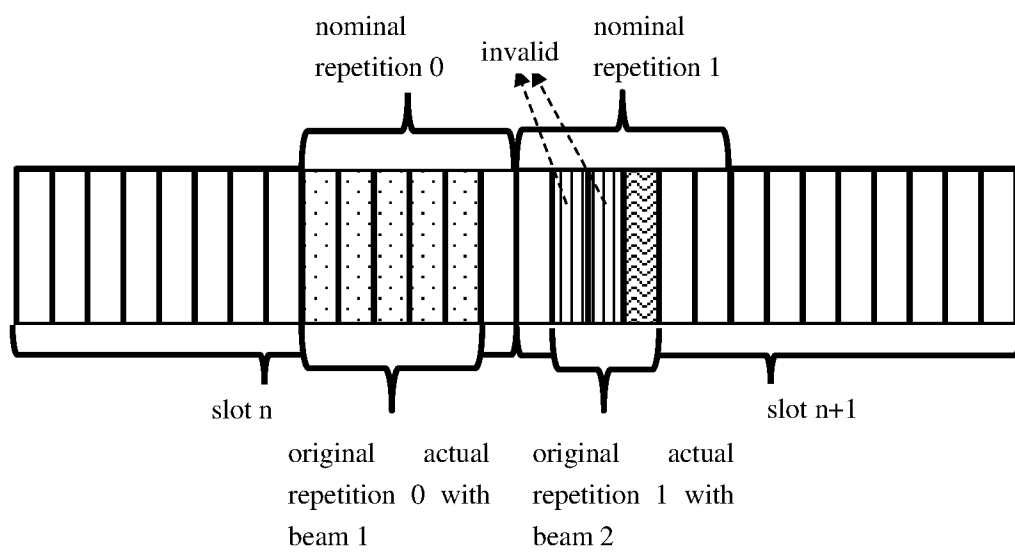


FIG. 6

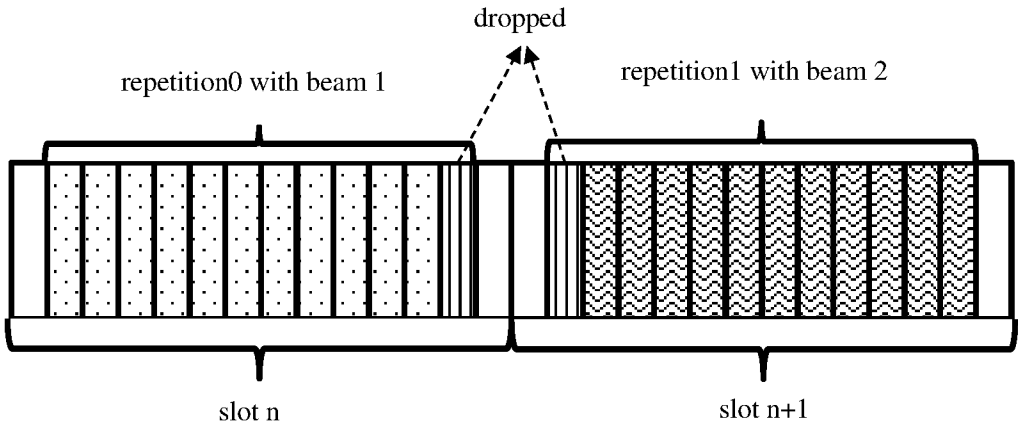


FIG. 7

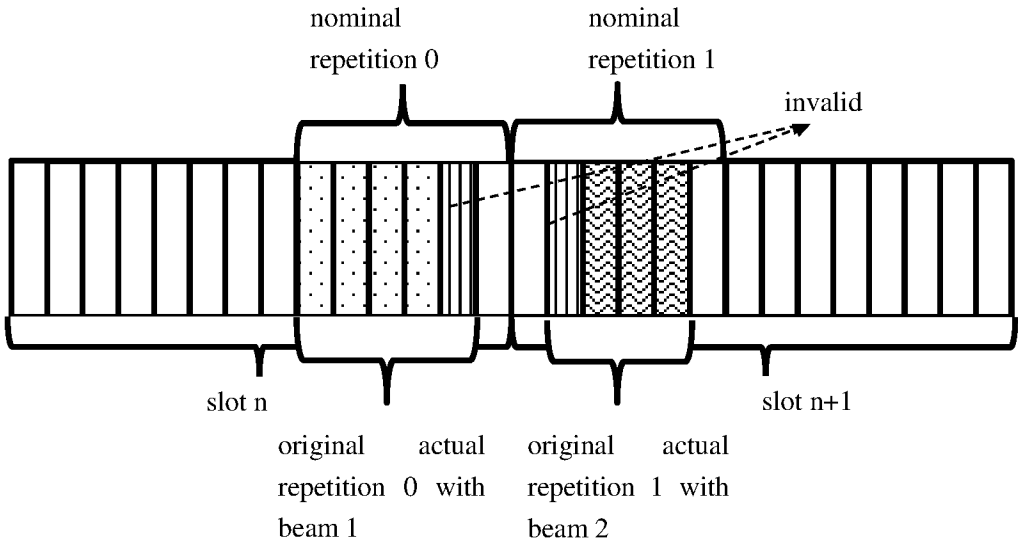


FIG. 8

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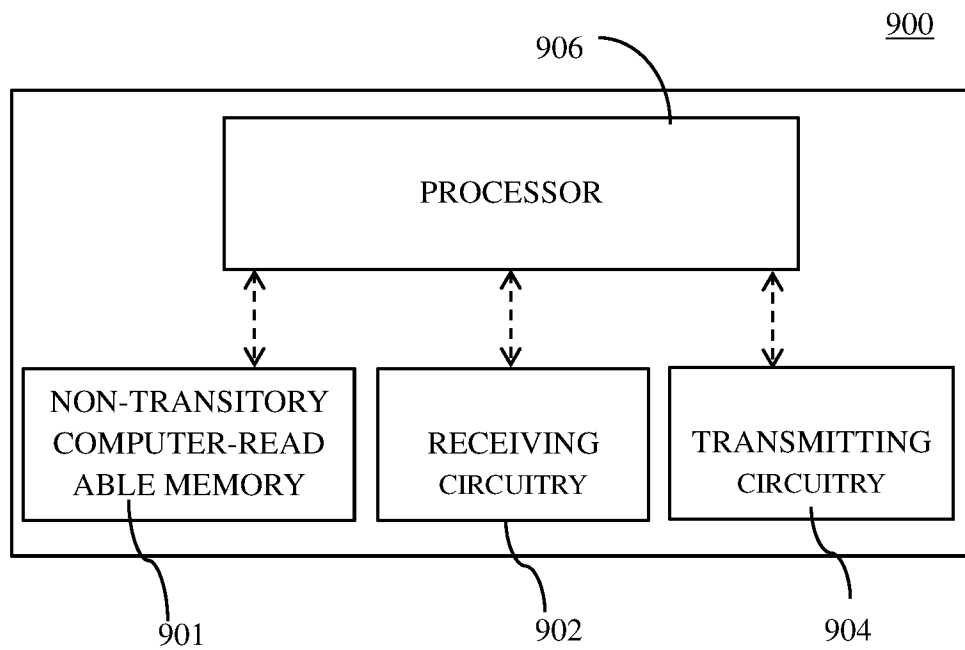


FIG. 9

INTERNATIONAL SEARCH REPORT

International application No.

PCT/CN2020/120181

A. CLASSIFICATION OF SUBJECT MATTER

H04W 72/04(2009.01)i

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

H04W; 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)

CNPAT, WPI, EPODOC, CNKI, 3GPP: PUSCH, diversity, beams, TRP, transmission reception points, spatial relation, time gap, adjacent, switch, threshold, sufficient

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	ZTE. "Multi-TRP enhancements for PDCCH, PUCCH and PUSCH" 3GPP TSG RAN WG1 Meeting #102-e R1-2005455, 28 August 2020 (2020-08-28), section 2	1-15
Y	QUALCOMM INCORPORATED. "Beam management for NR" 3GPP TSG-RAN WG1 Meeting 93 R1-1807341, 25 May 2018 (2018-05-25), section 6	1-15
A	SPREADTRUM COMMUNICATIONS. "Discussion on enhancements on Multi-TRP for PDCCH, PUCCH and PUSCH" 3GPP TSG RAN WG1 #102-e R1-2006258, 28 August 2020 (2020-08-28), the whole document	1-15
A	CN 110351856 A (INTEL CORPORATION) 18 October 2019 (2019-10-18) the whole document	1-15
A	CN 110392380 A (INTEL CORPORATION) 29 October 2019 (2019-10-29) the whole document	1-15
A	US 2019363919 A1 (QUALCOMM INCORPORATED) 28 November 2019 (2019-11-28) the whole document	1-15



Further documents are listed in the continuation of Box C.



See patent family annex.

* Special categories of cited documents:

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

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

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

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

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

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

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

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

"&" document member of the same patent family

Date of the actual completion of the international search

28 June 2021

Date of mailing of the international search report

08 July 2021

Name and mailing address of the ISA/CN

National Intellectual Property Administration, PRC
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100088
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Facsimile No. (86-10)62019451

Authorized officer

KOU, Limin

Telephone No. 86-(10)-53961731

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.

PCT/CN2020/120181

Patent document cited in search report			Publication date (day/month/year)	Patent family member(s)			Publication date (day/month/year)
CN	110351856	A	18 October 2019	None			
CN	110392380	A	29 October 2019	None			
US	2019363919	A1	28 November 2019	WO	2019226442	A1	28 November 2019
				CN	112189313	A	05 January 2021