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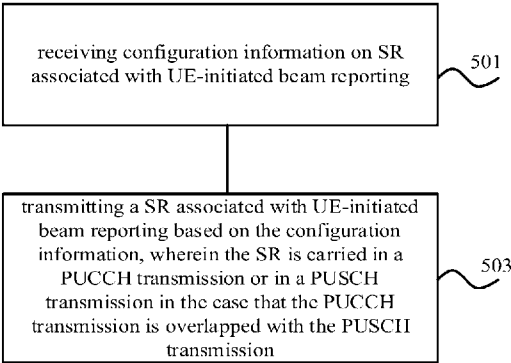


Figure 5

(57) Abstract: Various aspects of the present disclosure relate to a method and apparatus of supporting beam reporting. An exemplary method performed by a UE may include: receiving configuration information on SR associated with UE-initiated beam reporting; and transmitting a SR associated with UE-initiated beam reporting based on the configuration information, wherein the SR is carried in a PUCCH transmission or in a PUSCH transmission in the case that the PUCCH transmission is overlapped with the PUSCH transmission.

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METHOD AND APPARATUS OF SUPPORTING BEAM REPORTING

TECHNICAL FIELD

[0001] The present disclosure relates to wireless communications, and more specifically to techniques of supporting beam reporting.

BACKGROUND

[0002] A wireless communications system may include one or multiple network communication devices, such as base stations, which may support wireless communications for one or multiple user communication devices, which may be otherwise known as user equipment (UE), or other suitable terminology. The wireless communications system may support wireless communications with one or multiple user communication devices by utilizing resources of the wireless communication system (e.g., time resources (e.g., symbols, slots, subframes, frames, or the like) or frequency resources (e.g., subcarriers, carriers, or the like). Additionally, the wireless communications system may support wireless communications across various radio access technologies including third generation (3G) radio access technology, fourth generation (4G) radio access technology, fifth generation (5G) radio access technology, among other suitable radio access technologies beyond 5G (e.g., sixth generation (6G)).

SUMMARY

[0003] An article “a” before an element is unrestricted and understood to refer to “at least one” of those elements or “one or more” of those elements. The terms “a,” “at least one,” “one or more,” and “at least one of one or more” may be interchangeable. As used herein, including in the claims, “or” as used in a list of items (e.g., a list of items prefaced by a phrase such as “at least one of” or “one or more of” or “one or both of”) indicates an inclusive list such that, for example, a list of at least one of A, B, or C means A or B or C or AB or AC or BC or ABC (i.e., A and B and C). Also, as used herein, the phrase “based on” shall not be construed as a reference to a closed set of conditions. For example, an example step that is

described as “based on condition A” may be based on both a condition A and a condition B without departing from the scope of the present disclosure. In other words, as used herein, the phrase “based on” shall be construed in the same manner as the phrase “based at least in part on. Further, as used herein, including in the claims, a “set” may include one or more elements.

[0004] Some implementations of the methods and apparatuses described herein may further include a UE for wireless communication, which includes: at least one memory; and at least one processor coupled with the at least one memory and configured to cause the UE to: receive configuration information on scheduling request (SR) associated with UE-initiated beam reporting; and transmit a SR associated with UE-initiated beam reporting based on the configuration information, wherein the SR is carried in a physical uplink control channel (PUCCH) transmission or in a physical uplink shared channel (PUSCH) transmission in the case that the PUCCH transmission is overlapped with the PUSCH transmission.

[0005] In some implementations of the methods and apparatuses described herein, in the case that the SR is carried in the PUSCH transmission, the at least one processor is configured to cause the UE to jointly encode a bit of the SR with hybrid automatic repeat request (HARQ)-acknowledge (ACK) bits determined to be transmitted in the PUSCH transmission to generate hybrid coded HARQ-ACK bits, wherein a number of the HARQ-ACK bits is equal to 0 or larger than 0.

[0006] In some implementations of the methods and apparatuses described herein, in the case that the number of the HARQ-ACK bits and the SR is less than or equal to 2, the hybrid coded HARQ-ACK bits are punctured in the PUSCH transmission; and in the case that the number of the HARQ-ACK bits and the SR is more than 2, the hybrid coded HARQ-ACK bits are rate matched in the PUSCH transmission.

[0007] In some implementations of the methods and apparatuses described herein, in the case that the number of the HARQ-ACK bits is larger than 0, the at least one processor is configured to cause the UE to: concatenate the bit of the SR after the HARQ-ACK bits before jointly encoding the bit of the SR with the HARQ-ACK bits.

[0008] In some implementations of the methods and apparatuses described herein, in the case that there are channel state information (CSI) bits determined to be transmitted in the PUSCH transmission, the at least one processor is configured to cause the UE to: determine coded CSI bits based a number of the bits of the SR and the number of the HARQ-ACK bits.

[0009] In some implementations of the methods and apparatuses described herein, in the case that the SR is carried in the PUSCH transmission, the at least one processor is configured to cause the UE to: jointly encode a bit of the SR with CSI part 1 bits determined to be transmitted in the PUSCH transmission to generate hybrid coded CSI part 1 bits, wherein a number of the CSI part 1 bits is equal to 0 or larger than 0.

[0010] In some implementations of the methods and apparatuses described herein, in the case that number of the CSI part 1 bits is larger than 0, the at least one processor is configured to cause the UE to: put the bit of the SR before the CSI part 1 bits before jointly encoding the bit of the SR with the CSI part 1 bits.

[0011] In some implementations of the methods and apparatuses described herein, the hybrid coded CSI part 1 bits are rate matched in the PUSCH transmission.

[0012] In some implementations of the methods and apparatuses described herein, in the case that the SR is carried in the PUSCH transmission, the at least one processor is configured to cause the UE to: separately encode a bit of the SR from any of HARQ-ACK bits or CSI bits determined to be transmitted in the PUSCH transmission; and transmit coded SR bits in reserved resource elements different from resource elements for transmission of any of the HARQ-ACK bits and CSI bits in the PUSCH transmission.

[0013] In some implementations of the methods and apparatuses described herein, the coded SR bits are determined in a manner as HARQ-ACK coded bit determination, and the at least one processor is configured to cause the UE to: puncture the coded SR bits in the reserved resource elements of the PUSCH transmission determined for SR transmission.

[0014] In some implementations of the methods and apparatuses described herein, in the case that there are 2 or less HARQ-ACK bits determined to be transmitted in the PUSCH transmission, the coded SR bits are punctured after punctured HARQ-ACK coded bits in the PUSCH transmission.

[0015] In some implementations of the methods and apparatuses described herein, the reserved resource elements for transmission of the coded SR bits are determined in a manner as reserved resource element determination for a transmission of HARQ-ACK bits with a number of less than or equal to 2.

[0016] In some implementations of the methods and apparatuses described herein, in the case that there are CSI part 1 bits determined to be transmitted in the PUSCH transmission, the at least one processor is configured to cause the UE to: determine coded CSI part 1 bits determined to be transmitted in the PUSCH transmission at least according to the reserved resource elements for transmission of the coded SR bits.

[0017] In some implementations of the methods and apparatuses described herein, in the case that the SR is carried in the PUSCH transmission, the at least one processor is configured to cause the UE to: transmit the SR by selecting one of two different initiation values for a scrambling sequence for the PUSCH transmission.

[0018] In some implementations of the methods and apparatuses described herein, in the case that a bit of the SR is '1,' a selected initiation value is different from an initiation value determined according to legacy specification; and in the case that a bit of the SR is '0,' the selected initiation value is an initiation value determined according to legacy specification.

[0019] In some implementations of the methods and apparatuses described herein, the SR indicates a UE-initiated beam report occurs or not, or requests a resource for an uplink channel to carry a UE-initiated beam report, or notifies an uplink channel to carry a UE-initiated beam report.

[0020] Some implementations of the methods and apparatuses described herein may further include a processor for wireless communication, which includes: at least one controller coupled with at least one memory and configured to cause the processor to: receive configuration information on SR associated with UE-initiated beam reporting; and transmit a SR associated with UE-initiated beam reporting based on the configuration information, wherein the SR is carried in a PUCCH transmission or in a PUSCH transmission in the case that the PUCCH transmission is overlapped with the PUSCH transmission.

[0021] Some implementations of the methods and apparatuses described herein may further include a network equipment (NE) for wireless communication, which includes: at least one memory; and at least one processor coupled with the at least one memory and configured to cause the NE to: transmit configuration information on SR associated with UE-initiated beam reporting; and receive a SR associated with UE-initiated beam reporting based on the configuration information, wherein the SR is carried in a PUCCH transmission or in a PUSCH transmission in the case that the PUCCH transmission is overlapped with the PUSCH transmission.

[0022] Some implementations of the methods and apparatuses described herein may further include a method performed by a UE, which includes: receiving configuration information on SR associated with UE-initiated beam reporting; and transmitting a SR associated with UE-initiated beam reporting based on the configuration information, wherein the SR is carried in a PUCCH transmission or in a PUSCH transmission in the case that the PUCCH transmission is overlapped with the PUSCH transmission.

BRIEF DESCRIPTION OF THE DRAWINGS

[0023] Figure 1 illustrates an example of a wireless communications system in accordance with aspects of the present disclosure.

[0024] Figure 2 illustrates an example of a UE in accordance with aspects of the present disclosure.

[0025] Figure 3 illustrates an example of a processor in accordance with aspects of the present disclosure.

[0026] Figure 4 illustrates an example of a NE in accordance with aspects of the present disclosure.

[0027] Figure 5 illustrates a flowchart of method performed by a UE in accordance with aspects of the present disclosure.

[0028] Figure 6 illustrates a flowchart of method performed by a NE in accordance with aspects of the present disclosure.

DETAILED DESCRIPTION

[0029] Beam management is an important topic in multiple-input multiple-output (MIMO) for new radio (NR). A "beam" can be represented by or be associated with spatial relation information, transmission configuration indication (TCI) state, or reference signal (RS) etc. Considering further enhancements on MIMO, UE-initiated (also referred to as UE triggered, or event-driven or the like) beam reporting is desired by the industry to reduce the overhead and latency of beam management. However, most details of UE-initiated beam reporting have not been solved yet, e.g., how to transmit UE-initiated beam reports.

[0030] For example, it has been agreed that two modes will be supported for a UE-initiated beam report transmission procedure. In one mode (hereinafter, Mode A), the network side will dynamically schedule resources (or channels) for uplink control information (UCI) transmissions, and there are three steps in Mode A. In step 1, UE will transmit a first PUCCH resource to request a resource for a second uplink (UL) channel to carry a beam report; in step 2, UE will detect the DCI format to indicate a resource for the second uplink channel to carry the beam report; and in step 3: UE will transmit the beam report in the second uplink channel. In the other mode (hereinafter Mode B), the network side will pre-configure resources for UCI transmissions, and there are two steps in Mode B. In step 1, UE will transmit a first PUCCH resource notifying a second uplink channel to carry a beam report; and in step 2, UE will transmit the beam report in the second uplink channel. However, details on the two modes need to be further studied. For example, one issue is related to step 1 either in Mode A or Mode B, what the request format or notification format is and how to transmit the request or notification in the case of resource collision or overlapping need to be solved.

[0031] Various aspects of the present disclosure propose that both the request format and the notification format are SR, that is the first PUCCH resource is a SR PUCCH (or PUCCH resource or PUCCH transmission or the like) or a PUCCH carrying one bit uplink control information (UCI) configured with a period either in Mode A or Mode B. The network side may transmit to UE configuration information on SR or a new type UCI with one bit associated with UE-initiated beam reporting. And in order to simplify the description, we only use SR in the following while it should be noted that the SR in the specification means a SR or a new type UCI with one bit. UE may transmit a SR associated with UE-initiated

beam reporting based on the configuration information, wherein the SR is supposed to be carried in a PUCCH transmission which is configured in the SR configuration information. When the PUCCH resource carrying the SR associated with UE-initiated beam reporting is overlapped with a PUSCH resource, the SR may be multiplexed in the PUSCH resource, rather than being dropped or discarded as legacy 3rd generation partnership project (3GPP) specification. That is, a SR associated with UE-initiated beam reporting to the network side may be carried in a PUCCH transmission or a PUSCH transmission. Accordingly, in the case that there is a UE-initiated beam report associated with the SR, the UE-initiated beam report will be transmitted timely.

[0032] Aspects of the present disclosure are described in the context of a wireless communications system.

[0033] Figure 1 illustrates an example of a wireless communications system 100 in accordance with aspects of the present disclosure. The wireless communications system 100 may include one or more NE 102, one or more UE 104, and a core network (CN) 106. The wireless communications system 100 may support various radio access technologies. In some implementations, the wireless communications system 100 may be a 4G network, such as an LTE network or an LTE-Advanced (LTE-A) network. In some other implementations, the wireless communications system 100 may be a NR network, such as a 5G network, a 5G-Advanced (5G-A) network, or a 5G ultrawideband (5G-UWB) network. In other implementations, the wireless communications system 100 may be a combination of a 4G network and a 5G network, or other suitable radio access technology including Institute of Electrical and Electronics Engineers (IEEE) 802.11 (Wi-Fi), IEEE 802.16 (WiMAX), IEEE 802.20. The wireless communications system 100 may support radio access technologies beyond 5G, for example, 6G. Additionally, the wireless communications system 100 may support technologies, such as time division multiple access (TDMA), frequency division multiple access (FDMA), or code division multiple access (CDMA), etc.

[0034] The one or more NE 102 may be dispersed throughout a geographic region to form the wireless communications system 100. One or more of the NE 102 described herein may be or include or may be referred to as a network node, a base station, a network element, a network function, a network entity, a radio access network (RAN), a NodeB, an eNodeB

(eNB), a next-generation NodeB (gNB), or other suitable terminology. An NE 102 and a UE 104 may communicate via a communication link, which may be a wireless or wired connection. For example, an NE 102 and a UE 104 may perform wireless communication (e.g., receive signaling, transmit signaling) over a Uu interface.

[0035] An NE 102 may provide a geographic coverage area for which the NE 102 may support services for one or more UEs 104 within the geographic coverage area. For example, an NE 102 and a UE 104 may support wireless communication of signals related to services (e.g., voice, video, packet data, messaging, broadcast, etc.) according to one or multiple radio access technologies. In some implementations, an NE 102 may be moveable, for example, a satellite associated with a non-terrestrial network (NTN). In some implementations, different geographic coverage areas 112 associated with the same or different radio access technologies may overlap, but the different geographic coverage areas may be associated with different NE 102.

[0036] The one or more UE 104 may be dispersed throughout a geographic region of the wireless communications system 100. A UE 104 may include or may be referred to as a remote unit, a mobile device, a wireless device, a remote device, a subscriber device, a transmitter device, a receiver device, or some other suitable terminology. In some implementations, the UE 104 may be referred to as a unit, a station, a terminal, or a client, among other examples. Additionally, or alternatively, the UE 104 may be referred to as an Internet-of-Things (IoT) device, an Internet-of-Everything (IoE) device, or machine-type communication (MTC) device, among other examples.

[0037] A UE 104 may be able to support wireless communication directly with other UEs 104 over a communication link. For example, a UE 104 may support wireless communication directly with another UE 104 over a device-to-device (D2D) communication link. In some implementations, such as vehicle-to-vehicle (V2V) deployments, vehicle-to-everything (V2X) deployments, or cellular-V2X deployments, the communication link 114 may be referred to as a sidelink. For example, a UE 104 may support wireless communication directly with another UE 104 over a PC5 interface.

[0038] An NE 102 may support communications with the CN 106, or with another NE 102, or both. For example, an NE 102 may interface with other NE 102 or the CN 106 through

one or more backhaul links (e.g., S1, N2, N2, or network interface). In some implementations, the NE 102 may communicate with each other directly. In some other implementations, the NE 102 may communicate with each other or indirectly (e.g., via the CN 106). In some implementations, one or more NE 102 may include subcomponents, such as an access network entity, which may be an example of an access node controller (ANC). An ANC may communicate with the one or more UEs 104 through one or more other access network transmission entities, which may be referred to as a radio heads, smart radio heads, or transmission-reception points (TRPs).

[0039] The CN 106 may support user authentication, access authorization, tracking, connectivity, and other access, routing, or mobility functions. The CN 106 may be an evolved packet core (EPC), or a 5G core (5GC), which may include a control plane entity that manages access and mobility (e.g., a mobility management entity (MME), an access and mobility management functions (AMF)) and a user plane entity that routes packets or interconnects to external networks (e.g., a serving gateway (S-GW), a Packet Data Network (PDN) gateway (P-GW), or a user plane function (UPF)). In some implementations, the control plane entity may manage non-access stratum (NAS) functions, such as mobility, authentication, and bearer management (e.g., data bearers, signal bearers, etc.) for the one or more UEs 104 served by the one or more NE 102 associated with the CN 106.

[0040] The CN 106 may communicate with a packet data network over one or more backhaul links (e.g., via an S1, N2, N2, or another network interface). The packet data network may include an application server. In some implementations, one or more UEs 104 may communicate with the application server. A UE 104 may establish a session (e.g., a protocol data unit (PDU) session, or the like) with the CN 106 via an NE 102. The CN 106 may route traffic (e.g., control information, data, and the like) between the UE 104 and the application server using the established session (e.g., the established PDU session). The PDU session may be an example of a logical connection between the UE 104 and the CN 106 (e.g., one or more network functions of the CN 106).

[0041] In the wireless communications system 100, the NEs 102 and the UEs 104 may use resources of the wireless communications system 100 (e.g., time resources (e.g., symbols, slots, subframes, frames, or the like) or frequency resources (e.g., subcarriers, carriers)) to

perform various operations (e.g., wireless communications). In some implementations, the NEs 102 and the UEs 104 may support different resource structures. For example, the NEs 102 and the UEs 104 may support different frame structures. In some implementations, such as in 4G, the NEs 102 and the UEs 104 may support a single frame structure. In some other implementations, such as in 5G and among other suitable radio access technologies, the NEs 102 and the UEs 104 may support various frame structures (i.e., multiple frame structures). The NEs 102 and the UEs 104 may support various frame structures based on one or more numerologies.

[0042] One or more numerologies may be supported in the wireless communications system 100, and a numerology may include a subcarrier spacing and a cyclic prefix. A first numerology (e.g., $\mu=0$) may be associated with a first subcarrier spacing (e.g., 15 kHz) and a normal cyclic prefix. In some implementations, the first numerology (e.g., $\mu=0$) associated with the first subcarrier spacing (e.g., 15 kHz) may utilize one slot per subframe. A second numerology (e.g., $\mu=1$) may be associated with a second subcarrier spacing (e.g., 30 kHz) and a normal cyclic prefix. A third numerology (e.g., $\mu=2$) may be associated with a third subcarrier spacing (e.g., 60 kHz) and a normal cyclic prefix or an extended cyclic prefix. A fourth numerology (e.g., $\mu=3$) may be associated with a fourth subcarrier spacing (e.g., 120 kHz) and a normal cyclic prefix. A fifth numerology (e.g., $\mu=4$) may be associated with a fifth subcarrier spacing (e.g., 240 kHz) and a normal cyclic prefix.

[0043] A time interval of a resource (e.g., a communication resource) may be organized according to frames (also referred to as radio frames). Each frame may have a duration, for example, a 10 millisecond (ms) duration. In some implementations, each frame may include multiple subframes. For example, each frame may include 10 subframes, and each subframe may have a duration, for example, a 1 ms duration. In some implementations, each frame may have the same duration. In some implementations, each subframe of a frame may have the same duration.

[0044] Additionally or alternatively, a time interval of a resource (e.g., a communication resource) may be organized according to slots. For example, a subframe may include a number (e.g., quantity) of slots. The number of slots in each subframe may also depend on the one or more numerologies supported in the wireless communications system 100. For

instance, the first, second, third, fourth, and fifth numerologies (i.e., $\mu=0$, $\mu=1$, $\mu=2$, $\mu=3$, $\mu=4$) associated with respective subcarrier spacings of 15 kHz, 30 kHz, 60 kHz, 120 kHz, and 240 kHz may utilize a single slot per subframe, two slots per subframe, four slots per subframe, eight slots per subframe, and 16 slots per subframe, respectively. Each slot may include a number (e.g., quantity) of symbols (e.g., OFDM symbols). In some implementations, the number (e.g., quantity) of slots for a subframe may depend on a numerology. For a normal cyclic prefix, a slot may include 14 symbols. For an extended cyclic prefix (e.g., applicable for 60 kHz subcarrier spacing), a slot may include 12 symbols. The relationship between the number of symbols per slot, the number of slots per subframe, and the number of slots per frame for a normal cyclic prefix and an extended cyclic prefix may depend on a numerology. It should be understood that reference to a first numerology (e.g., $\mu=0$) associated with a first subcarrier spacing (e.g., 15 kHz) may be used interchangeably between subframes and slots.

[0045] In the wireless communications system 100, an electromagnetic (EM) spectrum may be split, based on frequency or wavelength, into various classes, frequency bands, frequency channels, etc. By way of example, the wireless communications system 100 may support one or multiple operating frequency bands, such as frequency range designations FR1 (410 MHz – 7.125 GHz), FR2 (24.25 GHz – 52.6 GHz), FR3 (7.125 GHz – 24.25 GHz), FR4 (52.6 GHz – 114.25 GHz), FR4a or FR4-1 (52.6 GHz – 71 GHz), and FR5 (114.25 GHz – 300 GHz). In some implementations, the NEs 102 and the UEs 104 may perform wireless communications over one or more of the operating frequency bands. In some implementations, FR1 may be used by the NEs 102 and the UEs 104, among other equipment or devices for cellular communications traffic (e.g., control information, data). In some implementations, FR2 may be used by the NEs 102 and the UEs 104, among other equipment or devices for short-range, high data rate capabilities.

[0046] FR1 may be associated with one or multiple numerologies (e.g., at least three numerologies). For example, FR1 may be associated with a first numerology (e.g., $\mu=0$), which includes 15 kHz subcarrier spacing; a second numerology (e.g., $\mu=1$), which includes 30 kHz subcarrier spacing; and a third numerology (e.g., $\mu=2$), which includes 60 kHz subcarrier spacing. FR2 may be associated with one or multiple numerologies (e.g., at least

2 numerologies). For example, FR2 may be associated with a third numerology (e.g., $\mu=2$), which includes 60 kHz subcarrier spacing; and a fourth numerology (e.g., $\mu=3$), which includes 120 kHz subcarrier spacing.

[0047] In accordance with various aspects of the present disclosure, a SR associated with UE-initiated reporting is one bit, which may indicate that a UE-initiated beam report will be transmitted or no UE-initiated beam report will be transmitted. For example, there is one SR bit, wherein in the case of the SR bit being '0,' it means that no UE-initiated beam report occurs or is to be transmitted, while in the case of the SR bit being '1,' it means that a UE-initiated beam report occurs and is to be reported. In some cases, e.g., in mode A, the SR may also request a resource for an uplink channel to carry a UE-initiated beam report. In some cases, e.g., in mode B, the SR may also notifies an uplink channel to carry a UE-initiated beam report. To ensure the low latency of UE-initiated beam reporting, when the PUCCH resource carrying the SR associated with UE-initiated beam reporting is overlapped with a PUSCH resource, the SR will be multiplexed to the PUSCH resource rather than being dropped.

[0048] In the case that the SR associated with UE-initiated beam reporting is carried in a PUCCH transmission, it will be performed as legacy 3GPP specification. In the case that the SR associated with UE-initiated beam reporting is carried in a PUSCH transmission, how to transmit the SR is novel and the present disclosure propose various implementations to solve it.

[0049] For example, in accordance with some implementations of the present disclosure (scheme 1), the SR associated with UE-initiated beam reporting will be regarded as HARQ-ACK information (may be referred to as virtual HARQ-ACK information or the like) and the SR bit will be jointly encoded with the HARQ-ACK bits (if any, e.g., according to Clause 9.1 of TS38.213) determined to be transmitted in the PUSCH transmission. In accordance with some other implementations of the present disclosure (scheme 2), the SR associated with UE-initiated beam reporting will be regarded as CSI part 1 information (may be referred to as virtual CSI part 1 information) and the SR bit will be jointly encoded with the CSI part 1 bits (if any, e.g., according to Clause 6.3.2.1.2 of TS38.212) determined to be transmitted in the PUSCH transmission. In accordance with some yet other implementations of the

present disclosure (scheme 3), the SR bit associated with UE-initiated beam reporting will be encoded separately from HARQ-ACK bits (if any) and CSI bits (if any) determined to be transmitted in the PUSCH transmission. In accordance with some yet other implementations of the present disclosure (scheme 4), the SR associated with UE-initiated beam reporting will be indicated by selecting one of two different initiation values of a scrambling sequence for the PUSCH transmission.

[0050] Details on each scheme will be illustrated in the following in view of various aspects of the present disclosure. In addition, although the schemes are illustrated mainly in the view of UE, persons skilled in the art would well know how to apply them in the network side considering the consistency between the network side and UE side, and thus will not repeat.

Scheme 1

[0051] In accordance with some implementations of the present disclosure, under scheme 1, if there are HARQ-ACK bits determined to be transmitted in the PUSCH transmission, e.g., according to Clause 9.1 of TS38.213, before jointly encoding the bit of the SR with the HARQ-ACK bits determined to be transmitted, the SR bit associated with UE-initiated beam reporting will be concatenated after the HARQ-ACK bits. In addition, "jointly encoding" under scheme 1 means that the SR bit will be encoded in the same manner as HARQ-ACK bits, and there may be no HARQ-ACK bits in some scenarios.

[0052] Considering the SR bit transmission under scheme 1, the HARQ-ACK bits recited in Clause 6.3.2.1.1 of TS38.212 may be updated by replacing with HARQ-ACK bits concatenated with the SR bit associated with UE-initiated beam reporting if any (or the like). Concerned contents in 6.3.2.1.1 of TS38.212 are reproduced below.

“6.3.2.1.1 HARQ-ACK

If HARQ-ACK bits are transmitted on a PUSCH, the UCI bit sequence

$a_0, a_1, a_2, a_3, \dots, a_{A-1}$ is determined as follows:

- If UCI is transmitted on PUSCH without UL-SCH and the UCI includes CSI part 1 without CSI part 2,
- if there is no HARQ-ACK bit given by Clause 9.1 of [5, TS 38.213], set $a_0 = 0$, $a_1 = 0$, and $A = 2$;

- if there is only one HARQ-ACK bit $\tilde{o}_0^{ACK}$ given by Clause 9.1 of [5, TS 38.213], set $a_0 = \tilde{o}_0^{ACK}$, $a_1 = 0$, and $A = 2$;
- otherwise, set $a_i = \tilde{o}_i^{ACK}$ for $i = 0, 1, \dots, O^{ACK} - 1$ and $A = O^{ACK}$, where the HARQ-ACK bit sequence $\tilde{o}_0^{ACK}, \tilde{o}_1^{ACK}, \dots, \tilde{o}_{O^{ACK}-1}^{ACK}$ is given by Clause 9.1 of [5, TS 38.213].”

[0053] In some implementations of the present disclosure, the HARQ-ACK bits concatenated with the SR bit associated with UE-initiated beam reporting if any will be encoded as legacy 3GPP specification, e.g., which is drafted in Clause 6.3.2.4.1.1 and Clause 6.3.2.4.2.1 of TS38.212, and the generated bits may be referred to as hybrid coded HARQ-ACK bits. Q'_{ACK} which is the number of coded modulation symbols per layer for the HARQ-ACK bits in the specification may be renamed as the number of coded modulation symbols per layer for the HARQ-ACK bits concatenated with the SR bit associated with UE-initiated beam reporting if any or the like.

[0054] In accordance with legacy 3GPP specification (e.g., Clause 6.2.7 of TS38.212), the coded HARQ-ACK bits will be punctured in the PUSCH transmission if the number of HARQ-ACK bits is no more than 2; otherwise, the coded HARQ-ACK bits will be rate matched in the PUSCH transmission.

[0055] Similarly, considering that the HARQ-ACK bits (if any) and the SR bit associated with UE-initiated beam reporting are jointly encoded as hybrid coded HARQ-ACK bits, if the total number of the HARQ-ACK bits (if any) plus the SR bit associated with UE-initiated beam reporting is no more than 2, the hybrid coded HARQ-ACK bits will be punctured in the PUSCH transmission, e.g., according to Clause 6.2.7 of TS38.212. Otherwise, the hybrid coded HARQ-ACK bits will be rate matched in the PUSCH transmission, e.g., also according to Clause 6.2.7 of TS38.212. Therefore, the coded SR bit may be punctured in the PUSCH transmission or be rate matched in the PUSCH transmission according to the total number of the HARQ-ACK bits (if any) plus the SR bit associated with UE-initiated beam reporting.

[0056] In addition, in accordance with legacy 3GPP specification, e.g., TS38.212, HARQ-ACK information and CSI information will be encoded and rate matched separately. Considering that the HARQ-ACK bits (if any) and the SR bit associated with UE-initiated beam reporting are jointly encoded as hybrid coded HARQ-ACK bits, if there are CSI bits

(e.g., according to Clause 6.3.2.1.2 of TS38.212) determined to be transmitted in the PUSCH transmission, the coded CSI bits in the PUSCH transmission will be determined based on the total number of the HARQ-ACK bits (if any) plus the SR bit associated with UE-initiated beam reporting.

Scheme 2

[0057] In accordance with legacy 3GPP specification, the priority of SR is higher than CSI. Therefore, under scheme 2, if there are CIS part 1 bits (e.g., according to Clause 6.3.2.1.2 of TS38.212) determined to be transmitted in the PUSCH transmission, the SR bit will be put before all the CSI part 1 bits considering its higher priority. That is, the SR bit associated with UE-initiated beam reporting is concatenated with the CSI part 1 bits (if any). Similarly, "jointly encoding" under scheme 2 means that the SR bit will be encoded in the same manner as CSI part 1 bits, and there may be no CSI part 1 bits in some scenarios.

[0058] In some implementations of the present disclosure, the SR bit associated with UE-initiated beam reporting concatenated with the CSI part 1 bits (if any) may be jointly encoded as legacy 3GPP specification, e.g., which is drafted in Clause 6.3.2.4.1.2 and Clause 6.3.2.4.2.2 of TS38.212. The generated bits may be referred to as hybrid coded CSI part 1 bits. $Q'_{\text{CSI-1}}$, which is the number of coded modulation symbols per layer for CSI part 1 transmitted on the PUSCH may be renamed as the number of coded modulation symbols per layer for the hybrid coded CSI part 1 bits transmitted on PUSCH or the like.

[0059] And the coded CSI part 2 bits in the PUSCH if any will be determined according to the hybrid coded CSI part 1 bits just as legacy scheme in Clause 6.3.2.3.1.3 of TS38.212.

[0060] In accordance with the legacy 3GPP specification, the coded CSI part 1 bits are rate matched in the PUSCH transmission. Therefore, under scheme 2, the SR bit will also be rate matched in the PUSCH transmission.

Scheme 3

[0061] Unlike scheme 1 and scheme 2, similar to legacy solutions for HARQ-ACK bits and CSI bits, which are separately encoded, the SR bit associated with UE-initiated beam reporting will also be separately encoded under scheme 3. The coded SR bits will be

transmitted in resource elements of the PUSCH transmission different from the resource elements respectively determined for the HARQ-ACK and CSI transmissions. In addition, the coded SR bits will be determined like the coded HARQ-ACK bits determination, e.g., in Clause 6.3.2.4.1.1 and Clause 6.3.2.4.2.1 of TS38.212. In the case that the number of SR bit is no more than 2, e.g., 1, the coded SR bits will be punctured in the reserved resource elements of the PUSCH transmission determined for SR transmission similar to the case that the number of HARQ-ACK bits is no more than 2. Moreover, in the case that there are HARQ-ACK bits and the number of the HARQ-ACK bits is no more than 2, the puncture of the coded SR bits will follow the puncture of coded HARQ-ACK bits, e.g., as specified in Clause 6.2.7 of TS38.212. Therefore, the reserved resource elements for the SR transmission associated with UE-initiated beam reporting will be determined similar to the reserved resource elements for potential HARQ-ACK transmission whose number of HARQ-ACK bits is no more than 2.

[0062] An exemplary implementation of the reserved resource element determination for the SR transmission associated with UE-initiated beam reporting under scheme 3 will be illustrated as follows.

[0063] Firstly, if the number of HARQ-ACK bits determined to be transmitted in the PUSCH transmission is more than 2, then step 1 of Clause 6.2.7 of TS38.212 as shown below may be used for the reserved resource elements for the SR transmission associated with UE-initiated beam reporting while the coded HARQ-ACK bits will be replaced with coded SR bits.

"Step 1:

Set $\bar{\Phi}_l^{\text{UL-SCH}} = \Phi_l^{\text{UL-SCH}}$ for $l = 0, 1, 2, \dots, N_{\text{sym},\text{all}}^{\text{PUSCH}} - 1$;

Set $\bar{M}_{\text{sc}}^{\text{UL-SCH}}(l) = |\bar{\Phi}_l^{\text{UL-SCH}}|$ for $l = 0, 1, 2, \dots, N_{\text{sym},\text{all}}^{\text{PUSCH}} - 1$;

Set $\bar{\Phi}_l^{\text{UCI}} = \Phi_l^{\text{UCI}}$ for $l = 0, 1, 2, \dots, N_{\text{sym},\text{all}}^{\text{PUSCH}} - 1$;

Set $\bar{M}_{\text{sc}}^{\text{UCI}}(l) = |\bar{\Phi}_l^{\text{UCI}}|$ for $l = 0, 1, 2, \dots, N_{\text{sym},\text{all}}^{\text{PUSCH}} - 1$;

if the number of HARQ-ACK information bits to be transmitted on PUSCH is 0, 1 or 2 bits and without CG-UCI:

the number of reserved resource elements for potential HARQ-ACK transmission is calculated according to Clause 6.3.2.4.2.1, by setting $O_{\text{ACK}} = 2$;

denote $G_{\text{rvd}}^{\text{ACK}}$ as the number of coded bits for potential HARQ-ACK transmission using the reserved resource elements;

if frequency hopping is configured for the PUSCH, let

$$G_{\text{rvd}}^{\text{ACK}}(1) = N_L \cdot Q_m \cdot \left\lfloor G_{\text{rvd}}^{\text{ACK}} / (2 \cdot N_L \cdot Q_m) \right\rfloor \text{ and } G_{\text{rvd}}^{\text{ACK}}(2) = N_L \cdot Q_m \cdot \left\lceil G_{\text{rvd}}^{\text{ACK}} / (2 \cdot N_L \cdot Q_m) \right\rceil;$$

if frequency hopping is not configured for the PUSCH, let $G_{\text{rvd}}^{\text{ACK}}(1) = G_{\text{rvd}}^{\text{ACK}}$;

denote $\overline{\Phi}_l^{\text{rvd}}$ as the set of reserved resource elements for potential HARQ-ACK transmission, in OFDM symbol l , for $l = 0, 1, 2, \dots, N_{\text{sym},\text{all}}^{\text{PUSCH}} - 1$;

Set $m_{\text{count}}^{\text{ACK}}(1) = 0$;

Set $m_{\text{count}}^{\text{ACK}}(2) = 0$;

$\overline{\Phi}_l^{\text{rvd}} = \emptyset$ for $l = 0, 1, 2, \dots, N_{\text{sym},\text{all}}^{\text{PUSCH}} - 1$;

for $i = 1$ to $N_{\text{hop}}^{\text{PUSCH}}$

$l = l^{(i)}$;

while $m_{\text{count}}^{\text{ACK}}(i) < G_{\text{rvd}}^{\text{ACK}}(i)$

if $\overline{M}_{\text{sc}}^{\text{UCI}}(l) > 0$

if $G_{\text{rvd}}^{\text{ACK}}(i) - m_{\text{count}}^{\text{ACK}}(i) \geq \overline{M}_{\text{sc}}^{\text{UCI}}(l) \cdot N_L \cdot Q_m$

$d = 1$;

$m_{\text{count}}^{\text{RE}} = \overline{M}_{\text{sc}}^{\text{UL-SCH}}(l)$;

end if

if $G_{\text{rvd}}^{\text{ACK}}(i) - m_{\text{count}}^{\text{ACK}}(i) < \overline{M}_{\text{sc}}^{\text{UCI}}(l) \cdot N_L \cdot Q_m$

$d = \left\lfloor \overline{M}_{\text{sc}}^{\text{UCI}}(l) \cdot N_L \cdot Q_m / (G_{\text{rvd}}^{\text{ACK}}(i) - m_{\text{count}}^{\text{ACK}}(i)) \right\rfloor$;

$m_{\text{count}}^{\text{RE}} = \left\lceil (G_{\text{rvd}}^{\text{ACK}}(i) - m_{\text{count}}^{\text{ACK}}(i)) / (N_L \cdot Q_m) \right\rceil$;

end if

for $j = 0$ to $m_{\text{count}}^{\text{RE}} - 1$

$\overline{\Phi}_l^{\text{rvd}} = \overline{\Phi}_l^{\text{rvd}} \cup \{\overline{\Phi}_l^{\text{UL-SCH}}(j \cdot d)\}$

$m_{\text{count}}^{\text{ACK}}(i) = m_{\text{count}}^{\text{ACK}}(i) + N_L \cdot Q_m;$

end for

end if

$l = l + 1;$

end while

end for

else

$\overline{\Phi}_l^{\text{rvd}} = \emptyset$ for $l = 0, 1, 2, \dots, N_{\text{symb,all}}^{\text{PUSCH}} - 1;$

end if

Denote $\overline{M}_{\text{sc,rvd}}^{\overline{\Phi}}(l) = |\overline{\Phi}_l^{\text{rvd}}|$ as the number of elements in $\overline{\Phi}_l^{\text{rvd}}.$ "

[0064] On the other hand, if the number of HARQ-ACK bits determined to be transmitted in the PUSCH transmission is no more than 2, after step 1 of Clause 6.2.7 of TS38.212 for the reserved resource elements for potential HARQ-ACK transmission, the reserved resource elements for the SR transmission associated with UE-initiated beam reporting may also be performed similar to step 1 of Clause 6.2.7 of TS38.212 for the reserved resource elements for potential HARQ-ACK transmission. More details on the SR transmission in the case that the number of HARQ-ACK bits determined to be transmitted in the PUSCH transmission is no more than 2 under scheme will be further illustrated in the following.

[0065] In some implementations of the present disclosure, firstly, if the last symbol containing the reserved resource elements for potential HARQ-ACK transmission has some remaining available resource elements for data are not reserved resource elements for potential HARQ-ACK transmission (that is, not all reserved resource elements of the last symbol are used for potential HARQ-ACK transmission), the last symbol containing the reserved resource elements for potential HARQ-ACK transmission will be considered as the first symbol for the reserved resource elements determination for SR transmission; otherwise, if the last symbol containing the reserved resource elements for potential HARQ-ACK transmission has no remaining available resource elements for data except for reserved resource elements for potential HARQ-ACK transmission (that is, all reserved resource elements of the last symbol are for potential HARQ-ACK transmission), the next symbol of

the last symbol containing the reserved resource elements for potential HARQ-ACK transmission will be considered as the first symbol for the reserved resource elements determination for SR transmission.

[0066] Then from each symbol for the reserved resource elements determination for SR transmission,

- if the remaining coded SR bits is larger than the number of available resource elements except for reserved resource elements for potential HARQ-ACK transmission multiplied by modulation order and multiplied by layer number,
 - then all the available resource elements except for reserved resource elements for potential HARQ-ACK transmission are reserved resource elements for SR transmission,
 - and the remaining coded SR bits are updated as the remaining coded SR bits minus the number of all the available resource elements except for reserved resource elements for potential HARQ-ACK transmission multiplying modulation order and then multiplying layer number;
- otherwise,
 - the number of reserved resource elements in this symbol will be the remaining coded SR bits divided by the modulation order and then divided by the layer number, and the reserved resource elements are uniformed placed in the symbol.

[0067] In the case that there are CSI part 1 bits determined to be transmitted in the PUSCH transmission, the number of coded modulation symbols per layer of CSI part 1, e.g., $Q'_{\text{CSI-1}}$, will be further determined at least according to the reserved resource elements for transmission of the number of coded modulation symbols per layer of SR, e.g., $Q'_{\text{SR}} = \sum_{l=0}^{N_{\text{symb,all}}^{\text{PUSCH}}-1} \tilde{M}_{\text{sc,rvd}}^{\text{SR}}(l)$ where $\tilde{M}_{\text{sc,rvd}}^{\text{SR}}(l)$ is the number of reserved resource elements for the SR transmission associated with UE-initiated beam reporting in orthogonal frequency division multiplexing (OFDM) symbol l , for $l=0,1,2,\dots,N_{\text{symb,all}}^{\text{PUSCH}}-1$. Therefore, the determination of coded CSI part 1 in the PUSCH is at least according to the SR bit transmitted in the PUSCH.

$$Q'_{\text{CSI-1}} = \min \left\{ \left\lceil \frac{(O_{\text{CSI-1}} + L_{\text{CSI-1}}) \cdot \beta_{\text{offset}}^{\text{PUSCH}} \cdot \sum_{l=0}^{N_{\text{symb,all}}^{\text{PUSCH}} - 1} M_{\text{sc}}^{\text{UCI}}(l)}{\sum_{r=0}^{C_{\text{UL-SCH}} - 1} K_r} \right\rceil, \left\lceil \alpha \cdot \sum_{l=0}^{N_{\text{symb,all}}^{\text{PUSCH}} - 1} M_{\text{sc}}^{\text{UCI}}(l) \right\rceil - Q'_{\text{ACK/CG-UCI}} - Q'_{\text{SR}} \right\}$$

While for the number of coded modulation symbols per layer of CSI part 2, e.g., $Q'_{\text{CSI-2}}$, the Q'_{SR} will be 0 in the case that the number of SR bit is 1 which will use the principle of HARQ-ACK as specified in Clause 6.3.2.4.1.3 of TS38.212 in legacy 3GPP specification that $Q'_{\text{ACK}} = 0$ if the number of HARQ-ACK bits is 1 or 2 bits.

$$Q'_{\text{CSI-2}} = \min \left\{ \left\lceil \frac{(O_{\text{CSI-2}} + L_{\text{CSI-2}}) \cdot \beta_{\text{offset}}^{\text{PUSCH}} \cdot \sum_{l=0}^{N_{\text{symb,all}}^{\text{PUSCH}} - 1} M_{\text{sc}}^{\text{UCI}}(l)}{\sum_{r=0}^{C_{\text{UL-SCH}} - 1} K_r} \right\rceil, \left\lceil \alpha \cdot \sum_{l=0}^{N_{\text{symb,all}}^{\text{PUSCH}} - 1} M_{\text{sc}}^{\text{UCI}}(l) \right\rceil - Q'_{\text{ACK/CG-UCI}} - Q'_{\text{CSI-1}} - Q'_{\text{SR}} \right\}.$$

Therefore, there is no impact for the determination of coded CSI part 2 bits even if considering the transmission of SR bit associated with UE-initiated beam reporting.

Scheme 4

[0068] Under scheme 4, UE will transmit the SR associated with UE-initiated beam reporting implicitly. For example, since there are two statuses of the SR transmission associated with UE-initiated beam reporting, which is associated with whether there is a UE-initiated beam report to be transmitted, the SR can be indicated by selecting one of two different initiation values of the scrambling sequence for the PUSCH transmission. For example, if the SR bit is '0', the legacy initiation value of the scrambling sequence will be used for the PUSCH transmission, while if the SR bit is '1', a new initiation value, rather than the legacy initiation value of the scrambling sequence will be used for the PUSCH transmission.

[0069] For example, the scrambling sequence generator of the PUSCH transmission will be initialized with

$$c_{\text{init}} = \begin{cases} n_{\text{RNTI}} \cdot 2^{16} + n_{\text{RAPID}} \cdot 2^{10} + n_{\text{ID}} & \text{for msgA on PUSCH} \\ n_{\text{RNTI}} \cdot 2^{15} + q \cdot 2^{14} + n_{\text{ID}} + 1 & \text{for case 1} \\ n_{\text{RNTI}} \cdot 2^{15} + q \cdot 2^{14} + n_{\text{ID}} & \text{for case 2} \end{cases}$$

where

- n_{RNTI} equals the random access (RA)- radio network temporary identifier (RNTI) for msgA, otherwise corresponds to the RNTI associated with the PUSCH transmission as described in clause 6.1 of TS 38.214 and clause 8.3 of TS 38.213 for case 1 and case 2;
- $n_{\text{ID}} \in \{0,1, \dots, 1023\}$ equals the higher-layer parameter *dataScramblingIdentityPUSCH* if configured and the RNTI equals the cell (C)-RNTI, modulation coding scheme (MCS)-C-RNTI, semi persistent (SP)-CSI-RNTI or configured scheduling (CS)-RNTI, and the transmission is not scheduled using DCI format 0_0 in a common search space;
- $n_{\text{ID}} \in \{0,1, \dots, 1023\}$ equals the higher-layer parameter *msgA-DataScramblingIndex* if configured and the PUSCH transmission is triggered by a Type-2 random access procedure as described in clause 8.1A of TS 38.213;
- $n_{\text{ID}} = N_{\text{ID}}^{\text{cell}}$ otherwise;
- n_{RAPID} is the index of the random-access preamble transmitted for msgA as described in clause 5.1.3A of TS 38.321;
- case 1 means a SR bit associated with UE-initiated beam reporting overlapped with a PUSCH transmission which is not a msgA PUSCH is '1' ; and
- case 2 means a SR bit associated with UE-initiated beam reporting overlapped with a PUSCH transmission which is not a msgA PUSCH is '0,' or a PUSCH transmission which is not a msgA PUSCH and is not associated with a SR bit.

[0070] Figure 2 illustrates an example of a UE 200 in accordance with aspects of the present disclosure. The UE 200 may include a processor 202, a memory 204, a controller 206, and a transceiver 208. The processor 202, the memory 204, the controller 206, or the transceiver 208, or various combinations thereof or various components thereof may be examples of means for performing various aspects of the present disclosure as described herein. These components may be coupled (e.g., operatively, communicatively, functionally, electronically, electrically) via one or more interfaces.

[0071] The processor 202, the memory 204, the controller 206, or the transceiver 208, or various combinations or components thereof may be implemented in hardware (e.g., circuitry). The hardware may include a processor, a digital signal processor (DSP), an application-specific integrated circuit (ASIC), or other programmable logic device, or any combination thereof configured as or otherwise supporting a means for performing the functions described in the present disclosure.

[0072] The processor 202 may include an intelligent hardware device (e.g., a general-purpose processor, a DSP, a CPU, an ASIC, an FPGA, or any combination thereof). In some implementations, the processor 202 may be configured to operate the memory 204. In some other implementations, the memory 204 may be integrated into the processor 202. The processor 202 may be configured to execute computer-readable instructions stored in the memory 204 to cause the UE 200 to perform various functions of the present disclosure.

[0073] The memory 204 may include volatile or non-volatile memory. The memory 204 may store computer-readable, computer-executable code including instructions when executed by the processor 202 cause the UE 200 to perform various functions described herein. The code may be stored in a non-transitory computer-readable medium such the memory 204 or another type of memory. Computer-readable media includes both non-transitory computer storage media and communication media including any medium that facilitates transfer of a computer program from one place to another. A non-transitory storage medium may be any available medium that may be accessed by a general-purpose or special-purpose computer.

[0074] In some implementations, the processor 202 and the memory 204 coupled with the processor 202 may be configured to cause the UE 200 to perform one or more of the functions described herein (e.g., executing, by the processor 202, instructions stored in the memory 204). For example, the processor 202 may support wireless communication at the UE 200 in accordance with examples as disclosed herein. The UE 200 may be configured to support a means for receiving configuration information on SR associated with UE-initiated beam reporting; and a means for transmitting a SR associated with UE-initiated beam reporting based on the configuration information, wherein the SR is carried in a PUCCH

transmission or in a PUSCH transmission in the case that the PUCCH transmission is overlapped with the PUSCH transmission.

[0075] The controller 206 may manage input and output signals for the UE 200. The controller 206 may also manage peripherals not integrated into the UE 200. In some implementations, the controller 206 may utilize an operating system such as iOS®, ANDROID®, WINDOWS®, or other operating systems. In some implementations, the controller 206 may be implemented as part of the processor 202.

[0076] In some implementations, the UE 200 may include at least one transceiver 208. In some other implementations, the UE 200 may have more than one transceiver 208. The transceiver 208 may represent a wireless transceiver. The transceiver 208 may include one or more receiver chains 210, one or more transmitter chains 212, or a combination thereof.

[0077] A receiver chain 210 may be configured to receive signals (e.g., control information, data, packets) over a wireless medium. For example, the receiver chain 210 may include one or more antennas for receive the signal over the air or wireless medium. The receiver chain 210 may include at least one amplifier (e.g., a low-noise amplifier (LNA)) configured to amplify the received signal. The receiver chain 210 may include at least one demodulator configured to demodulate the receive signal and obtain the transmitted data by reversing the modulation technique applied during transmission of the signal. The receiver chain 210 may include at least one decoder for decoding the processing the demodulated signal to receive the transmitted data.

[0078] A transmitter chain 212 may be configured to generate and transmit signals (e.g., control information, data, packets). The transmitter chain 212 may include at least one modulator for modulating data onto a carrier signal, preparing the signal for transmission over a wireless medium. The at least one modulator may be configured to support one or more techniques such as amplitude modulation (AM), frequency modulation (FM), or digital modulation schemes like phase-shift keying (PSK) or quadrature amplitude modulation (QAM). The transmitter chain 212 may also include at least one power amplifier configured to amplify the modulated signal to an appropriate power level suitable for transmission over the wireless medium. The transmitter chain 212 may also include one or more antennas for transmitting the amplified signal into the air or wireless medium.

[0079] Figure 3 illustrates an example of a processor 300 in accordance with aspects of the present disclosure. The processor 300 may be an example of a processor configured to perform various operations in accordance with examples as described herein. The processor 300 may include a controller 302 configured to perform various operations in accordance with examples as described herein. The processor 300 may optionally include at least one memory 304, which may be, for example, an L1/L2/L3 cache. Additionally, or alternatively, the processor 300 may optionally include one or more arithmetic-logic units (ALUs) 306. One or more of these components may be in electronic communication or otherwise coupled (e.g., operatively, communicatively, functionally, electronically, electrically) via one or more interfaces (e.g., buses).

[0080] The processor 300 may be a processor chipset and include a protocol stack (e.g., a software stack) executed by the processor chipset to perform various operations (e.g., receiving, obtaining, retrieving, transmitting, outputting, forwarding, storing, determining, identifying, accessing, writing, reading) in accordance with examples as described herein. The processor chipset may include one or more cores, one or more caches (e.g., memory local to or included in the processor chipset (e.g., the processor 300) or other memory (e.g., random access memory (RAM), read-only memory (ROM), dynamic RAM (DRAM), synchronous dynamic RAM (SDRAM), static RAM (SRAM), ferroelectric RAM (FeRAM), magnetic RAM (MRAM), resistive RAM (RRAM), flash memory, phase change memory (PCM), and others).

[0081] The controller 302 may be configured to manage and coordinate various operations (e.g., signaling, receiving, obtaining, retrieving, transmitting, outputting, forwarding, storing, determining, identifying, accessing, writing, reading) of the processor 300 to cause the processor 300 to support various operations in accordance with examples as described herein. For example, the controller 302 may operate as a control unit of the processor 300, generating control signals that manage the operation of various components of the processor 300. These control signals include enabling or disabling functional units, selecting data paths, initiating memory access, and coordinating timing of operations.

[0082] The controller 302 may be configured to fetch (e.g., obtain, retrieve, receive) instructions from the memory 304 and determine subsequent instruction(s) to be executed to

cause the processor 300 to support various operations in accordance with examples as described herein. The controller 302 may be configured to track memory address of instructions associated with the memory 304. The controller 302 may be configured to decode instructions to determine the operation to be performed and the operands involved. For example, the controller 302 may be configured to interpret the instruction and determine control signals to be output to other components of the processor 300 to cause the processor 300 to support various operations in accordance with examples as described herein. Additionally, or alternatively, the controller 302 may be configured to manage flow of data within the processor 300. The controller 302 may be configured to control transfer of data between registers, arithmetic logic units (ALUs), and other functional units of the processor 300.

[0083] The memory 304 may include one or more caches (e.g., memory local to or included in the processor 300 or other memory, such RAM, ROM, DRAM, SDRAM, SRAM, MRAM, flash memory, etc. In some implementations, the memory 304 may reside within or on a processor chipset (e.g., local to the processor 300). In some other implementations, the memory 304 may reside external to the processor chipset (e.g., remote to the processor 300).

[0084] The memory 304 may store computer-readable, computer-executable code including instructions that, when executed by the processor 300, cause the processor 300 to perform various functions described herein. The code may be stored in a non-transitory computer-readable medium such as system memory or another type of memory. The controller 302 and/or the processor 300 may be configured to execute computer-readable instructions stored in the memory 304 to cause the processor 300 to perform various functions. For example, the processor 300 and/or the controller 302 may be coupled with or to the memory 304, the processor 300, the controller 302, and the memory 304 may be configured to perform various functions described herein. In some examples, the processor 300 may include multiple processors and the memory 304 may include multiple memories. One or more of the multiple processors may be coupled with one or more of the multiple memories, which may, individually or collectively, be configured to perform various functions herein.

[0085] The one or more ALUs 306 may be configured to support various operations in accordance with examples as described herein. In some implementations, the one or more

ALUs 306 may reside within or on a processor chipset (e.g., the processor 300). In some other implementations, the one or more ALUs 306 may reside external to the processor chipset (e.g., the processor 300). One or more ALUs 306 may perform one or more computations such as addition, subtraction, multiplication, and division on data. For example, one or more ALUs 306 may receive input operands and an operation code, which determines an operation to be executed. One or more ALUs 306 be configured with a variety of logical and arithmetic circuits, including adders, subtractors, shifters, and logic gates, to process and manipulate the data according to the operation. Additionally, or alternatively, the one or more ALUs 306 may support logical operations such as AND, OR, exclusive-OR (XOR), not-OR (NOR), and not-AND (NAND), enabling the one or more ALUs 306 to handle conditional operations, comparisons, and bitwise operations.

[0086] The processor 300 may support wireless communication in accordance with examples as disclosed herein. The processor 300 may be configured to or operable to support a means for receiving configuration information on SR associated with UE-initiated beam reporting; and a means for transmitting a SR associated with UE-initiated beam reporting based on the configuration information, wherein the SR is carried in a PUCCH transmission or in a PUSCH transmission in the case that the PUCCH transmission is overlapped with the PUSCH transmission.

[0087] Figure 4 illustrates an example of a NE 400 in accordance with aspects of the present disclosure. The NE 400 may include a processor 402, a memory 404, a controller 406, and a transceiver 408. The processor 402, the memory 404, the controller 406, or the transceiver 408, or various combinations thereof or various components thereof may be examples of means for performing various aspects of the present disclosure as described herein. These components may be coupled (e.g., operatively, communicatively, functionally, electronically, electrically) via one or more interfaces.

[0088] The processor 402, the memory 404, the controller 406, or the transceiver 408, or various combinations or components thereof may be implemented in hardware (e.g., circuitry). The hardware may include a processor, a digital signal processor (DSP), an application-specific integrated circuit (ASIC), or other programmable logic device, or any

combination thereof configured as or otherwise supporting a means for performing the functions described in the present disclosure.

[0089] The processor 402 may include an intelligent hardware device (e.g., a general-purpose processor, a DSP, a CPU, an ASIC, an FPGA, or any combination thereof). In some implementations, the processor 402 may be configured to operate the memory 404. In some other implementations, the memory 404 may be integrated into the processor 402. The processor 402 may be configured to execute computer-readable instructions stored in the memory 404 to cause the NE 400 to perform various functions of the present disclosure.

[0090] The memory 404 may include volatile or non-volatile memory. The memory 404 may store computer-readable, computer-executable code including instructions when executed by the processor 402 cause the NE 400 to perform various functions described herein. The code may be stored in a non-transitory computer-readable medium such the memory 404 or another type of memory. Computer-readable media includes both non-transitory computer storage media and communication media including any medium that facilitates transfer of a computer program from one place to another. A non-transitory storage medium may be any available medium that may be accessed by a general-purpose or special-purpose computer.

[0091] In some implementations, the processor 402 and the memory 404 coupled with the processor 402 may be configured to cause the NE 400 to perform one or more of the functions described herein (e.g., executing, by the processor 402, instructions stored in the memory 404). For example, the processor 402 may support wireless communication at the NE 400 in accordance with examples as disclosed herein. The NE 400 may be configured to support a means for transmitting configuration information on SR associated with UE-initiated beam reporting; and a means for receiving a SR associated with UE-initiated beam reporting based on the configuration information, wherein the SR is carried in a PUCCH transmission or in a PUSCH transmission in the case that the PUCCH transmission is overlapped with the PUSCH transmission.

[0092] The controller 406 may manage input and output signals for the NE 400. The controller 406 may also manage peripherals not integrated into the NE 400. In some implementations, the controller 406 may utilize an operating system such as iOS®,

ANDROID®, WINDOWS®, or other operating systems. In some implementations, the controller 406 may be implemented as part of the processor 402.

[0093] In some implementations, the NE 400 may include at least one transceiver 408. In some other implementations, the NE 400 may have more than one transceiver 408. The transceiver 408 may represent a wireless transceiver. The transceiver 408 may include one or more receiver chains 410, one or more transmitter chains 412, or a combination thereof.

[0094] A receiver chain 410 may be configured to receive signals (e.g., control information, data, packets) over a wireless medium. For example, the receiver chain 410 may include one or more antennas for receive the signal over the air or wireless medium. The receiver chain 410 may include at least one amplifier (e.g., a low-noise amplifier (LNA)) configured to amplify the received signal. The receiver chain 410 may include at least one demodulator configured to demodulate the receive signal and obtain the transmitted data by reversing the modulation technique applied during transmission of the signal. The receiver chain 410 may include at least one decoder for decoding the processing the demodulated signal to receive the transmitted data.

[0095] A transmitter chain 412 may be configured to generate and transmit signals (e.g., control information, data, packets). The transmitter chain 412 may include at least one modulator for modulating data onto a carrier signal, preparing the signal for transmission over a wireless medium. The at least one modulator may be configured to support one or more techniques such as amplitude modulation (AM), frequency modulation (FM), or digital modulation schemes like phase-shift keying (PSK) or quadrature amplitude modulation (QAM). The transmitter chain 412 may also include at least one power amplifier configured to amplify the modulated signal to an appropriate power level suitable for transmission over the wireless medium. The transmitter chain 412 may also include one or more antennas for transmitting the amplified signal into the air or wireless medium.

[0096] Figure 5 illustrates a flowchart of a method in accordance with aspects of the present disclosure. The operations of the method may be implemented by a UE as described herein. In some implementations, the UE may execute a set of instructions to control the function elements of the UE to perform the described functions.

[0097] At step 501, the method may include receiving configuration information on SR associated with UE-initiated beam reporting. The operations of step 501 may be performed in accordance with examples as described herein. In some implementations, aspects of the operations of 501 may be performed by a UE as described with reference to Figure 2.

[0098] At step 503, the method may include transmitting a SR associated with UE-initiated beam reporting based on the configuration information, wherein the SR is carried in a PUCCH transmission or in a PUSCH transmission in the case that the PUCCH transmission is overlapped with the PUSCH transmission. The operations of step 503 may be performed in accordance with examples as described herein. In some implementations, aspects of the operations of step 503 may be performed by a UE as described with reference to Figure 2.

[0099] It should be noted that the method described herein describes a possible implementation, and that the operations and the steps may be rearranged or otherwise modified and that other implementations are possible.

[0100] Figure 6 illustrates a flowchart of a method in accordance with aspects of the present disclosure. The operations of the method may be implemented by a NE as described herein. In some implementations, the NE may execute a set of instructions to control the function elements of the NE to perform the described functions.

[0101] At step 601, the method may include transmitting configuration information on SR associated with UE-initiated beam reporting. The operations of step 601 may be performed in accordance with examples as described herein. In some implementations, aspects of the operations of step 601 may be performed by a NE as described with reference to Figure 4.

[0102] At step 603, the method may include receiving a SR associated with UE-initiated beam reporting based on the configuration information, wherein the SR is carried in a PUCCH transmission or in a PUSCH transmission in the case that the PUCCH transmission is overlapped with the PUSCH transmission. The operations of step 603 may be performed in accordance with examples as described herein. In some implementations, aspects of the operations of step 603 may be performed by a NE as described with reference to Figure 4.

[0103] It should be noted that the method described herein describes a possible implementation, and that the operations and the steps may be rearranged or otherwise modified and that other implementations are possible.

[0104] The description herein is provided to enable a person having ordinary skill in the art to make or use the disclosure. Various modifications to the disclosure will be apparent to a person having ordinary skill in the art, and the generic principles defined herein may be applied to other variations without departing from the scope of the disclosure. Thus, the disclosure is not limited to the examples and designs described herein but is to be accorded the broadest scope consistent with the principles and novel features disclosed herein.

CLAIMS

What is claimed is:

1. A user equipment (UE) for wireless communication, comprising:
 - at least one memory; and
 - at least one processor coupled with the at least one memory and configured to cause the UE to:
 - receive configuration information on scheduling request (SR) associated with UE-initiated beam reporting; and
 - transmit a SR associated with UE-initiated beam reporting based on the configuration information, wherein the SR is carried in a physical uplink control channel (PUCCH) transmission or in a physical uplink shared channel (PUSCH) transmission in the case that the PUCCH transmission is overlapped with the PUSCH transmission.
2. The UE of claim 1, wherein in the case that the SR is carried in the PUSCH transmission, the at least one processor is configured to cause the UE to:
 - jointly encode a bit of the SR with hybrid automatic repeat request -acknowledge (HARQ-ACK) bits determined to be transmitted in the PUSCH transmission to generate hybrid coded HARQ-ACK bits, wherein a number of the HARQ-ACK bits is equal to 0 or larger than 0.
3. The UE of claim 2, wherein,
 - in the case that the number of the HARQ-ACK bits and the SR is less than or equal to 2, the hybrid coded HARQ-ACK bits are punctured in the PUSCH transmission; and
 - in the case that the number of the HARQ-ACK bits and the SR is more than 2, the hybrid coded HARQ-ACK bits are rate matched in the PUSCH transmission.
4. The UE of claim 2, wherein in the case that the number of the HARQ-ACK bits is larger than 0, the at least one processor is configured to cause the UE to:

concatenate the bit of the SR after the HARQ-ACK bits before jointly encoding the bit of the SR with the HARQ-ACK bits.

5. The UE of claim 2, wherein in the case that there are channel state information (CSI) bits determined to be transmitted in the PUSCH transmission, the at least one processor is configured to cause the UE to:

determine coded CSI bits based a number of the bits of the SR and the number of the HARQ-ACK bits.

6. The UE of claim 1, wherein in the case that the SR is carried in the PUSCH transmission, the at least one processor is configured to cause the UE to:

jointly encode a bit of the SR with CSI part 1 bits determined to be transmitted in the PUSCH transmission to generate hybrid coded CSI part 1 bits, wherein a number of the CSI part 1 bits is equal to 0 or larger than 0.

7. The UE of claim 6, wherein in the case that number of the CSI part 1 bits is larger than 0, the at least one processor is configured to cause the UE to:

put the bit of the SR before the CSI part 1 bits before jointly encoding the bit of the SR with the CSI part 1 bits.

8. The UE of claim 6, wherein the hybrid coded CSI part 1 bits are rate matched in the PUSCH transmission.

9. The UE of claim 1, wherein in the case that the SR is carried in the PUSCH transmission, the at least one processor is configured to cause the UE to:

separately encode a bit of the SR from any of HARQ-ACK bits or CSI bits determined to be transmitted in the PUSCH transmission; and

transmit coded SR bits in reserved resource elements different from resource elements for transmission of any of the HARQ-ACK bits and CSI bits in the PUSCH transmission.

10. The UE of claim 9, wherein the coded SR bits are determined in a manner as HARQ-ACK coded bit determination, and the at least one processor is configured to cause the UE to:

puncture the coded SR bits in the reserved resource elements of the PUSCH transmission determined for SR transmission.

11. The UE of claim 10, wherein in the case that there are 2 or less HARQ-ACK bits determined to be transmitted in the PUSCH transmission, the coded SR bits are punctured after punctured HARQ-ACK coded bits in the PUSCH transmission.

12. The UE of claim 9, wherein the reserved resource elements for transmission of the coded SR bits are determined in a manner as reserved resource element determination for a transmission of HARQ-ACK bits with a number of less than or equal to 2.

13. The UE of claim 9, wherein in the case that there are CSI part 1 bits determined to be transmitted in the PUSCH transmission, the at least one processor is configured to cause the UE to:

determine coded CSI part 1 bits determined to be transmitted in the PUSCH transmission at least according to the reserved resource elements for transmission of the coded SR bits.

14. The UE of claim 1, wherein in the case that the SR is carried in the PUSCH transmission, the at least one processor is configured to cause the UE to:

transmit the SR by selecting one of two different initiation values for a scrambling sequence for the PUSCH transmission.

15. The UE of claim 14, wherein,

in the case that a bit of the SR is '1,' a selected initiation value is different from an initiation value determined according to legacy specification; and

in the case that a bit of the SR is '0,' the selected initiation value is an initiation value determined according to legacy specification.

16. The UE of claim 1, wherein the SR indicates a UE-initiated beam report occurs or not, or requests a resource for an uplink channel to carry a UE-initiated beam report, or notifies an uplink channel to carry a UE-initiated beam report.

17. A processor for wireless communication, comprising:
at least one controller coupled with at least one memory and configured to cause the processor to:

receive configuration information on scheduling request (SR) associated with UE-initiated beam reporting; and

transmit a SR associated with UE-initiated beam reporting based on the configuration information, wherein the SR is carried in a physical uplink control channel (PUCCH) transmission or in a physical uplink shared channel (PUSCH) transmission in the case that the PUCCH transmission is overlapped with the PUSCH transmission.

18. A network equipment (NE) for wireless communication, comprising:
at least one memory; and
at least one processor coupled with the at least one memory and configured to cause the NE to:

transmit configuration information on scheduling request (SR) associated with UE-initiated beam reporting; and

receive a SR associated with UE-initiated beam reporting based on the configuration information, wherein the SR is carried in a physical uplink control channel (PUCCH) transmission or in a physical uplink shared channel (PUSCH) transmission in the case that the PUCCH transmission is overlapped with the PUSCH transmission.

19. A method performed by a user equipment (UE), comprising:

receiving configuration information on scheduling request (SR) associated with UE-initiated beam reporting; and

transmitting a SR associated with UE-initiated beam reporting based on the configuration information, wherein the SR is carried in a physical uplink control channel (PUCCH) transmission or in a physical uplink shared channel (PUSCH) transmission in the case that the PUCCH transmission is overlapped with the PUSCH transmission.

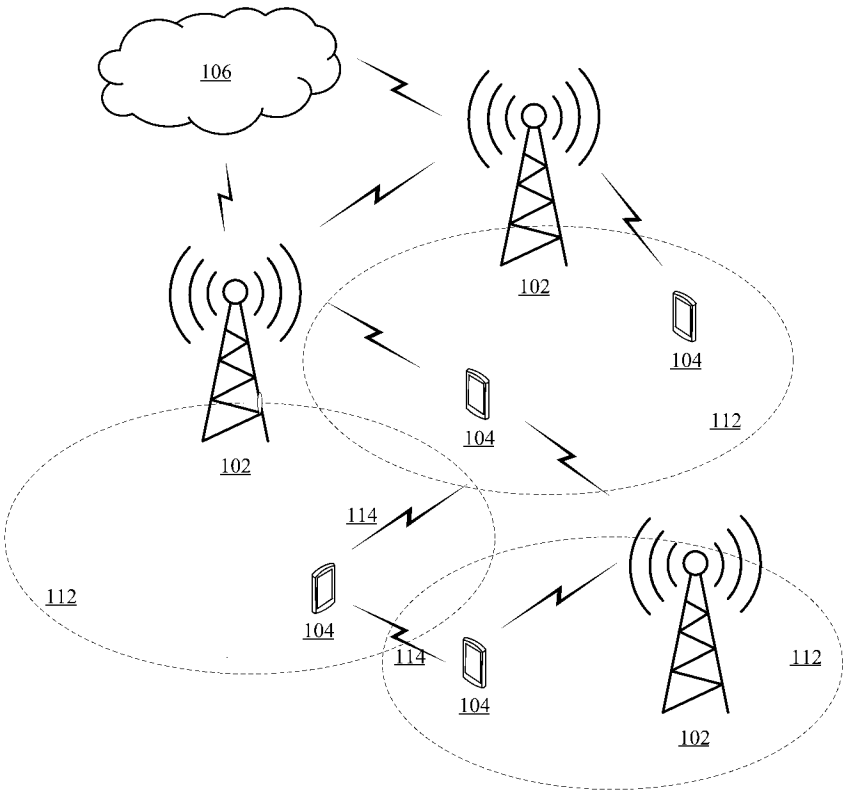


Figure 1

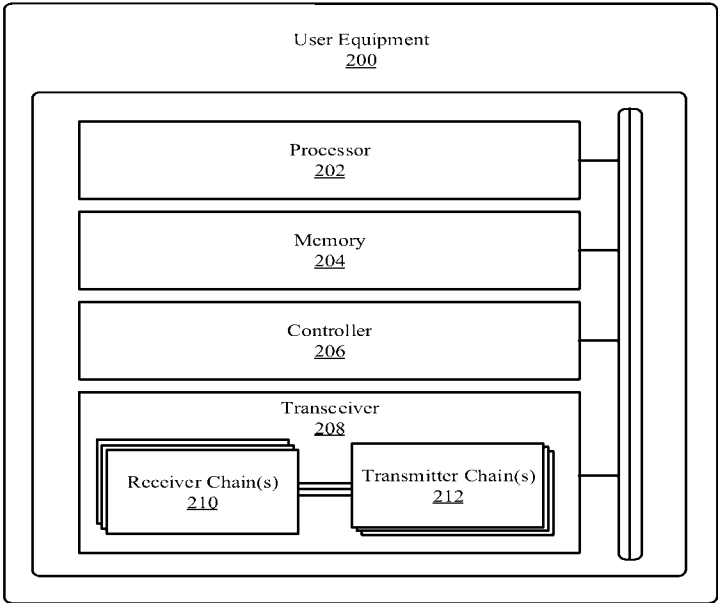


Figure 2

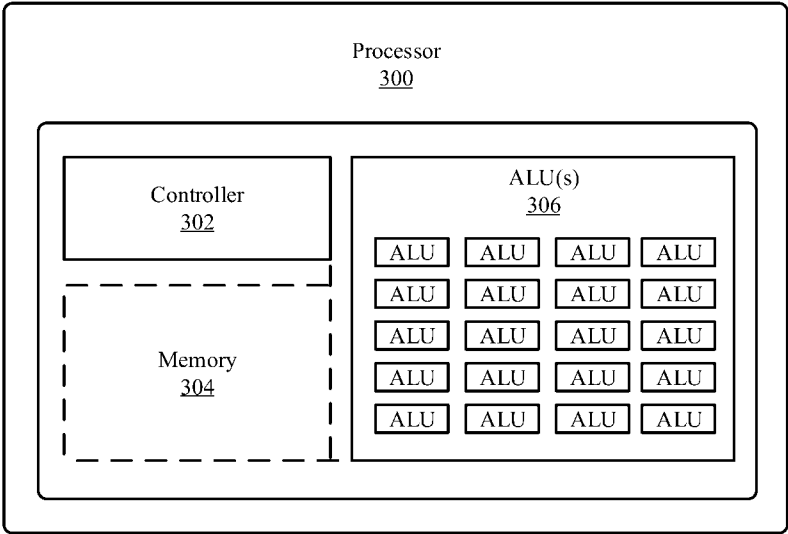


Figure 3

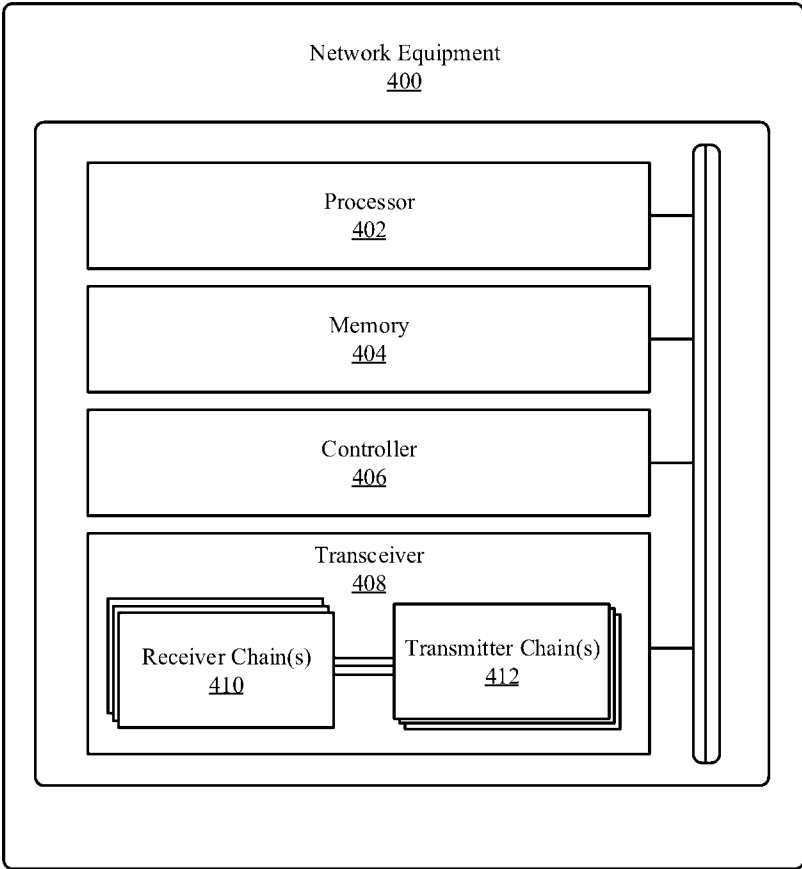


Figure 4

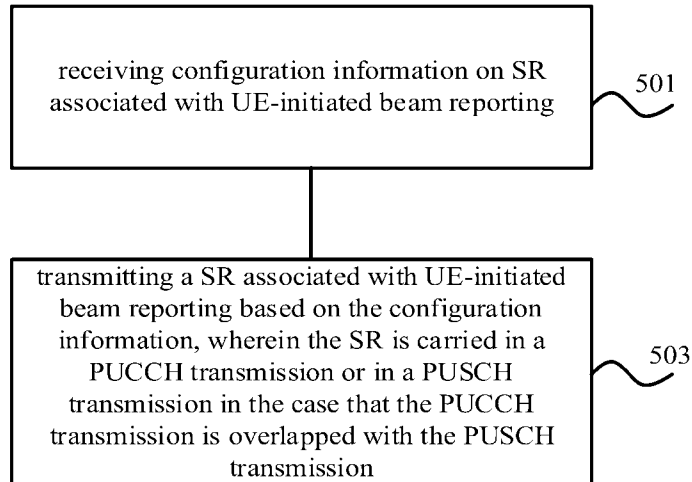


Figure 5

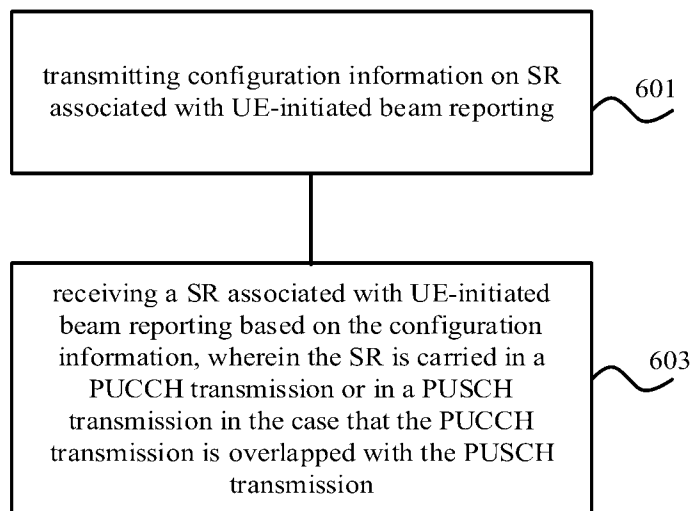


Figure 6

INTERNATIONAL SEARCH REPORT

International application No.

PCT/CN2024/091918

A. CLASSIFICATION OF SUBJECT MATTER H04L5/00(2006.01)i; H04W72/00(2023.01)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) IPC: H04L H04W Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched Electronic data base consulted during the international search (name of data base and, where practicable, search terms used) CNTXT, ENTXT, ENTXTC, WPABS, DWPI, 3GPP: beam, report, BFR, SR, schedule, request, pucch, pusch, harq, csi, cqi, joint, encode, separate, multiplex, piggyback, overlap, conflict, collide, collision, puncture, rate match, implicit, scramble, positive, negative, 0, 1		
C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 2024074081 A1 (LENOVO (BEIJING) LIMITED) 11 April 2024 (2024-04-11) description, paragraphs [0126]-[0129]	1、 16-19
Y	WO 2024074081 A1 (LENOVO (BEIJING) LIMITED) 11 April 2024 (2024-04-11) description, paragraphs [0126]-[0129]	2-15
Y	US 2020228248 A1 (INTEL CORPORATION) 16 July 2020 (2020-07-16) description, paragraphs [0124]-[0132]	2-5
Y	US 2021084644 A1 (LG ELECTRONICS INC.) 18 March 2021 (2021-03-18) description, paragraphs [0277]-[0278]	6-8、 14-15
Y	WO 2023008017 A1 (SHARP KABUSHIKI KAISHA) 02 February 2023 (2023-02-02) description, paragraphs [0252]-[0257]	9-13
X	WO 2020251757 A1 (QUALCOMM INCORPORATED) 17 December 2020 (2020-12-17) description, paragraphs [0037], [0062]-[0065]	1、 16-19
☒ 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 “D” document cited by the applicant in the international application “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 17 January 2025		Date of mailing of the international search report 05 February 2025
Name and mailing address of the ISA/CN CHINA NATIONAL INTELLECTUAL PROPERTY ADMINISTRATION 6, Xitucheng Rd., Jimen Bridge, Haidian District, Beijing 100088, China		Authorized officer XUE,YongXu Telephone No. (+86) 010-53961657

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	NOKIA et al. "R2-1711450, Beam Recovery in NR" 3GPP TSG-RAN WG2 #99bis, 13 October 2017 (2017-10-13), the whole document	1-19
A	OPPO. "R1-2101842, Summary#1 of email thread [104-e-NR-R17-IIoT_URLLC-04]" 3GPP TSG RAN WG1 #104-e, 05 February 2021 (2021-02-05), the whole document	1-19

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/CN2024/091918

Patent document cited in search report			Publication date (day/month/year)	Patent family member(s)		Publication date (day/month/year)	
WO	2024074081	A1	11 April 2024	None			
US	2020228248	A1	16 July 2020	US	11381346	B2	05 July 2022
				US	2022321276	A1	06 October 2022
				US	11984987	B2	14 May 2024
US	2021084644	A1	18 March 2021	WO	2019216740	A1	14 November 2019
				EP	3793303	A1	17 March 2021
				EP	3793303	A4	23 February 2022
				CN	112425244	A	26 February 2021
WO	2023008017	A1	02 February 2023	US	2024348379	A1	17 October 2024
WO	2020251757	A1	17 December 2020	US	2020389221	A1	10 December 2020
				US	11664871	B2	30 May 2023