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(54) **ENHANCED CSI REPORTING ACTIVATION/DEACTIVATION OPERATION**

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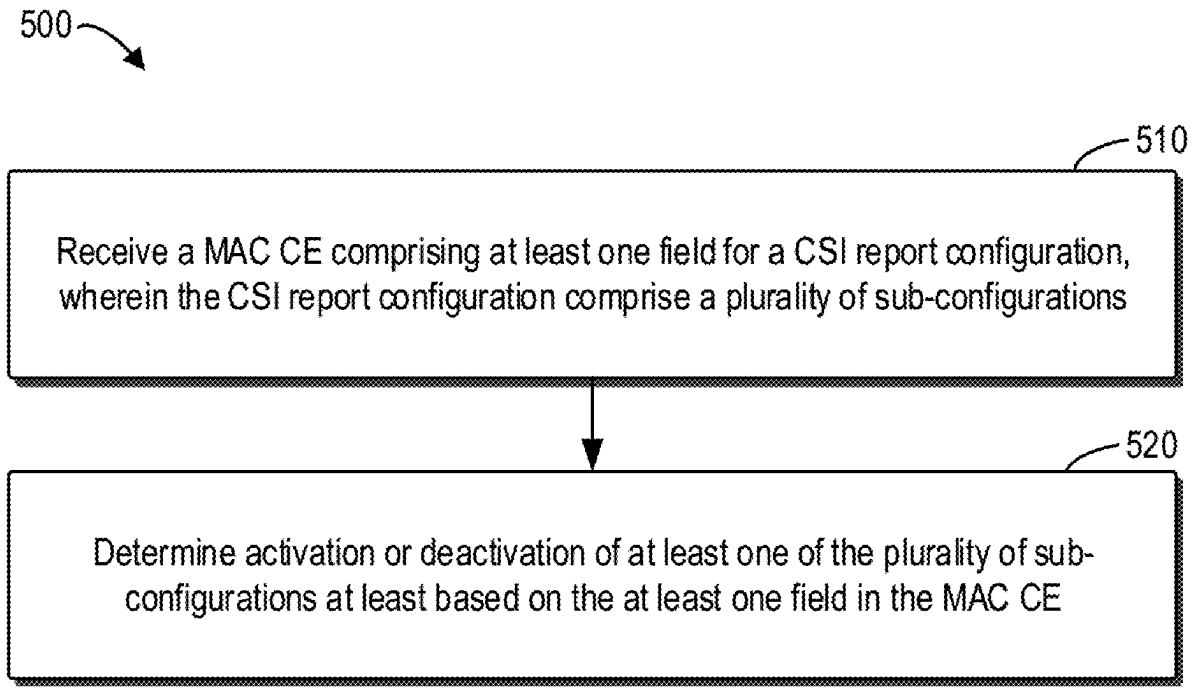
(57) **ABSTRACT**

Example embodiments of the present disclosure provide solutions for enhanced channel state information (CSI) activation/deactivation operation. In an example method, a terminal device receives a MAC CE comprising at least one field for a CSI report configuration, wherein the CSI report configuration comprises a plurality of sub-configurations. The terminal device further determines activation or deactivation of at least one of the plurality of sub-configurations at least based on the at least one field in the MAC CE. In this way, the operation of activating/deactivating CSI reporting for one or more sub-configurations is enabled when multiple sub-configurations are included or associated with a same CSI reporting configuration.



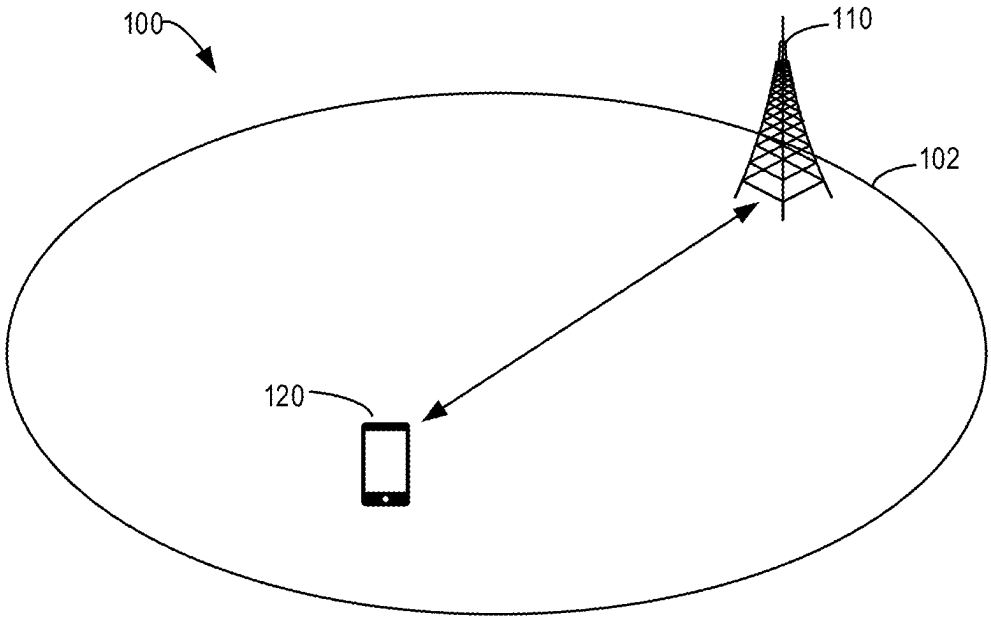


FIG. 1

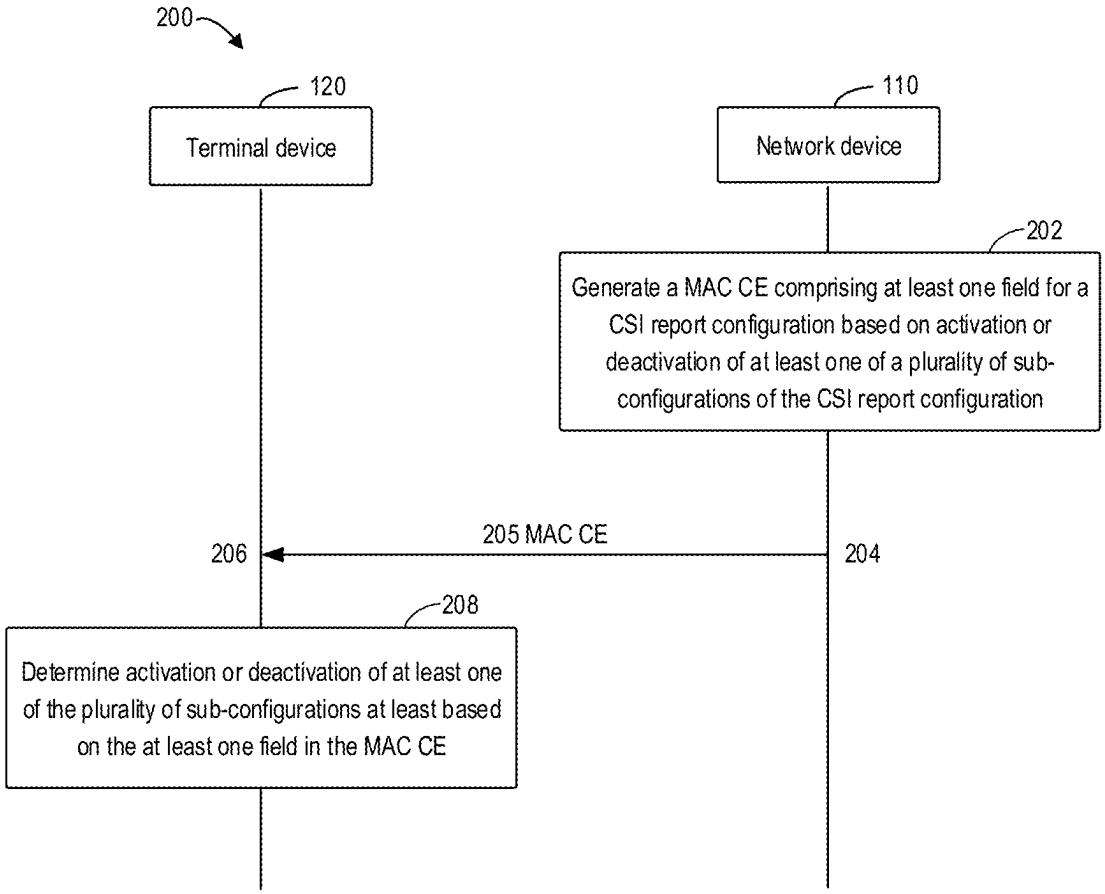

200
120
Terminal device
110
Network device
202
Generate a MAC CE comprising at least one field for a CSI report configuration based on activation or deactivation of at least one of a plurality of sub-configurations of the CSI report configuration
205 MAC CE
206
204
208
Determine activation or deactivation of at least one of the plurality of sub-configurations at least based on the at least one field in the MAC CE

FIG. 2

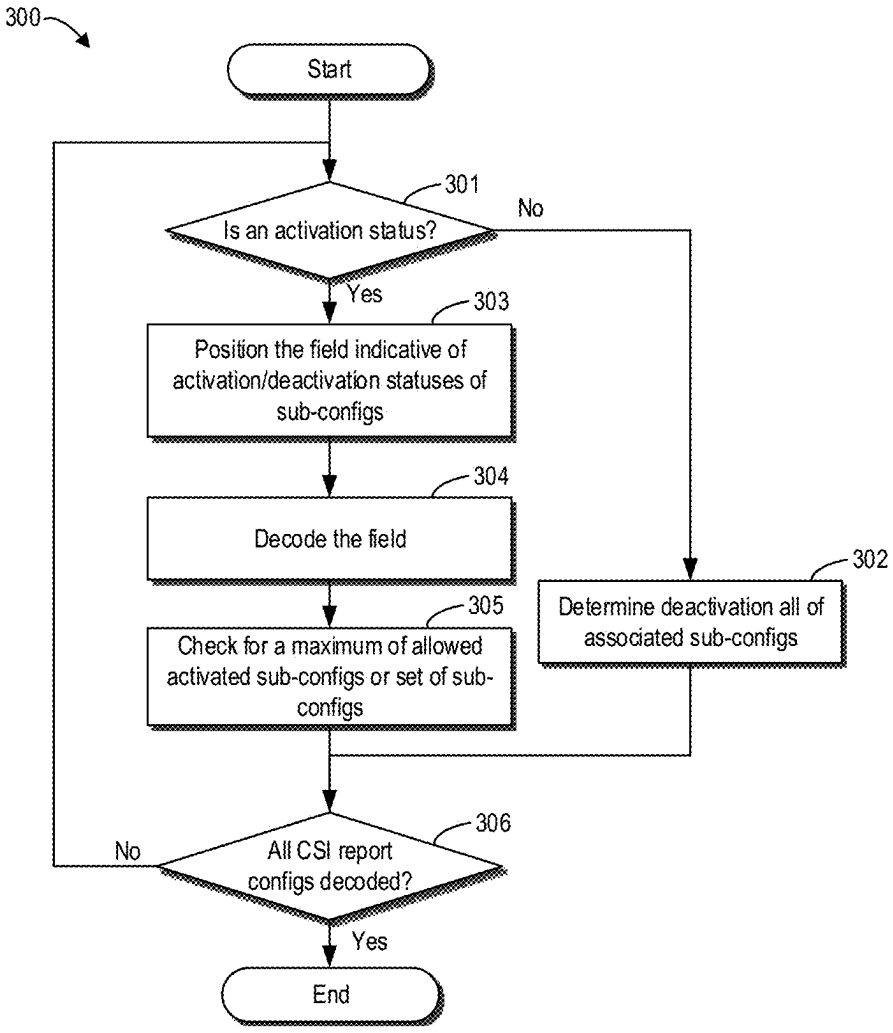

300
Start
301
Is an activation status?
No
Yes
303
Position the field indicative of activation/deactivation statuses of sub-configs
304
Decode the field
305
Check for a maximum of allowed activated sub-configs or set of sub-configs
302
Determine deactivation all of associated sub-configs
306
All CSI report configs decoded?
No
Yes
End

FIG. 3

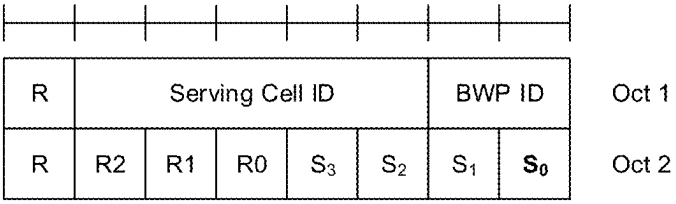

R
Serving Cell ID
BWP ID
Oct 1
R
R2
R1
R0
S_3
S_2
S_1
S_0
Oct 2

FIG. 4A

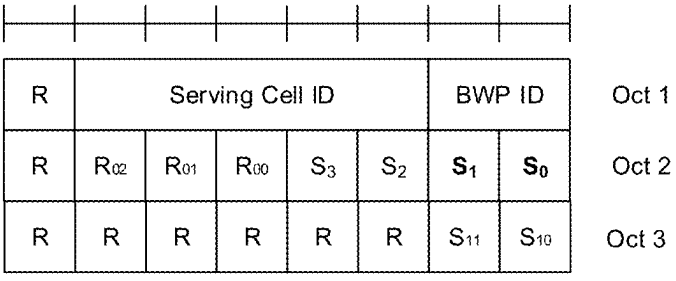

R
Serving Cell ID
BWP ID
Oct 1
R
R_{02}
R_{01}
R_{00}
S_3
S_2
S_1
S_0
Oct 2
R
R
R
R
R
R
S_{11}
S_{10}
Oct 3

FIG. 4B

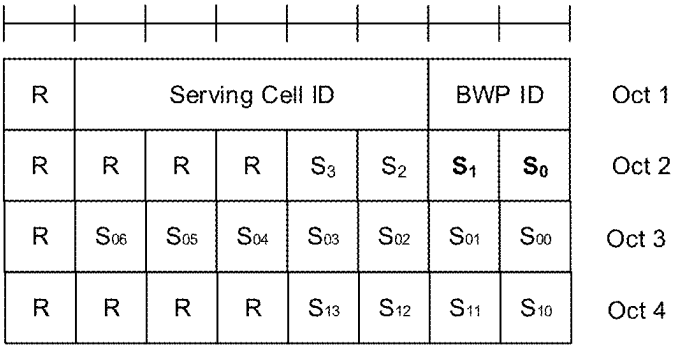

R
Serving Cell ID
BWP ID
Oct 1
R R R R S3 S2 S1 S0
Oct 2
R S06 S05 S04 S03 S02 S01 S00
Oct 3
R R R R S13 S12 S11 S10
Oct 4

FIG. 4C

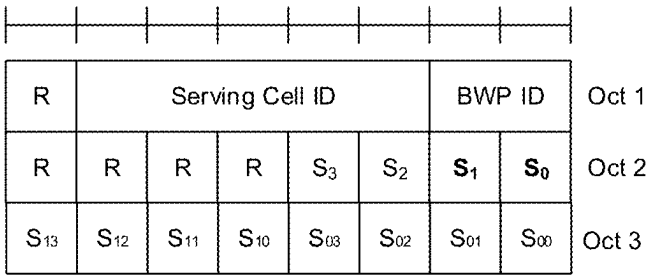

R
Serving Cell ID
BWP ID
Oct 1
R R R R S3 S2 S1 S0
Oct 2
S13 S12 S11 S10 S03 S02 S01 S00
Oct 3

FIG. 4D

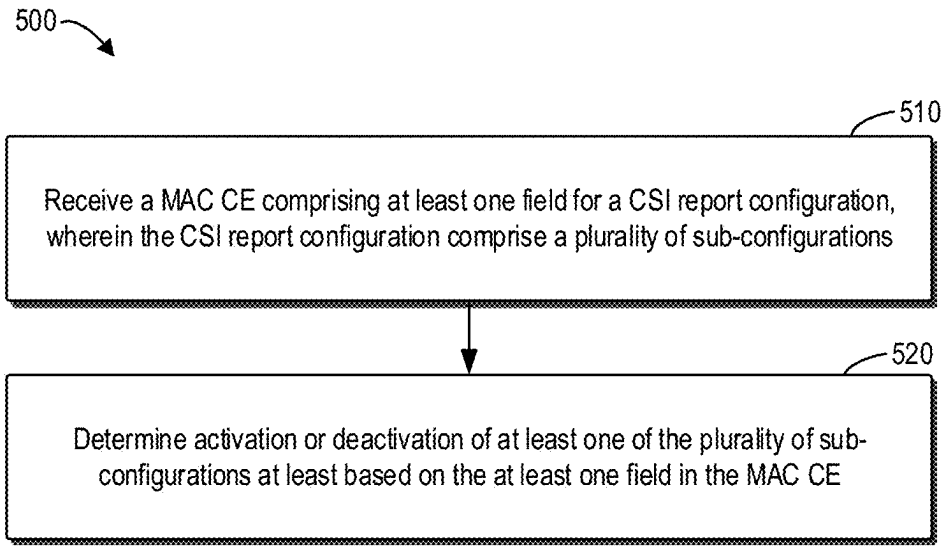

500
510
Receive a MAC CE comprising at least one field for a CSI report configuration, wherein the CSI report configuration comprise a plurality of sub-configurations
520
Determine activation or deactivation of at least one of the plurality of sub-configurations at least based on the at least one field in the MAC CE

FIG. 5

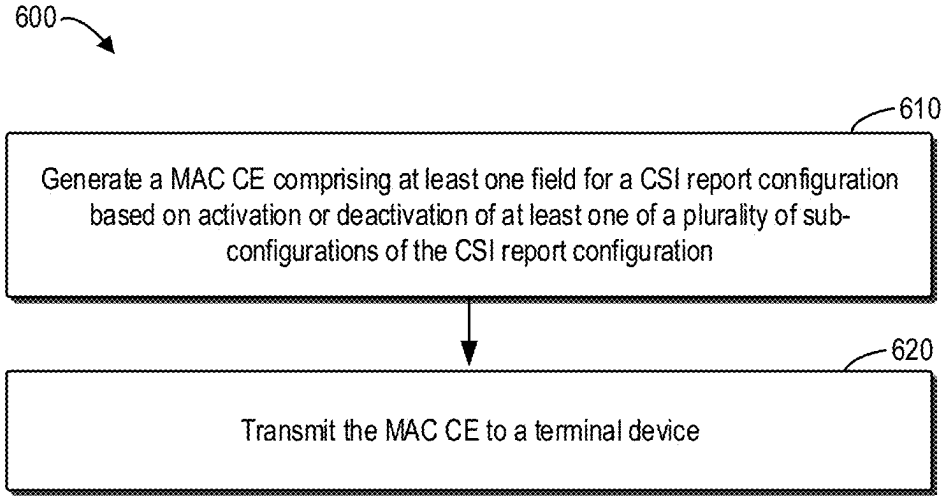

600
610
Generate a MAC CE comprising at least one field for a CSI report configuration based on activation or deactivation of at least one of a plurality of sub-configurations of the CSI report configuration
620
Transmit the MAC CE to a terminal device

FIG. 6

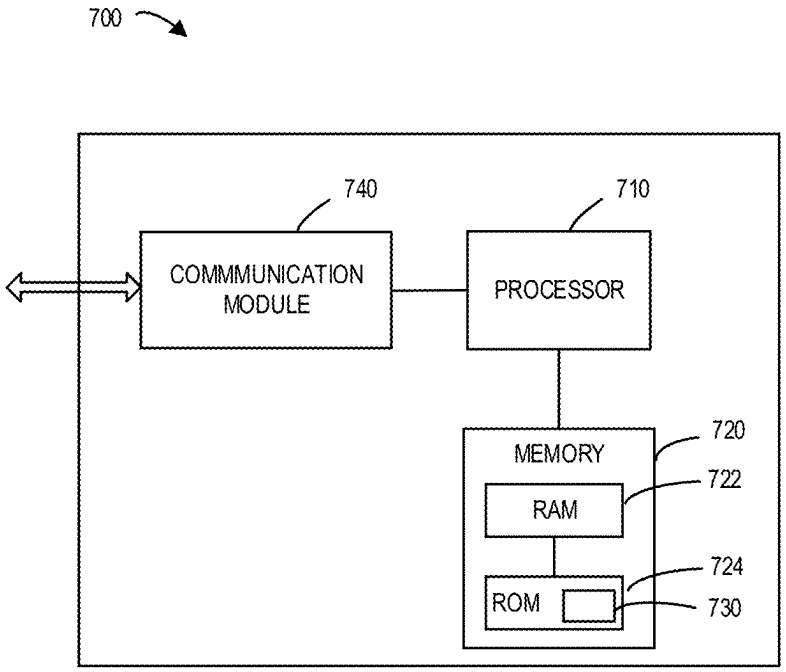

700
740
710
COMMMUNICATION MODULE
PROCESSOR
720
MEMORY
722
RAM
724
ROM
730

FIG. 7

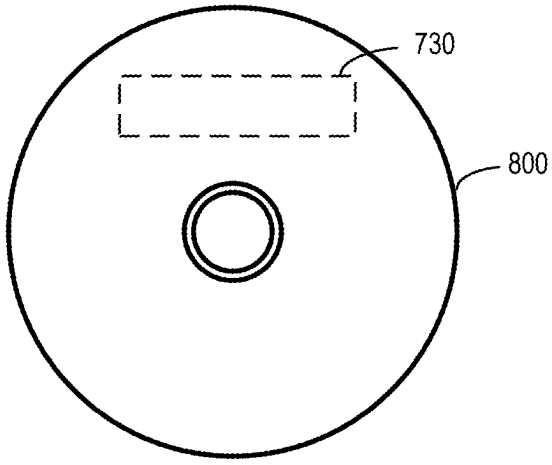

730
800

FIG. 8

ENHANCED CSI REPORTING ACTIVATION/DEACTIVATION OPERATION

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application is a continuation of International Application No. PCT/CN2023/093882, filed May 12, 2023, the entire contents of which are incorporated herein by reference.

FIELD

[0002] Example embodiments of the present disclosure generally relate to the field of communication, and in particular, to a terminal device, a network device, methods, apparatuses, and a computer readable medium for enhanced channel state information (CSI) activation/deactivation operation.

BACKGROUND

[0003] Network energy saving is of great importance for environmental sustainability, to reduce environmental impact (greenhouse gas emissions), and for operational cost saving. As new radio (NR), also known as fifth-generation technology standard for broadband cellular networks (5G), is becoming pervasive across industries and geographical areas, handling more advanced services and applications requiring very high data rates, networks are being denser, use more antennas, larger bandwidths and more frequency bands, which means an increasing energy consumption.

[0004] Therefore, the environmental impact of 5G and the operational operating expense need to stay under control, and improved solutions for energy saving in 5G need to be further investigated and studied.

SUMMARY

[0005] In general, example embodiments of the present disclosure provide solutions for enhanced channel state information (CSI) activation/deactivation operation.

[0006] In a first aspect, there is provided a terminal device. The terminal device comprises at least one processor and at least one memory storing instructions that, when executed by the at least one processor, cause the terminal device at least to: receive a medium access control (MAC) control element (MAC CE) comprising at least one field for a channel state information (CSI) report configuration, wherein the CSI report configuration comprises a plurality of sub-configurations; and determine activation or deactivation of at least one of the plurality of sub-configurations at least based on the at least one field in the MAC CE.

[0007] In a second aspect, there is provided a network device. The network device comprises at least one processor and at least one memory storing instructions that, when executed by the at least one processor, cause the network device at least to: generate a medium access control (MAC) control element (MAC CE) comprising at least one field for a channel state information (CSI) report configuration based on activation or deactivation of at least one of a plurality of sub-configurations of the CSI report configuration; and transmit the MAC CE to a terminal device.

[0008] In a third aspect, there is provided a method. The method comprises: receiving, at a terminal device, a medium access control (MAC) control element (MAC CE) comprising at least one field for a channel state information (CSI) report configuration, wherein the CSI report configuration comprises a plurality of sub-configurations; and determining activation or deactivation of at least one of the plurality of sub-configurations at least based on the at least one field in the MAC CE.

[0009] In a fourth aspect, there is provided a method. The method comprises: generating, at a network device, a medium access control (MAC) control element (MAC CE) comprising at least one field for a channel state information (CSI) report configuration based on activation or deactivation of at least one of a plurality of sub-configurations of the CSI report configuration; and transmitting the MAC CE to a terminal device.

[0010] In a fifth aspect, there is provided an apparatus. The apparatus comprises: means for receiving, at a terminal device, a medium access control (MAC) control element (MAC CE) comprising at least one field for a channel state information (CSI) report configuration, wherein the CSI report configuration comprises a plurality of sub-configurations; and means for determining activation or deactivation of at least one of the plurality of sub-configurations at least based on the at least one field in the MAC CE.

[0011] In a sixth aspect, there is provided an apparatus. The apparatus comprises: means for generating, at a network device, a medium access control (MAC) control element (MAC CE) comprising at least one field for a channel state information (CSI) report configuration based on activation or deactivation of at least one of a plurality of sub-configurations of the CSI report configuration; and means for transmitting the MAC CE to a terminal device.

[0012] In a seventh aspect, there is provided a non-transitory computer-readable storage medium comprising program instructions. The program instructions, when executed by an apparatus, cause the apparatus to perform at least the following: receiving, at a terminal device, a medium access control (MAC) control element (MAC CE) comprising at least one field for a channel state information (CSI) report configuration, wherein the CSI report configuration comprises a plurality of sub-configurations; and determining activation or deactivation of at least one of the plurality of sub-configurations at least based on the at least one field in the MAC CE.

[0013] In an eighth aspect, there is provided a non-transitory computer-readable storage medium comprising program instructions. The program instructions, when executed by an apparatus, cause the apparatus to perform at least the following: generating, at a network device, a medium access control (MAC) control element (MAC CE) comprising at least one field for a channel state information (CSI) report configuration based on activation or deactivation of at least one of a plurality of sub-configurations of the CSI report configuration; and transmitting the MAC CE to a terminal device.

[0014] In a ninth aspect, there is provided a computer program comprising instructions, which, when executed by an apparatus, cause the apparatus at least to: receive, at a terminal device, a medium access control (MAC) control element (MAC CE) comprising at least one field for a channel state information (CSI) report configuration, wherein the CSI report configuration comprises a plurality of sub-configurations; and determine activation or deactivation of at least one of the plurality of sub-configurations at least based on the at least one field in the MAC CE.

[0015] In a tenth aspect, there is provided a computer program comprising instructions, which, when executed by an apparatus, cause the apparatus at least to: generate, at a network device, a medium access control (MAC) control element (MAC CE) comprising at least one field for a channel state information (CSI) report configuration based on activation or deactivation of at least one of a plurality of sub-configurations of the CSI report configuration; and transmit the MAC CE to a terminal device.

[0016] In an eleventh aspect, there is provided a terminal device. The terminal device comprises: a receiving circuitry configured to: receive a medium access control (MAC) control element (MAC CE) comprising at least one field for a channel state information (CSI) report configuration, wherein the CSI report configuration comprises a plurality of sub-configurations; and determine activation or deactivation of at least one of the plurality of sub-configurations at least based on the at least one field in the MAC CE.

[0017] In a twelfth aspect, there is provided a network device. The network device comprises: a transmitting circuitry configured to: generate a medium access control (MAC) control element (MAC CE) comprising at least one field for a channel state information (CSI) report configuration based on activation or deactivation of at least one of a plurality of sub-configurations of the CSI report configuration; and transmit the MAC CE to a terminal device.

[0018] It is to be understood that the summary section is not intended to identify key or essential features of embodiments of the present disclosure, nor is it intended to be used to limit the scope of the present disclosure. Other features of the present disclosure will become easily comprehensible through the following description.

BRIEF DESCRIPTION OF THE DRAWINGS

[0019] Some example embodiments will now be described with reference to the accompanying drawings, in which:

[0020] FIG. **1** illustrates an example network environment in which example embodiments of the present disclosure may be implemented;

[0021] FIG. **2** illustrates an example of a process flow in accordance with some example embodiments of the present disclosure;

[0022] FIG. **3** illustrates an example process implemented at a terminal device according to example embodiments of the present disclosure;

[0023] FIG. **4**A illustrates a first example MAC CE design for activating/deactivating semi-persistent CSI reporting according to example embodiments of the present disclosure;

[0024] FIG. **4**B illustrates a second example MAC CE design for activating/deactivating semi-persistent CSI reporting according to example embodiments of the present disclosure;

[0025] FIG. **4**C illustrates a third example MAC CE design for activating/deactivating semi-persistent CSI reporting according to example embodiments of the present disclosure;

[0026] FIG. **4**D illustrates a fourth example MAC CE design for activating/deactivating semi-persistent CSI reporting according to example embodiments of the present disclosure;

[0027] FIG. **5** illustrates an example flowchart of a method implemented at a terminal device according to example embodiments of the present disclosure;

[0028] FIG. **6** illustrates an example flowchart of a method implemented at a network device according to example embodiments of the present disclosure;

[0029] FIG. **7** illustrates an example simplified block diagram of a device that is suitable for implementing embodiments of the present disclosure; and

[0030] FIG. **8** illustrates an example block diagram of an example computer readable medium in accordance with some embodiments of the present disclosure.

[0031] Throughout the drawings, the same or similar reference numerals represent the same or similar elements.

DETAILED DESCRIPTION

[0032] Principles of the present disclosure will now be described with reference to some example embodiments. It is to be understood that these embodiments are described only for the purpose of illustration and help those skilled in the art to understand and implement the present disclosure, without suggesting any limitation as to the scope of the disclosure. The disclosure described herein can be implemented in various manners other than the ones described below.

[0033] In the following description and claims, unless defined otherwise, all technical and scientific terms used herein have the same meaning as commonly understood by one of ordinary skills in the art to which this disclosure belongs.

[0034] References in the present disclosure to "one embodiment," "an embodiment," "an example embodiment," and the like indicate that the embodiment described may include a particular feature, structure, or characteristic, but it is not necessary that every embodiment includes the particular feature, structure, or characteristic. Moreover, such phrases are not necessarily referring to the same embodiment. Further, when a particular feature, structure, or characteristic is described in connection with an embodiment, it is submitted that it is within the knowledge of one skilled in the art to affect such feature, structure, or characteristic in connection with other embodiments whether or not explicitly described.

[0035] It shall be understood that although the terms "first" and "second" etc. may be used herein to describe various elements, these elements should not be limited by these terms.

[0036] These terms are only used to distinguish one element from another. For example, a first element could be termed a second element, and similarly, a second element could be termed a first element, without departing from the scope of example embodiments. As used herein, the term "and/or" includes any and all combinations of one or more of the listed terms.

[0037] The terminology used herein is for the purpose of describing particular embodiments only and is not intended to be limiting of example embodiments. As used herein, the singular forms "a", "an" and "the" are intended to include the plural forms as well, unless the context clearly indicates otherwise. It will be further understood that the terms "comprises", "comprising", "has", "having", "includes" and/or "including", when used herein, specify the presence of stated features, elements, and/or components etc., but do not preclude the presence or addition of one or more other features, elements, components and/or combinations thereof. As used herein, "at least one of the following: <a list of two or more elements>" and "at least one of <a list of two

or more elements>" and similar wording, where the list of two or more elements are joined by "and" or "or", mean at least any one of the elements, or at least any two or more of the elements, or at least all the elements.

[0038] As used in this application, the term "circuitry" may refer to one or more or all of the following:

[0039] (a) hardware-only circuit implementations (such as implementations in only analog and/or digital circuitry) and

[0040] (b) combinations of hardware circuits and software, such as (as applicable):

[0041] (i) a combination of analog and/or digital hardware circuit(s) with software/firmware and

[0042] (ii) any portions of hardware processor(s) with software (including digital signal processor(s)), software, and memory(ies) that work together to cause an apparatus, such as a mobile phone or server, to perform various functions) and

[0043] (c) hardware circuit(s) and or processor(s), such as a microprocessor(s) or a portion of a microprocessor (s), that requires software (for example, firmware) for operation, but the software may not be present when it is not needed for operation.

[0044] This definition of circuitry applies to all uses of this term in this application, including in any claims. As a further example, as used in this application, the term circuitry also covers an implementation of merely a hardware circuit or processor (or multiple processors) or portion of a hardware circuit or processor and its (or their) accompanying software and/or firmware. The term circuitry also covers, for example and if applicable to the particular claim element, a baseband integrated circuit or processor integrated circuit for a mobile device or a similar integrated circuit in server, a cellular network device, or other computing or network device.

[0045] As used herein, the term "network", "communication network" or "data network" refers to a network following any suitable communication standards, such as long term evolution (LTE), LTE-advanced (LTE-A), wideband code division multiple access (WCDMA), high-speed packet access (HSPA), narrow band Internet of things (NB-IoT), wireless fidelity (Wi-Fi) and so on. Furthermore, the communications between a terminal device and a network device/element in the communication network may be performed according to any suitable generation communication protocols, including, but not limited to, the fourth generation (4G), 4.5G, the future fifth generation (5G), IEEE 802.11 communication protocols, and/or any other protocols either currently known or to be developed in the future. Embodiments of the present disclosure may be applied in various communication systems. Given the rapid development in communications, there will of course also be future type communication technologies and systems with which the present disclosure may be embodied. It should not be seen as limiting the scope of the present disclosure to only the aforementioned system.

[0046] As used herein, the term "network device" refers to a node in a communication network via which a terminal device accesses the network and receives services therefrom. The network device may refer to a base station (BS) or an access point (AP) or a transmission and reception point (TRP), for example, a node B (NodeB or NB), an evolved NodeB (eNodeB or eNB), a NR NB (also referred to as a gNB), a remote radio unit (RRU), a radio header (RH), a remote radio head (RRH), a WiFi device, a relay, a low power node such as a femto, a pico, and so forth, depending on the applied terminology and technology. In the following description, the terms "network device", "AP device", "AP" and "access point" may be used interchangeably.

[0047] The term "terminal device" refers to any end device that may be capable of wireless communication. By way of example rather than limitation, a terminal device may also be referred to as a communication device, user equipment (UE), a subscriber station (SS), a portable subscriber station, a mobile station (MS), a station (STA) or station device, or an access terminal (AT). The terminal device may include, but not limited to, a mobile phone, a cellular phone, a smart phone, voice over IP (VOIP) phones, wireless local loop phones, a tablet, a wearable terminal device, a personal digital assistant (PDA), portable computers, desktop computer, image capture terminal devices such as digital cameras, gaming terminal devices, music storage and playback appliances, vehicle-mounted wireless terminal devices, wireless endpoints, mobile stations, laptop-embedded equipment (LEE), laptop-mounted equipment (LME), USB dongles, smart devices, wireless customer-premises equipment (CPE), an Internet of Things (IoT) device, a watch or other wearable, a head-mounted display (HMD), a vehicle, a drone, a medical device and applications (for example, remote surgery), an industrial device and applications (for example, a robot and/or other wireless devices operating in an industrial and/or an automated processing chain contexts), a consumer electronics device, a device operating on commercial and/or industrial wireless networks, and the like. In the following description, the terms "station", "station device", "STA", "terminal device", "communication device", "terminal", "user equipment" and "UE" may be used interchangeably.

[0048] The term "transceiver" may refer to any device that may be coupled to one or more antennas or antenna ports to wirelessly transmit and/or receive communication signals. The antennas or antenna ports may be the same or different types. The antennas or antenna ports may be located in different positions of an apparatus. One or more transceivers allow the apparatus to communicate with other devices that may be wired and/or wireless. The one or more transceivers may include processors, controllers, radios, sockets, plugs, buffers, or the like circuits to form one or more communication channels to one or more radio frequency units. The one or more transceivers may be integrated in an apparatus or a system, for example a cellular communication apparatus or system, a WLAN system, or a short ranging system for example Bluetooth system.

[0049] For physical uplink control channel (PUCCH)-based semi-persistent reporting, activation/deactivation is performed by transmitting a medium access control (MAC) control element (MAC CE) message. A UE shall perform semi-persistent CSI reporting on the PUCCH applied starting from slot $n+3N_{slot}^{subframe,\mu}+1$ after the Hybrid Automatic Repeat request Acknowledgment (HARQ-ACK) corresponding to the physical uplink shared channel PDSCH carrying the selection command MAC CE is transmitted in slot n.

[0050] Semi-persistent CSI reporting on the PUCCH supports Type I CSI. Semi-persistent CSI reporting on the PUCCH format 2 supports Type I CSI with wideband frequency granularity. Semi-persistent CSI reporting on

PUCCH formats 3 or 4 supports Type I CSI with wideband and sub-band frequency granularities and Type II CSI Part 1.

[0051] Below is the existing MAC CE design for activation/deactivation of SP (semi-persistent) CSI reporting on PUCCH (in TS 38.321).

6.1.3.16 SP CSI reporting on PUCCH Activation/Deactivation MAC CE

The SP CSI reporting on PUCCH Activation/Deactivation MAC CE is identified by a MAC subheader with LCID as specified in Table 6.2.1-1. It has a fixed size of 16 bits with following fields:

- Serving Cell ID: This field indicates the identity of the Serving Cell for which the MAC CE applies. The length of the field is 5 bits;
- BWP ID: This field indicates a UL BWP for which the MAC CE applies as the codepoint of the DCI bandwidth part indicator field as specified in TS 38.212 [9]. The length of the BWP ID field is 2 bits;
- S_i: This field indicates the activation/deactivation status of the Semi-Persistent CSI report configuration within csi-ReportConfigToAddModList, as specified in TS 38.331 [5]. So refers to the report configuration which includes PUCCH resources for SP CSI reporting in the indicated BWP and has the lowest CSI-ReportConfigId within the list with type set to semiPersistentOnPUCCH, S_i to the report configuration which includes PUCCH resources for SP CSI reporting in the indicated BWP and has the second lowest CSI-ReportConfigId and so on. If the number of report configurations within the list with type set to semiPersistentOnPUCCH in the indicated BWP is less than i + 1, MAC entity shall ignore the S_i field. The S_i field is set to 1 to indicate that the corresponding Semi-Persistent CSI report configuration shall be activated. The S_i field is set to 0 to indicate that the corresponding Semi-Persistent CSI report configuration i shall be deactivated;
- R: Reserved bit, set to 0.

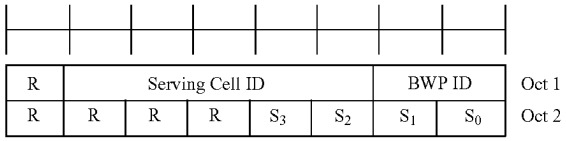


Figure 6.1.3.16-1: SP CSI reporting on PUCCH Activation/Deactivation MAC CE

[0052] It is approved in the Rel-18 work item description (WID) to specify necessary enhancements on CSI and beam management related procedures including measurement and report, and signaling to enable efficient adaptation of spatial elements (e.g. antenna ports, active transceiver chains) [RAN1, RAN2].

[0053] One of the recent RAN1 agreements is below.

Agreement
At least support A2-2, i.e. one CSI report configuration contains multiple CSI report sub-configurations where each sub-configuration corresponds to one spatial adaptation pattern.
-FFS: impact on CSI processing requirement
Agreement
For CSI report configuration, if L>1 in a CSI report configuration, at least the following can be included for each sub-configuration for Type 1 SD adaptation
-N1, N2 for single-panel and N1, N2, Ng for multi-panel
-FFS: details on explicit indication or implicit derivation
-Port subset indication when A1-2 is used (if A1-2 is supported)
-FFS: details on explicit indication or implicit derivation
-FFS: rank restriction
-FFS: codebook subset restriction
-FFS: supported codebook types for PMI, e.g., Type-I or Type-II
-FFS: report quantity
-FFS: reportFreqConfiguration
-FFS: Group identity of NZP CSI-RS resource(s) in a resource set for channel measurement when A1-1 is used
For CSI report configuration for type 2 SD adaptation, further study under which cases sub-configurations may or may not be needed including sub-configuration content.

[0054] As mentioned, Rel-18 will specify enhancements for network energy saving, including spatial pattern adaptation. RAN1 reached the following agreement regarding the support of semi-persistent and aperiodic CSI reporting where, for a CSI report configuration that includes L configurations, N CSIs out of this L (where N<=L) can be triggered in one reporting instance.

Agreement
For a CSI report config with L sub-configuration(s), support a framework that enables a UE toreport N CSI(s) in one reporting instance where the N CSI(s) are associated with N sub-configuration(s) from L (where) and each CSI corresponds to one sub-configuration.
-For discussion purpose, N=1 refers to single-CSI while N>1 refers to multi-CSI.
-For Semi-persistent/Aperiodic CSI reporting, support gNB trigger/indicate/activate report of N≤L CSIs where N>=1
-The maximum value of N and L are subject to UE capability
-Further study how to address/minimize additional UE complexity
The following bullet not agreed due to objection from Apple and vivo
-For Periodic CSI reporting, at least the case of N=L is supported where N>=1

[0055] In view of above, some embodiments of the disclosure propose an efficient design and encoding/decoding of the MAC CE for the activation or deactivation of CSI report configuration(s) to enable the above operation.

[0056] For illustrative purposes, principles and example embodiments of the present disclosure will be described below with reference to FIG. **1** to FIG. **8**. However, it is to be noted that these embodiments are given to enable the skilled in the art to understand inventive concepts of the present disclosure and implement the solution as proposed herein, and not intended to limit scope of the present application in any way.

[0057] FIG. **1** illustrates an example of an application scenario **100** in which some example embodiments of the present disclosure may be implemented. The application scenario **100**, which is a part of a communication network, includes terminal devices and network devices.

[0058] In the descriptions of the example embodiments of the present disclosure, the network environment **100** may also be referred to as a communication system **100** (for example, a portion of a communication network). For illustrative purposes only, various aspects of example embodiments will be described in the context of one or more terminal devices and network devices that communicate with one another. It should be appreciated, however, that the description herein may be applicable to other types of apparatus or other similar apparatuses that are referenced using other terminology.

[0059] As illustrated in FIG. **1**, the communication network **100** may include a network device **110** (which may also be referred to as a gNB or BS). The communication network **100** may further include a terminal device **120** (which may also be referred to as user equipment **120** or UE **120**. Although only one network device **110** and one terminal devices **120** are shown in FIG. **1**, the numbers of the network device and the terminal device are not limited. In other words, there may be one or more network devices **110** and one or more terminal devices **120** in the network.

[0060] The network device **110** can provide services to the terminal device **120**, and the network device **110** and the terminal device **120** may communicate data and control information with each other. In some embodiments, the network device **110** and the terminal device **120** may communicate with direct links/channels.

[0061] In the communication system **100**, a link from the network device **110** to the terminal device **120** is referred to as a downlink (DL), while a link from the terminal device **120** to the network device **110** is referred to as an uplink (UL). In downlink, the network device **110** is a transmitting (TX) device (or a transmitter) and the terminal device **120** is a receiving (RX) device (or a receiver). In uplink, the terminal device **120** is a transmitting (TX) device (or a transmitter) and the network device **110** is a RX device (or a receiver). It is to be understood that the network device **110** may provide one or more serving cells. As illustrated in FIG. **1**, the network device **110** provides one serving cell **102**, and the terminal device **120** camps on the serving cell **102**. In some embodiments, the network device **110** can provide multiple serving cells and the terminal device **120** may switch from a source cell to a target cell between the serving cells during its mobility. It is to be understood that the number of serving cell(s) shown in FIG. **1** is for illustrative purposes without suggesting any limitation.

[0062] Communications in the network environment **100** may be implemented according to any proper communication protocol(s), comprising, but not limited to, cellular communication protocols of the fourth generation (4G) and the fifth generation (5G) and on the like, wireless local network communication protocols such as Institute for Electrical and Electronics Engineers (IEEE) 802.11 and the like, and/or any other protocols currently known or to be developed in the future, such as universal mobile telecommunications System (UMTS), long term evolution (LTE), LTE-Advanced (LTE-A), the fifth generation (5G) new radio (NR), wireless fidelity (Wi-Fi) and worldwide interoperability for microwave access (WiMAX) standards, and employs any suitable communication technologies, including, for example, multiple-input multiple-output (MIMO), orthogonal frequency division multiplexing (OFDM), time division multiplexing (TDM), frequency division multiplexing (FDM), code division multiplexing (CDM), Bluetooth, ZigBee, and machine type communication (MTC), enhanced mobile broadband (eMBB), massive machine type communication (mMTC), ultra-reliable low latency communication (URLLC), carrier aggregation (CA), dual connectivity (DC), and new radio unlicensed (NR-U) technologies.

[0063] In some embodiments of the present disclosure, the terminal device **120** may receive a MAC CE from the network device **110** to activate or deactivate at least one CSI report configuration (for example, preconfigured via a radio resource control (RRC) message). The CSI report configuration may comprise or be associated with multiple sub-configurations. The MAC CE comprises at least one field indicative of activation or deactivation status of the sub-configurations of the CSI report configuration. Upon reception of the MAC CE, the terminal device **120** may decode or determine activation or deactivation of the sub-configurations. Afterwards, the terminal device **120** may perform CSI measurements on the activated sub-configurations and report the CSI measurement results to the network device **120**.

[0064] FIG. **2** illustrates an example of a process flow in accordance with some example embodiments of the present disclosure. For ease of understanding, the process flow **200** will be described with reference to FIG. **1**. It would be appreciated that although the process flow **200** has been described referring to the communication network **100** of FIG. **1**, this process flow **200** may be likewise applied to other similar communication scenarios.

[0065] As shown in FIG. **2**, the network device **110** generates (**202**) a MAC CE comprising at least one field for a CSI report configuration based on activation or deactivation of at least one of a plurality of sub-configurations of the CSI report configuration. In some embodiments, the network device **110** may configure in advance the terminal device **120** with at least one CSI report configurations (e.g., 4 configurations configurations) and via for example RRC signaling. The CSI report configuration may be used for semi-persistent CSI reporting on physical PUCCH, and may be activated or deactivated via MAC CE.

[0066] In some embodiments, one or more of the multiple CSI report configurations may include or be associated with a plurality of sub-configurations. The sub-configurations of the CSI report configuration may also be configured via RRC signaling. In some embodiments, a sub-configuration among the plurality of sub-configurations may correspond to or be associated or be replaced with one or more of: a spatial pattern; a power level; an energy level; a CSI-reference signal (RS) resource; a CSI-RS resource set; a resource setting; a CSI report configuration; a codebook configuration; or a CSI triggering state. The spatial pattern may refer to a spatial configuration of active/inactive antenna ports/elements at the network device **120**, and may be associated with a corresponding power consumption level.

[0067] In some embodiments, the network device **110** may encode the activation or deactivation statuses of the CSI report configuration and at least one associated sub-configuration into the MAC CE. The activation or deactivation status of the CSI report configuration may be encoded as a bitmap in at least one octet of the MAC CE, where one bit

for one CSI report configuration. For example, the value "1" may indicate the activation status, and the value "0" may indicate the deactivation status. In addition, the activation or deactivation status of at least one sub-configuration is encoded in at least one additional field of the MAC CE. This field may indicate, for example, in form of a codepoint or a bitmap, a number of sub-configurations among the plurality of sub-configurations of the CSI report configuration to activate or deactivate at the terminal device **120**. For brevity, details will be described with reference to FIG. **3** from a perspective of the terminal device **120** at a decoding stage.

[0068] Then, the network device **110** transmits (**204**) the MAC CE (**205**) to the terminal device **120**. Accordingly, the terminal device **120** receives (**206**) the MAC CE. Upon reception of the MAC CE (**205**), the terminal device **120** determines activation or deactivation of at least one of the plurality of sub-configurations at least based on the at least one field in the MAC CE.

[0069] In some embodiments, the terminal device **120** may perform a decoding procedure to obtain the activation or deactivation status of the CSI report configuration and associated sub-configurations encoded in the MAC CE. In some embodiments, the activation of a sub-configuration or a set of sub-configurations may indicate that the sub-configuration or the set of sub-configurations is applicable, and the deactivation of a sub-configuration or a set of sub-configurations may indicate that the sub-configuration or the set of sub-configurations is inapplicable.

[0070] Afterwards, the terminal device **120** may perform CSI measurements on CSI resources associated with the activated sub-configurations and report CSI(s) in one reporting instance to the network device **110**.

[0071] FIG. **3** illustrates an example process **300** implemented at UE side according to example embodiments of the present disclosure. The process **300** may be an example implementation of block **208** in FIG. **2** and may be implemented by a UE as example of the terminal device **120**. It is to be understood that the process **300** may include additional acts not shown and/or omit some of the illustrated acts. The scope of the disclosure is not limited in this regard.

[0072] As mentioned, the UE may be configured with a CSI report configuration that includes or is associated with multiple sub-configurations. Examples of encoding/decoding of at least part of the MAC CE activating/deactivating semi-persistent CSI reporting for one or more sub-configurations in case of semi-persistent CSI reporting on PUCCH will be described in the following.

[0073] If the at least one bit in the MAC CE deactivates the semi-persistent CSI reporting configuration, e.g., through bit value '0', all the sub-configurations belonging or associated to this configuration are assumed deactivated. The UE considers that no reserved/existing bit(s) or additional field(s)/octet(s)/subfield(s) for the indication related to sub-configurations is used/present/made available in the MAC CE.

[0074] If at least one bit in this MAC CE activates a semi-persistent CSI reporting configuration on PUCCH, e.g., through bit value '1', and this configuration includes or is associated with multiple sub-configurations, activating or deactivating at least one sub-configuration may be done using one or more of the following options.

[0075] In Option 1, the UE considers that at least one reserved/existing bit in the MAC CE is made available and used to indicate the activation or deactivation of at least one sub-configuration. The at least one reserved/existing bit may be in the same octet as the activation or deactivation statuses of the multiple preconfigured CSI report configurations.

[0076] In Option 2, the UE considers that at least one field (e.g., at least one octet (8 bits)) and/or at least one subfield (consisting of at least one or two bits) is present or is not reserved in the MAC CE and is used to indicate the activation or deactivation of at least one sub-configuration. The at least one field for the sub-configurations may comprise at least one bit beyond the octet including the activation or deactivation statuses of the multiple preconfigured CSI report configurations. In some embodiments, the MAC CE may include at least one additional octet for the sub-configurations.

[0077] Option 1 may be assumed if the number of sub-configurations in the report configuration is lower than or equal to a threshold. Option 2 may be assumed if the number of configurations in the report configuration is greater than a threshold. Also, Option 2 may be assumed if a certain number of active CSI report configurations that includes multiple sub-configurations is greater than or equal to a threshold such as 2. In addition, the Option 1 and Option 2 may be combined.

[0078] By use of one or more of Option 1 and Option 2, the MAC CE may include at least one field to indicate activation or deactivation of the sub-configurations of CSI report configuration(s). In some embodiments, this indication may be in form of a codepoint representing index of a sub-configuration to activate or deactivate or representing a set of sub-configurations to activate or deactivate. The set of sub-configurations may be included or associated with the CSI report configuration, i.e., one or more sub-configurations may be grouped in a set (and there may be several of such sets). Alternatively, this indication may be in form of a bitmap where a bit in the bitmap may indicate the activation or deactivation of at least one sub-configuration (or a set of sub-configurations). Alternatively, a number of sub-configurations to activate or deactivate may be indicated, and the UE follows a defined order (based on specifications or configuration) to determine the sub-configuration(s) to activate or deactivate, such as by e.g., considering the sub-configurations with lowest/highest index or identity first.

[0079] In some embodiments, the field/subfield/octet may be at least partially shared between at least two CSI report configurations, or alternatively, one field/subfield/octet is assumed per CSI report configuration.

[0080] In some embodiments, the field/subfield/bitmap size to consider/add for a CSI report configuration in the MAC CE may depend on the number of sub-configurations (or sub-configuration sets) belonging or corresponding to this CSI report configuration.

[0081] In some embodiments, the need for a new octet/field/sub-field may depend on whether the existing/reserved bits are sufficient or not, e.g., whether Option 1 is sufficient or not. This may also depend on whether at least one other CSI report configuration is activated, where this at least other configuration includes or is associated with sub-configurations, and at least one of these sub-configurations is indicated to be activated/deactivated.

[0082] In some embodiments, considering a CSI report configuration, the need for more than one octet/field/subfield may depend on whether the number of sub-configurations or sets of sub-configurations is greater than a threshold, such as 8. For example, if a bit map is used and the CSI report

configuration includes more than 8 sub-configurations, the field for the CSI report configuration would require more than 8 bits (1 octet).

[0083] In some embodiments, a maximum number of sub-configurations or sub-configuration set, belonging/associated to the same CSI report configuration, may be specified/configured not to be active at a time. Thus, for example, if this number is set to 1, if one sub-configuration (or sub-configuration set) is activated, this may mean that the other sub-configuration(s) (or sub-configuration set(s)) is automatically deactivated. More generally, if this number is set to X, if X sub-configurations (or sub-configuration sets) are activated, this may mean that the other sub-configuration (s) (or sub-configuration set(s)) are automatically deactivated.

[0084] In the process **300**, the UE decodes activation or deactivation status in the MAC CE per CSI report configuration. At block **301**, for a given CSI report configuration, the UE checks whether the CSI report configuration has an activation status. If the bit value for the CSI indicates a deactivation status (e.g., "0"), the process proceeds to block **302**, where the UE may determine deactivation of all of associated sub-configurations of the CSI report configuration, and then move on to block **306** to check for the next CSI report configuration (if any).

[0085] If the CSI report configuration has an activation status, the process **300** proceeds to block **303**. At block **303**, the UE positions the field indicative of activation/deactivation statuses of sub-configurations of the CSI report configuration. In some embodiments, the position of the field may be based on the activation or deactivation statuses of the multiple CSI report configurations pre-configured at the UE. If a CSI report configuration is to be deactivated via the MAC CE, there may be no corresponding field for its sub-configurations in the MAC CE. The position may be further based on an index or an identity of the CSI report configuration. For example, the fields for the activated CSI configurations may be ordered one by one in the MAC CE. In addition, the position may be based on a number of sub-configurations or sets of sub-configurations of each of at least (activated) one of the multiple CSI report configurations. That is, the position also depends on the sizes of fields for the preceding CSI report configuration(s). Alternatively, the positions of the fields may be fixed in the MAC CE, regardless of the activation or deactivation statuses of the multiple CSI report configurations.

[0086] After the field is positioned in the MAC CE, the UE may obtain the value of the field, and at block **304** decode the field. As mentioned, the field may be in form of a codepoint representing index of a sub-configuration to activate or deactivate or represent a set of sub-configurations to activate or deactivate. Alternatively, the field may be in form of a bitmap where a bit in the bitmap may indicate the activation or deactivation of at least one sub-configuration or a set of sub-configurations. For example, a bit value "1" indicates the activation status, and a bit value "0" indicates the activation status for the corresponding sub-configuration or set of sub-configurations.

[0087] In some embodiments, a size of the field may be based on a number of the sub-configurations or sets of sub-configurations of the CSI report configuration. For example, if the field comprises a bitmap, the size of the bitmap in bits is equal to the number of sub-configurations or the number of sets of sub-configurations. As another example, if the field comprises a codepoint, the size of in bits is equal to the number of binary digits for representing the maximum/largest index of the sub-configuration or set of sub-configurations.

[0088] By decoding the field, the UE knows the sub-configuration(s) or set(s) of sub-configurations to activate or deactivate. In some embodiments, the UE may be configured or specified with a maximum number of sub-configurations or sets of sub-configurations that could activated for a CSI report configuration. This maximum number may impact the size of the field. In some embodiments, the UE may be configured with a restriction on which sub-configurations or sets of sub-configurations could be activated or not activated. This restriction may also impact the size of the field, as only sub-configurations or sets of sub-configurations that are not restricted from being activated could be indicated in the field (via MAC CE).

[0089] In addition, at block **305** the UE may check for a maximum of allowed activated sub-configurations or set of configurations. The UE may be configured or specified with a threshold indicative of the maximum activated sub-configurations or set of configurations. The UE may determine, based on the field and the threshold, activation or deactivation of a sub-configuration or set of sub-configurations, such that a number of activated sub-configurations or sets of sub-configurations is equal to or less than the threshold. For example, if this threshold is set to 1, if one sub-configuration (or sub-configuration set) is activated, this may mean that the other sub-configuration(s) (or sub-configuration set(s)) is to be automatically deactivated.

[0090] At block **306**, the UE checks whether all CSI report configurations are decoded. If no, the process **300** returns to block **301** and repeat the actions in blocks **301** to **305** for the next CSI report configuration. If all CSI report configuration are decoded, the process **300** ends.

[0091] FIG. **4**A illustrates a first example MAC CE design for activating/deactivating semi-persistent CSI reporting when multiple sub-configurations are associated with a CSI report configuration. The multiple sub-configurations may correspond to e.g., different spatial adaption patterns or even different power offsets (for PDSCH relative to CSI-RS).

[0092] In FIG. **4**A, Oct 2 comprises bits S_0 to S_3 each indicating an activation or deactivation status of a CSI report configuration. As an example, S_0 (0 or 1) refers to one CSI report configuration. Assume S_0=1, i.e., the corresponding CSI report configuration is activated. This configuration includes or is associated with multiple sub-configurations (or set of sub-configurations). Since S_0=1, existing/reserved bits (in this example, 3 bits) R0, R1 and R2 in Oct 2 are used to indicate activation/deactivation of at least one sub-configuration from the sub-configurations belonging to or corresponding to the CSI report configuration referred to by S_0. In this example, 1 out of up to 8 sub-configurations (or set of sub-configurations) can be activated/referred to.

[0093] FIG. **4**B illustrates a second example MAC CE design for activating/deactivating semi-persistent CSI reporting when multiple sub-configurations are associated with a CSI report configuration. The multiple sub-configurations may correspond to e.g., different spatial adaption patterns.

[0094] In FIG. **4**B, Oct 2 comprises bits S_0 to S_3 each indicating an activation or deactivation status of a CSI report configuration. As an example, S_0 (0 or 1) refers to one CSI report configuration. Assume S_0=1, i.e., the corresponding

CSI report configuration is activated. This configuration includes or is associated with (up to) 8 multiple sub-configurations. Since S_0=1, existing/reserved bits (in this example, 3 bits) R_{00}, R_{01}, R_{02} in Oct 2 are used to indicate activation/deactivation of at least one sub-configuration from the sub-configurations belonging to or corresponding to the CSI report configuration referred to by S_0. In this example, 1 out of up to 8 sub-configurations can be activated/referred to.

[0095] In addition, S_1 (0 or 1) refers to one CSI report configuration. Assume S_1=1, i.e., the corresponding CSI report configuration is activated. This configuration includes or is associated with e.g., (up to) 4 sub-configurations. Since S_1=1, new field/octet (Oct 3) is added where 2 bits S_{11}, S_{10} are considered for the activation/deactivation of at least one sub-configuration from the sub-configurations belonging to or corresponding to the CSI report configuration referred to by S_1. In this example, 1 out of (up to) 4 sub-configurations can be activated/referred to.

[0096] FIG. **4**C illustrates a third example MAC CE design for activating/deactivating semi-persistent CSI reporting when multiple sub-configurations are associated with a CSI report configuration. The multiple sub-configurations may correspond to e.g., different spatial adaption patterns.

[0097] In FIG. **4**C, Oct 2 comprises bits S_0 to S_3 each indicating an activation or deactivation status of a CSI report configuration. S_0 (0 or 1): It refers to one CSI report configuration. Assume S_0=1, i.e., the corresponding CSI report configuration is activated. This configuration includes or is associated with 7 multiple sub-configurations. Since S_0=1, new field/octet (Oct 3) is added where a bitmap of size 7 is considered for the activation/deactivation of at least one sub-configuration from the sub-configurations belonging to or corresponding to the CSI report configuration referred to by S_0. In this example, any combinations of 1-7 sub-configurations can be activated/deactivated/referred to. If the bitmap of size is larger than 8, the field may span across multiple octets.

[0098] In addition, S_1 (0 or 1) refers to one CSI report configuration. Assume S_1=1, i.e., the corresponding CSI report configuration is activated. This configuration includes or is associated with 4 sub-configurations. Since S_1=1, new field/octet (Oct 4) is added where a bitmap of size 4 is considered for the activation/deactivation of at least one sub-configuration from the sub-configurations belonging to or corresponding to the CSI report configuration referred to by S_1. In this example, any combination of 1-4 sub-configurations can be activated/deactivated/referred to.

[0099] FIG. **4**D illustrates a fourth example MAC CE design for activating/deactivating semi-persistent CSI reporting when multiple sub-configurations are associated with a CSI report configuration. The multiple sub-configurations may correspond to e.g., different spatial adaption patterns.

[0100] In FIG. **4**D, Oct 2 comprises bits S_0 to S_3 each indicating an activation or deactivation status of a CSI report configuration. S_0 (0 or 1) refers to one CSI report configuration. Assume S_0=1, i.e., the corresponding CSI report configuration is activated. This configuration includes or is associated with 4 multiple sub-configurations. Since S_0=1, new field/octet (Oct 3) is added where a bitmap of size 4 (S_{00}, S_{01}, S_{02}, and S_{03}) is considered for the activation/deactivation of at least one sub-configuration from the sub-configurations belonging to or corresponding to the CSI report configuration referred to by S_0. In this example, any combinations of 1-4 sub-configurations can be activated/deactivated/referred to.

[0101] In addition, S_1 (0 or 1) refers to one CSI report configuration. Assume S_1=1, i.e., the corresponding CSI report configuration is activated. This configuration includes or is associated with 4 sub-configurations. Since S_1=1, new field/octet is added where a bitmap of size 4 (S_{10}, S_{11}, S_{12}, and S_{13}) is considered for the activation/deactivation of at least one sub-configuration from the sub-configurations belonging to or corresponding to the CSI report configuration referred to by S_1. In this example any combination of 1-4 sub-configurations can be activated/deactivated/referred to. Note that the field for the CSI report configuration S_1 is positioned in the same octet as S_1, since there is enough space in Oct 3.

[0102] It is to be understood that the examples of MAC CE in FIG. **4**A to FIG. **4**D are provided for illustrative purpose without limiting. The MAC CE according to the embodiments of the present disclosure may have different designs, for example, with more or less CSI report configurations, more or less sub-configurations associated with a CSI report configuration, or with field(s) indicative of activation or deactivation of sub-configurations in sets.

[0103] In view of above, some embodiments of the disclosure provide an efficient design/encoding of MAC CE for the activation of semi-persistent CSI report to enable the operation of activating/deactivating CSI for one or more sub-configurations when multiple sub-configurations (referring to e.g., different spatial adaptation patterns) are included or associated with a same CSI reporting configuration

[0104] FIG. **5** illustrates a flowchart of an example method **500** implemented at a terminal device in accordance with some other embodiments of the present disclosure. For ease of understanding, the method **500** will be described from the perspective of the terminal device **120** with reference to FIG. **1**.

[0105] At block **510**, the terminal device **120** receives a medium access control (MAC) control element (MAC CE) comprising at least one field for a channel state information (CSI) report configuration, wherein the CSI report configuration comprises a plurality of sub-configurations. At block **520**, the terminal device **120** determines activation or deactivation of at least one of the plurality of sub-configurations at least based on the at least one field in the MAC CE.

[0106] In some embodiments, the at least one field may indicate an index of a sub-configuration or a set of sub-configurations among the plurality of sub-configurations to activate or deactivate.

[0107] Additionally or alternatively, the at least one field may comprise a bitmap for the plurality of sub-configurations. A bit in the bitmap indicates an activation or deactivation status of a sub-configuration or a set of sub-configurations among the plurality of sub-configurations.

[0108] Additionally or alternatively, the at least one field may indicate a number of sub-configurations among the plurality of sub-configurations to activate or deactivate. The terminal device **120** may determine an index of the at least one of the plurality of sub-configurations to activate or deactivate based on the indicated number and a defined order of indexes of the plurality of sub-configurations.

[0109] In some embodiments, a size of the at least one field may be based on a number of the plurality of sub-configurations or sets of sub-configurations of the CSI report configuration.

[0110] In some embodiments, the MAC CE further may comprise activation or deactivation statuses of multiple CSI report configurations configured at the terminal device. In some embodiments, the activation or deactivation statuses of the multiple CSI report configurations may be included in at least one octet. Additionally or alternatively, the at least one field may comprise at least one reserved bit of the at least one octet. Additionally or alternatively, the at least one field may comprise at least one bit beyond the at least one octet. Additionally or alternatively, the at least one field may comprise at least one additional octet other than the at least one octet.

[0111] In some embodiments, the terminal device **120** may determine activation or deactivation of at least one of the plurality of sub-configurations by determining, based on determining that the CSI report configuration has a deactivation status, deactivation of the plurality of sub-configurations of the CSI report configuration.

[0112] In some embodiments, the terminal device **120** may determine activation or deactivation of at least one of the plurality of sub-configurations by determining, based on determining that the CSI report configuration has an activation status, activation or deactivation of the at least one of the plurality of sub-configurations based on the at least one field in the MAC CE.

[0113] In some embodiments, the terminal device **120** may determine activation or deactivation of at least one of the plurality of sub-configurations by positioning the at least one field for the CSI report configuration in the MAC CE and determining activation or deactivation of at least one of the plurality of sub-configurations based on a value of the at least one field.

[0114] In some embodiments, the positioning of the at least one field may be at least based on at least one of the following: the activation or deactivation statuses of the multiple CSI report configurations; a number of the plurality of sub-configurations or sets of sub-configurations of each of at least one of the multiple CSI report configurations; or an index or an identity of the CSI report configuration.

[0115] In some embodiments, the at least one field may be at least shared between the CSI report configuration and another one of the multiple CSI report configurations.

[0116] In some embodiments, the terminal device **120** may determine activation or deactivation of at least one of the plurality of sub-configurations by determining, based on the at least one field and a threshold, activation or deactivation of at least one sub-configuration or set of sub-configurations, such that a number of activated sub-configurations or sets of sub-configurations is equal to or less than the threshold.

[0117] In some embodiments, the activation or deactivation of at least one of the plurality of sub-configurations may indicate that the at least one sub-configuration is applicable or inapplicable respectively.

[0118] In some embodiments, a sub-configuration among the plurality of sub-configurations may correspond to or be associated with at least one of the following: a spatial pattern; a power level; an energy level; a CSI-reference signal (RS) resource; a CSI-RS resource set; a resource setting; a CSI report configuration; a codebook configuration; or a CSI triggering state.

[0119] In some embodiments, the CSI report configuration may be for semi-persistent CSI reporting on physical uplink control channel (PUCCH).

[0120] FIG. **6** illustrates another flowchart of an example method implemented at a network device in accordance with some embodiments of the present disclosure. For ease of understanding, the method **600** will be described from the perspective of the network device **110** with reference to FIG. **1**.

[0121] At block **610**, the network device **110** generates a medium access control (MAC) control element (MAC CE) comprising at least one field for a channel state information (CSI) report configuration based on activation or deactivation of at least one of a plurality of sub-configurations of the CSI report configuration. At block **620**, the network device **110** transmits the MAC CE to a terminal device.

[0122] In some embodiments, the at least one field may indicate an index of a sub-configuration or a set of sub-configurations among the plurality of sub-configurations to activate or deactivate. Additionally or alternatively, the at least one field may comprise a bitmap for the plurality of sub-configurations. A bit in the bitmap indicates an activation or deactivation status of a sub-configuration or a set of sub-configurations among the plurality of sub-configurations. Additionally or alternatively, the at least one field may indicate a number of sub-configurations among the plurality of sub-configurations to activate or deactivate.

[0123] In some embodiments, a size of the at least one field may be based on a number of the plurality of sub-configurations or sets of sub-configurations of the CSI report configuration.

[0124] In some embodiments, the MAC CE may further comprise activation or deactivation statuses of multiple CSI report configurations configured at the terminal device. In some embodiments, the activation or deactivation statuses of the multiple CSI report configurations may be included in at least one octet. Additionally or alternatively, the at least one field may comprise at least one reserved bit of the at least one octet. Additionally or alternatively, the at least one field may comprise at least one bit beyond the at least one octet. Additionally or alternatively, the at least one field may comprise at least one additional octet other than the at least one octet.

[0125] In some embodiments, a position of the at least one field may be at least based on at least one of the following: the activation or deactivation statuses of the multiple CSI report configurations; a number of the plurality of sub-configurations or sets of sub-configurations of each of at least one of the multiple CSI report configurations; or an index or an identity of the CSI report configuration.

[0126] In some embodiments, the at least one field may be at least shared between the CSI report configuration and another one of the multiple CSI report configurations.

[0127] In some embodiments, the activation or deactivation of at least one of the plurality of sub-configurations may indicate that the at least one sub-configuration is applicable or inapplicable respectively.

[0128] In some embodiments, a sub-configuration among the plurality of sub-configurations may correspond to or be associated with at least one of the following: a spatial pattern; a power level; an energy level; a CSI-reference signal (RS) resource; a CSI-RS resource set; a resource setting; a CSI report configuration; a codebook configuration; or a CSI triggering state.

[0129] In some embodiments, the CSI report configuration may be for semi-persistent CSI reporting on physical uplink control channel (PUCCH).

[0130] In some embodiments, an apparatus capable of performing the method **500** (for example, the terminal device **120**) may comprise means for performing the respective steps of the method **500**. The means may be implemented in any suitable form. For example, the means may be implemented in a circuitry or software module.

[0131] In some example embodiments, the apparatus comprises: means for receiving, at a terminal device, a medium access control (MAC) control element (MAC CE) comprising at least one field for a channel state information (CSI) report configuration, wherein the CSI report configuration comprises a plurality of sub-configurations; and means for determining activation or deactivation of at least one of the plurality of sub-configurations at least based on the at least one field in the MAC CE.

[0132] In some embodiments, the at least one field may indicate an index of a sub-configuration or a set of sub-configurations among the plurality of sub-configurations to activate or deactivate.

[0133] Additionally or alternatively, the at least one field may comprise a bitmap for the plurality of sub-configurations. A bit in the bitmap indicates an activation or deactivation status of a sub-configuration or a set of sub-configurations among the plurality of sub-configurations.

[0134] Additionally or alternatively, the at least one field may indicate a number of sub-configurations among the plurality of sub-configurations to activate or deactivate. The apparatus may further comprise means for determining an index of the at least one of the plurality of sub-configurations to activate or deactivate based on the indicated number and a defined order of indexes of the plurality of sub-configurations.

[0135] In some embodiments, a size of the at least one field may be based on a number of the plurality of sub-configurations or sets of sub-configurations of the CSI report configuration.

[0136] In some embodiments, the MAC CE further may comprise activation or deactivation statuses of multiple CSI report configurations configured at the terminal device. In some embodiments, the activation or deactivation statuses of the multiple CSI report configurations may be included in at least one octet. Additionally or alternatively, the at least one field may comprise at least one reserved bit of the at least one octet. Additionally or alternatively, the at least one field may comprise at least one bit beyond the at least one octet. Additionally or alternatively, the at least one field may comprise at least one additional octet other than the at least one octet.

[0137] In some embodiments, means for determining activation or deactivation of at least one of the plurality of sub-configurations may comprise means for determining, based on determining that the CSI report configuration has a deactivation status, deactivation of the plurality of sub-configurations of the CSI report configuration.

[0138] In some embodiments, means for determining activation or deactivation of at least one of the plurality of sub-configurations may comprise means for determining, based on determining that the CSI report configuration has an activation status, activation or deactivation of the at least one of the plurality of sub-configurations based on the at least one field in the MAC CE.

[0139] In some embodiments, means for determining activation or deactivation of at least one of the plurality of sub-configurations may comprise means for positioning the at least one field for the CSI report configuration in the MAC CE and means for determining activation or deactivation of at least one of the plurality of sub-configurations based on a value of the at least one field.

[0140] In some embodiments, the positioning of the at least one field may be at least based on at least one of the following: the activation or deactivation statuses of the multiple CSI report configurations; a number of the plurality of sub-configurations or sets of sub-configurations of each of at least one of the multiple CSI report configurations; or an index or an identity of the CSI report configuration.

[0141] In some embodiments, the at least one field may be at least shared between the CSI report configuration and another one of the multiple CSI report configurations.

[0142] In some embodiments, means for positioning the at least one field for the CSI report configuration in the MAC CE may comprise means for determining, based on the at least one field and a threshold, activation or deactivation of at least one sub-configuration or set of sub-configurations, such that a number of activated sub-configurations or sets of sub-configurations is equal to or less than the threshold.

[0143] In some embodiments, the activation or deactivation of at least one of the plurality of sub-configurations may indicate that the at least one sub-configuration is applicable or inapplicable respectively.

[0144] In some embodiments, a sub-configuration among the plurality of sub-configurations may correspond to or be associated with at least one of the following: a spatial pattern; a power level; an energy level; a CSI-reference signal (RS) resource; a CSI-RS resource set; a resource setting; a CSI report configuration; a codebook configuration; a CSI triggering state.

[0145] In some embodiments, the CSI report configuration may be for semi-persistent CSI reporting on physical uplink control channel (PUCCH).

[0146] In some embodiments, the apparatus further comprises means for performing other steps in some embodiments of the method **500**. In some embodiments, the means comprises at least one processor and at least one memory including computer program code, the at least one memory and computer program code configured to, with the at least one processor, cause the performance of the apparatus.

[0147] In some embodiments, an apparatus capable of performing the method **600** (for example, the network device **110**) may comprise means for performing the respective steps of the method **600**. The means may be implemented in any suitable form. For example, the means may be implemented in a circuitry or software module.

[0148] In some example embodiments, the apparatus comprises: means for generating, at a network device, a medium access control (MAC) control element (MAC CE) comprising at least one field for a channel state information (CSI) report configuration based on activation or deactivation of at least one of a plurality of sub-configurations of the CSI report configuration; and means for transmitting the MAC CE to a terminal device.

[0149] In some embodiments, the at least one field may indicate an index of a sub-configuration or a set of sub-configurations among the plurality of sub-configurations to activate or deactivate. Additionally or alternatively, the at least one field may comprise a bitmap for the plurality of

sub-configurations. A bit in the bitmap indicates an activation or deactivation status of a sub-configuration or a set of sub-configurations among the plurality of sub-configurations. Additionally or alternatively, the at least one field may indicate a number of sub-configurations among the plurality of sub-configurations to activate or deactivate.

[0150] In some embodiments, a size of the at least one field may be based on a number of the plurality of sub-configurations or sets of sub-configurations of the CSI report configuration.

[0151] In some embodiments, the MAC CE may further comprise activation or deactivation statuses of multiple CSI report configurations configured at the terminal device. In some embodiments, the activation or deactivation statuses of the multiple CSI report configurations may be included in at least one octet. Additionally or alternatively, the at least one field may comprise at least one reserved bit of the at least one octet. Additionally or alternatively, the at least one field may comprise at least one bit beyond the at least one octet. Additionally or alternatively, the at least one field may comprise at least one additional octet other than the at least one octet.

[0152] In some embodiments, a position of the at least one field may be at least based on at least one of the following: the activation or deactivation statuses of the multiple CSI report configurations; a number of the plurality of sub-configurations or sets of sub-configurations of each of at least one of the multiple CSI report configurations; or an index or an identity of the CSI report configuration.

[0153] In some embodiments, the at least one field may be at least shared between the CSI report configuration and another one of the multiple CSI report configurations.

[0154] In some embodiments, the activation or deactivation of at least one of the plurality of sub-configurations may indicate that the at least one sub-configuration is applicable or inapplicable respectively.

[0155] In some embodiments, a sub-configuration among the plurality of sub-configurations may correspond to or be associated with at least one of the following: a spatial pattern; a power level; an energy level; a CSI-reference signal (RS) resource; a CSI-RS resource set; a resource setting; a CSI report configuration; a codebook configuration; or a CSI triggering state.

[0156] In some embodiments, the CSI report configuration may be for semi-persistent CSI reporting on physical uplink control channel (PUCCH).

[0157] In some embodiments, the apparatus further comprises means for performing other steps in some embodiments of the method **600**. In some embodiments, the means comprises at least one processor and at least one memory including computer program code, the at least one memory and computer program code configured to, with the at least one processor, cause the performance of the apparatus.

[0158] FIG. **7** illustrates a simplified block diagram of a device **700** that is suitable for implementing some example embodiments of the present disclosure. The device **700** may be provided to implement a communication device, for example, the network device **110** or the terminal device **120** as shown in FIG. **1**. As shown, the device **700** includes one or more processors **710**, one or more memories **720** coupled to the processor **710**, and one or more communication modules **740** coupled to the processor **710**.

[0159] The communication module **740** is for bidirectional communications. The communication module **740** has at least one antenna to facilitate communication. The communication interface may represent any interface that is necessary for communication with other network elements.

[0160] The processor **710** may be of any type suitable to the local technical network and may include one or more of the following: general purpose computers, special purpose computers, microprocessors, digital signal processors (DSPs) and processors based on multicore processor architecture, as non-limiting examples. The device **700** may have multiple processors, such as an application specific integrated circuit chip that is slaved in time to a clock which synchronizes the main processor.

[0161] The memory **720** may include one or more non-volatile memories and one or more volatile memories. Examples of the non-volatile memories include, but are not limited to, a Read Only Memory (ROM) **724**, an electrically programmable read only memory (EPROM), a flash memory, a hard disk, a compact disc (CD), a digital video disk (DVD), and other magnetic storage and/or optical storage. Examples of the volatile memories include, but are not limited to, a random access memory (RAM) **722** and other volatile memories that will not last in the power-down duration.

[0162] A computer program **730** includes computer executable instructions that are executed by the associated processor **710**. The program **730** may be stored in the ROM **724**. The processor **710** may perform any suitable actions and processing by loading the program **730** into the RAM **722**.

[0163] The embodiments of the present disclosure may be implemented by means of the program **730** so that the device **700** may perform any process of the disclosure as discussed with reference to FIGS. **3**, **5** and **6**. The embodiments of the present disclosure may also be implemented by hardware or by a combination of software and hardware.

[0164] In some example embodiments, the program **730** may be tangibly contained in a computer-readable medium which may be included in the device **700** (such as in the memory **720**) or other storage devices that are accessible by the device **700**. The device **700** may load the program **730** from the computer-readable medium to the RAM **722** for execution. The computer-readable medium may include any types of tangible non-volatile storage, such as ROM, EPROM, a flash memory, a hard disk, CD, DVD, and the like.

[0165] FIG. **8** illustrates a block diagram of an example of a computer-readable medium **600** in accordance with some example embodiments of the present disclosure. The computer-readable medium **800** has the program **730** stored thereon. It is noted that although the computer-readable medium **800** is depicted in form of CD or DVD in FIG. **8**, the computer-readable medium **800** may be in any other form suitable for carry or hold the program **730**.

[0166] Generally, various embodiments of the present disclosure may be implemented in hardware or special purpose circuits, software, logic or any combination thereof. Some aspects may be implemented in hardware, while other aspects may be implemented in firmware or software which may be executed by a controller, microprocessor or other computing device. While various aspects of embodiments of the present disclosure are illustrated and described as block diagrams, flowcharts, or using some other pictorial representations, it is to be understood that the block, apparatus, system, technique or method described herein may be imple-

mented in, as non-limiting examples, hardware, software, firmware, special purpose circuits or logic, general purpose hardware or controller or other computing devices, or some combination thereof.

[0167] The present disclosure also provides at least one computer program product tangibly stored on a non-transitory computer-readable storage medium. The computer program product includes computer-executable instructions, such as those included in program modules, being executed in a device on a target real or virtual processor, to carry out the process or method **300**, **500** or **600** as described above with reference to FIG. **3**, **5** or **6**. Generally, program modules include routines, programs, libraries, objects, classes, components, data structures, or the like that perform particular tasks or implement particular abstract data types. The functionality of the program modules may be combined or split between program modules as desired in various embodiments. Machine-executable instructions for program modules may be executed within a local or distributed device. In a distributed device, program modules may be located in both local and remote storage media.

[0168] Program code for carrying out methods of the present disclosure may be written in any combination of one or more programming languages. These program codes may be provided to a processor or controller of a general purpose computer, special purpose computer, or other programmable data processing apparatus, such that the program codes, when executed by the processor or controller, cause the functions/operations specified in the flowcharts and/or block diagrams to be implemented. The program code may execute entirely on a machine, partly on the machine, as a stand-alone software package, partly on the machine and partly on a remote machine or entirely on the remote machine or server.

[0169] In the context of the present disclosure, the computer program codes or related data may be carried by any suitable carrier to enable the device, apparatus or processor to perform various processes and operations as described above. Examples of the carrier include a signal, computer-readable medium, and the like.

[0170] The computer-readable medium may be a computer-readable signal medium or a computer-readable storage medium. A computer-readable medium may include but not limited to an electronic, magnetic, optical, electromagnetic, infrared, or semiconductor system, apparatus, or device, or any suitable combination of the foregoing. More specific examples of the computer-readable storage medium would include an electrical connection having one or more wires, a portable computer diskette, a hard disk, a random access memory (RAM), a read-only memory (ROM), an erasable programmable read-only memory (EPROM or Flash memory), an optical fiber, a portable compact disc read-only memory (CD-ROM), an optical storage device, a magnetic storage device, or any suitable combination of the foregoing. The term "non-transitory," as used herein, is a limitation of the medium itself (i.e., tangible, not a signal) as opposed to a limitation on data storage persistency (e.g., RAM vs. ROM).

[0171] Further, while operations are depicted in a particular order, this should not be understood as requiring that such operations be performed in the particular order shown or in sequential order, or that all illustrated operations be performed, to achieve desirable results. In certain circumstances, multitasking and parallel processing may be advantageous. Likewise, while several specific implementation details are contained in the above discussions, these should not be construed as limitations on the scope of the present disclosure, but rather as descriptions of features that may be specific to particular embodiments. Certain features that are described in the context of separate embodiments may also be implemented in combination in a single embodiment. Conversely, various features that are described in the context of a single embodiment may also be implemented in multiple embodiments separately or in any suitable sub-combination.

[0172] Although the present disclosure has been described in languages specific to structural features and/or methodological acts, it is to be understood that the present disclosure defined in the appended claims is not necessarily limited to the specific features or acts described above. Rather, the specific features and acts described above are disclosed as example forms of implementing the claims.

What is claimed is:

1. A terminal device comprising:

at least one processor; and

at least one memory storing instructions that, when executed by the at least one processor, cause the terminal device at least to:

receive a medium access control (MAC) control element (MAC CE) comprising at least one field for indicating an activation or deactivation status of a channel state information (CSI) report configuration, wherein the CSI report configuration comprises a plurality of sub-configurations,

and wherein the MAC CE comprises at least one further field indicating an activation or deactivation status of at least one of the plurality of sub-configurations; and

determine the activation or deactivation status of the at least one of the plurality of sub-configurations at least based on the at least one further field of the MAC CE.

2. The terminal device of claim **1**, wherein the MAC CE comprises an octet including the at least one field indicating activation status of the CSI report configuration, and wherein the MAC CE further comprises, based on the activation status of the CSI report configuration, a further octet including the at least one further field indicating the activation or deactivation status of at least one of the plurality of sub-configurations of the CSI report configuration.

3. The terminal device of claim **1**, wherein the terminal device is caused to:

perform CSI measurement using a sub-configuration having an activation status; and

report results of the CSI measurement to the network device.

4. The terminal device of claim **1**, wherein the at least one further field indicates an index of a sub-configuration or a set of sub-configurations among the plurality of sub-configurations to activate or deactivate.

5. The terminal device of claim **1**, wherein the at least one further field comprises a bitmap for the plurality of sub-configurations, and a bit in the bitmap indicates the activation or deactivation status of a sub-configuration or a set of sub-configurations among the plurality of sub-configurations.

6. The terminal device of claim 1, wherein the at least one further field indicates a number of sub-configurations among the plurality of sub-configurations to activate or deactivate, and wherein the terminal device is caused to determine activation or deactivation of at least one of the plurality of sub-configurations by:

determining an index of the at least one of the plurality of sub-configurations to activate or deactivate based on the indicated number and a defined order of indexes of the plurality of sub-configurations.

7. The terminal device of claim 1, wherein a size of the at least one further field is based on a number of the plurality of sub-configurations or sets of sub-configurations of the CSI report configuration.

8. The terminal device of claim 1, wherein the MAC CE comprises activation or deactivation statuses of multiple CSI report configurations configured at the terminal device.

9. The terminal device of claim 8, wherein the activation or deactivation statuses of the multiple CSI report configurations are included in at least one octet, wherein the at least one field comprises at least one of the following:

at least one reserved bit of the at least one octet;

at least one bit beyond the at least one octet; and

at least one additional octet other than the at least one octet.

10. The terminal device of claim 8, wherein the terminal device is caused to determine activation or deactivation of at least one of the plurality of sub-configurations by:

based on determining that the CSI report configuration has a deactivation status, determining deactivation of the plurality of sub-configurations of the CSI report configuration; or

based on determining that the CSI report configuration has an activation status, determining activation or deactivation of the at least one of the plurality of sub-configurations based on the at least one further field in the MAC CE; or

positioning the at least one field for the CSI report configuration in the MAC CE and determining activation or deactivation of at least one of the plurality of sub-configurations based on a value of the at least one field.

11. The terminal device of claim 10, wherein the positioning of the at least one field is at least based on at least one of the following:

the activation or deactivation statuses of the multiple CSI report configurations;

a number of the plurality of sub-configurations or sets of sub-configurations of each of at least one of the multiple CSI report configurations; or

an index or an identity of the CSI report configuration.

12. The terminal device of claim 8, wherein the at least one further field is at least shared between the CSI report configuration and another one of the multiple CSI report configurations.

13. The terminal device of claim 1, wherein the terminal device is caused to determine activation or deactivation of at least one of the plurality of sub-configurations by:

determining, based on the at least one further field and a threshold, activation or deactivation of at least one sub-configuration or set of sub-configurations, such that a number of activated sub-configurations or sets of sub-configurations is equal to or less than the threshold.

14. The terminal device of claim 1, wherein the activation or deactivation of at least one of the plurality of sub-configurations indicate that the at least one sub-configuration is applicable or inapplicable respectively.

15. The terminal device of claim 1, wherein a sub-configuration among the plurality of sub-configurations corresponds to or is associated with at least one of the following:

a spatial pattern;

a power level;

an energy level;

a CSI-reference signal (RS) resource;

a CSI-RS resource set;

a resource setting;

a CSI report configuration;

a codebook configuration; or

a CSI triggering state.

16. The terminal device of claim 1, wherein the CSI report configuration is for semi-persistent CSI reporting on physical uplink control channel (PUCCH).

17. A network device comprising:

at least one processor; and

at least one memory storing instructions that, when executed by the at least one processor, cause the network device at least to:

generate a medium access control (MAC) control element (MAC CE) comprising at least one field for indicating an activation or deactivation status of a channel state information (CSI) report configuration based on the activation or deactivation status of at least one of a plurality of sub-configurations of the CSI report configuration, wherein the MAC CE comprises at least one further field indicating an activation or deactivation status of at least one of the plurality of sub-configurations; and

transmit the MAC CE to a terminal device.

18. The network device of claim 17, wherein the MAC CE comprises an octet including the at least one field indicating activation status of the CSI report configuration, and wherein the MAC CE further comprises, based on the activation status of the CSI report configuration, a further octet including the at least one further field indicating the activation or deactivation status of at least one of the plurality of sub-configurations of the CSI report configuration.

19. The network device of claim 17, wherein the at least one further field indicates an index of a sub-configuration or a set of sub-configurations among the plurality of sub-configurations to activate or deactivate.

20. The network device of claim 17, wherein the at least one further field comprises a bitmap for the plurality of the sub-configurations, and a bit in the bitmap indicates an activation or deactivation status of a sub-configuration or a set of sub-configurations among the plurality of sub-configurations.

21. The network device of claim 17, wherein the at least one field indicates a number of sub-configurations among the plurality of sub-configurations to activate or deactivate.

22. The network device of claim 17, wherein a size of the at least one further field is based on a number of the plurality of sub-configurations or sets of sub-configurations of the CSI report configuration.

23. The network device of claim **17**, wherein the MAC CE further comprises activation or deactivation statuses of multiple CSI report configurations configured at the terminal device.

24. The network device of claim **17**, wherein the activation or deactivation statuses of the multiple CSI report configuration are included in at least one octet, wherein the at least one field comprises at least one of the following:

at least one reserved bit of the at least one octet;

at least one bit beyond the at least one octet; and

at least one additional octet other than the at least one octet.

25. The network device of claim **24**, wherein a position of the at least one field in the MAC CE is at least based on at least one of the following:

the activation or deactivation statuses of the multiple CSI report configuration;

a number of the plurality of sub-configurations or sets of sub-configurations of each of at least one of the multiple CSI report configurations; or

an index or an identity of the CSI report configuration.

26. The network of device of claim **23**, wherein the at least one further field is at least shared between the CSI report configuration and another one of the multiple CSI report configurations.

27. The network device of claim **17**, wherein a sub-configuration among the plurality of sub-configurations corresponds to or is associated with at least one of the following:

a spatial pattern;

a power level;

an energy level;

a CSI-reference signal (RS) resource;

a CSI-RS resource set;

a resource setting;

a CSI report configuration;

a codebook configuration; or

a CSI triggering state.

28. The network device of claim **17**, wherein the CSI report configuration is for semi-persistent CSI reporting on physical uplink control channel (PUCCH).

29. A method comprising:

receiving, at a terminal device, a medium access control (MAC) control element (MAC CE) comprising at least one field for indicating an activation or deactivation status of a channel state information (CSI) report configuration, wherein the CSI report configuration comprises a plurality of sub-configurations,

and wherein the MAC CE comprises at least one further field indicating an activation or deactivation status of at least one of the plurality of sub-configurations; and

determining the activation or deactivation status of the at least one of the plurality of sub-configurations at least based on the at least one further field of the MAC CE.

30. A method comprising:

generating, at a network device, a medium access control (MAC) control element (MAC CE) comprising at least one field for indicating an activation or deactivation status of a channel state information (CSI) report configuration based on the activation or deactivation status of at least one of a plurality of sub-configurations of the CSI report configuration, wherein the MAC CE comprises at least one further field indicating an activation or deactivation status of at least one of the plurality of sub-configurations; and

transmitting the MAC CE to a terminal device.

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