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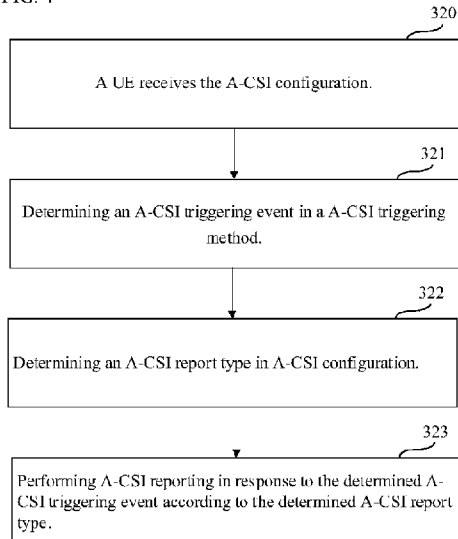
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FIG. 4



(57) Abstract: A method for aperiodic channel state information (A-CSI) feedback is executed by user equipment (UE) and a base station. The UE determines an A-CSI triggering event in a A-CSI triggering method, receives A-CSI configuration from the base station, and determines an A-CSI report type in A-CSI configuration. The UE performs A-CSI reporting in response to the determined A-CSI triggering event according to the determined A-CSI report type, such as A-CSI reporting on a physical uplink control channel (PUCCH) or a physical uplink shared channel (PUSCH). The triggering event includes at least one of negative-Acknowledgment (NACK), uplink scheduling downlink control information (UL DCI), and downlink scheduling downlink control information (DL DCI). Configuration of different A-CSI report types can be configured separately, activated and deactivated individually, and sub-selected, and signaled between the UE and the base station.

METHOD, USER EQUIPMENT, AND BASE STATION FOR APERIODIC CHANNEL STATE INFORMATION
FEEDBACK**Technical Field**

[0001] The present disclosure relates to the field of communication systems, and more particularly, to a method, user equipment, and base station for aperiodic channel state information (A-CSI) feedback.

Background Art

[0002] Wireless communication systems and networks have developed towards being a broadband and mobile system. In cellular wireless communication systems, user equipment (UE) is connected by a wireless link to a radio access network (RAN). The RAN comprises a set of base stations (BSs) which provide wireless links to the UEs located in cells covered by the base station, and an interface to a core network (CN) which provides overall network control. As will be appreciated the RAN and CN each conduct respective functions in relation to the overall network. The 3rd Generation Partnership Project (3GPP) has developed the so-called Long Term Evolution (LTE) system, namely, an Evolved Universal Mobile Telecommunication System Territorial Radio Access Network, (E-UTRAN), for a mobile access network where one or more macro-cells are supported by a base station known as an eNodeB or eNB (evolved NodeB). More recently, LTE is evolving further towards the so-called 5G or NR (new radio) systems where one or more cells are supported by a base station known as a gNB.

[0003] Ultra-reliable low-latency communication (URLLC), is one of several different types of use cases supported by the 5G NR standard, as stipulated by 3GPP Release 15. URLLC is a communication service for successfully delivering packets with stringent requirements, particularly in terms of availability, latency, and reliability. URLLC is developed to support the emerging applications and services, such as wireless control and automation in industrial factory environments, inter-vehicular communications for improved safety and efficiency, and the tactile internet. Thus, URLLC is important for 5G as it supports verticals bringing new business to the whole telecommunication industry.

[0004] One of the key features of URLLC is low latency which is the key point to make autonomous vehicle and remote surgeries possible. Low latency allows a network to be optimized for processing incredibly large amounts of data with minimal delay or latency. URLLC requires a quality of service (QoS) totally different from mobile broadband services.

[0005] URLLC guarantees latency to be 1ms or less. Time-sensitive networking (TSN) is another component of the 5G URLLC. All devices along a URLLC connection have to synchronize on the same time-base. Enabling technologies for URLLC, for example, include: integrated frame structure, incredibly fast turnaround, efficient control and data resource sharing, grant-free based uplink transmission, and advanced channel coding schemes.

Technical Problem

[0006] Channel state information (CSI) feedback enhancement can facilitate reliability and real-time nature of URLLC services. Whether to transmit aperiodic CSI (A-CSI) on physical uplink control channel (PUCCH) is a pending issue. According to previous releases of new radio (NR) standard, A-CSI reported on physical uplink shared channel (PUSCH) can only be triggered with an uplink (UL) DCI. UL DCI, such as DCI format 0_0, is a format for UL scheduling DCI used to schedule PUSCH in one cell according to technical specification (TS) 38.212 clause 7.3.1.1. However, the current A-CSI triggering method cannot be applied to some scenarios. For example, when no UL data is transmitted for scheduling in heavy DL traffic, transmitting an UL DCI only for triggering A-CSI report is not resource efficient. An UL grant, such as a UL DCI, should be avoided for URLLC services when no UL data is in

progress. Therefore, new triggering methods for A-CSI are desired.

Technical Solution

[0007] An object of the present disclosure is to propose a method, user equipment, and base station for aperiodic channel state information (A-CSI) feedback.

[0008] A first aspect of the disclosure provides a method for aperiodic channel state information (A-CSI) feedback executable in a user equipment (UE), comprising:

determining an A-CSI triggering event in a A-CSI triggering method;

determining an A-CSI report type in A-CSI configuration; and

performing A-CSI reporting in response to the determined A-CSI triggering event according to the determined A-CSI report type.

[0009] A second aspect of the disclosure provides a method for aperiodic channel state information (A-CSI) feedback executable in a base station, comprising:

determining A-CSI configuration comprising an A-CSI report type;

transmitting the A-CSI configuration in a downlink channel to trigger A-CSI reporting; and

receiving A-CSI on an A-CSI reporting channel according to the determined A-CSI report type.

[0010] A third aspect of the disclosure provides a user equipment comprising a transceiver and a processor connected with the transceiver. The processor is configured to execute the following steps comprising:

determining an A-CSI triggering event in a A-CSI triggering method;

determining an A-CSI report type in A-CSI configuration; and

performing A-CSI reporting in response to the determined A-CSI triggering event according to the determined A-CSI report type.

[0011] A fourth aspect of the disclosure provides a base station comprising a transceiver and a processor connected with the transceiver. The processor is configured to execute the following steps comprising:

determining A-CSI configuration comprising an A-CSI report type;

transmitting the A-CSI configuration in a downlink channel to trigger A-CSI reporting; and

receiving A-CSI on an A-CSI reporting channel according to the determined A-CSI report type.

[0012] The disclosed method may be implemented in a chip. The chip may include a processor, configured to call and run a computer program stored in a memory, to cause a device in which the chip is installed to execute the disclosed method.

[0013] The disclosed method may be programmed as computer executable instructions stored in non-transitory computer readable medium. The non-transitory computer readable medium, when loaded to a computer, directs a processor of the computer to execute the disclosed method.

[0014] The non-transitory computer readable medium may comprise at least one from a group consisting of: a hard disk, a CD-ROM, an optical storage device, a magnetic storage device, a Read Only Memory, a Programmable Read Only Memory, an Erasable Programmable Read Only Memory, EPROM, an Electrically Erasable Programmable Read Only Memory and a Flash memory. The disclosed method may be programmed as computer program product, that causes a computer to execute the disclosed method. The disclosed method may be programmed as computer program, that causes a computer to execute the disclosed method.

Advantageous Effects

[0015] This disclosure provides the CSI feedback enhancements for URLLC and industrial internet of things (IIOT).

In this disclosure, mainly focuses on the new triggering methods for A-CSI since the legacy A-CSI triggering method is not for all scenarios. How to transmit A-CSI on PUCCH is not clear currently. The disclosure provides several detailed embodiments for configuration of A-CSI on PUCCH. The proposed embodiments may significantly improve CSI feedback efficiency, and meet higher quality of service (QoS) requirements especially for URLLC services.

[0016] This invention mainly provides improvement at least in two aspects: the first is new triggering methods for A-CSI, the second is detailed configuration for A-CSI transmitted on PUCCH. For technical problems of the two aspects, several embodiments are given in this disclosure. For example, one embodiment provides detail solutions for downlink (DL) control information (DCI) triggered and NACK triggered A-CSI, and explain how to combine the two solutions and to use corresponding scheduling rules. Additionally, seven alternative embodiments are proposed to support A-CSI on PUCCH and corresponding detail configurations for differentiating A-CSI on PUCCH and A-CSI on PUSCH. The embodiments of the disclosure are proposed to improve the CSI resource efficiency and reduce the A-CSI feedback latency.

Description of Drawings

[0017] In order to more clearly illustrate the embodiments of the present disclosure or related art, the following figures will be described in the embodiments are briefly introduced. It is obvious that the drawings are merely some embodiments of the present disclosure, a person having ordinary skill in this field can obtain other figures according to these figures without paying the premise.

[0018] FIG. 1 is a schematic diagram showing a telecommunication system.

[0019] FIG. 2 is a schematic diagram showing a CRAN with a baseband unit pool, remote radio heads, and UEs.

[0020] FIG. 3 is a schematic diagram showing the disclosed method executed at a base station side according to an embodiment of the present disclosure.

[0021] FIG. 4 is a schematic diagram showing the disclosed method executed at a user equipment (UE) side according to an embodiment of the present disclosure.

[0022] FIG. 5 is a schematic diagram showing the disclosed method with an overwriting indication according to a first alternative embodiment of the present disclosure.

[0023] FIG. 6 is a schematic diagram showing the disclosed method with a time preference setting according to a second alternative embodiment of the present disclosure.

[0024] FIG. 7 is a schematic diagram showing the disclosed method with a priority indication according to a third alternative embodiment of the present disclosure.

[0025] FIG. 8 is a schematic diagram showing the disclosed method with pre-configured A-CSI configuration according to a fourth alternative embodiment of the present disclosure.

[0026] FIG. 9 is a schematic diagram showing the disclosed method with historical A-CSI configuration according to a fifth alternative embodiment of the present disclosure.

[0027] FIG. 10 is a schematic diagram showing pre-processing of CSI measurement and calculation for NACK-triggered A-CSI and according to a sixth alternative embodiment of the present disclosure.

[0028] FIG. 11 is a schematic diagram showing two-stage A-CSI reporting according to a eighth alternative embodiment of the present disclosure.

[0029] FIG. 12 is a schematic diagram showing same-slot A-CSI reporting according to a ninth alternative embodiment of the present disclosure.

[0030] FIG. 13 is a schematic diagram showing the disclosed method with A-CSI configurations differentiated by higher level signaling according to a tenth alternative embodiment of the present disclosure.

[0031] FIG. 14 is a schematic diagram showing the disclosed method with prioritized A-CSI reporting according to an eleventh alternative embodiment of the present disclosure.

[0032] FIG. 15 is a schematic diagram showing the disclosed method with prioritized A-CSI reporting according to a twelfth alternative embodiment of the present disclosure.

[0033] FIG. 16 is a schematic diagram showing the disclosed method with a UE selected A-CSI report type according to a thirteenth alternative embodiment of the present disclosure.

[0034] FIG. 17 is a block diagram of a system for wireless communication according to an embodiment of the present disclosure.

DETAILED DESCRIPTION OF EMBODIMENTS

[0035] Embodiments of the disclosure are described in detail with the technical matters, structural features, achieved objects, and effects with reference to the accompanying drawings as follows. Specifically, the terminologies in the embodiments of the present disclosure are merely for describing the purpose of the certain embodiment, but not to limit the disclosure.

[0036] With reference to FIG. 1, a telecommunication system including a group 100a of a plurality of UEs, a base station (BS) 200a, and a network entity device 300 executes the disclosed method according to an embodiment of the present disclosure. The group 100a of a plurality of UEs may include a UE 10a, a UE 10b, and other UEs. FIG. 1 is shown for illustrative not limiting, and the system may comprise more UEs, BSs, and CN entities. Connections between devices and device components are shown as lines and arrows in the FIGs. Connections between devices may be realized by wireless connections. Connections between device components may be realized by wirelines, buses, traces, cables or optical fabrics. The UE 10a may include a processor 11a, a memory 12a, and a transceiver 13a. The UE 10b may include a processor 11b, a memory 12b, and a transceiver 13b. The base station 200a may include a baseband unit (BBU) 204a. The base band unit 204a may include a processor 201a, a memory 202a, and a transceiver 203a. The network entity device 300 may include a processor 301, a memory 302, and a transceiver 303. Each of the processors 11a, 11b, 201a, and 301 may be configured to implement proposed functions, procedures and/or methods described in the description. Layers of radio interface protocol may be implemented in the processors 11a, 11b, 201a, and 301. Each of the memory 12a, 12b, 202a, and 302 operatively stores a variety of program and information to operate a connected processor. Each of the transceiver 13a, 13b, 203a, and 303 is operatively coupled with a connected processor, transmits and/or receives radio signals or wireline signals. The UE 10a may be in communication with the UE 10b through a sidelink. The base station 200a may be an eNB, a gNB, or one of other types of radio nodes.

[0037] Each of the processor 11a, 11b, 201a, and 301 may include a central processing unit (CPU), an application-specific integrated circuits (ASICs), other chipsets, logic circuits and/or data processing devices. Each of the memory 12a, 12b, 202a, and 302 may include a read-only memory (ROM), a random access memory (RAM), a flash memory, a memory card, a storage medium and/or other storage devices. Each of the transceiver 13a, 13b, 203a, and 303 may include baseband circuitry and radio frequency (RF) circuitry to process radio frequency signals. When the embodiments are implemented in software, the techniques described herein can be implemented with modules, units, procedures, functions, entities and so on, that perform the functions described herein. The modules can be stored in a memory and executed by the processors. The memory can be implemented within a processor or external to the processor, in which those can be communicatively coupled to the processor via various means are known in the art.

[0038] The network entity device 300 may be a node in a CN. CN may include LTE CN or 5G core (5GC) which includes user plane function (UPF), session management function (SMF), mobility management function (AMF), unified data management (UDM), policy control function (PCF), control plane (CP)/user plane (UP) separation (CUPS), authentication server (AUSF), network slice selection function (NSSF), and the network exposure function (NEF).

[0039] With reference to FIG. 2, base station 200b is an embodiment of the base station 200a and includes a central controller (CC) 210, access points 211-1, 211-2, ...and 211-M. M is a positive integer. The central controller 210 may be implemented into a central unit (CU), and may include a BBU, such as BBU 204a, in connection with the access points (APs) 211-1, 211-2, ...and 211-M. Each of the access points 211-1, 211-2, ...and 211-M may be implemented into a radio node, a remote unit (RU), or a remote radio head (RRH), and may include a transmission and reception point (TRP). The access points 211-1, 211-2, ...and 211-M may be located in different locations.

[0040] The central controller 210 receives wireless signals from a group 100b of V user equipments (UEs) through a group of M distributed radio nodes. V is a positive integer. The group of V user equipments includes UEs 10-1, 10-2, 10-3, and ...10-V. The UEs 10-1, 10-2, 10-3, and ...10-V may be located in different locations.

[0041] The considered technical problem falls in the area of high density connectivity and non-orthogonal multiple access (NOMA) in CRAN systems. In an example, a CRAN network operating in a time division duplex (TDD) mode where channel estimation is performed through uplink pilot transmission.

[0042] Each coherence slot is divided between two instances of uplink training using orthogonal uplink pilots, uplink and downlink data transmission. An embodiment of the disclosure processes uplinks from V UEs to M single antenna access points (APs). At each time slot, each AP performs uplink channel estimation independently.

[0043] The APs 211-1, 211-2, ...and 211-M are distributed within a coverage area and are managed by the central controller 210 that contains a centralized baseband unit (BBU) pool and handles operations of a physical layer and a medium access control (MAC) layer, such as data decoding and encoding, scheduling, and power allocation. The APs are linked to the central controller 210 through high performance transport links known as fronthaul. Fronthaul may be implemented by optical cables or high bandwidth wireless channels. The system in FIG. 2 including the base station 200b and the UEs is a simplified example of a CRAN. The APs 211-1, 211-2, ...and 211-M perform channel estimation and the link level transmission chain until equalization. The central controller 210 performs signal decoding, encoding, modulation, demodulation, scheduling and MAC layer operations. Uplink (UL) transmission of a control signal or data may be a transmission operation from a UE to a base station. Downlink (DL) transmission of a control signal or data may be a transmission operation from a base station to a UE.

[0044] With cross reference to FIG. 3 and FIG. 4, a base station, such as the base station 200a, and a UE, such as one of the UE 10a or UE 10b, execute a method for aperiodic channel state information (A-CSI) feedback. The base station determines A-CSI configuration comprising an A-CSI report type for A-CSI reporting (block 310), and transmits the A-CSI configuration in a downlink channel to trigger A-CSI reporting (block 311). The A-CSI configuration may be transmitted in form of a control signal including UL DCI, DL DCI, a radio resource control (RRC) parameter, and a medium access control (MAC) control element (CE), or in form of a combination of the control signals.

[0045] The UE receives the A-CSI configuration (block 320). The UE determines an A-CSI triggering event in a A-CSI triggering method (block 321), and determines an A-CSI report type in A-CSI configuration (block 322). The A-CSI report type indicates an A-CSI reporting channel. The UE performs A-CSI reporting in response to the

determined A-CSI triggering event according to the determined A-CSI report type (block 323). A-CSI is sent by the UE on an A-CSI reporting channel indicated by the A-CSI report type. The base station receives A-CSI on the A-CSI reporting channel according to the determined A-CSI report type (block 312).

A-CSI is triggered by DL scheduling DCI:

[0046] In an embodiment, an A-CSI report can be triggered by a DL grant for scheduling a PDSCH transmission. The DL grant may be a DL DCI of a DCI format. DL DCI is DL scheduling DCI used to schedule PDSCH. If retransmission of the PDSCH is needed, the triggered A-CSI may be used to determine the modulation and coding scheme (MCS) parameters for the retransmission. In the description, CSI and a CSI report are interchangeably used.

[0047] First of all, a new indicator parameter is defined in a DL DCI format as an indication mechanism to trigger an A-CSI report. The indication mechanism in previous releases of NR standard may be reused. For example, a new *n*-bits *CSI request* field may be included in a DL DCI format. The DCI format may include, for example, any combination of DCI format 1_0, DCI format 1_1, DCI format 1_2, and other DCI formats for scheduling PDSCH. And the number of '*n*' may be determined by a higher layer parameter, such as a radio resource control (RRC) parameter *reportTriggerSize*. The parameter *reportTriggerSize* may be reused and configured for an UL DCI triggering A-CSI. Alternatively, a new parameter, such as *reportTriggerSize_DL*, may be introduced to specifically indicate such DL DCI.

[0048] Additionally, for the coexistence of A-CSI triggered by DL DCI and A-CSI triggered by UL DCI, some scheduling rules need to be defined:

- The DL DCI triggering A-CSI may be specifically for an URLLC service:

Since an URLLC service requires higher transmit reliability and lower latency, decoding failure followed by data retransmission is not desired. To ensure that the retransmitted data can be decoded successfully, the CSI report needs to be reported timely. However, for the eMBB service, the latency requirement is not stringent, and the network can schedule the data retransmission using the information reported by periodic CSI. Thus, the CSI report triggered by the DL DCI brings more benefits to the URLLC service. The base station may enable DL DCI triggering A-CSI specifically for the service type of URLLC.

- The network may trigger A-CSI by a DL grant only when scheduling a PDSCH:
The DL DCI triggering method may improve signaling efficiency. During no UL data transmission, sending a UL DCI dedicated to trigger A-CSI is not efficient control signaling. Similarly, transmitting DL DCI to trigger A-CSI without PDSCH scheduled is also inefficient. Thus, the network may trigger A-CSI by a DL grant only when scheduling a PDSCH. The base station may trigger A-CSI by a DL grant, such as in form of DL DCI, only when the DL DCI is configured to schedule a physical downlink shared channel (PDSCH). The UE receives the DL DCI scheduling a PDSCH and performs A-CSI reporting in response to the DL DCI. Transmission of the DL scheduling DCI is bundled with transmission of a PDSCH.
- When A-CSI triggered by DL DCI and A-CSI triggered by UL DCI exist at the same time, the following options are provided to solve the coexistence of DL DCI triggered A-CSI and UL DCI triggered A-CSI:

- Option 1: Since A-CSI triggered by DL DCI has higher priority and more stringent low latency requirements, A-CSI triggered by DL DCI may override A-CSI triggered by UL DCI. With reference to FIG. 5, the base station may transmit an overwriting indication to the UE that the DL scheduling DCI overwrites a UL scheduling DCI for A-CSI reporting (block 310a) and transmits a DL DCI for triggering A-CSI and a UL DCI for triggering A-CSI to a UE (block 311a). When receiving a DL DCI for triggering A-CSI and a UL DCI for triggering A-CSI (block 330), a UE, such as one of the UE 10a or 10b, may perform A-CSI reporting according to the DL DCI overwriting the UL DCI which may be received by the UE before or after the DL DCI (block 331). The base station receives the CSI feedback (block 312a).
- Option 2: A UE may subject to one of an earlier or a later triggering signal. That is, a time preference setting indicates one of an earlier received DCI or a later received DCI as an active A-CSI triggering DCI for triggering A-CSI reporting. The time preference setting may be determined by a network entity, such as the base station, and sent to the UE. Alternatively, the time preference setting may be determined by the UE. With reference to FIG. 6, the base station transmits A-CSI configuration including time preference setting to a UE (block 311b). The UE obtains the time preference setting (block 333) and performs A-CSI reporting to a base station in response to the active A-CSI triggering DCI according to the time preference setting (block 334). The base station receives the CSI feedback (block 312b).
- Option 3: With reference to FIG. 7, the base station determines one of DL DCI triggered A-CSI reporting or UL DCI triggered A-CSI reporting as a prioritized A-CSI triggering method (block 340) and transmits an indication that indicates the determined prioritized A-CSI triggering method to the UE by DCI or higher layer parameters, such as a radio resource control (RRC) signal (block 341). The UE receives the indication of the determined prioritized A-CSI triggering method (block 342), and performs A-CSI reporting to a base station according to the prioritized A-CSI triggering method (block 343). The UE receives the indication indicating one of DL scheduling DCI triggered A-CSI reporting or UL scheduling DCI triggered A-CSI reporting. The UE receives an UL DCI of a DCI format comprising a field of CSI request for triggering A-CSI reporting, and a DL DCI of a DCI format comprising a field of CSI request for triggering A-CSI reporting. The UE performs the A-CSI reporting in response to the UL scheduling DCI when the indication indicates the UL scheduling DCI triggered A-CSI reporting, or performs the A-CSI reporting in response to the DL scheduling DCI when the indication indicates the DL scheduling DCI triggered A-CSI reporting.
- Separate configurations of *aperiodicTriggeringOffset*:

The higher layer parameter *aperiodicTriggeringOffset* is configured in IE *NZP-CSI-RS-ResourceSet* for A-CSI triggering UL DCI. The parameter *aperiodicTriggeringOffset* represents an offset X between a time slot containing a DCI that triggers a set of aperiodic NZP CSI-RS resources and a time slot in which the set of

aperiodic non-zero-power (NZP) CSI-RS resources is transmitted. This parameter for DL DCI triggering may be configured separately from the UL DCI triggering. A parameter is configured for UL scheduling DCI to represent an offset X between a time slot containing a UL scheduling DCI that triggers a set of aperiodic non-zero-power (NZP) CSI-RS resources and a time slot in which the set of aperiodic NZP CSI-RS resources is transmitted. Similarly, another parameter such as *aperiodicTriggeringOffset_DL* may be included in IE *NZP-CSI-RS-ResourceSet* for A-CSI triggering DL DCI to represent an offset X between a time slot containing a DL DCI that triggers a set of aperiodic NZP CSI-RS resources and a time slot in which the set of aperiodic NZP CSI-RS resources is transmitted.

[0049] An embodiment of the invention may utilize any combination of the rules described above. An example of the UE in the description may include one of the UE 10a or UE 10b. An example of the base station in the description may include the base station 200a. A-CSI reporting or A-CSI feedback is performed on an uplink from a UE to a base station. In the description, a CSI report and a CSI are interchangeably used. Additionally, HARQ-ACK represents HARQ feedback which may include acknowledgment (ACK) and negative-acknowledgment (NACK). Downlink control information (DCI) of a DCI format is sent from a BS, such as the BS 200a, to a UE, such as the UE 10a or the UE 10b. Radio resource control parameters includes a parameter carried in an RRC control signal sent from a BS, such as the BS 200a, to a UE, such as the UE 10a or the UE 10b. The term “network” may include a base station, a CN network entity, or a combination of a base station and a CN network entity.

A-CSI is triggered by NACK:

[0050] An embodiment of the invention provides A-CSI triggered by NACK as an alternative triggering method for A-CSI reporting. The NACK triggered A-CSI reporting may include two cases: the first one is A-CSI triggered by NACK without DCI scheduling, and the second one is NACK triggering with DCI scheduling.

[0051] For the first case, A-CSI triggered by NACK without DCI scheduling has one problem needs to be solved: how to indicate to the UE detailed configuration of A-CSI reporting. According to technical specification (TS) 38.321 clause 6.1.3.13, each codepoint of a DCI field “CSI request” is associated with one trigger state that is configured in RRC information element (IE) *CSI-AperiodicTriggerStateList*. IE *CSI-AperiodicTriggerStateList* is configured to provide a UE with a list of aperiodic trigger states. For each trigger state, the *associatedReportConfigInfoList* in RRC IE *CSI-AperiodicTriggerStateList* provides resource information for various types of CSI measurement. Upon receiving a value representing a codepoint associated with a trigger state, the UE may perform measurement of CSI reference signals (CSI-RS), CSI interference measurement (CSI-IM) and/or synchronization signal block (SSB) and A-CSI reporting on L1 according to all entries in the *associatedReportConfigInfoList* for the received trigger state. Since A-CSI triggered by NACK without DCI cannot provide such resource information to the UE, the UE cannot perform the A-CSI reporting.

[0052] In an embodiment of the invention, a base station indicates A-CSI configuration for A-CSI reporting to the UE without DCI. In a first example of the embodiment, the UE is pre-configured with the resource information and triggering information associated with A-CSI reporting. For example, default A-CSI configuration may be pre-stored in the UE. When the NACK triggered CSI reporting is performed, the UE may perform the A-CSI reporting based on this pre-stored A-CSI configuration. In a second example of the embodiment, the base station may indicate default A-CSI configuration to the UE by higher layer signaling, such as an RRC parameter. The default A-CSI configuration for example may be configured and shown in *CSI-MeasConfig*. This default A-CSI configuration may be defined as

DefaultCSIRequest in the UE when no A-CSI triggering DCI or CSI request field is provided in DCI to the UE. The UE may perform A-CSI reporting based on configuration information provided by *DefaultCSIRequest*.

With reference to FIG. 8, the base station transmits a downlink transmission, such as PDCCH or PDSCH, to the UE (block 350). The UE receives and decodes the downlink transmission (block 351). When decoding of the downlink transmission is failed, the UE generates a negative-Acknowledgment (NACK) as HARQ feedback to the downlink transmission. The UE determines the NACK responding to the downlink transmission as the A-CSI triggering event, and triggers A-CSI reporting to the base station in response to the NACK (block 352). In reporting A-CSI, the UE retrieves pre-configured A-CSI configuration to perform CSI measurement and calculation (block 353), and uses a result of the CSI measurement and calculation as CSI feedback for the A-CSI reporting (block 354). The base station receives the CSI feedback (block 355).

[0053] Additionally, if the historical DCI contains one or more CSI requests, the UE may obtain the default A-CSI configuration from historical DCI. The UE may also reuse the resource information and triggering information from the historical DCI associated with A-CSI reporting as the default A-CSI configuration. That is, the UE may perform the A-CSI measurement using the resource information and perform A-CSI reporting using the triggering information from the historical DCI. However, without historical DCI, the UE may use other solutions.

[0054] With reference to FIG. 9, the base station transmits a downlink transmission, such as PDCCH or PDSCH, to the UE (block 360). The UE receives and decodes the downlink transmission (block 361). When decoding of the downlink transmission is failed, the UE generates a negative-Acknowledgment (NACK) as HARQ feedback to the downlink transmission. The UE determines the NACK responding to the downlink transmission as the A-CSI triggering event, and triggers A-CSI reporting to the base station in response to the NACK (block 362). In reporting A-CSI, the UE obtains A-CSI configuration from historical A-CSI configuration to perform CSI measurement and calculation (block 363), and uses a result of the CSI measurement and calculation as CSI feedback for the A-CSI reporting (block 364). The base station receives the CSI feedback (block 365).

[0055] A-CSI triggered by NACK with DCI scheduling has one problem: when to start the A-CSI measurement and calculation. The UE performs A-CSI measurement and calculation after recognizing whether a HARQ feedback to be sent to the base station is ACK or NACK may prolong A-CSI reporting and increase latency. Some embodiments of the invention to address the problem are provided in the following.

Always calculating A-CSI report for URLLC:

[0056] To meet the latency requirement of URLLC services, the UE may perform A-CSI measurement and calculation in response to each CSI request indicated by DCI. With reference to FIG. 10, the base station transmits a plurality of DCI signals with CSI requests to a UE (block 370). The UE receives the DCI signals with CSI requests and performing A-CSI measurement and calculation in response to each CSI request indicated by the DCIs (block 371). When decoding of the downlink transmission is failed, the UE generates a negative-Acknowledgment (NACK) as HARQ feedback to the downlink transmission. The UE determines the NACK responding to the downlink transmission as the A-CSI triggering event, and triggers A-CSI reporting to the base station in response to the NACK (block 372). In reporting A-CSI, the UE uses a result of the CSI measurement and calculation as CSI feedback for the A-CSI reporting (block 374). The base station receives the CSI feedback (block 375).

[0057] When performs A-CSI reporting in response to a NACK according to the NACK triggered A-CSI reporting method, the UE may transmit the A-CSI together with the HARQ feedback of NACK. The base station can schedule

data retransmission associated with the HARQ feedback based on the A-CSI. Alternatively, the HARQ feedback may also be omitted during the A-CSI reporting to improve the signaling efficiency, since the A-CSI report may represent that the HARQ-ACK is NACK.

Simplified A-CSI report:

[0058] Different from the previous solution, A-CSI measurement and calculation may be performed after the result of HARQ-ACK is obtained. To report A-CSI timely, the A-CSI reported may be simplified, for example, by reporting only a portion of the A-CSI. The portion of the A-CSI may be reported first, and the remaining portion of the A-CSI may then be optionally reported on available resources. With reference to FIG. 11, the UE performs A-CSI reporting in response to an A-CSI triggering event (block 381). In performing the A-CSI reporting, the UE reports a first portion of the A-CSI to the base station in a first stage of the A-CSI reporting (block 383), and reports a second portion of the A-CSI to the base station in a second stage of the A-CSI reporting (block 385), thus to form two-stage A-CSI reporting. The base station receives the first portion of the A-CSI in a first stage (block 384) and the second portion of the A-CSI in a second stage (block 386). The portion of A-CSI which reported first may have higher priority and be reported together with the HARQ-ACK. Determination of the CSI priority may follow priority rules defined in TS 38.214 section 5.2.5. *DCI format in the embodiment may be UL DCI or DL DCI.*

[0059] The A-CSI triggering method used by the UE may be adapt to various A-CSI use cases to provide flexibility for different scenarios. The A-CSI triggering method may be configured by DCI or higher layer parameters, such as a RRC parameter, as an indication of an A-CSI trigger method. This parameter may be *ACSITriggerMethodInd*. As shown in Table 1, for example, the base station sends to the UE *ACSITriggerMethodInd* = 0 to activate the A-CSI triggered by DL DCI, *ACSITriggerMethodInd* = 1 to activate the A-CSI triggered by NACK with DCI scheduling, *ACSITriggerMethodInd* = 2 to activate the A-CSI triggered by NACK without DCI scheduling, and *ACSITriggerMethodInd* = 3 to activate one of other A-CSI triggering methods.

Table 1

Values of Parameter <i>ACSITriggerMethodInd</i>	A-CSI triggering method activated
0	A-CSI triggered by DL DCI
1	A-CSI triggered by NACK with DCI scheduling
2	A-CSI triggered by NACK without DCI scheduling
3	one of other A-CSI triggering methods

[0060] The UE receives the indication of an activated A-CSI triggering method and performs A-CSI reporting in response to an A-CSI triggering event according to the activated A-CSI triggering method. It may be noted that the triggering methods detailed above are not limited to one A-CSI reporting channel. The UE may report A-CSI on PUCCH, PUSCH or other channels.

Detailed solutions for A-CSI on PUCCH:

[0061] A-CSI reporting on PUCCH is desirable. A-CSI on PUCCH may enhance scheduling flexibility for the base station, and reduce signalling overhead. Allocating an entire PUSCH transmission for few bits of CSI is inefficient. An embodiment of the invention may provide same-slot CSI feedback. With reference to FIG. 12, the base station

transmits a DCI the UE to trigger same-slot CSI feedback (block 390). The UE receives the DCI from the base station in the beginning of one time slot (block 391) and performs same-slot CSI feedback. In performing same-slot CSI feedback, the UE triggers a short PUCCH carrying A-CSI to the base station before the end of the same time slot in response to the DCI received in the beginning of the same time slot (block 392). The base station receives the A-CSI in the short PUCCH (block 395). The same-slot CSI feedback facilitates very fast CSI feedback which improves the CSI accuracy, especially in case of fast moving UE or rapid interference variation.

Configurations for A-CSI on PUCCH:

[0062] A-CSI on PUCCH also induce many technical problems to be solved, including, for example, how to configure the related configuration parameters for A-CSI on PUCCH, whether to distinguish configuration parameters of A-CSI on PUCCH and A-CSI on PUSCH, how to coordinate the relationship between A-CSI on PUCCH and A-CSI on PUSCH, and others. Some embodiments are provided in the following to address such technical problems.

Separate configurations in DCI for A-CSI on PUCCH and A-CSI on PUSCH:

[0063] In an embodiment, the base station may configure A-CSI on PUCCH and A-CSI on PUSCH separately and indicate the A-CSI configurations to one or more UEs. That is to say, all the related configuration of A-CSI reporting may be configured separately for PUCCH and PUSCH.

[0064] An A-CSI report is triggered with DCI by indicating which CSI report shall be reported in the CSI request field. The *CSI request* field is configured in the A-CSI triggering DCI. The *CSI request* field in DCI may be configured separately for A-CSI on PUCCH and A-CSI on PUSCH. That is, the base station configures a CSI request field in the A-CSI triggering DCI for A-CSI reporting on PUCCH and a CSI request field in the A-CSI triggering DCI for A-CSI reporting on PUSCH. The base station transmits A-CSI configuration comprising the CSI request field for A-CSI reporting on PUCCH and the CSI request field for A-CSI reporting on PUSCH to the UE in form of the A-CSI triggering DCI. The UE receives the A-CSI configuration in form of the A-CSI triggering DCI, and performs A-CSI reporting according to the A-CSI configuration. For A-CSI on PUSCH, the original configuration in previous releases can be retained. For A-CSI on PUCCH, a new parameter can be configured. For example, the new parameter for A-CSI on PUCCH may be referred to as *a CSI request for PUCCH*. The *CSI request* for A-CSI on PUSCH may be a n1-bit(s) parameter which is determined by higher layer parameter *reportTriggerSize*. Accordingly, a *CSI request for PUCCH* may be an n2-bit(s) parameter which is determined by higher layer parameter *reportTriggerSize_PUCCH*. The values of n1 and n2 are configured by higher layer parameters *reportTriggerSize* and *reportTriggerSize_PUCCH* individually, which can be the same or different.

[0065] The parameter *aperiodicTriggerStateList* is a A-CSI trigger state list comprising a list of trigger states for one or more A-CSI reporting configurations and resource sets for channel and/or interference measurement. When the number of CSI trigger states in *aperiodicTriggerStateList* is less than or equal to the number of code-points in *CSI request*, the *CSI request* field in the A-CSI triggering DCI directly indicates one the triggering states. The parameter *aperiodicTriggerStateList* may be configured separately to distinguish configuration for A-CSI on PUCCH and configuration for A-CSI on PUSCH. For example, *aperiodicTriggerStateList_forPUCCH* may be introduced to indicate the list of trigger states for A-CSI on PUCCH. Additionally, a new CSI report type '*aperiodicOnPUCCH*' may be introduced for the higher layer parameter *CSI-ReportConfig* to indicate the A-CSI reporting on PUCCH, and the original '*aperiodic*' in *CSI-ReportConfig* represents A-CSI on PUSCH. A CSI report type is a mode where CSI reporting is performed on one type of channels, such as PUCCH or PUSCH. A CSI report type may be referred to as a CSI mode or a CSI transmission mode in the description.

[0066] The base station configures an A-CSI trigger state list in the A-CSI triggering DCI for A-CSI reporting on PUCCH and an A-CSI trigger state list in the A-CSI triggering DCI for A-CSI reporting on PUSCH. The base station transmits A-CSI configuration comprising the A-CSI trigger state list for A-CSI reporting on PUCCH and the A-CSI trigger state list for A-CSI reporting on PUSCH to the UE in form of the A-CSI triggering DCI, and the UE receives the A-CSI configuration in form of the A-CSI triggering DCI, and performs A-CSI reporting according to the A-CSI configuration.

Separate RRC configurations for A-CSI on PUCCH and A-CSI on PUSCH:

[0067] Different from the previous solution, in this embodiment, the configurations for A-CSI on PUCCH and A-CSI on PUSCH are only separated in higher layers while A-CSI triggering DCI has only one *CSI request* being configured, thus to save DCI signalling overhead. The configuration of RRC parameters for the A-CSI reporting is the same as described in the previous embodiment while the RRC parameters *reportTriggerSize*, *aperiodicTriggerStateList*, *CSI-ReportConfig* or other parameters related to A-CSI reporting may be configured separately for A-CSI reporting on PUCCH and A-CSI reporting on PUSCH. The base station may use a 1-bit indication to notify the UE of on which channel the A-CSI reporting is performed. This 1-bit parameter can be configured by DCI or higher layer parameters, such as an RRC parameter.

[0068] With reference to FIG. 13, the base station transmits common A-CSI configuration in a DCI for different A-CSI report types and separate A-CSI configurations in an RRC signal for different A-CSI report types to the UE (block 400). The DCI may be UL scheduling DCI or DL scheduling DCI. The common A-CSI configuration in the DCI is shared by an A-CSI report type of A-CSI reporting on a PUCCH and an A-CSI report type of A-CSI reporting on a PUSCH. The separate A-CSI configuration in the RRC signal comprises one or more RRC parameters for the A-CSI report type of A-CSI reporting on the PUCCH and one or more RRC parameters for the A-CSI report type of A-CSI reporting on the PUSCH. The UE receives the common A-CSI configuration in the DCI and the separate A-CSI configurations in the RRC signal (block 401). The UE performs A-CSI reporting to transmit CSI feedback according to the common A-CSI configuration and the separate A-CSI configurations (block 403). The base station receives the CSI feedback (block 406).

Unified configuration for A-CSI on PUCCH and A-CSI on PUSCH:

[0069] An embodiment with less impact on the current protocol is to keep the existing configuration mechanism unchanged and not to configure A-CSI reporting on PUCCH and A-CSI reporting on PUSCH separately. In other words, two A-CSI transmission modes, that is, A-CSI reporting on PUCCH and A-CSI reporting on PUSCH, do not coexist, and only one of the A-CSI transmission modes is enabled in each A-CSI reporting. A mode of A-CSI reporting on a channel is referred to as a CSI mode or a CSI transmission mode. Without a mechanism to inform the UE on which channel a current A-CSI report is transmitted, the UE cannot recognize the currently enable A-CSI transmission mode. Embodiments are provided in the following to address the problem.

a) Indication determined by DCI or higher layers:

In an embodiment, the A-CSI configuration comprises an A-CSI report type indication indicating one of an A-CSI report type of A-CSI reporting on the PUCCH or an A-CSI report type of A-CSI reporting on the PUSCH as the determined A-CSI report type. The UE performs the A-CSI reporting in the determined A-CSI report type according to the A-CSI configuration. The base station use an A-CSI report type indication parameter *AperiodicCSIMode* in DCI or higher layer parameters, such as an RRC parameter, to inform the UE about the A-

CSI transmission mode. The A-CSI transmission mode represents A-CSI reporting on one type of uplink channel for A-CSI reporting. The new indication parameter *AperiodicCSIMode* of only 1 bit may be sufficient to indicate one of PUCCH or PDSCH. As shown in Table 2, for example, *AperiodicCSIMode* = 0 represents A-CSI reporting on PUCCH, and *AperiodicCSIMode* = 1 represents A-CSI reporting on PUSCH.

Table 2

Value of A-CSI report type indication parameter <i>AperiodicCSIMode</i>	A-CSI transmission mode/A-CSI report type
0	A-CSI reporting on PUCCH
1	A-CSI reporting on PUSCH

b) Distinguished by different DCI formats:

The A-CSI mode can also be distinguished by a DCI format to the DCI signalling overhead. For example, the base station may use a first UL DCI format to trigger A-CSI reporting on PUSCH, and a second DL DCI format to trigger A-CSI reporting on PUSCH. Alternatively, DCI formats may be classified to separately trigger a CSI transmission mode. That is, each DCI format represents an A-CSI transmission mode. Each of A-CSI reporting on PUCCH and A-CSI reporting on PUSCH is triggered by a unique DCI format. In an example where the base station uses DL DCI to trigger A-CSI, the base station may use DCI format1_0 to trigger A-CSI reporting on PUCCH as the determined A-CSI report type, and DCI format1_1 to trigger A-CSI reporting on PUSCH as the determined A-CSI report type according to a mapping relationship between a DCI format and a CSI mode. Optionally this mapping relationship may be configurable, and determined by a network entity.

c) New RNTI

The A-CSI mode may be indicated by a new radio network temporary identifier (RNTI). The new RNTI may include *A-CSI-PUCCH-RNTI*. For A-CSI reporting on PUCCH, the base station may scramble the CSI request field in DCI with *A-CSI-PUCCH-RNTI* to activate one of the trigger states for A-CSI reporting on PUCCH. On the other hand, the base station may use the CSI request field in DCI without being scrambled by *A-CSI-PUCCH-RNTI* to activate one of the trigger states for A-CSI reporting on PUSCH. Similarly, this new RNTI may include an *A-CSI-PUSCH-RNTI* used to scramble the CSI request field in DCI. The base station may scramble the CSI request field in DCI with *A-CSI-PUSCH-RNTI* to activate one of the trigger states for A-CSI reporting on PUSCH. On the other hand, the base station may use the CSI request field in DCI without being scrambled by *A-CSI-PUSCH-RNTI* to activate one of the trigger states for A-CSI reporting on PUCCH.

A-CSI activation/deactivation by MAC CE:

[0070] In an embodiment, the base station and the UE may distinguish the configuration of one of A-CSI on PUCCH or A-CSI on PUSCH from the other through a new medium access control (MAC) control element (CE). The advantage of this embodiment is that the configuration of A-CSI on PUSCH can be same with current standard, and the impact on the current protocol may be minimized. Activation and deactivation of A-CSI on PUCCH can be triggered by the new MAC CE. The base station may use a new CSI report type '*aperiodicOnPUCCH*' in the higher layer parameter *CSI-ReportConfig* to indicate a report type of the A-CSI reporting on PUCCH.

[0071] Activation and deactivation of the A-CSI reporting on PUCCH may be identified by a MAC sub-header with logic channel identifier (LCID) in a MAC CE. For example, the MAC CE is X-bits and comprises several fields, such as serving cell ID, bandwidth part (BWP) ID, status indications, reserved bits, and others. The serving cell ID field indicates an identity of a serving cell for which the MAC CE applies. The BWP ID field indicates a UL BWP for which the MAC CE applies as a codepoint of the DCI BWP ID field. The field of status indications indicates the activation and deactivation status of the A-CSI configuration within a list *csi-ReportConfigToAddModList* which is configured in *CSI-MeasConfig*. The list *csi-ReportConfigToAddModList* is a list of a plurality of A-CSI configurations.

[0072] The MAC CE comprises several status indications. The field of status indications may comprise m-bits, and be denoted as a variable S_i to represent a codepoint in the field, where a value of i may be in a range from 0 to $2^m - 1$. One codepoint in the field of a status indication that indicates activation or deactivation of an entry of the list of A-CSI configurations. A codepoint S_i in the field of the status indication refers to A-CSI configuration which includes PUCCH resources for A-CSI reporting in an indicated bandwidth part (BWP) and has a j-th CSI report configuration identifier within the list with a report type set to the A-CSI report type of A-CSI reporting on the PUCCH. The variable j be derived from i. For example, $j=i+1$. For example, a first code point S_0 refers to A-CSI configuration which includes PUCCH resources for A-CSI reporting in the indicated BWP and has the lowest *CSI-ReportConfigId* within the list *csi-ReportConfigToAddModList* with a report type set to *aperiodicOnPUCCH*, and a second codepoint S_1 refers to A-CSI configuration which includes PUCCH resources for A-CSI reporting in the indicated BWP and has the second lowest *CSI-ReportConfigId* within the list *csi-ReportConfigToAddModList* with a report type set to *aperiodicOnPUCCH*, and so on. If the number of CSI configurations in the list with a CSI report type set to *aperiodicOnPUCCH* in the indicated BWP is less than 2^m , an MAC entity in the UE may apply all of the CSI configurations disregarding the S_i field. The S_i field is set to 1 to indicate that a corresponding A-CSI configuration i referred by the S_i field shall be activated. The S_i field is set to 0 to indicate that the corresponding A-CSI configuration i referred by the S_i field shall be deactivated.

[0073] Similarly, the configurations can also be applied to A-CSI reporting on PUSCH. For example, the A-CSI reporting on PUSCH may be activated and deactivated by the MAC CE, and the A-CSI reporting on PUCCH may use the legacy configuration mechanism. Activation and deactivation of the A-CSI reporting on PUSCH may be identified by a MAC sub-header with logic channel identifier (LCID) in a MAC CE. For example, the MAC CE is X-bits and comprises several fields, such as serving cell ID, bandwidth part (BWP) ID, status indications, reserved bits, and others. The serving cell ID field indicates an identity of a serving cell for which the MAC CE applies. The BWP ID field indicates a UL BWP for which the MAC CE applies as a codepoint of the DCI BWP ID field.

[0074] The field of status indications indicates the activation and deactivation status of the A-CSI configuration within *csi-ReportConfigToAddModList* which is configured in *CSI-MeasConfig*. The MAC CE comprises several status indications. The field of status indications may comprise m-bits, and be denoted as a variable S_i to represent a codepoint in the field, where a value of i may be in a range from 0 to $2^m - 1$. S_0 refers to A-CSI configuration which includes PUSCH resources for A-CSI reporting in the indicated BWP and has the lowest *CSI-ReportConfigId* within the list *csi-ReportConfigToAddModList* with type set to *aperiodicOnPUSCH*, S_1 refers to A-CSI configuration which includes PUSCH resources for A-CSI reporting in the indicated BWP and has the second lowest *CSI-ReportConfigId* within the list *csi-ReportConfigToAddModList* with type set to *aperiodicOnPUSCH* and so on. If the number of CSI configurations in the list with a CSI report type set to *aperiodicOnPUSCH* in the indicated BWP is less than 2^m , an MAC entity in the UE may apply all of the CSI configurations disregarding the S_i field. The S_i

field may be set to 1 to indicate that a corresponding A-CSI configuration i referred by the S_i field is activated. The S_i field is set to 0 to indicate that the corresponding A-CSI configuration i referred by the S_i field is deactivated.

Trigger states subselection MAC CE

[0075] The difference between the configurations of A-CSI reporting on PUCCH and A-CSI reporting on PUSCH lies in which channel is used to transmit A-CSI. The resource information including parameters and configuration for A-CSI measurement and calculation can be the same and reused by the UE for A-CSI measurement and calculation no matter whether the UE reports and transmits A-CSI on PUCCH or PUSCH. In other words, the configuration of *CSI request* in DCI may only be configured once for A-CSI on PUSCH, and configuration of *CSI request* in DCI including the trigger states for A-CSI reporting on PUCCH may be a subset of the configuration for A-CSI reporting on PUSCH. Accordingly, a MAC CE for subselection of A-CSI configuration is proposed and referred to as a subselection MAC CE.

[0076] Similar to the previous embodiment, a new CSI report type 'aperiodicOnPUCCH' in the higher layer parameter *CSI-ReportConfig* may indicate the report type for the A-CSI reporting on PUCCH. The subselection MAC CE may be identified by a MAC sub-header with LCID. The MAC CE may comprise Y-bits and include several parts, such as serving cell ID, BWP ID, trigger state subselection, DCI format indication, reserved bit, and others. The field of serving cell ID indicates the identity of a serving cell for which the MAC CE applies. The BWP ID field indicates a UL BWP for which the MAC CE applies as a codepoint of the DCI BWP ID field. The field of trigger state subselection indicates selection status of the aperiodic trigger states configured within *aperiodicTriggerStateList*. The *aperiodicTriggerStateList* may be an A-CSI configuration for A-CSI reporting on PUSCH or a pre-stored A-CSI configuration for A-CSI reporting on PUCCH. Selection status of a trigger state indicate whether the referred trigger state is selected from the trigger states in the list *aperiodicTriggerStateList*. Codepoints in the field of trigger state subselection refers to the trigger states in the list *aperiodicTriggerStateList* ordinally. Each codepoint in the field of trigger state subselection refers to one trigger state in the list *aperiodicTriggerStateList* and indicate whether the referred trigger state is selected from the trigger states in the list *aperiodicTriggerStateList*.

[0077] The field of trigger state subselection in the subselection MAC CE may comprise k-bits, and be denoted as a variable T_i representing a codepoint in the field of trigger state subselection, where a value of i may be in a range from 0 to $2^k - 1$. A codepoint T_i in the field of the trigger state subselection indicates that a j-th trigger state in the list of trigger states is selected or not in the subselection for A-CSI reporting, where $j=i+1$. For example, T_0 refers to a first aperiodic trigger states configured in *aperiodicTriggerStateList*, T_1 refers to a second aperiodic trigger states configured in *aperiodicTriggerStateList*, and so on. The T_i field may set to 1 to indicate that an associated j-th trigger state referred by the T_i field is selected in the subselection for A-CSI reporting. The T_i field may be set to 0 to indicate that an associated j-th trigger state referred by the T_i field is not selected in the subselection. The variable j can be derived from i. For example, $j=i+1$. The *aperiodicTriggerStateList* may be an A-CSI configuration for A-CSI reporting configured in one of DCI formats. Additionally, the subselection MAC CE may be applied to subselection of A-CSI configuration from an A-CSI configuration for an arbitrary CSI report type.

[0078] And the field of DCI format indication indicates which A-CSI trigger state list this MAC CE refers to, since different DCI format may correspond to different *aperiodicTriggerStateList*.

Separate transmission of A-CSI

[0079] A-CSI on PUCCH may reduce signalling overhead and improve the feedback efficiency especially for URLLC service. However, the base station does not necessarily need all CSI reports to determine MCS, especially

for URLLC services which have very high requirements for low latency and high reliability. Hence, in an embodiment, the UE may report A-CSI separately for MCS determination by the base station. With reference to FIG. 14, the UE performs A-CSI reporting in response to an A-CSI triggering event to generate A-CSI and determines a portion of the A-CSI as a first portion of high importance for MCS determination and a portion of the A-CSI as a second portion of low importance for MCS determination (block 411). The UE may report the first portion of the A-CSI of high importance for MCS determination on a PUCCH (block 413), and the second portion of the A-CSI with low importance for MCS determination on available resources of a PUSCH optionally (block 415). The base station receives the first portion of the A-CSI on the PUCCH (block 414) and determines MCS based on the first portion of the A-CSI (block 416). The base station receives the second portion of the A-CSI on the PUSCH (block 418).

[0080] With reference to FIG. 15, the UE performs A-CSI reporting in response to an A-CSI triggering event to generate A-CSI and determines a portion of the A-CSI as a first portion with high priority and a portion of the A-CSI as a second portion with low priority (block 421). The UE may report the first portion of the A-CSI with high priority on a PUCCH (block 423), and the second portion of the A-CSI with low priority on available resources of a PUSCH optionally (block 425). The base station receives the first portion of the A-CSI on the PUCCH (block 424) and determines MCS based on the first portion of the A-CSI (block 426). The base station receives the second portion of the A-CSI on the PUSCH (block 428).

[0081] The second portion of the A-CSI with lower priority may be kept by the UE and not reported. Determination of priority of CSI may follow priority rules defined in TS 38.214 section 5.2.5. A threshold may be defined to distinguish high and low priority, CSI with priority being higher than this threshold may be transmitted on PUCCH, and the CSI with priority being not higher than this threshold may be transmitted on available PUSCH or ignored.

Separate configurations for A-CSI on PUCCH and A-CSI on PUSCH may be applied in the embodiment.

UE-selected mode

[0082] In an embodiment, the UE selects on which channel to transmit A-CSI to the base station. With reference to FIG. 16, the UE selects an A-CSI report type as the determined A-CSI report type to transmit A-CSI on an A-CSI reporting channel of the A-CSI report type, such as one of PUCCH or PUSCH (block 431). The resource information and configuration for A-CSI may be configured by the base station in advance. Separate configurations for A-CSI on PUCCH and A-CSI on PUSCH as previously described may be applied in the embodiment.

[0083] The UE may transmit an indication of the UE selected A-CSI report type indicating the A-CSI reporting channel to the base station (block 433). The base station receives the indication of the UE selected A-CSI report type (block 434) and detects for A-CSI on the A-CSI reporting channel, such as one of PUCCH or PUSCH (block 436). The UE may transmit the indication on PUCCH. If the UE does not transmit this indication, the base station may detect for the A-CSI on both PUCCH and PUSCH.

[0084] Alternatively, the aforementioned embodiments may be applied with the following modifications and rules:

- Separate configurations for different DCI format:

Although the description mainly addresses how to distinguish configurations for A-CSI on PUCCH and A-CSI on PUSCH, A-CSI configurations for different DCI formats may be different. For each A-CSI transmission mode, the CSI resources and A-CSI configuration may be configured separately for different DCI formats. That is, the A-CSI configuration comprises different sets of A-CSI configuration configured separately for different DCI formats.

- A-CSI on PUCCH is only supported for URLLC service:

A-CSI on PUCCH may increase the scheduling flexibility and reduce the latency of CSI feedback. These advantages are more beneficial to URLLC services. In an embodiment, the base station and the UE support A-CSI on PUCCH for URLLC only. Accordingly, the CSI mode of A-CSI reporting on PUCCH may be an identity of a service type of URLLC which differentiate URLLC services from enhanced mobile broadband (eMBB).

[0085] FIG. 17 is a block diagram of an example system 700 for wireless communication according to an embodiment of the present disclosure. Embodiments described herein may be implemented into the system using any suitably configured hardware and/or software. FIG. 17 illustrates the system 700 including a radio frequency (RF) circuitry 710, a baseband circuitry 720, a processing unit 730, a memory/storage 740, a display 750, a camera 760, a sensor 770, and an input/output (I/O) interface 780, coupled with each other as illustrated.

[0086] The processing unit 730 may include a circuitry, such as, but not limited to, one or more single-core or multi-core processors. The processors may include any combinations of general-purpose processors and dedicated processors, such as graphics processors and application processors. The processors may be coupled with the memory/storage and configured to execute instructions stored in the memory/storage to enable various applications and/or operating systems running on the system.

[0087] The baseband circuitry 720 may include a circuitry, such as, but not limited to, one or more single-core or multi-core processors. The processors may include a baseband processor. The baseband circuitry may handle various radio control functions that enable communication with one or more radio networks via the RF circuitry. The radio control functions may include, but are not limited to, signal modulation, encoding, decoding, radio frequency shifting, etc. In some embodiments, the baseband circuitry may provide for communication compatible with one or more radio technologies. For example, in some embodiments, the baseband circuitry may support communication with 5G NR, LTE, an evolved universal terrestrial radio access network (EUTRAN) and/or other wireless metropolitan area networks (WMAN), a wireless local area network (WLAN), a wireless personal area network (WPAN). Embodiments in which the baseband circuitry is configured to support radio communications of more than one wireless protocol may be referred to as multi-mode baseband circuitry. In various embodiments, the baseband circuitry 720 may include circuitry to operate with signals that are not strictly considered as being in a baseband frequency. For example, in some embodiments, baseband circuitry may include circuitry to operate with signals having an intermediate frequency, which is between a baseband frequency and a radio frequency.

[0088] The RF circuitry 710 may enable communication with wireless networks using modulated electromagnetic radiation through a non-solid medium. In various embodiments, the RF circuitry may include switches, filters, amplifiers, etc. to facilitate the communication with the wireless network. In various embodiments, the RF circuitry 710 may include circuitry to operate with signals that are not strictly considered as being in a radio frequency. For example, in some embodiments, RF circuitry may include circuitry to operate with signals having an intermediate frequency, which is between a baseband frequency and a radio frequency.

[0089] In various embodiments, the transmitter circuitry, control circuitry, or receiver circuitry discussed above with respect to the UE, eNB, or gNB may be embodied in whole or in part in one or more of the RF circuitries, the baseband circuitry, and/or the processing unit. As used herein, “circuitry” may refer to, be part of, or include an Application Specific Integrated Circuit (ASIC), an electronic circuit, a processor (shared, dedicated, or group), and/or a memory (shared, dedicated, or group) that execute one or more software or firmware programs, a combinational

logic circuit, and/or other suitable hardware components that provide the described functionality. In some embodiments, the electronic device circuitry may be implemented in, or functions associated with the circuitry may be implemented by, one or more software or firmware modules. In some embodiments, some or all of the constituent components of the baseband circuitry, the processing unit, and/or the memory/storage may be implemented together on a system on a chip (SOC).

[0090] The memory/storage 740 may be used to load and store data and/or instructions, for example, for system. The memory/storage for one embodiment may include any combination of suitable volatile memory, such as dynamic random access memory (DRAM)), and/or non-volatile memory, such as flash memory. In various embodiments, the I/O interface 780 may include one or more user interfaces designed to enable user interaction with the system and/or peripheral component interfaces designed to enable peripheral component interaction with the system. User interfaces may include, but are not limited to a physical keyboard or keypad, a touchpad, a speaker, a microphone, etc. Peripheral component interfaces may include, but are not limited to, a non-volatile memory port, a universal serial bus (USB) port, an audio jack, and a power supply interface.

[0091] In various embodiments, the sensor 770 may include one or more sensing devices to determine environmental conditions and/or location information related to the system. In some embodiments, the sensors may include, but are not limited to, a gyro sensor, an accelerometer, a proximity sensor, an ambient light sensor, and a positioning unit. The positioning unit may also be part of, or interact with, the baseband circuitry and/or RF circuitry to communicate with components of a positioning network, e.g., a global positioning system (GPS) satellite. In various embodiments, the display 750 may include a display, such as a liquid crystal display and a touch screen display. In various embodiments, the system 700 may be a mobile computing device such as, but not limited to, a laptop computing device, a tablet computing device, a netbook, an ultrabook, a smartphone, etc. In various embodiments, system may have more or less components, and/or different architectures. Where appropriate, methods described herein may be implemented as a computer program. The computer program may be stored on a storage medium, such as a non-transitory storage medium.

[0092] Embodiments of the present disclosure may be a combination of techniques/processes that can be adopted in 3GPP specification to create an end product. Any combination of the above embodiments may be possible.

[0093] A person having ordinary skill in the art understands that each of the units, algorithm, and steps described and disclosed in the embodiments of the present disclosure are realized using electronic hardware or combinations of software for computers and electronic hardware. Whether the functions run in hardware or software depends on the condition of application and design requirement for a technical plan. A person having ordinary skill in the art can use different ways to realize the function for each specific application while such realizations should not go beyond the scope of the present disclosure. It is understood by a person having ordinary skill in the art that he/she can refer to the working processes of the system, device, and unit in the above-mentioned embodiment since the working processes of the above-mentioned system, device, and unit are basically the same. For easy description and simplicity, these working processes will not be detailed.

[0094] It is understood that the disclosed system, device, and method in the embodiments of the present disclosure can be realized with other ways. The above-mentioned embodiments are exemplary only. The division of the units is merely based on logical functions while other divisions exist in realization. It is possible that a plurality of units or components are combined or integrated in another system. It is also possible that some characteristics are omitted or skipped. On the other hand, the displayed or discussed mutual coupling, direct coupling, or communicative coupling

operate through some ports, devices, or units whether indirectly or communicatively by ways of electrical, mechanical, or other kinds of forms.

[0095] The units as separating components for explanation are or are not physically separated. The units for display are or are not physical units, that is, located in one place or distributed on a plurality of network units. Some or all of the units are used according to the purposes of the embodiments. Moreover, each of the functional units in each of the embodiments can be integrated in one processing unit, physically independent, or integrated in one processing unit with two or more than two units.

[0096] If the software function unit is realized and used and sold as a product, it can be stored in a readable storage medium in a computer. Based on this understanding, the technical plan proposed by the present disclosure can be essentially or partially realized as the form of a software product. Or, one part of the technical plan beneficial to the conventional technology can be realized as the form of a software product. The software product in the computer is stored in a storage medium, including a plurality of commands for a computational device (such as a personal computer, a server, or a network device) to run all or some of the steps disclosed by the embodiments of the present disclosure. The storage medium includes a USB disk, a mobile hard disk, a read-only memory (ROM), a random access memory (RAM), a floppy disk, or other kinds of media capable of storing program codes.

[0097] This invention mainly provides improvement at least in two aspects: the first is new triggering methods for A-CSI, the second is detailed configuration for A-CSI transmitted on PUCCH. For technical problems of the two aspects, several embodiments are given in this disclosure.

[0098] While the present disclosure has been described in connection with what is considered the most practical and preferred embodiments, it is understood that the present disclosure is not limited to the disclosed embodiments but is intended to cover various arrangements made without departing from the scope of the broadest interpretation of the appended claims.

Claims

1. A method for aperiodic channel state information (A-CSI) feedback executable in a user equipment (UE), comprising:
determining an A-CSI triggering event in a A-CSI triggering method;
determining an A-CSI report type in A-CSI configuration; and
performing A-CSI reporting in response to the determined A-CSI triggering event according to the determined A-CSI report type.
2. The method for A-CSI feedback of claim 1, further comprising:
receiving a downlink (DL) scheduling downlink control information (DCI) of a DCI format; and
determining the DL scheduling DCI as the A-CSI triggering event when the DCI format of the DL scheduling DCI comprises a field of a CSI request for A-CSI reporting, wherein bit width of the CSI request field is configurable by a radio resource control (RRC) parameter.
3. The method for A-CSI feedback of claim 1, further comprising:
receiving a downlink (DL) scheduling downlink control information (DCI) of a DCI format; and
determining the DL scheduling DCI as the A-CSI triggering event when the DCI format of the DL scheduling DCI comprises a field of a CSI request for A-CSI reporting, wherein the DL scheduling DCI is enabled for a service type of ultra reliable and low latency communication (URLLC).
4. The method for A-CSI feedback of claim 1, further comprising:
receiving a downlink (DL) scheduling downlink control information (DCI) of a DCI format; and
determining the DL scheduling DCI as the A-CSI triggering event when the DCI format of the DL scheduling DCI comprises a field of a CSI request for A-CSI reporting, wherein transmission of the DL scheduling DCI is bundled with transmission of a physical downlink shared channel (PDSCH).
5. The method for A-CSI feedback of claim 1, further comprising:
receiving a downlink (DL) scheduling downlink control information (DCI) of a DCI format;
receiving an uplink (UL) scheduling downlink control information (DCI) of a DCI format comprising a field of CSI request; and
performing the A-CSI reporting according to the DL scheduling DCI overwriting the UL scheduling DCI.
6. The method for A-CSI feedback of claim 1, further comprising:
obtaining a time preference setting indicating one of an earlier received DCI or a later received DCI as an active A-CSI triggering DCI; and
performs the A-CSI reporting in response to the active A-CSI triggering DCI according to the time preference setting.
7. The method for A-CSI feedback of claim 1, further comprising:
receiving an indication indicating one of DL scheduling DCI triggered A-CSI reporting or uplink (UL) scheduling DCI triggered A-CSI reporting as a prioritized A-CSI triggering method;
receiving an UL scheduling downlink control information (DCI) of a DCI format comprising a field of CSI request for triggering A-CSI reporting and a DL scheduling DCI of a DCI format comprising a field of CSI request for triggering A-CSI reporting; and
performing the A-CSI reporting in response to the UL scheduling DCI when the indication indicates the UL scheduling DCI triggered A-CSI reporting as the prioritized A-CSI triggering method, or performing the A-CSI reporting in response to the DL scheduling DCI when the indication indicates the DL scheduling DCI triggered A-CSI reporting as the prioritized A-CSI triggering method.

8. The method for A-CSI feedback of claim 1, wherein a parameter is configured for the DL scheduling DCI to represent an offset X between a time slot containing a DL scheduling DCI that triggers a set of aperiodic non-zero-power (NZP) CSI reference signal (RS) resources and a time slot in which the set of aperiodic NZP CSI-RS resources is transmitted; and
a parameter is configured for UL scheduling DCI to represent an offset X between a time slot containing a UL scheduling DCI that triggers a set of aperiodic non-zero-power (NZP) CSI-RS resources and a time slot in which the set of aperiodic NZP CSI-RS resources is transmitted.
9. The method for A-CSI feedback of claim 1, further comprising:
receiving and decoding a downlink transmission;
determining a negative-Acknowledgment (NACK) responding to the downlink transmission as the A-CSI triggering event when decoding of the downlink transmission is failed;
retrieving pre-configured A-CSI configuration to perform CSI measurement; and
using a result of the CSI measurement for the A-CSI reporting.
10. The method for A-CSI feedback of claim 1, further comprising:
receiving and decoding a downlink transmission;
determining a negative-Acknowledgment (NACK) responding to the downlink transmission as the A-CSI triggering event when decoding of the downlink transmission is failed;
obtaining the A-CSI configuration from historical A-CSI configuration;
using the obtained A-CSI configuration to perform CSI measurement; and
using a result of the CSI measurement for the A-CSI reporting.
11. The method for A-CSI feedback of claim 1, further comprising:
receiving an A-CSI triggering method indication to activate the A-CSI triggering method, wherein the A-CSI triggering method indication is configurable to activate A-CSI triggered by DL scheduling DCI, A-CSI triggered by NACK with DCI scheduling, and A-CSI triggered by NACK without DCI scheduling.
12. The method for A-CSI feedback of claim 1, further comprising:
performing same-slot CSI feedback, where the UE receives a DCI in beginning of one time slot and triggers the A-CSI reporting before an end of the same time slot in response to the DCI received in the beginning of the same time slot.
13. The method for A-CSI feedback of claim 1, wherein the A-CSI configuration comprises a CSI request field for an A-CSI report type of A-CSI reporting on a physical uplink control channel (PUCCH) and a CSI request field for an A-CSI report type of A-CSI reporting on a physical uplink shared channel (PUSCH), and the A-CSI reporting is performed according to the A-CSI configuration.
14. The method for A-CSI feedback of claim 13, wherein bit width of the CSI request for the A-CSI report type of A-CSI reporting on PUCCH is configurable by an RRC parameter.
15. The method for A-CSI feedback of claim 1, wherein the A-CSI configuration comprises an A-CSI trigger state list field for an A-CSI report type of A-CSI reporting on a physical uplink control channel (PUCCH) and an A-CSI trigger state list field for an A-CSI report type of A-CSI reporting on a physical uplink shared channel (PUSCH), and the A-CSI reporting is performed according to the A-CSI configuration.
16. The method for A-CSI feedback of claim 1, further comprising:
receiving the A-CSI configuration in a DL scheduling DCI, wherein the A-CSI configuration in the DL scheduling DCI is shared by an A-CSI report type of A-CSI reporting on a PUCCH and an A-CSI report type of A-CSI reporting

on a PUSCH;

receiving the A-CSI configuration in an RRC signal, wherein the A-CSI configuration in the RRC signal comprises one or more RRC parameters for the A-CSI report type of A-CSI reporting on the PUCCH and one or more RRC parameters for the A-CSI report type of A-CSI reporting on the PUSCH, and the A-CSI reporting is performed according to the A-CSI configuration.

17. The method for A-CSI feedback of claim 1, wherein the A-CSI configuration comprises an A-CSI report type indication indicating one of an A-CSI report type of A-CSI reporting on the PUCCH or an A-CSI report type of A-CSI reporting on the PUSCH as the determined A-CSI report type; and the A-CSI reporting is performed in the determined A-CSI report type according to the A-CSI configuration.

18. The method for A-CSI feedback of claim 17, wherein the A-CSI report type indication is configurable by DCI signaling or radio resource control (RRC) signaling.

19. The method for A-CSI feedback of claim 17, wherein the A-CSI report type indication is represented by one of a plurality of DCI formats, a first DCI format of the plurality of DCI formats represents activation of the A-CSI report type of A-CSI reporting on the PUCCH as the determined A-CSI report type, and a second DCI format of the plurality of DCI formats represents activation of the A-CSI report type of A-CSI reporting on the PUSCH as the determined A-CSI report type.

20. The method for A-CSI feedback of claim 17, wherein the A-CSI report type indication is represented by a radio network temporary identifier (RNTI), a CSI request in a DCI when scrambled with the RNTI represents activation of a trigger state for the A-CSI report type of A-CSI reporting on the PUCCH, and the CSI request in the DCI when not scrambled with the RNTI represents activation of the trigger state for the A-CSI report type of A-CSI reporting on the PUSCH.

21. The method for A-CSI feedback of claim 17, wherein the A-CSI report type indication is configurable by a medium access control (MAC) control element (CE).

22. The method for A-CSI feedback of claim 17, wherein a medium access control (MAC) control element (CE) comprises a field of a status indication, and a codepoint in the field of the status indication indicates activation or deactivation of an entry of a list of A-CSI configurations.

23. The method for A-CSI feedback of claim 22, wherein a codepoint S_i in the field of the status indication refers to A-CSI configuration which includes PUCCH resources for A-CSI reporting in an indicated bandwidth part (BWP) and has a j-th CSI report configuration identifier within the list with a report type set to the A-CSI report type of A-CSI reporting on the PUCCH, where $j=i+1$.

24. The method for A-CSI feedback of claim 17, wherein a medium access control (MAC) control element (CE) comprises a field of a trigger state subselection for subselection of the A-CSI configuration, and a codepoint in the field of the trigger state subselection indicates selection or not of an entry of a list of trigger states for A-CSI reporting.

25. The method for A-CSI feedback of claim 22, wherein a codepoint T_i in the field of the trigger state subselection indicates that a j-th trigger state in the list of trigger states is selected in the subselection for A-CSI reporting, where $j=i+1$.

26. The method for A-CSI feedback of claim 1, further comprising:

reporting a first portion of A-CSI with higher priority on a PUCCH, and a second portion of the A-CSI with lower priority on a PUSCH.

27. The method for A-CSI feedback of claim 1, further comprising:

reporting a first portion of A-CSI of high importance for MCS determination on a PUCCH, and a second portion of

the A-CSI of low importance for MCS determination on a PUSCH.

28. The method for A-CSI feedback of claim 1, further comprising:

selecting an A-CSI mode as the determined A-CSI report type to transmit A-CSI on an A-CSI reporting channel; and transmitting an indication of the selected A-CSI mode indicating the A-CSI reporting channel.

29. The method for A-CSI feedback of claim 1, wherein the A-CSI configuration comprises different sets of A-CSI configuration configured separately for different DCI formats.

30. The method for A-CSI feedback of claim 1, wherein an A-CSI report type of A-CSI reporting on a PUCCH is enabled for a service type of URLLC.

31. A method for aperiodic channel state information (A-CSI) feedback executable in a base station, comprising:

determining A-CSI configuration comprising an A-CSI report type;

transmitting the A-CSI configuration in a downlink channel to trigger A-CSI reporting; and

receiving A-CSI on an A-CSI reporting channel according to the determined A-CSI report type.

32. The method for A-CSI feedback of claim 31, further comprising:

transmitting a downlink (DL) scheduling downlink control information (DCI) of a DCI format comprising a field of CSI request;

wherein bit width of the CSI request is configurable by a radio resource control (RRC) parameter.

33. The method for A-CSI feedback of claim 31, further comprising:

transmitting a downlink (DL) scheduling downlink control information (DCI) of a DCI format comprising a field of CSI request;

wherein the DL scheduling DCI is enabled for a service type of ultra reliable and low latency communication (URLLC).

34. The method for A-CSI feedback of claim 31, further comprising:

transmitting a downlink (DL) scheduling downlink control information (DCI) of a DCI format comprising a field of CSI request;

wherein transmission of the DL scheduling DCI is bundled with transmission of a physical downlink shared channel (PDSCH).

35. The method for A-CSI feedback of claim 31, further comprising:

transmitting a downlink (DL) scheduling downlink control information (DCI) of a DCI format comprising a field of CSI request and an indication that the DL scheduling DCI overwrites a UL scheduling DCI for A-CSI reporting.

36. The method for A-CSI feedback of claim 31, further comprising:

transmitting a time preference setting indicating one of an earlier received DCI or a later received DCI as an active A-CSI triggering DCI.

37. The method for A-CSI feedback of claim 31, further comprising:

transmitting an indication indicating one of DL scheduling DCI triggered A-CSI reporting or uplink (UL) scheduling DCI triggered A-CSI reporting as a prioritized A-CSI triggering method.

38. The method for A-CSI feedback of claim 31, wherein a parameter is configured for the DL scheduling DCI to represent an offset X between a time slot containing a DL scheduling DCI that triggers a set of aperiodic non-zero-power (NZP) CSI reference signal (RS) resources and a time slot in which the set of aperiodic NZP CSI-RS resources is transmitted;

a parameter is configured for UL scheduling DCI to represent an offset X between a time slot containing a UL scheduling DCI that triggers a set of aperiodic non-zero-power (NZP) CSI-RS resources and a time slot in which the set of aperiodic NZP CSI-RS resources is transmitted.

39. The method for A-CSI feedback of claim 31, further comprising:
transmitting an A-CSI triggering method indication to activate the A-CSI triggering method, wherein the A-CSI triggering method indication is configurable to activate A-CSI triggered by DL scheduling DCI, A-CSI triggered by NACK with DCI scheduling, and A-CSI triggered by NACK without DCI scheduling.
40. The method for A-CSI feedback of claim 31, further comprising:
transmitting a DCI to trigger same-slot CSI feedback, where the DCI in beginning of one time slot triggers the A-CSI reporting before an end of the same time slot.
41. The method for A-CSI feedback of claim 31, wherein the A-CSI configuration comprises a CSI request field for an A-CSI report type of A-CSI reporting on a physical uplink control channel (PUCCH) and a CSI request field for an A-CSI report type of A-CSI reporting on a physical uplink shared channel (PUSCH).
42. The method for A-CSI feedback of claim 41, wherein bit width of the CSI request field for the A-CSI report type of A-CSI reporting on PUCCH is configurable by an RRC parameter.
43. The method for A-CSI feedback of claim 31, wherein the A-CSI configuration comprises an A-CSI trigger state list field for an A-CSI report type of A-CSI reporting on a physical uplink control channel (PUCCH) and an A-CSI trigger state list field for an A-CSI report type of A-CSI reporting on a physical uplink shared channel (PUSCH).
44. The method for A-CSI feedback of claim 31, wherein the A-CSI configuration in the DL scheduling DCI is shared by an A-CSI report type of A-CSI reporting on a PUCCH and an A-CSI report type of A-CSI reporting on a PUSCH; transmitting the A-CSI configuration in an RRC signal, wherein the A-CSI configuration in the RRC signal comprises one or more RRC parameters for the A-CSI report type of A-CSI reporting on the PUCCH and one or more RRC parameters for the A-CSI report type of A-CSI reporting on the PUSCH.
45. The method for A-CSI feedback of claim 31, wherein the A-CSI configuration comprises an A-CSI report type indication indicating one of an A-CSI report type of A-CSI reporting on the PUCCH or an A-CSI report type of A-CSI reporting on the PUSCH as the determined A-CSI report type.
46. The method for A-CSI feedback of claim 45, wherein the A-CSI report type indication is configurable by DCI signaling or radio resource control (RRC) signaling.
47. The method for A-CSI feedback of claim 45, wherein the A-CSI report type indication is represented by one of a plurality of DCI formats, a first DCI format of the plurality of DCI formats represents activation of the A-CSI report type of A-CSI reporting on the PUCCH as the determined A-CSI report type, and a second DCI format of the plurality of DCI formats represents activation of the A-CSI report type of A-CSI reporting on the PUSCH as the determined A-CSI report type.
48. The method for A-CSI feedback of claim 45, wherein the A-CSI report type indication is represented by a radio network temporary identifier (RNTI), a CSI request in a DCI when scrambled with the RNTI represents activation of a trigger state for the A-CSI report type of A-CSI reporting on the PUCCH, and the CSI request in the DCI when not scrambled with the RNTI represents activation of the trigger state for the A-CSI report type of A-CSI reporting on the PUSCH.
49. The method for A-CSI feedback of claim 45, wherein the A-CSI report type indication is configurable by a medium access control (MAC) control element (CE).
50. The method for A-CSI feedback of claim 45, wherein a medium access control (MAC) control element (CE) comprises a field of a status indication, and a codepoint in the field of the status indication indicates activation or deactivation of an entry of a list of A-CSI configurations.
51. The method for A-CSI feedback of claim 50, wherein a codepoint S_i in the field of the status indication refers to

A-CSI configuration which includes PUCCH resources for A-CSI reporting in an indicated bandwidth part (BWP) and has a j -th CSI report configuration identifier within the list with a report type set to the A-CSI report type of A-CSI reporting on the PUCCH, where $j=i+1$.

52. The method for A-CSI feedback of claim 45, wherein a medium access control (MAC) control element (CE) comprises a field of a trigger state subselection for subselection of the A-CSI configuration, and a codepoint in the field of the trigger state subselection indicates selection or not of an entry of a list of trigger states for A-CSI reporting.

53. The method for A-CSI feedback of claim 50, wherein a codepoint T_i in the field of the trigger state subselection indicates that a j -th trigger state in the list of trigger states is selected in the subselection for A-CSI reporting, where $j=i+1$.

54. The method for A-CSI feedback of claim 31, further comprising:

receiving a first portion of A-CSI with higher priority on a PUCCH, and a second portion of the A-CSI with lower priority on a PUSCH.

55. The method for A-CSI feedback of claim 31, further comprising:

receiving a first portion of A-CSI of high importance for MCS determination on a PUCCH, and a second portion of the A-CSI of low importance for MCS determination on a PUSCH.

56. The method for A-CSI feedback of claim 31, further comprising:

receiving an indication of a UE-selected A-CSI mode indicating the A-CSI reporting channel; and
detecting for A-CSI on the A-CSI reporting channel.

57. The method for A-CSI feedback of claim 31, wherein the A-CSI configuration comprises different sets of A-CSI configuration configured separately for different DCI formats.

58. The method for A-CSI feedback of claim 31, wherein an A-CSI report type of A-CSI reporting on a PUCCH is enabled for a service type of URLLC.

59. A user equipment (UE) comprising:

a transceiver; and

a processor connected with the transceiver and configured to execute the following steps comprising:

determining an aperiodic channel state information (A-CSI) triggering event in a A-CSI triggering method;

determining an A-CSI report type in A-CSI configuration; and

performing A-CSI reporting in response to the determined A-CSI triggering event according to the determined A-CSI report type.

60. The user equipment of claim 59, wherein the processor further executes:

receiving a downlink (DL) scheduling downlink control information (DCI) of a DCI format; and

determining the DL scheduling DCI as the A-CSI triggering event when the DCI format of the DL scheduling DCI comprises a field of a CSI request for A-CSI reporting;

wherein bit width of the CSI request is configurable by a radio resource control (RRC) parameter.

61. The user equipment of claim 59, wherein the processor further executes:

receiving a downlink (DL) scheduling downlink control information (DCI) of a DCI format; and

determining the DL scheduling DCI as the A-CSI triggering event when the DCI format of the DL scheduling DCI comprises a field of a CSI request for A-CSI reporting;

wherein the DL scheduling DCI is enabled for a service type of ultra reliable and low latency communication (URLLC).

62. The user equipment of claim 59, wherein the processor further executes:

receiving a downlink (DL) scheduling downlink control information (DCI) of a DCI format; and

determining the DL scheduling DCI as the A-CSI triggering event when the DCI format of the DL scheduling DCI comprises a field of a CSI request for A-CSI reporting;

wherein transmission of the DL scheduling DCI is bundled with transmission of a physical downlink shared channel (PDSCH).

63. The user equipment of claim 59, wherein the processor further executes:

receiving a downlink (DL) scheduling downlink control information (DCI) of a DCI format comprising a field of CSI request;

receiving an uplink (UL) scheduling downlink control information (DCI) of a DCI format comprising a field of CSI request; and

performing the A-CSI reporting according to the DL scheduling DCI overwriting the UL scheduling DCI.

64. The user equipment of claim 59, wherein the processor further executes:

obtaining a time preference setting indicating one of an earlier received DCI or a later received DCI as an active A-CSI triggering DCI; and

performs the A-CSI reporting in response to the active A-CSI triggering DCI according to the time preference setting.

65. The user equipment of claim 59, wherein the processor further executes:

receiving an indication indicating one of DL scheduling DCI triggered A-CSI reporting or uplink (UL) scheduling DCI triggered A-CSI reporting as a prioritized A-CSI triggering method;

receiving an UL scheduling downlink control information (DCI) of a DCI format comprising a field of CSI request for triggering A-CSI reporting and a DL scheduling DCI of a DCI format comprising a field of CSI request for triggering A-CSI reporting; and

performing the A-CSI reporting in response to the UL scheduling DCI when the indication indicates the UL scheduling DCI triggered A-CSI reporting as the prioritized A-CSI triggering method, or performing the A-CSI reporting in response to the DL scheduling DCI when the indication indicates the DL scheduling DCI triggered A-CSI reporting as the prioritized A-CSI triggering method.

66. The user equipment of claim 59, wherein a parameter is configured for the DL scheduling DCI to represent an offset X between a time slot containing a DL scheduling DCI that triggers a set of aperiodic non-zero-power (NZP) CSI reference signal (RS) resources and a time slot in which the set of aperiodic NZP CSI-RS resources is transmitted; and

a parameter is configured for UL scheduling DCI to represent an offset X between a time slot containing a UL scheduling DCI that triggers a set of aperiodic non-zero-power (NZP) CSI-RS resources and a time slot in which the set of aperiodic NZP CSI-RS resources is transmitted.

67. The user equipment of claim 59, wherein the processor further executes:

receiving and decoding a downlink transmission;

determining a negative-Acknowledgment (NACK) responding to the downlink transmission as the A-CSI triggering event when decoding of the downlink transmission is failed;

retrieving pre-configured A-CSI configuration to perform CSI measurement; and

using a result of the CSI measurement for the A-CSI reporting.

68. The user equipment of claim 59, wherein the processor further executes:

receiving and decoding a downlink transmission;

determining a negative-Acknowledgment (NACK) responding to the downlink transmission as the A-CSI triggering event when decoding of the downlink transmission is failed;

obtaining the A-CSI configuration from historical A-CSI configuration;
using the obtained A-CSI configuration to perform CSI measurement; and
using a result of the CSI measurement for the A-CSI reporting.

69. The user equipment of claim 59, wherein the processor further executes:

receiving and decoding a downlink transmission;

determining a negative-Acknowledgment (NACK) responding to the downlink transmission as the A-CSI triggering event when decoding of the downlink transmission is failed;

performing A-CSI measurement and calculation in response to each CSI request indicated by DCI; and .

using a result of the CSI measurement and calculation for the A-CSI reporting in NACK triggered A-CSI reporting.

70. The user equipment of claim 59, wherein the processor further executes:

receiving an A-CSI triggering method indication to activate the A-CSI triggering method, wherein the A-CSI triggering method indication is configurable to activate A-CSI triggered by DL scheduling DCI, A-CSI triggered by NACK with DCI scheduling, and A-CSI triggered by NACK without DCI scheduling.

71. The user equipment of claim 59, wherein the processor further executes:

performing same-slot CSI feedback, where the UE receives a DCI in beginning of one time slot and triggers the A-CSI reporting before an end of the same time slot in response to the DCI received in the beginning of the same time slot.

72. The user equipment of claim 59, wherein the A-CSI configuration comprises a CSI request field for an A-CSI report type of A-CSI reporting on a physical uplink control channel (PUCCH) and a CSI request field for an A-CSI report type of A-CSI reporting on a physical uplink shared channel (PUSCH), and the A-CSI reporting is performed according to the A-CSI configuration.

73. The user equipment of claim 72, wherein bit width of the CSI request field for the A-CSI report type of A-CSI reporting on PUCCH is configurable by an RRC parameter.

74. The user equipment of claim 59, wherein the A-CSI configuration comprises an A-CSI trigger state list field for an A-CSI report type of A-CSI reporting on a physical uplink control channel (PUCCH) and an A-CSI trigger state list field for an A-CSI report type of A-CSI reporting on a physical uplink shared channel (PUSCH), and the A-CSI reporting is performed according to the A-CSI configuration.

75. The user equipment of claim 59, wherein the processor further executes:

receiving the A-CSI configuration in a DL scheduling DCI, wherein the A-CSI configuration in the DL scheduling DCI is shared by an A-CSI report type of A-CSI reporting on a PUCCH and an A-CSI report type of A-CSI reporting on a PUSCH;

receiving the A-CSI configuration in an RRC signal, wherein the A-CSI configuration in the RRC signal comprises one or more RRC parameters for the A-CSI report type of A-CSI reporting on the PUCCH and one or more RRC parameters for the A-CSI report type of A-CSI reporting on the PUSCH, and the A-CSI reporting is performed according to the A-CSI configuration.

76. The user equipment of claim 59, wherein the A-CSI configuration comprises an A-CSI report type indication indicating one of an A-CSI report type of A-CSI reporting on the PUCCH or an A-CSI report type of A-CSI reporting on the PUSCH as the determined A-CSI report type; and the A-CSI reporting is performed in the determined A-CSI report type according to the A-CSI configuration.

77. The user equipment of claim 76, wherein the A-CSI report type indication is configurable by DCI signaling or radio resource control (RRC) signaling.

78. The user equipment of claim 76, wherein the A-CSI report type indication is represented by one of a plurality of DCI formats, a first DCI format of the plurality of DCI formats represents activation of the A-CSI report type of A-CSI reporting on the PUCCH as the determined A-CSI report type, and a second DCI format of the plurality of DCI formats represents activation of the A-CSI report type of A-CSI reporting on the PUSCH as the determined A-CSI report type.

79. The user equipment of claim 76, wherein the A-CSI report type indication is represented by a radio network temporary identifier (RNTI), a CSI request in a DCI when scrambled with the RNTI represents activation of a trigger state for the A-CSI report type of A-CSI reporting on the PUCCH, and the CSI request in the DCI when not scrambled with the RNTI represents activation of the trigger state for the A-CSI report type of A-CSI reporting on the PUSCH.

80. The user equipment of claim 76, wherein the A-CSI report type indication is configurable by a medium access control (MAC) control element (CE).

81. The user equipment of claim 76, wherein a medium access control (MAC) control element (CE) comprises a field of a status indication, and a codepoint in the field of the status indication indicates activation or deactivation of an entry of a list of A-CSI configurations.

82. The user equipment of claim 81, wherein a codepoint S_i in the field of the status indication refers to A-CSI configuration which includes PUCCH resources for A-CSI reporting in an indicated bandwidth part (BWP) and has a j-th CSI report configuration identifier within the list with a report type set to the A-CSI report type of A-CSI reporting on the PUCCH, where $j=i+1$.

83. The user equipment of claim 76, wherein a medium access control (MAC) control element (CE) comprises a field of a trigger state subselection for subselection of the A-CSI configuration, and a codepoint in the field of the trigger state subselection indicates selection or not of an entry of a list of trigger states for A-CSI reporting.

84. The user equipment of claim 81, wherein a codepoint T_i in the field of the trigger state subselection indicates that a j-th trigger state in the list of trigger states is selected in the subselection for A-CSI reporting, where $j=i+1$.

85. The user equipment of claim 59, wherein the processor further executes:

reporting a first portion of A-CSI with higher priority on a PUCCH, and a second portion of the A-CSI with lower priority on a PUSCH.

86. The user equipment of claim 59, wherein the processor further executes:

reporting a first portion of A-CSI of high importance for MCS determination on a PUCCH, and a second portion of the A-CSI of low importance for MCS determination on a PUSCH.

87. The user equipment of claim 59, wherein the processor further executes:

selecting an A-CSI mode as the determined A-CSI report type to transmit A-CSI on an A-CSI reporting channel; and transmitting an indication of the selected A-CSI mode indicating the A-CSI reporting channel.

88. The user equipment of claim 59, wherein the A-CSI configuration comprises different sets of A-CSI configuration configured separately for different DCI formats.

89. The user equipment of claim 59, wherein an A-CSI report type of A-CSI reporting on a PUCCH is enabled for a service type of URLLC.

90. A base station, comprising:

a transceiver; and

a processor connected with the transceiver and configured to execute the following steps comprising:

determining aperiodic channel state information (A-CSI) configuration comprising an A-CSI report type;

transmitting the A-CSI configuration in a downlink channel to trigger A-CSI reporting; and

receiving A-CSI on an A-CSI reporting channel according to the determined A-CSI report type.

91. The base station of claim 90, wherein the processor further executes:

transmitting a downlink (DL) scheduling downlink control information (DCI) of a DCI format comprising a field of CSI request, wherein bit width of the CSI request field is configurable by a radio resource control (RRC) parameter.

92. The base station of claim 90, wherein the processor further executes:

transmitting a downlink (DL) scheduling downlink control information (DCI) of a DCI format comprising a field of CSI request, wherein the DL scheduling DCI is enabled for a service type of ultra reliable and low latency communication (URLLC).

93. The base station of claim 90, wherein the processor further executes:

transmitting a downlink (DL) scheduling downlink control information (DCI) of a DCI format comprising a field of CSI request, wherein transmission of the DL scheduling DCI is bundled with transmission of a physical downlink shared channel (PDSCH).

94. The base station of claim 90, wherein the processor further executes:

transmitting a downlink (DL) scheduling downlink control information (DCI) of a DCI format comprising a field of CSI request and an indication that the DL scheduling DCI overwrites a UL scheduling DCI for A-CSI reporting.

95. The base station of claim 90, wherein the processor further executes:

transmitting a time preference setting indicating one of an earlier received DCI or a later received DCI as an active A-CSI triggering DCI.

96. The base station of claim 90, wherein the processor further executes:

transmitting an indication indicating one of a DL scheduling DCI triggered A-CSI reporting or a uplink (UL) scheduling DCI triggered A-CSI reporting as a prioritized A-CSI triggering method.

97. The base station of claim 90, wherein a parameter is configured for the DL scheduling DCI to represent an offset X between a time slot containing a DL scheduling DCI that triggers a set of aperiodic non-zero-power (NZP) CSI reference signal (RS) resources and a time slot in which the set of aperiodic NZP CSI-RS resources is transmitted; and

a parameter is configured for UL scheduling DCI to represent an offset X between a time slot containing a UL scheduling DCI that triggers a set of aperiodic non-zero-power (NZP) CSI-RS resources and a time slot in which the set of aperiodic NZP CSI-RS resources is transmitted.

98. The base station of claim 90, wherein the processor further executes:

transmitting an A-CSI triggering method indication to activate the A-CSI triggering method; wherein the A-CSI triggering method indication is configurable to activate A-CSI triggered by DL scheduling DCI, A-CSI triggered by NACK with DCI scheduling, and A-CSI triggered by NACK without DCI scheduling.

99. The base station of claim 90, wherein the processor further executes:

transmitting a DCI to trigger same-slot CSI feedback, where the DCI in beginning of one time slot triggers the A-CSI reporting before an end of the same time slot.

100. The base station of claim 90, wherein the A-CSI configuration comprises a CSI request field for an A-CSI report type of A-CSI reporting on a physical uplink control channel (PUCCH) and a CSI request field for an A-CSI report type of A-CSI reporting on a physical uplink shared channel (PUSCH).

101. The base station of claim 49, wherein bit width of the CSI request field for the A-CSI report type of A-CSI reporting on PUCCH is configurable by an RRC parameter.

102. The base station of claim 90, wherein the A-CSI configuration comprises an A-CSI trigger state list field for an

A-CSI report type of A-CSI reporting on a physical uplink control channel (PUCCH) and an A-CSI trigger state list field for an A-CSI report type of A-CSI reporting on a physical uplink shared channel (PUSCH).

103. The base station of claim 90, wherein the A-CSI configuration in the DL scheduling DCI is shared by an A-CSI report type of A-CSI reporting on a PUCCH and an A-CSI report type of A-CSI reporting on a PUSCH; transmitting the A-CSI configuration in an RRC signal, wherein the A-CSI configuration in the RRC signal comprises one or more RRC parameters for the A-CSI report type of A-CSI reporting on the PUCCH and one or more RRC parameters for the A-CSI report type of A-CSI reporting on the PUSCH.

104. The base station of claim 90, wherein the A-CSI configuration comprises an A-CSI report type indication indicating one of an A-CSI report type of A-CSI reporting on the PUCCH or an A-CSI report type of A-CSI reporting on the PUSCH as the determined A-CSI report type.

105. The base station of claim 104, wherein the A-CSI report type indication is configurable by DCI signaling or radio resource control (RRC) signaling.

106. The base station of claim 104, wherein the A-CSI report type indication is represented by one of a plurality of DCI formats, a first DCI format of the plurality of DCI formats represents activation of the A-CSI report type of A-CSI reporting on the PUCCH as the determined A-CSI report type, and a second DCI format of the plurality of DCI formats represents activation of the A-CSI report type of A-CSI reporting on the PUSCH as the determined A-CSI report type.

107. The base station of claim 104, wherein the A-CSI report type indication is represented by a radio network temporary identifier (RNTI), a CSI request in a DCI when scrambled with the RNTI represents activation of a trigger state for the A-CSI report type of A-CSI reporting on the PUCCH, and the CSI request in the DCI when not scrambled with the RNTI represents activation of the trigger state for the A-CSI report type of A-CSI reporting on the PUSCH.

108. The base station of claim 104, wherein the A-CSI report type indication is configurable by a medium access control (MAC) control element (CE).

109. The base station of claim 104, wherein a medium access control (MAC) control element (CE) comprises a field of a status indication, and a codepoint in the field of the status indication indicates activation or deactivation of an entry of a list of A-CSI configurations.

110. The method for A-CSI feedback of claim 109, wherein a codepoint S_i in the field of the status indication refers to A-CSI configuration which includes PUCCH resources for A-CSI reporting in an indicated bandwidth part (BWP) and has a j-th CSI report configuration identifier within the list with a report type set to the A-CSI report type of A-CSI reporting on the PUCCH, where $j=i+1$.

111. The base station of claim 104, wherein a medium access control (MAC) control element (CE) comprises a field of a trigger state subselection for subselection of the A-CSI configuration, and a codepoint in the field of the trigger state subselection indicates selection or not of an entry of a list of trigger states for A-CSI reporting.

112. The base station of claim 58, wherein a codepoint T_i in the field of the trigger state subselection indicates that a j-th trigger state in the list of trigger states is selected in the subselection for A-CSI reporting, where $j=i+1$.

113. The base station of claim 90, wherein the processor further executes: receiving a first portion of A-CSI with higher priority on a PUCCH, and a second portion of the A-CSI with lower priority on a PUSCH.

114. The base station of claim 90, wherein the processor further executes: receiving a first portion of A-CSI of high importance for MCS determination on a PUCCH, and a second portion of the A-CSI of low importance for MCS determination on a PUSCH.

115. The base station of claim 90, wherein the processor further executes:

receiving an indication of a UE-selected A-CSI mode indicating the A-CSI reporting channel; and

detecting for A-CSI on the A-CSI reporting channel.

116. The base station of claim 90, wherein the A-CSI configuration comprises different sets of A-CSI configuration configured separately for different DCI formats.

117. The base station of claim 90, wherein an A-CSI report type of A-CSI reporting on a PUCCH is enabled for a service type of URLLC.

118. A chip, comprising:

a processor, configured to call and run a computer program stored in a memory, to cause a device in which the chip is installed to execute any of the methods of claims 1 to 30.

119. A chip, comprising:

a processor, configured to call and run a computer program stored in a memory, to cause a device in which the chip is installed to execute any of the methods of claims 31 to 58.

120. A computer readable storage medium, in which a computer program is stored, wherein the computer program causes a computer to execute any of the methods of claims 1 to 30.

121. A computer readable storage medium, in which a computer program is stored, wherein the computer program causes a computer to execute any of the methods of claims 31 to 58.

122. A computer program product, comprising a computer program, wherein the computer program causes a computer to execute any of the methods of claims 1 to 30.

123. A computer program product, comprising a computer program, wherein the computer program causes a computer to execute any of the methods of claims 31 to 58.

124. A computer program, wherein the computer program causes a computer to execute any of the methods of claims 1 to 35.

125. A computer program, wherein the computer program causes a computer to execute any of the methods of claims 31 to 58.

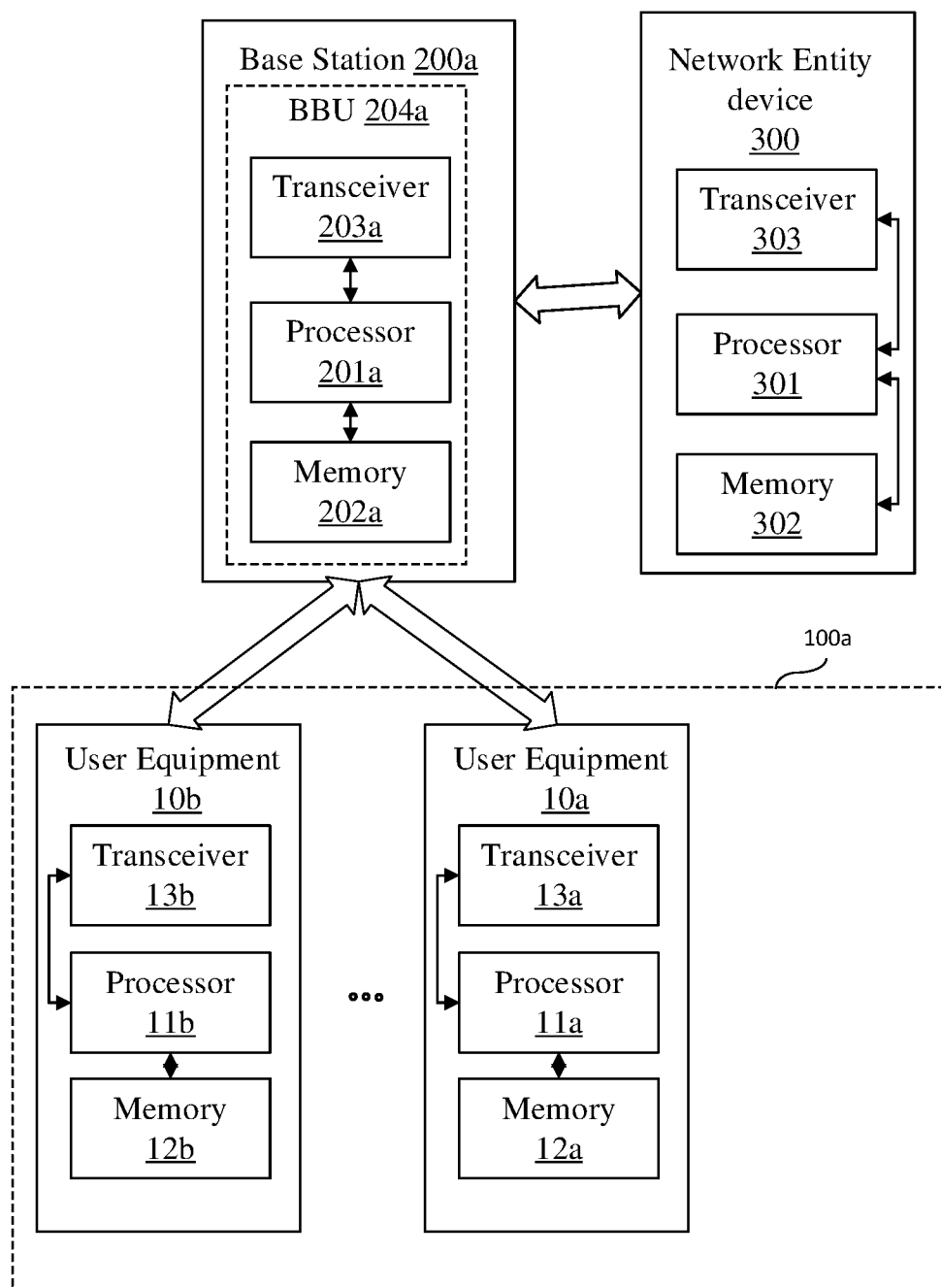


FIG. 1

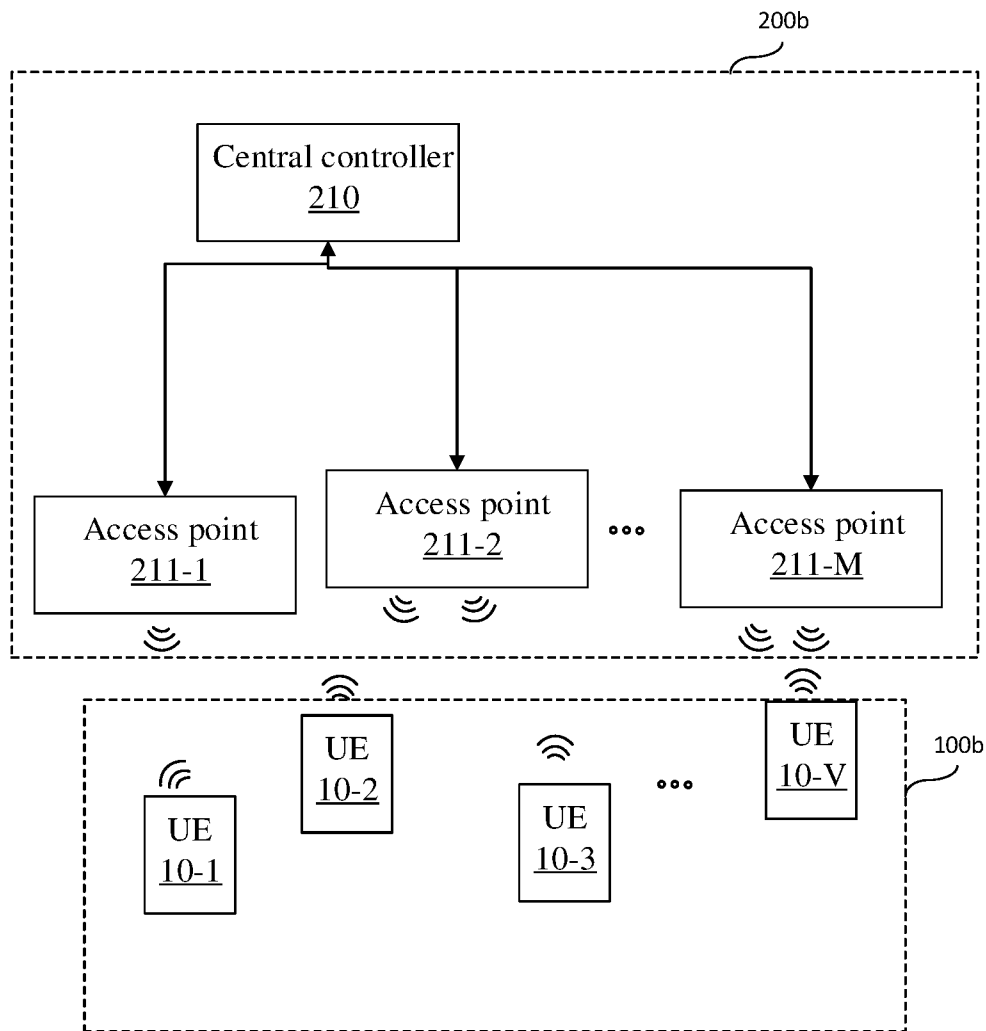


FIG. 2

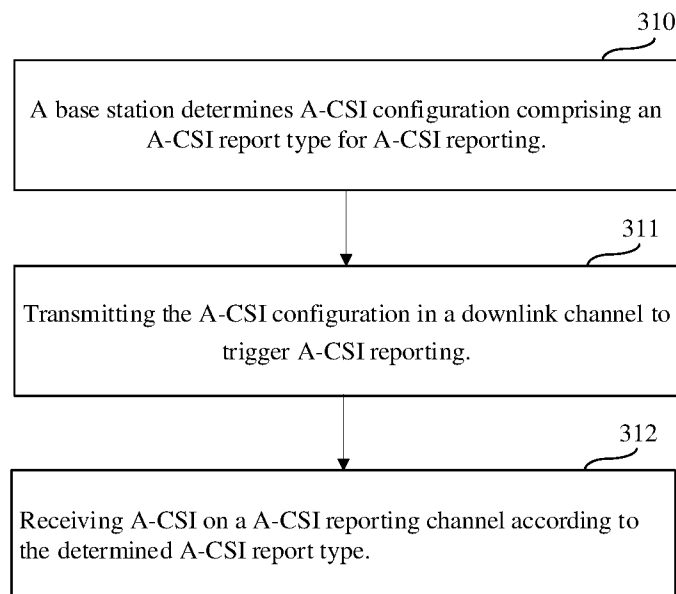


FIG. 3

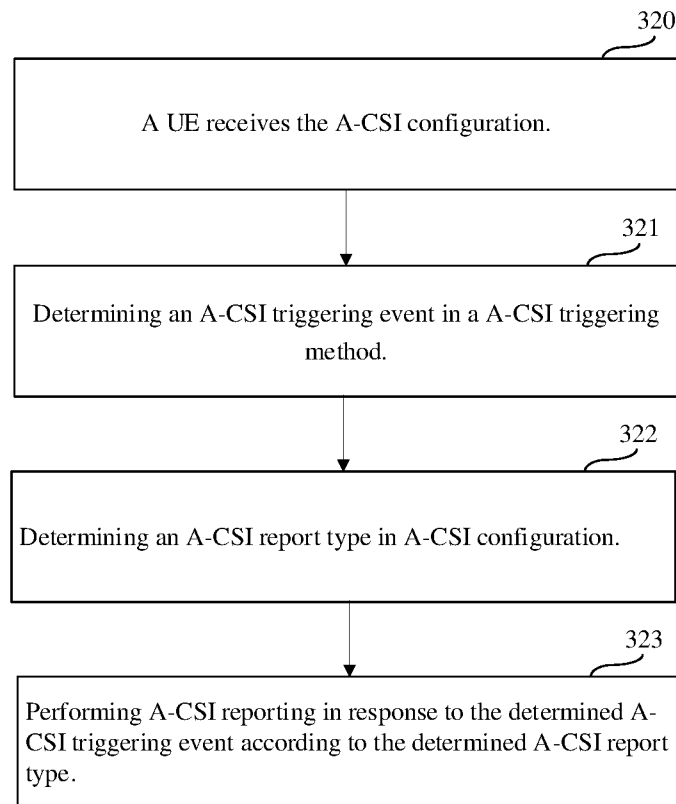


FIG. 4

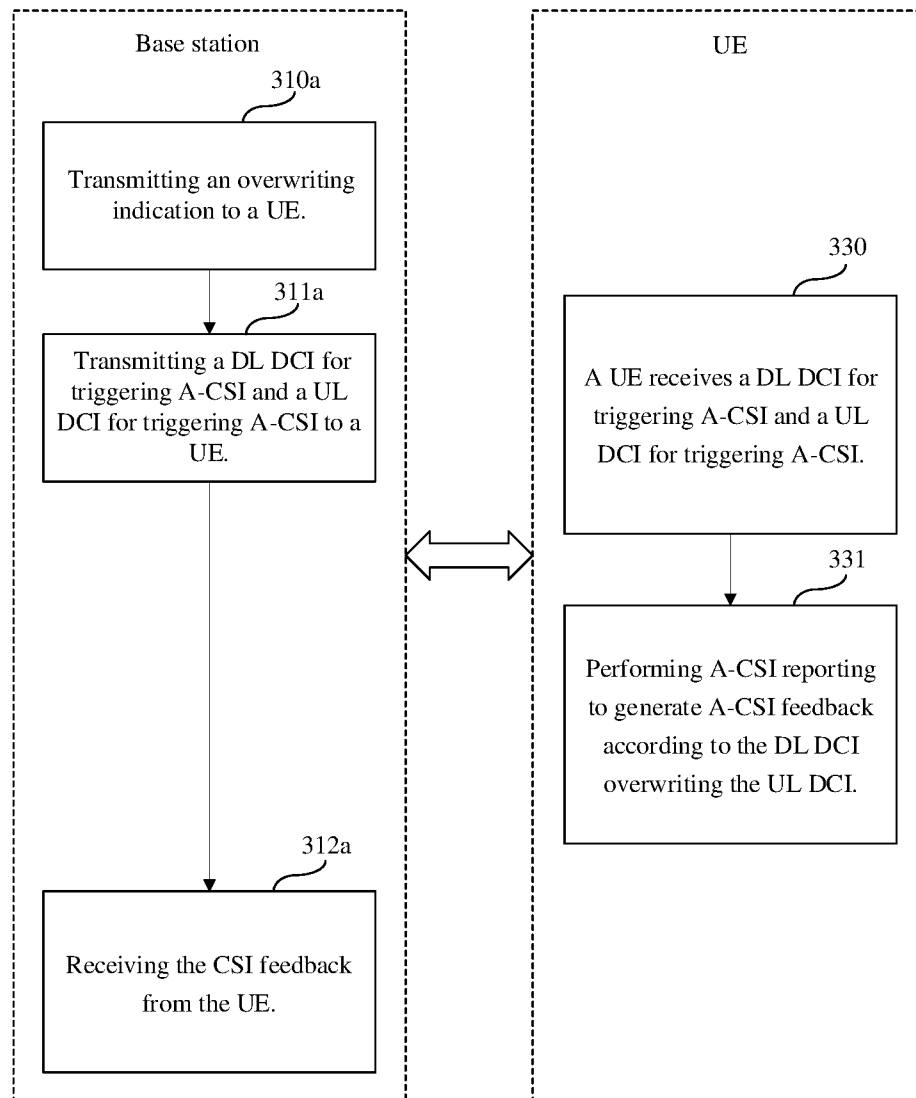


FIG. 5

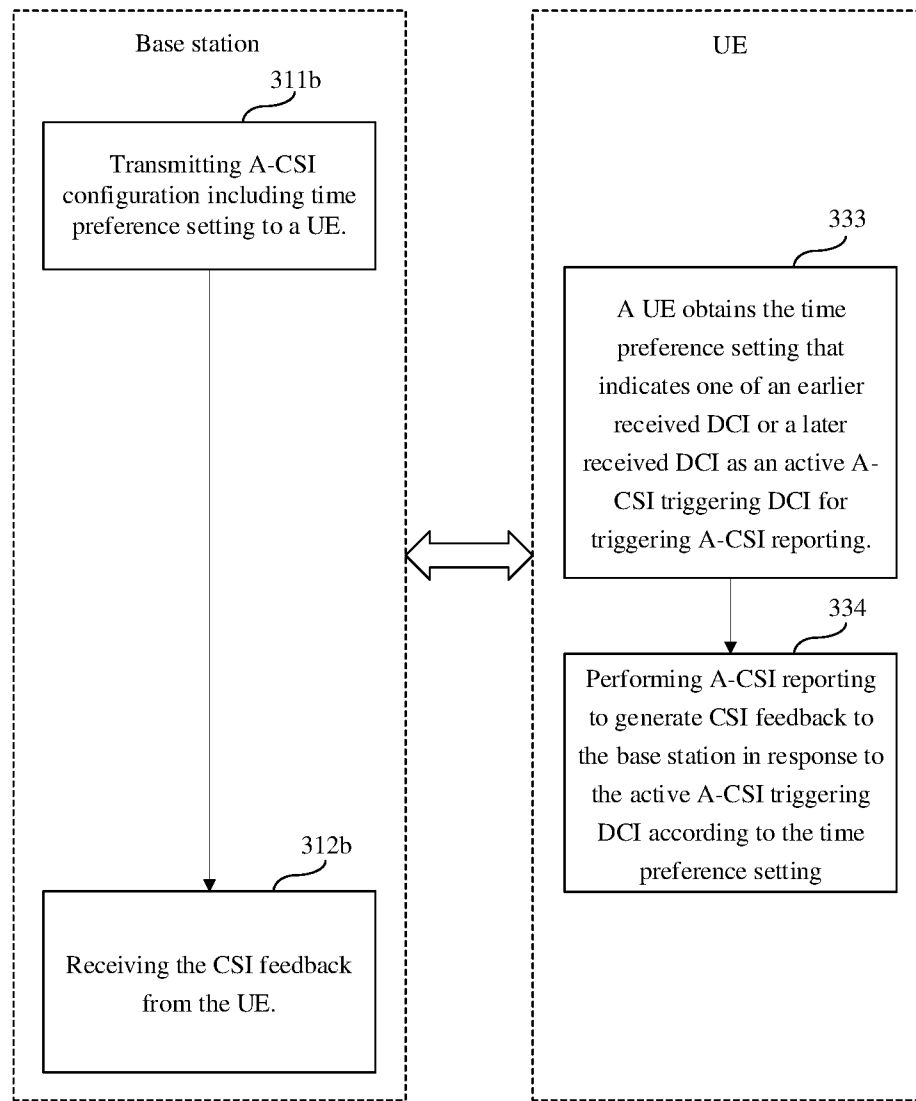


FIG. 6

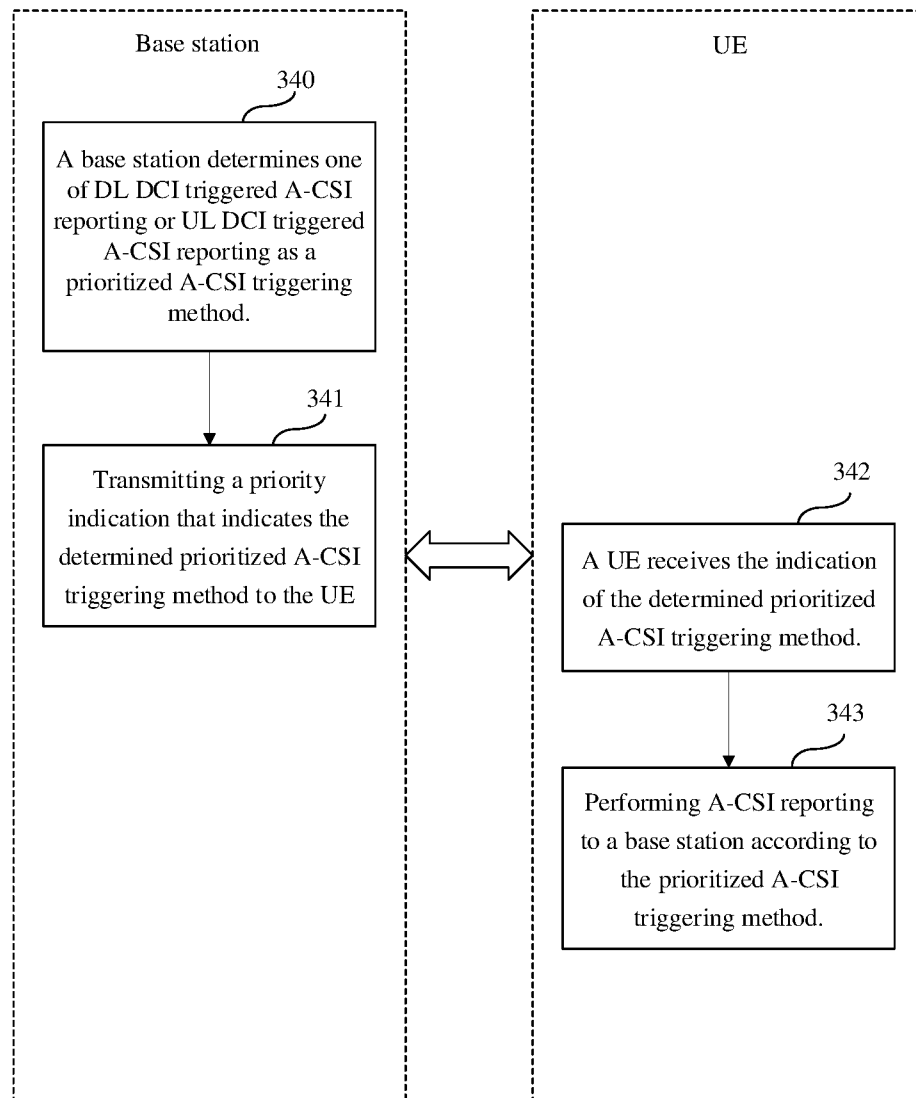


FIG. 7

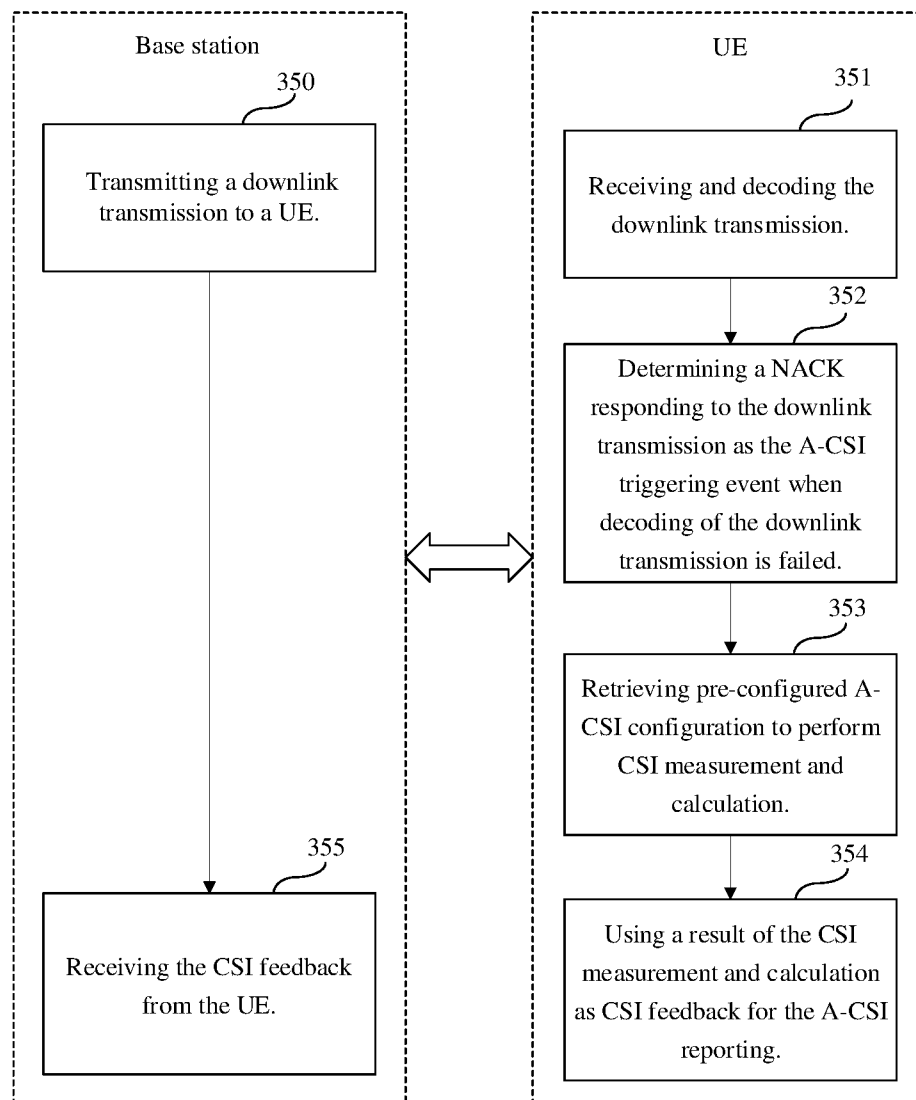


FIG. 8

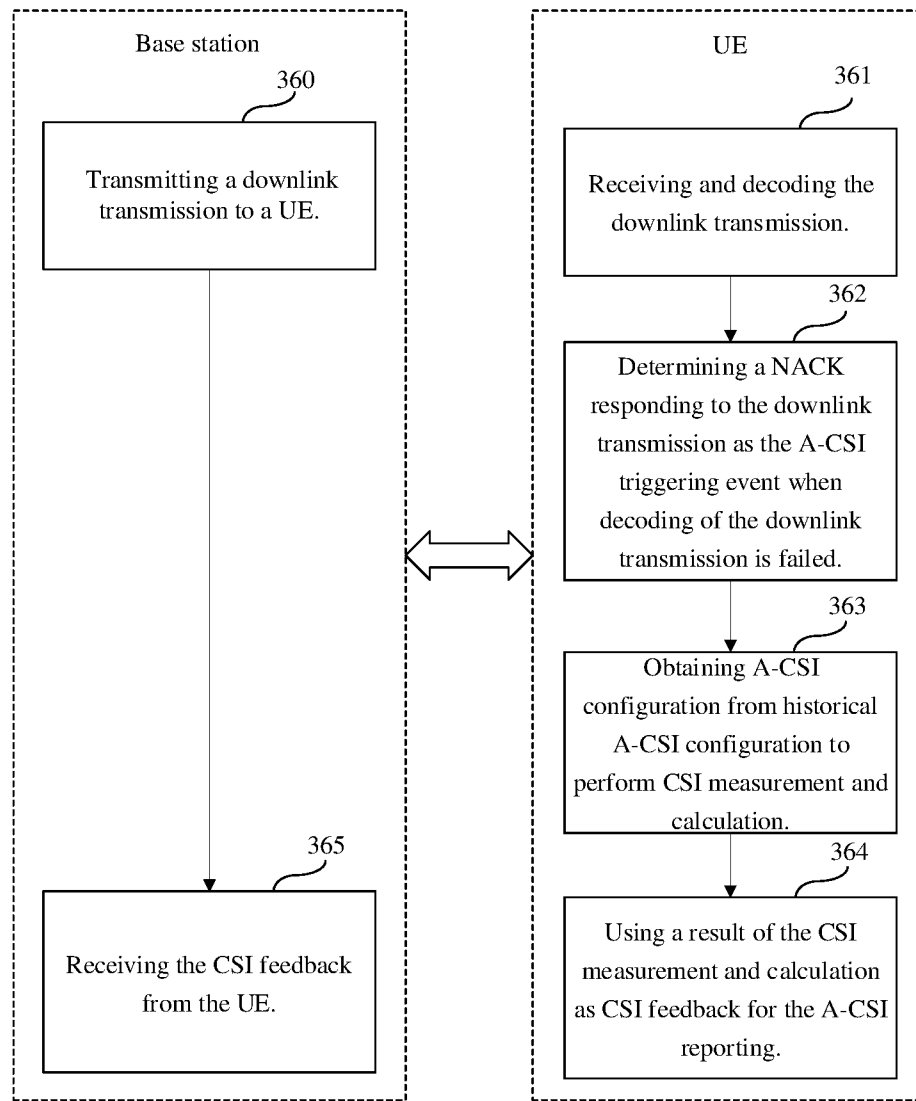


FIG. 9

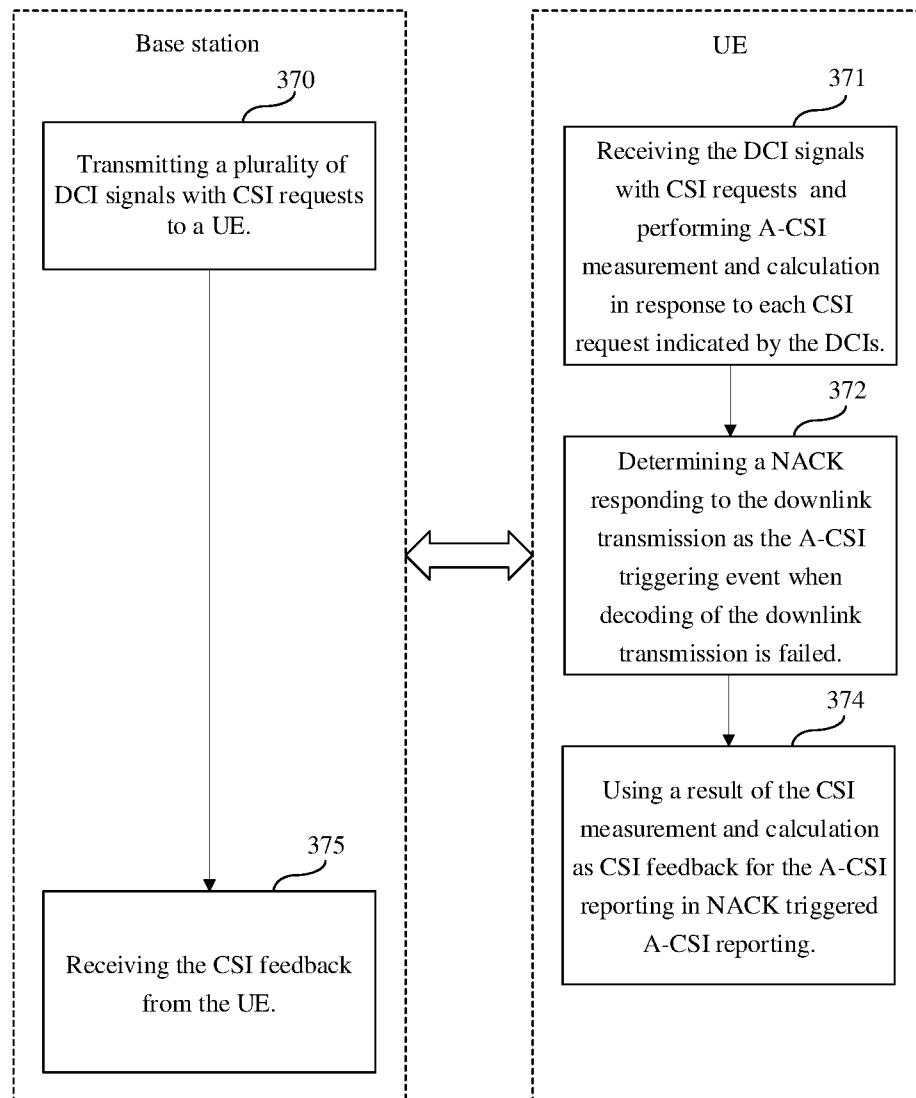


FIG. 10

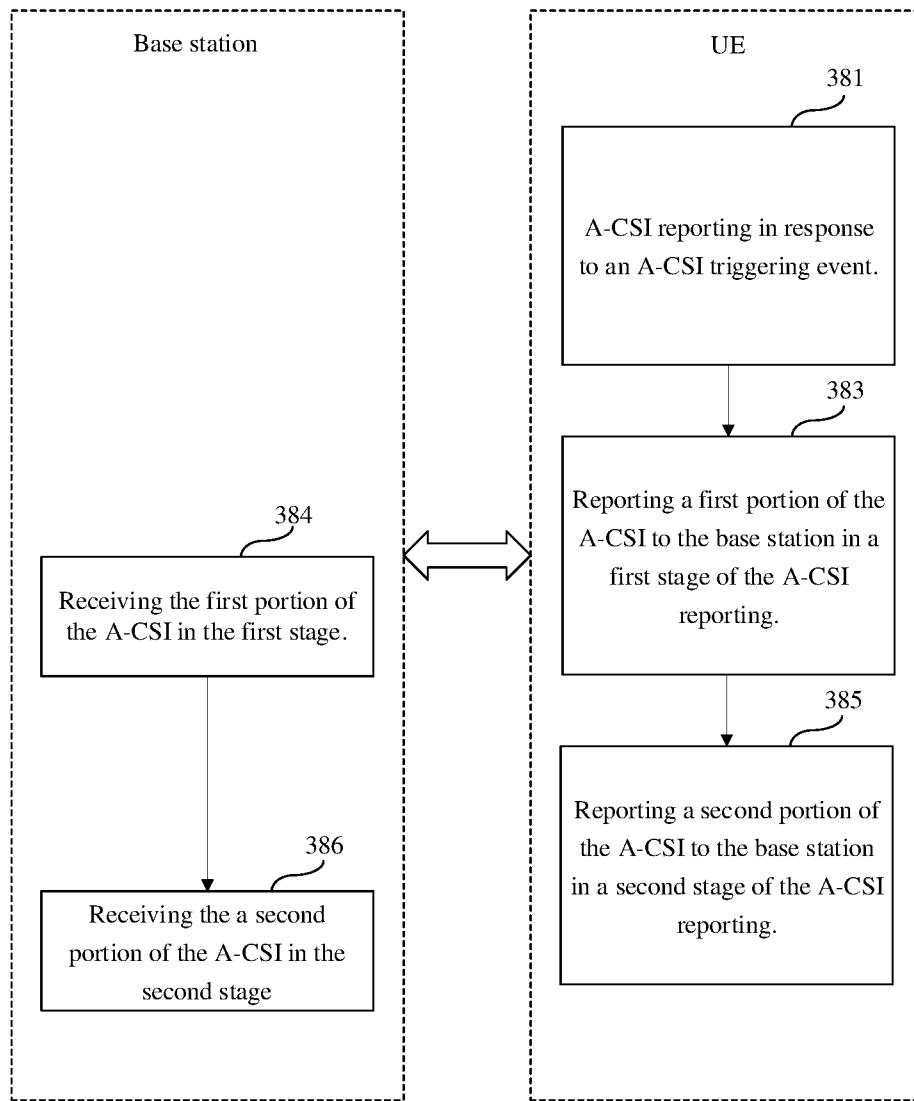


FIG. 11

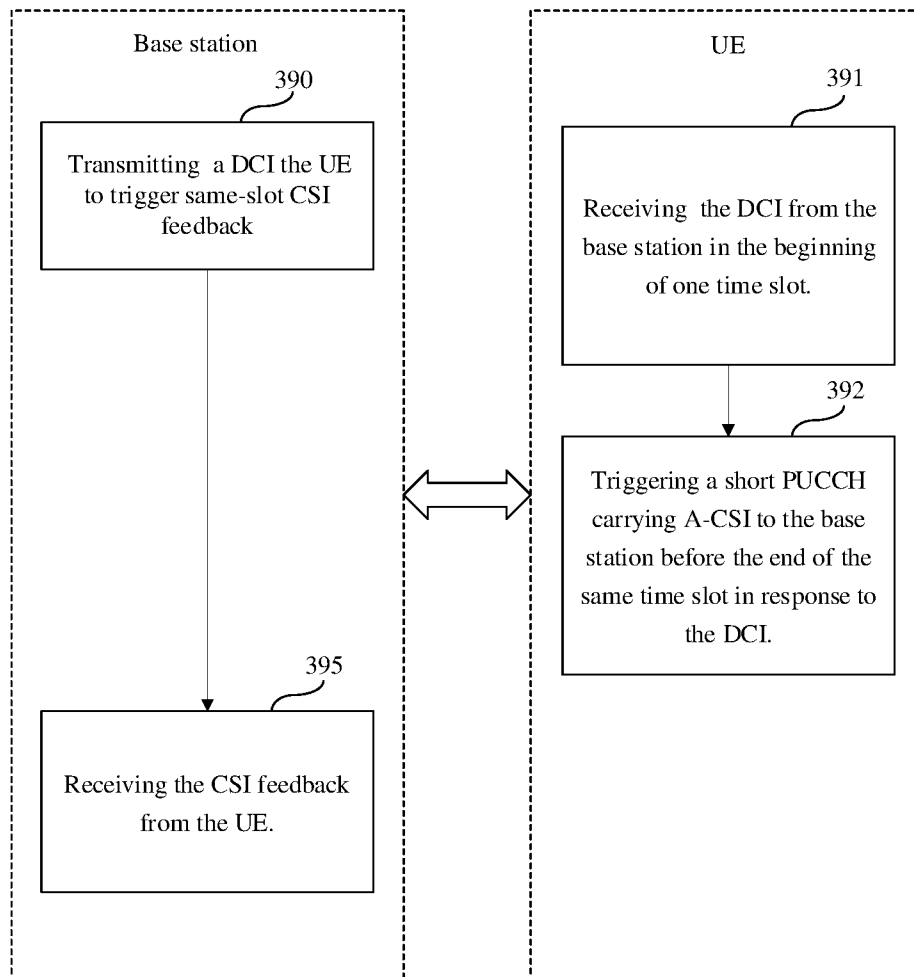


FIG. 12

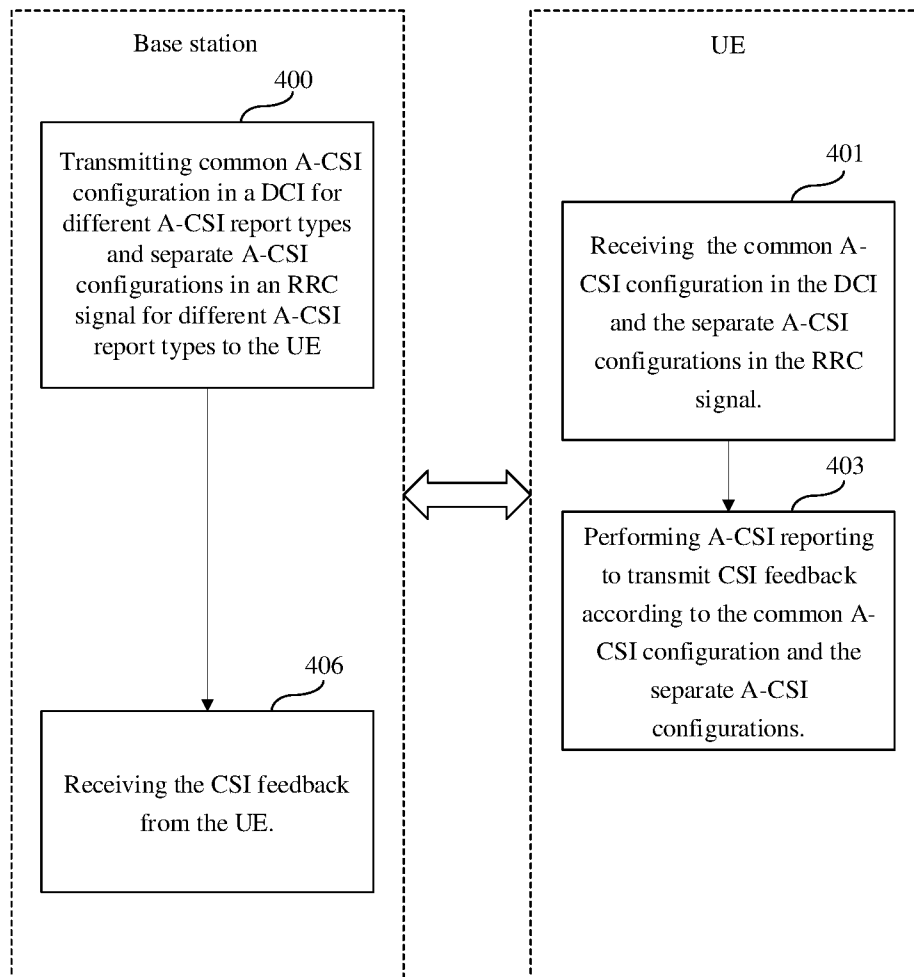


FIG. 13

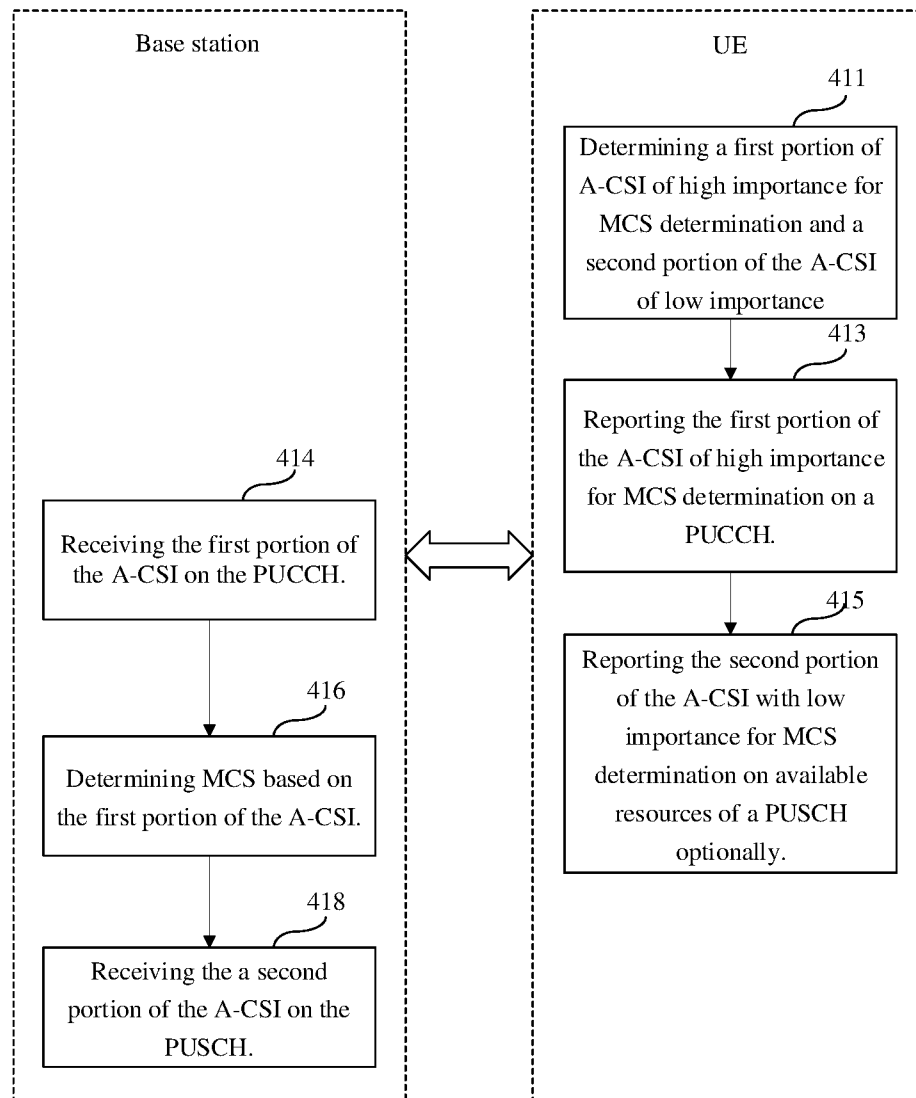


FIG. 14

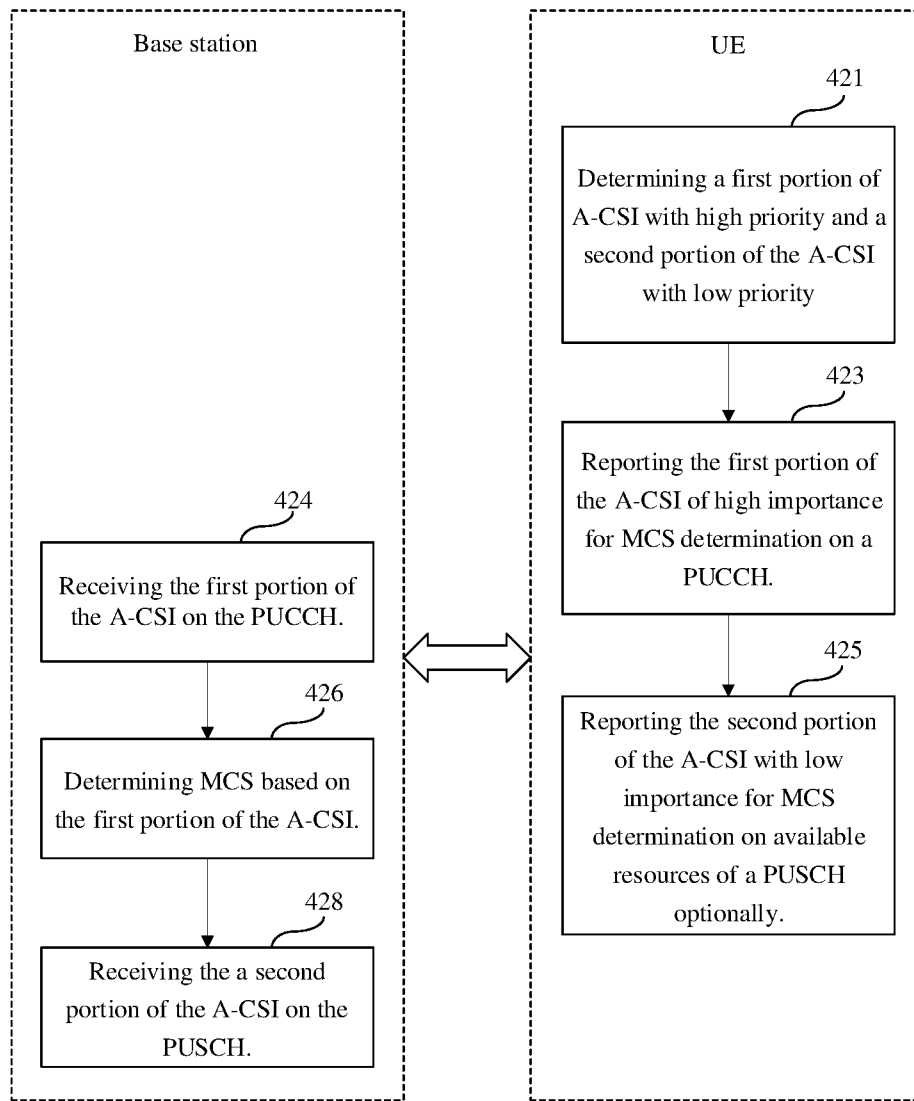


FIG. 15

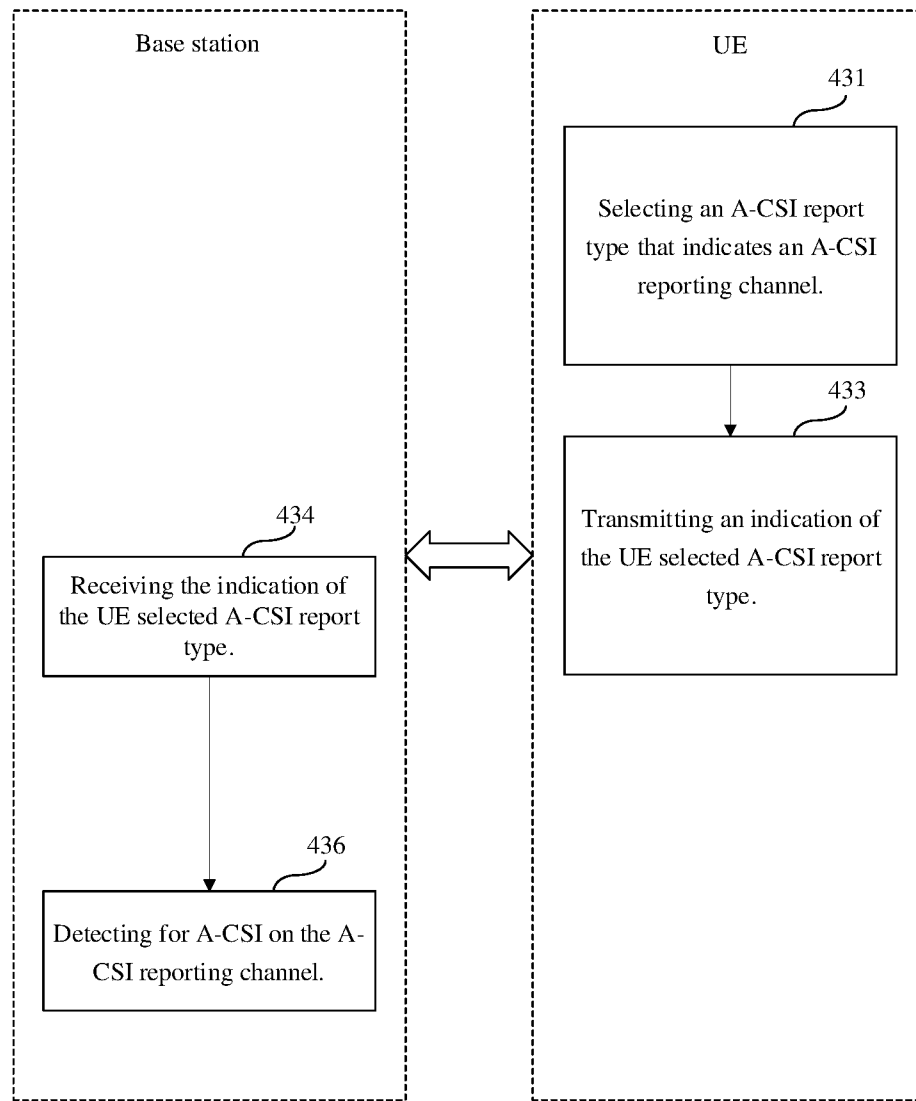


FIG. 16

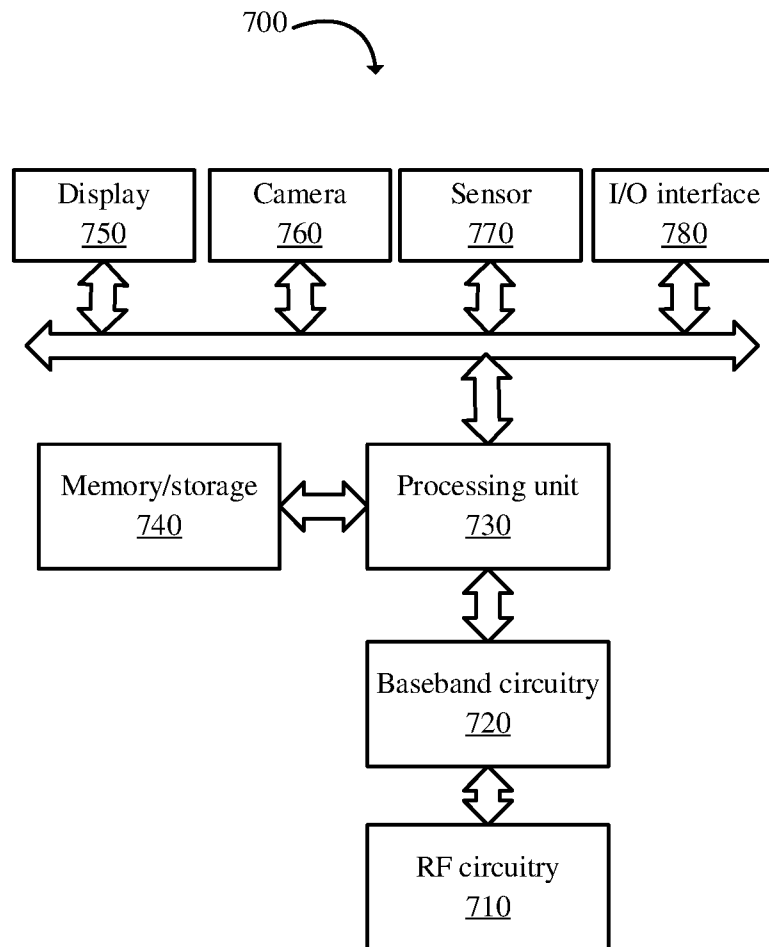


FIG. 17

INTERNATIONAL SEARCH REPORT

International application No.

PCT/CN2020/120957

A. CLASSIFICATION OF SUBJECT MATTER

H04W 72/00(2009.01)i

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

H04W; H04M; H04Q; H04L

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

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

EPTXT;USTXT;WOTXT;CNTXT;VEN;3GPP;CNKI:A-CSI, periodic, aperiodic, triggering, method, event, dci, nack, resource, pucch, pusch

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 2019053089 A1 (SAMSUNG ELECTRONICS CO LTD) 14 February 2019 (2019-02-14) the whole document	1-125
A	CN 104980252 A (PUTIAN INFORMATION TECHNOLOGY INST) 14 October 2015 (2015-10-14) the whole document	1-125
X	"3gpp-R1-2005432" <i>Discussion on CSI feedback enhancements for eURLLC3GPP</i> , 31 August 2020 (2020-08-31), section 2	1-125

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

* Special categories of cited documents:

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

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

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

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

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

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

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

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

"&" document member of the same patent family

Date of the actual completion of the international search

21 June 2021

Date of mailing of the international search report

12 July 2021

Name and mailing address of the ISA/CN

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Facsimile No. (86-10)62019451

Telephone No. 86-(010)-62411392

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.

PCT/CN2020/120957

Patent document cited in search report			Publication date (day/month/year)	Patent family member(s)			Publication date (day/month/year)
US	2019053089	A1	14 February 2019	KR	20190017586	A	20 February 2019
				WO	2019031940	A1	14 February 2019
CN	104980252	A	14 October 2015	CN	104980252	B	20 April 2018