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Electronic device and method used for wireless communication, and computer-readable storage medium

Abstract

Provided by the present disclosure are an electronic device and method used for wireless communication, and a computer-readable storage medium, the electronic device comprising: a processing circuit that is configured to: acquire from a base station information that is allocated by the base station for a user equipment (UE) and that is used for a beam management sounding reference signal (SRS) resource set; and, according to a pre-determined rule, determine an antenna panel of a UE corresponding to the SRS resource set indicated by the information, wherein the pre-determined rule limits the mapping between SRS resource sets used for beam management and antenna panels of UEs.

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Background/Summary

CROSS-REFERENCE TO RELATED APPLICATIONS (1) This application is a continuation of U.S. application Ser. No. 17/293,039, filed May 12, 2021, which is based on PCT filing PCT/CN2019/129098, filed Dec. 27, 2019, which claims priority to Chinese Patent Application No. 201910004300.X, titled “ELECTRONIC DEVICE AND METHOD USED FOR WIRELESS COMMUNICATION, AND COMPUTER-READABLE STORAGE MEDIUM”, filed on Jan. 3, 2019 with the China National Intellectual Property Administration, each of which is incorporated herein by reference in its entirety.

FIELD

(1) The present disclosure relates to the technical field of wireless communications, in particular to uplink beam management in a wireless communication system, and more in particular to an electronic apparatus and a method for wireless communications, and a computer-readable storage medium.

BACKGROUND

(2) With the development of wireless communication technology, communication terminals such as user equipment (UE) may have multiple antenna panels, and each of the multiple antenna panels may form beams in different spatial directions. Within a time unit, each antenna panel may only emit beams in one direction, and the multiple antenna panels may emit beams simultaneously. Therefore, a base station may configure multiple sounding reference signal (SRS) resource sets for the UE for the purpose of uplink beam management.

(3) FIG. 1 is a schematic diagram showing UE having 4 antenna panels. SRS resource sets required for uplink beam scanning are allocated to the 4 antenna panels respectively. Each of the SRS resource sets includes N SRS resources. FIG. 2 is a schematic diagram of performing uplink beam scanning utilizing the SRS resource sets allocated in FIG. 1. It can be seen that on a same OFDM symbol, the 4 antenna panels emit beams in 4 directions respectively.

SUMMARY

(4) In the following, an overview of the present disclosure is given simply to provide basic understanding to some aspects of the present disclosure. It should be understood that this overview is not an exhaustive overview of the present disclosure. It is not intended to determine a critical part or an important part of the present disclosure, nor to limit the scope of the present disclosure. An object of the overview is only to give some concepts in a simplified manner, which serves as a preface of a more detailed description described later.

(5) An electronic apparatus for wireless communications is provided according to an aspect of the present disclosure. The electronic apparatus includes processing circuitry, which is configured to: acquire, from a base station, information of an SRS resource set for beam management configured by the base station for user equipment; and determine, based on a predetermined rule, an antenna panel of the user equipment corresponding to the SRS resource set indicated by the information. The predetermined rule defines a mapping relationship between SRS resource sets for beam management and antenna panels of the user equipment.

(6) A method for wireless communications is provided according to another aspect of the present disclosure. The method includes: acquiring, from a base station, information of an SRS resource set for beam management configured by the base station for user equipment; and determining, based on a predetermined rule, an antenna panel of the user equipment corresponding to the SRS resource set indicated by the information, where the predetermined rule defines a mapping relationship between SRS resource sets for beam management and antenna panels of the user equipment.

(7) An electronic apparatus for wireless communications is provided according to an aspect of the present disclosure. The electronic apparatus includes processing circuitry, which is configured to: generate information of an SRS resource set for beam management configured for user equipment, where there is mapping relationship defined by a predetermined rule between the SRS resource set indicated by the information and an antenna panel of the user equipment; and transmit the information to the user equipment.

(8) A method for wireless communications is provided according to another aspect of the present disclosure. The method includes: generating information of an SRS resource set for beam management configured for user equipment, where there is a mapping relationship defined by a predetermined rule between the SRS resource set indicated by the information and an antenna panel of the user equipment; and transmitting the information to the user equipment.

(9) An electronic apparatus for wireless communications is provided according to an aspect of the

present disclosure. The electronic apparatus includes processing circuitry, which is configured to: determine, based on a predetermined rule, an SRS resource set for beam management corresponding to a particular antenna panel of user equipment, where the predetermined rule defines a mapping relationship between SRS resource sets for beam management and antenna panels of the user equipment; and transmit information of the determined SRS resource set to the base station.

(10) A method for wireless communications is provided according to another aspect of the present disclosure. The method includes: determining, based on a predetermined rule, an SRS resource set for beam management corresponding to a particular antenna panel of user equipment, where the predetermined rule defines a mapping relationship between SRS resource sets for beam management and antenna panels of the user equipment; and transmitting information of the determined SRS resource set to the base station.

(11) An electronic apparatus for wireless communications is provided according to an aspect of the present disclosure. The electronic apparatus includes processing circuitry, which is configured to: acquire, from user equipment, information of an SRS resource set for beam management; and determine, based on a predetermined rule, an antenna panel of user equipment corresponding to the SRS resource set indicated by the information, where the predetermined rule defines a mapping relationship between SRS resource sets for beam management and antenna panels of the user equipment.

(12) A method for wireless communications is provided according to another aspect of the present disclosure. The method includes: acquiring, from user equipment, information of an SRS resource set for beam management; and determining, based on a predetermined rule, an antenna panel of the user equipment corresponding to the SRS resource set indicated by the information, where the predetermined rule defines a mapping relationship between SRS resource sets for beam management and antenna panels of the user equipment.

(13) According to other aspects of the present disclosure, there are further provided computer program codes and computer program products for implementing the methods for wireless communications above, and a computer readable storage medium having recorded thereon the computer program codes for implementing the methods for wireless communications described above.

(14) With the electronic apparatuses and the methods according to embodiments of the present disclosure, the mapping relationship between the SRS resource sets and the antenna panels of the UE is defined based on a predetermined rule, so that the base station can acquire knowledge of, for each antenna panel of the UE, which SRS resource set is utilized in particular, in a deterministic manner.

(15) These and other advantages of the present disclosure will be more apparent by illustrating in detail a preferred embodiment of the present disclosure in conjunction with accompanying drawings below.

Description

BRIEF DESCRIPTION OF THE DRAWINGS

(1) To further set forth the above and other advantages and features of the present disclosure, detailed description will be made in the following taken in conjunction with accompanying drawings in which identical or like reference signs designate identical or like components. The accompanying drawings, together with the detailed description below, are incorporated into and form a part of the specification. It should be noted that the accompanying drawings only illustrate, by way of example, typical embodiments of the present disclosure and should not be construed as a limitation to the scope of the disclosure. In the accompanying drawings:

- (2) FIG. 1 is a schematic diagram showing a UE having 4 antenna panels;
- (3) FIG. 2 is a schematic diagram showing performing uplink beam scanning utilizing SRS resource sets allocated in FIG. 1;
- (4) FIG. 3 is a block diagram showing functional modules of an electronic apparatus for wireless communications according to an embodiment of the present disclosure;
- (5) FIG. 4 is a schematic diagram of performing SRS transmitting based on RRC configuration;
- (6) FIG. 5 is a schematic diagram of performing SRS transmitting through MAC CE for activation;
- (7) FIG. 6 shows an example of MAC CE for activating or deactivating an antenna panel;
- (8) FIG. 7 is a block diagram showing functional modules of an electronic apparatus for wireless communications according to an embodiment of the present disclosure;
- (9) FIG. 8 is a block diagram showing functional modules of an electronic apparatus for wireless communications according to another embodiment of the present disclosure;
- (10) FIG. 9 is a schematic diagram showing performing downlink beam scanning by a base station utilizing a channel state information reference signal (CSI-RS);
- (11) FIG. 10 is a block diagram showing functional modules of an electronic apparatus for wireless communications according to another embodiment of the present disclosure;
- (12) FIG. 11 shows a diagram of an example of a measurement report for a downlink reference signal transmitted by UE in a case that the downlink reference signal is a CSI-RS;
- (13) FIG. 12 is a block diagram showing functional modules of an electronic apparatus for wireless communications according to another embodiment of the present disclosure;
- (14) FIG. 13 shows a flowchart of a method for wireless communications according to an embodiment of the present disclosure;
- (15) FIG. 14 shows a flowchart of a method for wireless communications according to another embodiment of the present disclosure;
- (16) FIG. 15 shows a flowchart of a method for wireless communications according to another embodiment of the present disclosure;
- (17) FIG. 16 shows a flowchart of a method for wireless communications according to another embodiment of the present disclosure;
- (18) FIG. 17 is a block diagram showing a first example of an exemplary configuration of an eNB or gNB to which the technology according to the present disclosure may be applied;
- (19) FIG. 18 is a block diagram showing a second example of an exemplary configuration of the eNB or gNB to which the technology according to the present disclosure may be applied;
- (20) FIG. 19 is a block diagram showing an example of an exemplary configuration of a smartphone to which the technology according to the present disclosure may be applied;
- (21) FIG. 20 is a block diagram showing an example of an exemplary configuration of a car navigation apparatus to which the technology according to the present disclosure may be applied;
- and
- (22) FIG. 21 is a block diagram of an exemplary block diagram illustrating the structure of a general purpose personal computer capable of realizing the method and/or device and/or system according to the embodiments of the present disclosure.

DETAILED DESCRIPTION OF EMBODIMENTS

(23) An exemplary embodiment of the present disclosure will be described hereinafter in conjunction with the accompanying drawings. For the purpose of conciseness and clarity, not all features of an embodiment are described in this specification. However, it should be understood that multiple decisions specific to the embodiment have to be made in a process of developing any such embodiment to realize a particular object of a developer, for example, conforming to those constraints related to a system and a business, and these constraints may change as the embodiments differs. Furthermore, it should also be understood that although the development work may be very complicated and time-consuming, for those skilled in the art benefiting from the present disclosure, such development work is only a routine task.

(24) Here, it should also be noted that in order to avoid obscuring the present disclosure due to unnecessary details, only a device structure and/or processing steps closely related to the solution according to the present disclosure are illustrated in the accompanying drawing, and other details having little relationship to the present disclosure are omitted.

First Embodiment

(25) FIG. 3 is a block diagram showing functional modules of an electronic apparatus **100** for wireless communications according to an embodiment of the present disclosure. As shown in FIG. 3, the electronic apparatus **100** includes an acquiring unit **101** and a determining unit **102**. The acquiring unit **101** is configured to acquire, from a base station, information of an SRS resource set for beam management configured by the base station for user equipment (UE). The determining unit **102** is configured to determine, based on a predetermined rule, an antenna panel of the UE corresponding to the SRS resource set indicated by the information. The predetermined rule defines a mapping relationship between the SRS resource set for beam management and the antenna panel of the UE.

(26) The acquiring unit **101** and the determining unit **102** may be implemented by one or more processing circuitries. The processing circuitry may be implemented as, for example, a chip or a processor. In addition, it should be understood that various functional units in the apparatus shown in FIG. 3 are just logical modules divided based on functions implemented by these functional units, and are not intended to limit the specific implementations, which is also applicable to examples of other electronic apparatus described subsequently.

(27) The electronic apparatus **100**, for example, may be arranged at a side of the user equipment (UE) or may be communicatively connected to the UE. Here, it should be further noted that the electronic apparatus **100** may be implemented at a chip level, or may be implemented at an apparatus level. For example, the electronic apparatus **100** may operate as the user equipment itself, and may further include external apparatuses such as a memory and a transceiver (not shown in the drawings). The memory may be configured to store programs required to be executed by the user equipment and related data information for implementing various functions. The transceiver may include one or more communication interfaces to support communication with different apparatuses (such as a base station, and other user equipment). An implementation form of the transceiver is not specifically limited herein. This also applies to subsequent description of other configuration examples of the electronic apparatus at the side of the user equipment.

(28) In the Rel.15 standard, the association relationship between the SRS resource sets and the antenna panels of the UE, that is, which antenna panel utilizing which SRS resource set, is implemented by the UE by itself, and is unknown to the base station. In this embodiment, the mapping relationship between the SRS resource sets and the antenna panels of the UE is determined by using the predetermined rule, so that the base station can acquire knowledge of the association relationship between the SRS resource sets and the antenna panels of the UE, so as to achieve more accurate uplink beam management.

(29) For example, the acquiring unit **101** may acquire the above mentioned information through radio resource control (RRC) signaling. The UE can report its beam capability, for example, information of the configured antenna panels, by reporting UE capability. The base station configures an SRS resource set for beam management for the antenna panel through the RRC signaling.

(30) For ease of understanding, FIG. 4 shows a schematic diagram of performing SRS transmitting through RRC configuration, where a transmitting period is 20 time slots and an offset is 10 time slots. Therefore, the UE, utilizing the configured SRS resource set, starts SRS transmission at the 10th time slot after a time slot in which the UE receives the RRC configuration. In addition, as shown in FIG. 5, the UE may perform SRS transmission utilizing configured SRS resources after receiving MAC CE for activation from the base station, and stop the SRS transmission after receiving MAC CE for deactivation from the base station, where a transmission period is also 20

time slots.

(31) It should be understood that, in order to save resources, the base station may configure, for the UE, SRS resource sets the number of which is smaller than the number of antenna panels of the UE. That is, the UE performs the SRS transmission utilizing only a part of the antenna panels. In order to enable the base station to determine by which antenna panel of the UE the received SRS signal is transmitted, a predetermined rule is set as a reference for the base station in this embodiment.

(32) In an example, the predetermined rule may include: mapping an SRS resource set with a small identifier (ID) to an antenna panel with a small identifier. For example, the UE has 4 antenna panels (respectively represented as panel 0 to 3). The SRS resource sets configured by the base station for the UE are SRS resource set 10, SRS resource set 18, SRS resource set 21, and SRS resource set 29, respectively. Based on the predetermined rule, the association (or mapping) may be set as follows. The SRS resource set 10 corresponds to the panel 0, the SRS resource set 18 corresponds to the panel 1, the SRS resource set 21 corresponds to the panel 2, and the SRS resource set 29 corresponds to the panel 3.

(33) In a case that the number of SRS resource sets allocated by the base station is smaller than 4, for example, the base station allocates only 2 SRS resource sets, the association (or mapping) may be set as follows. The SRS resource set 10 corresponds to the panel 0, the SRS resource set 18 corresponds to the panel 1, and no resource sets correspond to the panel 2 and the panel 3.

(34) In this case, the base station can accurately determine, based on the predetermined rule, the received SRS signal is from which antenna panel of the UE. It should be understood that the foregoing is only an example of the predetermined rule, and this example is not restrictive, and other appropriate predetermined rules may be adopted.

(35) In addition, an ON/OFF state of the antenna panel of the UE may be changed over time. For example, the base station may control each antenna panel of the UE to be on or off in various ways. In an example, the determining unit **102** may further be configured to change the ON/OFF state of each antenna panel based on the above information of SRS resource set. The ON/OFF state of the antenna panel may be changed periodically, semi-statically or aperiodically. Correspondingly, the configuration of the SRS resource set may also be periodically, semi-statically or aperiodically.

(36) For example, the acquiring unit **101** may be configured to periodically acquire the information, so that the determining unit **102** may be configured to periodically change the ON/OFF state of each antenna panel based on the information, for example, turning on or off a particular antenna panel of the UE. In the foregoing example where the UE has 4 antenna panels and the number of configured SRS resource sets decreases from 4 (that is, the SRS resource sets 10, 18, 21, and 29) to 2 (that is, the SRS resource sets 10 and 18), the antenna panels 2 and 3 are turned off.

(37) In addition, the acquiring unit **101** may be further configured to acquire the MAC CE from the base station to activate or deactivate the antenna panel corresponding to the SRS resource set indicated by the information. This manner is called a semi-static manner, as shown in FIG. 5. The MAC CE may include information of the ID of the SRS resource set. The UE changes the ON/OFF state of the antenna panel corresponding to the ID. For example, the UE turns the antenna panel to be off in a case that it is currently in the on state, and turns the antenna panel to be on in a case that it is currently in the off state. FIG. 6 shows an example of MAC CE for activating or deactivating an antenna panel. The MAC CE includes an ID of an SRS resource set and an ID of a bandwidth part (BWP) to which the SRS resource set belongs.

(38) Alternatively, the determining unit **102** may be configured to change the ON/OFF state of the antenna panel corresponding to the SRS resource set indicated by the information based on downlink control information (DCI). This manner is called an aperiodic manner. For example, in the case that the UE has 4 antenna panels, the determining unit **102** may change an ON/OFF state of one of the 4 antenna panels using 2-bit information in the DCI.

(39) On the other hand, the UE itself may control the ON/OFF state of its antenna panel. In this

case, the electronic apparatus **100** may further include a transmitting unit **103** configured to notify the base station of the change of the ON/OFF state of the antenna panel of the UE, as shown in FIG. 7. For example, the transmitting unit **103** is configured to transmit a request for configuring an SRS resource set for beam management to the base station, in a case that a particular antenna panel is turned on, and transmit a request for releasing the SRS resource set corresponding to the particular antenna panel to the base station in a case that the particular antenna panel is turned off. (40) These requests may each include an identifier of the SRS resource set that has a mapping relationship with the particular antenna panel. The identifier, for example, may be acquired based on a stored historical mapping relationship between the SRS resource set and the antenna panel. These requests may be transmitted to the base station through the RRC signaling.

(41) In addition, the transmitting unit **103** may further be configured to transmit a request for activating the SRS resource set for beam management to the base station in the case that the particular antenna panel is turned on, and transmit a request for deactivating the SRS resource set corresponding to the particular antenna panel to the base station in the case that the particular antenna panel is turned off. These requests may be transmitted through MAC signaling. Similarly, these requests may each include the identifier of the SRS resource set that has a mapping relationship with the particular antenna panel.

(42) According to this aspect of the present disclosure, the identifier of the SRS resource set is used as an indication to notify the base station to configure the SRS resources, so that the base station can acquire knowledge of a switching operation performed by the UE on a particular antenna panel.

(43) In summary, the electronic apparatus **100** according to this embodiment determines the mapping relationship between the SRS resource sets and the antenna panels of the UE based on the predetermined rule, so that the base station can acquire knowledge of, for each antenna panel of the UE, which SRS resource set is utilized in particular, in a deterministic manner, thereby achieving more accurate and effective beam management.

Second Embodiment

(44) FIG. 8 is a block diagram showing functional modules of an electronic apparatus **200** according to another embodiment of the present disclosure. As shown in FIG. 8, the electronic apparatus **200** includes a generating unit **201** and a transmitting unit **202**. The generating unit **201** is configured to generate information of an SRS resource set configured for UE for beam management. There is a mapping relationship defined by a predetermined rule between the SRS resource set indicated by the information and an antenna panel of the UE. The transmitting unit **202** is configured to transmit the information to the UE.

(45) The generating unit **201** and the transmitting unit **202** may be implemented by one or more processing circuitries. The processing circuitry may be implemented as, for example, a chip or a processor. In addition, it should be understood that various functional units in the apparatus shown in FIG. 8 are just logical modules divided based on functions implemented by these functional units, and are not intended to limit the specific implementations, which is also applicable to examples of other electronic apparatus described subsequently.

(46) The electronic apparatus **200**, for example, may be arranged at a side of a base station or may be communicatively connected to a base station. The base station described in the present disclosure may also be a transmit receive point (TRP) or an access point (AP). Here, it should further be noted that the electronic apparatus **200** may be implemented at a chip level, or may be implemented at an apparatus level. For example, the electronic apparatus **100** may operate as the base station itself, and may further include external apparatuses such as a memory and a transceiver (not shown in the drawings). The memory may be configured to store programs required to be executed by the base station and related data information for implementing various functions. The transceiver may include one or more communication interfaces to support communication with different apparatuses (such as user equipment, and another base station). An implementation form of the transceiver is not specifically limited herein. This also applies to subsequent description of

other configuration examples of the electronic apparatus at the side of the base station.

(47) Since there is a mapping relationship defined by a predetermined rule between the SRS resource set and the antenna panel of the UE, the base station can determine, based on the predetermined rule, which antenna panel of the UE each SRS resource set would be associated with, thereby achieving antenna panel-specific beam management.

(48) The predetermined rule includes, for example, mapping an SRS resource set with a small identifier to an antenna panel with a small identifier. Specific examples have been given in the first embodiment and are not repeated here. Further, it should be understood that the predetermined rule is not limited thereto, and may be appropriately modified or changed.

(49) In an example, the transmitting unit **202** may transmit the information through RRC signaling.

(50) As described in the first embodiment, this information may be used to change an ON/OFF state of each antenna panel. Depending on time domain attributes, the ON/OFF state of each antenna panel may be changed periodically, semi-statically or aperiodically.

(51) For example, the transmitting unit **202** may periodically transmit the information, so as to change of the ON/OFF state of the antenna panel periodically. Alternatively, in addition to the RRC signaling, the transmitting unit **202** may instruct, through the MAC CE, the UE to activate or deactivate the antenna panel corresponding to the SRS resource set indicated by the information, so as to semi-statically control the ON/OFF state of the antenna panel. The MAC CE may further include an ID of an SRS resource set corresponding to an antenna panel whose ON/OFF state is to be changed, as shown in FIG. 6, for example.

(52) In addition, the transmitting unit **202** may instruct, through DCI, the UE to change the ON/OFF state of the antenna panel corresponding to the SRS resource set indicated by the information. This manner is an aperiodic control manner. For example, in the case that the UE has 4 antenna panels, the transmitting unit **202** may indicate an ON/OFF state of which antenna panel is to be changed through the 2-bit information in the DCI.

(53) In summary, the electronic apparatus **200** according to the present disclosure can acquire knowledge of, for each antenna panel of the UE, which SRS resource set is utilized in particular, in a deterministic manner based on a predetermined rule commonly known by the base station and the UE, thereby achieving more accurate and effective beam management.

Third Embodiment

(54) In a case that uplink and downlink channels have beam symmetry, for example, in a time division duplexing (TDD) system, the base station may perform uplink beam management based on a downlink reference signal. As shown in FIG. 9, the base station utilizes a channel state information reference signal (CSI-RS) as a reference signal for beam scanning. The UE performs receiving by utilizing two receiving (Rx) beams of the antenna panel, and reports an ID of the CSI-RS resource, that is, CRI. After receiving the report, the base station can acquire knowledge of an appropriate emitting beam. If the base station can also acquire related information indicating which antenna panel the UE utilizes for receiving, the base station may configure the SRS resource set for beam management accordingly.

(55) FIG. 10 is a block diagram showing functional modules of an electronic apparatus **300** for wireless communications according to this embodiment. As shown in FIG. 10, the electronic apparatus **300** includes a determining unit **301** and a transmitting unit **302**. The determining unit **301** is configured to determine, based on a predetermined rule, an SRS resource set for beam management corresponding to a particular antenna panel of UE. The predetermined rule defines a mapping relationship between the SRS resource sets for beam management and the antenna panels of the UE. The transmitting unit **302** is configured to transmit information of the determined SRS resource set to the base station.

(56) The determining unit **301** and the transmitting unit **302** may be implemented by one or more processing circuitries. The processing circuitry may be implemented as, for example, a chip or a processor. The electronic apparatus **300**, for example, may be arranged at a side of user equipment

(UE) or may be communicatively connected to UE.

(57) The predetermined rule may include, for example, mapping an SRS resource set with a small identifier to an antenna panel with a small identifier. The determining unit **301** may determine, based on the predetermined rule, the SRS resource set corresponding to the particular antenna panel. The base station may acquire the same mapping relationship based on the predetermined rule, so that the can determine which of the antenna panels the particular antenna panel of the UE is, upon receipt of the information of the SRS resource set. Here, the information of the SRS resource set may be an identifier (ID) of the SRS resource set. In a case of there being multiple particular antenna panels, the information may include IDs of multiple SRS resource sets.

(58) In an example, the determining unit **301** may perform the determining based on an SRS resource set in historical configuration. The historical configuration includes, for example, an ID of an SRS resource set recently configured by the base station for the UE.

(59) The determining unit **301** may further be configured to determine a particular antenna panel based on a measurement result for the downlink reference signal. The transmitting unit **302** may be configured to include an identifier of the SRS resource set corresponding to the determined particular antenna panel in a measurement report of the downlink reference signal and transmit the identifier to the base station. The downlink reference signal is, for example, the previously mentioned CSI-RS signal or a synchronization signal block (SSB).

(60) FIG. **11** shows a diagram of an example of a measurement report for a downlink reference signal transmitted by the UE in a case that the downlink reference signal is a CSI-RS. In the measurement report, the 1st to 4th rows show IDs of CSI-RS resources, that is, CRIs, corresponding to four emitting beams that are reported, respectively. The 5th to 8th rows show reference signal receiving power (RSRP) of the CSI-RS resources shown in the 1st to 4th rows, respectively. The 9th to 12th rows show identifiers of SRS resource sets corresponding to antenna panels at which receiving beams with best reception effect for the emitting beams shown in the 1st to 4th rows are located, respectively. It can be seen that, for one emitting beam, there may be multiple optimal receiving beams and these receiving beams may belong to different antenna panels. In this case, IDs of SRS resource sets respectively corresponding to the multiple antenna panels are to be included in the measurement report, as shown in the 9th and 12th rows in FIG. **11**.

(61) FIG. **11** only shows an example of the measurement report for the downlink reference signal, which is not restrictive, and the form and content of the report may be changed appropriately. Upon receipt of the measurement report, the base station may determine, based on the content in the last four rows, a corresponding antenna panel using the predetermined rule, and configure an SRS resource set for the UE based on the determined antenna panel.

(62) Correspondingly, an electronic apparatus **400** at a side of the base station is further provided according to this embodiment. As shown in FIG. **12**, the electronic apparatus **400** includes an acquiring unit **401** and a determining unit **402**. The acquiring unit **401** is configured to acquire, from the UE, the information of the SRS resource set for beam management. The determining unit **402** is configured to determine, based on the predetermined rule, an antenna panel of the UE corresponding to the SRS resource set indicated by the information. The predetermined rule defines a mapping relationship between the SRS resource sets for beam management and the antenna panels of the UE.

(63) The acquiring unit **401** and the determining unit **402** may be implemented by one or more processing circuitries. The processing circuitry may be implemented as, for example, a chip or a processor.

(64) Similarly, for example, the predetermined rule may include mapping an SRS resource set with a small identifier to an antenna panel with a small identifier.

(65) The information is, for example, included in the measurement report for the downlink reference signal reported by the UE, and the information is the identifier of the SRS resource set. The downlink reference signal is, for example, a CSI-RS or SSB. The determining unit **402** may

determine, for example, according to an SRS resource set historically configured for the UE, the corresponding antenna panel using the predetermined rule.

(66) In addition, the determining unit **402** may further be configured to configure an SRS resource set for the UE based on the determined antenna panel.

(67) In summary, the electronic apparatuses **300** and **400** according to this embodiment can achieve delivery of information about the particular antenna panel between the UE and the base station through the information of the SRS resource set based on the predetermined rule, thereby realizing uplink beam management based on the downlink reference signal.

Fourth Embodiment

(68) In the above description of embodiments of the electronic apparatuses for wireless communications, it is apparent that some processing and methods are further disclosed. In the following, a summary of the methods are described without repeating details that are described above. However, it should be noted that although the methods are disclosed when describing the electronic apparatuses for wireless communications, the methods are unnecessary to adopt those components or to be performed by those components described above. For example, implementations of the electronic apparatuses for wireless communications may be partially or completely implemented by hardware and/or firmware. Methods for wireless communications to be discussed below may be completely implemented by computer executable programs, although these methods may be implemented by the hardware and/or firmware for implementing the electronic apparatuses for wireless communications.

(69) FIG. **13** is a flowchart of a method for wireless communications according to an embodiment of the present disclosure. The method includes: acquiring, from a base station, information of an SRS resource set for beam management configured by the base station for UE (**S11**); and determining, based on a predetermined rule, an antenna panel of the UE corresponding to the SRS resource set indicated by the information (**S12**), where the predetermined rule defines a mapping relationship between SRS resource sets for beam management and antenna panels of the UE. This method may be performed at a side of the UE.

(70) For example, in step **S11**, the information may be acquired through RRC signaling. The predetermined rule may include: mapping an SRS resource set with a small identifier to an antenna panel with a small identifier.

(71) As shown in a dashed line block in FIG. **13**, the above method may further include a step **S13** of changing an ON/OFF state of each antenna panel based on the information.

(72) In an example, the information may be acquired periodically. In another example, the above method further includes the following step of: acquiring MAC CE from the base station to activate or deactivate the antenna panel corresponding to the SRS resource set indicated by the information. In yet another example, the above method further includes the following step of: changing, based on DCI, an ON/OFF state of an antenna panel corresponding to the SRS resource set indicated by the information.

(73) In an example that the UE controls the ON/OFF state of the antenna panel, the UE transmits a request for configuring an SRS resource set for beam management to the base station in a case that a particular antenna panel is turned on, and transmits a request for releasing the SRS resource set corresponding to the particular antenna panel to the base station in a case that the particular antenna panel is turned off. These requests may be transmitted through RRC signaling.

(74) Alternatively, the UE transmits a request for activating the SRS resource set for beam management to the base station in the case that the particular antenna panel is turned on, and transmits a request for deactivating the SRS resource set corresponding to the particular antenna panel to the base station in the case that the particular antenna panel is turned off. These requests may be transmitted through MAC signaling.

(75) These requests may each include an identifier of the SRS resource set that has a mapping relationship with the particular antenna panel.

(76) FIG. 14 shows a flowchart of a method for wireless communications according to another embodiment of the present disclosure. The method includes: generating information of an SRS resource set for beam management configured for UE (S21), where there is a mapping relationship defined by a predetermined rule between the SRS resource set indicated by the information and an antenna panel of the UE; and transmitting the information to the UE (S22). This method may be performed at a side of the base station.

(77) The predetermined rule may include: mapping an SRS resource set with a small identifier to an antenna panel with a small identifier. In step S22, the information may be transmitted through RRC signaling. In an example, the information may be transmitted periodically.

(78) The above method may further include the following steps of: instructing the UE to activate or deactivate an antenna panel corresponding to the SRS resource set indicated by the information through MAC CE; or instructing the UE to change an ON/OFF state of an antenna panel corresponding to the SRS resource set indicated by the information through the DCI.

(79) FIG. 15 is a flowchart of a method for wireless communications according to another embodiment of the present disclosure. The method includes: determining, based on a predetermined rule, an SRS resource set for beam management corresponding to a particular antenna panel of the UE (S31), where the predetermined rule defines a mapping relationship between the SRS resource set for beam management and the antenna panel of the UE; and transmitting information of the determined SRS resource set to the base station (S32). This method may be performed at a side of the UE.

(80) In an example, the particular antenna panel may be determined based on a measurement result of a downlink reference signal. In step S32, an identifier of the SRS resource set corresponding to the determined particular antenna panel is included in the measurement report for the downlink reference signal and is transmitted to the base station. The downlink reference signal is, for example, a CSI-RS or SSB. In step S31, the determining may be performed based on a historically configured SRS resource set.

(81) FIG. 16 is a flowchart of a method for wireless communications according to another embodiment of the present disclosure. The method includes: acquiring, from user equipment, information of an SRS resource set for beam management (S41); and determining, based on a predetermined rule, an antenna panel of the UE corresponding to the SRS resource set indicated by the information, where the predetermined rule defines a mapping relationship between the SRS resource set for beam management and the antenna panel of the UE. This method may be performed at a side of the base station.

(82) For example, the information is included in a measurement report for a downlink reference signal reported by the UE, and the information is an identifier of the SRS resource set. The above method may further include: configuring an SRS resource set for the UE based on the determined antenna panel.

(83) It should be noted that, the above methods may be used in combination or separately, which are described in detail in the first to third embodiments, and are not repeated here.

(84) The technology according to the present disclosure is applicable to various products.

(85) For example, the electronic apparatus 200 and the electronic apparatus 400 may be implemented as various base stations. The base station may be implemented as any type of evolved node B (eNB) or gNB (5G base station). The eNB includes, for example, a macro eNB and a small eNB. The small eNB may be an eNB covering a cell smaller than a macro cell, such as a pico eNB, a micro eNB, and a home (femto) eNB. The case for the gNB is similar to the above. Alternatively, the base station may be implemented as any other type of base station, such as a NodeB and a base transceiver station (BTS). The base station may include: a main body (also referred to as a base station apparatus) configured to control wireless communication; and one or more remote wireless head ends (RRH) located at positions different from the main body. In addition, various types of user equipment may each serve as a base station by performing functions of the base station

temporarily or semi-permanently.

(86) The electronic apparatus **100** and electronic apparatus **300** may be implemented as various user equipments. The user equipment may be implemented as a mobile terminal (such as a smartphone, a tablet personal computer (PC), a notebook PC, a portable game terminal, a portable/dongle mobile router, and a digital camera) or a vehicle terminal (such as a vehicle navigation apparatus). The user equipment may also be implemented as a terminal that performs machine-to-machine (M2M) communication (also referred to as a machine type communication (MTC) terminal). Furthermore, the user equipment may be a wireless communication module (such as an integrated circuitry module including a single die) mounted on each of the terminals described above.

Application Example Regarding a Base Station

First Application Example

(87) FIG. **17** is a block diagram showing a first example of an exemplary configuration of an eNB or gNB to which technology according to the present disclosure may be applied. It should be noted that the following description is given by taking the eNB as an example, which is also applicable to the gNB. An eNB **800** includes one or more antennas **810** and a base station apparatus **820**. The base station apparatus **820** and each of the antennas **810** may be connected to each other via a radio frequency (RF) cable.

(88) Each of the antennas **810** includes a single or multiple antennal elements (such as multiple antenna elements included in a multiple-input multiple-output (MIMO) antenna), and is used for the base station apparatus **820** to transmit and receive wireless signals. As shown in FIG. **17**, the eNB **800** may include the multiple antennas **810**. For example, the multiple antennas **810** may be compatible with multiple frequency bands used by the eNB **800**. Although FIG. **17** shows the example in which the eNB **800** includes the multiple antennas **810**, the eNB **800** may also include a single antenna **810**.

(89) The base station apparatus **820** includes a controller **821**, a memory **822**, a network interface **823**, and a radio communication interface **825**.

(90) The controller **821** may be, for example, a CPU or a DSP, and operates various functions of a higher layer of the base station apparatus **820**. For example, the controller **821** generates a data packet from data in signals processed by the radio communication interface **825**, and transfers the generated packet via the network interface **823**. The controller **821** may bundle data from multiple base band processors to generate the bundled packet, and transfer the generated bundled packet. The controller **821** may have logical functions of performing control such as radio resource control, radio bearer control, mobility management, admission control and scheduling. The control may be performed in corporation with an eNB or a core network node in the vicinity. The memory **822** includes a RAM and a ROM, and stores a program executed by the controller **821** and various types of control data (such as terminal list, transmission power data and scheduling data).

(91) The network interface **823** is a communication interface for connecting the base station apparatus **820** to a core network **824**. The controller **821** may communicate with a core network node or another eNB via the network interface **823**. In this case, the eNB **800**, and the core network node or another eNB may be connected to each other via a logic interface (such as an S1 interface and an X2 interface). The network interface **823** may also be a wired communication interface or a wireless communication interface for wireless backhaul. If the network interface **823** is a wireless communication interface, the network interface **823** may use a higher frequency band for wireless communication than that used by the radio communication interface **825**.

(92) The radio communication interface **825** supports any cellular communication scheme (such as Long Term Evolution (LTE) and LTE-advanced), and provides wireless connection to a terminal located in a cell of the eNB **800** via the antenna **810**. The radio communication interface **825** may typically include, for example, a baseband (BB) processor **826** and an RF circuit **827**. The BB processor **826** may perform, for example, encoding/decoding, modulating/demodulating, and

multiplexing/demultiplexing, and performs various types of signal processing of layers (such as L1, Media Access Control (MAC), Radio Link Control (RLC), and a Packet Data Convergence Protocol (PDCP)). The BB processor **826** may have a part or all of the above-described logical functions instead of the controller **821**. The BB processor **826** may be a memory storing communication control programs, or a module including a processor and a related circuit configured to execute the programs. Updating the program may allow the functions of the BB processor **826** to be changed. The module may be a card or a blade that is inserted into a slot of the base station apparatus **820**. Alternatively, the module may also be a chip that is mounted on the card or the blade. Meanwhile, the RF circuit **827** may include, for example, a mixer, a filter, and an amplifier, and transmits and receives wireless signals via the antenna **810**.

(93) As shown in FIG. **17**, the radio communication interface **825** may include the multiple BB processors **826**. For example, the multiple BB processors **826** may be compatible with multiple frequency bands used by the eNB **800**. The radio communication interface **825** may include multiple RF circuits **827**, as shown in FIG. **17**. For example, the multiple RF circuits **827** may be compatible with multiple antenna elements. Although FIG. **17** shows the example in which the radio communication interface **825** includes the multiple BB processors **826** and the multiple RF circuits **827**, the radio communication interface **825** may also include a single BB processor **826** and a single RF circuit **827**.

(94) In the eNB **800** shown in FIG. **17**, transceivers of the electronic apparatus **200** and the electronic apparatus **400** as well as the transmitting unit **202** of the electronic apparatus **200** may be implemented by the radio communication interface **825**. At least a part of functions may be implemented by the controller **821**. For example, the controller **821** may configure the SRS resource sets for the UE by performing functions of the generating unit **201** and the transmitting unit **202**, and may determine the particular antenna panel based on the information of the SRS resource sets for beam management by performing functions of the acquiring unit **401** and the determining unit **402**.

Second Application Example

(95) FIG. **18** is a block diagram showing a second example of the exemplary configuration of an eNB or gNB to which the technology according to the present disclosure may be applied. It should be noted that the following description is given by taking the eNB as an example, which is also applied to the gNB. An eNB **830** includes one or more antennas **840**, a base station apparatus **850**, and an RRH **860**. The RRH **860** and each of the antennas **840** may be connected to each other via an RF cable. The base station apparatus **850** and the RRH **860** may be connected to each other via a high speed line such as an optical fiber cable.

(96) Each of the antennas **840** includes a single or multiple antennal elements (such as multiple antenna elements included in an MIMO antenna), and is used for the RRH **860** to transmit and receive wireless signals. As shown in FIG. **18**, the eNB **830** may include the multiple antennas **840**. For example, the multiple antennas **840** may be compatible with multiple frequency bands used by the eNB **830**. Although FIG. **18** shows the example in which the eNB **830** includes the multiple antennas **840**, the eNB **830** may also include a single antenna **840**.

(97) The base station apparatus **850** includes a controller **851**, a memory **852**, a network interface **853**, a radio communication interface **855**, and a connection interface **857**. The controller **851**, the memory **852**, and the network interface **853** are the same as the controller **821**, the memory **822**, and the network interface **823** described with reference to FIG. **17**.

(98) The radio communication interface **855** supports any cellular communication scheme (such as LTE and LTE-advanced), and provides wireless communication to a terminal located in a sector corresponding to the RRH **860** via the RRH **860** and the antenna **840**. The radio communication interface **855** may typically include, for example, a BB processor **856**. The BB processor **856** is the same as the BB processor **826** described with reference to FIG. **17**, except that the BB processor **856** is connected to an RF circuit **864** of the RRH **860** via the connection interface **857**. As show in

FIG. 18, the radio communication interface **855** may include the multiple BB processors **856**. For example, the multiple BB processors **856** may be compatible with multiple frequency bands used by the eNB **830**. Although FIG. 18 shows the example in which the radio communication interface **855** includes the multiple BB processors **856**, the radio communication interface **855** may also include a single BB processor **856**.

(99) The connection interface **857** is an interface for connecting the base station apparatus **850** (radio communication interface **855**) to the RRH **860**. The connection interface **857** may also be a communication module for communication in the above-described high speed line that connects the base station apparatus **850** (radio communication interface **855**) to the RRH **860**.

(100) The RRH **860** includes a connection interface **861** and a radio communication interface **863**.

(101) The connection interface **861** is an interface for connecting the RRH **860** (radio communication interface **863**) to the base station apparatus **850**. The connection interface **861** may also be a communication module for communication in the above-described high speed line.

(102) The radio communication interface **863** transmits and receives wireless signals via the antenna **840**. The radio communication interface **863** may typically include, for example, the RF circuit **864**. The RF circuit **864** may include, for example, a mixer, a filter and an amplifier, and transmits and receives wireless signals via the antenna **840**. The radio communication interface **863** may include multiple RF circuits **864**, as shown in FIG. 18. For example, the multiple RF circuits **864** may support multiple antenna elements. Although FIG. 18 shows the example in which the radio communication interface **863** includes the multiple RF circuits **864**, the radio communication interface **863** may also include a single RF circuit **864**.

(103) In the eNB **800** shown in FIG. 18, transceivers of the electronic apparatus **200** and the electronic apparatus **400** as well as the transmitting unit **202** of the electronic apparatus **200** may be implemented by the radio communication interface **855** and/or radio communication interface **863**. At least a part of functions may be implemented by the controller **851**. For example, the controller **851** may configure the SRS resource sets for the UE by performing functions of the generating unit **201** and the transmitting unit **202**, and may determine the particular antenna panel based on the information of the SRS resource sets for beam management by performing functions of the acquiring unit **401** and the determining unit **402**.

Application Example Regarding User Equipment

First Application Example

(104) FIG. 19 is a block diagram showing an exemplary configuration of a smartphone **900** to which the technology according to the present disclosure may be applied. The smartphone **900** includes a processor **901**, a memory **902**, a storage **903**, an external connection interface **904**, a camera **906**, a sensor **907**, a microphone **908**, an input device **909**, a display device **910**, a speaker **911**, a radio communication interface **912**, one or more antenna switches **915**, one or more antennas **916**, a bus **917**, a battery **918**, and an auxiliary controller **919**.

(105) The processor **901** may be, for example, a CPU or a system on a chip (SoC), and controls functions of an application layer and another layer of the smartphone **900**. The memory **902** includes a RAM and a ROM, and stores a program executed by the processor **901** and data. The storage **903** may include a storage medium such as a semiconductor memory and a hard disk. The external connection interface **904** is an interface for connecting an external device (such as a memory card and a universal serial bus (USB) device) to the smartphone **900**.

(106) The camera **906** includes an image sensor (such as a charge coupled device (CCD) and a complementary metal oxide semiconductor (CMOS)), and generates a captured image. The sensor **907** may include a group of sensors, such as a measurement sensor, a gyro sensor, a geomagnetism sensor, and an acceleration sensor. The microphone **908** converts sounds that are inputted to the smartphone **900** to audio signals. The input device **909** includes, for example, a touch sensor configured to detect touch onto a screen of the display device **910**, a keypad, a keyboard, a button, or a switch, and receives an operation or information inputted from a user. The display device **910**

includes a screen (such as a liquid crystal display (LCD) and an organic light-emitting diode (OLED) display), and displays an output image of the smartphone **900**. The speaker **911** converts audio signals that are outputted from the smartphone **900** to sounds.

(107) The radio communication interface **912** supports any cellular communication scheme (such as LTE and LTE-advanced), and performs a wireless communication. The radio communication interface **912** may include, for example, a BB processor **913** and an RF circuit **914**. The BB processor **913** may perform, for example, encoding/decoding, modulating/demodulating, and multiplexing/de-multiplexing, and perform various types of signal processing for wireless communication. The RF circuit **914** may include, for example, a mixer, a filter and an amplifier, and transmits and receives wireless signals via the antenna **916**. It should be noted that although FIG. **19** shows a case that one RF link is connected to one antenna, which is only illustrative, and a case that one RF link is connected to multiple antennas through multiple phase shifters may also exist. The radio communication interface **912** may be a chip module having the BB processor **913** and the RF circuit **914** integrated thereon. The radio communication interface **912** may include multiple BB processors **913** and multiple RF circuits **914**, as shown in FIG. **19**. Although FIG. **19** shows the example in which the radio communication interface **912** includes the multiple BB processors **913** and the multiple RF circuits **914**, the radio communication interface **912** may also include a single BB processor **913** or a single RF circuit **914**.

(108) Furthermore, in addition to a cellular communication scheme, the radio communication interface **912** may support another type of wireless communication scheme such as a short-distance wireless communication scheme, a near field communication scheme, and a radio local area network (LAN) scheme. In this case, the radio communication interface **912** may include the BB processor **913** and the RF circuit **914** for each wireless communication scheme.

(109) Each of the antenna switches **915** switches connection destinations of the antennas **916** among multiple circuits (such as circuits for different wireless communication schemes) included in the radio communication interface **912**.

(110) Each of the antennas **916** includes a single or multiple antenna elements (such as multiple antenna elements included in an MIMO antenna) and is used for the radio communication interface **912** to transmit and receive wireless signals. The smartphone **900** may include the multiple antennas **916**, as shown in FIG. **19**. Although FIG. **19** shows the example in which the smartphone **900** includes the multiple antennas **916**, the smartphone **900** may also include a single antenna **916**.

(111) Furthermore, the smartphone **900** may include the antenna **916** for each wireless communication scheme. In this case, the antenna switches **915** may be omitted from the configuration of the smartphone **900**.

(112) The bus **917** connects the processor **901**, the memory **902**, the storage **903**, the external connection interface **904**, the camera **906**, the sensor **907**, the microphone **908**, the input device **909**, the display device **910**, the speaker **911**, the radio communication interface **912**, and the auxiliary controller **919** to each other. The battery **918** supplies power to blocks of the smart phone **900** shown in FIG. **19** via feeder lines that are partially shown as dashed lines in FIG. **19**. The auxiliary controller **919**, operates a minimum necessary function of the smart phone **900**, for example, in a sleep mode.

(113) In the smartphone **900** shown in FIG. **19**, transceivers of the electronic apparatuses **100** and **300** and the transmitting units **103**, **302** may be implemented by the radio communication interface **912**. At least a part of functions may be implemented by the processor **901** or the auxiliary controller **919**. For example, the processor **901** or the auxiliary controller **919** may determine the antenna panel of the UE corresponding to the SRS resource sets by performing functions of the acquiring unit **101** and the determining unit **102**, and may determine the SRS resource sets for beam management corresponding to the particular antenna panel by performing functions of the determining unit **301**.

Second Application Example

(114) FIG. 20 is a block diagram showing an example of a schematic configuration of a car navigation apparatus 920 to which the technology according to the present disclosure may be applied. The car navigation apparatus 920 includes a processor 921, a memory 922, a global positioning system (GPS) module 924, a sensor 925, a data interface 926, a content player 927, a storage medium interface 928, an input device 929, a display device 930, a speaker 931, a radio communication interface 933, one or more antenna switches 936, one or more antennas 937, and a battery 938.

(115) The processor 921 may be, for example a CPU or a SoC, and controls a navigation function and additional function of the car navigation apparatus 920. The memory 922 includes RAM and ROM, and stores a program that is executed by the processor 921, and data.

(116) The GPS module 924 determines a position (such as latitude, longitude and altitude) of the car navigation apparatus 920 by using GPS signals received from a GPS satellite. The sensor 925 may include a group of sensors such as a gyro sensor, a geomagnetic sensor and an air pressure sensor. The data interface 926 is connected to, for example, an in-vehicle network 941 via a terminal that is not shown, and acquires data (such as vehicle speed data) generated by the vehicle.

(117) The content player 927 reproduces content stored in a storage medium (such as a CD and a DVD) that is inserted into the storage medium interface 928. The input device 929 includes, for example, a touch sensor configured to detect touch onto a screen of the display device 930, a button, or a switch, and receives an operation or information inputted from a user. The display device 930 includes a screen such as an LCD or OLED display, and displays an image of the navigation function or content that is reproduced. The speaker 931 outputs a sound for the navigation function or the content that is reproduced.

(118) The radio communication interface 933 supports any cellular communication scheme (such as LTE and LTE-Advanced), and performs wireless communication. The radio communication interface 933 may typically include, for example, a BB processor 934 and an RF circuit 935. The BB processor 934 may perform, for example, encoding/decoding, modulating/demodulating and multiplexing/demultiplexing, and perform various types of signal processing for wireless communication. The RF circuit 935 may include, for example, a mixer, a filter and an amplifier, and transmits and receives wireless signals via the antenna 937. The radio communication interface 933 may also be a chip module having the BB processor 934 and the RF circuit 935 integrated thereon. The radio communication interface 933 may include multiple BB processors 934 and multiple RF circuits 935, as shown in FIG. 20. Although FIG. 20 shows the example in which the radio communication interface 933 includes the multiple BB processors 934 and the multiple RF circuits 935, the radio communication interface 933 may also include a single BB processor 934 and a single RF circuit 935.

(119) Furthermore, in addition to a cellular communication scheme, the radio communication interface 933 may support another type of wireless communication scheme such as a short-distance wireless communication scheme, a near field communication scheme, and a wireless LAN scheme. In this case, the radio communication interface 933 may include the BB processor 934 and the RF circuit 935 for each wireless communication scheme.

(120) Each of the antenna switches 936 switches connection destinations of the antennas 937 among multiple circuits (such as circuits for different wireless communication schemes) included in the radio communication interface 933.

(121) Each of the antennas 937 includes a single or multiple antenna elements (such as multiple antenna elements included in an MIMO antenna), and is used by the radio communication interface 933 to transmit and receive wireless signals. As shown in FIG. 20, the car navigation apparatus 920 may include the multiple antennas 937. Although FIG. 20 shows the example in which the car navigation apparatus 920 includes the multiple antennas 937, the car navigation apparatus 920 may also include a single antenna 937.

(122) Furthermore, the car navigation apparatus 920 may include the antenna 937 for each wireless

communication scheme. In this case, the antenna switches **936** may be omitted from the configuration of the car navigation apparatus **920**.

(123) The battery **938** supplies power to the blocks of the car navigation apparatus **920** shown in FIG. **20** via feeder lines that are partially shown as dash lines in FIG. **20**. The battery **938** accumulates power supplied from the vehicle.

(124) In the car navigation apparatus **920** shown in FIG. **20**, transceivers of the electronic apparatuses **100** and **300** and the transmitting units **103**, **302** may be implemented by the radio communication interface **933**. At least a part of functions may be implemented by the processor **921**. For example, the processor **921** may determine the antenna panel of the UE corresponding to the SRS resource sets by performing functions of the acquiring unit **101** and the determining unit **102**, and may determine the SRS resource sets for beam management corresponding to the particular antenna panel by performing functions of the determining unit **301**.

(125) The technology of the present disclosure may also be implemented as an in-vehicle system (or a vehicle) **940** including one or more blocks of the car navigation apparatus **920**, the in-vehicle network **941** and a vehicle module **942**. The vehicle module **942** generates vehicle data (such as a vehicle speed, an engine speed, and failure information), and outputs the generated data to the in-vehicle network **941**.

(126) The basic principle of the present disclosure has been described above in conjunction with particular embodiments. However, as can be appreciated by those ordinarily skilled in the art, all or any of the steps or components of the method and apparatus according to the disclosure can be implemented with hardware, firmware, software or a combination thereof in any computing device (including a processor, a storage medium, etc.) or a network of computing devices by those ordinarily skilled in the art in light of the disclosure of the disclosure and making use of their general circuit designing knowledge or general programming skills.

(127) Moreover, the present disclosure further discloses a program product in which machine-readable instruction codes are stored. The aforementioned methods according to the embodiments can be implemented when the instruction codes are read and executed by a machine.

(128) Accordingly, a memory medium for carrying the program product in which machine-readable instruction codes are stored is also covered in the present disclosure. The memory medium includes but is not limited to soft disc, optical disc, magnetic optical disc, memory card, memory stick and the like.

(129) In the case where the present disclosure is realized with software or firmware, a program constituting the software is installed in a computer with a dedicated hardware structure (e.g. the general computer **2100** shown in FIG. **21**) from a storage medium or network, wherein the computer is capable of implementing various functions when installed with various programs.

(130) In FIG. **21**, a central processing unit (CPU) **2101** executes various processing according to a program stored in a read-only memory (ROM) **2102** or a program loaded to a random access memory (RAM) **2103** from a memory section **2108**. The data needed for the various processing of the CPU **2101** may be stored in the RAM **2103** as needed. The CPU **2101**, the ROM **2102** and the RAM **2103** are linked with each other via a bus **2104**. An input/output interface **2105** is also linked to the bus **2104**.

(131) The following components are linked to the input/output interface **2105**: an input section **2106** (including keyboard, mouse and the like), an output section **2107** (including displays such as a cathode ray tube (CRT), a liquid crystal display (LCD), a loudspeaker and the like), a memory section **2108** (including hard disc and the like), and a communication section **2109** (including a network interface card such as a LAN card, modem and the like). The communication section **2109** performs communication processing via a network such as the Internet. A driver **2110** may also be linked to the input/output interface **2105**, if needed. If needed, a removable medium **2111**, for example, a magnetic disc, an optical disc, a magnetic optical disc, a semiconductor memory and the like, may be installed in the driver **2110**, so that the computer program read therefrom is installed in

the memory section **2108** as appropriate.

(132) In the case where the foregoing series of processing is achieved through software, programs forming the software are installed from a network such as the Internet or a memory medium such as the removable medium **2111**.

(133) It should be appreciated by those skilled in the art that the memory medium is not limited to the removable medium **2111** shown in FIG. **21**, which has program stored therein and is distributed separately from the apparatus so as to provide the programs to users. The removable medium **2111** may be, for example, a magnetic disc (including floppy disc (registered trademark)), a compact disc (including compact disc read-only memory (CD-ROM) and digital versatile disc (DVD)), a magneto optical disc (including mini disc (MD) (registered trademark)), and a semiconductor memory. Alternatively, the memory medium may be the hard discs included in ROM **2102** and the memory section **2108** in which programs are stored, and can be distributed to users along with the device in which they are incorporated.

(134) To be further noted, in the apparatus, method and system according to the present disclosure, the respective components or steps can be decomposed and/or recombined. These decompositions and/or recombinations shall be regarded as equivalent solutions of the disclosure. Moreover, the above series of processing steps can naturally be performed temporally in the sequence as described above but will not be limited thereto, and some of the steps can be performed in parallel or independently from each other.

(135) Finally, to be further noted, the term “include”, “comprise” or any variant thereof is intended to encompass nonexclusive inclusion so that a process, method, article or device including a series of elements includes not only those elements but also other elements which have been not listed definitely or an element(s) inherent to the process, method, article or device. Moreover, the expression “comprising a(n) . . .” in which an element is defined will not preclude presence of an additional identical element(s) in a process, method, article or device comprising the defined element(s)” unless further defined.

(136) Although the embodiments of the present disclosure have been described above in detail in connection with the drawings, it shall be appreciated that the embodiments as described above are merely illustrative rather than limitative of the present disclosure. Those skilled in the art can make various modifications and variations to the above embodiments without departing from the spirit and scope of the present disclosure. Therefore, the scope of the present disclosure is defined merely by the appended claims and their equivalents.

Claims

1. A base station for wireless communications, comprising: circuitry, configured to: acquire, from a user equipment served by the base station, a capability report indicating an uplink beam management capability of the user equipment, the uplink beam management capability being related to a plurality of antenna panels of the user equipment; generate, based on the capability report, sounding reference signal (SRS) resource set configuration information, the SRS set configuration information identifying a plurality of SRS resource sets available for use by the base station and the user equipment; transmit the SRS set configuration information to the user equipment; transmit one or more downlink reference signals to the user equipment; and in response to the one or more downlink reference signals, acquire a downlink reference signal measurement report from the user equipment, the downlink reference signal measurement report including one or more downlink reference signal resource IDs and one or more indexes indicating one or more SRS resource sets of the plurality of SRS resource sets respectively corresponding to the one or more reference signal resource IDs, the downlink reference signal measurement report identifying to the base station one or more antenna panels of the plurality of antenna panels selected for uplink by the user equipment based on the one or more downlink reference signals.

2. The base station according to claim 1, wherein the base station is implemented as a gNB, the one or more downlink reference signals are channel state information reference signals (CSI-RSs) or Synchronization Signal Blocks (SSBs), and the circuitry is configured to include the SRS set configuration information in Radio Resource Control (RRC) signaling transmitted by the base station to the user equipment.
3. The base station according to claim 2, wherein the downlink reference signal measurement report comprises a channel state information (CSI) report that includes N CSI fields, each of the N CSI fields containing a respective one of N CSI-RS identifiers (CRIs), and wherein the one or more indexes correspond to the N CRIs, wherein N is 1, 2, 3 or 4.
4. The base station according to claim 3, wherein N is 2, 3 or 4, and wherein the N CSI fields further comprise a first reference signal receiving power (RSRP) corresponding to a first CRI of the N CRIs and N-1 differential RSRPs in terms of the first RSRP, the N-1 differential RSRPs corresponding to N-1 remaining CRIs of the N CRIs.
5. The base station according to claim 1, wherein there is a mapping relationship between each SRS resource set of the plurality of SRS resource sets and each antenna panel of the plurality of antenna panels.
6. The base station according to claim 1, wherein the circuitry is configured to generate a Medium Access Control Control Element (MAC CE) instructing the user equipment to activate or deactivate the one or more antenna panels that have been determined based on the downlink reference signal measurement report; and transmit the MAC CE to the user equipment.
7. The base station according to claim 6, wherein the MAC CE includes a SRS resource set ID and a Bandwidth Part (BWP) ID of each of the SRS resource sets of the plurality of SRS resource sets respectively corresponding to the one or more reference signal resource IDs.
8. The base station according to claim 1, wherein the circuitry is configured to generate Downlink Control Information (DCI) instructing the user equipment to activate or deactivate the one or more antenna panels that have been determined based on the downlink reference signal measurement report.
9. The base station according to claim 1, wherein the circuitry is further configured to receive data from the one or more antenna panels selected for uplink by the user equipment.
10. An electronic device for wireless communications, comprising: circuitry, configured to: generate a capability report indicating an uplink beam management capability of the electronic device, the uplink beam management capability being related to a plurality of antenna panels of the electronic device; transmit the capability report to a base station serving the electronic device; acquire, from the base station, sounding reference signal (SRS) set configuration information, the SRS set configuration information identifying a plurality of SRS resource sets to be used by the base station and the electronic device, wherein the SRS set configuration information is generated by the base station based on the capability report; receive one or more downlink reference signals from the base station; in response to the one or more downlink reference signals, generate a downlink reference signal measurement report for the base station, the downlink reference signal measurement report including one or more downlink reference signal resource IDs and one or more indexes indicating SRS resource sets of the plurality of SRS resource sets respectively corresponding to the one or more reference signal resource IDs, the downlink reference signal measurement report identifying to the base station one or more antenna panels of the plurality of antenna panels selected for uplink by the electronic device based on the one or more downlink reference signals; and transmit the downlink reference signal measurement report to the base station.
11. The electronic device according to claim 10, wherein the electronic device is implemented as a user equipment, and wherein the one or more downlink reference signals are channel state information reference signals (CSI-RSs) or Synchronization Signal Blocks (SSBs), and the circuitry is configured to receive the SRS set configuration information in Radio Resource Control

(RRC) signaling received by the electronic device from the base station.

12. The electronic device according to claim 10, wherein there is a mapping relationship between each SRS resource set of the plurality of SRS resource sets and each antenna panel of the plurality of antenna panels.

13. The electronic device according to claim 10, wherein the circuitry is configured to acquire a Medium Access Control Control Element (MAC CE) from the base station instructing the electronic device to activate or deactivate the one or more antenna panels that have been determined based on the downlink reference signal measurement report.

14. The electronic device according to claim 13, wherein the MAC CE includes a SRS resource set ID and a Bandwidth Part (BWP) ID of each of the SRS resource sets of the plurality of SRS resource sets respectively corresponding to the one or more reference signal resource IDs.

15. The electronic device according to claim 10, wherein the circuitry is configured to acquire Downlink Control Information (DCI) from the base station instructing the electronic device to activate or deactivate the one or more antenna panels that have been determined based on the downlink reference signal measurement report.

16. The electronic device according to claim 10, wherein the downlink reference signal measurement report comprises a channel state information (CSI) report that includes N CSI fields, each of the N CSI fields containing a respective one of N CSR-RS identifiers (CRIs), and wherein the one or more indexes correspond to the N CRIs, wherein N is 1, 2, 3 or 4.

17. The electronic device according to claim 16, wherein N is 2, 3 or 4, and wherein the N CSI fields further comprise a first reference signal receiving power (RSRP) corresponding to a first CRI of the N CRIs and N-1 differential RSRPs in terms of the first RSRP, the N-1 differential RSRPs corresponding to N-1 remaining CRIs of the N CRIs.

18. The electronic device according to claim 10, wherein the circuitry is further configured to transmit data to the base station via the one or more antenna selected for uplink by the electronic device.

19. A method of a base station for wireless communications, the method comprising: acquiring from a user equipment served by the base station, a capability report indicating an uplink beam management capability of the user equipment, the uplink beam management capability being related to a plurality of antenna panels of; generating, based on the capability report, sounding reference signal (SRS) resource set configuration information, the SRS set configuration information identifying a plurality of SRS resource sets available for use by the base station and the user equipment; transmitting the SRS set configuration information to the user equipment; transmitting one or more downlink reference signals to the user equipment; and in response to the one or more downlink reference signals, acquiring a downlink reference signal measurement report from the user equipment, the downlink reference signal measurement report including one or more downlink reference signal resource IDs and one or more indexes indicating one or more SRS resource sets of the plurality of SRS resource sets respectively corresponding to the one or more reference signal resource IDs, the downlink reference signal measurement report identifying to the base station one or more antenna panels of the plurality of antenna panels selected for uplink by the user equipment based on the one or more downlink reference signals.

20. The method of the base station according to claim 19, wherein the base station is implemented as a gNB, the one or more downlink reference signals are channel state information reference signals (CSI-RSs) or Synchronization Signal Blocks (SSBs), and the method further comprises: transmitting the SRS set configuration information in Radio Resource Control (RRC) signaling to the user equipment; generating a Medium Access Control Control Element (MAC CE) instructing the user equipment to activate or deactivate the one or more antenna panels that have been determined based on the downlink reference signal measurement report; and transmitting the MAC CE to the user equipment, wherein the MAC CE includes a SRS resource set ID and a Bandwidth Part (BWP) ID of each of the SRS resource sets of the plurality of SRS resource sets respectively

- corresponding to the one or more reference signal resource IDs, wherein the downlink reference signal measurement report comprises a channel state information (CSI) report that includes N CSI fields, each of the N CSI fields containing a respective one of N CSR-RS identifiers (CRIs), and wherein the one or more indexes correspond to the N CRIs, wherein N is 1, 2, 3 or 4.
21. The method of the base station according to claim 19, further comprising: receiving data from the determined one or more antenna panels selected for uplink by the user equipment.
22. A method of a user equipment for wireless communications, the method comprising: generating a capability report indicating an uplink beam management capability of the user equipment, the uplink beam management capability being related to a plurality of antenna panels of the user equipment; transmitting the capability report to a base station serving the user equipment; acquiring, from the base station, sounding reference signal (SRS) set configuration information, the SRS set configuration information identifying a plurality of SRS resource sets to be used by the base station and the user equipment, wherein the SRS set configuration information is generated by the base station based on the capability report; receiving one or more downlink reference signals from the base station; in response to the one or more downlink reference signals, generating a downlink reference signal measurement report for the base station, the downlink reference signal measurement report including one or more downlink reference signal resource IDs and one or more indexes indicating one or more SRS resource sets of the plurality of SRS resource sets respectively corresponding to the one or more reference signal resource IDs, the downlink reference signal measurement report identifying to the base station one or more antenna panels of the plurality of antenna panels selected for uplink by the user equipment based on the one or more downlink reference signals; and transmitting the downlink reference signal measurement report to the base station.
23. The method of the user equipment according to claim 10, wherein the one or more downlink reference signals are channel state information reference signals (CSI-RSs) or Synchronization Signal Blocks (SSBs), wherein the method further comprises: receiving the SRS set configuration information in Radio Resource Control (RRC) signaling from the base station; and receiving a Medium Access Control Control Element (MAC CE) from the base station instructing the user equipment to activate or deactivate the one or more antenna panels that have been determined based on the downlink reference signal measurement report, wherein the MAC CE includes a SRS resource set ID and a Bandwidth Part (BWP) ID of each of the SRS resource sets of the plurality of SRS resource sets respectively corresponding to the one or more reference signal resource IDs, wherein the downlink reference signal measurement report comprises a channel state information (CSI) report that includes N CSI fields, each of the N CSI fields containing a respective one of N CSR-RS identifiers (CRIs), and wherein the one or more indexes correspond to the N CRIs, wherein N is 1, 2, 3 or 4.
24. The method of the user equipment according to claim 22, further comprising: transmitting data to the base station via the one or more antenna panels selected for uplink by the user equipment.
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