United States Patent	12395976
Kind Code	B2
Date of Patent	August 19, 2025
Inventor(s)	Xu; Jin et al.

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

Abstract

An electronic device and a method for wireless communication, and a computer-readable storage medium. The electronic device comprises: a processing circuit, configured to: acquire, from a base station, configuration information containing a first candidate beam set for beam failure recovery, the first candidate beam set comprising candidate beams of a serving cell and candidate beams of a non-serving cell; and determine, on the basis of the first candidate beam set and/or a second candidate beam set, an identification candidate beam to be used for beam failure recovery, the second candidate beam set comprising beams which serve as candidate beams of the non-serving cell and are detected by user equipment.

Inventors: **Xu; Jin (Beijing, CN), Wang; Xinli (Beijing, CN), Zhou; Ying (Beijing, CN), Cao; Jianfei (Beijing, CN)**

Applicant: **Sony Group Corporation** (Tokyo, JP)

Family ID: **1000008766856**

Assignee: **SONY GROUP CORPORATION (Tokyo, JP)**

Appl. No.: **19/073324**

Filed: **March 07, 2025**

Prior Publication Data

Document Identifier	Publication Date
US 20250203595 A1	Jun. 19, 2025

Foreign Application Priority Data

CN	202010535175.8	Jun. 12, 2020

Related U.S. Application Data

continuation parent-doc US 17921989 US 12273868 WO PCT/CN2021/098600 20210607 child-doc US 19073324

Publication Classification

Int. Cl.: **H04W72/044** (20230101); **H04B7/06** (20060101)

U.S. Cl.:

CPC **H04W72/046** (20130101); **H04B7/0695** (20130101);

Field of Classification Search

CPC: H04W (72/046); H04W (36/0083); H04W (36/0005); H04W (36/085); H04W (72/20); H04B (7/0695); H04B (7/06964)

References Cited

U.S. PATENT DOCUMENTS

Patent No.	Issued Date	Patentee Name	U.S. Cl.	CPC
11122472	12/2020	Da Silva	N/A	H04W 72/046
11368205	12/2021	Guan et al.	N/A	N/A
12273868	12/2024	Xu	N/A	H04B 7/06964
2018/0206170	12/2017	Nagaraja et al.	N/A	N/A
2019/0364445	12/2018	Kang et al.	N/A	N/A
2020/0083947	12/2019	Islam et al.	N/A	N/A
2020/0084089	12/2019	Da Silva	N/A	N/A
2020/0374960	12/2019	Deenoo et al.	N/A	N/A
2021/0068123	12/2020	Zhu	N/A	H04W 72/046
2021/0185754	12/2020	Da Silva et al.	N/A	N/A
2021/0227613	12/2020	Zhang et al.	N/A	N/A
2022/0094416	12/2021	Huang et al.	N/A	N/A
2022/0141814	12/2021	Fan	370/329	H04W 24/04
2022/0174567	12/2021	Awada et al.	N/A	N/A
2022/0225421	12/2021	Miao et al.	N/A	N/A
2023/0144010	12/2022	Kwak et al.	N/A	N/A
2023/0156845	12/2022	Khoshnevisan	370/216	H04L 5/0023
2023/0216625	12/2022	Gao	370/228	H04W 16/26

FOREIGN PATENT DOCUMENTS

Patent No.	Application Date	Country	CPC
110178317	12/2018	CN	N/A
110268741	12/2018	CN	N/A
111479289	12/2019	CN	N/A

OTHER PUBLICATIONS

International Search Report and Written Opinion mailed on Aug. 4, 2021, received for PCT Application No. PCT/CN2021/098600, Filed on Jun. 7, 2021, 11 pages. cited by applicant
ZTE, “Further details on Multi-beam and Multi-TRP operation”, 3GPP TSG RAN WG1 Meeting #104-e e-Meeting, R1-2100292, Jan. 25-Feb. 5, 2020, 20 pages. cited by applicant

---

Primary Examiner: Lam; Kenneth T

Attorney, Agent or Firm: XSENSUS LLP

Background/Summary

CROSS-REFERENCE TO RELATED APPLICATIONS (1) This application is a continuation of U.S. application Ser. No. 17/921,989, filed Oct. 28, 2022, which is based on PCT filing PCT/CN2021/098600, filed Jun. 7, 2021, which claims the priority to Chinese Patent Application No. 202010535175.8 titled “ELECTRONIC DEVICE AND METHOD FOR WIRELESS COMMUNICATION, AND COMPUTER-READABLE STORAGE MEDIUM”, filed on Jun. 12, 2020 with the China National Intellectual Property Administration (CNIPA), the entire contents of each of which are incorporated herein by reference in its entirety.

FIELD
(1) The present disclosure relates to the technical field of wireless communications, and in particular to a beam failure recovery (BFR) mechanism. More particularly, the present disclosure relates to an electronic apparatus and a method for wireless communications and a computer-readable storage medium.
BACKGROUND
(2) BFR is designed to avoid frequent link failures caused by a beam misalignment between a base station (gNB) and user equipment (UE). In a BFR procedure, a set q.sub.0 of resource indexes for a beam failure detection (BFD) reference signal (BFD-RS) (such as, a periodic channel state information reference signal (CSI-RS)) is defined. The UE determines whether a beam failure event occurs by measuring quality of the BFD-RS in the set. When a beam failure event occurs, the UE is required to identify a candidate beam for BFR in a set q.sub.1 of candidate beams. The set q.sub.1 of candidate beams is a periodic CSI-RS resource index and/or a synchronous signal/physical broadcast channel (SS/PBCH) block index configured by a high-layer parameter Candidate-Beam-RS-List.
(3) In a process of the candidate beam identification, only when a physical layer reference signal received power (L1-RSRP) of a beam in the set q.sub.1 is greater than or equal to a threshold Q.sub.in,LR, the beam is considered as an available candidate beam and is reported to the high layer. Therefore, according to a current BFR procedure, the UE can only be reconnected to a current serving cell during the BFR. However, in some cases, a L1-RSRP value of a beam from a non-serving cell may be greater than a L1-RSRP value of a beam from a serving cell. Since beams from the non-serving cell are not in the set q.sub.1, the UE cannot determine the beams as the candidate beams and reconnect to the non-serving cell.
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 configured to: acquire, from a base station, configuration information including a first candidate beam set for beam failure recovery, where the first candidate beam set includes a candidate beam of a serving cell and a candidate beam of a non-serving cell; and determine, based on the first candidate beam set and/or a second candidate beam set, an identified candidate beam to be used for the beam failure recovery, where the second candidate beam set includes a beam of a non-serving cell which serves as a candidate beam and is detected by the user equipment.

(6) A method for wireless communications is provided according to an aspect of the present disclosure. The method includes: acquiring, from a base station, configuration information including a first candidate beam set for beam failure recovery, where the first candidate beam set includes a candidate beam of a serving cell and a candidate beam of a non-serving cell; and determining, based on the first candidate beam set and/or a second candidate beam set, an identified candidate beam to be used for the beam failure recovery, where the second candidate beam set includes a beam of a non-serving cell which serves as a candidate beam and is detected by the user equipment.

(7) An electronic apparatus for wireless communications is provided according to another aspect of the present disclosure. The electronic apparatus includes processing circuitry configured to: provide, to user equipment, configuration information including a first candidate beam set for beam failure recovery, where the first candidate beam set includes a candidate beam of a serving cell and a candidate beam of a non-serving cell; and acquire, from the user equipment, information of an identified candidate beam to be used for the beam failure recovery determined by the user equipment based on the first candidate beam set and/or a second candidate beam set, where the second candidate beam set includes a beam of a non-serving cell which serves as a candidate beam and is detected by the user equipment.

(8) A method for wireless communications is provided according to another aspect of the present disclosure. The method includes: providing, to user equipment, configuration information including a first candidate beam set for beam failure recovery, where the first candidate beam set includes a candidate beam of a serving cell and a candidate beam of a non-serving cell; and acquiring, from the user equipment, information of an identified candidate beam to be used for the beam failure recovery determined by the user equipment based on the first candidate beam set and/or a second candidate beam set, where the second candidate beam set includes a beam of a non-serving cell which serves as a candidate beam and is detected by the user equipment.

(9) According to the electronic apparatus and the method in the present disclosure, the UE can recover to the non-serving cell when a beam failure event occurs, thereby improving the communication quality of the UE.

(10) 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.

(11) These and other advantages of the present disclosure will be more apparent from the following detailed description of preferred embodiments of the present disclosure in conjunction with the accompanying drawings.

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 beam failure recovery in a scenario of multiple cells;

(3) FIG. **2** is a block diagram showing functional modules of an electronic apparatus for wireless communications according to an embodiment of the present disclosure;

(4) FIG. **3** is a schematic diagram showing an information procedure related to BFR between the gNB and UE;

(5) FIG. **4** is a block diagram showing functional modules of an electronic apparatus for wireless communications according to an embodiment of the present disclosure;

(6) FIG. **5** is a schematic diagram showing an example that a UE recovers to a non-serving cell;

(7) FIG. **6** is a schematic diagram showing an information procedure combining BFR with a cell handover procedure;

(8) FIG. **7** is a block diagram showing functional modules of an electronic apparatus for wireless communications according to another embodiment of the present disclosure;

(9) FIG. **8** is a flow chart showing a method for wireless communications according to an embodiment of the present disclosure;

(10) FIG. **9** is a flow chart showing a method for wireless communications according to another embodiment of the present disclosure;

(11) FIG. **10** is a block diagram showing a first example of an exemplary configuration of an eNB or gNB to which the technology of the present disclosure may be applied;

(12) FIG. **11** is a block diagram showing a second example of an exemplary configuration of an eNB or gNB to which the technology of the present disclosure may be applied;

(13) FIG. **12** 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;

(14) FIG. **13** 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

(15) FIG. **14** 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

(16) 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 service, 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.

(17) 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

(18) FIG. **1** is a schematic diagram showing beam failure recovery in a scenario of multiple cells. A cell A is a serving cell of a UE, and a cell B is a non-serving cell of the UE. A beam failure event occurs due to shadow of a house. In the conventional technology, even if the cell B may provide better service quality, the UE may only recover to the cell A. In order to further improve the service quality for the UE, an electronic apparatus **100** for wireless communication is provided according to the embodiment, so that the UE may recover to the serving cell or the non-serving cell when a beam failure event occurs, to improve flexibility and reliability of the beam failure recovery.

(19) FIG. **2** is a block diagram showing functional modules of an electronic apparatus **100** for wireless communications according to an embodiment of the present disclosure. 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, configuration information including a first candidate beam set for beam failure recovery, where the first candidate beam set includes a candidate beam of a serving cell and a candidate beam of a non-serving cell. The determining unit **102** is configured to determine, based on the first candidate beam set and/or a second candidate beam set, an identified candidate beam to be used for beam failure recovery, where the second candidate beam set includes a beam of a non-serving cell which serves as a candidate beam and is detected by the user equipment.

(20) 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. In addition, it should be understood that various functional units in apparatus shown in FIG. **2** are logical modules divided based on functions implemented by these functional units, and are not intended to limit specific implementations.

(21) The electronic apparatus **100** may be, for example, arranged on a user equipment (UE) side, or may be communicatively connected to the UE. Here, it is further to be noted that the electronic apparatus **100** may be implemented in a chip level or a device level. For example, the electronic apparatus **100** may function as the user equipment itself and may further include external devices such as a memory and a transceiver (not shown in FIG. **2**). The memory may be configured to store programs to be executed when the user equipment implements various functions and related data information. The transceiver may include one or more communication interfaces to support communications with different devices (for example, a base station, other user equipment and the like). Implementations of the transceiver are not limited herein.

(22) In addition, it should be noted that “first”, “second” and the like in the present disclosure are only used to distinguish one object from another object, and represent no meaning of order.

(23) For convenience of understanding, FIG. **3** is a schematic diagram showing an information procedure related to BFR between a gNB and UE. First, the gNB transmits configuration information related to the BFR to the UE, for example, through radio resources control (RRC) signaling. The configuration information may include the configuration information of the above mentioned first candidate beam set, and may also include other configuration information, such as configuration information of the BFD-RS. The UE performs beam quality detection on a BFD-RS in a set q, and determines that a beam failure event occurs. At this time, the UE transmits a beam failure recovery request (BFRQ) to the gNB. For example, the UE transmits a link recovery request (LRR) to the gNB through a physical uplink control channel (PUCCH) to request uplink grant (UL grant). The gNB then transmits the UL grant to the UE. Based on the UL grant, the UE transmits a MAC CE to the base station on corresponding physical uplink shared channel (PUSCH) resources. The MAC CE may include information for an identified candidate beam determined by the UE. The gNB transmits a beam failure recovery request response (BFRR) to the UE in response to the received BFRQ.

(24) It can be seen that a BFR mechanism executed on a UE side may include, for example, a beam

failure determination phase, a candidate beam identification phase, a BFRQ transmission phase and a BFRR acquisition phase. During the beam failure determination phase, the UE performs beam quality detection on a current serving beam to determine whether a trigger condition for beam failure is met. For example, a block error rate (BLER) of the serving beam may be compared with a threshold of the BLER to determine whether a beam failure occurs. During the candidate beam identification phase, a candidate beam that may be used as an alternative to the current serving beam is selected from other beams. During the BFRQ transmission phase, the BFRQ is transmitted to the base station (such as, the gNB). During the BFRR acquisition phase, the UE monitors the BFRR in response to BFRQ from the base station within a specific time window.
(25) According to the embodiment, during the candidate beam identification phase, beams for candidate beam selection may include not only a candidate beam of the serving cell, but also a candidate beam of the non-serving cell. In addition, the candidate beam of the non-serving cell may be configured by the base station for the UE, or may be detected by the UE itself.
(26) As described above, the first candidate beam set includes the candidate beam of the serving cell and the candidate beam of the non-serving cell that are configured by the base station for the UE, and the second candidate beam set includes the candidate beam of the non-serving cell detected by the UE itself. It should be understood that the first candidate beam set may include only the candidate beam of the serving cell. In this case, all candidate beams of the non-serving cell are detected by the UE itself. Alternatively, all the candidate beam of the non-serving cell may also be configured by the base station. In this case, the UE does not detect the candidate beam of the non-serving cell by itself, that is, the second candidate beam set is empty.
(27) Herein, when a beam failure event occurs, the determining unit **102** determines an available candidate beam from among the first candidate beam set and/or the second candidate beam set, and the determined available candidate beam is referred to as the identified candidate beam. During the BFRQ transmission phase, the UE provides information of the identified candidate beam to the base station, so that the base station can determine a beam to which the UE is to recover.
(28) The candidate beam may be indicated by a reference signal. The reference signal includes, for example, a CSI-RS and an SSB. For example, configuration information acquired from the base station may include an index of the reference signal corresponding to the candidate beam and a physical cell identification (PCI) of a cell corresponding to the reference signal. The corresponding pseudo codes are shown below, for example.
(29) TABLE-US-00001 CandidateBeamRS ::= SEQUENCE { candidateBeamConfig CHOICE { ssb-r16 SSB-Index, csi-RS-r16 NZP-CSI-RS-ResourceId }, PCI Physical Cell ID OPTIONAL -- Need R }
(30) If the reference signal corresponds to the serving cell, a PCI of the corresponding serving cell may be omitted or set to a default value. As described above, the acquiring unit **101** may acquire the configuration information through RRC signaling.
(31) In an example, the candidate beam in the first candidate beam set may include a beam corresponding to a reference signal for mobility management configured by the base station for the UE. The corresponding pseudo codes are shown below, for example.
(32) TABLE-US-00002 CSI-RS-CellMobility ::= SEQUENCE { cellId PhysCellId, csi-rs-MeasurementBW SEQUENCE { nrofPRBs ENUMERATED { size24, size48, size96, size192, size264}, startPRB INTEGER (0..2169) }, density ENUMERATED {d1,d3} OPTIONAL, -- Need R csi-rs-ResourceList-Mobility SEQUENCE (SIZE (1..maxNrofCSI-RS-ResourcesRRM)) OF CSI-RS-Resource-Mobility }
(33) In the example, since the base station has configured the reference signals for mobility management for the UE, the UE may reuse the reference signals without additional configuration, reducing signaling overhead.
(34) In addition, the second candidate beam set may include a beam corresponding to a SSB of the non-serving cell which is detected by the UE. The determining unit **102** may determine a PCI of the

cell corresponding to the candidate beam in the second candidate beam set by decoding a primary synchronization signal/a secondary synchronization signal (PSS/SSS).

(35) As shown in FIG. **4**, the electronic apparatus **100** may further include a reporting unit **103**. The reporting unit **103** is configured to report information of the identified candidate beam to the base station. The information of the identified candidate beam includes, for example, the identification or an index of a reference signal corresponding to the identified candidate beam.

(36) In a case that the identified candidate beam is a candidate beam in the first candidate beam set, since the beams in the first candidate beam set are configured by the base station, the reporting unit **103** is not required to report the PCI of the identified candidate beam to the base station. On the other hand, in a case that the identified candidate beam includes the candidate beam in the second candidate beam set, since such an identified candidate beam is not configured by the base station, the UE is further required to provide information of a cell to which the identified candidate beam belongs to the base station. At this time, the information of the identified candidate beam may further include a PCI of a cell corresponding to the identified candidate beam.

(37) For example, the reporting unit **103** is configured to provide, to the base station, information of the candidate beam belonging to the second candidate beam set which is included in the identified candidate beam and a PCI of a cell corresponding to the candidate beam. In this way, the base station may determine which non-serving cell the candidate beam belongs to.

(38) As shown in FIG. **3**, the reporting unit **103** may provide information of the identified candidate beam by transmitting the MAC CE on the PUSCH.

(39) A range of a candidate beam for BFR in the present disclosure is extended to beams of the non-serving cell, and thus it is expected to provide a method for quickly determining the identified candidate beam to meet delay requirements of BFR.

(40) As an example, a double threshold determination method may be used. Specifically, the acquiring unit **101** acquires information of a first threshold and a second threshold from the base station. In a case that the number of times of occurrences of beam failure event instances reaches or exceeds the first threshold, the determining unit **102** starts determination of the identified candidate beam; in a case that the number of times of occurrences of the beam failure event instances reaches or exceeds the second threshold, the determining unit **102** determines that a beam failure event occurs and starts a BFR procedure, where the first threshold is smaller than or equal to the second threshold. Similarly, the acquiring unit **101** may acquire, from the base station, the information of the first threshold and the second threshold through RRC signaling.

(41) It can be seen that with the double threshold determination method, the determination of the identified candidate beam may be started before the BFR procedure is started (that is, the beam failure event is reported to the base station), so that the information of the identified candidate beam can be quickly provided to the base station after the BFR procedure is started, thereby reducing the time delay.

(42) For example, the determining unit **102** may establish a first counter and a second counter respectively to count the number of times of occurrences of the beam failure event instances, compare a count value of the first counter with the first threshold, and compare a count value of the second counter with the second threshold.

(43) For example, an existing BFI-COUNTER serves as the second counter, and a BFI-COUNTER* is additionally established as the first counter, an existing threshold beamFailureInstanceMaxCount for determining the occurrence of the beam failure event serves as the second threshold, and a new counter threshold beamFailureInstance* serves as the first threshold, where beamFailureInstance*≤beamFailureInstanceMaxCount.

(44) Upon receipt of a beam failure event instance from a bottom layer, both BFI-COUNTER*and BFI-COUNTER are increased by one. In a case that BFI-COUNTER*>=beamFailureInstance*, BFI-COUNTER* is no longer increased, and the UE performs the determination of the identified candidate beam at this time. A range of the beams for determination includes a candidate beam of

non-serving cell. In a case that BFI-COUNTER>=beamFailureInstanceMaxCount, BFI-COUNTER is no longer increased, the BFR procedure is started at this time, and the UE reports the beam failure event and information of the identified candidate beam to the gNB.
(45) In addition, when a beam failure event occurs, recovering the beam to the non-serving cell incurs more signaling overhead than recovering the beam to the serving cell, and thus a specific condition may be set for recovering to the non-serving cell. For example, the determining unit **102** is configured to determine a candidate beam of a non-serving cell in the first candidate beam set and/or the second candidate beam set as the identified candidate beam in the following conditions: beam quality of the candidate beam of the serving cell being lower than predetermined quality; and beam quality of the candidate beam of the non-serving cell being higher than the beam quality of the candidate beam of the serving cell by more than a predetermined value.
(46) The acquiring unit **101** may acquire, from the base station, settings of the predetermined quality and the predetermined value. For example, the acquiring unit **101** may acquire the settings through RRC signaling. Alternatively, the settings about the predetermined quality and the predetermined value may further be default by the UE and the base station.
(47) FIG. **5** is a schematic diagram showing an example that the UE recovers to a non-serving cell. The quality of the candidate beam of the serving cell is poor due to the block of the house and the quality of the candidate beam of the non-serving cell is good, so as to meet the above two conditions. Therefore, the UE determines the candidate beam of the non-serving cell as the identified candidate beam and recovers to the non-serving cell.
(48) By setting specific conditions, the communication quality of the UE can be improved, while unnecessary signaling overhead can be reduced as much as possible.
(49) In a case that the identified candidate beam is the candidate beam of the non-serving cell in the first candidate beam set and/or the second candidate beam set, that is, in a case that the UE is to recover to the candidate beam of the non-serving cell, considering that the original configuration of the UE may become invalid in a different cell, the process of the UE in an RRC connected state recovering to the non-serving cell would involve a cell handover. In order to simplify the complexity and reduce the signaling overhead and delay, the cell handover procedure is combined with the BFR procedure in the embodiment.
(50) For example, the acquiring unit **101** may be configured to acquire, from the base station, RRC reconfiguration information for the non-serving cell during the BFR procedure. For example, the RRC reconfiguration information for the non-serving cell may be included in the BFRR transmitted by the base station.
(51) FIG. **6** is a schematic diagram showing an information procedure combining BFR with the cell handover procedure. A source gNB is a gNB of a current serving cell. The BFRQ may represent an LLR and provision of information of the identified candidate beam shown in FIG. **3**. The source gNB determines that the UE is to recover to a target cell based on the information of the identified candidate beam, and transmits a handover request to the gNB (that is, a target gNB) of the target cell. The target gNB transmits a handover request acknowledgement to the source gNB after the determination of admission control. Next, the source gNB transmits a BFRR to the UE. The BFRR includes RRC reconfiguration information of the target cell. The UE switches to the target cell and completes the RRC reconfiguration.
(52) It can be seen that the signaling overhead and delay can be effectively reduced by including the RRC reconfiguration information of the target cell in the BFRR. It should be noted that the information procedure in FIG. **6** is only schematic and does not constitute limitation to the present disclosure.
(53) In summary, the electronic apparatus **100** according to the embodiment enables the UE to recover to the non-serving cell when a beam failure event occurs, thereby improving the communication quality of the UE. In addition, by improving the identification operation of the candidate beam and/or improving the procedure of recovering to the non-serving cell, the signaling

overhead and delay are reduced, further improving the communication quality of the UE.

Second Embodiment

(54) FIG. **7** is a block diagram showing functional modules of an electronic apparatus **200** for wireless communications according to another embodiment of the present disclosure. As shown FIG. **7**, the electronic apparatus **200** includes a providing unit **201** and an acquiring unit **202**. The providing unit **201** is configured to provide, to a UE, configuration information including a first candidate beam set for beam failure recovery, where the first candidate beam set includes a candidate beam of a serving cell and a candidate beam of a non-serving cell. The acquiring unit **202** is configured to acquire, from the UE, information of an identified candidate beam to be used for the BFR determined by the UE based on the first candidate beam set and/or a second candidate beam set, where the second candidate beam set includes a beam of a non-serving cell which serves as a candidate beam and is detected by user equipment.

(55) The providing unit **201** and the acquiring unit **202** may be implemented by one or more processing circuitries. The processing circuitry may be implemented as, for example, a chip. In addition, it should be understood that various functional units in apparatus shown in FIG. **7** are logical modules divided based on functions implemented by these functional units, and are not intended to limit specific implementations.

(56) The electronic apparatus **200** may be, for example, arranged on a base station side, or may be communicatively connected to the base station. Here, it is further to be noted that the electronic apparatus **200** may be implemented in a chip level or a device level. For example, the electronic apparatus **200** may function as the base station itself and may further include external devices such as a memory and a transceiver (not shown in FIG. **7**). The memory may be configured to store programs to be executed when the base station implements various functions and related data information. The transceiver may include one or more communication interfaces to support communications with different devices (for example, user equipment, other base stations and the like). Implementations of the transceiver are not limited herein.

(57) According to the embodiment, the base station may configure the candidate beam of the non-serving cell for the UE as a candidate beam for BFR, so that the UE can recover to the non-serving cell as needed. In addition, the candidate beam of the non-serving cell may be configured by the base station for the UE, or may be detected by the UE itself. As in the first embodiment, the candidate beam of the non-serving cell detected by the UE may be included in the second candidate beam set.

(58) It should be understood that the first candidate beam set may include only the candidate beam of the serving cell. In this case, all the candidate beams of the non-serving cell are detected by the UE itself. Alternatively, all the candidate beams of the non-serving may be configured by the base station. In this case, the UE does not detect the candidate beam of the non-serving cell itself, that is, the second candidate beam set is empty.

(59) When a beam failure event occurs, the UE determines an available candidate beam from among the first candidate beam set and/or the second candidate beam set, and the determined available candidate beam is referred to as the identified candidate beam. The base station acquires information of the identified candidate beam from the UE and determines a beam to which the UE is to recover.

(60) As described above, the candidate beam may be indicated by the reference signal. The reference signal includes, for example, a CSI-RS, an SSB or the like. For example, the configuration information may include the index of the reference signal corresponding to the candidate beam and the PCI of the cell corresponding to the reference signal. The corresponding pseudo codes are described in the first embodiment and are not repeated herein. If the reference signal corresponds to a serving cell, the PCI of the corresponding serving cell may be omitted or set as a default value. The providing unit **201** may provide the configuration information, for example, through RRC signaling.

(61) In an example, the candidate beam in the first candidate beam set may include a beam corresponding to a reference signal for mobility management configured by the base station for the UE. In this example, since the base station has configured the reference signals for mobility management for the UE, the UE may reuse the reference signals without additional configuration, reducing signaling overhead.
(62) In addition, the second candidate beam set may include the beam corresponding to the SSB of the non-serving cell detected by the UE. Moreover, the UE may determine a PCI of the cell corresponding to the candidate beam in the second candidate beam set by decoding the PSS/SSS.
(63) The acquiring unit **202** is further configured to acquire the information of the identified candidate beam from the UE. The information of the identified candidate beam includes, for example, an identification or index of a reference signal corresponding to the identified candidate beam.
(64) In a case that the identified candidate beam is a candidate beam in the first candidate beam set, since beams in the first candidate beam set are configured by the base station for the UE, the UE is not required to report the PCI of the identified candidate beam to the base station. On the other hand, in a case that the identified candidate beam includes the candidate beam in the second candidate beam set, since the identified candidate beam is not configured by the base station, the UE is further required to provide information of a cell to which the identified candidate beam belongs to the base station. At this time, the information of the identified candidate beam may further include a PCI of a cell corresponding to the identified candidate beam. Accordingly, the acquiring unit **202** is configured to acquire the information of the identified candidate beam and a PCI of a cell corresponding to the identified candidate beam from the UE. In this way, the base station may determine which non-serving cell the identified candidate beam belongs to. For example, the acquiring unit **202** may acquire the information of the identified candidate beam by receiving the MAC CE on the PUSCH.
(65) A range of a candidate beam for BFR is extended to beams of the non-serving cell, and thus it is expected to provide a method for quickly determining the identified candidate beam to meet delay requirements of BFR.
(66) Similarly, a double threshold determination method may be used. Specifically, the providing unit **201** is configured to provide the information of the first threshold and the second threshold to the UE. In a case that the number of times of occurrences of beam failure event instances reaches or exceeds the first threshold, the UE starts the determination of the identified candidate beam. In a case that the number of times of occurrences of the beam failure event instances reaches or exceeds the second threshold, the UE determines that a beam failure event occurs and starts the BFR procedure. The first threshold is smaller than or equal to the second threshold. Further, the providing unit **201** may provide the information of the first threshold and the second threshold to the UE through RRC signaling.
(67) It can be seen that with the double threshold determination method, the determination of the identified candidate beam may be started before the BFR procedure is started (that is, UE reports the beam failure event to the base station), so that the UE can quickly provide the information of the identified candidate beam to the base station after the BFR procedure is started, thereby reducing the time delay. The specific description of the double threshold determination method is described in the first embodiment and is not repeated herein.
(68) In addition, when a beam failure event occurs, recovering the beam to the non-serving cell incurs more signaling overhead than recovering the beam to the serving cell, and thus a specific condition may be set for recovering to the non-serving cell. For example, the providing unit **201** is further configured to provide, to the UE, conditions for the candidate beam of the non-serving cell being determined as the identified candidate beam. The conditions include, for example: beam quality of the candidate beam of the serving cell being lower than predetermined quality; and beam quality of the candidate beam of the non-serving cell being higher than the beam quality of the

candidate beam of the serving cell by more than a predetermined value. For example, the providing unit **201** may provide settings about the predetermined quality and the predetermined value to the UE. The providing unit **201** may provide the settings through RRC signaling. Alternatively, the settings about the predetermined quality and the predetermined value may also be default by the UE and the base station.

(69) By setting specific conditions, the communication quality of the UE can be improved, while unnecessary signaling overhead can be reduced as much as possible.

(70) In a case that the identified candidate beam is the candidate beam of the non-serving cell in the first candidate beam set and/or the second candidate beam set, that is, in a case of determining that the UE is to recover to the candidate beam of the non-serving cell, considering that the original configuration of the UE may become invalid in a different cell, a process of the UE in an RRC connected state recovering to the non-serving cell would involve a cell handover. In order to simplify the complexity and reduce the signaling overhead and delay, the cell handover procedure may be combined with the BFR procedure.

(71) For example, the providing unit **201** may transmit a handover request to the non-serving cell as a handover target when the acquiring unit **202** receives the BFRQ from the UE during the BFR procedure, the acquiring unit **202** receives a handover request acknowledgement from the non-serving cell, and the providing unit **201** provides the RRC reconfiguration information for the non-serving cell to the UE. For example, the RRC reconfiguration information for the non-serving cell may be included in the BFRR transmitted by the base station. The specific information procedure is described in detail in the first embodiment with reference to FIG. **6**, and is not repeated herein.

(72) By including the RRC reconfiguration information for the non-serving cell in the BFRR, the signaling overhead and the delay can be effectively reduced.

(73) In summary, the electronic apparatus **200** according to the embodiment enables the UE to recover to the non-serving cell when a beam failure event occurs, thereby improving the communication quality of the UE. In addition, by improving the identification operation of the candidate beam and/or improving the process of recovering to the non-serving cell, the signaling overhead and delay are reduced, further improving the communication quality of the UE.

Third Embodiment

(74) 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 blow 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.

(75) FIG. **8** is a flow chart showing a method for wireless communications according to an embodiment of the present disclosure. The method includes: acquiring, from a base station, configuration information including a first candidate beam set for BFR, where the first candidate beam set includes a candidate beam of a serving cell and a candidate beam of a non-serving cell (S**11**); and determining an identified candidate beam to be used for the BFR based on the first candidate beam set and/or a second candidate beam set (S**12**), where the second candidate beam set includes a beam of a non-serving cell which serves as a candidate beam and is detected by user equipment. The method for example, may be performed at a UE side.

(76) For example, the second candidate beam set includes a beam corresponding to a SSB of the non-serving cell which is detected by the UE. A PCI of the cell corresponding to the candidate

beam in the second candidate beam set may be determined by decoding a primary synchronization signal/a secondary synchronization signal.
(77) The configuration information may include an index of a reference signal corresponding to the candidate beam and a PCI of a cell corresponding to the reference signal. The reference signal may be one of the SSB and the CSI-RS. For example, the candidate beam in the first candidate beam set may include a beam corresponding to a reference signal for mobility management configured by the base station for the UE.
(78) In an example, a candidate beam of a non-serving cell in the first candidate beam set and/or the second candidate beam set may be determined as the identified candidate beam in the following conditions: beam quality of the candidate beam of the serving cell being lower than predetermined quality; and beam quality of the candidate beam of the non-serving cell being higher than the beam quality of the candidate beam of the serving cell by more than a predetermined value. Settings of the predetermined quality and the predetermined value may be acquired from the base station.
(79) In a case that the identified candidate beam includes a candidate beam in the second candidate beam set, the UE provides, to the base station, information of the candidate beam belonging to the second candidate beam set which is included in the identified candidate beam and a PCI of a cell corresponding to the candidate beam. For example, information of the identified candidate beam may be provided by transmitting MAC CE on a physical uplink shared channel.
(80) For example, in a case that the identified candidate beam is a candidate beam of a non-serving cell in the first candidate beam set and/or the second candidate beam set, RRC reconfiguration information for the non-serving cell may be acquired from the base station during the BFR procedure. The RRC reconfiguration information for the non-serving cell may be included in the BFRR transmitted by the base station.
(81) In addition, the method further includes acquiring, from the base station, information of a first threshold and a second threshold, where in a case that the number of times of occurrences of beam failure event instances reaches or exceeds the first threshold, determination of the identified candidate beam is started; in a case that the number of times of occurrences of the beam failure event instances reaches or exceeds the second threshold, it is determined that a beam failure event occurs and a beam failure recovery procedure is started, where the first threshold is smaller than or equal to the second threshold.
(82) For example, a first counter and a second counter are established respectively to count the number of times of occurrences of the beam failure event instances, a count value of the first counter is compared with the first threshold, and a count value of the second counter is compared with the second threshold. Information of the first threshold and the second threshold may be acquired from the base station through RRC signaling.
(83) FIG. **9** is a flow chart showing a method for wireless communications according to another embodiment of the present disclosure. The method includes: providing, to UE, configuration information including a first candidate beam set for beam failure recovery, where the first candidate beam set includes a candidate beam of a serving cell and a candidate beam of a non-serving cell (S**21**); and acquiring, from the UE, information of an identified candidate beam to be used for the BFR determined by the UE based on the first candidate beam set and/or a second candidate beam set (S**22**), where the second candidate beam set includes a beam of a non-serving cell which serves as a candidate beam and is detected by user equipment. The method for example, may be performed at a base station side.
(84) For example, the second candidate beam set may include a beam corresponding to a SSB of the non-serving cell which is detected by the UE.
(85) The configuration information may include an index of a reference signal corresponding to the candidate beam and a PCI of a cell corresponding to the reference signal. The reference signal may be one of the SSB and the CSI-RS. The candidate beam in the first candidate beam set may include a beam corresponding to a reference signal for mobility management configured by the base station

for the UE.
(86) In a case that the identified candidate beam includes a candidate beam in the second candidate beam set, information of the candidate beam and a PCI of a cell corresponding to the candidate beam are acquired from the UE. For example, information of the identified candidate beam may be acquired by receiving MAC CE on a PUSCH.
(87) The method further includes providing information of a first threshold and a second threshold to the UE. In a case that the number of times of occurrences of beam failure event instances reaches or exceeds the first threshold, the UE starts the determination of the identified candidate beam. In a case that the number of times of occurrences of the beam failure event instances reaches or exceeds the second threshold, the UE determines that a beam failure event occurs and starts the BFR procedure. The first threshold is smaller than or equal to the second threshold. For example, the information of the first threshold and the second threshold may be provided to the UE through RRC signaling.
(88) Further, conditions for the candidate beam of the non-serving cell being determined as the identified candidate beam can be provided to the UE. The condition includes: beam quality of the candidate beam of the serving cell being lower than predetermined quality; and beam quality of the candidate beam of the non-serving cell being higher than the beam quality of the candidate beam of the serving cell by more than a predetermined value. For example, settings about the predetermined quality and the predetermined value may be provided to the UE.
(89) In a case that the identified candidate beam is the candidate beam of the non-serving cell in the first candidate beam set and/or the second candidate beam set, a handover request is transmitted to the non-serving cell when the UE receives the BFRQ during the BFR procedure, a handover request acknowledgement from the non-serving cell is received, and the RRC reconfiguration information for the non-serving cell is provided to the UE. The RRC reconfiguration information for the non-serving cell may be, for example, included in the BFRR.
(90) Note that the above methods may be used in combination with each other or separately, the details of which are described in the first embodiment and the second embodiment and are not repeated herein.
(91) The technology of the present disclosure is applicable to various products.
(92) For example, the electronic apparatus **200** may be implemented as various base stations. The base station may be implemented as any type of evolved Node B (cNB) or gNB (5G base station). The eNB includes, for example, a macro eNB and a small eNB. The small eNB may be an eNB of a cell with coverage smaller than that of a macro cell, such as a pico-eNB, a micro-eNB and a household (femto) eNB. The gNB is similar to the eNB. Alternatively, the base station may be implemented as any other type of base stations, 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 device) configured to control wireless communications, and one or more remote radio heads (RRH) arranged in a different place 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.
(93) The electronic device **100** 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 type mobile router, and a digital camera), or an in-vehicle terminal (such as a car navigation device). The user equipment may also be implemented as a terminal (that is also referred to as a machine type communication (MTC) terminal) that performs machine-to-machine (M2M) communication. Furthermore, the user equipment may be a wireless communication module (such as an integrated circuit module including a single die) mounted on each of the terminals.
(94) [Application Examples Regarding a Base Station]
First Embodiment

(95) FIG. **10** 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. 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.
(96) 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. **10**, 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. **10** shows the example in which the eNB **800** includes the multiple antennas **810**, the eNB **800** may include a single antenna **810**.
(97) The base station apparatus **820** includes a controller **821**, a memory **822**, a network interface **823**, and a radio communication interface **825**.
(98) 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 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 a terminal list, transmission power data and scheduling data).
(99) 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 SI interface and an X2 interface). The network interface **823** may also be a wired communication interface or a wireless communication interface for wireless backhaul. In a case that 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**.
(100) 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 CNB **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 perform 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, to replace 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 inserted into a slot of the base station apparatus **820**. Alternatively, the module may be a chip 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**.
(101) As shown in FIG. **10**, the radio communication interface **825** may include 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. **10**. For example, the multiple RF circuits **827** may be compatible with multiple antenna elements. Although FIG. **10** shows the example in which the radio communication interface **825** includes multiple BB processors **826** and multiple RF circuits **827**, the radio communication interface **825** may include a single BB processor **826** and a single RF circuit **827**.

(102) In the eNB **800** shown in FIG. **10**, the providing unit **201**, the acquiring unit **202**, and the transceiver of the electronic apparatus **200** may be implemented by the radio communication interface **825**. At least a part of the functions may be implemented by the controller **821**. For example, the controller **821** may enable the UE to recover to the non-serving cell when a beam failure event occurs by performing the functions of the providing unit **201** and the acquiring unit **202**.

Second Embodiment

(103) FIG. **11** is a block diagram showing a second example of an 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.

(104) 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. **11**, the eNB **830** may include multiple antennas **840**. For example, the multiple antennas **840** may be compatible with multiple frequency bands used by the eNB **830**. Although FIG. **11** shows the example in which the eNB **830** includes multiple antennas **840**, the eNB **830** may include a single antenna **840**.

(105) 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. **10**.

(106) 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. **10**, 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. **11**, the radio communication interface **855** may include 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. **11** shows the example in which the radio communication interface **855** includes multiple BB processors **856**, the radio communication interface **855** may include a single BB processor **856**.

(107) 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**.

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

(109) 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.

(110) The radio communication interface **863** transmits and receives wireless signals via the

antenna **840**. The radio communication interface **863** may typically include, for example, an 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. **11**. For example, the multiple RF circuits **864** may support multiple antenna elements. Although FIG. **11** shows the example in which the radio communication interface **863** includes multiple RF circuits **864**, the radio communication interface **863** may include a single RF circuit **864**.

(111) In the eNB **830** shown in FIG. **11**, the providing unit **201**, the acquiring unit **202**, and the transceiver of the electronic apparatus **200** may be implemented by the radio communication interface **855** and/or the communication interface **863**. At least a part of the functions may be implemented by the controller **851**. For example, controller **851** may enable the UE to recover to the non-serving cell when a beam failure event occurs by performing the functions of the providing unit **201** and the acquiring unit **202**.

(112) [Application Examples Regarding User Equipment]

First Application Example

(113) FIG. **12** 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**.

(114) 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**.

(115) 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 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 outputted from the smartphone **900** to sounds.

(116) The radio communication interface **912** supports any cellular communication scheme (such as LTE and LTE-advanced), and performs wireless communications. 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. **12** shows a case that one RF link is connected to one antenna, which is only illustrative, and a situation where one RF link is connected to multiple antennas through multiple phase shifters is also possible. 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. **12**. Although FIG. **12** shows the example in which the radio communication interface **912** includes

multiple BB processors **913** and multiple RF circuits **914**, the radio communication interface **912** may include a single BB processor **913** or a single RF circuit **914**.
(117) 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 wireless 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.
(118) 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**.
(119) 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. **12**. Although FIG. **12** shows the example in which the smartphone **900** includes multiple antennas **916**, the smartphone **900** may include a single antenna **916**.
(120) 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**.
(121) 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 smartphone **900** shown in FIG. **12** via feeder lines, which are partially shown as dashed lines in FIG. **12**. The auxiliary controller **919** operates a minimum necessary function of the smartphone **900**, for example, in a sleep mode.
(122) In the smartphone **900** shown in FIG. **12**, the acquiring unit **101**, the reporting unit **103** and the transceiver of the electronic apparatus **100** may be implemented by the radio communication interface **912**. At least a part of the functions may be implemented by the processor **901** or the auxiliary controller **919**. For example, the processor **901** or the auxiliary controller **919** may enable the UE to recover to the non-serving cell when a beam failure event occurs by performing the functions of the acquiring unit **101**, the determining unit **102** and the reporting unit **103**.
Second Embodiment
(123) FIG. **13** 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**.
(124) 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 executed by the processor **921**, and data.
(125) 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.
(126) The content player **927** reproduces content stored in a storage medium (such as a CD and 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 reproduced content. The speaker **931** outputs a sound for the navigation function or the reproduced content.

(127) 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. **13**. Although FIG. **13** shows the example in which the radio communication interface **933** includes multiple BB processors **934** and multiple RF circuits **935**, the radio communication interface **933** may include a single BB processor **934** and a single RF circuit **935**.

(128) 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.

(129) 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**.

(130) 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 for the radio communication interface **933** to transmit and receive wireless signals. As shown in FIG. **13**, the car navigation apparatus **920** may include multiple antennas **937**. Although FIG. **13** shows the example in which the car navigation apparatus **920** includes multiple antennas **937**, the car navigation apparatus **920** may include a single antenna **937**.

(131) 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**.

(132) The battery **938** supplies power to the blocks of the car navigation apparatus **920** shown in FIG. **13** via feeder lines that are partially shown as dash lines in FIG. **14**. The battery **938** accumulates power supplied from the vehicle.

(133) In the car navigation apparatus **920** shown in FIG. **13**, the acquiring unit **101**, the reporting unit **103** and the transceiver of the electronic apparatus **100** may be implemented by the radio communication interface **933**. At least part of the functions may be implemented by the processor **921**. For example, the processor **921** may enable the UE to recover to the non-serving cell when a beam failure event occurs by performing the functions of the acquiring unit **101**, the determining unit **102** and the reporting unit **103**.

(134) The technology according to 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 device **920**, the in-vehicle network **941**, and a vehicle module **942**. The vehicle module **942** generates vehicle data (such as vehicle speed, engine speed, and failure information), and outputs the generated data to the in-vehicle network **941**.

(135) 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.

(136) 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.

(137) 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.

(138) 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 **1400** shown in FIG. **14**) from a storage medium or network, wherein the computer is capable of implementing various functions when installed with various programs.

(139) In FIG. **14**, a central processing unit (CPU) **1401** executes various processing according to a program stored in a read-only memory (ROM) **1402** or a program loaded to a random access memory (RAM) **1403** from a memory section **1408**. The data needed for the various processing of the CPU **1401** may be stored in the RAM **1403** as needed. The CPU **1401**, the ROM **1402** and the RAM **1403** are linked with each other via a bus **1404**. An input/output interface **1405** is also linked to the bus **1404**.

(140) The following components are linked to the input/output interface **1405**: an input section **1406** (including keyboard, mouse and the like), an output section **1407** (including displays such as a cathode ray tube (CRT), a liquid crystal display (LCD), a loudspeaker and the like), a memory section **1408** (including hard disc and the like), and a communication section **1409** (including a network interface card such as a LAN card, modem and the like). The communication section **1409** performs communication processing via a network such as the Internet. A driver **1410** may also be linked to the input/output interface **1405**, if needed. If needed, a removable medium **1411**, for example, a magnetic disc, an optical disc, a magnetic optical disc, a semiconductor memory and the like, may be installed in the driver **1410**, so that the computer program read therefrom is installed in the memory section **1408** as appropriate.

(141) 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 **1411**.

(142) It should be appreciated by those skilled in the art that the memory medium is not limited to the removable medium **1411** shown in FIG. **14**, which has program stored therein and is distributed separately from the apparatus so as to provide the programs to users. The removable medium **1411** 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 **1402** and the memory section **1408** in which programs are stored, and can be distributed to users along with the device in which they are incorporated.

(143) 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 re-combinations 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.

(144) 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.
(145) 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. An electronic apparatus for wireless communications, comprising: processing circuitry, configured to: acquire, from a base station, configuration information comprising a first candidate beam set for beam failure recovery, wherein the first candidate beam set comprises a candidate beam from a first transmission point and a candidate beam of a second transmission point; and determine, based on the first candidate beam set or a second candidate beam set, an identified candidate beam to be used for the beam failure recovery, wherein the second candidate beam set comprises a beam of a non-serving cell which serves as a candidate beam and is detected by user equipment, wherein the configuration information comprises an index of a reference signal corresponding to the candidate beam and a physical cell identification of a cell corresponding to the reference signal.
2. The electronic apparatus according to claim 1, wherein the second candidate beam set comprises a beam corresponding to a synchronization signal block of a non-serving cell which is detected by the user equipment.
3. The electronic apparatus according to claim 1, wherein the processing circuitry is configured to determine the candidate beam of a non-serving cell in the second candidate beam set as the identified candidate beam in the following conditions: beam quality of the candidate beam of the first transmission point being lower than predetermined quality; and beam quality of the candidate beam of the non-serving cell being higher than the beam quality of the candidate beam of the first transmission point by more than a predetermined value.
4. The electronic apparatus according to claim 3, wherein the processing circuitry is further configured to acquire, from the base station, settings of the predetermined quality and the predetermined value.
5. The electronic apparatus according to claim 1, wherein, in a case that the identified candidate beam is a candidate beam of a non-serving cell in the second candidate beam set, the processing circuitry is configured to acquire, from the base station, radio resources control reconfiguration information for the non-serving cell during the beam failure recovery procedure.
6. The electronic apparatus according to claim 5, wherein the radio resources control reconfiguration information for the non-serving cell is comprised in a beam failure recovery request response transmitted by the base station.
7. The electronic apparatus according to claim 1, wherein the reference signal is one of a synchronization signal block and a channel state information reference signal.
8. The electronic apparatus according to claim 1, wherein the candidate beam in the first candidate beam set comprises a beam corresponding to a reference signal for mobility management configured by the base station for the user equipment.

9. The electronic apparatus according to claim 1, wherein the processing circuitry is further configured to determine a physical cell identification of a cell corresponding to the candidate beam in the second candidate beam set by decoding a primary synchronization signal or a secondary synchronization signal.
10. The electronic apparatus according to claim 1, wherein, in a case that the identified candidate beam comprises a candidate beam in the second candidate beam set, the processing circuitry is further configured to provide, to the base station, information of the candidate beam belonging to the second candidate beam set which is comprised in the identified candidate beam and a physical cell identification of a cell corresponding to the candidate beam.
11. The electronic apparatus according to claim 10, wherein the processing circuitry is configured to provide information of the identified candidate beam by transmitting MAC CE on a physical uplink shared channel.
12. The electronic apparatus according to claim 1, wherein, the processing circuitry is further configured to acquire, from the base station, information of a first threshold and a second threshold, wherein in a case that the number of times of occurrences of beam failure event instances reaches or exceeds the first threshold, the processing circuitry starts determination of the identified candidate beam; in a case that the number of times of occurrences of the beam failure event instances reaches or exceeds the second threshold, the processing circuitry determines that a beam failure event occurs and starts a beam failure recovery procedure, wherein the first threshold is smaller than or equal to the second threshold.
13. The electronic apparatus according to claim 12, wherein the processing circuitry is configured to: establish a first counter and a second counter respectively to count the number of times of occurrences of the beam failure event instances, compare a count value of the first counter with the first threshold, and compare a count value of the second counter with the second threshold.
14. The electronic apparatus according to claim 12, wherein the processing circuitry is configured to acquire, from the base station, information of the first threshold and the second threshold through radio resources control signaling.
15. An electronic apparatus for wireless communications, comprising: processing circuitry, configured to: provide, to user equipment, configuration information comprising a first candidate beam set for beam failure recovery, wherein the first candidate beam set comprises a candidate beam of a first transmission point and a candidate beam of a second transmission point; and acquire, from the user equipment, information of an identified candidate beam to be used for the beam failure recovery determined by the user equipment based on the first candidate beam set or a second candidate beam set, wherein the second candidate beam set comprises a beam of a non-serving cell which serves as a candidate beam and is detected by the user equipment, wherein the configuration information comprises an index of a reference signal corresponding to the candidate beam and a physical cell identification of a cell corresponding to the reference signal.
16. The electronic apparatus according to claim 15, wherein the processing circuitry is further configured to provide conditions for the candidate beam of the non-serving cell being determined as the identified candidate beam to the user equipment, and the conditions comprise: beam quality of the candidate beam of the serving cell being lower than predetermined quality; and beam quality of the candidate beam of the non-serving cell being higher than the beam quality of the candidate beam of the first transmission point by more than a predetermined value.
17. The electronic apparatus according to claim 15, wherein in a case that the identified candidate beam is a candidate beam of a non-serving cell in the second candidate beam set, the processing circuitry is configured to transmit a handover request to the non-serving cell and receive a handover request acknowledgement from the non-serving cell upon receiving a beam failure recovery request from the user equipment during a beam failure recovery procedure, and provide radio resources control reconfiguration information for the non-serving cell to the user equipment.
18. The electronic apparatus according to claim 17, wherein the processing circuitry is configured

to comprise the radio resources control reconfiguration information for the non-serving cell in a beam failure recovery request response to be provided to the user equipment.

19. A method for wireless communications, the method performed by an electronic apparatus and comprising: acquiring, from a base station, configuration information comprising a first candidate beam set for beam failure recovery, wherein the first candidate beam set comprises a candidate beam of a first transmission point and a candidate beam of a second transmission point; and determining, based on the first candidate beam set or a second candidate beam set, an identified candidate beam to be used for the beam failure recovery, wherein the second candidate beam set comprises a beam of a non-serving cell which serves as a candidate beam and is detected by the user equipment, wherein the configuration information comprises an index of a reference signal corresponding to the candidate beam and a physical cell identification of a cell corresponding to the reference signal.