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(54) **ELECTRONIC DEVICE AND USER EQUIPMENT IN WIRELESS COMMUNICATION SYSTEM AND WIRELESS COMMUNICATION METHOD**

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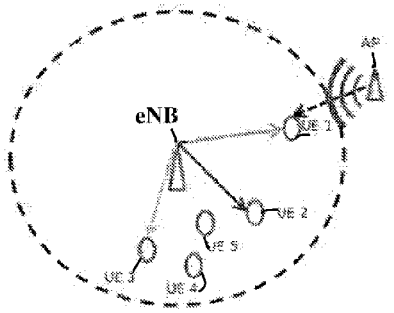
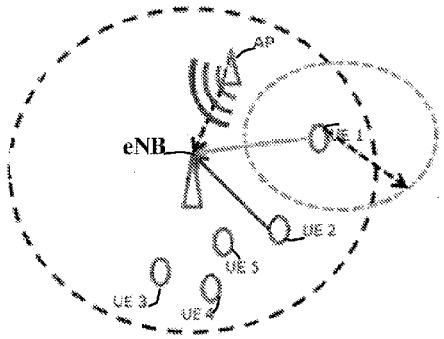
(57) **ABSTRACT**

An electronic device and a user equipment in a wireless communication system and a wireless communication method. The electronic device includes: one or more processing circuits configured to acquire NACK information indicating an information transmission failure between a transmitting end and a receiving end in a wireless communication system and to acquire failure cause information indicating a cause of the information transmission failure, wherein the cause of the information transmission failure is classified as a link quality cause or a non-link quality cause; and when the cause of the information transmission failure is determined to be the non-link quality cause, generating spectrum sensing parameter information to adjust a spectrum sensing parameter at the transmitting end to increase a probability of successful information transmission between the transmitting end and the receiving end.





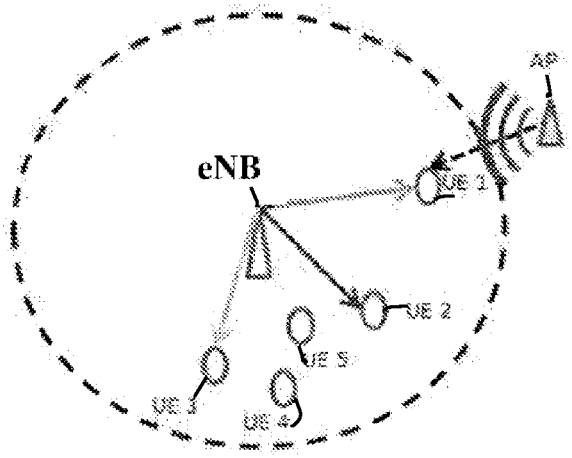


Figure 1(a)

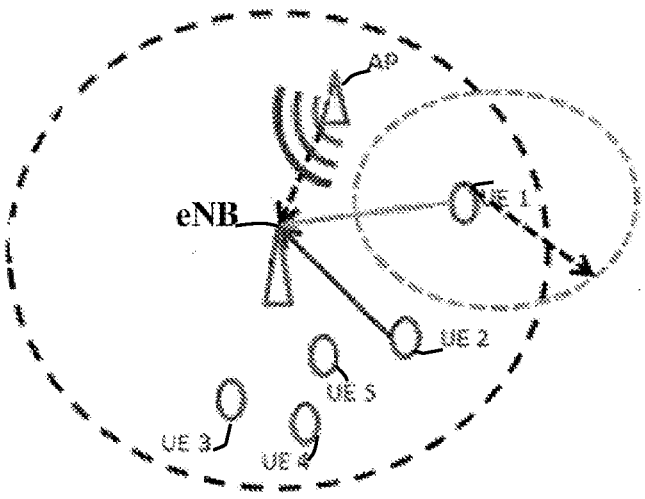


Figure 1(b)

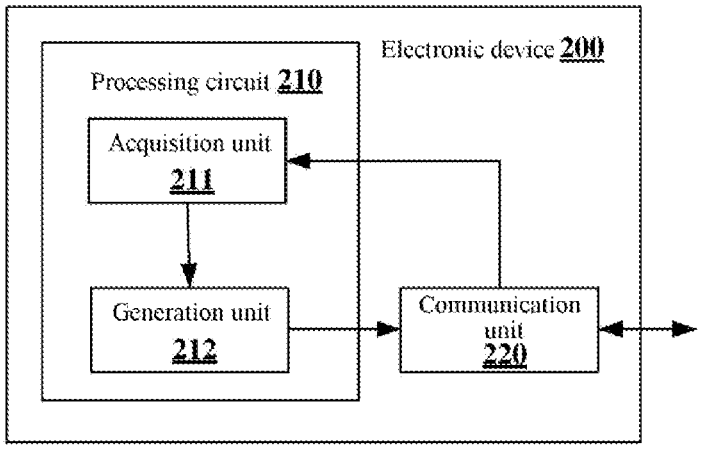


Figure 2

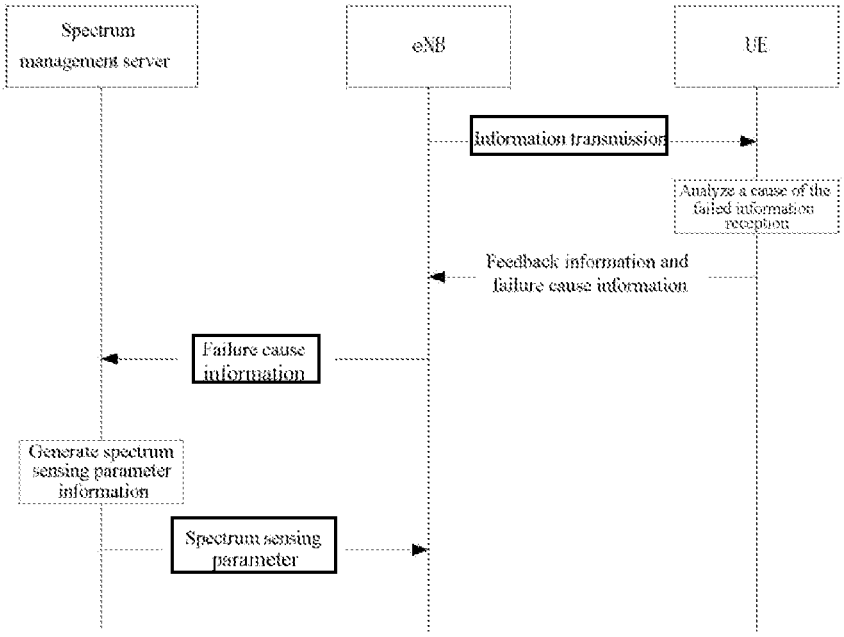


Figure 3

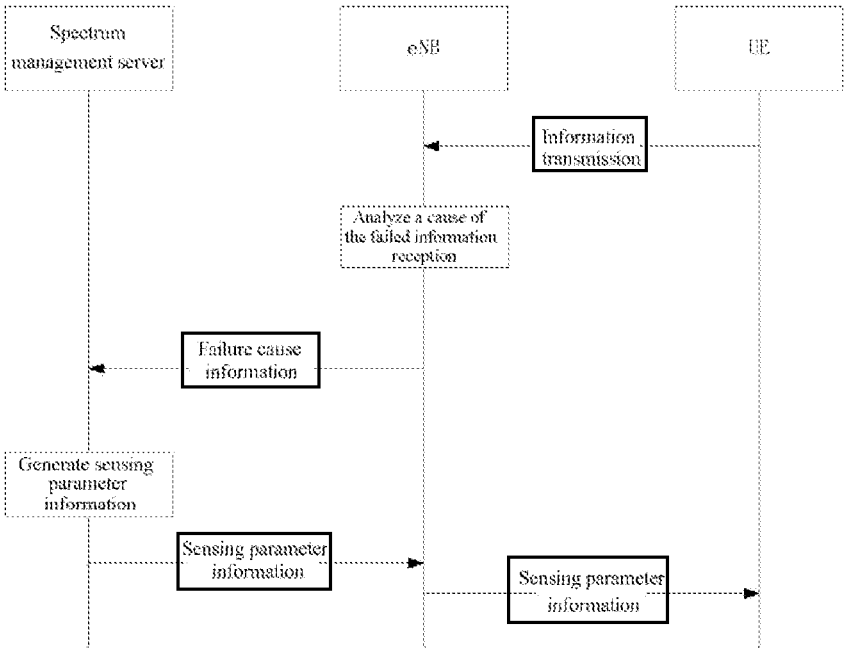


Figure 4

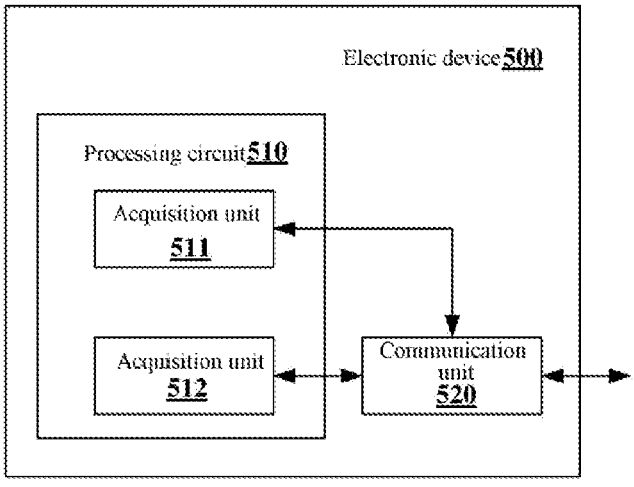


Figure 5

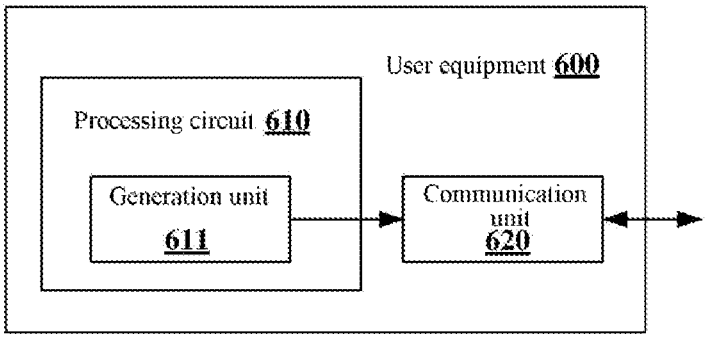


Figure 6

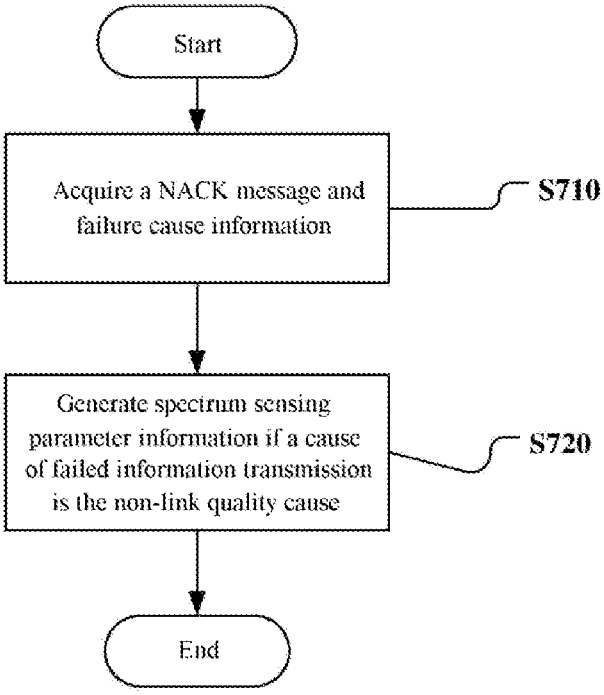


Figure 7

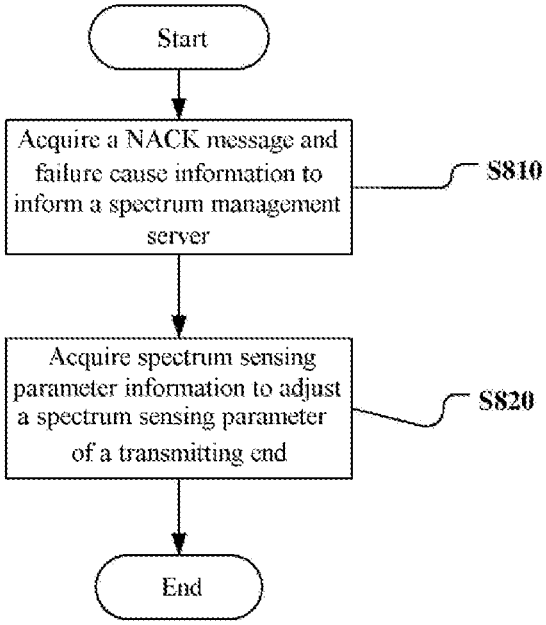


Figure 8

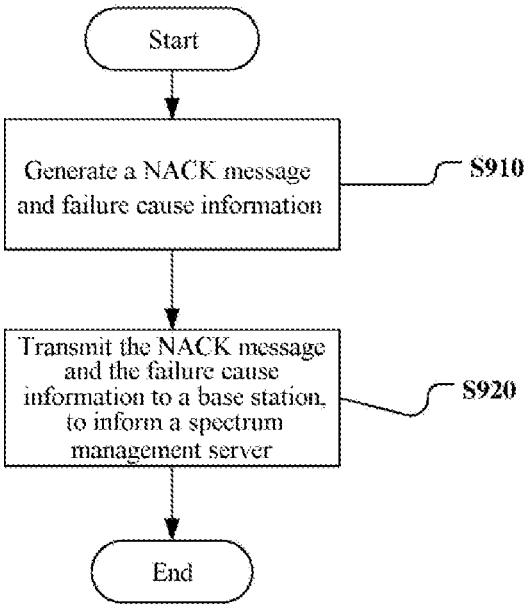


Figure 9

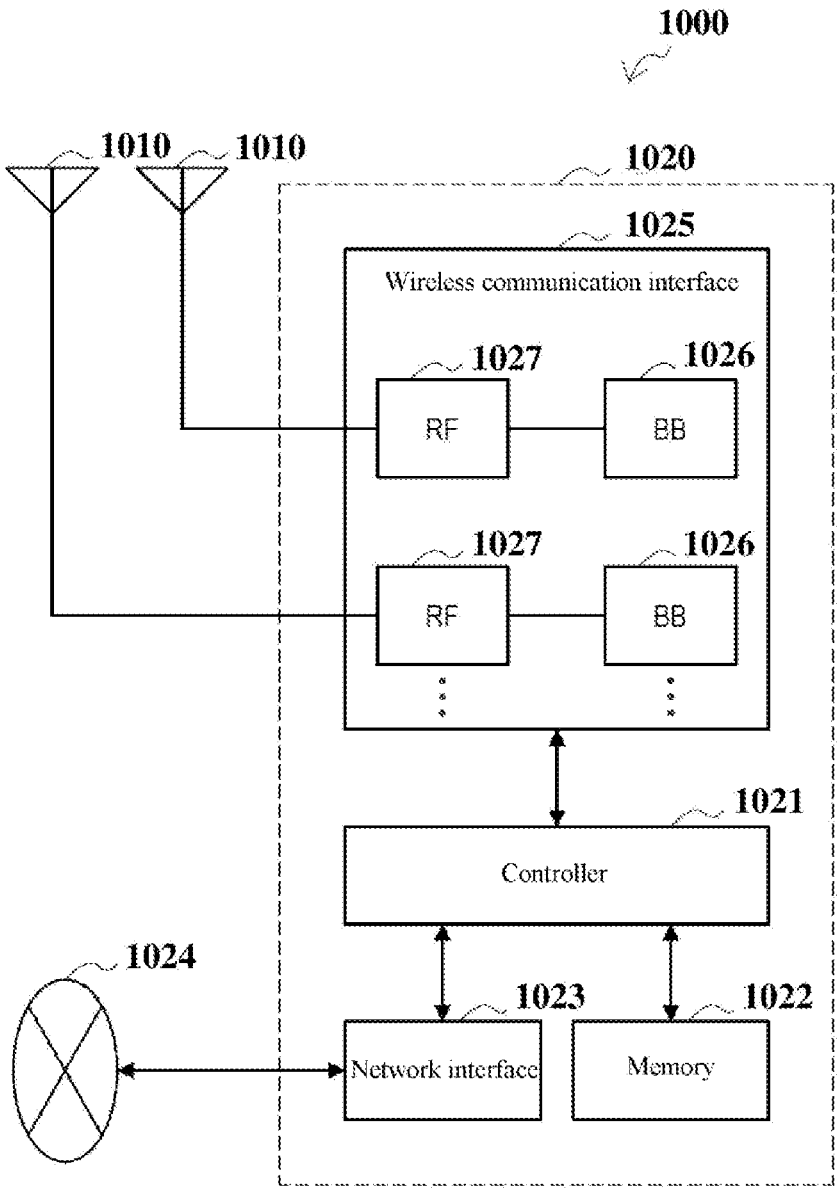

1000
1010
1010
1020
1025
Wireless communication interface
1027
1026
RF
BB
1027
1026
RF
BB
1021
Controller
1024
1023
1022
Network interface
Memory

Figure 10

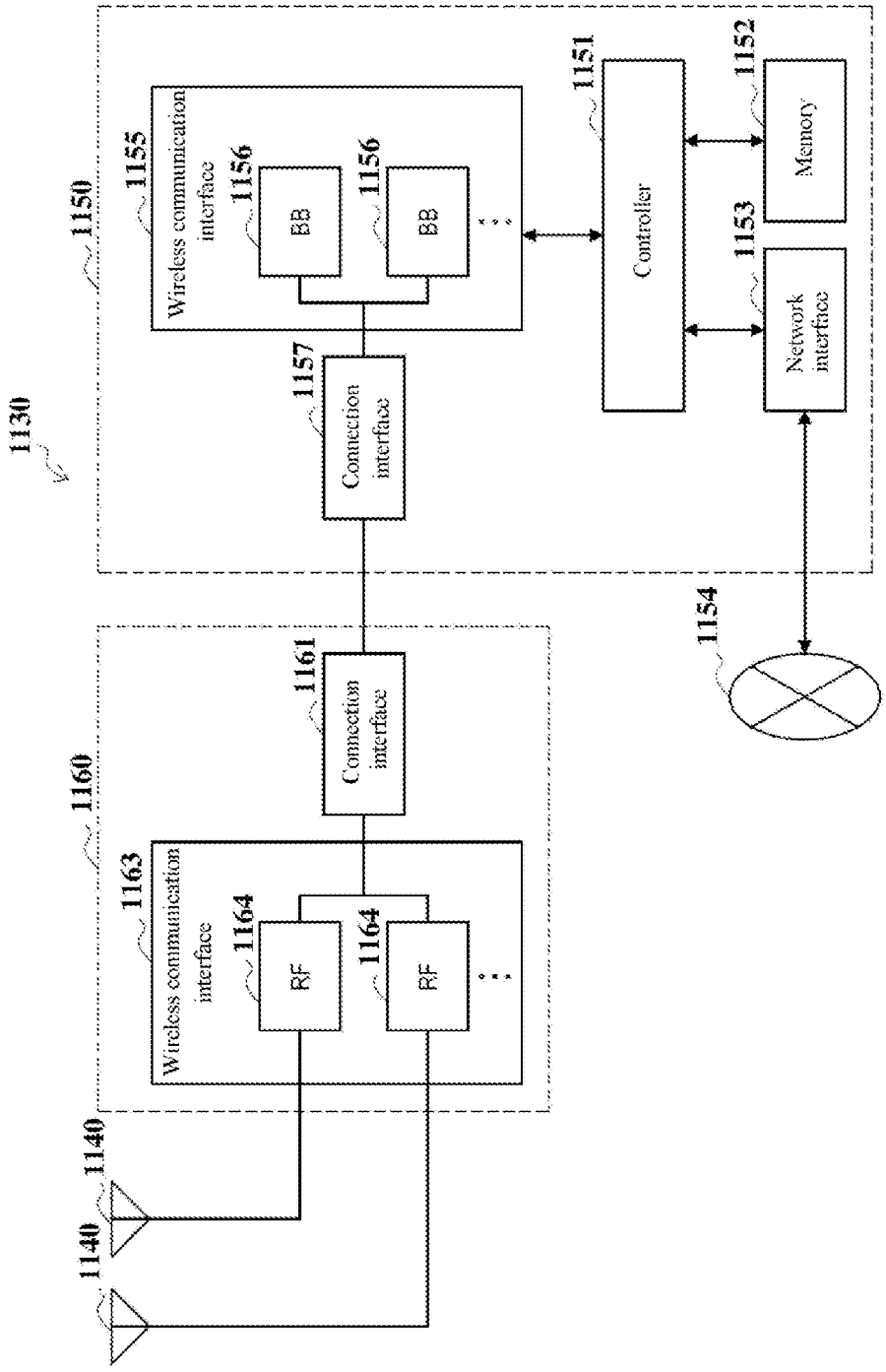

1130
1150
1155
Wireless communication interface
1156
BB
1156
BB
1157
Connection interface
1151
Controller
1152
Memory
1153
Network interface
1154
1160
1161
Connection interface
1163
Wireless communication interface
1164
RF
1164
RF
1140
1140

Figure 11

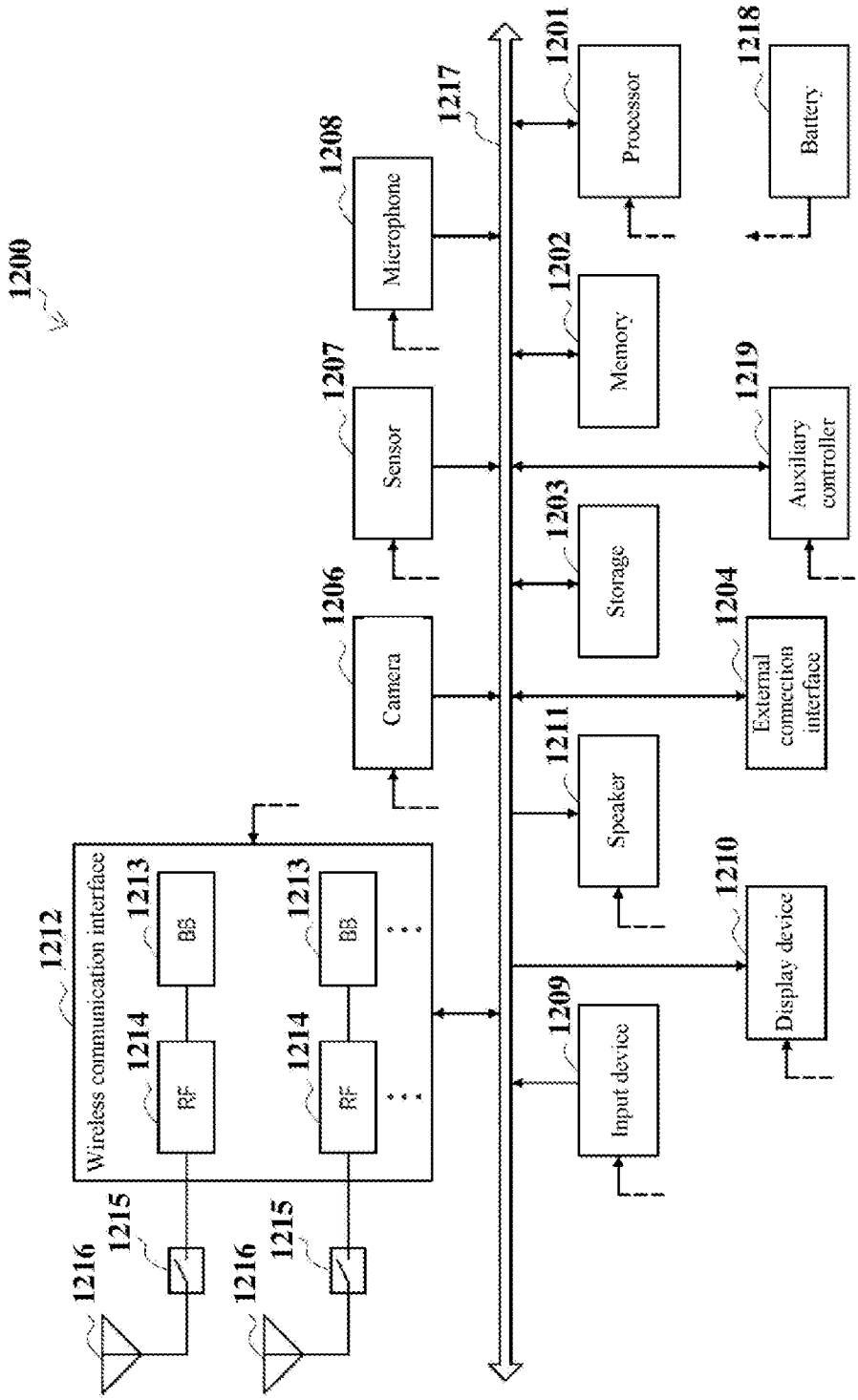

1200
1201
Processor
1202
Memory
1203
Storage
1204
External connection interface
1206
Camera
1207
Sensor
1208
Microphone
1209
Input device
1210
Display device
1211
Speaker
1212
Wireless communication interface
1213
BB
1214
RF
1215
1216
1217
1218
Battery
1219
Auxiliary controller

Figure 12

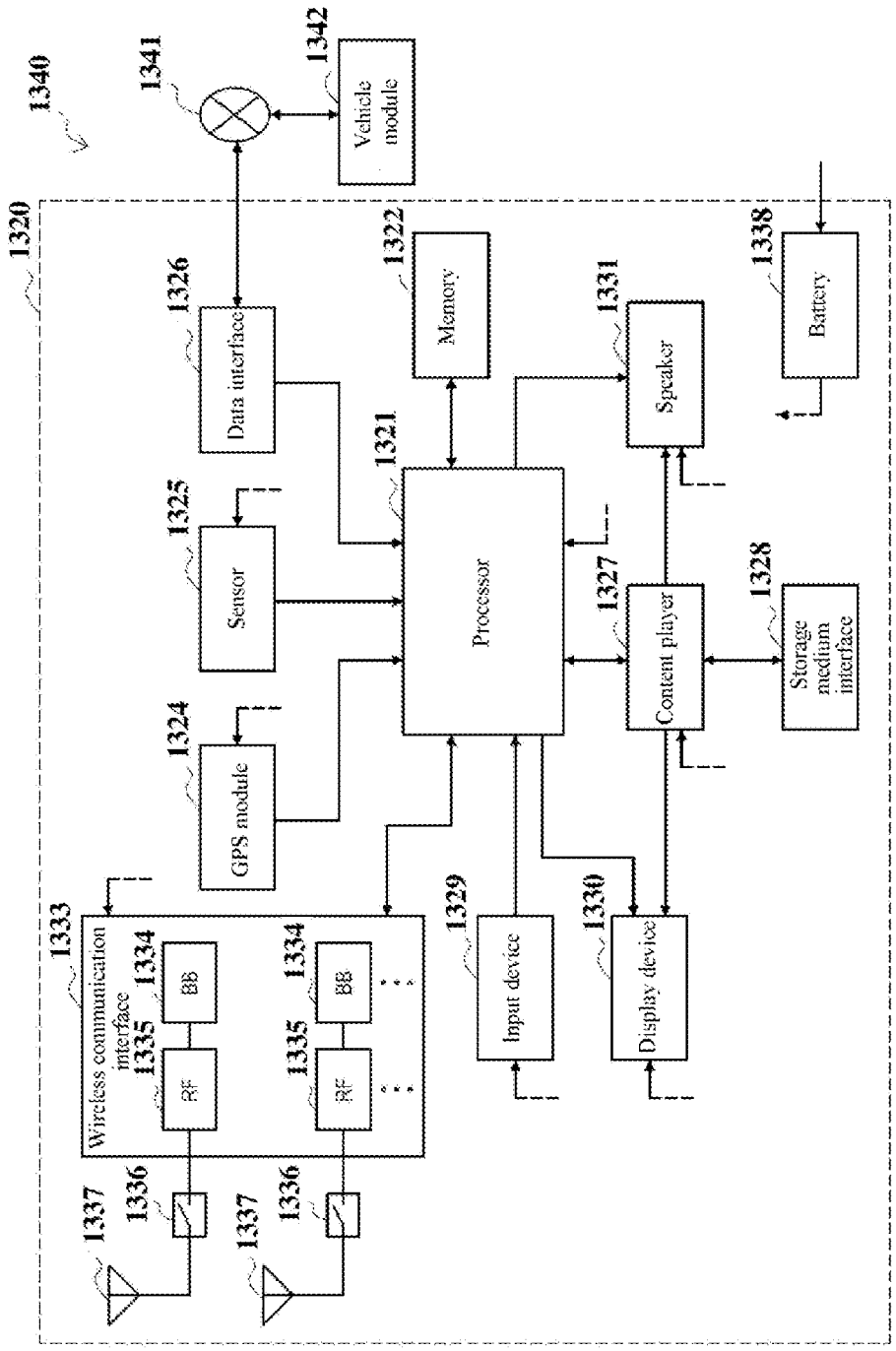

1340
1341
1342
Vehicle module
1320
1326
Data interface
1322
Memory
1331
Speaker
1338
Battery
1321
Processor
1325
Sensor
1327
Content player
1328
Storage medium interface
1324
GPS module
1333
Wireless communication interface
1334
BB
1335
RF
1329
Input device
1330
Display device
1336
1337

Figure 13

ELECTRONIC DEVICE AND USER EQUIPMENT IN WIRELESS COMMUNICATION SYSTEM AND WIRELESS COMMUNICATION METHOD

[0001] The present application claims the priority to Chinese Patent Application No. 201510747087.3, titled "ELECTRONIC DEVICE AND USER EQUIPMENT IN WIRELESS COMMUNICATION SYSTEM AND WIRELESS COMMUNICATION METHOD", filed on Nov. 5, 2015 with the Chinese State Intellectual Property Office, which is incorporated herein by reference in its entirety.

FIELD

[0002] The present disclosure relates to the technical field of wireless communication, and in particular to an electronic device and a user equipment in a wireless communication system, and a method for performing wireless communication in a wireless communication system.

BACKGROUND

[0003] This part provides background information related to the present disclosure, which is not necessarily the conventional technology.

[0004] With the development and evolution of wireless networks, more and more services are carried by the wireless networks. In this case, additional spectrum resources are required to support transmission of a large amount of data. Cellular wireless network operators start discussing how to use unlicensed spectrum resources such as the 5 GHz ISM (Industrial Scientific Medical) frequency band, on the basis of utilization of the existing LTE (Long Term Evolution) networks. On the other hand, in the WiFi wireless industry, more WiFi systems are deployed on the unlicensed spectrum. Communication systems between different operators and different systems have equal rights to use the unlicensed frequency band. However, different operators and different systems may be interfered with each other when using unlicensed spectrum resources, which results in failed information transmission on one side.

[0005] In a WiFi system, a contention window (CW) is one of the effective solutions for resolving the resource conflict. When a transmitting node configured with a contention window is to perform data transmission, the transmitting node needs to randomly select a random number in the range of the contention window as a waiting time period, and transmits data using corresponding resources when the waiting time period elapses. A spectrum management server in the system may set a contention window size (CWS) for each transmitting node according to different requirements, where a greater contention window size corresponds to a smaller probability of using the unlicensed spectrum by the transmitting node, and a smaller contention window size corresponds to a greater probability of using the unlicensed spectrum by the transmitting node. In a system that does not support the contention window, such as an LTE system, a counter may be configured for each transmitting node, which plays a same role as the contention window. When a transmitting node configured with the counter is to perform data transmission, the transmitting node may use a value of the counter as a waiting time period, and transmit data using corresponding resources when the waiting time period elapses. A node on the network side, for example, the base station, may set the value of the counter for each transmitting node according to different requirements, where a greater value of the counter value corresponds to a smaller probability of using the unlicensed spectrum by the transmitting node, and a smaller value of the counter corresponds to a greater probability of using the unlicensed spectrum by the transmitting node.

[0006] In addition, during information transmission using the unlicensed spectrum resources, if a hidden node which is outside the sensing range of the transmitting end and thus is invisible to the transmitting end also performs information transmission, the information transmission of the hidden node interferes with the information transmission by the transmitting end, which results in failed information transmission. In order to solve the problem, an energy detection threshold of the transmitting end may be reduced to extend the sensing range of the transmitting end so that the hidden node is sensed and monitored by the transmitting end.

[0007] During the information transmission of a node in a wireless communication system operating on the unlicensed band, failed information transmission may occur due to change in quality of a channel between the transmitting end and the receiving end, or due to inference to the receiving end from a hidden node as described above or from other access mechanisms. In the case of the failed information transmission due to the change in quality of the channel between the transmitting end and the receiving end, it is obviously inappropriate to adjust a spectrum sensing parameter, such as the contention window size or the value of the counter. Therefore, it is important to acquire the cause of the failed information transmission.

[0008] Therefore, a new wireless communication technology solution is required, with which the cause of the failed information transmission can be acquired, and the spectrum sensing parameter is adjusted only in a case where the cause of the failed information transmission is a non-link quality cause, thereby increasing a probability of successful information transmission between the transmitting end and the receiving end, and avoiding unnecessary adjustment.

SUMMARY

[0009] This part provides an overview of the present disclosure, rather than a full scope or all features of the present disclosure.

[0010] An object of the present disclosure is to provide an electronic device and a user equipment in a wireless communication system and a method for performing wireless communication in a wireless communication system, with which a cause of failed information transmission between a transmitting end and a receiving end can be acquired and a spectrum sensing parameter of the transmitting end is adjusted in a case where the cause of the failed information transmission is a non-link quality cause, thereby increasing a probability of successful information transmission between the transmitting end and the receiving end.

[0011] According to an aspect of the present disclosure, an electronic device in a wireless communication system is provided. The electronic device includes one or more processing circuits configured to: acquire a NACK message indicating failed information transmission between a transmitting end and a receiving end in the wireless communication system and failure cause information indicating a cause of the failed information transmission, where the cause of the failed information transmission includes a link quality cause and a non-link quality cause; and generate

spectrum sensing parameter information if it is determined that the cause of the failed information transmission is the non-link quality cause to adjust a spectrum sensing parameter of the transmitting end, so as to increase a probability of successful information transmission between the transmitting end and the receiving end.

[0012] According to another aspect of the present disclosure, an electronic device in a wireless communication system is provided. The electronic device includes one or more processing circuits configured to: acquire a NACK message indicating failed information transmission between a transmitting end and a receiving end in the wireless communication system and failure cause information indicating a cause of the failed information transmission, to inform a spectrum management server in the wireless communication system, where the cause of the failed information transmission includes a link quality cause and a non-link quality cause; and acquire spectrum sensing parameter information from the spectrum management server to adjust a spectrum sensing parameter of the transmitting end, so as to increase a probability of successful information transmission between the transmitting end and the receiving end.

[0013] According to another aspect of the present disclosure, a user equipment in a wireless communication system is provided. The user equipment operates as a receiving end and includes a transceiver; and one or more processing circuits configured to: generate a NACK message indicating failed information transmission between a base station serving as a transmitting end and the user equipment in the wireless communication system and failure cause information indicating a cause of the failed information transmission, where the cause of the failed information transmission includes a link quality cause and a non-link quality cause; and control the transceiver to transmit the NACK message and the failure cause information to the base station, to inform a spectrum management server in the wireless communication system.

[0014] According to another aspect of the present disclosure, a method for performing wireless communication in a wireless communication system is provided. The wireless communication method includes: acquiring a NACK message indicating failed information transmission between a transmitting end and a receiving end in the wireless communication system and failure cause information indicating a cause of the failed information transmission, where the cause of the failed information transmission includes a link quality cause and a non-link quality cause; and generating spectrum sensing parameter information if it is determined that the cause of the failed information transmission is the non-link quality cause to adjust a spectrum sensing parameter of the transmitting end, so as to increase a probability of successful information transmission between the transmitting end and the receiving end.

[0015] According to another aspect of the present disclosure, a method for performing wireless communication in a wireless communication system is provided. The wireless communication method includes: acquiring NACK information indicating failed information transmission between a transmitting end and a receiving end in the wireless communication system and failure cause information indicating a cause of the failed information transmission, to inform a spectrum management server in the wireless communication system, where the cause of the failed information transmission includes a link quality cause and a non-link quality cause; and acquiring spectrum sensing parameter information from the spectrum management server to adjust a spectrum sensing parameter of the transmitting end, so as to increase a probability of successful information transmission between the transmitting end and the receiving end.

[0016] According to another aspect of the present disclosure, a method for performing wireless communication in a wireless communication system is provided. The wireless communication method includes: generating a NACK message indicating failed information transmission between a base station serving as a transmitting end and a user equipment serving as a receiving end in the wireless communication system and failure cause information indicating a cause of the failed information transmission, where the cause of the failed information transmission includes a link quality cause and a non-link quality cause; and transmitting the NACK message and the failure cause information to the base station, to inform a spectrum management server in the wireless communication system.

[0017] With the electronic device and the user equipment in the wireless communication system and the method for performing wireless communication in the wireless communication system according to the present disclosure, the cause of failed information transmission between the transmitting end and the receiving end can be acquired, and the spectrum sensing parameter of the transmitting end is adjusted in a case where the cause of the failed information transmission is the non-link quality cause, thereby greatly increasing the probability of successful information transmission between the transmitting end and the receiving end, and avoiding adjustment of the spectrum sensing parameter in a case where the cause of the failed information transmission is the link quality cause, thus the system performance is improved.

[0018] A further applicability range is apparent from the description provided herein. The description and specific examples in the overview are merely for the purpose of illustration and are not intended to limit the scope of the present disclosure.

BRIEF DESCRIPTION OF THE DRAWINGS

[0019] The drawings described herein are provided merely for the purpose of illustrating selected embodiments rather than all possible embodiments, and are not intended to limit the scope of the present disclosure. In the drawings:

[0020] FIG. **1**(*a*) is a schematic diagram showing a downlink transmission being interfered by a hidden node or other access mechanisms in a wireless communication system according to an embodiment of the present disclosure;

[0021] FIG. **1**(*b*) is a schematic diagram showing an uplink transmission being interfered by a hidden node or other access mechanisms in a wireless communication system according to an embodiment of the present disclosure;

[0022] FIG. **2** is a block diagram showing a structure of an electronic device in a wireless communication system according to an embodiment of the present disclosure;

[0023] FIG. **3** is a schematic diagram showing signaling interactions in downlink transmission according to an embodiment of the present disclosure;

[0024] FIG. **4** is a schematic diagram showing signaling interactions in uplink transmission according to an embodiment of the present disclosure;

[0025] FIG. **5** is a block diagram showing a structure of an electronic device in a wireless communication system according to another embodiment of the present disclosure;

[0026] FIG. **6** is a block diagram showing a structure of a user equipment in a wireless communication system according to an embodiment of the present disclosure;

[0027] FIG. **7** is a flowchart of a method for performing wireless communication according to an embodiment of the present disclosure;

[0028] FIG. **8** is a flowchart of a method for performing wireless communication according to another embodiment of the present disclosure;

[0029] FIG. **9** is a flowchart of a method for performing wireless communication according to another embodiment of the present disclosure;

[0030] FIG. **10** is a block diagram showing a first schematic configuration example of an eNB (evolution node base station) to which the present disclosure may be applied;

[0031] FIG. **11** is a block diagram showing a second schematic configuration example of an eNB to which the present disclosure may be applied;

[0032] FIG. **12** is a block diagram showing a schematic configuration example of a smartphone to which the present disclosure may be applied; and

[0033] FIG. **13** is a block diagram showing a schematic configuration example of a car navigation apparatus to which the present disclosure may be applied.

[0034] While specific embodiments of the present disclosure are shown as examples in the drawings and are described herein in detail, various modifications and variations may be made to the present disclosure. It should be understood that the description for the specific embodiments herein is not intended to limit the present disclosure to the disclosed specific forms, and the present disclosure is intended to encompass all modifications, equivalents and alternatives that fall within the spirit and scope of the present disclosure. It should be noted that reference numerals indicate corresponding parts throughout the drawings.

DETAILED DESCRIPTION OF EMBODIMENTS

[0035] Examples of the present disclosure are described more fully with reference to the drawings. The following description is merely exemplary rather than being intended to limit the present disclosure and applications or purposes of the present disclosure.

[0036] Exemplary embodiments are provided to make the present disclosure be exhaustive and fully convey the scope of the present disclosure to those skilled in the art. Various specific details such as examples of specific parts, devices and methods are set forth to provide thorough understanding for the embodiments of the present disclosure. It is apparent to those skilled in the art that the exemplary embodiments may be embodied in many different forms without the specific details, and are not interpreted as a limit for the scope of the present disclosure. In some exemplary embodiments, well-known processes, well-known structures and well-known technologies are not described in detail.

[0037] A UE (user equipment) in the present disclosure includes but is not limited to a terminal having a wireless communication function such as a mobile terminal, a computer or an in-vehicle apparatus. Further, depending on a function described, the UE in the present disclosure may also be the UE itself or a component such as a chip in the UE. Similarly, a base station in the present disclosure may be, for example, an eNB (evolution node base station) or a component such as a chip in the eNB.

[0038] FIG. **1**(*a*) is a schematic diagram showing a downlink transmission being interfered by a hidden node or other access mechanisms in a wireless communication system according to an embodiment of the present disclosure. As shown in FIG. **1**(*a*), UE**1** to UE**5** exist in the coverage of an eNB, and uplink information transmission and downlink information transmission may be performed between the eNB and each of the UEs. When the eNB transmits downlink data to the UE**1**, an AP (access point) which is close to the UE**1** and outside the energy detection range of the eNB may also transmit data. Since the AP is located outside the energy detection range of the eNB, the eNB cannot detect the existence of the AP and cannot detect whether the AP is transmitting data. In other words, the AP may be regarded as a hidden node. The AP herein may also come from other operators or other access mechanisms. In this case, the UE**1** may receive data from both the eNB and the AP when receiving data. Therefore, the UE**1** may be interfered by the data from the AP.

[0039] FIG. **1**(*b*) is a schematic diagram showing an uplink transmission being interfered by a hidden node or other access mechanisms in a wireless communication system according to an embodiment of the present disclosure. As shown in FIG. **1**(*b*), UE**1** to UE**5** exist in the coverage of an eNB, and uplink information transmission and downlink information transmission may be performed between the eNB and each of the UEs. When the UE**1** transmits uplink data to the eNB, an AP (access point) which is close to the eNB and outside the energy detection range of the UE**1** may also transmit data. Since the AP is outside the energy detection range of the UE**1**, the UE**1** cannot detect the existence of the AP and cannot detect whether the AP is transmitting data. In other words, the AP may be regarded as a hidden node. The AP herein may also come from other operators or other access mechanisms. In this case, the eNB may receive data from both the UE**1** and the AP when receiving data.

[0040] Therefore, the eNB may be interfered by the data from the AP.

[0041] In the scenarios shown in FIG. **1**(*a*) and FIG. **1**(*b*), failed information transmission between the eNB and the UE**1** may be caused by: poor quality of the link between the eNB and the UE**1**; interference from the hidden node AP; and interference from other operators or access mechanisms. However, in the conventional method, the eNB or the UE**1** as a receiving end cannot acquire a cause of the failed information transmission, and may make an inappropriate adjustment. According to the basic principle of the present disclosure, a cause of the failed information transmission or information on the cause of the failed transmission can be acquired by the transmitting end, and an adjustment may be made based on different causes, to increase a probability of successful information transmission between the transmitting end and the receiving end.

[0042] In view of the above technical issue, a technical solution according to the present disclosure is provided. FIG. **2** shows a structure of an electronic device **200** in a wireless communication system according to an embodiment of the present disclosure.

[0043] As shown in FIG. **2**, the electronic device **200** may include a processing circuit **210**. It should be noted that the electronic device **200** may include one processing circuit

210 or multiple processing circuits **210**. The electronic device **200** may further include a communication unit **220**.

[0044] Further, the processing circuit **210** may include various discrete functional units to perform various different functions and/or operations. It should be noted that the functional units may be physical entities or logical entities, and units referred to by different names may be implemented as a same physical entity.

[0045] For example, as shown in FIG. **2**, the processing circuit **210** may include an acquisition unit **211** and a generation unit **212**.

[0046] According to the embodiment of the present disclosure, the acquisition unit **211** may acquire a NACK message indicating failed information transmission between a transmitting end and a receiving end in the wireless communication system and failure cause information indicating a cause of the failed information transmission. The cause of the failed information transmission includes a link quality cause and a non-link quality cause.

[0047] The acquisition unit **211** may receive the NACK message and the failure cause information from the transmitting end in the wireless communication system, or from the receiving end in the wireless communication system. Further, the acquisition unit **211** may also receive information related to the fail cause from the transmitting end or the receiving end in the wireless communication system. The processing circuit **210** (for example, an analysis unit, which is not shown) analyzes the cause of the failure. The acquisition unit **211** may then transmit the failure cause information indicating the cause of the failed information transmission to the generation unit **212**.

[0048] According to an embodiment of the present disclosure, if it is determined that the cause of the failed information transmission is the non-link quality cause, the generation unit **212** may generate spectrum sensing parameter information to adjust a spectrum sensing parameter of the transmitting end, so as to increase a probability of successful information transmission between the transmitting end and the receiving end.

[0049] The generation unit **212** may acquire the failure cause information from the acquisition unit **211**, and may directly or indirectly transmit the generated spectrum sensing parameter information to the transmitting end to adjust the spectrum sensing parameter of the transmitting end.

[0050] With the electronic device **200** according to the embodiment of the present disclosure, the cause of failed information transmission between the transmitting end and the receiving end is acquired, and the spectrum sensing parameter of the transmitting end is adjusted only in a case where the cause of the failed information transmission is the non-link quality cause, thereby avoiding adjustment of the spectrum sensing parameter in a case where the cause of the failed information transmission is the link quality cause, and increasing the probability of successful information transmission between the transmitting end and the receiving end.

[0051] According to the embodiment of the present disclosure, the spectrum sensing parameter may include an energy detection threshold, a contention window size, a counter, and the like.

[0052] According to an embodiment of the present disclosure, if it is determined that the cause of the failed information transmission is the link quality cause, the generation unit **212** of the electronic device **200** may further generate control information to adjust a MCS (Modulation And Coding Set) and an open loop link adaption parameter of the transmitting end.

[0053] According to an embodiment of the present disclosure, the electronic device **200** may be a spectrum management server in a core network. The transmitting end may be an eNB or a UE, and the receiving end may be a UE or an eNB. The electronic device **200** may also be located in the eNB.

[0054] The electronic device **200** according to the embodiment of the present disclosure is described below in detail in the case of downlink transmission and uplink transmission.

[0055] Downlink Transmission

[0056] FIG. **3** is a schematic diagram showing signaling interactions in downlink transmission according to an embodiment of the present disclosure. As shown in FIG. **3**, the electronic device **200** may be a spectrum management server in a core network, the transmitting end is an eNB, and the receiving end is a UE. First, the eNB transmits downlink data to the UE. Next, failed transmission occurs on the UE side. On the UE side, a cause of the failed downlink information transmission is analyzed to determine whether the cause of the failed downlink information transmission is a link quality cause or a non-link quality cause. Next, the UE transmits feedback information such as the NACK message for indicating the failed information transmission to the eNB. In addition, the UE also transmits failure cause information indicating the cause of the failed information transmission to the eNB. Next, the eNB forwards the failure cause information to the spectrum management server. Next, the acquisition unit **211** in the spectrum management server acquires the failure cause information.

[0057] If it is determined that the failure cause is the non-link quality cause, the generation unit **212** in the spectrum management server generates spectrum sensing parameter information, which is transmitted to the eNB through the communication unit **220**. Next, the eNB adjusts a spectrum sensing parameter based on the received spectrum sensing parameter information.

[0058] According to the embodiment of the present disclosure, one bit of information may be used to indicate the failure cause information. For example, the link quality cause is indicated when a value of a certain bit is "1", and the non-link quality cause is indicated when the value of the certain bit is "0". In addition, the UE may transmit the failure cause information via a PUSCH (physical uplink shared channel) and/or a PUCCH (physical uplink control channel). For example, in a case where the UE is to transmit uplink data while transmitting the failure cause information, the UE may use the PUSCH to carry the uplink data, the NACK and the failure cause. In addition, in a case where the UE is not to transmit uplink data while transmitting the failure cause information, the UE may use the PUCCH to carry the uplink data, the NACK and the failure cause. Further, the UE may also use the PUSCH to carry the failure cause and use the PUCCH to carry the NACK to save the resource of the PUCCH.

[0059] According to an embodiment of the present disclosure, the non-link quality cause may include interference from a hidden node in the vicinity of the receiving end and interference from other operators or access mechanisms.

[0060] According to an embodiment of the present disclosure, the acquisition unit **211** of the electronic device **200** may further acquire hidden node information indicating

whether a hidden node exists. In a case where the hidden node information indicates that the hidden node exists, an energy detection threshold of the transmitting end may be reduced based on the spectrum sensing parameter information generated by the generation unit **212**, so that the hidden node is sensed by the transmitting end.

[0061] According to an embodiment of the present disclosure, the UE can determine not only whether the cause of the failed information transmission is the link quality cause or the non-link quality cause, but also whether the non-link quality cause is interference from a hidden node in the vicinity of the receiving end or from other operators or access mechanisms. The UE may detect whether the hidden node exists with methods known in the art, and then determine that the non-link quality cause is interference from which of the above two sources. For example, the UE may determine whether the hidden node exists by detecting a beacon of a Wifi communication system, or detecting a reference signal and a PLMN (Public Land Mobile Network) identifier from other operators. Of course, the UE may also detect whether the hidden node exists with other methods, which is not limited in the present disclosure.

[0062] According to an embodiment of the present disclosure, if the UE determines that the cause of the failed information transmission is the non-link quality cause, the UE may actively continue to determine whether the non-link quality cause is the interference from which of the two sources. Next, the UE may also transmit information indicating whether the hidden node exists in the vicinity of the UE to the eNB. In this case, two bits of information may be used to indicate the failure cause information. For example, the link quality cause is indicated if the values of certain two bits are "10", it is indicated if the values of the two bits are "00" that the hidden node exists in the vicinity of the UE, and it is indicated if the values of the two bits are "01" that no hidden node exists in the vicinity of the UE and the failure cause is interference from other operators or access mechanisms, and other causes are indicated if the values of the two bits are "11".

[0063] According to another embodiment of the present disclosure, in the downlink data transmission, if the UE determines that the cause of the failed information transmission is the non-link quality cause, the UE may only report to the eNB that the failure cause is the non-link quality cause, and wait for a further instruction from the eNB. In this case, the processing circuit **210** may transmit a command to the eNB through the communication unit **220** to instruct the UE to sense whether the hidden node exists in the vicinity of the UE after the spectrum management server receives the failure cause indicating the non-link quality cause. Next, the eNB forwards the command to the UE. Next, the UE continues to determine that the non-link quality cause is the interference from which of the two sources upon receiving the command. If the UE determines that a hidden node exists in the vicinity of the

[0064] UE, the UE may transmit information indicating whether a hidden node exists in the vicinity of the UE to the eNB. In this case, one bit of information may be used to indicate whether a hidden node exists. For example, it is indicated that a hidden node exists if the value of the bit is "1"; and it is indicated that no hidden node exists if the value of the bit is "0".

[0065] According to an embodiment of the present disclosure, in a case where the failure cause indicates that the hidden node exists in the vicinity of the UE, the spectrum management server generates spectrum sensing parameter information for reducing an energy detection threshold of the eNB and transmits the reduced energy detection threshold to the eNB, so that the eNB can extend a range of energy detection and find the hidden node in the vicinity of the UE. After that, the eNB may also perform other operations. For example, the eNB may monitor the hidden node.

[0066] According to an embodiment of the present disclosure, in a case where the failure cause indicates that no hidden node exists in the vicinity of the UE, that is, the cause of the failed information transmission is interference from other operators or access mechanisms, the generation unit **212** of the processing circuit **210** generates spectrum sensing parameter information. The eNB increases a contention window size or a value of a counter based on the spectrum sensing parameter information.

[0067] According to an embodiment of the present disclosure, in a case where a contention window is configured on the eNB side, the spectrum management server may increase a contention window size of the eNB and transmit the increased contention window size to the eNB to reduce a probability that the eNB accesses to a certain frequency. In addition, in a case where a counter is configured on the eNB side, the spectrum management server may increase a value of the counter of the eNB and transmit the increased value of the counter to the eNB to reduce a probability that the eNB accesses to the certain frequency. The contention window size and the value of the counter herein indicate a waiting time period for the eNB to access to a certain frequency.

[0068] According to an embodiment of the present disclosure, the processing circuit **210** is further configured to generate a command to recover the spectrum sensing parameter of the transmitting end upon elapse of a preset time period in a case where a probability of successful information transmission between the transmitting end and the receiving end is increased.

[0069] After the spectrum sensing parameter of the eNB is adjusted, the eNB may continue data transmission with the UE. That is, for each successful information transmission, the UE feeds an ACK message indicating the successful information transmission back to the eNB. In addition, for each failed information transmission, the UE feeds a NACK message indicating the failed information transmission and a failure cause back to the eNB. The eNB may transmit the ACK/NACK message to the spectrum management server. Next, the spectrum management server may determine, based on the ACK/NACK message, whether a probability of successful information transmission between the eNB and the UE is increased. For example, during a preset time period, if a ratio of the number of the ACKs to a sum of the number of the ACKs and the number of the NACKs is greater than a preset threshold, the spectrum management server determines that the probability of the successful information transmission between the eNB and the UE is increased. In this case, the generation unit **220** of the processing circuit **210** may generate spectrum sensing parameter information to recover the spectrum sensing parameter of the eNB. For example, the energy detection threshold of the eNB may be increased, or the contention window size or the value of the counter of the eNB may be reduced.

[0070] According to another embodiment of the present disclosure, the processing circuit **210** is further configured to generate a command to recover the spectrum sensing parameter of the transmitting end upon elapse of a preset time period. In this case, the spectrum management server generates spectrum sensing parameter information upon elapse of a preset time period regardless of whether the probability of the successful information transmission between the eNB and the UE is increased, in order to recover the spectrum sensing parameter of the eNB.

[0071] According to an embodiment of the present disclosure, the processing circuit **210** is further configured to: acquire multiple NACK messages and multiple pieces of failure cause information during a preset time period; and determine the cause of the failed information transmission is the non-link quality cause based on a ratio of the number of pieces of failure cause information indicating that the cause of the failed information transmission is the non-link quality cause to the number of the NACK messages.

[0072] In this embodiment, data transmission may be performed between the eNB and the UE for multiple times. For each failed information transmission, the UE feeds one NACK message and one piece of failure cause information back to the eNB. That is, each NACK message corresponds to one cause. On the electronic device **200** side (for example, the analysis unit, which is not shown), the total number of NACK messages and the number of NACK messages indicating that the failure cause is the non-link quality cause during a time period may be counted, and a ratio of the number of the NACK messages indicating the non-link quality cause to the total number of the NACK messages may be calculated. Next, the electronic device **200** (for example, the analysis unit, which is not shown) determines whether the cause of the failed information transmission is the non-link quality cause based on the calculated ratio. For example, in a case where the ratio of the number of the NACK messages indicating the non-link quality cause to the total number of the NACK messages is greater than a first threshold, it is determined that the cause of the failed information transmission is the non-link quality cause. In addition, in a case where the ratio of the number of the NACK messages indicating the non-link quality cause to the total number of the NACK messages is less than or equal to the first threshold, it is determined that the cause of the failed information transmission is the link quality cause.

[0073] According to another embodiment of the present disclosure, the processing circuit **210** is further configured to: acquire multiple NACK messages and multiple pieces of the failure cause information as well as multiple ACK messages indicating successful information transmission between the transmitting end and the receiving end during a preset time period; and determine whether the cause of the failed information transmission is the non-link quality cause based on a ratio of the number of pieces of failure cause information indicating that the cause of the failed information transmission is the non-link quality cause to a sum of the number of the NACK messages and the number of the ACK messages.

[0074] In this embodiment, on the electronic device **200** side (for example, the analysis unit, which is not shown), the total number of the ACK messages, the total number of the NACK messages, and the number of the NACK messages indicating that the failure cause is the non-link quality cause during a time period may be counted, and a ratio of the number of the NACK messages indicating the non-link quality cause to a sum of the number of the NACK messages and the number of the ACK messages may be calculated. Next, the electronic device **200** (for example, the analysis unit, which is not shown) determines whether the cause of the failed information transmission is the non-link quality cause based on the calculated ratio. For example, in a case where the ratio of the number of the NACK messages indicating the non-link quality cause to the sum of the number of the NACK messages and the number of the ACK messages is greater than a second threshold, it is determined that the cause of the failed information transmission is the non-link quality cause. In addition, in a case where the ratio of the number of the NACK messages indicating the non-link quality cause to the sum of the number of the NACK messages and the number of the ACK messages is less than or equal to the second threshold, it is determined that the cause of the failed information transmission is the link quality cause.

[0075] According to an embodiment of the present disclosure, the electronic device **200** may determine, based on a ratio regarding the failure cause during a preset time period, that the failure cause is indeed the non-link quality cause, thereby avoiding inaccurate analysis of the cause on the UE side, so that analysis for the failure cause is accurate.

[0076] According to the above description, in the downlink transmission between the eNB and the UE, in a case where the cause of failed transmission is the non-link quality cause, the UE side can determine whether the non-link quality cause is interference from a hidden node in the vicinity of the UE or from other operators or access mechanisms. According to another embodiment of the present disclosure, in a case where the cause of the failed transmission is the non-link quality cause, the network side, i.e., the electronic device **200** side can also determine whether the cause of the failed information transmission is interference from which of the above two sources.

[0077] According to an embodiment of the present disclosure, the processing circuit **210** is further configured to: determine whether a hidden node exists based on a ratio of the number of pieces of the failure cause information indicating the non-link quality cause to a number of the NACK messages, or a ratio of the number of pieces of the failure cause information indicating the non-link quality cause to the sum of the number of the NACK messages and the number of the ACK messages. The transmitting end reduces an energy detection threshold based on the spectrum sensing parameter information in a case where the hidden node exists, so that the hidden node is sensed by the transmitting end. The transmitting end increases a contention window size or a value of a counter based on the spectrum sensing parameter information in a case where no hidden node exists.

[0078] According to an embodiment of the present disclosure, as described above, on the electronic device **200** side (for example, the analysis unit, which is not shown), the total number of the NACK messages and the number of NACK messages indicating that the failure cause is the non-link quality cause during a time period are counted, and a ratio of the number of NACK messages indicating the non-link quality cause to the total number of the NACK messages is calculated. Next, the electronic device **200** (for example, the analysis unit, which is not shown) determines whether the cause of the failed information transmission is a hidden node

in the vicinity of the UE based on the calculated ratio. For example, in a case where the ratio of the number of the NACK messages indicating the non-link quality cause to the total number of the NACK messages is greater than a third threshold, it is determined that the cause of the failed information transmission is the hidden node in the vicinity of the UE. In addition, in a case where the ratio of the number of the NACK messages indicating the non-link quality cause to the total number of the NACK messages is greater than the first threshold and less than or equal to the third threshold, it is determined that the cause of the failed information transmission is interference from other operators or access mechanisms to the UE.

[0079] According to another embodiment of the present disclosure, as described above, on the electronic device **200** side (for example, the analysis unit, which not shown), the total number of the ACK messages, the total number of the NACK messages, and the number of NACK messages indicating that the failure cause is the non-link quality cause during a time period may be counted, and a ratio of the number of the NACK messages indicating the non-link quality cause to a sum of the number of the NACK messages and the number of the ACK messages may be calculated. Next, the electronic device **200** (for example, the analysis unit, which is not shown) determines whether the cause of the failed information transmission is the hidden node in the vicinity of the UE based on the calculated ratio. For example, in a case where the ratio of the number of the NACK messages indicating the non-link quality cause to the sum of the number of the NACK messages and the number of the ACK messages is greater than a fourth threshold, it is determined that the cause of the failed information transmission is the hidden node in the vicinity of the UE. In addition, in a case where the ratio of the number of the NACK messages indicating the non-link quality cause to the sum of the number of the NACK messages and the number of the ACK messages is greater than the second threshold and is less than or equal to the fourth threshold, it is determined that the cause of the failed information transmission is interference from other operators or access mechanisms to the UE.

[0080] In the present disclosure, multiple thresholds are set and exemplarily represented as a first threshold, a second threshold, a third threshold, a fourth threshold and the like. However, the "first", "second", "third "and" fourth" are only for identification rather than actual limitation, and may be set by a system designer according to actual needs. The first threshold and the third threshold are set for the ratio of the number of the NACK messages indicating the non-link quality cause to the total number of the NACK messages, where the first threshold is used to make a determination between the link quality cause and the non-link quality cause, and the third threshold is used to determine whether the hidden node exists. In addition, the second threshold and the fourth threshold are set for a ratio of the number of the NACK messages indicating the non-link quality cause to the sum of the total number of the NACK messages and the total number of the ACK messages, where the second threshold is used to make a determination between the link quality cause and the non-link quality cause, and the fourth threshold is used to determine whether the hidden node exists.

[0081] Further, in a case where the electronic device side **200** determines that the cause of the failed information transmission is the hidden node in the vicinity of the UE or interference from other operators or access mechanisms to the UE, operations performed on the electronic device **200** side are similar to operations performed on the UE side in a case where the cause is determined on the UE side. That is, in a case where the hidden node exists, the eNB reduces the energy detection threshold based on the spectrum sensing parameter information so that the hidden node is sensed by the eNB. In addition, in a case where no hidden node exists, the eNB increases the contention window size or the value of the counter based on the spectrum sensing parameter information.

[0082] Uplink Transmission

[0083] FIG. **4** is a schematic diagram showing signaling interactions in uplink transmission according to an embodiment of the present disclosure. As shown in FIG. **4**, the electronic device **200** may be a spectrum management server in a core network, the transmitting end is a UE, and the receiving end is an eNB. First, the UE transmits uplink data to the eNB. Next, failed transmission occurs on the eNB side. On the eNB side, a cause of the failed uplink information transmission is analyzed to determine whether the cause of the failed uplink information transmission is the link quality cause or the non-link quality cause. Next, the eNB transmits failure cause information indicating the cause of the failed information transmission to the spectrum management server. Next, the acquisition unit **211** in the spectrum management server acquires the failure cause. If it is determined that the failure cause is the non-link quality cause, the generation unit **212** in the spectrum management server generates spectrum sensing parameter information and transmits the spectrum sensing parameter information to the eNB through the communication unit **220**. Next, the eNB transmits the received spectrum sensing parameter information to the UE. Then, the UE adjusts a spectrum sensing parameter based on the received spectrum sensing parameter information.

[0084] According to an embodiment of the present disclosure, one bit of information may be used to indicate the failure cause information. For example, the link quality cause is indicated when a value of a certain bit is "1", and the non-link quality cause is indicated when the value of the certain bit is "0".

[0085] According to an embodiment of the present disclosure, the non-link quality cause may include interference from a hidden node in the vicinity of the receiving end and interference from other operators or access mechanisms.

[0086] According to an embodiment of the present disclosure, the acquisition unit **211** of the electronic device **200** may further acquire hidden node information indicating whether a hidden node exists. In a case where the hidden node information indicates that the hidden node exists, an energy detection threshold of the transmitting end may be reduced based on the spectrum sensing parameter information generated by the generation unit **212**, so that the hidden node is sensed by the transmitting end.

[0087] According to an embodiment of the present disclosure, the eNB may determine not only whether the cause of the failed information transmission is the link quality cause or the non-link quality cause, but also whether the non-link quality cause is interference from a hidden node in the vicinity of the receiving end or interference from other operators or access mechanisms. The eNB may determine that the non-link quality cause is interference from which of

above two sources by means of methods known in the art, such as an energy sensing method.

[0088] According to an embodiment of the present disclosure, if the eNB determines that the cause of the failed information transmission is the non-link quality cause, the eNB may actively continue to determine that the non-link quality cause is the interference from which of the two sources. Next, the eNB may also transmit information indicating whether the hidden node exists in the vicinity of the eNB to the spectrum management server. In this case, two bits of information may be used to indicate the failure cause information. For example, the link quality cause is indicated if the values of certain two bits are "10", it is indicated if the values of the two bits are "00" that the hidden node exists in the vicinity of the eNE, and it is indicated if the values of the two bits are "01" that no hidden node exists in the vicinity of the eNB and the failure cause is interference from other operators or access mechanisms, and other cause is indicated if the values of the two bits are "11".

[0089] According to another embodiment of the present disclosure, if the eNB determines that the cause of the failed information transmission is the non-link quality cause, the eNB may only report to the spectrum management server that the failure cause is the non-link quality cause, and wait for a further instruction from the spectrum management server. In this case, the processing circuit **210** may transmit a command to the eNB through the communication unit **220** to instruct the eNB to sense whether the hidden node exists in the vicinity of the eNB after the spectrum management server receives the failure cause indicating the non-link quality cause. Next, the eNB continues to determine that the non-link quality cause is the interference from which of the two sources upon receiving the command. If the eNB determines that the hidden node exists in the vicinity of the eNB, the eNB may transmit information indicating whether the hidden node exists in the vicinity of the eNB to the spectrum management server. In this case, one bit of information may be used to indicate whether the hidden node exists. For example, it is indicated that the hidden node exists if the value of the bit is "1"; and it is indicated that no hidden node exists if the value of the bit is "0".

[0090] According to an embodiment of the present disclosure, in a case where the failure cause indicates that the hidden node exists in the vicinity of the eNB, the spectrum management server generates spectrum sensing parameter information for reducing an energy detection threshold of the UE and transmits the reduced energy detection threshold to the eNB. The eNB then forwards the reduced energy detection threshold to the UE. Next, the UE performs adjustment to extend a range of energy detection, such that the hidden node in the vicinity of the eNB can be found.

[0091] According to an embodiment of the present disclosure, in a case where the failure cause indicates that no hidden node exists in the vicinity of the eNB, that is, the cause of the failed information transmission is interference from other operators or access mechanisms, the generation unit **212** of the processing circuit **210** generates spectrum sensing parameter information. A contention window size or a value of a counter of UE is increased based on the spectrum sensing parameter information.

[0092] According to an embodiment of the present disclosure, in a case where a contention window is configured on the UE side, the spectrum management server may increase a contention window size of the UE and transmit the increased contention window size to the eNB. The eNB then forwards the increased contention window size to the UE to reduce a probability that the UE accesses to a certain frequency. In addition, in a case where a counter is configured on the UE side, the spectrum management server may increase a value of the counter of the UE and transmit the increased value of the counter to the eNB. The eNB then forwards the increased value of the counter to the UE to reduce a probability that the UE accesses to the certain frequency. The contention window size and the value of the counter herein indicate a waiting time period for the UE to access into a certain frequency.

[0093] According to the embodiment of the present disclosure, the processing circuit **210** is further configured to generate a command to recover the spectrum sensing parameter of the transmitting end upon elapse of a preset time period in a case where a probability of successful information transmission between the transmitting end and the receiving end is increased.

[0094] After the spectrum sensing parameter of the UE is adjusted, the UE may continue data transmission with the eNB. That is, for each successful uplink information transmission, the eNB generates an ACK message. In addition, for each failed uplink information transmission, the eNB generates a NACK message and analyzes a cause of the failed transmission. The eNB may then transmit the ACK/NACK messages and the failure causes to the spectrum management server. Next, the spectrum management server may determine, based on the ACK/NACK messages, whether a probability of successful information transmission between the UE and the eNB is increased. For example, during a preset time period, if a ratio of the number of the ACK messages to a sum of the number of the ACK messages and the number of the NACK messages is greater than a preset threshold, the spectrum management server determines that the probability of the successful information transmission between the UE and the eNB is increased. In this case, the generation unit **212** of the processing circuit **210** may generate spectrum sensing parameter information to recover the spectrum sensing parameter of the UE. For example, the energy detection threshold of the

[0095] UE may be increased, or the contention window size or the value of the counter of the UE may be reduced.

[0096] According to another embodiment of the present disclosure, the processing circuit **210** is further configured to generate a command to recover the spectrum sensing parameter of the transmitting end upon elapse of a preset time period. In this case, the spectrum management server generates spectrum sensing parameter information for recovering the spectrum sensing parameter of the UE upon elapse of a preset time period regardless of whether the probability of the successful information transmission between the UE and the eNB is increased.

[0097] According to an embodiment of the present disclosure, the processing circuit **210** is further configured to: acquire multiple NACK messages and multiple pieces of failure cause information during a preset time period; and determine whether the cause of failed information transmission is the non-link quality cause based on a ratio of the number of pieces of failure cause information indicating that the cause of the failed information transmission is the non-link quality cause to the number of the NACK messages.

[0098] In this embodiment, data transmission may be performed between the UE and the eNB for multiple times. For each failed information transmission, the eNB not only feeds the NACK message back to the UE, but also feeds the NACK message and the failure cause information back to the spectrum management server. In addition, for each successful information transmission, the eNB not only feeds the ACK message back to the UE, but also feeds the ACK message back to the spectrum management server. On the electronic device **200** side (for example, the analysis unit, which is not shown), the total number of the NACK messages and the number of the NACK messages indicating that the failure cause is the non-link quality cause during a time period may be counted, and a ratio of the number of the NACK messages indicating the non-link quality cause to the total number of the NACK messages may be calculated. Next, the electronic device **200** (for example, the analysis unit, which is not shown) determines whether the cause of the failed information transmission is the non-link quality cause based on the calculated ratio. For example, in a case where the ratio of the number of the NACK messages indicating the non-link quality cause to the total number of the NACK messages is greater than a first threshold, it is determined that the cause of the failed information transmission is the non-link quality cause. In addition, in a case where the ratio of the number of the NACK messages indicating the non-link quality cause to the total number of the NACK messages is less than or equal to the first threshold, it is determined that the cause of the failed information transmission is the link quality cause.

[0099] According to another embodiment of the present disclosure, the processing circuit **210** is further configured to: acquire multiple NACK messages and multiple pieces of the failure cause information as well as multiple ACK messages indicating successful information transmission between the transmitting end and the receiving end during a preset time period; and determine whether the cause of the failed information transmission is the non-link quality cause based on a ratio of the number of pieces of failure cause information indicating that the cause of the failed information transmission is the non-link quality cause to a sum of the number of the NACK messages and the number of the ACK messages.

[0100] In this embodiment, on the electronic device **200** side (for example, the analysis unit, which is not shown), the total number of the ACK messages, the total number of the NACK messages, and the number of NACK messages indicating that the failure cause is the non-link quality cause during a time period may be counted, and a ratio of the number of the NACK messages indicating the non-link quality cause to a sum of the total number of the NACK messages and the total number of the ACK messages may be calculated. Next, the electronic device **200** (for example, the analysis unit, which is not shown) determines whether the cause of the failed information transmission is the non-link quality cause based on the calculated ratio. For example, in a case where the ratio of the number of the NACK messages indicating the non-link quality cause to the sum of the total number of the NACK messages and the total number of the ACK messages is greater than a second threshold, it is determined that the cause of the failed information transmission is the non-link quality cause. In addition, in a case where the ratio of the number of the NACK messages indicating the non-link quality cause to the sum of the total number of the NACK messages and the total number of the ACK messages is less than or equal to the second threshold, it is determined that the cause of the failed information transmission is the link quality cause.

[0101] According to an embodiment of the present disclosure, the electronic device **200** may determine, based on a ratio regarding the failure cause during a preset time period, that the failure cause is indeed the non-link quality cause, thereby avoiding inaccurate analysis of the cause on the eNB side, so that analysis for the failure cause is accurate.

[0102] According to the above description, in the downlink transmission between the eNB and the UE, in a case where the cause of failed transmission is the non-link quality cause, the eNB side can determine whether the non-link quality cause is interference from a hidden node in the vicinity of the eNB or from other operators or access mechanisms. According to another embodiment of the present disclosure, in a case where the cause of the failed transmission is the non-link quality cause, the network side, i.e., the electronic device **200** side can also determine whether the cause of the failed information transmission is interference from which of the above two sources.

[0103] According to an embodiment of the present disclosure, the processing circuit **210** is further configured to: determine whether a hidden node exists based on a ratio of the number of pieces of the failure cause information indicating the non-link quality cause to a sum of the number of the NACK messages, or a ratio of the number of the NACK messages indicating the non-link quality cause to the sum of the number of the NACK messages and the number of the ACK messages. The transmitting end reduces an energy detection threshold based on the spectrum sensing parameter information in a case where the hidden node exists, so that the hidden node is sensed by the transmitting end. The transmitting end increases a contention window size or a value of a counter based on the spectrum sensing parameter information in a case where no hidden node exists.

[0104] According to an embodiment of the present disclosure, as described above, on the electronic device **200** side (for example, the analysis unit, which is not shown), the total number of the NACK messages and the number of NACK messages indicating that the failure cause is the non-link quality cause during a time period are counted, and a ratio of the number of the NACK messages indicating the non-link quality cause to the total number of the NACK messages is calculated. Next, the electronic device **200** (for example, the analysis unit, which is not shown) determines whether the cause of the failed information transmission is a hidden node in the vicinity of the eNB based on the calculated ratio. For example, in a case where the ratio of the number of the NACK messages indicating the non-link quality cause to the total number of the NACK messages is greater than a third threshold, it is determined that the cause of the failed information transmission is the hidden node in the vicinity of the eNB. In addition, in a case where the ratio of the number of the NACK messages indicating the non-link quality cause to the total number of the NACK messages is greater than the first threshold and less than or equal to the third threshold, it is determined that the cause of the failed information transmission is interference from other operators or access mechanisms to the eNB.

[0105] According to another embodiment of the present disclosure, as described above, on the electronic device **200**

side (for example, the analysis unit, which not shown), the total number of the ACK messages, the total number of the NACK messages, and the number of the NACK messages indicating that the failure cause is the non-link quality cause during a time period may be counted, and a ratio of the number of the NACK messages indicating the non-link quality cause to a sum of the total number of the NACK messages and the total number of the ACK messages may be calculated. Next, the electronic device **200** (for example, the analysis unit, which is not shown) determines whether the cause of the failed information transmission is the hidden node in the vicinity of the eNB based on the calculated ratio. For example, in a case where the ratio of the number of the NACK messages indicating the non-link quality cause to the sum of the total number of the NACK messages and the total number of the ACK messages is greater than a fourth threshold, it is determined that the cause of the failed information transmission is the hidden node in the vicinity of the eNB. In addition, in a case where the ratio of the number of the NACK messages indicating the non-link quality cause to the sum of the total number of the NACK messages and the total number of the ACK messages is greater than the second threshold and is less than or equal to the fourth threshold, it is determined that the cause of the failed information transmission is interference from other operators or access mechanisms to the eNB.

[0106] Further, in a case where the electronic device side **200** determines that the cause of the failed information transmission is the hidden node in the vicinity of the eNB or interference from other operators or access mechanisms to the eNB, operations performed on the electronic device **200** side are similar to operations performed on the eNB side in a case where the cause is determined on the eNB side. That is, in a case where the hidden node exists, the UE reduces the energy detection threshold based on the spectrum sensing parameter information so that the hidden node is sensed by the UE. In addition, in a case where no hidden node exists, the UE increases the contention window size or the value of the counter based on the spectrum sensing parameter information.

[0107] As described above, with the electronic device **200** according to the present disclosure, whether the cause of failed information transmission between the transmitting end and the receiving end is the link quality cause or the non-link quality cause may be determined. In addition, whether the non-link quality cause is the hidden node in the vicinity of the receiving end or interference from other operators or access mechanisms may further be determined by the electronic device **200**, and operations may be performed based on the cause of the failed information transmission, thereby greatly increasing the probability of successful information transmission between the transmitting end and the receiving end. Further, adjustment of the spectrum sensing parameter in a case where the cause of the failed information transmission is the link quality cause can be avoided.

[0108] FIG. **5** is a block diagram showing a structure of an electronic device in a wireless communication system according to another embodiment of the present disclosure.

[0109] As shown in FIG. **5**, an electronic device **500** may include a processing circuit **510**. It should be noted that the electronic device **500** may include one processing circuit **510** or multiple processing circuits **510**. In addition, the electronic device **500** may further include a communication unit **520** such as a transceiver.

[0110] Similarly, the processing circuit **510** may also include various discrete functional units to perform various different functions and/or operations as mentioned above. The functional units may be physical entities or logical entities, and units referred to by different names may be implemented as a same physical entity.

[0111] For example, as shown in FIG. **5**, the processing circuit **510** may include an acquisition unit **511** and an acquisition unit **512**.

[0112] The acquisition unit **511** may acquire a NACK message indicating failed information transmission between a transmitting end and a receiving end in the wireless communication system and failure cause information indicating a cause of the failed information transmission, to inform a spectrum management server in the wireless communication system, wherein the cause of the failed information transmission includes a link quality cause and a non-link quality cause.

[0113] The acquisition unit **512** may acquire spectrum sensing parameter information from the spectrum management server to adjust a spectrum sensing parameter of the transmitting end, so as to increase a probability of successful information transmission between the transmitting end and the receiving end.

[0114] Preferably, the processing circuit **510** may be further configured to, before acquiring the spectrum sensing parameter information from the spectrum management server, acquire hidden node information indicating whether a hidden node exists, to inform the spectrum management server.

[0115] Preferably, the electronic device **500** may be located on a side of the transmitting end, and the processing circuit **510** may acquire the NACK message, the failure cause information and the hidden node information from the receiving end.

[0116] Preferably, the processing circuit **510** may be further configured to perform, based on the spectrum sensing parameter information, at least one of: reducing an energy detection threshold of the transmitting end so that the hidden node is sensed by the transmitting end; and increasing a contention window size or a value of a counter of the transmitting end.

[0117] Preferably, the electronic device **500** may be a base station in the wireless communication system.

[0118] Preferably, the electronic device **500** may be located on a side of the receiving end, and for acquiring the NACK message and the failure cause information, the processing circuit **510** may be further configured to: generate the NACK message when the failed information transmission occurs; detect a value of a reference signal received power RSRP of a communication link between the receiving end and the transmitting end; detect an interference value of an interference signal from a neighbor cell; and generate the failure cause information based on the value of the RSRP and the interference value.

[0119] According to an embodiment of the present disclosure, the electronic device **500** being located on the side of the receiving end indicates that the UE performs uplink data transmission with the eNB. The eNB may determine whether the cause of the failed information transmission is the link quality cause or the non-link quality cause, as mentioned above. In this embodiment, the eNB may detect

the value of the RSRP between the receiving end and the transmitting end and the interference value of the interference signal from the neighbor cell. Next, the eNB generates the failure cause information based on the value of the RSRP and the interference value.

[0120] In this embodiment, the eNB may detect a value of a physical layer RSRP and a value of a network layer RSRP during a process of detecting the value of the RSRP between the receiving end and the transmitting end. Great values of the physical layer RSRP and the network layer RSRP indicate that the quality of the link between the eNB and the UE is good, while small values of the physical layer RSRP and the network layer RSRP indicate that the quality of the link between the eNB and the UE is poor.

[0121] In this embodiment, the eNB may also detect the interference value of the interference signal from the neighbor cell and determine whether the neighbor cell and the eNB belong to a same operator, for example, by detecting a PLMN identifier of the neighbor cell. If the neighbor cell and the eNB belong to a same operator and the interference value of the interference signal from the neighbor cell is small, it is indicated that the interference from the same operator to the eNB is weak. In addition, if the neighbor cell and the eNB belong to a same operator and the interference value of the interfering signal from the neighbor cell is great, it is indicated that the interference from the same operator to the eNB is strong. The eNB may detect the interference signal from the neighbor cell and detect the value of the RSRP between the receiving end and the transmitting end with a technology known in the art.

[0122] According to the embodiment of the present disclosure, for generating the failure cause information based on the value of the RSRP and the interference value, the processing circuit **510** is further configured to: generate failure cause information indicating that the cause of the failed information transmission is the non-link quality cause in a case where the value of the RSRP is greater than a first threshold and the interference value is less than a second threshold; and generate failure cause information indicating that the cause of the failed information transmission is the link quality cause in a case where the value of the RSRP is less than or equal to the first threshold and/or the interference value is greater than or equal to the second threshold.

[0123] In this embodiment, if the value of the RSRP is greater than the first threshold and the interference value is less than the second threshold, it is indicated that the quality of the link between the eNB and the UE is good and the interference from the same operator is weak. In this case, if failed information transmission occurs on the eNB side, the failure cause is the non-link quality cause. In addition, if the value of the RSRP is less than or equal to the first threshold and/or the interference value is greater than or equal to the second threshold, it is indicated that the quality of the link between the eNB and the UE is poor or the interference from the same operator to the eNB is strong. In this case, the failure cause is the link quality cause.

[0124] Preferably, for acquiring the hidden node information, the processing circuit **510** may be further configured to: sense whether a hidden node exists in the vicinity of the receiving end; and generate the hidden node information based on a sensed result.

[0125] Next, a user equipment in the wireless communication system is described in detail. FIG. **6** shows a structure of a user equipment **600** in a wireless communication system according to an embodiment of the present disclosure. The user equipment **600** operates as a receiving end, that is, an eNB performs downlink data transmission with the user equipment **600**.

[0126] As shown in FIG. **6**, the user equipment **600** may include a processing circuit **610**. It should be noted that the user equipment **600** may include one processing circuit **610** or multiple processing circuits **610**. In addition, the user equipment **600** may further include a communication unit **620** such as a transceiver.

[0127] Similarly, the processing circuit **610** may also include various discrete functional units to perform various different functions and/or operations as mentioned above. The functional units may be physical entities or logical entities, and units referred to by different names may be implemented as a same physical entity.

[0128] For example, as shown in FIG. **6**, the processing circuit **610** may include a generation unit **611**.

[0129] The generation unit **611** may generate a NACK message indicating failed information transmission between a base station as a transmitting end and the user equipment **600** in the wireless communication system and failure cause information indicating a cause of the failed information transmission. The cause of the failed information transmission may include a link quality cause and a non-link quality cause.

[0130] The communication unit **620** may transmit the NACK message and the failure cause information to the base station, to inform a spectrum management server in the wireless communication system.

[0131] Preferably, the processing circuit **610** may be further configured to, if it is determined that the cause of the failed information transmission is the non-link quality cause, sense whether a hidden node exists in the vicinity of the user equipment **600**; generate, based on a sensed result, hidden node information indicating whether the hidden node exists; and control the communication unit **620** to transmit the hidden node information to the base station, to inform the spectrum management server.

[0132] Preferably, for generating the NACK message and the failure cause information, the processing circuit **610** may further be configured to: generate the NACK message when the failed information transmission occurs; detect a value of a reference signal received power RSRP of a communication link between the base station and the user equipment **600**; detect an interference value of an interference signal from a neighbor cell; and generate the failure cause information based on the value of the RSRP and the interference value.

[0133] As mentioned above, the UE may determine whether the cause of the failed information transmission is the link quality cause or the non-link quality cause. In this embodiment, the UE may detect the value of the RSRP between the receiving end and the transmitting end and detect the interference value of the interference signal from the neighbor cell. Next, the UE may generate the failure cause information based on the value of the RSRP and the interference value.

[0134] In this embodiment, the UE may detect a value of a physical layer RSRP and a value of a network layer RSRP during a process of detecting the value of the RSRP between the receiving end and the transmitting end. Great values of the physical layer RSRP and the network layer RSRP indicate that the quality of the link between the eNB and the UE is good, while small values of the physical layer RSRP

and the network layer RSRP indicate that the quality of the link between the eNB and the UE is poor.

[0135] In this embodiment, the UE may also detect the interference value of the interference signal from the neighbor cell and determine whether the neighbor cell and the UE belong to a same operator, for example, by detecting a PLMN (Public Land Mobile Network) identifier of the neighbor cell. If the neighbor cell and the UE belong to a same operator and the interference value of the interference signal from the neighbor cell is small, it is indicated that the interference from the same operator to the UE is weak. In addition, if the neighbor cell and the UE belong to a same operator and the interference value of the interfering signal from the neighbor cell is great, it is indicated that the interference from the same operator to the UE is strong. The UE may detect the interference signal from the neighbor cell and detect the value of the RSRP between the receiving end and the transmitting end with a technology known in the art.

[0136] Preferably, for generating the failure cause information based on the value of the RSRP and the interference value, the processing circuit **610** is further configured to: generate failure cause information indicating that the cause of the failed information transmission is the non-link quality cause in a case where the value of the RSRP is greater than a first threshold and the interference value is less than a second threshold; and generate failure cause information indicating that the cause of the failed information transmission is the link quality cause in a case where the value of the RSRP is less than or equal to the first threshold and/or the interference value is greater than or equal to the second threshold.

[0137] In this embodiment, if the value of the RSRP is greater than the first threshold and the interference value is less than the second threshold, it is indicated that the quality of the link between the eNB and the UE is good and the interference from the same operator is weak. In this case, if failed information transmission occurs on the UE side, the failure cause is the non-link quality cause. In addition, if the value of the RSRP is less than or equal to the first threshold and/or the interference value is greater than or equal to the second threshold, it is indicated that the quality of the link between the eNB and the UE is poor or the interference from the same operator to the UE is strong. In this case, the cause of the failed information transmission is the link quality cause.

[0138] FIG. **7** is a flowchart of a method for performing wireless communication according to an embodiment of the present disclosure. As shown in FIG. **7**, in step S**710**, a NACK message indicating failed information transmission between a transmitting end and a receiving end in a wireless communication system and failure cause information indicating a cause of the failed information transmission are acquired. The cause of the failed information transmission includes a link quality cause and a non-link quality cause.

[0139] Next, in step S**720**, if it is determined that the cause of the failed information transmission is the non-link quality cause, spectrum sensing parameter information is generated to adjust a spectrum sensing parameter of the transmitting end, so as to increase a probability of successful information transmission between the transmitting end and the receiving end.

[0140] Preferably, the generating the spectrum sensing parameter information may include: acquiring hidden node information indicating whether a hidden node exists, and enabling the spectrum sensing parameter information to be used for reducing an energy detection threshold of the transmitting end in a case where the hidden node information indicates that a hidden node exists, such that the hidden node is sensed by the transmitting end.

[0141] Preferably, before acquiring the hidden node information, the method may further include: generating a command to instruct the receiving end to sense whether a hidden node exists in the vicinity of the receiving end.

[0142] Preferably, in a case where the hidden node information indicates that no hidden node exists, the method may further include: enabling the spectrum sensing parameter information to be used for increasing a contention window size or a value of a counter of the transmitting end.

[0143] Preferably, the method may further include: generating a command to recover the spectrum sensing parameter of the transmitting end upon elapse of a preset time period in a case where the probability of successful information transmission between the transmitting end and the receiving end is increased.

[0144] Preferably, the determining whether the cause of the failed information transmission is a non-link quality cause may include: acquiring multiple NACK messages and multiple pieces of failure cause information during a preset time period; and determining whether the cause of the failed information transmission is the non-link quality cause based on a ratio of the number of pieces of failure cause information indicating that the cause of the failed information transmission is the non-link quality cause to the number of the NACK messages.

[0145] Preferably, the determining whether the cause of the failed information transmission is the non-link quality cause may include: acquiring multiple NACK messages and multiple pieces of failure cause information as well as multiple ACK messages indicating successful information transmission between the transmitting end and the receiving end during a preset time period; and determining whether the cause of the failed information transmission is the non-link quality cause based on a ratio of the number of pieces of failure cause information indicating that the cause of the failed information transmission is the non-link quality cause to a sum of the number of the NACK messages and the number of the ACK messages.

[0146] Preferably, if it is determined the cause of the failed information transmission is the non-link quality cause, the method may further include: determining whether a hidden node exists based on a ratio of the number of pieces of failure cause information indicating that the cause of the failed information transmission is the non-link quality cause to the number of the NACK messages or a ratio of the number of pieces of failure cause information indicating that the cause of the failed information transmission is the non-link quality cause to a sum of the number of the NACK messages and the number of the ACK messages; enabling the spectrum sensing parameter information to be used for reducing an energy detection threshold of the transmitting end if the hidden node exists, such that the hidden node is sensed by the transmitting end; and enabling the spectrum sensing parameter information to be used for increasing a contention window size or a value of a counter of the transmitting end if a hidden node does not exist.

[0147] Preferably, the method may be performed by a spectrum management server in a core network.

[0148] FIG. **8** is a flowchart of a method for performing wireless communication according to another embodiment of the present disclosure. As shown in FIG. **8**, in step

[0149] S**810**, a NACK message indicating failed information transmission between a transmitting end and a receiving end in a wireless communication system and failure cause information indicating a cause of the failed information transmission are acquired to inform a spectrum management server in the wireless communication system. The cause of the failed information transmission includes a link quality cause and a non-link quality cause.

[0150] In step S**820**, spectrum sensing parameter information is acquired from the spectrum management server to adjust a spectrum sensing parameter of the transmitting end, so as to increase a probability of successful information transmission between the transmitting end and the receiving end.

[0151] Preferably, before acquiring the spectrum sensing parameter information from the spectrum management server, the method may further include: acquiring hidden node information indicating whether a hidden node exists, to inform the spectrum management server.

[0152] Preferably, downlink data transmission is performed in the wireless communication system, and the method may further include acquiring the NACK message, the failure cause information and the hidden node information from the receiving end.

[0153] Preferably, the method may further include performing, based on the spectrum sensing parameter information, at least one of: reducing an energy detection threshold of the transmitting end so that the hidden node is sensed by the transmitting end; and increasing a contention window size or a value of a counter of the transmitting end.

[0154] Preferably, uplink data transmission is performed in the wireless communication system, and the acquiring the NACK message and the failure cause information may include: generating the NACK message when failed information transmission occurs; detecting a value of a reference signal received power RSRP of a communication link between the receiving end and the transmitting end; detecting an interference value of an interference signal from a neighbor cell; and generating the failure cause information based on the value of the RSRP and the interference value.

[0155] Preferably, the generating the failure cause information based on the value of the RSRP and the interference value may include: generating failure cause information indicating that the cause of the failed information transmission is the non-link quality cause in a case where the value of the RSRP is greater than a first threshold and the interference value is less than a second threshold; and generating failure cause information indicating that the cause of the failed information transmission is the link quality cause in a case where the value of the RSRP is less than or equal to the first threshold and/or the interference value is greater than or equal to the second threshold.

[0156] Preferably, the acquiring the hidden node information may include: sensing whether a hidden node exists in the vicinity of the receiving end; and generating the hidden node information based on a sensed result.

[0157] Preferably, the method may be performed by a base station in the wireless communication system.

[0158] FIG. **9** is a flowchart of a method for performing wireless communication according to another embodiment of the present disclosure. As shown in FIG. **9**, in step S**910**, a NACK message indicating failed information transmission between a base station serving as a transmitting end and a user equipment serving as a receiving end in the wireless communication system and failure cause information indicating a cause of the failed information transmission are generated. The cause of the failed information transmission includes a link quality cause and a non-link quality cause.

[0159] In step S**920**, the NACK message and the failure cause information are transmitted to the base station, to inform a spectrum management server in the wireless communication system.

[0160] Preferably, the determining whether the cause of the failed information transmission is a non-link quality cause may include: sensing whether a hidden node exists in the vicinity of the user equipment; generating, based on a sensed result, hidden node information indicating whether a hidden node exists; and transmitting the hidden node information to the base station, to inform the spectrum management server.

[0161] Preferably, the generating the NACK message and the failure cause information may include: generating the NACK message when the failed information transmission occurs; detecting a value of a reference signal received power RSRP of a communication link between the base station and the user equipment; detecting an interference value of an interference signal from a neighbor cell; and generating the failure cause information based on the value of the RSRP and the interference value.

[0162] Preferably, the generating the failure cause information based on the value of the RSRP and the interference value may include: generating failure cause information indicating that the cause of the failed information transmission is the non-link quality cause in a case where the value of the RSRP is greater than a first threshold and the interference value is less than a second threshold; and generating failure cause information indicating that the cause of the failed information transmission is the link quality cause in a case where the value of the RSRP is less than or equal to the first threshold and/or the interference value is greater than or equal to the second threshold.

[0163] Various implementations of the above-described steps of a method for performing wireless communication in a wireless communication system according to the embodiment of the present disclosure are described above in detail, and are not repeated herein.

[0164] The technology according to the present disclosure can be applied to various types of products. For example, the base station mentioned in the present disclosure may be implemented as any type of evolution Node B (eNB), such as a macro eNB and a small eNB.

[0165] The small eNB may be an eNB covering a cell smaller than a macro cell, such as a pico eNB, a micro eNB or a home (femto) eNB. 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 radio heads (RRH) arranged at positions different from the main body. In addition, various types of terminals described below may operate as a base station by performing functions of the base station temporarily or in a semi-persistent manner.

[0166] For example, the UE mentioned in the present disclosure 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 device) or an in-vehicle terminal (such as a car navigation apparatus). The UE may also be implemented as a terminal (also referred to as a machine-type communication (MTC) terminal) performing machine to machine (M2M) communication. In addition, the UE may be a wireless communication module (such as an integrated circuit module including a single chip) installed on each of the above terminals.

[0167] FIG. **10** is a block diagram showing a first schematic configuration example of an eNB to which the technology of the present disclosure may be applied. An eNB **1000** includes one or more antennas **1010** and a base station apparatus **1020**. Each antenna **1010** and the base station apparatus **1020** may be connected to each other via an RF cable.

[0168] Each of the antennas **1010** includes a single or multiple antenna elements (such as multiple antenna elements included in an MIMO antenna), and is used for the base station apparatus **1020** to transmit and receive radio signals. As shown in FIG. **10**, the eNB **1000** may include the multiple antennas **1010**. For example, the multiple antennas **1010** may be compatible with multiple frequency bands used by the eNB **1000**. Although FIG. **10** shows the example in which the eNB **1000** includes the multiple antennas **1010**, the eNB **1000** may also include a single antenna **1010**.

[0169] The base station apparatus **1020** includes a controller **1021**, a memory **1022**, a network interface **1023**, and a wireless communication interface **1025**.

[0170] The controller **1021** may be, for example, a CPU or a DSP, and operates various functions of a higher layer of the base station apparatus **1020**. For example, the controller **1021** generates a data packet from data in signals processed by the wireless communication interface **1025**, and transfers the generated packet via the network interface **1023**. The controller **1021** may bundle data from multiple base band processors to generate the bundled packet, and transfer the generated bundled packet. The controller **1021** 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 **1022** includes a RAM and a ROM, and stores a program executed by the controller **1021**, and various types of control data (such as a terminal list, transmission power data, and scheduling data).

[0171] The network interface **1023** is a communication interface for connecting the base station apparatus **1020** to a core network **1024**. The controller **1021** may communicate with a core network node or another eNB via the network interface **1023**. In that case, the eNB **1000**, and the core network node or the other eNB may be connected to each other through a logical interface (such as an S1 interface and an X2 interface). The network interface **1023** may also be a wired communication interface or a wireless communication interface for wireless backhaul. If the network interface **1023** is a wireless communication interface, the network interface **1023** may use a higher frequency band for wireless communication than a frequency band used by the wireless communication interface **1025**.

[0172] The wireless communication interface **1025** supports any cellular communication scheme (such as Long Term Evolution (LTE) and LTE-Advanced), and provides wireless connection to a terminal positioned in a cell of the eNB **1000** via the antenna **1010**. The wireless communication interface **1025** may typically include, for example, a baseband (BB) processor **1026** and an RF circuit **1027**. The BB processor **1026** may perform, for example, encoding/decoding, modulating/demodulating, and multiplexing/demultiplexing, and performs various types of signal processing of layers (such as L1, medium access control (MAC), wireless link control (RLC), and a packet data convergence protocol (PDCP)). The BB processor **1026** may have a part or all of the above-described logical functions instead of the controller **1021**. The BB processor **1026** may be a memory that stores a communication control program, or a module that includes a processor and a related circuit configured to execute the program. Updating the program may allow the functions of the BB processor **1026** to be changed. The module may be a card or a blade that is inserted into a slot of the base station apparatus **1020**. Alternatively, the module may also be a chip that is mounted on the card or the blade. Meanwhile, the RF circuit **1027** may include, for example, a mixer, a filter, and an amplifier, and transmits and receives wireless signals via the antenna **1010**.

[0173] As shown in FIG. **10**, the wireless communication interface **1025** may include the multiple BB processors **1026**. For example, the multiple BB processors **1026** may be compatible with multiple frequency bands used by the eNB **1000**. As shown in FIG. **10**, the wireless communication interface **1025** may include the multiple RF circuits **1027**. For example, the multiple RF circuits **1027** may be compatible with multiple antenna elements. Although FIG. **10** shows the example in which the wireless communication interface **1025** includes the multiple BB processors **1026** and the multiple RF circuits **1027**, the wireless communication interface **1025** may also include a single BB processor **1026** or a single RF circuit **1027**.

[0174] FIG. **11** is a block diagram showing a second schematic configuration example of an eNB to which the technology of the present disclosure may be applied. An eNB **1130** includes one or more antennas **1140**, a base station apparatus **1150**, and an RRH **1160**. Each antenna **1140** and the RRH **1160** may be connected to each other via an RF cable. The base station apparatus **1150** and the RRH **1160** may be connected to each other via a high speed line such as an optical fiber cable.

[0175] Each of the antennas **1140** includes a single or multiple antenna elements (such as multiple antenna elements included in an MIMO antenna), and is used for the RRH **1160** to transmit and receive radio signals. As shown in FIG. **11**, the eNB **1130** may include the multiple antennas **1140**. For example, the multiple antennas **1140** may be compatible with multiple frequency bands used by the eNB **1130**. Although FIG. **11** shows the example in which the eNB **1130** includes the multiple antennas **1140**, the eNB **1130** may also include a single antenna **1140**.

[0176] The base station apparatus **1150** includes a controller **1151**, a memory **1152**, a network interface **1153**, a wireless communication interface **1155**, and a connection interface **1157**. The controller **1151**, the memory **1152**, and the network interface **1153** are the same as the controller **1021**, the memory **1022**, and the network interface **1023** described with reference to FIG. **10**.

[0177] The wireless communication interface **1155** supports any cellular communication scheme (such as LTE and LTE-Advanced), and provides wireless communication to a

terminal positioned in a sector corresponding to the RRH **1160** via the RRH **1160** and the antenna **1140**. The wireless communication interface **1155** may typically include, for example, a BB processor **1156**. The BB processor **1156** is the same as the BB processor **1026** described with reference to FIG. **10**, except the BB processor **1156** is connected to the RF circuit **1164** of the RRH **1160** via the connection interface **1157**. As shown in FIG. **11**, the wireless communication interface **1155** may include the multiple BB processors **1156**. For example, the multiple BB processors **1156** may be compatible with multiple frequency bands used by the eNB **1130**. Although FIG. **11** shows the example in which the wireless communication interface **1155** includes the multiple BB processors **1156**, the wireless communication interface **1155** may also include a single BB processor **1156**.

[0178] The connection interface **1157** is an interface for connecting the base station apparatus **1150** (wireless communication interface **1155**) to the RRH **1160**. The connection interface **1157** may also be a communication module for communication in the above-described high speed line that connects the base station apparatus **1150** (wireless communication interface **1155**) to the RRH **1160**.

[0179] The RRH **1160** includes a connection interface **1161** and a wireless communication interface **1163**.

[0180] The connection interface **1161** is an interface for connecting the RRH **1160** (wireless communication interface **1163**) to the base station apparatus **1150**. The connection interface **1161** may also be a communication module for communication in the above-described high speed line.

[0181] The wireless communication interface **1163** transmits and receives wireless signals via the antenna **1140**. The wireless communication interface **1163** may typically include, for example, the RF circuit **1164**. The RF circuit **1164** may include, for example, a mixer, a filter, and an amplifier, and transmits and receives wireless signals via the antenna **1140**. As shown in FIG. **11**, the wireless communication interface **1163** may include multiple RF circuits **1164**. For example, the multiple RF circuits **1164** may support multiple antenna elements. Although FIG. **11** shows the example in which the wireless communication interface **1163** includes the multiple RF circuits **1164**, the wireless communication interface **1163** may also include a single RF circuit **1164**.

[0182] In the eNB **1000** shown in FIG. **10** and the eNB **1130** shown in FIG. **11**, the processing circuit **510** described with reference to FIG. **5** and the acquisition units **511** and **512** thereof may be implemented by the controller **1021** and/or the controller **1151**, and the communication unit **520** described with reference to FIG. **5** may be implemented by the wireless communication interface **1025** and the wireless communication interface **1155** and/or the wireless communication interface **1163**. At least a part of the functions may also be implemented by the controller **1021** and the controller **1151**. For example, the controller **1021** and/or the controller **1151** may implement the functions of acquiring the NACK message and failure cause information to inform a spectrum management server and acquiring spectrum sensing parameter information by executing instructions stored in memories.

[0183] FIG. **12** is a block diagram showing a schematic configuration example of a smartphone **1200** to which the technology of the present disclosure may be applied. The smartphone **1200** includes a processor **1201**, a memory **1202**, a storage **1203**, an external connection interface **1204**, a camera **1206**, a sensor **1207**, a microphone **1208**, an input device **1209**, a display device **1210**, a speaker **1211**, a wireless communication interface **1212**, one or more antenna switches **1215**, one or more antennas **1216**, a bus **1217**, a battery **1218**, and an auxiliary controller **1219**.

[0184] The processor **1201** 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 **1200**. The memory **1202** includes RAM and ROM, and stores a program that is executed by the processor **1201** and data. The storage **1203** may include a storage medium such as a semiconductor memory and a hard disk. The external connection interface **1204** is an interface for connecting an external device (such as a memory card and a universal serial bus (USB) device) to the smartphone **1200**.

[0185] The camera **1206** 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 **1207** may include a group of sensors such as a measurement sensor, a gyro sensor, a geomagnetic sensor and an acceleration sensor. The microphone **1208** converts sounds that are input to the smartphone **1200** to audio signals. The input device **1209** includes, for example, a touch sensor configured to detect touch onto a screen of the display device **1210**, a keypad, a keyboard, a button or a switch, and receives an operation or an information input from a user. The display device **1210** 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 **1200**. The speaker **1211** converts audio signals outputted from the smartphone **1200** to sounds.

[0186] The wireless communication interface **1212** supports any cellular communication scheme such as LET and LTE-Advanced, and performs wireless communication. The wireless communication interface **1212** may typically include, for example, a BB processor **1213** and an RF circuit **1214**. The BB processor **1213** may perform, for example, encoding/decoding, modulating/demodulating, and multiplexing/demultiplexing, and performs various types of signal processing for wireless communication. Meanwhile, the RF circuit **1214** may include, for example, a mixer, a filter and an amplifier, and transmits and receives wireless signals via the antenna **1216**. The wireless communication interface **1212** may be a one chip module having the BB processor **1213** and the RF circuit **1214** integrated thereon. As shown in FIG. **12**, the wireless communication interface **1212** may include the multiple BB processors **1213** and the multiple RF circuits **1214**. Although FIG. **12** shows the example in which the wireless communication interface **1212** includes the multiple BB processors **1213** and the multiple RF circuits **1214**, the wireless communication interface **1212** may also include a single BB processor **1213** or a single RF circuit **1214**.

[0187] Furthermore, in addition to a cellular communication scheme, the wireless communication interface **1212** 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 that case, the wireless communication interface **1212** may include the BB processor **1213** and the RF circuit **1214** for each wireless communication scheme.

[0188] Each of the antenna switches **1215** switches connection destinations of the antennas **1216** among multiple circuits (such as circuits for different wireless communication schemes) included in the wireless communication interface **1212**.

[0189] Each of the antennas **1216** includes a single or multiple antenna elements (such as multiple antenna elements included in an MIMO antenna), and is used for the wireless communication interface **1212** to transmit and receive wireless signals. As shown in FIG. **12**, the smartphone **1200** may include the multiple antennas **1216**. Although FIG. **12** shows the example in which the smartphone **1200** includes the multiple antennas **1216**, the smartphone **1200** may also include a single antenna **1216**.

[0190] Furthermore, the smartphone **1200** may include the antenna **1216** for each wireless communication scheme. In that case, the antenna switches **1215** may be omitted from the configuration of the smartphone **1200**.

[0191] The bus **1217** connects the processor **1201**, the memory **1202**, the storage **1203**, the external connection interface **1204**, the camera **1206**, the sensor **1207**, the microphone **1208**, the input device **1209**, the display device **1210**, the speaker **1211**, the wireless communication interface **1212**, and the auxiliary controller **1219** to each other. The battery **1218** supplies power to blocks of the smartphone **1200** shown in FIG. **12** via feed lines, which are partially shown as dashed lines in the FIG. **12**. The auxiliary controller **1219** operates a minimum necessary function of the smartphone **1200**, for example, in a sleep mode.

[0192] In the smartphone **1200** shown in FIG. **12**, the processing circuit **610** described with reference to FIG. **6** and the generation unit **611** thereof may be implemented by the processer **1201** or the auxiliary controller **1219**, and the communication unit **620** described with reference to FIG. **6** may be implemented by the wireless communication interface **1212**. At least a part of the functions may also be implemented by the processor **1201** or the auxiliary controller **1219**. For example, the processor **1201** or the auxiliary controller **1219** can implement the function of generating the NACK message and the failure cause information by executing instructions stored in the memory **1202** or the storage **1203**.

[0193] FIG. **13** is a block diagram showing an example of a schematic configuration of a car navigation apparatus **1320** to which the technology of the present disclosure may be applied. The car navigation apparatus **1320** includes a processor **1321**, a memory **1322**, a global positioning system (GPS) module **1324**, a sensor **1325**, a data interface **1326**, a content player **1327**, a storage medium interface **1328**, an input device **1329**, a display device **1330**, a speaker **1331**, a wireless communication interface **1333**, one or more antenna switches **1336**, one or more antennas **1337**, and a battery **1338**.

[0194] The processor **1321** may be, for example, a CPU or a SoC, and controls a navigation function and another function of the car navigation apparatus **1320**. The memory **1322** includes a RAM and a ROM, and stores a program executed by the processor **1321**, and data.

[0195] The GPS module **1324** uses GPS signals received from a GPS satellite to determine a position (such as latitude, longitude, and altitude) of the car navigation apparatus **1320**. The sensor **1325** may include a group of sensors such as a gyro sensor, a geomagnetic sensor, and an air pressure sensor. The data interface **1326** is connected to, for example, an in-vehicle network **1341** via a terminal that is not shown, and acquires data (such as vehicle speed data) generated by the vehicle.

[0196] The content player **1327** reproduces content stored in a storage medium (such as a CD and a DVD) that is inserted into the storage medium interface **1328**. The input device **1329** includes, for example, a touch sensor configured to detect touch onto a screen of the display device **1330**, a button or a switch, and receives an operation or information inputted from a user. The display device **1330** includes a screen such as a LCD or an OLED display, and displays an image of the navigation function or content that is reproduced. The speaker **1331** outputs sounds of the navigation function or the content that is reproduced.

[0197] The wireless communication interface **1333** supports any cellular communication scheme (such as LTE and LTE-Advanced), and performs wireless communication. The wireless communication interface **1333** may typically include, for example, a BB processor **1334** and an RF circuit **1335**. The BB processor **1334** may perform, for example, encoding/decoding, modulating/demodulating, and multiplexing/demultiplexing, and performs various types of signal processing for wireless communication. Meanwhile, the RF circuit **1335** may include, for example, a mixer, a filter, and an amplifier, and transmits and receives wireless signals via the antenna **1337**. The wireless communication interface **1333** may also be a one chip module that has the BB processor **1334** and the RF circuit **1335** integrated thereon. As shown in FIG. **13**, the wireless communication interface **1333** may include the multiple BB processors **1334** and the multiple RF circuits **1335**. Although FIG. **13** shows the example in which the wireless communication interface **1333** includes the multiple BB processors **1334** and the multiple RF circuits **1335**, the wireless communication interface **1333** may also include a single BB processor **1334** or a single RF circuit **1335**.

[0198] Furthermore, in addition to the cellular communication scheme, the wireless communication interface **1333** 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 that case, the wireless communication interface **1333** may include the BB processor **1334** and the RF circuit **1335** for each wireless communication scheme.

[0199] Each of the antenna switches **1336** switches connection destinations of the antennas **1337** among multiple circuits (such as circuits for different wireless communication schemes) included in the wireless communication interface **1333**.

[0200] Each of the antennas **1337** includes a single or multiple antenna elements (such as multiple antenna elements included in an MIMO antenna), and is used for the wireless communication interface **1333** to transmit and receive wireless signals. As shown in FIG. **13**, the car navigation apparatus **1320** may include the multiple antennas **1337**. Although FIG. **13** shows the example in which the car navigation apparatus **1320** includes the multiple antennas **1337**, the car navigation apparatus **1320** may also include a single antenna **1337**.

[0201] Furthermore, the car navigation apparatus **1320** may include the antenna **1337** for each wireless communication scheme. In that case, the antenna switches **1336** may be omitted from the configuration of the car navigation apparatus **1320**.

[0202] The battery **1338** supplies power to blocks of the car navigation apparatus **1320** shown in FIG. **13** via feed lines that are partially shown as dashed lines in the FIG. **13**. The battery **1338** accumulates power supplied form the vehicle.

[0203] In the car navigation apparatus **1320** shown in FIG. **13**, the processing circuit **610** described with reference to FIG. **6** and the generation unit **611** thereof may be implemented by the processer **1321**, and the communication unit **620** described with reference to FIG. **6** may be implemented by the wireless communication interface **1333**. At least a part of the functions may also be implemented by the processor **1321**. For example, the processor **1321** can implement the function of generating the NACK message and the failure cause information by executing instructions stored in the memory **1322**.

[0204] The technology of the present disclosure may also be implemented as an in-vehicle system (or a vehicle) **1340** including one or more blocks of the car navigation apparatus **1320**, the in-vehicle network **1341** and a vehicle module **1342**. The vehicle module **1342** generates vehicle data (such as a vehicle speed, an engine speed or failure information), and outputs the generated data to the in-vehicle network **1341**.

[0205] In the system and method according to the present disclosure, the respective components or steps can be decomposed and/or recombined. These decompositions and/or recombination shall be regarded as equivalent solutions of the present disclosure. Moreover, steps for executing the above series of processing can naturally be executed chronologically in the sequence as described above, but is not limited thereto, and some of the steps can be performed in parallel or individually.

[0206] 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 for 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.

1. An electronic device in a wireless communication system, comprising:

one or more processing circuits configured to:

acquire a NACK message indicating failed information transmission between a transmitting end and a receiving end in the wireless communication system and failure cause information indicating a cause of the failed information transmission, wherein the cause of the failed information transmission comprises a link quality cause and a non-link quality cause; and

generate spectrum sensing parameter information if it is determined that the cause of the failed information transmission is the non-link quality cause to adjust a spectrum sensing parameter of the transmitting end, so as to increase a probability of successful information transmission between the transmitting end and the receiving end.

2. The electronic device according to claim **1**, wherein for generating the spectrum sensing parameter information, the processing circuit is further configured to:

acquire hidden node information indicating whether a hidden node exists, and

enable the spectrum sensing parameter information to be used for reducing an energy detection threshold of the transmitting end, in a case where the hidden node information indicates that a hidden node exists, such that the hidden node is sensed by the transmitting end.

3. The electronic device according to claim **2**, wherein before acquiring the hidden node information, the processing circuit is further configured to:

generate a command to instruct the receiving end to sense whether a hidden node exists in the vicinity of the receiving end.

4. The electronic device according to claim **2**, wherein in a case where the hidden node information indicates that no hidden node exists, the processing circuit is further configured to:

enable the spectrum sensing parameter information to be used for increasing a contention window size or a value of a counter of the transmitting end.

5. The electronic device according to claim **1**, wherein in a case where the probability of successful information transmission between the transmitting end and the receiving end is increased, the processing circuit is further configured to:

generate a command to recover the spectrum sensing parameter of the transmitting end upon elapse of a preset time period.

6. The electronic device according to claim **1**, wherein for determining the cause of the failed information transmission is the non-link quality cause, the processing circuit is further configured to:

acquire a plurality of NACK messages and a plurality of pieces of failure cause information during a preset time period; and

determine the cause of the failed information transmission is the non-link quality cause based on a ratio of the number of pieces of failure cause information indicating that the cause of the failed information transmission is the non-link quality cause to the number of the NACK messages.

7. The electronic device according to claim **1**, wherein for determining the cause of the failed information transmission is the non-link quality cause, the processing circuit is further configured to:

acquire a plurality of NACK messages and a plurality of pieces of failure cause information, as well as a plurality of ACK messages indicating successful information transmission between the transmitting end and the receiving end during a preset time period,; and

determine the cause of the failed information transmission is the non-link quality cause based on a ratio of the number of pieces of failure cause information indicating that the cause of the failed information transmission is the non-link quality cause to a sum of the number of the NACK messages and the number of the ACK messages.

8. The electronic device according to claim **6**, wherein if it is determined the cause of the failed information transmission is the non-link quality cause, the processing circuit is further configured to:

determine, based on the ratio, whether a hidden node exists;

enable the spectrum sensing parameter information to reduce an energy detection threshold of the transmitting end if the hidden node exists, such that the hidden node is sensed by the transmitting end; and

enable the spectrum sensing parameter information to increase a contention window size or a value of a counter of the transmitting end if a hidden node does not exist.

9. The electronic device according to claim **1**, wherein the electronic device is a spectrum management server in a core network.

10. An electronic device in a wireless communication system, comprising:

one or more processing circuits configured to:

acquire a NACK message indicating failed information transmission between a transmitting end and a receiving end in the wireless communication system and failure cause information indicating a cause of the failed information transmission, to inform a spectrum management server in the wireless communication system, wherein the cause of the failed information transmission comprises a link quality cause and a non-link quality cause; and

acquire spectrum sensing parameter information from the spectrum management server to adjust a spectrum sensing parameter of the transmitting end, so as to increase a probability of successful information transmission between the transmitting end and the receiving end.

11. The electronic device according to claim **10**, wherein before acquiring the spectrum sensing parameter information from the spectrum management server, the processing circuit is further configured to:

acquire hidden node information indicating whether a hidden node exists, to inform the spectrum management server.

12. The electronic device according to claim **11**, wherein the electronic device is located on a side of the transmitting end, and the processing circuit acquires the NACK message, the failure cause information and the hidden node information from the receiving end.

13. The electronic device according to claim **12**, wherein the processing circuit is further configured to perform, based on the spectrum sensing parameter information, at least one of:

reducing an energy detection threshold of the transmitting end so that the hidden node is sensed by the transmitting end; and

increasing a contention window size or a value of a counter of the transmitting end.

14. The electronic device according to claim **11**, wherein the electronic device is located on a side of the receiving end, and for acquiring the NACK message and the failure cause information, the processing circuit is further configured to:

generate the NACK message when the failed information transmission occurs;

detect a value of a reference signal received power RSRP of a communication link between the receiving end and the transmitting end;

detect an interference value of an interference signal from a neighbor cell; and

generate the failure cause information based on the value of the RSRP and the interference value.

15. The electronic device according to claim **14**, wherein for generating the failure cause information based on the value of the RSRP and the interference value, the processing circuit is further configured to:

generate failure cause information indicating that the cause of the failed information transmission is the non-link quality cause in a case where the value of the RSRP is greater than a first threshold and the interference value is less than a second threshold; and

generate failure cause information indicating that the cause of the failed information transmission is the link quality cause in a case where the value of the RSRP is less than or equal to the first threshold and/or the interference value is greater than or equal to the second threshold.

16. The electronic device according to claim **14**, wherein for acquiring the hidden node information, the processing circuit is further configured to:

sense whether a hidden node exists in the vicinity of the receiving end; and

generate the hidden node information based on a sensed result.

17. (canceled)

18. A user equipment in a wireless communication system, wherein the user equipment operates as a receiving end and comprises:

a transceiver; and

one or more processing circuits configured to:

generate a NACK message indicating failed information transmission between a base station serving as a transmitting end and the user equipment in the wireless communication system and failure cause information indicating a cause of the failed information transmission, wherein the cause of the failed information transmission comprises a link quality cause and a non-link quality cause; and

control the transceiver to transmit the NACK message and the failure cause information to the base station, to inform a spectrum management server in the wireless communication system.

19. The user equipment according to claim **18**, wherein if it is determined that the cause of the failed information transmission is the non-link quality cause, the processing circuit is further configured to:

sense whether a hidden node exists in the vicinity of the user equipment;

generate, based on a sensed result, hidden node information indicating whether the hidden node exists; and

control the transceiver to transmit the hidden node information to the base station, to inform the spectrum management server.

20. The user equipment according to claim **18**, wherein for generating the NACK message and the failure cause information, the processing circuit is further configured to:

generate the NACK message when the failed information transmission occurs;

detect a value of a reference signal received power RSRP of a communication link between the base station and the user equipment;

detect an interference value of an interference signal from a neighbor cell; and

generate the failure cause information based on the value of the RSRP and the interference value.

21. The user equipment according to claim **20**, wherein for generating the failure cause information based on the value of the RSRP and the interference value, the processing circuit is further configured to:

generate failure cause information indicating that the cause of the failed information transmission is the non-link quality cause in a case where the value of the RSRP is greater than a first threshold and the interference value is less than a second threshold; and

generate failure cause information indicating that the cause of the failed information transmission is the link quality cause in a case where the value of the RSRP is less than or equal to the first threshold and/or the interference value is greater than or equal to the second threshold.

22-24. (canceled)

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