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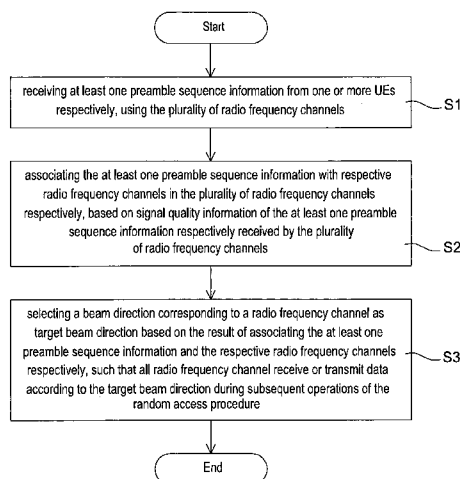
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- (54) **Title:** METHOD AND APPARATUS FOR PERFORMING UPLINK RANDOM ACCESS IN A BASE STATION

**Fig. 2**

- (57) **Abstract:** An objective of the present invention is to provide a method and apparatus for performing uplink random access in a base station. The method according to the present invention comprises steps of: receiving at least one preamble sequence information from one or more UEs respectively, using the plurality of radio frequency channels; associating the at least one preamble sequence information with respective radio frequency channels in the plurality of radio frequency channels respectively, based on signal quality information of the at least one preamble sequence information respectively received by the plurality of radio frequency channels; selecting a beam direction corresponding to a radio frequency channel as target beam direction based on the result of associating the at least one preamble sequence information and the respective radio frequency channels respectively, such that all radio frequency channels receive or transmit data according to the target beam direction during subsequent operations of the random access procedure. The advantages of the present invention lies in obtaining higher beamforming gains during an uplink random access procedure and enhancing the successful rate of UE access.

Method and Apparatus for Performing Uplink Random Access in a Base Station

FIELD OF THE INVENTION

[1] The present invention relates to the field of communication technologies, and more specifically relates to a method and apparatus for performing uplink random access in a base station (eNB).

BACKGROUND OF THE INVENTION

[2] A main frequency range of a millimeter wave band is 30GHz – 300 GHz. Due to its abundant frequency resources (corresponding to more than 200 times of a 4G network), it is believed in the industry most prosperous to realize gigabit radio access in the future 5th Generation Radio Communication (5G) technologies.

[3] However, high frequency band of mmWave also results in large path loss and significant signal attenuation, which becomes the rising challenges for millimeter wave communications. For data transmission in millimeter wave band, signal attenuation can be effectively alleviated by employing highly directional transmit and receive beamforming and aligning the corresponding beams in direction using massive MIMO (Multi-Input & Multi-Output, MIMO) technique. Limited number of radio frequency (RF) chains, less than antenna number, are generally performed in massive MIMO taking into account the tradeoff between performance benefits and implementation cost, including hardware cost proportional to RF chain number as well as computational complexity and energy consumption of signal processing.

[4] Due to lack of information on optimal transmit or receive beam direction, the uplink random access procedure cannot benefit from beamforming gain. Therefore, if the approach of traditional uplink random access procedure is applied to a millimeter band, the high path loss very likely causes a user equipment (UE) unable to access due to a too poor signal quality of the receive base station (eNB).

[5] Fig. 1 schematically illustrates a flow diagram of an uplink random access method using a beamforming technology according to the prior art. As shown in Fig. 1, the UE and the eNB use 8 beam directions to transmit or receive data respectively; when the UE needs to access the eNB, the UE randomly selects a preamble sequence in step P1, and transmit the selected preamble sequence for multiple times according to respective beam directions of the UE; and the eNB receives, according to each beam direction of its own, the preamble sequence transmitted based on each beam direction of the UE, such that it can determine the optimal pair of beam directions based on which the eNB and the UE transmit or receive data between each other, so as to be available for the eNB and UE to use the determined optimal beam directions to transmit or receive data in subsequent steps respectively.

[6] Next, in step P2, after detecting the preamble sequence transmitted by the UE, the eNB uses the determined optimal beam direction to transmit a random access response (RAR) information to the UE, which random access response information including the detected preamble sequence information, uplink timing information, and indication of resource allocation. Moreover, the UE uses the determined optimal beam direction to receive the random access response message.

[7] Next, in step P3, the UE transmits a random access message to the eNB using a physical uplink shared channel (PUSCH), the random access message including identification information of the UE.

[8] Next, in step P4, the eNB transmits a contention-resolution message including the UE identification information using a physical downlink shared channel (PDSCH) to confirm that contentions among multiple UEs attempting to use a same random access resource have been resolved, and the random access procedure is completed.

- 5 [9] Although the solution can achieve higher beamforming gains, it requires the UE to repetitively transmit preamble sequence for multiple times so as to determine the optimal beam directions for receiving or transmitting data; consequently, the procedure of transmitting the preamble sequence is rather long, which prolongs the time of the random access procedure, particularly when there are too many UEs waiting to access, many UEs may not access
10 successfully. Moreover, in this solution, the optimal beam direction is determined based on an access request from a single UE so as to establish uplink connection. However, the beam directions determined for individual UEs might be different, which further prolongs the random access process and increases complexity of implementing the solution.

15 **SUMMARY OF THE INVENTION**

[10] An objective of the present invention is to provide a method and apparatus for performing uplink random access in an eNB.

- [11] According to one aspect of the present invention, there is provided a method for performing uplink random access in an eNB, wherein the eNB employs a plurality of radio frequency channels
20 corresponding to different beam directions respectively, the method comprising steps of:

[12] a. receiving at least one preamble sequence information from one or more UEs respectively, using the plurality of radio frequency channels;

- [13] b. associating the at least one preamble sequence information with respective radio frequency channels in the plurality of radio frequency channels respectively, based on signal
25 quality information of the at least one preamble sequence information respectively received by the plurality of radio frequency channels;

- [14] c. selecting a beam direction corresponding to a radio frequency channel as target beam direction based on the result of associating the at least one preamble sequence information and the respective radio frequency channels respectively, such that all radio frequency channels
30 receive or transmit data according to the target beam direction during subsequent operations of the random access procedure.

- [15] According to one aspect of the present invention, there is provided an access apparatus for performing uplink random access in an eNB, wherein the eNB employs a plurality of radio frequency channels corresponding to different beam directions respectively, the access apparatus
35 comprising:

[16] a first receiving device configured to receive at least one preamble sequence information from one or more UEs respectively, using the plurality of radio frequency channels;

- [17] an associating device configured to associate the at least one preamble sequence information with respective radio frequency channels in the plurality of radio frequency channels
40 respectively, based on signal quality information of the at least one preamble sequence information respectively received by the plurality of radio frequency channels;

[18] a selecting device configured to select a beam direction corresponding to a radio frequency channel as target beam direction based on the result of associating the at least one preamble sequence information and the respective radio frequency channels respectively, such that all

radio frequency channels receive or transmit data according to the target beam direction during subsequent operations of the random access procedure.

[19] Compared with the prior art, the present invention has the following advantages: by making the eNB to receive preamble sequences transmitted by UEs using a plurality of radio frequency channels during the uplink random access procedure and select a beam direction that can serve more UEs to perform subsequent operations of random access; in this way, higher beamforming gains are achieved during the uplink random procedure; besides, a UE needn't transmit the preamble sequence for multiple times to determine an optimal beam direction; particular when applying in millimeter wave frequency bands, the UE access successful rate can be enhanced.

BRIEF DESCRIPTION OF THE ACCOMPANYING DRAWINGS

[20] Other features, objectives and advantages of the present invention will become more apparent by reading detailed depiction of the non-limiting embodiments with reference to the accompanying drawings:

[21] Fig. 1 schematically illustrates a flow diagram of an uplink random access method according to the prior art;

[22] Fig. 2 schematically illustrates a flow diagram of a method for performing uplink random access in an in a base station (eNB) according to the invention;

[23] Fig. 3 schematically illustrates a diagram of an access apparatus for performing uplink random access in an eNB according to the invention;

[24] Fig. 4a schematically illustrates a diagram of an exemplary LTE system according to the invention;

[25] Fig. 4b schematically illustrates a diagram of exemplary beam directions corresponding to an eNB according to the invention.

[26] In the accompanying drawings, same or similar reference numerals represent same or similar components.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[27] Hereinafter, the present invention will be described in more detail with reference to the accompanying drawings.

[28] Fig. 2 schematically illustrates a flow diagram of a method for performing uplink random access in an in a base station (eNB) according to the invention. Particularly, the method comprises step S1, step S2, and step S3.

[29] Particularly, the method according to the invention is implemented by an access apparatus included in a base station (eNB). The eNB includes, but not limited to, a macro base station, a micro base station, a home base station, etc. Particularly, the eNB employs a plurality of radio frequency channels corresponding to different beam directions respectively.

[30] Referring to Fig. 2, in step S1, the access apparatus receives at least one preamble sequence information from one or more UEs respectively, using the plurality of radio frequency channels.

[31] Specifically, when it is needed to access the eNB, a UE randomly selects a preamble sequence, and transmits corresponding preamble sequence information to the eNB, to request for accessing the eNB.

[32] Preferably, the UE may transmit or receive data based on a plurality of predetermined beam directions; the UE transmits the preamble sequence information to the eNB using an appropriate

beam direction determined in a previous broadcast channel decoding stage.

[33] Then, the access apparatus receives at least one preamble sequence information from one or more UEs respectively, using the plurality of radio frequency channels.

[34] According to first example of the present invention, Fig. 4a schematically illustrates an exemplary communication system. Referring to Fig. 4a, the system comprises one eNB and 4 user equipments UE_1 – UE_4 waiting to access. Fig. 4b illustrates a schematic diagram of beam directions corresponding to the eNB. Referring to Fig. 4b, the eNB may transmit 4 beam directions with different directions (direction 1 to direction 4). Continuing reference to Fig. 4a, the eNB adopts 4 radio frequency channels (RFchain_1 to RFchain_4), wherein RFchain_1 corresponds to direction 1, RFchain_2 corresponds to direction 2, RFchain_3 corresponds to direction 3, and RFchain_4 corresponds to direction 4.

[35] UE_1 to UE_4 randomly select a preamble sequence respectively, and transmit their respective preamble sequence information to the eNB to request for accessing the eNB. Particularly, the preamble sequences transmitted by UE_1 and UE_4 are pre_1, the preamble sequence transmitted by UE_2 is pre_2, and the preamble sequence transmitted by UE_3 is pre_3. The access apparatus receives all preamble sequences from UE_1 to UE_4 respectively, using RFchain_1 to RFchain_4.

[36] In step S2, the access apparatus associates the at least one preamble sequence information with respective radio frequency channels in the plurality of radio frequency channels respectively, based on signal quality information of the at least one preamble sequence information respectively received by the plurality of radio frequency channels.

[37] Particularly, each preamble sequence is only associated with one radio frequency channel.

[38] Specifically, for each preamble sequence information, associating the preamble sequence information with a radio frequency channel with the best reception quality based on reception quality information of the preamble sequence information respectively received by the plurality of radio frequency channels.

[39] Particularly, the reception quality information includes various kinds of information that may reflect signal reception quality.

[40] Preferably, the reception quality information includes, but not limited to, any one of the following information:

[41] 1) magnitude of receive signal power;

[42] 2) quality reference information of the receive signal; the quality reference information includes various kinds of information that may reflect quality of the receive signal, e.g., signal-to-noise ratio, signal-to-interference-plus-noise ratio, etc.

[43] Continue to illustrate the first example above. An association rule corresponding to the access apparatus comprises: associating a preamble sequence information to a radio frequency channel with the maximum receive signal power. Then, according to the association rule, the access apparatus associates the preamble sequence information pre_1, pre_2, and pre_3 with respective radio frequency channels in radio frequency channels RFchain_1 to RFchain_4 based on the signal power magnitudes of preamble sequence information pre_1, pre_2, and pre_3 respectively received by radio frequency channels RFchain_1 to RFchain_4, obtaining results of associating the preamble sequence information pre_1, pre_2 and pre_3 with radio frequency channels RFchain_1 to RFchain_4, as shown in Table 1 below:

Table 1

Preamble sequence	Associated radio frequency channel
pre_1	RFchain_2
pre_2	RFchain_2
pre_3	RFchain_4

[44] Continue referring to Fig. 2, in step S3, the access apparatus selects a beam direction corresponding to a radio frequency channel as target beam direction based on the result of associating the at least one preamble sequence information and the respective radio frequency channels respectively, such that all radio frequency channels receive or transmit data according to the target beam direction during subsequent operations of the random access procedure.

[45] Preferably, the access apparatus selects a beam direction corresponding to a radio frequency channel which most associated as the target beam direction, based on the association results of the at least one preamble sequence information with the respective radio frequency channels respectively.

[46] The access apparatus may also select a target beam direction based on other rules, e.g., selecting a beam direction corresponding to a radio frequency channel with the best reception quality as the target beam direction.

[47] Continue illustrating the first example above. The access apparatus selects direction 2 corresponding to the radio frequency channel RFchain_2 which most associated as the target beam direction, based on the association results shown in Table 1 above, such that during subsequent operations of the random access procedure, radio frequency channels RFchain_1 to RFchain_4 all transmit data according to direction 2.

[48] Particularly, the method according to the present invention comprises step S4 (not shown), step S5 (not shown), and step S6 (not shown).

[49] In step S4, the access apparatus transmits random access response information to the one or more UEs, wherein the random access response information indicates to respond to one or more preamble sequence information associated with the selected radio frequency channel.

[50] Preferably, the access apparatus also transmits uplink timing information corresponding to one or more preamble sequence information associated with the selected radio frequency channel to the one or more UEs respectively, such that the UEs corresponding to the one or more preamble sequence information performs timing adjustment based on the received timing information, so as to keep uplink synchronization with the eNB.

[51] In step S5, the access apparatus receives random access information from at least one UE in the one or more UEs, wherein the random access information includes identification information of the UE and its corresponding preamble sequence information.

[52] In step S6, the access apparatus transmits access confirmation information to the at least one UE according to the target beam direction ,so as to complete random access.

[53] Preferably, step S6 in the method according to the present invention further comprises step S601 (not shown).

[54] In step S601, when receiving random access information from a plurality of UEs

corresponding to the same preamble sequence information, the access apparatus selects one accessible UE therefrom based on signal quality information of respective random access information of the plurality of UEs so as to transmit access confirmation information to the accessible UE.

5 [55] Continue illustrating the first example above, the access apparatus transmits random access response information to UE_1 to UE_4 in step S4, wherein the random access response information indicates to respond to preamble sequence information pre_1 and pre_2 associated with the selected radio frequency channel RFchain_2. Then UE_1, UE_2 and UE_4, which correspond to the preamble sequence information pre_1 and pre_2, transmit the random access
10 information including their respective identification information and preamble sequence information to the eNB respectively.

[56] The access apparatus receives random access information respectively from UE_1, UE_2, and UE_4 in step S5. Moreover, the access apparatus determines that UE_2 corresponds to preamble sequence information pre_2, and UE_1 and UE_4 correspond to preamble sequence
15 information pre_1, based on the received random access information.

[57] The signal power of the random access information received by the access apparatus from UE_1 is greater than the signal power of the random access information from UE_4. Then, the access apparatus selects UE_1 as an accessible UE from UE_1 and UE_4 corresponding to pre_1 in step S601. Next, the access apparatus transmits access confirmation information to UE_1 and
20 UE_2 respectively, so as to complete random access.

[58] Preferably, after completing random access of the at least one UE, the method according to the present invention also comprises S7 (not shown).

[59] In step S7, the access apparatus resumes the beam directions which the plurality of radio frequency channels initially corresponding to respectively, such that the plurality of radio
25 frequency channels receive data according to their respective corresponding beam directions so as to receive preamble sequence information transmitted by other UEs.

[60] Continue illustrating the first example above. After completing random access of UE_1 and UE_2, the access apparatus resumes the beam directions which radio frequency channels RFchain_1 to RFchain_4 initially corresponding to respectively, such that they receive data based
30 on their respective corresponding beam directions, namely, RFchain_1 corresponds to direction 1, RFchain_2 corresponding to direction 2, RFchain_3 corresponding to direction 3, and RFchain_4 corresponding to direction 4, so as to receive preamble sequence information transmitted by other UEs.

[61] Preferably, after completing random access of the at least one UE, the access apparatus may also sequentially and randomly selects a beam direction from the remaining one or more beam directions, as the target beam direction to complete access of a corresponding UE. Next, the access apparatus resumes initial beam directions of respective radio channels, such that the plurality of radio frequency channels receive data based on their respective corresponding beam directions, to receive the preamble sequence information transmitted by other UEs.

40 [62] Continue illustrating the first example above, after completing random access of UE_1 and UE_2, the access apparatus randomly selects direction 4 as the target beam direction, and transmits random access response information to UE_3 in step S4, wherein the random access response information indicates to respond to preamble sequence information pre_3 associated with the radio frequency channel RFchain_4 corresponding to direction 4, thereby completing

access of the UE_3 corresponding to the preamble sequence information pre_3. Next, the access apparatus resumes initial beam directions of RFchain_1 to RFchain_4 respectively, such that they receive data based on their respective corresponding beam directions, so as to receive preamble sequence information transmitted by other UEs.

5 [63] According to the method of the present invention, by making the eNB to receive preamble sequences transmitted by UEs using a plurality of radio frequency channels during the uplink random access procedure and select a beam direction that can serve more UEs to perform subsequent operations of random access; in this way, higher beamforming gains are achieved during the uplink random access procedure; besides, a UE needn't transmit the preamble
10 sequence for multiple times to determine an optimal beam direction; particular when applying in millimeter wave frequency bands, the UE access successful rate can be enhanced.

[64] Fig. 3 schematically illustrates a diagram of an access apparatus for performing uplink random access in an eNB according to the invention. The access apparatus according to the present invention comprises first receiving device 1, an associating device 2, and selecting device
15 3.

[65] Referring to Fig. 3, the first receiving device 1 receives at least one preamble sequence information from one or more UEs respectively, using the plurality of radio frequency channels.

[66] Specifically, when it is needed to access the eNB, a UE randomly selects a preamble sequence, and transmits corresponding preamble sequence information to the eNB, to request
20 for accessing the eNB.

[67] Preferably, the UE may transmit or receive data based on a plurality of predetermined beam directions; the UE transmits the preamble sequence information to the eNB using an appropriate beam direction determined in a previous broadcast channel decoding stage.

[68] Then, the first receiving apparatus 1 receives at least one preamble sequence information from one or more UEs respectively, using the plurality of radio frequency channels.
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[69] According to first example of the present invention, Fig. 4a schematically illustrates an exemplary communication system. Referring to Fig. 4a, the system comprises one eNB and 4 user equipments UE_1 – UE_4 waiting to access. Fig. 4b illustrates a schematic diagram of beam directions corresponding to the eNB. Referring to Fig. 4b, the eNB may transmit 4 beam directions with different directions (direction 1 to direction 4). Continuing reference to Fig. 4a,
30 the eNB adopts 4 radio frequency channels (RFchain_1 to RFchain_4), wherein RFchain_1 corresponds to direction 1, RFchain_2 corresponds to direction 2, RFchain_3 corresponds to direction 3, and RFchain_4 corresponds to direction 4.

[70] UE_1 to UE_4 randomly select a preamble sequence respectively, and transmit their respective preamble sequence information to the eNB to request for accessing the eNB. Particularly, the preamble sequences transmitted by UE_1 and UE_4 are pre_1, the preamble sequence transmitted by UE_2 is pre_2, and the preamble sequence transmitted by UE_3 is pre_3. The receiving device 1 receives all preamble sequences from UE_1 to UE_4 respectively, using RFchain_1 to RFchain_4.
35

[71] The associating apparatus 2 associates the at least one preamble sequence information with respective radio frequency channels in the plurality of radio frequency channels respectively, based on signal quality information of the at least one preamble sequence information respectively received by the plurality of radio frequency channels.
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[72] Particularly, each preamble sequence is only associated with one radio frequency channel.

[73] Specifically, for each preamble sequence information, the associating device 2 associates the preamble sequence information with a radio frequency channel with the best reception quality based on reception quality information of the preamble sequence information respectively received by the plurality of radio frequency channels.

5 [74] Particularly, the reception quality information includes various kinds of information that may reflect signal reception quality.

[75] Preferably, the reception quality information includes, but not limited to, any one of the following information:

[76] 1) magnitude of receive signal power;

10 [77] 2) quality reference information of the receive signal; the quality reference information includes various kinds of information that may reflect quality of the receive signal, e.g., signal-to-noise ratio, signal-to-interference-plus-noise ratio, etc.

[78] Continue to illustrate the first example above. An association rule corresponding to the access apparatus comprises: associating a preamble sequence information to a radio frequency channel with the maximum receive signal power. Then, according to the association rule, the associating apparatus 2 associates the preamble sequence information pre_1, pre_2, and pre_3 with respective radio frequency channels in radio frequency channels RFchain_1 to RFchain_4, based on the signal power magnitudes of preamble sequence information pre_1, pre_2, and pre_3 respectively received by radio frequency channels RFchain_1 to RFchain_4, obtaining results of associating the preamble sequence information pre_1, pre_2 and pre_3 with radio frequency channels RFchain_1 to RFchain_4, as shown in Table 1 below:

Table 1

Preamble sequence	Associated radio frequency channel
pre_1	RFchain_2
pre_2	RFchain_2
pre_3	RFchain_4

25 [79] Continue referring to Fig. 3, the selecting device 3 selects a beam direction corresponding to a radio frequency channel as target beam direction based on the result of associating the at least one preamble sequence information and the respective radio frequency channels respectively, such that all radio frequency channels receive or transmit data according to the target beam direction during subsequent operations of the random access procedure.

[80] Preferably, the selecting device 3 selects a beam direction corresponding to a radio frequency channel which most associated as the target beam direction, based on the association results of the at least one preamble sequence information with the respective radio frequency channels respectively.

[81] The selecting device 3 may also select a target beam direction based on other rules, e.g., selecting a beam direction corresponding to a radio frequency channel with the best reception quality as the target beam direction.

[82] Continue illustrating the first example above. The selecting device 3 selects direction 2

corresponding to the radio frequency channel RFchain_2 which most associated as the target beam direction, based on the association results shown in Table 1 above, such that during subsequent operations of the random access procedure, radio frequency channels RFchain_1 to RFchain_4 all transmit data according to direction 2.

5 [83] The access apparatus according to the present invention further comprises a first transmitting device (not shown), a second receiving device (not shown), and a second transmitting device (not shown).

[84] The first transmitting device transmits random access response information to the one or more UEs, wherein the random access response information indicates to respond to one or more
10 preamble sequence information associated with the selected radio frequency channel.

[85] Preferably, the access apparatus also transmits uplink timing information corresponding to one or more preamble sequence information associated with the selected radio frequency channel to the one or more UEs, respectively, such that the UEs corresponding to the one or more preamble sequence information performs timing adjustment based on the received timing
15 information, so as to keep uplink synchronization with the eNB.

[86] The second receiving device receives random access information from at least one UE in the one or more UEs, wherein the random access information includes identification information of the UE and its corresponding preamble sequence information.

[87] Next, the second receiving device transmits access confirmation information to the at least
20 one UE according to the target beam direction, so as to complete random access.

[88] Preferably, the second transmitting device according to the present invention further comprises a equipment selecting device (not shown).

[89] when receiving random access information from a plurality of UEs corresponding to the same preamble sequence information, the equipment selecting device selects one accessible UE
25 therefrom based on signal quality information of respective random access information of the plurality of UEs so as to transmit access confirmation information to the accessible UE.

[90] Continue illustrating the first example above, the first transmitting device transmits random access response information to UE_1 to UE_4 in step S4, wherein the random access response information indicates to respond to preamble sequence information pre_1 and pre_2 associated
30 with the selected radio frequency channel RFchain_2. Then UE_1, UE_2 and UE_4, which correspond to the preamble sequence information pre_1 and pre_2, transmit the random access information including their respective identification information and preamble sequence information to the eNB respectively.

[91] The second receiving device receives random access information respectively from UE_1, UE_2, and UE_4 in step S5. Moreover, the access apparatus determines that UE_2 corresponds to preamble sequence information pre_2, and UE_1 and UE_4 correspond to preamble sequence
35 information pre_1 based on the received random access information.

[92] The signal power of the random access information received by the second receiving device from UE_1 is greater than the signal power of the random access information from UE_4. Then,
40 the equipment selecting device selects UE_1 as an accessible UE from UE_1 and UE_4 corresponding to pre_1. Next, The second transmitting device transmits access confirmation information to UE_1 and UE_2 respectively, so as to complete random access.

[93] Preferably, the access apparatus according to the present invention further comprises a direction resuming device (not shown).

[94] The direction resuming device resumes the beam directions which the plurality of radio frequency channels initially corresponding to respectively, such that the plurality of radio frequency channels receive data according to their respective corresponding beam directions so as to receive preamble sequence information transmitted by other UEs.

5 [95] Continue illustrating the first example above. After completing random access of UE_1 and UE_2, the direction resuming device resumes the beam directions which radio frequency channels RFchain_1 to RFchain_4 initially corresponding to respectively, such that they receive data based on their respective corresponding beam directions, namely, RFchain_1 corresponds to direction 1, RFchain_2 corresponding to direction 2, RFchain_3 corresponding to direction 3, and
10 RFchain_4 corresponding to direction 4, so as to receive preamble sequence information transmitted by other UEs.

[96] Preferably, after completing random access of the at least one UE, the access apparatus may also sequentially and randomly selects a beam direction from the remaining one or more beam directions, as the target beam direction to complete access of a corresponding UE. Next, the
15 access apparatus resumes initial beam directions of respective radio channels, such that the plurality of radio frequency channels receive data based on their respective corresponding beam directions, to receive the preamble sequence information transmitted by other UEs.

[97] Continue illustrating the first example above, after completing random access of UE_1 and UE_2, the access apparatus randomly selects direction 4 as the target beam direction, and
20 transmits, using the first transmitting device, random access response information to UE_3, wherein the random access response information indicates to respond to preamble sequence information pre_3 associated with the radio frequency channel RFchain_4 corresponding to direction 4, thereby completing access of the UE_3 corresponding to the preamble sequence information pre_3. Next, the direction resuming device initial beam directions of RFchain_1 to
25 RFchain_4 respectively, such that they receive data based on their respective corresponding beam directions, so as to receive preamble sequence information transmitted by other UEs.

[98] According to the solution of the present invention, by making the eNB to receive preamble sequences transmitted by UEs using a plurality of radio frequency channels during the uplink random access procedure and select a beam direction that can serve more UEs to perform
30 subsequent operations of random access; in this way, higher beamforming gains are achieved during the uplink random access procedure; besides, a UE needn't transmit the preamble sequence for multiple times to determine an optimal beam direction; particular when applying in millimeter wave frequency bands, the UE access successful rate can be enhanced.

[99] It should be noted that the present disclosure may be implemented in software or a
35 combination of software and hardware; for example, it may be implemented by a dedicated integrated circuit (ASIC), a general-purpose computer, or any other similar hardware device. In an embodiment, the software program of the present disclosure may be executed by a processor so as to implement the above steps or functions. Likewise, the software program of the present disclosure (including relevant data structure) may be stored in a computer readable recording
40 medium, for example, a RAM memory, a magnetic or optical driver, or a floppy disk, and similar devices. Besides, some steps of functions of the present disclosure may be implemented by hardware, for example, a circuit cooperating with the processor to execute various functions or steps.

[100] To those skilled in the art, it is apparent that the present disclosure is not limited to the

details of the above exemplary embodiments, and the present disclosure may be implemented with other forms without departing from the spirit or basic features of the present disclosure. Thus, in any way, the embodiments should be regarded as exemplary, but not limitative; the scope of the present disclosure is limited by the appended claims, instead of the above depiction.

5 Thus, all variations intended to fall into the meaning and scope of equivalent elements of the claims should be covered within the present disclosure. No reference signs in the claims should be regarded as limiting the involved claims. Besides, it is apparent that the term “comprise/comprising/include/including” does not exclude other units or steps, and singularity does not exclude plurality. A plurality of units or means stated in the apparatus claims may also
10 be implemented by a single unit or means through software or hardware. Terms such as the first and the second are used to indicate names, but do not indicate any particular sequence.

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Claims

1. A method for performing uplink random access in an eNB, wherein the eNB employs a plurality of radio frequency channels corresponding to different beam directions respectively, the method comprising steps of:
- 5 a. receiving at least one preamble sequence information from one or more UEs respectively, using the plurality of radio frequency channels;
- b. associating the at least one preamble sequence information with respective radio frequency channels in the plurality of radio frequency channels respectively, based on signal quality information of the at least one preamble sequence information respectively received by
- 10 the plurality of radio frequency channels;
- c. selecting a beam direction corresponding to a radio frequency channel as target beam direction based on the result of associating the at least one preamble sequence information and the respective radio frequency channels respectively, such that all radio frequency channels
- 15 receive or transmit data according to the target beam direction during subsequent operations of the random access procedure.
2. The method according to claim 1, wherein the step b comprises a step of:
- for each preamble sequence information, associating the preamble sequence information
- 20 with a radio frequency channel with the best reception quality based on reception quality information of the preamble sequence information respectively received by the plurality of radio frequency channels.
3. The method according to claim 1 or 2, wherein the step c comprises:
- 25 - selecting a beam direction corresponding to a radio frequency channel which most associated as the target beam direction, based on the association results of the at least one preamble sequence information with the respective radio frequency channels respectively.
4. The method according to any one of claims 1-3, wherein the method comprises steps of:
- 30 m. transmitting random access response information to the one or more UEs, wherein the random access response information indicates to respond to one or more preamble sequence information associated with the selected radio frequency channel;
- n. receiving random access information from at least one UE in the one or more UEs, wherein the random access information includes identification information of the UE and its
- 35 corresponding preamble sequence information;
- o. transmitting access confirmation information to the at least one UE according to the target beam direction, so as to complete random access.
5. The method according to claim 4, wherein the step o further comprises a step of:
- 40 - when receiving random access information from a plurality of UEs corresponding to the same preamble sequence information, selecting one accessible UE therefrom based on signal quality information of respective random access information of the plurality of UEs so as to transmit access confirmation information to the accessible UE.

6. The method according to any one of claims 1-5, wherein after completing random access of the at least one UE, the method further comprises a step of:

- resuming the beam directions which the plurality of radio frequency channels initially corresponding to respectively, such that the plurality of radio frequency channels receive data according to their respective corresponding beam directions so as to receive preamble sequence information transmitted by other UEs.

7. An access apparatus for performing uplink random access in an eNB, wherein the eNB employs a plurality of radio frequency channels corresponding to different beam directions respectively, the access apparatus comprising:

a first receiving device configured to receive at least one preamble sequence information from one or more UEs respectively, using the plurality of radio frequency channels;

an associating device configured to associate the at least one preamble sequence information with respective radio frequency channels in the plurality of radio frequency channels respectively, based on signal quality information of the at least one preamble sequence information respectively received by the plurality of radio frequency channels;

a selecting device configured to select a beam direction corresponding to a radio frequency channel as target beam direction based on the result of associating the at least one preamble sequence information and the respective radio frequency channels respectively, such that all radio frequency channels receive or transmit data according to the target beam direction during subsequent operations of the random access procedure.

8. The access apparatus according to claim 7, wherein the associating device is configured to:

- for each preamble sequence information, associating the preamble sequence information with a radio frequency channel with the best reception quality based on reception quality information of the preamble sequence information respectively received by the plurality of radio frequency channels.

9. The access apparatus according to claim 7 or 8, wherein the selecting device is configured to:

- selecting a beam direction corresponding to a radio frequency channel which most associated as the target beam direction, based on the association results of the at least one preamble sequence information with the respective radio frequency channels respectively.

10. The access apparatus according to any one of claims 7-9, wherein the access apparatus comprises:

a first transmitting device configured to transmit random access response information to the one or more UEs, wherein the random access response information indicates to respond to one or more preamble sequence information associated with the selected radio frequency channel.

a second receiving device configured to receive random access information from at least one UE in the one or more UEs, wherein the random access information includes identification information of the UE and its corresponding preamble sequence information.

a second transmitting device configured to transmit access confirmation information to the at least one UE according to the target beam direction, so as to complete random access.

11. The access apparatus according to claim 10, wherein the second transmitting device further comprises:

5 a device selecting device configured to when receiving random access information from a plurality of UEs corresponding to the same preamble sequence information, select one accessible UE therefrom based on signal quality information of respective random access information of the plurality of UEs so as to transmit access confirmation information to the accessible UE.

12. The access apparatus according to any one of claims 7-11, wherein the access apparatus further comprises:

10 a direction resuming device configured to resume the beam directions which the plurality of radio frequency channels initially corresponding to respectively, such that the plurality of radio frequency channels receive data according to their respective corresponding beam directions so as to receive preamble sequence information transmitted by other UEs.

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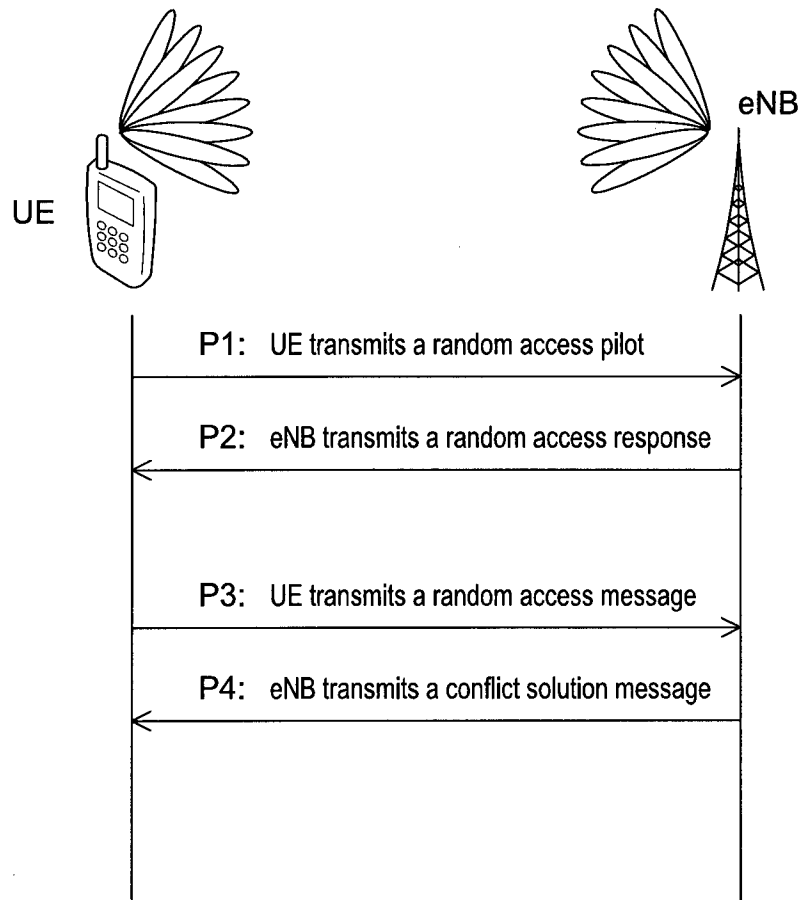
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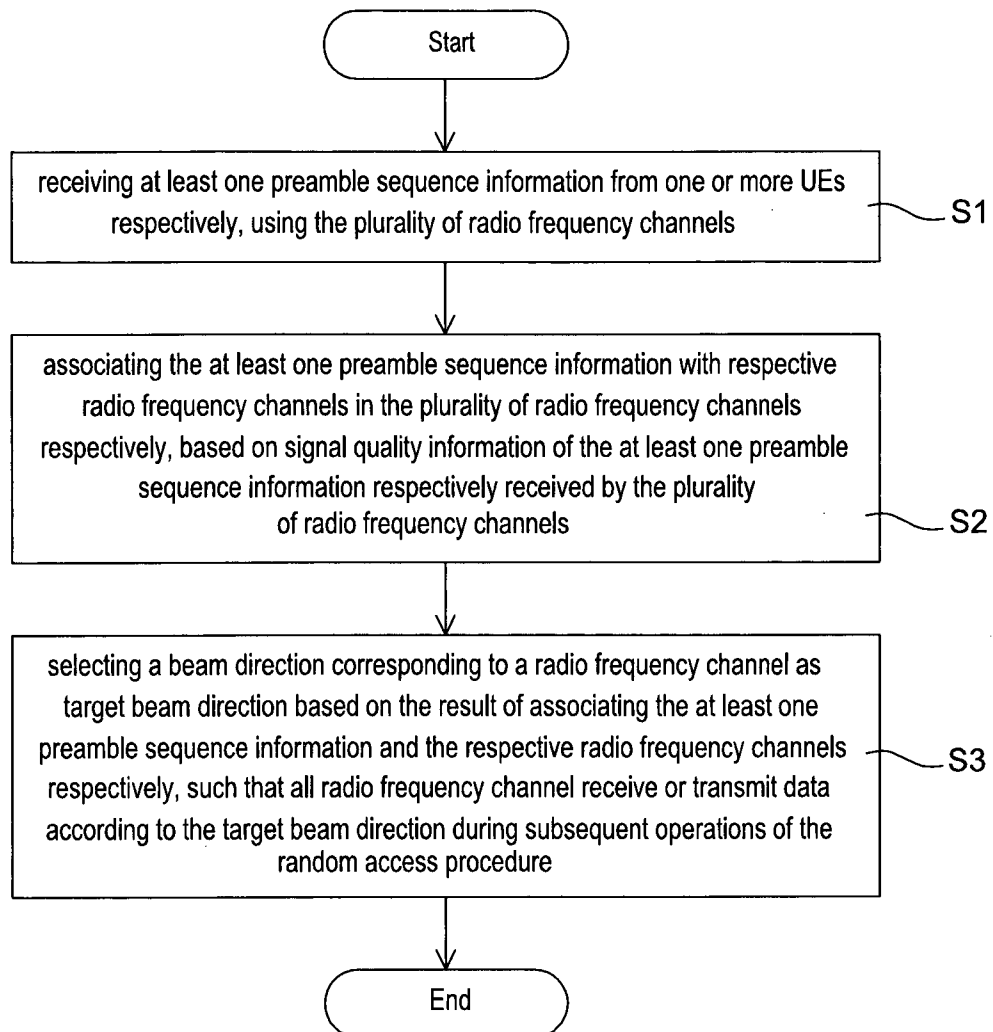
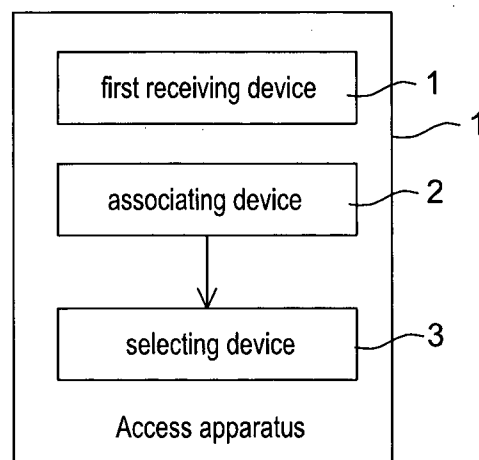
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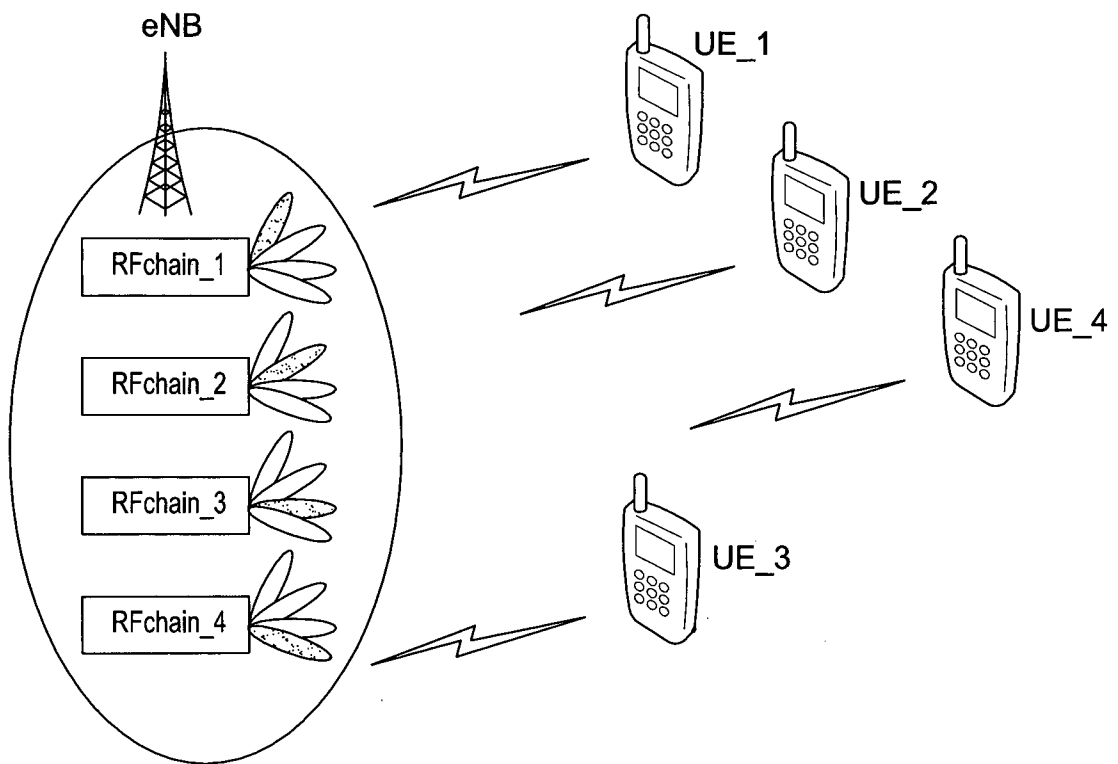
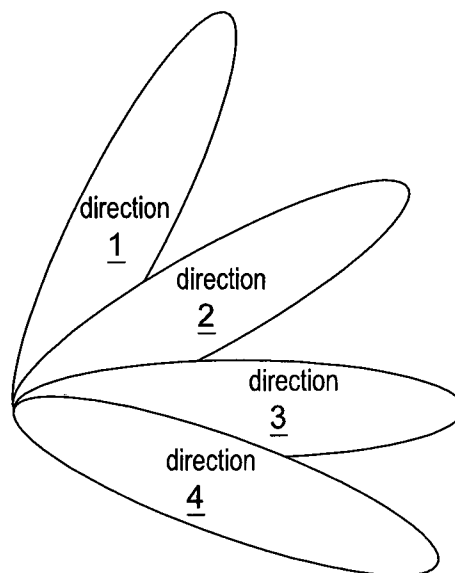
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**Fig. 1**

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**Fig. 2****Fig. 3**

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**Fig. 4a****Fig. 4b**

INTERNATIONAL SEARCH REPORT

International application No

PCT/IB2016/001876

A. CLASSIFICATION OF SUBJECT MATTER

INV. H04B7/06 H04B7/08

ADD.

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

H04B

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

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

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2007/054701 A1 (HOVERS OMRI [IL] ET AL) 8 March 2007 (2007-03-08) paragraph [0061] figure 3 figure 12 figure 13 paragraph [0239] paragraph [0172] paragraph [0173] paragraph [0165] paragraph [0180] - paragraph [0184] figure 23	1-12
A	----- US 2012/052898 A1 (HEGGE STEPHAN [JP]) 1 March 2012 (2012-03-01) paragraph [0050] - paragraph [0054]; figure 2 ----- -/-	4,5,10, 11



Further documents are listed in the continuation of Box C.



See patent family annex.

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Date of the actual completion of the international search

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INTERNATIONAL SEARCH REPORT

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C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

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