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Description

BACKGROUND

[0001] Geographically isolated antennas may be deployed to provide enhanced downlink multiple input, multiple output (MIMO) transmissions. For example, such a deployment may be utilized for indoor antenna deployment, in heterogeneous networks, coordinated multipoint (CoMP) transmissions wherein join transmission may be considered as one or more geographically separated antennas in a single cell. However, geographically isolated antennas may present potential issues such as with reference signal received power (PvSRP) measurements or resulting antenna gain imbalance (AGI) caused by the large antenna separation distance between different antennas. Geographically separated antenna subsets may experience different channel conditions resulting in severe AGI which may potentially impact performance of the system. Current systems assume that all antennas of a base station or enhanced node B (eNB) in a cell are geographically co-located. The RSRP measurements are only obtained for one or two antennas, for example from common reference signal (CRS) port 0 or port 1 , and the measurements are applied to all of the antennas of the system. However, the assumption may not be valid for geographically separated antennas that experience different channel conditions depending on their specific location, and as a result the measurements will not adequately reflect the real conditions of the cell.

[0002] Reference is made to WO 2010/102583 A1, which discloses a system and method for channel information feedback in a wireless communications system. The method for communications device operation includes receiving a pilot transmitted by a controller, computing a channel estimate for a channel between the controller and a communications device, the computing based on the pilot, computing a channel correlation matrix for the channel based on the channel estimate, and transmitting a reduced rank representation of the channel correlation matrix to the controller as a first feedback information. The method also includes adapting a first codebook based on the reduced rank representation of the channel correlation matrix, computing a representation of the channel using the adapted codebook, transmitting the representation of the channel as a second feedback information, and receiving a transmission beamformed based on the first feedback information and the second feedback information.

DESCRIPTION OF THE DRAWING FIGURES

[0003] Claimed subject matter is particularly pointed out and distinctly claimed in the concluding portion of the specification. However, such subject matter may be understood by reference to the following detailed description when read with the accompanying drawings in which:

Figure 1 is a diagram of an enhanced Node B (eNB) having geographically separated antennas in accordance with one or more embodiments;

Figure 2 is a diagram of an enhanced Node B (eNB) having geographically separated antennas in a cell utilizing a remote radio unit (RRU) in accordance with one or more embodiments;

Figure 3 is a diagram of an enhanced Node B (eNB) utilizing a codebook to select a precoding vector based at least in part on a channel condition in accordance with one or more embodiments;

Figure 4 is a flow diagram of a method to adjust the codebook for geographically separated antennas based at least in part on measured antenna gain imbalance (AGI) in accordance with one or more embodiments;

Figure 5 is a flow diagram of an alternative method to adjust the codebook for geographically separated antennas based at least in part on measured antenna gain imbalance (AGI) in accordance with one or more embodiments;

Figure 6 is a flow diagram of a method to adjust the codebook for geographically separated antennas based at least in part on channel state indicator reference signals (CSI-RS) based RSRP measurement in accordance with one or more embodiments;

Figure 7 is a block diagram of an information handling system capable of adjusting a codebook for geographically separated antennas in accordance with one or more embodiments; and

Figure 8 is an isometric view of the information handling system of Figure 7 that optionally may include a touch screen in accordance with one or more embodiments.

[0004] It will be appreciated that for simplicity and/or clarity of illustration, elements illustrated in the figures have not necessarily been drawn to scale. For example, the dimensions of some of the elements may be exaggerated relative to other elements for clarity. Further, if considered appropriate, reference numerals have been repeated among the figures to indicate corresponding and/or analogous elements.

DETAILED DESCRIPTION

[0005] In the following detailed description, numerous specific details are set forth to provide a thorough understanding of claimed subject matter. However, it will be understood by those skilled in the art that claimed subject matter may be practiced without these specific details. In other instances, well-known methods, procedures, components and/or circuits have not been described in detail.

[0006] In the following description and/or claims, the terms coupled and/or connected, along with their derivatives, may be used. In particular embodiments, connected may be used to indicate that two or more elements are in direct physical and/or electrical contact with each other. Coupled may mean that two or more elements are in direct physical and/or electrical contact. However, coupled may also mean that two or more elements may not be in direct contact with each other, but yet may still cooperate and/or interact with each other. For example, "coupled" may mean that two or more elements do not contact each other but are indirectly joined together via another element or intermediate elements. Finally, the terms "on," "overlying," and "over" may be used in the following description and claims. "On," "overlying," and "over" may be used to indicate that two or more elements are in direct physical contact with each other. However, "over" may also mean that two or more elements are not in direct contact with each other. For example, "over" may mean that one element is above another element but not contact each other and may have another element or elements in between the two elements. Furthermore, the term "and/or" may mean "and", it may mean "or", it may mean "exclusive-or", it may mean "one", it may mean "some, but not all", it may mean "neither", and/or it may mean "both", although the scope of claimed subject matter is not limited in this respect. In the following description and/or claims, the terms "comprise" and "include," along with their derivatives, may be used and are intended as synonyms for each other.

[0007] Referring now to Figure 1, a diagram of an enhanced Node B (eNB) having geographically separated antennas in accordance with one or more embodiments will be discussed. As shown in Figure 1, a wireless network 100 may comprise an enhanced Node B (eNB) 110 serving one or more user equipment (UE) devices such as UE 116, UE 118, UE 120, and UE 120 in the embodiment shown. The eNB 110 may have multiple antennas, for example a first set of antennas 112 and a second set of antennas 114 wherein the first set of antennas 112 and the second set of antennas 114 may be geographically separated by a significant distance. In other words, the first set of antennas 112 and the second set of antennas 114 are not co-located. In such an arrangement, a first group of UE devices such as UE 116 and UE 118 may be in communication with the eNB 112 via the first set of antennas 112, and a second group of UE devices such as UE 120 and UE 122 may be in communication with the eNB 110 via the second set of antennas 114. It should be noted that the eNB 110 and the UE devices may be operating in compliance with a Long Term Evolution (LTE) standard and/or any developments or advancements of such a standard, for example LTE-Advanced, wherein network 100 may comprise an LTE network. In general, eNB 110 may be referred to generically as a base transceiver station or just a base station, and any one or more of the UEs may be referred to generically as a mobile station, mobile device, or just device, and the scope of the claimed subject matter is not limited in these respects. It should be noted network 100 may be discussed herein as an LTE network for purposes of discussion, but network 100 may comprise any type of wireless network such as a wireless wide area network (WWAN), a wireless local area network (WLAN), or the like, in compliance with any various wireless network standard such as a Worldwide Interoperability for Microwave Access (WiMAX) network in compliance with an Institute of Electrical and Electronics Engineers (IEEE) 802.16e standard, a WiMAX-II network in compliance with an IEEE 802.16m standard, and so on, and the scope of the claimed subject matter is not limited in this respect.

[0008] As shown in Figure 1, since the two sets of antennas of eNB 110 are geographically separated, the first set of antennas 112 may experience different channel conditions than that of the second set of antennas 114. As a result, there may be resulting antenna gain imbalance (AGI) among the antennas of the eNB 110. In such a situation, any channel measurements made with the first set of antennas 112, for example reference signal received power (RSRP) measurements, may not be valid for the second set of antennas 114. For example, in the current LTE specification, the RSRP measurement utilizes common reference signal (CRS) port 0 and optionally utilizes CRS port 1, both of which may be mapped to the first set of antennas 112. The measurements for the first set of antennas 112 are then applied to all of the antennas of eNB 110 including the second set of antennas 114. However, with any AGI resulting from the geographically separated antennas, the measurements taken on only one set of antennas cannot be applied to the other sets of antennas. As a result, adjustments may be made in order to accommodate for such AGI as discussed in further detail, below.

[0009] Referring now to Figure 2, a diagram of an enhanced Node B (eNB) having geographically separated antennas in a cell utilizing a remote radio unit (RRU) in accordance with one or more embodiments will be discussed. In the example shown in Figure 2, enhanced Node B (eNB) 110 of network 200 may serve three cells such as Cell 0, Cell 1, and Cell 2. The first set of antennas 112 of eNB 110 may be utilized to communicate with user equipment (UE) 116 that is in close proximity to the first set of antennas 112. UE devices that are located toward a distal region of any of the cells away from the eNB 110, such as UE 120, may communicate with eNB 110 via a second set of antennas 114 that are geographically separated in a cell from the first set of antennas 112. In some embodiments, the second set of antennas 114 may be the antennas of a remote radio unit (RRU) 210 coupled to eNB 110, for example in a Coordinated Multipoint (CoMP) deployment. In some embodiments, multiple RRUs coupled to eNB 110 may be utilized within a single cell wherein the RRUs have a corresponding additional set of antennas to communicate with one or more UEs depending on the location of the UE with respect to eNB 110 and given RRU, signal strength, channel conditions, and so on. It should be noted, however, that Figure 2 illustrates an example deployment of multiple sets of geographically separated antennas using one or more

RRUs, and the scope of the claimed subject matter is not limited in this respect.

[0010] Referring now to Figure 3, a diagram of an enhanced Node B (eNB) utilizing a codebook to select a precoding vector based at least in part on a channel condition in accordance with one or more embodiments will be discussed. As shown in Figure 3, the enhanced Node B (eNB) 110 may utilize a codebook 316 to select an appropriate precoding vector W based at least in part on a condition of the channel H 314. In such an arrangement, the transmitter of the transceiver 310 of eNB 110 transmits reference signals to the receiver of the transceiver 312 of user equipment (UE) 116. The UE 116 then may estimate the channel via channel estimation block 314 as determined from the received reference signals. The UE 116 may then provide feedback to the eNB 110, for example as a precoding matrix index (PMI), that is utilized by the eNB 100 to select an appropriate precoding vector from the codebook 316. The eNB 110 may then transmit data to the UE 116 using the precoding vector to weight the transmitted data to accommodate for the conditions of the channel H 314. In one or more embodiments, the precoding vector W may be adjusted via adjustment of the codebook 316 in order to accommodate any antenna gain imbalance (AGI) that is detected between two or more sets of geographically separated antennas.

[0011] Referring now to Figure 4, a flow diagram of a method to adjust the codebook for geographically separated antennas based at least in part on measured antenna gain imbalance (AGI) in accordance with one or more embodiments will be discussed. Although method 400 of Figure 4 illustrates one particular embodiment of a method to adjust a codebook 316, other embodiments of method 400 may include greater or fewer blocks than shown, and/or in various different orders, and the scope of the claimed subject matter is not limited in this respect. Method 400 adjusts the codebook 316 based at least in part on a determined AGI among two or more sets of antennas of eNB 110. Since the codebook 316 of a current Long Term Evolution (LTE) standard is designed for co-located antennas without considering AGI, on one or more embodiments, the AGI may be determined at least in part, and an appropriate adjustment of the precoding vector may be performed as follows:

$$\mathbf{W_{adj} = G * W_{org}}$$

wherein W_{org} is the original precoding vector from the codebook 316, G is the weight adjustment vector, and $\mathbf{W_{adj}}$ is the precoding vector after adjustment with the weight adjustment vector. The weight adjustment vector G is able to indicate the relative value of antenna gain for the distributed antennas of the multiple sets of antennas that may experience AGI. In one or more embodiments, the weight adjustment vector G may be derived from reference signal received power (RSRP) measurements reported by the UE 116, or alternatively by sounding reference signals (RS) measured at the eNB 110. For example, the weight adjustment vector G may be calculated as follows:

$$\mathbf{G = diag([RSRP_1\ RSRP_2 \ldots RSRPn_t])}$$

wherein $\mathbf{n_t}$ represents the number of transmission antennas at the eNB 110. Method 400 represents one embodiment to implement utilizing a weight adjustment vector G to adjust the precoding vector obtained from codebook 316. The approach of method 400 may be referred to as non-transparent to the UE 116 wherein the UE 116 adjusts the codebook 316 with the weight adjustment vector G before the precoding matrix indicator (PMI) search. In such an embodiment, reference signals are transmitted from the eNB 110 to the UE 116 at block 410. The UE 116 then estimates the channel at block 412 using the received reference signals. The UE 116 then calculates the weight adjustment vector G at block 414 which may be based at least in part on the reference signals, for example RSRP measurements. The UE 116 utilizes the weight adjustment vector G in the PMI search at block 416 and provides PMI feedback to the eNB 110. With this PMI feedback received from the UE 116, the eNB 110 selects a precoding vector from the codebook 316 at block 418 based on the PMI feedback and applies the adjustment vector G to the selected precoding vector at block 420. The weight adjustment vector G is calculated or reconstructed by the eNB 110 from RSRP feedback or sounding reference signal (RS). The eNB 110 may then transmit data at block 422 using the adjusted precoding vector.

[0012] Referring now to Figure 5, a flow diagram of an alternative method to adjust the codebook for geographically separated antennas based at least in part on measured antenna gain imbalance (AGI) in accordance with one or more embodiments will be discussed. Although method 500 of Figure 5 illustrates one particular embodiment of a method to adjust a codebook 316, other embodiments of method 500 may include greater or fewer blocks than shown, and/or in various different orders, and the scope of the claimed subject matter is not limited in this respect. Method 500 of Figure 5 is similar to method 400 of Figure 4 except that method 500 may be referred to as transparent to the UE 116 wherein the UE 116 searches and feeds back the precoding matrix indicator (PMI) without codebook adjustment by the UE 116. In such an embodiment, the eNB 100 transmits reference signals to the UE 116 at block 510, and the UE 116 estimates the channel at block 512. The UE 116 then provides PMI feedback to the eNB 110 at block 514 without having the UE 116 provide any adjustment to the codebook 316 or without the UE 116 calculating the weight adjustment vector G. Based on RSRP feedback received from the UE 116 or on a sounding reference signal (RS), the eNB 110 calculates the weight adjustment vector G at block 516, and at block 518 adjusts the precoding vector selected from the codebook 316 based on the PMI feedback by applying the calculated weight adjustment vector. The weight adjustment vector may be obtained by the eNB 110 from a sounding RS measurement or other measurement. The eNB 110 may then transmit data at block 520 using the thus adjusted precoding vector. In one or more embodiments, a physical downlink shared channel (PDSCH) may be decoded based at least in part on such RS measurements, which may obviate any need for standardization for the UE transparent method 500, although the scope of the claimed subject matter is not limited in this respect.

[0013] Referring now to Figure 6, a flow diagram of a method to adjust the codebook for geographically separated antennas based at least in part on channel state indicator reference signals (CSI-RS) based RSRP measurement in accordance with one or more embodiments will be discussed. Although method 600 of Figure 6 illustrates one particular embodiment of a method to adjust a codebook 316, other embodiments of method 600 may include greater or fewer blocks than shown, and/or in various different orders, and the scope of the claimed subject matter is not limited in this respect. Figure 6 illustrates approach to obtain reference signal received power (RSRP) measurements for the respective antennas of geographically separated antenna sets wherein the codebook 316 may be adjusted using such RSRP measurements. In a general deployment, each antenna of eNB 110 may have a corresponding channel state indicator reference signals (CSI-RS or just CRS) port. By obtaining RSRP measurements for all of the CRS ports, the RSRP measurements may be utilized to determine the performance difference among different sets of geographically separated antennas. Thus, in one or more embodiments the CRS ports may be mapped at block 610 to multiple antennas of eNB 110 including to the sets of geographically separated antennas. In one or more particular embodiments, CRS ports may be mapped to fewer than all of the antennas, for example where each respective set of antennas is mapped with at least one CRS port. Then, per port RSRP measurements may be made at block 612 using the CSI-RS ports for the mapped antennas. In such embodiments per port RSRP measurements may be made for the mapped CSI-RS ports. The UE 116 then feeds back the RSRP measurements to the eNB 110 at block 614. The eNB 110 calculates the weight adjustment vector G at block 616 using the RSRP measurements which may be utilized at block 618 to adjust the precoding vector obtained from the codebook 316. The eNB 110 may then transmit data to UE 116 using the adjusted precoding vector 620. In one or more embodiments, the Layer 3 mobility measurements may be adjusted according to the method 600 of Figure 6, although the scope of the claimed subject matter is not limited in this respect.

[0014] Referring now to Figure 7, a block diagram of an information handling system capable of adjusting a codebook for geographically separated antennas in accordance with one or more embodiments will be discussed. Information handling system 700 of Figure 7 may tangibly embody one or more of any of the network elements, infrastructure nodes, or devices of the network 100 or network 200 as shown in and described with respect to Figure 1 or Figure 2. For example, information handling system 700 may represent the hardware of eNB 110, UE 116, and/or RRU 118, with greater or fewer components depending on the hardware specifications of the particular device, node, or network element. Although information handling system 700 represents one example of several types of computing platforms, information handling system 700 may include more or fewer elements and/or different arrangements of elements than shown in Figure 7, and the scope of the claimed subject matter is not limited in these respects.

[0015] In one or more embodiments, information handling system 700 may include an applications processor 710 and a baseband processor 712. Applications processor 710 may be utilized as a general purpose processor to run applications and the various subsystems for information handling system 700. Applications processor 710 may include a single core or alternatively may include multiple processing cores wherein one or more of the cores may comprise a digital signal processor or digital signal processing core. Furthermore, applications processor 710 may include a graphics processor or coprocessor disposed on the same chip, or alternatively a graphics processor coupled to applications processor 710 may comprise a separate, discrete graphics chip. Applications processor 710 may include on board memory such as cache memory, and further may be coupled to external memory devices such as synchronous dynamic random access memory (SDRAM) 714 for storing and/or executing applications during operation, and NAND flash 716 for storing applications and/or data even when information handling system 700 is powered off. Baseband processor 712 may control the broadband radio functions for information handling system 700. Baseband processor 712 may store code for controlling such broadband radio functions in a NOR flash 718. Baseband processor 712 controls a wireless wide area network (WWAN) transceiver 720 which is used for modulating and/or demodulating broadband network signals, for example for communicating via a 3GPP LTE network or the like as discussed herein with respect to Figure 2. The WWAN transceiver 720 couples to one or more power amps 722 respectively coupled to one or more antennas 724 for sending and receiving radiofrequency signals via the WWAN broadband network. The baseband processor 712 also may control a wireless local area network (WLAN) transceiver 726 coupled to one or more suitable antennas 728 and which may be capable of communicating via a Wi-Fi, Bluetooth, and/or an amplitude modulation (AM) or frequency modulation (FM) radio standard including an IEEE 802.11 a/b/g/n standard or the like. It should be noted that these are merely example implementations for applications processor 710 and baseband processor 712, and the scope of the claimed subject matter is not limited in these respects. For example, any one or more of SDRAM 714, NAND flash 716 and/or NOR flash 718 may comprise other types of memory technology such as magnetic memory, chalcogenide memory, phase change memory, or ovonic memory, and the scope of the claimed subject matter is not limited in this respect.

[0016] In one or more embodiments, applications processor 710 may drive a display 730 for displaying various information or data, and may further receive touch input from a user via a touch screen 732 for example via a finger or a stylus. An ambient light sensor 734 may be utilized to detect an amount of ambient light in which information handling system 700 is operating, for example to control a brightness or contrast value for display 730 as a function of the intensity of ambient light detected by ambient light sensor 734. One or more cameras 736 may be utilized to capture images that are processed by applications processor 710 and/or at least temporarily stored in NAND flash 716. Furthermore, applications processor may couple to a gyroscope 738, accelerometer 740, magnetometer 742, audio coder/decoder (CODEC) 744, and/or global positioning system (GPS) controller 746 coupled to an appropriate GPS antenna 748, for detection of various environmental properties including location, movement, and/or orientation of information handling system 700. Alternatively, controller 746 may comprise a Global Navigation Satellite System (GNSS) controller. Audio CODEC 744 may be coupled to one or more audio ports 750 to provide microphone input and speaker outputs either via internal devices and/or via external devices coupled to information handling system via the audio ports 750, for example via a headphone and microphone jack. In addition, applications processor 710 may couple to one or more input/output (I/O) transceivers 752 to couple to one or more I/O ports 754 such as a universal serial bus (USB) port, a high-definition multimedia interface (HDMI) port, a serial port, and so on. Furthermore, one or more of the I/O transceivers 752 may couple to one or more memory slots 756 for optional removable memory such as secure digital (SD) card or a subscriber identity module (SIM) card, although the scope of the claimed subject matter is not limited in these respects.

[0017] Referring now to Figure 8, an isometric view of the information handling system of Figure 7 that optionally may include a touch screen in accordance with one or more embodiments will be discussed. Figure 8 shows an example implementation of information handling system 700 of Figure 7 tangibly embodied as a cellular telephone, smartphone, or tablet type device or the like. In one or more embodiments, the information handling system 700 may comprise any one of the user equipment (UE) devices of Figure 1 or Figure 2, although the scope of the claimed subject matter is not limited in this respect. The information handling system 700 may comprise a housing 810 having a display 730 which may include a touch screen 732 for receiving tactile input control and commands via a finger 816 of a user and/or a via stylus 818 to control one or more applications processors 710. The housing 810 may house one or more components of information handling system 700, for example one or more applications processors 710, one or more of SDRAM 714, NAND flash 716, NOR flash 718, baseband processor 712, and/or WWAN transceiver 720. The information handling system 700 further may optionally include a physical actuator area 820 which may comprise a keyboard or buttons for controlling information handling system via one or more buttons or switches. The information handling system 700 may also include a memory port or slot 756 for receiving non-volatile memory such as flash memory, for example in the form of a secure digital (SD) card or a subscriber identity module (SIM) card. Optionally, the information handling system 700 may further include one or more speakers and/or microphones 824 and a connection port 754 for connecting the information handling system 700 to another electronic device, dock, display, battery charger, and so on. In addition, information handling system 700 may include a headphone or speaker jack 828 and one or more cameras 736 on one or more sides of the housing 810. It should be noted that the information handling system 700 of Figure 8 may include more or fewer elements than shown, in various arrangements, and the scope of the claimed subject matter is not limited in this respect.

[0018] Although the claimed subject matter has been described with a certain degree of particularity, it should be recognized that elements thereof may be altered by persons skilled in the art without departing from the spirit and/or scope of claimed subject matter. It is believed that the subject matter pertaining to geographically isolated antennas and/or many of its attendant utilities will be understood by the forgoing description, and it will be apparent that various changes may be made in the form, construction and/or arrangement of the components thereof without departing from the scope of the claimed subject matter or without sacrificing all of its material advantages, the form herein before described being merely an explanatory embodiment thereof, and/or further without providing substantial change thereto. It is the intention of the claims to encompass and/or include such changes.

Claims

1. A method (400) to adjust a codebook (316), comprising:

transmitting (410) a reference signal to a first device from a base transceiver station (110) having a first set of antennas (112) and a second set of antennas (114) geographically separated from the first set of antennas;

receiving feedback from the first device, the

feedback representing information that can be used to construct a weight adjustment vector;
selecting (418) a precoding vector from a codebook based at least in part on the feedback received from the first device;
calculating (420) the weight adjustment vector based at least in part on the feedback and applying the weight adjustment vector to the selected precoding vector to provide an adjusted precoding vector; and
transmitting (422) data to the first device using the adjusted precoding vector, wherein:

information represented in the feedback accommodates antenna gain imbalance between the first set of antennas and a second set of antennas.

2. The method as claimed in claim 1, further comprising transmitting a reference signal to a second device;
receiving feedback from the second device, the feedback representing information that can be used to construct the weight adjustment vector;
selecting a precoding vector from the codebook based at least in part on the feedback received from the second device;
calculating the weight adjustment vector based at least in part on the feedback received from the second device and applying the weight adjustment vector to the selected precoding vector to provide an adjusted precoding vector; and
transmitting data to the second device using the adjusted precoding vector.

3. The method as claimed in any of claim 1 or claim 2, wherein the first device or the second device comprises user equipment (UE) and the base transceiver station comprises an enhanced Node B (eNB).

4. The method as claimed in any of claim 1 or claim 2, wherein the weight adjustment vector is calculated with a reference signal received power, RSRP, measurement from the reference signal, wherein the RSRP measurement is obtained per each channel state indicator port reference signal, CSI-RS, port mapped to one or more of the first set of antennas or one or more of the second set of antennas.

5. The method as claimed in claim 1, further comprising:

receiving a reference signal from the base transceiver station;
calculating a weight adjustment vector based at least in part on the received reference signal;
sending feedback to the base transceiver station, the feedback representing the weight adjustment vector to allow the base transceiver to adjust a selected precoding vector from the codebook based at least in part on the feedback; and
receiving data transmitted from the base transceiver station via the first set of antennas wherein the transmitted data is adjusted the adjusted precoding vector.

6. A mobile station (116), comprising:

a transceiver (310) configured to receive a reference signal from base transceiver station (110) having a first set of antennas (112) and a second set of antennas (114) geographically separated from the first set of antennas; and
a processor to calculate a weight adjustment vector based at least in part on the received reference signal;

wherein the mobile station sends feedback to the base transceiver station, the feedback representing the weight adjustment vector to allow the base transceiver to adjust a selected precoding vector from the codebook based at least in part on the feedback, and the mobile station receives data transmitted from the base transceiver station via the first set of antennas wherein the transmitted data is adjusted using
the adjusted precoding vector, wherein:

the weight adjustment vector represented in the feedback accommodates antenna gain imbalance between the first set of antennas and the second set of antennas.

7. The mobile station as claimed in claim 6, wherein the mobile station comprises user equipment, UE, and the base transceiver station comprises an enhanced Node B, eNB.

8. The mobile station as claimed in claim 6, wherein the feedback comprises a precoding matrix indicator.

9. The mobile station as claimed in claim 6, wherein the weight adjustment vector is calculated with a reference signal received power, RSRP, measurement from the reference signal.

10. The mobile station as claimed in claim 9, wherein the RSRP measurement is obtained per each channel state indicator port reference signal, CSI-RS, port mapped to one or more of the first set of antennas or one or more of the second set of antennas.

11. The mobile station as claimed in claim 6, further comprising a touch screen to receive an input command from a finger or a stylus to control the processor.

12. An apparatus comprising means to perform a method as claimed in any claim 1-5.

13. Machine-readable storage including machine-readable instructions, when executed, to implement a method as claimed in any claim 1-5.

Patentansprüche

1. Verfahren (400) zum Gewichten eines Codebuchs (316), umfassend:

Senden (410) eines Referenzsignals von einer BTS (Base Transceiver Station) (110) mit einem ersten Satz Antennen (112) und einem zweiten Satz Antennen (114), der geografisch von dem ersten Satz Antennen getrennt ist, an eine erste Vorrichtung;
Empfangen einer Rückmeldung von der ersten Vorrichtung, wobei die Rückmeldung Informationen repräsentiert, die zum Konstruieren eines Gewichtungsvektors verwendbar sind;
Auswählen (418) eines Vorcodiervektors aus einem Codebuch zumindest teilweise auf der Grundlage der von der ersten Vorrichtung erhaltenen Rückmeldung;
Berechnen (420) des Gewichtungsvektors zumindest teilweise auf der Grundlage der Rückmeldung und Anlegen des Gewichtungsvektors an den ausgewählten Vorcodiervektor zum Bereitstellen eines gewichteten Vorcodiervektors; und
Senden (422) von Daten an die erste Vorrichtung unter Verwendung des gewichteten Vorcodiervektors, wobei:

die in der Rückmeldung repräsentierten Informationen ein Ungleichgewicht der Antennenverstärkung zwischen dem ersten Satz Antennen und einem zweiten Satz Antennen enthalten.

2. Verfahren nach Anspruch 1, weiterhin umfassend Senden eines Referenzsignals an eine zweite Vorrichtung;
Empfangen einer Rückmeldung von der zweiten Vorrichtung, wobei die Rückmeldung Informationen repräsentiert, die zum Konstruieren des Gewichtungsvektors verwendbar sind;
Auswählen eines Vorcodiervektors aus dem Codebuch zumindest teilweise auf der Grundlage der von der zweiten Vorrichtung erhaltenen Rückmeldung;
Berechnen des Gewichtungsvektors zumindest teilweise auf der Grundlage der von der zweiten Vorrichtung empfangenen Rückmeldung und Anlegen des Gewichtungsvektors an den ausgewählten Vorcodiervektor zum Bereitstellen eines gewichteten Vorcodiervektors; und
Senden von Daten an die zweite Vorrichtung unter Verwendung des gewichteten Vorcodiervektors.

3. Verfahren nach einem der Ansprüche 1 oder 2, wobei die erste Vorrichtung oder die zweite Vorrichtung ein Teilnehmerendgerät (UE) umfasst und die BTS einen erweiterten Knoten B (eNB) umfasst.

4. Verfahren nach einem der Ansprüche 1 oder 2, wobei der Gewichtungsvektor mit einer RSRP(Reference Signal Received Power)-Messung des Referenzsignals berechnet wird, wobei die RSRP-Messung pro CSI-RS(Channel State Indicator Reference Signal)-Port erhalten wird, der an einer oder mehreren des ersten Satzes Antennen oder einer oder mehreren des zweiten Satzes Antennen abgebildet wird.

5. Verfahren nach Anspruch 1, weiterhin umfassend:

Empfangen eines Referenzsignals von einer BTS;
Berechnen eines Gewichtungsvektors zumindest teilweise auf der Grundlage des empfangenen Referenzsignals;
Senden einer Rückmeldung an die BTS, wobei die den Gewichtungsvektor repräsentierende Rückmeldung der BTS das Gewichten eines aus dem Codebuch ausgewählten Vorcodiervektors zumindest teilweise auf der Grundlage der Rückmeldung ermöglicht; und
Empfangen von Daten, die von der BTS über den ersten Satz Antennen gesendet werden, wobei die gesendeten Daten den gewichteten Vorcodiervektor gewichtet werden.

6. Mobilstation (116), umfassend:

einen Transceiver (310), der zum Empfangen eines Referenzsignals von einer BTS (110) mit einem ersten Satz Antennen (112) und einem zweiten Satz Antennen (114), der geografisch von dem ersten Satz Antennen getrennt ist, konfiguriert ist; und
einen Prozessor zum Berechnen eines Gewichtungsvektors zumindest teilweise auf der Grundlage des empfangenen Referenzsignals;

wobei die Mobilstation eine Rückmeldung an die BTS sendet, wobei die den Gewichtungsvektor repräsentierende Rückmeldung der BTS das Gewichten eines aus dem Codebuch ausgewählten Vorcodiervektors zumindest teilweise auf der Grundlage der Rückmeldung ermöglicht, und wobei die Mobilstation Daten empfängt, die von der BTS über den ersten Satz Antennen gesendet werden, wobei die gesendeten Daten unter Verwendung des gewichteten Vorcodiervektors gewichtet werden, wobei:

der in der Rückmeldung repräsentierte Gewichtungsvektor ein Ungleichgewicht der Antennenverstärkung zwischen dem ersten Satz Antennen und dem zweiten Satz Antennen enthält.

7. Mobilstation nach Anspruch 6, wobei die Mobilstation ein Teilnehmerendgerät (UE) umfasst und die BTS einen erweiterten Knoten B (eNB) umfasst.

8. Mobilstation nach Anspruch 6, wobei die Rückmeldung einen Indikator für eine Vorcodiermatrix umfasst.

9. Mobilstation nach Anspruch 6, wobei der Gewichtungsvektor mit einer RSRP-Messung des Referenzsignals berechnet wird.

10. Mobilstation nach Anspruch 9, wobei die RSRP-Messung pro CSI-RS-Port erhalten wird, der an einer oder mehreren des ersten Satzes Antennen oder einer oder mehreren des zweiten Satzes Antennen abgebildet wird.

11. Mobilstation nach Anspruch 6, weiterhin umfassend einen Touchscreen zum Empfangen eines Eingabebefehls von einem Finger oder einem Stift zum Steuern des Prozessors.

12. Vorrichtung, umfassend Mittel zum Durchführen eines Verfahrens nach einem der Ansprüche 1-5.

13. Maschinenlesbarer Speicher mit maschinenlesbaren Anweisungen, die bei Ausführung ein Verfahren nach einem der Ansprüche 1-5 umsetzen.

Revendications

1. Procédé (400) pour régler un livre de codes (316), consistant à :

transmettre (410) un signal de référence à un premier dispositif depuis une station d'émetteur-récepteur de base (110) ayant un premier ensemble d'antennes (112) et un second ensemble d'antennes (114) séparé géographiquement du premier ensemble d'antennes ;
recevoir une rétroaction du premier dispositif, la rétroaction représentant des informations qui peuvent être utilisées pour construire un vecteur d'ajustement de coefficient de pondération ;
sélectionner (418) un vecteur de précodage à partir d'un livre de codes en se basant, du moins en partie, sur la rétroaction reçue du premier dispositif ;
calculer (420) le vecteur d'ajustement de coefficient de pondération en se basant, du moins en partie, sur la rétroaction et appliquer le vecteur d'ajustement de coefficient de pondération au vecteur de précodage sélectionné pour donner un vecteur de précodage ajusté ; et
transmettre (422) des données au premier dispositif à l'aide du vecteur de précodage ajusté, dans lequel :

des informations représentées dans la rétroaction contiennent un déséquilibre de gain d'antenne entre le premier ensemble d'antennes et le second ensemble d'antennes.

2. Procédé selon la revendication 1, consistant en outre à transmettre un signal de référence à un second dispositif ;
recevoir une rétroaction du second dispositif, la rétroaction représentant des informations qui peuvent être utilisées pour construire le vecteur d'ajustement de coefficient de pondération ;
sélectionner un vecteur de précodage à partir du livre de codes en se basant, du moins en partie, sur la rétroaction reçue du second dispositif ;
calculer le vecteur d'ajustement de coefficient de pondération en se basant, du moins en partie, sur la rétroaction reçue du second dispositif et appliquer le vecteur d'ajustement de coefficient de pondération au vecteur de précodage sélectionné pour donner un vecteur de précodage ajusté ; et
transmettre des données au second dispositif à l'aide du vecteur de précodage ajusté.

3. Procédé selon l'une quelconque de la revendication 1 ou de la revendication 2, dans lequel le premier dispositif ou le second dispositif comprend un équipement utilisateur (UE) et la station d'émetteur-récepteur de base comprend un noeud B évolué (eNB).

4. Procédé selon l'une quelconque de la revendication 1 ou de la revendication 2, dans lequel le vecteur d'ajustement de coefficient de pondération est calculé avec une mesure de puissance reçue de signal de référence (RSRP) provenant du signal de référence, la mesure de puissance RSRP étant obtenue pour chaque port de signal de référence de port indicateur d'état de canal (CSI-RS) mappé sur une ou plusieurs antennes du premier ensemble d'antennes ou sur une ou plusieurs antennes du second ensemble d'antennes.

5. Procédé selon la revendication 1, consistant en outre à :

recevoir un signal de référence de la station d'émetteur-récepteur de base ;

calculer un vecteur d'ajustement de coefficient de pondération en se basant, du moins en partie, sur le signal de référence reçu ;
envoyer une rétroaction à la station d'émetteur-récepteur de base, la rétroaction représentant le vecteur d'ajustement de coefficient de pondération pour permettre à l'émetteur-récepteur de base d'ajuster un vecteur de précodage sélectionné à partir du livre de codes en se basant, du moins en partie, sur la rétroaction ; et
recevoir des données transmises depuis la station d'émetteur-récepteur de base par le biais du premier ensemble d'antennes, les données transmises étant ajustées le vecteur de précodage ajusté.

6. Station mobile (116), comprenant :

un émetteur-récepteur (310) configuré pour recevoir un signal de référence de la station d'émetteur-récepteur de base (110) ayant un premier ensemble d'antennes (112) et un second ensemble d'antennes (114) séparé géographiquement du premier ensemble d'antennes ; et
un processeur pour calculer un vecteur d'ajustement de coefficient de pondération en se basant, du moins en partie, sur le signal de référence reçu ;

la station mobile envoyant une rétroaction à la station d'émetteur-récepteur de base, la rétroaction représentant le vecteur d'ajustement de coefficient de pondération pour permettre à l'émetteur-récepteur de base d'ajuster un vecteur de précodage sélectionné à partir du livre de codes en se basant, du moins en partie, sur la rétroaction, et la station mobile recevant des données transmises depuis la station d'émetteur-récepteur de base par le biais du premier ensemble d'antennes, les données transmises étant ajustées à l'aide du vecteur de précodage ajusté, dans laquelle :

le vecteur d'ajustement de coefficient de pondération représenté dans la rétroaction contient un déséquilibre de gain d'antenne entre le premier ensemble d'antennes et le second ensemble d'antennes.

7. Station mobile selon la revendication 6, la station mobile comprenant un équipement utilisateur (UE) et la station d'émetteur-récepteur de base comprend un noeud B évolué (eNB).

8. Station mobile selon la revendication 6, dans laquelle la rétroaction comprend un indicateur de matrice de précodage.

9. Station mobile selon la revendication 6, dans laquelle le vecteur d'ajustement de coefficient de pondération est calculé avec une mesure de puissance reçue de signal de référence (RSRP) provenant du signal de référence.

10. Station mobile selon la revendication 9, dans laquelle la mesure RSRP est obtenue pour chaque port de signal de référence de port indicateur d'état de canal (CSI-RS) mappé sur une ou plusieurs antennes du premier ensemble d'antennes ou sur une ou plusieurs antennes du second ensemble d'antennes.

11. Station mobile selon la revendication 6, comprenant en outre un écran tactile pour recevoir une commande de saisie d'un doigt ou d'un stylet pour commander le processeur.

12. Appareil comprenant un moyen pour exécuter un procédé selon l'une quelconque des revendications 1 à 5.

13. Stockage lisible par une machine comportant des instructions lisibles par une machine, lorsqu'elles sont exécutées, pour mettre en ouvre un procédé selon l'une quelconque des revendications 1 à 5.

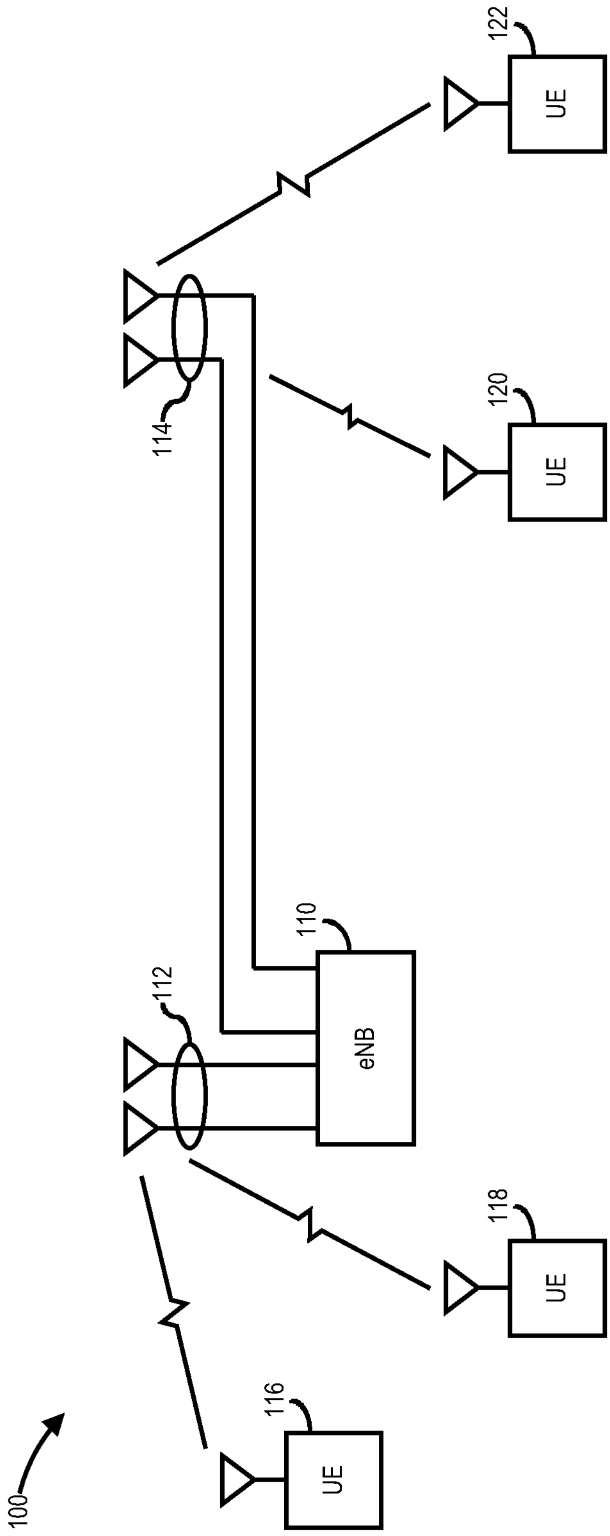

FIG. 1

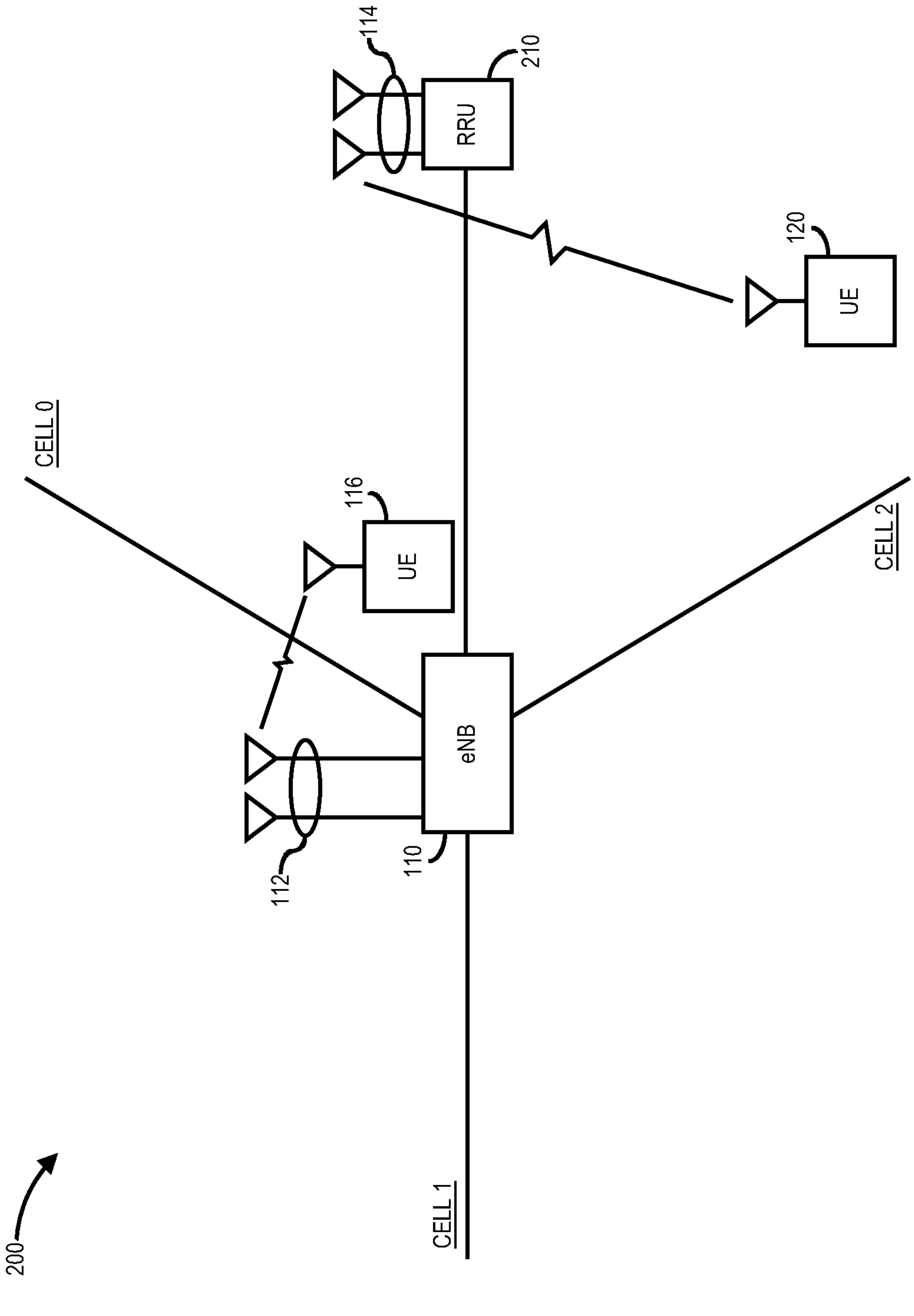

FIG. 2

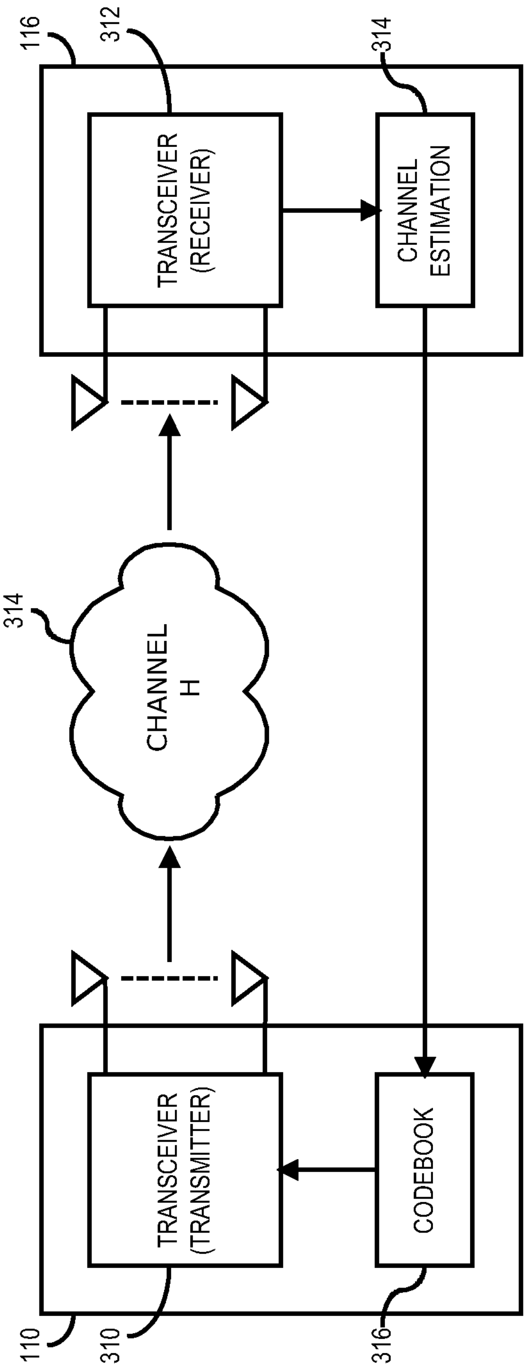
116
312
TRANSCEIVER (RECEIVER)
314
CHANNEL ESTIMATION
314
CHANNEL H
TRANSCEIVER (TRANSMITTER)
CODEBOOK
110
310
316

FIG. 3

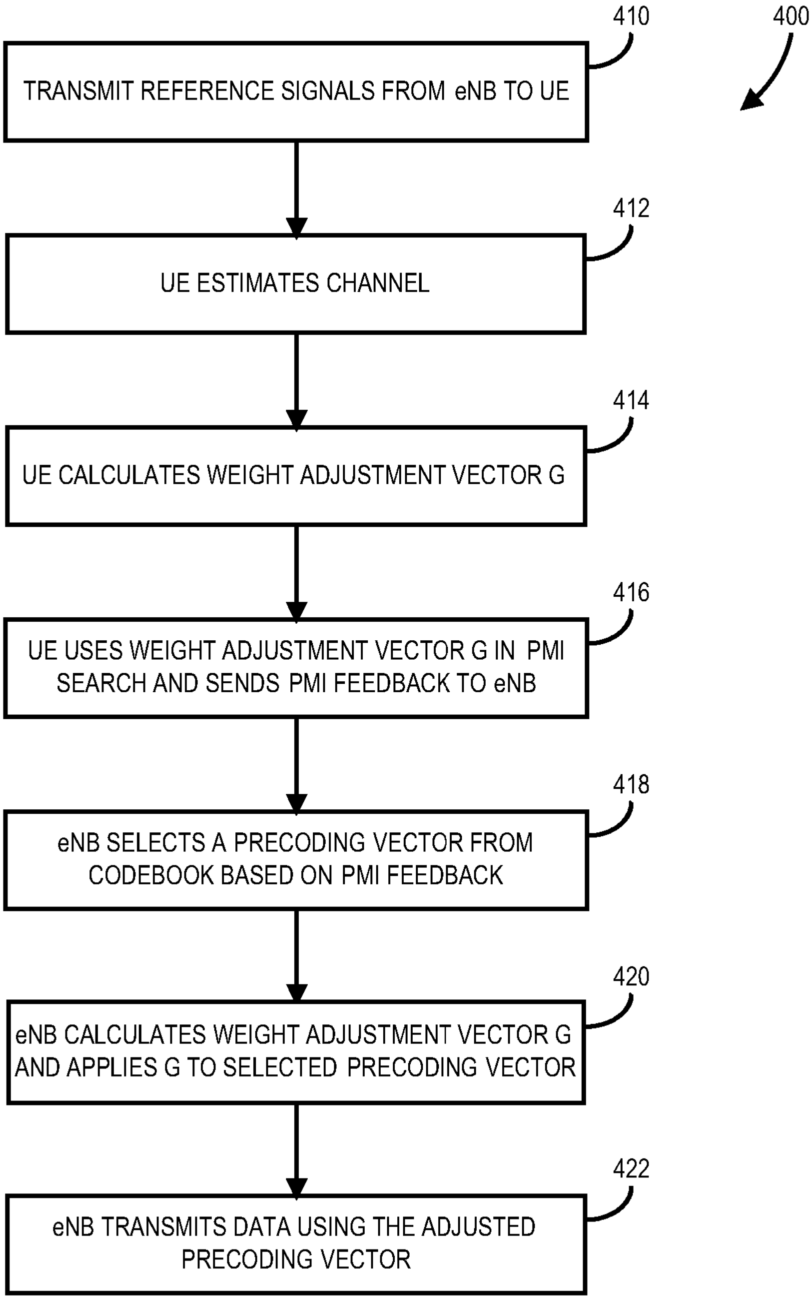
400
410
TRANSMIT REFERENCE SIGNALS FROM eNB TO UE
412
UE ESTIMATES CHANNEL
414
UE CALCULATES WEIGHT ADJUSTMENT VECTOR G
416
UE USES WEIGHT ADJUSTMENT VECTOR G IN PMI SEARCH AND SENDS PMI FEEDBACK TO eNB
418
eNB SELECTS A PRECODING VECTOR FROM CODEBOOK BASED ON PMI FEEDBACK
420
eNB CALCULATES WEIGHT ADJUSTMENT VECTOR G AND APPLIES G TO SELECTED PRECODING VECTOR
422
eNB TRANSMITS DATA USING THE ADJUSTED PRECODING VECTOR

FIG. 4

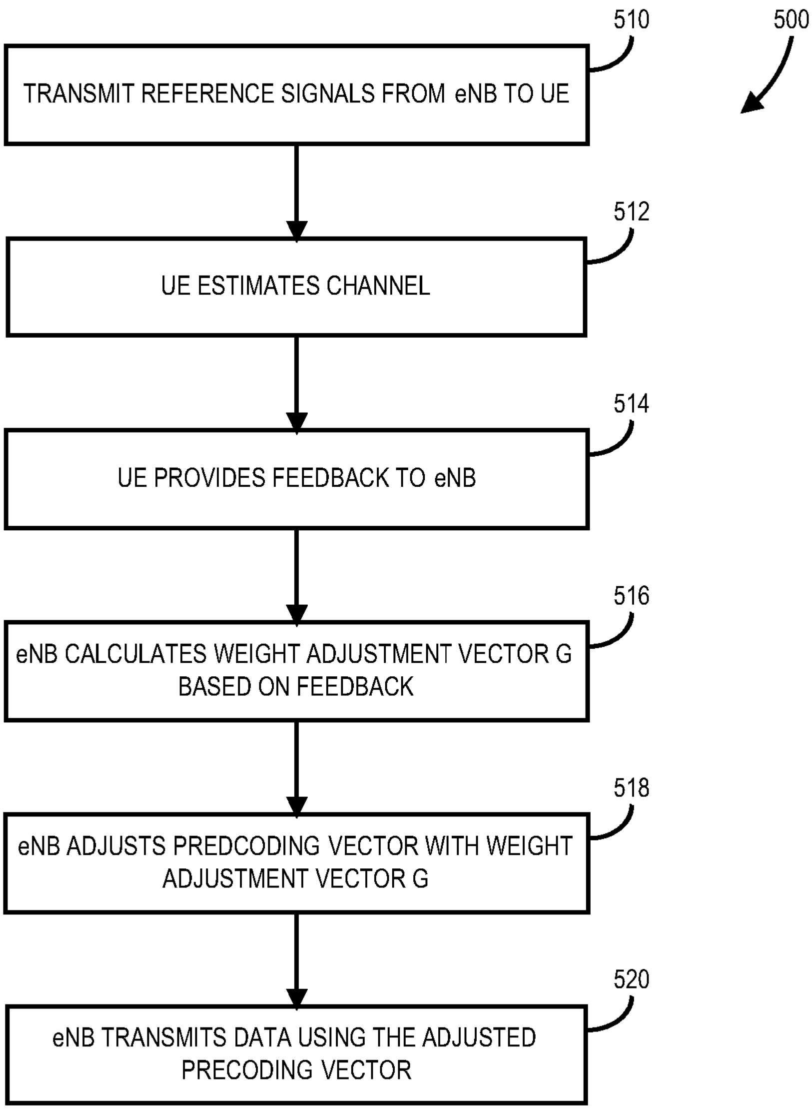
510
500
TRANSMIT REFERENCE SIGNALS FROM eNB TO UE
512
UE ESTIMATES CHANNEL
514
UE PROVIDES FEEDBACK TO eNB
516
eNB CALCULATES WEIGHT ADJUSTMENT VECTOR G BASED ON FEEDBACK
518
eNB ADJUSTS PREDCODING VECTOR WITH WEIGHT ADJUSTMENT VECTOR G
520
eNB TRANSMITS DATA USING THE ADJUSTED PRECODING VECTOR

FIG. 5

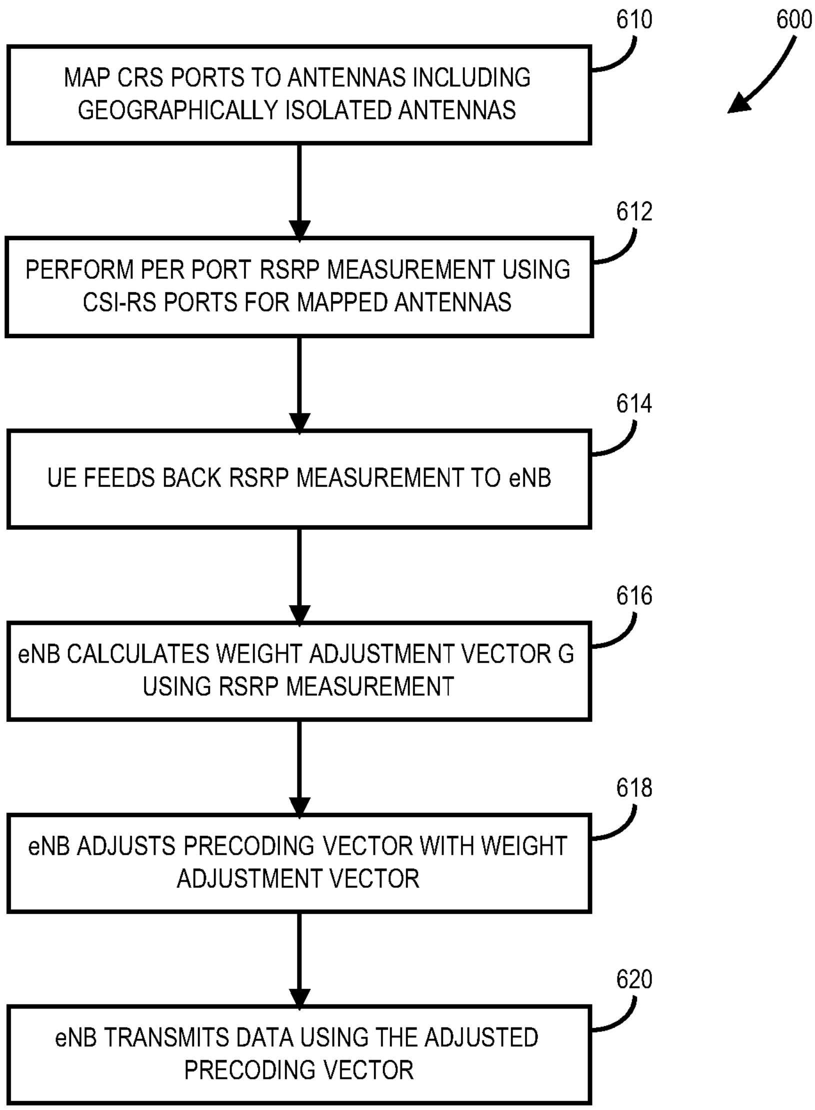
610
600
MAP CRS PORTS TO ANTENNAS INCLUDING GEOGRAPHICALLY ISOLATED ANTENNAS
612
PERFORM PER PORT RSRP MEASUREMENT USING CSI-RS PORTS FOR MAPPED ANTENNAS
614
UE FEEDS BACK RSRP MEASUREMENT TO eNB
616
eNB CALCULATES WEIGHT ADJUSTMENT VECTOR G USING RSRP MEASUREMENT
618
eNB ADJUSTS PRECODING VECTOR WITH WEIGHT ADJUSTMENT VECTOR
620
eNB TRANSMITS DATA USING THE ADJUSTED PRECODING VECTOR

FIG. 6

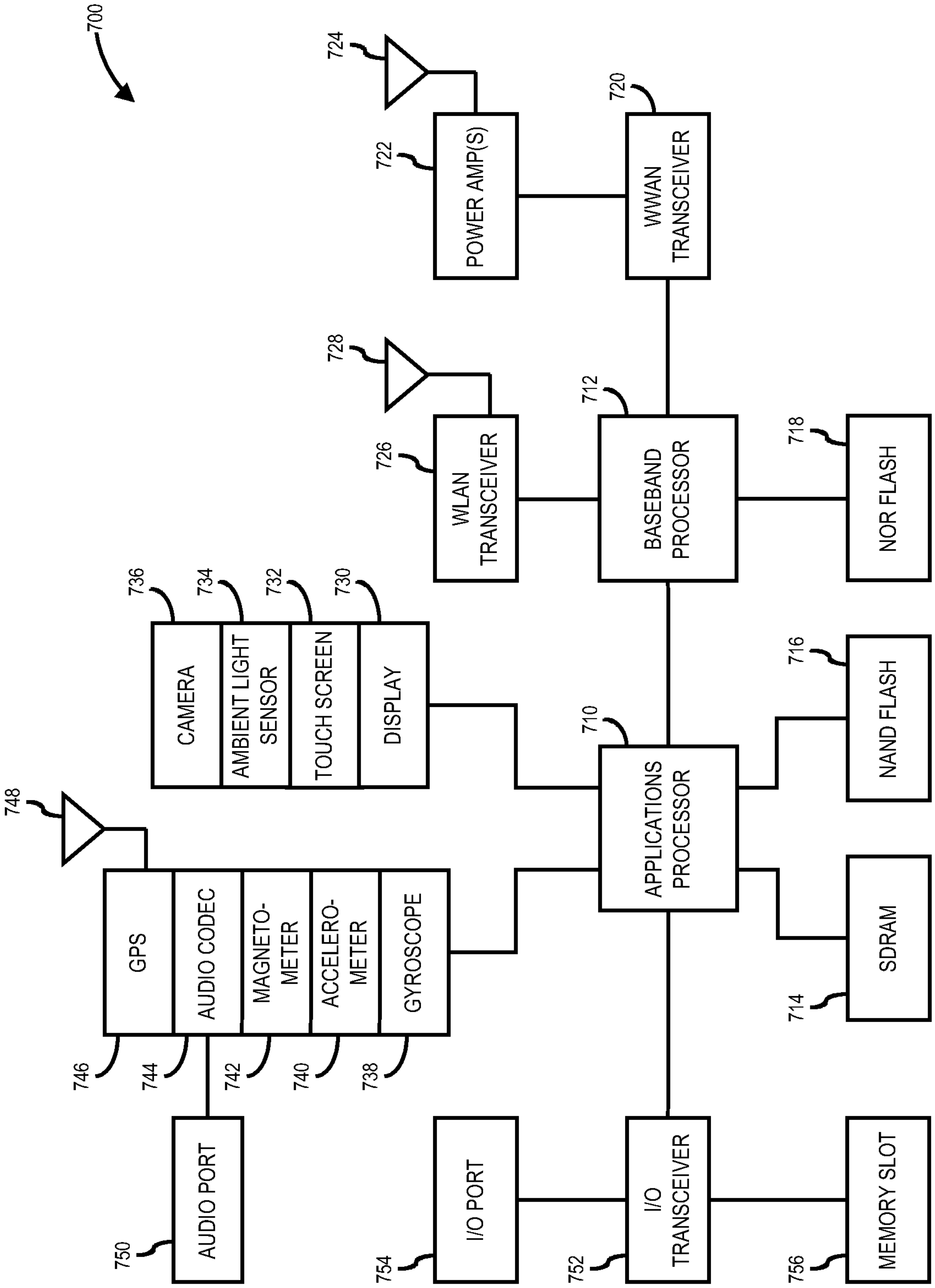
700
724
722
POWER AMP(S)
720
WWAN TRANSCEIVER
728
726
WLAN TRANSCEIVER
712
BASEBAND PROCESSOR
718
NOR FLASH
736
734
732
730
CAMERA
AMBIENT LIGHT SENSOR
TOUCH SCREEN
DISPLAY
710
APPLICATIONS PROCESSOR
716
NAND FLASH
714
SDRAM
748
GPS
AUDIO CODEC
MAGNETO-METER
ACCELERO-METER
GYROSCOPE
746
744
742
740
738
750
AUDIO PORT
754
I/O PORT
752
I/O TRANSCEIVER
756
MEMORY SLOT

FIG. 7

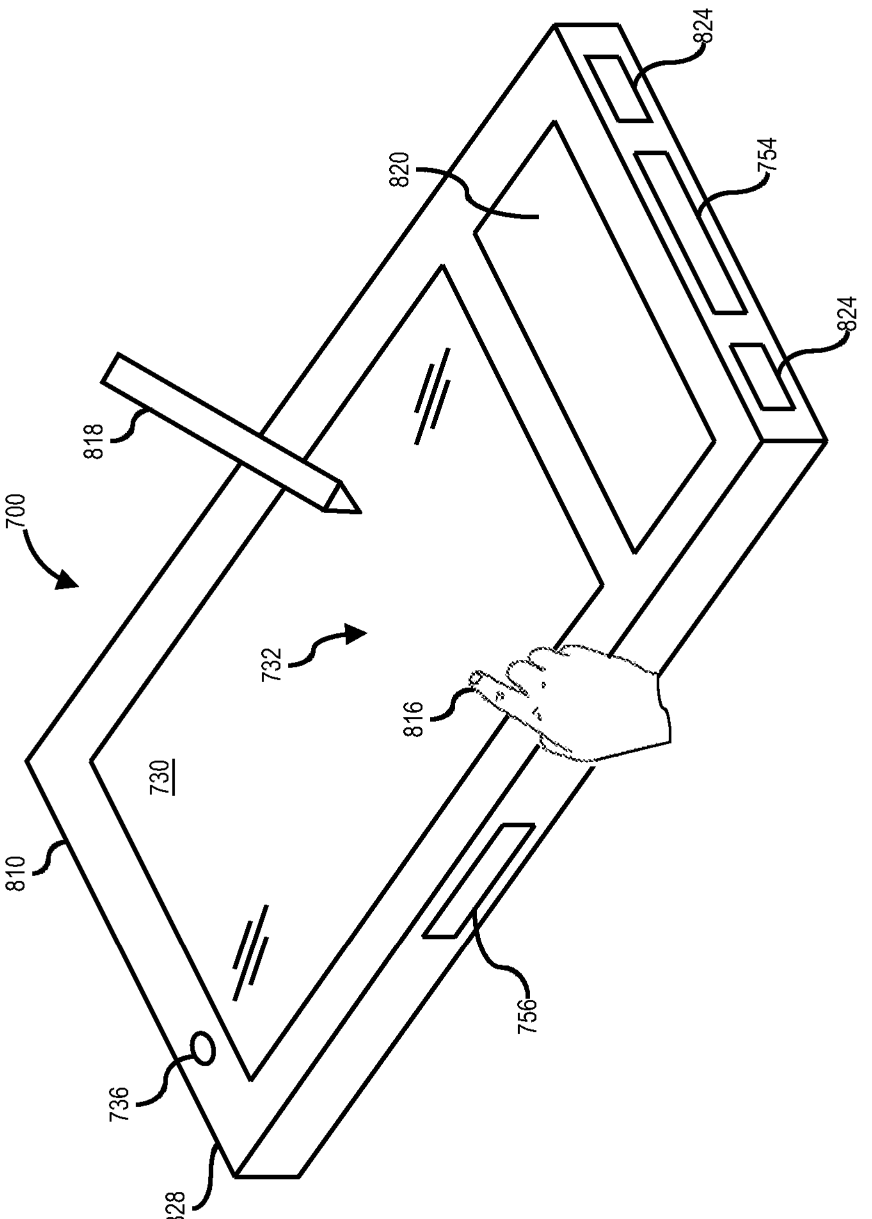

FIG. 8

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- WO 2010102583 A1 **[0002]**

Földrajzilag izolált antennák

SZTNH-100007341

Szabadalmi igénypontok

1. Eljárás (400) egy kódkönyv (316) beállítására, az eljárás tartalmazza:

egy referenciajel átvitelét (410) egy első készülékhez egy első antennakészlettel (112) és az első antennakészlettől földrajzilag izolált második antennakészlettel (114) rendelkező bázis adó-vevő állomástól;

visszacsatolás vételét az első készüléktől, a visszacsatolás egy súlyozás beállító vektor létrehozásához használható információt jelent;

egy előkódoló vektor kiválasztását (418) egy kódkönyvből, legalább részben az első készüléktől kapott visszacsatolás alapján;

a súlyozás beállító vektor kiszámítását (420) legalább részben a visszacsatolás alapján, és a súlyozás beállító vektor alkalmazását a kiválasztott előkódoló vektoron, egy beállított előkódoló vektor létrehozásához; és

adatok átvitelét (422) az első készülékhez a beállított előkódoló vektor használatával, ahol:

a visszacsatolásban lévő információ az első antennakészlet és a második antennakészlet közötti antenna nyereség kiegyensúlyozatlanságot tartalmaz.

2. Az 1. igénypont szerinti eljárás, amely tartalmazza továbbá egy referenciajel átvitelét egy második készülékhez;

visszacsatolás vételét a második készüléktől, a visszacsatolás a súlyozás beállító vektor létrehozásához használható információt jelent;

egy előkódoló vektor kiválasztását a kódkönyvből, legalább részben a második készüléktől kapott visszacsatolás alapján,

a súlyozás beállító vektor kiszámítását legalább részben a második készüléktől kapott visszacsatolás alapján, és a súlyozás beállító vektor alkalmazását a második előkódoló vektoron, beállított előkódoló vektor létrehozásához; és

adatok átvitelét a második készülékhez a beállított előkódoló vektor használatával.

3. Az 1. vagy 2. igénypontok bármelyike szerinti eljárás, ahol az első készülék vagy a második készülék felhasználói készüléket (UE) tartalmaz, és a bázis adó-vevő állomás egy enhanced NodeB-t (eNB) tartalmaz.

4. Az 1. vagy 2. igénypontok bármelyike szerinti eljárás, ahol a súlyozás beállító vektort egy a referenciajelekre vonatkozó referenciajel vett teljesítmény, RSRP, méréssel számítjuk ki, ahol az RSRP mérést az első antennakészlet vagy a második antennakészlet egy vagy több antennájára leképezett csatornaállapot indikátor referenciajel, CSI-RS, portonként kapjuk.

5. Az 1. igénypont szerinti eljárás, amely tartalmazza továbbá:

egy referenciajel vételét a bázis adó-vevő állomástól;

egy súlyozás beállító vektor kiszámítását, legalább részben a vett referenciajel alapján;

visszacsatolás küldését a bázis adó-vevő állomáshoz, a visszacsatolás a súlyozás beállító vektort jelenti, lehetővé téve, hogy a bázis adó-vevő egy kiválasztott előkódoló vektort állítson be a kódkönyvből, legalább részben a visszacsatolás alapján; és

a bázis adó-vevő állomástól az első antennakészlet útján átvitt adatok vételét, ahol az átvitt adat beállítása a beállított előkódoló vektor használatával történik.

6. Mobil állomás (116), amely tartalmaz:

egy adó-vevőt (310), amely úgy van konfigurálva, hogy egy referenciajelet vegyen egy első antennakészlettel (112) és az első antennakészlettől földrajzilag különálló második antennakészlettel (114) rendelkező bázis adó-vevő állomástól (110); és

egy processzort egy súlyozás beállító vektor kiszámítására, legalább részben a vett referenciajel alapján;

ahol a mobil állomás visszacsatolást küld a bázis adó-vevő állomáshoz, a visszacsatolás a súlyozás beállító vektort jelenti, lehetővé téve, hogy a bázis adó-vevő beállítson egy kiválasztott elődkódoló vektort a kódkönyvből, legalább részben a visszacsatolás alapján, és a mobil állomás a bázis adó-vevő állomástól az első antennakészlettel átvitt adatot vesz, ahol az átvitt adat a beállított előkódoló vektor használatával van beállítva, ahol:

a visszacsatolásban lévő súlyozás beállító vektor az első antennakészlet és a második antennakészlet közötti antennanyereség kiegyensúlyozást tartalmaz.

7. A 6. igénypont szerinti mobil állomás, ahol a mobil állomás felhasználói készüléket, UE, tartalmaz, és a bázis adó-vevő állomás egy enhanced NodeB-t, eNB, tartalmaz.

8. A 6. igénypont szerinti mobil állomás, ahol a visszacsatolás egy előkódoló mátrix indikátort tartalmaz.

9. A 6. igénypont szerinti mobil állomás, ahol a súlyozás beállító vektor egy a referenciajelből kapott referenciajel vett teljesítmény, RSRP, méréssel van kiszámítva.

10. A 9. igénypont szerinti mobil állomás, ahol az RSRP mérést csatorna állapot indikátor referenciajel, CSI-RS, portonként kapjuk, amely az első antennakészlet egy vagy több antennájára, vagy a második antennakészlet egy vagy több antennájára van leképezve.

11. A 6. igénypont szerinti mobil állomás, amely tartalmaz továbbá egy érintőképernyőt egy ujjtól vagy egy stylustól származó bevitt utasítás vételére, a processzor vezérlésére.

12. Berendezés, amely az 1-5. igénypontok bármelyike szerinti eljárást végrehajtó eszközt tartalmaz.

13. Géppel olvasható tároló, amely géppel olvasható utasításokat tartalmaz, amelyek végrehajtásuk esetén az 1-5. igénypontok bármelyike szerinti eljárást valósítják meg.