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(54) **METHOD AND APPARATUS FOR VIRTUALIZING ANTENNA IN WIRELESS COMMUNICATION SYSTEM**

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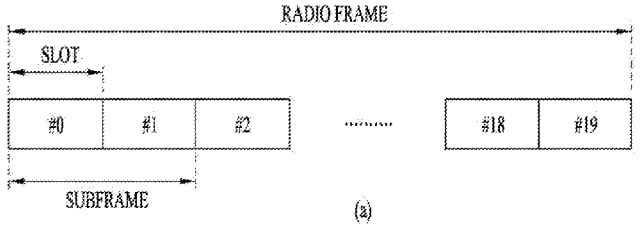
(57) **ABSTRACT**

The present invention relates to a wireless communication system, and more specifically, disclosed are a method and an apparatus for virtualizing an antenna. A method for communicating using a virtual antenna of a terminal in the wireless communication system, according to one embodiment of the present invention, comprises the steps of: configuring one or more virtual antennas according to an antenna virtualization pattern that is determined based on information indicating a movement status of the terminal and/or information indicating a communication status of the terminal; and communicating with the base station by using the one or more virtual antennas, wherein one or more physical antennas that are mapped to the one or more virtual antennas can be determined base on the direction of movement of the terminal.



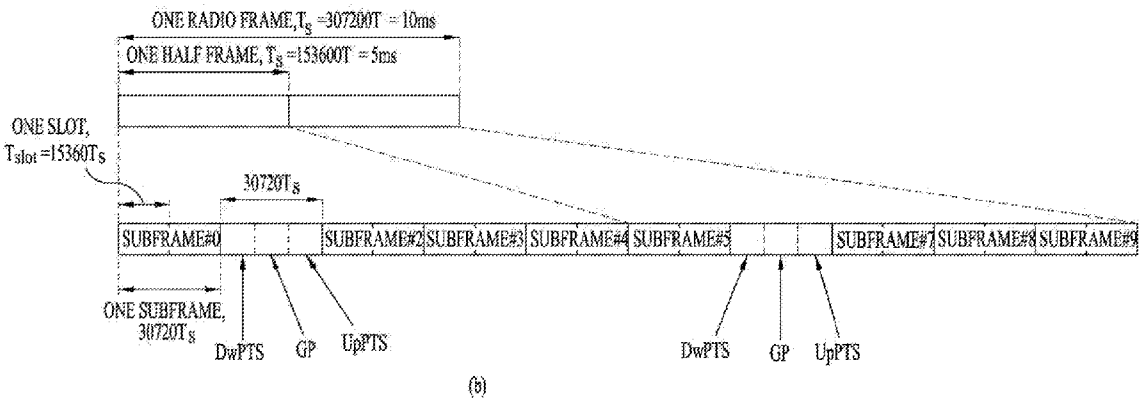


FIG. 1

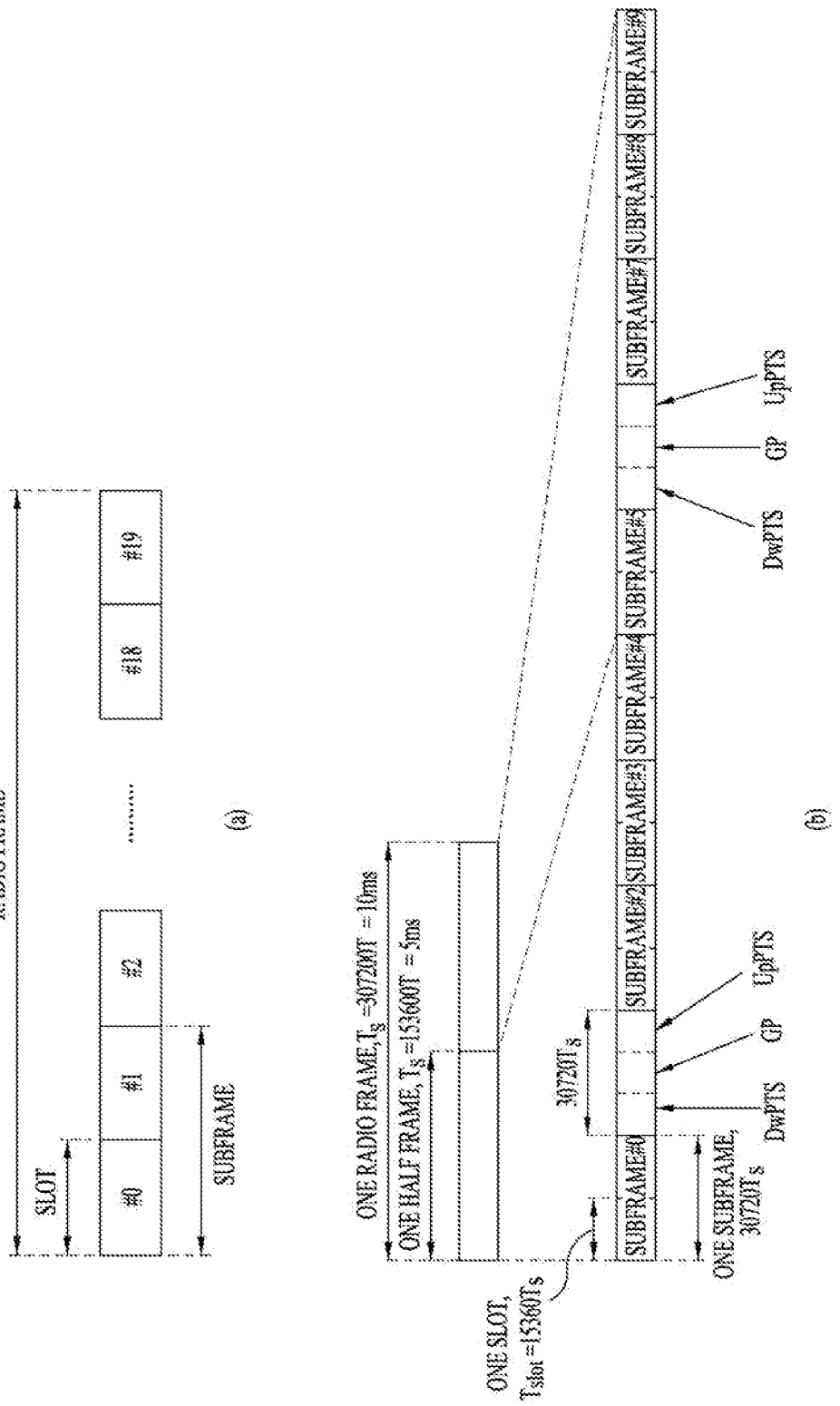

RADIO FRAME
SLOT
#0
#1
#2
#18
#19
SUBFRAME
(a)
ONE RADIO FRAME, T_s =30720T = 10ms
ONE HALF FRAME, T_s =15360T = 5ms
ONE SLOT, T_{slot} =15360T_s
30720T_s
SUBFRAME#0
SUBFRAME#2
SUBFRAME#3
SUBFRAME#4
SUBFRAME#5
SUBFRAME#7
SUBFRAME#8
SUBFRAME#9
DwPTS
GP
UpPTS
ONE SUBFRAME, 30720T_s
(b)

FIG. 2

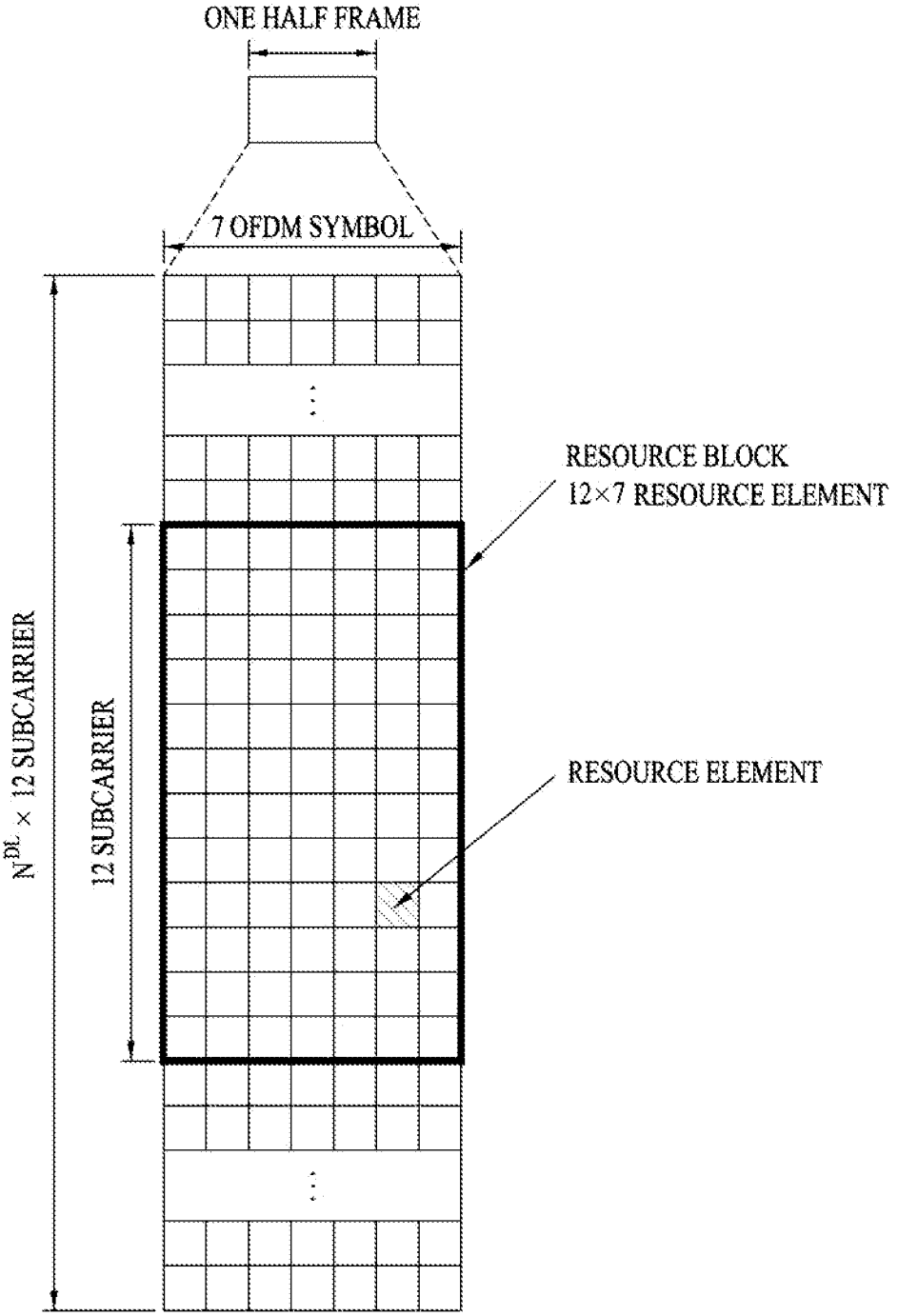

ONE HALF FRAME
7 OFDM SYMBOL
RESOURCE BLOCK
12×7 RESOURCE ELEMENT
RESOURCE ELEMENT
N^{DL} × 12 SUBCARRIER
12 SUBCARRIER

FIG. 3

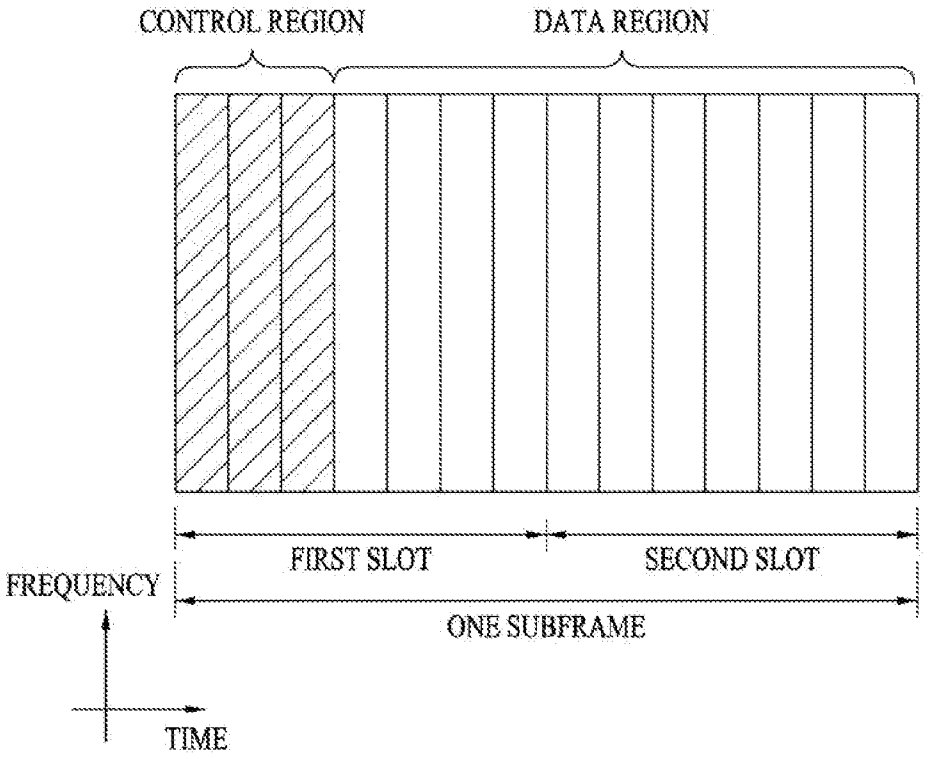

CONTROL REGION
DATA REGION
FIRST SLOT
SECOND SLOT
FREQUENCY
ONE SUBFRAME
TIME

FIG. 4

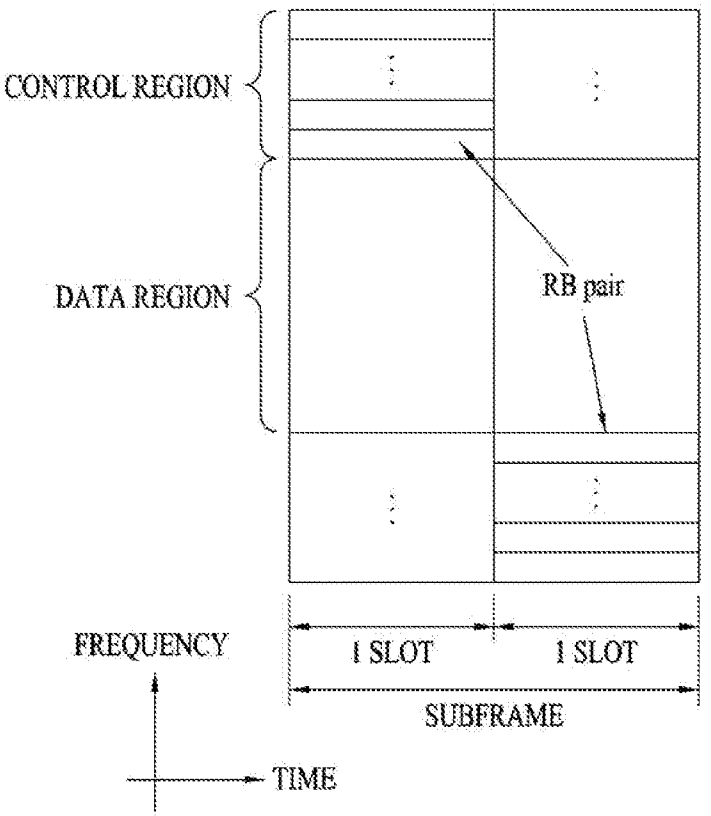
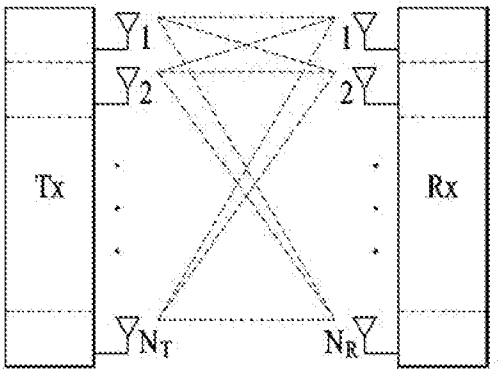
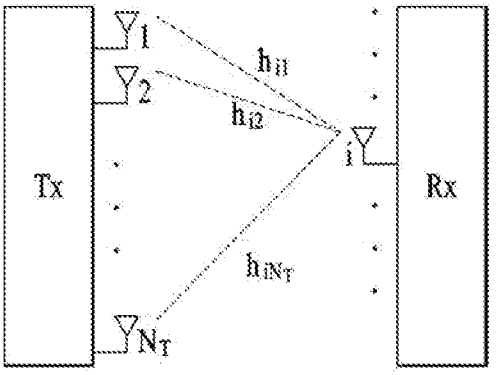

CONTROL REGION
DATA REGION
RB pair
FREQUENCY
1 SLOT
1 SLOT
SUBFRAME
TIME

FIG. 5



(a)



(b)

FIG. 6

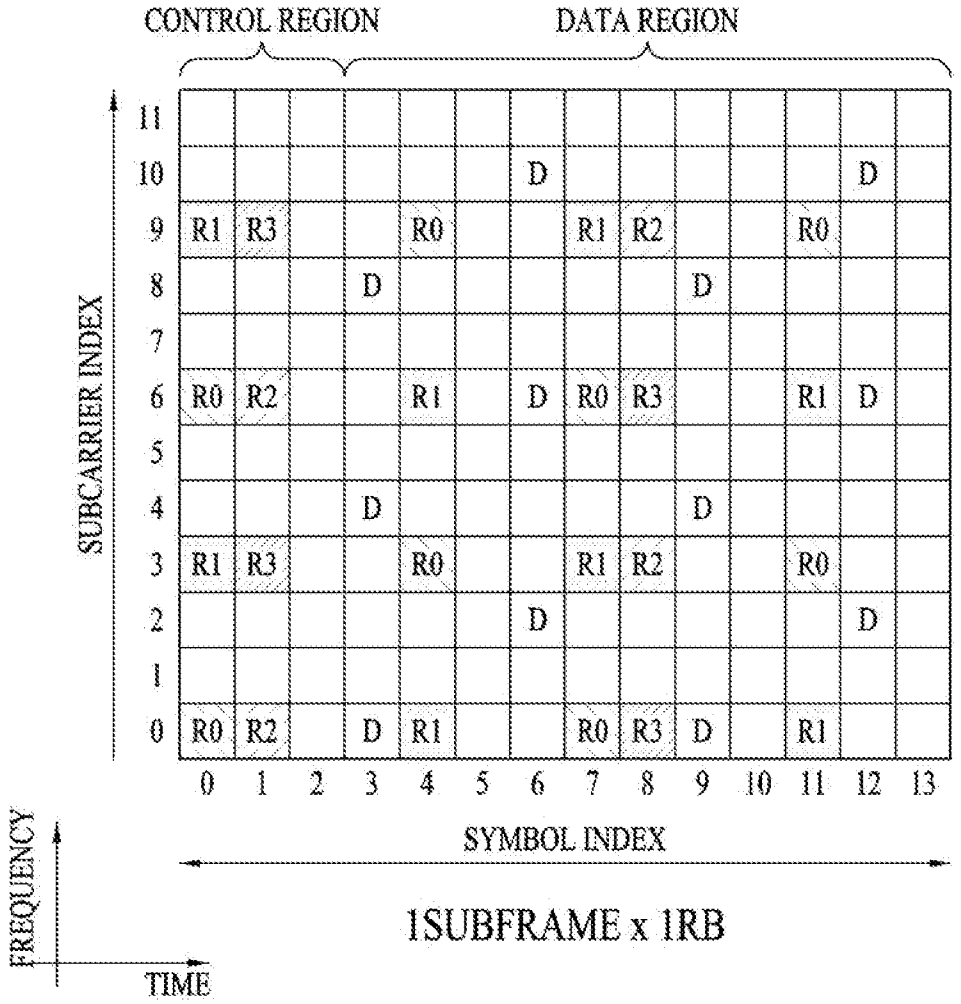

CONTROL REGION
DATA REGION
SUBCARRIER INDEX
11
10 D D
9 R1 R3 R0 R1 R2 R0
8 D D
7
6 R0 R2 R1 D R0 R3 R1 D
5
4 D D
3 R1 R3 R0 R1 R2 R0
2 D D
1
0 R0 R2 D R1 R0 R3 D R1
0 1 2 3 4 5 6 7 8 9 10 11 12 13
SYMBOL INDEX
FREQUENCY
TIME
1SUBFRAME x 1RB

FIG. 7

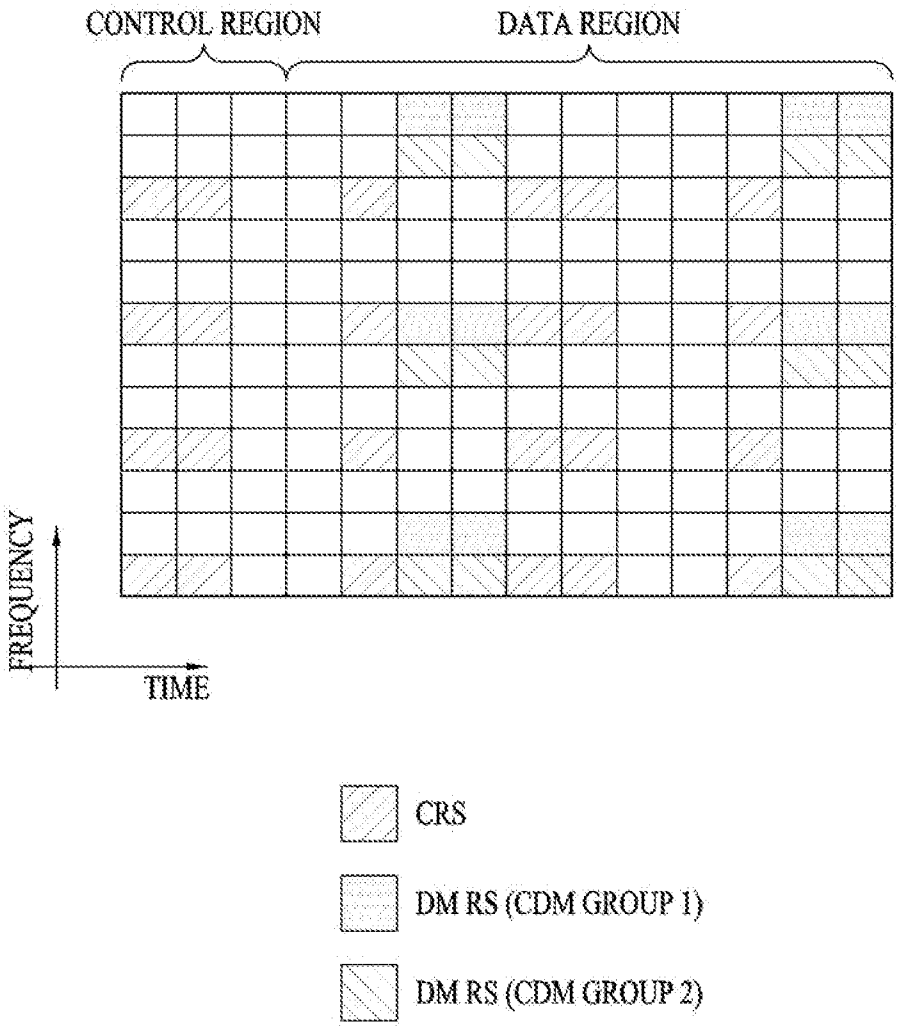

CONTROL REGION
DATA REGION
FREQUENCY
TIME
CRS
DM RS (CDM GROUP 1)
DM RS (CDM GROUP 2)

FIG. 8

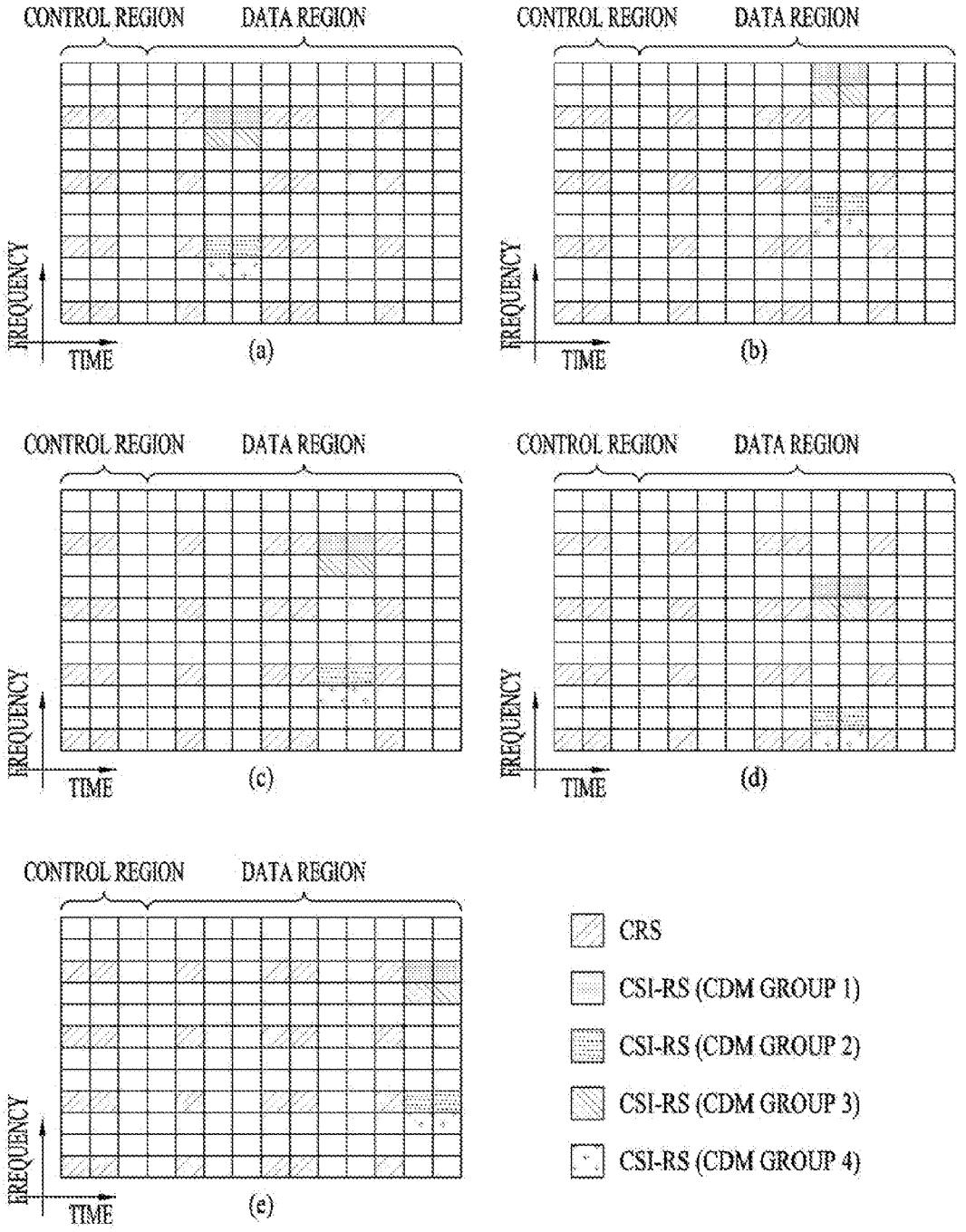
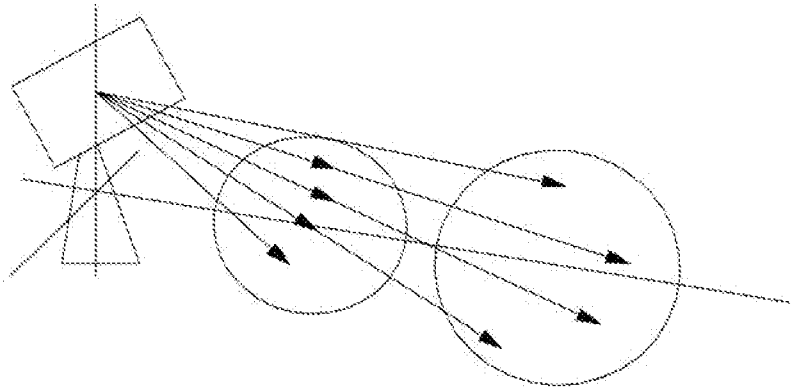
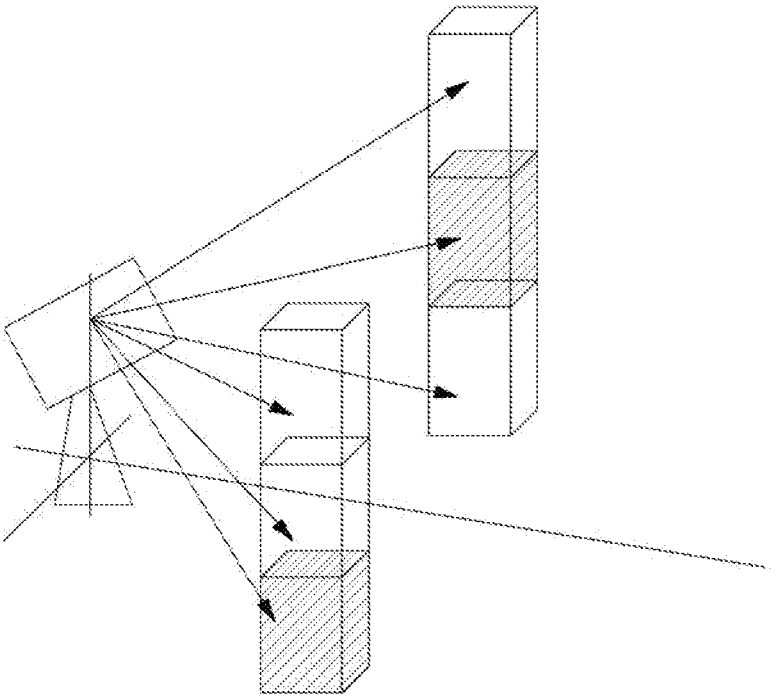

CONTROL REGION
DATA REGION
FREQUENCY
TIME
(a)
(b)
(c)
(d)
(e)
CRS
CSI-RS (CDM GROUP 1)
CSI-RS (CDM GROUP 2)
CSI-RS (CDM GROUP 3)
CSI-RS (CDM GROUP 4)

FIG. 9



(a)



(b)

FIG. 10

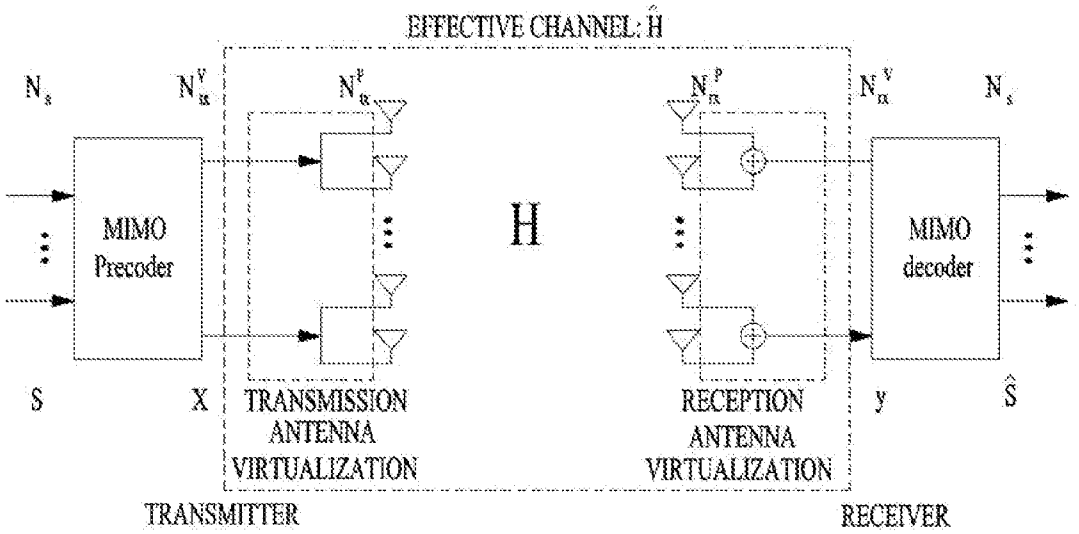

EFFECTIVE CHANNEL: Ĥ
N_s
N_tx^v
N_tx^p
N_rx^p
N_rx^v
N_s
MIMO Precoder
H
MIMO decoder
S
X
TRANSMISSION ANTENNA VIRTUALIZATION
RECEPTION ANTENNA VIRTUALIZATION
y
Ŝ
TRANSMITTER
RECEIVER

FIG. 11

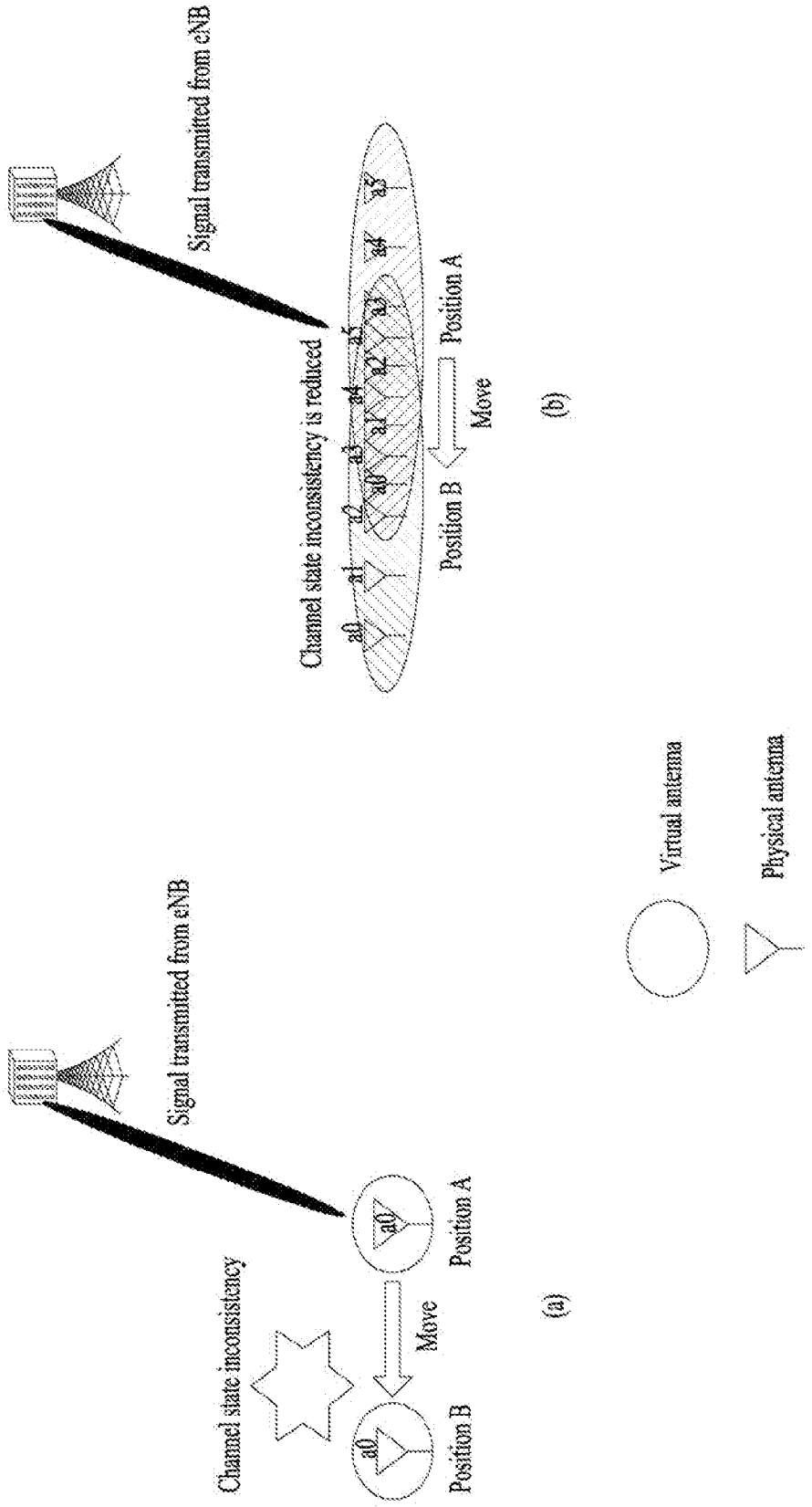

Signal transmitted from eNB
Channel state inconsistency
a0
Position B
Move
a0'
Position A
(a)
Signal transmitted from eNB
Channel state inconsistency is reduced
a0
a1
a2
a3
a4
a0'
a1'
a2'
a3'
a4'
a5'
a3''
Position B
Move
Position A
(b)
Virtual antenna
Physical antenna

FIG. 12

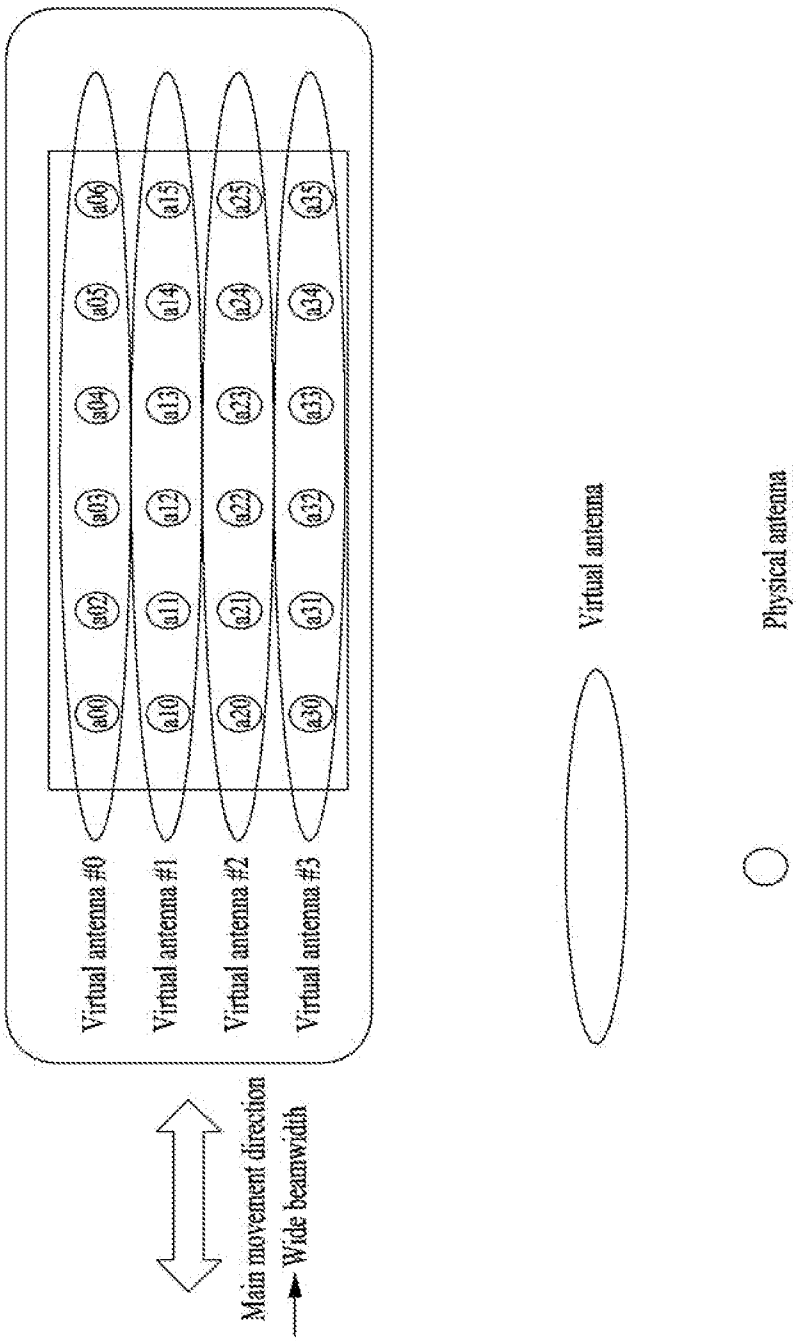

Virtual antenna #0
Virtual antenna #1
Virtual antenna #2
Virtual antenna #3
a00
a01
a02
a03
a04
a05
a06
a10
a11
a12
a13
a14
a15
a20
a21
a22
a23
a24
a25
a30
a31
a32
a33
a34
a35
Main movement direction
Wide beamwidth
Virtual antenna
Physical antenna

FIG. 13

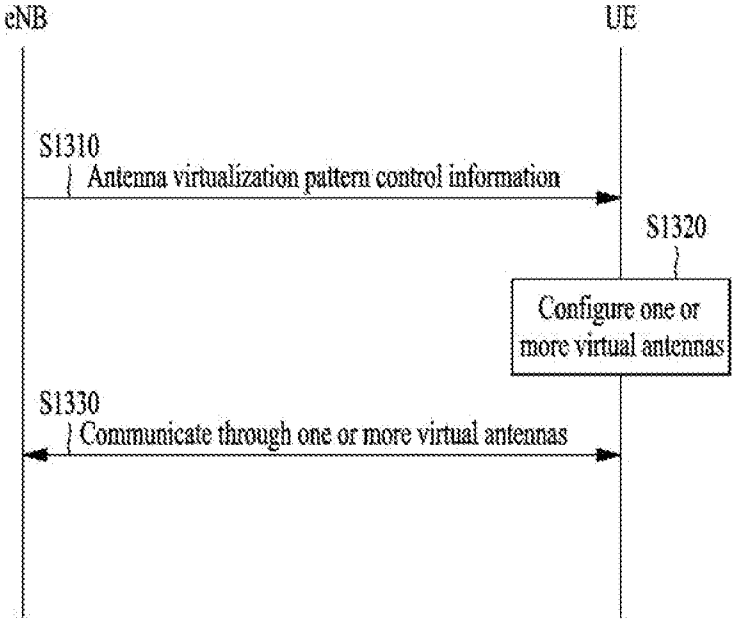
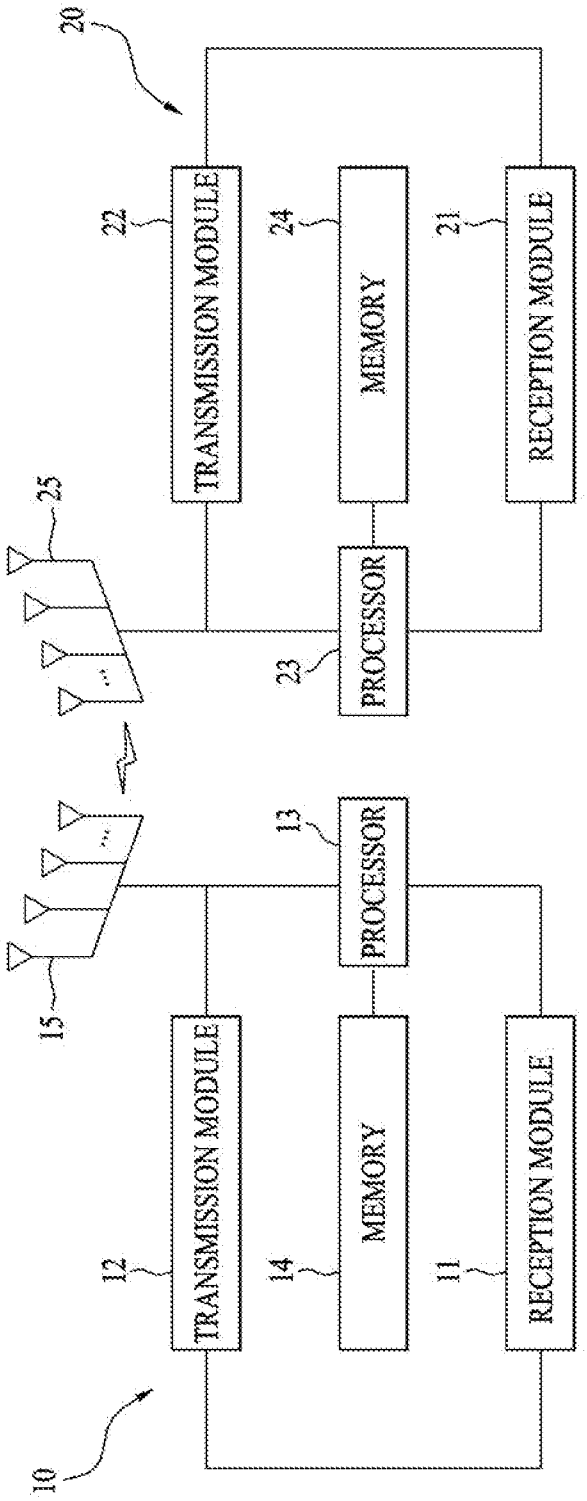

eNB
UE
S1310
Antenna virtualization pattern control information
S1320
Configure one or more virtual antennas
S1330
Communicate through one or more virtual antennas

FIG. 14


20
22
TRANSMISSION MODULE
24
MEMORY
21
RECEPTION MODULE
25
23
PROCESSOR
13
PROCESSOR
15
12
TRANSMISSION MODULE
14
MEMORY
11
RECEPTION MODULE
10

METHOD AND APPARATUS FOR VIRTUALIZING ANTENNA IN WIRELESS COMMUNICATION SYSTEM

TECHNICAL FIELD

[0001] The following description relates to a wireless communication system and, more specifically, to a method and apparatus for virtualizing an antenna.

BACKGROUND ART

[0002] MIMO (multiple-input multiple-output) refers to a method for improving data transmission/reception efficiency by adopting multiple transmit (Tx) antennas and multiple receive (Rx) antennas instead of a single Tx antenna and a single Rx antenna. When a single antenna is used, a receiver receives data through a single antenna path. However, when multiple antennas are used, the receiver receives data through multiple paths. Accordingly, a data transfer rate, throughput or signal-to-interference-and-noise-ratio (SINR) can be increased and coverage can be improved. A case in which both a transmitter and a receiver use a single antenna is referred to as SISO (Single-Input Single-Output), a case in which only the transmitter uses a plurality of antennas is referred to as MISO (Multiple-Input Single-Output), and a case in which only the receiver uses a plurality of antennas is referred to as SIMO (Single-Input Multiple-Output). In general, MIMO, SIMO, MISO and SISO schemes are commonly called MIMO technology.

[0003] To increase a multiplexing gain of MIMO operation, channel state information (CSI) can be fed back from an MIMO receiver and used for a MIMO transmitter. The receiver can determine the CSI by performing channel measurement using a predetermined reference signal (RS).

DISCLOSURE

Technical Problem

[0004] In enhanced wireless communication systems, support for more accurate beamforming is considered. As beamforming resolution increases, performance deterioration due to channel aging may be aggravated. Furthermore, as a moving speed of a UE increases, a channel that the UE suffers remarkably changes and thus performance deterioration due to channel aging may become serious.

[0005] An object of the present invention devised to solve the problem lies in a method and apparatus for virtualizing an antenna to minimize performance deterioration due to channel aging even when channel aging occurs due to precise beamforming and/or high-speed movement.

[0006] The technical problems solved by the present invention are not limited to the above technical problems and those skilled in the art may understand other technical problems from the following description.

Technical Solution

[0007] In an aspect of the present invention, a communication method using a virtual antenna of a terminal in a wireless communication system includes: configuring one or more virtual antennas according to an antenna virtualization pattern determined on the basis of at least one of information indicating a movement state of the terminal and information indicating a communication state of the terminal; and communicating with a base station using the one or more virtual antennas, wherein one or more physical antennas mapped to one virtual antenna are determined on the basis of a direction of movement of the terminal.

[0008] In another aspect of the present invention, provided herein is a method for supporting, by a base station, communication using a virtual antenna of a terminal in a wireless communication system, including: transmitting, to the terminal, control information with respect to an antenna virtualization pattern of the terminal, determined on the basis of at least one of information indicating a movement state of the terminal and information indicating a communication state of the terminal; and communicating with the terminal through one or more virtual antennas of the terminal, configured according to the control information with respect to the antenna virtualization pattern, wherein one or more physical antennas mapped to one virtual antenna are determined on the basis of a direction of movement of the terminal.

[0009] In another aspect of the present invention, provided herein is a terminal performing communication using a virtual antenna in a wireless communication system, including: a transmitter; a receiver; and a processor, wherein the processor is configured: to configure one or more virtual antennas according to an antenna virtualization pattern determined on the basis of at least one of information indicating a movement state of the terminal and information indicating a communication state of the terminal; and to communicate with a base station using the one or more virtual antennas through one of the transmitter and the receiver, wherein one or more physical antennas mapped to one virtual antenna are determined on the basis of a direction of movement of the terminal.

[0010] In another aspect of the present invention, provided herein is a base station supporting communication using a virtual antenna of a terminal in a wireless communication system, including: a transmitter; a receiver; and a processor, wherein the processor is configured: to transmit, to the terminal, control information with respect to an antenna virtualization pattern of the terminal, determined on the basis of at least one of information indicating a movement state of the terminal and information indicating a communication state of the terminal, through the transmitter; and to communicate with the terminal through one or more virtual antennas of the terminal, configured according to the control information with respect to the antenna virtualization pattern, through one of the transmitter and the receiver, wherein one or more physical antennas mapped to one virtual antenna are determined on the basis of a direction of movement of the terminal.

[0011] The following can be commonly applied to the aforementioned embodiments of the present invention.

[0012] The width of a beam formed by the one or more physical antennas mapped to one virtual antenna may be extended in the same direction as the direction of movement of the terminal.

[0013] The one or more physical antennas mapped to one virtual antenna may be one or more physical antennas arranged in the direction of movement of the terminal.

[0014] The antenna virtualization pattern may include at least one of the number of one or more physical antennas mapped to one virtual antenna and information specifying the one or more physical antennas.

[0015] The number of one or more physical antennas mapped to one virtual antenna may be determined on the basis of a moving speed of the terminal.

[0016] The information indicating the movement state may include at least one of information on whether the terminal is

moving, information on the direction of movement of the terminal, information on the moving speed of the terminal and information about an acceleration state or a deceleration state.

[0017] The information indicating the communication state may include at least one of information on a distance between the terminal and the base station, information on relative positions of the terminal and the base station and information on a channel state between the terminal and the base station.

[0018] The antenna virtualization pattern may be adaptively determined according to change of at least one of the information indicating the movement state of the terminal and the information indicating the communication state of the terminal.

[0019] Control information with respect to the antenna virtualization pattern may be received from the base station.

[0020] One or more of the information indicating the movement state of the terminal, position information of the terminal and channel state information may be reported by the terminal to the base station.

[0021] Information indicating the antenna virtualization pattern preferred by the terminal may be reported by the terminal to the base station.

[0022] The configuring of one or more virtual antennas according to the antenna virtualization pattern may be performed when the terminal does not perform data transmission and reception.

[0023] The above description and the following detailed description of the present invention are exemplary and are for additional explanation of the invention disclosed in the claims.

Advantageous Effects

[0024] According to the present invention, it is possible to provide a method and apparatus for virtualizing an antenna to minimize performance deterioration due to channel aging even when channel aging occurs due to precise beamforming and/or high-speed movement.

[0025] The effects of the present invention are not limited to the above-described effects and other effects which are not described herein will become apparent to those skilled in the art from the following description.

DESCRIPTION OF DRAWINGS

[0026] The accompanying drawings, which are included to provide a further understanding of the invention, illustrate embodiments of the invention and together with the description serve to explain the principle of the invention. In the drawings:

[0027] FIG. **1** illustrates a radio frame structure;

[0028] FIG. **2** illustrates a resource grid of a downlink slot;

[0029] FIG. **3** illustrates a downlink subframe structure;

[0030] FIG. **4** illustrates an uplink subframe structure;

[0031] FIG. **5** illustrates a configuration of a wireless communication system having multiple antennas;

[0032] FIG. **6** illustrates exemplary CRS and DRS patterns in one resource block pair;

[0033] FIG. **7** illustrates an exemplary DMRS pattern defined in LTE-A;

[0034] FIG. **8** illustrates exemplary CSI-RS patterns defined in LTE-A;

[0035] FIG. **9** illustrates exemplary beamforming according to a 2-dimensional antenna configuration;

[0036] FIG. **10** illustrates antenna virtualization;

[0037] FIG. **11** illustrates an example of antenna virtualization according to the present invention;

[0038] FIG. **12** illustrates an antenna virtualization method for two-dimensional antenna arrangement according to the present invention;

[0039] FIG. **13** is a flowchart illustrating a communication method using a virtual antenna according to the present invention; and

[0040] FIG. **14** illustrates configurations of a base station and a UE according to the present invention.

BEST MODE

[0041] Embodiments described hereinbelow are combinations of elements and features of the present invention. The elements or features may be considered selective unless otherwise mentioned. Each element or feature may be practiced without being combined with other elements or features. Further, an embodiment of the present invention may be constructed by combining parts of the elements and/or features. Operation orders described in embodiments of the present invention may be rearranged. Some constructions of any one embodiment may be included in another embodiment and may be replaced with corresponding constructions of another embodiment.

[0042] In the embodiments of the present invention, a description is given, centering on a data transmission and reception relationship between a base station (BS) and a user equipment (UE). The BS is a terminal node of a network, which communicates directly with a UE. In some cases, a specific operation described as performed by the BS may be performed by an upper node of the BS.

[0043] Namely, it is apparent that, in a network comprised of a plurality of network nodes including a BS, various operations performed for communication with a UE may be performed by the BS, or network nodes other than the BS. The term "BS" may be replaced with the term "fixed station", "Node B", "evolved Node B (eNode B or eNB)", "Access Point (AP)", etc. The term "UE" may be replaced with the term "terminal", "Mobile Station (MS)", "Mobile Subscriber Station (MSS)", "Subscriber Station (SS)", etc.

[0044] Specific terms used in the embodiments of the present invention are provided to aid in understanding of the present invention. These specific terms may be replaced with other terms within the scope and spirit of the present invention.

[0045] In some cases, to prevent the concept of the present invention from being obscured, structures and apparatuses of the known art will be omitted, or will be shown in the form of a block diagram based on main functions of each structure and apparatus. In addition, wherever possible, the same reference numbers will be used throughout the drawings and the specification to refer to the same or like parts.

[0046] The embodiments of the present invention can be supported by standard documents disclosed for at least one of wireless access systems including Institute of Electrical and Electronics Engineers (IEEE) 802, 3GPP, 3GPP LTE, LTE-A, and 3GPP2. Steps or parts that are not described to clarify the technical features of the present invention can be supported by those documents. Further, all terms as set forth herein can be explained by the standard documents.

[0047] Embodiments of the present invention are applicable to a variety of wireless access technologies such as Code Division Multiple Access (CDMA), Frequency Divi-

sion Multiple Access (FDMA), Time Division Multiple Access (TDMA), Orthogonal Frequency Division Multiple Access (OFDMA), and Single Carrier Frequency Division Multiple Access (SC-FDMA). CDMA can be implemented as a radio technology such as Universal Terrestrial Radio Access (UTRA) or CDMA2000. TDMA can be implemented as a radio technology such as Global System for Mobile communications (GSM)/General Packet Radio Service (GPRS)/Enhanced Data Rates for GSM Evolution (EDGE). OFDMA can be implemented as a radio technology such as Institute of Electrical and Electronics Engineers (IEEE) 802.11 (Wireless Fidelity (Wi-Fi)), IEEE 802.16 (Worldwide interoperability for Microwave Access (WiMAX)), IEEE 802.20, and Evolved UTRA (E-UTRA). UTRA is a part of Universal Mobile Telecommunications System (UMTS). 3rd Generation Partnership Project (3GPP) Long Term Evolution (LTE) is a part of Evolved UMTS (E-UMTS) using E-UTRA, employing OFDMA for downlink and SC-FDMA for uplink. LTE-Advanced (LTE-A) is an evolution of 3GPP LTE. WiMAX can be described by the IEEE 802.16e standard (Wireless Metropolitan Area Network (WirelessMAN-OFDMA Reference System) and the IEEE 802.16m standard (WirelessMAN-OFDMA Advanced System). For clarity, this application focuses on the 3GPP LTE/LTE-A system. However, the technical features of the present invention are not limited thereto.

[0048] FIG. **1** illustrates a radio frame structure.

[0049] In a cellular OFDM wireless packet communication system, uplink/downlink data packet transmission is performed on a subframe-by-subframe basis. A subframe is defined as a predetermined time interval including a plurality of OFDM symbols. 3GPP LTE supports a type-1 radio frame structure applicable to FDD (Frequency Division Duplex) and a type-2 radio frame structure applicable to TDD (Time Division Duplex).

[0050] FIG. **1**(*a*) illustrates a type-1 radio frame structure. A downlink subframe includes 10 subframes, each of which includes 2 slots in the time domain. A unit time during which one subframe is transmitted is defined as a transmission time interval (TTI). For example, each subframe has a length of 1 ms and each slot has a length of 0.5 ms. A slot includes a plurality of orthogonal frequency division multiplexing (OFDM) symbols in the time domain and includes a plurality of resource blocks (RBs) in the frequency domain. Since 3GPP LTE adopts OFDMA for downlink, an OFDM symbol represents one symbol period. An OFDM symbol may be referred to as an SC-FDMA symbol or symbol period. A resource block (RB) is a resource allocation unit including a plurality of contiguous subcarriers in a slot.

[0051] The number of OFDM symbols included in one slot may depend on cyclic prefix (CP) configuration. CPs include an extended CP and a normal CP. When an OFDM symbol is configured with the normal CP, for example, the number of OFDM symbols included in one slot may be 7. When an OFDM symbol is configured with the extended CP, the duration of one OFDM symbol increases, and thus the number of OFDM symbols included in one slot is smaller than that in case of the normal CP. In case of the extended CP, the number of OFDM symbols allocated to one slot may be 6. When a channel state is unstable, such as a case in which a UE moves at a high speed, the extended CP can be used to reduce inter-symbol interference.

[0052] When the normal CP is used, one subframe includes 14 OFDM symbols since one slot has 7 OFDM symbols. The first two or three OFDM symbols in each subframe can be allocated to a physical downlink control channel (PDCCH) and the remaining OFDM symbols can be allocated to a physical downlink shared channel (PDSCH).

[0053] FIG. **1**(*b*) illustrates a type-2 radio frame structure. The type-2 radio frame includes 2 half frames. Each half frame includes 5 subframes, a downlink pilot time slot (DwPTS), a guard period (GP) and an uplink pilot time slot (UpPTS). One subframe consists of 2 slots. The DwPTS is used for initial cell search, synchronization or channel estimation in a UE. The UpPTS is used for channel estimation in a BS and UL transmission synchronization acquisition in a UE. The GP eliminates UL interference caused by multi-path delay of a DL signal between UL and DL. One subframe includes 2 slots irrespective of radio frame type.

[0054] The radio frame structure is purely exemplary and thus the number of subframes in a radio frame, the number of slots in a subframe, or the number of OFDM symbols in a slot may vary.

[0055] FIG. **2** illustrates a resource grid in a downlink slot.

[0056] While one downlink slot includes 7 OFDM symbols in the time domain and one RB includes 12 subcarriers in the frequency domain in FIG. **2**, the present invention is not limited thereto. For example, one slot includes 7 OFDM symbols in the case of normal CP whereas one slot includes 6 OFDM symbols in the case of extended CP. Each element on the resource grid is referred to as a resource element (RE). One RB includes 12×7 REs. The number NDL of RBs included in the downlink slot depends on a downlink transmit bandwidth. The structure of an uplink slot may be same as that of the downlink slot.

[0057] FIG. **3** illustrates a downlink subframe structure.

[0058] A maximum of three OFDM symbols located in a front portion of a first slot within a subframe correspond to a control region to which a control channel is allocated. The remaining OFDM symbols correspond to a data region to which a physical downlink shared chancel (PDSCH) is allocated.

[0059] Examples of downlink control channels used in 3GPP LTE include a physical control format indicator channel (PCFICH), a physical downlink control channel (PDCCH), a physical hybrid ARQ indicator channel (PHICH), etc. The PCFICH is transmitted at a first OFDM symbol of a subframe and carries information regarding the number of OFDM symbols used for transmission of control channels within the subframe. The PHICH is a response to uplink transmission and carries a HARQ acknowledgment (ACK)/negative-acknowledgment (NACK) signal. Control information transmitted through the PDCCH is referred to as downlink control information (DCI). The DCI includes uplink or downlink scheduling information or uplink Tx power control commands for an arbitrary UE group. The PDCCH may carry a transport format and resource allocation of a downlink shared channel (DL-SCH), resource allocation information of an uplink shared channel (UL-SCH), paging information on a paging channel (PCH), system information on the DL-SCH, information on resource allocation of an upper-layer control message such as a random access response transmitted on the PDSCH, a set of Tx power control commands on individual UEs within an arbitrary UE group, a Tx power control command, information on activation of a voice over IP (VoIP), etc. A plurality of PDCCHs can be transmitted within a control region. The UE can monitor the plurality of PDCCHs.

[0060] The PDCCH is transmitted on an aggregation of one or several consecutive control channel elements (CCEs). The CCE is a logical allocation unit used to provide the PDCCH with a coding rate based on a state of a radio channel. The CCE corresponds to a plurality of resource element groups (REGs). A format of the PDCCH and the number of bits of the available PDCCH are determined by correlation between the number of CCEs and a coding rate provided by the CCEs.

[0061] The BS determines a PDCCH format according to DCI to be transmitted to the UE, and attaches a cyclic redundancy check (CRC) to control information. The CRC is masked with an identifier referred to as a radio network temporary identifier (RNTI) according to an owner or usage of the PDCCH. If the PDCCH is for a specific UE, a cell-RNTI (C-RNTI)) of the UE may be masked to the CRC. Alternatively, when the PDCCH is for a paging message, a paging indicator identifier (P-RNTI) may be masked to the CRC. When the PDCCH is for system information (more specifically, a system information block (SIB)), a system information identifier and system information RNTI (SI-RNTI) may be masked to the CRC. To indicate a random access response corresponding to a response to transmission of a random access preamble of the UE, a random access-RNTI (RA-RNTI) may be masked to the CRC.

[0062] FIG. **4** illustrates an uplink subframe structure.

[0063] An uplink subframe may be divided into a control region and a data region in the frequency domain. The control region is allocated a physical uplink control channel (PUCCH) including uplink control information. The data region is allocated a physical uplink shared channel (PUSCH) including user data. To maintain single carrier property, one UE cannot simultaneously transmit a PUCCH and a PUSCH. A PUCCH for a UE is allocated to an RB pair. RBs belonging to an RB pair occupy different subcarriers in 2 slots. That is, an RB pair allocated to a PUCCH is frequency-hopped at a slot boundary.

[0064] MIMO System Modeling

[0065] FIG. **5** illustrates configurations of wireless communication systems including multiple antennas.

[0066] As shown in FIG. **5**(*a*), when the number of transmit (Tx) antennas increases to N_T, and at the same time the number of receive (Rx) antennas increases to N_R, a theoretical channel transmission capacity of the MIMO communication system increases in proportion to the number of antennas, differently from a case in which only a transmitter or receiver uses several antennas, so that transmission rate and frequency efficiency can be greatly increased. In this case, the transfer rate acquired by the increased channel transmission capacity can theoretically increase by a predetermined amount that corresponds to a product of a maximum transfer rate (R_o) acquired when one antenna is used and a rate of increase (R_i).

$$R_i = \min(N_T, N_R) \quad \text{[Equation 1]}$$

[0067] For example, provided that a MIMO system uses four Tx antennas and four Rx antennas, the MIMO system can theoretically acquire a high transfer rate which is four times higher than that of a single antenna system. After the above-mentioned theoretical capacity increase of the MIMO system was demonstrated in the mid-1990s, many developers began to conduct intensive research into a variety of technologies which can substantially increase data transfer rate using the theoretical capacity increase. Some of the above technologies have been adopted in a variety of wireless communication standards, for example, third-generation mobile communication or next-generation wireless LAN, etc.

[0068] A variety of MIMO-associated technologies have been intensively researched, for example, research into information theory associated with MIMO communication capacity under various channel environments or multiple access environments, research into radio frequency (RF) channel measurement and modeling of the MIMO system, and research into space-time signal processing technology.

[0069] Mathematical modeling of a communication method for use in the above-mentioned MIMO system will hereinafter be described in detail. As can be seen from FIG. **10**(*a*), it is assumed that there are N_T Tx antennas and N_R Rx antennas.

[0070] In the case of a transmission signal, a maximum number of transmission information pieces is N_T under the condition that N_T Tx antennas are used, so that the transmission information can be represented by a specific vector shown in the following equation.

$$s=[s_1, s_2, \ldots, S_{N_T}]^T \quad \text{[Equation 2]}$$

[0071] Individual transmission information pieces s_1, s_2, s_{NT} may have different transmission powers. In this case, if the individual transmission powers are denoted by $P_1, P_2, \ldots, P_{NT}$, then transmission information having an adjusted transmission power can be represented by a specific vector shown in the following equation.

$$\hat{s}=[\hat{s}_1, \hat{s}_2, \ldots, \hat{s}_{N_T}]^T=[P_1S_1, P_2s_2, \ldots, P_{N_T}s_{N_T}]^T \quad \text{[Equation 3]}$$

[0072] $\hat{s}$ can be represented by the following equation using a diagonal matrix P of a transmission power.

$$\hat{s} = \begin{bmatrix} P_1 & & & 0 \\ & P_2 & & \\ & & \ddots & \\ 0 & & & P_{N_T} \end{bmatrix} \begin{bmatrix} s_1 \\ s_2 \\ \vdots \\ s_{N_T} \end{bmatrix} = Ps \quad \text{[Equation 4]}$$

[0073] The information vector $\hat{S}$ having an adjusted transmission power is applied to a weight matrix W, so that N_T transmission signals $x_1, x_2, \ldots, x_{NT}$ to be actually transmitted are configured. In this case, the weight matrix W is adapted to properly distribute transmission information to individual antennas according to transmission channel situations. The above-mentioned transmission signals x_1, x_2, x_{NT} can be represented by the following equation using the vector X.

$$x = \begin{bmatrix} x_1 \\ x_2 \\ \vdots \\ x_i \\ \vdots \\ x_{N_T} \end{bmatrix} \quad \text{[Equation 5]}$$

-continued

$$= \begin{bmatrix} w_{11} & w_{12} & \dots & w_{1N_T} \\ w_{21} & w_{22} & \dots & w_{2N_T} \\ \vdots & & \ddots & \\ w_{i1} & w_{i2} & \dots & w_{iN_T} \\ \vdots & & \ddots & \\ w_{N_T1} & w_{N_T2} & \dots & w_{N_TN_T} \end{bmatrix} \begin{bmatrix} \hat{s}_1 \\ \hat{s}_2 \\ \vdots \\ \hat{s}_j \\ \vdots \\ \hat{s}_{N_T} \end{bmatrix}$$

$$= W\hat{s}$$

$$= WPs$$

[0074] Here, W_{ij} denotes a weight corresponding to the i-th Tx antenna and j-th information. W represents a weight matrix or precoding matrix.

[0075] When N_R Rx antennas are used, received signals y_1, y_2, . . . , y_{NR} of individual antennas can be represented by a specific vector (y) shown in the following equation.

$$y=[y_1, y_2, \dots, y_{N_R}]^T \quad \text{[Equation 6]}$$

[0076] When channel modeling is executed in the MIMO communication system, individual channels can be distinguished from each other according to Tx/Rx antenna indexes. A specific channel passing the range from a Tx antenna j to an Rx antenna i is denoted by h_{ij}. In this case, it should be noted that the index order of the channel h_{ij} is located before an Rx antenna index and is located after a Tx antenna index.

[0077] FIG. **5**(*b*) shows channels from N_T Tx antennas to an Rx antenna i. Several channels are tied up, so that they are displayed in the form of a vector or matrix. Referring to FIG. **5**(*b*), the channels passing the range from the N_T Tx antennas to the Rx antenna i can be represented by the following equation.

$$h_i^T=[h_{i1}, h_{i2}, \dots, h_{iN_T}] \quad \text{[Equation 7]}$$

[0078] Accordingly all channels passing the range from the N_T Tx antennas to N_R Rx antennas can be represented by the following equation.

$$H = \begin{bmatrix} h_1^T \\ h_2^T \\ \vdots \\ h_i^T \\ \vdots \\ h_{N_R}^T \end{bmatrix} = \begin{bmatrix} h_{11} & h_{12} & \dots & h_{1N_T} \\ h_{21} & h_{22} & \dots & h_{2N_T} \\ \vdots & & \ddots & \\ h_{i1} & h_{i2} & \dots & h_{iN_T} \\ \vdots & & \ddots & \\ h_{N_R1} & h_{N_R2} & \dots & h_{N_RN_T} \end{bmatrix} \quad \text{[Equation 8]}$$

[0079] Additive white Gaussian noise (AWGN) is added to an actual channel which has passed the channel matrix H. The AWGN n_1, n_2, . . . , n_{NR} added to each of N_R Rx antennas can be represented by a specific vector shown in the following equation.

$$n=[n_1, n_2, \dots, n_{N_R}]^T \quad \text{[Equation 9]}$$

[0080] A reception signal calculated by the above-mentioned equations can be represented by the following equation.

$$y = \begin{bmatrix} y_1 \\ y_2 \\ \vdots \\ y_i \\ \vdots \\ y_{N_R} \end{bmatrix} = \begin{bmatrix} h_{11} & h_{12} & \dots & h_{1N_T} \\ h_{21} & h_{22} & \dots & h_{2N_T} \\ \vdots & & \ddots & \\ h_{i1} & h_{i2} & \dots & h_{iN_T} \\ \vdots & & \ddots & \\ h_{N_R1} & h_{N_R2} & \dots & h_{N_RN_T} \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \\ \vdots \\ x_j \\ \vdots \\ x_{N_T} \end{bmatrix} + \begin{bmatrix} n_1 \\ n_2 \\ \vdots \\ n_i \\ \vdots \\ n_{N_R} \end{bmatrix} = Hx + n \quad \text{[Equation 10]}$$

[0081] In the meantime, the number of rows and the number of columns of a channel matrix H indicating a channel condition are determined by the number of Tx/Rx antennas. In the channel matrix H, the number of rows is equal to the number (N_R) of Rx antennas, and the number of columns is equal to the number (N_T) of Tx antennas. Namely, the channel matrix H is denoted by an $N_R \times N_T$ matrix.

[0082] A matrix rank is defined by a smaller number between the number of rows and the number of columns, in which the rows and the columns are independent of each other. Therefore, the matrix rank cannot be higher than the number of rows or columns. The rank rank(H) of the channel matrix H can be represented by the following equation.

$$\text{rank}(H) \le \min(N_T, N_R) \quad \text{[Equation 11]}$$

[0083] The rank may be defined as the number of non-zero Eigen values when Eigen value decomposition is performed on the matrix. Similarly, the rank may be defined as the number of non-zero singular values when singular value decomposition is performed on the matrix. Accordingly, the rank of the channel matrix refers to a maximum number of information pieces that can be transmitted on a given channel.

[0084] In description of the specification, "rank" with respect to MIMO transmission refers to the number of paths through which signals can be independently transmitted in a specific frequency resource at a specific time, and "the number of layers" refers to the number of signal streams transmitted through each path. Since a transmitter generally transmits as many layers as the number of ranks used for signal transmission, "rank" has the same meaning as "number of layers" unless otherwise mentioned.

[0085] As described above, when the transmitter loads data in Ns data streams (or layers) and simultaneously transmits the data streams, a receiver can decompose received signals into Nx data streams (or layers) and simultaneously receive the data streams. Specifically, when the transmitter precodes the Ns data streams s into a signal x transmitted through a Tx antenna and transmits the signal x, a MIMO receiver can perform a decoding process for decomposing a signal y received through a channel H into Nx received data streams.

That is, a MIMO precoder function is important for the transmitter and an MIMO decoder function is important for the receiver.

[0086] While description of the example of FIG. **5** is based on the narrow-band system, description of the MIMO system can be easily extended to a wideband system. For example, a transmitter performs OFDM modulation and a receiver performs OFDM demodulation in an OFDM system, and thus one wideband system can be modeled as a set of a plurality of narrow-band systems corresponding to a plurality of subcarriers. One narrow-band system can be modeled as the MIMO system as shown in FIG. **5**. Even though the following description is based on modeling of one narrow-band system for clarity, the description can be directly extended and applied to operations in wideband systems.

[0087] Reference Signal (RS)

[0088] Since a packet is transmitted through a radio channel in a wireless communication system, a signal may be distorted during transmission. A receiver needs to correct the distorted signal using channel information in order to correctly receive the distorted signal. To detect channel information, a signal known to both the receiver and a transmitter is transmitted and channel information is detected using a degree of distortion of the signal when the signal is received through a certain channel. This signal is called a pilot signal or a reference signal.

[0089] When multiple antennas are used to transmit and receive data, a correct signal can be received only when channel state between each Tx antenna and each Rx antenna is detected. Accordingly, a reference signal is required for each Tx antenna.

[0090] Reference signals (RSs) can be classified into two types according to purpose in a mobile communication system. One is an RS used for channel information acquisition and the other is an RS used for data demodulation. The former needs to be transmitted in wide band since the RS is used for a UE to acquire downlink channel information. Even a UE that does not receive downlink data in a specific subframe needs to receive and measure the RS for channel information acquisition. This RS is also used for measurement such as handover measurement. The latter is an RS transmitted along with a corresponding resource when a BS performs downlink transmission. A UE can perform channel estimation by receiving the RS and thus can demodulate data. This RS needs to be transmitted in a region in which data is transmitted.

[0091] 3GPP LTE (e.g. 3GPP LTE release-8) defines two types of downlink RSs for unicast service: a common RS (CRS) and a dedicated RS (DRS). The CRS is used for acquisition of information about a channel state and measurement for handover and may be called a cell-specific RS. The DRS is used for data demodulation and may be called a UE-specific RS. In 3GPP LTE, the DRS is used for data demodulation only and the CRS can be used for both channel information acquisition and data demodulation.

[0092] The CRS is transmitted cell-specifically. The CRS is transmitted per subframe in wideband. The CRS can be transmitted for a maximum of four antenna ports according to the number of Tx antennas of a BS. For example, when the number of Tx antennas of the BS is 2, CRSs with respect to antenna ports #**0** and #**1** are transmitted. When the number of Tx antennas of the BS is 4, CRSs with respect to antenna ports #**0**, #**1**, #**2** and #**3** are transmitted.

[0093] FIG. **6** illustrates exemplary CRS and DRS patterns in one resource block pair.

[0094] FIG. **6** shows CRS and DRS patterns in one resource block pair (14 OFDM symbols in the time domain×12 subcarriers in the frequency domain in the case of normal CP) in a system in which a base station supports 4 Tx antennas. In FIG. **6**, REs indicated by "R**0**", "R**1**", "R**2**" and "R**3**" respectively represent CRS positions with respect to antenna port indices **0**, **1**, **2** and **3**. An RE indicated by "D" represents the position of a DRS defined in LTE.

[0095] In LTE-A evolving from LTE, a maximum of 8 Tx antennas can be supported on downlink. Accordingly, reference signals for a maximum of 8 Tx antennas need to be supported. Since only downlink reference signals for a maximum of 4 antenna ports are defined in LTE, reference signals for added antenna ports need to be additionally defined and designed when a BS has 4 to 8 downlink Tx antennas in an LTE-A system. Both the channel measurement reference signal and data demodulation reference signal need to be employed as reference signals for a maximum of 8 Tx antenna ports.

[0096] One important consideration in design of an LTE-A system is backward compatibility. That is, LTE UEs need to operate in LTE-A systems and the LTE-A system needs to support the same. In reference signal transmission, reference signals for a maximum of 8 Tx antenna ports need to be additionally defined in a time-frequency region in which a CRS defined in LTE is transmitted per subframe in the entire bandwidth. In LTE-A, however, when a reference signal pattern for a maximum of 8 transmit antennas is added per subframe to the entire bandwidth as in LTE, reference signal transmission overhead excessively increases.

[0097] Reference signals newly designed in LTE-A are categorized into a channel state information reference signal (CSI-RS) (or channel state information-RS) for channel measurement for selecting a modulation and coding scheme (MCS) and a precoding matrix index (PMI) and a demodulation RS (DMRS) for demodulation of data transmitted through 8 transmit antennas.

[0098] The CSI-RS is designed for the purpose of channel measurement, whereas the CRS is used for measurement, such as channel measurement and handover measurement, and data demodulation in LTE. The CSI-RS may also be used for handover measurement. The CSI-RS need not be transmitted per subframe since the CSI-RS is used to obtain channel state information, differently from the CRS in LTE. Accordingly, the CSI-RS can be designed such that the CSI-RS is intermittently (e.g. periodically) transmitted in the time domain to reduce CSI-RS transmission overhead.

[0099] If data is transmitted in a downlink subframe, a DMRS dedicated to a UE scheduled to transmit data is transmitted to the UE. That is, the DMRS may be called a UE-specific RS. A DMRS dedicated to a specific UE can be designed such that the DMRS is transmitted only in a resource region for which the UE is scheduled, that is, a time-frequency domain in which data with respect to the UE is transmitted.

[0100] FIG. **7** illustrates an exemplary DMRS pattern defined in LTE-A.

[0101] FIG. **7** shows the position of an RE through which a DMRS is transmitted on one RB pair (14 OFDM symbols in the time domain×12 subcarriers in the frequency domain in the case of normal CP) through which downlink data is transmitted. DMRSs can be transmitted for 4 antenna ports (antenna port indices **7**, **8**, **9** and **10**) additionally defined in LTE-A. DMRSs with respect to different antenna ports can be

identified by being located in different frequency resources (subcarriers) and/or different time resources (OFDM symbols) (i.e. multiplexed according to FDM and/or TDM). In addition, DMRSs with respect to different antenna ports, which are located in the same time-frequency resource, can be identified using an orthogonal code (i.e. multiplexed according to CDM). In the example of FIG. **7**, DMRSs with respect to antenna ports **7** and **8** may be located in REs corresponding to DMRS CDM group **1** and multiplexed according to an orthogonal code. Similarly, DMRSs with respect to antenna ports **9** and **10** may be located in REs corresponding to DMRS CDM group **2** and multiplexed according to an orthogonal code.

[0102] When a BS transmits a DMRS, the same precoding as precoding applied to data is applied to the DMRS. Accordingly, channel information estimated by a UE using the DMRS (or UE-specific RS) is precoded channel information. The UE can easily perform data demodulation using the precoded channel information estimated through the DMRS. However, the UE cannot acquire unprecoded channel information from the DMRS since the UE cannot be aware of precoding information applied to the DMRS. The UE can acquire unprecoded channel information using a reference signal other than the DMRS, that is, the aforementioned CSI-RS.

[0103] FIG. **8** illustrates exemplary CSI-RS patterns defined in LTE-A.

[0104] FIG. **8** shows positions of REs on which CSI-RSs are transmitted on one RB pair (14 OFDM symbols in the time domain×12 subcarriers in the frequency domain in the case of normal CP) through which downlink data is transmitted. One of CSI-RS patterns of FIGS. **8**(*a*) to **8**(*e*) can be used in a downlink subframe. CSI-RSs can be transmitted for 8 antenna ports (antenna port indices **15** to **22**) additionally defined in LTE-A. CSI-RSs with respect to different antenna ports can be identified by being located in different frequency resources (subcarriers) and/or different time resources (OFDM symbols) (that is, multiplexed according to FDM and/or TDM). In addition, CSI-RSs with respect to different antenna ports, which are located in the same time-frequency resource, can be identified using an orthogonal code (i.e. multiplexed according to CDM). In FIG. **8**(*a*), CSI-RSs with respect to antenna ports #**15** and #**16** can be located in REs represented as CSI-RS CDM group **1** and can be multiplexed using an orthogonal code. In addition, CSI-RSs with respect to antenna ports #**17** and #**18** can be located in REs represented as CSI-RS CDM group **2** and can be multiplexed using an orthogonal code. CSI-RSs with respect to antenna ports #**19** and #**20** can be located in REs represented as CSI-RS CDM group **3** and can be multiplexed using an orthogonal code. CSI-RSs with respect to antenna ports #**21** and #**22** can be located in REs represented as CSI-RS CDM group **4** and can be multiplexed using an orthogonal code. The principle described with reference to FIG. **8**(*a*) can be equally applied to FIGS. **8**(*b*) to **8**(*e*).

[0105] RS patterns shown in FIGS. **6**, **7** and **8** are exemplary and various embodiments of the present invention are not limited to specific RS patterns. That is, various embodiments of the present invention can be equally applied to a case in which an RS pattern different from those of FIGS. **6**, **7** and **8** is defined and used.

[0106] Channel State Information (CSI)

[0107] MIMO may be classified into open loop and closed loop schemes. Open loop MIMO refers to MIMO transmission performed by a transmitter without CSI feedback of a MIMO receiver. Closed loop MIMO refers to a scheme by which the transmitter receives CSI feedback from the MIMO receiver and performs MIMO transmission. According to closed loop MIMO, the transmitter and receiver can perform beamforming based on CSI to obtain a multiplexing gain of MIMO Tx antennas. The transmitter (e.g. BS) may allocate a UL control channel or UL shared channel to the receiver (e.g. UE) such that the receiver (e.g. UE) can feed back CSI.

[0108] A UE can perform downlink channel estimation and/or measurement using a CRS and/or a CSI-RS. Channel state information (CSI) fed back by the UE to a BS may include a rank indicator (RI), a precoding matrix index (PMI) and a channel quality indicator (CQI).

[0109] The RI is information regarding a channel rank which indicates the number of layers (or streams) capable of transmitting different pieces of information through the same time-frequency resource. Since a rank value is determined according to long term fading of a channel, RI can be fed back in a long period (i.e. less frequently) compared to the PMI and CQI.

[0110] The PMI is information regarding a precoding matrix used for data transmission of a transmitter and reflecting spatial characteristics of a channel. Precoding refers to mapping of a transport layer to a Tx antenna and layer-antenna mapping relationship may be determined by a precoding matrix. PMI corresponds to a precoding matrix index of a preferred BS of a UE on the basis of metrics such as a signal-to-interference plus noise ratio (SINR). To reduce precoding information feedback overhead, the transmitter and receiver may share a codebook including various precoding matrices and only an index indicating a specific precoding matrix in the codebook may be fed back. For example, the PMI can be determined on the basis of a most recently reported RI.

[0111] The CQI is information regarding channel quality or channel intensity. The CQI may be represented by a predetermined MCS combination. That is, a fed back CQI index represents a corresponding modulation scheme and code rate. The CQI can be calculated by setting a specific resource region (e.g. a region specified by valid subframes and/or physical resource blocks) as a CQI reference resource and assuming that PDSCH transmission is present in the CQI reference resource and a PDSCH can be received without exceeding a predetermined error probability (e.g. 0.1). In general, the CQI is a value reflecting reception SINR that can be obtained when a BS configures a spatial channel using the PMI.

[0112] A system (e.g. LTE-A) supporting extended antenna configurations considers acquisition of additional multi-user diversity using multi-user MIMO (MU-MIMO). In MU-MIMO, an interference channel is present between UEs multiplexed in an antenna domain, and thus it is necessary to prevent generation of interference in a UE when a BS performs DL transmission using CSI fed back from another UE from among multiple users. Accordingly, for correct MU-MIMO operation, CSI with higher accuracy needs to be fed back as compared to single user MIMO (SU-MIMO).

[0113] For more accurate CSI measurement and reporting, a method of feeding back new CSI obtained by improving the conventional CSI including RI, PMI and CQI may be applied. For example, precoding information fed back by a receiver can be indicated by a combination of two PMIs (e.g. i**1** and

i2). Accordingly, a more accurate PMI can be fed back and a more accurate CQI can be calculated and reported on the basis of the accurate PMI.

[0114] CSI may be periodically transmitted through a PUCCH or aperiodically transmitted through a PUSCH. In addition, various reporting modes can be defined according to which one of an RI, a first PMI (e.g. W1), a second PMI (e.g. W2) and a CQI is fed back and whether a fed back PMI and/or CQI are for wideband (WB) or subband (SB).

[0115] Deployment of Multiple Antennas

[0116] A beam generated by a conventional one-dimensional antenna configuration is specified only in the azimuth angle (e.g. horizontal domain) direction and cannot be specified in the elevation angle (e.g. vertical domain) direction, and thus only 2-dimensional beamforming is supported therefor. The one-dimensional antenna configuration (e.g. uniform linear array (ULA)) can support adaptive beamforming or spatial multiplexing in the azimuth angle direction, and only MIMO transmission and reception schemes for adaptive beamfoming or spatial multiplexing are designed in conventional wireless communication systems (e.g. systems conforming to 3GPP LTE release-8, 9, 10 and 11).

[0117] When MIMO transmission and reception schemes based on a 2-dimensional antenna configuration (e.g. uniform rectangular array (URA)) for system performance improvement are supported, a beam generated by the 2-dimensional antenna configuration can be specified in the azimuth angle direction and the elevation angle direction and thus 3-dimensional beamforming can be performed therefor.

[0118] FIG. **9** illustrates examples of beamforming according to a 2-dimensional antenna configuration.

[0119] FIG. **9**(*a*) shows examples of sector-specific beamforming, generated by limiting a predetermined range of the azimuth angle and a predetermined range of the elevation angle. FIG. **9**(*b*) shows examples of UE-specific beamforming, generated by varying the elevation angle at the same azimuth angle.

[0120] According to the aforementioned function of generating a beam by specifying the azimuth angle and elevation angle, it is possible to support new beamforming such as sector-specific elevation beamforming (e.g. adaptive control according to a vertical pattern beamwidth and/or downtilt), improved sectorization in the vertical domain and user (or UE)-specific elevation beamforming Vertical sectorization can improve average system performance through a gain of a vertical sector pattern. UE-specific elevation beamforming can increase SINR with respect to a UE by designating a vertical antenna pattern in the direction of the UE.

[0121] Antenna Virtualization

[0122] A transmission antenna and/or a reception antenna, defined to describe operations of a communication system, may be referred to as a virtual antenna or an antenna port. The virtual antenna may or may not be one-to-one mapped to a physical antenna of a transmitter and/or a physical antenna or a receiver.

[0123] FIG. **10** illustrates antenna virtualization.

[0124] When the number of transmission virtual antennas (or transmission antenna ports) is N_{tx}^{V} and the number of transmission physical antennas is N_{tx}^{P}, some physical antennas can be grouped to transmit the same signal all the time if $N_{tx}^{P}>N_{tx}^{V}$. Here, since grouped antennas operate as if the antennas are a single antenna, the grouped antennas can be considered to form one virtual antenna. This can be referred to as transmission antenna virtualization.

[0125] When the number of reception virtual antennas (or reception antenna ports) is N_{rx}^{V}, the number of reception physical antennas is N_{rx}^{P} and $N_{rx}^{P}>N_{rx}^{V}$, the sum of received signals at some grouped physical antennas can be mapped to the input of a MIMO decoder. In this case, the grouped antennas can operate as if the antennas are a single antenna. This can be referred to as reception antenna virtualization.

[0126] Since transmission antenna virtualization and reception antenna virtualization are independent technologies, only one thereof may be applied and different antenna virtualization schemes may be used according to signals even in one system. For example, different antenna virtualization schemes can be respectively applied to transmission of a CSI-RS and a CRS defined in LTE Rel-10 (or LTE-A). LTE Rel-10 supports a maximum of 8 CRS-RS antenna ports (i.e. 8 virtual antennas) and a maximum of 4 CRS antenna ports (or 4 virtual antennas). This means that one system supports up to 8 virtual antennas for a specific pilot (RS) and supports up to 4 virtual antennas for a different type of pilot. Consequently, different antenna virtualization schemes can be applied according to signal type even in the same system. If 16 transmission physical antennas are present, then every two antennas can be grouped to form 8 virtual antennas for CSI-RS transmission or every four antennas can be grouped to form 4 virtual antennas for CRS transmission.

[0127] As described above, antenna virtualization is a technology for mapping a physical antenna to a virtual antenna (or antenna port). Since a virtual antenna-to-physical antenna mapping scheme may depend on a device implementation method, communication standards for defining operations of communication systems define only communication schemes based on the virtual transmission antenna and virtual reception antenna.

[0128] In addition, the purpose of antenna virtualization is to change a channel between a virtual transmission antenna and a virtual reception antenna to a channel more advantageous for communication. The channel between the virtual transmission antenna and the virtual reception antenna is defined as an effective channel $\hat{H}$.

[0129] Channel Aging

[0130] There is a time difference between a time when a UE measures CSI (e.g. an RI, a PMI, a CQI and the like) on a downlink channel and a time when an eNB that has been notified by the UE of the CSI transmits data through the downlink channel. When a channel severely changes with time, the CSI reported to the eNB by the UE may not correctly reflect a channel state at the data transmission time. This phenomenon is called channel aging. Channel aging may cause performance deterioration. Further, channel aging is closely related to temporal variation of the channel, and thus performance deterioration due to channel aging is aggravated as a UE moving speed increases. In addition, since a channel state that a moving UE undergoes may abruptly change as beamforming resolution increases according to 2-dimensional antenna configuration, and thus performance deterioration due to channel aging becomes serious.

[0131] Antenna Virtualization Method for Supporting High-Speed Movement

[0132] The present invention provides an antenna virtualization method for minimizing performance deterioration due to channel aging in a wireless communication system supporting accurate high-speed movement and/or beamforming

Embodiment 1

[0133] According to the present embodiment, antenna virtualization is performed such that channel state variation (or beam pattern variation) due to movement of a UE is minimized. For example, transmission/reception antenna virtualization can be performed in a main movement direction of the UE.

[0134] FIG. **11** illustrates an example of antenna virtualization according to the present invention.

[0135] In the example shown in FIG. **11**, an eNB may have a two-dimensional antenna configuration as in the example of FIG. **9**. Accordingly, resolution of a beam transmitted from the eNB can be increased and the beam can be focused on a specific point.

[0136] FIG. **11**(*a*) is a view for explaining a problem of the conventional method. A channel state, which is measured by a UE on the basis of a virtual antenna (e.g. a virtual antenna composed of a physical antenna a_0) at a position A, is referred to as CSI-A and a channel state, which is measured by the UE on the basis of the virtual antenna (e.g. a virtual antenna composed of the physical antenna a_0) at a position B, is referred to as CSI-B. When a signal transmitted from an eNB is focused on position A, there is a high possibility that CSI-A and CSI-B are inconsistent with each other. For example, the channel state at the position A can be expected to be better than the channel state at position B, and thus channel state can be measured/calculated such that CSI-A can use a higher rank and higher MCS level than CSI-B.

[0137] FIG. **11**(*b*) is a view for explaining the effect obtained when antenna virtualization provided by the present invention is applied. When the UE moves from position A to position B, a plurality of physical antennas located in the moving direction of the UE may be grouped and defined as a virtual antenna. For example, antennas a_0, a_1, a_2, a_3, a_4 and a_5 can be grouped to form one virtual antenna. In this case, it can be expected that a channel state that affects the antennas a_0, a_1, a_2 and a_3 from among the physical antennas constituting the virtual antenna at position A is similar to or substantially the same as a channel state that affects the antennas a_2, a_3, a_4 and a_5 at position B. Accordingly, channel state information CSI-A calculated/measured by the UE at position A can be expected to be very similar to channel state information CSI-B calculated/measured by the UE at position B. Therefore, channel state inconsistency at positions A and B can be remarkably reduced compared to the example of FIG. **11**(*a*) when antenna virtualization is applied as shown in FIG. **11**(*b*).

[0138] That is, antenna virtualization can be performed such that an antenna pattern having a wide beamwidth in the moving direction of the UE. In other words, an antenna virtualization pattern can be determined such that a beamwidth is extended in the same direction as the moving direction of the UE. Otherwise, the antenna virtualization pattern can be determined such that physical antennas arranged in a main movement direction of the UE (or arranged in a direction closest to the main movement direction of the UE) are grouped. For example, virtualization of transmission antennas of the UE can be performed such that the width of a beam transmitted from a virtual antenna of the UE becomes wide so as to reduce inconsistency between states of channels generated according to the transmission antennas when the UE moves at a high speed. In addition, virtualization of reception antennas of the UE can be performed such that inconsistency between channel states that affect the UE moving at a high speed at different positions is reduced when the UE receives a beam transmitted from a specific point (e.g. eNB).

[0139] FIG. **12** illustrates an antenna virtualization method with respect to a two-dimensional antenna configuration according to the present invention.

[0140] In the example of FIG. **12**, it is assumed that a UE has a two-dimensional antenna configuration in which 24 physical antennas are arranged in four columns and 6 rows. The UE may be a vehicle and the physical antennas may be arranged outside the vehicle. If the vehicle moves in the horizontal direction (column direction) in the figure, one virtual antenna can be configured by grouping antennas arranged in a traverse direction from the front to the rear of the vehicle. For example, physical antennas a_{00}, a_{01}, a_{02}, a_{03}, a_{04} and a_{05} can be grouped to configure one virtual antenna #**0**, physical antennas a_{10}, a_{11}, a_{12}, a_{13}, a_{14} and a_{15} can be grouped to configure one virtual antenna #**1**, physical antennas a_{20}, a_{21}, a_{22}, a_{23}, a_{24} and a_{25} can be grouped to configure one virtual antenna #**2**, and physical antennas a_{30}, a_{31}, a_{32}, a_{33}, a_{34} and a_{35} can be grouped to configure one virtual antenna #**3**.

[0141] When the virtual antennas are configured as described above, antenna virtualization is performed such that a wide beamwidth is obtained in the moving direction of the vehicle, and thus inconsistency of channel states that affect the vehicle moving at a high speed can be reduced and antenna gain can be increased.

[0142] In application of embodiments of the present invention, the transmission antenna virtualization method and the reception antenna virtualization method are not limited to the same method. For example, part of a plurality of antennas may be transmission dedicated antennas, the remaining part thereof may be reception dedicated antennas, and a transmission antenna virtualization method and a reception antenna virtualization method may be independently configured. Alternatively, when some or all antennas are used for both transmission and reception, an antenna virtualization method when the antennas operate as transmission antennas and an antenna virtualization method when the antennas operate as reception antennas may be differently applied to one antenna.

[0143] In addition, an antenna virtualization method may be defined per system. Further, different antenna virtualization methods may be respectively defined for frequencies even in the same system.

Embodiment 2

[0144] In the present embodiment, antenna virtualization is adaptively applied according to a movement state and/or a communication state of a UE. Information indicating the movement state of the UE may include parameters indicating whether the UE moves, a movement direction, a moving speed, an acceleration/deceleration state and the like. Information indicating the communication state may include parameters indicating a distance between the UE and a device (e.g. eNB) that transmits/receives signals to/from the UE, relative positions, channel state (e.g. CSI) and the like. Adaptive antenna virtualization refers to variable application of the number of physical antennas included in one virtual antenna, information indicating physical antennas mapped to a virtual antenna (i.e. information indicating/specifying one or more physical antennas (e.g. physical antenna index information)) and the like.

[0145] A description will be given of an antenna virtualization method considering the movement state of the UE.

[0146] Virtual antenna to physical antenna mapping may be determined on the basis of the moving speed of the UE. For example, a large number of physical antennas included in one virtual antenna (or mapped to one virtual antenna) does not always ensure high performance. When channel aging is not severe, such as a case in which the UE moves relatively slowly, higher performance may be expected when the number of physical antennas included in one virtual antenna is not large. For example, when a large number of physical antennas configures one transmission virtual antenna, performance deterioration can occur due to transmission power dispersion. Furthermore, when a large number of physical antennas configures one reception virtual antenna, performance deterioration can occur due to antenna gain dispersion. Accordingly, it is necessary to appropriately control the number of physical antennas mapped to a virtual antenna for concentration of transmission power or antenna gain. The number of physical antennas included in one virtual antenna may be increased such that a virtual antenna pattern robust against channel aging is generated when the UE moves at a high speed (or when the UE moves at a speed higher than a predetermined threshold value). When the UE moves at a low speed (or when the UE moves at a speed higher than the predetermined threshold value), the influence of channel aging is not large and thus the number of physical antennas included in one virtual antenna may be reduced (i.e. the number of virtual antennas may be increased) in order to increase transmission power efficiency/antenna gain. That is, the number of physical antennas included in one virtual antenna can be set to be proportional to the moving speed of the UE. However, this is exemplary and the relationship between the number of physical antennas included in one virtual antenna and the moving speed of the UE is not limited to a proportional relationship. In a specific case, the number of physical antennas included in one virtual antenna may be inversely proportional to the moving speed of the UE. For example, when the number of physical antennas included in a virtual antenna increases and thus the aperture of the virtual antenna increases (when the antenna effective area actually related to signals transmitted and received through the virtual antenna increases, for example) according to configuration of physical antennas, a gain variation of the virtual antenna according to signal transmission/reception directions may increase (i.e. beam pattern fluctuation may increase). In this case, higher performance may be expected when the number of physical antennas included in a virtual antenna decreases as the moving speed of the UE increases. Consequently, the mapping relationship between virtual antennas and physical antennas, such as the number of virtual antennas and the number of physical antennas included in a virtual antenna, can be adaptively applied according to movement state of the UE and the like.

[0147] Antenna virtualization may be applied when the UE moves and may not be applied when the UE does not move. In addition, the number of antennas included in one virtual antenna may be increased when the UE moves and decreased when the UE does not move.

[0148] Physical antennas arranged in the moving direction of the UE (e.g. forward and backward direction or left and right direction when the UE is a vehicle) may be grouped to configure a virtual group according to the moving direction of the UE.

[0149] A description will be given of an antenna virtualization method considering a communication state.

[0150] A method of configuring a virtual antenna by grouping physical antennas arranged in the moving direction of the vehicle (i.e. arranged in a traverse direction from the front to the rear of the vehicle), as shown in FIG. **12**, can obtain higher performance when a device that transmits/receives signals to/from the vehicle is located perpendicularly to the moving direction of the vehicle (e.g. an eNB, a roadside AP or the like is located higher than or far from the vehicle). When the device that transmits/receives signals to/from the vehicle is located in the same direction as the moving direction of the vehicle (e.g. when a plurality of devices is arranged at the center of a road at a height similar to the vehicle), a virtual antenna in a form different from a virtual antenna including physical antennas arranged in the moving direction of the vehicle may be configured or the number of physical antennas included in one virtual antenna may be controlled.

[0151] Even in the antenna virtualization method considering the communication state of the UE, channel state variation (or beam pattern variation) due to a change of the location of the UE needs to be minimized Accordingly, a virtual antenna can be configured such that performance deterioration due to channel aging is minimized

[0152] To adaptively apply an antenna virtualization pattern, as described above, an eNB (or remote radio head (RRH), network node, AP or the like) that transmits/receives signals to/from the UE may signal information on the location thereof to the UE (or cellular phone, vehicle or the like). In addition, the UE may report, to the eNB, information indicating the movement state thereof (e.g. moving speed, moving direction, acceleration/deceleration related information and the like) and/or information indicating the communication thereof (e.g. the location of the UE, channel state information (CSI) and the like). Further, the eNB may determine an antenna virtualization method using the information thereof and/or the information reported by the UE and provide control information about the antenna virtualization method (e.g. the number of physical antennas, pattern, information designating a virtualization mode (e.g. an antenna virtualization mode applied to low-speed movement/antenna virtualization mode applied to high-speed movement) and the like). The UE may transmit information about a preferred antenna virtualization method (e.g. information indicating the number of physical antennas, pattern or virtualization mode, which is recommended by the UE) to the eNB.

[0153] In addition, the number of available antenna virtualization patterns (e.g. information indicating the number of configured transmission virtual antennas, the number of configured reception virtual antennas, the number of physical antennas configuring one virtual antenna, physical antennas mapped to one virtual antenna (i.e. information indicating/specifying one or more physical antennas) and the like) may remarkably increase according to the number of physical antennas of the UE and arrangement of the physical antennas. Accordingly, when control information capable of indicating a large number of cases is defined, overhead of control information transmitted/received between the UE and the eNB considerably increases, which is inefficient. Therefore, the present invention predetermines antenna virtualization pattern candidates between the eNB and the UE and defines control information with respect to an antenna virtualization pattern in the form of information that directly or indirectly indicates a specific pattern from among the antenna virtualization pattern candidates.

[0154] In adaptive application of an antenna virtualization method, changing antenna characteristics (e.g. antenna virtualization pattern) during data transmission and reception between the UE and the eNB may affect transmission and reception performance Accordingly, a virtual antenna configuration scheme may be limited such that a virtual antenna configuration is changed only when the UE does not perform data transmission and reception (e.g. when the UE is idle or turns off a communication function).

[0155] FIG. **13** is a flowchart illustrating a communication method using a virtual antenna according to the present invention.

[0156] An eNB may transmit, to a UE, control information with respect to an antenna virtualization pattern of a UE in step S**1310**. The antenna virtualization pattern may be determined on the basis of information indicating a movement state of the UE and/or information indicating a communication state of the UE. The control information with respect to the antenna virtualization pattern may indicate the number of physical antennas mapped to one virtual antenna, information specifying physical antennas and the like.

[0157] The UE may configure one or more virtual antennas on the basis of the antenna virtualization pattern in step S**1320**. One or more physical antennas mapped to one virtual antenna may be determined on the basis of the moving direction of the UE in the present invention. For example, one or more physical antennas mapped to one virtual antenna can be determined such that the width of a beam formed by the one or more physical antennas is extended in the same direction as the moving direction of the UE or one or more physical antennas arranged in the moving direction of the UE are mapped to one virtual antenna. Accordingly, a virtual antenna robust against channel aging can be configured.

[0158] Communication may be performed between the UE and the eNB through the one or more virtual antennas of the UE in step S**1330**.

[0159] The total number of virtual antennas, determined according to the adaptive antenna virtualization method provided by the present invention (or changed from a previous number), may affect the number of transmitted pilot signals, the number of received pilot signals and/or calculation and configuration of CSI feedback information.

[0160] One of various embodiments of the present invention or combinations of two or more thereof can be applied to the communication method using a virtual antenna according to the present invention, described with reference to FIG. **13**.

[0161] FIG. **14** illustrates a configuration of a UE and an eNB according to a preferred embodiment of the present invention.

[0162] Referring to FIG. **14**, an eNB **10** according to the present invention may include a transmitter **11**, a receiver **12**, a processor **13**, a memory **14** and a plurality of antennas **15**. The transmitter **11** can transmit signals, data and information to an external device (e.g. UE). The receiver **12** can receive signals, data and information from an external device (e.g. UE). The processor **13** can control the overall operation of the eNB **10**. The plurality of antennas **15** can be configured according to a two-dimensional antenna configuration.

[0163] The processor **13** of the eNB **10** according to an embodiment of the present invention can be configured to support communication using a virtual antenna of the UE according to embodiments provided by the present invention. The processor **13** of the eNB **10** can control the eNB **10** to generate control information with respect to an antenna virtualization pattern of the UE, which is determined on the basis of information indicating a movement state of the UE **20** and/or information indicating a communication state of the UE **20**, and transmit the control information to the UE **20** through the transmitter **11**. In addition, the processor **13** of the eNB **10** can control the eNB **10** to perform communication with the UE **20** through one or more virtual antennas, which are configured by the UE **20** according to the control information with respect to the antenna virtualization pattern, using the transmitter **11** and/or the receiver **12**. Here, physical antennas mapped to one virtual antenna of the UE **20** can be determined on the basis of the moving direction of the UE **20**, and thus the eNB **10** can support configuration of a virtual antenna robust against channel aging at the UE **20**.

[0164] In addition, the processor **13** of the eNB **10** can process information received by the eNB **10**, information to be transmitted to the outside and the like, and the memory **14** can store processed information for a predetermined time and may be replaced by a component such as a buffer (not shown).

[0165] Referring to FIG. **14**, the UE **20** according to the present invention may include a transmitter **21**, a receiver **22**, a processor **23**, a memory **24** and a plurality of antennas **25**. The plurality of antennas **25** means that the UE **20** supports MIMO transmission and reception. The transmitter **21** can transmit signals, data and information to an external device (e.g. eNB). The receiver **22** can receive signals, data and information from an external device (e.g. eNB). The processor **23** can control the overall operation of the UE **20**.

[0166] The processor **23** of the UE **20** according to an embodiment of the present invention can be configured to perform communication using a virtual antenna according to the embodiments of the present invention. The processor **12** of the UE **20** can control the UE **20** to configure one or more virtual antennas according to an antenna virtualization pattern determined on the basis of information indicating a movement state of the UE **20** and/or information indicating a communication state of the UE **20**. Further, the processor **23** of the UE **20** can control the UE **20** to perform communication with the eNB **10** using the one or more virtual antennas through the transmitter **21** and/or the receiver **220**. Here, one or more physical antennas mapped to one virtual antenna can be determined on the basis of the moving direction of the UE and thus a virtual antenna robust against channel aging can be configured.

[0167] In addition, the processor **23** of the UE **20** can process information received by the UE **20**, information to be transmitted to the outside and the like, and the memory **24** can store processed information for a predetermined time and may be replaced by a component such as a buffer (not shown).

[0168] Configurations of the eNB **10** and the UE **20** can be implemented such that the above-described various embodiments of the present invention are independently applicable or two or more thereof are simultaneously applicable and redundant description is omitted for clarity.

[0169] While an eNB is exemplarily used as a downlink transmission entity or an uplink reception entity and a UE is exemplarily used as a downlink reception entity or an uplink transmission entity in description of various embodiments of the present invention, the scope or spirit of the present invention is not limited thereto. For example, description of the eNB can be equally applied to a case in which a cell, an antenna port, an antenna port group, an RRH, a transmission point, a reception point, an access point, a relay and the like are downlink transmission entities for downlink transmission

to a UE or uplink reception entities for uplink reception from the UE. In addition, the principle of the present invention, described through various embodiments of the present invention, can be equally applied to a case in which a relay is a downlink transmission entity for downlink transmission to the UE or an uplink reception entity for uplink reception from the UE or a case in which the relay is an uplink transmission entity for uplink transmission to an eNB or a downlink reception entity for downlink reception from the eNB.

[0170] The embodiments of the present invention may be achieved by various means, for example, hardware, firmware, software, or a combination thereof.

[0171] In a hardware configuration, an embodiment of the present invention may be achieved by one or more ASICs (application specific integrated circuits), DSPs (digital signal processors), DSPDs (digital signal processing devices), PLDs (programmable logic devices), FPGAs (field programmable gate arrays), processors, controllers, microcontrollers, microprocessors, etc.

[0172] In a firmware or software configuration, an embodiment of the present invention may be implemented in the form of a module, a procedure, a function, etc. Software code may be stored in a memory unit and executed by a processor. The memory unit is located at the interior or exterior of the processor and may transmit and receive data to and from the processor via various known means.

[0173] The detailed description of the preferred embodiments of the present invention is given to enable those skilled in the art to realize and implement the present invention. While the present invention has been described referring to the preferred embodiments of the present invention, those skilled in the art will appreciate that many modifications and changes can be made to the present invention without departing from the spirit and essential characteristics of the present invention. For example, the structures of the above-described embodiments of the present invention can be used in combination. The above embodiments are therefore to be construed in all aspects as illustrative and not restrictive. Therefore, the present invention is not intended to limit the embodiments disclosed herein but to give a broadest range matching the principles and new features disclosed herein.

[0174] Those skilled in the art will appreciate that the present invention may be carried out in other specific ways than those set forth herein without departing from the spirit and essential characteristics of the present invention. The above embodiments are therefore to be construed in all aspects as illustrative and not restrictive. The scope of the invention should be determined by the appended claims and their legal equivalents, not by the above description, and all changes coming within the meaning and equivalency range of the appended claims are intended to be embraced therein. Therefore, the present invention intends not to limit the embodiments disclosed herein but to give a broadest range matching the principles and new features disclosed herein. It is obvious to those skilled in the art that claims that are not explicitly cited in each other in the appended claims may be presented in combination as an embodiment of the present invention or included as a new claim by a subsequent amendment after the application is filed.

INDUSTRIAL APPLICABILITY

[0175] The aforementioned embodiments of the present invention can be applied to various mobile communication systems.

1. A communication method using a virtual antenna of a terminal in a wireless communication system, comprising:

configuring one or more virtual antennas according to an antenna virtualization pattern determined on the basis of at least one of information indicating a movement state of the terminal and information indicating a communication state of the terminal; and

communicating with a base station using the one or more virtual antennas,

wherein one or more physical antennas mapped to one virtual antenna are determined on the basis of a direction of movement of the terminal.

2. The communication method according to claim **1**, wherein the width of a beam formed by the one or more physical antennas mapped to one virtual antenna is extended in the same direction as the direction of movement of the terminal.

3. The communication method according to claim **1**, wherein the one or more physical antennas mapped to one virtual antenna are one or more physical antennas arranged in the direction of movement of the terminal.

4. The communication method according to claim **1**, wherein the antenna virtualization pattern includes at least one of the number of one or more physical antennas mapped to one virtual antenna and information specifying the one or more physical antennas.

5. The communication method according to claim **4**, wherein the number of one or more physical antennas mapped to one virtual antenna is determined on the basis of a moving speed of the terminal.

6. The communication method according to claim **1**, wherein the information indicating the movement state includes at least one of information on whether the terminal is moving, information on the direction of movement of the terminal, information on the moving speed of the terminal and information about an acceleration state or a deceleration state.

7. The communication method according to claim **1**, wherein the information indicating the communication state includes at least one of information on a distance between the terminal and the base station, information on relative positions of the terminal and the base station and information on a channel state between the terminal and the base station.

8. The communication method according to claim **1**, wherein the antenna virtualization pattern is adaptively determined according to change of at least one of the information indicating the movement state of the terminal and the information indicating the communication state of the terminal.

9. The communication method according to claim **1**, wherein control information with respect to the antenna virtualization pattern is received from the base station.

10. The communication method according to claim **1**, wherein one or more of the information indicating the movement state of the terminal, position information of the terminal and channel state information is reported by the terminal to the base station.

11. The communication method according to claim **1**, wherein information indicating the antenna virtualization pattern preferred by the terminal is reported by the terminal to the base station.

12. The communication method according to claim **1**, wherein the configuring of one or more virtual antennas

according to the antenna virtualization pattern is performed when the terminal does not perform data transmission and reception.

13. A method for supporting, by a base station, communication using a virtual antenna of a terminal in a wireless communication system, comprising:

transmitting, to the terminal, control information with respect to an antenna virtualization pattern of the terminal, determined on the basis of at least one of information indicating a movement state of the terminal and information indicating a communication state of the terminal; and

communicating with the terminal through one or more virtual antennas of the terminal, configured according to the control information with respect to the antenna virtualization pattern,

wherein one or more physical antennas mapped to one virtual antenna are determined on the basis of a direction of movement of the terminal.

14. A terminal performing communication using a virtual antenna in a wireless communication system, comprising:

a transmitter;

a receiver; and

a processor,

wherein the processor is configured: to configure one or more virtual antennas according to an antenna virtualization pattern determined on the basis of at least one of information indicating a movement state of the terminal and information indicating a communication state of the terminal; and to communicate with a base station using the one or more virtual antennas through one of the transmitter and the receiver,

wherein one or more physical antennas mapped to one virtual antenna are determined on the basis of a direction of movement of the terminal.

15. A base station supporting communication using a virtual antenna of a terminal in a wireless communication system, comprising:

a transmitter;

a receiver; and

a processor,

wherein the processor is configured: to transmit, to the terminal, control information with respect to an antenna virtualization pattern of the terminal, determined on the basis of at least one of information indicating a movement state of the terminal and information indicating a communication state of the terminal, through the transmitter; and to communicate with the terminal through one or more virtual antennas of the terminal, configured according to the control information with respect to the antenna virtualization pattern, through one of the transmitter and the receiver,

wherein one or more physical antennas mapped to one virtual antenna are determined on the basis of a direction of movement of the terminal.

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