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(54) METHOD AND APPARATUS FOR PERFORMING COMMUNICATION ON THE BASIS OF CYCLIC SHIFT DIVERSITY

(57) Embodiments of this application provide a cyclic shift diversity-based communication method and apparatus. A maximum number of antennas supported in this method is greater than 8, and cyclic shift is performed on a first preamble part of each antenna by using a cyclic shift diversity value, so that an automatic gain control error can be reduced in a scenario in which transmission using more antennas (for example, 16 antennas) is supported.

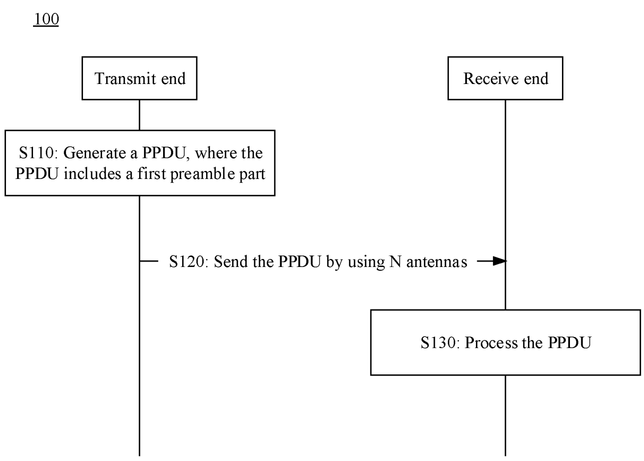

FIG. 4

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Description

[0001] This application claims priority to Chinese Patent Application No. 202110201124.6, filed with the China National Intellectual Property Administration on February 23, 2021 and entitled "CYCLIC SHIFT DIVERSITY-BASED COMMUNICATION METHOD AND APPARATUS", which is incorporated herein by reference in its entirety.

TECHNICAL FIELD

[0002] This application relates to the communication field, and more specifically, to a cyclic shift diversity-based communication method and apparatus.

BACKGROUND

[0003] In a wireless local area network (wireless local area network, WLAN) technology, the institute of electrical and electronics engineers (institute of electrical and electronics engineers, IEEE) has introduced a multi-input multi-output (multi-input multi-output, MIMO) technology on the basis of an orthogonal frequency division multiplexing (orthogonal frequency division multiplexing, OFDM) technology to support multi-antenna transmission. A maximum number of antennas supported in the IEEE 802.11n protocol is four, the maximum number of antennas supported in the IEEE 802.11ac protocol is expanded to eight, and the IEEE 802.11ax protocol inherits the maximum number of antennas supported in the 802.11ac protocol.

[0004] With development of technologies, a new communication protocol (for example, the IEEE 802.11be protocol) may support transmission of more than eight antennas (for example, 16 antennas) and more antennas. However, a current 8-antenna transmission technology cannot meet a communication requirement of the new communication protocol. Therefore, how to perform communication based on more antennas is a problem of attention.

SUMMARY

[0005] Embodiments of this application provide a cyclic shift diversity-based communication method and apparatus. A maximum number of antennas supported in this method is greater than 8, and cyclic shift is performed on a first preamble part of each antenna by using a cyclic shift diversity value, so that an automatic gain control (automatic gain control, AGC) error can be reduced in a scenario in which transmission using more antennas (for example, 16 antennas) is supported.

[0006] According to a first aspect, a cyclic shift diversity-based communication method, where a maximum number of antennas supported in the method is M, M is a positive integer greater than 8, and the method includes:

generating a physical layer protocol data unit PPDU, where the PPDU includes a first preamble part; and
sending the PPDU by using N antennas, where cyclic shift is performed, based on a cyclic shift diversity CSD value, on a first preamble part of a PPDU sent on an i^{th} antenna of the N antennas, and N is a positive integer less than or equal to M.

[0007] For example, the CSD value may be predefined in a protocol.

[0008] In an example, the first preamble part includes a legacy short training field (legacy-short training field, L-STF), a legacy long training field (legacy-long training field, L-LTF), and a legacy signal field (legacy-signal field, L-SIG).

[0009] In another example, the first preamble part includes an L-STF, an L-LTF, an L-SIG, and a signaling field defined in a new communication protocol.

[0010] For example, in 802.11 be, the first preamble part includes an L-STF, an L-LTF, an L-SIG, a repeated legacy-signal field (repeated legacy-signal field, RL-SIG), and a universal signal field (universal signal field, U-SIG).

[0011] For example, in 802.11 be, the first preamble part includes an L-STF, an L-LTF, an L-SIG, an RL-SIG, a U-SIG, and an extremely high throughput signal field (extremely high throughput signal field, EHT-SIG).

[0012] According to the cyclic shift diversity-based communication method provided in embodiments of this application, a maximum number of antennas supported in this method is greater than 8, and cyclic shift is performed on a first preamble part of each antenna by using a CSD value, so that an AGC error can be reduced in a scenario in which transmission using more antennas (for example, 16 antennas) is supported.

[0013] With reference to the first aspect, in some implementations of the first aspect, M = 16, and the CSD value belongs to a CSD set.

[0014] According to the cyclic shift diversity-based communication method provided in embodiments of this application, the maximum number of antennas can be expanded to 16, and this method can be better applicable to a communication scenario with a large communication requirement, to better improve a system capacity.

[0015] With reference to the first aspect, in some implementations of the first aspect,

N = 9, and the CSD value in the CSD set includes: 0, -175 ns, -87.5 ns, -62.5 ns, -200 ns, -187.5 ns, -100 ns, -50 ns, and -12.5 ns;
N = 10, and the CSD value in the CSD set includes: 0, -175 ns, -87.5 ns, -62.5 ns, - 200 ns, -187.5 ns, -100 ns, -50 ns, -12.5 ns, and -25 ns;
N = 11, and the CSD value in the CSD set includes: 0, -175 ns, -87.5 ns, -200 ns, - 187.5 ns, -100 ns, -50 ns, -12.5 ns, -25 ns, -37.5 ns, and -125 ns;
N = 12, and the CSD value in the CSD set includes: 0, -175 ns, -200 ns, -187.5 ns, - 100 ns, -50 ns, -12.5 ns, -25 ns, -37.5 ns, -75 ns, -162.5 ns, and -112.5 ns;
N = 13, and the CSD value in the CSD set includes: 0, -87.5 ns, -200 ns, -187.5 ns, - 100 ns, -50 ns, -12.5 ns, -25 ns, -37.5 ns, -75 ns, -162.5 ns, -125 ns, and -137.5 ns;
N = 14, and the CSD value in the CSD set includes: 0, -175 ns, -62.5 ns, -200 ns, - 187.5 ns, -100 ns, -50 ns, -12.5 ns, -25 ns, -37.5 ns, -75 ns, -150 ns, -112.5 ns, and -162.5 ns;
N = 15, and the CSD value in the CSD set includes: 0, -175 ns, -87.5 ns, -200 ns, - 187.5 ns, -100 ns, -50 ns, -12.5 ns, -25 ns, -37.5 ns, -75 ns, -150 ns, -125 ns, -162.5 ns, and - 137.5 ns; or
N = 16, and the CSD value in the CSD set includes: 0, -175 ns, -62.5 ns, -200 ns, - 187.5 ns, -100 ns, -50 ns, -12.5 ns, -25 ns, -37.5 ns, -75 ns, -150 ns, -125 ns, -162.5 ns, -137.5 ns, and -112.5 ns.

[0016] According to the cyclic shift diversity-based communication method provided in embodiments of this application, when the maximum number of antennas supported in the method is 16, a CSD set corresponding to each of 9 to 16 antennas is provided. The CSD set acts on the first preamble part, so that an AGC error can be better reduced in a scenario in which transmission using 16 antennas is supported. In addition, when the maximum number of antennas supported in the method is 16 and a number of used antennas is 1 to 8, CSD sets corresponding to one to eight antennas in an earlier communication protocol (for example, the 802.11n protocol, the 802.11ac protocol, or the 802.11ax protocol) may be used, so that the earlier communication protocol can be compatible, thereby facilitating smooth evolution of a system.

[0017] With reference to the first aspect, in some implementations of the first aspect,

N = 1, and the CSD value in the CSD set includes 0;
N = 2, and the CSD value in the CSD set includes: 0, -175 ns;
N = 3, and the CSD value in the CSD set includes: 0, -175 ns, and -87.5 ns;
N = 4, and the CSD value in the CSD set includes: 0, -175 ns, -87.5 ns, and -62.5 ns;
N = 5, and the CSD value in the CSD set includes: 0, -175 ns, -87.5 ns, -62.5 ns, and -200 ns;
N = 6, and the CSD value in the CSD set includes: 0, -87.5 ns, -200 ns, -187.5 ns, - 125 ns, and -12.5 ns;
N = 7, and the CSD value in the CSD set includes: 0, -87.5 ns, -62.5 ns, -200 ns, - 187.5 ns, -100 ns, and -150 ns;
N = 8, and the CSD value in the CSD set includes: 0, -200 ns, -187.5 ns, -100 ns, -50 ns, -25 ns, -125 ns, and -150 ns;
N = 9, and the CSD value in the CSD set includes: 0, -175 ns, -87.5 ns, -200 ns, - 187.5 ns, -100 ns, -50 ns, -12.5 ns, and -25 ns;
N = 10, and the CSD value in the CSD set includes: 0, -175 ns, -200 ns, -187.5 ns, - 100 ns, -50 ns, -12.5 ns, -25 ns, -137.5 ns, and -162.5 ns;
N = 11, and the CSD value in the CSD set includes: 0, -87.5 ns, -200 ns, -187.5 ns, - 100 ns, -50 ns, -12.5 ns, -25 ns, -37.5 ns, -137.5 ns, and -150 ns;
N = 12, and the CSD value in the CSD set includes: 0, -175 ns, -87.5 ns, -200 ns, - 187.5 ns, -100 ns, -12.5 ns, -25 ns, -37.5 ns, -75 ns, -150 ns, and -162.5 ns;
N = 13, and the CSD value in the CSD set includes: 0, -175 ns, -62.5 ns, -187.5 ns, - 100 ns, -50 ns, -12.5 ns, -25 ns, -37.5 ns, -75 ns, -150 ns, -162.5 ns, and -125 ns;
N = 14, and the CSD value in the CSD set includes: 0, -175 ns, -87.5 ns, -187.5 ns, - 100 ns, -50 ns, -12.5 ns, -25 ns, -37.5 ns, -75 ns, -150 ns, -125 ns, -162.5 ns, and -137.5 ns;
N = 15, and the CSD value in the CSD set includes: 0, -175 ns, -87.5 ns, -200 ns, - 187.5 ns, -100 ns, -50 ns, -12.5 ns, -25 ns, -75 ns, -125 ns, -162.5 ns, -137.5 ns, -112.5 ns, and -150 ns; or
N = 16, and the CSD value in the CSD set includes: 0, -175 ns, -87.5 ns, -200 ns, - 187.5 ns, -100 ns, -50 ns, -12.5 ns, -25 ns, -37.5 ns, -75 ns, -150 ns, -125 ns, -162.5 ns, -137.5 ns, and -112.5 ns.

[0018] According to the CSD-based communication method provided in embodiments of this application, when the maximum number of antennas supported in the method is 16, a CSD set corresponding to each of 1 to 16 antennas is provided. The CSD set acts on the first preamble part, so that an AGC error can be better reduced in a scenario in which transmission using 16 antennas is supported.

[0019] With reference to the first aspect, in some implementations of the first aspect, the CSD is determined based on a range of a ratio of receive power of a legacy short training field L-STF of a PPDU to receive power of an extremely high throughput short training field EHT-STF of the PPDU.

[0020] With reference to the first aspect, in some implementations of the first aspect, the CSD is determined based on a first criterion value, and the first criterion value is a maximum value that is in ranges of ratios of receive power of the L-STF to receive power of the EHT-STF and that is obtained in a plurality of scenarios.

[0021] According to a second aspect, a cyclic shift diversity-based communication method, where the method includes:

receiving a physical layer protocol data unit PPDU, where the PPDU includes a first preamble part, the first preamble part is received based on a cyclic shift diversity CSD value, and the CSD value is a CSD value based on which a transmit end sends the first preamble part; and
processing the PPDU.

[0022] According to a third aspect, a cyclic shift diversity-based communication apparatus is provided, where the apparatus is configured to perform the method provided in the first aspect. Specifically, the apparatus may include a module configured to perform any one of the first aspect and the possible implementations of the first aspect.

[0023] According to a fourth aspect, a cyclic shift diversity-based communication apparatus is provided, where the apparatus is configured to perform the method provided in the second aspect. Specifically, the apparatus may include a module configured to perform any one of the second aspect and the possible implementations of the second aspect.

[0024] According to a fifth aspect, a cyclic shift diversity-based communication apparatus is provided, including a processor. The processor is coupled to a memory, and may be configured to execute instructions in the memory, to implement the method according to any one of the first aspect and the possible implementations of the first aspect. Optionally, the apparatus further includes the memory. Optionally, the apparatus further includes a communication interface, and the processor is coupled to the communication interface.

[0025] According to a sixth aspect, a cyclic shift diversity-based communication apparatus is provided, including a processor. The processor is coupled to a memory, and may be configured to execute instructions in the memory, to implement the method according to any one of the second aspect and the possible implementations of the second aspect. Optionally, the apparatus further includes the memory. Optionally, the apparatus further includes a communication interface, and the processor is coupled to the communication interface.

[0026] According to a seventh aspect, a computer-readable storage medium is provided. The computer-readable storage medium stores a computer program. When the computer program is executed by an apparatus, the apparatus is enabled to implement the method according to any one of the first aspect and the possible implementations of the first aspect.

[0027] According to an eighth aspect, a computer-readable storage medium is provided. The computer-readable storage medium stores a computer program. When the computer program is executed by an apparatus, the apparatus is enabled to implement the method according to any one of the second aspect and the possible implementations of the second aspect.

[0028] According to a ninth aspect, a computer program product including instructions is provided. When the instructions are executed by a computer, an apparatus is enabled to implement the method provided according to any one of the first aspect and the possible implementations of the first aspect.

[0029] According to a tenth aspect, a computer program product including instructions is provided. When the instructions are executed by a computer, an apparatus is enabled to implement the method according to any one of the second aspect and the possible implementations of the second aspect.

BRIEF DESCRIPTION OF DRAWINGS

[0030]

FIG. 1 is a schematic diagram of a possible communication system according to an embodiment of this application;
FIG. 2 is a schematic diagram of a frame structure of the 802. 1 The protocol according to an embodiment of this application;
FIG. 3 is a schematic diagram of another frame structure of the 802.11be protocol according to an embodiment of this application;
FIG. 4 is a schematic flowchart of a cyclic shift diversity-based communication method according to an embodiment of this application;
FIG. 5 is a schematic flowchart of a method for determining a cyclic shift diversity value according to an embodiment of this application;
FIG. 6 is a schematic block diagram of a cyclic shift diversity-based communication apparatus according to an

embodiment of this application; and

FIG. 7 is a schematic diagram of a structure of a cyclic shift diversity-based communication apparatus according to an embodiment of this application.

DESCRIPTION OF EMBODIMENTS

[0031] The following describes technical solutions of this application with reference to accompanying drawings.

[0032] The technical solutions of embodiments of this application may be applied to various communication systems, for example, a wireless local area network (wireless local area network, WLAN) communication system, a global system for mobile communications (global system of mobile communications, GSM), a code division multiple access (code division multiple access, CDMA) system, a wideband code division multiple access (wideband code division multiple access, WCDMA) system, a general packet radio service (general packet radio service, GPRS) system, a long term evolution (long term evolution, LTE) system, an LTE frequency division duplex (frequency division duplex, FDD) system, an LTE time division duplex (time division duplex, TDD), a universal mobile telecommunications system (universal mobile telecommunications system, UMTS), a worldwide interoperability for microwave access (worldwide interoperability for microwave access, WiMAX) communication system, a 5th generation (5th generation, 5G) system, or new radio (new radio, NR).

[0033] For example, the following describes an application scenario in embodiments of this application and a method in embodiments of this application by using a WLAN system as an example.

[0034] Embodiments of this application may be applied to a wireless local area network (wireless local area network, WLAN), and embodiments of this application are applicable to any one of the institute of electrical and electronics engineers (institute of electrical and electronics engineers, IEEE) 802.11 series protocols currently used in the WLAN. The WLAN may include one or more basic service sets (basic service set, BSS), and network nodes in the basic service set include an access point (access point, AP) and a station (station, STA).

[0035] In some embodiments, a transmit end in embodiments of this application may be a user station (STA) in the WLAN. The user station may also be referred to as a system, a subscriber unit, an access terminal, a mobile station, a remote station, a remote terminal, a mobile device, a user terminal, a terminal, a wireless communication device, a user agent, a user apparatus, or user equipment (user equipment, UE). The STA may be a cellular phone, a cordless phone, a session initiation protocol (session initiation protocol, SIP) phone, a wireless local loop (wireless local loop, WLL) station, a personal digital assistant (personal digital assistant, PDA), a handheld device having a wireless local area network (for example, Wi-Fi) communication function, a wearable device, a computing device, or another processing device connected to a wireless modem. Optionally, in these embodiments, a receive end may be an AP in the WLAN.

[0036] In some other embodiments, a transmit end in embodiments of this application may alternatively be an AP in the WLAN. The AP is an access point for a mobile user to access a wired network; and is mainly deployed in a home, a building, and a campus, or is deployed outdoors. The AP is equivalent to a bridge that connects a wired network and a wireless network. The AP is mainly used to connect mobile users to each other, and then connect the wireless network to the Ethernet. For example, the AP may be a terminal device or a network device with a wireless fidelity (wireless fidelity, Wi-Fi) chip. Optionally, the AP may be a device that supports a plurality of WLAN standards such as the 802.11. Optionally, in these embodiments, a receive end may be a STA in the WLAN.

[0037] For ease of understanding embodiments of this application, a communication system shown in FIG. 1 is first used as an example to describe in detail a communication system applicable to embodiments of this application. The communication system shown in FIG. 1 may be a WLAN system. The WLAN system may include one or more APs and one or more STAs. In FIG. 1, one AP and two STAs are used as examples. Wireless communication may be performed between the AP and the STA according to various standards. For example, wireless communication may be performed between the AP and the STA by using a single-user multiple-input multiple-output (single-user multiple-input multiple-output, SU-MIMO) technology or a multi-user multiple-input multiple-output (multi-user multiple-input multiple-output, MU-MIMO) technology.

[0038] To facilitate understanding of embodiments of this application, a frame structure of a physical layer protocol data unit (PHY protocol data unit, PPDU) of the 802.11be protocol is first described with reference to FIG. 2 and FIG. 3.

[0039] FIG. 2 is a schematic diagram of a frame structure of the 802. 1 1be protocol according to an embodiment of this application. The frame structure may be a frame structure of an extremely high throughput (extremely high throughput, EHT) multi-user (multi-user, MU) PPDU in the 802.11be protocol.

[0040] Refer to FIG. 2. The EHT MU PPDU includes two parts. One part is a pre-EHT modulated field, including a legacy short training field (legacy-short training field, L-STF), a legacy long training field (legacy-long training field, L-LTF), a legacy signal field (legacy-signal field, L-SIG), a repeated legacy-signal field (repeated legacy-signal field, RL-SIG), a universal signal field (universal signal field, U-SIG), and an extremely high throughput signal field (extremely high throughput signal field, EHT-SIG). The other part is an EHT modulated field, including an extremely high throughput short training field (extremely high throughput short training field, EHT-STF), an extremely high throughput long training field (extremely high throughput long training field, EHT-LTF), and a data (data) field.

[0041] The U-SIG field may occupy two OFDM symbols, and the U-SIG field may include a version independent information (version independent info) field, a version dependent information (version dependent info) field, a cyclic redundancy code (cyclic redundancy code, CRC) field, and a tail field. The version independent info field may include a wireless fidelity Wi-Fi version field of 3 bits, a downlink/uplink field of 1 bit, a BSS color field of at least 6 bits, and a transmission opportunity (transmit opportunity, TXOP) field of at least 7 bits. Optionally, the version independent info field may further include a bandwidth field, and the version dependent info field may further include a PPDU format field, and may further include one or more of a modulation and coding scheme field, a spatial stream field, an encoding field, and the like.

[0042] In a possible implementation, the EHT-SIG includes an EHT-SIG common field and an EHT-SIG user specific field. The EHT-SIG common field carries resource allocation information allocated to a station, and the EHT-SIG user specific field carries user information.

[0043] FIG. 3 is a schematic diagram of another frame structure of the 802.11be protocol according to an embodiment of this application. The frame structure may be a frame structure of an EHT trigger-based (trigger based, TB) PPDU in the 802.11be protocol.

[0044] Refer to FIG. 3. The EHT TB PPDU includes two parts: a pre-EHT modulated field and an EHT modulated field. The pre-EHT modulated field includes an L-STF, L-LTF, L-SIG, an RL-SIG, and a U-SIG, and the EHT modulated field includes an EHT-STF, an EHT-LTF, and a data field.

[0045] It should be understood that the frame structure of the EHT-PPDU in this embodiment of this application is merely an example. In a standard formulation process or a technical development process, there may be another structure. This is not limited in this embodiment of this application.

[0046] In the foregoing frame structures and frame structures of the PPDU of various types that are not shown, for ease of description, a plurality of fields before the data field of the PPDU are collectively referred to as a preamble part, and the preamble part is used for data transmission. For example, the preamble part is used for carrier collection, channel estimation, and frame structure parameter (for example, a code rate or a frame length) transmission. For example, the preamble part includes the pre-EHT modulated field and the EHT-STF and the EHT-LTF in the EHT modulated field. In addition, a plurality of fields starting from the L-STF in the preamble part are denoted as a first preamble part.

[0047] In an example, the first preamble part includes an L-STF, an L-LTF, and an L-SIG.

[0048] In another example, the first preamble part includes an L-STF, an L-LTF, an L-SIG, and at least one signaling field newly defined in each generation of protocol.

[0049] For example, in the 802.11be protocol, the first preamble part includes all fields in the pre-EHT modulated field. To be specific, in FIG. 2, the first preamble part includes an L-STF, an L-LTF, an L-SIG, an RL-SIG, a U-SIG, and an EHT-SIG; and in FIG. 3, the first preamble part includes an L-STF, an L-LTF, an L-SIG, an RL-SIG, and a U-SIG.

[0050] It should be understood that content of the first preamble part in the foregoing example is merely an example for description, and should not constitute a limitation on this embodiment of this application.

[0051] To greatly improve a service transmission rate of a WLAN system, the institute of electrical and electronics engineers (institute of electrical and electronics engineers, IEEE) has introduced a MIMO technology on the basis of an orthogonal frequency division multiplexing (orthogonal frequency division multiplexing, OFDM) technology to support multi-antenna transmission.

[0052] To reduce an AGC error, when sending the PPDU, a transmit end performs cyclic shift diversity (cyclic shift diversity, CSD) on a first preamble part sent on each antenna, and sends, on each antenna, a first preamble part obtained after cyclic shift.

[0053] When a CSD value is set for each antenna, the CSD value needs to be properly designed to minimize the AGC error as much as possible.

[0054] A maximum number of antennas supported in the 802.11n protocol is four, and CSD values corresponding to one to four antennas are defined. Table 1 shows a CSD set corresponding to each antenna number in the first preamble part (for example, the pre-HT modulated field) in 802.11n. A number of CSD values in one CSD set is the same as a number of antennas. In Table 1, cells not filled with data indicate that there is no corresponding CSD value.

[0055] Refer to Table 1. When a number of transmit antennas is 1, a CSD value corresponding to a 1^{st} antenna is 0 (that is, no cyclic shift is performed); when a number of transmit antennas is 2, a CSD value corresponding to a 1^{st} antenna is 0, and a CSD value corresponding to a 2^{nd} antenna is -200 nanoseconds (nanosecond, ns); when a number of transmit antennas is 3, a CSD value corresponding to a 1^{st} antenna is 0, a CSD value corresponding to a 2^{nd} antenna is -100 ns, and a CSD value corresponding to a 3^{rd} antenna is -200 ns; and when a number of transmit antennas is 4, a CSD value corresponding to a 1^{st} antenna is 0, a CSD value corresponding to a 2^{nd} antenna is -50 ns, a CSD value corresponding to a 3^{rd} antenna is -100 ns, and a CSD value corresponding to a 4^{th} antenna is -150 ns.

Table 1

Number of transmit antennas (N)	CSD value on an antenna i (ns)			
	1	2	3	4
1	0	-	-	-
2	0	-200	-	-
3	0	-100	-200	-
4	0	-50	-100	-150

[0056] A maximum number of antennas supported in the 802.1 1ac protocol is eighth, and CSD values corresponding to one to eight antennas are defined, as shown in Table 2 below. For related descriptions, refer to related descriptions in Table 1. For brevity, details are not described herein again. The 802.11ax protocol inherits the CSD value defined in the 802.11ac protocol, that is, the CSD value shown in Table 2 is also used in the 802.11ax protocol.

Table 2

Number of transmit antennas (N)	CSD value on an antenna i (ns)							
	1	2	3	4	5	6	7	8
1	0	-	-	-	-	-	-	-
2	0	-200	-	-	-	-	-	-
3	0	-100	-200	-	-	-	-	-
4	0	-50	-100	-150	-	-	-	-
5	0	-175	-25	-50	-75	-	-	-
6	0	-200	-25	-150	-175	-125	-	-
7	0	-200	-150	-25	-175	-75	-50	-
8	0	-175	-150	-125	-25	-100	-50	-200

[0057] It should be noted that, the 802.11ac protocol or the 802.11ax protocol is compatible with a design of the CSD value in 802.11n, that is, CSD values corresponding to one to four antennas in the 802.11ac protocol or the 802.11ax protocol are the same as the CSD values corresponding to one to four antennas in 802.11n.

[0058] With evolution of standards, current eight-antenna communication cannot meet communication requirements in some scenarios. Based on this, this application proposes a CSD-based communication method. A maximum number of antennas supported in this method is greater than 8, and cyclic shift is performed on a first preamble part of each antenna by using a cyclic shift value, so that an AGC error can be reduced in a scenario in which transmission using more antennas (for example, 16 antennas) is supported.

[0059] The following describes embodiments of this application in detail with reference to FIG. 4 and FIG. 5.

[0060] The method in embodiments of this application may be applied to a first communication system, the first communication system supports a first communication protocol, and the first communication protocol may be the 802. 1The protocol or a next-generation protocol of 802.11be.

[0061] A maximum number of antennas supported by the first communication protocol is M, and M is a positive integer greater than 8. For example, when the first communication protocol is the 802.11be protocol, a maximum number of antennas supported by the 802.1 1be protocol is 16.

[0062] The first communication system in embodiments of this application includes a transmit end and a receive end. FIG. 1 is used as an example. For uplink transmission, a STA may be used as the transmit end, and an AP may be used as the receive end. For downlink transmission, the AP may be used as the transmit end, and the STA may be used as the receive end. For another transmission scenario, for example, data transmission between APs, one AP may be used as the transmit end, and the other AP may be used as the receive end. For another example, for uplink transmission between STAs, one STA may be used as the transmit end, and the other STA may be used as the receive end. For ease of description, the following describes embodiments of this application based on the transmit end and the receive end.

[0063] FIG. 4 is a schematic flowchart of a cyclic shift diversity-based communication method 100 according to an embodiment of this application.

[0064] S110: The transmit end generates a PPDU, where the PPDU includes a first preamble part.

[0065] When the transmit end supports more than eight antennas, the first preamble part includes an L-STF, an L-LTF, an L-SIG, and at least one signaling field newly defined in each generation of protocol.

[0066] The 802.11be protocol is used as an example. In an example, the PPDU is the EHT MU PPDU shown in FIG. 2, and the first preamble part includes a field in a pre-EHT modulated field. Specifically, the first preamble part includes an L-STF, an L-LTF, an L-SIG, an RL-SIG, a U-SIG, and an EHT-SIG.

[0067] The 802.11be protocol is still used as an example. In another example, the PPDU is the EHT TB PPDU shown in FIG. 3, and the first preamble part includes a field in a pre-EHT modulated field. Specifically, the first preamble part includes an L-STF, an L-LTF, an L-SIG, an RL-SIG, and a U-SIG.

[0068] In a process of generating the PPDU, cyclic shift may be performed on the first preamble part by using a preset CSD value, to obtain a first preamble part obtained after cyclic shift. The preset CSD value may be predefined in a protocol.

[0069] A number of antennas actually used by the transmit end is N, where N is a positive integer less than or equal to M. Based on the foregoing description, M is a maximum number of antennas supported by a first communication protocol. One antenna corresponds to one CSD value, and N antennas correspond to N CSD values. The N CSD values are different. A first preamble part sent on an i^{th} antenna in the N antennas is obtained by performing, based on a corresponding CSD value, cyclic shift on a first preamble part on which no cyclic shift is performed, where i is a positive integer less than or equal to N, that is, i = 1, 2, ..., N.

[0070] For example, M = 16, N = 9, nine antennas correspond to nine CSD values, and the nine CSD values are different.

[0071] For another example, M = 16, N = 16, 16 antennas correspond to 16 CSD values, and the 16 CSD values are different.

[0072] It should be noted that when the maximum number of antennas supported in this embodiment of this application is M, the transmit end may send the PPDU by using any number of antennas in M antennas based on an actual situation. M CSD sets may be predefined in a system. One antenna number corresponds to one CSD set, and a number of CSD values included in one CSD set is the same as a number of antennas.

[0073] For example, M = 16, there are 16 antennas, including 1 to 16 antennas, and 16 antenna numbers correspond to 16 CSD sets. One antenna corresponds to one CSD set, and the CSD set includes one CSD value. Two antennas correspond to another CSD set, and the CSD set includes two CSD values. By analogy, 16 antennas correspond to still another CSD set, and the CSD set includes 16 CSD values.

[0074] S120: The transmit end sends the PPDU by using the N antennas. Correspondingly, the receive device receives the PPDU.

[0075] In a process of sending the PPDU by using the N antennas, the transmit end may perform, based on a CSD value corresponding to the i^{th} antenna in the N antennas, cyclic shift on the first preamble part sent on the i^{th} antenna.

[0076] Correspondingly, when receiving the PPDU, the receive end receives the first preamble part of the PPDU based on the CSD value, where the CSD value is a CSD value based on which the transmit end sends the first preamble part. Specifically, the receive end receives the first preamble part on the i^{th} antenna based on the CSD value corresponding to the i^{th} antenna.

[0077] When receiving the PPDU, the receive end may set an AGC gain on a field other than an L-STF in a first preamble part based on receive power that is of the L-STF and that is received on each antenna. In this embodiment of this application, the CSD value acts on the first preamble part, so that a range of a ratio of receive power of the L-STF in the first preamble part sent on each antenna to receive power of the field other than the L-STF in the first preamble part is stable. Therefore, when the receive end sets the AGC gain on the field other than the L-STF in the first preamble part based on the receive power of the L-STF, an AGC error can be reduced.

[0078] S130: The receive end processes the PPDU.

[0079] The receive end may process a service based on data carried in the data field of the PPDU. This is not specifically limited in this application.

[0080] In this embodiment of this application, for the receive end, the CSD value may have different functions.

[0081] In some scenarios, the receive end does not need to know a CSD value used by the transmit end on each antenna. The CSD value is part of an equivalent channel response and is consistently applied to an entire frame. The receive end performs channel estimation on each frame, and may obtain a first preamble part before cyclic shift.

[0082] In some other scenarios, the receive end needs to know a CSD value used on each antenna.

[0083] For example, when operating in a transmit-end beamforming mode, the receive end needs to cancel the CSD before channel quantization/feedback.

[0084] For another example, when channel smoothing is performed, the CSD value needs to be removed to restore a frequency-domain correlation.

[0085] According to the CSD-based communication method provided in embodiments of this application, the maximum number of antennas supported in this method is greater than 8, and cyclic shift is performed on the first preamble part of each antenna by using the CSD value, so that the AGC error can be reduced in a scenario in which transmission using more antennas (for example, 16 antennas) is supported.

[0086] With reference to FIG. 4, the foregoing describes a procedure of the CSD-based communication method 100 in this embodiment of this application. The following describes in detail the CSD value provided in this embodiment of this application.

[0087] In some embodiments, M = 16.

[0088] In other words, a maximum number of antennas supported by the transmit end is 16, and a first communication protocol may be the 802.11 be protocol.

[0089] In an embodiment in which M = 16, this embodiment of this application provides the following possible CSD sets.

[0090] An example in which N represents a number of transmit antennas and different values of N correspond to different CSD sets is still used for description. A value of N is 1, 2, ..., M.

[0091] In some embodiments, a relationship between a value of N and a CSD set is as follows:

N = 1, and the CSD set includes one CSD value, and the CSD value is 0;
N = 2, and the CSD set includes two CSD values: 0 and -175 ns;
N = 3, and the CSD set includes three CSD values: 0, -175 ns, and -87.5 ns;
N = 4, and the CSD set includes four CSD values: 0, -175 ns, -87.5 ns, and -62.5 ns;
N = 5, and the CSD set includes five CSD values: 0, -175 ns, -87.5 ns, -62.5 ns, and -200 ns;
N = 6, and the CSD set includes six CSD values: 0, -87.5 ns, -200 ns, -187.5 ns, -125 ns, and -12.5 ns;
N = 7, and the CSD set includes seven CSD values: 0, -87.5 ns, -62.5 ns, -200 ns, - 187.5 ns, -100 ns, and -150 ns;
N = 8, and the CSD set includes eight CSD values: 0, -200 ns, -187.5 ns, -100 ns, -50 ns, -25 ns, -125 ns, and -150 ns;
N = 9, and the CSD set includes nine CSD values: 0, -175 ns, -87.5 ns, -200 ns, - 187.5 ns, -100 ns, -50 ns, -12.5 ns, and -25 ns;
N = 10, and the CSD set includes 10 CSD values: 0, -175 ns, -200 ns, -187.5 ns, -100 ns, -50 ns, -12.5 ns, -25 ns, -137.5 ns, and -162.5 ns;
N = 11, and the CSD set includes 11 CSD values: 0, -87.5 ns, -200 ns, -187.5 ns, -100 ns, -50 ns, -12.5 ns, -25 ns, -37.5 ns, -137.5 ns, and -150 ns;
N = 12, and the CSD set includes 12 CSD values: 0, -175 ns, -87.5 ns, -200 ns, -187.5 ns, -100 ns, -12.5 ns, -25 ns, -37.5 ns, -75 ns, -150 ns, and -162.5 ns;
N = 13, and the CSD set includes 13 CSD values: 0, -175 ns, -62.5 ns, -187.5 ns, - 100 ns, -50 ns, -12.5 ns, -25 ns, -37.5 ns, -75 ns, -150 ns, -162.5 ns, and -125 ns;
N = 14, and the CSD set includes 14 CSD values: 0, -175 ns, -87.5 ns, -187.5 ns, - 100 ns, -50 ns, -12.5 ns, -25 ns, -37.5 ns, -75 ns, -150 ns, -125 ns, -162.5 ns, and -137.5 ns;
N = 15, and the CSD set includes 15 CSD values: 0, -175 ns, -87.5 ns, -200 ns, -187.5 ns, -100 ns, -50 ns, -12.5 ns, -25 ns, -75 ns, -125 ns, -162.5 ns, -137.5 ns, -112.5 ns, and -150 ns; or
N = 15, and the CSD set includes 16 CSD values: 0, -175 ns, -87.5 ns, -200 ns, -187.5 ns, -100 ns, -50 ns, -12.5 ns, -25 ns, -37.5 ns, -75 ns, -150 ns, -125 ns, -162.5 ns, -137.5 ns, and -112.5 ns.

[0092] The CSD set corresponding to the antenna number N may be predefined in a protocol, and is pre-stored in a device. When a PPDU is sent, cyclic shift is performed on a first preamble part by using a corresponding CSD value based on a number of actually used antennas.

[0093] For example, a CSD value corresponding to an i^{th} antenna in N antennas is an i^{th} CSD value in a corresponding CSD set, and the transmit end performs cyclic shift on the first preamble part based on the i^{th} CSD, and sends a processed first preamble part by using the i^{th} antenna.

[0094] It should be understood that, in this embodiment of this application, only N CSD values in the CSD set corresponding to the N antennas are shown, and a sequence of the N CSD values in the CSD set may change and is not fixed.

[0095] N = 16 is used as an example. In an example, a sequence of the 16 CSD values in the CSD set may be: 0, -175 ns, -87.5 ns, -200 ns, -187.5 ns, -100 ns, -50 ns, -12.5 ns, -25 ns, - 37.5 ns, -75 ns, -150 ns, -125 ns, -162.5 ns, -137.5 ns, and -112.5 ns.

[0096] N = 16 is still used as an example. In another example, a sequence of the 16 CSD values in the CSD set may also be: -175 ns, -87.5 ns, -200 ns, -187.5 ns, -100 ns, -50 ns, -12.5 ns, -25 ns, -37.5 ns, -75 ns, -150 ns, -125 ns, -162.5 ns, -137.5 ns, -112.5 ns, and 0.

[0097] Overall, N = 16 is used as an example. N = 16, and the CSD set includes 16 CSD values: 0, -175 ns, -87.5 ns, -200 ns, -187.5 ns, -100 ns, -50 ns, -12.5 ns, -25 ns, -37.5 ns, -75 ns, -150 ns, -125 ns, -162.5 ns, -137.5 ns, and -112.5 ns. A specific sequence is not fixed, and various combinations may be included.

[0098] Table 3 is a possible CSD set corresponding to each of 1 to 16 antennas provided in this embodiment of this application. It should be understood that in Table 3, cells not filled with data indicate that there is no corresponding CSD value.

[0099] N = 16 is used an example. A CSD value corresponding to a 1^{st} antenna is 0, no cyclic shift is performed, a CSD value corresponding to a 2^{nd} antenna is -175 ns, a CSD value corresponding to a 3^{rd} antenna is -87.5 ns, ..., and a CSD value corresponding to a 16^{th} antenna is -112.5 ns.

Table 3

Number of transmit antennas (N)	CSD value on an antenna i (ns)															
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	0	-175	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	0	-175	-87.5	0	0	0	0	0	0	0	0	0	0	0	0	0
4	0	-175	-87.5	-62.5	0	0	0	0	0	0	0	0	0	0	0	0
5	0	-175	-87.5	-62.5	-200	0	0	0	0	0	0	0	0	0	0	0
6	0	-87.5	-200	-187.5	-125	-12.5	0	0	0	0	0	0	0	0	0	0
7	0	-87.5	-62.5	-200	-187.5	-100	-150	0	0	0	0	0	0	0	0	0
8	0	-200	-187.5	-100	-50	-25	-125	-150	0	0	0	0	0	0	0	0
9	0	-175	-87.5	-200	-187.5	-100	-50	-12.5	-25	0	0	0	0	0	0	0
10	0	-175	-200	-187.5	-100	-50	-12.5	-25	-137.5	-162.5	0	0	0	0	0	0
11	0	-87.5	-200	-187.5	-100	-50	-12.5	-25	-37.5	-137.5	-150	0	0	0	0	0
12	0	-175	-87.5	-200	-187.5	-100	-12.5	-25	-37.5	-75	-150	-162.5	0	0	0	0
13	0	-175	-62.5	-187.5	-100	-50	-12.5	-25	-37.5	-75	-150	-162.5	-125	0	0	0
14	0	-175	-87.5	-187.5	-100	-50	-12.5	-25	-37.5	-75	-150	-125	-162.5	-137.5	0	0
15	0	-175	-87.5	-200	-187.5	-100	-50	-12.5	-25	-75	-125	-162.5	-137.5	-112.5	-150	0
16	0	-175	-87.5	-200	-187.5	-100	-50	-12.5	-25	-37.5	-75	-150	-125	-162.5	-137.5	-112.5

[0100] When performing AGC setting, the receive end sets an AGC gain on a field other than an L-STF in a first preamble part based on receive power that is of the L-STF and that is received on each antenna. In this embodiment of this application, the CSD value acts on the first preamble part to reduce an AGC error. Therefore, whether a design of the CSD value is proper may be checked by measuring a range of a ratio of the receive power of the L-SFT to receive power of the field other than the L-STF in the first preamble part. Theoretically, a smaller range of the ratio of the receive power of the L-SFT to the receive power of the field other than the L-STF in the first preamble part indicates a smaller AGC error and a more proper design of the CSD value.

[0101] Generally, the range of the ratio of the receive power of the L-STF to the receive power of the another field in the first preamble part is positively correlated with a range of a ratio of the receive power of the L-STF to receive power of the EHT-STF. To be specific, if the range of the ratio of the receive power of the L-STF to the receive power of the EHT-STF is small, it means that the range of the ratio of the receive power of the L-STF to the receive power of the another field in the first preamble part is also small.

[0102] Therefore, based on the foregoing considerations, in this embodiment of this application, whether the design of the CSD value is proper may be checked by measuring the range of the ratio of the receive power of the L-STF to the receive power of the EHT-STF.

[0103] Definitely, in an actual design, the range of the ratio of the receive power of the L-STF to the receive power of the another field in the first preamble part may also be measured first, and when the value is small and effect of the CSD value cannot be determined, the range of the ratio of the receive power of the L-STF to the receive power of the EHT-STF is measured, to check properness of the design of the CSD value. The two methods of checking the CSD value can be used flexibly.

[0104] Table 4 lists ranges of ratios of the receive power of the L-STF to the receive power of the EHT-STF in a plurality of scenarios. A20 MHz bandwidth and a 40 MHz bandwidth are listed. Four channel models are listed, which are represented by B, C, D, and E. The four channel models are defined in 802.11. Parameters of the channel models are different. 1 to 16 antennas are listed. Angles of 0 degrees and 180 degrees (represented by pi) are listed for an initial phase difference between odd and even antennas.

[0105] A scenario may be represented by a number of antennas, an initial phase difference between odd and even antennas, a bandwidth, and a channel model. Number of antennas-initial phase difference between odd and even antennas represents a combination of the number of antennas and the initial phase difference between odd and even antennas, and a bandwidth-channel model represents a combination of the bandwidth and the channel model. For example, when the number of antennas is 2 and the initial phase difference between odd and even antennas is pi, 2-pi is used for representing. When the bandwidth is 20M and the channel model is the model B, 20M-B is used for representing.

[0106] A value in one cell indicates a range of a ratio of the receive power of the L-STF to the receive power of the EHT-STF in one scenario.

[0107] For example, a value in row 3 and column 1 in a value area is 15.49. The value indicates that the range of the ratio of the receive power of the L-STF to the receive power of the EHT-STF is 15.49 in a scenario in which the number of antennas is 2, the initial phase difference between the odd and even antennas is 0, the bandwidth is 20M, and the channel model is the model B.

[0108] For another example, a value in row 4 and column 1 in a value area is 15.35 (a word in black in the table). The value indicates that the range of the ratio of the receive power of the L-STF to the receive power of the EHT-STF is 15.35 in a scenario in which the number of antennas is 2, the initial phase difference between the odd and even antennas is pi, the bandwidth is 20M, and the channel model is the model B. It can be learned from Table 4 that, based on the CSD sets with different antenna numbers provided in this embodiment of this application, when the CSD set acts on the first preamble part, the range of the ratio of the receive power of the L-STF to the receive power of the EHT-STF is small, which also means that the range of the ratio of the receive power of the L-STF to the receive power of the field other than the L-STF in the first preamble part is also small. Therefore, the AGC error is small.

Table 4

Number of antennas-initial phase difference between odd and even antennas (degree)	Range of a ratio of receive power of the L-STF to receive power of the EHT-STF							
	Bandwidth-channel model							
	20M-B	20M-C	20M-D	20M-E	40M-B	40M-C	40M-D	40M-E
1-0	19.11	16.49	13.93	11.09	14.86	12.88	10.33	8.5
1-pi	19.11	16.49	13.93	11.09	14.86	12.88	10.33	8.5
2-0	15.49	15.41	12.65	8.77	12.34	11.84	9.65	7.03
2-pi	15.35	15.02	11.73	9.86	12.54	12.1	9.58	7.04

(continued)

Number of antennas-initial phase difference between odd and even antennas (degree)	Range of a ratio of receive power of the L-STF to receive power of the EHT-STF							
	Bandwidth-channel model							
	20M-B	20M-C	20M-D	20M-E	40M-B	40M-C	40M-D	40M-E
3-0	14.21	14.59	12.41	8.63	11.58	11.69	9.23	6.81
3-pi	12.57	14.38	11.71	9.55	11.19	11.74	9.44	6.89
4-0	14.11	13.39	12.33	9.11	11.67	11.06	9.3	6.38
4-pi	14.29	14.27	13.1	9.56	11.49	11.43	9.1	6.86
5-0	13.79	12.24	12.77	9.16	11.52	10.98	9.63	5.81
5-pi	13.04	14.34	11.58	8.81	10.69	11.22	8.46	6.28
6-0	14.92	13.98	11.29	8.98	9.64	10.25	7.73	6.79
6-pi	11.99	14.97	11.98	10.1	11.41	11.25	8.48	6.72
7-0	11.95	12.96	11.34	8.37	11.73	11.87	7.06	6.58
7-pi	14.22	15.2	11.46	6.79	11.82	10.19	9.02	7.11
8-0	12.55	11.78	11.9	8.36	11.6	12.9	8.36	6.43
8-pi	13.54	13.87	11.15	9.04	9.8	10.2	7.96	6.96
9-0	13.17	11.7	11.71	9.8	9.57	10.34	9.77	5.88
9-pi	14.03	14.65	12	9.29	11.03	11.35	7.89	6.88
10-0	14.19	12.78	11.76	10.18	10.84	11.45	8.17	6.64
10-pi	14.37	13.8	11.58	9.22	10.49	11.74	8.36	5.74
11-0	12.59	12.1	10.12	9.19	8.38	10.09	9.26	6.17
11-pi	13.4	14.31	9.79	9.31	10.49	11.25	7.41	7.13
12-0	12.17	11.63	12.5	8.78	9.85	10.17	9.33	6.46
12-pi	13.88	14.13	9.89	9.38	9.49	11.45	6.77	6.5
13-0	10.91	12.76	11.67	9.98	9.83	10.04	8.59	6.49
13-pi	13.82	14.01	11.08	9.41	10.74	11.84	7.55	6.86
14-0	13.28	13.52	11.5	9.31	10	11.7	8.3	7.17
14-pi	13.81	14.06	11.38	9.52	9.93	12.01	7.6	6.92
15-0	12.95	9.55	11.19	9.45	9.68	10.85	9.53	7.18
15-pi	12.93	13.99	10.3	9.29	9	11.55	8.23	7.09
16-0	11.57	12.61	12.97	9.84	9.69	10.35	9.37	6.02
16-pi	13.9	14.58	11	8.37	8.73	11.38	7.22	6.71

[0109] According to the CSD-based communication method provided in embodiments of this application, when the maximum number of antennas supported in the method is 16, a CSD set corresponding to each of 1 to 16 antennas is provided. The CSD set acts on the first preamble part, so that the AGC error can be better reduced in a scenario in which transmission using 16 antennas is supported.

[0110] In some other embodiments, a relationship between a value of N and a CSD set is as follows:

N = 9, and the CSD set includes nine CSD values: 0, -175 ns, -87.5 ns, -62.5 ns, -200 ns, -187.5 ns, -100 ns, -50 ns, and -12.5 ns;

N = 10, and the CSD set includes 10 CSD values: 0, -175 ns, -87.5 ns, -62.5 ns, -200 ns, -187.5 ns, -100 ns, -50 ns, -12.5 ns, and -25 ns;

N = 11, and the CSD set includes 11 CSD values: 0, -175 ns, -87.5 ns, -200 ns, -187.5 ns, -100 ns, -50 ns, -12.5 ns, -25 ns, -37.5 ns, and -125 ns;

N = 12, and the CSD set includes 12 CSD values: 0, -175 ns, -200 ns, -187.5 ns, -100 ns, -50 ns, -12.5 ns, -25 ns, -37.5 ns, -75 ns, -162.5 ns, and -112.5 ns;

N = 13, and the CSD set includes 13 CSD values: 0, -87.5 ns, -200 ns, -187.5 ns, - 100 ns, -50 ns, -12.5 ns, -25 ns, -37.5 ns, -75 ns, -162.5 ns, -125 ns, and -137.5 ns;

N = 14, and the CSD set includes 14 CSD values: 0, -175 ns, -62.5 ns, -200 ns, -187.5 ns, -100 ns, -50 ns, -12.5 ns, -25 ns, -37.5 ns, -75 ns, -150 ns, -112.5 ns, and -162.5 ns;

N = 15, and the CSD set includes 15 CSD values: 0, -175 ns, -87.5 ns, -200 ns, -187.5 ns, -100 ns, -50 ns, -12.5 ns, -25 ns, -37.5 ns, -75 ns, -150 ns, -125 ns, -162.5 ns, and -137.5 ns; or

N = 15, and the CSD set includes 16 CSD values: 0, -175 ns, -62.5 ns, -200 ns, -187.5 ns, -100 ns, -50 ns, -12.5 ns, -25 ns, -37.5 ns, -75 ns, -150 ns, -125 ns, -162.5 ns, -137.5 ns, and -112.5 ns.

[0111] The CSD set corresponding to the antenna number N may be predefined in a protocol, and is pre-stored in a device. When a PPDU is sent, cyclic shift is performed on a first preamble part by using a corresponding CSD set based on a number of actually used antennas.

[0112] For example, a CSD value corresponding to an i^{th} antenna in N antennas is an i^{th} CSD value in a corresponding CSD set, and the transmit end performs cyclic shift on the first preamble part based on the i^{th} CSD, and sends a processed first preamble part by using the i^{th} antenna.

[0113] It should be understood that, in this embodiment of this application, only N CSD values in the CSD set corresponding to the N antennas are shown, and a sequence of the N CSD values in the CSD set may change and is not fixed.

[0114] N = 9 is used as an example. In an example, a sequence of the nine CSD values in the CSD set may be: 0, -175 ns, -87.5 ns, -62.5 ns, -200 ns, -187.5 ns, -100 ns, -50 ns, and -12.5 ns.

[0115] N = 9 is still used as an example. In another example, a sequence of the 9 CSD values in the CSD set may also be: -175 ns, -87.5 ns, -62.5 ns, -200 ns, -187.5 ns, -100 ns, -50 ns, - 12.5 ns, and 0.

[0116] Overall, N = 9 is used as an example. N = 9, and the CSD set includes 16 CSD values: 0, -175 ns, -87.5 ns, -62.5 ns, -200 ns, -187.5 ns, -100 ns, -50 ns, and -12.5 ns. A specific sequence is not fixed, and various combinations may be included.

[0117] Table 5 is a possible CSD set corresponding to each of 9 to 16 antennas provided in this embodiment of this application. It should be understood that in Table 5, cells not filled with data indicate that there is no corresponding CSD value.

[0118] N = 9 is used an example. A CSD value corresponding to a 1^{st} antenna is 0, no cyclic shift is performed, a CSD value corresponding to a 2^{nd} antenna is -175 ns, a CSD value corresponding to a 3^{rd} antenna is -87.5 ns, ..., and a CSD value corresponding to a 9^{th} antenna is - 12.5 ns.

Table 5

Send Number of transmit antennas (N)	CSD value on an antenna i (ns)															
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
9	0	-175	-87.5	-62.5	-200	-187.5	-100	-50	-12.5	0	0	0	0	0	0	0
10	0	-175	-87.5	-62.5	-200	-187.5	-100	-50	-12.5	-25	0	0	0	0	0	0
11	0	-175	-87.5	-200	-187.5	-100	-50	-12.5	-25	-37.5	-125	0	0	0	0	0
12	0	-175	-200	-187.5	-100	-50	-12.5	-25	-37.5	-75	-162.5	-112.5	0	0	0	0
13	0	-87.5	-200	-187.5	-100	-50	-12.5	-25	-37.5	-75	-162.5	-125	-137.5	0	0	0
14	0	-175	-62.5	-200	-187.5	-100	-50	-12.5	-25	-37.5	-75	-150	-112.5	-162.5	0	0
15	0	-175	-87.5	-200	-187.5	-100	-50	-12.5	-25	-37.5	-75	-150	-125	-162.5	-137.5	0
16	0	-175	-62.5	-200	-187.5	-100	-50	-12.5	-25	-37.5	-75	-150	-125	-162.5	-137.5	-112.5

[0119] In this embodiment, when the number of antennas is 1 to 8, a CSD set in an earlier communication protocol may be used. For example, the earlier communication protocol may be the 802.11n protocol, the 802.11ac protocol, or the 802.11ax protocol. CSD sets corresponding to one to four antennas are CSD sets corresponding to one to four antennas in the 802.11n protocol (as shown in Table 1), and CSD sets corresponding to one to eight antennas are CSD sets corresponding to one to eight antennas in the 802.11ac protocol or the 802.11ax protocol (as shown in Table 2).
[0120] That is, when the CSD sets corresponding to one to eight antennas are the CSD sets of the earlier communication protocol, so that the earlier communication protocol can be compatible, thereby facilitating smooth evolution of a system.
[0121] Table 6 lists ranges of ratios of the receive power of the L-STF to the receive power of the EHT-STF in a plurality of scenarios. For related descriptions, refer to descriptions in Table 4. Details are not described herein.
[0122] It can be learned from Table 6 that, based on the CSD sets with different antenna numbers provided in this embodiment of this application, when the CSD set acts on the first preamble part, the range of the ratio of the receive power of the L-STF to the receive power of the EHT-STF is small, which also means that the range of the ratio of the receive power of the L-STF to the receive power of the field other than the L-STF in the first preamble part is also small. Therefore, the AGC error is small.

Table 6

Number of antennas-initial phase difference between odd and even antennas	Range of a ratio of receive power of the L-STF to receive power of the EHT-STF							
	Bandwidth-channel model							
	20M-B	20M-C	20M-D	20M-E	40M-B	40M-C	40M-D	40M-E
9-0	2.86	3.46	3.69	4.02	1.55	1.93	1.88	2.52
9-pi	2.84	3.52	3.44	3.88	2.39	2.91	2.28	2.64
10-0	2.64	3.14	3.38	3.96	1.51	2.03	2.01	2.6
10-pi	3.3	4.15	3.35	3.91	2.21	3.06	2.16	2.68
11-0	2.8	3.28	3.62	3.88	1.77	2.36	2.17	2.68
11-pi	3.27	4.09	3.23	4.17	2.33	2.91	2.34	2.69
12-0	3.37	3.52	3.84	3.77	2	2.22	2.27	2.45
12-pi	3.14	3.89	3.59	3.95	2.61	2.98	2.34	2.75
13-0	3.47	3.91	3.66	3.85	2.17	2.51	2.35	2.59
13-pi	3.82	4.14	3.39	4.12	2.49	2.81	2.54	2.83
14-0	3.51	4.18	3.82	3.88	2.33	2.38	2.62	2.95
14-pi	3.27	3.95	4.13	4.07	2.91	2.92	2.46	2.81
15-0	3.56	3.79	3.8	4.17	2.27	2.25	2.55	2.71
15-pi	3.31	3.97	3.91	3.91	2.65	3.3	2.49	3.07
16-0	3.65	4.08	3.94	3.96	2.42	2.19	2.71	2.89
16-pi	3.44	3.88	4.08	3.93	3.04	2.71	2.46	2.93

[0123] According to the CSD-based communication method provided in embodiments of this application, when the maximum number of antennas supported in the method is 16, a CSD set corresponding to each of 9 to 16 antennas is provided. The CSD set acts on the first preamble part, so that an AGC error can be better reduced in a scenario in which transmission using 16 antennas is supported. In addition, when the maximum number of antennas supported in the method is 16 and a number of used antennas is 1 to 8, CSD sets corresponding to one to eight antennas in an earlier communication protocol (for example, the 802.11n protocol, the 802.11ac protocol, or the 802.11ax protocol) may be used, so that the earlier communication protocol can be compatible, thereby facilitating smooth evolution of a system.
[0124] It should be understood that the unit ns of the CSD value provided in this embodiment of this application is merely an example for description. In some other embodiments, the unit of the CSD value may be another time unit, for example, microsecond (microsecond, μs). This is not specifically limited in this application.
[0125] It should be further understood that when the unit of the CSD value is the another time unit, unit conversion needs to be performed. For example, when the another time unit is microsecond (microsecond, μs), the CSD value changes from -175 ns to -0.175 μs.

[0126] The foregoing describes the CSD set provided in this embodiment of this application. The following provides a method for determining the CSD set. The CSD set corresponding to the antenna number N may be determined according to the method. Certainly, the CSD set corresponding to the 16 antennas provided in this embodiment of this application may also be determined by using another method. This is not specifically limited in this embodiment of this application.

[0127] FIG. 5 shows a method 200 for determining a CSD set according to an embodiment of this application. The method may be executed by any apparatus having a data processing capability.

[0128] S210: Determine a candidate set.

[0129] The candidate set includes X elements, and each element may be considered as a candidate CSD value.

[0130] In some embodiments, a range of the candidate set may be determined based on factors such as a period of an L-STF, a precision requirement for start of packet detection, and an acceptable AGC error.

[0131] In some embodiments, time intervals between any two adjacent elements in the candidate set are equal.

[0132] In an example, a quotient of duration of the range of the candidate set divided by the time interval is a number of elements included in the candidate set. In view of this, all elements in the candidate set are multiples of the time interval.

[0133] For example, it is assumed that the range of the candidate set is [0, -200], and if the time interval is -12.5, the candidate set may be [0 -12.5 -25 -37.5 -50 -62.5 -75 -87.5 -100 - 112.5 -125 -137.5 -150 -162.5 -175 -187.5 -200], where X = 17.

[0134] It should be understood that the time interval may alternatively be another value, for example, -6.25 ns or -25 ns. This is not limited in this embodiment of this application.

[0135] S220: Perform selection for a plurality of times based on the candidate set, to obtain M target elements.

[0136] As described above, M is the maximum number of antennas that can be supported by the system.

[0137] In this step, limited M target elements may be preliminarily selected from a plurality of elements in the candidate set. The M target elements include all values of CSD sets corresponding to each of different antenna numbers. Subsequently, in S230, the CSD set corresponding to each antenna number may be further determined from the M target elements.

[0138] In some embodiments, selection is performed on the candidate set for a plurality of times based on a first criterion value, to obtain the M target elements.

[0139] In a first possible implementation, the first criterion value is related to a range of a ratio of receive power of an L-STF in a first preamble part to receive power of a field other than the L-STF in the first preamble part.

[0140] An objective of designing the CSD value is to make the range of the ratio of the receive power of the L-STF in the first preamble part to the receive power of the field other than the L-STF in the first preamble part as small as possible. Therefore, when the CSD value is designed, the range of the ratio of the receive power of the L-STF in the first preamble part to the receive power of the field other than the L-STF in the first preamble part may be used as a design criterion.

[0141] In an example, the first criterion value may be a range of a ratio that is of the receive power of the L-STF to the receive power of the field other than the L-STF in the first preamble part and that is obtained in any one of the following plurality of scenarios.

[0142] In another example, the first criterion value may be a maximum value that is in ranges of ratios of the receive power of the L-STF to the receive power of the another field in the first preamble part and that is obtained in at least two of the following plurality of scenarios.

[0143] For example, the plurality of scenarios may include the following scenarios:

Scenario 1: In a 20 MHz bandwidth, an initial phase difference between odd and even transmit antennas is 0 degrees by using a channel model B.

Scenario 2: In a 20 MHz bandwidth, an initial phase difference between odd and even antennas is 180 degrees by using a channel model B.

Scenario 3: In a 20 MHz bandwidth, an initial phase difference between odd and even transmit antennas is 0 degrees by using a channel model C.

Scenario 4: In a 20 MHz bandwidth, an initial phase difference between odd and even antennas is 180 degrees by using a channel model C.

Scenario 5: In a 20 MHz bandwidth, an initial phase difference between odd and even transmit antennas is 0 degrees by using a channel model D.

Scenario 6: In a 20 MHz bandwidth, an initial phase difference between odd and even antennas is 180 degrees by using a channel model D.

Scenario 7: In a 20 MHz bandwidth, an initial phase difference between odd and even transmit antennas is 0 degrees by using a channel model E.

Scenario 8: In a 20 MHz bandwidth, an initial phase difference between odd and even antennas is 180 degrees by using a channel model E.

[0144] It should be understood that the eight scenarios in the foregoing examples are merely examples for description, and first criterion values in more scenarios may be calculated based on an actual situation.

[0145] The range of the ratio of the receive power of the L-STF to the receive power of the field other than the L-STF in the first preamble part represents a distribution range of a ratio of an average power of sample points of the L-STF to an average power of sample points of the another field, where the average power of the sample points of the L-STF represents an average power of sample points when the L-STF is cyclic shifted, passes through a channel, and reaches a receive antenna of a receive end, and the average power of the sample points of the another field represents an average power of sample points when the another field is cyclic shifted, passes through a channel, and reaches a receive antenna of a receive end.

[0146] The range of the ratio of the receive power of the L-STF to the receive power of the field other than the L-STF in the first preamble part may be represented by using the following formula:

$$E_{AGC} = 10\log_{10}\left(\frac{mean(|X_i|^2)}{mean(|Y_{1i}|^2)}\right)$$

[0147] E_{AGC} represents a power ratio, X_i represents signal sampling of the L-STF, Y_{1i} represents signal sampling of the field other than the L-STF in the first preamble part, i is a sampling sequence number, and mean represents an average value function of a plurality of sampling points. A calculation manner of the range of the ratio of the receive power of the L-STF to the receive power of the another field may be understood as: counting an interval difference between power ratios of a probability result between 2.5% and 97.5% in a cumulative distribution function (cumulative distribution function, CDF) of the power ratio E_{AGC}. A smaller interval difference indicates more centralized power distribution and better CSD performance.

[0148] In a second possible implementation, the first criterion value is related to a range of a ratio of receive power of an L-STF of a PPDU to receive power of an EHT-STF of the PPDU.

[0149] It should be noted that an objective of designing the CSD value is to make the range of the ratio of the receive power of the L-STF in the first preamble part to the receive power of the field other than the L-STF in the first preamble part as small as possible. However, in some cases, the range of the ratio of the receive power of the L-STF to the receive power of the field other than the L-STF in the first preamble part is usually small, and is not easy to indicate a feature of the CSD value, while the range of the ratio of the receive power of the L-STF to the receive power of the EHT-STF can better indicate a feature of the CSD value. Therefore, in this embodiment of this application, the range of the ratio of the receive power of the L-STF to the receive power of the EHT-STF may be used as a criterion for designing the CSD value.

[0150] It should also be understood that, generally, the range of the ratio of the receive power of the L-STF to the receive power of the another field in the first preamble part is in direct proportion to the range of the ratio of the receive power of the L-STF to the receive power of the EHT-STF. To be specific, if the range of the ratio of the receive power of the L-STF to the receive power of the EHT-STF is small, it means that the range of the ratio of the receive power of the L-STF to the receive power of the another field in the first preamble part is also small. In this embodiment of this application, when effect of the CSD value in the CSD set is tested after the CSD set corresponding to each of the different antenna numbers is determined, the range of the ratio of the receive power of the L-STF to the receive power of the another field in the first preamble part may be first measured. When the effect of the CSD value cannot be determined because of the small value, the range of the ratio of the receive power of the L-STF to the receive power of the EHT-STF may be measured, a small range of the ratio of the receive power of the L-STF to the receive power of the EHT-STF indicates a proper design of the CSD value.

[0151] In an example, the first criterion value may be a range of a ratio that is of the receive power of the L-STF to the receive power of the EHT-STF and that is obtained in any one of a plurality of scenarios.

[0152] In another example, the first criterion value may be a maximum value that is in ranges of ratios of the receive power of the L-STF of the PPDU to the receive power of the EHT-STF of the PPDU and that is obtained in at least two of the plurality of scenarios.

[0153] For descriptions of the plurality of scenarios, refer to the plurality of scenarios described in the first possible implementation. Details are not described again.

[0154] The range of the ratio of the receive power of the L-STF to the receive power of the EHT-STF represents a distribution range of a ratio of an average power of sample points of the L-STF to an average power of sample points of the EHT-STF, where the average power of the sample points of the L-STF represents an average power of sample points when the L-STF is cyclic shifted, passes through a channel, and reaches a receive antenna of a receive end, and the average power of the sample points of the EHT-STF represents an average power of sample points when the EHT-STF is cyclic shifted, passes through a channel, and reaches a receive antenna of a receive end.

[0155] The range of the ratio of the receive power of the L-STF to the receive power of the EHT-STF may be represented by using the following formula:

$$E_{AGC} = 10\log_{10}(\frac{mean(|X_i|^2)}{mean(|Y_{2i}|^2)})$$

[0156] E_{AGC} represents a power ratio, X_i represents signal sampling of the L-STF, Y_{2i} represents signal sampling of the EHT-STF, i is a sampling sequence number, and mean represents an average value function of a plurality of sampling points. A calculation manner of the range of the ratio of the receive power of the L-STF to the receive power of the EHT-STF may be understood as: counting an interval difference between power ratios of a probability result between 2.5% and 97.5% in a CDF of the power ratio E_{AGC}. A smaller interval difference indicates more centralized power distribution and better CSD performance.

[0157] The following describes a process of determining the M target elements by using an example in which the first criterion value is the maximum value in that is in the ranges of ratios of the receive power of the L-STF of the PPDU to the receive power of the EHT-STF of the PPDU and that is obtained in the foregoing eight scenarios.

[0158] For ease of description, the candidate set is denoted as a candidate set A, and the candidate set A = [a_1, a_2, ..., ax]. In addition, in this embodiment of this application, a selected set B is further defined, and is used to calculate the first criterion value to determine the M target elements.

[0159] Because a value of one element in the M target elements is definitely 0, for example, an element in an initial selected set B may be set to 0. Subsequently, selection is performed each time, another target element is obtained, and the obtained target element is added to the selected set B. After selection is performed for a plurality of times (M - 1 times), when a number of target elements in the selected set B reaches M, this step is completed.

[0160] It should be understood that a larger number of elements in the initial selected set B indicates a smaller number of times for selecting the target element from the candidate set A. A sum of a number M_1 of elements in the initial selected set B and a number M_2 of times for selecting is M.

[0161] If an element of the initial selected set B is defined to be 0, selection may be performed for M - 1 times to obtain M - 1 target elements, where the M - 1 target elements and the initial element 0 form the M target elements, and M_2 = M - 1.

During selection for the first time:

[0162] First, a plurality of elements in the candidate set A are sequentially added to the selected set B, to obtain a plurality of intermediate sets B_1, where each intermediate set B_1 includes two elements, that is, 0 and one element in the candidate set A.

[0163] Second, a first criterion value obtained based on an element in each intermediate set B_1 is calculated, and a plurality of first criterion values are obtained. Values of the plurality of first criterion values are compared, and an element in an intermediate set B_1 corresponding to a smallest criterion value in the first criterion values is used as a finally obtained target element.

[0164] It should be noted that, if the initial selected set B already includes the element 0, and the candidate set A also includes the element 0, the element 0 in the candidate set A does not need to be added to the selected set B.

[0165] For example, the candidate set A = [ai a_2, ..., ax], the candidate set A does not include the element 0, and the initial selected set B = [0]. a_1, a2, ..., and ax are sequentially added to the selected set B to obtain X intermediate sets B_1, where an x[th] of the X intermediate sets B_1 is denoted as B_{1x}, x = 1, 2, ..., X, and X intermediate sets B_1 are: B_{11} = [0 a_1], B_{12} = [0 a_2], ..., B_{1X} = [0 ax]. A first criterion value obtained based on the x[th] intermediate set B_{1x} is P_{1x}, and X first criterion values are obtained based on the X intermediate sets B_1: P_{11}, P_{12}, ..., Pix. Assuming that a value of P_{11} is the smallest, the element ai corresponding to P_{11} is used as a target element.

[0166] Certainly, if the candidate set A = [ai a_2, ..., ax] includes the element 0, X - 1 intermediate sets B_1 are obtained, and X - 1 first criterion values are obtained.

[0167] After the target element is determined, the target element is deleted from the candidate set A, to obtain a candidate set A obtained after the first update, where the candidate set A obtained after the first update includes X - 1 elements. The target element is added to the selected set B, to obtain a selected set B obtained after the first update, that is, a selected set corresponding to the smallest first criterion value is the selected set B obtained after the first update, and the selected set B obtained after the first update includes two target elements.

During selection for the second time:

[0168] First, a plurality of elements in a candidate set A obtained after the first update are sequentially added to a selected set B obtained after the first update, to obtain a plurality of intermediate sets B_2. Each intermediate set B_2 includes three elements, that is, two target elements in the selected set B obtained after the first update and one element in the candidate set A.

[0169] Second, a first criterion value obtained based on an element in each intermediate set B_2 is calculated, and a plurality of first criterion values are obtained. Values of the plurality of first criterion values are compared, and a smallest value in the first criterion values is used as a finally obtained target element.

[0170] Likewise, in an example, X - 1 elements in the candidate set A obtained after the first update may be sequentially added to the selected set B obtained after the first update, to finally obtain X - 1 intermediate sets B_2 and obtain X - 1 first criterion values.

[0171] Next, in the example during selection for the first time, the candidate set A = [a_2, ..., ax] after the first update and the selected set B = [0 a_2] after the first update are used as an example, a_2, ..., and ax are sequentially added to the selected set B after the first update, to obtain X - 1 intermediate sets B_2, and an x^{th} of the X - 1 intermediate sets B_2 is denoted as B_{2x}, x = 1, 2, ... X - 1, and the X - 1 intermediate sets B_2 are: B_{21} = [0 a2], B_{22} = [0 a_3], ..., and B_{2X-1}=[0 ax]. A first criterion value obtained based on the x^{th} intermediate set B_{1x} is P_{1x}, and X - 1 first criterion values are obtained based on the X - 1 intermediate sets B_2: P_{21}, P_{22}, ..., P_{2X-1}. Assuming that a value of P_{21} is the smallest, the element a_2 corresponding to P_{21} is used as another target element.

[0172] Certainly, if the candidate set A = [a_2, ..., ax] includes the element 0, X - 2 intermediate sets B_2 are obtained, and X - 2 first criterion values are obtained.

[0173] After the target element selected for the second time is determined, the target element is deleted from the candidate set A updated for the first time, to obtain a candidate set A updated for the second time, where the candidate set A updated for the second time includes X - 2 elements. The target element is added to the selected set B updated for the first time, to obtain a selected set B updated for the second time, where the selected set B updated for the second time includes three target elements.

[0174] In this way, by analogy, each time a new target element is selected, the target element is deleted from a candidate set A that is updated last time, to obtain a currently updated candidate set A, and the target element is added to a selected set B that is updated last time, to obtain a currently updated selected set B. Finally, the M target elements may be obtained after selection is performed for M - 1 times.

[0175] For example, an initial candidate set A = [0 -12.5 -25 -37.5 -50 -62.5 -75 -87.5 -100 -112.5 -125 -137.5 -150 -162.5 -175 -187.5 -200] and an initial selected set B = [0] are used as an example to describe a process of determining the M target elements.

During selection for the first time:

[0176] The candidate set A = [0 -12.5 -25 -37.5 -50 -62.5 -75 -87.5 -100 -112.5 -125 - 137.5 -150 -162.5 -175 -187.5 -200], the selected set B = [0], X = 17, and 16 elements other than 0 in the candidate set A are added to the selected set B, to obtain 16 intermediate sets B_1.

[0177] The 16 intermediate sets B_1 are as follows:

a 1st intermediate set B_1 is [0 -12.5];
a 2nd intermediate set B_1 is [0 -25];
a 3rd intermediate sets B_1 is [0 -37.5];
a 4th intermediate sets B_1 is [0 -50];
a 5th intermediate sets B_1 is [0 -62.5];
a 6th intermediate sets B_1 is [0 -75];
a 7th intermediate sets B_1 is [0 -87.5];
an 8th intermediate sets B_1 is [0 -100];
a 9th intermediate sets B_1 is [0 -112.5];
a 10th intermediate sets B_1 is [0 -125];
an 11th intermediate sets B_1 is [0 -137.5];
a 12th intermediate sets B_1 is [0 -150];
a 13th intermediate sets B_1 is [0 -162.5];
a 14th intermediate sets B_1 is [0 -175];
a 15th intermediate sets B_1 is [0 -187.5]; and
a 16th intermediate sets B_1 is [0 -200].

[0178] A first criterion value corresponding to each intermediate set B_1 is calculated, and an intermediate set B_1 whose first criterion value is the smallest is selected from the 16 intermediate sets. In this case, the intermediate set whose first criterion value is the smallest is a selected set after the first update. After calculation, a first criterion value corresponding to the 14th intermediate set B_1 is the smallest, and therefore a selected set after the first update is [0 -175], and a candidate set A after the first update is A = [0 -12.5 -25 -37.5 -50 -62.5 -75 -87.5 -100 -112.5 -125 -137.5 -150 -162.5

-187.5 -200].

[0179] By analogy, the foregoing process is repeated until a number of target elements in the selected set B reaches M.

[0180] Finally, after calculation, a finally obtained selected set B = [0 -175 -87.5 -62.5 -200 -187.5 -100 -50 -12.5 -25 -37.5 -75 -150 -125 -162.5 -137.5], which includes the M target elements.

[0181] S230: Determine L CSD sets corresponding to L antenna numbers based on the M target elements, where one antenna number corresponds to one CSD set, and L is a positive integer greater than 1 and less than or equal to M - 1.

[0182] When the earlier communication protocol is incompatible, a CSD set corresponding to each antenna number being greater than 1 is determined, where L = M - 1.

j antennas in the L antenna numbers are used as an example, and a process of determining a CSD set corresponding to the j antennas is described, where j = 2, 3, ..., L.

1. Determine a discrete time set

[0183] A manner of determining the discrete time set may be the same as the manner of determining the candidate set in S220, and details are not described again. In addition, the discrete time set may be the same as the candidate set.

[0184] For example, the discrete time set Q is Q = [0 -12.5 -25 -37.5 -50 -62.5 -75 -87.5 - 100 -112.5 -125 -137.5 -150 -162.5 -175 -187.5 -200].

2. Determine a first initial set and a second initial set

[0185] The first initial set includes j target elements in the M target elements. For example, the j target elements are the first j elements in the M target elements.

[0186] The second initial set is determined based on the discrete time set and the first initial set.

[0187] In some embodiments, the second initial set is obtained in the following manner:

determining a third initial set, where the third initial set includes elements other than the j target elements in the discrete time set; and

determining the second initial set based on the first initial set and the third initial set.

[0188] In an example, the determining the second initial set based on the first initial set and the third initial set includes: deleting any element from the first initial set, and adding any element in the third initial set to a tail of a first initial set obtained after the element is deleted, to obtain the second initial set.

[0189] For example, a process of determining the first initial set and the second initial set is described by using j = 3, the selected set B = [0 -175 -87.5 -62.5 -200 -187.5 -100 -50 -12.5 - 25 -37.5 -75 -150 -125 -162.5 -137.5] including the M target elements in S230, and the foregoing exampled discrete time set Q = [0 -12.5 -25 -37.5 -50 -62.5 -75 -87.5 -100 -112.5 -125 -137.5 -150 -162.5 -175 -187.5 -200] as an example.

[0190] The first initial set is denoted as a set T, the second initial set is denoted as a time T', and the third initial set is denoted as Q'.

[0191] The first initial set T is T = [0 -175 -87.5], and the third initial set Q' is Q = [-12.5 - 25 -37.5 -50 -62.5 -75 -100 -112.5 -125 -137.5 -150 -162.5 -187.5 -200].

[0192] The element 0 in the first initial set T is deleted to obtain a set [-175 -87.5], and the element -12.5 in the third initial set Q' is added to the set [-175 -87.5], to obtain the second initial set T' = [-175 -87.5 -12.5].

[0193] 3. Determine, based on the first initial set and the second initial set, the CSD set corresponding to the j antennas, where the CSD set includes j CSD values.

[0194] A first criterion value corresponding to the first initial set and a first criterion value corresponding to the second initial set are calculated.

[0195] If the first criterion value corresponding to the first initial set is less than the first criterion value corresponding to the second initial set, the second initial set is used as a new first initial set, then step 2 and step 3 are repeatedly performed for a preset number of times, and finally j CSD values obtained after the preset number of times are used as the CSD set corresponding to the j antennas.

[0196] If the first criterion value corresponding to the first initial set is greater than or equal to the first criterion value corresponding to the second initial set, it means that the CSD set corresponding to the j antennas is not calculated, and step 2 and step 3 are continuously performed again until the first criterion value corresponding to the first initial set is less than the first criterion value corresponding to the second initial set, and the second initial set is used as a new first initial set. Then, step 2 and step 3 are repeatedly performed for a preset number of times. It should be understood that, if the first criterion value corresponding to the first initial set is greater than or equal to the first criterion value corresponding to the second initial set, when step 2 is repeatedly performed, an element deleted from the first initial set or an element added to the third initial set should be different from that in the previous step, so that the first criterion value corresponding to the first initial set may possibly be less than the first criterion value corresponding to the second initial set.

[0197] The first initial set T = [0 -175 -87.5] and the second initial set T' = [-175 -87.5 -12.5] that are obtained in step 2 are still used as an example. During execution for the first time, if a first criterion value corresponding to the first initial set T is less than a first criterion value corresponding to the second initial set T', a new first initial set T = [-175 -87.5 -12.5] is obtained. Step 2 and step 3 continue to be performed for a preset number of times, to obtain a final result. After calculation, a CSD set corresponding to finally obtained three antennas is [0 -175 -87.5].

[0198] In this way, the foregoing steps 1 to 3 are performed on each of the L antenna numbers, to obtain a CSD set corresponding to each antenna number.

[0199] For example, M = 16, and the obtained CSD set corresponding to the 16 antennas may be shown in Table 4.

[0200] When the earlier communication protocol is compatible, only a CSD set corresponding to each antenna number in a new communication protocol needs to be determined, where L is less than M - 1. The CSD set corresponding to each antenna number may be obtained by using the foregoing steps 1 to 3.

[0201] When a communication protocol with eight antennas is compatible, a CSD set corresponding to M - 9 antennas need to be determined.

[0202] For example, M = 16, and CSD sets corresponding to 9 to 16 antennas may be shown in Table 3, or CSD sets corresponding to 9 to 16 antennas may be the CSD sets corresponding to the 9 to 16 antennas shown in Table 4.

[0203] The foregoing describes in detail the cyclic shift diversity-based communication method according to embodiments of this application with reference to FIG. 1 to FIG. 5.

[0204] An embodiment of this application provides a cyclic shift diversity-based communication apparatus. In a possible implementation, the apparatus is configured to implement the steps or procedures corresponding to the receive end in the foregoing method embodiments. In another possible implementation, the apparatus is configured to implement the steps or procedures corresponding to the transmit end in the foregoing method embodiments.

[0205] With reference to FIG. 6 and FIG. 7, the following describes in detail the cyclic shift diversity-based communication apparatus according to an embodiment of this application.

[0206] FIG. 6 is a schematic block diagram of a cyclic shift diversity-based communication apparatus according to an embodiment of this application. As shown in FIG. 6, the apparatus 300 may include a processing unit 310 and a communication unit 320. The communication unit 320 may communicate with an external device, and the processing unit 310 is configured to process data. The communication unit 320 may also be referred to as a communication interface or a transceiver unit.

[0207] In a possible design, the apparatus 300 may implement the steps or procedures performed by the transmit end in the foregoing method embodiments. The processing unit 310 is configured to perform processing-related operations of the transmit end in the foregoing method embodiments, and the communication unit 320 is configured to perform receiving/sending-related operations of the transmit end in the foregoing method embodiments.

[0208] In some embodiments, the processing unit 310 is configured to generate a physical layer protocol data unit PPDU, where the PPDU includes a first preamble part.

[0209] The communication unit 320 is configured to send the PPDU by using N antennas, where cyclic shift is performed, based on a cyclic shift diversity CSD value, on a first preamble part of a PPDU sent on an i^{th} antenna of the N antennas, and N is a positive integer less than or equal to M.

[0210] In another possible design, the apparatus 300 may implement the steps or procedures performed by the receive end in the foregoing method embodiments. The communication unit 320 is configured to perform receiving/sending-related operations of the receive end in the foregoing method embodiments, and the processing unit 310 is configured to perform processing-related operations of the receive end in the foregoing method embodiments.

[0211] In some embodiments, the communication unit 320 is configured to receive a physical layer protocol data unit PPDU, where the PPDU includes a first preamble part, the first preamble part is received based on a cyclic shift diversity CSD value, and the CSD value is a CSD value based on which a transmit end sends the first preamble part.

[0212] The processing unit 310 is configured to process the PPDU.

[0213] In the foregoing two possible designs, optionally, M = 16, and the CSD value belongs to a CSD set.

[0214] Optionally, N = 9, and the CSD value in the CSD set includes: 0, -175 ns, -87.5 ns, - 62.5 ns, -200 ns, -187.5 ns, -100 ns, -50 ns, and -12.5 ns;

N = 10, and the CSD value in the CSD set includes: 0, -175 ns, -87.5 ns, -62.5 ns, - 200 ns, -187.5 ns, -100 ns, -50 ns, -12.5 ns, and -25 ns;

N = 11, and the CSD value in the CSD set includes: 0, -175 ns, -87.5 ns, -200 ns, - 187.5 ns, -100 ns, -50 ns, -12.5 ns, -25 ns, -37.5 ns, and -125 ns;

N = 12, and the CSD value in the CSD set includes: 0, -175 ns, -200 ns, -187.5 ns, - 100 ns, -50 ns, -12.5 ns, -25 ns, -37.5 ns, -75 ns, -162.5 ns, and -112.5 ns;

N = 13, and the CSD value in the CSD set includes: 0, -87.5 ns, -200 ns, -187.5 ns, - 100 ns, -50 ns, -12.5 ns, -25 ns, -37.5 ns, -75 ns, -162.5 ns, -125 ns, and -137.5 ns;

N = 14, and the CSD value in the CSD set includes: 0, -175 ns, -62.5 ns, -200 ns, - 187.5 ns, -100 ns, -50 ns, -12.5 ns, -25 ns, -37.5 ns, -75 ns, -150 ns, -112.5 ns, and -162.5 ns;
N = 15, and the CSD value in the CSD set includes: 0, -175 ns, -87.5 ns, -200 ns, - 187.5 ns, -100 ns, -50 ns, -12.5 ns, -25 ns, -37.5 ns, -75 ns, -150 ns, -125 ns, -162.5 ns, and - 137.5 ns; or
N = 16, and the CSD value in the CSD set includes: 0, -175 ns, -62.5 ns, -200 ns, - 187.5 ns, -100 ns, -50 ns, -12.5 ns, -25 ns, -37.5 ns, -75 ns, -150 ns, -125 ns, -162.5 ns, -137.5 ns, and -112.5 ns.

[0215] Optionally, N = 1, and the CSD value in the CSD set includes 0;

N = 2, and the CSD value in the CSD set includes: 0, -175 ns;
N = 3, and the CSD value in the CSD set includes: 0, -175 ns, and -87.5 ns;
N = 4, and the CSD value in the CSD set includes: 0, -175 ns, -87.5 ns, and -62.5 ns;
N = 5, and the CSD value in the CSD set includes: 0, -175 ns, -87.5 ns, -62.5 ns, and -200 ns;
N = 6, and the CSD value in the CSD set includes: 0, -87.5 ns, -200 ns, -187.5 ns, - 125 ns, and -12.5 ns;
N = 7, and the CSD value in the CSD set includes: 0, -87.5 ns, -62.5 ns, -200 ns, - 187.5 ns, -100 ns, and -150 ns;
N = 8, and the CSD value in the CSD set includes: 0, -200 ns, -187.5 ns, -100 ns, -50 ns, -25 ns, -125 ns, and -150 ns;
N = 9, and the CSD value in the CSD set includes: 0, -175 ns, -87.5 ns, -200 ns, - 187.5 ns, -100 ns, -50 ns, -12.5 ns, and -25 ns;
N = 10, and the CSD value in the CSD set includes: 0, -175 ns, -200 ns, -187.5 ns, - 100 ns, -50 ns, -12.5 ns, -25 ns, -137.5 ns, and -162.5 ns;
N = 11, and the CSD value in the CSD set includes: 0, -87.5 ns, -200 ns, -187.5 ns, - 100 ns, -50 ns, -12.5 ns, -25 ns, -37.5 ns, -137.5 ns, and -150 ns;
N = 12, and the CSD value in the CSD set includes: 0, -175 ns, -87.5 ns, -200 ns, - 187.5 ns, -100 ns, -12.5 ns, -25 ns, -37.5 ns, -75 ns, -150 ns, and -162.5 ns;
N = 13, and the CSD value in the CSD set includes: 0, -175 ns, -62.5 ns, -187.5 ns, - 100 ns, -50 ns, -12.5 ns, -25 ns, -37.5 ns, -75 ns, -150 ns, -162.5 ns, and -125 ns;
N = 14, and the CSD value in the CSD set includes: 0, -175 ns, -87.5 ns, -187.5 ns, - 100 ns, -50 ns, -12.5 ns, -25 ns, -37.5 ns, -75 ns, -150 ns, -125 ns, -162.5 ns, and -137.5 ns;
N = 15, and the CSD value in the CSD set includes: 0, -175 ns, -87.5 ns, -200 ns, - 187.5 ns, -100 ns, -50 ns, -12.5 ns, -25 ns, -75 ns, -125 ns, -162.5 ns, -137.5 ns, -112.5 ns, and -150 ns; or
N = 16, and the CSD value in the CSD set includes: 0, -175 ns, -87.5 ns, -200 ns, - 187.5 ns, -100 ns, -50 ns, -12.5 ns, -25 ns, -37.5 ns, -75 ns, -150 ns, -125 ns, -162.5 ns, -137.5 ns, and -112.5 ns.

[0216] Optionally, the first preamble part includes: a legacy short training field L-STF, a legacy long training field L-LTF, a legacy signal field L-SIG, a repeated legacy-signal field RL-SIG, and a universal signal field U-SIG.

[0217] Optionally, the first preamble part further includes an extremely high throughput signal field EHT-SIG.

[0218] It should be understood that the apparatus 300 herein is embodied in a form of a functional unit. The term "unit" herein may refer to an application-specific integrated circuit (application-specific integrated circuit, ASIC), an electronic circuit, a processor (for example, a shared processor, a dedicated processor, or a group processor) configured to execute one or more software or firmware programs, a memory, a merged logic circuit, and/or another appropriate component that supports the described function. In an optional example, a person skilled in the art may understand that the apparatus 300 may be specifically the transmit end in the foregoing embodiments, and may be configured to perform the procedures and/or steps corresponding to the transmit end in the foregoing method embodiments. Alternatively, the apparatus 300 may be specifically the receive end in the foregoing embodiments, and may be configured to perform the procedures and/or steps corresponding to the receive end in the foregoing method embodiments. To avoid repetition, details are not described herein again.

[0219] The apparatus 300 in each of the foregoing solutions has a function of implementing the corresponding steps performed by the transmit end in the foregoing method, or the apparatus 300 in each of the foregoing solutions has a function of implementing the corresponding steps performed by the receive end in the foregoing method. The function may be implemented by hardware, or may be implemented by hardware executing corresponding software. The hardware or software includes one or more modules corresponding to the foregoing function. For example, the communication unit may be replaced with a transceiver (for example, a sending unit of the communication unit may be replaced with a transmitter, and a receiving unit of the communication unit may be replaced with a receiver), and another unit such as the processing unit may be replaced with a processor, to separately perform sending/receiving operations and processing-related operations in the method embodiments.

[0220] In addition, the communication unit may alternatively be a transceiver circuit (which may include, for example, a receiving circuit and a transmitter circuit), and the processing unit may be a processing circuit. In this embodiment of this application, the apparatus in FIG. 7 may be the receive end or the transmit end in the foregoing embodiments, or may be a chip or a chip system, for example, a system on chip (system on chip, SoC). The communication unit may be an input/output circuit or a communication interface. The processing unit is a processor, a microprocessor, or an integrated circuit integrated on the chip. This is not limited herein.

[0221] FIG. 7 shows a cyclic shift diversity-based apparatus 400 according to an embodiment of this application. The apparatus 400 includes a processor 410 and a transceiver 420. The processor 410 and the transceiver 420 communicate with each other through an internal connection path, and the processor 410 is configured to execute instructions, to control the transceiver 420 to send a signal and/or receive a signal.

[0222] Optionally, the apparatus 400 may further include a memory 430. The memory 430 communicates with the processor 410 and the transceiver 420 through internal connection paths. The memory 430 is configured to store instructions, and the processor 410 may execute the instructions stored in the memory 430. In a possible implementation, the apparatus 400 is configured to implement procedures and steps corresponding to the transmit end in the foregoing method embodiment. In another possible implementation, the apparatus 400 is configured to implement procedures and steps corresponding to the receive end in the foregoing method embodiment.

[0223] It should be understood that the apparatus 400 may be specifically the transmit end or the receive end in the foregoing embodiments, or may be a chip or a chip system. Correspondingly, the transceiver 420 may be a transceiver circuit of the chip. This is not limited herein. Specifically, the apparatus 400 may be configured to perform the steps and/or the procedures corresponding to the transmit end or the receive end in the foregoing method embodiments. Optionally, the memory 430 may include a read-only memory and a random access memory, and provide instructions and data for the processor. A part of the memory may further include a non-volatile random access memory. For example, the memory may further store information of a device type. The processor 410 may be configured to execute the instructions stored in the memory. When the processor 410 executes the instructions stored in the memory, the processor 410 is configured to perform the steps and/or procedures of the method embodiment corresponding to the transmit end or the receive end.

[0224] In an implementation process, steps in the foregoing methods can be implemented by using a hardware integrated logical circuit in the processor, or by using instructions in a form of software. The steps of the method disclosed with reference to embodiments of this application may be directly performed by a hardware processor, or may be performed by using a combination of hardware in the processor and a software module. A software module may be located in a mature storage medium in the art, such as a random access memory, a flash memory, a read-only memory, a programmable read-only memory, an electrically erasable programmable memory, or a register. The storage medium is located in the memory, and a processor reads information in the memory and completes the steps in the foregoing methods in combination with hardware of the processor. To avoid repetition, details are not described herein again.

[0225] It should be noted that, the processor in embodiments of this application may be an integrated circuit chip, and has a signal processing capability. In an implementation process, steps in the foregoing method embodiments can be implemented by using a hardware integrated logical circuit in the processor, or by using instructions in a form of software. The processor may be a general purpose processor, a digital signal processor (DSP), an application specific integrated circuit (ASIC), a field programmable gate array (FPGA) or another programmable logic device, a discrete gate or a transistor logic device, or a discrete hardware component. The processor in embodiments of this application may implement or perform the methods, the steps, and the logical block diagrams that are disclosed in embodiments of this application. The general-purpose processor may be a microprocessor, or the processor may be any conventional processor or the like. The steps of the method disclosed with reference to embodiments of this application may be directly performed by a hardware decoding processor, or may be performed by using a combination of hardware in the decoding processor and a software module. A software module may be located in a mature storage medium in the art, such as a random access memory, a flash memory, a read-only memory, a programmable read-only memory, an electrically erasable programmable memory, or a register. The storage medium is located in the memory, and a processor reads information in the memory and completes the steps in the foregoing methods in combination with hardware of the processor.

[0226] It may be understood that the memory in embodiments of this application may be a volatile memory or a nonvolatile memory, or may include a volatile memory and a nonvolatile memory. The nonvolatile memory may be a read-only memory (read-only memory, ROM), a programmable read-only memory (programmable ROM, PROM), an erasable programmable read-only memory (erasable PROM, EPROM), an electrically erasable programmable read-only memory (electrically EPROM, EEPROM), or a flash memory. The volatile memory may be a random access memory (random access memory, RAM), used as an external cache. Through example but not limitative description, many forms of RAMs may be used, for example, a static random access memory (static RAM, SRAM), a dynamic random access memory (dynamic RAM, DRAM), a synchronous dynamic random access memory (synchronous DRAM, SDRAM), a double data rate synchronous dynamic random access memory (double data rate SDRAM, DDR SDRAM), an enhanced synchronous dynamic random access memory (enhanced SDRAM, ESDRAM), a synchronous link dynamic random access memory (synchlink DRAM, SLDRAM), and a direct rambus dynamic random access memory (direct rambus RAM, DR RAM). It should be noted that the memory of the systems and methods described in this specification includes but is not limited to these and any memory of another proper type.

[0227] According to the methods provided in embodiments of this application, an embodiment of this application further provides a computer program product. The computer program product includes computer program code. When the computer program code is run on a computer, the computer is enabled to perform the method in the embodiment shown in FIG. 4.

[0228] According to the method provided in embodiments of this application, this application further provides a computer-readable medium. The computer-readable medium stores program code. When the program code is run on a computer, the computer is enabled to perform the method in the embodiment shown in FIG. 4.

[0229] According to the methods provided in embodiments of this application, this application further provides a system. The system includes the foregoing one or more stations and the foregoing one or more access points.

[0230] It should be noted that, in the implementation of this application, the "protocol" may refer to a standard protocol in the communication field.

[0231] In addition, although embodiments of this application are proposed based on the WLAN protocol, in a technically feasible case, embodiments of this application are not limited to the WLAN protocol, and may be further applied to another protocol, for example, an LTE protocol, an NR protocol, and a related protocol applied to a future communication system. This is not limited in this application.

[0232] It should be further understood that in embodiments of this application, "predefined" may be implemented by prestoring corresponding code or a table in a device (for example, including a station and an access point), or in another manner used for indicating related information. A specific implementation of the foregoing "predefinition" is not limited in this application. For example, "predefined" may be "defined in a protocol".

[0233] It should be further noted that "storing" in embodiments of this application may refer to storing in one or more memories. The one or more memories may be separately disposed, or may be integrated into an encoder or a decoder, a processor, or a communication apparatus. Alternatively, a part of the one or more memories may be separately disposed, and a part of the one or more memories are integrated into the translator, the processor, or the communication apparatus. A type of the memory may be a storage medium in any form. This is not limited in this application.

[0234] It should be noted that the term "at least one" means one or more. The term "at least one of A and B", similar to the term "A and/or B", describes an association relationship between the associated objects and represents that three relationships may exist. For example, at least one of A and B may represent the following three cases: Only A exists, both A and B exist, and only B exists.

[0235] A person of ordinary skill in the art may be aware that, in combination with the examples described in embodiments disclosed in this specification, units and algorithm steps may be implemented by electronic hardware or a combination of computer software and electronic hardware. Whether the functions are performed by hardware or software depends on particular applications and design constraint conditions of the technical solutions. A person skilled in the art may use different methods to implement the described functions for each particular application, but it should not be considered that the implementation goes beyond the scope of this application.

[0236] It may be clearly understood by a person skilled in the art that, for the purpose of convenient and brief description, for a detailed working process of the foregoing system, apparatus, and unit, refer to a corresponding process in the foregoing method embodiments. Details are not described herein again.

[0237] In the several embodiments provided in this application, it should be understood that the disclosed system, apparatus and method may be implemented in other manners. For example, the described apparatus embodiment is merely an example. For example, division into the units is merely logical function division and may be other division in actual implementation. For example, a plurality of units or components may be combined or integrated into another system, or some features may be ignored or not performed. In addition, the displayed or discussed mutual couplings or direct couplings or communication connections may be implemented by using some interfaces. The indirect couplings or communication connections between the apparatuses or units may be implemented in electronic, mechanical, or other forms.

[0238] The units described as separate parts may or may not be physically separate, and parts displayed as units may or may not be physical units, may be located in one position, or may be distributed on a plurality of network units. Some or all of the units may be selected based on actual requirements to achieve the objectives of the solutions of embodiments.

[0239] In addition, functional units in embodiments of this application may be integrated into one processing unit, each of the units may exist independently physically, or two or more units may be integrated into one unit.

[0240] When the functions are implemented in the form of a software functional unit and sold or used as an independent product, the functions may be stored in a computer-readable storage medium. Based on such an understanding, the technical solutions of this application essentially, or the part contributing to the conventional technology, or some of the technical solutions may be implemented in a form of a software product. The computer software product is stored in a storage medium, and includes several instructions for instructing a computer device (which may be a personal computer, a server, or a network device) to perform all or some of the steps of the methods described in embodiments of this application. The foregoing storage medium includes any medium that can store program code, such as a USB flash drive, a removable hard disk, a read-only memory (Read-Only Memory, ROM), a random access memory (Random Access Memory, RAM), a magnetic disk, or an optical disc.

[0241] The foregoing descriptions are merely specific implementations of this application, but are not intended to limit the protection scope of this application. Any variation or replacement readily figured out by a person skilled in the art within the technical scope disclosed in this application shall fall within the protection scope of this application. Therefore, the protection scope of this application shall be subject to the protection scope of the claims.

Claims

1. A cyclic shift diversity-based communication method, wherein a maximum number of antennas supported in the method is M, M is a positive integer greater than 8, and the method comprises:

generating a physical layer protocol data unit PPDU, wherein the PPDU comprises a first preamble part; and sending the PPDU by using N antennas, wherein cyclic shift is performed, based on a cyclic shift diversity CSD value, on a first preamble part of a PPDU sent on an i^{th} antenna of the N antennas, and N is a positive integer less than or equal to M.

2. The method according to claim 1, wherein M = 16 and the CSD value belongs to a CSD set.

3. The method according to claim 2, wherein

N = 9, and the CSD value in the CSD set comprises: 0, -175 ns, -87.5 ns, -62.5 ns, -200 ns, -187.5 ns, -100 ns, -50 ns, and -12.5 ns;
N = 10, and the CSD value in the CSD set comprises: 0, -175 ns, -87.5 ns, -62.5 ns, -200 ns, -187.5 ns, -100 ns, -50 ns, -12.5 ns, and -25 ns;
N = 11, and the CSD value in the CSD set comprises: 0, -175 ns, -87.5 ns, -200 ns, -187.5 ns, -100 ns, -50 ns, -12.5 ns, -25 ns, -37.5 ns, and -125 ns;
N = 12, and the CSD value in the CSD set comprises: 0, -175 ns, -200 ns, -187.5 ns, -100 ns, -50 ns, -12.5 ns, -25 ns, -37.5 ns, -75 ns, -162.5 ns, and -112.5 ns;
N = 13, and the CSD value in the CSD set comprises: 0, -87.5 ns, -200 ns, -187.5 ns, -100 ns, -50 ns, -12.5 ns, -25 ns, -37.5 ns, -75 ns, -162.5 ns, -125 ns, and -137.5 ns;
N = 14, and the CSD value in the CSD set comprises: 0, -175 ns, -62.5 ns, -200 ns, -187.5 ns, -100 ns, -50 ns, -12.5 ns, -25 ns, -37.5 ns, -75 ns, -150 ns, -112.5 ns, and -162.5 ns;
N = 15, and the CSD value in the CSD set comprises: 0, -175 ns, -87.5 ns, -200 ns, -187.5 ns, -100 ns, -50 ns, -12.5 ns, -25 ns, -37.5 ns, -75 ns, -150 ns, -125 ns, -162.5 ns, and -137.5 ns; or
N = 16, and the CSD value in the CSD set comprises: 0, -175 ns, -62.5 ns, -200 ns, -187.5 ns, -100 ns, -50 ns, -12.5 ns, -25 ns, -37.5 ns, -75 ns, -150 ns, -125 ns, -162.5 ns, -137.5 ns, and -112.5 ns.

4. The method according to claim 2, wherein

N = 1, and the CSD value in the CSD set comprises 0;
N = 2, and the CSD value in the CSD set comprises: 0, -175 ns;
N = 3, and the CSD value in the CSD set comprises: 0, -175 ns, and -87.5 ns;
N = 4, and the CSD value in the CSD set comprises: 0, -175 ns, -87.5 ns, and -62.5 ns;
N = 5, and the CSD value in the CSD set comprises: 0, -175 ns, -87.5 ns, -62.5 ns, and -200 ns;
N = 6, and the CSD value in the CSD set comprises: 0, -87.5 ns, -200 ns, -187.5 ns, -125 ns, and -12.5 ns;
N = 7, and the CSD value in the CSD set comprises: 0, -87.5 ns, -62.5 ns, -200 ns, -187.5 ns, -100 ns, and -150 ns;
N = 8, and the CSD value in the CSD set comprises: 0, -200 ns, -187.5 ns, -100 ns, -50 ns, -25 ns, -125 ns, and -150 ns;
N = 9, and the CSD value in the CSD set comprises: 0, -175 ns, -87.5 ns, -200 ns, -187.5 ns, -100 ns, -50 ns, -12.5 ns, and -25 ns;
N = 10, and the CSD value in the CSD set comprises: 0, -175 ns, -200 ns, -187.5 ns, -100 ns, -50 ns, -12.5 ns, -25 ns, -137.5 ns, and -162.5 ns;
N = 11, and the CSD value in the CSD set comprises: 0, -87.5 ns, -200 ns, -187.5 ns, -100 ns, -50 ns, -12.5 ns, -25 ns, -37.5 ns, -137.5 ns, and -150 ns;
N = 12, and the CSD value in the CSD set comprises: 0, -175 ns, -87.5 ns, -200 ns, -187.5 ns, -100 ns, -12.5

ns, -25 ns, -37.5 ns, -75 ns, -150 ns, and -162.5 ns;
N = 13, and the CSD value in the CSD set comprises: 0, -175 ns, -62.5 ns, -187.5 ns, -100 ns, -50 ns, -12.5 ns, -25 ns, -37.5 ns, -75 ns, -150 ns, -162.5 ns, and -125 ns;
N = 14, and the CSD value in the CSD set comprises: 0, -175 ns, -87.5 ns, -187.5 ns, -100 ns, -50 ns, -12.5 ns, -25 ns, -37.5 ns, -75 ns, -150 ns, -125 ns, -162.5 ns, and -137.5 ns;
N = 15, and the CSD value in the CSD set comprises: 0, -175 ns, -87.5 ns, -200 ns, -187.5 ns, -100 ns, -50 ns, -12.5 ns, -25 ns, -75 ns, -125 ns, -162.5 ns, -137.5 ns, -112.5 ns, and -150 ns; or
N = 16, and the CSD value in the CSD set comprises: 0, -175 ns, -87.5 ns, -200 ns, -187.5 ns, -100 ns, -50 ns, -12.5 ns, -25 ns, -37.5 ns, -75 ns, -150 ns, -125 ns, -162.5 ns, -137.5 ns, and -112.5 ns.

5. The method according to any one of claims 1 to 4, wherein the first preamble part comprises: a legacy short training field L-STF, a legacy long training field L-LTF, a legacy signal field L-SIG, a repeated legacy-signal field RL-SIG, and a universal signal field U-SIG.

6. The method according to claim 5, wherein the first preamble part further comprises an extremely high throughput signal field EHT-SIG.

7. A cyclic shift diversity-based communication method, wherein the method comprises:

receiving a physical layer protocol data unit PPDU, wherein the PPDU comprises a first preamble part, the first preamble part is received based on a cyclic shift diversity CSD value, and the CSD value is a CSD value based on which a transmit end sends the first preamble part; and
processing the PPDU.

8. A cyclic shift diversity-based communication apparatus, wherein a maximum number of antennas supported in the apparatus is M, M is a positive integer greater than 8, and the apparatus comprises:

a processing unit, configured to generate a physical layer protocol data unit PPDU, wherein the PPDU comprises a first preamble part; and
a communication unit, configured to send the PPDU by using N antennas, wherein cyclic shift is performed, based on a cyclic shift diversity CSD value, on a first preamble part of a PPDU sent on an i^{th} antenna of the N antennas, and N is a positive integer less than or equal to M.

9. The apparatus according to claim 8, wherein M = 16 and the CSD value belongs to a CSD set.

10. The apparatus according to claim 9, wherein

N = 9, and the CSD value in the CSD set comprises: 0, -175 ns, -87.5 ns, -62.5 ns, -200 ns, -187.5 ns, -100 ns, -50 ns, and -12.5 ns;
N = 10, and the CSD value in the CSD set comprises: 0, -175 ns, -87.5 ns, -62.5 ns, -200 ns, -187.5 ns, -100 ns, -50 ns, -12.5 ns, and -25 ns;
N = 11, and the CSD value in the CSD set comprises: 0, -175 ns, -87.5 ns, -200 ns, -187.5 ns, -100 ns, -50 ns, -12.5 ns, -25 ns, -37.5 ns, and -125 ns;
N = 12, and the CSD value in the CSD set comprises: 0, -175 ns, -200 ns, -187.5 ns, -100 ns, -50 ns, -12.5 ns, -25 ns, -37.5 ns, -75 ns, -162.5 ns, and -112.5 ns;
N = 13, and the CSD value in the CSD set comprises: 0, -87.5 ns, -200 ns, -187.5 ns, -100 ns, -50 ns, -12.5 ns, -25 ns, -37.5 ns, -75 ns, -162.5 ns, -125 ns, and -137.5 ns;
N = 14, and the CSD value in the CSD set comprises: 0, -175 ns, -62.5 ns, -200 ns, -187.5 ns, -100 ns, -50 ns, -12.5 ns, -25 ns, -37.5 ns, -75 ns, -150 ns, -112.5 ns, and -162.5 ns;
N = 15, and the CSD value in the CSD set comprises: 0, -175 ns, -87.5 ns, -200 ns, -187.5 ns, -100 ns, -50 ns, -12.5 ns, -25 ns, -37.5 ns, -75 ns, -150 ns, -125 ns, -162.5 ns, and -137.5 ns; or
N = 16, and the CSD value in the CSD set comprises: 0, -175 ns, -62.5 ns, -200 ns, -187.5 ns, -100 ns, -50 ns, -12.5 ns, -25 ns, -37.5 ns, -75 ns, -150 ns, -125 ns, -162.5 ns, -137.5 ns, and -112.5 ns.

11. The apparatus according to claim 9, wherein

N = 1, and the CSD value in the CSD set comprises 0;
N = 2, and the CSD value in the CSD set comprises: 0, -175 ns;

N = 3, and the CSD value in the CSD set comprises: 0, -175 ns, and -87.5 ns;
N = 4, and the CSD value in the CSD set comprises: 0, -175 ns, -87.5 ns, and -62.5 ns;
N = 5, and the CSD value in the CSD set comprises: 0, -175 ns, -87.5 ns, -62.5 ns, and -200 ns;
N = 6, and the CSD value in the CSD set comprises: 0, -87.5 ns, -200 ns, -187.5 ns, -125 ns, and -12.5 ns;
N = 7, and the CSD value in the CSD set comprises: 0, -87.5 ns, -62.5 ns, -200 ns, -187.5 ns, -100 ns, and -150 ns;
N = 8, and the CSD value in the CSD set comprises: 0, -200 ns, -187.5 ns, -100 ns, -50 ns, -25 ns, -125 ns, and -150 ns;
N = 9, and the CSD value in the CSD set comprises: 0, -175 ns, -87.5 ns, -200 ns, -187.5 ns, -100 ns, -50 ns, -12.5 ns, and -25 ns;
N = 10, and the CSD value in the CSD set comprises: 0, -175 ns, -200 ns, -187.5 ns, -100 ns, -50 ns, -12.5 ns, -25 ns, -137.5 ns, and -162.5 ns;
N = 11, and the CSD value in the CSD set comprises: 0, -87.5 ns, -200 ns, -187.5 ns, -100 ns, -50 ns, -12.5 ns, -25 ns, -37.5 ns, -137.5 ns, and -150 ns;
N = 12, and the CSD value in the CSD set comprises: 0, -175 ns, -87.5 ns, -200 ns, -187.5 ns, -100 ns, -12.5 ns, -25 ns, -37.5 ns, -75 ns, -150 ns, and -162.5 ns;
N = 13, and the CSD value in the CSD set comprises: 0, -175 ns, -62.5 ns, -187.5 ns, -100 ns, -50 ns, -12.5 ns, -25 ns, -37.5 ns, -75 ns, -150 ns, -162.5 ns, and -125 ns;
N = 14, and the CSD value in the CSD set comprises: 0, -175 ns, -87.5 ns, -187.5 ns, -100 ns, -50 ns, -12.5 ns, -25 ns, -37.5 ns, -75 ns, -150 ns, -125 ns, -162.5 ns, and -137.5 ns;
N = 15, and the CSD value in the CSD set comprises: 0, -175 ns, -87.5 ns, -200 ns, -187.5 ns, -100 ns, -50 ns, -12.5 ns, -25 ns, -75 ns, -125 ns, -162.5 ns, -137.5 ns, -112.5 ns, and -150 ns; or
N = 16, and the CSD value in the CSD set comprises: 0, -175 ns, -87.5 ns, -200 ns, -187.5 ns, -100 ns, -50 ns, -12.5 ns, -25 ns, -37.5 ns, -75 ns, -150 ns, -125 ns, -162.5 ns, -137.5 ns, and -112.5 ns.

12. The apparatus according to any one of claims 8 to 11, wherein the first preamble part comprises: a legacy short training field L-STF, a legacy long training field L-LTF, a legacy signal field L-SIG, a repeated legacy-signal field RL-SIG, and a universal signal field U-SIG.

13. The apparatus according to claim 12, wherein the first preamble part further comprises an extremely high throughput signal field EHT-SIG.

14. A cyclic shift diversity-based communication apparatus, wherein the apparatus comprises:

a communication unit, configured to receive a physical layer protocol data unit PPDU, wherein the PPDU comprises a first preamble part, the first preamble part is received based on a cyclic shift diversity CSD value, and the CSD value is a CSD value based on which a transmit end sends the first preamble part; and
a processing unit, configured to process the PPDU.

15. A cyclic shift diversity-based communication apparatus, wherein the apparatus comprises:

a memory, configured to store computer instructions; and
a processor, configured to invoke the computer instructions stored in the memory, to perform the method according to any one of claims 1 to 6, or to perform the method according to claim 7.

16. A computer-readable storage medium, configured to store computer instructions, wherein the computer instructions are used to implement the method according to any one of claims 1 to 6, or a computer program is used to implement the method according to claim 7.

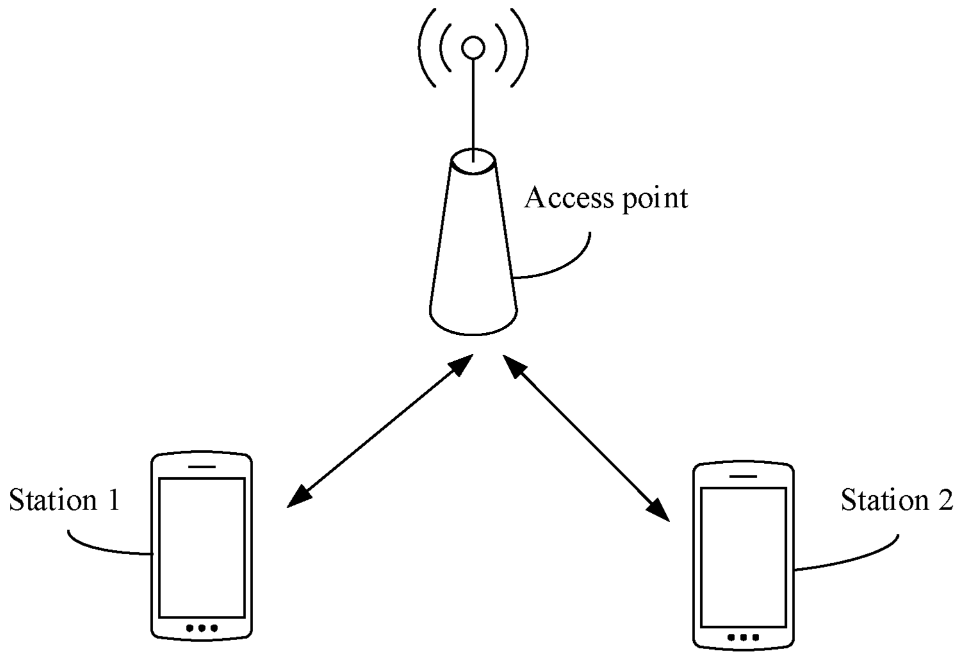

FIG. 1

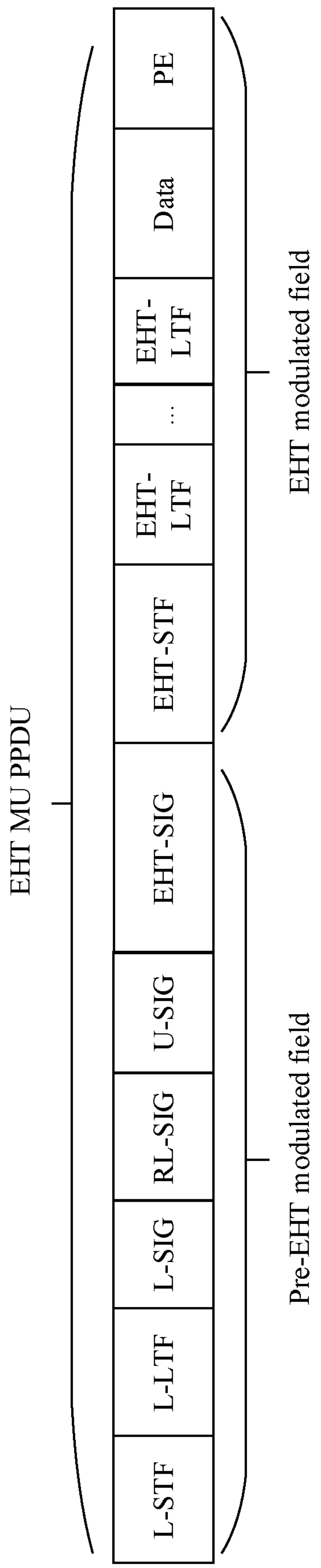
EHT MU PPDU
L-STF
L-LTF
L-SIG
RL-SIG
U-SIG
EHT-SIG
EHT-STF
EHT-LTF
...
EHT-LTF
Data
PE
Pre-EHT modulated field
EHT modulated field

FIG. 2

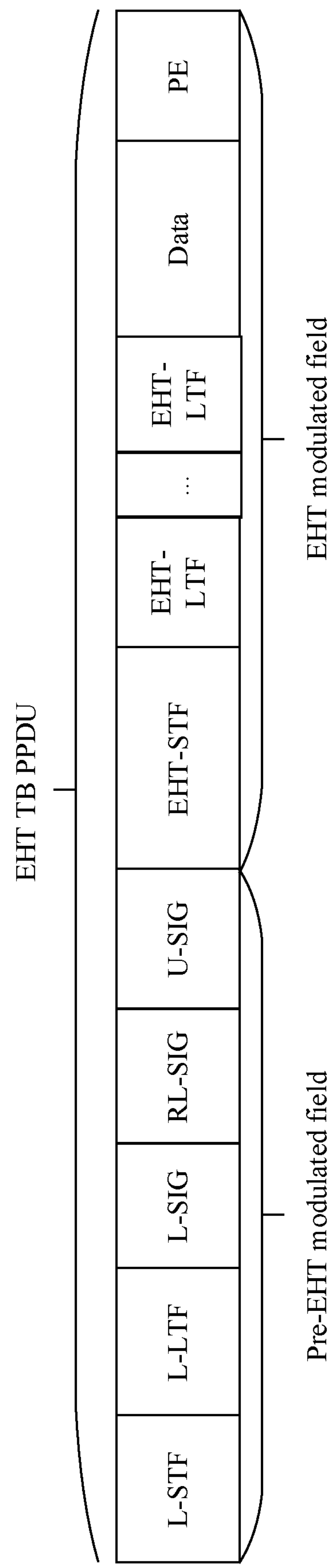
EHT TB PPDU
L-STF
L-LTF
L-SIG
RL-SIG
U-SIG
EHT-STF
EHT-LTF
...
EHT-LTF
Data
PE
Pre-EHT modulated field
EHT modulated field

FIG. 3

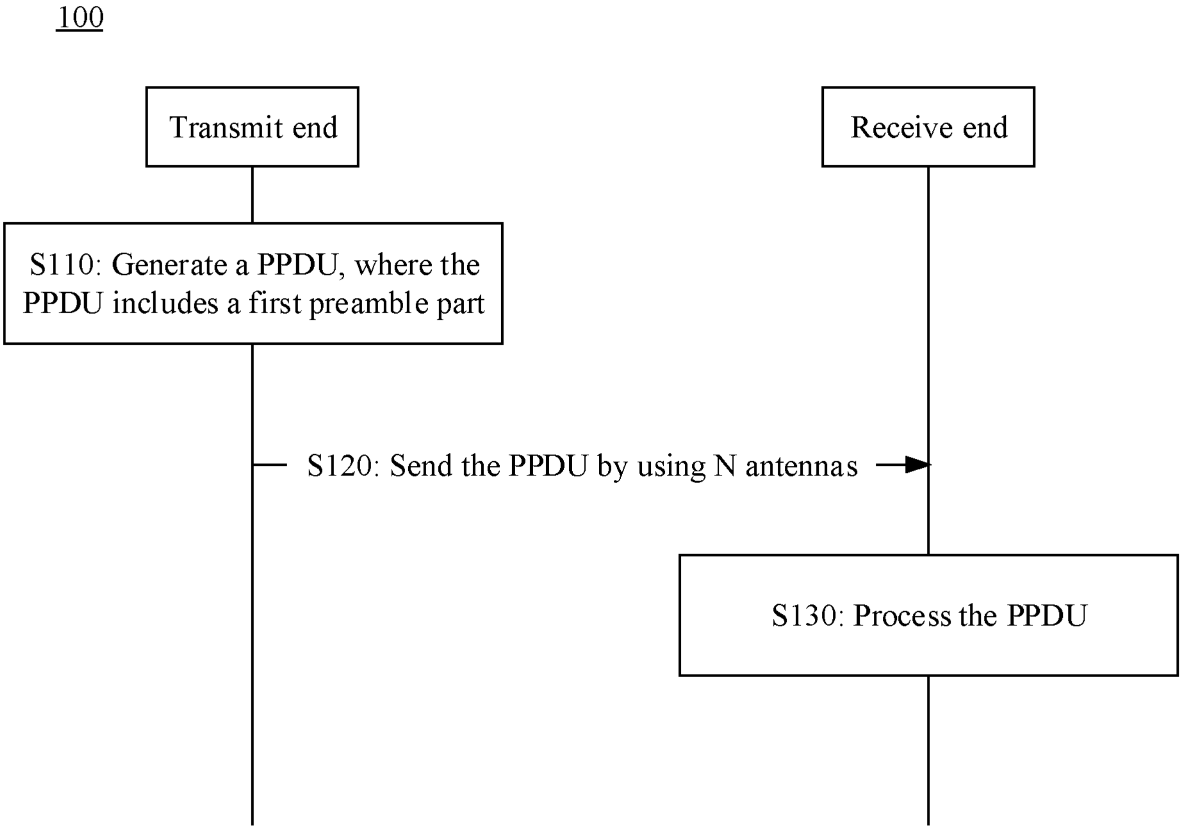
100
Transmit end
Receive end
S110: Generate a PPDU, where the PPDU includes a first preamble part
S120: Send the PPDU by using N antennas
S130: Process the PPDU

FIG. 4

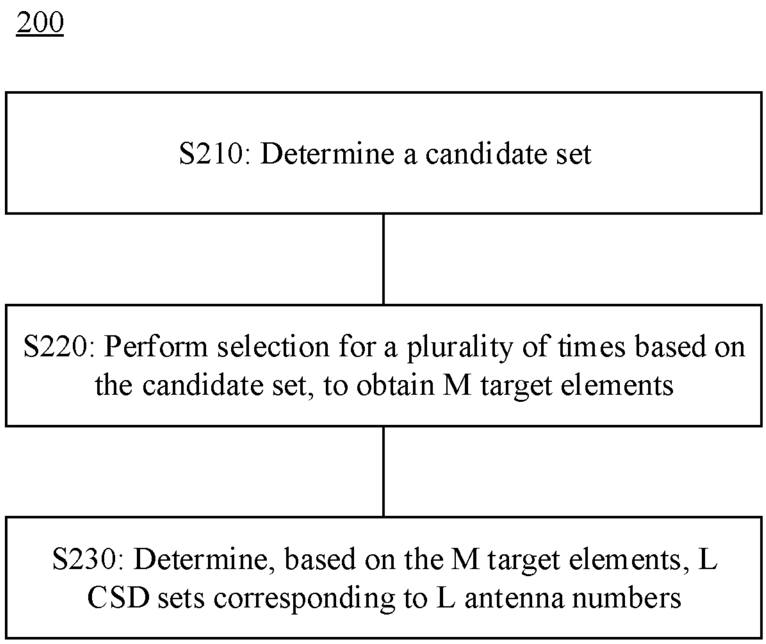
200
S210: Determine a candidate set
S220: Perform selection for a plurality of times based on the candidate set, to obtain M target elements
S230: Determine, based on the M target elements, L CSD sets corresponding to L antenna numbers

FIG. 5

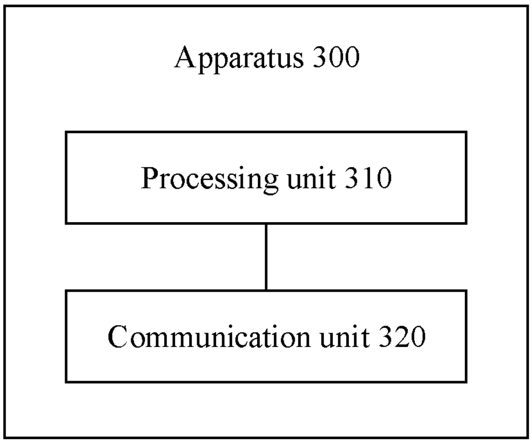
Apparatus 300
Processing unit 310
Communication unit 320

FIG. 6

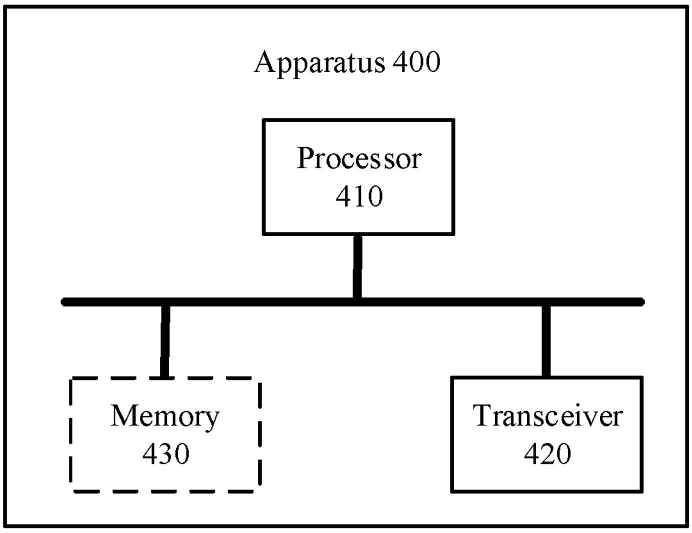
Apparatus 400
Processor 410
Memory 430
Transceiver 420

FIG. 7

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CN2022/077307

A. CLASSIFICATION OF SUBJECT MATTER

H04B 7/0413(2017.01)i；H04B 7/06(2006.01)i

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

H04B;H04L;H04W

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

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

CNTXT; CNKI; ENTXT; ENTXTC; IEEE: 循环位移, 循环移位, 分集, 序列, 天线, 数量, 最大, 最多, 协议数据单元, 前导, 前同步码, cyclic shift, diversity, sequence, antenna, number, maximum, largest, protocol data unit, preamble, pilot, PPDU, CSD, EHT

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	CN 111817764 A (HUAWEI TECHNOLOGIES CO., LTD.) 23 October 2020 (2020-10-23) description paragraphs 5-6, 82-262, claims 12-14	1, 2, 5-9, 12-16
X	US 2019261352 A1 (CARIOU, L. et al.) 22 August 2019 (2019-08-22) description, paragraphs [0088]-[0161]	1, 2, 5-9, 12-16
A	CN 105830380 A (HUAWEI TECHNOLOGIES CO., LTD.) 03 August 2016 (2016-08-03) entire document	1-16
A	CN 108028691 A (MARVELL WORLD TRADE LTD.) 11 May 2018 (2018-05-11) entire document	1-16
A	CN 106130945 A (TELINK SEMICONDUCTOR (SHANGHAI) CO., LTD.) 16 November 2016 (2016-11-16) entire document	1-16
A	US 2020112469 A1 (PANASONIC INTELLECTUAL PROPERTY CORPORATION OF AMERICA) 09 April 2020 (2020-04-09) entire document	1-16

☐ Further documents are listed in the continuation of Box C.　☑ See patent family annex.

* Special categories of cited documents:
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- "O" document referring to an oral disclosure, use, exhibition or other means
- "P" document published prior to the international filing date but later than the priority date claimed
- "T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
- "X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
- "Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
- "&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
23 April 2022	**29 April 2022**

Name and mailing address of the ISA/CN	Authorized officer
China National Intellectual Property Administration (ISA/CN) **No. 6, Xitucheng Road, Jimenqiao, Haidian District, Beijing 100088, China**	
Facsimile No. **(86-10)62019451**	Telephone No.

Form PCT/ISA/210 (second sheet) (January 2015)

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/CN2022/077307

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		CN 111034141 A	17 April 2020

Form PCT/ISA/210 (patent family annex) (January 2015)

REFERENCES CITED IN THE DESCRIPTION

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