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COMMUNICATION DEVICE, COMMUNICATION METHOD THEREOF, INFORMATION PROCESSING DEVICE, CONTROL METHOD THEREOF, AND COMPUTER-READABLE STORAGE MEDIUM

Abstract

A communication device communicates a radio frame including a preamble and a data field of a physical layer (PHY). The preamble includes an L-STF (Legacy Short Training Field), an L-LTF (Legacy Long Training Field), an L-SIG (Legacy Signal Field), an EHT-SIG-A (Extremely High Throughput Signal A Field), an EHT-STF (EHT Short Training Field), and an EHT-LTF (EHT Long Training Field), and the EHT-SIG-A includes a subfield indicating whether data are concurrently transmitted from a plurality of communication devices to a common partner device.

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Background/Summary

CROSS-REFERENCE TO RELATED APPLICATIONS [0001] This application is a Continuation of U.S. patent application Ser. No. 17/395,498, filed Aug. 6, 2021, which is a Continuation of International Patent Application No. PCT/JP2020/004258, filed Feb. 5, 2020, which claims the benefit of Japanese Patent Application No. 2019-036402 filed Feb. 28, 2019, both of which are hereby incorporated by reference herein in their entirety.

BACKGROUND OF THE INVENTION
Field of the Invention
[0002] The present invention relates to a communication device, a communication method thereof, an information processing device, a control method thereof, and a computer-readable storage medium and, more particularly, to a communication control technique in a wireless LAN.
Background Art
[0003] Along with the increase in data amount to be communicated in recent years, communication techniques such as a wireless LAN (Local Area Network) have been developed. As a major communication standard of the wireless LAN, the IEEE (Institute of Electrical and Electronics Engineers) 802.11 standard series is known. The IEEE802.11 standard series includes standards such as IEEE802.11a/b/g/n/ac/ax. For example, in the latest standard, IEEE802.11ax, a technique that uses OFDMA (Orthogonal Frequency-Division Multiple Access) to implement a high peak throughput of up to 9.6 gigabits per second (Gbps) and additionally improve the communication speed under a congestion situation has been standardized (see PTL 1).
[0004] On the other hand, in order to further improve throughput, a study group called IEEE802.11EHT (Extremely High Throughput) has been formed as a successor standard of IEEE802.11ax. In the EHT, to achieve throughput improvement, assigning transmission data for a single STA (Station) to a plurality of access points (APs) arranged while being spatially distributed and causing these to concurrently transmit the data to the STA has been examined.
CITATION LIST
Patent Literature
[0005] PTL 1: Japanese Patent Laid-Open No. 2018-050133
[0006] It is useful to recognize whether an STA receives a frame from a single AP or receives frames from a plurality of APs. On the other hand, in the conventional standard, an STA is assumed to communicate with a single AP but not assumed to concurrently communicate with a plurality of APs. For this reason, there exists no mechanism configured to allow the STA to recognize that frames are concurrently transmitted from a plurality of APs.
SUMMARY OF THE INVENTION
[0007] The present invention provides a technique of enabling to recognize whether a terminal of a wireless LAN is concurrently communicating with a plurality of access points.
[0008] According to one aspect of the present invention, there is provided a communication device that transmits a radio frame including a preamble and a data field of a physical layer (PHY), wherein the preamble includes an L-STF (Legacy Short Training Field), an L-LTF (Legacy Long Training Field), an L-SIG (Legacy Signal Field), an EHT-SIG-A (Extremely High Throughput Signal A Field), an EHT-STF (EHT Short Training Field), and an EHT-LTF (EHT Long Training

Field), and the EHT-SIG-A includes a subfield indicating whether data is concurrently transmitted from another communication device different from the communication device to a common partner device.
[0009] Further features of the present invention will become apparent from the following description of exemplary embodiments with reference to the attached drawings.

Description

BRIEF DESCRIPTION OF THE DRAWINGS
[0010] FIG. **1** is a view showing an example of the configuration of a network;
[0011] FIG. **2** is a block diagram showing an example of the functional configuration of an AP;
[0012] FIG. **3** is a block diagram showing an example of the hardware configuration of the AP;
[0013] FIG. **4** is a flowchart showing an example of the procedure of processing executed in the AP;
[0014] FIG. **5** is a sequence chart showing an example of the procedure of processing executed in a network;
[0015] FIG. **6** is a view showing an example of the PHY frame structure of an EHT SU PPDU;
[0016] FIG. **7** is a view showing an example of the PHY frame structure of an EHT MU PPDU; and
[0017] FIG. **8** is a view showing an example of the PHY frame structure of an EHT ER PPDU.
DESCRIPTION OF THE EMBODIMENTS
[0018] Hereinafter, embodiments will be described in detail with reference to the attached drawings. Note, the following embodiments are not intended to limit the scope of the claimed invention. Multiple features are described in the embodiments, but limitation is not made to an invention that requires all such features, and multiple such features may be combined as appropriate. Furthermore, in the attached drawings, the same reference numerals are given to the same or similar configurations, and redundant description thereof is omitted.
(Network Configuration)
[0019] FIG. **1** shows an example of the configuration of a wireless communication network according to this embodiment. This wireless communication network is configured to include access points (AP **102**, AP **103**, and AP **104**) and terminals (STA **105**, STA **106**, and STA **107**), each of which is an EHT (Extremely High Throughput) device. Each of these devices complies with IEEE802.11EHT (Extremely High Throughput), and is configured to be capable of performing wireless communication complying with standards defined before the IEEE802.11EHT standard. Note that the name “IEEE802.11EHT” is provided for convenience, and can be another name when the standard was established, but this specification and the appended claims are to cover all the standards that can support the processing to be described later. In the following description, in a case in which a specific device is not referred to or the like, the access point may be referred to as “AP” and the station may be referred to as “STA” without reference numerals. Note that in FIG. **1**, the wireless communication network including three APs and three STAs is shown as an example, but the numbers of these communication devices may be two or less or four or more. In FIG. **1**, the communicable area of the network formed by the AP **102**, the AP **103**, and the AP **104** is indicated by a circle **101**. Note that this communicable area may cover a larger area, or may cover only a smaller area. In addition, although FIG. **1** shows STAs that support EHT, an STA that supports only a standard (legacy standard) of a generation before EHT may exist. Note that it may be understood that EHT is an acronym of Extreme High Throughput.
[0020] Note that in this example, the AP **103** and the AP **104** can receive a signal transmitted from the AP **102**, and the AP **102** can receive signals transmitted from the AP **103** and the AP **104**. However, the connection form is not particularly limited, and the AP **102**, the AP **103**, and the AP

104 may be connected by a wire or wirelessly. Note that the AP **103** and the AP **104** may be able or unable to transmit/receive signals to/from each other. Note that the AP **102** to the AP **104** can form the Multi-AP Coordination configuration of the IEEE802.11EHT. That is, the AP **102** to the AP **104** support a configuration in which a plurality of APs cooperatively communicate with one STA, as defined by IEEE802.11EHT. For example, the STA **105** can concurrently transmit/receive radio frames to/from the AP **103** and the AP **104**, which cooperatively operate. The STA **105** can be configured to, for example, include a plurality of wireless LAN control units and transmit/receive radio frames to/from a plurality of APs using different radio channels. Note that the STA **105** may include one physical control unit capable of processing a plurality of frames concurrently received via a plurality of radio channels. That is, the STA **105** has a configuration capable of logically concurrently processing a plurality of wireless communications physically using one or a plurality of control devices.

[0021] Here, an AP that directly transmits/receives signals to/from each STA, like the AP **103** and the AP **104**, will be referred to as a slave access point (S-AP). Also, an AP capable of at least indirectly transmitting/receiving frames to/from each STA by issuing instructions to the AP **103** and the AP **104**, like the AP **102**, will be referred to as a master access point (M-AP). Note that the M-AP may directly transmit/receive signals to/from the STA **105**. For example, the AP **102** can operate as an M-AP or an S-AP. In this case, for example, the AP **102** may issue an instruction to the AP **103** or the AP **104** to cause it to transmit/receive a radio frame to/from an STA while performing transmission/reception of radio frames between the self-device and the STA **105**. Note that when causing an S-AP to transmit a radio frame, the M-AP can transmit transmission target data to the S-AP. However, the present invention is not limited to this, and the S-AP may directly obtain the transmission target data from, for example, the Internet. In addition, the M-AP can receive, from the S-AP, data that the S-AP has received from an STA. The S-AP may transfer the data received from the STA not to the M-AP but to the partner device of the STA.

[0022] Note that all APs in the same network can operate as M-APs, and which AP should operate as an M-AP can be decided based on a certain criterion. Note that the M-AP does not operate as an AP for beacon transmission or the like, and may execute only the role of an M-AP to, for example, send an instruction to each AP. Also, each AP may operate as a plurality of S-APs by including a plurality of wireless LAN control units. The M-AP may be implemented as a logical function, and one physical AP may operate as one or more S-APs while operating as an M-AP.

[0023] Examples of the configuration and processing of each of the AP **103** and the AP **104**, as an AP (S-AP) that directly transmits a radio frame to an STA, will be described below.

(Configuration of AP)

[0024] FIG. **2** shows the functional configuration of the AP **103**. Note that the AP **104** has the same functions. As an example, the AP **103** includes two sets of function units (a wireless LAN control unit **201** and an antenna **207**, and a wireless LAN control unit **206** and an antenna **208**) configured to perform communication of a wireless LAN. The number of wireless LAN control units provided in the AP **103** is not limited to two, and may be one or three or more. The AP **103** further includes a frame generation unit **202**, an M-AP signal analysis unit **203**, a UI control unit **204**, and a storage unit **205**.

[0025] The wireless LAN control unit **201** and the wireless LAN control unit **206** are each configured to include circuits that transmit/receive radio signals to/from another wireless LAN device (for example, another AP or STA), and programs configured to control these. The wireless LAN control unit **201** and the wireless LAN control unit **206** each execute communication control of wireless LAN such as transmission of a frame generated by the frame generation unit **202** and reception of a radio frame from another wireless LAN device in accordance with the IEEE802.11 standard series. The frame generation unit **202** generates a radio frame to be transmitted by each of the wireless LAN control unit **201** and the wireless LAN control unit **208** based on contents analyzed by the M-AP signal analysis unit **203**. Note that if the AP operates as an M-AP or does not cooperate with another AP, the frame generation unit **202** may generate a radio frame independently of the analysis by the M-AP signal analysis unit **203**. If the self-device (AP **103**) operates as an S-AP, the M-AP signal analysis unit **203** interprets the contents of a radio frame that is received from an M-AP and is to be transmitted to an STA. For example, concerning a frame to be transmitted from the AP **103** to the STA **105**, pieces of information concerning how many APs that transmit frames to the STA **105** exist in addition to the AP **103**, which channel is to be used for transmission/reception, and the like are obtained by this analysis.

[0026] The UI control unit **204** is configured to include hardware concerning user interfaces (UIs) such as a touch panel and buttons configured to accept an operation on the AP **103** by the user (not shown) of the AP **103**, and programs configured to control these. Note that the UI control unit **204** also has a function of, for example, presenting information to the user, such as display of an image or the like or audio output. The storage unit **205** is configured to include a storage device such as a ROM (Read Only Memory) or a RAM (Random Access Memory) configured to store programs to be executed by the AP **103** and various kinds of data.

[0027] FIG. **3** shows the hardware configuration of each of the AP **103**. The AP **103** includes, as an example of its hardware configuration, a storage unit **301**, a control unit **302**, a function unit **303**, an input unit **304**, an output unit **305**, a communication unit **306**, and antennas **307** and **308**. Note that the AP **104** and the STAs can have the same hardware configuration. Note that since the STA has a general wireless LAN function, a description of its functional configuration will be omitted.

[0028] The storage unit **301** is formed by both of a ROM and a RAM or one of them, and stores programs for performing various kinds of operations to be described later and various kinds of information such as communication parameters for wireless communication. Note that other than the memories such as a ROM and a RAM, a storage medium such as a flexible disk, a hard disk, an optical disk, a magnetooptical disk, a CD-ROM, a CD-R, a magnetic tape, a nonvolatile memory card, or a DVD may be used as the storage unit **301**.

[0029] The control unit **302** is formed by, for example, one or more processors such as a CPU and an MPU, an ASIC (Application Specific Integrated Circuit), a DSP (Digital Signal Processor), an FPGA (Field Programmable Gate Array), or the like. Here, CPU is an acronym of Central Processing Unit, and MPU is an acronym of Micro Processing Unit. The control unit **302** executes the programs stored in the storage unit **301**, thereby controlling the entire AP **103**. Note that the control unit **302** may control the entire AP **103** by cooperation of the programs stored in the storage unit **301** and an OS (Operating System).

[0030] In addition, the control unit **302** controls the function unit **303** to execute predetermined processing such as image capturing, printing, or projection. The function unit **303** is hardware used by the AP **103** to execute predetermined processing. For example, if the AP **103** is a camera, the function unit **303** is an image capturing unit and performs image capturing processing. For example, if the AP **103** is a printer, the function unit **303** is a printing unit and performs print processing. For example, if the AP **103** is a projector, the function unit **303** is a projection unit and performs projection processing. Data to be processed by the function unit **303** may be data stored in the storage unit **301**, or may be data communicated with another AP or STA via the communication unit **306** to be described later.

[0031] The input unit **304** accepts various kinds of operations from a user. The output unit **305** performs various kinds of outputs for the user. Here, the output by the output unit **305** includes, for example, at least one of display on a screen, audio output by a loudspeaker, vibration output, and the like. Note that both the input unit **304** and the output unit **305** may be implemented by one module, like a touch panel.

[0032] The communication unit **306** controls wireless communication complying with the IEEE802.11 standard series, or controls IP communication. The communication unit **306** is a so-called radio chip, and may itself include one or more processors and memories. In this embodiment, the communication unit **306** can execute processing complying with at least the

IEEE802.11ax standard. In addition, the communication unit **306** controls the antennas **307** and **308** to transmit and receive radio signals for wireless communication. The AP **103** communicates contents such as image data, document data, or video data with another communication device via the communication unit **306**. Each of the antennas **307** and **308** is an antenna that can transmit and receive signals in at least any one of, for example, a sub-GHz band, 2.4 GHz band, 5 GHz band, and 6 GHz band. Note that the frequency band (and a combination of frequency bands) to which the antennas **307** and **308** are adaptable is not particularly limited. Each of the antennas **307** and **308** may be one antenna, or may be configured to include two or more antennas to perform MIMO (Multi-Input and Multi-Output) transmission/reception. Note that FIG. **3** shows at least two antenna **307** and **308**, but the AP **103** may include only one antenna by using, for example, a multiband antenna that supports two or more of the plurality of frequency bands described above. Also, the AP **103** may include more antennas.

(Procedure of Processing)

[0033] Examples of the procedure of processing executed by the AP **103** and the AP **104** as described above and the procedure of processing executed by a wireless communication network will be described next. FIGS. **4** and **5** shows an example of the procedure of processing of deciding that the AP **103** should operate as an S-AP, and after information exchange with the AP **102**, transmitting data to the STA **105** in cooperation with the AP **104**.

[0034] In this processing, first, which AP should operate as an M-AP (and which AP should operate as an S-AP) is decided among the AP **102** to the AP **104** (step S**401**). For example, a parameter as an AP is transmitted from the AP **103** to the AP **102** (F**501**), and parameters are compared, thereby deciding an AP that should operate as an M-AP. Note that the AP parameter can also be transmitted from the AP **104** to the AP **102** (not shown). Note that in this processing example, it is decided that the AP **102** should operate as an M-AP, and the AP **103** and the AP **104** should operate as S-APs. After that, the AP **102** operating as the M-AP notifies the APs **103** and **104** operating as the S-APs of network information such as an SSID and a BSSID. The AP **103** and the AP **104** receive the notified network information (step S**402**, F**502**). Note that if the roles of the M-AP and the S-APs are determined in advance, the processes of steps S**401** and S**402** and F**501** and F**502** may be omitted.

[0035] The AP **103** transmits a beacon in accordance with the notified information (F**503**). Note that the beacon includes information indicating that a plurality of APs can cooperatively perform data transmission/reception to the connected STA. Note that the APs here include logical APs, and one AP can include, for example, an AP that operates in the 2.4 GHz band and an AP that operates in the 5 GHz band. That is, data transmission/reception by the plurality of APs can include data transmission/reception by one physical AP capable of operating as a plurality of logical APs. The AP **103**, for example, adds a Multi-AP Information Element into the beacon and transmits information including the information of SSIDs, BSSIDs, and operation radio channels to be used by the plurality of APs capable of cooperatively operating. The storage method and configuration of these pieces of information are not limited to these, and the AP **103** may transmit similar information stored in a similar format. Upon receiving the beacon, the STA **105** performs connection processing to at least one of the plurality of S-APs based on the information included in the beacon (step S**403**, F**504**). The connection processing here includes processing such as authentication and association defined by the IEEE802.11 standard series. In a connection state in which connection with the STA **105** is established, the AP **103** notifies the M-AP that the connection state with the STA is established, in addition to connection parameters (step S**404**, F**505**). At this time, if one physical AP serves as two logical APs, and each of these is set in the connection state with the STA, the M-AP may be notified of this. Note that in FIG. **5**, only the AP **103** is set in the connection state with the STA **105**. However, the AP **104** can also be connected to the STA **105** by transmitting the beacon and notify the M-AP (AP **102**) that the connection state is established. However, the present invention is not limited to this and, for example, the STA may be set in the connection state with only one of the plurality of S-APs. In this case, for example, a radio frame transmitted from another S-AP that is not in the connection state is handled by the STA as a radio frame from an S-AP that is in the connection state. Note that even in the connection state with only one of the plurality of S-APs, the STA may be able to recognize that the transmission source S-APs are different concerning radio frames from the S-APs. Note that in this embodiment, the preamble of the physical layer (PHY) of the radio frame is decoded, thereby enabling to recognize that signals are transmitted from the plurality of S-APs (that the Multi-AP Coordination system is formed). That is, information representing that the Multi-AP Coordination system is formed is included in the PHY preamble of a frame that the S-AP has received from the M-AP or a frame that the STA has received from the S-AP (or the M-AP). This allows the device that has received the frame to confirm whether a single or a plurality of APs transmit data to the STA. This will be described later.

[0036] The M-AP manages the connection parameters of the S-AP that is in the connection state with the STA, thereby deciding transmission parameters based on the information and performing transmission data assignment later (F**506**). The S-AP is notified of the information of the transmission parameters decided by the M-AP, and the AP **103** decides the transmission parameters of its own based on the notified information (step S**405**). The connection parameters may include the information of the transmission rate and the error rate of each connection. The M-AP can assign a large amount of transmission data to an S-AP having connection of a high transmission rate and assign a small amount of transmission data to an S-AP having connection of a low transmission rate. According to this, data transmission from the S-APs to the STA can efficiently be executed. To reflect the current connection situation, the connection parameters may be updated at a predetermined period in each S-AP and notified to the M-AP. After that, upon receiving the transmission data from the M-AP to the STA (step S**406**, F**507**), the S-AP transmits the data to the STA (step S**407**, F**508**).

[0037] Such concurrent transmission of data from the plurality of S-APs to one STA can be performed by, for example, transmitting a trigger frame configured to trigger transmission from the M-AP to the S-APs after the transmission target data is transmitted from the M-AP to the S-APs. That is, in a state in which preparation of the transmission target data is completed, the S-APs transmit the data to the STA at once based on reception of the trigger frame from the M-AP. Note that when the transmission target data is transmitted from the M-AP to the S-APs, the S-APs may be notified of information for instructing the transmission timing of the data together with the transmission target data. In this case, the plurality of S-APs transmit the transmission target data at the instructed transmission timing, thereby concurrently transmitting the data to the STA.

[0038] On the other hand, upon receiving data from the STA (step S**408**), the S-AP transmits the received data to the M-AP (step S**409**). Note that the order of data transmission and reception is an example and, for example, data may be transmitted/received in a mode other than the mode shown in FIGS. **4** and **5** such that, for example, data reception from the STA is performed before data transmission to the STA.

(Frame Structure)

[0039] Each of FIGS. **6** to **8** shows an example of a PPDU (Physical Layer (PHY) Protocol Data Unit) defined by the IEEE802.11EHT standard and transmitted in steps S**406** and S**407**, F**503**, F**507**, and F**508**. FIG. **6** shows an example of an EHT SU (Single User) PPDU that is a PPDU for single-user communication, and FIG. **7** shows an example of an EHT MU (Multi User) PPDU for multi-user communication. FIG. **8** shows an example of an EHT ER (Extended Range) PPDU for long distance transmission. The EHT ER PPDU is used when the communication area should be extended in communication between an AP and a single STA.

[0040] The PPDU includes fields including an STF (Short Training Field), an LTF (Long Training Field), and a SIG (Signal Field). As shown in FIG. **6**, the PPDU head portion includes an L (Legacy)-STF **601**, an L-LTF **602**, and an L-SIG **603** for ensuring backward compatibility with the

IEEE802.11a/b/g/n/ax standards. Note that each of frame formats shown in FIGS. **7** and **8** includes an L-STF (L-STF **701** or L-STF **801**), an L-LTF (L-LTF **702** or L-LTF **802**), and an L-SIG (L-SIG **703** or L-SIG **803**). Note that the L-LTF is arranged immediately after the L-STF, and the L-SIG is arranged immediately after the L-LTF. Note that each of the structures shown in FIGS. **6** to **8** further includes an RL-SIG (Repeated L-SIG, RL-SIG **604**, RL-SIG **704**, or RL-SIG **804**) arranged immediately after the L-SIG. In the RL-SIG field, the contents of the L-SIG are repeatedly transmitted. The RL-SIG is used to enable a receiver to recognize that this PPDU complies with a standard after the IEEE802.11ax standard, and may be omitted in IEEE802.11EHT in some cases. In addition, a field for enabling the receiver to recognize that this PPDU complies with the IEEE802.11EHT may be provided in place of the RL-SIG. Note that the respective fields of each PPDU may not necessarily be arranged in the order shown in each of FIGS. **6** to **8**, or may include a new field not shown in each of FIGS. **6** to **8**.

[0041] The L-STF **601** is used for detection of a PHY frame signal, AGC (Automatic Gain Control), timing detection, or the like. The L-LTF **602** is used for highly accurate frequency/time synchronization, obtainment of propagation channel information (CSI: Channel State Information), or the like. The L-SIG **603** is used for transmitting control information including information such as a data transmission rate and a PHY frame length. A legacy device complying with the IEEE802.11a/b/g/n/ax standards can decode the above-described various kinds of legacy fields.

[0042] Each PPDU further includes an more EHT-SIG (EHT-SIG-A **605**, EHT-SIG-A **705**, EHT-SIG-B **706**, or EHT-SIG-A **805**) arranged immediately after the RL-SIG and used for transmitting control information for EHT. Each PPDU further includes an STF for EHT (EHT-STF **606**, **707**, or **806**) and an LTF for EHT (EHT-LTF **607**, **708**, or **807**). Each PPDU includes, after these controlling fields, a data field **608**, **709**, or **808** and a Packet extension field **609**, **710**, or **809**. The portion including the fields from the L-STF to the EHT-LTF of each PPDU is referred to as a PHY preamble.

[0043] Note that each of FIGS. **6** to **8** shows the PPDU that can ensure the backward compatibility as an example. However, if it is unnecessary to ensure the backward compatibility, for example, the legacy fields may be omitted. In this case, for example, the EHT-STF and EHT-LTF are used in place of the L-STF and the L-LTF to establish synchronization. Then, in this case, the EHT-STF and one of the plurality of EHT-LTFs after the EHT-SIG field can be omitted.

[0044] The EHT-SIG-A **605** and **805** included in the EHT SU PPDU and the EHT ER PPDU include an EHT-SIG-A**1** and an EHT-SIG-A**2** necessary for reception of the PPDU, respectively, as shown in Tables 1 and 2 below. In this embodiment, a “Multi-AP” subfield representing whether data is transmitted from a plurality of APs to an STA is included in the EHT-SIG-A**1**. Also, the EHT-SIG-A **705** of the EHT MU PPDU shown in FIG. **7** includes an EHT-SIG-A**1** and an EHT-SIG-A**2** necessary for reception of the PPDU as shown in Tables 3 and 4 below. In this embodiment, the “Multi-AP” subfield representing whether data is transmitted from a plurality of APs to an STA is included in the EHT-SIG-A**2**. For example, if data is transmitted from a plurality of APs to an STA, **1** is stored in the “Multi-AP” subfield. If data is transmitted from a single AP to an STA, **0** is stored in the “Multi-AP” subfield. Note that the configurations of Tables 1 to 4 are merely examples and, for example, in the EHT SU PPDU and the EHT ER PPDU, the information of Multi-AP may be notified at a position other than the 15th bit of the EHT-SIG-A**1** field. Similarly, in the EHT MU PPDU, the information of Multi-AP may be notified at a position other than the eighth bit of the EHT-SIG-A**2** field. Also, the information of Multi-AP may designate whether data is transmitted from a plurality of physical APs to an STA, or may designate whether data is transmitted from a plurality of logical APs to an STA. For example, even if data is physically transmitted from one AP to an STA, if data is logically transmitted from a plurality of APs to an STA, **1** may be designated in Multi-AP subfield.

TABLE-US-00001 TABLE 1 Bit Position Subfield Bit Count Description EHT-SIG-A1 B0 Format 1 “1” is set for an EHT PPDU and an EHT ER PPDU to distinguish them from an EHT TB PPDU.

B1 Beam 1 “1” is set if the prc-EHT of the Change PPDU is arranged in a space different from the first symbol of the EHT-LTF, or “0” is set if the pre-EHT is mapped similarly to the first symbol. B2 UL/DL 1 This subfield indicates whether the PPDU is for UL or DL, and has the same value as TXVECTOR UPLINK_ FLAG. B3-B6 MCS 4 This subfield indicates the value of the Modulation and Coding Scheme. In a case of an EHT SU PPDU, n = 0, 1, 2, . . . , 11 (12 to 15 are reserved). In a case of an EHT ER SU PPDU and Bandwidth = 0, n = 0, 1, 2 (3 to 15 are reserved areas). In a case of an EHT ER SU PPDU and Bandwidth = 1, n = 0 for MCS 0 (1 to 15 are reserved areas). B7 DCM 1 This subfield indicates whether Dual Carrier Modulation is applied to the data field. If “0” is set in the STBC field, “1” is set. (If both the DCM and STBC fields are “1”, neither of them is applied) If DCM is not applied, “0” is set. B8-B13 BSS Color 6 6-bit number for identifying the BSS B14 Multi-AP 1 “1” is set if data transmission/reception is performed with a plurality of APs. “0” is set if data transmission/reception is performed with a single AP. B15-B18 Spatial 4 This subfield indicates whether Reuse Spatial Reuse is allowed during transmission of this PPDU. The value of Spatial Reuse field encoding shown in the separate table is set. B19-B20 Bandwidth 2 In a case of an EHT SU PPDU: “0” is set for 20 MHz, “1” is set for 40 MHz, “2” is set for 80 MHz, or “3” is set for 160 MHz (80 + 80 MHz). In a case of an EHT ER SU PPDU: “0” is set for 242-tone RU, or “1” is set for upper 106-tone RU of 20 MHz. B21-B22 GI + LTF 2 This subfield indicates the Guard Size Interval period and the EHT-LTF size. “0” is set for 1 × EHT-LTF and 0.8 μs GI, “1” is set for 2 × EHT-LTF and 0.8 μs GI, “2” is set for 2 × EHT-LTF and 1.6 μs GI, “3” is set if both the DCM and STBC fields are “1” and for 4 × EHT-LIF and 0.8 μs GI, or “3” is set for 4 × EHT-LTF other than the above case and 3.2 μs GI. B23-B25 NSTS And 2 This subfield indicates the number Midamble, of space-time streams and the Periodicity midamble period for frame synchronization. If the Doppler field is “0”, “(the number of space-time streams) − 1” is set. If the Doppler field is “1”, B23 and B24 indicate the number of space-time streams. B25 is “0” if the midamble period is 10, or “1” if the midamble period is 20.

TABLE-US-00002 TABLE 2 Bit Bit Position Sub-field Count Description EHT- B0-B6 TXOP 1 Transmission Opportunity SIG-A2 if TXOP_DURATION of TXVECTOR is UNSPECIFIED and there is no period information, 127 is set. If TXOP_DURATION of TXVECTOR is smaller than 512, a value smaller than 127 is set to set NAV. At this time, if B0 is “0”, FLOOR of TXOP_DURATION/8 (round down) is set in B1 to B6. If B0 is “1”, FLOOR of (TXOP_DURATION − 512)/8 is set in B1 to B6. B7 Coding 1 “0” is set for BCC (Binary Convolutional Code), or “1” is set for LDPC (Low Density Parity Check). B8 LDPC Extra 1 This subfield indicates the presence/absence of Symbol an extra OFDM symbol segment Segment for LDPC. B9 STBC 1 “1” is set in this field if STBC (Space-Time Block Coding) is used and the DCM subfield is “0”, “1” is also set if neither DCM nor STBC is applied, or “0” is set otherwise. B10 Beamformed 1 “1” is set if beamforming steering is applied to the waveform of SU transmission. B11-B12 Pre-FEC 2 “0” is set if the Pre-FEC Padding Factor is 4 Padding “1” is set if the Pre-FEC Padding Factor is 1, Factor “2” is set if the Pre-FEC Padding Factor is 2, or “3” is set if the Pre-FEC Padding Factor is 3. B13 PE 1 Disambiguity field of Packet Extension Disainbiguity B14 Reserved 1 Reserved field B15 Doppler 1 “1” is set if either of the following conditions is met: the number of OFDM symbols in the data field is larger than “the value indicated by the midamble period + 1”, and a midamble exists, and the number of OFDM symbols in the data field is equal to or smaller than “the value indicated by the midamble period + 1”, no midamble exists, and the channel changes rapidly. B16-B19 CRC 4 The CRC of the EHT-SIG-A (26 bits of A1 and 16 bits up to B15 of A2, that is, 42 bits in total) field up to here. B20-B25 Tail 6 An area to set “0” to indicate the end portion to a trellis convolution decoder.

TABLE-US-00003 TABLE 3 Bit Position Subfield Bit Count Description EHT-SIG-Al B0 UL/DL 1 This subfield indicates whether the PPDU is for UL or DL, and has the same value as TXVECTOR UPLINK FLAG. B1-B3 SIGB MCS 3 This subfield indicates the MCS of the EHT-SIG-B field. “0” is set for MCS 0, “1” is set for MCS 1, “2” is set for MCS 2, “3” is set for MCS 3, “4” is set for MCS 4, or “5” is set for MCS 5. “6” and “7” are reserved areas. B4 SIGB DCM 1 “1” is set if the HT-SIG-B field is modulated using DCM. B5-B10 BSS Color 6 6-bit number for identifying the BSS B11-B14 Spatial 4 This subfield indicates whether Reuse Spatial Reuse is allowed during transmission of this PPDU. The value of Spatial Reuse field encoding shown in the separate table is set. B15-B17 Bandwidth 3 “0” is set for 20 MHz “1” is set for 40 MHz; or “3” is set for 160 MHz (80 + 80 MHz). When the SIGB Compression field is “0” , “4” is set if only the secondary 20 MHz is puncturing in 80 MHz preamble puncturing. “5” is set if two 20 MHz of the secondary 40 MHz are puncturing in 80 MHz preamble puncturing “6” is set if only the secondary 20 MHz is puncturing in 160 (or 80 + 80) MHz preamble puncturing, or “7” is set if only the secondary 40 MHz is puncturing in 160 (or 80 + 80) MHz is preamble puncturing If the SIGB field is “1” the value between “4” to “7” means “reserved” B18-B21 Number of 4 When the SIGB Compression field is EHT-SIG-B “0” , this subfield indicates the number Symbols or of OFDMA symbols in the EHT-SIG-B. MU-MIMO If the number of OFDM symbols in Users the EHT-SIG-B is smaller than 16, the number obtained by subtracting 1 from the number of OFDM symbols in the EHT-SIG-B is set. If at least one receiving terminal has set the capability of supporting the number of EHT SIG-B OFDM symbols larger than 16 to “0”,“15” is set to indicate that the number of OFDM symbols in the EHT-SIG-B is 16. If all the receiving terminals have set the capability of supporting the number of EHT-SIG-B OFDM symobls larger than 16 to “0” and the data rate of the EHT-SIG-B is smaller than MCS 4 which does not use DCM,“15” is set to indicate that the number of OFDM symbols in the EHT-SIG-B is equal to or larger than 16. When the SIGB Compresson field is “1”, the value set here means the number obtained by subtracting 1 from the number of MU-MIMO users. B23-B24 GI + LTF 2 This subfield indicates the Guard Size Interval period and the EHT-LTF size. “0” is set for 4 × EHT-LTF and 0.8 μs GI, “1” is set for 2 × EHT-LTF and 0.8 μs. GI, “2” is set for 2 × EHT-LTF and 1.6 μs GI, or “3” is for 4 × EHT-LTF and 3.2 μs GI. B25 Doppler 1 “1” is set if either of the following conditions is met: the number of OFDM symbols in the data field is larger than “the value indicated by the midamble period +1” and a midamble exists, and the number of OFDM symbols in the data field is equal to or smaller than “the value indicated by the midamble period + 1”, no midamble exists, and the channel changes. rapidly.
TABLE-US-00004 TABLE 4 Bit Position Subfield Bit Count Description EHT-SIG-A2 B0-B6 TXOP 1 Transmission Opportunity If TXOP_DURATION of TXVECTOR is UNSPECIFIED and there is no period information, 127 is set. If TXOP_DURATION of TXVECTOR is smaller than 512, a value smaller than 127 is set to set NAV. At this time, if B0 is “0”, FLOOR of TXOP_DURATION/8 (round down) is set in B1 to B6. If B0 is “1”, FLOOR of (TXOP_Duration - 512)/8 is set in B1 to B6. B7 Multi-AP 1 “1” is set if data transmission/reception is performed with a plurality of APs. “0” is set of data transmission/reception is performed with a single AP. B8-B10 Number of 3 This subfield indicates the number of EHT- EHT-LTF LTFs. Symbols And “0” is set for one EHT-LTF, “1” is set for two Midamble EHT-LTFs, “2” is set for four EHT-LTFs, “3” Periodicity is set for six EHT-LTFs, or “4” is set for eight EHT-LTFs. When the Doppler field is “1”, B8 and B9 indicate the number of EHT-LTF symbols, and B10 indicates the midamble period. B11 LDPC Extra 1 This subfield indicates the presence/absence of Symbol an extra OFDM symbol segment Segment for LDPC B12 STBC 1 When the number of users of each RU (Resource Unit) is not larger than 1, “1” is set to indicate that STBC is used for encoding. B13-B14 Pre-FEC 2 “0” is set if the Pre-FEC Padding Factor is 4, Padding “1” is set if the Pre-FEC Padding Factor is 1, Factor “2” is set if the Pre-FEC Padding Factor is 2, or “3” is set

if the Pre-FEC Padding Factor is 3. B15 PE 1 Disambiguity field of Packet Extension Disambiguity B16-B19 CRC 4 The CRC of the EHT-SIG-A (26 bits of A1 and 16 bits up to B15 of A2, that is, 42 bits in total) field up to here. B20-B25 Tail 6 An area to set "0" to indicate the end portion to a trellis convolution decoder.

[0045] Note that the EHT-SIG-B **706** of the EHT MU PPDU includes the information of Common field as shown in Table 5 and the information of User Block field as shown in Table 6, which are necessary for reception of the PPDU.

TABLE-US-00005 TABLE 5 Subfield Bit Count Description Common field RU N × 8 This subfield indicates RU allocation Allocation used in the data portion of a frequency axis When N = 1, EHT MU PPDUs of 20 MHz and 40 MHz are allocated. When N = 2, an EHT MU PPDU of 80 MHz is allocated. When N = 4, and EHT MU PPDU of 160 MHz or 80 + 80 MHz is allocated. Center 26- 1 This subfield is used only when the Bandwidth tone RU field of EHT-SIG-A field of an EHT MU PPDU is larger than 1 (if the frequency is equal to or highter than 80 MHz). This subfield indicates whether to use a 26-tone RU at the center. CRC 4 CRC calculation value Tail 4 Trailer bit, which is set to 0.

TABLE-US-00006 TABLE 6 Subfield Bit Count Description User Block User field N × 21 This subfield indicates field information for each user. CRC 4 CRC calculation value Tail 6 Trailer bit, which is set to 0.

[0046] As shown in Table 6, in the User Block field, User field is included, and information for each user is stored. The format of User field changes depending on whether data is transmitted to a plurality of users by OFDMA or data is transmitted by MU-MIMO. Table 7 shows User field when data is transmitted by OFDMA, and Table 8 shows User field when data is transmitted by MU-MIMO.

TABLE-US-00007 TABLE 7 Bit Bit Position Subfield Count Description User field B0-B10 STA-ID 11 This subfield indicates the ID of an STA or an STA group that is the receiver of the RU of an HE MU PPDU B11-B13 NSTS 3 This subfield indicates the number of Space-time streams. B14 Tx 1 When transmission Beam- Beamforming is used, "1" is forming set. When transmission Beamforming is not used, "0" is set. B15-B18 MCS 4 This subfield indicates the value of Modulation and Coding Scheme B19 DCM 1 This subfield indicates whether Dual Carrier Modulation is applied to the data field. B20 Coding 1 When BCC (Binary Convolutional Code) is used, "0" is set. When LDPC (Low Density Parity Check) is used "1" is set.

TABLE-US-00008 TABLE 8 Bit Bit Position Subfield Count Description User field B0-B10 STA-ID 11 This subfield indicates the ID of an STA or an STA group that is the receiver of the RU of an HE MU PPDU B11-B14 Spatial 4 This subfield indicates the Configuration number of Spatial Streams of an STA in MU-MIMO Allocation B15-B18 MCS 4 This subfield indicates the value of Modulation and Coding Scheme B19 Reserved 1 Reserved area B20 Coding 1 When BCC (Binary Convolutional Code) is used, "0" is set. When LDPC (Low Density Parity Check) is used, "1" is set.

[0047] Note that the contents of these subfields are the same as the contents defined by the IEEE802.11ax standard, and a description thereof will be omitted here.

[0048] As described above, in the frame structures of the PPDUs (the EHT SU PPDU, the EHT ER PPDU, and the EHT MU PPDU) used in the IEEE802.11EHT standard, it is possible to notify the STA whether a single or a plurality of APs transmit data. That is, the S-AP can notify the STA whether an AP that concurrently transmits data to the common partner device (STA) exists in addition to the self-device. In addition, by transmitting this frame, the M-AP can notify the S-AP whether another S-AP that concurrently transmits data to the common partner device (STA) exists (or whether the M-AP concurrently transmits data). At this time, for example, if the STA executes connection processing to only one AP, the STA can recognize, by a radio channel different from the AP for which the connection processing has been executed, that is, by a radio channel different from the radio channel on which the self-device is operating, that another AP that the STA should communicate with exists. Note that the radio channel here can include, for example, a frequency channel or a space channel. For example, upon confirming the PHY preamble and confirming that data from a plurality of APs are received, the STA can operate to specify the plurality of APs that are the data transmission sources. The STA can confirm, for example, a transmitter address in a MAC (Medium Access Control) header for each of the plurality of data streams, thereby obtaining the information of the plurality of APs. Also, for example, if the pieces of information of the plurality of APs are confirmed, the STA can individually transmit an acknowledgement (ACK/NACK) to each AP. Also, if the radio quality of data from some APs has degraded, the STA can notify any one of the APs (for example, the M-AP) that the APs should be excluded from the target of Multi-AP Coordination. This makes it possible to maintain communication at high radio quality in the STA. Additionally, in the STA or AP, the user may be notified, via a UI, of information representing whether data are transmitted from a plurality of APs to the STA. Also, if the self-device does not support the Multi-AP Coordination, and a PPDU representing that data are transmitted from a plurality of APs is received, the STA can immediately discard the PPDU. According to this, in the STA, for a PPDU to which the self-device is not adaptable, information after the Multi-AP subfield is not unnecessarily decoded. Hence, power consumption can be suppressed. Note that the present invention can be implemented not only by the APs **102** to **104** and the STAs **105** to **107**, which are communication devices, but also by an information processing device (for example, a radio chip) configured to generate the above-described PHY preamble.

[0049] Note that in the above-described example, the Multi-AP subfield is prepared as a 1-bit field to represent whether data are transmitted from a plurality of APs to the STA. However, the present invention is not limited to this. For example, the Multi-AP subfield may be prepared as a field of two or more bits to show the number of APs that transmit data to the STA. For example, if a 2-bit field is prepared, it can show by “00” that data is transmitted from one AP, by “01” that data are transmitted from two APs, by “10” that data are transmitted from three APs, and by “11” that data are transmitted from four or more APs. Similarly, when a field of three or more bits is prepared, it can represent a larger number of APs.

[0050] According to the present invention, it is possible to recognize whether a terminal of a wireless LAN is concurrently communicating with a plurality of access points.

OTHER EMBODIMENTS

[0051] Embodiment(s) of the present invention can also be realized by a computer of a system or apparatus that reads out and executes computer executable instructions (e.g., one or more programs) recorded on a storage medium (which may also be referred to more fully as a ‘non-transitory computer-readable storage medium’) to perform the functions of one or more of the above-described embodiment(s) and/or that includes one or more circuits (e.g., application specific integrated circuit (ASIC)) for performing the functions of one or more of the above-described embodiment(s), and by a method performed by the computer of the system or apparatus by, for example, reading out and executing the computer executable instructions from the storage medium to perform the functions of one or more of the above-described embodiment(s) and/or controlling the one or more circuits to perform the functions of one or more of the above-described embodiment(s). The computer may comprise one or more processors (e.g., central processing unit (CPU), micro processing unit (MPU)) and may include a network of separate computers or separate processors to read out and execute the computer executable instructions. The computer executable instructions may be provided to the computer, for example, from a network or the storage medium. The storage medium may include, for example, one or more of a hard disk, a random-access memory (RAM), a read only memory (ROM), a storage of distributed computing systems, an optical disk (such as a compact disc (CD), digital versatile disc (DVD), or Blu-ray Disc (BD)™), a flash memory device, a memory card, and the like.

[0052] While the present invention has been described with reference to exemplary embodiments, it is to be understood that the invention is not limited to the disclosed exemplary embodiments. The scope of the following claims is to be accorded the broadest interpretation so as to encompass all such modifications and equivalent structures and functions.

Claims

1.-**14**. (canceled)
15. A communication apparatus comprising: one or more memories that store a set of instructions; and at least one processing circuit, wherein the communication apparatus is caused, by the at least one processing circuit executing the instructions and/or the at least one processing circuit itself operating, to perform operations comprising: communicating a radio frame including a preamble and a data field of a physical layer, wherein the preamble includes: a Legacy Short Training field (L-STF), a Legacy Long Training field (L-LTF) following the L-STF, a Legacy Signal field (L-SIG) following the L-SIG and a second Signal field (second SIG), wherein the second SIG includes a field indicating whether a multi Access Point (AP) coordination is performed, wherein the second SIG consists of a first part and a second part following the first part, and wherein the second part of the second SIG includes the field indicating whether the multi AP coordination is performed.
16. The communication apparatus according to claim 15, wherein the first part of the second SIG includes a Bandwidth field, a UL/DL field, and a BSS color field, and wherein the second part of the second SIG further includes a CRC field and a Tail field.
17. The communication apparatus according to claim 15, wherein the preamble further includes a third Signal field (third SIG) following the second SIG, and wherein the third SIG includes a common field and a field including information of each user.
18. The communication apparatus according to claim 15, wherein the preamble further includes a Repeated Legacy Signal field (RL-SIG) following the L-SIG, and wherein the second SIG follows to the RL-SIG.
19. The communication apparatus according to claim 15, wherein the communication apparatus operates as an access point and the communication apparatus transmits the radio frame to another access point.
20. The communication apparatus according to claim 15, wherein the communication apparatus operates as an access point and the communication apparatus transmits the radio frame to a station apparatus.
21. The communication apparatus according to claim 15, wherein the communication apparatus operates as a non-AP station and the communication apparatus receives the radio frame.
22. The communication apparatus according to claim 15, wherein the communication apparatus is a radio chip.
23. The communication apparatus according to claim 15, wherein the communication apparatus is one of a camera, a printer and a projector.
24. The communication apparatus according to claim 15, wherein the communication apparatus is an apparatus according to IEEE802.11 series standard.
25. A communication method comprising: generating a radio frame including a preamble and a data field of a physical layer; and transmitting the radio frame, wherein the preamble includes: a Legacy Short Training field (L-STF), a Legacy Long Training field (L-LTF) following the L-STF, a Legacy Signal field (L-SIG) following the L-SIG and a second Signal field (second SIG), wherein the second SIG includes a field indicating whether a multi Access Point (AP) coordination is performed, wherein the second SIG consists of a first part and a second part following the first part, and wherein the second part of the second SIG includes the field indicating whether the multi AP coordination is performed.
26. The communication method according to claim 25, wherein the first part of the second SIG includes a Bandwidth field, a UL/DL field, and a BSS color field, and wherein the second part of the second SIG further includes a CRC field and a Tail field.

27. The communication method according to claim 25, wherein the preamble further includes a third Signal field (third SIG) following the second SIG, and wherein the third SIG includes a common field and a field including information of each user.
28. The communication method according to claim 25, wherein the preamble further includes a Repeated Legacy Signal field (RL-SIG) following the L-SIG, and wherein the second SIG follows to the RL-SIG.
29. The communication method according to claim 25, wherein the communication apparatus is an apparatus according to IEEE802.11 series standard.
30. A communication method comprising: receiving a radio frame including a preamble and a data field of a physical layer; and decoding the received radio frame, wherein the preamble includes: a Legacy Short Training field (L-STF), a Legacy Long Training field (L-LTF) following the L-STF, a Legacy Signal field (L-SIG) following the L-SIG and a second Signal field (second SIG), wherein the second SIG includes a field indicating whether a multi Access Point (AP) coordination is performed, wherein the second SIG consists of a first part and a second part following the first part, and wherein the second part of the second SIG includes the field indicating whether the multi AP coordination is performed.
31. The communication method according to claim 30, wherein the first part of the second SIG includes a Bandwidth field, a UL/DL field, and a BSS color field, and wherein the second part of the second SIG further includes a CRC field and a Tail field.
32. The communication method according to claim 30, wherein the preamble further includes a third Signal field (third SIG) following the second SIG, and wherein the third SIG includes a common field and a field including information of each user.
33. The communication method according to claim 30, wherein the preamble further includes a Repeated Legacy Signal field (RL-SIG) following the L-SIG, and wherein the second SIG follows to the RL-SIG.
34. The communication method according to claim 30, wherein the communication apparatus is an apparatus according to IEEE802.11 series standard.
35. A non-transitory computer readable storage medium that stores a program that causes a communication apparatus to perform: generating a radio frame including a preamble and a data field of a physical layer; and transmitting the radio frame, wherein the preamble includes: a Legacy Short Training field (L-STF), a Legacy Long Training field (L-LTF) following the L-STF, a Legacy Signal field (L-SIG) following the L-SIG and a second Signal field (second SIG), wherein the second SIG includes a field indicating whether a multi Access Point (AP) coordination is performed, wherein the second SIG consists of a first part and a second part following the first part, and wherein the second part of the second SIG includes the field indicating whether the multi AP coordination is performed.
36. A non-transitory computer readable storage medium that stores a program that causes a communication apparatus to perform: receiving a radio frame including a preamble and a data field of a physical layer; and decoding the received radio frame, wherein the preamble includes: a Legacy Short Training field (L-STF), a Legacy Long Training field (L-LTF) following the L-STF, a Legacy Signal field (L-SIG) following the L-SIG and a second Signal field (second SIG), wherein the second SIG includes a field indicating whether a multi Access Point (AP) coordination is performed, wherein the second SIG consists of a first part and a second part following the first part, and wherein the second part of the second SIG includes the field indicating whether the multi AP coordination is performed.