DESCRIPTION

Title of Invention: COMMUNICATION APPARATUS, CONTROL METHOD, AND PROGRAM

Technical Field

[0001]

The present disclosure relates to a communication apparatus that performs data communication.

Background Art

[0002]

In recent years, the increase in the amount of data to be transmitted via communication has prompted the development of communication technologies such as wireless LAN (Local Area Network). The IEEE (Institute of Electrical and Electronics Engineers) 802.11 standard series is known as major wireless LAN communication standards. The IEEE 802.11 standard series includes standards such as IEEE 802.11a/b/g/n/ac/ax.

[0003]

Techniques have also been studied that utilize a sleep mode operation, an intermittent operation, or the like to reduce the power consumption of a communication apparatus. For example, PTL 1 illustrates a procedure for achieving power saving by causing an AP (Access Point) and an STA (Station) to arrange the wake-up time of the devices thereof in advance and performing communication at the wake-up time

while suppressing power consumption during other times.

[0004]

The IEEE 802.11be standard, which is a successor standard to IEEE 802.11ax, is being developed. Specifications for the IEEE 802.11bn standard, which is a successor standard to the IEEE 802.11be standard, are also being studied by the UHR (Ultra High Reliability) task group.

Citation List

Patent Literature

[0005]

PTL 1: PCT Japanese Translation Patent Publication No. 2016-511600

Summary of Invention

Technical Problem

[0006]

In the 802.11be standard, attempts have been made to improve a communication rate compared with previous standards. Attempts have also been made to provide a Multi-Link Operation function that uses a plurality of communication links for high-speed transmission or redundant transmission of data. A communication apparatus using a new function such as the Multi-Link Operation function may receive data on a plurality of Links, with a plurality of spatial streams, a wide bandwidth, and a high MCS

(Modulation and Coding Scheme). Accordingly, in general, a signal reception circuit and an antenna need to be controlled such that signals of any pattern can be received even in an idle state to wait for reception. The new functions that constitute the main features of these standards are certainly useful from an aspect such as higher-speed and higher-reliability communication, and contribute to improvement of user experience. However, there is a problem in that power required for appropriately operating a communication apparatus increases not only during communication but also in a communication standby state. Thus, in recent communication apparatuses, even standby power consumption while such an apparatus is on standby for communication, such as for reception, has reached a non-negligible level.

[0007]

The present disclosure has been made in view of at least one of the problems described above. According to one aspect of the present disclosure, an object is to provide a specific mechanism for more actively reducing power consumption during standby. Specifically, a new function is provided for actively reducing power consumption during standby by selectively using a normal operation mode and an operation mode with a plurality of communication conditions customized for power saving, such as a small number of

Links, a small number of streams, and a low MCS. The new function is hereinafter also referred to as a Low Power Listen function for convenience of explanation. According to another aspect of the present disclosure, an object is to provide a mechanism that enables advance indication of whether the Low Power Listen function, which is the new function, is supported, thereby allowing for appropriate operation of the function.

Solution to Problem

[0008]

A communication apparatus according to one aspect of the present disclosure is a communication apparatus that performs wireless communication compliant with an IEEE 802.11 standard series. The communication apparatus includes transmission control means for controlling transmission of a frame to another communication apparatus, the frame including an information element in which information indicating whether a second Listen mode is supported is stored, the second Listen mode being a Listen mode for suppressing power consumption in a case where a Listen operation that is an operation of waiting for communication is performed, as compared with power consumption in a case where the Listen operation is performed in a first Listen mode, the second Listen mode enabling the Listen operation to be performed under a

condition expected to consume less power than in the first Listen mode with respect to at least one of the number of communication links, a bandwidth, the number of spatial streams, and Modulation and Coding Scheme (MCS).

Advantageous Effects of Invention

[0009]

According to an aspect of the present disclosure, it is possible to provide a mechanism for more actively reducing power consumption during standby. According to another aspect of the present disclosure, advance indication of whether the above-described mechanism is supported allows for appropriate operation of the function.

Brief Description of Drawings

[0010]

[Fig. 1] Fig. 1 is a diagram illustrating an example of a configuration of a communication system.

[Fig. 2] Fig. 2 is a diagram illustrating an example of a hardware configuration of a communication apparatus (AP/STA).

[Fig. 3] Fig. 3 is a diagram illustrating an example of a functional configuration of the communication apparatus (AP/STA).

[Fig. 4] Fig. 4 is a sequence diagram illustrating a procedure of an LPL (Low Power Listen) function.

[Fig. 5A] Fig. 5A illustrates an example of an

information element for providing a notification of whether LPL is supported.

[Fig. 5B] Fig. 5B illustrates an example of an information element for providing a notification of whether LPL is supported.

[Fig. 6] Fig. 6 illustrates an example of an information element for providing a notification of LPL operation information.

[Fig. 7] Fig. 7 illustrates an example of a frame used for providing a notification of operation information via an action frame.

[Fig. 8] Fig. 8 illustrates an example of an ICF.

[Fig. 9] Fig. 9 illustrates an example of a response to the ICF.

[Fig. 10] Fig. 10 is a flowchart illustrating an example of control performed by an STA.

[Fig. 11] Fig. 11 is a flowchart illustrating an example of control performed by an AP.

[Fig. 12] Fig. 12 is a flowchart illustrating an example of control performed by the STA.

[Fig. 13] Fig. 13 is a transition diagram of operation modes and operation states for describing the LPL function.

Description of Embodiments

[0011]

An embodiment will be described in detail hereinafter

with reference to the accompanying drawings. The following embodiment does not limit the claimed invention. Although the embodiment describes multiple features, not all of these multiple features are necessarily essential to the invention, and the multiple features may be combined in any desired manner. Furthermore, in the accompanying drawings, the same or similar components are denoted by the same reference numerals, and redundant description thereof is omitted.

[0012]

Fig. 1 illustrates an example configuration of a communication system according to the present embodiment. The communication system according to the present embodiment is configured to include one access point apparatus (hereinafter also simply referred to as an AP, an AP STA, or an access point), and one station apparatus (hereinafter simply referred to as an STA, a Non-AP STA, or a station).

[0013]

An AP 101 and an STA 102 are configured to be capable of performing communication of wireless frames compliant with the IEEE 802.11bn standard, which is a successor standard to the IEEE 802.11be standard aiming at a maximum transmission rate of 46.08 Gbps.

[0014]

IEEE stands for Institute of Electrical and Electronics

Engineers. IEEE 802.11bn, which is a successor standard to IEEE 802.11be, mainly features high-reliability communication, low-latency communication, and throughput improvement during congestion. Furthermore, one of the goals of IEEE 802.11bn is to reduce power consumption in APs. A wireless frame transmitted via communication under the successor standard is also referred to as a UHR (Ultra High Reliability) PPDU. PPDU is an abbreviation for Physical Layer Protocol Data Unit.

[0015]

The name "UHR" is provided for convenience in view of goals to be achieved by the successor standard and key features of the standard, and may be replaced with another name upon completion of the standardization. The name "IEEE 802.11bn" may also be replaced with another name upon completion of the standardization. However, it should be noted that the present specification and the appended claims are essentially applicable to any successor standard to the 802.11be standard. The AP 101 and the STA 102 can also transmit wireless frames compliant with legacy standards, which are standards preceding the IEEE 802.11bn standard. Examples of the legacy standards include the IEEE 802.11a/b/g/n/ac/ax/be standards.

[0016]

The AP 101 and the STA 102 exchange wireless signals

and perform communication in frequency bands such as the 2.4 GHz band, the 3.6 GHz band, the 5 GHz band, the 6 GHz band, and millimeter-wave bands such as the 45 GHz band and the 60 GHz band. The frequency bands used by the AP 101 and the STA 102 are not limited to these frequency bands, and may be, for example, a Sub1GHz band or the like. The AP 101 and the STA 102 may perform communication using bandwidths of 20 MHz, 40 MHz, 80 MHz, 160 MHz, 320 MHz, 540 MHz, 640 MHz, 1080 MHz, and 2160 MHz. The bandwidths used by a communication apparatus are not limited to these bandwidths, and may be, for example, 240 MHz, 4 MHz, and the like. In the IEEE 802.11 series standards, frequency channels using a bandwidth of 20 MHz are defined as basic channels in frequency bands such as the 2.4 GHz band, the 5 GHz band, and the 6 GHz band. In the standards, a plurality of available channels are defined in each of the 2.4 GHz band, the 5 GHz band, and the 6 GHz band. In the standards, furthermore, a certain channel can be used in combination with another channel adjacent thereto. In the present embodiment, using a certain channel in combination with another channel adjacent thereto is referred to as channel bonding. A bundle of channels formed by one channel or two or more mutually adjacent channels is referred to as a communication link (link). That is, one link formed by combining two channels each having a bandwidth of 20 MHz

uses a bandwidth of 40 MHz. The AP 101 is an access point that supports a multi-band function of providing networks on a plurality of different frequency channels. In the present embodiment, a case is illustrated in which the AP 101 is, as an example, a dual-band access point that provides a network in the 2.4 GHz band and a network in the 5 GHz band.

[0017]

The STA 102 establishes one or more links between the STA 102 and the AP 101 to perform data communication with the AP 101 or another communication apparatus. For example, to establish a link with the AP 101, the STA 102 performs a connection procedure with the AP 101. Upon completion of the connection procedure between the STA 102 and the AP 101, a link is established therebetween. The establishment of a link allows the communication apparatus to access a wireless medium and perform data communication or the like with a partner communication apparatus.

[0018]

Furthermore, the AP 101 and the STA 102 according to the present embodiment can establish a plurality of links therebetween and perform Multi-Link communication via the plurality of links. A communication link is hereinafter also simply referred to as a link. The AP 101 that performs Multi-Link communication is also referred to as an AP MLD (AP Multi-Link Device) 101, and the STA 102 that performs

Multi-Link communication is also referred to as a non-AP MLD 102. For example, the AP 101 can establish a link with the STA 102 in a network in the 2.4 GHz band and perform communication. In parallel therewith, the AP 101 and the STA 102 can also establish a second link in, for example, the 5 GHz band and perform communication. In this case, the STA 102 performs Multi-Link communication in which communication is carried out using the two links. The STA 102 can perform an STR (Simultaneous transmit and receive) operation that enables simultaneous execution of reception on link 1 and transmission on link 2 between the STA 102 and the AP 101. That is, the STA 102 can perform STR communication. The STA 102 can also perform an NSTR operation constrained such that all links are simultaneously used for either transmission to or reception from the AP 101. NSTR is an abbreviation for Nonsimultaneous transmit and receive. The NSTR operation is used in a case where the frequency distance between links is short and mutual interference occurs.

[0019]

For example, in a case where link 1 using a bandwidth of 160 MHz and link 2 using a bandwidth of 80 MHz are established between apparatuses, the communication apparatus performs communication using channels constituting the links. The link using a bandwidth of 160 MHz is configured

by bundling eight channels each having a bandwidth of 20 MHz. The link using a bandwidth of 80 MHz is configured by bundling four channels each having a bandwidth of 20 MHz.
[0020]

Further, the AP 101 and the STA 102 can perform communication using a plurality of spatial streams for more efficient communication with other communication apparatuses. That is, SU-MIMO (Single User Multiple Input Multiple Output) communication with 2 SS and 4 SS can be performed. Further, MU-MIMO (Multi User Multiple Input Multiple Output) communication with 2 SS to 16 SS can be performed. In SU-MIMO communication and MU-MIMO communication, the actual communication rate can be increased in proportion to the number of streams. A plurality of spatial streams can be used for higher reliability. Furthermore, also for modulation, communication can be performed using BPSK, QPSK, 16QAM, 64QAM, 256QAM, 1024QAM, 4096QAM, or the like to provide a notification of information with higher density. The MCS (Modulation and Coding Scheme) is an index indicating a combination of a modulation method and a coding scheme such as a coding rate, and the communication apparatus can select any MCS from MCS 0 to MCS 15 and perform communication.
[0021]

As described above, a communication apparatus, such as

the STA 102, uses the above-described MLO function to perform communication via a plurality of Links or receive data with the above-described plurality of spatial streams, wide bandwidth, and high MCS. Accordingly, in general, a signal reception circuit and an antenna need to be controlled such that signals of any pattern can be received even in an idle state to wait for reception. Use of these functions is certainly useful from an aspect such as higher-speed and higher-reliability communication, and contributes to improvement of user experience. However, there is also a problem in that power required for appropriately operating a communication apparatus increases not only during communication but also in an idle state to wait for start of communication. Thus, in recent communication apparatuses, even standby power consumption while such an apparatus is on standby for reception has reached a non-negligible level.
[0022]

Accordingly, the present embodiment provides a specific mechanism for more actively reducing power consumption during standby. Specifically, a new LPL function is provided to perform communication using communication parameters defining a plurality of communication conditions customized for power saving, such as support for only a small number of Links, a small number of streams, and a low MCS. LPL is an abbreviation for Low Power Listen. In the

LPL function, an LPL Enabled Mode and an Active Mode, which is a normal operation mode, are selectively used to actively reduce power consumption during standby. The new function is hereinafter also referred to as a Low Power Listen function for convenience of explanation. A mechanism is also provided that enables advance indication of whether the Low Power Listen function is supported, thereby allowing for appropriate operation of the function.

[0023]

First, the concept of the LPL function will be described with reference to Fig. 13. Fig. 13 is a transition diagram of operation modes of a communication apparatus for describing the LPL function. Communication apparatuses, such as the AP 101 and the STA 102, support an Active Mode corresponding to normal operation, and an LPL Enabled Mode in which the LPL function for actively reducing power consumption during standby is enabled. Communication apparatuses, such as the AP 101 and the STA 102, operate in any one of a plurality of operation modes including at least the above two operation modes. In the present embodiment, the Active Mode is also referred to as an LPL Disabled Mode or an LPL Disabled State. The Active Mode can also be considered a normal mode that enables communication under normal communication conditions agreed upon between the AP and the STA. A communication apparatus operating in the

Active Mode, such as the STA 102, can perform, with the AP 101, Multi-Link communication, communication using a large number of streams, communication using a wide bandwidth such as 80 MHz, 160 MHz, or 320 MHz, and communication using a high MCS. Prior to switching the operation mode, the communication apparatus, such as the STA 102, notifies a partner apparatus, such as the AP 101, of the mode switching. The notification can be performed using an Action frame.

[0024]

After transitioning to the LPL Enabled Mode, the communication apparatus, such as the STA 102, operates in either an NPCS state or an LPCS state. NPCS is an abbreviation for Normal Power Communication State, and LPCS is an abbreviation for Low Power Listen Communication State.

[0025]

The communication apparatus operating in the NPCS operation state, such as the STA 102, can perform high-speed communication and/or high-reliability communication under normal communication conditions agreed upon between the AP 101 and the STA 102, as in the Active Mode. The STA 102 transitions the operation state thereof to the LPCS in response to a predetermined time having elapsed after external data communication ends, or in response to the communication of a frame indicating an intention to end the

communication, such as a CF-End frame indicating an end of a transmission opportunity. The LPCS is an operation state in which reduction of power consumption can be expected. In a case of transitioning the operation state to the LPCS, the communication apparatus, such as the STA 102, switches its operation settings to communication conditions customized to reduce power consumption related to waiting for communication, such as a single link, a single spatial stream, a bandwidth of 20 MHz, and a low MCS. In the present embodiment, a state in which bidirectional communication is ongoing/possible in the LPCS is also referred to as a Low Power Awake state, based on the feature that a state in which bidirectional communication is possible can be maintained with low power consumption. In other words, the Low Power Awake state can also be considered a state that allows for operation with lower power consumption than a state in which bidirectional communication is ongoing/possible in the Active Mode or the NPCS operation state. In the present embodiment, furthermore, communication conditions constrained for operation in the LPCS are also referred to as Low-Capability conditions. Normal communication conditions for operation in the Active Mode or in the NPCS of the LPL Enabled Mode are also referred to as High-Capability conditions.

[0026]

The communication apparatus operating in the LPCS operation state, such as the STA 102, transitions the operation state thereof to the NPCS in accordance with its own request, or in response to reception of a frame indicating a request to perform communication in a normal state from an AP that is a partner communication apparatus, such as the AP 101.

[0027]

Thus, the communication apparatus operating in the LPL Enabled Mode, such as the STA 102, selectively uses the NPCS and the LPCS as the operation states thereof. For example, the communication apparatus transitions to the NPCS in a normal state to enable high-speed communication, and transitions to the LPCS during standby to reduce power consumption. An STA operating in the LPL Enabled Mode can achieve both convenience and power saving by selectively using these operation states.

[0028]

In Fig. 13, two modes, namely, the Active Mode and the LPL Enabled Mode, are illustrated as a plurality of operation modes; however, the plurality of operation modes are not limited thereto. Communication apparatuses, such as the STA 102, can also support operation in other operation modes known in the related art, such as a Scheduled PS mode and an Unscheduled PS mode. A communication apparatus

operating in the Scheduled PS mode or the Unscheduled PS mode, such as the STA 102, has a long period of a Doze state, and enters an Awake state only during a period in which a DTIM (delivery traffic indication message) for monitoring the presence of uplink data is transmitted. The communication apparatus, such as the STA 102, maintains the Doze state substantially during a period in which the communication apparatus operates in the PS mode, except for an extremely short period of the Awake state. During the period of the Doze state, the communication apparatus, such as the STA 102, stops supply of power to a circuit for communication. These controls enable a reduction in average power consumption during a period in which the communication apparatus operates in the PS mode. The communication apparatus may be configured to use the Low Power Awake state to operate in the Awake state in these PS (Power Saving) modes. The communication apparatus operating in these PS modes, such as the STA 102, transitions the operation mode to the LPL Enabled Mode or the Active Mode in accordance with its own request or based on the reception state of the DTIM. Which operation mode the communication apparatus transitions to may be determined based on past communication history and the like. Appropriately switching among the plurality of operation modes in accordance with the communication status and the like in the way described above

reduces power consumption. The other operation modes may include an EMLSR (Enhanced Multi-Link Single Radio) mode and the like.

[0029]

In summary, the LPL Enabled Mode in which the LPL function according to the present embodiment is enabled can be considered a mode having lower average power consumption than the Active Mode. The LPL Enabled Mode can also be considered a highly convenient communication mode that allows small-volume data communication to be performed at any time, although its average power consumption is higher than that in the Scheduled/Unscheduled PS mode.

[0030]

A specific mechanism for switching among the above modes will be specifically described with reference to Fig. 2 and subsequent figures. In Fig. 1, a communication system including a single AP 101 and a single STA 102 is illustrated as an example. However, the number of STAs constituting the communication system may be greater than that illustrated. An STA that supports only the above-described legacy standards and does not support the LPL function can also be connected to a network of the AP 101 to constitute the communication system.

[0031]

The AP 101 and the STA 102 may also be configured to

support wireless communication based on other communication standards such as Bluetooth (registered trademark), NFC, and Bluetooth (registered trademark) LE (Low Energy). NFC is an abbreviation for Near Field Communication. The AP 101 and the STA 102 may also be configured to support wired communication using an Ethernet cable and wired communication using an optical fiber. Specific examples of the AP 101 include, but are not limited to, wireless LAN routers and personal computers (PCs). Further, the AP 101 and the STA 102 may each be an information processing apparatus such as a wireless chip that supports UHR PPDU transmission and reception. In this case, a hardware circuit inside the wireless chip can be configured to perform various controls. A processor such as an ASIP inside the wireless chip, a memory, and a hardware circuit can also be configured to cooperate with each other to perform various processes. ASIP is an abbreviation for Application-specific instruction set processor.

[0032]

Specific examples of the STA 102 include a camera, a printer, a tablet, a smartphone, a projector, a PC, a gaming device, a video camera, smart glasses, and a wearable device such as a head-mounted display. Examples also include, but are not limited to, an IoT device such as a sensor node, a network video camera, and the like.

[0033]

<Hardware Configuration of Communication Apparatus>

Fig. 2 illustrates an example of a hardware configuration of a communication apparatus (the AP 101 and the STA 102). The communication apparatus includes, as an example of the hardware configuration thereof, a storage unit 201, a control unit 202, a functional unit 203, an input unit 204, an output unit 205, a communication unit 206, and antennas 207.

[0034]

The storage unit 201 includes both of a ROM and a RAM or either of them, and stores programs for performing various operations described below and various kinds of information such as communication parameters for wireless communication. RAM is an abbreviation for Random Access Memory, and ROM is an abbreviation for Read Only Memory. As the storage unit 201, in addition to a memory such as a ROM or a RAM, a storage medium such as a non-volatile storage device such as a hard disk or an SSD (Solid State Drive) may be used.

[0035]

The control unit 202 includes, for example, a processor such as a CPU or an MPU, an ASIC (application-specific integrated circuit), a DSP (digital signal processor), an FPGA (field programmable gate array), or the like. CPU is

an abbreviation for Central Processing Unit, and MPU is an abbreviation for Micro Processing Unit. The control unit 202 executes a program stored in the storage unit 201 and operates a hardware circuit such as an ASIC to control the entire apparatus. The control unit 202 may control the entire apparatus through cooperation between an OS (Operating System) and the programs stored in the storage unit 201.

[0036]

Further, the control unit 202 controls the functional unit 203 to execute predetermined processing such as imaging, printing, and projection. The functional unit 203 is hardware for the apparatus to execute predetermined processing. For example, in a case where the communication apparatus is a camera such as a digital still camera or a smartphone having a camera, the functional unit 203 is an image capture unit to perform imaging processing on an image of the surroundings via a camera unit (not illustrated) included in the communication apparatus. For example, in a case where the communication apparatus is a printer, the functional unit 203 is a printing unit to perform printing processing on a sheet such as paper based on print data obtained from the outside via wireless communication. For example, in a case where the communication apparatus is a projector or smart glasses, the functional unit 203 is a

projection unit to perform projection processing on image data or video data obtained from the outside via wireless communication. In the case of smart glasses, the projection surface is, for example, the retina of an end user. Data processed by the functional unit 203 may be data stored in the storage unit 201, or may be data communicated with another AP or STA via the communication unit 206 described below. The communication apparatus, such as the AP 101, can further provide a network storage function such as NAS (Network Attached Storage). The function is provided to other communication apparatuses as a Web service such as a network storage service. For example, a communication apparatus such as an STA connects to a network storage service provided by the AP 101 or the like by using a protocol such as SMB over QUIC. The communication apparatus such as the STA then uploads a file to the storage service or downloads a file from the storage service. The data communication for the upload or the download is also implemented through communication of UHR PPDUs between the apparatuses. SMB is an abbreviation for Server Message Block, and QUIC is an abbreviation for Quick UDP Internet Connections.

[0037]

The input unit 204 receives various operations from a user. The output unit 205 performs various outputs to the

user. The output by the output unit 205 includes, for example, at least one of display on a screen, audio output by a speaker, and vibration output. Both the input unit 204 and the output unit 205 may be implemented by a single module such as a touch panel. The output unit 205 functions as display means for presenting information to the user. The input unit 204 functions as reception means for receiving a user operation.

[0038]

The communication unit 206 performs control of wireless communication compliant with the IEEE 802.11 standard series or control of IP communication. In the present embodiment, the communication unit 206 can cooperate with the antennas 207 to execute communication control for transmitting and receiving a UHR PPDU, which is a wireless frame of the UHR standard, and a PPDU supporting a standard preceding the UHR standard. The plurality of antennas 207 are antennas capable of transmitting and receiving signals in at least one of frequency bands such as a sub-GHz band, a 2.4 GHz band, a 5 GHz band, a 6 GHz band, and a millimeter-wave band. In Fig. 2, a case is illustrated in which the AP 101 and the STA 102 according to the present embodiment have three antennas; however, the number of antennas is not limited thereto and may be greater or smaller.

[0039]

In a case where the communication apparatus supports the above-described NFC standard, Bluetooth standard, wired communication standards, and the like, the communication unit 206 may be configured to control wireless communication or wired communication compliant with these communication standards. The communication unit 206 of each of the AP 101 and the STA 102 also has a hardware circuit for decoding or encoding signals communicated on each link. Each antenna and each hardware circuit are configured to enable individual power control. The communication apparatus may also be configured to individually include communication units corresponding to the respective links.

[0040]

Next, a functional configuration of the AP 101 and the STA 102 will be described with reference to Fig. 3. Communication apparatuses such as the AP 101 and the STA 102 each include functional units such as a frame processing unit 301, a mode control unit 302, an RXTX control unit 303, a frame transmission and reception unit 304, and a UI control unit 305.

[0041]

The mode control unit 302 cooperates with each functional unit and each hardware component to implement control of the above-described operation modes, control of connection with a partner apparatus, and the like. During a

connection process, specifically, an Authentication process, an Association process, a 4-way handshake process, and the like are performed to establish a communication link with a partner communication apparatus. In the case of the AP 101, the partner apparatus is an STA such as the STA 102. In the case of the STA 102, the partner apparatus is an AP such as the AP 101. Further, the mode control unit 302 manages communication parameters and the like to be used in each operation mode. Prior to switching the operation mode, the mode control unit 302 requests the RXTX control unit 303 to switch communication conditions by using the managed communication parameters and the like. Upon receiving the switching request, the RXTX control unit 303 and the frame transmission and reception unit 304 control the communication unit 206 and the plurality of antennas 207 to switch communication conditions required for transmission or reception.

[0042]

The frame processing unit 301 executes processes for generation and analysis of a signal (frame) for communicating with a partner communication apparatus. The frame processing unit 301 generates a management frame for the communication apparatus to execute a connection procedure and a control frame for controlling communication. Management frames generated or analyzed by the frame

processing unit 301 include Beacon, Probe Request, Probe Response, Association Request, Association Response, FILS (Fast Initial Link Setup) Discovery, and Action. The management frames also include an Authentication Request frame, an Authentication Response frame, and the like. The management frames also include ReAssociation Request and ReAssociation Response. While the frame processing unit 301 also appropriately generates or analyzes other management frames of the IEEE 802.11 standard series, description thereof is omitted for the sake of brevity.

[0043]

Control frames generated or analyzed by the frame processing unit 301 include a frame and the like for causing a transition of an operation state of the LPL function in a situation where the LPL function is enabled. The control frames also include, for example, a frame and the like for prompting a partner apparatus in the LPCS operation state to transition the operation state to the NPCS. The frame is referred to as an ICF (Initial Communication Frame) for descriptive convenience. The frames generated or analyzed by the frame processing unit 301 also include ICF Response, which is a response to the ICF. The control frames generated by the frame processing unit 301 are not limited to those described above. The frame processing unit 301 also generates a data frame, a QoS (Quality of Service) data

frame, or the like in accordance with an instruction from an upper-layer application or the like (not illustrated). The frame processing unit 301 generates information elements specified in the IEEE 802.11 series standards, such as a UHR Capabilities element and a UHR Operation element. The frame processing unit 301 can also generate a UHR Protected action frame relating to the LPL function.

[0044]

The UHR Capabilities element can include an information element indicating whether the communication apparatus has a capability to execute the LPL function. An element in the UHR Protected action frame can also include an information element for performing negotiation as to whether to, for example, enable the LPL function. Details of these elements will be described below.

[0045]

The frame transmission and reception unit 304 performs a process for transmitting a wireless frame generated by the frame processing unit 301 and a process for receiving a wireless frame from a partner apparatus. Received digital data obtained through the reception process is transferred to the frame processing unit 301. The frame processing unit 301 analyzes the received digital data transferred from the frame transmission and reception unit 304, and performs a process for generating an appropriate response frame or

notifying an upper layer (not illustrated) of analyzed data (such as IP data included in a payload) in accordance with the analysis result. The frame transmission and reception unit 304 cooperates with the respective units to perform transmission control to transmit a frame or reception control to receive a frame.

[0046]

The UI (User Interface) control unit 305 provides a setting screen as a UI for a user to input settings relating to communication. Further, the UI control unit 305 receives a user operation on the setting screen via the input unit 204, and stores the settings in the storage unit 201 as settings for the operation of the communication apparatus. The UI control unit 305 receives, via a setting screen (not illustrated), a setting change operation for enabling or disabling the LPL function. Further, the UI control unit 305 stores, in the storage unit 201, a user setting as to whether to enable or disable the LPL function corresponding to the setting change operation. The settings for the operation are appropriately referred to in flowcharts described below.

[0047]

<LPL Execution Procedure>

Next, a procedure for the AP 101 and the STA 102 to use the LPL function will be described with reference to Fig. 4.

Fig. 4 is a sequence diagram illustrating an LPL function execution procedure performed between the AP 101 and the STA 102.

[0048]

First, the STA 102 performs a process for connecting to the AP 101 (F401). The connection process will be described. The AP 101 uses a Beacon frame or a FILS Discovery frame to periodically broadcast information required for another communication apparatus (such as the STA 102) to connect to the AP 101. Upon receiving a Beacon or an FILS Discovery, the STA 102 recognizes an AP present nearby, such as the AP 101, and starts a wireless connection procedure. For example, in a case where the AP 101 does not transmit a Beacon or in a case where the STA 102 has failed to appropriately receive a Beacon transmitted from the AP 101, the STA 102 can start the wireless connection procedure without receiving a Beacon. For example, the STA 102 can start the wireless connection procedure by using connection information registered in advance by a user, such as an SSID (Service Set Identifier) or a passphrase. To connect to the AP 101, the STA 102 first transmits a Probe Request frame to the AP 101. Upon receiving the Probe Request, the AP 101 transmits a Probe Response frame addressed to the STA 102. In a Multi-Link connection, an ML Probe Request and an ML Probe Response may be transmitted and received separately

from the Probe Request and the Probe Response. Upon receiving the Probe Response, the STA 102 transmits an Authentication Request frame to the AP 101. Upon receiving the Authentication Request frame, the AP 101 transmits an Authentication Response frame to the STA 102. Each Authentication frame may be transmitted and received twice. Upon receiving the Authentication Response frame, the STA 102 transmits an Association Request frame. Upon receiving the Association Request frame, the AP 101 transmits an Association Response frame. Through these procedures, a connection procedure is performed between the AP 101 and the STA 102, and a link using a wireless medium is established between the AP 101 and the STA 102. After the above connection procedure, the AP 101 and the STA 102 may execute a 4-way handshake or the like to exchange security information. The AP 101 and the STA 102 may use a method other than that described above to execute the wireless connection procedure.

[0049]

The AP 101 and the STA 102 exchange capability information via at least one frame that is used in the wireless connection procedure and includes an information element indicating capability information indicating whether the AP 101 and the STA 102 themselves support a Low Power Listen mode.

[0050]

Specifically, in the wireless connection procedure, each of the AP 101 and the STA 102 shares, with its partner communication apparatus, capability information indicating whether it supports the Low Power Listen mode. Each of the AP 101 and the STA 102 also shares, with its partner communication apparatus, information that can identify a Link, a bandwidth, a spatial stream, an MCS, and the like to be used to execute Low Power Listen. In the present embodiment, information for identifying an optional function supported by communication apparatuses in wireless communication is referred to as capability information.

[0051]

A specific example of capability information exchanged in the wireless connection procedure will be described with reference to Figs. 5A and 5B. As an example, the capability information is transmitted to the partner apparatus by using a UHR Capabilities element illustrated in Fig. 5A. Fig. 5A illustrates an example of a UHR Capabilities element included in a frame for performing the wireless connection procedure.

[0052]

The UHR Capabilities element is included in the above-described Beacon, Probe Request, Probe Response, Association Request, Association Response, and the like. In other

words, the UHR Capabilities element is an information element for transmitting capability information indicating whether optional functions of the 802.11bn standard are supported.

[0053]

The UHR Capabilities element includes an Element ID field 501, a Length field 502, and an Extended Element ID field 503. The UHR Capabilities element further includes an LPL (Low Power Listen) Support field 504. The UHR Capabilities element also includes fields and the like indicating whether other optional capability information is supported. For example, a field indicating whether UORA (uplink OFDMA-based random access)-based low-latency channel access is supported may be included.

[0054]

The combination of the Element ID field 501 and the Extended Element ID field 503 indicates the type of the element. In the present embodiment, as an example, an element in which the Element ID field 501 specifies 255 and the Extended Element ID field 503 specifies 138 is defined as the UHR Capabilities element. However, the present disclosure is not limited thereto. Another combination may be defined as the UHR Capabilities element. The Length field 502 indicates the length of the element illustrated in Fig. 5A. The LPL (Low Power Listen) Support field 504

stores a value indicating whether the communication apparatus transmitting the frame supports the Low Power Listen function. Storing "1" in the field indicates that the communication apparatus transmitting the frame supports the Low Power Listen function. Storing "0" in the field indicates that the communication apparatus transmitting the frame does not support the Low Power Listen function. In a modification, "0" may indicate that the Low Power Listen function is not supported or that the function is disabled. That is, in a modification, "0" may indicate a disabled state.

[0055]

The LPL Support field 504 may be included in a subfield included in the UHR Capabilities element. For example, it is possible that the LPL Support field 504 is included in a UHR MAC Capabilities Information field. However, the present disclosure is not limited thereto, and the LPL Support field 504 may be included in an EHT PHY Capabilities Information field. Alternatively, the LPL Support field 504 may be defined as a field within another field that conveys another group of pieces of capability information.

[0056]

Fig. 5B illustrates a modification of the UHR Capabilities element. The difference from Fig. 5A is that the LPL capability information is subdivided into an LPL Tx

Support field 514 indicating transmission capability and an LPL Rx Support field 515 indicating reception capability to indicate the capability. An AP needs to be capable of transmitting an ICF to an STA in the LPCS to make a transition of the operation state of the STA. Accordingly, the AP 101 needs to set the LPL Tx Support field 514 to 1. An AP setting the field to 1 indicates that the AP supports control for transmitting the ICF with the number of streams, the MCS, and the number of links that allow an STA in the LPCS operation state to appropriately perform reception. The STA, such as the STA 102, may set the LPL Tx Support field 514 to 1. The STA, such as the STA 102, needs to set the LPL Rx Support field 515 to 1. The AP, such as the AP 101, may set the LPL Rx Support field 515 to 1.

[0057]

That is, in the modification, the LPL Tx Support field 514 indicates the presence or absence of capability to perform frame transmission while maintaining the LPCS operation state, and the LPL Rx Support field 515 indicates the presence or absence of capability to perform data reception while maintaining the LPCS operation state.

[0058]

An element including a field similar to the LPL Support field 504 or the LPL Tx Support field 514 and the LPL Rx Support field 515 in Fig. 5A or 5B may also be configured to

be included in a frame different from the frames used in the wireless connection procedure described above.

[0059]

The AP 101 and the STA 102 enable or disable the LPL function, based on transmitted or acquired capability information indicating whether the AP 101 and the STA 102 themselves support the LPL function, or based on the communication status. In other words, the AP 101 and the STA 102 each switch the operation mode thereof to the Active Mode or the LPL Enabled Mode, which are described with reference to Fig. 13.

[0060]

In the present embodiment, in a case where an STA, such as the STA 102, is caused to operate in the LPCS operation state in the LPL Enabled Mode, a single specific link is designed to be used to listen for a frame from an AP. However, the present disclosure is not limited thereto, and a plurality of links may be used during operation in the LPCS. For example, in a case where the number of links used during operation in the NPCS is 3, it is sufficient to reduce the number of links used during operation in the LPCS compared with the number of links used during operation in the NPCS, such as reducing the number of links used during operation in the LPCS to 2. That is, in the present embodiment, the number of communication links in the LPCS is

designed to be reduced compared with the NPCS or the Active Mode. Alternatively, the number of links may be the same in both the LPCS operation state and the NPCS operation state. In that case, prior to transitioning to the LPCS, two or more other communication conditions, such as the MCS and the number of spatial streams, are customized for power saving to suppress power consumption during standby.

[0061]

An AP, such as the AP 101, can transmit detailed information on operation parameters to be used by an STA operating in the LPL Enabled Mode to the STA in advance by using a UHR Operation element illustrated in Fig. 6.

[0062]

Fig. 6 illustrates an example of a UHR Operation element included in a frame used for the wireless connection procedure by the AP 101.

[0063]

The element illustrated in Fig. 6 is included in a frame used for the wireless connection procedure. Accordingly, via the frame, the AP 101 transmits two or more communication conditions to be used for operation in an operation state such as the LPCS to a partner apparatus, such as the STA 102. Specifically, the AP 101 appropriately determines a link to be listened to and communication parameters to be used in the LPCS in a case where a

subordinate STA operates in the LPCS of the LPL function. The AP 101 then transmits Beacon, Probe Response, and Association Response frames including a UHR Operation element including the determined communication parameters. The UHR Operation element may be included only in one of the enumerated frames. The UHR Operation element may be included in other frames.

[0064]

Fig. 6 illustrates an example of the UHR Operation element. The UHR Operation element includes an Element ID field 601, a Length field 602, and an Extended Element ID field 603. The UHR Operation element further includes a Padding Delay field 604, an MCS field 605, and a Listen Link field 606. The UHR Operation element further includes a Listen Interval field 607, a Listen duration field 608, and a Listen offset field 609. The Element ID field 601 and the Extended Element ID field 603 are fields for uniquely identifying the element. Accordingly, values different from those in the above-described combination of the Element ID field 501 and the Extended Element ID field 503 in Figs. 5A and 5B are stored.

[0065]

The Length field 602 stores the length of the element.

[0066]

The Padding Delay field 604 stores a minimum MAC

padding period to be included in the ICF by the AP 101. The MCS field 605 stores an upper limit value of MCSs to be supported in a case where the STA operates in the LPCS. For example, an upper limit value indicating that only MCSs up to a QAM (e.g., 16-QAM, 64-QAM, 256-QAM, or the like) lower than a QAM usable for operation in the NPCS (e.g., 4096-QAM) are supported is stored. More specifically, the field stores an index value corresponding to an upper-limit UHR-MCS expected to be used for operation in the LPCS. As an example, storing "7" indicates the MCS that can be used with 64-QAM and a coding rate of 5/6 as the upper limit. In other words, in a case where "7" is stored, the UHR-MCS usable for operation in the LPCS is restricted to an MCS indicated by any index value from 0 to 6.

[0067]

The Listen Link field 606 is a field that stores a Link ID indicating which Link is to be used to await reception in a case of operation in the LPCS.

[0068]

The Listen Interval field 607, the Listen duration field 608, and the Listen offset field 609 are optionally provided fields. These fields are fields that store parameters for enabling awaiting of reception with lower power consumption. The fields are provided from the AP to the STA to perform optional control in which states such as

the Low Power Awake state and the Doze state are provided in the LPCS operation state to achieve a further power-saving effect. The Listen Interval field 607 indicates an interval at which the Low Power Awake state, in which communication can be performed at low power, is entered during operation in the LPCS. For example, a setting of 100 indicates that a transition to the Low Power Awake state is made every 100 ms. The Listen duration field 608 indicates how long the Low Power Awake state is maintained. For example, a setting of 15 indicates that the Low Power Awake state is kept for 15 ms. The Listen offset field 609 indicates a time interval from Beacon transmission to the Low Power Awake state. For example, a setting of 20 indicates that the initial time of a loop in which the Low Power Awake state is entered after Beacon transmission is 20 ms. An STA, such as the STA 102, identifies, based on the parameters, a time at which the STA is to enter Awake and a time at which the STA is to enter Doze, and controls switching, based on the identified times, between the Doze state and an Awake state of waiting for communication with the Low-Capability conditions. Accordingly, even in the LPCS operation state, Doze operation can be performed during part of a period, and more adaptive power-saving control can be performed. Other communication parameters may be included. For example, a parameter such as the number of spatial streams used in the

LPCS and a parameter for the bandwidth to be used may be included.

[0069]

Returning to the description of Fig. 4, a sequence for enabling the LPL function will be described. The STA 102 transmits a frame for enabling the LPL to the AP 101. Upon receiving the frame, the AP 101 transmits a response frame. Upon receiving the response frame, the STA 102 transitions the operation mode to the LPL Enabled Mode. In the present embodiment, a case is illustrated in which a transition to the LPCS operation state described above is made in response to reception of the response frame; however, the present disclosure is not limited thereto.

[0070]

A frame for enabling the LPL will be described with reference to Fig. 7. Fig. 7 illustrates an example of an Action field of an Action frame for providing a notification of enabling/disabling of Low Power Listen. In the present embodiment, the field is referred to as a Low Power Listen Mode Notification frame Action field. However, the field is not limited thereto, and may be referred to by a different name. The field includes a Category field 701, a Protected UHR Action field 702, a Dialog Token field 703, and a Low Power Listen Control field 704. The Low Power Listen Mode Notification frame Action field may also include a Low Power

Listen Parameter Update field 705. The Category field 701 indicates the category of the Action field. For example, the Category field 701 stores an identification number corresponding to Protected UHR Action. The Protected UHR Action field 702 indicates the identifier of this Action field in the Protected UHR Action category. For example, the Protected UHR Action field 702 stores an identification number indicating the Low Power Listen Mode Notification frame Action field. The Dialog Token field 703 indicates an identifier for executing a series of information exchanges between the AP 101 and the STA 102. For example, the Dialog Token field 703 stores an identifier assigned by a requesting communication apparatus. A responding communication apparatus transmits a response frame of which the Dialog Token field 703 stores a value included in the received Dialog Token field 703. A MAC frame that stores the Action field of Fig. 7 is referred to as an LPL Operating Mode Notification frame.

[0071]

The Low Power Listen Control field 704 includes an LPL Mode field 711 and a Low Power Listen Parameter Update Control field 712. The LPL Mode field 711 indicates whether to use the LPL function. For example, the STA 102 stores 1 in the field to request initiation of its use of the Low Power Listen function. On the other hand, the STA 102

stores 0 in the field to request stop of use of the LPL function. The LPL Mode field 711 may be configured to have 2 bits each indicating whether to use the LPL function for a corresponding one of transmission and reception. For example, in a case where the STA 102 specifies 0 for the first bit and specifies 1 for the second bit, the STA 102 requests use of reception processing during the LPCS and non-use of transmission processing during the LPCS.

[0072]

The Low Power Listen Parameter Update Control field 712 indicates the presence or absence of the Low Power Listen Parameter Update field 705. The field stores 1 in a case where, for example, the Low Power Listen Mode Notification frame Action field includes the Low Power Listen Parameter Update field 705. On the other hand, the field stores 0 in a case where the Low Power Listen Mode Notification frame Action field does not include the Low Power Listen Parameter Update field 705. The Low Power Listen Parameter Update field 705 includes a Padding Delay field 604, an MCS field 605, a Listen Link field 606, a Listen Interval field 607, a Listen duration field 608, and a Listen offset field 609. Since these fields have the same roles as the identically named fields described with reference to Fig. 6, description thereof is omitted. Similarly to Fig. 6, a parameter for the number of spatial streams used in the LPCS and a

parameter for the bandwidth to be used may be included. To customize communication parameters of the LPCS, an STA, such as the STA 102, transmits an Action frame to which the Low Power Listen Parameter Update field 705 is added.

[0073]

The AP 101 determines whether to use the LPL function, based on the frame received from the STA 102. Specifically, the AP 101 acquires the value of the LPL Mode field 711 included in the UHR Protected action frame received from the STA 102, and determines, based on the value, the intention of the partner STA, such as the STA 102.

[0074]

The AP 101 sends to the STA 102 a response frame to which a Status Code is added in addition to the respective fields described with reference to Fig. 7. The STA 102 analyzes the value of the Status Code in the response frame, and determines whether the request as to whether to use the LPL function is accepted by the AP 101. In a case where the request is accepted by the AP 101, the STA 102 changes the operation mode thereof to an operation mode corresponding to the request. In Fig. 4, a case is illustrated in which the STA 102 makes a request to use the LPL function and the AP 101 accepts the request. The STA 102 updates the communication parameters thereof to communication parameters corresponding to the LPCS. Specifically, in a case where

update information of communication parameters is communicated by using an Enabling sequence frame indicated by F402 as an example, the STA 102 sets the communication parameters. On the other hand, in a case where update information of communication parameters is not communicated via the Enabling sequence, the STA 102 uses the UHR Operation element to set, in the STA 102, communication parameters for the LPCS, which are shared in advance from the AP 101. Subsequently, the STA 102 starts a frame waiting process in the LPCS.

[0075]

Next, a state transition from the LPCS to the NPCS will be described. Upon at least determining that data to be transmitted to the STA 102 has occurred, the AP 101 transmits an ICF to the STA 102 to trigger control for changing the STA operation state from the LPCS to the NPCS (F403).

[0076]

Upon receiving the ICF transmitted in F403, the STA 102 transmits a response signal to the ICF (F404). A specific example of the ICF and the response signal to the ICF will be described with reference to Figs. 8 and 9. The ICF frame is a type of Control frame, and includes a Frame Control field 801, a Duration field 802, an RA field 803, a TA field 804, and a Link Info List field 805. The Frame Control

field 801 is a field for identifying the type of the frame, and contains a value indicating that the frame is an ICF frame of the LPL function. The Duration field 802 indicates the maximum duration of the NPCS that is initialized by the ICF frame. Upon receiving the ICF frame, the STA 102 transitions to a state in which, during the period specified in the Duration field 802, the STA 102 is capable of receiving frames using the parameters specified in the Link Info List field 805 while waiting for reception. The RA field 803 stores the MAC address of the STA 102, indicating the recipient of the frame. MAC is an abbreviation for Medium Access Control. The TA field 804 stores the MAC address of the AP 101, indicating the transmitter of the frame. The Link Info List field 805 stores one or more pieces of association information, each representing a combination of information identifying a link used in the NPCS state and communication parameters for the link. In a case of operating the STA 102 in the NPCS operation state, the AP 101 stores a plurality of pieces of association information in the Link Info List field 805 in a case where a plurality of links are to be enabled. Each piece of association information is made up of fields 811 to 815. The association information will be described specifically. The association information includes a Link ID field 811, a BW field 812, an NSS field 813, an MCS field 814, and a

Delay field 815. The Link ID field 811 is information identifying a link used in the NPCS. The fields 812 to 815 indicate communication parameters to be used for communication on the link identified by the Link ID field 811. The fields 812 to 815 will be described specifically. The BW field 812 indicates a bandwidth to be used for communication. For example, values 0, 1, 2, 3, and 4 indicate that frames are to be listened for or transmitted at 20 MHz, 40 MHz, 80 MHz, 160 MHz, and 320 MHz, respectively. The NSS field 813 indicates the number of spatial streams. For example, it is indicated that frames are to be listened for or transmitted using the number of spatial streams obtained by adding 1 to the value indicated by the NSS field 813. NSS is an abbreviation for number of spatial streams. The MCS field 814 indicates the maximum MCS used for communication. The Delay field 815 specifies a grace period from transmission of the ICF frame until execution of frame transmission according to the specified parameters. Instead of the Delay field 815, a Padding field may be added to the end of the ICF frame for time adjustment. The ICF frame is transmitted across the Link and bandwidth where the STA 102 in the LPCS operation state waits for communication. At the same time, the ICF may also be transmitted on a different Link that is expected to be used for communication after transition to the NPCS is made,

for the purpose of securing transmission rights also on the different Link.

[0077]

Next, the response frame to the ICF will be described with reference to Fig. 9. Fig. 9 illustrates an example of an ICF Response frame. The ICF Response frame may include a Frame Control field 801, a Duration field 802, an RA field 803, a TA field 804, a Status Code field 901, and a Link Info List field 805. Fields common to those of Fig. 8 are denoted by the same reference numerals, and description thereof is omitted. The Status Code field 901 indicates whether communication is possible with the values specified by the ICF. Transmission of the ICF Response frame may be omitted. Instead of the ICF Response frame illustrated in Fig. 9, a CTS (Clear To Send) frame may be returned. At this time, the CTS frame may be returned for every 20 MHz across all links and bandwidths specified by the ICF.

[0078]

Subsequently, the STA 102 starts a frame waiting process in the NPCS. Specifically, the STA 102 updates the communication parameters thereof with the communication parameters included in the ICF, and starts waiting for frames using communication parameters corresponding to High-Capability conditions. That is, the STA 102 switches to the High-Capability communication conditions for high-speed

communication or high-reliability communication.

[0079]

After waiting for the grace period, the AP 101 transmits a data frame to the STA 102 (F405). The AP 101 transmits the data frame using transmission parameters corresponding to the High-Capability conditions notified in F403.

[0080]

Upon receiving the data frame, the STA 102 returns an Ack frame as a response frame to the received data frame (F406). During the grace period indicated by the Duration field 802 of the ICF, the STA 102 and the AP 101 repeatedly perform the sequence indicated in F405 and F406, thereby enabling transmission of downlink data.

[0081]

Upon determining that a series of data transmissions to the STA 102 is completed, the AP 101 transmits a CF-End frame or a QoS Null frame (F407). The frame functions as a frame for terminating the NPCS operation state and prompting transition to the LPCS state. The frame for prompting transition to the LPCS is not limited thereto, and may be another frame. For example, the frame may be a control frame newly defined for the LPL function. Upon receiving the CF-End frame or the QoS Null frame, the STA 102 changes the operation state thereof to the LPCS again. That is, the

STA 102 switches to the Low-Capability communication conditions in which functions are intentionally restricted to save power.

[0082]

In Fig. 4, a case is illustrated in which downlink communication is performed using, as a trigger, an ICF issued by the AP 101. However, in a case where the STA 102 determines to voluntarily perform high-speed communication and/or high-reliability communication, such as in a case where uplink data occurs in the STA 102, the STA 102 determines by itself communication conditions corresponding to the NPCS and transitions to the NPCS. Upon transitioning to the NPCS, the STA 102 performs CCA (Clear Channel Assessment) using transmission parameters corresponding to the updated communication conditions, and transmits a CTS frame based on a determination that channel access has been obtained. The STA 102 may then be configured to transmit a data frame in a case where the STA 102 has successfully received an RTS (Request To Send) frame from the AP 101 in response to the CTS frame. Upon determining that the operation mode is to be switched to the LPCS after the series of data transmissions is completed, the STA 102 transmits a CF-End frame. Instead of the CF-End frame, a QoS Null frame or a QoS data frame in which an RDG/More PPDU subfield of a CAS Control field is set to 0 may be

transmitted. In response to transmitting the frame, the STA 102 causes the operation state thereof to transition to the LPCS. That is, the STA 102 switches to the Low-Capability communication conditions in which functions are intentionally restricted.

[0083]

Although omitted from Fig. 4 for the sake of brevity, upon determining that the operation mode is to be changed to the Active Mode in accordance with the communication status or the like, the STA 102 transmits a request to the AP 101 to disable the LPL. Upon receiving the request, the AP 101 transmits a response frame indicating that disabling of the LPL is accepted. In the LPL Disabling sequence described above, it is only required to request disabling by using the LPL Operating Mode Notification frame described with reference to Fig. 7. In a case of requesting disabling, the STA 102 stores 0 in the LPL Mode field 711 included in the frame to request disabling.

[0084]

<Communication Control Using LPL Function>

Next, communication control using the LPL function according to the present embodiment will be described with reference to flowcharts of Figs. 10 to 12.

[0085]

Figs. 10 and 12 are flowcharts illustrating an example

of communication control performed by the STA 102, and Fig. 11 is a flowchart illustrating an example of communication control performed by the AP 101.

[0086]

The processes illustrated in the flowcharts of Figs. 10 and 12 are executed by a processor of the control unit 202 of the STA 102 executing a computer program stored in the storage unit 201. Some processes such as transmission and modulation are implemented through cooperation of the processor of the control unit 202, various processors, an ASIC, a DSP, an FPGA, and an antenna included in the communication unit 206, and an ASIC, a DSP, an FPGA, and the like included in the control unit 202. The present disclosure is not limited thereto, and the communication unit 206 and the antenna may be configured to cooperate with each other to execute the respective processes illustrated in the flowcharts. To clearly indicate the entity that performs processing, the functional units described with reference to Fig. 3 are used as the subject of description. Control indicated by a dotted line is optional, and need not necessarily be executed.

[0087]

The processes illustrated in the flowchart of Fig. 11 are executed by a processor of the control unit 202 of the AP 101 executing a computer program stored in the storage

unit 201. Some processes such as transmission and modulation are implemented through cooperation of the processor of the control unit 202, various processors, an ASIC, a DSP, and an FPGA included in the communication unit 206, and an ASIC, a DSP, an FPGA, and the like included in the control unit 202. The present disclosure is not limited thereto, and the communication unit 206 and the antenna may be configured to cooperate with each other to execute the respective processes illustrated in the flowcharts. To clearly indicate the entity that performs processing, the functional units described with reference to Fig. 3 are used as the subject of description.

[0088]

First, control performed by the STA 102 will be described with reference to Fig. 10. The respective processes illustrated in Fig. 10 are an extract of a series of processes executed until the STA 102 discovers an AP such as the AP 101 and determines whether to use the LPL function. Fig. 12 illustrates an extract of specific processes performed in a case where the LPL function is determined to be used.

[0089]

In S1000, the control unit 202 of the STA 102 determines whether to start connection with an AP such as the AP 101. If the control unit 202 determines to start the

connection, the control unit 202 advances the process to S1001. If the control unit 202 determines not to start the connection, the control unit 202 waits until a condition determined as requiring start of connection with the AP is satisfied.

[0090]

In S1001, the control unit 202 performs the connection process described with reference to Fig. 4, and acquires capability information of the AP, such as the AP 101, from a frame received from the AP for the connection process. Specifically, the control unit 202 acquires the capability information included in the UHR Capabilities element described above. Further, the STA 102 performs the connection process illustrated in Fig. 4, and completes the connection with the destination AP such as the AP 101. At a timing when the connection is completed, the LPL function is in a disabled state, and the STA 102 operates in the Active Mode as the operation mode thereof. That is, the STA 102 starts operating with communication parameters that enable high-speed communication and/or high-reliability communication and correspond to the High-Capability conditions negotiated with the AP in the connection process.

[0091]

In S1002, the mode control unit 302 refers to the user setting stored in the storage unit 201 as to whether to

enable or disable the LPL function. The mode control unit 302 then determines whether a setting to disable the LPL function has been made as the user setting. If the mode control unit 302 determines that a setting to disable the LPL function has been made as the user setting, the mode control unit 302 advances the process to S1009. On the other hand, if the mode control unit 302 determines that a setting to disable the LPL function has not been made as the user setting, the mode control unit 302 advances the process to S1003.

[0092]

In S1003, the mode control unit 302 determines whether the destination AP to which the STA 102 is connected supports the LPL function. Specifically, if the LPL Support field 504 of the capability information acquired in S1001 from the destination AP specifies 1, the mode control unit 302 determines that the destination AP supports the LPL function. As another example, if the LPL Tx Support field 514 of the acquired capability information specifies 1, the mode control unit 302 determines that the destination AP supports the LPL function. If the mode control unit 302 determines that the destination AP supports the LPL function, the mode control unit 302 advances the process to S1005. If the mode control unit 302 determines that the destination AP does not support the LPL function, the mode

control unit 302 advances the process to S1009.

[0093]

In S1005, the mode control unit 302 determines whether an NSTR link for Multi-Link communication has been established with the destination AP. If the mode control unit 302 determines that the NSTR link has been established, the mode control unit 302 advances the process to S1009. If the mode control unit 302 determines that the NSTR link has not been established, the mode control unit 302 advances the process to S1006. More specifically, the mode control unit 302 determines that NSTR link has not been established if an STR link for Multi-Link communication has been established or if a single link has been established. In the present embodiment, in the case of an NSTR link, it is determined that the LPL function is not to be used because the control of transitioning to the NPCS is complicated due to synchronization control of links and the like.

[0094]

In S1006, the mode control unit 302 acquires, from an OS that centrally manages the operation of the STA 102 (not illustrated), the current remaining battery level and a charging status indicating whether charging is in progress. If the acquired remaining battery level is less than or equal to a threshold and the charging status indicates that charging is not in progress, the mode control unit 302

determines that the battery is in a Low state, and advances the process to S1010. On the other hand, if the acquired remaining battery level is greater than the threshold, or if the acquired remaining battery level is less than or equal to the threshold but the charging status indicates that charging is in progress, the mode control unit 302 determines that the battery is not in the Low state, and advances the process to S1007. The battery threshold used for the determination may be set to, for example, 20% or the like.

[0095]

In S1007, the mode control unit 302 determines whether communication quality with the AP 101 is less than or equal to a predetermined threshold. If the mode control unit 302 determines that the communication quality with the AP 101 is less than or equal to the predetermined threshold, the mode control unit 302 advances the process to S1009. If the mode control unit 302 determines that the communication quality with the AP 101 is higher than the predetermined threshold, the mode control unit 302 advances the process to S1008.

[0096]

In S1008, the mode control unit 302 determines whether a low-latency communication application is running. If the mode control unit 302 determines that the low-latency communication application is running, the mode control unit

302 advances the process to S1009. If the mode control unit 302 determines that the low-latency communication application is not running, the mode control unit 302 advances the process to S1010. The determination is made in cooperation with an OS that manages an application (process) in execution. As another example, instead of the determination, a determination may be made as to whether low-latency communication is required, based on QoS parameters and the like of an IP packet received from the destination AP or an IP packet to be transmitted to the destination AP. In this case, the mode control unit 302 advances the process to S1009 if it is determined that low-latency communication is required.

[0097]

In S1009, the mode control unit 302 determines not to use the LPL function, and maintains operation in the Active Mode. On the other hand, in S1010, the mode control unit 302 determines to use the LPL function, and causes the operation mode of the STA 102 to transition to the LPL Enabled Mode. Specific control performed in a case where a transition to the LPL Enabled Mode is made will be described below with reference to Fig. 12.

[0098]

Next, control performed by the AP 101 will be described with reference to Fig. 11. The respective control processes

illustrated in Fig. 11 indicate processes executed after power is supplied to the AP 101, a startup sequence is completed, and normal operation as an AP is started.

[0099]

In S1100, the frame processing unit 301 of the AP 101 determines whether data transmission to an STA in the NPCS is required. If the frame processing unit 301 determines that data transmission to the STA in the NPCS is required, the frame processing unit 301 advances the process to S1101. If the frame processing unit 301 determines that data transmission to the STA in the NPCS is not required, the frame processing unit 301 advances the process to S1107.

[0100]

In S1101, the frame processing unit 301 identifies a traffic type required for data transmission to a destination STA to which data transmission is determined in S1100 to be required, and estimates the traffic amount. For example, the frame processing unit 301 identifies, based on QoS information of the data, a traffic type into which the data is classified. For example, the frame processing unit 301 stores past communication history and the like, and estimates the traffic amount, which is a characteristic of generated traffic, based on a comparison between the communication history and features of data to be transmitted (e.g., source information/destination information of the

data, and the like). The estimation method is not limited thereto.

[0101]

In S1102, the frame processing unit 301 determines whether to perform communication of the estimated traffic while maintaining the destination STA in the LPCS. If the frame processing unit 301 determines to perform communication of the estimated traffic while maintaining the destination STA in the LPCS, the frame processing unit 301 advances the process to S1103. On the other hand, if the frame processing unit 301 determines not to perform communication of the estimated traffic while maintaining the destination STA in the LPCS (i.e., if the frame processing unit 301 determines to make a transition to the NPCS), the frame processing unit 301 advances the process to S1104. For example, the frame processing unit 301 determines whether the transmission time in a case of transmitting the estimated traffic amount at the communication rate at which communication is performed while the LPCS is maintained falls within a predetermined time. If the frame processing unit 301 determines that the transmission time falls within the predetermined time, the frame processing unit 301 determines to perform communication of the estimated traffic while maintaining the destination STA in the LPCS.

[0102]

In S1103, the frame processing unit 301 cooperates with the RXTX control unit 303, and sets, for the communication unit 206 and the antennas 207, communication parameters for the LPCS corresponding to the destination STA, as transmission parameters. Subsequently, the frame processing unit 301 cooperates with the frame transmission and reception unit 304, the communication unit 206, and the antennas 207 to perform data transmission using the communication parameters for the LPCS. Upon completion of the data transmission, the frame processing unit 301 updates the communication parameters to normal communication parameters, and advances the process to S1100.

[0103]

On the other hand, in S1104, the frame processing unit 301 cooperates with the respective units to transmit the ICF described with reference to Fig. 8 to the destination STA. At this time, the frame processing unit 301 cooperates with the mode control unit 302, and determines, based on the traffic characteristics (the traffic type and the traffic amount) identified and estimated in S1101, communication parameters to be used for the destination STA to transition to the NPCS. At this time, furthermore, the mode control unit 302 manages the determined communication parameters and operation state as current state information associated with the destination STA. In other words, the mode control unit

302 updates the operation state, which is included in the state information corresponding to the destination STA, from the LPCS to the NPCS, and stores, as the state information, communication parameters used in the NPCS. The frame processing unit 301 then transmits an ICF including, in the Link Info List field 805, communication conditions corresponding to the determined communication parameters.

[0104]

In S1105, the frame processing unit 301 cooperates with the mode control unit 302 and the RXTX control unit 303, the frame transmission and reception unit 304, the communication unit 206, and the antennas 207 to transmit data to the destination STA using the communication parameters indicated by the ICF after waiting for a time of transition to the NPCS. If the frame processing unit 301 determines, based on a data accumulation state in a transmission buffer and the like, that a series of transmissions of traffic data to the destination STA is completed, the frame processing unit 301 advances the process to S1106.

[0105]

In S1106, the frame processing unit 301 transmits a CF-End frame or a QoS Null frame in response to completion of a series of traffic transmissions. The frame processing unit 301 then instructs the mode control unit 302 to update the operation state of the destination STA to the LPCS. Upon

receiving the instruction, the mode control unit 302 updates the operation state included in the state information corresponding to the destination STA from the NPCS to the LPCS.

[0106]

In S1107, the mode control unit 302 determines whether LPL Enabling/Disabling for the STA is required. Specifically, in a case where the mode control unit 302 receives an LPL Operating Mode Notification frame in cooperation with the respective units, the mode control unit 302 determines that LPL Enabling/Disabling is required. Further, the mode control unit 302 determines, based on the communication status, whether LPL Enabling/Disabling for a specific STA is required. For example, the mode control unit 302 can determine that LPL Enabling is required for an STA in the Active Mode with a decreased data transmission frequency. For example, the mode control unit 302 can determine that LPL Disabling is required for an STA in the LPL Enabled Mode for which a large amount of downlink data or low-latency data has occurred. This means that, based on the communication state recognized by the AP, the AP determines that there is a need to change the operation mode of a specific STA unsuitable or estimated to become unsuitable for the current operation mode.

[0107]

If the mode control unit 302 determines that LPL Enabling/Disabling is required, the mode control unit 302 advances the process to S1108. If the mode control unit 302 determines that LPL Enabling/Disabling is not required, the mode control unit 302 advances the process to S1109.

[0108]

In S1108, the mode control unit 302 cooperates with the respective units to execute an LPL Enabling/Disabling procedure. Specifically, in a case where the mode control unit 302 receives an LPL Operating Mode Notification frame in cooperation with the respective units, the mode control unit 302 transmits a response frame. Further, the mode control unit 302 updates information indicating the operation mode of the destination STA in the response frame to a new operation mode.

[0109]

If it is determined that there is a need to change the operation mode of the specific STA based on a determination made by the AP, the AP transmits an LPL Operating Mode Notification frame corresponding to the determination result and requests the specific STA to change the operation mode. Upon receiving the response frame, the mode control unit 302 updates information indicating the operation mode of the source STA in the response frame to the new operation mode.

[0110]

On the other hand, in S1109, the control unit 202 determines whether to stop the AP operation. If the control unit 202 determines to stop the AP operation, the series of processes ends. If the control unit 202 determines not to stop the AP operation, the control unit 202 advances the process to S1110. For example, the control unit 202 can determine to stop the AP operation upon receiving a user operation of pressing a shutdown button or a power button (not illustrated).

[0111]

In S1110, the control unit 202 executes other communication control. Specifically, the control unit 202 performs the connection control described with reference to Fig. 4, and communication control with an STA in the Active Mode or an STA in the NPCS operation state. As described above, in some cases, an STA in the LPCS operation state spontaneously transitions to the NPCS operation state and communicates data to the AP by using communication parameters corresponding to the High-Capability conditions. In a case where the mode control unit 302 receives data from an STA for which the currently managed state information indicates the LPCS by using communication parameters corresponding to the High-Capability conditions, the mode control unit 302 updates the operation state of the STA serving as the transmission source of the data. That is,

the mode control unit 302 updates the operation state included in the currently managed state information of the source STA from the LPCS to the NPCS.

[0112]

Finally, communication control performed by an STA that has transitioned to the LPL Enabled Mode, such as the STA 102, will be described with reference to Fig. 12.

[0113]

In S1200, the mode control unit 302 of the STA 102 cooperates with the frame processing unit 301 and the frame transmission and reception unit 304 to execute an LPL enabling procedure. Specifically, the mode control unit 302 transmits an LPL Operating Mode Notification frame in which the LPL Mode field 711 stores "1". Upon receiving a normal response to the frame, the mode control unit 302 cooperates with the RXTX control unit 303, the communication unit 206, and the antennas 207 to change the transmission and reception parameters to those for the LPCS. In a case where the LPL Operating Mode Notification frame includes the Low Power Listen Parameter Update field 705, the mode control unit 302 changes the transmission and reception parameters to transmission and reception parameters corresponding to the parameters indicated in the Low Power Listen Parameter Update field 705. In a case where the LPL Operating Mode Notification frame does not include the Low Power Listen

Parameter Update field 705, the mode control unit 302 changes the transmission and reception parameters to transmission and reception parameters shared in advance from the destination AP, such as the AP 101, by using a UHR Operation element.

[0114]

In S1201, the frame processing unit 301 cooperates with the respective units to determine whether a frame addressed to the STA 102 is received. If the frame processing unit 301 determines that a frame addressed to the STA 102 is received, the frame processing unit 301 advances the process to S1202. If the frame processing unit 301 determines that a frame addressed to the STA 102 is not received, the frame processing unit 301 advances the process to S1203.

[0115]

In S1202, the frame processing unit 301 determines whether the received frame is an LPL ICF. If the frame processing unit 301 determines that the received frame is an LPL ICF, the frame processing unit 301 advances the process to S1207. If the frame processing unit 301 determines that the received frame is not an LPL ICF, the frame processing unit 301 advances the process to S1206. The LPL ICF is, for example, the frame described with reference to Fig. 8.

[0116]

In S1203, the frame processing unit 301 determines

whether data transmission to the AP is required. If the frame processing unit 301 determines that data transmission to the AP is required, the frame processing unit 301 advances the process to S1204. If the frame processing unit 301 determines that data transmission to the AP is not required, the frame processing unit 301 advances the process to S1210.

[0117]

In S1204, the frame processing unit 301 identifies and estimates traffic characteristics. Specific processes are similar to those of the processing of S1101 described in the control performed by the AP, and description thereof is thus omitted.

[0118]

In S1205, the mode control unit 302 determines whether to perform communication of the traffic identified and estimated in S1204 while maintaining the LPCS. If the mode control unit 302 determines to perform communication of the traffic while maintaining the LPCS, the mode control unit 302 advances the process to S1206. If the mode control unit 302 determines not to perform communication of the traffic while maintaining the LPCS, the mode control unit 302 advances the process to S1207. For example, the frame processing unit 301 determines whether the transmission time in a case of transmitting the estimated traffic amount at

the communication rate at which communication is performed while the LPCS is maintained falls within a predetermined time. If the frame processing unit 301 determines that the transmission time falls within the predetermined time, the frame processing unit 301 determines to perform communication of the estimated traffic while maintaining the destination STA in the LPCS.

[0119]

In S1206, the control unit 202 cooperates with the respective units to execute data communication using communication parameters for the LPCS. In the case of a data reception process, the control unit 202 receives a frame using set reception parameters for the LPCS, analyzes a payload of the received frame as appropriate, and processes the payload. In the case of a data transmission process, the control unit 202 generates a frame including data to be transmitted using set transmission parameters for the LPCS, and transmits the frame. Upon completion of the data communication in the LPCS, the control unit 202 advances the process to S1210.

[0120]

In S1207, the mode control unit 302 cooperates with the respective units to change the communication parameters to those of the High-Capability conditions for the NPCS. In a case where no ICF is received, the communication parameters

are set to communication parameters used in the Active Mode and agreed upon in the connection process. In a case where an ICF is received, the communication parameters are changed to communication parameters stored in the ICF.

[0121]

In S1208, the control unit 202 executes data communication using the changed communication parameters. For data transmission, the control unit 202 executes data transmission using the changed transmission parameters for the NPCS. For data reception, the control unit 202 executes data reception using the changed reception parameters. Upon completion of the series of data communications, the control unit 202 advances the process to S1209.

[0122]

In S1209, the mode control unit 302 cooperates with the respective units to perform communication of a CF-End/QoS Null frame. After performing communication of the frame, the mode control unit 302 cooperates with the respective units to change the communication parameters to communication parameters corresponding to the Low-Capability conditions for the LPCS.

[0123]

In S1210, the mode control unit 302 determines whether Disabling of the LPL function is required. Specifically, the mode control unit 302 determines whether Disabling is

required, based on a determination similar to the determination described above with reference to S1005 to S1008. That is, in a case where any one of the following conditions is satisfied: a condition that the remaining battery level decreases to less than or equal to a threshold; a condition that a communication link is re-set up as an NSTR link pair; and a condition that communication quality is less than or equal to a predetermined threshold, the mode control unit 302 determines that Disabling is required. The mode control unit 302 also determines that Disabling is required in a case where a condition that a low-latency communication application is running is satisfied. The mode control unit 302 also determines that Disabling is required, based on a determination similar to the determination described with reference to S1002, that is, in a case where the user setting is changed and is changed to a setting to disable the LPL function during operation in the LPL Enabled Mode. If the mode control unit 302 determines that Disabling of the LPL function is required, the mode control unit 302 advances the process to S1211. If the mode control unit 302 determines that Disabling of the LPL function is not required, the mode control unit 302 advances the process to S1201.

[0124]

In S1211, the mode control unit 302 cooperates with the

respective units to execute an LPL Disabling procedure. Subsequently, the mode control unit 302 cooperates with the respective units to change the communication parameters for transmission and reception to communication parameters corresponding to the High-Capability conditions for the Active Mode. The parameters to be changed are communication parameters for the Active Mode, which are negotiated in advance in the connection process.

[0125]

<Modification 1>

In the embodiment described above, a case is illustrated in which an LPL Operating Mode Notification frame or a frame including a UHR Operation element is used to provide a notification of the MCS, the number of spatial streams, and the like used in the LPCS operation state. However, the present disclosure is not limited thereto. It is also possible to provide a notification of only information identifying a link corresponding to the Listen Link field 606 and use default communication parameters as the other communication parameters. As the default communication parameters, for example, communication parameters may be used, such as a single spatial stream, a minimum MCS for receiving a control frame such as an ICF, and only a primary 20-MHz bandwidth. A specific example will be described. The STA 102 operates as a Non-AP MLD. In

the Active Mode, the STA 102 performs Multi-Link communication established with the AP 101. On one of the links, MIMO communication may also be used, and communication with a high MCS and a 160-MHz bandwidth is also possible. In this state, upon receiving an LPL Operating Mode Notification, the STA 102 transitions to a condition in which communication can be performed with a bandwidth of 20 MHz on a single link specified by a link ID. Alternatively, the STA 102 transitions to a condition in which communication is performed with a single spatial stream without using MIMO or the like.

[0126]

<Modification 2>

In the embodiment described above, a case is illustrated in which communication parameters to be used are included in an ICF frame after transition to the NPCS is made; however, the present disclosure is not limited thereto. For example, transmission of the communication parameters may be omitted. In this case, it is only required to use the default communication parameters in a case where the state returns to the NPCS. As the default communication parameters, for example, communication parameters used for operation in the Active Mode negotiated in the connection process may be used.

[0127]

<Modification 3>

Information indicating whether the LPL function is supported, which is included in the UHR Capabilities element illustrated in Figs. 5A and 5B, may instead be configured to be included in the Multi-Link element. For example, a new field referred to as Extended MLD Capabilities is provided in a Common Info field of a Basic Multi-Link element of the Multi-Link element. The field may be configured to include information corresponding to the LPL Support field 504 or information corresponding to the LPL Tx Support field 514 and the LPL Rx Support field 515. The element may be included in a MAC frame such as an ML Probe Request, ML Probe Response, or Beacon frame.

[0128]

<Other Embodiment 1>

The disclosure of the present embodiment includes the following configurations.

[0129]

(Configuration 1)

A communication apparatus that performs wireless communication compliant with an IEEE 802.11 standard series, the communication apparatus including

transmission control means for controlling transmission of a frame to another communication apparatus, the frame including an information element in which information

indicating whether a second mode is supported is stored, the second mode being a mode in which communication is awaited in a state in which at least two or more conditions among the number of communication links, a bandwidth, and the number of spatial streams are changed to conditions estimated to consume less power than in a first mode, in order to suppress power consumption in a case where communication is awaited as compared with power consumption in a case where communication is awaited in the first mode.

[0130]

(Configuration 2)

The communication apparatus according to configuration 1, wherein the transmission control means controls transmission of the information to the other communication apparatus by transmitting a Beacon frame or an Association Response frame, the Beacon frame or the Association Response frame including the information element.

[0131]

(Configuration 3)

The communication apparatus according to configuration 1 or 2, wherein the transmission control means controls transmission of the information to the other communication apparatus by transmitting at least an Association Request frame including the information element.

[0132]

(Configuration 4)

The communication apparatus according to any one of configurations 1 to 3, wherein

the transmission control means controls transmission of the frame including the information element in which information indicating that the second mode is supported is stored, and

the communication apparatus further includes

transition means for, after a link for communication with the other communication apparatus is established, in a case where the other communication apparatus operates in the first mode, changing the two or more conditions to conditions estimated to consume less power than in the first mode, and causing an operation mode of the communication apparatus to transition to the second mode after information relating to enabling of the second mode is transmitted to the other communication apparatus.

[0133]

(Configuration 5)

The communication apparatus according to configuration 4, wherein

in a case where the communication apparatus is a non-AP (Access Point) MLD (Multi-Link Device) and operates in the first mode, the communication apparatus is capable of establishing a plurality of links with the other

communication apparatus and performing STR communication, and

the transition means changes to a condition in which communication with the other communication apparatus on a single link with a bandwidth of 20 MHz is possible and in which communication with the other communication apparatus is performed using a single spatial stream, and causes the operation mode to transition to the second mode.

[0134]

(Configuration 6)

The communication apparatus according to any one of configurations 1 to 5, wherein the information element is an information element included in a UHR MAC Capabilities Element or a UHR PHY Capabilities Element.

[0135]

(Configuration 7)

The communication apparatus according to any one of configurations 1 to 6, wherein the information element is capable of storing 1 or 0, 1 indicates that the second mode is supported, and 0 indicates that the second mode is not supported or that the second mode is in a disabled state.

[0136]

(Configuration 8)

The communication apparatus according to any one of configurations 1 to 7, wherein the frame in which the

information element is stored is at least one of a Beacon frame, a Probe Request frame, a Probe Response frame, an Association Request frame, an Association Response frame, a ReAssociation Request frame, a ReAssociation Response frame, and an Action frame.

[0137]

(Configuration 9)

A communication apparatus that performs wireless communication compliant with an IEEE 802.11 standard series, the communication apparatus including

transmission control means for transmitting a frame to another communication apparatus operating in a second mode, the frame causing transition to a first mode, the second mode being a mode in which communication is awaited in a state in which at least two or more conditions among the number of communication links, a bandwidth, and the number of spatial streams are changed to conditions estimated to consume less power than in the first mode, in order to suppress power consumption in a case where communication is awaited as compared with power consumption in a case where communication is awaited in the first mode, wherein

the transmission control means further transmits, to the other communication apparatus, information identifying a link to be used in the second mode.

[0138]

(Configuration 10)

The communication apparatus according to configuration 9, wherein the transmission control means transmits the frame including information indicating the two or more conditions.

[0139]

(Configuration 11)

The communication apparatus according to configuration 10, further including

determination means for determining the two or more conditions for causing the other communication apparatus to operate in the second mode, in accordance with a communication status with the other communication apparatus, wherein

the transmission control means transmits the determined two or more conditions to the other communication apparatus.

[0140]

(Configuration 12)

A control method for a communication apparatus that performs wireless communication compliant with an IEEE 802.11 standard series, the control method including

controlling transmission of a frame to another communication apparatus, the frame including an information element in which information indicating whether a second mode is supported is stored, the second mode being a mode in

which communication is awaited in a state in which at least two or more conditions among the number of communication links, a bandwidth, and the number of spatial streams are changed to conditions estimated to consume less power than in a first mode, in order to suppress power consumption in a case where communication is awaited as compared with power consumption in a case where communication is awaited in the first mode.

[0141]

(Configuration 13)

A control method for a communication apparatus that performs wireless communication compliant with an IEEE 802.11 standard series, the control method including

transmitting, to another communication apparatus operating in a second mode, a frame causing transition to a first mode and information identifying a link to be used in the second mode, the second mode being a mode in which communication is awaited in a state in which at least two or more conditions among the number of communication links, a bandwidth, and the number of spatial streams are changed to conditions estimated to consume less power than in the first mode, in order to suppress power consumption in a case where communication is awaited as compared with power consumption in a case where communication is awaited in the first mode.

[0142]

(Configuration 14)

A program for causing a computer to execute the control method for a communication apparatus according to configuration 12 or 13.

[0143]

<Other Embodiment 2>

The present disclosure may also be implemented by processing in which a program for implementing one or more functions in the embodiment described above is supplied to a system or an apparatus via a network or a storage medium and one or more processors in a computer of the system or the apparatus read and execute the program. The present disclosure may also be implemented by circuitry (e.g., an ASIC) that implements the one or more functions.

[0144]

The invention is not limited to the embodiment described above, and may be changed and modified in various ways without departing from the spirit and scope of the invention. Accordingly, to apprise the public of the scope of the invention, the following claims are made.

[0145]

This application is based upon and claims the benefit of priority from Japanese Patent Application No. 2024-057554 filed March 29, 2024, the disclosure of which is incorporated herein in its entirety by reference.

Reference Signs List

[0146]

101 AP MLD

102 non-AP MLD

206 communication unit

CLAIMS

[Claim 1]

A communication apparatus that performs wireless communication compliant with an IEEE 802.11 standard series, the communication apparatus comprising

transmission control means for controlling transmission of a frame to another communication apparatus, the frame including an information element in which information indicating whether a second Listen mode is supported is stored, the second Listen mode being a Listen mode for suppressing power consumption in a case where a Listen operation that is an operation of waiting for communication is performed, as compared with power consumption in a case where the Listen operation is performed in a first Listen mode, the second Listen mode enabling the Listen operation to be performed under a condition expected to consume less power than in the first Listen mode with respect to at least one of the number of communication links, a bandwidth, the number of spatial streams, and Modulation and Coding Scheme (MCS).

[Claim 2]

The communication apparatus according to claim 1, wherein the transmission control means controls transmission of the information to the other communication apparatus by transmitting a Beacon frame or an Association Response

frame, the Beacon frame or the Association Response frame including the information element.

[Claim 3]

The communication apparatus according to claim 1, wherein the transmission control means controls transmission of the information to the other communication apparatus by transmitting at least an Association Request frame including the information element.

[Claim 4]

The communication apparatus according to claim 1, wherein

the transmission control means controls transmission of the frame including the information element in which information indicating that the second Listen mode is supported is stored, and

the communication apparatus further comprises

transition means for, after a link for communication with the other communication apparatus is established, in a case where the other communication apparatus operates in the first Listen mode, changing a condition for at least one of the number of communication links, the bandwidth, the number of spatial streams, and the MCS to a condition estimated to consume less power than in the first Listen mode, and causing an operation mode of the communication apparatus to transition to the second Listen mode after information

relating to enabling of the second Listen mode is transmitted to the other communication apparatus.

[Claim 5]

The communication apparatus according to claim 4, wherein

in a case where the communication apparatus is a non-AP (Access Point) MLD (Multi-Link Device) and operates in the first Listen mode, the communication apparatus is capable of establishing a plurality of links with the other communication apparatus and performing STR communication, and

the transition means changes to a condition in which communication with the other communication apparatus on a single link with a bandwidth of 20 MHz is possible and in which communication with the other communication apparatus is performed using a single spatial stream, and causes the operation mode to transition to the second Listen mode.

[Claim 6]

The communication apparatus according to claim 1, wherein the information element is an information element included in a UHR MAC Capabilities Element or a UHR PHY Capabilities Element.

[Claim 7]

The communication apparatus according to claim 1, wherein the information element is capable of storing 1 or

0, 1 indicates that the second Listen mode is supported, and 0 indicates that the second Listen mode is not supported or that the second Listen mode is in a disabled state.

[Claim 8]

The communication apparatus according to any one of claims 1 to 7, wherein the frame in which the information element is stored is at least one of a Beacon frame, a Probe Request frame, a Probe Response frame, an Association Request frame, an Association Response frame, a ReAssociation Request frame, a ReAssociation Response frame, and an Action frame.

[Claim 9]

The communication apparatus according to claim 1, wherein the second Listen mode enables the Listen operation to be performed under conditions expected to consume less power than in the first Listen mode with respect to at least two or more of the number of communication links, the bandwidth, the number of spatial streams, and the Modulation and Coding Scheme (MCS).

[Claim 10]

The communication apparatus according to claim 1, wherein the Listen operation includes a Carrier Sense operation for checking a usage status of a wireless channel on which communication is to be attempted.

[Claim 11]

The communication apparatus according to claim 1, wherein conditions for at least two or more items among the number of communication links, the bandwidth, the number of spatial streams, and the MCS in the Listen operation are set based on a notification from the other apparatus.

[Claim 12]

The communication apparatus according to claim 1, wherein the first Listen mode is a mode in which the Listen operation is performed under communication conditions for all of the number of communication links, the bandwidth, the number of spatial streams, and the MCS under which the communication apparatus is capable of communicating.

[Claim 13]

A wireless communication apparatus comprising

transmission control means for controlling transmission of a frame to another communication apparatus, the frame including an information element indicating whether a second mode is supported, the second mode being a mode for suppressing power consumption in a communication standby state as compared with power consumption in the communication standby state in a first mode, the second mode enabling standby for communication in a state in which an MCS (Modulation and Coding Scheme) is expected to consume less power than in the first mode.

[Claim 14]

A communication apparatus that performs wireless communication compliant with an IEEE 802.11 standard series, the communication apparatus comprising

transmission control means for transmitting a frame to another communication apparatus operating in a second Listen mode, the frame causing transition to a first Listen mode, the second Listen mode being a Listen mode for suppressing power consumption in a case where a Listen operation that is an operation of waiting for communication is performed, as compared with power consumption in a case where the Listen operation is performed in the first Listen mode, the second Listen mode enabling the Listen operation to be performed with a condition of at least one of the number of communication links, a bandwidth, the number of spatial streams, and a Modulation and Coding Scheme (MCS) changed to a condition expected to consume less power than in the first Listen mode, wherein

the transmission control means further transmits, to the other communication apparatus, information identifying a link to be used in the second Listen mode.

[Claim 15]

The communication apparatus according to claim 14, wherein the transmission control means transmits the frame including information indicating two or more conditions among the number of communication links, the bandwidth, the

number of spatial streams, and the MCS.

[Claim 16]

The communication apparatus according to claim 15, further comprising

determination means for determining the two or more conditions for causing the other communication apparatus to operate in the second Listen mode, in accordance with a communication status with the other communication apparatus, wherein

the transmission control means transmits the determined two or more conditions to the other communication apparatus.

[Claim 17]

A control method for a communication apparatus that performs wireless communication compliant with an IEEE 802.11 standard series, the control method comprising

controlling transmission of a frame to another communication apparatus, the frame including an information element in which information indicating whether a second Listen mode is supported is stored, the second Listen mode being a Listen mode for suppressing power consumption in a case where a Listen operation that is an operation of waiting for communication is performed, as compared with power consumption in a case where the Listen operation is performed in a first Listen mode, the second Listen mode enabling the Listen operation to be performed under a

condition expected to consume less power than in the first Listen mode with respect to at least one of the number of communication links, a bandwidth, the number of spatial streams, and Modulation and Coding Scheme (MCS).

[Claim 18]

A control method for a communication apparatus that performs wireless communication compliant with an IEEE 802.11 standard series, the control method comprising:

transmitting a frame to another communication apparatus operating in a second mode, the frame causing transition to a first Listen mode, the second mode being a Listen mode for suppressing power consumption in a case where a Listen operation that is an operation of waiting for communication is performed, as compared with power consumption in a case where the Listen operation is performed in the first Listen mode, the second mode enabling the Listen operation to be performed with a condition of at least one of the number of communication links, a bandwidth, the number of spatial streams, and a Modulation and Coding Scheme (MCS) changed to a condition expected to consume less power than in the first Listen mode; and

transmitting information identifying a link to be used in the second Listen mode.

[Claim 19]

A program for causing a computer to execute the control

method for a communication apparatus according to claim 17 or 18.