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Application number: 202010924423.8

Application type: invention patent

Invention Name: Channel access method and related device for multi-link equipment

Application date: September 4, 2020

Applicant: Huawei Technologies Co., Ltd.

Inventors or designers: Guo Yuchen, Li Yunbo, Li Yiqing, Gan Ming

Director

Shen Changyu

May 28, 2021

# claims

1. A channel access method for a multi-link device, comprising:

When the length of a first physical layer protocol data unit (PPDU) sent by a first multi-link device on a first link is less than or equal to a first value, the first multi-link device does not start a media synchronization delay timer on a second link, wherein the first multi-link device cannot transmit and receive on the first link and the second link at the same time.

2. The method according to claim 1, wherein the first multi-link device does not start a media synchronization delay timer on the second link, comprising:

The energy detection threshold used by the idle channel assessment CCA on the second link is set to the first threshold, wherein the first threshold is -62dBm;

Alternatively, the first multi-link device sends frames other than the RTS frame and the MU-RTS frame after the backoff counter on the second link backs off to 0.

3. The method according to any one of claims 1 or 2, characterized in that the method further comprises:

The first multi-link device receives a first value, where the first value is carried in a beacon frame, an association response frame, or a reassociation response frame.

4. The method according to any one of claims 1 to 3, characterized in that the method further comprises:

When the length of the first PPDU is greater than the first value, the first multi-link device determines an initial value of a media synchronization delay timer corresponding to the length of the first PPDU, and starts the media synchronization delay timer with the initial value on the second link.

5. The method according to claim 4, further comprising:

The first multi-link device receives first indication information, where the first indication information is used to indicate a mapping relationship between a PPDU length and an initial value of a media synchronization delay timer.

6. The method according to any one of claims 1 to 5, characterized in that the method further comprises:

When the length of the first PPDU is greater than the first value, the first multi-link device starts the media synchronization delay timer on the second link;

During the time period of the media synchronization delay timer, if the first multi-link device performs channel contention on the second link, an energy detection threshold used by CCA on the second link is set to a threshold value corresponding to the length of the first PPDU.

7. The method according to claim 6, wherein before the first multi-link device sends the first PPDU on the first link, the method further comprises:

The first multi-link device receives second indication information, where the second indication information is used to indicate a mapping relationship between a PPDU length and an energy detection threshold.

8. A channel access method for a multi-link device, comprising:

When the type of the first frame sent by the first multi-link device on the first link is the first type, the first multi-link device

The first multi-link device does not start a media synchronization delay timer on the second link, wherein the first multi-link device cannot send and receive on the first link and the second link at the same time.

9. The method according to claim 8, wherein when the first frame is any of the following frames, the type of the first frame is the first type: a request to send (RTS) frame, a multi-user request to send (MU-RTS) frame, a power save poll (PS-Poll) frame, a clear to send (CTS) frame, a status report (BSR) frame, a bandwidth query report (BQR) frame, a null data packet (NDP) frame, an acknowledgement (ACK) frame, and a block acknowledgement (BA) frame.

10. The method according to claim 8 or 9, wherein the first multi-link device does not start a media synchronization delay timer on the second link, comprising:

The energy detection threshold used by the idle channel assessment CCA on the second link is set to the first threshold, wherein the first threshold is -62dBm;

Alternatively, the first multi-link device sends frames other than the RTS frame and the MU-RTS frame after the backoff counter on the second link backs off to 0.

11. A first multi-link device, comprising:

a processing unit, configured to, when a length of a first PPDU sent by the first multi-link device on a first link is less than or equal to a first value, not start a media synchronization delay timer on a second link, wherein the first multi-link device cannot transmit and receive on the first link and the second link at the same time.

12. The first multi-link device according to claim 11, wherein the processing unit is specifically configured to: set an energy detection threshold used by a clear channel assessment (CCA) on the second link to a first threshold, wherein the first threshold is -62dBm;

Alternatively, the first multi-link device further includes a transceiver unit, configured to send frames other than the RTS frame and the MU-RTS frame after the backoff counter on the second link backs off to 0.

13. The first multi-link device according to claim 11 or 12, characterized in that the first multi-link device further comprises a transceiver unit, wherein the transceiver unit is configured to receive a first value, wherein the first value is carried in a beacon frame, an association response frame, or a reassociation response frame.

14. The first multi-link device according to any one of claims 11 to 13, wherein the processing unit is further configured to: when the length of the first PPDU is greater than the first value, determine an initial value of a media synchronization delay timer corresponding to the length of the first PPDU, and start the media synchronization delay timer with the initial value on the second link.

15. The first multi-link device according to claim 14, further comprising a transceiver unit, wherein the transceiver unit is configured to receive first indication information, wherein the first indication information is configured to indicate a mapping relationship between a PPDU length and an initial value of a media synchronization delay timer.

16. The first multi-link device according to any one of claims 11 to 15, wherein the processing unit is further configured to:

When the length of the first PPDU is greater than the first value, starting the media synchronization delay timer on the second link;

During the time period of the media synchronization delay timer, if the communication device performs channel contention on the second link, an energy detection threshold used by CCA on the second link is set to a threshold value corresponding to the length of the first PPDU.

17. The first multi-link device according to claim 16, characterized in that the first multi-link device further comprises

The transceiver unit is used to receive second indication information, where the second indication information is used to indicate a mapping relationship between the PPDU length and the energy detection threshold.

18. A first multi-link device, comprising:

a processing unit, configured to, when a type of a first frame sent by the first multi-link device on a first link is a first type, cause the first multi-link device to not start a media synchronization delay timer on a second link, wherein the first multi-link device cannot transmit and receive on the first link and the second link at the same time.

19. The first multi-link device according to claim 18, wherein when the first frame is any of the following frames, the type of the first frame is the first type: request to send (RTS), multi-user request to send (MU-RTS), power save poll (PS-Poll), CTS, status report (BSR), bandwidth query report (BQR), null data packet (NDP), acknowledgement (ACK), or block acknowledgement (BA).

20. The first multi-link device according to claim 18 or 19, characterized in that the processing unit is specifically configured to set the energy detection threshold used by the idle channel assessment CCA on the second link to the first threshold, wherein the first threshold is -62dBm;

Alternatively, the first multi-link device further includes a transceiver unit, configured to send frames other than the RTS frame and the MU-RTS frame after the backoff counter on the second link backs off to 0.

21. A first multi-link device, comprising a processor configured to disable a media synchronization delay timer on a second link when a length of a first PPDU sent by the first multi-link device on a first link is less than or equal to a first value, wherein the first multi-link device cannot transmit and receive on the first link and the second link simultaneously.

22. A first multi-link device, characterized in that it includes a processor, wherein when the type of a first frame sent by the first multi-link device on a first link is a first type, the first multi-link device does not start a media synchronization delay timer on a second link, wherein the first multi-link device cannot send and receive on the first link and the second link at the same time.

23. A computer-readable storage medium storing program instructions, wherein when the program instructions are executed on a computer, the computer is caused to execute the method according to any one of claims 1 to 10.

24. A computer program product comprising program instructions, which, when executed on a computer, causes the computer to execute the method according to any one of claims 1 to 10.

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# Channel access method and related device for multi-link equipment

## Technical field

The present application relates to the field of wireless communication technology, and in particular to a channel access method and related apparatus for a multi-link device.

## Background technology

With the advancement of wireless communication technology, more and more wireless communication devices support multi-link communication. For example, they can communicate simultaneously on the 2.4 GHz, 5 GHz, and 6 GHz frequency bands, or on different channels within the same frequency band. Such wireless communication devices are commonly called multi-link devices (MLDs). Multi-link devices can significantly increase transmission rates by using multiple links for parallel communication.

While multi-link devices can increase transmission rates by communicating on multiple links in parallel, when the frequency spacing between the multiple bands supported by extremely high throughput (EHT) multi-link devices is close, transmitting on one band can affect receiving on another. For example, if an EHT multi-link device transmits on Link 1, due to the small frequency spacing between Links 1 and 2, the signal transmitted on Link 1 will cause channel interference on Link 2, affecting channel access and reception on Link 2. Therefore, this device cannot independently transmit and receive on multiple bands simultaneously to avoid mutual interference. The 802.11 TGbe standards group currently defines EHT multi-link devices as capable of both simultaneous transmitting and receiving (STR) and non-simultaneous transmitting and receiving (non-STR).

When a non-STR-capable MLD (non-STR MLD) transmits on a link, interference affects the clear channel assessment (CCA) on other links, resulting in a blindness period (also known as a deaf period). A blind period means it is unable to detect any information on the channel, or is unable to detect any information on the channel. Therefore, when a non-STR MLD is inactive on certain links, how to access the channel on these links becomes a pressing issue.

## Contents of the invention

The embodiments of the present application provide a channel access method and related apparatus for a multi-link device, which can improve the efficiency of channel access when a non-STR MLD is in a blind state or a self-interference state.

The present application is introduced below from different aspects. It should be understood that the implementation methods and beneficial effects of the following different aspects can be referenced to each other.

In a first aspect, the present application provides a channel access method for a multi-link device, the method comprising: when the length of a first PPDU sent by a first multi-link device on a first link is less than or equal to a first value, the first multi-link device does not start a media synchronization delay timer on a second link, wherein the first multi-link device cannot transmit and receive on the first link and the second link at the same time.

The first multi-link device not starting the media synchronization delay timer on the second link includes: when the first multi-link device performs channel contention on the second link, setting an energy detection threshold used by a clear channel assessment (CCA) to a first threshold, where the first threshold is -62 dBm; or, after a backoff counter on the second link reaches 0, allowing the first multi-link device to send frames other than RTS frames and MU-RTS frames.

In this scheme, when the length of the PPDU sent on one link is less than or equal to a certain value, the media synchronization delay timer is not started on the other link, or the energy detection threshold used by CCA is set to 1 when channel contention occurs on the other link.

The channel access efficiency or channel access success rate of the first multi-link device on the other link is improved, or the channel access opportunity of the first multi-link device on the other link is increased.

In conjunction with the first aspect, in one possible implementation, the method further includes: the first multi-link device receiving a first value. The first value may be carried in a beacon frame, or in an association response frame or a reassociation response frame.

Optionally, the first value may be carried in a multi-link element, an extremely high throughput operation element, or a newly defined element.

In conjunction with the first aspect, in one possible implementation, the method further includes: when the length of the first PPDU is greater than the first value, the first multi-link device determines an initial value of a media synchronization delay timer corresponding to the length of the first PPDU, and starts the media synchronization delay timer on the second link using the initial value.

Optionally, the method further includes: the first multi-link device receiving first indication information, where the first indication information is used to indicate a mapping relationship between a physical layer protocol data unit (PPDU) length and an initial value of a media synchronization delay timer.

This solution determines the initial value of the media synchronization delay timer according to the length of the first PPDU, making the setting of the media synchronization delay timer more flexible.

In conjunction with the first aspect, in one possible implementation, the method further includes: when the length of the first PPDU is greater than the first value, the first multi-link device starting the media synchronization delay timer on the second link; and within the time period of the media synchronization delay timer, if the first multi-link device performs channel contention on the second link, setting the energy detection threshold used by CCA on the second link to the threshold value corresponding to the length of the first PPDU.

Optionally, before the first multi-link device sends the first PPDU on the first link, the method further includes: the first multi-link device receives second indication information, where the second indication information is used to indicate a mapping relationship between the PPDU length and the energy detection threshold.

This solution determines the energy detection threshold based on the length of the first PPDU, making the channel access mechanism on the second link more flexible, thereby improving the channel access efficiency.

In a second aspect, the present application provides a first multi-link device or a chip in the first multi-link device, such as a Wi-Fi chip. The first multi-link device may be a non-STR Multi-Link Device (MLD). The first multi-link device includes a processing unit configured to disable a media synchronization delay timer on a second link when the length of a first PPDU sent by the first multi-link device on a first link is less than or equal to a first value, wherein the first multi-link device cannot transmit and receive on the first and second links simultaneously.

The processing unit is specifically configured to set an energy detection threshold used by a clear channel assessment (CCA) on the second link to a first threshold, where the first threshold is -62 dBm. Alternatively, the first multi-link device further includes a transceiver unit configured to transmit frames other than RTS frames and MU-RTS frames after a backoff counter on the second link reaches 0.

In conjunction with the second aspect, in one possible implementation, the first multi-link device further includes a transceiver unit, the transceiver unit further configured to receive a first value. The first value may be carried in a beacon frame, or in an association response frame or a reassociation response frame.

Optionally, the first value may be carried in a multi-link element, an extremely high throughput operation element, or a newly defined element.

In conjunction with the second aspect, in one possible implementation, the processing unit is further configured to: when the length of the first PPDU is greater than the first value, determine an initial value of a media synchronization delay timer corresponding to the length of the first PPDU, and start the media synchronization delay timer on the second link using the initial value.

Optionally, the first multi-link device further includes a transceiver unit, the transceiver unit further configured to: receive the first indication information, The first indication information is used to indicate a mapping relationship between the PPDU length and the initial value of the media synchronization delay timer.

In conjunction with the second aspect, in one possible implementation, the processing unit is further configured to: when the length of the first PPDU is greater than the first value, start the media synchronization delay timer on the second link; and within a time period of the media synchronization delay timer, if the first multi-link device performs channel contention on the second link, set the energy detection threshold used for CCA on the second link to a threshold value corresponding to the length of the first PPDU.

Optionally, the first multi-link device further includes a transceiver unit, which is further configured to: the first multi-link device receives second indication information, where the second indication information is used to indicate a mapping relationship between the PPDU length and the energy detection threshold.

In a third aspect, the present application provides a channel access method for a multi-link device, the method comprising: when a first frame sent by a first multi-link device on a first link is of a first type, the first multi-link device does not start a media synchronization delay timer on a second link, wherein the first multi-link device cannot transmit and receive simultaneously on the first link and the second link.

The first multi-link device not starting the media synchronization delay timer on the second link includes: when the first multi-link device performs channel contention on the second link, setting an energy detection threshold used by a clear channel assessment (CCA) to a first threshold, where the first threshold is -62 dBm; or, after a backoff counter on the second link of the first multi-link device backs off to 0, allowing transmission of frames other than RTS frames and MU-RTS frames.

Optionally, when the above-mentioned first frame is any of the following frames, the type of the first frame is the first type: request to send (RTS) frame, multi-user request to send (MU-RTS) frame, power save-Poll (PS-Poll) frame, CTS frame, buffer status report (BSR) frame, bandwidth query report (BQR) frame, null data packet (NDP) frame, acknowledgment (ACK) frame, and block acknowledgment (BA) frame.

Optionally, the first frame is a request to send (RTS) frame or a multiple user RTS (MU-RTS) frame. If the first multi-link device does not receive a clear to send (CTS) frame on the first link within a preset time, the first multi-link device does not start a media synchronization delay timer on the second link.

Optionally, the first frame is a power save-poll (PS-Poll) frame. If the first multi-link device does not receive a PS-Poll frame indicating permission to send on the first link within a preset time, the first multi-link device does not start a media synchronization delay timer on the second link.

Optionally, the first frame is a CTS frame. Before the first multi-link device sends the first PPDU on the first link, the method further includes: the first multi-link device receives an RTS frame or an MU-RTS frame on the first link.

Optionally, the first frame is a status report (BSR) frame. Before the first multi-link device sends the first PPDU on the first link, the method further includes: the first multi-link device receives a status report (BSRP) trigger frame on the first link.

Optionally, the first frame is a bandwidth query report (BQR) frame. Before the first multi-link device sends the first PPDU on the first link, the method further includes: the first multi-link device receiving a bandwidth query report poll (BQRP) trigger frame on the first link.

Optionally, the first frame is a Null Data Packet (NDP) frame. Before the first multi-link device sends the first PPDU on the first link, the method further includes: the first multi-link device receives a Beamforming Report Poll (BFRP) trigger frame on the first link.

Optionally, the first frame is an ACK frame or a BA frame. Before the first multi-link device sends the first PPDU on the first link, the first multi-link device receives a data frame or a management frame on the first link.

In a fourth aspect, the present application provides a first multi-link device or a chip in the first multi-link device, such as a Wi-Fi chip. The first multi-link device may be a non-STR Multi-Link Device (MLD). The first multi-link device includes a processing unit configured to, when a first frame sent by the first multi-link device on a first link is of a first type, disable a media synchronization delay timer on a second link by the first multi-link device, wherein the first multi-link device cannot transmit and receive on both the first and second links simultaneously.

The processing unit is specifically configured to set an energy detection threshold used by a clear channel assessment (CCA) on the second link to a first threshold, where the first threshold is -62 dBm. Alternatively, the first multi-link device further includes a transceiver unit configured to transmit frames other than RTS frames and MU-RTS frames after a backoff counter on the second link reaches 0.

Optionally, when the above-mentioned first frame is any of the following frames, the type of the first frame is the first type: request to send (RTS) frame, multi-user request to send (MU-RTS) （Power frame, power save poll save-Poll (PS-Poll) frame, CTS frame, buffer status report (BSR) frame, bandwidth query report (BQR) frame, null data packet (NDP) frame, acknowledgment (ACK) frame, (block ACK, BA) block acknowledgment frame.

Optionally, the first frame is an RTS frame or an MU-RTS frame. The processing unit is specifically configured to: when the first multi-link device does not receive a clear to send (CTS) frame on the first link within a preset time, not start a media synchronization delay timer on the second link.

Optionally, the first frame is a PS-Poll frame. The processing unit is specifically configured to: when the first multi-link device does not receive a PS-Poll frame indicating permission to send on the first link within a preset time, not start a media synchronization delay timer on the second link.

Optionally, the first frame is a CTS frame. The first multi-link device further includes a transceiver unit, the transceiver unit being configured to: receive an RTS frame or an MU-RTS frame on the first link.

Optionally, the first PPDU is a status report BSR frame. The first multi-link device further includes a transceiver unit configured to receive a status report polling BSRP trigger frame on the first link.

Optionally, the first PPDU is a bandwidth query report (BQR) frame. The first multi-link device further includes a transceiver unit configured to receive a bandwidth query report poll (BQRP) trigger frame on the first link.

Optionally, the first PPDU is a Null Data Packet (NDP) frame. The first multi-link device further includes a transceiver unit configured to receive a beamforming report polling (BFRP) trigger frame on the first link.

Optionally, the first PPDU is an ACK frame or a BA frame. The first multi-link device further includes a transceiver unit configured to receive a data frame or a management frame on the first link.

In a fifth aspect, the present application provides a method for determining an initial duration of a media synchronization delay timer, the method comprising: a first multi-link device receiving first indication information, the first indication information being used to indicate a mapping relationship between a PPDU length and an initial value (or initial duration) of a media synchronization delay timer; the first multi-link device determining, based on the length of a first PPDU sent on a first link, an initial value of the media synchronization delay timer corresponding to the length of the first PPDU, the initial value being used to determine whether to enable the media synchronization delay timer on a second link. The first multi-link device cannot transmit and receive on the first link and the second link simultaneously.

Optionally, the first multi-link device determines whether to start the media synchronization delay timer on the second link according to the initial value of the media synchronization delay timer corresponding to the length of the first PPDU.

Optionally, if the determined initial value of the media synchronization delay timer is equal to 0, the first multi-link device does not start the media synchronization delay timer on the second link. If the determined initial value of the media synchronization delay timer is equal to 0, the first multi-link device starts the media synchronization delay timer on the second link using the initial value.

The first multi-link device starts the mediumSyncDelay timer on the second link. This can be understood (or described) as follows: During the time the mediumSyncDelay timer is running, the first multi-link device can use a more conservative channel access mechanism on the second link. This more conservative channel access mechanism includes, but is not limited to: 1) using a lower energy detection threshold (here, an ED threshold lower than -62dBm) to determine whether the channel is busy; and 2) requiring the transmission of an RTS frame to test channel availability.

In this solution, different PPDU lengths/byte lengths correspond to different initial values of the mediumSyncDelay timer, making the setting of the mediumSyncDelay timer more flexible and improving channel access efficiency.

In a sixth aspect, the present application provides a method for determining the initial duration of a media synchronization delay timer, the method comprising: a second multi-link device generating and sending first indication information, the first indication information being used to indicate a mapping relationship between the PPDU length and the initial value (or initial duration) of the media synchronization delay timer.

In a seventh aspect, the present application provides a first multi-link device or a chip in the first multi-link device, such as a Wi-Fi chip. The first multi-link device may be a non-STR MLD. The communication device includes: a transceiver unit configured to receive first indication information indicating a mapping relationship between a PPDU length and an initial value of a media synchronization delay timer; and a processing unit configured to determine, based on the length of a first PPDU sent over a first link, an initial value of the media synchronization delay timer corresponding to the length of the first PPDU. The communication device cannot transmit and receive simultaneously on the first link and the second link.

Optionally, the above-mentioned processing unit is further used to determine whether to start the media synchronization delay timer on the second link based on the initial value of the media synchronization delay timer corresponding to the length of the first PPDU.

Optionally, the above-mentioned processing unit is specifically used to: if the determined initial value of the media synchronization delay timer is equal to 0, then the media synchronization delay timer is not started on the second link; if the determined initial value of the media synchronization delay timer is equal to 0, then the media synchronization delay timer is started on the second link.

In an eighth aspect, the present application provides a second multi-link device or a chip in the second multi-link device, such as a Wi-Fi chip. The second multi-link device may be an MLD of a STR. The communication device includes: a processing unit configured to generate first indication information indicating a mapping relationship between a PPDU length and an initial value (or initial duration) of a media synchronization delay timer; and a transceiver configured to transmit the first indication information.

In a ninth aspect, the present application provides a method for determining an energy detection threshold during a CCA process, the method comprising: a first multi-link device receiving second indication information, the second indication information being used to indicate a mapping relationship between a PPDU length and an energy detection threshold; the first multi-link device sending a first PPDU on a first link; the first multi-link device determining, based on the length of the first PPDU sent on the first link, an energy detection threshold corresponding to the length of the first PPDU, the energy detection threshold being used to determine whether to enable a media synchronization delay timer on a second link. The first multi-link device cannot transmit and receive on the first link and the second link simultaneously.

Optionally, the first multi-link device determines whether to start the media synchronization delay timer on the second link according to an energy detection threshold corresponding to the length of the first PPDU.

Optionally, if the determined energy detection threshold is equal to -62 dBm, the first multi-link device does not start the media synchronization delay timer on the second link. If the determined energy detection threshold is less than -62 dBm, the first multi-link device starts the media synchronization delay timer on the second link.

In this solution, different PPDU lengths/byte lengths correspond to different energy detection thresholds, making the channel access mechanism on the second link more flexible and improving the channel access efficiency.

In a tenth aspect, the present application provides a method for determining an energy detection threshold during a CCA process, the method comprising: a second multi-link device generates and sends second indication information, the second indication information being used to indicate a mapping relationship between the PPDU length and the energy detection threshold.

In an eleventh aspect, the present application provides a first multi-link device or a chip in the first multi-link device, such as a Wi-Fi chip. The first multi-link device may be a non-STR MLD. The communication device includes: a transceiver unit configured to receive second indication information indicating a mapping relationship between PPDU length and an energy detection threshold; and a processing unit configured to determine, based on the length of a first PPDU sent on the first link, an energy detection threshold corresponding to the length of the first PPDU. The energy detection threshold is used to determine whether to enable the media synchronization delay timer on the second link. The first multi-link device cannot transmit and receive on the first link and the second link simultaneously.

Optionally, the processing unit is further configured to determine whether to start the media synchronization delay timer on the second link based on an energy detection threshold corresponding to the length of the first PPDU. The communication device cannot transmit and receive simultaneously on the first link and the second link.

Optionally, the processing unit is specifically configured to: if the determined energy detection threshold is equal to -62dBm, then the first multi-link device does not start the media synchronization delay timer on the second link; if the determined energy detection threshold is less than -62dBm, then the first multi-link device starts the media synchronization delay timer on the second link.

In a twelfth aspect, the present application provides a second multi-link device or a chip in the second multi-link device, such as a Wi-Fi chip. The second multi-link device may be an MLD of a STR. The communication device includes: a processing unit configured to generate second indication information indicating a mapping relationship between a PPDU length and an energy detection threshold; and a transceiver configured to transmit the second indication information.

In a thirteenth aspect, the present application provides a first multi-link device, comprising a processor. Optionally, the device further comprises a transceiver. The processor is configured to, when a length of a first PPDU sent by the first multi-link device on a first link is less than or equal to a first value, not start a media synchronization delay timer on a second link, wherein the first multi-link device cannot transmit and receive on the first link and the second link simultaneously.

In one possible design, the processor is configured to, when a first frame sent by a first multi-link device on a first link is of a first type, cause the first multi-link device to not start a media synchronization delay timer on a second link, wherein the first multi-link device cannot transmit and receive simultaneously on the first link and the second link.

In one possible design, the transceiver is configured to receive first indication information indicating a mapping relationship between a PPDU length and an initial value (or initial duration) of a media synchronization delay timer; and the processor is configured to determine, based on the length of a first PPDU sent over a first link, an initial value of the media synchronization delay timer corresponding to the length of the first PPDU. The communication device cannot simultaneously transmit and receive on the first link and the second link.

In one possible design, the transceiver is configured to receive second indication information indicating a mapping relationship between a PPDU length/byte length and an energy detection threshold; the processor is configured to determine, based on the length of a first PPDU sent on the first link, an energy detection threshold corresponding to the length of the first PPDU, the energy detection threshold being used to determine whether to enable the media synchronization delay timer on the second link. The first multi-link device cannot transmit and receive on the first link and the second link simultaneously.

In a fourteenth aspect, the present application provides a second multi-link device, comprising a processor and a transceiver. The processor is configured to generate first indication information, the first indication information being configured to indicate a mapping relationship between a PPDU length and an initial value (or initial duration) of a media synchronization delay timer; and the transceiver is configured to transmit the first indication information.

In one possible design, the processor is used to generate second indication information, where the second indication information is used to indicate a mapping relationship between a PPDU length and an energy detection threshold; and the transceiver is used to send the second indication information.

In a fifteenth aspect, the present application provides a first multi-link device, which may be implemented as a chip product. The first multi-link device includes an input/output interface and a processing circuit. The input/output interface is configured to receive code instructions and transmit them to the processing circuit. The processing circuit is configured to disable a media synchronization delay timer on a second link when the length of a first PPDU is less than or equal to a first value. The first multi-link device cannot transmit and receive on both the first and second links simultaneously.

In one possible design, the input/output interface is used to receive code instructions and transmit them to the processing circuit, and the processing circuit is used to, when a first frame sent by a first multi-link device on a first link is of a first type, cause the first multi-link device to not start a media synchronization delay timer on a second link, wherein the first multi-link device cannot transmit and receive on the first link and the second link simultaneously.

In one possible design, the transceiver is used to receive the first indication information, and the input and output interface is used to receive the first indication information from the transceiver.

First indication information is received and sent to the processing circuit for processing, thereby obtaining a mapping relationship between the PPDU length indicated by the first indication information and the initial value (or initial duration) of the media synchronization delay timer; the processing circuit is configured to determine, based on the length of the first PPDU sent on the first link, the initial value of the media synchronization delay timer corresponding to the length of the first PPDU, wherein the initial value is used to determine whether to enable the media synchronization delay timer on the second link. The first multi-link device cannot simultaneously transmit and receive on the first link and the second link.

In one possible design, the transceiver is used to receive second indication information, the input/output interface is used to receive the second indication information from the transceiver, and send the second indication information to the processing circuit for processing, to obtain a mapping relationship between the PPDU length indicated by the second indication information and the energy detection threshold; the processing circuit is used to determine the energy detection threshold corresponding to the length of the first PPDU based on the length of the first PPDU sent on the first link, and the energy detection threshold is used to determine whether to start the media synchronization delay timer on the second link. The first multi-link device is used to determine whether to start the media synchronization delay timer on the first link and the second link. Cannot send and receive at the same time.

In a sixteenth aspect, the present application provides a second multi-link device, which may be in the form of a chip product. The structure of the second multi-link device includes an input/output interface and a processing circuit. The input/output interface is configured to receive code instructions and transmit them to the processing circuit. The processing circuit is configured to generate first indication information, the first indication information indicating a mapping relationship between the PPDU length and the initial value (or initial duration) of the media synchronization delay timer. The input/output interface is configured to transmit the first indication information to a transceiver, and the transceiver is configured to transmit the first indication information.

In one possible design, the input-output interface is used to receive code instructions and transmit them to the processing circuit; the processing circuit is used to generate second indication information, where the second indication information is used to indicate a mapping relationship between the PPDU length and the energy detection threshold; the input-output interface is used to send the second indication information to the transceiver; and the transceiver is used to send the second indication information.

In the seventeenth aspect, the present application provides a computer-readable storage medium, which stores instructions. When the instructions are executed on a computer, the computer executes the method described in the first aspect, or the third aspect, or the fifth aspect, or the seventh aspect, or the ninth aspect, or the tenth aspect.

In an eighteenth aspect, the present application provides a computer program product comprising program instructions, which, when executed on a computer, enables the computer to execute the method described in the first aspect, or the third aspect, or the fifth aspect, or the seventh aspect, or the ninth aspect, or the tenth aspect.

By implementing the embodiments of the present application, the efficiency of channel access can be improved when the non-STR MLD is in a blind state or a self-interference state.

## Description of drawings

In order to more clearly illustrate the technical solutions of the embodiments of the present application, the following briefly introduces the drawings required for describing the embodiments.

Figure 1 is a schematic diagram of non-AP MLD and APMLD communication provided in an embodiment of the present application;

Figure 2 is a schematic diagram of the architecture of a wireless communication system provided in an embodiment of the present application;

Figure 3a is a schematic structural diagram of a multi-link device provided in an embodiment of the present application;

Figure 3b is another schematic structural diagram of a multi-link device according to an embodiment of the present application;

Figure 4 is a schematic flow chart of a channel access method for a multi-link device provided in an embodiment of the present application;

Figure 5 is another schematic flow chart of a channel access method for a multi-link device provided in an embodiment of the present application;

Figure 6a is a schematic diagram of the frame structure of a multi-link element provided in an embodiment of the present application;

Figure 6b is a schematic diagram of the frame structure of the EHT operation element provided in an embodiment of the present application;

Figure 6c is a schematic diagram of the frame structure of a non-STR MLD parameter set element provided in an embodiment of the present application;

Figure 7 is a schematic flow chart of a method for determining the initial duration of a media synchronization delay timer according to an embodiment of the present application;

FIG8 is a mapping relationship between the PPDU length and the initial value of the media synchronization delay timer provided in an embodiment of the present application Schematic diagram:

Figure 9 is a schematic flowchart of a method for determining an energy detection threshold during CCA according to an embodiment of the present application;

Figure 10 is a schematic diagram of the mapping relationship between the PPDU length and the energy detection threshold provided in an embodiment of the present application;

Figure 11 is a schematic structural diagram of a first multi-link device provided in an embodiment of the present application;

FIG12 is a schematic structural diagram of a second multi-link device provided in an embodiment of the present application.

Detailed implementation

The technical solutions in the embodiments of the present application will be described clearly and completely below in conjunction with the accompanying drawings in the embodiments of the present application.

To facilitate understanding of the channel access method for a multi-link device provided in the embodiments of this application, the system architecture and/or application scenarios of the channel access method for a multi-link device provided in the embodiments of this application are described below. It should be understood that the system architecture and/or application scenarios described in the embodiments of this application are intended to more clearly illustrate the technical solutions of the embodiments of this application and do not constitute a limitation of the technical solutions provided in the embodiments of this application.

Embodiments of the present application provide a channel access method for non-STR MLDs, which can improve channel access efficiency when the non-STR MLD is in a blind state or self-interference state. This channel access method for a multi-link device can be implemented by a communication device in a wireless communication system, or by a chip or processor within the communication device. The communication device can be a wireless communication device that supports parallel transmission of multiple links, for example, a multi-link device or a multi-band device. Compared to communication devices that only support single-link transmission, multi-link devices have higher transmission efficiency and greater throughput.

A multi-link device includes one or more affiliated stations (affiliated STAs). An affiliated station is a logical station that can operate on a link, a frequency band, or a channel. An affiliated station can be an access point (AP) or a non-access point station (non-APSTA). For ease of description, this application refers to a multi-link device whose affiliated station is an AP as a multi-link AP, a multi-link AP device, or an AP multi-link device (APMLD), and a multi-link device whose affiliated station is a non-APSTA as a multi-link non-AP, a multi-link non-AP device, or a non-AP multi-link device (non-AP MLD).

Optionally, a multi-link device may include multiple logical sites, each of which operates on one link, but multiple logical sites are allowed to operate on the same link.

Optionally, one or more STAs in a non-AP MLD can establish an association with one or more APs in an AP MLD before communicating. See Figure 1, which is a schematic diagram of communication between a non-AP MLD and an AP MLD, provided in an embodiment of the present application. As shown in Figure 1, the AP MLD includes AP1, AP2, ..., APn; the non-AP MLD includes STA1, STA2, ..., STAn. The AP MLD and non-AP MLD can communicate in parallel using links 1, 2, ..., and 3. STA1 in the non-AP MLD establishes an association with AP1 in the AP MLD, STA2 in the non-AP MLD establishes an association with AP2 in the AP MLD, and STAn in the non-AP MLD establishes an association with APn in the AP MLD.

Optionally, the multi-link device can implement wireless communication in accordance with the IEEE 802.11 series of protocols, for example, an extremely high throughput (EHT) station, or a station based on or compatible with IEEE 802.11be, to communicate with other devices.

The channel access method of the multi-link device provided in the embodiment of the present application can be applied to the scenario where one node communicates with one or more nodes; it can also be applied to the uplink/downlink communication scenario of a single user, the uplink/downlink communication scenario of multiple users, and the like.

It can also be applied to device-to-device (D2D) communication scenarios.

Any of the above nodes can be an APMLD or a non-APMLD. For example, an AP MLD communicates with a non-AP MLD, or an APMLD communicates with an APMLD, or a non-AP MLD communicates with a non-AP MLD. This is not limited in the present embodiment.

in any of the above scenarios, there is at least one node that cannot send and receive at the same time, that is, it has non-STR capability.

Optionally,

Optionally, for ease of description, the following describes the system architecture of the present application using a scenario in which an APMLD communicates with a non-AP MLD as an example. The channel access method for a multi-link device provided in an embodiment of the present application can be applied in a wireless local area network (WLAN). See Figure 2, which is a schematic diagram of the architecture of a wireless communication system provided in an embodiment of the present application. As shown in Figure 2, the wireless communication system includes at least one AP MLD and at least one non-AP MLD. The APMLD is a multi-link device that provides services for the non-AP MLD, and the non-AP MLD can communicate with the AP MLD using multiple links. An AP in the AP MLD can communicate with a STA in the non-AP MLD via a single link. It is understood that the number of APMLDs and non-AP MLDs in Figure 2 is merely exemplary. Optionally, the wireless communication system includes at least one MLD with non-STR capabilities.

Exemplarily, a multi-link device (which can be either a non-AP MLD or an AP MLD) is a device with wireless communication capabilities. The device can be a complete device, or a chip or processing system installed in the complete device. Devices installed with these chips or processing systems can implement the methods and functions of the embodiments of the present application under the control of these chips or processing systems. For example, the non-AP multi-link device in the embodiment of the present application has wireless transceiver capabilities, can support the 802.11 series protocols, and can communicate with AP multi-link devices or other non-AP multi-link devices. For example, a non-AP multi-link device is any user communication device that allows a user to communicate with an AP and then communicate with a WLAN. For example, a non-AP multi-link device can be a tablet computer, desktop, laptop, notebook computer, ultra-mobile personal computer, or similar. These devices include ultra-mobile personal computers (UMPCs), handheld computers, netbooks, personal digital assistants (PDAs), mobile phones, and other internet-connected user devices, as well as IoT nodes in the Internet of Things (IoT) and in-vehicle communication devices in the Internet of Vehicles (IoV). Non-AP multi-link devices can also be chips and processing systems within these terminals. AP multi-link devices can be devices that provide services to non-AP multi-link devices and support the 802.11 family of protocols. For example, AP multi-link devices can be communication entities such as communication servers, routers, switches, and bridges. Alternatively, AP multi-link devices can include various types of macro base stations, micro base stations, and relay stations. AP multi-link devices can also be chips and processing systems within these various devices. The 802.11 protocol can be one that supports or is compatible with 802.11be.

It is understood that multi-link devices can support high-speed, low-latency transmission. As wireless LAN application scenarios continue to evolve, multi-link devices can be applied to more scenarios, such as sensor nodes in smart cities (e.g., smart water meters, smart electricity meters, and smart air quality monitoring nodes), smart devices in smart homes (e.g., smart cameras, projectors, display screens, televisions, speakers, refrigerators, washing machines, etc.), nodes in the Internet of Things, entertainment terminals (e.g., wearable devices such as AR and VR), smart devices in smart offices (e.g., printers and projectors), Internet of Vehicles devices, and some infrastructure in daily life scenarios (e.g., vending machines, self-service navigation kiosks in supermarkets, self-service checkout devices, and self-service ordering machines). The specific form of the multi-link device is not limited in the embodiments of this application and is provided for illustrative purposes only.

Optionally, refer to Figure 3a, which is a structural diagram of a multi-link device provided in an embodiment of the present application. The IEEE 802.11 standard focuses on the 802.11 physical layer (PHY) and media access control (MAC) layer in a multi-link device. As shown in Figure 3, the multiple STAs included in the multi-link device are independent of each other in the low MAC layer and the PHY layer, and are also independent of each other in the high MAC layer. Refer to Figure 3b, which is another structural diagram of a multi-link device provided in an embodiment of the present application. As shown in Figure 3b, the multiple STAs included in the multi-link device are independent of each other in the low MAC layer and the PHY layer, and share the high MAC layer. Of course, Non-AP

A multi-link device can employ a structure in which the high MAC layer is independent of each other, or a structure in which the high MAC layer is shared. Similarly, an AP multi-link device can employ a structure in which the high MAC layer is shared or independent of each other. The embodiments of the present application are not limited to the schematic diagram of the internal structure of the multi-link device; Figures 3a and 3b are merely exemplary. For example, the high MAC layer or the low MAC layer can be implemented by a processor in the chip system of the multi-link device, or respectively by different processing modules in the chip system.

For example, the multi-link device in the embodiments of the present application can be a single-antenna device or a multi-antenna device. For example, it can be a device with two or more antennas. The embodiments of the present application do not limit the number of antennas included in the multi-link device. In the embodiments of the present application, the multi-link device can allow services of the same access category (AC) to be transmitted on different links, and even allow the same data packet to be transmitted on different links. Alternatively, the multi-link device can disallow services of the same access category from being transmitted on different links, but allow services of different access categories to be transmitted on different links.

The frequency bands in which the multi-link device operates may include one or more frequency bands of sub 1 GHz, 2.4 GHz, 5 GHz, 6 GHz, and high frequency 60 GHz.

When a non-STR MLD is transmitted on one link (for example, Link 1), channel interference can cause it to misjudge the channel status on one or more links (for example, Link 2). This can also affect its reception of overlapping basic service set (OBSS) frames on Link 2. OBSS frames are used by sites to update the network allocation vector (NAV). Therefore, before a non-STR MLD finishes transmitting on one link, it may miss OBSS frames on other links, thus missing the NAV update. This can cause the non-STR MLD to compete for and access the channel on Link 2 after completing its transmission on Link 1. This can lead to collisions between the data sent on Link 2 and the received OBSS frames. This is known as a blinding problem or self-interference.

It can be understood that NAV can be thought of as a countdown timer that gradually decreases with the passage of time. When the countdown reaches 0, the medium is considered idle. Specifically, when a station receives a frame, if the frame's recipient address is not the station itself, the station can update the NAV based on the duration field in the received frame. If the frame's recipient address is the station itself, it indicates that the station is the receiving station and the NAV cannot be updated. Before updating the NAV, it can also determine whether the value of the duration field in the current frame is greater than the station's current NAV value. If so, the NAV is updated; otherwise, if it is less than or equal to the current NAV, the NAV is not updated. The NAV value is calculated from the end of the received frame.

To address the blinding issue of non-STR MLD, embodiments of the present application propose a medium Sync Delay mechanism. Specifically, after a non-STR MLD is transmitted on one link (e.g., link 1), a timer, namely the medium Sync Delay timer, is started on another link. During the duration of this medium Sync Delay timer, the non-STR MLD must adopt a more conservative channel access mechanism on link 2. This more conservative channel access mechanism includes, but is not limited to: 1) using a lower energy detection (ED) threshold to determine whether the channel is busy. In channel access mechanisms, -62dBm is typically used as the ED threshold. If the energy detected on the channel exceeds this threshold, i.e., -62dBm, the channel is considered busy. When using an ED threshold lower than -62dBm, signals farther away during CCA detection will cause the channel to be busy, resulting in more conservative channel access. The lower ED threshold can be, for example, -82dBm or -72dBm. 2) A request to send (RTS) frame must be sent to test the channel availability. Optionally, the number of times the test is performed (or the number of times the RTS frame is sent) can be only one, or a finite number of times.

In the above media synchronization delay mechanism, no matter what type of frame non-STRMLD sends on link 1, as long as it is sent on link 1, non-STRMLD will adopt a more conservative channel access mechanism on link 2. However, the frames sent by non-STRMLD on link 1 are various, which may be control frames, data frames or management frames. Data frames can also be

Frames can be long or short. Therefore, when the length of the frame sent by the non-STR MLD on Link 1 is short, the non-STR MLD is blinded for a correspondingly shorter period on Link 2, making it less likely (or likely) that the non-STR MLD will miss important information (such as NAV) on Link 2. Therefore, in this media synchronization delay mechanism, as long as the non-STR MLD is transmitted on Link 1, its channel access on Link 2 must be restricted. This will result in low channel access efficiency, a low channel access success rate, or reduced channel access opportunities on Link 2.

In this application, "non-STR MLD is in a blind state on a certain link" can also be understood as that the STA working on the link in the non-STR MLD is in a blind state.

It is understandable that the "blind state" mentioned in this application can also be called "self-interference state" or "unreceivable state". or "deaf state", etc.

It is understandable that the "non-STR MLD" in this application may refer to an EHTMLD that is not capable of simultaneously transmitting and receiving.

It is understood that the "long frames" and "short frames" mentioned in this application are distinguished by the length of time a frame occupies the air interface. For example, a "long frame" may refer to a frame that occupies the air interface for a length greater than or equal to a preset value A, while a "short frame" may refer to a frame that occupies the air interface for a length less than or equal to a preset value B. Preset value A and preset value B may be the same or different. For example, the preset value A may be 1 ms (milliseconds), and the preset value B may be 100 us (microseconds).

Embodiments of the present application provide a channel access method for a multi-link device, which can improve the channel access efficiency or channel access success rate of a non-STR MLD on these links, or increase the channel access opportunities of a non-STR MLD on these links, when the non-STR MLD is in a blind state or a self-interference state.

The technical solution provided in this application will be described in detail below with reference to more drawings.

It is understandable that the first multi-link device in this application can be a non-STR MLD, and the second multi-link device can be a STR MLD. For ease of description, this application uses the example of two MLDs communicating via two or more links. While the following embodiments illustrate the technical solution of this application using two links as an example, the technical solution of this application is also applicable to two MLDs supporting multiple links.

The technical solutions provided in this application are illustrated through Examples 1 to 4. Example 1 describes how to perform channel access on one link when a specific type of frame is sent on another link. Example 2 describes how to determine whether a more conservative channel access mechanism is needed on another link based on the length of frames sent on one link. Example 3 describes how to determine the initial duration of the mediumSyncDelay timer. Example 4 describes how to determine the ED threshold used in the CCA process.

The following describes in detail the first to fourth embodiments. It is understood that the technical solutions described in the first to fourth embodiments of the present application can be combined in any way to form new embodiments.

Embodiment 1

Embodiment 1 of the present application introduces how to determine whether a more conservative channel access mechanism needs to be adopted on another link based on the type of frames sent on one link.

Referring to FIG4 , FIG4 is a schematic flow chart of a channel access method for a multi-link device provided in an embodiment of the present application. As shown in FIG4 , the channel access method for a multi-link device includes but is not limited to the following steps:

S101: When a first frame sent by a first multi-link device on a first link is of a first type, the first multi-link device does not start a media synchronization delay timer on a second link, and the first multi-link device cannot transmit and receive simultaneously on the first link and the second link.

Wherein, when the first frame is any of the following frames, the type of the first frame is the first type: a request to send frame, a multiple user request to send (multiple user RTS) frame, a power save-poll (PS-Poll) frame,

frame, clear to send (CTS) frame, buffer status report (BSR) frame, bandwidth query report (BQR) frame, null data packet (NDP) frame, acknowledgement (ACK) frame, and block acknowledgement (BA) frame.

In a first implementation, the first frame is an RTS frame or an MU-RTS frame. Specifically, if the first multi-link device sends an RTS frame or an MU-RTS frame on the first link and the first multi-link device does not receive a clear-to-send frame within a preset time, the first multi-link device does not start the mediumSyncDelay timer on the second link. The first multi-link device cannot transmit and receive on the first link and the second link simultaneously. In other words, if the first multi-link device does not receive a CTS frame on the first link within a preset time (e.g., a short inter-frame space (SIFS) plus a slot time, plus a physical layer reception delay, i.e., aSIFST Time + a Slot Time + a RxPHYStartDelay) after sending an RTS/MU-RTS frame on the first link, the first multi-link device does not start the mediumSyncDelay timer on the second link.

The first multi-link device not starting the mediumSyncDelay timer on the second link can be understood (or described) as follows: when the first multi-link device performs channel contention on the second link, the energy detection threshold used in the CCA operation is the first threshold; or, after the first multi-link device backs off to 0 on the second link, it is allowed to directly send frames other than RTS and MU-RTS frames. In other words, after the first multi-link device backs off to 0 on the second link, it does not send RTS/MU-RTS frames to perform channel protection or channel availability testing. The first threshold can be -62dBm.

Understandably, the reason why the first multi-link device did not receive the CTS frame within the preset time (e.g., a SIFS time + a slot time + a RxPHY start delay) may be: (a) the RTS frame sent by the first multi-link device conflicts with a frame sent by another device; (b) the receiver of the RTS frame sent by the first multi-link device fails to successfully receive the RTS frame; or (c) the receiver of the RTS frame sent by the first multi-link device is busy.

Optionally, if the first multi-link device has started a mediumSyncDelay timer on the second link after sending the RTS/MU-RTS frame on the first link, and the first multi-link device has not received a CTS frame within the preset time, the first multi-link device turns off (or stops, or cancels) the mediumSyncDelay timer.

Optionally, if the first multi-link device receives a CTS frame within the preset time, the first multi-link device may start the mediumSyncDelay timer. The first multi-link device starting the mediumSyncDelay timer on the second link can be understood (or described) as the first multi-link device adopting a more conservative channel access mechanism on the second link. Specifically, a lower energy detection threshold (lower than -62dBm, such as -82dBm) is used to determine whether the channel is busy, and RTS/MU-RTS frames must be sent to test channel availability. Optionally, the number of probes (or the number of RTS/MU-RTS frames sent) can be limited to one or a finite number of times.

Optionally, the "RTS frame or MU-RTS frame" in the first implementation described above can be replaced by a Power Save-Poll (PS-Poll) frame, and the "CTS frame" can be replaced by a data frame or an acknowledgment (ACK) frame. Therefore, the first implementation described above can also be described as follows: if the first multi-link device sends a PS-Poll frame on the first link and the first multi-link device does not receive a data frame or an acknowledgment frame within the preset time, the first multi-link device does not start the media synchronization delay timer on the second link. Optionally, if the first multi-link device sends a PS-Poll frame on the first link and the first multi-link device receives a data frame or an acknowledgment frame within the preset time, the first multi-link device may start the mediumSyncDelay timer.

It can be seen that in the embodiment of the present application, when the non-STRMLD (i.e., the first multi-link device) sends an RTS (or MU-RTS) on the first link but does not receive a CTS frame, the mediumSyncDelay timer is not started on the second link, so that the non-STR MLD performs normal channel contention on the second link, that is, the energy detection threshold used in the CCA operation is -62dBm, or RTS/CTS frames may not be used for channel protection. This improves the non-STRMLD's channel protection on the second link.

The channel access efficiency or channel access success rate can be improved, or the channel access opportunity of non-STR MLD on the second link can be increased.

In a second implementation, the first frame is a CTS frame. Specifically, if the first multi-link device receives an RTS frame or MU-RTS frame on the first link and replies to/sends a CTS frame on the first link, the mediumSyncDelay timer is not started on the second link. The first multi-link device cannot transmit and receive on the first and second links simultaneously. In other words, the second multi-link device sends an RTS frame or MU-RTS frame on the first link. Accordingly, the first multi-link device receives the RTS frame or MU-RTS frame on the first link and replies to/sends a CTS frame on the first link. After the first multi-link device sends the CTS frame on the first link, the mediumSyncDelay timer is not started on the second link.

The first multi-link device not starting the medium SyncDelay timer on the second link can be understood (or described) as follows: when the first multi-link device performs channel contention on the second link, the energy detection threshold used in the CCA operation is the first threshold; or, after the first multi-link device backs off to 0 on the second link, it is allowed to directly send frames other than RTS and MU-RTS frames. In other words, after the first multi-link device backs off to 0 on the second link, it does not send RTS/MU-RTS frames to perform channel protection or channel availability testing. The first threshold can be -62dBm.

Optionally, if the first multi-link device has started a mediumSyncDelay timer on the second link after sending a CTS frame on the first link, the first multi-link device turns off (or stops or cancels) the mediumSyncDelay timer.

Optionally, the "RTS/CTS frame" in the second implementation above can be replaced by a buffer status report poll trigger (BSRP Trigger) frame/a buffer status report (BSR) frame, or a bandwidth query report poll trigger (BQRP Trigger) frame/a bandwidth query report. The multi-link device may receive a BSRP Trigger frame (BQR), a beamforming report poll trigger (BFRP Trigger) frame/null data packet (NDP) frame, a data frame/acknowledgement (ACK) frame, a management frame/ACK frame, or a data frame/block acknowledgement (BA) frame. Therefore, step S201 may also be described as: the first multi-link device receives a BSRP Trigger frame on the first link and replies to/sends a BSR frame on the first link; or the first multi-link device receives a BQRP Trigger frame on the first link and replies to/sends a BQR frame on the first link; or the first multi-link device receives a BFRP Trigger frame on the first link and replies to/sends an NDP frame on the first link; or the first multi-link device receives a data frame or a management frame on the first link and replies to/sends an ACK frame on the first link; or the first multi-link device receives a data frame on the first link and replies to/sends a BA frame on the first link. Accordingly, the second implementation manner can also be described as: after the first multi-link device sends a BSR frame, a BQR frame, or an NDP frame on the first link, it does not start the media synchronization delay timer on the second link.

It is understood that after the first multi-link device replies to/sends a CTS frame, NDP frame, BSR frame, BQR frame, ACK frame, or BA frame on the first link, the first multi-link device is in a receiving state on the first link. Therefore, reception on the first link does not affect channel contention on the second link. The first multi-link device can perform normal channel contention on the second link, i.e., the energy detection threshold used in the CCA operation is -62dBm, or RTS/CTS frames can be omitted for channel protection.

It can be seen that in the embodiment of the present application, after the non-STR MLD (i.e., the first multi-link device) receives an RTS (or MU-RTS) frame on the first link and replies with a CTS frame, the mediumSyncDelay timer is not started on the second link. This can improve the channel access efficiency or channel access success rate of the non-STR MLD on the second link, or increase the channel access opportunity of the non-STR MLD on the second link.

In the embodiment of the present application, when sending a specific type of frame, the media synchronization delay timer is not started on the second link.

When the non-STR MLD is in a blind state or a self-interference state, the channel access efficiency or channel access success rate of the non-STR MLD on these links is improved, or the channel access opportunities of the non-STR MLD on these links are increased.

Embodiment 2

Implementation 2 of this application introduces how the non-STR MLD performs channel access on the second link when the length of the PPDU sent by the non-STR MLD on the first link is less than a preset value.

Referring to FIG5 , FIG5 is another schematic flow chart of a channel access method for a multi-link device provided in an embodiment of the present application. As shown in FIG5 , the channel access method for a multi-link device includes but is not limited to the following steps:

S201: When a length of a first PPDU sent by a first multi-link device on a first link is less than or equal to a first value, the first multi-link device does not start a media synchronization delay timer on a second link, wherein the first multi-link device cannot transmit and receive on the first link and the second link simultaneously.

The first multi-link device not starting the medium SyncDelay timer on the second link can be understood (or described) as follows: when the first multi-link device performs channel contention on the second link, the energy detection threshold used in the CCA operation is the first threshold; or, after the first multi-link device backs off to 0 on the second link, it is allowed to directly send frames other than RTS and MU-RTS frames. In other words, after the first multi-link device backs off to 0 on the second link, it does not send RTS/MU-RTS frames to perform channel protection or channel availability testing. The first threshold can be -62dBm.

Optionally, if the first multi-link device has started a mediumSyncDelay timer on the second link after sending the first PPDU on the first link, then when it is determined that the length of the first PPDU is less than or equal to the first value, the first multi-link device turns off (or stops or cancels) the mediumSyncDelay timer.

Optionally, the first value may be a fixed value specified in the protocol, such as 50 us, 100 us, or 200 us.

Optionally, the first value may be determined by an access point (or AP MLD) and sent to a station (i.e., a non-AP MLD). Specifically, before step S201, the channel access method for a multi-link device in an embodiment of the present application may further include: step S202, where the second multi-link device sends indication information indicating the first value. Accordingly, the first multi-link device receives the indication information. The indication information may be carried in a beacon frame, or in an association response frame or a reassociation response frame. The first multi-link device may be a non-STR MLD, specifically a non-AP MLD of a non-STR. The second multi-link device may be a STR MLD, specifically an AP MLD of a STR.

In one implementation, the indication information may be located in a multi-link element. See Figure 6a, which is a schematic diagram of the frame structure of a multi-link element provided in an embodiment of the present application. As shown in Figure 6, the multi-link element may include an element ID field, a length field, an element ID extension field, a multi-link control field, a medium Sync Delay timer threshold field, and optional subelements fields. The medium Sync Delay timer threshold field is used to indicate a first value.

In another implementation, the indication information may be located in an EHT operation element. See Figure 6b, which is a schematic diagram of the frame structure of an EHT operation element provided in an embodiment of the present application. As shown in Figure 6b, the EHT operation element may include an element ID field, a length field, an element ID extension field, and a medium Sync Delay timer threshold field. The medium Sync Delay timer threshold field is used to indicate a first value.

In another implementation, a new information element may be defined to carry the indication information. This new information element is used to carry the configuration parameters of the non-STR MLD. Optionally, this new information element may be called a non-STR MLD parameter set element. It is understood that this new information element may have other names, which are not limited in this embodiment of the present application. See Figure 6c, which shows a non-STR MLD parameter set element provided in this embodiment of the present application.

6c, the non-STR MLD parameter set element may include an element ID field, a length field, an element ID extension field, and a mediumSyncDelay timer threshold field. The mediumSyncDelay timer threshold field is used to indicate a first value.

Optionally, when the length of the first PPDU is greater than the first value, the first multi-link device may enable a media synchronization delay timer on the second link. During the duration of the media synchronization delay timer, the first multi-link device may employ a more conservative channel access mechanism on the second link. The more conservative channel access mechanism includes, but is not limited to: 1) employing a lower energy detection threshold (here, an ED threshold lower than -62dBm) to determine whether the channel is busy; 2) requiring the transmission of an RTS frame to test channel availability. Optionally, the number of probes (or the number of RTS frames sent) may be limited to one or a finite number. It is understood that when the length of the first PPDU is equal to the first value, the first multi-link device may either not enable the media synchronization delay timer on the second link or enable the media synchronization delay timer on the second link. The embodiments of the present application may configure the operation of the first multi-link device when the length of the first PPDU is equal to the first value based on actual circumstances.

Optionally, before the first multi-link device starts the media synchronization delay timer on the second link, the first multi-link device may determine an initial value of the media synchronization delay timer corresponding to the length of the first PPDU, and then start the media synchronization delay timer on the second link. It is understood that the initial value of the media synchronization delay timer started by the first multi-link device on the second link is the initial value corresponding to the determined length of the first PPDU.

The standard protocol may specify a mapping relationship between the PPDU length and the initial value (or initial duration) of the media synchronization delay timer. Alternatively, before the first multi-link device sends the first PPDU on the first link, the second multi-link device sends first indication information, and the first multi-link device receives the first indication information accordingly. The first indication information is used to indicate the mapping relationship between the PPDU length and the initial value (or initial duration) of the media synchronization delay timer.

Optionally, after or simultaneously with starting the media synchronization delay timer on the second link, the first multi-link device determines an energy detection threshold corresponding to the length of the first PPDU, and when performing channel contention on the second link, sets the energy detection threshold used in the CCA operation to the threshold value corresponding to the length of the first PPDU.

The standard protocol may specify a mapping relationship between the PPDU length and the energy detection threshold. Alternatively, before the first multi-link device sends the first PPDU on the first link, the second multi-link device sends second indication information, and the first multi-link device receives the second indication information accordingly. The second indication information is used to indicate the mapping relationship between the PPDU length and the energy detection threshold.

It is understandable that the first indication information and the second indication information may be one indication information, that is, one indication information simultaneously indicates the mapping relationship between the PPDU length and the initial value (or initial duration) of the media synchronization delay timer, and the mapping relationship between the PPDU length and the energy detection threshold. In other words, the first indication information and the second indication information are carried in one frame.

As can be seen, the embodiments of the present application improve the channel access efficiency or channel access success rate of the non-STR MLD on the other link, or increase the channel access opportunity of the non-STR MLD on the other link by restricting the non-STR MLD from sending a short frame on one link and not starting the mediumSyncDelay timer on the other link, or setting the energy detection threshold used by CCA to -62dBm when performing channel competition on the other link, or eliminating the need to use RTS frames to perform channel protection/channel availability testing on the other link.

As an optional embodiment, the above-mentioned "length of the first PPDU" can be replaced by "the length of the medium access control (MAC) frame in the first PPDU (in bytes or bits)". Accordingly, the above-mentioned step S301 can be replaced by: when the length of the MAC frame in the first PPDU sent by the first multi-link device on the first link is less than or equal to the second value, the first multi-link device does not start the media synchronization delay timer on the second link, wherein the first multi-link device cannot transmit and receive on the first link and the second link at the same time.

As another optional embodiment, the channel access methods provided in the aforementioned first and second embodiments can also be applied to single-link, multi-access channel scenarios. For example, assuming that an AP can use two channels for channel access, but can only complete access on one channel at a time, not both channels simultaneously. Specifically, the AP competes for a channel on a primary channel (e.g., the first channel). When the primary channel is busy, the AP can switch to another channel (e.g., the second channel) for channel contention. After backing off to 0 on the second channel, the AP can then transmit on the second channel. Regarding the aforementioned single-link, multi-access channel scenario, this embodiment of the present application proposes that after the AP sends a short frame (e.g., an RTS frame, a CTS frame, a block acknowledgement (BA) frame, a BSR frame, a BQR frame, a PS-Poll frame, an NDP frame, etc.) on the second channel, the AP does not start a timer on the primary channel. This timer can be a media synchronization delay timer. Optionally, an embodiment of the present application further proposes: the AP sends a first PPDU on the second channel; when the PPDU length of the first PPDU is less than or equal to a first value, the AP does not start a media synchronization delay timer on the first channel.

Optionally, the AP not starting a timer on the first channel can be understood (or described) as follows: when the AP performs channel contention on the first channel, the energy detection threshold used in the CCA operation is the first threshold; or, after the AP backs off to 0 on the first channel, it is allowed to directly send frames other than RTS and MU-RTS frames. In other words, after the AP backs off to 0 on the first channel, it does not send RTS/MU-RTS frames to protect the channel or test channel availability. The first threshold can be -62dBm.

It can be understood that the second channel in the embodiment of the present application is equivalent to the first link in the aforementioned embodiment 1 and embodiment 2, and the first channel in the embodiment of the present application is equivalent to the second link in the aforementioned embodiment 1 and embodiment 2.

It can be seen that the channel access method provided in the embodiment of the present application can also be applied to the scenario of single link and multiple access channels, which expands the scenario of the method and can also improve the channel access efficiency or channel access success rate of the AP on the first channel.

Embodiment 3

Embodiment 3 of the present application provides a method for determining the initial duration of a media synchronization delay timer. The method determines the initial duration of the media synchronization delay timer based on the length of a frame sent on a first link (or a second channel).

Referring to FIG. 7 , FIG. 7 is a schematic flow chart of a method for determining the initial duration of a media synchronization delay timer according to an embodiment of the present application. As shown in FIG. 7 , the method for determining the initial duration of a media synchronization delay timer includes, but is not limited to, the following steps:

S301: A second multi-link device sends first indication information, where the first indication information is used to indicate a mapping relationship between a PPDU length/byte length and an initial value (or initial duration) of a media synchronization delay timer.

Specifically, the second multi-link device may be an AP MLD, and the AP MLD may be STR-capable. The link over which the AP MLD sends the first indication information may be the first link or another link, and this embodiment of the present application is not limited thereto. The first indication information may be used to indicate a mapping relationship between the PPDU length and the initial value (or initial duration) of the media synchronization delay timer.

In one example, see Figure 8, which illustrates the mapping between the PPDU length and the initial value of the media synchronization delay timer, as provided in an embodiment of the present application. As shown in Figure 8, when the PPDU length is in the range of 0 to 100μs (microseconds) (i.e., the interval [0, 100μs], or the interval (0, 100μs), or the interval (0, 100μs], or the interval [0, 100μs)), the initial value of the media synchronization delay timer is 0ms. When the PPDU length is in the range of 100μs to 1ms (i.e., the interval [100μs, 1000μs], or the interval (100μs, 1000μs), or the interval (100μs, 1000μs], or the interval [100μs, 1000μs)), the initial value of the media synchronization delay timer is 3ms. When the PPDU length is greater than or equal to 1ms, the initial value of the media synchronization delay timer is 6ms.

Among them, the mapping relationship shown in Figure 8 can be summarized as shown in the following Table 1.

Table 1

| PPDU length | Initial value (or initial duration) of the media synchronization delay timer |
|---|---|
| <=100us | 0 |
| >=100us and <=1ms | 3ms |
| >=1ms | 6ms |

It should be understood that the mapping relationships shown in Figure 8 and Table 1 are merely examples. In actual applications, the mapping relationships can be determined based on the actual application scenario. For example, when the PPDU length is less than or equal to 50μs, the initial value of the media synchronization delay timer is 0ms; when the PPDU length is greater than or equal to 50μs and less than or equal to 200μs, the initial value of the media synchronization delay timer is 1ms; when the PPDU length is greater than or equal to 200μs and less than or equal to 500μs, the initial value of the media synchronization delay timer is 3ms; and when the PPDU length is greater than or equal to 500μs, the initial value of the media synchronization delay timer is 5ms. This embodiment of the present application does not limit this.

Optionally, the first indication information may include an array. For example, the array (0, 100, 0) indicates that when the PPDU length is in the range of 0 to 100 μs, the initial value of the media synchronization delay timer is 0 ms; the array (100, 1000, 3) indicates that when the PPDU length is in the range of 100 μs to 1 ms, the initial value of the media synchronization delay timer is 3 ms; and the array (1000, maximum PPDU length, 6) indicates that when the PPDU length is in the range of 1 ms to the maximum PPDU length, the initial value of the media synchronization delay timer is 6 ms. The maximum PPDU length is specified by the standard protocol.

Optionally, the above-mentioned first indication information may include two fields, the first field is used to determine N intervals, and the second field is used to indicate the initial value of the media synchronization delay timer corresponding to each interval in the N intervals.

The first field may include N+1 subfields, where the values of the N+1 subfields are monotonically increasing. The values of two adjacent subfields can define an interval, so the N+1 subfields can define N intervals. For example, the value of the first subfield is 0; the value of the N+1 subfield is the maximum PPDU length, or a value greater than the maximum PPDU length, such as 6 ms. Optionally, the first subfield (or the N+1 subfield) may not be included in the first field.

The second field includes N subfields, and the value of a subfield represents the initial value of the media synchronization delay timer corresponding to an interval.

S302: The first multi-link device receives the first indication information.

S303: The first multi-link device determines, based on the length of a first PPDU sent on the first link, an initial value of a media synchronization delay timer corresponding to the length of the first PPDU. The initial value is used to determine whether to start the media synchronization delay timer on the second link. The first multi-link device cannot transmit and receive on the first link and the second link simultaneously.

Specifically, the first multi-link device may be a non-AP MLD that has non-STR capabilities. The first multi-link device may determine the initial value (or initial duration) of the media synchronization delay timer corresponding to the PPDU length of the first PPDU based on the mapping relationship between the PPDU length indicated by the first indication information and the initial value (or initial duration) of the media synchronization delay timer, and the PPDU length of the first PPDU. For example, the mapping relationship is shown in Table 1 above. Assuming the length of the first PPDU is 200 μs, the initial value (or initial duration) of the media synchronization delay timer is 3 ms.

Optionally, the first multi-link device determines whether to start the media synchronization delay timer on the second link based on the initial value (or initial duration) of the media synchronization delay timer corresponding to the length of the first PPDU.

Specifically, if the initial value (or initial duration) of the media synchronization delay timer is equal to 0, the first multi-link device does not start the media synchronization delay timer on the second link. If the initial value (or initial duration) of the media synchronization delay timer is greater than 0, the first multi-link device starts the media synchronization delay timer on the second link, and the initial value/initial duration of the media synchronization delay timer is the value determined in step S404.

The first multi-link device starts the mediumSyncDelay timer on the second link. This can be understood (or described) as follows: During the time the mediumSyncDelay timer is ticking, the first multi-link device may adopt a more conservative channel access mechanism on the second link. This more conservative channel access mechanism includes, but is not limited to: 1) using a lower energy detection threshold (here, an ED threshold lower than -62dBm) to determine whether the channel is busy; 2) requiring the transmission of an RTS frame to test channel availability. Optionally, the number of probes (or RTS frames sent) can be limited to one or a finite number of times.

The first multi-link device does not start the mediumSyncDelay timer on the second link. This can be understood (or described) as follows: when the first multi-link device performs channel contention on the second link, the energy detection threshold used in the CCA operation is the first threshold; or, after the first multi-link device backs off to 0 on the second link, it is allowed to directly send frames other than RTS and MU-RTS frames. The first threshold can be -62dBm.

It is understandable that the method for determining the initial duration of the media synchronization delay timer provided in the embodiments of the present application can also be applied to single-link, multi-access channel scenarios. The first channel in the single-link, multi-access channel scenario is equivalent to the second link described above, and the second channel in the single-link, multi-access channel scenario is equivalent to the first link described above. This description will not be repeated here.

As can be seen, the embodiment of the present application uses the first indication information to indicate the mapping relationship between the PPDU length and the initial value (or initial duration) of the media synchronization delay timer. This allows the first multi-link device to determine the initial value of the media synchronization delay timer corresponding to the length of the first PPDU sent on the first link based on this mapping relationship and the length of the first PPDU sent on the first link. If the initial value is 0, the mediumSyncDelay timer is not enabled on the second link. If the initial value is greater than 0, the mediumSyncDelay timer is enabled on the second link. Different PPDU lengths correspond to different initial values of the mediumSyncDelay timer, making the mediumSyncDelay timer setting more flexible and improving channel access efficiency.

As an optional embodiment, the mapping relationship between the PPDU length and the initial value (or initial duration) of the media synchronization delay timer may be specified in a standard protocol. When this mapping relationship is specified in a standard protocol, the method for determining the initial duration of the media synchronization delay timer shown in FIG7 may not include steps S301 and S302. That is, the method for determining the initial duration of the media synchronization delay timer may include step S303.

Embodiment 4

A fourth embodiment of the present application provides a method for determining an energy detection threshold during a CCA process. This method determines the ED threshold used during the CCA process during backoff on the second link during a mediumSyncDelay period, based on the length of a frame sent on a first link (or a second channel).

Referring to FIG9 , FIG9 is a schematic flow chart of a method for determining an energy detection threshold during a CCA process according to an embodiment of the present application. As shown in FIG9 , the method for determining an energy detection threshold during a CCA process includes but is not limited to the following steps:

S401: A second multi-link device sends second indication information, where the second indication information is used to indicate a mapping relationship between a PPDU length and an energy detection threshold.

Specifically, the second multi-link device may be an AP MLD, and the AP MLD may be STR-capable. The link over which the AP MLD sends the second indication information may be the first link or another link, and this embodiment of the present application is not limited thereto. The second indication information may be used to indicate a mapping relationship between the PPDU length and the energy detection threshold.

In one example, see Figure 10, which illustrates the mapping relationship between PPDU length and energy detection thresholds, as provided in an embodiment of the present application. As shown in Figure 10, when the PPDU length is in the range of 0 to 100 µs (microseconds) (i.e., the interval [0, 100 µs], or the interval (0, 100 µs), or the interval (0, 100 µs], or the interval [0, 100 µs)), the energy detection threshold is -62 dBm. When the PPDU length is in the range of 100 µs to 1 ms (i.e., the interval [100 µs, 1000 µs], or the interval (100 µs, 1000 µs), or the interval (100 µs, 1000 µs], or the interval [100 µs, 1000 µs)), the energy detection threshold is -72 dBm. When the PPDU length is greater than or equal to 1 ms, the energy detection threshold is -82 dBm.

Among them, the mapping relationship shown in Figure 10 can be summarized as shown in the following Table 2.

Table 2

| PPDU duration | Energy detection threshold |
|---|---|
| <=100us | -62dBm |
| >=100us and <=1ms | -72dBm |
| >=1ms | -82dBm |

It should be understood that the mapping relationships shown in Figure 10 and Table 2 are merely examples. In actual applications, the mapping relationships can be determined based on the actual application scenario. For example, when the PPDU length is less than or equal to 50us, the energy detection threshold is -62dBm; when the PPDU length is greater than or equal to 50us and less than or equal to 200us, the energy detection threshold is -67dBm; when the PPDU length is greater than or equal to 200us and less than or equal to 500us, the energy detection threshold is -72dBm; and when the PPDU length is greater than or equal to 500us, the energy detection threshold is -82dBm. This embodiment of the present application is not limited to this.

Optionally, the second indication information may include an array. For example, the array (0, 100, -62) indicates that when the PPDU length is in the range of 0 to 100 μs, the energy detection threshold is -62 dBm; the array (100, 1000, -72) indicates that when the PPDU length is in the range of 100 μs to 1 ms, the energy detection threshold is -72 dBm; and the array (1000, maximum PPDU length, -82) indicates that when the PPDU length is in the range of 1 ms to the maximum PPDU length, the energy detection threshold is -62 dBm. The maximum PPDU length is specified by the standard protocol.

Optionally, the above-mentioned second indication information may include two fields, the first field is used to determine N intervals, and the second field is used to indicate the energy detection threshold corresponding to each interval in the N intervals.

The first field may include N+1 subfields, where the values of the N+1 subfields are monotonically increasing. The values of two adjacent subfields can define an interval, so the N+1 subfields can define N intervals. For example, the value of the first subfield is 0; the value of the N+1 subfield is the maximum PPDU length, or a value greater than the maximum PPDU length, such as 6 ms. Optionally, the first subfield (or the N+1 subfield) may not be included in the first field.

The second field includes N subfields, and the value of a subfield represents the energy detection threshold corresponding to an interval.

S402: The first multi-link device receives the second indication information.

S403: The first multi-link device determines an energy detection threshold corresponding to the length of the first PPDU sent on the first link according to the length of the first PPDU, where the energy detection threshold is used to determine whether to start the media synchronization delay timer on the second link.

Specifically, the first multi-link device may be a non-AP MLD, and the non-AP MLD has non-STR capabilities. The first multi-link device may determine the energy detection threshold corresponding to the length of the first PPDU based on the mapping relationship between the PPDU length and the energy detection threshold indicated by the second indication information and the length of the first PPDU. For example, the mapping relationship is shown in Table 2 above. Assuming that the length of the first PPDU is 200 μs, the energy detection threshold is -72 dBm.

Optionally, the first multi-link device determines whether to enable the media synchronization delay timer on the second link based on the energy detection threshold corresponding to the length of the first PPDU. Specifically, if the energy detection threshold determined in step S403 is equal to -62 dBm, the first multi-link device does not enable the media synchronization delay timer on the second link. If the energy detection threshold determined in step S403 is less than -62 dBm, the first multi-link device enables the media synchronization delay timer on the second link. If the first multi-link device enables the media synchronization delay timer on the second link, indicating that the second link is in the mediumSyncDelay period, the first multi-link device sets the energy detection threshold used for CCA to the energy detection threshold corresponding to the length of the first PPDU (i.e., the energy detection threshold determined in step S504) when performing channel contention on the second link.

Among them, the first multi-link device starts the mediumSyncDelay timer on the second link, which can be understood (or can be described as): during the mediumSyncDelay period, the first multi-link device can adopt a more conservative channel access mechanism on the second link. The more conservative channel access mechanism includes but is not limited to: 1) using a lower energy detection threshold (here refers to an ED threshold lower than -62dBm) to determine whether the channel is busy. 2) RTS frames must be sent to test the channel availability. Optionally, the number of tests (or the number of RTS frames sent) can only be 1, or a limited number of times. The first multi-link device does not start the mediumSyncDelay timer on the second link, which can be understood (or can be described as): when the first multi-link device competes for the channel on the second link, the energy detection threshold used for the CCA operation is the first threshold; or, after the first multi-link device backs off to 0 on the second link, it is allowed to directly send signals other than RTS and MU-RTS Other frames outside the frame. The first threshold may be -62dBm.

It is understandable that the energy detection threshold determination method during the CCA process provided in the embodiments of the present application can also be applied to single-link, multi-access channel scenarios. The first channel in the single-link, multi-access channel scenario is equivalent to the second link described above, and the second channel in the single-link, multi-access channel scenario is equivalent to the first link described above. These details will not be repeated here.

As can be seen, in this embodiment of the present application, the second indication information indicates the mapping relationship between PPDU length and energy detection threshold. This allows the first multi-link device to determine the energy detection threshold corresponding to the length of the first PPDU sent on the first link based on this mapping relationship and the length of the first PPDU. When the energy detection threshold is equal to -62dBm, the mediumSyncDelay timer is not started on the second link. When the energy detection threshold is less than -62dBm, the mediumSyncDelay timer is started on the second link. Different PPDU lengths correspond to different energy detection thresholds, making the channel access mechanism on the second link more flexible and improving channel access efficiency.

As an optional embodiment, the mapping relationship between the PPDU length and the energy detection threshold may be specified in a standard protocol. When the mapping relationship is specified in a standard protocol, the method for determining the energy detection threshold during the CCA process shown in FIG9 may not include steps S401 and S402. That is, the method for determining the energy detection threshold during the CCA process may include step S403.

As another optional embodiment, the first indication information in the aforementioned embodiment 3 and the second indication information in the aforementioned embodiment 4 can be a single indication information, or the first indication information and the second indication information can be carried in the same frame. Therefore, the aforementioned embodiments 3 and 4 can be combined into a single embodiment. Specifically, the second multi-link device sends indication information indicating the mapping relationship between the PPDU length and the initial value (or initial duration) of the media synchronization delay timer, and the mapping relationship between the PPDU length and the energy detection threshold; the first multi-link device receives the indication information; the first multi-link device sends a first PPDU on the first link; the first multi-link device determines, based on the length of the first PPDU, the initial value of the media synchronization delay timer corresponding to the length of the first PPDU and the energy detection threshold corresponding to the length of the first PPDU. Optionally, the first multi-link device can also determine whether to enable the media synchronization delay timer on the second link based on the energy detection threshold corresponding to the length of the first PPDU or the initial value of the media synchronization delay timer corresponding to the length of the first PPDU.

The above content describes in detail the method provided by the present application. In order to facilitate better implementation of the above-mentioned scheme of the embodiments of the present application, the embodiments of the present application also provide corresponding devices or equipment.

The embodiments of the present application can divide the functional modules of the communication device according to the above-mentioned method examples. For example, each functional module can be divided according to each function, or two or more functions can be integrated into a single processing module. The above-mentioned integrated modules can be implemented in the form of hardware or software functional modules. It should be noted that the module division in the embodiments of the present application is schematic and only represents a logical functional division. In actual implementation, other division methods may be used.

In the case of using an integrated unit, see FIG11, FIG11 is a first multi-link device provided in an embodiment of the present application.

As shown in FIG11 , the first multi-link device includes: a transceiver unit 11 and a processing unit 12.

In one design, the processing unit 12 is configured to not start a media synchronization delay timer on a second link when the length of a first PPDU sent by a first multi-link device on a first link is less than or equal to a first value, wherein the first multi-link device cannot transmit and receive on the first link and the second link simultaneously.

The processing unit 12 is specifically configured to set the energy detection threshold used in the CCA operation to a first threshold during channel contention on the second link. Alternatively, the transceiver unit 11 is configured to transmit frames other than RTS and MU-RTS frames after backing off to 0 on the second link. The first threshold may be -62 dBm.

It should be understood that the first multi-link device in this design can correspondingly execute the aforementioned embodiment 2, and the above-mentioned operations or functions of each unit in the first multi-link device are respectively for implementing the corresponding operations of the first multi-link device in the aforementioned embodiment 2. For the sake of brevity, they are not further described here.

In one design, the processing unit 12 is configured to, when a first frame sent by a first multi-link device on a first link is of a first type, not start a media synchronization delay timer on a second link by the first multi-link device, wherein the first multi-link device cannot transmit and receive simultaneously on the first link and the second link.

The processing unit 12 is specifically configured to set the energy detection threshold used in the CCA operation to a first threshold during channel contention on the second link. Alternatively, the transceiver unit 11 is further configured to transmit frames other than RTS and MU-RTS frames after backing off to 0 on the second link. The first threshold may be -62 dBm.

It should be understood that the first multi-link device in this design can correspondingly execute the aforementioned embodiment 1, and the above-mentioned operations or functions of each unit in the first multi-link device are respectively for implementing the corresponding operations of the first multi-link device in the aforementioned embodiment 1. For the sake of brevity, they are not further described here.

In one design, a transceiver unit 11 is configured to receive first indication information indicating a mapping relationship between a PPDU length and an initial value of a media synchronization delay timer; a processing unit 12 is configured to determine, based on the length of a first PPDU sent on a first link, an initial value of the media synchronization delay timer corresponding to the length of the first PPDU, the initial value being used to determine whether to enable the media synchronization delay timer on a second link. The first multi-link device cannot simultaneously transmit and receive on the first and second links.

Optionally, the processing unit 12 is further configured to determine whether to start the media synchronization delay timer on the second link based on the initial value of the media synchronization delay timer corresponding to the length of the first PPDU.

Optionally, the processing unit 12 is specifically configured to: if the determined initial value of the media synchronization delay timer is equal to 0, not start the media synchronization delay timer on the second link; if the determined initial value of the media synchronization delay timer is equal to 0, start the media synchronization delay timer on the second link.

It should be understood that the first multi-link device in this design can correspondingly execute the aforementioned embodiment 3, and the above-mentioned operations or functions of each unit in the first multi-link device are respectively for implementing the corresponding operations of the first multi-link device in the aforementioned embodiment 3. For the sake of brevity, they are not further described here.

In one design, a transceiver unit 11 is configured to receive second indication information indicating a mapping relationship between a PPDU length and an energy detection threshold; and a processing unit 12 is configured to determine, based on the length of a first PPDU sent over a first link, an initial value of a media synchronization delay timer corresponding to the length of the first PPDU. The communication device cannot simultaneously transmit and receive on the first link and the second link.

Optionally, the processing unit 12 is further configured to determine whether to start the media synchronization delay timer on the second link based on an energy detection threshold corresponding to the length of the first PPDU.

Optionally, the processing unit 12 is specifically configured to: if the determined energy detection threshold is equal to -62 dBm, then the first multi-link device does not start the media synchronization delay timer on the second link; and if the determined energy detection threshold is less than -62 dBm, then the first multi-link device starts the media synchronization delay timer on the second link.

It should be understood that the first multi-link device in this design can correspondingly execute the aforementioned fourth embodiment, and the above-mentioned operations or functions of each unit in the first multi-link device are respectively for implementing the corresponding operations of the first multi-link device in the aforementioned fourth embodiment. For the sake of brevity, they are not further described here.

Referring to FIG. 12 , FIG. 12 is a schematic diagram illustrating the structure of a second multi-link device according to an embodiment of the present application. As shown in FIG. 12 , the second multi-link device includes a processing unit 21 and a transceiver unit 22.

In one design, the processing unit 21 is used to generate first indication information, which is used to indicate the mapping relationship between the PPDU length and the initial value (or initial duration) of the media synchronization delay timer; the transceiver unit 22 is used to send the first indication information.

It should be understood that the second multi-link device in this design can correspondingly execute the aforementioned embodiment 3, and the above-mentioned operations or functions of each unit in the second multi-link device are respectively for implementing the corresponding operations of the second multi-link device in the aforementioned embodiment 3. For the sake of brevity, they are not further described here.

In another design, the processing unit 21 is used to generate second indication information, where the second indication information is used to indicate a mapping relationship between the PPDU length and the energy detection threshold; and the transceiver unit 22 is used to send the second indication information.

It should be understood that the second multi-link device in this design can correspondingly execute the aforementioned fourth embodiment, and the above-mentioned operations or functions of each unit in the second multi-link device are respectively for implementing the corresponding operations of the second multi-link device in the aforementioned fourth embodiment. For the sake of brevity, they are not further described here.

The above describes the first and second multi-link devices according to the embodiments of the present application. The following describes possible product forms of the first and second multi-link devices. It should be understood that any product that possesses the functions of the first multi-link device described in FIG. 11 and any product that possesses the functions of the second multi-link device described in FIG. 12 fall within the scope of protection of the embodiments of the present application. It should also be understood that the following description is merely illustrative and does not limit the product forms of the first and second multi-link devices according to the embodiments of the present application to these specific forms.

As a possible product form, the first multi-link device and the second multi-link device described in the embodiment of the present application can be implemented by a general bus architecture.

The first multi-link device includes a processor and a transceiver connected to and communicating with the processor.

In one design, the processor is configured to disable a media synchronization delay timer on a second link when a length of a first PPDU sent by a first multi-link device on a first link is less than or equal to a first value, wherein the first multi-link device cannot transmit and receive on the first link and the second link simultaneously. Optionally, the transceiver is configured to transmit the first PPDU on the first link;

In one design, the processor is configured to not start a media synchronization delay timer on a second link when a first frame sent by a first multi-link device on a first link is of a first type, wherein the first multi-link device cannot transmit and receive simultaneously on the first link and the second link.

In one design, the transceiver is configured to receive first indication information indicating a mapping relationship between a PPDU length and an initial value of a media synchronization delay timer; the processor is configured to determine, based on the length of a first PPDU sent on a first link, an initial value of the media synchronization delay timer corresponding to the length of the first PPDU, the initial value being used to determine whether to enable the media synchronization delay timer on a second link. The first multi-link device cannot transmit and receive on the first link and the second link simultaneously.

In one design, the transceiver is configured to receive a second indication message, the second indication message being configured to indicate the PPDU length/

A mapping relationship between byte length and energy detection threshold is provided; the processor is configured to determine, based on the length of a first PPDU sent on a first link, an initial value of a media synchronization delay timer corresponding to the length of the first PPDU. The communication device cannot transmit and receive on the first link and the second link simultaneously.

The second multi-link device includes a processor and a transceiver connected to and communicating with the processor.

In one design, the processor is used to generate first indication information, which is used to indicate the mapping relationship between the PPDU length and the initial value (or initial duration) of the media synchronization delay timer; and the transceiver is used to send the first indication information.

In another design, the processor is used to generate second indication information, where the second indication information is used to indicate a mapping relationship between the PPDU length and the energy detection threshold; and the transceiver is used to send the second indication information.

As a possible product form, the first multi-link device and the second multi-link device described in the embodiment of the present application can be implemented by a chip.

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In one design, the input/output interface is used to receive code instructions and transmit them to the processing circuit, and the processing circuit is used to not start the media synchronization delay timer on the second link when the length of the first PPDU is less than or equal to a first value, wherein the first multi-link device cannot transmit and receive on the first link and the second link at the same time.

In one design, the input/output interface is used to receive code instructions and transmit them to the processing circuit, and the processing circuit is used to, when the type of the first frame sent by the first multi-link device on the first link is the first type, cause the first multi-link device to not start the media synchronization delay timer on the second link, wherein the first multi-link device cannot transmit and receive on the first link and the second link at the same time.

In one design, a transceiver is configured to receive first indication information; the input/output interface is configured to receive the first indication information from the transceiver and send the first indication information to the processing circuit for processing, thereby obtaining a mapping relationship between the PPDU length indicated by the first indication information and the initial value (or initial duration) of the media synchronization delay timer; the processing circuit is configured to determine, based on the length of the first PPDU sent on the first link, the initial value of the media synchronization delay timer corresponding to the length of the first PPDU; the initial value is used to determine whether to enable the media synchronization delay timer on the second link. The first multi-link device cannot transmit and receive on the first link and the second link simultaneously.

In one design, the transceiver is configured to receive second indication information, the input/output interface is configured to receive the second indication information from the transceiver and send the second indication information to the processing circuit for processing, thereby obtaining a mapping relationship between the PPDU length indicated by the second indication information and an energy detection threshold. The processing circuit is configured to determine, based on the length of the first PPDU sent on the first link, an energy detection threshold corresponding to the length of the first PPDU, and the energy detection threshold is used to determine whether to enable the media synchronization delay timer on the second link. The first multi-link device cannot transmit and receive on the first link and the second link simultaneously.

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In one design, the input/output interface is used to receive code instructions and transmit them to the processing circuit; the processing circuit is used to generate first indication information, the first indication information being used to indicate a mapping relationship between the PPDU length and the initial value (or initial duration) of the media synchronization delay timer; the input/output interface is used to send the first indication information to a transceiver; and the transceiver is used to send the first indication information.

In another design, the input/output interface is used to receive code instructions and transmit them to the processing circuit; the processing circuit is used to generate second indication information, where the second indication information is used to indicate a mapping relationship between the PPDU length and the energy detection threshold; the input/output interface is used to send the second indication information to the transceiver; and the transceiver is used to send the second indication information.

As a possible product form, the first multi-link device and the second multi-link device described in the embodiments of the present application may also be implemented using: one or more FPGAs (field programmable gate arrays), PLDs (programmable logic devices), controllers, state machines, gate logic, discrete hardware components, any other suitable circuits, or any combination of circuits capable of performing the various functions described throughout this application.

It should be understood that the communication devices in the various product forms described above have any of the functions of the first multi-link device or the second multi-link device in the above method embodiments, which will not be described in detail here.

An embodiment of the present application further provides a computer-readable storage medium having instructions stored therein. When the instructions are executed on a computer, the computer executes the method in any of the aforementioned embodiments.

An embodiment of the present application also provides a computer program product, which, when executed on a computer, enables the computer to execute the method of any of the aforementioned embodiments.

An embodiment of the present application also provides a communication device, which can exist in the form of a chip product. The structure of the device includes a processor and an interface circuit. The processor is used to communicate with other devices through a receiving circuit, so that the device executes the method in any of the aforementioned embodiments.

The steps of the methods or algorithms described in conjunction with the disclosure of this application can be implemented in hardware or by a processor executing software instructions. The software instructions can be composed of corresponding software modules, which can be stored in random access memory (RAM), flash memory, erasable programmable read-only memory (EPROM), electrically erasable programmable read-only memory (EEPROM), registers, a hard disk, a removable hard disk, a compact disc read-only memory (CD-ROM), or any other form of storage medium known in the art. An exemplary storage medium is coupled to the processor, enabling the processor to read information from and write information to the storage medium. Of course, the storage medium can also be an integral part of the processor. The processor and storage medium can be located in an ASIC. Alternatively, the ASIC can be located in a core network interface device. Of course, the processor and storage medium can also exist as discrete components in the core network interface device.

Those skilled in the art will appreciate that, in one or more of the examples above, the functions described herein can be implemented using hardware, software, firmware, or any combination thereof. When implemented using software, these functions can be stored on a computer-readable medium or transmitted as one or more instructions or codes on a computer-readable medium. Computer-readable media include computer-readable storage media and communication media, including any medium that facilitates the transfer of computer programs from one location to another. Storage media can be any available medium that can be accessed by a general-purpose or special-purpose computer.

The specific implementation methods described above further illustrate the purpose, technical solutions and beneficial effects of this application. It should be understood that the above description is only the specific implementation methods of this application and is not intended to limit the scope of protection of this application. Any modifications, equivalent replacements, improvements, etc. made on the basis of the technical solutions of this application should be included in the scope of protection of this application.

Instructions for use with attached drawings

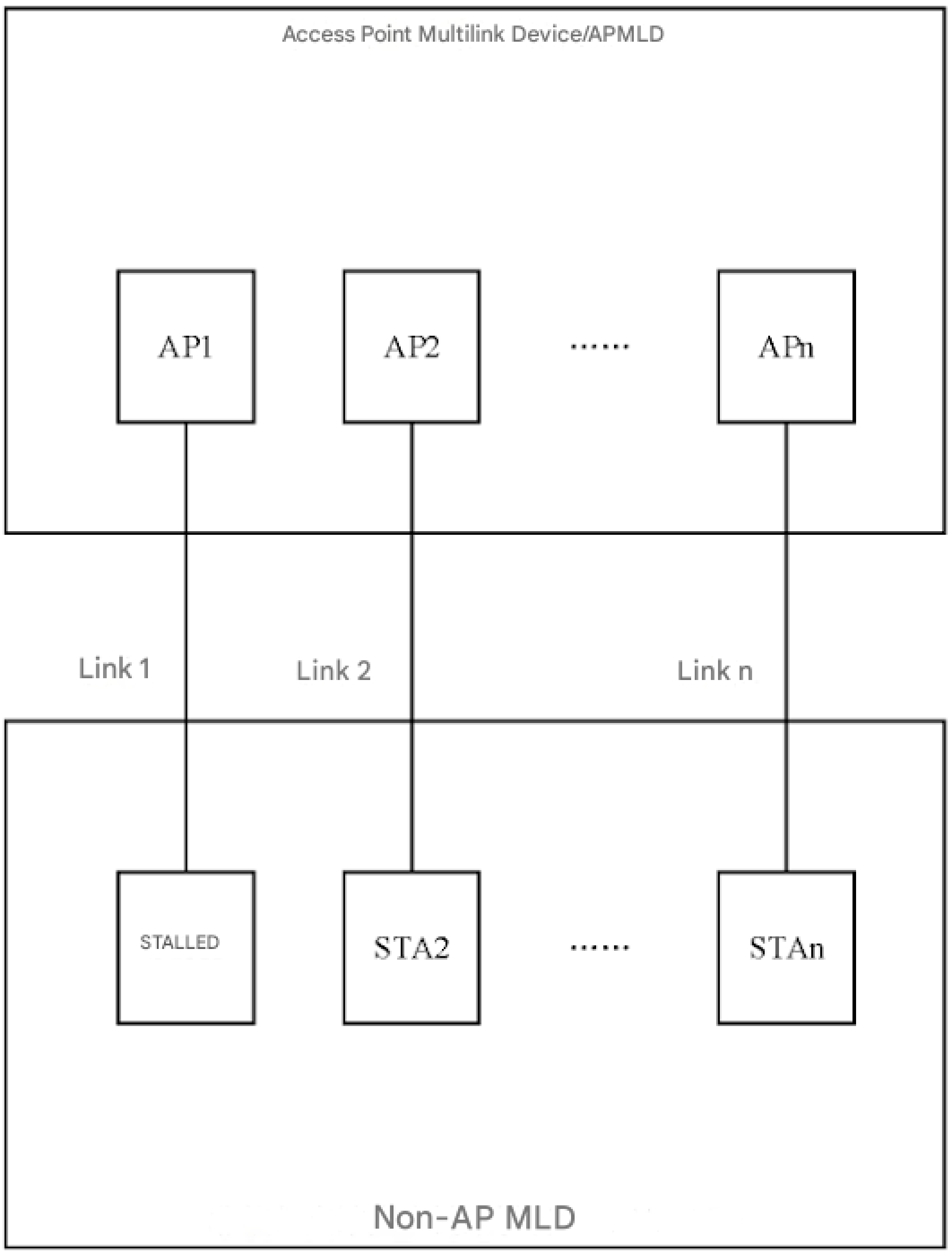


Figure 1

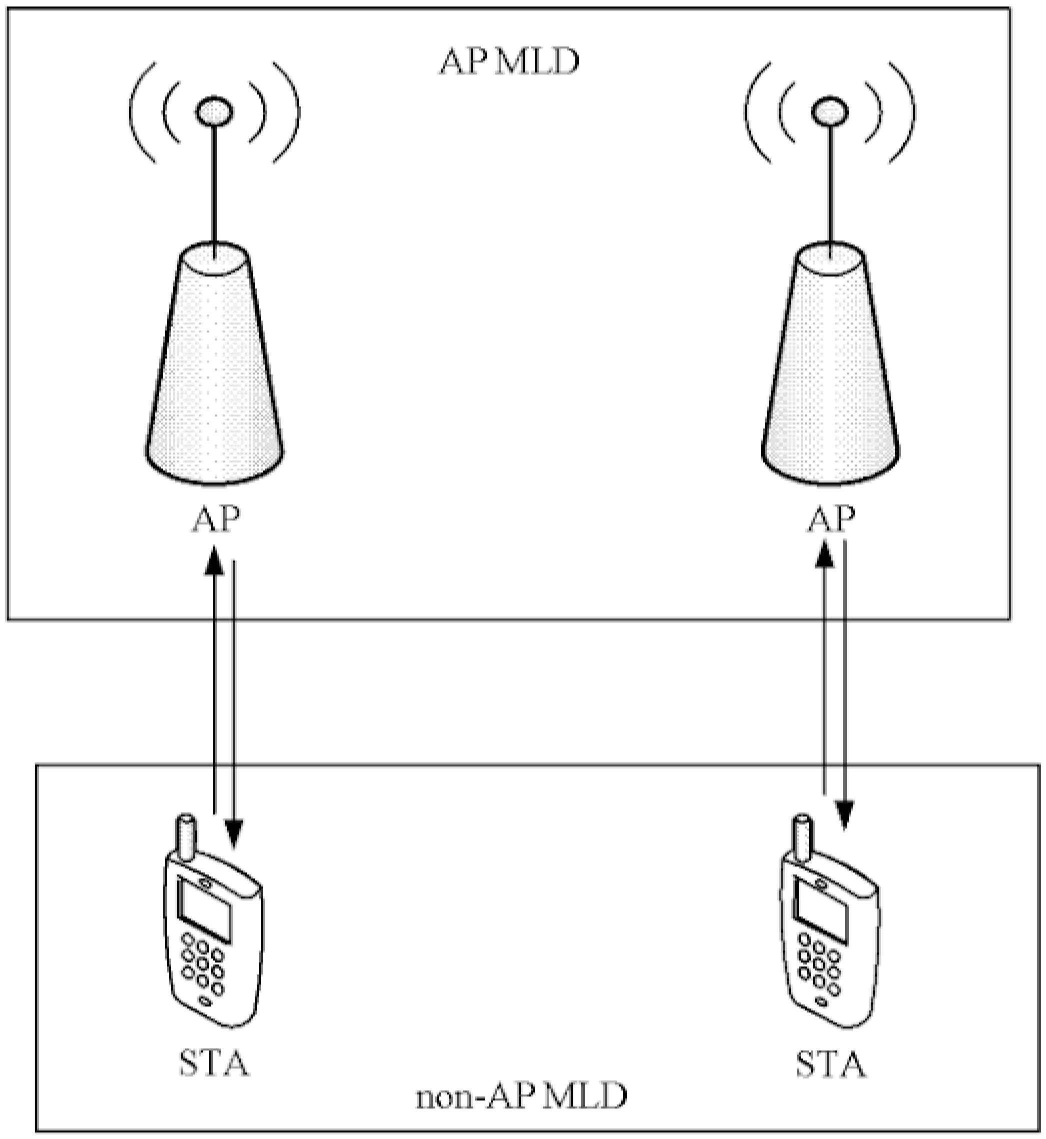


Figure 2

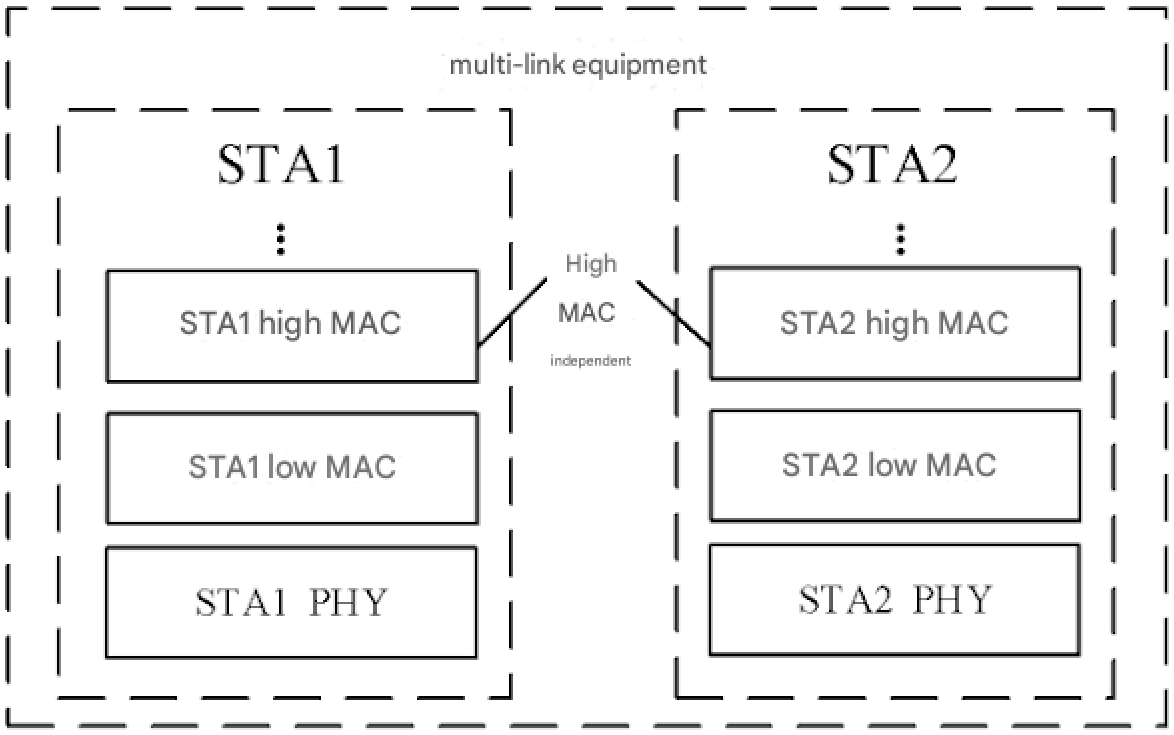


Figure 3a

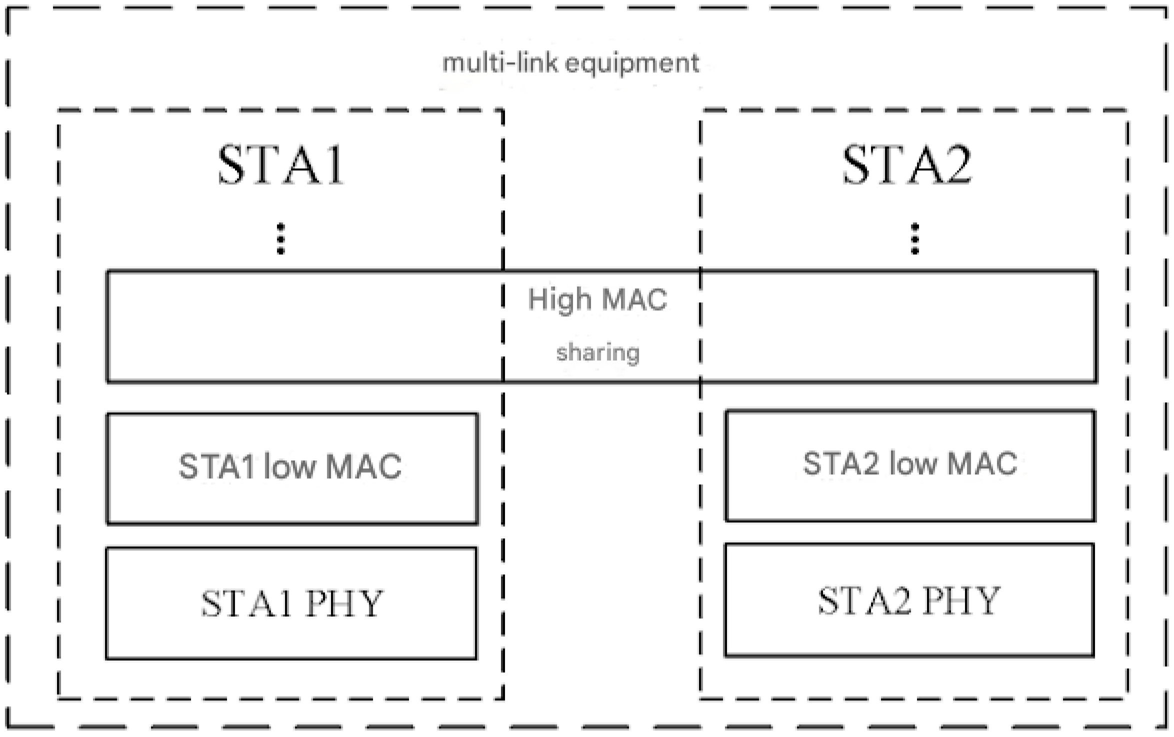


Figure 3b

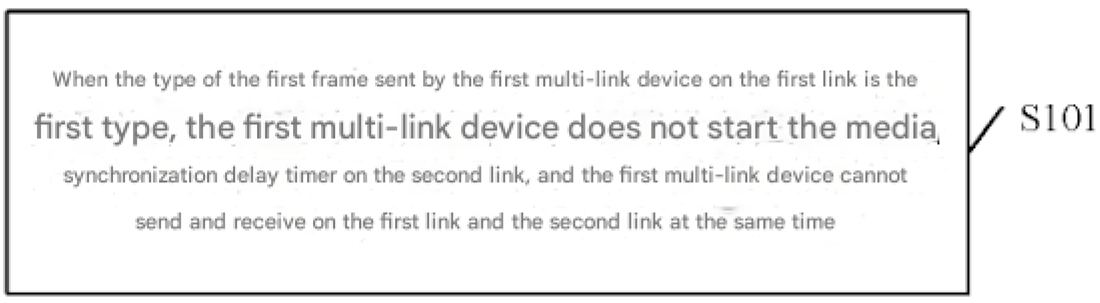


Figure 4

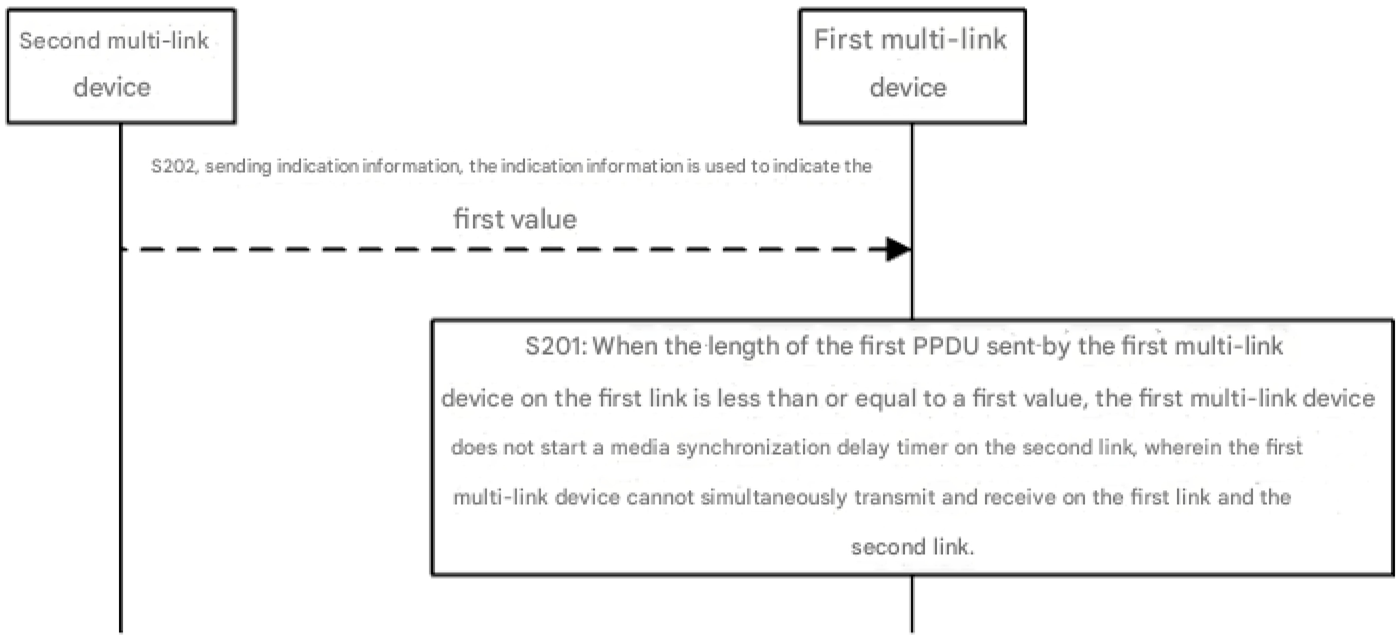
Second multi-link device
First multi-link device
S202, sending indication information, the indication information is used to indicate the first value
S201: When the length of the first PPDU sent by the first multi-link device on the first link is less than or equal to a first value, the first multi-link device does not start a media synchronization delay timer on the second link, wherein the first multi-link device cannot simultaneously transmit and receive on the first link and the second link.

Figure 5

| Multi-link element | Element ID element identification | Length length | Element ID Extension | Multi-Link Control | mediumSyncDelay timer threshold Media synchronization delay timing threshold | ...... | Optional subelements |
|---|---|---|---|---|---|---|---|

Figure 6a

| EHT operation element Extremely high throughput operation element | Element ID element identifier | Length length | Element ID Extension | ...... | mediumSyncDelay timer threshold Media synchronization delay timing threshold | ...... |
|---|---|---|---|---|---|---|

Figure 6b

| non-STR MLD parameter set element non-simultaneous transmission and reception multi-link device parameter set element | Element ID element identification | Length length | Element ID Extension | ...... | mediumSyncDelay timer threshold media synchronization delay timing threshold | ...... |
|---|---|---|---|---|---|---|

Figure 6c

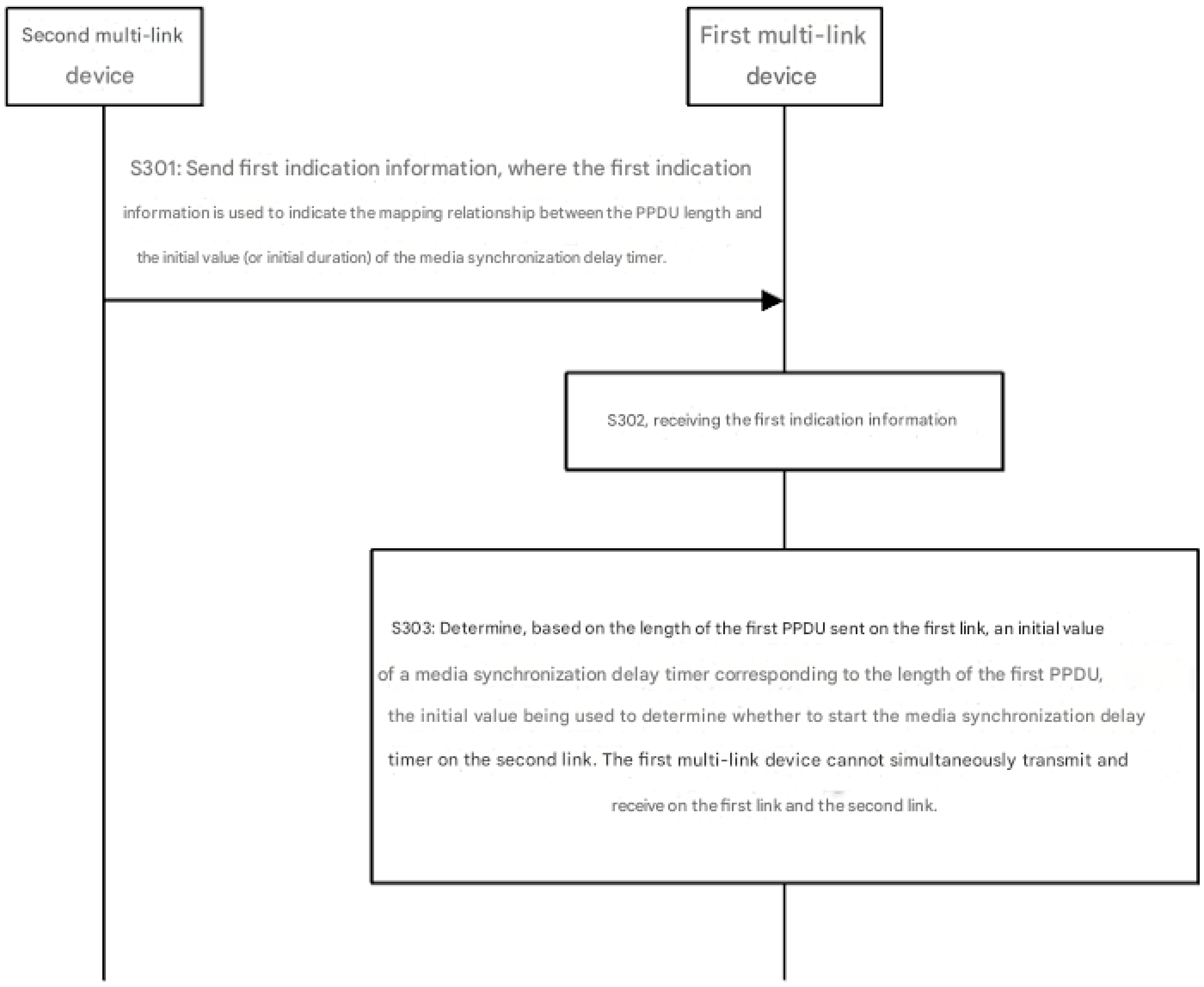


Figure 7

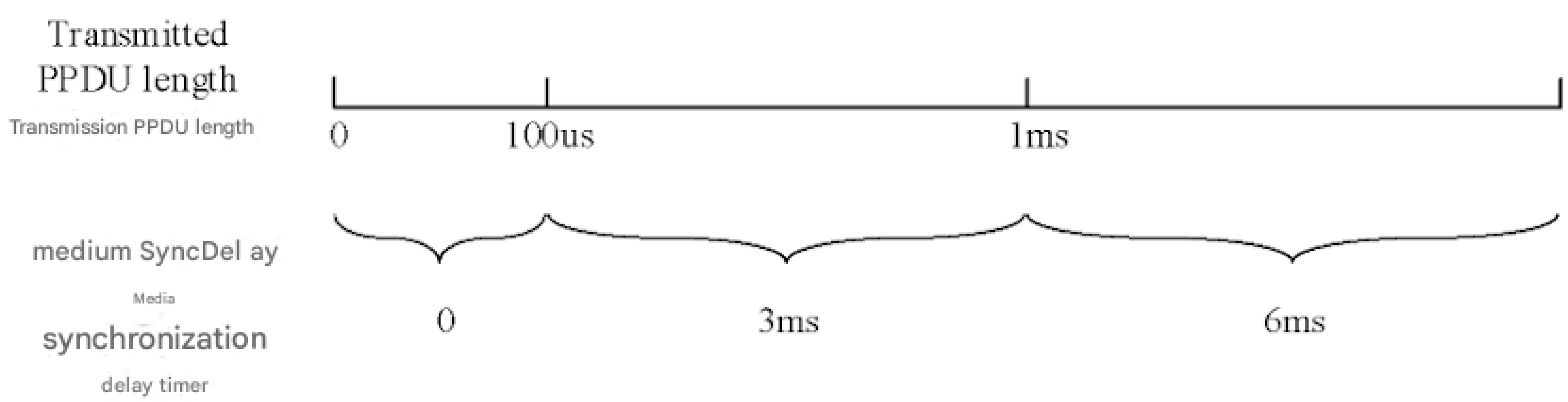


Figure 8

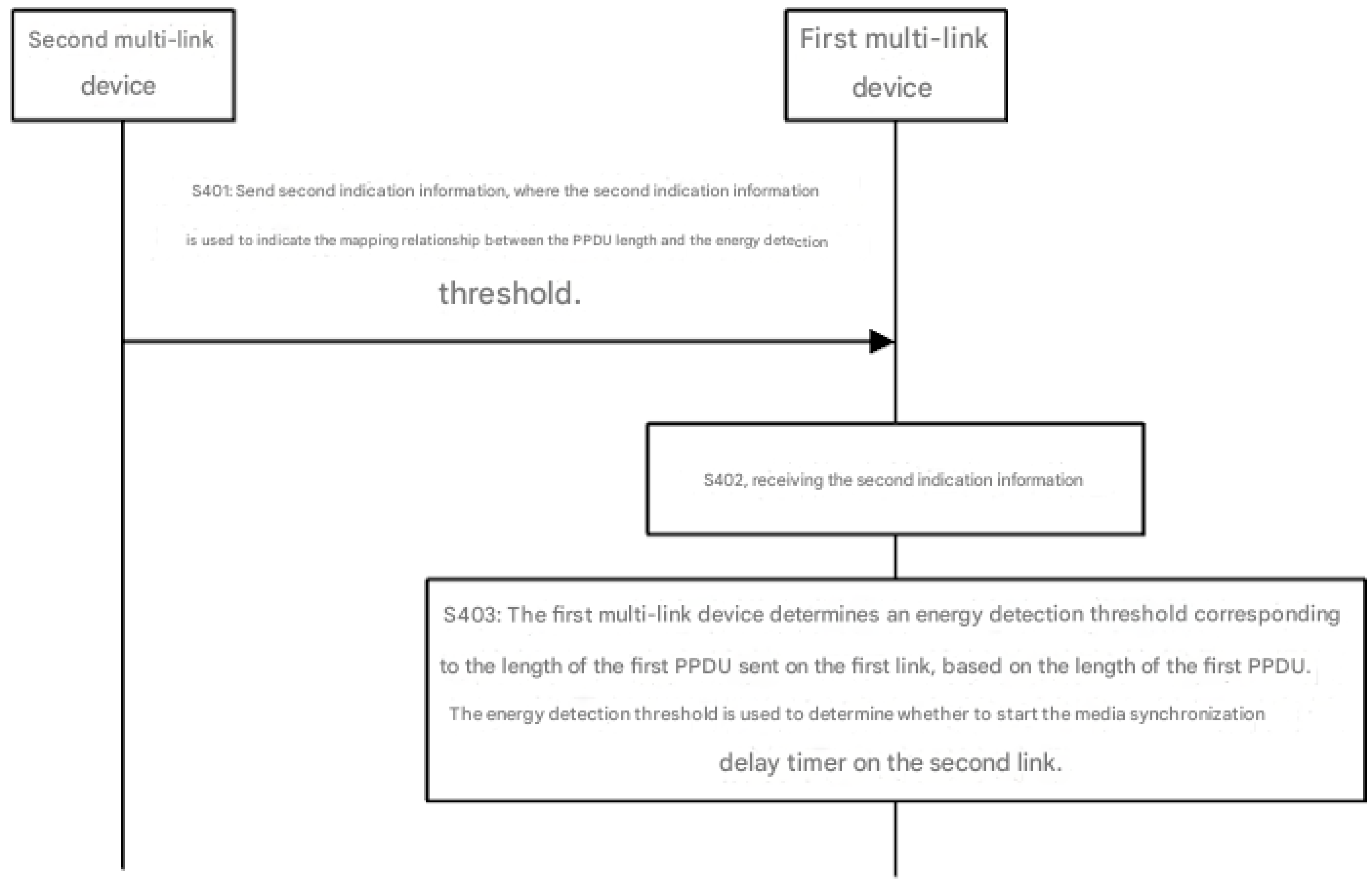


Figure 9

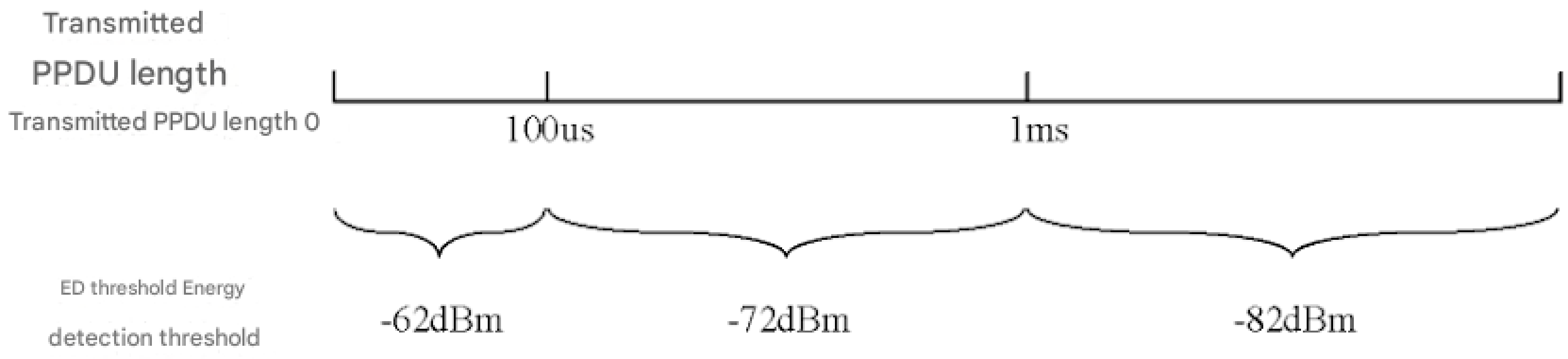


Figure 10

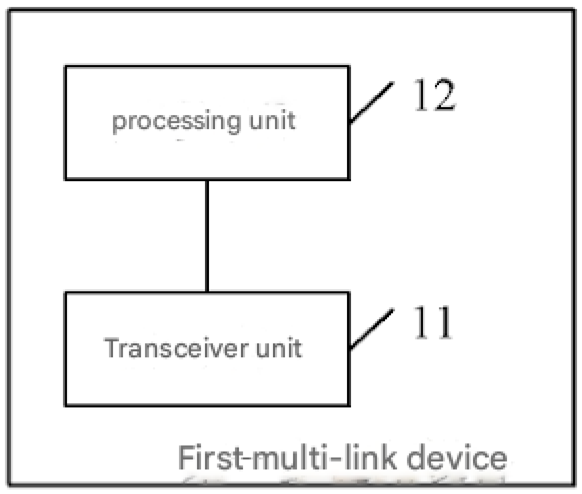


Figure 11

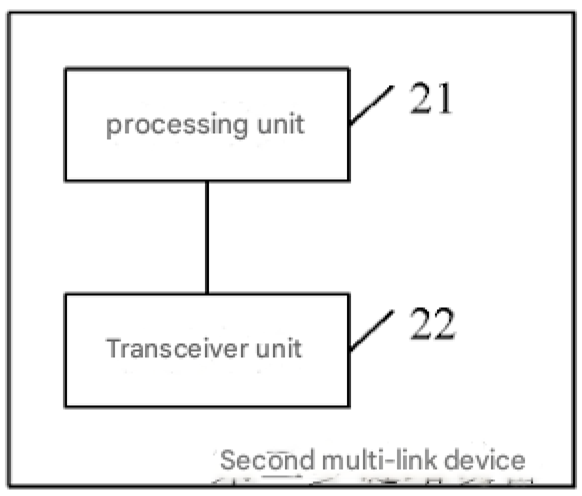


Figure 12