IEEE P802.11
Wireless LANs

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| Proposed Draft Text for MLO Multi-Link Channel Access: PPDU End Time Alignment |
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Abstract

This submission proposes draft text for MLO Multi-Link Channel Access: PPDU End Alignment based on the following portions of the SFD:

Revisions:

* Rev 0: Initial version of the document.
* Rev 1: Updated based on the comments from Laurent, Dmitry, Tomo and Yunbo.
* Rev 2: Updated based on the comments from Mark Rison, Young-Hoon, Greg, Ming, George, Gaurav, Alfred.
* Rev 3: Updated based on the comments from Young-Hoon and some editorial comment from Mark Rision.
* Rev 4: Including the motion tag.
* Rev 5: Updated based on additional editorial comments from Alfred.
1. 802.11be supports the following PPDU transmission restriction for the constrained multi-link operation:
* If an AP MLD intends to align the ending time of DL PPDUs carrying a frame soliciting an immediate response simultaneously sent to the same non-STR non-AP MLD on multiple links, the AP MLD shall ensure that the difference between the ending times of transmitting DL PPDUs is less than or equal to 8 μs ((aSIFSTime + aSignalExtension)/2).
	+ Where the reference of the ending time of the PPDU is not including the Signal Extension field.

[Motion 111, #SP0611-31, [15] and [169]]

[Motion 122, #SP152, [8] and [170]]

1. 802.11be supports the following Trigger frame transmission rule in the MLO:
* An AP in the AP MLD shall not send a Trigger frame with the CS Required subfield set to 1 to a STA in a non-STR non-AP MLD, when at least one PPDU from other STAs affiliated to the same non-STR non-AP MLD is scheduled for transmission before (aSIFSTime + aSignalExtention – aRxTxTurnaroundTime) has expired after the PPDU containing the Trigger frame.
	+ Note– In the above, aRxTxTurnaroundTime is 4 μs.
	+ Note– The ending time of a first PPDU that carrying a frame soliciting an immediate response frame cannot be earlier more than aRxTxTurnaroundTime of the ending time of a second PPDU containing a Trigger frame with the CS Required subfield set to 1.
	+ Note– The AP STA still follows the CS Required rule defined in 802.11ax.

[Motion 122, #SP153, [8] and [171]]

1. 802.11be supports the following Trigger frame transmission rule in the MLO in R1:
* When an AP MLD triggers simultaneously TB PPDUs from more than one STAs affiliated to the same non-STR non-AP MLD and allows the frames in the TB PPDUs to solicit control response frames from the AP MLD, then the UL Length subfield values in the soliciting Trigger frames shall be set to the same value.

[Motion 122, #SP154, [8] and [171]]

1. An AP MLD shall align the end of DL PPDUs (that contain QoS data soliciting an immediate UL response) that are sent simultaneously on multiple links to the same non-STR non-AP MLD, in such a way that the response to any of the PPDUs will not overlap with any of the DL PPDUs in R1.

An exception is that a high priority DL PPDU sent on one link may not be aligned with another DL PPDU sent on the other link.

[Motion 122, #SP159, [8] and [172]]

1. 802.11be supports that the padding procedures of 802.11ax can be used when transmitting a Trigger frame to extend the frame length to meet the ending time requirement of the PPDU carrying the Trigger frame in the MLO.
* NOTE- The Padding field in the Trigger frame is also included in the padding procedure.

[Motion 122, #SP168, [8] and [173]]

***Editing instructions formatted like this are intended to be copied into the TGbe Draft (i.e. they are instructions to the 802.11 editor on how to merge the text with the baseline documents).***

***TGbe Editor: Editing instructions preceded by “TGbe Editor” are instructions to the TGbe editor to modify existing material in the TGbe draft. As a result of adopting the changes, the TGbe editor will execute the instructions rather than copy them to the TGbe Draft.***

***Insert new Clause 33 following Clause 32 as follows:***

33. Extremely High Throughput (EHT) MAC specification

33.x Multi-link channel access

33.x.y1 PPDU end time alignment

In this subclause “simultaneously transmit” means more than one PPDU is transmitted on more than one link, where each PPDU is transmitted over one link, and those transmissions overlap in time. Likewise, “simultaneously trigger” means more than one HE or EHT TB PPDU is triggered on more than one link, where each PPDU is triggered over one link, and those transmissions overlap in time. If a non-STR MLD that is receiving a PPDU on a first link simultaneously transmits another PPDU on a second link, then the non-STR MLD might fail to receive the PPDU on the first link because of the interference caused by its transmission on the second link. This subclause specifies a mechanism to align the end time of PPDUs that are simultaneously transmitted to the same non-STR non-AP MLD, which helps reduce the chances of the occurence of such self-interference among STAs affiliated to the same non-STR MLD.

When an AP MLD simultaneously transmits more than one PPDU to the same non-STR non-AP MLD and at least one of the PPDUs carries a frame that is a QoS data soliciting an immediate response, then the AP shall align the end time of the PPDUs per the rules defined in this subclause, except if one of the PPDUs meets one of the following conditions:

* The PPDU carries a high priority frame (the definition of the high priority frame is TBD), in which case the PPDU carrying the high priority frame might not be aligned with another PPDU sent simultaneously on the other links.
* The PPDU does not solicit an immediate response and the end time of the PPDU is earlier than the end time of any of PPDUs that solicits an immediate response.
* Other condition is TBD.

(#Motion 122, SP159)

NOTE 1- In this way the response PPDU to any of the PPDUs transmitted by the AP will not overlap with any of these PPDUs.

When an AP MLD is required to align the end time of simultaneously transmitted PPDUs, it shall satisfy the following conditions:

* The AP MLD shall ensure that the difference between the end times of simultaneously transmitted PPDUs is less than or equal to 8 μs (see NOTE 2), where the end time of the PPDU is the time of end of the last OFDM symbol or the time of the end of the packet extension if present, whichever is later.
* The AP MLD shall ensure that the end time of one or more PPDUs that carries a frame soliciting an immediate response frame is at most 4 μs (see NOTE 3) earlier than the end time of any of PPDUs containing a Trigger frame with the CS Required subfield set to 1.

(#Motion 122, SP152)(#Motion 122, SP153)

NOTE 2- The difference between the end times of transmitting PPDUs needs to be less than SIFS minus a timing margin, so that the response PPDU to any of the PPDUs transmitted by the AP will not overlap with any of these PPDUs. To balance the implementation complexity at a transmitter side and a receiver side, the timing margin is set to half of SIFS.

NOTE 3- The value of 4 μs is derived from aRxTxTurnaroundTime being equal to 4 μs for the purpose of this requirement.

An AP MLD may use any type of padding to align the end time of transmitted PPDUs, such as using the Padding field in a Trigger frame, post-EOF A-MPDU padding, aggregating other MPDUs in the A-MPDU, or a packet extension.

(#Motion 122, SP168)

When an AP MLD simultaneously solicits one or more HE or EHT TB PPDUs from the same non-STR non-AP MLD, each AP affiliated to the AP MLD shall independently solicit an HE or EHT TB PPDU following the mechanisms defined in 26.5.2 (UL MU operation) with the following exceptions:

* An AP affiliated to the AP MLD shall not transmit a Trigger frame with the CS Required subfield set to 1 to a STA affiliated to a non-STR non-AP MLD, when at least one PPDU from other STAs affiliated to the same non-STR non-AP MLD is scheduled for transmission before a timer with a value of 12 μs (see NOTE 4) has expired after the PPDU containing the Trigger frame.
* If the AP MLD allows the frames in the TB PPDUs to solicit control response frames from the AP MLD, then the UL Length subfield values in the soliciting Basic Trigger frames shall be set to the same value.

(#Motion 122, SP153)(#Motion 122, SP154)

NOTE 4- 12 μs is derived from aSIFSTime + aSignalExtension – aRxTxTurnaroundTime, where aRxTxTurnaroundTime is equal to 4 μs for the purpose of this calculation.

The relationship between the end times of DL PPDUs sent over link 1, link 2, and link 3 between an AP MLD and a STA MLD is shown in Figure 33-xy (PPDU end time alignment timing relationships). An AP in the AP MLD operating on link 1 solicits an HE or EHT TB PPDU requiring the carrier sense from a STA in the STA MLD. In this case the difference between the end time of the soliciting DL PPDU sent on on link 1 and the starting time of the first solicited PPDU (in the figure, Ack frame on link 2) that is sent from any STA in the same STA MLD immediately after the soliciting DL PPDU is greater than or equal to 12 μs. Accordingly, the end time of the soliciting PPDU sent on link 2 cannot be more than 4 μs earlier than the end time of the soliciting PPDU sent on link 1. To avoid overlapping in time between any of the DL PPDUs and the response PPDU to any of the DL PPDUs, the difference between the end times of the DL PPDUs on link 2 and link 3 cannot be greater than 8 μs.

(#Motion 122, SP152)(#Motion 122, SP153)(#Motion 122, SP154)

**Figure 33-xy—PPDU end time alignment timing relationships**

9.3.1.22 Trigger frame format

9.3.1.22.1 General

***Change the last paragraph as follows:***

The Padding field is optionally present in a Trigger frame to extend the frame length for the following purposes:

1. To~~to~~ give the recipient STAs enough time to prepare a response for transmission a SIFS after the frame is received.
2. To align the end time of simultaneously transmitted PPDUs as described in 33.x.y1 (PPDU end time alignment).

The Padding field, if present, is at least two octets in length and is set to all 1s. If the Padding field is present in a Trigger frame, its length is computed as described in 26.5.2.2.3 (Padding for Trigger frame or frame containing TRS Control subfield).

(#Motion 122, SP168)

**Straw Poll: Do you support to incorporate the proposed draft text in this document 11-20/1271r5 to the TGbe Draft 0.1?**

**Result: Yes/No/Abstain**