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Wireless LANs

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| Proposed Draft TextMAC MLO EMLMR TBDs |
| Date: 2021-2-26 |
| Author(s): |
| Name | Affiliation | Address | Phone | email |
| Young Hoon Kwon | NXP |  |  | younghoon.kwon@nxp.com |
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Abstract

This submission proposes draft text for resolving TBDs in sub-clause 35.3.14 Enhanced multi-link multi-radio operation of 802.11bd Draft 0.2, which are:

* An MLD with dot11EHTEMLMROptionImplemented equal to true shall set the EMLMR Support subfield of the TBD Capabilities element, which indicates MLD level capabilities, to 1; otherwise, the MLD shall set the EMLMR Support subfield to 0.
* A non-AP MLD with dot11EHTEMLMROptionImplemented equal to true operates in the EMLMR mode by TBD signaling.
* A non-AP MLD with dot11EHTEMLMROptionImplemented equal to true may indicate its link switch delay in a TBD management frame.

Revisions:

* Rev 0: Initial version of the document.
* Rev 1: Incorporated email discussion results.
* Rev 2: Removed EML capabilities definition and editorial change for EMLMR switching behavior
* Rev 3: Undeleted EML capabilities definition
* Rev 4: Modified text for EMLMR mode switch
* Rev 5: Modified text for EMLMR mode switching delay and EMLMR links
* Rev 6: Modified Transition Timeout values
* Rev 7: Added the case that AP cannot send EML OM Notification frame before the timer expires.

**Discussions:**

1. EMLMR support capability indication:
* As EMLMR support capability is an MLD level capability, it is reasonable to use Common Info field of an ML element to carry this information.
1. EMLMR enabling/disabling mode indication:
* Two candidate solutions are possible: Use of A-Control subfield or use of management frame exchange.
* Considering that EMLMR mode switching happens once in a while depending on operation scenario changes, it is preferrable to use management frame exchange compared to A-Control subfield.
* In this sense, an action frame is defined to carry this information, which can be applied to both EMLSR and EMLMR mode switching as EMLSR/EMLMR share the same mode switching concept.
1. Indication of link switch delay:
* In EMLSR operation, the link switch delay is defined as for a Padding field in a Trigger frame.
	+ In EMLSR operation, the initial control frame is limited to a Trigger frame in non-HT (duplicate) PPDU format.
	+ Therefore, limiting the addition of required padding to the Padding field is reasonable.
* However, in EMLMR operation:
	+ Initial frame exchange follows per-link spatial stream capabilities and operating mode, and there’s no additional restriction.
	+ Therefore, we cannot restrict the addition of required padding to the Padding field in a Trigger frame.
	+ Rather, we better follow general padding rule of 11ax Trigger frame:
		- An AP may use any type of padding to satisfy the MinTrigProcTime requirement of a non-AP STA, such as using the Padding field in a Trigger frame, post-EOF A-MPDU padding, or aggregating other MPDUs in the A-MPDU.
* EMLMR Delay field is defined in a MLD level element (Common Info field of the basic variant ML element) for this purpose.
	+ Similar values as EMLSR Delay field is used.

***TGbe editor: Modify the subclause 9.6.35.1 (EHT Action field) as follows:***

9.6.35 EHT Action frame details

9.6.35.1 EHT Action field

An EHT Action field, in the octet immediately after the Category field, differentiates the EHT Action frame formats. The EHT Action field values associated with each frame format within the EHT category are defined in [Table 9-526q (EHT Action field values)](#bookmark56).

### Table 9-526q—EHT Action field values

|  |  |
| --- | --- |
| **Value** | **Meaning** |
| 0 | EHT compressed beamforming/CQI |
| 1 | Enhanced Multi-Link (EML) Operating Mode Notification |
| 2–255 | Reserved |

***TGbe editor: Add a new subclause 9.6.35.x after the end of 9.6.35.2 (EHT Compressed Beamforming/CQI frame format) as follows:***

9.6.35.x EML Operating Mode Notification frame format

The Enhanced Multi-Link (EML) Operating Mode Notification frame is used to indicate that a non-AP MLD with which the transmitting STA is affiliated is changing its Enhanced Multi-Link operation.

The Action field of the EML Operating Mode Notification frame contains the information shown in Table 9-xyz1 (EML Operation frame Action field format).

|  |
| --- |
| **Table 9-xyz1 – EML Operating Mode Notification frame Action field format** |
| **Order** | **Information** |
| 1 | Category |
| 2 | EHT Action |
| 3 | Dialog Token |
| 4 | EML Control (see 9.4.1.xx (EML Control field)) |
|  |  |

The Category field is defined in 9.4.1.11 (Action field).

The EHT Action field is defined in 9.6.x.1 (EHT Action field).

The Dialog Token field is set by a non-AP MLD to a nonzero value chosen by the non-AP MLD and is set by an AP MLD to the value copied from the corresponding received EML Operating Mode Notification frame.

***TGbe editor: Add a new subclause 9.4.1.xx as follows:***

9.4.1.xx EML Control field

The Enhanced Multi-Link (EML) Control field is defined in Figure 9-xyz (EML Control field format).

|  |  |  |  |
| --- | --- | --- | --- |
|  | B0 | B1 | B2 B7 |
|  | EMLSR Mode | EMLMR Mode | Reserved |
| Bits: | 1 | 1 | 6 |
|  | **Figure 9-xyz – EML Control field** |

A non-AP MLD that supports Enhanced multi-link single-radio operation (see 35.3.13 (Enhanced multi-link single-radio operation)) sets the EMLSR Mode subfield to 1 to indicate that the non-AP MLD operates in EMLSR mode and to 0 to indicate that the non-AP MLD does not operate in EMLSR mode. The EMLSR Mode subfield is set to 0 for all non-AP MLDs that don’t support Enhanced multi-link single-radio operation, for all non-AP MLDs that have set the EMLMR Mode subfield to 1. An AP MLD sets the EMLSR Mode subfield to the value obtained from the corresponding received EML Operating Mode Notification frame.

A non-AP MLD that supports Enhanced multi-link multi-radio operation (see 35.3.14 (Enhanced multi-link multi-radio operation)) sets the EMLMR Mode subfield to 1 to indicate that the non-AP MLD operates in EMLMR mode and to 0 to indicate that the non-AP MLD does not operate in EMLMR mode. The EMLMR Mode subfield is set to 0 for all non-AP MLDs that don’t support Enhanced multi-link multi-radio operation, for all non-AP MLDs that have set the EMLSR mode subfield to 1. An AP MLD sets the EMLMR Mode subfield to the value obtained from the corresponding received EML Operating Mode Notification frame.

***TGbe Editor to make the following changes in Subclause 9.4.2.295b.2 (Basic variant Multi-Link element):***

***[Note to Editor: This resolution is based on the assumption that resolutions shown in 11-21/319r7 is incorporated into the draft specification.]***

**9.4.2.295b.2 Basic variant Multi-Link element**

The Basic variant Multi-link element is used to carry information of an MLD and its affiliated STAs during multi-link discovery (see 35.3.4.4 (Multi-link element usage rules in the context of discovery)) and multi-link setup (see 35.3.5.4 (Usage and rules of Basic variant Multi-link element in the context of multi-link setup)).

The format of the Common Info field of the Basic variant Multi-Link element is defined in Figure 9-788eh (Common Info field of the Basic variant Multi-Link element format).

|  |  |  |  |
| --- | --- | --- | --- |
|  | MLD MAC Address | EML Capabilities | TBD |
| Octets: | 0 or 6 | 0 or 4 | TBD |

**Figure 9-788eh – Common Info field of the Basic variant Multi-Link element format**

The condition for the presence of the MLD MAC Address field in the Common Info field is defined in 35.3.5.4 (Usage and rules of Basic variant Multi-link element in the context of multi-link setup) and 35.3.4.4 (Multi-link element usage rules in the context of discovery).

The condition for the presence of the EML Capabilities field in the Common Info field is defined in 35.3.14 (Enhanced multi-link single radio operation) and 35.3.15 (Enhanced multi-link multi-radio operation).

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  | B0 | B1 B3 | B4 | B5 B7 | B8 B11 | B12 B15 | B16 B31 |
|  | EMLSR Support | EMLSR Delay | EMLMR Support | EMLMR Delay | Transition Timeout | Reserved | EMLMR Link Bitmap |
| Bits: | 1 | 3 | 1 | 3 | 4 | 4 | 16 |

**Figure 9-788eh1—EML Capabilities subfield format**

The format of the EML Capabilities subfield is defined in Figure 9-788eh1 (EML Capabilities subfield format). The EML Capabilities subfield contains a number of subfields that are used to advertise the capabilities for EMLSR operation and EMLMR operation.

The EMLSR Support subfield indicates support of the EMLSR operation for an MLD. The EMLSR Support subfield is set to 1 if the MLD supports the EMLSR operation; otherwise set to 0. (#1773, 2603)

The EMLSR Delay subfield indicates the MAC padding duration of the Padding field of the initial Control frame defined in 35.3.14 (Enhanced multi-link single radio operation). The EMLSR Delay field is 3 bits and set to 0 for 0 µs, set to 1 for 32 µs, set to 2 for 64 µs, set to 3 for 128 µs, set to 4 for 256 µs, and the values 5 to 7 are reserved.(#1773, 2603, 3206, 2745, 2917)

The EMLMR Support subfield indicates support of the EMLMR operation for an MLD. The EMLMR Support subfield is set to 1 if the MLD supports the EMLMR operation; otherwise set to 0.

The EMLMR Delay subfield indicates the minimum padding duration required for a non-AP MLD for EMLMR link switch when operating in EMLMR mode (see 35.3.15 (Enhanced multi-link multi-radio operation)).

When the EMLMR Delay subfield is included in a frame sent by a STA affiliated with a non-AP MLD, the EMLMR Delay subfield is set to 0 for 0 µs, set to 1 for 32 µs, set to 2 for 64 µs, set to 3 for 128 µs, set to 4 for 256 µs, and the values 5 to 7 are reserved. When the EMLMR Delay subfield is included in a frame sent by an AP affiliated with an AP MLD, the EMLMR Delay subfield is set to 0.

The Transition Timeout subfield indicates the timeout value for EML Operating Mode Notification frame exchange in EMLMR mode (see 35.3.15 (Enhanced multi-link multi-radio operation)).

When the Transition Timeout subfield is included in a frame sent by an AP affiliated with an AP MLD, the Transition Timeout subfield is set to 0 for 0 TU, set to 1 for 1 TU, set to 2 for 2 TU, set to 3 for 4 TU, set to 4 for 8 TU, set to 5 for 16 TU, set to 6 for 32 TU, set to 7 for 64 TU, set to 8 for 128 TU, and the values 9 and 15 are reserved. When the Transition Timeout subfield is included in a frame sent by a non-AP STA affiliated with a non-AP MLD, the Transition Timeout subfield is set to 0.

When the EMLMR Link Bitmap subfield is included in a frame sent by a STA affiliated with a non-AP MLD, the i-th bit in the EMLMR Link Bitmap subfield is set to 1 if a link with Link ID equal to i is a member of the EMLMR links; otherwise it is set to 0. When the EMLMR Link Bitmap subfield is included in a frame sent by an AP affiliated with an AP MLD, the EMLMR Links Bitmap subfield is set to all 0s.

***TGbe editor: Please update subclause 35.3.15 (Enhanced multi-link multi-radio operation) as follows:***

* + 1. Enhanced multi-link multi-radio operation

A non-AP MLD may operate in the enhanced multi-link multi-radio (EMLMR) mode on a specified set of the enabled links between the non-AP MLD and its associated AP MLD. The specified set of the enabled links in which the EMLMR mode is applied is called EMLMR links.

An MLD with dot11EHTEMLMROptionImplemented equal to true shall set the EML Capabilities Present subfield to 1 and shall set the EMLMR Support subfield of the Common Info field of transmitted Basic variant ML elements to 1; otherwise, the MLD shall set the EMLMR Support subfield to 0.

A non-AP MLD with dot11EHTEMLMROptionImplemented equal to true shall set the EMLMR Rx NSS subfield of TBD element to dot11SupportedEMLMRRxNSS and the EMLMR Tx NSS subfield of TBD element to dot11SupportedEMLMRTxNSS, which indicate MLD level capabilities.

If a non-AP MLD with dot11EHTEMLMROptionImplemented equal to true intends to switch EMLMR mode after multi-link setup, then a non-AP STA affiliated with the non-AP MLD shall transmit an EML Operating Mode Notification frame with EMLMR Mode subfield equal to 1 or 0 to enable or disable EMLMR mode, respectively.

After successful transmission of the EML Operating Mode Notification frame from the non-AP STA affiliated with the non-AP MLD to an AP affiliated with an AP MLD, the non-AP STA and the AP initialize the Transition Timeout timer with the Transition Timeout subfield value in the EML Capabilities subfield of the Basic variant Multi-Link element received from the AP. The Transition Timeout timer begins counting down from the end of the PPDU containing the immediate response to the EML Operating Mode Notification frame. The AP should send an EML Operating Mode Notification frame to the non-AP STA with EML Control field set to the same value as EML Control field in the received EML Operating Mode Notification frame from the non-AP STA before the Transition Timeout expires.

The non-AP MLD shall transition to the indicated mode right after successfully receiving the EML Operating Mode Notification frame from the AP or right after the Transition Timeout timer expires, whichever comes first.

A non-AP MLD with dot11EHTEMLMROptionImplemented equal to true shall indicate the minimum padding duration required for the non-AP MLD for EMLMR link switch in the EMLMR Delay subfield in the Common Info field of transmitted Basic variant ML elements. .

NOTE — The link switching can happen during the transmission time of the initial response frame. However, the duration of initial response frame can be different depending on the initial frame. The non-AP MLD might determine the minimum padding duration such that it can be satisfied even when the shortest initial response frame is used on EMLMR links (E.g., a CTS frame in non-HT PPDU with the highest rate in the BSSBasicRateSet parameters).

When an AP of an AP MLD transmits a PPDU that initiates a frame exchange with a non-AP MLD operating in EMLMR mode, the AP shall ensure that the padding duration of the PPDU is longer than or equal to the minimum padding duration value indicated by the EMLMR Delay field of the Basic variant Multi-Link element received from the non-AP MLD.

When a non-AP MLD operates in the EMLMR mode, after initial frame exchange subject to its per-link spatial stream capabilities and operating mode on one of the EMLMR links, the non-AP MLD shall be able to support the following until the end of the frame exchange sequence initiated by the initial frame exchange:

* Receive PPDUs with the number of spatial streams up to the value as indicated in the EMLMR Rx NSS subfield of TBD element at a time on the link for which the initial frame exchange was made.
* Transmit PPDUs with the number of space-time streams up to the value as indicated in the EMLMR Tx NSS subfield of TBD element at a time on the link for which the initial frame exchange was made.

After the end of the frame exchange sequence, each STA of the non-AP MLD in the EMLMR mode shall be able to transmit or receive PPDU, subject to its per-link spatial stream capabilities and operating mode and subject to any switching delay indicated by the non-AP MLD.