IEEE P802.11
Wireless LANs

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| LB266 CR for ML SM Power Save Mode |
| Date: July 18, 2022 |
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 Abstract

This submission proposes resolutions for following 1 CID received for TGbe LB266:

13793

Revisions:

* Rev 0: Initial version of the document.
* Rev 1: Some text change.
* Rev 2: add some clarification text regarding the relationship between the ML SM Power Save mode and other modes, including the link level dynamic/static SM Power Save mode, EMLSR Mode and the EMLMR mode.
* Rev 3: further polish the text based on offline feedback.

Interpretation of a Motion to Adopt

A motion to approve this submission means that the editing instructions and any changed or added material are actioned in the TGbe Draft. This introduction is not part of the adopted material.

***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.***

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **CID** | **Commenter** | **Page** | **Clause** | **Comment** | **Proposed Change** | **Resolution** |
| 13793 | Yuchen Guo | 440.50 | 35.3.12 | According to Motion 146, #SP343 in doc 20/1935, 802.11be will define a ML (multi-link) SM power save mode. Currently the text for ML SM PS mode is missing | Please add the corresponding text for ML SM PS mode. The commenter will bring a contribution to add the text. | Revised-Agree with the comment. Corresponding text is added to define the ML SM PS mode.TGbe editor:Please implement changes as shown in this document tagged as 13793. |

Discussion:

This submission resolves CID 13793 by proposing spec texts for the following motion:

802.11be define a ML (multi-link) SM power save mode in R2 as follows.

* A non-AP MLD that is in ML SM PS mode can use only one link and one active receive chain for receiving and responding to an initial frame sent by the AP, and addressed to it.
* The non-AP MLD becomes available on other links after responding to the initial frame.
	+ How and which device determines the “other links” is TBD.
* The non-AP MLD may become unavailable on any of the “other links” if one of the followings is satisfied:
	+ The TXOP on the “other link” has ended.
	+ Other TBD condition to deal with the case when the non-AP MLD does not receive any frame addressed to it on the “other links”.
* This is an optional feature for both AP and non-AP MLD.

[Motion 146, #SP343, [23] and [249]]

Here are some system level simulation results showing the benefit of the ML SM PS mode.

Simulation settings:

Traffic: DL ; AP MLD number: 1-2 ; non-AP MLD number: 1-4; Link number: 2 ; NSS per link: 1 ; Link 1 (primary) is 20MHz (assuming 2.4GHz band) ; Link 2 is 80MHz (assuming 5GHz band) ; Packet size: 1500 bytes

Simulation scheme 1 (ML SM PS mode):

Non-AP behavior: monitor on link 1 only. After receiving an initial frame (e.g., RTS), turn on link 2.

AP behavior: contend the channel on both link 1 and link 2, need to transmit an RTS on link 1 first, then transmit on link 2.

Simulation scheme 2 (independent access):

Assume two links are STR, each link can perform transmission independently.

Simulation scheme 3 (cross-link power state indication):

AP MLD only contends on link 1 and transmits to the non-AP MLD, the non-AP MLD will indicate to the AP MLD whether it turns on the other link (probability is p). In the figures below, the line marked as “COMP 1.0” corresponds to this scheme 3 with p=1.0, the line marked as “COMP 0.3” corresponds to this scheme 3, with p=0.3, and the line marked as “COMP 0.6” corresponds to this scheme 3, with p=0.6.

Simulation output:

Metric 1: transmission delay

Metric 2: the amount of time that the radio is active (normalized to scheme 2. Note that in scheme 2, two links are always active.)





***TGbe editor: Please note baselines are Draft P802.11be\_D2.0 and REVme D1.0***

***TGbe editor: Please add the following subclause 35.3.12.7 (Multi-Link SM Power Save Mode) after subclause 35.3.12.6 (Operation for MLD listen interval)***

**35.3.12.7 Multi-Link SM Power Save Mode (#13793)**

The multi-link SM (MLSM) power save mode defined in this subclause allows a non-AP MLD with multiple receive chains to listen on a single link with a single receive chain, and become available on multiple links after responding to an initial frame sent by the AP addressed to it. This helps to reduce the power consumption of the non-AP MLD during an idle period, and allows a high data rate when traffic arrives.

In MLSM power save mode, a non-AP MLD shall follow the rules defined in this subclause.

A non-AP MLD may operate in the MLSM power save 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 on which the MLSM power save mode is applied is called MLSM links. The MLSM links shall be indicated in the MLSM Link Bitmap subfield in the MLSM Power Control field of the MLSM Power Save frame by setting the bit positions of the MLSM Link Bitmap subfield to 1.

A non-AP MLD shall not operate in the MLSM power save mode if any of its affiliated STA is operating in the dynamic SM power save mode. A non-AP MLD shall not operate in the MLSM power save mode if it is operating in the EMLSR mode or the EMLMR mode. When a non-AP MLD is operating in the MLSM power save mode, the non-AP MLD shall not operate in the EMLSR mode or the EMLMR mode, each STA affiliated with the non-AP MLD shall not operate in the dynamic SM power save mode.

When a non-AP MLD with dot11EHTMLSMPowerSaveOptionImplemented equal to true (re)associates with an AP MLD, the MLSM power save mode is disabled by default.

An MLD with dot11EHTMLSMPowerSaveOptionImplemented equal to true shall set the MLSM Capabilities Present subfield to 1 and shall set the MLSM Power Save Support subfield of the Common Info field of the Basic Multi-Link element (9.4.2.312.2 (Basic Multi-Link element)) to 1 in all Management frames that include the Basic Multi-Link element except Authentication frames. An MLD with dot11EHTMLSMPowerSaveOptionImplemented equal to false shall set the MLSM Capabilities Present subfield to 0.

When a non-AP MLD with dot11EHTMLSMPowerSaveOptionImplemented equal to true intends to operate in the MLSM power save mode, a STA affiliated with the non-AP MLD shall transmit an MLSM Power Save frame, with the MLSM Power Save Enabled subfield of the MLSM Power Control field of the frame set to 1, to an AP affiliated with an AP MLD with dot11EHTMLSMPowerSaveOptionImplemented equal to true. The link identified by the MLSM Primary Link ID subfield in the MLSM Power Control field of the MLSM Power Save frame is defined as the MLSM primary link. The non-AP MLD shall indicate the minimum MAC padding duration of the Padding field of the initial frame in the MLSM Padding Delay subfield of the MLSM Capabilities subfield in the Common Info field of the Basic Multi-Link element.

An AP affiliated with the AP MLD that received the MLSM Power Save frame from a STA affiliated with the non-AP MLD should transmit an MLSM Power Save frame to one of the STAs affiliated with the non-AP MLD within the timeout interval indicated in the MLSM Power Save Transition Timeout subfield in the MLSM Capabilities subfield of the Common Info field of the Basic Multi-Link element, starting at the end of the PPDU transmitted by the AP affiliated with the AP MLD carrying the immediate acknowledgement to the MLSM Power Save frame transmitted by the STA affiliated with the non-AP MLD.

After the successful transmission of the MLSM Power Save frame with the MLSM Power Save Enabled subfield set to 1 by the STA affiliated with the non-AP MLD, the non-AP MLD shall operate in the MLSM power save mode after the transition delay indicated in the MLSM Power Save Transition Timeout subfield in the MLSM Capabilities subfield of the Common Info field of the Basic Multi-Link element or immediately after receiving an MLSM Power Save frame from one of the APs operating on the MLSM links and affiliated with the AP MLD.

When a non-AP MLD with dot11EHTMLSMPowerSaveOptionImplemented equal to true intends to disable the MLSM power save mode, a STA affiliated with the non-AP MLD shall transmit an MLSM Power Save frame with the MLSM Power Save Enabled subfield of the MLSM Power Control field of the frame set to 0, to an AP affiliated with an AP MLD. The non-AP MLD shall disable the MLSM power save mode after the successful transmission of the MLSM power save frame.

When a non-AP MLD is operating in the MLSM power save mode, the following applies:

— The non-AP MLD may use a single receive chain to transmit or receive frames on the MLSM primary link.

— The STAs on the MLSM links that are not the MLSM primary link may become unavailable.

— The non-AP MLD becomes available on its MLSM link(s) by having the corresponding STA(s) in an awake state when the STA affiliated with the non-AP MLD that operates on the MLSM primary link receives the start of a frame exchange sequence addressed to it. The number of spatial streams that the corresponding STA(s) shall be able to receive is subject to the spatial stream capabilities and operating mode of the corresponding STA(s) before the non-AP MLD enabled the MLSM power save mode.

— An AP affiliated with the AP MLD that initiates frame exchanges with the non-AP MLD on the MLSM primary link shall begin the frame exchange sequence by transmitting an initial frame to the non-AP MLD with the number of spatial streams of the initial frame set to 1. The AP shall ensure that the padding duration of the PPDU carrying the initial frame is greater than or equal to the maximum of the values indicated in the MLSM Padding Delay subfield of the Basic Multi-Link element received from the non-AP MLDs with which the frame exchanges are initiated.

— After the AP transmits the initial frame and receives an immediate response frame as a response to the initial frame, the APs affiliated with the AP MLD that are operating on the MLSM link(s) may transmit frames to the STA(s) affiliated with the non-AP MLD with the number of spatial streams, subject to the spatial stream capabilities and operating mode of the corresponding STA(s) before the non-AP MLD enables the MLSM power save mode.

— The non-AP MLD may become unavailable on any MLSM link except the MLSM primary link if the non-AP STA affiliated with the non-AP MLD that operates on the MLSM link:
• does not receive any frame addressed to it within an aPPDUMaxTime.
• is in a frame exchange sequence, and determines the end of the fame exchange sequence through any of the conditions defined in 11.2.6 (SM power save).

— The non-AP MLD may use a single receive chain to transmit or receive frames on the MLSM primary link when it determines the end of the frame exchange sequence on the MLSM primary link through any of the conditions defined in 11.2.6 (SM power save).

**9.4.2.312.2.1 Multi-Link Control field of the Basic Multi-Link element**

The format of the Presence Bitmap subfield of the Basic Multi-Link element is defined in Figure 9-1002g (Presence Bitmap subfield of the Basic Multi-Link element format).

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | B0 | B1 | B2 | B3 | B4 | B5 | B6 | B7   B11 |
|  | Link ID InfoPresent | BSSParametersChangeCountPresent | MediumSynchronizationDelayInformationPresent | EMLCapabilitiesPresent (#24417) | MLDCapabilitiesandOperationsPresent | MLD IDPresent | MLSM Capabilities Present | Reserved |
| Bits: | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 5 |
|  |  | **Figure 9-1002g—Presence Bitmap subfield of the Basic Multi-Link element format** |

***TGbe editor: Please insert the following paragraph at the end of this subclause***

(#13793)The MLSM Capabilities Present subfield is set to 1 if the MLSM Capabilities subfield is present in the Common Info field. Otherwise, the MLSM Capabilities Present subfield is set to 0.

**9.4.2.312.2.2 Common Info field of the Basic Multi-Link element**

The format of the Common Info field of the Basic Multi-Link element is defined in Figure 9-1002h (Common Info field of the Basic Multi-Link element format).

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | CommonInfoLength | MLDMACAddress | Link IDInfo | BSSParametersChangeCount (#24417) | MediumSynchronizationDelayInformation | EMLCapabilities | MLDCapabilitiesandOperations | MLDID | MLSM Capabilities |
| Octets: | 1 | 6 | 0 or 1 | 0 or 1 | 0 or 2 | 0 or 2 | 0 or 2 | 0 or 1 | 0 or 1 |
|  | **Figure 9-1002h—Common Info field of the Basic Multi-Link element format** (#13793) |

***TGbe editor: Please insert the following paragraphs at the end of this subclause***

(#13793)The format of the MLSM Capabilities subfield is defined in Figure 9-1002la (MLSM Capabilities subfield format).

|  |  |  |  |
| --- | --- | --- | --- |
|  | B0 | B1 B4 | B5 B7 |
|  | MLSM Power Save Support | MLSM Power Save Transition Timeout | MLSM Padding Delay |
| Bits: | 1 | 4 | 3 |
| **Figure 9-1002la MLSM Capabilities subfield format** |

The MLSM Power Save Support subfield indicates support of the MLSM power save mode operation for an MLD. The MLSM Power Save Support subfield is set to 1 if the MLD supports the MLSM power save mode operation; otherwise, it is set to 0.

The MLSM Power Save Transition Timeout subfield indicates the timeout value for the MLSM Power Save frame exchange in MLSM power save mode. When the MLSM Power Save Transition Timeout subfield is included in a frame sent by an AP affiliated with an AP MLD, the MLSM Power Save Transition Timeout subfield is set as defined in Table 9-401ia (Encoding of the MLSM Power Save Transition Timeout subfield). When the MLSM Power Save Transition Timeout subfield is included in a frame sent by a non-AP STA affiliated with a non-AP MLD, the MLSM Power Save Transition Timeout subfield is reserved.

**Table 9-401ia—Encoding of the MLSM Power Save Transition Timeout subfield**

|  |  |
| --- | --- |
| **MLSM Power Save Transition Timeout****subfield value** | **Timeout value** |
| **0** | 0 µs |
| **1** | 128 µs |
| **2** | 256 µs |
| **3** | 512 µs |
| **4** | 1 TU |
| **5** | 2 TUs |
| **6** | 4 TUs |
| **7** | 8 TUs |
| **8** | 16 TUs |
| **9** | 32 TUs |
| **10** | 64 TUs |
| **11** | 128 TUs |
| **12-15** | Reserved |

The MLSM Padding Delay subfield indicates the minimum MAC padding duration of the Padding field of the initial frame requested by the non-AP MLD as defined in 35.3.12.7 (Multi-Link SM Power Save Mode). When the MLSM Padding Delay subfield is included in a frame sent by an AP affiliated with an AP MLD, the EMLSR Padding Delay subfield is set to 0. The MLSM Padding Delay subfield includes 3 bits and is set as defined in Table 9-401ib (Encoding of the MLSM Padding Delay subfield).

**Table 9-401ib—Encoding of the MLSM Padding Delay subfield**

|  |  |
| --- | --- |
| **MLSM Padding Delay subfield value** | **MLSM Padding Delay** |
| **0** | 0 µs |
| **1** | 32 µs |
| **2** | 64 µs |
| **3** | 128 µs |
| **4** | 256 µs |
| **5-7** | Reserved |

**9.6.35.1 Protected EHT Action field**

***TGbe editor: Please modify Table 9-623c (Protected EHT Action field values) as the following.***

**Table 9-623c—Protected EHT Action field values** (#13793)

|  |  |  |
| --- | --- | --- |
| Value | Meaning | Time priority |
| 0 | TID-To-Link Mapping Request | No |
| 1 | TID-To-Link Mapping Response | No |
| 2 | TID-To-Link Mapping Teardown | No |
| 3 | EPCS Priority Access Enable Request | No |
| 4 | EPCS Priority Access Enable Response | No |
| 5 | EPCS Priority Access Teardown | No |
| 6 | EML Operating Mode Notification | No |
| 7 | MLSM Power Save | No |
| 8-255 | Reserved |  |

***TGbe editor: Please add the following subclause 9.6.35.9 (MLSM Power Save frame details) after subclause 9.6.35.8 (EML Operating Mode Notification frame details)***

**9.6.35.9 MLSM Power Save frame details (#13793)**

The MLSM Power Save frame is used to indicate that a non-AP MLD with which the transmitting STA is affiliated is changing its MLSM power save operation.

The Action field of the MLSM Power Save frame contains the information shown in Table 9-623k (Protected MLSM Power Save frame Action field format).

**Table 9-623k—** **Protected MLSM Power Save frame Action field format**

|  |  |
| --- | --- |
| **Order** | **Information** |
| 1 | Category |
| 2 | Protected EHT Action |
| 3 | Dialog Token |
| 4 | MLSM Power Control (see 9.4.1.75 (MLSM Power Control field)) |

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

The Protected EHT Action field is defined in 9.6.35.1 (Protected 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 MLSM Power Save frame.

**9.4.1.75 MLSM Power Control field (#13793)**

The MLSM Power Control field is defined in Figure 9-144k (MLSM Power Control field format).

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | B0 | B1          B4 | B5          B7 | B8       B23 |
|  | MLSM Power Save Enabled | MLSM Primary Link ID | Reserved | MLSM Link Bitmap |
| Bits: | 1 | 4 | 3 | 0 or 16 |
| **Figure 9-144k—** **MLSM Power Control field format** |

A non-AP MLD with dot11EHTMLSMPowerSaveOptionImplemented equal to true sets the MLSM Power Save Enabled subfield to 1 to indicate that the non-AP MLD intends to operate in MLSM power save mode and to 0 to indicate that the non-AP MLD does not operate in MLSM power save mode. An AP MLD with dot11EHTMLSMPowerSaveOptionImplemented equal to true that receives an MLSM Power Save frame from a STA affiliated with a non-AP MLD, sets the MLSM Power Save Enabled subfield of the MLSM Power Save frame that is sent in response, to the value obtained from the received MLSM Power Save frame.

The MLSM Primary Link ID subfield indicates the link ID of the MLSM primary link. A non-AP MLD with dot11EHTMLSMPowerSaveOptionImplemented equal to true sets the MLSM Primary Link ID subfield to indicate the MLSM primary link that the non-AP MLD intends to operate on. An AP MLD with dot11EHTMLSMPowerSaveOptionImplemented equal to true that receives an MLSM Power Save frame from a STA affiliated with a non-AP MLD, sets the MLSM Primary Link ID subfield of the MLSM Power Save frame that is sent in response, to the value obtained from the received MLSM Power Save frame.

The MLSM Link Bitmap subfield indicates the subset of the enabled links that is used by the non-AP MLD in the MLSM power save mode. The bit position *i* of the MLSM Link Bitmap subfield corresponds to the link with the
Link ID equal to *i* and is set to 1 to indicate that the link is used by the non-AP MLD for the MLSM power save mode
and is a member of the MLSM links; otherwise the bit position is set to 0.