IEEE P802.11
Wireless LANs

|  |
| --- |
| 11be Spec text for MLO Power-save Procedure |
| Date: 2020-08-20 |
| Author(s): |
| Name | Affiliation | Address | Phone | email |
| Abhishek Patil | Qualcomm |  |  | appatil@qti.qualcomm.com |
| George Cherian |  |  |  |
| Alfred Asterjadhi |  |  |  |
| Duncan Ho |  |  |  |
| Yanjun Sun |  |  |  |
| Menzo Wentink |  |  |  |
| Rojan Chitrakar | Pansonic |  |  |  |
| Yonggang Fang | ZTE |  |  |  |
| Young Hoon Kwon | NXP |  |  |  |
| Laurent Cariou | Intel |  |  |  |
| Jarkko Kneckt | Apple |  |  |  |
| Greg Ko | Wilus Group |  |  |  |

Abstract

We propose the draft specification skeleton for MLD to help the creation of TGbe draft D0.1.

Revisions:

* Rev 0: Initial version of the document.
* Rev 1: Changed based on offline feedback from TTT members
* Rev 2: Changed based on feedback when the doc was presented 8/31/20
* Rev 3: Revised based on feedback from Greg Ko

The texts is prepared for the following motions.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| MAC | MLO-Power save: General and other procedures | Abhishek Patil | Minyoung Park, Ming Gan, Laurent Cariou, Young Hoon Kwon, Yongho Seok, Jarkko Kneckt, Rojan Chitrakar, Namyeong Kim, Sharan Naribole, Matthew Fischer, PEYUSH Agarwal, Jay Yang, Jason Yuchen Guo, Jason Yuchen Guo, Xiaofei Wang , Jonghun Han, Gabor Bajko, Chunyu Hu, Yonggang Fang, Liuming Lu | Basics in R1 (see note). | Motion 51Motion 104Motion 110Motion 112, #SP55Motion 115, #SP62Motion 115, #SP100 |

For each of the enabled links, frame exchanges are possible when the corresponding non-AP STA of the enabled link is in the awake state.

NOTE 1 – A link is enabled when that link can be used to exchange frames subject to STA power states.

NOTE 2 – When a link is disabled (i.e., not enabled) by an MLD the frame exchanges are not possible.

[Motion 51, [21] and [133]]

A non-AP MLD monitors and performs basic operations (such as traffic indication, BSS parameter updates, etc.) on one or more link(s).

[Motion 104, [21] and [137]]

Each non-AP STA affiliated with a non-AP MLD that is operating on an enabled link maintains its own power state/mode.

[Motion 110, [21] and [117]]

Not every STA operating in PS mode in a non-AP MLD is required to receive the beacon frames periodically.

* This is an exemption besides the existing ones, such as individual TWT agreement, WNM sleep mode and NonTIM mode.

[Motion 112, #SP55, [13] and [141]]

The MLD Max Idle Period of an AP MLD applies at the MLD level and not at the STA level.

The MLD Max Idle Period of an AP MLD indicates, for a non-AP MLD, the time period during which a non-AP MLD can be inactive (i.e., refrain from transmitting frames to the AP MLD on any of the setup links) without the Multi-link setup to be torn down.

A non-AP MLD is considered inactive if none of the APs of the AP MLD have received a Data frame, PS-Poll frame, or Management frame (protected or unprotected) of a frame exchange sequence initiated by a STA from the non-AP MLD for a time period greater than or equal to the time specified by the MLD Max Idle Period of the AP MLD.

If the non-AP MLD is inactive for a duration greater than the MLD Max Idle Period, then the AP MLD may tear down the multi-link setup for that non-AP MLD.

[Motion 115, #SP100, [10] and [142]]

**Proposed spec text:**

The baseline for this text is 802.11 REVmd draft 3.4.

33. Extreme High Throughput (EHT) MAC specification

**33.x Multi-link operation**

***TGbe editor: Add new a subclause 33.x.y (Multi-link Power Management) under clause 33 as follows:***

**33.x.y Multi-link power management**

**33.x.y.1 General**

***[Motion 110, [21] and [117]]***

***[Motion 51, [21] and [133]]***

Each STA of a non-AP MLD that is operating on an enabled link shall independently maintain its own power management mode and power states as defined in 11.2 (Power management) and 10.47 (Target wake time (TWT)). Frame exchanges on an enabled link are possible when the STA of the non-AP MLD operating on that link is in the awake state (see 11.2.3 (Power management in a non-DMG infrastructure network)).

NOTE – A setup link is defined as enabled if at least one TID is mapped to that link and is defined as disabled if no TIDs are mapped to that link (see 33.x.p.q (TID-to-link mapping)).

Figure 33-xxx (Each STA of a non-AP MLD maintains its own power state) illustrates the power save operation for multi-link. As depicted in the figure, during the initial portion of the illustration, both STAs of the non-AP MLD are in active mode and involved in frame exchange. At a later point in time, STA 2 of non-AP MLD operating on link 2 signals PM=1 to AP 2 to enter power-save mode and transitions to doze state. It remains in doze state for the rest of the illustration. STA 1 of non-AP MLD continues to remaining active mode and participates in frame exchanges with AP1 of AP MLD operating on link 1. When STA 1 enters power-save mode, it provides an indication (i.e., PM=1) to AP 1. While in power-save mode, STA 1 signals awake state to AP 1 by transmitting a frame (such as PS-Poll) on link 1. STA 1 participates in frame exchange with AP 1 while in awake state.



Figure 33-xxx – Each STA of a non-AP MLD maintains its own power state

***TGbe editor: doc 11-20/1289r1 provides the Visio file for the above Figures 33-xxx***

**33.x.y.2 Basic BSS Operation**

***[Motion 104, [21] and [137]]***

***[Motion 112, #SP55, [13] and [141]]***

A non-AP MLD may perform basic operations (such as receiving a traffic indication, time synchronization, receiving BSS parameter updates etc) by monitoring Beacon frames on one or more links. A STA of a non-AP MLD operating in power-save mode is not required to receive beacon frames periodically. This is in addition to mechanisms such has individual TWT agreement, WNM sleep mode and non-TIM mode. With these mechanisms, a non-AP MLD can receive basic information about the AP MLD and one or more APs of the AP MLD on a single link while the other STA(s) of the non-AP MLD are in doze state.

NOTE 1 – A single AID is assigned to a non-AP MLD during multi-link setup (see 33.x.e.f (Multi-link Discovery and ML Setup Procedure)). Therefore, the traffic indication for the non-AP MLD is consistent across Beacon frames transmitted by different APs of the same AP MLD.

NOTE 2 – Each AP of an AP MLD provides a Critical Updates Indication when there is an update to the BSS parameters for another AP of the AP MLD (see 33.x.a.b (Critical Updates Indication)).

***[Motion 115, #SP100, [10] and [142]]***

**Discussion**:

Today for single link case, a non-S1G AP provides BSS Max Idle Period in an Association Response frame. BSS Max Idle Period is not carried in a broadcast frame (such as Beacon frame) – it is always in a unicast frame (Association Response) and is assigned per STA.

In case of MLO, the Max Idle Period is at the MLD level (same across all the links). Therefore, there is no concept of per-BSS or per-AP value – i.e., the BSS Max Idle Period in Assocition Response frame has no meaning.

As a result, for MLO, we have two options for signaling MLD Max Idle Period:

**Option 1: ML IE carries signaling for MLD Max Idle Period**

MLD Max Idle Period is carried in a field in the common portion of ML IE which is included in the (Re-)Association Response frame during multi-link setup. The BSS Max Idle Period element is not carried in (Re-)Association Response frame during multi-link setup.

**Option 2: BSS Max Idle Period element signals for MLD Max Idle Period**

Update the spec language to say that the values carried in BSS Max Idle Period element included in (Re-)Association Response frame during multi-link setup apply to MLD-level Max Idle Period.

**OPTION 1: ML IE carries signaling for MLD Max Idle Period**

* **Wireless network management**
* **BSS max idle period management**

***TGbe editor: Modify the following subclause as follows***

BSS max idle period management service is applicable when either the AP or the non-AP STA or both are not affiliated with an MLD. This service enables an AP to indicate a time period during which the AP does not disassociate a STA due to nonreceipt of frames from the STA. This supports improved STA power saving and AP resource management.

***TGbe editor: Please add a new subclause as the last subclause of 4.3.19 as follows***

**4.3.19.x MLD max idle period management**

MLD max idle period management service is applicable between an AP MLD and a non-AP MLD. This service enables an AP MLD to indicate a time period during which the AP MLD does not tear-down the multi-link setup due to nonreceipt of frames from the non-AP MLD on any setup link. This supports improved power saving at the non-AP MLD and resource management at the AP MLD.

* Semantics of the service primitive

***TGbe editor: Modify the following subclause as follows***

The primitive parameters are as follows:

MLME-ASSOCIATE.confirm( …

MLDMaxIdlePeriod,

VendorSpecificInfo)

***TGbe editor: Please add a new row as follows***

|  |  |  |  |
| --- | --- | --- | --- |
| Name | Type | Valid range | Description |
| MLDMaxIdlePeriod | As defined in MLD Max Idle Period field of Multi-Link element | As defined in 9.4.2.xx (Multi-Link element) | Indicates the MLD max idle period parameters of the AP MLD. This parameter is present if the transmitting AP is affiliated with an AP MLD and is performing multi-link setup with a non-AP MLD; Otherwise not present. |

* Semantics of the service primitive

***TGbe editor: Modify the following subclause as follows***

The primitive parameters are as follows:

MLME-ASSOCIATE.response ( …

MLDMaxIdlePeriod,

VendorSpecificInfo)

***TGbe editor: Please add a new row as follows***

|  |  |  |  |
| --- | --- | --- | --- |
| Name | Type | Valid range | Description |
| MLDMaxIdlePeriod | As defined in MLD Max Idle Period field of Multi-Link element | As defined in 9.4.2.xx (Multi-Link element) | Indicates the MLD max idle period parameters of the AP MLD. This parameter is present if the transmitting AP is affiliated with an AP MLD and is performing multi-link setup with a non-AP MLD; Otherwise not present. |

* Semantics of the service primitive

***TGbe editor: Modify the following subclause as follows***

The primitive parameters are as follows:

MLME-REASSOCIATE.confirm( …

MLDMaxIdlePeriod,

VendorSpecificInfo)

***TGbe editor: Please add a new row as follows***

|  |  |  |  |
| --- | --- | --- | --- |
| Name | Type | Valid range | Description |
| MLDMaxIdlePeriod | As defined in MLD Max Idle Period field of Multi-Link element | As defined in 9.4.2.xx (Multi-Link element) | Indicates the MLD max idle period parameters of the AP MLD. This parameter is present if the transmitting AP is affiliated with an AP MLD and is performing multi-link setup with a non-AP MLD; Otherwise not present. |

* Semantics of the service primitive

***TGbe editor: Modify the following subclause as follows***

The primitive parameters are as follows:

MLME-REASSOCIATE.response( …

MLDMaxIdlePeriod,

VendorSpecificInfo)

***TGbe editor: Please add a new row as follows***

|  |  |  |  |
| --- | --- | --- | --- |
| Name | Type | Valid range | Description |
| MLDMaxIdlePeriod | As defined in MLD Max Idle Period field of Multi-Link element | As defined in 9.4.2.xx (Multi-Link element) | Indicates the MLD max idle period parameters of the AP MLD. This parameter is present if the transmitting AP is affiliated with an AP MLD and is performing multi-link setup with a non-AP MLD; Otherwise not present. |

* Association Response frame format

***TGbe editor: Please update the row corresponding to BSS Max Idle Period as follows***

|  |
| --- |
| * Table 9-37 – Association Response frame body
 |
| Order | Information | Notes |
| 20 | BSS Max Idle Period | The BSS Max Idle Period element is present if the soliciting Association Request frame was sent by a non-AP STA that is not affiliated with an MLD and dot11WirelessManagementImplemented is true or optionally present if dot11S1GOptionImplemented is true. |

* Reassociation Response frame format

***TGbe editor: Please update the row corresponding to BSS Max Idle Period as follows***

|  |
| --- |
| * Table 9-39 – Reassociation Response frame body
 |
| Order | Information | Notes |
| 21 | BSS Max Idle Period | The BSS Max Idle Period element is present if the soliciting Reassociation Request frame was sent by a non-AP STA that is not affiliated with an MLD and dot11WirelessManagementImplemented is true or optionally present if dot11S1GOptionImplemented is true. |

9.4.2.x Multi-Link element

***TGbe editor: Please update the following figures in this subclause as shown below***

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | Element ID | Length | Element ID Extension | Multi-Link Control | MLD MAC Address | MLD Idle Period Information  | TBD | Optional Subelements |
| Octets: | 1 | 1 | 1 | 2 | 0 or 6 | 0 or 3 | TBD | variable |
|  | Figure 9-xxx1 – Multi-Link element format |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | B0 – B2 | B3 | B4 | TBD |
|  | Number Of Link | MLD MAC Address Present | MLD Idle Period Information Present | TBD |
| Bits: | 3 | 1 | 1 | TBD |
|  | Figure 9-xxx2 – Multi-Link Control field format |

***TGbe editor: Please add the following description of MLD Idle Period Information subfield after MLD MAC Address Presence subfield in the Multi-Link Control field as shown below***

The MLD Idle Period Information Present subfield in The Multi-Link Control field is set to 1 if the MLD Idle Period Information field is present in the Multi-Link element and is set to 0 otherwise. The conditions for which the MLD Idle Period Information field is present are defined in 33.x.y.3 (MLD Max Idle Period Management).

***TGbe editor: Please add the following paragraphs and figures after the paragraph describing the MLD MAC Address field as shown below***

The MLD Idle Period Information field contains the time period a non-AP MLD can refrain from transmitting frames to the AP MLD on any of the setup links before the AP MLD tears down the multi-link setup with the non-AP MLD due to inactivity. The format of the MLD Max Idle Period Information field is shown in Figure 9-xxx (MLD Max Idle Period Information field format).

|  |  |  |
| --- | --- | --- |
|  | MLD Max Idle Period | MLD Idle Options |
| Octets: | 2 | 1 |
| Figure 9-xxx3 – MLD Max Idle Period Information field format |

The MLD Max Idle Period subfield is an unsigned integer that contains the value of the parameter MLDMaxIdlePeriod. The time period is specified in units of 1000 TUs. The value of 0 is reserved.

The MLD Idle Options subfield indicates the options associated with the MLD Idle capability. The MLD Idle Options subfield is shown in Figure 9-xxx4 (MLD Idle Options subfield format).

|  |  |  |
| --- | --- | --- |
|  | B0 | B1 B7 |
|  | MLD Protected Keep-Alive Required | Reserved |
| Bits: | 1 | 7 |
| Figure 9-xxx4 – MLD Idle Options subfield format |

The MLD Protected Keep-Alive Required subfield is set to 1 to indicate that only a protected frame transmitted by a STA of the non-AP MLD on any setup link indicates activity. The MLD Protected Keep-Alive Required subfield is set to 0 to indicate that either an unprotected or a protected frame transmitted by a STA of the non-AP MLD on any setup link indicates activity.

The use of the MLD Max Idle Period subfield and the frames that include MLD Idle Period Information field are described in 33.x.y.3 (MLD Max Idle Period Management).

**11.22.13 BSS max idle period management**

***TGbe editor: Modify the 1st paragraph in this subclause as follows***

If dot11BssMaxIdlePeriod is nonzero, and the Association Request frame or the Reassociation Request frame is received from a non-AP STA that is not affiliated with a non-AP MLD, then the STA shall include the BSS Max Idle Period element in the Association Response frame or the Reassociation Response frame. Otherwise, the STA shall not include the BSS Max Idle Period element in the Association Response frame or the Reassociation Response frame. A non-S1G STA may send protected or unprotected keepalive frames, as indicated in the Idle Options field.

NOTE – An AP of an AP MLD would know that a (Re-)Association Request frame was transmitted by a STA that is not affiliated with a non-AP MLD if the frame does not include Multi-Link element.

***TGbe editor: Please add a new subclause under Multi-link power management as follows***

**33.x.y Multi-link power management**

**33.x.y.3 MLD max idle period management**

If dot11MldMaxIdlePeriod is nonzero, an AP of an AP MLD shall include the MLD Max Idle Period field in the Multi-Link element carried in the Association Response frame or the Reassociation Response frame that it transmits. Otherwise, the AP of an AP MLD shall not include the MLD Max Idle Period field in the Multi-Link element carried in the Association Response frame or the Reassociation Response frame that it transmits.

A STA of a non-AP MLD may send at least one protected or unprotected keepalive frame per MLDMaxIdlePeriod, as indicated in the MLD Idle Options subfield. When a STA of a non-AP MLD transmits an unprotected keepalive frame, it shall use a frame that has 48-bit TA and RA fields.

The MLD Max Idle Period subfield of the MLD Idle Period Information field indicates the time period during which a non-AP MLD can refrain from transmitting frames on any setup link to the AP MLD, with whom it has perform multi-link setup, without causing a tear-down of the multi-link setup. A non-AP MLD is considered inactive if the AP MLD has not received a Data frame, PS-Poll frame, or Management frame (protected or unprotected as specified in this paragraph) of a frame exchange sequence initiated by the non-AP MLD on any setup link for a time period greater than or equal to the time specified by the MLD Max Idle Period subfield. If the MLD Idle Options subfield requires protected keepalive frames, then the AP MLD may tear-down the multi-link setup with the non-AP MLD if no protected frames are received from any STA of the non-AP MLD for a duration of MLDMaxIdlePeriod. If the MLD Idle Options subfield allows unprotected or protected keepalive frames, then the AP MLD may tear-down the multi-link setup with the non-AP MLD if no protected or unprotected frames with 48-bit TA and RA fields are received from any STA of the non-AP MLD for a duration of MLDMaxIdlePeriod.

NOTE—The AP MLD can tear-down or deauthenticate the non-AP MLD at any time for other reasons even if the non-AP MLD satisfies the keep-alive frame transmission requirements.

**OPTION 2: BSS Max Idle Period element signals MLD Max Idle Period**

* **Wireless network management**
* **BSS max idle period management**

***TGbe editor: Modify the following subclause as follows***

BSS max idle period management service is applicable when either the AP or the non-AP STA or both have are not affiliated with an MLD. This service enables an AP to indicate a time period during which the AP does not disassociate a STA due to nonreceipt of frames from the STA. This supports improved STA power saving and AP resource management.

***TGbe editor: Please add a new subclause as the last subclause of 4.3.19 as follows***

**4.3.19.x MLD max idle period management**

MLD max idle period management service is applicable between an AP MLD and a non-AP MLD. This service enables an AP MLD to indicate a time period during which the AP MLD does not tear-down the multi-link setup due to nonreceipt of frames from the non-AP MLD on any setup link. This supports improved power saving at the non-AP MLD and resource management at the AP MLD.

* Semantics of the service primitive

***TGbe editor: Modify the row corresponding to BSSMaxIdlePeriod as follows***

|  |  |  |  |
| --- | --- | --- | --- |
| Name | Type | Valid range | Description |
| BSSMaxIdlePeriod | As defined in BSS Max Idle Period element | As defined in 9.4.2.78 (BSS Max Idle Period element) | Indicates the BSS max idle period parameters of the AP or PCP that is not affiliated with an AP MLD or is affiliated with an AP MLD and is performing association with a STA that is not affiliated with a non-AP MLD; otherwise indicates the MLD max idle period parameter of the AP MLD. This parameter is present if dot11WirelessManagementImplemented is true and is not present otherwise. |

* Semantics of the service primitive

***TGbe editor: Modify the row corresponding to BSSMaxIdlePeriod as follows***

|  |  |  |  |
| --- | --- | --- | --- |
| Name | Type | Valid range | Description |
| BSSMaxIdlePeriod | As defined in BSS Max Idle Period element | As defined in 9.4.2.78 (BSS Max Idle Period element) | Indicates the BSS max idle period parameters of the AP or PCP that is not affiliated with an AP MLD or is affiliated with an AP MLD and is performing association with a STA that is not affiliated with a non-AP MLD; otherwise indicates the MLD max idle period parameter of the AP MLD. This parameter is present if dot11WirelessManagementImplemented is true and is not present otherwise. |

* Semantics of the service primitive

***TGbe editor: Modify the row corresponding to BSSMaxIdlePeriod as follows***

|  |  |  |  |
| --- | --- | --- | --- |
| Name | Type | Valid range | Description |
| BSSMaxIdlePeriod | As defined in BSS Max Idle Period element | As defined in 9.4.2.78 (BSS Max Idle Period element) | Indicates the BSS max idle period parameters of the AP or PCP that is not affiliated with an AP MLD or is affiliated with an AP MLD and is performing association with a STA that is not affiliated with a non-AP MLD; otherwise indicates the MLD max idle period parameter of the AP MLD. This parameter is present if dot11WirelessManagementImplemented is true and is not present otherwise. |

* Semantics of the service primitive

***TGbe editor: Modify the row corresponding to BSSMaxIdlePeriod as follows***

|  |  |  |  |
| --- | --- | --- | --- |
| Name | Type | Valid range | Description |
| BSSMaxIdlePeriod | As defined in BSS Max Idle Period element | As defined in 9.4.2.78 (BSS Max Idle Period element) | Indicates the BSS max idle period parameters of the AP or PCP that is not affiliated with an AP MLD or is affiliated with an AP MLD and is performing association with a STA that is not affiliated with a non-AP MLD; otherwise indicates the MLD max idle period parameter of the AP MLD. This parameter is present if dot11WirelessManagementImplemented is true and is not present otherwise. |

**11.22.13 BSS max idle period management**

***TGbe editor: Modify the 1st paragraph in this subclause as follows (additional text and splitting of the paragraph)***

If dot11BssMaxIdlePeriod is nonzero or dot11MldMaxIdlePeriod is nonzero, the STA shall include the BSS Max Idle Period element in the Association Response frame or the Reassociation Response frame. Otherwise, the STA shall not include the BSS Max Idle Period element in the Association Response frame or the Reassociation Response frame.

When the AP is affiliated with an AP MLD and the Association Request frame or Reassociation Request frame is received from a STA that is affiliated with an non-AP MLD, then the values carried in the BSS Max Idle Period element apply at the MLD-level. The MLD max idle period procedure is as define in 33.x.y.3 (MLD Max idle period management). The rest of this subclause defines the procedure for BSS max idle period when either the AP or the non-AP STA or both are not affiliated with an MLD.

NOTE – An AP of an AP MLD would know that a (Re-)Association Request frame was transmitted by a STA that is not affiliated with a non-AP MLD if the frame does not include Multi-Link element.

A non-S1G STA may send protected or unprotected keepalive frames, as indicated in the Idle Options field.

***TGbe editor: Please add a new subclause under Multi-link power management as follows***

**33.x.y Multi-link power management**

**33.x.y.3 MLD max idle period management**

A STA of a non-AP MLD may send at least one protected or unprotected keepalive frame per BSSMaxIdlePeriod, as indicated in the Idle Options subfield. When a STA of a non-AP MLD transmits an unprotected keepalive frame, it shall use a frame that has 48-bit TA and RA fields.

The Max Idle Period subfield of the BSS Max Idle Period element indicates the time period during which a non-AP MLD can refrain from transmitting frames on any setup link to the AP MLD, with whom it has perform multi-link setup, without causing a tear-down of the multi-link setup. A non-AP MLD is considered inactive if the AP MLD has not received a Data frame, PS-Poll frame, or Management frame (protected or unprotected as specified in this paragraph) of a frame exchange sequence initiated by the non-AP MLD on any setup link for a time period greater than or equal to the time specified by the Max Idle Period subfield. If the Idle Options subfield requires protected keepalive frames, then the AP MLD may tear-down the multi-link setup with the non-AP MLD if no protected frames are received from any STA of the non-AP MLD for a duration of BSSMaxIdlePeriod. If the Idle Options subfield allows unprotected or protected keepalive frames, then the AP MLD may tear-down the multi-link setup with the non-AP MLD if no protected or unprotected frames with 48-bit TA and RA fields are received from any STA of the non-AP MLD for a duration of BSSMaxIdlePeriod.

NOTE—The AP MLD can tear-down or deauthenticate the non-AP MLD at any time for other reasons even if the non-AP MLD satisfies the keep-alive frame transmission requirements.