IEEE P802.11
Wireless LANs

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| --- |
| LB266 CR on CID 12328 AP MLD Power Save |
| Date: July 1, 2022 |
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 Abstract

This submission contains proposed comment resolutions to comments on P802.11be D2.0.

CID 12328 is resolved.

Revisions:

- Rev 0: Initial version of the document.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **CID** | **Commenter** | **subclause** | **Pg/Ln** | **Comment** | **Proposed Change** | **Resolution** |
| 12328 | Guogang Huang | 35.3.19.1 | 468.40 | Considering the green communication and global warming, a wakeup-based power save mechanism should be defined for the AP MLD, not just for the NSTR mobile AP MLD. | The commenter will provide contribution. | RevisedAgree in principle. When a subset of affiliated APs is operating in PS mode, we should consider the need of the high throughput from the non-AP MLD. Hence, the non-AP MLD is allowed to send a Wakeup Request to wake up the corresponding affiliated AP in PS mode for the frame exchange. Instructions to the editor:Please make the changes to the spec as shown in 11/22-1313r1 |

**Q&A.**

Q1. Why do we need to define a power save mechanism for the AP MLD?

1. Before 11be, the power save operation is only considered for the STA side. The reason is, for the single-link AP, we cannot allow the AP to enter the doze state and do the power save especially there exits the legacy STA. But with the multi-link being standardized, it makes the power save of the AP MLD feasible by managing the legacy STA’s association.

In addition, driven by targets to combat/limit climate change, European regulation on ‘per 24 hour’ power consumption envelopes may lead the way (Please refer to doc. 22/0059r0). For instance, in the near future, an AP power save function will be mandatory in all products in the European market.

Hence, we should consider the power save issue for the AP MLD, not just for the NSTR mobile AP MLD.

Q2. Why do we need to define a wakeup mechanism for an affiliated AP in the power save mode?

1. Assume an AP MLD has three affiliated APs: AP 1, AP 2 and AP 3. If the current traffic load is very low, an AP MLD may let one affiliated AP (e.g. AP 1) operate in the active mode and other affiliated APs (e.g. AP 2 and AP 3) operate in the power save mode. At some point, a non-AP MLD may want to improve the throughput and latency by exploiting the multi-link delivery, it should be allowed to send a wakeup request through the link on which the corresponding affiliated AP in the active mode (i.e. AP 1) to wake up the corresponding affiliated AP in PS mode (i.e. AP 2 and AP 3).

For example, assuming the AP MLD has an affiliated AP which is operating in the 60 GHz band. As we known, the power consumption in the 60 GHz band is a big issue. In this case, both the AP operating in the 60 GHz and associated STAs can work in PS mode and this link is only used for high throughput. When some STA is needed to use the 60GHz link, then it can send a wakeup request to wake up the AP operating in the 60 GHz.

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

**9.4.2.170 Reduced Neighbor Report element**

**9.4.2.170.2 Neighbor AP Information field**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  | B0 B7 | B8 B11 | B12 B19 | B20 | B21 | B22 |  B23 |
|  | MLD ID | Link ID | BSS Parameters Change Count | All Updates Included | Disabled Link Indication | Power Management | Reserved |
| Bits: | 8 | 8 | 4 | 1 | 1 | 1 | 1 |
| **Figure 9-709c MLD parameters subfield format** |

The Power Management subfield indicates the power management mode of the corresponding reported AP that is affiliated with an AP MLD and its encoding is defined in Table 9-xyz (Power Management Mode subfield values).

**Table 9-xyz—Power Management subfield values**

|  |  |  |
| --- | --- | --- |
| Values | Meaning | Description |
| 0 | Active mode | The affiliated AP in active mode is always in the awake state. |
| 1 | Power save mode | The affiliated AP in PS mode enters the awake state to receive or transmit frames. Otherwise it remains in the doze state. |

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

***TGbe editor: Update the following Figure 9-1002g (Presence Bitmap subfield of the Basic Multi-Link element format) as follows:***

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | B0 | B1 | B2 | B3 | B4 | B5 | B6 |  B7 B11 |
|  | Link ID Info Present | BSSParameters Change Count Present | Medium Synchronization Delay Information Present | EMLCapabilities Present | MLDCapabilities Present | AP MLD ID present | Power Management Info 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: Add the following at the end of this subclause as follows:***

The Power Management Info Present subfield is set to 1 if the Power Management Info subfield is present in the Common Info field. Otherwise, the Power Management Information Present subfield is set to 0.

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

***TGbe editor: Update the following Figure 9-1002h (Common Info field of the Basic Multi-Link element format) as follows:***

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | Common Info Length | MLD MACAddress | Link ID Info | BSSParameters Change Count | Medium Synchronization Delay Information | EMLCapabilities | MLDCapabilities | AP MLD ID | Power Management Info |
| Octets: | 1 | 6 | 0 or 1 | 0 or 1 | 0 or 2 | 0 or 2 | 0 or 2 | 0 or 1 | 0, 1 or 3 |
| **Figure 9-1002h— Common Info field of the Basic Multi-Link element format** |

***TGbe editor: Add the following at the end of this subclause as follows:***

The format of the Power Management Information subfield is defined in figure 9-1002x (Power Management Info subfield format).

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | B0 | B1 B2 | B3 | B4 B7 | B8 B23 |
|  | Power Management | Wakeup Delay | Start TimePresent | Reserved | Start Time |
| Bits: | 1 | 2 | 1 | 4 | 0 or 16 |
| **Figure 9-1002x—Power Management Info subfield format** |

The Power Management subfield indicates the power management mode of the corresponding reporting AP that is affiliated with an AP MLD and its encoding is defined in Table 9-xyz (Power Management subfield values).

The Wakeup Delay subfield indicates the transition delay time needed by an AP that is affiliated with an AP MLD to switch from the doze state to the awake state. The Wakeup Delay subfield includes 2 bits and is set as define in Table 9-xxx (Encoding of the Wakeup Delay subfield).

Table 9-xxx Encoding of the Wakeup Delay subfield

|  |  |
| --- | --- |
| Wakeup Delay subfield value | Wakeup delay |
| 0 | 0 us |
| 1 | 32 us |
| 2 | 64 us |
| 3 | 128 us |

The Start Time Present subfield is set to 1 if the Start Time subfield is present in the Power Management Info subfield. Otherwise, the Start Time Present subfield is set to 0.

The Start Time subfield is set to the time in TU after which the AP will enter the power save mode.

**9.4.2.312.2.3 Link Info field of the Basic Multi-link element**

***TGbe editor: Update the following Figure 9-1002k (STA control field format) as follows:***

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | B0 B3 | B4 | B5 | B6 | B7 | B8 | B9 | B10 | B11 | B12 | B13 B15 |
|  | Link ID | Complete Profile | STA MACAddress Present | Beacon Interval Present | TSF Offset Present | DTIM Info Present | NSTRLink Pair Present | NSTRBitmap Size | BSS Parameters Change Count Present | Power Management InfoPresent | Reserved |
| Bits: | 4 | 1 | 1 | 1 |  | 1 | 1 | 1 | 1 | 1 | 3 |
| **Figure 9-1002n— STA Control field format** |

***TGbe editor: Add the following paragraph of this subclause as follows:***

The Power Management Info Present subfield is set to 1 if the Power Management Info subfield is present in the STA Info field. Otherwise, the Power Management Information Present subfield is set to 0.

***TGbe editor: Update the following Figure 9-1002l (STA Info field format) as follows:***

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  | STA Info Length | STA MACAddress | Beacon Interval | DTIM Info | NSTRIndication Bitmap | BSS Parameters Change Count | Power Management Info |
| Octets: | 1 | 0 or 6 | 0 or 2 | 0 or 2 | 0 or 1 or 2 | 0 or 1 | 0, 1 or 3 |
|  |  |  |  |  |  |  |  |

**Figure 9-1002o— STA Info field format**

***TGbe editor: Add the following paragraph of this subclause as follows:***

The format of the Power Management Info subfield is defined in section 9.4.2.312.2.2, figure 9-1002x (Power Management Info subfield format) and applies to the AP corresponding to the Per-STA Profile subelement.

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

**9.2.4.7.10 AAR Control**

The Control Information subfield in an AAR Control subfield contains information related to the procedure that allows an AP affiliated with an AP MLD to assist a non-AP STA affiliated with a non-AP MLD that belongs (#7555)an NSTR link pair to recover its medium synchronization (35.3.16.8.2 (AP assisted medium synchronization recovery procedure)).

It is also used to wake up the corresponding AP affiliated with an AP MLD and that is operating in the power save mode (35.3.13 Power save for AP MLD).

The format of this subfield is shown in Figure 9-33c (Control Information subfield format in an AAR Control subfield).

|  |  |  |  |
| --- | --- | --- | --- |
|  | B0 B7 | B8 | B9 B11 |
|  | Assisted Link ID Bitmap | Type | Reserved |
| Bits: | 16 | 1 | 3 |
| **Figure 9-33c Control Information subfield format in an AAR Control subfield** |

If the Type subfield is set to 0, the Assisted AP Link ID Bitmap subfield indicates the link identifier(s) of an AP affiliated with an AP MLD that is solicited to transmit a Trigger frame to a non-AP STA affiliated with a non-AP MLD that belongs to (#7555)an NSTR link pair after a frame that contains AAR Control subfield sent by another non- AP STA affiliated with the same non-AP MLD to its associated AP affiliated with the same AP MLD. If the Type subfield is set to 1, the Assisted AP Link ID bitmap subfield indicates the link identifier(s) of an AP affiliated with an AP MLD that operating in the power save mode is requested to wake up after a frame that contains AAR Control subfield sent by another non-AP STA affiliated with the same non-AP MLD to its associated AP affiliated with the same AP MLD. A value of 1 in bit position i of the Assisted AP Link ID Bitmap subfield means that the link ID i is the link identifier of the solicited AP affiliated with the AP MLD. A value of 0 in bit position i of the Assisted AP Link ID Bitmap subfield means that the link ID i is not the link identifier of the solicited AP affiliated with the AP MLD.

The Type subfield specifies the function of the AAR Control subfield. The Type subfield is set to 0 if the AAR Control subfield is used to solicit to transmit a Trigger frame and set to 1 if the AAR Control subfield is used to wake up the corresponding APs in PS mode for the frame exchange.

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

**35.3.12.7 AP MLD Power save**

The AP MLD power save operation defined in this subclause allows a subset of affiliated APs to operate in the power save mode and at least one affiliated AP to operate in the active mode. This helps to reduce the power consumption of the AP MLD and allows a high data rate when needed.

An AP MLD shall advertise the change on the power management of an affiliated AP by using the Power Management subfield within the Reduced Neighbor Report element and the Power Management Info subfield within the Basic Multi-link element carried in the Beacon and Probe response frames.

NOTE—To optimize the power consumption, the AP MLD may try to manage the non-MLD devices. For example, the AP MLD may request the non-MLD device to transition to an AP affiliated with the same AP MLD and in the active mode in advance before the affiliated AP enters the power save mode.

NOTE—The AP MLD shall not allow all its affiliated APs to operate in the power save mode simultaneously.

An AP affiliated with an AP MLD may enter the power save mode by setting the Power Management subfield in the Reduced Neighbor Report element and the Basic Multi-link element to 1 carried in the Beacon and Probe response frames. The affiliated AP in the doze state is not able to transmit or receive any PPDU.

An AP affiliated with an AP MLD that intends to enter the power save mode shall start including the Power Management Info subfield for a duration that is greater than or equal to the maximum value of the DTIM interval corresponding to each of APs affiliated with the same AP MLD.

NOTE—Advertising the Power Management Information subfield for a duration that includes the DTIM beacon on another link makes it possible for a non-AP MLD that is monitoring only the other link and is in the doze state to wake up only to receive the DTIM beacon on that link to get this notification.

When an AP affiliated with an AP MLD is operating in the power save mode, the following applies subject to any link disablement schedule:

* The AP MLD shall not schedule the transmission of Beacon and Probe Response frames on the link on which the affiliated AP is in the power save mode.
* The AP MLD shall advertise the corresponding wakeup delay through the Wakeup Delay subfield of the Basic Multi-link element carried in the Beacon and Probe response frames.
* The reporting AP affiliated with the same AP MLD shall include a Neighbor AP Information field in a Reduced Neighbor Report element with the MLD Parameters subfield for that AP. And the corresponding TBTT Information Field Type subfield and the TBTT Information Length subfield of the TBTT Information field shall be set to 1 and 3, respectively.
* If a non-AP MLD wants to use the corresponding link for delivery, it shall send a PPDU carrying an AAR Control subfield with the Type subfield equal to 1 to wake up this AP through an affiliated STA and corresponding affiliated AP in the active mode, respectively. Meanwhile, the corresponding STA affiliated with the non-AP MLD shall transition to the awake state.
* The AP in the power save mode shall transition to the awake state within the wakeup delay after successfully receiving a PPDU carrying an AAR Control subfield with the Type subfield equal to 1. When an affiliated AP that is changing from the doze state to the awake state in order to transmit shall perform CCA until a frame is detected by which it can set its NAV, or until a period of time indicated by the NAVSyncDelay has transpired.
* All the existing TWT agreements on this link and TID-to-link mapping are still valid. The affiliated AP in PS mode shall set the Responder PM Mode subfield within the TWT element to 1. The affiliated AP and member STAs shall transition to the awake state before the TWT SP starts. After the TWT SP is ended, the corresponding AP and its member STAs may transition from the awake state to the doze state.
* As long as any associated STA is determined to be in the awake state, the affiliated AP shall remain in the awake state. Otherwise, it may transition to the doze state.
* All the TID-to-link mapping agreements are still valid. The affiliated AP in the power save mode may switch back to the doze state if one of the following conditions is met:
	+ The channel has been idle for a given time period.
	+ No associated STA is determined to be in the awake state.

An AP affiliated with an AP MLD may switch from the power save mode to the active mode by setting the Power Management subfield to 0 within the Reduced Neighbor Report element and the Basic Multi-link element carried in the Beacon and Probe response frames. If the affiliated AP is operating in the active mode, it always remains in the awake state.

**35.3.4 Discovery of an AP MLD**

**35.3.4.1 AP Behavior**

***TGbe editor: Add the following paragraph in the following subclause as follows:***

If a reported AP affiliated with an AP MLD is operating in PS mode, then the reporting AP shall include a Neighbor AP Information field in a Reduced Neighbor Report element with the MLD Parameters subfield for that reported AP. The corresponding TBTT Information Field Type and TBTT Information Field Length shall be set to 1 and 3, respectively.

* More Data subfield

***TGbe editor: Insert the following paragraph as follows:***

The More Data subfield is used differently by a DMG, an S1G STA, and a non-DMG non-S1G STA(#464).

A non-DMG and non-S1G STA uses the More Data subfield to indicate to a STA in PS mode that more BUs are buffered for that STA at the AP. The More Data subfield is valid in individually addressed Data or Management frames transmitted by an AP to a STA in PS mode. The More Data subfield is set to 1 to indicate that at least one additional buffered BU is present for the same STA.

(11ax)An AP optionally sets the More Data subfield to 1 in Ack frames sent to a non-DMG non-S1G non-HE STA and in Ack, BlockAck, and Multi-STA BlockAck frames sent to an HE STA. An HE AP indicates that it supports setting the More Data subfield to 1 in these control response frames by setting the More Data Ack subfield to 1 in the QoS Info field of elements it includes in frames transmitted to the STA.

(11ax)The AP can set the More Data subfield to 1 to indicate that it has a pending transmission for the STA if it has received a frame that contains a QoS Info field in which the More Data Ack subfield is equal to 1 from the STA and one of the following conditions is true:

— The STA is in PS mode and has one or more ACs that are delivery enabled (see 11.2.3.6 (AP operation)).

— The STA is in PS mode and is a TWT requester or a TWT scheduled STA (see 26.8 (TWT operation)).

For MLO, a STA affiliated with a non-AP MLD uses the More Data subfield to indicate to an AP in PS mode affiliated with the AP MLD that more BUs, corresponding to Data frames with TIDs that are mapped to this link by the most recent UL TID-to-link mapping (negotiated TID-to-link mapping or default link mapping, see 35.3.7.1 (TID-to-link mapping)) or Management frames that are not measurement MMPDUs (see 35.3.12.4 (Traffic indication)) are buffered for the AP MLD at the non-AP MLD. The More Data subfield is valid in individually addressed Data or Management frames transmitted by a STA affiliated with a non-AP MLD to an AP affiliated with an AP MLD that is in PS mode and in certain control frames as defined below.

**9.4.1.17 QoS Info field**

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

(11ax)An HE AP sets the More Data Ack subfield to 1 to indicate that it can generate individually addressed Ack and BlockAck frames with the More Data bit in the Frame Control field equal to 1; otherwise, the AP sets the More Data Ack subfield to 0. For a non-HE AP, the More Data Ack subfield is reserved. An EHT AP affiliated with an AP MLD sets the More Data Ack subfield to 1 to indicate that it can generate and process individually addressed Ack and BlockAck frames with the More Data bit in the Frame Control field equal to 1; otherwise, the EHT AP sets the More Data Ack subfield to 0. When an EHT AP affiliated with an AP MLD that is in PS mode receives an Ack or BlockAck frame with the More Data Ack subfield equal to 1, then it remains in the awake state.

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

Non-AP non-HE STAs set the More Data Ack subfield to 1 to indicate that they can process Ack frames with the More Data bit in the Frame Control field equal to 1 and remain in the awake state. Non-AP HE STAs set the More Data Ack subfield to 1 to indicate that they can process Ack and BlockAck frames with the More Data bit in the Frame Control field equal to 1 and remain in the awake state. Non-AP STAs set the More Data Ack subfield to 0 otherwise.(11ax) Non-AP EHT STAs set the More Data Ack subfield to 1 to indicate that they can generate and process Ack and BlockAck frames with the More Data bit in the Frame Control field equal to 1. Non-AP STAs set the More Data Ack subfield to 0 otherwise. When an EHT STA receives an Ack or BlockAck frame with the More Data Ack subfield equal to 1, then it remains in the awake state.