IEEE P802.11
Wireless LANs

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| Comment Resolution on TWT |
| Date: July 10th, 2022 |
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 Abstract

This submission proposes resolutions for following 6 comments received for TGbe LB266:

* 6 CIDs: 11113, 11114, 11115, 13633, 13642, 13643

SP: Do you agree to the resolutions provided in doc 11-22/1051r0 for the following CIDs for inclusion in the latest 11be draft?

11113, 11114, 11115, 13633, 13642, 13643

Revisions:

* Rev 0: Initial version of the document.

***TGbe editor: Please note Baseline is 11be D2.0***

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.

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| **CID** | **Commenter** | **Pg/Ln** | **Comment** | **Proposed Change** | **Resolution** |
| 13633 | Rubayet Shafin | 510.51 | 11be includes multi-link operation. However, how restricted TWT will operate on multi-link devices (MLDs) is not clear. In general, mechanism for Broadcast TWT, which is a basis for restricted TTWT, for MLDs need to be defined. | Commenter will present a contribution on this. | **Revised.**Agree in principle. Necessary text on broadcast TWT operation for MLD is included.**TGbe editor, please make change as shown in this doc 11-22/1051r0 tagged by #13633.** |

**Discussion:**

Text related to broadcast TWT for multi-link operation is currently missing in the spec and needs to be added. In general, an AP affiliated with an AP MLD and an STA affiliated with a non-AP MLD should be able to negotiate a broadcast TWT schedule over one link between the AP MLD and the non-AP MLD on behalf of multiple links between the same AP MLD and the non-AP MLD. We need the necessary signalling to enable this for broadcast TWT (the procedure for individual TWT has been added in Draft 1.1). The following example can be helpful in illustrating this process and the outcome we strive to realize in this document:



Figure D-1: Example of Broadcast TWT schedule negotiation over a single link for multiple links

In the example of Figure D-1, an AP MLD has three affiliated APs: AP 1 operates on 2.4 GHz band, AP 2 operates on 5 GHz band, and AP 3 operates on 6 GHz band. A non-AP MLD has three affiliated STAs: STA 1 operates on 2.4 GHz band, STA 2 operates on 5 GHz band, and STA 3 operates on 6 GHz band. Three links are set up and enabled between the AP MLD and the non-AP MLD: Link 1 between AP 1 and STA 1; Link 2 between AP 2 and STA 2; Link 3 between AP 3 and STA 3. The AP MLD advertises a broadcast TWT schedules, namely Schedule A, over all three links. Non-AP STA 1 affiliated with the non-AP MLD sends a broadcast TWT element to AP 1 affiliated with the AP MLD. The broadcast TWT element contains a Broadcast TWT Parameter Set field corresponding to Schedule A. Also, the Broadcast TWT Parameter Set field sent by non-AP STA 1 indicates (*note--this signalling needs to be defined*) the three links, Link 1, Link 2, and Link 3, and sets the TWT Setup Command field as Request TWT. Upon receiving the TWT element, AP 1 sends a TWT element to non-AP STA 1 and includes the Broadcast TWT Parameter Set field corresponding to Schedule A. AP 1, in this Broadcast TWT Parameter Set field, also indicates the same three links, Link 1, Link 2, and Link 3, and sets the TWT Setup Command field as Accept TWT. After the successful broadcast TWT negotiation, Schedule A is established over all the three links: Link 1, Link 2, and Link 3.

**Signalling:**

In order to indicate multiple links for individual TWT operation, in 11be draft, a Link ID Bitmap subfield was introduced in the Individual TWT Parameter Set field. The corresponding bitmap presence indicator is placed in the Control field of the TWT element (see Figure D-2 for reference).



Figure D-2: TWT element format

An Individual TWT element contains a single parameter set corresponding to a single TWT agreement (presence of a second parameter set is possible to indicate TWT parameter ranges corresponding to a single TWT agreement). So, placing the Link ID Bitmap Present subfield in the Control field of the TWT element works out for individual TWT since there is a one-to-one mapping between the Link ID Bitmap in the individual TWT parameter set and the related presence indicator in the Control field of the TWT element as shown in Figure D-3.



Figure D-3: Link ID indication for individual TWT

In a broadcast TWT element, however, there can be multiple parameter sets corresponding to different broadcast TWT schedules. In MLO context, each parameter set may be negotiated for a different set of links. Hence, to indicate the presence of the Link ID Bitmap in a broadcast TWT parameter set, the presence indicator needs to be within the corresponding broadcast TWT parameter set. The needed change is shown in yellow in Figure D-4.



Figure D-4: Link ID indication for broadcast TWT

**9. Frame formats**

**9.4.2.199 TWT element**

***TGbe editor: Please Change Figure 9-766 (Broadcast TWT Parameter Set field format) as follows:***

 

**Figure 9-766: Broadcast TWT Parameter Set field format (#13633)**

***TGbe editor: Please* change the paragraph (The Link ID Bitmap subfield indicates the links…) in Clause 9.4.2.199 as follows:**

The Link ID Bitmap subfield indicates the links to which an individual or broadcast TWT parameter set contained in the TWT element sent by a STA affiliated with an MLD applies. A value of 1 in bit position $i$ of the Link ID Bitmap subfield means that the link to which the TWT parameter set in the TWT element sent by a STA affiliated with an MLD applies. A value of 0 in bit position $i$ of the Link ID Bitmap subfield means that the link associated with the link ID $i $is not the link to which the TWT parameter set in the TWT element sent by a STA affiliated with an MLD applies (#13633).

***TGbe editor: Please Change Figure 9-768 (Request Type field format in Broadcast TWT Parameter Set field) as follows:***

 

**Figure 9-768:** **Request Type field format in Broadcast TWT Parameter Set field (#13633)**

***TGbe editor: Please* insert the following paragraph after the paragraph (In a TWT element transmitted by a TWT requesting or TWT scheduled STA, the TWT Wake Interval is equal to…..) in clause 9.4.2.199:**

The Broadcast TWT Link ID Bitmap Present subfield indicates whether or not a Link ID Bitmap subfield is present in the corresponding Broadcast TWT Parameter Set field. The Broadcast TWT Link ID Bitmap Present subfield is set to 1 if the Link ID Bitmap subfield is present in the corresponding Broadcast TWT Parameter Set field; otherwise, it is set to 0. This subfield is set to 0 when the corresponding Broadcast TWT Parameter Set field is carried in a TWT element with Negotiation Type subfield set to 2 (#13633).

**35.8 TWT operation**

***TGbe editor: Please insert the following subclause 35.8.3 (Broadcast TWT operation) under clause 35.8***

**35.8.3 Broadcast TWT operation (#13633)**

A TWT scheduling AP affiliated with an AP MLD and a TWT scheduled STA affiliated with a non-AP MLD, for negotiating membership of a broadcast TWT schedule, shall follow the rules defined in 26.8.3.1 (General), 26.8.3.2 (Rules for TWT scheduling AP), and 26.8.3.3 (Rules for TWT scheduled STA) with the following additional rules:

* The TWT scheduled STA affiliated with the non-AP MLD or the TWT scheduling AP affiliated with the AP MLD, while negotiating for a broadcast TWT schedule, may indicate the link(s) between the AP MLD and the non-AP MLD for which the negotiation is being conducted. The TWT scheduled STA or the TWT scheduling AP transmitting the TWT element may make the link indication in the Link ID Bitmap subfield in the Broadcast TWT Parameter Set field corresponding to the broadcast TWT schedule.
	+ If one or more links are indicated in the Link ID Bitmap subfield in the Broadcast TWT Parameter Set field transmitted by a TWT scheduled STA affiliated with the non-AP MLD or a TWT scheduling AP affiliated with the AP MLD, the corresponding broadcast TWT schedule is negotiated on behalf of the STAs affiliated with the same MLD and operating on the indicated links between the AP MLD and the non-AP MLD. The Target Wake Time field in the Broadcast TWT Parameter Set field shall be in reference to the TSF time of the setup link between the AP MLD and the non-AP MLD that has the lowest Link ID value. The target wake time of the intended link is derived by adjusting the TSF offset with respect to the TSF time of the reference link, the link with the lowest Link ID value.
* A TWT scheduling AP affiliated with an AP MLD that receives a TWT element with Link ID Bitmap subfield in a Broadcast TWT Parameter Set field from a TWT scheduled STA affiliated with a non-AP MLD may respond by including a Link ID Bitmap subfield in the TWT response that indicates a different link set of links as that of the received Link ID Bitmap or the same set of links as that of the received Link ID Bitmap but with different TWT parameters if the TWT Setup Command field in the Request Type field in the corresponding Broadcast TWT Parameter Set field in the response frame is set to Alternate TWT or Dictate TWT. The TWT scheduling AP shall respond with a Link ID Bitmap that indicates the same set of links as that of the received Link ID Bitmap and the same TWT parameters as that indicated in the received Broadcast TWT Parameter Set field if the TWT Setup Command field in the Request Type field in the corresponding Broadcast TWT Parameter Set field in the response frame is set to Accept TWT or Reject TWT.

If a TWT scheduling AP affiliated with an AP MLD or a TWT scheduled STA affiliated with a non-AP MLD transmits a broadcast TWT element that contains a Link ID Bitmap subfield in at least one of the Broadcast TWT Parameter Set fields included in the TWT element, then the TWT scheduling AP or the TWT scheduled STA shall set the Link ID Bitmap Present subfield in the Control field of the broadcast TWT element to 1. Otherwise, the TWT scheduling AP or the TWT scheduled STA shall set the Link ID Bitmap Present subfield to 0.

The AP MLD or the non-AP MLD shall not transmit a TWT element over any of the links set up between them that includes a TWT parameter set field containing a Link ID Bitmap subfield with $k$-th bit in the bitmap set to 1 if the corresponding $k$-th link is disabled for the non-AP MLD through TID-to-Link mapping.

***TGbe editor: Please add the following subsection 35.9.6 (Restricted TWT with multi-link operation) under clause 35.9***

**35.9 Restricted TWT (r-TWT)**

**35.9.6 Restricted TWT with multi-link operation (#13633)**

An r-TWT scheduling AP or an r-TWT scheduled STA, in the context of multi-link operation, for negotiating membership of a restricted TWT schedule, shall follow the rules defined in 35.8.3 (Broadcast TWT operation) with additional rules described in this subclause.

For r-TWT operation between an AP MLD and a non-AP MLD, the AP MLD or the non-AP MLD shall not transmit a TWT element over any of the set up links between them that includes an r-TWT parameter set with the $k$-th bit in the Restricted TWT DL TID Bitmap subfield or Restricted TWT UL TID Bitmap subfield, if present, set to 1 if the TID $k$ for the respective direction is not mapped on the intended link for which the restricted TWT schedule is being negotiated. The AP MLD or the non-AP MLD shall not transmit a TWT element over any of the links between them that includes an r-TWT parameter set with the DL TID Bitmap Valid subfield or UL TID Bitmap Valid subfield, if present, to 0 if any of the TIDs is not mapped on the desired link for the respective direction (#13633).

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| **CID** | **Commenter** | **Pg/Ln** | **Comment** | **Proposed Change** | **Resolution** |
| 11113 | Brian Hart | 512.18 | Unbalanced comma in "and, if there is not enough time then " | Try "and, if there is not enough time, then" | **Accepted.**TGbe editor, please make change as shown in this doc 11-22/1051r0 tagged by #11113 |
| 11114 | Brian Hart | 512.19 | In math, "series" is the cumulative sum of a sequence of numbers; probably "sequence" is meant in " (without advancing to the next value in the series)" | Try " (without advancing to the next value in the sequence)" | **Accepted**TGbe editor, please make change as shown in this doc 11-22/1051r0 tagged by #11114 |
| 11115 | Brian Hart | 512.19 | Since an MSDU or AMSDU has a single AC, likely "are" should be "is" | Try " The QSRC[AC] for the MSDU or A-MSDU is not affected." | **Accepted**TGbe editor, please make change as shown in this doc 11-22/1051r0 tagged by #11115 |

***TGbe editor: Please* change the paragraph (A non-AP EHT STA with …) in Clause 35.9.4.1 as follows:**

A non-AP EHT STA with dot11RestrictedTWTOptionImplemented set to true as a TXOP holder shall ensure the TXOP ends before the start time of any r-TWT SPs advertised by the associated AP. Before starting transmission of any MPDU, a non-AP EHT STA with dot11RestrictedTWTOptionImplemented set to true that is not a TXOP responder and not a member of the upcoming restricted TWT service period shall check if there is enough time for the frame exchange to complete prior to the start of the restricted TWT service period and, if there is not enough time, (#11113) then the STA shall defer transmission by selecting a random backoff count using the present CW (without advancing to the next value in the sequence) (#11114). The QSRC[AC] for the MSDU or A-MSDU is not affected (#11115).

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| **CID** | **Commenter** | **Pg/Ln** | **Comment** | **Proposed Change** | **Resolution** |
| 13642  | Rubayet Shafin | 510.51  | According to current specifications, for PPDU transmission on a link that forms an NSTR link pair with other STA(s) affiliated with the same non-AP MLD, the end time of the PPDUs transmitted on those links need to be aligned in order to prevent self-interference at the non-AP MLD side due to NSTR constraints. However, if a restricted TWT schedule is established on a link that is a part of an NSTR link pair and if PPDUs transmitted during restricted TWT service period (SP) need to be aligned, for example through adding extra padding, with PPDU transmitted on other links, then the traffic flow for the low-latency traffic during restricted TWT SP can get severely interrupted. This can disrupt the latency-sensitive applications at the client side. | Please provide text to handle the NSTR constraints as depicted in the comment when an rTWT schedule is established on a link of an NSTR link pair.  | **Revised.**Agree in principle. Necessary text for handling NSTR issue with r-TWT operation has been added.**TGbe editor, please make change as shown in this doc 11-22/1051r0 tagged by #13642.** |
| 13643 | Rubayet Shafin | 510.51 | For the scenario where a restricted TWT schedule, which is not a trigger-enabled TWT, is established on a link between an AP MLD and a non-AP MLD that forms NSTR link pair(s) between the same AP MLD and non-AP MLD, while UL PPDU is being transmitted during the restricted TWT SP on the that link, if DL PPDU is being transmitted on another link that forms the NSTR link pair with the first link, then the overlapped portions of UL PPDU and DL PPDU will suffer from interference due to NSTR constraints. This may affect the latency-sensitive traffic flow during restricted TWT SP. | Please provide text to handle the NSTR constraints as depicted in the comment when an rTWT schedule is established on a link of an NSTR link pair. | **Revised.**Agree in principle. Necessary text for handling NSTR issue with r-TWT operation has been added.**TGbe editor, please make change as shown in this doc 11-22/1051r0 tagged by #13643.** |

***TGbe editor: Please insert the following subclause 35.3.16.10 (Restricted TWT operation) under clause 35.3.16 (Multi-Link channel access)* (#13642, #13643)**

**35.3.16.10 Restricted TWT operation (#13642)**

When a non-trigger enabled r-TWT schedule is established on a link (the first link) between an AP MLD and a non-AP MLD that forms NSTR link pair(s) with another link (the second link) between the same AP MLD and the non-AP MLD, the AP affiliated with the AP-MLD and operating on the second link shall end transmission of any frames on the second link before the restricted TWT SP starts on the first link, and if the frame transmitted on the second link solicits an immediate response, then the AP affiliated with the AP MLD should end the transmission of the frame on the second link at least aSIFSTime duration before the r-TWT SP starts on the first link. (#13642)

When an r-TWT schedule is established on a link (the first link) between an AP MLD and a non-AP MLD that forms NSTR link pair with another link (the second link) between the same AP MLD and the non-AP MLD and the second link also has another r-TWT schedule established such that the r-TWT SP on the second link overlaps in time with the r-TWT SP on the first link and the r-TWT schedule on the second link has higher priority TIDs negotiated than that of the r-TWT schedule on the first link, then for handling NSTR interference, the r-TWT SP on the second link should be prioritized over the r-TWT SP on the first link such that any kind of adjustment in the PPDU transmission, either through padding the PPDU or through truncation of the TXOP, needs to be made at the PPDU transmission on the first link so that PPDU transmission on the second link remains uninterrupted. (#13643)