IEEE P802.11
Wireless LANs

|  |
| --- |
| Link Recommendation Enhancements |
| Date: 2022-05-15 |
| Author(s): |
| Name | Affiliation | Address | Phone | email |
| Laurent Cariou | Intel |  |  | laurent.cariou@intel.com |
| Pooya Monajemi | Cisco |  |  | pmonajem@cisco.com  |
| Brian Hart | Cisco |  | brianh@cisco.com |
| Arik Klein | Huawei |  |  | arik.klein@huawei.com  |
| Yong Liu | Apple |  |  | yongliu@apple.com |
| Jarkko Kneckt | Apple |  |  | jkneckt@apple.com |
| Abhishek Patil | Qualcomm |  |  | appatil@qti.qualcomm.com |
| George Cherian | Qualcomm |  |  | gcherian@qti.qualcomm.com |
| Eldad Perahia | HPE |  |  | eldad.perahia@hpe.com |
| Gaurav Patwardhan | HPE |  |  | gaurav.patwardhan@hpe.com |
| Matthew Fischer | Broadcom |  |  | matthew.fischer@broadcom.com |
| Zhou Lan | Broadcom |  |  | zhou.lan@broadcom.com |
| Liuming Lu | Oppo |  |  | luliuming@oppo.com |
| Lei Huang | Oppo |  |  | huang.lei1@oppo.com |
| James Yee  | Mediatek |  |  | james.yee@mediatek.com |
| Yongho Seok | Mediatek |  |  | yongho.seok@mediatek.com |
| Insun Jang | LG |  |  | insun.jang@lge.com |
| SunHee Baek | LG |  |  | Sunhee.baek@lge.com |
| Binita Gupta | Meta |  |  | binitagupta@fb.com |
| Chunyu Hu | Meta |  |  | chunyuhu@fb.com |
| Stephane Baron | Canon |  |  | Stephane.baron@crf.canon.fr |
| Pascal Viger | Canon |  |  | Pascal.viger@crf.canon.fr |
| Mickael Lorgeoux | Canon |  |  | Mickael.lorgeoux@crf.canon.fr |
| Ming Gan | Huawei |  |  |  |
| Guogang Huang | Huawei |  |  |  |

Abstract

Proposed draft text for enhancements to TID mapping.

The submission proposes text changes to resolve the following CIDs from LB266. All proposed changes are based on 802.11be Draft 2.0.

Please see discussion notes below for a review of introduced changes.

List of CIDs:

12779 12605 12808 11762

R8 compared to R7:

- make AID Bitmap element extensible

- use latest spec text from D2.1 for subclause 9.4.2.315

- add missing word “use” at the beginning of p12

# Revision History

|  |  |  |
| --- | --- | --- |
| **Date** | **Revision** | **Changes** |
| 2021-11-6 | 0 | Initial draft |

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **CID** | **Subclause** | **Page.Line** | **Comment** | **Proposed change** | **Resolution** |
| 12779 | 9.4.2.315 | 249.34 | The link recommendation addressed in 35.3.10.4 is for the downlink traffic, it may be necessary to have a mechanism of link recommendation for uplink traffic. | Propose an equivalent mechanism of link recommendation for uplink traffic to help AP for the scheduling. For instance, add the link id information in the buffer status report | Revised – agree with the commenter. Extend the mechanism so that it applies to all non-AP MLDs (not only the ones that have STAs in PS mode) and that apply for DL and UL. Define a Link Recommendation frame that will include the ML Traffic Indication element to achieve this. Apply the changes marked as #12779 in this document. |
| 12605 | 9.4.2.315 | 251.31 | In case the Per-Link Traffic Indication bitmap includes a link recommendation, is it allowed to have more than a single recommended link?Please add a note or clarification to the following sentence: "When the Per-Link Traffic Indication Bitmap subfield corresponds to a non-AP MLD that is in the default mapping mode or has negotiated a TID-to-link mapping with an AP MLD and all TIDs are mapped to all the enabled links, a value of 1 in the bit position i in the bitmap indicates that the link with the link ID equal to i is recommended for retrieving buffered BU(s)" | As in comment | Revised – agree with the commenter. Add a Note to clarify this. Apply the changes marked as #12605 in this document. |
| 12808 | 35.3.12.4 | 442.43 | The link recommendation tool is very important for enterprise deployments for the load balancing use case. Current mechanism however allows to provide recommendations only for non-AP MLDs that are using PS mode, and mostly for DL traffic. It is important to extend the mechanism in order to allow a group-address recommendation similar to what is currently defined in D2.0, but which can also apply to STAs that are in active mode and for both DL and UL traffic. | Define a link recommendation frame that can include the link recommendation for a set of STAs the same way as it is done in D2.0 (using the ML Traffic Indication element) and that would provide recommendation for both DL and UL traffic. | Revised – agree with the commenter. Extend the mechanism so that it applies to all non-AP MLDs (not only the ones that have STAs in PS mode) and that apply for DL and UL. Define a Link Recommendation frame that will include the ML Traffic Indication element to achieve this. Apply the changes marked as #12808 in this document. |
| 11762 | 35.3.12 | 442.29 | When an AP affiliated with an AP MLD needs to perform administrative actions, it should be able to signal to its associated non-AP MLDs to not transmit data in the UL, nor poll for data on the DL on that specific link on which the AP affiliated with the AP MLD is perfoming administrative actions and use other recommended setup links for a short period of time. A way to signal this link recommendation is required. Additionally, the Multi-Link Traffic Element does not scale well beyond a couple of links and tens of non-AP MLDs when sent in a Beacon and leads to massive Beacon bloating. Remove the Multi-Link Traffic Element and in its place the aforementioned link recommendation frame should carry an AID list to signal to the appropriate non-AP MLDs the link recommendation. | Add the signaling and relevant reason codes as per the comment. | Revised – agree with the commenter. Extend the mechanism so that it applies to all non-AP MLDs (not only the ones that have STAs in PS mode) and that apply for DL and UL. Define a Link Recommendation frame that will include the ML Traffic Indication element to achieve this. Apply the changes marked as #11762 in this document. |

# LB266 Comments and discussion [against Draft 2.0]

**Discussion:**

**Link Recommendation**

The text introduces an enhancement to the link recommendation mechanism that is available currently only for buffered traffic indication. A frame is added that allows the AP to recommend links for a number of STAs with using an AID bitmap.

This tool can be used for quick recommendation of links to a number of non-AP MLDs when a permanent and/or mandatory negotiation of TID to link mapping is not desired or not feasible.

### **9.4.2 Elements**

### **9.4.2.1 General**

TGbe editor: ***Insert two new rows to*** [***Table 9-128 (Element IDs(#1009)(#1121))***](file:///C%3A%5CUsers%5Cpmonajem%5CDocuments%5CDocs%5CIEEE%20802.11%5C11be%5CSource%5CTGbe_Cl_09.doc#bookmark86)(#12779, #12808, #11762)***:***

**Table 9-128—Element IDs(#1009)(#1121)**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Element** | **Element ID** | **Element ID Extension** | **Extensible** | **Fragmentable** |
| EHT Operation (see [9.4.2.311 (EHT](file:///C%3A%5CUsers%5Cpmonajem%5CDocuments%5CDocs%5CIEEE%20802.11%5C11be%5CSource%5CTGbe_Cl_09.doc#bookmark113) [Operation element)](file:///C%3A%5CUsers%5Cpmonajem%5CDocuments%5CDocs%5CIEEE%20802.11%5C11be%5CSource%5CTGbe_Cl_09.doc#bookmark113)) | 255 | 106 | Yes | No |
| Multi-Link (see [9.4.2.312 (Multi-Link](file:///C%3A%5CUsers%5Cpmonajem%5CDocuments%5CDocs%5CIEEE%20802.11%5C11be%5CSource%5CTGbe_Cl_09.doc#bookmark116) [element)](file:///C%3A%5CUsers%5Cpmonajem%5CDocuments%5CDocs%5CIEEE%20802.11%5C11be%5CSource%5CTGbe_Cl_09.doc#bookmark116)) | 255 | 107 | Yes | Yes |
| EHT Capabilities (see [9.4.2.313 (EHT](file:///C%3A%5CUsers%5Cpmonajem%5CDocuments%5CDocs%5CIEEE%20802.11%5C11be%5CSource%5CTGbe_Cl_09.doc#bookmark142) [Capabilities element(#4819))](file:///C%3A%5CUsers%5Cpmonajem%5CDocuments%5CDocs%5CIEEE%20802.11%5C11be%5CSource%5CTGbe_Cl_09.doc#bookmark142)) | 255 | 108 | Yes | No |
| TID-To-Link Mapping (see [9.4.2.314](file:///C%3A%5CUsers%5Cpmonajem%5CDocuments%5CDocs%5CIEEE%20802.11%5C11be%5CSource%5CTGbe_Cl_09.doc#bookmark159) [(TID-To-Link Mapping element)](file:///C%3A%5CUsers%5Cpmonajem%5CDocuments%5CDocs%5CIEEE%20802.11%5C11be%5CSource%5CTGbe_Cl_09.doc#bookmark159)) | 255 | 109 | Yes | Yes |
| Multi-Link Traffic (see [9.4.2.315 (Multi-](file:///C%3A%5CUsers%5Cpmonajem%5CDocuments%5CDocs%5CIEEE%20802.11%5C11be%5CSource%5CTGbe_Cl_09.doc#bookmark162) [Link Traffic Indication element(#2341))](file:///C%3A%5C%5CUsers%5C%5Cpmonajem%5C%5CDocuments%5C%5CDocs%5C%5CIEEE%20802.11%5C%5C11be%5C%5CSource%5C%5CTGbe_Cl_09.doc%22%20%5Cl%20%22bookmark162)) | 255 | 110 |  |  |
| (#4918)QoS Characteristics (see [9.4.2.316](file:///C%3A%5CUsers%5Cpmonajem%5CDocuments%5CDocs%5CIEEE%20802.11%5C11be%5CSource%5CTGbe_Cl_09.doc#bookmark167) [(QoS Characteristics element(#4918))](file:///C%3A%5CUsers%5Cpmonajem%5CDocuments%5CDocs%5CIEEE%20802.11%5C11be%5CSource%5CTGbe_Cl_09.doc#bookmark167) | 255 | <ANA> | Yes | Yes |
| AID Bitmap (see 9.4.2.317 AID Bitmap element) | 255 | <ANA> | Yes | Yes |

TGbe editor: ***Insert the following new subclause at the end of subclause 9.4.2*** (#12779, #12808, #11762)***:***

### **9.4.2.317 AID Bitmap element**

The AID Bitmap element is used to signal a list of AIDs in a frame transmitted by an AP. The format of this element is shown in Figure 9-1002ah (AID Bitmap element format).

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | Element ID | Length | Element ID Extension | Partial AID Bitmap Length | Bitmap Control | Partial AID Bitmap |
| Octets: | 1 | 1 | 1 | 1 | 1 | 0 –251 |

**Figure 9-1002ah—AID Bitmap element format**

The Element ID, Length, and Element ID Extension fields are defined in [9.4.2.1 (General)](file:///C%3A%5C%5CUsers%5C%5Cpmonajem%5C%5CDocuments%5C%5CDocs%5C%5CIEEE%20802.11%5C%5C11be%5C%5CSource%5C%5CTGbe_Cl_09.doc%22%20%5Cl%20%22bookmark85).

The Partial Bitmap Length field is a one octet field and carries the length of the Partial AID Bitmap field.

The Bitmap Control field is a single octet. Bit 0 of the field is reserved. The remaining 7 bits of the field form the Bitmap Offset as shown in Figure 9-1002ai Bitmap Control field format.

|  |  |  |
| --- | --- | --- |
|  | B0 | B1 B7 |
|  | Reserved | Bitmap Offset |
| Bits: | 1 | 7 |
| **Figure 9-1002ai—Bitmap Control field of the AID Bitmap element** |

An AID bitmap is a bitmap consisting of 2008 bits where a bit position k is set to 1 if AID k is a member of the signaled list of AIDs and otherwise is set to 0. The AID bitmap is organized into 251 octets such that bit number *N* (0 £ *N* £ 2007) in the bitmap corresponds to bit number (*N* mod 8) in octet number ë*N* / 8û where the low order bit of each octet is bit number 0, and the high order bit is bit number 7.

The Partial AID Bitmap field consists of octets numbered *N*1 to *N*2 of the AID bitmap, where *N*1 is the largest even number such that bits numbered 1 to (*N*1 ´ 8) – 1 in the AID bitmap are all 0 and *N*2 is the smallest number such that bits numbered (*N*2 + 1) ´ 8 to 2007 in the AID bitmap are all 0. The Bitmap Offset subfield value contains the number *N*1/2, and the Length field is set to (*N*2 – *N*1) + 3.

* + 1. **Protected EHT Action frame details(#1119)(#1488)**
			1. **Protected EHT Action field**

***Tgbe editor: Please add the following line to Table 9-623c Protected EHT Action field values as follows*** (#12779, #12808, #11762)

**Table 9-623c—Protected EHT Action field values**

|  |  |  |
| --- | --- | --- |
| **Value** | **Meaning** | **Time priority** |
| 7 | Link Recommendation | No |
| 8-255 | Reserved |  |

***Tgbe editor: Please add the following subclause 9.6.34.4 Link Recommendation frame format as follows*** (#12779, #12808, #11762)

**9.6.35.9 Link Recommendation frame format**

The Link Recommendation frame is an Action No Ack frame of category EHT. The Action field of an Link Recommendation frame contains the information shown in [Table 9-xxx](#bookmark188) [(Link Recommendation frame Action field format(#6078))](#bookmark188).

**Table 9-xxx—Link Recommendation frame Action field format(#6078)**

|  |  |
| --- | --- |
| **Order(#6078)** | **Meaning** |
| 1 | Category |
| 2 | Protected EHT Action |
| 3 | Reason Code |
| 4 | AID Bitmap element |
| 5 | Multi-Link Traffic Indication element (see 9.4.2.315 (Multi-Link Traffic Indication element)) |

The Category field is defined in Table 9-79 (Category values). The Protected EHT Action field is defined in Table 9-623a (EHT Action field values). The Reason Code field is defined in 9.4.1.7 (Reason Code field) and provides the reason why the AP MLD is sending the link recommendation.

The AID Bitmap element is described in 9.4.2.317 (AID Bitmap element) and is used to identify the non-AP MLDs for which a link recommendation is provided.

The Multi-Link Traffic Indication element is described in 9.4.2.315 (Multi-Link Traffic Indication element) and is used to describe the link recommendations for all the non-AP MLDs that are identified in the AID Bitmap element.

***TGbe editor: Please modify following paragraphs in subclause 9.4.2.315 Multi-Link Traffic Indication element as follows*** (#12779, #12808, #11762)

The Per-Link Traffic Indication List field is defined in [Figure 9-1002ap (Per-Link Traffic Indication List](#bookmark165) [field format)](#bookmark165). The Per-Link Traffic Indication List field contains Per-Link Traffic Indication Bitmap sub- fields that correspond to the AIDs of the non-AP MLDs starting from the bit numbered *k* of the traffic indi- cation virtual bitmap or the AID bitmap. The Per-Link Traffic Indication List field contains *l* Per-Link Traffic Indication Bitmap subfields, where *l* is the number of the bits that correspond to the AIDs of the non-AP MLDs and STAs and set to 1, counting from the bit numbered *k* of the:

* + traffic indication virtual bitmap in the Partial Virtual Bitmap sub- field of the TIM element that is included in a Beacon frame with the Multi-Link Traffic Indication element
	+ AID Bitmap, in the Partial AID Bitmap subfield of the AID Bitmap element that is included in a Link Recommendation frame with the Multi-Link Traffic Indication element

***TGbe editor: Please modify following paragraphs in subclause 9.4.2.315 Multi-Link Traffic Indication element as follows*** (#12779, #12808, #11762)

Each bit in the Per-Link Traffic Indication Bitmap subfield corresponds to a link and the bit position *i* of the bitmap, B*i*, corresponds to a link with link ID equal to *i*. In a Beacon frame when the Per-Link Traffic Indication Bitmap subfield corresponds to a non-AP MLD that has successfully negotiated TID-to-link mapping and not all TIDs are mapped to all the enabled links, a value of 1 in the bit position *i* in the bitmap that corresponds to a link on which a STA affiliated with a non-AP MLD is operating indicates that there is buffered BU(s) with TID(s) mapped to the link with the link ID equal to *i* or MMPDU(s); a value of 0 in a bit position in the bitmap indicates that there is no buffered BU(s) with TID(s) mapped to the corresponding link nor MMPDU(s). In a Beacon frame when the Per-Link Traffic Indication Bitmap subfield corresponds to a non-AP MLD that is in the default mapping mode or has negotiated a TID-to-link mapping with an AP MLD and all TIDs are mapped to all the enabled links, a value of 1 in the bit position *i* in the bitmap indicates that the link with the link ID equal to *i* is recommended for retrieving buffered BU(s).

In a Link Recommendation frame, when the Per-Link Traffic Indication Bitmap subfield corresponds to a non- AP MLD, a value of 1 in the bit position *i* in the bitmap indicates that the link with the link ID equal to *i* is recommended for frame exchanges both in DL and in UL, as defined in 35.3.12.4 (Traffic indication) ; a value of 0 in the bit position *i* in the bitmap indicates that the link with the link ID equal to *i* is not recommended for frame exchanges both in DL and in UL, as defined in 35.3.12.4 (Traffic indication).

**35.3.12.4 Traffic indication**

***Tgbe editor: Please modify the 4th paragraph in subclause 35.3.12.4 Traffic indication as follows***) (#12779, #12808, #11762)

An AP MLD may use Multi-Link Traffic Indication element and TIM element carried in a Beacon frame to recommend a non-AP MLD to use one or more enabled links to retrieve individually addressed buffered BU(s).(#3256)(#3322).An AP MLD may also use Multi-Link Traffic Indication element and AID Bitmap element in a Link Recommendation frame to recommend a non-AP MLD to use one or more enabled links for all exchanges both for DL and UL. The AP’s indication may be carried in a broadcast or a unicast frame.

***Tgbe editor: Please insert the following paragraphs after paragraph 11 in subclause 35.3.12.4 Traffic indication*** (#12779, #12808, #11762)

An AP affiliated with an AP MLD may also schedule for transmission a Link Recommendation frame to provide link recommendation for a set of non-AP MLDs as follows:

* The bit corresponding to the AID of a non-AP MLD shall be set to 1 in the Partial AID Bitmap subfield of the AID Bitmap element in the Link Recommendation frame if the AP intends to provide a link recommendation for this non-AP MLD.
* The Multi-Link Traffic Indication element includes Per-Link Traffic Indication Bitmap subfield(s), in the Per-Link Traffic Indication Bitmap List field, that correspond(s) to the AID(s) of the non-AP MLD(s), starting from the bit number *k* of the AID Bitmap of the AID Bitmap element carried in the Link Recommendation frame. The AID Offset subfield of the Multi-Link Traffic Control field of the Multi-Link Traffic Indication element contains the value *k*. The order of the Per-Link Traffic Indication Bitmap subfield(s) follows the order of the bits that are set to 1 in the Partial AID Bitmap subfield of the AID Bitmap element carried in the Link Recommendation frame that corresponds to the AID(s) of the non-AP MLD(s). The bit position *i* of the Per-Link Traffic Indication Bitmap subfield in the Multi-Link Traffic Indication element that corresponds to the link with the link ID equal to *i* on which a STA affiliated with the non-AP MLD is operating shall be set to 1 to indicate to the non-AP MLD that it should exchange frames on this link both in DL and UL, while following the rules defined in 35.3.7.1.1 (General).
* A link shall not be recommended by the AP MLD for a non-AP MLD if the link is disabled for the non-AP MLD (see 35.3.7.1.1 General).
* The address 1 field of the Link Recommendation frame shall be set to the broadcast address.

NOTE – One or more links can be recommended by the AP MLD to a non-AP MLD. (#12605)

If a non-AP MLD receives a Link Recommendation frame with the bit corresponding to its AID set to 1 in the Partial AID Bitmap subfield of the AID Bitmap element in the Link Recommendation frame, it should exchange frames both in DL and UL on enabled links identified as recommended in the Multi-Link Traffic Indication element in the Link Recommendation frame, while following the rules defined in 35.3.7.1.1 (General).

***Tgbe editor: Please modify the following paragraph in subclause 35.3.12.4 Traffic indication*** (#12779, #12808, #11762)

An AP MLD shall set dot11MultiLinkTIMActivated to true if dot11TIDtoLinkMappingActivated is true and if any of the following conditions is met and otherwise shall set to false:

— At least one of the associated non-AP MLD(s) has successfully negotiated a TID-to-link mapping (see 35.3.7.1.3 (Negotiation of TID-to-link mapping)) with the AP MLD and not all TIDs are mapped to all the enabled links (i.e., TID-to-link Mapping Negotiation Supported subfield set to 1) and the AP MLD has buffered BU(s) for that non-AP MLD

— The AP MLD intends to provide link recommendations in a Beacon frame to retrieve individually addressed buffered BUs to at least one of the associated non-AP MLD(s) that has successfully negotiated a TID-to-link mapping with the AP MLD and all TIDs are mapped to all the enabled links and the AP MLD has buffered BU(s) for that non-AP MLD

— The AP MLD intends to provide link recommendations in a Beacon frame to retrieve individually addressed buffered BUs to at least one of the associated non-AP MLD(s) that is in the default mapping mode (see 35.3.7.1.2 (Default mapping mode)) and the AP MLD has buffered BU(s) for that non-AP MLD.