IEEE P802.11
Wireless LANs

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| 11be Spec text for Multi-Link element |
| Date: 2020-08-20 |
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Abstract

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

Revisions:

* Rev 0: Initial version of the document.
* Rev 1: Several updates based on feedback received on r0
* Rev 2: Updates based on feedback from Jay and Laurent
	+ Additions/modifications marked in blue
	+ Deletions were not tracked
* Rev 3: Further updates based on feedback received on the reflector
	+ Additions/modifications marked in green
	+ Deletions were not tracked
	+ Added tags to call out the motions for proposed text
* Rev 4: Revised based on feedback from Young Hoon, Insun, and discussion on the reflector
	+ Additions/modifications marked in purple
	+ Deletions were not tracked
* Rev 5: Simplified the text in ‘33.x.y.z.1 (General)’ and ‘33.x.y.z.2 (Complete or partial per-STA profile)’.
	+ Additions/modifications marked in grey
	+ Deletions were not tracked
* Rev 6: Changes based on feedback received when the doc was presented in 11be MAC telco 9/21
	+ Additions/modifications marked in red
		- Text to indicate that ML IE can be present in the Authentication frame
	+ Deletions were not tracked
		- Deleted ‘Number Of Supported Links’ subfield from Multi-Link Control field.
	+ Several editorial changes throughout the doc based on feedback from Payam

The texts is prepared for the following motions.

|  |  |  |  |  |  |
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| MAC | MLO-Discovery: ML element structure/general | Abhishek Patil | Laurent Cariou, Ming Gan, Liwen Chu, Jarkko Kneckt, Namyeong Kim, Cheng Chen, Rojan Chitrakar, Xiaofei Wang, James Yee, Yonggang Fang, Liuming Lu, Payam Torab | R1 | Motion 115, #SP98Motion 115, #SP99Motion 115, #SP91Motion 115, #SP92Motion 115, #SP93 Motion 119, #SP124 |

802.11be shall define mechanism(s) for an AP of an AP MLD to advertise complete or partial information of other links:

* Partial information to prevent frame bloating.
* For example, frames exchanged during ML setup are expected to carry complete information while Beacon frame is expected to carry partial information.
* The exact set of elements/fields that constitute partial information is TBD.

[Motion 115, #SP93, [14] and [115]]

802.11be defines mechanism(s) to include MLO information that a STA of an MLD provides in its mgmt. frames, during discovery and ML setup, as described below:

* MLD (common) Information
	+ Information common to all the STAs of the MLD.
* Per-link information
	+ Capabilities and Operational parameter of other STAs of the MLD other than the advertising STA.

[Motion 115, #SP91, [10] and [93]]

802.11be agrees to define a new Multi-Link element (MLE) to report/describe multiple STAs of an MLD with at least the following characteristics:

* MLD-level information may be included
* A STA profile subelement is included for each reported STA (if any) and is made of a variable number of elements describing this STA

Note: a control field for the element is not considered as MLD-level information.

Note: Name can be changed.

[Motion 115, #SP98, [10] and [97]]

802.11be agrees to include a Control field in Multi-Link element to indicate the presence of certain fields.

[Motion 119, #SP124, [3] and [98]]

802.11be supports that the MLO framework should follow an inheritance model when advertising complete information of other link(s):

* Note: inheritance mechanism is similar to that defined in 802.11ax for multiple BSSID feature.

[Motion 115, #SP92, [10] and [93]]

802.11be supports that, for the ML element, an inheritance model is defined to prevent frame bloating when advertising complete information of other links.

* Define the inheritance mechanism, similar to 802.11ax, so that the value of an element of a reported STA that is not present in a STA profile of a ML element in a frame sent by a reporting STA is the same as the element of the reporting STA, present elsewhere in the frame.
* Define the inheritance mechanism, similar to 802.11ax, so that the value of an element of a reported STA that is not present in a STA profile of a ML element, if any, included in a non-transmitted BSSID profile of a non-transmitted BSSID in a multiple BSSID element in a frame sent by a reporting STA is the same as the element of the non-transmitted BSSID, present elsewhere in the frame or as the element of the reporting STA, present elsewhere in the frame.
* Note: an “element of a STA” refers in the text above to the instance of the element describing the capabilities/operation/functionalities of that STA, in a frame where multiple instances of the element can be found for other STAs.
* Note: some elements may not be inherited, signaling TBD.

[Motion 115, #SP99, [10] and [97]]

**Proposed spec text:**

The baseline for this text is 802.11 REVmd draft 4.0.

**9.3.3 Management frames**

*[Motion 115, #SP93, [14] and [115]]*

*[Motion 115, #SP91, [10] and [93]]*

* Beacon frame format

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| Table 9-32 – Beacon frame body |

 |
| Order | Information | Notes |
| <ANA> | Multi-Link | The Multi-Link element is present if the AP is affiliated with an AP MLD. Otherwise it is not present. |

* Association Request frame format

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| Table – 9-34 – Association Request frame body |
| Order | Information | Notes |
| <ANA> | Multi-Link | The Multi-Link element is present if the STA is affiliated with a non-AP MLD and initiates a multi-link setup with an AP affiliated with an AP MLD. Otherwise it is not present. |

* Association Response frame format

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| Table 9-35— Association Response frame body |
| Order | Information | Notes |
| <ANA> | Multi-Link | The Multi-Link element is present if the AP is affiliated with an AP MLD and the soliciting Association Request frame is received from a STA affiliated with a non-AP MLD. Otherwise it is not present. |

* Reassociation Request frame format

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| Table 9-36 – Reassociation Request frame body |
| Order | Information | Notes |
| <ANA> | Multi-Link | The Multi-Link element is present if the STA is affiliated with a non-AP MLD and initiates a multi-link setup with an AP affiliated with an AP MLD. Otherwise it is not present. |

* Reassociation Response frame format

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| Table 9-37 – Reassociation Response frame body  |
| Order | Information | Notes |
| <ANA> | Multi-Link | The Multi-Link element is present if the AP is affiliated with an AP MLD and the soliciting Ressociation Request frame is received from a STA affiliated with a non-AP MLD. Otherwise it is not present. |

* Probe Request frame format

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|  |
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| Table 9-38 – Probe Request frame body |
| Order | Information | Notes |
| <ANA> | Multi-Link | The Multi-Link element is TBD present if the STA is affiliated with a non-AP MLD and the frame is a non-ML or ML Probe Request frame. Otherwise it is not present. |

* Probe Response frame format

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|  |
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| Table 9-39 – Probe Response frame body |
| Order | **Information** | **Notes** |
| <ANA> | Multi-Link | The Multi-Link element is TBD present if the AP is affiliated with an AP MLD and the frame is a non-ML Probe Response frame. The Multi-Link element is present if the frame is a ML Probe Response frame. Otherwise it is not present. |

* Authentication frame format

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|  |
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| Table 9-40 – Authentication frame body |
| Order | **Information** | **Notes** |
| <ANA> | Multi-Link | The Multi-Link element is optionally present if the STA is affiliated with an MLD and the frame exchange is with a peer STA that is affiliated with an MLD. Otherwise it is not present. |

* Elements
* General

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*[Motion 115, #SP98, [10] and [97]]*

*[Motion 119, #SP124, [3] and [98]]*

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| --- |
| Table 9-92 – Element IDs  |
| Element | Element ID | Element ID Extension | Extensible | Fragmentable |
| Multi-Link (see 9.4.2.x (Multi-Link element)) | <ANA> | <ANA> | Yes | Yes |

***TGbe editor: Please add a subclause in 9.4.2 as follows***

9.4.2.x Multi-Link element

The format of the Multi-Link element is defined in Figure 9-xxx1 (Multi-Link element format). The frames carrying this element and usage of this element is described in 33.x.y.z (Container for Multi-Link Information).

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

The Element ID, Length and Element ID Extension fields are defined in 9.4.2.1 (General).

The format of the Multi-Link Control field is defined in Figure 9-xxx2 (Multi-Link Control field format).

|  |  |  |
| --- | --- | --- |
|  | B0 | TBD |
|  | MLD MAC Address Present | TBD |
| Bits: | 1 | TBD |

**Figure 9-xxx2 – Multi-Link Control field format**

The MLD MAC Address Present subfield is set to 1 if the MLD MAC Address field is present in the element. Otherwise the subfield is set to 0. The condition for MLD MAC Address presence are defined in clause 33.a.b.c (Usage and Rules of Multi-Link element in the context of multi-link setup) and 33.3.2.3 (Multi-link element usage rules in the context of discovery).

Other subfields are TBD

The MLD MAC Address field specifies the MAC Address of the MLD.

Other fields are TBD

The Optional Subelements field contains zero or more subelements. The subelement format and ordering of subelements are defined in 9.4.3 (Subelements).

The Subelement ID field values for the defined subelements are shown in Table 9-xxx (Optional subelement IDs for Multi-Link).

|  |
| --- |
| Table 9-xxx – Optional subelement IDs for Multi-Link |
| Subelement ID | Name | Extensible |
| 0 | Per-STA Profile | Yes |
| 1–220 | Reserved |  |
| 221 | Vendor Specific | Vendor defined |
| 222–255 | Reserved |  |

Each Per-STA Profile subelement starts with Per-STA Control field followed by variable number of fields and elements as defined in 33.x.y.z (Container for Multi-Link Information).

The format of the Per-STA Control field is defined in Figure 9-xxx3 (Per-STA Control field format).

|  |  |  |  |
| --- | --- | --- | --- |
|  |  |  |  |
|  | Link ID | Complete Profile | TBD |
| Bits: | TBD | 1 | TBD |
| Figure 9-xxx3 – Per-STA Control field format |

The Link ID subfield specifies a value that uniquely identifies the link where the reported STA is operating on.

The Complete Profile subfield is set to 1 when the Per-STA Profile subelement of the Multi-Link element is complete as defined in 33.x.y.z (Container for Multi-Link Information). Otherwise the subfield is set to 0.

Other subfields are TBD.

The Vendor Specific subelements have the same format as their corresponding elements (see 9.4.2.25 (Vendor Specific element)). Zero or more Vendor Specific subelements are included in the list of optional subelements.

33. Extreme High Throughput (EHT) MAC specification

**33.x Multi-link operation**

**33.x.y Multi-Link Discovery and ML Setup Procedure**

***TGbe editor: Add new a subclause 33.x.y.z (Container for Multi-Link Information ) under clause 33 as follows:***

**33.x.y.z** **Container for Multi-Link Information**

*[Motion 115, #SP98, [10] and [97]]*

*[Motion 119, #SP124, [3] and [98]]*

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

*[Motion 115, #SP93, [14] and [115]]*

*[Motion 115, #SP91, [10] and [93]]*

A STA of an MLD shall advertise multi-link capabilities and information of other STA of the MLD it is affiliated with by including a Multi-Link element in certain Management frames that it transmits.

An AP of an AP MLD shall follow the rules defined in 33.3.2.3 (Multi-link element usage rules in the context of discovery) for including a Multi-Link element in the Beacon frames and non-ML Probe Response frames that it transmits.

An AP of an AP MLD shall follow the rules in 33.3.2.2 (MLD Probing) for including a Multi-Link element in the Probe Response frame that it transmits.

An AP of an AP MLD shall follow the rules in 33.a.b.c (Usage and Rules of Multi-Link element in the context of multi-link setup) for including a Multi-Link element in the (Re-)Association Response frame that it transmits.

A STA of a non-AP MLD shall follow the rules in 33.3.2.2 (MLD Probing) for including a Multi-Link element in the Probe Request frame that it transmits.

A STA of a non-AP MLD shall follow the rules in 33.a.b.c (Usage and Rules of Multi-Link element in the context of multi-link setup) for including a Multi-Link element in the (Re-)Association Request frame that it transmits.

A STA of an MLD shall follow the rules defined in 33.a.b.c (Usage and Rules of Multi-Link element in the context of multi-link setup) and 33.3.2.3 (Multi-link element usage rules in the context of discovery) for including a Multi-Link element in Authentication frame that it transmits.

In order to prevent duplication of information, an AP of an AP MLD shall not include a Reduced Neighbor Report element or a Multiple BSSID element or another Multi-Link element in the Per-STA Profile subelement of the Multi-Link element for a reported AP.

**33.x.y.z.2 Complete or partial per-STA profile**

*[Motion 115, #SP93, [14] and [115]]*

A STA of an MLD may provide complete or partial information of another STA of its MLD in the Per-STA Profile subelement of the Multi-Link element that it transmits. The exact set of elements/fields that constitute partial information is TBD.

A STA of an MLD shall set the Complete Profile subfield of the Per-STA Control field to 1 when the Per-STA Profile subelement carries all the elements that would be included if the reported STA were to transmit the frame that carried the Multi-Link element. Otherwise the STA shall set the subfield to 0.

**33.x.y.z.3 Inheritance in a per-STA profile**

[Motion 115, #SP92, [10] and [93]]

[Motion 115, #SP99, [10] and [97]]

STAs of an MLD are expected to have similar capabilities and operational parameters on different links. Therefore, some of the elements that could be carried in the per-STA profile for a reported STA would have the same value as the reporting STA. In order to reduce frame bloating, when a per-STA profile carries complete information for a reported STA, it would inherit the elements from the reporting STA.

An element is considered to be specific to a reported STA if its value is different from the corresponding element advertised by the reporting STA or if the reported STA satisfies the condition as specified in the Table 9-34 (Beacon frame body) if the reporting STA is an AP or Table 9-36 (Association Request frame body) if the reporting STA is a non-AP for that element to be present while the reporting STA does not satisfy the corresponding condition. If any of the elements carried in the frame of the reporting STA are not present in a per-STA profile, the values to use for the reported STA are the values of the corresponding element of the reporting STA unless the element is listed in the Non-Inheritance element (if included) in the per-STA profile for that STA.

When carried in a Management frame transmitted by a STA of an MLD, each Per-STA Profile subelement in a Multi-Link element that is a complete profile shall contain a list of elements as follows:

* The Per-STA Control field is the first field
* TBD fields in fixed order
* TBD elements in fixed order
* If the reporting STA is an AP, a variable number of elements that provide the capabilities and operation parameters of the reported AP in the order defined in Table 9-34 (Beacon frame body)
* If the reporting STA is a non-AP, a variable number of elements that provide capability information of the reported STA in the order defined in Table 9-36 (Association Request frame body).
* Any element specific to the reported STA or with content that is not inherited from the reporting STA.
* When included in the Per-STA Profile subelement for the reported STA, the Non-Inheritance element appears as the last element in the profile and carries a list of elements that are not inherited by the reported STA from the reporting STA.

An example of a Multi-Link element containing a complete per-STA profile is shown in Figure 33-xxx (Illustration of Multi-Link element carrying a complete per-STA profile).



Figure 33-xxx – Illustration of Multi-Link element carrying a complete per-STA profile

***TGbe editor: doc 11-20/1288r2 provides the Visio file for the above Figure 33-xxx***

An AP corresponding to the transmitted BSSID may include a Multi-Link element in the Nontransmitted BSSID Profile subelement of a Multiple BSSID element when the corresponding nontransmitted BSSID is affiliated with an AP MLD. See 33.3.14 (Multi-BSSID) for inheritance rules when the Multi-Link element is carried in a Multiple BSSID element.

**33.3.14 Multi-BSSID**

[Motion 115, #SP92, [10] and [93]]

[Motion 115, #SP99, [10] and [97]]

***TGbe editor: Please add the following paragraph to this subclause as shown***

When Multi-Link element is carried in a Nontransmitted BSSID Profile subelement in a Multiple BSSID element, the value of an element, that is not present in the Per-STA Profile subelement of the Multi-Link element for a reported AP, shall be the same as the corresponding element value as that of the nontransmitted BSSID profile that carried the Multi-Link element or as the element of the transmitted BSSID, present elsewhere in the frame, which is inherited by the nontransmitted BSSID. The hierarchy of inheritance is from transmitted BSSID to the nontransmitted BSSID that carried the Multi-Link element and from the nontransmitted BSSID to the AP reported in the per-STA profile.

* **Non-Inheritance element**

[Motion 115, #SP92, [10] and [93]]

[Motion 115, #SP99, [10] and [97]]

***TGbe editor: Please add new paragraphs before and after the first paragraph in this subclause as follows***

The Non-Inheritance element can be present as the last element in the Nontransmitted BSSID Profile subelement of a Multiple BSSID element or as the last element in the Per-STA Profile subelement of a Multi-Link element when the profile is complete.

The Non-Inheritance element when present in the Nontransmitted BSSID Profile subelement of a Multiple BSSID element identifies one or more elements that are not inherited by the BSS corresponding to the nontransmitted BSSID profile that carried it. The identified elements are present in the Management frame of the transmitted BSSID that carried the Multiple BSSID element.

The Non-Inheritance element when present in the Per-STA Profile subelement of a Multi-link element identifies one or more elements that are not inherited by the STA corresponding to the per-STA profile. The identified elements are present in the Management frame of the STA that carried the Multi-Link element.