IEEE P802.11
Wireless LANs

|  |
| --- |
| Proposed Draft Text (PDT-Joint): Spatial Stream and MIMO Protocol Enhancement |
| Date: 2020-11-05 |
| Author(s): |
| Name | Affiliation | Address | Phone | email |
| Wook Bong Lee | Samsung |  |  | wookbong.lee@samsung.com |

Abstract

This submission proposed the draft text on spatial stream and MIMO protocol enhancement for TGbe D0.2.

This document is based on P802.11ax D7.0.

* VHT/HE/EHT NDP Announcement frame based on VHT/HE NDP Announcement frame format
* EHT Control field based on HE Control field
* EHT Compressed Beamforming Report field based on HE Compressed Beamforming Report field
* EHT MU Exclusive Beamforming Report field based on HE MU Exclusive Beamforming Report field

Yellow highlighted texts are TBD.

R2: Update subcarrier indices for 20MHz. Two motions are conflict.

The following feedback tone sets are supported:

* 20/40 MHz: Reuse 802.11ax feedback tone sets for 802.11be.
* …

[Motion 142, #SP300, [23] and [24]]

|  |
| --- |
| **20 MHz** |
| [-122:Ng:-4, 4:Ng:122] |

[Motion 142, #SP301, [23] and [24]]

In this contribution, we follow 11ax

|  |  |
| --- | --- |
| Ng=4  | [-122, -120:4:-4, -2, 2, 4:4:120, 122] |
| Ng=16 | [-122, -116:16:-4, -2, 2, 4:16:116, 122] |

R3: Fixed typo, and added Ross’s comments/discussions.

R4: Based on P802.11ax D8.0. Segment related change, EHT action frame. Also modified based on Mark’s comment.

This document is based on following motions:

There is at least one reserved bit in EHT NDPA STA Info Subfield and EHT MIMO Control field.

* NOTE – If needed, this reserved bit may be used for codebook size expansion or other purpose.

[Motion 137, #SP249, [187] and [119]]

**Straw poll #307**

Do you agree with the following two rules

* NDPA shall not request feedback on a 242RU that is signaled as punctured in the U-SIG of the NDP that follows it
* MIMO Control Field’s Partial BW Info field (naming TBD) will be the same as the one in NDPA ***[#SP307]***

[20/1436r6 (NDPA and MIMO Control Field Design for EHT, Sameer Vermani, Qualcomm), SP#5, Y/N/A/No answer: 121/2/45/174]

The design of an EHT NDPA frame is based on the VHT/ HE NDPA frame.

* The EHT NDPA frame will have the same Type/Subtype subfield in the FC field of the VHT/HE NDPA frame.

[Motion 137, #SP293, [3] and [267]]

The length of an EHT STA Info field in the NDPA frame is 4 bytes.

[Motion 137, #SP294, [3] and [268]]

A new EHT NDPA variant using the encoding value 11 for B0-B1 is created in the Sounding Dialog Token field.

[Motion 137, #SP295, [3] and [269]]

The design of STA Info field is shown as follows.

* Partial BW Info field (naming is TBD) can be 7–9 bits [the figure will be modified accordingly if the field size is different from 9 bits]
* The codebook size may be increased, and the location of the Nc and Codebook Size fields are TBD.



[Motion 142, #SP304, [23] and [89]]

The design of the EHT MIMO Control Field Design is shown as follows.

* The size of codebook information may be increased.
* Reserved bits (number and location) may change.
* Sounding Dialogue Token and Feedback Segment related bits are TBD.
* Partial BW Info field (naming is TBD) can be 7–9 bits [the figure will be modified accordingly if the field size is different from 9 bits].



[Motion 142, #SP305, [23] and [89]]

The following feedback tone sets are supported:

* 20/40 MHz: Reuse 802.11ax feedback tone sets for 802.11be.
* 80 MHz
	+ Ng = 4: Reuse the 802.11ax feedback tones of Ng = 4 for 802.11be.
	+ Ng = 16: Redefine the feedback tones of Ng = 16 for 802.11be as [-500:16:-260, -252:16:-12, -4, 4, 12:16:252, 260:16:500]
* 160 / 320 MHz: Duplicate the feedback tone set of 80 MHz.
* Full BW sounding feedback the entire tone set.

[Motion 142, #SP300, [23] and [24]]

802.11be supports that the partial BW CSI feedback request uses 20 MHz (RU242) granularity.

NOTE – Feedback request granularity change does not impact the CSI computation scheme. For example, CQI feedback computation is still based on RU26.

[Motion 135, #SP232, [21] and [20]]

The following feedback tone indices table with RU242 granularity for both Ng = 4 and Ng = 16 is supportedL

* If feedback request does not cover the entire 80 MHz segment, use the following table:

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **RU242 Index** | **20 MHz** | **40 MHz** | **80 MHz** | **160 MHz** | **320 MHz** |
| **1** | [-122:Ng:-4, 4:Ng:122] | [-244:Ng:-4] | [-500:Ng:-260] | [-1012:Ng:-772] | [-2036:Ng:-1796] |
| **2** |   | [4:Ng:244] | [-252:Ng:-12] | [-764:Ng:-524] | [-1788:Ng:-1548] |
| **3** |   |   | [12:Ng:252] | [-500:Ng:-260] | [-1524:Ng:-1284] |
| **4** |   |   | [260:Ng:500] | [-252:Ng:-12] | [-1276:Ng:-1036] |
| **5** |   |   |   | [12:Ng:252] | [-1012:Ng:-772] |
| **6** |   |   |   | [260:Ng:500] | [-764:Ng:-524] |
| **7** |   |   |   | [524:Ng:764] | [-500:Ng:-260] |
| **8** |   |   |   | [772:Ng:1012] | [-252:Ng:-12] |
| **9** |   |   |   |   | [12:Ng:252] |
| **10** |   |   |   |   | [260:Ng:500] |
| **11** |   |   |   |   | [524:Ng:764] |
| **12** |   |   |   |   | [772:Ng:1012] |
| **13** |   |   |   |   | [1036:Ng:1276] |
| **14** |   |   |   |   | [1284:Ng:1524] |
| **15** |   |   |   |   | [1548:Ng:1788] |
| **16** |   |   |   |   | [1796:Ng:2036] |

* If feedback request covers the entire 80 MHz segment, feedback the entire 80 MHz segment feedback tone set using the following tables:
	+ Feedback tone table for Ng = 4

|  |  |  |  |
| --- | --- | --- | --- |
| **RU996 Index** | **80 MHz** | **160 MHz** | **320 MHz** |
| **1** | [-500:4:-4, 4:4:500] | [-1012:4:-516, -508:4:-12] | [-2036:4:-1540, -1532:4:-1036] |
| **2** |   | [12:4:508, 516:4:1012] | [-1012:4:-516, -508:4:-12] |
| **3** |   |   | [12:4:508, 516:4:1012] |
| **4** |   |   | [1036:4:1532, 1540:4:2036] |

* + Feedback tone table for Ng = 16

|  |  |  |  |
| --- | --- | --- | --- |
| **RU996 Index** | **80 MHz** | **160 MHz** | **320 MHz** |
| **1** | [-500:16:-260, -252:16:-12, -4, 4, 12:16:252, 260:16:500] | [-1012:16:-772, -764:16:-524, -516, -508, -500:16:-260, -252:16:-12] | [-2036:16:-1796, -1788:16:-1548, -1540, -1532, -1524:16:-1284, -1276:16:-1036] |
| **2** |   | [12:16:252, 260:16:500, 508, 516, 524:16:764, 772:16:1012] | [-1012:16:-772, -764:16:-524, -516, -508, -500:16:-260, -252:16:-12] |
| **3** |   |   | [12:16:252, 260:16:500, 508, 516, 524:16:764, 772:16:1012] |
| **4** |   |   | [1036:16:1276, 1284:16:1524, 1532, 1540, 1548:16:1788, 1796:16:2036] |

[Motion 142, #SP301, [23] and [24]]

Proposed Changes #1:

*Instruction to 11be Editor: Underline text is for addition, and strikeout text is for deletion.*

*Change the title of 9.3.1.19 as follows:*

* VHT/HE/EHT NDP Announcement frame format

***Change the 1st paragraphs as follows:***

The VHT/HE/EHT NDP Announcement frame has ~~two~~ three variants, the VHT NDP Announcement frame ~~and~~, the HE NDP Announcement frame and the EHT NDP Announcement frame. The ~~two~~ ~~formats~~ variants are distinguished by the setting of the Ranging subfield and the HE subfield in the Sounding Dialog Token field.

Change paragraphs 3-4 as follows:

The VHT/HE/EHT NDP Announcement frame contains at least one STA Info field. If the VHT/HE/EHT NDP Announcement frame contains only one STA Info field, then the RA field is set to the address of the STA that can provide feedback (see 10.37.5.2 (Rules for VHT sounding protocol sequences)). If the VHT/HE/EHT NDP Announcement frame contains more than one STA Info field, then the RA field is set to the broadcast address.

The TA field is set to the address of the STA transmitting the VHT/HE/EHT NDP Announcement frame or the bandwidth signaling TA of the STA transmitting the VHT/HE/EHT NDP Announcement frame. In a VHT/HE/EHT NDP Announcement frame transmitted by a VHT ~~or~~, HE or EHT STA in a non-HT or non-HT duplicate format and where the scrambling sequence carries the TXVECTOR parameter CH\_BANDWIDTH\_IN\_NON\_HT, the TA field is set to a bandwidth signaling TA.

Change Figure 9-59 (Sounding Dialog Token field format) as follows:

|  |  |  |  |
| --- | --- | --- | --- |
|  | B0 | B1 | B2                  B7 |
|  | Ranging ~~Reserved~~ | HE | Sounding Dialog Token Number |
| Bits: | 1 | 1 | 6 |
| * Sounding Dialog Token field format
 |

Change the 5th paragraph as follows:

The HE subfield and Ranging subfield in the Sounding Dialog Token field ~~is~~ are set to 0 to identify the frame as a VHT NDP Announcement frame; the HE subfield and Ranging subfield are set to 1 and 0 respectively to identify the frame as an HE NDP Announcement frame; the HE subfield and Ranging subfield are set to 1 to identify the frame as an EHT NDP Announcement frame.

***Change the first paragraph after Figure 9-59***

The HE subfield and Ranging subfield in the Sounding Dialog Token field ~~is~~ are set to 0 to identify the frame as a VHT NDP Announcement frame ~~and set to 1 to identify the frame as an HE NDP Announcement frame~~.

***Change the second paragraph after Figure 9-61a***

The HE subfield and Ranging subfield in the Sounding Dialog Token field ~~is~~ are set to 1 and 0 respectively to identify the frame as an HE NDP Announcement frame.

***Insert the following at the end of 9.3.1.19:***

The frame format of the EHT NDP Announcement frame is the same as the HE NDP Announcement frame shown in Figure 9-61a (HE NDP Announcement frame format). *(Motion 137, #SP293)*

The Duration, RA, and TA fields are set as in a VHT NDP Announcement frame.

The HE subfield and Ranging subfield are set to 1 to identify the frame as an EHT NDP Announcement frame. *(Motion 137, #SP295)*

The Sounding Dialog Token Number field in the Sounding Dialog Token field contains a value selected by the beamformer to identify the EHT NDP Announcement frame.

The format of a STA Info field in an EHT NDP Announcement Frame if the AID11 subfield is not set to 2047 is defined in Figure 9-X1 (STA Info field format in an EHT NDP Announcement frame if the AID11 subfield is not 2047).

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | B0           B10 | B11         B19 | B20 | B21 B24 | B25        B26 | B27 | B28 | B29        B31 |
|  | AID11 | Partial BW Info | Reserved | Nc | Feedback Type And Ng | Disambiguation | Codebook Size | Reserved |
| Bits: | 11 | 9 | 1 | 4 | 2 | 1 | 1 | 3 |
| Figure 9-X1—STA Info field format in an EHT NDP Announcement frame if the AID11 subfield is not 2047 |

Note that Partial BW Info subfield (naming is TBD) can be 7-9 bits, size of the Codebook Size subfield may be increased, and the location of the Nc and Codebook Size subfields are TBD. *(SP #304)*

An EHT NDP Announcement frame contains at most one STA Info field per STA.

If the AID11 subfield is not 2047, then it contains an identifier of a STA expected to process the following EHT sounding NDP and prepare the sounding feedback.

The Partial BW Info subfield is defined in Figure 9-X2 (Partial BW Info subfield format).

|  |  |
| --- | --- |
|  | B0                B8 |
|  | TBD |
| Bits: | 9 |
| Figure 9-X2— Partial BW Info subfield format  |

*(Place holder for description of Partial BW Info subfield.)*

An EHT NDP Announcement frame shall not request feedback on a 242-tone RU that is signaled as punctured in the U-SIG of the NDP that follows the EHT NDP Announcement frame. *(SP #306)*

 (#24511)The Feedback Type And Ng and Codebook Size subfields for EHT TB sounding are defined in Table 9-29a (Feedback Type And Ng subfield and Codebook Size subfield encoding for HE TB sounding).

The Feedback Type And Ng and Codebook Size subfields for EHT non-TB sounding are defined in Table 9-29b (Feedback Type And Ng subfield and Codebook Size subfield encoding for HE non-TB sounding).

The Disambiguation subfield is set to 1.

NOTE—Setting the Disambiguation subfield to 1 prevents a non-EHT VHT STA from wrongly identifying its AID in the EHT NDP Announcement frame. The Disambiguation subfield coincides with the MSB of the AID12 subfield of a VHT NDP Announcement frame if the EHT NDP Announcement field is parsed as VHT NDP Announcement frame by a non-EHT VHT STA. The MSB of the AID12 subfield is always 0 since the maximum AID is 2007.(#24454)

In a broadcast EHT NDP Announcement frame that has more than one STA Info field with a value other than 2047 in the AID11 field the following applies to each STA Info subfield with a value other than 2047:

* If the Feedback Type And Ng subfield and Codebook Size subfield indicate SU or MU, the Nc subfield indicates the number of columns, *Nc*, in the compressed beamforming feedback matrix and is set to *Nc* – 1
* If the Feedback Type And Ng subfield and Codebook Size subfield indicate CQI, the Nc subfield indicates the number of space-time streams, *Nc*, in the CQI report and is set to *Nc* – 1

In an individually addressed EHT NDP Announcement frame with a single STA Info field, the STA Info field having a value in the AID11 field other than 2047, the Nc subfield is reserved.(#24473)

The format of the STA Info field in an EHT NDP Announcement frame if the AID11 subfield is set to 2047 is defined in Figure 9-X3 (STA Info field format in an EHT NDP Announcement frame if the AID11 subfield is 2047).

|  |  |
| --- | --- |
|  | B0              B31 |
|  | TBD |
| Bits: | 32 |
| Figure 9-X3— STA Info field format in an EHT NDP Announcement frame if the AID11 subfield is 2047 |

*(Place holder for description of STA Info field format in an EHT NDP Announcement frame if the AID11 subfield is 2047.)*

***Insert the following subclauses after 9.4.1.68:***

9.4.1.X1 EHT MIMO Control field

The EHT MIMO Control field is defined in Figure 9-X4 (EHT MIMO Control field format).

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | B0  B3 | B4  B7 | B8 B10 | B11 | B12 | B13  B14 |
|  | Nc Index | Nr Index | BW | Grouping | Codebook Information | Feedback Type |
| Bits: | 4 | 4 | 3 | 1 | 1 | 2 |
|  | B15      B17 | B18 | B19   B27 | B28     B33 | B34        B39 |
|  | Remaining Feedback Segments | First Feedback Segment | Partial BW Info | Sounding Dialog Token Number | Reserved |
| Bits: | 3 | 1 | 9 | 6 | 6 |
| Figure 9-X4— EHT MIMO Control field format |

Note that Partial BW Info subfield (naming is TBD) can be 7-9 bits, size of the Codebook Information subfield may be increased, reserved bits (number and location) may change, and Sounding Dialogue Token and Feedback Segment related bits are TBD. *(SP #305)*

The subfields of the EHT MIMO Control field are defined in Table 9-X1 (EHT MIMO Control field encoding).

|  |
| --- |
| Table 9-X1—EHT MIMO Control field encoding  |
| **Subfield** | **Description** |
| Nc Index | If the Feedback Type subfield indicates SU or MU, the Nc Index subfield indicates the number of columns, *Nc*, in the compressed beamforming feedback matrix and is set to *Nc* – 1.If the Feedback Type subfield indicates CQI, the Nc Index subfield indicates the number of space time streams, *Nc*, in the CQI Report and is set to *Nc* – 1. |
| Nr Index | If the Feedback Type subfield indicates SU or MU, then the Nr Index subfield indicates the number of rows, *Nr*, in the compressed beamforming feedback matrix and is set to *Nr* – 1.The value 0 is reserved.If the Feedback Type subfield indicates CQI, then the Nr Index subfield is reserved. |
| BW | Indicates the channel width used to determine the starting and ending subcarrier indices when interpreting the Partial BW Info subfields.Set to 0 for 20 MHzSet to 1 for 40 MHzSet to 2 for 80 MHzSet to 3 for 160 MHzSet to 4 for 320 MHz  |
| Grouping | If the Feedback Type subfield indicates SU or MU, then the Grouping subfield indicates the subcarrier grouping, *Ng*, used for the compressed beamforming feedback matrix:Set to 0 for *Ng* = 4Set to 1 for *Ng* = 16If the Feedback Type subfield indicates CQI, then the Grouping subfield is reserved. |
| Codebook Information | Indicates the size of codebook entries.If the Feedback Type subfield indicates SU:Set to 0 for 4 bits for ϕ and 2 bits for ψSet to 1 for 6 bits for ϕ and 4 bits for ψIf the Feedback Type subfield indicates MU:Set to 0 for 7 bits for ϕ and 5 bits for ψSet to 1 for 9 bits for ϕ and 7 bits for ψIf the Feedback Type subfield indicates CQI, then the Codebook Information subfield is reserved.NOTE—The codebook size for MU Feedback with *Ng*= 16 is limited to (ϕ, ψ) = {9, 7} |
| Feedback Type | Indicates the feedback type:Set to 0 for SUSet to 1 for MUSet to 2 for CQI3 is reserved |
| Remaining Feedback Segments | Indicates the number of remaining feedback segments for the associated EHT Compressed Beamforming/CQI frame:Set to 0 for the last feedback segment of a segmented report or the only feedback segment of an unsegmented report.Set to a value between 1 and 7 for a feedback segment that is not the last feedback segment of a segmented report.In a retransmitted feedback segment, the subfield is set to the same value associated with the feedback segment in the original transmission. |
| First Feedback Segment | Set to 1 for the first feedback segment of a segmented report or the only feedback segment of an unsegmented report.Set to 0 if not the first feedback segment or if the EHT Compressed Beamforming Report field and EHT MU Exclusive Beamforming Report field are not present in the frame.In a retransmitted feedback segment, the subfield is set to the same value associated with the feedback segment in the original transmission.NOTE—The First Feedback Segment subfield is always set to 0 if the Feedback Type subfield indicates CQI because the EHT Compressed Beamforming/CQI Report frame is always less than 11 454 octets in length. |
| Partial BW Info | TBD |
| Sounding Dialog Token Number | Set to the same value as the Sounding Dialog Token Number field in the corresponding EHT NDP Announcement frame. |

In an EHT Compressed Beamforming/CQI frame not carrying all or part of an EHT compressed beamforming/CQI report (see 26.7 (HE sounding protocol) for a description of such a case), the Nc Index, Nr Index, BW, Grouping, Codebook Information, Feedback Type and Sounding Dialog Token Number subfields are reserved, the First Feedback Segment subfield is set to 0 and the Remaining Feedback Segments subfield is set to 7.(#24496)

9.4.1.x2 EHT Compressed Beamforming Report field

The EHT Compressed Beamforming Report field carries the average SNR of each space-time stream and compressed beamforming feedback matrices *V* for use by a transmit beamformer to determine steering matrices *Q*, as described in 10.32.3 (Explicit feedback beamforming) and 19.3.12.3 (Explicit feedback beamforming).

The size of the EHT Compressed Beamforming Report field depends on the values in the EHT MIMO Control field. The EHT Compressed Beamforming Report field contains EHT Compressed Beamforming Report information or successive (possibly zero-length) portions thereof in the case of segmented EHT compressed beamforming/CQI report (see 26.7.4 (Rules for generating segmented feedback)). EHT Compressed Beamforming Report information is included in the EHT compressed beamforming/CQI report if the Feedback Type subfield in the EHT MIMO Control field indicates SU or MU.

The EHT Compressed Beamforming Report information contains the channel matrix elements indexed, first, by matrix angles in order shown in Table 9-73 (Order of angles in the Compressed Beamforming Feedback Matrix subfield when used in a non-S1G band), and second, by data and pilot subcarrier index from lowest frequency to highest frequency. An explanation of how these angles are generated from the beamforming feedback matrix *V* is given in 19.3.12.3.6 (Compressed beamforming feedback matrix), where *Nc* is the number of columns in a compressed beamforming feedback matrix determined by the Nc Index subfield of the EHT MIMO Control field, and *Nr* is the number of rows in a compressed beamforming feedback matrix determined by the Nr Index subfield of the EHT MIMO Control field.

The beamforming feedback matrix *V* is formed by the beamformee as follows. The beamformer transmits an EHT sounding NDP with *NSTS,NDP* space-time streams, where *NSTS,NDP* takes a value between 2 and 16. Based on this EHT sounding NDP, the beamformee estimates the *NRX,BFEE* × *NSTS,NDP* channel, and based on that channel it determines a *Nr*× *Nc* orthogonal matrix *V*, where *Nr* and *Nc* satisfy Equation (9-1). *NRX,BFEE* is the number of receiver chains used to receive the EHT sounding NDP at the beamformee.

Further restrictions on *Nc* are described in 36.2 (EHT PHY service interface). The angles are quantized as defined in Table 9-76 (Quantization of angles) with *b*ψ defined by the Codebook Information field of the EHT MIMO Control field (see 9.4.1.X1 (EHT MIMO Control field)).

The EHT Compressed Beamforming Report information has the structure and order defined in Table 9-93b (HE Compressed Beamforming Report information), where *Na* is the number of angles used for the compressed beamforming feedback matrix (see Table 9-73 (Order of angles in the compressed beamforming feedback matrix when used in a non-S1G band)).

In Table 9-93b (HE Compressed Beamforming Report information), *Ns* is the number of subcarriers for which a compressed beamforming feedback matrix is sent back to the beamformer. A beamformer or beamformee, depending upon which of the two determines the feedback parameters, reduces *Ns* by using a method referred to as grouping, in which only a single compressed beamforming feedback matrix is reported for each group of *Ng* adjacent subcarriers. *Ns* is a function of the BW, Partial BW Info and Grouping subfields in the EHT MIMO Control field (see 9.4.1.X1 9.4.1.64 (HE MIMO Control field)).

Subcarrier indices *scidx(0)* to *scidx(Ns*– 1*)* are identified by the Partial BW Info subfields respectively, together with the BW and Grouping subfields, as defined in Table 9-X3 (Subcarrier indices when feedback request does not cover the entire 80 MHz segment), Table 9-X4 (Subcarrier indices when feedback covers the entire 80 MHz segment for Ng = 4) and Table 9-X5 (Subcarrier indices when feedback covers the entire 80 MHz segment for Ng = 16). *(#SP301)*

|  |
| --- |
| Table 9-X3—Subcarrier indices when feedback request does not cover the entire 80 MHz segment   |

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **242-tone RU Index** | **20 MHz** | **40 MHz** | **80 MHz** | **160 MHz** | **320 MHz** |
| **1** | *Ng*=4  | [-122, -120:4:-4, -2, 2, 4:4:120, 122] | [-244:*Ng*:-4] | [-500:*Ng*:-260] | [-1012:*Ng*:-772] | [-2036:*Ng*:-1796] |
| *Ng*=16 | [-122, -116:16:-4, -2, 2, 4:16:116, 122] |
| **2** |  | [4:*Ng*:244] | [-252:*Ng*:-12] | [-764:*Ng*:-524] | [-1788:*Ng*:-1548] |
| **3** |  |  | [12:*Ng*:252] | [-500:*Ng*:-260] | [-1524:*Ng*:-1284] |
| **4** |  |  | [260:*Ng*:500] | [-252:*Ng*:-12] | [-1276:*Ng*:-1036] |
| **5** |  |  |  | [12:*Ng*:252] | [-1012:*Ng*:-772] |
| **6** |  |  |  | [260:*Ng*:500] | [-764:*Ng*:-524] |
| **7** |  |  |  | [524:*Ng*:764] | [-500:*Ng*:-260] |
| **8** |  |  |  | [772:*Ng*:1012] | [-252:*Ng*:-12] |
| **9** |  |  |  |  | [12:*Ng*:252] |
| **10** |  |  |  |  | [260:*Ng*:500] |
| **11** |  |  |  |  | [524:*Ng*:764] |
| **12** |  |  |  |  | [772:*Ng*:1012] |
| **13** |  |  |  |  | [1036:*Ng*:1276] |
| **14** |  |  |  |  | [1284:*Ng*:1524] |
| **15** |  |  |  |  | [1548:*Ng*:1788] |
| **16** |  |  |  |  | [1796:*Ng*:2036] |
| Note- “:*Ng*:” denotes an arithmetic progression in *Ng* increments. |

|  |
| --- |
| Table 9-X4—Subcarrier indices when feedback request covers the entire 80 MHz segment for *Ng* = 4 |

|  |  |  |  |
| --- | --- | --- | --- |
| **996-tone RU Index** | **80 MHz** | **160 MHz** | **320 MHz** |
| **1** | [-500:4:-4, 4:4:500] | [-1012:4:-516,-508:4:-12] | [-2036:4:-1540, -1532:4:-1036] |
| **2** |  | [12:4:508, 516:4:1012] | [-1012:4:-516, -508:4:-12] |
| **3** |  |  | [12:4:508, 516:4:1012] |
| **4** |  |  | [1036:4:1532, 1540:4:2036] |
| Note- “:*Ng*:” denotes an arithmetic progression in *Ng* increments. |

|  |
| --- |
| Table 9-X5—Subcarrier indices when feedback request covers the entire 80 MHz segment for *Ng* = 16 |

|  |  |  |  |
| --- | --- | --- | --- |
| **996-tone RU Index** | **80 MHz** | **160 MHz** | **320 MHz** |
| **1** | [-500:16:-260, -252:16:-12,-4, 4, 12:16:252, 260:16:500] | [-1012:16:-772,-764:16:-524,-516, -508,-500:16:-260,-252:16:-12] | [-2036:16:-1796,-1788:16:-1548, -1540, -1532,-1524:16:-1284,-1276:16:-1036] |
| **2** |  | [12:16:252, 260:16:500,508, 516, 524:16:764, 772:16:1012] | [-1012:16:-772,-764:16:-524,-516, -508,-500:16:-260,-252:16:-12] |
| **3** |  |  | [12:16:252, 260:16:500, 508, 516,524:16:764, 772:16:1012] |
| **4** |  |  | [1036:16:1276, 1284:16:1524,1532, 1540,1548:16:1788, 1796:16:2036] |
| Note- “:*Ng*:” denotes an arithmetic progression in *Ng* increments. |

In case of 20 MHz or 40 MHz, subcarrier indices *scidx*(*i*), *i* = 0, …, *Ns* – 1 are the subset of the subcarrier indices identified by the BW and Grouping subfields, as defined in Table 9-X3 (Subcarrier indices when feedback request does not cover the entire 80 MHz segment), starting with *scidx*(0) and ending with *scidx*(*Ns*– 1), in the order given. In case of 80 MHz, 160 MHz or 320 MHz, subcarrier indices *scidx*(*i*), *i* = 0, …, *Ns* – 1 are the subset of the subcarrier indices identified by the BW and Grouping subfields, as defined in Table 9-X4 (Subcarrier indices when feedback covers the entire 80 MHz segment for Ng = 4) and Table 9-X5 (Subcarrier indices when feedback covers the entire 80 MHz segment for Ng = 16), starting with *scidx*(0) and ending with *scidx*(*Ns*– 1), in the order given.

NOTE 1—This implicitly defines *Ns*.

The Average SNR of Space-Time Stream *i* subfield in Table 9-93b (HE Compressed Beamforming Report information) is an 8-bit 2s complement integer defined in Table 9-79 (Average SNR of Space-Time Stream i subfield).

The *AvgSNRi* in Table 9-79 (Average SNR of Space-Time Stream i subfield) is found by computing the SNR per subcarrier in decibels for the subcarriers identified in Table 9-X3 (Subcarrier indices when feedback request does not cover the entire 80 MHz segment), Table 9-X4 (Subcarrier indices when feedback covers the entire 80 MHz segment for Ng = 4) and Table 9-X5 (Subcarrier indices when feedback covers the entire 80 MHz segment for Ng = 16), and then computing the arithmetic mean of those values. Each SNR value per subcarrier in stream *i* (before being averaged) corresponds to the SNR associated with column *i* of the beamforming feedback matrix *V* determined at the beamformee. Each SNR corresponds to the predicted SNR at the beamformee when the beamformer applies all columns of the matrix *V*.

Padding is not present between angles in the EHT Compressed Beamforming Report information, even if they correspond to different subcarriers. If the size of the EHT Compressed Beamforming Report information is not an integer multiple of 8 bits, up to seven 0s are appended to the end of the field to make its size an integer multiple of 8 bits.

9.4.1.X3 EHT MU Exclusive Beamforming Report field

The EHT MU Exclusive Beamforming Report field carries explicit feedback in the form of delta SNRs. The information in the EHT Compressed Beamforming Report field and the EHT MU Exclusive Beamforming Report field can be used by the transmit MU beamformer to determine the steering matrices *Q*, as described in 36.3.3.1 (DL MU-MIMO).

The size of the EHT MU Exclusive Beamforming Report field depends on the values in the EHT MIMO Control field. The EHT MU Exclusive Beamforming Report field contains EHT MU Exclusive Beamforming Report information or successive (possibly zero-length) portions thereof in the case of segmented EHT compressed beamforming/CQI report (see 26.7.4 (Rules for generating segmented feedback)). EHT MU Exclusive Beamforming Report information is included in the EHT compressed beamforming/CQI report (in addition to EHT Compressed Beamforming Report information) if the Feedback Type subfield in the EHT MIMO Control field indicates MU.

The EHT MU Exclusive Beamforming Report information consists of Delta SNR subfields for each of the space-time streams, 1 to *Nc*, of a subset of subcarriers typically spaced *Ng* apart, where *Ng* is signaled in the Grouping subfield of the EHT MIMO Control field. The subset of subcarriers starts from the lowest frequency subcarrier and continues to the highest frequency subcarrier. The subcarrier indices of the feedback for each Delta SNR subfield are identical to the subcarrier indices for the compressed beamforming feedback matrix *V*.

NOTE—The feedback subcarrier spacings are mostly equal to *Ng*, but there are a few exceptions, generally around the RU edge and the DC tone, where extra feedback subcarriers are added to improve the channel interpolation/extrapolation quality.(#24221)

No padding is present between *∆SNRk,i*, in the EHT MU Exclusive Beamforming Report field, even if they correspond to different subcarriers. The subset of subcarriers included is determined by the values of the Partial BW Info, and Grouping subfields of the EHT MIMO Control field. For each subcarrier included, the deviation in dB of the SNR of that subcarrier for each column of *V* relative to the average SNR of the corresponding space-time stream is computed using Equation (9-2) except that *k* is the subcarrier index in the range *scidx*(0), …, *scidx*(*Ns* – 1) and *SNRi* is the average SNR of space-time stream *i* reported in the Average SNR of Space-Time Stream *i* field of the EHT Compressed Beamforming Report Information field.

The EHT MU Exclusive Beamforming Report information has the structure and order defined in Table 9-91f (HE MU Exclusive Beamforming Report information).

In Table 9-93f (HE MU Exclusive Beamforming Report information), *Ns* and *scidx()* are defined in 9.4.1.X2 (EHT Compressed Beamforming Report field).

9.4.1.X4 EHT CQI Report field

The EHT CQI Report field carries the per-RU average SNRs of each space-time stream, where each per-RU average SNR is the arithmetic mean of the SNR in decibels over a 26-tone RU for which the feedback is being requested. The EHT CQI Report field contains information about the quality of the link.

The size of the EHT CQI Report field depends on the values in the EHT MIMO Control field. The EHT CQI Report field contains EHT CQI Report information. EHT CQI Report information is included in the EHT compressed beamforming/CQI report if the Feedback Type subfield in the EHT MIMO Control field indicates CQI feedback.

The EHT CQI Report field has the structure and order defined in Table 9-93g (HE CQI Report information).

*Ncqi* is the number of RU indices for which the CQI report is sent back to the beamformer. *Ncqi* is based on number of 26-tone RU indicated in the Partial BW Info subfield of the EHT MIMO Control field. The 26-tone RU subcarrier indices for 20 MHz, 40 MHz, 80 MHz, 160 MHz and 320 MHz are defined in Table 27-7 (Data and pilot subcarrier indices for RUs in a 20 MHz HE PPDU and in a non-OFDMA 20 MHz HE PPDU), Table 27-8 (Data and pilot subcarrier indices for RUs in a 40 MHz HE PPDU and in a non-OFDMA 40 MHz HE PPDU), Table 36-5 (Data and pilot subcarrier indices for RUs in an 80 MHz EHT PPDU), Table 36-6 (Data and pilot subcarrier indices for RUs in an 160 MHz EHT PPDU) and Table 36-7 (Data and pilot subcarrier indices for RUs in an 320 MHz EHT PPDU), respectively.

The Average SNR of space-time stream *i* for the RU index *k* subfield in the Table 9-93g (HE CQI Report information) is a 6-bit 2s complement integer whose definition is shown in Table 9-93h (Average SNR of RU index k for space-time stream i subfield).

The *AvgSNRk,i* in Table 9-93h (Average SNR of RU index k for space-time stream i subfield) is found by computing the arithmetic mean of the SNR per subcarrier in decibels for space-time stream *i* over the subcarriers in RU index *k* for which the feedback is being requested. The SNR per subcarrier calculation is defined in 9.4.1.X2 (EHT Compressed Beamforming Report field).

Padding is not present between per-RU average SNRs of each space-time stream information, even if they correspond to different RUs and space-time streams. If the size of the EHT CQI Report information is not an integer multiple of 8 bits, up to seven 0s are appended to the end of the field to make its size an integer multiple of 8 bits.

* Action frame format

Change Table 9-45 (Action frame body and Action No Ack frame body) as follows:

|  |
| --- |
| * Action frame body and Action No Ack frame body
 |
| **Order** | Information |
| Last – 2 | One or more vendor-specific elements are optionally present.These elements are absent when the Category subfield of the Action field is Vendor-Specific, Vendor-Specific Protected, or Self-protected or when the Category subfield of the Action field is VHT and the VHT Action subfield of the Action field is VHT Compressed Beamforming, or when the Category subfield of the Action field is HE and the HE Action subfield of the Action field is HE Compressed Beamforming/CQI, or when the Category subfield of the Action field is EHT and the EHT Action subfield of the Action field is EHT Compressed Beamforming/CQI. |

* Action field

Insert the following rows into Table 9-53 (Category values) in numerical order and update the Reserved row:

|  |
| --- |
| * Category values
 |
| Code | Meaning | See subclause | Robust | Group addressed privacy  |
| TBD | EHT | 9.6.XX (EHT Action frame details) | No | No |

Insert subclauses 9.6.X5 to at the end of 9.6:

9.6.X5 EHT Action frame details

9.6.X5.1 EHT Action field

An EHT Action field, in the octet immediately after the Category field, differentiates the EHT Action frame formats. The EHT Action field values associated with each frame format within the EHT category are defined in Table 9-X6 (EHT Action field values).

|  |
| --- |
| Table 9-X6—EHT Action field values  |
| Value | Meaning |
| 0 | EHT Compressed Beamforming/CQI |
| 1-255 | Reserved |

9.6.X5.2 EHT Compressed Beamforming/CQI frame format

The EHT Compressed Beamforming/CQI frame is an Action No Ack frame of category EHT. The Action field of an EHT Compressed Beamforming/CQI frame contains the information shown in Table 9-X7 (EHT Compressed Beamforming/CQI frame Action field format).

|  |
| --- |
| Table 9-X7—EHT Compressed Beamforming/CQI frame Action field format  |
| Order | Information |
| 1 | Category |
| 2 | EHT Action |
| 3 | EHT MIMO Control (see 9.4.1.X1 (EHT MIMO Control field)) |
| 4 | EHT Compressed Beamforming Report (see 9.4.1.X2 (EHT Compressed Beamforming Report field)) |
| 5 | EHT MU Exclusive Beamforming Report (see 9.4.1.X3 (EHT MU Exclusive Beamforming Report field)) |
| 6 | EHT CQI Report (see 9.4.1.X4 (EHT CQI Report field)) |

The Category field is defined in Table 9-53 (Category values).

The EHT Action field is defined in Table 9-X6 (EHT Action field values).

(#24302)The presence and contents of the EHT Compressed Beamforming Report field, EHT MU Exclusive Beamforming Report field and EHT CQI Report field are dependent on the values of the Feedback Type subfield of the EHT MIMO Control field (see 9.4.1.X2 (EHT Compressed Beamforming Report field), 9.4.1.X3 (EHT MU Exclusive Beamforming Report field) and 9.4.1.X4 (EHT CQI Report field)).

A Vendor Specific element is not present in the EHT Compressed Beamforming/CQI frame.

* Channel Width selection for Control frames

Change the 2nd paragraph as follows:

If a VHT ~~or~~, HE or EHT STA transmits to another VHT ~~or~~, HE or EHT STA a Control frame that is not an RTS frame or a CF-End frame, if that Control frame is an HE NDP Announcement frame or an EHT NDP Announcement frame or elicits a control response frame, a VHT Compressed Beamforming frame, ~~or~~ an HE Compressed Beamforming/CQI frame, or an EHT Compressed Beamforming/CQI frame, and

* If the Control frame is transmitted in a non-HT duplicate PPDU (channel width 40 MHz or wider), the transmitting ~~VHT or, HE~~ STA shall set the TA field to a bandwidth signaling TA.
* If the Control frame is transmitted in a non-HT PPDU (channel width 20 MHz), the transmitting ~~VHT or, HE~~ STA may set the TA field to a bandwidth signaling TA.
* Multiple frame transmission in an EDCA TXOP

Change the 1st paragraph as follows:

A frame exchange, in the context of multiple frame transmission in an EDCA TXOP, may be one of the following:

* A frame not requiring immediate acknowledgment (such as a group addressed frame or a frame transmitted with an ack policy that does not require immediate acknowledgment) or an A-MPDU containing only such frames
* A frame requiring immediate acknowledgment (such as an individually addressed frame transmitted with an ack policy that requires immediate acknowledgment) or an A-MPDU containing at least one such frame, followed after SIFS by a corresponding acknowledgment frame
* A triggering frame or an A-MPDU containing at least one such frame, followed after SIFS by an HE TB PPDU where the HE TB PPDU is optionally followed after SIFS by an acknowledgment
* Either
* a VHT NDP Announcement frame followed after SIFS by a VHT NDP followed after SIFS by a PPDU containing one or more VHT Compressed Beamforming frames, or
* a Beamforming Report Poll frame followed after SIFS by a PPDU containing one or more VHT Compressed Beamforming frames
* an HE NDP Announcement frame followed after SIFS by an HE sounding NDP followed after SIFS by a PPDU containing one or more HE Compressed Beamforming/CQI frames, or
* a broadcast HE NDP Announcement frame followed after SIFS by an HE sounding NDP followed after SIFS by a BFRP Trigger frame followed by HE TB PPDUs, or
* a BFRP Trigger frame followed after SIFS by an HE TB PPDU containing one or more HE Compressed Beamforming/CQI frames
* an EHT NDP Announcement frame followed after SIFS by an EHT sounding NDP followed after SIFS by a PPDU containing one or more EHT Compressed Beamforming/CQI frames, or
* a broadcast EHT NDP Announcement frame followed after SIFS by an EHT sounding NDP followed after SIFS by a BFRP Trigger frame followed by EHT TB PPDUs, or
* a BFRP Trigger frame followed after SIFS by an EHT TB PPDU containing one or more EHT Compressed Beamforming/CQI frames
* TXOP limits

Change as follows:

The duration of a TXOP is the time a STA obtaining a TXOP (the TXOP holder) maintains uninterrupted control of the medium, and it includes the time required to transmit frames sent as an immediate response to TXOP holder transmissions. The TXOP holder shall, subject to the exceptions below, ensure that the duration of a TXOP does not exceed the TXOP limit, when nonzero.

The TXOP limits are advertised by the AP in the EDCA Parameter Set element in Beacon and Probe Response frames transmitted by the AP.

A TXOP limit of 0 indicates that the TXOP holder may transmit or cause to be transmitted (as responses) the following within the current TXOP:

* One of the following at any rate, subject to the rules in 10.6 (Multirate support)
* One or more SU PPDUs carrying fragments of a single MSDU or MMPDU
* An SU PPDU or a VHT MU PPDU or an HE MU PPDU or an HE TB PPDU carrying a single MSDU, a single MMPDU, a single A‑MSDU, or a single A-MPDU
* A VHT MU PPDU or an HE MU PPDU carrying A-MPDUs to different users (a single A-MPDU to each user)
* A QoS Null frame or PS-Poll frame that is not an PS-Poll+BDT frame
* A Basic Trigger frame, BSRP Trigger frame or BQRP Trigger frame
* An HE TB PPDU carrying A-MPDUs from different users (a single A-MPDU from each user)
* Any required acknowledgments
* Any frames required for protection, including one of the following:
* An RTS/CTS or MU-RTS Trigger/CTS frame exchange
* CTS to it
* Dual CTS as specified in 10.3.2.10 (Dual CTS protection)
* Any frames required for beamforming as specified in 10.32 (Sounding PPDUs), 10.37.5 (VHT sounding protocol), 26.7 (HE sounding protocol), 36.y (EHT sounding protocol) and 10.43 (DMG beamforming).
* Any frames required for link adaptation as specified in 10.33 (Link adaptation) and 27.13 (Link adaptation using the HE variant HT Control field).
* Any number of BlockAckReq, MU-BAR Trigger or Multi-TID BlockAckReq or GCR MU-BAR Trigger frames

NOTE 1—This is a rule for the TXOP holder. A TXOP responder need not be aware of the TXOP limit nor of when the TXOP was started.

NOTE 2—This rule prevents the use of RD, BDT, and TXOP sharing when the TXOP limit is 0.

When dot11OCBActivated is true, TXOP limits shall be 0 for each AC.

The TXOP holder may exceed the TXOP limit only if it does not transmit more than one Data or Management frame in the TXOP, only if it does not transmit a DL-MU-MIMO PPDU in the TXOP, and only for the following situations:

* Retransmission of an MPDU, not in an A-MPDU consisting of more than one MPDU, where the size of the retransmitted MPDU is the same as the initially transmitted MPDU
* Transmission of an MSDU or MMPDU less than 600 octets by an S1G non-sensor STA
* Transmission of a fragment of an MSDU or MMPDU, the fragment being less than 256 octets, by an S1G non-sensor STA
* Initial transmission of an MSDU under a block ack agreement, where the MSDU is not in an A-MPDU consisting of more than one MPDU and the MSDU is not in an A-MSDU
* Transmission of a Control frame or a QoS Null frame, not in an A-MPDU consisting of more than one MPDU
* Initial transmission of a non-dynamic fragment of an MSDU or MMPDU (see 10.4 (MSDU, A-MSDU, and MMPDU fragmentation)), if a previous fragment of that MSDU or MMPDU was retransmitted
* Transmission of a non-dynamic fragment of an MSDU or MMPDU fragmented into 16 fragments
* Transmission of the 16th dynamic fragment of an MSDU or MMPDU
* Initial transmission of the first dynamic fragment of an MSDU or MMPDU, where the size of the first fragment is equal to the minimum fragment size specified by the receiver STA and the MSDU or MMPDU is not in an A-MPDU consisting of more than one MPDU
* Transmission of an A-MPDU consisting of the initial transmission of a single MPDU not containing an MSDU and that is not an individually addressed Management frame
* Transmission of a group addressed MPDU, not in an A-MPDU consisting of more than one MPDU
* Transmission of a null data PPDU (NDP)
* Transmission of a VHT NDP Announcement frame and NDP or transmission of a Beamforming Report Poll frame, where these fit within the TXOP limit and it is only the response and the immediately preceding SIFS that cause the TXOP limit to be exceeded.
* Transmission of one of the following sequences, provided that the sequence fits within the TXOP limit and it is only the response and the immediately preceding SIFS that causes the TXOP limit to be exceeded:
* An HE NDP Announcement frame and HE sounding NDP
* An HE NDP Announcement frame and HE sounding NDP and BFRP Trigger frame
* A BFRP Trigger frame
* An EHT NDP Announcement frame and EHT sounding NDP
* An EHT NDP Announcement frame and EHT sounding NDP and BFRP Trigger frame

Except as described above, a STA shall fragment an individually addressed MSDU or MMPDU so that the initial transmission of the first fragment does not cause the TXOP limit to be exceeded.

NOTE—The TXOP limit is not exceeded for the following situations:

* Initial transmission of an MPDU containing an unfragmented though fragmentable (see 10.2.7 and 26.3 (Fragmentation and defragmentation)) MSDU/MMPDU
* Initial transmission of the first fragment of a fragmented MSDU/MMPDU, except if the MSDU/MMPDU is fragmented into 16 fragments
* Initial transmission of an A-MSDU
* Initial transmission of a non-dynamic fragment of a fragmented MSDU/MMPDU, if no previous fragment of that MSDU/ MMPDU was retransmitted, except if the MSDU/MMPDU is fragmented into 16 fragments
* Initial transmission of a dynamic fragment of a fragmented MSDU/MMPDU, except for either the first dynamic fragment of a fragmented MSDU/MMPDU using the minimum fragment size specified by the receiver STA, or the 16th dynamic fragment of a fragmented MSDU/MMPDU
* Transmission of an A-MPDU consisting of a single MPDU containing an A MSDU or individually addressed Management frame, unless this is a retransmission of that MPDU
* Transmission of an A-MPDU consisting of more than one MPDU, even if some or all of the MPDUs are retransmissions
* Transmission of a Trigger frame, other than a BFRP Trigger frame, where either the Trigger frame or its response does not fit within the TXOP limit

If the TXOP holder exceeds the TXOP limit, it should use as high a PHY rate as possible to minimize the duration of the TXOP.

The duration of a TXOP for a mesh STA that has dot11MCCAActivated true shall not exceed the time between the start of the TXOP and the end of the current MCCAOP reservation.

NOTE—The rules in this subclause also apply to priority-downgraded MSDUs and A-MSDUs (see 10.23.4.2 (Contention based admission control procedures)).

If the Duration field in a frame carried in an HE TB PPDU is set to 0, the HE TB PPDU shall not include any frames that solicit a control response frame from the AP.

Proposed Changes #2:

***TGbe Editor: Modify ‘VHT/HE NDP Announcement frame’ or ‘HE/VHT NDP Announcement frame’ to ‘VHT/HE/EHT NDP Announcement frame’***

---- End of text proposal ----