IEEE P802.11
Wireless LANs

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| Comment Resolution on SU/MU-MIMO BF Training and Feedback |
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Abstract

This submission proposes resolution of comment received from TGay comment collection (TGay Draft 0.3).

- 14 CID: 48, 49, 84, 85, 86, 87, 350, 352, 394, 436, 437, 438, 486, 503

In more details, this submission proposes the formats of MIMO BF Poll frame and MIMO BF Feedback frame as well as the modications on the texts related to SU/MU-MIMO BF training and feedback.

1. **Introduction**

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 TGay Draft. The introduction and the explanation of the proposed changes are not part of the adopted material.

***Editing instructions formatted like this are intended to be copied into the TGay Draft (i.e. they are instructions to the 802.11 editor on how to merge the text with the baseline documents).***

***TGay Editor: Editing instructions preceded by “TGay Editor” are instructions to the TGay editor to modify existing material in the TGay draft. As a result of adopting the changes, the TGay editor will execute the instructions rather than copy them to the TGay Draft.***

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| CID | Page Number | Line Number | Comment | Proposed Change | Resolution |
| 84 | 73 | 16 | Frame format for "BF Feedback" is not defined | Please add this defnition | Revised-TGay editor to make the changes shown in 11-17/xxxxr0 under all headings that include CID 84. |
| 85 | 70 | 46 | Frame format for "MIMO Feedback" is not defined | Please add this defnition | Revised-TGay editor to make the changes shown in 11-17/xxxxr0 under all headings that include CID 85. |
| 86 | 73 | 15 | Frame format for "MU-MIMO Feedback" is not defined | Please add this defnition | Revised-TGay editor to make the changes shown in 11-17/xxxxr0 under all headings that include CID 86. |
| 503 | 67 | 31 | Please resolve editor's note | Please provide frame structure for SU-MIMO training | Revised-TGay editor to make the changes shown in 11-17/xxxxr0 under all headings that include CID 503. |
| 486 | 67 | 4 | During the MU-MIMO BF training subphase in the MU-MIMO beamforming, it is not clear which EDMG PPDU should be used for training. | Clarify if the EDMG PPDU used for training is MU PPDU or SU PPDU. | Revised-EDMG BRP-RX/TX packet will be used in the MU-MIMO BF training subphase.TGay editor to make the changes shown in 11-17/xxxxr0 under all headings that include CID 486. |
| 436 | 69 | 30 | (e.g., SINR or time domain channel response). What happens in the OFDM case? Should we have frequency domain channel response? | add "frequency domain channel response) | Rejected-The structure of EDMG BRP-RX/TX packet used in MIMO BF training is not useful for OFDM because it lacks the OFDM CEF. In addition, OFDM digital BF could be performed based on a 11ac-like sounding procedure after the analog MIMO BF is completed.  |
| 394 | 69 | 31 | If the STA perfroming the measurement is not the decision maker of the link, the channel information needs to be fed back to the decision maker. However, the current EDMG channel mesurement feedback element does not convey the information of rx sector, and the decision maker does not know which set of channels can be received simultaneously | add rx sector id in EDMG channel measurement feedback element or in the MIMO feedback frame | Rejected-For SU-MIMO BF, the receiver recommends multiple best TX sector combinations and the transmitter decides which TX sector combination will be used in the subsequent SU-MIMO transmission. As a result, there is no need of feedbacking RX sector IDs. |
| 437 | 69 | 33 | The decision maker indicates whether the initiator or the responder is responsible for determining transmit and receive antenna settings for SU-MIMOoperation. what is the relationship between the decision maker, the initiator, responder, transmitter and receiver ?What happens if the decision maker is the receiver ? How does it get the information of the desired antenna set to the transmitter ? | define relationship between decision maker and transmitter/receiver as well | Revised-For SU-MIMO BF, the receiver recommends multiple best TX sector combinations and the transmitter decides which TX sector combination will be used in the subsequent SU-MIMO transmission. TGay editor to make the changes shown in 11-17/xxxxr0 under all headings that include CID 437. |
| 48 | 70 | 14 | "are masked with orthogonal sequences" They are not maksed, and not all the sequences are othogonal. If necessary point to appropriate PHY behaviour | Replace "are masked with orthogonal sequences" with "are transmitted with the sequences defined in 30.9.2.2.6" | Revised-TGay editor to make the changes shown in 11-17/xxxxr0 under all headings that include CID 48. |
| 49 | 70 | 47 | "best transmit and receive sector" - there may be no receive sectors. The respodner receive sectors or AWVs are non of the business of the initiator, only the transmit sectors. | Remove "and receive" in this and above paragraph | Revised-TGay editor to make the changes shown in 11-17/xxxxr0 under all headings that include CID 49. |
| 87 | 73 | 18 | What does "antennas/sectors" mean? Is it antenna, sector, or both? Be precise | Please clarify | Revised-TGay editor to make the changes shown in 11-17/xxxxr0 under all headings that include CID 87. |
| 438 | 73 | 18 | "the BF Feedback framecarries the list of received initiator's transmit DMG antennas/sectors, each with its correspondingresponder's receive DMG antenna/sector and the associated quality indicated." The term "associated channel quality" needs to be defined. | Define metric. Is this a MIMO metric, SNR? | Revised-TGay editor to make the changes shown in 11-17/xxxxr0 under all headings that include CID 438. |
| 350 | 69 | 10 | To avoid confusion with the MIMO phase of MU-MIMO beamforming, it is better to change the title of Figure 50 to "The MIMO phase of SU-MIMO beamforming training" | as per comment | Revised-TGay editor to make the changes shown in 11-17/xxxxr0 under all headings that include CID 350. |
| 352 | 73 | 28 | To avoid confusion with the MIMO phase of SU-MIMO beamforming, it is better to change the title of Figure 52 to "The MIMO phase of MU-MIMO beamforming training" | as per comment | Revised-TGay editor to make the changes shown in 11-17/xxxxr0 under all headings that include CID 352. |

**Discussion:**

Propose:

Revised for 12 CIDs 48, 49, 84, 85, 86, 87, 350, 352, 437, 438, 486, 503 as per discussion and editing instructions in 11-17/0xxxr0.

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**9.6.22.1 Unprotected DMG Action field**

***#1: Change Table 9-415(Unprotected DMG Action field values) as follows (CID #84, #85, #86, #503):***

|  |
| --- |
| Table 9-415—Unprotected DMG Action field values(11ad) |
| Unprotected DMG Action field value | Meaning |
| 0 | Announce |
| 1 | BRP |
| X | MIMO BF Poll |
| xx  | MIMO BF Feedback |

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***#2: insert the following clauses (CID #84, #86):***

9.6.22.xx MIMO BF Poll frame format

The MIMO BF Poll frame is an Action No Ack frame. The format of a MIMO BF Poll frame Action field is shown in Table 9-xx (MIMO BF Poll frame Action field format).

|  |
| --- |
| Table 9-xx−MIMO BF Poll frame Action field format(11ad) |
| Order | Information |
| 1 | Category |
| 2 | Unprotected DMG Action |
| 3 | Dialog Token |
| 4 | MIMO Poll Control element |

The Category field is defined in 9.4.1.11 (Action field).(#3403)

The Unprotected DMG Action field is defined in 9.6.22.1 (Unprotected DMG Action field).(#3403)

The Dialog Token field is set to a value chosen by the STA sending the frame to uniquely identify the transaction.

The MIMO Poll Control element is defined in 9.4.2.x.

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***#3: insert the following clause (CID #84, #86):***

9.4.2.x MIMO Poll Control element

The MIMO Poll Control element is shown in Table 9-xxx (MIMO Poll Control element format).

|  |
| --- |
| Table 9-xxx MIMO Poll Control element format  (11ad) |
| Field | Size | Meaning |
| Element ID | 8 bits |  |
| Length | 8 bits |  |
| Element ID Extension | 8 bits |  |
| Poll Type | 1 bit | Sets to 1 to indicate training packet poll used in uplink MIMO phase of MU-MIMO beamforming and sets to 0 to indicate MIMO BF feedback poll used in downlink MIMO phase of MU-MIMO beamforming. |
| L-TX-RX | 8 bits | Indicates the requested number of consecutive TRN-Units in which the same AWV is used in the transmission of the last M TRN subfields of each TRN-Unit. This field is reserved when the Poll Type field is set to 0. |
| Requested EDMG TRN-Unit M | 4 bits | The value of this field plus one indicates the requested number of TRN subfields in a TRN-Unit transmitted with the same AWV following a possible AWV change. This field is reserved when the Poll Type field is set to 0. |
| Requested EDMG TRN-Unit P | 2 bits | Indicates the requested number of TRN subfields at the start of a TRN-Unit that use the same AWV. A value of zero indicates zero requested TRN subfields, a value of one indicates one requested TRN subfield, a value of two indicates two requested TRN subfields and a value of three indicates four requested TRN subfields. This field is reserved when the Poll Type field is set to 0. |

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

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***#4: insert the following clauses (CID #84, #85, #86, #503):***

9.6.22.xx MIMO BF Feedback frame format

The MIMO BF Feedback frame is an Action No Ack frame. The format of a MIMO BF Feedback frame Action field is shown in Table 9-xx (MIMO BF Feedback frame Action field format).

|  |
| --- |
| Table 9-xx−MIMO BF Feedback frame Action field format(11ad) |
| Order | Information |
| 1 | Category |
| 2 | Unprotected DMG Action |
| 3 | Dialog Token |
| 4 | MIMO Feedback Control element |
| 5 | One or more Channel Measurement Feedback elements |
| 6 | One or more EDMG Channel Measurement Feedback elements |

The Category field is defined in 9.4.1.11 (Action field).(#3403)

The Unprotected DMG Action field is defined in 9.6.22.1 (Unprotected DMG Action field).(#3403)

The Dialog Token field is set to a value chosen by the STA sending the frame to uniquely identify the transaction.

The MIMO Feedback Control element is defined in 9.4.2.x.

The Channel Measurement Feedback element is defined in 9.4.2.136.

The EDMG Channel Measurement Feedback element is defined in 9.4.2.253.

The Sector ID Order subfield shall not be present in the Channel Measurement Feedback element. The SNR subfield shall be present in the Channel Measurement Feedback element. The EDMG Sector ID Order and BRP CDOWN subfields shall be present in the EDMG Channel Measurement Feedback element.

The MIMO BF Feedback frame contains more than one Channel Measurement Feedback element if the measurement information exceeds 255 octets. The content of each Channel Measurement Feedback element that follows the first one in a single MIMO BF Feedback frame is a continuation of the content in the previous element. The SNR, Channel Measurement and Tap Delay subfields can be split between several elements. Each Channel Measurement Feedback element that is not the last Channel Measurement Feedback element in the frame is 257 octets long. Channel measurement information for a single channel measurement is always contained within a single MIMO BF Feedback frame.

The MIMO BF Feedback frame contains more than one EDMG Channel Measurement Feedback element if the measurement information exceeds 254 octets. The content of each EDMG Channel Measurement Feedback element that follows the first one in a single MIMO BF Feedback frame is a continuation of the content in the previous element. The EDMG Sector ID Order and BRP CDOWN subfields can be split between several elements. Each EDMG Channel Measurement Feedback element that is not the last EDMG Channel Measurement Feedback element in the frame is 257 octets long. Channel measurement information for a single channel measurement is always contained within a single MIMO BF Feedback frame.

NOTE—The length of a MIMO BF Feedback frame can limit the choice of channel measurement parameters such as the number of measurements and the number of taps.

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***#5: insert the following clause (CID #84, #85, #86, #503):***

9.4.2.x MIMO Feedback Control element

The MIMO Feedback Control element, as shown in Table 9-xxx (MIMO Feedback Control element format), is used to carry configuration information for accompanying Channel Measurement Feedback element and EDMG Channel Measurement Feedback element.

|  |
| --- |
| Table 9-xxx MIMO Feedback Control element format  (11ad) |
| Field | Size | Meaning |
| Element ID | 8 bits |  |
| Length | 8 bits |  |
| Element ID Extension | 8 bits |  |
| SU/MU | 1 bit | Sets to 1 to indicate SU-MIMO beamforming and sets to 0 to indicate MU-MIMO beamforming. |
| Link Type | 1 bit | Sets to 1 to indicate initiator link and sets to 0 otherwise. This field shall be set to 1 when the SU/MU field is set to 0. |
| MIMO FBCK-TYPE | 10 bits |  |

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

The MIMO FBCK-TYPE field is defined in Figure 9-x and is described in Table 9-xxxx.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | Channel Measurement Present | Tap Delay Present | Number of Taps Present | Number of TX Sector Combinations Present |
| Bits: | 1 | 1 | 2 | 6 |

Figure 9-x-MIMO FBCK-TYPE field format

Table 9-xxxx-MIMO FBCK-TYPE field description

|  |  |
| --- | --- |
| **Subfield** | **Meaning** |
| Channel Measurement Present | If set to 1, the Channel Measurement subfield is present as part of the MIMO BF feedback. Otherwise, set to 0.  |
| Tap Delay Present | If set to 1, the Tap Delay subfield is present as part of the MIMO BF feedback. Otherwise, set to 0.  |
| Number of Taps Present | Number of taps in each channel measurement. |
| Number of TX Sector Combinations Present | The value of this field plus one indicates the number of TX sector combinations, *N*tsc, for the MIMO BF feedback. The number of measurements, *N*meas, is *N*TX×*N*RX multiples of the number of TX sector combinations, *N*tsc. |

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**9.4.2.253 EDMG Channel Measurement Feedback element**

***#6: Change the the second paragraph as follows (CID #84, #85, #86, #503):***

The format and size of the EDMG Channel Measurement Feedback element are defined by the parameter values specified in the accompanying DMG Beam Refinement element or MIMO Feedback Control element. The EDMG Channel Measurement Feedback element is shown in Table 4.

***#7: Change Table 4 as follows (CID #84, #85, #86, #503):***

Table 4—EDMG Channel Measurement Feedback element format

|  |  |  |
| --- | --- | --- |
| Field | Size | Meaning |
| Element ID | 8 bits | Defined in 9.4.2.1 |
| Length | 8 bits | Defined in 9.4.2.1 |
| Element ID Extension | 8 bits | Defined in 9.4.2.1 |
| EDMG Sector ID Order | Sector ID1/CDOWN1/AWV Feedback ID1 | 11 bits |  |
| TX Antenna ID1 | 3 bits |  |
| RX Antenna ID1 | 3 bits |  |
| Sector ID2/CDOWN2/AWV Feedback ID2 | 11 bits |  |
| TX Antenna ID2 | 3 bits |  |
| RX Antenna ID2 | 3 bits |  |
| … | … |  |
| Sector IDNmeas/CDOWNNmeas /AWV Feedback IDNmeas | 11 bits |  |
| TX Antenna IDNmeas | 3 bits |  |
| RX Antenna IDNmeas | 3 bits |  |
| BRP CDOWN | BRP CDOWN1 | 6 bits |  |
| BRP CDOWN2 | 6 bits |  |
| … | … |  |
| BRP CDOWNNmeas | 6 bits |  |
| ~~Beam Tracking Feedback~~ | ~~TX Sector Combination 1 AWV 1~~ | ~~11 bits~~ | ~~Contains the AWV for TX DMG antenna 1~~ |
| ~~TX Sector Combination 1 AWV 2~~ | ~~11 bits~~ | ~~Contains the AWV for TX DMG antenna 2~~ |
| ~~…~~ | ~~…~~ |  |
| ~~TX Sector Combination 1 AWV N~~~~TX~~ | ~~11 bits~~ | ~~Contains the AWV for TX DMG antenna N~~~~TX~~ |
| ~~TX Sector Combination 2 AWV 1~~ | ~~11 bits~~ | ~~Contains the AWV for TX DMG antenna 1~~ |
| ~~TX Sector Combination 2 AWV 2~~ | ~~11 bits~~ | ~~Contains the AWV for TX DMG antenna 2~~ |
| ~~…~~ | ~~…~~ |  |
| ~~TX Sector Combination 2 AWV N~~~~TX~~ | ~~11 bits~~ | ~~Contains the AWV for TX DMG antenna N~~~~TX~~ |
| ~~…~~ | ~~…~~ | ~~…~~ |
| ~~TX Sector Combination N~~~~meas~~ ~~AWV 1~~ | ~~11 bits~~ | ~~Contains the AWV for TX DMG antenna 1~~ |
| ~~TX Sector Combination N~~~~meas~~ ~~AWV 2~~ | ~~11 bits~~ | ~~Contains the AWV for TX DMG antenna 2~~ |
| ~~…~~ | ~~…~~ |  |
| ~~TX Sector Combination N~~~~meas~~ ~~AWV N~~~~TX~~ | ~~11 bits~~ | ~~Contains the AWV for TX DMG antenna N~~~~TX~~ |

***#8: Change the second paragrap following Table 4 as follows (CID #84, #85, #86, #503):***

When the EDMG Channel Measurement Feedback element is included in a BRP frame, the EDMG Sector ID Order subfield indicates the TX sector IDs, TX antenna IDs and RX antenna IDs corresponding to the SNRs in the SNR subfield when the SNR Present subfield is equal to 1 and the Short SSW Packet Used subfield is equal to 0 in the DMG Beam Refinement element contained in the frame. The EDMG Sector ID Order subfield indicates the CDOWN values and RX antenna IDs corresponding to the SNRs in the SNR subfield when the SNR Present subfield is equal to 1 and the Short SSW Packet Used subfield is equal to 1 in the DMG Beam Refinement element contained in the frame. The EDMG Sector ID Order subfield indicates the TX sector IDs or CDOWN values ranked in the decreasing order of link quality, determined in an implementation dependent manner, when the SNR Present subfield is equal to 0 in the DMG Beam Refinement element contained in the frame. The TX Antenna ID subfield per channel measurement feedback data is reserved when the Short SSW Packet Used subfield is equal to 1 in the DMG Beam Refinement element contained in the frame.

When the EDMG Channel Measurement Feedback element is included in a MIMO BF Feedback frame, the EDMG Sector ID Order subfield indicates AWV feedback IDs, TX antenna IDs and RX antenna IDs; and the BRP CDOWN subfield indicates BRP CDOWN values. The EDMG Sector ID Order field and the BRP CDOWN field can be divided into *N*meas SISO ID subsets, each comprising an AWV feedback ID, a TX antenna ID, a RX antenna ID and a BRP CDOWN value. Specifically, the *i* SISO ID subset (*i* = 1,2,…, *N*meas) comprises the values of the AWV feedback ID*i*, TX antenna ID*i*, RX antenna ID*i* and BRP CDOWN*i* subfields, where the AWV feedback ID*i* subfield indicates the AWV for a TX DMG antenna having its TX antenna ID equal to the TX antenna ID*i* value, which is used to transmit an EDMG BRP-RX/TX packet with the BRP CDOWN field set to the BRP CODWN*i* value. Every *N*TX×*N*RX consecutive SISO ID subsets constitue a set which corresponds to a specific TX sector combination (or equivalently a specific TX-RX AWV configuration). Each TX sector combinationcomprises a single TX sector for each of *N*TX TX DMG antennas. *N*tsc TX sector combinationsare ranked in the decreasing order of an implementation dependent metric, where *N*tsc is the value of the Number of TX Sector Combinations Present field in the accompanying MIMO Feedback Control element. Specifically, the *j* set (*j* = 1, 2, …, *N*tsc), which corresponds to the *j* TX-RX AWV configuration, comprises the ((*j*-1)×*N*TX×*N*RX+1) SISO ID subset to the (*j*×*N*TX×*N*RX) SISO ID subset. Assume that the MIMO channel corresponding to the *j* TX-RX AWV configuration is defined by

where (*m* =1,2,…, *N*TX and *n* = 1,2,…, *N*RX) represents the channel between the *m* TX DMG antenna and the *n* RX DMG antenna and is indicated by the ((*j*-1)×*N*TX×*N*RX+(*m-*1)×*N*RX*+n*) SISO ID subset. In particular, for the *j* TX sector combination (*j* = 1, 2, …, *N*tsc), the AWV used by the *m* TX antenna (*m* =1,2,…, *N*TX) is indicated by the values of the AWV feedback ID*l* and BRP CDOWN*l* subfields,where *l* = ((*j*-1)×*N*TX×*N*RX+(*m-*1)×*N*RX*+n* and *n* is any interger between 1 and *N*RX.

***#9: delete the fourth paragrap following Table 4 as follows (CID #84, #85, #86, #503):***

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* + - 1. Channel Measurement Feedback element

***#10: Change Table 9-240 as follows (CID #84, #85, #86, #503):***

|  |  |  |
| --- | --- | --- |
| Field | Size | Meaning |
| Element ID | 8 bits |  |
| Length | 8 bits |  |
| SNR | SNR1 | 8 bits | SNR as measured in the first TRN-T field, or at the first sector from which SSW frame or Short SSW packet is received, or at the channel indicated by the first SISO ID subset. |
| SNR2 | 8 bits | SNR as measured in the second TRN-T field or at the second sector from which SSW frame or Short SSW packet is received, or at the channel indicated by the second SISO ID subset. |
| ... |  |  |
| SNRNmeas | 8 bits | SNR as measured in the Nmeas TRN-T field or at sector Nmeas from which SSW frame or Short SSW packet is received, or at the channel indicated by the Nmeas SISO ID subset. |
| Channel Measurement | Channel Measurement 1 | *Ntaps×*16 bits | Channel measurement for the first TRN-T field or for the channel indicated by the first SISO ID subset. |
| Channel Measurement 2 | *Ntaps×*16 bits | Channel measurement for the second TRN-T field or for the channel indicated by the second SISO ID subset. |
| ... |  |  |
| Channel Measurement Nmeas | *Ntaps×*16 bits | Channel measurement for the Nmeas TRN-T field or for the channel indicated by the Nmeas SISO ID subset. |
| Tap Delay | Relative Delay Tap #1 | 8 bits | The delay of Tap #1 in units of TC/NCB relative to the path with the shortest delay detected, where NCB is the integer number of 2.16 GHz channels over which the measurement was taken. |
| Relative Delay Tap #2 | 8 bits | The delay of Tap #2 in units of TC/NCB relative to the path with the shortest delay detected, where NCB is the integer number of contiguous 2.16 GHz channels over which the measurement was taken. |
| ... |  |  |
| Relative Delay Tap #Ntaps | 8 bits | The delay of Tap #Ntaps in units of TC/NCB relative to the path with the shortest delay detected, where NCB is the integer number of contiguous 2.16 GHz channels over which the measurement was taken. |
| Sector ID Order | Sector ID1 | 6 bits | Sector ID for SNR1 being obtained, or sector ID of the first detected beam. |
| Antenna ID1 | 2 bits | Antenna ID corresponding to sector ID1. |
| Sector ID1 | 6 bits | Sector ID for SNR2 being obtained, or sector ID of the second detected beam. |
| Antenna ID1 | 2 bits | Antenna ID corresponding to sector ID2. |
| ... |  |  |
| Sector IDNmeas or sector IDNbeam | 6 bits | Sector ID for SNRNmeas being obtained, or sector ID of the detected beam Nbeam. |
| Antenna IDNmeas or Antenna IDNbeam | 2 bits | Antenna ID corresponding to sector IDNmeas or sector IDNbeam. |

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10.38.9.2.3.3 MIMO phase

***#11: Replace Figure 57 by the following figure (#350):***



Figure 57—The MIMO phase of SU-MIMO beamforming

***#12: Change the last six paragraphes in this clause as follows (CID#48, #49, #437):***

The initiator shall initiate the initiator SMBT subphase a MBIFS following reception of the MIMO BF Setup frame from the responder. In the initiator SMBT subphase, the initiator shall transmit EDMG BRP-RX/TX packets to the responder. Each EDMG BRP-RX/TX packet shall be separated by SIFS. Each transmitted EDMG BRP-RX/TX packet is used to train one or more transmit sectors and, for each transmit sector, a number of receive AWVs. In each EDMG BRP-RX/TX packet, the initiator shall include, for each selected transmit sector, TRN subfields in the TRN field for the responder to perform receive AWV training. For each EDMG BRP-RX/TX packet, the TXVECTOR parameter EDMG\_TRN\_LEN shall be set to a value greater than zero, and the parameters RX\_TRN\_PER\_TX\_TRN and EDMG\_TRN\_M shall be set to the values of the L-TX-RX and EDMG TRN-Unit M subfields received in the feedback from the responder in the SISO phase, respectively. The initiator may transmit each EDMG BRP-RX/TX packet to train multiple TX DMG antennas simultaneously using TRN subfields defined in 30.9.2.2.6 to reduce training time. The TX Antenna Mask field of each EDMG BRP-RX/TX packet shall indicate the TX DMG antenna(s) which is being used by the initiator to transmit the EDMG BRP-RX/TX packet. The BRP CDOWN field of each EDMG BRP-RX/TX packet shall indicate the number of remaining EDMG BRP RX-TX packets transmitted by the initiator in the initiator SMBT subphase.

The responder shall initiate the responder SMBT subphase a MBIFS following reception of the EDMG BRP-RX/TX packet with the BRP CDOWN field set to 0 from the initiator. In the responder SMBT subphase, the responder shall transmit EDMG BRP-RX/TX packets to the initiator. Each EDMG BRP-RX/TX packet shall be separated by SIFS. For each EDMG BRP-RX/TX packet, the TXVECTOR parameter EDMG\_TRN\_LEN shall be set to a value greater than zero, and the parameters RX\_TRN\_PER\_TX\_TRN and EDMG\_TRN\_M shall be set to the values of the L-TX-RX and Requested EDMG TRN-Unit M subfields in the MIMO BF Setup frame received from the initiator in the SU-MIMO BF setup subphase, respectively. The responder may transmit each EDMG BRP-RX/TX packet to train multiple TX DMG antennas simultaneously using TRN subfields defined in 30.9.2.2.6 to reduce training time. The TX Antenna Mask field of each EDMG BRP-RX/TX packet shall indicate the TX DMG antenna(s) which is being used by the responder to transmit the EDMG BRP-RX/TX packet. The BRP CDOWN field of each EDMG BRP-RX/TX packet shall indicate the number of remaining EDMG BRP RX-TX packets transmitted by the responder in the responder SMBT subphase.

The initiator shall initiate the SU-MIMO BF feedback subphase a MBIFS following reception of the EDMG BRP-RX/TX packet with the BRP CDOWN field set to 0 from the responder. All frames transmitted during the SU-MIMO BF feedback subphase should be sent using the DMG control mode. In the SU-MIMO BF feedback subphase, the initiator shall send a MIMO BF Feedback frame with the SU/MU field set to 1 and the Link Type field set to 0 to the responder. The TA field of the MIMO BF Feedback frame shall be set to the MAC address of the initiator and the RA field shall be set to the MAC address of the responder. The MIMO BF Feedback frame shall carry the dialog token in the Dialog Token field that identifies the SU-MIMO BF training. The EDMG Channel Measurement Feedback element in the MIMO BF Feedback frame shall indicate best transmit sector combinations in the EDMG Sector ID Order field and the BRP CDOWN field, which are determined based on channel measurement data captured from the responder SMBT subphase. The Channel Measurement Feedback element in the MIMO BF Feedback frame shall contain s corresponding to the transmit sector combinations in the SNR field. If the Channel Measurement Requested field of the MIMO BF Setup frame received from the responder in the preceding SU-MIMO BF setup subphase is 1, the Channel Measurement Present field of the MIMO BF Feedback frame shall be set to 1 and the Channel Measurement Feedback element in the MIMO BF Feedback frame shall contain channel measurements corresponding to the transmit sector combinations in the Channel Measurement field.

The responder shall send a MIMO BF Feedback frame with the SU/MU field set to 1 and the Link Type field set to 1 to the initiator a SIFS following reception of the MIMO BF Feedback frame from the initiator. The TA field of the MIMO BF Feedback shall be set to the MAC address of the responder and the RA field shall be set to the MAC address of the initiator. The MIMO BF Feedback frame shall carry the dialog token in the Dialog Token field that identifies the SU-MIMO BF training. The EDMG Channel Measurement Feedback element in the MIMO BF Feedback frame shall indicate best transmit sector combinations in the EDMG Sector ID Order field and the BRP CDOWN field, which are determined based on channel measurement data captured from the initiator SMBT subphase. The Channel Measurement Feedback element in the MIMO BF Feedback frame shall contain s corresponding to the transmit sector combinations in the SNR field. If the Channel Measurement Requested field of the MIMO BF Setup frame received from the initiator in the preceding SU-MIMO BF setup subphase is 1, the Channel Measurement Present field of the MIMO BF Feedback frame shall be set to 1 and the Channel Measurement Feedback element in the MIMO BF Feedback frame shall contain channel measurements corresponding to the transmit sector combinations in the Channel Measurement field.

The best transmit sector combinations (or equivalently best TX-RX AWV configurations) for the initiator link and the best transmit sector combinations (or equivalently best TX-RX AWV configurations) for the responder link shall be determined in such a way that no determined transmit or receive AWV come from the same DMG antenna. The algorithms for determining the best transmit sector combinations for the initiator link and for determining the best transmit sector combinations for the responder link are implementation dependent.

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10.38.9.2.4.3.2 Downlink MIMO phase

***#13: Replace Figure 59 by the following figure (#352):***



Figure 59—The downlink MIMO phase of MU-MIMO beamforming

***#14: Change the fourth and fifth paragraphes in this clause as follows (CID #87, #438, #486):***

The initiator shall initiate the MU-MIMO BF training subphase a MBIFS following the transmission of the MIMO BF Setup frame. In the MU-MIMO BF training subphase, the initiator shall transmit one or more EDMG BRP-RX/TX packets to the remaining responders in the MU group. Each EDMG BRP-RX/TX packet shall be separated by SIFS. Each transmitted EDMG BRP-RX/TX packet is used to train one or more transmit sectors and, for each transmit sector, a number of receive AWVs. In each EDMG BRP-RX/TX packet, the initiator shall include, for each selected transmit sector, TRN subfields in the TRN field for remaining responders to perform receive AWV training. For each EDMG BRP-RX/TX packet, the TXVECTOR parameter EDMG\_TRN\_LEN shall be set to a value greater than zero. The parameters RX\_TRN\_PER\_TX\_TRN and EDMG\_TRN\_M shall be set in such a manner that the number of TRN subfields included in the TRN field used for receive AWV training is the maximum number of receive sectors across all the remaining responders based on the L-TX-RX subfields and the EDMG TRN-Unit M subfields in the feedback from all the remaining responders in the SISO phase. The initiator may transmit each EDMG BRP-RX/TX packet to train multiple TX DMG antennas simultaneously using TRN subfields defined in 30.9.2.2.6 to reduce the training time. The TX Antenna Mask field of each EDMG BRP-RX/TX packet shall indicate the TX DMG antenna(s) which is being used by the responder to transmit the EDMG BRP-RX/TX packet. The BRP CDOWN field of each EDMG BRP-RX/TX packet shall indicate the number of remaining EDMG BRP RX-TX packets transmitted by the initiator in the MU-MIMO BF training subphase.

The initiator shall initiate the MU-MIMO BF feedback subphase a MBIFS following the transmission of the EDMG BRP RX-TX packet with the BRP CDOWN field set to 0. In the MU-MIMO BF feedback subphase, the initiator shall transmit a MIMO BF Poll frame with the Poll Type field set to 0 to poll each remaining responder to collect MU-MIMO BF feedback from the preceding MU-MIMO BF training subphase. The MIMO BF Poll frames should be sent using the DMG control mode. The TA field of each MIMO BF Poll frame shall be set to the BSSID of the initiator and the RA field shall be set to the MAC address of the corresponding responder. Each MIMO BF Poll frame carries the dialog token in the Dialog Token field that identifies the MU-MIMO BF training. Upon receiving a MIMO BF Poll frame for which a remaining responder is the addressed recipient, the responder shall transmit a MIMO BF Feedback frame with the SU/MU field set to 1 to the initiator. The RA field of the MIMO BF Feedback frame shall be set to the BSSID of the initiator and the TA field shall be set to the MAC address of the responder. The MIMO BF Feedback frame carries the dialog token in the Dialog Token field that identifies the MU-MIMO BF training. The EDMG Channel Measurement Feedback element in the MIMO BF Feedback frame shall indicate transmit sector combinations in the EDMG Sector ID Order field and the BRP CDOWN field, which are obtained based on channel measurement data captured from the MU-MIMO BF training subphase. The Channel Measurement Feedback element in the MIMO BF Feedback frame shall indicate s corresponding to transmit sector combinations in the SNR field. If the Channel Measurement Requested field of the MIMO BF Setup frame received from the initiator in the preceding MU-MIMO BF setup subphase is 1, the Channel Measurement Present field of the MIMO BF Feedback frame shall be set to 1 and the Channel Measurement Feedback element in the MIMO BF Feedback frame shall contain the channel measurements corresponding to transmit sector combinations in the Channel Measurement field. Each MIMO BF Poll frame and MIMO BF Feedback frame shall be separated by SIFS.

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10.38.9.2.3.3 Uplink MIMO phase

***#15: Replace Figure 60 by the following figure:***



Figure 60—The uplink MIMO phase of MU-MIMO beamforming

***#16: Change the second last paragraph in this clause as follows:***

The initiator shall initiate the MU-MIMO BF training subphase a MBIFS following the transmission of the MIMO BF Setup frame. In the MU-MIMO BF training subphase, the initiator shall transmit a MIMO BF Poll frame with the Poll Type field set to 1 to each remaining responder in the MU group. The MIMO BF Poll frames should be sent using the DMG control mode. The TA field of each MIMO BF Poll frame shall be set to the BSSID of the initiator and the RA field shall be set to the MAC address of the corresponding responder. Each MIMO BF Poll frame carries the dialog token in the Dialog Token field that identifies the MU-MIMO BF training. Additionally, in order to reduce training time, the initiator may reduce the number of TRN subfields used for receive AWV training in the following EDMG BRP-RX/TX packets transmitted by each remaining responder based on the SNRs of transmit sectors collected from each remaining responder in the SISO phase. The L-TX-RX subfield and the Requested EDMG TRN-Unit M subfield of each MIMO BF Poll frame shall indicate the number of TRN subfields required for receive AWV training in the following EDMG BRP-RX/TX packets to be transmitted by the corresponding responder. The Requested EDMG TRN-Unit P subfield of each MIMO BF Poll frame shall indicate the number of TRN subfields in a TRN-Unit which need to be transmitted with the same AWV as the preamble and data field in the following EDMG BRP-RX/TX packets to be transmitted by the corresponding responder.

Upon receiving a MIMO BF Poll frame for which a remaining responder is the addressed recipient, the responder shall transmit one or more EDMG BRP-RX/TX packet to the initiator, where the TXVECTOR parameter EDMG\_TRN\_LEN is set to a value larger than zero, and the parameters RX\_TRN\_PER\_TX\_TRN, EDMG\_TRN\_M and EDMG\_TRN\_P are set to the values of the L-TX-RX field, the Requested EDMG TRN-Unit M field and the Requested EDMG TRN-Unit P field in the corresponding MIMO BF Poll frame received from the initiator, respectively. Additionally, the responder may transmit each EDMG BRP-RX/TX packet to train multiple TX DMG antennas simultaneously using TRN subfields defined in 30.9.2.2.6 to reduce the training time. The TX Antenna Mask field of each EDMG BRP-RX/TX packet shall indicate the TX DMG antenna(s) which is being used by the responder to transmit the EDMG BRP-RX/TX packet. The BRP CDOWN field of each EDMG BRP-RX/TX packet shall indicate the number of remaining EDMG BRP RX-TX packets transmitted by the responder.

Each MIMO BF Poll frame and each EDMG BRP-RX/TX packet shall be separated by SIFS.

**Straw Poll:**

* **Do you agree to accept comment resolution as proposed in doc 11-17/1041r0?**