IEEE P802.11  
Wireless LANs

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| Comment Resolutions on Clause 26.3.13 | | | | |
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Abstract

This submission proposes resolutions for multiple comments related to TGax D0.2 as follows:

* 507, 949, 1005, 1785, 1778, 1862

Revisions:

* Rev 0: Initial version of the document.

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 TGax Draft. This introduction is not part of the adopted material.

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

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

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| --- | --- | --- | --- | --- | --- |
| **CID** | **Clause Number** | **P.L** | **Comment** | **Proposed Change** | **Resolution** |
| 507 | 26.3.12 | 154.34 | some of the functionalities and descriptions for MU-MIMO is very relevant for OFDMA operations as well. For example, uplink power control should apply to both UL MU-MIMO as well as UL OFDMA operation, pre corrections for UL MU-MIMO should also apply to UL OFDMA operations. I suggest tht either change the 26.3.12 MU-MIMO section to be general enough to cover both MU-MIMO and OFDMA or have a separate dedicated section for OFDMA right after section 26.3.12. | As commented | Revised.  Proposed resolution accounts for the suggested change.  TGax Editor to make the changes shown in IEEE 802.11-16/xxr0 under all headings that include CID 507. |
| 949 | 26.3.12.4.2 | 156.00 | Need clarification | Where is this 1 bit indicated? In which specific field of TF? | Revised.  Proposed resolution accounts for the suggested change.  TGax Editor to make the changes shown in IEEE 802.11-16/xxr0 under all headings that include CID 949. |
| 1005 | 26.3.12.3.4 | 155.48 | Update the TBD on the compression mode according to the agreed PHY motion #141 - #143 | Replace the following sentence: "If the value of SIGB Compression field in HE-SIG-A is 1, there is no RU allocation signaling in HE-SIG-B common field. The number of STAs in the MU MIMO group is indicated in the TBD field in HE-SIG-A." with the following: "If the value of SIGB Compression field in HE-SIG-A is 1, there is no HE-SIG-B common field and contains only user specific field. The SIGB number of symbols field in the HE-SIG-A is repurposed to indicate the number of STAs in the MU MIMO group. For bandwidths > 20 MHz, the user specific sub-fields are split equitably between the two HE-SIG-B Channels, i.e., for a k user MU-MIMO PPDU, 1,..., ceil (k/2) user fields are carried in HE-SIG-B content channel 1 and ceil(k/2) +1, ..., k user fields in HE-SIG-B content channel 2" | Revised.  Proposed resolution accounts for the suggested change.  TGax Editor to make the changes shown in IEEE 802.11-16/xxr0 under all headings that include CID 1005. |
| 1785 | 26.3.12.3.3 | 155.34 | The "DL MU-MIMO STS Capability" is not present in the HE Capabilities element and does not make a lot of sense. How can a STA support receiption of something signaling by the AP? Typically, capability is something inherent in the device -- built in by des | Let's fix the requirement. Total number of streams is 8. | Revised.  Proposed resolution accounts for the suggested change.  TGax Editor to make the changes shown in IEEE 802.11-16/xxr0 under all headings that include CID 1785.  Note total number of streams is a capability and not a fixed value of 8. |
| 1778 | 26.3.12.4.2 | 156.43 | "The Trigger frame shall use..." Belongs in the Trigger frame format description | Add the field to the Trigger frame in 9.3.1.23. Add a TXVECTOR parameter for this option. In the PHY clause define the waveform for each case with statements like "If the TXVECTOR parameter YYY is SINGLE\_STREAM\_PILOTS, then the HE-LTF field is ....". | Revised.  Proposed resolution accounts for the suggested change.  TGax Editor to make the changes shown in IEEE 802.11-16/xxr0 under all headings that include CID 1778. |
| 1862 | 26.3.12.3.2 | 155 | PHY Motions 38, 101, 102 and MU Motion 46, and several related PHY motions in March 2016 were approved but no corresponding spec text is present in the draft | as comment | Revised.  Proposed resolution accounts for the suggested change including PHY motions in May 2016.  TGax Editor to make the changes shown in IEEE 802.11-16/0836r1 under all headings that include CID 1862. |

*Changes to D0.2 related to CID 507, CID 949, CID 1005, CID 1785, CID 1778 and CID 1862*

***Change the subsections below as follows (#507, #949, #1005, #1785, #1778, #1862):***

**26.3.13 ~~MU-MIMO~~ MU Transmission (#507)**

**26.3.13.1 Introduction**

~~DL MU-MIMO is specified in 22.3.11 for full band transmission. In this amendment, MU-MIMO is also applicable on a subset of active RUs within PPDU bandwidth in both DL and UL. The non-AP STAs in the same MU-MIMO group are allocated the same resource unit. The combination of SU-MIMO and MU-MIMO on different RU for different non-AP STA in one PPDU is supported.~~

The MU transmissions include DL MU transmissions and UL MU transmissions.

The DL MU transmission allows an AP to simultaneously transmit frames to more than one non-AP STAs. For the DL MU transmission, the AP uses the HE MU PPDU format, and employs either DL OFDMA, DL MU-MIMO, or a mixture of both. The UL MU transmission allows an AP to receive simultaneous frames from more than one non-AP STAs. Non-AP STAs transmit their frames using HE trigger-based PPDU format and employ either UL OFDMA, UL MU-MIMO, or a mixture of both.

**26.3.13.1.1 OFDMA and MU-MIMO**

HE PHY supports OFDMA transmissions, both in the DL and the UL where different users can occupy different RUs in a PPDU (see 26.3.7). On an RU in a PPDU, it is allowed to have single stream transmissions to one user or spatial multiplexing to one user (SU-MIMO) or spatial multiplexing to multiple users (MU-MIMO). Note that the VHT PHY supports only full bandwidth DL MU-MIMO as described in 22.3.11. HE PHY defines DL MU-MIMO and UL MU-MIMO, for the full bandwidth case as well as for the case where they are being used on only certain RUs in the PPDU. The combination of SU transmissions and MU-MIMO transmissions on different RUs in one PPDU is also supported.

**~~26.3.13.3 Mimimum RU size in MU-MIMO transmission~~**

~~Both DL and UL MI-MIMO shall transmit on the RU of at least 106 tones.~~

**~~26.3.13.4 DL MU-MIMO~~**

**~~26.3.13.4.1 Introduction~~**

~~For SU-MIMO and DL MU-MIMO beamforming in RU~~ *~~r,~~* ~~the receive signal vector in subcarrier (where subcarrier~~ ~~is one of the subcarriers in RU~~ *~~r,~~* ~~) at beamformee , is shown in Equation (26-146), where denotes the transmit signal vector in subcarrier for all beamformees, with being the transmit signal for beamformee .~~

~~where~~

~~is the channel matrix from the beamformee in subcarrier with dimensions~~

~~is the number of receive antennas at beamformee~~

~~is a steering matrix for beamformee in subcarrier with dimensions~~

~~is the number of VHT MU PPDU recipients (see Table 26-9 (Frequently used parameters)~~

~~is a vector of additive noise and may include interference~~

~~The DL MU-MIMO steering matrix can be determined by the beamformer using the beamforming feedback for subcarrier from beamformee , where The feedback report format is TBDdescribed in 9.4.1.62 and 9.4.1.63. The steering matrix that is computed (or updated) using new beamforming feedback from some or all of participating beamformees might replace the existing steering matrix for the next DL MU-MIMO data transmission. The beamformee group for the DL MU transmission is signaled in HE-SIG-B (see 26.3.9.8.3 (Time domain encoding) and 26.3.13.4.4 (Resource indication and STA self identification)).~~

**~~26.3.13.4.2 Beamforming feedback~~**

**26.3.13.2 DL MU Transmission**

DL MU transmission allows an AP to simultaneously transmit to more than one non-AP STA. The AP uses HE MU PPDU format for DL MU transmission.

**26.3.13.2.1 DL MU-MIMO**

**26.3.13.2.1.1 Minimum RU size in DL MU-MIMO**

A STA capable of receiving DL MU-MIMO transmission on one RU in an HE MU PPDU shall support reception of DL MU-MIMO transmissions for all RU sizes greater than or equal to 106-tones.

**26.3.13.2.2 Maximum number of spatial streams in an HE MU PPDU**

An HE STA shall support reception of DL MU-MIMO transmissions on full bandwidth with maximum number of space-time streams (per user) equal to minimum of 4 and the maximum number of space-time streams supported for reception of HE SU PPDUs. The maximum number of space-time streams supported for reception of HE SU PPDUs is indicated for various bandwidths in ‘Nss Support for > 40 MHz field’ and ‘HE-MCS and Nss Map’ field in the HE Capabilities element.

An HE STA shall support reception of DL MU-MIMO transmissions on full bandwidth with the total number of space-time streams (across NUM\_USERS) is less than or equal to a maximum value indicated by the Beamformee STS Capability in the HE Capabilities element (#1785).

All of the aforementioned restrictions on the per-user and total number of space-time-streams are also applicable to an MU-MIMO transmission on an RU in an HE MU PPDU where the RU does not span the entire PPDU bandwidth.

**~~26.3.13.4.3~~  ~~Maximum number of total spatial streams in an HE MU PPDU~~**

~~A DL MU-MIMO capable STA shall support reception of DL MU PPDUs with the total number of space-time streams across the users being less than or equal to its DL MU-MIMO STS Capability in the HE Capabilities.~~

**~~26.3.13.4.4~~ 26.3.13.2.3 Resource indication and STA self-identification in an HE MU PPDU**

~~AP shall transmit HE MU PPDU.The UL/DL field in the HE-SIG-A shall be set to TBD (for DL).~~ An AP transmitting an HE MU PPDU shall set the UL/DL field in the HE-SIG-A to 0 (#1862). A full bandwidth MU-MIMO transmission using HE MU PPDU format has a value of 1 for the SIGB Compression field in HE-SIG-A and there is no SIGB C~~c~~ommon field. If the value of SIGB Compression field in HE-SIG-A is 0, the RU allocation signaling in the HE-SIG-B C~~c~~ommon field indicates the combination of RUs in current PPDU bandwidth and the number of STAs on each RU for SU/MU-MIMO transmission. The number of users in RU *r* for MU-MIMO transmission, is indicated together with the RU allocation as defined in Table 26-24 (RU allocation signaling: Arrangement and number of MU-MIMO allocations). If the value of SIG Compression field in HE-SIG-A is 1, there is no ~~RU allocation signaling in~~ HE-SIG-B C~~c~~ommon field and HE-SIG-B contains only User specific fields. The number of STAs in the MU-MIMO group is indicated in the ~~Number Of HE-SIG-B Symbols Or MU-MIMO Users field~~ SIGB Number of Symbols/Number of MU-MIMO users field in HE-SIG-A. For bandwidths larger than 20 MHz, the User block fields are split equitably between two SIG-B channels, i.e., for a user MU-MIMO PPDU, 1, …., ceil(/2) User fblock fields are carried in HE-SIG-B content channel 1 and ceil(/2)+1,……, User block fields in HE-SIG-B content channel 2 (#1005). The number of spatial streams, is indicated by the field in the User specific block as defined in Table 26-26 (Fields of the HE-SIG-B User field for a non-MU-MIMO allocation) and Table26-27 (Fields for the HE-SIG-B User field for an MU-MIMO allocation). The allocated spatial streams for a designated MU-MIMO user and the total number of spatial streams on the RU are indicated in spatial configuration field of U~~u~~ser specific block containing the STA ID of designated MU-MIMO STA as defined in Table 26-28 (Spatial Configuration subfield encoding).

When processing the HE-SIG-B, a STA will look at information of each RU to find out its ~~M~~membership ~~S~~status, i.e., if it belongs to a beamformee group in a certain RU. If STAs are scheduled in RU *r,* there are U~~u~~ser specific blocks for RU *r*. Each U~~u~~ser specific block has an 11-bit field indicating the STA ID. A STA identifies itself as a member in the beamformee group in the RU, if its STA ID matches one of the STA IDs. The user position is indicated by the block index. From a multiplexing information lookup table for , the ordered number of spatial streams for all members in the beamformee group in RU *r,* , where *u* = 1, …, ~~could be~~ is obtained. The spatial streams of different users are ordered in accordance to user position values, i.e., the spatial streams for the user in user position 0 come first, followed by the spatial streams for the user in position 1, followed by the spatial streams for the user in position 2, and followed by the spatial streams for the user in position 3, and so on.

A STA is also able to identify the space-time streams intended for other STAs that act as interference. HE-LTF symbols in the DL HE ~~DL~~ MU PPDU are used to measure the channel for the space-time streams intended for the STA and can also be used to measure the channel for the interfering space-time streams. To successfully demodulate the space-time streams intended for the STA, it is recommended that the STA uses the channel knowledge for all space-time streams to reduce the effect of interfering space-time streams.

If a STA finds that it is a member of the beamformee group in RU *r,* its corresponding interpreted from the HE-SIG-B U~~u~~ser specific blocks shall not be zero for the STA in the PPDU. If a STA finds that it is not a member of the beamformee group in RU *r,* then the STA may elect not to process RU *r* in the remainder of the PPDU.

**~~26.3.13.5 UL MU-MIMO~~**

**~~26.3.13.5.1 Introduction~~**

~~UL MU-MIMO is a technique to allow multiple STAs to transmit simulatenously over the same frequency resource to the receiver. The concept is very similar to SU-MIMO where multiple space-time streams are transmitted simultaneously over the same frequency resource utilizing spatial multiplexing through multiple antennas at the transmitter and receiver. The key difference from SU-MIMO is that in UL MU-MIMO, the transmitted streams originate at multiple STAs.~~

~~For full bandwidth UL MU-MIMO transmissions, support for both single stream pilots and the masking LTF sequence of each spatial stream by a distinct orthogonal code is mandatory at the transmitted side (non-AP STA).~~

**26.3.13.3 UL MU Transmission**

UL MU transmissions allow an AP to receive simultaneous frames from more than one non-AP STA. UL MU transmissions are preceded by a Trigger frame from the AP. The non-AP STA use HE Trigger-based PPDU format for UL MU transmission.

**26.3.13.3.1 UL MU-MIMO**

**26.3.13.3.1.1 Introduction**

UL MU-MIMO is a technique to allow multiple STAs to transmit simultaneously over the same frequency resource to the receiver. The concept is very similar to SU-MIMO where multiple space-time streams are transmitted simultaneously over the same frequency resource utilizing spatial multiplexing through multiple antennas at the transmitter and receiver. The key difference from SU-MIMO is that in UL MU-MIMO, the transmitted streams originate from multiple STAs.

**26.3.13.3.1.2 Minimum RU size in UL MU-MIMO**

A STA capable of an UL MU-MIMO transmission on one RU in an HE trigger-based PPDU shall support UL MU-MIMO transmission for all RU sizes greater than or equal to 106-tones (#1862).

**26.3.13.3.1.3 MU-MIMO LTF Mode (#1778)**

A STA capable of UL MU-MIMO transmission on full bandwidth shall support single stream pilot and masking LTF sequence of each spatial stream by a distinct orthogonal code.

A STA capable of UL OFDMA with MU-MIMO transmission on an RU in an HE trigger-based PPDU shall support single stream pilot for any UL OFDMA transmission, including UL OFDMA with MU-MIMO transmission on an RU in an HE trigger-based PPDU.

**~~26.3.13.5.5~~ 26.3.13.3.2 Maximum number of spatial streams in an HE trigger-based PPDU**

~~An UL MU-MIMO capable STA shall support transmission of UL MU PPDUs with the number of space-time streams being less than or equal to its UL MU-MIMO STS Capability in HE Capabilities.~~

A STA capable of UL MU-MIMO transmission shall support UL MU-MIMO transmissions on full bandwidth with maximum number of space-time streams (per user) equal to minimum of 4 and the maximum number of space-time streams supported for transmission of HE SU PPDUs. The maximum number of space-time streams supported for transmission of HE SU PPDUs is indicated for various bandwidths in Nss Support for > 40 MHz’ field and ‘HE-MCS and Nss Map’ field in the HE Capabilities element (#1785).

A STA capable of UL MU-MIMO transmission on the full bandwidth shall support a total of up to 8 space-time streams in the UL MU-MIMO transmission.

All of the aforementioned restrictions on the per-user and total number of space-time-streams are also applicable to an MU-MIMO transmission on an RU in an HE MU PPDU where the RU does not span the entire PPDU bandwidth.

**~~26.3.13.5.2~~ 26.3.13.3.3 Resource allocation for an HE trigger-based PPDU**

UL MU~~-MIMO~~ transmissions are preceded by a Trigger frame from the AP. ~~Similar as UL OFDMA cases,~~ ~~t~~The Trigger frame indicates the transmitting STAs in the Common Info field about when to transmit the UL MU-MIMO PPDUs, the duration of the payload, and packet extension. The GI duration for UL OFDMA/MU-MIMO transmissions shall also be explicitly indicated by AP in the Trigger frame. The value of GI duration for all users addressed by the Trigger frame shall be the same. The MU-MIMO LTF Mode in Trigger frame ~~shall use 1 bit to indicate~~ indicates (#949) whether the UL MU~~MIMO~~ transmission following it uses single stream pilots or a mask on each spatial stream of the LTF sequence by a distinct orthogonal code. When single stream pilot is used, no masking is applied to the HE LTF. Single stream pilot is used for any UL OFDMA transmission, including UL OFDMA with MU-MIMO transmissions. The appropriate MU-MIMO LTF mode indicated in MU-MIMO LTF Mode is used for full bandwidth UL MU-MIMO transmission (#1862). The allocated RU and spatial streams are carried in the fields of RU allocation info and SS allocation of User Info field, where Address field is set as the AID of designated UL MU OFDMA/MIMO STA. ~~Detials TBD.~~

If a STA finds that there is no User Info field in Trigger frame carrying the STA’s AID in the Address field, then the STA will not transmit in the following HE trigger-based PPDU.

**~~26.3.14~~ 26.3.13.3.4 Transmit requirements for HE trigger-based PPDU**

**~~26.3.14.1~~ 26.3.13.3.4.1 Introduction**

**~~26.3.14.2~~ 26.3.13.3.4.2 Power Pre-correction**

**~~26.3.14.3~~ 26.3.13.3.4.3 Pre-correction accuracy requirements**

**26.3.14 SU-MIMO and DL MU-MIMO Beamforming (#1862)**

**26.3.14.1 General**

For SU-MIMO and DL MU-MIMO beamforming in RU *r,* the receive signal vector in subcarrier (where subcarrier is one of the subcarriers in RU *r,* ) at beamformee , is shown in Equation (26-146), where denotes the transmit signal vector in subcarrier for all beamformees in RU , with being the transmit signal for beamformee .

where

is the channel matrix from the beamformee in subcarrier with dimensions

is the number of receive antennas at beamformee

is a steering matrix for beamformee in subcarrier with dimensions

is the number of HE MU PPDU recipients (see Table 26-9 (Frequently used parameters) in RU

is a vector of additive noise and may include interference

The DL MU-MIMO steering matrix can be determined by the beamformer using the beamforming feedback for subcarrier from beamformee , where The feedback report format is described in 9.4.1.62 and 9.4.1.63. The steering matrix that is computed (or updated) using new beamforming feedback from some or all of participating beamformees may replace the existing steering matrix for the next DL MU-MIMO data transmission.

For SU-MIMO beamforming, the steering matrix Qk can be determined from the beamforming feedback matrix Vk that is sent back to the beamformer by the beamformee using the compressed beamforming feedback matrix format as defined in 20.3.12.3.6. The feedback report format is described in 9.4.1.62."

**26.3.14.2 Beamforming Feedback Matrix V**

Upon receipt of a HE NDP sounding PPDU, the beamformee computes a set of matrices for feedback to the beamformer as described in 22.3.11.2. The eligible beamformees shall remove the space-time stream CSD in Table 22-11 from the measured channel before computing a set of matrices for feedback to the beamformer.

The beamforming feedback matrix,, found by the beamformee for subcarrier in RU shall be compressed in the form of angles using the method described in 20.3.12.3.6. The angles, and , are quantized according to Table 8-53e. The number of bits for quantization is set by the beamformer, i.e., HE AP. The number of bits for quantization, tone grouping factor, and the number of columns in the HE Compressed beamforming feedback are set by the beamformee, i.e., non-AP STA, only if NDPA is addressed to a single non-AP STA and SU type feedback is solicited. The compressed beamforming feedback matrix using 20.3.12.3.6 is the only Clause 26 beamforming feedback matrix defined.

The beamformee shall generate the beamforming feedback matrices with the number of rows (*Nr*) equal to the of the NDP.

After receiving the angle information, and , the beamformer reconstructs using Equation (20-79). For SU-MIMO beamforming, the beamformer uses , matrix to determine the steering matrix . For MU-MIMO beamforming, the beamformer may calculate a steering matrix using and () in order to suppress crosstalk between participating beamformees. The method used by the beamformer to calculate the steering matrix is implementation specific.

**26.3.14.3 CQI-only Feedback**

Whenever the HE-NDPA is requesting a CQI-only feedback, upon receipt of  the HE NDP, the beamformee computes HE CQI-only feedback as described in 9.4.1.64. The CQI-only feedback,, in RU for space time stream shall be estimated using the method described in 9.4.1.64. The CQI values to be fed back are derived from quantized SNRs according to Table XX-4. The beamformee shall transmit the HE CQI-only feedback for space-time stream 1,…,Nc for each of the RU indices for which the CQI-only report is being requested by the beamformer. After receiving the CQI information, the beamformer may use it to identify the best range of RUs for compressed beamforming feedback or for RU assignment during subsequent MU transmissions. The actual use is implementation specific.

**26.3.~~13~~15 Transmit specification**

**26.3.~~14~~16 HE transmit procedure**

**26.3.~~15~~17 HE receive procedure**

*Changes to D0.2 related to CID 1778:*

**26.2.2 TXVECTOR and RXVECTOR parameters**

***TGax Editor: Add the following text to the end of the Table 26-1(TXVECTOR and RXVECTOR parameters) (#1778):***

**Table 26-1 – TXVECTOR AND RXVECTOR parameters**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Parameter** | **Condition** | **Value** | **TXVECTOR** | **RXVECTOR** |
| MU MIMO LTF\_TYPE | FORMAT is HE\_TRIG | Indicates the LTF mode for an HE trigger-based PPDU transmission.  0 indicates use of single stream pilots for HE trigger-based PPDU transmission.  1 indicates use of masked LTF sequence for HE trigger-based PPDU transmission. | Y | N |

**25.11 TXVECTOR parameters ~~STA\_ID, UPLINK\_FLAG, and BSS\_COLOR~~ for an HE PPDU**

***TGax Editor: Add the following text after line 63 on page 66 (#1778):***

The TXVECTOR parameter MU-MIMO\_LTF\_MODE is only present for HE trigger-based PPDUs and is set as follows:

* A non-AP STA transmitting an HE trigger-based PPDU shall set the TXVECTOR parameter MU-MIMO\_LTF\_MODE to 0 to indicate use of single stream pilots.
* A non-AP STA transmitting an HE trigger-based PPDU shall set the TXVECTOR parameter MU-MIMO\_LTF\_MODE to 1 to indicate use of masked LTF sequence.

**References:**

1. **IEEE P802.11axTM/D0.2, June 2016.**
2. **11-15/132r17 Spec Framework, Robert Stacey (Intel)**