IEEE P802.11
Wireless LANs

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| Comment Resolution on CIDs for Hybrid Beamforming (Draft Text for Introduction to HBF) |
| Date: 2017-09-09 |
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Abstract

This submission proposes resolution of comment received from TGay comment collection (TGay Draft 0.5).

- CIDs: 277, 435, 500, 547

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.***

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| **CID** | **Clause** | **Page** | **Comment** | **Proposed Change** | **Proposed Resolution** |
| 277 | 10.38.9.2.1 | 66.22 | No mechanism defined for hybrid beamforming | Define hybrid beamforming procedure | RevisedAs in the proposed resolution. Editor to make changes in 11/17/xxx and add Section 10.38.9.2.5 to D0.5 |
| 435 | 10.38.9.2.1 | 66.26 | Need feedback etc for hybrid beamforming | will bring proposal | Revisedsee resolution to CID 277 |
| 500 | 10.38.9.2.1 | 66.26 | Please resolve editor's note | Please provide mechanisms for hybrid MIMO | RevisedSee resolution to CID 277 |
| 547 | 10.38.9.2.1 | 66.22 | How the technical term "hybrid precoding" is supported by this spec is not given. | The spec needs to add description how the technical term "hybrid precoding" is supported | RevisedSee resolution to CID 277 |

**Discussion**: The text below introduces the HBF protocol and its phases and updates the beamforming capability field for SU and MU MIMO HBF. Discussion of the details may be found in 11/17xxxx.

***Make the following changes on D0.5:***

*Insert the following Section as follows:*

# Hybrid Beamforming for SU-MIMO and MU-MIMO.

An EDMG STA is Hybrid Beamforming capable if either (or both) of the Hybrid Beamforming and SU MIMO Supported field or the Hybrid Beamforming and MU-MIMO Supported field in the STA’s EDMG Capabilities element is set to one. A Hybrid Beamforming capable STA shall be Hybrid Beamforming and SU-MIMO capable if the Hybrid Beamforming and SU MIMO supported field in the STA’s EDMG Capability element is set to one. A Hybrid Beamforming capable STA shall be Hybrid Beamforming and MU-MIMO capable if the Hybrid Beamforming and MU MIMO supported field in the STA’s EDMG Capability element is set to one. The Hybrid Beamforming capable STA may be Hybrid Beamforming and SU-MIMO capable, Hybrid Beamforming and MU-MIMO capable or both. A Hybrid Beamforming capable STA supports the Hybrid Beamforming protocol described in this sub-clause.

The Hybrid Beamforming protocol enables the determination of the baseband beamformer based on the antenna configuration selected in the SU-MIMO or MU-MIMO beamforming protocol. It supports digital baseband training and hybrid beamforming information feedback for subsequent Hybrid Beamforming transmission which is the transmission and reception of multiple spatial streams using a combination of analog beamforming and digital beamforming between a SU-MIMO capable initiator and an SU-MIMO capable responder or between an MU-MIMO capable initiator and one or more MU-MIMO capable responders. It can also be used to support the transmission of a single spatial stream using multiple DMG antennas with a combination of analog beamforming and digital beamforming between a SU-MIMO capable initiator and an SU-MIMO capable responder.

The analog beamformer may be selected during the SU-MIMO beamforming protocol (10.38.9.2.3) or MU-MIMO beamforming protocol (10.38.9.2.4) procedures which enable the determination of the antenna configuration for the simultaneous transmission of single or multiple spatial streams from the initiator to the responder(s) (or vice versa in the case of SU-MIMO).

The relationship between the transmitted signal, $x$, and received signal, $Y,$ in Hybrid Beamforming transmission can be represented as:

$Y=Q\_{Br,i}Q\_{Ar,i}H\_{i} Q\_{At,i}Q\_{Bt,i}x\_{i}+n\_{i} ; $$H\_{BB,i}$***=*** $Q\_{Ar,i}H\_{i} Q\_{At,i}$

where

$H\_{i}$ = Channel between Tx and Rx antennas,

$n\_{i} $ = Additive white noise

$H\_{BB,i} $= Effective baseband channel, i.e., the channel based on combining the analog beamformer(s) and the actual channel,

$Q\_{At,i} $= Ntx x Nsts Transmit Analog beamformer, $Q\_{Ar,i} $= Nsts x Nrx Receive Analog beamformer

$Q\_{Bt,i} $= Nss x Nsts Transmit Baseband beamformer, $Q\_{Br,i} $= Nsts x Nss Receive Baseband beamformer

$x\_{i} $ = The transmitted Single User or Multi-user MIMO signal

$i $= Subcarrier Index. For SC PPDU transmission, $i=0, $while for OFDM PPDU transmission, $0\leq i\leq ND\_{DC}-1$.

The Hybrid Beamforming protocol may be explicit or implicit.

In the explicit Hybrid beamforming protocol, the transmitter acquires hybrid beamforming information based on feedback from the receiver derived from the channel in the direction between the transmitter and receiver.

In the implicit Hybrid Beamforming Protocol, the transmitter acquires hybrid beamforming information directly from the channel in the direction between the receiver and the transmitter without the need for feedback. The initiator or responder may initiate an implicit hybrid beamforming protocol procedure if the Antenna Pattern Reciprocity subfield in the DMG STA Capability Information field of the responder and the Antenna Pattern Reciprocity subfield in the DMG STA Capability Information field of the initiator are both equal to 1.

The Hybrid Beamforming Protocol comprises the following phases

* Announcement Phase (for explicit and implicit HBF protocol, optional if configuration has been previously set)
* Sounding Phase
* Feedback Phase (for explicit HBF protocol only)

***10.38.9.2.5.1 Announcement Phase***

***10.38.9.2.5.2 Sounding Phase***

***10.38.9.2.5.3 Feedback Phase***

**9.4.2.250.2 Beamforming field**

*Change 1st paragraph in [1] as follows*

The Beamforming Capability field is defined in Figure 23.

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| B0 B4 | B5 | B6 | B7 | B8 | B9 | B10 | B11 B15 |
| Requested BRP SC Blocks | MU-MIMO Supported | UL-MU-MIMO Supported | SU-MIMO Supported | Grant Required | Hybrid Beamforming and MU MIMO Supported | Hybrid Beamforming and SU MIMO Supported | Reserved |
| 5 | 1 |  | 1 | 1 | 1 | 1 | 5 |

**Figure 22 —Beamforming Capability field format**

*Insert after 6th paragraph in [1] as follows*

The MU-MIMO supported field and Hybrid Beamforming and MU-MIMO Supported field shall be set to one to indicate that the STA supports the hybrid beamforming protocol during MU-MIMO transmission including the Hybrid beamforming protocol described in 10.38.9.2.5. If the MU-MIMO supported field is set to one, and the Hybrid Beamforming and MU-MIMO Supported field is set to zero, then the STA supports analog MU-MIMO beamforming only.

The SU-MIMO Supported field and Hybrid Beamforming and SU MIMO Supported field shall be set to one to indicate that the STA supports hybrid beamforming protocol during SU-MIMO transmission including the Hybrid beamforming protocol described in 10.38.9.2.5. If the SU-MIMO supported field is set to one, and the Hybrid Beamforming and SU-MIMO supported field is set to zero, then the STA supports analog SU-MIMO beamforming only.

**References:**

1. Draft P802.11ay\_D0.5
2. 802.11-2016