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Wireless LANs

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| Proposed Text Change in MU-MIMO Section |
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Abstract

Improve current text in the MU-MIMO section and include the UL MU-MIMO training mechanism.

**Proposed changes in Section 10.38.9.2.4**

**10.38.9.2.4 MU-MIMO beamforming**

**10.38.9.2.4.1 General**

An EDMG STA is MU-MIMO capable if the MU-MIMO Supported field in the STA’s EDMG Capabilities

element is one. The MU-MIMO beamforming protocol enables a MU-MIMO capable initiator and one or

more MU-MIMO capable responders in an MU group to establish an antenna configuration which allows

the initiator to transmit an EDMG MU PPDU to the responders in the MU group, such that the mutual

interference among the streams transmitted in the MU PPDU is minimized. In this context, the method of

minimizing interference is implementation dependent.

The MU-MIMO beamforming protocol is started and controlled by the initiator, and comprises the

following consecutive phases:

SISO phase, and

MIMO phase

The execution of the MU-MIMO beamforming protocol uses the EDMG Group ID Set element transmitted

by the AP or PCP of the BSS. The AP or PCP shall transmit an EDMG Group ID Set element prior to

performing MU-MIMO beamforming protocol. The EDMG Group ID Set element shall include all existent

groups in a BSS. A MU-MIMO capable EDMG STA shall store the groups in the last received EDMG

Group ID Set element transmitted by the AP or PCP.

**10.38.9.2.4.2 SISO phase**

The goal of the SISO phase is to collect feedback on one or more suitable initiator’s TX and responder’s

RX DMG antennas and sectors between the initiator and each responder intended to be part of the MU

group. This information is then used to perform the following MIMO phase. All transmissions during the

SISO phase should use the DMG control mode.

Figure 51 depicts the SISO phase, which consists of two subphases, namely, an I-TXSS subphase and a

SISO Feedback subphase. The initiator may perform the I-TXSS subphase. The I-TXSS subphase enables

the initiator to obtain feedback from the responders in the MU group on one or more sectors for each of the

initiator’s TX DMG antenna.

The initiator performs the I-TXSS subphase through the use of the Short SSW packet (see 30.9.1). In each

Short SSW packet transmitted as part of the I-TXSS, the initiator shall set the Direction field to zero, shall

set the Addressing Mode field to indicate MU-MIMO and shall set the Destination AID field to contain a

group ID announced by the PCP or AP in the last transmitted EDMG Group ID Set element. In addition,

the CDOWN field shall be set to the number of Short SSW packets remaining until the end of the I-TXSS

subphase and the Setup Duration field shall be set to the duration of the following SISO Feedback

subphase.

A MU-MIMO capable EDMG STA that receives a Short SSW packet indicating MU-MIMO transmission

determines that it is an intended recipient of the packet by matching the value of the Destination AID field

in the packet with a value of the EDMG Group ID field contained in the last received EDMG Group ID Set

element. In case a match is found, the EDMG STA is an intended recipient of the packet if its AID is

included in the EDMG Group ID field of the corresponding group. Otherwise, the EDMG STA is not an

intended recipient of the packet and can ignore the remaining of the I-TXSS and SISO Feedback subphase,

which can be done through the use of the value of the CDOWN and Setup Duration fields contained in the

received Short SSW packet.

The initiator shall perform the SISO Feedback subphase. If the I-TXSS is present, the SISO Feedback

subphase shall start MBIFS following the end of the I-TXSS subphase. During the SISO Feedback

subphase, the initiator transmits a BRP frame to poll each responder intended to be part of the MU group to

obtain a list of sectors per each TX DMG antenna, and their associated quality indicators, between the

initiator and each responder. A responder shall respond to a received BRP frame with a BRP frame, which

contains the sectors for each TX DMG antenna of the initiator and the sector’s corresponding quality

indicator. The BRP frame shall be transmitted SIFS following the reception of the corresponding BRP

frame.

**10.38.9.2.4.3 MIMO phase**

The MIMO phase shall consist of a downlink MIMO phase or of an uplink MIMO phase.

The downlink MIMO phase shall be supported by all EDMG STAs that are MU-MIMO capable. The uplink MIMO phase may be supported by EDMG STAs that are MU-MIMO capable.

The initiator shall start the MIMO phase MBIFS following the end of the SISO phase.

**10.38.9.2.4.3.1 Downlink MIMO phase**

The downlink MIMO phase is

shown in Figure 52 and consists of four subphases, namely, a downlink MU-MIMO BF setup subphase, a downlink MU

MIMO BF training subphase, a downlink MU-MIMO FB poll subphase, and a MU-MIMO selection subphase.

Each subphase shall be separated by MBIFS.

Based on the feedback from the SISO phase, in the downlink MU-MIMO BF setup subphase the initiator may

exclude some responders from the following downlink MU-MIMO BF training subphase and downlink MU-MIMO FB poll

subphase if the multiuser interference the responders are expected to suffer due to MU-MIMO transmission

is negligible. If all of the responders are excluded from the following downlink MU-MIMO BF training subphase and

downlink MU-MIMO FB poll subphase, these two subphases are not present in the downlink MIMO phase.

In the downlink MU-MIMO BF setup subphase, the initiator shall transmit a BF Setup frame to each intended

responder. The BF Setup frame indicates the AID of each remaining responder, the training type (downlink MU-MIMO BF training), a unique dialog token identifying MU-MIMO training, the number of simultaneous TX

DMG antennas employing orthogonal waveforms, the order in which transmit sectors are trained. To

reduce the downlink MU-MIMO training time, the initiator may select a subset of TX sectors for each DMG antenna

and the number of receive training fields based on the feedback from responders received at the SISO

phase. The initiator should transmit the minimum number of BF Setup frames to reach all responders. All

frames transmitted during the downlink MU-MIMO BF setup subphase should be sent using the DMG control mode.

A responder whose AID does not match any AID included in the received BF Setup frame can ignore

frames transmitted in the following downlink MU-MIMO BF training subphase and downlink MU-MIMO FB Poll subphase.

In the downlink MU-MIMO BF training subphase, the initiator shall transmit BRP frames using the EDMG PHY.

Each transmitted BRP frame is used to train one or more transmit sectors and, for each transmit sector, a

number of receive AWVs. In each BRP frame the initiator shall include, for each selected sector, TRN

Units in the TRN field for intended responders to perform receive sector training. The number of TRN-Unit

included in the TRN field should be the maximum number of receive sectors across all the remaining

intended responders based on the feedback from the SISO phase. An initiator may transmit a BRP frame

with orthogonal waveforms to train multiple (up to 4) transmit DMG antennas simultaneously through the

same BRP frame and hence reduce the training time. The downlink MU-MIMO BF training subphase is performed

by setting, for a BRP frame, the TXVECTOR parameter EDMG\_TRN\_LEN to a value greater than zero

and the parameter RX\_TRN\_PER\_TX\_TRN to a value greater than one.

In the downlink MU-MIMO FB poll subphase, the initiator shall transmit a BF Poll frame to poll each remaining

intended responder to collect MU-MIMO feedback from the preceding downlink MU-MIMO BF training subphase.

Each BF Poll frame and BF Feedback frame sent back by the responder shall be separated by SIFS. Each

BF Poll frame carries the dialog token that identifies the MU-MIMO training. The BF Feedback frame

carries the list of received initiator’s transmit DMG antennas/sectors, each with its corresponding

responder’s receive DMG antenna/sector and the associated quality indicated.

In the MU-MIMO selection subphase, the initiator shall transmit a BF Selection frame to each responder in

the MU group containing the dialog token identifying the downlink MU-MIMO training, one or multiple sets of the

MU transmission configurations, and the intended recipient STAs for each MU transmission configuration.

The final set of selected responders in the MU group contained in the BF Selection frame does not have to

be the same as the initial set of intended responders. The initiator should transmit the minimum number of

BF Selection frames to selected responders.

**10.38.9.2.4.3.2 Uplink MIMO phase**

The initiator may initiate an uplink MIMO phase procedure if the corresponding subfield (TBD) in initiator’s and intended recipients EDMG Capabilities element equals one (for this to hold it is required, at least, that the initiator has antenna pattern reciprocity). This might potentially shorten the MU-MIMO BF training duration.

The uplink MIMO phase is shown in Figure 53 and consists of three subphases, namely, an uplink MU-MIMO BF setup subphase, an uplink MU-MIMO BF training subphase and a MU-MIMO selection subphase. The frames used in the MU-MIMO selection subphase are the same as in Section 10.38.9.2.4.3.2. Each subphase shall be separated by MBIFS.



Figure 53.

Based on the feedback from the SISO phase, in the uplink MU-MIMO BF setup subphase the initiator may

exclude some responders from the following uplink MU-MIMO BF training subphase. This might happen

if the multiuser interference the responders are expected to suffer due to MU-MIMO transmission

is negligible or if they do not support the uplink MIMO BF training subphase. If all of the responders are excluded from the following uplink MU-MIMO BF training subphase, this subphase is not present in the uplink MIMO phase.

In the uplink MU-MIMO BF setup subphase, the BF Setup frame (same format as in Section 10.38.9.2.4.3.1, TBD) transmitted to each STA shall indicate the AID of each remaining responder, the training type (uplink MU-MIMO BF training), and a unique dialog token identifying MU-MIMO training. The initiator should transmit the minimum number of BF Setup frames to reach all responders. All

frames transmitted during the uplink MU-MIMO BF setup subphase should be sent using the DMG control mode. A responder whose AID is not present in the AID list of the BF Setup frame can ignore the subsequent uplink MU-MIMO BF training phase.

In the uplink MU-MIMO BF training subphase, the initiator shall transmit a BF Poll frame (TBD) to each STA in the MU group. Each

BF Poll frame carries the dialog token that identifies the MU-MIMO training. In the BF Poll frame, the L-RX field from the EDMG BRP Request element is set to a value larger than 0 by the initiator to train its receive AWVs. No transmit or receive AWV training is performed by the BF Poll frame. Upon receiving the BF poll frame, the responder shall transmit a single BRP-RX/TX frame to the initiator, where the TXVECTOR parameter EDMG\_TRN\_LEN is set to a value larger than zero and the parameter RX\_TRN\_PER\_TX\_TRN is set to the L-RX value received in the previous BF poll frame. Additionally, the BRP-RX/TX frame contains the number of simultaneous TX DMG antennas employing orthogonal waveforms. The BRP frame is used to train different transmit AWVs of the responder as well as receive AWVs of the initiator. Each BF poll frame and BRP-RX/TX frame sent by the responder shall be separated by SIFS.

**References:**

1. Training Protocols for DL MU-MIMO in 802.11ay (11-17-0419r1)