IEEE P802.11  
Wireless LANs

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Resolution to CIDs related to MIMO channel access | | | | |
| Date: 2018-05-07 | | | | |
| Author(s): | | | | |
| Name | Company | Address | Phone | email |
| Cheng Chen | Intel |  |  | cheng.chen@intel.com |
| Oren Kedem | Intel |  |  | oren.kedem@intel.com |
| Carlos Cordeiro | Intel |  |  | carlos.cordeiro@intel.com |
| Claudio da Silva | Intel |  |  | claudio.da.silva@intel.com |

Abstract

This submission proposes spec text revisions for the section of MIMO channel access, which also serves as resolutions to 32 CIDs related to MIMO channel access. These CIDs include:

1228 1229 1230 1372 1373 1378 1379 1409 1681 1897 2005 2182 2338 1405 1406 1407 1475 2291 1476 1477 1478 1479 1570 1654 1655 1782 1783 2292 1894 2293 2294 2296

The CIDs are in reference to Draft IEEE P802.11ay/D1.0. The resolutions are in reference to Draft IEEE P802.11ay/D1.1.

|  |  |  |  |
| --- | --- | --- | --- |
| CID | Clause | Comment | Proposed change |
| 1228 | Page 139, Line 24 | "An EDMG STA that has either the MU-MIMO Supported set to 1"  this is inadequate for normative specification. It is kind-of using the name of a field as a proxy for a capability. | Reword e.g. "An EDMG STA that transmits an EDMG Capability element with either the MU-MIMO Supported field equal to 1..." or reword in terms of MIB variable values, as I anticipate most of the capabilities will be reflected in MIB values when the group finally gets around to writing a MIB.  Make similar changes to the other two "Supported set to 1" in this subclause. |

**Proposed resolution:** Revised

1. See proposed draft text in this document.

|  |  |  |  |
| --- | --- | --- | --- |
| CID | Clause | Comment | Proposed change |
| 1229 | Page 141, Line 03 | A 13-line paragraph is hard to accurately digest. | Recommend that the editor looks for structural ways to improve over-long paras, such as turning into a dashed list. |

**Proposed resolution:** Revised

1. See proposed draft text in this document.

|  |  |  |  |
| --- | --- | --- | --- |
| CID | Clause | Comment | Proposed change |
| 1372 | 10.36.11.4.2 | "which are determined by the MIMO beamforming protocols" - the language is (slightly) confusing. They were previously determined by applying the beamforming protocols | replace "which are determined by the MIMO beamforming protocols" by "which have been determined by applying the beamforming protocols" |

**Proposed resolution:** Accepted

|  |  |  |  |
| --- | --- | --- | --- |
| CID | Clause | Comment | Proposed change |
| 1373 | 10.36.11.4.2 | "When the channel is clear for SISO transmission (physical and virtual 2 CS are clear) and the backoff timer reaches 0" - The referenced 10.3 and 10.22.2 do discuss SISO transmission. The assumption is that all (active) RX/TX chain are part of CCA sensing and NAV setting. If a device can transmit a SISO PPDU, it can transmit a MIMO PPDU. | replace this subclause by saying "MIMO access ruels are the same as SISO access rules" or define access according to RX/TX chains. Submission will be provided |

**Proposed resolution:** Rejected

1. The assumption that all (active) RX/TX chains are part of CCA setting and NAV setting is not necessarily true. Therefore, it is not true that “If a device can transmit a SISO PPDU, it can transmit a MIMO PPDU”.

|  |  |  |  |
| --- | --- | --- | --- |
| CID | Clause | Comment | Proposed change |
| 1230 | Page 142 Line 1 | The editor's note says it all. | Define "small delay" at 141.26 in terms of existing <x>IFS values. |
| 1378 | 10.36.11.4.3 | "This RTS frame should be transmitted using all SU-MIMO sectors, with a small delay between each sector." - This is extremely opaque, small delay is undefined, also SU-MIMO sectors are also undefined. | replace with "This RTS frame should be transmittted using the same set of antennas and antenna setting planned to be used during the SU-MIMO transmission and a CSD between the transmission in different antennas as defined in 30.4.6.2." |
| 1379 | 10.36.11.4.3 | "The DMG CTS frame should be transmitted using all SU-MIMO sectors, with a small delay between each sector" - extremely opaque. Small delay is undefined, also SU-MIMO sectors are undefined. | replace with "The DMG CTS frame should be transmitted using the same set of atennas and antenna settings planned to be sued during the SU-MIMO transmission and a CSD between the transmission in different antennas as defined in 30.4.6.2." |
| 1409 | 10.36.11.4.3 | The "small delay" needs to be clarified. Similar to what is defined in MU-MIMO case, maybe just call it SU-MIMO antenna setting. | See the advice provided in comment. |
| 1681 | 10.36.11.4.3 | What is a "small delay"? This needs to be defined | Define small delay. |
| 1897 | 10.36.11.4.3 | Editor Note: what is a "small delay"? This needs to be defined. | Address editor comment |
| 2005 | 10.36.11.4.3 | It is not clear for "with a small delay between each sector". If "small delay" refers to CSD, need to refer to the related subclause. | Please clarify it. |
| 2182 | 10.36.11.4.3 | calls out small delay between each sector in text. Small delay not defined. | Define "Small delay”. See note to editor. |
| 2338 | 10.36.11.4.3 | Please remove "small delay" per Editor's Note. | Please replace "small delay" with a specific value or range of values. |

**Proposed resolution:** Accept the proposed resolution in CID 1378, and see the proposed draft text in this document.

|  |  |  |  |
| --- | --- | --- | --- |
| CID | Clause | Comment | Proposed change |
| 1405 | 10.36.11.4.4 | Similar to what is described in SU-MIMO channel access procedure section, here in MU-MIMO channel access procedure section, the use of Grant/Grant Ack frame before the channel access initiation should also be stated. Particularly for those STAs whose Grant Required field within the EDMG Capabilities element is set to 1. | Add statements similar to the first three paragraphs in the SU-MIMO channel access procedure section to describe the use of Grant/Grant Ack frame. |

**Proposed resolution:** Revised, and see the proposed text in this document.

|  |  |  |  |
| --- | --- | --- | --- |
| 1406 | 10.36.11.4.3 | "The control trailer also indicates the corresponding DMG antenna configuration for the upcoming SU-MIMO transmission or hybrid beamforming."---Table 52 defines the TX Sector Combination Index that indicates the TX sector combination and the corresponding RX AWVs to be used in the following SU-MIMO transmission. Here it should be explicitly pointed out that this field will be used. | Explicitly states that the "TX Sector Combination Index" field in the control trailer will be used. |

**Proposed resolution:** Revised, and see the proposed text in this document.

|  |  |  |  |
| --- | --- | --- | --- |
| 1407 | 10.36.11.4.4 | Except for the EDMG Group ID field, the MU-MIMO Transmission Configuration field Type and MU-MIMO Transmission Configuration Index field in the Control Trailer shall also be set accordingly, since as defined in 9.4.2.262, a MU group associated with an EDMG Group ID can have multiple different configuration indexes. | Add corresponding statements about the mentioned fields in comment apart from EDMG Group ID. |

**Proposed resolution:** Revised, and see the proposed text in this document.

|  |  |  |  |
| --- | --- | --- | --- |
| CID | Clause | Comment | Proposed change |
| 1475 | 10.36.11.4.2 | This phrase makes no sense. "that sensed at least all the MIMO TX antennas was BUSY." "At least all" would seem to mean the same as "all". Is that what is meant? | Change "all" to "one". |
| 2291 | 10.36.11.4 | should be one of the MIMO TX antennas | change to 'one of' |

**Proposed resolution:** Accepted

|  |  |  |  |
| --- | --- | --- | --- |
| CID | Clause | Comment | Proposed change |
| 1476 | 10.36.11.4.2 | 802.11n and 802.11ac managed to operate MIMO in billions of devices without a MIMO access procedure. It is not at all clear why this is necessary for all 802.11ay devices. | Make the SU-MIMO channel access procedure entirely optional. Allow devices to transmit MIMO frames without it. |

**Proposed resolution:** Rejected

1. 11n and 11ac are operating in the lower bands and omni reception and transmission are dominant, and it is easy for devices to hear the activities nearby. In 11ay where operations happen in higher bands, most data transmissions are performed in a directional way. Moreover, the SU-MIMO responder STA has to configure its antennas accordingly prior to a MIMO transmission. Without the SU-MIMO channel access, it has no way to know a MIMO transmission is upcoming. As a result, channel access is needed here.

|  |  |  |  |
| --- | --- | --- | --- |
| CID | Clause | Comment | Proposed change |
| 1477 | 10.36.11.4.3 | It would make the paragraph much clearer to put this phrase first "Otherwise if the Grant Required field within the peer STA's EDMG Capabilities is zero, the STA may transmit a Grant frame." | Re-write this paragraph. |

**Proposed resolution:** Revised, and see the proposed text in this document.

|  |  |  |  |
| --- | --- | --- | --- |
| CID | Clause | Comment | Proposed change |
| 1478 | 10.36.11.4.3 | The requirement to transmit an RTS frame in all SU-MIMO sectors is unnecessary. Also the "small delay" between sectors is ambiguous. | Remove the first 2 sentences of this paragraph. |
| 1479 | 10.36.11.4.3 | The requirement to transmit a CTS frame in all SU-MIMO sectors is unnecessary. Also the "small delay" between sectors is ambiguous. | Remove this sentence |

**Proposed resolution:** Rejected

1. NAV protection is needed in all channels that will be used during the SU-MIMO transmission.

|  |  |  |  |
| --- | --- | --- | --- |
| CID | Clause | Comment | Proposed change |
| 1570 | 10.36.11.4.2 | please clarify SISO definition is based on one transmit antenna or one spatial stream. | please clarify it SISO is for single antenna or single stream case or move 2.16+2.16GHz and 4.32+4.32 GHz to MIMO case |

**Proposed resolution:** Rejected

1. Section 3.2 in D1.1 already defines SISO as follows:

**single input, single output (SISO)**: A physical layer (PHY) configuration in which both transmitter and receiver use a single antenna.

|  |  |  |  |
| --- | --- | --- | --- |
| CID | Clause | Comment | Proposed change |
| 1654 | 10.36.11.4.3 | In this section, when an EDMG STA is mentioned, it seems better and much clearer to use SU-MIMO initiator/responder as illustrated in the example Figure. | Please revise |

**Proposed resolution:** Revised, and see the proposed text in this document.

|  |  |  |  |
| --- | --- | --- | --- |
| CID | Clause | Comment | Proposed change |
| 1655 | 10.36.11.4.4 | there seems no carrier sensing from the client side for the MU-MIMO channel access before sending back DMG CTS. It might be better to explicitly spell this out. | Is it safe for the clients? Please clarify |

**Proposed resolution:** Revised, and see the proposed text in this document.

|  |  |  |  |
| --- | --- | --- | --- |
| CID | Clause | Comment | Proposed change |
| 1782 | 10.36.11.4 | MIMO set up procedure for TDD channel access is not defined. We have to define a procedure to enable MIMO without immediate response. | Please consider to define MIMO setup procedures for TDD channel access. |

Discussion:

1. The CTS-to-self without response option defined in MU-MIMO channel access procedure enables MU-MIMO channel access within a TDD SP.
2. We can also enable the CTS-to-self without response option in SU-MIMO channel access procedure to enable SU-MIMO channel access within a TDD SP.

**Proposed resolution:** Revised, and see the proposed text in this document.

|  |  |  |  |
| --- | --- | --- | --- |
| CID | Clause | Comment | Proposed change |
| 1783 | 10.36.11.4 | Subclause 10.36.11.4.2 talks about MIMO channel access rules. It seems that all rules described here are assuming the MIMO is used in CBAP. There should be some description specifying how EDMG STA shall use MIMO in SP. | Please add MIMO channel access rules for SP. |
| 2292 | 10.36.11.4.3 | Whether this Grant frame can be sent in a SP?  In 9.5.2, it is required to set such Grant frame with RA=broadcast address. However, the information in CT is only meaningful if it is addressed to a specific (group of ) STA | Clarify in what type of allocation this procedure can happen, or modify 9.5.2 to allow this procedure in a SP |

**Discussion:**

1. The existing MIMO channel access procedures should also be applicable to SP.
2. The transmission of the Grant frame is not within the SP that will be performing MIMO transmissions. It is sent by the initiator before the SP. When the SP starts, the initiator can directly initiate MIMO channel access and strat MIMO transmission.

**Proposed resolution:** Revised. Adding a constraint that the Grant frame is sent in a CBAP before the SU/MU-MIMO channel access begins. See the proposed text in this document.

|  |  |  |  |
| --- | --- | --- | --- |
| CID | Clause | Comment | Proposed change |
| 1894 | 10.36.11.4.2 | Based on the statement "The parameter value is BUSY if the assessment of the channel by the PHY determines that the channel on at least one of the MIMO TX antennas is not idle." MIMO transmission may fail in a congested environment. Is it possible to modify the behavior to just drop the offending transmission? This may be especially important in MU-MIMO transmission. | Modify behavior so that if one of the MIMO Tx antennas is busy, it may be dropped from the transmission and data may be transmitted to the other DMG antennas |

**Proposed resolution:** Rejected

1. If just dropping the DMG antennas that are busy, continuing using the orginal AWVs will typically not work since it is not the appropriate AWVs for the remaining subset of DMG antennas.
2. There is no data or other evidence to verify that dropping the busy DMG antennas and continue the MIMO transmission using the original AWVs will bring any benefits.

|  |  |  |  |
| --- | --- | --- | --- |
| CID | Clause | Comment | Proposed change |
| 2293 | 10.36.11.4.3 | why it is 'not able to perform SU-MIMO transmission'? | change to 'SU-MIMO reception' |

**Proposed resolution:** Accepted

|  |  |  |  |
| --- | --- | --- | --- |
| CID | Clause | Comment | Proposed change |
| 2294 | 10.36.11.4.3 | How do CT of Grant Ack and DTS indicate MIMO is temporarily disabled? | change the figure to match the content of the CT defined in table 51 and 52  or add in Description which fields in table 51 and 52 serve this purpose |

**Proposed resolution:** Revised, and see the proposed text in this document.

|  |  |  |  |
| --- | --- | --- | --- |
| CID | Clause | Comment | Proposed change |
| 2296 | 10.36.11.4.4 | For the STA addressed by the DMG CTS frame to successfully receive the frame'  The successful reception of DMG CTS is also useful for 3rd party STAs | Change the sentence to 'For the successful reception of the DMG CTS frame' |

**Proposed resolution:** Accepted

**10.36.11.4 MIMO Channel Access**

**10.36.11.4.1 General**

This subclause describes the MIMO channel access mechanisms that are applicable to EDMG STAs. General MIMO channel access rules are defined in 10.36.11.4.2. The SU-MIMO channel access procedure and the MU-MIMO channel access procedure are specified in 10.36.11.4.3 and 10.36.11.4.4, respectively, and both procedures shall follow the MIMO channel access rules specified in 10.36.11.4.2.

In this subclause, the EDMG STA that obtains a TXOP or is the source STA of an allocated SP, and initiates MIMO channel access procedures is referred to as the initiator, and the EDMG STA(s) that is the intended receiver(s) of the MIMO transmission of the initiator is referred to as the responder(s).

**10.36.11.4.2 MIMO channel access rules**

An EDMG STA that has either the MU-MIMO Supported subfield set to 1 or the SU-MIMO Supported subfield set to 1 in the Beamforming Capability field of its EDMG Capabilities element shall maintain physical and virtual CS and backoff procedure as specified in 10.22.2 (HCF contention based channel access (EDCA)) in order to be able to transmit and receive a single stream (SISO) PPDU used for the establishment of a TXOP during which a MIMO transmission is to take place.

When an EDMG STA that has either the MU-MIMO Supported set to 1 or the SU-MIMO Supported set to 1 in the Beamforming Capability field of its EDMG Capabilities attempts to obtain a TXOP for MIMO transmission, CCA shall be maintained such that at least all the MIMO TX antennas intended to be used in the TXOP, which have been determined by applying the beamforming protocols defined in 10.38.9.2.2 or in 10.38.9.2.3, are observed. The STATE parameter of PHY-CCA.indication can be one of two values: BUSY or IDLE. The parameter value is BUSY if the assessment of the channel by the PHY determines that the channel on at least one of the MIMO TX antennas is not idle. The parameter value is IDLE if the assessment of the channel on all the MIMO TX antennas by the PHY determines that the channel is idle.

In the following, “MIMO channel was idle for an interval of PIFS” means that the STATE parameter of the most recent PHY-CCA.indication primitive that sensed at least all the MIMO TX antennas was IDLE for a period of PIFS that ends at the start of the transmission. “MIMO channel was busy” means that the STATE parameter of the most recent PHY-CCA.indication primitive that sensed at least one of the MIMO TX antennas was BUSY.

The initiator uses the procedures in 10.3 and 10.22.2 to obtain a TXOP, or use the procedures in 11.4.13 to obtain an SP allocation prior to initiating MIMO channel access. When the channel is clear for SISO transmission (physical and virtual CS are clear) for the corresponding DMG antenna that is used for SISO transmission and the backoff timer reaches 0, a STA is permitted to obtain a TXOP.

In the case of TXOP, if the initiator has at least one MSDU pending for transmission during the permitted TXOP, the initiator shall perform exactly one of the following actions:

* Transmit a MIMO PPDU if the MIMO channel was idle for an interval of PIFS immediately preceding the start of the TXOP.
* Transmit a SISO PPDU using the same DMG antenna that obtains the TXOP if the MIMO channel was busy during an interval of PIFS immediately preceding the start of the TXOP.
* Restart the channel access attempt by invoking the backoff procedure as specified in 10.22.2 (HCF contention based channel access (EDCA)) as though the medium is busy as indicated by either physical or virtual CS and the backoff timer has a value of 0.

In the case of SP, if the initiator has at least one MSDU pending for transmission during the SP, the initiator transmits a MIMO PPDU at the start of the SP.

If the Grant Required field within a responder’s EDMG Capabilities element is one, the initiator shall transmit a Grant frame with a control trailer in a CBAP to this responder before initiating MIMO channel access, to indicate the intent to transmit a MIMO PPDU to the responder or announce the start of the hybrid beamforming protocol. Otherwise if the Grant Required field within a responder’s EDMG Capabilities is zero, the initiator may transmit a Grant frame to the responder.

In the transmitted Grant frame, the value of the Allocation Duration field plus the Duration field of the Grant frame indicates the estimated time offset from the PHY-TXEND.indication primitive of the Grant frame transmission when the initiatorintends to initiate access to the channel to transmit to or start the hybrid beamforming protocol with the responder. For the transmitted Grant frame, the TXVECTOR parameter SCRAMBLER\_INIT\_SETTING shall be set to CONTROL\_TRAILER and the parameter CT\_TYPE shall be set to GRANT\_RTS\_CTS2Self. The SISO/MIMO field shall be set to 1 and the SU/MU MIMO field shall be set to 0 to indicate that the following transmission or hybrid beamforming is performed in SU-MIMO, or set to 1 to indicate the following transmission or hybrid beamforming is performed in MU-MIMO. The control trailer shall also indicate the corresponding DMG antenna configuration for the upcoming MIMO transmission or hybrid beamforming.

If an EDMG STA receives a Grant frame with a control trailer indicating a SU-MIMO or MU-MIMO transmission or hybrid beamforming announcement to itself and is able to perform the SU-MIMO or MU-MIMO reception, or hybrid beamforming at the target time indicated by the Grant frame, it shall:

* Configure its DMG antennas according to the settings included in the control trailer of the received Grant frame within a time period determined by the value of the Allocation Duration field plus the value of the Duration field of the received Grant frame starting from the PHY-TXEND.indication primitive of the Grant frame transmission.
* Transmit a Grant Ack frame in response to the received Grant frame. For this transmitted Grant Ack frame, the TXVECTOR parameter SCRAMBLER\_INIT\_SETTING shall be set to CONTROL\_TRAILER and the parameter CT\_TYPE shall be set to GRANT\_RTS\_CTS2Self.
* If it uses SU-MIMO for the transmission of the reverse direction or desires to announce the hybrid beamforming protocol in the reverse direction, the SISO/MIMO field shall be set to 1. In this case, the control trailer shall indicate the corresponding DMG antenna configuration for the upcoming SU-MIMO transmission in the reverse direction. If the responder STA intends to use SISO for the transmission in the reverse direction, the SISO/MIMO field shall be set to 0.

**10.36.11.4.3 SU-MIMO channel access procedure**

An EDMG STA is SU-MIMO capable if the SU-MIMO Supported field in the STA’s EDMG Capabilities element is set to 1. The SU-MIMO channel access procedure describes how an SU-MIMO capable initiator and an SU-MIMO capable responder access the channel to start exchanging one or more EDMG SU PPDUs using SU-MIMO, and also describes how an SU-MIMO capable initiator and responder that are also hybrid beamforming capable (see 10.39.9.2.4) start an hybrid beamforming protocol.

Prior to initiating the SU-MIMO channel access with a responder, the initiator shall perform SU-MIMO beamforming with the responder (see 10.39.9.2.2).

An EDMG STA initiates SU-MIMO channel access, by transmitting an RTS frame or a DMG CTS-to-self frame to the intended SU-MIMO responder. The SU-MIMO initiator shall transmit the RTS frame or DMG CTS-to-self frame with a control trailer to the SU-MIMO responder. The RTS frame or DMG CTS-to-self frame shall be transmitted using the same set of DMG antennas and antenna configuration planned to be used during the SU-MIMO transmission and a CSD between the transmissions in different antennas as defined in 30.4.6.2. For the transmitted RTS frame or DMG CTS-to-self frame, the TXVECTOR parameter SCRAMBLER\_INIT\_SETTING shall be set to CONTROL\_TRAILER and the parameter CT\_TYPE shall be set to GRANT\_RTS\_CTS2Self. In the control trailer, the SISO/MIMO field shall be set to 1 and the SU/MU MIMO field shall be set to 0 to indicate that the following transmission or hybrid beamforming is performed in SU-MIMO. The Tx Sector Combination Index field shall indicate the corresponding DMG antenna configuration for the upcoming SU-MIMO transmission or hybrid beamforming.

If a responder receives an RTS frame with a control trailer indicating a SU-MIMO transmission or hybrid beamforming to itself and is able to perform the SU-MIMO reception, it shall:

* Configure its DMG antennas according to the settings included in the Tx Sector Combination Index field in the control trailer of the received RTS frame.
* Transmit a DMG CTS frame with a control trailer in response of the received RTS frame. For this transmitted DMG CTS frame, the TXVECTOR parameter SCRAMBLER\_INIT\_SETTING shall be set to CONTROL\_TRAILER and the parameter CT\_TYPE shall be set to CTS\_DTS.
* If the responder uses SU-MIMO for the transmission in the reverse direction, the SISO/MIMO field in the control trailer shall be set to 1 and the SU/MU MIMO field shall be set to 0. The Tx Sector Combination Index field shall indicate the corresponding DMG antenna configuration for the upcoming SU-MIMO transmission in the reverse direction.The DMG CTS frame shall be transmitted using the same set of DMG antennas and antenna configuration planned to be used during the SU-MIMO transmission and a CSD between the transmissions in different antennas as defined in 30.4.6.2. If it uses SISO for the transmission of the reverse direction, the SISO/MIMO field shall be set to 0. The DMG CTS frame shall be sent using the SISO antenna setting.

Alternatively, if the responder is not able to perform the SU-MIMOreception, it may transmit a DMG DTS frame with a control trailer to the initiator to provide further information. The DMG DTS frame shall be sent usingthe SISO antenna setting.

A responder that receives a DMG CTS-to-self frame with a control trailer indicating a SU-MIMO transmission or hybrid beamforming to itself shall:

* Configure its DMG antennas according to the settings included in the Tx Sector Combination Index field in the control trailer of the received CTS-to-self frame.
* The SU-MIMO transmission or hybrid beamforming begins SIFS interval following the end of the DMG CTS-to-self frame transmission by the initiator.

Figure 102 and Figure 103 illustrate examples of frame exchange sequence using the SU-MIMO channel access procedure.

The SU-MIMO initiator may send a CF-END frame to reset the NAV and release the remaining time of the TXOP. The CF-END frameshall be sent using the same set of DMG antennas and antenna configuration during the SU-MIMO transmission and a CSD between the transmissions in different antennas as defined in 30.4.6.2.



Figure 102---SU-MIMO channel access procedure when RTS/DMG CTS is used



Figure 103---SU-MIMO channel access procedure when DMG CTS-to-self is used

**10.37.11.4.4 MU-MIMO channel access procedure** An EDMG STA is MU-MIMO capable if the MU-MIMO Supported field in the STA’s EDMG Capabilities element is set to 1. The MU-MIMO channel access procedure describes how an MU-MIMO capable initiator and multiple MU-MIMO capable responders access the channel to start exchanging one or more EDMG MU PPDUs, and also describes how an MU-MIMO capable initiator and multiple MU-MIMO capable responders that are also hybrid beamforming capable (see 10.39.9.2.4) start the hybrid beamforming protocol.

Prior to initiating the MU-MIMO channel access with a set of responder STAs within an MU group, the initiator shall:

* Include the MU group within the EDMG Group ID Set element and communicate the resulting element to the STAs in the BSS (see 10.39.9.2.3.1).
* Perform MU-MIMO beamforming with the responders of the MU group (see 10.39.9.2.3).

An EDMG STA initiates MU-MIMO channel access, by transmitting an RTS frame or a DMG CTS-to-self frame to the intended MU-MIMO group of responders. The EDMG STA shall transmit the RTS frame or DMG CTS-to-self frame with a control trailer to the group of responders. The RTS or DMG CTS-to-self frame shall be transmitted using the the same set of DMG antennas and antenna configuration planned to be used during the MU-MIMO transmission and a CSD between the transmissions in different antennas as defined in 30.4.6.2. For the transmitted RTS or DMG CTS-to-self frame, the TXVECTOR parameter SCRAMBLER\_INIT\_SETTING shall be set to CONTROL\_TRAILER and the parameter CT\_TYPE shall be set to GRANT\_RTS\_CTS2self. In the control trailer, the SISO/MIMO field shall be set to 1, and the SU/MU MIMO field shall be set to 1 to indicate that the following transmission or hybrid beamforming is performed in MU-MIMO.. The EDMG Group ID field shall be set to the value that identifies the corresponding group of responders that are the intended destinations of the EDMG MU PPDU to be transmitted. The MU-MIMO Transmission Configuration Type field and the MU-MIMO Transmission Configuration Index field indicate the corresponding DMG antenna configuration for the upcoming MU-MIMO transmission or hybrid beamforming.The RA field of the RTS shall be set to the broadcast MAC address. After transmitting the RTS frame, the initiator should configure its receive antenna to quasi-omni receive pattern to receive the DMG CTS frames.

If a responder receives an RTS frame addressed to an MU group that the STA belongs to and is able to perform the MU-MIMO reception, it shall:

* Transmit a DMG CTS frame back to the initiator employing the most recent SISO antenna configuration used between the responder and the initiator. The TA field of the DMG CTS shall be set to the broadcast MAC address and the Scrambler Initialization field shall be set to the same value as the Scrambler Initialization field of the PPDU that contained in the received RTS frame.
* For the successful reception of the DMG CTS frame, the difference in time between all the DMG CTS transmissions as measured at the receiving STA should be no more than ±30 ns. A STA that transmits the DMG CTS should pre-compensate for carrier frequency offset (CFO) error. After compensation, the absolute value of residual CFO error with respect to the RTS should not exceed 12 KHz.
* Following transmission of the DMG CTS, the responder shall then configure its antennasaccording to the settings indicated in the the MU-MIMO Transmission Configuration Type field and the MU-MIMO Transmission Configuration Index field in the control trailer of the received RTS frame.
* The MU-MIMO transmission or hybrid beamforming protocol begins SIFS interval following the reception or expected reception of the DMG CTS frame by the initiator. This is shown in Figure 104.

A responder that receives a DMG CTS-to-self frame addressed to an MU group that the STA belongs to shall:

* Configure its antennasaccording to the settings indicated in the the MU-MIMO Transmission Configuration Type field and the MU-MIMO Transmission Configuration Index field in the control trailer of the received CTS-to-self frame..
* The MU-MIMO transmission or hybrid beamforming begins SIFS interval following the end of the DMG CTS-to-self frame transmission by the initiator. This is shown in Figure 105.

A responder that receives an RTS frame or a DMG CTS-to-self frame addressed to an MU group that the STA belongs to shall expect to receive and transmit PPDUs in the bandwidth indicated in the BW field in the control trailer appended to the RTS frame or DMG CTS-to-self frame.

Section 10.3.2.12 describes the MU PPDU acknowledgement procedure.

The initiator may send a CF-End frame to one or more responders in an MU-MIMO TXOP to truncate the TXOP



Figure 104---MU-MIMO channel access flow when RTS/DMG CTS is used



Figure 105---MU-MIMO channel access flow when DMG CTS-to-self is used

**Straw Poll:**

* **Do you agree to accept comment resolutions and the proposed text in doc 11-18/0723r1?**