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| Beamforming for mmWave Distributed Network |
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Abstract

This document proposes 11ay draft specification text on Beamforming training for TDD Distributed Network as described in (11-17-1646-01-00ay-beamforming-for-mmwave-distribution-networks).

*Change the following subclause*

**6.3.3.2 MLME-SCAN.request**

**6.3.3.2.2 Semantics of the service primitive**

The primitive parameters are as follows:

MLME-SCAN.request(

BSSType,

BSSID,

SSID,

ScanType,

ProbeDelay,

ChannelList,

MinChannelTime,

MaxChannelTime,

ScanSectorList,

SectorDwellTime,

RequestInformation,

SSID List,

ChannelUsage,

AccessNetworkType,

HESSID,

MeshID,

DiscoveryMode,

VendorSpecificInfo

)

|  |  |  |  |
| --- | --- | --- | --- |
| **Name** | **Type** | **Valid range** | **Description** |
| … |  |  |  |
| ScanType | Enumeration | ACTIVE, PASSIVE, TDD PASSIVE | Indicates either active, passive or TDD passive Scanning |
| ….. |  |  |  |
| MaxChannelTime | … |  |  |
|  |  |  |  |
| ScanSectorIDList | List of Sector configurations  | Each sector configuration is a valid configuration for the scanning STA. | Sector configurations, in no particular order, to be used during the scan using TDD beamforming. |
| SectorDwellTime | Integer | N/A | The time (in microseconds) to dwell on each sector during TDD beamfoming. |
| RequestInformation | … |  |  |
| … |  |  |  |

*Insert the following subclause*

**6.3.XX TDD beamforming
6.3.XX.1 General**This subclause describes the management procedures associated with TDD beamforming.

**6.3.XX.2 MLME-TDD-BF-TRAINING.request
6.3.XX.2.1 Function**

This primitive requests that TDD beamforming training occur with a peer STA.

**6.3.XX.2.2 Semantics of the service primitive**The primitive parameters are as follows:

MLME-TDD-BF-TRAINING.request (

PeerSTAAddress,

BeamformingStartTimestamp,

TXSectorIDList,

SectorRepetitions

)

|  |  |  |  |
| --- | --- | --- | --- |
| **Name**  | **Type**  | **Valid range**  | **Description** |
| PeerSTAAddress  | MACAddress  | Any valid individualMAC address | Specifies the address of the peerMAC entity with which to perform TDD beamforming training. |
| BeamformingStartTimestamp  | Integer | N/A | Timestamp that indicates when the TDD beamforming procedure should be started by the STA |
| TXSectorIDList | List of Sector ID configurations  | Each sector configuration is a valid configuration for the transmitting STA. | Sector ID configurations, in no particular order, to be used during the TDD beamforming transmission. |
| SectorRepetitions  | Integer  | 1 - 1024 | Indicates the number of repetitions for each TX Sector ID being utilized.  |

**6.3.XX.2.3 When generated**

This primitive is generated by the SME to request that TDD beamforming training be performed with a peer STA.

**6.3.XX.2.4 Effect on receipt**On receipt of this primitive, the MLME invokes the MAC sublayer TDD beamforming training procedures
defined in 10.38.

**6.3.XX.3 MLME-TDD-BF-TRAINING.confirm
6.3.XX.3.1 Function**

This primitive reports the outcome of a requested TDD beamforming training procedure.

**6.3.95.3.2 Semantics of the service primitive**The primitive parameters are as follows:

MLME-TDD-BF-TRAINING.confirm (

PeerSTAAddress,

NumberOfTDDFeedbacks,

TDDFeedback,

ResultCode

)

|  |  |  |  |
| --- | --- | --- | --- |
| **Name**  | **Type**  | **Valid range**  | **Description** |
| PeerSTAAddress  | MACAddress  | Any valid individualMAC address | Specifies the address of the peerMAC entity with whichTDD beamforming training was performed or attempted. |
| NumberOfTDDFeedbacks | Integer | 0 - 1024 | Indicates the number of TDD Feedbacks included.  |
| TxBeamFeedback | Set of Tx Beam Feedback fields | As defined in 9.4.2.xxx1 (TDD Route element) | Zero or more Tx Beam Feedback fields are present.  |
| ResultCode  | Enumeration  | SUCCESS, FAILURE | Indicates the result of the TDDbeamforming procedure. |

**6.3.XX.3.3 When generated**

This primitive is generated by the MLME to report the result of TDD beamforming training with a peer STA.

**6.3. XX.3.4 Effect on receipt**

The SME is notified of the result of the procedure.

**6.3.XX.4 MLME-TDD-BF-TRAINING.indication
6.3.XX.4.1 Function**

This primitive indicates that TDD beamforming training with a peer STA, and at the request of that peer, has
completed

.
**6.3.XX.4.2 Semantics of the service primitive**The primitive parameters are as follows:

MLME-BF-TRAINING.indication (

PeerSTAAddress,

NumberOfTDDFeedbacks,

TDDFeedback,

ResultCode

)

|  |  |  |  |
| --- | --- | --- | --- |
| **Name**  | **Type**  | **Valid range**  | **Description** |
| PeerSTAAddress  | MACAddress  | Any valid individualMAC address | Specifies the address of the peerMAC entity with which TDD beamforming training was performedor attempted. |
| NumberOfTDDFeedbacks | Integer | 0 – 1024 | Indicates the number of TDD Feedbacks included.  |
| TxBeamFeedback | Set of Tx Beam Feedback fields | As defined in 9.4.2.xxx1 (TDD Route element) | One or more Tx Beam Feedback fields are present.  |
| ResultCode  | Enumeration  | SUCCESS, FAILURE | Indicates the result of the TDDbeamforming procedure. |

**6.3.XX.4.3 When generated**

This primitive is generated by the MLME to indicate that results of TDD Beamforming training procedure was initiated by the peer STA.

**6.3.XX.4.4 Effect on receipt**The SME is notified of the result of the procedure.

**6.3.XX TDD Sector Switch
6.3.XX.1 General**

This subclause describes the management procedures associated with TDD sector switch.

**6.3.XX.2 MLME-TDD-SECTOR-SWITCH.request
6.3.XX.2.1 Function**

This primitive requests that a sector switch be performed with a peer STA.

**6.3.XX.2.2 Semantics of the service primitive**The primitive parameters are as follows:

MLME-TDD-SECTOR-SWITCH.request (

PeerSTAAddress,

SectorSwitchTimestamp,

SectorRevertTimestamp,

InitiatorTXSectorID,

InitiatorRXSectorID,

ResponderTXSectorID,

ResponderRXSectorID

)

|  |  |  |  |
| --- | --- | --- | --- |
| **Name**  | **Type**  | **Valid range**  | **Description** |
| PeerSTAAddress  | MACAddress  | Any valid individualMAC address | Specifies the address of the peerMAC entity with which to perform TDD sector switch procedure. |
| SectorSwitchTimestamp | Integer | N/A | Timestamp that indicates when the sector switch should take effect |
| SectorRevertTimestamp | Integer | N/A | Timestamp that indicates when the sector revert should take effect in case of failure. The timestamp indicated by SectorRevertTimestamp is always later than the timestamp indicated by SectorSwitchTimestamp. |
| InitiatorTXSectorID | Integer  | 0 – 1023 | Indicates the TX Sector ID to be utilized by the initiator STA.  |
| InitiatorRXSectorID | Integer  | 0 – 1023 | Indicates the RX Sector ID to be utilized by the initiator STA.  |
| ResponderTXSectorID | Integer  | 0 – 1023 | Indicates the TX Sector ID to be utilized by the responder STA.  |
| ResponderRXSectorID | Integer  | 0 – 1023 | Indicates the RX Sector ID to be utilized by the responder STA.  |

**6.3.XX.2.3 When generated**

This primitive is generated by the SME to request that a sector switch be performed with a peer STA.

**6.3.XX.2.4 Effect on receipt**On receipt of this primitive, the MLME invokes the MAC sublayer sector switch procedure defined in 11.XX.

**6.3.95.4 MLME-TDD- SECTOR-SWITCH.indication
6.3.95.4.1 Function**

This primitive indicates that a TDD sector switch request or a TDD sector switch acknowledgement has been received successfully.

.
**6.3.95.4.2 Semantics of the service primitive**The primitive parameters are as follows:

MLME- SECTOR-SWITCH.indication (

PeerSTAAddress,

SectorSwitchTimestamp,

SectorRevertTimestamp,

InitiatorTXSectorID,

InitiatorRXSectorID,

ResponderTXSectorID,

ResponderRXSectorID

)

|  |  |  |  |
| --- | --- | --- | --- |
| **Name**  | **Type**  | **Valid range**  | **Description** |
| PeerSTAAddress  | MACAddress  | Any valid individualMAC address | Specifies the address of the peerMAC entity with the indication was received  |
| SectorSwitchTimestamp | Integer | N/A | Future timestamp which indicates when the sector switch should takes effect |
| SectorRevertTimestamp | Integer | N/A | Timestamp that indicates when the sector revert should take effect in case of failure. The timestamp indicated by SectorRevertTimestamp is always later than the timestamp indicated by SectorSwitchTimestamp. |
| InitiatorTXSectorID | Integer  | 0 – 1023 | Indicates the TX Sector ID to be utilized by the initiator STA.  |
| InitiatorRXSectorID | Integer  | 0 – 1023 | Indicates the RX Sector ID to be utilized by the initiator STA.  |
| ResponderTXSectorID | Integer  | 0 – 1023 | Indicates the TX Sector ID to be utilized by the responder STA.  |
| ResponderRXSectorID | Integer  | 0 – 1023 | Indicates the RX Sector ID to be utilized by the responder STA.  |

**6.3.95.4.3 When generated**

This primitive is generated by the MLME to indicate successful reception of a TDD sector switch request or TDD sector switch acknowledgement by a STA.

**6.3.95.4.4 Effect on receipt**The SME is notified of the result of the reception.

**6.3.XX.3 MLME-TDD- SECTOR-SWITCH.confirm
6.3.XX.3.1 Function**

This primitive reports the outcome of a TDD sector switch procedure.

**6.3.95.3.2 Semantics of the service primitive**The primitive parameters are as follows:

MLME-TDD- SECTOR-SWITCH.confirm (

TXSectorID,

RXSectorID,

ResultCode

)

|  |  |  |  |
| --- | --- | --- | --- |
| **Name**  | **Type**  | **Valid range**  | **Description** |
| PeerSTAAddress  | MACAddress  | Any valid individualMAC address | Specifies the address of the peerMAC entity with which to perform TDD sector switch procedure |
| TXSectorID | Integer  | 0 – 1023 | Indicates the TX Sector ID to be utilized by the STA.  |
| RXSectorID | Integer  | 0 – 1023 | Indicates the RX Sector ID to be utilized by the STA.  |
| ResultCode  | Enumeration  | SUCCESS, FAILURE | Indicates the result of the TDDsector switch procedure. |

**6.3.95.3.3 When generated**

This primitive is generated by the MLME to report the result of TDD sector switch with a peer STA.

**6.3.95.3.4 Effect on receipt**

The SME is notified of the result of the procedure.

9. Frame formats

**9.2 MAC frame formats**

**9.2.4 Frame fields**

**9.2.4.1 Frame Control field**

**9.2.4.1.3 Type and Subtype subfields**

*Change Table 9-2 as follows*

|  |  |  |  |
| --- | --- | --- | --- |
| **Type valueB3 B2** | **Subtype valueB7 B6 B5 B4** | **Control Frame Extension valueB11 B10 B9 B8** | **Description** |
| 01  | 0110  | 0000  | Sector Ack |
| 01  | 0110  | 0001  | Block Ack Schedule |
| 01  | 0110  | 0010  | Poll |
| 01  | 0110  | 0011  | SPR |
| 01  | 0110  | 0100  | Grant |
| 01  | 0110  | 0101  | DMG CTS |
| 01  | 0110  | 0110  | DMG DTS |
| 01  | 0110  | 0111  | Grant Ack |
| 01  | 0110  | 1000  | SSW |
| 01  | 0110  | 1001  | SSW-Feedback |
| 01  | 0110  | 1010  | SSW-Ack |
| 01  | 0110  | 1011 | TDD Beamforming  |
| 01  | 0110  | 1100 – 1111  | Reserved |

*Add below sections as follows*

**9.3.1.23 TDD Beamforming frame format**

**9.3.1.23.1 Overview**

The frame format for the TDD Beamforming frame is defined in Figure 9-X1.

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|   |   |   |   |   |  |   |  |
|   | Frame Control  | Duration  | RA | TA  | TDD Beamforming Control  | TDD Beamforming Information  | FCS |
| Octets : | 2 | 2 | 6 | 6 | 1 | 6 | 4 |

**Figure 9-X1—TDD Beamforming frame format**

The Duration field is set to the time until the end of the current TDD Slot (see 10.36.6.2.2).

The RA field contains the MAC address of the STA that is the intended receiver of the TDD Beamforming frame.
The TA field contains the MAC address of the transmitter STA of the TDD Beamforming frame.

The TDD Beamforming Control field is shown in Figure 9-X2.

|  |  |  |  |
| --- | --- | --- | --- |
|   |   |   |   |
|   | TDD Beamforming Frame Type | End of Training | Reserved  |
| Bits: | 2 | 1 | 5 |

**Figure 9-X2—TDD Beamforming Control subfield format**

The TDD Beamforming Frame Type subfield is defined as shown in Table T1.

Table T1

|  |  |
| --- | --- |
| **Value**  | **Meaning** |
| 0 | TDD SSW (Sector Sweep).The TDD Beamforming Frame Type subfield is set to this value when the sender transmits TDD SSW frame (See 10.38.10). |
| 1  | TDD SSW Feedback.The TDD Beamforming Frame Type subfield is set to this value when the sender transmits TDD SSW Feedback frame (See 10.38.10). |
| 2 | TDD SSW Ack.The TDD Beamforming Frame Type subfield is set to this value when the sender transmits TDD SSW Ack frame (See 10.38.10). |
| 3 | Reserved |

The meaning of the End of Training subfield depends to the value of the TDD Beamforming Frame Type subfield:

* The End of Training subfield set to 1 in a TDD SSW frame indicates that the initiator intend to end the TDD beamforming training after the transmission of the remaining TDD SSW frames with the current Sector ID; this subfield is set to zero otherwise;
* The End of Training subfield is set to 1 in a TDD SSW Feedback frame if the TDD SSW Feedback is sent in response to a TDD SSW frame in which its End of Training subfield was set to 1; this subfield is set to zero otherwise.
* The End of Training subfield is set to 1 in a TDD SSW Ack frame to indicate that the TDD beamforming training has completed; otherwise, this subfield is set to zero.

**9.3.1.23.2 TDD SSW (Sector Sweep)**

The TDD Beamforming Information field of the TDD SSW frame is shown in Figure 9-X3.

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|   |  |  |  |  |  |  |  |
|   | TX Sector ID | Count Index  | Beamforming Time Unit | Transmit Period | Responder Feedback Offset | Initiator Ack Offset | Reserved |
| Bits : | 10 | 3 | 4 | 8 | 10 | 10 | 3 |

**Figure 9-X3—TDD Beamforming Information field format (TDD SSW)**

The TX Sector ID subfield is set to indicate the antenna sector through which the TDD SSW frame is transmitted.

The Count Index subfield indicates the repetition of the initiator TDD Beamforming frames within a TDD slot, with the subfield set to 0 for the first transmission and increased by one for each successive transmission within a TDD slot.

The Beamforming Time Unit (BTU) subfield is defined in Table 9-T1.

**Table 9 – T1 — Beamforming Time Unit subfield**

|  |  |
| --- | --- |
| **Value**  | **Time Unit**  |
| 0  | 1us |
| 1  | 100us  |
| 2 | 400us |
| 3 - 15  | Reserved |

The BTU subfield indicates the beamforming time unit for the Transmit Period, Responder Feedback Offset and Initiator Ack Offset subfields in the TDD Beamforming Information field of TDD SSW frames. This subfield also defines the time unit for the Transmit Period, Initiator Transmit Offset and Responder Transmit Offset subfields in the TDD Beamforming Information field of the TDD SSW Ack frames.

The Transmit Period subfield indicates the offset, in units of BTUs, between TDD SSW transmissions with the same Count Index subfield value in different TDD slots.

The Responder Feedback Offset subfield indicates the offset, in units of BTUs, beginning immediately after the end of the TDD SSW frame, the TDD slot in which the TDD SSW Feedback frame is to be transmitted by the responder.

The Initiator Ack Offset subfield indicates the offset, in units of BTUs, beginning immediately after the end of the TDD SSW frame of when the TDD slot in which the TDD SSW Ack frame is to be transmitted by the initiator.

**9.3.1.23.3 TDD SSW Feedback**

The TDD Beamforming Information field of the TDD SSW Feedback frame is shown in Figure 9-X4.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|   |  |  |  |  |
|   | TX Sector ID  | Decoded TX Sector ID | SNR Report  | Reserved |
| Bits : | 10 | 10 | 8 | 20 |

**Figure 9-X4—TDD Beamforming Information field format (TDD SSW Feedback)**

The TX Sector ID subfield is set to indicate the sector through which the TDD SSW Feedback frame is transmitted.

The Decoded TX Sector ID subfield contains the value of the TX Sector ID subfield of a TDD SSW frame that the feedback frame is sent in response to and that the TDD SSW frame was received from the initiator with the best quality.

The SNR Report subfield is set to the value of the SNR achieved while decoding the TDD SSW frame received with the best quality and which is indicated in the Decoded TX Sector ID subfield. The SNR Report subfield is unsigned integers referenced to a level of –8 dB. Each step is 0.25 dB. SNR values less than or equal to –8 dB are represented as 0. SNR values greater than or equal to 55.75 dB are represented as 0xFF.

**9.3.1.23.4 TDD SSW Ack**

The TDD Beamforming Information field of the TDD SSW Ack frame is shown in Figure 9-X5.

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|   |  |  |  |  |  |  |  |
|   | Decoded TX Sector ID | Count Index  | Transmit Period | SNR Report | Initiator Transmit Offset | Responder Transmit Offset  | Reserved |
| Bits : | 10 | 3 | 8 | 8 | 8 | 8 | 3 |

**Figure 9-X5—TDD Beamforming Information field format (TDD SSW Ack)**

The Decoded TX Sector ID subfield contains the value of the TX Sector ID subfield of the TDD SSW Feedback frame that was received from the responder.

The Count Index subfield indicates the index of the frame transmission within a TDD slot, with the subfield set to 0 for the first frame transmission and increased by one for each successive frame transmission within a TDD slot.

The Transmit Period subfield indicates the interval, in units of BTUs, between successive TDD SSW transmissions with the same Count Index subfield value in different TDD slots.

The SNR Report subfield is set to the value of the SNR achieved while decoding the TDD SSW Feedback frame. The SNR Report subfield is unsigned integers referenced to a level of –8 dB. Each step is 0.25 dB. SNR values less than or equal to –8 dB are represented as 0. SNR values greater than or equal to 55.75 dB are represented as 0xFF.

The Initiator Transmit Offset subfield indicates the offset, in units of BTUs, beginning immediately after the end of the TDD SSW Ack frame, the TDD slot in which the initiator is expected to transmit additional frame, such as announce frame carrying the network configuration, to the responder. When the Initiator Transmit Offset subfield is set to zero, no time offset indication is specified by the initiator.

The Responder Transmit Offset subfield indicates the offset, in units of BTUs, beginning immediately after the TDD SSW Ack frame, the TDD slot in which the responder is expected to respond to frames sent by the initiator. When the Responder Transmit Offset subfield is set to zero, no time offset indication is specified by the initiator.

*Add below sections as follows*

**9.4.2.xxx1 TDD Route element**

The TDD Route element is used to communicate TDD beamforming results and sector switch configuration as described in 10.38.10 and 11.XX2. The format of the TDD Route element is shown in Figure 9-x6.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|   |   |   |   |   |
|   | Element ID | Length | Element ID Extension | TDD Route Subelements |
| Octets : | 1 | 1 | 1 | Variable |

**Figure 9-X6---TDD Route element format**

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

The TDD Route Subelements field is defined in Table 9-T2. The TDD Route element contains one or more of the subelements defined in Table 9-T2.

**Table 9 – T2 — TDD Route subelement IDs**

|  |  |  |
| --- | --- | --- |
| **Subelement ID**  | **Name**  | **Length**  |
| 0  | TDD Feedback Results | Variable  |
| 1  | TDD Sector Setting  | 24 |
| 2-220  | Reserved |  |
| 221  | Vendor specific |  |
| 222-225  | Reserved |  |

The TDD Feedback Results subelement is used to communicate all the initiator TX Sector IDs as received by the responder during a TDD beamforming training procedure as described in 10.38.10. The format of the TDD Feedback Results element is shown in Figure 9-x7.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|   |   |   |   |   |   |   |
|   | Subelement ID | Length | Number of Tx Beams | Tx Beam Feedback 1 |  …. | Tx Beam Feedback N |
| Octets : | 1 | 1 | 2 | Variable  |   | Variable |

**Figure 9-X7---TDD Feedback Results subelement format**

The Subelement ID field is defined in Table 9 – T2.

The Length field is defined in 9.4.2.1.

The Number of Tx Beams subfield indicates the number of Tx Beam Feedback fields included in the TDD Route element.

The TDD TX Beam Feedback field is defined in Figure 9-x8.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|   |   |   |   |   |   |
|   | TX Sector ID  | Number of Decoded RX Sectors | Decoded RX Sector Information 1  |  …….. | Decoded RX Sector Information M |
| Bits : | 10 | 8 | 32 |  | 32 |

**Figure 9-X8--- TDD Tx Beam Feedback field format**

The TX Sector ID subfield contains the value of the TX Sector ID subfield of the TDD SSW frame that were sent by the initiator and that the information in the TDD Feedback field relate to.

The Decoded RX Sectors Information field is defined in Figure 9-x9.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|   | B0 B9 | B10 B15 | B16 B23 | B24 B32 |
|   | Decoded RX Sector ID | Reserved | SNR Report | RSSI Report |
| Bits : | 10 | 6 | 8 | 8 |

**Figure 9-X9---Decoded RX Beam Information subfield format**

The Decoded RX Sector ID subfield indicates the receive sector index used by the responder while it decoded the respective TDD SSW frame transmitted in the respective TX Sector ID.

The SNR Report subfield is set to the value of the SNR achieved while decoding the TDD SSW frame with the respective TX Sector ID and RX Decoded Sector ID. The SNR Report subfield is 8 bit unsigned integers referenced to a level of –8 dB. Each step is 0.25 dB. SNR values less than or equal to –8 dB are represented as 0. SNR values greater than or equal to 55.75 dB are represented as 0xFF.

The RSSI Report subfield is set to the value of the received power while receiving the L-STF field of the TDD SSW frame with the respective TX Sector ID and RX Decoded Sector ID. RSSI Report is an 8-bit signed integer in the range -128 dBm to 127 dBm and is measured by the PHY of the power observed at the input of the antennas plus the antenna gain, or equivalent antenna gain for a phased-array antenna, used to receive the current PPDU

The TDD Sector Setting subelement is used to request the peer to configure its antenna to a specific receive and transmit sector combination as described in 11.XX2. The format of the TDD Sector Setting subelement is shown in Figure 9-x10.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|   |   |   |   |  |  |   |
|   | Subelement ID | Length | TDD Sector Setting Control  | Switch Timestamp | Revert Timestamp | TDD Switch Sectors |
| Octets : | 1 | 1 |  1 | 8 | 8 | 5 |

**Figure 9-X10---TDD Sector Setting subelement format**

The Subelement ID field is defined in Table 9 – T2.

The Length field is defined in 9.4.2.1.

The TDD Sector Setting Control field is defined in Figure 9-x11

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|   | B0  | B1 | B2 | B3 – B7 |
|   | Set SectorRequest | Set Sector Response | Set Sector Acknowledge | Reserved |
| Bits : | 1 | 1 | 1 | 5 |

**Figure 9-X11---TDD Sector Setting Control field format**

The Set Sector Request subfield set to 1 by the initiator to indicate the responder to change its receiver sector setting according to the Responder RX Sector ID subfield and its transmitter sector setting according to Responder TX Sector ID subfield in the TDD Switch Sectors field.

The Set Sector Response subfield set to 1 by the responder to indicate the reception of a successful TDD Sector Setting subelement with Set Sector Request subfield set to 1.

The Set Sector Acknowledge subfield set to 1 by the initiator to acknowledge the reception of a successful TDD Sector Setting subelement with Sector Response subfield set to 1.

The Reserved subfield should be set to 0.

The Switch Timestamp subfield indicates the future TSF timer value (see 9.4.1.10) in which the new sector configuration setting is to take effect.

The Revert Timestamp subfield indicates the future TSF timer value (see 9.4.1.10) in which the previous sector configuration will be reverted to in case sector switching fails.

The TDD Switch Sectors field is defined in Figure 9-x12

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|   | B0 B9 | B10 B19 | B20 B29 | B30 B39 |
|   | Responder RX Sector ID  | Responder TX Sector ID  | Initiator RX Sector ID  | Initiator TX Sector ID  |
| Bits : | 10 | 10 | 10 | 10 |

**Figure 9-X12---TDD Switch Sectors field format**

The Responder RX Sector ID subfield contains the value of the sector ID the responder uses to set it’s receive sector.

The Responder TX Sector ID subfield contains the value of the sector ID the responder uses to set it’s transmit sector.

The Initiator RX Sector ID subfield contains the value of the sector index the initiator uses to set it’s receive sector.

The Initiator TX Sector ID subfield contains the value of the sector index the initiator uses to set it’s transmit sector.

**9.6.22.2 Announce frame format**

*Change Table 9-416 as follows*

**Table 9-416—Announce frame Action field format *(continued)***

|  |  |  |
| --- | --- | --- |
| **Order**  | **Information**  | **Notes** |
| 9  | Multiple BSSID  | The Multiple BSSID element is defined in 9.4.2.46. The MultipleBSSID element is optionally present. If present, the MultipleBSSID element signals all the BSSIDs in use by the BSS. |
| . | . | . |
| . | . | . |
| 22  | UPSIM  | The UPSIM element is defined in 9.4.2.167. The UPSIM element is optionally present. |
| 23  | TDD Route | The TDD Route element is defined in 9.4.2.xxx1. The TDD Route element is optionally present. |

**10.7.7.1 Usage of DMG Control modulation class***Change below sections as follows*

The DMG Control modulation class has only one MCS, which is DMG MCS 0 defined in Clause 20. The
DMG Beacon, SSW-Feedback, SSW-Ack, RTS, DMG CTS, DMG CTS-to-self, DMG DTS, CF-End,
Grant, SPR, Poll, TDD Beamforming type frames (i.e. TDD SSW, TDD SSW Feedback and TDD SSW Ack) and first BRP packet in beam refinement shall be transmitted using the DMG Control modulation class.

**10.36.6.2.2 SP with TDD channel access**

*Change below sections as follows*

Except for the transmission of a TDD Beamforming frame prior to association, A DMG STA shall not transmit during a TDD SP unless it receives a TDD Slot Schedule element that indicates it is assigned to at least one TDD slot within the TDD SP by the DMG AP or DMG PCP. The DMG AP or DMG PCP shall transmit the TDD Slot Schedule element to each DMG STA that is assigned to access the TDD SP through an Announce frame or Association Response frame before the time indicated by the value of the Slot Schedule Start Time within the element. Upon reception of a TDD Slot Schedule element corresponding to allocations identified by the Allocation ID subfield value within the element, a DMG STA shall adopt the schedule within the element at the time indicated by the value of the Slot
Schedule Start Time subfield within the element

*Add below sections as follows*

10.38 DMG Beamforming

10.38.10 TDD Beamforming

**10.38.10.1 General**

The TDD beamforming (BF) procedure is used by a pair of STAs to perform beamforming during a TDD SP. TDD BF training is a bidirectional sequence of TDD beamforming frames and provides the necessary signalling to allow each STA to determine appropriate DMG antenna configuration for both transmission and reception. TDD beamforming training supports initial connection establishment when both transmit and receive antennas use a directional configuration. The TDD beamforming procedure assumes antenna reciprocity of both the initiator and responder STAs. A TDD beamforming frame is a TDD SSW frame, a TDD SSW-Feedback frame or a TDD SSW-Ack frame.

Figure 10-X1 gives an example of the TDD beamforming training procedure.

 

**Figure 10-x1—An example of TDD beamforming training**

A STA that has not established a DMG control mode connection with an intended peer, switches its antenna configuration through all its receive sectors. In order to establish a DMG control mode connection, an initiator sends multiple TDD SSW frames during its assigned TDD slots. A TDD SSW frame indicates to the responder the TX Sector ID used by the initiator for the transmission of the TDD SSW frames, the time offset for which the responder should send its TDD SSW Feedback frame as response and the time offset the responder shall be ready to get the TDD SWW Ack frame. The responder sends its TDD SSW Feedback frame with the same sector it received the TDD SSW with the best quality. Following the reception of a TDD SSW Feedback frame, the initiator sends a TDD SSW Ack frame that acknowledges the received configuration. During the TDD beamforming training, the TDD SSW frame is sent periodically and will be repeated multiple times for each TX Sector ID. The TDD BF training sequence is continued until the initiator sets the End of Training subfield in the TDD SSW Ack frame to 1 in which will includes also the time offsets indication in the Initiator Transmit Offset subfield on when the responder obtains the network configuration parameters and time offset indication in the Responder Transmit Offset on when the responder sends the total results of the TDD beamforming procedure.

**10.38.10.2 Initiator Operation**

To initiate TDD beamforming, the initiator shall send multiple TDD SSW frames with the RA field set to the Responder STA’s MAC Address as indicated by the PeerSTAAddress parameter of the MLME-TDD-BF-TRAINING.request primitive.

TDD SSW frames that are sent from the same transmit antenna sector shall have the same TX Sector ID subfield value; frames shall be transmitted at the same transmit power and shall not include BRP training fields.

Initiator shall send TDD SSW frames with the same TX Sector ID subfield for multiple number of times as indicated in the SectorRepetitions parameter of the MLME-TDD-BF-TRAINING.request primitive.

Initiator shall send the TDD SSW frames with the TX Sector ID values as indicted in the TXSectorIDList parameter of the MLME-TDD-BF-TRAINING.request primitive.

TDD SSW and TDD SSW Ack frames transmitted in the same TDD slot shall be be separated with SBIFS interval and shall have a strictly increasing Count Index subfield value with the first transmitted TDD SSW frame or TDD SSW Ack frame in the TDD slot has this subfield equal to zero.

The initiator shall set its receive antenna to the same sector as was indicated in the TX Sector ID subfield of the respective TDD SSW frames to receive the responder TDD SSW Feedback frame at the time offset indicated by the below equation:

*ResponderFeedbackOffset – [(CountIndex+1) x TXTIME(TDD SSW) + (Count Index x SBIFS)]*  (10-X1)

Where:

*ResponderFeedbackOffset*  is the Responder Feedback Offset subfield value in the TDD SSW type frame with the same TX Sector ID (in microsecond)

*CountIndex*  is the Count Index subfield value from the respective TDD SSW or TDD SSW Ack (integer)

Figure 10-X2 depict the calculation of time to transmit the TDD SSW feedback.



**Figure 10-x2—TDD SSW feedback transmit time**

If the initiator received a TDD SSW Feedback frame, after the time offset indicated by equation (10-X2), the initiator shall set its DMG antenna to the same sector that was used to transmit the respective TDD SSW frame to transmit a TDD SSW Ack frame to the responder.

*InitiatorAckOffset – [(CountIndex+1) x TXTIME(TDD SSW) + (Count Index x SBIFS)]*  (10-X2)

Where:

*InitiatorAckOffset*  is the Initiator Ack Offset subfield value in the TDD SSW type frame with the same TX Sector ID (in microsecond)

*CountIndex*  is the Count Index subfield value from the received TDD SSW or TDD SSW Ack (integer)

The TDD SSW Ack frame shall include the sector used by the initiator to transmit the TDD SSW Ack in the TX Sector ID subfield, the sector used by the responder to transmit the TDD SSW Feedback frame in the Decoded TX Sector ID subfield, the measured SNR of the decoded TDD SSW Feedback frame in the SNR Report subfield and the time offsets to exchange announce frames with STA capabilities and network configuration.

An initiator may request the responder to stop its receive sector sweeping by setting the End of Training subfield of the TDD SSW Ack frames to 1. After sending TDD SSW Ack frame with End of Training subfield equal to 1, the initiator shall configure its DMG antenna to the sector index as indicated in the Decoded TX Sector ID subfield of the TDD SSW Feedback frame received from the responder during the respective TDD beamforming training in which its End of Training subfield was set to 1. The initiator shall use this sector for its subsequent transmissions and receptions with the responder, until another sector is negotiated.

If the initiator sent TDD SSW Ack frame with the End Of Training subfield set to 1, after the time offset indicated by equation (10-X3), the initiator shall set its DMG antenna to the same sector that was used to transmit the respective TDD SSW Ack frame to transmit a announce frame to the responder.

*InitiatorTransmitOffset – [(CountIndex+1) x TXTIME(TDD SSW) + (Count Index x SBIFS)]*  (10-X3)

Where:

*InitiatorTransmitOffset*  is the Initiator Transmit Offset subfield value in the TDD SSW Ack type frame with the End of Training subfield set to 1. (in microsecond)

*CountIndex*  is the Count Index subfield value from the received TDD SSW or TDD SSW Ack (integer)

The initiator shall set its receive antenna to the same sector as was indicated in the TX Sector ID subfield of the respective TDD SSW Ack frame with the End Of Training subfield set to 1, in order to receive the responder announce frame at the time offset indicated by the below equation:

*ResponderTransmitOffset – [(CountIndex+1) x TXTIME(TDD SSW) + (Count Index x SBIFS)]*  (10-X4)

Where:

*ResponderTransmitOffset*  is the Responder Transmit Offset subfield value in the TDD SSW Ack type frame with the End of Training subfield set to 1. (in microsecond)

*CountIndex*  is the Count Index subfield value from the respective TDD SSW or TDD SSW Ack (integer)

**10.38.10.3 Responder Operation**

A responder STA that has lost its network configuration or has not yet receive TDD SSW frame or has not yet acquired the TDD Slot Structure element used by the BSS shall sweep its receiver antenna through all its receive sectors while dwelling on each sector for a time equal to SectorDwellTime as indicted by the MLME-TDD-BF-SCAN.request primitive

NOTE – To increase the likelihood of detecting initiator’s TDD SSW frame, the responder SME can set SectorDwellTime to at least [2 × TXTIME (TDD SSW) + SBIFS].

A responder STA that has received TDD SSW frame shall sweep its receiver antenna configuration through its receive sectors between TDD beamforming frames received in a TDD slot and between TDD slots used for BF training according to the period as indicated by the Transmit Period subfield of the received TDD SSW frame.

Figure 10-X3 gives an example of the Responder receiver sweeping procedure.



**Figure 10-x3—Responder Receiver Sweeping**

Once the first TDD SSW frame is received, the responder proceeds with the following operation.

Upon reception of one or more TDD SSW frames on single receive sector, the responder shall switch to its next receive sector to be ready to receive the next TDD SSW frame transmission within SBIFS interval or at the time instant specified by the Transmit Period in the TDD SSW frame. While sweeping through its receive sectors, the responder shall continue decoding all the received TDD SSW frames.

The responder shall transmit a TDD SSW Feedback frame using the sector from which the responder received the TDD SSW with the best link quality at the time indicated equation (10-X1). The TDD SSW Feedback frame shall include the sector index used by the initiator to transmit the TDD SSW frame in the Decoded TX Sector ID subfield, the sector index used by the responder to transmit the TDD SSW Feedback frame in the TX Sector ID subfield, and the SNR of the TDD SSW frame received with best quality in the SNR Report subfield.

At the time offset indicated by equation (10-X2) of the decoded TDD SSW frame, the responder shall set its receive DMG antenna to the same sector that was indicated in the TX Sector ID subfield of the TDD SSW Feedback in order to be ready to receive a TDD SSW Ack frame from the initiator.

The responder shall continue sweeping through its receive sectors until successfully receiving and decoding a TDD SSW Ack frame with End of Training subfield equal to 1. Upon the reception of TDD SSW Ack frame with End of Training subfield equal to 1, the responder shall stop its receive sweeping and shall configure its DMG antenna to the sector as indicated in the Decoded TX Sector ID subfield of the TDD SSW Ack frame received from the initiator and which its End of Training subfield is set to 1. The responder shall use this sector for its subsequent transmissions and receptions with the initiator, until another sector is negotiated.

Responder that transmits TDD SSW Feedback frame in response to TDD SSW frames sent with End of Training subfield set to 1 shall set the End of Training subfield in the TDD SSW Feedback frame to 1.

Upon reception of TDD SSW Ack with End of Training subfield set to 1, the responder shall be ready to receive an announce frame from the initiator at the time offset indicated by (10-X3) and shall transmit to the initiator an announce frame containing a TDD Route element listing the ordered pairs of TX Sector IDs and Decoded TX Sector IDs obtained from the TDD beamforming training transmitted at the time offset indicated by (10-X4).

*Add below sections as follows*

**11.38.2 TDD beamforming**

Upon receipt of an MLME-TDD-BF-TRAINING.request primitive, a DMG STA shall act as TDD beamforming initiator and shall undertake beamforming training with the STA indicated by the PeerSTAAddress parameter according to the procedures defined in 10.38.10. This training shall start by the time indicated in the BeamformingStartTimestamp parameter with a transmission of TDD SSW in TDD slots.

Upon receipt of the MLME-SCAN.request primitive with the ScanType parameter set to TDD passive, a DMG

STA shall passively scan for TDD SSW frames by sweeping its receiver antenna through all the receive sectors specified in ScanSectorIDList parameter while dwelling on each sector for a time equal to SectorDwellTime and shall be performed through all channels specified within the ChannelList parameter.

A STA receiving the MLME-TDD-BF-TRAINING.request primitive shall issue an MLME-TDD-BF-TRAINING.confirm primitive on completion of the requested TDD beamforming training after receiving an Announce frame containing the TDD Route element from the responder as specified in 10.38.10 and shall add the parameters NumberOfTDDFeedbacks and TDDFeedbackTXSectorID according to the received TDD Route element from the responder.

A STA that performs TDD beamforming training with a peer STA at the request of the peer STA shall issue an
MLME-TDD-BF-TRAINING.indication primitive on completion of that beamforming training as specified in 10.38.10 after it received TDD SSW Ack with End of Training subfield set to 1 and shall add the parameters RXSectorID and SNR according to the received RX Sector ID and SNR from the respective TDD SSW Ack received from the initiator.

Figure 11-XX1 illustrates an example of the TDD beamforming training procedure.



**Figure 11-X1— TDD Beamforming training procedure.**

**11.38.3 TDD Sector Switch procedure**

The TDD sector switch procedure allows a pair of DMG STAs operating in an SP with TDD channel access to synchronize switch of transmit and receive sectors for communication between them. Only a PCP or AP shall initiate the TDD sector switch procedure. An AP or PCP can make use of the information in TDD Feedback Results subelements and the results of measurements undertaken by STAs in the BSS to determine when to invoke a TDD sector switch procedure.

Upon receipt of an MLME-TDD-SECTOR-SWITCH.request primitive, a DMG STA shall send the peer STA indicated by the PeerSTAAddress parameter an Announce frame of subtype Action with a TDD Route element that includes a TDD Sector Setting subelement with the Set Sector Request subfield set to 1. This is referred to as a TDD sector switch request message. Messages with Set Sector Response subfield set to 1 and messages with Set Sector Acknowledge subfield set to 1 are referred as TDD sector response and TDD sector acknowledge messages, respectively. STA shall not set to ‘1’ more than one bit of the TDD Sector Setting Control field in a given transmitted element.

The Responder TX Sector ID, Responder RX Sector ID, Initiator TX Sector ID and Initiator RX Sector ID subfields in the TDD Sector Setting subelement shall be set to, respectively, the ResponderTXSectorID, ResponderRXSectorID, InitiatorTXSectorID and InitiatorRXSectorID parameters of the request primitive. The Set Sector Request subfield in the TDD Sector Setting subelement shall be set to 1.

The Switch Timestamp subfield in the TDD Sector Setting subelement shall be set to the value of the SectorSwitchTimestamp parameter of the request primitive. The Switch Timestamp subfield value shall be set to a time value that allow at least three retransmissions of the Announce frame and the corresponding Ack frame sent in response.

The Revert Timestamp subfield in the TDD Sector Setting subelement shall be set to the value of the SectorRevertTimestamp parameter of the request primitive. The Revert Timestamp subfield value shall be set to a time value that allows the responder at least three retransmissions of a TDD sector response message, for the case the responder does not receive the TDD sector acknowledge message from the initiator, plus time to allow the initiator at least three retransmissions of a TDD sector acknowledge message, for the case the initiator does not receive the Ack frame from the responder.

An initiator STA that does not receive an Ack frame in response to a TDD sector switch request message should retransmit the message until the time indicated by the Switch Timestamp subfield.

A MLME-TDD-SECTOR-SWITCH.request primitive incorporating a new SectorSwitchTimestamp value shall not be issued until the SectorRevertTimestamp of the previous request primitive has been elapsed.

A responder shall send an Ack frame in response to the reception of a TDD sector switch request message and perform the following:

* Issue an MLME-TDD-SECTOR-SWITCH.indication primitive with the PeerSTAAddress parameter set to the TA of the received message, and the ResponderTXSectorID, ResponderRXSectorID, InitiatorTXSectorID and InitiatorRXSectorID parameters of the primitive set to, respectively, the Responder TX Sector ID, Responder RX Sector ID, Initiator TX Sector ID and Initiator RX Sector ID subfields of the TDD Sector Setting subelement within the received message.
* Respond with an Ack frame to any TDD sector switch request messages that arrive before the time indicated by the Switch Timestamp subfield value within the message.
* Set its receive and transmit antenna configuration corresponding to the Responder RX Sector ID and Responder TX Sector ID subfield values in the TDD sector switch request message, respectively, at the time indicated by the Switch Timestamp subfield.
* Send to the initiator a TDD sector switch response message by transmitting an Announce frame of subtype Action No Ack with the same Sector Setting subelement that was received by the responder, except that the Set Sector Request subfield shall be set to 0 and the Set Sector Response subfield shall be set to 1. The TDD sector switch message should be sent at the earliest TDD slot occurring after the time indicated by the value of the Switch Timestamp subfield.

An initiator receiving an Ack frame to a transmitted TDD sector switch request message shall perform the following:

* Issue an MLME-TDD-SECTOR-SWITCH.indication primitive with the ResponderTXSectorID, ResponderRXSectorID, InitiatorTXSectorID and InitiatorRXSectorID parameters of the primitive set to the Responder TX Sector ID, Responder RX Sector ID, Initiator TX Sector ID and Initiator RX Sector ID subfields in the TDD Sector Setting subelement as was sent in the respective TDD sector switch request.
* Set its receive and transmit antenna configuration corresponding to the Initiator TX Sector ID and Initiator RX Sector ID subfield values, respectively, at the time indicated by the value of the Switch Timestamp subfield.

An initiator receiving a TDD sector switch response message shall send the responder a TDD sector switch acknowledge message by transmitting an Announce frame of subtype Action with the same Sector Setting subelement that was received by the initiator, except that the Set Sector Response subfield shall be set to 0 and the Set Sector Acknowledge subfield shall be set to 1. The TDD sector switch acknowledge message should be sent at the earliest TDD slot occurring after the time indicated by the value of the Switch Timestamp subfield.

A responder sending an Ack frame in response to a TDD sector switch acknowledge message received before the time indicated by the Revert Timestamp value shall issue an MLME-TDD-SECTOR-SWITCH.confirm primitive. The TXSectorID and RXSectorID parameters of the primitive shall be set to the new transmit sector index and receive sector indexes, respectively, and the ResultCode parameter shall be set to SUCCESS.

An initiator receiving an Ack frame in response to a transmitted TDD sector switch acknowledge message before the time indicated by the Revert Timestamp value shall issue MLME-TDD-SECTOR-SWITCH.confirm primitive. The TXSectorID and RXSectorID parameters of the primitive shall be set to the new transmit sector index and receive sector indexes, respectively, and the ResultCode parameter shall be set to SUCCESS.

A responder that did not receive a TDD sector switch acknowledge message in response to a transmitted TDD sector switch response message should retransmit the TDD sector switch message until the time indicated by the Revert Timestamp subfield value.

An initiator STA that did not receive an Ack frame in response to a transmitted TDD sector switch acknowledge message should retransmit the TDD sector switch acknowledge message until the time indicated by the Revert Timestamp subfield value.

A responder that did not send an Ack frame in response to a received TDD sector switch acknowledge message by the time indicated by the Revert Timestamp subfield value shall issue an MLME-TDD-SECTOR-SWITCH.confirm primitive with the ResultCode parameter set to FAILURE and shall revert to the antenna configuration used atthe start of the TDD sector switch procedure.

An initiator STA that did not receive an Ack frame in response to a transmitted TDD sector switch acknowledge message by the time indicated by the Revert Timestamp subfield value shall issue an MLME-TDD-SECTOR-SWITCH.confirm primitive with the ResultCode parameter shall be set to FAILURE and shall revert to the antenna configuration used at the start of the TDD sector switch procedure.

An initiator STA that reverted to the previous antenna configuration at the time indicated by the Revert Timestamp subfield value, shall send a PPDU that requires Ack frame at the earliest TDD slots occurring after the Revert Timestamp subfield value. An initiator STA receiving an Ack frame in response to the PPDU it transmitted after the time indicated by the Revert Timestamp subfield shall issue an MLME-TDD-SECTOR-SWITCH.indication primitive. The TXSectorID and RXSectorID parameters of the primitive shall be set to the sectors used at the start of the TDD sector switch procedure and the ResultCode parameter shall be set to SUCCESS.

A responder sending an Ack frame in response to a PPDU it received after the time indicated by the Revert Timestamp subfield value shall issue an MLME-TDD-SECTOR-SWITCH.indication primitive. The TXSectorID and RXSectorID parameters of the primitive shall be set to the sectors used at the start of the TDD sector switch procedure and the ResultCode parameter shall be set to SUCCESS.

A TDD initiator that did not receive an Ack frame in response to a transmitted PPDU shall initiate the TDD beamforming procedure as described in 10.38.10.

A responder that reverted to the antenna configuration at the time indicated by the Revert Timestamp subfield value and that did not receive a PPDU from the initiator at a TDD slot occurring after the Revert Timestamp subfield value shall start the TDD beamforming procedure as a responder as described in 10.38.10.

Figure 11-XX2 illustrates an example of successful TDD sector switch procedure.

 

**Figure 11-X2— TDD Sector Switch procedure.**

**References:**

1. Draft P802.11ay\_D1.0.pdf
2. IEEE Std 802.11-2016