IEEE P802.11
Wireless LANs

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| --- |
| TDD network entry |
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Proposed resolutions to CID 6235 (clarifying the TDD network entry process). Proposed text changes are based on 11md Draft 3.4 and 11ay Draft 5.0.

|  |  |  |  |
| --- | --- | --- | --- |
| **CID** | **Comment** | **Proposed change** | **Resolution** |
| 6235 | Network entry (including association and initial TDD slot structure/schedule establishment) following initial beamforming is not clear, in particular, (1) there is a need for periodic transmit opportunity to retry transmission, and (2) initial frame from the DN/initiator should be Probe Response (avoiding Class 0 Announce for mmWave use case) | Define the operation and applicable frames. | Revised  |

**Discussion:**

We find the comment generally valid in the sense that (1) there is a need for clearly defined frame exchange opportunities for initiator and responder after beamforming completion and in the absence of slot structure and schedule, and (2) there is value to defining an active scan flow. However, we defer the active scan flow definition to future.

First, we clarify that the Transmit Period subfield in the TDD SSW Ack frame defines a periodic transmit opportunity to exchange non-beamforming frames after beamforming completion, which is necessary to have multiple frame exchanges and with possible retries (see the table below in discussion section). The periodic nature was described in Document 802.11-18/0381 (Slide 2), but not correctly reflected in the implementation text.

one recommended frame exchange sequence for discovery is shown below.

|  |  |
| --- | --- |
| **Initiator -->** | **<-- Responder** |
| … | … |
|  |  |
| TDD SSW |  |
|  | TDD SSW Feedback |
| TDD SSW Ack |  |
|  |  |
|  |  |
| Announce (as Action No Ack) |  |
|  | Association Request |
| Association Response |  |
| … |  |
|  |  |
|  |  |

**Resolution:** Revised. Text implementation follows.

**Revision history**

R1 updates

* Removed the suggestion for active scan flow [more detail needed, for future]
* Various bug fixes and clarifications related to beamforming timing definitions

***Editor: Change Section 9.3.1.25.2 as follows***

**9.3.1.25.2 TDD SSW frame**

…

The Responder Feedback Offset subfield indicates the offset, in units of BTUs, from the beginning of the first TDD SSW frame to when the first TDD SSW Feedback frame is to be transmitted by the responder. This subfield is reserved when the TDD SSW frame is transmitted exclusively for TDD beam measurement.

The Initiator Ack Offset subfield indicates the offset, in units of BTUs, from the beginning of the first TDD SSW frame to when the first TDD SSW Ack frame is to be transmitted by the initiator. This subfield is reserved when the TDD SSW frame is transmitted exclusively for TDD beam measurement.

***Editor: Change Section 9.3.1.25.4 as follows***

**9.3.1.25.4 TDD SSW Ack frame**

…

The Transmit Period subfield indicates the interval, in units of BTUs, between successive transmit opportunities for the initiator to transmit frames other than TDD Beamforming frames to the responder, and also between successive transmit opportunities for the responder to transmit frames other than TDD Beamforming frames to the initiator, after completion of the unscheduled beamforming procedure, as defined in 10.42.11 (TDD beamforming).

…

The Initiator Transmit Offset subfield is reserved when the End of Training subfield in the TDD SSW Ack frame is 0. Otherwise, it indicates the offset, in units of BTUs, from the beginning of the first TDD Beamforming frame that is sent in the same TDD slot as the TDD SSW Ack frame (which can be the TDD SSW Ack frame itself), to the first transmit opportunity for the initiator to transmit a frame other than a TDD beamforming frame (a non-beamforming frame) to the responder. The Initiator Transmit Offset subfield is set to 0 to indicate that the initiator will transmit non-beamforming frames to the responder according to a TDD slot schedule available to the initiator.

The Responder Transmit Offset subfield is reserved when the End of Training subfield in the TDD SSW Ack frame is 0. Otherwise, it indicates the offset, in units of BTUs, from the beginning of the first TDD Beamforming frame that is sent in the same TDD slot as the TDD SSW Ack frame (which can be the TDD SSW Ack frame itself), to the first transmit opportunity for the responder to transmit a frame other than a TDD beamforming frame (a non-beamforming frame) to the initiator. The Responder Transmit Offset subfield is set to 0 to indicate that the responder will transmit non-beamforming frames to the initiator according to a TDD slot schedule available to the responder.

***Editor: Change Sections 9.3.3.5 through 9.3.3.8 as follows***

9.3.3.5 Association Request frame format

*Insert the following rows in Table 9-36 (Association Request frame body)*

|  |  |  |
| --- | --- | --- |
|  |  |  |
| 49 | EDMG Capabilities | The EDMG Capabilities element is present if dot11EDMGOptionImplemented is true. |
| 50 | QoS Triggered Unscheduled | The QoS Triggered Unscheduled element is optionally present if dot11EDMGOptionImplemented is true. |
| 51 | Unsolicited Block Ack Extension | The Unsolicited Block Ack Extension element is optionally present if dot11UnsolicitedBAActivated is true and is absent otherwise.  |
| 52 |  |  |
| 53 | TDD Route | This element is optionally present if dot11TDDOptionImplemented is true; otherwise not present. If present, the element specifies theTDD beamforming results and sector switch configuration. |

* + - 1. Association Response frame format

*Insert the following rows in Table 9-37 (Association Response frame body)*

|  |  |  |
| --- | --- | --- |
|  |  |  |
| 65 | EDMG Capabilities | The EDMG Capabilities element is present if dot11EDMGOptionImplemented is true. |
| 66 | EDMG Operation | The EDMG Operation element is present if dot11EDMGOptionImplemented is true. |
| 67 | QoS Triggered Unscheduled | The QoS Triggered Unscheduled element is optionally present if dot11EDMGOptionImplemented is true. |
| 68 | Unsolicited Block Ack Extension | The Unsolicited Block Ack Extension element is optionally present if dot11UnsolicitedBAActivated is true and is absent otherwise. |
| 69 | TDD Slot Structure | The TDD Slot Structure element is optionally present if dot11DMGOptionImplemented is true.  |
| 70 |  |  |
| 71 | TDD Route | This element is optionally present if dot11TDDOptionImplemented is true; otherwise not present. If present, the element specifies theTDD beamforming results and sector switch configuration. |

* + - 1. Reassociation Request frame format

*Insert the following rows in Table 9-38 (Reassociation Request frame body)*

|  |  |  |
| --- | --- | --- |
|  |  |  |
| 54 | EDMG Capabilities | The EDMG Capabilities element is present if dot11EDMGOptionImplemented is true. |
| 55 | QoS Triggered Unscheduled | The QoS Triggered Unscheduled element is optionally present if dot11EDMGOptionImplemented is true. |
| 56 | Unsolicited Block Ack Extension | The Unsolicited Block Ack Extension element is optionally present if dot11UnsolicitedBAActivated is true and is absent otherwise. |
| 57 |  |  |
| 58 | TDD Route | This element is optionally present if dot11TDDOptionImplemented is true; otherwise not present. If present, the element specifies theTDD beamforming results and sector switch configuration. |

* + - 1. Reassociation Response frame format

*Insert the following rows in Table 9-39 (Reassociation Response frame body)*

|  |  |  |
| --- | --- | --- |
|  |  |  |
| 69 | EDMG Capabilities | The EDMG Capabilities element is present if dot11EDMGOptionImplemented is true. |
| 70 | EDMG Operation | The EDMG Operation element is present if dot11EDMGOptionImplemented is true. |
| 71 | QoS Triggered Unscheduled | The QoS Triggered Unscheduled element is optionally present if dot11EDMGOptionImplemented is true. |
| 72 | Unsolicited Block Ack Extension | The Unsolicited Block Ack Extension element is optionally present if dot11UnsolicitedBAActivated is true and is absent otherwise. |
| 73 | TDD Slot Structure | The TDD Slot Structure element is optionally present if dot11DMGOptionImplemented is true. |
| 74 |  |  |
| 75 | TDD Route | This element is optionally present if dot11TDDOptionImplemented is true; otherwise not present. If present, the element specifies theTDD beamforming results and sector switch configuration. |

***Editor: Change Section 10.42.11.2 as follows***

**10.42.11.2 Initiator operation for TDD individual beamforming**

…

To receive a TDD SSW Feedback frame from the responder, the initiator shall set its receive antenna to the same DMG antenna and sector as was indicated, respectively, in the TX Antenna ID and TX Sector ID subfield of the respective TDD SSW frame, at the following offset from the end of the last transmitted TDD SSW frame:

*ResponderFeedbackOffset* – [(*CountIndex* + 1) × TXTIME(TDD SSW) + (*CountIndex* × SBIFS)] (3)

where:

*ResponderFeedbackOffset* is the value of the Responder Feedback Offset subfield in the TDD SSW frame with the same TX Sector ID within the same TDD slot.

*CountIndex* is the value of the Count Index subfield in the received TDD SSW frame

Figure 10-94t depicts the timing to transmit the TDD SSW Feedback frame for unscheduled TDD individual BF.



*Editor: Shift the 3 curly braces by the size of one TDD SSW frame to the left*

*(for clarity)*

Figure 10-94t – TDD SSW Feedback frame transmit time for unscheduled TDD individual BF

If the initiator received a TDD SSW Feedback frame, it shall set its DMG antenna to the same sector that was used to transmit the respective TDD SSW frame, and transmit one or more TDD SSW Ack frames to the responder, starting at the following offset from the end of the last transmitted TDD SSW frame:

*InitiatorAckOffset* – [(*CountIndex* + 1) × TXTIME(TDD SSW) + (*CountIndex* × SBIFS)] (4)

where:

*InitiatorAckOffset* is the value of the Initiator Ack Offset subfield in the TDD SSW frame with the same TX Sector ID within the same TDD slot.

*CountIndex* is the value of the Count Index subfield value in the received TDD SSW frame

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 when performing unscheduled TDD beamforming, the time offsets to exchange frames containing TDD Route, TDD Slot Structure, and TDD Slot Schedule elements.

…

After the initiator has sent the last TDD SSW Ack frame with the End of Training subfield set to 1 to the responder, it may transmit a single PPDU other than a TDD Beamforming frame to the responder, setting its transmit antenna to the same sector it used to transmit the last TDD SSW Ack frame, at the following offset from the end of the last transmitted TDD SSW Ack frame:

*InitiatorTransmitOffset* – [(*CountIndex* + 1) × TXTIME(TDD SSW) + (*CountIndex* × SBIFS)] (5)

where:

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

*CountIndex* is the value of the Count Index subfield in the received TDD SSW Ack frame

Subsequent opportunities for the initiator to transmit to the responder are separated by the value of the Transmit Period subfield in the last TDD SSW Ack frame.

Additionally, after the initiator has sent the last TDD SSW Ack frame with the End of Training subfield set to 1 to the responder, it can receive a single PPDU other than a TDD Beamforming frame from the responder, setting its receive DMG antenna and sector to what was indicated in the TX Antenna ID and TX Sector ID subfield of the respective TDD SSW Ack frame, at the following offset from the end of the last transmitted TDD SSW Ack frame:

*ResponderTransmitOffset* – [(*CountIndex* + 1) × TXTIME(TDD SSW) + (*CountIndex* × SBIFS)] (6)

where:

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

*CountIndex* is the value of the Count Index subfield value in the received TDD SSW Ack frame

Subsequent opportunities for the responder to transmit to the initiator are separated by the value of the Transmit Period subfield in the last TDD SSW Ack frame.

For the unscheduled TDD beamforming procedure, equations (3) and (4) establish transmit opportunities to exchange TDD Beamforming frames, and equations (5) and (6) establish transmit opportunities to exchange frames other than TDD Beamforming frames after TDD beamforming training completion with the responder.

In the unscheduled TDD beamforming procedure, upon transmission of the last TDD SSW Ack frame with End of Training subfield equal to 1, the initiator shall transmit an Announce frame to the responder, at the time offset indicated by equation (5). The Announce frame shall include a TDD Slot Structure element, and a TDD Route element that lists the ordered pairs of TX sector IDs and decoded RX sector IDs obtained during the TDD beamforming training with the responder. The initiator shall then, at the time offset indicated by equation (6), be ready to receive a frame from the responder. If necessary, the initiator shall transmit additional frames at the periodic transmit opportunities following the time offset indicated by Equation (5), and shall be ready to receive additional frames at the periodic opportunities following the offset indicated by Equation (6).

In the scheduled TDD beamforming procedure, the initiator shall send TDD SSW and TDD SSW Ack frames during BF TDD slots assigned to transmit from the initiator to the responder. The exchange of TDD Route elements takes place during Basic or Data TDD slots available to the initiator and to the responder after completion of the TDD beamforming training with the responder.

***Editor: Change Section 10.42.11.3 as follows***

**10.42.11.3 Responder operation for TDD individual beamforming**

…

In the unscheduled TDD beamforming procedure, upon reception of a TDD SSW Ack frame with End of Training subfield equal to 1, the responder shall be ready to receive an Announce frame from the initiator at the time offset indicated by Equation (5). The responder shall then, at the time offset indicated by Equation (6), transmit an Announce or (Re)Association Request frame that includes a TDD Route element listing the ordered pairs of transmit sectors and decoded receive sectors obtained during the TDD beamforming training with the initiator. If necessary, the responder shall transmit additional frames at the periodic transmit opportunities following the time offset indicated by Equation (6), and shall be ready to receive additional frames at the periodic opportunities following the offset indicated by Equation (5).

In the scheduled TDD beamforming procedure, the responder shall send TDD SSW Feedback frames during BF TDD slots assigned to transmit from the responder to the initiator. The exchange of TDD Route elements takes place during Basic or Data TDD slots available to the initiator and the responder after completion of the TDD beamforming training.

***Editor: Change Section 10.42.11.4 as follows***

**10.42.11.4 Initiator operation for TDD group beamforming**

…

To receive a TDD SSW Feedback frame from the responder, the initiator shall set its receive antenna to the same DMG antenna and sector as was indicated, respectively, in the TX Antenna ID and TX Sector ID subfields of the respective TDD SSW frame, at the following offset from the end of the last transmitted TDD SSW frame:

*ResponderFeedbackOffsetn* – [*AckCountIndex* × TXTIME(TDD SSW Ack) + (*CountIndex* + 1 – *AckCountIndex*) × TXTIME(TDD SSW) + (*CountIndex* × SBIFS)] (7)

where:

*ResponderFeedbackOffsetn* is the value of the Responder Feedback Offset subfield in the *nth* responder’s Responder Info subfield of the TDD SSW frame with the same TX Sector ID within the same TDD slot. In order to avoid collision of TDD SSW Feedback frames, different Responder Feedback Offset subfield values should be used for different responders.

*CountIndex* is the value of the Count Index subfield in the received TDD SSW frame

*AckCountIndex* is the value of the Ack Count Index subfield in the received TDD SSW frame

Figure 10-94w depicts the calculation of time to transmit a TDD SSW Feedback frame for unscheduled TDD group BF.



Figure 10-94w – TDD SSW Feedback frame transmit time for unscheduled TDD group BF

If the initiator received a TDD SSW Feedback frame, it shall set its DMG antenna to the same sector that was used to transmit the respective TDD SSW frame, and transmit one or more TDD SSW Ack frames to the responder, starting at the following offset from the end of the last transmitted TDD SSW frame:

*InitiatorAckOffsetn* – [*AckCountIndex* × TXTIME(TDD SSW Ack) + (*CountIndex* + 1 – *AckCountIndex*) × TXTIME(TDD SSW) + (*Count Index* × SBIFS)] (8)

where:

*InitiatorAckOffsetn* is the value of the Initiator Ack Offset subfield in the *nth* responder’s Responder Info subfield of the TDD SSW frame with the same TX Sector ID within the same TDD slot.

*CountIndex* is the value of the Count Index subfield in the received TDD SSW frame

*AckCountIndex* is the value of the Ack Count Index subfield in the received TDD SSW frame

The TDD SSW Ack frame shall include the DMG antenna and the sector used by the initiator to transmit the TDD SSW Ack frame in, respectively, the TX Antenna ID and TX Sector ID subfields, the DMG antenna and sector used by the responder to transmit the TDD SSW Feedback frame in, respectively, the Decoded TX Antenna ID and Decoded TX Sector ID subfields, the measured SNR of the decoded TDD SSW Feedback frame in the SNR Report subfield and, when performing unscheduled TDD beamforming, time offsets to exchange frames containing TDD Route, TDD Slot Structure, and TDD Slot Schedule elements.

…

Once the initiator sends a TDD SSW Ack frame with the End of Training subfield equal to 1 to a target responder, it may transmit a single PPDU other than a TDD Beamforming frame to the target responder, setting its transmit antenna to the same sector it used to transmit the last TDD SSW Ack frame, at the following offset from the end of the last transmitted SSW Ack frame, or, alternatively, in an assigned BF TDD slot:

*InitiatorTransmitOffset* – [(*AckCountIndex* + 1) × TXTIME(TDD SSW Ack) + (*CountIndex* – *AckCountIndex*) × TXTIME(TDD SSW) + (*Count Index* × SBIFS)] (9)

where:

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

*CountIndex* is the value of the Count Index subfield in the received TDD SSW or TDD SSW Ack frame

*AckCountIndex* is the value of the Ack Count Index subfield in the transmitted TDD SSW Ack frame

Subsequent opportunities for the initiator to transmit to the responder are separated by the value of the Transmit Period subfield in the last TDD SSW Ack frame.

Additionally, after the initiator has sent the last TDD SSW Ack frame with the End of Training subfield equal to 1 to a target responder, it can receive a single PPDU other than a TDD Beamforming frame from the responder, setting its receive DMG antenna and sector to what was indicated in the TX Antenna ID and TX Sector ID subfields of the respective TDD SSW Ack frame, and at the following offset from the end of the last transmitted TDD SSW Ack frame:

*ResponderTransmitOffset* – [(*AckCountIndex* + 1) × TXTIME(TDD SSW Ack) + (*CountIndex* – *AckCountIndex*) × TXTIME(TDD SSW) + (*Count Index* × SBIFS)] (10)

where:

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

*CountIndex* is the value of the Count Index subfield in the respective TDD SSW or TDD SSW Ack frame

*AckCountIndex* is the value of the Ack Count Index subfield in the transmitted TDD SSW Ack frame

Subsequent opportunities for the responder to transmit to the initiator are separated by the value of the Transmit Period subfield in the last TDD SSW Ack frame.

For the unscheduled TDD beamforming procedure, equations (7) and (8) establish transmit opportunities to exchange TDD Beamforming frames, and equations (9) and (10) establish transmit opportunities to exchange frames other than TDD Beamforming frames after TDD beamforming training completion with the target responder.

In the unscheduled TDD beamforming procedure, upon transmission of the last TDD SSW Ack frame with End of Training subfield equal to 1, the initiator shall follow the same procedure as the initiator in Section 10.42.11.2 with *InitiatorTransmitOffset* and *ResponderTransmitOffset* parameters given by Equations (9) and (10) instead of Equations (5) and (6).

In the scheduled TDD beamforming procedure, the initiator shall send TDD SSW and TDD SSW Ack frames during BF TDD slots assigned to transmit from the initiator to the responder. The exchange of TDD Route elements takes place during non-beamforming TDD slots available to the initiator and the target responder after completion of the TDD beamforming training with the target responder.

***Editor: Change Section 10.42.11.5 as follows***

**10.42.11.5 Responder operation for TDD group beamforming**

…

In the unscheduled TDD beamforming procedure, upon reception of a TDD SSW Ack frame with End of Training subfield equal to 1, the responder, at the time offset indicated by equation (10), shall follow the same procedure as the responder in Section 10.42.11.3 with *InitiatorTransmitOffset* and *ResponderTransmitOffset* parameters given by Equations (9) and (10) instead of Equations (5) and (6).

In the scheduled TDD beamforming procedure, the responder shall send TDD SSW Feedback frames during BF TDD slots assigned to transmit from the responder to the initiator. The exchange of TDD Route elements takes place during Basic or Data TDD slots available to the initiator and the responder after completion of the TDD beamforming training.

***Editorial: Change 3 instances of “End of Training field” to “End of Training subfield” in Draft 5.0.***