IEEE P802.11
Wireless LANs

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| Draft text for asymmetric beamforming training procedure enhancements |
| Date: 2017-09-08 |
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Abstract

This document proposes text changes for subclauses 9.4.2.252, 9.3.1.22, 9.5.7, 10.36.6.1 and 10.38.9.3 of the spec

*Change the following subclause*

* + - 1. EDMG Extended Schedule element

The EDMG Extended Schedule element defines the channel scheduling for an EDMG BSS, including an indication of which channels an allocation is scheduled on.

The format of the EDMG Extended Schedule element is shown in Figure 1.

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  | Element ID | Length | Element ID Extension | Number of Allocations | Channel Allocation 1 | … | Channel Allocation N |
| Octets: | 1 | 1 | 1 | 1 | 5 or 19 |  | 5 or 19 |

1. —EDMG Extended Schedule element format

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

The Number of Allocations field indicates the number, *N*, of Channel Allocation fields following it.

Each Channel Allocation field starts with a Scheduling Type subfield, which defines the format of the remaining of the Channel Allocation field.

If the Scheduling Type subfield is 0, the Channel Allocation field contains incremental signaling to the Extended Schedule element. In this case, the Channel Allocation field is defined in Figure 2 and specifies the allocation and the bandwidth that the allocation occupies.

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | B0 | B1 B24 | B25 | B26 B33 |  |  |  | B34 B39 |
|  | Scheduling Type | Allocation Key | Channel Aggregation | BW |  |  |  | Reserved |
| Bits: | 1 | 24 | 1 | 8 |  |  |  | 6 |

1. —Channel Allocation field format when Scheduling Type is 0

The contents of the Allocation Key subfield are used to identify the allocation. This is done by matching the contents of this subfield with the information obtained from the Extended Schedule element transmitted in the same frame containing the EDMG Extended Schedule element. The Allocation Key subfield is formatted as shown in Figure 3.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | B0 B3 | B4 B11 | B12 B19 | B20 B23 |
|  | Allocation ID | Source AID | Destination AID | Reserved |
| Bits: | 4 | 8 | 8 | 4 |

1. —Allocation Key field format

The Allocation ID, Source AID and Destination AID subfields are collectively used to identify the allocation included as part of the Extended Schedule element.

The Channel Aggregation and BW subfields are defined in Table 24. These fields specify the channel(s) over which the allocation is scheduled on.

|  |  |  |  |
| --- | --- | --- | --- |
|  |  |  |  |
|  |  |  |  |
|  |  |  |  |

1.

If the Scheduling Type subfield is 1, the Channel Allocation field contains the complete allocation scheduling information. In this case, the Channel Allocation field is defined in Figure 5.

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | B0 | B1 | B2 B9 | B10 | B11 B19 | B20 B24 | B25 B26 | B27 B31 | B32 B151 |
|  | Scheduling Type | Channel Aggregation | BW | Asymmetric Beamforming Training | Receive Direction | N STS  | Nmax STS  | Reserved | Allocation |
| Bits: | 1 | 1 | 8 | 1 | 9 | 5 | 2 | 5 | 120 |

1. —Channel Allocation field format when Scheduling Type is 1

|  |  |  |  |
| --- | --- | --- | --- |
|  |  |  |  |
|  |  |  |  |
|  |  |  |  |

The value of the N STS subfield indicates the number of space-time slots allocated by AP or PCP for asymmetric beamforming training. The N STS subfield is reserved if the Asymmetric Beamforming Training subfield is zero.

 The value 2STS should be no more that the value of N STS subfield.

The Allocation subfield is defined in Figure 9-517. Other subfields are defined in the paragraphs above.

*Add the following subclause*

9.3.1.22 Sector ACK frame format

The Sector ACK frame is shown in Figure 9-xxx.

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | Frame Control | Duration | RA | TA | Number of Sector Feedback Fields | Sector Feedback 1 | …  | Sector Feedback N | FCS |
| Octets: | 2 | 2 | 6 | 6 | 1 | 14 | … | 14 | 4 |

The Duration field is set to the time until the end of the current allocation.

If the value of Number of Sector Feedback Fields is 1, the RA field contains the MAC address of the STA that is the intended destination of the Sector ACK frame. If the value of Number of Sector Feedback Fields is greater than 1, the RA field is set to the broadcast MAC address.

The TA field contains the MAC address of the STA transmitting the Sector ACK frame.

The Number of Sector Feedback Fields indicates the number, N, of Sector Feedback fields following it.

The Sector Feedback field is defined in 9.5.7.

*Add the following subclause*

9.5.7 Sector Feedback field

The Sector Feedback field is shown in Figure 9-xxx.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | RA | SSW Feedback | BRP Request | Beamformed Link Maintenance |
| Octets: | 6 | 3 | 4 | 1 |

The RA field contains the MAC address of the STA that is the intended destination of this Sector Feedback field.

The SSW Feedback field is defined in Figure 9-638.

The BRP Request field is defined in 9.5.4.

1. The Beamformed Link Maintenance field is defined in 9.5.6.
	* + 1. Channel access in scheduled DTI

*Change the third paragraph as follows*

The schedule of the DTI of a beacon interval shall be communicated through the Extended Schedule
element and, in an EDMG BSS, also through the EDMG Extended Schedule element. The AP or PCP transmits the Extended Schedule element in either or both an Announce frame or a DMG Beacon frame. The Extended Schedule element shall contain the scheduling information of all allocations in the DTI, except if transmitted in an EDMG BSS where the Extended Schedule element may exclude one or more allocations that are included in EDMG Extended Sсhedule element transmitted through at least one sector. The same Allocation field shall not appear more than once in the Extended Schedule element or EDMG Extended Schedule element transmitted in a beacon interval. The content of the Extended Schedule element and the EDMG Extended Schedule element communicated in a beacon interval shall not change if transmitted more than once in the beacon interval, except:

* If the STA transmitting the Extended Schedule element or the EDMG Extended Schedule element is a PCP with multiple DMG antennas then the value of the PCP Active field of CBAP allocations within the Extended Schedule element or the EDMG Extended Schedule element might change when this elements ~~is~~ are transmitted through different DMG antennas.
* For the EDMG Extended Schedule element, fields that are related to directional allocation (10.36.11.3) or beamforming training allocation (10.38.9.3.3) may change during the beacon interval when transmitted through different sectors.

The AP or PCP should schedule SPs for a STA such that the scheduled SPs do not overlap in time with the traffic scheduling constraints indicated by this STA in the Traffic Scheduling Constraint Set field of the associated DMG TSPEC element.

*Insert the following subclause*

* 1. + 1. Beamforming for asymmetric links
				1. General

An asymmetric link is present when a STA is able to receive frames from the peer STA, but its frame transmissions are not received by the peer STA due to a difference in link budget between the uplink and downlink between the STAs. The difference in the number of antenna elements between a pair of STAs may cause an asymmetric link if a quasi-omni antenna configuration is used by one of the STAs when attempting communication with the peer STA.

The procedure defined in this subclause enables an initiator and a responder that would otherwise have an asymmetric link if a quasi-omni antenna configuration were to be used for communication between them, to perform beamforming according to the procedure described in this subclause. Following the establishment of the beamformed link, all frame exchanges between the STAs take place using the established beamformed link.

* + - * 1. Scheduling during the BTI

To enable beamforming for asymmetric links, a PCP or AP shall:

* In the PPDU containing a DMG Beacon frame transmitted in a BTI through the sector for which the asymmetric beamforming training is considered to be performed, include TRN-R subfields within the TRN field of the PPDU as specified in 10.38.4.
* Include an EDMG Extended Schedule element in the DMG Beacon frame that is transmitted in the step above. The EDMG Extended Schedule element shall include at least one allocation that has the Asymmetric Beamforming Training subfield for the allocation set to 1.

A non-PCP and non-AP STA receiving a DMG Beacon with appended TRN-R fields and that decides to perform beamforming using the procedure described in this subclause shall use the TRN-R fields to perform receive beamforming as specified in 10.38.2. The STA may then use one or more of the allocations announced in the EDMG Extended Schedule element that have the Asymmetric Beamforming Training subfield equal to 1 to perform the procedure specified in 10.38.9.3.3.

* + - * 1. Beamforming training allocation in DTI

A beamforming training allocation in the DTI is scheduled through the EDMG Extended Schedule element. A beamforming training allocation has the Asymmetric Beamforming Training subfield for the allocation equal to 1. Channel access during a beamforming training allocation is as follows:

* The PCP or AP shall listen on the combination of sector and DMG antenna which was used for transmission of the DMG Beacon frame describing this allocation during the last BTI. The PCP or AP shall listen for NSTS space-time slots for any responder’s transmission, where NSTS is the value of the N STS subfield describing the allocation. A space-time slot has a duration of aAirPropagationTime + TXTIME(SSW) + aSIFSTime.
* At the start of the allocation, the responder(s) shall invoke a random backoff procedure to transmit a SSW frame. The random backoff procedure begins at the start of the beamforming training allocation with the responder selecting a backoff count as a random integer drawn from a uniform distribution [0, NSTS), i.e., 0 to NSTS – 1. The responder shall decrement the backoff count by one at the end of each space-time slot, even if the CS function at the responder indicates the medium busy condition for that space-time slot. The responder may transmit the SSW frame only at the start of the space-time slot for which the backoff count is 0 at the beginning of the space-time slot. The responder’s transmission is performed in directional mode using the sector trained by the TRN-R subfields received in the last BTI
* A responder may transmit more than one consecutive SSW frame within one listen period, but shall not exceed the maximum number of space-time slots a responder can occupy as given by 2STS, where STS is the value of the Nmax STS subfield describing the allocation.
* After transmitting the SSW frame(s), the responder switches to directional receive in the sector trained by TRN-R in the last BTI.
* MBIFS after the PCP or AP completes listening for NSTS space-time slots, it shall transmit a Sector ACK frame (see 9.3.1.22) on the same combination of sector and DMG antenna which was used for listening. The Sector ACK frame contains the information about the STAs that have been during the allocation. In case several SSW frames have been received from a STA, the Sector ACK refers to the SSW frame which was received with best quality. The determination of which packet was received with best quality is implementation dependent.

An example of beamforming training for asymmetric links of three EDMG STAs and an EDMG PCP or AP is shown in Figure 6. In the example, STA#1 selects the second (out of four) space-time slot and transmits the SSW frame with a beamforming link determined by the TRN-R appended during the last BTI. STAs #2 and #3 choose the third space-time slot and transmitting SSW frames get into a collision. MBIFS after the fourth space-time slot AP transmits Sector ACK frame which includes information about all STAs which SSW frames were received correctly: STA#1 and either one of STAs #2 and #3 or none of them. In case if after reception of Sector ACK the STA cannot find itself in the list of identified STAs, it may try to perform asymmetric beamforming training during the next beamforming training allocation for this sector.



1. — An example of beamforming training for asymmetric links in a beamforming training allocation

Following the successful completion of the beamforming training, the AP or PCP can schedule directional allocations for data exchange with the non-PCP and non-AP STA (see 10.36.11.3).

**SP:**

Do you agree to include the text changes proposed in (11-17-1422-01-00ay-Draft text for asymmetric beamforming training procedure enhancements) to the spec draft?

**References:**

1. IEEE802.11-2016
2. Draft P802.11ay\_D0.5