IEEE P802.11Wireless LANs

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| LB230 CR on BSS Load Information in subclause 9.4.2 |
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Abstract

This submission proposes resolutions of comments received from TGax LB230. (The proposed change is based on TGax Draft 2.3)

* CIDs: 12016, 13045 (2 CIDs)

Revisions:

* Rev 0: Initial version of the document.
* Rev 1: Modification with blue color according to the comments, and add two options
* Rev 2: Remove the option 2 because option 1 got more support based on the straw poll

Interpretation of a Motion to Adopt

A motion to approve this submission means that the editing instructions and any changed or added material are actioned in the TGax Draft. This introduction is not part of the adopted material.

***Editing instructions formatted like this are intended to be copied into the TGax Draft (i.e. they are instructions to the 802.11 editor on how to merge the text with the baseline documents).***

***TGax Editor: Editing instructions preceded by “TGax Editor” are instructions to the TGax editor to modify existing material in the TGax draft. As a result of adopting the changes, the TGax editor will execute the instructions rather than copy them to the TGax Draft.***

| **CID** | **Page** | **Clause** | **Comment** | **Proposed Change** | **Resolution** |
| --- | --- | --- | --- | --- | --- |
| 12016  | 118.01  | 9.4.2 | With the introduction of new features such as OFDMA and UL MU MIMO, the existing BSS load elements (9.4.2.160 & 9.4.2.28), which address STA numbers, primary/secondary channel busy condition and DL MU-MIMO underutilization (11ac) are not sufficient for addressing the BSS load status in a 11ax BSS. A further enhanced BSS Load element needs to be defined. | Add a new information element or element extension to define 11ax BSS Load. The new IE shall address utilization status of OFDMA as well as UL/DL MU MIMO, as well as provisions to allow future extensions. | Revised- Agree in principal. The proposed resolution is to provide a spatial/frequency underutilization to solve load unbalancing problem in 802.11axTGax editor makes changes as shown in the as specified in 11-18/0181r2. |
| 13045  | 118.01  | 9.4.2 | BSS load element provides the channel utilization such that the unassociated STA can choose the proper AP, and extended BSS load element further provides the the spatial stream underutilization given the busy channel such that unassociated STA with MU-MIMO capability can choose the proper AP. Now 11ax introduce OFDMA, there is the probability of frequence underutilization given the busy channel. | Define a HE BSS load element considering frequency utilization such to help unassociated STA to choose a best AP | Revised- Agree in principal. The proposed resolution is to provide a spatial/frequency underutilization to solve load unbalancing problem in 802.11axTGax editor makes changes as shown in the as specified in 11-18/0181r2. |

**Discussion: *…***

Load balancing problem were considered 802.11-2016[1] which includes

* + Channel utilization in time domain was proposed in 9.4.2.28 BSS Load element
	+ Spatial stream underutilization in space domain was proposed in 9.4.2.160 Extended BSS Load element
	+ STAs use it for implementation-specific AP selection, in order to obtain more transmission opportunities.

802.11ax introduced OFDMA and MU-MIMO two key features where partial bandwidth MU-MIMO is allowed which is different from the downlink full bandwidth MU-MIMO in 802.11ac, but these two key features are not reflected in traffic load for HE BSSs

Frequency underutilization regarding OFDMA and spatial stream underutilization regarding MU-MIMO (including both full bandwidth MU-MIMO and partial bandwidth MU-MIMO) were first present in [2] and [3]

**The concept of frequency and spatial stream underutilization for OFDMA/MU-MIMO was agreed in 2017 Korea IEEE MAY F2F meeting [4].**

We discusse frequency underutilization and spatial stream underutilization frome three aspects, including OFDMA only transmission, partial bandwidth MU-MIMO transmission and full bandwidth MU-MIMO transmission. We assume that the maximum supported streams on AP side is 8 and the bandiwth is 20 MHz in the following discussion.

1. Regarding OFDMA only transmission, each RU will be selected to assign to some STA according to frequency selective. However, in some case, some RU is not assigned because that this RU is deep fading for the scheduled STA which have traffic or non-contiguous RUs are not allowed to assigned to one STA as shown in the following figure. According to the following figure, AP has underutilized frequency domain resource (52 tone RU is available) for given busy time of the medium which is not reflected in BSS Load element and extended BSS Load element.

106 RU

26

RU

52 RU

52 RU

Frequency

SS

Occupied RU

Available RU

OFDMA only transmission

8

1

2. Regarding partial bandwidth MU-MIMO transmission, follow the bellow figure, except the unassigned RU in this transmission, AP only allocates 4 streams to the 2 STAs on the 106-tone RU, but still to have 4 streams available. This kind of underutilized spatial domain resources are not reflected in BSS Load element and Extended BSS Load element.

Note: the minimum RU size for MU-MIMO is 106-tone.

106 RU

(2 STAs)

26

RU

52 RU

52 RU

Frequency

SS

Available sptial steams

Occupied RU

Available RU

Partial bandwithd MU-MIMO transmission

4

8

3. Regarding full bandwidth MU-MIMO transmission, as shown in the following figure there are still 6 spatial space steams available which can be assigned to another users to form MU-MIMO. This case was discussed in extended BSS load element, but it does not cover UL full bandwidth MU-MIMO.

Frequency

SS

Available spatial steams

Occupied RU

Available RU

Full bandwidth MU-MIMO transmission

8

2

242 RU (2 STAs)

Besides that the frequency underutilization and spatial space streams are needed for 802.11ax, a baseline Utilization field is required becase all the unutilization fields are computed in a given busy time .

In the “Optimized\_Connectivity\_Experience\_TechnicalSpecification\_v1.0”, it says

1.1 Metrics for AP selection

An OCE AP shall transmit the BSS Load element (section 9.4.2.28 [3]) in its Beacon and Probe Response frames. An OCE AP that supports a VHT PHY may also transmit the Extended BSS Load element (section 9.4.2.160 [3]) in its Beacon and Probe Response frames.

It shows OCE AP shall implement BSS Load Element although the medium is dynamic.

**Reference**

[1] Draft P802.11-2016

[2] 11-17-0361-01-00ax-bss-load-information-in-802-11ax

[3] 11-17-0308-04-00ax-cr-for-section-9-4-2-bss-load-ppt

[4] 11-17-0308-02-00ax-cr-for-section-9-4-2-bss-load-ppt

**9.4.2 Elements**

**TGax Editor: *Add the following subsection***

**9.4.2.246 HE BSS load element**

The HE BSS Load element reported by the AP contains information on utilization, frequency underutilization and spatial stream underutilization. The element format is defined in Figure 9-xxx (HE BSS Load element format). A STA receiving the element might use the information it conveys in an implementation-specific AP selection algorithm.



**Figure 9-xxx—HE BSS Load element format**

The Element ID, Length and Element ID extension fields are defined in 9.4.2.1 (General).

The HE STA Count field indicates the total number of STAs currently associated with this BSS that declare that they are HE STAs by transmitting their HE Capabilities elements.

The Utilization field, Frequency Underutilization field and Spatial Stream Underutilization field are defined as the percentage of time, linearly scaled with 255 representing 100%.

The Utilization field is that AP sensed the medium was busy due to a transmission between the AP and HE STAs, as indicated by the physical carrier sense (CS) mechanism. When more than one channels are in use for the BSS, the Utilization field value is calculated only for the primary channel. This percentage is computed using the formula

The Frequency Underutilization field is that AP has underutilized frequency domain resources for given busy time of the medium. This percentage is computed using the formula

The Spatial Stream Underutilization field is that AP has underutilized spatial domain resources for given busy time of the medium. This percentage is computed using the formula

where

dot11ChannelUtilizationBeaconIntervals represents the number of consecutive beacon intervals during which the channel busy time is measured (see subclause 9.4.2.28 (BSS Load element)). The default value of dot11ChannelUtilizationBeaconIntervals is defined in Annex C.

 is the number of microseconds during which CCA indicated the channel was busy due to a transmission between the AP and HE STAs during the measurement duration. The resolution of the CCA busy measurement is in microseconds.

 is the time interval, in units of microseconds, during which the primary 20 MHz channel is busy due to a transmission between the AP and HE STAs;

N is the number of busy events that occurred during the total measurement time which is less than or equal to dot11ChannelUtilizationBeaconIntervals consecutive beacon intervals.

 is the number of RUs which are allocated within the BSS bandwidth during time interval ;

 is a normalizing factor depending on the RU size and equals the ratio of the jth RU size to the maximum RU size within the BSS bandwidth, i.e., if the j-th RU is a 26-tone RU and the BSS bandwidth is 20 MHz, then ;

 is 1 if thej-th RU is occupied or interfered in the busy time , otherwise it is 0;

 is a normalizing factor depending on the maximum RU size of the BSS bandwidth, and is set to 1;

 is the maximum number of spatial streams supported by the AP.

 is the number of RUs whose size are at least 106 tones or greater and which are allocated within the BSS bandwidth during time interval ;

 is a normalizing factor depending on the RU size. RUM is applied in respect of RUs whose size is at least 106 tones and equals the ratio of the jth RU size to the maximum RUM size within the BSS bandwidth, i.e.,. If the j-th RUM is a 106-tone RU and the BSS bandwidth is 20 MHz, then.

 is the number of streams over the j-th RUM in the busy time.

If is 0, the Utilization filed, Frequency Underutilization field and Spatial Stream Underutilization field are reserved.

**9.3.3.3 Beacon frame format**

***TGax editor: Insert the HE BSS load element in*** ***Table 9-27 Beacon frame body*** and renumber the reserved values accordingly***:***

**Table 9-27—Beacon frame body**

|  |  |  |
| --- | --- | --- |
| Order | Information | Notes |
| <ANA> | HE BSS load element | The HE BSS Load element is optionally present if dot11QosOptionImplemented and dot11QBSSLoadImplemented and dot11HEOptionImplemented are true. |

**9.3.3.11 Probe Response frame format**

***TGax editor: Insert the HE BSS load element in*** ***Table 9-34 Probe Response frame body*** and renumber the reserved values accordingly***:***

**Table 9-34—Probe Response frame body**

|  |  |  |
| --- | --- | --- |
| Order | Information | Notes |
| <ANA> | HE BSS load element | The HE BSS Load element is optionally present if dot11QosOptionImplemented and dot11QBSSLoadImplemented and dot11HEOptionImplemented are true. |

**9.4.2 Elements**

 **9.4.2.1 General**

TGax editor: Insert the following row in table 9-77, and renumber the reserved values accordingly:

Table 9-77—Element IDs

|  |  |  |  |
| --- | --- | --- | --- |
| Element | Element ID | Element ID Extension | Extensible |
| HE BSS Load element (see 9.4.2.246 (HE BSS load element)) | 255 | <ANA> | Yes |