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Wireless LANs

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| **Specification Framework for TGbe** |
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Abstract

This document provides the framework from which the draft TGbe amendment will be developed. The document provides an outline of each the functional blocks that will be a part of the final amendment. The document is intended to reflect the working consensus of the group on the broad outline for the draft specification. As such it is expected to begin with minimal detail reflecting agreement on specific techniques and highlighting areas on which agreement is still required. It may also begin with an incomplete feature list with additional features added as they are justified. The document will evolve over time until it includes sufficient detail on all the functional blocks and their inter-dependencies so that work can begin on the draft amendment itself.

# Revision history

|  |  |  |
| --- | --- | --- |
| Revision | Date | Changes |
| 0 | July 15, 2019 | Initial draft version for task group review |
| 1 | July 18, 2019 | Revised draft version based on the inputs from task group members |
| 2 | July 18, 2019 | Further revised draft version based on the inputs from task group members |
| 3 | October 9, 2019 | Incorporated motions 1, 6, 10, and 11 approved in the September 2019 interim. |
| 4 | October 9, 2019 | Incorporated motion 9 approved in the September 2019 interim. |
| 5 | November 17, 2019 | Incorporated motions 14-38, 40-49 approved in the November 2019 plenary. |
| 6 | November 27, 2019 | Further revised draft version based on [the input from a task group member](http://www.ieee802.org/11/email/stds-802-11-tgbe/msg00322.html). |
| 7 | January 26, 2020 | Incorporated motions 50-63, 65-76, and 78-110 approved in the January 2020 interim. |

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# Abbreviations and acronyms

BIGTK beacon integrity group temporal key

BPSK binary phase shift keying

BU bufferable unit

BSS basic service set

BW bandwidth

CCA clear channel assessment

DL downlink

DS distribution system

EHT extremely high throughput

EP emergency preparedness

GLK group temporal key

HE high efficiency

IGTK integrity group temporal key

LLC logical link control

L-LTF Non-HT Long Training field

L-SIG Non-HT SIGNAL field

L-STF Non-HT Short Training field

LTF long training field

MAC medium access protocol

MCS modulation and coding scheme

MLD multi-link device

MU multi-user

MU-MIMO multi-user multiple input, multiple output

NDP null data PPDU

NS national security

OFDM orthogonal frequency division multiplexing

PHY physical layer

PN packet number

PPDU PHY protocol data unit

PSDU PHY service data unit

RA receiver address

RL-SIG Repeated Non-HT SIGNAL field

RU resource unit

RX receive or receiver

SAP service access point

STA station

SU single user

SU-MIMO single user multiple input, multiple output

TA transmitter address

TID traffic identifier

TX transmit or transmitter

TXOP transmission opportunity

UL Uplink

U-SIG Universal SIGNAL field

WM wireless medium

# EHT PHY

1.
2.

## General

This section describes the functional blocks in the EHT PHY.

## Channelization and tone plan

### Wideband and noncontiguous spectrum utilization

802.11be supports 320 MHz and 160+160 MHz PPDU.

[Motion 10, [1] and [2]]

802.11be supports 240 MHz and 160+80 MHz transmission

* Whether 240/160+80 MHz is formed by 80 MHz channel puncturing of 320/160+160 MHz is TBD.

[Motion 16, [3] and [4]]

240/160+80 MHz bandwidth is constructed from three 80 MHz channels which include primary 80 MHz.

[Motion 17, [3] and [5]]

802.11be reuses 802.11ax tone plan for 20/40/80/160/80+80 MHz PPDU.

For 320 MHz and 160+160 MHz PPDU, 802.11be uses duplicated HE160 for OFDMA tone plan.

[Motion 33, [3] and [6]]

802.11be 240/160+80 MHz transmission consists of 3x80 MHz segments while the tone plan of each 80 MHz segment is the same as HE80 in 802.11ax.

[Motion 35, [3] and [6]]

A 160 MHz tone plan is duplicated for the non-OFDMA tone plan of 320/160+160 MHz PPDU.

* The 160 MHz tone plan is TBD.

[Motion 18, [3] and [7]]

The 802.11be 320/160+160 MHz non-OFDMA tone plan uses duplicated tone plan of HE160.

NOTE – Puncturing design TBD.

[Motion 34, [3] and [6]]

12 and 11 null tones are placed at the left and right edges in each 160 MHz segment for the non-OFDMA tone plan of 320/160+160 MHz PPDU.

[Motion 19, [3] and [7]]

802.11be uses the same subcarrier spacing for the data portion of EHT PPDU as 802.11ax data portion.

[Motion 11, [1] and [2]]

## Resource unit

802.11be shall allow more than one RUs to be assigned to a single STA.

Coding and interleaving schemes for multiple RUs assigned to a single STA are TBD.

Maximum number of RUs (>1) assigned to a single STA is also TBD.

[Motion 6, [1] and [8]]

Small-size RUs can only be combined with small-size RUs and large-size RUs can only be combined with large-size RUs.

RUs with equal to or more than 242 tones are defined as large-size RUs.

RUs with less than 242 tones are defined as small-size RUs.

[Motion 76, [9] and [10]]

### Small-size RUs

Combination of small-size RUs shall not cross 20 MHz channel boundary.

* The combination that includes RU 106 plus center 26-tone RU case is TBD.

[Motion 69, [9] and [10]]

Only allowed small-size RU combinations are RU106+RU26 and RU52+RU26.

[Motion 78, [9] and [10]]

For 20 MHz and 40 MHz PPDU, within 20 MHz boundary, any contiguous RU26 and RU106 can be combined.

[Motion 79, [9] and [10]]

For 20 MHz and 40 MHz PPDU, the blue colored combination of RU52 and RU26 are allowed.



Figure 1 – Allowed combination of RU52+RU26 for 20 MHz and 40 MHz PPDU

[Motion 80, [9] and [10]]

For 80 MHz PPDU, the blue colored combination of RU52 and RU26 are allowed.



Figure 2 – Allowed combination of RU52+RU26 for 80 MHz PPDU

[Motion 81, [9] and [10]]

For LDPC coding, for combined RUs sent to a user with RU size less than 242-tone, a single tone mapper shall be used.

[Motion 82, [9] and [11]]

### Large-size RUs

For the OFDMA transmission in 320/160+160 MHz, for one STA large size RU aggregation is allowed only within primary 160 MHz or secondary 160 MHz, respectively.

* Note that primary 160 MHz is composed of primary 80 MHz and secondary 80 MHz and secondary 160 MHz is 160 MHz channel other than the primary 160 MHz in 320/160+160 MHz.

Exception: 3×996 is supported.

3×996+484 RU combinations is TBD.

[Motion 87, [9] and [12]]

For the OFDMA transmission in contiguous 240 MHz, for one STA large size RU aggregation is allowed only within 160 MHz which is composed of two adjacent 80 MHz channels.

For the OFDMA transmission in noncontiguous 160+80 MHz, for one STA large size RU aggregation is allowed only within contiguous 160 MHz or the other 80 MHz, respectively.

2×996+484 RU combinations is TBD.

[Motion 86, [9] and [12]]

In 160 MHz OFDMA the following large RU combinations are supported.

|  |  |  |
| --- | --- | --- |
| **RU size** | **Aggregate BW** | **Notes** |
| 484 + 996 | 120 MHz | 4 options |

[Motion 98, [9] and [13]]

In 80 MHz OFDMA the following large RU combinations are supported.

|  |  |  |
| --- | --- | --- |
| **RU size** | **Aggregate BW** | **Notes** |
| 484 + 242 | 60 MHz | 4 options |

[Motion 97, [9] and [13]]

In 80 MHz non-OFDMA the following conditional mandatory (conditional on supporting puncturing) large RU combinations are supported.

* Any one of four 242 RU can be punctured.

|  |  |  |
| --- | --- | --- |
| **RU size** | **Aggregate BW** | **Notes** |
| 484 + 242 | 60 MHz | 4 options |

[Motion 93, [9] and [13]]

In 160 MHz non-OFDMA the following conditional mandatory (conditional on supporting puncturing) large RU combinations are supported.

* Any one of eight 242 RUs can be punctured.
* Any one of four 484 RUs can be punctured.

|  |  |  |  |
| --- | --- | --- | --- |
| **80 MHz RU Size** | **80 MHz RU size** | **Aggregate BW** | **Notes** |
| 484 | 996 | 120 MHz | 4 options |
| 484 + 242 | 996 | 140 MHz | 8 options |

[Motion 94, [9] and [13]]

In 240 MHz non-OFDMA the following conditional mandatory (conditional on supporting puncturing) large RU combinations are supported.

* Any one of six 484 RUs can be punctured.
* Any one of three 996 RUs can be punctured.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **80 MHz RU size** | **80 MHz RU size** | **80 MHz RU size** | **Aggregate BW** | **Notes** |
| 484 | 996 | 996 | 200 MHz  | 6 options |
| - | 996 | 996 | 160 MHz  | 3 options |

[Motion 95, [9] and [13]]

In 320 MHz non-OFDMA the following conditional mandatory (conditional on supporting puncturing) large RU combinations are supported.

* Any one of eight 484 RUs can be punctured.
* Any one of four 996 RUs can be punctured.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **80 MHz** **RU size** | **80 MHz** **RU size** | **80 MHz** **RU size** | **80 MHz** **RU size** | **Aggregate BW** | **Notes** |
| 484 | 996 | 996 | 996 | 280 MHz | 8 options |
| - | 996 | 996 | 996 | 240 MHz | 4 options |

[Motion 96, [9] and [13]]

## EHT preamble

### L-STF, L-LTF, L-SIG, and RL-SIG

For EHT PPDU, L-STF, L-LTF and L-SIG shall be transmitted at the beginning of the EHT PPDU.

For EHT PPDU, the first symbol after L-SIG shall be BPSK modulated.

[Motion 1, [1] and [14]]

The LENGTH field in L-SIG set to a value *N* such that mod(*N*, 3) = 0.

[Motion 29, [3] and [15]]

Phase rotation is applied to the legacy preamble part of EHT PPDU.

Coefficients applied to each 20 MHz channel are TBD.

Application to the other fields is TBD.

[Motion 41, [3] and [16]]

EHT PPDU shall have a RL-SIG field, which is a repeat of the L-SIG field, immediately following the L-SIG field.

[Motion 49, [3] and [17]]

The extra 4 subcarriers are applied to L-SIG and RL-SIG.

The indices for extra subcarriers are [-28, -27, 27, 28].

The extra subcarriers are BPSK modulated.

The coefficients [-1 -1 -1 1] as in 802.11ax are mapped to the extra subcarriers.

[Motion 107, [9] and [18]]

### U-SIG

There shall be a 2 OFDM symbol long, jointly encoded U-SIG in the EHT preamble immediately after the RL-SIG.

* The U-SIG will contain version independent fields. The intent of the version independent content is to achieve better coexistence among future 802.11 generations.
* In addition, the U-SIG can have some version dependent fields.
* The size of the U-SIG for the case of an Extended Range Mode (if such a mode were to be adopted) is TBD.
* The U-SIG will be sent using 52 data tones and 4 pilot tones per-20MHz.

[Motion 27, [3] and [19]]

The U-SIG is modulated in the same way as the HE-SIG-A field of 802.11ax.

* Extended range SU mode is TBD.

[Motion 45, [3] and [20]]

The U-SIG includes Version-independent bits followed by Version-dependent bits.



Figure 3 – U-SIG

* Version-independent bits have static location and bit definition across different generations/PHY versions.
* Version-dependent bits may have variable bit definition in each PHY version.

[Motion 47, [3] and [21]]

The U-SIG shall contain the following version independent fields:

* PHY version identifier: 3 bits.
* UL/DL flag: 1 bit.

[Motion 42, [3] and [20]]

PHY version identifier field shall be one of the version independent fields in the U-SIG.

* Purpose is to simplify autodetection for future 802.11 generations, i.e., value of this field is used to identify the exact PHY version starting with 802.11be.
* Exact location of this field is TBD.

[Motion 28, [3] and [22]]

The U-SIG field includes the following bits in Version-independent bits portion:

* BSS color, number of bits TBD.
* TXOP duration, number of bits TBD.

[Motion 48, [3] and [21]]

The U-SIG shall contain Bandwidth Information, carried as a version independent field.

* This field may also convey some puncturing information.
* Number of bits for this field is TBD.

[Motion 88, [9] and [23]]

The U-SIG shall contain a PPDU type field, carried as a version dependent field.

* Number of bits for this field is TBD.

[Motion 89, [9] and [23]]

The following subfields exist in U-SIG of an EHT PPDU sent to multiple users:

* EHT-SIG MCS
* Number of EHT-SIG Symbols

[Motion 59, [9] and [24]]

The following subfield exists in U-SIG or EHT-SIG of an EHT PPDU sent to multiple users:

* GI+EHT-LTF Size

[Motion 100, [9] and [24]]

The following subfields exist in U-SIG and/or EHT-SIG of an EHT PPDU sent to single user:

* MCS
* NSTS
* GI+EHT-LTF Size
* Coding

[Motion 99, [9] and [24]]

### EHT-SIG

There shall be a variable MCS and variable length EHT-SIG, immediately after the U-SIG, in an EHT PPDU sent to multiple users.

[Motion 43, [3] and [20]]

The EHT-SIG (immediately after the U-SIG) in an EHT PPDU sent to multiple users shall have a common field and user-specific field(s).

* Special case compressed modes (e.g., full BW MU-MIMO) are TBD.

[Motion 44, [3] and [20]]

An RU Allocation subfield is present in the Common field of the EHT-SIG field of an EHT PPDU sent to multiple users.

* Compressed modes are TBD.
* Contents of the RU Allocation subfield are TBD.

[Motion 57, [9] and [24]]

There exists at least one compressed mode in which RU Allocation subfield does not exist in the Common field of the EHT-SIG field of an EHT PPDU sent to multiple users.

* Signaling method is TBD.

[Motion 58, [9] and [24]]

For the PPDU transmitted to MU, the User field having TBD bits is contained in the user-specific field of EHT-SIG

* The User field indicates user information assigned to each RU similar to that used in HE MU PPDU.
* Detailed descriptions are TBD.

[Motion 85, [9] and [25]]

### EHT-LTF

802.11be shall include 1x EHT-LTF and 2x EHT-LTF.

[Motion 74, [9] and [26]]

802.11be shall include 4x EHT-LTF.

[Motion 75, [9] and [26]]

802.11be supports EHT-LTF for 16 spatial streams.

[Motion 83, [9] and [27]]

### Preamble puncture

CCA minimum BW resolution is 20 MHz.

Preamble puncturing resolution is 20 MHz.

[Motion 90, [9] and [28]]

In 802.11be, there is only one PSDU per STA for each link.

[Motion 91, [9] and [28]]

In 802.11be, for LDPC encoding each PSDU only uses one encoder.

[Motion 92, [9] and [28]]

The 802.11be amendment shall support a preamble puncture mechanism for an EHT PPDU transmitted to multiple STAs.

[Motion 30, [3] and [29]]

The 802.11be amendment shall support a preamble puncture mechanism for an EHT PPDU transmitted to a single STA.

[Motion 31, [3] and [29]]

# EHT MAC

1.

## General

This section describes the functional blocks in the EHT MAC.

The 802.11be amendment shall define mechanism(s) for an AP to assist a STA that communicates with another STA.

[Motion 22, [3] and [30]]

The 802.11be amendment shall define mechanism(s) in support of priority access to a non-AP STA for national security (NS)/emergency preparedness (EP) priority service

NOTE – A non-AP STA for NS/EP priority service is a regular non-AP STA authorized to NS/EP service.

[Motion 50, [9] and [31]]

## Feature #1

Description for feature #1

# Coexistence and regulatory rules

1.

## General

This section describes the functional blocks that support coexistence. It additionally describes, if needed, adaption to regulatory rules specific to 6 GHz spectrum.

## Coexistence feature #1

Description for coexistence feature #1

# Wideband and noncontiguous spectrum utilization

1.

## General

This section describes features related to the support of wider bandwidth and utilization of noncontiguous spectrum.

## Feature #1

Description for feature #1

# Multi-link operation

1.

## General

This section describes features related to multi-link operation.

Multi-link device (MLD): A device that has more than one affiliated STA and has one MAC SAP to LLC, which includes one MAC data service.

NOTE 1 – The device can be logical.

NOTE 2 – It is TBD for a MLD to have only one STA.

NOTE 3 – Whether the WM MAC address of each STA affiliated with the MLD is the same or different is TBD.

[Motion 23, [3] and [32]]

AP multi-link device (AP MLD): A MLD, where each STA affiliated with the MLD is an AP.

Non-AP multi-link device (non-AP MLD): A MLD, where each STA affiliated with the MLD is a non-AP STA.

[Motion 24, [3] and [32]]

## Multi-link setup

A MLD has a MAC address that identifies the MLD management entity.

For example, the MAC address can be used in multi-link setup between a non-AP MLD and an AP MLD.

[Motion 40, [3] and [32]]

The value of the RA/TA fields sent over-the-air in the MAC header of a frame is the MAC address of the STA affiliated with the MLD corresponding to that link

[Motion 108, [9] and [33]]

The MAC address of each affiliated AP within an AP MLD shall be different from each other unless the affiliated APs cannot perform simultaneous TX/RX operation (e.g., due to near band in-device interference), in which case the MAC address properties are TBD.

NOTE – It is TBD whether we allow the operation of an AP MLD without simultaneous TX/RX operation.

[Motion 109, [9] and [33]]

802.11be defines a multi-link setup signaling exchange executed over one link initiated by a non-AP MLD with an AP MLD as follows:

* Capability for one or more links can be exchanged during the multi-link setup.
* The AP MLD serves as the interface to the DS for the non-AP MLD after successful multi-link setup

NOTE 1 – The link identification is TBD.

NOTE 2 – Details for non-infrastructure mode of operation TBD.

[Motion 25, [3] and [34]]

A MLD can indicate capability to support exchanging frames simultaneously on a set of affiliated STAs to another MLD.

[Motion 26, [3] and [34]]

A new element will be defined as a container to advertise and exchange capability information for multi-link setup.

[Motion 68, [9] and [35]]

802.11be supports a mechanism for multi-link operation:

* An AP affiliated with an AP MLD can indicate the capabilities and operational parameters for one or more STAs of the multi-link device.
* A non-AP STA affiliated with a non-AP MLD can indicate the capabilities for one or more non-AP STAs of the non-AP MLD.
* Specific information of capabilities and operational parameters of multi-link device is TBD.

[Motion 21, [3] and [36]]

A MLD that supports multiple links can announce whether it can support transmission on one link concurrent with reception on the other link for each pair of links.

NOTE 1 – The 2 links are on different channels.

NOTE 2 – Whether to define a capability of announcing the support transmission on one link concurrent with transmission on the other link is TBD.

[Motion 38, [3] and [37]]

802.11be defines mechanism(s) for multi-link operation that enables the following:

* Indication of capabilities and operating parameters for multiple links of an AP MLD.
* Negotiation of capabilities and operating parameters for multiple links during a single setup signaling exchange.

[Motion 32, [3] and [38]]

802.11be shall define a mechanism to teardown an existing multi-link setup agreement.

[Motion 70, [9] and [39]]

After multi-link setup between two MLDs, different GTK/IGTK/BIGTK in different links with different PN spaces are used

* GTK/IGTK/BIGTK in different links can be delivered in one 4-way handshake.

[Motion 71, [9] and [39]]

## TID-to-link mapping

802.11be defines a directional-based TID-to-link mapping mechanism among the setup links of a MLD.

* By default, after the multi-link setup, all TIDs are mapped to all setup links.
* The multi-link setup may include the TID-to-link mapping negotiation.
	+ TID-to-link mapping can have the same or different link-set for each TID unless a non-AP MLD indicates that it requires to use the same link-set for all TIDs during the multi-link setup phase.

 NOTE – Such indication method by the non-AP MLD is TBD (implicit or explicit).

* The TID-to-link mapping can be updated after multi-link setup through a negotiation, which can be initiated by any MLD.
	+ Format TBD.

 NOTE – When the responding MLD cannot accept the update, it can reject the TID-to- link mapping update.

[Motion 54, [9] and [40]]

At any point in time, a TID shall always be mapped to at least one link that is set up, unless admission control is used.

[Motion 101, [9] and [41]]

A link, that is setup as part of a multi-link setup, is defined as Enabled if that link can be used for frame exchange and at least one TID is mapped to that link.

NOTE – Frame exchange on a link is subject to the power state of the corresponding non-AP STA.

[Motion 105, [9] and [42]]

Management frames are allowed on all enabled links, following baseline.

[Motion 102, [9] and [41]]

If a TID is mapped in UL to a set of enabled links for a non-AP MLD, then the non-AP MLD can use any link within this set of enabled links to transmit data frames from that TID.

If a TID is mapped in DL to a set of enabled links for a non-AP MLD, then:

* The non-AP MLD can retrieve buffered BUs corresponding to that TID on any links within this set of enabled links
* The AP MLD can use any link within this set of enabled links to transmit data frames from that TID, subject to existing restrictions for transmissions of frames that apply to those enabled links.
* An example of restriction is if the STA is in doze state

[Motion 103, [9] and [41]]

802.11be define mechanism(s) for multi-link operation that enables the following:

* An operational mode for concurrently exchanging frames on more than one link for one or more TID(s).
* An operational mode for restricting exchanging frames of one or more TID(s) to be on one link at a time.

[Motion 9, [1] and [43]]

A single block ack agreement is negotiated between two MLDs for a TID that may be transmitted over one or more links.

NOTE – The format of the setup frames is TBD.

[Motion 36, [3] and [44]]

Setup a block ack agreement for multi-link operation by using ADDBA request and ADDBA response frames.

[Motion 67, [9] and [45]]

The established block ack agreement allows the QoS Data frames of the TID, aggregated within the A-MPDUs, to be exchanged between the two MLDs on any available link.

[Motion 61, [9] and [46]]

For each block ack agreement, there exists one receive reordering buffer based on MPDUs in the MLD which is the recipient of the QoS Data frames for that block ack agreement.

The receive reordering buffer operation is based on the Sequence Number space that is shared between the two MLDs.

[Motion 62, [9] and [46]]

The receive status of QoS Data frames of a TID received on a link shall be signaled on the same link and may be signaled on other available link(s)

[Motion 63, [9] and [46]]

Sequence numbers are assigned from a common sequence number space shared across multiple links of a MLD, for a TID that may be transmitted to a peer MLD over one or more links.

[Motion 37, [3] and [44]]

## Power save

For each of the enabled links, frame exchanges are possible when the corresponding non-AP STA of the enabled link is in the awake state.

NOTE 1 – A link is enabled when that link can be used to exchange frames subject to STA power states.

NOTE 2 – When a link is disabled (i.e., not enabled) by an MLD the frame exchanges are not possible.

[Motion 51, [9] and [47]]

An AP of an AP MLD may transmit on a link a frame that carries an indication of buffered data for transmission on other enabled link(s).

[Motion 52, [9] and [47]]

An AP MLD can recommend a non-AP MLD to use one or more enabled links.

* The AP’s indication could be carried in a broadcast or a unicast frame.

[Motion 106, [9] and [48]]

For a link setup between an AP MLD and a non-AP MLD, a non-AP STA operating on that link can send to an AP operating on that link an indication that (an)other non-AP STA(s) within the same non-AP MLD that has(have) transition to doze state is(are) in awake state.

[Motion 84, [9] and [49]]

A non-AP MLD monitors and performs basic operations (such as traffic indication, BSS parameter updates, etc.) on one or more link(s).

[Motion 104, [9] and [50]]

Each non-AP STA affiliated with a non-AP MLD that is operating on an enabled link maintains its own power state/mode.

[Motion 110, [9] and [42]]

## Multi-link channel access

802.11be shall allow the following asynchronous multi-link channel access:

* Each of STAs belonging to a MLD performs a channel access over their links independently in order to transmit frames.
* Downlink and uplink frames can be transmitted simultaneously over the multiple links.

[Motion 20, [3] and [51]]

802.11be shall allow a MLD that has constraints to simultaneously transmit and receive on a pair of links to operate over this pair of links.

* Signaling of these constraints is TBD.

[Motion 46, [3] and [52]]

# Multi-band and multichannel aggregation and operation

1.

## General

This section describes features related to multi-band and multichannel aggregation and operation.

## Feature #1

Description for feature #1

# Spatial stream and MIMO protocol enhancement

1.

## General

This section describes features related to 16 spatial stream operation and MIMO protocol enhancement.

## 16 spatial stream operation

802.11be supports a maximum of 16 spatial streams (total across all the scheduled STAs) for MU-MIMO.

[Motion 65, [9] and [53]]

802.11be defines a maximum of 16 spatial streams for SU-MIMO.

[Motion 66, [9] and [53]]

# Multi-AP operation

1.

## General

This section describes features related to multi-AP operation.

## Setup

An EHT AP supporting the Multi-AP coordination can send a frame (e.g., Beacon or other management frame) including capabilities of Multi-AP transmission schemes.

NOTE – Multi-AP transmission schemes are TBD (e.g., Coordinated OFDMA).

[Motion 72, [9] and [54]]

An EHT AP which obtains a TXOP and initiates the Multi-AP coordination is the Sharing AP.

An EHT AP which is coordinated for the Multi-AP transmission by the Sharing AP is the Shared AP.

NOTE – The name of the Sharing AP and the Shared AP can be modified.

[Motion 73, [9] and [54]]

## Channel sounding

802.11be shall provide a joint NDP sounding scheme as optional mode for multiple-AP systems.

* Sequential sounding scheme that each AP transmits NDP independently and sequentially without overlapped sounding period of each AP can also be used in multi-AP systems.

[Motion 14, [3] and [55]]

Joint NDP sounding scheme for multi-AP system with less or equal to total 8 antennas at AP has all antennas active on all LTF tones and uses 802.11ax P matrix across OFDM symbols.

[Motion 15, [3] and [55]]

## Coordinated transmission

11be shall define a mechanism to determine whether an AP is part of an AP candidate set and can participate as a shared AP in coordinated AP transmission initiated by a sharing AP.

[Motion 55, [9] and [56]]

Define a procedure for an AP to share its frequency/time resources of an obtained TXOP with a set of APs

* Set of APs is TBD.

[Motion 56, [9] and [57]]

An AP that intends to use the resource (i.e., frequency or time) shared by another AP shall be able to indicate its resource needs to the AP that shared the resource.

[Motion 53, [9] and [58]]

Coordinated OFDMA is supported in 11be, and in a coordinated OFDMA, both DL OFDMA and its corresponding UL OFDMA acknowledgement are allowed.

[Motion 60, [9] and [59]]

# Link adaptation and retransmission protocols

1.

## General

This section describes features related to enhanced link adaptation and retransmission protocols.

## Feature #1

Description for feature #1

# Low latency

1.

## General

This section describes features related to low latency.

## Feature #1

Description for feature #1

# Bibliography

|  |  |
| --- | --- |
| [1]  | TGbe, “Compendium of motions related to the contents of the TGbe specification framework document,” *19/1755r0,* October 2019.  |
| [2]  | Alice Chen (Qualcomm), “320MHz channelization and tone plan,” *19/0797r1,* September 2019.  |
| [3]  | TGbe, “Compendium of motions related to the contents of the TGbe specification framework,” *19/1755r1,* November 2019.  |
| [4]  | Eunsung Park (LGE), “Tone plan discussion,” *19/1066r3,* November 2019.  |
| [5]  | Eunsung Park (LGE), “Discussion on 240MHz bandwidth,” *19/1889r2,* November 2019.  |
| [6]  | Bin Tian (Qualcomm), “Further thoughts on 11be tone plan,” *19/1521r2,* November 2019.  |
| [7]  | Eunsung Park (LGE), “Non-OFDMA tone plan for 320MHz,” *19/1492r3,* November 2019.  |
| [8]  | Jianhan Liu (MediaTek), “Enhanced resource allocation schemes for 11be,” *19/1126r1,* September 2019.  |
| [9]  | TGbe, “Compendium of motions related to the contents of the TGbe specification framework,” *19/1755r2,* January 2020.  |
| [10]  | Jianhan Liu (MediaTek), “Multiple RU combinations for EHT,” *19/1907r2,* January 2020.  |
| [11]  | Ross Yu (Huawei), “Multiple RU discussion,” *19/1914r4,* January 2020.  |
| [12]  | Eunsung Park (LGE), “Multiple RU aggregation,” *20/0023r2,* January 2020.  |
| [13]  | Ron Porat (Broadcom), “Multi-RU support,” *19/1908r4,* January 2020.  |
| [14]  | Ross Yu (Huawei), “Preamble structure,” *19/1099r2,* September 2019.  |
| [15]  | Dongguk Lim (LGE), “Further discussion for 11be preamble,” *19/1486r9,* November 2019.  |
| [16]  | Eunsung Park (LGE), “Phase rotation for 320MHz,” *19/1493r1,* November 2019.  |
| [17]  | Xiaogang Chen (Intel), “11be preamble structure,” *19/1516r4,* November 2019.  |
| [18]  | Dongguk Lim (LGE), “11be PPDU format,” *20/0019r1,* January 2020.  |
| [19]  | Sameer Vermani (Qualcomm), “Forward compatibility for WiFi preamble design,” *19/1519r5,* November 2019.  |
| [20]  | Sameer Vermani (Qualcomm), “Further ideas on EHT preamble design,” *19/1870r4,* November 2019.  |
| [21]  | Rui Cao (Marvell), “EHT preamble design,” *19/1540r7,* November 2019.  |
| [22]  | Dongguk Lim (LGE), “Further discussion for 11be preamble,” *19/1486r8,* November 2019.  |
| [23]  | Sameer Vermani (Qualcomm), “PPDU types and U-SIG content,” *20/0049r2,* January 2020.  |
| [24]  | Mengshi Hu (Huawei), “Preamble structure and SIG contents,” *20/0029r3,* January 2020.  |
| [25]  | Eunsung Park (LGE), “Consideration on 240/160+80 MHz and preamble puncturing,” *20/0022r1,* January 2020.  |
| [26]  | Dandan Liang (Huawei), “EHT P matrices discussion,” *19/1980r2,* January 2020.  |
| [27]  | Jinmin Kim (LGE), “Consideration of EHT-LTF,” *19/1925r2,* January 2020.  |
| [28]  | Bin Tian (Qualcomm), “Preamble puncturing and RU aggregation,” *19/1869r2,* January 2020.  |
| [29]  | Oded Redlich (Huawei), “Improved preamble puncturing in 802.11be,” *19/1190r3,* November 2019.  |
| [30]  | Stephane Baron (Canon), “Direct link MU transmissions,” *19/1117r2,* November 2019.  |
| [31]  | Subir Das (Perspecta Labs), “Priority access support in IEEE 802.11be: what and why?,” *19/1901r4,* January 2020.  |
| [32]  | Po-Kai Huang (Intel), “Extremely efficient multi-band operation,” *19/0822r9,* November 2019.  |
| [33]  | Duncan Ho (Qualcomm), “MLA MAC addresses considerations,” *19/1899r7,* January 2020.  |
| [34]  | Po-Kai Huang (Intel), “Multi-link operation framework,” *19/0773r8,* November 2019.  |
| [35]  | Yunbo Li (Huawei), “Multi-link association,” *19/1549r5,* January 2020.  |
| [36]  | Insun Jang (LGE), “Discussion on multi-link setup,” *19/1509r5,* November 2019.  |
| [37]  | Liwen Chu (Marvell), “Multiple link operation capability announcement,” *19/1159r5,* November 2019.  |
| [38]  | Abhishek Patil (Qualcomm), “Multi-link association setup,” *19/1525r2,* November 2019.  |
| [39]  | Po-Kai Huang (Intel), “Multi-link setup follow up,” *19/1823r3,* January 2020.  |
| [40]  | Yongho Seok (MediaTek), “Multi-link operation management,” *19/1358r4,* January 2020.  |
| [41]  | Laurent Cariou (Intel), “Multi-link: steps for using a link,” *19/1924r1,* January 2020.  |
| [42]  | Abhishek Patil (Qualcomm), “Multi-link: link management,” *19/1528r5,* January 2020.  |
| [43]  | Abhishek Patil (Qualcomm), “Multi-link operation: dynamic TID transfer,” *19/1082r3,* September 2019.  |
| [44]  | Rojan Chitrakar (Panasonic), “Multi-link acknowledgment,” *19/1512r6,* November 2019.  |
| [45]  | Yuchen Guo (Huawei), “BA setup for multi-link aggregation,” *19/1591r5,* January 2020.  |
| [46]  | Liwen Chu (NXP), “A-MPDU and BA,” *19/1856r3,* January 2020.  |
| [47]  | Alexander Min (Intel), “Multi-link power save operation,” *19/1544r5,* January 2020.  |
| [48]  | Abhishek Patil (Qualcomm), “MLO: link management – follow up,” *19/1904r3,* January 2020.  |
| [49]  | Jeongki Kim (LGE), “EHT power saving considering multi-link,” *19/1510r6,* January 2020.  |
| [50]  | Abhishek Patil (Qualcomm), “Multi-link operation: anchor channel,” *19/1526r3,* January 2020.  |
| [51]  | Insun Jang (LGE), “Channel access for multi-link operation,” *19/1144r6,* November 2019.  |
| [52]  | Sharan Naribole (Samsung), “Multi-link channel access discussion,” *19/1405r7,* November 2019.  |
| [53]  | Wook Bong Lee (Samsung), “16 Spatial Stream Support,” *19/1877r1,* January 2020.  |
| [54]  | Sungjin Park (LGE), “Setup for Multi-AP coordination,” *19/1895r2,* January 2020.  |
| [55]  | Jianhan Liu (MediaTek), “Joint sounding for multi-AP systems,” *19/1593r3,* November 2019.  |
| [56]  | Cheng Chen (Intel), “Multi-AP group formation follow-up,” *19/1931r2,* January 2020.  |
| [57]  | Lochan Verma (Qualcomm), “Coordinated AP time/frequency sharing in a transmit opportunity in 11be,” *19/1582r2,* January 2020.  |
| [58]  | Yongho Seok (MediaTek), “Coordinated OFDMA operation,” *19/1788r1,* January 2020.  |
| [59]  | Liwen Chu (NXP), “Coordinated OFDMA,” *19/1919r3,* January 2020.  |