IEEE P802.11
Wireless LANs

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| Update on Proposed Draft Text (PDT-PHY): Introduction to EHT PHY |
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Abstract

This submission proposes the updated draft text on the Introduction to the EHT PHY for TGbe D0.2 based on passed motions.

The baseline for this text is 802.11be D0.1

**Related motions and Discussion**

Regarding preamble puncture flexibility for OFDMA, up to one hole per 80 MHz segments is supported. If punctured, the puncture pattern of each segment shall be one of the followings:

* X212
* 1X12
* 12X2
* 121X
* XX12
* 12XX
* 1XX2

NOTE – Left-to-right represents low-to-high 20MHz channels.

[Motion 131, #SP195, [21] and [73]]

**Discussion: The above motion should be added to 36.3.11.11, which will be referred in this introduction section when discussing supported preamble puncturing pattern.**

For non-AP STA, it is mandatory to support the following:

* In OFDMA Rx, any preamble puncturing pattern allowed by Motion 131, #SP195
* In non-OFDMA Tx and Rx, any preamble puncturing pattern needed to support mandatory MRU for non-OFDMA as specified in subclause 36.3.2.3.3 in D0.1.

For AP, it is mandatory to support the following:

* In OFDMA Tx and non-OFDMA Tx and Rx, any preamble puncturing pattern that needs to be supported for mandatory MRU in non-OFDMA as specified in subclause 36.3.2.3.3 in D0.1.

[Motion 137, #SP278, [3] and [40]]

The followings are the requirements to support DCM+MCS0:

* Mandatory in
	+ RU 26, 52, 106, and 242 for 20 MHz-only STAs.
	+ RU 26, 52, 106, 242, 484, and 996 for non 20 MHz-only STAs.
* Conditional mandatory in
	+ RU 2×996 when STA supports 160 MHz
	+ RU 2×996 and 4×996 when STA supports 320 MHz
* Optional in
	+ MRU 52+26, 106+26, 484+242, 996+484, 996+484+242, and 3×996
* Not supported in
	+ MRU 2×996+484, 3×996+484

[Motion 137, #SP279, [3] and [40]]

The optional Dup+DCM mode for 6 GHz band LPI channel is supported.

[Motion 137, #SP280, [3] and [40]]

The following mandatory/optional support requirements of LTF+GI combinations are supported:

* MU PPDU
	+ 2× LTF + 0.8 μs GI (M)
	+ 2× LTF + 1.6 μs GI (M)
	+ 4× LTF + 3.2 μs GI (M)
	+ 4× LTF + 0.8 μs GI (O)
* TB PPDU
	+ 2× LTF+1.6 μs GI (M)
	+ 4× LTF + 3.2 μs GI (M)
	+ 1× LTF + 1.6 μs GI (M)
	+ Note: 1× LTF + 1.6 μs GI only for non-OFDMA transmission
* NDP
	+ 2× LTF + 0.8 μs GI (M)
	+ 2× LTF + 1.6 μs GI (M)
	+ 4× LTF + 3.2 μs GI (O)

[Motion 137, #SP281, [3] and [40]]

802.11be agrees with the following MU-MIMO support:

* DL MU-MIMO
	+ Mandatory support for AP with ≥ 4 antennas.
	+ Mandatory support for STA.
	+ Mandatory for non-OFDMA on all RU/MRU size ≥ 242 in supported BW.
	+ Optional for OFDMA+MU-MIMO operation.
* UL MU-MIMO
	+ Mandatory support for AP with ≥ 4 antennas.
	+ Mandatory support for STA.
	+ Mandatory for non-OFDMA on all RU/MRU size - 242 in supported BW.
	+ Optional for OFDMA+MU-MIMO operation.

[Motion 124, #SP181, [1] and [2]]

[Motion 137, #SP284, [3] and [40]]

The non-AP EHT STA shall support transmitting UL MU-MIMO where the total spatial streams summed across all users is less than or equal to 8 in R1.

* NOTE –It is the same as in 802.11ax.

[Motion 137, #SP283, [3] and [40]]

EHT-SIG support the following MCSs:

* MCS0, MCS1, MCS3 and ‘MCS0+DCM’.

[Motion 135, #SP215, [23] and [43]]

Middle 26-tone RUs shall not be allocated to 20 MHz operating STAs for 40 / 80 / 160 / 320 MHz DL / UL OFDMA transmission

* 80+80 / 160+160 MHz is TBD.

This is for R1.

[Motion 137, #SP271, [3] and [39]]

Middle 26 + 52/106 MRUs shall not be allocated to 20 MHz operating STAs for 40 / 80 / 160 / 320 MHz DL / UL OFDMA transmission

* 80+80 / 160+160 MHz is TBD.

This is for R1.

[Motion 137, #SP272, [3] and [39]]

242-tone RUs may be allocated to 20 MHz operating STAs for 40 / 80 / 160 / 320 MHz DL OFDMA

* 80+80 / 160+160 MHz is TBD.
* NOTE 1 – For Downlink OFDMA, receiving 242-tone RUs is optional for 20 MHz operating STAs.
* NOTE 2 – UL OFDMA case is TBD.

This is for R1.

[Motion 137, #SP270, [3] and [39]]

802.11be defines 20 MHz-only client in 2.4/5 GHz band only.

[Motion 124, #SP180, [1] and [2]]

**TGbe Editor: please find the proposed changes below**

1. Extremely High Throughput (EHT) PHY specification
2. 1 Introduction
	* 1. Introduction to the EHT PHY

Clause 33 (Extremely High Throughput (EHT) PHY specification) specifies the PHY entity for an extremely high throughput (EHT) orthogonal frequency division multiplexing (OFDM) system. In addition to the requirements in Clause 33 (Extremely High Throughput (EHT) PHY specification), an EHT STA shall be capable of transmitting and receiving PPDUs that are compliant with the mandatory requirements of the following PHY specifications:

* Clause 19 (High Throughput (HT) PHY specification), Clause 21 (Very High Throughput (VHT) PHY specification) and Clause 27 (High Efficiency (HE) PHY specification) if the EHT STA supports an operating channel width greater than or equal to 80 MHz and is operating in the 5 GHz band.
* Clause 19 (High Throughput (HT) PHY specification), Clause 21 (Very High Throughput (VHT) PHY specification) and Clause 27 (High Efficiency (HE) PHY specification) transmission and reception on 20 MHz channel width (see 26.17.1 (Basic HE BSS operation)) if the EHT STA is a 20 MHz-only non-AP EHT STA and is operating in the 5 GHz band.
* Clause 19 (High Throughput (HT) PHY specification) and Clause 27 (High Efficiency (HE) PHY specification) if the EHT STA is operating in the 2.4 GHz band.
* Clause 17 (Orthogonal frequency division multiplexing (OFDM) PHY specification) and Clause 27 (High Efficiency (HE) PHY specification) if the EHT STA is operating in the 6 GHz band.

For 2.4 GHz band operation, the EHT PHY is based on HE PHY defined in Clause 27 (High Efficiency (HE) PHY specification), which is based on the HT PHY defined in Clause 19 (High Throughput (HT) PHY specification), which is based on the OFDM PHY defined in Clause 17 (Orthogonal frequency division multiplexing (OFDM) PHY specification).

For 5 GHz band operation, the EHT PHY is based on the HE PHY defined in Clause 27 (High Efficiency (HE) PHY specification), which is based on the VHT PHY defined in Clause 21 (Very High Throughput (VHT) PHY specification), which is based on the HT PHY defined in Clause 19 (High Throughput (HT) PHY specification), which is based on the OFDM PHY defined in Clause 17 (Orthogonal frequency division multiplexing (OFDM) PHY specification).

For 6 GHz band operation, the EHT PHY is based on HE PHY defined in Clause 27 (High Efficiency (HE) PHY specification), which is based on the OFDM PHY defined in Clause 17 (Orthogonal frequency division multiplexing (OFDM) PHY specification).

The EHT PHY provides support for DL OFDMA, UL OFDMA, DL MU-MIMO, and UL MU-MIMO. Both DL and UL MU-MIMO transmissions are supported on portions of the PPDU bandwidth (on resource units greater than or equal to 242 tones). In a MU-MIMO resource unit, there is support for up to 8 users with up to 4 spatial streams per user with the total across all users not exceeding 16 space-time streams.

The EHT PHY provides support of multiple Resource Unit (MRU) assigned to a single STA. The EHT PHY also supports preamble puncturing of EHT MU PPDU.

The EHT PHY provides support for 0.8 µs, 1.6 µs and 3.2 µs guard interval durations.

The EHT PHY provides support for 3.2 µs (1x), 6.4 µs (2x), and 12.8 µs (4x) EHT-LTF symbol durations, excluding the GI duration.

The EHT PHY supports a DFT period of 3.2 µs for the pre-EHT modulated fields and 12.8 µs for the EHT modulated fields in an EHT PPDU.

The EHT PHY data subcarrier frequency spacing is the same as for the HE PHY and a quarter of the VHT PHY and HT PHY subcarrier frequency spacing.

The EHT PHY data subcarriers are modulated using BPSK, BPSK DCM, QPSK, 16-QAM, 64-QAM, 256-QAM, 1024-QAM and 4096-QAM. Forward error correction (FEC) coding (convolutional or LDPC coding) is used with coding rates of 1/2, 2/3, 3/4 and 5/6.

An EHT STA shall support the following features:

* Single user transmission and reception of an EHT MU PPDU with single RU or MRU in the entire PPDU bandwidth.
* BCC coding (transmit and receive). BCC coding is not used in the following cases:
* An RU or MRU of size greater than 242 subcarriers in an EHT MU PPDU or an EHT TB PPDU
* An RU or MRU with number of spatial streams greater than 4 in an EHT MU PPDU or an EHT TB PPDU
* An RU or MRU using EHT-MCSs 10, 11, 12 and 13 in an EHT MU PPDU or an EHT TB PPDU
* LDPC coding (transmit and receive) in all supported EHT PPDU types, RU and MRU sizes, and number of spatial streams if the STA supports transmitting and receiving in channel bandwidths greater than 20 MHz.
* LDPC coding (transmit and receive) in all supported EHT PPDU types, RU and MRU sizes, and number of spatial streams if the STA declares support for transmitting or receiving more than 4 spatial streams.
* LDPC coding (transmit and receive) in all supported EHT PPDU types, RU sizes, and number of spatial streams if the STA declares support for EHT-MCSs 10, 11, 12 and 13 (transmit and receive).
* Single spatial stream EHT-MCSs 0 to 7 (transmit and receive) in all supported channel widths of EHT PPDU
* Single spatial stream EHT-MCS 15 (transmit and receive) in
* 26-, 52-, 106- and 242-tone RU for 20 MHz-only STA
* 26-, 52-, 106-, 242-, 484- and 996-tone RU for non-20 MHz-only STA
* 2x996-tone RU if the STA declares support for 160 MHz PPDU
* 2x996- and 4x996-tone RU if the STA declares supports for 320 MHz PPDU
* Reception of the EHT-SIG field in an EHT MU PPDU at MCS 0, 1, 3 and 15
* EHT MU PPDU with a 2x EHT-LTF and 0.8 µs GI duration on the EHT-LTF and Data field OFDM symbols (transmit and receive for single user).
* EHT MU PPDU with a 2x EHT-LTF and 1.6 µs GI duration on the EHT-LTF and Data field OFDM symbols (transmit and receive for single user).
* EHT MU PPDU with a 4x EHT-LTF and 3.2 µs GI duration on the EHT-LTF and Data field OFDM symbols (transmit and receive for single user).20 MHz channel width and all RU and MRU sizes and locations applicable to the 20 MHz channel width in 2.4 GHz, 5 GHz and 6 GHz bands (transmit and receive).

An EHT STA may support the following features:

* EHT-MCSs 10 to 13 (transmit and receive) if the STA is not a 20 MHz only non-AP STA. EHT-MCSs 8 to 13 transmit and receive) if the STA is a 20 MHz only non-AP STA.
* Single spatial stream EHT-MCS 14 in 6 GHz LPI channel
* Single spatial stream EHT-MCS 15 (transmit and receive) in 52+26-, 106+26-, 484+242-, 996+484-, 996+484+242-, and 3×996-tone MRU
* Two or more spatial streams (transmit and receive).
* Single user transmission using EHT MU PPDU with a 4x EHT-LTF and 0.8 µs GI duration on the EHT-LTF and Data field OFDM symbols (transmit and receive).
* LDPC coding (transmit and receive) if the maximum number of spatial streams the STA is capable of transmitting or receiving in an EHT MU PPDU less than or equal to 4.

An EHT AP shall support the following features:

* Transmission of an EHT MU PPDU where none of the RUs or MRUs utilize MU-MIMO (DL OFDMA).
* Reception of an EHT TB PPDU where none of the RUs or MRUs utilize MU-MIMO (UL OFDMA).

Transmission of an EHT MU PPDU consisting of a single RU or MRU of size >=242 tones in supported bandwidth non-OFDMA transmission and utilizing MU-MIMO (DL MU-MIMO) if the AP is capable of transmitting 4 or more spatial streams.

* MU-MIMO reception on an RU or MRU in an EHT TB PPDU where the RU or MRU is of size >=242 tones in supported bandwidth non-OFDMA transmission (UL MU-MIMO) if the AP is capable of receiving 4 or more spatial streams
* Single spatial stream EHT-MCSs 0 to 9 in all supported channel widths and RU sizes for EHT MU PPDUs (transmit) or EHT TB PPDUs (receive).
* 40 MHz and 80 MHz channel widths and all RU/MRU sizes and locations applicable to the 40 MHz and 80 MHz channel widths in 5 GHz (transmit and receive).
* 40 MHz, 80 MHz and 160 MHz channel widths and all RU/MRU sizes and locations applicable to the 40 MHz, 80 MHz and 160 MHz channel widths in 6 GHz bands (transmit and receive).
* Transmission of EHT MU PPDU to multiple users with a 2x EHT-LTF and 0.8 µs GI duration on the EHT-LTF and Data field OFDM symbols .
* Transmission of an EHT MU PPDU to multiple users with a 2x EHT-LTF and 1.6 µs GI duration on the EHT-LTF and Data field OFDM symbols
* Transmission of an
* Reception of a non-OFDMA EHT TB PPDU with a 1x EHT-LTF and 1.6 µs GI duration on the EHT-LTF and Data field OFDM symbols.
* Reception of an EHT TB PPDU with a 2x EHT-LTF and 1.6 µs GI duration on the EHT-LTF and Data field OFDM symbols.
* Reception of an EHT TB PPDU with a 4x EHT-LTF and 3.2 µs GI duration on the EHT-LTF and Data field OFDM symbols.
* All RU/MRU sizes and locations applicable to 40 MHz channel width in the 2.4 GHz band if 40 MHz channel width is supported in the 2.4 GHz band (transmit and receive)
* Transmission and reception of a non-OFDMA EHT MU PPDU with any preamble puncturing pattern needed to support mandatory MRU for non-OFDMA as specified in subclause 36.3.2.3.3
* Transmission of an OFDMA EHT MU PPDU with any preamble puncturing pattern needed to support mandatory MRU for non-OFDMA as specified in subclause 36.3.2.3.3

An EHT AP may support the following features:

* MU-MIMO transmission on an RU/MRU in an EHT MU PPDU where there are multiple RU/MRUs in the PPDU bandwidth (DL MU-MIMO within OFDMA).
* MU-MIMO reception on an RU/MRU in an EHT TB PPDU where the RU or MRU is of size >=242 in the supported bandwidth non-OFDMA transmission (UL MU-MIMO) when the AP is capable of receiving less than 4 spatial streamsMU-MIMO reception on an RU/MRU in an EHT TB PPDU which consists of multiple RU/MRU =in the entire PPDU bandwidth (UL MU-MIMO within OFDMA).
* 40 MHz channel width in the 2.4 GHz band (transmit and receive)
* 160 MHz channel width in the 5 GHz band (transmit and receive)
* 320 MHz channel width in the 6 GHz band (transmit and receive)
* Transmission of an EHT MU PPDU to multiple users with a 4x EHT-LTF and 0.8 µs GI duration on the EHT-LTF and Data field OFDM symbols.
* Transmission of an OFDMA EHT MU PPDU with any preamble puncturing pattern as specified in subclause 36.3.11.11 but excluding any pattern needed to support mandatory MRU for non-OFDMA as specified in subclause 36.3.2.3.3
* Punctured sounding operation

A non-AP EHT STA shall support the following features:

* Reception of an EHT MU PPDU where the RU/MRU allocated to the non-AP STA is not utilizing MU-MIMO (DL OFDMA).
* Transmission of an EHT TB PPDU where the RU/MRU allocated to the non-AP STA is not utilizing MU-MIMO (UL OFDMA).
* Reception of an EHT MU PPDU consisting of a single RU or MRU in the entire PPDU bandwidth and utilizing MU-MIMO (DL MU-MIMO). The maximum number of spatial streams per user the non-AP EHT STA can receive in the DL MU-MIMO transmission shall be equal to the minimum of 4 and the maximum number of spatial streams supported for reception of EHT MU PPDU sent to that EHT STA as an SU transmission. The non-AP EHT STA shall be able to receive its intended spatial streams in a DL MU-MIMO transmission with a total number of spatial streams across all users of at least 4.
* MU-MIMO transmission in an EHT TB PPDU with single RU or MRU in the entire PPDU bandwidth (UL MU-MIMO). The non-AP EHT STA shall support transmitting UL MU-MIMO where the total spatial streams summed across all users is less than or equal to 8
* Responding with requested beamforming feedback in an EHT sounding procedure with the maximum number of space-time streams in the EHT sounding NDP that the non-AP EHT STA can respond to equal to at least 4.
* Single spatial stream EHT-MCSs 0 to 9 in all supported channel widths and RU and MRU sizes if the non-AP EHT STA is not a 20 MHz only non-AP EHT STA.
* Single spatial stream EHT-MCSs 0 to 7 in all supported channel widths and RU and MRU sizes if the non-AP EHT STA is a 20 MHz only non-AP EHT STA.
* 40 MHz and 80 MHz channel widths and all RU and MRU sizes and locations applicable to the 40 MHz and 80 MHz channel widths in the 5 GHz and 6 GHz band (transmit and receive) for non-AP EHT STA except for 20 MHz-only non-AP EHT STA.
* Reception of a 320 MHz EHT MU PPDU, or transmission of a 320 MHz EHT TB PPDU in 6 GHz band where the assigned RU/MRU is in the primary 160 MHz channel if the non-AP EHT STA is capable of up to 160 MHz channel width and operating with 160 MHz channel width
* Reception of an EHT MU PPDU to multiple users with a 2x EHT-LTF and 0.8 µs GI duration on the EHT-LTF and Data field OFDM symbols.
* Reception of an EHT MU PPDU to multiple users with a 2x EHT-LTF and 1.6 µs GI duration on the EHT-LTF and Data field OFDM symbols.
* Reception of an EHT MU PPDU to multiple users with a 4x EHT-LTF and 3.2 µs GI duration on the EHT-LTF and Data field OFDM symbols.
* Transmission of a non-OFDMA EHT TB PPDU with a 1x EHT-LTF and 1.6 µs GI duration on the EHT-LTF and Data field OFDM symbols.
* Transmission of an EHT TB PPDU with a 2x EHT-LTF and 1.6 µs GI duration on the EHT-LTF and Data field OFDM symbols.
* Transmission of an EHT TB PPDU with a 4x EHT-LTF and 3.2 µs GI duration on the EHT-LTF and Data field OFDM symbols.
* Transmission and reception of a non-OFDMA EHT MU PPDU with any preamble puncturing pattern needed to support mandatory MRU for non-OFDMA as specified in subclause 36.3.2.3.3
* Reception of an OFDMA EHT MU PPDU with any preamble puncturing pattern as specified in subclause 36.3.11.11

A non-AP EHT STA may support the following:

* 40 MHz channel width in the 2.4 GHz band (transmit and receive). If 40 MHz channel width in the 2.4 GHz band is supported then all RU/MRU sizes and locations applicable to 40 MHz channel width are supported except for a 20 MHz-only non-AP EHT STA, in which case the 40 MHz channel width and all RU/MRU sizes and locations of 40 MHz channel width in 2.4 GHz band are not applicable.
* 160 MHz channel width and RU and MRU size > 996 tone in the 5 GHz and 6 GHz bands (transmit and receive) except for a 20 MHz-only non-AP EHT STA, in which case the 160 MHz channel width and RU and MRU size > 242 tone in the 5 GHz and 6 GHz bands are not applicable.
* 320 MHz channel width and RU and MRU size > 996 tone in the 6 GHz bands (transmit and receive)
* MU-MIMO reception on an RU or MRU in an EHT MU PPDU which consist of multiple RUs and/or MRUs in the entire PPDU bandwidth (DL MU-MIMO within OFDMA). The maximum number of spatial streams per user in the DL MU-MIMO within OFDMA transmission that the non-AP STA can receive shall be a minimum of 4 and the maximum number of spatial streams supported for reception of EHT MU PPDU sent to that non-AP STA as an SU transmission. The total number of spatial streams (across all users) in the DL MU-MIMO within OFDMA transmission that the non-AP STA can receive shall be at least 4.
* MU-MIMO transmission on an RU or MRU in an EHT TB PPDU which consists of multiple RUs and/or MRUs in the entire PPDU bandwidth (UL MU-MIMO within OFDMA). If supported, then the non-AP EHT STA shall support transmitting UL MU-MIMO where the total spatial streams summed across all users is less than or equal to 8.
* .
* Reception of an EHT MU PPDU to multiple users with a 4x EHT-LTF and 0.8 µs GI duration on the EHT-LTF and Data field OFDM symbols.
* Punctured sounding operation.

A 20 MHz-only non-AP EHT STA shall support the following:

* 26-, 52-, 106-tone RU and 26+52,MRU sizes on locations allowed in 36.3.2.5 (RU/MRU restrictions for 20 MHz operation) in the primary 20 MHz channel within 40 MHz, 80 MHz, and 160 MHz channel widths in the 5 GHz

A 20 MHz-only non-AP EHT STA may support the following:

* Reception of 242-tone RU in in the primary 20 MHz channel within 40 MHz, 80 MHz, and 160 MHz channel widths in the 5 GHz
* 26-, 52-, 106- and 242- tone RU sizes and 26+52-, 26+106-tone MRU sizes on locations allowed in section36.3.2.5 (RU/MRU restrictions for 20 MHz operation) in any 20 MHz channel within 40 MHz channel width in the 2.4 GHz band if the 20 MHz-only non-AP EHT STA support the EHT subchannel selective transmission operation described in 35.5.1 (EHT subchannel selective transmission).
* 26-, 52-,106- and 242- tone RU sizes and 26+52-, 26+106-tone MRU sizes on locations allowed in section 36.3.2.5 (RU/MRU restrictions for 20 MHz operation) in any 20 MHz channel within 40 MHz, 80 MHz, 160 MHz channel widths in the 5 GHz band if the 20 MHz-only non-AP EHT STA support the EHT subchannel selective transmission operation described in 35.5.1 (EHT subchannel selective transmission).

A 20 MHz-operating non-AP EHT STA shall support the following:

* 26-, 52-, 106-tone RU and 26+52- tone MRU sizes on locations allowed in 36.3.2.5 (RU/MRU restrictions for 20 MHz operation) in the primary 20 MHz channel within 40 MHz, 80 MHz, and 160 MHz channel widths in the 5 GHz and 6 GHz bands and 320 MHz channel width in the 6 GHz band.

A 20 MHz operating non-AP EHT STA may support

* Reception of 242-tone RU in in the primary 20 MHz channel within 40 MHz, 80 MHz, and 160 MHz channel widths in the 5 GHz and 6 GHz bands and 320 MHz channel width in the 6 GHz band