IEEE P802.11
Wireless LANs

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| 11bn PDT Introduction to the UHR PHY |
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| Author(s): |
| Name | Affiliation | Address | Phone | email |
| Eugene Baik | Qualcomm Technologies, Inc. |  |  | eugeneb@qti.qualcomm.com |
| Bin Tian | Qualcomm Technologies, Inc. |  |  | btian@qti.qualcomm.com |
| Gong Bo | Huawei |  |  |  |
| Shengquan Hu | Mediatek |  |  |  |
| Jianhan Liu | Mediatek |  |  |  |
| Bo Sun | Sanechips |  |  |  |
| Youhan Kim | Qualcomm Technologies, Inc. |  |  |  |
| Ross Yu | Huawei |  |  |  |
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Abstract

This document contains Proposed Draft Text (PDT) for the Introduction subclause (38.1) of the proposed TGbn (UHR, Ultra High Reliability) amendment to the 802.11 standard.

**Revision information**

The following is a summary of the important changes that occurred within each revision of this document:

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| **Revision** | **Major changes** |
| 0 | Initial revision |
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**Introduction**

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 TGbn Draft. The abstract, revision information, introduction, explanation of the proposed changes, and references sections are not part of the adopted material.

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

**Explanation of the proposed changes:**

The proposed changes to the 802.11 TGbn draft within this document are based on the following motions adopted by the TGbn task group.

**Relevant passing motions:**

Related to the inclusion of the DRU feature in UHR:

* Motion #3 in [1]
	+ TGbn will define distributed tone RU (“DRU”) transmission
* Motion #1 in [1]
	+ The DRU means an RU which consists of subcarriers spreading across a certain bandwidth

Related to the inclusion of the UEQM feature in UHR:

* Motion #23 in [1]
	+ TGbn defines unequal modulation (UEQM) over different spatial streams.

Related to the inclusion of Intermediate MCS in UHR:

* Motion #34 in [1]
	+ Introduce new MCSs which are applicable to single spatial stream transmissions, as well as to equal modulation and unequal modulation cases in multiple spatial stream transmissions.
* Motion #42 in [1]
	+ Add the following modulation and code rate combinations as the new MCSs for 11bn:
		- Modulations of {QPSK, 16QAM, 256QAM} with code rate R=2/3
		- Modulation of 16QAM with code rate R=5/6

Related to the inclusion of the ELR feature in UHR:

* Motion #24 in [1]
	+ TGbn defines Enhanced Long Range (ELR) PPDU and potentially other Range Extension mechanisms.
* Motion #74 in [1]
	+ Define ELR PPDU in IEEE 802.11bn with the following targets
		- Downlink and Uplink in 2.4 GHz (within BSS range with 11b beacon)
		- Uplink only in 5 GHz and 6 GHz bands
		- Minimum data rate is greater than or equal to 1.5 Mbps
* Motion #92 in [1]
	+ The BW of ELR PPDU is 20MHz and one Spatial stream is used for ELR transmission.

Related to the inclusion of 2xLDPC in UHR:

* Motion #25 in [1]
	+ Define LDPC codeword length larger than 1944, including 2x1944

Related to the inclusion of COBF in UHR:

* Motion #29 in [1]
	+ TGbn defines multi-AP Coordinated Beamforming (Co-BF).

Related to the inclusion of CSR in UHR:

* Motion #29 in [1]
	+ TGbn defines a multi-AP Coordinated Spatial Reuse (Co-SR) at TXOP-level with power control.

Related to the inclusion of Interference Mitigation in UHR:

* Motion #35 in [1]
	+ Define a mode with additional pilots, located within the data portion of the PPDU, which are used for interference estimation and mitigation.
		- Note: zero-energy pilots alternative to be considered as well

**Text to be adopted begins here.**

***TGbn editor: Please add the following text for the subclause 38.1 Introduction to the 802.11bn draft version D0.1:***

# Ultra high reliability (UHR) PHY specification

## Introduction

### Introduction to the UHR PHY

Clause 38 (Ultra high reliability (UHR) PHY specification) specifies the PHY entity for an ultra high reliability (UHR) orthogonal frequency division multiplexing (OFDM) system. In addition to the requirements in Clause 38 (Ultra high reliability (UHR) PHY specification), an UHR STA shall be capable of transmitting and receiving PPDUs that are compliant with the mandatory requirements of Clause 36 (Extremely high throughput (EHT) PHY specification), Clause 27 (High Efficiency (HE) PHY specification), Clause 21 (Very High Throughput (VHT) PHY specification), Clause 19 (High Throughput (HT) PHY specification), and Clause 17 (Orthogonal frequency division multiplexing (OFDM) PHY specification).

For 2.4 GHz band operation, the UHR PHY is based on the EHT PHY defined in Clause 36 (Extremely high throughput (EHT) PHY specification), which is further based on the HE PHY defined in Clause 27 (High Efficiency (HE) PHY specification), the HT PHY defined in Clause 19 (High Throughput (HT) PHY specification), and the OFDM PHY defined in Clause 17 (Orthogonal frequency division multiplexing (OFDM) PHY specification) and Clause 18 (Extended Rate PHY (ERP) specification).

For 5 GHz band operation, the UHR PHY is based on the EHT PHY defined in Clause 36 (Extremely high throughput (EHT) PHY specification), which is further based on the HE PHY defined in Clause 27 (High Efficiency (HE) PHY specification), the VHT PHY defined in Clause 21 (Very High Throughput (VHT) PHY specification), the HT PHY defined in Clause 19 (High Throughput (HT) PHY specification), and the OFDM PHY defined in Clause 17 (Orthogonal frequency division multiplexing (OFDM) PHY specification).

For 6 GHz band operation, the UHR PHY is based on the EHT PHY defined in Clause 36 (Extremely high throughput (EHT) PHY specification), which is further based on the HE PHY defined in Clause 27 (High Efficiency (HE) PHY specification), and the OFDM PHY defined in Clause 17 (Orthogonal frequency division multiplexing (OFDM) PHY specification).

The UHR PHY continues support for DL OFDMA, UL OFDMA, DL MU-MIMO, and UL MU-MIMO as defined in the EHT PHY. Preamble puncturing as defined in the EHT PHY continues to be supported for the UHR MU PPDU, for both OFDMA and non-OFDMA.

The UHR PHY continues support for modulation of data subcarriers using the EHT MCS set, which comprises BPSK, QPSK, 16-QAM, 64-QAM, 256-QAM, 1024-QAM, and 4096-QAM modulation orders and FEC coding (convolutional and LDPC) with code rates of 1/2, 2/3, 3/4, and 5/6. Additionally, the UHR PHY defines new four MCS values for new combinations of existing modulation orders and coding rates, specifically MCS ***TBD1*** for QPSK with 2/3 code rate, MCS ***TBD2*** for 16-QAM with 2/3 code rate, MCS ***TBD3*** for 16-QAM with 5/6 code rate and MCS ***TBD4*** for 256-QAM with 2/3 code rate. The UHR PHY introduces support for a new longer LDPC codeword size of 2x1944 bits that may be used alongside the prior defined LDPC codeword sizes specified in the EHT PHY.

The UHR PHY provides support for Unequal Modulation, in which different spatial streams within a beamformed PPDU can use different modulation orders. This new feature can be used alongside the existing method of Equal Modulation transmit beamforming, as defined in the EHT PHY.

The UHR PHY continues support for the OFDM symbol numerology, tone plans, and RUs and MRUs specified for the EHT PHY as defined in Clause 36. Additionally, the UHR PHY defines Distributed RUs (DRU), which use a separate OFDM tone plan and distribution mapping designed to provide power and range benefits for STAs operating in frequency bands with power spectrum density limits. Distributed RUs are specifically for use only with uplink UHR TB PPDUs.

The UHR PHY provides support for a new Extended Long Range (ELR) PPDU format, designed to overcome link budget imbalances between the uplink and downlink, and to improve spectrum efficiency for STAs operating further away from APs. ELR PPDUs have a fixed bandwidth of 20 MHz and can be used for downlink and uplink in 2.4 GHz band operation, while they can only to be used for the uplink in 5 GHz and 6 GHz band operation.

The UHR PHY provides support for Coordinated Beamforming and Coordinated Spatial Reuse to improve spectrum efficiency and system wide reliability through multiple AP coordination.

The UHR PHY provides support for an Interference Mitigation mode to enable receivers to estimate interference and mitigate its impacts.

### Scope

The services provided to the MAC by the UHR PHY consist of the following protocol functions:

1. A function that maps the PSDU received from the MAC into a PPDU for transmission to one or more receiving STAs.
2. A function that defines the characteristics and method of transmitting and receiving data through a wireless medium between two or more STAs. Depending on the PPDU format, these STAs support a mixture of UHR, Clause 36 (Extremely high throughput (EHT) PHY specification), Clause 27 (High efficiency (HE) PHY specification), Clause 21 (Very high throughput (VHT) PHY specification), Clause 19 (High-throughput (HT) PHY specification), Clause 18 (Extended Rate PHY (ERP) specification), Clause 17 (Orthogonal frequency division multiplexing (OFDM) PHY specification), Clause 16 (High rate direct sequence spread spectrum (HR/DSSS) PHY specification), and Clause 15 (DSSS PHY specification for the 2.4 GHz band designated for ISM applications) PHYs.

### UHR PHY functions

#### General

The UHR PHY contains two functional entities: the PHY function, and the physical layer management function (i.e., the PLME). These functions are described in detail in 38.3 (UHR PHY) and 38.4 (UHR PLME). The UHR PHY service is provided to the MAC through the PHY service primitives defined in Clause 8 (PHY service specification). The UHR PHY service interface is described in 38.2 (UHR PHY service interface).

#### PHY management entity (PLME)

The PLME performs management of the local PHY functions in conjunction with the MLME.

#### Service specification method

The models represented by figures and state diagrams are intended to be illustrations of the functions provided. It is important to distinguish between a model and a real implementation. The models are optimized for simplicity and clarity of presentation.

The service of a layer is the set of capabilities that it offers to a user in the next higher layer. Abstract services are specified here by describing the service primitives and parameters that characterize each service. This definition is independent of any particular implementation.

### PPDU formats

The structure of the PPDU transmitted by an EHT STA is determined by the TXVECTOR parameters as defined in Table 38-1 (TXVECTOR and RXVECTOR parameters).

The FORMAT parameter determines the overall structure of the PPDU and can take on one of the following values:

* Non-HT format (NON\_HT), based on Clause 17 (Orthogonal frequency division multiplexing (OFDM) PHY specification) or Clause 18 (Extended Rate PHY (ERP) specification), and including non-HT duplicate format based on 38.3.15 (Non-HT duplicate transmission).
* HT-mixed format (HT\_MF) as specified in Clause 19 (High Throughput (HT) PHY specification).
* HT-greenfield format (HT\_GF) as specified in Clause 19 (High Throughput (HT) PHY specification).
* VHT format (VHT) as defined in Clause 21 (Very High Throughput (VHT) PHY specification).
* HE SU PPDU format (HE\_SU) as defined in Clause 27 (High Efficiency (HE) PHY specification).
* HE ER SU format (HE\_ER\_SU) as defined in Clause 27 (High Efficiency (HE) PHY specification).
* HE MU PPDU format (HE\_MU) as defined in Clause 27 (High Efficiency (HE) PHY specification).
* HE TB PPDU format (HE\_TB) as defined in Clause 27 (High Efficiency (HE) PHY specification).
* EHT MU PPDU format (EHT\_MU) as defined in Clause 36 (Extremely high throughput (EHT) PHY specification).
* EHT TB PPDU format (EHT\_TB) as defined in Clause 36 (Extremely high throughput (EHT) PHY specification).
* UHR MU PPDU format (UHR\_MU) that carries one or more PSDUs to one or more users as defined in 38.3.4 (UHR PPDU formats)
* UHR TB PPDU format (UHR\_TB) that carries a single PSDU and is sent in response to a PPDU that carries a triggering frame as defined in 38.3.4 (UHR PPDU formats).
* UHR ELR PPDU format (UHR\_ELR) that carries a single PSDU in Enhanced Long Range operation as defined in 38.3.4 (UHR PPDU formats).

**Text to be adopted ends here.**

**References:**

1. [11-24-0171r22](https://mentor.ieee.org/802.11/dcn/24/11-24-0171-22-00bn-tgbn-motions-list-part-1.pptx): 11-24-0171-22-00bn-tgbn-motions-list-part-1, Alfred Asterjadhi (Qualcomm Inc.)