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Wireless LANs

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| **Specification Framework for TGbn** | | | | |
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Abstract

This document provides the framework from which the draft TGbn 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 | Jan 25, 2024 | Initial version |
| 1 | Mar 25, 2024 | Add motions passed in 2024 March meeting |
| 2 | May 23, 2024 | Added motions passed in 2024 May meeting |
| 3 | May 29, 2024 | Updated the references |
| 4 | July 22, 2024 | Added motions passed in 2024 July meeting |
| 5 | Sep 22, 2024 | Added motions passed in 2024 Sep meeting |

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# Abbreviations and acronyms

AP access point

BSS basic service set

BW bandwidth

Co-BF coordinated beamforming

Co-RTWT coordinated restricted TWT

Co-SR coordinated spatial reuse

Co-TDMA coordinated TDMA

CSD cyclic shift diversity

DL downlink

DRU distributed tone RU

DS distribution system

ELR enhanced long range

FCS frame check sequence

HC higher capability

LC lower capability

LDPC low-density parity check

L-STF non-HT short training field

L-LTF non-HT long training field

L-SIG non-HT signal field

MAC medium access control

MCS modulation and coding scheme

MLD multi-link device

Multi-AP multiple AP

Non-AP none AP

NAV network allocation vector

NPCA non-primary channel access

OBSS overlapping basic service set

OFDMA orthogonal frequency division multiple access

PHY physical layer

PPDU physical layer (PHY) protocol data unit

RL-SIG repeated non-HT signal field

RRU regular RU

RU resource unit

SP service period

SS spatial stream

STA station

STF short training field

TB trigger-based

TBD to be decided

TDMA time division multiple access

TID traffic identifier

TWT target wake time

TXOP transmission opportunity

UHR ultra high reliability

UL uplink

# UHR PHY



## General

This section describes the functional blocks in the UHR PHY.

* “PHY version identifier” is set to 1 in U-SIG field for UHR PPDUs.

[Motion #22, [1] and [38]]

## Distributed-tone RU

### General

* TGbn will define distributed tone RU (“DRU”) transmission

[Motion #3, [1] and [10]]

* TGbn supports a distributed tone RU (DRU) for a TB PPDU transmission
  + The DRU means an RU which consists of subcarriers spreading across a certain bandwidth

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

* DRU is allowed in a punctured UHR TB transmission

[Motion #4, [1] and [11]]

* TGbn supports the hybrid mode with DRUs (Distributed tone RU) and RRUs (Regular RU as existing RU defined in 11ax/be) in UHR UL TB OFDMA transmissions
  + Minimum PPDU BW for hybrid mode is TBD

[Motion #7, [1] and [14]]

* UL MU-MIMO is not applicable to DRU.

[Motion #37, [1] and [89]]

* DRU only supports up to 2ss

[Motion #38, [1] and [89]]

### Tone plan

* DRUs tone plan design on distribution BW 20MHz and 40MHz is 26-tone RU based DRU method (using 26-tone DRUs as basic building blocks).
  + DRUs tone plan design on other distribution BWs is TBD.

[Motion #14, [1] and [33]]

* In a non-punctured 80 MHz PPDU, the following distribution bandwidth modes are allowed for DRU
  + 80 MHz
  + 20 MHz + 20 MHz + 40 MHz (or 40 MHz + 20 MHz + 20 MHz)

[Motion #20, [1] and [36]]

### L-preamble

* If a DRU for a PPDU occupies more than one 20 MHz channel, then the L-STF, L-LTF, L-SIG, and RL-SIG fields are duplicated over all the 20 MHz channels which are occupied by the DRU.

[Motion #21, [1] and [37]]

### UHR-STF

* Global CSD is used for DRU UHR-STF transmission to solve unintentional beamforming issue
* Global CSD is applied in each distribution BW

[Motion #15, [1] and [34]]

* DRU transmission reuses the 8 CSD table/values in 11ax/be for global CSD allocation

[Motion #16, [1] and [34]]

* The UHR-STF for DRU in a TB PPDU uses 11ax/11be trigger based STF sequences.

[Motion #18, [1] and [35]]

* For UHR-STF corresponding to distribution bandwidth for DRU,
  + STF sequence depends on PPDU BW.
  + Occupied STF tones are the same as that of the largest RRU corresponding to the distribution BW within PPDU BW.

[Motion #19, [1] and [35]]

### Pilot

* TGbn supports hierarchical pilot structure for DRU
  + Pilot locations of a larger DRU is a subset of pilot locations of smaller component DRUs within the same PPDU BW

[Motion #5, [1] and [12]]

* The number of pilot tones for the same size DRU and RRU (regular RU) is the same
  + The RRU means the existing RU defined in 11ax and 11be

[Motion #6, [1] and [13]]

## Unequal modulation and new MCS

### General

* TGbn defines unequal modulation over different spatial streams.

[Motion #23, [1] and [39]]

* UHR defines unequal modulation only for LDPC.

[Motion #53 [1] and [159]]

* 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 #34, [1] and [86]]

* For 4 SS, the UEQM patterns only include:

|  |  |  |  |
| --- | --- | --- | --- |
| 1st ss | 2nd SS | 3rd SS | 4th SS |
| M | M | M | M-1 |
| M | M | M | M-2 |
| M | M | M-1 | M-2 |
| M | M-1 | M-1 | M-2 |

Note: M is the constellation index; M-1 refers to the constellation that is one order lower than M; M-2 refers to the constellation that is two orders lower than M.

[Motion #39, [1] and [90]]

* UEQM patterns for Nss=3 are limited to three:

|  |  |  |
| --- | --- | --- |
| 1st ss | 2nd SS | 3rd SS |
| M | M | M-1 |
| M | M | M-2 |
| M | M-1 | M-2 |

Note: M is the constellation index; M-1 refers to the constellation that is one order lower than M; M-2 refers to the constellation that is two orders lower than M.

[Motion #43 [1] and [92]]

* UEQM patterns for Nss=2 are limited to two as:

|  |  |
| --- | --- |
| 1st ss | 2nd SS |
| M | M-1 |
| M | M-2 |

Note: M is the constellation index; M-1 refers to the constellation that is one order lower than M; M-2 refers to the constellation that is two orders lower than M.

[Motion #52 [1] and [159]]

* 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

[Motion #42, [1] and [86]]

### Signaling

* For a (non-ELR) UHR MU PPDU, there exists a 1-bit EQM/UEQM indication in a User field for non-MU-MIMO in the UHR-SIG field.

[Motion #40, [1] and [91]]

## Enhanced long range extension

* TGbn defines Enhanced Long Range (ELR) PPDU and potentially other Range Extension mechanisms.

[Motion #24, [1] and [40]]

* ELR PPDU starts with a legacy preamble in the PPDU for the ELR transmission.
  + The legacy preamble contains the L-STF, L-LTF, L-SIG, RL-SIG, and U-SIG
* [Motion #32, [1] and [84]]
* In the U-SIG field of a UHR ELR PPDU, the PHY Version Identifier is set to 1. And the PPDU Type And Compression Mode is used to indicate ELR PPDU.
* [Motion #33, [1] and [85]]
* ELR-SIG is located right after ELR-LTF in ELR PPDU.
  + Note that ELR-LTF is the short name of UHR-LTF for ELR PPDU
* [Motion #36, [1] and [88]]

## LDPC enhancement

* Define LDPC codeword length larger than 1944, including 2x1944

[Motion #25, [1] and [41]]

## Interference mitigation

* Define a mode with additional pilots, located within the data portion of the PPDU, which are used for interference estimation & mitigation.
  + Note: zero-energy pilots alternative to be considered as well
* [Motion #35, [1] and [87]]

## PHY feature #6

Description for PHY feature #6

# UHR MAC



## General

This section describes the functional blocks in the UHR MAC.

## Roaming

* TGbn defines a mechanism that enables a non-AP MLD to roam from one AP MLD to another AP MLD and the non-AP MLD remains in state 4 (see 11.3) during and after roaming to the other AP MLD

[Motion #2, [1] and [3-9]]

* TGbn defines that when a non-AP MLD is in the process of roaming from the current AP MLD to a target AP MLD, the context related to the non-AP MLD is transferred to the target AP MLD such that it preserves the data exchange context for the non-AP MLD or the context can be renegotiated with the target AP MLD.
  + Details on what context can be transferred and what context can be renegotiated are TBD.
  + How to transfer the context is TBD.

[Motion #26, [1] and [7,8,42-47]]

* As part of the seamless roaming procedure, during roaming,
  + after the request/response exchange that initiates notification of the DS mapping change from the current AP MLD to the target AP MLD,
    - The current AP MLD may deliver buffered DL data frames for a TBD period of time.
    - The non-AP MLD may retrieve buffered DL data frames from the current AP MLD
    - The non-AP MLD may send UL data to target AP MLD.
    - It is assumed that the target AP MLD is able to deliver data frames to non-AP MLD after the DS mapping change
  + The current AP MLD may forward DL data to the target AP MLD.
    - When and how to initiate the forwarding of DL data is TBD

[Motion #27, [1] and [3, 7, 8, 42-48]]

* Define a request frame sent by a non-AP MLD in state 4 to initiate the roaming procedure
* The roaming procedure performs context transfer to the target AP MLD and perform the necessary changes of the DS mapping from the current AP MLD to the target AP MLD
* Define a response frame sent to the non-AP MLD to indicate readiness for the non-AP MLD to send class 3 frames to the target AP MLD
* TBD on data transmission from non-AP MLD to current AP MLD during the request/response frame exchange
* NOTE – What context is transferred is TBD.
* NOTE – TBD on which request/response frame to use

[Motion #44, [1] and [3, 7, 8, 42-47, 93]]

## Power save

* TGbn defines a power save mode for a STA that is a UHR Mobile AP or a UHR non-AP STA wherein the STA may transition from a lower capability mode to a higher capability mode upon reception of an initial control frame
  + Lower capability mode (e.g., 20 MHz BW, one SS, limited data rates, PPDU format)
  + Higher capability mode (e.g., operating BW, NSS and MCSs, with at least one higher capability than that in the lower power capability mode)
  + Initial Control frame is TBD
  + Whether that applies for a non-mobile AP is TBD

[Motion #9, [1] and [15-19]]

* TGbn defines cross link power save signaling mechanism
  + Allowing a non-AP MLD to indicate to its associated AP MLD that supports the mechanism, in a frame sent on one enabled link, the power management mode for one or more of its affiliated non-AP STAs
  + Whether support for the mechanism is mandatory or optional is TBD
* [Motion #10, [1] and [19-20]]
* An UHR STA that uses the power save mode to transition from lower capability (LC) mode to higher capability (HC) mode, advertises the amount of padding it needs in a received initial control frame.
  + Padding values range between 0 and a maximum value that is TBD with a TBD resolution.

[Motion #45, [1] and [31, 16, 94-101]]

* Define a new mechanism and/or enhance existing mechanism for AP power save

[Motion #49, [1] and [15, 69, 149, 150, 94, 97, 98, 95]]

## Non-primary channel access

* TGbn defines a mode of operation that enables a STA to access the secondary channel while the primary channel is known to be busy due to OBSS traffic or other TBD conditions.
  + The mode of operation shall not assume that the STA is capable to detect or decode a frame and obtain NAV information of the secondary channel concurrently with the primary channel.
  + A BSS shall only have a single NPCA primary channel (name TBD) on which the STA contends while the primary channel of the BSS is known to be busy due to OBSS traffic or other TBD conditions.
* [Motion #11, [1] and [21-30]]

## Buffer status report

* TGbn enables per-TID buffer size reporting of a larger queue in UHR.
  + Note: It is an optional feature.
  + Note: In the baseline, the maximum approximate per-TID queue size to report is 2,147,328 octets
* [Motion #13, [1] and [32]]

## Multi-AP Cooridnation

* 11bn defines a common framework of a Multi-AP Coordination for various coordination schemes.
  + Note - Coordination schemes such as (but not limited to): Co-SR (TXOP-based with power control), Co-BF, Co-TDMA, Co-RTWT, etc.

[Motion #50, [1] and [131, 151, 134, 137, 141, 152-156, 117, 157, 158]]

* 11bn defines a common framework of a Multi-AP Coordination that can enable the following procedures:
  + Multi-AP Coordination Discovery procedure
  + Multi-AP Coordination agreement negotiation procedure
  + Note: Details of the procedures and whether the above procedures are mandatory/optional - TBD

[Motion #51, [1] and [131, 151, 134, 137, 141, 152-156, 117, 157, 158]]

## Coordinated spatial reuse

* TGbn defines a multi-AP Coordinated Spatial Reuse (Co-SR) at TXOP-level with power control.
* Other multi-AP coordination modes are TBD.

[Motion #29, [1] and [49-65]]

## Coordinated beamforming

* TGbn defines multi-AP Coordinated Beamforming (Co-BF).
* Other multi-AP coordination modes are TBD.

[Motion #29, [1] and [49-65]]

## Coordinated TDMA

* TGbn shall define a Coordinated TDMA (Co-TDMA) procedure for an AP to share its time resources of an obtained TXOP with a set of APs.
  + Set of APs is TBD.
  + The set can consist of one AP.

[Motion #46, [1] and [102-125]]

## Coordinated restricted TWT (Co-RTWT)

* Define mechanisms that enable APs to coordinate their rTWT schedule(s) and/or to ensure that one AP provides the protection of the rTWT schedule(s) of the other AP.
* NOTE – TBD mechanisms including negotiation between 2 APs and advertisement.

[Motion #48, [1] and [131-148]]

## In-device coexistence

* 11bn defines a mechanism for a non-AP STA to report unavailability at TXOP level and define or reuse/update existing mechanism for a non-AP STA to report long term (periodic) unavailability.

[Motion #30, [1] and [66-82]]

## Target wake time service period management

* TGbn defines a mechanism that enables a non-AP STA to indicate that it does not have pending traffic to deliver during the current ongoing TWT SP.
  + NOTE 1 – The exact signaling mechanism is TBD
  + NOTE 2 – This does not propose changing the SP termination mechanism/signaling itself. As per current spec, a TWT SP may be terminated by an AP as specified in 26.8.5
  + NOTE 3 – It is optional for the non-AP STA to provide such an indication

[Motion #31, [1] and [83]]

## MAC feature #12

Description for MAC feature #9

# Frame format



## General

## Intermediate FCS

* TGbn defines a way in 11bn to include in an initial control frame an intermediate FCS for UHR STA(s) that precedes padding and the FCS field.

[Motion #11, [1] and [31, 19]]

* If an initial control frame includes an intermediate FCS for UHR STA(s) that precedes padding and the FCS field, the intermediate FCS has the size of 32 bits.

[Motion #47, [1] and [99, 31, 126-128, 100, 129-130]]

## Field #1

Description for Field #1

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68. [11-23/1964r1](https://mentor.ieee.org/802.11/dcn/23/11-23-1964-01-00bn-coexistence-protocols-for-uhr.pptx): 11-23-1964-01-00bn-coexistence-protocols-for-uhr, Alfred Asterjadhi (Qualcomm Inc.)
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120. [11-24/0887r0](https://mentor.ieee.org/802.11/dcn/24/11-24-0887-00-00bn-consideration-on-relay-operation-for-11bn.pptx): 11-24-0887-00-00bn-consideration-on-relay-operation-for-11bn, Liuming Lu (OPPO)
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128. [11-24/0544r1](https://mentor.ieee.org/802.11/dcn/24/11-24-0544-01-00bn-power-save-protocols-for-uhr-follow-up.pptx): 11-24-0544-01-00bn-power-save-protocols-for-uhr-follow-up, Sherief Helwa (Qualcomm Technologies Inc)
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137. [11-23/1932r3](https://mentor.ieee.org/802.11/dcn/23/11-23-1932-03-00bn-further-considerations-on-coordinated-twt.pptx): 11-23-1932-03-00bn-further-considerations-on-coordinated-twt, Rubayet Shafin (Samsung Research America)
138. [11-23/1952r3](https://mentor.ieee.org/802.11/dcn/23/11-23-1952-03-00bn-coordinated-r-twt-for-multi-ap-scenarios-follow-up.pptx): 11-23-1952-03-00bn-coordinated-r-twt-for-multi-ap-scenarios-follow-up, Liuming Lu (OPPO)
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141. [11-23/2022r1](https://mentor.ieee.org/802.11/dcn/23/11-23-2022-01-00bn-r-twt-for-multi-ap-follow-up.pptx): 11-23-2022-01-00bn-r-twt-for-multi-ap-follow-up, Laurent Cariou (Intel)
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