IEEE P802.11
Wireless LANs

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| **Specification Framework for TGba** |
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Abstract

This document provides the framework from which the draft TGba 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**

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| Revision | Date | Changes |
| 0 | April 10, 2017 | Added motioned text agreed in March IEEE F2F [1] |
| 1 | May 30, 2017 | Added motioned text agreed in May IEEE F2F [2] |
| 2 | Aug 7, 2017 | Added motioned text agreed in July IEEE F2F [3]. Updated abbreviations and acronyms. |
| 3 | Aug 8, 2017 | Revised motioned text related to 17/964r4 based on the latest revision of July IEEE F2F minute [3].  |
| 4 | Sep 25, 2017 | Added motioned text agreed in July IEEE F2F [4]. Have the folloing editorial reivison:* Replace “packet” or “signal” with PPDU or frame based on the context to comply with the suggestion in editorial style guide [5].
* Replace “wake-up packet” with “WUR PPDU” in the WUR PHY section.
* Create data rate and symbol structure subsection in the WUR Payload section.
* Create channel access subsection in WUR MAC section.
* Remove corresponding TBD for the past motions related to data rate
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# Definitions

# Abbreviations and acronyms

|  |  |
| --- | --- |
| AC  | access category |
| AP | access point |
| BPSK | binary phase shift keying |
| CRC | cyclic redundancy code |
| CW | contention window |
| EDCA | enhanced distributed channel access |
| EDCAF | enhanced distributed channel access function |
| DFS | dynamic frequency selection |
| FCS | frame check sequence |
| HT | high-throughput |
| L-LTF | non-HT Long Training field |
| L-SIG | non-HT SIGNAL field |
| L-STF | non-HT Short Training field |
| MAC | medium access control |
| OFDM | orthogonal frequency division multiplexing |
| OOK | on-off keying |
| PCR | primary connectivity radio |
| PHY | physical layer |
| PPDU | physical layer protocol data unit |
| PS | power save |
| STA | station |
| TBD | to be determined |
| TD | type dependent |
| TSF | timing synchronization function |
| TWT | target wake time |
| WNM | wireless network management |
| WUR | wake-up radio |
| WURx | wake-up receiver |

# WUR Physical Layer

## General

This section describes the functional blocks in the physical layer.

1. A 20 MHz non-HT preamble is prepended in any WUR PPDU, including L-STF, L-LTF and L-SIG fields. A 20 MHz OFDM symbol, with tone spacing 312.5 kHz and BPSK, and of duration 4 us, is present immediately after the L-SIG field and right before the narrow band portion of any WUR PPDU.

[Motion, May 2017, See [2] [6]]

## WUR Preamble

## WUR Payload

1. Use OOK for modulation of the payload portion of the WUR PPDU. The Preamble design is TBD. The operation in DFS channels is TBD.

[Motion 1, March 2017, see [1] [7]]

1. The OOK waveform of WUR PPDU is generated by populating TBD number of 802.11 OFDM subcarriers:
* The WUR preamble part is TBD.
* The operation in DFS channel is TBD.

[Motion 1, March 2017, see [1] [8]]

1. When a single band is used for transmission of WUR PPDU, the OOK waveform of WUR PPDU is generated by using contiguous 13 subcarriers with the subcarrier spacing of 312.5 kHz:
* The center subcarrier is TBD.

 [Motion, July 2017, see [3] [9]]

### Data Rate

1. IEEE 802.11ba supports multiple data rates for the payload part of the WUR PPDU.

[Motion 1, May 2017, see [2] [10]]

1. The lowest data rate for the payload part of WUR PPDU is 62.5 kb/s.

[Motion, July 2017, see [3] [11]]

1. IEEE 802.11ba supports the following data rates: 62.5 kb/s and 250 kb/s.
* ~~Support of any data rates higher than 250 kb/s is TBD~~

[Motion, July 2017 and Sep 2017, see [3] [12] [4] [13]]

1. IEEE 802.11ba has only two data rates: 62.5 kb/s and 250 kb/s.

[Motion, Sep 2017, see [4] [13]]

### Symbol Structure

1. Use Manchester Coding in the WUR PHY Design:
* The structure of the OFDM symbol ~~and the data rate~~ is TBD.
* The Preamble design is TBD.

[Motion, May 2017 and Sep 2017, see [2] [14] [4] [13]]

1. Manchester code shall be used for all of the data rates for the payload part of the WUR PPDU. [Motion 2, May 2017, see [2] [10]]
2. Symbol structure of the data rate of 250 kb/s for each information is as follows:



* For 2us ON-signal, there is always energy.

[Motion, Sep 2017, see [4] [15]]

# WUR MAC

## General

This section describes general MAC functional blocks.

1. IEEE 802.11ba shall provide mechanisms to enable re-discovery of WUR stations by AP. [Motion, March 2017, see [1] [16]]
2. A STA shall not transmit WUR frame if the primary connectivity radio of the STA is turned off. [Motion 2, March 2017, see [1] [17]]

## WUR Negotiation

1. Define WUR Action frame to enable WUR negotiation:
* Note that WUR Action frame is sent through primary connectivity radio.

[Motion 1, March 2017, see [1] [18]]

1. The WUR Action frame sent by an AP through the PCR includes a WUR ~~receiver~~ identifier (WID):
* The WID uniquely identifies a WUR STA within ~~a~~the BSS of the AP.
* The WID is included in a unicast wake-up frame ~~as the receiver identifier~~ to identify the intended immediate recipient ~~wake up the~~ WUR STA within the BSS of the AP.
* The size of the WID is TBD, and how it is computed is TBD.

[Motion, Sep 2017, see [4] [19] and [20]]

1. AP decides the WUR operating channel in the band(s) supported by the associated non-AP STA operating in WUR Mode.

[Motion, Sep 2017, see [4] [21]]

## WURx Schedule

1. STA can have Duty cycle mode for wake-up receiver (WURx).

[Motion 2, March 2017, see [1] [18]]

1. The period of the WUR duty cycle as shown below is a multiple of a basic unit. The basic unit is indicated by the AP. The on duration in each period for WUR duty cycle as shown below is larger than or equal to a minimum wake-up duration. The minimum wake-up duration is indicated by the AP.



[Motion 1 and 2, May 2017, see [2] [22]]

1. AP decides the starting point for one WUR duty cycle schedule. How to indicate the starting point is TBD.

[Motion 3, May 2017, see [2] [22]]

## WUR Beacon

1. Define a WUR Beacon frame which can be transmitted periodically:
* The WUR Beacon is transmitted to WURs.

[Motion 4, March 2017, see [1] [17]]

1. WUR Beacon interval can be indicated in WUR Mode element:
* Note that WUR mode element is sent through primary connectivity radio.

[Motion 2, March 2017, see [1] [23]]

1. Define a synchronization mechanism to solve the timing mismatch problems associated with WUR duty cycle mode.

[Motion 1, March 2017, see [1] [24]]

1. The WUR beacon frame may carry partial TSF for synchronization. The number of bits of the partial TSF is TBD.

[Motion, May 2017, see [2] [25]]

## WUR Mode

1. WUR mode signaling shall be defined for the WUR STA to enter the WUR mode by explicit signalling:
* ~~Explicit or implicit signaling is TBD~~
* ~~If signaling is explicit,~~ WUR mode signaling is done on the Primary connectivity radio.
* Wake-up operating parameter is ~~may be~~ notified in WUR mode signalling:
	+ Detailed parameters are TBD.

[Motion, May 2017 and July 2017, see [2] [26] [3] [27]]

1. If a non-AP STA is in WUR mode, then:
* the non-AP STA’s WURx follows the duty cycle schedule (including WURx always on) agreed between AP and non-AP STA if the non-AP STA is in the doze state.
* the existing negotiated service period between AP and non-AP STA for the non-AP STA’s PCR schedule (e.g. TWT, schedule for WNM Sleep Mode) is suspended:
	+ STA is not required to wake up during the service period if the service period is suspended.
	+ The parameters of the negotiated service period for the non-AP STA’s PCR schedule is still saved by the AP and non-AP STA when the negotiated service period is suspended.

[Motion, July 2017, see [3] [28]]

1. If a non-AP STA is in WUR mode, then:
* the non-AP STA may not listen for Beacon frames if the non-AP STA is in PS mode.

[Motion, Sep 2017, see [4] [29]]

## Channel Access

1. Use EDCA to send wake-up frames:
* The EDCA parameter set for wake-up frames is TBD.

[Motion 5, March 2017, see [1] [17]]

1. An AP reuses existing 4 ACs and corresponding EDCA parameters to transmit WUR frame:
* Note that WUR frame includes unicast wake-up frame, multicast wake-up frame, and WUR Beacon.

[Motion 1, May 2017, see [2] [30]]

1. An AP may use any AC for sending a multicast wake-up frame. An AP may use any AC for sending a WUR Beacon.

[Motion 2, May 2017, see [2] [30]]

1. An AP may use any AC for sending a unicast wake-up frame to a STA if the AP does not have pending buffered frame to the STA.

[Motion 3, May 2017, see [2] [30]]

1. After an AP sends a WUR frame using EDCAF of a particular AC, the AP shall not update CW and retry count of the AC. After identifying failure for a unicast wake-up frame that is sent using EDCAF of a particular AC, AP shall not update CW and retry count of the AC.

[Motion 4, May 2017, see [2] [30]]

## Wake-up Operation

### General

1. The AP can send a Trigger Frame in 11ax to solicit response frames from one or more STAs after sending a wake-up frame to the STA(s).

[Motion 3, March 2017, see [1] [17]]

### Unicast Wake-up Operation

1. After AP sends a unicast wake-up frame to a STA, AP waits for a timeout interval:
* If AP receives any transmission from the STA within the timeout interval, then the wake-up frame transmission is successful.
* Otherwise, the wake-up frame transmission fails, and AP may retransmit the wake-up frame to the STA.

[Motion 3, March 2017, see [1] [18]]

1. A STA should send a response frame to the AP using primary connectivity radio after receiving a unicast wake-up frame.

[Motion 1, March 2017, see [1] [17]]

### Multicast Wake-up Operation

1. IEEE 802.11ba spec shall define a mechanism to wake up multiple WUR mode STAs (e.g., multi-user wake-up frame).

[Motion 2, March 2017, see [1] [31]]

1. After the transmission of broadcast wake-up frame, the AP can transmit broadcast/multicast frames through primary connectivity radio after the preparation period.

[Motion 3, March 2017, see [1] [32]]

## WUR Frame formats

### General

1. The WUR frame has the following format:



* The length of the MAC header is fixed.
* Whether the Address field contains more than one identifier is TBD.

[Motion 1, Sep 2017, see [4] [33]]

1. A Type subfield identifies the WUR frame type:
* The Type subfield is contained in the Frame Control field of the MAC header.
* One Type subfield value assigned to WUR Beacon and one to wake-up frame.

[Motion 2, Sep 2017, see [4] [33]]

1. The Type Dependent (TD) Control field in the MAC header contains type dependent control information.

[Motion 4, Sep 2017, see [4] [33]]

1. The WUR frame has an optionally present Frame Body field:
* It is optional for a STA to support reception of a frame with nonzero length Frame Body.

[Motion 5, Sep 2017, see [4] [33]]

1. The WUR frame has a Frame Check Sequence (FCS) that carries the CRC of the frame:
* Length and computation of FCS is TBD.

[Motion 6, Sep 2017, see [4] [33]]

### WUR Beacon

1. The Address field contains an identifier of the transmitter when the frame is WUR Beacon. [Motion 3, Sep 2017, see [4] [33]]
2. The TD Control field of a WUR Beacon contains the partial TSF.

[Motion 4, Sep 2017, see [4] [33]]

### Wake-up frame

1. The identifier of transmitter and/or receiver in a wake-up frame shall not be the MAC address.

[Motion 1, March 2017, see [1] [32]]

1. The unicast wake-up frame contains a WUR identifier that identifies both the transmitter and the receiver.

[Motion, Sep 2017, see [4] [20] and [19]]

1. AP indicates a BSS parameter update by incrementing a counter in the wake-up frame.

[Motion, Sep 2017, see [4] [34]]

# References

|  |  |
| --- | --- |
| [1]  | Leif Wilhelmsson (Ericsson), “17/526r0 Meeting Minutes March 2017”.  |
| [2]  | Leif Wilhelmsson (Ericsson), “17/843r0 Meeting Minutes May 2017”.  |
| [3]  | Leif Wilhelmsson (Ericsson), “17/1197r1 Meeting Minutes July 2017”.  |
| [4]  | Leif Wilhelmsson (Ericsson), “17/1522r2 Meeting Minutes Sep 2017”.  |
| [5]  | Adrian Stephens (Intel), “15/1034r11 802.11 Editorial Style Guide”.  |
| [6]  | Rui Cao (Marvell), “17/647r4 WUR Legacy Preamble Design”.  |
| [7]  | Shahrnaz Azizi (Intel Corp), “17/368r1 Motion for High Level PHY Design”.  |
| [8]  | Jia Jia (Huawei Technologies), “17/373r2 Performance Investigations on Single-carrier and Multiple-carrier-based WUR”.  |
| [9]  | Eunsung Park (LG), “17/964r4 Signal Bandwidth and Sequence for OOK Signal Generation”.  |
| [10]  | Eunsung Park (LG), “17/654r3 Multiple Data Rates for WUR”.  |
| [11]  | Eunsung Park (LG), “17/965r1 Data Rate for Range Requirement in 11ba”.  |
| [12]  | Steve Shellhammer, “17/1147r0 WUR Data Rate Motion”.  |
| [13]  | Hongyuan Zhang (Marvell), “17/1345r5 11ba PHY Frame Format Proposal”.  |
| [14]  | Steve Shellhammer (Qualcomm), “17/668r1 Motion on Manchester Coding”.  |
| [15]  | Eunsung Park (LG Electronics), “17/1347r3 Symbol structure”.  |
| [16]  | Jianhan Liu (Mediatek Inc.) , “17/27r4 Re-Discovery Problems in WUR WLAN”.  |
| [17]  | Jason Yuchen Guo (Huawei Technologies), “17/354r2 Initial thoughts on MAC procedures”.  |
| [18]  | Po-Kai Huang (Intel), “17/342r4 WUR Negotiation and Acknowledgement Procedure Follow up”.  |
| [19]  | Jeongki Kim (LG Electronics), “17/0977r4 Address structure in unicast wake-up frame”.  |
| [20]  | Liwen Chu (Marvell), “17/1115r4 Wakeup Frame Format”.  |
| [21]  | Po-Kai Huang (Intel), “17/1333r2 WUR Operating Channel”.  |
| [22]  | Po-Kai Huang (Intel), “17/651r1 Indication for WUR Duty Cycle”.  |
| [23]  | Po-Kai Huang (Intel), “17/343r3 WUR Beacon”.  |
| [24]  | Tianyu Wu (Mediatek), “17/371r4 WUR duty cycle mode and timing synchronization follow up”.  |
| [25]  | Steve Shellhammer (Qualcomm), “17/671r2 Considerations on WUR Synchronization”.  |
| [26]  | Suhwook Kim (LG), “17/379r4 SFD MAC proposal”.  |
| [27]  | Suhwook Kim, “17/954r2 WUR Mode Signaling”.  |
| [28]  | Po-Kai Huang (Intel), “17/972r2 Definition of WUR Mode”.  |
| [29]  | Woojin Ahn (WILUS), “17/1349r4 Discussion on WUR mode”.  |
| [30]  | Po-Kai Huang (Intel), “17/652r1 Consideration of EDCA for WUR Signal”.  |
| [31]  | Jeongki Kim(LG Electronics) , “17/54r3 WUR MAC issus”.  |
| [32]  | Liwen Chu (Marvell), “17/124r4 WUR MAC and Wakeup Frame”.  |
| [33]  | Alfred Asterjadhi (Qualcomm), “17/1004r4 Considerations on WUR frame format”.  |
| [34]  | Ming Gan (Huawei), “17/1368r2 BSS parameters update notification”.  |