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. |
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# Definitions

# Abbreviations and acronyms

|  |  |
| --- | --- |
| AC  | access category |
| AP | access point |
| BPSK | binary phase shift keying |
| CW | contention window |
| EDCA | enhanced distributed channel access |
| EDCAF | enhanced distributed channel access function |
| DFS | dynamic frequency selection |
| 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 |
| STA | station |
| TBD | to be determined |
| 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] [4]]

## WUR Preamble

## WUR Payload

1. Use OOK for modulation of the payload portion of the wake-up packet. The Preamble design is TBD. The operation in DFS channels is TBD. [Motion 1, March 2017, see [1] [5]]
2. The OOK waveform of wake-up packet 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] [6]]

1. When the subcarrier spacing is 312.5 kHz and a single band is used for transmission of wake-up packet, the OOK waveform of wake-up packet is generated by using contiguous 13 subcarriers
* The center subcarrier of 13 subcarriers can be null

[Motion, July 2017, see [3] [7]]

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, see [2] [8]]

1. IEEE 802.11ba supports multiple data rates for the payload part of the wake-up packet. [Motion 1, May 2017, see [2] [9]]
2. Manchester code shall be used for all of the data rates for the payload part of the wake-up packet. [Motion 2, May 2017, see [2] [9]]
3. The lowest data rate for the payload part of wake-up packet is 62.5 kb/s.

[Motion, July 2017, see [3] [10]]

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, see [3] [11]]

# 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] [12]]

## 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] [13]]

## WURx Schedule

1. STA can have Duty cycle mode for wake-up receiver (WURx). [Motion 2, March 2017, see [1] [13]]
2. 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] [14]]

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] [14]]

## 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] [15]]

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] [16]]

1. Define a synchronization mechanism to solve the timing mismatch problems associated with WUR duty cycle mode. [Motion 1, March 2017, see [1] [17]]
2. 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] [18]]

## WUR Mode

1. WUR mode signaling shall be defined for the WUR STA to enter the WUR mode by explicit signaling
* ~~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 signaling
	+ Detailed parameters are TBD

[Motion, May 2017 and July 2017, see [2] [19] [3] [20]]

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] [21]]

## Wake-up Operation

### General

1. A STA shall not transmit WUR signal if the primary connectivity radio of the STA is turned off. [Motion 2, March 2017, see [1] [15]]
2. The AP can send a Trigger Frame in 11ax to solicit response frames from one or more STAs after sending a wake-up packet to the STA(s). [Motion 3, March 2017, see [1] [15]]

### Channel Access

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

[Motion 5, March 2017, see [1] [15]]

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

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

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

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

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

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

1. After an AP sends a WUR signal 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 packet 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] [22]]

### Unicast Wake-up Operation

1. After AP sends a unicast wake-up packet 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 packet transmission is successful
* Otherwise, the wake-up packet transmission fails, and AP may retransmit the wake-up packet to the STA

[Motion 3, March 2017, see [1] [13]]

1. A STA should send a response frame to the AP using primary connectivity radio after receiving a unicast wake-up packet. [Motion 1, March 2017, see [1] [15]]

### 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] [23]]
2. 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] [24]]

## WUR Frame formats

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] [24]]

# References

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| --- | --- |
| [1]  | Leif Wilhelmsson (Ericsson), “17/526r0 Meeting Minutes March 2017”.  |
| [2]  | Leif Wilhelmsson (Ericsson), “17/843r0 Meeting Minutes May 2017”.  |
| [3]  | Leif Wilhelmsson (Ericsson), “17/1197r0 Meeting Minutes July 2017”.  |
| [4]  | Rui Cao (Marvell), “17/647r4 WUR Legacy Preamble Design”.  |
| [5]  | Shahrnaz Azizi (Intel Corp), “17/368r1 Motion for High Level PHY Design”.  |
| [6]  | Jia Jia (Huawei Technologies), “17/373r2 Performance Investigations on Single-carrier and Multiple-carrier-based WUR”.  |
| [7]  | Eunsung Park (LG), “17/964r4 Signal Bandwidth and Sequence for OOK Signal Generation”.  |
| [8]  | Steve Shellhammer (Qualcomm), “17/668r1 Motion on Manchester Coding”.  |
| [9]  | Eunsung Park (LG), “17/654r3 Multiple Data Rates for WUR”.  |
| [10]  | Eunsung Park (LG), “17/965r1 Data Rate for Range Requirement in 11ba”.  |
| [11]  | Steve Shellhammer, “17/1147r0 WUR Data Rate Motion”.  |
| [12]  | Jianhan Liu (Mediatek Inc.) , “17/27r4 Re-Discovery Problems in WUR WLAN”.  |
| [13]  | Po-Kai Huang (Intel), “17/342r4 WUR Negotiation and Acknowledgement Procedure Follow up”.  |
| [14]  | Po-Kai Huang (Intel), “17/651r1 Indication for WUR Duty Cycle”.  |
| [15]  | Jason Yuchen Guo (Huawei Technologies), “17/354r2 Initial thoughts on MAC procedures”.  |
| [16]  | Po-Kai Huang (Intel), “17/343r3 WUR Beacon”.  |
| [17]  | Tianyu Wu (Mediatek), “17/371r4 WUR duty cycle mode and timing synchronization follow up”.  |
| [18]  | Steve Shellhammer (Qualcomm), “17/671r2 Considerations on WUR Synchronization”.  |
| [19]  | Suhwook Kim (LG), “17/379r4 SFD MAC proposal”.  |
| [20]  | Suhwook Kim, “17/954r2 WUR Mode Signaling”.  |
| [21]  | Po-Kai Huang (Intel), “17/972r2 Definition of WUR Mode”.  |
| [22]  | Po-Kai Huang (Intel), “17/652r1 Consideration of EDCA for WUR Signal”.  |
| [23]  | Jeongki Kim(LG Electronics) , “17/54r3 WUR MAC issus”.  |
| [24]  | Liwen Chu (Marvell), “17/124r4 WUR MAC and Wakeup Frame”.  |