802.11ba Draft Specification

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| Spec Text for TSF Update and Wake-up Operation |
| Date: 2018-05-07 |
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Abstract

This submission contains spec text to be incorporated in P802.11ba D0.3 related to revision of WUR Mode neogitation and these motions:

1. [Assigned D0.3] IEEE 802.11ba shall provide mechanisms to enable re-discovery of WUR stations by AP.
2. [Assigned D0.3] A STA shall not transmit WUR frame if the primary connectivity radio of the STA is turned off.

R.4.4.C: [Assigned D0.3] WUR Beacon Period subfield indicates the WUR beacon period directly with the unit of TU.

1. For the transmitter of WUR Beacon:
* The Partial TSF field contains the bits X to X+11 of the transmitting STA’s TSF timer at the time that the start of the data symbol, containing the first bit of Partial TSF field, is transmitted by the PHY plus the transmitting STA’s delays through its local PHY from the MAC-PHY interface to its interface with the WM.

[Motion 1, March 2018, see [8] [48]]

1. [Assigned D0.3] For a WUR non-AP STA that receives a WUR Beacon carrying partial TSF with bit position X to X+11 of the TSF, the received partial TSF is adjusted to consider STA’s delay as shown below
* Create temporal timestamp by concatenating received partial TSF with X bits containing an implementation specific value that represents the assumed value of bit position 0 to X-1 of temporal timestamp
* Add an amount equal to the receiving STA’s delay through its local PHY components plus the time since the first bit of the Partial TSF field was received at the MAC/PHY interface to the temporal timer
* The adjusted value of the received partial TSF is set as the value of bit position X to X+11 of the temporal timestamp
1. [Assigned D0.3] For a WUR non-AP STA that receives a WUR Beacon carrying partial TSF with bit position X to X+11 of the TSF,
	* If the most significant bit (MSB) of the adjusted value of the received partial TSF is not equal to the bit X+11 of the local TSF timer then the value of bits X+12 to 63 of the local TSF timer shall be adjusted to account for roll over as follows:
		+ The value shall be increased by one unit (modulo 2^(52-X)) if LT[X:X+11] > AT and LT[X:X+11] > AT + 2^(11)
		+ The value shall be decreased by one unit (modulo 2^(52-X)) if LT[X:X+11] < AT and LT[X:X+11] < AT – 2^(11)

where AT is the adjusted value of the received partial TSF and LT[X:X+11] is the value of bits X to X+11 of the local TSF timer

* + The bits X to X+11 of the STA’s local TSF timer shall be set to the adjusted value of the received partial TSF.
1. [Assigned D0.3] The TSF timer accuracy in the MAC layer for WUR STA is within ±100 ppm.
2. [Assigned D0.3] 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).
3. [Assigned D0.3] After AP sends an individual addressed 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.
1. [Assigned D0.3] A STA should send a response frame to the AP using primary connectivity radio after receiving an individual addressed wake-up frame.
2. IEEE 802.11ba shall define a mechanism to wake up multiple WUR mode STAs (e.g., multi-user wake-up frame).
3. [Assigned D0.3] After the transmission of broadcast wake-up frame, the AP can transmit broadcast/group addressed frames through primary connectivity radio after the preparation period.
4. [Assigned D0.3] A non-individually addressed wake-up frame may include the information for indicating the group addressed frame transmission through PCR
* The details of indicating the group addressed frame transmission (e.g., using Group ID or additional bit) is TBD
1. [Assigned D0.3] If a STA receives a non-individually addressed wake-up frame indicating a group addressed frame through the PCR, the STA may attempt to receive a group addressed frame through PCR
2. [Assigned D0.3] A STA and an AP may reuse existing traffic filter sets to control the wake-up frame transmission. The AP should not send a wake-up frame to a STA in WUR mode when the AP obtains a DL frame that matches one or more traffic filter sets that configure not to send a wake-up frame.
3. [Assigned D0.3] A non-AP STA that receives a wake-up frame that satisfies condition 1 shall follow existing PCR operation to retrieve individually addressed buffered BU(s)
* (Condition 1) The wake-up frame is either an individual addressed wake-up frame that addresses the non-AP STA, or a wake-up frame that contains a group ID that identifies a group of non-AP STAs of which the non-AP STA is a member, or a wake-up frame with a list of WIDs in frame body where one of the WIDs identifies the non-AP STA

A non-AP STA that receives a wake-up frame with an indication of buffered group addressed BU(s) shall follow existing PCR operation to receive group addressed BU(s). A non-AP STA that receives a wake-up frame with an indication to check PCR beacon shall follow existing PCR operation to attempt to receive the PCR Beacon information.

1. An AP that transmits a wake-up frame addressed to a non-AP STA and satisfying condition 1 shall follow existing PCR operation to deliver individually addressed buffered BU(s)
* (Condition 1) The wake-up frame is either an individual addressed wake-up frame that addresses the non-AP STA, or a wake-up frame that contains a group ID that identifies a group of non-AP STAs of which the non-AP STA is a member, or a wake-up frame with a list of WIDs in frame body where one of the WIDs identifies the non-AP STA
* If AP schedule a transmission to the non-AP STA, AP shall schedule the transmission through PCR to the non-AP STA if any of the following conditions is met:
	+ The PCR transition delay indicated by the non-AP STA in the WUR Capabilities elements following the most recent transmitted wake-up frame intended to the non-AP STA has expired
	+ The non-AP STA has indicated it is in awake state after transmitting a frame through the PCR to the AP
	+ Note that the transmission is not limited to the individually addressed buffered BU(s)
1. [Assigned D0.3] An AP that transmits a wake-up frame indicating group addressed buffered BU(s) shall follow existing PCR operation to deliver group addressed buffered BU(s)
* AP shall schedule for transmission of group addressed buffered BU(s) through PCR if the following condition is met:
* The maximum PCR transition delay indicated by all the non-AP STAs in the WUR Capabilities elements, that are not in awake state and have negotiated WUR service with AP, following the most recent transmitted wake-up frame indicating buffered group addressed BU(s) of PCR has expired

**Reference slide deck(s):**

Revision History:

* Rev 0: Initial version of the document
* Rev 1: Revise based on the suggestion during presentation. Settle down on Option 2 of reusing TFS for wake-up frame transmission control. Straw Poll result: option 1: 3 option 2: 7.

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

***TGba Editor: Editing instructions preceded by “TGba Editor” are instructions to the TGba editor to modify or insert material in the TGba draft. As a result of adopting the changes, the TGba editor will execute the instructions rather than copy them to the TGba Draft.***

**TGba Editor: *Instruction: Modify 4.3.15a as the following: (Track Change on)***

* Components of the IEEE Std 802.11 architecture

***Insert a new subclause after subclause 4.3.15 as follows:***

* Wake-up radio (WUR) STA

WUR AP supports the features of HT AP, VHT AP, or HE AP, and has the capability to transmit WUR PPDU.

WUR non-AP STA includes a PCR component, which supports the features of HT non-AP STA, VHT non-AP STA, or HE non-AP STA, and a WURx, which has the capability to receive WUR PPDU.A WUR non-AP STA does not have the capability to transmit WUR PPDU.

The main PHY features in a WUR STA are the following:

<Texts to be filled>

The main MAC features in a WUR STA are the following:

<Texts to be filled>

**TGba Editor: *Instruction: Add a new row to Table 9-217 and renumber the following Bits(s) column values as shown below: (Track change on)***

9.4.2.79 TFS Request element

**Table 9-217—TFS Action Code field values**

|  |  |  |
| --- | --- | --- |
| **Bit(s)** | **Name** | **Notes** |
| 0 | Delete After Match  | Setting this field to 1 for any traffic filter set indicates all traffic filter sets established at the AP for the non-AP STA are deleted when a frame matches any of the traffic filter sets established for the non-AP STA. A value of 0 for this field indicates no deletion of the traffic filter set upon a match.  |
| 1 | Notify  | Setting this field to 1 indicates the STA is to be sent either a TFS Notify frame or WUR wake-up frame as described in 31.5.3 (AP Operation) upon the first frame matching to the traffic filter set or the first frame match after the AP receives a Notify Response frame containing the corresponding TFS ID. Setting this field to 0 indicates the AP does not send TFS Notify frame or WUR wake-up frame to the requesting STA.  |
| 2–7 | Reserved  | All other bits are reserved.  |

**TGba Editor: *Instruction: Modify 9.4.2.264 as the following: (Track Change on)***

* WUR Operation element

*(…existing texts…)*

The WUR Beacon period field represents the number of time units (TUs) between consecutive target WUR beacon transmission times (TWBTTs).

**TGba Editor: *Instruction: Modify 31.1 Introduction as the following: (Track Change on)***

31.1 Introduction

Clause 31 defines the MAC functions of WUR STA.

**TGba Editor: *Instruction: Modify 31.3.1 General as the following: (Track Change on)***

* General

A STA’s TSF timer shall be accurate to within ±100 ppm (See 11.1.3.9 (TSF timer accuracy)).

A non-AP STA that is in WUR mode expects to receive WUR Beacon frames every dot11WURBeaconPeriod.

An AP sending a WUR Beacon frame shall set the TD Control field of the WUR Beacon frame to the TSF timer [X: X+11] of the transmitting STA’s TSF timer at the time that the start of the data symbol, containing the first bit of TD Control field, is transmitted by the PHY plus the transmitting STA’s delays through its local PHY from the MAC-PHY interface to its interface with the WM.

* TGba Editor: *Instruction: Modify 31.3.2 WUR Beacon generation as the following: (Track Change on)*WUR Beacon generation

The AP shall define the timing for WUR by transmitting WUR Beacon frames according to dot11WURBeaconPeriod. This defines a series of TWBTTs exactly dot11WURBeaconPeriod TUs apart. At each TWBTT, the AP shall schedule a WUR Beacon frame as the next frame for transmission according to the medium access rules specified in Clause 10 except that one of the following conditions is met:

* There is zero WUR non-AP STA associated with the AP
* AP does not provide WUR service to any associated WUR non-AP STA
* All the PCR components of the associated WUR non-AP STAs are in awake state

NOTE—To achieve this requirement, the AP suspends any pending transmissions until the WUR beacon has been transmitted.

The WUR beacon period is included in the WUR Operation element sent by AP, and a non-AP STA with WURx shall adopt that WUR beacon period when joining the BSS, i.e., the non-AP STA shall set the dot11WURBeaconPeriod to the value of the WUR Beacon Period field of the received WUR Operation element.

NOTE—Though the transmission of a WUR Beacon frame might be delayed because of CSMA deferrals, subsequent WUR Beacon frames are scheduled at the undelayed nominal WUR beacon interval.

**TGba Editor: *Instruction: Add 31.3.3 TSF Timer update with WUR Beacon as the following:***

31.3.3 TSF Timer update with WUR Beacon

Upon receiving a WUR Beacon frame with a valid FCS and Transmit ID that matches the Transmit ID of the AP to wich the STA is associated, a non-AP STA shall update its TSF timer
according to the algorithm described below.

The received partial TSF timestamp, obtained from the TD Control field of the WUR Beacon frame, is adjusted to consider the WUR STA’s delay as shown below

* Create a temporary timestamp by concatenating the received partial TSF timestamp with X bits containing an implementation specific value that represents the assumed value of bit position 0 to X-1 of temporal timestamp
* Add an amount equal to the receiving STA’s delay through its local PHY components plus the time since the first bit of the Partial TSF field was received at the MAC/PHY interface to the temporal timer
* The adjusted value of the received partial TSF timestamp is set as the value of bit position X to X+11 of the temporal timestamp

If the most significant bit (MSB) of the adjusted value of the received partial TSF timestamp is not equal to the bit X+11 of the local TSF timer then the value of bits X+12 to 63 of the local TSF timer shall be adjusted to account for roll over as follows:

* + - The value shall be increased by one unit (modulo 2^(52-X)) if LT[X:X+11] > AT and LT[X:X+11] > AT + 2^(11)
		- The value shall be decreased by one unit (modulo 2^(52-X)) if LT[X:X+11] < AT and LT[X:X+11] < AT – 2^(11)

where AT is the adjusted value of the received partial TSF timestamp and LT[X:X+11] is the value of bits X to X+11 of the local TSF timer

* + The bits X to X+11 of the STA’s local TSF timer shall be set to the adjusted value of the received partial TSF timestamp.

**TGba Editor: *Instruction: Add 31.6 Wake-up operation as the following:***

31.6 Wake-up operation

31.6.1 General

An AP may send a WUR wake-up frame to a non-AP STA as described in 31.5.3 (AP Operation) to notify the non-AP STA that the AP intends to have PCR operation with the non-AP STA as described in 31.6.2 (AP operation) and 31.6.3 (non-AP STA operation).

If the AP and the non-AP STA support traffic filtering service (TFS) as specified in 11.24.12 (TFS Procedures), then the AP and the non-AP STA may reuse existing traffic filter sets to control the WUR wake-up frame transmission as described in 31.6.2 (AP operation).

The AP may transmit a WUR wake-up frame to a non-AP STA to indicate that individually addressed BU(s) are available for the STA via the PCR. The WUR wake up frame shall satisfy any of the conditions below:

* The Address field of the wake-up frame contains a WID that identifies the non-AP STA
* The Address field of the wake-up frame contains a group ID that identifies a group of non-AP STAs of which the non-AP STA is a member
* The WUR wake-up frame has a list of identifiers in the Frame Body field where one of the identifiers identifies the non-AP STA

The AP may transmit a WUR wake-up frame to a non-AP STA to indicate that group addressed buffered BU(s) are available for the STA via the PCR.

The AP may transmit a broadcast WUR wake-up frame to a non-AP STA to indicate that a critical update to the PCR’s BSS parameters is available for the STA via the PCR. The critical update is indicated in the Counter field of the TD Control.

31.6.2 AP operation

An AP that transmits a WUR wake-up frame to a non-AP STA that indicates the availability of individualy addressed buffered BU(s) via the PCR shall follow the existing PCR operation to deliver individually addressed buffered BU(s) to the non-AP STA. When the AP schedules a transmission to the non-AP STA, the AP shall ensure that either of the conditions below is met:

* + The PCR transition delay indicated by the non-AP STA in the WUR Capabilities elements following the most recent transmitted wake-up frame intended to the non-AP STA has expired
	+ The non-AP STA has indicated that it is in awake state by transmitting a frame through the PCR to the AP

NOTE - The frames scheduled by the AP to be delivered via the PCR are not limited to individually addressed buffered BU(s) only.

An AP that transmits a WUR wake-up frame to a non-AP STA that indicates the availability of group addressed buffered BU(s) via the PCR shall follow existing PCR operation to deliver group addressed buffered BU(s) to the non-AP STA. When the AP schedules a transmission of group addressed buffered BU(s) through PCR to the non-AP STA, the AP shall ensure that the following condition is met:

* The maximum PCR transition delay indicated by all the non-AP STAs in the WUR Capabilities elements, that are not in awake state and have negotiated WUR service with AP, following the most recent transmitted wake-up frame indicating buffered group addressed BU(s) of PCR has expired

An AP that sends a WUR wake-up frame to the STA(s) may send a Trigger Frame to solicit response frames from one or more STAs.

When a traffic filtering agreement is established for a non-AP STA and Bit 1 of the TFS Action Code field is set to 1, then the AP should transmit a wake-up frame to the non-AP STA when the AP receives an individually addressed buffered BU destined to the non-AP STA that matches the traffic filter set.

When a traffic filtering agreement is established for a non-AP STA and Bit 1 of the TFS Action Code field is set to 0, then the AP should not transmit a wake-up frame to the non-AP STA when the AP receives an individually addressed buffered BU destined to the non-AP STA that matches the traffic filter set.

After an AP sends a wake-up frame with Address field set to a WID that identifies a non-AP STA, the AP waits for a timeout interval that is larger than the PCR transition delay indicated by the non-AP STA in the WUR Capabilities elements:

* If the AP receives any transmission from the non-AP STA within the timeout interval, then the wake-up frame transmission is successful.
* Otherwise, the wake-up frame transmission fails, and the AP may retransmit the wake-up frame to the non-AP STA.

The method by which an AP determines the exact value of the timeout interval is implementation specific.

The method by which an AP determines the number of retries after the transmission of individually addressed wake-up frame fails is implementation specific.

31.6.3 non-AP STA operation

A non-AP STA that receives a wake-up frame addressed to itself with an indication of individualy addressed buffered BU(s) shall follow existing PCR operation to retrieve individually addressed buffered BU(s).

NOTE - For example, rule b), c), and d) in 11.2.3.8 (Receive operation for STAs in PS mode during the CP) describes one operation for a non-AP STA to retrieve individually addressed buffered BU(s) using PS-Poll or U-APSD.

A non-AP STA that receives a wake-up frame with an indication of buffered group addressed BU(s) shall follow existing PCR operation to receive group addressed BU(s).

NOTE - For example, rule e) in 11.2.3.8 (Receive operation for STAs in PS mode during the CP) describes one operation for a non-AP STA to receive group addressed frame.

A non-AP STA that receives a wake-up frame with an indication of critical update to the PCR’s BSS parameters shall follow existing PCR operation to attempt to receive the PCR Beacon information.

NOTE - For example, 11.2.3.17 (TIM Broadcast) describes one operation for a non-AP STA to attempt to receive the next Beacon frame.

A non-AP STA should send a response frame to the associated AP using its PCR component after receiving a wake-up frame with Address field set to the WID that identifies the non-AP STA.

ASN.1 encoding of the MAC and PHY MIB

* MIB Detail

*TGba Editor: Instruction: Change Dot11StationConfigEntry as follows:*

Dot11StationConfigEntry ::= SEQUENCE

 {

 …,

 dot11FutureChannelGuidanceActivated TruthValue,

 dot11WUROptionImplemented TruthValue,

 dot11WURBeaconPeriod Unsigned32,

 }

TGba Editor: Instruction: Insert the following after the dot11FutureChannelGuidanceActivated OBJECT-TYPE element in the Dot11StationConfig TABLE:

dot11WUROptionImplemented OBJECT-TYPE

 SYNTAX TruthValue

 MAX-ACCESS read-only

 STATUS current

 DESCRIPTION

 "This is a capability variable. Its value is determined by device capabilities. This attribute, when true, indicates that the WUR feature is implemented and operational. This attribute, when false or not present, indicates that the WUR feature is not implemented or not operational."

::= { dot11StationConfigEntry <ANA>}

dot11WURBeaconPeriod OBJECT-TYPE

 SYNTAX Unsigned32(1..TBD)

 MAX-ACCESS read-write

 STATUS current

 DESCRIPTION

 "This is a control variable.

 It is written by an external management entity. Changes take effect for the next

 MLME-START.request primitive. For WUR STAs, this attribute specifies the number of

 TUs that a station uses for scheduling WUR Beacon transmissions. This value is transmitted in Beacon, Probe Response frames, Association Response frames, or Reassociation Response frames."

::= { dot11StationConfigEntry <ANA>}