IEEE P802.11  
Wireless LANs

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| OPS | | | | |
| Date: 2018-03-01 | | | | |
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Abstract

1. **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 TGax Draft. The introduction and the explanation of the proposed changes are not part of the adopted material.

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

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

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| **CID** | **Clause Number(C)** | **Page** | **Comment** | **Proposed Change** | **Resolution** |
| 11019 | 9.4.2.237.2 | 137 | OPS Support subfield applies only if the STA supports Broadcast TWT | Replace text in 'Encoding' column to:  "If Broadcast TWT Support subfield is 1  Set to 1 if supported.  Set to 0 otherwise.  Reserved otherwise." | Revised – OPS is currently using only the TWT element to determine when the TIM frame is sent. Support on STA or AP side of BC TWT is not needed. OPS works without BC TWT in a much simpler way. Define OPS frame to be self contained. Apply the changes proposed in doc 768r0. |
| 12032 | 9.4.2.6 | 119 | Please ensure that TIM element used in TIM frame or FILS Discovery frame also describes "traditional TIM bit setting rule" that is used for non-OPS STAs. | Add the folllowing bulleted text to line 44:" Bit Number N that corresponds to non-OPS STA with AID N is 1 to indicate that AP has buffered frames for the STA and set to 0 otherwise." | Revised – agree with the commenter. Apply the changes in doc 768r0. |

1. **Discussion**

TWT is designed for STAs in PS mode. It allows to schedule the time spent in awake and doze state.

OPS on the contrary is meant for STAs in active mode. The main use case is STAs with bursty traffic that stay in PS mode (doze state) for long period of time (few seconds) between the bursts of data, and then move to active when the burst happens (as the burst is usually a large amount of data – typical youtube traffic pattern for instance). Those STAs stay in the active mode to try and finish the burst as fast as possible, and to be able to go back to sleep as soon as possible.

In non-congested environments, these STAs don’t need anything for power save, they stay active for just the time they need to finish the DL or UL buffer and go back to sleep. In congested environment, these STAs stay in the active mode for longer time as they need to share the airtime with other STAs. OPS is used in that particular scenario. It allows the AP to send an information to the STAs to tell them if they will not be scheduled in the incoming period (20ms for instance). In such case, the STAs can go to power save and come back active after 20ms. This is a very lightweight solution where the AP does not need to negotiate anything or renegotiate if new STAs get active or leave active mode…

OPS is therefore fully orthogonal from TWT.

OPS got to use TWT for the argument that it is a good way to determine when the TIM frame will be transmitted, and that it was the only thing that would be used in TWT. The issue is that TWT comes with many rules for scheduled and scheduling STAs, for power save and others. This adds unnecessary complexity for supporting this feature. What is needed is just the ability for the STA and AP to know when a frame will be transmitted. The negotiation, rules for operation inside and outside the TWT SP and power save rules are not needed.

For us, the best approach is to not use TWT and simply define a new OPS frame (which solves also coexistence with TIM Broadcast procedure), which contains a TIM element (for the bitmap indicating who will be scheduled and who will not be scheduled) and the duration after the frame for which the OPS information is valid. In such case, we don’t even need to schedule the OPS frame, this is purely unscheduled.

The second option is to define a specific mode inside TWT, with a specific capability element associated to it, for which the only function is to define a time at which a frame will be transmitted.

1. **Proposed changes**

***CID 11019***

Option 1 (#11019)

* Elements
* General

***Editor: Insert the following new row into Table 9-77 (Element IDs) (header row shown for convenience):***

|  |  |  |  |
| --- | --- | --- | --- |
| * Element IDs | | | |
| Element | Element ID | Element ID Extension | Extensible |
| OPS Information (see 9.4.2.xxx OPS Information element) | 255 | ANA | Yes |

Editor: Add a new subclause 9.4.2.xxx OPS Information element

9.4.2.xxx OPS Information element

The OPS Information element provides information needed by STAs when operating with OPS as defined in 27.14.3 (Opportunisitic power save). The format of the OPS Information element is defined in OPS Information element).

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | Element ID | Length | Element ID Extension | OPS Duration |
| Octets: | 1 | 1 | 1 | 1 |
| * OPS Information element | | | | |

The Element ID, Element ID extension and Length fields are defined in 9.4.2.1 (General).

When the OPS Information elment is included in an OPS frame or a FILS Discovery frame, the OPS Duration field indicates the period duration, in units of TUs, during which a STA may go to doze state if it is explicitly not scheduled during that period, as defined in 27.14.3 (Opportunistic power save). The OPS duration field is encoded in ms.

* HE Action field

***Editor: Insert the following new row into Table 9-421z (HE Action field values):***

|  |  |
| --- | --- |
| * HE Action field values | |
| Value | Meaning |
| 2 | OPS |
| 3-255 | Reserved |

Editor: Add a new subclause 9.6.28.xxx OPS frame format:

9.6.28.xxx OPS frame format

The OPS frame is an Action No Ack frame of category HE. The Action field of an OPS frame contains the information shown in Table xxx (OPS frame Action field format).

|  |  |
| --- | --- |
| Table xxx - OPS frame Action field format | |
| Order | Information |
| 1 | Category |
| 2 | HE Action |
| 3 | TIM element |
| 4 | OPS Information element |

The Category field is defined in Table 9-47 (Category values).

The HE Action field is defined in Table 9-421z (HE Action field values).

The TIM element is defined in 9.4.2.6 (TIM element) is always present in the frame.

The OPS Information element is defined in 9.4.2.xxx (OPS Information element) is always present in the frame.

Editor Change Table 9-325a (FILS Discovery frame format) as follows (only modified rows are shown):

|  |  |  |
| --- | --- | --- |
| * FILS Discovery frame format | | |
| Order | Information | Notes |
| ~~6~~ | ~~Vendor Specific element~~ | ~~One or more Vendor Specific elements are optionally~~  ~~present.~~ |
| 7 | TIM element | The TIM element is optionally present if(#Ed) dot11HEOptionImplemented is true, otherwise it is not present. |
| 8 | OPS Information element | The OPS Information element is optionally present if(#Ed) dot11HEOptionImplemented is true and is present if the TIM element is present, otherwise it is not present. |
| 9 | TWT element | The TWT element is optionally present if(#Ed) dot11HEOptionImplemented is true, otherwise it is not present. If present, the Broadcast field of the TWT element is 1(#12046) |

Editor: Modify subclause 27.14.3 Opposrtunistic power save as follows:

* Opportunistic power save(#6041)
* General

An OPS STA is a non-AP HE STA that sets the OPS Support subfield in the HE MAC Capabilities Information field of the HE Capabilities element to 1(#Ed).

An OPS AP is an AP HE STA that sets the OPS Support subfield in the HE MAC Capabilities Information field in HE Capabilities element to 1(#Ed).

Opportunistic power save mechanism has the objective to allow OPS STAs to opportunistically go to doze state for a defined period. To achieve this, an OPS AP sends an OPS frame of a FILS discovery frame to provide the scheduling information for all OPS STAs for the OPS service period that follows the transmission of the OPS frame or FILS discovery frame. Based on this information, the OPS STAs may opportunistically go to doze state during the OPS service period.

The OPS AP may also split a beacon interval into several consecutive OPS service periods by scheduling the transmission of the OPS frame or FILS discovery frame with a periodic broadcast TWT SPs with TWT ID 0 and by setting the periodicity of the TWT SPs equal to the OPS service period duration. (#5509)

* AP operation for opportunistic power save

(#5509)To enable opportunistic power save, an OPS AP shall transmit an OPS frame or a FILS Discovery frame that includes a TIM element (see 9.4.2.6 (TIM element)) and an OPS Information element (see 9.4.2.xxx (OPS Information element)). The AP should transmit a FILS Discovery frame instead of an OPS frame if the target transmission time aligns with the transmission time of a FILS Discovery frame. The OPS Information element includes the duration of the OPS service period that immediately follows the transmission of the OPS frame or FILS Discovery frame. The TIM element is encoded specifically as defined in 9.4.2.6 (TIM element) in order to provide the information of which STAs are scheduled and not scheduled during the OPS service period.

An OPS AP may also define periodic consecutive OPS service periods, by including a TWT element in beacons to set a periodic Broadcast TWT SP with the following information:

* The TWT flow identifier field set to 3
* The Broadcast TWT ID subfield is set to 0
* The TWT Wake Interval Mantissa is set to define a TWT Wake Interval equal to the OPS service period duration.
* The Nominal Minimum TWT Wake Duration is set to the duration of the Broadcast TWT SP with TWT ID 0 during which the OPS frame or the FILS discovery frame is scheduled for transmission.

At the beginning of these periodic OPS SP and during the TWT SPs with the TWT Flow Identified field set to 3, the AP shall transmit a TIM frame or a FILS Discovery frame that includes a TIM element (see 9.4.2.6 (TIM element)). The AP should transmit a FILS Discovery frame instead of a TIM frame if the TWT SP start time aligns with the transmission time of a FILS Discovery frame. (#7594, #9959)

* STA operation for opportunistic power save

When an OPS STA in the awake state (#12034), either in active mode or in power save mode, with AID *N* receives a TIM element in OPS frame or FILS Discovery frame from the associated OPS AP, the STA may enter the doze state until the end of the OPS SP duration, if the bit *N* in the traffic indication virtual bitmap field of the current TIM element is set to 0.

NOTE – If the OPS frame or FILS Discovery frame is scheduled with TWT SP with the TWT flow identifier field set to 3, the OPS SP duration is equal to duration until the next TWT SP with the TWT flow identifier field set to 3.

NOTE—The opportunistic power save protocol does not restrict the OPS STA's channel access. The OPS STA can always access the channel with EDCA.(#5674)

Option 2 (#11019)

***11ax Editor: Modify 27.7 TWT operation as follows:***

* TWT operation
* General

Target wake times (TWTs) allow STAs to manage activity in the BSS by scheduling STAs to operate at different times in order to minimize contention between STAs and to reduce the required amount of time that a STA in PS mode needs to be awake. A specific mode of TWT is also used to inform STAs of the time at which a particular frame is scheduled for transmission.

An HE STA can negotiate individual TWT agreements, as defined in 10.43 (Target wake time (TWT)), subject to the additional rules and restrictions that are defined in 27.7.2 (Individual TWT agreements). An HE STA can negotiate membership in broadcast TWT schedules, as defined in 27.7.3 (Broadcast TWT operation), which can be used as defined in 27.7.3.3 (Rules for TWT scheduled STA).

The Broadcast TWT operation with TWT ID 0 is a TWT mode used to inform STAs of the time at which a particular frame is scheduled for transmission, which does not require membership, does not require BC capability support and for which the TWT rules do not apply. It is used as described in 27.14.2 (Power save with UORA), and 27.14.3 (Opportunistic power save).

A STA does not need(#13777) to be aware of the values of TWT parameters of the TWT agreements of other STAs in the BSS of the STA or of TWT agreements of STAs in other BSSs. A STA does not need to be aware that a TWT service period (SP) can be used to exchange frames with other STAs. Frames transmitted during a TWT SP can be carried in any PPDU format supported by the pair of STAs that have established the TWT agreement corresponding to that TWT SP, including HE MU PPDU, HE TB PPDU, etc.

An HE STA with dot11TWTOptionActivated equal to true shall set:

* The TWT Requester Support subfield to 1 in the HE Capabilities element that it transmits if it supports operating in the role of a TWT requesting STA; otherwise set to 0.
* The TWT Responder Support subfield to 1 in the HE Capabilities elements that it transmits if it supports operating in the role of a TWT responding STA; otherwise set to 0.
* The Broadcast TWT Support subfield to 1 in the HE Capabilities element that it transmits if it supports operating in the role of a TWT scheduled STA or in the role of a TWT scheduling AP; otherwise set to 0.

An HE AP shall set the TWT Responder Support subfield(#12183) of the Extended Capabilities element and HE Capabilities element to 1.

An HE AP may set the TWT Required subfield to 1 in HE Operation elements it transmits to request TWT participation by all HE STAs that are associated to it and that have declared support for TWT. A STA that supports TWT and is associated with an HE AP from which it receives an HE Operation element whose TWT Required subfield is 1 shall either negotiate individual TWT agreements, as defined in 27.7.2 (Individual TWT agreements), or participate in broadcast TWT operation, as defined in 27.7.3 (Broadcast TWT operation).

NOTE—The AP sets the TWT Required subfield to 1 when it is unavailable outside of TWT SPs (see 27.7.2 (Individual TWT agreements) and 10.43.7 (TWT Sleep Setup)).

* Individual TWT agreements

An HE STA may negotiate individual TWT agreements with another HE STA as defined in 10.43.1 (TWT overview), except that the STA:

* May set the Responder PM Mode subfield to 1 if it is a TWT responding STA that intends to go to doze state outside of TWT SPs.
* If the TWT responding STA is an AP then it may set the Responder PM Mode subfield to 1 only if all non-AP STAs that are associated to it indicate support of TWT in the role of a TWT requester and the AP has set the TWT Required subfield to 1 in the HE Operation element it transmits; otherwise it shall set the Responder PM Mode subfield to 0.
* An AP that sets the Responder PM Mode subfield to 1 follows the rules defined in 10.43.7 (TWT Sleep Setup).
* Shall set the Implicit subfield to 1 and the NDP Paging Indicator subfield to 0 in all TWT elements that it transmits during the TWT setup.
* May set the Trigger subfield to 1 in the TWT element it transmits during the TWT setup to negotiate a trigger-enabled TWT.
* A successful TWT agreement whose Trigger subfield in the TWT response sent by the AP is 1 is a trigger-enabled TWT; otherwise it is not a trigger-enabled TWT.
* Shall set the TWT Channel subfield in the TWT element it transmits to 0.
* May set the TWT Protection field to 1 to indicate that TXOPs within the TWT SPs shall be initiated with a NAV protection mechanism, such as (MU) RTS/CTS, or CTS-to-self frame; otherwise it shall set it to 0.
* An HE STA shall not use the RAW mechanism for protection of TWT SPs.

An HE STA that successfully sets up a TWT agreement with another HE STA shall follow the rules defined in 10.43.1 (TWT overview) and 10.43.4 (Implicit TWT operation), except that all the additional rules defined in this subclause supersede all the respective rules defined in 10.43.1 (TWT overview) and 10.43.4 (Implicit TWT operation). A TWT or TWT SP that is set up under an implicit TWT agreement is an implicit TWT or implicit TWT SP, respectively (see 10.43.1 (TWT overview)). A TWT or TWT SP that is set up under a trigger-enabled TWT agreement is a trigger-enabled TWT or trigger-enabled TWT SP, respectively.

An HE STA may execute the TWT setup exchanges defined in Table 27-3 (HE individual TWT setup exchange command interpretation) in addition to the exchanges defined in 10.43 (Target wake time (TWT)). An HE STA that supports TWT shall set the Broadcast subfield as indicated in 10.43 (Target wake time (TWT)) or as indicated in Table 27-3 (HE individual TWT setup exchange command interpretation). For all exchanges listed in Table 27-3 (HE individual TWT setup exchange command interpretation), the Wake TBTT Negotiation subfield shall be set to 0.

|  |  |  |
| --- | --- | --- |
| * HE individual TWT setup exchange command interpretation | | |
| Initiating frame: TWT Setup Command field value within a TWT Setup frame transmitted from a first STA to a second STA | Response frame: TWT Setup Command field value within a TWT Setup frame transmitted from the second STA to the first STA | TWT condition after the completion of the exchange |
| Request TWT or Suggest TWT or Demand TWT with Broadcast subfield = 0 | Accept TWT with Broadcast subfield = 1 | This response is not allowed. |
| Request TWT with Broadcast subfield = 0 | Dictate TWT with Broadcast subfield = 1 | No individual TWT agreement exists with the associated TWT Flow identifier. A broadcast TWT schedule exists that uses the TWT parameters identified in the response frame including a Broadcast TWT ID subfield. The broadcast TWT schedule is not necessarily a newly created broadcast TWT schedule. The responding STA will not create any new individual TWT agreement with the requester at this time. The STA transmitting the initiating frame is not a member of the broadcast TWT. |
| Accept TWT with Broadcast subfield set to 0 and with an individual address in the RA field of the MPDU. | No frame transmitted | The STA receiving this frame now has an individual TWT agreement with the transmitter of the frame where the parameters of the individual TWT agreement are identified by the initiating frame. |
| Accept TWT with Broadcast subfield set to 1 and with an individual address in the RA field of the MPDU. | No frame transmitted | Only an HE AP is permitted to transmit this sequence. The STA receiving this frame is a member of the broadcast TWT identified by the initiating frame. |
| Alternate TWT or Dictate TWT with Broadcast subfield = 0 | No frame transmitted | The STA receiving this frame is not, through the receipt of this frame, a member of the TWT identified by the initiating frame but can use the information provided to create a request to join a TWT in a subsequent initiating frame that it transmits. |
| NOTE—Request frame settings not listed in the table are not allowed. | | |

An HE STA that successfully sets up an individual TWT agreement and operates in PS mode may listen to Beacon frames, but is exempt from the requirements for receiving Beacon frames as defined in 11.2.2.1 (General).

An HE AP may send an unsolicited TWT response frame with the Trigger subfield equal to 1 to a non-AP HE STA that has set the TWT Requester Support subfield to 1 in the HE Capabilities elements that it transmits to the AP. The TWT response frame shall have one of these values in the TWT Command field: Accept TWT, Alternate TWT or Dictate TWT. An unsolicited TWT response frame with TWT Command of Alternate TWT or Dictate TWT contains an advisory notification to the recipient of TWT parameters that are likely to be accepted by the AP if the recipient transmits a subsequent TWT request frame to the AP that includes those TWT parameters. An unsolicited TWT response frame with the TWT Command of Accept TWT creates a TWT agreement between the two STAs. A STA that received an unsolicited TWT response frame with the TWT Command of Accept TWT might transmit a TWT Teardown frame to delete the unsolicited individual TWT agreement.

An HE STA shall not transmit BAT, TACK, or STACK frames.

A TWT requesting STA should not transmit frames to the TWT responding STA outside of negotiated TWT SPs for that TWT agreement and should not transmit frames that are not contained within HE TB PPDUs to the TWT responding STA within trigger-enabled TWT SPs for that TWT agreement.

NOTE—The non-AP STA decides what frames to transmit within or outside TWT SPs and while it is recommended that the STA not to transmit it is still permitted to do so.

The TWT responding STA of a trigger-enabled TWT agreement shall schedule for transmission of a Trigger frame for the TWT requesting STA, as described in 27.5.3 (UL MU operation), within each TWT SP for that TWT agreement. The TWT responding STA should solicit buffer status reports from the TWT requesting STA at the start of the TWT SP following the procedure described in 27.5.3.6 (HE buffer status feedback operation for UL MU) or as described in 27.5.6 (NDP feedback report procedure). The TWT responding STA that intends to transmit additional Trigger frames during a trigger-enabled TWT SP shall set the More TF subfield in the Common Info field(#11003) of the Trigger frame to 1 to indicate that it will transmit another Trigger frame within the same TWT SP. The TWT responding STA shall set the More TF subfield(#11003) to 0 when the Trigger frame is the last Trigger frame of the TWT SP or when the Trigger frame is sent outside of a TWT SP.

NOTE 1—The TWT responding STA might not schedule for transmission of a Trigger frame for the TWT requesting STA when the TWT agreement is not a trigger-enabled TWT agreement or when the TWT requesting STA has sent an OM Control subfield(#14137) that has the UL MU disable bit equal to 1 (see 27.8 (Operating mode indication).

NOTE 2— The Trigger frame can also be an UMRS Control subfield(#14137) contained in an MPDU carried in a DL MU PPDU, provided that the AP allocates enough resources in the HE TB PPDU for the STA to at least deliver its BSRs in response to the soliciting DL MU PPDU.

A TWT requesting STA transmits an HE TB PPDU as a response to a Trigger frame that is intended for it and is sent during a trigger-enabled TWT SP (see 27.5.3 (UL MU operation)). A TWT requesting STA that is in PS mode and is awake shall include a PS-Poll frame or a U-APSD trigger frame(#13320) in the HE TB PPDU if the TWT is an announced TWT unless the STA has already transmitted a PS-Poll or U-APSD trigger frame(#13320) or transmitted any other indication that the STA is in the awake state within that TWT SP or has, previous to the TWT SP, otherwise indicated to the AP that it is currently in the awake state. The STA may include other frames in the HE TB PPDU when other rules do not prohibit their inclusion, see 27.5.3 (UL MU operation).

NOTE–A Trigger frame is intended for a TWT requesting STA if it is sent by the AP to which the STA is associated and the frame contains the 12 LSBs of the STA’s AID in any of its User Info fields. The Trigger frame can have multiple recipients, each of which is identified by the presence of the 12 LSBs of the recipient’s AID in any of its User Info fields (see 27.5.3 (UL MU operation)), and can have in the TA field the MAC address of the AP or the(#11036, #13780) transmitted BSSID under the conditions defined in 27.5.3.2.3 (Allowed settings of the Trigger frame fields and UMRS Control subfield(#14137)).

A TWT responding STA that receives a PS-Poll frame or a U-APSD trigger frame(#13320) or any other indication from a TWT requesting STA that is in PS mode during or before an announced TWT SP that the STA is in the awake state during the TWT SP shall follow the rules defined in 11.2.3.6 (AP operation during the CP) to deliver buffered BUs to the STA except that it may deliver multiple buffered BUs as defined here. A TWT responding STA that sends frames to a TWT requesting STA that is in PS mode during an unannounced TWT SP shall follow the rules defined in 11.2.3.6 (AP operation during the CP) to deliver buffered BUs to the STA except that it may deliver multiple buffered BUs as defined here. A TWT responding STA may deliver multiple buffered BUs to a TWT requesting STA in PS mode during:

* An announced TWT SP, without following the rules regarding the number of buffered BUs to be delivered in 11.2.3.6 (AP operation during the CP) as long as the BU delivery does not exceed the duration of the TWT SP and the TWT requesting STA has indicated that it is awake for that TWT SP and as long as the TWT requesting STA has not entered the doze state (see 27.7.4.2 (TWT information for individual TWT) and 27.7.5 (Power save(#11955) operation during TWT SPs)).
* An unannounced TWT SP, without following the rules regarding the number of buffered BUs to be delivered in 11.2.3.6 (AP operation during the CP) if the BU delivery does not exceed the duration of the TWT SP and as long as the TWT requesting STA has not entered the doze state (see 27.7.4.2 (TWT information for individual TWT) and 27.7.5 (Power save(#11955) operation during TWT SPs)).

NOTE—The TWT responding STA can deliver the buffered BUs in an A-MPDU under a block ack agreement if the TWT is an announced TWT and the TWT requesting STA is awake for that TWT SP, or if the TWT is an unannounced TWT. The TWT responding STA can transmit frames to TWT requesting STA after the end of the TWT SP if the STA is in Active mode.

A TWT responding STA may transmit to a TWT requesting STA that is in Active mode at any time.

NOTE—A TWT requesting STA that is in the Active mode does not need to transmit a frame during an announced TWT SP to indicate that it is in the awake state.

* Broadcast TWT operation with TWT ID different than 0
* General

A TWT scheduling AP is an HE AP with dot11TWTOptionActivated equal to true that sets the Broadcast TWT Support field of the HE Capabilities element it transmits to 1 and that follows the rules in 27.7.3.2 (Rules for TWT scheduling AP), 27.14.2 (Power save with UORA), and 27.14.3 (Opportunistic power save).

A TWT scheduling AP may include a broadcast TWT element in the Beacon frame.

The TWT scheduling AP shall not include the broadcast TWT element in broadcast Probe Response frames unless both of the following conditions are met:

* The AP has dot11FILSOmitReplicateProbeResponses is equal to true
* The TWT Flow Identifier subfield is set to 2 and the AP has scheduled transmission of a Trigger frame with at least one RU with the AID12 subfield equal to 2045 during the next scheduled TWT SP

A TWT scheduling AP may include a TWT element with the Broadcast subfield equal to 1 within an Association Response frame or within a TWT setup frame to assign the recipient STA to a broadcast TWT schedule without having received a request from the STA to become a member of the broadcast TWT schedule.

The TWT scheduling AP shall not include a broadcast TWT element in FILS Discovery frames unless the TWT Flow Identifier subfield is set to 2 and the AP has scheduled transmission of a Trigger frame with at least one RU with the AID12 subfield set to 2045 during the next scheduled TWT SP.

An HE BSS belonging to a Multiple BSSID set (see 11.11.14 (Multiple BSSID set)) may advertise TWT element carried in the Management frames transmitted by the transmitted BSSID. An HE AP may include the TWT element in a Nontransmitted BSSID profile carried in the Multiple BSSID element (see 9.4.2.46 (Multiple BSSID element)) to provide different TWT parameter values for STAs associated with that nontransmitted BSSID.(#11339)

A non-AP HE STA shall obtain TWT parameter values from the most recently received TWT element carried in the Management frames of its associated AP. A non-AP HE STA with dot11MultiBSSIDActivated set to true and associated with a nontransmitting BSSID shall inherit the TWT parameter values from the TWT element when advertised by the transmitted BSSID if the element is not carried in the Nontransmitted BSSID Profile for that BSSID.(#11339)

A TWT scheduled STA is an non-AP HE STA that sets the Broadcast TWT Support field of the HE Capabilities element it transmits to 1 and receives a broadcast TWT element transmitted by an HE AP that is a TWT scheduling AP.

A TWT scheduled STA follows the schedule provided by the TWT scheduling AP as described in 27.7.3.3 (Rules for TWT scheduled STA), 27.14.2 (Power save with UORA), and 27.14.3 (Opportunistic power save). A TWT scheduled STA can negotiate the wake TBTT and wake interval for Beacon frames it intends to receive as described in 27.7.3.3 (Rules for TWT scheduled STA) or join a particular broadcast TWT as described below.

An example of broadcast TWT operation is shown in Figure 27-8 (Example of broadcast TWT operation), where the AP is the TWT scheduling AP and STA 1 and STA 2 are the TWT scheduled STAs.

|  |
| --- |
|  |
| * Example of broadcast TWT operation |

The TWT scheduling AP includes a broadcast TWT element in the Beacon frame that indicates a broadcast TWT at or after which the AP intends to send Trigger frames, or DL BUs to the TWT scheduled STAs. STA 1 and STA 2 wake to receive the Beacon determine the broadcast TWT. During the trigger-enabled TWT SP the AP sends a Trigger frame to which STA 1 and STA 2 indicate that they are awake during the TWT SP. STA 1 indicates that it is awake by sending a PS-Poll and STA 2 indicates that it is awake by sending a QoS Null frame in response to the Trigger frame. STA 1 and STA 2 receive their DL BUs in a subsequent exchange with the AP and go to doze state outside of this TWT SP.

Each broadcast TWT is uniquely identified by the <broadcast TWT ID, MAC address> tuple, where the broadcast TWT ID is the value of the Broadcast TWT ID subfield and is greater than 0 and the MAC address is the address of the TWT scheduling AP.

Broadcast TWT schedules are advertised by TWT scheduling APs in frames that carry TWT elements with the Broadcast subfield equal to 1 and the Wake TBTT Negotiation subfield equal to 0 as described in 27.7.3.2 (Rules for TWT scheduling AP).

Negotiations to join or leave a Broadcast TWT are performed with an exchange of frames that carry TWT elements with the Broadcast subfield equal to 1 and the Wake TBTT Negotiation subfield equal to 1 as described in 27.7.3.3 (Rules for TWT scheduled STA).

* Rules for TWT scheduling AP

A TWT scheduling AP may include(#11996) a broadcast TWT element in a Beacon frame that is scheduled at a TBTT (see 11.1.3.2 (Beacon generation in non-DMG infrastructure networks)). The TWT scheduling AP shall include one or more TWT parameter sets in the TWT element, and each TWT parameter set may indicate a periodic occurrence of TWTs. The TWT scheduling AP shall set the NDP Paging Indicator subfield to 0, the Broadcast subfield to 1, the Implicit subfield to 1, the Wake TBTT Negotiation subfield to 0 and the Responder PM Mode subfield to 0 in the TWT element (see 10.43.7 (TWT Sleep Setup)). Each TWT parameter set specifies the TWT parameters of a specific broadcast TWT that are valid within a broadcast TWT SP. Each specific broadcast TWT is identified as indicated in 27.7.3.1 (General). Individual STAs may have membership in broadcast TWTs as the result of negotiation with a TWT scheduling AP as described in 27.7.3.1 (General).

The TWT scheduling AP sets the TWT parameters of each TWT parameter set as described below.

The TWT scheduling AP shall set the TWT Request subfield to 0 and the TWT Setup Command subfield to Accept TWT, except that it may set the TWT Setup Command subfield to:

* Reject TWT when the periodic TWT is being terminated or,
* Alternate TWT when the periodic TWT is being modified

A TWT scheduling AP that sets the TWT Setup Command subfield to Reject TWT should indicate the TBTT at which the periodic broadcast TWT will be terminated by setting the value of the Broadcast TWT Persistence subfield equal to the number of beacon intervals during which the broadcast TWT will continue to exist, rounded up to the nearest integer and not counting the current beacon interval.

A TWT scheduling AP that sets the TWT Setup Command subfield to Alternate TWT should indicate the TBTT at which the periodic broadcast TWT parameter set will be modified by setting the value of the Broadcast TWT Persistence subfield equal to the number of beacon intervals during which the broadcast TWT will continue to operate with the current broadcast TWT parameter set, rounded up to the nearest integer and not counting the current beacon interval.

The TWT scheduling AP shall set the Trigger field to 1 to indicate a trigger-enabled TWT. Otherwise, it shall set the Trigger field to 0 (i.e., the TWT is not a trigger-enabled TWT).

The TWT scheduling AP shall schedule for transmission of a Trigger frame addressed to one or more TWT scheduled STAs during a trigger-enabled TWT SP. A TWT scheduling AP should not include the 12 LSBs of the STA's AID in a User Info field of a Trigger frame transmitted within a broadcast TWT SP unless the STA is in the awake state, has established membership in the broadcast TWT with that Broadcast TWT ID, or has indicated to receive the Beacon, as defined in 27.7.3.4 (Negotiation of wake TBTT and wake interval), preceding the beacon interval that contains this TWT SP.

The TWT scheduling AP that intends to transmit additional Trigger frames during a trigger-enabled TWT SP shall set the More TF subfield in the Common Info field(#11003) of the Trigger frame to 1 to indicate that it will transmit another Trigger frame within the same TWT SP. The TWT scheduling AP shall set the More TF subfield(#11003) to 0 when the Trigger frame is the last Trigger frame of the TWT SP or when the Trigger frame is sent outside of a trigger-enabled TWT SP.

NOTE 1—The TWT scheduling AP might not schedule for transmission of a Trigger frame for the TWT scheduled STA when the broadcast TWT is not a trigger-enabled TWT or when the TWT scheduled STA has sent an OM Control subfield(#14137) that has the UL MU disable bit equal to 1 (see 27.8 (Operating mode indication)).

NOTE 2—The Trigger frame can also be an UMRS Control subfield(#14137) contained in an MPDU carried in a DL MU PPDU, provided that the AP allocates enough resources in the HE TB PPDU for the STA to at least deliver its BSRs in response to the soliciting DL MU PPDU.

The TWT scheduling AP shall set the Flow Type field to 1 to indicate an unannounced TWT. Otherwise, it shall set the Flow Type field to 0 to indicate an announced TWT.

The TWT scheduling AP should schedule delivery of DL BUs during unannounced TWT SPs.

The TWT scheduling AP shall set the TWT Flow Identifier field according to Table 9.262kl (TWT Flow Identifier field for a broadcast TWT element).

A Trigger frame transmitted during a broadcast TWT SP whose TWT parameter set has the TWT Flow Identifier subfield equal to 0 or 3 may contain zero or more RA-RUs(#11033) (see 27.5.5 (UL OFDMA-based random access (UORA))). A Trigger frame transmitted during a broadcast TWT SP whose TWT parameter set has the TWT Flow Identifier subfield equal to 1 shall contain no RA-RU(#11033) (see 27.5.5 (UL OFDMA-based random access (UORA))). A Trigger frame transmitted during a broadcast TWT SP whose TWT parameter set has the TWT Flow Identifier subfield equal to 2 shall contain at least one RA-RU(#11033) (see 27.5.5 (UL OFDMA-based random access (UORA))). The TWT scheduling AP sends a TIM frame or FILS Discovery frame at the start of a broadcast TWT SP whose TWT parameter set has the TWT Flow Identifier subfield equal to 3 (see 27.14.3 (Opportunistic power save)).

The TWT scheduling AP shall set the TWT field to the TSF timer [4: 19] at which the first TWT is scheduled for this TWT parameter set.

The TWT scheduling AP shall include a nonzero value for the TWT wake interval in the TWT Wake Interval Exponent and TWT Wake Interval Mantissa fields for a periodic TWT and a zero value for an aperiodic TWT.

The TWT parameters are valid for each successive TWT of the periodic TWT or for the only TWT of the aperiodic TWT.

The TWT scheduling AP may include a non-zero value in the Broadcast TWT Persistence subfield for each Broadcast TWT to indicate the number of Beacon Intervals for which the Broadcast TWT schedule will be in existence, counting forward from the current TBTT. The AP may change the value of the Broadcast TWT Persistence subfield for any Broadcast TWT within any transmitted TWT element. If the AP reduces the value of the subfield, it shall not reduce the value by more than one as compared to the value transmitted during the immediately preceding beacon interval. If the AP increases the value of the Broadcast TWT Persistence subfield, it may increase the value by any amount as compared to the value transmitted during the immediately preceding beacon interval.

The TWT scheduling AP shall include a unique value in the Broadcast TWT ID subfield for each Broadcast TWT to allow identification of each Broadcast TWT.

The TWT scheduling AP may set the TWT Protection field to 1 to indicate that TXOPs within the TWT SP shall be initiated with a NAV protection mechanism defined in 10.3.2.4 (Setting and resetting the NAV), 27.2.5 (MU-RTS/CTS procedure), or CTS-to-self as described in 10.3.2.13 (NAV distribution); otherwise it shall set it to 0.

A TWT scheduling AP that receives a PS-Poll or a U-APSD trigger frame(#13320) or any other indication from a TWT scheduled STA that is in PS mode that the STA is in the awake state during an announced TWT SP shall follow the rules defined in 11.2.3.6 (AP operation during the CP) to deliver buffered BUs to the STA except that it may deliver multiple buffered BUs as defined here. A TWT scheduling AP that sends frames to a TWT scheduled STA that is in PS mode during an unannounced TWT SP shall follow the rules defined in 11.2.3.6 (AP operation during the CP) to deliver buffered BUs to the STA except that it may deliver multiple buffered BUs as defined here. A TWT scheduling AP may deliver multiple buffered BUs to the TWT scheduled STA during:

* An announced TWT SP, without following the rules regarding the number of buffered BUs to be delivered in 11.2.3.6 (AP operation during the CP) as long as the BU delivery does not exceed the duration of the TWT SP and the TWT scheduled STA has indicated to be awake for that TWT SP and as long as the TWT scheduled STA has not entered the doze state (see 27.7.4.2 (TWT information for individual TWT) and 27.7.5 (Power save(#11955) operation during TWT SPs)).
* An unannounced TWT SP, without following the rules regarding the number of buffered BUs to be delivered in 11.2.3.6 (AP operation during the CP) as long as the BU delivery does not exceed the duration of the TWT SP and as long as the TWT scheduled STA has not entered the doze state (see 27.7.4.2 (TWT information for individual TWT) and 27.7.5 (Power save(#11955) operation during TWT SPs)).

NOTE—The TWT scheduling AP can deliver the buffered BUs in an A-MPDU under a BlockAck agreement if the TWT is an announced TWT and the TWT scheduled STA is awake for that TWT SP, or if the TWT is an unannounced TWT. The TWT scheduling AP can exceed the duration of the TWT SP if the TWT scheduled STA is in Active mode.

A TWT scheduling AP may transmit to a TWT scheduled STA that is in Active mode at any time.

NOTE—A TWT scheduled STA that is in the Active mode does not need to transmit a frame during an announced TWT SP to indicate that it is in the awake state.

A TWT scheduling AP should indicate Alternate TWT or Reject TWT in the TWT Command Setup field of the broadcast TWT element for as many beacon intervals as needed to exceed the longest interval any STA is expected to not receive Beacon frames either when:

* The TWT parameters of a periodic TWT will change, or
* The periodic TWT specified by that TWT parameter set will be terminated.

A change in the TWT parameter set occurs in a subsequent Beacon frame that is indicated in the Broadcast TWT Persistence subfield.

A TWT scheduling AP that receives a TWT element with the TWT Request field equal to 1, the Broadcast field equal to 1, the Wake TBTT Negotiation field set to 1 and the TWT Command field set to Suggest or Demand may respond with a frame containing a TWT element as shown in Table 27-5 (Broadcast TWT membership exchanges)(#11842).

A TWT scheduling AP that receives a TWT element with the TWT Request field equal to 1, the Broadcast field equal to 1, the Wake TBTT Negotiation field set to 1 and the TWT Command field set to Reject shall delete the membership of the STA corresponding to the TA of the MMPDU that contained the TWT element from the broadcast TWT schedule that has the Broadcast TWT ID value that is equal to the value of the Broadcast TWT ID field of the TWT element.

NOTE—MMPDUs that contain a broadcast TWT element generated by a TWT scheduling AP can be Probe Response, Beacon, (Re)Association Response, and TWT Setup frames with TWT Request field equal to 0. The Wake TBTT Negotiation subfield is 0 if the TWT element is carried in a broadcast MMPDU and is 1 if the TWT element is carried in an individually addressed MMPDU. The TWT scheduling AP can include a TWT parameter set with Broadcast TWT ID greater than 0 to indicate a TWT intended to TWT scheduled STAs that are members of that broadcast TWT. Broadcast TWT ID value 0 is for all STAs and has a specific mode of operation defined in 27.7.3 (Broadcast TWT operation with TWT ID 0),

Valid broadcast TWT announcements are described in Table 27-4 (Broadcast TWT announcements).

|  |  |  |
| --- | --- | --- |
| * Broadcast TWT announcements | | |
| Initiating frame: TWT Setup Command field value within a TWT Setup frame transmitted from a first STA to a second STA, with Broadcast set to 1 and Wake TBTT Negotiation set to 1 | Response frame: TWT Setup Command field value within a TWT Setup frame transmitted from the second STA to the first STA with Broadcast set to 1 and Wake TBTT Negotiation set to 1 | Condition after the completion of the exchange |
| Accept TWT with an individual address in the RA field of the MPDU carrying the command | No frame transmitted | Only an HE AP is permitted to transmit this sequence. The STA receiving this frame is a member of the broadcast TWT identified by the initiating frame. A broadcast TWT schedule is either created or already exists and uses the TWT parameters identified in the initiating frame, including a broadcast TWT ID. The broadcast TWT schedule is identified by the broadcast TWT ID and the TA of the initiating frame. |
| Alternate TWT | No frame transmitted | When transmitted by a TWT scheduling AP, some of the parameters of the broadcast TWT schedule identified by the broadcast TWT ID and the TA of the initiating frame will change in the future. The new parameters will be present in the next frame transmitted by the TWT scheduling AP that has a broadcast TWT with the same broadcast TWT ID and same TA, but with the TWT command value set to Accept TWT. |
| Reject TWT | No frame transmitted | When transmitted by a TWT scheduling AP, the broadcast TWT schedule identified by the broadcast TWT ID and the TA of the initiating frame will be terminated in the future. The termination occurs when a Beacon is transmitted by the TWT scheduling AP that does not include a broadcast TWT with the same broadcast TWT ID and same TA as the initiating frame. |

* Rules for TWT scheduled STA

A TWT element with the Broadcast field equal to 1 is referred to as broadcast TWT element. A TWT scheduled STA that receives a broadcast TWT element in a Beacon frame shall follow the rules defined in this subclause to interact with the TWT scheduling AP.

A TWT scheduled STA should not transmit frames to the TWT scheduling AP outside of broadcast TWT SPs and within trigger-enabled TWT SPs.

A TWT scheduled STA may request to become a member of a broadcast TWT by transmitting a frame to its associated AP that contains a TWT element with the Broadcast subfield set to 1 and the Wake TBTT Negotiation set to 1 and the TWT command field set to Request TWT or Suggest TWT or Demand TWT. The TWT Parameter set indicates the Broadcast TWT ID of the broadcast TWT that the STA is requesting to join. See Table 27-5 (Broadcast TWT membership exchanges).

A TWT scheduled STA may terminate membership in a broadcast TWT by transmitting a frame to its associated AP that contains a TWT element with the Broadcast subfield set to 1 and the Wake TBTT Negotiation set to 1 and the TWT command field set to Reject TWT.

A TWT scheduled STA that receives a TWT element with the TWT Request field equal to 0, the Broadcast field equal to 1,the Wake TBTT Negotiation field equal to 1 and the TWT Command field equal to Accept TWT(#12093) is a member of the broadcast TWT identified by the <broadcast TWT ID, MAC address> tuple, where the broadcast TWT ID is the value of the Broadcast TWT ID subfield in the TWT element and the MAC address which is the TA of the MMPDU that contained the TWT element is equal to the MAC address of the AP with which the STA is associated, regardless of whether the TWT scheduled STA had previously transmitted a corresponding TWT element to the AP with the value Suggest TWT or Demand TWT in the TWT Command field.

Valid broadcast TWT membership exchanges are described in Table 27-5 (Broadcast TWT membership exchanges). In addition to the exchanges shown in Table 27-5 (Broadcast TWT membership exchanges), the TWT scheduling AP may respond to an initiating frame that solicits membership in a broadcast TWT schedule with an indication or solicitation of the establishment of an individual TWT agreement.

|  |  |  |
| --- | --- | --- |
| * Broadcast TWT membership exchanges | | |
| Initiating frame: TWT Setup Command field value within a TWT Setup frame transmitted from a first STA to a second STA, with Broadcast set to 1 and Wake TBTT Negotiation set to 1 | Response frame: TWT Setup Command field value within a TWT Setup frame transmitted from the second STA to the first STA with Broadcast set to 1 and Wake TBTT Negotiation set to 1 | Condition after the completion of the exchange |
| Demand TWT | Accept TWT | A broadcast TWT schedule exists or has been created with the TWT parameters indicated in the initiating frame and repeated in the responding frame. The STA transmitting the initiating frame is a member of the Broadcast TWT schedule identified by the Broadcast TWT ID and the TA of the response frame. |
| Request TWT or Suggest TWT | Accept TWT | A broadcast TWT schedule exists or has been created with the TWT parameters indicated in the response frame. The STA transmitting the initiating frame is a member of the broadcast TWT schedule identified by the broadcast TWT ID and the TA of the response frame. |
| Suggest TWT | Alternate TWT | No new broadcast TWT schedule has been created with the TWT parameters indicated in the initiating frame. The responder is offering an alternative set of parameters vs. those indicated in the initiating frame, as a means of negotiating TWT parameters with the requester. The TWT scheduled STA can send a new request with any set of TWT parameters and the TWT scheduling AP might create(#11845) a new broadcast TWT schedule using the parameters indicated in the responding frame. |
| Request TWT or Demand TWT | Alternate TWT | This response is not allowed. |
| Suggest TWT or Demand TWT | Dictate TWT | A broadcast TWT schedule is either created or already exists and is using the TWT parameters identified in the response frame, including a broadcast TWT ID. The TWT scheduling AP(#12094) will not create any new broadcast TWT schedule with the TWT scheduled STA at this time. The STA transmitting the initiating frame is not a member of the broadcast TWT schedule identified by the broadcast TWT ID and the TA of the response frame. |
| Request TWT or Suggest TWT or Demand TWT | Reject TWT | The STA transmitting the initiating frame is a not a member of a broadcast TWT identified by the broadcast TWT ID and the TA of the response frame, if such a broadcast TWT exists. |
| Accept TWT | No frame transmitted | Not permitted to be transmitted by a TWT scheduled STA.  When transmitted by a TWT scheduling AP, the recipient STA's membership in the broadcast TWT schedule identified by the broadcast TWT ID and the TA of the initiating frame is established. |
| Alternate TWT | No frame transmitted | Not permitted to be transmitted by a TWT scheduled STA or a TWT scheduling AP. |
| Reject TWT | No frame transmitted | When transmitted by a TWT scheduled STA, the transmitting STA's membership in the broadcast TWT schedule identified by the broadcast TWT ID and the RA of the initiating frame is terminated. |

NOTE 1—MMPDUs that contain a broadcast TWT element generated by a TWT scheduled STA can be (Re)Association Request, and TWT Setup frames with TWT Request field equal to 1. The TWT element has the Broadcast subfield set to 1 and the Wake TBTT Negotiation subfield equal to 1 and the Broadcast TWT ID(s) that the STA intends to join or withdraw.

A TWT scheduled STA that is in PS mode may enter the doze state after receiving a Beacon frame with a TWT element indicating the existence of a broadcast TWT and shall be in the awake state at the broadcast TWT start times which the STA has indicated it will be awake by either establishing a membership for the broadcast TWT with those broadcast TWT IDs, or by negotiating a wake TBTT and wake interval between Beacon frames that the STA receives, as defined in 27.7.3.4 (Negotiation of wake TBTT and wake interval), or has sent a PS-Poll or U-APSD trigger frame(#13319) or any other indication that it is in the awake state during that beacon interval.

A TWT scheduled STA that did not receive a beacon corresponding to a TBTT shall act as(#12240) if it had received the expected beacon containing a TWT element for a broadcast TWT, if the missed beacon corresponds to a TBTT that is within the next n Beacon Intervals beyond the most recently received Beacon that included a TWT element for that broadcast TWT, where n is equal to one plus the value of the Broadcast TWT Persistence subfield of the corresponding Broadcast TWT, except that n is infinite when the value of the subfield is 7. The value of the Broadcast TWT Persistence subfield is dynamic.

A TWT scheduled STA transmits an HE TB PPDU as a response to a Trigger frame that is intended for it and is sent during a trigger-enabled TWT SP (see 27.5.3 (UL MU operation)). A TWT scheduled STA that is in PS mode and is awake during an announced TWT SP shall include a PS-Poll frame or a U-APSD trigger frame(#13320) in the HE TB PPDU if it intends to solicit buffered BUs from the TWT scheduling AP (see 11.2.2.8 (Receive operation for STAs in PS mode during the CP)) unless the STA has already transmitted a PS-Poll or U-APSD trigger frame(#13320) or transmitted any other indication that the STA is in the awake state within that announced TWT SP.A TWT scheduled STA that is in PS mode shall transition to the awake state at the start of an unannounced TWT SP of which it is a member.

NOTE 2—A TWT scheduling AP sets the bit in the TIM element of the Beacon frame that corresponds to the AID of the TWT scheduled STA to 1 to indicate that it expects the TWT scheduled STA to solicit available buffered BUs (see 11.2.2.8 (Receive operation for STAs in PS mode during the CP)).

A TWT scheduled STA should only send frames that satisfy the TWT flow identifier recommendations defined in Table 9.248l1 (TWT Flow Identifier field for a broadcast TWT element) during the corresponding TWT SP(s). Frames sent as a response to a Trigger frame are subject to further restrictions as defined in 27.5.3 (UL MU operation).

* Negotiation of wake TBTT and wake interval

A TWT scheduled STA that intends to operate in power save mode (see 11.2.2.2 (STA Power Management modes)) may transmit a TWT request frame to the TWT scheduling AP that identifies the wake TBTT of the first Beacon frame and the wake interval between subsequent Beacon frames it intends to receive. The TWT request frame shall contain:

* The Wake TBTT Negotiation subfield equal to 1 and the TWT Command field to Suggest TWT or Demand TWT, the Broadcast subfield equal to 0, and
* The requested first wake TBTT in the Target Wake Time field,
* The requested wake interval between consecutive TBTTs in the TWT Wake Interval Mantissa and TWT Wake Interval Exponent fields.
* All other fields in the TWT element are reserved.

A TWT scheduling AP that receives a TWT request frame from a STA whose value of the Wake TBTT Negotiation subfield is 1 and Broadcast subfield is 0 shall respond with a TWT response frame that contains either Accept TWT or Reject TWT in the TWT Command field and, in the case of an Accept TWT, it shall also contain:

* The Wake TBTT Negotiation subfield equal to 1, the Broadcast subfield equal to 0, and
* The allocated first wake TBTT in the Target Wake Time field, and
* The allocated wake interval between consecutive TBTTs in the TWT Wake Interval Mantissa and TWT Wake Interval Exponent fields.
* All other fields in the TWT element are reserved.

After successfully completing the negotiation, the TWT scheduled STA may go to doze state until its TSF matches the next negotiated wake TBTT provided that the STA is in power save mode, and no other condition requires the STA to remain awake. The TWT scheduled STA shall be in the awake state to listen to Beacon frames transmitted at negotiated wake TBTTs and shall operate as described in 27.7.3.3 (Rules for TWT scheduled STA).

After receiving the Beacon frame at or after TBTT, the TWT scheduled STA may go to doze state until the next wake TBTT if no other condition requires the STA to remain awake. The TWT scheduled STA may go to doze state after AdjustedMinimumTWTWakeDuration time has elapsed from the TBTT start time if no Beacon frame is received.

Either STA that is a party to an established wake TBTT agreement can tear down the wake TBTT agreement by following the tear down procedure described in 10.43.8 (TWT Teardown) and by setting the Wake TBTT Negotiation subfield to 1 in the TWT Teardown frame.

Table 27-6 (Wake TBTT negotiation exchanges)(#12096) summarizes the interactions between devices that negotiate a Wake TBTT agreement.

|  |  |  |
| --- | --- | --- |
| * Wake TBTT negotiation exchanges | | |
| Initiating frame | Response frame |  |
| TWT Setup Command field value within a TWT Setup frame transmitted from a first STA to a second STA, with Broadcast set to 0 and Wake TBTT Negotiation set to 1 | TWT Setup Command field value within a TWT Setup frame transmitted from the second STA to the first STA with Broadcast set to 0 and Wake TBTT Negotiation set to 1 | Condition after the completion of the exchange |
| Request TWT | Accept TWT or Alternate TWT or Dictate TWT or Reject TWT or no response | This exchange is not allowed. |
| Demand TWT or Suggest TWT | Accept TWT | A Wake TBTT agreement has been created with the Wake TBTT parameters indicated in the initiating frame. |
| Demand TWT or Suggest TWT | Reject TWT | No Wake TBTT agreement has been created. |
| Demand TWT or Suggest TWT | Alternate TWT | No Wake TBTT agreement has been created. The responder is offering an alternative set of parameters vs. those indicated in the initiating frame. The TWT scheduled STA can send a new request with any set of Wake TBTT parameters and the responder might create a Wake TBTT agreement using those parameters. |
| Reject TWT | None | An existing Wake TBTT agreement between the initiator and the responder has been terminated. |

* Broadcast TWT operation with TWT ID 0
* General

An AP may include a broadcast TWT element with the TWT ID field set to 0. The TWT SP defined by the broadcast TWT element with the TWT ID field set to 0 is only used to define the period during which a specific frame is scheduled to be transmitted by the AP. The TWT Flow Idenfier field indicates which frame is scheduled for transmission. An AP that sends a Broadcast TWT with TWT ID 0 is not a TWT scheduling AP and the STAs that receive this TWT element are not scheduled STAs. There is therefore no negotiation process, no membership, and the rules defined in.27.7.3.3 (Rules for TWT scheduled STA), in 27.7.3.2 (Rules for TWT scheduling AP) and in 27.7.5 (Power save operation during TWT SPs) don’t apply. The rules defined in 27.7.3.1 (General) don’t apply either except for the following:

* An AP may include a broadcast TWT element with TWT ID field set to 0 in a Beacon frame, in a probe response or a (re)association response.
* An HE BSS belonging to a Multiple BSSID set (see 11.11.14 (Multiple BSSID set)) may advertise TWT element carried in the Management frames transmitted by the transmitted BSSID. An HE AP may include the TWT element in a Nontransmitted BSSID profile carried in the Multiple BSSID element (see 9.4.2.46 (Multiple BSSID element)) to provide different TWT parameter values for STAs associated with that nontransmitted BSSID.(#11339)
* A non-AP HE STA shall obtain TWT parameter values from the most recently received TWT element carried in the Management frames of its associated AP. A non-AP HE STA with dot11MultiBSSIDActivated set to true and associated with a nontransmitting BSSID shall inherit the TWT parameter values from the TWT element when advertised by the transmitted BSSID if the element is not carried in the Nontransmitted BSSID Profile for that BSSID.(#11339)

The AP shall set:

* The negotiation type subfield to 2 or 3
* The Broadcast TWT ID to 0
* the TWT field to the TSF timer [4: 19] at which the start of the TWT SP is scheduled for this TWT parameter set.
* The Nominal Minimum TWT Wake Duration is set to the duration of the TWT SP.
* the TWT wake interval in the TWT Wake Interval Exponent and TWT Wake Interval Mantissa fields to a non zero value for a periodic TWT.

The TWT Request, TWT Setup Command, Trigger, Implicit/Last Broadcast Parameter Set, Flow Type, TWT protection subfields of the Request Type field are reserved.

The TWT Flow Identifier describes the frame that should be sent by the AP during each periodic TWT SP.

* Use of TWT Information frames
* General

An HE STA may transmit a TWT Information frame to its peer STA during an individual TWT session, broadcast TWT session, or at any time as defined in 27.7.4.2 (TWT information for individual TWT), 27.7.4.3 (TWT information for broadcast TWT) and 27.7.4.4 (TWT information for flexible TWT), respectively.

The TWT Information frame shall have the Response Requested subfield equal to 0, the Next TWT Request subfield equal to 0, and one of the following:

* A nonzero value in the Next TWT subfield when the frame is transmitted by a TWT responding STA, a TWT scheduling AP, or by any HE STA to a peer STA that supports TWT.
* The value of the Next TWT shall be selected from existing TWT values for a TWT session if the Flexible TWT Schedule Support field of the peer STA is 0.
* The Next TWT may contain any nonzero value if Flexible TWT Schedule Support field of the peer STA is 1.
* A Next TWT subfield that is present when the frame is transmitted by a TWT requesting STA, a TWT scheduled STA, or any HE STA to a peer STA that supports TWT.
* The Next TWT indicates the TWT at which the TWT session is resumed and shall be selected from existing TWT values for that TWT session if the Flexible TWT Schedule Support field of the peer STA is 0.
* The Next TWT may contain any nonzero value if Flexible TWT Schedule Support field of the peer STA is 1.  
  NOTE—In such case, the TWT requesting STA or TWT scheduled STA or peer STA that transmitted the TWT Information frame preserves the PM mode from the time it sent the TWT Information frame to the time it is expected to wake up.
* A Next TWT subfield that is not present when the frame is transmitted by a TWT requesting STA or a TWT scheduled STA to indicate suspension of the TWT session.

The TWT Information frame may have the Broadcast Reschedule subfield set to 1 to indicate reschedule of all broadcast TWT sessions and a flexible TWT as defined below.

* TWT information for individual TWT

An HE STA that has an individual TWT agreement may transmit a TWT Information frame to the STA with which it has an agreement. The HE STA sets the fields of the TWT Information frame as defined in Table 27.7.4.1 (General).

A TWT requesting STA that receives a TWT Information frame follows the rules defined in 10.43.4 (Implicit TWT operation). A TWT requesting STA that receives an acknowledgment in response to a TWT Information frame that:

* Does not contain a Next TWT field shall consider that TWT session suspended, and can follow other individual TWT sessions, the procedure in 27.7.3 (Broadcast TWT operation), or the default PS procedure defined in 11.2 (Power management) until the TWT session is resumed.
* Contains a Next TWT field shall resume the corresponding TWT session, starting from the value indicated in the Next TWT field of the transmitted TWT Information frame.

NOTE—The TWT Flow Identifier, together with the MAC addresses of the TWT requesting STA and TWT Responding STA identifies the TWT agreement for which the TWT Information frame is sent (see 10.43.1 (TWT overview)).

A TWT requesting STA that is in PS mode and that transmits a TWT Information frame to a peer STA may transition to doze state after receiving the acknowledgment even if it has previously transmitted a PS-Poll or U-APSD trigger frame(#13321) and has not yet received the expected frames from the AP in response and shall resume TWT operation for the corresponding TWT session at the specified TWT indicated in the TWT Information frame. A TWT requesting STA that is in PS mode and that receives a TWT Information frame from a peer STA may go to doze state after transmitting the acknowledgment even if it has previously transmitted a PS-Poll or U-APSD trigger frame(#13322) and has not yet received the expected frames from the AP in response and shall resume TWT operation for the corresponding TWT session at the specified TWT indicated in the TWT Information frame.

* TWT information for broadcast TWT

The rules defined in this subclause don’t apply to broadcast TWT with TWT ID 0.

An HE STA that is a TWT scheduling AP may transmit a TWT Information frame to any of the members of a broadcast TWT schedule. An HE STA that is a TWT scheduled STA may transmit a TWT Information frame to the TWT scheduling AP corresponding to a broadcast TWT schedule established by that STA. The HE STA sets the fields of the TWT Information frame as defined in 27.7.4.1 (General).

A TWT scheduled STA that receives a TWT Information frame that contains a Broadcast Reschedule subfield equal to 1 follows the rules defined in 27.7.3.3 (Rules for TWT scheduled STA), except that it shall use the Next TWT value contained in the received TWT Information frame.

A TWT scheduled STA that receives an acknowledgment in response to a TWT Information frame that contains a Broadcast Reschedule subfield equal to 1 and:

* Does not contain a Next TWT field shall consider all broadcast TWT sessions suspended, and can follow the default PS procedure defined in 11.2 (Power management) until the TWT session is resumed.
* Does contain a Next TWT field shall resume all broadcast TWT sessions, starting from the value indicated in the Next TWT field of the transmitted TWT Information frame.

NOTE—TWT suspension and resumption as indicated by a TWT Information frame with the Broadcast Reschedule subfield equal to 1 applies to all broadcast TWT sessions of the TWT scheduling AP.

A TWT scheduled STA that is in PS mode and that transmits a TWT Information frame to a peer STA may transition to doze state after receiving the acknowledgment, even if it has previously transmitted a PS-Poll or U-APSD trigger frame(#13323) and has not yet received the expected frames from the TWT scheduling AP in response and shall resume TWT operation for the corresponding TWT session at the specified TWT indicated in the TWT Information frame. A TWT scheduled STA that is in PS mode and that receives a TWT Information frame from a TWT scheduling AP may transition to doze state after transmitting the acknowledgment, even if it has previously transmitted a PS-Poll or U-APSD trigger frame(#13324) and has not yet received the expected frames from the TWT scheduling AP in response and shall resume TWT operation for the corresponding TWT session at the specified TWT indicated in the TWT Information frame.

* TWT information for flexible TWT

An HE STA may transmit a TWT Information frame to its peer STA at any time (i.e., without participating in any TWT sessions) if the peer STA has set the Flexible TWT Schedule Support field of the HE Capabilities it transmits. An HE STA may transmit a TWT Information frame to a TWT scheduling AP. The HE STA sets the fields of the TWT Information frame as defined in 27.7.4.1 (General).

A non-AP HE STA that transmits a TWT Information frame with Broadcast Reschedule subfield equal to 1 to a peer STA may go to doze state after receiving the acknowledgment and shall be in the awake state at the specified TWT indicated in the TWT Information frame. A non-AP HE STA that receives a TWT Information frame with Broadcast Reschedule subfield equal to 1 from a peer STA may go to doze state after transmitting the acknowledgment and shall be in the awake state at the specified TWT indicated in the TWT Information frame.

* Power save(#11955) operation during TWT SPs

The following rules apply to TWT SPs for both broadcast TWT schedules and individual TWT agreements.

A TWT requesting STA that is not in PS mode and that transmits a frame with the Power Management subfield set to 1 during a TWT SP shall remain in the awake state until the AdjustedMinimumTWTWakeDuration time has elapsed from the TWT SP start time as identified by the TWT requesting STA or until a TWT SP termination event is detected, whichever occurs first.

A TWT requesting STA in PS mode that is awake for an individual TWT SP may transition to the doze state after AdjustedMinimumTWTWakeDuration time has elapsed from the TWT SP start time as identified by the TWT requesting STA even if it has previously transmitted a PS-Poll frame or U-APSD trigger frame(#Ed) and has not yet received the expected frames from the AP in response.

When a TWT SP termination event is detected within a TWT SP by a STA in PS mode that is participating in the TWT SP, the STA may transition to the doze state without waiting for the expiration of the AdjustedMinimumTWTWakeDuration time as described in 10.43.1 (TWT Overview), even if it has previously transmitted a PS-Poll frame or U-APSD trigger frame(#Ed) and has not yet received the expected frames from the AP in response.

A TWT requesting STA or TWT responding STA may terminate an individual TWT SP by transmitting a TWT Information frame as described in 27.7.4 (Use of TWT Information frames). A TWT scheduled STA or TWT scheduling AP may terminate its participation in a broadcast TWT SP by transmitting a TWT Information frame as described in 27.7.4 (Use of TWT Information frames).

In addition to a TWT Information frame that terminates a TWT SP, the following events also terminate a TWT SP:

* The transmission by the TWT requesting STA or TWT scheduled STA of an acknowledgment(#11208) in response to a frame sent by the TWT responding STA or TWT scheduling AP, respectively, that had the EOSP subfield equal to 1
* The transmission by the TWT requesting STA or TWT scheduled STA of an acknowledgment(#11208) in response to an individually addressed frame sent by the TWT responding STA or TWT scheduling AP, respectively with the More Data field equal to 0 when the frame does not contain an EOSP subfield
* The reception of a frame sent by the TWT responding STA or TWT scheduling AP that does not solicit an immediate response and that had an EOSP subfield present with a value equal to 1
* The reception of an individually addressed frame sent by the TWT responding STA or TWT scheduling AP that does not solicit an immediate response and that had no EOSP subfield present but had the More Data field equal to 0

The classification of a More Data field equal to 0 in an Ack, BlockAck and Multi-STA BlockAck frame as an event that terminates a TWT SP is only possible when both STAs have indicated support of transmitting or receiving the frame with a nonzero More Data subfield, which is indicated in the More Data Ack subfield of the QoS Info field of frames they transmit (see 11.2.2 (Power management in a non-DMG infrastructure network)).

NOTE 1—A STA participating in multiple TWT SPs which overlap in time stays in the awake state until the latest AdjustedMinimumTWTWakeDuration time of all of the TWT SPs expires, except that a TWT termination event causes all of the overlapping TWT SPs to terminate.

A TWT requesting STA or TWT scheduled STA in PS mode that is awake for an announced trigger-enabled TWT SP and did not transmit any indication that it is in the awake state to the TWT responding STA or TWT scheduling AP may transition to the doze state after the reception of a Trigger frame sent by the TWT responding STA or TWT scheduling AP with the More TF subfield(#11003) equal to 0 that is not intended for the TWT requesting STA or TWT scheduled STA. A TWT requesting STA or TWT scheduled STA in PS mode that is awake for an unannounced trigger-enabled TWT SP may transition to the doze state after the reception of a Trigger frame sent by the TWT responding STA or TWT scheduling AP with the More TF subfield(#11003) equal to 0 that is not intended for the TWT requesting STA or TWT scheduled STA.

NOTE 2—A Trigger frame, sent by the TWT scheduling AP, is defined as intended for the TWT scheduled STA when the Trigger frame contains the AID of the STA in one of its Per User Info fields (see 27.5.3 (UL MU operation)), and can have in the TA field the MAC address of the AP or the(#11036, #13794) transmitted BSSID under the conditions defined in 27.5.3.2.3 (Allowed settings of the Trigger frame fields and UMRS Control subfield(#14137)). Otherwise, the Trigger frame is not intended for the STA. If the Trigger frame contains one or more RA-RUs(#11033) for which the STA can gain access according to 27.5.5 (UL OFDMA-based random access (UORA)) then the STA can follow the rules defined in 27.14.2 (Power save with UORA) to determine an early TWT SP termination event.

***CID 12032***

***11ax Editor: Modify 9.4.2.6 TIM element as follows: (#12032)***

* TIM element

Change the 4th paragraph as follows:

The DTIM Count field indicates how many Beacon frames (including the current frame) appear before the next DTIM. A DTIM count of 0 indicates that the current TIM is a DTIM. The DTIM Count field is a single octet. When a TIM element is included in a TIM frame or FILS Discovery frame, the DTIM Count field is reserved.

Insert the following at the end of the subclause:

When included in OPS frames and FILS Discovery frames by an OPS AP the following apply:

* The DTIM Count field is reserved
* The DTIM Period field is reserved
* The bit number *N* in the traffic indication virtual bitmap that corresponds to an OPS STA with AID *N* is determined as follows:
* Bit number *N* in the traffic indication virtual bitmap is 0 if the OPS AP does not intend to transmit to the OPS STA including to trigger the OPS STA for an UL MU transmission during the TWT SP and before the next TWT SP.
* Otherwise, bit number *N* in the traffic indication virtual bitmap for the OPS STA is 1.
* The bit number *N* in the traffic indication virtual bitmap that corresponds to an non-OPS STA with AID *N* is determined as follows:

"Bit number *N* in the traffic indication virtual bitmap is 1 to indicate that AP has buffered frames for the STA and set to 0 otherwise.