IEEE P802.11  
Wireless LANs

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| 802.11-2012 resolutions for Power Management subfield | | | | |
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|  |  |  |  |  |

Abstract

This document proposes resolutions for CIDs 86, 89, 119, 120, 121 and 122 on 802.11-2012, regarding the Power Management subfield in the Frame Control field.

## Revision History

r0: Initial revision.

## Comments

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| 86 | Mark Hamilton | 8.2.4.1.7 (384.58) | Bufferable Management frames was intended (my opinion) to talk about frames that it made sense for an AP to buffer for a PS STA. We then mixed in allowing PM=1 only in bufferable management frames, but PM=1 is a STA tx concept, and those don't necessarily go together. For example, a DeAuth can be buffered - good. But a STA can send a DeAuth that enters PS mode? That seems wrong/odd/confusing. | Devise a better rule for which frames can set the PM subfield. These should be frames which can go from non-AP STA to AP, or to peer IBSS/MBSS STAs, and where power management mode change makes sense. Also, check P1008.30 (subclause 10.2.2.4), which restates this for the IBSS case - probably just delete this limitation here as it is redundant (or replace with text similar to 10.2.1.2's fourth paragraph). |
| 89 | Mark Hamilton | 8.2.4.1.7 (384.58) | Does PM bit apply to any/all Control frames (not sent by an AP)? | Clarify PM bit on Control frames, adding to the discussion for Management and Data frames. Note, 10.2.1.2 has discussion about requiring a frame exchange that includes and ACK or BlockAck, so Control frames (today) probably can't do PM set, but that could change out from under this text (look out for TGai!) |
| 119 | Mark RISON |  | The concepts "MMDU is bufferable" and "PM bit is reserved" need to be separated. It makes no sense to say that an Action MMDU sent by a non-AP STA is bufferable, for example, just because you want to be able to say that the PM is valid in the MPDUs used to send it | Bufferability should only pertain to MMDUs sent by APs or IBSS STAs, not non-AP STAs. Separately, the MPDUs in which the PM bit is valid should be enumerated (being clear that the PM bit in PS-Polls, for example, is not valid, and also that the PM bit in the ACK sent after a data frame sent in immediate response to a PS-Poll isn't not valid either) |
| 120 | Mark RISON |  | The exception for the PM bit in Probe Responses sent in response to unicast Probe Requests in an IBSS makes no sense | Get rid of this special case (in 3.2, 8.2.4.1.7 and 10.2.2.4) |
| 121 | Mark RISON |  | It's not clear enough which Control MPDUs have non-reserved PM bits and when. Note for example that 8.2.4.1.7 implies the PM bit in ACKs sent by a non-AP STA are not reserved | Make it clear |
| 122 | Mark RISON |  | It's not clear enough what the meaning of the PM bit in an MPDU for which this bit is reserved is. Is it "must be 0 on tx and therefore indicates active mode" or is it "must be 0 on tx and must be ignored on rx such that the power management mode is unchanged"? | Make it clear |

## Discussion

The commenters are right.

We should clearly define which frames the Power Management subfield is significant in and which it is not (we can’t say “reserved” because existing implementations may be setting the PM subfield in those frames). We should make these rules as simple as possible, to maximise the chances that implementations will actually get it right. We should make it clear that the PM mode is a matter of perspective for each receiver separately. We should not tie the rules to the frames which are used for bufferable units.

This is best achieved by saying that the PM subfield is significant only in:

* unicast MPDUs of Type Management and Subtype Action, – but see below
* unicast MPDUs of Type Data and Subtype not one of the QoS ones (including Null), and
* MPDUs of Type Data and Subtype one of the QoS ones (including QoS Null) and with Ack Policy Normal Ack/Implicit BAR (these are necessarily unicast) – not sure about PSMP Ack

that are sent by:

* a non-AP STA to the AP with which it is associated (from the perspective of the AP)
* an IBSS STA to another STA in the IBSS (from the perspective of all the IBSS STAs)
* a TDLS (but not DLS) STA to a peer TDLS STA with which it has established a DL (from the perspective of the peer TDLS STA)
  + Note that TDLS STAs do not exchange any Management MPDUs after the DL has been established, so only the Type Data rules apply – does TDLS require QoS too?
* not sure about mesh – it seems to have its own set of completely different rules!

and is not significant (so shall be ignored by the receiver and shall not cause the STA's PM mode to be considered to have changed from the perspective of the receiver) in any other MPDUs, including:

* all MPDUs of Type Control, e.g. RTS/CTS and BAR/BA
* all MPDUs sent by an AP
* all MPDUs which are not acked
* all MPDUs sent by a STA to an AP with which it is not associated
* all MPDUs sent by a STA to a non-AP infrastructure STA with which it does not have a DL
* all group-addressed MPDUs (including e.g. group-addressed Probe Requests)
* unicast Probe Requests not addressed to the receiver and (from the perspective of IBSS STAs only) not addressed to an IBSS STA (including e.g. those sent to a peer TDLS STA, from the perspective of the AP the sending non-AP STA is associated with)

Are Action frames always PM-significant? Things like this suggest that in some contexts only MPDUs of type Data carry a significant PM subfield:

**13.14.3.1 General**

When a mesh STA is in active mode for a mesh peering, it shall set the Power Management subfield in the

Frame Control field to 0 in all individually addressed Mesh Data or QoS Null frames transmitted to the

corresponding peer mesh STA.

## Proposed changes

The changes are relative to D0.3. The changes are shown using Word change tracking (it may be worth not showing formatting changes, if Word is being more stupid than it usually is). Select “Final Showing Markup” or “Final” as appropriate. Editorial instructions are shown using bold italics; those with “Editor:” prefix are to be effected by the editor before the next draft; those without are to be given as-is in the draft. Any Word comments should be ignored when merging the proposed changes in.

TBD – for now just capturing all references to the power management bit/field/subfield and canonicalising all except those in 8.2.4.1.7 to “Power Management subfield in the Frame Control field”

* Frame formats
* MAC frame formats
* Frame fields
* Frame Control field
* General

The Frame Control field consists of the following subfields: Protocol Version, Type, Subtype, To DS, From DS, More Fragments, Retry, Power Management, More Data, Protected Frame, and Order. The format of the Frame Control field is illustrated in Frame Control field.

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | B0     B1 | B2   B3 | B4      B7 | B8 | B9 | B10 | B11 | B12 | B13 | B14 | B15 |
|  | Protocol  Version | Type | Subtype | To DS | From DS | More  Fragments | Retry | Power  Management | More Data | Protected Frame | Order |
| Bits: | 2 | 2 | 4 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| * Frame Control field | | | | | | | | | | | |

* Power Management field

The Power Management field is 1 bit in length and is used to indicate the power management mode of a STA. The value of this field is either reserved (as defined below) or remains constant in each frame from a particular STA within a frame exchange sequence (see Annex G). The value indicates the mode of the STA after the successful completion of the frame exchange sequence.

In an infrastructure BSS, the following applies:

* The Power Management field is reserved in all management frames that are not bufferable management frames.
* The Power Management field is reserved in all management frames transmitted by a STA to an AP with which it is not associated.
* The Power Management field is reserved in all frames transmitted by the AP.
* Otherwise, a value of 1 indicates that the STA will be in PS mode. A value of 0 indicates that the STA will be in active mode.

In an IBSS, the following applies:

* The Power Management field is reserved in all management frames that are not bufferable management frames and that are not individually addressed Probe Request frames.
* Otherwise, a value of 1 indicates that the STA will be in PS mode. A value of 0 indicates that the STA will be in active mode.

In an MBSS, the following applies:

* A value of 0 in group addressed frames, in management frames transmitted to nonpeer STAs, and in Probe Response frames indicates that the mesh STA will be in active mode towards all neighbor mesh STAs. A value of 1 in group addressed frames, in management frames transmitted to nonpeer STAs, and in Probe Response frames indicates that the mesh STA will be in deep sleep mode towards all nonpeer mesh power STAs.
* A value of 0 in individually addressed frames transmitted to a peer mesh STA indicates that the mesh STA will be in active mode towards this peer mesh STA A value of 1 in individually addressed frames transmitted to a peer mesh STA, except Probe Response frames, indicates that the mesh STA will be in either light sleep mode or deep sleep mode towards this peer mesh STA. When the QoS Control field is present in the frame, the Mesh Power Save Level subfield in the QoS Control field indicates whether the mesh STA will be in light sleep mode or in deep sleep mode for the recipient mesh STA as specified in Mesh Power Save Level subfield.

The mesh power mode transition rules are described in 13.14.3 (Mesh power mode indications and transitions).

* QoS Control field
* Mesh Power Save Level subfield

The Mesh Power Save Level subfield is 1 bit in length and indicates whether the mesh STA’s peer-specific mesh power mode will be deep sleep mode or light sleep mode after the successful completion of the frame exchange sequence.

When the Power Management subfield in the Frame Control field in the frame is 1, the following applies:

In individually addressed Mesh Data frames, a value of 0 indicates that the mesh STA’s peer-specific mesh power mode for the recipient mesh STA will be light sleep mode (see 13.14.8.4 (Operation in light sleep mode for a mesh peering)). In individually addressed Mesh Data frames, a value of 1 indicates that the mesh STA’s peer-specific mesh power mode for the recipient mesh STA will be deep sleep mode (see 13.14.8.5 (Operation in deep sleep mode for a mesh peering)).

In group addressed Mesh Data frames, a value of 0 indicates that none of the peer-specific mesh power modes of the mesh STA will be deep sleep mode. In group addressed Mesh Data frames, a value of 1 indicates that at least one of the peer-specific mesh power modes of the mesh STA is deep sleep mode.

The Mesh Power Save Level subfield is reserved if the Power Management subfield in the Frame Control field is 0.

* Format of individual frame types
* Control frames
* Format of control frames

In the following descriptions, “immediately previous” frame means a frame whose reception concluded within the SIFS interval preceding the start of the current frame.

The subfields within the Frame Control field of control frames are set as illustrated in Frame Control field subfield values within control frames.

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | B0     B1 | B2     B3 | B4     B7 | B8 | B9 | B10 | B11 | B12 | B13 | B13 | B15 |
|  | Protocol Version | Type (Control) | Subtype | To DS (0) | From DS (0) | More Frag (0) | Retry (0) | Power Management | More Data (0) | Protected Frame (0) | Order (0) |
| Bits: | 2 | 2 | 4 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| * Frame Control field subfield values within control frames | | | | | | | | | | | |

* Management frame body components
* Information elements
* Mesh Capability

The Mesh Capability field comprises a set of values indicating whether a mesh STA is a possible candidate for mesh peering establishment. The details of the Mesh Capability field are shown in Mesh Capability field.

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | B0 | B1 | B2 | B3 | B4 | B5 | B6 | B7 |
|  | Accepting Additional Mesh Peerings | MCCA Supported | MCCA Enabled | Forwarding | MBCA Enabled | TBTT Adjusting | Mesh Power Save Level | Reserved |
| Bits: | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| * Mesh Capability field | | | | | | | | |

The Accepting Additional Mesh Peerings subfield is set to 1 if the mesh STA is willing to establish additional mesh peerings with other mesh STAs and set to 0 otherwise (i.e., the Accepting Additional Mesh Peerings subfield is set in accordance with dot11MeshAcceptingAdditionalPeerings). When the Mesh Configuration element is included in the Mesh Peering Open frame and in the Mesh Peering Confirm frame, the Accepting Additional Mesh Peerings subfield is set to 1.

The MCCA Supported subfield is set to 1 if the mesh STA implements MCCA and set to 0 otherwise (i.e., the MCCA Supported subfield is set in accordance with dot11MCCAImplemented).

The MCCA Enabled subfield is set to 1 if the mesh STA is using the MCCA and set to 0 otherwise (i.e., the MCCA Enabled subfield is set in accordance with dot11MCCAActivated).

The Forwarding subfield is set to 1 if the mesh STA forwards MSDUs and set to 0 otherwise (i.e., the Forwarding subfield is set in accordance with dot11MeshForwarding).

The MBCA Enabled subfield is set to 1 if the mesh STA is using MBCA, and is set to 0 otherwise (i.e., the MBCA Enabled subfield is set in accordance with dot11MBCAActivated). (See 13.13.4 (Mesh beacon collision avoidance (MBCA)).)

The TBTT Adjusting subfield is set to 1 while the TBTT adjustment procedure is ongoing, and is set to 0 otherwise. (See 13.13.4.4.3 (TBTT scanning and adjustment procedures).)

The Mesh Power Save Level subfield is set to 1 if at least one of the peer-specific mesh power modes is deep sleep mode and set to 0 otherwise. The Mesh Power Save Level subfield is reserved when the Power Management subfield in the Frame Control field is set to 0. See 8.2.4.5.11 (Mesh Power Save Level subfield).

* MLME
* Power management
* Power management in an infrastructure network
* General

STAs changing Power Management mode shall inform the AP of this fact using the Power Management subfield in the Frame Control field of transmitted frames. A STA shall remain in its current Power Management mode until it informs the AP of a Power Management mode change via a frame exchange that includes an acknowledgment from the AP. Power Management mode shall not change during any single frame exchange sequence, as described in Annex G.

NOTE—This means the Power Management subfield in the Frame Control field is the same for all MPDUs in an A-MPDU.

The AP shall buffer individually addressed BUs addressed to STAs operating in a PS mode. These buffered BUs shall be transmitted only at designated times.

If any STA in its BSS is in PS mode, the AP shall buffer all non-GCR-SP(11aa) group addressed BUs and deliver them to all STAs immediately following the next Beacon frame containing a DTIM transmission.

The STAs that currently have buffered BUs within the AP are identified in a TIM, which shall be included as an element within all Beacon frames generated by the AP. A STA shall determine that a BU is buffered for it by receiving and interpreting a TIM.

STAs operating in PS modes shall periodically listen for Beacon frames, as determined by the STA's ListenInterval and the ReceiveDTIMs parameter in the MLME-POWERMGT.request primitive.

In a BSS operating under the DCF, or during the CP of a BSS using the PCF, upon determining that a BU is currently buffered in the AP, a STA operating in the PS mode shall transmit a short PS-Poll frame to the AP, which shall respond with the corresponding buffered BU immediately, or acknowledge the PS-Poll and respond with the corresponding BU at a later time. If the TIM indicating the buffered BU is sent during a CFP, a CF-Pollable STA operating in the PS mode does not send a PS-Poll frame, but remains active until the buffered BU is received (or the CFP ends).

A non-AP QoS STA may be in PS mode before the setup of DLS or Block Ack. Once DLS is set up, both of the QoS STAs associated with a DLS link suspend the PS mode and shall be awake. When a STA enters normal (non-APSD) PS mode, any downlink Block Ack agreement without an associated schedule is suspended for the duration of this PS mode. BUs for a TID without a schedule are sent using Normal Ack following a PS-poll as described in rest of Power management in an infrastructure network. Uplink Block Ack, Block Acks for any TID with a schedule, and any Block Acks to APSD STA continue to operate normally.

A STA may use both WNM-Sleep mode and PS mode simultaneously.

* STA Power Management modes

A STA may be in one of two different power states:

* *Awake:* STA is fully powered.
* *Doze:* STA is not able to transmit or receive and consumes very low power.

The manner in which a STA transitions between these two power states shall be determined by the STA’s Power Management mode and reflected in dot11PowerManagementMode. These modes are summarized in Power Management modes.

|  |  |
| --- | --- |
| * Power Management modes | |
| Active mode or AM | STA may receive frames at any time. In Active mode, a STA shall be in the Awake state. A STA on the polling list of a PCF shall be in Active mode for the duration of the CFP. |
| PS | STA listens to selected Beacon frames (based upon the ListenInterval parameter of the MLME-ASSOCIATE.request or MLME-REASSOCIATE.request primitive) and sends PS-Poll frames to the AP if the TIM element in the most recent Beacon frame indicates an individually addressed BU is buffered for that STA.  The AP shall transmit buffered individually addressed BUs to a PS STA only in response to a PS-Poll from that STA, during the CFP in the case of a CF-Pollable PS STA,(11aa) during a scheduled or unscheduled APSD service period for the STA, or during the SP of a scheduled GCR-SP.(11aa) In PS mode, a STA shall be in the Doze state and shall enter the Awake state to receive selected Beacon frames, to receive group addressed transmissions following certain received Beacon frames, to receive transmissions during the SP of a scheduled GCR-SP,(11aa) to transmit, and to await responses to transmitted PS-Poll frames or (for CF-Pollable STAs) to receive CF transmissions of buffered BUs. |

The Power Management mode of a STA is selected by the PowerManagementMode parameter of the MLME-POWERMGT.request primitive. Once the STA updates its Power Management mode, the MLME shall issue an MLME-POWERMGT.confirm primitive indicating the success of the operation.

To change Power Management modes, a STA shall inform the AP through a successful frame exchange as described in Annex G initiated by the STA and that includes an ACK frame or a BlockAck frame from the AP. The Power Management subfield(s) in the Frame Control field of the frame(s) sent by the STA in this exchange indicates the Power Management mode that the STA shall adopt upon successful completion of the entire frame exchange, except where it is reserved (see 8.2.4.1.7 (Power Management field)). The Power Management subfield in the Frame Control field shall be ignored in frame exchanges initiated by the AP. A non-AP STA shall not change power management mode using a frame exchange that does not receive an ACK or BlockAck from the AP, or using a BlockAckReq frame.

NOTE—A PS-Poll frame exchange does not necessarily result in an ACK from the AP, so a non-AP STA cannot change power management mode using a PS-Poll frame.

A STA that is changing from Doze to Awake in order to transmit shall perform CCA until a frame sequence is detected by which it can correctly set its NAV, or until a period of time equal to the ProbeDelay has -transpired.

* AP TIM transmissions

The TIM shall identify the STAs for which traffic is pending and buffered in the AP. This information is coded in a *partial virtual bitmap*, as described in 8.4.2.7 (TIM element). In addition, the TIM contains an indication whether group addressed traffic is pending. Every STA is assigned an AID by the AP as part of the association process. AID 0 (zero) is reserved to indicate the presence of buffered non-GCR-SP(11aa) group addressed BUs. The AP shall identify those STAs for which it is prepared to deliver buffered BUs by set-ting bits in the TIM’s partial virtual bitmap that correspond to the appropriate AIDs.

* TIM types

Two different TIM types are distinguished: TIM and DTIM. After a DTIM, the AP shall transmit buffered non-GCR-SP(11aa) group addressed BUs, before transmitting any individually addressed frames.

The AP shall transmit a TIM with every Beacon frame. Every dot11DTIMPeriod, a TIM of type *DTIM* is transmitted within a Beacon frame, rather than an ordinary TIM.

**Error! Reference source not found.** illustrates the AP and STA activity under the assumptions that no PCF is operating and that a DTIM is transmitted once every three TIMs. The top line in **Error! Reference source not found.** represents the time axis, with the beacon interval shown together with a DTIM Interval of three beacon intervals. The second line depicts AP activity. The AP schedules Beacon frames for transmission every beacon interval, but the Beacon frames may be delayed if there is traffic at the TBTT. This is indicated as “busy medium” on the second line. For the purposes of this figure, the important fact about Beacon frames is that they contain TIMs, some of which are DTIMs. Note that the second STA with ReceiveDTIMs equal to false does not power-on its receiver for all DTIMs.

The third and fourth lines in **Error! Reference source not found.** depict the activity of two STAs operating with different power management requirements. Both STAs power-on their receivers when they need to listen for a TIM. This is indicated as a ramp-up of the receiver power prior to the TBTT. The first STA, for example, powers up its receiver and receives a TIM in the first Beacon frame; that TIM indicates the presence of a buffered BU for the receiving STA. The receiving STA then generates a PS-Poll frame, which elicits the transmission of the buffered BU from the AP. Non-GCR-SP(11aa) group addressed BUs are sent by the AP subsequent to the transmission of a Beacon frame containing a DTIM. The DTIM is indicated by the DTIM count field of the TIM element having a value of 0.

* Power management with APSD
* Power Management with APSD procedures

QoS APs capable of supporting automatic power save delivery (APSD) shall signal this capability through the use of the APSD subfield in the Capability Information field in Beacon, Probe Response, and (Re)Association Response management frames.

QoS STAs use the Power Management subfield in the Frame Control field of a frame to indicate whether it is in active or PS mode. As APSD is a mechanism for the delivery of downlink data and bufferable management frames to power-saving STAs, the frames transmitted by a STA in PS mode that is using APSD have the Power Management subfield in the Frame Control field set to 1, thereby causing buffering to take place at the AP.

APSD defines two delivery mechanisms, namely *unscheduled APSD* (U-APSD) and *scheduled APSD* (S‑APSD). STAs may use U-APSD to have some or all of their BUs delivered during unscheduled SPs. STAs may use S-APSD to schedule delivery of some or all of their BUs during scheduled SPs.

If there is no unscheduled SP in progress, the unscheduled SP begins when the AP receives a trigger frame from a STA, which is a QoS data or QoS Null frame using an AC the STA has configured to be trigger-enabled. An A-MPDU that contains one or more trigger frames acts as a trigger frame. An unscheduled SP ends after the AP has attempted to transmit at least one BU using a delivery-enabled AC and destined for the STA, but no more than the number indicated in the Max SP Length field of the QoS Capability element of the STA’s (Re)Association Request frame if the field has a nonzero value. By setting the EOSP field to 1 in the last frame sent during the SP, an unscheduled SP may be terminated before the maximum number of BUs in the SP has been reached.(11aa)

In order to configure an AP to deliver BUs during an unscheduled SP, a STA designates one or more of its ACs to be delivery-enabled and one or more of its AC to be trigger-enabled. A STA may configure an AP to use U-APSD using two methods. First, the STA may set individual U-APSD Flag bits in the QoS Info subfield of the QoS Capability element carried in (Re)Association Request frames. When a U-APSD Flag bit is 1, it indicates that the corresponding AC is both delivery- and trigger-enabled. When all four U-APSD Flag subfields are equal to 1 in (Re)Association Request frames, all the ACs associated with the STA are trigger- and delivery-enabled during (re)association. When all four U-APSD Flag subfields are equal to 0 in (Re)Association Request frames, none of the ACs associated with the STA is trigger- or delivery-enabled during (re)association.

NOTE—Bufferable MMPDUs are transmitted using AC\_VO. Thus the AC of an MMPDU is, by definition, AC\_VO.

Alternatively, the STA may designate one or more AC as trigger-enabled and one or more AC as delivery-enabled by sending an ADDTS Request frame per AC to the AP with the APSD subfield set to 1 and the Schedule subfield set to 0 in the TS Info field in the TSPEC element. APSD settings in a TSPEC request take precedence over the static U-APSD settings carried in the QoS Capability element. In other words, a TSPEC request overwrites any previous U-APSD setting of an AC. The request may be sent for ACs for which the ACM subfield is 0.

A STA may set an AC to be trigger- or delivery-enabled for its own use by setting up TSPECs with the APSD subfield set to 1 and the Schedule subfield set to 0 in the uplink or downlink direction, respectively. An uplink TSPEC plus a downlink TSPEC, or a bidirectional TSPEC with the APSD subfield equal to 1 and the Schedule subfield equal to 0, makes an AC both trigger- and delivery-enabled. An uplink TSPEC plus a downlink TSPEC, or a bidirectional TSPEC with the APSD and the Schedule subfields both equal to 0, makes an AC neither trigger- nor delivery-enabled.

* Change of article a->the in “If the SI is nonzero, the(11aa) STA” is wrong because there is no clear antecedent. Oh, and congratulations on making an already overlong para even overlonger :0).

A scheduled SP starts at fixed intervals of time specified in the Service Interval field. If the scheduled Service Interval field equals 0 (for example, with the GCR-A delivery method), the scheduled SP starts from the service start time without a fixed delivery interval.(11aa) In order to use a scheduled SP for a TS when the access policy is controlled channel access, a STA shall send an ADDTS Request frame to the AP with the APSD subfield of the TS Info field in the TSPEC element set to 1. To use a scheduled SP for a TS for a AC when the access policy is contention-based channel access, a STA shall send an ADDTS Request frame to the AP with the APSD and Schedule subfields of the TS Info field in the TSPEC element both set to 1. If the APSD mechanism is supported by the AP and the AP accepts the corresponding ADDTS Request frame from the STA, the AP shall respond to the ADDTS Request frame with a response containing the Schedule element indicating that the requested service can be accommodated by the AP. When the access policy is contention-based channel access for a GCR group addressed stream, a scheduled SP is set up according to **Error! Reference source not found.**.(11aa) The first scheduled SP starts when the lower order 4 octets of the TSF timer equals the value specified in the Service Start Time field. If the SI is nonzero, the(11aa) STA using scheduled SP shall first wake up at the service start time(11aa) to receive downlink individually addressed and/or GCR-SP group addressed(11aa) BUs buffered and/or to receive(11aa) polls from the AP/HC. If the SI is nonzero,(11aa) the STA shall wake up subsequently at a fixed time interval equal to the SI. The AP may modify the non-GCR(11aa) service start time by indicating so in the Schedule element in a successful ADDTS Response frame (which is sent in response to an ADDTS Request frame) and in Schedule frames (which are sent at other times). The AP may modify the GCR service start time by indicating so in the Schedule element in the GCR Response subelements (see 8.4.2.91 (DMS Response element) and **Error! Reference source not found.**). In both non-GCR and GCR cases, the service start time shall be updated (using the previously described service start time modification procedures) whenever the upper 4 octets of the TSF timer change.(11aa)

A scheduled SP begins at the scheduled wakeup time that corresponds to the SI and the service start time indicated in the Schedule element sent in response to a TSPEC or GCR Request.(11aa) If the SI is nonzero,(11aa) the STA shall wake up at a subsequent time when

(TSF – service start time) mod minimum SI = 0.

If the SI is nonzero, a scheduled SP for a GCR group ends after the AP has attempted to transmit at least one BU associated with the GCR group but no more than the number indicated in the Max SP Length field of the QoS Capability element of the STA’s (Re)Association Request frame. The last frame of the GCR SP shall have the EOSP field set to 1.(11aa)

* “frames individually addressed” is a curious construction.

If a scheduled SP overlaps the period during which the AP is required to transmit non-GCR-SP group addressed frames and frames individually addressed to STAs in PS mode that follow a DTIM beacon that has at least 1 bit set to 1 in the partial virtual bitmap of its TIM, the scheduled SP shall be deferred until the AP has transmitted all such buffered frames.(11aa)

When the GCR-A delivery method is used, the scheduled Service Interval field is 0. If a STA has a GCR agreement with an AP for a group address using the GCR-A delivery method, there is no defined end of the scheduled SP. The STA in PS mode shall enter the Awake state and shall remain awake in order to receive the buffered group addressed BUs until the AP changes the delivery method of the stream to a method other than GCR-A or until the GCR agreement is cancelled.(11aa)

* There is no antecedent for “the non-GCR ... flows” below.

If scheduled SPs(11aa) are supported in a BSS, a STA may use both unscheduled and scheduled APSD on different ACs at the same time. The GCR-SP delivery method may be used on any AC, irrespective of the non-GCR unscheduled or scheduled APSD flows.(11aa) When a STA establishes scheduled delivery for an AC the AP shall not transmit BUs using that AC during an SP that is initiated by a trigger frame, and it shall not treat BUs using the AC that are received from the STA as trigger frames. The AP shall decline any ADDTS Request frame that indicates the use of both scheduled and unscheduled APSD to be used on non-GCR-SP frames of(11aa) the same AC at the same time.

APSD shall be used only to deliver individually addressed BUs and GCR-SP BUs to a STA. Non-GCR and non-GCR-SP(11aa) group addressed BU delivery shall follow the frame delivery rules defined for group addressed BUs as defined in AP operation during the CFP.

* U-APSD Coexistence

A non-AP STA that uses U-APSD may not be able to receive all AP transmitted frames during the service period due to interference observed at the non-AP STA. Although the AP may not observe the same interference, it is able to determine that the frames were not received correctly by the non-AP STA. The U-APSD Coexistence capability enables the non-AP STA to indicate a requested transmission duration to the AP for use during U-APSD service periods. Use of the transmission duration enables the AP to transmit frames during the service period and improve the likelihood that the non-AP STA receives the frames when the non-AP STA is experiencing interference. The U-APSD Coexistence capability reduces the likelihood that the AP transmits frames during the service period that are not received successfully.

A STA that has a value of true for dot11MgmtOptionUAPSDCoexistenceActivated is defined as a STA that supports U-APSD Coexistence. A STA for which dot11MgmtOptionUAPSDCoexistenceActivated is true shall set the U-APSD Coexistence field of the Extended Capabilities element to 1, set to 0 otherwise.

A non-AP STA that is associated to an AP where both have previously advertised support for the U-APSD Coexistence capability may transmit ADDTS Request frames including the U-APSD Coexistence element to the AP.

The content of the ADDTS Request frame excluding the U-APSD Coexistence element is referred to in subsequent text as the Base ADDTS Request. Upon successful reception of the ADDTS Request frame, the AP shall process the content of the Base ADDTS Request frame as described in Power management with APSD. If the AP determines that the Base ADDTS Request cannot be granted it shall respond as described in Power management with APSD, without processing the U-APSD Coexistence element. If the AP determines the Base ADDTS Request can be granted, it shall process the U-APSD Coexistence element. If the AP supports transmission of frames during the U-APSD service period for the duration value specified in the U-APSD Coexistence element Interval/Duration field, it shall grant the ADDTS Request as described in Power management with APSD. Otherwise, it shall deny the ADDTS Request.

If the AP has previously granted an ADDTS Request with U-APSD Coexistence, a non-AP STA that continues using QoS services provided by an ADDTS Request frame without U-APSD coexistence may terminate the use of U-APSD Coexistence by transmitting an ADDTS Request frame without the U-APSD Coexistence element. If the non-AP STA wants to terminate use of all QoS services provided by an ADDTS Request frame including U-APSD Coexistence, it may transmit a DELTS Request frame to the AP.

The non-AP STA may transmit multiple ADDTS Request frames to the AP where the last successfully received ADDTS Request frame will override any previously received ADDTS Request frame.

An AP that supports U-APSD Coexistence and accepts an ADDTS request limits the U-APSD Coexistence Service Period according to the parameters specified in the ADDTS frame U-APSD Coexistence element, and shall transmit frames to the requesting non-AP STA according to the rules in 9.2.4.2 (HCF contention-based channel access (EDCA)) and the following rules:

* If the non-AP STA specified a nonzero TSF 0 Offset value in the U-APSD Coexistence element, the AP should not transmit frames to the non-AP STA outside of the U-APSD Coexistence Service Period, which begins when the AP receives the U-APSD trigger frame and ends after the transmission period specified by the result of the following calculation:

*End of transmission period* = *T* + (*Interval* – ((*T* – *TSF 0 Offset*) mod *Interval*))

where

*T* is the time the U-APSD trigger frame was received at the AP

*Interval* is the UAPSD Coexistence element Duration/Interval field value (see 8.4.2.93 (U-APSD Coexistence element))

or upon the successful transmission of a frame with EOSP bit set to 1, whichever is earlier.

* If the non-AP STA specified a TSF 0 Offset value of 0 in the U-APSD Coexistence element, the AP should not transmit frames to the non-AP STA outside of the U-APSD Coexistence Service Period, which begins when the AP receives a U-APSD trigger frame and ends after the transmission period specified by the result of the following calculation:

*End of transmission period* = *T* + *Duration*

where

*T* is the time the U-APSD trigger frame was received at the AP

*Duration* is the UAPSD Coexistence element Duration/Interval field value (see 8.4.2.93 (U-APSD Coexistence element))

or upon the successful transmission of a frame with EOSP bit set to 1, whichever is earlier.

Throughout the U-APSD Coexistence Service Period, the AP shall set the More bit to 1 if it has more frames to be transmitted and it can determine the frame might be received successfully before the service period expires.

The AP should set the EOSP bit to 1 in the frame that it expects to be the last frame transmitted to the non-AP STA during the U-APSD Coexistence duration. If the last frame expected to be transmitted cannot be successfully transmitted to the non-AP STA before the termination of the U-APSD SP, the AP should transmit a QoS null frame with the EOSP bit set to 1.

The non-AP STA may enter Doze State at the end of the U-APSD Coexistence Service Period.

* AP operation during the CP

APs shall maintain a Power Management status for each currently associated STA that indicates in which Power Management mode the STA is currently operating. APs that implement and signal their support of APSD shall maintain an APSD and an access policy status for each currently associated STA that indicates whether the STA is presently using APSD and shall maintain the schedule (if any) for the STA. An AP shall, depending on the Power Management mode of the STA, temporarily buffer BUs destined to the STA. An AP implementing APSD shall, if a STA is using APSD and is in PS mode, temporarily buffer BUs destined to that STA. No BUs addressed directly to STAs operating in the Active mode shall be buffered for power management reasons.

The following rules describe operation during the CP:

* BUs destined for PS STAs shall be temporarily buffered in the AP. The algorithm to manage this buffering is beyond the scope of this standard, with the exception that if the AP is QoS-enabled, it shall preserve the order of arrival of frames on a per-TID, per-STA basis.
* Nonbufferable MMPDUs and BUs destined for STAs in the Active mode shall be directly transmitted to those STAs.
* At every beacon interval, the AP shall assemble the partial virtual bitmap containing the buffer status per destination for STAs in the PS mode and shall send this out in the TIM field of the Beacon frame. At every beacon interval, the APSD-capable AP shall assemble the partial virtual bitmap containing the buffer status of nondelivery-enabled ACs (if there exists at least one nondelivery-enabled AC) per destination for STAs in PS mode and shall send this out in the TIM field of the Beacon frame. When all ACs are delivery-enabled, the APSD-capable AP shall assemble the partial virtual bitmap containing the buffer status for all ACs per destination. If FMS is enabled, the AP shall include the FMS Descriptor element in every Beacon frame. The FMS Descriptor element shall indicate all FMS group addressed frames that the AP buffers.
* If a STA has set up a scheduled SP, it shall automatically wake up at each SP. Therefore, the APSD-capable AP shall transmit frames associated with admitted traffic with the APSD subfield equal to 1 in the TSPECs buffered for the STA during a scheduled SP. If the STA has set up to use unscheduled SPs, the AP shall buffer BUs using delivery-enabled ACs until it has received a trigger frame using a trigger-enabled AC from the non‑AP STA, which indicates the start of an unscheduled SP. A trigger frame received by the AP from a STA that already has an unscheduled SP underway shall not trigger the start of a new unscheduled SP. The AP transmits BUs destined for the STA and using delivery-enabled ACs during an unscheduled SP. The bit for AID 0 (zero) in the bit map control field of the TIM element shall be set to 1 when non-GCR-SP(11aa) group addressed traffic is buffered, according to 8.4.2.7 (TIM element).
* If any associated STAs are in PS mode, all non-GCR-SP(11aa) group addressed BUs except those with a service class of StrictlyOrdered shall be buffered.
* When dot11MgmtOptionFMSActivated is false, the AP shall transmit all buffered non-GCR-SP(11aa) group addressed BUs immediately after every DTIM.

When dot11MgmtOptionFMSActivated is true and the AP has established an FMS delivery interval for a multicast stream, the AP shall transmit all non-GCR-SP(11aa) group addressed BUs belonging to particular FMS stream immediately after the DTIM that has the Current Count field value of the FMS Counter field set to 0 for that particular FMS stream.

The More Data field of each group addressed frame shall be set to indicate the presence of further buffered non-GCR-SP(11aa) group addressed BUs. If the AP is unable to transmit all of the buffered non-GCR-SP(11aa) group addressed BUs before the primary or secondary TBTT following the DTIM, the AP shall set the bit for AID 0 (zero) in the TIM element to 1 for a single BSSID or set the corresponding group address bit to 1 for multiple BSSIDs, as defined in 8.4.2.7 (TIM element), and when dot11MgmtOptionFMSActivated is true, shall set the appropriate bits in the FMS Descriptor element as described in 8.4.2.77 (FMS Descriptor element) to indicate for which non-GCR-SP(11aa) group addresses there are still buffered BUs, until all buffered non-GCR-SP(11aa) group addressed BUs have been transmitted.

When the AP transmits an STBC DTIM or TIM Beacon frame, the AP shall retransmit all non-GCR-SP(11aa) group addressed BUs that were transmitted following the non-STBC DTIM or TIM Beacon frame except that they are transmitted using the basic STBC MCS. It may be the case that a complete set of buffered non-GCR-SP(11aa) group addressed BUs is sent over a period of time during which non-STBC and STBC transmissions are interleaved, but the transition from non-STBC group addressed transmissions to STBC group addressed transmissions shall be preceded by the transmission of an STBC Beacon frame and the transition from STBC group addressed transmissions to non-STBC group addressed transmissions shall be preceded by the transmission of a non-STBC Beacon frame.

* A single buffered BU for a STA in the PS mode shall be forwarded to the STA after a PS-Poll has been received from that STA. For a STA using U-APSD, the AP transmits one BU destined for the STA from any AC that is not delivery-enabled in response to PS-Poll from the STA. When all ACs associated with the STA are delivery-enabled, AP transmits one BU from the highest priority AC. The AP can respond with either an immediate data or management frame or with an ACK, while delaying the responding data or management frame.

For a STA in PS mode and not using U-APSD, the More Data field of the response data or management frame shall be set to indicate the presence of further buffered BUs for the polling STA. For a STA using U-APSD, the More Data field shall be set to indicate the presence of further buffered BUs that do not use delivery-enabled ACs. When all ACs associated with the STA are delivery-enabled, the More Data field shall be set to indicate the presence of -further buffered BUs using delivery-enabled ACs. If there are buffered BUs to transmit to the STA, the AP may set the More Data bit in a QoS +CF-Ack frame to 1, in response to a QoS data frame to indicate that it has one or more pending BUs buffered for the PS STA identified by the RA in the QoS +CF-Ack frame. An AP may also set the More Data bit in an ACK frame to 1 in response to a QoS data frame to indicate that it has one or more pending BUs buffered for the PS STA identified by the RA in the ACK frame, if that PS STA has set the More Data Ack subfield in the QoS Capability element to 1.

Further PS-Poll frames from the same STA shall be acknowledged and ignored until the BU has either been successfully delivered or presumed failed due to maximum retries being exceeded. This prevents a retried PS-Poll from being treated as a new request to deliver a buffered BU.

* At each scheduled APSD SP for a STA, the APSD-capable AP (i.e., an AP for which dot11APSDOptionImplemented is true) shall attempt to transmit at least one BU, using admitted TSPECs with the APSD and Schedule subfields both set to 1, that are destined for the STA. At each unscheduled SP for a STA, the AP shall attempt to transmit at least one BU, but no more than the value specified in the Max SP Length field in the QoS Capability element from delivery-enabled ACs, that are destined for the STA.

The More Data bit of the individually addressed data or bufferable management frame using delivery-enabled ACs and destined for that STA indicates that more BUs are buffered for the delivery-enabled ACs. The More Data bit equal to 1 in data or bufferable management frames using nondelivery-enabled ACs and destined for that STA indicates that more BUs are buffered for the nondelivery-enabled ACs. For all frames except for the final frame of the SP, the EOSP subfield of the QoS Control field of the QoS data frame shall be set to 0 to indicate the continuation of the SP. An AP may also set the More Data bit to 1 in a QoS +CF-Ack frame in response to a QoS data frame to indicate that it has one or more pending BUs buffered for the target STA identified by the RA in the QoS +CF-Ack frame. If the QoS data frame is using a delivery-enabled AC, the More Data bit in the QoS +CF-Ack frame indicates more BUs for all delivery-enabled ACs. If the QoS data frame is not using a delivery-enabled AC, the More Data bit in the QoS +CF-Ack frame indicates more BUs for all ACs that are not delivery-enabled.

The AP considers an APSD STA to be in Awake state after it has sent a QoS +CF-Ack frame, with the EOSP subfield in the QoS Control field equal to 0, to the APSD STA. If necessary, the AP may generate an extra QoS Null frame, with the EOSP set to 1. When the AP has transmitted an individually addressed frame to the STA with the EOSP subfield set to 1 during the SP except for retransmissions of that frame, the AP shall not transmit any more frames to that STA using this mechanism until the next SP. The AP shall set the EOSP subfield to 1 to indicate the end of the SP in APSD.

* If the AP does not receive an acknowledgment to an individually addressed data or bufferable management frame sent to a STA in PS mode following receipt of a PS-Poll from that STA, it may -retransmit the frame for at most the lesser of the maximum retry limit and dot11QAPMissingAckRetryLimit times before the next Beacon frame, but it shall retransmit that frame at least once before the next Beacon frame, time permitting and subject to its appropriate lifetime limit. If an acknowledgment to the retransmission is not received, it may wait until after the next Beacon frame to further retransmit that frame subject to its appropriate lifetime limit.
* If the AP does not receive an acknowledgment to an individually addressed data frame containing all or part of an MSDU or A-MSDU sent with the EOSP subfield equal to 1, it shall retransmit that frame at least once within the same SP, subject to applicable retry or lifetime limit. The maximum number of retransmissions within the same SP is the lesser of the maximum retry limit and dot11QAPMissingAckRetryLimit. If an acknowledgment to the retransmission of this last frame in the same SP is not received, it may wait until the next SP to further retransmit that frame, subject to its applicable retry or lifetime limit.

NOTE—An AP that transmits an A-MPDU containing data MPDUs in which the EOSP field is set to 1 and that receives a BlockAck that does not acknowledge all of those MPDUs, cannot transmit any missed data MPDUs within the current service period because the destination STA might now be asleep.

* An AP may delete buffered BUs for implementation-dependent reasons, including the use of an aging function and availability of buffers. The AP may base the aging function on the Listen Interval specified by the STA in the (Re)Association Request frame or the WNM-Sleep Interval specified by the non-AP STA in the WNM-Sleep Mode Request frame.
* When an AP is informed that a STA has changed to the Active mode, then the AP shall send buffered BUs (if any exist) to that STA without waiting for a PS-Poll. When an AP is informed that an APSD-capable STA is not using APSD, then the AP shall send buffered BUs (if any exist) to that STA according to the rules corresponding to the current PS mode of the STA.
* AP operation during the CFP

APs shall maintain a Power Management status for each currently associated CF-Pollable STA that indicates in which Power Management mode the STA is currently operating. An AP shall, for STAs in PS mode, temporarily buffer BUs addressed to the STA.

The following rules describe operation during the CFP:

* BUs destined for PS STAs shall be temporarily buffered in the AP. The algorithm to manage this buffering is beyond the scope of this standard.
* Nonbufferable MMPDUs and all BUs destined to STAs in the Active mode shall be transmitted as defined in Clause 9 (MAC sublayer functional description).
* Prior to every CFP, and at each beacon interval within the CFP, the AP shall assemble the partial vir-tual bitmap containing the buffer status per destination for STAs in the PS mode, set to 1 the bits in the partial virtual bitmap for STAs the PC is intending to poll during this CFP, and shall send this out in the TIM field of the DTIM. The bit for AID 0 (zero) in the Bit Map Control field of the TIM element shall be set to 1 when group addressed traffic is buffered, according to 8.4.2.7 (TIM element).
* All non-GCR-SP(11aa) group addressed MSDUs except those with a service class of StrictlyOrdered shall be buffered if any associated STAs are in the PS mode, regardless of whether those STAs are CF-Pollable.
* When dot11MgmtOptionFMSActivated is false, the AP shall transmit all buffered non-GCR-SP(11aa) group addressed BUs immediately after every DTIM (Beacon frame with DTIM Count field of the TIM element equal to 0).

When dot11MgmtOptionFMSActivated is true and the AP has set up an FMS delivery interval for a multicast stream, the AP shall send all non-GCR-SP(11aa) group addressed BUs belonging to a particular FMS stream immediately after the DTIM with the Current Count field value of the FMS Counter field set to 0 for that particular FMS stream.

The More Data field shall be set to 1 in the headers of all but the final frame containing one of these buffered non-GCR-SP(11aa) group addressed BUs to indicate the presence of further buffered group addressed BUs. If the AP is unable to transmit all of the buffered non-GCR-SP(11aa) group addressed BUs before the non-STBC or STBC TBTT following the DTIM, the AP shall set the bit for AID 0 (zero) in the TIM element to 1 for a single BSSID or set the corresponding group addressed bit to 1 for multiple BSSIDs, as defined in 8.4.2.7 (TIM element), and when dot11MgmtOptionFMSActivated is true, shall set the appropriate bits in the FMS Descriptor element as described in 8.4.2.77 (FMS Descriptor element) to indicate for which group addresses there are still buffered BUs, until all buffered non-GCR-SP(11aa) group addressed BUs have been transmitted.

When the AP transmits an STBC DTIM or TIM Beacon frame, the AP shall retransmit all non-GCR-SP(11aa) group addressed BUs that were transmitted following the non-STBC DTIM or TIM Beacon frame except that they are transmitted using the basic STBC MCS. It may be the case that a complete set of buffered non-GCR-SP(11aa) group addressed BUs is sent over a period of time during which non-STBC and STBC transmissions are interleaved, but the transition from non-STBC group addressed transmissions to STBC group addressed transmissions shall be preceded by the transmission of a STBC Beacon frame and the transition from STBC group addressed transmissions to non-STBC group addressed transmissions shall be preceded by the transmission of a non-STBC Beacon frame.

* Buffered BUs for STAs in the PS mode shall be forwarded to the CF-Pol-lable STAs under control of the PC. Transmission of these buffered BUs as well as CF-Polls to STAs in the PS mode that were indicated in the DTIM in accordance with Prior to every CFP, and at each beacon interval within the CFP, the AP shall assemble the partial vi of this subclause shall begin immediately after transmission of buffered non-GCR-SP(11aa) group addressed frames (if any), and shall occur in order by increasing AID of CF-Pollable STAs. A CF-Pollable STA for which the TIM element of the most recent Beacon frame indicated buffered BUs shall be in the Awake state at least until the receipt of an individually addressed frame from the AP in which the Frame Control field does not indicate the existence of more buffered BUs. After acknowledging the last of the buffered BUs, the CF-Pollable STA operating in the PS mode may enter the Doze state until the next DTIM is expected.
* An AP shall have an aging function to delete pending traffic buffered for an excessive time period. The exact specification of the aging function is beyond the scope of this standard.
* When an AP detects that a CF-Pollable STA has changed from the PS mode to the Active mode, then the AP shall queue any buffered BUs addressed to that STA for transmission to that CF-Pol-lable STA as directed by the AP’s PC.
* Receive operation for STAs in PS mode during the CP

A STA in PS mode shall operate as follows to receive a BU from the AP when no PC is operating and during the CP when a PC is operating.

The following rules describe operation of a STA in PS mode during the CP:

* The STA shall wake up early enough to be able to receive the first Beacon frame scheduled for transmission at the time corresponding to the last TBTT plus the ListenInterval.
* When the STA detects that the bit corresponding to its AID is 1 in the TIM, the STA shall issue a PS-Poll, or a trigger frame if the STA is using U-APSD and all ACs are delivery-enabled, to retrieve the buffered BU. The PS-Poll or trigger shall be transmitted after a random delay uniformly distributed between zero and aCWmin slots following a DIFS.
* The STA shall remain in the Awake state until it receives the BU in response to its poll or it receives another Beacon frame whose TIM indicates that the AP does not have any BUs buffered for this STA. If the bit corresponding to the STA’s AID is 1 in the subsequent TIM, the STA shall issue another PS-Poll to retrieve the buffered BU. When a STA that is using U-APSD and has all ACs delivery-enabled detects that the bit corresponding to its AID is 1 in the TIM, the STA shall issue a trigger frame or a PS-Poll frame to retrieve the buffered BU.
* If the More Data field in the received data or bufferable management frame indicates that more traffic for that STA is buffered, the STA, at its convenience, shall Poll until no more BUs are buffered for that STA.
* When dot11MgmtOptionFMSActivated is false and ReceiveDTIMs is true, the STA shall wake up early enough to be able to receive either every non-STBC DTIM or every STBC DTIM sent by the AP of the BSS.

When dot11MgmtOptionFMSActivated is true and ReceiveDTIMs is true and the STA has been granted by the AP an alternate delivery interval for a multicast stream, the STA shall wake up before the non-STBC DTIM or STBC DTIM having Current Count of FMS Counter field set to 0 for that particular FMS stream.

A STA that stays awake to receive group addressed BUs shall elect to receive all group addressed non-STBC transmissions or all group addressed STBC transmissions and remain awake until the More Data field of the appropriate type (non-STBC or STBC) of group addressed BUs indicates there are no further buffered group addressed BUs of that type, or until a TIM is received indicating there are no more buffered group addressed BUs of that type, or until an FMS Descriptor element is received indicating that there are no further buffered group addressed BUs for which the STA has previously received an FMS Response element in a frame that has a value in address1 that matches its MAC address or that has an address1 value that is a group address corresponding to a group of which it is a member and that was transmitted by the AP with which it is associated and which had an Element Status value in FMS Status subelement of Accept. If a STA receives a QoS +CF-Ack frame from its AP with the More Data bit equal to 1, then the STA shall operate exactly as if it received a TIM with its AID bit equal to 1. If a STA has set the More Data Ack subfield in QoS Capability element to 1, then if it receives an ACK frame from its AP with the More Data bit equal to 1, the STA shall operate exactly as if it received a TIM with its AID bit equal to 1. For example, a STA that is using the PS-Poll delivery method shall issue a PS-Poll frame to retrieve a buffered BU. See also 9.3.6 (Group addressed MPDU transfer procedure).

* Receive operation for STAs in PS mode during the CFP

A STA in PS mode that is associated as CF-Pollable shall operate as follows in a BSS with an active PC to receive BUs from the AP during the CFP:

* The STA shall enter the Awake state so as to receive the Beacon frame (which contains a DTIM) at the start of each CFP.
* To receive group addressed BUs, the STA shall wake up early enough to be able to receive either every non-STBC DTIM or every STBC DTIM that may be sent during the CFP. A STA receiving group addressed BUs shall elect to receive all group addressed non-STBC transmissions or all group addressed STBC transmissions and remain awake until the More Data field of the frames containing the group addressed BUs indicates there are no fur-ther buffered group addressed BUs of that type, or until a TIM is received indicating there are no more group addressed BUs of that type buffered or until an FMS Descriptor element is received indicating that there are no further buffered group addressed BUs for which the STA has previously received an FMS Response element in a frame that has an address1 value that matches its MAC address or that has an address1 value that is a group address corresponding to a group of which it is a member and that was transmitted by the AP with which it is associated and which had an Element Status value in FMS Status subelement of Accept. See also 9.3.6 (Group addressed MPDU transfer procedure).
* When the STA detects that the bit corresponding to its AID is 1 in the DTIM at the start of the CFP (or in a subsequent TIM during the CFP), the STA shall remain in the Awake state for at least that portion of the CFP through the time that the STA receives an individually addressed BU from the AP carried in a frame with the More Data field in the Frame Control field indicating that no further traffic is buffered.
* If the More Data field in the Frame Control field of the last data or bufferable management frame received from the AP indicates that more traffic for the STA is buffered, then, when the CFP ends, the STA may remain in the Awake state and transmit PS-Poll frames during the CP to request the delivery of additional buffered BUs, or may enter the Doze state dur-ing the CP (except at TBTTs for DTIMs expected during the CP), awaiting the start of the next CFP.
* Receive operation using APSD

A STA using APSD shall operate as follows to receive a BU from the AP:

* If a scheduled SP has been set up, the STA wakes up at its scheduled start time. (The STA shall wake up early enough to receive transmissions at the scheduled SP.)
* If the STA is initiating an unscheduled SP, the STA wakes up and transmits a trigger frame to the AP. When one or more ACs are not delivery-enabled, the STA may retrieve BUs using those ACs by sending PS-Poll frames to the AP.
* The STA shall remain awake until it receives a QoS data frame or QoS Null frame addressed to it, with the EOSP subfield in the QoS Control field equal to 1.
* The STA may send additional PS-Poll frames if the More Data subfield is 1 in downlink individually addressed data or bufferable management frames that do not use any delivery-enabled ACs. The STA may send additional trigger frames if the More Data subfield is 1 in downlink individually addressed data or bufferable management frames that use delivery-enabled ACs.
* STAs operating in the Active mode

A STA operating in this mode shall have its receiver activated continuously; such STAs do not need to interpret the TIM elements in Beacon frames.

* AP aging function

Any AP aging function shall not cause the buffered BU to be discarded after any period that is shorter than the ListenInterval of the STA for which the BUs are buffered. The exact specification of the aging function is beyond the scope of this standard.

NOTE—This aging function is independent of (i.e., in addition to) other causes of MSDU discard within the MAC, such as due to the operation of a per-TS MSDU lifetime, or related to dot11QAPEDCATableMSDULifetime.

* PSMP power management

An AP transmits a PSMP frame containing a schedule only for STAs that are awake.

A STA with an established PSMP session (see **Error! Reference source not found.**) shall be awake at the start of the session's SP and shall remain awake until the end of the SP unless permitted to return to sleep as described in this subclause.

NOTE—A STA in power save mode can also be determined to be awake following receipt of a trigger frame according to the operation of the U-APSD protocol (as defined in Power management with APSD), following receipt of a PS-Poll frame (as defined in Receive operation for STAs in PS mode during the CP), or following a DTIM Beacon (as defined in Receive operation for STAs in PS mode during the CP).

The AP may signal the end of the SP for all awake associated PSMP-capable STAs by setting the More PSMP field to 0 or by sending CF-End frame instead of the next PSMP frame.

NOTE 1—The AP can also signal the end of an SP on a per-STA basis using the EOSP field set to 1 in the QoS Control field, as defined in 8.2.4.5.3 (EOSP (end of service period) subfield) and AP operation during the CP. This field remains set to 1 for any retransmissions of the same frame, and no more new frames are sent to this particular STA in the current SP.

NOTE 2—If a STA is awake at the start of a scheduled PSMP session, the operation of the More Data field in the Frame Control field and the TIM element are defined by the S-APSD rules in Power management with APSD, AP operation during the CP, and Receive operation using APSD.

A STA shall wake up at the start of the next PSMP frame if the More PSMP field is equal to 1 in the current PSMP frame, unless the STA has been permitted to return to sleep through the reception of a frame addressed to it with the EOSP field equal to 1 or the maximum SP interval has elapsed.

Within a PSMP sequence, a PPDU containing MPDUs addressed to a STA shall not start after expiry of the STA’s PSMP-DTT. A STA completes the reception of any PPDU that starts before the end of the PSMP-DTT. If no frames addressed to a STA begin within a PSMP-DTT, it can assume that no frame addressed to it will arrive during this PSMP sequence.

The STA shall be awake to receive at the start of the PSMP-DTT determined from a STA\_INFO field that has the STA\_INFO Type subfield equal to 2 and the AID field matching the STA’s AID where the PSMP-DTT Duration subfield is not equal to 0.

* TDLS Peer Power Save Mode

TDLS Peer Power Save Mode (TDLS Peer PSM) is a power save mechanism that can be used between TDLS peer STAs, and which is based on a periodic wakeup schedule. A STA supports TDLS Peer PSM if dot11TDLSPeerPSMActivated is true. A STA supporting this capability may indicate support through any TDLS Setup Request frame or TDLS Setup Response frame. A STA indicating this support shall signal this by setting the TDLS Peer PSM Support subfield in the Extended Capabilities element included in the TDLS Setup Request frame or TDLS Setup Response frame to 1. A station that signals support for this capability is capable of acting in both the TDLS Peer PSM initiator and the TDLS Peer PSM responder role.

A STA that intends to enter TDLS Peer PSM (TDLS Peer PSM initiator) shall send a TDLS Peer PSM Request frame to the TDLS peer STA (TDLS Peer PSM responder), including a proposed periodic Wakeup Schedule. A TDLS Peer PSM Request frame shall not be transmitted to a STA that did not indicate support for TDLS Peer PSM. When the TDLS Peer PSM responder accepts the proposed Wakeup Schedule, it shall respond with a TDLS Peer PSM Response frame indicating status code 0 (“Successful”). Otherwise, the TDLS Peer PSM responder shall respond with a TDLS Peer PSM Response frame indicating the appropriate status code for rejecting the schedule. An alternative schedule shall be included in the TDLS Peer PSM Response frame when the status code is equal to 2 (“TDLS Wakeup Schedule rejected but alternative schedule provided”). The alternative schedule may be used by the TDLS Peer PSM initiator to generate a new TDLS Peer PSM Request frame. After successfully transmitting or receiving a TDLS Peer PSM Response frame indicating status code 0 (“Successful”), the TDLS Peer PSM initiator and TDLS Peer PSM responder have established a periodic wakeup schedule between them. The wakeup schedule remains valid until one of the following occurs:

* The TDLS direct link is torn down;
* The STAs explicitly update the existing wakeup schedule; or
* No MPDUs containing data have been exchanged for Idle Count consecutive Awake Windows.

A STA transmitting a TDLS Peer PSM Request frame shall remain in the wake state until it received the corresponding TDLS Peer PSM Response frame. A TDLS Peer PSM Request frame may be transmitted via the AP path or via the direct path (which is up to the implementer to decide). A TDLS Peer PSM Response frame shall be transmitted over the direct path.

The timing of the periodic schedule of the TDLS Peer PSM Awake Windows is based on the Offset field, the Interval field, the Awake Window Slots field, and the Maximum Awake Window Duration field of the Wakeup Schedule element that is contained in the TDLS Peer PSM Setup Request frame that established TDLS Peer PSM operation on the link.

Awake Windows begin at TSF values that satisfy the equation TSF mod Interval = Offset. The interval between the start of two successive Awake Windows is equal to the time in microseconds of the Interval field. The periodic wakeup schedule may be unrelated to the target beacon transmission time (TBTT) or the beacon interval.

Awake Windows end when the Awake Window Slot Counter reaches 0 or when the Maximum Awake Window Duration has been reached, whichever comes first.

The Awake Window Slot Counter counts down backoff slots that are determined using AIFS[AC\_BE] in the same manner that normal backoff slots are determined according to 9.19.2.5 (EDCA backoff procedure).

The initial value of the Awake Window Slot Counter at the start of the Awake Window shall be equal to the value in the Awake Window Slots field of the Wakeup Schedule element that is contained in the TDLS Peer PSM Setup Request frame that established TDLS Peer PSM operation on the link.

The Awake Window Slot Counter begins counting at the beginning of the Awake Window and stops counting when it reaches 0.

A value of 0 in the Maximum Awake Window Duration field of the Wakeup Schedule element that is contained in the TDLS Peer PSM Setup Request frame that established TDLS Peer PSM operation on the link means that the end of the Awake Window duration is determined only by the Awake Window Slot Counter.

A value of 0 in the Awake Window Slots field of the Wakeup Schedule element that is contained in the TDLS Peer PSM Setup Request frame that established TDLS Peer PSM operation on the link means that the duration of the Awake Window is determined only by the Maximum Awake Window Duration.

The Maximum Awake Window Duration field and the Awake Window Slots field shall not both be set to 0 in a TDLS Peer PSM Setup Request frame.

The Awake Window Slots field in a TDLS Peer PSM Setup Request frame should be set to a value that is larger than CWmin[AC\_BE].

A TDLS Peer PSM service period is a contiguous period of time during which one or more individually addressed frames are transmitted between two TDLS peer STAs when at least one STA employs TDLS Peer PSM. A TDLS Peer PSM service period may be initiated during an Awake Window. A TDLS peer STA in power save mode may enter a doze state when it has successfully transmitted to and received from the corresponding TDLS peer STA in power save mode a QoS frame with the end of service period (EOSP) subfield equal to 1, ending the TDLS Peer PSM service period. A TDLS peer STA in power save mode may enter a doze state when it has successfully received from the corresponding TDLS peer STA in active mode a QoS frame with the EOSP subfield equal to 1.

Either STA may update an existing schedule by initiating a TDLS Peer PSM Request/Response exchange. If the TDLS Peer PSM Response frame indicates status code 0 (“Successful”), a new wakeup schedule is established for the TDLS direct link. Otherwise, the existing schedule still applies. The new schedule takes effect after the termination of the current TDLS Peer PSM service period.

After the successful PSM setup, a STA informs its TDLS peer STA that it will enter power save mode per direct link by setting the Power Management subfield in the Frame Control field to 1 in an MPDU requiring acknowledgement. The STA enters power save mode after successful transmission of the MPDU. The power save status on one direct link is independent of the power save status on other links (direct or with the AP) the STA may have.

If a TDLS peer STA enters power save mode when a Wakeup Schedule is active, it shall be awake at the beginning of each scheduled periodic Awake Window, and stay awake for the duration of the Awake Window or until the end of a TDLS Peer PSM service period. Otherwise, it may enter a doze state, depending on the current requirements to be awake, imposed by other links. A TDLS peer STA that did not enter power save mode shall remain in the awake state.

When both TDLS peer STAs set the More Data ACK subfield in their QoS Capability element to 1, then the More Data field inside an ACK frame set to 0 shall have the same function as the EOSP subfield inside a QoS frame set to 1. Transmission of an ACK frame with the More Data subfield set to 0 under these conditions is equivalent to a successful transmission of a QoS frame with the EOSP subfield set to 1.

When waking up at the beginning of an Awake Window, if a STA has no buffered BU to send to a TDLS Peer STA that had the More Data Ack subfield in its QoS Capability element equal to 1 during the TDLS setup exchange, the TDLS STA may send a QoS-Null frame with the EOSP subfield of the QoS Control field set to 1, and the More Data subfield of the Frame Control field set to 0. If the TDLS peer STA that is the recipient of this QoS-Null frame also has no buffered BU to deliver either, and it had the More Data Ack subfield in its QoS Capability element equal to 1 during the TDLS setup exchange, then the TDLS peer STA shall respond with an ACK frame that has the More Data subfield set to 0. The STA may discard the QoS-Null frame if it has not been successfully transmitted at the end of the Awake Window. Before the successful transmission of the QoS-Null frame, if a Data or QoS-Null frame with an EOSP subfield equal to 1 is received from the TDLS peer STA the STA may cancel the pending transmission of the QoS-Null frame after the transmission of an ACK response frame with the More Data subfield set to 0.

To keep track of the connectivity over the direct link and to maintain the wakeup schedule, TDLS peer STAs may start an acknowledged frame exchange at least once per Idle Count consecutive Awake Windows, as a keepalive. For instance a QoS-Null frame may be used as a keepalive frame. When a TDLS Peer PSM Response frame was successfully transmitted or received and no subsequent TDLS Peer PSM service period has started for Idle Count consecutive wakeup periods, the TDLS peer STAs shall delete the wakeup schedule for this link, which means that the related periodic wakeup no longer occurs (i.e., the TDLS peer STAs no longer have to wake up during this period) and that a wakeup schedule no longer exists for this link. When traffic arrives at a TDLS peer STA in TDLS Peer PSM mode for a link with no existing wakeup schedule, the STA shall send a TDLS Peer PSM Request frame through the AP path to the TDLS peer STA to activate a new wakeup schedule. When both TDLS peer STAs enter active mode while a wakeup schedule is active, no more TDLS Peer PSM service periods will occur, causing the wakeup schedule to be deleted.

If a TDLS peer STA does not receive an acknowledgment to an individually addressed QoS frame sent with the EOSP subfield equal to 1 that terminates a TDLS Peer PSM service period, it shall retransmit that frame at least once within the same service period, subject to the applicable retry or lifetime limit. The maximum number of retransmissions within the same service period is the lesser of the maximum retry limit and dot11TDLSPeerSTAMissingAckRetryLimit. If an acknowledgment to the retransmission of this last frame in the same service period is not received, the TDLS peer STA may wait until the next Awake Window to further retransmit that frame, subject to its applicable retry or lifetime limit. When the TDLS peer STA has transmitted an individually addressed frame that terminates a TDLS Peer PSM service period then, except for retransmissions of that frame, the TDLS peer STA shall not transmit any more frames to the TDLS peer STA until the next Awake Window.

A TDLS peer STA that has an active Wakeup Schedule shall not decrement a backoff count outside the Awake Windows, if that backoff precedes a frame that is destined for transmission on the related TDLS direct link.

At the start of an Awake Window, the backoff procedure shall be invoked at an EDCAF if there is a frame available for transmission at that EDCAF, and the backoff timer for that EDCAF has been 0 for at least one backoff slot.

Outside of its Awake Windows, and during Awake Windows when on the base channel, a TDLS peer STA can engage in communications with the AP.

* TDLS Peer U-APSD
* General

A STA supports the TDLS Peer U-APSD Buffer STA function if dot11TDLSPeerUAPSDBufferSTAActivated is true. A STA supporting this capability may indicate support through any TDLS Setup Request frame or TDLS Setup Response frame. A STA indicates support by setting the TDLS Peer U-APSD Buffer STA Support subfield in the Extended Capabilities element included in the TDLS Setup Request frame or TDLS Setup Response frame to 1. Support for the TDLS Peer U-APSD Buffer STA function means that the STA has the capability to buffer BUs destined to the TPU sleep STA, and to deliver them during unscheduled service periods.

To operate as the TPU Sleep STA in TDLS Peer U-APSD, a STA shall configure its TDLS Peer U-APSD capable TDLS peer STA by setting one or more U-APSD Flag subfields inside the QoS Info subfield of the QoS Capability element carried in a TDLS Setup Response frame to 1, or by setting one or more U-APSD Flag subfields inside the QoS Info subfield of the EDCA Parameter Set element carried in a TDLS Setup Confirm frame to 1.

A STA that configured TDLS Peer U-APSD at a TDLS peer STA enters power save mode on a TDLS direct link after the successful transmission to the TDLS peer STA over the direct link of an acknowledged MPDU with the Power Management subfield in the Frame Control field equal to 1. The STA that transmitted the frame with the Power Management subfield in the Frame Control field equal to 1 is then referred to as a TPU sleep STA. The STA that received the frame with the Power Management subfield in the Frame Control field equal to 1 is referred to as a TPU buffer STA. A TPU sleep STA may be a TPU buffer STA at the same time and on the same link, by sending a frame to the TDLS peer STA with the Power Management subfield in the Frame Control field set to 1 (this transmission will be preceded by the transmission of a Peer Traffic Indication frame and the subsequent receipt of a trigger frame that starts a service period). The power save status on one direct link is independent of the power save status on other links (direct or with the AP) the STA may have.

The procedure to trigger and terminate an unscheduled SP between TPU buffer STA and a TPU sleep STA are described in Power management with APSD and AP operation during the CP, where the TPU buffer STA shall take the role of the AP and the TPU sleep STA shall take the role of the non-AP STA using U-APSD, except that a frame with the EOSP field equal to 1 shall not act as a trigger frame.

* TDLS Peer U-APSD Behavior at the TPU buffer STA

BUs at a TPU buffer STA destined for a TPU sleep STA shall be temporarily buffered at the TPU buffer STA. The algorithm to manage this buffering is beyond the scope of this standard, except that the TPU buffer STA shall preserve the order of buffered BUs on a per-TID, per-STA basis.

A TPU buffer STA shall transmit an individually addressed TDLS Peer Traffic Indication frame to a TPU sleep STA, through the AP, if and only if all of the following conditions are met:

* A BU destined for a TPU sleep STA was placed into a buffer at the TPU buffer STA;
* The buffer into which the BU was placed contained no other frames with the same RA; and
* One or more periods of dot11TDLSPeerUAPSDIndicationWindow beacon intervals have expired after the last service period.

The TDLS Peer Traffic Indication frame shall be transmitted through the AP path.

The transmitted TDLS Peer Traffic Indication frame shall indicate the nonempty AC(s), by setting the corresponding AC Traffic Available subfield of the TDLS Peer Traffic Indication frame to 1.

A PTI Control element may be included in the TDLS Peer Traffic Indication frame, to allow the TPU sleep STA to not start a service period when the indicated traffic has already been received by the TPU sleep STA.

The TID field contained in the PTI Control element (if included) shall be set to the TID of the latest MPDU that has been transmitted over the TDLS direct link to the TPU sleep STA that is the destination of the TDLS Peer Traffic Indication frame that contains the PTI Control element.

The Sequence Control field contained in the PTI Control element (if included) shall be set to the sequence number of the latest MPDU that has been transmitted over the TDLS direct link to the TPU sleep STA that is the destination of the TDLS Peer Traffic Indication frame that contains the PTI Control element.

After transmitting a TDLS Peer Traffic Indication frame without a PTI Control element, the TPU buffer STA shall stay awake at least until the corresponding or a subsequent TDLS Peer Traffic Response frame is received.

After transmitting a TDLS Peer Traffic Indication frame without a PTI Control element, the TPU buffer STA shall stay awake at least until the MPDU following the MPDU indicated in the Sequence Control field of the PTI Control element is successfully transmitted.

When no corresponding TDLS Peer Traffic Response frame has been received within dot11TDLSResponseTimeout after sending a TDLS Peer Traffic Indication frame, the STA shall tear down the direct link.

* TDLS Peer U-APSD Behavior at the TPU sleep STA

When a TPU sleep STA receives a TDLS Peer Traffic Indication frame without a PTI Control element, the TPU sleep STA shall initiate a service period with the TPU buffer STA during which it shall transmit at least a TDLS Peer Traffic Response frame. The TDLS Peer Traffic Response frame shall echo the Dialog Token and the Link Identifier from the corresponding TDLS Peer Traffic Indication frame. The TDLS Peer Traffic Response frame shall be sent via the direct path.

When a TPU sleep STA receives a TDLS Peer Traffic Indication frame with a PTI Control element, and the TPU sleep STA has not received from the TPU buffer STA the MPDU following the MPDU that is indicated in the TDLS Peer Traffic Indication frame, the TPU sleep STA shall initiate a service period with the TPU buffer STA to retrieve the buffered traffic for the AC(s) for which no unscheduled SP is currently active.

* FMS power management
* General

Implementation of FMS is optional for a WNM STA. A STA that has a value of true for dot11MgmtOptionFMSActivated is defined as a STA that supports FMS. A STA for which dot11MgmtOptionFMSActivated is true shall set the FMS field of the Extended Capabilities element to 1.

* FMS general procedures

When dot11MgmtOptionFMSActivated is true at the AP, the AP shall include the FMS Descriptor element in every Beacon frame. The FMS Descriptor indicates the FMS group addressed buffered BUs at the AP. If there are no buffered BUs for FMS streams accepted by the AP, the AP shall set the Length field in the FMS Descriptor element to 1. The AP shall include the FMS Descriptor element for a nontransmitted BSSID in the Multiple BSSID element sent in a Beacon frame.

When dot11MgmtOptionFMSActivated is true at the AP, the AP shall support from one to eight different FMS Stream delivery intervals for any number of FMS streams. Corresponding to these eight delivery intervals are eight FMS counters. More than one FMSID may have the same delivery interval and therefore will share the same FMS Counter. An FMS Counter corresponds to each unique delivery interval of one or more FMS Streams.

Each FMS counter decrements once per DTIM beacon and when the FMS counter reaches 0, buffered group addressed BUs assigned to that particular interval are scheduled for delivery immediately following the next Beacon frame containing the DTIM transmission. After transmission of the buffered group addressed BUs, the AP shall reset the FMS counter to the delivery interval for the FMS streams associated with that FMS counter.

A non-AP STA that does not use FMS wakes every DTIM interval and follows group addressed BU reception rules as defined in Receive operation for STAs in PS mode during the CP.

A STA that supports FMS shall be capable of supporting a delivery interval of 1 for any stream.

* FMS Request procedures

A non-AP STA that supports FMS may request use of FMS by sending an FMS Request frame or Reassociation Request frame that includes one or more FMS Request elements to an AP that supports FMS. Each FMS Request element includes one or more FMS subelements. Each FMS subelement identifies an FMS stream, the requested delivery interval and the maximum delivery interval for that stream. The FMS delivery interval shall be an integer multiple of the DTIM period.

Upon reception of an FMS Request frame or Reassociation Request frame, the AP shall transmit a corresponding single FMS Response frame or Reassociation Response frame that contains a corresponding FMS Response element for each FMS Request element in the same order received. Each FMS Response element shall contain an FMS Status subelement and zero or more other subelements drawn from Table 8-160 (Status subelements) that corresponds to each FMS subelement in the FMS Request element, in the same order.

For each FMS subelement, the following rules apply:

If the AP accepts the FMS subelement and the requested delivery interval, the Element Status in the corresponding FMS Status subelement shall be set to Accept and the FMSID is assigned to a nonzero value. In addition:

* If the FMS stream identified in the FMS subelement matches a delivery interval already in use at the AP, the AP shall assign the FMS stream to use the FMS Counter ID assigned for that delivery interval.
* When an FMS Stream is accepted by the AP, the Current Count value for that FMS Stream is decremented by 1 for each DTIM Beacon frame in which the Current Count field appears.
* The AP may reschedule transmission of the FMS Stream identified by an FMSID to align the transmission time of the FMS stream to the transmission time of other FMS streams that the STA is already receiving at the same delivery interval. The AP has the following two options:
* Notify the STAs using that FMS Stream. The AP shall keep the nonzero Current Count value the same across two consecutive Beacon frames in which the Current Count field appears. The algorithm by which the AP chooses to align or offset the different FMS counters is unspecified.
* Transmit an unsolicited FMS Response frame to the group address included in the original FMS Response frame for the stream with the updated Delivery Interval field when the Current Count field value reaches 0. Since the AP transmits this FMS Response frame as a group addressed frame, the frame will be scheduled for delivery at the appropriate DTIM interval when all non-AP STAs are awake to receive the frame.
* An AP may terminate the use of FMS and resume default (non-FMS) transmission rules for any FMS stream identified by FMSID for any reason. To terminate the FMS stream, the AP shall send an unsolicited FMS Response frame to the group address included in the original FMS Response frame with Delivery Interval set to 0 and the Element Status in the FMS Status subelement set to “Terminate.”
* If the FMS subelement contained a nonzero delivery interval and the non-AP STA specified a maximum delivery interval as part of the FMS request, the AP shall not modify the delivery interval for the stream greater than the maximum delivery interval specified by the non-AP STA.
* An AP shall transmit MSDUs belonging to the same FMSID in the same order that they were received at the MAC Data SAP. MSDUs belonging to the different FMSIDs are transmitted by the AP at the appropriate DTIM in the order received at the MAC data SAP based on the interval configured for the FMS stream.

If the AP denies the FMS subelement for any reason, including requested delivery interval, maximum delivery interval and TCLAS, the Element Status in the corresponding FMS Status subelement shall be set to Deny.

If the AP selects an alternate delivery interval or alternate maximum delivery interval from the value specified in the FMS Request, the FMS Status subelement shall be set to Alternate Preferred, and the FMS subelement shall indicate the AP selected value(s).

To terminate the use of FMS for an FMS Stream identified by FMSID, the non-AP STA shall transmit an FMS Request frame with an FMS Request element and FMS subelement with the FMSID matching the FMS stream and the delivery interval set to 0.

The AP shall respond to a malformed FMS Request frame or Reassociation Request frame with an FMS Response frame or Reassociation Response frame that denies all FMS Request elements by including an FMS Status code “Deny, due to request format error or ambiguous classifier” in the Element Status field in each FMS Status subelement in the FMS Response element.

* FMS Response procedures

Upon reception of an FMS Response element in a frame that has a value in Address1 that matches its MAC address or that is a group address corresponding to a group of which it is a member and that was transmitted by the AP with which it is associated, a non-AP STA that supports FMS shall use the following procedures, based on the value of the Element Status value in FMS Status subelement in the received FMS Response element.

* If the Element Status value in FMS Status subelement is Accept:
* The AP has accepted the FMS subelement contained within the FMS Request element. If the FMS Request element specified a nonzero delivery interval, the AP will deliver the requested streams at the delivery interval as specified by the non-AP STA in the FMS Request element.
* After receiving the FMS Response element, the non-AP STA shall be awake for the next DTIM beacon so that the non-AP STA can synchronize with the FMS Current Count for the requested FMS Stream. Once synchronized with the FMS Current Count, the non-AP STA need not wake up at every DTIM interval to receive group addressed BUs.
* If the Element Status value in FMS Status subelement is Deny:
* The AP will not deliver the requested streams at the delivery interval as specified by the non-AP STA in the FMS Request element. If the AP denies the usage of FMS for a particular stream, the stream is transmitted at every DTIM interval.
* If the Element Status value in FMS Status subelement is Alternate Preferred due to AP changed the maximum delivery interval:
* The AP does not deliver the requested streams at the delivery interval as specified by the non-AP STA in the FMS Request element. The delivery interval specified in the FMS Status subelement specifies a delivery interval that the AP is willing to accept for the specified streams if the non-AP STA sends another FMS Request with that delivery interval specified.
* The non-AP STA may submit a new FMS Request that includes the delivery interval value received from the AP. If the AP accepts this new FMS Request, it shall respond as described in FMS general procedures.
* If the Element Status value in FMS Status subelement is Alternate Preferred due to AP unable to provide requested TCLAS-based classifiers:
* The AP does not deliver the requested streams at the delivery interval as specified by the non-AP STA in the FMS Request element. The TCLAS element(s) or TCLAS Processing element in the TCLAS Status subelement contains one or more fields or subfields whose values have been modified by the AP. The AP may include fewer TCLAS elements in the FMS Response element than were present in the request; when the AP’s response includes a single TCLAS element, it does not include a TCLAS processing element. If the AP changes a TCLAS element’s Classifier Type field in the FMS Response element but is unable to suggest a value for the Classifier Mask field, it shall set that field to 0. If the AP changes a TCLAS element’s Classifier Type field or Classifier Mask field in the FMS Response element but is unable to suggest values for one or more Classifier Parameter subfields, it shall set those fields to 0.
* A non-AP STA receiving a modified TCLAS element having a Classifier Mask field equal to 0 or Classifier Parameter subfields equal to 0 shall interpret these values as meaning that no suggested value has been provided by the AP.
* TIM Broadcast

Implementation of TIM Broadcast is optional for a WNM STA. A STA that implements TIM Broadcast     has dot11MgmtOptionTIMBroadcastImplemented set to true. When dot11MgmtOptionTIMBroadcastImplemented is true, dot11WirelessManagementImplemented shall be true. A STA that has a value of true for dot11MgmtOptionTIMBroadcastActivated is defined as a STA that supports TIM Broadcast. A STA for which dot11MgmtOptionTIMBroadcastActivated is true shall set the TIM Broadcast field of the Extended Capabilities element to 1. This subclause describes TIM Broadcast procedures for STAs that have dot11MgmtOptionTIMBroadcastActivated equal to true.

TIM frames have shorter duration than Beacon frames and are potentially transmitted at a higher data rate. TIM Broadcast allows a non-AP STA to receive a TIM element without receiving a Beacon frame that may reduce the required wake time in a power save mode. The shorter receive time will reduce the power consumption for non-AP STAs in a power save mode. The shorter receive time may reduce the power consumption for stations in a standby mode.

A non-AP STA may activate the TIM Broadcast service by including a TIM Broadcast Request element in a TIM Broadcast Request frame, Association Request frame or Reassociation Request frame that is transmitted to the AP, which specifies the requested interval between TIM frame transmissions (the TIM Broadcast Interval). On receipt of a properly formatted TIM Broadcast Request element in a TIM Broadcast Request frame, Association Request frame or Reassociation Request frame, the AP shall include a TIM Broadcast Response element in the corresponding TIM Broadcast Response frame, Association Response frame or Reassociation Response frame, when dot11MgmtOptionTIMBroadcastActivated is true. When the requested TIM Broadcast Interval is acceptable, the AP shall include a TIM Broadcast Response element specifying the requested TIM Broadcast Interval and a Status field indicating “accept” when no valid TSF timestamp is present in the TIM frames, or “accept, valid timestamp present in TIM frames” when a valid TSF timestamp is present in the TIM frames. When the AP overrides the request, it shall include a TIM Broadcast Response element with a Status field indicating “Overridden,” and include in the TIM Broadcast Response element the smallest TIM Broadcast Interval that is currently active. Otherwise, the AP shall include a TIM Broadcast Response element with a Status field indicating “denied.” The Status field in a TIM Broadcast Response element that is included in an Association Response frame or Reassociation Response frame has implications only for the TIM Broadcast negotiation.

An AP transmitting a TIM frame with a valid TSF timestamp shall set the value of the TIM frame timestamp as defined in **Error! Reference source not found.**, for the Beacon frame timestamp.

If the AP accepted at least one TIM Broadcast Request with a nonzero TIM Broadcast Interval, and at least one non-AP STA in PS mode still associated with the AP received in its latest TIM Broadcast Response a status field value equal to 0 (Accepted) in response to a TIM Broadcast Request with a nonzero TIM Broadcast Interval, the AP shall transmit one or two TIM frames per TIM Broadcast Interval. The AP shall not transmit TIM frames otherwise. When TIM Broadcast Intervals overlap, a transmitted TIM frame serves both intervals and does not need to be duplicated.

If the AP transmits two TIM frames per TIM Broadcast Interval, the AP shall transmit the high data rate TIM frame first, followed by the low data rate TIM frame.

The AP shall transmit the low data rate TIM frame at the same data rate or MCS as the Beacon frame. The AP shall transmit the high data rate TIM frame at a higher data rate or using an MCS that corresponds to a higher data rate. For Clause 19 (Extended Rate PHY (ERP) specification) and Clause 20 (High Throughput (HT) PHY specification) PHYs, if the Beacon frame is transmitted using ERP-DSSS/CCK, the AP shall transmit the high data rate TIM frame using ERP-OFDM, and its transmission is mandatory. Otherwise, transmitting the high data rate TIM frame is optional. If the high data rate TIM is not transmitted, the AP shall set the High Data Rate TIM field to 0 in the TIM Broadcast Response element.

The TIM Broadcast Interval from the latest received TIM Broadcast Response element together with the dot11BeaconPeriod define a series of TTTTs TIM Broadcast Interval  dot11BeaconPeriod TUs apart. Time 0 is a TTTT. Non-AP STAs may use the information in the High Rate TIM Rate and Low Rate TIM Rate fields to determine which of the two TIM frames they will be receiving. The first TIM frame per TIM Broadcast Interval is scheduled to be transmitted at the TTTT plus the indicated TIM Broadcast Offset. The offset may have a negative value that allows the TIM frame(s) to be transmitted before the TBTT. The value of the offset shall not be changed as long as an associated non-AP STA is using the TIM Broadcast service.

The AP should accept new TIM Broadcast Interval requests if this implies transmitting TIM frames more frequently. For instance, if the AP currently transmits TIM frames every fourth beacon period and it receives a new request for every 3 beacon periods, then the AP should accept the new request and transmit TIM frames both every 3 and every 4 beacon periods. The AP may override incongruent requests once available resources (such as counters) have been depleted. An incongruent request is a request that contains an interval that is not an integer divide or a multiple of a currently active TIM Broadcast interval.

The AP shall accept a TIM Broadcast Interval of 1.

The AP shall increase the value (modulo 256) of the Check Beacon field in the next transmitted TIM frame(s) when a critical update occurs to any of the elements inside the Beacon frame. The following events shall classify as a critical update:

* Inclusion of a Channel Switch Announcement
* Inclusion of an Extended Channel Switch Announcement
* Modification of the EDCA parameters
* Inclusion of a Quiet element
* Modification of the DSSS Parameter Set
* Modification of the CF Parameter Set
* Modification of the FH Parameter Set
* Modification of the HT Operation element

An AP may classify other changes in the Beacon frame as critical updates.

The non-AP STA shall attempt to receive the next Beacon frame when it receives a Check Beacon field that contains a value that is different from the previously received Check Beacon field.

When dot11MgmtOptionMultiBSSIDActivated is true, the bitmap of the TIM element is interpreted as specified in 8.4.2.7 (TIM element).

When dot11MgmtOptionMultiBSSIDActivated is true, the A1 field of the TIM frame is the Broadcast address, the A2 field and the A3 field are set to the transmitted BSSID.

* WNM-Sleep mode
* WNM-Sleep mode capability

Implementation of the WNM-Sleep mode capability is optional for a WNM STA. A STA that implements WNM-Sleep mode has dot11MgmtOptionWNMSleepModeImplemented set to true. When dot11MgmtOptionWNMSleepModeImplemented is true, dot11WirelessManagementImplemented shall be true. A STA where dot11MgmtOptionWNMSleepModeActivated is true is defined as a STA that supports WNM-Sleep mode. A STA supporting WNM-Sleep mode shall set the WNM-Sleep Mode field of the Extended Capabilities element to 1. When dot11MgmtOptionWNMSleepModeActivated is true, dot11MgmtOptionTFSActivated shall be true.

A STA with a value of true for dot11MgmtOptionWNMSleepModeActivated may send a WNM-Sleep Mode Request or WNM-Sleep Mode Response frame to a STA within the same infrastructure BSS whose last received Extended Capabilities element contained a value of 1 for the WNM-Sleep Mode bit in the Capabilities field. WNM-Sleep mode is a service that may be provided by an AP to its associated STAs. The WNM-Sleep mode is not supported in an IBSS.

WNM-Sleep Mode enables an extended power save mode for non-AP STAs in which a non-AP STA need not listen for every DTIM Beacon frame, and need not perform GTK/IGTK updates. The non-AP STA can sleep for extended periods as indicated by the WNM-Sleep Interval.

* WNM-Sleep mode non-AP STA operation

To use the WNM-Sleep mode service, the non-AP STA’s SME shall issue an MLME-SLEEPMODE.request primitive to send a WNM-Sleep Mode Request frame. The MLME-SLEEPMODE.request primitive shall include a valid SleepMode parameter with a WNM-Sleep Mode element. The Action Type field in the WNM-Sleep Mode element shall be set to “Enter WNM-Sleep Mode,” and the Sleep Interval field shall be included. The Sleep Interval field shall be less than the BSS Max idle period (see **Error! Reference source not found.**). The MLME-SLEEPMODE.request primitive shall also include a valid TFSRequest parameter as defined in the TFS Request element that the AP shall use as triggers to set the STA’s TIM bit.

When a traffic filter for group addressed frames is enabled at the AP, the STA may request a notification frame (see **Error! Reference source not found.**) be sent when requesting the establishment of the traffic filter.

The receipt of an MLME-SLEEPMODE.confirm primitive with a valid SleepMode parameter indicates to the STA’s SME that the AP has processed the corresponding WNM-Sleep Mode Request frame. The content of the WNM-Sleep mode parameter in the WNM-Sleep Mode Response frame provides the status of WNM-Sleep Mode elements processed by the AP. The non-AP STA shall delete the GTKSA if the response indicates success. If RSN is used with management frame protection, the non-AP STA shall delete the IGTKSA if the response indicates success.

While in WNM-Sleep mode, the non-AP STA need not wake up every DTIM interval for group addressed frames.

The STA wakes up every Sleep interval to check whether the corresponding TIM bit is set or group addressed traffic is pending. The non-AP STA does not participate in GTK/IGTK updates.

To exit WNM-Sleep mode, the non-AP STA’s SME shall issue an MLME-SLEEPMODE.request primitive to send a WNM-Sleep Mode Request frame with an Action Type field in the WNM-Sleep Mode element set to “Exit WNM-Sleep Mode.”

* WNM-Sleep mode AP operation

When an AP’s SME receives an MLME-SLEEPMODE.indication primitive with a valid SleepMode parameter and an Action Type in the WNM-Sleep Mode element of “Enter WNM-Sleep Mode,” it shall issue an MLME-SLEEPMODE.response primitive with SleepMode parameters indicating the status of the request.The value of the Action Type field of the WNM-Sleep Mode element in the WNM-Sleep Mode Response frame shall be set to “Enter WNM-Sleep Mode.”

When WNM-Sleep mode is enabled for an associated STA, the AP shall stop sending all individually addressed MPDUs to the non-AP STA. The AP may disassociate or deauthenticate the STA at any time for any reason while the non-AP STA is in WNM-Sleep mode. An AP shall perform the TFS AP operation, as specified in **Error! Reference source not found.** for non-AP STAs for which it has received TFS Request elements. The AP shall set the TIM bit corresponding to the AID of the associated STA for which the AP has queued either a TFS Notify frame or matching frame. An AP shall not perform GTK/IGTK updates for the STAs in WNM-Sleep Mode.

When an AP’s SME receives an MLME-SLEEPMODE.indication primitive with a valid SleepMode parameter and an Action Type in the WNM-Sleep Mode element of “Exit WNM-Sleep Mode,” the AP shall disable WNM-Sleep mode service for the requesting STA, and the AP’s SME shall issue an MLME-SLEEPMODE.response primitive with a SleepMode parameter indicating the status of the associated request.

If RSN is used with management frame protection and a valid PTK is configured for the STA, the current GTK and IGTK shall be included in the WNM-Sleep Mode Response frame. If a GTK/IGTK update is in progress, the pending GTK and IGTK shall be included in the WNM-Sleep Mode Response frame. If RSN is used without management frame protection and a valid PTK is configured for the STA, the current GTK shall be sent to the STA in a GTK update following the WNM-Sleep Mode Response frame.

* Power management in an IBSS
* Introduction

Subclause Power management in an IBSS specifies the power management mechanism for use within an IBSS.

* Basic approach

The basic approach is similar to the infrastructure case in that the STAs are synchronized, and group addressed BUs and the BUs that are to be transmitted to a power-conserving STA are first announced during a period when all STAs are awake. The announcement is done via an ATIM sent in an ATIM Window. A STA in the PS mode shall listen for these announcements to determine if it needs to remain in the Awake state. The presence of the ATIM window in the IBSS indicates if the STA may use PS mode. To maintain correct information on the power save state of other STAs in an IBSS, a STA needs to remain awake during the ATIM window. At other times the STA may enter the Doze state except as indicated in the following procedures.

When a BU is to be transmitted to a destination STA that is in a PS mode, the transmitting STA first transmits an ATIM frame during the ATIM Window, in which all the STAs including those operating in a PS mode are awake. The ATIM Window is defined as a specific period of time, defined by the value of the ATIM Window parameter in the IBSS Parameter Set supplied to the MLME-START.request primitive, fol-lowing a TBTT, during which only RTS, CTS, or ACK Control frames; Beacon or ATIM management frames; or (QoS) Null data frames shall be transmitted. ATIM transmission times are randomized, after a Beacon frame is either transmitted or received by the STA, using the backoff procedure with the CW equal to aCWmin. Individually addressed ATIMs shall be acknowledged. If a STA transmitting an individually addressed ATIM does not receive an acknowledgment, the STA shall execute the backoff procedure for retransmission of the ATIM. Group addressed ATIMs shall not be acknowledged.

If a STA receives an individually addressed ATIM frame during the ATIM Window, it shall acknowledge the individually addressed ATIM and stay awake to receive the announced BUs for the entire beacon interval or until it has completed successful transmission to and reception from the source STA of the received ATIM, a frame with EOSP field equal to 1. If a STA does not receive an ATIM, it may enter the Doze state at the end of the ATIM Window. Transmissions of BUs announced by ATIMs are randomized after the ATIM Window, using the backoff procedure described in Clause 9 (MAC sublayer functional description).

It is possible that an ATIM may be received from more than one STA, and that a STA that receives an ATIM may receive more than a single BU from the transmitting STA. ATIM frames are only addressed to the destination STA of the BU.

An ATIM for a BU shall have a destination address identical to that of the BU.

After the ATIM interval, only individually addressed BUs that have been successfully announced with an acknowledged ATIM and group addressed BUs that have been announced with an ATIM shall be transmitted to STAs in the PS mode. These frames shall be transmitted using the DCF (for non-QoS STAs) or EDCAF (for QoS STAs).

**Error! Reference source not found.** illustrates the basic PS operation.

The estimated power-saving state of another STA may be based on the power management information transmitted by that STA and on additional information available locally, such as a history of failed transmission attempts. The use of RTS/CTS in an IBSS may reduce the number of transmissions to a STA that is in PS mode. If an RTS is sent and a CTS is not received, the transmitting STA may assume that the destination STA is in PS mode. The method of estimating the power management state of other STAs in the IBSS is outside the scope of this standard.

* Initialization of power management within an IBSS

The following procedure shall be used to initialize power management within a new IBSS, or to learn about the power management being used within an existing IBSS:

* A STA joining an existing IBSS by the procedure in **Error! Reference source not found.** shall update its ATIM Window with the value contained in the ATIM Window field of the IBSS Parameter Set element within the Beacon or Probe Response management frame received during the scan procedure.
* A STA creating a new IBSS by the procedure in **Error! Reference source not found.** shall set the value of the ATIM Window field of the IBSS Parameter Set element within the Beacon management frames transmitted to the value of its ATIM Window.
* The start of the ATIM Window shall be the TBTT, defined in **Error! Reference source not found.**. The end of the ATIM Window shall be defined as

TSF timer MOD dot11BeaconInterval = ATIMWindow, where ATIMWindow is the value of the ATIM Window parameter of the IBSS Parameter Set from the MLME-START.request or MLME-JOIN.request primitives.

* The ATIM Window period shall be static during the lifetime of the IBSS.
* An ATIM Window value of 0 shall indicate that power management is not usable within the IBSS.
* STA power state transitions

A STA may enter PS mode if the value of the ATIM window in use within the IBSS is greater than 0. A STA shall not enter PS mode if the value of the ATIM window in use within the IBSS is equal to 0. A STA shall set the Power Management subfield in the Frame Control field of frames containing all or part of a BU or individually addressed Probe Request frame that it transmits using the rules in 8.2.4.1.7 (Power Management field).

A STA in PS mode shall transition between Awake and Doze states according to the following rules:

* If a STA is operating in PS mode, it shall enter the Awake state prior to each TBTT.
* If a STA receives a group addressed ATIM management frame during the ATIM Window, the STA shall remain in the Awake state until either the STA receives a group addressed frame from the source STA with the EOSP field equal to 1 or the end of the next ATIM Window, whichever occurs first.
* If a STA receives at least one individually addressed ATIM management frame containing the STA’s individual address in the RA field during the ATIM Window then the STA shall remain in the Awake state at least until the earlier of the completion of the successful transmission to and reception from the source STA of each received ATIM, a frame with EOSP field equal to 1, and the end of the next ATIM Window.
* If a STA transmits at least one individually addressed ATIM management frame containing a STA’s individual address in the RA field during the ATIM Window then the STA shall remain in the Awake state at least until the earlier of the completion of the successful transmission to and reception from the destination STA of each transmitted ATIM, a frame with EOSP field equal to 1, and the end of the next ATIM Window.
* If a STA transmits a Beacon, the STA shall remain in the Awake state until the end of the next ATIM Window.
* If the STA has not transmitted an ATIM and does not receive either an individually addressed ATIM management frame containing the STA’s individual address, or a group addressed ATIM management frame during the ATIM Window, the STA may return to the Doze state following the end of the current ATIM Window.
* ATIM and frame transmission

If power management is in use within an IBSS, all STAs shall buffer individually addressed BUs for STAs that are known to be in PS mode. BUs may be sent to STAs in Active mode at any valid time.

The following rules describe operation of the ATIM and frame transmission to STAs in PS mode in an IBSS:

* Following the reception or transmission of the Beacon frame, during the ATIM Window, the STA shall transmit an individually addressed ATIM management frame to each STA for which it has one or more buffered individually addressed BUs. If the STA has one or more buffered group addressed MSDUs (excluding those with a service class of StrictlyOrdered) or has one or more buffered group addressed MMPDUs, it shall transmit an appropriately addressed group addressed ATIM frame.
* All STAs shall use the backoff procedure defined in 9.3.4.3 (Backoff procedure for DCF) for transmission of the first ATIM following the Beacon frame. All remaining ATIMs shall be transmitted using the conventional DCF access procedure.
* ATIM management frames shall be transmitted only during the ATIM Window.
* A STA shall transmit no frame types other than RTS, CTS, and ACK Control frames, Beacon and ATIM management frames and (QoS)Null data frames during the ATIM Window.
* Individually addressed ATIM management frames shall be acknowledged. If no acknowledgment is received, the ATIM shall be retransmitted using either the DCF (for non-QoS STAs) or the EDCAF (for QoS STAs). Group addressed ATIM man-agement frames shall not be acknowledged.
* If a STA is unable to transmit an ATIM during the ATIM Window, for example due to contention with other STAs, the STA should retain the buffered BUs and attempt to transmit the ATIM dur-ing the next ATIM Window.
* Immediately following the ATIM Window, a STA shall begin transmission of any buffered group addressed frames for which an ATIM was previously transmitted. Following the transmission of any group addressed frames, any BUs addressed to STAs for which an acknowledgment for a previously transmitted ATIM frame was received shall be transmitted. All STAs shall use the backoff procedure defined in 9.3.4.3 (Backoff procedure for DCF) for transmission of the first frame following the ATIM Window. All remaining frames shall be transmitted using either the DCF (for non-QoS STAs) or the EDCAF (for QoS STAs).
* If a buffered BU is transmitted using fragmentation and if the BU has been partially transmitted when the next Beacon frame is sent, the STA shall retain the buffered BU and announce the remaining fragments by transmitting an ATIM during the next ATIM Window.
* If a STA is unable to transmit a buffered BU during the beacon interval in which it was announced, for example due to contention with other STAs, the STA shall retain the buffered BU and announce the BU again by transmitting an ATIM during the next ATIM Window.
* Following the transmission of all buffered BUs, a STA may transmit BUs without announcement to STAs that are known to be in the Awake state for the current beacon interval.
* A STA may discard BUs buffered for later transmission to power-saving STAs if the STA determines that the BU has been buffered for an excessive amount of time or if other conditions internal to the STA implementation make it desirable to discard buffered BUs (e.g., buffer starvation). A BU should not be discarded that has been buffered for less than dot11BeaconPeriod. The algorithm to manage this buffering is beyond the scope of this standard.
* A STA may transmit individually addressed or group addressed Null data frames within the ATIM window to indicate the STA’s intent to change power management modes. The STA may transition into PS mode after acknowledgements have been successfully received for all individually addressed Null data frames or after the STA has transmitted group addressed Null data frames at least dot11BSSBroadcastNullCount times.
* Power management in an MBSS

Power management in an MBSS is described in 13.14 (Power save in a mesh BSS).

* MLME mesh procedures
* Power save in a mesh BSS
* General

A mesh STA may use mesh power modes to reduce its power consumption. A mesh STA manages each of its mesh peerings with a peer-specific mesh power mode as described in Peer-specific mesh power modes. A mesh STA may set the mesh power mode for a mesh peering independently of the mesh power modes for its other mesh peerings. A mesh STA also manages a nonpeer mesh power mode as described in Nonpeer mesh power modes. When a mesh STA is in light sleep mode or in deep sleep mode for a mesh peering, the mesh STA shall maintain its mesh awake window as described in Mesh awake window.

A mesh STA shall have the capability to buffer frames and to perform mesh power mode tracking for the peer-specific mesh power modes of its peer mesh STAs, as described in Power save support. A mesh STA shall use mesh peer service periods for individually addressed frame transmissions to neighbor peer mesh STAs that are either in light sleep mode or in deep sleep mode towards this mesh STA, as described in Mesh peer service periods. A mesh STA transmits group addressed frames after the Beacon frame containing DTIM when any of its peer mesh STAs is in light sleep mode or deep sleep mode for the mesh peering with the mesh STA (see TIM transmissions in an MBSS and TIM types). These capabilities are referred to as support for power save.

* Mesh power modes
* General

A mesh STA is in one of two different power states, Awake or Doze, as defined in 10.2.1.2 (STA Power Management modes).

The manner in which a mesh STA transitions between power states is determined by its peer-specific mesh power modes and its nonpeer mesh power mode. A mesh STA shall be in Awake state if any of the conditions specified in Conditions for Doze state is not fulfilled. A mesh STA maintains peer-specific mesh power modes for each of its mesh peerings as described in Peer-specific mesh power modes. A mesh STA may have a different peer-specific mesh power mode for each mesh peering. A mesh STA maintains a nonpeer mesh power mode for nonpeer mesh STAs that is described in Nonpeer mesh power modes. An example illustration of the use of peer specific and nonpeer mesh power modes is shown in An example of mesh power mode usage.

|  |
| --- |
|  |
| * An example of mesh power mode usage |

* Peer-specific mesh power modes

The peer-specific mesh power mode specifies the activity level of the mesh STA for the corresponding mesh peering. Three mesh power modes are defined: active mode, light sleep mode, and deep sleep mode. The peer-specific mesh power modes are defined as follows:

* *Active mode:* The mesh STA shall be in Awake state all the time.
* *Light sleep mode:* The mesh STA alternates between Awake and Doze states, as specified in Operation in light sleep mode for a mesh peering. The mesh STA shall listen to all the Beacon frames from the corresponding peer mesh STA.
* *Deep sleep mode:* The mesh STA alternates between Awake and Doze states, as specified in Operation in deep sleep mode for a mesh peering. The mesh STA may choose not to listen to the Beacon frames from the corresponding peer mesh STA.

The combination of the Power Management subfield in the Frame Control field and the Mesh Power Save Level subfield in the QoS Control field contained in Mesh Data frames indicates the peer-specific mesh power mode as shown in the Peer-specific mesh power mode definition .

|  |  |  |  |
| --- | --- | --- | --- |
| * Peer-specific mesh power mode definition | | | |
| Activity level | Peer-specific mesh power mode | Power Management  field | Mesh Power Save Level subfield |
| Highest  Lowest | Active mode | 0 | Reserved |
| Light sleep mode | 1 | 0 |
| Deep sleep mode | 1 | 1 |

* Nonpeer mesh power modes

The nonpeer mesh power mode indicates the mesh power mode of the mesh STA toward the nonpeer mesh STAs. Two nonpeer mesh power modes are defined: active mode and deep sleep mode. The nonpeer mesh power mode is indicated by the Power Management subfield in the Frame Control field in group addressed frames, management frames transmitted to nonpeer neighbor STAs, and in Probe Response frames. When the Power Management subfield in the Frame Control field is set to 1, the nonpeer mesh power mode is deep sleep mode. When the Power Management subfield in the Frame Control field is set to 0, the nonpeer mesh power mode is active mode.

A mesh STA may send Probe Request and Mesh Peering Open Request frames to a nonpeer mesh STA that sets its nonpeer mesh power mode to deep sleep mode only during the mesh awake window of the mesh STA.

* Mesh power mode indications and transitions
* General

When a mesh STA is in active mode for a mesh peering, it shall set the Power Management subfield in the Frame Control field to 0 in all individually addressed Mesh Data or QoS Null frames transmitted to the corresponding peer mesh STA.

When a mesh STA is in light sleep mode for a mesh peering, it shall set the Power Management subfield in the Frame Control field to 1 and the Mesh Power Save Level subfield in the QoS Control field to 0 in all individually addressed Mesh Data or QoS Null frames transmitted to the corresponding peer mesh STA.

When a mesh STA is in deep sleep mode for a mesh peering, it shall set the Power Management subfield in the Frame Control field to 1 and the Mesh Power Save Level subfield in the QoS Control field to 1 in all individually addressed Mesh Data or QoS Null frames transmitted to the corresponding mesh STA.

When a mesh STA is in deep sleep mode for any of its mesh peerings, the Mesh Power Save Level subfield in the QoS Control field in group addressed Mesh Data frames and the Mesh Power Save Level subfield in the Mesh Capability field in the Mesh Configuration element shall be set to 1. When a mesh STA is not in deep sleep mode for any of its mesh peerings, these subfields shall be set to 1.

To change peer-specific mesh power modes, a mesh STA shall inform its peer mesh STAs through a successful frame exchange initiated by the mesh STA. The Power Management subfield in the Frame Control field and the Mesh Power Save Level subfield in the QoS Control field of the frame sent by the mesh STA in this exchange indicates the peer-specific mesh power mode that the STA shall adopt upon successful completion of the entire frame exchange.

The algorithm to trigger the change of a peer-specific mesh power mode is beyond the scope of this standard.

The nonpeer mesh power mode is determined by the peer-specific mesh power modes of the mesh STA. When a mesh STA is in light sleep mode or deep sleep mode for at least one mesh peering, it shall set the nonpeer mesh power mode to deep sleep mode.

When a mesh STA is in active mode for nonpeer STAs, it shall set the Power Management subfield in the Frame Control field to 0 in group addressed frames, in management frames transmitted to nonpeer mesh STAs, and in Probe Response frames.

When a mesh STA is in deep sleep mode for nonpeer STAs, it shall set the Power Management subfield in the Frame Control field to 1 in group addressed frames, in management frames transmitted to nonpeer mesh STAs, and in Probe Response frames.

* Transition to a higher activity level

A mesh STA may use group addressed or individually addressed Mesh Data or QoS Null frames to change its mesh power mode to a higher activity level, for example; from deep sleep to light sleep or to active mode; or from light sleep to active mode.

Individually addressed frames may be used to temporarily raise the activity level of the mesh STA for a mesh peering. This is useful in cases when a link temporarily requires efficient data transmission with the peer mesh STA and the mesh STA desires to be able to transit back to lower activity level without performing the mesh power mode transition signaling with all peer mesh STAs.

* Transition to a lower activity level

A mesh STA shall use acknowledged individually addressed Mesh Data or QoS Null frames to change its peer-specific mesh power mode to a lower activity level, for example; from active mode to light or deep sleep mode; or from light sleep to deep sleep mode.

* TIM transmissions in an MBSS

The TIM element identifies the peer mesh STAs for which traffic is pending and buffered in the reporting mesh STA. This information is coded in a partial virtual bitmap, as described in 8.4.2.7 (TIM element). In addition, the TIM contains an indication whether group addressed traffic is pending. Every neighbor peer mesh STA is assigned an AID by the reporting mesh STA as part of the mesh peering establishment process (see **Error! Reference source not found.**). The mesh STA shall identify those peer mesh STAs for which it is prepared to deliver buffered MSDUs and MMPDUs by setting bits in the TIM's partial virtual bitmap that correspond to the appropriate AIDs.

* TIM types

There are two different TIM types: TIM and DTIM. A mesh STA shall transmit a TIM with every Beacon frame. Every DTIMPeriod, a TIM of type DTIM is transmitted with a Beacon frame. After transmitting a Beacon containing a DTIM, the mesh STA shall send the buffered group addressed MSDUs and MMPDUs, before transmitting any individually addressed frames. The More Data field of each group addressed frame shall be set to indicate the presence of further buffered group addressed MSDUs and MMPDUs. The mesh STA sets the More Data field to 0 in the last transmitted group addressed frame following the transmission of the DTIM Beacon.

When a mesh STA expects to receive a group addressed frame and CCA is IDLE for the duration of the PHY specific Group Delivery Idle Time, the receiving mesh STA may assume that no more frames destined to group addresses will be transmitted and may return to Doze state. The Group Delivery Idle Time is identical to the TXOP Limit for AC\_VI specified by the default EDCA Parameter Set shown in Table 8-106 (Default EDCA Parameter Set element parameter values if dot11OCBActivated is false).

* Mesh awake window

A mesh STA shall be in Awake state when its mesh awake window is active. A mesh awake window is active after the Beacon and Probe Response frames containing the Mesh Awake Window element. A mesh STA shall include the Mesh Awake Window element in its DTIM Beacon frames and may include the Mesh Awake Window element in its TIM Beacon and Probe Response frames. A mesh STA that operates in light sleep mode or deep sleep mode for any of its mesh peerings shall include the Mesh Awake Window element in its Beacon frame if the Beacon frame indicates buffered traffic for at least one peer mesh STA. The start of the mesh awake window is measured from the end of the Beacon or Probe Response transmission. The duration of the mesh awake window period is specified by dot11MeshAwakeWindowDuration. A mesh STA shall set the Mesh Awake Window field in the Mesh Awake Window element to dot11MeshAwakeWindowDuration. If the Mesh Awake Window element is not contained in the Beacon frame of a mesh STA, the duration of the mesh awake window period following this beacon is zero.

If the mesh STA that has its mesh awake window active transmits frames destined to group addresses, the duration of the mesh awake window is extended by an additional PostAwakeDuration. The PostAwakeDuration follows the group address frame, and the mesh STA that has its mesh awake window active shall stay in Awake state until it has transmitted all of its group addressed frames and the PostAwakeDuration has expired. The PostAwakeDuration is equal to duration of the mesh awake window.

A mesh STA may send a frame to a peer mesh STA that is in light sleep mode or deep sleep mode for the corresponding mesh peering during the mesh awake window of this peer mesh STA. When a peer trigger frame is successfully transmitted it initiates a mesh peer service period as described in Mesh peer service periods.

A mesh STA may send class 1 or class 2 frames, such as Probe Request or Mesh Peering Open frames, to a nonpeer mesh STA that is in deep sleep mode for nonpeer mesh STAs during the mesh awake window of this nonpeer mesh STA.

* Power save support

As described in Mesh power modes, a mesh STA indicates its peer-specific mesh power modes and performs mesh power mode tracking of the peer-specific mesh power modes of its peer mesh STAs. A mesh STA shall not arbitrarily transmit frames to mesh STAs operating in a light or deep sleep mode, but shall buffer frames and only transmit them at designated times.

A mesh STA shall only transmit frames to a mesh STA operating in a light or deep sleep mode if the recipient mesh STA is in the Awake state as defined in Operation in light sleep mode for a mesh peering, Operation in deep sleep mode for a mesh peering, and Mesh peer service periods; otherwise, the mesh STA shall buffer frames.

As described in TIM transmissions in an MBSS, a mesh STA indicates the presence of buffered traffic in TIM elements for all peer mesh STAs that operate in light or deep sleep mode towards the mesh STA. The mesh STA sets the bit for AID 0 (zero) in the bit map control field of the TIM element to 1 when group addressed traffic is buffered, according to 8.4.2.7 (TIM element). As described in TIM types, a mesh STA transmits its group addressed frames after its DTIM Beacon if any of its peer mesh STA is in light or deep sleep mode towards the mesh STA.

As described in Mesh peer service periods, mesh peer service periods are used for frame transmissions towards a mesh STA that operates in light or deep sleep mode. Mesh peer service periods are not used in frame exchanges towards active mode mesh STAs.

A mesh STA may initiate a mesh peer service period with a peer mesh STA in deep or light sleep mode by transmitting a peer trigger frame when the mesh awake window of the peer mesh STA is active.

* Operation in peer-specific and nonpeer mesh power modes
* General

Detailed operations of mesh STA in each mesh power mode are described in the following subclauses. **Error! Reference source not found.** depicts example power state transitions of mesh STAs, when three mesh STAs are in the mesh power modes shown in the An example of mesh power mode usage.

* Operation in active mode

When a mesh STA is in active mode for a mesh peering or for nonpeer mesh STAs, it shall be in Awake state. Mesh peer service periods are not used in frame exchanges towards mesh STAs that are in active mode.

An active mode mesh STA may receive peer trigger frames from a peer mesh STA in light or deep sleep mode when there is no mesh peer service period ongoing between the peer mesh STAs.

* Operation in deep sleep mode for nonpeer mesh STAs

If a mesh STA is in deep sleep mode for nonpeer mesh STAs, it shall enter the Awake state prior to every TBTT of its own and shall remain in Awake state after the beacon transmission for the duration of the mesh awake window and the duration of its group addressed frame transmissions. The mesh STA may receive frames during its mesh awake window as described in Mesh awake window.

When receiving a frame initiating a mesh peering management procedure, an authentication procedure, or a passive scanning procedure, a mesh STA in deep sleep mode for nonpeer mesh STAs shall operate in Awake state at least until the completion of the mesh peering management procedure (see **Error! Reference source not found.** and **Error! Reference source not found.**), until the completion of the authentication procedure (see **Error! Reference source not found.** and **Error! Reference source not found.**), or the transmission of the Probe Response frame.

If a mesh STA receives a peer trigger frame initiating a mesh peer service period from a peer mesh STA, the mesh STA shall remain in Awake state until the mesh peer service period is terminated as defined in Termination of a mesh peer service period.

A mesh STA may return to Doze state after its mesh awake window if no frame initiating a response transaction or a mesh peer service period is received during the mesh awake window.

* Operation in light sleep mode for a mesh peering

If a mesh STA is in light sleep mode for a mesh peering, it shall enter the Awake state prior to every TBTT of the corresponding peer mesh STA to receive the Beacon frame from the peer mesh STA. The mesh STA may return to the Doze state after the beacon reception from this peer mesh STA, if the peer mesh STA did not indicate buffered individually addressed or group addressed frames. If an indication of buffered individually addressed frames is received, the light sleep mode mesh STA shall send a peer trigger frame with the RSPI field set to 1 to initiate a mesh peer service period with the mesh STA that transmitted the Beacon frame (see Initiation of a mesh peer service period). If an indication of buffered group addressed frames is received, the light sleep mode mesh STA shall remain in Awake state after the DTIM Beacon reception to receive group addressed frames The mesh STA shall remain Awake state until the More Data field of a received group addressed frame is set to 0 or if no group addressed frame is received within the PHY specific Group Delivery Idle Time. (See TIM types.)

NOTE—When a mesh STA is in light sleep mode for a mesh peering, it sets its nonpeer mesh power mode to deep sleep mode. This implies that a mesh STA operating in light sleep mode a mesh peering is required to conform to the rules described in Operation in deep sleep mode for nonpeer mesh STAs.

* Operation in deep sleep mode for a mesh peering

A mesh STA operating in deep sleep mode for a mesh peering might not receive Beacon frames from the corresponding peer mesh STA. The logic of how the mesh STA in deep sleep mode maintains synchronization among neighbors is beyond the scope of this standard. Guidance for the synchronization maintenance by the mesh STA in deep sleep mode is given in W.3.6 (Synchronization maintenance of mesh STAs in deep sleep mode).

NOTE—When a mesh STA is in deep sleep mode for a mesh peering, it sets its nonpeer mesh power mode to deep sleep mode. This implies that a mesh STA operating in deep sleep mode for a mesh peering is required to conform to the rules described in Operation in deep sleep mode for nonpeer mesh STAs.

* Conditions for Doze state

A mesh STA may enter Doze state if all of the following conditions are fulfilled:

* The mesh STA operates in light sleep mode or deep sleep mode for all of its mesh peerings, as described in Operation in light sleep mode for a mesh peering or Operation in deep sleep mode for a mesh peering
* The mesh STA has no mesh peer service period ongoing, as described in Mesh peer service periods
* The mesh STA has no pending transaction of mesh peering management, authentication, nor passive scanning (see Operation in deep sleep mode for nonpeer mesh STAs)
* The mesh awake window indicated by the mesh STA has expired, as described in Mesh awake window
* The mesh STA has terminated its group addressed frames delivery sequence after its DTIM Beacon, as described in TIM types

Guidance for using the power save in mesh BSS and default parameter values are given in W.3 (Power save parameters selection).

* Mesh peer service periods
* General

Mesh peer service periods are used for individually addressed frame exchanges between neighbor peer mesh STAs in which at least one of the mesh STAs is in light or deep sleep mode for the corresponding mesh peering. A mesh peer service period is a contiguous period of time during which one or more individually addressed frames are transmitted between two peer mesh STAs. Within a mesh peer service period, a mesh STA may obtain multiple TXOPs. A mesh peer service period is directional. One mesh STA is the owner of the mesh peer service period. It obtains TXOPs in order to transmit Data frames or Management frames to the recipient in the mesh peer service period. At the end of the frame transmissions, the owner of the mesh peer service period terminates the mesh peer service period. The other mesh STA operates as the recipient of the mesh peer service period and does not obtain TXOPs for transmitting Data frames or Management frames to the owner of the mesh peer service period. A mesh STA may have multiple mesh peer service periods concurrently toward multiple neighbor peer mesh STAs. At most, one mesh peer service period is set up in each direction with each peer mesh STA.

A mesh peer service period is initiated by a peer trigger frame. A peer trigger frame may initiate two mesh peer service periods. This enables both the transmitter and the receiver of the peer trigger frame to become the owner of a mesh peer service period. An example mesh peer service period between two mesh STAs in light or deep sleep mode is shown in Mesh peer service period. The numbering on the left-hand-side describes the phase of the operation: 1 indicates the Initiation phase, 2 indicates the data transmission phase, and 3 indicates the termination phase of the mesh peer service period.

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| * Mesh peer service period |

* Initiation of a mesh peer service period

A Mesh Data frame or a QoS Null frame that requires acknowledgement are used as a peer trigger frame. The RSPI and the EOSP subfields in the QoS Control field control the initiation of a mesh peer service period. Mesh peer service period triggering with RSPI and EOSP field combinations in lists how mesh peer service periods shall be initiated with different combinations of RSPI and EOSP field values.

Mesh peer service periods are not used in frame transmissions toward active mode mesh STAs.

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| * Mesh peer service period triggering with RSPI and EOSP field combinations in peer trigger frame | | |
| RSPI | EOSP | Mesh peer service period triggering |
| 0 | 0 | One mesh peer service period is initiated. The transmitter of the trigger frame is the owner in the mesh peer service period. |
| 0 | 1 | No mesh peer service period is initiated. |
| 1 | 0 | Two mesh peer service periods are initiated. Both mesh STAs are owners in a mesh peer service period. |
| 1 | 1 | One mesh peer service period is initiated. The receiver of the trigger frame is the owner in the mesh peer service period. |

The mesh peer service period may be initiated in the following cases:

* A mesh STA in light or deep sleep mode receives a peer trigger frame during its mesh awake window as described in Mesh awake window
* A mesh STA in active mode receives a peer trigger frame from the peer mesh STA in light or deep sleep mode as described in Operation in active mode
* A mesh STA receives a peer trigger frame from the peer mesh STA in light sleep mode as described in Operation in light sleep mode for a mesh peering

In addition, when a mesh STA uses MCCA with a neighbor peer mesh STA while in a light sleep mode for the corresponding mesh peering, a scheduled service period begins at the each MCCAOP start time as described in MCCA use by power saving mesh STA. A mesh STA in a light or deep sleep mode shall enter the Awake state prior to the start time of scheduled service period.

* Operation during a mesh peer service period

During the mesh peer service period, the owner and the recipient of the mesh peer service period shall operate in Awake state. The mesh peer service period may contain one or more TXOPs.

Reverse Direction Grant (RDG) shall not be used when the receiver of the TXOP operates in light or deep sleep mode for the link and there is no mesh peer service period ongoing toward the TXOP holder.

* Termination of a mesh peer service period

The mesh peer service period is terminated after a successfully acknowledged QoS Null or Mesh Data frame with the EOSP subfield set to 1 from the owner of the mesh peer service period.

If the mesh STA does not receive an acknowledgement to a frame that requires an acknowledgement and that is sent with the EOSP subfield set to 1, the mesh STA shall retransmit that frame at least once within the same mesh peer service period—subject to applicable retry or lifetime limit. The maximum number of retransmissions within the same mesh peer service period is the lesser of the Max Retry Limit and the MIB attribute dot11MeshSTAMissingAckRetryLimit.

NOTE—If an Ack to the retransmission of this last frame in the same mesh peer service period is not received, the mesh STA might use the next mesh peer service period to further retransmit that frame subject to the applicable retry or lifetime limit.

* MCCA use by power saving mesh STA

When dot11MCCAActivated is true and the mesh STA establishes MCCAOPs, the mesh STA shall be in active mode or light sleep mode towards the neighbor peer mesh STAs with which it has established MCCAOPs.

A scheduled mesh peer service period begins at the MCCAOP start time, if the MCCAOP responder operates in light sleep mode for the MCCAOP owner. The MCCAOP owner is the owner of the scheduled mesh peer service period. The MCCAOP responder is the recipient of the scheduled mesh peer service period. Scheduled mesh peer service periods are not used if the MCCAOP responder is in active mode for the MCCAOP owner.

The scheduled mesh peer service period continues until it is successfully terminated by the acknowledged QoS Null or Mesh Data frame with the EOSP subfield set to 1 from the owner of the mesh peer service period to the recipient of the mesh peer service period as described in Mesh peer service periods.

## Proposed resolution

86, 89, 119, 120, 121 and 122: REVISED. See Proposed changes in 12/1199r$last\_revision, which agree in principle with the commenter.