IEEE P802.11  
Wireless LANs

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| DMG Power Save Corrections | | | | |
| Date: 15 July 2015 | | | | |
| Author(s): | | | | |
| Name | Affiliation | Address | Phone | email |
| Payam Torab | Broadcom Corporation |  |  | [ptorab@broadcom.com](mailto:ptorab@broadcom.com) |
| Solomon Trainin | Intel Corporation |  |  | [solomon.trainin@intel.com](mailto:solomon.trainin@intel.com) |
| Carlos Cordeiro | Intel Corporation |  |  | [carlos.cordeiro@intel.com](mailto:carlos.cordeiro@intel.com) |
| Erez Kirshenbaum | Qualcomm |  |  | [erezk@qti.qualcomm.com](mailto:erezk@qti.qualcomm.com) |
| Mordechay Aharon | Qualcomm |  |  | [maharon@qti.qualcomm.com](mailto:maharon@qti.qualcomm.com) |

### ****Abstract****

In DMG networks, the PCP is required to announce the time of transition to PCP Power Save (PPS) mode by including a DMG Wakeup Schedule element in DMG Beacon or Announce frames for a minimum of dot11MaxLostBeacons times before the transition. This requirement limits how soon the PCP can enter the PPS mode from the time a decision is made at the PCP SME; it also increases the number of required PCP Doze BIs (resulting in larger application-level latency) when trying to meet a certain power consumption target for the PCP.

This document explains that advertisements of the DMG Wakeup Schedule element over dot11MaxLostBeacons can be shortened if reception of the element by each associated non-PCP STA has been confirmed through unicast delivery. It also demonstrates that the PCP can attempt to enter the PPS mode in as early as the subsequent beacon interval as long as it can track the delivery of the DMG Wakeup Schedule element and upstream traffic (non-PCP STA to PCP) on a per-STA basis.

Other editorial corrections and clarifications related to DMG power management are also included; in particular, selected text from three previous submissions to TGm (with no corresponding CID) are integrated into this document,

11-15-0254-01-000m-802-11ad-non-pcp-sta-power-management-clarifications.docx

11-15-0255-01-000m-802-11ad-pcp-power-management-clarifications.docx

11-15-0256-01-000m-802-11ad-atim-frame-usage-clarifications.docx

The document is submitted as proposed resolution to CID 3263, CID 5989, CID 5005, CID 5006, CID 5007, CID 5008, and CID 5009.

### ****Revision History****

Rev 0: Initial revision

### ****Background****

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| CID | Page | Clause | Comment | Proposed change |
| 3263 | 1567.58 | 10.2.6.3 | "To enter PS mode, the PCP shall announce the start of the first PCP Doze BI and the length of the PCP sleep interval through the Wakeup Schedule element and include this element within DMG Beacon frame. The Wakeup Schedule element shall be transmitted at least dot11MaxLostBeacons times before the PCP goes into PS mode."  PCP should also be able to announce the Doze BI schedule through Announce frames with acknowledgement, and hence a more aggressive (shorter) advertise cycle than broadcasting through beacons. |  |
| 5989 | 1584.38 | 10.2.6.3 | "To enter PPS mode, the PCP shall announce the start of the first PCP Doze BI and the length of the PCP sleep interval through the DMG Wakeup Schedule element and include this element within DMG Beacon or Announce frames. The DMG Wakeup Schedule element shall be transmitted at least dot11MaxLostBeacons times before the PCP goes into PS mode."  (1) PCP doze schedule should be periodic so it will not need constant announcements, except when making a change.  (2) Advertising the DMG Wakeup Schedule element for dot11MaxLostBeacons is not necessary if the PCP has confirmed that all intended recipients (i.e., all associated non-PCP STAs) have received the DMG Wakeup Schedule element.  (3) There is opportunity to use the Awake Window element as part of power save schedule to influence the Awake Window length. |  |
| 5006 | 1580 | 10.2.6.1 | Power state for a CBAP allocation and for an Awake Window time are not defined when a STA resides in Awake BI | Definition is presented in 11-15-0254-01-000m 802 11ad non-PCP STA Power management clarifications |
| 5007 | 1583 | 10.2.6.2.3 | There is requirement that STA shall be awake in Awake window but in no place delivery of the Awake Window element is defined. | Propose delivering the Awake Window element by a PSC-REQ frame and a PSC-RSP frame the same way as a WSE is delivered. Definition is presented in 11-15-0254-01-000m 802 11ad non-PCP STA Power management clarifications |
| 5008 | 1009 | 8.4.2.130 | Existent definition of WSE for PCP makes the PPS mode non periodical with only Doze BI's presented in PPS mode with no way to wake the PCP up in BI's with CBAP only subfield set to 1 where ATI does not exist. | Proposed changes unify PPS mode and non-PCP STA PS mode. Definition is presented in 11-15-0255-01-000m 802.11ad PCP Power management clarifications |
| 5009 | 1586 | 10.2.6.4 | One more case of a CBAP is missed that is scheduled by CBAP Only field is set to one in the DMG Parameters field. | Add the missed case and provide references to an Awake window delivery. Definition is presented in 11-15-0256-00-000m 802.11ad ATIM frame usage clarifications |

### ****Discussion****

According to Section 10.2.6.3 (PCP Power management mode), "To enter PPS mode, the PCP shall announce the start of the first PCP Doze BI and the length of the PCP sleep interval through the DMG Wakeup Schedule element and include this element within DMG Beacon or Announce frames. The DMG Wakeup Schedule element shall be transmitted at least dot11MaxLostBeacons times before the PCP goes into PS mode."

This contribution proposes corrections, extensions and clarifications to the above paragraph,

1. [Correction/Extension] While non-PCP and non-AP STAs can establish a periodic wake up schedule (with periodicity a power-of-two multiple of beacon intervals), according to the current text PCP cannot establish a periodic wake up schedule (WS), and instead needs to constantly advertise a new set of Awake and Doze BI. We suggest to make the periodic wakeup schedule also applicable to non-AP and non-PCP STAs, and to use a common definition of the DMG Wakeup Schedule element (referred to as DWS element for short) to describe WS for all non-AP STAs.
2. [Clarification/Extension] the “BI Start Time” field in the DWS element that communicates the wakeup schedule may point to a TBTT in the past or future. We propose a valid range for the field at transmit and clarify how to interpret the value of the field at receive. In particular, by limiting the range of the field values at transmission we create a cushion time (proposed as 60 seconds) during which the receiver of the field can still unambiguously tell past from the future by using circular 32-bit (mod 232) arithmetic.
3. [Extension] The PCP can transmit a DWS element through frame subtypes other than DMG Beacon or Announce, including Information Request, Information Response, FST Setup Request, FST Setup Response, ADDTS Request and ADDTS Response. While DMG Beacon and Announce frames are the most common way to communicate a DWS element, these frame subtypes can be opportunistically used by the PCP. For example, the PCP may use an unsolicited Information Response transmitted in the context of listing all associated STAs to also carry a DWS element indicating an upcoming set of PCP Doze BIs. Unicast frames that are acknowledged by the receiving STA are an attractive alternative to broadcast DMG Beacon frames.
4. [Extension] The intention behind advertising the DWS element for a minimum of dot11MaxLostBeacons times is to maximize the likelihood that all associated STAs are aware of the PCP’s intention to enter the PPS mode. If the element is delivered through Announce or through other unicast frames that are acknowledged, and if the PCP receives confirmation that a unicast frame carrying the DWS element has been received by each associated STA, the extended announcement of the element is unnecessary. We note however that the need to advertise the element for over least dot11MaxLostBeacons beacon intervals is still present with unicast delivery, as long as the PCP has not received an acknowledgement from at least one associated STA.

1. [Clarification] A PCP implementation may satisfy the requirement “The DWS element shall be transmitted at least dot11MaxLostBeacons times before the PCP goes into PPS mode” by transmitting the element through multiple DMG Beacon frames during the same beacon interval (or over fewer beacon intervals than dot11MaxLostBeacons). We doubt if this has been the intention of the text, and in the interest of spreading the broadcast transmissions over time, propose to clarify this requirement when applied to broadcast transmissions as “transmission over at least dot11MaxLostBeacons beacon intervals”, subject to the relaxation in (2). Note the dot11MaxLostBeacons beacon intervals in the requirement do not need to be contiguous.
2. [Extension] A convenient conclusion from “advertising the DWS element for at least dot11MaxLostBeacons times before entering the PPS mode” is that the PPS mode cannot be entered sooner than dot11MaxLostBeacons beacon intervals once a decision is made at the PCP SME. This conclusion is based on two additional assumptions,

(A) No Doze BI can be used to advertise the DWS element (i.e., beginning of the next PPS entry cannot be advertised while in PPS mode), and

(B) The BI Start Time field in all transmitted DWS element points to a time in the future.

Neither of these assumptions needs to hold in general, and in fact they may increase the application-level latency as discussed below.

Figure 1 illustrates a simple interpretation of “advertising the DWS element for at least dot11MaxLostBeacons times before entering the PPS mode” based on the additional assumptions (A) and (B) above. We note that with this interpretation and with typical values for dot11MaxLostBeacons and dot11BeaconPeriod the transition to PPS mode requires several hundred milliseconds. When PCP finds itself having to frequently modify, cancel, or start a new WS, to achieve a desired power save duty cycle the large number of required Awake BIs to advertise the WS needs to be offset with a larger number of Doze BIs, which results in worst case application latencies of few seconds. For example, achieving a duty cycle of 25% with dot11MaxLostBeacons = 8 would require 24 PCP Doze BIs, resulting in worst case application latency of close to 2.5 seconds when dot11BeaconPeriod = 100 TU.



Figure 1 – Transition to PPS mode after announcing the DMG Wakeup Schedule element over dot11MaxLostBeacons Awake BIs

Figure 2 illustrates a more efficient interpretation of “advertising the DWS element for at least dot11MaxLostBeacons times before entering the PPS mode” by removing assumption (A). Using Doze BIs to advertise the DWS element for a new Wakeup Schedule is possible and improves the responsiveness.



Figure 2 – Transition to PPS mode after announcing the DMG Wakeup Schedule element over dot11MaxLostBeacons beacon intervals consisting of Awake and Doze BIs

Now consider that the BI Start Time field (parameter T in Figure 1 and Figure 2, which remains the same in all transmitted instances of the DWS element) does not have to point to a time (a TBTT to be exact) in future, i.e., both assumptions (A) and (B) under (5) are removed. Consider the same scenario with dot11MaxLostBeacons = 8, and further assume that the DWS element is advertised to three associated STAs - STA A, STA B and STA C - through Announce frames (or through other unicast frames that are acknowledged). For the sake of discussion, the beacon interval where the DWS element is first transmitted is numbered BI 0.

Figure 3 shows an example where transition to PPS mode is planned in 2 beacon intervals. The PCP advertises the DWS element through Announce frames sent to the 3 STAs. In this example some of the Announce frames (or acknowledgements to Announce frames) are lost, and the DWS element is delivered to STAs over 4 beacon intervals as follows,

* BI 0: PCP confirms reception by STA A, unable to confirm reception by STA B and STA C
* BI 1: PCP still unable to confirm reception by STA B and STA C
* BI 2: PCP confirms reception by STA B, unable to confirm reception by STA C
* BI 3: PCP confirms reception by STA C



Figure 3 – Transition to PPS mode before dot11MaxLostBeacons beacon intervals

In this example, BI 2 is the beginning of the new WS for PCP, which happens to be an Awake BI. Even though STA B and STA C have not confirmed the reception of the WS, PCP can proceed with the schedule as the BI is an Awake BI, and use BI 2 to attempt to deliver the WS to STA B and STA C (and successfully delivers the WS to STA B).

BI 3 is the first PCP Doze BI according to the published WS; however, since the PCP has not still confirmed reception of the WS by STA C, it will stay in active mode to make itself available to STA C as a PCP in Awake BI would be available; for example, PCP will make itself available during allocations in BI 3 with broadcast Source or Destination AID where STA C is allowed to transmit to PCP. Specifically, PCP withholds any downstream traffic targeting all STAs, and stays available to STA C for possible upstream traffic, wherever STA C has a chance to transmit in accordance with the allocation rules. During BI 3, and subsequent BIs, as long as necessary, the PCP schedules an ATI and attempts to deliver a DWS element to STA C at minimum. In this example, the PCP confirms reception of the element by STA C in BI 3, and operates the next 2 beacon intervals as PCP Doze BIs to all STAs. We note this scenario is rather pessimistic, and unicast delivery of the DWS element to a few STAs is likely successful over one or two beacon intervals, especially since unicast frames can be repeated over the same beacon interval.

In summary,

* The PCP can attempt to have a Doze BI as early as “the next BI”
* The PCP may need to stay in active mode for one or more BIs into the advertised wakeup schedule if it has been unable to confirm that all STAs that could possibly transmit to the PCP have received its DWS element
* At worst this is the same as the dot11MaxLostBeacons rule (and associated application level latency), but almost always it is more efficient; the PCP has a high chance of successfully communicating the DWS element to one or two associated STAs in one ATI period (one beacon interval) and start its PCP Doze BIs as early as the next BI, in contrast with having to wait for 4, 8 or more beacon intervals
* Generalizing the above examples, Table 1 compares the worst case latency resulting from additional assumptions (A) and (B),

Table 1 – Improvement in application latency with PCP power save

|  |  |  |
| --- | --- | --- |
| Worst case application latency in terms of number of beacon intervals for a duty cycle (ratio of Awake BIs to Awake BIs + Doze BIs) of 1/N | | Example with 1/N=0.25 and dot11MaxLostBeacons = 8 |
| Assumption (A) & Assumption (B) | (N–1) × dot11MaxLostBeacons | 24 |
| Assumption (B) only | (N–1) × dot11MaxLostBeacons / N | 6 |
| No assumption | (N–1) | 3 |

In particular, for the same PCP duty cycle of 1/N, allowing the “BI Start Time” field in the DWS element to point to a time in the past improves the worst case application latency by (1 – N/dot11MaxLostBeacons). For example, with N=4 and dot11MaxLostBbeacons = 8 improvement in latency is 1 – 4/8 = 50% (6 beacon intervals reduced to 3).

* Regarding the scope of changes and compatibility with .11ad,
* PCP implementations
  + No existing implementation is affected; .11ad rules are extended
* Non-PCP STA implementations
  + Need to be aware that the “BI Start Time” field in a received DWS element may point to a time (more accurately a TBTT) in the past – something that implementations likely have done already, as (1) .11ad does not put any requirement on the “BI Start Time” field value, and (2) a DMG STA receiving a peer STA WS through an Information Request/Response exchange often receives it in a form anchored to a past TBTT.
  + For example, an .11ad STA receiving a DWS element (perhaps for the first time) with the “BI Start Time” field pointing to 3 beacon intervals back, and the “Number of Awake/Doze BIs” field indicating 8 BIs, must be able to conclude that the PCP will be in PPS mode for the next 8 – 3 = 5 beacon intervals. The STA behavior during PCP Doze BIs remains unchanged.
* In conclusion, the essence of this generalization is that the PCP has the option to manage the distribution of the DMG Wakeup Schedule element and traffic flows on a per-STA basis to achieve efficient power save schedules without compromise on the dot11MaxLostBeacons parameter. The extra optional complexity falls on PCP implementation. All needed for interoperability is that STAs do not assume a received “BI Start Time” field in the DMG Wakeup Schedule element points to a future TBTT.

**8.3.4.2 DMG Beacon**

...

*[Editorial]*

The Next Beacon subfield indicates the number of beacon intervals following the current beacon interval during which the DMG Beacon frame will not be present.

**8.4.2.130 DMG Wakeup Schedule element**

…

*[The DMG Wakeup Schedule element definition is unified for PCP and non-PCP STAs. The BI Start Time meaning at receive is clarified using the signed/circular arithmetic to unambiguously point to past or present, with up to 60 seconds between the moment the element is transmitted and the moment it is processed (The BI Start Time is always in absolute time per 802.11ad and carries the lower 4 octets of the TSF timer). Modify the following paragraphs.]*

The Element ID and Length fields are defined in 8.4.2.1 (General).

The DMG Wakeup Schedule element is used to communicate the wakeup schedule (WS) of DMG STAs.

The BI Start Time field indicates the lower order 4 octets of the TSF timer at the start of the first Awake BI in the WS defined by the DMG Wakeup Schedule element. A transmitted BI Start Time field points to a TBTT not more than 231 microseconds minus aDMGDWSValidPeriod before, and not more than (231 – 1) microseconds after the TBTT of the beacon interval during which the BI Start Time filed is transmitted.

NOTE—The delay between the moment a STA receives a DMG Wakeup Schedule element over the air and the moment the STA interprets the value of the BI Start Time field in the element can be large, to the extent that the beacon interval during which the BI Start Time filed is interpreted is different from the the beacon interval during which the DMG Wakeup Schedule element is received. Excluding an interval from the range of BI Start Time values at transmission enables the receiving STA to be able to correctly interpret any received value for the BI Start Time field of the DMG Wakeup Schedule element belonging to a STA in PS mode without having to remember the beacon interval during which the DMG Wakeup Schedule element was received, as long as the beginning of the beacon interval at the time of interpretation has not advanced more than aDMGDWSValidPeriod relative to the beginning of the beacon interval at the time of reception.

The Sleep Cycle field indicates the sleep cycle duration in beacon intervals, i.e., the sum of Awake BIs and Doze BIs that make up the sleep cycle.

The Number of Awake BIs field indicates the number of Awake BIs at the beginning of each sleep cycle. A value of 0 for this field indicates that all BIs in the WS are Doze BIs.

*[Modify the field name in Figure 8-510—DMG Wakeup Schedule element.]*

Number of Awake BIs

*[Add new line to the Table 10-24—DMG MAC sublayer attribute values.]*

|  |  |
| --- | --- |
| aDMGDWSValidPeriod | 60 seconds |

*[Rename the Awake Window field to Awake Window Duration field to avoid having the same name for the element and one of its fields.]*

**8.4.2.136 Awake Window element**

The Awake Window element is defined as shown in Figure 8-521 (Awake Window element format).

The Element ID and Length fields are defined in 8.4.2.1 (General).

|  |  |  |  |
| --- | --- | --- | --- |
|  | Element ID | Length | Awake Window Duration |
| Octets: | 1 | 1 | 2 |

**Figure 8-521—Awake Window element format**

The Awake Window Duration field is 2 octets in length and contains the duration of the Awake Window in microseconds.

*[Editor – Rename all references to “Awake Window field” (Awake Window capitalized) to “Awake Window Duration field” – not to be mistaken with the Awake Window element.]*

**10.1.3.3.2 Beacon generation in a PBSS**

*[While in PPS mode, a PCP can skip sending Announce frames during PCP Doze BIs.]*

In a PBSS, every beacon interval shall start with a BTI or ATI, except in PCP Power Save (PPS) mode, where a PCP Doze BI may not start with a BTI or ATI.

**10.2.2 Power management in a non-DMG infrastructure network**

**10.2.2.1 General**

…

*[Editorial - Replace PM bit with Power Management bit – this is how the bit is referred to throughout the text.]*

The Power Management bit of the Frame Control field may be set to 0 or 1 within a frame sent by a STA in WNM-sleep mode.

**10.2.6.1 General**

…

*[The set “non-AP and non-PCP STAs and PCPs” is the same as “non-AP STAs”. Also 10.2.6 defines more than one power save mechanism for non-AP/non-PCP STAs and more than one power save mechanism for PCP STAs.]*

To enable non-AP STAs to sleep for one or more beacon intervals or part of a beacon interval, non-AP and non-PCP STA power save mechanisms and PCP power save mechanisms are defined in this subclause.

*[Awake and Doze power states may have little to do with power consumption – they just indicate STA availability or unavailability to transmit or receive frames]*

A STA may operate in one of two power states:

— Awake: STA is able to transmit and receive DMG frames.

— Doze: STA is not able to transmit or receive DMG frames.

The manner in which a STA transitions between these two power states shall be determined by the STA’s Power Management mode:

— Active mode: A STA is in the awake state, except that the STA can switch to doze state in an Awake

BI when the STA is allowed to doze as indicated in Table 10-3 (Power states for an Awake BI).

— Power Save (PS) mode: A STA alternates between the awake state and the doze state, as determined by the rules defined in this subclause

An AP or PCP keeps track of the wakeup schedule of all associated non-AP and non-PCP STAs. A non-AP and non-PCP STA keeps track of the wakeup schedule of all associated non-AP and non-PCP STAs it is communicating with. There is no end time to a wakeup schedule. Once a STA enters PS mode according to its wakeup schedule it stays indefinitely in PS mode until it leaves the PS mode through mechanisms defined in this section. Once a STA is made aware of the wakeup schedule of another STA, it is able to keep track of the wakeup schedule on its own. Each STA delivers traffic to a peer STA only when the peer STA is in awake state.

*P1580L23*

*[Add the following 3 rows to Table 10-3.]*

|  |  |  |  |
| --- | --- | --- | --- |
| DTI | Awake window | Awake | Awake |
| DTI with CBAP Only subfield set to 1 | Doze or Awake | Doze or Awake |
| Destination AID field of a CBAP equal to the broadcast AID in the schedule | Doze or Awake | Doze or Awake |

P1581L1

*[Add the following 2 rows to Table 10-4.]*

|  |  |  |  |
| --- | --- | --- | --- |
| DTI | DTI with CBAP Only subfield set to 1 | Doze | Doze |
| Destination AID field of a CBAP equal to the broadcast AID in the schedule | Doze | Doze |

**10.2.6.2.3 Non-AP and non-PCP STA operation with a wakeup schedule**

*[Require the AP or PCP to establish awake windows as long as there are STAs with scheduled power save.]*

To transition from active mode to PS mode, a non-AP and non-PCP STA that is associated with an AP or PCP shall establish a wakeup schedule (WS) with the AP or PCP. A WS is established with the AP or PCP following the successful transmission of a PSC-REQ frame to the AP or PCP with the DPM field set to 1 and an acknowledged receipt of the corresponding PSC-RSP frame from the AP or PCP provided that the PSC-RSP frame contained a status code indicating success. After receiving a PSC-RSP frame from the AP or PCP with a status code indicating success and responding with an acknowledgment, the STA switches to the PS mode at the instant specified by the BI Start Time field of the DMG Wakeup Schedule element transmitted to the AP or PCP. In PS mode, the STA shall cycle between Awake BIs and Doze BIs following the WS the STA has established with the AP or PCP.

As long as there is at least one STA that is in PS mode, the AP or PCP shall establish an awake window. The AP or PCP may include an Awake Window element in a DMG Beacon or Announce frame it transmits even if no STA in the BSS has entered PS mode.

*[Delete unnecessary restriction: STA can go ahead with scheduled power save even with pseudo-static allocations; also, highlight Awake Window element presence in PSC-REQ/PSC-RSP.]*

A DMG Wakeup Schedule element shall be included in any PSC-REQ frame that the STA transmits to the AP or PCP as an explicit request for a WS. An Awake Window element may also be included in the same PSC-REQ frame to indicate a requested duration for the awake window. If the AP or PCP accepts the proposed WS and the optionally present awake window duration in the PSC-REQ frame, it shall reply with a PSC-RSP frame indicating a status code of SUCCESS. Otherwise, it shall respond with a PSC-RSP frame with a status code indicating the reason for rejecting the request. The AP or PCP may suggest an alternative WS and optionally an awake window duration in the PSC-RSP frame and set the status code to REJECT\_WITH\_SCHEDULE. If the STA accepts the alternative WS, it shall include this WS in a subsequently transmitted PSC-REQ frame. If the non-AP and non-PCP STA does not accept the alternative WS, it shall not send a PSC-REQ frame for dot11PSRequestSuspensionInterval beacon intervals following the receipt of the PSC-RSP frame from the AP or PCP.

NOTE—The AP or PCP can recommend an alternative WS, for example to align the Awake BIs of some or all non-AP and non-PCP STAs.

NOTE—The awake window duration sent by the AP or PCP in a PSC-RSP frame is to assist the STA for awake window planning. The awake window duration is always set by the Awake Window element in the most recent DMG Beacon or Announce frame received from the AP or PCP.

*[Wakeup Schedule can be established with or without pseudo-static allocations; remove the implicit concept.]*

*[There is no need for explicit and implicit concepts when it comes to establishing a WS. A WS is established through PSC-REQ/RSP exchange and DMG Wakeup Schedule element. Use correct field name; clarify awake window presence and non-AP/non-PCP behavior during awake window, if present.]*

If a non-AP and non-PCP STA has established a WS with the AP or PCP and the non-AP and non-PCP STA is in PS mode, the non-AP and non-PCP STA shall have *m* successive Awake BIs repeating every *n* beacon interval, where *n* is the value of the Sleep Cycle field of the DMG Wakeup Schedule element contained in the PSC-RSP frame received from the AP or PCP during the frame exchange that established the WS, and *m* is the value of the Number of Awake BIs field in the DMG Wakeup Schedule element contained in that PSC-RSP frame. During each of its Awake BIs, the non-AP and non-PCP STA shall be awake during the awake window if it is present, and during all allocated SPs in which it is either the source or destination DMG STA.

…

*[No such thing as WS implicitly established; remove these two paragraphs.]*

**10.2.6.2.4 Non-AP and non-PCP STA operation with or without a wakeup schedule**

…

*[Editorial move, also clarify that the AP or PCP needs to “translate” each STA’s WS if it moves the TBTT, changes the beacon interval duration or resets the TSF.]*

In order for a STA to learn the WS of another STA within the BSS, the STA may send an Information Request frame to the other STA or to the AP or PCP as defined in 10.30.1 (Information Request and Response). Ifthe AP or PCP moves the TBTT, changes the duration of the beacon interval, or resets the TSF, or if transmit to When transmitting the DMG Wakeup Schedule element for a STA that is in PS mode, the transmitting STA shall use a value for the BI Start Time field that points to a TBTT that is earlier, but not more than 231 microseconds minus aDMGDWSValidPeriod earlier than the TBTT of the beacon interval during which the BI Start Time field is transmitted, so that the receiving STA can correctly identifiy the Power Management mode of the STA the WS belongs to.

If the Information Request frame is transmitted to the AP or PCP and the STA indicated in the Information Request’s Subject Address field does not have an established WS with the AP or PCP, the AP or PCP shall set the length of the DMG Wakeup Schedule element to 0 in the Information Response frame.

**10.2.6.3 PCP Power management mode**

…

*[Modify the following paragraphs.]*

To enter PPS mode, or to modify an established WS, the PCP announces a WS through a DMG Wakeup Schedule element (8.4.2.130 (DMG Wakeup Schedule element)) included in a DMG Beacon, Announce, or any Action frame. The PCP may also include an Awake Window element (8.4.2.136 (Awake Window element)) together with the DMG Wakeup Schedule element to indicate the intended length of the awake window beginning with first BI in the WS.

The PCP can assume that all associated STAs have received a WS and the Awake Window element that can optionally be transmitted with the WS at the earlier of the following events,

* The PCP has transmitted the DMG Wakeup Schedule element in DMG Beacon or Announce frames for at least dot11MaxLostBeacons successive beacon intervals.
* The PCP has confirmed that each associated STA has received the DMG Wakeup Schedule element by receiving an ACK or a response frame from each associated STA in response to a request frame that includes the DMG Wakeup Schedule element.

The first PCP Awake BI of a sleep cycle in a WS starts at the instant specified by the value of the BI Start Time field of the announced DMG Wakeup Schedule element, and the number of successive PCP Awake BIs is specified by the Number of Awake BIs field in the DMG Wakeup Schedule element. Once in PPS mode, the PCP transitions between Awake BI and Doze BI according to the WS it has established.

NOTE—The PCP may need to behave as it is in active mode or in an Awake BI to some associated STAs for a number of planned successive PCP Doze BIs if it has not been able to confirm the reception of its WS by each associated STA, and it has not transmitted its WS through DMG Beacon or Announce frames over dot11MaxLostBeacons successive beacon intervals.

In order to transition from PPS mode to active mode, the PCP stops including the DMG Wakeup Schedule element in DMG Beacon and Announce frames. A DMG STA that has received a PCP WS shall assume the PCP WS is in effect until it either receives a DMG Beacon or Announce frame that does not include a DMG Wakeup Schedule element or receives a different PCP WS.

In a PCP Doze BI, the PCP should schedule a BTI or ATI. If scheduling an ATI, the PCP should transmit an Announce frame during the ATI to associated STAs during the ATI.

NOTE—The PCP provides the PBSS timing synchronization (TSF). Transmitting frequent TSF information through DMG Beacon or Announce frames is important when there are non-PCP STAs in the PBSS that rely on TSF information to communicate directly with each other.

**10.2.6.4 ATIM frame usage for power management of non-AP STAs**

*[Awake window is allowed to be present in the first broadcast CBAP of the beacon interval, even if it is not the first CBAP in the beacon interval. Also, a CBAP covering the entire DTI (i.e., scheduled with CBAP Only field in the DMG Parameters field set to 1) may not have its Destination AID set to broadcast AID, but is still allowed to have an awake window.]*

An awake window is present within the first CBAP of a beacon interval that has the Destination AID field equal to the broadcast AID, or in a CBAP that is scheduled through the CBAP Only field in the DMG Parameters field (8.4.1.46 (DMG Parameters field)) set to 1, for dot11MaxLostBeacons beacon intervals following the most recent transmission of the Awake Window element (8.4.2.136 (Awake Window element)) by the AP or PCP with the Awake Window Duration field set to a nonzero value.

A non-AP and non-PCP STA delivers the Awake Window element to an AP or PCP as defined in 10.2.6.2.3 (Non-AP and non-PCP STA operation with a wakeup schedule). An AP or PCP delivers the Awake Window element to a non-AP and a non-PCP STA as defined 10.2.6.3 (PCP Power management mode).

If present, the awake window starts from the beginning of a CBAP and has a duration that is defined by the value of the Awake Window Duration field in the Awake Window element or the CBAP duration, whichever is smaller. During the awake window, a STA shall transmit only ATIM frames. A DMG STA in PS mode shall be in the awake state during each awake window that lies within each Awake BI for that STA.

...

*[ATIM frame does not contain AIDs. Also, announced BUs may be delivered in any appropriate allocation – SP or CBAP. A space is missing.]*

If a STA receives an ATIM frame during the awake window, it shall be awake during allocations within the current beacon interval that have the Source AID equal to broadcast AID or Source AID matching the TA field of the received ATIM frame, or during any DTI that is scheduled through the CBAP Only field in the DMG Parameters field (8.4.1.46 (DMG Parameters field)) set to 1 . If a STA transmits an ATIM frame during the awake window, it shall attempt to deliver its BUs during allocations within the current beacon interval that have the Destination AID equal to broadcast AID or Destination AID matching the RA field of the transmitted ATIM frame, or during any DTI that is scheduled through the CBAP Only field in the DMG Parameters field (8.4.1.46 (DMG Parameters field)) set to 1. A STA that receives or transmits an ATIM frame during the awake window may enter the doze state when it has successfully transmitted to and received from all corresponding peer STAs for this beacon interval a QoS Data frame with the EOSP subfield set to 1 otherwise it shall stay active till end of the current BI. ATIM frame transmissions and MSDU transmissions follow the rules defined in 10.2.3.5 (ATIM frame and frame transmission).