IEEE P802.11
Wireless LANs

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| Usage of ATI period during PCP Doze BIs  |
| Date: 15 July 2014 |
| Author(s): |
| Name | Affiliation | Address | Phone | email |
| Qi Wang | Broadcom Corporation |  |  | qi.wang@broadcom.com |
| Payam Torab | Broadcom Corporation |  |  | ptorab@broadcom.com |

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

This document discusses the usage of ATI period during PCP Doze BIs in DMG networks. It also includes corrections and clarifications related to the DMG Wakeup Schedule element. It is submitted as a resolution to CID 3262.

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

(1) Usage of ATI period during PCP Doze BIs

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Section 10.2.6.3 (PCP Power management mode) states that “In a PCP Doze BI, the PCP shall transmit an Announce frame during the ATI to each associated STA”. While this sentence is technically not the same as “In a PCP Doze BI, the PCP shall schedule an ATI and transmit an Announce frame during the ATI to each associated STA”, it seems the intention of the sentence has been to indeed require the PCP to allocate an ATI in each Doze BI and transmit Announce frames to associated STAs. This is weakly confirmed by the additional sentence in Section 10.1.3.3.1 that “For any beacon interval that does not include a DMG Beacon frame transmission in the BTI, the AP shall begin the beacon interval with an ATI, and the PCP begins the beacon interval with an ATI…” (note however that the PCP language is crafted differently.

The hard requirement for a PCP to have an ATI in every PCP Doze BI (if it indeed has been the intention, because it contradicts the example and figure at the end of Section 10.2.6.3 as highlighted at the end) is unnecessary, and creates two problems with PCPs: (1) It degrades the PCP power saving capability, as the PCP Doze state (sleep state) has to be interrupted at the beginning of every Doze BI, and (2) it makes simultaneous operation in multiple DMG BSSs using a common (time-shared) PHY difficult, as the need to skip transmitting Announce frames in some beacon interval in order to be present in another DMG BSS is inevitable.

DMG Beacon and Announce frames provide the foundation of the network management and state synchronization (most notably TSF), and their constant transmission is essential to a DMG network robustness. The dot11MaxLostBeacons parameter, specific to DMG, highlights the importance of “a good flow” of DMG Beacon or Announce frames to network time and state synchronization. In a DMG PBSS in particular, non-AP and non-PCP STAs can communicate directly even if the PCP is in a low-power mode, whuich makes these STAs even more dependent on the timing reference provided by the PCP.

It is important to note however that when it comes to synchronization the dot11MaxLostBeacons parameter *is a reflection of the number of received (or more accurately, not received) DMG Beacon or Announce frames, and not the number of transmitted DMG Beacon frames:*

[Section 10.1.3.1] “In a PBSS, DMG STAs expect to receive at least one DMG Beacon frame or one Announce frame every dot11BeaconPeriod × dot11MaxLostBeacons TUs.”

That is, the PBSS operation should be designed in a way that DMG STAs receive a sufficient number of DMG Beacon or Announce frames as outlined above; which is very different from *transmitting* a DMG Beacon or Announce frame at every BI. For example, the following PBSS networks exhibit the same level of robustness with respect to synchronization and network state persistence,

1. PBSS operating at dot11MaxLostBeacons = N, PCP in a long cycle of power save (large number of successive PCP Doze BIs), PCP transmitting Announce frames at every PCP Doze BI.
2. PBSS operating at dot11MaxLostBeacons = N+M, PCP in a long cycle of power save (large number of successive PCP Doze BIs), PCP skipping transmitting Announce frames for M out of every N+M PCP Doze BIs.

We also observe that the PCP staying in Doze state for the entire Doze BI is already reflected in the figure and example at the end of Section 10.2.6.3: Figure 10-11 illustrates the PCP in Doze state for the entire 2nd and 4th beacon intervals, and the paragraph above the figure confirms this as highlighted below,

“Following the CBAP of the first beacon interval, the PCP enters the Doze state and sleeps for more than one beacon interval. The PCP switches from the Doze state to the Awake state after sleeping through the remainder of the first beacon interval and through the entire second beacon interval, which is the start of the third beacon interval in Figure 10-11 (Example operation of PPS mode). Since in this example the schedule of the third beacon interval and the fourth beacon interval are different, the PCP transmits the Extended Schedule element containing the individual allocations for the third beacon interval and fourth beacon interval. The PCP enters the Doze state after it completes all exchanges in the third beacon interval and wakes up at the start of the fifth beacon interval.”



Finally, we note that DMG STAs not receiving a DMG Beacon or Announce frame during a beacon interval is a common scenario when BTI beamforming is completed over multiple beacon intervals, i.e, when the TXSS Span parameter is > 1 (TXSS Span is the number of beacon intervals it takes the AP or PCP to cover all sectors in all DMG antennas).

(2) Clarifications

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Also included are corrections and clarification related to the DMG Wakeup Schedule element. The element is used by both non-AP/non-PCP STAs and PCPs, but the element definition and references to it throughout the text do not accurately capture its dual use.

**8.4.2.130 DMG Wakeup Schedule element**

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*[Note for editor: Modify the following paragraph].*

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 a non-AP and non-PCP STA with the AP or PCP, and also to announce that a PCP is entering the PCP Power Save (PPS) mode.

When the element is used to communicate the wakeup schedule of a non-AP and non-PCP STA,

* The BI Start Time field indicates the lower order 4 octets of the TSF timer at the start of the next Awake BI.
* 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 Sleep Cycle field value can only be a power of two. Other values are reserved.
* The Number of Awake/Doze BIs field indicates the number of Awake BIs at the beginning of each sleep cycle.

When the element used by a PCP to announce entering the PCP Power Save (PPS) mode,

* The BI Start Time field indicates the lower order 4 octets of the TSF timer at the start of the next PCP Doze BI.
* The Sleep Cycle field is reserved.
* The Number of Awake/Doze BIs field indicates the number of successive PCP Doze BIs.

**10.1.3.3 Beacon generation in a DMG infrastructure BSS and in a PBSS**

**10.1.3.3.1 General**

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*[Note for editor: Modify the following paragraph].*

An AP or PCP may transmit DMG Beacon frames through different antenna configurations during the BTI, but shall not transmit more than one DMG Beacon frame through the same antenna configuration during the BTI of any beacon interval. For any beacon interval that does not include a DMG Beacon frame transmission in the BTI, the AP shall begin the beacon interval with an ATI, and the PCP may begin the beacon interval with an ATI (10.2.6.3 (PCP Power management mode)).

**10.2.6.2.3 Power management mode operation of a non-AP and non-PCP STA with a wakeup schedule**

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*[Note for editor: Modify the following paragraphs].*

If a non-AP and non-PCP STA has not established a pseudo-static SP with the AP or PCP, 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 wakeup schedule. If the AP or PCP accepts the proposed WS, 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 nonzero status code indicating the reason for rejecting the request. The AP or PCP may suggest an alternative schedule in the PSC-RSP frame and set the status code to REJECT\_WITH\_SCHEDULE. If the STA accepts the alternative schedule, 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 schedule, it shall not send a PSC-REQ frame for dot11PSRequestSuspensionInterval beacon intervals following the receipt of the PSC-RSP frame.

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If a non-AP and non-PCP STA has established a pseudo-static SP schedule with the AP or PCP, it may omit the WS in the PSC-REQ frames that it sends to the AP or PCP. In this case, all outstanding pseudo-static SPs for the non-AP and non-PCP STA become an implicit WS request. When no DMG Wakeup Schedule element is contained in a PSC-REQ frame, the AP or PCP shall reply with a PSC-RSP frame indicating a status code of SUCCESS and shall adopt all outstanding pseudo-static service period schedules (9.35.6.4 (Pseudo-static allocations)) as the wakeup schedule for that STA.

If a non-AP and non-PCP STA has explicitly 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/Doze BIs field in the DMG Wakeup Schedule element contained in that PSC-RSP frame. The non-AP and non-PCP STA shall be awake during allocated SPs in which it is either the source or destination DMG STA during each Awake BI.

**10.2.6.3 PCP Power management mode**

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*[Note for editor: Replace the 3 “WS element” references in Figure 10-10 with “DMG Wakeup Schedule element”].*

*[Note for editor: Modify the following paragraphs].*

To enter PPS mode, the PCP announces the start of the first PCP Doze BI and the number of successive PCP Doze BIs through the DMG Wakeup Schedule element (8.4.2.130 (DMG Wakeup Schedule element)) and includes this element within DMG Beacon or Announce frames. The DMG Wakeup Schedule element shall be transmitted at least dot11MaxLostBeacons times before the PCP enters PPS mode. The first PCP Doze BI 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 Doze BIs is specified by the Number of Awake/Doze BIs field of the DMG Wakeup Schedule element. 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.

NOTE—As long as the PCP has not transmitted a DMG Beacon or Announce frame that does not include a DMG Wakeup Schedule element it is in PPS mode, including possibly after the last PCP Doze BI indicated in an announced DMG Wakeup Schedule element.

In a PCP Doze BI, the PCP should schedule an ATI to transmit an Announce frame to and possibly exchange management frames with each associated STA.

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The PCP shall check that the schedule of pseudo-static allocations transmitted in the last Extended Schedule element before the PCP entered PPS mode is valid during the PCP Doze BIs. Thus, a STA participating in such a pseudo-static allocation assumes that the allocation is present during the following consecutive PCP Doze BIs.