IEEE P802.15
Wireless Personal Area Networks

Project	IEEE P802.15 Working Group for Wireless Personal Area Networks (WPANs)	
Title	Power save proposal	
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Re:	[Power save mechanism in TG3-MAC]	
Abstract	[This contribution is a proposal for power save mechanisms to be used in TG3 MAC]	
Purpose	[power save mechanisms to be used in TG3 MAC.]	
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Overview of the Power save proposal

In this paper there are two power save states that are proposed, Snooze state and Sleep state. The Snooze state is completely controlled by the DEV and Sleep state needs coordination from the PNC as the DEV needs to be in sync with the ongoings within the piconet. The Sleep states is requested by the DEV and permitted/rejeted by the PNC. When Sleep state for a DEV is permitted, the PNC must indicate the "traffic pending" state for the DEV in the Power-Save-Information-element in its Beacons. Using this information, the DEVs enter a sleep-cycle at the end of which if the traffic is pending at the PNC, the DEVs send "Active-state-indication" command to the PNC so that the PNC can start sending the buffered frames to the DEV. Since the PNC is involved, the mechanism apply equally well to buffering multicast and broadcast frames for the DEV.

MAC Frame Formats

7.1.x Power save information element

Octets: 1	**1**	**2**	**2**	**-----**	**2**
Element ID	Length = (n * 2)	TIB-1	TIB-2	……..	TIB-n

Figure 1—Power save information element

The Power save information element shall be present only in Beacons . This element consists of multiple, 2-octet wide traffic-indication blocks (TIB), and the TIBs shall be arranged in an increasing order of the start-DEV address contained in them. The contetns of a TIB is illustrated in Figure 2.

Octets: 1	**1**
Start DEV address	"traffic pending" indication. LS bit of the octet is the indiation corresponding to "start-DEV-address"

Figure 2—Traffic Indication Block (TIB)

The TIB consist of Start-DEV-address and an octet of "traffic-indication". A '1' in any of the bit positions in trafic-pending-indication octet means that some traffic is pending for the DEV whose allocated address is the sum of the start-DEV-address contained in the first octet of the TIB and the position of the current bit. Hence the least significant bit (b0) in traffic-indication octet indicates whether there is any traffic is pending at PNC for the DEV whose address is mentioned as the start-DEV-address in the current TIB. Absence of a TIB containing "traffic pending" indication for a DEV shall mean that there is no traffic pending for that DEV at the PNC.

Command types

NOTE: Alternatively, it is possible to make the response by the PNC (permit/reject) as the immediate response to the sleep-state-req by the DEV (or always permit sleep state by sending just ACK). Hence only the DEV is responsible as how long it wants to sleep.

1.2.x1 **Sleep time request**

A DEV that is associated with a PNC indicating its intention to use sleep state during the association state shall use this command to obtain permission to enter sleep state.The command structure is illustrated in Figure 3.

octets: 2	**2**	**2**
Command Type	Length (= 2)	Requested sleep state duration (in TU)

Figure 3—Sleep time request command format

The requested sleep state duration is the length of time that the PNC is being requested to buffer the frames for the requesting DEV.

1.2.x2 **Sleep time permit**

PNC shall use this command to permit a requesting DEV to enter sleep state. The requesting DEV shall enter the sleep state only after it has succesfully acknowledged this command from the PNC. The command structure is illustrated in Figure 4.

octets: 2	**2**	**2**
Command Type	Length (= 2)	Max sleep state duration (in TU)

Figure 4—Sleep time permit command format

The max sleep state duration is the length of time that the PNC is agreeing to buffer the frames for the requesting DEV.

1.2.x3 **Sleep time reject**

PNC shall use this command to reject a requesting DEV to enter sleep state. The requesting DEV shall not enter the sleep state if it receives this command from the PNC. The command structure is illustrated in Figure 5.

octets: 2	**2**	**1**	**1**
Command Type	Length (= 2)	reserved	Reason code

Figure 5—Sleep time reject command format

The max sleep state duration is the length of time that the PNC is agreeing to buffer the frames for the requesting DEV.

- 0 -> No resources available
- 1 -> Channel change is in progress
- 2 -> PNC hand over is in progress
- 3 -> Pending buffered frames from previous sleep state
- 4-> Unknown reason
- 5-255-> Reserved

1.2.x4 **Active state indication**

A DEV that was permitted to enter sleep state by the PNC uses this command to indicate its intention to be back in active state. After succesfully acknowledging this frame, the PNC shall stop buffering frames for the requesting DEV and start delivering the currently buffered frames to this DEV. The command structure is illustrated in Figure 6.

octets: 2	**2**
Command Type	Length (= 0)

Figure 6—Active state indication command format

NOTE: This command in reality can be any command (even just a NULL command frame) from the DEV to the PNC

8.x Desription of Power save modes and operation

There are three states in power management (PM) at MAC, (a) Active state (b) Snooze state and (c) Sleep state. The PS bit in capability field shall be set to 1 if the DEV is planning to use sleep state during an association state.

NOTE: Snooze state is same as the RPS in doc#262r0 and Sleep state is same as the EPS in doc #262r0 as the basic descriptions of these states were drawn from doc#292r1 and 293r1.

The DEV shall remain awake as long it is in active state.

In Snooze state, the DEV shall be awake at the beacon tx time and for the entire CAP. During CFP the DEV uses the channel time allocation received in Beacon or channel time grant command to decide when to be awake. Each DEV shall be awake at all GTSs in which its address is listed as either the source or the source DEV-address. All DEVs, except those in sleep state, shall be awake at all GTSs for which the destination DEV-address is Broadcast DEV-address. The rest of the time during the superframe the DEV is free to snooze and not transmit or receive any frame on the channel. Each DEV is free to use snooze state and save power in any superframe only if it has correctly received beacon frame for that superframe.

In Sleep state, the DEV may not receive or be able to transmit for several superframes at a time. The PNC is required to buffer all the frames to the sleeping DEV and all the broadcast frames received during the sleep state of the DEV and make them available to the DEV when it is awake. PNC is also responsible for indicating the “traffic pending” information in the beacon using Power-save-information element described above. The PNC needs to check its local buffers meant for the repeat service to decide if the “traffic-indication” for a DEV needs to be set in the outgoing Beacon. Before going to Sleep state, the DEV shall inform the same to PNC its intention to go to sleep state using “Sleep State Request” command and wait for PNC to respond. Only after the reception of “Sleep state permit” command from PNC, shall the DEV is allowed to shut itself off for a maximum sleep time duration as indicated by the PNC in “Sleep state permit” command. Note that the DEV must awake sufficient time before the expiration of that maximum sleep time in order to inform the

PNC that the DEV is awake. If the DEV did not successfully indicate its awake state to PNC within the expiration of that maximum sleep time, the PNC shall disassociate the DEV from its piconet. If the DEV receives “Sleep state reject” command from the PNC instead of “Sleep state permit” command, the DEV shall not go to sleep state and wait for atleast one more beacon interal before attempting to send another “Sleep state request” command to PNC. But the device is free to use snooze state following the rules to enter snooze state described above. In addition to simply using the sleep state request and permit commands for the power save operation, the DEVs can adopt a sleep cycle that is described in Figure 8 below. The DEVs can wakeup at periodic intervals, receive a beacon and check the power-save-information element in the received beacon to decide one of the following

(a) Go back to sleep immediately if there is no traffic pending indication for the DEV and if the maximum sleep time has not expired. However the DEV must wakeup before the maximum sleep time permitted by the PNC expire.

(b) Send another sleep state request, if there is no traffic pending indication for the DEV but the maximum sleep time is close to being expired.

(c) Send “active-state-indication” to PNC and expect the frames from PNC if there is traffic pending indication for the DEV

When the DEV wakes up from sleep, it shall remain awake until atleast one beacon is correctly received so as to detect the CAP correctly.

The PNC shall set the repeater bit to 1 in all the frames it is relaying to a DEV that is awake from sleep state. Since the PNC is buffering broadcast frames and transmitting them when the DEV is awake, it is possible for any DEV in the piconet to receive the same broadcast frames multiple times with or without repeater bit set. Hence each DEV shall use duplication detection mechanism described in 8.6.6 to reject all the multiply received broadcast frames.

The sequence chart in Figure 7 show the sequence of frames/commands exchanged between DEV and PNC for sleep-state management.

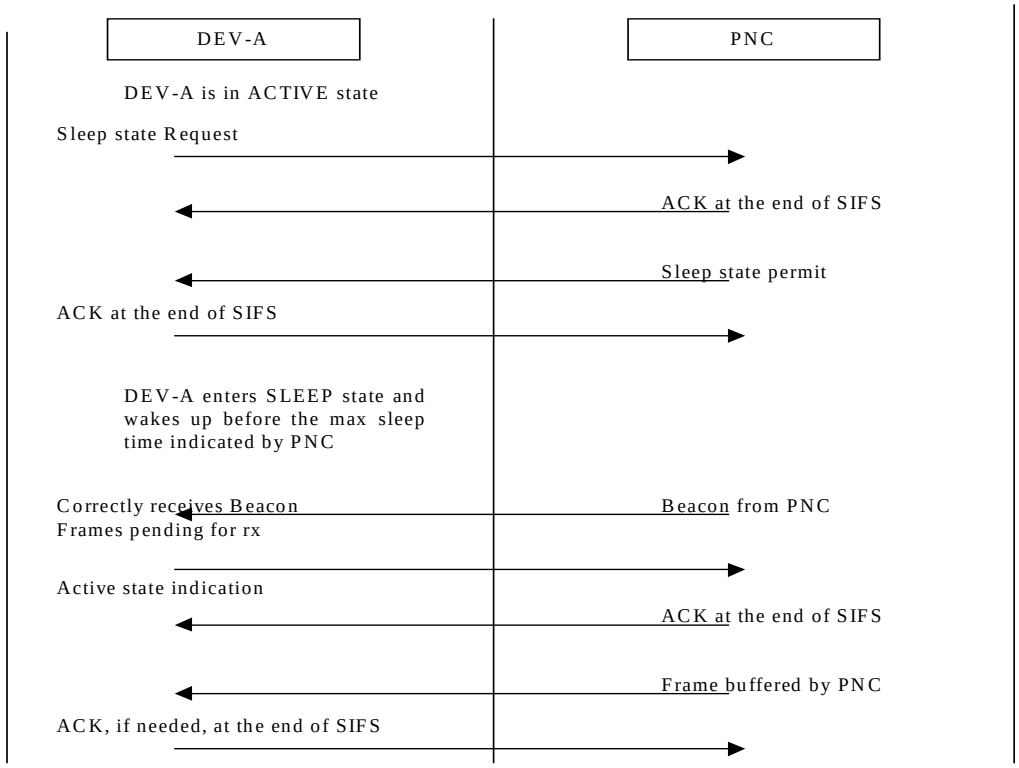

Figure 7—Message sequence chart for entering sleep state and buffered data reception at a DEV

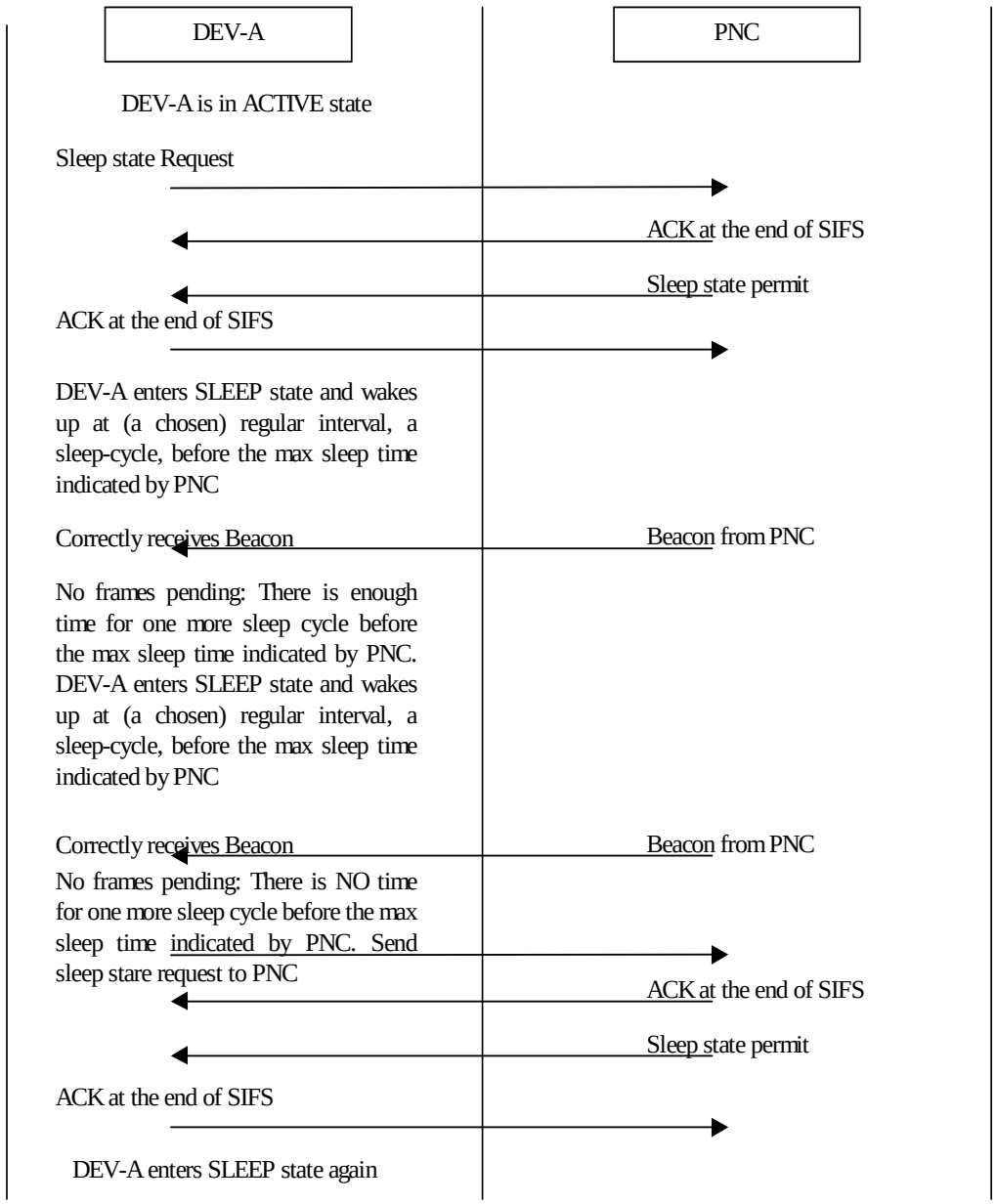

Figure 8—Message sequence chart for entering sleep state and buffered data reception at a DEV