IEEE P802.15
Wireless Personal Area Networks

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Re:	IEEE Draft P802.15.3/D10	
Abstract	This document provides recommended draft text for the Asynchronous Power Save (APS) and Synchronous Power Save (SPS) clauses of the 802.15.3 MAC to be incorporated into D0.10	
Purpose	The recommendations contained in this document are to be applied to the 802.15.3 MAC baseline.	
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Release	The contributor acknowledges and accepts that this contribution becomes the property of IEEE and may be made publicly available by P802.15.	

List of changes to go from 02/118r1 to r2 (this document) power save text

The purpose of this revision is to provide Framemaker formated text for the clause sub-editors, and to incorporate the changes annotated in the St. Louis version (r1)of the word document. Clause 8 text is not fully updated with this revision.

Take the figure and table numbering for this version with a grain of salt as they are an auto numbering done by Frame. The clause numbering is not Frame formated and is still referenced to the d09 numbering. The sub-editors will have to elevate the text to get the appropriate clause numbering.

Removed graphics prior to conversion and did bulk conversion. Organized the graphics and did save as eps. Saved the vsds as eps with parameters (normal, line cap=device, no TIFF preview). Rebuilt figures for tables and frame structures. Did the format change for structure of primitives in MLME-pm primitives.

Removed the 6.3.3.2 MLME-WAKEOPERATION.indicate primative and its sub-clauses as we are now using beacon indicate for this function.

Removed the MACPIBPowerManagementWakeIndicationEnable table entry. Since we are using the beacon indication, it doesn't match up to anything.

The MACPIBPowerManagementRecovery table entry may change or be deleted. Discussion in St. Louis on this subject took place.

Added the DEVidbitmap entry to table 1 for power management parameters. This is part of the response to an inquiry primitive.

Added the DEVidbitmap for the inquiry response command. This is a change dictated by the r1 change notes.

Merged the APS sleep permit and reject commands into APS sleep response

Changed the 15-3MLMEWake-operation-MSC.vsd to reflect agreement of r1 to use beacon indication.

The following was deleted from 8.13 per r1 instruction. “For both APS and SPS mode, if a beacon is not received in any superframe that the DEV is AWAKE, that DEV shall follow the same requirements for DEVs that have missed a beacon, as defined in {xref 8.x.x} note that this is from the resolution of a comment.)”

The following was deleted from 7.4.3 per r1 instruction. “The PSAVE bit shall be set to 1 if the DEV is planning to use APS/SPS state as part of power management. Otherwise the PS bit shall be set to 0. The PNC shall always set this bit to 0 in its capability field.”

The following was deleted from 8.9 peer discovery, it is the subject of a comment resolution so is not needed here -- {ps editor note: Third paragraph is specific to SPS mode. Delete this text and add appropriate wording to replace the concept that a dev may not be able to hear a probe request when in APS or SPS mode. I think we have a comment resolution on this paragraph.}

The following has been removed -- “The PNC shall only switch the ACTIVE mode DEV to SPS mode if the DEV has first been granted at least one SPS channel time request.””{ps editor note: the above states that a SPS DEV can't get to SLEEP unless the SPS CTR is granted. Why? An SPS DEV doesn't need a channel time necessarily. It can send a CTR in an open MTS if it needs one later. If a DEV wants to send something to the SLEEPing SPS DEV, "IT" does a CTR and the PNC will provide the CTA for the SPS DEV to "see".}

The following has been removed from the text as it is the subject of an other comment resolution (56) --{PS editor note: We still have an open issue on the table as to response time for the PNC to CTRs. There is also a concern that reasonable switching for EPS mode to ACTIVE CTAs will be an inhibiter to optimum operation. Further, a request for a non-persisent EPS-CTA could would be very far off from when the originating DEV sent the information. } Still unresolved, hopefully by Thursday am

end of change record

Clause 3 Definitions

{add definitions from 02/075r14}

Awake state: A power management state in which a device that is using asynchronous power save or synchronous power save is communicating during the superframe.

Synchronous power save: {see definition in comment resolution}

Asynchronous power save: {see definition in comment resolution}

Sleep state: A power management state in which a device that is using asynchronous power save or synchronous power save is in a reduced power condition and is not participating in piconet activities.

Clause 4 Acronyms and abbreviations

APS Asynchronous Power Save

SPS Synchronous Power Save

Clause 5 General description

5.3.5 Power Management

{add the following}

Two specific modes of power saving are provided with Asynchronous Power Save (APS) and Synchronous Power Save (SPS). APS is well suited for DEVs having little or no information flow but should associate with a piconet. SPS is provided for situations where regular information at a less than superframe rate is required but that substantial power savings are also desired.

6.0 Layer Management

6.3.1 Asynchronous power save operation

This mechanism supports the process of establishment and maintenance of the asynchronous power saving operation of a DEV.

6.3.1.1 MLME-APSCONFIGURE.request

To request a new APS activity for the DEV. Figure {xref} provides information on the parameters.

```
MLME-APSCONFIGURE.request    (
                             LengthOfAPSState,
                             LengthOfAPSCycle
                             )
```

6.3.1.1.1 When generated

This primitive is generated by the DME to implement the asynchronous power saving operation for the local device. It is generated at a time after the DEV is associated with the piconet.

6.3.1.1.2 Effect of receipt

When the MLME receives this primitive from its DME, it passes the information to the PNC for action. The PNC will respond and the result in an MLME-APSCONFIGURE.response primitive when the PNC either responds favorably or rejects the primitive.

6.3.1.2 MLME-APSCONFIGURE.response

This primitive is generated by the MLME to indicate completion of the MLME-APSCONFIGURE.request. Figure {xref} provides information on the parameters of the primitive.

```
MLME-APSCONFIGURE.request    (
                             LengthOfAPSState,
                             LengthOfAPSCycle,
                             ReasonCode
                             )
```

6.3.1.2.1 When generated

This primitive is sent by the MLME as a result of a response from the PNC on the DME MLME-APSCONFIGURE.request.

6.3.1.2.2 Effect of receipt

The DME is informed of the result of the MLME-APSCONFIGURE.request. It is up to the DME to determine use of the information.

6.3.2 Synchronous power save operation

This mechanism supports the process of synchronous power saving operation of a DEV. MLME-STREAMCONNECT primitives, {xref within clause 6}, are used to establish channel time allocations for SPS DEVs.

6.3.2.1 MLME-SPSCONFIGURE.request

This primitive requests management of PNC SPS time bases in support of a DEV operating in SPS mode of power management. It provides for management of SPS sets. Figure {xref} provides information on the parameters of the primitive. The semantics of the primitive are as follows:

```
MLME-SPSCONFIGURE.request    (
                             RequestType,
                             SPSSetIndex
                             SPS Interval
                             )
```

6.3.2.1.1 When generated

This primitive is used in the configuration of SPS parameters for the DEV in the piconet. It is available for use after the DEV is associated in the piconet.

6.3.2.1.2 Effect of receipt

Changes to DEV SPS set operation after use to start or join an SPS set require the that the primitive to release the SPS set first be used.

6.3.2.2 MLME-SPSCONFIGURE.response

Figure {xref} provides information on the parameters of the primitive.

```
MLME-SPSCONFIGURE.response  (
                            RequestType,
                            SPSSetIndex,
                            SPSInterval,
                            NextAwakeBeacon,
                            ReasonCode
                            )
```

6.3.2.2.1 When generated

This primitive is generated as a result of a DME requesting MLME-SPSCONFIGURE.request and the internal response by the PNC to the local MLME.

6.3.2.2.2 Effect of receipt

The information on SPS set is made available to the DME. A DME initiated request for SPS channel time allocation is likely to follow.

6.3.2.3 MLME-SPSINQUIRY.request

This primitive requests a disclosure of SPS set information that the PNC locally stores.

```
MLME-SPSINQUIRY.request  (
                         )
```

6.3.2.3.1 When generated

This primitive is generated when a DME is interested in determining the SPS configuration held by the PNC. It would normally be generated before a SPSCONFIGURE.request primitive.

6.3.2.3.2 Effect of receipt

When received, the local MLME generates an SPS inquiry command to the PNC.

6.3.2.4 MLME-SPSINQUIRY.response

Figure {xref} provides information on the parameters of the primitive.

```
MLME-SPSINQUIRY.response (
                            SPSsupported,
```

SPSinuse,
SPSsetindex,
SPS Interval,
NextAwakeBeacon
NumberDEVsinset
DEVidbitmap (32 bytes long)
… {repeat until completed list}
)

6.3.2.4.1 When generated

This primitive is generated by the MLME with the return by the PNC of information requested in an MLME-SPSINQUIRY.request

6.3.2.4.2 Effect of receipt

This primitive provides a complete set of information to the DME on SPS power management from the perspective of the PNC. This information would typically be used to determine the parameters for a MLME-SPSCONFIGURE.request

6.3.3 MLME-WAKEOPERATION

This mechanism supports the process of switching between states of operation for a APS or SPS DEV. It also provides indication to the destination DME on the state change. Portions of these primitives provide support for SPS DEVs that sleep the MAC_SAP interface during SPS operation.

6.3.3.1 MLME-WAKEOPERATION.request

This primitive provides for local wakeup of the APS or SPS DEV and to request that the PNC use a specific, previously defined, channel time request as appropriate. Figure {xref} provides information on the parameters of the primitive.

MLME-WAKEOPERATION.request (
WakeupType,
StreamID
)

6.3.3.1.1 When generated

{add the consideration of an active vs. inactive MAC-SAP interface}

APS is for wake or sleep, SPS is for previously defined CTA stream switch or momentary operation. For SPS also used for local wake or sleep.

6.3.3.1.2 Effect of receipt

Will wake or sleep the local device and or send CTA stream switch to PNC.

Add PNC to diagram. Show request goes to PNC and PNC generates beacon. Beacon reception causes beacon.indication. There is a table below with a PIB entry related to this. Dump it.

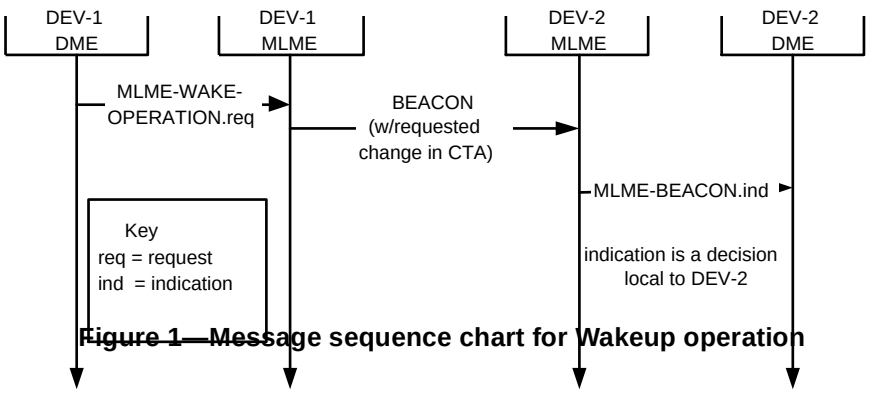


Figure 1—Message sequence chart for Wakeup operation

{ps editor note: Since the beacon indicate primitive is the right side of the MSC, make sure that the text and figures match up between this section and the beacon indicate.

{replaces current table 2}

{following are additions to table 37 from d0.9}

{following are additions to the table 38 from d0.9}

Clause 7 MAC frame formats

7.3.1 Beacon frame format

7.4 Information elements

7.4.3 Capability information

7.4.13 Power management parameters

{PS editor note: need to address the Figure 34 PM parameters element. This has changed. Also figure 34 SPS info fields. Raju has some textual changes to pick up.} (Delete subclass 7.4.13 and all references to it.)

Table 1—MLME-power save primitive parameters

Name	Type	Valid Range	Description
Request type	Enumeration	NEW, JOIN, END	Provides the information for the SPS configure command {xref}
SPS set index	Octet	0x00 to 0x0F	The SPS set for which the command applies, as defined in {xref}
SPS set supported	Octet	0x00 to 0x0F	The maximum supported number of SPS sets supported by the PNC of this piconet {xref}
SPS Interval	Integer	0-65,535 superframes. Values are restricted to binary progression. Non-binary progression values will cause an error response	The interval, expressed in superframes skipped, for an SPS DEV to be in SLEEP state and unavailable for reception of packets. Defined in {xref}
Next Awake Beacon	4 octets	0-0xFFFFFFFF	The superframe number for the first instance of SPS interval as reported. Defined in {xref}
Wakeup Type	Enumeration	SPS, ACTIVE, SHORT-TERM	An indication that a mode change is to be made or has occured based on network information as described in clause {xref - also check this with change to use beacon indicate to relay the change}
Reason Code	Octet	0-255	The result of a power management configuration primative. The codes are returned by an APS or SPS configuration command as described in clause {xref}
Stream ID	Octet	0-255	Piconet-wide identifier of a specific stream. SPS and ACTIVE have different values. {xref - also, stream ID may not be as global as understood - check}
DEVidbitmap	Bit map	Boolean per bit 0=DEV not in set 1=DEV is in set	The bit map for DEVs within an SPS set. Part of the result of an Inquiry primitive {xref}
APSSleepCycle	Octet	0-255	{xref}
APSSleepState	Octet	0-255	{xref}

Table 2—MAC PIB PNC group parameters

Managed Object	Number of octets	Definition	Type
MACPIBMaxSPSSets	1	The maximum number of SPS sets supported by the PNC	Static

Table 3—MAC PIB characteristic group parameters

Managed Object	Number of octets	Definition	Type
MACPIBPowerManage-mentMode	1	The current power man-agement mode of the DEV. 0x00=PM_OFF 0x01=APS 0x02=SPS	Dynamic
MACPIBPowerManag-mentAllowed	1	The DEV-host desired power management mode of the DEV 0x00=PM_OFF 0x01=APS 0x02=SPS	Dynamic
MACPIBPowerManage-mentSupported	1	The DEV capability for power management	Static
MACPIBPowerManage-mentRecovery	1	Determines what action to take when a beacon is missed by an SPS DEV, as defined in {xref} 0 is no-recovery 1 is attempt to recover	Dynamic

Table 4—Beacon frame body {adds shown}

Information element	Sub-clause	Note	Present in beacon
Traffic indication map	7.4.14.1	Traffic indication map for currently sleeping APS DEVs	As needed
SPS information	7.4.14.2	Information on current SPS sets	As needed

7.4.14.1 Traffic indication map (TIM) information element

The TIM information element is present when APS mode is operational in the piconet. The format of the traffic indication map is in figure {xref}.

Table 5—Information element {only adds are shown}

Element ID Hex value	Element	Sub-clause
0x0D	Power management paremeters	7.4.13
0x0E	Traffic indication map (TIM)	7.4.14.1
0x10	SPS information element	7.4.14.2
0x11 - 0xFF	Reserved	

Octets:1	1	1	Variable (1-32)
Element ID	Length (2 to 33)	Start AD-AD	Traffic indication map (TIM)

Figure 2—Traffic indication map format

Octets: 11 1 Variable (1-32)

The TIM field is a bit map of 1 to 32 octets, with each bit when set to 1 indicating that there is traffic indicating for a DEV whose AD-AD is equal to start AD-AD plus the bit position in the map.

The bit corresponding to BC address (0xFF) indicates that there is broadcast frame(s) or GTS-request(s) is pending.

The bit corresponding to MC address (0xFD) indicates that there is broadcast frame(s) or GTS-request(s) is pending.

The bit corresponding the AD-AD of zero is reserved. Bits corresponding to the reserved values of AD-AD are reserved. All the reserved bit positions shall be set to zero upon transmission by PNC and shall be ignored upon reception.

7.4.14.2 SPS information element

The SPS information element is present for each SPS set that is currently being used by the PNC to provide timing for the Wake beacons of at least one device in SPS mode. The SPS information element format is shown in Figure {xref}.

The AD list field contains the address of every device that is currently in SPS mode.

Octets:1	1	1	variable (0-n)
Element ID	Length (2 to (2+n)	SPS set	AD list

Figure 3—SPS information element format

7.5 Command types

PS editor note: change the command type table as follows

Table 6—Command type

Command type Hex value	Command Name	Sub-clause
	Power save information command	{xref 7.5.7.1
	APS sleep request	{xref 7.5.7.2.1
	APS sleep response	{xref 7.5.7.2.2
	SPS configuration request command	{xref 7.5.7.3.1
	SPS configuration response command	{xref 7.5.7.3.2
	SPS inquiry command	{xref 7.5.7.3.3
	SPS inquiry response command	{xref 7.5.7.3.4

7.5.7 Power save commands

7.5.7.1 PS information command

{PS editor note: An attempt is being made to have a single command to the PNC to cover both switching of CTAs directed to a remote and also to tell the PNC the local state of the DEV. The attempt also is to include APS operation. The text below is not totally complete.}

The PS information command is sent from a DEV to the PNC. The structure of this command shall be formatted as illustrated in Figure {xref} and Figure {xref)

Octets: 2	2	1	1
Command type	length (=2)	Stream index	PowerSaveInfo

Figure 4—PS information command format

Bits: b0-b1	b2	b3-b7
PowerSaveMode	Persistence field	Reserved

Figure 5—PowerSaveInfo field

The stream index contains the stream index owned by the DEV sending the message. It directs the PNC to change to the previously defined CTR. A value of zero is for no stream change. {PS editor note: need to confirm that a 0 value of stream index does not have another meaning} (Stream index value of 0 is okay for this application.)

(Does not seem to have an application to APS.)

The PowerSaveInfo field contains the PowerSaveMode and persistence field. PowerSaveMode shall be 0 for no power save, 1 for APS mode and 2 for SPS mode for the DEV sending the message. The PowerSaveMode value of 3 is reserved. The persistence field is 0 for the CTA of stream index to be applied for a single wake period of an SPS DEV. The persistence field is 1 for the CTA of the stream index to be applied until another PS information command changes the value.

If mode is 2, it indicates local DEV is sleeping

7.5.7.2 Asynchronous power save (APS) commands

7.5.7.2.1 APS sleep request

A DEV that is associated with a PNC indicating its intention to use APS mode shall use this command to obtain permission for the same from PNC. The command structure shall be formatted as illustrated in Figure {xref}.

Octets: 2	2	1	1
Command type	Length (=2)	Length of APS sleep cycle	Length of APS sleep state

Figure 6—APS sleep request command format

The Length of APS sleep-cycle is one octet field and represents the number of superframes that the DEV is willing to wakeup and look for beacon.

The Length of APS sleep state is one octet field and represents the number of superframes that the DEV is wishing to be in APS mode before completely reverting to AWAKE state.

7.5.7.2.2 APS sleep response

PNC shall use this command to permit or deny a requesting DEV to enter APS mode. The DEV may enter APS mode at the end of the supreframe in which this command was received from PNC. The command structure shall be formatted as illustrated in Figure {xref}

Octets:2	2	1	1	1
Command type	Length (=2)	Reason code	Length of APS sleep cycle	Length of APS sleep state

Figure 7—APS sleep response command format

The Length of APS sleep-cycle is one octet field and represents the number of superframes that the DEV is required to wakeup and look for beacon.

The Length of APS sleep state is one octet field and represents the number of superframes that the DEV is allowed to be in APS mode before completely reverting to AWAKE state.

Allowed reason codes to for permit or reject of the APS sleep for a DEV are listed below. The requesting DEV shall not enter the APS mode if it receives a non-zero value from the PNC.

0 - APS sleep request permitted.

1-> No resources available

2-> Channel change is in progress

3-> PNC hand over is in progress

4-> Pending frames or a GTS-request from previous APS mode

5-> BC/MC traffic or GTS-request for BC/MC traffic pending

6-> Unspecified reason

7-255-> Reserved

{PS editor note: To be done: Force fit the APS and SPS reason codes into same table. The MLME primitives presume this merger already.}

7.5.7.3 Synchronous power save (SPS) commands

7.5.7.3.1 SPS configuration request command

The SPS configuration request command shall be formatted as illustrated in Figure {xref} . This command is used to manage SPS set membership for an SPS DEV.. When an SPS set is confirmed as created, the PNC shall begin keeping the time base specified for that SPS set.

Octets: 2	2	1	1	2	4
Command type	Length (=2 or 8)	Operation type	SPS set index	SPS interval	Next awake beacon

Figure 8—SPS configuration request/response command format

The value of the action type determines the length of the command since the SPS Interval and Next Awake Beacon fields may be left out for certain operation types. The valid request types and the corresponding values for SPS set, SPS Interval and Next Awake Beacon are given in Table {xref}

The SPS set index is a octet that is assigned by the PNC to a group of DEVs that share the same SPS Interval and Next Awake Beacon.

The SPS Interval has a range of 0 to 65,535 beacons. A value of zero indicates that the DEV is waking for each superframe. The remaining values are constrained to binary series values only.

Next Awake Beacon is a beacon number as defined in piconet synchronization parameters element, 7.4.2. For configure request operations, Next Awake Beacon is the current piconet beacon value plus the value of SPS interval. The current piconet beacon is for when the MLME-CONFIGURATION.request primitive is seen by the DEV-MAC.

Table 7—SPS configuration request command entries

Operation type	Operation type value	SPS set index	SPS interval & next awake beacon
Release request	0	Value required	Not present
New request	1	Set to 0	Required
Place in set	2	Value required	Not present
Reserved	3-255		

7.5.7.3.2 SPS configuration response command

The SPS configuration response command shall be formatted as illustrated in Figure {xref same as request command}. This command is used to create and maintain SPS sets as well as SPS set membership. When an SPS set is confirmed as created, the PNC shall begin keeping the time base specified for that SPS set.

The definitions of the SPS set value, SPS Interval and Next Awake Beacon fields in the command are the same as for the SPS configuration request, 7.5.7.3.1.

The value of the operation type determines the length of the command since the SPS Interval and Next Awake Beacon fields may be left out for certain action types. The valid action types for an SPS action response and the corresponding values for SPS set, SPS Interval and Next Awake Beacon are given in Table {xref}

Table 8—SPS configuration response command entries

Operation type	Operation type value	SPS set index	SPS duration & next awake beacon
Release confirm	0	Value released	Not present
New confirm	1	New value provided	Not present
Place in set confirm	2	Value of set placed into	Not present
Incorrect command length	3	Set to 0	Not present
Already a member	4	Set to 0	Not present
SPS set does not exist	5	Set to 0	Not present
Cannot create new set	6	Set to 0	Not present
Illegal command	7	Set to 0	Not present
Reserved	8-255		

7.5.7.3.3 SPS inquiry command

{add brief description}

Octets: 2	2
Command type	Length (=0)

Figure 9—SPS inquiry command format

7.5.7.3.4 SPS inquiry response command

{add brief description}

Octets: 2	2	1	Variable
Command type	Length (=2 to n)	Supported SPS sets	SPS set structure

Figure 10—SPS inquiry response format

Octets: 1	2	4	32
SPS set index	SPS duration	SPS next	Bit map of DEVs in set

Figure 11—SPS set structure format

8.13 Power management

There are two states defined for the DEVs in this standard. They are AWAKE state and SLEEP state. There are two modes of power save supported for sleep state in this standard. They are asynchronous power save (APS) and synchronous power save (SPS). In any of the power save modes, the maximum length of SLEEP state shall not exceed the ATP.

Additionally, DEVs not already in APSsleep or SPSsleep are permitted to sleep during portions of the CFP where they are not expected to be receiving either a directed or BC/MC frame.

In APS mode, the DEV can go to sleep asynchronously irrespective of any other DEV in the piconet going to sleep or being awake. The length of SLEEP state can span multiple superframes, but must be less than ATP. In APS mode, the decision to enter SLEEP state or exit SLEEP state is left to the DEV depending on the type of application it is currently supporting and hence is out of the scope of this standard.

In SPS mode, the DEV, the SLEEP state of is synchronized with the DEVs in the same SPS-set. An SPS set is formed by PNC to include all the DEVs that are communicating with each other and have similar power save requirements. The length of SLEEP state can span multiple superframes, but must be less than ATP.

The channel time allocation methods defined in this standard permit a DEV to SLEEP other than in APS or SPS modes of operation. All DEVs not already in SPS or APS mode of operation are ACTIVE for the beacon and the entire duration of CAP of every superframe. They also participate in MTS operations. During the CFP, the DEV is ACTIVE during GTSs assigned to it or group address for reception. (Change pending due to comment resolution) If no information is received in those slots for more than 25 percent of the slot time with CCA indicating channel being idle, the DEV is not required to be available for the remainder of that GTS. The DEV is not required to be powered during transmission GTSs that will be unused for a given superframe. For any remaining periods in the CFP, the DEV may suspend transmit and receive activity and remove power or reduce power to sections of the DEV.

8.13.1 Changing power save mode and operation

{PS editor note: Work stilll required on the PS information command in this clause. The following paragraph has valuable content and can be the basis for the "switch to" CTA and operating mode/state information. As such, both APS and SPS are served by the same command and that is good.}}

Each DEV in the piconet using SPS mode shall inform the same to PNC by sending PS information command, every time their power save requirements change causing the change in the parameters sent in this command. The PNC shall remember the last such information from the DEV and use it in GTS allocations

and to indicate if the DEV is AWAKE or SLEEP for other piconet DEVs to see. The actual algorithms used for use of this information in GTS allocations is beyond the scope of this standard.

8.13.2 Asynchronous power save (APS) mode

The APS mode allows a DEV that is very sensitive to power utilization to remain associated with a piconet but have power savings significantly greater than an RPS DEV. In APS mode, the DEVs are permitted to be in a very low power state in sleep for an extended period of time spanning many superframes.

When APS devices have higher volumes of data to transfer during portions of their association in a piconet, they can revert to ACTIVE state of operation.

If a DEV is planning to use APS mode, then the DEV shall set the APS bit in the capability field to 1 at the association time to let the PNC know the intention of DEV. If PNC can not support APS mode then the association may be rejected.

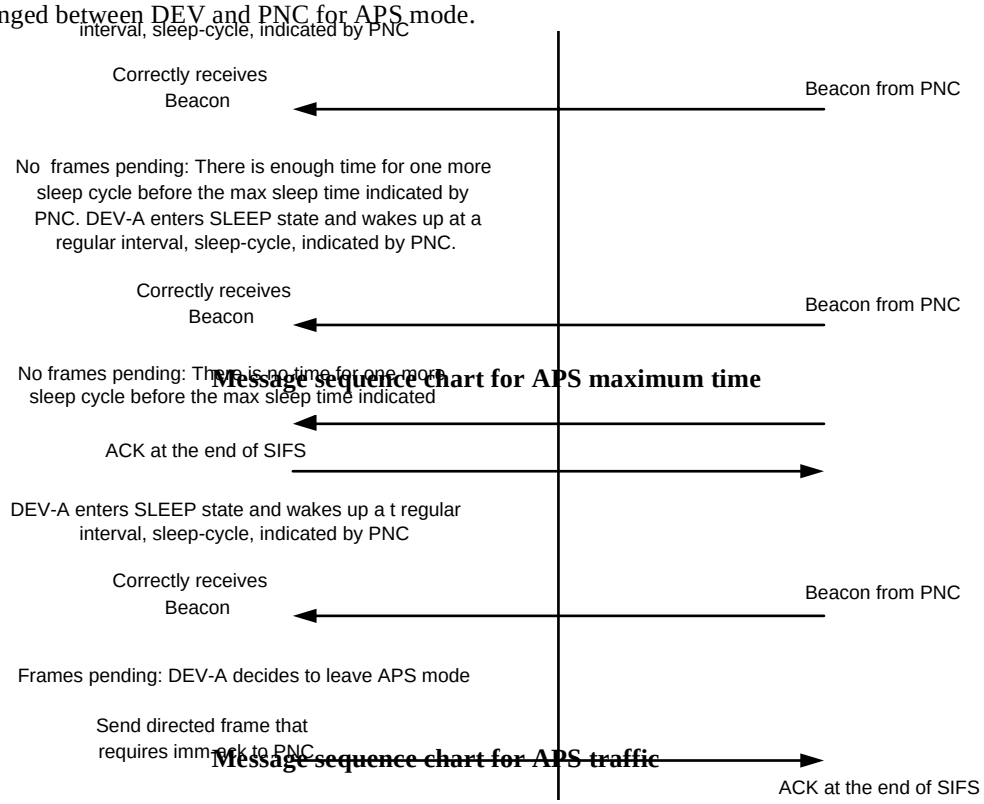
The PNC shall not allocate GTS with any DEV that is currently in SLEEP state as the destination DEV. The PNC shall not allocate GTSs for multicast dest-address if the PNC knows that any of the destination member for that multicast-group is currently in SLEEP state.

PNC is responsible for indicating the "traffic pending" status in the beacon in TIM-information element described in {xref to clause 7}. The PNC shall check the pending GTS-request list to decide if the traffic-indication for a DEV needs to be set to 1 in the outgoing Beacon.

In APS mode, before going to SLEEP state, the DEV shall inform the PNC of its intention by sending "APS sleep request" command and waiting for PNC to respond. Only at the end of the superframe in which the DEV receives a "APS sleep response" command from PNC, shall the DEV is allowed to enter SLEEP state for a maximum sleep time duration as indicated by the PNC in that command. The DEV is required to wakeup and check for TIM in the beacon once in number of superframes indicated by PNC in "Length of APS sleep-cycle" field in "APS sleep response" command. When the DEV wakes up and receives a beacon, if the TIM bit corresponding to the current DEV is set in the beacon, then the DEV may completely revert to AWAKE state. In any case the DEV shall revert to AWAKE state at the end of number of superframes indicated by PNC in "Length of APS sleep state" field in "APS sleep response" command. Whenever the DEV is coming out of APS mode and reverting to AWAKE state, the DEV shall send a directed frame, including command frame with no payload, that requires immediate ack to PNC until PNC acknowledges it. At the end of SLEEP state in APS mode, the DEV shall wakeup sufficient time before the expiration of the maximum sleep time in order to inform the PNC that it is awake.

If the DEV receives "APS sleep response" command from the PNC that disapproves entering APS sleep, the DEV shall not enter APS mode and instead wait for at least one more superframe before attempting to send another "APS sleep request" command to PNC.

The message sequence chart in Figure {xref} and Figure {xref} show the sequence of frames/commands exchanged between DEV and PNC for APS mode.



8.13.3 Synchronous power save (SPS) mode

SPS mode allows a DEV that is very sensitive to power utilization but requiring synchronization of SLEEP state among its peer DEVs for its QoS management. The SPS mode is based on grouping DEVs having similar power save requirements into SPS sets. These SPS sets are created and managed by PNC, although upon request by the DEVs that want to participate in those SPS sets. When an SPS set has no member DEV, the PNC shall terminate that SPS set. The PNC shall support at least one SPS set when the PNC is battery powered and support at least four SPS sets when the PNC is AC powered.

In order to use SPS mode, the DEV is required to request and register its address in an SPS set. The goal of the SPS Set is to establish a sharable time base among multiple DEVs for the occurrence of periodic GTSs for pending traffic while allowing the DEVs in the same SPS set to be in SLEEP state when there is no pending traffic.

8.13.3.1 Creation, use and management of SPS sets

Each SPS set has a unique parameter tuple associated with it, SPS Interval and Next Awake Beacon. SPS Interval is the the number of superframes between two successive wake beacons, defined as SPS-cycle, of DEVs registered in that SPS set. Next Awake Beacon is the beacon number corresponding to the immediate

next wake beacon of DEVs registered in that SPS set. These parameters of an SPS set are maintained by the PNC. The parameters of an SPSset, wake beacons and SPS-cycle are illustrated in Figure {xref}

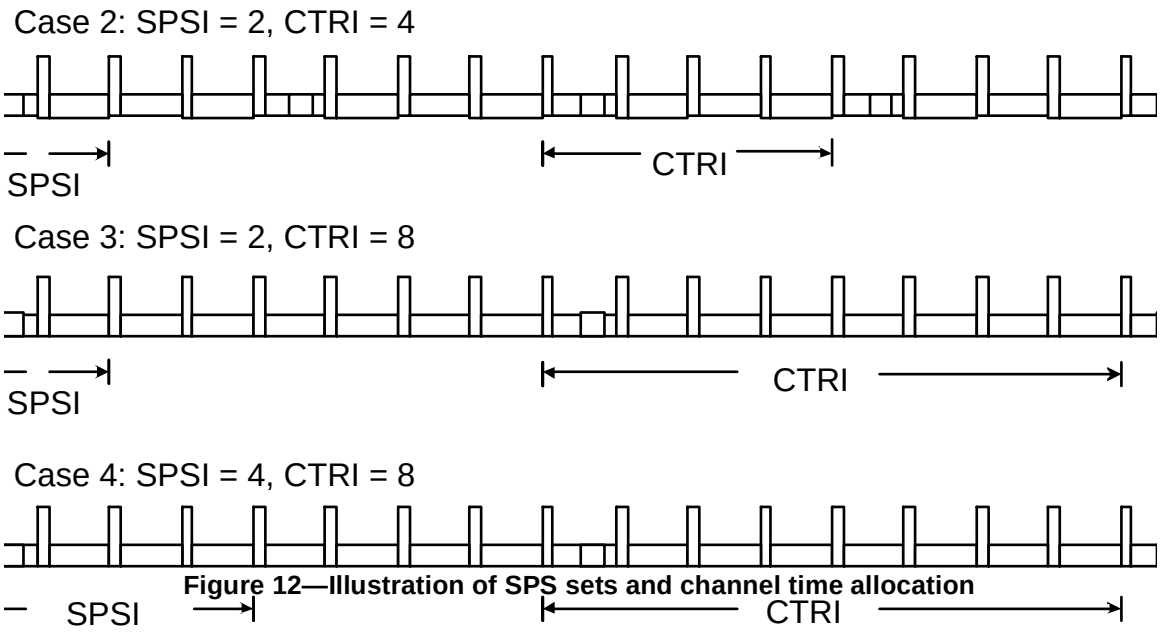


Figure 12—Illustration of SPS sets and channel time allocation

Any DEV associated with a PNC can request the information about the existing SPS set by sending SPS inquiry command, described in {xref to clause 7}, to PNC. The PNC shall respond by sending SPS inquiry response command, described in {xref to clause 7}, and provide the SPS parameters of the SPS sets currently in use within the piconet.

The selection of an SPS set for a DEV to participate in is left to that DEV. If there are no SPS sets that are currently in existence that match the DEVs requirements, the DEV may request the formation of a new SPS set by setting the operation type in SPS configuration request command to "new request". If the PNC creates a new SPS set, the DEV is informed of the same through the operation type of "new confirm" in the SPS configuration response command. The SPS set value is assigned by PNC and it is just an index that represents the set. Once an SPS set is created, the PNC shall keep the Next Awake Beacon for that set updated at all times.

A DEV may register in an existing SPS set by sending SPS configuration request command to PNC with operation type set to "place in set". If the DEV is added to the set, the PNC shall confirm the same by sending SPS configuration response command to the DEV with operation type set to "place in set confirm". Since a DEV can support multiple applications with different requirements, a DEV may register in more than one SPS set at a given time.

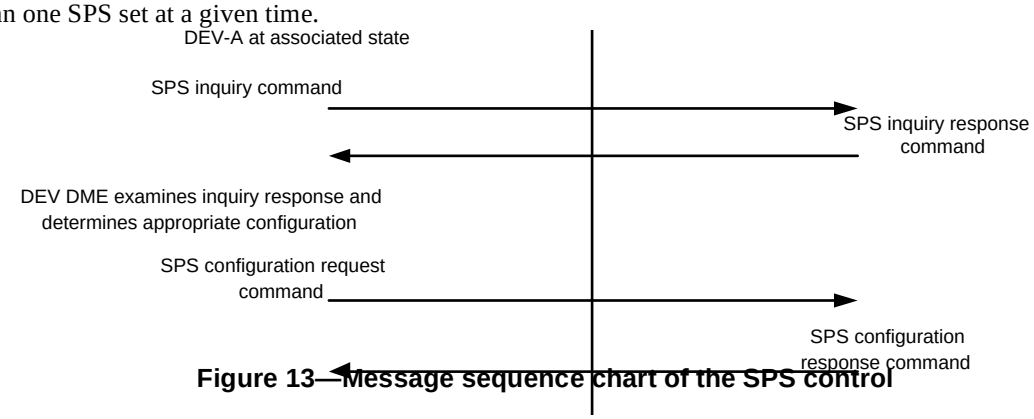


Figure 13—Message sequence chart of the SPS control

Figure xx - Message sequence chart of the SPS control process.

8.13.3.2 SPS Information Element

One or more SPS information elements is provided in the beacon when operating SPS sets are present in the piconet. The PNC shall create one SPS information element for each SPS Set that the PNC is currently using to time Awake beacons for an SPS DEV. Each SPS information element provides SPS Set index and the associated Next Awake Beacon and the SPS Interval for the set. In addition, the SIE shall list all piconet ADs for DEVs that are both currently in SPS mode and using that SPS Set as its time base. No SPS information element is created for SPS Sets with no members currently in SPS mode.

Continuously powered DEVs may look at the SIE to learn when to transmit to an SPS DEV. In addition, the SPS information element informs SPS capable DEVs, which SPS Set it must use to synchronize data transfers in SPS mode.

8.13.3.3 GTS Slot Timing in SPS Mode

A GTS slot belonging to a device in SPS mode is called an SPS slot. The timing of SPS slots is specified by DEV using an SPS channel time request {ref}). The number of superframes between SPS slots is specified the CTR Interval field of the CTRB, which is the same as an ACTIVE channel time request. An additional condition placed on the timing is that the value of the CTR Interval must not be less than the number of superframes between Awake beacons (SPS Interval). Since the CTR Interval like the SPS Interval must be a power of 2, the frequency of SPS slots must be a power of 2 subrate of the Wake beacon rate. This is illustrated in figure {xref this is where the big diagram showing the examples belongs}.

An SPS DEV shall listen to every Awake beacon regardless of the frequency with which Awake slots are allocated. If the SPS DEV is the DA of any CTA in the Awake beacon, then the SPS DEV shall listen during the associated GTS slot in that Awake superframe.