IEEE P802.15
Wireless Personal Area Networks

Project	IEEE P802.15 Working Group for Wireless Personal Area Networks (WPANs)	
Title	Draft Text (Approved and Yet-to-be-approved) for MPM/CSM-Related Sub-clauses	
Date Submitted	Jan., 2011	
Source	[Chin-Sean Sum, Alina Lu Liru, Fumihide Kojima, Hiroshi Harada]	Voice: [+81-46-847-5092] Fax: [+81-46-847-5440] E-mail: [sum@nict.go.jp]
Re:	Contains the Approved and Yet-to-be-approved Text for MPM/CSM Related Text	
Abstract	IEEE 802.15 Task Group TG4g Comment Resolution	
Purpose	To provide an idea on how the MPM/CSM text looks like after completion	
Notice	This document has been prepared to assist the IEEE P802.15. It is offered as a basis for discussion and is not binding on the contributing individual(s) or organization(s). The material in this document is subject to change in form and content after further study. The contributor(s) reserve(s) the right to add, amend or withdraw material contained herein.	
Release	The contributor acknowledges and accepts that this contribution becomes the property of IEEE and may be made publicly available by P802.15.	

****START - Not Part of the Draft Modification****

General Idea:

The purpose of this document is to provide a general overview on how the MPM/CSM text will look like after all the comments are resolved.

This document shows only the draft text in Clause 7, which consists of most of the MPM/CSM related text.

Other MPM subclauses (*i.e.* 5.5.5a and 6.1a) that are not substantially modified are not shown here.

This document:

- Resolves a total of 110 comments listed in DCN 10/948r3.
- Reflects the modifications (in red font - unapproved) in 7.1.5, 7.1.11.1, 7.1.14.1 as given in DCN 10/872r6.

Font color codes:

Black fonts: The MPM/CSM related texts that are already approved.

Red fonts: The MPM/CSM related texts that are yet to be approved.

****END - Not Part of the Draft Modification****

7. MAC sublayer specification

7.1 MAC sublayer service specification

7.1.1 MAC data service

7.1.1.1 MCPS-DATA.request

7.1.1.1.1 Semantics of the service primitive

7.1.5 Beacon notification primitive

7.1.5.1 MLME-BEACON-NOTIFY.indication

7.1.5.1.1 Semantics of the service primitive

Insert the following new parameter at the end of the list in 7.1.5.1.1 (before the closing parenthesis):

CoexSpecification

Insert the following new row at the end of Table 90:

Table 90—MLME-BEACON-NOTIFY.indication parameters

Name	Type	Valid Range	Description
CoexSpecification	Set of octets	See 7.2.2.4a.1	The information on the multi-PHY management (MPM)

~~7.1.5a Coex beacon notification primitive~~

~~7.1.5a.1.1 Semantics of the service primitive~~

~~7.1.5a.1.2 When generated~~

~~7.1.5a.1.3 Appropriate usage~~

7.1.11 Primitives for channel scanning

7.1.11.1 MLME-SCAN.request

7.1.11.1.1 Semantics of the service primitive

Insert the following new parameters at the end of the list in 7.1.11.1.1 (before the closing parenthesis):

ScanDurationBPAN,
ScanDurationNBPAN
MPMScanChannels

Change Table 103 (the entire table is not shown) as indicated:

Table 103—MLME-SCAN.request parameters

Name	Type	Valid range	Description
ScanChannels	Bitmap	27-bit field. If *phyCurrentPage* = 7 or 8, it is a (*phyMaxSUNChannelSupported*+1)-bit field.	The ~~27~~ bits (b_0, b_1,... ~~b_{26}~~b_{n-1}), where n=27 or (*phyMaxSUNChannelSupported* -1), indicate which channels are to be scanned (1 = scan, 0 = do not scan) for each of the ~~27~~ channels supported by the PHY PIB attribute *phyCurrentPage*~~ChannelPage parameter~~.
ScanDurationBPAN	Integer	0–14	The maximum time spent scanning for enhanced beacon in a beacon-enabled PAN on the channel is [*aBaseSuperframeDuration* * 2^n] symbols, where symbol refers to the symbol time in the current PHY, and *n* is a parameter to specify the scan duration.
ScanDurationNBPAN	Integer	0–16383	The maximum time spent scanning for enhanced beacon in a non-beacon-enabled PAN on the channel is [*aBaseSlotDuration* * *n*] symbols, where symbol refers to the symbol time in the current PHY, and *n* is a parameter to specify the scan duration.
MPMScanChannels	Bitmap	*phyMaxSUNChannelSupported* + 1 bits	This parameter defines the specific channels where an EB request is transmitted or an EB is scanned for in a location where multiple PANs may be operating and it is possible that more than one PHY (MR-FSK, MR-OQPSK or MR-OFDM) is in use. A bit is set (=1) for channel(s) where the EB request is to be sent or the EB is to be scanned for.

~~***Insert the following new subclauses (7.1.11a–7.1.11a.2.2) after 7.1.11:***~~

~~7.1.11a Primitives for coex-beacon scanning~~

~~7.1.11a.1 MLME-COEX-SCAN.request~~

~~7.1.11a.1.1 Semantics of the service primitive~~

~~7.1.11a.1.2 Appropriate usage~~

~~7.1.11a.2 MLME-COEX-SCAN.confirm~~

~~7.1.11a.2.1 When generated~~

~~7.1.11a.2.2 Appropriate usage~~

7.1.14.1 MLME-START.request

7.1.14.1.1 Semantics of the service primitive

Insert the following new parameters at the end of the list in 7.1.14.1.1 (before the closing parenthesis)

AttributeID
EnhancedBeaconOrder
OffsetTimeSlot
NBPANEnhancedBeaconOrder

Insert the following new rows at the end of Table 108:

Table 108—MLME-START.request primitives

Name	Type	Valid range	Description
AttributeID	Integer	—	Determines which IEs are sent in the EB. Otherwise set to zero.
EnhancedBeaconOrder	Integer	0–15	Indicates how often the EB is to be transmitted in a beacon-enabled PAN. A value of 15 indicates that no EB will be transmitted.
OffsetTimeSlot	Integer	1–15	Indicates the time difference between the EB and the preceding periodic beacon.
NBPANEnhancedBeaconOrder	Integer	0–16384	Indicates how often the EB is to be transmitted in a non-beacon-enabled PAN (i.e., *macBeaconOrder* = 15). A value of 16384 indicates that no EB will be transmitted.

7.1.14.1.3 Effect on receipt

Insert the following new paragraph before the last paragraph of 7.1.14.1.3:

In a beacon-enabled PAN (BeaconOrder<15), the MLME examines the OffsetTimeOrder parameter to determine the time to begin transmitting the EB following the periodic beacon. EB intervals are determined by the value of EnhancedBeaconOrder.

In a non-beacon-enabled PAN (BeaconOrder=15), the MLME examines the NBPANEnhancedBeaconOrder parameter to determine the interval between EBs.

See 7.5.1.2a for the description of enhanced beacon timing.

7.2 MAC frame formats

7.2.1 General MAC frame format

7.2.1.9 FCS field

7.2.2 Format of individual frame types

7.2.2.1 Beacon frame format

7.2.2.2 Data frame format

7.2.2.3 Acknowledgment frame format

7.2.2.3.1 Acknowledgment frame MHR fields

7.2.2.4 MAC command frame format

7.2.2.4a Enhanced beacon (EB) frame format for multi-PHY management

When generated in response to an enhanced beacon request (EBR), the content of the EB shall include the IE specified in Table 80o.

< Editor's note: Table 80o is a table in the TG4e draft. If we are going to reference it here, we need to include it here (at least until 4e is published, assuming they will publish first). By including Table 80o, we will also need to include everything that goes along with it (e.g., PIB attributes introduced, Table 80p, etc.).>

7.2.2.4a.1 Coex Specification IE

The Coex Specification field shall be formatted as illustrated in Figure 92ap.

The IE Descriptor subfield contains the first bit (set to 0), the Element ID subfield, and IE Content Length subfield.

The Beacon Order subfield shall specify the transmission interval of the periodic beacon. See 7.5.1.2a for an explanation of the relationship between the periodic beacon order and the periodic beacon interval.

Bits: 0	1–8	9–15	16–19	20–23	24–27	28–31	
0	Element ID	IE Content Length	Beacon Order	Superframe Order	Final CAP Slot	Enhanced Beacon Order	...
IE Descriptor							

	32–35	36–39	40–55	56–87	88–95
...	Offset Time Slot	CAP Backoff Offset	NBPAN Enhanced Beacon Order	Channel Page	Reserved

Figure 92ap—Format of the Coex Specification field

The Superframe Order subfield shall specify the length of time during which the superframe is active (i.e., receiver enabled), including the beacon frame transmission time. See 7.5.1.1 for an explanation of the relationship between the superframe order and the superframe duration.

The Final CAP Slot subfield specifies the final superframe slot utilized by the CAP. The duration of the CAP, as implied by this subfield, shall be greater than or equal to the value specified by *aMinCAPLength*. However, an exception is allowed for the accommodation of the temporary increase in the beacon frame length needed to perform GTS maintenance (see 7.2.2.1.3).

The Enhanced Beacon Order subfield shall specify the transmission interval of the EB frames. See 7.5.1.2a for an explanation of the relationship between enhanced beacon order and enhanced beacon interval.

The Offset Time Slot subfield shall specify the interval between the EB and the preceding periodic beacon. See 7.5.1.2a for more explanation.

The CAP Backoff Offset subfield specifies the actual slot position the EB is transmitted due to backoff procedure in CAP.

The NBPAN Enhanced Beacon Order subfield shall specify the transmission interval between consecutive EBs in the non-beacon-enabled mode.

The Channel Page subfield shall be specified as in 6.1.2.7.

Additionally, if the source and destination PAN are operating in different PHY modes and both intend to employ the same frequency diversity scheme, all corresponding frames facilitating that frequency diversity scheme shall be conducted using the CSM specified in 6.1a.

If the Beacon Order subfield is set to 15, the Superframe Order, Final CAP Slot, and Offset Time Slot subfields shall be set to zero upon transmission and ignored upon reception.

~~**7.2.2.4a.2 Frequency Hopping Specification field**~~

~~The Frequency Hopping Specification field shall be formatted as illustrated in Figure 92aq.~~

~~The Timing Information subfield shall be set to the MSB (1 octet) of the absolute slot number (ASN) of the timeslot being used for transmission of this frame if security is enabled in the MHR. Otherwise it is set to the ASN (5 octets).~~

Octets: 1/5	1	2	4	variable	1	0/1	variable	...
Timing Information	Channel Page	Number of Channels	PHY Configuration	Extended Bitmap[a]	Hopping Sequence ID	Hopping Sequence Length	Hopping Sequence	

[a]For channel pages 7 and 8

...	0/1	1	0/22	1	1	variable	0/4/8/16
	Current Hop in Sequence	Timeslot Template ID	Timeslot Template[a]	Join Priority	Number of Slot-frames	Slot-frame Information and Links[b]	MIC

Figure 92aq—Format of the Frequency Hopping Specification field

[a]Without Timeslot Template ID
[b]For each slot-frame

The Channel Page subfield shall be set to the five MSBs (b27, ..., b31) of the row in *phyChannelsSupported* being used by the advertising device. This corresponds to the *channelPage* field of the *macHoppingSequence* PIB attribute.

The Number of Channels subfield shall be set to the number of channels supported by the PHY being used by the advertising device. This corresponds to the *numberOfChannels* field of the *macHoppingSequence* PIB attribute.

For channel pages 0-6, the 27 LSBs (b0, b1, ..., b26) of the PHY Configuration subfield are set indicate the status (1=to be used, 0=not to be used) for each of the up to 27 valid channels available to the PHY. For channel pages 7 and 8, the 27 LSBs indicate the configuration of the PHY, and the channel list is contained in the *extendedBitmap*.

For channel pages 7 and 8, the Extended Bitmap subfield shall contain a bitmap of *numberOfChannels* bits, where b_k shall indicate the status of channel k for each of the up to *numberOfChannels* valid channels supported by that channel page and *phyConfiguration*. Otherwise, the subfield is 0 octets.

Bits 0–6 of the Hopping Sequence subfield shall be set to the *macHoppingSequenceID* used by the MAC. Bit 7 is set to one to indicate that the hopping sequence length and hopping sequence are carried inline in the advertisement. Otherwise, it is set to zero, and the hopping sequence length and hopping sequence are omitted. Hop sequence 0 is well-known and need never be carried inline. The *macHoppingSequence* is defined in the MAC PIB table.

Figure 92ar shows the Hopping Sequence ID subfield.

Bits: 0–6	7
Hopping Sequence ID	Hopping Sequence Inline

Figure 92ar—Hopping Sequence subfield

If carried inline, the Hopping Sequence Length subfield shall be set to *macHoppingSequenceLength* field of the *macHoppingSequence* PIB attribute corresponding to the *macHoppingSequenceID*.

If carried inline, the Hopping Sequence subfield shall be set to the *macHoppingSequence* field of the *macHoppingSequence* PIB attribute corresponding to the *macHoppingSequenceID*.

The Current Hop in Sequence subfield shall be set to current location in the hopping sequence element of the *macHoppingSequence*, i.e. (ASN + channelOffset for the link being used to transmit the advertisement) % *macHoppingSequenceLength*.

Bits 0–6 of the Timeslot Template ID subfield shall be set to the ID of the timeslot template used by the MAC. Bit 7 is set to one to indicate that the Timeslot Template is carried inline in the advertisement. Otherwise, it is set to zero, and the template is omitted. The Timeslot Template is defined in the MAC PIB table.

Figure 92as shows the Timeslot Template ID subfield.

Bits: 0–6	**7**
Timeslot Template ID	Timeslot Template Inline

Figure 92as—Timeslot Template ID subfield

The Timeslot Template subfield shall be set to the *macTimeslotTemplate* from the MAC PIB table corresponding to the Timeslot Template ID in the previous subfield, minus the timeslot template ID.

Figure 92at shows the Join Priority subfield.

Bits: 0–5	**6–7**
Join Priority	Reserved

Figure 92at—Join Priority subfield

The Join Priority subfield can be used by a joining device to decide which devices to send an Association Request if it hears advertisements from more than one device. The PAN coordinator's join priority is zero. A lower value of join priority indicates that the device is a preferred one to connect to.

The advertising device's join priority is the lowest join priority heard when it joined the network + 1.

The Number of Slotframes subfield is set to the total number of slotframes for which information is being advertised in this command frame.

The Slotframe Information and Links subfield is included for each slotframe. The format of the Slotframe Information and Links subfield is depicted as shown in Figure 92au.

Slotframe Handle shall be set to the slotframeHandle that uniquely identifies the slotframe.

Slotframe Size shall be set to the size of the slotframe in number of timeslots.

~~Octets: 1~~	~~2~~	~~1~~	~~5 × number of links~~
~~Slotframe Handle~~	~~Slotframe Size~~	~~Number of Links~~	~~Link information (for each link)~~

Figure 92au—Slotframe Information and Links subfield

~~The Number of Links shall be set to the number of links that belong to the specific slotframe indicated in slotframeHandle.~~

~~Link Information describes the attributes of each link. The format of Link Information is depicted as shown in Figure 92av.~~

~~Octets: 2~~	~~2~~	~~1~~
~~Timeslot~~	~~Channel Offset Information~~	~~Link Option~~

Figure 92av—Link information

~~Timeslot shall be set to the timeslot of this link.~~

~~Channel Offset Information shall be set to the channelOffset of this link.~~

~~Link Option indicates whether this link is a TX link, an RX link, or a SHARED TX link, and whether the device being linked to is to be used for clock synchronization. It corresponds to the linkOptions field in the link table for the receiving device. SHARED TX links are used for a joining device to send an Association Request command. RX links are used for a joining device to receive an Association Response command from an advertising device. RX links must have the Timekeeping LinkOptions bit set. It is possible for one link to be used as both SHARED_TX and RX link.~~

~~The MIC subfield is set to the Message Integrity Check of the Advertisement command frame if security is on.~~

Insert the following new subclause (7.3a) after 7.3.9.2:

7.3a SUN PHY Capabilities information elements (IEs)

7.4 MAC constants and PIB attributes

7.4.1 MAC constants

7.5 MAC functional description

Insert the following new subclause after 7.5.1.2:

Table 127—MAC PIB attributes

Attribute	Identifier	Type	Range	Description	Default
macSyncSymbolOffset†	0x5b	Integer	0x000–0x100 for the 2.4 GHz PHY 0x000–0x400 for the 868/915 MHz PHY, the MR-FSK PHY, and the MR-OFDM PHY	The offset, measured in symbols, between the symbol boundary at which the MLME captures the timestamp of each transmitted or received frame, and the onset of the first symbol past the SFD~~, namely, the first symbol of the Length field~~.	Implementation specific
macEnhancedBeaconOrder		Integer	0–15	Specification of how often the coordinator transmits its EB. If *macEnhancedBeaconOrder* = 15, no EB will be transmitted.	0
macNBPANEnhancedBeaconOrder		Integer	0–16384	Specification of how often the coordinator transmits its EB in a non-beacon-enabled PAN (i.e., *macBeaconOrder* = 15). If *macNBPANEnhancedBeaconOrder* = 16384, no EB will be transmitted.	16383
macOffsetTimeSlot		Integer	1–15	The time, in symbols, between the EB and the preceding periodic beacon.	15

7.5.1.2a MPM EB timing

In a beacon-enabled PAN, a coordinator operating as a SUN device shall transmit an EB at fixed intervals, in addition to the usual periodic beacons. The superframe timing shall be as specified in Figure 105a.

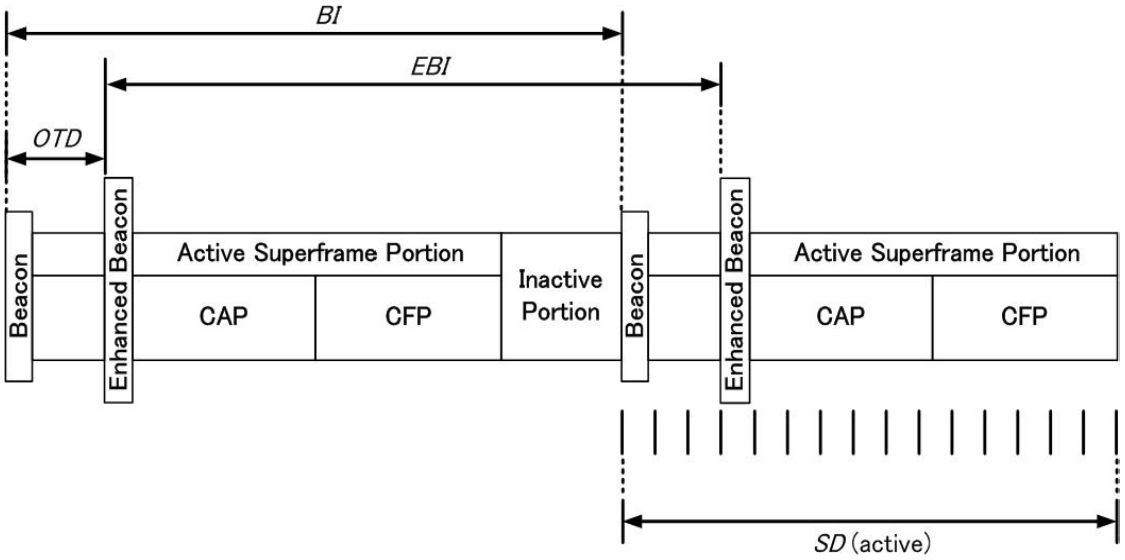

Figure 105a—Timing information for EB frames

The MAC PIB attribute *macEnhancedBeaconOrder* describes the interval at which the coordinator shall transmit its enahnced beacon frames. The values of *macEnhancedBeaconOrder* and the enhanced beacon interval (EBI) are related as follows:

$$EBI = aBaseSuperframeDuration \times 2^{macEnhancedBeaconOrder} \quad \text{symbols} \qquad (22)$$

The interval between an EB and the preceding periodic beacon is described by the MAC PIB attribute *macOffsetTimeSlot*. The values of *macOffsetTimeSlot* and offset time duration (OTD) are related as follows:

$$OTD = aBaseSlotDuration \times macOffsetTimeSlot \quad \text{symbols} \qquad (23)$$

In a non-beacon-enabled PAN, the interval between two EB frames is described by the NBPAN enhanced beacon order, *macNBPANEnhancedBeaconOrder*. The resolution of time shall be *aBaseSlotDuration*. The values of *macNBPANEnhancedBeaconOrder* and the NBPAN enhanced beacon interval (EBI_{NBPAN}) are related as follows:

$$EBI_{NBPAN} = aBaseSlotDuration \times macNBPANEnhancedBeaconOrder \text{ symbols}$$

7.5.2 Starting and maintaining PANs

7.5.2.3 Starting and realigning a PAN

7.5.2.3.1 Starting a PAN

Change the first paragraph of 7.5.2.3.1 as indicated:

A PAN should be started by an FFD only after having first performed a MAC sublayer reset, by issuing the MLME-RESET.request primitive with the SetDefaultPIB parameter set to TRUE, an active channel scan,

and a suitable PAN identifier selection. Scanning for enhanced beacons should take place prior to scanning for periodic beacons. The algorithm for selecting a suitable PAN identifier from the list of PAN descriptors returned from the active channel scan procedure is out of the scope of this standard. In addition, an FFD should set macShortAddress to a value less than 0xffff.

7.5.6.1 Transmission, reception, and acknowledgment

Insert the following new paragraph after the second paragraph of 7.5.6.1:

Each coordinator shall store its current enhanced beacon sequence number (EBSN) value in the MAC PIB attribute *macEBSN* and initialize it to a random value: the algorithm for choosing a random number is out of the scope of this standard. Each time an EB frame is generated, the MAC sublayer shall copy the value of *macEBSN* into the Sequence Number field of the MHR of the outgoing frame and then increment *macEBSN* by one. The value of *macEBSN* shall be permitted to roll over.

Change the third paragraph of 7.5.6.1 as indicated:

It should be noted that ~~both~~ the DSN, ~~and~~ BSN, and EBSN are 8-bit values and, therefore, have limited use to the next higher layer (e.g., in the case of the DSN, in detecting retransmitted frames).

7.5.6.4.2 Acknowledgment

7.5.8a Inter-PHY coexistence with EB frames for SUNs

In order to effectively manage multiple SUNs utilizing different PHYs in the same location, the MPM scheme specifies that all SUN coordinators operating at duty ratio (cycle) of more than 1% shall be able to transmit and receive CSM, as given in Table 6a (see 6.1a). In the MPM scheme, an EB shall be sent in the CSM.

In a beacon-enabled PAN, an existing coordinator shall transmit an EB at a fixed interval by using CSM. Any intending coordinator shall first scan for the EB for the maximum duration of the EBI or until one is detected, which ever is longer in time. If an intending coordinator detects an EB, it shall either occupy another channel, achieve synchronization with the existing PAN, or stop communication. While specific mechanisms to achieve synchronization between two PANs utilizing different PHY modes are

implementation-dependent, the timing information applicable for synchronization purposes is specified in the EB. The illustration of the procedure is given in Figure 112a.

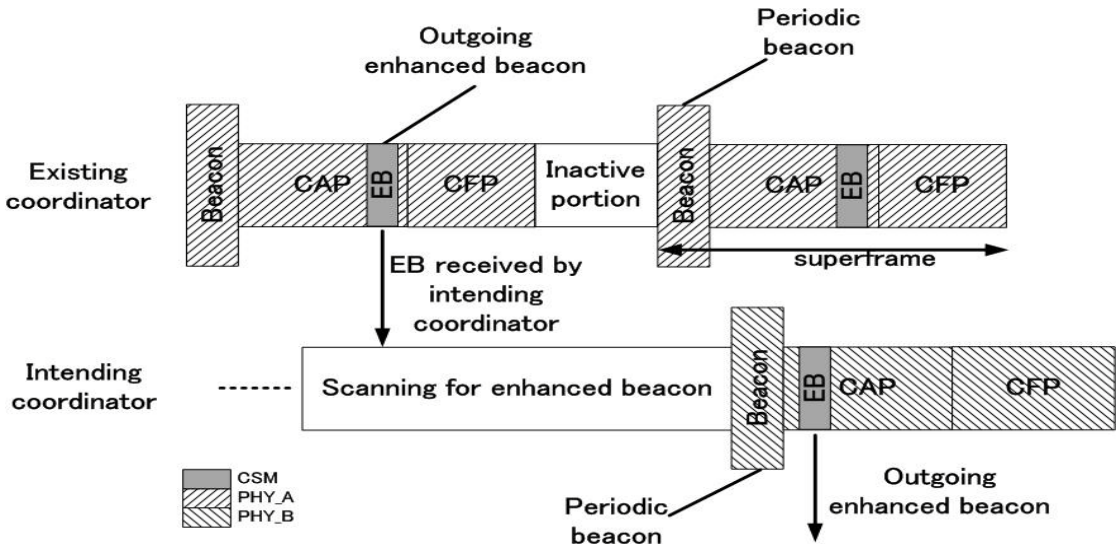

Figure 112a—Inter-PHY mode coexistence in a beacon-enabled PAN

The EB is sent only in the CAP. The MAC sublayer shall ensure that, after the random backoff, the remaining CSMA-CA operations can be undertaken and the entire transaction can be transmitted before the end of the CAP. If the number of backoff periods is less than or equal to the remaining number of backoff periods in the CAP, the MAC sublayer shall apply its backoff delay and then evaluate whether it can proceed. The MAC shall proceed if the remaining CSMA-CA algorithm steps and the EB transmission can be completed before the end of the CAP.

If the number of backoff periods is greater than the remaining number of backoff periods in the CAP, the MAC sublayer shall pause the backoff countdown at the end of the CAP and resume it at the start of the CAP in the next superframe.

In a nonbeacon-enabled PAN, an existing coordinator should transmit an EB periodically using the CSM. Any intending coordinator shall first scan for the EB until the expiration of EBI_{NBPAN} or until an EB is detected, whichever occurs first. The illustration of the procedure is given in Figure 112b.

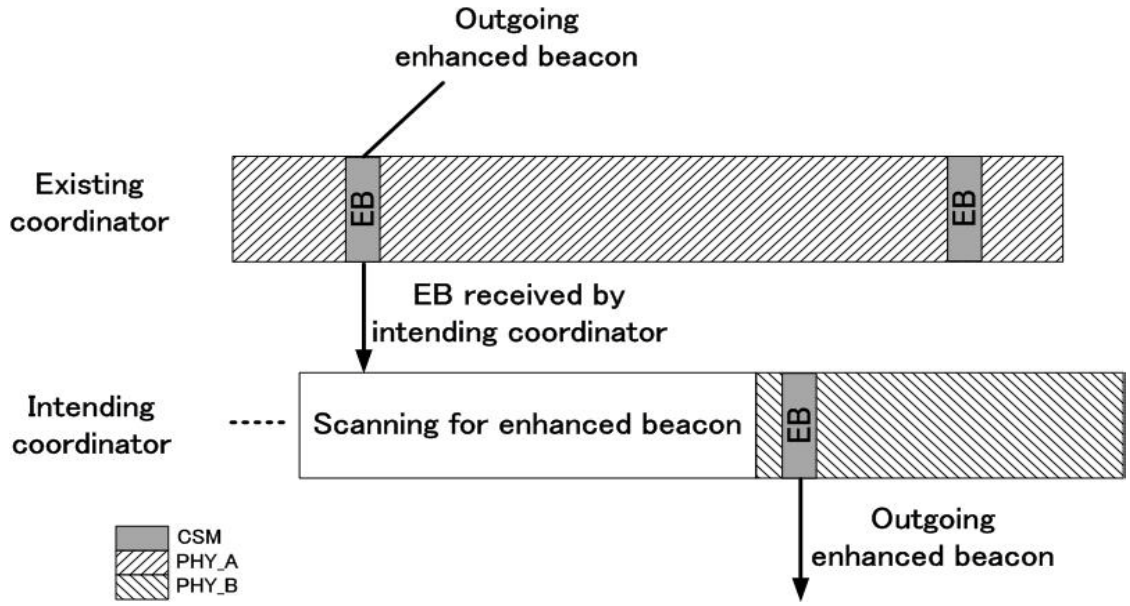

Figure 112b—Inter-PHY mode coexistence in a nonbeacon-enabled PAN

Alternatively, the EB may be obtained in an on-demand manner. In this case, the EBR is sent by the intending coordinator requesting the EB from the existing coordinator. Upon receiving the EBR, the existing coordinator (or any other coordinator-capable device receiving the EBR within the same POS) may respond by sending the EB to the intending coordinator.