IEEE P802.15
Wireless Personal Area Networks

Project	IEEE P802.15 Working Group for Wireless Personal Area Networks (WPANs)	
Title	Frequency Hopping Network Discovery across Multiple PHYs	
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Re:		
Abstract	IEEE 802.15 Task Group TG4g Comment Resolution	
Purpose		
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Text – General Idea of this document

****Not Part of the Draft Modification****

General Idea:

The purpose of this document is to include a simple discovery mechanism between hopping and non-hopping system across multiple PHYs. **The primary objective of the mechanism is to facilitate basic coexistence between the existing network (*i.e.* hopping network) and the incoming network.** The procedures are to facilitate in the simplest way, discovery between the existing and the incoming network.

The basic features of the mechanism:

(1) The existing network (*i.e.* hopping network) sends out EB, while the incoming network tries to capture it

(2) For obtaining the enhanced beacon EB (previously coex-beacon), procedures for both periodic and on-demand EB are possible

(3) For periodic EB
- the existing coordinator shall send EB in every hop
- the incoming coordinator shall scan the EB in one channel for the total time of one full cycle of hopping sequence

(4) For on-demand EB
- the incoming coordinator shall send the enhanced beacon request (EBR) in one channel at least once in every channel dwell time

(5) In case of on-demand EB, besides the existing coordinator, other coordinator-capable devices in the existing network may send out the EB.

(6) In cases where the upper layer conveys the list of channel where the EB will be transmitted, the incoming coordinator does not need to scan every channel in the hopping sequence.

The basic structure of this document:

(1) Field in EB frame with timing information to facilitate discovery (see in this document 7.2.2.4a.3)

(2) Details of timing description (see in this document 7.5.1.2b)

(3) Newly added MAC constants and attributes (see in this document Tables 126 and 127)

(4) Functional description for the discovery mechanism (see in this document 7.5.8b)

Instructions to the editors are given in ***Editorial Notes*** in red font.

Editorial note: Replace sub-clause 7.2.2.4a.3 with the following:

7.2.2.4a.3 Frequency Hopping Specification field

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

Bits: 0	**1-8**	**9-15**	**variable**	
0	Element ID	IE Content Length	MPM Available Channels	…
IE Descriptor				

	2 octets	**2 octets**	**2 octets**	**2 octets**
…	Dwell Time Order	Hopping Sequence Length	Frequency Hopping Enhanced Beacon Order	Hopping Channel Switch Order

Figure 92c – Format of the Frequency Hopping Specification field

The IE Descriptor subfield contains the first bit set to 0, the Element ID subfield and IE Content Length subfield as specified in Table 120b.

The MPM Available Channels subfield shall identify the specific channels able to be occupied in the multi-PHY network, including the frequency hopping network. The maximum length of the subfield is *phyMaxSUNChannelSupported* + 1 bits, where a bit is used to represent the availability of a particular channel. A bit is set (=1) if the channel can be occupied.

The Dwell Time Order (DTO) subfield shall specify the dwell time for occupancy in one channel (*i.e.* one hop) in the frequency hopping sequence. See 7.5.1.2b for detailed explanation.

The Frequency Hopping Enhanced Beacon Order (FHEBO) shall specify the transmission interval between enhanced beacons. See 7.5.1.2b for the relationship between FHEBO and Frequency Hopping Enhanced Beacon Interval (FHEBI).

The Hopping Channel Switch Order (HCSO) shall specify the interval between the transmission of an EB and the starting time boundary of that particular hop. See 7.5.1.2b for the relationship between HCSO and Hopping Channel Switch Duration (HCSD).

The Hopping Sequence Length (HSL) subfield shall specify the number of hops contained in the frequency hopping sequence. See 7.5.1.2b for detailed explanation.

Editorial note: Add new sub-clause 7.5.1.2b as the following:

7.5.1.2b Enhanced beacon frame timing during frequency hopping

In a frequency hopping network, a coordinator as a SUN device shall either transmit an enhanced beacon (EB) in every hop of the frequency hopping sequence, or upon receiving an enhanced beacon request (EBR). The timing information shall be specified according to Figure 105b.

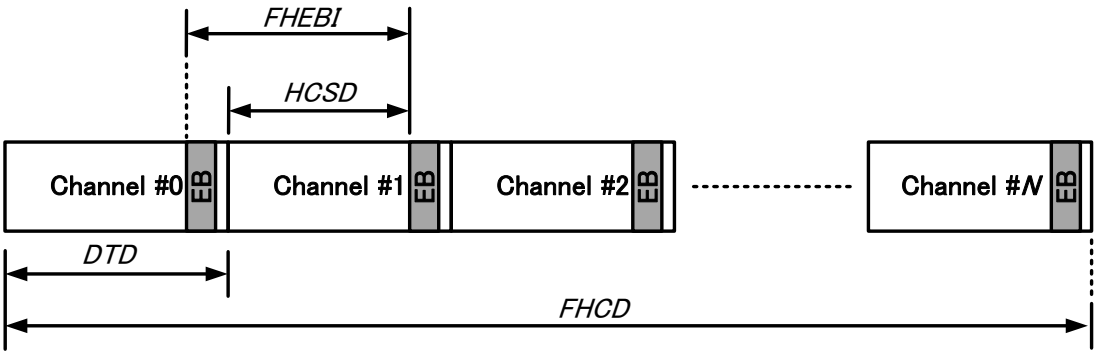

Figure 105b Timing information for enhanced beacon during frequency hopping

The dwell time for the existing coordinator to occupy one channel (*i.e.* one hop) in the hopping sequence is described by the dwell time order (DTO). The MAC PIB attribute for DTO is *macDwellTimeOrder*. The values of DTO and dwell time duration (DTD) are related as follows:

$$DTD = aFrequencyHoppingSlotDuration * \text{DTO} \quad \text{symbols}$$

The duration for the existing coordinator to complete a hopping cycle through all the

channels specified the frequency hopping sequence can thus be described by frequency hopping cycle duration (FHCD). The values of FHCD and DTD are related as follows:

FHCD = DTD * HSL symbols

where HSL is the number of hops in the hopping sequence. The MAC PIB for HSL is *macHoppingSequenceLength*.

The interval between two enhanced beacon frames is described as the frequency hopping enhanced beacon order (FHEBO). The MAC PIB attribute for FHEBO is *macFrequencyHoppingEnhancedBeaconOrder*. The values of *FHEBO* and the frequency hopping enhanced beacon interval (FHEBI) are related as follows:

FHEBI = *aBaseSlotDuration* * FHEBO symbols

The interval between the transmission of an EB and the starting time boundary of that particular channel is described by the hopping channel switch order (HCSO). The MAC PIB attribute for HCSO is *macHoppingChannelSwitchOrder*. The values of HCSO and hopping channel switch duration (HCSD) are related as follows:

HCSD = *aBaseSlotDuration* * HSCO symbols

Editorial note: Add the new MAC attributes in Table 127, as below:

Attribute	Identifier	Type	Range	Description	Default
macDwellTimeOrder		Integer	0-16383	Specification of the dwell time for occupancy of one channel (*i.e.* one hop) in the frequency hopping sequence.	0
macHoppingSequenceLength		Integer	2-2047	The number of hops in the frequency hopping sequence	

macFrequencyHoppingEnhancedBeaconOrder		Integer	0-16383	Specification of how often the coordinator transmits its EB in a frequency hopping network. If *macFrequencyHoppingEnhancedBeaconOrder* = 16384, no EB will be transmitted.	
macHoppingChannelSwitchOrder		Integer	0-16383	Specification of the duration between the EB and the starting time boundary of that particular channel.	

Editorial note: Add new sub-clause 7.5.8b as the following:

7.5.8b Inter-PHY coexistence in frequency hopping networks

In order to facilitate multi-PHY coexistence in a frequency hopping network, the MPM scheme specifies that all coordinators operating in a frequency hopping network shall transmit an enhanced beacon at a fixed interval, or upon receiving an EBR, by using CSM.

In a frequency hopping network, an existing coordinator shall transmit an EB at fixed interval, FHEBI by using CSM. Any potential incoming coordinator should first, in one particular channel, perform passive scan for the EB until the expiration of the FHCD or until an EB is detected, whichever occurs first. If an incoming coordinator detects an EB, it may either join the network, or achieve time synchronization for the purpose of avoiding the existing network.

Alternatively, the EB may be obtained in an on-demand manner. In this case, the EBR is sent by the incoming coordinator requesting the EB from the existing coordinator. The EBR should be sent in the same channel at most DTD apart, for at least HSL times.

Upon receiving the EBR, the existing coordinator (or any other coordinator-capable device receiving the EBR within the same POS) should respond by sending the EB to the incoming coordinator.

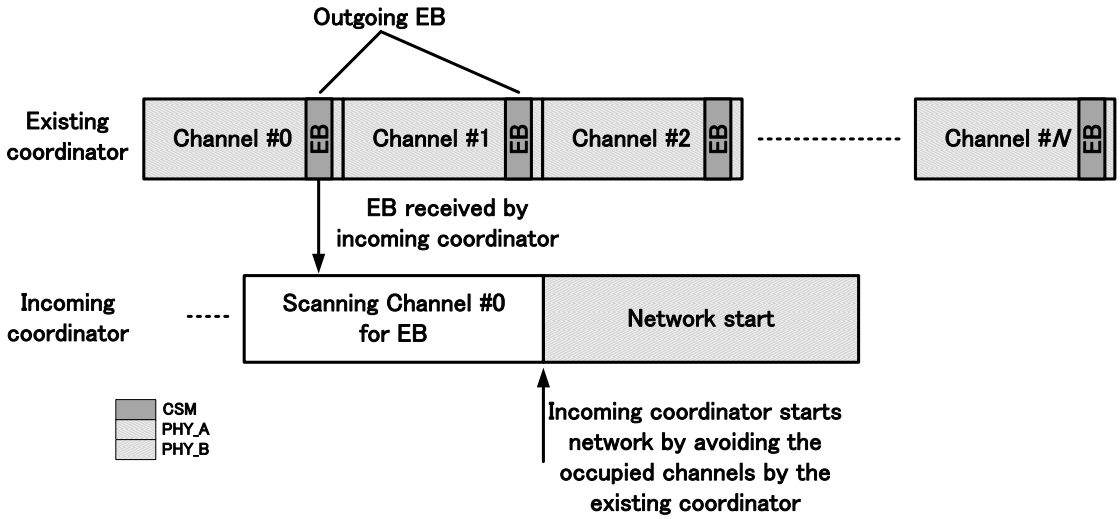

Figure 112d Inter-PHY coexistence in a frequency hopping network