IEEE P802.15
Wireless Personal Area Networks

Project	IEEE P802.15 Working Group for Wireless Personal Area Networks (WPANs)
Title	**Frequency Hopping Support for SUN Devices**
Date Submitted	July 2010
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Re:	Frequency Hopping Support for SUN Devices
Abstract	This document proposes resolutions to address comments submitted against letter ballot 51 (TG4g) and letter ballot 53 (TG4e) that are related to frequency hopping support for new TG4g PHY modes that require frequency hopping to meet regulatory requirements.
Purpose	Propose resolution text for comments submitted against the TG4g and TG4e letter ballots.
Notice	
Release	

TG4g (LB 51) Comment Resolution:
This document proposes resolutions for the following TG4g comments: 1637, 1799, 1804, 1805, 1806, 1808, 1814, 1815, 1816

TG4e (LB 53) Comment Resolution:
This document proposes resolutions for the following TG4e comments: 12, 13, 313, 314, 959, 960, 1009, 1010, 1028, 1029, 1041, 1042, 1172, 1173, 1198, 1340, 1341, 1474

Proposed changes to be included in the 802.15.4g amendment:

Add the following to Section 5.5:

5.5.x Frequency Hopping Mechanisms to Support SUN PHY Modes

5.5.x.1 Overview

Depending on the region they are deployed, SUN devices using the MR-FSK PHY may be required to operate in a frequency hopping mode to meet regulatory requirements. When *macSunFrequencyHopping* is TRUE, the MAC sublayer:

- supports frequency hopping using PIB attributes that define the channel list and channel dwell time,
- maintains a relative timer from the start of the hopping sequence, and uses this timer value, the channel dwell time and the channel hopping sequence to properly set the PHY channel (*phyCurrentChannel*).

The PIB attributes that control SUN frequency hopping are illustrated in Figure x.

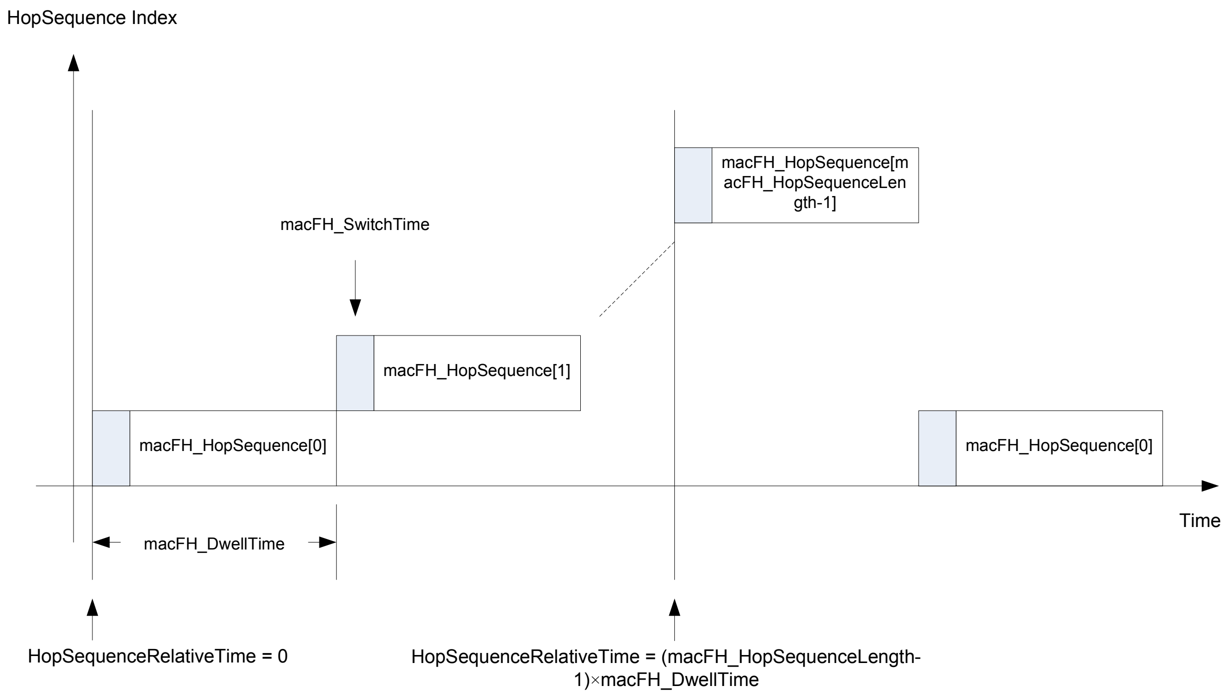


Figure x: SUN Frequency Hopping Channel Sequence in the Time Domain

5.5.x.2 Mechanisms to Find, Form, and Join a SUN Frequency Hopping Network

In addition to the MAC PIB attributes, MLME primitives and MAC command frames are defined to provide mechanisms to find, form, and join a frequency hopping network. Specifically, the MLME-ACQUIRE_FH_INFO primitive can be used to request the MAC to send Frequency Hopping Acquisition Request MAC command frames to request the information necessary for synchronized (i.e. frequency hopping synchronized) communications.

Modify the following entry in Table 47, section 7.1.3.1.1:

LogicalChannel	Integer	Selected from the available logical channels supported by the PHY (see 6.1.2).	The logical channel on which to attempt association. **This parameter is ignored if *macSunFrequencyHopping* is TRUE.**

Modify the MLME-START.request primitive in 7.1.14.1.1 as follows:

Deleted text in ~~**bold strikeout**~~.
New text in **bold blue**.

```
MLME-START.request        (
                          PANId,
                          LogicalChannel,
                          ChannelPage,
                          HoppingSequenceID,
                          StartTime,
                          BeaconOrder,
                          SuperframeOrder,
                          PANCoordinator,
                          BatteryLifeExtension,
                          CoordRealignment,
                          CoordRealignSecurityLevel,
                          CoordRealignKeyIdMode,
                          CoordRealignKeySource,
                          CoordRealignKeyIndex,
                          BeaconSecurityLevel,
                          BeaconKeyIdMode,
                          BeaconKeySource,
                          BeaconKeyIndex
                          )
```

Modify and add the following entries in Table 72, section 7.1.14.1.1:

LogicalChannel	Integer	Selected from the available logical channels specified by the ChannelPage parameter	The logical channel on which to start using the new superframe configuration. **This parameter is ignored if**

			***macSunFrequencyHopping* is TRUE.**
HoppingSequenceID	**Integer**	**0x0000-0xffff**	**The frequency hopping sequence ID that will be used starting with the new superframe configuration.** **This parameter is ignored if *macSunFrequencyHopping* is FALSE.**

Modify the second and third paragraphs of section: 7.1.14.1.3

When the CoordRealignment parameter is set to TRUE, the coordinator attempts to transmit a coordinator realignment command frame as described in 7.5.2.3.2. If the transmission of the coordinator realignment command fails due to a channel access failure, the MLME will not make any changes to the superframe configuration (i.e., no PIB attributes will be changed) and will issue an MLME-START.confirm with a status of CHANNEL_ACCESS_FAILURE. If the coordinator realignment command is successfully transmitted, the MLME updates the appropriate PIB parameters with the values of the BeaconOrder, SuperframeOrder, PANId, ChannelPage, **HoppingSequenceID,** and LogicalChannel parameters, as described in 7.5.2.3.4, and will issue an MLME-START.confirm with a status of SUCCESS.

When the CoordRealignment parameter is set to FALSE, the MLME updates the appropriate PIB parameters with the values of the BeaconOrder, SuperframeOrder, PANId, ChannelPage, **HoppingSequenceID,** and LogicalChannel parameters, as described in 7.5.2.3.4.

Modify the MLME-SYNC-LOSS.indication primitive in 7.1.15.2.1 as follows:

```
MLME-SYNC-LOSS.indication    (
                             LossReason,
                             PANId,
                             LogicalChannel,
                             HoppingSequenceID,
                             ChannelPage,
                             SecurityLevel,
                             KeyIdMode,
                             KeySource,
                             KeyIndex
                             )
```

Modify and add the following entries in Table 75, section 7.1.15.2.1:

LossReason	Enumeration	PAN_ID_CONFLICT, REALIGNMENT, **FH_REALIGNMENT**, or BEACON_LOST	The reason that synchronization was loss.
LogicalChannel	Integer	Selected from the available logical channels supported by the PHY (see 6.1.2).	The logical channel on which the device lost synchronization or to which it was realigned. **This parameter is ignored if LossReason is FH_REALIGNMENT.**
HoppingSequence ID	**Integer**	**0x0000-0xffff**	**The frequency hopping sequence ID that is in use after frequency hopping realignment.** **This parameter is ignored if LossReason is not FH_REALIGNMENT.**

Add the following to Section 7.1.x:

7.1.x Primitives for frequency hopping information acquisition

MLME-SAP frequency hopping acquisition primitives define how a device can determine the frequency hopping patterns and other relevant information of other devices within the POS.

All SUN devices with *macSunFrequencyHopping* set to TRUE shall provide an interface for these frequency hopping acquisition primitives.

7.1.x.1 MLME-ACQUIRE-FH-INFO.request

The MLME-ACQUIRE-FH-INFO.request primitive is used to initiate acquisition of frequency hopping information over a given list of channels. A device can use frequency hopping acquisition to develop its own hopping pattern when forming a new PAN, or to align with other devices when joining a PAN.

7.1.x.1.1 Semantics of the service primitive

The semantics of the MLME-ACQUIRE-FH-INFO.request primitive are as follows:

```
MLME-ACQUIRE-FH-INFO.request    (
                                ChannelListSize,
                                ChannelList,
                                NumAttemptsPerChannel,
                                TransmitInterval,
                                TransmitRandomization,
                                ResponseTime,
                                ChannelListIterations,
                                StopAfterFirstResponse
                                )
```

Table T specifies the parameters for the MLME-ACQUIRE-FH-INFO.request primitive.

Table T—MLME-ACQUIRE-FH-INFO.request parameters

Name	Type	Valid Range	Description
ChannelListSize	Integer	0x01–0x80	The number of elements in the channel list.
ChannelList	List of integers	—	The list of channels over which to acquire frequency hopping information. Note – ChannelList can be all of the available channels in the operating frequency band, the channels of a particular hop sequence in use by the targeted device/network, or a subset of either of these.
NumAttemptsPerChannel	Integer	0x0001–0xffff	The number of times to send frequency hopping acquisition request commands on each channel in ChannelList.

TransmitInterval	Integer	0x0001–0xffff	The time between frequency hopping acquisition request commands. Resolution is 1 ms.
TransmitRandomization	Integer	0x00–0xff	Maximum random value that can be added to the TransmitInterval between two frequency hopping acquisition request commands. Resolution is 1 ms.
ResponseTime	Integer	0x0000–0xffff	The length of time to listen for frequency hopping acquisition response commands after sending a request. ResponseTime shall be less than TransmitInterval. A value of zero for ResponseTime indicates “listen until the next transmit interval.” Resolution is 1 ms.
ChannelListIterations	Integer	0x00-0xff	The number of times to iterate through ChannelList
StopAfterFirstResponse	Boolean	TRUE or FALSE	Indication of whether the frequency hopping information acquisition process should terminate after the first response has been received or if it should complete every attempt on every channel in the ChannelList.

Table T+1 describes the elements of the frequency hopping descriptor type.

Table T+1—Elements of FHDescriptor

Name	Type	Valid Range	Description
PANId	Integer	0x0000–0xffff	The PAN ID of the device that sent the frequency hopping acquisition response command.
HopSequenceId	Integer	0x0000–0xffff	An implementation-specific value provided by the responding device to identify its hopping sequence.
HopSequenceLength	Integer	2–511	The number of elements in the hopping sequence.
HopSequence	List of integers	—	The repeating channel sequence the responding device uses for frequency hopping.
RelativeTime	Integer	0x00000000–0xffffffff	Time measurement of how far the responding device is into its present hopping cycle. The MAC sublayer maintains the relative time from the start of the hop sequence (rolling around to a relative time of zero at the end of the hopping sequence and re-starting the

			relative timer). The MAC sublayer maintains this relative timer (see 7.1.x.1.3). Resolution is 1 μs.
DwellTime	Integer	0x0001–0xffff	The length of time that any one HopSequence element is active (time spent listening on the channel *plus* time spent switching to the next channel in the sequence). Resolution is 10 μs.

7.1.x.1.2 Appropriate usage

The MLME-ACQUIRE-FH-INFO.request primitive is generated by the next higher layer and issued to its MLME to initiate acquisition of frequency hopping information within the POS of the querying device.

All SUN devices with *macSunFrequencyHopping* set to TRUE shall be capable of performing frequency hopping information acquisition.

7.1.x.1.3 Effect on receipt

If the MLME receives the MLME-ACQUIRE-FH-INFO.request primitive while performing a previously initiated acquisition operation, it issues the MLME-ACQUIRE-FH-INFO.confirm primitive with a status of ACQUISITION_IN_PROGRESS. Otherwise, the MLME initiates acquisition across all channels specified in the ChannelList parameter.

The frequency hopping information acquisition is performed on each channel by the MLME first sending a frequency hopping acquisition request command (see 7.3.x). The MLME then enables the receiver for a duration given by the ResponseTime parameter. Information contained in frequency hopping acquisition response commands (see 7.3.y) during this period are recorded in a frequency hopping descriptor structure (see Table T+1 in 7.1.x.1.1).

The MLME will repeat this process on a channel NumAttemptsPerChannel times. The *n*th network information request command for a particular channel will be sent at the time ((*n* – 1) * TransmitInterval), plus a random value between 0 and TransmitRandomization, after the first information request command for the channel. Unless terminated as described in the following sections, the process repeats for ChannelListIterations.

The frequency hopping information acquisition process ends after all NumAttemptsPerChannel requests have been performed on all ChannelListSize channels ChannelListIterations number of times. If the StopAfterFirstResponse parameter is TRUE, then the process will terminate (regardless of the number of attempts remaining for the present channel under investigation, regardless of the number of channels in ChannelList remaining, and regardless of the number of ChannelListIterations remaining) after the first frequency hopping acquisition response command is received. In both cases, the MAC sublayer will issue the MLME-ACQUIRE-FH-INFO.confirm primitive with a status of SUCCESS and a set of frequency hopping descriptor values.

The process will also terminate if the number of stored frequency hopping descriptor values equals an implementation-specific maximum.

The results of a frequency hopping information acquisition are reported to the next higher layer through the MLME-ACQUIRE-FH-INFO.confirm primitive. The primitive results will include a set of frequency hopping descriptor values. The MAC sublayer maintains all entries in the frequency hopping descriptor list until a MLME-SET-SUN-FH-RELATIVE-TIME.request, a MLME-RESET.request or a MLME-ACQUIRE-FH-INFO.request primitive is

received. Maintenance of the frequency hopping descriptor list includes updating RelativeTime using HopSequenceLength, DwellTime, and the Hop Sequence Relative Time received in the Frequency hopping acquisition response.
If the acquisition process terminates due to reaching the implementation-specific maximum number of stored frequency hopping descriptor values, the MAC sublayer will issue the MLME-ACQUIRE-FH-INFO.confirm primitive with a status of LIMIT_REACHED and include the set of recorded frequency hopping descriptor values.

If any parameter in the MLME-ACQUIRE-FH-INFO.request primitive is not supported or is out of range, the MAC sublayer will issue the MLME-ACQUIRE-FH-INFO.confirm primitive with a status of INVALID_PARAMETER.

7.1.x.2 MLME-ACQUIRE-FH-INFO.confirm

The MLME-ACQUIRE-FH-INFO.confirm primitive reports the result of the frequency hopping information acquisition request.

7.1.x.2.1 Semantics of the service primitive

The semantics of the MLME-ACQUIRE-FH-INFO.confirm primitive are as follows:

```
MLME-ACQUIRE-FH-INFO.confirm        (
                                    status,
                                    ResultListSize,
                                    FHDescriptorList
                                    )
```

Table T+3 specifies the parameters for the MLME-ACQUIRE-FH-INFO.confirm primitive.

Table T+3—MLME-ACQUIRE-FH-INFO.confirm parameters

Name	Type	Valid Range	Description
Status	Enumeration	SUCCESS, LIMIT_REACHED, ACQUISITION_IN_PROGRESS, INVALID_PARAMETER	The status of the acquisition request.
ResultListSize	Integer	Implementation specific	The number of elements returned in the frequency hopping descriptor list.
FHDescriptorList	List of frequency hopping descriptor values	See Table T+1	The list of frequency hopping descriptors, one for each frequency hopping acquisition response command received during the acquisition process.

7.1.x.2.2 When generated

The MLME-ACQUIRE-FH-INFO.confirm primitive is generated by the MLME and issued to the next higher layer when the frequency hopping information acquisition initiated with the MLME-ACQUIRE-FH-INFO.request primitive has been completed.

The MLME-ACQUIRE-FH-INFO.confirm primitive returns a status of either SUCCESS, indicating that the requested acquisition was successful, or the appropriate error code. The status values are fully described in 7.1.x.1.3.

7.1.x.2.3 Appropriate usage

On receipt of the MLME-ACQUIRE-FH-INFO.confirm primitive, the next higher layer is notified of the results of the frequency hopping information acquisition procedure. If the requested acquisition was successful, the status parameter will be set to SUCCESS. Otherwise, the status parameter indicates the error.

7.1.x.3 Frequency hopping information acquisition sequence charts

Figure F illustrates the sequence of messages necessary to perform frequency hopping information acquisition. This figure includes steps taken by the PHY.

7.1.y Primitives for setting the SUN frequency hopping relative time

The MLME-SAP set SUN frequency hopping relative time primitive allows the next higher layer to set the relative time of the frequency hopping sequence used by a SUN device.

All SUN devices with *macSunFrequencyHopping* set to TRUE shall support this set SUN frequency hopping relative time primitive.

7.1.y.1 MLME-SET-SUN-FH-RELATIVE-TIME.request

The MLME-SET-SUN-FH-RELATIVE-TIME.request primitive is used to set the relative time in the SUN channel hopping sequence. This primitive would typically be used after MLME-SET.request primitives were used to set the appropriate SUN frequency hopping PIB attributes.

When the device is joining a network or attempting to start communications to a previously unsynchronized device, this primitive would be used after the device has acquired frequency hopping information from the network or device to which it is attempting to communicate. In this case, this primitive would be used to set the relative time equal to the relative time maintained by the MAC sublayer for the appropriate FHDescriptor received in the MLME-ACQUIRE-FH-INFO.confirm primitive.

If a coordinator is initiating a new PAN, it may set the relative time to a value of zero to start the desired hopping sequence at the beginning of *macFH_HopSequence*.

7.1.y.1.1 Semantics of the service primitive

The semantics of the MLME-SET-SUN-FH-RELATIVE-TIME.request primitive are as follows:

```
SET-SUN-FH-RELATIVE-TIME.request    (
                                    UseFHDescriptor,
                                    FHDescriptorIndex
                                    )
```

Table T+4 specifies the parameters for the SET-SUN-FH-RELATIVE-TIME.request primitive.

Table T+4 - SET-SUN-FH-RELATIVE-TIME.request parameters

Name	Type	Valid Range	Description
UseFHDescriptor	Boolean	TRUE or FALSE	If this value is TRUE, the device will set the SUN frequency hopping relative time to the value maintained

			by the MAC sublayer for the FHDescriptor identified by FHDescriptorIndex. If this value is FALSE, the device will set the SUN frequency hopping relative time to the value specified by RelativeTime.
FHDescriptorIndex	Integer	—	The index in the FHDescriptor array of the FHDescriptor-RelativeTime value to be used to set the SUN frequency hopping time
RelativeTime	Integer	0x00000000–0xffffffff	Relative time from the start of macFH_HopSequence. Resolution is 1 μs.

7.1.y.1.2 Appropriate usage

The MLME-SET-SUN-FH-RELATIVE-TIME.request primitive is generated by the next higher layer and issued to its MLME to set the relative time of *macFH_HopSequence*.

All SUN devices with *macSunFrequencyHopping* set to TRUE shall accept this primitive.

7.1.y.1.3 Effect on receipt

If *macSunFrequencyHopping* = TRUE, the MAC sublayer sets the SUN frequency hopping relative time to the value specified and from that point forward maintains the relative time using *macFH_HopSequenceLength* and *macFH_DwellTime*. When the receiver is enabled, the MAC sublayer sets *phyCurrentChannel* equal to the correct channel in *macFH_HopSequence*.

If *macSunFrequencyHopping* = FALSE, it issues the MLME-SET-SUN-FH-RELATIVE-TIME.confirm primitive with a status of INVALID_PARAMETER.

If the FHDescriptorIndex parameter in the MLME-SET-SUN-FH-RELATIVE-TIME.request primitive is invalid or if RelativeTime is invalid for the specified frequency hopping descriptor, the MAC sublayer will issue the MLME-SET-SUN-FH-RELATIVE-TIME.confirm primitive with a status of INVALID_PARAMETER.

7.1.y.2 MLME-SET-SUN-FH-RELATIVE-TIME.confirm

The MLME-SET-SUN-FH-RELATIVE-TIME.confirm primitive reports the results of the attempt to set the SUN frequency hopping relative time.

7.1.y.2.1 Semantics of the service primitive

The semantics of the MLME-SET-SUN-FH-RELATIVE-TIME.confirm primitive are as follows:

```
MLME-SET-SUN-FH-RELATIVE-TIME.confirm    (
                                          status
                                          )
```

Table T+5 specifies the parameters for the MLME-SET-SUN-FH-RELATIVE-TIME.confirm primitive.

Table T+5 - MLME-SET-SUN-FH-RELATIVE-TIME.confirm parameters

Name	Type	Valid Range	Description
Status	Enumeration	SUCCESS, INVALID_PARAMETER	The status of the set SUN frequency hopping relative time request.

7.1.y.2.2 When generated

The MLME-SET-SUN-FH-RELATIVE-TIME.confirm primitive is generated by the MLME and issued to the next higher layer in response to a MLME-SET-SUN-FH-RELATIVE-TIME.request primitive.

The MLME-ACQUIRE-FH-INFO.confirm primitive returns a status of either SUCCESS, indicating that the requested acquisition was successful, or the appropriate error code. The status values are fully described in 7.1.y.1.3.

7.1.y.2.3 Appropriate usage

On receipt of the MLME-SET-SUN-FH-RELATIVE-TIME.confirm primitive, the next higher layer is notified of the result of its request to set the frequency hopping relative time. If the MAC sublayer has been successful, the status parameter will be set to SUCCESS. Otherwise, the status parameter indicates the error.

7.1.y.3 Message sequence chart for setting the SUN frequency hopping relative time

Figure xx illustrates the sequence of messages necessary to set the SUN frequency hopping relative time. NOTE – Insert figure xx.

In Section 7.3, add the following MAC command frame identifiers to Table 82:

Command frame identifier	Command name	RFD		Subclause
		Tx	Rx	
(next identifier in the list)	Frequency hopping acquisition request	X		7.3.x
(next identifier in the list)	Frequency hopping acquisition response		X	7.3.y

Modify Figure 63 in section 7.3.8:

octets: 17/18/23/24	1	2	2	~~1~~ **2**	2	0/1	**0/2**
MHR fields	Command Frame Identifier (see Table 82)	PAN Identifier	Coordinator Short Address	Logical Channel	Short Address	Channel page	**Hopping Sequence ID**

Modify section 7.3.8.4:

The Logical Channel field shall contain the logical channel that the coordinator intends to use for all future communications. **This field is unused when *macSunFrequencyHopping* is TRUE.**

Modify section 7.3.8.6:

The Channel Page field, if present, shall contain the channel page that the coordinator intends to use for all future communications. This field may be omitted if the new channel page is the same as the previous channel page. **However, the Channel Page field must not be omitted unless the Hopping Sequence ID field is also omitted.**

Add section 7.3.8.7:

7.3.8.7 Hopping Sequence ID field

The Hopping Sequence ID field, if present, shall contain the frequency hopping sequence ID that the coordinator intends to use for all future communications. This field may be omitted if the new hopping sequence ID is the same as the old hopping sequence ID, or if *macSunFrequencyHopping* is FALSE.

Add the following section to 7.3:

7.3.x Frequency Hopping Acquisition request command

The frequency hopping acquisition request command is used by a device to acquire frequency hopping information necessary for communicating when the MAC PIB attribute macSunFrequencyHopping is TRUE.

All devices shall be capable of transmitting this command, although an RFD is not required to be capable of receiving it.

The frequency hopping acquisition request command shall be formatted as illustrated in Figure xx.

octets: 15	1
MHR fields	Command Frame Identifier (see Table 82)

Figure xx - Frequency hopping acquisition request command format

The Source Addressing Mode subfield of the Frame Control field shall be set to three (i.e., 64-bit extended addressing). The Destination Addressing Mode subfield shall be set to two (i.e., 16-bit short addressing).

The Frame Pending subfield and Acknowledgment Request subfield of the Frame Control field shall be set to zero and ignored upon reception.

The PAN ID Compression subfield of the Frame Control field shall be set to one. In accordance with this value of the PAN ID Compression subfield, the Destination PAN Identifier field shall contain the value of the broadcast PAN identifier (i.e., 0xffff), while the Source PAN Identifier field shall be omitted. The Destination Address field shall contain the broadcast short address (i.e., 0xffff). The Source Address field shall contain the value of *aExtendedAddress*.

7.3.y Frequency Hopping Acquisition response command

The frequency hopping acquisition response command allows a device to communicate the results of a frequency hopping acquisition request back to the device requesting frequency hopping information.

This command shall only be sent in response to a frequency hopping acquisition request. A device only responds to a frequency hopping acquisition request command if *macSunFrequencyHopping* = TRUE.

All devices shall be capable of receiving this command, although an RFD is not required to be capable of transmitting it.

The association response command shall be formatted as illustrated in Figure xx.

octets: 21 (see 7.2.2.4)	**1**	**2**	**1**	**x**	**4**	**2**
MHR fields	Command Frame Identifier (see Table 82)	Hop Sequence Id	Hop Sequence Length	Hop Sequence	Hop Sequence Relative Time	Dwell Time

Figure xx - Frequency hopping acquisition response command format

7.3.y.1 MHR fields

The Destination Addressing Mode and Source Addressing Mode subfields of the Frame Control field shall each be set to three (i.e., 64-bit extended addressing).

The Frame Pending subfield and Acknowledgment Request subfield of the Frame Control field shall be set to zero and ignored upon reception.

The PAN ID Compression subfield of the Frame Control field shall be set to one. In accordance with this value of the PAN ID Compression subfield, the Destination PAN Identifier field shall contain the value of *macPANId*, while the Source PAN Identifier field shall be omitted.

7.3.y.2 Hop Sequence Id

The hop sequence identifier currently in use by the responding device. This corresponds to the responding device's value of *macFH_HopSequenceID*.

7.3.y.3 Hop Sequence Length

The hop sequence length currently in use by the responding device. This corresponds to the responding device's value of *macFH_HopSequenceLength*.

7.3.y.4 Hop Sequence

The hop sequence currently in use by the responding device. This corresponds to the responding device's value of *macFH_HopSequence*. The size of Hop Sequence is equal to (Hop Sequence Length x 2).

7.3.y.4 Hop Sequence Relative Time

The current time of the hopping sequence relative to the start of the hopping sequence. A 32-bit field with a resolution of 1 µsec.

7.4.2 MAC PIB Attributes

Add the following PIB attributes to Table 127:

Attribute	Identifier	Type	Range	Description	Default
macSunFrequencyHopping	(increment the last value)	Boolean	TRUE or FALSE	TRUE if the device is operating in a frequency hopping mode and the macFH_ PIB attributes define the behavior FALSE if the system is not operating in a frequency hopping mode controlled by the macFH_ PIB attributes.	-
macFH_HopSequenceID	(increment the last value)	Integer	0x00 – 0xFFFF	An identifier used to assist in identifying the hopping sequence.	-
macFH_HopSequenceLength	(increment the last value)	Integer	2 – 511	Number of channels in the hop sequence.	-
macFH_HopSequence	(increment the last value)	Array	A 2 x {2-511} octet array (2 octet channel number, with an array size controlled by macFH_HopSequenceLength).	This is the ordered sequence of channels that define the hopping sequence.	-
macFH_DwellTime	(increment the last value)	Integer	10 µsec – 655.35 msec	The total dwell time on each channel. A 16-bit field with a resolution of 10 µsec.	

macFH_SwitchTime	(increment the last value)	Integer	1 µsec – 1 msec	The time allocated for the PHY to change to a new frequency. When macSunFrequencyHopping = TRUE, the MAC shall change the PHY channel such that the PHY is stable at the start of the next channel in the hopping sequence. Note - The dwell time includes the hop time, therefore macFH_DwellTime must be greater than macFH_SwitchTime. macFH_SwitchTime is a 16-bit field with a resolution of 1 µsec.	

Modify section 7.5.2.3.2:

If a coordinator receives the MLME-START.request primitive (see 7.1.14.1) with the CoordRealignment parameter set to TRUE, the coordinator shall attempt to transmit a coordinator realignment command containing the new parameters for PANId, LogicalChannel, and, if present, ChannelPage **and HoppingSequenceId**.

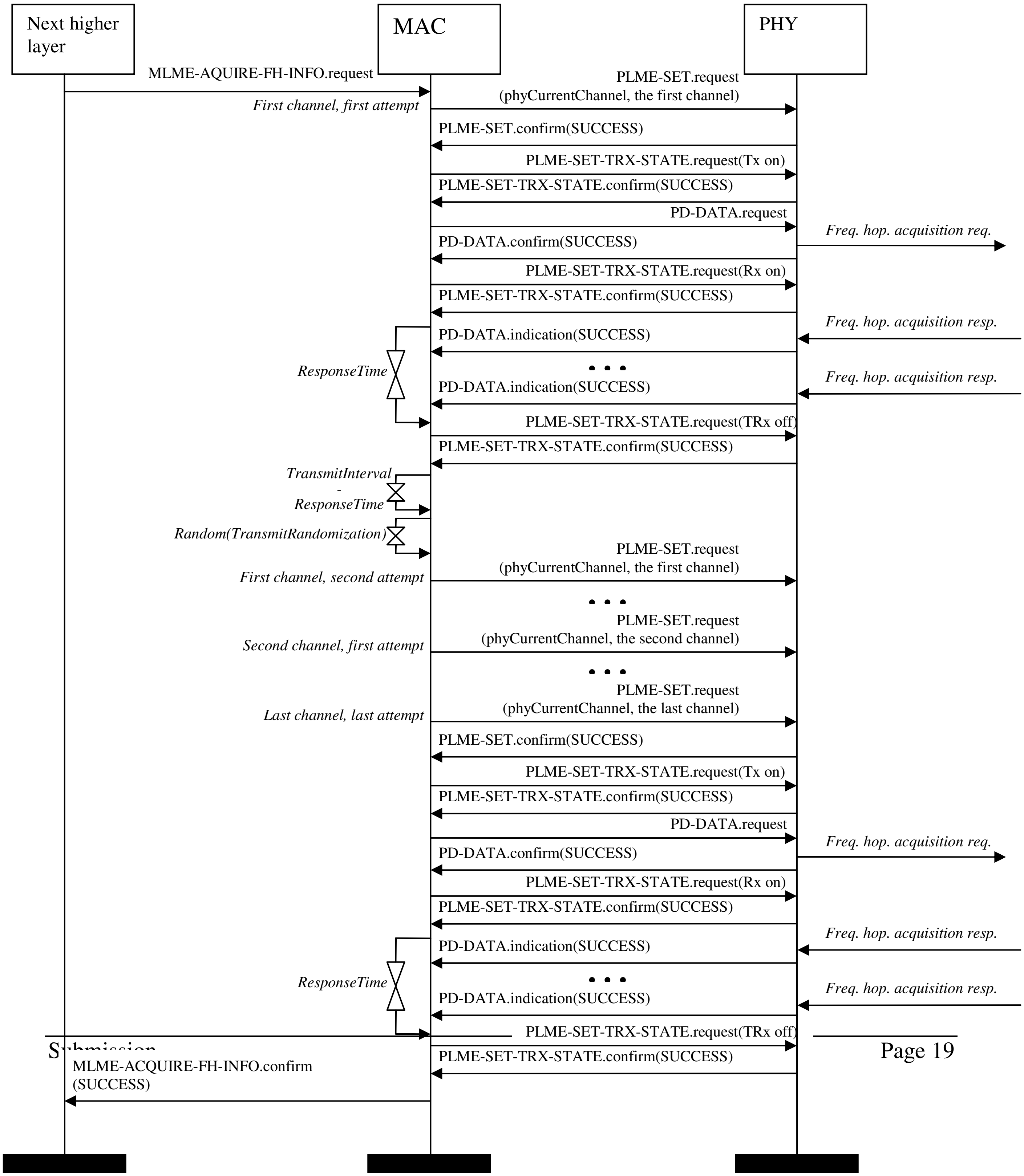
Modify section 7.5.2.3.4:

To update the superframe configuration and channel attributes, the MLME shall assign values from the MLME-START.request primitive parameters to the appropriate PIB attributes. The MLME shall set *macBeaconOrder* to the value of the BeaconOrder parameter. If *macBeaconOrder* is equal to 15, the MLME will also set *macSuperframeOrder* to 15. In this case, this primitive configures a nonbeacon enabled PAN. If *macBeaconOrder* is less than 15, the MAC sublayer will set *macSuperframeOrder* to the value of the SuperframeOrder parameter. The MAC sublayer shall also update *macPANID* with the value of the PANId parameter and update *phyCurrentPage* ~~**and *phyCurrentChannel***~~ with the value**s** of the ChannelPage ~~**and LogicalChannel**~~ parameter~~**s, respectively, by twice issuing the PLME-SET.request primitive**~~. **If *macSunFrequencyHopping* is FALSE, then the MAC sublayer updates *phyCurrentChannel* with the value of the LogicalChannel parameter. If *macSunFrequencyHopping* is TRUE, then *phyCurrentChannel* is not updated as this will be handled by the frequency hopping mechanism. The MAC sublayer updates *phyCurrentPage* and *phyCurrentChannel* by twice issuing the PLME-SET.request primitive.**

Add the following figure to Section 7.7 (Message sequence charts illustrating MAC-PHY interaction)

7.7 Message sequence charts illustrating MAC-PHY interaction

Note, the sequence chart is drawn for the case where MLME-ACQUIRE-FH-INFO.request ChannelListIterations parameter is set to a value of zero.



Annex N (or next available letter)

Example of SUN Frequency Hopping and Device Synchronization

N.1 Introduction

For devices to communicate in a frequency hopping network, they must be synchronized to the frequency hopping communication parameters, namely, the channel hop sequence, the dwell time for each channel, and the relative time from the start of the hop sequence to the current location of the hop sequence.

Devices that are not synchronized with the device to which they wish to communicate must first synchronize using the frequency hopping acquisition request MAC command.

N.2 Example Synchronization Time Calculations

The following assumptions will be used as an example calculation of the time required for a device to synchronize to another device:

MAC PIB attributes for the network or device to which the device is attempting to synchronize:

- *macFH_HopSequenceLength* = 64
- macFH_HopSequence = 4, 12, 25, 33, 1, 51, 63, ……… (typically a pseudo-random sequence)
- *macFH_DwellTime* = 400 msec

Parameters used for the MLME-ACQUIRE-FH-INFO primitive:

- ChannelListSize = 32
- ChannelList = 1, 2, 3, 4, …… 32
- NumAttemptsPerChannel = 2 * *macFH_HopSequenceLength* + 1 = 129
- TransmitInterval = 199 msec
- TransmitRandomization = 0
- ResponseTime = 0 (listen until next transmit interval)
- ChannelListIterations = 0
- StopAfterFirstResponse = TRUE

A typical synchronization is illustrated in Figure N-1:

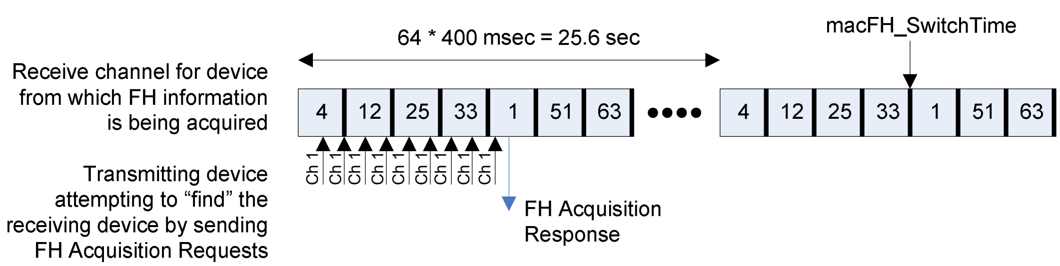


Figure N-1: Frequency Hopping Acquisition Behavior

Assuming there is not a packet error, the FH Acquisition Response would be received within a period of time equal to NumAttemptsPerChannel * TransmitInterval. For this example, this equates to:

129 * 199 msec = 25.7 seconds

Note that the actual time would often be less than this time because the alignment of the transmit channel (e.g. channel 1) and the receiver dwelling on channel 1, is likely to occur before this maximum time. An example of a typical acquisition response time is shown in Figure N-1.

The maximum response time would typically be controlled by the values of *macFH_HopSequenceLength* and *macFH_DwellTime*, and the time to receive a FH Acquisition Response would be reduced if these parameters were shorter in length.

A network with *macFH_DwellTime* equal to 400 msec would typically be a worst case condition as this dwell time is equal to the maximum permissible transmit interval per FCC regulations.

When the packet transfer rate is 100% reliable, the maximum response time is as described above. If the packet success rate is less than 100%, the response time will increase. For example, assume a non-ideal medium with a packet success rate of 70%. To estimate the acquisition time in this scenario, assume that the first 3 acquisition attempts (on channels 1, 2, and 3) fail due to packet loss, but the fourth acquisition attempt (on channel 4) is successful. In this scenario, the total acquisition time be approximately 25.7 sec * 4 ~= 103 seconds.