**IEEE P802.15**

**Wireless Personal Area Networks**

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| Project | IEEE P802.15 Working Group for Wireless Personal Area Networks (WPANs) | |
| Title | Ranging related comment resolution for IEEE 802.15.4p | |
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|  |  | |
| Abstract | This document provides the IEEE 802.15.4p Ranging related comment resolution | |
| Purpose |  | |
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Contents

Table of Figures............................................................................................................................. 5

Contents

1 Introduction 4

1 CID 15 5

2 CID 25, CID 26 6

3 CID 27 12

4 CID 31 13

5 CID 32, CID 33 19

6 CID 38 20

7 CID 47 53

8 CID 54 54

9 CID 65 55

10 CID 66 56

11 CID 68 57

Table of Figures

# 1 Introduction

The following comment resolutions are based on P802.15.4p/D1 (April, 2013) and the corresponding Ranging related comments (see 15-13-0283-04-004p-letter-ballot-consolidated-comments.docx).

# 1 CID 15

*Section* **5.1.8b DCSS ranging using phase difference measurement**

*Append first sentence in this section:*

DCSS ranging using phase difference measurement is an optional feature and is primarily for stationary objects.

# 2 CID 25, CID 26

*Rename section*

**5.1.8b.1 Initialization of local phase difference measurement**

***to***

**5.1.8b.1 Initialization of ~~local~~ phase difference measurement**

*Replace the text in section* ***5.1.8b.1***

~~In order to perform a local phase difference measurement between the ranging originator and the ranging recipient, the originator starts a frame exchange sequence between ranging nodes to negotiate the current ranging parameter set.~~

~~If the recipient does not accept the requested ranging parameters from the originator, or is currently not able to perform the requested phase difference measurement, it returns a frame including the rejection status of the current ranging request.~~

~~If the recipient accepts the requested ranging parameters from the originator, it returns the negotiated parameter set back to the originator. The originator then extracts the final ranging parameters set.~~

~~Once the involved nodes have agreed upon the ranging parameters set to be used, the actual, and possibly additional, phase difference measurement(s) is initiated by means of a dedicated start frame.~~

~~If any required response frame is not received from the ranging recipient, the MAC sublayer of the ranging originator notifies the next higher layer about the timeout condition.~~

~~For any frame transmitted by the originator, the source address is derived from the originator address information contained in the MLME-RANGING.request primitive. The destination address is derived from the recipient address information contained in the MLME-RANGING.request primitive.~~

*Add new text instead:*

The process of a phase difference measurement is initiated at the ranging originator upon receipt of an MLME-RANGING.request primitive with the requested ranging mode and the requested number of ranging measurements.

If the initiation of a ranging measurement is currently supported (based on *macPMRangingEnabled*)*,* the MAC sublayer generates a Ranging command frame of subtype Range request to the ranging recipient (see 5.3.9b.2) based on the settings of the required ranging attributes. If, upon successful transmission of the frame, the device does not receive a Ranging command frame of subtype Range response (see 5.3.9b.3) within *macPMRangeResponseWaitTime*, the device shall initiate an MLME-RANGING.confirm primitive indicating a timeout condition.

Upon reception of the Ranging command frame of subtype Range request at the ranging recipient, the recipient checks whether it is currently able to perform a ranging measurement. If not it shall reject the ranging measurement by returning a Ranging command frame of subtype Range response including the Range acceptance status indicating that ranging is currently not supported.

If ranging is acceptable, the recipient verifies the requested ranging protocol version (see 5.3.9b.2.2 and 5.3.9b.1), ranging mode (see 5.3.9b.2.2), and ranging parameters (see 5.3.9b.2.4 and 5.3.9b.2.5). If any of these parameters is not supported by the recipient, it shall reject the ranging measurement by returning a Ranging command frame of subtype Range response including the Range acceptance status (see 5.3.9b.3.3) indicating an unsupported ranging protocol, unsupported ranging mode, undefined entry in *phyPMDeviceTable* (see Table 71), or invalid ranging parameters.

In case the Range acceptance status indicates that only the dynamic ranging parameters are not accepted, and proposed supported dynamic ranging parameters are appended, the originator may store these received parameters and repeat the ranging procedure using the proposed dynamic ranging parameters.

If the ranging request is supported, the recipient shall verify the requested number of ranging measurements (see 5.3.9b.2.3) and the requested ranging configuration field (see 5.3.9b.2.6).

If, upon successful transmission of the Range response frame, the recipient does not receive a Ranging command frame of subtype Range sync request (see 5.3.9b.5) or Range abort (see 5.3.9b.4) within *macPMRangeResponseWaitTime*, the device shall abort the current ranging measurement.

Upon reception of the Ranging command frame of subtype Range response at the ranging originator, the originator shall check the received Range acceptance status. If the status indicates, that ranging is rejected, the originator shall abort the current ranging measurement and issue an MLME-RANGING.confirm primitive indicating the ranging rejections reason.

If the status indicates, that ranging is accepted, but the recipient has returned any parameter that is not acceptable by the originator, the originator shall transmit a Ranging command frame of subtype Range abort and initiate an MLME-RANGING.confirm primitive indicating ranging abort.

If the status indicates, that ranging is accepted, and the returned parameter from the recipient within this frame are fully acceptable by the originator, the originator shall transmit a Ranging command frame of subtype Range sync request in order to gain synchronization with the recipient for the phase difference measurement.

If, upon successful transmission of the subtype Range sync request frame, the device does not receive a Ranging command frame of subtype Range start (see 5.3.9b.6) within *macPMSyncWaitTime*, the device shall abort the current ranging measurement and initiate an MLME-RANGING.confirm primitive indicating an unsuccessful synchronization.

If, after the transmission of a Range response frame, the recipient receives a Ranging command frame of subtype Range abort, the recipient shall abort the current ranging measurement.

If the recipient receives a Ranging command frame of subtype Range sync request, it checks the received ranging protocol version and remaining ranging measurement counter (see 5.3.9b.5.3). If the received protocol version is not supported, or the received remaining measurement counter value is larger than the counter in the previously received Range sync request frame, the recipient shall return a Ranging command frame of subtype Range abort to the originator and abort the current ranging procedure.

If the received parameters within the Range sync request frame are acceptable by the recipient, it shall initiate the transmission of a Ranging command frame of subtype Range start to gain synchronization with the ranging originator (see 21.3.1) and start the actual phase difference measurement (see 21.3.2).

If the ranging originator receives a Range abort frame instead of a Range start frame, the originator shall abort the current ranging measurement and initiate an MLME-RANGING.confirm primitive indicating the ranging abort condition.

If the originator receives the expected Ranging command frame of subtype Range start, it synchronizes with the recipient (see 21.3.1) and starts the actual phase difference measurement (see 21.3.2).

Figures 5.1.8b.1a to 5.1.8b.1d depict the initialization of a phase difference measurement.

*Add new following figures:*

Local_ranging_initiation-Successfull_init.wmf

Figure 5.1.8b.1a—Initialization of a phase difference measurement procedure

Local_ranging_initiation-Timeout.wmf

Figure 5.1.8b.1b—Timeout during initialization of a phase difference measurement procedure

**Local_ranging_initiation-Error_handling.wmf**

Figure 5.1.8b.1c—Error handling during Range response handling

**Local_ranging_initiation-Error_handling_2.wmf**

Figure 5.1.8b.1d—Error handling during ranging synchronization procedure

# 3 CID 27

Addressed in CID 38

# 4 CID 31

*Rename section*

**5.1.8b.2 Data exchange after a local phase difference measurement**

*To*

**5.1.8b.2 Data exchange after a ~~local~~ phase difference measurement**

*Replace the text in section* ***5.1.8b.2:***

~~Once the originator has received the measured ranging data from the recipient, it calculates the final result values. Afterwards, the originator reports the calculated ranging result values back to the ranging coordinator using a dedicated frame. The MAC sublayer of the ranging coordinator notifies the next higher layer about the received results of the requested ranging measurement.~~

~~In case the ranging coordinator does not receive a response from the requested originator within the phase difference measurement timeout, the MAC sublayer of the ranging coordinator notifies the next higher layer about the timeout condition.~~

After completion of the phase difference measurement procedure, both the originator and the recipient shall immediately enable their receiver.

Afterwards both devices shall perform compression of the measured phase measurement result data as negotiated in the initial Range Request / Range response handshake based on *macPMSuppressResultCompression*. Phase measurement result compression is performed by generating a single averaged phase measurement result value for each set of n (n is equal to number of phase measurements per frequency) phase measurement result data (for a given frequency, inner loop count, and outer loop count). In ranging is done using uncompressed phase measurement result data, this step is not performed.

If, at this point, the recipient does not receive a Ranging command frame of subtype Range result confirm within *macPMRangeExtWaitTime*, the device shall abort the current ranging measurement.

The originator shall generate the initial Ranging command frame of subtype Range result request to the ranging recipient, to request the phase measurement result data from the recipient. If the originator does not receive a Ranging command frame of subtype Range result confirm within *macPMRangeResponseWaitTime*, the device shall initiate an MLME-RANGING.confirm primitive with the status of TIMEOUT.

In case the recipient has not finished its result compression at reception of the initial Range result request frame, is shall reply using a Range result confirm frame indicating busy condition by using the result data type field set to 0x00 (see 5.3.9b.8.3). After finally having finished the result compression, the recipient shall initiate the transmission using the same Result request frame but with the result data type field set to the proper result data type.

Upon reception of the Ranging command frame of subtype Range result request at the ranging recipient (i.e.., the recipient has finished the result compression), the recipient shall check the requested phase measurement result data. If the Range result request frame contains invalid information (e.g. in invalid value in the requested outer loop counter that exceeds the actual measurement, see 5.3.9b.7.4), the recipient shall return a Ranging command frame of subtype Range abort to the originator and abort the current ranging procedure.

If the received Range result request frame is correct, the recipient shall return the requested phase measurement result data to the originator by transmitting a Range result confirm frame. If the recipient has more phase measurement result data to be transmitted to the originator, it shall await the next Ranging command frame of subtype Range result request within *macPMRangeResponseWaitTime*. If the recipient does not receive the expected frame within this time, the device shall abort the current ranging measurement.

If the originator expects a Range result confirm frame, but instead receives a Range abort frame, the originator shall abort the current ranging measurement and issue an MLME-RANGING.confirm primitive indicating the ranging abort condition.

Otherwise, if the originator receives the expected Ranging command frame of subtype Range result confirm, it shall extract the delivered phase measurement result data. If the received phase measurement result data indicate a busy condition at the recipient, the originator shall wait for *macPMRangeExtWaitTime* to again receive the same Range result confirm frame with the proper requested measurement result data. If no Range result confirm frame is received from the recipient within *macPMRangeExtWaitTime*, the originator shall issue an MLME-RANGING.confirm primitive indicating a timeout condition.

If the received phase measurement result data are correct, and if the originator has not yet requested all phase measurement results, it shall repeat the described sequence using the Range result request / Range result confirm handshake, until the completion of the result data has finished or an abort condition has occurred by utilizing the *macPMRangeResponseWaitTime* for each subsequent frame exchange.

After successful completion of the data exchange, i.e. the originator has received all required phase measurement result data, the originator shall calculate the final ranging results, and inform the NHLE of the ranging originator by issuing an MLME-RANGING.confirm primitive indicating a status of SUCCESS including the final ranging results.

Figures 5.1.8b.2a to 5.1.8b.2d depict the data exchange after a phase difference measurement procedure.

*Add new following figures:*

Data_exchange-Successful_data_exchange.wmf

Figure 5.1.8b.2a—Data exchange

Data_exchange-Error_initial_request_frame.wmf

Figure 5.1.8b.2b—Error handling due to unacknowledged initial Range result request frame due to slow recipient device

Data_exchange-Timeout.wmf

Figure 5.1.8b.2c—Timeout during data exchange

Data_exchange-Error_handling.wmf

Figure 5.1.8b.2d—Error handling during Range response handling

# 5 CID 32, CID 33

*Remove sections* **5.1.8b.3 Initialization of remote phase difference measurement** *and* **5.1.8b.4 Data exchange after a remote phase difference measurement** *completely*

*Section* **5.1.8b DCSS ranging using phase difference measurement**

*Change text in this section by removing the text in strike-through:*

DCSS ranging using phase difference measurement is an optional feature and is primarily for stationary objects.

~~The phase difference measurement supports two different types of ranging:~~

~~— Local phase difference measurement between a ranging originator and a ranging recipient.~~

~~— Remote phase difference measurement initiated by a ranging coordinator and performed between~~

~~ranging nodes (a ranging originator and a ranging recipient). It is not necessary for the ranging~~

~~coordinator to support the DCSS PHY. The coordination channel required to control DCSS~~

~~operation uses a PHY, applicable to the actual operating band used by the DCSS PHY, as already~~

~~defined in this standard.~~

# 6 CID 38

*Add (new) section* **5.1.8b.3 Retrieval of Phase Difference Measurement ranging capabilities**

In order to allow for any ranging device to retrieve the available ranging capabilities from any other ranging device before initiating a ranging measurement with appropriate ranging parameters, the next higher layer of a device may initiate an MLME-RANGING-CAPABILITIES.request primitive. This results in the transmission of a Ranging command frame of subtype Ranging capabilities request to the corresponding ranging device.

If, upon successful transmission of the frame, the device does not receive a Ranging command frame of subtype Ranging capabilities response within *macPMRangeResponseWaitTime*, the device shall initiate an MLME-RANGING-CAPABILITIES.confirm primitive indicating a timeout condition.

Upon reception of the Ranging command frame of subtype Ranging capabilities request, the recipient shall generate a Ranging command frame of subtype Ranging capabilities response including its own ranging capabilities based on the values in *phyPMCapTable*.

The originator informs the next higher layer about the results of the ranging capabilities retrieval by issuing an MLME-RANGING-CAPABILITIES.confirm primitive. If it has received the expected Ranging command frame of subtype Ranging capabilities response; the status is SUCCESS.

Figure 5.1.8b.3a depict the ranging capabilities retrieval.

**Ranging_caps-Successful_caps_request.wmf**

Figure 5.1.8b.3a—Successful ranging capabilities retrieval

*Update the following sections (5.3 & 6.2.25):*

**5.3 MAC command frames**

*Append Table 5—MAC command frames:*

*(please use next non-reserved command frame identifier for the new command frame)*

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Command frame identifier** | **Command name** | **RFD** | | **Subclause** |
|  |  | **Tx** | **Rx** |  |
| 0x21 | Ranging command | X | X | 5.3.9b |

**5.3.9b Ranging Command**

The Ranging command is used by a device that is performing any kind of ranging measurement activity. The Ranging command shall be formatted as illustrated in Figure 59a.

|  |  |  |  |
| --- | --- | --- | --- |
| **Octets: variable** | **1** | **1** | **variable** |
| MHR fields | Command frame identifier (defined in Table 5) | Ranging command subtype identifier  (defined in Table 5a) | Command payload as defined for each Ranging command subtype |

Figure 59a—Formatting of Ranging command frame

The Ranging command subtype identifiers are listed in Table 5a.

**Table 5a—Ranging command subtype identifiers**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Ranging command subtype identifier** | **Subtype name** | **Direction** | | **Subclause** |
|  |  | **Ranging originator** | **Ranging recipient** |  |
| 0x00 | Range request | Tx | Rx | 5.3.9b.2 |
| 0x01 | Range response | Rx | Tx | 5.3.9b.3 |
| 0x02 | Range abort | Tx/Rx | Tx/Rx | 5.3.9b.4 |
| 0x03 | Range sync request | Tx | Rx | 5.3.9b.5 |
| 0x04 | Range start | Rx | Tx | 5.3.9b.6 |
| 0x05 | Range result request | Tx | Rx | 5.3.9b.7 |
| 0x06 | Range result confirm | Rx | Tx | 5.3.9b.8 |
| 0x07 | Ranging capabilities request | Tx/Rx | Tx/Rx | 5.3.9b.11 |
| 0x08 | Ranging capabilities response | Tx/Rx | Tx/Rx | 5.3.9b.12 |

**5.3.9b.1Handling of Ranging protocol version field**

The Ranging command frames of subtype Range request and Range sync request contain a field indicating the ranging protocol version specifying the applied ranging protocol version.

This field shall be set to 0x00. All other field values are reserved.

If a device receives any of the above Ranging command frames including an incompatible ranging protocol version, it shall reject this frame. In case of a received Range request frame this is done by initiating a Range respond frame including the range acceptance status indicating an unsupported ranging protocol version. In case of a received Range sync request frame this is done by initiating a Range abort frame.

**5.3.9b.2 Range request command**

The Ranging command frame of subtype Range request is used to initiate a ranging measurement and shall be sent by the ranging originator to the ranging recipient.

**5.3.9b.2.1 MHR fields**

The Source Addressing Mode, the Source Address, and the Source PAN Identifier fields shall be set according to the OrigAddrMode, OrigPANId, and OrigAddr parameters specified by the MLME-RANGING.request primitive.

The Destination Addressing Mode, the Destination Address, and the Destination PAN Identifier fields shall be set according to the RecAddrMode, RecPANId, and RecAddr parameters specified by the MLME-RANGING.request primitive.

The PAN ID compression field shall be handled according to 5.2.1.1.5.

The Frame Pending field shall be set to zero and ignored upon reception, and the AR field shall be set to one.

**5.3.9b.2.2 Range request payload fields**

The payload fields of the Ranging command frame of subtype Range request shall be formatted as illustrated in Figure 59b.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Octets: 1** | **1** | **1** | **1/11** | **1/7** | **1** | **1/2** |
| Ranging protocol version (defined in 5.3.9b.1 Ranging protocol version handling) | Ranging mode  (according to parameter RangingMode specified by the MLME-RANGING.request primitive in 6.2.25.1) | Requested number of ranging measurements  (according to parameter NumberOfMeasurements specified by the MLME-RANGING.request primitive) | Static ranging parameter fields | Dynamic ranging parameter fields | Requested ranging configuration field | Requested ranging measure-ment transmit power fields |

Figure 59b—Payload of Ranging command frame of subtype Range request

**5.3.9b.2.3 Requested number of ranging measurements field**

This field contains the requested number of ranging measurements during the current ranging measurement between the originator and the recipient. The value shall be set according to the NumberOfMeasurements parameter specified by the MLME-RANGING.request primitive.

The values of the requested number of ranging measurements field are defined in table 5b.

**Table 5b—Values of the requested number of ranging measurement field**

|  |  |
| --- | --- |
| **Requested number of ranging measurements** | **Description** |
| 0x00 | Invalid (shall be considered as 0x01 on reception) |
| 0x01 | Single-shot ranging measurement |
| 0x02-0xff | Multi-shot ranging measurement |

**5.3.9b.2.4 Static ranging parameter fields**

The static ranging parameter fields shall be formatted as illustrated in Figure 59c.

|  |  |
| --- | --- |
| **Octets: 1** | **0/10** |
| Static ranging parameter handling mode | Requested static ranging parameters |

Figure 59c—Static ranging parameter fields

Valid values of the static ranging parameter handling mode field are defined in Table 5c.

**Table 5c—Valid values of the static ranging parameter handling mode field**

|  |  |  |
| --- | --- | --- |
| **Static ranging parameter handling mode** | **Description** | **Comment** |
| 0x00 | Request usage of static ranging parameters as included within this frame | The originator has included its *phyPMDefaultTable* based parameters in this frame which shall be extracted by the recipient and used for this ranging measurement. |
| 0x01 | Request usage of network based values for static ranging parameters if available | The originator implicitly requests the usage of the *phyPMNetworkTable* based parameters, but does not include these parameters in this frame explicitly. |
| 0x02 | Request usage of device based values for static ranging parameters if available | The originator implicitly requests the usage of the *phyPMDeviceTable* based parameters, but does not include these parameters in this frame explicitly. |

The actual value of the static ranging parameter handling mode field is a direct mapping of the current value of *macPMAttributeUsageMode.*

The requested static ranging parameters are only present, if the static ranging parameter handling mode indicates that the requested static ranging parameters are included in this frame (see Table 5c), and shall be formatted as illustrated in Figure 59d. The actual values are taken from the *phyPMDefaultTable* attributes.

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Octets: 1** | **1** | **1** | **1** | **1** | **1** | **1** | **1** | **1** | **1** |
| phyPM-Setup-Duration time in us | phyPM-ShiftFreq in 100kHz | phyPM-FreqSettle-Duration time in us | phyPM-TxSetup-Duration-Rec time in us | phyPM-Sampling-DurationOrig time in us | phyPM-TxSetup-Duration-Orig time in us | phyPM-Sampling-DurationRec time in us | phyPM-Inner-Loop-Repeti-tions | phyPM-Outer-Loop-Repeti-tions | phyPM-Curr-Numbers-OfPhase-Meas-PerFreq |

**Figure 59d—Requested static ranging parameters**

**5.3.9b.2.5 Dynamic ranging parameter fields**

The dynamic ranging parameter fields shall be formatted as illustrated in Figure 59e.

|  |  |
| --- | --- |
| **Octets: 1** | **0/6** |
| Dynamic ranging parameter handling mode | Requested dynamic ranging parameters |

Figure 59e—Dynamic ranging parameter fields

Valid values of the dynamic ranging parameter handling mode field are defined in Table 5d.

**Table 5d—Valid values of the dynamic ranging parameter handling mode field**

|  |  |  |
| --- | --- | --- |
| **Dynamic ranging parameter handling mode** | **Description** | **Comment** |
| 0x00 | Request usage of dynamic ranging parameters as included within this frame | The originator has included its *phyPMDefaultTable* based parameters in this frame which shall be extracted by the recipient and used for this ranging measurement. |
| 0x01 | Request usage of network based values for dynamic ranging parameters if available | The originator implicitly requests the usage of the *phyPMNetworkTable* based parameters, but does not include these parameters in this frame explicitly. |
| 0x02 | Request usage of device based values for dynamic ranging parameters if available | The originator implicitly requests the usage of the *phyPMDeviceTable* based parameters, but does not include these parameters in this frame explicitly. |

The actual value of the dynamic ranging parameter handling mode field is a direct mapping of the current value of *macPMAttributeUsageMode.*

The requested dynamic ranging parameters are only present, if the dynamic ranging parameter handling mode indicates that the requested dynamic ranging parameters are included in this frame (see Table 5d), and shall be formatted as illustrated in Figure 59f.

|  |  |  |  |
| --- | --- | --- | --- |
| **Octets: 1** | **2** | **2** | **1** |
| phyPMMeasMode  (0x00) | phyPMStartFreq in 100kHz | phyPMStopFreq in 100kHz | phyPMStepFreq in 100kHz |

**Figure 59f—Requested dynamic ranging parameters**

**5.3.9b.2.6 Requested ranging configuration field**

The requested ranging configuration field shall be formatted as illustrated in Figure 59g.

|  |  |
| --- | --- |
| **Bits:  0** | **1-7** |
| Uncompressed Phase measurement results | Reserved |

**Figure 59g—Requested ranging configuration field**

The uncompressed Phase measurement results field requests the provisioning of uncompressed phase measurement results by the ranging recipient to the ranging originator. If this value is set to zero, the phase measurement results are provided compressed, resulting in minimum frame exchanges during the data exchange phase of the ranging measurement. If this value is set to one, the recipient forwards the complete uncompressed measurement values to the recipient, resulting in extended frame exchanges during the data exchange phase of the ranging measurement. The value of this field is derived from the attribute *macPMSuppressResultCompression.*

The reserved fields shall be set to zero and ignored at reception.

**5.3.9b.2.7 Requested ranging measurement transmit power fields**

The requested ranging measurement transmit power fields shall be formatted as illustrated in Figure 59h.

|  |  |
| --- | --- |
| **Octets: 1** | **0/1** |
| Requested ranging measure-ment transmit power handling mode | Requested ranging measure-ment transmit power |

Figure 59h—Requested ranging measurement transmit power fields

Valid values of the requested ranging measurement transmit power handling mode field are defined in Table 5e.

**Table 5e—Valid values of the requested ranging measurement transmit power handling mode field**

|  |  |
| --- | --- |
| **Requested ranging measurement transmit power handling mode** | **Description** |
| 0x00 | Requested ranging measurement transmit power not included in frame |
| 0x01 | Requested ranging measurement transmit power included in frame |

The actual value of the requested ranging measurement transmit power handling mode field shall be derived from the current value of the attribute *macPMProvideRangingTxPower.*

The requested ranging measurement transmit power is only available if the requested ranging measurement transmit power handling mode indicates that the requested ranging measurement transmit power is included in this frame (see Table 5e), and shall set as defined in *phyPMRangingTxPower.*

**5.3.9b.3 Range response command**

The Ranging command frame of subtype Range response is used to either accept or reject a previously requested ranging measurement and shall be sent by the ranging recipient to the ranging originator.

**5.3.9b.3.1 MHR fields**

The Source Addressing Mode, the Source Address, and the Source PAN Identifier fields shall be set according to the parameters Destination Addressing Mode, the Destination Address, and the Destination PAN Identifier within the previously received Range request frame.

The Destination Addressing Mode, the Destination Address, and the Destination PAN Identifier fields shall be set according to the parameters Source Addressing Mode, the Source Address, and the Source PAN Identifier within the previously received Range request frame.

The PAN ID compression field shall be handled according to 5.2.1.1.5.

The Frame Pending field shall be set to zero and ignored upon reception, and the AR field shall be set to one.

**5.3.9b.3.2 Range response payload fields**

The payload fields of the Ranging command frame of subtype Range response shall be formatted as illustrated in Figure 59i.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Octets: 1** | **1** | **1** | **1** | **1/7** | **1** |
| Range acceptance status | Ranging mode | Accepted number of ranging measurements | Static ranging parameter acceptance status | Dynamic ranging parameter acceptance fields | Accepted ranging configuration field |

Figure 59i—Payload of Ranging command frame of subtype Range response

**5.3.9b.3.3 Range acceptance status field**

Valid values of the range acceptance status field are defined in Table 5f.

**Table 5f—Valid values of the range acceptance status field**

|  |  |
| --- | --- |
| **Range acceptance status** | **Description** |
| 0x00 | Ranging request accepted |
| 0x01 | Ranging rejected since ranging is currently not supported (*macPMRangingEnabled is set to false*) |
| 0x02 | Ranging rejected since ranging is already ongoing |
| 0x03 | Ranging rejected due to unsupported ranging protocol version |
| 0x04 | Ranging rejected due to unsupported ranging mode |
| 0x05 | Ranging rejected due to requested usage of device based ranging parameters but device not in *phyPMDeviceTable* |
| 0x06 | Ranging rejected due to unsupported dynamic ranging parameters; proposed changes are appended |
| 0x07 | Ranging rejected due to invalid ranging parameters |

**5.3.9b.3.4 Ranging mode field**

If the retrieved ranging mode within the previously received Range request frame is accepted by the ranging recipient, if shall return the same value for the ranging mode in the ranging mode field.

Otherwise the ranging recipient shall reject the ranging request by setting the range acceptance status indicating an unsupported ranging mode, and shall update the ranging mode field with a proposed ranging mode.

**5.3.9b.3.5 Accepted number of ranging measurements field**

If the requested number of ranging measurements within the previously received Range request frame is accepted by the ranging recipient, if shall return the same value in the accepted number of ranging measurements field.

Otherwise the ranging recipient shall update the accepted number of ranging measurements field with a supported value less than originally requested, but the ranging request itself shall not be rejected solely due to this procedure.

Valid values of the accepted number of ranging measurements field are defined in Table 5g.

**Table 5g—Values of the accepted number of ranging measurement field**

|  |  |
| --- | --- |
| **Accepted number of ranging measurements** | **Description** |
| 0x00 | Invalid (shall be considered as 0x01 on reception) |
| 0x01 | Single-shot ranging measurement |
| 0x02-0xff | Multi-shot ranging measurement |

A value of one indicates a single-shot ranging measurement; other values indicate a multi-shot ranging measurement.

**5.3.9b.3.6 Static ranging parameter acceptance status fields**

The static ranging parameter acceptance field shall contain one of the following valid values as defined in Table 5h.

**Table 5h—Valid values of the static ranging parameter acceptance status field**

|  |  |
| --- | --- |
| **Static ranging parameter acceptance status** | **Description** |
| 0x00 | Requested static ranging parameters are accepted, no changes required |
| 0x01 | Requested static ranging parameters are not accepted |
| 0x02 | No static ranging parameters stored |

If the recipient has accepted the requested static ranging parameters and no changes are required, the recipient sets the static ranging parameter acceptance status to 0x00. This is independent whether the requested static ranging parameters were included in the previously received Range request frame.

If the recipient cannot accept the requested static ranging parameters, the recipient sets the static ranging parameter acceptance status to 0x01. Furthermore the ranging recipient shall reject the ranging request by setting the range acceptance status indicating ranging rejected due to invalid ranging parameters.

If the recipient is requested to use either the *phyPMDeviceTable* or the *phyPMNetworkTable* based static ranging parameters, but this cannot be fulfilled (due to the capabilities based on *phyPMParameterStorage* and/or an undefined entry in *phyPMDeviceTable*), the recipient sets the static ranging parameter acceptance status to 0x02. Furthermore the ranging recipient shall reject the ranging request by setting the range acceptance status indicating ranging rejected due to invalid ranging parameters (in case of requested *phyPMNetworkTable)* orto invalid device (in case of requested *phyPMDeviceTable)*.

**5.3.9b.3.7 Dynamic ranging parameter acceptance fields**

The dynamic ranging parameter acceptance fields shall be formatted as illustrated in Figure 59i.

|  |  |
| --- | --- |
| **Octets: 1** | **0/6** |
| Dynamic ranging parameter acceptance status | Proposed dynamic ranging parameters |

Figure 597—Dynamic ranging parameter acceptance fields

The dynamic ranging parameter acceptance status shall contain one of the following valid values as defined in Table 5i.

**Table 5i—Valid values of the dynamic ranging parameter acceptance status field**

|  |  |
| --- | --- |
| **Dynamic ranging parameter acceptance status** | **Description** |
| 0x00 | Requested dynamic ranging parameters are accepted, no changes required |
| 0x01 | Requested dynamic ranging parameters are not accepted; proposed changes are appended |
| 0x02 | No dynamic ranging parameters stored |

If the recipient has accepted the requested static ranging parameters and no changes are required, the recipient sets the dynamic ranging parameter acceptance status to 0x00. This is independent whether the requested dynamic ranging parameters were included in the previously received Range request frame.

If the recipient cannot accept the requested dynamic ranging parameters, the recipient sets the dynamic ranging parameter acceptance status to 0x01, and shall fill in the proposed dynamic ranging parameter field to allow for the originator to extract the supported dynamic ranging parameters and initiate a new ranging procedure with supported dynamic ranging parameters. Furthermore the ranging recipient shall reject the ranging request by setting the range acceptance status indicating ranging rejected due to invalid ranging parameters.

If the recipient is requested to use either the *phyPMDeviceTable* or the *phyPMNetworkTable* based dynamic ranging parameters, but this cannot be fulfilled (due to the current capabilities based on *phyPMParameterStorage* and/or an undefined entry in *phyPMDeviceTable*), the recipient sets the dynamic ranging parameter acceptance status to 0x02. Furthermore the ranging recipient shall reject the ranging request by setting the range acceptance status indicating ranging rejected due to invalid ranging parameters (in case of requested *phyPMNetworkTable)* orto invalid device (in case of requested *phyPMDeviceTable)*.

The proposed dynamic ranging parameters are only present, if the dynamic ranging parameter acceptance status is set to 0x01 (see Table 5i), and shall be formatted as illustrated in Figure 59j.

|  |  |  |  |
| --- | --- | --- | --- |
| **Octets: 1** | **2** | **2** | **1** |
| phyPMMeasMode  (0x00) | phyPMStartFreq in 100kHz | phyPMStopFreq in 100kHz | phyPMStepFreq in 100kHz |

**Figure 59j—Proposed dynamic ranging parameters**

**5.3.9b.3.8 Accepted ranging configuration field**

The accepted ranging configuration field shall be formatted as illustrated in Figure 59n.

|  |  |
| --- | --- |
| **Bits:  0** | **1-7** |
| Uncompressed Phase measurement results | Reserved |

**Figure 59n—Accepted ranging configuration field**

The uncompressed phase measurement results field defines whether the phase measurement results by the ranging recipient to the ranging originator shall be done uncompressed or compressed. If this value is set to zero, the phase measurement results are provided compressed, resulting in minimum frame exchanges during the data exchange phase of the ranging measurement. If this value is set to one, the recipient forwards the complete uncompressed measurement values to the recipient, resulting in extended frame exchanges during the data exchange phase of the ranging measurement.

This value shall only be set to one, if provisioning of uncompressed data was requested form the originator, and uncompressed phase measurement data provisioning is supported by the recipient. In all other cases this field shall be set to zero.

The reserved fields shall be set to zero and ignored at reception.

**5.3.9b.4 Range abort command**

The Ranging command frame of subtype Range abort shall be used by the originator if the recipient has accepted the Range request, but the originator detects a condition where it cannot continue with the current ranging procedure (e.g. due to invalid returned ranging parameters from the recipient) to abort the ranging procedure, and shall be sent by the ranging originator to the ranging recipient.

The frame shall also be used by the recipient if the device has received a Range sync request frame containing invalid parameters or a Range result request frame containing invalid parameters, and shall then be sent by the ranging recipient to the ranging originator.

The Range abort frame does not contain any payload fields.

**5.3.9b.4.1 MHR fields**

If the frame is sent by the originator to the recipient, the Source Addressing Mode, the Source Address, and the Source PAN Identifier fields shall be set according to the OrigAddrMode, OrigPANId, and OrigAddr parameters specified by the MLME-RANGING.request primitive. The Destination Addressing Mode, the Destination Address, and the Destination PAN Identifier fields shall be set according to the RecAddrMode, RecPANId, and RecAddr parameters specified by the MLME-RANGING.request primitive.

If the frame is sent by the recipient to the originator, the Source Addressing Mode, the Source Address, and the Source PAN Identifier fields shall be set according to the parameters Destination Addressing Mode, the Destination Address, and the Destination PAN Identifier within the previously received Ranging command frame. The Destination Addressing Mode, the Destination Address, and the Destination PAN Identifier fields shall be set according to the parameters Source Addressing Mode, the Source Address, and the Source PAN Identifier within the previously received Ranging command frame.

The PAN ID compression field shall be handled according to 5.2.1.1.5.

The Frame Pending field shall be set to zero and ignored upon reception, and the AR field shall be set to one.

**5.3.9b.5 Range sync request command**

The Ranging command frame of subtype Range sync request is used

* after the successful Range request / Range response handshake to start a single shot ranging measurement, or
* in case the accepted number of ranging measurements field within the Range response frame was larger than one (indicating multi-shot ranging measurement), after finishing the previous data exchange phase to start the next ranging measurement of the same originator - recipient device pair (without another Range request / Range response handshake) using the same ranging parameters (but with a decremented value of the Remaining ranging measurements counter field; see 5.3.9b.5.2).

The frame shall be sent by the ranging originator to the ranging recipient.

**5.3.9b.5.1 MHR fields**

The Source Addressing Mode, the Source Address, and the Source PAN Identifier fields shall be set according to the OrigAddrMode, OrigPANId, and OrigAddr parameters specified by the MLME-RANGING.request primitive.

The Destination Addressing Mode, the Destination Address, and the Destination PAN Identifier fields shall be set according to the RecAddrMode, RecPANId, and RecAddr parameters specified by the MLME-RANGING.request primitive.

The PAN ID compression field shall be handled according to 5.2.1.1.5.

The Frame Pending field shall be set to zero and ignored upon reception, and the AR field shall be set to one.

**5.3.9b.5.2 Range sync request payload fields**

The payload fields of the Ranging command frame of subtype Range sync request shall be formatted as illustrated in Figure 59o.

|  |  |
| --- | --- |
| **Octets: 1** | **1** |
| Ranging protocol version (defined in 5.3.9b.1 Ranging protocol version handling) | Remaining ranging measurements counter |

Figure 59o—Payload of Ranging command frame of subtype Range sync request

**5.3.9b.5.3 Remaining ranging measurements counter field**

This field contains the remaining number of ranging measurements to be performed after the current ranging measurement between the originator and recipient node. A value of zero indicates a single-shot ranging measurement or the initiation of the last multi-shot ranging measurement procedure.

**5.3.9b.6 Range start command**

The Ranging command frame of subtype Range start is used to gain synchronization between the ranging originator and recipient for the current ranging procedure and start the actual phase difference measurement, and shall be sent by the ranging recipient to the ranging originator.

The Range start frame does not contain any payload fields.

**5.3.9b.6.1 MHR fields**

The Source Addressing Mode, the Source Address, and the Source PAN Identifier fields shall be set according to the parameters Destination Addressing Mode, the Destination Address, and the Destination PAN Identifier within the previously received Range sync request frame.

The Destination Addressing Mode, the Destination Address, and the Destination PAN Identifier fields shall be set according to the parameters Source Addressing Mode, the Source Address, and the Source PAN Identifier within the previously received Range sync request frame.

The PAN ID compression field shall be handled according to 5.2.1.1.5.

The Frame Pending field shall be set to zero and ignored upon reception.

The AR field shall be set to zero.

**5.3.9b.7 Range result request command**

The Ranging command frame of subtype Range result request is used after finishing a single phase difference measurement (even when operating a multi-shot ranging) to initiate the retrieval of phase measurement data, and shall be sent by the ranging originator to the ranging recipient.

**5.3.9b.7.1 MHR fields**

The Source Addressing Mode, the Source Address, and the Source PAN Identifier fields shall be set according to the OrigAddrMode, OrigPANId, and OrigAddr parameters specified by the MLME-RANGING.request primitive.

The Destination Addressing Mode, the Destination Address, and the Destination PAN Identifier fields shall be set according to the RecAddrMode, RecPANId, and RecAddr parameters specified by the MLME-RANGING.request primitive.

The PAN ID compression field shall be handled according to 5.2.1.1.5.

The Frame Pending field shall be set to zero and ignored upon reception, and the AR field shall be set to one.

**5.3.9b.7.2 Range result request payload fields**

The payload fields of the Ranging command frame of subtype Range request shall be formatted as illustrated in Figure 59p.

|  |  |  |  |
| --- | --- | --- | --- |
| **Octets: 1** | **1** | **1** | **2** |
| Result data type field | Requested outer loop counter | Requested inner loop counter | Requested result data start address for current outer and inner loop count |

Figure 59p—Payload of Ranging command frame of subtype Range result request

**5.3.9b.7.3 Result data type field**

This field contains the requested type of result data. A value of one indicates phase measurement data. All other values are reserved and shall be ignored upon reception, i.e. treated as phase measurement data type.

**5.3.9b.7.4 Requested outer and inner loop counter fields**

These fields contain the current outer and inner loop counter values, which the result data are requested for. Both loop counts start with zero and are updated after successful data retrieval for each range result data exchange.

The outer loop counter starts at zero, and is incremented once the inner loop counter has reached the limit according to the accepted parameter handshake for the current inner loop counter.

The inner loop counter starts at zero, and is incremented for each new Range result request frame (after successful reception of the previous Range result confirm frame) until the limit according to the accepted parameter handshake has been reached. Once this limit is reached, the inner loop count is reset to zero, and the outer loop counter is incremented.

Example: The originator and the recipient have agreed on an outer loop count of 2 (i.e. phyPMOuterLoopRepetitions is 1) and an inner loop count of 3 (i.e. phyPMInnerLoopRepetitions is 2). Furthermore it is assumed that the originator is able to receive and process all requested Range result confirm frames, and thus does not initiate any retransmissions of already received result data.

The actual values of the outer and inner loop counter fields for this example are illustrated in Table 5j.

**Table 5j—Values of the outer and inner loop counter fields for given example**

|  |  |  |
| --- | --- | --- |
| **Range result request frame number** | **Outer loop counter field value** | **Inner loop counter field value** |
| 1 | 0 | 0 |
| 2 | 0 | 1 |
| 3 | 0 | 2 |
| 4 | 1 | 0 |
| 5 | 1 | 1 |
| 6 | 1 | 2 |

**5.3.9b.7.5 Requested result data start address**

This value specifies the start address of the requested result data of the measurement data based on the specified outer and inner loop counter. This value is updated for each transmitted Range result request frame. In case the previous result retrieval was not successful, the originator may repeat the last result data start address to repeat the retrieval of the same result data.

**5.3.9b.8 Range result confirm command**

The Ranging command frame of subtype Range result confirm is used in response to a received Range result request frame to provide the requested phase measurement data, and shall be sent by the ranging recipient to the ranging originator.

**5.3.9b.8.1 MHR fields**

The Source Addressing Mode, the Source Address, and the Source PAN Identifier fields shall be set according to the parameters Destination Addressing Mode, the Destination Address, and the Destination PAN Identifier within the previously received Range request frame.

The Destination Addressing Mode, the Destination Address, and the Destination PAN Identifier fields shall be set according to the parameters Source Addressing Mode, the Source Address, and the Source PAN Identifier within the previously received Range result request frame.

The PAN ID compression field shall be handled according to 5.2.1.1.5.

The Frame Pending field shall be set to zero and ignored upon reception, and the AR field shall be set to one.

**5.3.9b.8.2 Range result confirm payload fields**

The payload fields of the Ranging command frame of subtype range confirm shall be formatted as illustrated in Figure 59q.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Octets: 1** | **1** | **1** | **2** | **2** | **Variable** |
| Result data type field | Current outer loop counter | Current inner loop counter | Number of included range result data values | Current result data start address for current outer and inner loop count | Range result data |

Figure 59q—Payload of Ranging command frame of subtype Range result confirm

**5.3.9b.8.3 Result data type field**

This field contains the provided type of result data.

Valid values of the result data type field are defined in Table 5k.

**Table 5k—Valid values of the result data type field**

|  |  |
| --- | --- |
| **Requested ranging mode** | **Description** |
| 0x00 | Busy condition at recipient (e.g. due to unfinished phase measurement data compression); Allows for the originator to later repeat the request for the same result data; All further included data in this frame shall be ignored upon reception |
| 0x01 | Phase measurement data; Only in this case all other payload fields of the frame are valid and shall be extracted upon reception |
| 0x02-0xff | Reserved; All further included data in this frame shall be ignored upon reception |

**5.3.9b.8.4 Current outer and inner loop counter fields**

These fields contain the current outer and inner loop counter values, which the result data are provided for, and shall be derived from the previously received Range result request frame.

**5.3.9b.8.5 Number of included range result data values**

This field contains the actually included number of range result data values. The length of this field is 2 octets to allow for using larger frames than 127 octets.

**5.3.9b.8.6 Current result data start address**

This value specifies the start address of the current result data for a given outer and inner loop counter, and shall be derived from the previously received Range result request frame, i.e. the Range result confirm frame shall contain exactly the requested result data from the Range result request frame.

**5.3.9b.8.6 Range result data**

This field contains the actual phase measurement data values. The length of this field is based on the value of the Number of included range result data values. The size of these data values is 1 octet for ranging protocol version 0x00 (see 5.3.9b1 Ranging protocol version handling).

**5.3.9b.9 Ranging capabilities request command**

The Ranging command frame of subtype Ranging capabilities request is used to initiate the retrieval of the ranging capabilities from a ranging peer device, and can be sent by any ranging device.

**5.3.9b9.1 MHR fields**

The Source Addressing Mode shall be set according to the SrcAddrMode parameter specified by the MLME-RANGING-CAPABILITIES.request primitive.

The Source Address shall contain the address of the device based on the corresponding address mode according to the SrcAddrMode parameter specified by the MLME-RANGING-CAPABILITIES.request primitive.

The Source PAN Identifier fields shall contain the value of macPANId.

The Destination Addressing Mode, the Destination Address, and the Destination PAN Identifier fields shall be set according to the PeerAddrMode, PeerPANId, and PeerAddr parameters specified by the MLME-RANGING-CAPABILITIES.request primitive.

The PAN ID compression field shall be handled according to 5.2.1.1.5.

The Frame Pending field shall be set to zero and ignored upon reception, and the AR field shall be set to one.

**5.3.9b.9.2 Ranging capabilities request payload field**

The Ranging capabilities request payload contains only one single field, i.e. the requested ranging mode field, which size is one octet.

Valid values of the Ranging capabilities request payload field are defined in Table 5l.

**Table 5l—Valid values of the Ranging capabilities request payload mode field**

|  |  |
| --- | --- |
| **Requested ranging mode** | **Description** |
| 0x00 | Request to provide capabilities of all supported ranging modes |
| 0x01 | Request to provide capabilities of ranging mode PM\_RANGING |
| 0x02-0xff | Reserved |

**5.3.9b.10 Ranging capabilities response command**

The Ranging command frame of subtype Ranging capabilities response is used to provide the requested ranging capabilities to the requesting device, and can be sent by any ranging device as response to a received Ranging capabilities request frame.

**5.3.9b10.1 MHR fields**

The Source Addressing Mode, the Source Address, and the Source PAN Identifier fields shall be set according to the parameters Destination Addressing Mode, the Destination Address, and the Destination PAN Identifier within the previously received Ranging capabilities request frame.

The Destination Addressing Mode, the Destination Address, and the Destination PAN Identifier fields shall be set according to the parameters Source Addressing Mode, the Source Address, and the Source PAN Identifier within the previously received Ranging capabilities request frame.

The PAN ID compression field shall be handled according to 5.2.1.1.5.

The Frame Pending field shall be set to zero and ignored upon reception, and the AR field shall be set to one.

**5.3.9b.10.2 Ranging capabilities response payload fields**

The payload fields of the Ranging command frame of subtype Ranging capabilities response shall be formatted as illustrated in Figure 59s.

|  |  |  |
| --- | --- | --- |
| **Octets: 1** | **1/variable** | **0/variable** |
| Ranging protocol version (defined in 5.3.9b.1 Ranging protocol version handling) | Included ranging modes fields | PM ranging capabilities fields |

Figure 59s—Payload of Ranging command frame of subtype Ranging capabilities response

**5.3.9b.10.3 Included ranging modes fields**

The Included ranging modes fields shall be formatted as illustrated in Figure 59t.

|  |  |
| --- | --- |
| **Octets: 1** | **variable** |
| Number of included ranging modes | Included ranging modes |

Figure 59t—Supported ranging modes fields

The field number of included ranging modes shall be set according to the requested ranging modes in the received Ranging capabilities request frame.

If the received Ranging capabilities request frame requests the capabilities of all supported ranging modes, the device shall include its number of supported ranging modes. If the device does not support any ranging mode, this field shall be set to zero. If a node supports only one single ranging mode, for example only PM\_RANGING, this field shall be set to one.

If the received Ranging capabilities request frame requests the retrieval the capabilities of one specific ranging mode (e.g. PM\_ RANGING, see 5.3.9b.9.2), which is actually supported by the device, this field shall be set to one. If the requested ranging mode is not supported by the device, this field shall be set to zero.

If the number of included ranging modes field is set to zero, no further octets containing the Included ranging modes are appended. If the number of included ranging modes field is set to one, exactly one octet specifying the Included ranging modes is appended. If the number of ranging modes field is set to any other value, the Included ranging modes comprises of one octet for each supported ranging mode containing the actually supported ranging mode.

Currently only PM\_RANGING is supported.

**5.3.9b.10.4 PM ranging capabilities fields**

The PM (Phase Difference Measurement) ranging capabilities fields shall be formatted as illustrated in Figure 59u.

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Octets: 1** | **1** | **1** | **1** | **1** | **1** | **1** | **1** |
| PM\_ RAN-GING = 0x01 | Length of PM ranging capabili-ties | phyPM-MaxNum-OfRangings | Minimum phyPM-Setup-Duration time in us | Maximum phyPM-Setup-Duration time in us | Minimum phyPM-ShiftFreq in 100kHz | phyPM-Supported-MeasModes | Maximum phyPM-ShiftFreq in 100kHz |

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **1** | **1** | **1** | **1** | **1** | **1** | **1** | **1** |
| Minimum phyPM-FreqSettle-Duration time in us | Maximum phyPM-FreqSettle-Duration time in us | Minimum phyPM-TxSetup-DurationRec time in us | Maximum phyPM-TxSetup-DurationRec time in us | Minimum phyPM-Sampling-DurationOrig time in us | Maximum phyPM-Sampling-DurationOrig time in us | Minimum phyPM-TxSetup-DurationOrig time in us | Maximum phyPM-TxSetup-DurationOrig time in us |

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **1** | **1** | **1** | **1** | **1** | **1** | **1** | **Variable (<=8)** | **1** |
| Minimum phyPM-Sampling-DurationRec time in us | Maximum phyPM-Sampling-DurationRec time in us | Minimum phyPM-Inner-Loop-Repetitions time in us | Maximum phyPM-Inner-Loop-Repetitions time in us | Minimum phyPM-Outer-Loop-Repetitions time in us | Maximum phyPM-Outer-Loop-Repetitions time in us | phyPM-LenOf- Numbers-Of- Phase-Meas-PerFreq | Set of octets containing a supported number of phase measure-ments per frequency (phyPM-NumbersOf-PhaseMeas-PerFreq) | phyPM-Parameter-Storage |

Figure 59t—PM ranging capabilities fields

The actual values to be included within the PM ranging capabilities fields shall be taken from the *phyPMCapTable* (see Table 71 and 71b).

The field Length of PM ranging capabilities is variable and depends on the length of the set of octets containing the supported numbers of phase measurements per frequency.

**6.2 MAC management service**

*Append Table 8—Summary of the primitives accessed through the MLME-SAP:*

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Name** | **Request** | **Indication** | **Response** | **Confirm** |
| MLME-RANGING-CAPABILITIES | 6.2.26.1 |  |  | 6.2.26.4 |

**6.2.25.1 MLME-RANGING.request**

*Remove and add the following lines:*

MLME-RANGING.request (

OrigAddrMode,

OrigPANId,

OrigAddr,

RecAddrMode,

RecPANId,

RecAddr,

~~CoordAddrMode,~~

RangingMode,

NumberOfMeasurements,

SecurityLevel,

KeyIdMode,

KeySource,

KeyIndex

)

*Remove parameter CoordAddrMode* *from Table 44ii—MLME-RANGING.request parameters  
Change parameter RangingMode from Table 44ii—MLME-RANGING.request parameters  
Add parameters NumberOfMeasurement, SecurityLevel, KeyIdMode, KeySource, KeyIndex to Table 44ii—MLME-RANGING.request parameters*

|  |  |  |  |
| --- | --- | --- | --- |
| **Name** | **Type** | **Valid range** | **Description** |
| ~~CoordAddrMode~~ | ~~Enumeration~~ | ~~NO\_ADDRESS,~~  ~~SHORT\_ADDRESS,~~  ~~EXTENDED\_ADDRESS~~ | ~~The addressing mode of the~~  ~~ranging coordinator.~~ |
| RangingMode | Enumeration | PM\_RANGING = 0x01  Reserved (0x02-0xff) | The requested ranging mode to be used during the ranging measurement. A value of PM\_RANGING indicates Phase Difference Measurement. |
| NumberOfMeasurements | Integer | 0x01-0xff | The requested number of ranging measurements between the originator and recipient based on the initial parameter negotiation. |
| SecurityLevel | Integer | As defined in Table 46 | As defined in Table 46. |
| KeyIdMode | Integer | As defined in Table 46 | As defined in Table 46. |
| KeySource | Set of octets | As defined in Table 46 | As defined in Table 46. |
| KeyIndex | Integer | As defined in Table 46 | As defined in Table 46. |

*Change the text below table 44ii to:*

On receipt of the MLME-RANGING.request primitive, the MAC sublayer entity initiates a ranging measurement procedure.

~~If the CoordAddrMode parameter specifies NO\_ADDRESS, this node is the originator in a local ranging measurement procedure.~~

~~If the CoordAddrMode parameter specifies SHORT\_ADDRESS or EXTENDED\_ADDRESS, this node is the ranging coordinator node in a remote ranging measurement procedure. The ranging request is then forwarded to the intended ranging originator using the originator address information as the destination address for any outgoing frame containing the recipient address information within the frame payload.~~

The SecurityLevel parameter specifies the level of security to be applied to the outgoing Ranging command frames.

**6.2.25.2 MLME-RANGING.confirm**

*Remove original text:*

~~The MLME-RANGING.confirm primitive allows the next higher layer to request a ranging measurement between an originator and a recipient node.~~

~~The semantics of the MLME-RANGING.confirm primitive are:~~

~~MLME-RANGING.confirm (~~

~~status,~~

~~Distance,~~

~~DistanceQuality~~

~~)~~

*Instead add text:*

The MLME-RANGING.confirm primitive allows the MAC layer to inform the next higher layer about the result of a finished ranging measurement.

The semantics of the MLME-RANGING.confirm primitive are:

MLME-RANGING.confirm (

status,

RangingResultListSize,

RangingResultList,

SecurityLevel,

KeyIdMode,

KeySource,

KeyIndex

)

*Change Table 44jj—MLME-RANGING.confirm parameters  
(Change parameter status, add parameters* RangingResultListSize and RangingResultList, *remove parameters* Distance and DistanceQuality)

|  |  |  |  |
| --- | --- | --- | --- |
| **Name** | **Type** | **Valid range** | **Description** |
| status | Enumeration | SUCCESS,  UNSUPPORTED\_RANGING,  RANGING\_IN\_PROGRESS,  RANGING\_IN\_PROGRESS\_AT\_REC,  ~~RANGING\_REJECTED,~~  INVALID\_ADDRESS,  INVALID\_DEVICE,  CHANNEL\_ACCESS\_FAILURE,  NO\_ACK,  INVALID\_PARAMETER,  UNSUPPORTED\_RANGING\_~~METHOD~~MODE,  RANGING\_TIMEOUT,  UNSUPPORTED\_RANGING\_PROTOCOL,  RANGING\_ABORT,  RANGE\_NO\_SYNC,  FRAME\_TOO\_LONG,  IMPROPER\_KEY\_TYPE,  IMPROPER\_SECURITY\_LEVEL,  SECURITY\_ERROR,  UNAVAILABLE\_KEY,  UNSUPPORTED\_LEGACY,  UNSUPPORTED\_SECURITY | The status of the last ranging measurement. |
| RangingResultListSize | Integer | 0x00-0xff | The number of ranging measurement results in the provided list of ranging result. This parameter is only valid if status is SUCCESS. |
| RangingResultList | Set of ranging result values | As defined in Table 44jk | The list of ranging results. This parameter is only valid if status is SUCCESS. |
| SecurityLevel | Integer | As defined in Table 46 or Table 48 | If the primitive were generated following failed outgoing processing of a frame to be transmitted by the ranging originator, then it is as defined in Table 46.  If the primitive were generated following receipt of response command from the ranging recipient, then it is as defined in Table 48. |
| KeyIdMode | Integer | As defined in Table 46 or Table 48 | If the primitive were generated following failed outgoing processing of a frame to be transmitted by the ranging originator, then it is as defined in Table 46.  If the primitive were generated following receipt of response command from the ranging recipient, then it is as defined in Table 48. |
| KeySource | Set of octets | As defined in Table 46 or Table 48 | If the primitive were generated following failed outgoing processing of a frame to be transmitted by the ranging originator, then it is as defined in Table 46.  If the primitive were generated following receipt of response command from the ranging recipient, then it is as defined in Table 48. |
| KeyIndex | Integer | As defined in Table 46 or Table 48 | If the primitive were generated following failed outgoing processing of a frame to be transmitted by the ranging originator, then it is as defined in Table 46.  If the primitive were generated following receipt of response command from the ranging recipient, then it is as defined in Table 48. |

*Add Table 44jk immediately below Table 44jj—Elements of Ranging Result*

**Table 44jl—Elements of Ranging Result**

|  |  |  |  |
| --- | --- | --- | --- |
| **Name** | **Type** | **Valid range** | **Description** |
| Distance | Integer | 0x0000 0000–0xffff ffff | The measured distance  between originator and  recipient in mm. |
| DistanceQuality | Integer | 0x00–0x64 | The confidence level of the ranging measurement in %. |

*Replace the original the text below Table 44jj:*

~~The parameters Distance and DistanceQuality are only valid if the returned status is SUCCESS.~~

~~If the OrigAddrMode or the RecAddrMode parameter is set to NO\_ADDRESS in the MLME-RANGING.request primitive, the status shall be set to INVALID\_ADDRESS.~~

~~If any ranging measurement relevant frame transmission uses CSMA-CA and the CSMA-CA algorithm failed due to adverse conditions on the channel, the status shall be set to CHANNEL\_ACCESS\_FAILURE.~~

~~If the RangingMethod parameter in the MLME-RANGING.request primitive is set to any method not supported by any node involved in the ranging measurement, the status shall be set to UNSUPPORTED\_RANGING\_METHOD.~~

~~If any node involved in the ranging measurement is currently not able to perform the ranging measurement request, the status shall be set to RANGING\_REJECTED.~~

*Instead add the following new text below table 44jk:*

If the OrigAddrMode or the RecAddrMode parameter is set to NO\_ADDRESS in the MLME-RANGING.request primitive, the ranging measurement shall not be started, and the status shall be set to INVALID\_ADDRESS.

If the *macPMRangingEnabled* attribute is set to false the ranging measurement shall not be started, and the status shall be set to UNSUPPORTED\_RANGING.

If the ranging measurement is requested while another ranging procedure is still ongoing, the new ranging measurement shall not be started, and the status shall be set to RANGING\_IN\_PROGRESS.

If any ranging measurement relevant frame transmission uses CSMA-CA and the CSMA-CA algorithm failed due to adverse conditions on the channel, the status shall be set to CHANNEL\_ACCESS\_FAILURE.

If any ranging measurement relevant frame transmission uses acknowledged transmission and the acknowledgement is not received after *macMaxFrameRetries* retransmissions, the status shall be set to NO\_ACK.

If the RangingMode parameter in the MLME-RANGING.request primitive is set to any method not supported by the originator, the ranging measurement shall be aborted, the status shall be set to ZNSUPPORTED\_RANGING\_MODE.

If the current value of the PIB attribute *macPMAttributeUsageMode* requests the usage of *phyPMDeviceTable*, but the *phyPMDeviceTable* does not contain a valid entry for the requested recipient device, the ranging measurement shall be aborted, and the status shall be set to INVALID\_DEVICE.

If the ranging recipient rejects the ranging measurement with the range acceptance status indicating ranging not supported, the status shall be set to UNSUPPORTED\_RANGING\_PROTOCOL.

If the ranging recipient rejects the ranging measurement with the range acceptance status indicating ranging already ongoing, the status shall be set to RANGING\_IN\_PROGRESS\_AT\_REC.

If the ranging recipient rejects the ranging measurement with the range acceptance status indicating unsupported ranging protocol version, the status shall be set to UNSUPPORTED\_RANGING\_PROTOCOL.

If the ranging recipient rejects the ranging measurement with the range acceptance status indicating unsupported ranging protocol mode, the status shall be set to UNSUPPORTED\_RANGING\_MODE.

If the ranging recipient rejects the ranging measurement with the range acceptance status indicating that the originator is not defined in *phyPMDeviceTable*, the status shall be set to INVALID\_DEVICE.

If the ranging recipient rejects the ranging measurement with the range acceptance status indicating invalid ranging parameters, the status shall be set to INVALID\_PARAMETER.

If the ranging originator does not receive an expected ranging response within *macPMRangeResponseWaitTime*, the ranging measurement shall be aborted, and the status shall be set to RANGING\_TIMEOUT.

If the ranging originator is about to synchronize with the recipient, but does not receive an expected Ranging command frame of subtype Range start within *macPMSyncWaitTime*, the ranging measurement shall be aborted, and the status shall be set to RANGING\_NO\_SYNC.

If the recipient has accepted the Range request, but the originator detects a condition where it cannot continue with the current ranging procedure (e.g. due to invalid returned ranging parameters from the recipient), the status shall be set to RANGING\_ABORT.

*Insert below section* **6.2.25.2 MLME-RANGING.confirm*:***

**6.2.26.1 MLME-RANGING-CAPABILITIES.request**

The MLME-RANGING-CAPABILITIES.request primitive allows the next higher layer to request the current phase difference measurement based ranging capabilities of a peer device.

The semantics of this primitive are:

MLME-RANGING-CAPABILITIES.request (

SrcAddrMode,

PeerAddrMode,

PeerPANId,

PeerAddr,

RangingMode,

SecurityLevel,

KeyIdMode,

KeySource,

KeyIndex

)

The primitive parameters are defined in Table 44jl.

**Table 44jl—MLME-RANGING-CAPABILITIES.request parameters**

|  |  |  |  |
| --- | --- | --- | --- |
| **Name** | **Type** | **Valid range** | **Description** |
| SrcAddrMode | Enumeration | SHORT\_ADDRESS,  EXTENDED\_ADDRESS | The addressing mode of the device initiating the ranging capacities request. |
| PeerAddrMode | Enumeration | SHORT\_ADDRESS,  EXTENDED\_ADDRESS | The addressing mode of the  requested ranging peer device |
| PeerPANId | Integer | 0x0000-0xffff | The PAN identifier of the requested ranging peer device. |
| PeerAddress | Device address | As specified by the  PeerAddrMode parameter | The individual device address of the requested ranging peer device. |
| RangingMode | Enumeration | All supported ranging modes = 0x00 PM\_RANGING = 0x01  Reserved (0x02-0xff) | The ranging mode that the ranging capacities are requested for. A value of PM\_RANGING indicates Phase Difference Measurement. A value of 0x00 indicates the request to retrieve the capabilities of all supported ranging modes. |
| SecurityLevel | Integer | As defined in Table 46 | As defined in Table 46. |
| KeyIdMode | Integer | As defined in Table 46 | As defined in Table 46. |
| KeySource | Set of octets | As defined in Table 46 | As defined in Table 46. |
| KeyIndex | Integer | As defined in Table 46 | As defined in Table 46. |

On receipt of the MLME-RANGING-CAPABILITIES.request primitive, the MAC sublayer entity initiates the retrieval of the ranging capabilities from the requested ranging peer device by transmitting a Range command frame of subtype Ranging capabilities request.

The SecurityLevel parameter specifies the level of security to be applied to the outgoing Ranging command frame of subtype Ranging capabilities request.

The device receiving the Range command frame of subtype Ranging capabilities request and supporting the ranging shall generate a Range command frame of subtype Ranging capabilities response.

**6.2.26.4 MLME-RANGING-CAPABILITIES.confirm**

The MLME-RANGING-CAPABILITIES.confirm primitive allows the MAC layer to inform the next higher layer about the result of a request to retrieve the ranging capabilities from a ranging peer node.

The semantics of the MLME-RANGING-CAPABILITIES.confirm primitive are:

MLME-RANGING-CAPABILITIES.confirm (

status,

PeerAddrMode,

PeerPANId,

PeerAddr,

OwnAddrMode,

NumberOfIncludedRangingModes,

RangingCapabilitiesList,

SecurityLevel,

KeyIdMode,

KeySource,

KeyIndex

)

The primitive parameters are defined in Table 44jo.

**Table 44jo—MLME-RANGING-CAPABILITIES.confirm parameters**

|  |  |  |  |
| --- | --- | --- | --- |
| **Name** | **Type** | **Valid range** | **Description** |
| status | Enumeration | SUCCESS,  INVALID\_ADDRESS,  CHANNEL\_ACCESS\_FAILURE,  NO\_ACK | The status of the last ranging capabilities retrieval procedure. |
| PeerAddrMode | Enumeration | SHORT\_ADDRESS,  EXTENDED\_ADDRESS | The addressing mode of the  device requesting the ranging capabilities. |
| PeerPANId | Integer | 0x0000-0xffff | The PAN identifier of the device requesting the ranging capabilities. |
| PeerAddress | Device address | As specified by the  PeerAddrMode parameter | The individual device address of the device requesting the ranging capabilities. |
| OwnAddrMode | Enumeration | SHORT\_ADDRESS,  EXTENDED\_ADDRESS | The device’s own addressing mode used in the received Ranging capacities response frame. |
| NumberOfIncludedRangingModes | Integer | 0x00-0x08 | The number of Ranging mode included in the RangingCapabilitiesList. A value of 0x00 indicates no supported ranging mode. |
| RangingCapabilitiesList | Set of ranging capabilities | As defined in Table 44jp | The list of ranging mode including their ranging capabilities. This parameter is empty NumberOfIncludedRangingModes is set to 0x00. |
| SecurityLevel | Integer | As defined in Table 46 or Table 48 | If the primitive were generated following failed outgoing processing of a Ranging command frame of subtype Ranging capabilities request, then it is as defined in Table 46.  If the primitive were generated following receipt of a Ranging command frame of subtype Ranging capabilities response, then it is as defined in Table 48. |
| KeyIdMode | Integer | As defined in Table 46 or Table 48 | If the primitive were generated following failed outgoing processing of a Ranging command frame of subtype Ranging capabilities request, then it is as defined in Table 46.  If the primitive were generated following receipt of a Ranging command frame of subtype Ranging capabilities response, then it is as defined in Table 48. |
| KeySource | Set of octets | As defined in Table 46 or Table 48 | If the primitive were generated following failed outgoing processing of a Ranging command frame of subtype Ranging capabilities request, then it is as defined in Table 46.  If the primitive were generated following receipt of a Ranging command frame of subtype Ranging capabilities response, then it is as defined in Table 48. |
| KeyIndex | Integer | As defined in Table 46 or Table 48 | If the primitive were generated following failed outgoing processing of a Ranging command frame of subtype Ranging capabilities request, then it is as defined in Table 46.  If the primitive were generated following receipt of a Ranging command frame of subtype Ranging capabilities response, then it is as defined in Table 48. |

**Table 44jp—Elements of Ranging capabilities**

|  |  |  |  |
| --- | --- | --- | --- |
| **Name** | **Type** | **Valid range** | **Description** |
| Supported RangingMode | Integer | PM\_RANGING = 0x01  Reserved (0x02-0xff) | The supported ranging mode. |
| Length of ranging capabilties | Integer | Variable | The length of the ranging capacities for the supported ranging mode |
| Maximum supported number of ranging measurements | Integer | 0x01-0xff | The maximum supported number of ranging measurements. |
| Minimum  phyPMSetupDuration time | Integer | 0x00-0xff  <= Maximum phyPMSetupDuration | The minimum  phyPMSetupDuration time in us |
| Maximum phyPMSetupDuration time | Integer | 0x00-0xff | The maximum phyPM-Setup-Duration time in us |
| Minimum  phyPMShiftFreq | Integer | 0x00-0xff  <= Maximum phyPMShiftFreq | The minimum  phyPMShiftFreq in 100kHz |
| phyPMSupportedMeasModes | Integer | 0x00-0xff | Bit field containing the supported PM measurement modes according to *phyPMMeasMode*; each set bit indicates a supported PM measurement mode;  e.g. a device supporting only PM\_ UseFreq shall set only bit 0 |
| Maximum phyPMShiftFreq | Integer | 0x00-0xff | The maximum phyPMShiftFreq in 100kHz |
| Minimum phyPMFreqSettleDuration time | Integer | 0x00-0xff  <= Maximum phyPMFreqSettleDuration | The minimum phyPMFreqSettleDuration time in us |
| Maximum phyPMFreqSettleDuration time | Integer | 0x00-0xff | The maximum phyPMFreqSettleDuration time in us |
| Minimum phyPMTxSetupDurationRec time | Integer | 0x00-0xff  <= Maximum phyPMTxSetupDurationRec | The minimum phyPMTxSetupDurationRec time in us |
| Maximum phyPMTxSetupDurationRec time | Integer | 0x00-0xff | The maximum phyPMTxSetupDurationRec time in us |
| Minimum phyPMSamplingDurationOrig time | Integer | 0x00-0xff | The minimum phyPMSamplingDurationOrig time in us |
| Maximum phyPMSamplingDurationOrig time | Integer | 0x00-0xff  <= Maximum phyPMSamplingDurationOrig | The maximum phyPMSamplingDurationOrig time in us |
| Minimum phyPMTxSetupDurationOrig time | Integer | 0x00-0xff | The minimum phyPMTxSetupDurationOrig time in us |
| Maximum phyPMTxSetupDurationOrig time | Integer | 0x00-0xff  <= Maximum phyPMTxSetupDurationOrig | The maximum phyPMTxSetupDurationOrig time in us |
| Minimum phyPMSamplingDurationRec time | Integer | 0x00-0xff | The minimum phyPMSamplingDurationRec time in us |
| Maximum phyPMSamplingDurationRec time | Integer | 0x00-0xff  <= Maximum phyPMSamplingDurationRec | The maximum phyPMSamplingDurationRec time in us |
| Minimum phyPMInnerLoopRepetitions | Integer | 0x00-0xff | The minimum phyPMInnerLoopRepetitions |
| Maximum phyPMInnerLoopRepetitions | Integer | 0x00-0xff  <= Maximum phyPMInnerLoopRepetitions | The maximum phyPMInnerLoopRepetitions |
| Minimum phyPMOuterLoopRepetitions | Integer | 0x00-0xff | The minimum phyPMOuterLoopRepetitions |
| Maximum phyPMOuterLoopRepetitions | Integer | 0x00-0xff  <= Maximum phyPMOuterLoopRepetitions | The maximum phyPMOuterLoopRepetitions |
| Appended octets containing supported number of phase measurements per frequency | Integer | 1-8 | The number of appended octets indicating containing supported number of phase measurements per frequency |
| Set of octets containing supported number of phase measurements per frequency | Integer | 0x01-0xff | The set of octets containing supported number of phase measurements per frequency. Each octet contains one supported number of phase measurements per frequency. |
| *phyPMParameterStorage* | Integer | 0x00-0x02 | The capability to store sets of ranging parameters. 0x00: Device is neither able to store network based nor device based ranging parameters; only the default parameter set is used 0x01: Device is able to store network based ranging parameters  0x02: Device is able to store both network based and device based set of ranging parameters |

If the SrcAddrMode or the PeerAddrMode parameter is set to NO\_ADDRESS in the MLME-RANGING-CAPABILITIES.request primitive, the retrieval of ranging capabilities shall be aborted, and the status shall be set to INVALID\_ADDRESS.

If the Ranging capabilities request frame transmission uses CSMA-CA and the CSMA-CA algorithm failed due to adverse conditions on the channel, the status shall be set to CHANNEL\_ACCESS\_FAILURE.

If any Ranging capabilities request frame transmission uses acknowledged transmission and the acknowledgement is not received after *macMaxFrameRetries* retransmissions, the status shall be set to NO\_ACK.

If the device initiating the retrieval of ranging capabilities does not receive the expected Ranging capabilities response within *macPMRangeResponseWaitTime*, the retrieval of ranging capabilities shall be aborted, and the status shall be set to RANGING\_TIMEOUT.

The included parameters NumberOfIncludedRangingModes and RangingCapabilitiesList are only valid if the status indicates SUCCESS.

**6.4.2 MAC PIB attributes**

***Add the following new entries at the end of Table 52:***

**Table 52— MAC PIB attributes**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Attribute** | **Type** | **Range** | **Description** | **Default** |
| *macPMRangeResponseWaitTime* | Integer | 2–64 | The maximum time, in multiples of *aBaseSuperframeDuration*, a device shall wait for a Range response command frame to be available following a Range request command frame. | macResponseWaitTime |
| *macPMSyncWaitTime* | Integer | 0x0001–0xffff | The maximum time in us, an originator device shall wait for an expected Range command frame of subtype Range start following a transmitted Range Sync request. This time starts immediately at the end of the successfully finished transmission of the Range Sync Request frame including the corresponding Acknowledgement frame. | 0xff |
| *macPMRangeExtWaitTime* | Integer | 2–4 | The maximum time, in multiples of *macPMRangeResponseWaitTime*, a recipient shall wait for the initial Range result request command frame after the phase measurement and phase measurement result compression if required, and for the originator to wait for a subsequent Range result response frame after receiving a busy indication from the recipient | 2 |
| *macPMAttributeUsageMode* | Enumeration | 0x00-0x02 | The usage mode of the phase difference measurement attributes.  0x00: PM attributes from *phyPMDefaultTable* to be used  0x01: PM attributes from *phyPMNetworkTable* to be used  0x02: PM attributes from *phyPMDeviceTable* to be used The value of this attribute must not be larger than the value of *phyPMParameterStorage* | 0x00 |
| *macPMSuppressResultCompression* | Boolean | TRUE, FALSE | Indication of whether Phase Measurement result compression (per frequency base) shall not be performed | FALSE |
| *macPMProvideRangingTxPower* | Boolean | TRUE, FALSE | Indication of whether the ranging originator shall send the ranging recipient its current value of the ranging transmit power.  If this attribute is set, the originator will sent the recipient its own value of the PIB attribute to be applied at the recipient during the phase difference measurement. The recipient shall then apply the received ranging transmit power during the phase difference measurement, but must not update its own value of *phyPMRangingTxPower*.  If this attribute is not set, the originator will not provide its own *phyPMRangingTxPower* and the, recipient shall apply its own value of *phyPMRangingTxPower*. | FALSE |

**9.3 PHY PIB attributes**

***Move the following entries from Table 71 to Table 71a (see Table 71a below):***

|  |  |  |  |
| --- | --- | --- | --- |
| **Attribute** | **Type** | **Range** | **Description** |
| *~~phyPMSetupDuration~~* | ~~Integer~~ |  | ~~Setup duration required to synchronize the start of a new Phase Difference measurement procedure in us for the originator and recipient node~~ |
| *~~phyPMStartFreq~~* | ~~Integer~~ | ~~0x0000-0xffff~~ | ~~Start frequency for Phase Difference measurement in 100 kHz~~ |
| *~~phyPMStopFreq~~* | ~~Integer~~ | ~~0x0000-0xffff~~ | ~~Stop frequency for Phase Difference measurement in 100 kHz~~ |
| *~~phyPMStepFreq~~* | ~~Integer~~ | ~~0x0000-0xffff~~ | ~~Frequency step for Phase Difference measurement in 100 kHz~~ |
| *~~phyPMShiftFreq~~* | ~~Integer~~ | ~~0x00-0xff~~ | ~~Transmit frequency shift between phase 1 and phase 2 during a Phase Difference measurement in 100kHz; f~~~~Phase2~~ ~~= f~~~~Phase1~~ ~~+ phyPMShiftFreq~~ |
| *~~phyPMFreqSettleDuration~~* | ~~Integer~~ |  | ~~Settle duration required for initializing a new frequency during a Phase Difference measurement in us~~ |
| *~~phyPMTxSetupDurationRec~~* | ~~Integer~~ |  | ~~Time required for transmitter settling of recipient node within Phase Difference measurement phase 1 in us~~ |
| *~~phyPMSamplingDurationOrig~~* | ~~Integer~~ |  | ~~Time required for actual phase measurement of originator node within Phase Difference measurement phase 1 in us~~ |
| *~~phyPMTxSetupDurationOrig~~* | ~~Integer~~ |  | ~~Time required for transmitter settling of originator node within Phase Difference measurement phase 2 in us~~ |
| *~~phyPMSamplingDurationRec~~* | ~~Integer~~ |  | ~~Time required for actual phase measurement of recipient node within Phase Difference measurement phase 2 in us~~ |
| *~~phyPMInnerLoopRepetitions~~* | ~~Integer~~ | ~~0x00-0xff~~ | ~~Repetition count for inner Phase Difference measurement loop including~~   * ~~phyPMTxSetupDurationOrig~~ * ~~phyPMTxSetupDurationRec~~ * ~~phyPMSamplingDurationOrig~~ * ~~phyPMSamplingDurationRec~~ |
| *~~phyPMOuterLoopRepetitions~~* | ~~Integer~~ | ~~0x00-0xff~~ | ~~Repetition count for outer Phase Difference measurement loop, including an entire Phase Difference measurement procedure consisting of ((~~*~~phyPMStopFreq – phyPMStartFreq)/phyPMStepFreq + 1~~*~~) individual cycles.~~  ~~One cycle incorporates the following sequences:~~   * ~~phyPMFreqSettleDuration~~ * ~~phyPMTxSetupDurationOrig~~ * ~~phyPMTxSetupDurationRec~~ * ~~phyPMSamplingDurationOrig~~ * ~~phyPMSamplingDurationRec~~ |

***Add the following entries to Table 71:***

**Table 71—PHY PIB attributes**

|  |  |  |  |
| --- | --- | --- | --- |
| **Attribute** | **Type** | **Range** | **Description** |
| *phyPMDefaultTable* | Set of *PM*  *attributes*, as  defined in Table 71a | – | The current default Phase difference measurements attributes for this device in case the default ranging parameters shall be used. |
| *phyPMCapTable* | Set of *PM*  *capabilities*, as  defined in Table 71b | – | The relevant Phase difference measurement capabilities for this device |
| *phyPMNetworkTable* | Set of *PM*  *attributes*, as  defined in Table 71a | - | The Phase difference measurements attributes for this ranging network in case network based ranging parameters shall be used. |
| *phyPMDeviceTable* | Set of PM device entries, as defined in Table71c | - | The Phase difference measurements attributes for a list of known ranging devices in case devices based ranging parameters shall be used. |

***Insert the following Table 71a:***

**Table 71a—Elements of PM attributes**

|  |  |  |  |
| --- | --- | --- | --- |
| **Attribute** | **Type** | **Range** | **Description** |
| *phyPMSetupDuration* | Integer | 0x00-0xff | Setup duration required to synchronize the start of a new Phase Difference measurement procedure in us for the originator and recipient node |
| *phyPMMeasMode* | Integer | 0-7 | Utilized Phase Measurement Mode   0: PM\_UseFreq (mandatory, enables *phyPMStartFreq,*  *phyPMStopFreq, and*  *phyPMStepFreq;* see scheme in 21.3.1 and 21.3.2)  1-7: Reserved |
| *phyPMStartFreq* | Integer | 0x0000-0xffff | Start frequency for Phase Difference measurement in 100 kHz |
| *phyPMStopFreq* | Integer | 0x0000-0xffff | Stop frequency for Phase Difference measurement in 100 kHz |
| *phyPMStepFreq* | Integer | 0x00-0xff | Frequency step for Phase Difference measurement in 100 kHz |
| *phyPMShiftFreq* | Integer | 0x00-0xff | Transmit frequency shift between phase 1 and phase 2 during a Phase Difference measurement in 100kHz; fPhase2 = fPhase1 + phyPMShiftFreq |
| *phyPMFreqSettleDuration* | Integer | 0x00-0xff | Settle duration required for initializing a new frequency during a Phase Difference measurement in us |
| *phyPMTxSetupDurationRec* | Integer | 0x00-0xff | Time required for transmitter settling of recipient node within Phase Difference measurement phase 1 in us |
| *phyPMSamplingDurationOrig* | Integer | 0x00-0xff | Time required for actual phase difference measurement of originator node within Phase Difference measurement phase 1 in us |
| *phyPMTxSetupDurationOrig* | Integer | 0x00-0xff | Time required for transmitter settling of originator node within Phase Difference measurement phase 2 in us |
| *phyPMSamplingDurationRec* | Integer | 0x00-0xff | Time required for actual phase difference measurement of recipient node within Phase Difference measurement phase 2 in us |
| *phyPMInnerLoopRepetitions* | Integer | 0x00-0xff | Repetition count for inner Phase Difference measurement loop including   * phyPMTxSetupDurationOrig * phyPMTxSetupDurationRec * phyPMSamplingDurationOrig * phyPMSamplingDurationRec |
| *phyPMOuterLoopRepetitions* | Integer | 0x00-0xff | Repetition count for outer Phase Difference measurement loop, including an entire Phase Difference measurement procedure consisting of ((*phyPMStopFreq – phyPMStartFreq)/phyPMStepFreq + 1*) individual cycles.  One cycle incorporates the following sequences:   * phyPMFreqSettleDuration * phyPMTxSetupDurationOrig * phyPMTxSetupDurationRec * phyPMSamplingDurationOrig * phyPMSamplingDurationRec |
| *phyPMCurrNumbersOf-PhaseMeasPerFreq* | Integer | 0x01-0xff | The currently supported number of phase measurements per frequency for a given inner and outer loop count. |
| *phyPMRangingTxPower* | Signed integer | — | The transmit power of the device in dBm to be used during the actual phase difference measurement. The value is handled similar to *phyTXPower* and the corresponding tolerance on the transmit power setting is taken from *phyTXPowerTolerance.* |

***Insert the following Table 71b:***

**Table 71b—Elements of PM capabilities**

|  |  |  |  |
| --- | --- | --- | --- |
| **Name** | **Type** | **Valid range** | **Description** |
| *phyPMMaxNumOfRangings* | Integer | 0x01-0xff | The maximum supported number of ranging measurements. |
| *phyPMMinSetupDuration* | Integer | 0x00-0xff  <= phyPMMaxSetupDuration | The minimum  phyPMSetupDuration time in us |
| *phyPMMaxSetupDuration* | Integer | 0x00-0xff | The maximum phyPMSetupDuration time in us |
| *phyPMSupportedMeasModes* | Integer | 0x00-0xff | Bit field containing the supported PM measurement modes according to *phyPMMeasMode*; each set bit indicates a supported PM measurement mode;  e.g. a device supporting only PM\_ UseFreq shall set only bit 0 |
| *phyPMMinShiftFreq* | Integer | 0x00-0xff  <= phyPMMaxShiftFreq | The minimum  phyPMShiftFreq in 100kHz |
| *phyPMMaxShiftFreq* | Integer | 0x00-0xff | The maximum phyPMShiftFreq in 100kHz |
| *phyPMMinFreqSettleDuration* | Integer | 0x00-0xff  <= phyPMMaxFreqSettleDuration | The minimum phyPMFreqSettleDuration time in us |
| *phyPMMaxFreqSettleDuration* | Integer | 0x00-0xff | The maximum phyPMFreqSettleDuration time in us |
| *phyPMMinTxSetupDurationRec* | Integer | 0x00-0xff  <= phyPMMaxTxSetupDurationRec | The minimum phyPMTxSetupDurationRec time in us |
| *phyPMMaxTxSetupDurationRec* | Integer | 0x00-0xff | The maximum phyPMTxSetupDurationRec time in us |
| *phyPMMinSamplingDurationOrig* | Integer | 0x00-0xff  <= phyPMMaxSamplingDurationOrig | The minimum phyPMSamplingDurationOrig time in us |
| *phyPMMaxSamplingDurationOrig* | Integer | 0x00-0xff | The maximum phyPMSamplingDurationOrig time in us |
| *phyPMMinTxSetupDurationOrig* | Integer | 0x00-0xff  <= phyPMMaxTxSetupDurationOrig | The minimum phyPMTxSetupDurationOrig time in us |
| *phyPMMaxTxSetupDurationOrig* | Integer | 0x00-0xff | The maximum phyPMTxSetupDurationOrig time in us |
| *phyPMMinSamplingDurationRec* | Integer | 0x00-0xff  <= phyPMMaxSamplingDurationRec | The minimum phyPMSamplingDurationRec time in us |
| *phyPMMaxSamplingDurationRec* | Integer | 0x00-0xff | The maximum phyPMSamplingDurationRec time in us |
| *phyPMMinInnerLoopRepetitions* | Integer | 0x00-0xff  <= phyPMMaxInnerLoopRepetitions | The minimum phyPMInnerLoopRepetitions |
| *phyPMMaxInnerLoopRepetitions* | Integer | 0x00-0xff | The maximum phyPMInnerLoopRepetitions |
| *phyPMMinOuterLoopRepetitions* | Integer | 0x00-0xff  <= phyPMMaxOuterLoopRepetitions | The minimum phyPMOuterLoopRepetitions |
| *phyPMMaxOuterLoopRepetitions* | Integer | 0x00-0xff | The maximum phyPMOuterLoopRepetitions |
| *phyPMLenOf- NumbersOf- PhaseMeasPerFreq* | Integer | 1-8 | The implemented number supported number of phase measurements per frequency |
| *phyPMNumbersOf-PhaseMeasPerFreq* | Set of phyPM-LenOf-NumbersOf-PhaseMeas-PerFreq octets | 0x01-0xff | The set of octets containing supported number of phase measurements per frequency. Each octet contains one supported number of phase measurements per frequency. |
| *phyPMParameterStorage* | Integer | 0x00-0x02 | The capability to store sets of ranging parameters. 0x00: Device is neither able to store network based nor device based ranging parameters; only the default parameter set is used 0x01: Device is able to store network based ranging parameters  0x02: Device is able to store both network based and device based set of ranging parameters |

***Insert the following Table 71c:***

**Table 71c—Elements of PM device entries**

|  |  |  |  |
| --- | --- | --- | --- |
| **Attribute** | **Type** | **Range** | **Description** |
| *PANId* | Device PAN ID | 0x0000–0xffff | The PAN identifier of the device in this device entry. |
| ShortAddress | Device short  address | 0x0000-0xffff | The short address of the device in this device entry. A value of 0xfffe indicates that this device is using only its extended address. A value of 0xffff indicates that this value is unknown. |
| ExtAddress | IEEE address | Any valid extended IEEE  address | The extended IEEE address of the device. |
| phyPMDeviceTable | Set of *PM*  *attributes*, as  defined in Table 71a | – | The Phase difference measurements attributes for this device in case the device based ranging parameters shall be used. |

# 7 CID 47

Already addressed in CID 38

See updated section 6.2.25.2 MLME-RANGING.confirm:

“If the *macPMRangingEnabled* attribute is set to false, the ranging measurement shall be aborted, and the status shall be set to UNSUPPORTED\_RANGING.”

See added section 5.3.9b.3.3 Range acceptance status field – Table 5f – Valid values of the range acceptance status field:

“Ranging rejected since ranging is currently not supported (*macPMRangingEnabled is set to false*) or already ongoing”

# 8 CID 54

Already addressed in CID 38

# 9 CID 65

*Add test at the end of Clause 21.3.1:*

This sequence of transmitting once in both directions is designated as the inner loop and is repeated for each frequency defined by *phyPMStartFreq*, *phyPMStopFreq*, and *phyPMStepFreq* (see Table 71b).

# 10 CID 66

**21.3.1 DCSS ranging method**

*Modify text and add text after the first sentence in Clause 21.3.1:*

A Ranging command frame of subtype Range start, Clause 5.3.9b.6, is send by the ranging originator to the ranging recipient to gain time synchronization between the ranging nodes. Immediately at the end of the transmission and reception of the Range start frame, and a period *phyPMSetupDuration*, ranging originator and ranging recipient, are synchronized by means of dedicated timers. The synchronized timers control the outer and inner loop repetitions, settling times, setup and sampling durations.

~~Based on this frame, both nodes wait phyPMSetupDuration before synchronizing their activities, so that TX mode and phase measurement always overlap.~~ The originator sets its PLL to the *phyPMStartFreq* frequency while the recipient sets its PLL to the *phyPMStartFreq* + *phyPMShiftFreq* frequency. This frequency offset relates to the intermediate frequency of a low-IF receiver, where the originator receiver operates on an inverse IF position.

# 11 CID 68

*Update Figure 173:*

