IEEE P802.15
Wireless Personal Area Networks

Project	IEEE P802.15 Working Group for Wireless Personal Area Networks (WPANs)	
Title	**LB34 Ranging comment resolution**	
Date Submitted	[8 June, 2006]	
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Re:	[15-06-0240-00-004a-lb34-comment-resolution.xls]	
Abstract	[This document is a record of comment resolutions and text for ranging comments in LB34.]	
Purpose	[To provide a record of the proposed changes to D2 of the WG recirculation letter ballot as a result of comments received from LB34.]	
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1. Ranging comment text development based on 6/265r4

1.1 Introduction

Table 1—6/265r4 ranging comment summary

Comment Group	#	CID's
Need an extra time snapshot in the timestamp report	6	2, 30, 50, 44, 50, 52
Private Ranging Dither Management	5	27, 49, 98, 105, 107
Calibration of internal delays	5	25, 26, 46, 48, 146
Poor explanation of the re-use of PD-DATA.confirm	3	24, 45, 47
Poor explanation of the use of HEADER_ONLY	2	32, 54
Leading edge computation overrun management	1	7
Leading edge computation offloading	1	145

1.2 Need an extra time snapshot in the timestamp report

Change timestamp report "Time snapshot" to "Start Time snapshop" and "Stop Time snapshot"

To address CID's 2.30.50,44,&52: We fix up the timestamp reports

The changes are unfortunately fairly widespread,

We start the fixing up in the second paragraph of clause 5.5.7.1.

In Figure 13b the bottom half of the sequence is grayed out to focus on the first frame of the two way exchange. This RFRAME is sent from the originating device to the responding device. A ranging counter {delete starts }{ start value is captured}{delete counting} in the originator device upon the RMARKER departure from the originator, and a { ranging} counter { start value is captured} in the responding device {delete begins counting} upon frame arrival at the responder. The RFRAME has the acknowledge request bit is set in the MAC header. In the most general case, the counter in the responder PHY may have already started running when a previous RFRAME arrived but the previous RFRAME was not intended for this device and thus did not get an acknowledge from this device. In the figures, the counter activity is labeled "start/snapshot" from the PHY perspective. For the PHY, the counter function is "start" for the first arriving frame and "snapshot" for subsequent frames. Snapshot means that the value of the counter is captured and stored at the instant of the snapshot, but the counter continues to count as if snapshot had not happened. The responder PHY initiates PD-DATA.indicate primitives with counter snapshot values for all arriving RFRAMES. The responder MAC discards those snapshot values which are for RFRAMES not intended for

the responder device. At the end of the first frame transmission in figure 13b the counters are running in both devices.

The next paragraph {also in 5.5.7.1} (below Figure 13b) also changes:

In Figure 13c the top half of the sequence is grayed out to focus on the second RFRAME of the two way exchange. This RFRAME is an acknowledge sent from the responding device to the originating device. The ranging counter { stop value} is snapshot in the responding device upon RMARKER departure from the responder. The responder PHY is now in transmit mode, and the counter is still running. Because the PHY is in transmit mode, it will not be receiving any frames or taking any counter snapshots. Leaving the counter running in the responder at this point in the algorithmic flow only serves to deplete the battery of a mobile device. For overview purposes, in figures 13a,b,c &d, the counter action is labeled stop, not because it really is stopped (it isn't!), but because the algorithmic flow is done with it, and because it will appear to the application like it has stopped because it will generate no more snapshots. The count{ er stop value} in the originator device is snapshot and saved upon RMARKER arrival at the originator. The originator MAC verifies that the frame was from the responder and ultimately the application will then stop the counter with a MLME-RX-ENABLE.request/PLME-SET-TRX-STATE.request primitive pair. The originator PHY is in receive mode, so until the counter is stopped, that PHY will continue to generate PD-DATA.indication primitives for all future arriving RFRAMES.

The paragraph {also in 5.5.7.1} immediately below Figure 13d also changes:

The discussion above risks confusion because it includes the general case of arriving frames not intended for the devices in the figures. That behavior is important for algorithmic robustness, but for understanding basic ranging it is a distraction. In Figure 13d the ranging pair holds 2 { different sets of} counter values, { with a start value and a stop value in each set}. Along the way, the application may have discarded counter snapshots due to frames destined for other devices, but in any case what remains at the end of the exchange are { pairs of} counter values which { (when subtracted)} represent the elapsed times between the arrival and departure of the intended frames.

The paragraph following that one {also in 5.5.7.1} also changes:

At the system state represented by Figure 13d, the necessary information required to compute the range between the devices is known. However, the information is still distributed in the system and before the ranging computation can be accomplished, the data must be brought to a common compute node. The { difference of the} counter { start and stop} value{I s} in the originator device represents the total elapsed time from the departure of the first message to the arrival of the acknowledgement. The { difference} of counter {start and stop} value{s} in the responder represents the total elapsed time from arrival of the data message to the departure of the acknowledgement. After these values are {all} brought together at a common compute node, they are subtracted and the difference divided by 2 and the time of flight (and thus the inferred range) is known.

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The very first line in 5.5.7.4 changes:

The standard specifies that the {start} counter value represent the times of arrival of the first pulse of the first

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We change 5.5.7.7

Section 5.5.7.1 introduced the ranging counter value. Section 5.5.7.4 introduced the ranging Figure of Merit. Section 5.5.7.5 introduced the two values which (as a ratio) characterize the crystal offsets. All of these values ({d four}{ five} in all: one ranging counter{ start} value, {one ranging counter stop value,} two numbers to characterize the crystals & 1 FoM) characterize a single ranging measurement. The {d four }{five} individual numbers which characterize a measurement are referred to in a group as a "timestamp report". It then takes (at least) two timestamp reports to do a time of flight computation. There are a total of {d12}{ 16} octets in a timestamp report. The numbers in a single timestamp report have meaning in the context of each other. They must be generated by the PHY as a set, and should not be split apart during subsequent data handling.

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Now we get into the messy stuff: We have to fix up 6.2.1.2.1:

Insert additional parameters into the PD-DATA.confirm at the end of the list but before the closing parenthesis.

UWBRangingReceived,
UWBRangingCounter{Start}{d Value},
{UWBRangingCounterStop,}
UWBRangingTrackingInterval,
UWBRangingOffset,
UWBRangingFOM

Then the row for counter value in table 7 gets replaced with 2 rows:

Table 7-PD-DATA.confirm parameters

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Then we have similar activity in Clause 6.2.1.3

Insert additional parameters into the PD-DATA.indication at the end of the list but before the closing parenthesis.

UWBPRF,
UWBPreambleSymbolRepetitions,
DataRate,
UWBRangingReceived,
{d UWBRangingCounterValue}
{UWBRangingCounterStart,
UWBRangingCounterStop,}
UWBRangingTrackingInterval,
UWBRangingOffset,
UWBRangingFOM

Then just like we did for Table 7, we have to bump up the rows in Table 8:

Table 8 -- PD-DATA.indication parameters

To:

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Table 2—

Name	Type	Valid range	Description
UWBRangingReceived	Boolean	OFF, ON	A value of OFF indicates that ranging is either not supported in an UWB PHY or is not to be indicated for the PSDU received. A value of ON denotes ranging operations requested for this PSDU. A value of OFF is used for non-UWB PHYs
{UWBRanging-CounterStart	Unsigned Integer	0x00000000-0xFFFFFFFF	4 octet count of the time units corresponding to an RMARKER at the antenna at the beginning of a ranging exchange. A value of x00000000 is used if ranging is not supported, or enabled, or this is not an UWB PHY. The value x00000000 is also used if the counter is not used for this PPDU. See 6.8a.14.1 }
{UWBRanging-CounterStop	Unsigned Integer	0x00000000-0xFFFFFFFF	4 octet count of the time units corresponding to an RMARKER at the antenna at the end of a ranging exchange. A value of x00000000 is used if ranging is not supported or not enabled or this is not an UWB PHY. The value x00000000 is also used if the counter is not used for this PPDU. See 6.8a.14.1 }

Table 2—

Name	Type	Valid range	Description
{ d UWBRanging-CounterValue	Unsigned Integer	0x00000000-0xFFFFFFFF	4 octet count of the time units corresponding to an RMARKER at the antenna. A value of x00000000 is used if ranging is not supported or this is not an UWB PHY. This value is also used if the counter is not used for this PPDU. See 6.8a.14.1 }
UWBRangingTrack-ingInterval	Unsigned Integer	0x00000000-0xFFFFFFFF	4 octet count of the time units in a message exchange over which the tracking offset was measured. If tracking based crystal characterization is not supported or this is not a UWB PHY, a value of x00000000 is used. See 6.8a.14.2.2
UWBRangingOffset	Signed Magnitude Integer	0x000000- 0x0FFFFF	3 octet count of the time units slipped or advanced the radio tracking system over the course of the entire tracking interval. The top 4 bits are reserved and set to zero. The most significant of the active bits is the sign bit. See 6.8a.14.2.1
UWBRangingFOM	Integer	0x00 - 0x7F	One octet Figure of Merit characterizing the ranging measurement. The MSB is reserved and must be zero. The remaining 7 bits are used in three sub-fields. The sub-fields are the Confidence Level, The Confidence Interval, and the Confidence Interval Scaling Factor. See 6.8a.14.3

Table 3—

Name	Type	Valid range	Description
UWBPRF	Enumeration	OFF, NOMINAL 4 M, NOMINAL 16 M	The pulse repetition value of the received PPDU. Non-UWB PHYs use a value of OFF.
UWBPreambleSymbol-Repetitions	Enumeration	0,16,64,1024,4096	The preamble symbol repetitions of the UWB PHY frame received by the PHY entity. A value of 0 is used with a non-UWB PHY
DataRate	Enumeration	0,1,2,3,4	The data rate of the PHY frame received by the PHY entity. A value of 0 is used with a non-UWB or non-CSS PHY
UWBRangingReceived	Boolean	OFF, ON	A value of OFF indicates that ranging is either not supported in an UWB PHY or is not to be used for the PSDU received. A value of ON denotes ranging operations requested for this PSDU. A value of OFF is used for non-UWB PHYs
{d UWBRanging-CounterValue	Unsigned Integer	0x00000000-0xFFFFFFFF	4 octet count of the time units corresponding to an RMARKER at the antenna. A value of x00000000 is used if ranging is not supported or this is not an UWB PHY. This value is also used if the counter is not used for this PPDU. See 6.8a.14.1}

Table 3—

Name	Type	Valid range	Description
{UWBRanging-CounterStart	Unsigned Integer	0x00000000-0xFFFFFFFF	4 octet count of the time units corresponding to an RMARKER at the antenna at the beginning of a ranging exchange. A value of x00000000 is used if ranging is not supported, or enabled, or this is not an UWB PHY. The value x00000000 is also used if the counter is not used for this PPDU. See 6.8a.14.1 }
{UWBRanging-CounterStop	Unsigned Integer	0x00000000-0xFFFFFFFF	4 octet count of the time units corresponding to an RMARKER at the antenna at the end of a ranging exchange. A value of x00000000 is used if ranging is not supported or not enabled or this is not an UWB PHY. The value x00000000 is also used if the counter is not used for this PPDU. See 6.8a.14.1 }
UWBRangingTrack-ingInterval	Unsigned Integer	0x00000000-0xFFFFFFFF	4 octet count of the time units in a message exchange over which the tracking offset was measured. If tracking based crystal characterization is not supported or this is not a UWB PHY, a value of x00000000 is used. See 6.8a.14.2.2

Table 3—

Name	Type	Valid range	Description
UWBRangingOffset	Signed Magnitude Integer	0x000000- 0x0FFFFF	3 octet count of the time units slipped or advanced the radio tracking system over the course of the entire tracking interval. The top 4 bits are reserved and set to zero. The most significant of the active bits is the sign bit. See 6.8a.14.2.1

A bit of tuning is needed in the second to last paragraph of 6.2.2.7.3:

Once every 2**32 times (VERY rarely) the counter will be wrapping through a value that would cause a final counter value of zero (after all corrections are applied) to be the proper and correct counter value to present in a timestamp report. There is nothing in the standard to preclude the ranging counter wrapping through zero. However, the standard does give zero special meaning associated with devices which have no counter or have counters that are not running. An RDEV with a running counter presenting a counter value of zero will be algorithmically disruptive. If an RDEV with a running counter would ever normally present a counter value of zero, it will trap that case and instead present a value of {d 0x00000002}{0x00000001}. This will lead to a half of a centimeter ranging error on the exceptionally rare occurrence of this event. {dCounter values of 0x00000001 are presented for counter start-up events.}

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The second paragraph of 6.8a.14 changes:

RDEVs produce results which are used by higher layers to compute the ranges between devices. These results shall comprise a set of {c 4 five} numbers occupying {c12 16} total octets and total collection of the {c 12 16} octets is called a timestamp report. An RDEV timestamp report shall consist of a 4 octet ranging counter {start} value, {a four octet ranging counter stop value,} a 4 octet ranging tracking interval, a 3 octet ranging tracking offset and a single octet ranging figure of merit. These 4 5 numbers are always reported together in the same primitive and remain together for their entire processing lifetime. It is not acceptable to have any pipelining of the individual results where (for example) in a timestamp report the ranging tracking offset and ranging tracking interval might be associated with the ranging counter value of the previous timestamp report and the ranging figure of merit might be associated with the ranging counter value of the timestamp report before that.

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Clause 6.8a.14.2 changes:

An RDEV which implements optional crystal characterization shall produce a tracking offset and a tracking interval for every {c value of the ranging counter timestamp report} which is produced. The tracking offset and the tracking interval are computed from measurements taken during an interval which includes the {interval bounded by the ranging counter start value and the ranging counter stop value.}{d instant represented by the value of the ranging counter. For example, if the ranging counter value is 0x00000001 (a very

typical example, as this is the starting value) then the time instant represented by 0x00000001 is in the interior of the interval represented by ranging tracking interval.}

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Similar changes keep rippling down into Clause 7.1.1.2.1 which changes:

Insert additional parameters into the MCPS-DATA.confirm at the end of the list but before the closing parenthesis.

UWBRangingReceived,
{dUWBRangingCounterValue,}
{UWBRangingCounterStart,
UWBRangingCounterStop,}
UWBRangingTrackingInterval,
UWBRangingOffset,
UWBRangingFOM

Then just like we did in Clause 6, we change Table 42

Table 42-MCPS-DATA.confirm parameters

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We're almost done… now we fix up Clause 7.1.1.3.1 which changes:

Insert additional parameters into the MCPS-DATA.indication at the end of the list but before the closing parenthesis.

UWBPRF,
UWBPreambleSymbolRepetitions,
DataRate,
UWBRangingReceived,
{d UWBRangingCounterValue,}
{UWBRangingCounterStart,
UWBRangingCounterStop,}
UWBRangingTrackingInterval,
UWBRangingOffset,
UWBRangingFOM

Then we have to fix up Table 43 which changes:

Table 43-MCPS-DATA.indication parameters

And I think that's all….. Mercifully, down in Clause 7.5.7a it just refers to timestamp reports as a complete assembly which we have now got established as a 5 number entity.

Table 4—

Name	Type	Valid range	Description
UWBRangingReceived	Boolean	OFF, ON	A value of OFF indicates that ranging is either not supported in an UWB PHY or is not to be indicated for the PSDU received. A value of ON denotes ranging operations requested for this PSDU. A value of OFF is used for non-UWB PHYs
{d UWBRanging-CounterValue	Unsigned Integer	0x00000000-0xFFFFFFFF	4 octet count of the time units corresponding to an RMARKER at the antenna. A value of x00000000 is used if ranging is not supported or this is not an UWB PHY. This value is also used if the counter is not used for this PPDU. See 6.8a.14.1 }
{UWBRanging-CounterStart	Unsigned Integer	0x00000000-0xFFFFFFFF	4 octet count of the time units corresponding to an RMARKER at the antenna at the beginning of a ranging exchange. A value of x00000000 is used if ranging is not supported, or enabled, or this is not an UWB PHY. The value x00000000 is also used if the counter is not used for this PPDU. See 6.8a.14.1 }
{UWBRangingCounter-Stop	Unsigned Integer	0x00000000-0xFFFFFFFF	4 octet count of the time units corresponding to an RMARKER at the antenna at the end of a ranging exchange. A value of x00000000 is used if ranging is not supported or not enabled or this is not an UWB PHY. The value x00000000 is also used if the counter is not used for this PPDU. See 6.8a.14.1 }

Table 4—

Name	Type	Valid range	Description
UWBRangingCounter-Start	Unsigned Integer	0x00000000-0xFFFFFFFF	4 octet count of the time units corresponding to an RMARKER at the antenna at the beginning of a ranging exchange. A value of x00000000 is used if ranging is not supported, or enabled, or this is not an UWB PHY. The value x00000000 is also used if the counter is not used for this PPDU. See 6.8a.14.1
UWBRangingTrack-ingInterval	Unsigned Integer	0x00000000-0xFFFFFFFF	4 octet count of the time units in a message exchange over which the tracking offset was measured. If tracking based crystal characterization is not supported or this is not a UWB PHY, a value of x00000000 is used. See 6.8a.14.2.2
UWBRangingOffset	Signed Magnitude Integer	0x000000- 0x0FFFFF	3 octet count of the time units slipped or advanced the radio tracking system over the course of the entire tracking interval. The top 4 bits are reserved and set to zero. The most significant of the active bits is the sign bit. See 6.8a.14.2.1
UWBRangingFOM	Integer	0x00 - 0x7F	One octet Figure of Merit characterizing the ranging measurement. The MSB is reserved and must be zero. The remaining 7 bits are used in three sub-fields. The sub-fields are the Confidence Level, The Confidence Interval, and the Confidence Interval Scaling Factor. See 6.8a.14.3

Table 5—

Name	Type	Valid range	Description
UWBPRF	Enumeration	OFF, NOMINAL 4 M, NOMINAL 16 M	The pulse repetition value of the received PPDU. Non-UWB PHYs use a value of OFF.
UWBPreambleSymbol-Repetitions	Enumeration	0,16,64,1024,4096	The preamble symbol repetitions of the UWB PHY frame received by the PHY entity. A value of 0 is used with a non-UWB PHY
DataRate	Enumeration	0,1,2,3,4	The data rate of the PHY frame received by the PHY entity. A value of 0 is used with a non-UWB or non-CSS PHY
UWBRangingReceived	Boolean	OFF, ON	A value of OFF indicates that ranging is either not supported in an UWB PHY or is not to be used for the PSDU received. A value of ON denotes ranging operations requested for this PSDU. A value of OFF is used for non-UWB PHYs
{d UWBRanging-CounterValue	Unsigned Integer	0x00000000-0xFFFFFFFF	4 octet count of the time units forresponding to an RMARKER at the antenna. A value of x00000000 is used if ranging is not supported or this is not an UWB PHY. This value is also used if the counter is not used for this PPDU. See 6.8a.14.1}

Table 5—

Name	Type	Valid range	Description
{UWBRanging-CounterStart	Unsigned Integer	0x00000000-0xFFFFFFFF	4 octet count of the time units corresponding to an RMARKER at the antenna at the beginning of a ranging exchange. A value of x00000000 is used if ranging is not supported, or enabled, or this is not an UWB PHY. The value x00000000 is also used if the counter is not used for this PPDU. See 6.8a.14.1}
{UWBRanging-CounterStop	Unsigned Integer	0x00000000-0xFFFFFFFF	4 octet count of the time units corresponding to an RMARKER at the antenna at the end of a ranging exchange. A value of x00000000 is used if ranging is not supported or not enabled or this is not an UWB PHY. The value x00000000 is also used if the counter is not used for this PPDU. See 6.8a.14.1}
UWBRangingTrack-ingInterval	Unsigned Integer	0x00000000-0xFFFFFFFF	4 octet count of the time units in a message exchange over which the tracking offset was measured. If tracking based crystal characterization is not supported or this is not a UWB PHY, a value of x00000000 is used. See 6.8a.14.2.2

Table 5—

Name	Type	Valid range	Description
UWBRangingOffset	Signed Magnitude Integer	0x000000- 0x0FFFFF	3 octet count of the time units slipped or advanced the radio tracking system over the course of the entire tracking interval. The top 4 bits are reserved and set to zero. The most significant of the active bits is the sign bit. See 6.8a.14.2.1
UWBRangingFOM	Integer	0x00 - 0x7F	One octet Figure of Merit characterizing the ranging measurement. The MSB is reserved and must be zero. The remaining 7 bits are used in three sub-fields. The sub-fields are the Confidence Level, The Confidence Interval, and the Confidence Interval Scaling Factor. See 6.8a.14.3

1.3 Private ranging dither management

Remove dither from the draft.

Clauses 5, 6, and 7

5.5.7 last paragraph, last three sentences - replace the three sentences “The standard supports a technique, private ranging as described in 5.5.7.8, that is an optional mode for enhancing ...”. DONE

5.5.7.8.2 remove this subclause. DONE

5.5.7.8.3 - renumber as 5.5.7.8.2. DONE

6.2.1.1 remove the dither from semantics; UWBRangingDitherValue parameter in table 6. DONE

6.4.2 table 23 - remove the bit for dither and description in phyRangingCapabilities. Range to 0x07; Upper 5 bits reserved; 0x08 becomes 0x04 after dither bit is removed. DONE

6.8a.14.4 remove this subclause on dither. DONE

7.1.1.1 remove UWBRangingDitherValue from primitive and table 41. DONE

7.1.2 dither is removed from the management service table 46, but retain the structure for the new MLME-SOUNDING primitive. DONE

7.1.16b remove all of the dither content but reuse the structure for the MLME-SOUNDING primitive. DONE

Fig 73a - replace the figure - the new figure removes the dither content and also adds the SOUNDING MLME/PLMEs. DONE

1.4 Calibration of internal delays

One command set:

PLME-CALIBRATE.request

PLME-CALIBRATE.indication

2 PHY PIB values:

phyTxRMARKEROffset

phyRxRMARKEROffset

1.4.0.11 PLME-CALIBRATE.request (UWB PHYs only)

The PLME-CALIBRATE.request primitive attempts to have the PHY perform calibration. The PLME-CALBRATE.request is optional except for implementations providing ranging.

1.4.0.11.1 Semantics of the service primitive

The semantics of the PLME-CALIBRATE.request is as follows:

PLME-CALIBRATE.request (
)

1.4.0.11.2 Appropriate usage

1.4.0.11.3 Effect on receipt

1.4.0.12 PLME-CALIBRATE.confirm (UWB PHYs only)

The PLME-CALIBRATE.confirm primitive reports the result of a request to the PHY to calibrate. The PLME-CALIBRATE.confirm is optional except for implementations providing ranging.

1.4.0.12.1 Semantics of the service primitive

The semantics of the PLME-CALIBRATE.confirm is as follows:

```
PLME-CALIBRATE.confirm      (
                            Status,
                            TxDelay,
                            RxDelay,
                            ScanTrace
                            )
```

Table 18y specifies the parameter for the PLME-CALIBRATE.confirm primitive.

Table 18y—PLME-CALIBRATE.confirm parameters

Name	Type	Valid range	Description
Status	Enumeration	SUCCESS, UNSUPPORTED_ATTRIBUTE,	
TxDelay			
RxDelay			
ScanTrace			{since this is optional, make sure that there is a value to indicate when this is not supplied}

1.4.0.12.2 When generated

1.4.0.12.3 Appropriate usage

1.5 Poor explanation of the re-use of PD-DATA.confirm

1.6 Poor explanation of the use of HEADER_ONLY

1.7 Leading edge computation overrun management

1.8 Leading edge computation offloading

DONE

note: the name “channel sounding” as introduced in Jacksonville, has been shortened to “sounding”. This is a more manageble string length particularly in the ranging MSC of 7.5.7a

MLME-SOUNDING.request

(no parameters)

MLME-SOUNDING.confirm

Has parameters: status (Okay, not okay); size of the list; the actual entries.

Each entry is 2 parameters: a time and an amplitude. (amplitude and time are both signed 16 bit numbers.

PLME-SOUNDING.request & PLME-SOUNDING.confirm work like the MLME primitives.

Note: pay attention to the size of the numbers… an integer is only 8 bits in this standard. (We’ll need 16 bit values for length at the least.) - the solution here is to specify in the range, a value range that has 16 bit representations.

Imported text provided to address aspects of this solution. This and the structures that follow are part of the cid 145 solution.

The following changes for Draft 3 are intended to implement the fix for comment ID # 145.

A new paragraph is added to the bottom of Clause 5.5.7.4:

The necessary characterization of the channel multipath response is generically called a channel sounding. The techniques that accomplish that task can be numerically intense. The standard does not preclude the system designer accomplishing that task in the PHY. However, if the PHY does not have significant computational capabilities yet the system designer still wishes to employ numerically intensive channel sounding algorithms, the standard provides a SOUNDING mechanism (involving both MLME and a PLME primitives) which allows the PHY to present raw data to a higher layer. The raw data can then be moved to whatever device has sufficient computational resources to support the desired algorithms. The actual handling of the raw data after the SOUNDING operation facilitates uploading to a next higher layer is beyond the scope of the standard.

A new sub-clause is added to the 5.5.7.4:

5.5.7.4.5 PHY deferral of the computations for leading edge search

As discussed in 5.5.7.4, the standard provides a mechanism to optionally allow the PHY to pass the computational burden of leading edge processing to a higher layer. If the computations are not done in the PHY, then the value in the timestamp report for UWBRangingCounterStart is not corrected for the leading edge and the UWBRangingFOM value is set to 0x80. This value of the FoM signals the higher layer that the UWBRangingCounterStart value has not been corrected and that it will be necessary for the higher layer to compute a correction based on data acquired using the SOUDING primitives. The higher layer issues a MLME-SOUNDING.request which in turn causes a PLME-SOUNDING.request. The associated MLME and PLME SOUNDING.confirm responses return a list of times and amplitudes representing data taken by

the PHY at time offsets from the point on the waveform represented by the uncorrected value in UWBRangingCounerStart. A time of zero in the list designates an amplitude value taken at the point indicated by UWBRangingCounterStart. Positive time values indicate amplitudes which occurred earlier in time than the zero point. The least significant bit of a time value represents 1/128 of a chip time at the mandatory chipping rate of 499.2 MHz. The amplitude values do not represent any particular voltage. They are only meaningful in a relative sense and in the context of each other. The values are linear (not logarithmic). The amplitude values are all consistent with each other. For example, it is perfectly fine if an Automatic Gain Control (AGC) circuit changed the gain during the measurement of the amplitudes, so long as the numbers are corrected by the PHY to "take out" the effect of the gain change and the numbers returned in a SOUNDING.confirm are the values that would have been measured had the gain been perfectly stable and unchanged for all measurements. The list of measurements returned by the SOUNDING.confirm begins with the size of the list. The maximum size which can be represented is 65 K value pairs. That large value is only because a single octet would not be adequate to represent lists larger than 255 pairs. In practical systems, lists larger than 255 pairs can occure. Two octets is the next choice to represent the list size, but that does not mean that lists approaching 65K pairs would be normal. There is no particular acceptable or unacceptable list size. Generally, more is better: see section 5.5.7.4.1. In the case where the PHY is deferring the leading edge computation to an upper layer, the PHY does not assign a FoM to the timestamp report. That does not mean that a FoM is unneeded by algorithms at the higher layers, it just means that the PHY will not be the source. In cases where the PHY defers computation, the upper layer will typically compute a FoM for itself based on the size and quality of the list returned with the SOUNDING.confirm primitive.

We have to fix up clause 6.8a.14.3 because we tampered with the definition of the FoM as it was originally presented in Draft 2.

6.8a.14.3 Ranging Figure of Merit.

An RDEV shall produce a ranging Figure of Merit for every ranging counter value which is produced. The UWB ranging figure of merit is an octet as shown in Figure 27p. The Figure of Merit is composed of 3 subfields and a{n}{ d reserved }{extension} bit. The FoM confidence level sub-field is defined in Table 39o. The FoM confidence interval sub-field is defined in Table 39p. The FoM confidence interval scaling factor sub-field is defined in Table 39q. The most significant bit of the FoM octet is {d reserved and equal to zero}{the extension bit. When the extension bit is set to zero, the subfields have the normal meanings given in table 39o, 39p, and 39q. When the extension bit is 1, the FOM has meaning given in table 39r.}

Table 19—FoM values with the extension bit set

Bit 7	6	5	4	3	2	1	0
{d Reserved} {Extension}	Confidence Interval scaling factor sub-field		Confdence Interval sub-field		Confidence Level sub-field		

Figure 27p - Ranging figure of merit

Insert table 39r

Table 39r - FoM values with the extension bit set

Table 20—FoM values with the extension bit set

	Bit 7	6	5	4	3	2	1	0
UWBRangingStart is uncorrected.	1	0	0	0	0	0	0	0
Reserved	1	Any non-zero value						

1.8.0.1 PLME-SOUNDING.request (UWB PHYs only)

The PLME-SOUNDING.request primitive attempts to have the PHY respond with channel sounding information. The PLME-SOUNDING.request is optional except for implementations providing ranging.

1.8.0.1.1 Semantics of the service primitive

The semantics of the PLME-SOUNDING.request is as follows:

PLME-SOUNDING.request (
)

1.8.0.1.2 Appropriate usage

1.8.0.1.3 Effect on receipt

1.8.0.2 PLME-SOUNDING.confirm (UWB PHYs only)

The PLME-CHANNEL.confirm primitive reports the result of a request to the PHY to provide channel sounding information. The PLME-SOUNDING.confirm is optional except for implementations providing ranging.

1.8.0.2.1 Semantics of the service primitive

The semantics of the PLME-SOUNDING.confirm is as follows:

```
PLME-SOUNDING.confirm (
                      Status,
                      SoundingSize,
                      SoundingAmplitude,
                      SoundingTime
                      )
```

Table 18z specifies the parameter for the PLME-SOUNDING.confirm primitive.

Table 18z—PLME-SOUNDING.confirm parameters

Name	Type	Valid range	Description
Status	Enumeration	SUCCESS, UNSUPPORTED_ATTRIBUTE,	The status of the attempt to return sounding data
SoundingSize	unsigned integer	0x0000 - 0xFFFF	Number of pairs of values to be returned. Each pair of values is a 2 octet time value and a 2 octet amplitude value. The maximum number of pairs is 65K.
SoundingTime	Signed integer	0x0000 - 0xFFFF	The least significant bit represents a nominal 16 ps. (1/127 of a chip time) See 5.5.7.5.4
SoundingAmplitude	Signed integer	0x0000 - 0xFFFF	The amplitude numbers represent relative amplitudes The amplitude numbers have no absolute meaning. See 5.5.7.5.4

1.8.0.2.2 When generated

1.8.0.2.3 Appropriate usage

The following changes are to be made to the PHY PIB attributes table

Table 19—PHY PIB attributes

Attribute	Identifier	Type	Range	Description
phyRangingCapabilities †	0x19	Bitmap	0x00 - 0x0f	{change this to reflect that dither is not in D3} The capabilities of the UWB PHY to support ranging options. The upper four bits are reserved. 0x01 is ranging support; 0x02 is tracking support; 0x04 is dither support; 0x08 is DPS support.
phyTxRMARKEROffset				
phyRxRMARKEROffset				
phyRangingProcessingTime				