IEEE P802.15
Wireless Personal Area Networks

Project	IEEE P802.15 Working Group for Wireless Personal Area Networks (WPANs)
Title	NBA UWB MMS MSC and Description
Date Submitted	23 August 2024
Source	Billy Verso (Qorvo), billy.verso at qorvo.com
Re:	IEEE P802.15.4ab
Abstract	Comment Resolutions for selected comments on the LB207 / P802.15.4ab D01.
Purpose	This document provides text changes intended to be part of the final IEEE Std 802.15.4ab (amendment to IEEE Std 802.15.4), as part of resolving selected comments from the consolidated spreadsheet (doc 15-24-0371) that have been assigned to the author to resolve.
Notice	This document does not represent the agreed views of the IEEE 802.15 Working Group or IEEE 802.15.4ab Task Group. It represents only the views of the participants listed in the "Source(s)" field above. It is offered as a basis for discussion and is not binding on the contributing individual(s) or organization(s). The material in this document is subject to change in form and content after further study. The contributor(s) reserve(s) the right to add, amend or withdraw material contained herein.
Release	The contributor acknowledges and accepts that this contribution becomes the property of IEEE and may be made publicly available by P802.15.
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CIDs addressed here

1 Comment Index # 1118

Index	page	clause	line	Comment	Proposed Change
1118 (Billy)	56	10.38.3	22	We are missing a subclause about the control of MMS from the next higher layer perspective and how it all hangs together. I think the interactions should be based on the thoughts captured in 15-23-0306, and new control and configuration parameters of the MCPS primitives added in clause 8.3, and it should employ a message sequence chart to illustrate the interactions.	I will prepare a submission to cover this, that we can insert in a suitable place in 10.38

Discussion/Introduction:

The commenter (me) said he would prepare a submission to provide the missing subclause, and this document (15-24-0444-00) is it. This is based on 15-23-0306.

The proposed resolution for this comment, index #1118, is “Revised”, with the resolution being to insert the text & figure from the subsequent pages of this submission into the draft. The proposed “suitable place” for this is after clause 10.38.8, as a new 10.38.9 (with the existing 10.38.9 and subsequent clauses renumbered accordingly).

The figure and supporting text, on the subsequent pages of this submission, present a message sequence chart for two HRP-ARDEV devices doing NBA UWB MMS, describing the interactions between the next higher layer and the MAC/PHYs of the HRP-ARDEV devices.

Note: The use of primitives in the standard is NOT defining a physical API that needs to be implemented, but rather a logical interface that serves to define the roles, the information that passes, and the separation of responsibilities between (a) what is considered to be part of the MAC+PHY specified by the standard and (b) what is considered to be the higher layer using the MAC and PHY. In products based on this standard this logical interface is generally invisible (buried internally) and does not need to exist in any concrete observable way.

The changes including the new clause text and the figure are on the following pages:

Changes with respect to P802.15.4ab D01:

Insert the following as a new 10.38.9 (with the D01 existing 10.38.9 and subsequent clauses renumbered accordingly):

10.38.X Control of UWB MMS Ranging

10.38.X.1 General

The next higher layer control of the UWB MMS ranging activity of the HRP-ARDEV is achieved using primitives. The next higher layer issues primitives to configure the various modes of operation needed for the UWB MMS ranging interactions, and to tell the MAC what to send and when to send it, and when to turn on its receiver. The MAC issues primitives to inform the next higher layer of packet receptions and to give responses to primitives issued by the next higher layer.

To illustrate, this 10.38.X.2 describes a sequence of interactions between two devices, (an initiator and a responder), engaging in an NBA UWB MMS ranging exchange, and employing the interleaved transmission and reception of UWB MMS ranging fragments. This type of interaction could represent a one-to-one ranging exchange or part of a one-to-many ranging round.

10.38.X.2 The interactions for an NBA UWB MMS ranging exchange

Figure A presents a message sequence chart for the case of two HRP-ARDEV devices engaging in an NBA UWB MMS ranging exchange. This shows the interactions between the next higher layer and the MAC/PHY in each device, and between the two devices, (initiator and responder), over the air-interface. The roles of initiator and responder, and the starting time, are assumed to have been predetermined. This typically would be via a Start of Ranging Compact frame sent by the initiator and received by the responder as part of the initialization and setup, (described in 10.38.3), which is the assumption in the description below, but it might also be achieved via some OOB means. The details of the figure and the various interactions it shows are described in the paragraphs below.

Figure A shows the three phases of the NBA UWB MMS ranging exchange, i.e., control phase, ranging phase, and reporting phase, with the interactions in each of these phases encompassed in a (numbered) dashed rectangle to distinguish the phase and the PHY being employed. That is, the NBA control phase utilizing the O-QPSK PHY, the ranging phase using the HRP UWB PHY, and the reporting phase again using the O-QPSK PHY.

Before each phase of the MMS ranging exchange shown in Figure A, there is a numbered dashed rectangle with the designation “setup” to indicate that the next higher layer needs to make the appropriate configuration changes for the upcoming phase. In each case this setup is shown as a single MLME-SET.request, which is the primitive used to set PIB attributes. In practice, several items may need to be configured, in which case more than one primitive invocation will be needed, but this depends on what happened last. For instance, if this is the second of a series of ranging exchanges, then for the setup labelled (1) in the figure the O-QPSK PHY may already be appropriately set up, (e.g., from the previous reporting phase), with no reconfiguration needed except perhaps to change the channel if channel switching is being employed.

With reference to Figure A, after the appropriate O-QPSK PHY configuration, in the dashed rectangle labelled (1), to complete the control phase, in dashed rectangle labelled (2), firstly the NBA poll Compact frame is sent/received, as follows:

The responding device next higher layer issues the MLME-RX-ENABLE.request to turn on its receiver at the time specified by the RxOnTime parameter in good time to receive the poll Compact frame it is expecting from the initiator, and the initiator next higher layer issues the MCPS-DATA.request to send the poll using the CompactFrameDescriptor parameter to specify the frame to send and the TxTimeSpecified and RangingTxTime parameters to specify the time at which to send it. For the initial ranging exchange, the initiator’s poll transmission is scheduled relative to its transmission of the Start of Ranging Compact frame, and the responder’s enabling of the receiver is scheduled relative to its reception of the Start of Ranging Compact frame, as shown in Figure 26.

On the initiator side, the next higher layer is informed that the poll transmission has completed by the MAC issuing the MCPS-DATA.confirm primitive, while on the responder side the arrival of the poll is reported to the next higher layer by the MAC issuing the MCPS-DATA.indication primitive. Here the RxRangingCounter parameter of the MCPS-DATA.indication conveys the arrival time of the poll, while the RangingTrackingInterval and RangingOffset parameters convey the clock offset of the initiator device as measured by the responder’s PHY during the poll reception.

Then secondly, the NBA response Compact frame is sent/received as follows:

The initiator next higher layer issues the MLME-RX-ENABLE.request to turn on its receiver at the time specified by the RxOnTime parameter in good time to receive the response Compact frame expected from the responder, and the responder issues

the MCPS-DATA.request to send the response, using the CompactFrameDescriptor parameter to specify the frame to send and the TxTimeSpecified and RangingTxTime parameters to specify the time at which to send it. The initiator's enabling of the receiver, and the responder's transmission, are both scheduled relative to the poll Compact frame sent by the initiator and received by the responder.

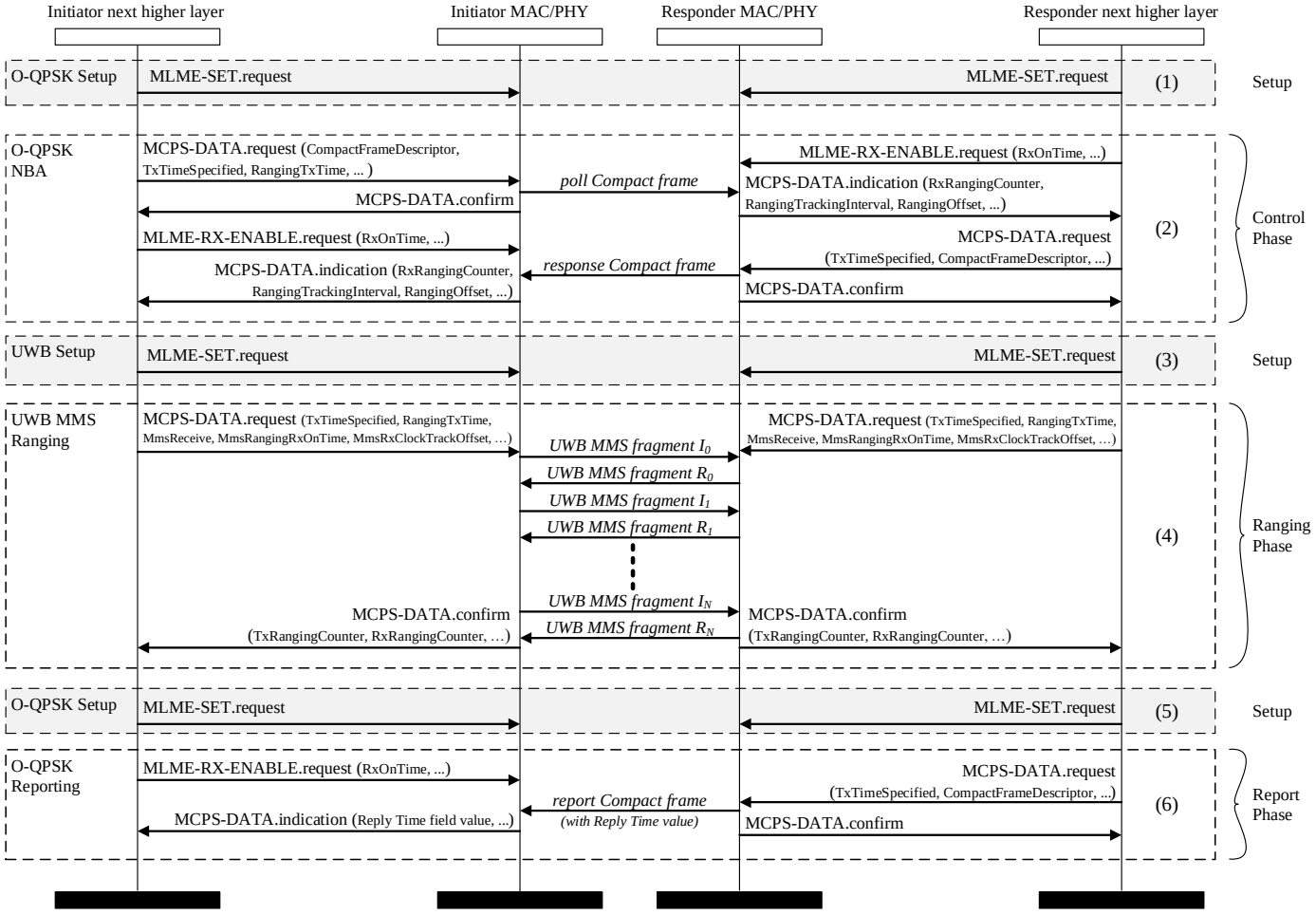

Figure A—Message sequence chart for a one-to-one NBA UWB MMS ranging exchange

On the responder side, the next higher layer is informed that the response transmission has completed by the MAC issuing the MCPS-DATA.confirm primitive, while on the initiator side the arrival of the response is reported to the next higher layer by the MAC issuing the MCPS-DATA.indication primitive. Here the RxRangingCounter parameter of the MCPS-DATA.indication conveys the arrival time of the response, while the RangingTrackingInterval and RangingOffset parameters convey the clock offset of the responder device as measured by the initiator's PHY during the response reception.

That ends the control phase.

Now initiator and responder devices transition to the ranging phase applying the appropriate UWB setup as part of this transition as illustrated in Figure A by the dashed rectangle labelled (3). While several items may need to be configured, at the very least the next higher layer on both devices will issue an MLME-SET.request to set the *phyCurrentChannelInfo* to select the UWB PHY, i.e., so that the next MCPS-DATA.request is launching a UWB packet instead of an O-QPSK packet. Other parameters defining the UWB MMS packet, (e.g., *phyUwbMmsRsfNumberFrags*, etc.), may also need to be configured if the initiator's poll included a Ranging PHY Configuration field specifying new values.

With reference to Figure A, after the appropriate UWB PHY configuration, in dashed rectangle labelled (3), to complete the ranging phase, labelled (4), the UWB MMS packet is sent/received as follows:

On the initiator side, the next higher layer issues the MCPS-DATA.request to send the UWB MMS packet with interleaved reception. This includes parameters:

- TxTimeSpecified and RangingTxTime to specify when to send the first fragment, which for the initiator will be relative to the transmission of its poll. This is time (A) in Figure 23, which for the initiator is 2 ms by default but possibly a different value depending in the slot size and number of slots allocated to the ranging control phase poll and response. This time, i.e., the time that the initiator starts to transmit the first fragment, marks the start of the ranging phase.
- MmsReceive set to TRUE to specify that interleaved reception of UWB MMS fragments is required.
- MmsRangingRxOnTime, MmsRxClockTrackInterval and MmsRxClockTrackOffset specifying the expected arrival time of the first fragment to be received from the responder, and the expected clock offset for the reception of the responder's fragments. While this reception, (for the simple single responder case), nominally starts 600 RSTU offset from start of the ranging phase, the MmsRangingRxOnTime might be based on the arrival time reported by the MCPS-DATA.indication for the NBA response Compact frame, which also reports the clock offset measurement for that frame.

Similarly, on the responder side, the next higher layer also issues a MCPS-DATA.request to send the UWB MMS packet with interleaved reception. This includes parameters:

- TxTimeSpecified and RangingTxTime to specify when to send the first fragment, which for the responder (in the single responder case) nominally starts 600 RSTU offset from start of the ranging phase. This time, denoted (A) in Figure 23, which for the responder would be relative to the transmission of the NBA response, is 1.5 ms by default, but might be different depending on the slot size and number of slots allocated to this part of the control phase.
- MmsReceive set to TRUE to specify that interleaved reception of UWB MMS fragments is required.
- MmsRangingRxOnTime, MmsRxClockTrackInterval and MmsRxClockTrackOffset specifying the expected arrival time of the first fragment to be received from the initiator, and the expected clock offset for the reception of the initiator's fragments. For the responder this time, MmsRangingRxOnTime, marks the start of the ranging phase. Its value should be based on the arrival time for the NBA poll Compact frame as reported by the MCPS-DATA.indication, (which also reports the clock offset measurement for this frame from the initiator).

At the end of the transmission and interleaved reception of all fragments, MCPS-DATA.confirm primitives are issued by the MACs in both initiator and responder devices to their respective next higher layers to indicate the UWB MMS packet transmission and overlapped reception has completed. This primitive includes the RangingReportDescriptor parameter with a TxRangingCounter element to convey the RMARKER transmit time for the transmitted UWB MMS packet fragments and an RxRangingCounter element and that convey the RMARKER receive time for the received UWB MMS packet fragments.

That ends the ranging phase.

At the initiator, the difference in the values, TxRangingCounter – RxRangingCounter, yields the round-trip time, T_{round}, while at the responder the difference in the values, RxRangingCounter – TxRangingCounter, yields the reply time, T_{reply}.

Now, the initiator and responder devices transition to the reporting phase applying the appropriate O-QPSK setup as illustrated in Figure A by dashed rectangle labelled (5). While several items may need to be configured, at the very least the next higher layer on both devices will issue an MLME-SET.request to set the *phyCurrentChannelInfo* to select the O-QPSK PHY.

While reports could be sent in either or both directions, for the purposes of illustrating this phase, a single report from the responder to the initiator is shown in Figure A and described here. This report conveys the reply time, T_{reply}. With reference to Figure A, after the O-QPSK PHY configuration (5), the NB report from the responder is sent/received as follows:

The initiator's next higher layer issues the MLME-RX-ENABLE.request to turn on its receiver to receive the expected report frame, and the responder's next higher layer issues the MCPS-DATA.request to send the report, using the CompactFrameDescriptor parameter to specify the frame to send, (in this case a One-to-one Responder Report Compact frame with the Reply Time field set to convey the T_{reply}), and the TxTimeSpecified and RangingTxTime parameters to specify the time at which to send it. The initiator's enabling of the receiver, and the responder's transmission, are both scheduled relative to the start of the ranging phase, i.e., adding the ranging phase duration to the time used to mark start of the ranging phase when they issued the MCPS-DATA.request initiate the UWB MMS packet transmission with interleaved fragment reception.

On the responder side, the next higher layer is informed of the transmission of the report, by the MAC issuing the MCPS-DATA.confirm primitive, while on the initiator side the arrival of the report is notified to the next higher layer by the MAC issuing the MCPS-DATA.indication primitive.

That ends the reporting phase and the NBA UWB MMS ranging exchange. The initiator now has the reply time, T_{reply}, measured by the responder which it can use with its own T_{round} measurement to calculate a TOF estimate as described in 10.29.1.2.2 for SS-TWR.

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