**IEEE P802.15**

**Wireless Personal Area Networks**

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| --- | --- |
| Project | IEEE P802.15 Working Group for Wireless Personal Area Networks (WPANs) |
| Title | **Proposed resolution for MMS without report related comments: CIDs 159, 170, 171, 178, 179, 180 and 181** |
| Date Submitted | May 2025 |
| Sources | Mickael Maman (STMicroelectronics) |  |
| Re: |   |
| Abstract |  |
| Purpose | To propose comments resolution for “P802.15.4ab™/D02 C Draft Standard for Low-Rate Wireless Networks”  |
| 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 “Sources” field above.It is offered as a basis for discussion and is not binding on the contributing individuals. The material in this document is subject to change in form and content after further study. The contributors reserve the right to add, amend or withdraw material contained herein. |

R1: add explanation and extension to UWB-Driven MMS + split between synchronized and reversed MMS.

R2: update after received feedback (Definition of the time interval A, clarification of the MMS ranging procedure for SS-TWR with fixed reply time, extension to non-interleaved MMS and other offsets)

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Commenter | Index # | page | Sub-Clause | Line | Comment | Proposed Change |
| MAMAN, MICKAEL | 159 | 64 | 10.39.1 | 17 | The value A in ms is linked to macMmsRcpPollNSlots and macMmsRcpRespNSlots. Missing information about macMmsRangingSlotDuration | add " and macMmsRangingSlotDuration to a value of 600 RSTUs" after both to a value of two. |
| MAMAN, MICKAEL | 170 | 80 | 10.39.5 | 19 | Optionnally the order between the Initiator and the responder can be reversed. Then In the ranging phase, the responder may transmit the HRP UWB PHY MMS packet (described in 16.2.11), and the Initiator may start transmitting its HRP UWB PHY MMS packet offset by 600 RSTU from the start into the ranging phase. | add text page 81 line 2. "Optionnally in the ranging phase, the responder may transmit the HRP UWB PHY MMS packet (described in 16.2.11), and the Initiator may start transmitting its HRP UWB PHY MMS packet offset by 600 RSTU from the start into the ranging phase. This option is signaled by the reversed\_fragment parameter described in 10.38.11.1.3.8". A new bit "reversed\_fragment" can be added in Figure 65 to indicate this configuration. A new DCN will be provided and will detail the full changes |
| MAMAN, MICKAEL | 171 | 80 | 10.39.5 | 19 | Optionnally, the responder may start transmitting its HRP UWB PHY MMS packet offset by 600 RSTU from the reception of the first fragment instead of the start into the ranging phase. This new option reduces the energy consumption of the interleaved MMS by avoiding the need to send the report | add text page 81 line 2. "Optionnally in the ranging phase, the responder may start transmitting its HRP UWB PHY MMS packet offset by 600 RSTU from the start of the HRP UWB PHY MMS packet received from the initiator.This option is signaled by the MMS\_Sync parameter described in 10.38.11.1.3.8". A new bit "MMS\_Sync" can be added in Figure 65 to indicate this configuration. A new DCN will be provided and will detail the full changes |
| MAMAN, MICKAEL | 178 | 93 | 10.39.10.2 | 23 | The time A can also depend on the MMS order between the initiator and the responder | change to "depending on the slot size, the order and number of slots allocated to the ranging control phase poll and response." |
| MAMAN, MICKAEL | 179 | 94 | 10.39.10.2 | 7 | Optionnally, the MMsRangingRXOnTime can be set 600 RSTU from the Ranging TxTime according to MMS\_Sync parameter | Optionnally, the MmsRangingRxOnTime can be set 600 RSTU from the RangingTxTime according to MMS\_Sync parameter |
| MAMAN, MICKAEL | 180 | 94 | 10.39.10.2 | 12 | Optionnally, the RangingTxTime can be set 600 RSTU from the MmsRangingRxOnTime according to MMS\_Sync parameter | Optionnally, the RangingTxTime can be set 600 RSTU from the MmsRangingRxOnTime according to MMS\_Sync parameter |
| MAMAN, MICKAEL | 181 | 94 | 10.39.10.2 | 15 | The time A can also depend on the MMS order between the initiator and the responder | change to "might be different depending on the slot size, the order and number of slots allocated to this part of the control phase." |

***Comment Index #159 in 15-25-0174-09-04ab-consolidated-comments-draft-2-0***

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| --- | --- | --- | --- | --- | --- | --- |
| Commenter | Index # | page | Sub-Clause | Line | Comment | Proposed Change |
| MAMAN, MICKAEL | 159 | 64 | 10.39.1 | 17 | The value A in ms is linked to macMmsRcpPollNSlots and macMmsRcpRespNSlots. Missing information about macMmsRangingSlotDuration | add " and macMmsRangingSlotDuration to a value of 600 RSTUs" after both to a value of two. |

**Discussion of comment ID 159:**

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**Proposed resolution:**

**Revised**

**Proposed text changes on P802.15.4ab™/D02 for comment ID 159:**

**Change page 64 line 13-20**

In Figure 24 and Figure 25, the time interval, A, is the time interval between the start of the packet in the control phase and the start of the MMS packet in the ranging phase as described in 10.39.4 and 10.39.5 respectively, where X is phyUwbMmsRsfNumberFrags and Y is phyUwbMmsRifNumberFrags. This time interval is (macMmsRcpPollNSlots+macMmsRcpRespNSlots)\*macMmsRangingSlotDuration and (macMmsRcpRespNSlots +1)\*macMmsRangingSlotDuration for the initiator and the responder respectively. For the NBA MMS UWB case of Figure 24, values of 2 ms and 1.5 ms shall be supported for the initiator and responder respectively (macMmsRcpPollNSlots and macMmsRcpRespNSlots both to a value of two and macMmsRangingSlotDuration to a value of 600 RSTUs). In the UWB driven case of Figure 25, the HRP UWB PHY MMS packet includes the initial SYNC and SFD fragment as specified in 16.2.11, and a value of 1 ms shall be supported for time interval A (macMmsRcpPollNSlots and macMmsRcpRespNSlots both to a value of one and macMmsRangingSlotDuration to a value of 600 RSTUs).

***Comment Index #171-179-180 in 15-25-0174-09-04ab-consolidated-comments-draft-2-0***

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Commenter | Index # | page | Sub-Clause | Line | Comment | Proposed Change |
| MAMAN, MICKAEL | 171 | 80 | 10.39.5 | 19 | Optionally, the responder may start transmitting its HRP UWB PHY MMS packet offset by 600 RSTU from the reception of the first fragment instead of the start into the ranging phase. This new option reduces the energy consumption of the interleaved MMS by avoiding the need to send the report | add text page 81 line 2. "Optionally in the ranging phase, the responder may start transmitting its HRP UWB PHY MMS packet offset by 600 RSTU from the start of the HRP UWB PHY MMS packet received from the initiator.This option is signaled by the MMS\_Sync parameter described in 10.38.11.1.3.8". A new bit "MMS\_Sync" can be added in Figure 65 to indicate this configuration. A new DCN will be provided and will detail the full changes |
| MAMAN, MICKAEL | 179 | 94 | 10.39.10.2 | 7 | Optionnally, the MMsRangingRXOnTime can be set 600 RSTU from the Ranging TxTime according to MMS\_Sync parameter | Optionnally, the MmsRangingRxOnTime can be set 600 RSTU from the RangingTxTime according to MMS\_Sync parameter |
| MAMAN, MICKAEL | 180 | 94 | 10.39.10.2 | 12 | Optionnally, the RangingTxTime can be set 600 RSTU from the MmsRangingRxOnTime according to MMS\_Sync parameter | Optionnally, the RangingTxTime can be set 600 RSTU from the MmsRangingRxOnTime according to MMS\_Sync parameter |

**Discussion of comment 171-179-180: MMS ranging procedure for SS-TWR with fixed reply time**

This CR is an extension of ranging procedure for SS-TWR with fixed reply time to MMS (Section 10.29.6.5 in 802.15.4\_2024)



The timing of the MMS ranging transmission (Figure 24) is managed by the MAC Layer. To evaluate the Time of Flight (ToF), the initiator needs to receive a report compact frame including a reply time from the responder.



In NBA-UWB MMS, the initiator sends a POLL compact frame in the POLL slot and sends the first RSF fragments 2400 RSTUs later and then each fragment 1200 RSTUs after. The Responder sends a RESP compact frame in the RESP slot and sends the first RSF fragments 1800 RSTUs later and then each fragment 1200 RSTUs after.

Both Initiator and Responder manage their NBA MMS UWB ranging transmission according to the beginning of the POLL and RESP slot respectively. The timing is managed by the MAC layer. To evaluate the ToF the initiator needs a report compact frame with the treply.

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In this CR, we propose an MMS ranging procedure for SS-TWR with fixed reply time. If the responder is able to accurately estimate the arrival time of the MMS UWB packet and to always reply with sufficiently accurate constant or pre-known reply time, it obviates the need for any transfer of the reply time as part of the ranging exchange.

The estimation of arrival time and the fixed reply time may be done on SYNC and SFD fragment for the UWB driven MMS mode or on RSF fragment for the NBA-UWB MMS mode.



The first condition is the responder has precise control of the transmit time of its MMS UWB packet with respect to the arrival time of the MMS UWB packet from the initiator, then the reply time may be a fixed known quantity, agreed between the parties participating in the ranging exchange. The second condition is the accuracy of the arrival time estimation.

In NBA-UWB MMS mode, the estimation of the arrival time is evaluated on the first MMS fragment and thus depends on the channel condition. It is preferable to limit the usage of SS-TWR with fixed reply time to a small number of fragments and with good channel condition. In UWB-driven MMS mode, the estimation of the arrival time is evaluated on the SYNC and SFD fragment and thus also depends on the channel condition. However, several fragments may be used to improve the first path detection. In non-interleaved MMS mode, the estimation of the arrival time can exploit the coherent integration of the MMS fragments, then the full MMS UWB packet can be used.

In the NBA-UWB MMS mode, the fixed reply time is the time between the reception of the first fragment received from the initiator and the transmission of the first fragment by the responder whereas in UWB-driven MMS mode, the fixed reply time is the time between the reception of the SYNC and SFD fragment received from the initiator and the transmission of the SYNC and SFD fragment by the responder.

This new option reduces the energy consumption of the MMS ranging as it is not required to embed Treply into the report compact frame. The accuracy of the resultant range will depend on how accurate the estimation of the arrival time is and how fine a control the responding device has on the transmit time of its MMS message, where every 1 ns error in TOF translates to approximately 30 cm range error.

In NBA-UWB MMS mode, we propose to offset the NBA MMS UWB ranging transmission (MMS UWB packet) of the Responder to the one of the initiator by setting a fixed and accurate reply time between the reception of the first fragment received from the initiator and the transmission of the first fragment by the responder. The initiator sends the POLL compact frame at the beginning of the POLL slot. The responder sends the RESP compact frame at the beginning of the RESP slot. The Initiation sends the first fragment exactly 2400RSTU after the beginning of the POLL compact frame. Until now, there is no change from the legacy procedure. However the Responder does not send the first fragment 1800RSTU after the beginning of the RESP compact frame but 600 RTSU after the reception of the first fragment from the initiator. At the end, the initiator does not need the report compact frame from the responder to compute the ToF.



In UWB-driven MMS mode, we propose to offset the NBA MMS UWB ranging transmission of the Responder to the one of the initiator by setting a fixed and accurate reply time between the reception of the first SYNC and SFD fragment received from the initiator and the transmission of the first SYNC and SFD fragment by the responder. The initiator sends the POLL compact frame at the beginning of the POLL slot. The responder sends the RESP compact frame at the beginning of the RESP slot. The Initiation sends the first SYNC and SFD fragment exactly 1200RSTU after the beginning of the POLL compact frame. Until now, there is no change from the legacy procedure. However, the Responder does not send the first SYNC and SFD fragment 1200RSTU after the beginning of the RESP compact frame but 600 RTSU after the reception of the first SYNC and SFD fragment from the initiator.

Note: In UWB-driven MMS mode, the fixed reply time can also be set between the UWB POLL compact frame and the UWB RESP compact frame.

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**Proposed resolution:**

**revised**

**Proposed text changes on P802.15.4ab™/D02 for comment ID 171-179-180:**

**Change in Table 8-29 p24. Add a new element of TxOptions.**

|  |  |  |  |
| --- | --- | --- | --- |
| Name | Type | Valid Range | Description |
| MmsFixedReplyTimeEnable | Boolean | TRUE, FALSE | For MMS UWB ranging, this parameter is set TRUE if the transmission of the MMS UWB packet is offset by *macMms*FixedReplyTimeRSTU from the reception of the MMS UWB packet, or FALSE otherwise. |

**Add page 26 line 33**

The MmsFixedReplyTimeEnable parameter of TxOptions applies to UWB multi-millisecond (MMS) packet transmissions. When MmsFixedReplyTimeEnable is the transmission of MMS UWB packetis offset by *macMms*FixedReplyTime RSTU from the reception of the initiator's MMS UWB packet. By default, MmsFixedReplyTimeEnable is FALSE.

The reply time *macMms*FixedReplyTime may be a fixed known quantity, agreed between the parties participating in the ranging exchange.

**Add page 81 line 2**

The MMS ranging procedure may be adapted for SS-TWR with fixed reply time. If the responder is able to accurately estimate the arrival time of the MMS UWB packet and to always reply with sufficiently accurate constant or pre-known reply time, it obviates the need for any transfer of the reply time as part of the ranging exchange.In the ranging phase, the responder may start transmitting its HRP UWB PHY MMS packet offset by *macMms*FixedReplyTime RSTU from the start of the HRP UWB PHY MMS packet received from the initiator. This option is signaled by the MMS Fixed Reply Time parameter described in 10.39.11.1.3.8. The default value of *macMms*FixedReplyTime is 600 RSTUs.

The accuracy of the resultant range will depend on how accurate the estimation of the arrival time is and how fine a control the responding device has on the transmit time of its MMS message, where every 1 ns error in TOF translates to approximately 30 cm range error.

**add page 94 line 9**

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. Optionally, the MmsRangingRxOnTime can be nominally set 600 RSTU from the RangingTxTime according to MMS Fixed Reply Time parameter.

**add page 94 line 12-16**

-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 24, 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, the order and number of slots allocated to this part of the control phase. Optionally, the RangingTxTime can be nominally set 600 RSTU from the MmsRangingRxOnTime (the time of the first fragment starting to be received at the responder) according to MMS Fixed Reply Time parameter.

**Modify page 103 paragraph 10.39.11.1.3.8**

10.39.11.1.3.8 The MMS ~~Number of~~ Fragments Configuration field

This is a one-octet field formatted as shown in Figure 65.

|  |  |  |  |
| --- | --- | --- | --- |
| Bits: 0–2  | 3–5  | 6~~–7~~  | 7 |
| Number of RSF  | Number of RIF  | ~~Reserved~~ MMS Fixed Reply Time | reserved |

The MMS Fixed Reply Time field specifies if the responder may start transmitting its HRP UWB PHY MMS packet offset by *macMms*FixedReplyTime RSTU from the reception of the first fragment instead of the start into the ranging phase. By default, the MMS Fixed Reply Time is FALSE.

**Add page 146 in Table 31**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Attribute**  | **Type**  | **Range**  | **Description**  | **Default**  |
| *macMms*FixedReplyTimeEnable | Boolean  | TRUE-FALSE  | Reception of the MMS UWB packet of the initiator and transmission of the MMS fragments of the responder are offset by *macMms*FixedReplyTimeRSTU. | FALSE |
| *macMms*FixedReplyTime | Integer | 300-612000 | Fixed reply time duration in RSTU | 600 RSTU |

***Comment Index #170-178-181 in 15-25-0174-09-04ab-consolidated-comments-draft-2-0***

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Commenter | Index # | page | Sub-Clause | Line | Comment | Proposed Change |
| MAMAN, MICKAEL | 170 | 80 | 10.39.5 | 19 | Optionally the order between the Initiator and the responder can be reversed. Then In the ranging phase, the responder may transmit the HRP UWB PHY MMS packet (described in 16.2.11), and the Initiator may start transmitting its HRP UWB PHY MMS packet offset by 600 RSTU from the start into the ranging phase. | add text page 81 line 2. "Optionally in the ranging phase, the responder may transmit the HRP UWB PHY MMS packet (described in 16.2.11), and the Initiator may start transmitting its HRP UWB PHY MMS packet offset by 600 RSTU from the start into the ranging phase. This option is signaled by the reversed\_fragment parameter described in 10.38.11.1.3.8". A new bit "reversed\_fragment" can be added in Figure 65 to indicate this configuration. A new DCN will be provided and will detail the full changes |
| MAMAN, MICKAEL | 178 | 93 | 10.39.10.2 | 23 | The time A can also depend on the MMS order between the initiator and the responder | change to "depending on the slot size, the order and number of slots allocated to the ranging control phase poll and response." |
| MAMAN, MICKAEL | 181 | 94 | 10.39.10.2 | 15 | The time A can also depend on the MMS order between the initiator and the responder | change to "might be different depending on the slot size, the order and number of slots allocated to this part of the control phase." |

**Discussion of comment 170-178-181:**

In this CR, we propose to change the order of the MMS UWB packet transmission (i.e. the responder sends the first fragment and the initiator sends its first fragment 600 RSTU after the first fragment from the responder) in the MMS ranging procedure for SS-TWR with fixed reply time. This means in NBA-UWB MMS, the initiator sends a POLL compact frame in the POLL slot and sends the first fragment 3000 RSTUs later and then each fragment 1200 RSTUs after. The Responder sends a RESP compact frame in the RESP slot and sends the first fragment 1200 RSTUs later and then each fragment 1200 RSTUs after.

Note: This option is interesting in the MMS ranging procedure for SS-TWR with fixed reply time. When the MmsFixedReplyTimeEnable \_field is set to TRUE, it is possible to compute the ToF at the responder side without the reception of the report.

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To allow a measurement of the ToF by the responder without a report compact frame in the MMS ranging procedure for SS-TWR with fixed reply time, we propose to reverse the order of the MMS UWB packettransmission of the initiator and the responder. The control phase is the same. The initiator sends the POLL compact frame in the POLL slot and the responder sends the RESP compact frame in the RESP slot. In this new option, the responder sends the first MMS fragment i.e. 1200 RSTU after the beginning of the transmission of the RESP compact frame. The initiator does not send the first MMS fragment 3000RSTU after the beginning of the POLL compact frame (POLL slot + RESP slot + Ranging slot = 1200+1200+600 RSTU) but 600 RTSU after the reception of the first MMS fragment from the responder. In that case, we offset the NBA MMS UWB ranging transmission of the Initiator to the one of the responder by setting a fixed and accurate reply time (*macMms*FixedReplyTime RSTUs). The Responder does not need the report compact frame from the initiator to compute the ToF.

**Proposed resolution:**

**revised**

**Proposed text changes on P802.15.4ab™/D02 for comment ID 170-178-181:**

**Add page 81 line 2**

Optionally in the ranging phase, by combining *macMms*FixedReplyTimeEnable and *macMmsReversedOrder,* the responder may transmit the HRP UWB PHY MMS packet (described in 16.2.11), and the Initiator may start transmitting its HRP UWB PHY MMS packet offset by *macMms*FixedReplyTime RSTU RSTU from the start of the HRP UWB PHY MMS packet received from the responder. This option is signaled by the reversed MMS Order parameter described in 10.39.11.1.3.8.

**Modify page 93 line 21-23 and page 94 line1-2**

1. - 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~~ TxTimeSpecified is time (A) in Figure 24, which for the initiator is 2 ms by default but possibly a different value depending on the slot size, the order and number of slots allocated to the ranging control phase poll and response. ~~This~~ RangingTxTime time is when the initiator starts to transmit the first fragment and marks the start of the ranging phase.

10.39.11.1.3.8 The MMS ~~Number of~~ Fragments Configuration field

This is a one-octet field formatted as shown in Figure 65.

|  |  |  |  |
| --- | --- | --- | --- |
| Bits: 0–2  | 3–5  | 6~~–7~~  | 7 |
| Number of RSF  | Number of RIF  | MMS Fixed Reply Time | Reversed MMS order |

The MMS Fixed Reply Time field specifies if the responder may start transmitting its HRP UWB PHY MMS packet offset by *macMms*FixedReplyTime RSTU from the reception of the first fragment instead of the start into the ranging phase. By default, the MMS Fixed Reply Time is FALSE.

 The Reversed MMS Order field specifies if the order of the transmissions of the MMS UWB packet of the Initiator and the responder is reversed. When TRUE, in the ranging phase, the responder may transmit the HRP UWB PHY MMS packet (described in 16.2.11), and the Initiator may start transmitting its HRP UWB PHY MMS packet offset by 600 RSTU from the start into the ranging phase. When Reversed MMS Order is TRUE and MMS Fixed Reply Time is TRUE, the responder may transmit the HRP UWB PHY MMS packet (described in 16.2.11), and the Initiator may start transmitting its HRP UWB PHY MMS packet offset by *macMms*FixedReplyTime RSTUs from the start of the HRP UWB PHY MMS packet received from the responder.

**Add page 123 line 2 paragraph 10.39.11.3.7**

When the Message Control field value is two (i.e. Reversed MMS), the Message Content field shall be formatted as shown in Figure XX.

|  |  |
| --- | --- |
| **Octets: 5**  | **0/variable**  |
| Reply Time  | Passthrough  |

**Figure XX—Format of the Message Content field in the One-to-one Initiator Report Compact frame when the Message Control field value is two**

The Reply Time field value is an unsigned integer that reports the time difference, measured at the initiator, between the RMARKER of the MMS fragments received from the responder and the RMARKER of the MMS fragments transmitted by the initiator in the reversed mode. The units of time are specified in 10.29.1.4.

The Passthrough field content is defined in 10.39.11.1.3.3. Its presence can be inferred from the frame length.

**Add page 124 line 23 paragraph 10.39.11.3.8**

When the Message Control field value is three (i.e. Reversed MMS), the Message Content field shall be formatted as shown in Figure XX.

|  |  |
| --- | --- |
| **Octets: 5**  | **0/variable**  |
| Round-trip Time  | Passthrough  |

**Figure 94—Format of the Message Content field in the One-to-one Responder Report Compact frame when the Message Control field value is three**

The Round-trip Time field value is an unsigned integer that reports the time difference, measured at the responder, between the RMARKER of the MMS fragments transmitted by the responder and the RMARKER of the MMS fragments received from the initiator in the reversed mode. The units of time are specified in 10.29.1.4.

The Passthrough field content is defined in 10.39.11.1.3.3. Its presence can be inferred from the frame length.

**Add page 146 in Table 31**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Attribute**  | **Type**  | **Range**  | **Description**  | **Default**  |
| *macMmsReversedOrder* | Boolean | TRUE-FALSE | The order between the Initiator and the responder. TRUE is reversed. | FALSE |