**IEEE P802.15**

**Wireless Personal Area Networks**

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| --- | --- |
| Project | IEEE P802.15 Working Group for Wireless Personal Area Networks (WPANs) |
| Title | IEEE 802.15.4z MAC  |
| Date Submitted |  |
| Source | Ayman Naguib (Apple) |
| Re: | Updated Text for 802.15.4z\_D006e |
| Abstract | This contribution proposes updated text for the baseline draft 802.15.4z\_D006e |
| Purpose | Provision of the text to facilitate its incorporation into the draft text of the IEEE 802.15.4z standard currently under development in TG4z. |
| Notice | This document does not represent the agreed views of the IEEE 802.15 Working 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 |  |
| Patent Policy | The contributor is familiar with the IEEE-SA Patent Policy and Procedures:<http://standards.ieee.org/guides/bylaws/sect6-7.html#6> and<http://standards.ieee.org/guides/opman/sect6.html#6.3>.Further information is located at <http://standards.ieee.org/board/pat/pat-material.html> and<http://standards.ieee.org/board/pat>. |

* ***IR-0164, IR-0167, IR-0256, IR-0169***

***Changes the text on page 20 Line 7-36***

1. *Delete Figure 14 and Keep updated figure 15. Also in Updated figure 15,*
2. *Move the whole text to the end of section 6.9.8.1 (i.e. just before 6.9.8.2)*

For STS ranging with HRP UWB PHY, RFRAMES without PHR and payload may be used. These are STS Mode 3 (SM3) frames (see section16.2). The round structure of SM3 ranging is shown in Figure 14. In addition to the Ranging Control Phase and the Ranging Phase. The controller may request certain information (e.g. AOA, reply time, or round trip time measurements) from the controlees participating in the ranging exchange. The controller may send its request in-band as part of the RCM, e.g., SM3 Ranging Request Angle-of-Arrival IE, SM3 Ranging Request Reply Time IE or SM3 Ranging Request Round-Trip Measurement IE defined in Section 7.4.4 or through an out of band mechanism.

Controlees may send their requests though an out of band mechanism to desired ranging devices. Controller broadcasts requests of controlees via RCM. Scheduling assignment for the SM3 Ranging Phase and Measurement Reporting phase be static (i.e. fixed) or dynamic by using the RS IE (Section 7.4.4.59).



 Figure 14 (Updated) SM3 Ranging Round Structure

[Please change NHD to SM3 in Figure 14]

Note that since there is no PHR or PHY payload in the SM3 RFRAME to distinguish the messages from different devices, SM3 ranging message exchanges have to be scheduled ahead of time. Therefore, contention-based SM3 ranging is not supported. This scheduling can be static (i.e. fixed) or dynamic via the RS IE (7.4.4.59). Note also that there can be SM3 ranging use cases without requests and/or measurements, where the measurement report and/or request exchange phases in the time structure can be removed. For example, a device may estimate the AOA of another device using that device’s SM3 RFRAME, without explicitly sending a request to the far-end device.

Moreover, in a ranging exchange that involves the use of SM3 frames and other messages with payload (for example to exchange requests and/or to report measurements), the Frame Counter in the MAC header of messages with payload shall be incremented accordingly to account for the number of SM3 frames.

***Page 36 line 12,13: replace “***NHD***” with “***SM3***”***

***Page 37 Figure 29: replace “***NHD***” with “***SM3***” in Figure and caption***

***Page 37 lines 5-19: replace “***NHD***” with “***SM3***”***

***Page 38 Figure 30: replace “***NHD***” with “***SM3***” in Figure and caption***

***Page 38 lines 7-15: replace “***NHD***” with “***SM3***”***

***Page 47 Table 7-16: replace “***NHD Ranging Request Angle-of- Arrival IE” ***with*** “ SM3 Ranging Request Angle-of- Arrival IE”

***Page 47 Table 7-16: replace “***NHD Ranging Request Reply Time IE ” ***with*** “ SM3 Ranging Request Reply Time IE”

***Page 47 Table 7-16: replace “***NHD Ranging Request Round-Trip Measurement IE” ***with*** “ SM3 Ranging Request Round-Trip Measurement IE”

***Page 60 lines 5,22: replace “***NHD” ***with*** “SM3 ranging”

***Page 64 lines 15, 16, and 19: replace “***NHD***” with “***SM3***”***

***Page 65 lines 1,3,18,20: replace “***NHD secure***” with “***SM3***”***

***Page 65 lines 8-11,25-28: replace “***NHD***” with “***SM3***”***

***Page 66 line 3: replace “***NHD secure***” with “***SM3***”***

***Page 66 line 5: replace “***NHD***” with “***SM3

***Page 52 Figure 41: Change figure as follows***

 ***Replace “Ranging Mode” with 2 fields:***

 ***Ranging Mode -2 bits. STS Mode – 2 bits***

***Page 53 Table 7: Replace Table 7 with the following table***

|  |  |
| --- | --- |
| Ranging Mode(2 bits) | STS Mode(2 bits) |
| 0 OWR1. SS-TWR
2. DS-TWR
3. Reserved
 | 1. Reserved
2. STS Mode 1
3. STS Mode 2
4. STS Mode 3
 |

* ***IR 0173, IR\_0174, IR\_175***

***Replace text on page 21, lines 1-25 with the following text***

As an example, a Ranging Round may consist of a Ranging Control phase (RCP), one or more Polling Phase (PP), one or more Ranging Response Phase (RRP), Measurement Reporting Periods (MRPs), and a Ranging Interval Update Phase (RIUP) as in Figure 16. During the RCP, the controller sends RCM. During the PP , the initiator sends polling messages to the responder(s). The responder(s) send their response messages to the initiator during the. Participating devices use the MRP to exchange ranging measurement whenever such measurement cannot be embedded in ranging frames. The controller uses the RIUP to send a Ranging Interval Update frame. In practice, it shall be possible one or more of these phases to be part of the same UWB message. For example, it shall be possible for the RCP and PP to be combined into a single RFRAME when Controller and the Initiator are the same device. Furthermore, it shall be possible to interlace the RRP and the second PP in DS-TWR multicast/broadcast ranging, where the initiator sends a poll frame immediately following the response frame it receives from each individual responder, as opposed to first receiving all the responses over an RRP and then responding to them in a separate PP. If Schedule Mode in ARC IE (7.4.4.39) is contention-based, the first slot index and the last slot index to end for each phase are specified in Ranging Contention Phase Structure IE (RCPS IE) described in 7.4.4.44. The RCPS IE provides the slot indices for the different phases in a of Ranging Round. If the RCPS IE is not included in RCM, then all the remaining slots are used for contention-based ranging. If Schedule Mode in ARC IE is schedule-based, the information for the slot allocation are specified in Ranging Scheduling IE described in 7.4.4.59.

A RCM will always be sent at the beginning of the first active Ranging Round in a Ranging Block. Transmission of RCM in any subsequent active Ranging Rounds in the Ranging Block is optional, i.e. it need only be sent to the ranging configuration. Ranging Interval Update Frame can be sent at the end of the active Ranging Round(s).

The Ranging Interval Update Frame is to specify the updated start time of the next active Ranging Round(s).

In Figure 16, the timing diagrams for seven example cases of ranging procedures are presented. In each case, the Ranging Control message (RCM) determines the type of ranging that is illustrated.

***Page 19 Line 21: Replace “***Period” ***with*** “Phase” ***in Figure 13***

***Page 23, lines 23,27: Replace “***the slot of RIU period” ***with*** “RIUP”

***Page 23, lines 25,29: Replace “***RC period” ***with*** “RCP”

***Page 25, line 25: Replace “***period” ***with*** “phase”

***Page 31, line 5: Replace “***period” ***with*** “phase”

***Page 34, lines 8,9: Replace “***period” ***with*** “phase”

***Page 35, lines 2,10,19,20: Replace “***period” ***with*** “phase”

***Page 36, lines 9,10: Replace “***period” ***with*** “phase”

***Page 37, line 5: Replace “***periods” ***with*** “phases”

***Page 37, line 16: Replace “***period” ***with*** “phase”

***Page 38, line 8: Replace “***period” ***with*** “phase”

***Page 46, Table 7-16 : Replace “***Ranging Contention Period Structure IE” ***with*** “Ranging Contention Phase Structure IE”

***Page 53, line 10: Replace “***Contention Period” ***with*** “Contention Structure Phase”

***Page 55, lines 25,26: Replace “***Period” ***with*** “Phase”

***Page 55, line 26: Replace “***periods” ***with*** “phases”

***Page 56, lines 1,4,6,7; table 47: Replace “***Period” ***with*** “Phase”

***Page 56, lines 3,9: Replace “***periods” ***with*** “phases”

***Page 56, line 8: Replace “***period” ***with*** “phase”

* ***IR\_0183:***

***Replace the sentence with***

***“***If a Ranging Block has the multiple Ranging Rounds, the RCMs of Ranging Rounds are required to include the same configuration of Ranging Block size"

* ***IR\_0184, IR\_0103:***

***Replace lines 9-16 with the following text***

If a Controlee fails to receive RCM or RIU message with updated value of intervals and has a data for the previous intervals updated by the previous RCM, the Controlee will continue using the previous round interval. One of these two possibilities will occur:

1. The updated round interval is shorter than the previous round interval. As the Controller will use the updated round interval it will not receive poll or response from the Controlee, the Controller shall resume using the previous round interval.
2. The updated round interval is longer than the previous round interval and Controlee continues with the previous round interval. In this case the Controllee will not receive the RCM, it will continue listening to the channel and will receive the RCM sent by the controller at the updated round interval.
* ***IR\_185:*** As stated in the St. Louise meeting, there are use cases that makes use of these modes
* ***IR\_0269, IR\_0105, IR\_187***

*Replace the whole section 6.9.8.3 text with the following text*

Devices participating in the ranging exchange may continue to use the same Ranging Round in the next Ranging Block (i.e. use the Ranging Round with the same round index in the next Ranging Block) or chose to use a different round (i.e. hop) in the next ranging block, for example due to interference or collision in the current active round. Similarly, while each RFRAME could be transmitted from the beginning of each Ranging Slot, the ranging devices may alternatively decide to start the transmission at a random offset *s*  within each the slot . The slot offset is expressed as a multiple of MAC time unit. It shall be assumed that all packets transmission within the same ranging round shall be transmitted with the same random offset *s* as illustrated in Figure 21. It shall be assumed that at the beginning of the ranging exchange (i.e. in the first ranging block), ranging devices will always start with slot offset 0. However, in subsequent ranging blocks, the ranging devices may decide to start with a slot offset > 0. Both the ranging round hopping and slot offset provide a way to manage interference and/or avoid collisions.

It is assumed that, as part of upper layer protocols, the devices participating in the ranging exchange have either (a) pre-negotiated a *Ranging\_Round\_Hopping\_Sequence* so that it is known at all devices, or (b) exchanged all the information necessary such that each device can generate the sequence. Only one device among the ranging devices shall be responsible for triggering the hopping mode and/or changing the slot offset. That device must be either a controller or an initiator, i.e. a controllee that is not an initiator shall not be responsible for triggering hopping mode and/or changing the slot offset. While the method of generating the hopping sequences and the criteria for triggering hopping and/or changing the Slot Offset is left to the application/upper layers, the ranging device (a controller or an initiator) shall signal the hopping mode, the new slot offset, and the ranging round index in the next ranging block in a RCM .

If the ranging exchange in Ranging Block *N* is in Ranging Round *j* and Slot Offset *s*, at the end of the exchange the ranging devices shall decide one of the following options:

* Stay in the current Ranging Round, i.e. no hopping. In this case, the ranging device will continue to range in Ranging Round *j* at Slot Offset *s* in Ranging Block *N*+1. The *HoppingMode* is set to 0, *RangingRoundIndex* is set to *j*, and *SlotOffset* to *s* in Next Ranging Round IE that will be sent in the last message in Ranging Round *j* in Ranging Block *N*.
* Hop to a different Ranging Round. In this case, the ranging device will use Ranging Round *k* at Slot Offset 0 (i.e. when ranging devices switch to hopping mode, they will always start with slot offset 0) in Ranging block *N*+1. The *HoppingMode* is set to 1, *RangingRoundIndex* is set to *k*, and *SlotOffset* to *0* in Next Ranging Round IE that will be sent in the last message in Ranging Round *j* in Ranging Block *N*. The new Ranging Round index “*k*” is determined based on current Ranging Slot index *j* , current Ranging Block index *N*, and *HoppingSequence*(*N*+1).

***Page 23, line 10: Insert the following text after line 10***

Controller shall also determine the Slot Offset for the next active Ranging Round in terms of multiple of TU and convey the same using RCM or RIU to the Controlee(s) where applicable. Controlee(s) determines the slot offset as given by the slot offset field in the Ranging Round Start IE for the current round.

* ***IR-0152:*** Withdraw comment
* ***IR-0153,IR-0154***: for HRP, the MAC unit of time is an integer multiple of chip duration, the value of that multiple is 416.

|  |  |
| --- | --- |
| PHY | TU |
| HRP UWB PHY | 416 |
| LRP UWB PHY |  |
| Others |  |

Table 1: Ranging Block PHY dependent MAC time unit (as a multiple of chip rate)

* ***IR-0155***: replace text on page 20 lines 1-6 with the following text. Also, replace Figure 13 with new figure

In a Ranging Round, SS-TWR or DS-TWR can be used for Ranging and Localization described in 6.9.8.4 to 6.9.8.8. Addtionally, One Way Ranging (OWR), as described in Applications of IEEE Std 802.15.4 [B3]. Each ranging round may include a Ranging Control Phase (RCP) at the beginning of the round, one or more Ranging Frame (RFRAMEs) Phase and one or more Measurement Report Phase as shown in Figure 13. Note that different phases can be part of the same UWB message.

New Figure 13

* ***IR\_0270, IR\_271, IR\_0272, IR\_0273,IR\_0274, IR\_345:***

Remove 7.4.4.32 (RRRT IE) and 7.4.4.36 (RCDT IE)

* ***IR-0379, IR\_0147:***

By definition, fixed reply time cannot be supported for broadcast mode with response contention. For multicast ranging (scheduled responses) it is supported by setting the slot duration to UWB packet duration + fixed reply time . Note also that for 1 to many ranging, different responders will have different fixed reply time.

***Page 21, line 23: Insert the following new text after line 23***

Note that, fixed reply time with 1 to many multicast ranging can be supported the block structure by setting the slot duration to the UWB packet duration + fixed reply time. Moreover, for 1 to many ranging, the reply time for responder *n* is *(n-1)\*Slot Duration+Fixed\_Reply\_Time.*

***Add figure for multicast with fixed turn around time***. Figure to be supplied by Ayman+Aditya

* ***IR\_0410, 0411:***

***Unresolved, need clarification from commenter***

* ***IR\_0190:***

***Page 31, line 5: Replace*** “final poll” with “final message”

* ***IR\_0191:***

***Page 35, lines 12, insert the following text after line 12***

It is the responsibility of the upper layers to ensure that each required response is supplied in good time to allow the MAC to transmit it at the specified time, and similarly to have enabled the receiver in good time to receive any message it needs to receive. The upper layers can ascertain this using RSIE.

***Change Figure 43 as follows***

|  |  |  |  |
| --- | --- | --- | --- |
| **Octets: 0/2** | **0/1** | **0/2** | **1** |
| Ranging Block | Hopping Mode | Round Index | Slot Offset |

**Figure 43—Ranging Round Start IE Content field format**

***Add the following Text in Section 7.4.4.41 on page 55: Ranging Round Start IE***

If only Slot Offset needs to be conveyed (e,g, in the Interval Based Mode), only Slot Offset field is formatted in the content field and IE spans only 1 octet.

If this IE is sent in the Ranging Control Phase, the configurations relate to the current ranging round. If they are sent at the end of the ranging round in the Ranging Interval Update Phase, it relates to the next ranging round.

***Remove Section 7.4.4.42 and Figure 44 on Page 55***

* ***IR\_0192:***

***Unresolved: Need to complete table***

* ***IR\_0193:***

Could Timestamp Difference IE in base standard have been reused for any of the new IE, rather creating a new one with same functionality?

No, we have to define a new IE since the existing IE does not include an address field. The new IE adds that definition

***Comment Rejected***

* ***IR\_0308:***

There appears an implied requirement that the RRTI IE is only used in a frame that also contains Advanced Ranging Control IE . This may be clearly stated elsewhere; if so provide a reference, state the requirement here.

That is not correct. There is no such requirement. RRTI IE can be used independent of ACR IE

***Comment Rejected***

* ***IR\_0312:***

***Page 50, line 35: Delete sentence starting with “***While these units are very precise an actual implementation may have ..”

* ***IR\_0313:***

***Page 51, line 1,2: replace with***

The value reported in the RRTI IE or RRTD IE shall be the resulting reply time of the corresponding individual ranging reply.

* ***IR\_315:***

***Page 52, line 3: Replace text on line 3-7 with***

When RRTM IE is used in multicast/broadcast mode, the RRTM IE content Address field shall be set to that of the device requesting the round trip measurement. For unicast ranging the Address field of RRTM IE shall be omitted. The units of time are specified in 6.9.1.1. The procedures for using the RRTM IE are defined in 6.9.7.

* ***IR\_0116:***

***Comment Rejected***

The schedule mode field in ARC IE is required for RCR IE so that the controlees can request change in schedule mode

* ***IR\_117:***

***Comment Rejected***

This time structure indicator is required so that the controlee can request change in schedule mode

* ***IR\_194:***

***Comment accepted. Zheda to revise the figure with request additional field***

* ***IR\_0197:***

***Page 53, line 9-11: Replace the following text with new text below***

***Old text***

***“***When Schedule Mode = 0, Ranging Initiator/Responder List IE and Ranging Contention Period IE can be invoked. When Schedule Mode = 1, Ranging Scheduling IE can be invoked.”

***New text***

***“***Ranging Initiator/Responder List IE and Ranging Contention Period IE are used when Schedule Mode is set to 0. When Schedule Mode = 1, Ranging Scheduling IE is used.”

* ***IR\_0195, IR\_316:***

***Comments Rejected***

1) Cast mode is needed to specify M2M

2) A controlee may request a different cast mode by using RCR IE

* ***IR\_0325:***

This is an editorial comment.

***Page 56, line 2, delete “***(size is still TBD)”

* ***IR\_0198:***

***Page 53, line 11: Replace*** “Schedule Mode applies when Cast Mode = 00, 01, and 11.” ***With*** “Schedule Mode is not applicable to Broadcast (Cast Mode = 10)”

* ***IR-200:***

***Page 53, line 15: Replace*** “The Time Structure Indicator field specifies whether the ranging used in the following ranging rounds is interval-based mode (0) invoking Ranging Interval Update IE or block-based mode (1) invoking Ranging Round Start IE, Next Ranging Round IE and Ranging Block Update IE.”

***with***

“The Time Structure Indicator field specifies whether the ranging used in the subsequent ranging rounds is interval-based mode (0), in which case Ranging Interval Update IE is transmitted, or block-based mode (1), in which case Next Ranging Round IE, and Ranging Block Update IE are transmitted”

* ***IR\_204:***

***Page 54, line 1: Replace with*** “The Minimum Block Duration field specifies the minimum duration of a Ranging Block in MAC time units.”

* ***IR\_320:***

***Remove 7.4.4.42. IE is the same as 7.4.4.41***

***Page 54, line 29 Change 7.4.4.41 “***Ranging Round Start IE” to “Ranging Round IE”

***Replace lines 30-35 on page 54, and lines 1-3 pages 55 with the following text***

The Ranging Round (RR) IE is included in the RCM, in the final ranging frame, or in the final data message of ranging message sequence . If RR IE is included in the RCM, then the content of the RR IE is applicable to the current ranging round. If RR IE is included in the final ranging frame or the final data message of a ranging message sequence, then the content of the RR IE is applicable in the next ranging round. Ranging Block field is to specify the index of the ranging block with range [0,65535]. Hopping Mode is to indicate whether hop mode for the ranging block: No Hopping (0), Hopping (1). Round Index field is to specify the ranging round index in the ranging block with range [0,65535]. Slot Offset field is to specify the value of slot offset of the ranging round in the current block. The time unit of Slot Offset shall be a multiple of TU. This offset shall be at most Ranging Slot Length – UWB Frame Length.

***Change figure 43 caption to*** “Ranging Round IE Content Field Format”

***In Table 7-16, Change*** “Ranging Round Start IE” ***to*** “Ranging Round IE”

***In Table 7-16, Remove*** “Next Ranging Round IE”