**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. |
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| 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 for the NHD text on page 20 (starting from Line 7)***

1. *Delete Figure 14 and Keep figure 15. Also in figure 15, note in the caption that the Request exchange phase and measurement phases are optional.*
2. *Move the whole text for NHD to the end of section 6.9.8.1 (i.e. just before 6.9.8.2)*

For secure ranging with HRP UWB PHY, RFRAMES without PHR and payload may be used. These are called NHD (no header no data) frames. The time structure of the NHD secure ranging round shall be as shown in Figure 14 and Figure 15. In addition to the Ranging Control Phase and the Ranging Phase, NHD ranging structure may include optional Request exchange phase and/or a Measurement Report 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. This request from the controller may be carried through out of band mechanism. Additionally, the controller may send its request in-band as part of the RCM, e.g., NHD Ranging Request Angle-of-Arrvial IE, NHD Ranging Request Reply Time IE or NHD Ranging Request Round-Trip Measurement IE defined in Section 7.4.4, or in a separate message in the optional Request Exchange phase as shown in Figure 14.

Controlees may send their requests though an out of band mechanism to desired ranging devices. Controller broadcasts requests of controlees via RCM. Or request IEs of controlees can be inserted in dedicated data frames/messages of theRequest Exchange phase.

Specifically, each requestor shall be scheduled to send request IEs in a dedicated data frame to one or more devices during the request exchange phase. Scheduling assignment can be realized by using the RS IE (Section 7.4.4.59). After successful exchange of requests, the NHD ranging phase starts.



Figure 14 (Old 15)

Scheduling assignment of the NHD devices in Request Exchange Phase, the Ranging Phase, and the Measurement Reporting Phase can be static (i.e. fixed) or dynamic via the RS IE (7.4.4.59).

Note that since there is no PHR or PHY payload in the NHD RFRAME to distinguish the messages from different devices, NHD ranging message exchanges have to be scheduled ahead of time. Therefore, contention-based NHD 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 NHD 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 NHD RFRAME, without explicitly sending a request to the far-end device.

Moreover, in a ranging exchange that involves the use of NHD 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 NHD frames.

* ***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.

***Change “***Ranging Contention Period Structure IE” To “Ranging Contention Phase Structure IE” in section 7.4.4.44 page 55

***Replace Period with Phase where appropriate throughout the document***

* ***IR\_0183:***

***Replace the sentence with***

***“***If a Ranging Block has the multiple Ranging Rounds, the RCMs of Ranging Rounds may be 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. 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).
* ***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 512.
* ***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.

* IR\_0270, IR\_271, IR\_0272, IR\_0273

Remove 7.4.4.32 (RRRT IE) and 7.4.4.36 (RCDT IE