**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>. |

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

1. *Swap Figure 14 and figure 15. Also in figure 15, note in the caption that the Request exchange period and measurement periods are optional.*
2. *Change the whole text as indicated below.*
3. *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. In addition to the Ranging Control Period and the Ranging Period, NHD ranging structure may include optional Request exchange period and/or a Measurement Report period. 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 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 period.

Controlees may send their requests though an out of band mechanism to desired ranging devices. Or they can send requests to controller via next higher layer, and controller broadcasts requests of controlees via RCM. Or request IEs of controlees can be inserted in dedicated data frames/messages of the Ranging Exchange period.



Figure 14 (Old 15)



Figure 15 (old 14)

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

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 cannot be supported. This scheduling can be static (i.e. fixed) or dynamic via the RS IE (7.4.4.59). Scheduling for Request Exchange Period and the Measurement Report Period shall be the same as the scheduling for the Ranging Period.

Note that there can be NHD ranging use cases without requests and/or measurements, where the measurement report and/or request exchange periods 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 shall be incremented accordingly to account for the number of NHD frames.

***Changes for 6.9.8.3 Slot and Round Hopping***

*Replace with 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).

In one possible implementation, the ranging devices may choose to use “random hopping”. In this case *HoppingSequence*(*k*) is an integer number such that:



In this case, if *HoppingMode* is 1, then Ranging Round index in Ranging Block *k* is



Alternatively, the ranging devices may choose to use “random-walk hopping”. In this case *HoppingSequence*(*k*) ∈{+1,-1} and if *HoppingMode* is 1, then Ranging Round index in Ranging Block *k* is



If the block structure needs to be changed, a new *HoppingSequence* corresponding to the new block structure shall be re-configured.