**IEEE P802.15**

**Wireless Personal Area Networks**

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| Source | Jinjing Jiang, Robert Golshan, Santhosh Mani Kumar, Alexander Krebs (Apple), Bin Qian, Lei Huang, Chenchen Liu, Kuan Wu, Rojan Chitrakar, David Xun Yang (Huawei), Mingyu Lee, Taeyoung Ha (Samsung) |
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| Abstract |  |
| Purpose | This submission proposes text to for the IEEE Std 802.15.4ab specification framework document. |
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1. Ranging Procedure for One-to-Many SS-TWR using NBA-MMS

## Introduction

In this document, we provide the texts for one-to-many SS-TWR ranging procedure using NBA-UWB MMS [1, 2] that will be incorporated into the draft-0 specification of IEEE 802.15.4ab.

## MAC

### 1.2.1 Basic Operation

In one-to-many SS-TWR using NBA-MMS, as shown in Figure 1, the ranging exchange is started by the initiator broadcasting to multiple responders the ranging initiation message on the narrow band.



Figure 1. Illustration of a ranging round of one-to-many SS-TWR using NBA-UWB

The configuration parameters of the one-to-many ranging round are embedded in the ranging initiation message. Such a configuration determines how the initiator ranges with multiple responders, divides the ranging slots in the ranging round into multiple *sub-rounds* and how the initiator completes the ranging control, ranging and optionally measurement report phase with one responder during each sub-round. Therefore, in the scheduled one-to-many ranging operation, the configuration shall include the list of responders that the initiator ranges with. The frame formats with signaling details are discussed in Section 1.2.3.

In each ranging sub-round, the ranging control, ranging, measurement report phases are the same as the one-to-one ranging using NBA-MMS. Particularly, in the first sub-round, the ranging initiation message allows CFO/SFO acquisition.

If the measurement report phase is not included in the ranging sub-round, the initiator shall reserve slots at the end of the ranging round to conduct measurement report phase for all the responders.

The examples in Figure 1 shows that the responder sends the measurement report back to the initiator and the initiator computes the range. It is also possible that the initiator sends the measurement report to the responder and then the responder calculates the range. These variations shall be part of the configuration parameters.

### 1.2.2 Other Configurations

In this section, further optimizations on the ranging configuration are described, which may be implemented to further improve the efficiency.

### 1.2.2.1 Contention-based Configuration

For contention-based one-to-many ranging, it is beneficial to switch the order of Poll and Response frame in a ranging sub-round. If no valid Response frame is received from a responder, the initiator should skip the sub-round without sending the UWB fragments as shown in Figure 2.



Figure 2. Illustration of a ranging round of contention based one-to-many SS-TWR using NBA-UWB, where Response message is sent first in a sub-round (excluding sub-round for Responder 1). In this example, the Response frame is not received correctly, the frames with dotted box are not sent accordingly.

### 1.2.2.2 Time Efficient Configuration

For some time-sensitive applications, e.g., VR/AR, it is useful to improve the time efficiency of the one-to-many ranging by allowing two responders to reply at different times within one ranging slot. The responders shall be capable of a fixed reply time of sufficient precision. The supported number of UWB MMS fragments (i.e., RSFs and/or RIFs) per ranging round is limited to 2.

As a ranging initialization message, the Poll frame with the MessageControl field set to 0x90 or 0xa0 serves to enable the time efficient one-to-many SS-TWR from an initiator to even number of responders. For two responders involved in each sub-round, the corresponding *StartSlotIndex* fields shall set to the same value; and the corresponding *TimeShiftIndication* fields shall set to 0 and 1, respectively. The *StartSlotIndex* field is used to indicate the slot index of the corresponding Poll frame.

In each sub-round as shown in Figure 3, the initiator may start transmitting the first UWB RSF fragment at *RpRsfOffset* slots into the ranging phase, and continue to send the second UWB RSF fragment at an interval of *1200* RSTUs. The responder with *TimeShiftIndication* field set to 0 may start transmitting the first UWB RSF fragment at *RpRsfOffset* slots plus *400* RSTUs into the ranging phase, and continue to send the second UWB RSF fragment at an interval of *1200* RSTUs. The responder with *TimeShiftIndication* field set to 1 may start transmitting the first UWB RSF fragment at *RpRsfOffset* slots plus *800* RSTUs into the ranging phase, and continue to send the second UWB RSF fragment at an interval of *1200* RSTUs.

A diagram of a diagram

Description automatically generated

Figure 3. Illustration of the time efficient one-to-many SS-TWR with different response time in a ranging slot using NBA-UWB RSF-only MMS ranging

For the time efficient one-to-many SS-TWR, the Report (from initiator in one-to-many ranging) frame with the MessageControl field set to 0x10 may serve to enable the transmission of the measurement report from the initiator to the two responders involved in the same sub-round. This message indicates the turnaround time of the two responders involved in the same sub-round in the TurnAroundTime1 and TurnAroundTime2 fields, respectively. Alternatively, two Report (from initiator in one-to-many ranging) frames with the MessageControl field set to 0x00 may be sent by the initiator individually to the two responders involved in the same sub-round.

### 1.2.3 Compressed PSDU messages

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Phase** | **Message Name** | **Octet 0 (Msg ID)** | **Octets 1-N [Len]** | **Description** |
| Initialization | POLL (one-to-many) | 0x10 | [RPA\_hash[3], RPA\_prand[3],  MessageControl[1],  MessageContent[],  CRC16] | MessageControl=0x00:  MessageContent={0x00, 0x00} This is the POLL message for ranging sub-rounds that are not the first one.  MessageControl=0x10: MessageContent={Numberof Responders[1], SlotsPerResponder[1], List of Responder Address[3]}  MessageControl = 0x20: MessageContent={Number of Responders[1], List of {Responder Address[3], StartSlotIndex[2], EndSlotIndex[2]}}  MessageControl = 0x30: Same as Message Control = 0x10, but both Initiator and Responder send the measurement report  MessageControl = 0x40: Same as MessageControl = 0x20, but both Initiator and Responder send the measurement report  MessageControl = 0x50: MessageContent={NumberOfSubRounds[1], SizeOfSubRounds[1]}  MessageControl = 0x60: Same as MessageControl = 0x50, but the Response frame and Poll frame in NB is switched  MessageControl = 0x90: MessageContent={Number of Responders[1], List of {Responder Address, StartSlotIndex[2], TimeShiftIndication[1]}  MessageControl = 0xa0: Same as Message Control = 0x90, but both Initiator and Responder send the measurement report  MessageControl = others: reserved |
| RESP (one-to-many) | 0x11 | [RPA\_hash[3],  MessageControl[1],  MessageContent[],  CRC16] | A qualifying response message for one-to-many ranging.  MessageControl=0x00:  MessageContent={0x00, 0x00, 0x00, 0x00, 0x00}  MessageControl=0x01-0xff: reserved |
| Report | REPORT (from responder in one-to-many ranging) | 0x12 | [RPA\_hash[3],  MessageControl[1],  MessageContent[],  CRC16] | A qualifying report message for one-to-many ranging.  MessageControl=0x00:  MessageContent={  ReplyTime[5],  PTDataLength[1],  PTData[PTDataLength]}, where PTDataLength and PTData fields are optionally present and represent pass through data to higher layers. |
| REPORT (from initiator in one-to-many ranging) | 0x13 | [RPA\_hash[3],  MessageControl[1],  MessageContent[],  CRC16] | A qualifying report message for one-to-many ranging.  MessageControl=0x00:  MessageContent={  TurnAroundTime[5],  PTDataLength[1],  PTData[PTDataLength]}, where PTDataLength and PTData fields are optionally present and represent pass through data to higher layers. |

References

[1] 15-23-0100-02-04ab-nba-uwb-technical-framework-for-draft0

[2] 15-22-0381-05-04ab-nba-uwb-ranging-text-proposal-for-15-4ab-tfd