**IEEE P802.15**

**Wireless Personal Area Networks**

|  |  |
| --- | --- |
| Project | IEEE P802.15 Working Group for Wireless Personal Area Networks (WPANs) |
| Title | One-to-Many Ranging using MMR Technical Framework Proposal |
| Date Submitted | Jan 2023 |
| 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) |
| Re: | Contribution to IEEE 802.15.4ab |
| Abstract |  |
| Purpose | This submission proposes text to for the IEEE Std 802.15.4ab specification framework document. |
| 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 “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. |

Contents

[1. Ranging Procedure for One-to-Many SS-TWR using Multi-milliseconds Ranging (MMR) 3](#_Toc124345312)

[1.1 Introduction 3](#_Toc124345313)

[1.2 MAC 3](#_Toc124345314)

[1.2.1 Basic Operation 3](#_Toc124345315)

[1.2.2 Other Configurations 4](#_Toc124345316)

[1.2.2.1 Contention-based Configuration 4](#_Toc124345317)

[1.2.2.2 Time Efficient Configuration 4](#_Toc124345318)

[1.2.3 Ranging Initiation Message Format 5](#_Toc124345319)

1. Ranging Procedure for One-to-Many SS-TWR using Multi-millisecond Ranging (MMR)

## Introduction

In this document, we would like to provide a skeleton for one-to-many SS-TWR ranging procedure using Multi-millisecond Ranging (MMR) that will be developed into a draft. This is a **live** document that will evolve over time. All contributions and suggestions are welcome.

## MAC

### 1.2.1 Basic Operation

For one-to-many SS-TWR using MMR, there are two types depending on whether Narrow Band Assisted method (NBA-UWB) is used, as shown in Figure 1. In both examples, the ranging exchange is started by the initiator broadcasting to multiple responders the ranging initiation message either on the narrow band or UWB band.



(a)



(b)

Figure 1. (a) Illustration of a ranging round of one-to-many SS-TWR using NBA-UWB, (b) Illustration of a ranging round of one-to-many SS-TWR using only 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 *access slots* and how ranging operation is executed with the responder. Each access slot consists of a continuous range of ranging slots such that the initiator completes the ranging control, ranging and optionally measurement report phase with one responder. Therefore, in the scheduled one-to-many ranging operation, the configuration shall include the list of responders that the initiator ranges with [frame format TBD].

In each access slot, the ranging control, ranging, measurement report phases are the same as the one-to-one ranging using MMR. Particularly, in access slot 0, the ranging initiation message also serves the time synchronization function as the Poll message.

If the measurement report phase is not included in the access slot, 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. If not specified, these additional configurations are illustrated using NBA-UWB MMR, but shall also apply to UWB only MMR.

### 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 an access slot. Furthermore, if no valid Response frame is received from a responder, the initiator could skip the access slot 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 an access slot (excluding access slot 0). 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 1ms-slot or reply using different MMR sequences (MMRS) that satisfying enough cross-correlation suppression among each other.

If response at different times in an 1ms-slot is used as shown in Figure 3, the ranging initiation message shall indicate the order of response times for different responders. For example, the order of the responders’ IDs included in the ranging initiation message implicitly indicates the transmission order of the responders in the same 1ms-slot. The responders shall be capable of a fixed reply time of sufficient precision. For the response time for each responder, the initiator and responders could negotiate the value of the response time such that the MMRS’s from different responders shall not overlap and have sufficient gap between each other to facilitate the initiator processing. It is recommended that the supported number of responders in a 1ms-slot is 2 and the supported number of RSFs and/or RIFs per ranging round is 2.



Figure 3. Illustration of the time efficient one-to-many SS-TWR with different response time in an 1ms-slot using NBA-UWB MMS ranging.

If responses using different MMR sequences with sufficient cross-correlation suppression, the responses may be sent at the same time in a ranging slot. An example is shown in Figure 4.



Figure 4. Illustration of the time efficient one-to-many SS-TWR with different responder’s MMRS in a ranging slot using NBA-UWB.

[TBD]

### 1.2.3 Ranging Initiation Message Format

[TBD]