**IEEE P802.15**

**Wireless Personal Area Networks**

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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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Multiple RSF Transmission

## Introduction

As the one of the PAR objectives provided by TG4ab, next generation UWB should improve link budget and/or reduced air-time. In this document we address the way to reduce air-time by allowing multiple transmitters to transmit ranging sequence fragments (RSFs) simultaneously.

There are two main sections: One focuses on MAC aspects of various features that rely on multiple RSF transmission, and the other one develops the message formats required to support the features introduced in the MAC section.

## Basic Operation

In order to support delay sensitive applications among the co-located devices at the same time, efficient use and scheduling of resources (i.e., slots) are required. The purpose of multiple RSF transmission is to increase slot efficiency by allowing simultaneous RSF transmission between devices. Support of multiple RSF transmission is optional.

As presented in Figure 1, Multiple RSF transmission can be applied devices in a ranging area network (RAN). For example, as shown in Figure 1, responders in a RAN can transmit RSFs simultaneously as scheduled by an initiator. In order to provide proper performance, it is recommended to maintain channel conditions between an initiator and responders (e.g., maintain the line-of-sight condition between an initiator and responders) to maintain signal strength difference of received signals from responders within the cross-correlation performance.



Figure 1 Multiple RSF Transmission in a RAN

Procedure of multiple RSF transmission is divided into 4 steps which are scheduling, trigger, transmission, and ranging report. Scheduling step of multiple RSF transmission schedules the RSF transmission timing of each responder. This step can be proceeded through sending a control message of UWB or sending a control message of NB by an initiator. This scheduling step of multiple RSF transmission can be achieved through out-of-band (OOB) procedures. Trigger step of multiple RSF transmission indicates the anchor point of multiple RSF transmission. Initiator sends (SYNC + SFD) packet of UWB or poll message of NB to trigger multiple RSF transmission. After trigger step of multiple RSF transmission, multiple RSF transmissions occur among the responders. Ranging report step of multiple RSF transmission delivers ranging results to the responders. Initiator sends Ranging report message to responders to conduct this step. Scheduling and ranging report steps of multiple RSF transmission can be omitted if unnecessary.

### UWB based Multiple RSF transmission

The operation of UWB based multiple RSF transmission is presented in Figure 2. Scheduling step of multiple RSF transmission is conducted by sending a control message of UWB. This control message shall include the scheduling IE. After scheduling step of multiple RSF transmission, (SYNC + SFD) only packet is transmitted to trigger multiple RSF transmission. After multiple RSF transmission occurs, ranging report step is proceeded by initiator sending ranging report messages of UWB to responders if necessary. If there is no change in scheduling, the scheduling step of multiple RSF transmission (i.e., control message of UWB) can be omitted.



Figure 2 UWB based Multiple RSF transmission

### NB assisted Multiple RSF transmission

The operation of NB assisted multiple RSF transmission is shown in Figure 3. Scheduling step of multiple RSF transmission is conducted by sending a control message of NB. After scheduling step of multiple RSF transmission, poll message is transmitted to trigger multiple RSF transmission. After multiple RSF transmission occurs, ranging report step is proceeded by initiator sending ranging report messages of NB to responders if necessary. If there is no change in scheduling, the scheduling step of multiple RSF transmission (i.e., control message of NB) can be omitted.



Figure 3 NB assisted Multiple RSF transmission

# Message Format

## UWB messages

### Scheduling IE

The scheduling IE is used by an initiator to send the scheduling information to a responder (in a unicast frame) or multiple responders (in a broadcast frame). The content field of the scheduling IE shall be formatted as shown in Figure 4.

|  |  |
| --- | --- |
| Octets: 2 | Variable |
| Control Field | Scheduling List |

Figure 4 Scheduling IE Content field format

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Bits: 0–3 | 4–6 | 7 | 8 | 9–15 |
| Scheduling List Length | Scheduling List Type | Address Size | Receiver Address Present | Reserved |

The Control field is formatted as Figure 5.

Figure 5 Control Field of the Scheduling IE

Address Size field specifies the size of the addresses used in the Scheduling List elements field. If the Address Size field is zero, all addresses in the Scheduling List elements are short addresses (i.e., 2 bytes). If the Address Size field is one, all addresses in the Scheduling List elements are extended addresses (i.e., 8 bytes).

The Scheduling List Length field indicates the number of elements in the Scheduling List field.

Scheduling List Type field specifies the type of Scheduling List field and shall have one of the values specified in Table 1.

Table 1 Values of the Scheduling List Type field in the Scheduling IE

|  |  |
| --- | --- |
| Scheduling List Type field value | The type of Scheduling List field |
| 0 | Per-slot scheduling |
| 1 | Consecutive slot scheduling |
| 2 | Bitmap-based scheduling |
| 3 | Periodic scheduling |
| 4 | RSF scheduling |
| 5–7 | Reserved |

If the multiple transmission scheduling mode is selected (i.e., value of Scheduling List Type is 2), the Scheduling List field shall be formatted as shown in Figure 6.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Bits: 0-6 | 7-10 | 11-15 | Octets: 2 or 8 | Octets: 1 | Octets: 1 | Octets: 1 |
| Starting Slot Index | Scheduling Step | Scheduling Repetition | Sender  Address | Sequence Index | Number of Gaps | Sequence  Repetition |

Figure 6 Scheduling List element format of Multiple RSF Transmission Scheduling Mode

Starting Slot Index field marks the first transmission slot after trigger step of multiple RSF transmission in the recurring periodic transmission pattern in unit of slots.

Scheduling Step field represents the period of the transmission pattern in unit of slots.

Scheduling Repetition field represents the number of repetitions of the transmission pattern in unit of slots.

The Sender Address field specifies the device that the scheduling information in this Scheduling List element relate to.

Sequence Index field indicates the code index of MMRS that allocated to the device in this Scheduling List element relate to.

If sequence index field indicates the code indices of MMRS based on the length-128 complementary set, Number of Gaps field shall be used to specify the length of zero between two parts of the length-128 complementary set. The value of this field shall be between 0 and 64.

Sequence Repetition field indicates the number of MMRS repetitions in RSF (i.e., N\_MSR), and the value of this field shall be between 32 and 256.

### Ranging Report

Ranging report follows Ranging Measurement Information IE (RMI IE) as defined in 7.4.4.46.

## NB Message

### Control Message

TBD

### Poll

TBD

### Ranging Report

TBD