**IEEE P802.15**

**Wireless Personal Area Networks**

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| Re: | Contribution to IEEE 802.15.4ab |
| 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

These information are included in [1] (Already approved).

## NB Message

### Control Message

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Phase** | **Message Name** | **Octet 0 (Msg ID)** | **Octets 1-N [Len]** | **Description** |
| **Control** | **MULTI-SCHED** | **TBD** | [RPA\_hash[3],  RPA\_prand[3],  MessageControl[1], MessageContent[], CRC16] | MessageControl=0x00: MessageContent={ Number of Responder [1], List of {Responder Address [3], Slot index [1], UWB PHY CONFIG[3]}}  MessageControl=0x01: MessageContent={ Number of Responder [1], List of {Responder Address [3], Slot index [1]}}  MessageControl=0x02: MessageContent={ Number of Responder [1], List of {Responder Address [3], UWB PHY CONFIG[3]}}  MessageControl=0x03: MessageContent={ same as MessageControl = 0x00}, but Poll Message will not be transmitted  MessageControl=0x04: MessageContent={ same as MessageControl = 0x01}, but Poll Message will not be transmitted  MessageControl=0x05: MessageContent={ same as MessageControl = 0x02}, but Poll Message will not be transmitted  MessageControl=0x06: MessageContent={ 0x00}, but Poll Message will not be transmitted  MessageControl=0x10: MessageContent={ same as MessageControl = 0x00}, but only Initiator send the measurement report  MessageControl=0x11: MessageContent={ same as MessageControl = 0x01}, but only Initiator send the measurement report  MessageControl=0x12: MessageContent={ same as MessageControl = 0x02}, but only Initiator send the measurement report  MessageControl=0x13: MessageContent={ same as MessageControl = 0x00}, but Poll Message will not be transmitted, and only Initiator send the measurement report  MessageControl=0x14: MessageContent={ same as MessageControl = 0x01}, but Poll Message will not be transmitted, and only Initiator send the measurement report  MessageControl=0x15: MessageContent={ same as MessageControl = 0x02}, but Poll Message will not be transmitted, and only Initiator send the measurement report  MessageControl=0x16: MessageContent={ 0x00}, but Poll Message will not be transmitted, and only Initiator send the measurement report  MessageControl=0x20: MessageContent={ same as MessageControl = 0x00}, but only Responder send the measurement report  MessageControl=0x21: MessageContent={ same as MessageControl = 0x01}, but only Responder send the measurement report  MessageControl=0x22: MessageContent={ same as MessageControl = 0x02}, but only Responder send the measurement report  MessageControl=0x23: MessageContent={ same as MessageControl = 0x00}, but Poll Message will not be transmitted, and only Responder send the measurement report  MessageControl=0x24: MessageContent={ same as MessageControl = 0x01}, but Poll Message will not be transmitted, and only Responder send the measurement report  MessageControl=0x25: MessageContent={ same as MessageControl = 0x02}, but Poll Message will not be transmitted, and only Responder send the measurement report  MessageControl=0x26: MessageContent={ 0x00}, but Poll Message will not be transmitted, and only Responder send the measurement report  MessageControl=0x30: MessageContent={ same as MessageControl = 0x00}, but Initiator and Responder send the measurement report  MessageControl=0x31: MessageContent={ same as MessageControl = 0x01}, but Initiator and Responder send the measurement report  MessageControl=0x32: MessageContent={ same as MessageControl = 0x02}, but Initiator and Responder send the measurement report  MessageControl=0x33: MessageContent={ same as MessageControl = 0x00}, but Poll Message will not be transmitted, and Initiator and Responder send the measurement report  MessageControl=0x34: MessageContent={ same as MessageControl = 0x01}, but Poll Message will not be transmitted, and Initiator and Responder send the measurement report  MessageControl=0x35: MessageContent={ same as MessageControl = 0x02}, but Poll Message will not be transmitted, and Initiator and Responder send the measurement report  MessageControl=0x36: MessageContent={ 0x00}, but Poll Message will not be transmitted, and Initiator and Responder send the measurement report |

### Poll

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Phase** | **Message Name** | **Octet 0 (Msg ID)** | **Octets 1-N [Len]** | **Description** |
| **Control** | **MULTI-POLL** | **TBD** | [RPA\_hash[3],  MessageControl[1], MessageContent[], CRC16] | MessageControl=0x00: MessageContent={ 0x00}  MessageControl=0x01: MessageContent={ Number of Responder [1], List of {Responder Address [3], UWB PHY CONFIG[3]}} |

### Ranging Report

These information are included in 1.6.3.1 of [2] (Already approved).

# References

[1] 15-23-0062-03-04ab-text-for-scheduling-ie, March 2023.

[2] 15-22-0381-05-04ab-nba-uwb-ranging-text-proposal-for-15-4ab-tfd, May 2023.