Nearby Interaction with UWB Interoperability Specification

Release R3

Developer

Contents

1. Introduction

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1.1. Requirements, recommendations, and permissions

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1.2. Terminology

Throughout this document, these terms have specific meanings:

- The term *Apple device* is used to refer to an iPhone, iPad, iPod, or Mac (running iOS, iPadOS, or macOS).
- The term *accessory* is used to refer to any product intended to interface with an Apple device through the means described in this specification.

2. General

2.1. Overview

The Nearby Interaction with Ultra Wideband Interoperability Specification defines how a UWB system comprised of a FiRa™ compliant UWB PHY [1] and MAC [2], along with Apple Nearby Interaction (NI) compliant middleware can successfully interoperate with an Apple device.

3. UWB PHY and MAC Requirements

3.1. Overview

The UWB chipset must meet the requirements outlined in the sections below.

3.2. Technical requirements

The PHY and MAC implementations shall be compliant with the technical requirements laid out in the following specification documents to the extent specified in the Ultra Wideband Interoperability Specification:

- IEEE Standard for Low-Rate Wireless Networks (IEEE Std 802.15.4z-2020)
- FiRa Physical Layer (PHY) Technical Specification, version 1.1 or later
- FiRa Medium Access Control (MAC) Technical Specification, version 1.1 or later

For details, refer to references [1]-[4].

3.3. Interoperability requirements

Select Apple devices support a subset of FiRa MAC features that pertain to unicast ranging in block-based mode with round hopping disabled.

Ranging methodology shall be DS-TWR with deferred mode, as illustrated in Figure 3-1. The Ranging Result Report message is optionally transmitted when it is enabled as described in Section 3.3.1.6.

The accessory may be configured either as the controller/initiator device, or as the controlee/responder device. In either case, the accessory shall refrain from operating in a mode that would be incompatible with the Apple device.

The following sections outline the requirements that are necessary for the accessory to interoperate with the Apple device.

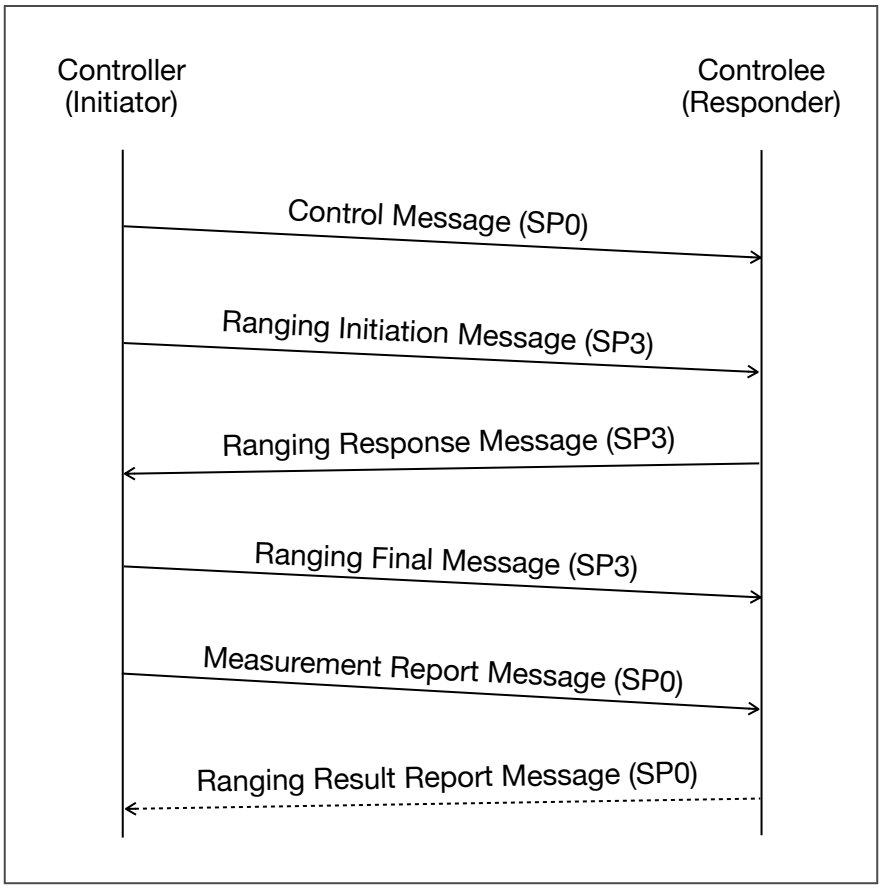

Figure 3-1. DS-TWR with deferred mode

3.3.1. Accessory as controller/initiator device

3.3.1.1. MAC header frame control

The following field within the MAC header frame control shall be set according to Table 3-1. The remaining fields of the MAC Header Frame Control not specified in Table 3-1 shall be set in accordance with Section 6.3.1.1 MAC Header of [2].

Table 3-1 MAC Header Frame Control

Element	Value
Frame Pending	0

3.3.1.2. MAC header IE payload content field

The following field within the MAC header IE content field shall be set according to Table 3-2. The remaining fields of the MAC header IE content field that are not specified in Table 3-2 shall be set in accordance with Section 5.9.4 Control Message Type 1 and Section 5.9.5 Measurement Report Message Type 1 of [2].

Table 3-2 MAC Header IE Payload Content Field

Element	Value
Padding	0x0808080808080808

3.3.1.3. MAC payload IE content field for control message

The following fields within the Control Message Type 1 shall be set according to Tables 3-3 through 3-8 in order to reflect a unicast mode of operation. The remaining fields of the Control Message Type 1 that are not specified in Tables 3-3 through 3-8 shall be set in accordance with Section 5.9.4 Control Message Type 1 of [2].

Table 3-3 MAC Payload IE Content Field for Control Message Type 1

Element	Value
Stride length	0
Ranging device management list length	4 or 5

Table 3-4 Ranging Device Management List Element 1

Element	Value
Ranging role	1
Ranging slot index	1
Scheduled UWB message	0
Stop ranging	0

Table 3-5 Ranging Device Management List Element 2

Element	Value
Ranging role	0
Ranging slot index	2
Scheduled UWB message	1
Stop ranging	0

Table 3-6 Ranging Device Management List Element 3

Element	Value
Ranging role	1
Ranging slot index	3
Scheduled UWB message	2
Stop ranging	0

Table 3-7 Ranging Device Management List Element 4

Element	Value
Ranging role	1
Ranging slot index	4
Scheduled UWB message	4
Stop ranging	0

When Range Result Report is enabled, ranging device management list length shall be set to 5 (Table 3-3), and element 5 shall be set in accordance with Table 3-8.

Table 3-8 Ranging Device Management List Element 5

Element	Value
Ranging role	0
Ranging slot index	5
Scheduled UWB message	5
Stop ranging	0

3.3.1.4. Ranging messages

Accessory shall transmit the Ranging Initiation Message and Ranging Final Message. Accessory shall receive the Ranging Response Message.

RFRAME configuration shall be set to SP3 with static STS generation.

3.3.1.5. MAC payload IE content field for Measurement Report message

Accessory shall report its measurements of Round Trip Time and Reply Time to the Apple device by sending the Measurement Report Message Type 1.

The following fields within the Measurement Report Message Type 1 shall be set according to Table 3-9 in order to reflect a non-hopping unicast ranging mode of operation. The remaining fields of the Measurement Report Message Type 1 that are not specified in Table 3-9 shall be set in accordance with Section 5.9.5 Measurement Report Message Type 1 of [2].

Table 3-9 Payload IE Content Field for Measurement Report Message Type 1

Element	Value
Round Index	0
Hopping mode	0
Round Index Present	1
Reply time list length	1

3.3.1.6. MAC payload IE content field for Ranging Result Report message

Accessory may be configured to get the ToF result from the Apple device by receiving the Ranging Result Report Message Type 1. The following fields within the Ranging Result Report Message Type 1 shall be set according to Table 3-10. The remaining fields of the Ranging Result Report Message Type 1

not specified in Table 3-10 shall be set in accordance with Section 5.9.7 Ranging Result Report Message Type 1 of [2].

Table 3-10 Message Control Field of Ranging Result Report Message Type 1

Element	Value
ToF Result present	1
AoA azimuth result present	0
AoA elevation result present	0
AoA FOM present	0

3.3.1.7. Ranging update message

Accessory shall not attempt to reconfigure the ranging session once the ranging session has already started.

3.3.2. Accessory as controlee/responder

3.3.2.1. Ranging messages

Accessory shall receive the Ranging Initiation message and Ranging Final message. Accessory shall transmit the Ranging Response message.

RFRAME configuration shall be set to SP3 with static STS generation.

3.3.2.2. MAC payload IE content field for Ranging Result Report message

Accessory may be configured to convey its ToF result to the Apple device by sending the Ranging Result Report Message Type 1. The fields within the Ranging Result Report Message Type 1 shall be set as described in Section 3.3.1.6.

4. UWB Configuration Requirements

4.1. Overview

The UWB system must provide an adequate interface to the host processor to achieve the requirements described in this section.

4.2. Versions

The formats described in this chapter have the following versions. The version values are only applicable to the Apple-defined configuration messages in sections 4.4 and 4.5 below.

Table 4-1 Supported Versions

Version Type	Value
Major	1
Minor	1

4.3. Configuration messages

The Nearby Interaction Application protocol requires the exchange of the following messages:

1. Accessory Configuration Data (see section 4.4 below)
2. Apple Shareable Configuration Data (see section 4.5 below)

4.3.1. Endianness

All data sent and received as a part of the configuration messages as defined in this section shall be transmitted with the least significant octet first (that is, little endian).

4.4. Accessory configuration data

4.4.1. Overview

For every intended UWB ranging session with an Apple device, the UWB middleware on the accessory shall be able to generate a new Accessory Configuration Data message, populate it with values as defined in this section, and provide it to the host processor. The host processor shall use the data given

by the UWB middleware to populate the UWBConfigDataLength and UWBConfigData fields as described in 3.4.4 of reference [5].

4.4.2. UWBConfigData format

Table 4-2 UWBConfigData field of Accessory Configuration Data message in [5]

Parameter	Data type	Size (octets)	Description
MajorVersion	Uint16	2	Must match the major version in Table 4-1.
MinorVersion	Uint16	2	Must match the minor version in Table 4-1.
Manufacturer ID	Uint32	4	Determined by manufacturer.
UWB chipset model ID	Uint32	4	Determined by manufacturer.
UWB middleware version	Uint32	4	Determined by manufacturer.
RANGING_ROLE	Uint8	1	0: Responder (and controlee) 1: Initiator (and controller).
SOURCE_ADDRESS	Uint16	2	View section 4.4.3.2 below.
Maximum UWB clock drift	Uint16	2	The maximum drift (in PPM) of the UWB clock of the accessory.

4.4.3. Configurable parameters

The accessory must select a RANGING_ROLE and generate a SOURCE_ADDRESS as noted below.

4.4.3.1. Ranging role

The accessory must select between the Initiator and responder ranging roles. This value should be used for both the DEVICE_ROLE (UCI Tag ID 0x11) and the DEVICE_TYPE (UCI Tag ID 0x00) configuration parameters provided to the accessory's UWB subsystem.

If the accessory's UWB subsystem is capable of supporting both the Initiator/Controller as well as the Responder/Controlee, the UWB middleware shall provide a configuration option to the host processor to select between the two.

4.4.3.2. Source address

The SOURCE_ADDRESS shall represent the identity of the accessory for a duration of a single UWB session with the Apple device. This value shall be used to configure the DEVICE_MAC_ADDRESS MAC parameter (UCI Tag ID 0x06).

4.4.3.2.1. Source address randomization

SOURCE_ADDRESS shall be randomly generated for every new Accessory Configuration Data message created by the accessory, using a cryptographically secure source of randomness.

4.5. Apple shareable configuration data

4.5.1. Overview

After a successful receipt and processing of the Accessory Configuration Data, the Apple device may send the Apple Shareable Configuration Data message to the accessory.

The Apple Shareable Configuration Data message contains an AppleUWBConfigData field, as described in reference [5]. The host processor on the accessory should provide the AppleUWBConfigData field as-is to the UWB middleware. The UWB system should be configured and ranging should be started on the accessory immediately following this message.

4.5.2. AppleUWBConfigData format

Table 4-4 AppleUWBConfigData field of Apple Shareable Configuration Data message in [5]

Parameter	Data type	Size (octets)	FiRa UCI ID	Description
MajorVersion	Uint16	2	N/A	Major version number.
MinorVersion	Uint16	2	N/A	Minor version number.
ConfigDataLength	Uint8	1	N/A	The length of the remaining message in bytes.
REGULATORY_COUNTRY_CODE	String	2	N/A	View 4.5.2.1 below.
SESSION_ID	Uint32	4	N/A	View 4.5.2.2 below.
PREAMBLE_ID	Uint8	1	0x14	Values between [9:12].
CHANNEL_NUMBER	Uint8	1	0x04	See UCI Generic Specification [4]
NUM_SLOTS_PER_RROUND	Uint16	2	0x1B	See UCI Generic Specification [4]
SLOT_DURATION	Uint16	2	0x08	See UCI Generic Specification [4]
RANGING_INTERVAL	Uint16	2	0x09	See UCI Generic Specification [4]
RANGING_ROUND_CONTROL	Uint8	1	0x0C	See UCI Generic Specification [4]
STS_INIT_IV	Bytes	6	0x28	See UCI Generic Specification [4]

Parameter	Data type	Size (octets)	FiRa UCI ID	Description
DEST_ADDRESS	Uint16	2	0x07	The destination address of the Apple device.
Maximum UWB clock drift	Uint16	2	N/A	The maximum drift (in PPM) of the UWB clock of the Apple device.

4.5.2.1. Regulatory country code

Country code of the region as defined in ISO-3166-1-ALPHA-2.

4.5.2.2. Session ID

The SESSION_ID shall be a unique, randomly generated value. It shall be used as a SESSION_ID by the accessory for all UWB configuration commands between the accessory host processor and the UWB subsystem for the particular session with the Apple device.

4.5.3. Default UWB configuration parameter values

The following default values should be used when configuring UWB ranging with an Apple device.

Table 4-5 Default Configuration Parameters

Parameter	Data type	Size (octets)	FiRa UCI ID	Default Value
VENDOR_ID	Uint16	2	0x27	0x004C
MULTI_NODE_MODE	Uint8	1	0x03	0x00
NUMBER_OF_CONTROLEES	Uint8	1	0x05	0x01

All other parameters which are not explicitly defined in the Apple Shareable Configuration Data message nor in Table 4-5 shall be set to their default values as specified in reference [5].

5. References

[1] FiRa Physical Layer (PHY) Technical Specification, version 1.1 or later

[2] FiRa Medium Access Control (MAC) Technical Specification, version 1.1 or later

[3] IEEE Standard for Low-Rate Wireless Networks (IEEE Std 802.15.4z-2020)

[4] FiRa UWB Command Interface (UCI) Technical Specification, version 1.1 or later

[5] Nearby Interaction Accessory Protocol Specification R3 or later

6. Revision History

This chapter describes the changes to *Nearby Interaction with Ultra Wideband Interoperability Specification* from the previous revision.

- R1: Initial release.
- R2: Updated UWB configuration version to 1.1. Added maximum UWB clock drift field to the Accessory Configuration Data and Apple Shareable Configuration Data messages.
- R3: Updated terms of use. Updated references.

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