**IEEE P802.15**

**Wireless Personal Area Networks**

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| Sources | Alexander Krebs, Yong Liu, Santhosh Kumar Mani, Robert Golshan, Lochan Verma, Jinjing Jiang, SK Yong (Apple), Lei Huang, Kuan Wu, Bin Qian, Peng Liu, Chenchen Liu, Ziyang Guo, Rojan Chitrakar, David Xun Yang (Huawei), Mingyu Lee, Taeyoung Ha, Youngwan So, Aniruddh Rao Kabbinale (Samsung), Hong Won Lee, Insun Jang, Jinsoo Choi, HanGyu Cho (LG Electronics) |  |
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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. NBA-UWB MMS Ranging
	1. NBA-UWB MMS ranging cycle
		1. Overview

The NBA-UWB MMS ranging uses the following nomenclature to indicate HRP-ARDEV roles, as defined in 6.9.7.1 of IEEE 802.15.4z.

* Initiator
* Responder

Unless noted otherwise, the initiator acts as the controller, and the responder acts as the controlee during an NBA-UWB MMS ranging cycle.

The NBA-UWB MMS ranging also uses

* the ranging block and round structure, as specified in 6.9.7.2 of IEEE 802.15.4z, and
* the block-based mode, as specified in subclause 6.9.7.3.3 of IEEE 802.15.4z.

Figure 6-48j and Figure 6-48r of IEEE 802.15.4z are quoted below as Figure 1.1.1.1 and Figure 1.1.1.2, respectively.



**Figure 1.1.1.1 - Illustration of ranging block, ranging round, and ranging slot**

The ranging block structure can be setup for NBA-UWB MMS by specifying:

* ranging block duration
* ranging round duration
* ranging slot duration

The time unit used in specifying the durations of ranging block, ranging round, and ranging slot is the RSTU as specified in subclause 6.9.1.5 of IEEE 802.15.4z. Ranging devices shall realize this ranging block structure such that the tolerance in the ranging block duration with respect to the PHY clock shall be within ±100 ppm (c.f., subclause 6.9.7.2 of IEEE 802.15.4z).

For a given block configuration, each ranging block is referenced by a ranging block index relative to the first block in that configuration (block number zero). Each ranging round in any ranging block is referenced by a ranging round index relative to the first ranging round in the current ranging block. Similarly, each ranging slot in a ranging round is referenced by a ranging slot index relative to the first ranging slot in the ranging round.

A ranging round is a period of sufficient duration to complete one entire ranging cycle. An initiator and a responder may use one or multiple ranging rounds from the first ranging block of a ranging session and repeat the same ranging round usage pattern in subsequent ranging blocks. The round hopping, as specified in subclause 6.9.7.3.3 of IEEE 802.15.4z, may be optionally applied to an NBA-UWB MMS ranging session. Transmission offset shall not be applied to NBA-UWB MMS ranging to ease enablement of carrier coherence among NBA-UWB MMS phases.

Extending over the 802.15.4z slot based ranging modes, for MMS, multiple consecutive ranging slots may be allocated for a single packet transmission. The ranging slot duration, the ranging round duration, and the ranging block duration shall be chosen as an integer multiple of 300 RSTUs (i.e., 250 µs).



**Figure 1.1.1.2 – Time diagram for an example of block-based mode**

A ranging cycle can be uniquely identified by a ranging block index and a ranging round index.

In the NBA-UWB MMS ranging, a ranging cycle consists of following phases:

* Control phase
* Ranging phase
* Report phase (via NB/UWB, or controlled by higher-layer)

Both the control phase and the ranging phase are mandatorily required in a ranging cycle. The report phase is supported by 802.15.4 NB O-QPSK PHYs enlisted in Table 1.2.3.1, or by using out-of-band radio technology controlled via higher layer functions. If the report phase packets are provided using the 802.15.4 NB-O-QPSK PHY, the ranging round length shall be configured to include ranging control, ranging, and report phases. If the ranging report information is provided by other than 802.15.4 NB O-QPSK radio technology, the ranging round length shall be configured to include at least both the control phase and the ranging phase. The protocol for non 802.15.4 NB O-QPSK ranging report transmission our of scope here.

Figure 1.1.1.3 illustrates the NBA-UWB MMS ranging round, ranging cycle, and phases.

 

**Figure 1.1.1.3 – NBA-UWB MMS ranging round contents**

The following nomenclature is used for control and report messages:

* Poll message (e.g., POLL from section 1.6.3): A NB message transmitted by an initiator at the beginning of the first ranging slot of a ranging round to initiate a ranging cycle within the ranging round.
* Response message (e.g., RESP from section 1.6.3): A NB message transmitted by a responder at the beginning of the ranging slot that immediately follows to the last ranging slot configured for the poll message, in response to a received poll message.
* Report message (e.g., REPORT from section 1.6.3): A NB message transmitted by either an initiator or a responder to report the ranging measurement to the peer.

The NB O-QPSK 250 kbps PHY is the default for the transfer of control and report messages. Other NB O-QPSK PHYs [1], UWB PHYs [1], and higher-layer transport mechanisms (out of scope) are supported optionally.

* + 1. NBA-UWB MMS control phase

An NBA-UWB MMS control phase starts at the beginning of an NBA-UWB MMS ranging cycle and includes 2 ranging control slots for peer-to-peer ranging.

An initiator starts an NBA-UWB MMS control phase by transmitting a poll message to a responder at the beginning of the first ranging slot of a ranging round. The initiator may extend transmission of the poll message up to the duration of *RcpPollSlot* if LBT is not enabled, or according to 1.4.2 otherwise. The responder that receives the poll message successfully shall transmit a response message back to the initiator in the ranging slot after the duration of *RcpPollSlot* from the beginning of the control phase. The responder may extend transmission of the response message for up to the duration of *RcpResponseSlot* in the control phase if LBT is not enabled, or according to section 1.4.2 otherwise. The responder that transmits the response message successfully shall continue the NBA-UWB MMS ranging cycle and enter the ranging phase. The initiator that receives the response message successfully shall also continue the NBA-UWB MMS ranging cycle and enter the ranging phase.

A poll message serves to enable carrier coherent transmissions from the initiator to the responder device. Additionally, a poll message may serve to transmit control information from the initiator to the responder. For example, a poll message may include a request for the responder to suggest short-term operating parameters for the next ranging cycle, e.g. NbaChannelMap, NB PHY configuration, UWB PHY configuration, and/or UWB MAC configuration. The poll message is transmitted at long-term NB PHY configuration.

A response message serves to enable carrier coherent transmissions from the responder to the initiator device. Additionally, a response message may serve to transmit control information from the responder to the initiator. For example, if the responder receives the request from the initiator to suggest short-term operating parameters in the poll message, and does not transmit any measurement report in the current ranging cycle, then the response message transmitted by the responder shall include the suggested short-term operating parameters. The initiator may make use of the suggested short-term operating parameters to determine updated short-term operating parameters to be used in the next ranging round. If the NB PHY configuration is indicated in the poll message, the response message is transmitted at the NB PHY configuration indicated in the poll message. Otherwise, the response message is transmitted at long-term NB PHY configuration.

If LBT is enabled before a NB transmission in the corresponding operating band (referring to section 1.4.2), a transmitter shall perform LBT in advance of the start of a NB transmission. If the performed LBT cannot warrant the transmission at the beginning of the ranging slot, for the remainder of the ranging round the transmitter shall not commence further transmissions.

An initiator shall discontinue an NBA-UWB MMS ranging cycle if at least one of following conditions is met:

* The LBT does not warrant the transmission of the poll message.
* The initiator fails to receive the response message at the expected ranging slot.
* All HRP-ARDEVs have requested to skip ranging for the current ranging block during control phase

A responder shall discontinue an NBA-UWB MMS ranging cycle if at least one of following conditions is met:

* The responder fails to receive the poll message at the beginning of the expected ranging round.
* The LBT does not warrant the transmission of the response message.
* All HRP-ARDEVs have requested to skip ranging for the current ranging block during control phase

If a ranging cycle is terminated before its completion, the involved HRP-ARDEVs shall stop the NB and UWB transmissions until the next ranging cycle.

Figure 1.1.2.1 illustrates an example of the NBA-UWB MMS control phase.

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**Figure 1.1.2.1 - NBA-UWB MMS control phase**

* + 1. NBA-UWB MMS ranging phase

An NBA-UWB MMS ranging phase starts when the NBA-UWB MMS control phase ends.

An initiator may start transmitting a first UWB RSF fragment at *RpInitiatorRsfOffset* slots into the ranging phase. The initiator may continue to send up to X UWB RSF fragments at regular intervals of *1200* RSTUs (where X refers to [5]).

An initiator may start transmitting a first UWB RIF fragment at *RpInitiatorRifOffset* slots into the ranging phase. The initiator may continue to send up to Y UWB RIF fragments at regular intervals of *1200* RSTUs (where Y refers to [5]).

A responder may start transmitting a first UWB RSF fragment at *RpResponderRsfOffset* slots into the ranging phase. The responder may continue to send up to X UWB RSF fragments at regular intervals of *1200* RSTUs (where X refers to [5]).

A responder may start transmitting a first UWB RIF fragment at *RpResponderRifOffset* slots into the ranging phase. The responder may continue to send up to Y UWB RIF fragments at regular intervals of *1200* RSTUs (where Y refers to [5]).

The total duration of the ranging phase is *RpDuration* slots. *RpDuration* shall be set at minimum to the required duration for all RSF and RIF fragments to be transmitted.

After an HRP-ARDEV, being either an initiator or a responder, completes the reception of all UWB fragments for the ranging phase, it shall generate the ranging report, if it is required to send the report to a peer. The value of *RpDuration* may be set to a value that is larger than its minimum required value in order to provide a flexibility in scheduling the ensuing report phase by allowing it to start at a later time.

If O-QPSK NBA-UWB MMS report phase is enabled for the ranging cycle, an HRP-ARDEV which completes its ranging phase shall enter the report phase, if

* It is required to send the report to a peer during the report phase, and it generates the report successfully; or
* It expects to receive the report from a peer during the report phase.

If an NBA-UWB MMS report phase is not included in an NBA-UWB MMS ranging cycle, the involved HRP-ARDEVs conclude the ranging cycle after they complete the ranging phase. An HRP-ARDEV which is required to send the report to a peer may either pass the report to the next higher layer and request the next higher layer to transmit the report to the peer, or engage using 802.15.4 NB O-QPSK in the report phase.

Figure 1.1.3.1illustrates an example of the NBA-UWB MMS ranging phase.

 

**Figure 1.1.3.1 - NBA-UWB MMS ranging phase**

* + 1. NBA-UWB MMS report phase

NB O-QPSK reports may be transferred during an optional report phase. If enabled, NB O-QPSK report phase starts when the ranging phase ends. The NB O-QPSK report phase is referred to as report phase in the following.

For a PAN with one initiator and one responder the report phase consists of one, or two packet transmissions. The duration of the first slot in the report phase is *MrpFirstSlot* slots. The duration of the second slot in the report phase is *MrpSecondSlot* slots.

If the report phase only contains one packet transmission, either the initiator, or the responder shall transmit a report packet in the slot. Whether the initiator, or the responder transmit a report packet is part of the ranging configuration in Chapter 1.2.3.

If the report phase contains two packet slots, the responder shall transmit a report packet in the first slot, and the initiator shall transmit a report packet in the second slot.

 

**Figure 1.1.4.1 - NBA-UWB MMS report phase**

The measure report phase may consist of a uni-directional or a bi-directional report exchange. The transmission of report packets shall be scheduled in the first two ranging slots of the report phase according to the following configuration modes:

|  |  |  |
| --- | --- | --- |
| **Report mode**  | **TX first report slot** | **TX second report slot** |
| Uni-directional, Responder only | Responder | - |
| Uni-directional, Initiator only | Initiator | - |
| Bi-directional | Responder | Initiator |

**Table 1.1.4.1 – NBA-UWB MMS report modes**

For the bi-directional report, the transmission of reports shall be performed independently in the first and the second slot of the report phase. In particular, the initiator shall transmit its report in the second slot, independent of whether it has received the initiator’s report in the first report slot, or not.

A report message primarily serves to provide ranging results obtained during the ranging phase. Additionally, report messages may be used to serve other purposes. For example, if the responder receives the request from the initiator to suggest short-term operating parameters in the poll message, then the report message transmitted by the responder shall include the suggested short-term operating parameters. The initiator may make use of the suggested short-term operating parameters to determine updated short-term operating parameters to be used in the next ranging round. If the NB PHY configuration is indicated in the poll message, the report message is transmitted at the NB PHY configuration indicated in the poll message. Otherwise, the report message is transmitted at long-term NB PHY configuration.

If an HRP-ARDEV fails to transmit its report during its assigned slot in the report phase, the HRP-ARDEV may defer and retry the transmission using radio technology other than NB O-QPSK that is controlled via higher layer functionality. If an HRP-ARDEV fails to receive a report during its assigned slot in the report phase, it may request retransmission via other than 802.15.4 NB O-QPSK transmission during the remaining time of the current ranging block.

* 1. NBA-UWB MMS initialization and setup
		1. Overview

An NBA-UWB MMS ranging session is configured by a set of parameters for PHY and MAC. The set of PHY parameters include NB and UWB channels, modulation, and data rate to be used for control, ranging, and report phases. The MAC parameters include the slot, round, and block configuration for control, ranging, and report phases.

To start an NBA-UWB MMS ranging session, a pair of initiator and responder devices may engage in an initialization and setup phase to negotiate a ranging configuration different from the default set of parameters. Configuration parameters enlisted in Table 1.2.3.1, including initialization channel and modulation, may be changed prior to initialization and setup phase by using higher layer functionality.

* + 1. Ranging session initialization
			1. Overview

Before entering the control phase, HRP-ARDEVs may engage in an initialization and setup stage. The initialization and setup stage provides time synchronization of the first poll packet transmitted by the initiator during an upcoming control phase. Furthermore, ranging session configuration may be altered by a two-way handshake packet exchange between the HRP-ARDEVs. Unless renegotiated during initialization and setup, the default ranging configuration parameters shall be used for the ranging session. Alternatively, the ranging session configuration may be set up by radio technology controlled by a higher layer.

To establish NB O-QPSK initialization, HRP-ARDEVs should opportunistically transmit and receive on the dedicated initialization channel using the PHY modulation, as specified in the default ranging session configuration or as configured prior to initialization via higher layer protocols. The initiator may send advertising poll (ADV-POLL) packets opportunistically at times and intervals to its discretion as deemed suitable for the higher layer functionality to be supported. Similarly, the responder may opportunistically listen for incoming ADV-POLL packets.

After transmitting ADV-POLL on the initialization channel, the initiator shall listen for an incoming advertising response packet (ADV-RESP) in the subsequent ranging slot. Once a responder has received ADV-POLL, it may transmit ADV-RESP in the subsequent ranging slot. When the responder has transmitted ADV-RESP, it shall listen for a start-of-ranging (SOR) packet in the ranging slot following the ADV-RESP packet. Once the initiator has received an ADV-RESP packet, it may transmit an SOR packet in the ranging slot following the ADV-RESP packet.

After transmitting the SOR packet, the initiator shall enter the control phase. After the initiator has confirmed receipt of the RESP from the responder during control phase, and unless initialization of further HRP-ARDEVs is required, the initiator shall discontinue ranging initialization and cease transmission of ADV-POLL packets.

Alternatively, public addresses may be used (PUBLIC-ADV-POLL, PUBLIC-ADV-RESP, and PUBLIC-SOR).

The initialization process is exemplified in the following figure:

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**Figure 1.2.2.1.1 - An example of NBA-UWB MMS initialization and ranging phase**

If the coordination is active, initiator determines the configuration of ranging session based on the knowledge of UWB channel usages via receptions of acquisition packets (APs) from other initiators described in 1.3. For coordination, Initiator may need to scan the initialization channel in NB and the default channel in UWB before the transmissions of SOR. To perform scanning for coordination and to defer the transmission of SOR, initiator sends ADV-CONF with the time offset between end of ADV-CONF packet and beginning of SOR after the reception of ADV-RESP.

If the coordination is activated and the scanning of APs nearby is required after ADV-CONF and before the SOR, the initialization process with ADV-CONF is exemplified in the following figure:



**Figure 1.2.2.1.2 - An example of the initialization process with ADV-CONF**

* + - 1. Initialization setup handshake

The responder (controlee) requests ranging session configuration in ADV-RESP.

The initiator (controller) receives the request from the responder via ADV-RESP, sets the session configuration, and communicates the session configuration in SOR to the responder.

The ADV-RESP and SOR packets are defined in subsection 1.6.3 and contain the common fields NB\_Channel\_Select, UWB\_PHY\_Config, UWB\_MAC\_Config, NB\_PHY\_Config, and NB\_MAC\_Config. For these fields, the initiator may either use the same values received via ADV-RESP from the responder, or change the values of each field before transmitting the updated field values in the SOR packet.

If the initiator changes the value of NB\_Channel\_Select received from ADV-RESP, it shall change the value to a subset of the channels requested by the responder. For all other fields, the initiator may choose all field values independent from the values requested by the responder via ADV-RESP if the selected configuration is mandatorily supported. If the initiator chooses field values that correspond to optional support features, the initiator may take a-priori information about the supported optional features of the responder into account. The acquisition of a-priori information on optional features supported by the responder device may be provided by higher layer functionality, e.g., a pairing process, that is out of scope here.

In addition to the common ranging configuration fields, the initiator shall provide synchronization information in the SOR packet. To synchronize the start of the first ranging block (RangingBlockIndex=0) with the responder, the initiator shall set the value of the field Time\_Offset to the time difference between the end of the SOR packet and the beginning of the first ranging block. To enable synchronized switching of NB channels the initiator shall set the value of NB\_Channel\_Seed. The responder shall apply the provided value to calculate the NB channel index used during the first and all following ranging blocks via the function defined in subsection 1.5.3.

Alternatively, the same procedure can be applied using public addresses (PUBLIC-ADV-POLL, PUBLIC-ADV-RESP, PUBLIC-ADV-SOR).

* + 1. Ranging session configuration

Before an NBA-UWB MMS ranging session is started, the ranging block structure and the ranging cycle are configured. Unless set up during ranging setup (1.2.2.2), or by the next higher layer, the default parameters shall be applied to the ranging session configuration. During an NBA-UWB MMS ranging session, some parameters of the ranging block structure and the ranging cycle may be updated by the next higher layer. For each parameter update, the next higher layer shall indicate the index of a future ranging block when the new parameters become effective. How the next higher layers of an initiator and a responder synchronize the parameters and the effective time is beyond the scope of this standard.

An initiator and a responder shall use the parameters which are set or updated by the next higher layers as the long-term operating parameters.

An initiator may override the long-term operating parameters of a ranging cycle by indicating a new set of short-term parameters during the control phase. The short-term parameters only affect the current ranging cycle. The long-term operating parameters resume being in effect on the next ranging cycle unless overridden again during the next control phase.

A responder may request short-term operating parameters for the next ranging cycke during the control phase. The initiator may serve the responder’s request in the next ranging cycle or ignore the request.

Table 1.2.3.1, Table 1.2.3.2, and Table 1.2.3.3 illustrate the NBA-UWB MMS ranging session general parameters, block structure parameters, and the ranging cycle parameters, respectively.

| Parameters | Value range/options | Default value | Description |
| --- | --- | --- | --- |
| Initialization channel | NB: 0-249 | 2 | NB channel used for transmissions during initialization phase (see Table 1.6.3.1) |
| Control and report channel allowlist (*NbaChannelAllowList*) | NB: {0-249} | 3 | List of one, or more NB channels used for transmissions during control and report phase (see Table 1.6.3.1) |
| UWB ranging channel | 1-16 | 9 | UWB channel used for MMRS ranging sequence transmission |
|  |  |  |  |
| NB PHY  | #1 - #5 [1]#6: #1 with optional symbol-to-chip mapping#7: #4 with optional symbol-to-chip mapping#8: in-band NB configuration SFD signaling with mandatory symbol-to-chip mapping#9: in-band NB configuration SFD signaling with optional symbol-to-chip mapping | #1: 250k uncoded |  |
| NB Initialization PHY | NB PHY |  | PHY layer used for transmissions during initialization phase |
| NB Control phase PHY | NB PHY |  | PHY layer used for transmissions during control phase |
| NB Report phase PHY | NB PHY |  | PHY layer used for transmissions during report phase, if report phase is performed using 802.15.4 NB-O-QPSK, |
|  |  |  |  |
|  |  |  |  |
|  |  |  |  |
|  |  |  |  |

**Table 1.2.3.1 – NBA-UWB MMS ranging session general parameters (example)**

| Parameters | Value range/options | Default value | Description |
| --- | --- | --- | --- |
| Ranging block duration  |  | 1209600 (1008ms) | RSTU |
| Ranging round duration |  | 16800 (14ms) | RSTU |
| Ranging slot duration | N\*300 | 600 (0.5ms) | RSTU |

**Table 1.2.3.2 – NBA-UWB MMS block structure parameters (example)**

| Phases | Parameters | Value range/options | Default value | Description |
| --- | --- | --- | --- | --- |
| Control phase  | *RcpPollSlot* | 1-16 slots | 2 (1ms) | slots |
| *RcpResponseSlot* | 1-16 slots | 2 | slots |
| Ranging phase | Number of RSF fragments (X in [1]) | 0, 1, 2, 4, 8, 16  | 8 |  |
| Number of RIF fragments (Y in [1]) | 0, 1, 2, 4, 8 | 0 |  |
| *RpDuration* | 0-4096 slots | 20 (10ms) | slots |
| *RpRsfOffset* | 0-16 slots | 0 (0ms) | slots |
| *RpRifOffset* | 0-16 slots | 4 (2ms) | slots |
| MMRS code index | 9-32 (Ipatov), 33-48 (Complementary Set) | 33 |  |
| MMRS complementary set zeros | 0-64 | 64 |  |
| STS segment length in RIF in 512-chip units | 32, 64, 128, 256 | 64 |  |
| MMRS symbol repetition in RSF (N\_MSR) | 32, 40, 48, 64, 128, 256 | 40 |  |
| Report phase | Report mode | Uni-directional initiator only, uni-directional responder only, bi-directional | Bi-directional |  |
| *MrpFirstSlot* | 0-16 slots | 2 slots | 0: Report is carried out by higher layer function |
| *MrpSecondSlot* | 0-16 slots | 2 slots | 0: Report is carried out by higher layer function |
|  |  |  |  |

**Table 1.2.3.3 – NBA-UWB MMS ranging cycle parameters (example)**

* 1. Coordination

For the discovery of UWB sessions nearby and the avoidance of collision driven by overlap of blocks, HRP-ARDEVs may use coordination method. The higher layers determines whether the coordination is active or not. If coordination is active, initiator opportunistically or periodically transmits acquisition packet (AP) with the information of UWB channel usage after a session is configured. The transmission of AP may start before the start of the first block. Initiator sends AP in either NB (NB AP) or UWB (UWB AP) or both. Initiator transmits NB AP in NB initialization channel and UWB AP in default UWB ranging channel described in Table 1.2.3.1. NB AP is described in 1.7.1 and UWB AP is described in 1.7.2. To provide the information of UWB channel usage, both NB AP and/or UWB AP include UWB Per-Session Info Fields described in 1.7.3. The higher layer determines the suitable interval between APs.

If coordination is active, before starting a new session, initiator scans the initialization channel of NB and/or the default ranging channel of UWB for receiving NB AP and/or UWB AP. The length of period for scanning is implementation specific. Initiator obtains the information of UWB channel usages from the received APs from other initiators.

With the knowledge of UWB channel usages by other sessions, initiator may select the values for configuring its new session. The selected values minimize the overlap of active periods between other sessions nearby. The actions on operations, e.g., selection of the values, on information received from AP(s) are implementation specific.

Otherwise, Initiator starts control phase without scanning nearby AP(s).

* 1. NBA-UWB MMS bands and channels
		1. Overview

The spectrum for NB access is located in the UNII-3 and UNII-5 bands at 5725-5850 MHz and 5925-6425 MHz. Both the UNII-3 and the UNII-5 bands are used in coexistence with 802.11 and other radio technology. Since the occupied bandwidth of the O-QPSK NB radio is less than 2.5 MHz, up to 50 NB channels can be allocated for NBA-UWB in the UNII-3 band. Up to 200 NB channels can be allocated in the UNII-5 band. The arrangement of 802.11 channels and NB channels is shown in the following Figure 1.4.1.1.

 

**Figure 1.4.1.1 – NB channels UNII-3, UNII-5**

The center frequencies *fn* for the NB channels 0 <= n <= 249 are defined as

$$f\_{n}=5726.25 MHz+n×2.5 MHz, \left(0\leq n\leq 49\right), in the UNII-3 band,$$

and

$$f\_{n}=5926.25 MHz+\left(n-50\right)×2.5 MHz, \left(50\leq n\leq 249\right), in the UNII-5 band.$$

The HRP-ARDEVs may configure all channels 0-249, or an arbitrary subset of channels 0-249 to be included in the *NbaChannelAllowList* as described in section 1.5.2. The HRP-ARDEVs may use the channel switching mechanisms described in section 1.5.3 with the resulting list of allowed channels.

* + 1. NBA listen before talk (LBT)

If LBT is required before a transmission in the corresponding operating band, or LBT is implemented for coexistence with IEEE 802.11 in a frequency band where regulations do not require LBT, then a transmitter shall perform LBT in advance of the start of the expected transmission. If the performed LBT cannot warrant the transmission at the beginning of the ranging slot, the transmitter shall not commence the transmission.

NB radios qualify as frame-based equipment (FBE) according to [3] with a fixed frame period (FFP). In accordance with 4.3.6 [3], the NB radio shall perform a CCA for at least 9 µs before any attempt to transmit in the allocated NB channel and ranging slot. The energy detection threshold (EDT) for CCA shall be considered as -75dBm/MHz in accordance with 4.4.6.3.3 [3]. After completing the CCA, if the channel is assessed as clear, the NB radio shall start transmission no later than 16 µs after completing the CCA. If the channel is assessed as occupied, the radio shall skip NB transmission for the current ranging block. The following figure shows the application of CCA for a two-sided packet exchange in two consecutive ranging slots between the initiator and responder, as needed during control phase. The LBT scheme is depicted in Figure 1.4.2.1.



**Figure 1.4.2.1 – NB LBT**

LBT shall be applied to NB channels 50-249 according to regulatory constraints. LBT may be applied to all NB channels 0-249 in the absence of regulatory constraints, for example, to improve QoS and coexistence with other shared spectrum radio, like IEEE 802.11.

* 1. NBA-UWB MMS channel switching
		1. Overview

NBA-UWB aggregates different properties of narrowband and UWB radio PHYs and application of the MAC protocols in shared spectrum in coexistence with 802.11 PHY and MAC. Since NB communication uses only a fraction of the available spectrum for transmission, a frequency diversity achieving method is defined here to ensure robust NB access and mitigate the impact of NB fading.

Section 1.5.2 defines a list-based mechanism to coordinate a set of NB channels that can be used by the initiator and the responder for NB channel access. Section 1.5.3 defines a mechanism to dynamically switch among the coordinated NB channels between successive ranging blocks.

Depending on the NB channel in use, band specific regulatory rules may apply. Section 1.4.2 defines the LBT protocol to be applied for NB channels 0-49 (UNII-3), and NB channels 50-249 (UNII-5). The LBT protocol shall be applied by initiator and responder independently in each transmission slot, even if the same channel is used consecutively.

* + 1. NBA channel lists

If a subset of the 250 NB channels is known to be unavailable, unusable, or deemed inefficient to be used, the initiator can mark the channels as blocked from the beginning of an NBA-UWB MMS session. For example, the initiator may be additionally equipped with an 802.11 radio and engaged in concurrent radio transmissions with other devices via known WLAN channels. In this case the initiator may deem it favourable to exclude the conflicting set of channels being used for WLAN. The list may be updated later on during the NBA-UWB MMS session.

The initiator can send the list of allowed channels *NbaChannelAllowList* to the responder in the format of *NbaChannelMap* as follows:

From Figure 1.3.1.1, the NB channels can be categorized as 802.11-non-occupied channels and 802.11-occupied channels. For the 802.11-occupied channels, it is efficient to indicate usable or unusable in a group manner to reduce the overhead. For example, one bit indicates one 802.11 20MHz channel, equivalent to eight 2.5MHz NB channels. *NbaChannelMap* is a compact format, which contains five parts: 802.11-non-occupied channels in the UNII-3 band, 802.11-occupied channels in the UNII-3 band, 802.11-non-occupied channels in the UNII-5 band, 802.11-occupied channels in the UNII-5 band, scaling factor.

The following table defines range and length of the necessary attributes:

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Attribute** | **Type** | **Range** | **Description** | **Default** |
| *NbaChannelMap* |  | 6 octets | Exchanged between the initiator and the responder to indicate *NbaChannelAllowList*Bits 0-3: NB channels 0-3Bits 4-9: 802.11 20MHz channels (UNII-3) 149,153,157,161,168,169Bits 10-17: NB channels 50-57Bits 18-41: 802.11 20MHz channels (UNII-5) 1, 5, 9,…,93Bits 42-47: Scaling Factor |  |
| *NbaChannelAllowList* | List | — | List of channels enabled for NB switching. | (f\_0,…,f\_249) |
| *NbaChannelAllowListLength* | Integer | 0-250 | Number of allowed channels. | 250 |
|  |  |  |  |  |
| *NbaUwbPrngSeed* | Integer | 0-255 | Seed value for channel switching function  | 0 |

**Table 1.5.2.1 – NB channels UNII-3, UNII-5**

After acquiring an allowed list *NbaChannelAllowList* from the initiator, the responder shall employ this list to assign a NB channel to each ranging block, ranging round, or ranging slot with the mechanism defined in section 1.5.3.

* + 1. NBA channel switch protocol

To accommodate the requirements of synchronised network access, randomness of channel choice, and statistical dependence of interference between neighbouring channels the following switching protocol for NB channels is defined.

The switching protocol is based on the ranging configuration in terms of the allowed list of NB channels *NbaChannelAllowList*, the pseudo-random number generating function *NbaUwbPrngFunction,* and the corresponding seed value *NbaUwbPrngSeed*.

*NbaUwbPrngFunction=*AES-128-ECB(*key*, *data*) function in counter mode [2] shall be used as the PRNG, where *key*=*NbaUwbPrngSeed,* and *data=RangingBlockIndex*.

The least significant 32 bits of the output of the PRNG are then calculated and as

*PrngValue = NbaUwbPrngFunction*(*NbaUwbPrngSeed*, *RangingBlockIndex*) mod 232

and shall then be further mapped to the NB channel via the allowed list of channels as

*SelectedChannel = NbaChannelAllowList*[*PrngValue* mod *NbaChannelAllowListLength*],

where mod is the integer modulus operator.

The mapping function is calculated independently by both the initiator and the responder based on the values defined in Table 1.5.2.1 that have been established during setup phase.

* 1. NBA-UWB MMS control channel messages
		1. Overview
		2. PSDU formats

When NB is used for control, report, and initialization messages, the compressed PSDU format defined in section 1.6.3 shall be used. Other PHYs but the ones specified in [1] may differ in PSDU format.

* + 1. Compressed PSDU format

The compressed PSDU format only contains a 1-octet header that conveys the message ID. All remaining PSDU content is message specific to the message ID. The following table presents the messages used during initialization, setup, control, and report phases in compressed PSDU format.

Compressed PSDU messages may be encapsulated as header IE type 0x2d data.

…

***Change the row for Element ID “0x2d–0x7d” in Table 7-7 and insert a new row above it as follows (unchanged rows not shown):***

**Table 7-7—Element IDs for Header IEs**

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Element ID**  | **Name**  | **Enhanced Beacon**  | **Enhanced ACK**  | **Data**  | **Multipurpose**  | **MAC command**  | **Format subclause**  | **Use description**  | **Used by**  | **Created by**  |
| **…** |
| 0x2d | MMS Ranging Compressed PSDU Encapsulation IE |  |  | X |  |  |  |  | UL | UL |
| ~~0x2d~~0x2e– 0x7d  | Reserved |

…

* + - 1. Compressed PSDU messages

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|  |  |  |  |  |
| **Phase** | **Message Name** | **Octet 0 (Msg ID)** | **Octets 1-N [Len]** | **Description** |
| Initialization | ~~ADV-POLL~~ | ~~0x01~~ | ~~[RPA\_hash[3], RPA\_prand[3],MessageControl[1],MessageContent[],CRC16]~~ | ~~Adverising poll message used by initiator during initialization phase.~~~~MessageControl=0x00:MessageContent={LEN[1] ARRAY[]}~~~~Where LEN is the number of octets of ARRAY[], and ARRAY is the list of supported message control commands for ADV-RESP and SOR.~~~~MessageControl=0x01-0xff: Reserved~~  |
| ADV-RESP | 0x02 | [RPA\_hash[3], MessageControl[1],MessageContent[], CRC16] | Advertising response packet used by responder during initialization phase.MessageControl=0x00:MessageContent={NB Channel Select[2],UWB PHY Config[3],UWB MAC Config[2],NB PHY Config[1],NB MAC Config[7]}MessageControl=0x01-0xff: Reserved |
| SOR | 0x03 | [RPA\_hash[3], MessageControl[1],MessageContent[],CRC16] | Start of ranging packet used by initiator during initialization phase.MessageControl=0x00:MessageContent={Time Offset[4],NB Channel Seed[1],NB Channel Select[2],UWB PHY Config[3],UWB MAC Config[2],NB PHY Config[1],NB MAC Config[7]}MessageControl=0x01-0xff: Reserved |
| ADV-CONF | 0x08 | [RPA\_hash[3], MessageControl[1],MessageContent[],CRC16] | Advertising confirmation packet used by initiator during initialization phase.MessageControl=0x00:MessageContent={SOR Time Offset [4]}MessageControl=0x01-0xff: Reserved |
| ~~PUBLIC-ADV-POLL~~ | ~~0x21~~ | ~~[AdvAddr[3],MessageControl[1],MessageContent[],CRC16]~~ | ~~Public Advertising poll message used by initiator during initialization phase for public advertisement purpose.~~~~MessageControl=0x00:MessageContent={LEN[1] ARRAY[]}~~~~Where LEN is the number of octets of ARRAY[], and ARRAY is the list of supported message control commands for PUBLIC-ADV-RESP and PUBLIC-SOR.~~~~MessageControl=0x01-0x19: Reserved~~ ~~MessageControl=0x20:MessageContent={LEN[1],ARRAY[],RandomDelay[1],~~~~AdvData[]}~~~~Where LEN is the number of octets of ARRAY[], and ARRAY is the list of supported message control commands for PUBLIC-ADV-RESP and PUBLIC-SOR.~~~~Where AdvData is the sequence of AD structure which shall have Length, Type and Value.~~~~MessageControl=0x21-0xff: Reserved~~ |
| ~~PUBLIC-ADV-RESP~~ | ~~0x22~~ | ~~[AdvAddr[3],RespAddr[2], MessageControl[1],MessageContent[], CRC16]~~ | ~~Public Advertising response packet used by responder during initialization phase.~~~~MessageControl=0x00:MessageContent={NB Channel Select[2],UWB PHY Config[3],UWB MAC Config[2],NB PHY Config[1],NB MAC Config[7]}~~~~MessageControl=0x01-0xff: Reserved~~~~AdvAddr is destination address and RespAddr is source address~~ |
| ~~PUBLIC-SOR~~ | ~~0x23~~ | ~~[AdvAddr[3], RespAddr[2],MessageControl[1],MessageContent[],CRC16]~~ | ~~Public Start of ranging packet used by initiator during initialization phase.~~~~MessageControl=0x00:MessageContent={Time Offset[4],NB Channel Seed[1],NB Channel Select[2],UWB PHY Config[3],UWB MAC Config[2],NB PHY Config[1],NB MAC Config[7]}~~~~MessageControl=0x01-0xff: Reserved~~~~AdvAddr is source address and RespAddr is destination address~~ |
|  |  |  |  |  |
| Control | POLL | 0x04 | [RPA\_hash[3], RPA\_prand[3], MessageControl[1],MessageContent[],CRC16] | A qualifying poll message. MessageControl=0x00:MessageContent={0x00, 0x00}MessageControl=0x01-0xff: reserved |
| RESP | 0x05 | [RPA\_hash[3], MessageControl[1],MessageContent[],CRC16] | A qualifying response message.MessageControl=0x00:MessageContent={0x00, 0x00, 0x00, 0x00, 0x00}MessageControl=0x01-0xff: reserved |
| POLL-SPN | 0x24 | [RPA\_hash[3], RPA\_prand[3],MessageControl[1],MessageContent[],CRC16]  | A poll message carrying short-term operating parameters for the current ranging cycle and/or a request of suggested short-term operating parameters for the next ranging cycle.MessageControl=0x00:MessageContent={0x00, 0x00, NbaChannelMap[6], UWB PHY Config[3],UWB MAC Config[2],NB PHY Config[1],NB MAC Config[7],Request Bitmap[1]}, where at least one of NbaChannelMap, UWB PHY Config, UWB MAC Config, NB PHY Config and NB MAC Config fields is present.MessageControl=0x01-0xff: reservedAfter receiving the NbaChannelMap*,* NB PHY config, NB MAC config, UWB PHY Config and/or UWB MAC configfrom the initiator, the responder shall update NbaChannelAllowList, NB PHY configuration, NB MAC configuration, UWB PHY configuration and/or UWB MAC configuration.See Table 1.5.2.1 for NbaChannelMap definition |
| RESP-SPN | 0x25 | [RPA\_hash[3], MessageControl[1],MessageContent[],CRC16] | A response message carrying the suggested short-term operating parameters for the next ranging cycle. MessageControl=0x00:MessageContent={0x00, 0x00, 0x00, 0x00, 0x00, NbaChannelMap[6], UWB PHY Config[3],UWB MAC Config[2],NB PHY Config[1]}, where at least one of NbaChannelMap, UWB PHY Config, UWB MAC Config and NB PHY Config fields is present.MessageControl=0x01-0xff: reserved. |
| ~~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 access slots that are not the first one.~~~~MessageControl = 0x10: MessageContent={Number of Responders[1], SlotsPerResponder[1], List of Responder Address[3]}~~~~MessageControl = 0x20: MessageContent={Number of Responders[1], SlotsPerResponder[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 = 0x10, but both Initiator and Responder send the measurement report~~~~MessageControl = 0x50: MessageContent={NumberOfAccessSlots[1], SizeOfAccessSlots[1]}~~~~MessageControl = 0x60: Same as MessageControl = 0x50, but the Response frame and Poll frame in NB is switched~~~~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 initiator) | 0x06 | [RPA\_hash[3],MessageControl[1],MessageContent[],CRC16] | A qualifying report message.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. |
| REPORT(from responder) | 0x07 | [RPA\_hash[3],MessageControl[1],MessageContent[],CRC16] | A qualifying report message.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-SPN (from responder)~~ | ~~0x27~~ | ~~[RPA\_hash[3],~~ ~~MessageControl[1],~~~~MessageContent[],~~~~CRC16]~~ | ~~A qualifying report message carrying the suggested short-term operating parameters for the next ranging cycle.~~~~MessageControl=0x00:MessageContent={ReplyTime[5],PTDataLength[1],PTData[PTDataLength],~~~~NbaChannelMap[6],~~ ~~UWB PHY Config[3],UWB MAC Config[2],NB PHY Config[1]}, where PTDataLength and PTData fields are optionally present and represent pass through data to higher layers; and at least one of NbaChannelMap, UWB PHY Config, UWB MAC Config and NB PHY Config fields is present.~~~~MessageControl=0x01-0xff: reserved~~ |
| ~~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.~~ |
|  | ~~Reserved~~ | ~~0x7f-0xff~~ | ~~Vendor specific~~ | ~~Reserved for 128x256 PSDUs with 2-byte message ID~~ |

* + - 1. Compressed PSDU message fields

|  |  |  |
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|  |  |  |
|  |  |  |
| **Field name** | **Length in bits** | **Description** |
| CRC16 | 16 | 2-octet FCS defined in 7.2.11 |
| RPA\_hash | 24 | = AES-128-ECB(key=IdentityResolvingKey, data=RPA\_prand]) % 2^24where PublicAddress may be an 802.15.4 MAC source/destination address and/or PAN ID, or an address set by a higher layer.(input MSBs zero-padded) |
| RPA\_prand | 24 | Static during one ranging block, at least |
| MessageControl | 8 | Control over MessageContent defined in Table 1.6.3.1. |
| MessageContent | var | Content controlled by MessageID and MessageControl on per message basis |
| PTDataLength | 8 | Number of octets in PTData, up to 32 bytes. |
| PTData | PTDataLength\*8 | Optional data passed through to next higher layer  |
| NB Channel Select | 16 | Bits 0-1: UNII-3 border channel exclusion {0, 1, 3, 7}: Number of NB channels excluded from NBChannelAllowList counting from both lower and upper border of UNII-3 channels 0-49Bits 2-4: UNII-5 low-side channel exclusion {0, 1, 3, 7, 15, 31, 63, 127}: Number of NB channels excluded from NBChannelAllowList counting from lower border of UNII-5 starting at channel 50.Bits 5-7: UNII-5 high-side channel exclusion {0, 1, 3, 7, 15, 31, 63, 127}: Number of NB channels excluded from NBChannelAllowList counting from upper border of UNII-5 starting at channel 249Bits 8-12: low-side channel start offset (0-31): Number of NB channels excluded from NBChannelAllowList, extending on the exclusion signaled, counting from the lowermost included channels included after bits 0-4. Applies to both UNII-3 and UNII-5.Bits 13-15: Channel skip length {0, 1, 3, 7, 15, 31, 63, 127}: Number of channels periodically excluded after each first allowed channel following bits 0-12 |
| UWB PHY Config | 24 | Bits 0-5: Preamble Code Indexes {9, …, 48}if (9 <= Preamble Code Index <= 32) { Bits 6-12: Reserved} elseif (33 <= Preamble Code Index <= 48) { Bits 6-12: MMRS complementary set zeros {0, …, 64}}Bits 13-15: N\_MSR {32, 40, 48, 64, 128, 256}Bits 16-17: STS Segment Length x512 {32, 64, 128, 256}Bits 18-21: UWB channel 1-16Bits 22-23: Reserved |
| UWB MAC Config | 8 | Bits 0-2: {0,1,2,4,8,16} X RSFsBits 3-5: {0,1,2,4,8} Y RIFsBits 6: {1ms/2ms} Z RSF-to-RIF gapBits 7: reserved |
| NB MAC Config | 56 | Bits 0-2: Ranging Slot Duration {300, 600, …, 2400} RSTUsBits 3-10: Ranging Round Duration 0-255 ranging slotsBits 11-18: Ranging Block Duration 0-255 ranging roundsBits 19: Channel Switching: 0=Disabled, 1=BlockwiseBits 20: Measurement Report Request: 0=No, 1=YesBits 21-23: ReservedBits 24-27: RcpPollSlots=0-15Bits 28-31: RcpResponseSlots=0-15Bits 32-43: RpDuration=0-4095Bits 44-47: RpOffset=0-15Bits 48-51: MrpFirstSlots=0-15Bits 52-55: MrpSecondSlots=0-15 |
| Request Bitmap | 8 | Bit 0: NbaChannelMap requestedBit 1: NB PHY Config requestedBit 2: NB MAC Config requestedBit 3: UWB PHY Config requestedBit 4: UWB MAC Config requestedBits 5-7: reserved |
| Time Offset | 32 | Time offset in 1/499.2MHz resolution between end of SOR packet and beginning of first POLL packet of starting ranging session. Range: 0 to ~8.6 seconds |
| SOR Time Offset  | 32 | Time offset in 1/499.2MHz resolution between end of ADV\_CONF packet and beginning of SOR packet Range: 0 to ~8.6 seconds |
| NB Channel Seed | 8 | 0-255: Sets key for switching function AES-128-ECB(key=Seed, …) referred to in section 1.4.3(input MSBs zero-padded) |
| NB PHY Config | 8 | Sets O-QPSK PHY #1-#9 referring to [1]{#1: 250k uncoded, …, #9}Bits 0-3: NB Control PhaseBits 4-7: NB Report Phase |
| ~~AdvAddr~~ | ~~24~~ | ~~Random address for advertising~~~~It is changed periodically (e.g. every 5 min). AdvAddr shall be generated uniquely in a network and maintained during a session temporarily by an initiator~~~~For PUBLIC-ADV-RESP, AdvAddr is destination address and for PUBLIC-SOR, AdvAddr is source address~~ |
| ~~RespAddr~~ | ~~2~~ | ~~Responder address generated by a responder~~~~For PUBLIC-ADV-RESP, RespAddr is source address and for PUBLIC-SOR, RespAddr is destination address~~ |
| ~~RandomDelay~~ | ~~8~~ | ~~Range for waiting time of PUBLIC-ADV-RESP which is transmitted by a responder. The unit of Random Delay value is RSTU and Random value in range from zero to {Random Delay value - 1} can be created by a responder. This field is used to avoid collision in crowded environment~~ |
| ~~AdvData~~ | ~~var~~ | ~~AdvData contains a sequence of AD structures. Each AD structure shall have Length, Type and Value. The sequence is terminated when Length field is zero in an AD structure . AdvData may not exceed 16 bytes in PUBLIC-ADV-POLL.~~~~AdvData={AD Structure1,…,AD StructureN}~~~~Where AD Structure={LEN[1], Type[1],Value[]}~~~~The AD Structure may contain information which an initiator wants to announce such as service representation, friendly name, advertising interval, vendor specific and so on. It is omitted if there is no advertisement information~~ |

* 1. AP message for Coordination
		1. NB AP MAC Payload

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Field Name** | **Sub Field Name** | **Bits** | **Bytes** | **Description** |
| Common Info | NB AP Type | 3 | 1 | Indicate NB AP Type0: Periodic coordination NB AP, 1: aperiodic coordination NB AP, 2-7 : Reserved |
| Reserved | 5 | Reserved |
| UWB AP Present | 1 | 1 | If NB AP Type = 0 or 10: No UWB AP sent after each NB AP1: UWB AP sent after each NB APIf UWB AP Present = 1, then UWB AP Info Field is Present in the NB AP with NB AP Type = 0 or 1If UWB AP Present = 0, then UWB AP Info Field is NOT Present in the NB AP with NB AP Type =0 or 1 |
| Type of UWBPer-Session Info | 3 | If NB AP Type =0 or 10: No UWB Per-Session Info Field present in the NB AP1: UWB Per-Session Info Field Type 1 present in the NB AP2: UWB Per-Session Info Field Type 2 present in the NB AP3: UWB Per-Session Info Field Type 3 present in the NB AP |
| Reserved | 4 | Reserved |
| Next NB AP | 16 | 2 | Time remaining in RSTU until the start of the next NB AP. It is not present when the NB AP Type = 0 |
| UWB AP Info | Delta T | 16 | 2 | Time Remaining in RSTU until the start of the next UWB AP relative to the start of the current packet |
| UWB Channel | 5 | 1 | UWB channel number on which UWB AP occurs after Delta T |
| Reserved | 3 | Reserved |
| Preamble Code | 8 | 1 | Preamble code used by UWB AP |
| UWB Per-Session Info(s) | If NB AP Type=0 and UWB Per-Session Info Type is not zero, see 1.7.3 All UWB Per-Session Info Field included in a NB AP MAC Payload are of same type (to ease pairing) |

* + 1. UWB AP MAC Payload

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Field Name** | **Sub Field Name** | **Bits** | **Bytes** | **Description** |
| Common Info | UWB AP Type | 3 | 1 | Indicate UWB AP Type0: Periodic coordination UWB AP, 1: Aperiodic coordination UWB AP, 2-7: Reserved |
| Reserved | 5 | Reserved |
| Type of UWBPer-Session Info | 3 | 1 | If UWB AP Type =0 or 10: Reserved1: UWB Per-Session Info Field Type 1 present in the UWB AP2: UWB Per-Session Info Field Type 2 present in the UWB AP3: UWB Per-Session Info Field Type 3 present in the UWB AP |
| Number of UWB Per Session Info | 4 | Number of Per-Session Info Field(s) |
| Reserved | 1 | Reserved |
| Next UWB AP | 16 | 2 | Time remaining in RSTU until the start of the next UWB AP. It is not present when the UWB AP Type = 0 |
| UWB Per-Session Info(s) | If UWB AP Type=0 and UWB Per-Session Info Type is not zero, see 1.7.3 If UWB Per-Session Info Field(s) are included in both NB AP and UWB AP, then ensure the order of UWB Per-Session Info Field(s) is identical  |

* + 1. UWB Per-Session Info

UWB Per-Session Type = 1 is described in

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Field Name** | **Sub Field Name** | **Bits** | **Bytes** | **Description** |
| UWB Per-Session Info(s) | Block Duration | 24 | 3 | In RSTU (Ranging Scheduling Time Unit) |
| Session CH  | 5 | 1 | UWB CH used by session |
| Hop Mode | 1 | 0: no hopping; 1: hopping. Hopping sequence NOT required to be known to all devices |
| Reserved | 2 | Reserved |
| Preamble Code | 8 | 1 | Preamble code used by session |

UWB Per-Session Type = 2 is described in

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Field Name** | **Sub Field Name** | **Bits** | **Bytes** | **Description** |
| UWB Per-Session Info(s) | Delta T | 24 | 3 | Time remaining in RSTU until the start of active period  |
| UWB CH | 5 | 1 | UWB channel used by the UWB session  |
| Reserved | 3 | Reserved |
| Preamble Code | 8 | Preamble code used by UWB session |
| Active Period Duration | 24 | 3 | Duration of active period of UWB session  |

UWB Per-Session Type = 3 is described in

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Field Name** | **Sub Field Name** | **Bits** | **Bytes** | **Description** |
| UWB Per-Session Info(s) | Delta T | 24 | 3 | Time remaining in RSTU until the start of block |
| UWB CH  | 5 | 1 | UWB CH used by session |
| Hop Mode | 1 | 0: no hopping; 1: hopping. Hopping sequence NOT required to be known to all devices |
| Reserved | 2 | Reserved |
| Preamble Code | 8 | 1 | Preamble code used by session |
| Round Duration | 24 | 3 | Round duration in a block of UWB session  |
| Number of Rounds in a Block | 8 | 1 | In units of rounds |
| Active Rounds | 24 | 3 | Bitmap indicates the index of active rounds |

* 1. References

[1] 15-23-0100-02-04ab-nba-uwb-technical-framework-proposal, March 2023.

[2] SP 800-38A Recommendation for Block Cipher Modes of Operation: Methods and Techniques”, National Institute of Standards and Technology (NIST), December 2001.

[3] ETSI EN 303 687 Draft 1.0.0, April 2022.