CCA Modes in 802.15.4

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Authors:

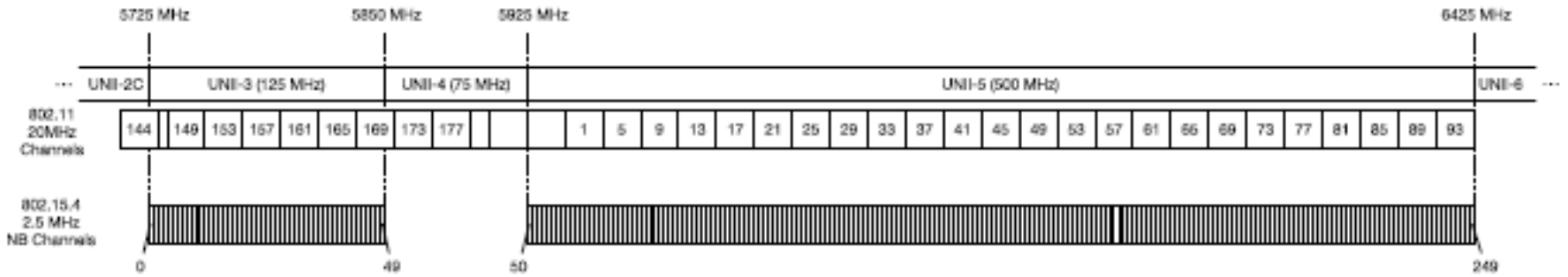
Name	Affiliations	Address	Phone	email
Carlos Aldana	Meta Platforms	1 Hacker Way, Menlo Park, CA 94025		caldana@meta.com

Abstract

This submission provides a background on 802.15.4ab NB modes, reviews the CCA Modes in 802.15.4me Draft 3, and deferred comments.

Background on NB Frequencies

- **802.15.4ab defines 250 total NB channels in UNII-3 (50) and UNII-5 (200)**



$f_c = 5726.25 + k \times 2.5$ in megahertz for $k = 0, \ldots, 49$

$f_c = 5926.25 + (k - 50) \times 2.5$ in megahertz for $k = 50, \ldots, 249$

where k is the channel number.

Background: No-LBT Data Transmission using NB (10.43)

10.43 UWB data offload to narrowband

10.43.1 Introduction

Given the combination of UWB with a narrowband radio for the narrowband assisted (NBA) MMS ranging specified in 10.38, the narrowband radio may also be useful as a data transport in situations where the UWB channels are congested. How the coordinating and enabling NB data communications is accomplished is beyond the scope of this standard and up to the implementer. Out-of-band signaling and/or custom messages may be used for this.

10.43.2 Operation

The initiator may transmit an NB allocation packet during the measurement report phase followed by the ranging phase. The NB allocation packet shall include an NB Allocation IE (defined in 10.43.3.1) to responder(s). After the ranging phase, ERDEVs are scheduled in the measurement phase to exchange the required information for NB data communications. In the example Figure 168, the initiator sends an NB allocation packet including the NB Allocation IE with NB channel and offset to responder for starting NB data communication during measurement phase.

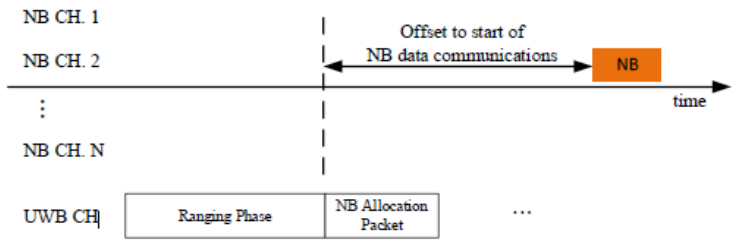
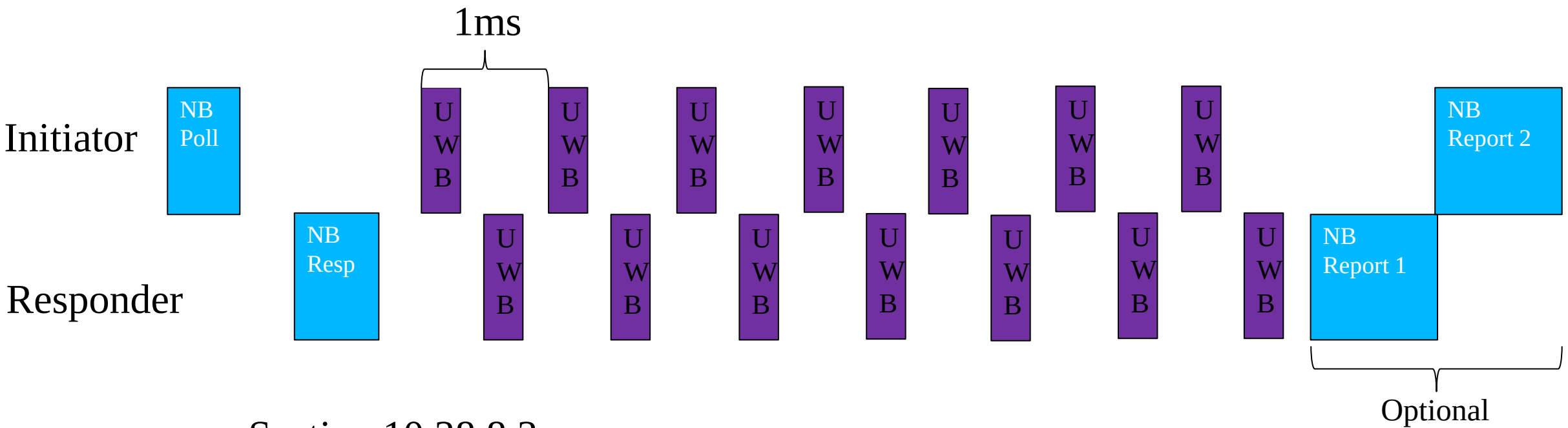


Figure 168—Example of NB data communication triggered by NB Allocation IE packet

At the end of time offset, initiator shall transmit NB packet on the allocated NB channel. The responder may listen for incoming NB packet. Once the responder has received NB packet, it may transmit NB packet.

Background: NBA-MMS (10.38) with optional LBT



Section 10.38.8.3

LBT shall be applied to channel numbers 50 to 249 according to regulatory constraints. LBT may be applied to all channels in the absence of regulatory constraints, for example, to improve coexistence with other spectrum users. The LBT protocol shall be applied by initiator and responder independently in each transmission slot, even if the same channel is used consecutively.

6 CCA Modes in 802.15.4me-D03

11.2.8 Clear channel assessment (CCA)

With the exception of the HRP UWB PHY, a compliant PHY shall provide the capability to perform CCA according to at least one of the following methods:

- *CCA Mode 1: Energy above threshold.* CCA shall report a busy medium upon detecting any energy above the ED threshold.
- *CCA Mode 2: Carrier sense only.* CCA shall report a busy medium only upon the detection of a signal compliant with this standard with the same modulation and spreading characteristics of the PHY that is currently in use by the device.
- *CCA Mode 3: Carrier sense with energy above threshold.* CCA shall report a busy medium using a logical combination of:
  - Detection of a signal with the modulation and spreading characteristics of this standard
  - Energy above the ED threshold, where the logical operator may be AND or OR
- *CCA Mode 4: ALOHA.* CCA shall always report an idle medium.

An HRP UWB PHY shall implement one CCA Mode 1 through CCA Mode 4 or one of the following methods:

- *CCA Mode 5: HRP UWB preamble sense based on the SHR of a frame.* In this mode, the CCA shall operate to detect the UWB preamble as specified in 16.2.6 and selected by the *phyCurrentCode*. The device shall spend at least its normal operational preamble detection time looking for this preamble before reporting an idle medium in the case where no preamble is detected. In the case where the preamble is detected, the CCA shall report a busy medium, and thereafter, shall not report an idle medium until a period has elapsed that is not shorter than the time required at the current network operational data rate and PSR, (e.g., as specified by the DataRate and UwbPreambleSymbolRepetitions parameters of the MCPS-DATA.request), to complete the transmission of a frame of 127 octets, or 1023 octets for the HRP-ERDEV in the HPRF mode, and to receive its acknowledgment.
- *CCA Mode 6: HRP UWB preamble sense based on the packet with the multiplexed preamble as specified in 16.6.* CCA shall report a busy medium upon detection of a preamble symbol as specified in 16.2.6.

Additional Text in Section 11.2.8 in 802.15.4me D03

- CCA mode 4 would typically be used in low duty cycle applications.
- The PHY PIB attribute *phyCcaMode*, as described in 12.3.2, shall indicate the appropriate operation mode. The CCA parameters are subject to the following criteria:
  a. Unless otherwise specified in this standard for the PHY being used, the ED threshold shall be *phyCcaEdThreshold*.
  b. The CCA detection time shall be equal to *phyCcaDuration*, as defined in Table 12-2.

CCA Mode, CCA Duration and ED Threshold in Table 12-2

phyCcaMode	Integer	1–6	The CCA mode, as defined in 11.2.8.

phyCcaDuration	Integer	0–1000000	The duration for CCA, specified in microseconds. If the recommeded value is not specified by the PHY clause the recommended duration of 8 symbols is used.

phyCcaEdThreshold	Implementation dependent	Implementation dependent	Threshold value for energy above threshold used in CCA. Typically specified in units of power, e.g. dBm, relative to a given frequency bandwidth, for example at most 10 dB greater than the specified receiver sensitivity for that PHY,

Deferred Comments on 802.15.4me

Carlos Aldana	Meta Platforms	caldana@meta.c	608	11.2.8	18	To aid in testing and predictable behavior, there should be more details as to the behavior of CCA mode 1.	Please add language to CCA mode 1 to reflect 3 additional requirements: max ED Threshold value to use (e.g. -80 dBm/MHz) , CCA listen duration (e.g. 9 us), and a probability of success (e.g. 95%).			
Carlos Aldana	Meta Platforms	caldana@meta.c	613	12.3.2	2	The minimum value of phyCcaDuration should be non-zero. Consider setting the minimum value to 9 us.	As in comment.	Technical	Yes	
Carlos Aldana	Meta Platforms	caldana@meta.c	613	12.3.2	2	There should at least be an upper bound for the phyCcaEdThreshold to prevent abusive behavior. Lack of an upper bound allows for "no-CCA" behavior, which is undesirable. Please add an upper bound (e.g. -80dBm/MHz in ETSI EN 300 440)	As in comment.	Technical	Yes	

References

- P802-15-04me-D03.pdf
- P802.15.4ab-pre-ballot-C.pdf
- IEEE 802.15-23/243r2 (NB Assisted Data Communications)
- IEEE 802.15-22/381r5 (NBA-UWB MMS Ranging Text Proposal for 15.4ab)
- IEEE 802.11-23/1259r1
- IEEE 802.11-24/130r0
- IEEE 802.11-24/148r0
- IEEE 802.11-23/1279r0
- IEEE 802.15-21/593r2
- IEEE 802.15-21/292r0

Appendix

CCA Text in 802.15.4ab

11.2.8 Clear channel assessment (CCA)

Change sub-paragraphs (a) and (b) at the end of subclause 11.2.8 as shown:

a) Except for the SUN O-QPSK PHY and when SSBD is being used, the ED threshold shall correspond to a received signal power of at most 10 dB greater than the specified receiver sensitivity for that PHY, or in accordance with local regulations. For the SUN O-QPSK PHY, the ED threshold shall comply with the specification in 22.5.13. When SSBD is being used, the ED threshold shall comply with the specification in 6.2.2.2.

b) Except when SSBD is being used, the CCA detection time shall be equal to phyCcaDuration, as defined in Table 12-2. When SSBD is being used, the CCA detection time shall comply with the specification in 6.2.2.2.

PhyCcaDuration in 802.15.4ab

Attribute	Type	Range	Description
phyCcaDuration	Integer	0–1000000	The duration for CCA, specified in μs. For the SUN PHYs other than SUN O-QPSK the default value is 8 symbol periods, as defined in 6.1. For the SUN O-QPSK PHY, default value is defined in Table 22-24. For all other PHYs, the default duration of 8 symbol periods, except when SSBD is being used in which case clause 6.2.2.2 specifies the CCA detection time.

SSBD Text (6.2.2.2)

6.2.2.2 Spectrum sensing based deferral (SSBD)

For applications where the channel access latency needs to be bounded, the SSBD channel access method is provided. The key elements of SSBD include:

The duration of sensing the channel during CCA is defined by the *macSsbdCcaDuration* attribute.

Deferral on CCA busy is provided, with random delay and a linear back-off to bound the channel access latency.

To provide for bounding channel access latency, after a configurable number of CCA attempts the algorithm may revert to unslotted Aloha and proceed as if the channel is idle and continue with transmission of the frame (i.e., as if CCA Mode 4 was used).

Conflict resolution by enlarging backoff window after unsuccessful packet transmission.

SSBD may be used for channel access where bounding latency in the channel access is desired. SSBD is optional in all device types. SSBD may be used for unscheduled random access or with one of the scheduled access schemes. SSBD employs channel sensing using CCA and bounded deferral using linearly growing random backoff at each deferral.

The timing and behavior of SSBD is controlled by the *macSsbdMinBf*, *macSsbdMaxBf*, , *macSsbdMaxBackoffs*, and *macSsbdTxOnEnd* attributes. Figure 1 illustrates the steps of the SSBD algorithm. When the algorithm ends in "Success" the MAC shall commence transmission of the frame, otherwise the algorithm terminates with a channel access failure.

macSsbdCcaDuration	Integer	1–31	CCA Duration in microseconds	9

One-to-many Ranging in 802.15.4ab

Below is an example where the many responders send reports so that initiator computes the TOF.

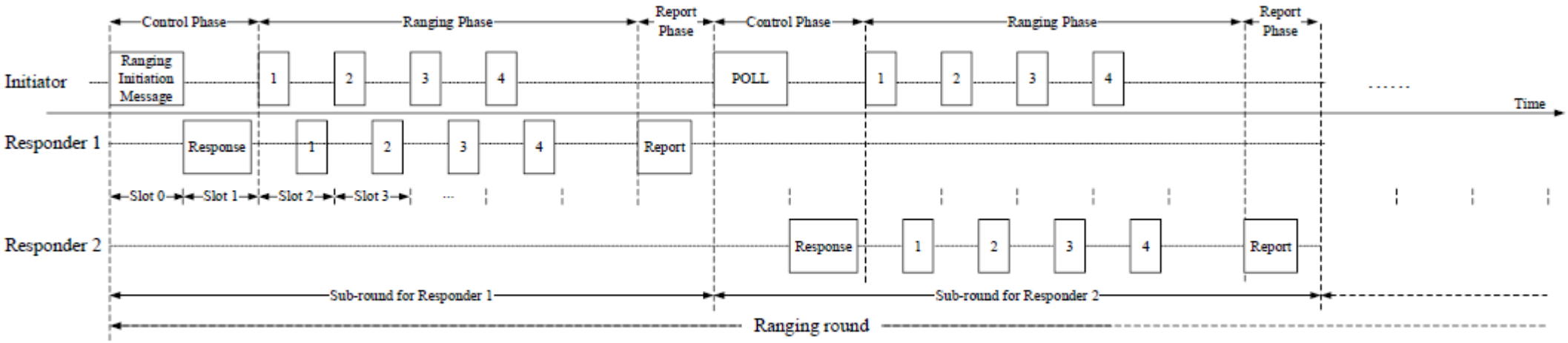


Figure 37—Illustration of one-to-many MMS ranging