**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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1. Narrowband assisted Ultrawideband (NBA-UWB)

## Introduction

In this document, we would like to provide a skeleton for narrow-band assisted UWB (NBA-UWB) that will be developed into a draft. This is a live document that will evolve over time. All contributions and suggestions are welcome.

There are two main sections: One focuses on MAC aspects of various features that rely on NBA-UWB, and the other one develops the PHY level aspects required to support the features introduced in the MAC section.

## MAC

NBA-UWB can be viewed as an umbrella feature that comprises several semi-independent features. All these features share some common principles among which the most important one is that there is a tight clock synchronization between NB and UWB. It is desirable that both PHYs are driven by the same clock so that there is no extra work need to determine relative accuracy. Otherwise, there should be an explicit requirement on the relative clock drift/accuracy between different PHYs/radios. Such a tight coupling between NB and UWB opens a plethora of opportunities for UWB. So far, we have seen contributions for the following features:

* Mirroring channel: A NB channel can be used for discovery and control of UWB channel. NB radio can be used as pilot to provide an additional CCA mode for UWB to IEEE 802.15.4-2020.
* Multi-millisecond UWB (including secure MMS): In MMS-UWB, acquisition (CFO/SFO) as well as data-exchange are going to be offloaded to the NB PHY which will enable link budget improvement as well as time-of-flight (ToF) accuracy improvement.
* NBA-TDOA: Any ranging improvement will benefit downlink TDOA.
* NBA-Sensing: Multi-static sensing require data exchange for which NB could be useful.

There could be some common themes to be reused between these features as well as unique requirements of each one. Coexistence aspects of both NB and UWB are important to address; considering that NBA-UWB systems will often operate in dense multi-user scenarios. Relevant topics for the NB radio include duty-cycle optimization, channelization, frequency hopping and blocked channel list agreement. Ranging session definition and PHY level parameters must also be specified. The goal in MAC section is to provide a clean and generic baseline for as many use cases as possible. Each application could have slightly different requirements; therefore, instead of trying to find a one-fits-all solution, it is desirable to focus on the common denominator among applications of interest. This would also speed up the standardization efforts.

## PHY

PHY section aims to add and/or improve the relevant IEEE 802.15.4 PHY sections to enable the NBA-UWB based features outlined in the MAC section. Particularly, O-QPSK from Clause 12 of IEEE 802.15.4-2020, and UWB from Clause 15 of IEEE 802.15.4-2020 and the amendment 802.15.4z are going to cover the PHY aspects of NBA-UWB with some modifications and improvements.

### O-QPSK

O-QPSK from Clause 12 of IEEE 802.15.4-2020 provides a very good field-tested baseline for the NB aspects of UWB thanks to its good link budget and efficient implementation. The 250 kbps mode is the main workhorse given its relatively optimized air time. The improvements to this chapter are, but not limited to,

* addition of new bands UNII-3 and UNII-5
* channelization of these bands to enable frequency-hopping and different services
* air-time reduction options (reduced preamble length and increased data rate)
* clock accuracy requirements.

In terms of clock accuracy, the additional NB mode can align with the UWB. Per IEEE 802.15.4z, both the carrier frequency and the chip rate frequency of HRP UWB shall be derived from the same reference oscillator and shall have an accuracy of ± 20 ppm or better. There should be a similar optional mode for O-QPSK to better facilitate the NBA-UWB feature set.

### UWB

UWB PHY from Clause 15 of IEEE 802.15.4-2020 will be the starting point. The 802.15.4z amendment already introduced a no-data packet format to improve link budget. The multi-millisecond UWB can be seen an extension of this packet format to improve the link budget and ToF accuracy further. In this packet format, there will be short fragments that are separated by at least a millisecond and the overall packet will span over multiple fragments, hence the name multi-millisecond. The improvements to this Clause are, but not limited to,

* A preamble-only packet format that will enable efficient and fast CIR generation with multi-millisecond coherent combining.
* A mixed multi-millisecond packet format where each millisecond consists of either preamble-only fragments or fragments containing randomly modulated pulses, aimed at providing ranging integrity. The fragments of randomly modulated pulses will follow preamble-only fragments. The number of fragments of each type will be defined. Pulse randomization could be AES-128 based, as in the IEEE 802.15.4z-2020 amendment.