**IEEE P802.15**

**Wireless Specialty Networks**

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| Project | IEEE P802.15 Working Group for Wireless Specialty Networks (WSNs) – 802.15.6ma |
| Title | **Proposed resolution draft for LB212 – time reference base**  |
| Date Submitted | Mar. 11, 2025 |
| Source | Seong-Soon Joo (Nano HiTech) | E-mail: [ssjoo@etri.sci.kr] |
| Re: | Contribution to IEEE 802.15.6ma  |
| Abstract | This document provides a proposed text draft for resolving LB212 comment, CID 129, on MAC time reference base and superframe structure. |
| Purpose | Support development of technical content for the draft |
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Draft for

1. Overview
	1. Scope
2. Normative references
3. Definitions, acronyms, and abbreviations
	1. Definitions
4. General framework elements
	1. General
	2. Time base

All nodes and coordinators are to establish a time reference base, as shown in Figure 4, if their medium access is to be scheduled in time, where the time axis is divided into beacon periods (superframes) of equal length and each beacon period (superframe) is composed of allocation slots of equal length and numbered from *0, 1, ..., s,* where *s* ≤ 214*.* An allocation interval may be referenced in terms of the numbered allocation slot comprising it, and a point of time may be referenced in terms of the numbered allocation slots preceding or following it as appropriate.



1. —Time reference base

If time reference is needed for access scheduling in its BAN, the coordinator is required to choose the boundaries of beacon periods (superframes) and hence of the allocation slots therein. In beacon mode operation for which beacons are transmitted, the coordinator shall communicate such boundaries by transmitting beacons at the start or other specified locations of beacon periods (superframes), and optionally timed frames (T-Poll frames) containing their transmit time relative to the start time of current beacon period (superframe). In non-beacon mode operation for which beacons are not transmitted but time reference is needed, the coordinator is required to communicate such boundaries by transmitting timed frames (T-Poll frames) also containing their transmit time relative to the start time of current superframe.

A node requiring a time reference in the BAN needs to derive and recalibrate the boundaries of beacon periods (superframes) and allocation slots from reception of beacons or/and timed frames (T-Poll frames).

A frame transmission may span more than one allocation slot, starting or ending not necessarily on an allocation slot boundary.

1. MAC frame formats
	1. Conventions
2. MAC functions
	1. MAC functions and IEEE Std 802.15.6-2012

Clause 6.2 describes the MAC functional description for the HRP UWB PHY described in clause 9.2. Clause 6.7 describes the MAC functional description for the PHYs of IEEE Std 802.15.6-2012.

* 1. HRP MAC

Table 1 shows the coexistence environment classes in which the revised MAC operates. The different MAC protocols specified in the standard are supported by the exchange of MAC commands, management, and data frames. Two modes of operation are used for the transmission of such MAC frames:

* A number of MAC commands and management frames are transmitted in a control channel, while the rest of MAC commands, management, and data frames are transmitted in a data channel. The use of an alternative control channel aims to facilitate the coordination of a group of multi-BANs coexisting and operating in a single superframe, henceforth denoted as a group superframe.
* All MAC commands, management, and data frames are transmitted in the data channel. Relaxing the requirements in the scaling of a group of multi-BANs enables to use of a single data channel for all MAC frames and the formation of a group superframe.
	+ 1. General

This subclause provides a major revision of MAC functions for enhanced dependability in classes of coexistences. Ensuring high dependability is focused in scenarios where multiple Body Area Networks (BANs) are operating together.

One of our key strategies is to allocate specific time slots and periods such as CAP and CFP to each BAN, which helps to prevent frame collisions, even among different BANs. To achieve this, we are proposing the use of a dedicated channel for exchanging network control frames and coordinator-to-coordinator frames.

This strategy will not only enable efficient time slot allocation to each BAN, but also allow for more precise Clear Channel Assessment (CCA), especially in dense environments. It is also crucial to maintain backward compatibility and establish coexistence with devices based on the original standard. We would also like to consider ways to establish this.

* + 1. Control Channel and Data Channel

The MAC layer is responsible for the following tasks:

* Frame synchronization
* Channel access control mechanisms
* Addressing
* QoS management
* Power management
* Security

The HRP MAC introduces a dual-channel structure for the operation of the MAC layer, consisting of a Control channel (CC) access by coordinators and a Data channel (DC) with a superframe structure for data transmission and ranging. Such structure supports:

* Efficient Clear Channel Assessment (CCA): With just one channel to monitor, CCA can be conducted more efficiently.
* Reduced Control Frame Collisions: By transmitting control frames on a less congested channel (where data frames are absent), we can significantly reduce the likelihood of frame collisions.
* Enhanced Dependability: Devices designed for an extra level of dependability may be able to utilize this dedicated control channel, thereby enhancing the overall reliability of the network.

If RF devices and modules can use two or more UWB frequency bands channels, one UWB band channel is employed for a control channel which is used for network control to manage coexistence among multiple BANs and other networks while other UWB frequency band channels is employed for a data channel which is used only to transmit data separate from the control channel for highly enhanced dependability. This will not only enable efficient time slot allocation to each BAN, but also allow for more precise CCA, especially in dense environments. Table 70 shows functionality of control and data channels. Table 71 shows UWB frequency bands channels in microwave.

If only a single UWB band channel is available in RF devices and modules, then a control channel is used in the same UWB frequency band as a data channel but in different time slots. It is also crucial to maintain backward compatibility and ensure coexistence with devices based on the legacy standard IEEE std.802.15.6-2012 in which both network control and data exchange happen on the same channel, with different frame types distinguishing between the two.

1. —Functionality of Control and Data Channels

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Channels** | **Periods** | **Frames** | **Sender** | **Receiver** |
| Control | n/a | Control Beacon | Coordinator | Other Coordinators and Nodes |
| Coordinator-to-Coordinator | Other Coordinators |
| Data | Network Management | Data Beacon | Coordinator | Other Coordinators and Nodes |
| Contention Free | Scheduled Downlink Data | Coordinator | Specific Node |
| Coordinator | Relay Node |
| Relay Node | Relay Node |
| Relay Node | Specific Node |
| Scheduled Uplink Data | Node | Own Coordinator |
| Node | Relay Node |
| Relay Node | Relay Node |
| Relay Node | Own Coordinator |
| Contention Access | Connection Request | Node | Own Coordinator |
| Connection Assignment | Coordinator | Specific Node |
| Disconnection Notification | Node | Own Coordinator |
| Unscheduled Uplink Data | Specific Node | Own Coordinator |

1. —UWB Frequency Band Channels in Microwave

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Band group** | **Channel number** | **Central frequency (MHz)** | **Bandwidth (MHz)** | **Channel attributein 802.15.6-2012** | **Channel attributefor the revision** |
| Low band | 0 | 3494.4 | 499.2 | Optional | **Control** | Optional |
| 1 | 3993.6 | 499.2 | **Mandatory** | Control/Data | **Mandatory** |
| 2 | 4492.8 | 499.2 | Optional | Optional |
| High band | 3 | 6489.6 | 499.2 | Optional | Control/Data | Optional |
| 4 | 6988.8 | 499.2 | Optional | Optional |
| 5 | 7488.0 | 499.2 | Optional | **Control** | Optional |
| 6 | 7987.2 | 499.2 | **Mandatory** | Control/Data | **Mandatory** |
| 7 | 8486.4 | 499.2 | Optional | Optional |
| 8 | 8985.6 | 499.2 | Optional | Optional |
| 9 | 9484.8 | 499.2 | Optional | Optional |
| 10 | 9984.0 | 499.2 | Optional | Optional |

In the original IEEE Std 802.15.6-2012, one specific channel is designated as mandatory for each band group.

To maintain backward compatibility with the original standard, the mandatory channel configuration remains unchanged in the proposed revision.

Additionally, in the proposed revision, one channel is designated as the control channel, which can be utilized as a common channel shared by multiple systems.

* + 1. Superframe structure

The MAC superframe is bounded by the transmission of a Beacon frame and may have an active portion and an inactive portion. The coordinator may enter a low power (sleep) mode during the inactive portion.

The structure of this superframe is described by the values of *macBeaconOrder* and *macSuperframeOrder.* The MAC PIB attribute *macBeaconOrder* describes the interval at which the coordinator shall transmit itsBeacon frames. The value of *macBeaconOrder* and the beacon interval (BI) are related as follows:

BI = *aBaseSuperframeDuration* × 2*macBeaconOrder*

for

0  *macBeaconOrder*  20

The MAC PIB attribute *macSuperframeOrder* describes the length of the active portion of the superframe, which includes the Beacon frame. The value of *macSuperframeOrder*, and the superframe duration (SD) are related as follows:

SD = *aBaseSuperframeDuration* × 2*macSuperframeOrder*

for

0  *macSuperframeOrder*  

The active portion of each superframe shall be divided into 2*macSuperframeOrder* equally spaced slots of duration *aBaseSlotDuration* and is composed of a beacon, a CAP, a CFP, and inactive period as shown in Figure 68.

The beacon shall be transmitted at the start of slot 0, and the CAP shall commence immediately following the beacon. The start of slot 0 is defined as the point at which the first symbol of the beacon PPDU is transmitted. The CFP, if present, follows immediately after the CAP and extends to the end of the active portion of the superframe. Any allocated GTSs shall be located within the CFP.

A coordinator shall set *macBeaconOrder* to a value between 0 and 20, and *macSuperframeOrder* to a value between 0 and 10.



1. —Superframe structure.

NOTE ― Figure 68 shows an example of *N* slot times. It does not assign two slot times to a beacon.

1. —MAC superframe attributes.

| **Attribute** | **Description, type and range** | **Value** |
| --- | --- | --- |
| *aBaseSlotDuration* | The length of a superframe slot at the highest transmission rate.A duration that can exchange a frame and ack for the initial communication application configured in 9.1.14.1.  | Constant  |
| *aSlotLength* | The number of *aBaseSlotDuration* forming a superframe slot according to the transmission rate. | 1, 2, 4, 8 |
| *aBaseSuperframeDuration* | The length of a superframe slot when *the superframe order* is equal to zero. | *aBaseSlotDuration × aSlotLength* |
| *aMaxSifsFrameSize* | The maximum size of an MPDU, in octets, that can be followed by a SIFS period. | Constant 18 |
| *aMinCapLength* | The minimum number of symbols forming the CAP. This establishes that MAC commands can still be transferred to devices when GTSs are being used. | Constant 440 |
|  |  |  |
| *macBeaconOrder* | Indicates the frequency with which thebeacon is transmitted. Integer, 0-20 | 20 |
| *macSuperframeOrder* | The length of the active portion of the outgoing superframe, including the beacon frame. Integer, 0-10. | 15 |

* + - 1. Contention access period (CAP)

The CAP shall start immediately following the Inactive period and complete before the beginning of the CFP of a superframe or at the end of the active portion of the superframe, if the CFP is zero length. The length of the CAP shall be at least *aMinCapLength*.

All frames transmitted in the CAP shall use a slotted Aloha mechanism to access the channel. A device transmitting within the CAP shall verify that its transaction is complete via the reception of an Ack frame. If this is not possible within the CAP, the device shall defer its transmission until the CAP of the following superframe.

* + - 1. Contention-free period (CFP)

The CFP shall start immediately following the CAP, and shall be completed at end of the active portion of the superframe.

The CFP shall be assigned to a node by a part of slots which is configured by the direction of transmission, length of a consecutive-slot, and time distribution of slot-parts. A single slot-part is set to downward transmission from the coordinator or upward transmission from the node, and is set to the length of consecutive slots for a slot-part. Equally distributed slot-parts is specified by the number of parts and interval of slot-parts. Unequally distributed slot-parts is specified by the number of parts, starting slot number of each slot-parts, and length of consecutive slots of each slot-parts.