

Overview on UWB standard 802.15.4-2024

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Abstract—The purpose of this survey is to understand and address these topics of the standard IEEE 802.15.4-2024, "IEEE Standard for Low-Rate wireless networks": Architecture, where we will s

I. INTRODUCTION

The standard covers many physical layers and one Medium Access Control layer (MAC) for low rate wireless personal area networks (LR-WPAN). There are some special applications such as Smart Utility Network, Rail Communications and Control, Radio Frequency Identification (RFID), Medical Body Area Networks. Among many others it covers the one we are interested in, the Ultra Wide Band (UWB) technology. UWB is a technology generally defined like others in the standard as a Wireless Personal Area Network (WPAN). So we will give an quick overview of the standard and then focus on the UWB technology.

II. GENERAL DESCRIPTION

A. Network Topologies

Topologies for LR-WPAN are two, star and peer-to-peer. In the star topology, the coordinator is the central device and the other devices are the end devices. The coordinator is the only device that can communicate with the end devices, and is usually wall powered, whilst end devices are battery powered. Suited for home automation, personal health care and games. The peer-to-peer topology is a network of devices that can communicate with each other, thus allowing for more complex networks, such as mesh networks, using multiple hops, implemented at higher level, thus not discussed in this standard. Suited for sensor networks, enabling smart agriculture, industrial control and monitoring and asset and inventory tracking.

Each independent PAN selects a UID (PAN Identifier) thus allowing for multiple PANs to coexist, moreover each device in a PAN can communicate within with a short address, permits to communicate also with another device from another PAN.

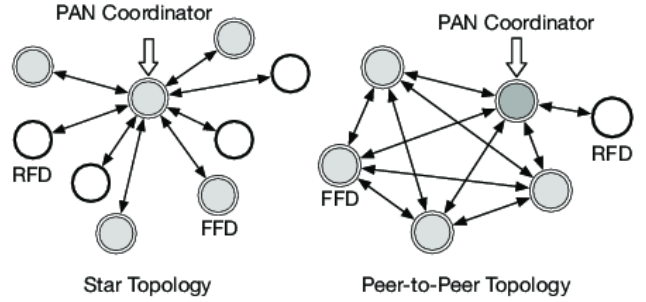


Fig. 1. Star and peer-to-peer topologies

B. Architecture

The architecture is composed of three layers:

- Physical Layer (PHY)
- Medium Access Control (MAC)
- Higher layers

Only PHY and MAC are defined in the standard, the higher layers, such as network, that involves its configuration, message routing and manipulation are left to the implementer, as well as the application layer.

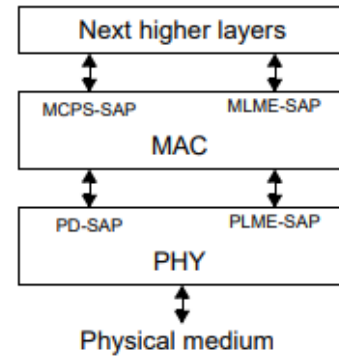


Fig. 2. IEEE 802.15.4-2024 architecture

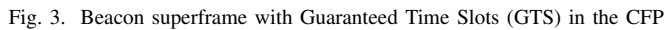
1) *Physical Layer (PHY)*: The PHY layer has its main focus on the activation and deactivation of the radio transceiver, energy detection, link quality indication, channel selection,

2) *Medium Access Control (MAC)*: The MAC overlay provides 2 services:

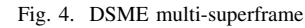
- The data service is responsible for the MAC protocol data units transmission and reception, whilst the management service is responsible for the interfacing with the MAC sublayer management entity service access point (MLME-SAP fig.2). In particular the MAC overlay provides the possibility to manage beacons, channel access, association and disassociation, acknowledged frame delivery, guaranteed time slots management and frame validation. In addition can provide security features (TODO: UWB?).

1) *Scheduled access*: Access is managed by different implementations of the superframe structure.

- Contention Access Period (CAP)
- Contention Free Period (CFP)



Time Slotted Channel Hopping (TSCH) sees the substitution of the superframe with a slotframe, also containing guaranteed or CSMA-CA periods. The difference is the shared notion of time between participants, thus allowing for automatic repetition of the slotframe, without involving beacon transmission. It can also communicate the



TWVS multichannel cluster tree PAN (TMCTP). A cluster tree network is a mesh of clusters, each with a coordinator, that can communicate with other clusters, forming a tree. The easiest is a single cluster, with a coordinator and end devices, but can be extended to multiple clusters by the first PAN coordinator, that instructs a device to become a coordinator of a new cluster. This augment the coverage area, with the downside of augmenting the message latency. The TMCTP is a cluster tree network with a Master PAN coordinator(Super Pan Coordinator), that synchronizes other PAN coordinators over different channels, that in turn synchronize their clusters. Parent PAN coordinator(s) communicate with their PAN-coordinator child(s) in its own channel CAP or CFP, whilst childs send beacons to their parent in a dedicated channel, Dedicated Beacon Slot (DBS) assigned by the coordinator in the Beacon Only Phase (BOP). So the TMCTP has an enhanced superframe structure, with a BOP, a CAP and a CFP.

- Transfer to a Coordinator from a device.
- Indirect transfer from a coordinator in which the device receives the data.
- Transfer between two peer devices. (TODO: UWB?)

- Immediate acknowledgment
- Enanced acknowledged
- Fragment acknowledgment

If *not enabled* it transmits directly to the coordinator.

Indirect data transfer using the superframe structure, the coordinator that has data for a device, indicates in the beacon that a data message is pending. Since devices are synchronized through the beacon, they can listen for pending messages, if present, they send a Data Request command to the coordinator, that in turn sends the data frame and when successfully completed, removes the message from the pending list in the beacon.

If not using the superframe structure, and a Data Frame is pending, the coordinator stores the data and sends it to the device up on request by the latter. Else the coordinator that has no data, either indicates it on the returned ACK if requested by the device that sent the Data Request, or in a Data Frame with zero payload.

Data transfer **between two peer** devices is managed either by a device that constantly receives or synchronizes with the sending device. In the first case the device attempts to send data when channel access is gained, in the second case other measures are taken to achieve sync.

3) *Frame Structure*: Thought to be reliable in noisy environments while keeping complexity low, the frames are passed from the MAC to the PHY layer as the PHY Service Data Unit (PSDU), that is then converted to the PHY Protocol Data Unit (PPDU) and transmitted. PPDU for HRP-UWB on UWB chapter.

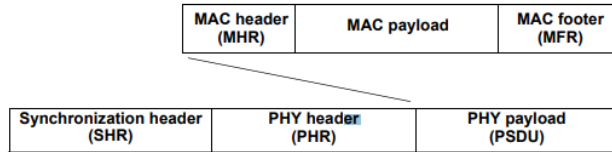


Fig. 5. PHY Protocol Data Unit (PPDU)

4) *Information Elements*: To transmit information between layers and devices, the standard uses Information Elements (IEs), that consist of an ID and a length field, followed by the information itself. If the IE is not recognized, it is ignored, else it can be accepted or discarded.

5) *Access Methods*: The standard defines the following access methods:

- Unslotted carrier sense multiple access with collision avoidance (CSMA-CA), used where is not used the superframe structure.
- Slotted CSMA-CA, used in the superframe structure.
- TSCH CCA (TSCH Clear Channel Assessment) in non shared slots where the MAC layer requests a CCA to the PHY layer at a designated time in the timeslot, that in turn returns the result.
- TSCH CSMA-CA, in shared slots (multiple devices can transmit in that assigned timeslot 10.3.2.2-10.3.9.2 section of the standard). Collisions are detected by not re-

civing an acknowledgment frame. In shared links if there is a collision, retransmission is implemented along with an exp. backoff mechanism to avoid further collisions (backoff exponent increased on every collision).

- CSMA-CA with Priority Channel Access (PCA), used in presence of MAC Service Data Units containing CriticalEventMessage parameter flag set to true
- LECIM (Low Energy Critical Infrastructure Monitoring) ALOHA with PCA, used in critical infrastructure monitoring, where the coordinator assigns a channel to a device for a certain time.

III. CONCLUSION

The conclusion goes here.

ACKNOWLEDGMENT

The authors would like to thank...

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