

ZigBee Communication Protocol

A study on the Zigbee Communication protocol

1st Yashodhan Vishvesh Deshpande
yashodhandesh@gmail.com

2nd Lochana Abhayawardana
lochana.abhayawardana@stud.hshl.de

3rd Emirkan Sali
emirkan.sali@stud.hshl.de

Abstract—Low-Rate wireless personal area networks are common use in many section of todays society. ZigBee is a communication protocol that works under the IEEE 802.15.4 standard to provide an easy, low cost way of connecting different sensors and actuators for a vast area of application. This paper explains the ZigBee communication protocol specifications and dives deeper into its advantages and challenges as well as its various areas of application in Industry, home, medicine and many more.

Index Terms—ZigBee, IEEE802.15.4, Wireless, Network, WPAN

I. INTRODUCTION

Wireless communication technology is one of the most important technology areas of this century and is now so widespread and used, that it is involved in almost any application one can imagine. Even today, wireless technology is still being improved in hope to find more prevalent ways to use it. One of these ways is the connection of sensors and actuators through a wireless network. Over the course of the years, so called wireless sensor networks (WSN) have become more and more common in almost every section of todays modern world.

WSN consist of actuators and sensors that are physically distributed in different places of the application area [1]. Such sensors or actuators could be temperature sensors, Electricity sensors, motors, LEDs and more. The sensors gather necessary information about their environment, while actuators influence it based on the given information. In any case, all the information is communicated with the central node of the network [1]. This central node contains a processing element, which can be used to save information, analyse it or visualise it even [1].

In reference [1] some general examples of application for WSN are as follows:

- Gathering medical information about patients in so called "Body-Area-Networks" [1].
- Automation of buildings e.g. smart home systems
- Surveillance of harmful substances in chemical companies or animal migration
- automation of merchandise management systems in stores and markets
- controlling and quering electric systems in medical environments
- many more...

With more benefits in dozens of areas of application, WSN have become a part of our industry, homes and cities. To be able to build a functioning WSN, a wireless communication protocol is needed. Therefore, different standards of communication have been specified by larger groups of companies to allow for an easier and more uniform use of wireless technology. ZigBee is a communication standard protocol that functions as a low-rate wireless personal area network (LR-WPAN) i.e. a type of WSN in which limited power consumption is prioritized [2]. In reference [2] the main objectives of LR-WPAN are as follows:

- Easy installation.
- Transferring data reliably while maintaining an extremely low cost
- Having a simple and flexible protocol with a adequate battery life

Zigbee is specifically applicable for usage in automation and control.

A. History of Zigbee

The Zigbee Communication protocol was developed by Connectivity standards alliance (CSA), former known as ZigBee alliance [8]. It's first release was in 2005 known as ZigBee 2004 [7]. CSA is a group of companies that dedicated themselves to developing iot solutions and promoting those and especially their Zigbee standards. They have 5000+ Zigbee certified Products and consist of 500+ member companies [8]

II. IEE 802.15.4 STANDARD

ZigBee is a communication protocol that is based on the IEEE 802.15.4 network specification and therefore uses its transportation services. To gain a further understanding about how the ZigBee protocol works and how it is not the same as the IEEE 802.15.4 standard, this section will discuss the IEEE 802.15.4 standard first [3].

A. IEEE 802.15.4 structure

IEEE 802.15.4 is a network that allows two different type of devices to participate in it [2]:

- 1) A full-function device (FFD)
- 2) a reduced-function device (RFD)

An FFD acts as as the central node of the network or in this case specifically as the personal area network (PAN)

coordinator [2]. An RFD serves as a simple sensor or actuator in the network without being capable of being a coordinator, thus being able to be implemented without any high cost or usage of resources [2]. In a system of this standard, several components with radio interfaces implementing a physical layer and a medium access control (MAC) layer are included [2]. To have a WPAN, one of these devices has to be a FFD that is responsible for communication with RFD's [2].

B. Network topologies

A WPAN in the IEEE 802.15.4 can function in two types of network topologies [2]:

- 1) Star Topology
- 2) Peer-to-Peer Topology

The star topology has different devices communicating with a single controller in the center of the network [2]. This controller is also referred to as the PAN coordinator and it is the primary control point for the PAN [2]. The peer-to-peer topology functions in a way that every device can communicate with the other device in range as long as it is an FFD, but it also has a PAN coordinator as a primary controller [2]. Both topology types are visualized in figure 1 from reference [2]

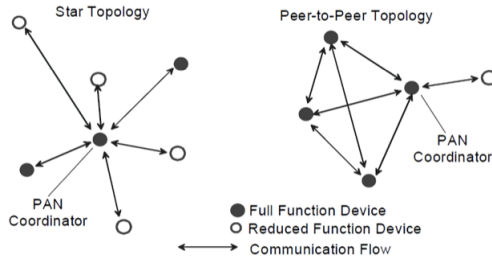


Fig. 1. Star Topology and Peer-to-Peer topology visualized

C. Architecture

The architecture of IEEE 802.15.4 is simplified in different types of layers. To be specific, it contains at least one physical and one MAC layer in which the physical layer is responsible for the radio frequency transceivers and low level control and the MAC layer is responsible for transfer access [2]. A simple visualization is provided from [2] in figure 2

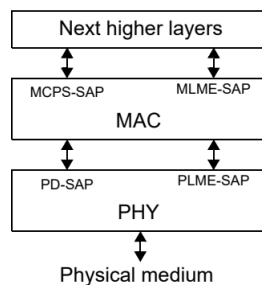


Fig. 2. Visualization of the layers in the IEEE 802.15.4 architecture

D. Zigbee specifications

III. ADVANTAGES OF ZIGBEE

bla bla balaaaa

IV. DISADVANTAGES AND CHALLENGES TO ZIGBEE

- 1) Security, privacy and compatibility.
Zigbee has plenty of security issues. If there is a lack of services or a theft to a certain node, it will affect whole entire node. If a hacker got access to the node he can manipulate a node in an illegal way. [4]
 - 2) Implementation of the ZigBee network might be costly.
There are several use cases for this. The availability of compatible items and the equipment also influence the price. The level of compatibility also influences the cost of a specific application. [4]
 - 3) Channel noise
Because the most common protocols and devices like Bluetooth, cordless phones, microwaves and other wireless devices share the common band of 2.4 GHz, there may be channel noise appear. [4]
 - 4) Low transmission rate
Because ZigBee is designed for low-rate data transmission, the technology used in it has a low bit rate. As a result, it has a lower transmission rate than WiFi and Bluetooth. Therefore Zigbee is unsuitable for high-speed data transmission.[4]
 - 5) Incompatibility:
ZigBee has some incompatibility with common devices like smartphones and computers. [4]
- Break down of challenges and advantages of ZigBee

V. APPLICATION OF ZIGBEE

A. Smart Home

Modern day smart homes are based on Internet of Things (Iot). The smart home system uses multiple sensors to collect data. The data can be from user input also. The system also consists of actuators that respond to the incoming commands of the system or its user. Zigbee communication protocol can be used to connect multiple devices to a hub in a mesh network. The hub is the master coordinator of the system that gives instructions to every other device. The Zigbee Alliance has developed a Home Automation standard [9]. Manufacturers of smart home devices use these standard for communications and operations with other devices. The following are the specifications for Zigbee Home automation.

B. Home Automation Clusters

The Home Automation clusters are group of smart home systems or sensors. They are classified based on their function: **General clusters** are common to all ZigBee Alliance profiles. **Measuring and sensing clusters** are used for measurement and sensing only. Examples of measuring and sensing clusters are luminance measurement, pressure measurement and temperature measurement. **HVAC clusters** (Heating, Ventilation and air conditioning) : HVAC clusters are used for controlling

heating and cooling. Examples are a thermostat and fan control. **Security and safety cluster** are responsible for operations for security applications. Examples are intruder alarm system device.

C. Home Automation Network Requirements

The Zigbee standard recommended some requirements for Home Automation systems. They are as follows:

- Device polling rate is 7.5 second, except for commissioning, which can be higher.
- Channels 11, 14, 15, 19, 20, 24, and 25 are recommended to be used as the operating channels.
- HA uses standard security.
- ZigBee Standard defines the following startup attributes for different ZigBee devices : Short address set to 0xFFFF, PAN ID set to 0, channel masks such as all channels in frequency band protocol version 2006 or higher

D. Commissioning

Commissioning is a method to setup a device in Zigbee network. Commissioning is a process that allows the installer to install devices, check networks operations and troubleshoot. This tool can be simple push button switch or laptop also. The Zigbee alliance uses three main types of commissioning modes:

- Automatic mode : Plug and play. In this mode the device configures itself.
- Easy mode : The devices contains some switches that the user configures to setup the device.
- System mode : A laptop or PDA device is used to install the device.

In smart home applications mainly the easy mode commissioning is used.

VI. COMPARISON TO OTHER WIRELESS NETWORK PROTOCOLS

This section is a comparison between ZigBee with WiFi and Bluetooth technologies. ZigBee has the lowest data rate compared with Bluetooth and WiFi. ZigBee has considerably longer battery life than the other mentioned technologies.

Each protocol has its advantages and disadvantages. We should know them before designing a new IOT network. IEEE802.11 is a standard to determine the Wireless local area network (WLAN) oftentimes called WiFi. IEEE802.11b is a modification of IEEE802.11 that extends up to 11 Mbits/s using 2.4 GHz bandwidth. [1] use-cases of this standard will be smart home applications, security and office use.

A. ZigBee vs. Bluetooth

Mesh capability: Zigbee configures it automatically. If the node is disabled or removed it has the ability to reconfigure it. No need to charge daily. Zigbee is opensource. Therefore different manufacturers can communicate seamlessly. Bluetooth classic is always short ranged technology and has higher bandwidth than Zigbee, is relatively power-hungry,

and is designed for devices which can be recharged easily and regularly. However there is Bluetooth Low Energy(BLE) technology, it is also low energy, low-bandwidth, long-lasting battery. applications are similar to ZigBee [3]

Both IOT protocols are vastly used for local communications

B. ZigBee vs. IEEE 802.11

IEEE 802.11 is the technical standard of the brand called WiFi.

VII. CONCLUSION

conclusion of studies on Zigbee technology in reference [4]

REFERENCES

- [1] M. Krauß and R. Konrad, *Drahtlose Zigbee-Netzwerke Ein Kompendium*. Springer Vieweg, 2014.
- [2] "Ieee standard for low-rate wireless networks," *IEEE Std 802.15.4-2020 (Revision of IEEE Std 802.15.4-2015)*, pp. 1–800, 2020.
- [3] C. M. Ramya, M. Shanmugaraj, and R. Prabakaran, "Study on zigbee technology," in *2011 3rd International Conference on Electronics Computer Technology*, vol. 6, 2011, pp. 297–301.
- [4] J. Muñoz, E. Riou, X. Vilajosana, P. Muhlethaler, and T. Watteyne, "Overview of ieee802.15.4g ofdm and its applicability to smart building applications," in *2018 Wireless Days (WD)*, 2018, pp. 123–130.