Introduction of ZigBee

Last Updated : 22 Feb, 2023

ZigBee is a Personal Area Network task group with low rate task group 4. It is a technology of home networking. ZigBee is a technological standard created for controlling and sensing the network. As we know that ZigBee is the Personal Area Network of task group 4 so it is based on IEEE 802.15.4 and is created by Zigbee Alliance.

ZigBee is an open, global, packet-based protocol designed to provide an easy-to-use architecture for secure, reliable, low power wireless networks. Flow or process control equipment can be place anywhere and still communicate with the rest of the system. It can also be moved, since the network doesn't care about the physical location of a sensor, pump or valve.

> *IEEE802.15.4 developed the PHY and MAC layer whereas, the ZigBee takes care of upper higher layers.*

ZigBee is a standard that addresses the need for very low-cost implementation of Low power devices with Low data rates for short-range wireless communications.

IEEE 802.15.4 supports star and peer-to-peer topologies. The ZigBee specification supports star and two kinds of peer-to-peer topologies, mesh and cluster tree. ZigBee-compliant devices are sometimes specified as supporting point-to-point and point-to-multipoint topologies.

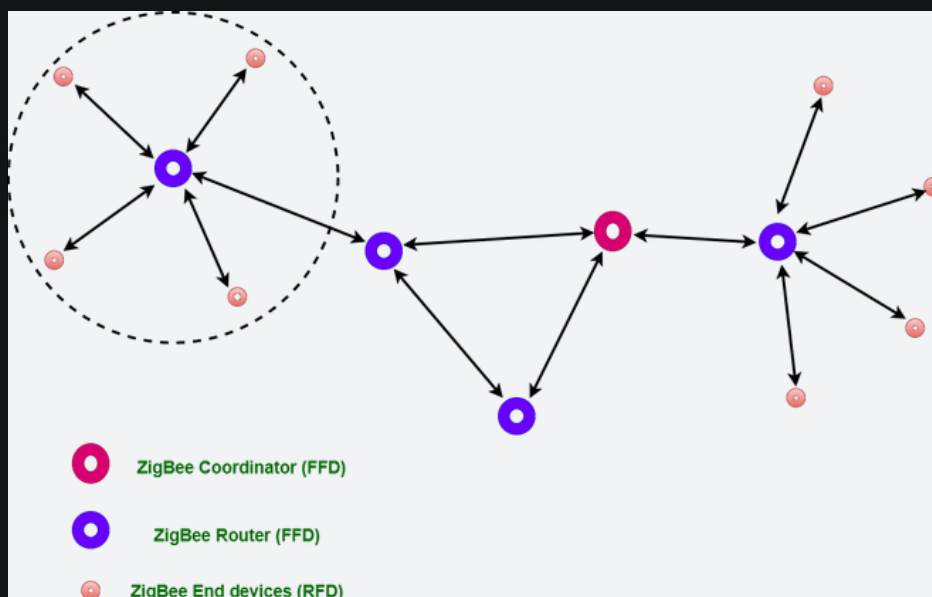**Why another short-range communication standard??**

Too much Power

High Data rate

7 Devices Max

Types of ZigBee Devices:

- **Zigbee Coordinator Device:** It communicates with routers. This device is used for connecting the devices.
- **Zigbee Router:** It is used for passing the data between devices.
- **Zigbee End Device:** It is the device that is going to be controlled.

ZigBee Coordinator (FFD)

ZigBee Router (FFD)

ZigBee End devices (RFD)

General Characteristics of Zigbee Standard:

- Low Power Consumption
- Low Data Rate (20- 250 kbps)
- Short-Range (75-100 meters)
- Network Join Time (~ 30 msec)

- Support Small and Large Networks (up to 65000 devices (Theory); 240 devices (Practically))
- Low Cost of Products and Cheap Implementation (Open Source Protocol)
- Extremely low-duty cycle.
- 3 frequency bands with 27 channels.

Operating Frequency Bands (Only one channel will be selected for use in a network):

1. **Channel 0**: 868 MHz (Europe)
2. **Channel 1-10**: 915 MHz (the US and Australia)
3. **Channel 11-26**: 2.4 GHz (Across the World)

Features of Zigbee:

1. Stochastic addressing: A device is assigned a random address and announced. Mechanism for address conflict resolution. Parents node don't need to maintain assigned address table.

2. Link Management: Each node maintains quality of links to neighbors. Link quality is used as link cost in routing.

3. Frequency Agility: Nodes experience interference report to channel manager, which then selects another channel

4. Asymmetric Link: Each node has different transmit power and sensitivity. Paths may be asymmetric.

5. Power Management: Routers and Coordinators use main power. End Devices use batteries.

Advantages of Zigbee:

1. Designed for low power consumption.
2. Provides network security and application support services operating on the top of IEEE.
3. Zigbee makes possible completely networks homes where all devices are able to communicate and be
4. Use in smart home
5. Easy implementation

6. Adequate security features.
7. **Low cost**: Zigbee chips and modules are relatively inexpensive, which makes it a cost-effective solution for IoT applications.
8. **Mesh networking:** Zigbee uses a mesh network topology, which allows for devices to communicate with each other without the need for a central hub or router. This makes it ideal for use in smart home applications where devices need to communicate with each other and with a central control hub.
9. **Reliability:** Zigbee protocol is designed to be highly reliable, with robust mechanisms in place to ensure that data is delivered reliably even in adverse conditions.

Disadvantages of Zigbee :

1. **Limited range:** Zigbee has a relatively short range compared to other wireless communications protocols, which can make it less suitable for certain types of applications or for use in large buildings.
2. **Limited data rate:** Zigbee is designed for low-data-rate applications, which can make it less suitable for applications that require high-speed data transfer.
3. **Interoperability:** Zigbee is not as widely adopted as other IoT protocols, which can make it difficult to find devices that are compatible with each other.
4. **Security:** Zigbee's security features are not as robust as other IoT protocols, making it more vulnerable to hacking and other security threats.
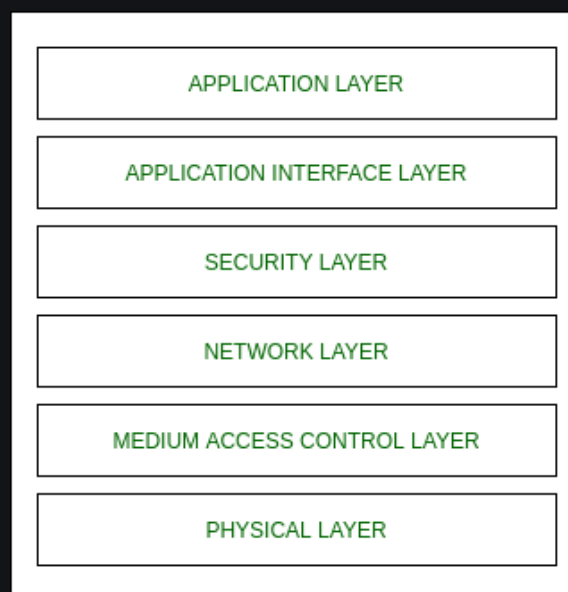
Zigbee Network Topologies:

- **Star Topology** (ZigBee Smart Energy): Consists of a coordinator and several end devices, end devices communicate only with the coordinator.
- **Mesh Topology** (Self Healing Process): Mesh topology consists of one coordinator, several routers, and end devices.
- **Tree Topology**: In this topology, the network consists of a central node which is a coordinator, several routers, and end devices. the function of the router is to extend the network coverage.

Architecture of Zigbee:

Zigbee architecture is a combination of 6 layers.

1. Application Layer
2. Application Interface Layer
3. Security Layer
4. Network Layer
5. Medium Access Control Layer
6. Physical Layer

- **Physical layer:** The lowest two layers i.e the physical and the MAC (Medium Access Control) Layer are defined by the IEEE 802.15.4 specifications. The Physical layer is closest to the hardware and directly controls and communicates with the Zigbee radio. The physical layer translates the data packets in the over-the-air bits for transmission and vice-versa during the reception.
- **Medium Access Control layer (MAC layer):** The layer is responsible for the interface between the physical and network layer. The MAC layer is also responsible for providing PAN ID and also network discovery through beacon requests.
- **Network layer:** This layer acts as an interface between the MAC layer and the application layer. It is responsible for mesh networking.
- **Application layer:** The application layer in the Zigbee stack is the highest protocol layer and it consists of the application support sub-

layer and Zigbee device object. It contains manufacturer-defined applications.

Channel Access:

1. **Contention Based Method** (Carrier-Sense Multiple Access With Collision Avoidance Mechanism)
2. **Contention Free Method** (Coordinator dedicates a specific time slot to each device (Guaranteed Time Slot (GTS)))

Zigbee Applications:

1. Home Automation
2. Medical Data Collection
3. Industrial Control Systems
4. meter reading system
5. light control system
6. Commercial
7. Government Markets Worldwide
8. Home Networking

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