ZigBee Technology and its Standards

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Abstract

In wireless sensor networks ZigBee is one of the most widely used transceiver standard .ZigBee over IEEE 802.15.4., defines specifications for low data rate WPAN (LR-WPAN) to support low power monitoring and controlling devices. In this paper ZigBee technology and its standards are discussed & described. Possible network topologies are shown.
KEYWORDS: ZigBee, IEEE802.15.4, wireless sensor network (WSN)

Introduction

Wireless sensor networking is one of the most exciting technology. Now days, wireless sensors will have a significant impact on almost all major industries as well as our home lives.

ZigBee is a global standard for wireless connectivity, focusing on standardizing and enabling interoperability of products. ZigBee is a communications standard that provides a short-range cost effective networking capability.

It has been developed with the emphasis on low-cost battery powered applications. ZigBee has been introduced by IEEE with IEEE 802.15.4 standard. ZigBee defines mesh, star and cluster tree network topologies with data security features and interoperable application profiles.

I. ZigBee Technology

ZigBee is a technology for data transfer with wireless networking. It is a high-level communication protocol using small, low-power digital radios based on the IEEE 802.15.4 standard and is commonly used for all lighting fixtures, sensors, and switches to communicate wirelessly.

The reasons for using ZigBee are:

- Reliable and self healing
- Supports large number of nodes.
- Easy to deploy
- Very long battery life
- Secure
- Low cost
- Can be used globally

- Vibrant industry support with thirty or more vendors supplying products and services
- Open Standards protocol with no or negligible licensing fees
- Chipsets available from multiple sources
- Remotely upgradeable firmware
- No new wires

There are number of standards i.e. Bluetooth, Wi-Fi, GPRS, GSM etc.Wi-Fi & Bluetooth, address mid to high data rates for voice, PC LANs, video, etc. For long battery lives Sensors and controls need low latency and very low energy consumption they don't need high bandwidth. Due to standards' high node costs, complex and power demanding RF-ICs and protocols, Bluetooth is not suitable for low power applications. ZigBee is simpler then Bluetooth, ZigBee has a lower data rate and spends most of its time snoozing, It has large number of nodes/sensors necessitates wireless solutions, very low system/node costs, need to operate for years on inexpensive batteries; this requires low power RF-ICs and protocols, reliable and secure links between network nodes, easy deployment and no need for high data rates.

Table 1: Standard comparisons

Standard	Range(m)	Nodes per network	Bandwidth (kbps)	System resource	Application	Battery Life(Days)	Key attributes
ZigBee 802.15.4.	1-75+	256/65k+	20-250	4kb-32kb	Monitoring &Control	100-1000+	Reliable, low power, costaffective
Bluetooth 802.15.1.	1-10+	7	720	250kb+	Cable replacement	1-7	Cost, convenience
Wi-Fi 802.11b	1-100	30	11000+	1 Mb +	Web,Video e-mail	0 1-5	speed, flexibility
GPRS /GSM	1000+	1000	64-128	16 Mb+	WAN/voice /data	1-7	reach, quality

ZigBee characteristics include:

- Global operation in the 2.4GHz frequency band according to IEEE 802.15.4
- Regional operation in the 915 MHz (Americas) and 868 MHz (Europe).
- Frequency agile solution operating over 16 channels in the 2.4GHz frequency.
- Incorporates power saving mechanisms for all device classes.
- Discovery mechanism with full application confirmation.
- Pairing mechanism with full application confirmation.
- Multiple star topology and inter-personal area network (PAN) communication.

- Various transmission options including broadcast.
- Security key generation mechanism.
- Utilizes the industry standard AES-128 security scheme.
- Supports Alliance standards (public application profiles) or manufacturer specific profiles.

II.General Characteristics and Standards

ZigBee and 802.15.4 are not the same. ZigBee is a standard based network protocol supported solely by the ZigBee alliance that uses the transport services of the IEEE802.15.4 network specification.

ZigBee alliance is responsible for ZigBee standard and IEEE is for IEEE802.15.4. It is like TCP/IP using IEEE 802.11b network specification. ZigBee alliance (software) defines the network, security and application layers. IEEE802.15.4 (hardware) defines the physical and media access control layers for low-rate wireless personal area networks (LR-WPAN).

The IEEE 802.15.4 standard employs 64-bit and 16-bit short addresses to support theoretically more than 65,000 nodes per network.

ZigBee network can have up to 653356 devices, the distance between ZigBee devices can be up to 50 meters, and each node can relay data to other nodes. This leads capability of making a very big network which covering significant distances.

Table 2: ZigBee (802.15.4) specifications

	Data Rate	Channels	TX Power	RX Sensitivity	Link budget	Adjacent channel rejection	Alternate channel rejection
868 MHz	20 kbps	1	-3 dBm	-92 dBm	89 dB	0 dB	30 dB
902-928 MHz	40 kbps	10	- 3dBm	-92 dBm	89 dB	0 dB	30 dB
2.450 GHz	250 kbps	16	-3 dBm	-85 dBm	82 dB	0 dB	30 dB

III. Network Topologies

ZigBee device are the combination of application (such as light sensor, lighting control etc), ZigBee logical (coordinator, router, end device), and ZigBee physical device types (Full Function Device and Reduced Function Device).

The ZigBee network node is designed for, battery powered or high energy savings, searches for available networks, transfers data from its application as necessary, determines whether data is pending, requests data from the network coordinator, can sleep for extended periods.

There are two physical device types for the lowest system cost defined by the IEEE. Full function device (FFD) can function in any topology, is capable of being the network coordinator and can talk to any other device. The FFD can operate in three modes, serving as a personal area network (PAN) coordinator, a coordinator, or a device

Reduced function device (RFD) is limited to star topology, cannot become a network coordinator, talks only to a network coordinator has very simple implementation. An RFD is intended for applications that are extremely simple, such as a light switch or a passive infrared sensor; they do not have the need to send large amounts of data and may only associate with a single FFD at a time. The RFD can be implemented using minimal resources and memory capacity.

An IEEE 802.15.4/ZigBee network requires at least one full function device as a network coordinator, but endpoint devices may be reduced functionality devices to reduce system cost.

Mesh networking makes up for the limited power of each individual node by leveraging the ability to relay data through nearby cooperating nodes. This happens transparently and provides redundancy and reliability, assuming the density of nodes is high enough.

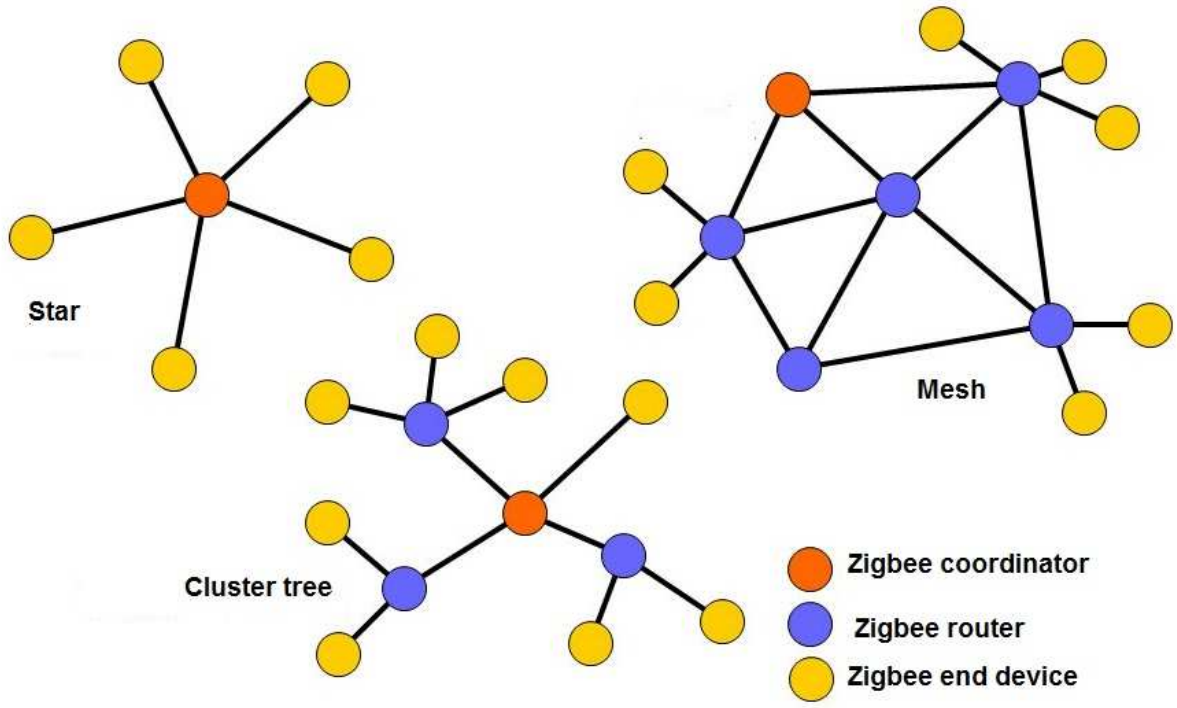
It's a case of the value of the network growing at a greater rate than the rate at which you add nodes to it. The overhead of occasional network reconfiguration takes only a few tens of milliseconds.

The ZigBee network coordinator sets up a network, transmits network beacons, manages network nodes , stores network node information, routes messages between paired nodes , typically operates in the receive state.

An FFD used as a coordinator needs sufficient memory to hold the network configuration, data, and processing power to self-configure the network in addition to its application task.

A router stores and forwards messages to and from devices that can't directly swap messages.

Fig: 03 Topology models



• Star Topology: Star topology consists of one coordinator and any number of end devices. In star topology a master-slave network model is adopted where master is the ZigBee coordinator which is FFD and slave will be either FFD or RFD. ZigBee end devices are physically and electrically separated from each other end devices and pass information through coordinator. Devices can only communicate with the coordinator. This is does not provide multi-hop networking and mesh networking.

• Cluster Tree Topology: The cluster tree topology is similar to the star topology. The difference is that other nodes can communicate with each other so that more RFD/FFDs can be connected to non-coordinator FFDs. The advantage of this topology is the possible geographical expansion of network.

• Mesh Topology: In mesh topology, each node can communicate any other node within its range. Mesh topology is complex to maintain. But it is more robust and tolerance to fault.

Conclusion

Through this study, we conclude that ZigBee plays vital role in most of the wireless application. In most industries it is observed that ZigBee is useful for applications needs low data rate (About 250 kbps) & there is an increasing demand of ZigBee based wireless

applications due to its small size, cost sensitivity, low latency, low power and interoperability.

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