Zigbee: An Advanced Low Power Consuming Technology for Wireless Sensor Network (WSN)

Mahesh Chhikara[1], Sumit Dalal[2]

[1] M. Tech Final year Student, Sat Kabir institute of Technology & Management, Vill. Ladrawan, Bahadurgarh, Haryana.
[2] HOD, Dept. of ECE, Sat Kabir institute of Technology & Management, Vill. Ladrawan, Bahadurgarh, Haryana.

ABSTRACT

Zigbee Technology specification for a suite of high level communication protocols using small, low-power digital radios. The technology is intended to be simpler and cheaper than Blue tooth. ZigBee is the newest specifications which have low data rates, consume very and low power. With ZigBee technology, interoperability will be enabled in multi-purpose, self-organizing mesh networks. ZigBee is standard for embedded application software. The bandwidth of Blue tooth is 1 Mbps and ZigBee has one fourth of this value. ZigBee has low costs and long battery life. ZigBee is meant to cater to the sensors and remote controls market and other battery operated products. As wireless sensor technology improves; an increasing number of organizations are using it for a wide range of purposes. ZigBee technology is a new standard in wireless personal area after Bluetooth. After an introduction to this technology, a new wireless meter-reading system based on ZigBee protocol has evolved. This system, which is comprised of ZigBee network and database management system, has many important advantages such as low cost, low power consumption, and low date rate. Wireless Sensor Network based on ZigBee technology is a wireless network which is composed of many nodes of ZigBee RF chip, sensor and MCU, especially suitable for application of the remote monitoring system in flammable and explosive environment. Fusion of RFID and Zigbee is also possible which turn out to be boon for wireless sensor network technology. A complete overview of wireless sensor network technology is given in this paper. Wireless sensor network technology has become one of technological basic needs of us.

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1. INTRODUCTION TO ZIGBEE TECHNOLOGY

ZigBee is new wireless communication technology with short distance, low complexity, low energy consumption, slow data rate and low cost, and it is based on IEEE 802.15.4 Standard with the capacity of coordinating mutual communication among thousands of tiny sensors.

Through the radio waves, these sensors can transmit the data from one sensor to another with small energy cost and high efficiency. Compared with various existing wireless communication technology, ZigBee technology has the lowest energy consumption and cost. Because of the slow data rate and the small range of communication, ZigBee technology is extremely suitable for agricultural field which has small amount of data flows. The technical features of this technology also make it the best choice for wireless sensor networks. Therefore, it has the practical significance when applied in the crop environmental monitoring system.

ZigBee has the following features. ZigBee uses a variety of power-saving modes to guarantee that it could be used for at least six months to two years powered by two AA batteries. ZigBee uses the avoidance collision mechanism in CSMACA and pre-set a prior particular time slot for a fixed bandwidth communications service in order to avoid competition and conflict when sending data. MAC layer adopts a fully confirmed data transport mechanism, and each packet sent by the receiver must wait for confirmation. Zigbee has self-organizing features that one node can sense other ones without any human interventions, and connect with each other automatically to create a completed network. It also obtains self-recovery function that the network can repair itself when a node is added or deleted, the position of a node is changed, or a breakdown occurred. It also can adjust the topology structure to ensure that the whole system can work normally without any human interventions.

A lot of applications of WSN have been proposed. For example, wildlife monitoring applications are discussed in and mobile object tracking issues are addressed.

2. ZIGBEE Vs BLUETOOTH and IEEE 802.11:

The comparison between ZigBee with Bluetooth and IEEE 802.11 WLAN helps for understanding how ZigBee differentiates itself from ex is ting established standards.

Technology	Data rate	Typical Range	Application
ZigBee	20 – 250 Kbps.	10 – 100 m	Wireless sensor networks
Bluetooth	1 – 3 Mbps.	2 – 20 m	Wireless mouse
IEEE 802.11b	1 – 11 Mbps.	30 – 100 m	Wireless Internet Connection

Table shows the basic characteristics of these three standards IEEE 802.11 is a family of standards; IEEE 802.11b is selected here because it operates in 2.4 GHz band, which is common with Bluetooth and ZigBee. IEEE 802.11b has a high data rate up to 11 Mbps, and providing a wireless Internet connection is one of its typical applications. The indoor range of IEEE 802.11b is typically between 30 and 100 meters. Bluetooth, on the other hand, has a lower data rate (less than 3 Mbps) and its indoor range is typically 2–10 meters. One popular application of Bluetooth is in wireless headsets, where Bluetooth provides the means for communication between a mobile phone and a hands-free headset. ZigBee has the lowest data rate and complexity among these three standards and provides significantly longer battery life.

ZigBee is very low data rate means that it is not the best choice for implementing a wireless Internet connection or a CD-quality wireless headset where more than 1Mbps is desired. However, if the goal of wireless communication is to transmit and receive simple commands and/or gather information from sensors such as temperature or humidity sensors, ZigBee provides the most power and the most cost-efficient solution compared to Bluetooth and IEEE 802.11b.

3.   ZIGBEE NETWORK TOPOLOGY

IEEE 802.15.4 can manage two types of networks, i.e., star topology or the peer-to peer. ZigBee is designed to support low-cost network layer. Both the topologies are illustrated in Figure. In ZigBee, these two topologies can be combined to build so-called mesh networks.

Star network:

The first FFD that is activated may establish its own network and become a Personal Area Network (PAN) coordinator. Then both FFD and RFD devices can connect to the PAN coordinator. All networks within the radio sphere of influence must have a unique PAN identity. All nodes in a PAN must talk to the PAN Coordinator.

Peer-to-Peer network:

In the peer-to-peer topology there is also a PAN coordinator, but it divers from the star topology in that any device can communicate with any other device as long as they are in the range of one another. The peer-to-peer topology allows more complex network formations to be implemented, such as the mesh topology.
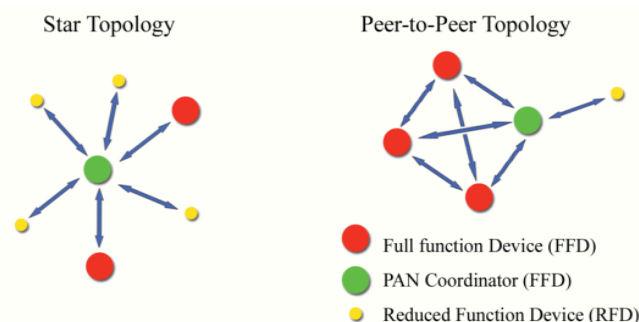
ZigBee can use so-called mesh networking which may extend over a large area and contain thousands of nodes. Each FFD in the network also acts as a router to direct messages. The routing protocol optimizes the shortest and most reliable path through the network and can dynamically change, so as to take evolving conditions into account. This enables an extremely reliable network, since the network can heal itself if one node is disabled. This is very similar to the redundancy employed in the Internet.

4.   TRAFFIC TYPES

ZigBee/IEEE 802.15.4 addresses three typical traffic types. IEEE 802.15.4 MAC can accommodate all the types.

1. Data is periodic. The application dictates the rate, and the sensor activates checks for data and deactivates.

2. Data is intermittent. The application or other stimulus, determines the rate, as in the case of say smoke detectors. The device needs to connect to the network only when communication is necessitated. This type enables optimum saving on energy.

3. Data is repetitive, and the rate is fixed a priori. Depending on allotted time slots, called GTS (guaranteed time slot), devices operate for fixed durations. ZigBee employs either of two modes, beacon or non-beacon to enable the to-and-fro data traffic. Beacon mode is used when the coordinator runs on batteries and thus offers maximum power savings, whereas the non-beacon mode finds favor when the coordinator is mains-powered. In the beacon mode, a device watches out for the coordinator's beacon that gets transmitted at periodically, locks on and looks for messages addressed to it. If message transmission is complete, the coordinator dictates a schedule for the next beacon so that the device 'goes to sleep'; in fact, the coordinator itself switches to sleep mode. While using the beacon mode, all the devices in a mesh network know when to communicate with each other. In this mode, necessarily, the timing circuits have to be quite accurate, or wake up sooner to be sure not to miss the beacon. This in turn means an increase in power consumption by the coordinator's receiver, entailing an optimal increase in costs.
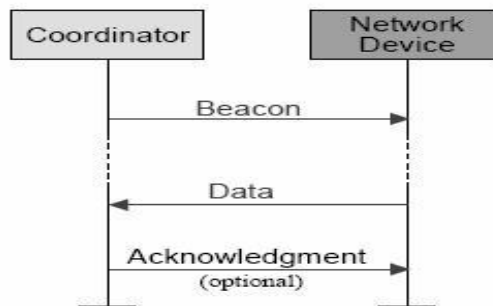

Figure: Beacon Network Communication

The non-beacon mode will be included in a system where devices are 'asleep' nearly always, as in smoke detectors and burglar alarms. The devices wake up and confirm their continued presence in the network at random intervals. On detection of activity, the sensors 'spring to attention', as it were, and transmit to the ever waiting coordinator's receiver (since it is mains powered). However, there is the remotest of chances that a sensor finds the channel busy, in which case the receiver unfortunately would 'miss a call'.
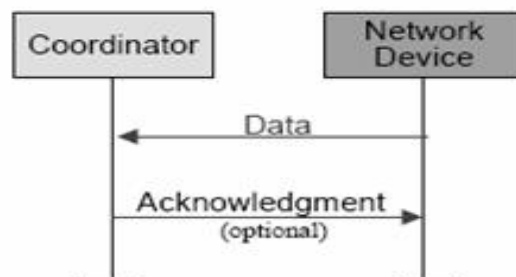

Figure: Non-Beacon Network Communication

5. ZIGBEE TECHNOLOGY FEATURES

Construction of ZigBee-based wireless network technology has the following features:

1) Data transfer rate low: Only 20 k bytes/s to 250 k bytes/sec, to focus on low-delivery applications;

2) Low power consumption: Due to the use of DSSS technology ZigBee replace FHSS technology, and use of hibernation wake-up mechanism for the work of machines, two on the 5th ordinary dry-cell batteries can be used for 6 months to 2 years, which eliminates the frequent replacement of the battery charge or trouble;

3) Low cost: because of low data rate ZigBee, the agreement is simple and royalty-free, so greatly reduced cost;

4) Network capacity: ZigBee Network Node Manager may be a number of sub-nodes; a node can manage up to 254 sub-nodes. At the same time, the node can be from one network node management, can be composed of 65,536 large-scale network nodes;

5) The short time delay: delay-sensitive applications for optimized, communication delay and activated from hibernation is very short delay, typically 15 ms latency to 30 milliseconds;

6) Safety: ZigBee provides the data integrity checks and authentication functions, the use of a common encryption algorithm AES2128, while the flexibility to determine their security attributes;

7) Flexible working band: the use of the Channel 2.4 GHz, 868 MHz (Europe) and 915 MHz (USA), are license-free band.

6. APPLICATION

The main application area of ZigBee Technology is wireless sensor Networks (WSN), where energy consumption is limited (the batteries should hold for years), transmission range must be small, and transmission rate also are to be small such as consumer electronics, industrial automation, home and building automation, PC peripherals, medical sensor applications, Robotics, toys and games.

- **Remote sensing:** Water/sewage level monitoring, Temperature sensing etc.
- **Industrial and commercial**: Monitor, control and automation links, Smoke and intruder warning etc.
- **Building automation**: Security, light, thermostat, Air condition control etc.
- **Heath care:** Patient monitoring, medical data collection, remote diagnosis etc.
- **Memory tagging**: Automotive service record, maintenance logging, Inventory control/ tracing.
- **Home Entertainment and Control:** Home automation, smart lighting, advanced temperature control, safety and security, movies and music.
- **Agriculture:** to keep track of parameters such as moisture, temperature, sunshine or air pollutants.

7. FUTURE SCOPE OF ZIGBEE

Zigbee has a very promising future in front of it. Research claims that fuelled by rapid rise in home networking, Zigbee would provide revolutionizing statistics in the upcoming years which would entirely change the wireless world.

A. Revenue Zigbee revenues would increase by astonishing 3400% in next four years.
B. Sales It sales would touch a remarkable figure of 700m$ in 2008.
C. Zigbee in every home Within next two to three years, a minimum of 100-150 Zigbee chips would be present in every home.
D. Cost It would cost only $5 for a single chip .But the smaller memory size of protocol stack will further lower the prize of Zigbee to around $2 per chip.

CONCLUSION

As a new wireless protocol in personal area, ZigBee has its unique characteristics including low cost, low data rate, and low power consumption which corresponds to a large market. This paper provides an application in the field of building automation. The fusion of two emerging technologies WSN and RFID that can give full play to the advantages of both technologies complement each other. It provides more reliable technique protection on the coal mine environmental

monitoring and has great significance in China Mine safety. In this paper wireless sensor network technology is discussed along with application and it is clear that WSN proves to be emerging technology.

Throughput of ZigBee is low; rate of data transfer is about 250kbps. So this ZigBee system is useful for Application that needs low data rate. Some of its applications are A Design of Greenhouse Monitoring & Control System Based on ZigBee Wireless Sensor Network, ZigBee Based Multi-Level Parking Vacancy Monitoring System, Design of intelligent warehouse Measure and Control System Based on Zigbee WSN Research of Wireless Sensor Networks based on ZigBee for Miner Position Applications of Wireless Sensor Networks in Environmental Monitoring. Also the standard applications supported are Home Automation and Control, Automatic Meter Reading, Residential & commercial utility systems, Building Automation, Personal health care, Body area networks, Fitness monitoring: home, gym, on-the move, ZigBee Smart Energy, Hospital & institutional, Patient monitoring, Cable replacements, Automotive, In vehicle control: vehicular & entertainment, Status monitoring, Telecom Services.

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