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RESEARCH ARTICLE

ZigBee Wireless Sensor Network Technology

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Abstract

A wireless sensor network (WSN) consisting of spatially distributed autonomous devices using sensors to cooperatively monitor physical or environmental conditions. A WSN consists of many inexpensive wireless sensors, which are capable of collecting, storing, processing environmental information, and communicating with neighboring nodes. ZigBee is newly develop technology that work on IEEE standard 802.15.4,Which can be use in wireless sensor network. Low data rates, low power consumption, low cost are the features of the ZigBee. ZigBee is world wide open standard for wireless radio network in monitoring and control field. ZigBee/IEEE 802.15.4 devices can be used to improve the current manufacturing control systems, detect unstable situations, control production pipelines, and so on. ZigBee and IEEE 802.15.4 are designed for lightweight sensor platforms.

Keywords — WSN; sensors; ZigBee; Topology

I. INTRODUCTION

A wireless sensor network (WSN) is a computer network consisting of spatially distributed autonomous devices using sensors to cooperatively monitor physical or environmental conditions, such as temperature, sound, vibration, pressure, motion or pollutants at different locations. A WSN (wireless sensor network) generally consists of base station (or) gateway that can communicate with a number of

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wireless sensors via a radio link. WSN network possesses self-organizing capability. [1] The size a single sensor node can vary from shoebox-sized nodes down to devices the size of grain of dust. Size and cost constraints on sensor nodes result in corresponding constraints on resources such as energy, memory, computational speed and bandwidth [2]. We use ZigBee modules based on IEEE 802.15.4/Zigbee Wireless Personal Area Network (WPAN) standard to build low power, low maintenance WSN. Small size, low power, low cost and long battery life are the reason for using Zigbee. Zigbee is expected to provide low cost and low power connectivity for equipment that needs very long battery life as several months to several years but does not require data transfer rate as high as those enabled by Bluetooth .ZigBee can be implemented large network than is possible with Bluetooth. ZigBee complaint wireless devices are operate in the unlicensed RF worldwide 2.4 GHz global, 915MHz Americas or 868 MHz Europe. The data rate is 250kbps at 2.4 GHz, 40kbps at 915 MHz and 20kbps at 868 MHz [3].

II. ZigBee Technology

ZigBee is the only standards-based wireless technology designed to address the unique needs of low-cost, low-power wireless sensor and control networks in just about any market. Since ZigBee can be used almost anywhere, is easy to implement and needs little power to operate, the opportunity for growth into new markets, as well as innovation in existing markets, is limitless. ZigBee is cost-effectively add intelligent new features that improve the efficiency, safety, security, reliability and convenience of your products. ZigBee utilizes IEEE 802.15.4 as the communication protocol. ZigBee networks operate in an unlicensed band shared by many other wireless networks. Any network structure using ZigBee uses 3 types of devices.

1) ZigBee Coordinator (ZC):
   It is the most capable device the forms the root of the network tree. There is exactly one ZigBee co coordinator in each network. During network initializing phase, the coordinator scans the available radio channels to find the most suitable one. Normally it is the channel with least traffic to minimize interference.
2) ZigBee Router (ZR):
   It acts as an intermediate device, passing on data from other ZigBees.
3) ZigBee End Device (ZED):
   It contains enough functionality to talk to the parent node (either the coordinator or a router) and it cannot relay data from other devices [4].

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ZigBee uses the 2.4 GHz radio frequency to deliver a variety of reliable and easy-to-use standards anywhere in the world. ZigBee gives you the freedom and flexibility to do more.

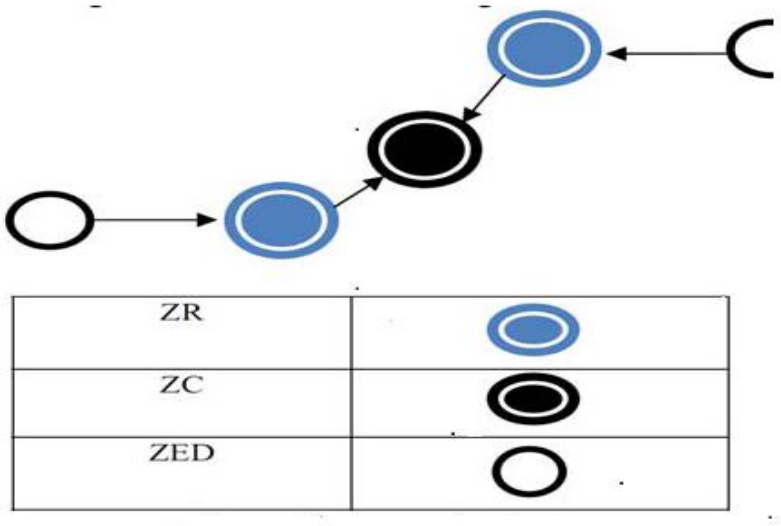

Fig 1: ZigBee Network Device

Consumer, business, government and industrial users rely on a variety of smart and easy-to-use ZigBee standards to gain greater control of everyday activities, With reliable wireless performance and battery operation. ZigBee offers a variety of innovative standards smartly designed to help you be green and save money. ZigBee/IEEE 802.15.4 is a global hardware and software standard designed for WSN requiring high reliability, low cost, low power, scalability, and low data rate. The ZigBee alliance (ZigBee, 2004) is to work on the interoperability issues of ZigBee/IEEE 802.15.4 protocol stacks [5].

III. 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 2.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.

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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.

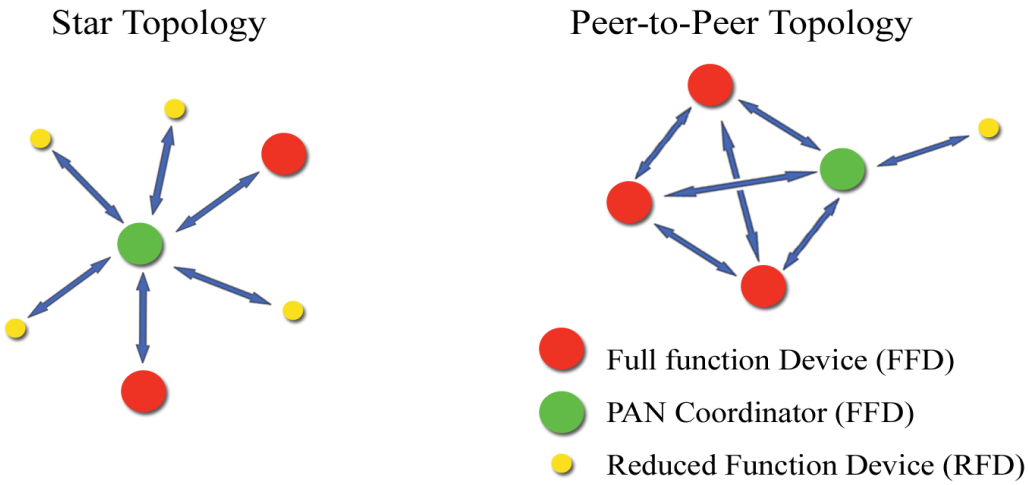

Figure 2 : Star Network and Peer-to-Peer topologies

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.

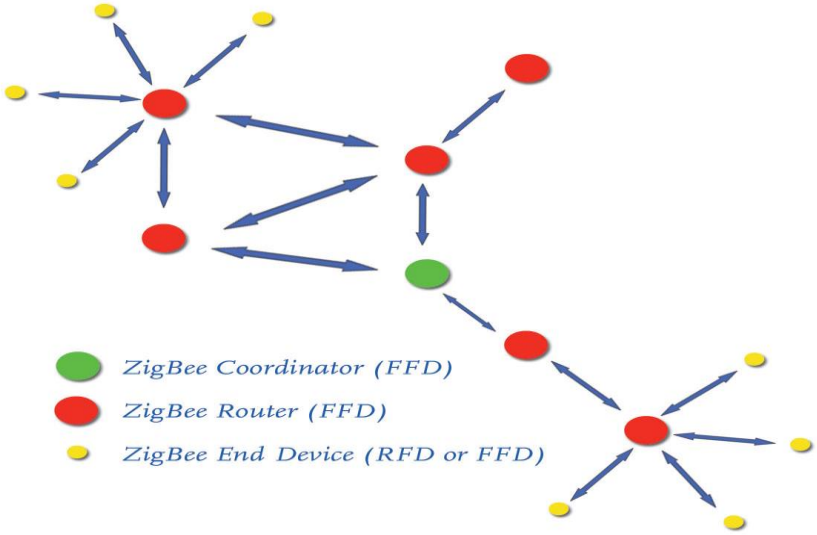

Fig 4: Mesh Topology

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ZigBee networks are primarily intended for low duty cycle sensor networks (<1%). A new network node may be recognized and associated in about 30ms. Waking up a sleeping node takes about 15 ms, as does accessing a channel or transmitting data. ZigBee applications benefit from the ability to quickly attach information, detach, and go to deep sleep, which results in low power consumption and extended battery life [5].

IV. Broadcasting in ZigBee Networks

The ZigBee network specification version 1.0 defines the broadcast procedure in mesh networks. The network layer informs the MAC layer to broadcast network-layer packets. In ZigBee, the broadcast initiator can specify the scope of this broadcast. A device that receives a broadcast packet will check whether the radius field in the broadcast packet is larger than zero. If so, the device will rebroadcast the packet; otherwise, this packet will not be further broadcast. ZigBee defines a passive acknowledgement mechanism to ensure the reliability of broadcasting. After broadcasting, the ZigBee device records the sent broadcast packet in its *broadcast transaction table (BTT)*. The BTT will be combined with its neighbor table. This allows devices to track whether their broadcast packets have been properly rebroadcast or not. If a device finds that a neighbor does not rebroadcast, it will rebroadcast to guarantee reliability. In ZigBee, devices use different strategies to broadcast packets according to the parameter *axRxOnWhenIdle* in the MAC layer. *maxRxOnWhenIdle* controls whether a device can receive data when idle. By the nature of wireless communication, devices can detect radio signals when idle. However, they will refuse to process the received signals if *maxRxOnWhenIdle* is False. When broadcasting is needed, a device with *maxRxOnWhenIdle* = True will do so immediately. This device will also unicast the broadcast packet to those neighbors with *macRxOnWhenIdle* set to False. On the other hand, a device with *cRxOnWhenIdle* set to False can only unicast the broadcast packet to its neighbors. This is because that the device may miss passive acknowledgements from neighbors. Unicasting can ensure reliability [3].

ADVANTAGES

- Data rate: ZigBee operates on low data rates. As it operates on rates up to 250 kbps it becomes and ideal choice for implementing WSN's.

- Data Security and Reliability: ZigBee uses Direct Sequence Spread Spectrum (DSSS) modulation technique which ensures data security .Due to the Carrier Sense Multiple Access –Collision Avoidance (CSMA-CA) technique being used for data transmission, reliability of data increases.

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- Compatibility: ZigBee devices can communicate with any other device working on IEEE 802.15.4 protocol.

- Mobility: Remote ZigBee modem, either moving or stationary can convey data as long as it is in the operating range.

DISADVANTAGES

- Scaling : If multiple ZEDs are being used in a network, the implementation becomes a tedious job.
- Dummy Data: ZigBee devices once configured, keep on sending dummy data even if no data input is provided [6].

FUTURE SCOPE

- Monitoring Applications: Mobile sensor nodes can be effectively used to monitor physical conditions inaccessible regions.

- Traffic Management: Sensors can be mounted on arterial roads to monitor real time traffic data.

- Industrial Monitoring: Sensor networks can be used in industrial setups to process parts of the system and keep a check on deployments [7].

V. Conclusion

ZigBee wireless sensor network topology is young and new technology. A lot of research institutes and industrial companies have developed their sensor platforms based on ZigBee/IEEE 802.15.4 solutions. ZigBee and IEEE802.15.4 are designed for lightweight sensor platforms. ZigBee/IEEE 802.15.4 is a global hardware and software standard designed for WSN requiring high reliability, low cost, low power, scalability, and low data rate. A WSN consists of many inexpensive wireless sensors, which are capable of collecting, storing, processing environmental information, and communicating with neighboring nodes. ZigBee is designed to support low-cost network layer. Here we discuss about the three network topologies i.e Star topology, Peer to Peer topology, mesh topology. ZigBee is mainly famous for mesh topology

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