Study of ZIGBEE Technology and its Application in Wireless Automation System

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ABSTRACT

Wireless Automation System has drawn acceptable attentions of researchers or people using it for more than a decade. These systems can be implemented by using technologies as mentioned: Z-Wave, Insteon, Bluetooth, WiFi, Wavenis and ZigBee. In the above mentioned technologies ZigBee based systems uses have increased gradually in different applications scenarios due to its low cost and low power consumption. ZigBee is formalized by IEEE 802.15.4 radio standards and it is one of the mostly used transceiver standard that is used as a communication technology to connect local networks. In this paper detailed study of ZigBee has been interpreted and its application in automation system has also been discussed.

KEYWORDS: Insteon, Sensors, ZigBee, Intelligent Surveillance, Topologies

1. INRODUCTION

The process of operating or controlling different equipments, machinery, industrial processes and application with the use of various control systems with less or no human interaction is termed as Automation System. These Automation System based on applications can be categorized in home automation, industrial automation, autonomous automation, building automation etc. So, in this research paper Home Automation System has been explained in detail. Home Automation is the process of controlling home appliances automatically with the help of various control system techniques. The appliances such as fan, lights, outdoor lights, fire alarm, etc., can be controlled using different techniques. The WHAS (Wireless Home Automation System) has reduced the cost of operation and maintenance and additionally, it has provided security, safety and remote monitoring capabilities. Normally Wireless Home Automation System consists of low power wireless sensors operated by battery and actuators attached with the home appliances. These sensors and actuator are connected to the backbone wireless network. Wireless Home Automation System has become popular and widely affordable due to cheap sensors, actuators and wireless modules. However nowadays, Wireless Home Automation System can be controlled and monitored from remote location at any time and from anywhere. In past few years many solutions have been proposed for Wireless Home Automation System such as Z-wave, Insteon, Wavenis, Bluetooth, WiFi and ZigBee. In this paper we have discussed about ZigBee based Wireless Home Automation System.

ZigBee Technology:

The ZigBee technology was introduced by ZigBee Alliance and it has been evolved based on standardized set of solutions called 'layers'. These layers have provided distinctive features which includes low cost, easy implementation, reliability, low power and high security to ZigBee. As ZigBee was built on the top of IEEE 802.15.4 standard, the IEEE 802.15.4 standard defines the characteristics of physical layer and Medium Access Control layer (MAC) for Wireless Personal Area Network (WPAN). Devices are the main components of WPAN which are actually defined as physical type and logical type. The physical type device has been further divided into two types such as Full Functional Device (FFD) and Reduced Functional Device (RFD). Any device can act as sensor node, control node, and composite node depending on its type. Only routing function of network is performed by FFD.

Logical type devices have been further divided into three types such as coordinator, router and end-device. Among these devices Coordinator device is the most capable device, which forms the root of network. There must be exactly one coordinator to initiate the formation of a network and it also acts as a bridge to other networks.
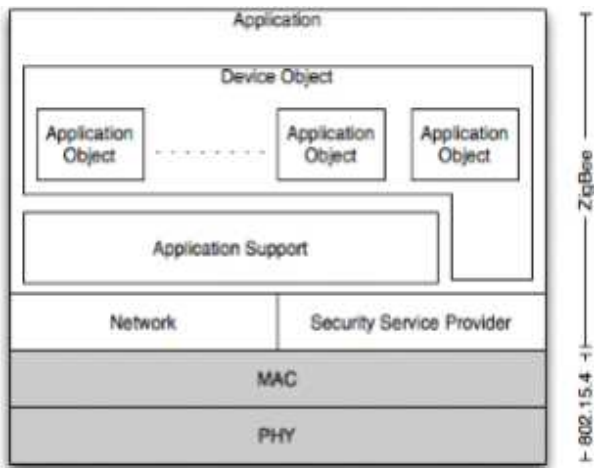
Fig: 1 the ZigBee and IEEE 802.15.4

The protocol stacks defined by the ZigBee Alliance according to IEEE 802.15.4 standard protocol stacks are shown in above mentioned figure1 [1] and this ZigBee architecture includes the Application Support (APS) sub-layer, ZigBee Device Object (ZDO), and user defined application profiles. Two modes of communication are used in ZigBee termed as Beacon Mode and Non-Beacon Mode. As to save power Beacon Mode is used by battery operator coordinator. So device waits for the Beacons that are periodically by coordinator and looks for messages addressed to it. If the message transmission is completed, the coordinator sets the schedule for next Beacon and after knowing the schedule for next schedule the device can go to sleep. Whereas Non-Beacon Mode is used by mains-powered coordinator. So all devices must know the schedule to communicate with each other and they must need to wake up at scheduled time so that they do not miss the Beacon.

2. Literature Review:

As we know early home automation began with labor-saving machines, such as self-contained electric or gas powered home appliances which became viable in the 1900s with the introduction of electric power distribution which led to the introduction of washing machines (1904), water heaters(1889), refrigerators, sewing machines, dishwashers, and clothes dryers [2]. The first general purpose home automation network technology, **x10,** was developed in 1975. This is a communication protocol for electronic devices. It uses electric power transmission wiring and signaling for control, where the signals involve brief radio frequency bursts of digital data [3]. Lately by 1978, **x10** products included 16 channel command console, a lamp module and an appliances module.

Home automation or Domotics [4] is building automation for a home, called as smart home or smart house. A home automation system will control climate, lighting, appliances and entertainment system and it may also include home security such as access controls and alarm systems [5]. Normally home automation system connects controlled devices to a central hub or "gateway". The user interface uses either wall-mounted terminals, tablet or desktop computers, a mobile phone application, or web interface, that may also be accessible off-site through the internet for control of the system.

In this present communication world there are varieties of communication standards which uses high data rate which are available, but none of these meet the sensors and control devices communication standards. As these high data rate communication standards requires low-latency and low-energy consumption. So in the available proprietary wireless systems ZigBee technology is low-cost and consumes less energy, and its excellent and superb characteristics make its communication best for several embedded applications, industrial control and home automation and so on [6].

ZigBee is specially built for control and sensor networks on IEEE 802.15.4 standard for wireless personal area networks. These WPANs operate at 868 MHz, 902-928MHz and 2.4 GHz frequencies. The data rate of 250 kbps is best suited for periodic as well as intermediate two-way transmission between sensors and controllers [6].

As we know ZigBee supports several network topologies, but the most commonly used topologies are star topology, cluster tree topology, mesh topology and in any of these topologies one can consists of more than one coordinator.
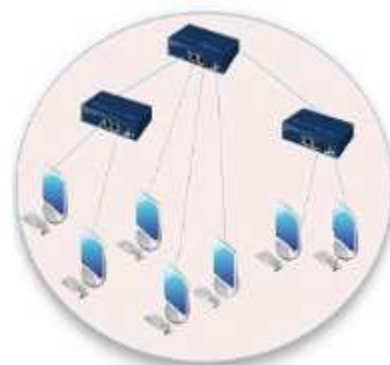
Star Topology:

In star topology the coordinator is located at the center of several end devices (nodes), as shown in following figure 2 [7]. So, each and every node is connected to the center coordinator. In star topology, end devices can only communicate with the coordinator, they can't communicate with the other end devices. So any packet transaction between end devices can only occur through the central coordinator.
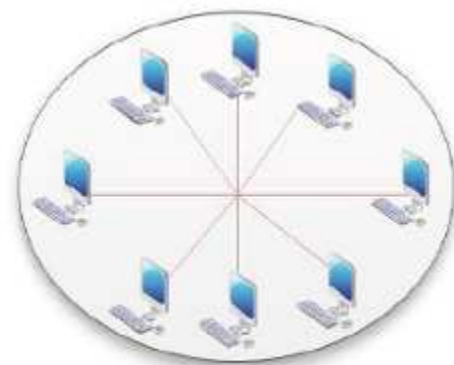

a)Star topology

Tree Topology:

In tree topology, the network consists of coordinator which acts as a root node, severel routers, and end devices. In this all the nodes are connected in the form of tree. So the and nodes are connected directly to the coordinatorand to the routers as children nodes and both, the router and coordinator can have children. If one of the parents becomes disabled, the children of that disabled parent will not be able to communicate with other devices in network.

b)Tree topology

Mesh Topology:

Mesh topology can also be called as peer to peer topology. Three types of nodes are included in ZigBee mesh network namely: a coordinator, routers, and more than one end devices. The coordinator can transfer packets to any node in the network and if any node is out of range, then the message will be forwarded to the neighboring node which will then forward it to destination node. The mesh network can cover a large range and it has a capability of shrinking or growing just by adding or removing nodes as per the needs of ones. If during transmission, any of the path fails, then the node will find an alternate path to the destination and due to this feature mesh network is self healing.
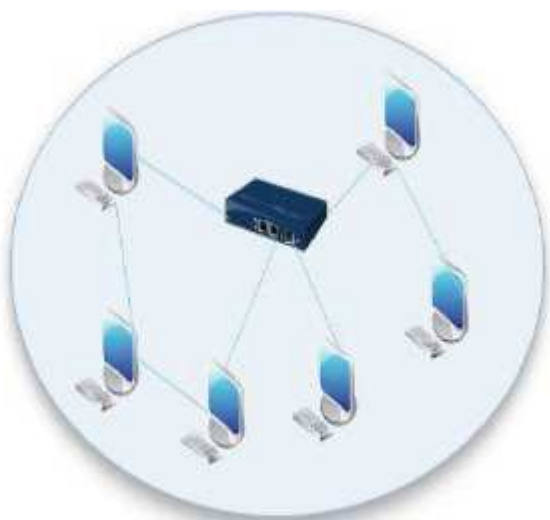
c)Mesh topology

3. Research Methodology:

Home Automation system is used to control the various household activities or appliances. Recently the use of Home Automation System has incresed significantly because of its simplicity and affordability of all these devices. Home Automation is closely related to "Internet of Things"(IoT) this technology can make integrated to various electrical and electronic devices to ech other. So these devices are able to control by personal computer or or by remote access with the help of home automation network. Radio waves and infrareds are used to provide communication between such networks. These systems are easily able to sense the various movements and it can be controlled by various controllers. Following described applications are the types of application in home automation system:

Security:

The control of gas leak, water flooding checking and other systems of a home becomes possible with the help of home automation system from remote access location. In security alarm systems microcontroller and ZigBee chip called MC 13192 are used for security.

Intelligent Survilience:

To monitor the various activities of home intelligent survilleince home automation system are used. This system consists of three components for monitoring the activities from remote location namely: indoor p[osition system monitor, Infrastructure and Gateway. Such types of ZigBee wireless home automation system performs better than other wireless systems.

Digital Living Alliance Network:

Digital Living Alliance Network (DLNA) are connected to ZigBee technology to control the digital home appliances with the help of Gateway and we can connect low rate wireless home network with the internet with the help DLNA network from remote location.

Power Monitoring System:

To control the electrical and electronics appliances at home ZigBee based power monitoring system are used. Digital Signal Processing and Web Service are also used by power management system to monitor the appliances. Digital Processing System is used to compute the various real time power parameters, whereas web services are used to communicate over the network.

Intelligent Self-Adjusting Sensors:

This sensor which is ZigBee based are implemented with the help of hardware and middleware layers and such types event driven self-adjusting networks are helpful in reducing the power consumption at home.

Wireless Network in space:

NASA scientist also uses Exo-brake circuits which are used by ZigBee networks. Ex-brake circuit are basically parachute like device which is normally used to collect sensor information. This circuit is also used on spacecraft for safe landing of different delicate instruments on different planets.

4. Conclusion:

ZigBee technology communications perhaps forms the basis of future wireless sensors, providing data reliability, long battery life, low cost of system implementation and good range through varius networks. As the population is increasing since last two years, this wireless network has become very popular in assurance to provide better life. The main effort of this technology to use is to provide low cost home automation devices as it will be affordable for large number of population. Lot of changes are to be implemented in this field to design a rhobust home automation system design. As the technology gets advanced these wireless home automation system becomes common in every home such as Television , computer etc. Mostly tree type and peer to peer topology of ZigBee network can make network more efficient to work.

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