Zigbee Technology (802.15.4) : A Survey

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Abstract – ***Technologists have never had trouble coming up with potential applications for wireless sensors. In a home security system for example , wireless sensors would be much easier to install than sensors that need wiring. The same is true in industrial environments, where wiring typically accounts for 80% of the cost of sensor installations and then there are applications for sensors where wiring isn't practical or even possible. The problem though is that most wireless sensors use too much power, which means that their batteries either have to be very large or get charged far too often. A low power wireless technology called ZigBee is rewriting the wireless sensor equation, however. This paper aims at presenting the concept of zigbee , the name of specification for a suite of high level communication protocol based on the IEEE 802.15.4 standard for wireless personal area networks (WPANs) The technology is intended to be simpler and less expensive than other WANs , such as Bluetooth. Zigbee is targeted at radio-frequency (RF) applications that require a low data rate , long battery life and secure networking.***

1. Introduction- IEEE 802.15.4

Zigbee is a communication protocol for wireless networks which is built for those devices that require low power and long battery life. Zigbee is based on **IEEE 802.15.4** standard. Though low powered Zigbee often transmit data over longer distances by passing data through intermediate devices to reach more distant ones, creating a mesh network that is network with no centralized control. The decentralized nature of such wireless networks make them suitable for applications where the centralized nodes can not be relied upon.

ZigBee has a defined rate of **250 kbit/s**, best suited for periodic or intermittent data or a single signal transmission from a sensor or input device. Applications include wireless light switches, electrical meters with in-home-displays, traffic management systems, and other consumer and industrial equipment that requires short-range wireless transfer of data at relatively low rates. It's physical range is approximately 10-100metres The technology defined by the ZigBee specification is intended to be simpler and less expensive than other W-PAN's such as Bluetooth. ZigBee was conceived in 1998,

standardized in 2003 and revised in 2006. The name refers to the waggle dance of honey bees after their return to the beehive.

1.1 Overview of IEEE 802.15.4 (Zigbee)

Zigbee is developed by zigbee alliance, The ZigBee Alliance is a group of companies who takes the overall responsibility of maintaining and publish the ZigBee standard. The term Zigbee is a registered trademark of this group. The purpose of the zigbee alliance was to create a specification defining how to create different network topologies with data security features and practicle application profiles. The association includes companies from a wide range of categories, from chip manufactures to system integration companies. The number of members in the association is fastly growing and is currently over 125 .Among the members, one can find Samsung, LG, Motorola, Phillips etc.

The first specification was ratified in Q4 2004 and first generation of Zigbee products have reached the market in 2005.A big challenge for the alliance was to make the interoperability to work among different products. To solve this problem, zigbee alliance had defined different profiles , depending on what type of category the product belongs to. For example there is profile called home lightening that exactly defines how different brands of home lightening products should communicate with each other. To get access to the specification one must currently become a member of Zigbee alliance

1.2 Zigbee Device Types

There are two types of devises of zigbee – logical and physical.

1.2.1 ZigBee physical device types

Based on data processing capabilities, two types of physical devices are provided in IEEE 802.15.4: Full Function Devices (FFD) and Reduced Function Devices (RFD). Full Function Devices can perform all available operations within the standard, including routing mechanism, coordination tasks and sensing task. The FFD plays role of coordinator or router or end devices (It can be either FFD or RFD depends on its intended application). A typical FFD in a ZigBee network will be powered from an AC-fed mains supply, as it must always be active and listening to the network. Reduced Function Devices, on the other hand, implements a limited version of the IEEE 802.15.4 protocol. The RFDs do not route packets and must be associated with an FFD. These are end devices such as sensors actuators which only doing limited tasks like recording temperature data, monitoring lighting condition or controlling external devices. The current ZigBee standard requires FFDs to be always on, which in practice means that FFDs must be constantly powered. Battery-powered FFDs have a lifetime on the order of a few days.

1.2.2 zigbee logical device types-There are three categories of nodes in a ZigBee system. Coordinators, Routers and End devices.

a)Coordinator: Forms the root of the network tree and might bridge to other networks. There is exactly one coordinator in each network. It is responsible for initiating the network and selecting the network parameters such as radio frequency channel, unique network identifier and setting other operational parameters. It can also store the information about network, security keys.

b) Router: Router acts as intermediate nodes, relaying data from other devices. Router can connect to an already existent network, also able to accept connections from other devices and be some kind of re-transmitters to the network. Network may be extended through the use of ZigBee routers.

c) End Devices: End Device can be low-power /battery-powered devices. They can collect information from sensors and switches. They have sufficient functionality to talk to their parents (either the coordinator or a router) and cannot relay data from other devices. This reduced functionality allows for the potential to reduce their cost. They support better low power models. These devices do not have to stay awake the whole time, while the devices belonging to the other two categories have to. Each end device can have up to 240 end nodes which are separate applications sharing the same radio.

2) Existing Work

ZigBee is one of the most widely used transceiver standard in wireless sensor networks. ZigBee over IEEE 802.15.4., defines specifications for low data rate WPAN (LR-WPAN) to support low power monitoring and controlling devices. A detailed study of Zigbee standard, IEEE 802.15.4 specification, ZigBee device types, the protocol stack architecture and its applications was done by Muthu Ramya.C et al. [1]. In the study, all the applications, device types, deployment techniques, standards and compatibility with other predecessor standards of zigbee was explored and it has been observed that in the industry, there is an increasing demand of ZigBee based wireless applications specifically from the perspective of security such that application of zigbee for fire alarms etc. In order to expand the application of ZigBee wireless communication based on IEEE802.15.4, network layer of ZigBee protocol stack is developed. After the introduction of the ZigBee protocol stack model, various key technologies of network layer and corresponding realization methods were proposed. The detailed analysis of all the network layer technologies, hardware and software platformsof ZigBee protocol stack and testing methods was done by Hu Guozhen [2]. The realization of ZigBee network layer (NWK) after the ZigBee physical layer (PHY) and ZigBee MAC layer was explained in detail with the whole Zigbee protocol stack and the illustration of all the key technologies of the ZigBee Network Layer is given. It has shown that proposed network layer was according with ZigBee standard ruled by ZigBee Alliance and ensured scalability and self-restorative of wireless network.

Control overhead is a very important indicator for measure performance of ZigBee routing protocol. More control overhead will add network energy consumption andreduce network survival time. By analyzing the architecture

features of ZigBee network and the key technologies of improved routing algorithm of control overhead is proposed by Jianpo Li et al. [3]. The algorithm (improved ZBR) uses Cluster-Tree parameter of ZigBee network and network addresses of destination nodes to control the transmission range and restrict its transmission direction. The algorithm restricts the transmitting range and direction of RREQ. It strives to realize reducing control overhead without influencing other performance of ZigBee network. It is tested and comparatively analyzed by using NS-2 simulator. The improved solution is considered from two perspectives. One is controlling the ZBR maximum transmission range and dropping the useless control overhead. The other is limiting the forward packet direction of every middle route and dropping the opposite direction control overhead. The control overhead is reduced obviously by the improved ZBR solution. The simulation results indicated that control overhead is reduced about a half without influencing packet delivery ratio and path length of ZigBee network. As user demands for unlicensed band services increase, various types of devices have adopted wireless technologies such as WLAN, Bluetooth, and ZigBee. Among WPAN technologies, many companies have interest in Bluetooth and ZigBee technologies because of their advantages such as low cost implementation and low energy consumption. However, since both Bluetooth and ZigBee technologies use a 2.4GHz industrial, scientific and medical (ISM) band, they can interfere with each other. The operation of ZigBee devices under the presence of Bluetooth interference was analyzed by Jo Woon Chong et al. [4] and a mathematical model for evaluating the performance of ZigBee devices was formulated. The proposed mathematical model for ZigBee devices is based on a Markov chain concept. The Bluetooth devices which adopt class 1 or class 2 Bluetooth chips as an interference source were considered and the transmission power of Bluetooth devices was set hundred times higher than that of ZigBee devices and an assumption was made that the Bluetooth devices interfere with ZigBee devices, but the ZigBee devices do not. After the intensive simulation of the proposed methods, the simulation results were matched with the results calculated by using the proposed mathematical method. It has been analyzed that as the number of interfering Bluetooth devices increases, the normalized saturation throughput decreases and the energy consumption increases. The proposed analysis model can be utilized in predicting the performance of ZigBee networks when Bluetooth devices are co-located. As many mathematical models have proposed to minimize the energy consumption by the zigbee devices, a real life implementation of the high energy conscious system based on zigbee standard was proposed by Chiung-Hsing Chen et al. [5]. ZigBee WSN and Hall current transducer were used to monitor the power consumption of load for each sensor node. If the power consumption of load is higher than maximal power, the ZigBee WSN will cut off the load to avoid disaster. It has been considered that ZigBee module must be small, so a new ZigBee module called ZBee was developed. Generally commercially available energy conservation system requires wiring and building system is

not easy, it can be solve by ZigBee wireless communication. For making the system, modular electrical control system and ZigBee wireless communication were used. Moreover, the designed system can be prevented unnecessary electrical disasters by set system's the upper and lower limits of electrical load current. The system uses in the general staircase light. For examples: buildings, traditional apartments, schools, etc. The building or school administrators only need to use their smart phone turned off the lights.

3. Future Scope

The future of zigbee is very bright. Research claims that powered by rapid increase in home networking , zigbee would provide revolutionizing statistics in the upcoming years which is going to redefine the wireless world.In the current era as so many wireless inventions and upgradations are taking place, in the face of zigbee we have got such a lethal weapon that is providing required impetus to wireless technology which is helping in revolutionizing the life of common man on the line similar to that of technologies like nanotechnology, biotechnology etc.

Currently, zigbee has its applications in many spheres that include Utilities, Hospitals, Resort Hotels, Manufacturing, and Energy Conservation etc. In addition to these, efforts have also been made to build a wireless sensor network based on ZigBee protocol for the measurement system in grain storage as an alternative to the cable system, which showed better efficiencies of the cost and time in the installation and maintenance than a cable system.

ZigBee devices are designed for low power consumption. Devices put themselves to sleep when not in use, thereby conserving power. This makes these devices ideal for battery-operated applications because they can last for several years before needing new batteries. This can be rated as one of the most significant advantages of Zigbee due to the ongoing power crisis in the world. Thus, with the help of Zigbee a lot of power can be saved and conserved for the future.

Zigbee also has its applications in home automation system. Further, ZigBee devices excel in commercial applications as Zigbee devices being open source. ZigBee's design lends itself to sensing and monitoring applications and its use in large scale wireless monitoring is growing fast. One of the reasons that ZigBee applications are succeeding in large scale commercial applications is because most installations use products only from one manufacturer, or if more than one; the products are thoroughly tested for compatibility before installation.

In addition to above , there are various other applications in which zigbee is contributing to a great extent and the bottom line is in the near future zigbee wireless technology is going to dominate the world and a minimum of 100-150 zigbee chips would be present in every home.

4. Conclusion

Past decade could be seen from the perspective of the revolution in the field of wireless communication. Many technologies of wireless

communication systems found their applications in many fields in various forms and wireless sensors are one of them. Due to the increase of dependability of people on the sensing devices, group of companies has released a wireless standard called Zigbee and registered by IEEE as IEEE 802.15.14. Zigbee found its many applications in many fields including war zones, fire alarms, house hold things, hospitals etc. Due to its initial phase of development, the technology has many loop holes from the perspective of quality of services, reliability and sustainability. But a lot of research has carried out and getting carried out to make the technology better and more reliable and usable. Therefore it is obvious that due to its different in approach to its respective application arena, Zigbee will soon revolutionize the field of wireless technology and will rule the world.

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