A Review Paper on Zigbee (IEEE 802.15.4) Standard

Parneet Dhillon
Research Scholar,CSE,RIMT , Mandigobindgarh, PTU

Dr. Harsh Sadawarti
Director, RIMT Mandigobindgarh, PTU

***Abstract*- Zigbee is specification formalized by IEEE 802.15.4 radio standard that interconnects simple,low power wireless sensor nodes.. Zigbee is a communication technology used to connect local networks with wireless sensing nodes which tend to consume low power without sacrificing the reliability and sustainability of the networks. Due to the emergence of Zigbee standard, the intensive research is going on to develop it further. All the research work that has been done by various researchers and various challenges that people are facing while deploying this technology are also provided in this paper This paper aims to find out the best topology for the placement of nodes in the network .Configuring the movement of the nodes according to the different mobility model that gives maximum throughput and possess minimum data dropped in the network will also be determined.**

Keywords-Sensor Networks ,Zigbee,Mobile coordinator

I. ZIGBEE AND IEEE 80.15.4

Technologists have never had trouble coming up with potential applications of wireless sensors.The wireless sensors are much easier to instal than the sensors that need wiring as 80% of cost is spent on the sensor installation in case of wired sensors.But there was still a problem with wireless sensors that it consumed too much power.So,Zigbee technology came into existence. Zigbee is a wireless technology formalized by IEEE 802.15.4 standard for transfer of data**.** It interconnects simple, low power, low processing capability wireless nodes. Power needed for ZigBee nodes is very small i.e 1mW (or less power). But still it provides range up to 150 meters in outdoor which is achieved by the technique called direct sequence spread spectrum (DSSS). ZigBee is developed by ZigBee alliance and task group, which include hundreds of member companies like Ember, Freescale, Chipcon, Invensys, Mitsubishi, CompXs, AMI Semiconductors, ENQ Semi conductors etc from semiconductor and software developers to original equipment manufacturers. ZigBee and 802.15.4 are not the same. ZigBee protocol is supported solely by the ZigBee alliance that uses the transport services of the IEEE 802.15.4 network specification. ZigBee alliance is responsible for ZigBee standard and IEEE is responsible for IEEE 802.15.4. It is like TCP/IP using IEEE 802.11b network specifications. ZigBee alliance defines the network, security and application layers whereas IEEE 802.15.4 defines the physical and media access control layers . ZigBee network can have up to 653356 devices. The distance between these devices can be up to 50 meters, and each node can relay data to other nodes in the network. This results in very big network which are capable of covering significant distances.

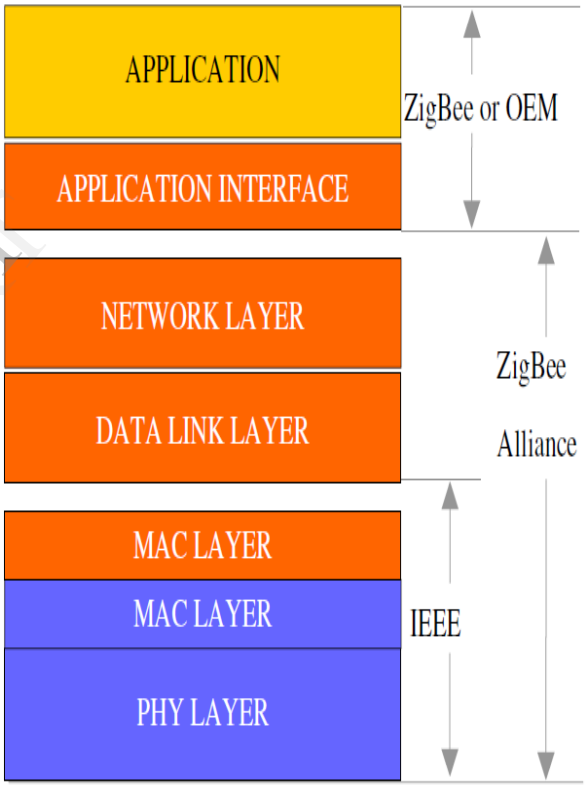


Fig 5.1 ZigBee's Protocol Stack

A. *Zigbee Physical Devices:*

Fully functional devices: Full Function Devices can perform all available operations within the standard, including routing mechanism, coordination tasks and sensing task. The FFD can serve as coordinator or router or an end device (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 main supply, as it must always be active and listening to the network.

Reduced functional devices: RFD has the least computing capability. The primary purpose of RFD is to search for an available network in order to transfer the data, check if there is any pending data, and send request to the network coordinator for the data. The RFD's often go to the sleep mode when they are not transmitting any data and this reduces the battery consumption. The RFDs do not route packets and must be associated with an FFD. These are end devices such as sensors, actuators which performs limited tasks like recording temperature data, monitoring lighting condition and has control over the external devices.

B. Zigbee logical devices:

Coordinators-The primary purpose of the coordinator is to set up all the network parameters for e.g. topology, packet size etc. It is the gateway for the outside world to interact with the network .It manages all nodes in the network.

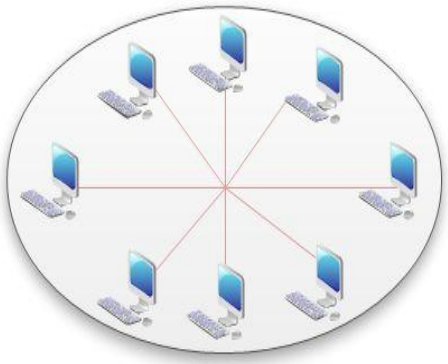
Zigbee router-Zigbee router is an intermediate device in a network which routes the data from the source to the destination. These devices route the data as well as sense the data from their surrounding environments.

End device-End device can be low-power /battery-powered devices and have the limited computing capabilities. An end device can be a FFD or a RFD. They can collect various information from sensors and switches. They depend upon their parents to send the data (either the coordinator or a router) and cannot relay data from other devices. This reduced functionality also leads to the reduced cost. 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.

C. Zigbee Topologies

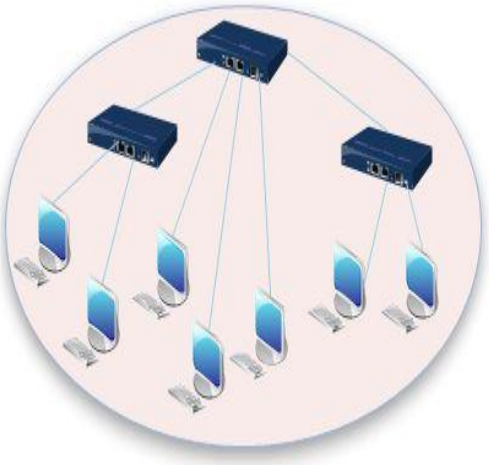
802.15.4 offers star, tree, cluster tree, and mesh topologies; however, ZigBee supports only star, tree, and mesh topology

Star topology: The star topology consists of a coordinator placed in the centre and several end devices (nodes), as shown in the figure. Each node is connected directly with the central coordinator. In this topology, the end devices can only communicate with the coordinator and not with other end devices. Any packet exchange between end devices can occur only through the coordinator.



a)Star topology

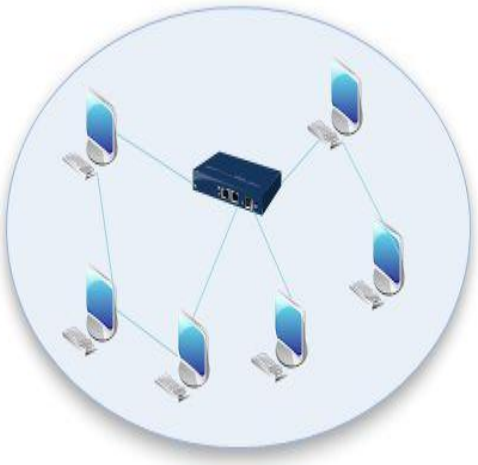
Tree topology: In this topology, the network consists of a root node which is a coordinator, several routers, and end devices, as shown in figure. All the nodes are connected in the form of the tree. The end nodes are connected directly to the coordinator and the routers as their children nodes. Both the routers and the coordinator can have children. Each end device can communicate with its parent nodes i.e coordinator and router. An end device cannot have children and, therefore, may not be a parent. An end device can communicate with another end device only through its parent node and there is no direct connection between end devices. Drawbacks of tree topology is that if one of the parents becomes disabled, the children of the disable parent cannot communicate with other devices in the network.



b)Tree topology

Mesh topology: Mesh topology is also known as peer to peer topology. A Zigbee mesh network consists of three types of nodes: a coordinator, several routers, and one or more end devices. The coordinator can send packets to any node in the network. If the node is not in range, the message will be sent to a neighbouring node which will then forward it onward to the destination. The mesh network can cover a larger range while using only a fraction of power. The ZigBee mesh network is capable of growing or shrinking depending on one's needs just by adding or removing nodes. A mesh topology is self-healing i.e during transmission, if

any of the path fails, the node will find an alternate path to the destination. Adding or removing a device is easy. Any source device can communicate with any destination device in the network. Compared with star topology, mesh topology requires greater overhead. Mesh routing uses a more complex routing protocol than a star topology.



c)Mesh topology

D. Zigbee Applications

1) ZigBee system is useful for applications that need low data rate. Some of these applications include home Automation and Control, Automatic Meter Reading, Residential & commercial utility systems, Building Automation, 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. Zigbee standard is a centralized system as it centralizes all the units in a single place for example sitting in one cabin,the whole factory unit can be monitored remotely. The low cost allows the technology to be widely deployed in various wireless control and monitoring applications, the low power-usage allows longer life with small batteries and the mesh networking provides high reliability and larger range. Zigbee technology is very useful from the perspective of the security as the devices maintain a list of trusted devices within the network and frame integrity to protect data from being modified by parties without cryptographic keys.

2) Building automation: It provides security, HVAC (Heating, Ventilation, and Air conditioning) refers to technology of indoor or automotive environmental comfort. Now HVAC is widely used in the buses and cabs. It is also used in lighting control, access control and Adaptive Multi-Rate (AMR or AMR-NB) audio codec is a patented audio data compression scheme optimized for speech coding

3) Personal health care: ZigBee Alliance provided many devices which helps for the fitness of patients such as personal wellness monitoring, Electrocardiograph (ECG), chronic disease monitoring, glucose meter and pulse oximeter

II. RELATED WORK

Routing in ZigBee network is exactly different from the routing in traditional MANET networks because the routing protocols or algorithms in MANET are mainly concerned about the node mobility while in ZigBee network Full Function Devices (FFD) can serve as network coordinators or network routers, Reduced Function Devices (RFD) can only associate and communicate with FFDs. Therefore, the node heterogeneity plays an important role in ZigBee network routing. Nia-Chang et al.(1) performed a comprehensive study to check how the different mixture of nodes affects the performance of zigbee mesh network routing. The research was particularly done to find out the impact of heterogeneous nodes i.e mobile ZigBee routers and mobile ZigBee end devices on the performance of the ZigBee mesh routing. The results of his research shown that big performance differences will be there if the the network is highly heterogeneous and the routing performance in ZigBee network will also degrade if the network consists of large number of end devices .As a result, the packet delivery ratio also worsens. Moreover, comparing to AODV routing results, significant differences in routing performance have seen, when network nodes are not assumed to be equally capable. It has also revealed that the ZigBee end devices tend to perform worse than ZigBee routers in both sending and receiving packets, since the end devices incur much overhead in associating with new parents when there is network mobility. On the other hand, ZigBee routers typically suffer less packet loss when there are intensive amounts of mobility in the ZigBee network, yet the additional service overhead of ZigBee (such as association with children devices) still degrades the performance of ZigBee routers in almost all scenarios.

Another research area to be noticed is the effect of the mobile nodes on the performance of ZigBee protocol . Jiasong Mu and Kaihua Liu [2] analyzed the effect of the mobility of the nodes and the change of the network dimension in Zigbee networks. The whole research was carried out by using tool named OPNET. This analysis was done by using various routing strategies such that Suppress Route Discovery (SRD), Enable Route Discovery (ERD) and Force Route Discovery (FRD) with the change of node mobility and network dimensions. After the extensive evaluation, it has found that although the forced routing made the network to always find the shortest path in the network, but the FRD always had the worst performance. In the dynamic networks, ERD had the greatest efficiency as it is more suitable for the dynamic environments. AODV and ERD have the same working methodologies and both gives the best performance working with dynamic environments. As to the stable network, ERD and SRD had similar efficiency in the small ones. However, the SRD based on tree routing, required no memory cache. SRD also had the lowest network load when the scale of the network expanded. Whereas the ERD might do reduplicate routing due to the restricted memory space. The SRD was the best routing option for the stable networks and the ERD performed most efficient in the unstable networks.

The positioning of the nodes is considered to be the most important factor for improving the performance (e.g., throughput) of ZigBee networks .Using the mobile sink is often considered as a safeguard against the so-called hot-spot problem and the effects of mobile coordinator on the performance of the Zigbee network also need to be considered. In order to analyze the impact of keeping the coordinator mobile in a zigbee mesh network, Harsh Dhaka et al. [3] performed extensive simulation, using OPNET Modeler and the results indicated that keeping the sink static gives the best performance. If a trajectory has to be chosen for other reasons, then the trajectory should give a considerable amount of time to each route that is the link route for a segment of the network. Otherwise (as in the case of Diagonal trajectory), it would result in a lower throughput. The factors that need to be considered specifically are: the type of the trajectory along with the node density and the network traffic. These are the factors that decide the performance of the system. Random topology is chosen to prevent exceptionally low throughput. Having the routers placed within range for effective meshing gives sharper curves which are closer but even in this case, it is better to keep the sink static at a location from where each route has an access to the sink possible with minimum hops. In circumstances sink movement is necessary, clever selection of the trajectory is essential for achieving the best throughput.

Ran Peng et al. [4] performed an extensive analysis to check the Zigbee network performance. According to this analysis, a strategy is proposed for the selection of ZigBee routing based on the various data services. The simulation results shown that this routing selection strategy gives excellent network performance with very less energy consumption. Additionally, the power control is not much considered in ZigBee Routing specification. But in case of the ad hoc wireless network application, power control is the most significant issue in ZigBee. So a power control strategy was also proposed to improve the ZigBee routing, the simulation results show that the proposed power control strategy will greatly balance the node energy, avoid that nodes use up all the battery power and die too early.

III. FUTURE SCOPE OF ZIGBEE

1) Various types of areas such as defence, national security, monitoring and control etc are facilitated by devices based on zigbee standard. To get the maximum throughput from a zigbee network, the placement of the nodes need to be considered specifically. An important role has been played by the movements of the nodes in a zigbee network from the perspective of the throughput and efficiency of the network.

2) In a zigbee network ,a wireless sensor network is usually constructed by using a tree topology. These wireless sensor networks are used for applications that require the delivery of data. Using the tree topology for the placement of nodes in the network and by configuring the movement of the nodes according to the group mobility model, network gives the maximum throughput and possess minimum data dropped in the network.

3) This is a significant obstacle to zigbee which means that most of the wireless devices should have a level of automated intelligence embedded in them so as to enable easy commissioning and flexible use. Addressing this challenge will require advanced planning to automate issues faced by the people who will actually have responsibility for installing the Zigbee application.

4) In the Wireless sensor networks,the coordinator is responsible for sending the signal to all the sensor nodes connected to it.As the distance from the coordinator increases, the signal strength becomes weak causing communication with target nodes difficult as a result the connection breaks with all the widely distributed wireless sensor nodes. Therefore, it is difficult to perform stable and reliable communication with wide range nodes.

5) Chipcon is using ZigBee to produce a road map product that reduces the chip and system costs and increases integration level with low power consumption. Sensors are currently being used in environmental and agricultural applications, but the main target - home automation. ZigBee technology is also being used and tested in applications related to health monitoring.

6) A Wireless sensor network(WSN) consists of spatially distributed wireless nodes at the bottom most layer. These sensor nodes are usually battery powered devices and consume very low power. Data is routed from these devices to the gateway by the help of the subsystem on the top of these devices. These sensor nodes can act both as a full functional device and reduced functional device. But one of the major issue in wireless sensor networks is the hot-spot i.e all the FFD's connected to the coordinator are responsible for sending the data to the coordinator on the behalf of nodes connected to them. So these nodes consume more power which increases the load on them and die out much earlier as compared to other nodes which breaks the connection with the entire network. In order to overcome the hot-spot problem, using the mobile coordinator is the best solution.

7) 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.

8) Energy consumption is also a challenge of Zigbee. ZigBee was specifically designed for home applications and have some features like high latency due to the low power consumption ,low cost, long battery life etc. The configuration is the main issue and it should be done very carefully. Selection of the routing method and type of topology plays an important role because Zigbee aims to achieve greater efficiency. A mixed routing strategy of AODV and Tree Routing is also designed in the ZigBee specification. But there is no method designed to balance these two Routing modes in order to achieve better

performance .So choosing the best method is also a challenge for Zigbee.

IV. CONCLUSION

Zigbee will play an important role in the future in the areas such as home automation,smart lighting,smoke and intruder warning traffic management, war fields etc and will make computer and communication technology more usable and accessible to the users. These networks are easy to deploy which is cheaper as compared to other technologies. It would cost only $5 for a single chip .But the smaller memory size of protocol stack will further lower t he prize of Zigbee to around $2 per chip. Zigbee technology is very useful from the perspective of the security as the devices maintain a list of trusted devices within the network and frame integrity to protect data from being modified by parties without cryptographic keys. Due to its emergence, researchers are facing many challenges in the development and deployment of the technology but due to the intensive research, all the problems are being sorted out day by day and the technology is becoming less prone to the problems and also becoming more reliable and sustainable. The wireless communication technologies are rapidly spreading to many new areas, including the wireless sensors and the importance of the use of wireless technologies in data-acquisition , building control , monitoring systems and automation of manufacturing processes will grow in future So,Zigbee has a very promising future in front of it.

REFERENCES

[1] Nia-Chiang Liang, Ping-Chieh Chen, Tony Sun, Guang Yang, Ling-Jyh Chen, and Mario Gerla, "Impact of Node Heterogeneity in ZigBee Mesh Networks." IEEE International Conference on Systems, Man and Cybernetics, p.p.187-191, October 2006, Taipei, Taiwan.

[2] Jiasong Mu and Kaihua Liu, "Effect of node mobility and network dimension to the Zigbee routing method." 6th International Conference Wireless Communications Networking and Mobile Computing (WiCOM), p.p. 1-5, September 2010, Tianjin, China.

[3] Harsh Dhaka, Atishay Jain and Karun Verma, " Impact of Coordinator Mobility on the throughput in a Zigbee Mesh Networks." IEEE 2nd International Advance Computing Conference, p.p. 279-284, June 2010, Patiala, India.

[4] Chiung-Hsing Chen, Hung-Wei Lin, Yen-Sou Huang, Jwu Jenq Chen, "Power Management System Based on ZigBee." International Conference on Anti-Conterfeiting, Security and Identification (ASID), p.p. 1-5, August 2012, Kaohsiung, Taiwan.

[5] Ran Peng, Sun Mao-heng, Zou You-min, "Zigbee Routing Selection Strategy Based on Data Services and Energy-balanced ZigBee Routing." IEEE Asia-Pacific Conference on Services Computing (APSCC'06), p.p. 400-404, December 2006, Tongji, China.

[6] Jianpo Li, Xuning Zhu, Ning Tang and Jisheng Sui, "Study on ZigBee Network Architecture and Routing Algorithm." 2nd International Conference on Signal Processing Systems (ICSPS), p.p. 389-393, Vol. 2, May 2010, Jilin, China.

[7] Jo Woon Chong, Ho Young Hwang, Chang Yong Jung, and Dan Keun Sung, "Analysis of Throughput and Energy Consumption in a ZigBee Network under the Presence of Bluetooth Interference." IEEE Global Telecommunications Conference (GLOBECOM), p.p.4749-4753, November 2007, Daejeon, Korea.

[8] Muthu Ramya. C, Shanmugaraj. M, Prabhakaran. R, "STUDY ON ZIGBEE TECHNOLOGY." International Conference on Electronics Computer Technology (ICECT), p.p. 297-301, Vol. 6, April 2011, Tiruchirappalli, India.