

# Review on Selecting Topologies in Zigbee Networks

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**Abstract-** Zigbee is specification formalized by IEEE 802.15.4 radio standard that interlinks simple, low power wireless sensor nodes.. Zigbee is a communication technique utilized to link local networks with wireless sensing nodes which lead to consume low power without sacrificing the sustainability and reliability of the networks. Because of the evolution of Zigbee standard, the intensive research is done to formulate it further. All the research work that has been performed by several researchers and many challenges that people are facing while deploying this technique are also offered in this paper This paper objectives to detect out the best topology for the nodes position in the network. Configuring the nodes movement according to the several mobility model that provides maximum throughput and minimum network data dropped will also be determined.

**Keywords-** Sensor Networks, Zigbee, Mobile coordinator

## I INTRODUCTION

Technologists have never had trouble coming up with powerful applications of wireless sensors. The wireless sensors are much simpler to install than the sensors that require wiring as 80% of price is spent on the sensor installation in situation of wired sensors. But there was still a issue with wireless sensors that it uses too much power. So, Zigbee technology came into presence. Zigbee is a wireless technique formalized by IEEE 802.15.4 standard for data transfer. It interlinks simple, low processing capability, low power wireless nodes. Power required for ZigBee nodes is very small such as 1mW (or less power). But still it offers range up to 150 meters in outdoor which is obtained by the mechanism known as direct sequence spread spectrum (DSSS). ZigBee is formulated by ZigBee alliance and task group,

which involve hundreds of member companies i.e. freescale, Ember, Invensys, Chipcon, CompXs, Mitsubishi, AMI Semiconductors, ENQ Semi conductors etc from semiconductor and software developers to original equipment manufacturers. 802.15.4 and ZigBee are not the same. ZigBee protocol is supported purely by the ZigBee alliance that utilizes the transport facilities of the IEEE 802.15.4 network specification. ZigBee alliance has responsibility for ZigBee standard and IEEE has responsibility for IEEE 802.15.4. It is like TCP/IP utilizing IEEE 802.11b network specifications. ZigBee alliance describes the network, security and application layers while IEEE 802.15.4 describes the physical and media access control layers. ZigBee network can have up to 653356 devices. The distance among these devices can be up to 50 meters, and every node can relay data to other nodes in the network. This results in very big network which are able of covering important distances.

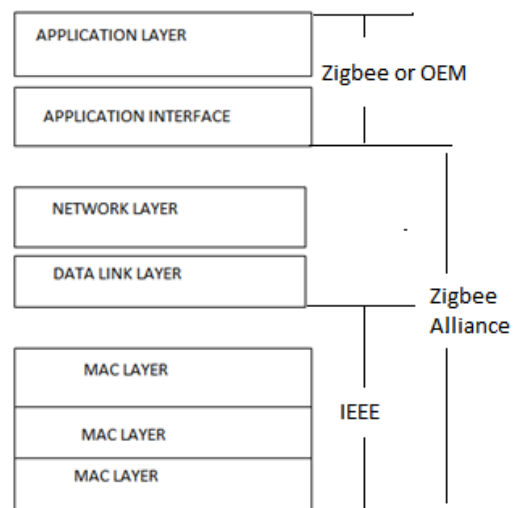


Fig 1: Zigbee's Protocol Stack

### A. Zigbee Physical Devices:

**Fully functional devices:** Full Function Devices can perform all existed operations within the standard, involving routing techniques, coordination tasks and sensing task. The FFD can support as router, coordinator or an end device (It can be either RFD or FFD based on its targeted application). A normal FFD in a ZigBee network will be powered from an AC-fed main supply, as it must always be active and hearing to the network.

**Reduced functional devices:** RFD has the minimum computing ability. The primary objective of RFD is to find an existed network for transferring the data, examine if there is any pending data, and forward request to the network coordinator for the data. The RFD's usually go to the sleep mode when they are not transferring any data and this decreases the battery consumption. The RFDs do not send packets and must be related with an FFD. These are end devices i.e. sensors, actuators which performs specific tasks i.e. monitoring lighting conditions, recording temperature data and has control over the external devices.

### B. Zigbee logical devices:

**Coordinators-**The primary aim of the coordinator is to establish all the network parameters for example: packet size and topology etc. It is the gateway for the outside world to communicate with the network .It maintains all the network nodes.

**Zigbee router-**Zigbee router is an intermediary device in a network which sends the data from the source node to the destination node. These devices forward the data as well as sense the data from their surrounding atmosphere.

**End device-**End device can be low-power /battery powered devices and have the restricted computing abilities. An end device can be a RFD or a FFD. They can gather different information from switches and sensors. They are based upon their parents to forward the data (either the router or a coordinator) and cannot relay data from other devices. This decreased services also leads to the decreased cost. These devices do not have to stay awake the entire time, while the devices relating to the other two categories have to. Every end device can have up to 240 end nodes.

## II. ZIGBEE TOPOLOGIES

802.15.4 provides tree, star, cluster tree, and mesh topologies; since, ZigBee supports only tree, star and mesh topology

**Star topology:** The star topology contains a coordinator positioned in the centre and various end devices (nodes), as illustrated in the fig. Every node is linked directly with the central coordinator. In this configuration, the end devices can only interact with the coordinator and not with other end devices. Any packet interchange among end devices can happen only via the coordinator.

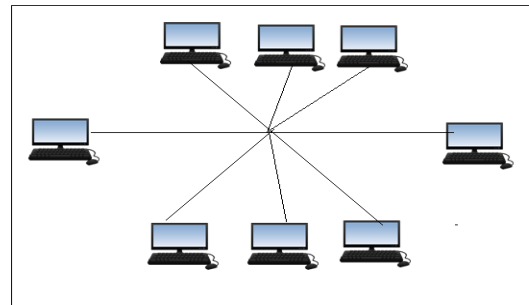


Fig 2: Star Topology

**Tree topology:** In this topology, the network contains a root node which is a coordinator, many routers, and end devices, as indicated in fig. All the nodes are linked in the tree form. The end nodes are linked directly to the coordinator and the routers as their children nodes. Both the coordinator and routers can have children. Every end device can interact with its parent nodes i.e router and coordinator. An end device cannot have children and, thus, may not be a parent. An end device can interact with another end device only through its parent node and there is no direct link among end devices. Disadvantages of tree topology is that if one of the parents becomes disabled, the children of the disable parent cannot interact with other network devices.

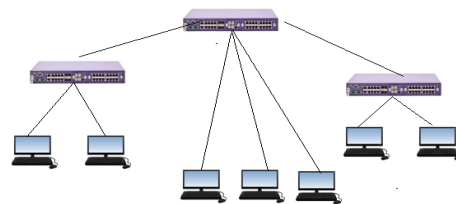
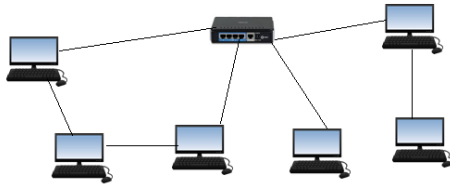


Fig 3: Tree Topology

**Mesh topology:** Mesh topology is also called peer to peer topology. A Zigbee mesh network contains three kinds of nodes: a coordinator, various routers, and one or more end devices. The coordinator can forward packets to any network node. If the node is not in coverage range, the message will be forwarded

to a neighboring node which will then send it onward to the target node. The mesh network can manage a larger range while utilizing only a fraction of power. The ZigBee mesh network is able of growing or shrinking based on one's requirements just by adding or eliminating nodes. A mesh topology is self-managing i.e during transmission, if any of the path fails, the node will discover an alternate path to the destination node. Adding or eliminating a device is easy. Any source device can interact with any destination device in the network. In comparison of star topology, mesh topology needs higher overhead. Mesh routing utilizes a more complicated routing protocol as compared to a star topology.



**Fig 4: Mesh Topology**

### III. ZIGBEE APPLICATIONS

1) ZigBee system is helpful for applications that require low data rate. Some of these applications involve Automatic Meter Reading, home Automation and Control, Residential & commercial utility systems, Body area networks, Building Automation, Fitness monitoring: home, gym, on-the-move, Hospital & institutional, ZigBee Smart Energy, Cable replacements, Patient monitoring, Automotive, In vehicle control: vehicular & entertainment, Telecom Services, Status monitoring. Zigbee standard is a centralized system as it manages all the units in a single place for example sitting in one cabin, the entire factory unit can be scanned remotely. The low cost permits the technology to be broadly deployed in several wireless control and monitoring applications, the low power-usage permits longer life with small batteries and the mesh networking offers large range and high reliability. Zigbee technology is very helpful from the security of point of view as the devices manage a list of trusted devices inside the network and frame integrity to secure data from being changed by parties without cryptographic keys.

2) Building automation: It offers security, HVAC (Heating, Ventilation, and Air conditioning) refers to

indoor or automotive environmental comfort technology. Now HVAC is broadly utilized in the cabs and buses. It is also utilized in access control, lighting control and Adaptive Multi- Rate (AMR or AMR-NB) audio codec is a patented audio data compression technique optimized for speech coding

3) Personal health care: ZigBee Alliance offered several devices which supports for the fitness of patients i.e. Electrocardiograph (ECG), personal wellness monitoring, glucose meter and pulse oximeter and chronic disease monitoring,

### IV. RELATED WORK

Routing in ZigBee network is exactly distinguishes from the routing in conventional MANET networks because the routing algorithms or protocols in MANET are primarily related about the node mobility whereas in ZigBee network Full Function Devices (FFD) can support as network routers or network coordinators, Reduced Function Devices (RFD) can only associate and interacts with FFDs. Thus, the node heterogeneity plays a significant role in ZigBee network routing, In paper [1] did a comprehensive study to examine how the different combination of nodes influences the zigbee mesh network routing performance. The research was specifically performed to find out the effect of heterogeneous nodes i.e mobile ZigBee routers and mobile ZigBee end devices on the ZigBee mesh routing performance. The results of his research indicated that large performance differences will be there if the the network is highly heterogeneous and the routing performance in ZigBee network will also decrease if the network contains huge no. of end devices. Consequently, the packet delivery ratio also decreases. Furthermore, comparing to AODV routing results, important differences in routing performance have viewed, when network nodes are not considered to be equally capable. It has also realized that the ZigBee end devices tend to perform poor than ZigBee routers in both forwarding and obtaining packets, however the end devices incur much overhead in relating with new parents when there is network mobility. On the other side, ZigBee routers generally endure less packet loss when there are large amounts of mobility in the ZigBee network, yet the extra service overhead of ZigBee (i.e. association with children devices) still decreases the ZigBee routers performance in almost all scenarios.

Another research field to be observed is the impact of the mobile nodes on the ZigBee protocol performance. Jiasong Mu and Kaihua Liu [2]

examined the impact of the nodes mobility and the change of the network dimension in Zigbee networks. The entire research was conducted by utilizing tool named OPNET. This analysis was performed by utilizing several routing strategies such that Enable Route Discovery (ERD), Suppress Route Discovery (SRD) and Force Route Discovery (FRD) with the node mobility and network dimensions change. After the extensive measurement, it has discovered that although the forced routing build the network to always discover the shortest path in the network, but the FRD always had the poor performance. In the dynamic networks, ERD had the highest efficiency as it is more appropriate for the dynamic atmosphere. AODV and ERD have the same working schemes and both provides the best performance working with dynamic atmosphere. As to the stable network, SRD and ERD had same efficiency in the small ones. Since, the SRD depending on tree routing, needed no memory cache. SRD also had the minimum network load when the network scale expanded. While the ERD might do reduplicate routing because of the limited memory space. The SRD was the best routing alternative for the stable networks and the ERD performed most effective in the unstable networks.

The nodes position is assumed to be the most significant factor for enhancing the performance (such as throughput) of ZigBee networks. Utilizing the mobile sink is usually assumed as a safeguard against the so-called hot-spot issue and the impacts of mobile coordinator on the Zigbee network performance also required to be assumed. For analyzing the effect of keeping the coordinator mobile in a zigbee mesh network, Harsh Dhaka et al. [3] did extensive simulation, utilizing OPNET Simulator and the results showed that holding the sink fixed provides the best performance. If a trajectory has to be selected for other causes, then the trajectory should provide a considerable amount of time to every route that is the connection route for a network segment. Else (as in the case of Diagonal trajectory), it would result in a lesser throughput. The factors that require to be taken particularly are: the trajectory type along with the network traffic and node density. These are the factors that decide the system performance. Random configuration is selected to prevent exceptionally low throughput. Having the routers positioned within range for efficient meshing provides sharper curves which are nearer but even in this case, it is better to hold the sink fixed at a location from where every route has an access to the sink possible with least hops. In situations, sink movement is essential, smart

selection of the trajectory is necessary for obtaining the best throughput.

Ran Peng et al. [4] did an extensive analysis to examine the performance of Zigbee network. According to this analysis, a technique is introduced for ZigBee routing selection depending on the several data services. The simulation result indicated that this routing selection technique provides excellent network performance with very low energy consumption. In addition, the power control is not much assumed in ZigBee Routing specification. But in case of the ad hoc wireless network application, power control is the most important issue in ZigBee. So a power control technique was also introduced to enhance the ZigBee routing, the simulation results indicate that the introduced power control scheme will highly balance the node energy, avoid that nodes consume all the battery power and die too early.

## V. FUTURE SCOPE OF ZIGBEE

- 1) Various types of fields i.e. national security, defence, monitoring and control etc are provided by devices depending on zigbee standard. To achieve the highest throughput from a zigbee network, the nodes position required to be considered particularly. A significant role has been played by the nodes movements in a zigbee network from the point of view of the throughput and network efficiency.
- 2) In a zigbee network, a wireless sensor network is often built by utilizing a tree topology. These wireless sensor networks are utilized for applications that need the data delivery. Utilizing the tree topology for the nodes position in the network and by configuring the nodes movement according to the group mobility model, network provides the highest throughput and possess least data dropped in the network.
- 3) This is an important obstacle to zigbee which means that most of the wireless devices should have a level of automated intelligenc introduced in them so as to enable easy commissioning and reliable usage. Approaching this challenge will need advanced planning to automate issues faced by the people who is actually responsible for installing the Zigbee application.
- 4) In the WSNs, the coordinator is responsible for forwarding the signal to all the sensor nodes linked to it. As the distance from the coordinator increases, the signal strength becomes weak causing interaction with destination nodes complex as a result the link breaks with all the broadly distributed wireless sensor nodes. Thus, it is complicated to perform reliable and stable communication with broad range nodes.

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

6) A Wireless sensor network (WSN) contains spatially distributed wireless nodes at the bottom most layer. These sensor nodes are often battery powered devices and consume very low power. Data is forwarded from these devices to the gateway by the support of the subsystem on the top of devices. These sensor nodes can behave both as a full functional device and decreased functional device. But one of the major issue in WSN is the hot-spot such as all the FFD's linked to the coordinator are responsible for forwarding the data to the coordinator on the behalf of nodes linked to them. So these nodes use more power which increases the load on them and die out much sooner in comparison of other nodes which breaks the link with the whole network. For overcoming the hot-spot issue, utilizing the mobile coordinator is the best solution.

7) Control overhead is a very significant indicator for evaluating ZigBee routing protocol performance. More control overhead will append network energy consumption and decrease network survival time.

8) Energy consumption is also a Zigbee challenge. ZigBee was particularly planned for home applications and have some characteristics i.e. high latency because of the low power consumption, long battery life, low cost etc. The configuration is the important issue and it should be performed very carefully. Routing method selection and type of topology plays a significant role because Zigbee objectives to obtain greater efficiency. A combined routing technique of AODV and Tree Routing is also planned in the ZigBee specification. But there is no mechanism designed to balance these two Routing modes for achieving better performance. So selecting the best mechanism is also a Zigbee challenge.

### CONCLUSION

Zigbee will play a significant part in the future in the fields i.e. smart lighting, home automation, war fields and smoke and intruder warning traffic management and will build computer and communication technology more accessible and usable to the subscribers. These networks are easy to deploy which is cheaper in comparison of other technologies. It would cost only \$5 for a single chip. But the smaller memory size of protocol stack will further lower

Zigbee price to around \$2 per chip. Zigbee technology is very helpful from security point of view as the devices manage a list of trusted devices inside the network and frame integrity to secure data from being altered by parties without cryptographic keys. Because of its emergence, researchers are facing several challenges in the deployment and development of the technology but because of the intensive research, all the issues are being sorted out day by day and the technology is becoming less vulnerable to the issues and also becoming more sustainable and reliable. The wireless communication technologies are frequently spreading to several new fields, involving the wireless sensors and the significance of the usage of wireless technologies in building control, data acquisition, monitoring systems and automation of manufacturing procedures will develop in future So, Zigbee has a very promising future in front of it.

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