Zigbee: Simulation and Investigation of Mesh topology under node failure by varying Channel Sensing Duration

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ABSTRACT

In these paper effect of node failure,router failure and coordinator failure is analysed by changing channel sensing duration by keeping acknowledgement and beacon on and then off. the result is compared in terms of Load, Delay and End to end Delay the simulation is carried out by using Opnet 14.5 modeller.The result shows with increase in channel sensing duration performance decreases. The result also shows that when acknowledgement and beacon is enable the performance decreases.
Keywords: ZigBee, WSN, Topology, IEEE 802.15.4, OPNET, Star, Mesh.

1. INTRODUCTION

Wireless sensor network is the one type Ad-Hoc networks which circulated the sensor nodes independently in environment. In WSN the sensor nodes arranged as a cooperative network, these nodes can sense and control the overall communication in between the individuals, embedded computers and the surroundings atmospheres, where we implement these networks.

Mainly a sensor network contains a three C's i.e.

- Collection,
- Computation
- Communication

In the base of this three C's communication is initiate in WSN and data will be transmitted. ZigBee is a worldwide open standard for wireless radio networks in the monitoring and control fields. ZigBee is formulated by ZigBee alliance which has hundreds of members companies like Mithsubishi, Freescale, CompXs, Chipcon, Ember, Invensys, AMI semiconductors, ENQ semiconductor etc. ZigBee sensor network is a standard based network protocol, supporte by the ZigBee alliance that uses the transported services of the IEEE 802.15.4 network specification. ZigBee alliance is also responsible for ZigBee standard and IEEE 802.15.4. WSN are used in many area like area monitoring, air quality monitoring, forest fire detection, landslide detection, water quality monitoring, natural disaster prevention, machine health monitoring, data logging, industrial sense, control applications, water/wastewater monitoring, agriculture, greenhouse monitoring, structural monitoring, passive localization and tracking and smart home monitoring.

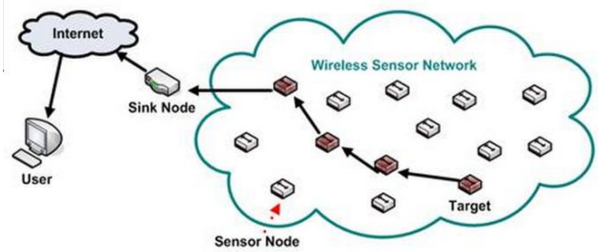

Figure 1: Structure of Wireless Sensor Network

2. ZIGBEE WIRELESS SENSOR NETWORK

As per discuses in introduction, ZigBee is a worldwide open standard for wireless radio networks in the monitoring and control fields These ZigBee wireless sensor network deals with three nodes i.e.

- Coordinator

Figure 2: Coordinator

- Router

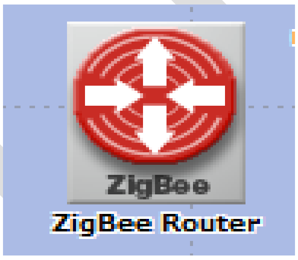

Figure 3: Router

- End device

Figure 4: End device

The most expert device in WSN is coordinator, this Coordinator makes the root from one network to another network or one to another topology. The network is established by adding the group of nodes, one ZigBee coordinator is sufficient to equip the whole responsibilities of wireless sensor network because the distance in between the two nodes is limited for end-to-end transmission. Zigee Router is used to provide a information of transmission in communication network. With the help of these three types of nodes the wireless sensor network is established, which can decide the topology of ZigBee sensor network i.e. star, tree and mesh topology. This concept is developed from peer-to-peer topology in IEEE 802.15.4 [10].

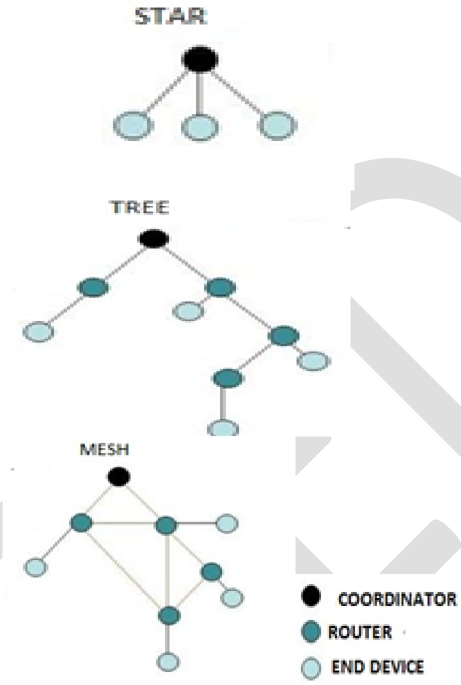

Figure 5: Star, Mesh and Tree Topology

In Star topology nodes are connected to a single hub or main node, if one node is failed then its cannot effect the overall network, if main node is fail then entire network will be failed. In tree topology the major node is coupled with one or more nodes which provide a point to point communication in between the communication network using end devices and the ZigBee coordinator. In mesh topology all nodes are connected with each other, the advantage of mesh topology is that if one communication route is broken down then it does not affect the other routes in communication network

A wireless sensor network is a special Ad-Hoc network comprises spatially distributed autonomous device using sensor are distributed randomly is in wide area [1, 2, 3, 14]. WSN can be generally described as a collection of sensor nodes organized into a cooperative network that can sense and control the environment enabling interaction between persons or embedded computers and the surrounding environment [12, 13]. A typical sensor node contains three C's are collection, computation and communication unit based on the request of sink, gathered information will be transmitted wireless network [5]. ZigBee is developed by ZigBee alliance which has hundreds of members companies (Ember, Freescale, Chipcon, Invensys, Mithsubishi, CompXs, AMI semiconductors, ENQ semiconductor) from semiconductor and software developers to originally equipments manufacturers. ZigBee and 802.15.4 are not the same. ZigBee is a standard base network protocol supported solely by the ZigBee alliance that uses the transported services. of the IEEE 802.15.4 network specification [5]. ZigBee alliance is responsible for ZigBee standard and IEEE is for IEEE 802.15.4. It is like TCP/IP using IEEE 802.11b network specification [6].

2.1 Applications of WSN

WSN are used in many fields like [15,13,5]:

- Area monitoring
- Environmental/Earth monitoring
- Air quality monitoring
- Forest fire detection
- Landslide detection
- Water quality monitoring
- Natural disaster prevention
- Machine health monitoring
- Data logging
- Industrial sense and control applications
- Water/wastewater monitoring
- Agriculture
- Greenhouse monitoring
- Structural monitoring
- Passive localization and tracking
- Smart home monitoring

2.2 The Structure and Research Platform of Zigbee Wireless Sensor Network

There are three types of nodes in ZigBee wireless sensor network: coordinator, router, and device [7,8]. The coordinator is responsible for intelligent network, selecting, suitable channel to create a network and adding child node to the network established. There is only one coordinator to complete these tasks in a netwok. Because the distance between two nodes in end-to-end transmission is limited, a kind of device, route node is needed to forward information transmission. The three types of nodes above are the concept of network layer and there deployment decide the ZigBee network topology, ZigBee networks can achieve the following three forms of network topology: Star network, Tree Network, Mesh Network [7, 9] are the developed from the concept of peer-to-peer topology in IEEE 802.15.4 [10].

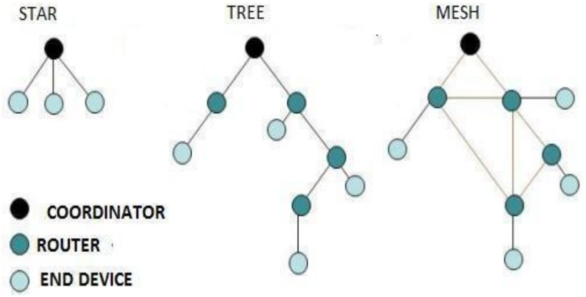

Figure 6 Star, Mesh and Tree Topology

In Star topology nodes are connected to a single hub node. If a communication link is cut its only effect on one node. However if the master node fail whole the network is fail [1]. In mesh topology all nodes are connected with each other and advantage of mesh topology is that if one communication link is cut it does not effect on other links. In tree topology the master connected to one or more child node that are one level lower in the hierarchy with point to point link between each of the end nodes and the master (coordinator).

3. RELATED WORK

In 2012 [16]Abdul Aziz, investigated performance of a ZigBee based wireless sensor network in two scenarios one with a static sink and other with random sink mobility through extensive ns2-based simulations for various topologies (star,tree and mesh). Wireless Sensor Networks (WSNs) can be considered as a glut of distributed sensor nodes which are able to sense a physical process or environmental parameters and also capable to transfer that information to a predefined sink node through some intermediate nodes. If sink remains static at a fixed position then neighboring nodes of the sink consume their energy more rapidly as compared to other nodes which are far away from the sink because they have to forward all the traffic of the farther away nodes to the sink that leads to complete isolation of sink in a less time and hence network performance is degraded due to non-uniform consumption of energy. There introduce a simple random mobility scheme in which sink moves randomly through whole network. There also investigate end-to-end delay of packets and throughput for identical network conditions in both the cases. The main aim of this work is to evaluate, through simulations, the impact of random sink mobility in a ZigBee/IEEE 802.15.4 based wireless

In 2013.[17] **M. Hussnain,** evaluated WSNs applications in agriculture, comparing different IEEE802.15.4/ZigBee topologies (Tree, Mesh and Grid) for the enhanced and precision agriculture. Multiple network scenarios are simulated to study the performance of WSNs topologies in terms of throughput, network load and end-to-end delay. Simulation results show that the WSNs have better throughput and network usage when tree topology is used. WSNs with tree topology show an increase of 11% and 57% in throughput as compare to Mesh and Grid topologies respectively. Tree topology also has 35% and 80% more network load than Mesh and Grid topologies respectively. Hotherever, the end-to-end delay of ZigBee based Tree topology has 1% and 2 % more delay than Mesh and Grid respectively, which is negligible in the proposed study.

In 2013,[18] Mumtaz M.Ali AL-Mukhtar based on the characteristics of ZigBee protocol, ZigBee technology is used to model and simulate a wireless sensor network. Nodes failures and their effect on the traffic are considered in different scenarios for cluster-tree topology to certify the reliability of this communication network. The parameters: throughput, delay, data traffic sent, and data traffic received are measured during these scenarios. These scenarios are performed taking into account the specific features and recommendations of the IEEE 802.15.4/ZigBee standard using OPNET Modeler 14.5.Simulation results quantify the impact of a ZigBee device failure on the performance factors.

4. EXPERIMENTAL SETUP

In these experiment effect of node failure,router failure and coordinator failure is analysed by changing channel sensing duration by keeping acknowledgement and beacon on and then off. In this experiment 50 end devices, 4 router and one coordinator is used.

Table 1: Coordinator's Network Layer Parameter

	Mac Layer Parameter
3	Minimum value of the back-off exponent in the CSMA/CA
4	Maximum no. of back-off in the CSMA/CA
1,2,3	Channel sensing duration (sec)
	Physical Layer Parameter
250	Data Rate (kbps)
-85	Receiver Sensitivity (db)
2.4	Transmission band (Ghz)
.05	Transmission Power (W)
	Application Layer Parameter
1	Packet interval time/type (sec/constant)
1024/constant	Packet size/type

Table 2: Coordinator's The Mac, Physical and Application Layer Simulation Parameters

255	Maximum no. of children
10	Maximum no. of routers
10	Route discovery time

OPNET Simulator [19] was used to carried out performance of Star, Mesh, and Tree ZigBee Topologies. We used OPNET modeler, because OPNET modeler provides a comprehensive development environment supporting the modeling of communication network and distributed systems . OPNET modeler provides better environment for simulation, data collection and data analysis [19]. The Simulation parameters used in our scenario for coordinator are shown in Table 1 and Table 2.
In this research, the matrices measured are Delay, Load and Retransmission Attempt.

5. RESULTS

5.1 Load

Fig.7 shows the result for node failure. Result shows that when we increase the channel sensing duration the load decreases. There is no effect when acknowledge and beacon is enable. The result shows that when channel sensing duration is 1 the load is high and as we increase to 3 it decreases.

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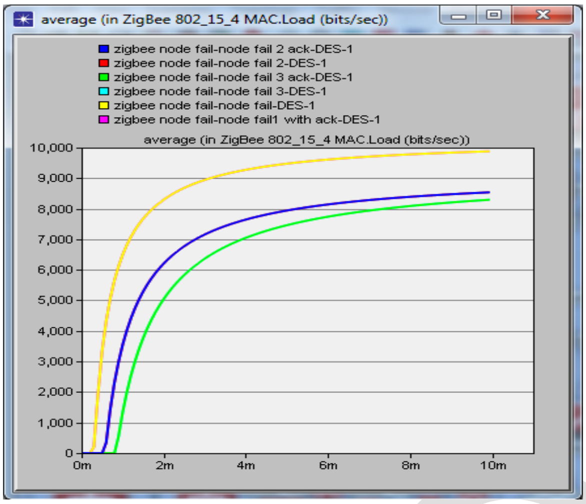

Figure 7 Load for node failure

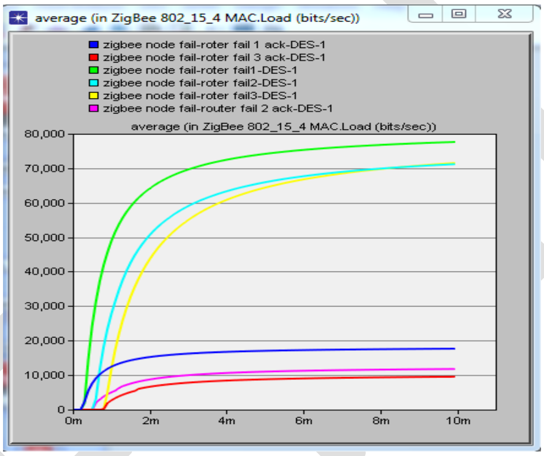

Figure 8 Laod for router failure

Fig. 8 shows the result when router is fail. The fig shows that when we increase the channel sensing duration the load is decrease. The fig also shows that when acknowledgement and beacon is on load decreases. Fig also shows that when acknowledgement and beacon is on and when we increase the channel sensing duration the load decrease.

When coordinator is fail there is no transmission of data take place.

5.2Delay

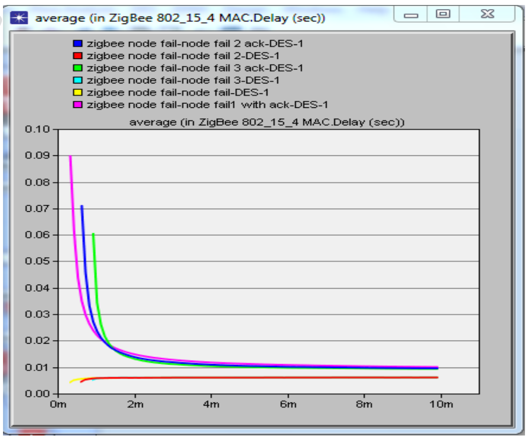

Figure 9 Delay when node is fail

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Fig 9 shows the result of Dealy when node is fail. The fig shows that the result shows that when acknowledgement and beacon is on the delay is more in starting for less channel sensing duration when we increase the channel sensing duration the delay decrease. The fig also shows that when acknowledgement and beacon is on the delay is more when it is off. Then fig also shows that when acknowledgement and beacon is off there is no effect of channel sensing duration.

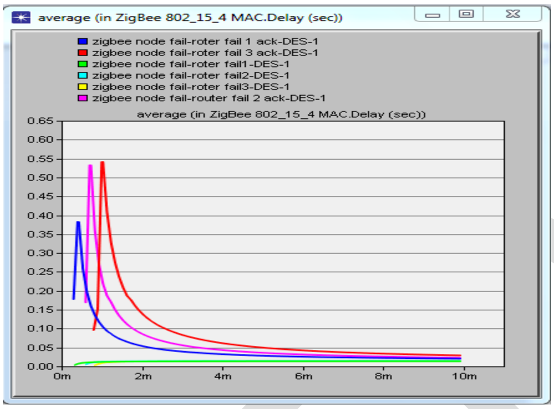

Figure 10 Delay when Router is fail

Fig 10 shows the result of delay when router is fails. The result shows that when acknowledgement and beacon is on and when we increase the channel sensing duration the delay is increase. The fig also shows that acknowledgement and beacon is off then there is no effect of channel sensing duration. The fig also shows that when acknowledgement and beacon is on delay is more than when it is off.

When coordinator is fail then there is no transmission of data so there is no result for coordinator fail.

5.3 End to end delay

Fig 11 shows the result for end to end delay when node is fail. The fig shows that when we increase the channel sensing duration the end to end delay decreases. The fig also shows that when acknowledgement and beacon is on and when we increase the channel sensing duration the end to end delay decreases. The fig also shows that when acknowledgement and beacon is off and when we increase the channel sensing duration the end to end delay delay decreases. The fig also shows that without acknowledgement and beacon end to end delay is less.

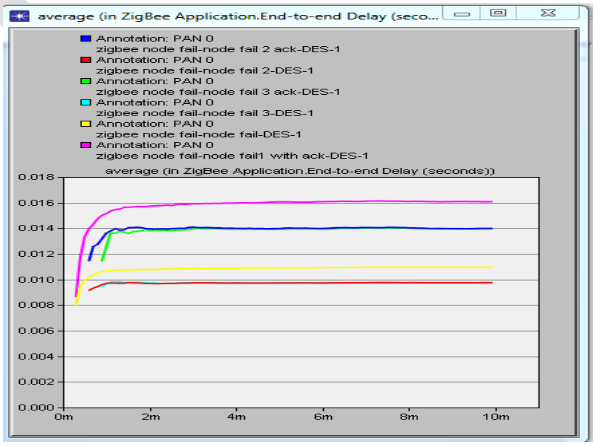

Figure 11 end to end delay fo node fail

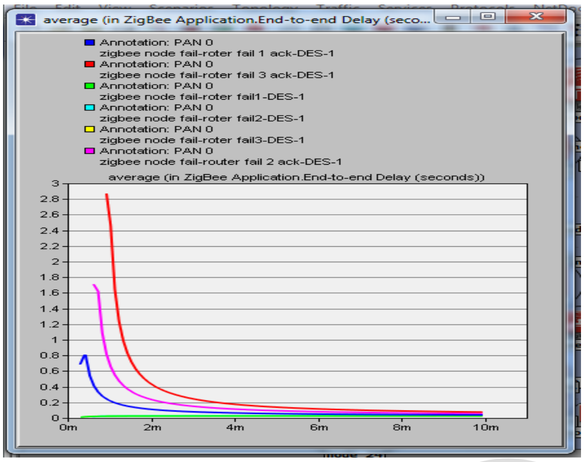

Figure 12 end to end delay for router fail

Fig 12 shows the result of end to end delay for router fail. The result shows that when acknowledgement and beacon is on and when we increase the channel sensing duration the end to end delay increases. The result also shows that when acknowledgement and beacon is off and when we increase the channel sensing duration the end to end delay remain same. The fig also shows that without acknowledgement and beacon end to end delay is less.

6. CONCLUSION

In this work we provided a versatile analysis of the performance of Mesh under node failure,router failure and coordinator failure by varying channel sensing duration. In this work the nodes are placed randomly. The router is placed in hexagonal shape.This can be analysed by keeping acknowledgement and beacon enable and then disable, The result is analyzed in the terms of Delay, end to end delay and load. The result shows with increase in channel sensing duration load decreases and delay and end to end delay also decreases. The result also shows that when acknowledgement and beacon is enable the performance decreases.

7. REFERENCES

[1] I.S. Hammodi et al, " A comprehensive performance study of OPNET modeler for ZigBee WSN " 3rd International conference on Next Generation Mobile Applications, 2009.
[2] Limin Sun et al, " WSN [M]. Benjing : Tsinghua University press", 2005.
[3] Yu Chengbo et al, "Research and application on the coverage range of ZigBee protocol", IEEE, 2009.
[4] You Ke, et al, ZigBee-based Wirelesssensor networks.
[5] Muthu Ramya.C et al, "Study on ZigBee Technology", IEEE 2011.
[6] "Hands-on ZigBee : implementing 802.15.4 with microcontrollers" fredeady.
[7] Yu Chengbo et al, "Reaserch and Application on the coverage range of the ZigBee Protocol", IEEE 2009
[8] IEEE STD 802.15.4[5], www.zigbee.org.
[9] ZigBee Alliance, ZigBee specification[z], www.zigbee.org.
[10] Agrawal, Dharma P. And Zeng, Oing-An, Introduction to wireless and mobile sys, Ze, Thomas , Inc, 2006.

[11] Boris Mihajlov et al., “Overview and Analysis of the Performances of ZigBee based Wireless Sensor Networks”, International Journal of Computer Applications Volume 29– No.12, pp. 0975 – 8887, (2011).
[12] Stéphane Lohier et al., “Multichannel Access for Bandwidth Improvement in IEEE 802.15.4 Wireless Sensor Networks”, IFIP/IEEE Wireless Days 2011 (IEEE WD'2011)
[13] Yu-Kai Huang et al., “A Comprehensive Analysis of Low-Power Operation for Beacon-Enabled IEEE 802.15.4 Wireless Networks” IEEE Transaction on Wireless Communications, VOL. 8, NO. 11, Nov (2009).
[14] B.E. Bilgin, V.C. Gungor “Performance evaluations of ZigBee in different smart grid environments”, Computer Networks 56 pp. 2196–2205 (2012).
[15] Yu-Kai Huang et al. “Distributed Throughput Optimization for ZigBee Cluster-Tree Network” IEEE Transaction On Parallel and Distributed Systems, VOL. 23, (2012).
[16] Abdul Aziz, M. Ali Qureshi, M. Umair Soorage, M. Noman Kashif, and M. Arsalan Hafeez”,Evaluation of ZigBee Based Wireless Sensor Network with Static Sink and Random Sink Mobility” International Journal of Computer and Electrical Engineering, Vol. 4, No. 4, August 2012
[17] M. Hussnain, M. Sharjeel, S. R. Chaudhry, S. A. Hussain, I. Raza and J. S. Mirza “Investigating Multi-Topological ZigBee Based Wireless Sensor Network in Precision Agriculture” J. Basic. Appl. Sci. Res., 3(2)195-201, 2013
[18] Mumtaz M.Ali AL-Mukhtar, Teeb Hussein Hadi” Modeling the Performance of Zigbee Cluster-Tree Wireless Sensor Networks in Presence of Failures” Journal of Advanced Computer Science and Technology Research, Vol.3 No.3, September 2013, 116-126
[19] Opnet Official website, http://www.opnet.com.