Study of Zigbee Protocol using Opnet

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ABSTRACT
Wireless Body Area Networks consisting of sensor nodes which are connected to each other through a wireless link. Sensor nodes sense the signal and send it to the sink node. Zigbee protocol is used in this study. It has various advantages over other communication standards in terms of low power consumption, low battery consumption, short range etc. Various network simulators are used for Wireless Sensor Network, Opnet is one of them. In this paper different network topologies are evaluated. Based on the results obtained from the paper, researchers will get the useful information about the simulator. Some drawbacks of simulator are also discussed in this paper.

Keywords
zigbee, opnet,coordinator,router,end devices.

1. INTRODUCTION
Wireless Sensor networks are used to monitor the different parameters in many applications like patient monitoring, environment monitoring, agriculture field monitoring etc. They have the tendency to change the lifestyle of people with these types of applications. WBAN is a subset of Wireless Sensor Networks. Sensor nodes are placed on the human body to sense the vital signs of the human body and send to the sink node. Various technologies are used for WSN, Zigbee technology is one of them [1]

Rest of this paper is organized as follows: Section 2 briefly describes the Zigbee Protocol. Section 3 gives the related work.Section 4 explains the performance of various zigbee components in opnet. In section 5 Zigbee router component is studied. Sections 6 explains the effect of router failure on the performance of Zigbee based wireless body area network. Section 7 gives the results and discussion. Section 7 concludes the paper.

2. ZIGBEE PROTOCOL
2.1 Model Features: ZigBee
The model implements the following features:

2.1.1 Features of Application layer
2.1.1.1 It has the facility to generate and receive the application traffic

2.1.1.2 Network discovery and network join facility is also present

2.1.2 Features of network layer
2.1.2.1 Network establishment

2.1.2.2 Network joining facility

2.1.2.3 Address Assignment

2.1.2.4 Neighbor table maintenance

2.1.2.5 Transmission and reception of data

2.1.2.6 Mobility facility

2.1.2.7 Tree routing

2.1.2.7 Beacon scheduling

2.1.3 Features of MAC layer
2.1.3.1 Channel Scanning

2.1.3.2 Co-existance

2.1.3.3 CSMA/CA

2.2 Model Limitations:ZigBee
The following features have not been implemented

2.2.1 Multicast traffic

2.2.2 Indirect transmission

2.2.3 Interframe spacing

2.2.4 Security

2.2.5 Slotted mode

2.2.6 Contention-free operation mode

2.2.7 Support for other application models (such as HTTP, e-mail and other standard network applications, custom applications, Transaction Analyzer and Transaction Whiteboard applications)

2.3 Node Models: ZigBee
2.3.1 *Zigbee-coordinator*

2.3.2 *Zigbee_end_device*

2.3.3 *Zigbee_router*

3. RELATED WORK
Zigbee mesh topology is analyzed by using different territories to move the nodes at different speed. In [2] Performance is analyzed using delay load and traffic received .Helbert Space , Outer square and hexagon trajectory are used. Results show that performance changes with change in trajectories. In [3] this research work the performance of tree and Mesh topology is analysed with the mobility of both ZigBee End Devices and ZigBee coordinator for different trajectories. The performance is analyzed in terms of Throughput and Load using OPNET 14.5 network simulation tool. Zigbee three types of devices are used coordinator router and end devices. end devices sense the signal and send that signal to the coordinator. Coordinator collects the signal from the end devices and process that signal. In this paper [4], region based priority mechanism is used to synchronize all the requests from the end devices with tree routing method. The results shows that the performance of the overall priority based ZigBee network model is better than without a priority based model. In this paper [5], an accurate simulation model, the behaviour of a mobile Zigbee node passing through the radius of multiple PANs is examined using OPNET simulator.

The performance metrics like: PAN Affiliation, Data Dropped, Traffic Received are reported. In [6] author provides an accurate simulation model with respect to the specifications of IEEE 802.15.4 standard. We simulate and analyzed two different scenarios, where we examine the topological features and performance of the IEEE 802.15.4 standard using OPNET simulator. We compared the three possible topologies (Star, Mesh and Tree) to each other

4. STUDY OF COVERAGE AREA OF ZIGBEE-MODEL COMPNENTS

In the following scenarios coverage area of the zigbee model components with different topology was studied.

4.1 Scenario 1

In this scenario One coordinator (node_0), 2 end devices (node_1 and node_2. In Scenario 1 node_1 act as transmitter and node_2 act as receiver. Node_1 sends data through node 0. From the Figure (1) it is clear that within 800 meter range nodes are connected to coordinator. Within this range packet drop is 0 and all the packets transmitted successfully to node 2.

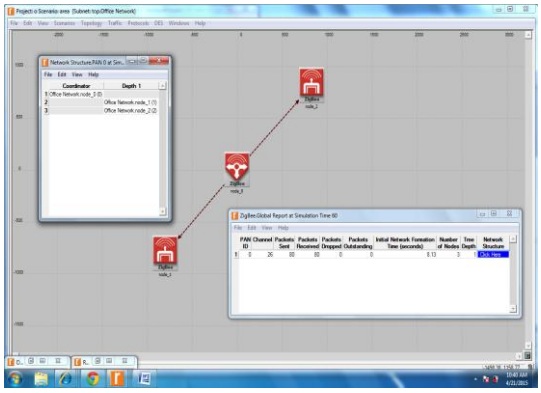

Figure 1. Star Topology

4.2 Scenario 2

In scenario 2 same nodes are used that are used in scenario 1 but end nodes are placed at 900 meter apart from the coordinator. After simulation it is observed that end nodes are not connected to coordinator. All Packets are dropped shown in Figure (2).

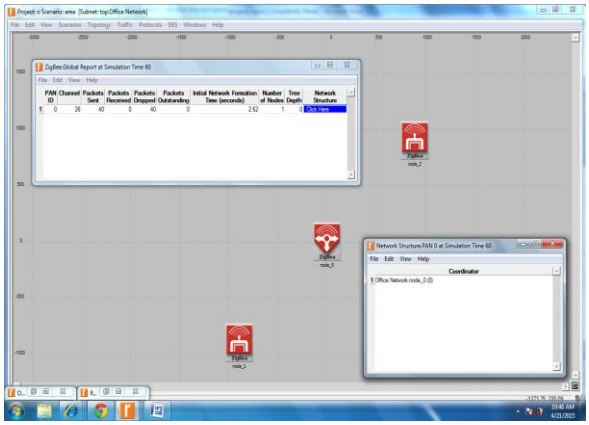

Figure 2. Star Topology

From scenario 1 and Scenario 2 it is clear that end nodes are connected 800 meters away from the coordinator after this range end nodes are disconnected from the coordinator.

4.3 Scenario 3

In Scenario 3, this paper tries to check the role of router in star topology. As it is shown in Figure 3. Four devices are used one coordinator, one router and two end devices. node _3 (router) and node_2 (end device) are connected at 800 meters away from the coordinator (node_0) and node_1 (end device) is connected at 900 meters away from the coordinator. After simulation it is observed that router and end device 2 is connected to coordinator but node 1 is not connected. The reason behind is that in star topology all the nodes interact with each other nodes through coordinator. From Scenario 1 and 2 it is clear that nodes are only connected within 800 meters range.

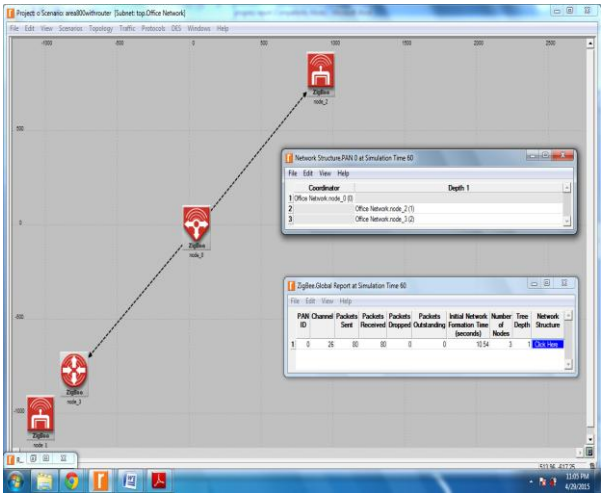

Figure 3. Star topology with router

In Scenario 3, this paper tries to check the role of router in star topology. As it is shown in Figure 3. Four devices are used one coordinator, one router and two end devices. node _3 (router) and node_2 (end device) are connected at 800 meters away from the coordinator (node_0) and node_1 (end device) is connected at 900 meters away from the coordinator. After simulation it is observed that router and end device 2 is connected to coordinator but node 1 is not connected. The reason behind is that in star topology all the nodes interact with each other nodes through coordinator. From Scenario 1 and 2 it is clear that nodes are only connected within 800 meters range.

4.4 Scenario 4

Topology : Tree with router

Scenario 4 is same as Scenario 3 the only difference is that we choose the tree topology rather than star. After simulation it is observed that node_1 (end device is connected to coordinator (node_0) through router (node3).

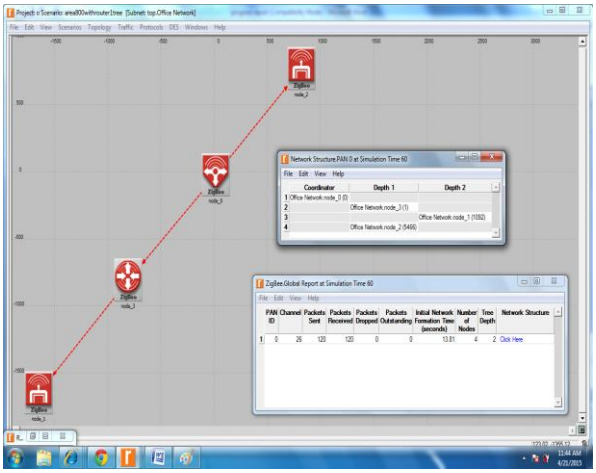

Figure 4. Tree topology with router

From Scenario 3 and Scenario 4 it is clear that star topology can cover only 800 meter range but in tree topology with the help of router we can expand the transmission area

4.5 Scenario 5

Scenario 5 is same as Scenario 4. But is this Scenario mesh topology is selected. All nodes are connected. From Scenario 3 and Scenario 4 it is clear that star topology can cover only 800 meter range but in tree topology with the help of router transmission area can be expanded.

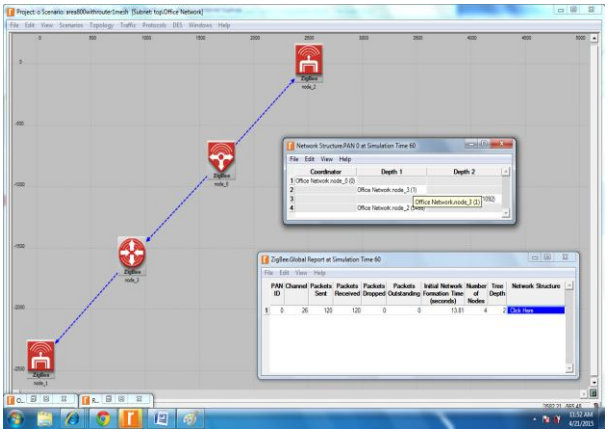

Figure 5. Mesh Topology with router

5. STUDY OF ROUTER COMPONENT

In the following scenarios capacity of the router is study that how many end devices are connected with coordinator and how many routers are connected with a router.

5.1 Scenario 6:

In Scenario 6 , the capacity of router is checked that how many end devices are connected with a single router. For this extra two end devices are used. After simulation it is observed that only two end devices are connected with router. This is the limitation of opnet.

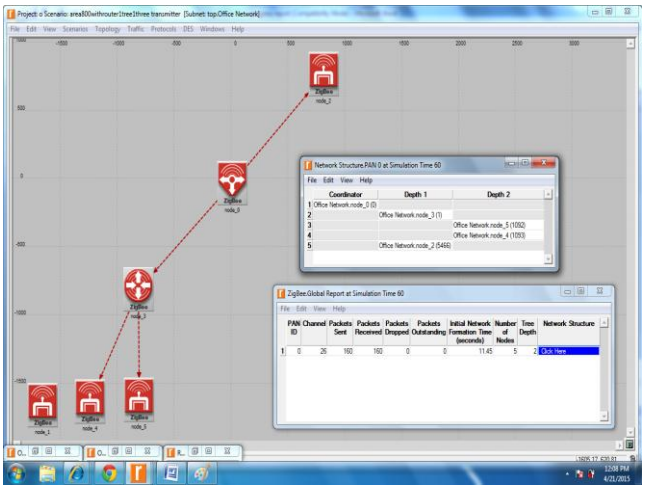

Figure 6. End devices connectivity with router

5.2 Scenario 7

In Scenario 7 ,7 routers and 3 end devices are used. After simulation it is observed that only 5 routers are connected with a router.

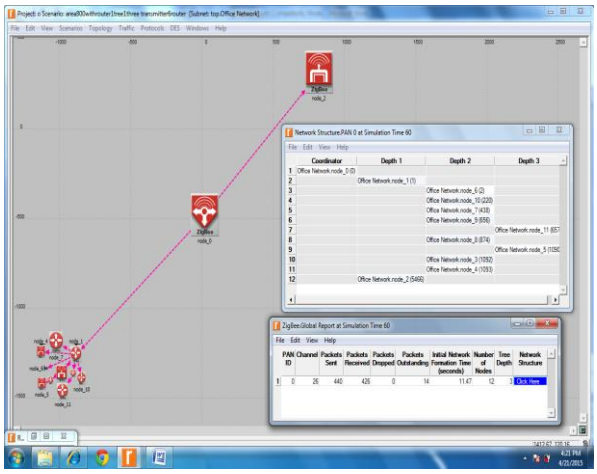

Figure 7. router to router connectivity

To see the difference this paper analyses the graphs which are obtained after simulation. Different scenarios are compared using MAC delay, throughput and packet drop parameters.

6. EFFECT OF ROUTERS FAILURES IN ZIGBEE BASED WIRELESS BODY AREA NETWORK

Routers failures [7] and their effect on the traffic are considered in different scenarios for tree and mesh topology to certify the reliability of this network. The parameters: Throughput ,Delay, Data Traffic received are measured and compared during these simulations.10 end devices, 5 routers and one coordinator device is used in the following scenarios. end devices are used to measure the signal(temperature,ECG, BP) of the human body and data is send to the coordinator through router using tree and mesh topology.Doctor collect the data from the coordinator (master node).Following scenarios checks the effect of router failure (2,3,4) on the performance of tree and mesh topology.

6.1 Scenario 8

Tree topology

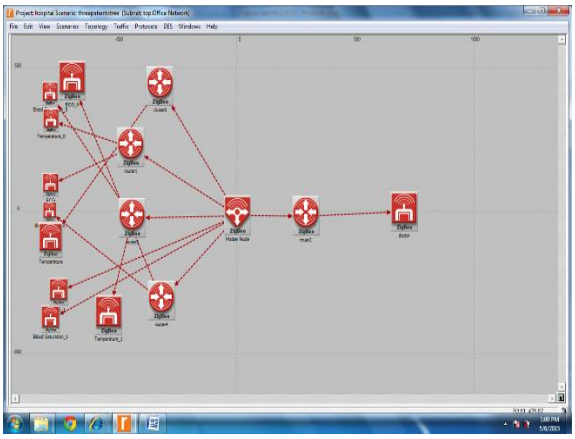

Figure 8. Zigbee network in tree topology

6.2 Scenario 9

Mesh topology

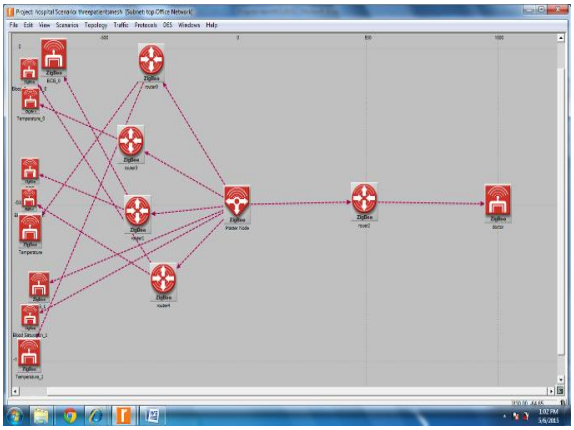

Figure 9. Zigbee network in mesh topology

7. RESULT AND DISCUSSION

MAC Throughput

Throughput is the total no packet received by the receiver within a specified time (seconds).If the delay in the network is low throughput is more. From Figure(6). It is observed that throughput for tree topology is more and for star topology is less.

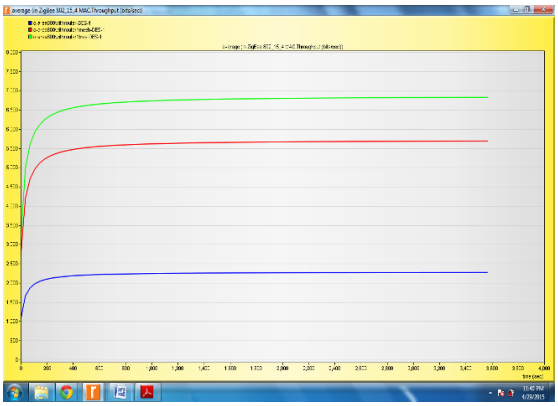

Figure 10. Throughput comparison for star, tree and mesh topology with router

End-to End Delay

End-to-end delay is the time taken by the packet to be transmitted from source to destination. From Figure (7).

From Fig. it is observed that end-to-end delay in tree topology is more and in star topology is less.In tree and mesh topology more number of hops travel, information takes extra time in order to reach to its destination in mesh topologies and tree topologies as compare to star.

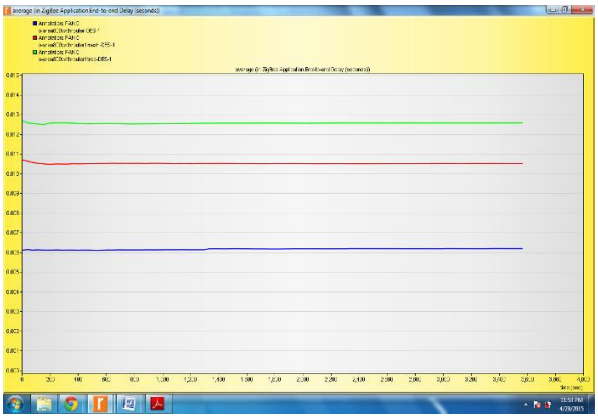

Figure 11. End-to End Delay comparison for star,tree and mesh topology

Tree Topology

Throughput

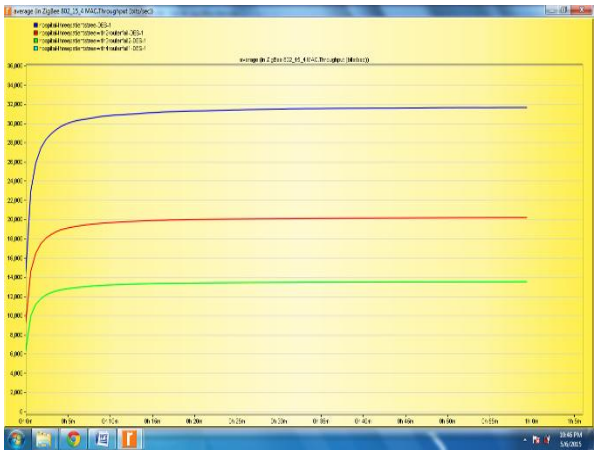

Figure 12. Comparison of throughput with 0,2,3,4 routers failures in tree topology

Figure (12) shows that throughput is decreased with router failure. Blue line shows the throughput with all the router alive. Red line for 2 router failure and green line for 3 router fail. It is also shown that throughput with 3 an routers failure are same.

Delay

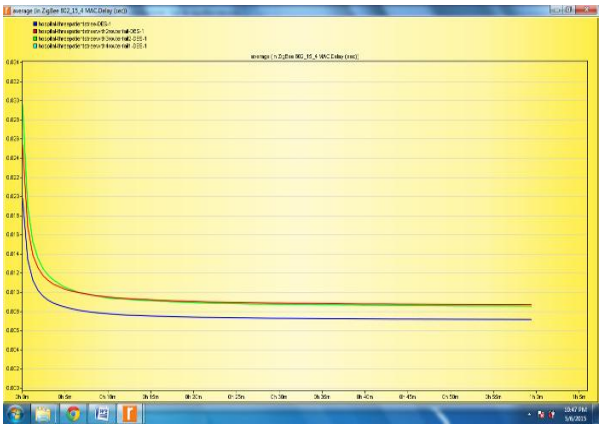

Figure 13.Comparison of Delay with 0,2,3,4 routers failures in tree topology

Figure (13) shows that when all the routers are alive delay is less.when 2 and 3 routers fail delay is almost same.

Data Traffic Received

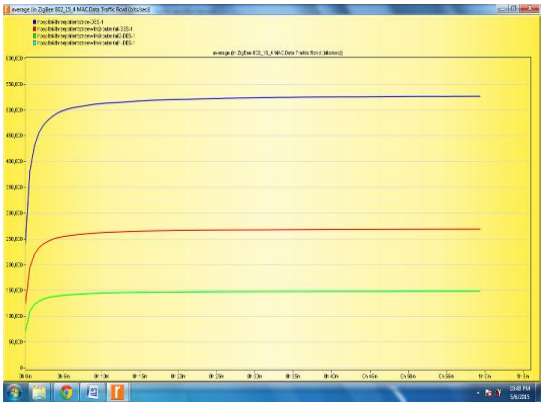

Figure 14. Comparison of Data Traffic Received with0,2,3,4 routers failures in tree topology

Mesh Topology

Throughput

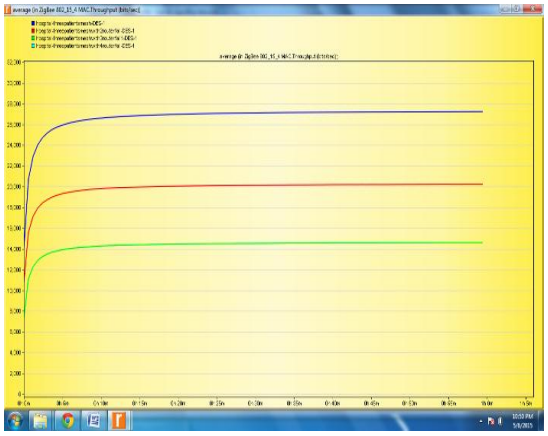

Figure 15.Comparison of throughput with 0,2,3,4 routers failures in mesh topology

Delay

Figure 16. Comparison of Delay with 0,2,3,4 routers failures in mesh topology

Data Traffic Received

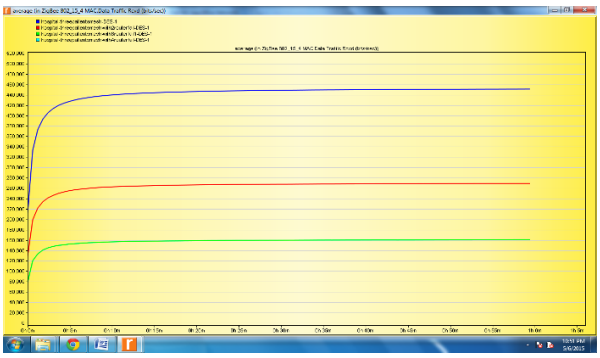

Figure 17.Comparison of Data Traffic Received with 0,2,3,4 routers failures in mesh topology

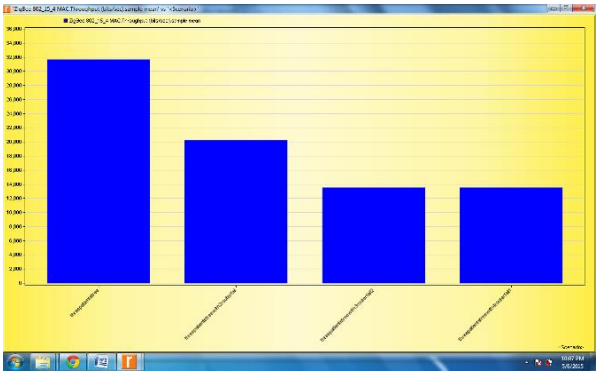

Figure 18. Bar Chart for throughput with 0, 2,3,4 routers failures in tree topology

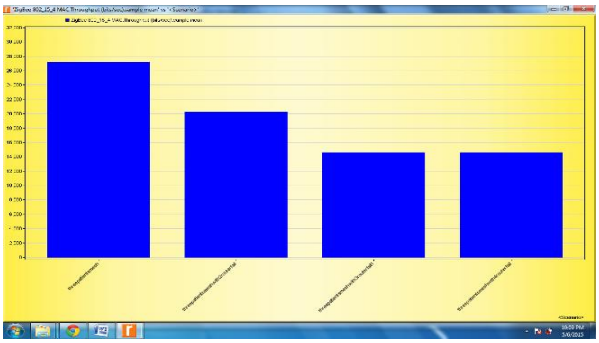

Figure 19. Bar Chart for throughput with 0, 2,3,4 routers failures in mesh topology

Figure(18) and Figure(19) shows that the throughout is decreased with router failure. it is also shown that throughput remains same after the 3 router failure.

Table 1. Comparison between two topology throughput with router failure

		Tree		**Mesh**	
		Normal	**Router fail**	**Normal**	**Router fail**
Throughput	**Mean value**	31,644	20,190	27,237	20219
	Min	14,278	9,190	14,1016	10718
	Max	32,413	20,496	27,456	20567
	Stddiv	1761	1,111	1329	960.969
Delay	**Mean value**	0.00713	0.00868	0.00680	0.00857
	Min	0.00683	0.00795	0.00661	0.00811
	Max	0.01982	0.02537	0.01402	0.01549
	Stddiv	0.00127	0.001693	0.00727	0.00729
DTR	**Mean value**	526,137	268,784	451,029	268,896
	Min	237,789	122,142	211,309	128,065
	Max	539,136	273,096	454,896	273,132
	Stddiv	29,268	14,806	24,111	14,234

Table 2. Comparison between two topology with router failure

		Mesh with two routers fail	Tree with two routers fail	Mesh with 3 routers fail	Tree with 3 routers fail	Mesh with 4 routers fail	Tree with 4 routers fail
Throughput	Mean value	20,219	20,190	14611	13515	14611	13515
	Min	10,718	9,169	7317	6277	7317	6277
	Max	20,567	20,496	15010	13759	15010	13759
	Stddiv	960,969	1,111	739	731351	739	731351
Delay	Mean value	0.00857	0.00868	0.00830	0.00852	0.00830	0.00852
	Min	0.001132	0.00795	0.00752	0.00753	0.00752	0.00753
	Max	0.015492	0.02537	0.02145	0.02963	0.02145	0.02963
	Stddiv	0.000729	0.001693	0.00135	0.00214	0.00135	0.00214
DTR	Mean value	268,896	268,784	160620	148229	160620	148229
	Min	128,065	122,142	78431	68949	78431	68949
	Max	273,132	273,096	164304	151020	164304	151020
	Stddiv	14,234	14,806	8368	8032	8368	8032

This work presents a measurement and analysis of the impact of routers failures in a zigbee tree and mesh topology WBAN. Results shows that throughput is low in case of Routers failures .Data traffic is low in case of Routers failures and delay is high in case of routers failures.

From Table1 and Table2 it is clear that Mesh topology is more reliable than the tree topology.

8. CONCLUSION

From scenario 1 and Scenario 2 it is clear that end nodes are connected 800 meters away from the coordinator after this range end nodes are disconnected from the coordinator. From Scenario 6 and Scenario 7 it is clear that only two end devices are connected with router and only 5 routers are connected with a router. Results obtained for three different topology shoes that throughput for tree topology is more and for star topology is less. It is also observed that end-to-end delay in tree topology is more and in star topology is less. In tree and mesh topology more number of hops travel, information takes extra time in order to reach to its destination in mesh topologies and tree topologies as compare to star. In future simulation model is designed in opnet. The modeled system consists of number of wards, each ward had number of sensors for each patient. That work will investigate which topology is best for the hospital environment with a stationary and mobile medical professional and patients.

9. REFERENCES

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