ZigBee –based WSN Topology Simulation Investigation and Performance Analysis using OPNET

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ABSTRACT

A ZigBee based wireless sensor network is proposed. It employs star topology, Tree topology and Mesh topology through the OPNET modular 14.5 in this research paper, the matrix we measured was MAC throughput, MAC media access delay, no of hopes, packet drops. We thus purpose simple simulation result and prototyping experiences are also reported.

Key words: ZigBee, WSN, Topology, IEEE 802.15.4, OPNET.

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INTRODUCTION

Wireless 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,].Wireless sensor network widely applicable in environment monitoring, military operation, medical and health, home intelligent monitoring, and other commercial field [4]. 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].

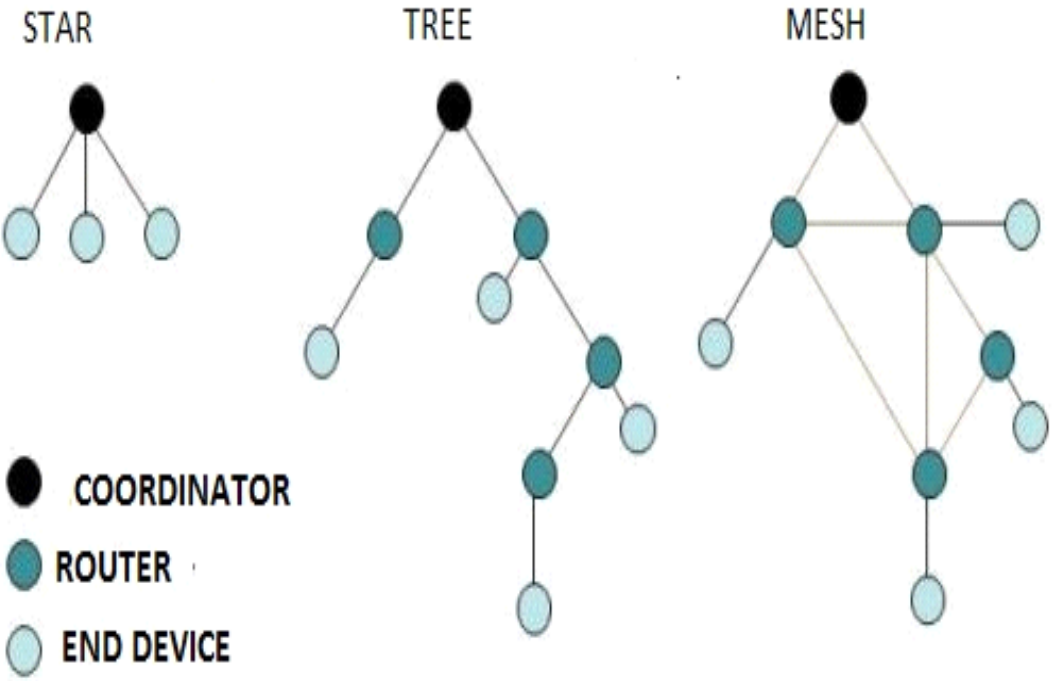
ZigBee is developed by ZigBee alliance which has hundreds of members companies (Ember, Free scale, Chipcon, Invensys, Mitsubishi, CompXs, AMI semiconductors, ENQ semiconductor) from semiconductor and software developers to originally equipments manufacturers.

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].

THE STRUCTURE AND RESEARCH PLATFORM OF ZIGBEE WSN

All There are three types of nodes in ZigBee wireless sensor network: coordinator, router, and device [3,7]. 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 achive the following three forms of network topology: Star network, Tree Network, Mesh Network [3, 8] are the developed from the concept of peer-to-peer topology in IEEE 802.15.4 [9].



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).

EXPERIMENTAL MODEL

The In this experiment we compare three topologies of ZigBee WSN. These three topologies are Star, Mesh, Tree. The basic Star topology scenarios consist of 15 ZigBee end devices and one coordinator as shown in fig 2. The basic mesh and tree topologies scenario consist of 15 ZigBee end devices, 8 Zigbee routers and one coordinator as shown in fig 3. The number of nodes varies from 210 to 290 in all topologies.

One coordinator as shown in figure 3. The number of nodes varies from 210 to 290 in all topologies.

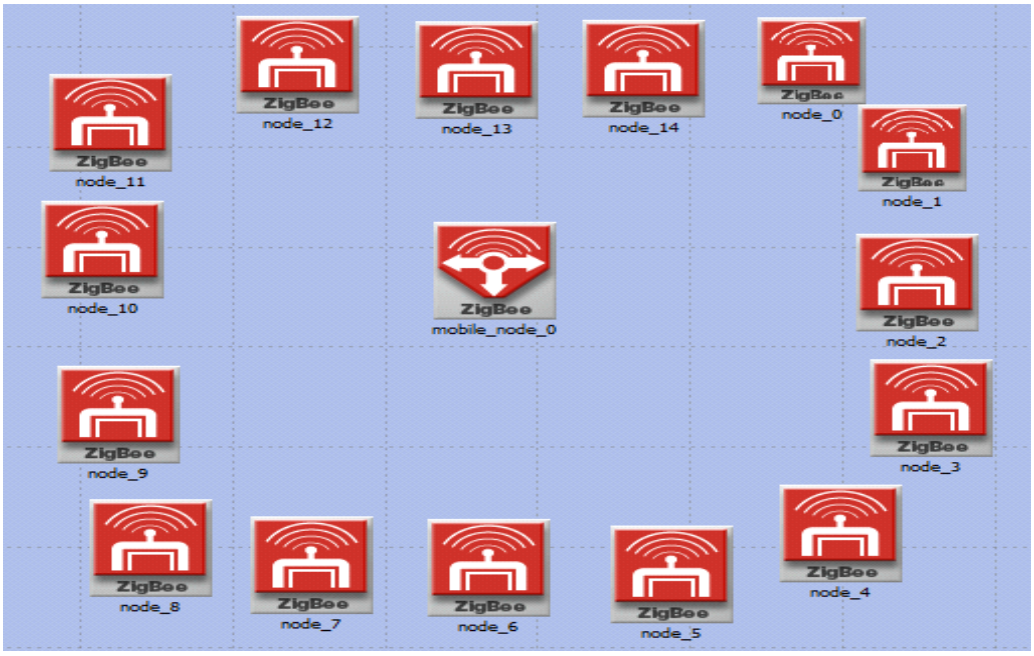


Figure 2 Star

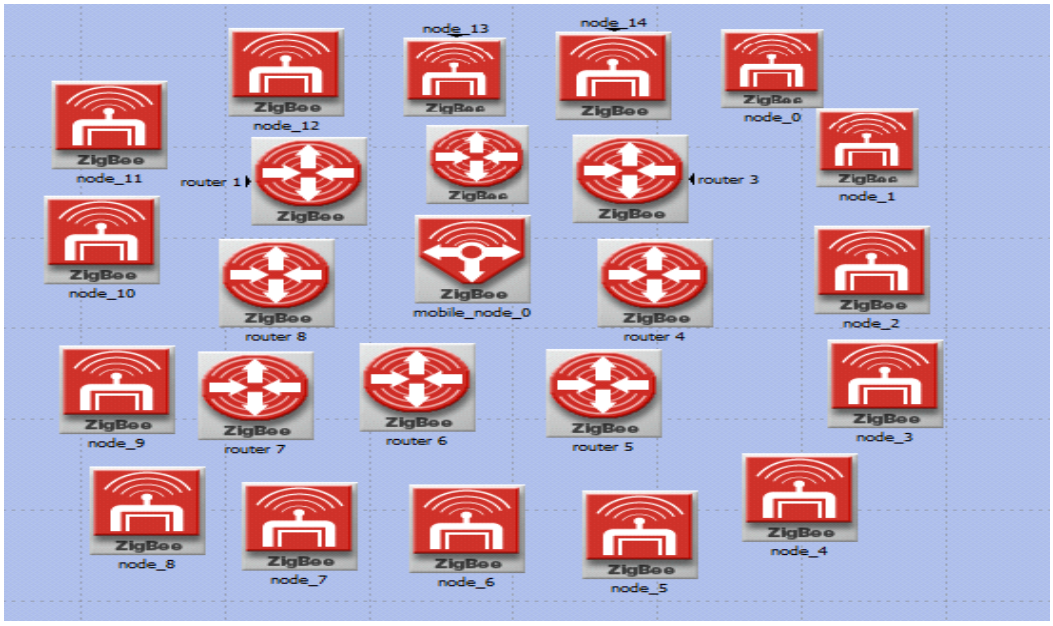


Figure 3 Mesh and Tree

OPNET Simulator was used to carry 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 [1]. OPNET modeler provides better environment for simulation, data collection and data analysis [10]. The Simulation parameters used in our scenario for coordinator are shown in Table 1 and Table 2.

Table 1: coordinator's Network Layer Parameter

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

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

Mac Layer Parameter	
ACK Wait Duration (sec)	0.1
no. of retransmissions	10
Minimum value of the back-off exponent in the CSMA/CA	3
Maximum no. of back-off in the CSMA/CA	5
Channel sensing duration(sec)	0.2
Physical Layer Parameter	
Data Rate (kbps)	250
Receiver Sensitivity (db)	-90
Transmission band (Ghz)	2.4
Transmission Power (W)	.1
Application Layer Parameter	
Packet interval time/type (sec/constant)	1
Packet size/type	1408/constant

In this research, the metrics we measured was MAC Throughput, MAC Media access delay, Mac Delay, no. of hopes and packet drops

MAC THROUGHPUT

Throughput is the sum of the data rates that are delivered to all terminals in a network. Fig 4, Fig 5 and Fig 6 shows the average MAC Throughput of Star, Tree and mesh. From Fig. 3 it can clearly be seen that in star topology when the number of nodes increases the MAC throughput decreases. This is correct because the data being received by the MAC layer increases. In case of tree and mesh topologies shows the fluctuation as we increase the no. of nodes.

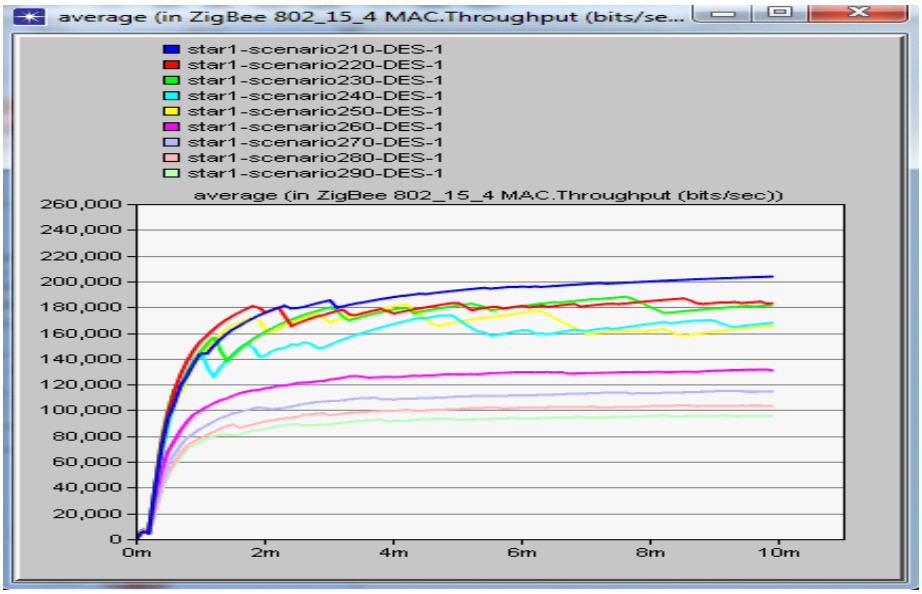


Figure 4 Star

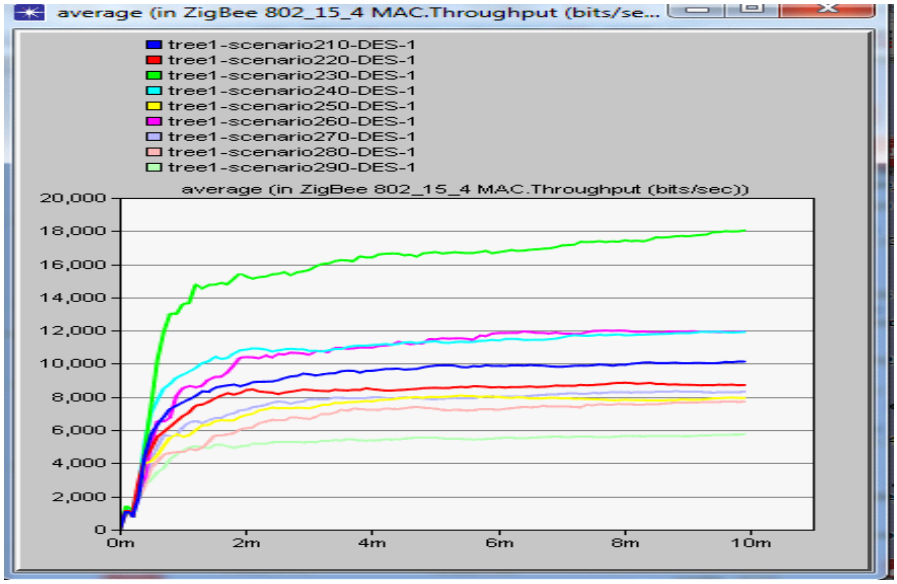


Figure 5 Tree

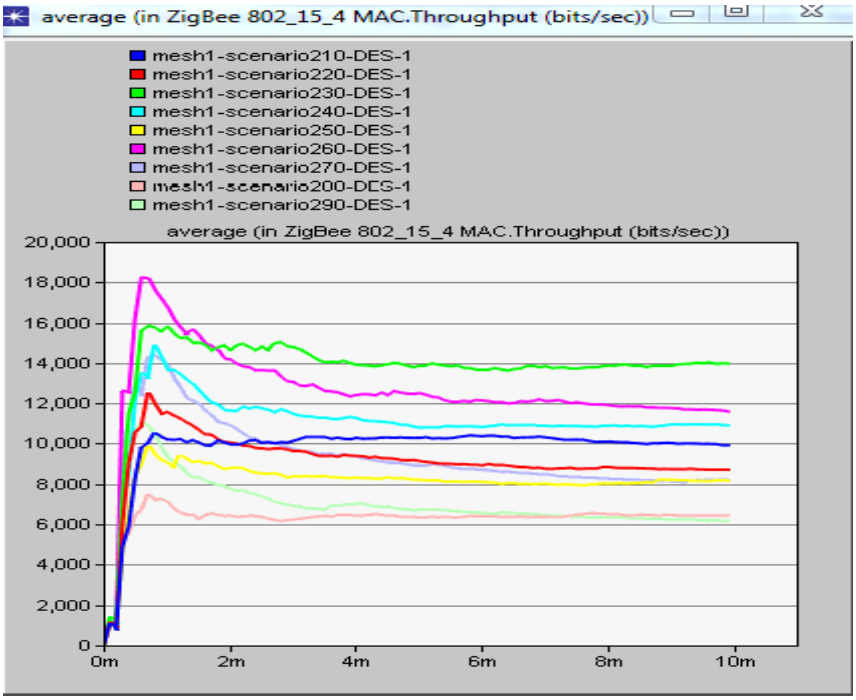


Figure 6 Mesh

NO. OF NETWORK LAYER PACKET DROPPED

Figure 7 shows average Network Layer Packet drop in mesh topology whereas Fig 8 and Fig 9 shows average packet drop in star and tree topologies respectively. These Figures show that as the no. of nodes increases the packet drop increases. This is because as we increase the no. of nodes the collision increases so packet drop increases. From Fig 7, Fig 8, Fig 9 it is clear that the packet drop in star is less than mesh and tree.

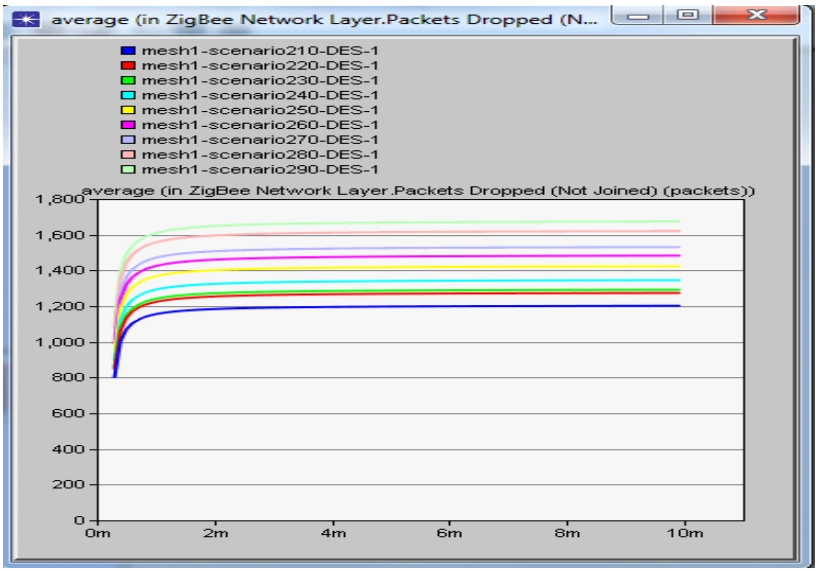


Figure 7 Mesh

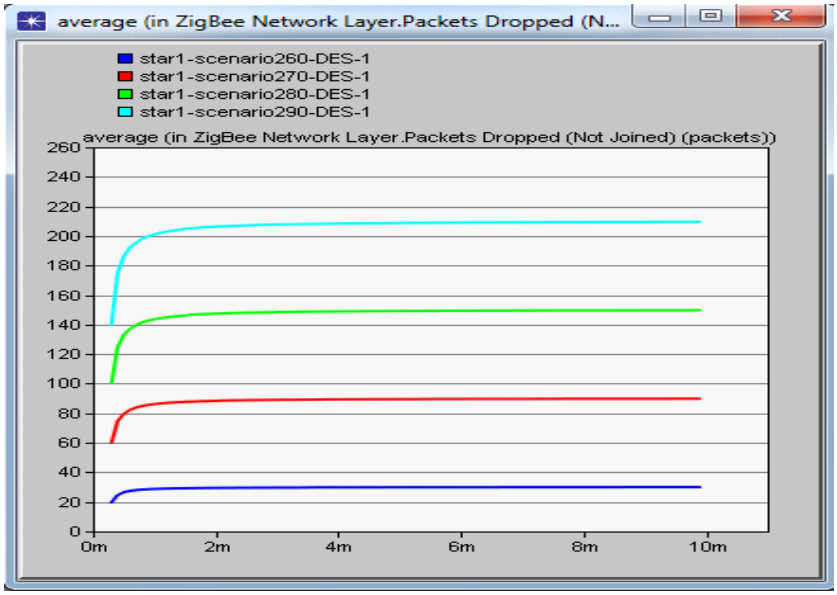


Figure 8 Star

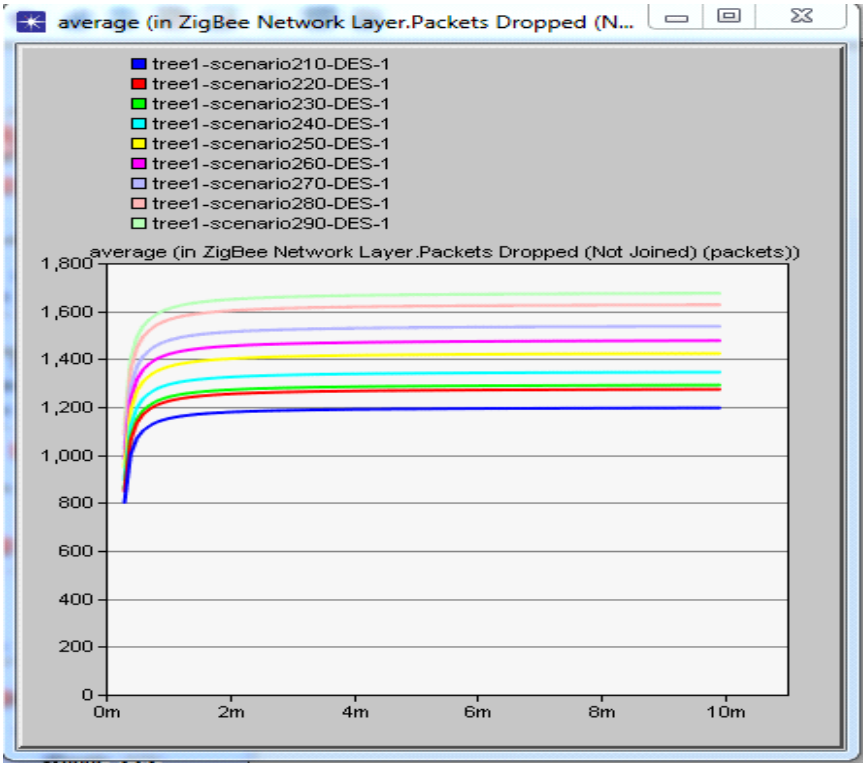


Figure 9 Tree

MAC MEDIA ACCESS DELAY:

Fig 10, Fig 11, Fig 12 shows average Mac Media Access delay for Mesh, Star and Tree respectively. As Figures show that as we increase the no. of nodes there is rise and fall in the Mac Media Access delay.

From Fig 10, Fig 11 and Fig 12 it is clear that the maximum value for mesh is 0.17 and for tree is 0.21 and for star is 21 which is correct because in star all nodes send data through on hub so it have only one path to send data from one node to another so delay is more than tree and mesh.

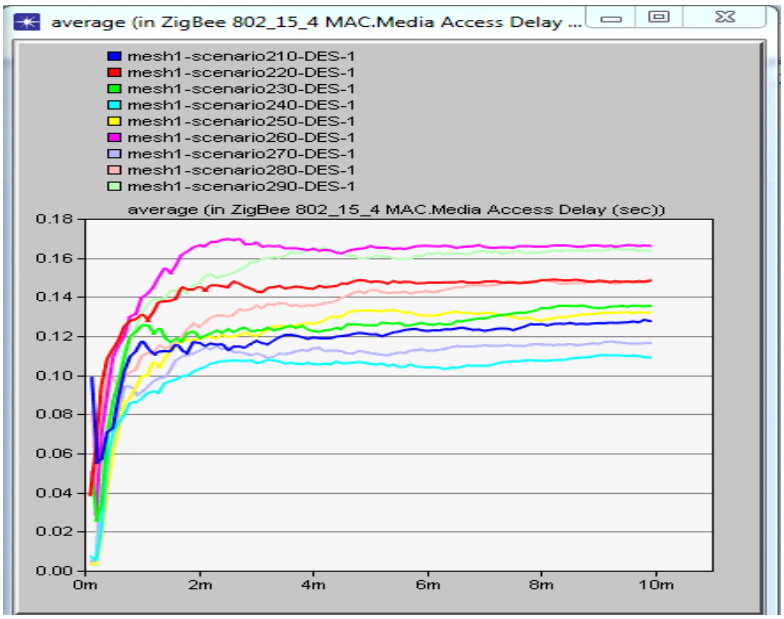


Figure 10 Mesh

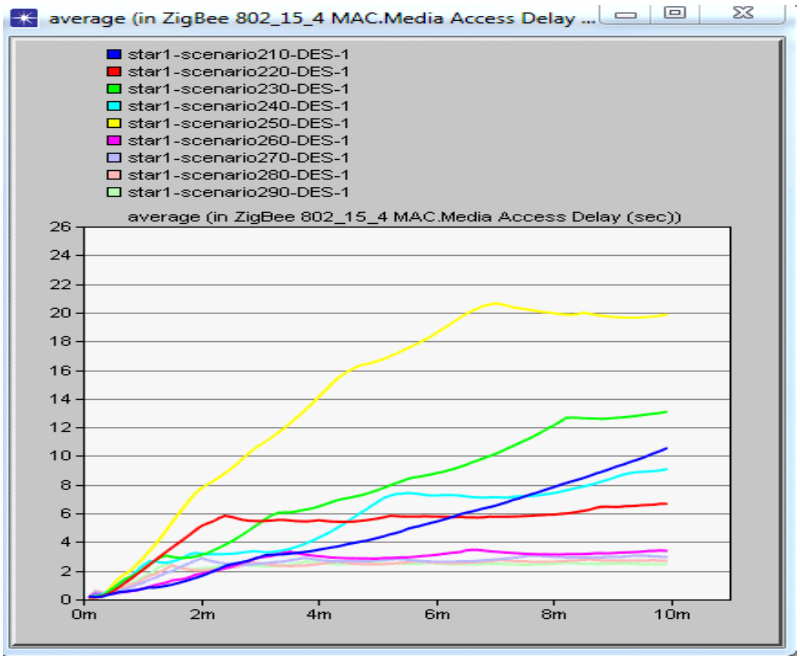


Figure 11 Star

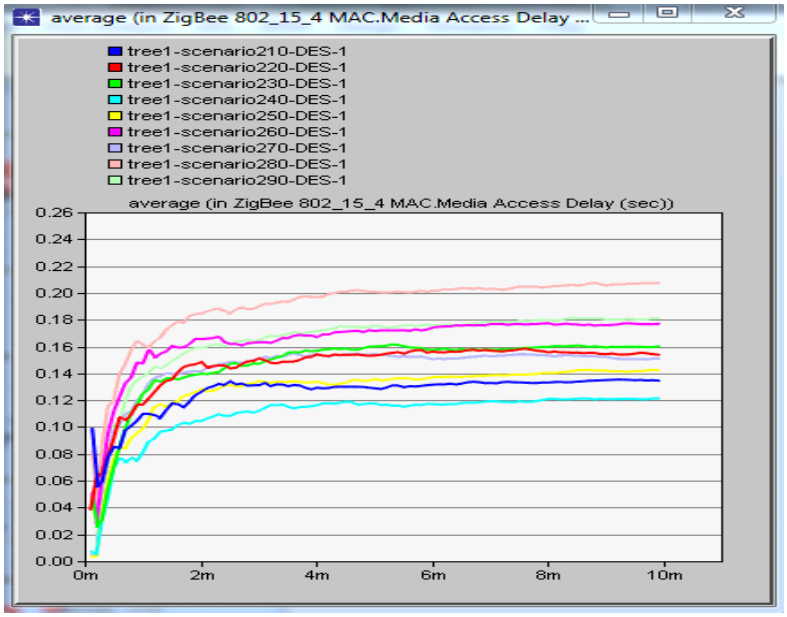


Figure 12

NUMBER OF HOPS

Fig.13, Fig 14 and Fig 15 shows the average no. of hopes for tree, star and mesh. These figure shows that the maximum no. of hopes for star is 2 and for mesh and tree increases to 3. This is true because in tree and mesh data transmitted for long route so in it data is passed form more hopes than in star.

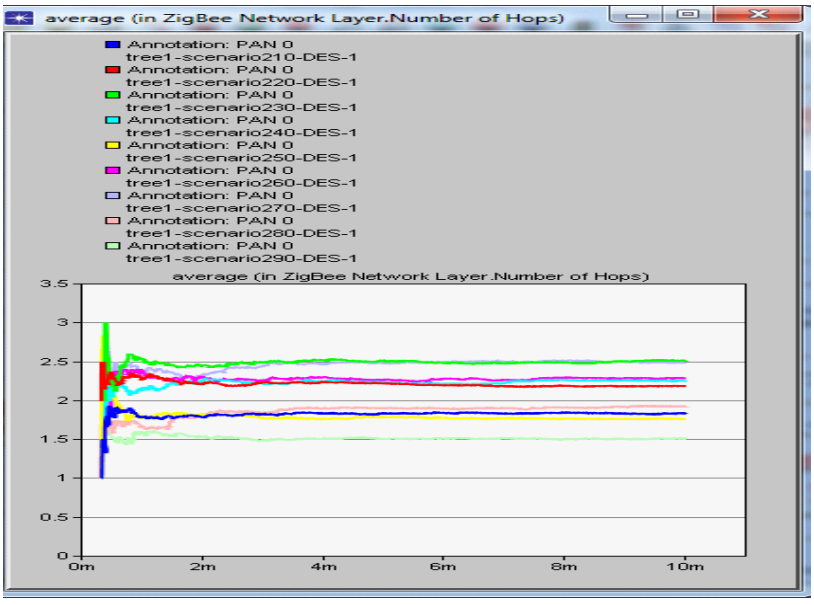


Figure 13 Tree

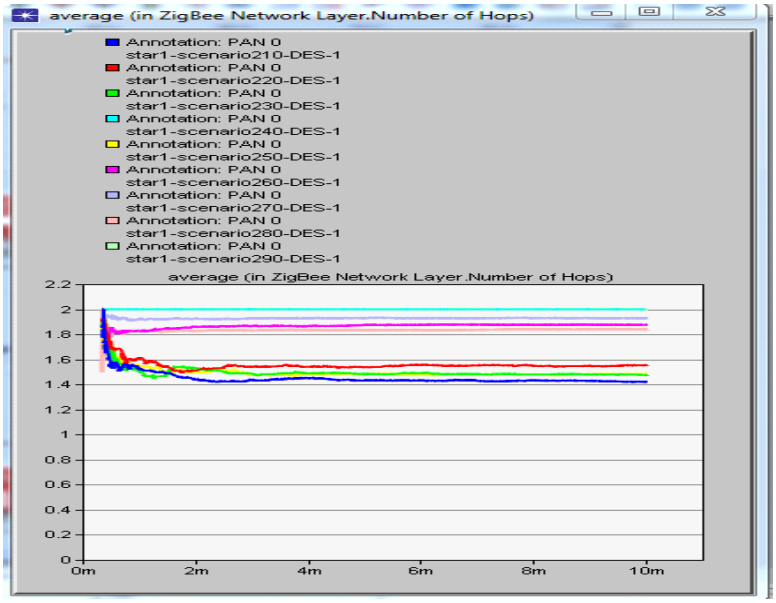


Figure 14 Star

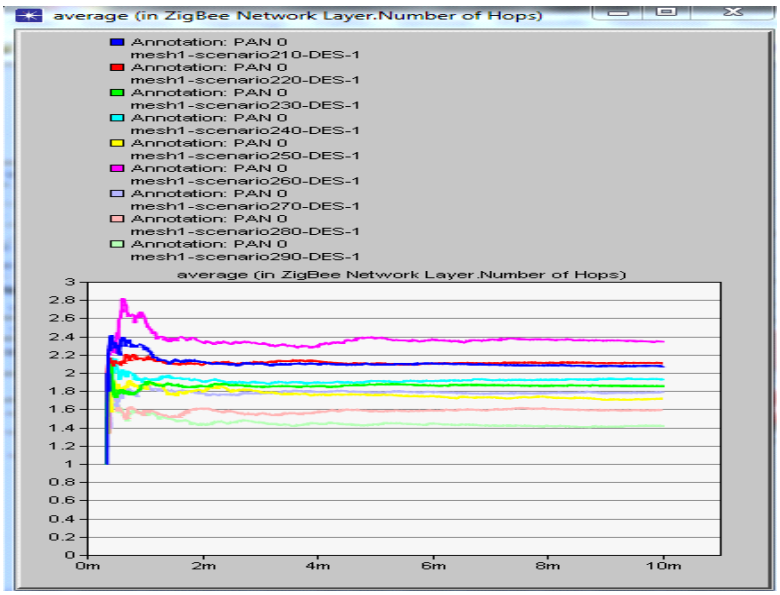


Figure 15 Mesh

CONCLUSION

In this paper simulate the ZigBee wireless sensor network using OPNET 14.5 modular in general analyze the performance check in ZigBee network using star topology, Mesh topology, and Tree topology with different types of nodes are end devices, coordinator, Zigbee routers varies from 210 to 290 in all topologies. Simulation shows that Mesh and Tree provide better result than Star.

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