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Performance Analysis of Mobility of Coordinator and End Devices for Mesh and Tree Topologies in Zigbee

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Abstract: Wireless sensor network, IEEE 802.15.4/ZigBee is a worldwide open standard for wireless radio networks which provides network, security, and application support services. ZigBee (IEEE 802.15.4-2006 standard) is a category in the IEEE 802 family and ZigBee alliance is responsible for ZigBee standard which uses the transported services of the 802.15.4 network specification therefore ZigBee is a specification for a suite of high level communication protocols using small, low-power digital radios based on an IEEE 802 standard for personal area networks In 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 analysed in terms of Throughput and Load using OPNET 14.5 network simulation tool.

Keywords: WSN, ZigBee, 802.15, OPNET

1. INTRODUCTION

ZigBee was developed by IEEE 802.15.4 Task Group and ZigBee Alliance. ZigBee alliance is responsible for ZigBee standard. The standard was developed to meet the following principal need of low cost, ultra-low power consumption, use of unlicensed radio bands, cheap and easy installation, flexible and extendable networks. A Wireless Sensor Network can be generally described as a collection of sensor nodes organized into a cooperatively network that can sense and control the environment enabling interaction between persons or embedded computers and the surrounding environment [2]. ZigBee operates in the industrial, scientific and medical (ISM) radio band, specifically at 2.4 GHz internationally and 868 MHz or 915 MHz in specific parts of the world.

1.1 IEEE 802.15.4/ ZigBee Architechture

ZigBee defines two layers of the OSI (Open Systems Interconnection) model: the Application Layer (APL) and the Network Layer (NWL). Each layer performs a specific set of services for the layer above. The different layers communicate through Service Access Points (SAP's). These SAPs enclose two types of entities: (1) a data entity (NLDE-SAP) to provide data transmission service and (2) a management entity (NLME-SAP) providing all the management services between layers. The ZigBee Network Layer (NWL) is responsible for Network management procedures (e.g. nodes joining and leaving the network), security and routing. It also encloses the neighbour tables and the storage of related information. The NWL provides one set of interfaces, the Network Layer Data Entity Service Access Point (NLDE-SAP) used to exchange data with the APS.

1.2 ZigBee Device Object

Regarding the devices role in the network, ZigBee defines 3 types of devices: ZigBee Coordinator (ZC), ZigBee Router (ZR) and ZigBee End Device (ZED).

ZigBee Coordinator (ZC): One for each ZigBee Network, Initiates and configures Network formation. The most capable device, the coordinator forms the root of the network tree and might bridge to other networks. It is able to store information about the network and also acting as the Trust Centre & repository for security keys.

ZigBee Router (ZR): Participates in multi-hop routing of messages in mesh and Cluster-Tree networks. Associates with ZC or with previously associated ZR in Cluster-Tree topologies. As well as running an application function a router can act as an intermediate router, passing data from other devices.

ZigBee End Device (ZED): Does not allow other devices to associate with it and also don't participate in routing. It is just a sensor/actuator node. Contains just enough functionality to talk to the parent node (either the coordinator or a router), it cannot relay data from other devices. This relationship allows the node to be asleep a significant amount of the time thereby giving long battery life. A ZED requires the least amount of memory, and therefore can be less expensive. It is a Reduced Function Device (RFD) – implementing a reduced subset of the protocol stack [8].

Figure 1: ZigBee Devices

1.3 ZigBee Topologies

The ZigBee standard allows the formation of three types of network topology: star, tree, and mesh.

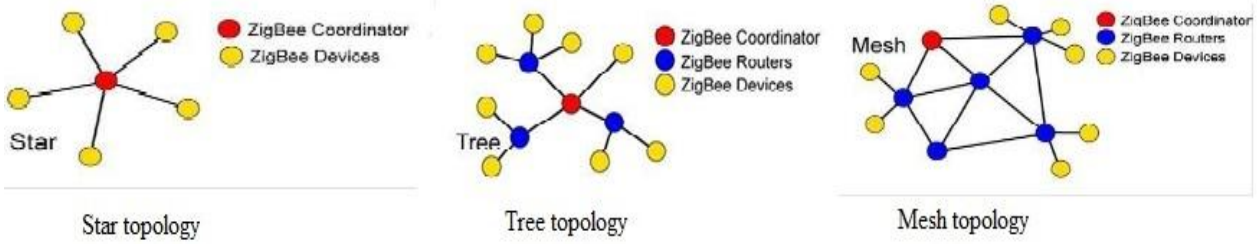


Figure 2: Topologies

The star topology is the simplest of the three topologies, consisting of only a single coordinator with a number of end-devices as its children. The terminal nodes cannot directly transmit data each other when needed they are linked together to communication with each other through the center node as medium. In the case of a tree topology, the devices organize themselves into a tree-like structure with the coordinator representing the root of the tree, routers representing the roots of sub-trees, and end-devices representing leaves. In a network of mesh topology routers and coordinators form multiple links among each other while having end-devices as their children. Although more complex in its formation and operation, mesh topology is characterized by link/path redundancy which is known to result in improved network robustness and network routing function.

2. Related work

In 2010 Harsh Dhaka *et.al*, performed extensive evaluation, using OPNET Modeller, to study the impact of coordinator mobility on ZigBee mesh network. The results show that the ZigBee mesh routing algorithm exhibits significant performance difference when the router are placed at different locations and the trajectories of coordinator are varied. We also show that the status of ACK in the packet also plays a critical role in deciding network performances.

In 2012 Ms. Sonal J. Rane *et. al*, proposed 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 2012 S. R. Ramyah et, al, performed extensive network evaluation, to study the Effect of coordinator mobility on ZigBee mesh network, using OPNET Modeller. In mobile coordinator, the type of the trajectory along with the node density and the traffic are the major factors that decide the system performance. The results obtained from the wide analysis of ZigBee mesh network shows variation when the routers are placed at Hexagonal configuration with a mobile coordinator. In this paper, variations in load metric is analysed in hexagonal configuration by enabling and disabling ACK. Thus the status of ACK also plays a critical role in analysing load metrics. In 2012 Neeti Bisht, *et. al* author analysed the effect of mobility on the performance of WSN models. We used well known network simulator QualNet 5.0 from scalable networks to evaluate the performance of the scenario. Several sensor nodes were randomly deployed in the networks to create sensing phenomena. The performance analysis is based on different network metrics such as total packets received, average end-to-end delay and throughput.

3. Experimental Setup

In this research the performance of Mesh and tree is analysed with the mobility of both ZigBee End Devices and ZigBee coordinator. To analyse the effect different scenarios are made. The number of nodes taken are 100, 150, 200. In each scenario the placement of nodes are random over an area of 100m*100m. The fixed mobility model is used. We used three trajectories Circle, inner square and outer square. To get the performance of Mesh and Tree OPNET modeller [11] is used, as OPNET modeler provides a comprehensive development environment supporting the modelling of communication network and distributed systems. OPNET modeller provides better environment for simulation, data collection and data analysis.

TABLE 1: SIMULATION PARAMETERS

Network Parameter	Parameter Value
Packet Size	1024 bits
CSMA-CA minimum backoff exponent	3
CSMA-CA maximum number of backoff	4
Channel sensing Duration	0.1 sec
Beacon Order	6
Super Frame Order	0

Maximum Children	30
Maximum Routers	6
Maximum Depth	7
Beacon	Disabled
Frequency Band	2.45 GHz
Packet Inter-Arrival Time	36 sec
Packet Inter-Arrival Time (Router)	120 sec
Packet Inter-Arrival Time(Coordinator)	10 sec
Route Discovery Timeout	10 sec
Packet Destination	Coordinator and Router

4. RESULT

Simulation is conducted to evaluate the performance of ZigBee 802.15.4 wireless sensor network using OPNET version 14.5. All results are clarified in the presence of two topology tree and mesh, with the mobility of both ZigBee End Devices and ZigBee coordinator for different trajectories.

We analysed the performance in the terms of Load and Throughput using different scenario, here we take a results with and without acknowledgement for 100, 150 and 200 nodes for both tree and mesh topologies.

4.1 LOAD

It represents the total load (in bits/sec) submitted to ZigBee 802.15.4 MAC by all higher layers in all WPAN nodes of the network.

Firstly, discussed about the ZigBee load without acknowledgement for both mesh and tree topology.

For mesh topology:

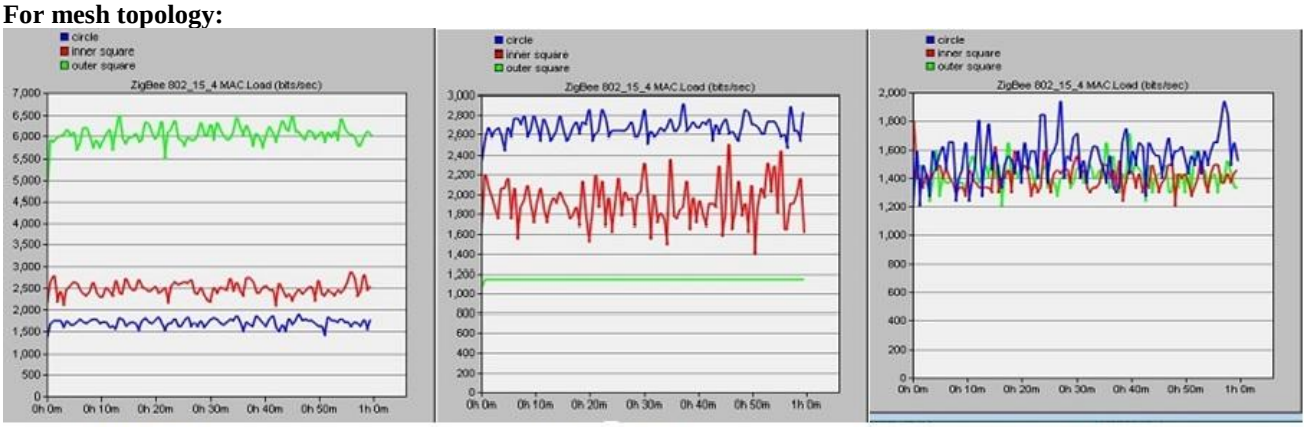


Figure 3: Load without ACK

Figure 3 shows the result of Mesh for nodes 100, 150 and 200 without acknowledgement. The result shows that as we increase the number of nodes from 100 to 150 the load is increase in case of circle trajectory and in case of inner square and outer square it decreases. The load shows most deviation (decrease) in case of outer square as nodes increases. Further we increase the nodes load again decrease for all trajectories. The result also shows that the performance of circle is better as we increase the number of nodes.

For tree topology:

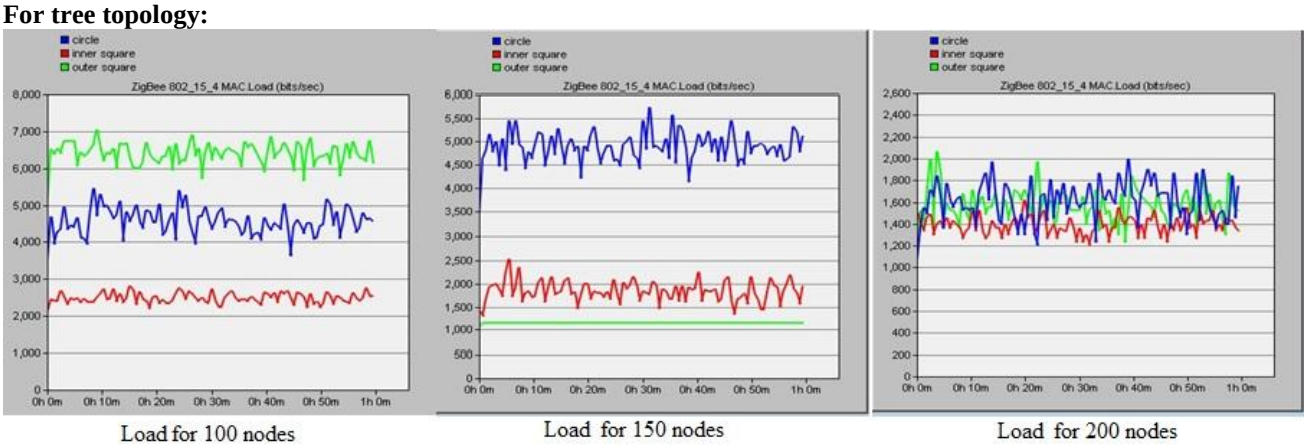
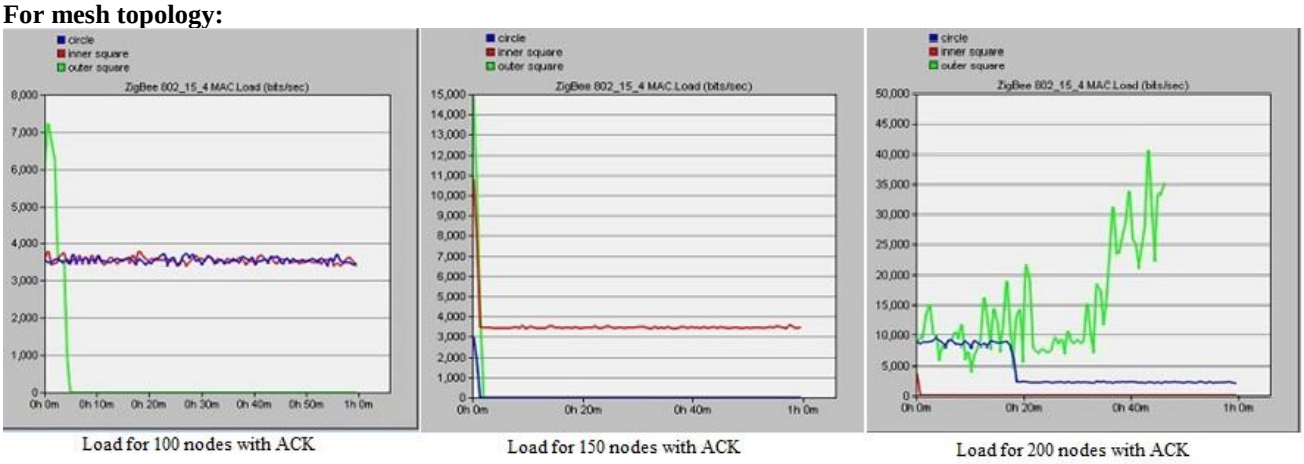


Figure 4: Load without ACK

Figure 4 shows the result of tree for 100, 150 and 200 nodes, without acknowledgement. The result shows that as we increase the number of nodes from 100 to 150 the load decreases. The result also shows that circle trajectory have better performance than other two.

Now discussed about the ZigBee load, with acknowledgement for both mesh and tree topology.

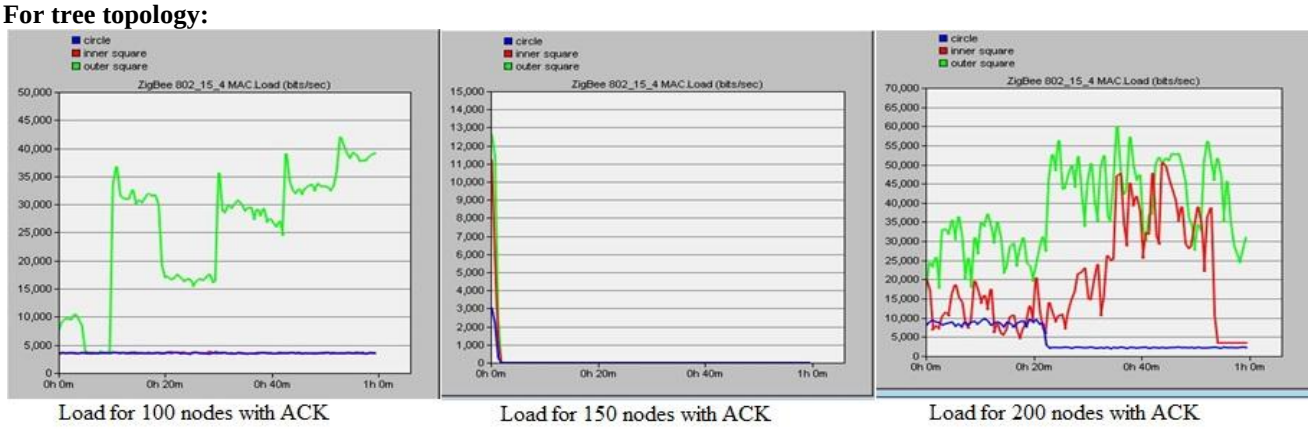
For mesh topology:



Load for 100 nodes with ACK | Load for 150 nodes with ACK | Load for 200 nodes with ACK

Figure 5: Load with ACK

For tree topology:



Load for 100 nodes with ACK | Load for 150 nodes with ACK | Load for 200 nodes with ACK

Figure 6: Load with ACK

Figure 5 shows the result of mesh for three trajectories for nodes 100,150 and 200 by using acknowledgement. The figure shows that as we increase the number of nodes the load is increased. The result also shows that as time passes the load reduces for all trajectories. But only in case of outer square for 200 nodes the load increase with increase of time. The result also shows that in starting the performance of outer square is better than other trajectories.

Figure 6 shows the result of mesh for three trajectories for nodes 100, 150 and 200 by using acknowledgement. The figures show that as we increase the number of nodes the load first decrease for 150 nodes and then increases as we increase nodes to 200. The result also shows that the performance of outer square is better than other two.

From the above figures results also show that in case of load both with and without acknowledgement, tree topology is better than mesh topology.

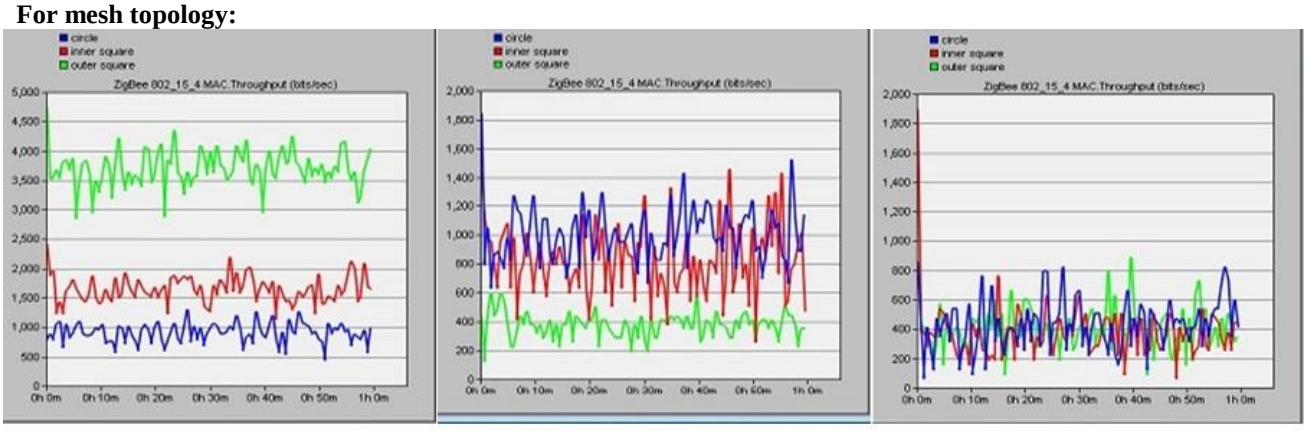
4.2 THROUGHPUT

It represents the total number of bits (in bits/sec) forwarded from ZigBee 802.15.4 MAC to higher layers in all WPAN nodes of the network.

ZigBee throughput is discussed in the term of with and without acknowledgement using 100, 150 and 200 nodes.

Let us discussed about the ZigBee throughput, without acknowledgement for both mesh and tree topology.

For mesh topology:



Throughput for 100 nodes | Throughput for 150 nodes | Throughput for 200 nodes

Figure 7: Throughput without ACK

For tree topology:

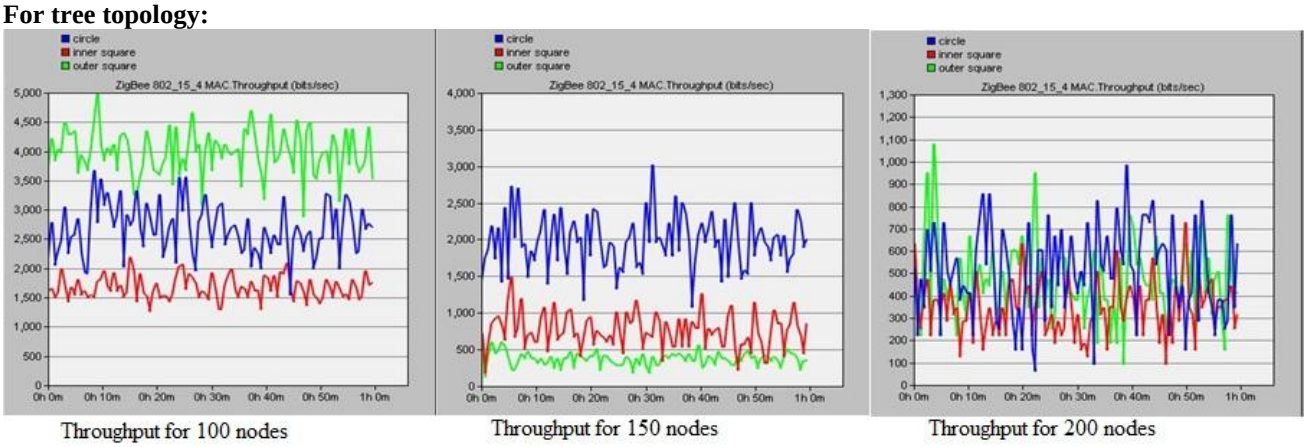


Figure 8: Throughput without ACK (tree)

Figure 7 shows the result of throughput for different nodes for three trajectories. The result shows that as we increase the number of nodes throughput decreases for all trajectories. The result also shows that as we increase the no. of nodes the performance of circle becomes better than other two.

Figure 8 shows the result of throughput for different nodes for three trajectories. The result shows that as we increase the number of nodes the throughput decreases for all trajectories. The result also shows that circle trajectory have better performance than other two.

Now discussed about the ZigBee throughput, with acknowledgement for both mesh and tree topology.

For mesh topology:

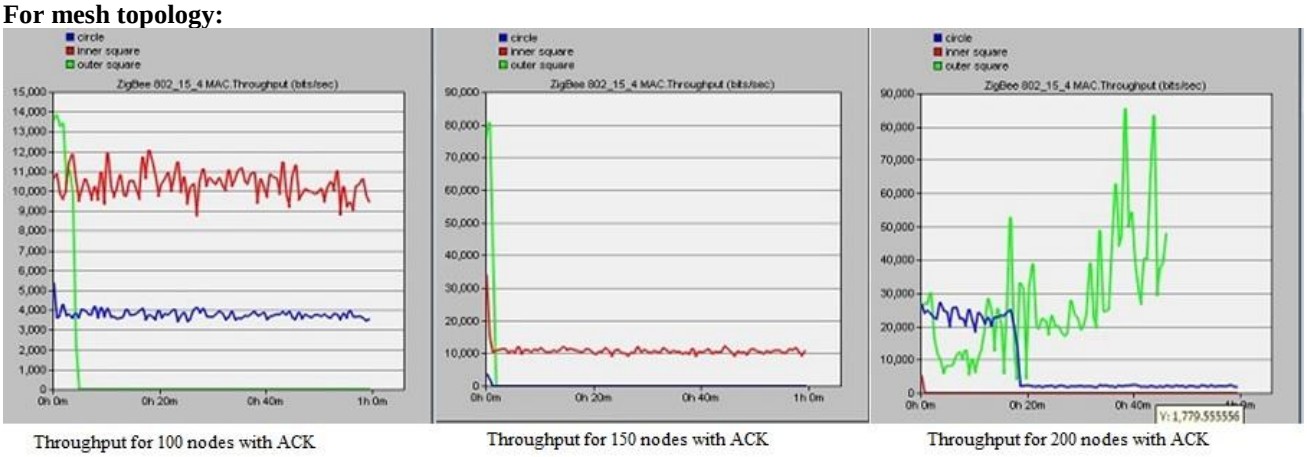


Figure 9: Throughput with ACK

For tree topology:

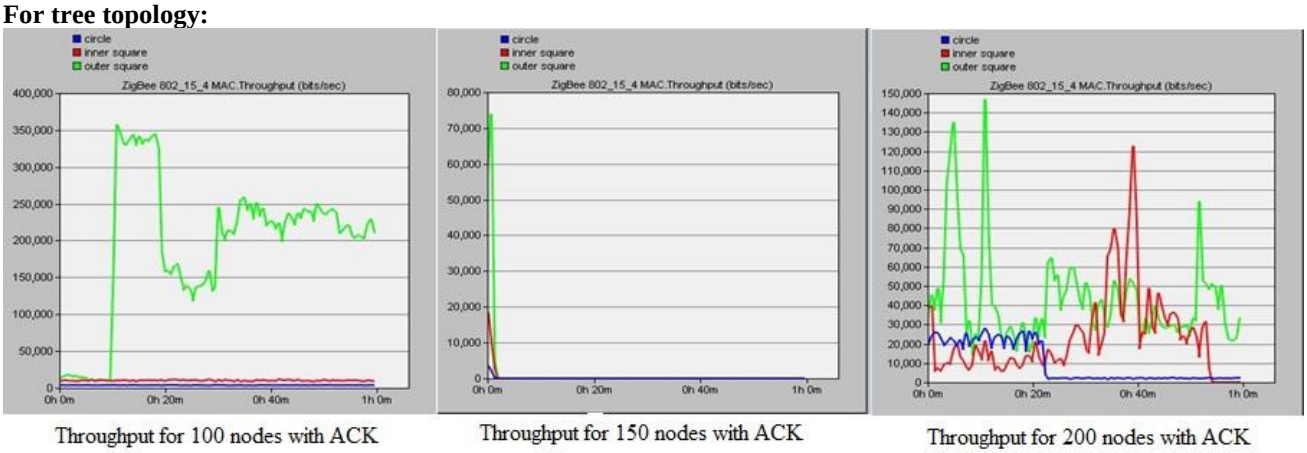


Figure 10: Throughput with ACK (tree)

Figure 9 shows the result of three trajectories for node 100,150 and 200 by using acknowledgement in mesh. The result shows that as we increase the number of nodes the throughput increases. The result also shows that as time is increased the throughput decreases. The result also shows that outer square trajectory have better performance than other two.

Figure 10 shows the result of three trajectories for node 100,150 and 200 by using acknowledgement in tree. The result shows that as we increase the number of nodes the throughput is increase. The result also shows that outer square trajectory have better performance than other two.

From the above figures results also show that in case of Throughput both with and without acknowledgement, tree topology is better than mesh topology

5. Conclusion and Future Scope

In this research the performance of performance of Mesh and Tree is analyzed with the mobility of both ZigBee End Devices and ZigBee coordinator. The performance is compared in terms of Load and Throughput. In this research the placement of nodes is random over 100m*100m area. The speed of end devices and coordinator is fixed 15m/s. The mobility model used is fixed. We use three trajectories circle, inner square and outer square. The results shows that without using Acknowledgement the performance of circle trajectory is better than other two trajectories but if we use acknowledgement than performance of outer square is better than other two in terms of Load and Throughput. The result also shows that the performance of tree is better than mesh. In future one can compare the performance of Star, mesh and tree by increasing the no. of nodes, area and by varying different speed.

References

[1] Kuldeep Vats A.Pennacchia, P.Mazzolai and P.Dario, "Development of a Programmable Sensor Interface for Wireless Net- work Nodes for Intelligent Agricultural Applications", Proceedings of IE, IEEE Computer and Communications Societies, Sydney, 2005,pp. 1-6.

[2] Yu Chengbo et al, "Research and Application on the coverage range of the ZigBee Protocol", IEEE 2009[3] IEEE STD 802.15.4[5], www.zigbee.org.

[3] 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).

[4] Yu-Kai Huang et al. "Distributed Throughput Optimization for ZigBee Cluster-Tree Network" IEEE Transaction on Parallel and Distributed Systems, VOL. 23, (2012).

[5] K.Konstantinos, X.Apostolos, K.Panagiotis and S.George, "Topology Optimization in Wireless Sensor Networks for Precision Agriculture Applications," Sensor Communication, 2007, pp. 526-530.

[6] I.S. Hammodi et al, "A comprehensive performance study of OPNET modeler for ZigBee WSN" 3rdInternational conference on Next Generation Mobile Applications, 2009.

[7] Harsh Dhaka et al, "Impact of Coordinator Mobility on the throughput in a Zigbee Mesh Networks" 2010 IEEE.

[8] Ms.Sonal J. Rane, "A Simulation Study of Behaviour of Mobile Zigbee Node," (IJSRET) Volume 1 Issue 6, pp001-003 September 2012.

[9] S. R. Ramyah, "Load Density Analysis of Mobile Zigbee Coordinator in Hexagonal Configuration," 2012 Scires.

[10] Neeti Bisht et al, "Mobility Based Performance Analysis of Wireless Sensor Networks" International Journal of Computer, Electronics & Electrical Engineering Volume 2– Issue 2.

[11] OPNET official website, http://www.opnet .com

[12] M. A. M. Vieira, C. N. Coelho, D. C. Jr. Silva and J. M. Mata, "Survey on Wireless Sensor Network Devices," IEEE Conference on Emerging Technologies and Factory Automation Proceedings, Vol. 1, 2003, pp. 537-544.

[13] J.S.Choi and M. Zhou, "Performance analysis of Zigbee-based body sensor networks," in Proc. IEEE Conf. Syst., Man Cybern., 2010, pp.2427–2433.

[14] Y.Gu,A.Lo, and I.G.Niemegeers, "A survey of indoor positioning systems for wireless personal networks," IEEE Commun. Surv. Tutorials, vol. 11, no. 1, pp. 13–32, First Quarter 2009.

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