Impact Analysis on the Performance of Zigbee Protocol Under Various Mobility Models

Parneet Dhillon   Dr. Harsh Sadawarti

Research Scholar,CSE,RIMT , Mandigobindgarh, PTU   Director, RIMT Mandigobindgarh, PTU

Abstract-Wireless sensor network, IEEE 802.15.4/Zigbee is a specification for a suite of high level communication protocols that interconnects simple low power low processing capability wireless nodes for the transfer of data This paper aims at finding out the suitable mobility model that determines the effective positioning of nodes that gives the best throughput. In this study, the effect of four different mobility models, such as group, random walk, random waypoint and pursue mobility models has evaluated on various IEEE 802.15.4 based zigbee standard network. After the intensive simulations, it has been seen that by using the tree topology for the placement of nodes in the network and by configuring the movement of the nodes according to the group mobility model, network gives the maximum throughput and possess minimum data dropped in the network. So, it has concluded that under the given conditions, group mobility model outperforms other three mobility models.

Keywords-Sensor Networks ,Zigbee,Mobile coordinator

1. Introduction

A Wireless sensor network can be generally described as a collection of sensor nodes spatially distributed at the bottommost layer. These sensor nodes are battery powered devices and consume very low power. The coordinator is responsible for sending the signal to all the sensor nodes connected to it.As the distance from the coordinator increases, the signal strength becomes weak causing communication with target nodes difficult as a result the connection breaks with all the widely distributed wireless sensor nodes. Therefore, it is difficult to perform stable and reliable communication with wide range nodes.

2. Zigbee And IEEE 802.15.4

Zigbee is a wireless technology formalized by IEEE 802.15.4 standard for transfer of data**.** It interconnects simple, low power, low processing capability wireless nodes. Power needed for ZigBee nodes is very small i.e 1mW (or less power). But still it provides range up to 150 meters in outdoor which is achieved by the technique called direct sequence spread spectrum (DSSS).It was developed by Zigbee alliance and task group in order to fulfil requirements such as low cost,low power consumption and easy installation. Zigbee alliance includes many companies like Ember, Chipkon, Mitsubishi, Freescale etc. The zigbee network can have up to 653356 devices and the distance between each node can be up to 50 meters. This helps in covering significant distances. Zigbee technology is

programmed in a chip form and is used in many devices to function automatically For controlling and monitoring a whole factory unit while sitting in one cabin is possible by using Zigbee technology. Many small equipments are coming with embedded Zigbee technology chips and really works like a miracle. Applications of Zigbee are smoke and heat sensor, medical and scientific equipments, control units of home and industry and wireless communication devices.

There are two types of Zigbee physical devices based on the data processing capabilities: Fully functional devices and Reduced functional devices. The fully functional devices perform all the available operations within the standard including routing mechanism, coordination tasks and sensing task. The FFD can operate in three modes serving as a PAN coordinator, a coordinator, or an end device. An FFD can talk to RFDs or other FFDs .On the other hand,the reduced functional devices do not route packets and can only be associated with a single FFD at a time. The RFD can communicate with only an FFD.

2.1 Zigbee devices are of three types:

1) *ZigBee coordinator (ZC)*: The most capable device, the coordinator sets all the network parameters like what will be the packet size, which topology will be used for eg tree, mesh, star etc. There is exactly one ZigBee coordinator in each network .It stores information about the entire network.

2) *ZigBee Router (ZR)*: A router acts as an intermediate device which passes on the data from other devices .In other words,it determines the route and then transfers the data from the source to the destination.

3) *ZigBee End Device (ZED)*: 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. But this is not the case with the other **two** devices i.e ZR and ZC as they stay awake whole time. Zigbee end device is also less expensive to manufacture than ZR or ZC.

2.2 Zigbee Topologies

802.15.4 offers star, tree, cluster tree, and mesh topologies; however, ZigBee supports only star, tree, and mesh topologies.

Star topology: The star topology consists of a coordinator placed in the centre and several end devices (nodes), as shown in the figure. Each node is connected directly with the central coordinator. In this topology, the end devices can only communicate with the coordinator and not with other end devices. Any packet exchange between end devices can occur only through the coordinator.
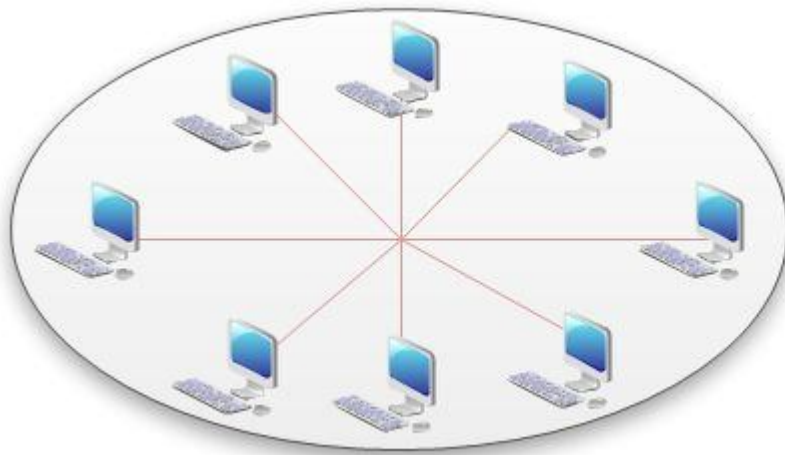
Tree topology: In this topology, the network consists of a root node which is a coordinator, several routers, and end devices, as shown in figure. All the nodes are connected in the form of the tree. The end nodes are connected directly to the coordinator and the routers as their children nodes. Both the routers and the coordinator can have children. Each end device can communicate with its parent nodes i.e coordinator and router. An end device cannot have children and, therefore, may not be a parent. An end device can communicate with another end device only through its parent node and there is no direct connection between end devices. Drawbacks of tree topology is that if one of the parents becomes disabled, the children of the disable parent cannot communicate with other devices in the network.
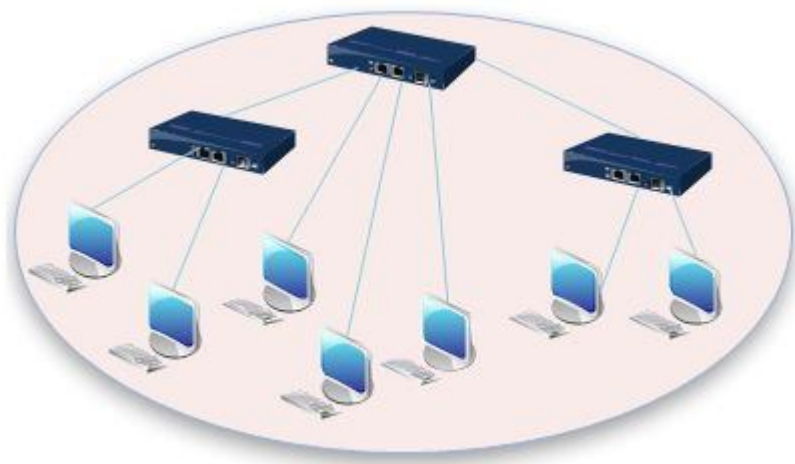
Mesh topology: Mesh topology is also known as peer to peer topology. A Zigbee mesh network consists of three types of nodes: a coordinator, several routers, and one or more end devices. The coordinator can send packets to any node in the network. If the node is not in range, the message will be sent to a neighbouring node which will then forward it onward to the destination. The mesh network can cover a larger range while using only a fraction of power. The ZigBee mesh network is capable of growing or shrinking depending on one's needs just by adding or

removing nodes. A mesh topology is self-healing i.e during transmission, if any of the path fails, the node will find an alternate path to the destination. Adding or removing a device is easy. Any source device can communicate with any destination device in the network. Compared with star topology, mesh topology requires greater overhead. Mesh routing uses a more complex routing protocol than a star topology.
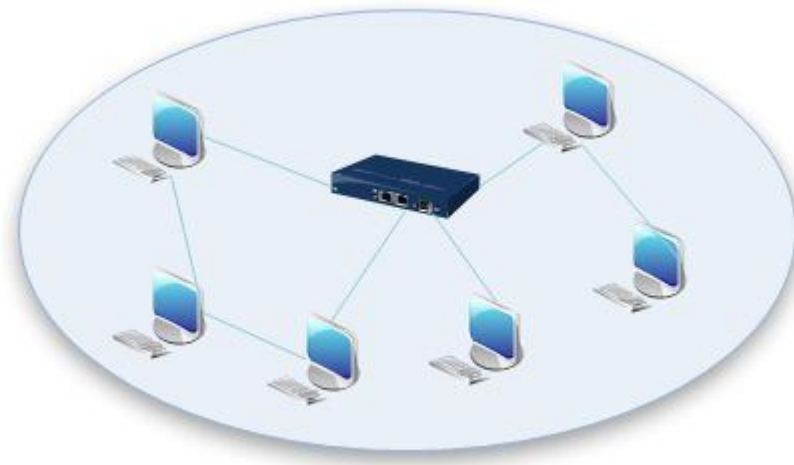
3. Related work

Nia-Chiang Liang et al. performed an extensive evaluation, to study the impact of node heterogeneity on ZigBee mesh network routing

The results indicate that the ZigBee mesh routing algorithm exhibits significant performance difference when the network is highly heterogenous. Routing performance in ZigBee network does degrade when the network comprises of an increasing number of ZigBee end devices. Moreover, the delivery ratio worsens when there are more instances of mobility in the network (in highly mobile scenarios. It has also revealed that the ZigBee end devices tend to perform worse than ZigBee routers in both sending and receiving packets, since the end devices incur loss when there are intensive amounts of mobility in the ZigBee network, yet the additional service overhead of ZigBee (such as association with children devices) still degrades the performance of ZigBee routers in almost all scenarios. . Harsh Dhaka et al. perform extensive evaluation, using OPNET Modeler, to study the impact of coordinator mobility on ZigBee mesh network. After the intensive simulation, it has been indicated that by keeping the sink static gives the best performance. If a trajectory has to be chosen for other reasons, then the trajectory should give a considerable amount of time to each route that is the link route for a segment of the network. Otherwise (as in the case of Diagonal trajectory), the throughput is very low. The type of the trajectory along much overhead in associating with new parents when there is network mobility. On the other hand, ZigBee routers typically suffer less packet with the node density and the traffic are also major factors that decide the system performance. Choosing a random topology is among the means possible to prevent exceptionally low throughput. Having the routers placed within range for effective meshing gives sharper curves which are closer but even in this case, it is better to keep the sink static at a location from where each route has an access to the sink possible with minimum hops. In circumstances sink movement is necessary, clever selection of the trajectory is essential for best throughput. Jiasong

Mu and Kaihua Liu analyzed the effect of the node mobility and the change of the network dimension in Zigbee networks. The whole research was carried out by using a network evaluation tool called OPNET. The analysis was done by using various route finding strategies specified in the network layer standard in ZigBee, such that Suppress Route Discovery (SRD), Enable Route Discovery (ERD) and Force Route Discovery (FRD) with the change of node mobility and network dimensions. After the extensive simulations, it has found that although the forced routing made the network always find the shortest path, the FRD always had the worst performance in all the scenes. In the dynamic networks, ERD had the most efficiency because ERD and AODV has the same working principle and both are more suitable for the dynamic environments. As to the stable network, ERD and SRD had similar efficiency in the small ones. However, the SRD based on tree routing, required no memory cache. SRD also had the lowest network load when the scale of the network expanded. Whereas the ERD might do reduplicate routing due to the restricted memory space. The SRD was the best routing option for the stable networks and the ERD performed most efficient in the unstable networks. The effective positioning of the nodes in a ZigBee network is particularly important in improving the performance (e.g., throughput) of ZigBee networks. In the wireless sensor networks (WSN) the use of a mobile sink is often recommended as an effective defense against the so-called hot-spot phenomenon and the effects of mobile coordinator on the performance of the network need to be considered.
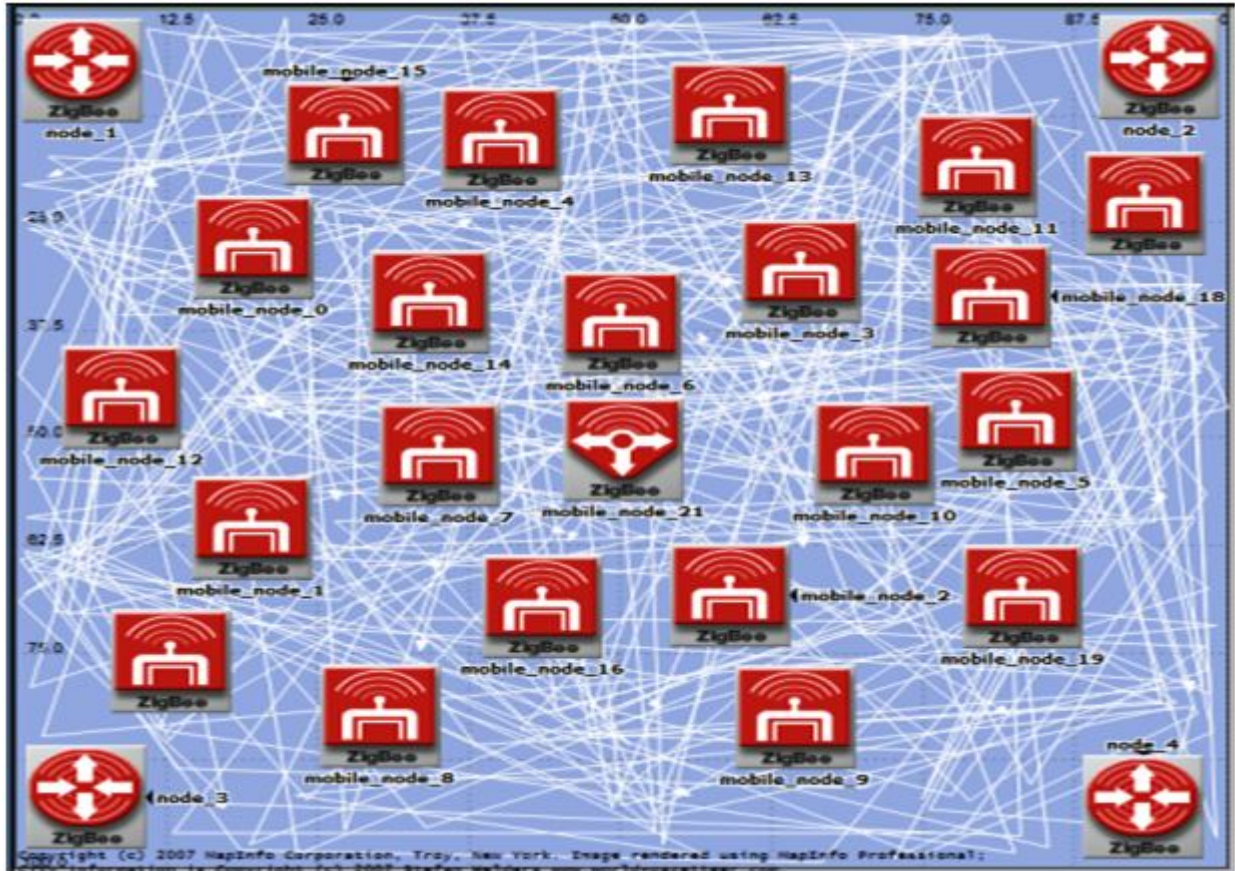
4. Various mobility models used by Zigbee

Figure shows the implementation of group mobility model. Group mobility model is the simulation of a tank unit moving in a group in a war zone. In this mobility model, all the nodes will form a group formation and then move towards the target. All the mobility models are designed by using the trajectory tools provided by the OPNET for designing the trajectories or moving patterns for the mobile nodes.
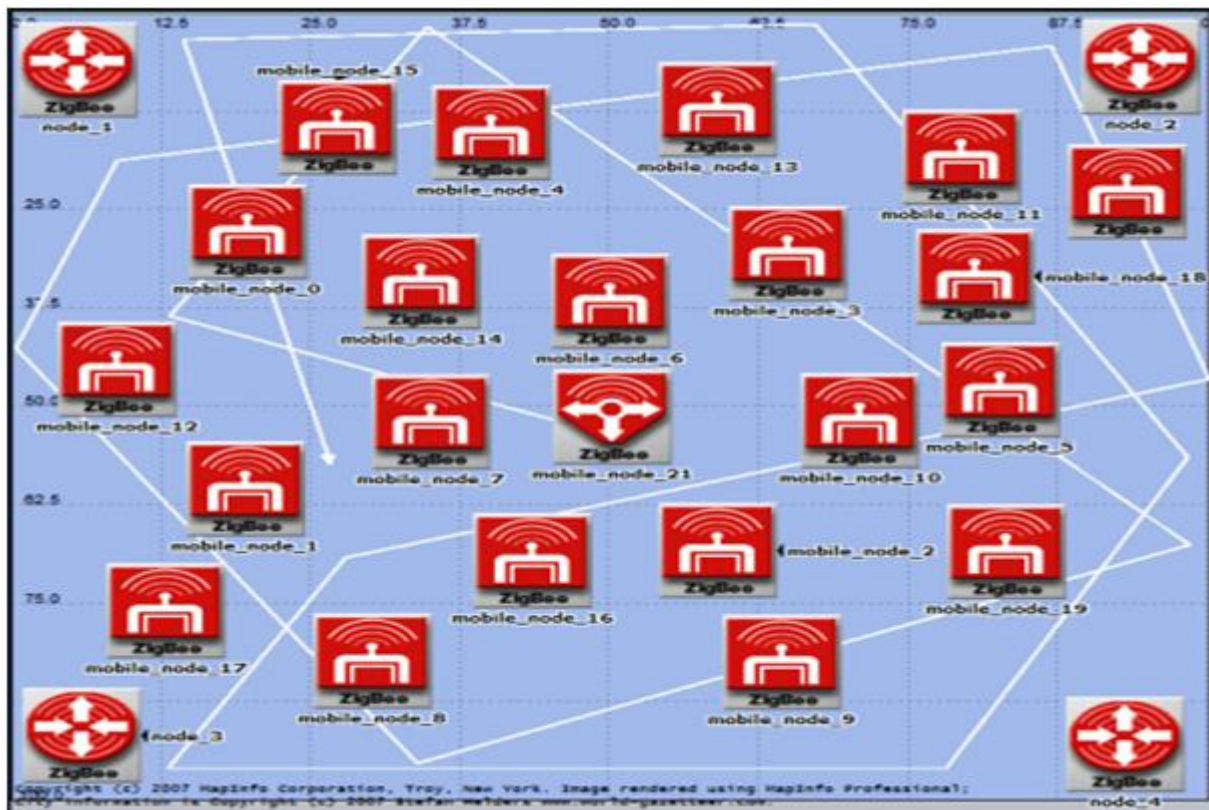
 The pursue mobility model is the implementation of a situation in which a crowd is chasing a thief. The path followed by a thief will be followed by the crowd as well. In the given implementation, mobile_node_21 (coordinator) act as an escort node (thief). The path that will be followed by the escort node will be followed by the rest of the nodes in the network. Initially all the nodes are at rest such that the nodes will not move except the coordinator. All the nodes will start chasing coordinator node which are placed near to that specific segment. In real life situation, there is no specific moving pattern for any mobile node or for any mobile device user.
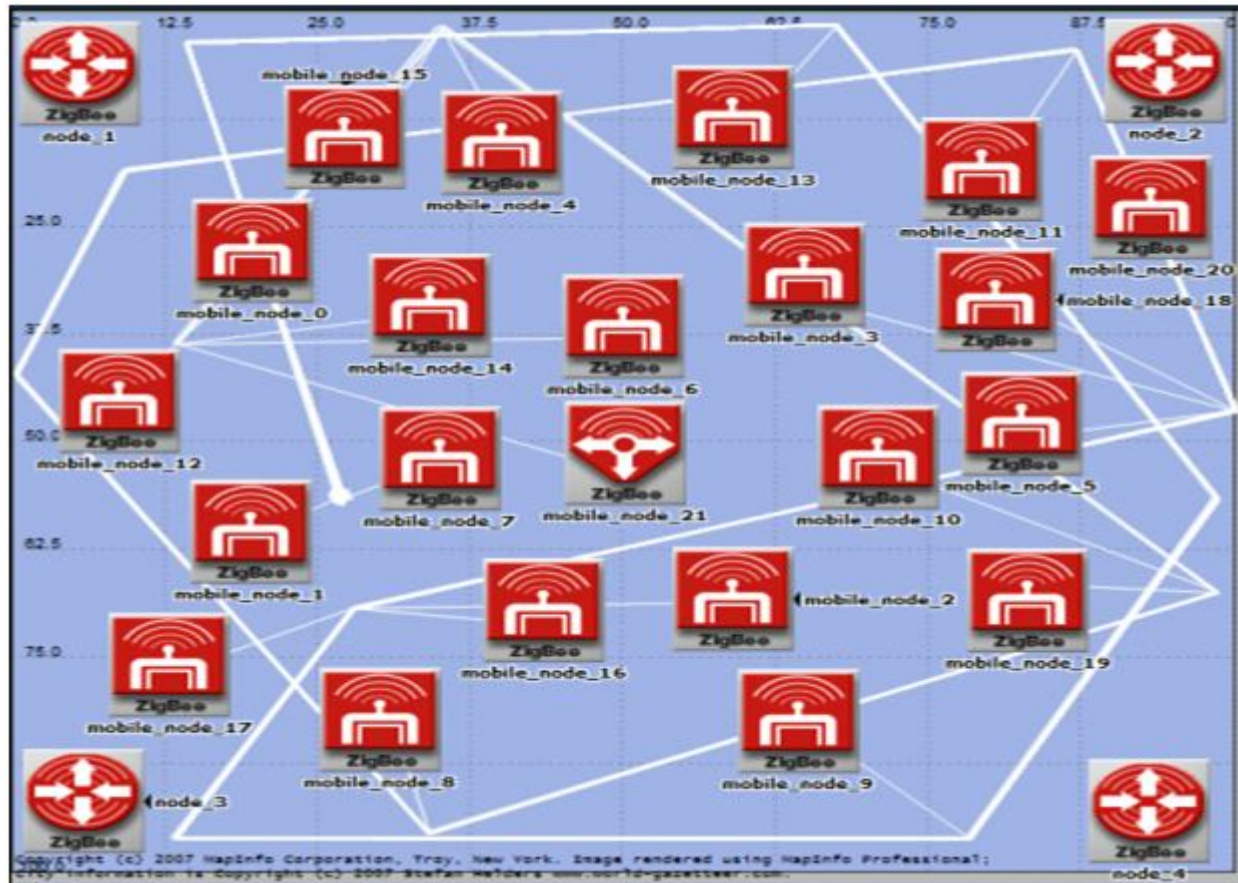
Random walk mobility model is the simulation of such real life situations. In random walk mobility model all the nodes are configured to move randomly in any direction in any pattern. The only difference between random walk mobility model and random way point mobility model is that a pause time has introduced at the end of each segment for random waypoint mobility model. Whenever a node will complete traversing a specific segment of it moving pattern or trajectory, it has to wait for a specific time, which is kept 10 seconds for this study. The moving pattern is same for random walk and random waypoint mobility models

5. Experimental setup

In this research, the performance of tree is analysed by using various mobility models. The number of nodes taken are 20 .To get the performance of tree, OPNET modeler is used, as the OPNET provides a comprehensive and better environment for simulation, collection of data as well as analysis of data.

S.No.	Attributes	Values
1.	Topology	Tree
2.	Packet Interval Time (sec)	Constant(1.0)
3.	Packet Size (bits)	Constant(1024)
4.	Carrier Sensing Duration	Constant (.1)
5.	Start Time	Constant (1)
6.	Packet Reception Power	-85

|	Threshold	
7.	Number of Nodes	20
8.	Number of Routers	4
9.	Number of Coordinators	1
10.	Simulation Duration (sec)	600

Simulation parameters

6. RESULT

(A).Throughput (bits/sec):

Represents the total number of bits (in bits/sec) forwarded from 802.15.4 MAC to higher layers in all WPAN nodes of the network. From the literature, it has seen that various researchers has considered throughput as a most important metrics to evaluate the performance of a network. Figure shows the throughput possessed by the various networks using different trajectories to define the movements of the nodes. From the figure, it has clearly seen that the group mobility model outperforms all the other mobility models by possessing less data dropped and by generating maximum data traffic which is successfully received at the client end in the network. On the other hand, networks using random walk and random waypoint mobility models are possessing minimum throughput such that decreased by 59.32 % and 61.73 %, respectively.
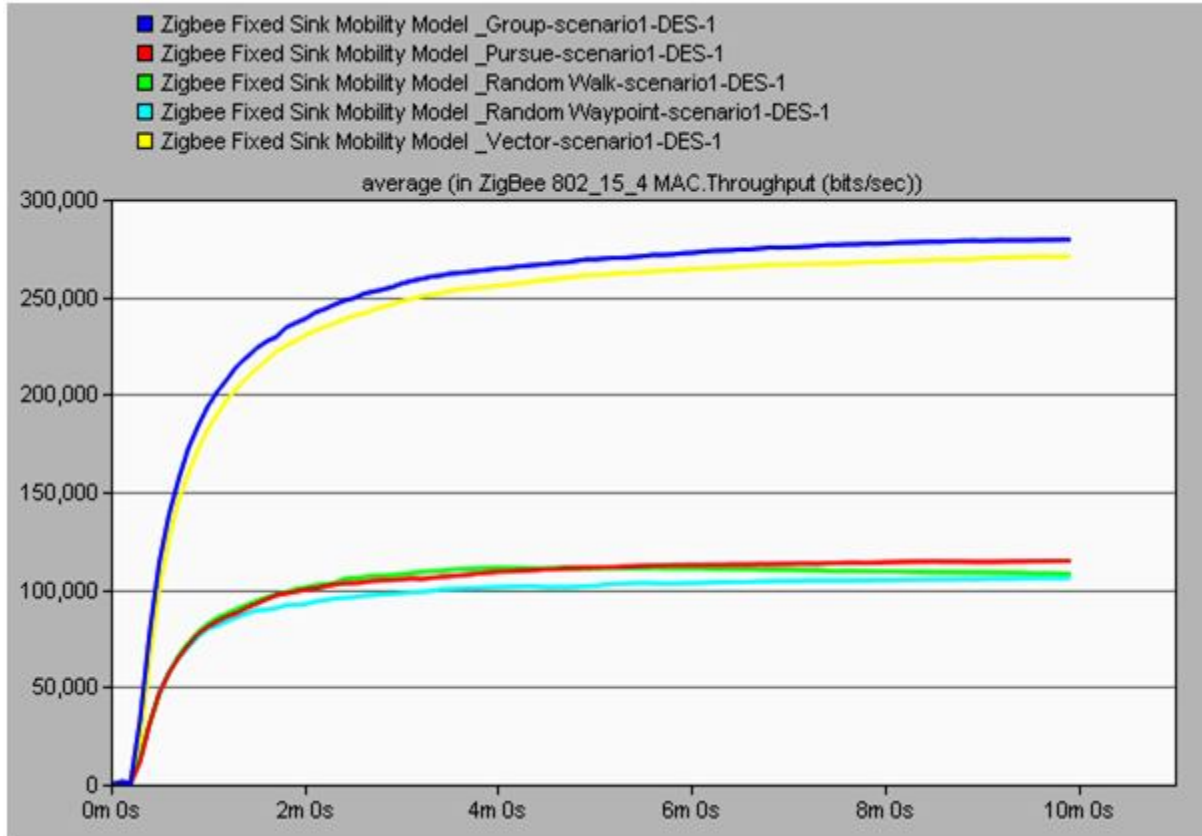
(B).Data Traffic received (bits/sec):

Application traffic received by the layer in bits/sec. This statistic is dimensioned by ZigBee Network (PAN ID) for values of PAN ID ranging from 1 to 255. All other PAN IDs (including auto-assigned PAN IDs) will be combined into the '0' statistic. Data traffic received by different zigbee networks has shown in figure. The rendered graph depicts that the nodes in the network using group mobility model are receiving more data than other networks using different mobility models, due to the flow of less control information between the nodes. For random walk mobility model network, a steep degradation in the data received has seen, such that it has decreased by 71.33 % whereas for pursue and random waypoint mobility models data received has decreased by 65.74 % and 67.70 % respectively.
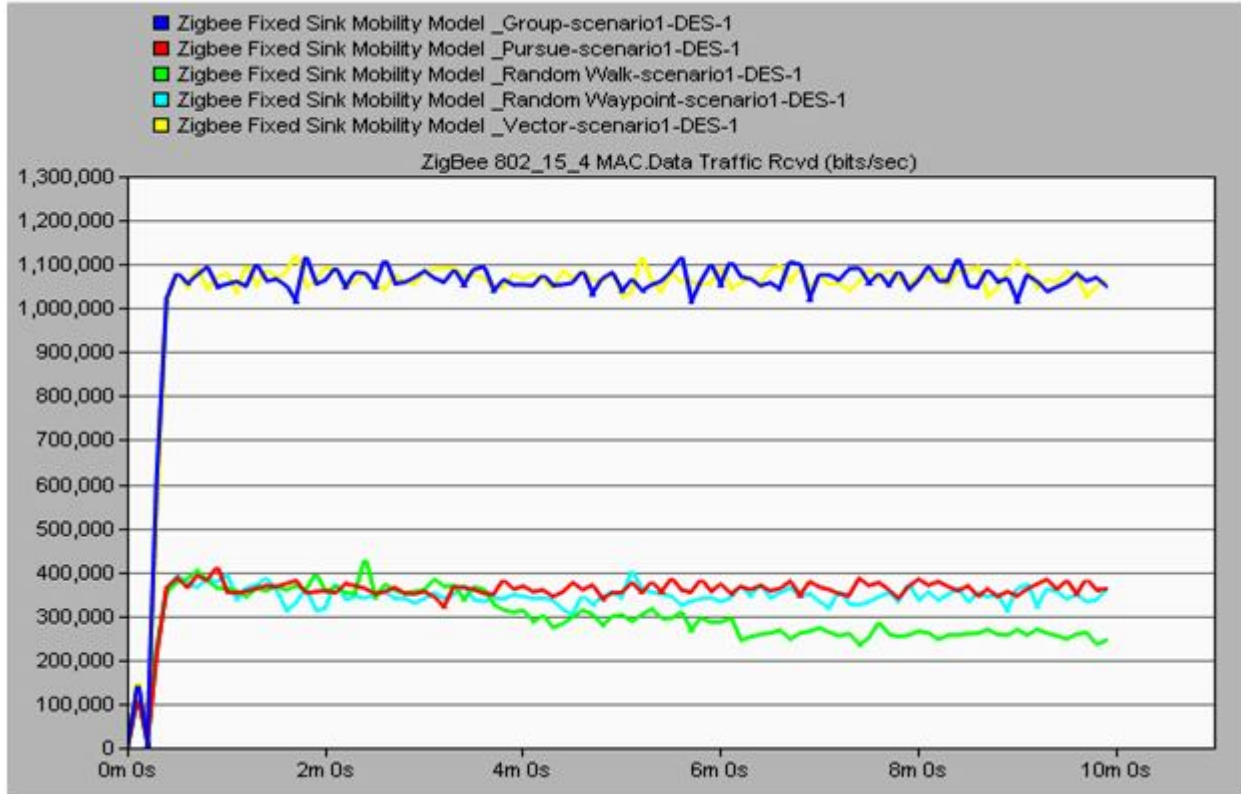
(C). Data Traffic sent (bits/sec):

Application traffic sent by the layer in packets/sec. This statistic is dimensioned by ZigBee Network (PAN ID) for values of PAN ID ranging from 1 to 255. All other PAN IDs (including auto-assigned PAN IDs) will be combined into the '0' statistic. Data traffic sent by the nodes of different zigbee based network using different mobility models are shown in figure. In the graph it has seen that group mobility model outperforms all the networks using different mobility models in terms of data traffic sent by the nodes of the networks. As explained earlier, the nodes using group mobility models to define their movements is able to send and receive data packets in the networks because all the nodes are following the same movements without changing the topology such that all the nodes are changing the positions according to the same coordinate values due to which very less control information need to be flown between the nodes of the network to maintain the routes and to update the routing caches of the nodes. For other mobility models such as random walk, random way point and pursue, the data traffic sent has decreased by 29.02 %, 15.07 % and 16.36 %, respectively from the data traffic sent by the nodes using group mobility model.

.
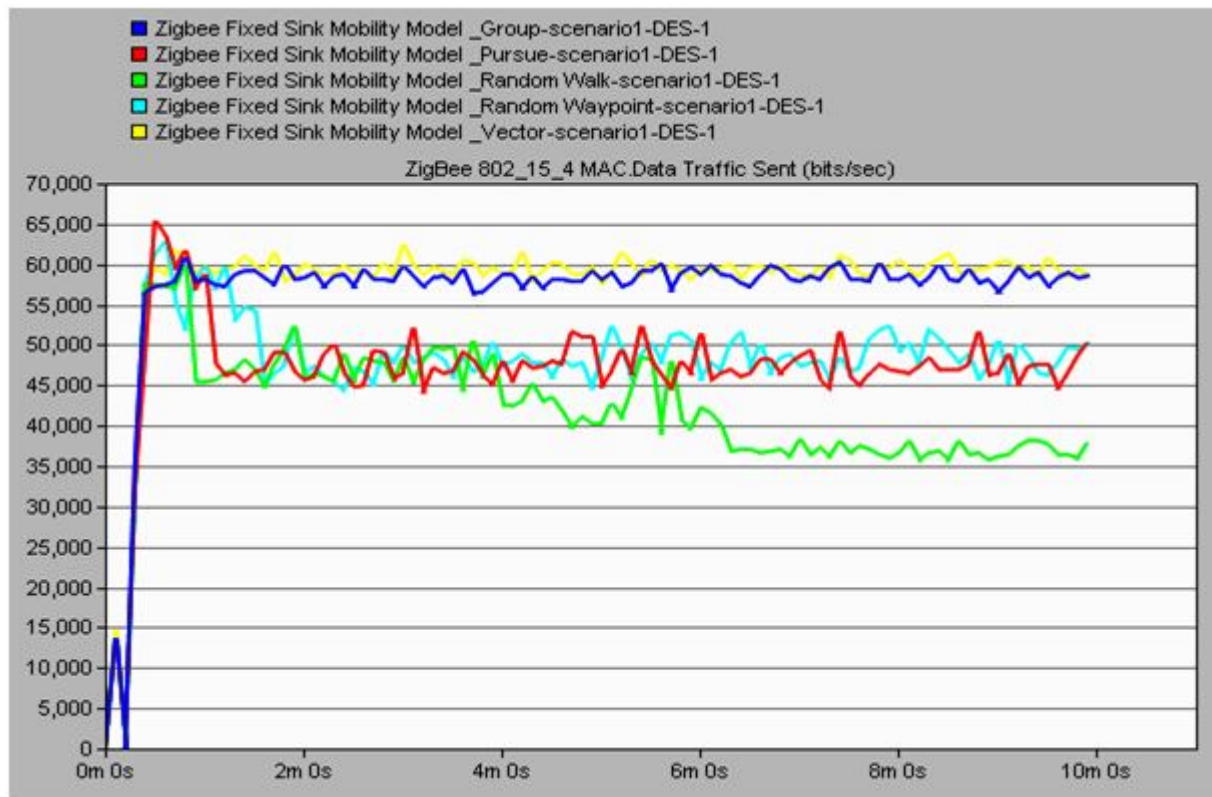
7. Conclusion

Movement pattern of the mobile nodes of any technology such that IEEE 802.11, IEEE 802.16 and IEEE 802.15 effects the performance of the network. It is very important to find out the suitable mobility model or trajectory for the nodes according to the given conditions or according to the deployment of the nodes in the networks. In this study, the effect of four different mobility models, such as group, random walk, random waypoint and pursue mobility models has evaluated on various IEEE 802.15.4 based zigbee standard network. After the intensive simulations, it has seen that by the tree topology to place the nodes in the network and by configuring the movement of the nodes according to the group mobility model, network gives the maximum throughput and possess minimum data dropped in the network. So, it has concluded that under the given conditions, group mobility model outperforms other three mobility models such as random walk, random waypoint and pursue mobility model.

8. Future scope

There will always a scope to improve the work done in this study by considering other mobility models from the literature and by evaluating the performance of networks under different node placement patterns, different

movement patterns, different configuration parameter and by using different performance evaluation metrics to make the concluded results more justified. Research claims that fuelled by rapid rise in home networking. Zigbee would provide revolutionizing statistics in the forthcoming years which would entirely change the wireless world. *A. Revenue* Zigbee revenues would increase by astonishing 3400% in next four years. *B. Sales* It sales would touch a remarkable figure of 700m$ in 2008. *C. Zigbee in every home* .Within next two to three years, a minimum of 100-150 Zigbee chips would be present in every home. *D. Cost* It would cost only $5 for a single chip .But the smaller memory size of protocol stack will further lower the prize of Zigbee to around $2 per chip. Therefore, Zigbee has a very promising future in front of it.

References

[1] Chiung-Hsing Chen, Hung-Wei Lin, Yen-Sou Huang, Jwu Jenq Chen, "Power Management System Based on ZigBee." International Conference on Anti-Conterfeiting, Security and Identification (ASID), p.p. 1-5, August 2012, Kaohsiung, Taiwan.

[2] Harsh Dhaka, Atishay Jain and Karun Verma, " Impact of Coordinator Mobility on the throughput in a Zigbee Mesh Networks." IEEE 2nd International Advance Computing Conference, p.p. 279-284, June 2010, Patiala, India.

[3] Hu Guozhen, "Key Technology Analysis of ZigBee Network Layer." 2nd International Conference on Computer Engineering and Technology (ICCET), p.p. 560-563, Vol. 7, April 2010, Huangshi, China.

[4] Jianpo Li, Xuning Zhu, Ning Tang and Jisheng Sui, "Study on ZigBee Network Architecture and Routing Algorithm." 2nd International Conference on Signal Processing Systems (ICSPS), p.p. 389-393, Vol. 2, May 2010, Jilin, China.

[5] Jiasong Mu and Kaihua Liu, "Effect of node mobility and network dimension to the Zigbee routing method." 6th Jo Woon Chong, Ho Young Hwang, Chang Yong Jung, and Dan Keun Sung, "Analysis of Throughput and Energy Consumption in a ZigBee Network under the Presence of Bluetooth Interference." IEEE Global Telecommunications Conference (GLOBECOM), p.p.4749-4753, November 2007, Daejeon, Korea.

[6] Muthu Ramya. C, Shanmugaraj. M, Prabhakaran. R, "STUDY ON ZIGBEE TECHNOLOGY." International Conference on Electronics Computer Technology (ICECT), p.p. 297-301, Vol. 6, April 2011, Tiruchirappalli, India.

[7] Nia-Chiang Liang, Ping-Chieh Chen, Tony Sun, Guang Yang, Ling-Jyh Chen, and Mario Gerla, "Impact of Node Heterogeneity in ZigBee Mesh Networks." IEEE International Conference on Systems, Man and Cybernetics, p.p.187-191, October 2006, Taipei, Taiwan.

[8] International Conference Wireless Communications Networking and Mobile Computing (WiCOM), p.p. 1-5, September 2010, Tianjin, China.