# A Simulation based Performance Analysis of co-ordinator Mobility in Zigbee Wireless Sensor Networks

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***Abstract* - ZigBee (IEEE 802.15.4) is the standard-based wireless technology designed to address the unique needs of low-cost, low-power wireless sensor and control networks. Zigbee innovation connects an immense range of simple and high tech devices for consumers and business. Different positioning of nodes affects the performance of the network. In many papers researchers recommend mobile sink but nobody took consideration on the mobility of coordinator. In this paper, various models will be used to define the movement of the zigbee coordinator, which provides communication between the zigbee routers. The effect of the movements of the coordinator according to the designed trajectories on a zigbee based tree network will be evaluated by using various performance evaluation metrics. On the basis of the results gathered in the graphical form, an optimized and suitable trajectory to define the movements of the zigbee coordinator will be proposed.**



***Keywords-Sensor Networks; Zigbee; Mobile Coordinator***

## 1. INTRODUCTION

ZigBee is a wireless technology developed as an open global standard to address the unique needs of low-cost, low-power wireless networks. The ZigBee standard operates on the IEEE 802.15.4 physical radio specification and operates in unlicensed bands including 2.4 GHz, 900 MHz and 868 MHz. It consists of large number of nodes called end devices which are battery powered devices . These sensor nodes connected to each other by the network gateway as shown in fig1.The 802.15.4 specification upon which the ZigBsee stack operates gained ratification by the Institute of Electrical and Electronics Engineers (IEEE) in 2003. The specification is a packet-based radio protocol intended for low-cost, battery-operated devices. The protocol allows devices to communicate in a variety of network topologies and can have battery life lasting several years.

The ZigBee protocol has been created and ratified by member companies of the ZigBee Alliance. Over 300 leading semiconductor manufacturers, technology firms, OEMs and service companies comprise the ZigBee Alliance membership. The ZigBee protocol was designed to provide an easy-to-use wireless data solution characterized by secure, reliable wireless network architectures. Mobility of the coordinator effects the throughput of the network in some trajectories but

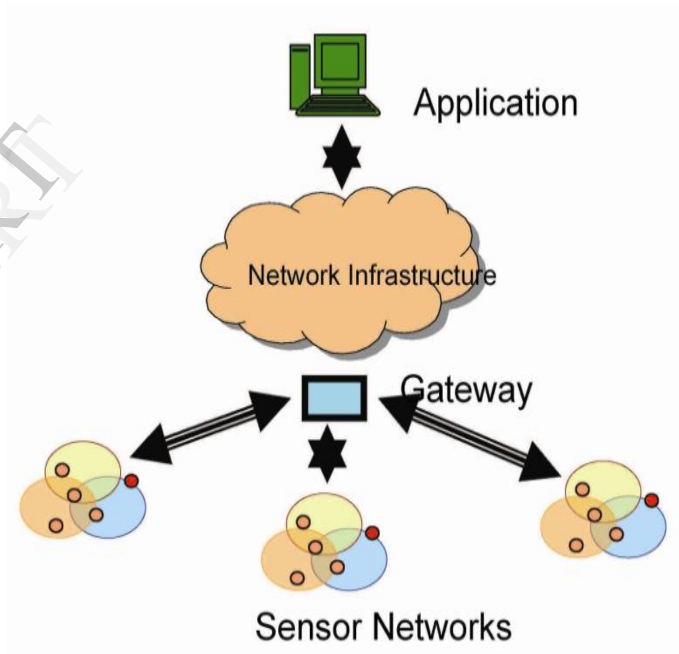


Fig1 Wireless sensor network

There are still many trajectories which give better results than the trajectories used in [2]. Also there are other matrices like load per pan, management traffic sent, delay, data dropped which may affect by the position of coordinator.

## 2. ZIGBEE PROTOCOL STACK

Zigbee architecture consists of 4 layers: Physical layer, MAC layer, Network and security layer and Application layer as show in Fig 2.

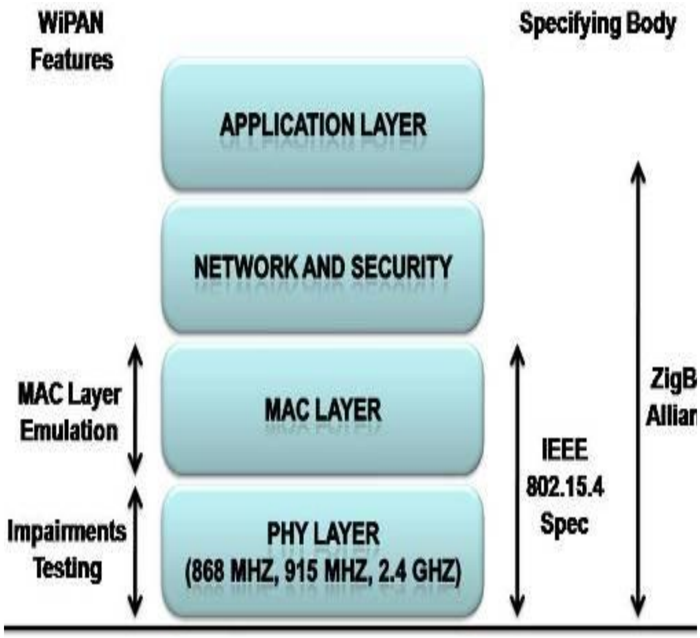


Fig 2. Zigbee Architecture

There are three types of devices used in the zigbee wireless sensor networks: Zigbee Coordinator (ZC), Zigbee router (ZR) and Zigbee End devices (ZED). There is only one zigbee coordinator for a network. It initiates the network formation and may act as a router or end devices after the connection has been set up. Zigbee router and Zigbee end devices are optional network components. There is two states of operations: active and sleep and also two modes of operation: beacon and non-beacon. There are different types of devices used in Zigbee networks which are FFDs (Full Functional Devices) and RFDs (Reduced Functional Devices) [1]. FFD are those which can act as coordinator as well as end devices and RFDs are those which can act as only end devices. FFDs are having more responsibilities as compared to RFDs as these are to participate in routing and repairing of the network. So FFDs can work as both RFDs and FFDs.

There are 3 different network topologies which are possible in the zigbee wireless sensor networks: Star, Mesh and Tree topology as shown in Fig 3. In star topology direct communication link is established between devices and a single central controller. In cluster tree there is a relationship of child and parent node. In mesh network, there is number of possible ways to communicate between one end device to another end device.

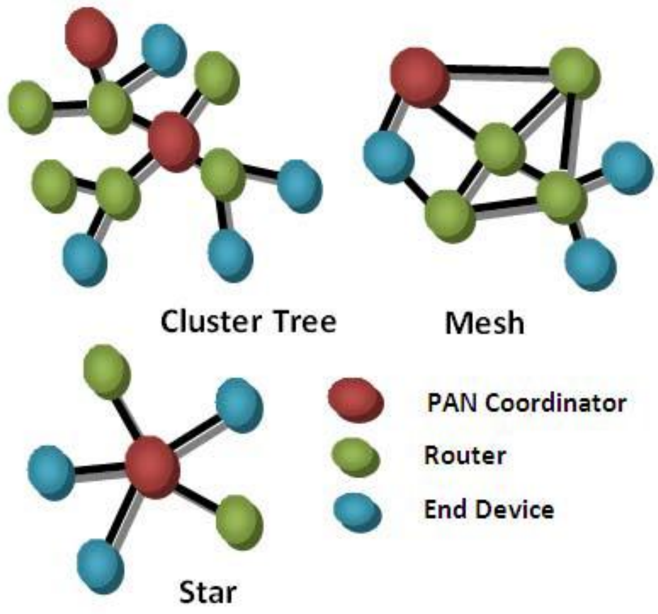


Fig 3: Network topologies



## 3. NETWORK ASSUMPTIONS

The network consists of 25-30 nodes and each node can send the data through router to the coordinator (sink) in tree topology. It has following assumptions:

a) Network field is square shaped and end devices are distributed randomly.

b) The coordinator can be static or dynamic

c) The path of the mobile coordinator can be one of the following- outer peripheries, inner periphery, along principal diagonal, circular and random trajectory, according to group model, random walk, random way point and Pursue model.

d) External interferences are considered zero.

### *A. ROUTER ARRANGEMENT*

Instead of the models used in [2] we implement some new models given in [3] like Random Way point, Random Walk, Group and Pursue Model in this work under the same circumstances in which the Circle, Diagonal, Inner and outer periphery, random sink and fixed sink mobility models were implemented.

*Random Walk Mobility Model*: In this mobility model, an MN moves from its current location to a new location by randomly

choosing a direction and speed in which to travel. The new speed and direction are both chosen from pre-defined ranges, [*speedmin*; *speedmax*] and [0;2p] respectively. Each movement in the Random Walk Mobility Model occurs in either a constant time interval *t* or a constant distance traveled *d*, at the end of which a new direction and speed are calculated. If an MN which moves according to this model reaches a simulation boundary, it "bounces" off the simulation border with an angle determined by the incoming direction. The MN then continues along this new path.

*Random Waypoint Mobility Model*: The Random Waypoint Mobility Model includes pause times between changes in direction and/or speed. An MN begins by staying in one location for a certain period of time (i.e., a pause time). Once this time expires, the MN chooses a random destination in the simulation area and a speed that is uniformly distributed between *[minspeed, maxspeed]*. The MN then travels toward the newly chosen destination at the selected speed. Upon arrival, the MN pauses for a specified time period before starting the process again.

*Group Mobility Model*: In an ad hoc network, however, there are many situations where it is necessary to model the behavior Of MNs as they move together. For example, a group of soldiers in a military scenario may be assigned the task of searching a particular plot of land in order to destroy land mines, capture enemy attackers, or simply work together in a cooperative manner to accomplish a common goal.

*Pursue Mobility Model*: the Pursue Mobility Model attempts to represent MNs tracking a particular target. For example, this model could represent police officers attempting to catch an escaped criminal. The Pursue Mobility Model consists of a single update equation for the new position of each

MN: (new position=old position+ acceleration+ random vector)

where *acceleration* is information on the movement of the MN being pursued and *random vector* is a random offset for each MN. The *random vector* value is obtained via an entity .mobility model (e.g., the Random Walk Mobility Model); the amount of randomness for each MN is limited in order to maintain effective tracking of the MN being pursued.

*B. Simulation Parameters*

The simulation done in this section is on OPNET modeler V14.5 [4]. The simulation will be performed in tree topology and there is 25-30 nodes in the different 9 networks with different trajectories. The will moves at constant speed of 10m/sec. The simulation parameters are summarized in Table 1.

Table1*:* Simulation parameters

| NETWORK PARAMETER | PARAMETER VALUE |
|---|---|
| Transmission Range | 60M |
| Packet Size | 1024 bits |
| GTS | Disabled |
| CSMA-CA minimum backoff exponent | 3 |
| CSMA-CA maximum number of backoffs | 4 |
| Channel sensing Duration | 0.1sec |
| Beacon Order | 6 |
| Super Frame Order | 0 |
| Maximum Children | 30 |
| Maximum Routers | 6 |
| Maximum Depth | 7 |
| Beacon | Disabled |
| Frequency Band | 2.45GHZ |
| Packet Inter-Arrival Time | 36 secs |
| Packet Inter-Arrival Time (Router) | 120 |
| Packet Inter-Arrival Time(Coordinator) | 10 |
| Route Discovery Timeout | 10 |
| Packet Destination | Coordinator |

Throughput represents the total number of bits (in bits/sec) forwarded from 802.15.4 MAC to upper layers in all WPAN nodes of the network. The overall simulation time is 3600 sec with the measurements taken aggregated at every 36 seconds.

## 4. ROUTING ALGORITHMS

*Table-driven Routing*: Table-driven routing is basically similar to the Ad-hoc on demand Distance Vector (AODV) routing Protocol for general multi-hop ad-hoc network in ZigBee networks. Although the ZigBee node cannot maintain a 2-hop routing table due to the limit of memory and energy like other AODV networks. The ZigBee specification defines the table-driven routing method in the ZigBee network the AODV [10]. In ZigBee mesh routing, route requests (RREQ) are broadcasted on-demand when data is to be transmitted to a destination of an unknown path. Routes are constructed based on the route replies (RRPL from intermediate nodes and destination node), and a route error (RERR) message is transmitted to the user when a path can't be found. The route repair mechanism repairs invalid routes when a previous route cannot be found. Since only coordinators/routers (FFDs) can actively participate in mesh routing, the end devices (RFDs) have to rely exclusively on their parent nodes to perform mesh routing on their behalves.

*Address Allocation Mechanism and Tree Routing:* The address of device in a ZigBee network is assigned by its parent node following the tree structure. The parameter nwkmaxChildren ($C_M$ ) represents the largest number of children nodes which can associate with a router or a coordinator. The parameter nwkmaxRouters ( $R_M$ ) means the number of children nodes which can be a router. The parameter nwkMaxDepth ($L_M$ ) decides the most depth in the network. And for the same network, different nodes usually have the constant $C_M$ and $R_M$. Every potential parent is provided with a finite sub-block of the address space, which is used to assign network addresses to its children. Given nwkmaxChildren ($C_M$), nwkMaxDepth ($L_M$), and nwkmaxRouters ($R_M$), we can compute the function Cskip(d) as the size of the address sub-block distributed by each parent at depth d as follows:

$$CSkip(d)= 1+C_M.(L_M-d-1) \quad \text{if } R_M =1$$

$$= (1+C_M -R_M -C_M .R_M^{\,L_M-d-1})/1-R_M \quad \text{if } RM\neq 1$$

## 5. ANALYSIS

In the analysis we will consider some matrices whose results may affected with the change in the position of a coordinator. The matrices we choose are throughput, load per PAN, delay, management traffic sent and data dropped.

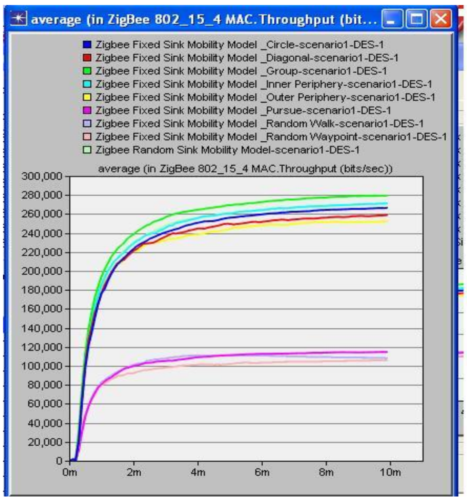


Fig 4: Throughput results of different trajectories

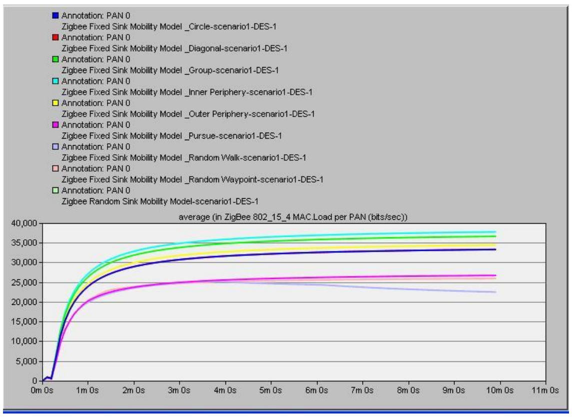


Fig 5: Load per PAN results of different trajectories

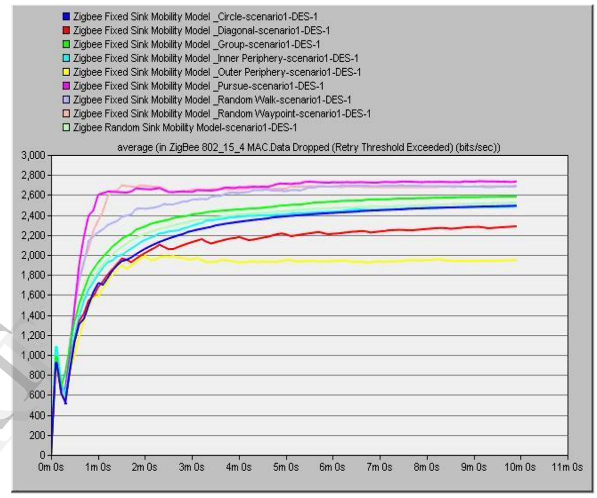


Fig 6: Data dropped results of different trajectories

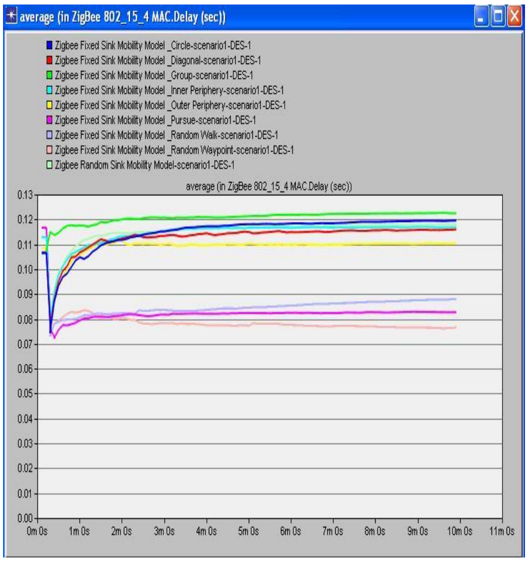


Fig 7: Delay results of different trajectories

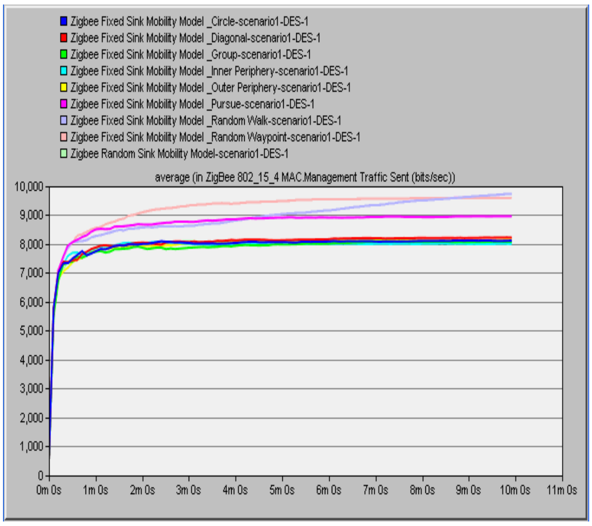


Fig 8: Management traffic sent results of different trajectories

*Group Mobility Model*: This model gives better results in throughput as compared to the models implemented in [3] as well as gives good results for Load per personal area network (PAN) and average results in data dropped.

*Random Walk Model*: Random walk model provides very less delay to send data to 802.15.4 protocol. The total management traffic by the MAC of all nodes in bits/sec is defined by Management traffic sent and this trajectory gives good results for this matrix.

*Random Way Point Model*: Random Way Point model does not give satisfactory results foe given matrices. As an example it sends more traffic to network which results into more delay and more data dropped.

*Pursue Model*: this model provides better results in delay matrix which represent end to end delay of all the packets received by the 802.15.14 MACs of all WPAN modes in the network and forwarded to the higher layer.

## 6. CONCLUSION

This simulation indicates that there is a great impact of the mobility of the coordinator in zigbee wireless sensor networks. With the movement of the coordinator there are some aspects of output which may change like throughput, delay, load per PAN, management traffic sent and data dropped. From the results of simulation we can indicate that if we need better throughput from the zigbee wireless sensor network then we must go through the Group mobility model. If we are concentrating on the delay only the Random Walk Mobility model is better from all proposed models. Pursue and Random way point may not be appropriate for the WSNs. In the end we can say that clever selection of trajectory is very important for better output of the Zigbee Wireless Sensor Networks.

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