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Journal of Science and Technology

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Comparative Analysis of Air Mobility Model with Random Waypoint Mobility Model and Circular Mobility Model for WSN

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***Abstract*— Mobile Wireless Sensor Networks (MWSN) has numerous applications in diverse fields like wildlife monitoring, pollutant level monitoring, health care monitoring etc. In MWSN, sensor nodes move freely in the network through wireless links without any infrastructure. Sensor nodes move in the network according to some mobility model. In this paper, performance of various mobility models on Multiple Mobile Sink (MMS) routing is analyzed. Three different patterns are considered for movement of sink node i.e. Random Waypoint Mobility Model, Circular Pathway Mobility Model and Air Mobility Model. Results show that Air mobility model is more efficient than circular and random waypoint mobility models.**

***Index Terms*— Wireless sensor network, MMS routing, RWMM, Circular Pathway Mobility, Mobile Sink Node**

I. INTRODUCTION

CURRENT progress in the field of technology has prompted the designers to produce low cost and tiny sensors [1, 2]. WSN is composed of sensor nodes [3-7] to meet the requirements of application. Sensors are designed for monitoring changes in physical environment and transmitting this information to entire network. Some of the applications of WSN include environmental sensing, industrial monitoring, infrastructure security and temperature sensor.

Manuscript received July 29, 2017; accepted December 8, 2017.

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Deployment of WSN can be static as well as dynamic. In dynamic WSN [8-10], nodes can move in the network. Dynamic WSN introduces many challenges to the real world application. Dynamic sensor network may have challenges e.g. routing protocols, coverage, data management and network security. These problems discussed above have been discussed by many researchers but for static networks. Present few research objectives focused few problems for dynamic sensor networks as well. One major problem in the dynamic network is the route stability during movements of nodes. The mobility pattern of the nodes must be considered for studying the performance of protocols under such circumstances.

II. BACKGROUND

Mobility models proposed for WSN [11, 12] are divided into memory based and memory-less models. Sensor node does require no memory for changing its location in the memory-less models. Whereas in memory based models, moving nodes keep records of their previous location and use this information for moving to new location. The classification of mobility models [13, 14, 15] is shown in *Fig. 1*.

In Random Walk Mobility Model, sensor nodes move to some new location from their current location after selecting a random speed and direction from some particular ranges that are defined i.e. $[V_{min}, V_{max}]$ and $[0, 2\pi]$ respectively. Each moving node in Random walk mobility model follows a constant period of time, after which new speed and direction are calculated. The Random Waypoint Mobility Model (RWMM) [16, 17, 18] requires a node that can move to a new location after it is selected randomly.

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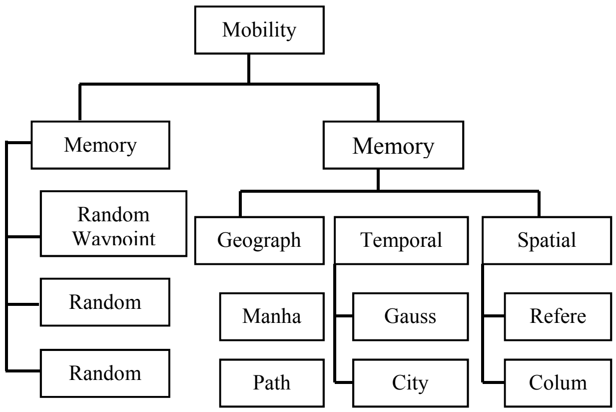

Fig. 1. Classification of Mobility Models.

The node stops for some period of time called pause time after reaching the destination. When this pause time period ends, node randomly selects another destination and speed. In the Random Direction Mobility Model a mobile sensor node randomly chooses a new direction instead of destination. The mobile node starts moving to boundary after selecting a random direction. When moving node reaches the boundary then it stops for an interval of time. It then selects some other angular direction from [0, π] and repeats the process. Gauss-Markov Model uses previous direction and speed to move to new location. City Section mobility model forces a constraint over a moving node on a street that is assigned a speed limit. The Manhattan mobility model is used to analyze the movement of nodes e.g. moving cars in a street grid. The freeway mobility model is utilized to exchange different status of traffic or to trace a vehicle on a freeway. In obstacle mobility model, obstacles are responsible for changes in the movement of mobile nodes.

III. MMS ROUTING

Large numbers of sink sensor nodes [19, 20] are used in WSN for dealing the mobile sensor nodes. In MMS routing, [21 - 23] multiple mobile sink nodes are used for routing. In MMS routing scheme, sink nodes collect data packets when they are in stationary position. When the position of the sink node is changed due to movement, then every sink node selects the disseminating node. Sink node selects the disseminating node from the nodes present in its coverage area. MMS routing is applicable for WSN deployed with mobile sink nodes and static sensor nodes. In this paper, a comparison of different mobility models is presented for same MMS routing scheme.

IV. MOBILITY MODEL CONSIDERED

Memory less models are good to select for WSN as the nodes have minimum amount of memory. But memory based models can also be selected if energy consumption for movement in of the node can be minimized by using only a little amount of memory. In this paper, different mobility models are studied and their impact on MMS routing is presented. Hence it has been proved that energy consumption is reduced. Random way point mobility model is selected from the memory-less models. Circular pathway mobility model (CPMM) is selected in this research work from the memory based models . The selected models are compared with the Air mobility model (AMM). After analyzing the results, it has been proven that AMM shows better performance than RWMM and CPMM.

A. *Impact of RWMM*

According to RWMM, new position of the sink node is determined by random velocity and direction. *Fig. 2* shows RWMM with eight static positions.

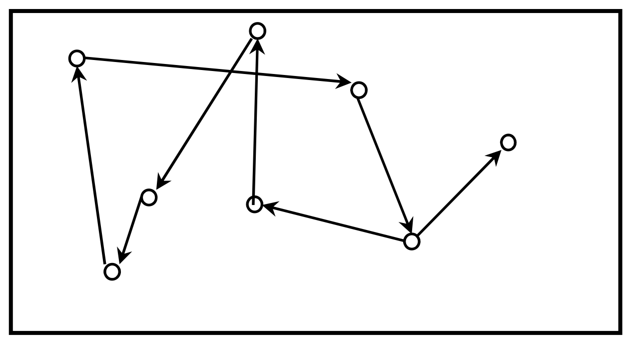

Fig. 2. Random Waypoint Mobility Model with eight (8) Points.

These static positions are pause times in RWMM. According to this model, time to reach at each location is calculated as well as energy consumed to reach each position is obtained. For random waypoint mobility, consumed energy is given by equation (1).

$$E(n) = \frac{K}{n} jTu \sum_{i=1}^{n} \left[\frac{{W_i}^2 \pi \beta}{L(rand(u,dist))} + \frac{1}{W_i \alpha} \right] \quad (1)$$

B. *Impact of Circular Path Mobility Model (CPMM)*

In CPMM, the sink node follows a circular path to move and collects data packets at static positions as in RWMM.

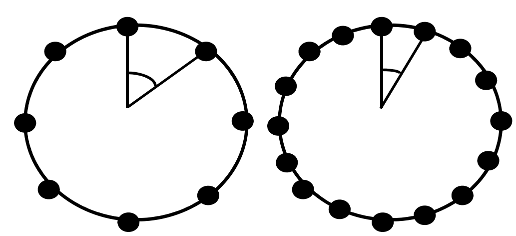

Fig. 3. Circular Path Mobility Model with eight (8) and sixteen (16) Points.

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Let r is the radius of circular path; a, b are coordinates of initial point; v is velocity for moving sink node. Next static position in circular mobility is obtained using the following equations.

$$a\ (new) = a + r\cos\theta$$
$$b\ (new) = b + r\sin\theta$$

Here $a\ (new)$, $b\ (new)$ shows next static position and θ is angle between old and new position. *Fig. 3* represents CPMM with 8 and 16 static positions. Consumed energy for CPMM is given by equation (2).

$$E(n) = \frac{k}{n}\ Tu\ \sum_{i=1}^{n}\left[\frac{W_i^2\beta}{Lr^2} + \frac{1}{W_i\alpha}\right] \qquad (2)$$

C. *Impact of Air Mobility Model (AMM)*

In AMM, direction of movement of sink node is based on the eight directions of Air. Sink node moves one by one in eight directions. This model resembles to an octagon because each moving path has equal length. AMM is similar to CPMM in many aspects but there is notable difference in consumed energy of sink node for moving and updating the location. We considered an equilateral octagon to model the Air mobility in each Air direction. *Fig. 4* shows this scenario of Air Mobility Model.

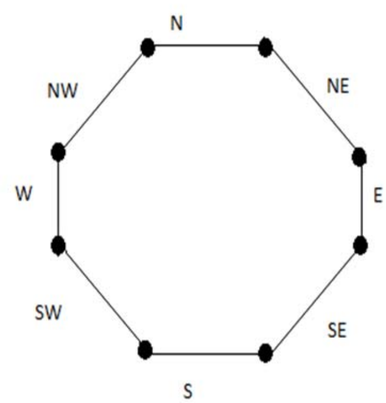

Fig. 4. Air Mobility Model with eight (8) and sixteen (16) points.

For Air mobility model, the energy spent in moving sink node is given by equation (3).

$$E(n) = \frac{K}{n} jTu\ \sum_{i=1}^{n}\left[\frac{{W_i}^2\pi\beta}{Lb^2\,(2+2\sqrt{2})} + \frac{1}{W_i\alpha}\right] \qquad (3)$$

In equation (1-3)

K = the number of static nodes
u = velocity of sink nodes
L = side length of the sensing field
n = the number of moving sink nodes
r = radius of coverage area of sink node

V. Simulation And Results

Simulation is done in MATLAB with the help of mathematical equations. *Fig. 5* represents RWWM scenario with eight (8) and sixteen (16) points.

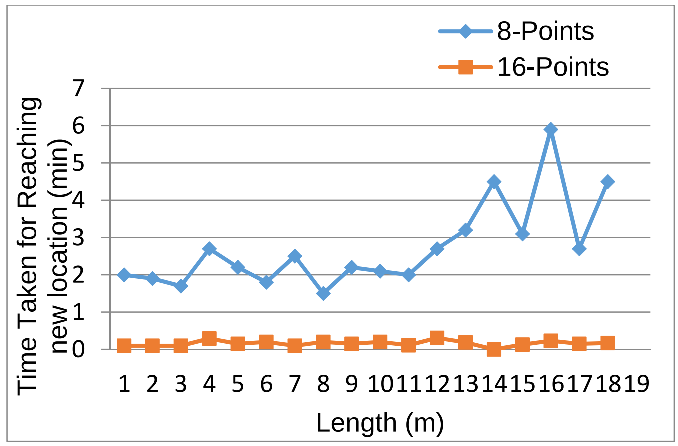

Fig. 5. Time spent by sink node in reaching new location in RWMM.

Fig. 6 and *Fig. 7* shows CPMM scenario with sixteen (16) and eight (8) points, with velocity 4m/min and 8m/min respectively.

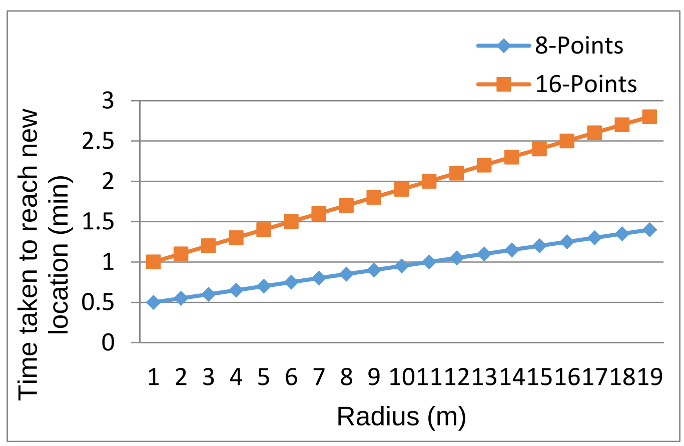

Fig. 6. Time spent by sink node in reaching new location in CPMM with velocity 4m/min.

Fig. 10 shows the remaining energy after updating new locations of mobile sink nodes to all nodes in network for one cycle. In this implementation one cycle represents eight static positions. Sink node collects data only when it is in static position. It has been observed from *Fig. 10* that in Air mobility consumed energy for updating of location of sink nodes is less while it is greater in CPMM and RWMM.

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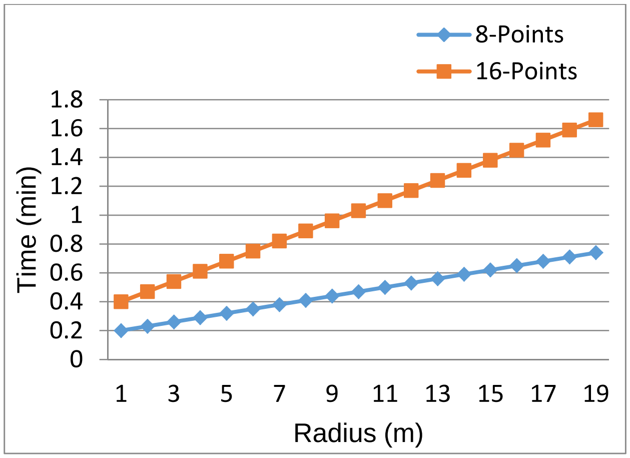

Fig. 7. Time spent by sink node in reaching new location in CPMM with velocity 8m/min.

Similarly, Air mobility scenario is given in *Fig. 8* and 9 with velocity 4m/min and 8m/min respectively.

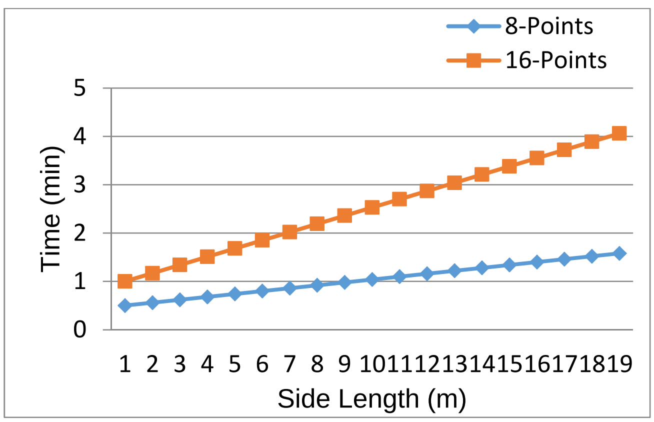

Fig. 8. Time spent by sink node to reach new location in AMM with velocity 4m/min.

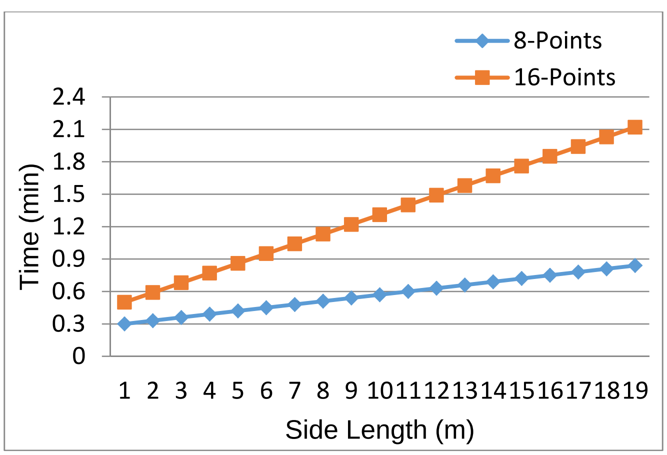

Fig. 9. Time spent by sink node in reaching new location in AMM with velocity 8m/min.

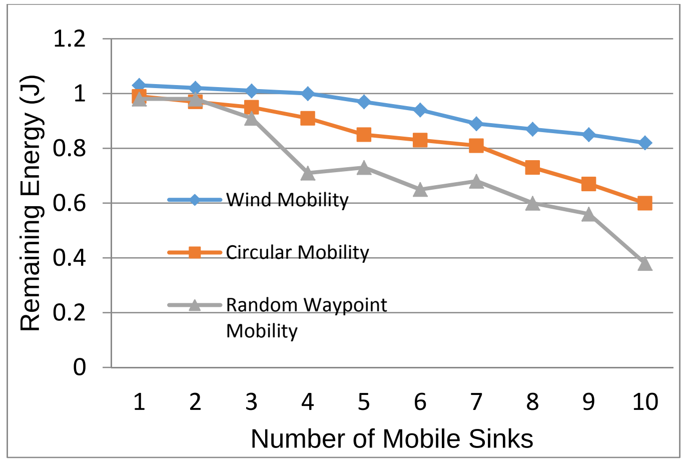

Fig. 10. Comparison of Remaining Energy after movement of 8 positions.

VI. Conclusions

In this research work, three mobility models i.e. RWMM, Circular mobility and Air mobility are considered for movement of sink node. Three mobility models are discussed for 8 and 16 static positions. From simulation results it has been observed that Air mobility model is efficient for MMS routing as applying this model more data is collected by sink node in a minimum time as compared to RWMM and Circular pathway mobility. Energy consumption in Air mobility model is less than other two models. Therefore, the lifetime of the network may increase due to less energy consumption. Hence it is concluded that Air mobility model is an energy efficient model for MMS routing.

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