International Journal of Innovative Technology and Exploring Engineering (IJITEE)
ISSN: 2278-3075, Volume-3, Issue-9, February 2014

Performance Analysis of Energy Aware LAR Protocol in IEEE 802.15.4 based Mobile Wireless Sensor Networks

P. Samundiswary, K Dilip

Abstract—In this paper, performance analysis of energy aware Location Aided Routing (LAR) Protocol is done for IEEE 802.15.4 based Mobile Wireless Sensor Networks considering mobile nodes. Random Waypoint Mobility Model is considered as the mobility model in the scenario. The various scenarios are designed and simulated by increasing the number of mobile nodes and varying the speed of the mobile nodes. The performance parameters such as throughput, average end to end delay, average jitter and residual energy for different type of scenarios are determined. The simulation is done by using Qualnet 6.1 simulator.

Index Terms—MWSN, Random Waypoint Mobility Model, LAR, Requested Zone, Expected Zone.

I. INTRODUCTION

A Wireless Sensor Networks (WSN) are the spatially distributed autonomous network [1] for monitoring environmental conditions like temperature, pressure, sound, etc., WSNs are subdivided into two classes: static WSNs and mobile WSNs. In static WSNs, the position of node will not be changed once it become as a part of the network. This leads to constant performance of the network over a long period. Mobile Wireless Sensor Networks (MWSNs) are much versatile than static networks as they can be deployed in any scenario and cope with change in the rapid topology. Hence MWSNs are playing the most significant role in the recent years.

In MWSNs the nodes in the network are having the capability to move according to requirement. Since the nodes are having the capability to move, the network topology will change as the nodes move with respective to time. In this scenario the network will show the different types of characteristics performance as the topology of networks changes [2]. However the performance of the network will be degraded due to the mobile nature of the nodes. Hence an attempt has been made to analyze and evaluate the performance of the network by incorporating energy aware algorithm in LAR protocol.

The rest of the paper is organized as literature review is given in section II. Section III explains about LAR protocol. In section IV, Energy Aware LAR Protocol is explained. Simulation Scenarios and Results are discussed in section V. Conclusion and Future Work regarding this paper are drawn in Section VI.

Manuscript received February, 2014.

Dr. P. Samundiswary, Ph.D., Assistant Professor, Department of Electronics Engineering, Pondicherry University, Pondicherry, INDIA.

K Dilip, Post Graduate Student, Department of Electronics Engineering, Pondicherry University, Pondicherry, INDIA.

II. RELATED WORK

A routing protocol specifies how routers communicate with each other, broadcast information between them that enables to select routes between any two nodes on WSNs. Routing algorithms determine the specific choice of route. There are different types of routing protocols. They are Table Driven (Proactive), On Demand (Reactive), Hybrid and Position based routing protocols.

Table Driven (Proactive) routing algorithms deals with classical routing techniques such as distance-vector routing (Destination-Sequenced Distance Vector Routing) and Link-State Routing (Optimized Link State Routing). These routing protocols maintain all the available paths to destination even though they are not currently using for routing the information. The main drawback of these routing algorithms is maintaining the unused paths in table manner in memory of all sensor nodes [3]. This will results in wastage of available bandwidth in MWSNs, since the topology will change frequently.

To overcome the problems in proactive, On-Demand (Reactive) routing protocols are developed. Dynamic Source Routing (DSR), Temporally-Ordered Routing Algorithm (TORA) and Ad-Hoc On-Demand Distance Vector (AODV) Routing Protocol are examples of On-Demand routing protocols. On-Demand protocols maintain only the routes that are currently in use, thereby reducing the burden on the network. However, they still have some in-built limitations [4]. Since routes are only maintained while in use, it is typically required to carry out a route discovery before packets can be exchanged between two nodes. This will result in a delay for the first packet of data that is to be transmitted. There may be a chance of data loss if the route discovery process takes a long time to discover the path between source and destination.

Hybrid routing protocols combines both proactive and reactive characteristics of routing in order to achieve greater efficiency and scalability. Even though this will combine both the properties it still needs to maintain the path information which is currently in use. Initially this protocol will establish the route based on proactive routing techniques and serves the same routes reactive basis. In practical scenarios the network topology changes rapidly with respective to time [5]. In these conditions these protocols will not serve with greater efficiency. Zone Routing Protocol (ZRP) is example of hybrid routing protocol.

Position based routing protocol uses the Global Positioning System (GPS) to determine the current position of the nodes in the network at a particular time. In positioned based

Published By:
Blue Eyes Intelligence Engineering
& Sciences Publication Pvt. Ltd.

routing source node has to be aware of its own location and locations of its neighbor nodes within its communication range and of the destination. So, the required node memory is minimal, consume reduced bandwidth and conserve less energy. Nodes use broadcasting (on demand or periodically) to let their one hop neighbors know their location, but discovery floods and state propagation are not needed. So geographic routing results in minimal overhead [6]. Also, because of the localized forwarding process, the network reacts faster, avoiding delays and overall latency. Greedy Perimeter Stateless Routing (GPSR) and Location Aided Routing Protocol (LAR) are the examples of this type of protocols.

III. LOCATION AIDED ROUTING

The Location Aided Routing (LAR) is a reactive [7] unicast routing scheme. The LAR algorithm is a source initiated, position based routing protocol. LAR contains mainly three phases to operate in MWSNs. They are Route Discovery using Flooding, Location Information and Zone Determination (i.e., Expected and Requested Zones).

A. Route Discovery Using Flooding

Route discovery using flooding is explained in this section. When a node S needs to find a route to node D, node S broadcasts a route request message to all its neighbours thereafter, node S will be referred to as the sender and node D as the destination. A node say X on receiving route request it will check its own identifier with the destination identifier. If it matches with that, it will send the request for the route otherwise it will broadcast the request to avoid the redundant transmission of route requests. Fig. 1 gives the pictorial representation of route discovery using flooding.

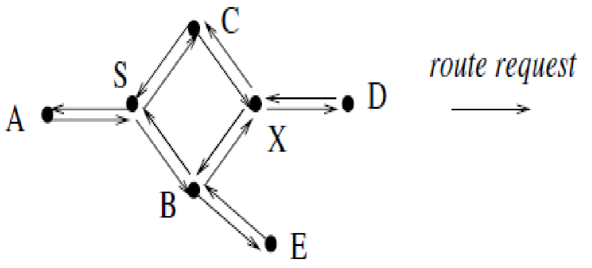


Fig. 1 Illustration of flooding

B. Location Information

LAR makes use of location information to reduce overhead. Location information is used by the protocol Global Positioning System (GPS). In practical, the location information provided by GPS will have error in GPS transmitted coordinates and actual coordinates of the node.

C. Expected Zone and Requested Zone

I. Expected Zone

Consider a node S that needs to find a route to node D. Assume that node S knows that node D was at location L at time t_0 , and that the current time is t_1 . Then, the "*expected zone*" of node D, from the view-point of node S at time t_1, is the region that node S expects to contain node D at time t_1 . Node S can determine the expected zone based on the knowledge that node D was at location L at time t_0. For instance, if node S knows that node D travels with average speed *v*, then S may assume that the expected zone is the circular region of radius $v(t_1\ t_0\ )$, centered at location L. Fig. 2 is an example of Expected zone.

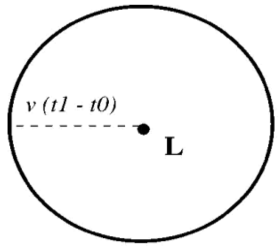
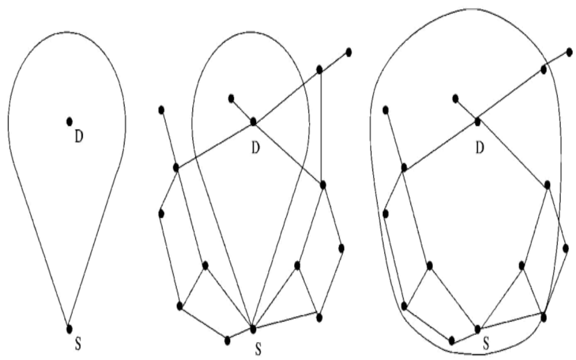


Fig. 2 Expected Zone

II. Requested Zone

Again, consider node S that needs to determine a route to node D. The proposed LAR algorithms use flooding with one modification. Node S defines a request zone for the route request. A node forwards a route request only if it belongs to the request zone. To increase the probability that the route request will reach node D, the request zone should include the expected zone. Additionally, the request zone may also include other regions around the request zone. An edge between two nodes means that they are neighbors.



(a) (b) (c)

Fig. 3 Request Zone

From Fig. 3, (a) represents the requested zone for an instant, (b) indicates the small request zone and (c) indicates larger request zone. By considering larger request zone there maybe more probability of route between source to destination.

III. Motivation of Work

WSN consists of large number of nodes to perform sensing operation. These sensor nodes are tiny in size with low memory and power constrained devices. Sensor is generally powered by battery which is inbuilt in it. In some cases batteries can be replaceable, but in most of the cases the batteries are non-replaceable. Since the nodes are repeatedly used for data sensing and processing, the battery of node will be drained with a higher rate. So the network durability is going to decrease with respective time. To achieve the efficient network durability, energy aware algorithm is proposed in this paper and performance analysis of the

Published By:
Blue Eyes Intelligence Engineering
& Sciences Publication Pvt. Ltd.

network with energy aware algorithm for LAR protocol is evaluated.

IV. ENERGY AWARE ALGORITHM

To increase the network life time, the energy consumption of nodes is to be kept minimal. An Energy-Aware Algorithm is incorporated in LAR protocol which is proposed in this paper to enhance the lifetime. In LAR protocol, routing is done by transmitting information between neighbor nodes towards destination from source to destination.

Consider the X numbers of nodes are deployed in the network. Those can be classified as source, destination and relay nodes [8]. The source and destination nodes are treated as non-forwarding nodes and the relay nodes are treated as forwarding nodes. To determine forwarding and non-forwarding node the following formula used

$$P_d = d(N,D) < d(S,D) \quad (1)$$

where P_d is the progress distance in meters, N is the neighbor node, S is the source node and D is the destination node. d(N,D) is the distance between neighboring node and source node and d(S,D) is the distance between source node and destination node.

The node which is following the above condition is treated as forwarding node with their forwarding flag (ff) set to 1. On the other hand the nodes which are not satisfying the above condition treated as non-forwarding nodes with their forwarding flag (ff) set to 0. The energy model of both forwarding and non-forwarding nodes are given below.

Let E_{tot} the total available energy in the network is given by

$$E_{tot} = \sum_{i=1}^{s} E_{in} \quad (2)$$

where, S is the number of nodes in the network and E_{in} is the initial energy of the each node in the network. Then the energy spent in neighbour discovery process can be classified as energy spent for forwarding and non-forwarding node.

A. Energy spent for neighbour discovery by non-forwarding node (source node:

Let E_c = Energy spent for neighbour discovery through RTR packets/node

$$E_c = E_{tx} + kE_{rx} \quad (3)$$

where E_{tx} is energy spent for transmission of RTR packet, E_{rx} is energy spent for reception RTR packet and k is number of route reply (RTR) packets received by source node.

Let E_d be the energy spent for transmission of a data packet and T be the updating time interval by a node, Then the total energy spent by a node to transmit '*l*' data packets within T interval is given by

$$E_{tl} = E_c + \sum_{p=1}^{l} E_d \quad (4)$$

where Ec is Energy spent for neighbour discovery through RTR packets/node and "*l*" is maximum number of data packets transmitted in 'T' intervals.

The remaining energy in each node is the difference between the initial energy and the energy spent for transmitting a data packet along with its control overheads is calculated as

$$E_{res} = E_{in} - E_{tl} \quad (5)$$

Substituting equation (4) in (5) results

$$E_{res} = E_{in} - \left\{ E_c + \sum_{p=1}^{l} E_d \right\} \quad (6)$$

Substituting equation (3) in (6) results

$$E_{res} = E_{in} - \left\{ E_{tx} + kE_{rx} + \sum_{p=1}^{l} E_d \right\} \quad (7)$$

B. Energy spent for neighbour discovery by forwarding nodes:

$$E_c = 2E_{tx} + (k+1)E_{rx} \quad (8)$$

where E_{tx} is transmission of RTR reply packet by forwarding node and (k+1) is Reception of RTR broadcast packet by source/ forwarder node.

Let E_d be the energy spent for transmission of a data packet and T be the updating time interval by a node, then the total energy spent by a node to transmit '*l*' data packets within T interval is given by

$$E_{tl} = E_c + \sum_{p=1}^{l} E_d \quad (9)$$

$$E_{res} = E_{in} - \left\{ E_c + \sum_{p=1}^{l} E_d \right\} \quad (10)$$

Substituting equation (8) and (9) in (10) results

$$E_{res} = E_{in} - \left[2E_{tx} + (k+1)E_{rx} + \sum_{p=1}^{l} E_d \right] \quad (11)$$

Flow chart of Energy Aware Algorithm is given in last page of this paper as Fig. 11.

V. SIMULATION SCENARIOS AND RESULTS

A. Proposed Scenarios

The simulator used to simulate MWSN model and evaluate the performance parameters of MWSN using LAR protocol is QUALNET 6.1 [9] developed by SCALABLE Network Technologies. In the architecture mode [10] of the simulator, the proposed network scenario is designed in an area of 1500X1500 square meters. Network traffic type is chosen as ZigBee type. The simulation time is considered as 300 seconds. A total of 100 data packets are sent with an individual payload of 50 bytes. The routing protocol is set as LAR. 150 nodes are considered for proposed model. The mobility model chosen for simulation is random deployment mode. The random waypoint model [11] is first proposed by Johnson and Maltz. It is one of the most popular mobility models in research community and the "benchmark" mobility model to evaluate other routing protocols, because of its simplicity and wide availability.

In random-based mobility simulation models, the mobile nodes move randomly and freely without restrictions.

Published By:
Blue Eyes Intelligence Engineering
& Sciences Publication Pvt. Ltd.

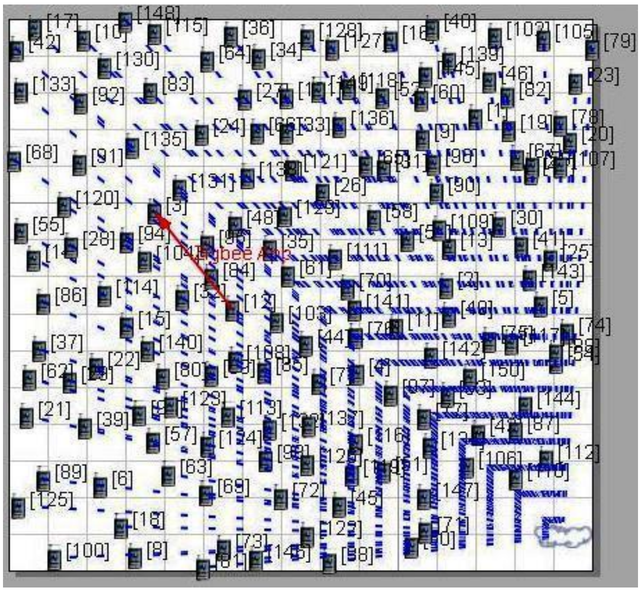


Fig. 4 Simulation Scenario

Fig. 4 represents the X-Y view of simulation scenario consisting of 150 nodes deployed in a random manner. The ZigBee traffic (indicated in RED color) is the traffic used between two arbitrary nodes which allow the data transmission between source and destination.

To be more specific, speed and direction are all chosen randomly and independently of other nodes. In random waypoint mobility model, the nodes randomly selects a position, moves towards it in a straight line at a constant speed that is randomly selected from a range [0, V_max], where V_max is the maximum allowable velocity for every mobile node, and after reaching the destination, the node stops for a duration defined by the 'pause time' parameter [12]. After this duration, it again chooses a random destination and repeats the whole process until the simulation ends. The parameters used in the simulation are given in Table 1.

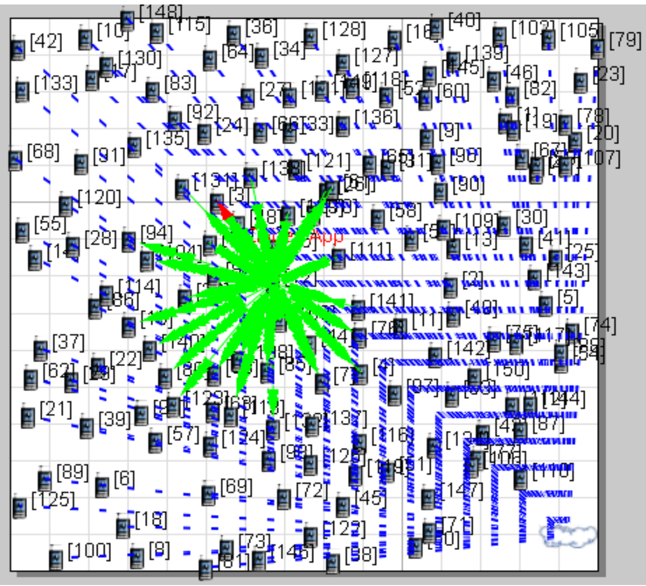


Fig. 5 Broadcasting view of simulated scenario

Fig. 5 represents broadcasting view of simulation scenario. In scenario green color flow indicates the information flow from sensor nodes to source and from source to sink.

Table 1. Simulation Parameters

S. No.	Parameter	Value
1	Terrain and Number of Nodes	1500*1500 m^2 and 150
2	MAC Protocol	MAC 802.15.4
3	Routing Protocol	LAR
4	Traffic Type	ZigBee
5	Number of Mobile Nodes	12, 27 and 50
6	Mobility Model	Random Waypoint
7	Speed	5 mps to 40 mps
8	Items Send	100
9	Simulation Time	300 Sec
10	Battery Capacity	1200 mAhr
11	Battery Voltage	5v

B. Simulation Results

I. Throughput Analysis

In a mobile or data communication networks, throughput is the average rate of successful message delivery in a communication channel. The throughput is generally measured in bits per second (bit/s or bps), and sometimes in data packets per second or data packets per time slot. Better the throughput better will be the communication system.

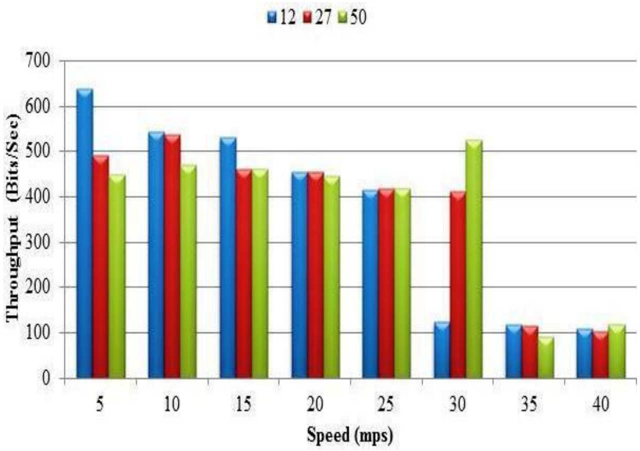


Fig. 6 Throughput analysis w.r.t Speed of mobile nodes

From Fig. 6 it is observed that as the speed of mobile node is increased, the throughput is decreased. The reduction in throughput may be due to link breakage, which is more probable as the length of the route increases and also speed increases.

II. Average End-To-End Delay Analysis

End to end delay refers to the time taken for a packet to be transmitted across a network from source to destination.

Published By:
Blue Eyes Intelligence Engineering
& Sciences Publication Pvt. Ltd.

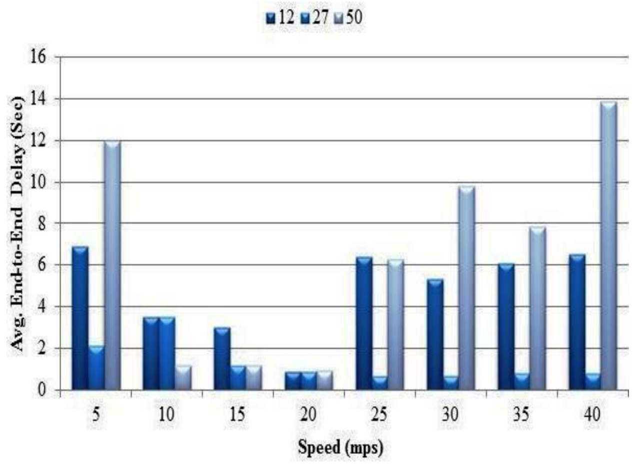


Fig. 7 Average End-to-End Delay analysis with respect to speed of mobile nodes

Form Fig. 7 it is inferred as the speed of the mobile node is increased initially the average end-to-end delay is decreased due to slow movement of node and data transmission is constant. But if the speed is still increased the movement of node is rapid in nature and there is no constant data transmission, delay is increased. So it is inferred that if the speed of the mobile is increased the average end-to-end delay is varied randomly because of congestion in the communication network. As speed is increased, the topology will change rapidly, so congestion might be more.

III. Average Jitter Analysis

Jitter is the variation in latency as measured in the variability over time of the packet latency across a network. A network with constant latency has no variation (or jitter). Jitter is the variation in delay by different data packets that reaches the destination and can seriously affect the quality of audio/video.

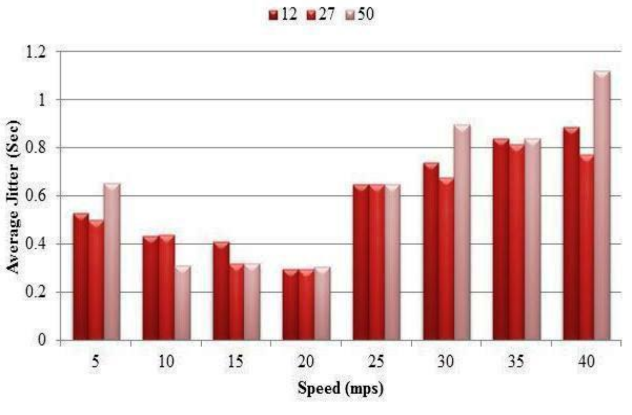


Fig. 8 Average Jitter analysis w.r.t Speed of mobile nodes

It is observed through the simulation result shown in Fig. 8 that if the speed of the mobile nodes is increased, the topology will change rapidly and the average jitter is varied randomly because of congestion in the communication network.

IV. Total Number of Packets Received Analysis

It accounts the total number of packets received out of total number of packets sent.

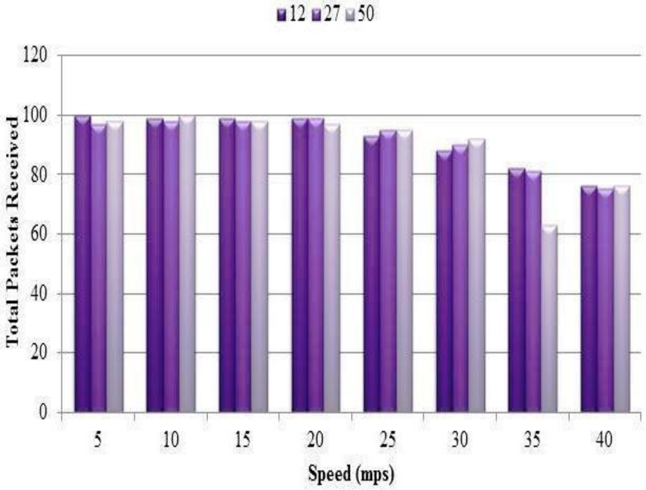


Fig. 9 Total Packets Received analysis with respect to speed of mobile nodes

From Fig. 9 it is inferred that as the speed of mobile node is increased, the total packets received is decreased. The reduction in total packets received may be due to more link breakage for the increased speed.

V. Residual Energy Analysis

Residual energy refers to approximately the remaining energy distribution within a sensor network.

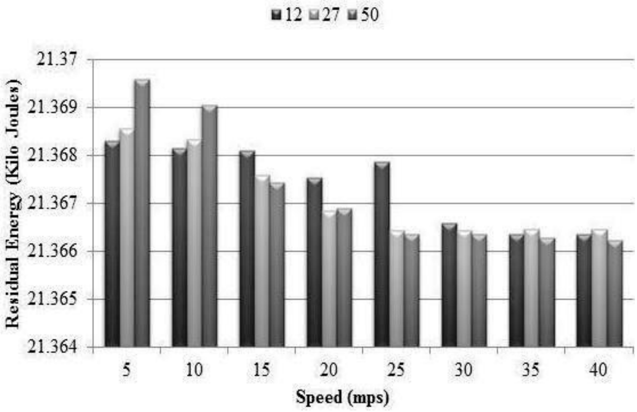


Fig.10 Residual Energy analysis w.r.t speed of mobile nodes

From Fig.10, it can be observed that as the speed of the mobile node is increased the residual energy of the network is decreased. Since the nodes are mobile in nature, more number of route discovery process is to be done. which will in turn consume more energy. Hence the residual energy is randomly varied as the speed is increased.

VI. CONCLUSION AND FUTURE WORK

The simulation of MWSNs is carried using Qualnet network simulator of version 6.1. Random waypoint model is used in simulation. From the simulated results, it is inferred that the performance parameters such as throughput, average end-to-end delay, average jitter, total packets received and residual energy are affected by the mobility of the sensor nodes. As the speed is increased, the throughput and the total packets received are decreased due to more link breakage. Further , the average end-to-end delay and the average jitter are varied randomly as the speed of the mobile node is

Published By:
Blue Eyes Intelligence Engineering
& Sciences Publication Pvt. Ltd.

increased.. In future the performance can be analysed by considering different mobility models, different terrain sizes, increasing mobile nodes etc.,

ACKNOWLEDGEMENT

The authors express their gratitude to UGC, New Delhi & Department of Electronics Engineering, School of Engineering and Technology, Pondicherry University for providing research facilities.

REFERENCES

[1] Waltenegus Dargie, Christian Poellabauer, "Fundamentals of Wireless Sensor Networks: Theory and Practice", Chapter 1: Motivation for a Network of Wireless Sensor Nodes, pp. 3-15,John Wiley and Sons Ltd., July 2010.

[2] Akyildiz, W. Su, Y. Sankarasubramaniam, and E. Cayirci, "A survey on sensor networks" IEEE Communications Magazine, vol. 40, no. 8, pp. 102-114, August 2002.

[3] Sonam Jain and Sandeep Sahu " Topology vs Position based Routing Protocols in Mobile Ad hoc Networks: A Survey" International Journal of Engineering Research & Technology, vol. 1 no. 3, pp. 1-11, May 2012 .

[4] Elizabeth M. Royer and Charles E. Perkins. "An Implementation Study of the AODV Routing Protocol." Proceedings of the IEEE Conference on Wireless Communications and Networking, Chicago, pp. 1-6 September 2000.

[5] Simardeep Kaur And Anuj K. Gupta "Position Based Routing In Mobile Ad-Hoc Networks: An Overview" International Journal Of Computer Science And Technology, vol. 3, no. 4, pp. 792-796, Oct - Dec 2012.

[6] B. Karp, H. Kung, GPSR: Greedy Perimeter Stateless Routing for Wireless Networks: Proceedings of ACM Mobile Communications, Boston, Massachusetts, USA, pp. 243–254, Aug 2000.

[7] Young- BaeKo and Nitin H. Vaidya, "Location Aided Routing (LAR) in Mobile Ad Hoc Networks" Wireless Networks, vol. 6 no. 4 pp. 307-321, July 2000.

[8] P.T.V.Bhuvaneswari and V.Vaidehi," Location Aided Energy Efficient Routing Protocol in Wireless Sensor Network", International Journal of Simulation Systems, Science &Technology, vol. 11, no. 4, pp. 41-50, 2011.

[9] QualNet Network Simulator; Available: http://www.scalable-networks.com.p#docs

[10] QualNet documentation,"QualNet 4.0 Model Library: Advanced Wireless";Available:http://www.scalablenetworks.com/products/qualnet/download.php

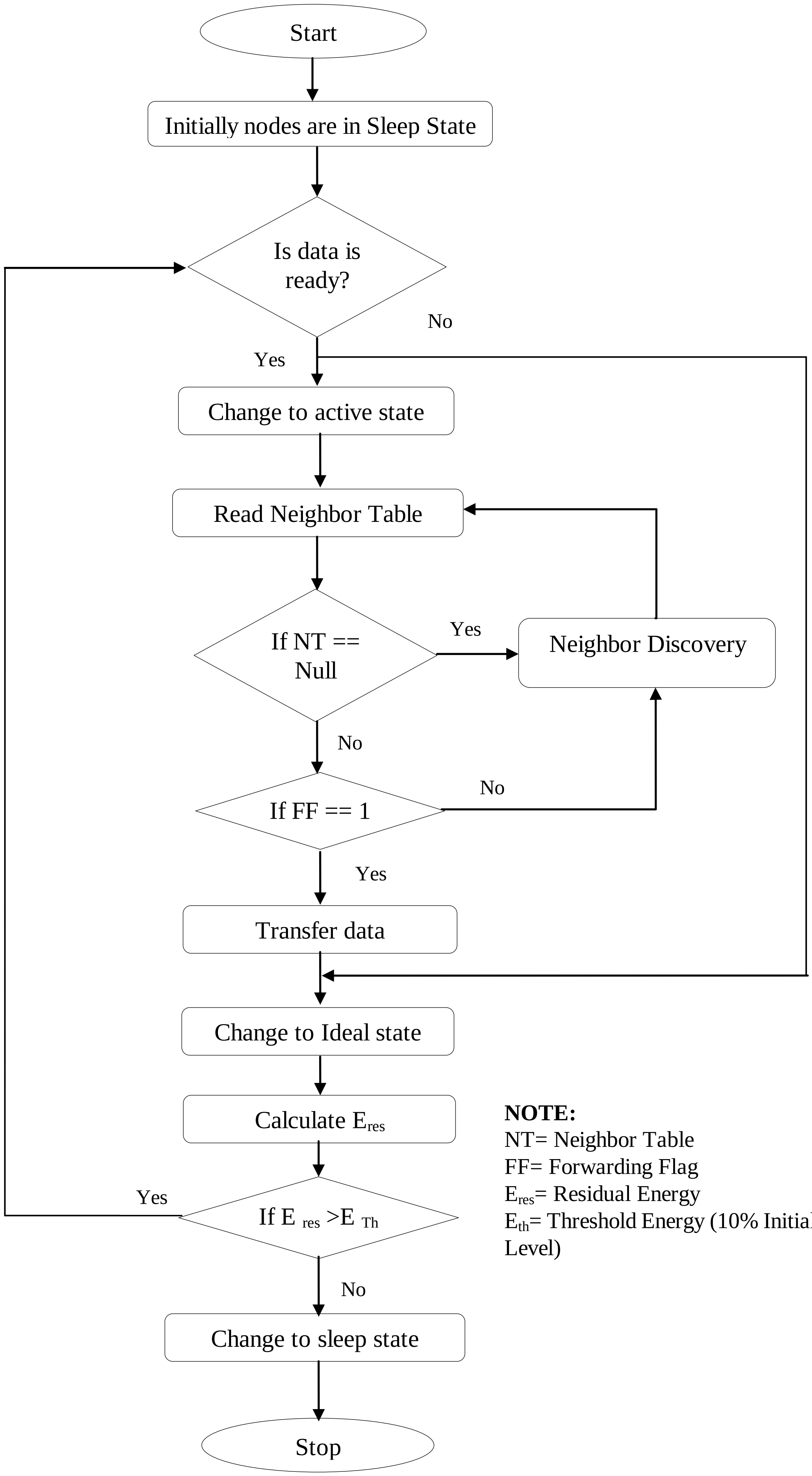
[11] Broch, J., Maltz, D.A., Johnson, D.B., Hu, Y.-C., and Jetcheva, J.: "A Performance Comparison of Multi-Hop Wireless ad Hoc Network Routing Protocols" Proceedings of IEEE International Conference on Mobile Computing and Networking , Dallas, Texas, pp. 85–97,Oct 25-30, 1998.

[12] Tracy Camp, Jeff Boleng and Vanessa Davies, "A Survey of Mobility Models for Ad Hoc Network" Special issue on Mobile Ad Hoc Networking: Research, Trends and Applications, vol. 2, no. 5, pp. 483-502, 2002.

P. SAMUNDISWARY received the B.Tech. degree (1997), M.Tech. degree (2003) and Ph.D. (2011) in the department of Electronics and Communication Engineering from Pondicherry Engineering College affiliated to Pondicherry University, Pondicherry, INDIA. She is having 15 years of teaching experience. She is currently working as Assistant Professor in the Department of Electronics Engineering, School of Engineering and Technology, Pondicherry University, Pondicherry, INDIA. Her research interests include Wireless Communication and Wireless Networks.

K DILIP received his B.Tech degree (2007) in Electronics and Communication Engineering from TKR College of Engineering and Technology affiliated to JNTU Hyderabad. Currently, he is studying M.Tech in the Department of Electronics, School of Engineering and Technology, Pondicherry University, Pondicherry, INDIA. His area of interest includes Wireless Communications, Wireless Sensor Networks , RF and Microwave Engineering.

Published By:
Blue Eyes Intelligence Engineering
& Sciences Publication Pvt. Ltd.



NOTE:
NT= Neighbor Table
FF= Forwarding Flag
E_{res}= Residual Energy
E_{th}= Threshold Energy (10% Initial Energy Level)

Fig. 11 Energy Aware Algorithm Flow Chart

Published By:
Blue Eyes Intelligence Engineering
& Sciences Publication Pvt. Ltd.