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Efficient Energy based Stable Multipath Routing Scheme for MANET

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ABSTRACT

In MANETs, mobile nodes consume more energy than the sensor nodes due to the presence of mobility. If the path stability is not maintained properly, network partition will occur. From the analysis of the previous work, it is concentrated on either energy or stability of path. So that performance of network will get degraded. In this work, Efficient Energy based Stable Multipath Routing Scheme is proposed to make a correct balance between stability of multipath and energy conservation. The main of the proposed work is to reduce energy consumption and provide better stability using the stability model. The proposed scheme consists of three phases like multipath routing, stability of multipath and energy consumption model. Multipath routing is developed to ensure better network lifetime and more energy efficiency. The multipath routing stability is calculated to ensure more network stability. Energy spent for transmission is reduced using the energy consumption model. By simulation results the proposed algorithm EESMRS achieves better performance in terms of packet delivery ratio, delay, overhead, network lifetime, energy consumption link availability than the existing method PLSS and LAER schemes.

General Terms

Multipath Routing, Energy consumption Model, Stability Model

Keywords

MANET, Link stability, Multipath routing, residual energy, energy consumption model, Mobility, packet delivery ratio, Network lifetime, stability weight, throughput, overhead and end to end delay.

1. INTRODUCTION

1.1. Mobile Ad Hoc Networks (MANET)

MANET is an autonomous system of mobile hosts without having any centralized administration. If two nodes are not within radio range, all message communication between them must pass through one or more intermediate nodes that double as routers. Nodes are allowed to move freely, thus hanging the network topology dynamically. In ad hoc networks, routing protocols must be adaptive and able to maintain routes in spite of the changing network connectivity. These networks are very useful in military and other tactical applications such as emergency rescue or exploration missions, where cellular infrastructure is unavailable or unreliable. Commercial applications are also likely where there is a need for ubiquitous communication services without the presence or use of a fixed infrastructure.

1.2. Issues and Main goals of Mobile Ad hoc networks

In our proposed scheme, stability and energy consumption are considered as major factors which affect the performance of mobile ad hoc networks. The following factors are considered as major issues and goals of MANETs which are described as follows.

1.2.1 Reliable routes

It is necessary to have reliable source – destination pair to maximize network throughput and reduce latency. Here the routes are selected based on probability model of the path future availability.

1.2.2 Route repair capability

Due to route failure, service disruption can be neglected by introducing alternative path before current path breaks with the presence of path duration. So some information on the path duration avoids waste of radio resources due to pre-allocation of backup paths.

1.2.3 Node to node connectivity

Connectivity and topology characteristics of mobile nodes are determined by the link dynamics. It finds the system capability to support user communications and their reliability level.

1.3 Predicting Network Performance

The network performance are predicted and achieved by means of higher layer protocols which are based on Quality of Service. For an example, the duration and frequency of route disruptions have a significant impact on Transmission Control Protocol (TCP) behavior, as well as on video streaming and VoIP services.

1.4 Energy management

It is a challenging factor in ad hoc environment where the wireless nodes should also consume energy to route packets for other nodes and to guarantee the connectivity of the network.. Mobile nodes are expected to rely on portable and very limited power sources. The route selection process should be performed by reducing the end-to end power needed to forward the packet at network layer. If the network layer may have access to energy information, battery-level metrics can be used in the routing process.

2. RELATED WORK

Shilpi Jain and Sourabh Jain [1] proposed Energy Efficient Maximum Lifetime Ad-Hoc Routing algorithm to improve the networks lifetime in MANET. Here, the energy cost is calculated for selecting the energy efficient path. It is considered that power level of the node while finding the route. If the node involves in any transaction, it loses some amount of energy which depends on the nature of packets, packet size and distance between the nodes.

Signal Strength and Energy Aware Reliable Routing protocol [2] is proposed to incorporate the signal strength and residual battery capacity of nodes into route selection through cross layer model. They have calculated metric is Reliability Factor for route selection among feasible routes. The goal of this work is to improve the reliability of route discovery in MANET by using signal strength and energy metrics through cross layer information sharing. Here the stable routes are selected based on the signal strength and residual energy level of the intermediate routes.

Tripti Nema et.al [3] developed the Energy based Ad hoc On – Demand Routing Algorithm to balance the energy among nodes. All nodes maintain their minimum energy level to improve the network lifetime. The threshold energy level of a mobile node is set here. If any node exceeds threshold value, node goes to the sleep mode and joint in the event. The link lifetime and nodes residual energy is initiated to augment the route discovery process that allows the routes with more network lifetime and less breakage.

A new route discovery scheme is proposed protocol [4] to ensure the maximum network lifetime while selecting the route. This protocol considers the network lifetime of the route as a metric for route discovery process. The route consists of multiple links and the route is broken if any of the link fails. Here, every link is formed by two adjacent mobile nodes, which have limited battery energy and can roam freely, and it is broken if any of the two nodes is not alive due to exhaustion of energy or if these two nodes move out of each other's transmission range.

Link lifetime based Backup Routing (LBR) protocol [5] is proposed to improve route stability which is based on link lifetime. The shortest paths are obtained between source and destination through limited flooding as the primary path, and then sets up a local backup path for each link in the primary path concerning link lifetime. This scheme effectively avoids backup paths being out-of-date prematurely and increases the availability of backup paths.

GunWoo Park and SangHoon Lee [6] proposed a Routing Protocol through the Residual Battery and Link Stability for extending network life time in MANET. It is considered that distance among neighbor nodes, Residual Battery Capacity and Link Stability. This scheme is able to increase the Lifetime of Network through minimizing the whole energy consumption and distribute the traffic load. It sets the approximate shortest route to minimize the transmission delay.

Nivedita N. Joshi and Radhika D. Joshi [7] modified a position based Location Aided Routing for energy conservation. This scheme controls the transmission power of a node according to the distance between the nodes. Energy information is included in every route request packet to select the efficient energy path. The protocol uses location information of a node for setting the path from source to destination. The main aim is to design a technique of variable transmission power control to reduce overall energy consumption of the network.

The new routing scheme [8] was focusing on energy conservation through hexagonal grid structures with the help of most popular Location-Aided Routing (LAR) scheme. This scheme uses the location of mobile node through GPS technique to improve the performance matrices such as energy saving, routing overhead and network life time in Ad-Hoc Networks.

Link lifetime based Backup Routing [9] is proposed to improve routing stability. This routing is based on link lifetime, while obtaining the shortest path between source and destination through flooding, and setting up a local backup path for each link in the primary path concerning link lifetime. This scheme effectively avoids backup paths being out-of-date and increases the availability of backup paths.

Jianzhen Sun et.al [10] introduced the link stability based routing to select a stable path while minimizing the number of hops. The transmission range of mobile nodes is divided in to stable and caution zone. Rerouting is initiated when the distance between two neighboring communicating nodes exceeds the stable zone, before the old path actually breaks, thus realizing soft handoff and reducing the data packet's delay.

Seema Verma et.al [11] explored energy efficient routing to discover an efficient energy aware routing scheme in MANETs that not only uses the node energy effectively but also finds the best route and increases the lifetime of the network. At the time of route selection, this scheme takes care of crucial things, battery status of the path, and number of drained nodes in the path. With these factors in consideration the proposed scheme always select more stable route for data delivery. Energy of the network is also reduced using variable transmission power when data transmission is done.

Ramalakshmi et.al [12] introduced a distributed algorithm for energy efficient stable Multi Point Relay (MPR) based Connected Domain Set (CDS) construction to extend the lifetime of ad hoc wireless networks by considering energy and velocity of nodes. They have also implemented route discovery protocol to make use of the CDS nodes to relay route request messages. They proposed two rules to reduce the connected dominating size and to prolong the life span of the nodes with residual energy level and velocity.

Floriano De Rango et.al [13] explored a Link-Stability and Energy aware Routing protocol (LAER) to make a correct balance between link stability and energy efficient. Each node broadcasts HELLO packets to all its neighbors that are in its communication range; each node in LAER maintains the table of its direct neighbors. If a node receives the HELLO packet, it updates the information of the neighbor, if neighbor ID is already present in table or adds a neighbor information, if it is a new neighbor. Here, they have not considered on path, negihbor node stability.

Sunil Taneja et.al [14] developed an effort has been made to perform analysis using random way point mobility model. The results have been derived using self created network scenarios for varying number of mobile nodes. The performance metrics used for evaluation are packet delivery ratio, average end to end delay, throughput, normalized routing load and packet loss. This scheme provided the energy efficient routing over mobile ad hoc networks in a very efficient way. It assumes that all nodes are capable of dynamically adjusting the transmission power used to communicate with other nodes. Routing protocols use metrics to evaluate what path will be the best for a packet to travel.

The paper is organized as follows. The Section 1 describes introduction about MANET, fundamental aspects of routing stability in MANET. Section 2 deals with the previous work which is related to the stability Section 3 is devoted for the implementation of efficient energy based stable multipath routing protocol. Section 4 describes the performance analysis and the last section concludes the work.

3. Implementation of Efficient Energy based Stable Multipath Routing Protocol (EESMRP)

The proposed scheme ensures high load balancing and minimum energy consumption in the network. It consists of multipath routing, stability and energy consumption model. In multipath routing, aggregate bandwidth is provided to route the data. The fault tolerance, high throughput and aggregate bandwidth can be easily achieved using the multipath routing. In Energy consumption model, node's energy efficiency is well improved. In order to achieve minimum energy consumption, each node is in either transmission mode or sleep mode. If one node is in multipath in transmission mode, other node will be in sleep mode to maintain minim energy consumption level.

Energy consumption status of the nodes and path are stored in routing table. Each time, the energy level of the node is verified using proposed packet format.

3.1 Multipath Routing Scheme

In EESMRP, the Multipath routing is deployed to provide high throughput and more network lifetime. It is used in several authentication techniques where hop to hop authentication is used to find the efficient path to improve network lifetime. Here the nodes are organized in a cluster group. Each cluster group communicates via multipath routing to maintain their effective communication and less communication overhead.
In Cluser1, Cluster Head 1 chooses the multipath to Cluster Head 2. If the cluster nodes want to send a packet to another cluster in different region, it should get authentication from both cluster heads. If any failure occurs, the route control message is forwarded to both cluster regions. The failure means like node failure, path failure etc. The multipath is illustrated in fig.1. Source node sends its packet to destination via multipath. If any path failure occurs , alternate shortest path will be chosen based on the stability of it. The main aim is to make network connectivity more by making the packet arrival time very less.

In multipath routing, it is assumed that source node S has three paths to destination D. If any path failure occurs, the source node will choose another path to reach packet at the destination. A message can be sent on alternating paths, or on multiple paths in parallel. Both reduce the impact of isolated failures.

To avoid this, the disjoint paths are chosen. Information is sent over multiple, strictly disjoint, paths. If different versions of information are received, the destination chooses the highest priority. So the remaining paths can be considered as untrustworthy, since it is delivered a presumably incorrect message. The following assumptions are made to construct efficient multipath routing as follows:

- Multipath requires a minimum degree of connectivity.
- More cluster nodes need to spend energy on routing.
- Multipath does not consider loosely connected mobile nodes.
- Maintenance of disjoint paths between communication end points are difficult in multipath.
- Multipath routing will get effect in to network partitioning while message is delivered in to the different parts of the network,
- Only chosen packets with less size can be sent via routing.
- Path in multipath routing which is having less energy consumption is considered as $PATH\_EFF_1$.
- More stability of the path is to be used in multipath routing.

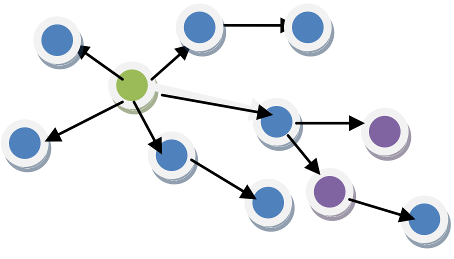


Fig.1. Mulitpath Routing Discovery Procedure

3.2 Stability of the multipath routing

If there are 'n' numbers of nodes then Mobility of path PS is measured as follows:
*Mob of path PS=Mob of PQ * Mob of QR * Mob of RS (9)*
And the link loss of the path PS is measured as follows: Link loss of path PS= link loss of PQ+ link loss of QR+ link loss of RS. Therefore, by using the two parameters the mobility and link loss, the stability of the multipath is measured as follows

$$S_{mp} = \frac{M_{mp} + LL_{mp}}{H_c} \qquad (1)$$

Where S_p = Stability of multipath
M_P = mobility of multipath
LL_p = link loss of multipath
H_c = Number of hop count

It is also proposed stability of path from stability of link by following calculations. If the distance between two nodes becomes very higher than the transmission range the nodes will be disconnected. For transmission range T_r link stability L_{sb} between any two nodes overtime period t can be calculated by:

$$L_{sb} = \frac{T_r}{\sqrt{\left\{\left(p_1^{'} - p_2^{'}\right) + t\left(n_1 \cos\theta_1 + n_2 \cos\theta_2\right)\right\}^2 + \left\{\left(q_1^{'} - q_2^{'}\right) + t\left(n_1 \sin\theta_1 + n_2 \sin\theta_2\right)\right\}^2}}$$

L_{sb} is the link stability of individual links between any two nodes and for a path and it is same as the minimum link stability along the path. For a path from source to destination path stability P_{sb} is given by,

$$P_{sb} = Min\left(L_{sb}(1), L_{sb}(2), L_{sb}(3)\ldots\ldots L_{sb}(N)\right) \quad (2)$$

Where 1,2,3…N is the number of links along the path.

3.3 Energy Consumption Model

Let the energy consumption per packet is taken as E_{Pac}. It includes both transmission and reception energy. The total energy consumption of a network is calculated as,

$$E = E_{tx} + E_{rx} + E_{path} = n_{tx} \times e_{tx} + n_{rx} \times e_{rx} + n_{tr} \times e_{path} \quad (3)$$

In the above equation (3.1), the n_{tx} and n_{rx} are the number of transmission and receptions respectively, where as n_{tr} is the number of both transmissions and receptions occurred in a path at a time. e_{tx},e_{rx},e_{path} are the energy spent on transmission, reception and path.

$e_{tx} = E_{em} \text{ x } K + \chi_{amp} \text{ x } K \text{ x } d^2$ (4)

K = bit which consists of current energy level of the node, path, data label, node's location and hop count.

E_{elec} = transmitted and Received energy on electronic device module (40 nJ/bit).

χ_{amp} = Transmitter Amplifier (100 pJ/bit/m^2)

d = distance between the two mobile nodes.

And the energy for receiving K bit is equal to:

$e_{rx} = E_{em} \text{ x } K$ (5)

Routing metric is also taken in to the consideration for the energy required for correct reception of packets. It is given as,

$$E^{kl} = \frac{KP_l}{GP_d(\gamma_{kl})} \quad (6)$$

K represents the length of the packet.

P_l is transmission power.

G means packet transmission rate.

$P_d(\gamma_{kl})$ represents the probability of correct reception of a packet.

γ_{kl} is the Signal to Interference ratio of link (*k*,*l*).

The energy needed for correction packet transmission on the specific multipath route is given as,

$$E_{mr} = \sum_{link(k,l)\in mr} E^{kl} \quad (7)$$

mr is the multipath route.

If choosing the path with minimum energy consumption, the energy efficiency of the network will be more improved.

In energy consumption model, there are four metrics are considered based on energy i.e. stability of multipath, link stability, energy spent on communication phase and link availability. In routing table, all the nodes energy status are calculated before and after transmission.

3.4 Proposed Packet Format

Source Address	Dest. Address	Energy status	Node Stability	Link Availability	Hop count
2	2	4	4	2	2	1

Fig.2 Proposed Packet format

In fig 2, the packet format of proposed algorithm is shown. Here the first two fields are source and destination address occupies 2 bytes. The third field occupies 4 byte field where the energy status of a node. In next field, Node stability fills 4 byte. SNR occupies 2 byte field. BER occupies 2 byte field. Finally the Hop count occupies 1 byte field for calculating number of hops from cluster node. Flowchart of EESMRS is shown in fig.3.

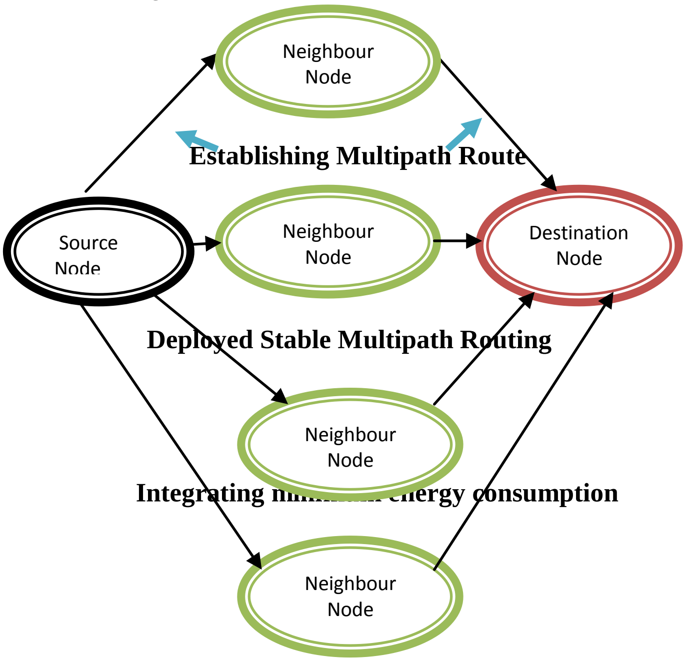


Fig.3. Flow chart of EESMRS

4. PERFORMANCE ANALYSIS

The proposed scheme EESMRS is simulated with the help of object oriented discrete simulator. In this simulation, 101 mobile nodes move in a 1300 meter x 1300 meter square region for 50 seconds simulation time. All nodes have the same transmission range of 250 meters. The simulated traffic is Constant Bit Rate (CBR). Our simulation settings and parameters are summarized in table1.

Table1. Simulation and settings parameters

No. of Nodes	101
Area Size	1300 X 1300
Mac	802.11
Radio Range	250m
Simulation Time	80 sec
Traffic Source	CBR
Packet Size	512 bytes
Mobility Model	Random Way Point
Packet Rate	8 pkts/sec
Protocol	DSR

4.1 Performance Metrics

We evaluate mainly the performance according to the following metrics.

Communication overhead: The communication overhead is defined as the total number of routing control packets normalized by the total number of received data packets during the route maintenance phase.

Packet Delivery Ratio: The packet delivery ratio (PDR) of a network is defined as the ratio of total number of data packets actually received and total number of data packets transmitted by senders.

Network Lifetime: It is defined as the time from beginning of simulation until first node in MANET runs out of energy.

End-to-End Delay: The End-to-End delay is defined as the difference between two time instances: one when packet is generated at the sender and the other, when packet is received by the receiving application.

The simulation results are presented here. It is compared that proposed scheme EESMRS with our previous scheme PLSS and existing scheme LAER [13] and in presence of stability environment.

Figure 4 shows the results of average end-to-end delay for varying the mobility from 20 to 100. From the results, we can see that EESMRS scheme has slightly lower delay than the PLSS and LAER scheme because of stable routing.

Figure 5, presents the residual energy while varying the time. The Comparison of EESMRS, LAER and PLSS energy consumption is shown. It is clearly seen that energy consumed by EESMRS is less compared to LAER and PLSS.

Fig. 6, presents the comparison of communication overhead. It is clearly shown that the overhead of EESMRS has low overhead than PLSS and LAER scheme.

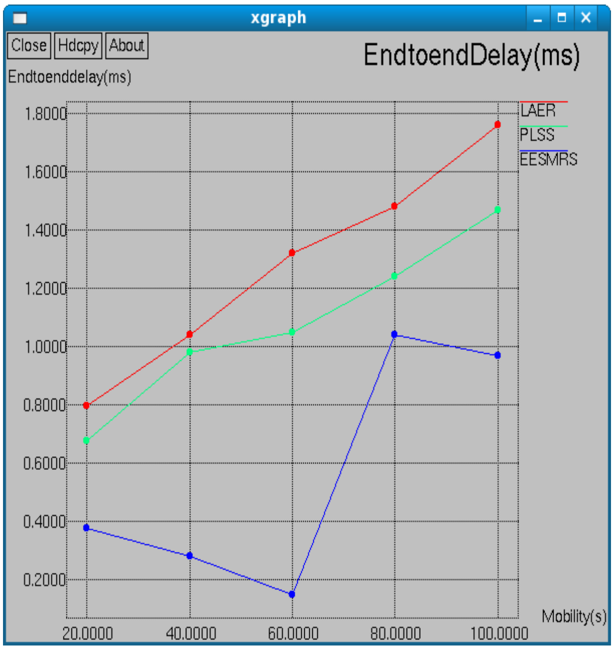


Fig. 4. Mobility Vs End to end Delay

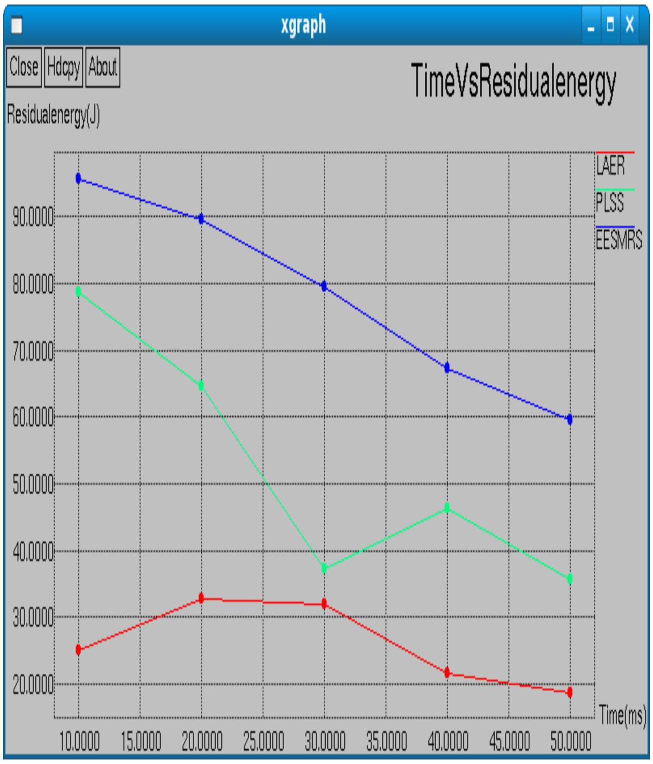


Fig. 5. Time Vs Residual Energy

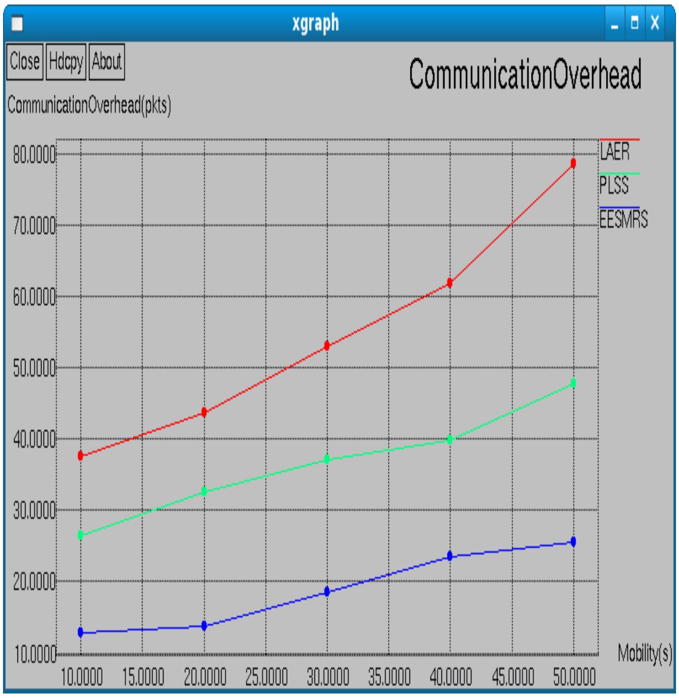
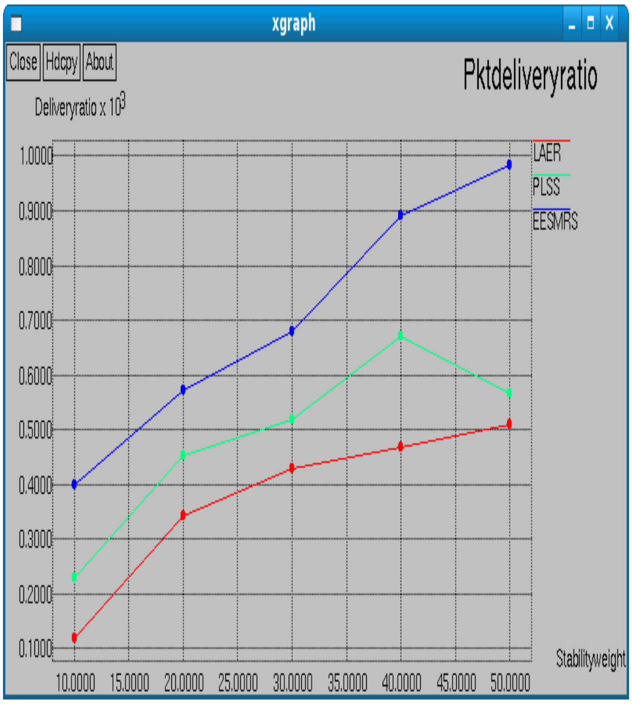


Fig. 6. Mobility Vs Communication Overhead



.**Fig.7. Stability Vs Packet Delivery Ratio**

Figure 7 show the results of average packet delivery ratio for the stability weight 10, 20…50 for the 100 nodes scenario. Clearly our EESMRS scheme achieves more delivery ratio than the PLSS and LAER scheme since it has both reliability and stability features.

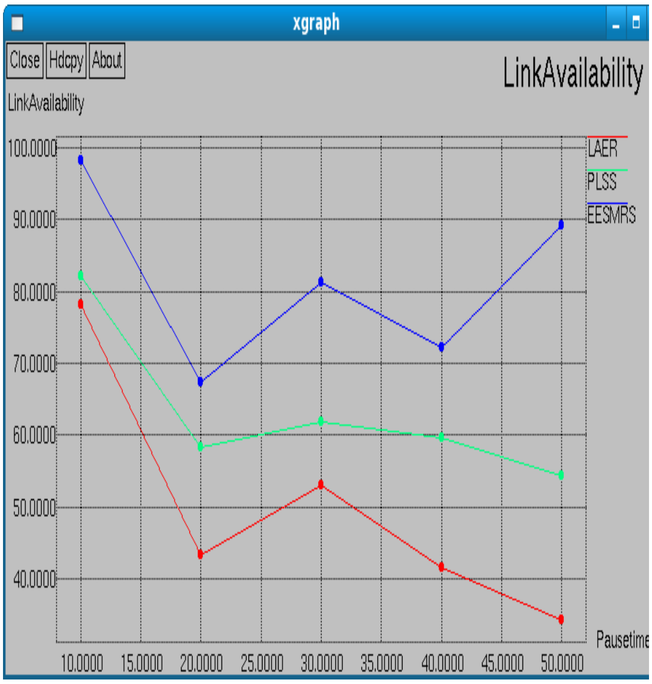


Fig.8. Pause time Vs Link Availability

Figure 8 show the results of link availability for the pause time 10, 20…50 for the 100 nodes scenario. Clearly our EESMRS scheme achieves high link availability than the PLSS and LAER scheme since it has both predicting stability features.

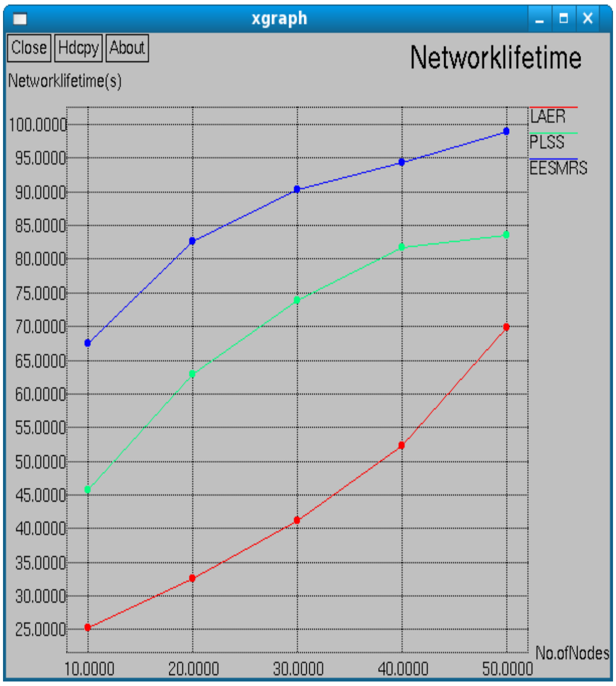


Fig.9. No.of Nodes Vs Network Lifetime

Figure 9 show the results of average network lifetime for the nodes from 10 to 50. Clearly our EESMRS scheme achieves more network lifetime than the PLSS and LAER scheme since it has more residual energy.

5. CONCLUSION

In MANET, mobile nodes are moving randomly without any centralized administration. If these nodes are not having reliable stability of multipath and minimum energy consumption, it will get degraded. In this paper, we have developed a Efficient Energy based Stable Multipath Routing Scheme which attains stability in multipath and energy efficiency. In the first phase of the scheme, multipath routing is developed to ensure high network lifetime. In second phase, stability of multipath routing is established. In third phase, energy consumption of nodes are kept low usinf energy model. Energy efficiency depends on uses four factors link stability, link availability, stability of multipath and energy spent on communication phase to favor packet forwarding by maintaining stability for each path with more energy. By simulation results we have shown that the EESMRS achieves good packet delivery ratio, more network lifetime while attaining low delay, overhead, minimum energy consumption than the existing scheme PLSS and LAER scheme while varying the number of nodes, node speed, throughput and stability weight.

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