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IMPLEMENTATION OF STABLE ENERGY BASED LOAD BALANCING PROTOCOL FOR MANET

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ABSTRACT

In general, 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, the load balancing of energy routing is not established well. It leads to network performance degradation. In this work, Efficient Energy based Load Balancing Routing Protocol (EELBP) is proposed to make a balance between load balancing and energy consumption. The main aim 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 Load balanced Routing, stability of path 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 EELBP 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.

Keywords: MANET, multipath routing, residual energy, energy consumption model, mobility, packet delivery ratio, network lifetime, pause time, communication overhead and end to end delay.

1. INTRODUCTION

A mobile, ad hoc network is an autonomous system of mobile hosts connected by wireless links. There is no static infrastructure such as base station. If two hosts are not within radio range, all message communication between them must pass through one or more intermediate hosts that double as routers. The hosts are free to move around randomly, thus hanging the network topology dynamically. Thus routing protocols must be adaptive and be able to maintain routes in spite of the changing network connectivity. Such 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. Examples include home-area wireless networking, on-the-fly conferencing applications, networking intelligent devices or sensors, communication between mobile robots, etc.

a) QoS requirements

To meet the quality of service requirements of mobile users, several metrics can be considered for selecting a source destination routing path. The fundamental aspects of Route stability are determined as follows:

b) Steady routes

To maximize throughput and reduce traffic latency, it is essential to ensure reliable source-destination connections over time. A route should therefore be selected based on some knowledge of the nodes' motion and on a probability model of the path available in future .

c) Efficient route repair

If an estimate of the path duration is available, service disruption due to route failure can be avoided by creating an alternative path before the current one breaks. Note that having some information on the path duration avoids waste of radio resources due to pre-allocation of backup paths.

d) Network connectivity

Connectivity and topology characteristics of a MANET are determined by the link dynamics. These are fundamental issues to network design, since they determine the system capability to support user communications and their reliability level.

e) Performance evaluation

The performances achieved by high-layer protocols, such as transport and application protocols, heavily depend on the quality of service metrics obtained at the network layer. As an example, the duration and frequency of route disruptions have a significant impact on TCP behaviour, as well as on video streaming and VoIP services. Thus, characterizing route stability is the basis to evaluate the quality of service perceived by the users.

f) Energy consumption

It is a limiting factor in the successful deployment of MANETs, because nodes are expected to rely on portable, limited power sources. Moreover, energy consumption is extremely challenging in multi-hop environments, where the wireless nodes should also consume energy to route packets for other nodes and to guarantee the connectivity of the network. At the MAC layer, some techniques can be used to reduce the energy consumed during transmission and reception; additionally,

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a careful policy may turn off the wireless device when the node is idle. At the network layer, the route selection process should be performed by reducing the end-to end power needed to forward the packet. If the network layer may have access to energy information, battery-level metrics can be used in the routing process.

2. RELATED WORK

Annapurnal Patel *et al*. [1] focused on emergency search and rescue operations which rely heavily on the availability of the network. The availability is a direct cost of the overall network lifetime, i.e., energy of the nodes. The first objective of this work is to select two existing energy efficient routing protocols based on AODV, each of which is based on a different energy cost metric. This protocol is a combination of two energy cost metrics in a single protocol. The performance of the proposed protocol is evaluated against the two protocols chosen for combination and against the traditional AODV.

Pariza Kamboi and Sharma [2] introduced a scalable and energy efficient location aware multicast algorithm, for mobile ad hoc networks based on creation of shared tree using the physical location of the nodes for the multicast sessions. It constructed a shared bi-directional multicast tree for its routing operations rather than a mesh, which helps in achieving more efficient multicast delivery. The algorithm uses the concept of small overlapped zones around each node for proactive topology maintenance within the zone. Protocol depends on the location information obtained using a distributed location service, which effectively reduces the overheads for route searching and shared multicast tree maintenance. Anew technique of local connectivity management was proposed that attempts to improve the performance and reliability. A preventive route reconfiguration was also employed to avoid the latency in case of link breakages and to prevent the network from splitting.

Pratik M. Zala *et al*. [3] proposed the proposed scheme to AODV that works on a reactive approach. It was proposed for the stable paths by satisfying a set of signal strength and energy level and Signal to Interference Ration based on threshold area. Once the sender send the route request to its neighbouring nodes the neighbouring nodes sends route reply which include the Received Signal Strength Indicator value, battery capacity.

Kalel and Deshmuk [4] studied the benefits & limitation of various routing protocols for energy management in MANET by representing three main parameters that are energy, delay and throughput. Parthesh *et al.* [5] introduced the energy aware routing protocol. When the source tries to send data to destination it first checks if the route is available or not and if route is available source can send the data directly but if route is not available the source send the RREQ their neighbour nodes. After it sends the RREQ it checks if is it intermediate node or not, after that if it is not the intermediate node then the node must be destination node but if it is intermediate node then it checks the RSS value of that particular intermediate node and hence this intermediate node becomes a source node and the same procedure will happen again and again to find the destination node. Source optimal path is determined based on stability of the link. Devika *et al.* [6] proposed a distributed energy efficient routing algorithm for mobile ad hoc networks (MANETs). For commitment delivery and to improve performance, most position-based routing protocols, e.g., greedy-face-greedy (GFG), forward a message in greedy routing mode until the message is forwarded to a local minimum where greedy forwarding is unbearable. It is then switched in to a less systematic mode known as face routing. Face routing requires the fundamental network to be a planar graph which makes geometric routing only apparently feasible. A virtual small-world network was constructed by adding virtual long links to the network to reduce the number of local minima. Virtual force method was applied to recover from local minima without depend on face routing. Waheb *et al*. [7] proposed approach considers the residual battery energy of the nodes during the route computation as a parameter in the link cost function. Then the multipath Dijkstra algorithm can use the cost based on the residual battery energy as the initial cost of the links between each pair of nodes to find the best path to a destination instead of number of hops. Aishwarya *et al*. [8] proposed the LEACH and DSR routing and find-out reliable cluster that gives information about energy of each cluster belongs zone. If energy of the node is higher, LEACH selects that particular node for data transmission, that work increases the reliability to the communication. Clusters are formed based on the received signal strength and use local cluster heads as routers to the sink. Energy will be saved since the transmissions will only be done by such cluster heads rather than all mobile sensor nodes. Dhanalakshmi Natarajan1 and Alli P Rajendran [9] proposed the Advanced OLSR protocol based on a modified Dijkstra's algorithm which permits routing in multiple paths of dense and sparse network topologies. The routing is based on the energy of nodes and links (implied from the lifetime) and the mobility of the nodes. Energy factors were used to determine the multiple parallel and disjoint routes. AOLSR is a hybrid ad hoc routing protocol because it integrates the proactive and reactive characteristics. It is also a source routing protocol which permits the sender of a data packet to partially or completely reveal the route that the packets traverse through a network. This enables the discovery of all possible paths to a host. Two cost functions were introduced to construct link-disjoint or node-disjoint routes. Secondary functions namely, path recovery and loop discovery process were included to manage the topology changes of the network. The network topology varies frequently due to the movement of the mobile nodes and energy constraints. Jaspinder and Meenakshi [10] proposed an algorithm called Signal and Energy Efficient Clustering (SEEC) based on the Signal level and energy of the nodes to increase the life time of Cluster head. Its emphasises on the cluster maintenance and formation at low cost, the resources used are signal strength and battery power of the node. If the signal

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strength or the power level of Cluster HEAD drops with their respective threshold value then next node which has high signal and power value is elected as cluster head. Komma Reddy and Dhanalakshmi [11] proposed a novel MANET routing protocol POR which takes advantage of the stateless property of geographic routing and broadcast nature of wireless medium. Besides selecting the next hop, several forwarding candidates were also explicitly specified in case of link break. Leveraging on such natural backup in the air, broken route can be recovered in a timely manner. The efficacy of the involvement of forwarding candidates against node mobility, as well as the overhead due to opportunistic forwarding is analyzed. Location information to guide the data flow and can always archive near optimal path. Utilizing in-the-air backup mechanism, communication was maintained without being interrupted. Mohammed A Mikki [12] introduced the Energy Efficient Location Aided Routing (EELAR) Protocol for MANETs that is based on the Location Aided Routing (LAR). It makes significant reduction in the energy consumption of the mobile nodes batteries by limiting the area of discovering a new route to a smaller zone. Thus, control packets overhead were significantly reduced. A reference wireless base station was used and the network's circular area centered at the base station is divided into six equal sub-areas. At route discovery instead of flooding control packets to the whole network area, they are flooded to only the sub-area of the destination mobile node. Deepthy Mathew's *et al.* [13] discussed about various energy efficient and link stability based protocols with the importance of energy efficiency and stability of links. It was concluded that there is not a single protocol which can give the best performance in ad-hoc network when considering both the above parameters. Performance of the protocol varies according to the variation in the network parameters. Sometimes the mobility of the node of the network is high reflecting on the node and its link stability and sometimes it is low. Kadiveti. Koteswar Rao *et al.* [14] proposed the Enhanced routing algorithm E-AODV which reduces the routing overhead and improves the efficiency. In standard AODV, hello packet broadcast mechanism is enhance to save time-and- gain discarding and rediscovering the routes. Ruchi Aggarwal and Amanpreet Kaur [15] explored an Energy Efficient Zone Based Location Aided Routing (EEZBLAR) Protocol for MANETs that is based on the Location Aided Routing (LAR). EEZBLAR makes reduction in the energy consumption of the mobile nodes' batteries by limiting the route discovery process only to specified nodes. In EEZBLAR network is divided into zones and each zone is provided with a zone Leader which keep track of all the nodes in the zone in the form of a table. When route discovery process is initiated, instead of flooding RREQ packets to the whole network area, the RREQ packets are sent only to the zone leaders. The zone leaders maintain routing table which stores all the information about its zonal nodes. Shahram *et al.* [16] explored the Binary Particle Swarm Optimization algorithm (BPSO) to add the energy awareness feature to the TORA routing protocol. The proposed protocol considers routes' length in its route selection process and also includes routes' energy level in its calculations. It formulates the routing issue as an optimization problem and then employs BPSO to choose a route that maximizes a weighted function of the route length and the route energy level. It redefines the routing algorithm as an optimization problem and then employs BPSO algorithm to solve it. The main feature of this work is that it distributes load among routes considering energy of routes. This causes the load to be distributed uniformly among routes and leads to long life of network. Shivasankar *et al.* [17] proposed the efficient power aware routing (EPAR) that increases the network lifetime of MANET. In contrast to conventional power aware algorithms, it identified the capacity of a node not just by its residual battery power, but also by the expected energy spent in reliably forwarding data packets over a specific link. Using a mini-max formulation, this routing selects the path that has the largest packet capacity at the smallest residual packet transmission capacity. This protocol must be able to handle high mobility of the nodes that often cause changes in the network topology.

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 PROPOSED SCHEME

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.

a) Load balancing through multipath routing

Multipath routing is organized in terms of path with disjoint links and path with disjoint nodes. To ensure the network connectivity, reducing the packet loss, the multipath routing is implemented in our proposed work. The proposed work mainly focuses on congestion control to avoid the retransmission and packet drop as well as the packet loss. For example in Figure-1, the multipath routing concept is enabled between the source S and

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Destination node D. Consider a packet transmission through the 1st path. In case, the packet travels through path which exceeds the capacity of the path, the drop will occur rapidly. So in this case, the multipath is deployed to overcome the effect of congestion. The alternative disjoint links and disjoints nodes are integrated to reach the packet to its destination without affecting other transmission and loss.

In alternate path routing, the shortest path between exchanges is typically one hop across the backbone network; the network core consists of a fully connected set of switches. When the shortest path for a particular source destination pair becomes unavailable (due to either link failure or full capacity), rather than blocking a connection, an alternate path, which is typically two hops, is used. Multipath routing increases fault-tolerance and reliability.

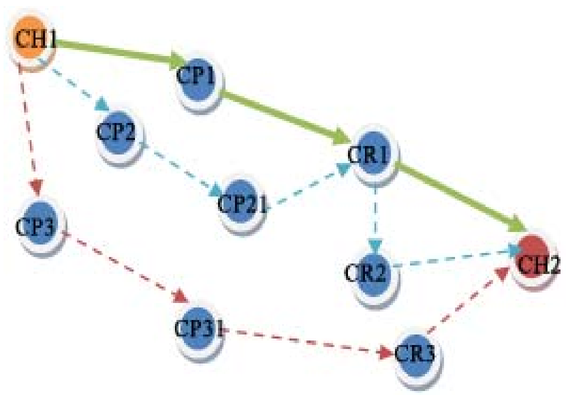
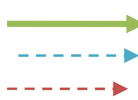


Figure-1. Implementation of multipath routing.

 ----- Cluster Head 1 (CH1)

 ------ Cluster Head 2 (CH2)

 ------ Cluster participant nodes (CP1, CP2,CP3, CP31, CP21, CR1, CR2, CR3)


First path
Path with displaced lines
Path with displaced nodes

The router can split the same label traffic flow into different paths with the given traffic engineering constraint. QoS constraints like minimum delay and maximum bandwidth are considered for splitting a given flow dynamically into these multiple paths.

b) Stability of the multipath routing

Stability of Multipath in Whole Network

Similarly, 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*

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

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

Where S_{mp} = Stability of multipath
M_{mP} = Mobility of multipath
LL_{mp} = 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.

c) Energy consumption model

In MANET, mobile node consumes more energy due to its mobility. In case any misbehaviour or link failure occurs, packet has to be transmitted again. To maintain the minimum energy consumption, the probability of the packet retransmission should be reduced. Position of node may be of three states like transmission, reception and idle mode. Each state represents the different level of energy consumption.

Steps in Energy consumption model as follows:

Step-1:

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,

$$E = E_{tx} + E_{rx} + E_{path} = n_{tx} \times e_{tx} + n_{rx} \times e_{rx} + n_{tr} \times e_{path} \quad (2)$$

In the above equation, 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.

Step-2:

In order to compute the energy dissipated by one transmission, these losses are taken in to account as follows,

$$\cos t_{tr}(k) = E_{tr} + m \times E_{rr} + P_{tar} \quad (3)$$

where m represents the number of non-sleeping nodes belonging to the interference zone of the transmitter k and P_{tar} represents the probability of packet loss occurred during transmission and reception phases. E_{rr} represents the energy spent during reception. $\cos t_{tr}(k)$ represents the angle where the route is taken for transmitting a packet. It is nothing but how far the source and destination nodes are communicating with each other at certain location.

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Step-3:

The estimation of energy for both packet (E_{pkt}^{mn}) and acknowledgement packets (E_{err}^{mn})are also determined as follows

$$E_{pkt}^{mn} = \lambda \times d_{mn}^{r} \times \tau_{pkt} \quad (4)$$

$$E_{err}^{mn} = \lambda \times d_{mn}^{r} \times \tau_{err} \quad (5)$$

Here, d_{mn} is the distance between the source node m and destination node n. λ is the approximated simulation value. τ_{pkt} and τ_{err} are the delay on transmission of both data and error packets.

Step-4:

The energy spent on the transmission path is follows,

$$e_{tx} = E_{em} \text{ x } J + \eta_{amp} \text{ x } J \text{ x } d^2 \quad (6)$$

J = bit contain some information like current energy level of the node, path, data label, node's location and hop count.
E_{elec} = Energy to be Transmitted and Received electronic device module (40 nJ/bit).
η_{amp} = Transmitter Amplifier (100 pJ/bit/m^2)
d = distance between the two nodes.
And the energy for receiving K bit is equal to:

$$e_{rx} = E_{em} \text{ x } J \quad (7)$$

Step-5:

The total energy E_{mn} is an important metric in all the energy routing schemes and it should be kept minimum. Whenever the source node chooses the packet to destination node, it will select only the minimum energy consumption path to reach the intended destination. The condition for minimum energy consumption is

$$\min \sum_{k=0}^{m-1} E_{mn} \quad (8)$$

Step-6:

If node's energy consumption exceeds threshold value, it is identified that more packets are dropped. In this period, nodes have to retransmit the packet; otherwise energy spent is totally lost.

d) Proposed Packet Format

Source ID	Dest. ID	Energy status	Node Stability	Load balancing Status	Hop count
2	2	4	4	2 2	1

Figure-2. Proposed Packet format.

In Figure-2, the packet format of proposed algorithm is shown. Here the first two fields are source and destination ID that 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. Load balancing indicates finally the Hop count occupies 1 byte field for calculating number of hops from cluster node.

4. PERFORMANCE ANALYSIS

The proposed scheme EELBP is simulated with the help of object oriented discrete simulator. In this simulation, 200 mobile nodes move in a 1200 meter x 1200 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 Table-1.

Table-1. Simulation settings and parameters of EELBP.

No. of Nodes	200
Area Size	1200 x 1200
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	AODV

a) 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 EELBP with our previous scheme EPAR [17] in presence of stability environment.

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Figure-3 shows the results of average end-to-end delay for varying the mobility from 20 to 100. From the results, we can see that EELBP scheme has slightly lower delay than the EPAR scheme because of stable routing.

Figure-4, presents the residual energy while varying the time. The Comparison of EELBP, EARP energy consumption is shown. It is clearly seen that residual energy by EELBP is high.

Figure-5, presents the comparison of communication overhead. It is clearly shown that the overhead of EELBP has low overhead than EPAR scheme.

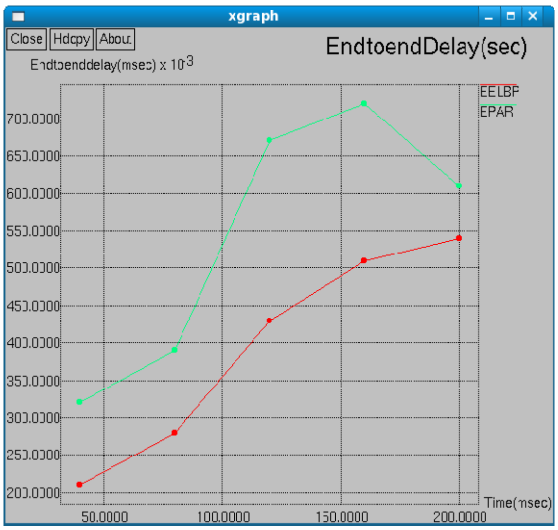

Figure-3. Time vs end to end delay.

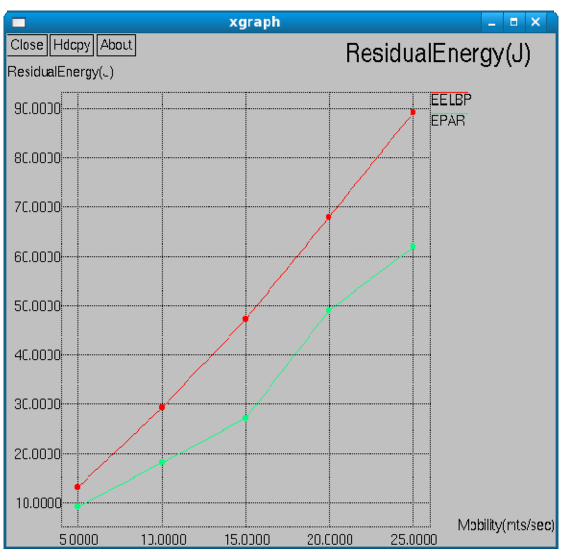

Figure-4. Mobility vs residual energy.

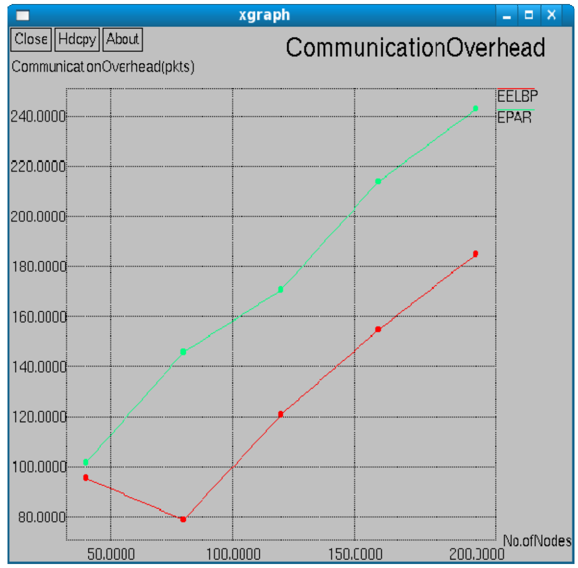

Figure-5. Mobility vs communication overhead.

Figure-6. Simulation time vs packet delivery ratio.

Figure-7 shows the results of average packet delivery ratio for the simulation time 10, 20…50 for the 200 nodes scenario. Clearly our EELBP scheme achieves more delivery ratio than the EPAR scheme since it has both reliability and stability features.

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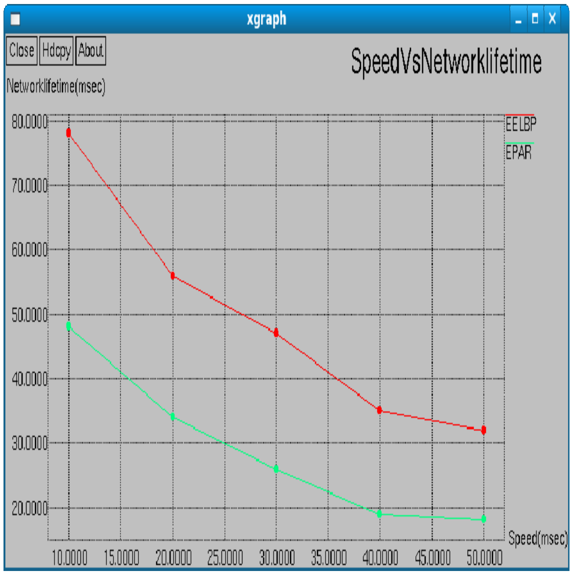

Figure-7. Speed vs network lifetime.

Figure-7 shows the results of Network Simulation time for the speed 10, 20…50 for the 200 nodes scenario. Clearly our EELBP scheme achieves high network lifetime than the EPAR scheme since it achieved high energy consumption. In Table-2, End to end delay of proposed scheme is low than existing because of integrated stable topology. Residual energy is calculated at each interval of pause time. Communication overhead of proposed scheme is low in proposed scheme. Packet delivery ratio is achieved high because of integrated stable routing.

Table-2. Comparison of existing scheme and proposed scheme.

S.No	Performnce metrics	Proposed	Existing
1.	End tod Delay(sec)	203-548	338-602
2.	Residual energy(joules)	13-90	9-62
3.	Communication overhead (pkts)	97-184	101-242
4.	Network Lifetime(msec)	78-32	48-18
5.	Packet delivery ratio(%)	99-38	77-12

5. CONCLUSIONS AND FUTURE WORK

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 Load Balancing Protocol (EELBP) 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 using energy model. Energy efficiency depends on multipath stability, stability of multipath and energy spent on communication phase to favour packet forwarding ,by maintaining stability for each path with more energy. Through simulation results we have shown that the EELBP achieves good packet delivery ratio, more network lifetime while attaining low delay, overhead, minimum energy consumption than the existing scheme EPAR protocol while varying the number of nodes, node speed, pause time and simulation time.

In future work, it is planned to implement multicast routing with secure authentication scheme to achieve data integrity and authentication rate.

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