Network Lifetime Extension by DSR Modification in Mobile Ad Hoc Networks

M. S. Vanjale, R. D. Joshi, S. B. Vanjale

Abstract: Mobile Ad hoc Network (MANET) is self-organizing and self-configuring network that provides mobile users with communication facility and information access regardless of location and any centralized control. The most important characteristic of such networks is the independence of any fixed infrastructure. Therefore, it can be rapid and easily deployed. The typical application of Ad Hoc networks includes battle field communication, emergency relief, information sharing at conference or classroom etc. Routing is one of the important issues in MANETs due to their highly dynamic and distributed nature. Also nodes in MANET are usually battery powered. Draining out of a node can partition the network and result into reduced packet delivery and network lifetime. In this paper one of the existing protocols is selected and modified to make it energy efficient. The modified algorithm tries to increase networklifetime by implementing few modifications to basic DSR protocol. Remaining node energy is used to implement energy conservation. It is observed from the simulations that this algorithm improves network lifetime of MANETs.

Keywords: Routing, DSR, AODV, DSDV, MANET

I. INTRODUCTION

An ad-hoc network uses no centralized administration. This is to be sure that the network won't collapse just because one of the mobile nodes moves out of transmitter range of the others. Nodes should be able to enter/leave the network as they wish. Because of the limited transmitter range of the nodes, multiple hops may be needed to reach other nodes. Every node wishing to participate in an ad-hoc network must be willing to forward packets for other nodes. Thus every node acts both as a host and as a router. A node can be viewed as an abstract entity consisting of a router and a set of affiliated mobile hosts. A router is an entity, which, among other things runs a routing protocol. A mobile host is simply an IP-addressable host/entity in the traditional sense. Ad-hoc networks are also capable of handling topology changes. It is fixed through network reconfiguration. For instance, if a node leaves the network and causes link breakages, affected nodes can easily request new routes and the problem will be solve. This will slightly increase the delay, but the network will still be operational.

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Routing in MANET:
Routing in a MANET is done with the goal of finding a short and optimized route from the source to the destination node. Numerous protocols have been developed for ad hoc mobile networks. Such protocols must deal with the typical limitations of these networks, which include high power consumption, low bandwidth, and high error rates.
In this paper three existing MANETs' routing protocols like AODV, DSDV and DSR are compared based on various Quality of Service (QoS) parameters. DSR is selected and improved for energy efficiency to extend the network lifetime. The simulation of is done using *network simulator ns-2*[4].
The rest of the paper is organized as follows. Section 2 describe brief overview of existing protocols. In Section 3 the three protocols are compared and one is selected for further modifications. Section 4 explains the modified routing algorithm. Section 5 discusses performance of modified algorithm. In section 6 conclusions are discussed.

II.ROUTING PROTOCOLS IN MANET

A mobile ad hoc network is a co-operative network of mobile nodes that communicate over a wireless medium. Mobile Ad hoc networks differ significantly from other existing networks as the topology of the nodes in the network is dynamic. Such networks do not assume all the nodes to be in the direct transmission range of each other. Hence these networks require specialized routing protocols that provide self-starting behavior. These protocols are broadly classified as proactive and reactive.

Proactive (Table-Driven) Routing Protocols

In proactive routing, each node has one or more tables that contain the latest information of the routes to any node in the network. Each node has the next hop for reaching to a node and the cost of this route. Various table-driven protocols differ in the way the information about change in topology is propagated through all nodes in the network. Examples of this class of Ad Hoc routing protocols are the Destination Sequenced Distance Vector (DSDV) [1] and the Optimized Link State Routing (OLSR) protocols.
Limitations of Proactive routing:

1. Tend to waste bandwidth and power in the network because of the need to broadcast the routing tables/updates.
2. As the number of nodes in the MANET increases, the size of the table will increase.
3. In addition, it needs control traffic for continually update stale route entries. Unlike the Internet, an Ad Hoc network may contain mobile nodes and therefore links are continuously broken and reestablished.

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Reactive (On-Demand) Routing Protocols

Reactive routing protocols do not maintain or constantly update their route tables with the latest route topology. Instead, when a source node wants to transmit a message, it floods a query into the network to discover the route to the destination. This discovery packet is called the Route Request (RREQ) packet and the mechanism is called Route Discovery. The destination replies with a Route Reply (RREP) packet. As a result, the source dynamically finds the route to the destination. The discovered route is maintained until the destination node becomes inaccessible or until the route is no longer desired. The protocols in this class differ in handling cache routes and in the way route discoveries and route replies are handled. Reactive protocols are generally considered efficient when the route discovery is employed rather infrequently in comparison to the data transfer. Examples of Reactive routing protocols are the Ad Hoc on-demand Distance Vector Routing (AODV) [2], Dynamic Source Routing (DSR) [3]. Since the route to destination will have to be acquired just before communication begins, the latency period for most applications is likely to increase drastically is the only limitation of reactive protocols

A. Ad Hoc On-Demand Distance Vector Routing (AODV)

The Ad Hoc On-Demand Distance Vector routing protocol discovers routes on an as needed basis and are maintained only as long as they are necessary. Each node maintains monotonically increasing sequence numbers and this number increases as it learns about a change in the topology of its neighborhood. This sequence number ensures that the most recent route is selected whenever route discovery is initiated. AODV uses routing table. This route table is used to store the destination and next-hop IP addresses as well as the destination sequence number. Associated with each routing table entry is a lifetime, which is updated whenever a route is used. Routing in AODV is carried out by the process of Route Discovery and Route Maintenance [2]. When a node wishes to send a packet to some destination node, it checks its route table to find whether it has a route to the destination node. If it does, it forwards the packet to the next hop towards the destination. However if the node does not have any valid route to the destination, it must initiate a route discovery process. The source node creates a route request (RREQ) packet that contains the source node's IP address, current sequence number, destination's IP address and last known sequence number. The RREQ also contains a broadcast ID and this is incremented every time the source node initiates a RREQ. Thus, the broadcast ID and the source IP address uniquely identify a route request. Once the RREQ is created, the node broadcasts this packet and sets a timer to wait for a reply. When a node receives a RREQ, it first checks whether it has seen it before noting the source IP address and broadcast ID pair. If it has already seen a RREQ with the same source IP address and broadcast ID, it silently discards the packet. Else, it records this information and processes the packet. The node sets up a reverse route entry for the source node in its route table. This reverse route entry contains the source node's IP address and the IP address of the neighbor from which the RREQ was received. The destination node responds with a unicast route reply (RREP) packet to the source. If the node is not the destination node, it increments the RREQ's hop count by one and re-broadcasts this packet to its neighbors. If the RREQ is lost, the source node is allowed to re-broadcast a route discovery again. The number of retries is fixed and if there is no route to the destination after the maximum number of retries, the destination is labeled unreachable. Once a route has been discovered for a given source/destination pair, it is maintained as long as needed by the source node. Movement within the Ad Hoc network affects only the routes that contain those nodes. If the source node moves, it can re-initiate a route discovery to establish a new route to the destination. When a link breaks, a route error (RERR) message is sent to the affected source nodes whenever a packet tries to use the link.

B. Destination-Sequence-Distance-Vector (DSDV)

DSDV is a hop-by-hop distance vector routing protocol. Each mobile node maintains a routing table that stores for all reachable destinations, the next-hop and number of hops to reach that destination and the sequence number assigned by the destination. The routing tables' updates are time-driven and event-driven, in which each mobile node transmits periodically itstables to itsneighbors, periodically roadcasting routing updates. This transmission takes place also in topology change cases. DSDV applies two types of routing updates: full dump or incremental update. Full dump carries the full table with all available routing information and this is suitable for fast changing networks. Incremental dump carries only the updated entries since last dump, which must fit in a packet and is suitable when network is stable [1]. DSDV possesses routes availability to all destinations at all times, which involves much less delay in the route setup process. The use of sequence number distinguishes stale routes from new ones, where routes with higher sequence numbers are favorable. However, the updates due to broken links lead to a heavy control overhead during high mobility, proportional to the number of nodes in the network and therefore affecting scalability.

C. Dynamic Source Routing (DSR)

DSR belongs to the class of reactive protocols. Source routing means that each packet in its header carries the complete ordered list of nodes through which the packet must pass [6]. DSR uses no periodic routing messages, thereby reducing network bandwidth overhead, conserving battery power and avoiding large routing updates throughout the ad-hoc network. DSR is a simple and efficient routing protocol designed specifically for use in multi-hop wireless ad hoc networks of mobile nodes. The protocol is composed of the two mechanisms of Route Discovery and Route Maintenance, which work together to allow nodes to discover and maintain source routes to arbitrary destinations in the ad hoc network.

1) Route Discovery: Route discovery process is initiated only when source S wishes to communicate with destination D. Source S broadcasts a route request (RREQ) containing the source address, the destination address and a unique identification number so that each node processes the RREQ only once. Each intermediate node appends its address to the route record of the packet, which is formed during the RREQ propagation, and forwards it to its neighbors. A route reply (RREP) is generated when the destination node or an intermediate node with routing information about the destination is reached.

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At that time the RREQ packet is containing a route record yielding the sequence of hops taken. The destination node D generates the RREP back to the source by placing the route record from route request packet into the route reply packet. Otherwise, if an intermediate node generates the RREP, then it appends its cached route to the destination to the route record in the RREQ packet and then generates the RREP packet.

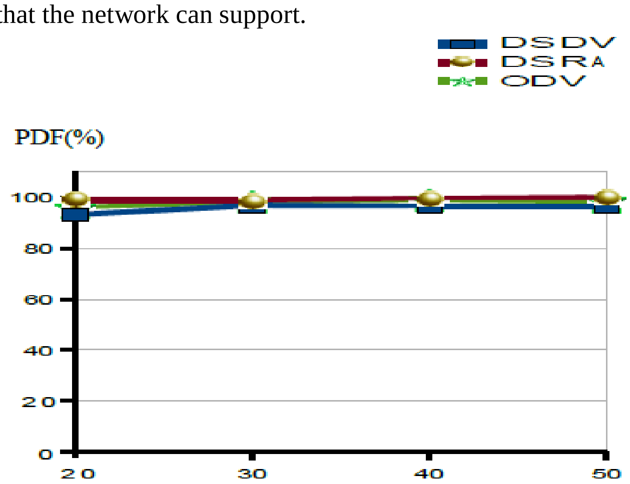
2) Route Maintenance: When the data link layer encounters a fatal transmitting problem, route error (RERR) packets are generated at a node to the original sender of the packet encountering the error. A node receiving a RERR, removes the hop in error from its cache and all routes containing the hop are truncated at that point. DSR takes a great advantage from the source routing concept, where intermediate nodes do not need to maintain up-to-date routing information, as the packets themselves contain all routing decisions. Moreover, loop formation is eliminated and the source learns all possible routes to the destination as well as to the intermediate nodes.

III.PERFORMANCE EVALUATION

The routing protocols are simulated using Network Simulator ns-2 [4]. NS-2 is a discrete event simulator, which means it simulates such events as sending, receiving, forwarding and dropping packets.We simulated a network of mobile nodes placed randomly within a square topography. Each node has a radio propagation range of 250 meters and a channel capacity of 2 Mbps. The IEEE 802.11 distributed coordination function (DCF) is used as the medium access control (MAC) protocol. The size of data payload is 512 bytes. For radio propagation model, a two-ray ground reflection model was used and for mobility model Random waypoint model was used. Effect of variation in node density and node mobility is observed on QoS parameters like Packet Delivery Fraction, Energy consumption, End to End Delay, throughput and Overheads.

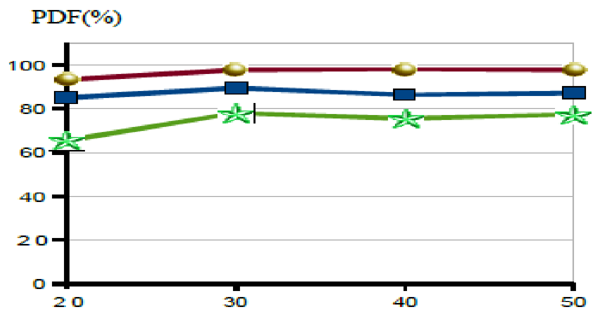
A. Packet Delivery Fraction (PDF)

This is the ratio of total number of packets successfully received by the destination nodes to the number of packets generated by the source nodes [5]. Packet delivery fraction is an important metric as it describes the loss rate. Thus packet delivery fraction in turn reflects the maximum throughput that the network can support.



No. of Nodes

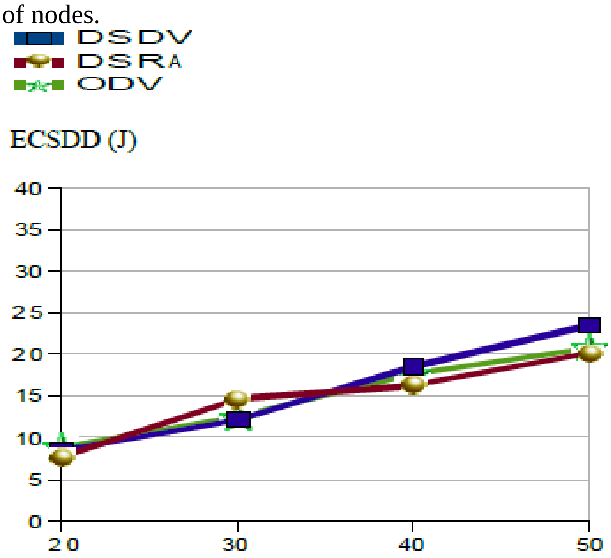
Figure 1: No. of nodes Vs PDF(%) for Speed = 5 m/s



No. of Nodes

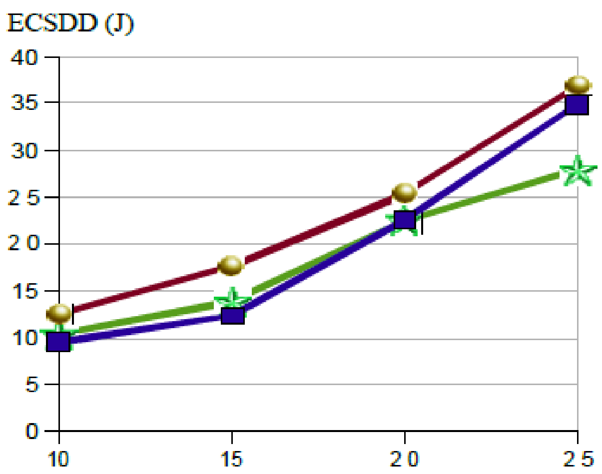
Figure 2: No. of nodes Vs PDF (%) for Speed = 25 m/s

Figures 1 and 2 show effect of variation in node density and speed on PDF. Number of nodes is varied from 20 to 50 for speed ranging from 5 m/s to 25 m/s. It's observed that DSR shows higher PDF than AODV and DSDV even at higher speed. The PDF goes on increasing with increase in number of nodes.



No. of Nodes

Figure 3: No. of nodes Vs ECSDD(J) for Speed = 5 m/s



No. of Nodes

Figure 4: No. of nodes Vs ECSDD(J) for Speed = 25 m/s

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B. *Energy Consumption per Successful Data Delivery (ECSDD)*

It is the ratio of total network energy consumption to the number of data packets successfully delivered to the sink. The network energy consumption includes all the energy consumptions except MAC layer controls**.** Energy consumption per successful delivery of data of DSR is less than that of AODV and DSDV for speeds of 5 m/s. For higher speeds ECSDD of DSR is greater than AODV and DSDV.

C. *End to End Delay (sec.)*

This metric indicates how fast the packets reach the destination. It is the ratio of time between reception of first and last packet to total number of packets reaching the application layer [6]. Figure 5 and 6 show graph of end to end

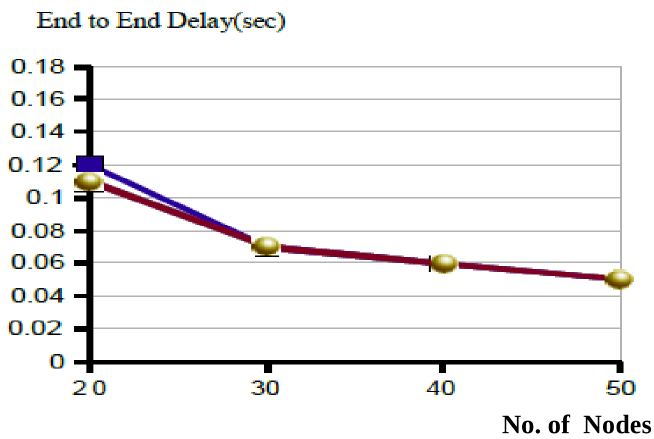

Figure 7: No. of nodes Vs Overheads for Speed = 1 m/s

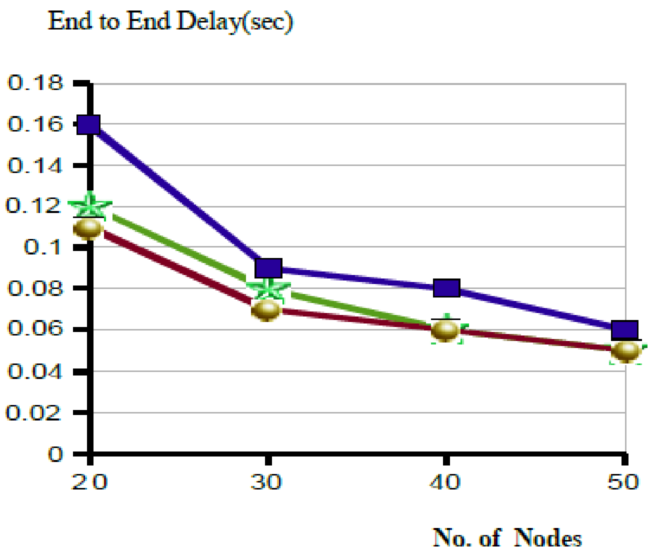

Figure 6: No. of nodes Vs End to End Delay(sec) for 25 m/s

Thus it is seen from above QoS parameters that DSR performs better than AODV and DSDV for scenarios like high node density and low speed. But its performance degrades for some parameters like ECSDD and control overheads at higher speeds which can be improved by modifying the original algorithm.

IV. MODIFICATION IN DSR ALGORITHM

In DSR algorithm, when a node receives a Route Request, for which it is not the ultimate recipient, before forwarding it to neighboring nodes, it waits for a pseudo-random time interval selected by a uniform distribution of probability between 0 and a constant "BroadcastJitter". The idea behind the modified DSR called as MEEDSR (Modified Energy Efficient DSR) is that rather than waiting for pseudo-random time interval in normal DSR, the RREQ is forwarded after a time interval inversely proportional to the residual energy of the node at that instant as explained by K. Murugan, S. Shanmugavel in [6]. The destination accepts only the first request packet and discards other duplicate requests. With the proposed delay mechanism, request packets with higher energy levels are transmitted after a smaller delay whereas the request packets from nodes with lower energy levels are transmitted after a larger delay. Some nodes may receive duplicate copies of the same RREQ packet. In MEEDSR, the duplicate copies of the same RREQ packets would be dropped as in the original DSR protocol. In this way, the first RREQ which will arrive at destination node was sent over the best path in terms of energy that it is maximum respect to all other possible paths from source to destination. Modifications are done only in route discovery process of DSR. The delay in proposed algorithm is calculated as

$$Variable\ Delay = \left(\frac{Ei}{Ec}\right) \times D$$

Where,

Ei is initial battery capacity at the start of simulation.

Ec is current residual battery capacity.

D is the maximum delay introduced before forwarding RREQ.

V. SIMULATION RESULTS

In this section, the performance results of original DSR and EDSR are observed based on various performance metrics with respect to simulation time. For a network size of 670m x 670m experimentations show better result node density equal to 20. Mobility is one of the important issues of MANET hence effect of node mobility on different QoS parameters is also studied.

Simulation Tabl

Parameter	Value
Network size	670 m x 670 m
Number of nodes	20
Node initial Energy	30 J
Pause time	0 s
Transmission rate	4 packet/sec

A. *Effect of varrying node mobility*

In this section, the performance results of original DSR and MEEDSR are observed based on various performance metrics with respect to node mobility. For a network size of 670m x 670m experimentations show better result node density equal to 20. Here effect of varying speed from 1 m/s t0 40 m/s on various QoS parameters is observed.

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1) Energy Consumption per successful data delivery

Figure 9 presents graph of ECSDD versus speed. The energy consumption increases with increase in mobility as more control packets are needed at higher mobility. The modified protocol, MEEDSR shows 16 % lesser energy consumption than that of DSR as it selects the nodes with higher energy for communication.

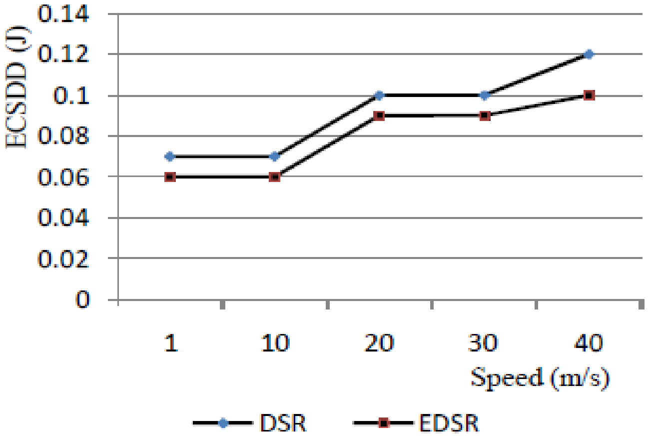

Figure 9: ECSDD(J) Vs Speed

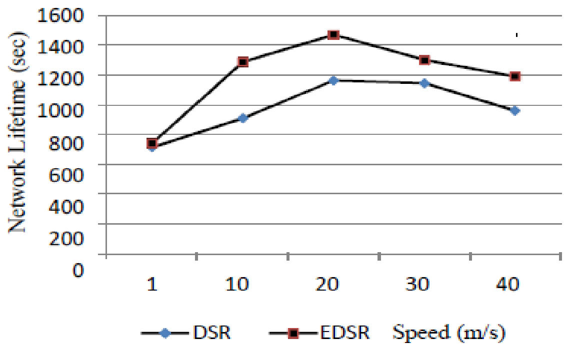

Figure 10: Network Lifetime Vs Speed

2) Network Lifetime

With increase in mobility the network lifetime decreases due to increase in control overheads and energy consumption as shown in figure 10. As EDSR has lesser energy consumption the node lifetime is prolonged. This results in increased overall network lifetime. While in DSR routes are selected with least hop metric in which nodes with less energy drain out earlier hence reducing network lifetime. At speed of 10 m/s network lifetime of EDSR is larger than DSR by around 40%.

3) End to End Delay

From Figure 11 it is observed that both DSR and EDSR have same end to end delay. Also it remains constant with varying speed. This indicates that introducing a delay mechanism in route selection based on minimum cost metric in EDSR does not increase the end to end delay.

4) Control Overheads

Figure 12 indicates that control overhead increases with increased mobility as more control packets are required to be sent to acquire routes at higher speeds. Frequent link breakages can occur due to higher mobility and route discovery is to be re-initiated. Also network partitioning due to exhausted nodes can require route reestablishment which in turn increases the overhead.

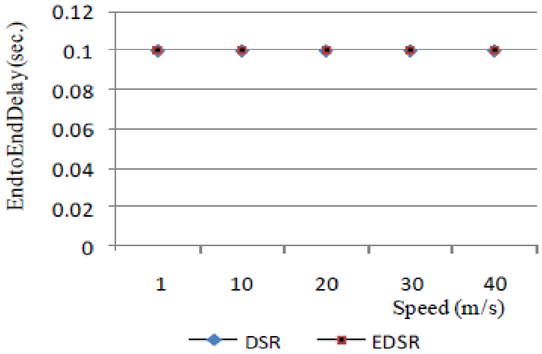

Figure 11: End to End Delay (sec) Vs Speed

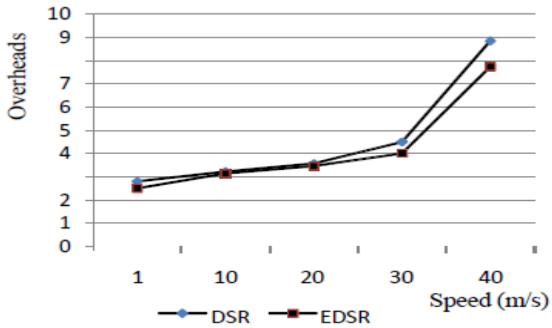

Figure 12: Control Overheads Vs Speed

VI. CONCLUSION

Energy consumption per successful delivery of data of DSR is less than that of AODV and DSDV for lower speeds. For higher speeds it is lightly greater than AODV and DSDV but it has higher PDF at the same time. DSR shows higher Packet Delivery Fraction than AODV and DSDV. As the speed increases PDF decreases but DSR shows higher PDF than AODV and DSDV for higher speeds also. The limitations of DSR like high ECSDD at higher speed are overcome by modifying it based on a mechanism that makes use of residual energy of node. The modified DSR i.e. EDSR has lesser ECSDD than DSR. For speed variation, network lifetime of EDSR is much higher than that of DSR. End to end delay of both the protocols is same. Energy variance of EDSR remains almost constant with increase in speed. Thus increase in overall network lifetime is achieved by implementing energy conservation at individual node. Improvement in various QoS parameters for variation in mobility is observed by implementing energy conservative algorithm which makes use of remaining node energy for selecting route. The proposed algorithm is suitable for applications like military battle fields or remote areas like forests.

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