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Energy Efficient and Load Balancing Scheme of DSR Protocol (EELB-DSR)

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Abstract- Mobile ad hoc networks (MANETs) composed of a collection of nodes that are linked in scattered way to enable wireless communications. All nodes are moveable and are dynamically connected in a random manner. MANETs could be used in numerous applications such as: military combats, WSN, in areas where it is tricky to construct wired network. Due to changing topology of MANET, limited power of battery , and limited bandwidth of wireless channels, it became design of routing schemes is one of the main defy in MANET. Commonly, MANETs' routing protocols are categorized into two types: proactive routing (e.g. DSDV) and reactive routing (e.g. AODV and DSR). A lot of studies manifested that reactive routing protocols are better than proactive protocols. As a result, the offered article attentive with performance improvement of DSR, which is one of the most celebrated reactive routing protocols. The original DSR is multi hop scheme in its nature, where route election between any two communicating nodes is merely based on minimum hops count as a metric, irrespective of another metrics like energy of nodes and traffic load of nodes, that may have passive effect on performance of the original DSR. This essay presents novel version of original DSR, called (EELB-DSR), through modification of route discovery stage, in such a way that minimizes energy consumption of nodes, reduces flooding of control packets and realization of balanced traffic load of nodes, resulting in prolong life time of nodes, thence increase life time of the routes and relative stability of network. In the suggested scheme, route selection is based on three merged metrics: nodes' energy, traffic load of nodes and received signal strength. Performance evaluation and comparison between proposed scheme (EELB-DSR) and original DSR has been implemented utilizing network imitator (NS2). Results of simulation proved that performance of the proposed protocol outperform original DSR in terms of: packet delivery ratio, end to end delay, normalized overhead and energy consumption of nodes.

Keywords— MANET, DSR, EELB-DSR, RREQ, RREP, NEF, RQF.

1- INTRODUCTION

Now a day, Mobile ad hoc network (MANET) is one of most important recent wireless networks, where it allows to the modern smart mobile nodes (e.g. mobile phones, laptops etc.) to communicate with each other at anytime and anywhere without needing any type of the centralized management [1]. Due to random mobility of nodes, any node has the ability to enter or depart network at any time, resulting in the network topology changes unpredictably and dynamically [2, 3]. Due to limited transmission range of wireless channel, if any node wants to communicate with anther node located outside of its transmission range, it is needed other intermediary nodes to act as routers to prepare a route in hops style between them. For this reason, each node in MANET should act as host and router in same time.

Due to dynamic topology of MANET, restricted battery power of nodes, and limited capacity of wireless channels. It becomes design of routing mechanism is one of the main challenges in MANET. In general, MANETs' routing protocols can be classified into two classes: proactive routing and reactive routing [4- 7]. In proactive routing schemes (e.g. DSDV and OLSR), directing information are exchanged among nodes at steady intervals and paths are computed constantly among nodes, regardless paths are required or not. And this leads to many consumed network resources (e.g. energy and bandwidth). On contrary, in reactive routing schemes (e.g. **AODV and DSR),** in lieu of exchanging routing information among nodes at consistent periods, the route is created merely when it is required (i.e. on demand). Hence, reactive routing schemes eschew the cost of routes upkeep which being not in use and also never launch tremendous control packets. Therefore, performance of reactive routing tactics outperform proactive routing methods.

Dynamic Source Routing protocol (DSR) is a valuable reactive routing schema for routing intent [7, 8], it is distributed routing mechanism. Where created routes among nodes take form of multi- hop. DSR is composed of two main stages: route discovery stage and route maintenance stage. For route unearthing, merely two control packets are utilized, called, Route Request (RREQ) packet and Route Reply (RREP) packet. For route creation between any two nodes, RREQ is broadcasted by source node. On receiving RREQ at destination node, it replies by sending RREP to source node to confirm route creation. While, in case of route maintenance, Route Error (RERR) packet is used, to inform source node that current used route during data transmission has been failed.

Although DSR has some advantages like: the route is established merely when it is needed, the nodes use route cache information efficiently to minimize the collision and control packets and route selection is based on minimum hop count. But during route discovery phase, DSR does not take into consideration nodes' energy, nodes' traffic load, and signal strength of exchanged packets. Whereas, all of these factors have a passive effect on performance of the standard DSR. Therefore, this article aims to improve performance of DSR through modification of route discovery mechanism, where the route selection is based on three merged metrics: nodes' energy, nodes' traffic load and signal strength of exchanged packets.

The rest of the paper is organized as follows: Section 2 presents the related works of routing techniques. While brief description of original DSR routing protocol is stated in Section 3. The proposed protocol is presented in Section 4. Simulation environment and parameters have been indicated in Section 5. In Section 6, simulation results and discussion have been presented. Finally, Section 7 concludes the article.

2- RELATED WORK

M. Sharifdeen and Dhavamaniprakash [9] suggested novel version of DSR, called EEDSR. Where, the route discovery scheme has been modified with aim to minimize energy consumption of nodes, thence prolong life time of network. In the suggested schema, selected route consists of minimum number of intermediate nodes having relatively high energy, resulting in more stabilized route for long time and hence decrease repetitions of route discovery mechanism. Simulation results proved that, in small size network, performance of both DSR and EEDSR is nearly identical with respect to energy consumption and throughput. While in moderate and large size network, EEDSR outperform of DSR from point of view of energy consumption and throughput.

Deepti D. and Rajendra S. K. [10] presented modified DSR algorithm, where path selection is based on node energy consumption as metric, for transmitting and receiving single packet instead of minimum hop counts. The article concluded that, performance of proposed algorithm is better than original DSR in terms of improving energy efficiency of nodes. Also the proposed mechanism reduces routing overhead by shun multipath propagation of RREP packets in standard DSR.

Uma R. Bhatt, N. Nema et al [11] introduced new schema, called DSRI, to reduce the flooding of RREQ packets, which cause to rebate energy consumption and network congestion. In suggested algorithm, route has been chosen based on three metrics: node’s speed, remaining energy and strength of receipted signal. These metrics have been chosen to avoid nodes that having low remaining energy, high mobility and low reception signal strength from participating in route creation, resulting in minimization of RREQ packets flooding, minus network congestion, minimum delay time and efficient bandwidth utilization. Results of simulation proved performance of DSRI outperform the original DSR from point of view of throughput, nodes' remaining energy and delay time.

In [12] the authors present a review and categorize the suggested energy conscious routing schemas of MANETs, which minifies either active wasted energy required to transmit and receipt packets or inactive energy consumed when the mobile node stays in idle mode but hears to the channel for any potential communication demands from another nodes.

Shweta S. and Gopal S. [13] proposed new version of DSR, where route maintenance mechanism has been modified to prolong active route life time. The basic idea beyond modification, is to account in advance the time at which active route is about to expire. This will assist to disclose new route before the old route become expired, resulting in saving more time of communication process.

Saurabh A. [14] presents an ideal energy conscious DSR algorithm, called EPAR-DSR, with the aim of prolong network life time, through decreasing nodes’ energy consumption. In addition, suggested approach leads to balanced distribution of traffic load among nodes, and precludes from partition of network into small zones.

Krishna D. S. [15] introduced modified version of original DSR, called LS-MDSR. It is an energy- efficient routing algorithm and balanced traffic load sharing, where there is no route becomes heavily loaded or remains idle.

Roy Leung, Jilei Liu, et al [16] present an enhanced version of DSR, named multipath DSR (MP-DSR), with the aim for improving quality of service from point of view of routes reliability among communicating nodes with a minimum routing overhead.

Jijesh J. J and Shivashankar [17] projected a modified version of DSR, with goal of reducing energy consumption of nodes and to make routes more stable. Performance assessment and comparative analysis have been performed among the modified DSR, DADV and AODV, where simulation results indicated that proposed modified DSR outperform the aforementioned routing protocols with respect to: consumed energy, maximum throughput and delay time.

P. Parthiban, et al [18] introduced modified route discovery schema of DSR to magnify network life time, where route selection based on nodes' remaining energy and minimal hops count.

3- DYNAMIC SOURCE ROUTING (DSR)

DSR is entirely a reactive routing protocol. It is source routing scheme, that is mean the exchanged data packets among node contain an tidy list of all addresses of intermediary nodes through which packets should be routed to destination node [5]. In DSR, all nodes enclose a medium storage, called routing cache, to maintain acquired route for any target node in network. DSR schema includes two fundamental phases which are: route discovery and route maintenance. During route discovery phase, only two control packets are used, named route request (RREQ) and route reply (RREP), for path discovery between any two nodes. While, in route maintenance phase merely one control packet, called Route Error (REER) packet, is used.

When a source node intends to connect with destination node**,** it searches its routing cache to get a route. If no route is found, route discovery mechanism is initiated by broadcasting a RREQ to its neighboring nodes [19]. On receipt RREQ, in case of an intermediary node has a valid path to destination node, it forwards RREP packet containing this route in its header, through reverse path of RREQ packet, to source node [20-22]. Otherwise, it adds its address in route record field of RREQ header and rebroadcasts RREQ packet to neighboring nodes. This process is repeated till RREQ packet arrive to destination node. Because of rebroadcasting transmissions, RREQ itself may be arrive to destination node, through various paths. On receipt 1st RREQ packet, destination node replies by sending RREP packet, through reverse path of this RREQ, to source node as illustrated in figure1[23-25]. Whereas, the route selection in DSR depends on minimum hop counts [26, 27], so, the identical RREQ packets that later arrive at destination node will be dropped.

In route maintenance phase, each intermediate node along the selected route must ensure that each transmitted data packet have been received successfully by its successor downstream node. On detecting link breakage at any intermediary node, it forwards route error (RERR) packet to source node through the predecessor nodes. On receipt RERR packet, source node begins route discovery mechanism to setup new route.

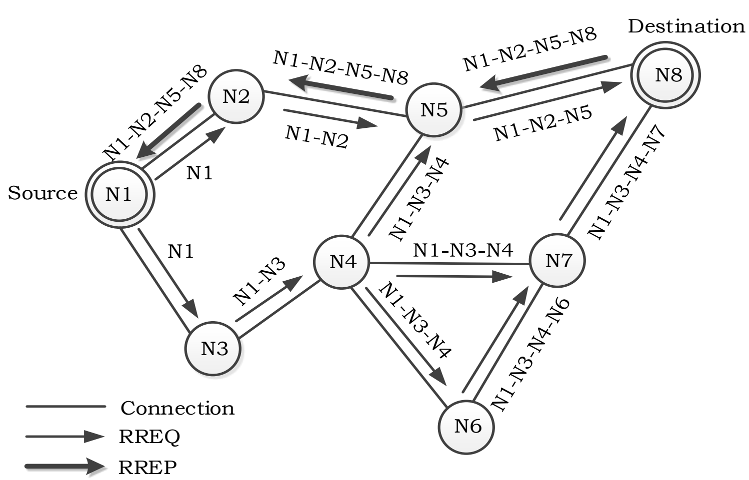


Figure 1 Route Discovery Mechanism of DSR

4- PROPOSED EELB-DSR

Although DSR is momentous protocol in MANET, it has many shortcomings like:

- DSR is not energy efficient routing, as nodes have a limited- power battery, so routing protocols in MANET must be energy efficient. Therefore, modification of DSR is required to be energy efficient.
- Route selection using DSR, among communicating nodes, is not energy efficient. Due to DSR chooses the path based on minimum hop count, which may result in poor route selection.
- DSR is unaware scheme with respect to traffic load of the nodes during route creation, which might leading to more routes congestion. Thence, resulting in more data packets loss and longer delay time.

The major aim of proposed EELB-DSR is to remedy the above mentioned shortcomings, by making DSR aware to nodes' energy and their traffic load during route discovery phase. Resulting in reducing power consumption of nodes, reducing flooding of control packets and realization of balanced traffic load among nodes, hence prolong life time for the selected route as well as increase network life time and relative stability of network. For implementing the suggested EELB-DSR, the following three models are taken into consideration to calculate node's energy factor, node's traffic load factor and signal strength of received RREQ packets for route discovery operation.

Energy Model

Whereas, an energy efficient routing protocol is the main trouble in MANETs. Therefore, the energy factor of nodes has very momentous effect in improvement of route life time and network life time. Node's energy factor (E_f) is calculated according to the following equations:

$$E_f = \frac{E_r}{E_i} \qquad (1)$$

$$E_r = E_c - (E_{tx} + E_{rx}) \qquad (2)$$

Where

E_r: Node's residual energy

E_i: Initial energy of node

E_c: Current energy of node

E_{tx}, E_{rx}: Consumed energy for each transmitted and received packet respectively.

Traffic Load Model

Whereas, the route selection of DSR is multi-hops in its nature. Therefore, the set of intermediate nodes along the selected route should has low traffic load. This is because, heavily loaded nodes resulting in more waiting of packets in transmission buffer and hence increase delay time. Also, heavy loaded nodes lead to network congestion. It easy to compute Traffic Load factor (TL_f) of node according to the following equation:

$$TL_f = \frac{L}{Q} \qquad (3)$$

Where

L: Current packets' count in transmitted queue.

Q: Maximum size of transmitted queue.

Energy factor and traffic load factor can be combined into one metric called Node Efficiency Factor (NEF) using the following equation:

$$NEF = \frac{E_f}{TL_f} \qquad (4)$$

Received Signal Strength Model

Suppose that two homogeneous nodes (A, B) are separated by known distance d, each of them has constant transmission power (P_t) and threshold power of received signal (P_{thr}), to detect signal by the receiving circuit. When node A transmits signal to node B. According to two- ray ground reflection paradigm [28], node B can calculate power of received signal (P_r) using the following equation:

$$P_r(d) = \frac{P_t\, G_t\, G_r\, {h_t}^2\, {h_r}^2}{d^4} \qquad (5)$$

$$\mathrm{PRF} = \frac{P_r}{P_{thr}} \geq 1 \qquad (6)$$

Where, PRF is the reception power factor.

The above three models could be merged by using the following equation:

$$\mu = \mathrm{NEF/PRF} \qquad (7)$$

Where μ is called the link efficiency factor.

It is worthwhile to pay our attention that, to get route consists of intermediate nodes of high energy and low traffic load, with relatively minimum hops count. Link efficiency factor μ should be high, that is mean NEF must be high and PRF small. Therefore, by taking μ as a metric for route selection during route discovery operation, the resulted new version (EEBL-DSR) is being able to create a path, between any two communicated nodes, that has relatively long- life time and minimum delay time. In addition, realization of minimizing power consumption of nodes resulting in prolong network's life time.

4.1 Operation of proposed EEBL-DSR Scheme

The suggested schema of DSR is merely concerned with modification of route discovery mechanism, while the route maintenance is the same as that of original DSR. To meet our requirements, humble modification has been made for the format of both RREQ and RREP packet. Where, two fields have been added to RREQ packet; first field uses for broadcasting current coordinates (x, y) of node and second field to record Route Request Factor (RQF). While, only one field has been added to RREP packet, named Route Efficiency Factor (REF). Also it is assumed that all nodes are homogeneous and equipped with GPS device to obtain their (x, y) coordinates.

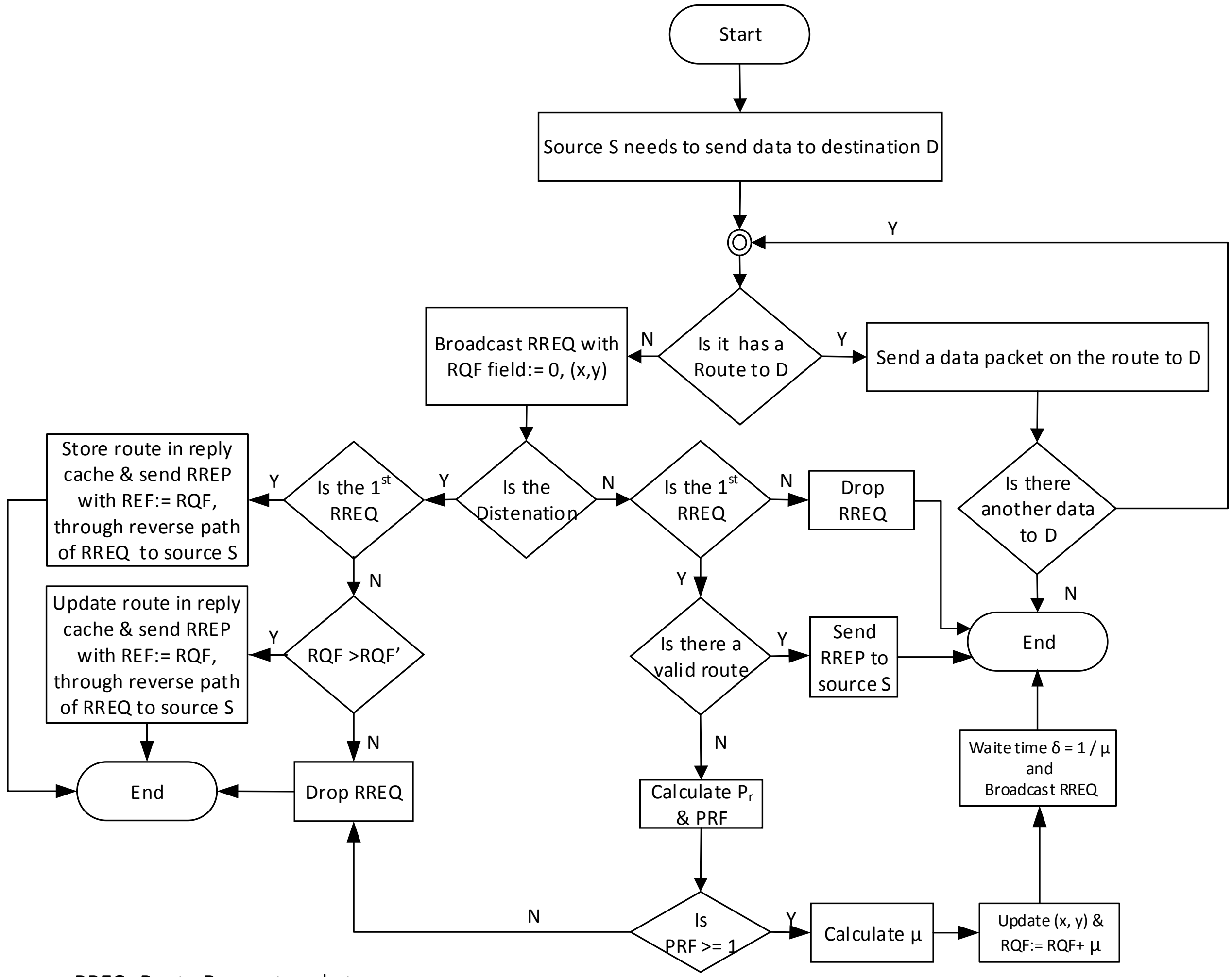
4.1.1 EELB-DSR Route Discovery Process

The proposed route discovery scheme aims to choice routes contain nodes which have high energy and lightly load of packets. Resulting in minimization of flooding of RREQ packets, reduction of power consumption of nodes. Thence, getting robust routes with high stability, which lead to prolong network life time.

When source node wishes to communicate to destination node, it searches its routing cache to get a route. If no route is found, it initiates route discovery operation through broadcasting RREQ packet, containing source node coordinates (x, y) and field of route request factor (RQF):= 0, to neighboring nodes. On receipt the first RREQ packet, each intermediary node obeys the following rules:

- If intermediary node has a valid route to destination node, it sends RREP packet, containing the full route into route record field, through reverse path of received RREQ packet, to source node. Otherwise,
- The intermediate node computes power factor of received signal (PRF) of RREQ packet, using equations 5 and 6. In case of PRF< 1, intermediate node drops RREQ packet. Else, it calculates Link Efficiency Factor (μ), using equations 1, 3, 4, 6 and 7. Then prepares RREQ packet by updating position field with its coordinates (x, y) and adding its μ in the RQF field. Thence, rebroadcasting RREQ packet after waiting time $\delta = 1 / \mu$. Rebroadcasting process is repeated until RREQ packet reaches to destination node.

On receipt the first RREQ, the destination node stores route in reply cache and sends RREP packet with REF:= RQF, through reverse path of the first RREQ to source node. Due to repetition of rebroadcasting process, RREQ packet itself may reach to destination node through different paths. Therefore, for each subsequently receipted RREQ packet; destination node compares value of RQF of the currently received RREQ packet with its counterpart (RQF') of the previous received RREQ packet. In case of RQF<RQF', destination node drops current received RREQ packet. Otherwise, it updates route in its reply cache and sends RREP packet with REF:=RQF, through reverse path of the current received RREQ packet, to source node. On receiving new RREP packet, source node starts sending data packets through the updated new route. Figure 2 shows action of nodes when receiving RREQ packet during modified route discovery mechanism.



RREQ: Route Request packet
RREP: Route Reply packet
RQF: Route Request Factor of the current RREQ
RQF': Route Request Factor of the previous RREQ
P_r: Received power
PRF: Received Power Factor
μ: Link Efficiency Factor
REF: Route Efficiency Factor

Figure 2 Action of Node on Receiving RREQ Packet

5- SIMULATION ENVIRONMENT AND PARAMETERS

The simulation is carried out using network's imitator NS2 [29]. It is open- source simulation gadget which operates under unix/linux/windows. NS2 is discrete events system, it is written by C++ and Tcl language. Most various routing protocols of MANET have been built in NS2 (e.g. DSR, AODV DSDV). Performance evaluation and comparison between the proposed protocol EELB-DSR and original DSR have been implemented using the network simulator NS2 version 2.34. All results of simulation generated in the trace file have been used by AWK command to perform computable data analysis. The used simulation parameters are presented in Table 1. The metrics used to evaluate performance of the EELB-DSR and DSR routing protocols are packet delivery fraction, energy consumption per, network life time, end to end delay and throughput.

Simulation Parameter	Value	Simulation Parameter	Value
"Simulator"	NS2 (V2.35)	Type of traffic	CBR
Topology Size	800mx400m	Number of Sources	25, 30, 35, 40,45, 50
Nodes number	50-90	Pause Time	0-500 sec.
Range of transmission	250m	Mobility Speed	5m/s-55m/s
Type of channel	Wireless	Mobility Model	Random Way point
MAC Layer	802.11	Antenna Type	Omni Antenna
Model of Radio propagation	Two ray ground	Rate of packets	4 packets/sec
Interface queue length	50	Simulation time	500sec

Table 1: Simulation Parameters

6- SIMULATION RESULTS AND DISCUSSION

This section is concerned with performance evaluation and comparison of the EELB-DSR and original DSR, under different scenarios, using aforementioned metrics.

6.1. Scenario 1

This scenario illustrates effect of changing pause time of nodes on performance of the proposed EELB-DSR and DSR from point of view of above mentioned criteria, using the parameters of table 2 and other parameters are mentioned in table 1.

Simulation Parameter	Value
Number of nodes	50
Simulation time	500 sec.
Simulation area	800m x 400m
Pause time	0 - 500 sec.
Max. mobility speed	5 m/sec.
Number of sources	25

Table 2: Simulation Parameters of Scenario 1

Figure 3 shows packet delivery fraction (PDF) versus pause time of both EELB-DSR and original DSR. It is lucid that, with increasing pause time (i.e. low mobility of nodes), PDF for the two protocols increases. This is due to, stability of routes among communicating nodes. On contrast, with decreasing pause time (i.e. high mobility of nodes), PDF of both protocols decreases. This because of, instability of routes which leads to more loss of data packets. It is noted that, average PDF of EELB-DSR (69%) is higher than counterpart of DSR (53%), with percentage of improvement 29%. This is due to, EELB-DSR scheme chooses routes contain nodes which have high energy and lightly load of packets. Resulting in more stabilization of routes among communication nodes. Thence, low loss of data packets.

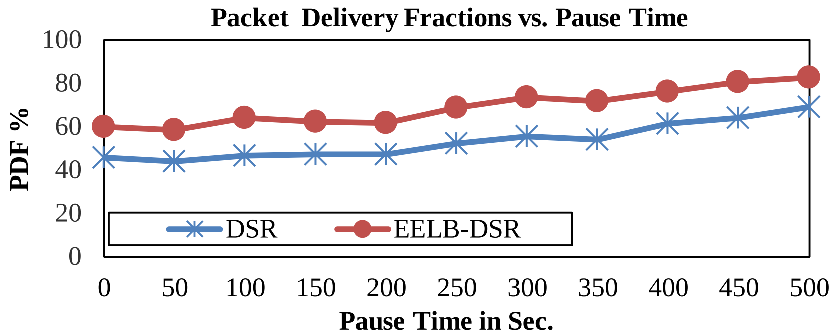


Figure 3 Packet Delivery Fraction versus Pause Time

Figure 4 displays end-to-end delay time against pause time of both EELB-DSR and original DSR. It is noticable that, with increasing pause time of nodes , E2E delay time of both two protocols decreases. This is because, routes stability which leads to minimizing the repetitions of route discovery operation, hence reduction of end-to-end delay time. It obvious that, average delay time of EELB-DSR (2.77 sec.) is lower than counterpart of DSR (4.55 sec.), with percentage of improvement 39%. This is due to, during route discovery procedure, the EELB-DSR mechanism elects routes contain nodes which have light traffic load, resulting in minimization of waiting time in the transmitting buffer. In addition, the EELB-DSR scheme produce more stable routes, that lead to minimize repeation of route discovery mechanism. All of these resulting in reduction of end-to-end delay time among communication nodes.

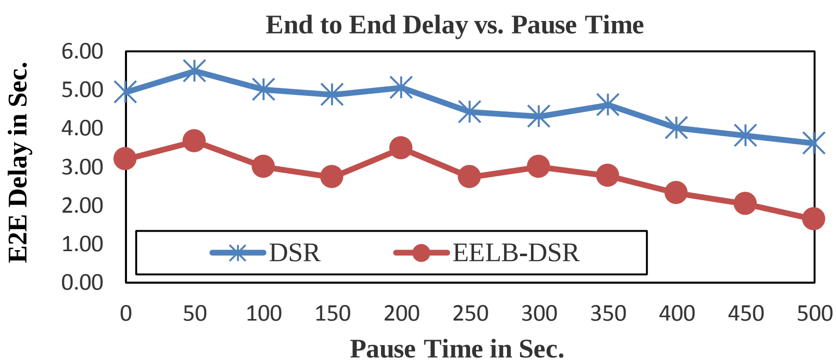


Figure 4 End to End Delay versus Pause Time

Figure 5 illustrates normalized overhead versus pause time of both EELB-DSR and original DSR. It is obvious that, with increasing pause time, the normalized overhead of both two protocols decreasing. This is due to, stability of routes leads to reduction of repeating of route discovery process, hence reduction of control packets. As shown from figure, normalized overhead of EELB-DSR (0.7) is lower by far than its counterpart of DSR (1.54), with percentage of improvement 54%. This is due to, EELB-DSR submits more stabilized routes comparing with its counterpart of DSR, resulting in reduction of repeating of route discovery process. In addition, EELD-DSR reduces flooding of RREQ packets during route discovery. All of these leading to reduction of normalized overhead.

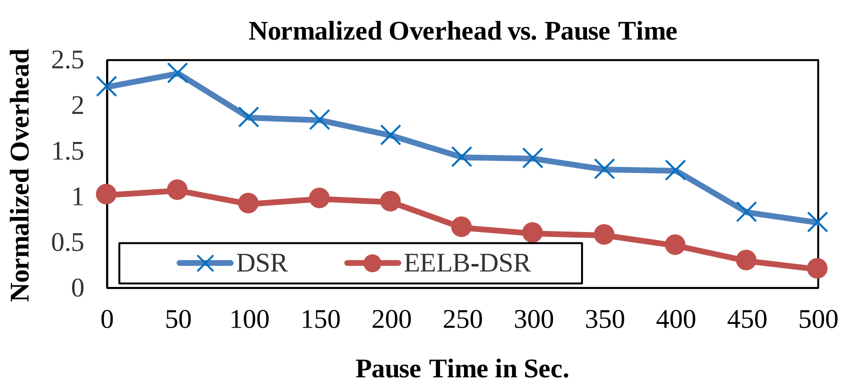


Figure 5 Normalized Overhead versus Pause Time

Figure 6 presents average energy consumption versus pause time of both EELB-DSR and original DSR. From figure we note that, with increasing pause time, average energy consumption of both protocols reduces. This is due to, stability of routes resulting in reduction of repeating of route discovery process, hence reduction of control packets which make minimization of energy consumption of nodes. It is lucid that, average energy consumption of EELB-DSR (2773 j) is lower by far than counterpart of DSR (10095 j), with percentage of improvement 73%. This is because, EELB-DSR takes into consideration the traffic load balancing mechanism among nodes. In addition, EELB-DSR reduces flooding of RREQ packets and minimizes probability of route discovery process. All of these resulting in minimizing average energy consumption of nodes.

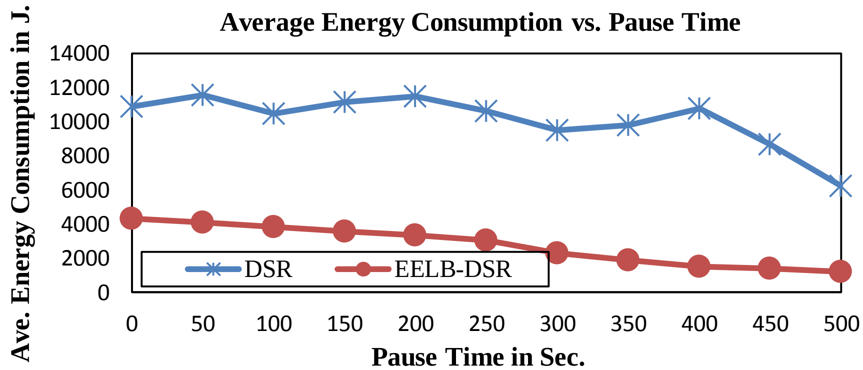


Figure 6 Energy Consumption versus Pause Time

6.2. Scenario 2

This scenario examines effect of nodes' speed on performance of suggested EELB-DSR and standard DSR, using the factors of table 3 and other factors are shown in table 1.

Simulation Parameter	**Value**
Number of nodes	50
Simulation time	500 sec.
Simulation area	800m x 400m
Pause time	0 - 500 sec.
Max. mobility speed	5 - 55 m/sec.
Number of sources	25

Table 3: Simulation Parameters of Scenario 2

Figure 7 illustrates packet delivery fraction (PDF) versus nodes' speed of both EELB-DSR and original DSR. It is noticeable that, with increasing nodes' speed (i.e. high mobility of nodes), PDF of both protocols reduces. This because of, when speed of nodes increases, probability of routes failure increases that leads to more data packets loss. Results of simulation show that, average PDF of EELB-DSR (73.36%) is higher than counterpart of DSR (50.89%), with percentage of improvement 44%. This is due to, EELB-DSR scheme chooses routes contain nodes which have high energy and lightly load of packets. Resulting in more stabilization of routes among communication nodes. Thence, low loss of data packets

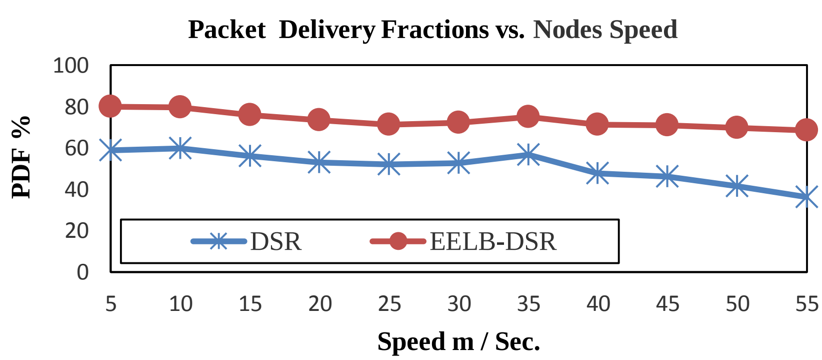


Figure 7 Packet Delivery Fraction versus Nodes Speed

Figure 8 displays end-to-end delay time against nodes' speed of both EELB-DSR and original DSR. Intuitively, as speed of nodes increases, the delay time of both two protocols increases. This is because, routes instability which leads to increasing the frequency of route discovery operation, hence increas of end-to-end delay time. It is noticable that, average delay time of EELB-DSR (2.28 sec.) is lower than counterpart of DSR (7.1 sec.), with percentage of improvement 68%. This is due to, during route discovery process, the EELB-DSR scheme elects routes contain nodes that have light traffic load, resulting in minimization of waiting time in the transmitting buffer. In addition, the EELB-DSR scheme produce more stable routes, that lead to minimize repeation of route discovery mechanism. All of these resulting in reduction of end-to-end delay time among communicating nodes.

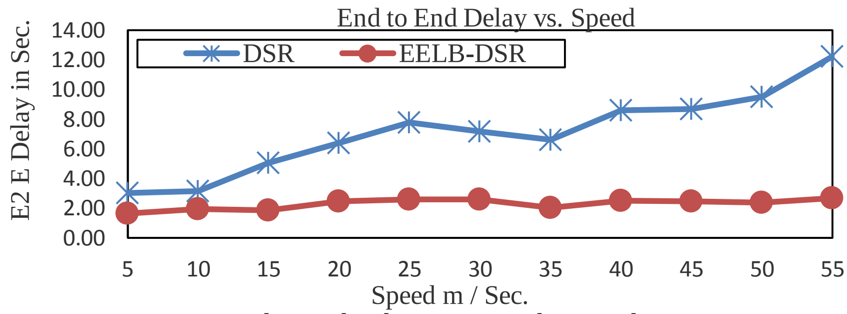


Figure 8 End to End Delay versus Nodes Speed

Figure 9 illustrates normalized overhead against speed of nodes of both EELB-DSR and standard DSR. It is lucid that, with increasing nodes' speed, normalized overhead of both two protocols is being increased. This is because, instability of routes which leads to high probability of repetition of route discovery process, thence increase of normalized overhead. As shown from figure, normalized overhead of EELB-DSR (1.68) is lower than its counterpart of DSR (3.68), with percentage of improvement 54%. This is due to, EELB-DSR submits more stabilized routes comparing with its counterpart of DSR, resulting in reduction of repeating of route discovery process. In addition, EELD-DSR reduces flooding of RREQ packets during route discovery. All of these leading to reduction of normalized overhead.

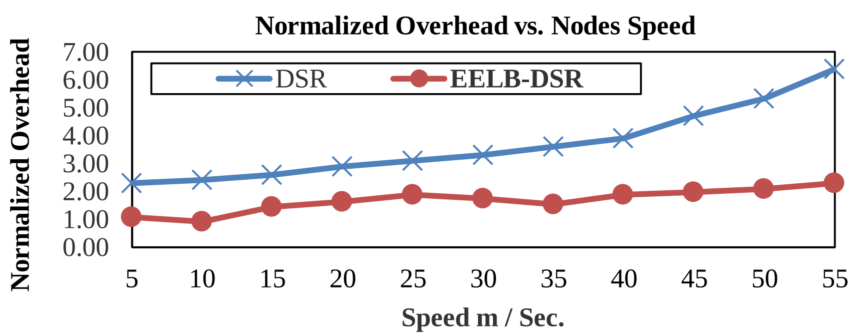


Figure 9 Normalized Overhead versus Nodes Speed

Figure 10 presents average energy consumption versus speed of nodes of both EELB-DSR and original DSR. From figure we note that, as speed of nodes increases, average energy consumption of both protocols is increased. This is due to, instability of routes leads to increase of repeating of route discovery process, thence increase of control packets which make maximization of energy consumption of nodes. It is lucid that, average energy consumption of EELB-DSR (4668.20 j) is lower by far than its counterpart of DSR (14505.04 j), with percentage of improvement 68%. This is because, EELB-DSR takes into consideration the traffic load balancing mechanism among nodes. In addition, EELB-DSR reduces flooding of RREQ packets and minimizes probability of route discovery process. All of these resulting in minimizing average energy consumption of nodes.

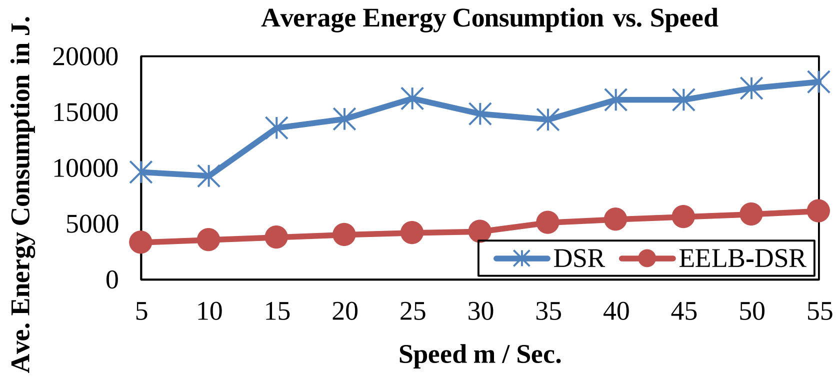


Figure 10 Energy Consumption versus Nodes Speed

6.3. Scenario 3

This scenario examines effect number of sources connection on performance of the suggested EELB-DSR and standard DSR, using the factors of table 4 and other factors are shown in table 1.

Simulation Parameter	**Value**
Number of nodes	50
Simulation time	500 sec.
Simulation area	800m x 400m
Pause time	15 sec.
Max. mobility speed	15 m/sec.
Number of sources	25 - 50

Table 4: Simulation Parameters of Scenario 3

Figure 11 illustrates Packet delivery fraction (PDF) versus number of sources connection. It is noticeable that, when number of coinciding sources connection increases, PDF of both protocols decreases. This is because, increase number of synchronized sources connection leads to high probability for transmitted data packets collision, which results in more data packets loss, thence reduction of PDF. It is obvious that, average PDF of EELB-DSR (59.8%) is higher than its counterpart of DSR (46.01%), with percentage of improvement 30%. This is due to, EELB-DSR scheme chooses routes contain nodes which have high energy and lightly load of packets. Resulting in more stabilization of routes among communication nodes. Thence, low loss of data packets.

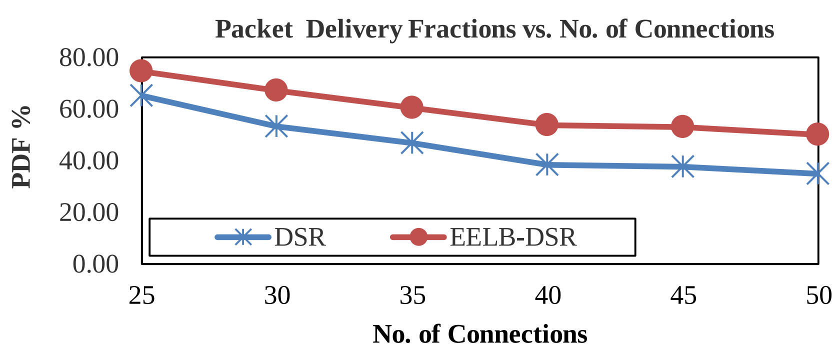


Figure 11 PDF versus No. of Connections

Figure 12 displays end-to-end delay time against number of connection sources of both EELB-DSR and original DSR. Intuitively, as number of connection sources increases, delay time of both two protocols is increase. This is because, increasing number of connection sources makes network more congested resulting in extra waiting time for data packets in transmission buffer of nodes along route between source and destination node. It is noticeable that, average delay time of EELB-DSR (6.24 sec.) is lower than counterpart of DSR (8.04 sec.), with percentage of improvement 22%. This is due to, during route discovery process, the EELB-DSR scheme elects routes contain nodes that have light traffic load, resulting in minimization of waiting time in the transmitting buffer. In addition, the EELB-DSR scheme produces more stable routes that lead to minimize repetition of route discovery mechanism. All of these resulting in reduction of end-to-end delay time among communicating nodes.

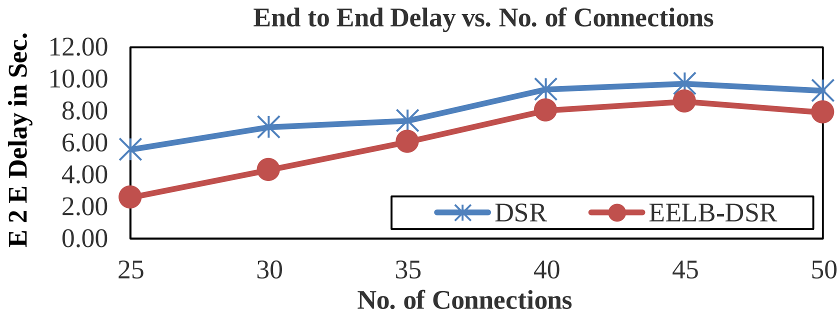


Figure 12 End to End Delay versus No. of Connections

Figure 13 demonstrates normalized overhead versus number of connection sources of both EELB-DSR and original DSR. Axiomaticly, with increasing connection sources, the normalized overhead of both protocols is increased. This is because, increasing connection sources leads to more repetions of route discovery operation, resulting in more generation of control packets. It is clear that, normalized overhead of EELB-DSR (1.85) is lower than its counterpart of DSR (1.25), with percentage of improvement 48%. This is due to, EELB-DSR submits more stabilized routes comparing with its counterpart of DSR, resulting in reduction of repeating of route discovery process. In addition, EELD-DSR reduces flooding of RREQ packets during route discovery. All of these leading to reduction of normalized overhead.

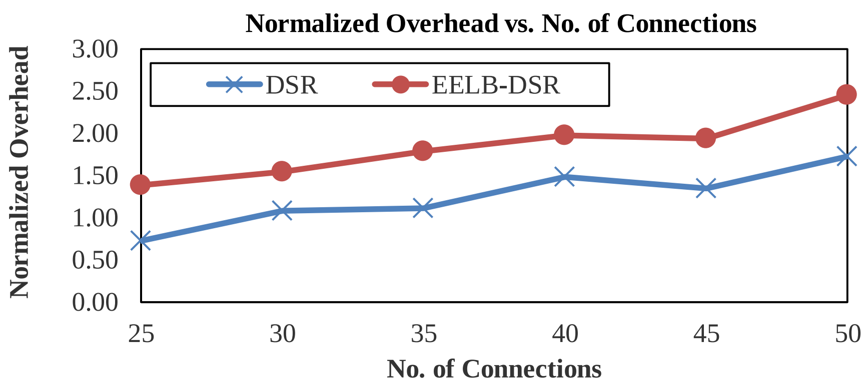


Figure 13 Normalized Overhead versus No. of Connections

Figure 14 presents average energy consumption versus number of connection sources of both EELB-DSR and original DSR. From figure we note that, as number of connection sources increases, average energy consumption of both protocols is increased. This is due to, increasing connection sources lead to increasing repetions of route discovery process, thence increase number of both control packets and data packets resulting in maximization of energy consumption of nodes. It is lucid that, average energy consumption of EELB-DSR (3678 j) is lower by far than its counterpart of DSR (14381 j), with percentage of improvement 74%. This is because, EELB-DSR takes into consideration the traffic load balancing mechanism among nodes. In addition, EELB-DSR reduces flooding of RREQ packets and minimizes probability of route discovery process. All of these resulting in minimizing average energy consumption of nodes.

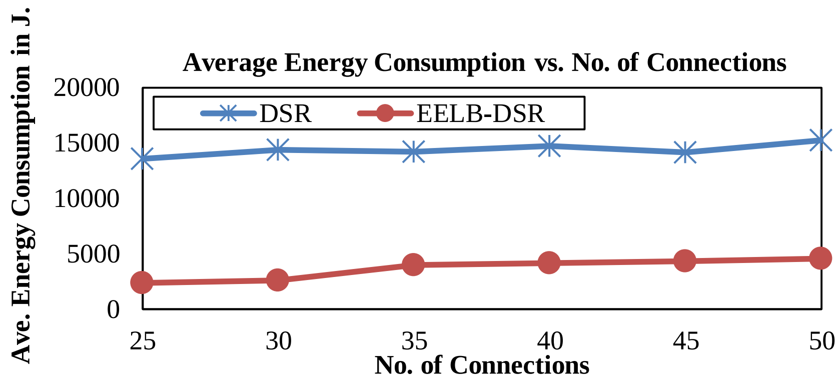


Figure 14 Energy Consumption versus No. of Connections

7- CONCLUSION

This essay presents improved version of standard DSR, called (EELB-DSR), through modification of route discovery mechanism, in such a way that minimize energy consumption of nodes, reduce flooding of control packets and realization of balanced traffic load among nodes, resulting in prolong life time of nodes, thence increase life time of the routes and relative stability of network. Performance evaluation and comparison between proposed scheme (EELB-DSR) and original DSR has been implemented utilizing network imitator (NS2). Results of simulation proved that performance of the proposed protocol outperform original DSR in terms of: packet delivery ratio, end- to- end delay, normalized overhead.

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