International Journal of Engineering and Advanced Technology (IJEAT)
ISSN: 2249-8958 (Online), Volume-9 Issue-1, October, 2019

A New Technique for Multiple-Path Creation in AODV Protocol Based on Composite Criterion Consisting of the Factors of Energy, Traffic Load and Stability of Nodes

May S. Nouh, Mohamed I. Youssef, Mahmoud I. Marei

***Abstract**: Not long ago mobile ad hoc networks (MANET) became one of the most recent and famous trends in the field of wireless communications. This is because, it permits the mobile appliances for communication with each other at any instant anyplace without the need of pre-defined infrastructure or centralized management. As the absence of centralized administration, the free movement of appliances and the limited resources of MANET, the designing of routing protocols have been becoming the main fundamental challenge that meet MANET till now. Furthermore, nodes with heavily traffic load may exhaust their energy in routing others packets resulting in unstable network and hence performance deterioration. In this essay we present a new version of one of the well prominent reactive routing protocols named Ad Hoc On Demand distance Vector (AODV). The suggested version aims to make the original AODV more efficient in terms of the energy consumption of nodes, traffic load distribution among nodes and routes stabilization. The suggested scheme is called, Energy efficient, Load balanced and Stabilized Multi routes- AODV (ELSM-AODV), where the paths selection is based on a composite criterion, named Node Efficiency Factor (NEF) which contain all factors that have direct impact on the performance level and life time of MANET (e.g. energy, speed, distance and traffic load of nodes). Performance assessment and comparison between suggested schema (ELSM-AODV) and standard AODV has been performed using network emulator NS2. Simulation results evidenced that performance of the suggested protocol outperform standard AODV from point of view: correct packets delivery ratio, end to end delay time, normalized routing load and nodes energy consumption.*

***Keywords**: AODV, ELSM-AODV, Energy, MANET, Routing protocols, Speed, Traffic load.*

Revised Manuscript Received on October 30, 2019.

* Correspondence Author

May S. Nouh, department of Electrical and Computers Engineering, Higher Technological Institute/10th of Ramadan, Cairo, Egypt. Email: mainouh41@gmail.com

Mhamed I. Youssef, department of Electrical Engineering, Fac. of Engineering, Al-Azhar Unive., Cairo, Egypt. Email: mohamdyousif12@gmail.com

Mahmoud I. Marei, department of Computers and Systems Engineering, Fac. of Engineering, Al-Azhar Unive., Cairo, Egypt. Email: mahmoudmarei@gmail.com

I. INTRODUCTION

Mobile ad hoc networks (MANETs) has been originated as the result of the formidable progression of wireless communication technology in conjugation with the development of mobile smart appliances technology [1-3].

The MANET structure is different from the others wired/wireless networks due to its distinct characteristics such as, freelance mobile devices with limited energy, finite bandwidth and dynamic network topology [4, 5]. Furthermore due to the absence of centralized management, all mobile devices acting as routers and hosts at same time [6, 7]. Due to the limited transmission range of mobile devices, often the created routes take the form of multi hops style. Therefore, the efficiency of intermediate mobile nodes constituting the routes has important role in routes stabilization, hence it has direct impact on MANET performance. Up to now the routing mechanisms still the major challenge of MANETs, where the performance of all the proposed routing mechanisms did not reach to the anticipated level [8, 9]. According to routing information update mechanism, MANET routing schemes can be classified into two classes: proactive and reactive schemes [10-13]. Most previous studies have concluded that performance of reactive schemes more efficient than proactive schemes especially when MANET is subjected to high dynamic topology [14, 15]. AODV is the most renowned reactive routing protocol in MANET [16], where route selection based on the criterion of minimum hops count, although this criterion achieves small delay time for data delivery at destination node, it is not adequate for realizing high network performance level, prolong life time of network operation and the paths stabilization among communicated nodes [17]. This is due to original AODV does not take into consideration the state of intermediate nodes that form the route while route discovery process. Whereas, the state of nodes is represented by their energies, speed of movement, distances among them, and traffic load, where all these factors have strong effect on the level of network performance, network life time and paths stability among the communicating nodes. Therefore, this article presents a new version of AODV through modification of both route discovery and route maintenance schemas, where the route selection based on compound criterion called Node Efficiency Factor (NEF). Where, this criterion is a function of coefficients of energy, traffic load and stability of node.

Unlike the original AODV, to reduce number of repeating of route discovery process, the new suggested version creates more than one path (two paths) during actuation of each route discovery operation. Where one of them is used as a principal path, while the other is used as an alternative path when the principal path fiasco. The suggested new version of AODV is called, Energy efficient, Load balancing and Stabilizing Multi route- AODV scheme (ELSM-AODV).

The remainder of the essay is arranged as follows: Section II debates the related works. The suggested ELSM-AODV is presented in Section III. Simulation environment and parameters are indicated in Section IV. In Section V, simulation results and performance appraisal have been presented. Finally, Section VI concludes the article and offers the future work.

II. RELATED WORKS

This section presents the related works, for example and not limited, for many various routing schemas which aim to ameliorate the performance and prolong life time of the mobile Ad hoc network by taking into consideration some criteria based on demands of certain field or enforcement like mobility, location, energy, quality of service or telecast conscious routing schemas.

K.Venkatachalapathy and D.Sundaranarayana [18], introduced new algorithm, named a min-max scheduling algorithm, for getting MANET related with energy efficiency and balanced traffic load for nodes, the suggested algorithm has been operated on two stages. The first stage is concerned with neighboring nodes selection based on energy of nodes, and packet delivery percentage. While, in the stage of balanced traffic load, the chosen nodes are affected by the waiting and scheduling operation to ameliorate the rate of data treating in irrespective of the sort of data traffic.

Andraws S., Haytham B. A., et al [19], submitted a new version of AODV called MDA-AODV. The authors' aim was to lessen the impact of the links breakdown among the communicating nodes, thence obtaining more stable and reliable paths. The route selection in the suggested version was based on the speed and direction of the sharing nodes for route formulation in such a way that avoiding the high speed nodes or which are moving far. The authors' did not take into consideration other factors during route selection like remaining energy and traffic load of nodes which have effect on the performance and stability of chosen routes.

To avert the repetition of route discovery operation by the original AODV particularly at high speed nodes, thence minimize the flooding of route request packets. M. B. Kalaf, et al [20] suggested two innovative velocity- aware probabilistic paradigms, named (SAVP) and (AVAP), with aim of excluding unsettled nodes during routes construction among the communication nodes. Thence, lessening the number of link breakages and to guarantee that all chosen links are often stable.

Shayesteh T. and Rasoul B. [21], introduced four different methods for getting stable paths in the dynamic topology environments of MANET. Where, any one of the four suggested schemes can be employed under the umbrella of reactive routing protocols. The four proposed mechanisms are called, Classical Logic-based Routing Algorithm (CLRA), Fuzzy Logic-based Routing Algorithm (FLRA), Reinforcement Learning based Routing Algorithm (RLRA), and Reinforcement Learning and Fuzzy Logic based (RLFLRA) Routing Algorithm. Where, the route selection through using the four algorithms is based on four significant fuzzy factors like ready bandwidth, remaining energy, mobility speed, and hops count. Simulation results illustrated that the performance of RLFLRA outperforms other three suggested schemes.

In [22], Vu Khanh Quy, et al suggested a new version of AODV, through modification of route set up operation, called HPLR, with aim to prolong the life time of network and ameliorate the total rendering of MANETs. The suggested HPLR utilizes a crossbred technique based on hop count and the cost function of residual energy of nodes for route selection.

In [23], Mueen Uddin, et al submitted novel version of Multipath- AODV (AOMDV), to overcome the problem of energy exhaustion of MANET. The suggested algorithm is called Multipath AODV with the Fitness Function (FF-AOMDV), in which the fitness function has been used for selecting the most perfect path, between any two communication nodes, to lessen the consumed energy in multipath routing mechanism. Therefore, to obtain the optimal path, the fitness factors that have been used are: residual energy of every node, distance between the neighbor nodes, and nodes' consumed energy.

A. Tiwari and I. Kaur [24], offered a fresh mechanism for getting energy efficient AODV. The idea behind the suggested technique is to make the route in active mode even if the link breakage has been occurred. Hence, shun re-dissemination once more of query packet from the originator node. The basic operation of the proposed scheme is based on a function called recvRevrese, That call up when the energy level of a node is less than particular threshold level, in order to return to the preceding node. Where it sends RREQ packet to discover a novel route without deactivating the current path.

Anita Yadav et al. [25] have propositioned improved version of AODV, called AODV with Link failure Prediction (AODVLP), through using new method of route maintenance, with aim to lessen data packet loss and E2E delay time. The suggested approach is how to foresee in early time the link failure before the route breakage between source and destination node. Where, a link failure prediction scheme is based on signal strength of the three successive receipted data packets and a threshold signal strength. After estimating the time after which the link will be broken, the node alerts the predecessor nodes about this fragile link, and thus the route can be reform locally or new route creation process starts in earlier time before the route breakage.

Santhi V. and S. K. Sarvepalli [26], introduced a new mechanism for geographical routing in MANETs called Load balance technique with Adaptive Position Updates (LAPU). Where, the suggested technique has been inspired from both Adaptive Position Update (APU) protocol and Multipath- AODV protocol (AOMDV). During route creation operation, LAPU scheme choose paths contain nodes having low velocity and low traffic load.

Where nodes' velocity is obtained using Mobility Prediction (MP) paradigm, while the level of traffic load at nodes is determined using queue length at nodes. Also, to achieve load balancing among nodes the transferred data packets are divided among different paths.

Bhavna Arora and Nipur [27], suggested a modified version of Multiple- route AODV (AOMDV), named Adaptive Transmission Power - AOMDV (ATP-AOMDV). Where, in the proposed version, each node has the ability to adjust the power of transmission of used control packets during route creation to every one of its neighboring nodes according to its distance from each neighbor and the used propagation model. The simulation results proved that ATP-AOMDV outperform AOMDV with respect to PDF, E2E and energy consumption of nodes.

In [28], Amina Guidoum and Aoued Boukelif submitted modified version as an extension of AODV- balanced protocol, with aim of getting a stabilized and minimal overloaded route. The suggested version is called AODV_SPB (AODV with Stable Path, less congested with load Balancing), it is a mixture of traffic load balancing mechanism and route failure foretelling schema. For predicting the route failure during the route upkeep stage, the authors utilized Newton polynomial interpolation (NPI) approach for continuous measuring the approximated signal strength of received data packets by the nodes. In case of the value of the approximated signal strength less than a certain threshold, the node invokes local repair function by sending RERR packet to the previous node for getting a substitutional path to attain the destination nodes.

Vignesh R. H. & R. Gunavathi [29], suggested a modified version of AODV protocol called EP-AODV, with the aim of improving the energy efficiency of the paths of WSN, hence elongate lifetime of the network. Where, the proposed scheme selects the route with short physical distance between source node and sink node, minimum hop count and nodes of high energy.

III. PROPOSED ELSM-AODV SCHEME

The prime goal of the suggested routing scheme is to improve the comprehensive performance of MANETs and protract the network lifetime at the same time, through moderation of route discovery and maintenance mechanism for AODV protocol. As the route construction between any two communicated nodes consists of a chain of wireless linked intermediary nodes. So, link breakdown between any two consecutive nodes along the route lead to entirely path failure. Where, link break off comes either from dying of any one of the two successive nodes; due to its energy exhaustion, or nodes movement so that two successive nodes are becoming out of their participated transmission range.

For making the proposed scheme aware with energy, stability and traffic load of nodes, the routes have been selected based on composite criterion, named Node Efficiency Factor (NEF). Where, this criterion is a function of coefficients of energy, traffic load and stability of node. Furthermore, to lessen number of iteration of route discovery operation, the suggested new version creates more than one path (two-path) during running of each route discovery operation. Where one of them is used as a cardinal path, while the other is used as standby path when the main path fiasco. To implement suggested protocol (ELSM-AODV), the following three paradigms have been taken into account for calculating energy factor, traffic load factor and stability factor for node.

Energy Paradigm

Because of nodes of MANET running on batteries of limited energy. So it is essential the nodes along the chosen route have high level of energy to warranty network connectivity and elongate the network lifetime. Where, node energy factor (E_f) could be computed according to the following equations:

$$E_f = E_s/E_i \qquad (1)$$

$$E_s = E_p - (E_{tx} + E_{rx}) \qquad (2)$$

Where,

E_s: surviving energy of node

E_i: incipient energy of node

E_p: present energy of node

E_{tx}, E_{rx}: the wasted energy from node for each transmitted and receipted data/control packet respectively.

N.B: For node of high energy level, E_f should be high.

Traffic Load Paradigm

Traffic load of each node along the selected route is very important factor. This is because in case of high traffic load, packet waiting time in the buffer of transmission (latency time) is increased, resulting in increased delay time to deliver data from source node to destination node. In addition, the nodes of high traffic load will die off faster than nodes of lower traffic load. The traffic load factor (TL_f) of node is calculated as follows:

$$TL_f = P_B/B_{max} \qquad (3)$$

Where,

P_B: Present packets' count in the transmission Buffer and

B_{max}: Maximum number of packets in transmission buffer.

N.B: For node with light traffic load, TL_f should be small.

Stability Paradigm

Whereas, nodes' movement level along the chosen route plays important role of route stability. Where, high speed movement of nodes can cause linkages break repeatedly among the nodes. Leading to frequently routing path failure, hence a more route re-discovery process is required, which result in performance degradation of MANET. Therefore, to lessen the impact of nodes' mobility on route stability, the presented stability model has been taken into consideration that enabling each node for getting information about its stability relative to every one of its neighbouring nodes. This is through calculating both relative speed and normalized distance of node relative to each one of its neighbouring nodes periodically.

To implement the stability paradigm, we assumed that all nodes in MANET are homogeneous and furnished with GPS system for obtaining their location coordinates (X, Y). For enabling a node to compute its relative speed and its distance relative to a neighbor node, the HELLO message which is broadcasted periodically by each node has been used.

To satisfy our requirements, a new field has been added in HELLO message format for putting position coordinates of node. According to the information involved in two consecutive HELLO messages from a neighbor, using the Euclidian distance equation, the receiving node can calculate its own relative speed and its distance relative to the source of HELLO message. For example, when node A receives HELLO message from node B containing (X_b, Y_b) at time t_1, it calculates its distance d_1 using the Euclidian distance equation and on receiving the next HELLO message at time t_2 it calculates d_2. Subsequently, node A can computes its relative speed with respect to node B using the following equation:

$$S_r = \Delta d_B/\Delta t \quad (4)$$

Where,
$\Delta d_B = |d_2 - d_1|$,
$\Delta t = t_2 - t_1$ = HELLO_INTERVAL

After that, the node A stores three parameters of the HELLO source node in the neighbor table < source's address of hello message, relative speed factor (S_{rf}), and normalized distance (D_n) >.

Where,

$$S_{rf} = S_r/S_{max} \quad (5)$$
$$D_n = d_2/R_{max} \quad (6)$$

Where,
S_{max}: Node's maximum speed
R_{max}: Maximum transmission range of node B.

Thence, the stability factor (S_f) of node A relative to node B can be expressed as follow:

$$S_f = S_{rf} + D_n \quad (7)$$

N.B: For long connectivity life time between any two neighbouring nodes, the stability factor (S_f) should be small.

The aforementioned three factors of the three models (energy factor, traffic load factor and stability factor) can be combined into one metric called Node Efficiency Factor (NEF) as follow:

$$NEF = E_f/(TL_f + S_f) \quad (8)$$

So, to ameliorate the inclusive performance of MANETs and prolong the network lifetime at the same time, NEF of nodes has been used as a criterion for route selection.

A. ELSM-AODV Route Discovery Process

The major aim of the amended route discovery schema is to eschew routes contain nodes having lowest efficiency factor, using NEF as a criterion for route selection, through choosing the paths with the maximum NEF from the set of minimum NEF elected paths. Furthermore, to lessen number of repeating of route discovery process, the modified route discovery scheme creates more than one path (two paths) during actuation of each route discovery operation. Where one of them is used as a principal path, while the other is used as an alternative path when the principal path fiasco.

To meet our needs, slight amendment has been made in the formatting of both route request packet (RREQ) and route reply packet (RREP). Where one field added to RREQ packet called linkage efficiency factor (LE_{Rq}), while another one has been added to RREP packet called route efficiency factor (RE_{Rp}).

When source node has inclination to communicate with destination node and it does not has a righteous route in its routing table, it inaugurates route origination process, through disseminate RREQ packet with link efficiency factor (LE_{Rq}):= 3, to neighbor nodes. On receipting a RREQ packet, every intermediary node checks whether it is a transcript of formerly receipted RREQ. If it is a transcript, then the node simply discards the repeated RREQ packet. On contrast, on receiving the RREQ at first time, it executes the following systematized steps:

1- Calculate its efficiency factor (NEF).

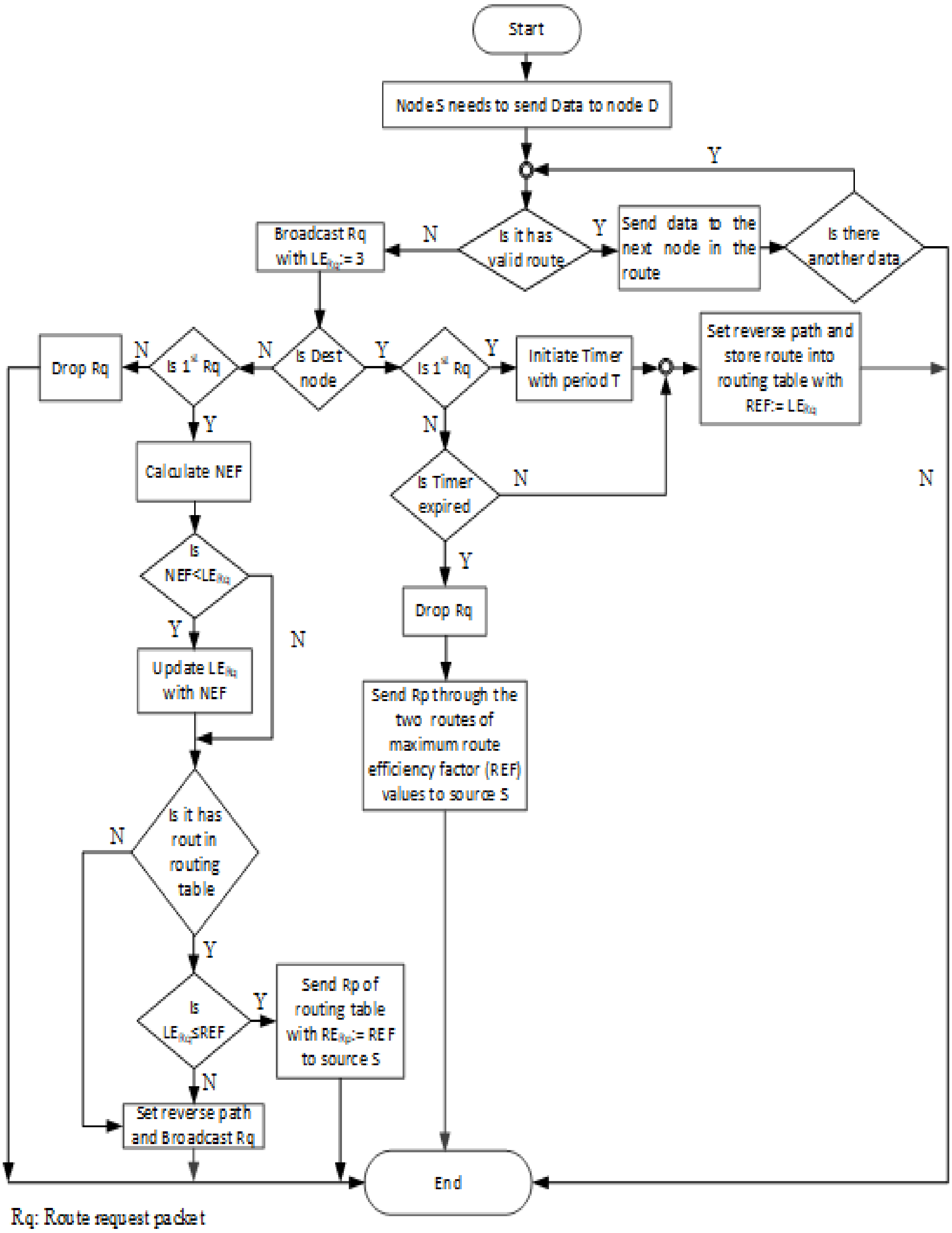
2- If NEF< LE_{Rq}, then LE_{Rq} field is updated with NEF (LE_{Rq}:= NEF). Otherwise, no change will be made in LE_{Rq} field of RREQ packet and performs one of the following states:
  * If there is no valid route in its routing table: It sets the reverse path and re-broadcast RREQ packet.
  * If there is a valid route with an efficiency factor (REF) ≥ LE_{Rq}, it sends RREP packet to source node. Otherwise, it sets the reverse path and re-broadcast RREQ packet.

Whereas, the same RREQ packet may arrive at destination node from various paths because recurrence of rebroadcast operation. So, on receiving the first RREQ packet the destination node stores the route through which the first RREQ has been received with REF:= LE_{Rq} into the routing table and waits a time period T for receiving the same RREQ from different paths. Where, for each RREQ subsequently receipted, it stores the corresponding route with its REF:= LE_{Rq}. After the waiting time T, the destination node sends two RREP packets via the two chosen routes based on the maximum route efficiency factor (REF) to source node. Figure 1 shows nodes' action during receiving RREQ packet.

After reception of the two RREP packets, source node organizes the corresponding two routes in descending order based on their route efficiency factor (REF) in its routing table, and start sending data packets over the route of the highest REF. Figure 2 shows nodes' action during receiving RREP packet.

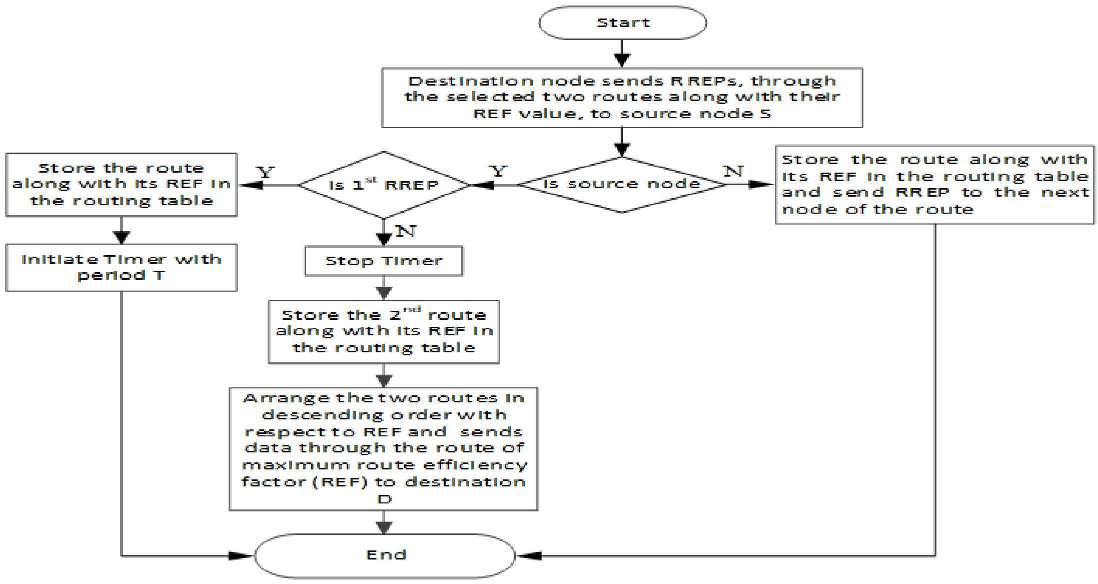
B. ELSM-AODV Route Maintenance Process

Route maintenance is a procedure for continues tracking the valid running of energetic route in ELSM-AODV protocol. In the course of sending of data packets, in situation of any fractured link, predecessor node from lost link transmits Route Error (RERR) packet, by method of hops style, to source node. During the voyage of RERR packet in direction of source node, each preceding intermediate node of the lost link, erases route to any inaccessible destination node of its routing table. At reception of RERR packet, source node removes the fractured path from routing table and sends route authentication message via the reserve path in the routing table to destination node and waiting a time period δ, as illustrated in Figure 3. In state of receiving message of positive response from destination node via the reserve route while it's waiting time, source node starts sending the residual data packages over the reserve route. Otherwise, it commences novel route discovery process.



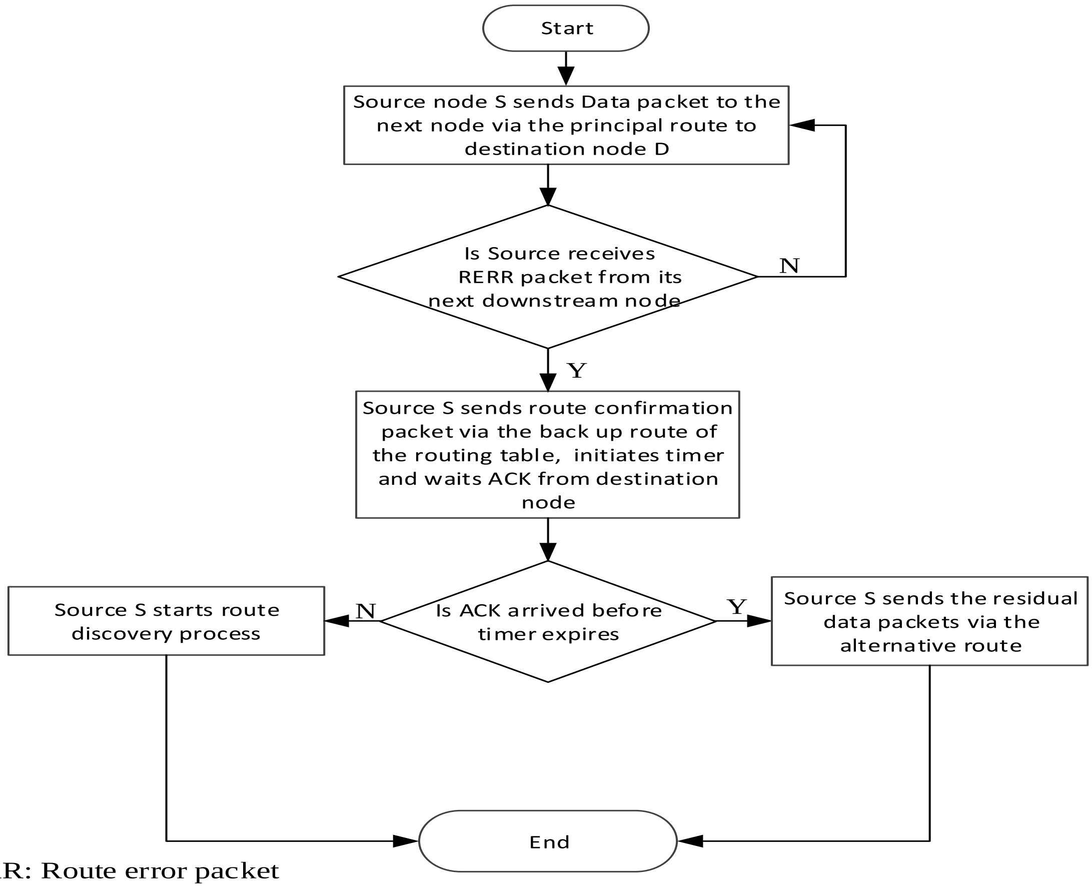
Rq: Route request packet
Rp: Route reply packet
NEF: Node efficiency factor
LE_{Rq}: Link efficiency factor of Rq
RE_{Rp}: Route efficiency factor of Rp
REF: Route efficiency factor of route in routing table

Fig. 1. Flow Chart That Shows Action of Nodes on Receiving RREQ of ELSM-AODV



RREP: Route Reply packet
REF: Route Efficiency Factor of RREP

Fig. 2. Flow Chart That Shows Action of Nodes on Receiving RREP of ELSM-AODV



RERR: Route error packet
ACK: Acknowledgment

Fig. 3. Flow Chart That Shows Route Maintenance Scheme of ELSM- AODV

IV. SIMULATION ENVIRONMENT AND PARAMETERS

For running and assessing the performance of the suggested ELSM-AODV protocol against the original AODV, the network simulator NS2 has been used. Where the AWK command has been used to perform mathematical analysis of the data of simulation outcomes created in trace file. Also, each experience was performed five times and the mean result has been taken into account to affirm the efficiency of the suggested schema. Where, the metrics which have been used for performance appraisal are packet delivery ratio (PDR), E2E delay time, normalized routing overhead and consumed energy of nodes. Simulation environment and used variables are elucidated in Table I.

Table- I: Simulation Parameters

Simulation Parameter	Value
Simulator	NS2 (V 2.35)
Topology size	1000m x1000m
Nodes number	60
Range of transmission	250m
Type of channel	Wireless
MAC layer	802.11
Initial energy of node	20J
Energy consumption for packet transmission (E_{tx})	0.6mJ
Energy consumption for packet reception (E_{rx})	0.2mJ
Hello packet interval	1 sec
Type of traffic	CBR
Number of sources	50
Pause time	5 sec.
Mobility speed	5m/s-55m/s
Mobility model	Random way point
Antenna type	Omni antenna
Model of radio propagation	Two ray ground
Interface queue length	50
Rate of packets	4 packets/sec
Simulation time	500sec

V. SIMULATION RESULTS AND PERFORMANCE APPRAISAL

This section is dedicated for assessing the performance and comparing the proposed scheme ELSM-AODV against the original AODV. As the suggested scheme aims to obtain stable routes and prolong the lifetime of network, especially in environment of high dynamic topology, so the performance appraisal and comparison is carried out based on testing the impact of nodes speed on performance of the proposed scheme ELSM-AODV and conventional AODV. Where, total number of nodes 60, pause time of node 5 sec, number of sources connection 50 and the maximum nodes' speed is varied between 5m/sec and 55m/sec. And the other factors are the same stated in Table I.

Figure 4 shows packet delivery ratio (PDR) of ELSM-AODV and AODV as a function in nodes' speed. It is visible that as the speed of nodes increase, the PDR of the two the schemas is decrease proportionally. This due to high speed of nodes lead to increase the prospect of routes failure, resulting in further data packets forfeiture. Also it is obvious that, the mean PDR of ELSM-AODV (40.06%) is higher than its peer of AODV (28.25%), with ratio of refinement 42%. This is due ELSM-AODV avoids routes selection containing nodes having low efficiency factor, leading to more stable elected routes. Hence, low loss of data packets percentage.

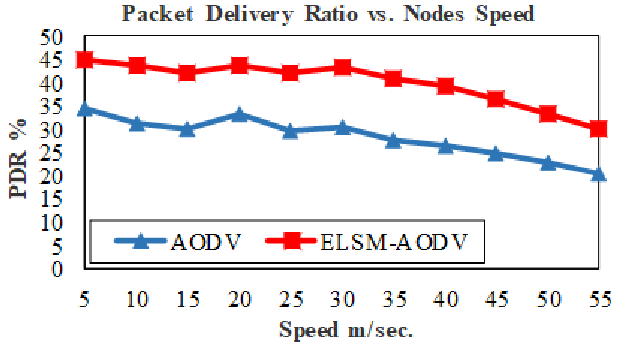


Fig. 4. Packet Delivery Ratio vs. Nodes Speed

Figure 5 compares average end-to-end delay time (E2E delay) of ELSM-AODV with the standard AODV. It is clear that E2E delay time for both schemes is directly proportional with speed of nodes. This due to at high nodes speed leads to increase the probability of routes breakage, resulting in more routes re-initialization process. Thence increase of E2E delay time. From the figure we note that, the mean E2E of ELSM-AODV (1.87ms) is less than its peer of AODV (2.74ms), with amelioration ratio 32%. This because of ELSM-AODV uses the concept of multi routes creation per each route discovery operation, hence minimizes the repetition of route creation process, in addition to averting nodes of high traffic load during routes selection, resulting in reducing the waiting time of data packets in the buffer for transmission. All of these lead to diminish E2E delay time.

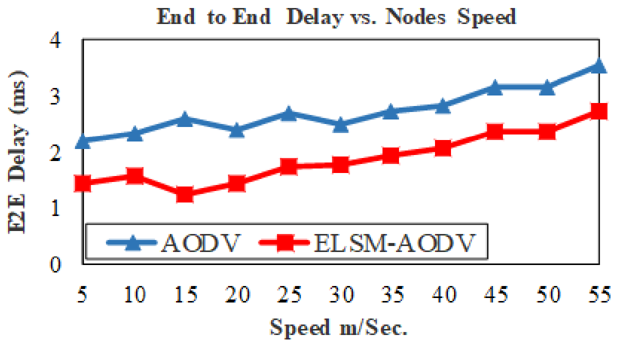


Fig. 5. End-to-End Delay vs. Nodes Speed

Figure 6 compares normalized routing load (NRL) of ELSM-AODV with the original AODV as a function in nodes speed. It is obvious that as the speed of nodes increase, the NRL increases for both schemes. This due to, high speed of nodes lead to increase the eventuality of routes failure, leading to more repetition of route discovery operation, hence increase the generation of RREQ and RREP packets. From the figure we observe the average NRL of ELSM-AODV (10.70) is less than its peer of AODV (15.83), with amelioration ratio 32%.

This because of ELSM-AODV creates more stable routes, in addition to utilizing the concept of multi routes creation per each route discovery operation, leading to lessening the repetition of route creation process, hence minimization of RREQ and RREP packets.

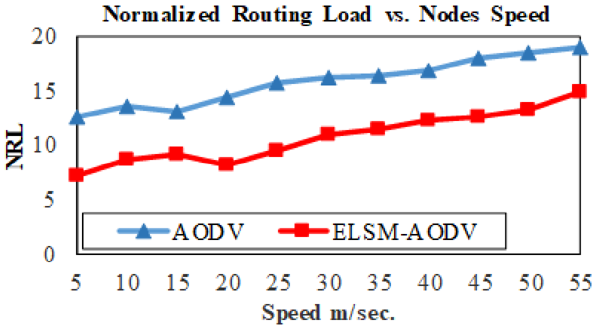


Fig. 6. Normalized Routing Load vs. Nodes Speed

Figure 7 illustrates mean consumed energy per node against nodes speed for both ELSM-AODV and standard AODV. It is lucid that with increasing nodes speed, average consumed energy per node increase. This is because of increasing prospect of routes breakage down, leading to more recurrence of route discovery operation, hence increase the generation of control packets, which in turns lead up to more energy consumption of nodes. From the figure we observe that average energy consumption of ELSM-AODV (0.727J) is less than its peer of AODV (1.192J), with amelioration ratio 39%. This because the proposed scheme ELSM-AODV produces more stable routes, in addition to utilization of multi paths mechanism; all of these leading to more reduction of generation of control packets, hence lessening energy consumption of nodes, giving rise to elongate life time for network.

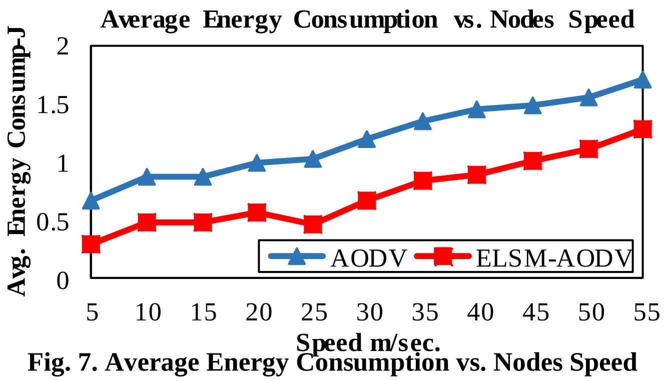


Fig. 7. Average Energy Consumption vs. Nodes Speed

VI. CONCLUSION AND FUTURE WORK

In this article a new version of AODV has been suggested, called ELSM-AODV, with aim to ameliorate the performance and prolong life time of the mobile Ad hoc network. Unlike the previous works, route selection in the proposed scheme is based on a compound criterion consisting of all factors that have direct effect on the performance level and life time of MANET (e.g. energy, speed, distance and traffic load of nodes). In addition we have used the technique of multi paths creation per each route discovery operation with aim to diminish the route re-discovery operation and eschewing the generation of more control packets especially at MANET of high dynamic topology. Simulation results have evidently shown that the suggested scheme has finer performance over AODV in terms of routes stability and successful data packets delivery ratio. It also diminishes E2E delay time, routing control packets and energy consumption of nodes.

As a future work, for more performance improvement we suggest to make the factors of the compound criterion of node efficiency (energy factor, load factor and stability factor) to be weighted by adaptive values according to the state of node. Also for lessening rate of exchanged hello packets, we will test the relation between the periodic time of sending hello packet and the nodes speed.

REFERENCES

1. M. Ayyash, Y. Alsbou and M. Anan, “Introduction to Mobile Ad Hoc and Vehicular Networks”, in Wireless Sensor and Mobile Ad-Hoc Networks. Springer, pp. 33–46, 2015.
2. Ali Mohamed E. Ejmaa, Shamala Subramaniam, et al, “ Neighbor-based Dynamic Connectivity Factor Routing Protocol for Mobile Ad Hoc Network”, Journal of IEEE Access, Vol. 4, No. 9, pp. 8053-8064, Nov. 2016.
3. Hoebeke J., Moerman I., Dhoedt B. and Demeester P.,“An Overview of Mobile Ad Hoc Networks: Applications and Challenges”, Journal of communications networks 3(3), pp. 60–66, July 2004.
4. Trilok Kumar Saini and Subhash C. Sharma, “Prominent Unicast Routing Protocols for Mobile Ad Hoc Networks: Criterion, Classification, and Key Attributes”, Ad Hoc Networks, Vol. 89, pp. 58-77, June 2019.
5. A. Moussaoui and A. Boukeream, “A survey of Routing Protocols Based on Link-Stability in Mobile Ad Hoc Networks”, Journal of Network and Computer Applications, Vol. 47, pp.1–10, 2015.
6. Rahma B. M. Mukta, “Performance Analysis of Node-Disjoint Multipath in MANET: A Modified Approach”, International Journal of Computer Applications, Vol. 162, No. 6, pp. 16-22, March 2017.
7. Divya M, S. Subasree and N. K. Sakthivel, “Performance Analysis of Efficient Energy Routing Protocols in MANET”, 3rd International Conference on Recent Trends in Computing, pp. 890- 897, 2015.
8. Kaur P., Kaur D., Mahajan R., “A review and Comparison of AODV, DSR and ZRP Routing Protocols on the Basis of Qualitative Metrics”, 3rd International Conference on Computing for Sustainable Global Development (INDIACom), IEEE, 2016.
9. Ali TE, Khalil al Dulaimi LA, Majeed YE, “Review and Performance Comparison of VANET Protocols: AODV, DSR, OLSR, DYMO, DSDV & ZRP”, Al-Sadeq International Conference on Multidisciplinary in IT and Communication Science and Applications (AIC-MITCSA), IEEE, 2016.
10. Thomas Clausen, Jiazi Yi and Ulrich Herberg, “Lightweight On-demand Ad hoc Distance-vector Routing - Next Generation (LOADng): Protocol, extension, and applicability”, Computer Networks, Vol. 126, pp. 125-140, July 2017.
11. Vivek Arya and Charu, “A survey of Enhanced Routing Protocols for MANETs”, International Journal on Ad Hoc Networking Systems (IJANS), Vol. 3, No. 3, pp. 1-9, July 2013.
12. Azzedine Boukerche, Begumhan Turgut, et al, “Routing Protocols in Ad Hoc Networks: A survey”, Computer Networks, Vol. 55, pp. 3032-3080, May 2011.
13. Priyanka K. and Sudip K. Sahana, “Comprehensive Survey and Comparative Experimental Performance Gain of AODV, DSR and OLSR in MANETs”, International Journal of Engineering and Advanced Technology (IJEAT), Vol.8 Issue 5, pp. 1036-1045, June 2019.
14. K. G. Preetha, A. Unnikrishnan, “Enhanced Domination Set Based Routing in Mobile Ad Hoc Networks with Reliable Nodes”, Computers and Electrical Engineering, Vol. 64, pp. 595-604, April 2017.
15. Xinming Zhang, Kaiheng Chen, et al, “A Probabilistic Broadcast Algorithm Based on the Connectivity Information of Predictable Rendezvous Nodes in Mobile Ad hoc Networks”, 23rd International Conference on Computer Communication and Networks (ICCCN), IEEE, Aug 2014.
16. RFC3561, https://www.ietf.org, accessed, April 21, 2018.

17. Devarajan Jinil Persis, T. Paul Robert,"Review of Ad-Hoc On-demand Distance Vector Protocol and Its Swarm Intelligent Variants for Mobile Ad-hoc Network", IET Networks Journal, Vol. 6, Issue 5, pp. 87-93, 2017.
18. K. Venkatachalapathy and D. Sundaranarayana, "A Min-Max Scheduling Load Balanced Approach to Enhance Energy Efficiency and Performance of Mobile Ad-Hoc Networks", International Journal of Computer Networks & Communications (IJCNC), Vol.11, No.3, pp. 85-96, May 2019.
19. Andraws S., Haytham B. A., et al, "Mobility and Direction Aware Ad-hoc On Demand Distance Vector Routing Protocol", The 13th International Conference on Mobile Systems and Pervasive Computing (MobiSPC 2016), Procedia Computer Science, Vol. 94, pp.49–56, 2016.
20. M. B. Khalaf, A. Y. Al-Dubai and GeyongMin, "New Efficient Velocity-Aware Probabilistic Route Discovery Schemes for High Mobility Ad Hoc Networks", Journal of Computer and System Sciences, Vol. 81, pp. 97-109, 2015.
21. Shayesteh T. and Rasoul B., "New Approaches to Routing in Mobile Ad hoc Networks", Wireless Personal Communication, Vol. 97, Issue 2, pp. 2167-2190, Nov. 2017.
22. Vu Khanh Quy, Nguyen Tien Ban and Nguyen Dinh Han, "A High Performance and Longer Lasting Network Lifetime Routing Protocol for MANETs", International Conference on Advanced Technologies for Communications, pp. 237-241, IEEE 2018.
23. Mueen Uddin, et al, "Energy Efficient Multipath Routing Protocol for Mobile ad-hoc Network Using the Fitness Function", IEEE Access, Vol. 5, pp. 10369-10381, May 2017.
24. A. Tiwari and I. Kaur, "Performance Evaluation of Energy Efficient for MANET Using AODV Routing Protocol", 3rd IEEE International Conference on Computational Intelligence and Communication Technology, pp.1-5, 2017.
25. Anita Yadav, Y. N. Singh and R. R. Singh, "Improving Routing Performance in AODV with Link Prediction in Mobile Ad hoc Networks", Wireless Personal Communication, Vol. 83, Issue 1, pp. 603-618, July 2015.
26. Santhi Venkatraman and Sai Kiran Sarvepalli, "Load Balance Technique with Adaptive Position Updates (LAPU) for Geographic Routing in MANETs", EURASIP Journal on Wireless Communications and Networking, Vol. 73, pp. 1-9, April 2018.
27. Bhavna Arora and Nipur, "An Adaptive Transmission Power Aware Multipath Routing Protocol for Mobile Ad hoc Networks", 3rd International Conference on Recent Trends in Computing, Procedia Computer Science, Vol. 57, pp. 1242-1248, 2015.
28. Amina Guidoum and Aoued Boukelif, "The AODV Extension Protocol Named AODV_SPB", International Journal of Computer Network and Information Security(IJCNIS), Vol.11, No.3, pp.15-21, 2019.
29. Vignesh R. H. and R. Gunavathi, "Improving the lifetime of Wireless Sensor Network through Energy Proficient AODV Protocol", International Journal of Engineering and Advanced Technology (IJEAT), Vol.8 Issue 6, pp. 3016-3020, August 2019.

AUTHORS FROFILE

May Sayed A. Nouh is assistant teacher at the Department of Electrical and Computer Engineering, the Higher Technological Institute Tenth of Ramadan City, Cairo, Egypt. She received her B.Sc. from Higher Technological Institute Tenth of Ramadan City in 2010 and MSc. from Faculty of Engineering, Ain Shams University in 2017. Since then, she served in different positions and built both practical and theoretical experience in electronics and communications field. Her areas of interest include mobile ad hoc networks, wireless sensor networks, modeling and simulation techniques. She supervised on different training students in industrial areas.

Mohamed I. Youssef is the professor of communication systems, Electrical Engineering Department, Faculty of Engineering, Al-Azhar University, Cairo, Egypt. He received the Ph.D. degree from Ruhr University, Germany in January 1988. He has published several papers in national and international conferences and journals, His research areas of interest include digital communication systems, signal processing, digital filters, IoT, wireless sensor networks, energy efficiency and scalable routing in MANETs, distributed and parallel computing, secure routing for MANETs.

Mahmoud I. Marei is the professor of computer networks, Computers and Systems Engineering Department, Faculty of Engineering, Al-Azhar University, Cairo, Egypt. He received the Ph.D. degree from Cairo University, Egypt. In 1985. His research areas of interest include wireless networks, mobile ad hoc networks, QoS routing in MANETs, digital communication systems, modeling & simulation, clustering techniques, energy efficiency and secure routing for MANETS