International Journal of Engineering Trends and Technology
ISSN: 2231 – 5381 /doi:10.14445/22315381/IJETT-V70I1P212

Volume 70 Issue 1, 108-117, January, 2022
©2022 Seventh Sense Research Group®

Energy and Congestion Aware Location Aided Routing (ECALAR) for MANETs

Gorre Narsimhulu [1], Dr. D. Srinivasa rao [2]

[1] *Assistant professor, Department of ECE,Vignana Bharathi Institute of Technology, Hyderabad, Telangana, India.*
[2] *Professor, Department of ECE, JNTUH,Hyderabad, Telangana, India.*

[1]narsiroopa@gmail.com, [2]dsraoece@gmail.com

Abstract *- In Mobile Adhoc Networks (MANETs),Location Aided Routing is one of the most significant mechanism which controls the unnecessary overhead by optimizing the network area. LAR derives an optimal zone called request zone which allows only a few nodes to participate in the routing and data transmission. However, LAR didn't focus on the resources (ex., Energy and memory) of mobile nodes, which are constrained in nature. Hence, this paper proposes a new version of LAR called Energy and Congestion Aware Location Aided Routing (ECALAR), which introduces two factors, namely Energy Drain Rate and Buffer Capacity, in the routing process. Based on energy consumption, the residual energy status and energy drain rate are measured. These two factors lessen the burden on the nodes in the request zone and help in the improvisation of network lifetime and Quality of Service. Simulation experiments are conducted with varying network parameters like node speed and data rate. For Performance analyses, Average Energy Consumption (AEC), Delay, Packet Delivery Ratio (PDR), and Throughput are measured and compared with existing methods. On average, the proposed method gained AEC as 33.35mj, delay as 318.6ms, and PDR as 84% for varying node speed. Furthermore, for varying data rates, the average AEC, delay, and throughput are observed as 30mj, 293.3ms, and 540kbps, respectively.*

Keywords - *Location Aided Routing, Residual energy, Drain rate, buffer capacity, Throughput, Delay...*

I. INTRODUCTION

Recently, wireless technology utilization has become most prominent for different sectors, including private, educational, and corporate sectors in which internet access is required locally and globally. Compared to the traditional wired networks, the deployment of the wireless network is much easier and also needs less deployment cost because the running cost and required effort to deploy are negligible. In such kind technology, if the devices deployed are equipped with wireless adapters and managed by an access point, then their cooperation must be controlled by a centralized administrator. Moreover, the devices must be in the surveillance of access points, and there is a need for continuous communication with them. This kind of system strictly depends on the infrastructure, and mainly they are limited to the mobility constraints. To solve these problems, the devices equipped with wireless communication technology must operate themselves and be able to take an appropriate decision. Mobile Adhoc Networks (MANETs) [1] is one such kind of technology in which the mobile nodes are equipped with wireless communication technology. In other words, the MANETs is defined as a set of mobile nodes that are able to form a dynamic and temporary network without any assistance of a centralized administrator or fixed infrastructure. The mobile nodes in MANETs are connected with wireless links, and they are free to move in a random fashion. Moreover, the major advantage with MANETs is no centralized administration, and hence the mobile nodes organize themselves arbitrarily. Due to these important features of MANETs, they attained a huge scope in different applications, including disaster management, collaborative distributed computing, emergency rescue operations, military operations, and some personal network applications [2].

The major challenge in MANETs is the design of an efficient routing mechanism that discovers an effective path for communication and data transfer between mobile nodes. Moreover, the mobile nodes are smaller in size and have limited resources like energy, memory, etc. By considering these facts, the design of an efficient routing is a serious issue on which most researchers concentrated [3]. Along with these problems, the basic property, i.e., mobility, causes serious changes in the topology and results in frequent route failures even after route discovery. In the past few years, so many routing protocols have been discovered by researchers and applied over MANETs. "Dynamic Source Routing (DSR)" [4], Optimized ink State Routing (OLSR) [5], and "Adhoc On-demand distance vector (AODV)" [6] are the major protocols that have gained an acceptable performance. However, these protocols follow a standard two-step procedure that involves route discovery and route maintenance. In the route discovery phase, the source node broadcasts the Route Request packet into the network, which results in a huge control overhead. To lessen this overhead, Y. Ko and N. H. Vaidya [7] developed a new way of routing called Location Aided Routing (LAR), in which the route request packet is forward by the nodes that have location restrictions. LAR utilizes the location information and forwards the route request packets only to the nodes that are within the zone called request zone. However, LAR creates the request zone, which is parallel to the horizontal and vertical axis. The request zone obtained through LAR still includes some nodes by which the control overhead still exists. Hence there is a need for an adaptive LAR which further reduces the size of the request zone followed by control overhead.

In LAR-assisted MANETs, there are two more serious problems, i.e., quick energy depletion and congestion. After the discovery of the request zone and routing past through LAR, the source node forwards the packets through the same path. However, the continuous support of only a few nodes for data transmission results in quick energy depletion of the corresponding nodes. Moreover, the request zone has only a limited number of nodes, and they only have to forward the data for multiple source-destination pairs. This kind of support by multi-hop nodes results in huge energy consumption as well congestion. Hence the source node needs to assess the energy status and congestion status of multi-hop nodes in a periodic fashion. Based on the obtained statuses, the decision needs to take whether to change the node or not.

With this motivation, this paper proposes a new routing mechanism called Energy and Congestion Aware Location Aided Routing (ECALAR). ECALAR initially determines an adaptive request zone whose sides are parallel to the line connecting between source and destination nodes. Next, the source node discovers an adaptive route through the multi-hop nodes that are within the request zone. At the data transmission phase, the source node periodically calculates the Energy drain rate and buffer capacity of the multi-hop nodes with the help of HELLO packets. Based on these two statuses, the source node decides whether to change the multi-hop node or not. If any intermediate node is found to have less residual energy or more drain rate, then the source node discards the corresponding node from the route and forwards the data to an alternative node that lies within the communication range as well in the request zone.

The rest of the paper is stipulated as follows; the full-pledged details of the Literature survey are exposed in Section II. Next, the overall particulars of the developed mechanism are stipulated in Section III. The particulars of experimental validations are explored in section IV, and the concluding remarks are exposed in section V.

II. Literature Survey

In the past few years, several researchers proposed several methods for energy optimization in LAR for MANETs. Most of the researchers tried to minimize the control overhead in LAR protocol, but only limited research is accomplished in the view of energy consumption and congestion. Mohammad A. Mikki [8] proposed an Energy Efficient Location Aided Routing (EELAR) for MANETs. In EELAR, a reference wireless bases station is employed, and the entire network region is segmented into six regions based on the distance and angle of arrival. At the route discovery, the flooding packets are routed only to the nodes that lie in the region of the destination node. The base station is responsible for storing the location information of mobile nodes in the form of a table. However, this approach is not suitable for highly dynamic environments because the shape of the region is triangular, which creates very limited neighbor nodes at the source node that lies at the center of the network.

Chandresh G. Ghodasara and Radhika D. Joshi [9] proposed a routing protocol named Energy-Aware Location Aided Routing protocol 1(EALAR1) that calculates the remaining lifetime of nodes at route discovery and chooses an optimal path that has a maximum lifetime. This method considered the LAR 1 [12] as a base reference since the LAR 1 has a higher packet delivery ratio and moderate energy consumption. The node's remaining lifetime is measured as the function of residual energy and drain rate of the node. EALAR1 also considers the transmission power with respect to the next-hop node’s distance. Even though this method is adopted for drain rate-based node selection, the LAR 1 introduces a huge overhead because the horizontal and vertical axes of the request zone are parallel to the real x- and y- axes. Moreover, the request zone derived through LAR 1 is not rectangular and also not tilted.

Similarly, Nivedita N. Joshi and Radhika D. Joshi [10] modified the traditional LAR 1 and named it as Variable Range Energy-Aware Location Aided Routing (ELAR1-VAR). ELAR1-VAR controls the transmission power of a node with respect to the distance between itself and the next-hop node. This approach includes the information related to energy on the route request packet and chooses an optimal path that has less energy consumption to transmit the data. However, the LAR 1 introduces a huge routing overhead and consequences to the less quality of service due to packet loss.

One more approach is proposed by Aakash Jasper et al. [11] to improve the LAR 1 protocol and named it MYLAR 1. MYLAR 1 employed two route request packets at the route discovery phase. They are (1) Modified route request (this packet is employed when there is no information about the destination node) and (2) original request packet (this packet is used when there is route breakage). The modified request packet is generated by removing the redundant fields like the flooding variable field and zone variable field. However, this approach didn’t consider the energy consumption of intermediate nodes during data transmission. For larger size data, this approach is not suitable because the node’s buffer fills up quickly.

A. G. Shaji et al. [13] proposed an Energy-Aware Multipath Location Aided Routing (EAMLAR) for MANETs. EAMLAR combined the energy metric with location information and tried to find the energy-efficient path for data transmission. In this approach, the information about energy consumption is obtained from route reply packets and declared that the information is more accurate. Since the route reply packets are not broadcasted in the network, the energy consumption is less. For this purpose, the route reply packet format is changed by introducing a new field called ‘min_batterry_level’. Due to the determination of multiple paths, the PDR is increased, but there is no information about node and link disjointness. In the case of node disjointness, some common nodes will exist for two different paths and lead to a quick buffer filling as well as quick energy depletion.

Recently Prasanth Dixit et al. [14] proposed a QoS Enabled Improved Location Aided Routing (QEILA), which considers the bandwidth and battery life as main reference parameters for the discovery of optimal path in MANETs. This approach is equipped with a QoS check mechanism during the selection of the next-hop forwarding node for path establishment. Moreover, a path preservation mechanism is also introduced, which repairs the broken link locally based on the next-hop node's table. This approach had shown a superior performance due to the flexibility of the local repair mechanism. However, this approach used the basic version of LAR, which has a major limitation of non-robustness for node mobility.

Priya Mishra et al. [15] proposed a fuzzy-based location-aware routing that can adjust the transmission range. In this approach, initially, a triangular-shaped request zone (called a broadcast region) is derived from the network. Next, a fuzzy-based forwarding method is applied, which integrates the direction and distance to discover the next hop forwarding node. This approach focused on the hole problem in the request zone and proposed a self-adjustable transmission range-based method to solve it. A triangle-shaped request zone lessens the routing overhead greatly. However, sometimes it can't provide even a single multi-hop node for data transmission to the destination node because of the very small area of the request zone.

Next, Khusbhoosingh et al. [16] proposed a power-aware LAR protocol. This approach uses linear regression and curves intersection point areas to lessen the area of the request zone. Node classification is done based on battery power awareness. This approach is considered the LAR 1, which has a larger-sized request zone that induces a huge routing overhead followed by quick energy depletion and buffer filling. Dahai Du and HuagangXiong [17] aimed at the reduction of energy consumption and proposed a Location Aided Energy Efficient Routing (LEER) Protocol based on the location information of mobile nodes. However, this approach is not concentrated on the QoS improvisation by considering the local buffer status of multi-hop nodes.

Jiangsu Lee et al. [18] tried to improve the LAR protocol by introducing energy parameters in the routing process. Initially, they minimized the spread of control messages and then provided energy awareness to obtain a proper transmission power based on the distance between nodes. This approach had shown significant performance in the improvisation of lifetime compared to LAR. However, the simple energy calculation won't contribute much information about the node behavior because there exist some nodes which are very close to the destination node but with less energy. Moreover, without knowing the buffer status of a node, if the data is forwarded, then it suffers from an unnecessary delay.

Some researchers focused on clustering and developed different clustering mechanisms to reduce the energy consumption in MANETs. S.V. Mangai and A. Tamilarasi [19] proposed An Improved Location aided Cluster-based Routing Protocol (ILCRP) in which all the nodes of a cluster are GPS enabled. In this approach, initially, the network is divided into different clusters. Next, they employed cluster maintenance to reconfigure and reorder the clusters. Finally, the route discovery process starts to establish an optimal route for a given source and destination node pair. This approach intensively utilized the clusters as well as location information for the routing process, and hence it gained a less control overhead. Next, Ranjith Anbalagan and Anitha Julian [20] proposed a routing mechanism called Handover Count Based Location Aided Routing (HCBLR) for Cluster networks which forwards the flooding messages only to the cluster heads that are present in the expected region. Due to this process, they claimed reduced energy consumption than the traditional LAR protocol and its subsequent approaches. Moreover, due to the accomplishment of the routing process only through cluster head, this method has achieved a reduced routing overhead, but it is not less than LAR because the clustering considers an entire area instead of only a request zone.

T.A.N. Abdali et al. [21] proposed a uniform Energy-Aware LAR (EALAR) by adopting an optimized Particle Swarm Optimization (PSO) via a uniform mutation operation. The conventional EALAR employed PSO [22] with a non0uniform mutation operation which makes the EALAR insufficient and provides improper solutions. However, the PSO-like algorithms introduce a huge computational burden due to their iterative problem-solving property. Similarly, Chaudhary R et al. [23] adaptively modified PSO and applied it in the Forwarding Search Space (FSS) heuristic technique to solve the slower convergence problem of PSO. In FSS, the forwarding zone is chosen between source and destination. Thereby the optimal solution lies in that area, and APSO is applied for an effective routing in the FZ area instead of a complete network.

Even though all the above methods focused on the minimization of energy consumption and improvisation of network lifetime, broadly, we observed the following drawbacks; (1). Only energy consumption parameters or residual energy won't contribute much towards the multi-hop node selection because they give only a little information about the current energy status of the node but not its probable deadline to die. For a sender node, it needs to know the data forwarding capability of the multi-hop nodes. (2) Due to the limited number of nodes available in LAR, most of the source nodes choose them only for data forwarding and making their buffer fill up quickly. As the buffer gets filled up, the nodes won't accept new packets, or simply they put the new packets in a queue and results in an increased delay.

To solve these problems, in our paper, we have considered two parameters, such as drain rate and buffer capacity, during the node selection. The first problem is solved by drain rate, and the second one is solved by buffer capacity. Along with these factors, we adopted Adaptive Location Aided Routing. Hence our method can achieve a reduced routing overhead along with improved network lifetime and QoS.

III. Proposed Method

A. Overview

In this paper, we propose a new routing mechanism for MANETs based on location, energy, and congestion. The basic theme of this paper is Location Aided Routing which is aimed at the reduction of control overhead in MANETs. However, the LAR didn't focus on the energy constraints of mobile nodes during data transmission. For a given network, the LAR determines only a portion of a network through which the routing packets are transmitted, which means only a few and limited nodes participate in the routing as well as the data transmission process. This entire process creates a huge energy consumption which has a direct impact on the network lifetime. Moreover, the limited availability of nodes in the request zone consequences to buffer overflow followed by huge packet drops. Hence, this paper concentrated on the design of an Energy and Congestion Aware Location Aided Routing (ECALAR), which simultaneously controls the overhead, energy consumption, and congestion. After route discovery through LAR, the source node has information about the nodes present in the request zone. Based on this information, the source node can change the nodes if it finds any of the nodes in the discovered path has more energy drain rate and more congestion. The energy drain rate is assessed through residual energy, and congestion is assessed through buffer capacity. The complete details of these two parameters are discussed in the following subsections.

B. Adaptive LAR

In this section, we briefly explore the Adaptive LAR (ALAR). ALAR is an extension to the traditional LAR, which aims at the reduction of control overhead more than LAR. In ALAR, an optimal request zone is derived based on the location of the source and destination nodes and their corresponding communication ranges. Unlike the request zone derived through LAR, whose sides are parallel to the horizontal and vertical axes, the request zone derived through ALAR has the sides parallel to the line connecting source and destination nodes. Moreover, the request zone of ALAR is rectangular in shape and tilted one which updates dynamically according to the movements of the source as well as the destination node. In the ALAR, initially, the expected zone is derived based on the communication range of the destination node. Next, four corner points are derived based on the current position of the destination node (x_d, y_d) And communication range (R). Consider the four corner points as $C_i, i \in \{1,2,3,4\}$, they are measured as

$$C_i(x,y) = (x_d \pm R,\ y_d \pm R) \quad (1)$$

In these four corner points, the first corner point is an extension of x_d and lies and the same y_d position, hence it can be written as $C_1(x,y) = (x_d + R,\ y_d)$. Next, the second corner point is an extension to the y_d and lies and the same y_d position, hence it can be written as $C_2(x,y) = (x_d,\ y_d + R)$. The third and fourth corner points are simply opposite to the first two corner points, and hence they can be written as $C_3(x,y) = (x_d - R,\ y_d)$ and $C_4(x,y) = (x_d,\ y_d - R)$. Based on these four corner points, the entire expected zone is divided into four regions. For every region, we derived a common coordinate based on two reference corner points. The subsequent coordinates of every region are named according to the reference corner points which were used for determination. Consider the region which lies in between second and third corner points, and then the common coordinate derived based on the two corner points $C_2(x,y)$ and $C_3(x,y)$, is named as $C_{23}(x,y)$. Similarly, for the region which lies in between the first and second corner points, then the common coordinate derived based on the two corner points $C_1(x,y)$ and $C_2(x,y)$, is named as $C_{12}(x,y)$. Hence the generalized representation for the common coordinate is shown as

$$C_{j(k)i}(x,y) = (x_d \pm R,\ y_d + R) \quad (2)$$

For the two common coordinates of top regions. Next, for the bottom two regions, the common coordinates are derived as

$$C_{p(q)r}(x,y) = (x_d \pm R,\ y_d - R) \quad (3)$$

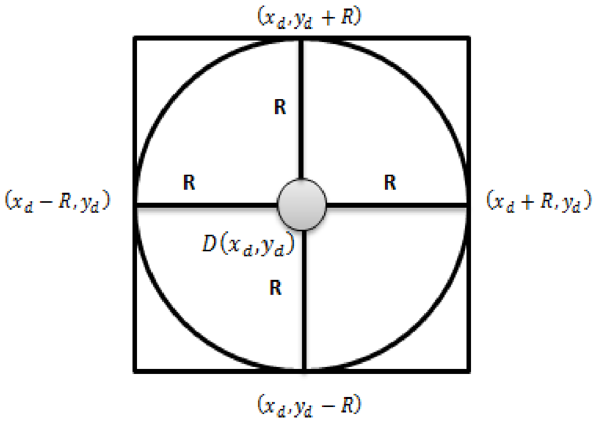
The common coordinate points derived through Eq.(2) are the common coordinates of the top two regions, while the coordinates derived through Eq.(3) are the common coordinates of the bottom two regions. Hence, at present, there are eight coordinate points for the destination node's expected zone. In the same manner, we derived eight coordinate points for the source node also. Hence the total number of coordinates is 16. Based on these 16 coordinates, the length of the optimal request zone is computed as

$$L = M_d^x - M_s^x \quad (4)$$

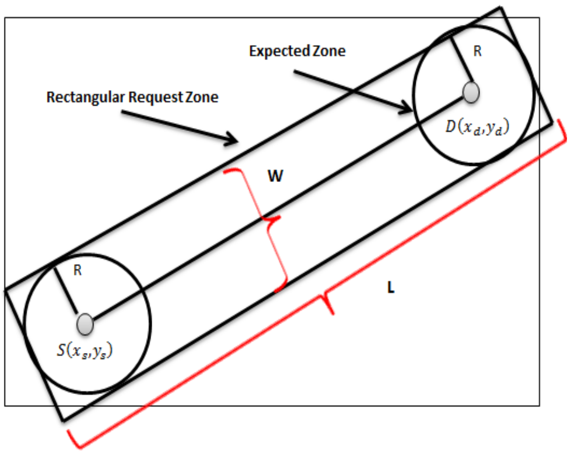
And the width is calculated as

$$W = M_d^y - M_s^y \quad (5)$$

Where M_d^x and M_s^x Are the maximum x-coordinate of destination and minimum x-coordinate of the source node, respectively. Next, M_d^y and M_s^y Are the maximum x-coordinate of destination and minimum y-coordinate of the source node, respectively. The following Figure.1(a) shows the region partitioning of the expected zone based on four major corner points, and Figue.1(b) shows the obtained rectangular and tilted request zone.



(a)



(b)

Figure.1 (a) Expected zone partitioning and (b) Rectangular and tilted shaped request zone

Once the request zone is derived, the source node broadcasts by specifying the location coordinates of the request zone, and every node checks its location with the locations present in the request packet and decides whether to forward the request packet or to discard it.

C. Energy Drain Rate

In the traditional LAR protocol, the mode selection is done based on location but not on other constraints like energy and buffer capacity. After route discovery, the source node transmits the entire data packets through the established path. If the topology is changed due to the movement of any mobile nodes participating in the data transmission, the source node will get updated information through HELLO packets, and based on that information, and the source node starts route discovery which introduces huge energy consumption. Moreover, in the established path, the common nodes receive the data packets from pre-hop nodes and forward them to the post-hop nodes. At this phase, there is a need for energy monitoring because a node with less residual energy can't support for a longer time in the data forwarding. The identification of such kinds of nodes is required; otherwise, the entire data packets may get dropped, which results in less Quality at the destination node. Hence the energy consumption details of a post-hop node are required to update at the pre-hop node such that it can take a decision whether to forward the next set of packets or not. Moreover, in the LAR, only a few nodes participate in the data transmission process, which results in a quick energy drain. As the energy consumption is more, the drain rate is fast and results in the quick die of mobile nodes. Hence in this work, the data transmission process considers the energy drain rate at every instance of data transmission.

In MANETs, the mobile nodes have limited energy, and there is no chance of energy replenishment. In the selection of multi-hop nodes, the energy status has a significant role. Hence this work considered energy consumption as one of the reference parameters at node selection. In general, the mobile node consumes more energy when it works under host mode. The main reason is due to the continuous reception and transmission of RREQ, RREP, data, and acknowledgment packets. Moreover, the mobile is found to have maximum energy consumption at the route discovery phase due to the rebroadcasting of RREQ packets. In the case of LAR, most of the methods didn't focus on the energy consumption means the source node transmits the data through only one fixed path (assumed to be no topology changes), which has fixed multi-hop nodes. Continuous assistance by common multi-hop nodes for data forwarding results in quick energy depletion. Hence the source node needs to keep on tracking the energy status of multi-hop nodes. Based on the residual energy status, the source node can decide whether to forward the data to the corresponding node or not. In general, there exist four modes in which the mobile nodes may present, they are namely sleeping, idle, receiving, and transmitting. Among these four modes, the first two modes, such as sleep and idle, have less energy consumption very much, and hence they are neglected here. Among the remaining two modes, the transmitting mode has a larger energy consumption because the energy required to receive packets is less compared to the energy required for packets transmission. Based on these analyses, the energy consumption of a node at time instant *t* is measured as the summation of receiving energy and transmitting energy. Here the residual energy is measured in a periodic fashion, and based on the obtained values, the node's energy drain rate is computed with reference to the initial energy of the corresponding node. Based on obtained energy drain rate, the node's forwarding capacity is measured. Consider a time instant *t*, the total energy consumed by a mobile node is calculated as [24]

$$E_{TT}(t) = E_{Tr}(t) + E_{Rr}(t) \qquad (6)$$

Where $E_{TT}(t)$ is the total energy consumed, $E_{Tr}(t)$ is the energy consumed due to the transmission of data packets and $E_{Rr}(t)$ Is the energy consumed due to the reception of data packets? The mathematical expression for $E_{Tr}(t)$ and $E_{Rr}(t)$ is shown as

$$E_{Tr}(t) = E_e \times k + E_a \times k \times d^2 \qquad (7)$$

And

$$E_{Rr}(t) = E_e \times k \quad (8)$$

Where E_e is the unit energy, E_a Is unit amplification energy, k is the number of bits, and d is the distance between transmitting and receiving nodes. Next, based on the total energy $E_{TT}(t)$, the residual energy left at a node is measured as

$$E_{Re}(t) = E_{Re}(t-1) - E_{TT}(t) \quad (9)$$

Where $E_{Re}(t)$ is the residual energy left at the node at time instant *t*, $E_{Re}(t-1)$ is the residual energy of a node at the previous instant. Based on the current residual energy, the energy drain rate is computed as

$$E_{dr}(t) = \frac{(E_I - E_{Re}(t))}{E_I} \quad (10)$$

Where E_I Is the initial energy present at a mobile node before starting data transmission? From this expression, we can say that the drain rate has an inverse relation with residual energy, as the higher residual energy, the less is drain rate and vice versa. Here the drain rate is time-dependent, and hence it can explore the node lifetime clearly such that the pre-hop node can get an idea about it and its forwarding capacity. A faster drain rate results in quick energy depletion. For a node to choose a next-hop node, it checks for more residual energy and a slow drain rate. Among the available neighbor nodes, the node selection is done, which can meet the above requirements. During the data transmission, if any node is found to have less residual energy, then it is removed from the route, and a new node is introduced into the path, which has a path to the destination node.

D. Buffer capacity

In LAR, the data transmission is accomplished only through a few nodes because the obtained request zone covers a limited number of nodes. For all e source and destination node pairs in that particular request zone, those few nodes only have to help in forwarding data. At this phase, these few nodes have to play routers for more than one node. For an obtained request zone, if more source and destination nodes are participating in the data transaction process, then the buffer of common multi-hop nodes fills up quickly. Since the multi-hop nodes have limited buffer size, they can't accept a huge flow of packets, and hence they may drop the packets. As the packet drop count increases, the quality of service decreases. Moreover, in MANETs, the mobile nodes play multiple roles like multi-hop forwarders, terminals, and routers, and also they need to transmit the control messages related to topology changes. When the amount of data is exceptionally high, the data traffic might get transmitted at a very low rate or might not get transmitted at all, which May consequences in its stagnation [25, 26]. Moreover, the congestion resulting from an excess amount of data packets that exceed the buffer capacity may also lead to packet loss by overflowing the buffer. In this work, we used a new metric called buffer capacity to measure the buffer status of neighbor nodes. Each forwarding node periodically samples the buffer length and communicates it to the source node as a part of HELLO packets.

Consider K to be the forwarding node, let b_j be the jth sample value which indicates the length of buffer at present instant and B be the total number of buffer length samples acquired over a time period, then the mean traffic at node K is computed as [27]

$$MT_K = \frac{1}{B}\sum_{j=1}^{N} b_j \quad (11)$$

Let b_{max} be the maximum size of the buffer of node K, then the buffer capacity at node K (BC_K) is measured as

$$BC_K = \frac{MT_K}{b_{max}} \quad (12)$$

Then the probability of successful packet forwarding by an intermediate node K is modeled according to the following expression

$$P_K = 1 - BC_K \quad (13)$$

Here the packet forwarding probability is linked with the buffer capacity, which means that the larger value of buffer capacity results in a lower probability of successful data packet forwarding. It also denotes that the larger node density normally results in more data traffic and hence the buffer capacity of the intermediate nodes results in lowering the probability of successful data forwarding.

In this work, after route discovery, the source node has information about possible nodes that have a path to the destination node. Based on this available information, the source node can change the multi-hop nodes if any node is found to have getting depleted or buffer overflowing. At this phase, the source node opts for the alternate nodes that are within the request zone. For every data transmission instance, the source node fetches the information related to residual energy and buffer capacity and takes the decision whether to forward the next set of packets or not. If the source node found any of the multi-hop nodes have less residual energy and buffer overflowing, then it chooses another alternative node for data forwarding. This process repeatedly happens such that the entire data packets will get delivered to the destination and preserves the quality of service. In case the node position is changing, the entire process is applied, and node selection is done based on residual energy and buffer capacity. For a change in node position of either source node or destination node, the proposed approach tunes the request zone according to the line connecting source and destination nodes. At this phase, the new intermediate nodes may enter, and the present nodes may move out of the request zone. These changes are updated dynamically through HELLO packets to the source node. Thus the proposed approach helps in reducing the RREQ overhead as well as enhances network lifetime, and improves the quality of service.

IV. Simulation Results

In this section, the complete details of simulation experiments are discussed. At first, we discuss the simulation set, i.es, the network environment created for the execution of the proposed methodology. Next, the discussion about the simulation results is explored. For this exploration, we have employed different performance metrics. Next, the performance comparison is also explained to elevate the effectiveness of the proposed method.

A. Simulation Setup

Under the simulation setup, initially, a random network is created with N number of nodes, and the network area is considered as 1000*1000 m^2. The creation of simulation setup is done in such a way that eh random nature of the mobile node could be realized. This means for every simulation, the positions of the nodes change randomly. Thereby the neighbor nodes also change. Once the mobile nodes are deployed in the network, every node finds its neighbor nodes based on their communication range. After the discovery, the source node broadcasts the route request packet, and based on the obtained route replies, a final path is established, and then the data transmission starts to the destination node. After the completion of data transmission from source to destination, the performance is analyzed through several performance metrics. To analyze the performance of the proposed approach, various kinds of simulations are conducted by varying different network parameters like Node speed and data rate. The node speed is varied from 5 m/s to 30 m/s, and the data rate is varied from 200 bits/sec to 1000 bits/sec. In the data transmission, the size of each packet is assumed as 100 bits, and it is kept constant at the simulation with varying node speed. On the other hand, at the varying data rate, the packet rate is varied such that the data rate also varies and node speed is kept constant. Table.1 shows the simulation setup details.

Table.1 Simulation set up

Network parameter	Value
Number of nodes	30
Network area	1000*1000 m^2
Transmission Range	25% of network area
Node speed	5 m/s to 25 m/s
Data rate	2 to 10 packets/sec
Nodes deployment	Random
Size of each packet	100 bits
Initial energy	100 mj
Maximum Buffer capacity	1000 packets

B. Results

Under the results section, the performance of the proposed approach is analyzed through four performance metrics such as Average Energy Consumption (AEC) in mille joules (mj), Delay in mille seconds, Packet Delivery Ratio (PDR), and Throughput (kbps). All these metrics are average values, and they are averaged for 25 runs. Furthermore, the comparison is drawn between the proposed ECALAR and several existing methods such as EELAR [9], ELAR1-VAR [10], and EAMLAR [13]. The comparison is done under two phases, they are (1) Varying node speed and (2) varying data rate.

a) Impact of varying node speed

Under this case study, we measure three performance metrics such as AEC, delay, and PDR. The node speed is varied from 5 m/s to 25 m/s. In general, as the node speed increase, the probability of link breakage is much high. In the conventional routing protocol such as AODV and DSR, there are no restrictions about locations. But the LAR strictly considers location; once the link breakage has happened, the availability of a link with another node is a slightly tough issue. Hence the node at which link breakage has to opt for the node which was available in its neighbor set. Based on this strategy, the observed consequences are described in the following figures.

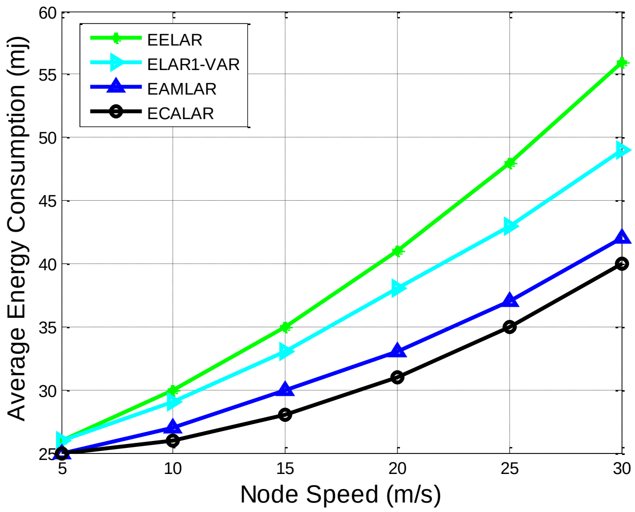


Figure.2 AEC for different node speeds

With an increase in speed, the mobile node changes its positions randomly and moves from one place to another place in a fast manner. In such a kind of environment, the links associated with the mobile nodes will break down. At that instant, the information sending node or source nodes have to search for an alternate node and has to retransmit the entire data. The data retransmission involves extra energy consumption, and hence the average energy consumption follows an increasing characteristic with node speed, as depicted in Figure.3. As the node movements are faster, the link breakages are huge in number, which all need data retransmission. To solve this problem, energy awareness is required, and it is provided in the proposed ECALAR through residual energy status. Hence the proposed ECALAR has less AEC when compared with the existing methods. Among the three earlier methods, the EAMLAR is recent, which considers the energy factor along with multipath routing. In case of route failure, the source node opts for the alternate route. Hence its AEC is nearer to the ECALAR's AEC. The remaining two methods, such as EELAR and ELAR1-VAR, considered energy factors but were not focused on the drain rate through which the node's sustainability can be estimated. The average AEC of the proposed ECALAR is observed as 30.8mj, while for existing methods, it is observed as 32.3mj, 36.9mj, and 39.5mj for EAMLAR EALR1-VAR and EELAR, respectively.

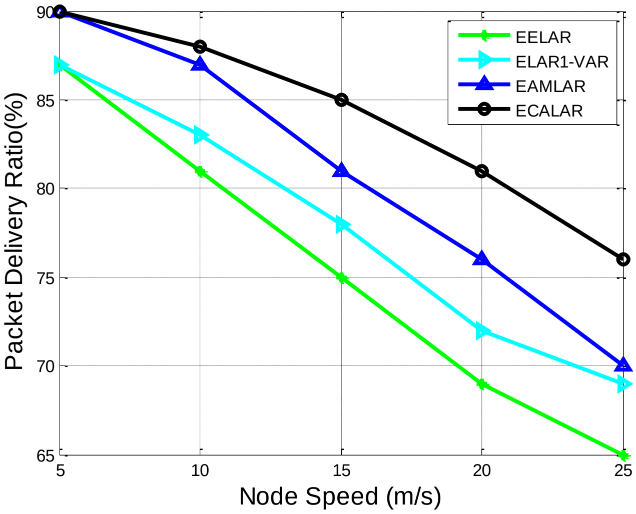


Figure.3 PDR for different node speeds

The node speed also has a significant impact on the information delivery at destination nodes. With an increase of node speed, the link breakage is high, and if any information is at the link, then the entire information will get dropped. As the packet drops are more, the PDR is less, which decreases linearly with nod speed. Hence, the sender node must have an awareness of the residual energy status of receiving node. The residual energy awareness is provided in the proposed ECALAR, and hence it has gained an optimal PDR even at larger node speeds, as shown in Figure.3. From this figure, we can see that the decreasing characteristics of existing methods are almost linear while the proposed method was exponential, which shows the least packet drops and optimal PDR. Even though the earlier methods concentrated on energy status, they didn't focus on the sustainability of nodes with their current residual energy status. The sustainability is dignified only through the drain rate, which was focused on in the proposed ECALAR. The average PDR of proposed ECALAR is observed as 80.5625%, while for existing methods, it is observed as 75.3214%, 71.2545%, and 65.3148%j for EAMLAR, EALR1-VAR, and EELAR, respectively.

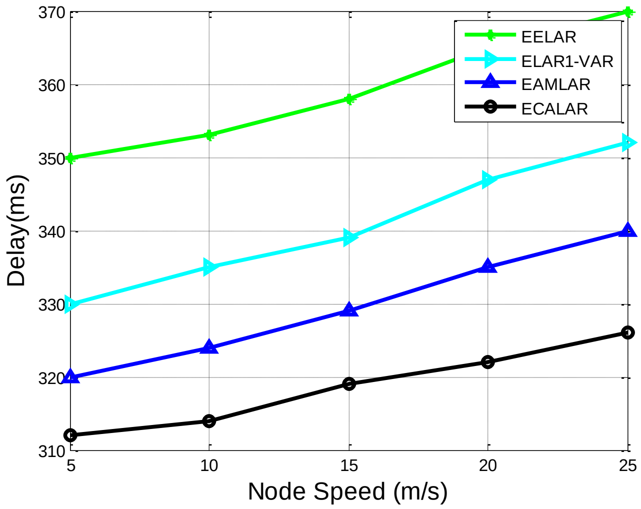


Figure.4 Delay for different node speeds

Delay is one of the important Quality of Service Assessment metrics that has a direct relation with node speed. As the node speed increases, the link breakages rise, followed by packet drops. Once the packet is dropped, it needs to retransmit, which consumes excess time and incurs an excessive delay. This delay rises exponentially with an increase in the speed of mobile nodes, as shown in Figure.4. Here, we consider the delay as the summation of route discovery delay and transmission delay. The major delay is due to route discovery, and the transmission delay has a minor effect. But, from the results, we observed that the retransmission of the packet induces an additional delay which can be called transmission delay and has significant. Hence the transmission delay is added and formulated as a delay. Due to the provision of energy awareness through EACLAR, the link breakages are less and result in less delay. The delay is a time factor that can be estimated accurately through the energy drain rate. As the mobile node energy drain rate is high, the delay is more because the drain rate is directly linked with node speed. The average delay of the proposed ECALAR is observed as 256.50ms, while for EAMLAR, EALR1-VAR, and EELAR, it is observed as 275.52ms, 285.32ms, and 300.24ms, respectively.

b) Impact of varying Data rate

Under this cases study, we measure three performance metrics such as AEC, delay, and Throughput. The data rate is varied from 2 packets/sec to 10 packets/sec. In general, as the data rate increases, the nodes have to spend more resources to forward the packets to their next-hop nodes because larger-sized data requires larger resources. Here, to analyze the effect of data rate on the network performance, it is varied, and the results are gathered. The obtained results are depicted in the following figures.

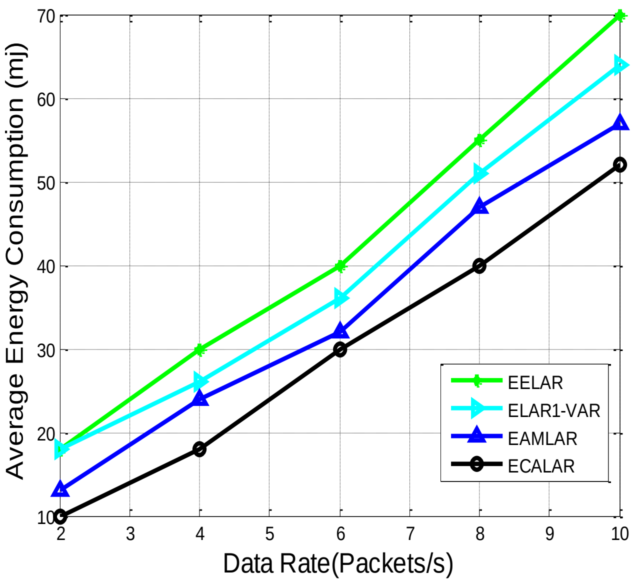


Figure.5 AEC for different data rates

With an increase in the data rate, the mobile nodes need to spend more energy to forward them. Hence the energy consumption rises with a rise in the data rate, as shown in Figure.5. However, with an appropriate selection of next-hop nodes, the energy consumption can be controlled. For this purpose, the pre-hop nodes need awareness about the energy statuses of next-hop nodes. This awareness is provided by the proposed ECALAR by calculating the drain rate and residual energy at a previous time instant. Based on these two factors, the mode selection is done such that the energy consumption can be controlled. If any node is found to have a faster drain ate and less residual energy, such node is chosen for data forwarding. Hence, the calculation of drain rate is also necessary, along with energy consumption. Due to this flexibility, the AEC of the proposed ECALAR is less when compared with the AEC of existing methods. The energy consumption of EAMLAR is high because it opted for multipath routing. The average AEC of the proposed ECALAR is observed as 30mj, while for existing methods, it is observed as 34.2145mj, 39.5647mj, and 42.1578mj for EAMLAR, EALR1-VAR, and EELAR, respectively.

Throughput has a linear relation with data rate, which means the throughput raises in proportion to the data rate. As the number of bits transmitted per second increases, the number of bits received at the destination node per second also increases. Hence, we can see a linear increment of throughput with data rate in Figure.6.

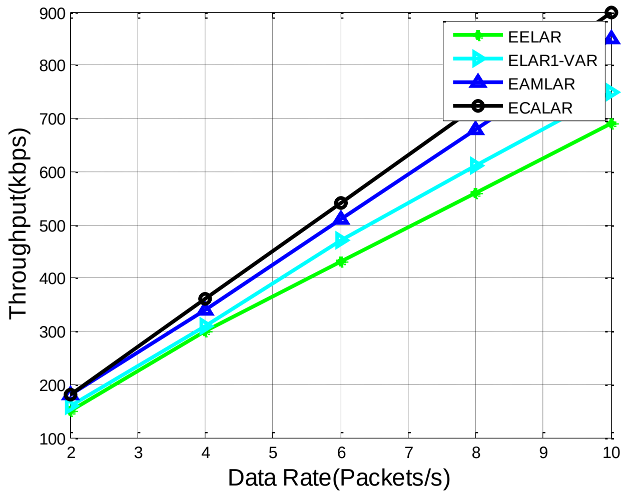


Figure.6 Throughput for different data rates

However, in the LAR, only a few nodes will participate in the data transmission process because of location constraints. This means only a few nodes will work as forwarders for multiple source nodes. This situation raises slight congestion followed by packets buffering at intermediate nodes. Hence throughput slightly deviates from linear increment. Hence the awareness of buffer capacity is required, which was provided through ECALAR. Compared to the existing methods, the throughput of the proposed approach is high because no earlier method included a buffer capacity metric at next-hop node selection. The average throughput of the proposed ECALAR is observed as 550 kbps, while for existing methods, it is observed as 490kbps, 450kbps, and 420kbps for EAMLAR, EALR1-VAR, and EELAR, respectively.

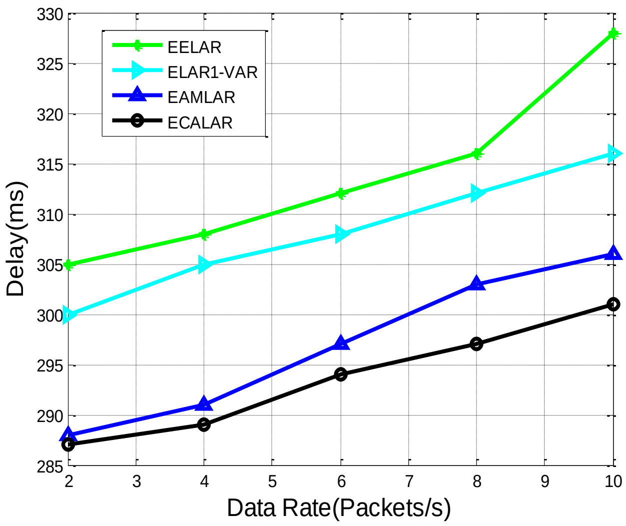


Figure.7 Delay for different data rates

In LAR protocols, only a few nodes participate in the data transmission, and they have limited buffer capacity. If they are working as forwarders for more nodes, then their buffer will fill up quickly. Once the buffer is coming to fill, they may drop the packets, or they may put the incoming packets in the queue. In the first case, the PDR falls down, and in the second case, the delay increases. Moreover, the increment in delay rises even with the data rate (number of packets transmitting per second), as shown in Figure.7. In such conditions, the sender node needs to know the current buffer capacity of next-hop nodes. This kind of awareness is provided through ECALAR, and hence it has gained less delay compared to the existing methods. Moreover, among the existing methods, the recent method EAMLAR also has less delay compared to EELAR and ELAR1-VAR. Since the EAMLAR accomplished multipath routing, the data is segmented and transmitted on multiple paths; the storage overload is less on nodes. Hence the difference of delay between proposed and earlier methods is high, which shows that the proposed approach can achieve a better QoS. The average delay of the proposed ECALAR is observed as 293.6ms, while for EAMLAR, EALR1-VAR, and EELAR, it is observed as 300.5ms, 322.4ms, and 324.24ms, respectively.

V. Conclusion

In location-based routing, the major focus is made on the control overhead, but only less contribution is done towards resource utilization and QoS preserving. In MANETs, control overhead indirectly lessens the energy consumption but raises new problems like less network lifetime and less QoS. Hence, this paper aimed at these issues and introduced a new strategy that includes energy and buffer capacity as additional factors in the LAR-based routing process. Based on energy consumption, the residual energy status and energy drain rate are measured. These two factors lessen the burden on the nodes in the request zone and help in the improvisation of network lifetime and QoS. Simulation experiments with varying network parameters proven the effectiveness of the proposed ECALAR in preserving network resources with sufficient QoS.

REFERENCES

[1] G. A. Walker, R. C. Biradar, A survey on hybrid routing mechanisms in mobile ad hoc networks, Journal of Network and Computer Applications (77) (2017) 48-63.

[2] M. Amadeo, C. Campolo, A. Molinaro, Forwarding strategies in named data wireless ad hoc networks: Design and evaluation, Journal of Network and Computer Applications, (50) (2015) 148-158.

[3] S. Choudhary and S. Jain, A survey of energy-efficient fair routing in MANET, International Journal of Scientific Research in Science, Engineering and Technology, (1) (2015) 416–421.

[4] D. B. Johnson, D. A. Maltz, Y. C. Hu, The Dynamic Source Routing Protocol for Mobile Ad Hoc Networks (DSR), IETF MANET DRAFT RFC 4728, (2007).

[5] MohanapriyaMarimuthu and Ilango Krishnamurthi, Enhanced OLSR for Defense against DOS Attack in Ad Hoc Networks, Journal of Communications and Networks, 15(1) (2013).

[6] S. Das, C. Perkins, E. Royer, Ad hoc on-demand distance vector (AODV) routing, 2ndIEEE Workshop on Mobile Computing Systems and Applications, New Orleans, LA, USA, (2002).

[7] Y. Ko and N. H. Vaidya, Location-Aided Routing (LAR) in Ad-hoc mobile networks, Wireless Networks, (2000) 307-321.

[8] Mohammad A. Mikki, Energy Efficient Location Aided Routing Protocol for Wireless MANETs, (IJCSIS) International Journal of Computer Science and Information Security, 4(1 & 2) (2009).

[9] Chandresh G. Ghodasara and Radhika D. Joshi, Energy Conservation using Location Aided Routing Protocol in MANET, In Proc. of the Intl. Conf. on Advances in Electronics, Electrical, and Computer Science Engineering—EEC (2012) 439-446.

[10] Nivedita N. Joshi and Radhika D. Joshi, Energy conservation in MANET using Variable range location aided Routing Protocol, International Journal of Wireless & Mobile Networks (IJWMN), 3(5) (2011).

[11] Aakash Jasper, Rajeev Paulus, Shubhanshi Rathore, Improvement of LAR1 Routing Protocol, 3rd International Conference on Recent Trends in Computing 2015 (ICRTC-2015), (2015) 77-83.

[12] Ko, Y.B and Vaidya, N.H., Location-aided routing (LAR) in mobile ad-hoc networks, in ACM/IEEE International Conference on Mobile andComputing networking(Mobicom'98), (1998) 66-75.

[13] A. G. Shaji, H. Naveen, and Manju Kaushik, Energy-Aware Multipath Location Aided Routing For MANET, International Journal of Computer Science and Information Security (IJCSIS), 14(12) (2016).

[14] Dixit, Prashant; Pillai, Anuradha; Rishi, Rahul, QoS Enabled Improved Location Aided Routing (QEILA), Recent Patents on Engineering, Volume 13(1) (2019) 28-38(11).

[15] Priya Mishra, Saurabh K Raina, and Buddha Singh, Effective fuzzy-based location-aware routing with adjusting transmission range in MANET, International Journal of Systems, Control, and Communications, 7(4) (2016).

[16] Khusbhoosingh, Anubav Singh and Nikhil Kumar Singh, Linear Regression-Based Energy-Aware Location-Aided Routing Protocol for Mobile Ad-Hoc Networks, International Conference on Computational Intelligence and Communication Networks (CICN), Jaipur, India, (2015).

[17] Dahai Du and HuagangXiong, A Location aided Energy-Efficient Routing Protocol for Ad hoc Networks, The 19th Annual Wireless and Optical Communications Conference (WOCC 2010), Shanghai, China, (2010).

[18] Jangsu Lee, SeunghwanYoo, and Sungchun Kim, Energy-aware Routing in Location-based ad-hoc networks, 4th International Symposium on Communications, Control and Signal Processing (ISCCSP), Limassol, Cyprus, (2010).

[19] S.V. Mangai, A. Tamilarasi, A new approach to geographic routing for location aided cluster-based MANETs, EURASIP Journal on Wireless Communications and Networking, (2011) 18.

[20] Ranjith Anbalagan and Anitha Julian, Handover Count Based Location Aided Routing for Cluster Networks (HCBLR), IEEE International Conference on Advanced Communications, Control and Computing Technologies, Ramanathapuram, India, (2014).

[21] T.A.N. Abdali, R. Hasan, R. C. Muniyandi, Optimized Particle Swarm Optimization Algorithm for the Realization of an Enhanced Energy-Aware Location-Aided Routing Protocol in MANET, Information 11 (2020) 529.

[22] Kennedy, J., Eberhart, R. Particle swarm optimization, In Proceedings of the ICNN'95-International Conference on Neural Networks, Perth, Australia, 27(1) (1995) 1942–1948.

[23] Chaudhry, R.; Tapaswi, S., Kumar, N., Forwarding Zone enabled PSO routing with Network lifetime maximization in MANET, Appl. Intell. 48 (2018) 3053–3080.

[24] Nguyen, T.D., Khan, J.Y., Ngo, D.T., A distributed energy-harvesting-aware routing algorithm for heterogeneous IOT networks, IEEE Trans. Green Commun. Netw. 2 (2018) 1115–1127.

[25] Z. Chen, Z. Ge, and M. Zhao, A load-based queue scheduling algorithm for MANET, J. Commun. Comput., 3(8) (2006) 11-16.

[26] S. Kumar, Y. Chaba, and A. Amandeep, Performance analysis and comparison of scheduling algorithm in MANETs, Netw. Commun. Eng., vol. 3(14) (2011) 909-914.

[27] J. Y. Kim, G. S. Tomar, L. Shrivastava, S. S. Bhadauria, and W. H. Lee, Load balanced congestion adaptive routing for mobile ad hoc networks, Int. J. Distrib. Sensor Netw., 10(7) (2014) 1-10.