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Fuzzy based Location Aided Routing Protocol to Minimize the Energy Consumption in MANETS

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Abstract:- Mobile Ad-hoc Network (MANET) consists of self-organizing, self-configuring low power mobile devices. Due to mobility link failures and route failures take place in the wireless network. So, Routing is one of the not easy tasks in MANETs. Link failures and route failures depends on Hello Interval Time (HIT). Optimization of HIT minimizes the link failures and route failures. As per IETF draft, de-facto value of HIT is not suitable for real time environment. Therefore, HIT place a vital role in energy consumption of LAR protocol in MANETs. Energy consumption is one of the challenging tasks in MANETs and it mainly effects on the lifetime of the network. An effort is made to fine tune configuration parameter HIT of LAR protocol by using Fuzzy Logic. In this paper, we proposed a Fuzzy Based inference system for analyzing the performance of LAR routing protocol (FBPSLAR) by varying network size in MANETs. The performance is evaluated by using different QoS metrics such as throughput, end-to-end delay and total energy consumption etc. Our simulation results show that total energy consumption is reduced by FBPSLAR in small, medium and large networks in comparison with PSLAR. The Total energy consumption reduced by 27.16% in small network, 38.23% in medium network and 35.13% in large network.

Keywords:- *MANET, Routing protocols, LAR, Fuzzy Logic, FBPSLAR.*

I. INTRODUCTION

Mobile Ad-hoc Network (MANET) is termed as an independent and self-configuring group of clients and servers connected by wireless links with the property of moving in the absence of fixed centralized infrastructure [1]. This network requires efficient distributed algorithms which are utilized to regulate the connectivity of network organizations, link scheduling, and routing. The efficiency of routing algorithms in networks is based on the route estimation. The shortest path depending on network metrics from a source to a destination is generally the optimal route in static networks, this is not that easily applicable to MANETs. Some factors like quality of wireless links, power, path losses, fading, interference and topological changes need to be measured in order to determine a new route [2]. In MANETs, the shortage of any of these necessities may lower the performance and consistency of the network many routing protocols for MANETs are defined with features like security, distributed operation, creation of loop free paths and QoS [17]. MANETs routing protocol has a standard that directs nodes to select the optimized route to forward packets in a mobile ad-hoc network[3].The routing protocols are essential to offer various levels of QoS to various applications of users.

The applications of MANET technology started gaining momentum in a variety of fields. These include military operations, policing and fire-fighting services, disaster management, industry and commercial enterprises. Another major area of application is the home or small office networking and collaboration computing with laptop have appeared facilitating conferences and convention centers. The applications of ad hoc networks also facilitate to tackle the emergency and rescue operations.

The limitations of power consumption set by small wireless radios lead to a node transmission range which is naturally insignificant comparatively with the lifetime of the networks. In mobile ad-hoc networks, the mobile terminals cannot always have direct radio links to all radio terminals in the network. this will result in a multi-hop networks with dynamic topology. Consequently, the terminals communicate with each other directly or indirectly, using relaying stations via intermediate mobile hosts. Due to limited power supply in a node, energy exhaustion is a risk to the network lifetime [4]. Efficient routing protocol is necessary in MANET. It is tough to change battery of a node in battle field and natural disaster relief operations. Therefore, it is very important to conserve power in MANETs as it increases network lifetime and capacity of the network [16]. Data processing and radio communication consumes maximum power by mobile computing devices. In Radio Communication, a mobile node in MANETs has the following modes: Transmit (Tx) Mode, Receive (Rx) Mode and Idle Mode.

According to IETF draft, fixed values do not seem to be appropriate for dynamic environment; defacto value of Hello Interval Time (HIT) is 3sec. It is a time sensitive problem. This can be solved by soft computing technique. Fuzzy Inference engine is able to fulfill these needs and helps in achieving a solution to route finding.

This paper is structured as follows: section II reviews the related work. Section III gives a concise explanation of the routing protocols. Section IV presents the Fuzzy Inference System. Section V describes methodology used. Section VI describes details of the simulation environment. Section VII describes Simulation results. Finally, section VIII presents our conclusion.

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II. RELATED WORK

Masoumeh Karimi et al., in their work analyzed the dynamic nature of MANETs. The author paid a special attention on basic difficulties and challenges that occur when trying to provide quality of service in this environment. Finally, they concluded with the necessity for new architectures and services for regular network controls for accomplishing good quality of service in MANETs [5]. Yangcheng et al., analyzed numerous strategies for updating topology in table driven routing to comprehend how these strategies impact the total performance. They included (1) a quantitative analysis on the impact of table driven update intervals on the performance of routing; (2) estimating the performance of on-demand topology updates and table driven updates for table driven routing protocol [6].

AbedalmotalebZadin et.al in their work entitled "Effect of HELLO Interval Duration on Stable Routing for Mobile Ad Hoc Networks", studied the impact of variation in HELLO interval duration on the performance of a routing protocol by utilizing the backup paths [7]. Er. HanishaGoyal et al., in their work entitled "Performance Investigation of DYMO, DSR, AODV and LAR Routing Protocols using Different Mobility and Energy Models in MANETs " investigated various scenarios by varying number of nodes, maximum velocity of the mobile nodes, Pause time and Packet size. Performance analysis is done on the basis of Throughput, Packet delivery ratio, Jitter, End to End Delay, Total Energy Consumption under different mobility and Energy models and they presented that mobility models and energy models have great effect on the performance of routing protocols.[8].

M.Uma et al, in their work entitled "A comparative study and performance evaluation of reactive quality of service routing protocols in mobile ad hoc networks" studied a comparison and performance evaluation of three reactive routing protocols AODV, DSR and LAR1 are done using qualnet simulator to identify the protocol that is best suited for MANETs**.**[9] Rajeev Paulus et al., in their work entitled "Performance Comparison of AODV, DSR and LAR1in Mobile Adhoc Networks based on Simulation Time" investigated performance estimation of mentioned protocols based on Average end to end delay, Average jitter and Packet delivery ratio by varying simulation time.[10].

Mohammad Ali Hussian, et al, in their work entitled "Energy Conservation Techniques in Ad Hoc Networks", investigated the cost of energy consumption and mechanisms to minimize the cost of energy consumption. The authors focused on particular MAC layer protocols which save energy. In their work, they have presented some proposals and specifications for achieving energy conservation [11]. Anil Yadav, et al, in their work entitled "A novel Approach for Energy Management in Wireless Ad Hoc Network by Topology Control", provided a summary on topology control problem. The authors compared their algorithm with two algorithms proposed by Lie Hou [12]. Hideyuki Takagi, in their work entitled, "Introduction to fuzzy systems, neural networks and genetic algorithms", introduced the fundamental ideas and actual methodologies for fuzzy systems, neural networks, and genetic algorithms. The attention is focused on two aspects- a) the similarities among the three technologies; b)Implementation of these technologies at a programming level [13].

A.Gowri, et al., in their work, "A Review: Optimal Path Selection in Ad hoc Networks using Fuzzy Logic" observed various challenges in achieving efficient routing. According to these authors there exists number of paths between source and destination. Among those paths, one of the routing paths is selected using any one of the available routing algorithms. Their work mainly involves the effective routing paths having smart routers to transfer data using fuzzy[14]. M. N. Doja et al. in their work entitled "Analysis of Reactive Routing Protocol Using Fuzzy Inference System" focused on two reactive routing protocols (AODV, DSR) for MANETs using Fuzzy Logic. The activities of these protocols is analyzed and observed that the usage of fuzzy inference system supports actual applications[15].

III. ROUTING PROTOCOLS

Numbers of routing protocols have been designed for MANETs. There are three main categories of routing schemes: Proactive, Reactive and Geographical position based routing protocols. Proactive protocol always broadcasts control message periodically to know the recent route to all destinations. This type of routing consumed huge amount of bandwidth for routing. These table driven protocols are less suitable for Mobile Ad-Hoc networks because of its constant power consumption, irrespective of the activity of network. Reactive protocol finds routes to its destination by initiating a route discovery procedure on demand only when data packets are to be transmitted.

Position based routing protocol utilizes location information of the nodes to find the correct location of the target node. By using location information, it provides more consistent as well as efficient routing through Global Positioning System (GPS).The performance of the position based routing protocols is greatly improved than topology based routing protocols. It shows better scalability, robustness compared to repeated topology changes. The performance of the network can be increased by using this type of protocols. Routing is completed in a hop-by-hop mode to send the data packets from sender to receiver. This type of routing is basically depending on location information to forward the data packet, rather than to keep the entire network information. This decreases the routing overhead in the network. One of the position based routing protocols is LAR (Location Aided Routing).

- *Location Aided Routing (LAR) Algorithm*

Position based LAR utilizes location information to improve the performance of the network. In order to reduce overhead, power utilization and to enhance performance of the network, position based LAR uses possible information to direct

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the target. LAR Protocol is a source based on-demand geographical routing protocol. The newness in the LAR is calculation of location of the target node that increases the efficacy of the route discovery process. The main aim of Position-based LAR is to decrease the control overhead by means of location data.

After source identifies that target node was located at (X_d, Y_d) at time t_0, expected zone at time t_1 defined as a circle of radius R = $v(t_1-t_0)$ centered at location (x_d, y_d) where v is the average speed with which destination can move. The request zone is well-defined as the smallest rectangle that contains the present location of S and the expected zone. If the source is inside the expected zone, the size of the request zone is reduced .

IV. FUZZY INFERENCE SYSTEM (FIS)

The Fuzzy technique involves classifying input data qualitatively to large, low, medium and many. Input data classification helps in analyzing random data and coming up with a set of broad category of rules. Lotfi Zadeh proposed " A set of membership ideas to many suitable decisions when ambiguity occurs and increasing degree of membership to adapt to a real time systems [0,1] [18] [19].

The advantages of fuzzy logic are:
- Natural language dependency
- its ease in understanding
- adaptability to adjust errors
- flexible
- Conventional control techniques are used for development

Membership Function determines how input point is mapped to a membership value ranging 0 to 1. Some of the typical membership functions used for modeling are Piecewise linear curve, Gaussian distribution curve, sigmoid function, quadratic function and cubic polynomial function. Triangular membership function is the simple one to implement. The main advantage of triangular membership function is its simplicity. Fuzzy if-than rules are of the form: if "x" is m them "y" is n, where m and n are mapped input and output values. Antecedent is the if section of the rule and consequent or conclusion is then part of the rule. Fuzzy system evaluates the antecedents and applies the rules on the consequent. Hence if antecedent is true to a particular grade of membership them conclusion becomes true to the some extent.

Framework of mapping input data to output data based on fuzzy logic consists of fuzzy inference. There are two types of inferences:
1. Mamdani FIS generates simple fuzzy set output.
2. Sugeno FIS provides an output that is weighted linear mathematical expression or constant.

1. Mamdani FIS provides the following advantages. This method is intuitive and well suited to human input. As such it commands widespread acceptance.
2. The advantage of sugeno model is that method works well not only with linearly techniques but also with optimization and adaptive techniques and it is computationally efficient and mathematically easily implementable. Due to mobility, there is dynamic change in structure of the network. Because of this dynamic topology link failures and route failures take place in the network. So, Routing is one of the interesting areas of research in MANETs. Link failures and route failures depends on Hello Interval Time (HIT).

Optimization of HIT minimizes the link failures and route failures. As per IETF draft, de-facto value of HIT is not suitable for real time environment. Therefore, HIT places a vital role in energy consumption of LAR protocol in MANETs. Due to limited power supply in a node, energy exhaustion has become a severe threat to the ad-hoc network lifetime. So, energy consumption in MANETs has become a research problem. Fine tuning of de-facto value of HIT is calculated by Network size and Mobility as inputs and Hello Interval Time as output. The FIS developed in this work takes two inputs: network size and mobility and gives hello interval time as its output. This is shown in figure 1.

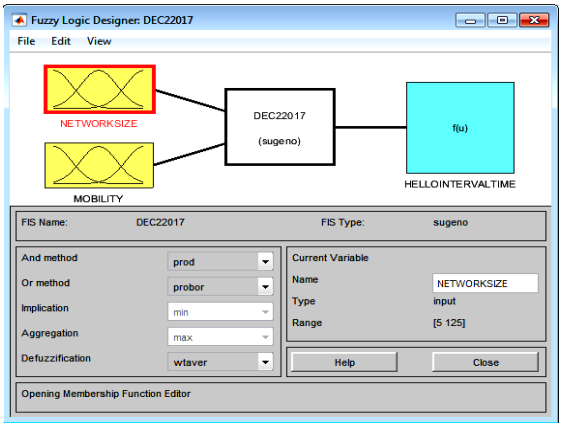

Fig 1:- Fuzzy Logic Inference System

The steps in fuzzy inference system are:

- *Fuzzy inputs*

Maps to some suitable fuzzy sets using membership functions.

- *Degree calculation*

When inputs are fuzzified, one can know the grade, each of the if section fulfils to the fuzzy rules.

- *Implication method*

In this every rule has weight (0 to 1) and is applied to antecedent inputs.

- *Aggregative method*

Defines a procedure that maps fuzzy output rule into aggregated single fuzzy set.

- *Defuzzyfication process*

Converts fuzzy output to crisp output.

Pseudo code for Fuzzy based PSLAR
- // Algorithm for calculation of dynamic Hello Interval Time for LAR using fuzzy logic
- // input1 : Network size

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- // input2 : Mobility
- // output : Hello Interval Time
- Start
- Set Fuzzy inference system ← sugeno;
- Set input1 Name ← Network Size;
- Set range of input1 ← [1, 120];
- Set number of Membership function for input1 ← 3;
- Set type of Membership function for input1 ←triangular;
- Set input2 Name ← mobility;
- Set range of input2 ← [5, 25];
- Set number of Membership function for input2 ←3;
- Set type of Membership function for input2 ← triangular;
- Set output Name ← Hello Interval Time;
- Set range of output ← [1, 8];
- Set number of Membership function for output ← 3;
- Set type of Membership function for output ← Constant;
- Write fuzzy if - then rules ;
- Set De-fuzzification method ← centroid;
- Choose rule viewer for evaluation;
- Record dynamic mobility for the given inputs;
- Select 3-D surface viewer;
- Stop.
- End procedure.

The first input parameter, netwoek size along with membership function with low medium and high ranges are shown in the figure 2.

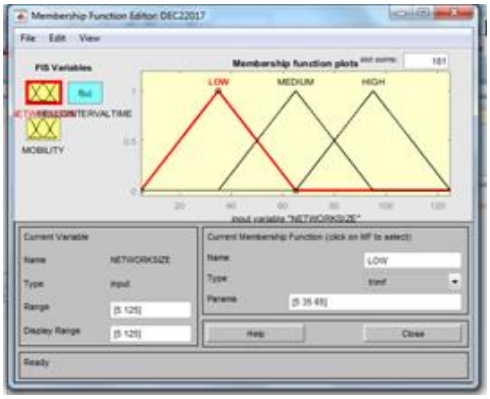

Fig 2:- Fuzzy membership functions

The fuzzy association rules are given in the figure 3, fuzzy association rules viewer is shown in figure 4 and 3D fuzzy surface viewer is shown in the figure 5..

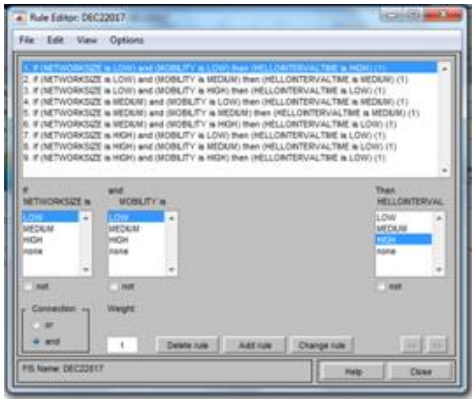

Fig 3:- Fuzzy rules in rule editor

Fig 4:- Fuzzy rule viewer

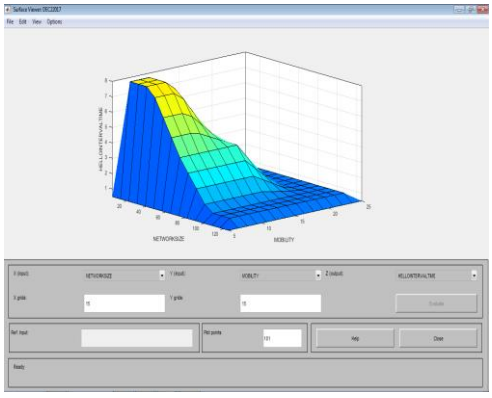

Fig 5:- Fuzzy surface viewer

V. METHODOLOGY

Several scholars have suggested number of solutions to provide QoS in dynamic MANET. To evaluate the designs proposed, researchers choose one of the most suitable evaluation methodologies are Simulation, Experimental and Mathematical Experimental methodology is not so practicable and mathematical methodology is highly restrictive, hence Simulation was selected. Among the simulators used for MANETs, the simulators which were identified popular are NS2, OPNET, Qualnet and EXata 5.4 etc. Simulation plays an important role in MANET technology.

To perform evaluations of routing protocols, researcher can assess different metrics on real network ,simulation can be used. Actual testing is not economic, because sufficient hardware is

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required. As the network size increases, the cost to setup a network also increases. It is more advantageous to make use of simulators, which permits a great change in the configurable parameters. The simulation takes very less time, whereas real time testing would need real physical time. So, simulation is used as research methodology in this work.

VI. SIMULATION ENVIRONMENT

The main purpose of this simulation work is to evaluate the performance of FBPSLAR using Random node deployment model in MANET's. The simulations have been carried-out within a 1000m X 1000m area for constant pause time and simulation time. The simulations are done using EXata version 5.4 simulator. Table 1 shows configuration parameters used in the simulation process.

Simulation Parameter	Parameter Value
Simulator	EXata-5.4
propagation model	Two Ray Ground
Mobility Model	Random Way Point
Simulation time (s)	900
Pause time (s)	0
Speed (m/s)	10
MAC Layer	IEEE 802.11
Traffic	CBR
Packet Size (bytes)	512
Antenna type	Omni directional
Terrain Region	1000 X 1000 m^2
Battery model	Linear
Data rate	2 Mbps
Network Size	30, 60, and 90 nodes

Table 1

VII. RESULTS AND DISCUSSION

We compare the results of proposed FBPSLAR protocol with the PSLAR protocol. The following performances metrics are considered for evaluation in the application layer and physical layer, by varying network size. We considered 30 nodes in small, 60 nodes in medium and 90 nodes in large network.

Throughput: The amount of data transferred over the period of time expressed in bits per second.

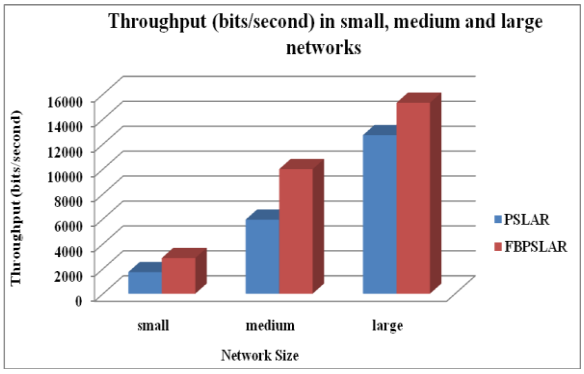

Fig 6:- Throughput for small, medium and large networks

From the above graph, Throughput is more in the case of FBPSLAR than PSLAR in small, medium and large networks. Average End-to-End Delay: This comprises of all possible delays produced by route discovery latency, re-transmission on delays at MAC and queuing at the interface queue etc.

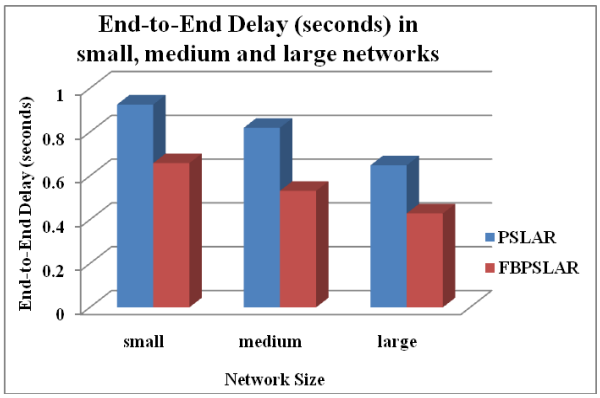

Fig 7:- End-to-End Delay for small, medium and large networks

From the above graph, End-to-End Delay of proposed FBPSLAR is less when compared to PSLAR protocol in small, medium and large networks.

Energy consumed (in mWh) in Transmit mode:

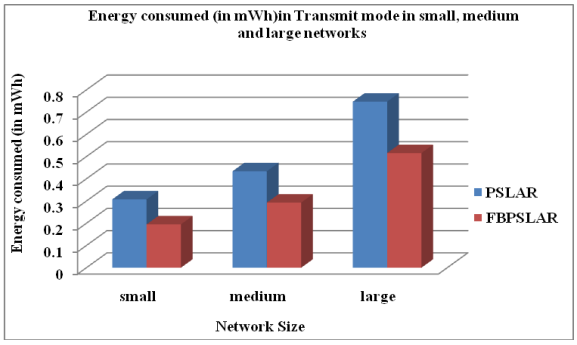

Fig 8:- Energy consumed in transmit mode for small, medium and large networks

From the above graph, Energy consumed in transmit mode is less in FBPSLAR when compared with PSLAR protocol in all network sizes.

Energy consumed (in mWh) in Receive mode:

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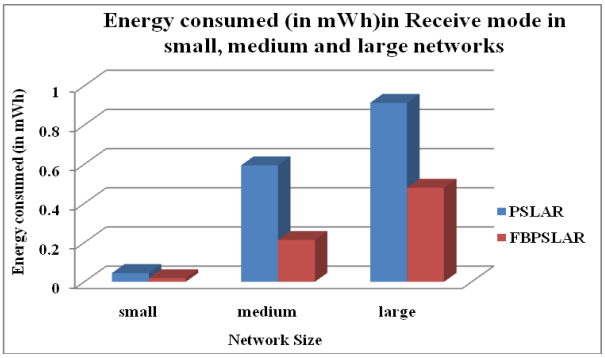

Fig 9:- Graph of Energy consumed in Receive mode for small, medium and large networks

From the above graph, Energy consumed in receive mode is less in FBPSLAR when compared with PSLAR protocol in all network sizes.

Energy consumed (in mWh) in Idle mode:

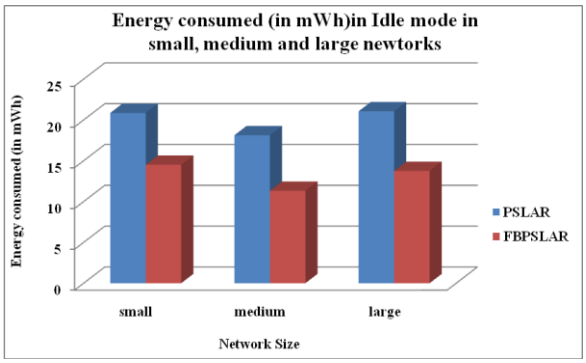

Fig 10:- Energy consumed in Idle mode for small, medium and large networks

From the above graph, Energy consumed in idle mode is less in FBPSLAR when compared with PSLAR protocol in all network sizes.

Total Energy consumed (in mWh): It is the summation of the energies consumed in Transmit mode, Receive mode and Idle mode.

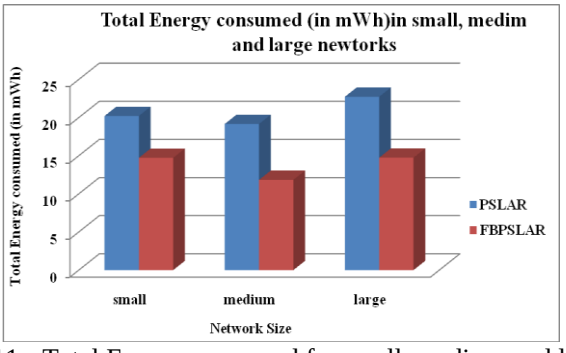

Fig 11:- Total Energy consumed for small, medium and large networks

From the above graph, Total energy consumed is less in FBPSLAR when compared with PSLAR protocol in all network sizes.

VIII. CONCLUSION

In this work, we performed simulation based performance analysis of proposed FBPSLAR protocol to minimize the energy consumption of LAR in MANETs. From the simulation results, we observed that the End-to-End Delay, Total energy consumption are considerably reduced with the increase in Throughput when compared with PSLAR protocol. The throughput was enhanced by 65.48%, end-to-end delay was reduced by 28.9% and total energy consumption was reduced by 27.16% in small size networks. The throughput was enhanced by 68.24%, end-to-end delay was reduced by 35.1% and total energy consumption was reduced by 38.23% in medium size networks. The throughput was enhanced by 20.42%, end-to-end delay was reduced by 33.84% and total energy consumption was reduced by 35.13% in large size networks. In future this work may be extended to minimize energy consumption in MANETs to enhance the life time of the network using other soft computing techniques.

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