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A Green LANMARK Routing Protocol in Mobile Ad hoc Networks

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Abstract

Networking Technology as changed the saying "necessity is the mother of invention" to "Comfort is the mother of invention" as it took the mankind to another level of the sophistication. It has evolved rapidly over the past few years that a communication with a simple two-way pager to being able to converse from one edge of the planet to the other edge through devices that has the property of moving. Such wireless technology includes the wireless devices like laptops, tablets, mobile phones and routers etc., and information technology equipment integration. The assemblage of wireless self-organizing mobile devices forms a mobile ad hoc network (MANET)as it doesn't deprive any infrastructure. MANET has several real-time applications. Devices in the MANET are energy constrained as they work on limited battery power. Saving energy is our big concern. An investigation discloses that the information, communications and technology (ICT) industry adds about 2% of global CO_2releases. Green is a simple way to live in harmony with the Mother Nature confronting the radiation. Minimization of energy consumption results in increased operational lifetime of the whole network. An attempt has been made implement green Landmark routing protocol (LANMAR)in MANETs by using the concept called fuzzy logic in EXata simulator/Emulator and MATLAB. To measure the performance of the green LANMAR, the proposed methodology uses seven metrics: throughput, Control overhead, number of control packets, energy consumption in transmit_mode, receive_mode, idle_mode and total energy consumption over different scales of network size. The proposed green LANMAR called Fuzzy-LANMAR routing protocol performs comparatively better.

Keywords: Green, LANMAR, Ad hoc, Fisheye, Fuzzy Logic, EXata, DoE, FUI.

I. INTRODUCTION

It is very phenomenal that the networking technology has remarkably grown from being no more than a simple two-way pager to being able to converse from one edge of the planet to the other edge through devices that has the property of moving. It has changed the notion of a great saying "Necessity is the mother of invention" to "Comfort is the mother of invention" as it took the living standard of mankind to another level of the technical sophistication. Such wireless technology includes the wireless devices like laptops, tablets, mobile phones, routers etc., and information technology equipment integration.It is always obvious that every technology s and cons.

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A novel investigation discloses that the information, communication and technology (ICT) industry releases about 2% of global CO_2.ICT industry comprising of Internet and cloud services, releases>830 million tons of CO_2 each year.CO_2 is one of the crucial greenhouse gases that is reason for the rise in global temperatures. Researches warn that the releases of carbon by the ICT sector may double in 2020. All over the world, numerous studies started highlighting on the shattering effects of massive greenhouse gases (GHG) emissions resulting in climate changes. Carbon footprint of the ICT includes the internet and the usage of internet, l**eaves a lasting effect on the environment.** Such wireless technology includes the wireless devices like laptops, tablets, mobile phones, routers etc., and information technology equipment integration.

McMaster Associate Professor. LotfiBelkhir with his teammate Ahmed Elmeligi investigated that ICT is the reason for **about 1.5% of worldwide CO_2**releases and is likely to rise to 14% by 2040. **Smartphones are the worst contributors** to tech's carbon footprint. It's because of the number of factors, including their moving ability and on the fly rapid and unpredictable topological changes.

The networking technology, MANET is an infrastructure-less, self-organizing network [1]. It is called as the multi-hop network since it relies on the intermediate nodes to relay the data to destination due to its limited transmission range. MANET is energy constrained. Energy consumption gain a big concern in MANET as nodes are battery operated, which is a limited source, and in some environments, it is pretty difficult to replace or renew battery. The node's lifetime is directly proportional to the battery operating in the node.

Fig 1: Don't be fuelish, save energy

Energy conservation is expansive than energy efficiency by including dynamic efforts to decline energy consumption. Examples of energy conservation without efficiency enhancements are warming a room less in winter seasons, using the vehicles less, air-drying clothes as a replacement of the dryer, or allowing energy saving modes on your computer, etc. The edge between efficient energy usage and energy conservation be seem fuzzy, but actually both impact environment and economic. "**Green**" products or services operate with minimal resources and are purposefully designed to last longer and reduce their energy consumption impacting the environment. Decreasein unnecessary energy consumption has become a big concern as it results in potential economic benefits and positive environmental impact. Network equipment, could be turned off when the load is low and turned on again when traffic grows.

Data-centers with networking infrastructure include high-performance and high-availability of machines demanding energy-consuming air

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conditioning to withstand their operation. The machines are organized in a redundant architecture enduring utter most load which are underutilized in normal operation, leaving an opportunity for applying methods to save energy. Selecting energy-efficient technologies and products that adjust with minimal energy resources is always good. Recently, valued efforts are put in reducing excessive energy spending termed as greening. Green is a simple way to live in harmony with the Mother Nature confronting the radiation as shown in Fig.1.

Making the networking technologies and protocols [2] [3] [4]green, optimized networking results in the reduction of energy consumption. Decreasing the use of energy and increasing the network lifetime is still one of the significant research challenges of Mobile Ad hoc network. The paper aims at minimizing the energy consumption and developing a green LANMAR. For this we investigated different methods. An attempt has been made implement green Landmark routing protocol (LANMAR) [5] [6] [7] in MANETs by using the concept called fuzzy logic by using EXata simulator/Emulator and MATLAB. To measure the performance of the green LANMAR, the proposed methodology uses seven metrics: throughput, Control overhead, number of control packets, energy consumption in transmit, receive, idle modes and total energy consumption over different scales of network size. The proposed green LANMAR called Fuzzy-LANMAR routing protocol enhances the QoS and lifetime of network by minimizing the energy consumption by a huge margin.

Firstly we investigated the parameters that effect the energy consumption using Taguchi Design of Experiments. The most significant parameter among all the parameters that are responsible for more energy consumption is fine-tuned using fuzzy logic. Providing QoS in MANETs is given a highest importance, different research schemes were suggested, but there is no common protocol that serves all network demands. Providing QoS is guaranteeing a qualitative and quantitative metrics like throughput, number of control packets, routing control overhead, etc. To achieve this, protocol must be fine-tuned with its parameters. Fuzzy logic is such fine tuning model that optimizes the parametric values of Fisheye Update Interval FUI. The computational fuzzy FUI improves the QoS in MANET and minimizes the energy consumption.

II. Literature Survey

Rajiv Devrajan, [9] [10] used Multi-Objective Optimization Approach for Energy-Aware Resource Allocation in Cellular Network. Rajiv Devrajan, highlighted Energy Aware Power Allocation in Cooperative Communication System with Imperfect CSI for the Power optimization by finding end-to-end Sinal-to-Noise Ratio.**Anveshini**[11] [12] [13] [14] [15] highlighted the effect of network size and the mobility speed on LANMAR routing protocol in MANET with the nodes having moving property and without mobility as well.**Swatisaxena**did analysis on SNR to find the best optimal combination of factors and analysis of variance (ANOVA) was done to find out the significant factors that affect the routing overhead. Adaptive Fault Tolerant Replication

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Routing (AFTR) protocol is proposed[16]. **Anveshini**proposed a Single-Input multiple-Output fuzzy inference systembasedenergy efficient LANDMARK routing protocol. Input and output variables are fuzzified by fivesimilartrianglular membership functions with 50 percent overlap. She studied the performance of LANMAR. Totally 25 (5*5 = 25) fuzzy inference (if-then) rules are written and the FUI is fine-tuned according to the network dynamics.

III LANMAR PROTOCOL

It adopts the notion of logical subnets in which a group of nodes move in a coordinated fashion. Every logical subnet has a header node called LANDMARK. Such LANDMARK maintains the information about all other nodes within its subnet. The LANMAR protocol uses Fisheye as the local scope routing protocol where fisheye scope is stated in terms of hop distance. The various timing parameters used in LANMAR are shown in **Table 1**. They worked well for high speed large mobile networks.

Table 1 Timing Parameters for LANMAR Routing Protocol

Timing Parameters	Default Value
MINIMUM-MEMBER-THRESHOLD	8
APHA	1.3
LANDMARK-UPDATE-INTERVAL	4s
NEIGHBOR-TIMEOUT-INTERVAL	6s
MAXIMUM-LANDMARK-ENTRY-AGE	12s
MAXIMUM-DRIFTER-ENTRY-AGE	12s
FISHEYE-SCOPE (HOPS)	2
FISHEYE-UPDATE-INTERVAL	2s
MAXIMUM-FISHEYE-ENTRY-AGE	6s

where minimum member threshold-States the minimum number of neighbours that a node should have in order to be elected as a landmark., alpha-Specifies the multiplication factor required to update the landmark., landmark update interval-Specifies the landmark update interval., neighbour timeout interval-Specifies the landmark neighbour timeout interval., maximum landmark entry age-Specifies the maximum age for landmark entries., maximum drifter entry age-States the maximum age for drifter entries., fisheye scope-Specifies the Fisheye scope for local routing., fisheye update interval-States the routing table update frequency within the Fisheye scope., maximum fisheye entry age-Specifies the maximum age for Fisheye entries.

Basically LANMAR routing protocol has nine specific parameters which are specified in above **Table 1**: Among which we found fisheye update interval showing maximum impact on the energy consumption by using Taguchi Design of Experiments (DoE). According to the IETF draft the usage of static values of the parametric values of the LANMAR routing protocol in the dynamic MANET environment doesn't yield good results. So, we used fuzzy logic to fine tune the fisheye update interval. For this, network size and mobility are considered as inputs and fisheye update interval as output.

1. Fuzzy Logic

It is a soft computing method which lodges the imprecision in the real world unlike the conventional hard computing. Soft computing is known for the uncertainty, tolerance for imprecision, robustness, partial truth to achieve tractability, and low solution cost too. Instead of saying complete/crisp yes or no, the truth value/

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membership in Fuzzy Logic elucidates a matter of degree. The fuzzy inference takes input variables by If-Then rules with fuzzy logical operators (AND, OR and NOT) to reach the output space. The If-Then rules are stated human words, and each word is considered as a fuzzy set. A membership function (MF) maps each point in the input space to a membership value in a closed unit interval [0, 1]. The x axis represents an input variable, and the y axis represents membership value μ(x) of the input variable.

IV. Proposed Work

To implement fuzzy logic following three steps are followed:

1. Fuzzification – convert crisp data to fuzzy data or Membership Functions (MFs).This is achieved through fuzzifiers (MF).The simplest membership function 'trimf' is formed using straight lines.

2. Fuzzy Inference Process – maps membership functions with If-Then rules to obtain the fuzzy output.

Most commonly used FISs are the Mamdani and the Sugeno.Sugeno is used in this paper as it is less complex. x, y and z are linguistic variables whereas A and B are fuzzy sets on universe of discourses X and Y, and f(x,y) is a mathematical function.

For any set X, a membership function on X is a function from X to the real unit interval [0, 1]. Membership functions on X represent fuzzy subset of X. The membership function set is usually denoted by μA. For an element x of X, the value μA(x) is called the membership degree of x in the fuzzy set. μA(x) quantifies the grade of membership of the element x to the fuzzy set.

- If μA(x) =0 ….. x is does not belong to a fuzzy set A.
- If μA(x) =1 ……x belongs to a fuzzy set A completely.
- If 0>μA(x)<1…….xbelong to a fuzzy set A partially.

The Sugeno fuzzy rule appears as IF x is A AND y is BTHEN z is f(x,y).

Green LANMAR protocol uses Fuzzy logic decision to find the dynamic fisheye update interval with respect to the network size and mobility speed. Fisheye update interval is taken as Very Low, Low, Medium, High and Very High. The rate/frequency of updating fisheye table depends on moving speed of nodes and the number of nodes in the network. The frequency of updating the fisheye table is found using fuzzy logic.

This particular input set is equally spaced on the input range of '0' number of nodes to '120' number of nodes. Network size input set is defined as the 5 fuzzy subsets asVery low network size, Low network size, Medium network size, High network size and Very high network size. The vertical axis in Fig.2 is Degree of membership function that goes from 0 to 100%.

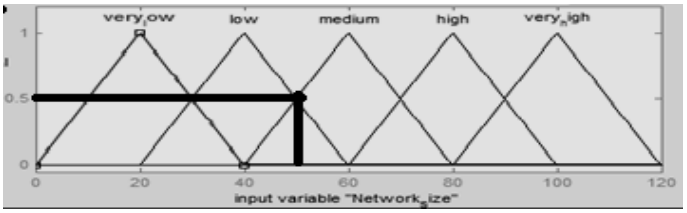

Fig. 2 Input variable-Network Size

For example: for the crisp input valve 50 network size, the degree of membership of the fuzzy subset: Very low is 0 or 0%, Low is 0.5 or 50%,

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Medium is 0.5 or 50% , High is 0 or 0% and Very high is 0 or 0%.

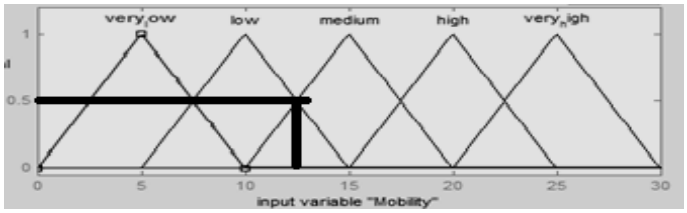

Fig. 3 Input variable-Mobility

For example: for the crisp input valve 12.5 mobility, the degree of membership as shown in Fig.3 of the fuzzy subset: Very low is 0 or 0%, Low is 0.5 or 50%, Medium is 0.5 or 50%, High is 0 or 0% and Very high is 0 or 0%. AND operator is used in if then rules by taking network size and mobility as two inputs and Fish Eye Update Interval as output variable.

Rule Evaluation

Green LANMAR is a fuzzy logic based protocol that finds the dynamic fisheye update interval based on the mobility speed and network size. The frequency of updating fisheye table depends on two inputs such as network size and mobility speed of nodes as shown in Fig.4.

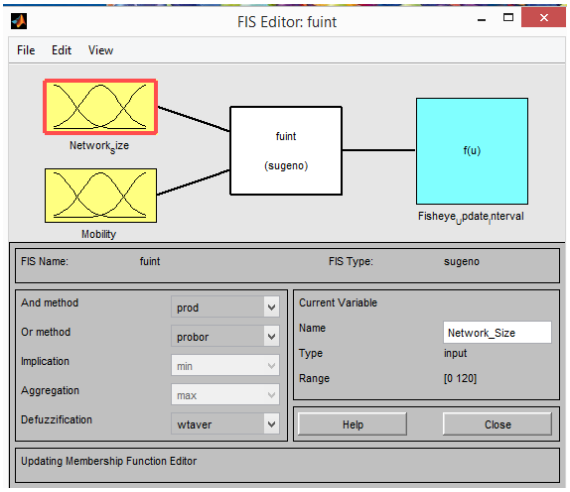

Fig. 4 Sugeno Fuzzy Inference System

Among Mamdani and takagi-sugeno models the sugeno fuzzy inference system is used. This FIS is given two inputs and one output. Fuzzy rule combines input and output parameters resembling the real world applications. For the developed fuzzy inference system, 25 rules are written.

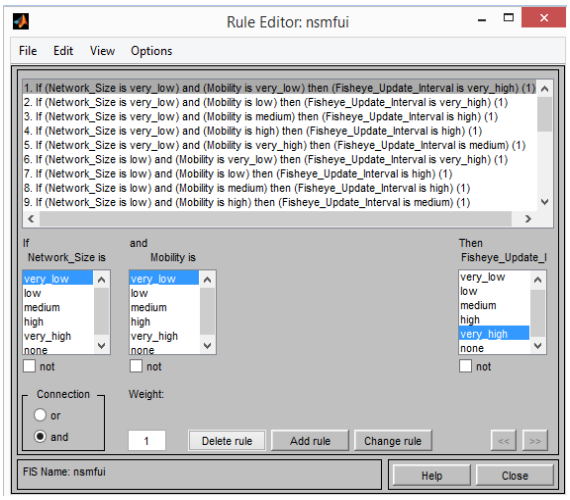

Fig. 5 Fuzzy If-then rules

Each rule contains antecedent and consequent part i.e., each rule appears in the form of "If antecedent Then consequent". AND operator is used to connect two input parameters in antecedent. Rules are written addressing all the conditions of network as shown in Fig. 5.

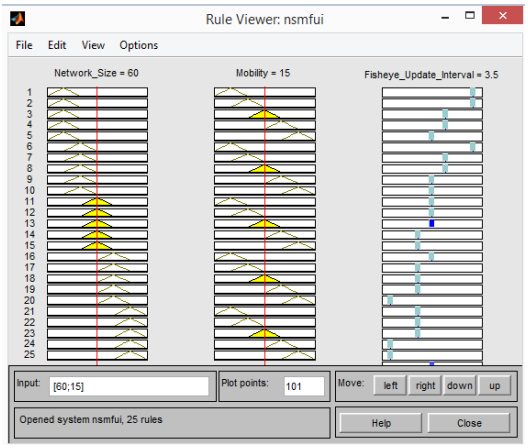

Fig. 6 Rule Viewer

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The Rule Viewer as shown in Fig. 6 displays a road map of the whole fuzzy inference process. Each column is a variable, and each rule is a row of plots. So the first and second columns of plots (yellow) show the membership functions referring antecedent, or if-part, of each rule. The third column of plots (blue) shows the membership functions referring consequent, or then-part of each rule.

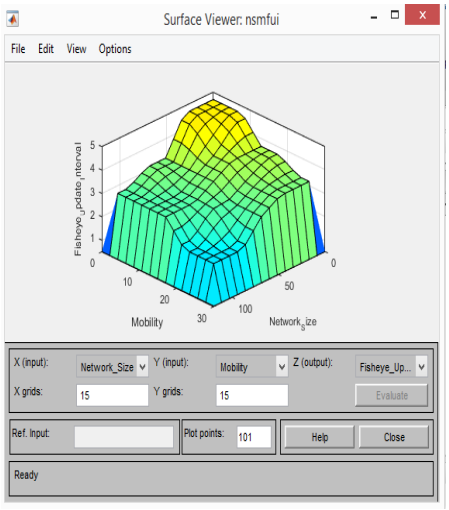

Fig. 7 Surface Viewer

The above picture shown in Fig. 7 is a 3D curve that maps the network size and mobility with the Fisheye Update Interval.

2. Simulation Environment

According to the IETF draft the static values are not suitable for dynamic environment i.e., MANET is very dynamic in nature, instead of using the fixed static configurable parametric values for all variety dynamic environments, if we tune the parametric values with respect to the dynamics of the network consequently it enhances the protocol performance

EXata simulator/emulator 5.41 [17] is used to create a simulation environment to develop and analyze the newly developed Fuzzy-LANMAR protocol and compare itsperformance with the already existing ad hoc routing protocol LANMAR.

The MANET scenario is created with different network sizes (20, 40, 60, 80, and 100) by dividing the nodes into four groups (group 0, 1, 2 and 3).Eachcolour represents different group. Number of mobile nodes as created and they are connected through wireless links in 1000X1000 square meters terrain. All the nodes are configured to move in 'reference point group mobility' fashion. Each group has 25nodes speed between 10 m/s to 20 m/s.

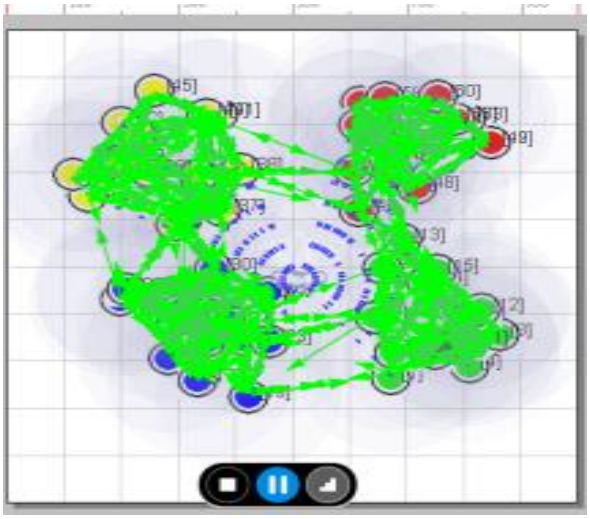

Fig. 8 Snap shot of simulating LANMAR routing protocol

The figure shown above Fig.8 is during simulating the created network scenario. During simulation, the mobile nodes of different groups in the terrain region start transmitting data by moving in a 'reference point group mobility' fashion with different mobility speeds

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V. Results and Analysis

Performance evaluation of routing protocols is presented below.

1. Throughput (bits/s): The rate of successfully transmitted data per second in the network during the simulation as shown in Fig. 9.

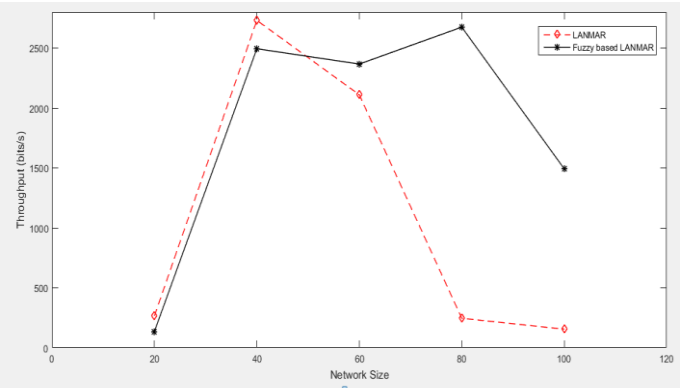

Fig. 9: Throughput with network size for traditional LANMAR and FB-LANMAR.

2. Control Overhead (bytes): Total number of bytes sent in control packets as shown in Fig.10.

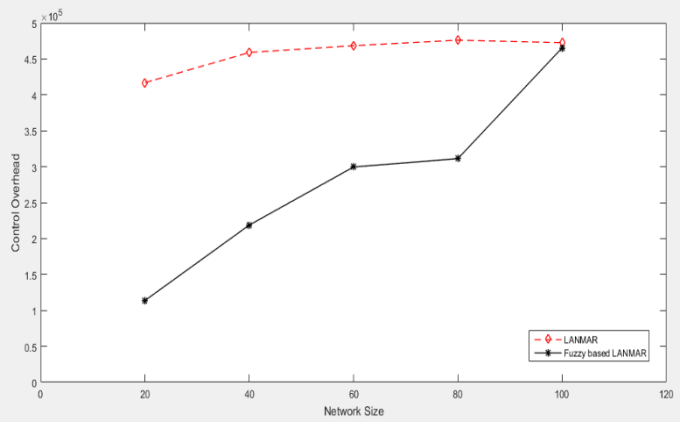

Fig. 10: Control overhead for traditional LANMAR, PS-LANMAR and FB-LANMAR.

3. Number of Control Packets: Total number of control packets sent as shown in Fig. 11.

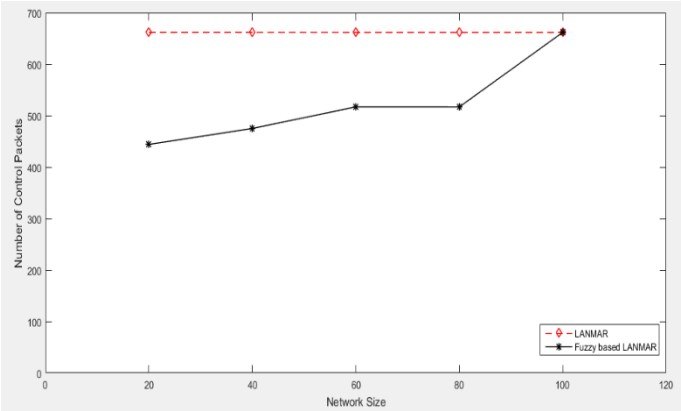

Fig. 11: Number of control packets for traditional LANMAR and FB-LANMAR.

4. Energy consumption in transmit mode (mj): Energy consumed by a node when it sends data packet to other nodes in network as shown in Fig. 12. The transmission energy can be formulated as:

$$Tx = (330*Plength)/2*106$$

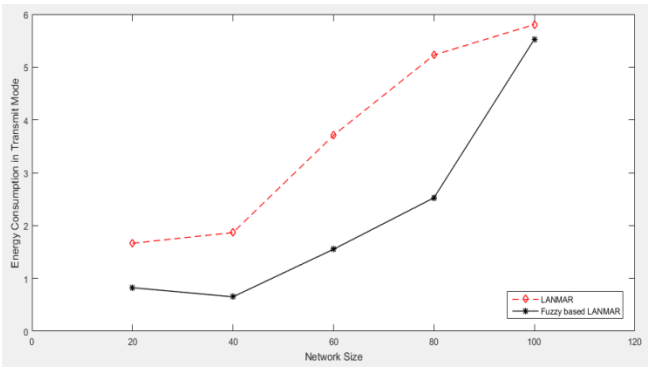

Fig. 12: Energy consumption in transmit mode for traditional LANMAR and FB-LANMAR.

5. Energy consumption in receive mode (mj): Energy consumed by a node when it receives a data packet from other nodes in network then it said to be in Reception Mode as shown in Fig. 13 and is given as:

$$Rx = (230* Plength)/2*106$$

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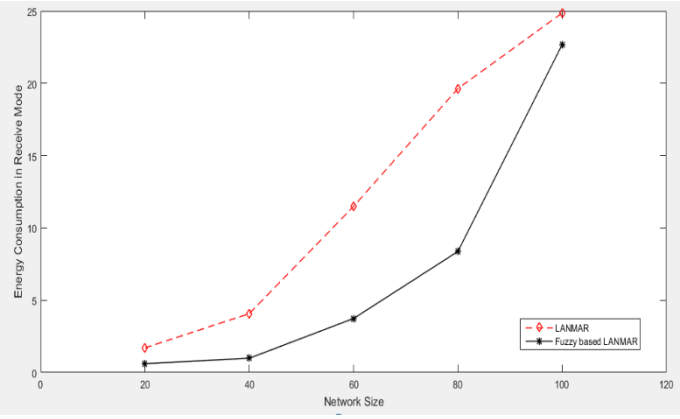

Fig. 13: Energy consumption in receive mode for traditional LANMAR and FB-LANMAR

6. Energy consumption in idle mode (mj): The node is neither transmitting nor receiving any data packets. But this mode consumes power because the nodes have to listen to the wireless medium continuously in order to detect a packet that it should receive, so that the node can then switch into receive mode from idle modeas shown in Fig. 14.

$$PI = PR$$

Where PI is power consumed in Idle Mode and PR is power consumed in Reception Mode.

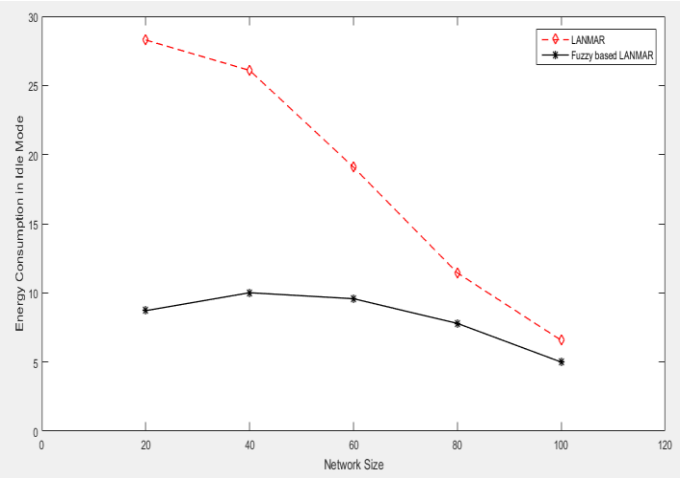

Fig. 14: Energy consumption in idle mode for LANMAR and FB-LANMAR,

7. Total Energy consumption (mj): sum of all the energy consumptions in transmit, receive and idle modes as shown in Fig. 15.

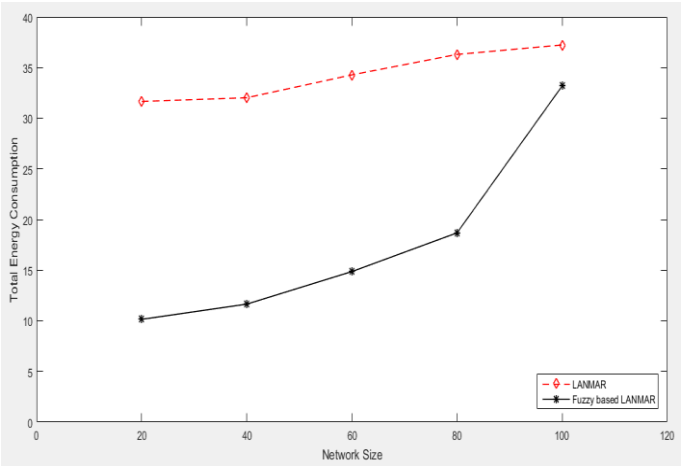

Fig. 15: Total energy consumption with network size for LANMAR and FB-LANMAR.

VI. Conclusion

This paper focuses on greening to develop a Green LANMAR routing protocol in MANETs. EXata simulator/Emulator is used and the default FUI value is 2 sec. However, as per IETF (Internet Engineering Task Force) draft of LANMAR, in a dynamic environment, static parametric values of a routing protocol are not suitable. Therefore, this paper generates optimal FUI values using fuzzy concept and obtained better results with dynamic FUI value. From experimental results, it is found that green/Fuzzy-LANMAR outperforms traditional LANMAR. This work can be extended by incorporating the above techniques into the routing protocols of the wireless sensor networks for minimizing the energy consumption.

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