Fuzzy Logic Based Approach for Dynamic Routing in Manet

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***Abstract*—This paper proposes a novel scheme of fuzzy logic based dynamic routing in Mobile Ad hoc Network (MANET). The wireless links in MANET are highly error prone and can go down frequently due to mobility of nodes, interference and less infrastructure. Therefore, routing in MANET is a critical task due to highly dynamic environment. Hence, fuzzy logic is applied to manage routing policies and to enhance routing performance dynamically. The parameters (signal power, bandwidth, mobility and packet forwarding ratio (PFR)) in MANET were classified with fuzzy degree of membership. The algorithm was developed and simulated using MATLAB. The results of the simulation showed that the performance of the dynamic routing algorithm was noticeably improved. Hence, it is feasible that the fuzzy logic algorithm is applied to optimize routing performance of MANET.**

Keywords: dynamic routing, fuzzy logic controller, MANET

I. INTRODUCTION

With the recent developments of advanced technologies, which include communications, Information networks continue to increase in size, complexity and importance. More and more devices are connected to computer networks, from desktop computers to cellular telephones, Web servers to pagers. As connections proliferate, network topologies necessarily become more and more dynamic. Networks must be flexible enough to allow these devices to communicate with each other in a variety of ways and across a variety of substrates. In MANET, due to the high mobility, low signal power, low PFR and limited bandwidth the wireless links are frequently broken and new links are frequently established.Such dynamic network topology presents a significant challenge for the network routing algorithms.

Several routing algorithms, such as shortest path routing algorithm like DBF (Distributed Bellman-Ford Algorithm) were proposed for ad hoc wireless networks. But, these algorithms suffer from very slow convergence. Besides, DBF-like algorithms incur large update message penalties. Protocols that attempted to cure some of the shortcomings of DBF, such as Destination-Sequences Distance Vector routing was proposed[1].Moreover, Extended Ad-hoc On-Demand Distance Vector (AODV) protocol has new metric for searching stable routing is proposed and performs idle channel routing but it has minimum influence on channel cognition by other nodes [2].Over the last 10 years, various MANET routing protocols have been proposed by network researchers and designed primarily to improve the MANET performance with respect to establishing correct and efficient routes between a pair of nodes for packet delivery [3]. And, TAODV (Tactical on Demand Distance Vector) algorithm has query localization technique that significantly reduces the network traffic and increases the performance of network. But, in this algorithm, load checking not done and efficiency of network to be improved [4].On-demand protocol, called Dynamic Source Routing, and show how intelligent use of multipath techniques can reduce the frequency of query floods and it provides alternate routes on intermediate nodes, in addition to the source node. The main disadvantage of this algorithm is alternate routes in practice will always tend to be longer than the primary routes and the maintenance cost is high as we maintain alternate routes [5].Besides, new on-demand bandwidth-efficient routing protocols for mobile ad-hoc networks called the Reactive Routing Protocol (RRP) were proposed. Since,the routes are discovered only whenthey are needed for communication and this algorithm minimizes the redundant link traversals and hence efficiently utilizing the available bandwidth. However, the time for route establishment is more, due to the incremental nature of the route search process [6].To provide quality of service in routing protocols, extensions can be added to the messages used during route discovery. These extensions specify the service requirements which must be met by nodes rebroadcasting a Route Request or returning a Route Reply for a destination[7].These algorithms do not satisfy the requirements of an ad hoc wireless network completely and despite their shortcomings, these works lay the foundation for the development of our algorithm.

The proposed evolutionary algorithm for solving the dynamic routing problem comprises of a fuzzy logic controller. The fuzzy logic system is a popular and powerful tool implemented by researchers for dynamic route selection [8–10]. Teodorovic and Kikuchi have used fuzzy logic for dynamic routing [10]. However, their proposed method only considers the travel time parameter and cannot be easily generalized to multiple routes [8, 9]. The underlying technology of the network imposes constraints on the networking objectives. It is the multi-objective, multi-constraint nature of the routing that makes it a complex problem in MANET. The network, in order to satisfy the above conditions should adapt itself to the present conditions. Alternative routes should be evaluated on real-time basis. Hence, fuzzy logic which is known for its adaptive nature is used in the proposed algorithm.

II. BACKGROUND

A. Dynamic Routing in MANET:

A MANET is a group of mobile nodes (MNs) that supportively communicate with each other without any pre-established infrastructures such as a centralized access point. These nodes may be computers or devices such as laptops, mobile phones, and pocket pc with wireless connectivity.Each device in a MANET is free to move independently in any direction, and will therefore change its links to other devices frequently. Each must forward traffic unrelated to its own use, and therefore be a router. MANETs are a kind of wireless ad hoc network that usually has a routable networking environment on top of a link layer ad hoc network [11].

B. Fuzzy Logic:

The Fuzzy Logic is an innovative approach to help control non-repeating or unpredictable systems to control accuracy. It uses a list of rules rather than complicated mathematical expression. The major components of the system consist of the knowledge base[rule base and data base], decision making, fuzzification and defuzzification [12].Gaussian membership function is often preferred where the output needs to be very smooth. In the proposed system, Gaussian membership function is used for getting the optimal and suitable route based on MANET parameters, which needs to be smooth. The membership function is given by,

$$\text{gaussian}(x; c, \sigma) = e^{-\frac{1}{2}\left(\frac{x-c}{\sigma}\right)^2} \quad (1)$$

A Gaussian MF is determined complete by c and σ; c represents the MFs centre and σ determines the MFs width.

And the most important two types of fuzzy inference method are Mamdani method and Sugeno method. In this paper we are usingMamdani type inference, as defined it for the Fuzzy Logic Toolbox, expects the output membership functions to be fuzzy sets. After the aggregation process, there is a fuzzy set for each output variable that needs defuzzification.Here we are using centroid defuzzification method because it is most commonly used technique and is very accurate [13]. The centroid defuzzification technique can be expressed as

$$z_{COG} = \frac{\int_z \mu_{A(z)zdx}}{\int_z \mu_{A(z)zdx}} \quad (2)$$

WhereZ_{COG} is the crisp output, μA(z) is the aggregated membership function and z is the output variable

III. PROPOSED STUDY

For efficient routing and management of MANET, fuzzy logic has been proposed. The proposed algorithm has been simulated in MATLAB 7.2.The proposed dynamic routing algorithm takes into account few MANET parameters as input variables to determine if the present route is optimal.

A. Fuzzy Variables:

1) Input Variables

In this paper four input variables (parameters) and one output variable are considered. The input variables are signal power, bandwidth, mobility and PFR and the output variable is route. These four parameters are taken for find out the optimal path or route.The absolute value of each of these parameters can take a large range at different points on the network. We have considered the normalized values for each parameter.

*a) Signal Power:*A mobile phone signal is the signal strength (measured in dBm) received by the mobile phone from the cellular network.

*b) Bandwidth:*Bandwidth describes the maximum data transfer rate of a network or Internet connection. It measures how much data can be sent over a specific connection in a given amount of time.

*c) Mobility:*A quality or capability of military forces which permits them to move from place to place while retaining the ability to fulfill their primary mission. Mobility models represent the movement of mobile user, and how their location, velocity and acceleration change over time.

*d) PFR: (Packet Forwarding Ratio)*PFR is the rate of successful forwarded packets. It is the ratio of number of successful forwarded packets to the total number of packets sends [15].

PFR = successful forwarded packets/total packet

The following figure shows the membership function of the variable ‘signal power’.

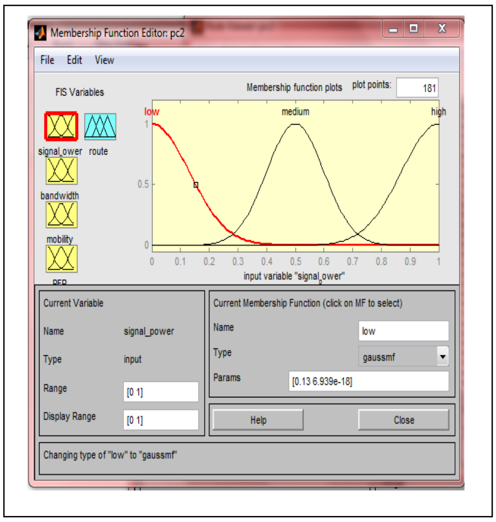

Fig 1. Input Variable ‘Signal Power’

2) *Membership Function:*

The network parameters can take a dynamic range of values based on various locations on the network.In the proposed work, the input parameters are normalized to hold values. Later during fuzzification, crisp normalized values are converted into fuzzy variables. For this, three fuzzy sets have been defined for each variable.The table below (Table 1) describes the input/output parameters and set values for membership functions.

TABLE I. The Various Parameters And Values For Membership Function

Parameters	**Input/output Membership function**	**Parameter value**		
		0 - 0.4	*0.2 -0.8*	*0.6 -1.0*
Signal power	Input	Low	medium	high
Bandwidth	Input	Poor	average	excellent
Mobility	Input	Low	medium	high
Packet Forwarding Ratio	Input	Low	medium	high
Route	Output	Below optimal	Sub optimal	Optimal

The standardized value of each parameter is mapped into the fine sets. In each set, all value will have some score of membership function. The memberships that have been defined for each of the fuzzy set for any particular input variable are sinusoidal in shape. The routes are defined as below optimal (from 0 to 0.4), suboptimal (from 0.2 to 0.8) and optimal (from 0.6 to 1.0) between two mobile hosts. The below optimal indicates not optimal path, the sub optimal indicates good path and the optimal path indicates the best path. The proposed routing algorithm can apply to different routing metrics. These routes have to satisfy the mobility, signal power and bandwidth requirements of the network. The grade of membership function can be anywhere between 0 and 1 for each fuzzy set. The defuzzified crisp value for selected variable was calculated from the derived algorithm.

3) *Choice of weight factors*

Though four MANET parameters were considered for dynamic routing, they do not share an equal priority. Hence weight factors were introduced to determine the priority of the network parameters. The values of the weight factors k1, k2, k3 and k4 cannot be constant due to varying nature of network load and varying demand of channel capacity as well as speed. Therefore during different network parameters, different weight factors have to be dominant. In the proposed study,higher weightage is given for signal power and bandwidth while compared to mobility and PFR. This isdue to the important role that signal power and bandwidth plays in the routing. The weightage for bandwidth and signal power were twice greater than the weightage that was given for mobility and PFR. In the proposed system, the output variable route is determined by the following equation

$$Route = \sum allpathsbetweennodestraveresed\,(k1 * sp + k2 * b + k3 * m + k4 * pfr) \quad (3)$$

4) Fuzzyinference rules:

Apart from input and output membership function 81 rules were applied on the membership function for optimal routing. The crisp value of input variable was given and a defuzzified crisp value for selected variable was calculated from the derived algorithm. An output linguistic variable is used to represent the route. Proposed optimal routes are based upon the fuzzy rules for different ranges of the metric availability.

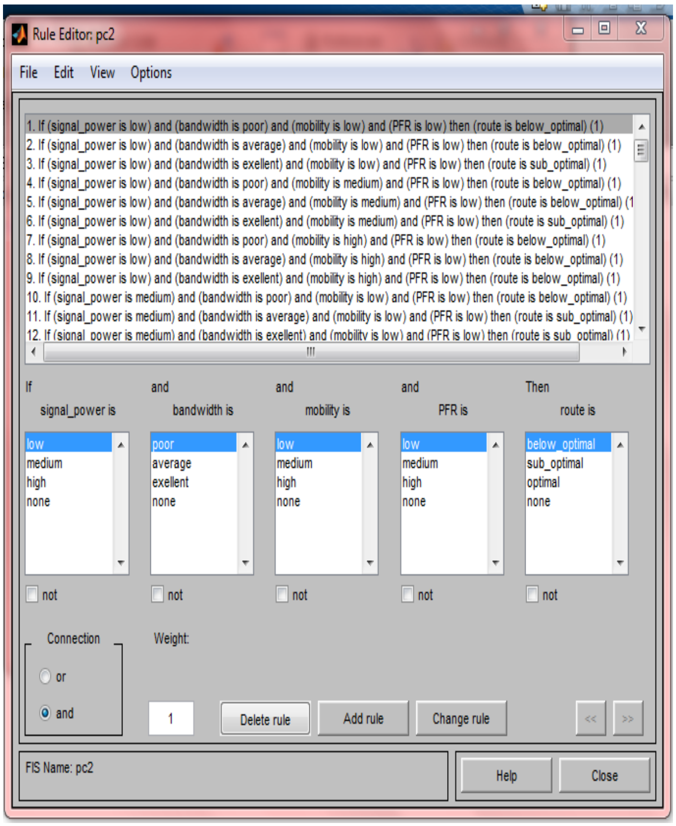

Fig 2. Rule Editor for used to write the fuzzy rules

IV. RESULTS & DISCUSSIONS

Experiments were carried out to check if the proposed system is able to evolve intelligently with an optimal route, in our daily changing networking environment. The proposed system grains out the optimal route considering the four networking parameters considered in MANET. First we consider signal power, mobility and PFR as low andbandwidth as excellent then the route will be sub optimal. And if we consider signal power, mobility and PFR as low and bandwidth also poor then the route will be optimal. The Rule Viewer displays a roadmap of the whole fuzzy inference process.

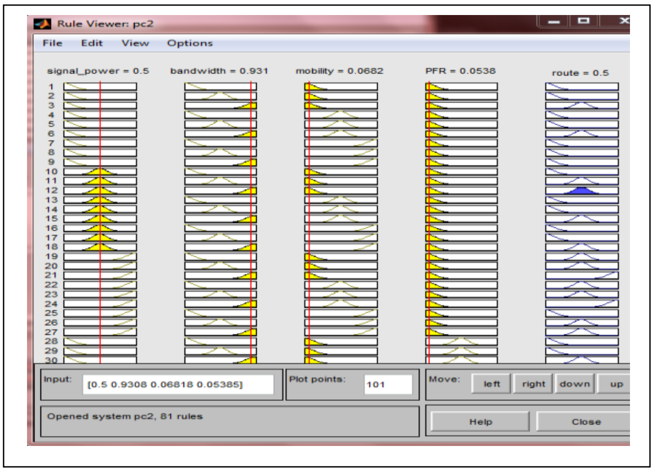

Fig 3. 'Route' O/P w.r.t. Medium 'Signal Power', Excellent 'bandwidth', low 'Mobility' and low 'PFR'

The Fig. 3 illustrates that when signal power is medium (0.5), bandwidth is excellent(0.931), mobility is low(0.682) and PFR is low(0.0538) then inthis condition the route is sub optimal(0.5). So this algorithm works well when mobility is low and signal power is medium. When we change the signal power as medium (0.523), bandwidth as average (.0469), mobility as low(0.053) and PFR as medium(0.515) then the route is optimal(0.896), but as we will decrease the signal power then the route will be below optimal.Here, we observe that at constant bandwidth and low signal power the route is below optimal but if the signal power is increased up to medium the route is sub optimal for poor bandwidth. Similarly at high signal power and poor bandwidth the route becomes below optimal. It can also be observed that with average bandwidth and high signal power the route is suboptimal and if we increase bandwidth up to excellent the route is optimal at high signal power.

In Figure 4 signal power and mobility are the fuzzy input variable for the proposed routing algorithm which lies on the horizontal axes and route is the output variable which has been shown on the vertical axis. It is very clear from the figure that at constant signal power and low mobility the Route is below optimal, but for any value of the signal power if we increase the mobility then the route also increases and becomes sub-optimal. Finally at high mobility the route will be below optimal for constant signal power.

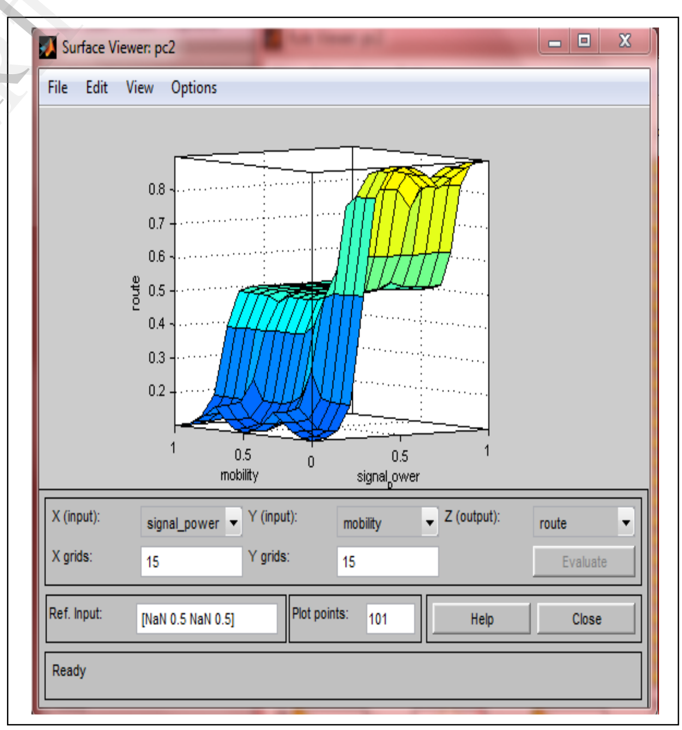

Fig 4. 'Route' O/P w.r.t. 'Signal Power' and 'Mobility'

V. CONCLUSIONS

Due to the explosive growth of mobile computing devices, a fuzzy based system is carried out to represent the characteristics of the constraints owing to select the most encouraging route. In this paper, a new dynamic routing protocol is proposed that has the capability of intelligently selecting an optimal route. The proposed algorithm is basedon mobility, signal power, bandwidth and PFR, where the segmentation of nodes will substantially reduce the overhead of the entire network and speed up the routing process. A route ranking is provided to the user forecasting the decision making more adaptive and naturist.Finally, we have done limited trials to show that our protocol is functional and effective.

REFERENCES:

[1] S. Murthy, J.J. Garcia-Luna-Aceves, "An efficient routing protocol for wireless networks," ACM Mobile Networks and App.J.,Special issue on routing in Mobile communication Networks, October1996, Vol.1, Issue 2, pp. 183-197.

[2] HuiYao Zhang, Marek E. Bialkowski, "An Extended AODV Protocol for VoIP Application in Mobile Ad Hoc Network",ECTTransactions on Electrical Eng., Electronics and Communications, Vol.7, No.2 August 2009, pp.114- 121.

[3] Sunil Taneja, Ashwani Kush, "A Survey of Routing Protocols in Mobile Ad Hoc Networks", International Journal of Innovation, Management and Technology, Vol. 1,No. 3,(ISSN: 2010-0248) August 2010, pp.279-285.

[4] Mueen Uddin1, Azizah Abdul Rahman1, "Improving Performance Of Mobile Ad Hoc Networks Using Efficient Tactical OnDemand Distance Vector (TAODV) Routing Algorithm", International Journal of Innovative Computing, Information andControl, Vol. 8, No. 6, June 2012, pp. 4375-4389.

[5] Asis Nasipuri, Samir R. Das, "On-Demand Multipath Routing for Mobile Ad Hoc Networks",Computer CommunicationsandNetworks, October 1999, pp.64-70.

[6] Arun Mukhija, Ranjan Bose, "RRP – A Bandwidth-efficient Routing Protocol for Mobile Ad-hoc Networks" 2nd International Information and Telecommunication Technologies Symposium (I2TS 2003), Florianopolis, Brazil, Nov. 2003.

[7] Yihai Zhang and Gulliver,T.A, "Quality of Service for Ad hoc On-Demand Distance Vector Routing", IEEE International Conference on , vol.3, Aug. 2005, pp.192-196.

[8] G. K. H. Pang, K. Takahashi, T. Yokota, H. Takenaga, "Adaptive route selection for dynamic route guidance system based on fuzzy-neural approaches," IEEE Transactions on Vehicular Technology,vol.48,no.6, 1999,pp.2028–2041.

[9] G.Pang, M.H. Chu, "Route selection for vehicle navigation and control," in Proceedings of the 5th IEEE International Conference on Industrial Informatics (INDIN '07), June 2007, pp. 693–698.

[10] Teodorovic, S. Kikuchi, "Transportation route choice model using fuzzy interface technique," inProceedings of the 1st International Conference Uncertainty Modeling and Analysis: Fuzzy Reasoning, Probabilistic Models, and Risk Management, Maryland University, College Park, 1990, pp. 140–145.

[11] J.S. Roger Jang, Ned Gulley,"MATLAB® User's Guide Fuzzy Logic" online ebook.

[12] S. N. Sivanandam, S. Sumathi , S. N. Deepa, "Introduction to Fuzzy Logic using MATLAB" Springer publishes, 2007.

[13] Sameena Naaz, Afshar Alam, Ranjit Biswas, "Effect of different defuzzification methods in a fuzzy based load balancing application "IJCSI International Journal of Computer Science Issues, Vol. 8, Issue 5, No 1, September 2011, pp.261-267.

[14] Amandeep Kaur, Dr.Rajiv Mahajan, "Survey of QoS Based Routing Protocol for MANET's", Vol. 3, Issue 7, July 2013, pp.172-177.

[15] Aarti Bairagi, "A New Parameter Proposed For Route Selection In Routing Protocol For MANET"Volume 4, Issue 1, January-April (2013), pp. 31-37.