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Improving the Quality of CGSR Routing Protocol by Electing Suitable Cluster-Head Using Fuzzy Logic System in MANET

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Abstract- A mobile ad-hoc network (MANET) is composed of mobile nodes that are dynamically reconfigurable, self organized and which provide on-demand networking solution. The goal of MANETs is to extend mobility into the realm of mobile, autonomous and wireless domains, where a group of nodes form the network routing infrastructure in an ad-hoc fashion. The nodes in the mobile ad hoc networks act as host and router, the routing protocol is the primary issue and has to be supported before any applications can be deployed for mobile ad-hoc networks. Recently, many research protocols are proposed for finding an efficient route between the nodes. The CGSR uses a hierarchical network topology unlike other table-driven routing approaches that employ flat topologies. CGSR protocol divide the network into several small areas called clusters and the members of each cluster entrusted to a special node called cluster-head. We propose a fuzzy logic system by which we select a suitable cluster-head to improve the quality of CGSR protocol. Selecting an appropriate cluster-head can save the power of overall network because the cluster-head node consumes more power than other ordinary nodes. In this paper we use fuzzy logic approach to choose the cluster-head based on the three parameters: distance of a node to the cluster centroid, energy of the node and node movement. These three parameters are the input of fuzzy logic system and it provides an output cluster-head chance, and the node with the highest chance is elected as the cluster-head.

Keywords: Fuzzy Logic System, Cluster-Head Gateway Switch Routing, Membership Function

1 Introduction

Mobile Ad Hoc network is a collection of wireless mobile hosts forming a temporary network without the aid of any centralized administration, in which individual nodes cooperate by forwarding packets to each other to allow nodes to communicate beyond direct wireless transmission range. Routing is a process of exchanging information from one station to other stations of the network. Routing protocols of mobile ad-hoc network tend to need different approaches from existing Internet protocols because of dynamic topology, mobile host, distributed environment, less bandwidth, less battery power. Ad Hoc routing protocols can be divided into two categories: table-driven (proactive schemes) and on-demand routing (reactive scheme) based on when and how the routes are discovered. In Table-driven routing protocols each node maintains one or more tables containing routing information about nodes in the network whereas in on-demand routing the routes are created as and when required. CGSR is a routing protocol that has a hierarchical-based design. CGSR organized nodes into cluster entrusted to a special node named cluster-head. This cluster-head is elected dynamically by employing a least cluster change (LLC) algorithm[6]. According to this algorithm, a node ceases to be a cluster-head only if it comes under the range of another cluster-head where the tie is broken either using the lowest id or highest connectivity algorithm. Clustering provides a mechanism to allocate bandwidth, which is a limited resource, among different clusters, thereby improving reuse. All member nodes of a cluster can be reached by a cluster-head to provide improved coordination among nodes that fall under its cluster. A token based scheduling [12] is used within a cluster for sharing the bandwidth among the member of the cluster. CGSR assume that all communication passes through the cluster-head. Communication between two clusters takes place through the common member nodes that are member of both the clusters. These nodes which are members of more than one cluster are called gateways.

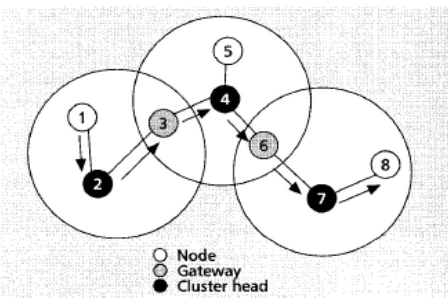

Figure 1:-CGSR: routing from node 1 to node 8.

The energy consumption can be reduced by allowing only some nodes to communicate with the base station. These nodes called cluster-heads collect the data sent by each node in that cluster compressing it and then transmitting the aggregated data to the base station[11].Appropriate cluster-head selection can significantly reduce energy consumption and enhance the lifetime of the MANET. In this paper, a fuzzy logic approach to the MANET. In this paper we use fuzzy logic approach to choose the cluster-head based on the three parameters are: distance of a node to the cluster Centroid, energy of the node and node movement.

II. Introduction of Fuzzy Logic Systems

Fuzzy systems are used to approximate functions. The fuzzy can be used to model any continuous function or system. Fig. 2 shows the generalized block diagram of fuzzy system. The quality of fuzzy approximation depends on the quality of the rules. The result always approximates some unknown non linear function that can change in time. Fuzzy systems theory or "fuzzy logic" is a linguistic theory that models how we reason with vague rules of thumb and commonsense. The basic unit of fuzzy function approximation is "if then" rules. A fuzzy system is a set of if- then rules that maps input to output.

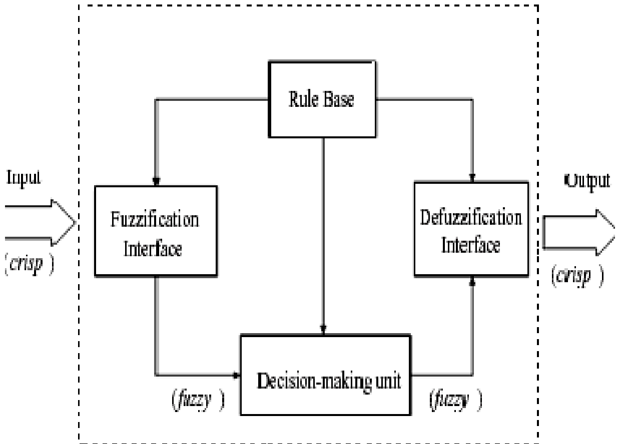

Figure 2: Structure of fuzzy logic system

Steps of fuzzy inference rule system are:-

Step 1: Fuzzy Inputs

This step will obtain inputs and determine the degree to which they belong to each of the appropriate fuzzy sets via membership functions. Fuzzification of the input amounts to either a table lookup or a function evaluation.

Step 2: Apply Fuzzy Operator

This step determines the degree to which each part of the antecedent has been satisfied for each rule. If the antecedent of a given rule has more than one part, the fuzzy operator is applied to obtain one number that represents the result of the antecedent for that rule. This number will then be applied to the output function. The input to the fuzzy operator is two or more membership values from fuzzified input variables. The output is a single truth value. The method used may be either AND or OR operation.

Step 3: Apply Implication Method

Before applying implication proper weights are assigned to each rule. The input for the implication process is a single number given by the antecedent, and the output is a fuzzy set.

Step 4: Aggregate all outputs

Aggregation is the process by which the fuzzy sets that represent the outputs of each rule are combined into a single fuzzy set. Aggregation only occurs once for each output variable, prior to the fifth and final step, defuzzification. The input of the aggregation process is the list of truncated output functions returned by the implication process for each rule. The output of the aggregation process is one fuzzy set for each output variable.

Step 5: Defuzzify

The input for the defuzzification process is a fuzzy set and the output is a single number. The aggregate of a fuzzy set encompasses a range of output values, and so must be defuzzified in order to resolve a single output value from the set. Figure 2 shows the structure of a fuzzy logic system (FLS). When an input is applied to a FLS, the inference engine computes the output set corresponding to each rule. The defuzzifer then computes a crisp output from these rule output sets. During defuzzification, it finds the point where a vertical line would slice the aggregate set chance into two equal masses. In practice, the COG (Center of Gravity) is calculated and estimated over a sample of points on the aggregate output membership function, using the following formula:

$$COG = (\sum \mu_A(x) * x) / \sum \mu_A(x)$$

where, $\mu_A(x)$ is the membership function of set A.

Many proposals have been made to select cluster heads. In the case of LEACH [12], to become a cluster-head, each node n opts a random number between 0 and 1. If the number is less than T(n), the node becomes the cluster-head. The

Threshold is set at:

$$T(n) = \frac{P}{1 - P \times \left(r \bmod \frac{1}{P} \right)} \quad \text{if } n \in G$$

$$T(n) = 0 \quad \text{otherwise}$$

Where cluster-head prob. represented by p, current round by r and set of nodes by G that have not been cluster -heads in the last 1/P rounds. Several disadvantages are there for selecting the cluster-head using only the local information in the nodes. Firstly, since each node probabilistically decides whether or not to become the cluster-head, there might be cases when two cluster-heads are selected in close vicinity of each other increasing the overall energy depleted in the network. Secondly, the number of cluster- head nodes generated is not fixed so in some rounds it may be more or less than the preferred value. Thirdly the node selected can be located near the edges of the network; wherein the other nodes will expend more energy to transmit data to that cluster-head. Fourthly, each node has to calculate the threshold and generate the random numbers in each round, which consumes CPU cycles. In [8] each node calculates its distance to the area centroid which will recommend nodes close to the area centroid and not the nodes that is central to a particular cluster, cluster centroid. Thus it leads to overall high energy consumption in the network for other nodes to transmit data through the selected node.

III. Overview of Cluster-Head Election

We collect, the knowledge for cluster head election on the following three parameters:

1. Distance of the node to cluster centroid.
2. Energy of the node.
3. Node Movement.

We design questions such as:-

If distance of a node to the cluster centroid is near and remaining node energy is low, and mobility of node is moderate, then possibility that this node will be elected as cluster head is:

we need to set up 3^3=27 rules for this FLS. Expert knowledge is represented based on the following three parameters:-

i. Node Remaining Energy- energy level available in each node, represented by the fuzzy variable Energy.

ii. Node Distance - distance of a node to the cluster centroid, designated by the fuzzy variable Distance.

iii. Node Movement- a value which classifies the nodes based on how central the node is to the cluster, designated by the fuzzy variable Mobility.

These are 3^3=27 rules for fuzzy rule base. The membership functions and their corresponding linguistic states are represented in table 1 and figure 3 to 8.

Table 1: Fuzzy Rule Base

	Energy	Mobility	Distance	Chance
1	low	High	Close	Small
2	low	High	adequate	Small
3	low	High	far	Vsmall
4	low	Medium	close	Small
5	low	Medium	adequate	Small
6	low	Medium	far	Small
7	low	Low	close	Rsmall
8	low	Low	adequate	Small
9	low	Low	far	Vsmall
10	medium	High	close	Rlarge
11	medium	High	adequate	Medium
12	medium	High	far	Small
13	medium	Medium	close	Large
14	medium	Medium	adequate	Rlarge
15	medium	Medium	far	Rsmall
16	medium	Low	close	Large
17	medium	Low	adequate	Rlarge
18	medium	Low	far	Rsmall
19	high	High	close	Rlarge
20	high	High	adequate	Medium
21	high	High	far	Rsmall
22	high	Medium	close	Large
23	high	Medium	adequate	Rlarge
24	high	Medium	far	medium
25	high	Low	close	vlarge
26	high	Low	adequate	rlarge
27	high	Low	far	Medium

Fuzzy Inference system takes energy, distance and mobility as inputs and provides us the chance of a cluster-head as in figure3.

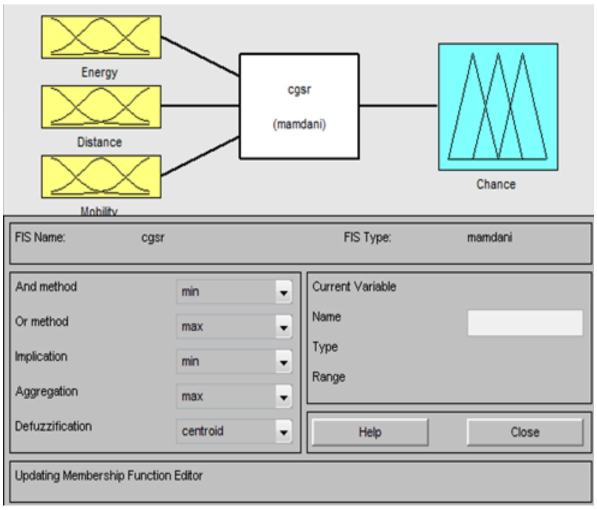

Figure 3: Fuzzy Inference System

The linguistic variables used to represent the node Energy are divided into three levels: low, medium and high. The trapezoid membership function is used to represent the fuzzy variable low and high and triangular membership function is used to represent medium fuzzy set as in figure 4.

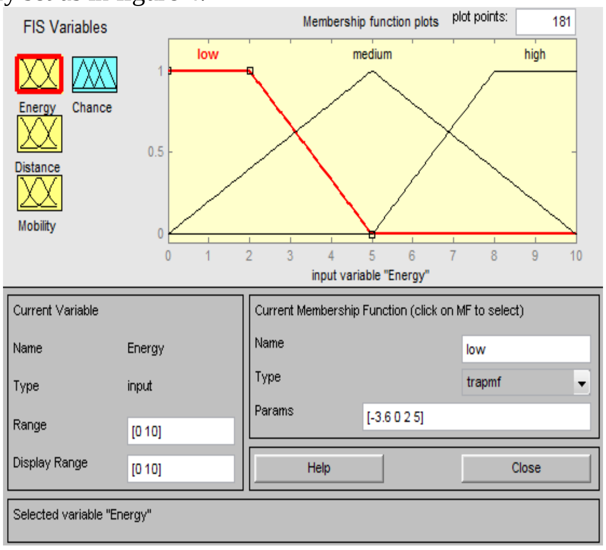

Figure 4: fuzzy set for fuzzy variable Energy

The linguistic variables used to represent the node Distance are divided into three levels: close, adequate and far. The trapezoid membership functions are used to represent the fuzzy variable close and far and triangular membership function is used to represent adequate fuzzy set, as shown in figure 5.

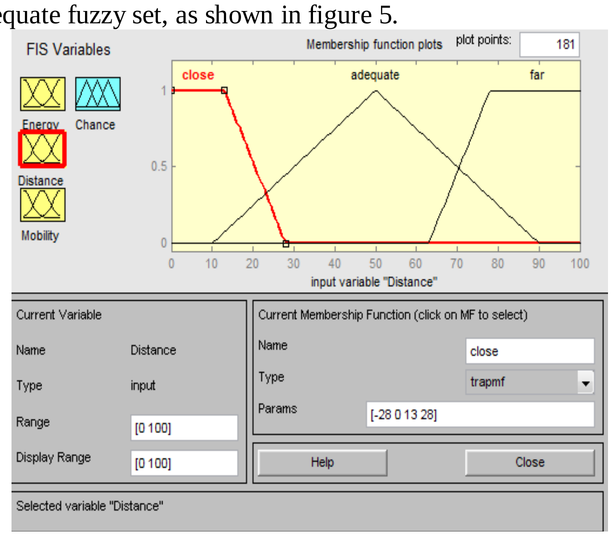

Figure 5: fuzzy set for fuzzy variable Distance

The linguistic variables used to represent the node Mobility are divided into three levels: high, medium and low. The trapezoid membership function is used to represent the fuzzy variable low and high and triangular membership function is used to represent medium fuzzy set, as shown in figure 6.

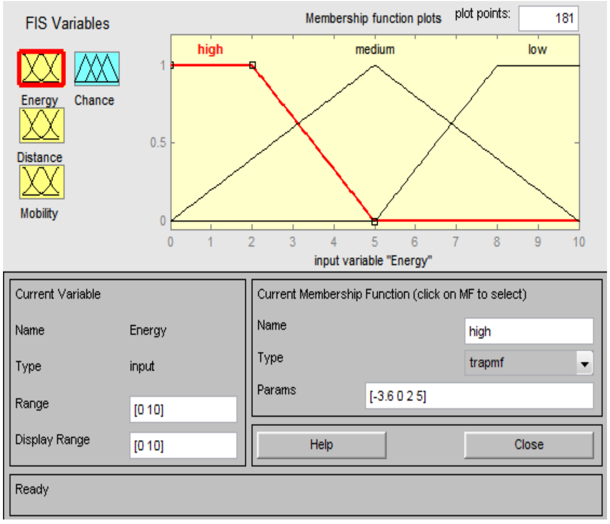

Figure 6: fuzzy set for fuzzy variable Mobility

The linguistic variables used to represent the node Energy are divided into seven levels: small, small, rsmall ,medium ,rlarge, large and vlarge.The trapezoid membership function are used to represent the fuzzy variable vsmall and vlarge and triangular membership function is used to represent small, rsmall, medium, rlarge and large fuzzy sets, as shown in figure 7.

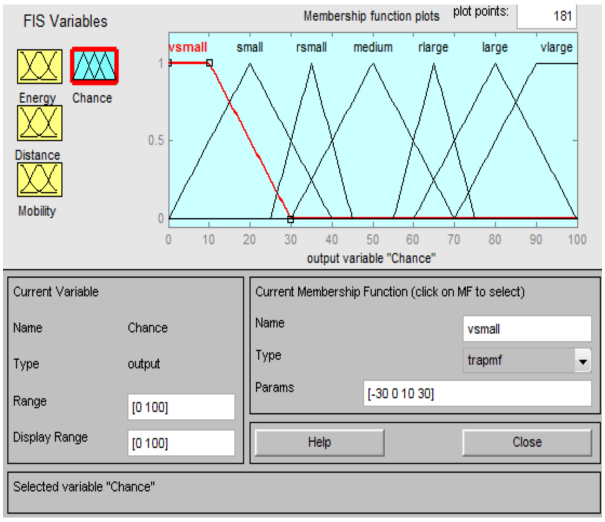

Figure 7: fuzzy set for fuzzy variable Chance

Surface Viewer depicts 3-dimensional co-relation among Energy, Distance, Mobility and Chance; with the help of surface viewer we can have the effect of any of two inputs on chance at any time, as shown in figure 8.

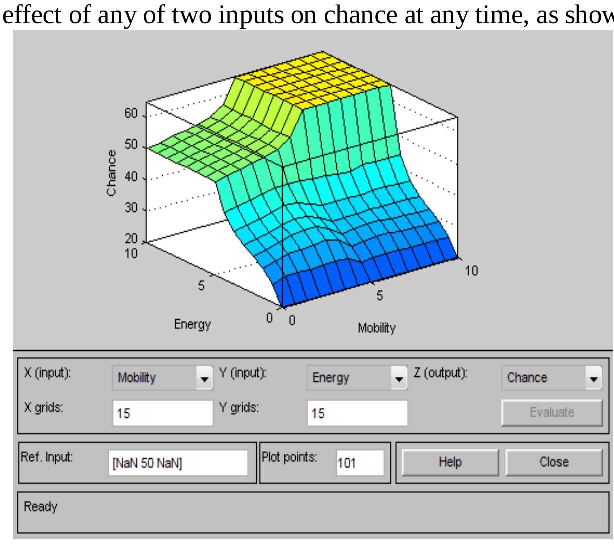

Figure 8: Surface viewer

IV Results

In this paper we have used fuzzy logic approach, and have established a relationship b/w Energy, Distance and Mobility corresponding to Chance. This relationship has been shown in figure 9 i.e. Rule Viewer. Now we have taken an example of three clusters cluster1, cluster2 and cluster3, where each cluster consists of its own nodes i.e. cluster1(a,b,c,d), cluster2(d,e,f,g,h) and cluster3(h,i,j,k). We have to find cluster-head among these nodes for each cluster, the node with the highest value of chance will be the cluster-head. Now, applying the above mentioned approach for each cluster, we notice a special trend of validation in the values of chance i.e. the node with high energy, node distance is closer to the centroid and minimum mobility of node will have the highest value of chance among the fellow nodes within the same cluster. We have shown the relationship/result in table 2.

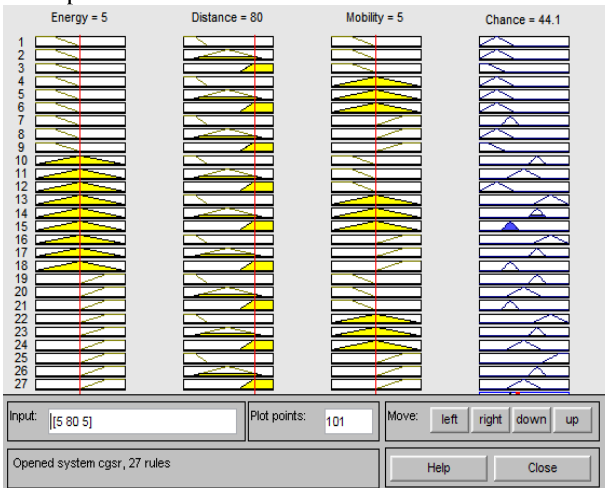

Figure 9: Rule Viewer

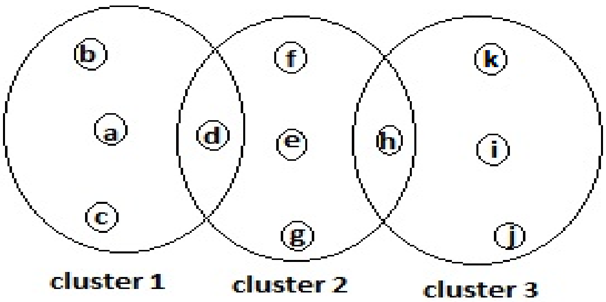

Figure 10: Network of three clusters

Table 2: Summary table

cluster	Node Name	I/P [E,D,M]	O/P (Chance)	Cluster-head
Cluster 1	A	[5 10 5]	65	Node A
	B	[5 40 3]	53.6	
	C	[4 40 3]	42.9	
	D	[4 50 4]	42.4	
Cluster 2	D	[4 50 4]	42.4	Node E
	E	[7 8 4]	77.7	
	F	[6 50 4]	55.8	
	H	[5 65 5]	58.3	
Cluster 3	H	[5 60 4]	55.7	Node I
	I	[6 9 5]	80	
	J	[4 60 4]	42.2	
	K	[5 50 4	55.8	

V **Conclusions**

Generally, cluster-head election for mobile ad hoc network is based on the distance to the centroid of a cluster, and the closer one is elected as the cluster-head. We have presented a cluster-head election scheme using fuzzy logic system (FLS) for mobile ad hoc wireless networks. Three parameters are used: distance of a node to cluster centroid, battery power remaining and mobility of node. The linguistic knowledge of cluster-head election is based on above three parameters and 27 FLS rules are set up based on this linguistic knowledge. The output are set up based on the linguistic knowledge. The output of the FLS provides a cluster-head possibility, and node with the highest possibility is elected as the cluster-head. Other appropriate rules can be created that optimize routing efficiency (e.g., number of hops, QOS, etc).

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