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Fuzzy Logic Implementation of Antcolony Based Clusterhead Selection Algorithm.

Swati Atri[1], Dr. Nasib Singh Gill[2], Jaideep Atri[3]

M.Tech., Department of Computer science and Application, MDU, Rohtak, India[1]

Professor, Department of Computer Science and Application, MDU, Rohtak, India[2]

Research Scholar, Department of Computer Science and Application, KU, Kurukshetra, India[3]

Abstract: In the mobile Ad hoc networks (MANETs) the mobility of nodes is one the important factor that needs to be taken care and hence there has to be a certain way to determine the relative location of any node and thus the cluster based algorithm provides one of the best solution to this problem. The fuzzy logic approach provides us the method to find the degree of truthness and hence can be best used to test the solution on the tool like MATLAB. In this paper proposed ABC (Antcolony Based Clusterhead) Selection algorithm have been testified based on the fuzzy logic on the MATLAB tool .This cluster formation algorithm provides us with a way to determine the node to be selected as a Clusterhead with in a cluster through the use of Ant colony optimization (ACO). The probability function designed in the paper helps in determining the probability for various nodes to be selected as a cluster head.

Keywords: MANETs, Clusterhead, Cluster, ACO, Fuzzy logic, MATLAB.

I. INTRODUCTION

Mobile Ad-hoc Network (MANET) is an infrastructure-less network which consists of a collection of wireless mobile hosts to form a temporary network without the aid of any base station. Since bandwidth is limited in an ad hoc network, it is important to construct a virtual backbone consisting of only a subset of nodes that have the privilege to forward packets. Such a virtual backbone called *spine* plays an important role in routing, broadcasting and connectivity management in wireless ad hoc networks [1]. The most popular method that developed to provide resource management over mobile ad hoc networks is clustering. This technique based on partitioning the network into a number of smaller and manageable groups each group called overlapped or disjointed clusters[2]. Clustering offers several benefits when it used with MANETs such as it enhances routing process and mobility, Stabilizes dynamic network topology, helps to perform more efficient resource allocation. A brief introduction to clustering mechanism has been discussed in section II. In section III basic introduction of Fuzzy logic system is given. In section IV a new proposed approach based on ant Colony Optimization has been introduced for formation of non overlapping cluster and an algorithm using ACO is proposed for finding cluster Head. Section V implemented ABC (Antcolony Based Clusterhead) selection Algorithm using fuzzy logic on MATLAB. In section VI results are shown, where node with highest value of probability function is chosen as a Clusterhead**.**

II. CLUSTER MECHANISM

In MANET during reactive routing whenever a data packet is send to a destined node we have to carry out a route discovery process. In a route discovery a route request packet (RREQ) is flooded over the network. In this each and every node of the network participate which lead huge bandwidth and energy uses. Finally it reduces network performance. In order to utilize our most scarce resources (energy, bandwidth..etc), clustering as a best known solution was proposed. In Clustering based routing two nodes that participate in flooding of route request packet (RREQ) are Cluster Head(CH) and Cluster Gateway(CG). Hence lesser the number of nodes participating in routing decision the more will be the increase in network performance .According to Cluster Based network scheme, we have three types of mobile node [2] in MANET.

A. Cluster Head: can be defined as a local coordinator for its cluster. Cluster Head keeps in regular contact with member nodes and gateway nodes of neighbouring clusters. It performs inter-cluster routing, data forwarding and many other operations.

B. Gateway Node: is a mobile node that acts as a communication medium between the clusters, can access neighbouring cluster and forward information between clusters.

C. Cluster Member or Ordinary Nodes: is the one which is neither a Cluster Head nor Gateway. A cluster member used to communicate with the Cluster Head of its cluster and update its table information according to its corresponding cluster Head.

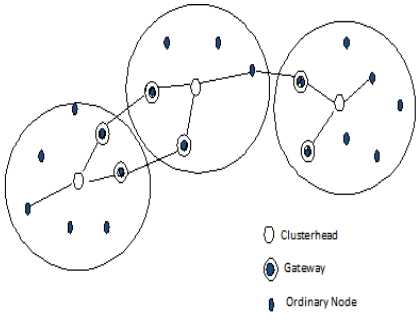

Fig. 1. Cluster Mechanism

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III. FUZZY LOGIC SYSTEM

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 [3].

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 ―*ifthen*‖ rules. A fuzzy system is a set of if- then rules that maps input to output.

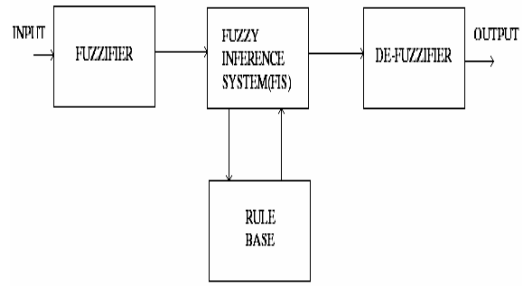

Fig. 2.Generalized Fuzzy System [3]

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 52 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.

IV. ABC (ANTCOLONY BASED CLUSTERHEAD) SELECTION ALGORITHM

Concept of Ant Colony algorithm is merged with clustering algorithm to form ABC (Antcolony Based Clusterhead) selection algorithm. This algorithm will provide advantage of both ant colony and cluster based algorithm. Although there are number of approach present for cluster formation in Ad-hoc networks but they suffers from limitation like overhead due to transmission of large number of packets .Here we are presenting a new approach which can divide the complete networks into non overlapping clusters.

The algorithm for cluster formation can be explained as follows

(1) Initially each node will broadcast a forward ant packet with a hop limit of 1(neighbour node) .With every node accepting atmost 1 forward ant and rejecting the forward ant packets received afterwards.

(2) Every node which will be getting a forward ant as in step 1 will produce a backward ant packet back to the source. Hence leading to the formation of disjoint clusters as shown in fig. 3.

(3) After step 2 the Cluster Head can be decided by counting the number of backward ant received on each node in the cluster. The node with maximum number of backward ant packet will be the Cluster Head.

(4) Thus each node in the cluster can be assigned a Cluster Head id corresponding to the id of the cluster head decided from the step 3.

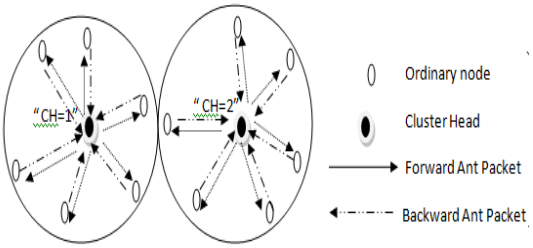

Fig. 3. Formation of clusters.

V. FUZZY LOGIC IMPLEMENTATION

we use fuzzy logic approach to choose the cluster-head based on the three parameters:

(1) BackwardAnt Packet (BackANT Pkt)
(2) Mobility of a nodes.
(3) Degree of the nodes.

Degree of Nodes(Xi) = Max. no. of nodes covered or reached by a node(Xi).

These three parameters are the input of fuzzy logic system and it provides an output cluster-head selection probability and the node with the highest probability is elected as the cluster-head.

$$P(Xi) = \frac{\text{(Total No. of BackANT Pkt) Xi}}{\sum_{i=0}^{n}\text{(Total number of BackANT Pkt) Xi}}$$

Fuzzy Input Variable: BackANT Pkt, Mobility, Degree of nodes.

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Fuzzy Output variable: Probability (P(Xi))
Fuzzzy Rule Base: There are three input variable so total no. of fuzzy rule generated are 3^3=27 rules for fuzzy rule base which are shown in following table:

TABLE I
FUZZY RULE BASE

Back(Ant) Packet	Mobility	Degree	Clusterhead selection (probability)
Less	High	High	Small
Less	High	medium	Small
Less	High	Less	VSmall
Less	Medium	High	Small
Less	Medium	medium	Small
Less	Medium	Less	Small
Less	Low	High	RSmall
Less	Low	Medium	Small
Less	Low	Less	VSmall
Medium	High	High	RLarge
Medium	High	Medium	Medium
Medium	High	Less	Small
Medium	Medium	High	RLarge
Medium	Medium	Medium	Medium
Medium	Medium	Less	Small
Medium	Low	High	Large
Medium	Low	Medium	Rlarge
Medium	Low	Less	RLarge
More	High	High	RLarge
More	High	Medium	Medium
More	High	Less	RSmall
More	Medium	High	Large
More	Medium	Medium	RLarge
More	Medium	Less	Medium
More	Low	High	VLarge
More	Low	Medium	RLarge
More	Low	Less	Medium

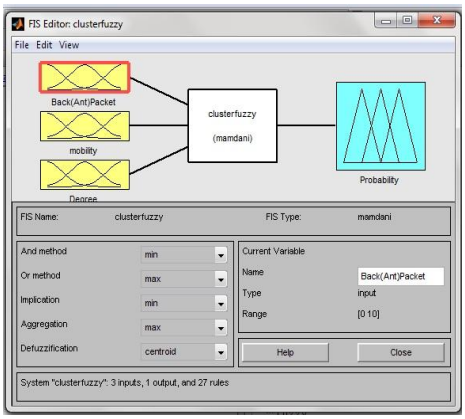

Fig. 4.Fuzzy Logic system with three input producing output probability function.

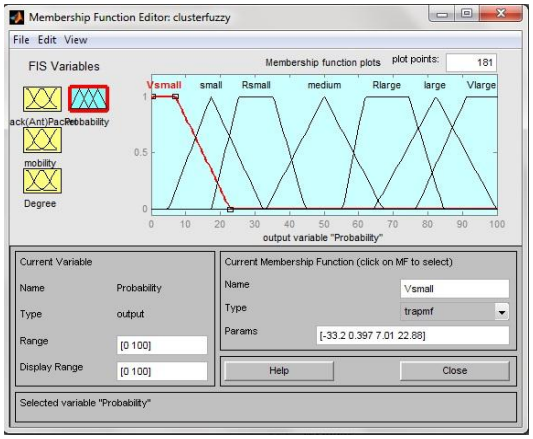

Fig. 5. Output Probability Function

IV. RESULTS

To implement Fuzzy logic on MATLAB, Here we have taken 3 cluster with 4 nodes each. For each node three input parameters (BackANT PKTs, mobility of Nodes, degree of nodes) are inputed. Using fuzzy logic tool on MATLAB, we get output probability of selection of node as a Clusterhead. The node with highest probability is named as Clusterhead of respective cluster. Table II with 3 input parameters [B M D] gives output P(x). In cluster 1, node A with highest probability of 81.7 is selected as Clusterhead. In cluster 2, node E with highest probability of 74.9 is selected as Clusterhead and in cluster 3, node I with highest probability of 82.2 is selected as Clusterhead. Here we can see more the number of backward ant packet, degree of nodes and less the mobility of nodes then we have highest output probability.

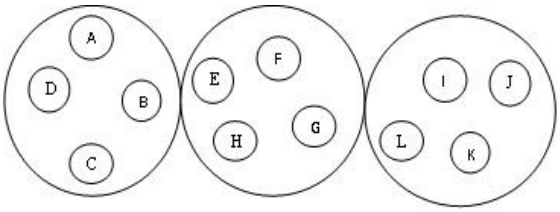

Fig.6. Network with 3 clusters

Using Fuzzy logic tool in MATLAB, we have established the relationship between BackANT PKTs, mobility of nodes and degree of nodes which are shown with Probability output in Fuzzy Rule Base viewer fig.6

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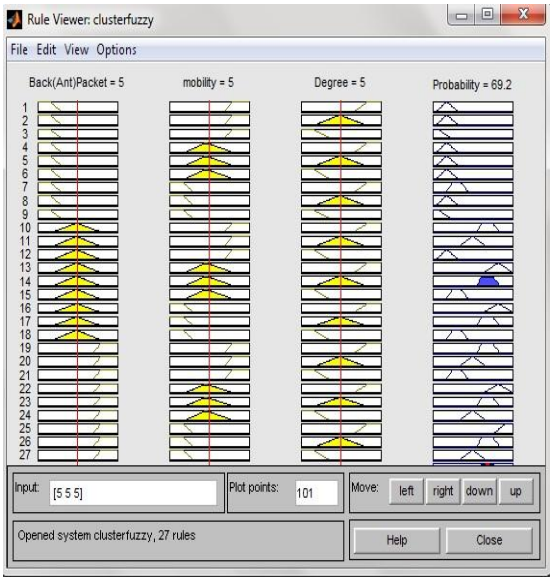

Fig. 7. Fuzzy Rule Base viewer.

TABLE III
RESULTS TABLE

	Node Name	Input [B M D]	Output P(x)	Node Selected
Cluster 1	A	[7 1 8]	81.7	Node A
	B	[1 5 6]	18.3	
	C	[0 7 8]	18.5	
	D	[8 2 2]	51.9	
Cluster 2	E	[5 2 7]	74.9	Node E
	F	[2 2 7]	27.5	
	G	[9 5 5]	69.2	
	H	[8 1 4]	69.3	
Cluster 3	I	[7 5 9]	82.2	Node I
	J	[0 1 2]	9.37	
	K	[6 9 5]	50.1	
	L	[5 0 7]	74.9	

Relationship between BackANT PKTs, mobility of nodes and Probability output is also shown in surface viewer in fig.8. Here X axis corresponds to BackANT PKTs, Y axis corresponds to Mobility and Z axis corresponds to probability of selection of nodse as a Clusterhead.

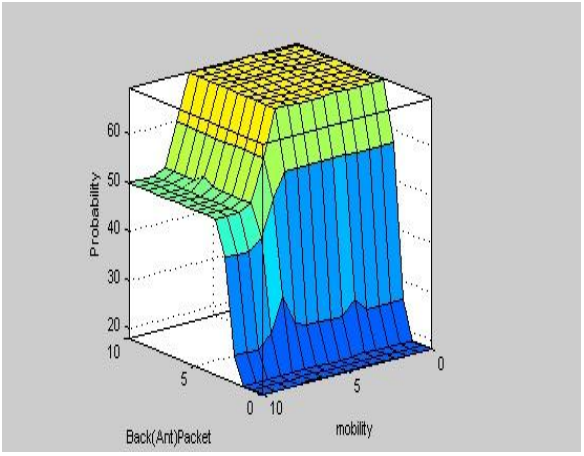

Fig.8. Surface viewer.

V. CONCLUSION

The cluster formation algorithm for disjoint clusters based on the Ant colony optimization promises to be one of the efficient way of clustering algorithm and the results yielded by the fuzzy logic implementation on the MATLAB tool clearly shows that the probability of given node to be selected as a cluster head is directly proportional to the number of backward Ant Packet received on a particular node.In future, this ABC (Antcolony Based Clusterhead) selection algorithm thus can be used further for overlapping cluster formation in highly dynamic networks.

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