# Cluster Based Routing in Mobile Ad hoc Wireless Networks Using Neuro-Genetic Paradigm

Anju Sharma, Shini Agarwal and Ravindra Singh Rathore

**Abstract –** *An Ad-Hoc network is a collection of wireless mobile nodes forming a temporary network without the aid of any established infrastructure or centralized administration. The topology of connections between nodes in ad hoc networks may be quite dynamic. Ad hoc networks require a highly adaptive* routing *scheme to deal with the frequent topology changes. In this paper we propose clustering based algorithm using both neural network and the mechanisms of a genetic algorithm (GA). Cluster head selection is proposed using neural networks with the objective of maximizing the network lifetime..We use GA's because GA mechanisms allow for self-configuration systems and maintain state information about the neighbouring network better than traditional MANET routing mechanisms. GA mechanisms allow a node to change routing information quickly and efficiently to adjust an ever changing local topology, initiating fewer link breakages. And we obtain the alternative path or backup path to avoid reroute discovery in the case of link failure or node failure.*
**Keywords**.-MANET, Routing Protocol, Clusters, Neural Network, Genetic Algorithm.

---

## 1 INTRODUCTION

An ad hoc network is a LAN that is built spontaneously as devices connect. Instead of relying on a base station to coordinate the flow of messages to each node in the network, the individual network nodes forward packets to and from each other. The characteristics of MANETs like no fixed network infrastructure, dynamic network configuration, mobility of nodes and frequent node failure, low battery power, etc differentiate them from other wireless networks. Hence routing in MANETs became one of the most challenging tasks [1][3]. Routing in networking is the process of selecting paths in a network to send network traffic. Therefore, the need to design a novel routing protocol which seamlessly adapt to changing network topology was inevitable

In ad–hoc networks nodes geographically close to each other are grouped into non overlapping sub networks, clusters. Each cluster has a leading node called the cluster head and a number of cluster members. When a cluster member wants to communicate with another node, a route is provided by its cluster head. Hence solutions to this problem are based on heuristics approaches. A good clustering scheme should preserve its structure as much as possible, when nodes are moving and/or the topology is slowly changing. Otherwise, recompilation of cluster heads and frequent information exchange among the participating nodes will result in high computation overhead.

The rest of the paper is organized as follows: section 2 deals with routing in ad hoc networks. Section 3 introduces the proposed work based on neural network and genetic algorithm as an optimization technique. Section 4 includes the steps that are required to apply the Genetic algorithm. Conclusions are summarized in section 5.

## 2 ROUTING IN AD-HOC NETWORKS

The existing ad hoc routing protocols can be divided into three categories: proactive (table driven routing protocols), reactive (on-demand routing protocols), and hybrid [2,3].In Proactive protocols (e.g. WRP or wireless routing protocol), each node periodically maintains one or more tables to store consistent and up-to-date routing information from one to every other node.

In Reactive protocols (e.g. AODV or Ad hoc on-demand distance vector routing), the evaluation of routes are done only when it is necessary. Hybrid protocols proactively maintains routes to the destination node within only a local network consisting of several neighbouring nodes, generally referred to as a cluster, while reactively acquiring routes beyond the cluster.

1.

## 3 RELATED WORK

- *Anju Sharma is an assistant professor, Dept. of Computer Science ,Birla Institute of Technology,Mesra,Jaipur campus, India. E-mail: anish_anju@rediffmail.com*
- *Shini Agarwal is currently pursuing Bachelors of Engg., Dept. of Computer Science ,Birla Institute of Technology,Mesra,Jaipur campus, India.E-mail: shinii.agarwal@gmail.com*
- *Ravindra Singh Rathore is currently pursuing Bachelors of Engg., Dept. of Computer Science ,Birla Institute of Technology,Mesra,Jaipur campus, India.E-mail: ingeniousrave@gmail.com*

A successful approach for dealing with the maintenance of mobile ad hoc networks is by partitioning the network into clusters. In this way the network becomes more manageable. It must be clear though that a clustering technique is not a routing protocol. Clustering is a method which aggregates nodes into groups [4]. These groups are contained by the network and they are known as clusters. A cluster is basically a subset of nodes of the network that satisfies a certain properties [5].However, the cluster organization of an ad hoc network cannot be achieved offline as in fixed networks [6]. Clustering presents several advantages for the medium access layer and the network layer in MANET [7]. The implementation of clustering schemes allows a better performance of the protocols for the Medium Access Control (MAC) layer by improving spatial reuse, throughput, scalability and power consumption. The purpose of a clustering algorithm is to produce and maintain a connected cluster [12]. In most clustering techniques nodes are selected to play different roles according to a certain criteria. In general, three types of nodes are defined:

1) Ordinary nodes

Ordinary nodes are members of a cluster which do not have neighbours belonging to a different cluster [13].

2) Gateway nodes

Gateway nodes are nodes in a non-cluster head state located at the periphery of a cluster. These types of nodes are called gateways because they are able to listen to transmissions from another node which is in a different cluster [11]. To accomplish this, a gateway node must have at least one neighbour that is a member of another cluster [14].

3) Cluster heads

Most clustering approaches for mobile ad hoc networks select a subset of nodes in order to form a network backbone that supports control functions. A set of the selected nodes are called cluster heads and each node in the network is associated with one. Cluster heads are connected with one another directly or through gateway nodes. The union of gateway nodes and cluster heads form a connected backbone. This connected backbone helps simplify functions such as channel access, bandwidth allocation, routing power control and virtual circuit support [15]. Since cluster heads must perform extra work with respect to ordinary nodes they can easily become a single point of failure within a cluster. For this reason, the cluster head election process should consider for the cluster head role, those nodes with a higher degree of relative stability [2]. The main task of a cluster head is to calculate the routes for long-distance messages and to forward inter-cluster packets. A packet from any source node is first directed to its cluster head. If the destination is located in the same cluster, the cluster head just forwards the packet to the destination node. If the destination node is located in a different cluster, the cluster head of the sending node routes the packet within the substructure of the network, to the cluster head of the destination node. Then, this cluster head forwards the packet to its final destiny [18]. Figure 1 shows different roles of nodes in a mobile ad hoc network organized by clusters.

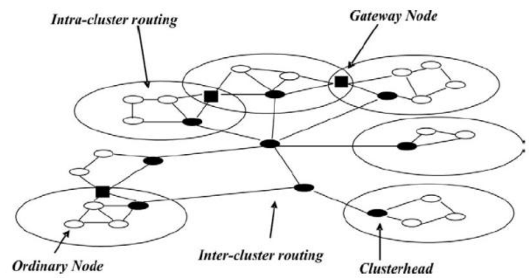


Fig 1. Cluster Configuration of an Ad hoc network and node roles

In summary, choosing an optimal number of cluster heads which will yield high throughput but incur as low latency as possible, is still an important problem. We could have a fully distributed system where all the nodes share the same responsibility and act as cluster heads. However, more cluster heads result extra number of hops for a packet when it gets routed from the source to the destination, since the packet has to go via larger number of cluster heads. Thus this solution leads to higher latency, more power consumption and more information processing per node. On the other hand, to maximize the resource utilization, we can choose to have the minimum number of cluster heads to cover the whole geographical area over which the nodes are distributed. The whole area can be split up into zones, the size of which can be determined by the transmission range of the nodes. This can put a lower bound on the number of cluster heads required.

## 4 THE PROPOSED TECHNIQUE

### 4.1 Neural Network Based Cluster Head Election:

Once the whole region is divided into different clusters, the next phase is to choose the cluster head among the participating nodes to balance energy consumption. Many CHs election mechanism are proposed over the years out of which many proposals favour uniformly distributed clusters with stable average cluster sizes [19,20]. But we propose a new neural network based coverage and connectivity aware clustering algorithm. The set of cluster head nodes can be selected based on the routing cost metric defined in equation 3. There are three layers in the proposed neural network approach: Input layer, Competition layer and Output Layer.

ISSN 2229-5518

Neural networks have good learning capabilities . A two-layer feed forward neural network that implements the idea of competitive learning is depicted in Figure2 above. The nodes in the input layer admit input patterns of nodes competing for CH and are fully connected to the output nodes in the competitive layer. Each output node corresponds to a cluster and is associated with weight $W_{i,j}$ =1,2,...., m, where m is the number of clusters. The neurons in the competitive layer then compete with each other, and only the one with the smallest $E_i^j$ value becomes activated or fired.

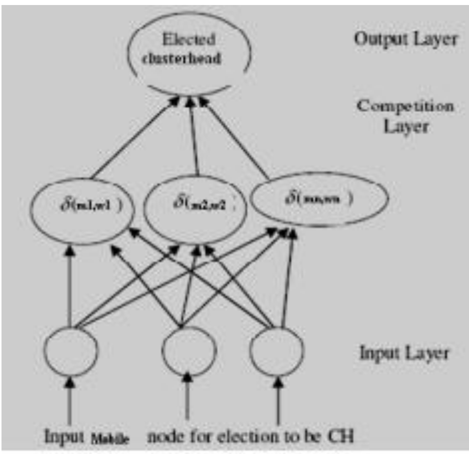


Fig 2. Selection of CH with Neural Network

Each neuron in the proposed algorithm for CH selection has an adaptive learning. The learning rate μ determines the adaptation of the vector towards the input pattern and is directly related to the convergence. If μ equals zero, there is no learning. If μ is set to one, it will result in fast learning, and the prototype vector is directly pointed to the input pattern. For the other choices of μ, the new position of the vector will be on the line between the old vector value and the input pattern. Generally, the learning rate could take a constant value or vary over time.

## 4.2 Algorithm for Cluster head selection:

The algorithm for cluster head election is described below[23]:

Step1. Initialize the Vector m = {m1, m2,......, mn}of nodes competing for Cluster head. //Processing at Input Layer

Step2. Choose a winner k from Mobile nodes as CH whose $E_i^j$ is minimum as follows

k = argmin $E_i^j$ // Competition Layer

Step3. Also take $Z_i^j$ as the smallest Euclidean distance of cluster head to Base node i.e. $Z_i^j = k \sum_{i=1,2...m} | S_i - BS |$ , where k is proportionality constant.

Step4. Initialize the weight vector as $w_j(old) = Z_i^j$ .

Step5. Update the value of weight vector as follows:

$W_l(new) = W_l(old) + \mu(S_i - W_l(old))$,

Where μ is learning rate of the neurons. $0 \leq \mu \leq 1$

Step6. Repeat Steps (2-4) iteratively.

Step7. Neuron with smallest value of $E_i^j$ is winner.// Output Layer

## 4.3 Routing Optimization Using a Genetic Algorithm

Genetic algorithm are computerized search and optimization algorithm based on the mechanics of natural genetics and natural selection. The goal consist to allocate near optimal path from source to destination based on time, giving priority to cluster heads to maximize utilization and minimum delay.[3][24]

Step1: Encoding and Initial Population

All nodes in the search space should be present and have a unique representation. If there is a one-to-one correspondence between the search space and string representation, the design of the genetic operator would be considerably less complex. These unique id's are used to encode the chromosome using integer permutation Encoding the individual chromosomes is an essential part of the mapping process; each chromosome contains information about the cluster heads and the members thereof, as obtained from the original clustering algorithm.

Each chromosome is represented by a link weight vector W = < w1….w(n)> where (n) is the total number of links in the network. The value of each weight is within the range from 1 to MAX_WEIGHT. We define the value of MAX_WEIGHT to be 64 for reducing the search space.The population size is set to 100, with the initial values inside each chromosome randomly varying from 1 to MAX_WEIGHT.

Step2: Fitness Evaluation

Chromosomes are selected according to their fitness. The bandwidth constraint is embedded into the fitness function as a penalty factor, such that the search space is explored with potential feasible solution. The fitness of each chromosome can be defined to be a two-dimensional function as shown in Eq 1. The overall network load (L1) and excessive bandwidth allocated to overloaded links (L2).

Fitness = f(L1,L2) =μ / (ά x L1 + β xL2) (1)

Where ά , β and μ are manually configured coefficients. L1 and L2 are expressed as shown in eq 2, 3, 4.

$$L1 = \sum_{g-1}^{G} D_g \quad (2)$$

$$L2 = \sum_{(i,j)\in E} W_{ij}\, x \left( \sum_{g-1}^{G} D_g - C_{ij} \right) \quad (3)$$

Where:

$$W_{ij} = 0 \ldots if \sum^{G} D_g <= C_{ij} \quad (4)$$

$$or\ 1 \ldots otherwise$$

$D_g$ : Bandwidth demand for cluster g on each link;

$C_{ij}$ : Bandwidth capacity of link (i ,j) ;

$G$ : Total number of active clusters.

So the objective function is two fields: first chromosomes of the new generations. And second, solutions obtained from the offspring should be feasible in that the total bandwidth allocated flows traveling through each link should not exceed its capacity. The tuning of ά and β can be regarded as a tradeoff between overall bandwidth conservation and load balancing. For example we let β= 0 then the objective is to conserve bandwidth resources only, while setting ά = 0 infers to minimize link overloading within the network.

Step3: Crossover and Mutation

According to the basic principle of Genetic algorithms, chromosomes with better fitness value have higher probability of being inherited into the next generation. To achieve this, first we rank all the chromosomes in descending order to their fitness, so the chromosomes with high fitness (lower overall load) are placed on the top of the ranking list. Then we partition this list into two disjointed sets, with the top 50 chromosomes belonging to the upper class (UC) and the bottom 50 chromosomes to the lower class (LC). During the crossover procedure, we select one parent chromosome $C_u^i$ from UC and other parent $C_l^i$ from LC in generation "i" for creating the child $C^{i+1}$ in generation i+1. We use a crossover probability threshold $K_C$ ∈ (0.05) to decide the genes of which parent to be inherited into the child chromosome in the next generation. We introduce a mutation probability threshold $K_M$ to randomly replace some old genes with new ones.

## 5 CONCLUSION

We presented a neuro-genetic algorithm as an optimization technique for routing in MANET. The results show that, with the neural network and genetic algorithmic technique each cluster head handles the maximum possible number of mobile nodes in its cluster in order to facilitate the optimal operation of the medium access control (MAC) protocol, reduce the number of clusters and hence cluster heads, as well as, the loads among clusters are more evenly balanced by factor of ten. The selection of cluster head is proposed using neural network with adaptive learning. The neurons are assigned weight according to the energy of the cluster head nodes in the network. Each cluster head handles the maximum possible number of nodes in its cluster. Also a fewer cluster heads are obtained by the genetic algorithm technique. With the genetic algorithm technique the cumulative distributions of the paths are almost the same. On the other hand, clustering helps improve routing at the network layer by reducing the size of the routing tables and by decreasing transmission overhead due to the update of routing tables after topological changes occur [7,10].

## REFERENCES

[1] Arash Dana, Amir Mansour Yadegari, Marzieh Hajhosseini, and Tina Mirfakhraie, "A Robust Cross-Layer Design of Clustering-Based Routing Protocol for MANET," pp. 1055-1059.ICACT, 2008.

[2] M. Rezaee and M. Yaghmaee, "Cluster based Routing Protocol for Mobile Ad Hoc Networks".

[3] Naveen Chauhan, L. K. Awasthi, Narottam chand, Vivek Katiyar, and Ankit Chug, "A Distributed Weighted Cluster Based Routing Protocol for Manets," World Academy of Science, Engineering and Technology 75,pp.1167-1171, 2011

[4] Roberto Carlos Hincapi´e, Blanca Alicia Correa, and Laura Ospina, "Survey on Clustering Techniques for Mobile Ad Hoc Networks," pp.1-8

[5] C. W. Ahn, R. S. Ramakrishna, and C. G. Kang, "Efficient Clustering-based Routing Protocol in Mobile Ad-Hoc Networks".

[6] B. An, S. Papavassiliou. "A mobility-based clustering approach to support mobility management and multicast routing in mobile ad-hoc wireless networks". International Journal of Network Management. Vol. 11. 2001.
pp. 387-395.

[7].L. Wang and S. Olariu. "Cluster maintenance in mobile ad-hoc networks". Cluster Computing. Vol. 8. 2005. pp. 111-118.

[8]. A. B. McDonald, T. F. Znati. "A mobility-based framework for adaptive clustering in wireless Ad Hoc networks". IEEE Journal on Selected Areas in Communications. Vol. 17. 1999. pp. 1466-1487.

[9]. T. C. Hou, T. J. Tsai. "An Access-Based Clustering Protocol for Multihop Wireless Ad Hoc Networks". IEEE J. Selected Areas Comm. Vol. 19. 2001. pp. 1201-1210.

[10].J. Wu, J. Cao. "Connected k-hop clustering in ad hoc networks". ICPP. 2005. pp 373-380.

[11]. I. Er and W. Seah. "Mobility-based d-hop clustering algorithm for mobile ad hoc networks". IEEE Wireless Communications and Networking Conference. Vol. 4. 2004. pp. 2359-2364.

[12]. G. Lugano. "Clustering for hierarchical routing". 2003.[Online]. Available: http://www.cs.helsinki.fi/u/floreen/ adhoc/lugano.pdf. Consultado julio de 2006.

[13]. R. Purtoosi, H. Taheri, A. Mohammadi, F. Foroozan. "A light-weight contention-based clustering algorithm for wireless ad hoc networks," Computer and Information Technology (CIT '04). 2004. pp. 627-632.

[14]. W. Lou, J. Wu. "An enhanced message exchange mechanism in cluster-based mobile ad hoc networks". ISPA. 2004. pp. 223-232.

[15]. L. Bao, J.J. Garcia-Luna-Aceves. "Topology management in ad hoc networks". Proceedings of the 4th ACM international symposium on mobile ad hoc networking & computing. Vol. 9. 2003. pp. 129-140.

[16]. M. Gerla, J. Tsai. "Multicluster, mobile, multimedia radio network". Wireless networks. Vol 1. 1995. pp. 255-265.

[17]. C.R. Lin, M. Gerla. "Adaptive clustering for mobile wireless networks". IEEE Journal of Selected Areas in Communications. Vol. 15. 1997. pp. 1265-1275.

[18]. Y.P. Chen, A. L. Liestman. "A zonal algorithm for clustering ad hoc networks". International Journal of Foundations of Computer Science. Vol.14. 2003.pp. 305-322.

[19] Sartini,Giorgio Mulas, Giuseppe Bonet, Lino Moretti, "Power Saving Ad-hoc: a MAC Protocol for Multihop Wireless Ad-hoc Networks," in proc. Vehicular Technology Conference, vol.3, pp.1603-1606, 17-19May 2004.

[20] Krishan Kumar,V.P.Singh," Selection for Power Control in Mobile Ad-hoc Networks" ,International Journal on Computer Science and Engineering (IJCSE), Vol. 3 No. 1 Jan 2011.

[21] L Davis, " Handbook of Genetic Algorithms". New York:Van Nostrand Reinhold, (1991).

[22] A.Riedl,"A Genetic Algorithm for Network Planning" in Proc. of EUNICE'98, Munich sep,1998.

[23] Krishan Kumar,V.P.Singh," Neural Network Model Based Cluster Head
Selection for Power Control in Mobile Ad-hoc Networks"in ISSN : 0975-3397 Vol. 3 No. 1 Jan 2011.

[24] *Mustafa AL-GHAZAL,Ayman EL-SAYED ,Hamedy KELASH,"* Routing Optimization using Genetic Algorithm in Ad Hoc Networks",in ISSPIT 2007, 15-18 December 2007, Cairo, Egypt.