Neural Network Model Based Cluster Head Selection for Power Control in Mobile Ad-hoc Networks

Krishan Kumar,A.P.(CSE),
Manav Rachna International University,
Faridabad, Haryana,

V.P.Singh,A.P.(CSE),
Thapar University,Punjab
India

Abstract— Mobile ad-hoc network has challenge of the limited power to prolong the lifetime of the network, because power is a valuable resource in mobile ad-hoc network. The status of power consumption should be continuously monitored after network deployment. In this paper, we propose coverage aware neural network based power control routing with the objective of maximizing the network lifetime. Cluster head selection is proposed using adaptive learning in neural networks followed by coverage. The simulation results show that the proposed scheme can be used in wide area of applications in mobile ad-hoc network.

Keywords- *Neuron, Network, Power, Control*

Introduction

A wireless ad-hoc network consists of mobile nodes that communicate with each other using wireless links. A MANET system does not require a predetermined infrastructure and nodes act as hosts and as routers for other nodes. Nodes are grouped into distinct or overlapping clusters. Clustering provides a hierarchical MANET system which assists in making the routing scalable. Some of the nodes are elected to be part of the backbone for the MANET system [2][3]. These nodes are called cluster heads or gateways. Cluster heads are elected according to several techniques. The cluster head allows for minimizing routing details overhead from other nodes within the cluster. Overlapping clusters might have nodes that are common among them which are called gateways [6]. MANET requires efficient routing algorithm in order to reduce the amount of signaling introduced due to maintaining valid routes[4][5], and therefore enhance the overall performance of the MANET system. As the cluster head is the central node of routing for packets destined outside the cluster in the distinct clustering configuration, the cluster head computing machine pays a penalty of unfair resource utilization such as battery [1], CPU, and memory. Several studies have proposed a cluster head election in order to distribute the load among multiple hosts in the cluster [1][3]. Our approach can use any of them to elect a cluster head. This paper is organized as follows: Section1. Discus the related work, Section2.Discus Energy Model and problem formulation Section3.Consist Problem with exiting solution, Section4. deals Proposed Solution, Section5.deals Simulation and Result and Section 6.includes conclusion

1.Related Work

Several mechanisms of cluster head election exist with an objective to provide stable and efficient routing in the MANET system [4][7][8-9]. Some mechanisms favor not changing the cluster head to reduce the signaling overhead involved in the process [10], which also makes the elected node usage of its own resources higher. Other mechanism assigns the cluster head based on the node id as in the Linked Cluster Algorithm, LCA, which selects as the cluster head the node with the highest ID [3]. However, this selection process burdens the node due to its ID. Other mechanisms favor allowing some type of fair share of cluster head responsibility by changing the clusterhead based on an assigned ID to the cluster head [2], where all nodes have a chance to be a clusterhead for a clusterhead duration budget. This mechanism keeps the clusterhead load within one node for the clusterhead duration budget, while it provides a balance of responsibilities for nodes within the cluster. A node with a high mobility rate may not get the chance to become a clusterhead if its mobility rate is higher than the duration of clusterhead rotation. Other clusterhead election mechanisms consider relative node mobility to ensure routing path availability [3][11][12], however, causing an added signaling overload and causing the elected clusterhead to pay the higher resource utilization penalty. We can conclude from the existing research that several tradeoffs exist for the elected clusterhead and the other cluster nodes. Firstly, the clusterhead has to bear higher resource utilization such as power, which may deplete its battery sooner than other nodes in the cluster. In addition, possibly causing more delay for its own application routing due to the competition with the routing for other nodes. Secondly, despite fair share responsibility of clusterhead role, it is possible that heavy burst of traffic takes place causing some clusterheads to use maximum resources, while others encounter low traffic bursts resulting in minimum resource use. Thirdly, the fair share or load balancing technique [2], might result in a clusterhead that will not provide the optimal path for routing, or yet a link breakage. However, nodes which are not elected as clusterheads don't pay a routing penalty and has its resources dedicated for its own usage. Therefore, there is no one common clusterhead election mechanism that is best for MANET systems, without some tradeoffs.

2. Energy Model and Problem Formulation

We consider a network of homogeneous and energy-constrained mobile nodes that are randomly distributed network. Nodes are initially powered by batteries with full capacities. Each node collects data which are typically correlated with other nodes and then the correlated data is sent to the BS via Cluster Head. Inside each fixed cluster, a node is periodically elected to act as CH through which communication to/from cluster takes place [14].

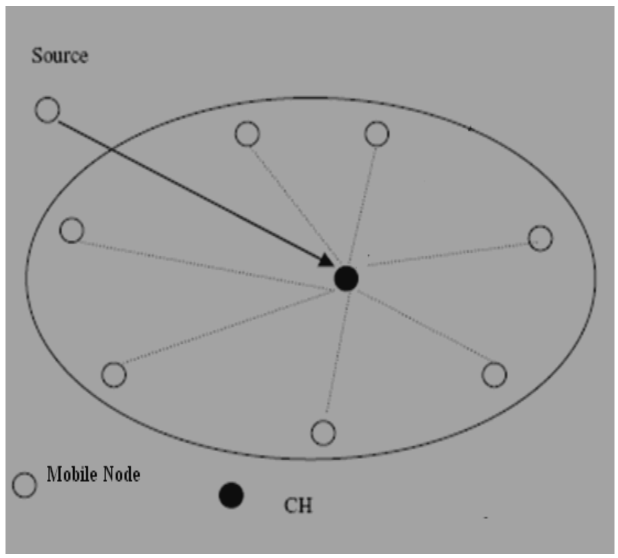


Figure1. Cluster Head(CH)

A. Energy Model

To ascertain the amount of energy consumed by a radio transceiver, we apply the following energy model. For each packet transmitted by a sending node to one or more receivers in its neighborhood, the energy is calculated as according to [14]:

rhe = et + ner + (N - n)e …………………..........(1)

Where et and er denote the amount of energy required to send and receive, n is the number of nodes which should receive the packet, and N the total number of neighbors in the transmission range. reh quantifies the amount of energy required to decode only the packet header According to model described in [14], et and er are defined as

$$e_t(d,k) = (e_{elect} + e_{amp} * d^{\rho})8k \qquad \text{………………..(2)}$$
$$e_r(k) = e_{elect} * 8k$$

B. Routing Metric

The cost of a link between two nodes Si and Sj is equal to the energy spent by these nodes to transmit and to receive one data packet, successfully. To establish the coverage and connectivity aware connection between two nodes, a proper routing metric is needed which will guide to form the connection between the sensors. The following routing metric R _C is chosen and calculated as follows:

$$R\_C = \left(\frac{E_i^{\,D}}{E_t(S_i,S_j) + E_r(S_i,S_j)} * \frac{1}{R} \right), \text{ ………..(3)}$$

where E_i^D is energy associated with the delivery ratio of the packet originating from source node Si and correctly received at destination node, while Et (Si,Sj) is the energy used in transmitting from Si to Sj and Er(Si,Sj) is the energy used in receiving the packet, R is the total coverage area

3. Problem with the Existing Solutions

On-demand power management framework introduced by Rong et al, in which node transmission power consumption is reduced with effective throughput in a network. Transmission power consumption is reduced by using on-demand ad-hoc routing protocols. Energy is saved by turning on and off the radios of specific nodes in the network. Power management depends on medium access layer. On-demand power management frame work is not effective for large size network [13]. Sun et al. have presented a power-saving algorithm based on ant algorithm. Algorithm is strongly distributed and adaptable. Ant algorithm is based on local topology information of the network. Algorithm has problem due to high speed dynamic topology in network. Ad-hoc medium access layer,which is designed for the implementation of high-speed terminals and high dynamic network topologies. The ad-hoc medium access control demands high power consumption. Sartini et al. have designed ad-hoc medium access for all those Ad-hoc networks where power consumption is actually an issue. Mobile ad-hoc network connections are changing very fast in a network. Ad-hoc medium access could not manage the quality of service [14].The potential problem in the existing protocols is that once the optimal route is determined, it will be used for every transmission. This may not be an ideal solution from network's point of view. Using the optimal path frequently leads to energy depletion of the nodes along that path and, in the worst case, may lead to network partition. To counteract this problem, data forwarding could use multiple paths at different times; thus, any single path does not get energy depleted quickly. Compared with the single path strategy, multipath routing can balance traffic loads among multiple nodes, and can respond to network dynamics where nodes can join and leave the network. Chang and Tassiulas [27] proposed an algorithm to route data through a path whose node have the largest residual energy. The path is changed adaptively whenever a better path is discovered. The primary path will be used until its energy falls below the energy of the backup path, at which point the backup path is used. In this way, the nodes in the primary path will not deplete their energy resources due to continual use of the same route, thus achieving longer network life. But they did not consider the coverage and connectivity issue with respect to routing so that every node can participate in CH election mechanism. Moreover, the valuable data to be sent by the nodes would not be missed, if coverage and connectivity is preserved.

4. PROPOSED SOLUTION

We have proposed an energy-aware routing protocol that uses a set of suboptimal paths to Increase the lifetime of the network. The whole network is partitioned into different disjoint sub regions. From these sub regions effective cover set is made depending upon the routing metric defined in equation (3) and defined constraints. The proposed solution to above cited optimization problem consists of following steps: Selection of Cluster head using neural network.

A. Neural Network Based Cluster Head Election

Once the whole region is divided into different regions, the next phase is to choose the CH among the participating nodes to balance energy consumption. Many CHs election mechanism are proposed over the years out of which many proposals favor uniformly distributed clusters with stable average cluster sizes [14-18]. 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.

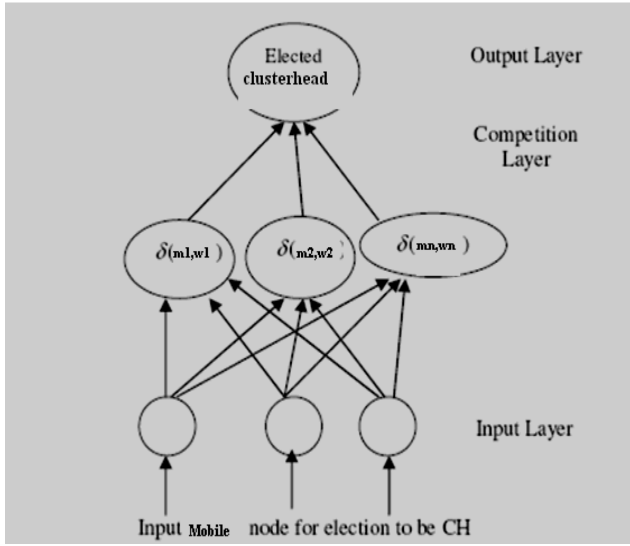


Figure.2. Selection of CH with Neural Network

Neural networks have solved a wide range of problems and have good learning capabilities. A two-layer feed forward neural network that implements the idea of competitive learning is depicted in Figure1 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 Wj,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^D value becomes activated or fired. 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.

B. Algorithm

The algorithm for cluster head election is described below:-

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^D is minimum as follows

k = argmin E_i^D **// Competition Layer**

Step3. Also take Z_i^D as the smallest Euclidean distance of cluster head to Base node i.e.

$$Z_i^D = k \sum_{i=1,2,\ldots m} |S_i - BS|,$$

,where k is proponality constant

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

Step5. Update the value of weight vector as follows:

Wj (new) = Wj (old) + μ (Si-Wj (old)),

where μ is learning rate of the neurons. $0 \le \mu \le 1$

Step6. Repeat Steps (2-4) iteratively.

Step7.Neuron with smallest value of E_i^D is winner.**// Output Layer**

5. Simulation and Result

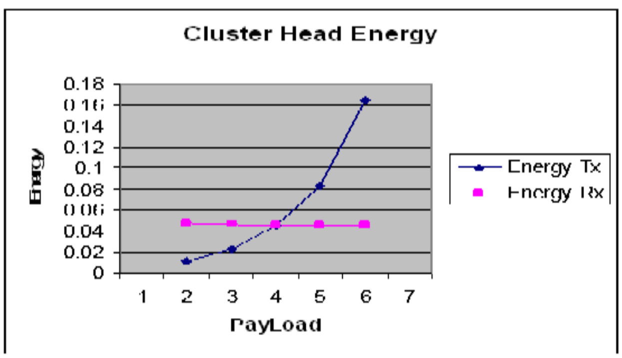
Number of nodes=50,
Sim-time-limit-130s,

CPU-time-limt-300s,
Total-stack-kb-160900,
DTR-DataTransferRate-
11.5Kbs, PayLoad-
63,127,255, 511,1023,
Bytesent-
2176,4352,8704,15872,31930.
Minimum Cluster Node Energy = 0.009

Table.

Sr. No.	Energy Data TX	Energy Switching	Energy sleep	Energy Tx	Energy Rx	Total Energy
1	0.0112	0.0023409	0.0009925	0.01216	0.0483693	0.63863
2	0.0224	0.0022513	0.00099	0.02336	0.0462956	0.072897
3	0.0448	0.0021443	0.0009816	0.04576	0.0455674	0.0944532
4	0.08192	0.0021443	0.0009661	0.08288	0.0455674	0.131558
5	0.16384	0.0021443	0.000932	0.1648	0.0455674	0.21344

Graph



Graph. CH Energy Vs Payload

From the graph observes that Cluster node consumes more energy/ power (TX and Rx) when we increase payload data.

6. Conclusion

In this paper, we propose coverage aware neural network based routing for mobile ad-hoc network. The selection of CH is proposed using neural network with adaptive learning. The neurons are assigned weight according to the energy of the CH nodes in the network. A coverage aware routing metric is also included to choose the best route from the available ones. Once the routes are decided and one of the routes is chosen from these routes. Hence the proposed scheme can be used in various scenarios with respect to coverage.

References

[1] A. Amis, P. Prakash, D. Huynh, and T. Vuong,“Max-Min D-Cluster Formation in Wireless Ad Hoc Networks”, in proc. Nineteenth Annual Joint Conference of the IEEE Computer and Communications Societies on Computer Communications,Volume1, pp 32-41,year 2000.

[2] A.Amis, and R. Prakash, “Load-Balancing Clusters in Wireless Ad Hoc Networks”, in Proceedings of the 3rd IEEE Symposium on Application-Specific Systems and Software Engineering Technology, pp.25,March,2000.

[3] D. J. Baker, and A. Ephremides, “The Architectural Organization of a Mobile Radio Network via a Distributed Algorithm” IEEE Transactions on Communications, pp.1694–1701, Nov., 1981.

[4] J.Broch,D.Maltz,D.Johnso, "A performance comparison of multi-hop wireless ad hoc routing protocols. In Proceedings of the Fourth Annual ACM/IEEE International Conference on Mobile Computing and Networking, Year 1998.

[5] M. Denko,"The Use of Mobile Agents for Clustering in Mobile Ad Hoc Networks", In Proceedings of ACM International Conference, Vol. 47, pp 241 – 247,Year 2003.

[6] I. Er, and W.Seah, M,"Mobility-based d-Hop Clustering Algorithm for Mobile Ad Hoc Networks", In Proceedings of WCNC'04,Year 2004.

[7] Er, and W. Seah,"Clustering Overhead and Convergence Time Analysis of the Mobility-Based Multi-Hop Clustering Algorithm for Mobile Ad Hoc Networks", in proc. International Conference on Parallel and Distributed Systems,July2005.

[8] S. Sivavakeesar, and G. Pavlou, "Stable Clustering Through Mobility Prediction for Large-Scale Multihop Intelligent Ad Hoc Networks", In Proceedings of the IEEE Wireless Communications and Networking Conference (WCNC'04), Georgia, USA, Mar. 2004, vol.3, 1488-1493.

[9] Y. Wang, W. Wang, X. Li, "Distributed Low- Cost Backbone Formation for Wireless Ad Hoc Networks", In the Proceedings of the 6th ACM international symposium on Mobile ad-hoc networking and computing**,** pp. 2–13,Year2005.

[10] C. Chiang, H. Wu, W. Liu,, and M. Gerla, "Routing in clustered multi-hop, mobile wireless networks with fading channel", in proc. IEEESICON, pp.197-211,Year 1997.

[11] I. Er, and W.Seah, "Mobility-based Hop Clustering Algorithm for Mobile Ad-Hoc Networks", In Proceedings of WCNC'04,Year 2004.

[12] A. McDonald, T. F. Znati, "A mobility based framework for adaptive clustering in wireless ad hoc networks," in proc. IEEE JSAC, 17(8):1466-1486, Aug.1999.

[13] RongZheng,RobinKravets,"On-demand Power Management for Ad-hoc Networks", in proc. IEEE Infocom, year 2003.

[14] 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.