International Journal of Application or Innovation in Engineering & Management (IJAIEM)
Web Site: www.ijaiem.org Email: editor@ijaiem.org, editorijaiem@gmail.com
Volume 2, Issue 1, January 2013 ISSN 2319 - 4847

Performance Evaluation Using Cluster Based Routing Protocol for MANET

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ABSTRACT

In Mobile Ad Hoc Networks (MANETS), Clustering based routing protocol can sufficiently enhance Performance, Scalability and Energy Efficiency. Through this paper, we propose a new clustering algorithm integrated along with a routing protocol. Our Approach is inspired from bird flocking behavior where birds travel long distances in flocks and conserve energy by constantly changing the leader of the Flock. We have mainly concentrated on clustering algorithm and designed our clustering algorithm based on moment-to moment decisions of individual nodes during communication. In this protocol, the network is divided into chunks of nodes known as clusters. The clusters are actively maintained and reassembled using specific algorithms and techniques. The proposed routing scheme is a position based routing approach which incorporates Dynamic Selection of the Gateway nodes to reduce the number of control packets flooded in the network required for efficient routing of data packets. This work presents routing algorithm, cluster algorithm and simulation environment.

Keywords: Bird Flock, Clustering, MANETS, Life time, routing.

1. INTRODUCTION

Mobile Ad Hoc Networks (MANET) is completely different from classic networks in the features such as mobility of the nodes, limited bandwidth and rapid change of the network topology. As the demand for the MANETS is increasing, the performance has to be improved which is reduced due increase in overhead with size of the network, mobility, limited energy and computational capacity of the nodes. The normal MANET routing protocols cannot cope up with the scalability of the network. An adaptive clustering algorithm improves the performance by increasing the scalability of the network, efficient band width usage and also decreases the control overhead of the routing protocol.. Also it sustains the mobility perfectly and maintains the stability and robustness of network. In clustered network architecture, the whole network is divided into self-managed groups of nodes called clusters. These clusters are dynamically reconfigured with change in topology of the network. Cluster head is the node which represents the entire cluster as a single entity and carries certain extra responsibilities. The lack of an efficient, scalable and practical methodology for ad hoc networks, in the field of routing integrated with clustering, inspired a study in this area. We propose clustering algorithm integrated with a routing algorithm inspired from bird flight which is distributed in nature, highly scalable, robust to failures in the network, energy efficient, requires low storage capacity at each node, has low routing overhead, it uses multiple paths for routing thus improving the bandwidth capacity, and above all it is dynamic in nature.

2. RELATED WORK

Most of Proposed routing protocol in MANET do not involve the clustering of nodes which decreases their scalability due to increase in routing overhead. To support large scale MANETS, large number of cluster based routing algorithm have been proposed. Previously suggested protocols have failed to solve issues like efficient bandwidth usage, routing overhead, efficient use of resources , energy usage by the nodes for transmission and storage capacity required at each node.

Routing strategies for large population and for mobility can be investigate [2]. This problem is practically relevant since one can foresee that most of the commercial laptops and personal digital assistants(PDA) will be equipped with radios enabling them to form ad hoc "virtual" wireless networks. This problem is challenging because of both large numbers and mobility. If nodes are stations the large population can be effectively handled with conventional hierarchical partitioning must be continuously updated. Mobile IP [19]solutions work well if there is a fixed infrastructure supporting the concept of "home agent". When all nodes move (including the home agent)such a strategy cannot be directly applied. In wireless scalable routing focusing mostly on hierarchical routing.

Control packet overhead required for constructing routing tables in a two level hierarchically organized network is considered[5].The analysis was performed to address primarily the overhead of updates due to link cost changes and did not address the control packet overhead incurred by node mobility. In control packet overhead required for routing table maintenance is also considered but for three level hierarchical network. The performance metrics under consideration is the control overhead required by hierarchical routing I terms of packet transmission per second. This assessment considers the overhead due to maintenance of routing tables and hierarchical clustering as well as overhead due to address management.

In simplest direct communication (Direct) routing protocol, each sensor node directly communicates with the base station [14].As the distance is large, it consumes the energy by minimum transmission energy (MTE)routing protocol. In LEACH [2], it considers the energy dissipation of the receivers and concludes that multi hop is energy efficient only in certain network topology. For power efficient routing (PEGASIS)Power efficient Gathering in sensor information system and (BCDCP)Base station controlled dynamic clustering protocol is used. Hierarchical cluster based routing (HCR)technique is an extension of LEACH protocol that is a self organized cluster based approach for continuous monitoring. In HLR, each cluster is managed by a set of associates and the energy efficient clusters are identified. For continuous monitoring applications, the simulation results show that HLR is more energy efficient than the traditional cluster based routing techniques. The main objective of the HLR protocol is to generate energy efficient clusters for randomly deployed sensor nodes where each cluster is managed by a set of associates called a head set.

3. PROPOSED WORK

Mobile Ad hoc network comprises of nodes that keep moving and communicate with each other using wireless links. In clustering the network is divided into chunks of nodes known as clusters where one node in each cluster functions as cluster head, which is responsible for routing. There are two phases in clustering: 1) cluster formation i.e. the creation of the clusters and 2) cluster management.

3.1 Clustering Algorithm

Our proposed clustering algorithm as stated above is inspired from bird flight where birds travel long distances in flocks which are ‘V’ shaped, where all the burden is on the sphere head of the flock due to the increase in the induced drag on the sphere head because of the down wash of the appositely rotating line vortices. But, this down wash on the sphere head also has a positive effect of up wash which reduces the up thrust required by the rest of the birds in the flock. Thus, it reduces the amount of energy required by the birds behind the wing of the sphere head to fly. This is the reason why birds travel long distances by loosing minimum amount of energy.

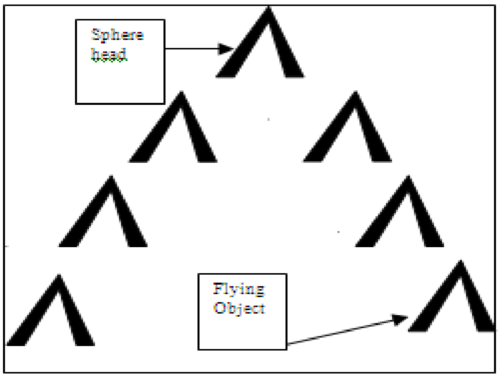

Fig 1: Flocking behavior in bird

In the proposed model, I follow a three tier hierarchy model. In first Layer we have Cluster Head, second layer Gateway Nodes and last layer being the nodes.

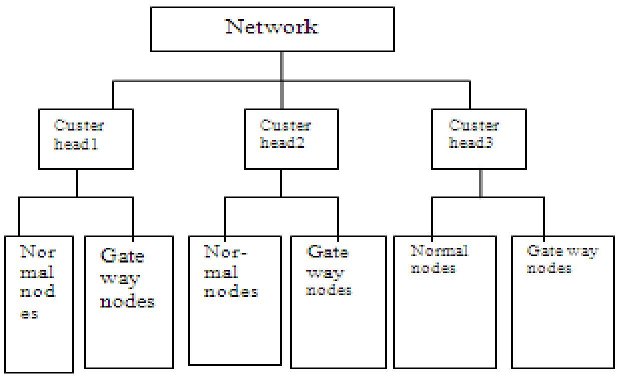

Fig 2 Hierarchy of nodes

The clustering algorithm is divided in to two phases 1. first phase is cluster formation and the 2.second phase is cluster maintenance.

3.2 Cluster Formation

I assume that each node is equipped with Global Positioning System (GPS). Each and every node in the network periodically broadcasts a hello packet which consists of the two dimensional positional coordinates, velocity vector, Energy, number of neighbors, its hierarchal level and the ID of the cluster head. Initially the id of the cluster head, hierarchal level and the number neighbors of the node are left blank.

3.3 Cluster Head Election

Initially, all the nodes start as cluster heads and start broadcasting Hello Packets. Now, each of the nodes receives Hello Packets of its neighboring nodes. When a node receives a Hello Packet from a new neighbor, it adds an entry to the neighbor table .Once you have Hello Packets from all your neighbors, it assigns priority given by equation [1] to each neighbor based on its energy level and the number of neighbors. Then node elects the neighbor with the highest priority and compares with its priority. If highest priority among the neighbors priority is greater than the nodes priority then node elects it as its cluster head, else node assumes itself as the cluster head.

$$Pi = \alpha \times E + \beta \times ni \qquad (1)$$

Where Pi denotes the priority of each neighboring node, E is the energy of node and ni is the number of neighbors of the neighboring node, α and β are the arbitrary proportionality constants

3.4 Gateway Nodes Election

3.4.1 Gateway Node

Nodes with maximum distance but also in the transmission range of the Cluster Head are elected as the Gateway Nodes. The main function of Gateway Node is to provide inter cluster communication. Election is done by the respective Cluster Heads. Assuming Cluster peripheral to be circular in nature, we partition peripheral in to 8 sectors with sector angle of 45 degrees having a gateway node. The Cluster Head computes the distance and the direction of the velocity vector of all the neighboring nodes using the information present in the neighbor table with respect to itself and then assigns a priority to each neighbor and elects the node with highest priority in each sector as the gate way node

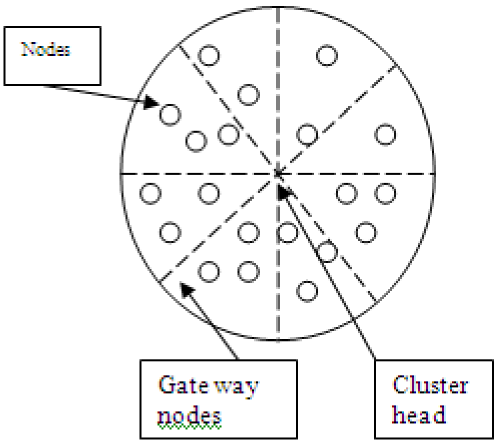

Fig 3 Partition of the peripheral of cluster

3.5 Cluster Maintenance

Re organization of the Cluster can be observed in three instances.

- Energy of the Cluster Head drops down.
- Arrival of a new node in to the cluster.
- Decrease in number of neighbors of the cluster head.

3.5.1 Energy of the Cluster Head Drops Down

With time, Energy of Cluster Head decreases more rapidly because it will has the burden of managing and coordinating the routing of data sent by each node in the cluster. Whenever a node receives a hello packet from its cluster head it gets to know the energy of the cluster head and reiterates the cluster head selection algorithm

3.5.2 Arrival of a new node in to the cluster

When a new node enters a different cluster from previous one in the network it broadcasts a Hello Packet and waits for the Hello Packets from its neighbors and initiates the cluster head election algorithm as stated above. Three different cases

- Energy Content and number of neighbors of this node is less than the Cluster Head and it acts like a normal node in the cluster.
- Energy Content and number of neighbors of this node is less than the Cluster Head but its distance is more than the present gateway
- Energy Content and number of neighbors of this node is more than the Cluster Head. Then, the new node becomes the cluster head of the cluster**.**

3.5.3 Decrease in number of neighbors of the cluster head

When the cluster head's is slowly but persistently moving out of the Cluster. This results in decreasing number of neighbors of the Cluster Head and also the velocity vector is in a different direction.

3.6 Gateway Maintenance

Whenever Cluster Head receives Hello Packets from the Gateway nodes it calculates the distance between itself and the nodes in the sector of the gateway node and checks whether any other node is at a greater distance .If this condition holds then it sends a message indicating the particular node's hierarchy, Else the Cluster Head sends no message.

4. ROUTING ALGORITHM

The proposed routing algorithm is a position based routing algorithm where we assume that each node is equipped with GPS (Global Positioning System) which provides the location of the destination node and the node itself. The Routing Algorithm uses four types of packets:

I. Hello Packets.

II. RREQ Packets.

III. RREP Packets.

IV. RRER Packets

The Routing Algorithm can be broadly divided into two phases: 1. Inter Cluster Routing 2. Intra Cluster Routing

Intra Cluster Routing

Cluster Head checks whether the destination node is within the Cluster or not .If the node is present within the cluster than the cluster head send the RREP reply packet with its ID embedded in the packet. Now, the node forwards all the data packets required to be sent to the destination node to the cluster head which forwards to the destination.

Inter Cluster Routing

The node is present within the cluster then the cluster head forwards the packet to the destination node. If the node is not present within the same cluster then the cluster head finds the location of the destination from GPS and sends a RREQ packet to the gateway nodes in the direction of the destination

- The destination is present within the Cluster of the Gateway nodes.
- The destination is not present within the Cluster of the Gateway nodes.

Recovery Routing

Whenever a link breaks down in a path while forwarding a data packet the node at which Link Broken Event occurs it stores the data packet in its cache and initiates a local repair procedure in which the node takes up the task to find the route to the particular destination.When the local node does not receive any RREP packets then it sends a RRER packet to the source indicating the Route failure.

5. PERFORMANCE EVALUATION

This section, we evaluate the performance of the proposed BFIRP routing scheme in various simulation scenarios. Simulations are performed in NS2 which provides support for number of routing protocols for wireless networks. We evaluate the performance of the proposed BFIRP routing scheme in two simulation scenarios by varying specific parameters: 1) Number of nodes, and 2) mobility of nodes in the network. In the two simulation scenarios, while varying any one of the above parameters, specifications of other parameters are kept constant and equal to the values specified in the table 1

Table 2. Simulation Parameter

Sr.No.	Simulation Parameters	
1	Simulation time	10min
2	Number of Nodes	10,20,30,40,50
3	Field Dimensions	400x400
4	MAC protocol	IEEE 802.11
5	PHY-MODEL	PHY 802.11b
6	Propagation path loss	Two ray ground
7	Placement of nodes	Random
8	Mobility model	Random wave point mobility model
9	Transmission Range	260 mtrs.
10	Power Drain for Transmission	0.6watt
11	Power Drain for Reception	0.3watt

The mobility model used for simulation is the Random wave point model (RWP) in which each node selects a destination point randomly and moves towards it. The speed with which each node moves towards the destination point is uniformly distributed between 0 m/s and maximum speed limit. After the node arrives at the destination point it remains stationary for the specified time period and follows the procedure described above. In our simulations, we set pause time equal to zero in order to test the dynamic nature of our proposed protocol.

5.1 Performance Metrics

There are various metrics for evaluating the performance of our proposed algorithm. The most important ones are:

5.1.1 Packet Delivery ratio

It indicates the number of data packet successfully transferred to the respective destination nodes. It is defined as the ratio of total number of packets that have reached the destination nodes to the total number of packets sent by the source.

5.1.2 Network Life time

This metric indicates the average amount of time after which the energy of a node decreases below a threshold which indirectly tells that the node is dead.

5.1.3 Control overhead

This indirectly the scalability of the protocol because lesser is the number of control packets higher is the scalability of the protocol. Here we normalize it with the number of data packets successfully received by the destination nodes.

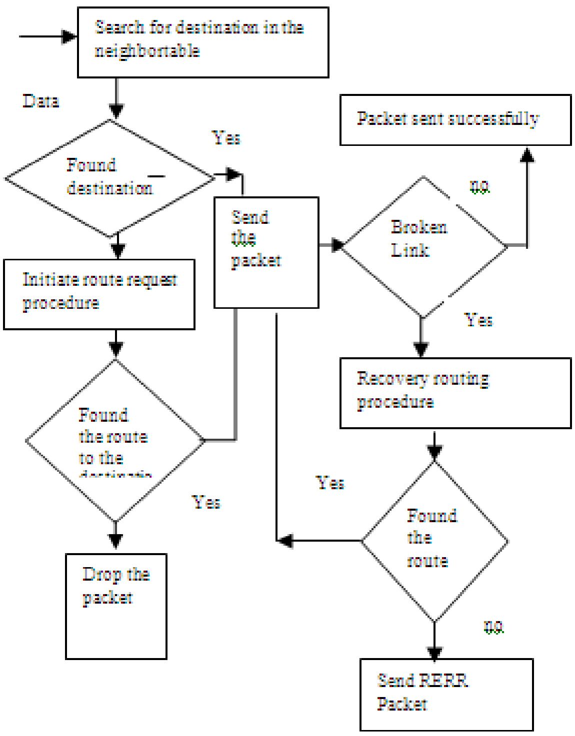

Fig 4: Routing Algorithm Flow diagram

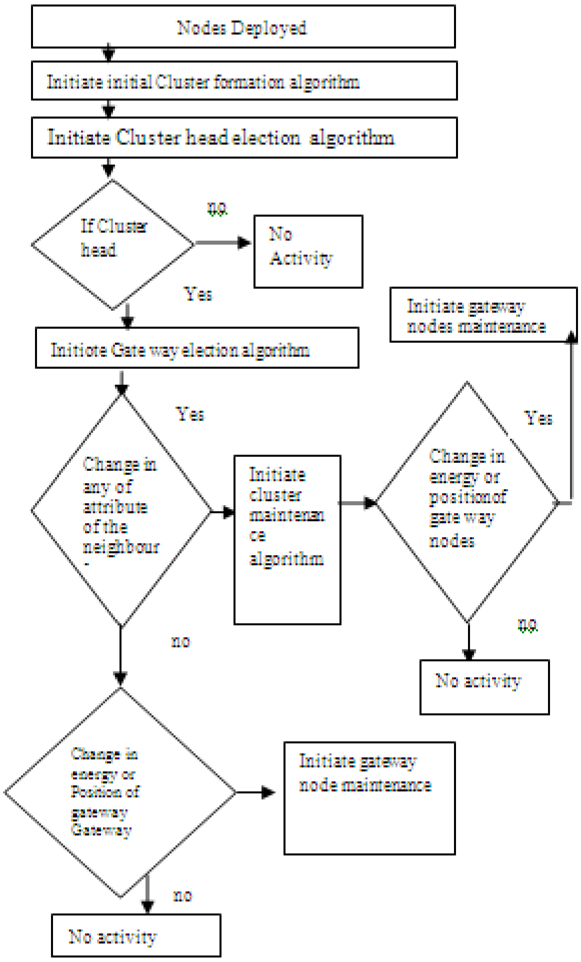

Fig 5 Cluster Algorithm Flow diagram

6. Conclusion

We have designed a new clustering algorithm integrated with the routing algorithm The important feature of the proposed algorithm is that it is not bonded by fixed infrastructure. We have not made any assumptions related to the transmission range and node mobility, complete care has been taken to generate all the cases involving considering different directions of the velocity vector of the Cluster Head as well as other nodes.

7. Result

Using NS2 (network simulator software) I have plotted the graph of packet received verses packet lost using clustering algorithm integrated with routing algorithm. As graph shows packet received is large packet delivery ratio is large.

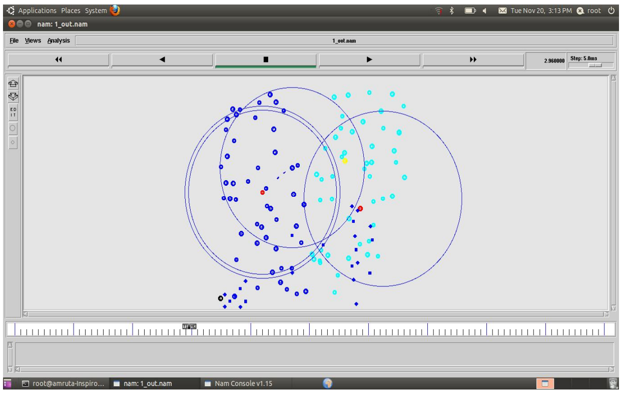

Fig 6 NAM window for 50 nodes simulation

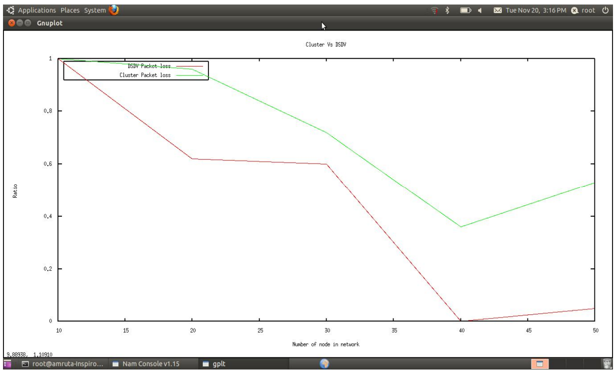

Fig 7 Delivery ratio varies with mobility

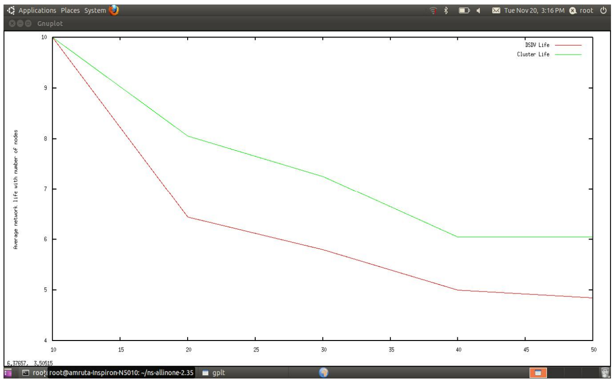

Fig 7 Life time varies with mobility

ACKNOWLEDGMENTS

I would like to thank Prof S.V.Sankpal for her encouragement and comments on earlier drafts of this paper. Without the support of my loving husband & my kid it would have been impossible to complete this work.

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