STUDY OF CLUSTERING SCHEMES FOR CHOOSING THE CLUSTER HEAD IN MOBILE AD HOC NETWORKS

KARTHIK.A[1], KAVITHA.R[2]

[1] *Student, Computer science and engineering, Kumaraguru College of Technology, (India)*

[2]*Assistant Professor, computer science and engineering, Kumaraguru College of Technology, (India)*

ABSTRACT-- *Mobile Ad Hoc Networks (MANET) is a network composed of many nodes connected via wireless links. The topology is dynamic in nature. Nodes of MANET are grouped into clusters to restrict the spreading of information between the set of nodes. Each node in a cluster is supervised by a leader node known as cluster head (CH). The work of cluster head is to maintain the affiliated node list and also to communicate with the other clusters. Maintaining cluster head has some advantages like it allows fast communication, topology management and better routing. Cluster head improves the performance of network parameters like routing delay bandwidth consumption and throughput. Cluster head selection is based on the parameters like mobility, connectivity, battery power, node degree and transmission range . This paper presents the survey of different schemes for choosing the cluster head and comparative analysis of some clustering techniques.*

Keywords: Mobile Ad Hoc Networks; Clustering, Gateway; Cluster Head Election; Node Degree

I. INTRODUCTION

Ad hoc networks are wireless, infrastructure less, multi-hop, dynamic networks established by a collection of mobile nodes. The network is ad hoc because it does not trust on a pre existing infrastructure, such as routers in wired networks or access points in managed (infrastructure) wireless networks. Instead, each node participates in routing by forwarding data for other nodes, so the determination of which nodes forward data is made dynamically on the basis of network connectivity. The major issues in cluster based MANETs are topology management, mobility management, overhead of cluster head and frequent leader re-election. There are no stationary nodes or base stations, each node in the network act as the router that forwards the packet to other nodes. Due to the node heterogeneity, nodes will have highly variable amount of resources and this produces the hierarchy in their roles inside the networks. Nodes with large computational and communication power, powerful batteries are suitable for MANET.

Cluster heads are analogous to the base station concept in current cellular systems .Electing the leader for a cluster is very important but sophisticated job. The factors like location of the node, mobility, energy and throughput are considered in electing the cluster head. Communication done with the node in the other cluster can be done through gateways. Gateway nodes are located at edge or boundary of the cluster which listen to transmissions from another cluster's node.

II. ROUTING IN MOBILE AD HOC NETWORKS:

An ad Hoc routing protocol is standard that reins how nodes decide which way to route packets between computing devices in mobile ad hoc networks . Every node in the network differs from one another in terms of energy, memory and mobility. The routing can be static or dynamic.

A. Static Routing

The static routing is that configured manually on a router by network administrator. The routing table holds the information about the network and is connected directly to the router.

B. Dynamic Routing

The routing makes use of the routing protocols to find the route to reach the destination.

III. CHARACTERISTICS OF ROUTING

The important characteristics of MANET are:

- Dynamic nature of the nodes
- Limited bandwidth
- Limited battery power
- Security issues

A. Terminologies Used in Routing

Some commonly used routing terminologies are briefed below

i) Routing

It is process of sending the data packets from one node to the other node.

ii) Router

It acts as a passage for directing the data packets among the network.

iii) Route Discovery

During communication when a source desires to establish a route to the destination, it searches across the network to find the destination (or)an intermediate node containing the route to destination.

iv) Route Establishment

When a source wants to communicate with other nodes it broadcasts the route requests all over the network and tries to identify the destination in order to transmit the data packets to destination.

v) Route Deletion

The route between the sender and the receiver are maintained until it is no longer needed in multicasting after which the route is removed using route deletion process.

vi) Routing Table

In MANET each and every node has the privilege to act as hosts and routers which periodically updates all the known routes for every other node into a table called the routing table.

IV. WHY CLUSTERING IS DONE IN MANETS

A successful technique for dealing with the maintenance of mobile ad hoc network is by portioning the network into clusters. Clustering is a method not a protocol.

A. Clustering advantage

1. Clustering methods allow fast connection, better routing and topology management
2. Reducing the size of the routing table
3. Update routing table after topological changes occur

V. CLUSTERING SCHEMES

A. *Lowest-ID Clustering Algorithm (LIC)*

In this algorithm each node is assigned a unique identifier (ID) and the clusters are formed based on the given steps:

1. It broadcasts the ID to all the nodes including itself
2. A node will hear the ID's of all other nodes that are greater than its own
3. The lowest ID node is considered to be the cluster-head, unless lowest ID gives up its role as a cluster-head
4. The node with the minimum ID is chosen to be a cluster-head

Major drawbacks of this algorithm are its bias towards nodes with smaller ids which may lead to the battery drainage of certain nodes, and it does not attempt to balance the load uniformly across all the nodes.

B. Highest Connectivity Clustering Algorithm (HCC)

This algorithm is also known as connectivity-based clustering algorithm. Each and every node will broadcast its ID to the neighbor nodes within its transmission range. The degree for each node is calculated and the node that contains the maximum number of neighbors is selected as the cluster head. Disadvantages are

- There will be lower throughputs when the degree of the node increases
- There is no limit of nodes in the cluster
- The re-affiliation(re-bonding)count of nodes is high due to node movement

C. Load Balancing Clustering (LBC)

It provides the balance of load on the elected clusterheads. It is desirable for the elected nodes to stay as a clusterhead up to some maximum specified amount of time, or budget. Budget is a user defined constraint placed on the heuristic and can be modified to meet the specific characteristics of the system. Two local variables are maintained physical Id (PID) - unique id for each node and Virtual ID (VID). Initially, PID is same as VID. And then VID is modified with time because it is used as the cluster election heuristic. Mobile nodes having the highest IDs in their local area is elected as cluster head first. LBC limits the maximum units that a node can serve as a clusterhead continuously by budget, so when its duration budget gets over, it resets its VID to 0 which is less than any other node and becomes a non-clusterhead node. When two cluster heads move into the range of each other, the one having higher VID wins the clusterhead role. When a cluster head resigns(renounce), a non-clusterhead with the largest VID value in the neighbourhood can resume the clusterhead function.

D. Power Aware Connected Domain Set

It is an energy efficient clustering algorithm that reduces the size of the dominating set (DS) without affecting its functions. Here routing is based on the connected dominating set so it removes the unnecessary nodes. Based on the energy level and node degree of each node the dominating set is connected. Energy level is used as the metric for the clusterhead election. Nodes in the DS consume more energy than nodes outside the set because they handle extra responsibilities like updating routing information and handling of traffics. So, it is required to minimize the energy consumption of the DS. A mobile node can be deleted from the DS when its close neighbour set is covered by one or two dominating neighbors, and at the same time it has less remaining energy than the dominating neighbors.

E. Weighted Clustering Algorithm (WCA)

The weighted clustering algorithm (WCA) is based on the use of a combined weight metric. i.e.the number of neighbors, distance with all neighbors, mobility and cumulative time for which the node acts as the clusterhead. The weight values are broadcast by each node and so each node knows the weight values of all other nodes and other cluster heads in the system. This leads to a overhead. A Hello message contains its ID and position. Each node builds its neighbor list based on the Hello messages received. Each node calculates its weight value by following algorithm. The disadvantage of WCA is, if a node moves into an area that is not covered by any cluster head then the cluster set-up procedure is invoked again which causes reaffiliations.

1. Find the set of neighbors of each node v called N(v). (e.g. if the distance between v and v' is less than the Transmission range of v then v' is neighbor of v). Set d_v, the degree of v.
2. Calculate the degree-difference for each node. It is the pre-defined threshold that a clusterhead can handle ideally.
3. For every node, calculate the sum of the distances *D* with all its neighbors. Then compute the running average of the speed for every node until current time T. This gives a measure of mobility *M* where it defines the position of the node v at instant *t*. Compute the cumulative time during which a node v acts as cluster-head. *v P* indicates how much battery power has been consumed.

4. Calculate the combined Weight *W* for each node v[(C(W)=D+T+M+P]
5. The node with the smallest *W* is elected as cluster-head.
6. Repeat steps 2 to 5 for the remaining nodes which are not yet selected as a cluster-head

F. A Distributed Weighted Clustering Algorithm

It works same as WCA except that power management and distributed cluster set up is done by localizing configuration and reconfiguration of clusters. The consumed battery power is a better measure than the cumulative time during which the node acts as a clusterhead that is used in WCA because it reflects the actual amount of power usage. If there is insufficient battery power then lifetime of topology can be increase by switching the role of the clusterhead to an ordinary node. Two situations can invoke the cluster maintenance phase-one when there is node movement outside the cluster boundary and another when there is excessive battery consumption at the clusterhead. When an ordinary node moves outside of its cluster boundary, it is required to find a new clusterhead to affiliate (bonding). If it finds a new clusterhead, it hand over to the new cluster. If not, it declares itself as a clusterhead. Each clusterhead updates the amount of consumed battery power when it sends and receives packets. If the amount of consumed battery power becomes more than a pre-defined threshold value then the clusterhead resigns and becomes an ordinary node. This algorithm provides better performance than WCA in terms of the number of reaffiliations, end-to-end throughput, overheads during the initial clustering set up phase, and the lifespan of nodes.

G. An Efficient Weighted Distributed Clustering (CBMD)

It uses different weight function which takes into consideration the following parameters: connectivity (C), residual battery power (B), average mobility (M), and distance (D) of the nodes. Furthermore, each mobile node starts to measure its weight after *n* (small integer in order to minimize the memory requirement) successive HELLO messages, where the result specifies the accurate value for the mobility and battery power. This algorithm is used to elect optimal clusterheads and divide optimal number of clusters without degrading the whole network performance, to satisfy the load balancing between clusters, to maximize the cluster stability and to reduce the communication overhead and minimizing the explicit control messages caused by cluster maintenance. Advantages of these clustering algorithms are load balancing between the clusters is achieved and less number of clusters formed by specifying the maximum and minimum number of nodes that a clusterhead can ideally hand.

VI. COMPARATIVE ANALYSIS

Comparative analysis of certain techniques has been shown in the following Table

Name of the Algo.	Metrics considered	Objectives	Advantages	Disadvantage
LIC	None	To Simplify the clusterhead election procedure. Nodes are selected as clusterheads based on their node *id*	Simple Procedure	(1)When there is a node movement or a node die in the network the re-clustering procedure is followed, (2) Certain nodes are prone to power drainage due to serving as clusterheads for longer periods of time because IDs are not going to be change with time.
HCC	Cardinality of the node	To decrease the no. of clusters	**N**o. of nodes in a cluster increases but no. of clusters in the network decreases.	(1) There is no limit on the maximum number of nodes in a cluster (2)CH becomes the Bottleneck. (3)Re-affiliation count is high.
LBC	Energy level (measured by previous total clusterhead serving time)	To achieve load balancing	(1)The newly chosen node would be having good energy level. So, no CH bottleneck (2)Its previous total clusterhead serving time is the shortest in its neighbourhood.	Cluster head serving time cannot be good indicator for energy consumption of a mobile node
WCA	Node degree, sum of Distance with all its neighbours,, Mobility , and Remaining battery power	To select clusterhead which is not biased towards a specific metric, by considering more than one metric.	(1)Avoids Communication overhead. The algorithm is not periodic and the Clusterhead election procedure is invoked based on node mobility and when the current dominant set is incapable to cover all the nodes. (2) Ensures that clusterheads	(1)Knowing the weights of all the nodes are required before starting the clustering process (2)Drains the power of CHs rapidly. (3)If a node moves into an area that is not covered by any clusterhead,

VII. CONCLUSION

Cluster based routing is a most convenient way for developing efficient routing scheme in MANET. But it has to deal with several problems like control overhead of cluster formation and maintenance, battery Power, stability of cluster, fairness, load balancing etc. So, to optimize the cluster head election algorithm and to perform efficient cluster based routing in MANET, it is necessary to consider all metrics rather than focusing on particular metric.

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