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CLUSTER HEAD SELECTION ALGORITHMS IN MANET: A SURVEY

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ABSTRACT

Mobile ad-hoc network are a specific kind of wireless network that can be quickly deployed without pre-existing infrastructure. The characteristics of MANET are dynamic topology, distributed operation, multihop etc. Clustering is an important research area, it offers several advantages like it improves stability and decreases the overhead of the network that increases the efficiency of the network. There are many clustering scheme have been proposed for MANETs. A systematic classification of these clustering schemes enables one to better understand and make improvement. Each clustering algorithm uses various parameter for selecting cluster head in cluster. Cluster head is work as a leader in cluster and maintain the whole network information. A comparative analysis of various techniques also have been covered in this paper. This paper presents a survey of different clustering schemes.

Keywords: Mobile Ad-Hoc Network, Clustering, Cluster Head, Cluster Gateway, Cluster Member.

I. INTRODUCTION

Basically Mobile ad-hoc network is the combination of different network nodes, which are able to communication among themselves. MANET is a continuously self-configuring infrastructure less network of mobile device connected wirelessly [1]. MANETs are a kind of wireless ad-doc network. That usually has a routable networking environment on top of a link layer Ad-hoc network. Each device in a MANET is free to move independently in any direction, and will therefore change its links to other devices frequently. MANET nodes can receive their network packets from their respective neighbours.Nodes during their movement, these nodes change their topologies time to time. This type of communication in MANET is helpful for large scale infrastructure. MANET typically uses distributed system environment and fixed infrastructure. MANET is capable of going off-grid and enabling peer to peer communication point or traditional network infrastructure. The unique feature of these protocols is their ability to trace routers in spite of a dynamic topology.

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Some of the important characteristics of MANETs are:

- ***Autonomous Terminal***

In MANET each mobile terminal is an autonomous node which may function as both a host and a router.

- ***Distributed Operation***

Every mobile node has individual functionality, since there is no background network for the central control of the network operation, the control and management of the network is distributed among the terminals.

- ***Multihop Routing***

In multihop routing when delivering data packets from a source to its destination out ofthe direct wireless transmission range, the packets should be forwarded via one or more intermediate nodes.

- ***Dynamic Network Topology***

The network topology may change rapidly and unpredictably and the connectivity among the terminals may vary with time. The mobile nodes in the network dynamically establish routing among themselves as they move about, forming their own network on the fly.

- ***Light Wight Terminals***

In most of the cases, the MANET nodes are mobile devices with less CPU processing capability, small memory size, and low power storage.

1.1 Challenges of Mobile Ad Hoc Network

- ***Quality of Service***

Quality of Service aware solutions are being developed to meet the emerging requirements of these applications. Voice, Live video & file transfer are just a few application having very diverse requirements.

- ***Routing***

An Ad hoc network is a collection of wireless mobile nodes dynamically forming a temporary network without the use of any pre-existing network infrastructure or centralized administration.

- ***Security***

Application like military and confidential meeting require high degree of security against enemies and active/passive eavesdropping attackers.

- ***Energy Conservation***

Energy Conservation network are becoming extremely popular within the ad hoc network research. Energy Conservation is currently being addressed in every layer of the protocol stack.

- ***Limited Bandwidth***

Wireless link continue to have significantly lower capacity than infrastructure network.

- ***Dynamic Topology***

Dynamic Topology membership may disturb the trust relationship among nodes. The may also be disturbed if some nodes are detected as compromised.

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1.2 Application of MANET

- ***Commercial Sector***

Ad hoc can be used in emergency or rescue operations for disaster relief efforts, e.g. in fire flood or earthquake.

- ***Military Battlefield***

Ad hoc networking would allow the military to take advantage of common place network technology to maintain an information network between soldiers' vehicles and military information head quarter.

- ***Local Level***

Ad hoc network can autonomously link an instant and temporary multimedia network using notebook computer to spread and share information among participants at an e.g. conference or classroom.

- ***Collaborative Work***

For some business environment the need for collaborative computing neight be more important outside office environment than inside and where people do need to have outside meeting to cooperate and exchange information on a given project.

- ***Personal area network and Bluetooth***

Short-range MANET such as Bluetooth can simplify the inter communication between various mobile devices such as a laptop, and a mobile phone.

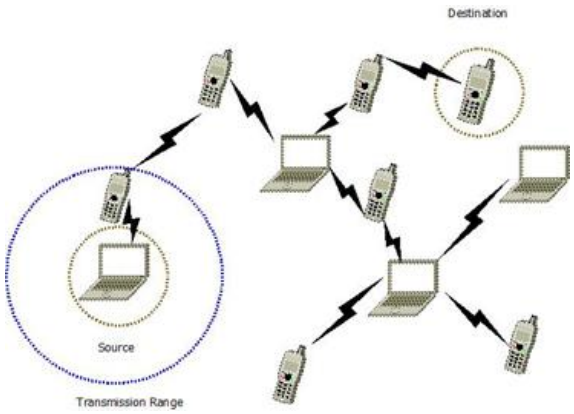

Fig 1. Mobile Ad hoc network

II.CLUSTERING IN MOBILE AD HOC NETWORK

2.1 Definition

The process that divides the network into interconnected substructures called **clusters**. Each cluster has a particular node elected as cluster head (CH) based on a specific metric or a combination of matrices such as identity, degree, mobility, weight and density etc. The cluster head plays the role of coordination within its

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substructure. Each CH acts as a temporary base within its cluster and communication with other CHs [2, 3]. In many network the main goal is that the information should flow among various nodes.

Every clustering algorithm consist of two mechanisms, clustering formation and cluster maintenance. In cluster formation cluster heads are selected among the nodes to form the hierarchical network.

A cluster is therefore composed of a cluster head, gateways and members node.

Cluster Head (CH) **-** Cluster head is the coordinator of the cluster.

Cluster Gateway- It is a common node between two or more clusters.

Member Node- It is also known as ordinary nodes. It is a node that is neither a CH nor gateway node.

Advantages of Clustering:

The advantages of clustering in Ad Hoc network is as following-

- It increase system capacity by spatial reusing available resources. [4]
- If two clusters are not neighbouring clusters and they are not overlapped then they can use same of frequency.
- Resources allocation can be done.
- Reduction of control packet in routing. [4]
- It allows the better performance of the protocol for the medium access control (MAC), layer by improving the spatial release throughput, scalability and power consumption.
- It helps to improve routing at the network layer by reducing the size of the routing tables.

Disadvantages of Clustering:

The disadvantages of clustering is as following-

- When any mobile node dies or node moves to another cluster it comes the re-clustering sometimes. It is called as the ripple effect of re – clustering.
- Clustering is dividing in to two phases cluster formation and cluster maintenance.
- During cluster formation all nodes are mobile nodes so routing strategies may be frequently changed that will decreases the performance of the network.

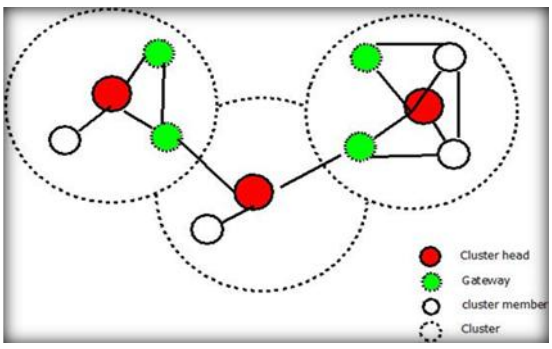

Fig 2. Clustering in MANET

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2.2. Algorithm for Cluster Heads Selection in MANETs

In such way, only cluster heads and gateways take part in the propagation of routing update or control message. This significantly reduces the routing overhead and also solves scalability problem in dense network. There are several algorithm in the literature for cluster head election in mobile ad hoc networks. Lowest ID [5], Highest Degree [6], Distributed Clustering Algorithm [7], Weighted Clustering Algorithm (WCA) [8] and Distributed Weighted Clustering Algorithm (DWCA) [9].

III.LITERATURE SURVEY

Clustering Schemes

In clustering schemes refer to how to form and maintenance a cluster structure-

3.1. Identifier-based clustering

The unique identifier is assigned to all the nodes:

1) ***Lowest – ID algorithm (LIC):***

The Lowest – ID [10, 11] algorithm also known as identifier – based clustering, provide three different roles for the nodes: original, gateway and cluster head nodes. Periodically each node broadcast the list of n nodes with whom it can communicate including itself. Node with the minimum ID is selected as cluster head [12]. Thus the ids of the neighbors of the cluster head will be higher than that of the cluster head.

The algorithm of selecting a cluster head is as follows:-

Step 1. In lowest – ID each node is assigned a unique id in the setup process.

Step 2. The node assigned with the lowest id in its group will be the cluster head of that group. Therefore the ids in the group will be higher than that of the cluster head.

Step 3. If a node lies in two different clusters, it will be set as a gateway. The functionality of a gateway is to act as a bridge or a connection between two or more clusters in the network to ease the workload of a cluster head.

Step 4. No cluster head can be neighbors of each other. In order to have an inter-cluster connection, message have to go through a gateway node.

It has its own disadvantages-

(i) Lowest - ID does not considered any network metrics.

(ii) Since the node ids don't change with time, the nodes having the smaller ids are more likely to be selected as cluster head.

2) Max – Min d – cluster formation algorithm:

The background of the cluster is localized to some particular *d*-hop distance from the cluster head [12, 13]. The various advantages of this cluster is (1) To avoiding clock synchronization the node energy can be saved and it is salutary when the network is large, (2) Flooding can be avoided to some extent. The maximum number of message the node can be send would be just in the multiple of *d,* instead of *n*. In this cluster d=the maximum

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number of hops away from the nearest cluster head. *n*= number of nodes in the network. The amount of resources needed at each node is minimum, consisting of four simple rules and two data structures that maintain node information over *2d* rounds of communication. Nodes are nominee candidate to be cluster head based on their node *id* rather than their degree of connectivity. If a node *A* is the largest in the d – neighbouring of other node *B* then node *A, A* will be elected a cluster head, even though node *A* may not be the largest in its d – neighbouring. This provides a smooth exchange of cluster heads rather than an erratic exchange.

3.2. Connectivity – Based Clustering

1) Highest – Degree Algorithm (HCC):

Highest– Degree [6, 12] also known as Connectivity – based clustering, it was one of the first developed clustering algorithms used in ad hoc network. Similar to Lowest – ID algorithm, a network consists of the two major components, Cluster Head and Member Node (Ordinary Node). Functionality of a cluster head node is to control the local traffic of the nodes in the cluster. The algorithm of selecting a cluster head is as follows:-

Step 1. Each node is assigned a unique id in the network.

Step 2. After an id is obtained, the node broadcast its id to other node which are inside of its transmission range.

Step 3. Any nodes receiving the signal is included as a part of the neighbour list of that node.

Step 4. The most number of neighbour a node has determines the node being selected as the cluster head of the group.

Step 5. If there is a tie, it means there are multiple nodes with the some number of maximum neighbour nodes in that group, the node with Lower-ID is selected as the cluster head of that group.

Step 6. Similar to the Lowest-ID algorithm, two or more cluster head can't be neighbour to each other simultaneously.

Step 7. Repeat step 2 through 6 until the remaining nodes in the network become a cluster head or join the cluster head.

2) K – hop connectivity ID clustering algorithm:[12, 14]

In this cluster, it is the combination of LIC and HCC. HCC is take as first measure and LIC as the second measure. By flooding process, initially clustering request is sent to all nodes by a node. If we used only LIC, then it causes more number of cluster than needed, as a result the set of cluster head increases. If we used only HCC, then it causes numerous ties between nodes. So when we used both cluster, it can limit on number of clusters by using HCC as first criterion that is the node having highest connectivity is selected as the cluster head, when number of hopes k=1, connectivity it same as node degree.

3)Mobility Aware Clustering

1) Mobility Based Metric for clustering algorithm (MOBIC): [12, 15]

It introduce a local mobility metric for the cluster formation process. Furthermore, cluster is formed in such a way that mobile nodes with very low speed relative to their neighbours have the great chance to become cluster

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heads. The only difference between LIC and MOBIC is that in this cluster we use mobility metric for cluster formation instead of ID information. In this algorithm, the received power levels of two successive Hello message transmissions is measured by each node from every neighbour. In Hello message every node broadcasts its own mobility metric to its 1-hop neighbors. And it is stored in the neighbour table of each neighbour with a break period.

4. *Combined Weight based clustering*

1) Weighted clustering algorithm (WCA): [16]

The WCA is based on the use of a combined weight metric. In this clustering, we selects a cluster head according to the number of nodes it can handle, mobility, transmission power and battery power. To avoid communications overhead, this algorithm is not periodic and the cluster head election procedure is only invoked based on node mobility and when the current rule set is unqualified to over all the nodes. WCA selects the cluster heads according to the value of each node. The weight associated to a node v is defined as:

$W_v = w1\ \Delta_v + w2\ D_v + w3\ M_v + w4\ Pv$ ---------- (1)

The node with the minimum weight is selected as a cluster head. The weighting factors are chosen so that w1 + w2 + w3 + w4 = 1. Where Mv is the measure of mobility who taken by computing the running average speed of every node during a specified time T. Δ_v is the degree difference, Δv is obtained by first calculating the number of neighbors of each node. The result of this calculation is defined as the degree of a node v, dv. To ensure load balancing the degree difference Δv is calculated as $|dv - \delta|$ for every node v, where δ is a pre-defined threshold. The parameter Dv is defined as the sum of distances from a given node to all its neighbors. This factor is related to energy consumption. The parameter Pv is the cumulative time of a node being a cluster head. Pv is a measure of how much battery than an ordinary node because it has extra responsibilities. The cluster head election algorithm finishes once all the nodes become either a cluster head or a member of a cluster head. The distance between members of a cluster head, must be less or equal to the transmission range between them.

IV.COMPARATIVE ANALYSIS

Comparative analysis of certain techniques has been shown in the following tables-

Algorithm	Working	Benefits	Drawbacks
Lowest –ID Clustering algorithm	Node with Lowest-ID is selected as Cluster Head.	Very easy to understand and Cluster Head will be selected on the basic of unique ID.	Few nodes are prone to power drainage due to serving as CH for long period of time.
Max – Min Clustering	If node A is largest in neighbourhood of node b, then A will be CH.	No of cluster head elected are controlled by value of d	How to select value of d is not specified

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Highest Degree Clustering algorithm	The node which is linked by highest number of node selected as a cluster head.	CH elected on the basis of degree. Rate of data transmission is easy and fast.	Leads to increases overhead. No re-election of CH. Load of network increase due to single CH. Number of nodes increases throughput decreases.
K – Hop connectivity ID clustering algorithm	Each node in the network is assigned a pair id = (d, ID).	If used LIC only creates maximum number of clusters then necessary. If uses HCC only it causes ties between nodes.	Each node needs to maintain two parameters connectivity and ID.
Mobility based D – Hop clustering algorithm	A node may be selected as CH if it is found to be the most stable node among its neighbourhood.	It reduces the re – clustering problems.	Each node has to compute mobility value that requires time.
Weight Clustering algorithm	Clusterhead is selects according to the number of nodes.	Refused overhead	Knowing the weight of all nodes before clustering.

V.CONCLUSION

In this survey paper, we first present fundamental concepts about clustering, including the definition of clustering, design goals and objectives of clustering. Then we classified clustering schemes into four categories based on their distinguishing features and their objectives as: Identifier based clustering, Mobility based clustering, Connectivity based clustering and Weight based clustering. We reviewed various clustering schemes which helps to organize MANETs in a hierarchical and presented some of their important characteristic, challenges, application. We also identified the most important merit and demerit of clustering algorithm. Most of the presented clustering schemes focus on important issues such as cluster structure stability, the total control overhead of cluster formation and maintenance etc.

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