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A Survey Paper on Cluster Head Selection Techniques for Mobile Ad-Hoc Network

Nilesh Goriya[1], Indr Jeet Rajput[2], Mihir Mehta[3]
[123] *Hasmukh Goswami College of Engineering, Ahmedabad, India*

Abstract: *Wireless Technologies are very useful due to their use. Mobile Ad-hoc Network (MANET) has become an essential technology in field of research In MANET, Clustering is an important research area, it offers several advantages like it improves stability and decrees the overhead of the network that increases the efficiency of the network. Clustering increases system capacity by reusing available resources. This Survey paper analyzes number of Cluster head Selection Techniques that are widely used for partitioning mobile host into distinct virtual groups. Each Clustering Technique uses various parameters for selecting Cluster head in cluster. Cluster head is work as leader in cluster and maintain the whole network information which decreases the computation cost and routing overhead of the network in MANET. Each technique is used on the bases of their parameters. Each approach has its own pros and cons.*

Keywords: *Mobile Ad-hoc Network, Clustering, Cluster head (CH), Cluster Gateway, Cluster Member*

I. Introduction

The term Ad-hoc, says it's just "Temporary Network" network. Mobile Ad-hoc Network is containing the mobile nodes that are also called as mobile host. All mobile hosts are connecting with each other through wireless links they all are contained by infrastructure-less environment. Such network referred as multi-hop networks. Each node working as router, it forwards data packets to the destination node of the network.The growth of laptops and 802.11/Wi-Fi wireless networking has made MANET a popular topic for research in recent time.

In Clustering, the mobile nodes in a network are partitioned into distinct virtual groups. Nodes are assigned geographically adjacent into same cluster according to some rules [1]. Cluster based network describes the three types of nodes in the network. They are as follows:

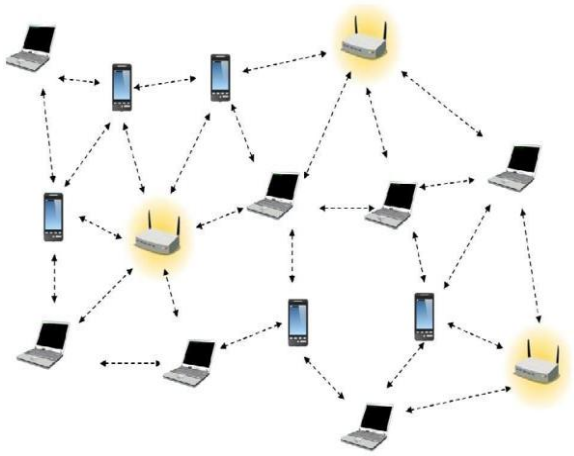

Figure 1: Mobile Ad Hoc Network (MANET) [15]

1. Cluster Head:

Cluster Head serves as a leader node for its Cluster. Through cluster head any node can easily communicate with each other. In network it is a key factor for communication of node. It performs responsible duties like inter-clustering, intra-clustering, data packet forwarding and maintains the entire network.

2. Cluster Gateway:

It is a non-Cluster Head node. It is one kind of intermediate node which provide link between two clusters. It is also called as Border node in Cluster. It can access neighboring cluster and transfer data packet between clusters.

3. Cluster Members:

It is also called as Ordinary nodes in the Cluster. It is neither Cluster Head node nor Border nodes. It does not have any inter cluster links.

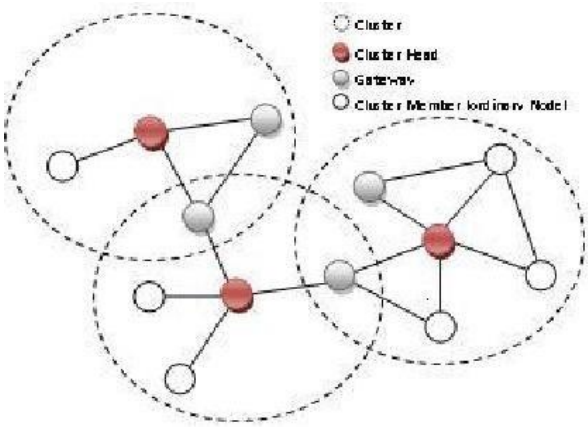

Figure 2: Clustering in MANET [4]

Clustering in MANET:

In Clustering, the mobile hosts in a network are divided into virtual groups and create sub network. Clustering is control based network in that there is cluster head that manage or maintain the whole cluster; it has ability in performing the role of the local coordinator. The MANET Clustering problem is to partition M into a set of Clusters, $C = \{c_1, c_2, c3... c_n\}$ such that $c_1 \cup c_2 \cup ... \cup c_n = M$.

Clustering offers several benefits when it is used with MANET:

1. It increases system capacity by spatial reusing available resources [10]. If two clusters are not neighbouring clusters and they are not overlapped then they can use same set of frequency.
2. Cluster Head and Border nodes form a virtual backbone for routing among neighbouring clusters. So generation and spreading of routing information is minimized to this set of nodes [11, 12].
3. Resource allocation can be done.
4. In cluster when mobile nodes moves to another cluster, only nodes present at that cluster need to update the information. So information stored by each node is reduced, thus overhead of storing information is decrees.
5. Reduction of control packet in routing [10].

Demerits of the clustering in MANET:

1. When any mobile node dies or node moves to another Cluster it causes the re-clustering sometimes. It is called as the ripple effect of re-clustering.
2. Clustering is divided into two phases, Cluster Formation and Cluster Maintenance. During Cluster Formation all nodes are mobile nodes so routing strategies may be frequently changed that will decrees the performance of the network.

The objective of this survey is to choose appropriate cluster head selection techniques by selecting most suitable node as cluster head. And to maintain a cluster to keep cluster head changes as least as possible. That reduces the effect of re-clustering.

The rest of this paper is organized as follows. Section 2 presents literature review on cluster head selection techniques for selecting suitable cluster head. Section 3 Comparative analysis of cluster head selection techniques. Conclusion and Future work is given in Section 4.

II. Survey On Cluster Head Selection Techniques In Manets

A. Lowest ID Clustering (LIC) [2]

In this Clustering approach unique identifier is assigned to each mobile host in the network. All nodes recognize its neighbors' ID and CH is chosen according to minimum ID, Thus the node IDs of the neighbors of the **CH** will be higher than that **CH.**The main drawback with this scheme is; here is no limitation to the number of nodes attached to the same CH. Also, CHs are prone to power drainage due to serving as cluster heads longer period of time.

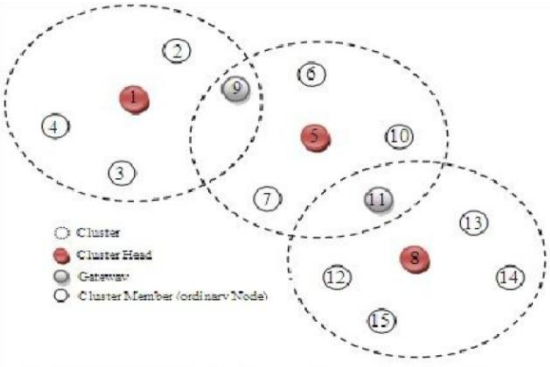

Figure3: Lowest ID Clustering [2]

B. Highest Degree Clustering (HCC) [2][4][6]

It is connectivity based Clustering approach. All nodes broadcast their ID to the nodes which are in their transmission range. In comparison with Lowest-ID scheme, the degree of nodes is computed based on its distance from each other's [6]. All nodes flood its connectivity value within their transmission range. Thus, a node decides to become a **CH** or remain as cluster node by comparing the connectivity value of its neighbors with its own value. Node with highest connectivity value in its vicinity will become **CH** as shown in Fig. 4. Connectivity-based clustering follows the same circumstances of ID-based regarding to cluster size and performance degradation. The node which has highest number of neighbors is selected as CH by this approach. There is a direct link between CH and its neighbors.

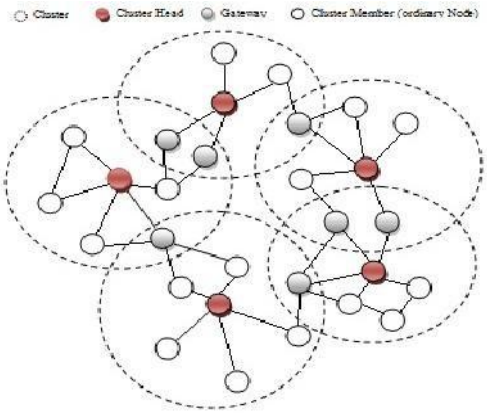

Figure 4: Highest Degree Connectivity Clustering [2]

C. K- hop connectivity ID Clustering (K-CONID) [3][5]

This approach combines Lowest ID Clustering approach with highest degree Clustering approach. HCC is considered as first criteria and Lowest Id as second criteria. In this Clustering technique the node connectivity D is paired with node ID which can be written as DID = (D, ID). The node is selected as Cluster Head if and only if it has highest degree and lowest ID.

D. Mobility Based D-Hop Clustering Algorithm [2]

Another technique can be used with clustering in MANETs. It applies partitioning ad-hoc network into D-Hop clusters. This process based on mobility metric as it follows the objectives of forming cluster with more flexible cluster diameter according to D-Hop. This technique is adaptable with respect to node mobility. Both of variation of estimated distance and relative mobility between hosts are used to calculate the local stability. A node may be selected as a **CH** if we found the most stable node among its neighborhood. Consequently, the node with the lowest value of local stability among its neighbors will be the **CH**.

E. Adaptive Cluster Load balance approach [3]

In Highest connectivity clustering algorithm (HCC) scheme, one CH can be exhausted when it serves too many mobile hosts. It is unpredictable and the CH becomes a bottleneck. So a new Technique is given. In hello message format, there is an "Option" item. If CH is a sender node, it will set the number of its dominated member nodes as "Option" value. When CH is not a sender node or it is undecided (CH or non-CH), "Option" item will be reset to 0. When a Cluster head's Hello message shows it's dominated nodes' number increase

beyond a threshold (the maximum number one CH can manage), no new node will take part in this cluster. As a result, this can eliminate the CH bottleneck phenomenon and optimize the cluster structure. Through this algorithm we can get load balance between different types of clusters. Thus, resource consumption and information transmission is distributed to all clusters.

F. Least Cluster change Algorithm [3][7]

LCC has a useful improvement over LIC and HCC algorithms as for as the cost of cluster maintenance is considered. The clustering procedures periodically considered by protocol, and re-cluster the nodes periodically in order to satisfy some proper characteristic of CH. In HCC, the clustering scheme is performed periodically to check the "local highest node degree" aspect of a cluster head. When a cluster head finds a member node with a higher degree, it is forced to hand over its cluster head role. Re-clustering is frequently involved by this mechanism. In LCC the clustering algorithm is further categorized into two steps: cluster formation and cluster maintenance. The LIC technique is followed by Cluster formation method, i.e. initially mobile nodes with the lowest ID in their neighborhoods are chosen as CH. Re-clustering is event-driven and invoked in only two cases:

- When two cluster heads move into the reach range of each other, one gives up the cluster head role.
- When a mobile node cannot access any CH, it re-constructs the cluster structure for the network according to LIC.

G. Load balancing Clustering [3][4]

It provides the balance of loads on Cluster Heads. Once a node is selected as a CH; it is desirable for it to stay as a Cluster Head up to some maximum specified time limit or budget. Budget is defined by user and it constraint placed on the heuristic and can be modified to meet some particular characteristics of the system. Two local parameters are maintained Physical ID – unique ID for each node and Virtual ID (VID). Initially VID is set as its ID number at first. Mobile nodes have highest IDs in their local area is elected as Cluster Head first. LBC limits the maximum time unit that a node can serve as a Cluster Head continuously by budget; so; when selected Cluster Heads budget is over; it is reset to zero. After that it becomes non Cluster Head node. When two Cluster Heads move into the range of each other; the one having higher VID wins as CH.

H. Power-aware connected dominant set [3][4][8]

It is an energy efficient clustering approach which decreases the size of Dominating set (DS) without affecting its functions. Unnecessary nodes are removed from the DS without. If all the nodes in the system are either in the set or neighbor of the nodes in the set is called as Dominating Set. In this schema energy level instead of ID or node degree is used as Metric for CH selection. Nodes in dominating set consume more energy than nodes outside the set because they handle extra responsibilities like updating routing information, data packet relay etc. So it is required to minimize the energy consumptions of Dominating set. A mobile node can be deleted from the Dominating set when its close neighbor set is covered by one or two dominating neighbors.

I. Weighted Clustering approach[4][9]

WCA is based on the use of a combined weight metric. For Cluster Head selection; used parameters are number of neighbors, distance with all neighbors, mobility, transmission power and battery power. To decrease communication overhead; this approach is not called periodically. Cluster Head elect ion procedure is invoked based on node mobility and when current Dominating set cannot cover all mobile nodes in the network.

Steps for WCA:

Step 1: Find the set of Neighbors of each node v called N(v).

Step 2: Calculate the degree difference for each node; $\Delta v = | d_v - \square |$ where d_v is the number of neighbor of nodes and $\square$ is the pre-defined threshold value which shows maximum number of nodes Cluster Head can handle ideally.

Step 3: For every node compute sum of distances D_v with all its neighbors. Then compute running average of the speed for every node until current time T. This gives a measure of mobility M_v where (Xt, Yt) defines the position of node V at instant. Mv

$$= \frac{1}{T} \sum_{t=1}^{t} \sqrt{(Xt - Xt-1)^2 + (Yt - Yt-1)^{\wedge}2}$$

Step 4: Compute the cumulative time P_v during which node V acts as Cluster Head. P_v measures how much battery power has been consumed.

Step 5: Calculate
$W_v = w1\ \Delta v + w2\ D_v + w3\ M_v + w4\ P_v$
The node with the minimum weight is elected as Cluster Head.

J. Max-Min d-cluster formation Algorithm [4][13]

In most clustering approaches, all nodes are one hop away from elected cluster head in the cluster. The main drawback of these approaches is they generate large number of cluster heads within the network. Because of it network becomes congested. So, in Max-Min heuristic clusters are formed by nodes that are d-hops away from the cluster head. A d - neighborhood of a node consists of node itself and the set of all nodes located within d-hops away from the node. In this approach d is defined as the maximum number of hops away from nearest cluster head. This value is an input to the clustering approach which allows control over the number of cluster heads to be selected.

K. Mobility based Cluster formation algorithm for wireless mobile ad-hoc network [14]

In this paper, The Author proposes learning automata based weighted cluster formation algorithm called MCFA in which the mobility parameters of the hosts are assumed to be random variables with unknown distributions. In the proposed clustering algorithm, the expected relative mobility of each host with respect to all its neighbors is estimated by sampling its mobility parameters in various epochs. MCFA is a fully distributed algorithm in which each mobile independently chooses the neighboring host with the minimum expected relative mobility as its cluster-head. This is done based solely on the local information each host receives from its neighbors and the hosts need not to be synchronized.

III. Comparitive Analysis

Clustering Technique	Cluster Head selection Criteria	Merits	Demerits
Lowest Id Cluster algorithm	Node with Minimum is selected as CH	Simple and easy to implement	No limitation of node in one cluster and power drainage
Max-Min d-clustering	If node A is largest in neighborhood 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
Highest connectivity clustering algorithm (HCC)	The node with maximum degree is chosen as CH	Number of nodes in the cluster gets increases	There is flooding of control messages
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
Adaptive cluster Load balance method	To overcome the disadvantage of HCC ,to achieve load balance distributing resources	Load balancing achieved and CH bottleneck phenomenon can be removed	Ties cannot be eliminated between nodes having same degree of connectivity
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 neighborhood	It reduces the re-clustering problem	Each node has to compute mobility value , that requires time
Least cluster change algorithm (LCC)	Follows the method of LIC for CH	Improve cluster stability	If single node moves outside to cluster; it may require cluster structure re-computation
Power-aware connected dominant set	Whether a node should serve as a cluster head	Reduces size of DS	
Weighted clustering algorithm	CH is selects according to the number of nodes	Refused overhead	Knowing the weight of all nodes before clustering

IV. Conclusion

We have surveyed some of the Clustering head selection techniques which is useful to organize Mobile Ad Hoc Networks in a classified manner. In this survey paper we have seen cluster head select on the bases of which parameter is used. We also have seen the importance of the Clustering approaches, we have also seen that a Cluster based Mobile Ad Hoc Networks have various issues to examine, such as the Cluster stability, the energy consumption of mobile nodes, the load distribution, and the fairness of serving as CHs for a mobile node.

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