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Survey on Algorithms for Efficient Cluster Formation and Cluster Head Selection in MANET

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Abstract

A Mobile Ad-hoc Network (MANET) is dynamic and self-configuring network that formed by collecting number of mobile nodes. Group of node make one cluster. It is necessary to have a good and efficient cluster formation and cluster head selection algorithm to connect with other neighbouring node. Their communication should do in very less time. The various techniques are available to make cluster. Battery life, speed, packet delivery ratio, delay these are some important parameter through which we can make efficient algorithm. This survey paper focuses on the Comparison between Lowest ID (LID), Highest Degree (HD), LEACH(Low Energy Adaptive Clustering Hierarchy).

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Keywords: Cluster; Cluster Head; Highest Degree; Lowest ID; LEACH (Low Energy Adaptive Clustering Hierarchy) ; Mobile Ad-hoc network (MANET); Wireless Sensor Network

1. Introduction

A Mobile ad-hoc network formed by a collection of nodes without help of the centralized management or fixed infrastructure¹. The networks thus form by mobile and the devices in the network, able to detect the presence of other devices and perform the necessary set-up to communicate up to facilitate communications¹⁰. It is a self-configured network. Each node has its wireless transmitter and receiver called as trans-receiver which allows it to

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communicate with other nodes in its radio communicating range. Communication via bidirectional wireless links². In order to forward a packet from one node of cluster to another node of another cluster, should be in one radio range. Then they can communicate. If they are not able to communicate means they are out of coverage area of each other. For communication network topology and routing algorithms required to increase the efficiency and network life time. The network topology frequently changes due to the mobility.

MANET is popular because of its self-configuring ability. In MANET, Cluster and Cluster head has an important role for gathering and transferring data. A Cluster helps to increase the performance of MANET at some extent. If algorithm is strong enough, it will increase data transferring rate, decrease delay rate. In a cluster, Cluster head and boundary node form a virtual backbone for routing among all clusters which are very close to cluster⁹. The cluster head plays the role of coordinator within its substructure, which acts as a medium for data transfer between the nodes. Each CH acts as a temporary base station within its cluster and communicates with other CHs by using gateway nodes. The Gateway node has two or more cluster heads as its neighbours. When the clusters are disjoint, at least there one cluster head and another gateway node should present. A cluster is therefore composed of a cluster head, gateways and members node.

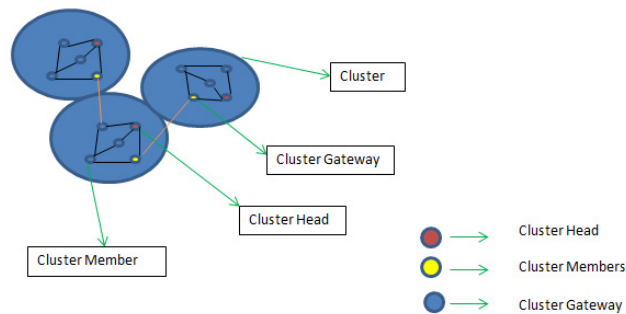


Fig.1.Cluster Network

The comprehensive survey focuses on the cluster and cluster Head selection algorithm in MANET. The main objective of the survey is to choose a specific node as a cluster head. It will perform the role of the local coordinator and transmitter in both intra cluster and inter cluster arrangements. Hierarchical routing is possible in clustering in which paths are recorded between clusters instead of between nodes. The LID algorithm works for lowest ID of the node, HD algorithm select Cluster Head on the basis of Highest Degree. LEACH performs re-clustering and self-organizing functions for every round. The paper describes the parameter through which efficiency and life time of network can be increased.

2. Background

The process of clustering deals with network which is divided into interconnected subsystem called as sub-cluster. The main function of Cluster is to select Cluster Head properly to perform task. The cluster is a collection of more than one node & select one node as a CH from the available set of node available in that cluster. A Clustering increases the capacity of network and reduces the routing overhead which brings more efficient and effective routing in MANET. Every clustering algorithm consists of two mechanisms, cluster formation and cluster maintenance. In cluster formation, cluster heads are selected among the nodes to form the hierarchical network and in Cluster maintenance, the health of cluster nodes maintain by preventing nodes from malicious attacks. Draining nodes reduces life of the network which will affect the network performance. Hierarchical network helps to communication between cluster nodes and cluster head. Cluster Head of one network communicates with other Cluster Head of another Cluster to make system secured as well as full proof. Traditional clustering algorithms suggest CH election exclusively based on node location information and involve frequent broadcasting of control packets, even when network topology remains unchanged.

Various algorithms are available to develop and create Cluster as well as selection of Cluster Head.

- Lowest ID
- Highest Degree Clustering Algorithm
- LEACH (Low Energy Adaptive Clustering Hierarchy)

These algorithms have worked according to their constraints. Every algorithms have their own different parameters.

3. Literature Survey

3.1. Lowest ID (LID)

This algorithm searches for lowest and oldest ID from current cluster. The node having lowest ID has chosen as a Cluster Head (CH). It is identifier based clustering algorithm. It will first assign unique id to assigned node or the nodes which are in one cluster.

The research proposed by Hao Wu, et.al.³ Proposed “Type-based clustering algorithm (TCA)” which outperforms both Lowest ID and Weighted Clustering Algorithm. They provide unique ID to each node. They assumed that node should be aware with their own location coordinates and assigned unique IP address in the network. With that unique ID and IP address it will broadcast the information to other node in that cluster. For selection of lowest ID, it will make cluster, and in that cluster search for lowest node having lowest ID. That node will be declared as a Cluster Head for that particular network. If node belongs to multiple cluster then it will served as a gateway between that two clusters. The single Cluster Head (CH) has to work for long time as no other Cluster Head selected further. The nodes tend to move in a concerted action as a group. They employing the stability factor S as the parameter to active the Cluster head selection process.

A Damianos Gavalas, et.al.⁴ Described Lowest ID (LID) algorithm work in simplified manner. They introduced a distributed algorithm for scalable and efficient clustering in MANET's. The proposed algorithm named as Lowest-ID with Adaptive ID Reassignment (LIDAR). It maintains process of algorithm fast, simple and low cost effective. It is specially designed for maintaining balanced computational load and power consumption among all movable nodes. All these parameter they achieved by identifying and electing most possible and prominent node as a Cluster Head. This will increases the battery life of that cluster head and energy consumption distributed uniformly throughout the network node. It reduces the problem of bottleneck.

A Jerzy Dolowaski, et.al.⁵ Proposed new modified clustering algorithm named as Lowest Node ID (LNID). The proposed algorithm has a hierarchical structure that can maintain a stable topology of MANET. The state of machine is semi-stable state and having ability to change state during work. So effects of that if power drainage occurs it will give its control to another node and prevent from losing data. It maintained MAC address as a ID of that node. Node which is lowest MAC address will be the Cluster Head for that particular network. Thereby, optimizes the network performance.

3.2. Highest Degree Clustering Algorithm (HD)

Highest Degree clustering algorithm is connectivity based clustering algorithm. The degree of a node is computed based on its distance from others. This algorithm takes that node which is having highest degree. The degree of node is calculated on the basis of number of nodes connected or linked with that node. As more number of local nodes is connected to the cluster node, the degree of cluster head increases. The highest degree node becomes the Cluster Head of that Cluster.

In Mohini Kumrawat, et.al.⁶ The nodes which are in transmission range of particular node they are receiving ID from one of the node. ID sending node is linked with highest number of node and participating in exchanging the information with all cluster nodes. The node with highest number of neighbors became the Cluster Head and other neighbors are just a member of Cluster Head and no longer participate in election process. If it successively linked with highest number of other nodes then that node will be considered as a Cluster head form that Cluster Head. Nodes from cluster are 2-hop away and cluster heads are directly connected to each other. In this, they required less number of clusters. This algorithm reduces the number of clusters by group mobility pattern, which is group of nodes moving with similar speed and direction. This concept also provides stability to network. But disadvantage of

this technique is it having very less throughput.

In Ratish Agrawal, et.al.⁷ explained the algorithm of Consistent clustering algorithm in that node which is having degree as i number and that degree is highest in that cluster then it will consider as a Cluster Head for particular network. The node with the maximum number of uncovered in-range neighbours (periodic broadcast messages are used for one-hop neighbor detection). It will works on Energy related fairness factor F_i it will check the energy of Cluster Head. F_i takes the previous information that how many times it served as a Cluster head for that Cluster.

3.3. Low Energy Adaptive Clustering Hierarchy (LEACH)

In LEACH at a time two nodes active and communicate with each other. CH will be selected by performing rounds. In each round having two stages one is set-up stage and other is steady stage. Time variations are depending upon frame. It is self-organized and self-adaptive protocol so Random selection of cluster head had done in LEACH. It is dense network of sensor nodes grouped into clusters. To reduce energy dissipation, protocol should be robust to node failure, scalable in order to increase system lifetime and fault tolerant. The energy load associated with being a cluster-head is evenly distributed among the nodes. Since the cluster-head node knows all the cluster members, it can create a TDMA schedule that tells each node exactly when to transmit its data But the disadvantage of LEACH algorithm is that, it does not provide clear information about position of sensor nodes and the number of cluster heads in the network. Each Cluster-Head directly communicates with BS no matter the distance between CH and BS. It will consume lot of its energy if the distance is far.

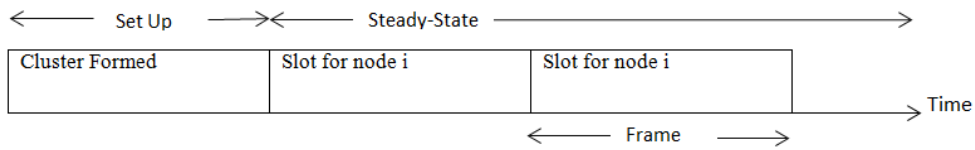


Fig.2. LEACH Protocol Process

Chunyao FU et.al.⁸ they improved previous LEACH algorithm into LEACH protocol with two level cluster head (LEACH-TLCH). In this Cluster Head formation is same as traditional method. In this process of data collection and transmission, the energy consumed by data transmission is greater than that of data fusion. If the current energy of a cluster head is less or the distance to base station is much far, then the cluster head will be died quickly because of a heavy energy burden. They pick up the any one number among all nodes in Cluster, Checks the energy if it goes below the threshold value it will stop receiving data. Then secondary head is responsible for receiving and fusing data. Primary head will idle now. LEACH Protocol is the first protocol of hierarchical Routings which proposed data fusion.

Meena Malik et.al.⁹ described in set up phase automatic decision taken by nodes to form cluster using distributed algorithm without any centralized control. Randomly choose cluster head assuming that all nodes have same energy initially. LEACH incorporates randomized rotation of the high-energy cluster-head position such that it rotates among the sensors in order to avoid draining the battery of any one sensor in the network Threshold value of cluster Head defined as

$$T(n) = p/p-1 * (r \bmod p-1)$$

It is to select random number r from 0 to 1. If the value of random number became less than threshold value then it is a Cluster Head for that current round. In Steady state operation divides into number of frames to send information. It will reduce energy dissipation. They used TDMA for efficient use of bandwidth.

In Anshu Arora et.al.⁹ explains way to minimize global energy usage. It will distributed load in a time in all points. It performs static clustering algorithms to acquire volunteers which is having high energy will be head for that cluster. It will adapt all the responsibility. LEACH is completely distributed; no control information is required

from base station. In order to operate LEACH no knowledge of global information required.

4. Comparison

Following table shows shortly the working, advantages & disadvantages of cluster formation & CH head selection algorithms:

Table.1. Comparisons of cluster formation and Cluster Head selection Algorithm

Algorithm	Working	Advantages	Disadvantages
Lowest ID Clustering Algorithm	Lowest ID node selected as CH	<ul style="list-style-type: none"> • Easy to understand. • Elected on the basis of unique ID 	<ul style="list-style-type: none"> • Single CH has to work for long time. • Prone to power drainage. • Speed of CH to transfer data decreases. • Bottleneck problem
Highest Degree Clustering Algorithm	The node which is linked by highest number of node, selected as a CH	<ul style="list-style-type: none"> • CH elected on the basis of degree. • Rate of data transmission is easy and fast 	<ul style="list-style-type: none"> • No re-election of Cluster Head. • Load of network increases due to single CH. • Leads to increase overhead. • Low chance of changing Cluster Head. • Number of nodes increases, throughput decreases.
LEACH	CH will be selected by performing rounds. Random selection of CH.	<ul style="list-style-type: none"> • CH elected on the basis of degree. • Rate of data 	<ul style="list-style-type: none"> • Time Consuming • More energy required for round execution

5. Conclusion

The Lowest ID, Highest Degree and LEACH are all Cluster formation and Cluster head selection algorithm. But each one has its own advantages and disadvantages. Lowest ID is prone to power drainage due to serving as Cluster Head for long time. And selection based on only lowest ID. No other criteria for selection of Cluster Head. Highest Degree Cluster head select on the basis of more numbers of node linked to node. But when node increases in the network, load of that node also increases. It will increase network overheads. In LEACH, Head selection criteria depend on the no of rounds and at a time only two nodes will be active others are sleep. But

this is time consuming because it will take long time to broadcast data as only two nodes alive so the packet delivery ratio to the destination node will be low. So from this survey we have to develop such system which will increase life time, packet delivery ratio decreases overheads, delay rate.

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