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Scrutiny of Clustering Algorithms in Wireless Mobile Ad-hoc Networks

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Abstract— *A Wireless mobile ad hoc network (MANET) consists of multiple mobile network nodes which can act as independent access points as and when needed. This ability of network nodes to work independently, distinguishes wireless ad hoc networks from conventional wired networks, of which the latter mandatorily require pre-existing network infrastructure. However, ad hoc networks have certain upper-limit on performance due to limited capability of individual nodes as these in turn have limited amount of battery-life, transmission power, transmission range and connectivity with other nodes. But, if the network nodes are divided into small virtual sub-groups rather than them working as a whole in a network, their combined capability can be increased to an extent. This is achieved by clustering the nodes and by exploiting different combinations of their individual properties; optimized in various ways using a number of algorithms. Till date, numerous clustering techniques have been proposed aiming at enhancing the performance of Wireless ad hoc networks wherein selection of cluster heads is one of the most critical tasks. In this paper, a novel approach to the problem of selecting right candidate for a cluster head has been proposed. This approach is believed to result in selection of a cluster head which can handle significant extent of traffic and reduce noticeable amount of computational overhead while preserving its own stability.*

Keyword — Ad-hoc Network; Clustering; Cluster-Head; Weight clustering; NS2.

I. Introduction

MANET is a self-configured and infrastructure-less network of mobile devices connected through wireless links. A self-configured network implies that a node should not need substantial knowledge of network specification in advance to joining the network. Similarly, an infrastructure less network needs no physical or organized group and administration facilities required for its operation. A mobile device or mobile host in a network connected via wireless links forms a temporary network in which each device can independently work both as a host as well as a router and can reform itself as and when need be. Many real world communication-related problems can be solved with this flexibility and simplicity of ad-hoc networks. Clustering technique is the basic practice used in the wireless sensor network to increase the lifetime of a sensor network by justifying energy consumption and provide efficiency, scalability, and security. Clustering is a process of in-between wireless sensor network into small networks of small sensor nodes. These undersized networks known as clusters and each cluster are under the administration of special sensor node often referred to as a Cluster Head. In each cluster, Cluster Head may be elected by the sensor nodes or pre-defined by the network administrator. The Cluster contains two kinds of nodes one is Cluster Head and other one is Sensor Node. Sensor Nodes are low energy node as compared to Cluster Head, higher energy nodes perform the all kinds of processing and routing of information even as low energy. Sensor Node can be used to perform only sensing task. The Cluster Head can prolong the battery life of the individual sensors and the network lifetime as well by implementing optimized management strategies. There are various clustering techniques designed for wireless sensor network for scalable and efficient communication. The concept of cluster based routing is also utilized to perform energy-efficient routing in wireless sensor network.

II. Literature survey

This section defines researcher has done so many things on Clustering in Wireless Mobile Ad-hoc Network and proposed different methods for clustering in wireless sensor network.

Vijayanand Kumar, Rajesh Kumar Yadav proposed a Weighted Clustering Algorithm which relies upon both absolute and relative attributes of the mobile nodes. Steps for clustering formation for WCA require a communication round for attributes such as the sum of distances and degree difference. There is one sequence of communication to locate number of neighbors along with the location of the mobile node in the neighborhood can help in judge sum of distances [1].

Yu-Xuan Wang and Forrest Sheng Bao proposed an entropy based WCA. Entropy based WCA precise the strength of the network. A minimal weighted node, on the basis of possible number of members, the summarized node distances to other nodes in its radio distance, the node's common dynamic speed, and time of it being a cluster head, is selected as the cluster head [2].

R. Pandi Selvam and V. Palanisamy proposed a flexible weight based 2-hop clustering algorithm. The achievement of the proposed clustering algorithm is that it defeats the existing Lowest ID, Highest Degree and Weighted Clustering Algorithm to make the number of clusters [3].

S. K.B. Rathika and J. Bhavithra introduced an algorithm which improves the load balancing and the stability in the MANET and is an enhancement on Weighted Clustering Algorithm. High transmission range, transmission power, mobility, battery power and energy are the factors considering which a cluster head is selected [4].

V. V. Neethu and Awadhesh Kumar Singh introduced a stable loose clustering algorithm by considering more powerful however less mobile nodes as cluster heads. Stable cluster organization limits the high overhead suffered during cluster maintenance. It is compatible with any kind of heterogeneous networks. This Algorithm forms a 2-hop cluster. The simulation analysis confirms that this algorithm delivers more stable clusters with low maintenance effort [5].

III. Clustering Algorithm

In this section we discus about the different methods used for clustering in wireless sensor network.

Cluster Head Election Algorithm:- A variety of clustering algorithms have been anticipated. The task of clustering algorithm is selection of cluster head. Cluster head coordinates and manages the ordinary nodes belong to its cluster. Some of these algorithms are converse below.

1) Lowest ID cluster algorithm

Lowest ID cluster algorithm is assigning a unique ID to each node in the network. It is well-known that IP address assigned to the network are unique. Thus in class full addressing host id is used as the unique ID [16]. At the moment by sending HELLO packets to its neighbors a node propagates information about itself. All nodes in the network after reception of neighbor information through HELLO packet selects the node with lowest cluster ID as its Cluster head. Sometimes, the node broadcasts the list of nodes from which it can hear to its neighbor.

- If a node hears only from the nodes with higher cluster Id than itself is a cluster head.
- The lowest Id node that is heard by a node becomes its cluster head.
- A node which can hear from more than one cluster head becomes a gateway.
- If a node is neither chosen as a gateway nor a cluster head it becomes an ordinary node.

This method is concerned with only lowest id which is assigned randomly. It means no other metrics of the node are in use into account such as its battery power, its connectivity, etc for the assortment of cluster head. Therefore certain number of nodes is flat to power reduction because of helping as cluster heads for longer period of time.

2) Highest Degree Algorithm

The highest degree algorithm also identified as connectivity based clustering algorithm, It was projected by Gerla and Parekh [6] [7], in this algorithm the degree of node is computed based on its quantity of neighbors. The objective of this algorithm is to reduce the number of clusters. All the nodes in the cluster are conscious of the number of its neighbors throughout exchange of control messages. A node with utmost degree that is one with utmost number of neighbors becomes the cluster head. Since we are considering only the nodes that are at one hop distance from each other therefore any two nodes in the cluster are at most two hops away from each other. The nodes which can listen from more than one cluster head becomes gateways and are used for put in the ground cluster communication. One of the key drawbacks of this algorithm is that there is no higher limit on the number of nodes that a cluster can have. As there is enlarge the number of nodes in the cluster, a drop in throughput is pragmatic and hence a there is a dreadful conditions in the system performance. Another disadvantage is that the re-affiliation count of the cluster head is high due to node movement as a result the node with highest degree may not be re-elected as a cluster head even if it loses one neighbor.

3) Node - Weight Algorithm

There is a node-weight algorithm in which each node is assigned weights on the basis of its appropriateness of becoming cluster head. A node which has highest weight than any of its neighbor is chosen as cluster head. If the scenario is that, two nodes have the same weight than break the tie between them and the smaller id node is chosen as the cluster head. Investigation proves that a smaller number of cluster head updates are essential than the Highest Degree and lowest id heuristics [8] [9]. There are no optimizations on the parameters such as throughput and power control.

4) A Weighted - Clustering Algorithm

The weighted clustering algorithm was originally proposed by M. Chatterjee et al. [10]. It selects and maintains the cluster head more reasonably. It considers four factors for selection of cluster head which are node degree, distance summation to all of its neighboring nodes, mobility and remaining battery power. Weights are assigned to each of the above mentioned factors. In classify to avoid communication overhead cluster head selection procedure is invoked on demand. To ensure that the cluster head do not get overloaded a predefined threshold is used to specify the number of nodes each cluster head can maintain.
Although weighted clustering algorithm gives superior performance than the previously discussed algorithm, some of the drawbacks are that the weights of all the nodes should be known before starting the clustering process and the cluster heads consume quickly. As a result the overhead incurred by WCA is very high.

5) Enhanced Weighted Clustering Algorithm

Enhanced Weighted Clustering algorithm is basically selection of cluster head is on demand and invoked based on the mobility of nodes or altering the relative distance between the nodes and cluster head [11]. In order to decide on the cluster head we follow the following procedure-

- Compute degree of all the nodes
- Calculate the degree differentiation for all the nodes
- Analyze the distance summary to its neighbor nodes
- Determine the running average of the speed of each node till current time. It gives a measure of mobility
- Compute the lasting battery power for each node
- Taking the node with nominal weight as the cluster head, all the neighbors of the chosen cluster head are not permitted to contribute in the selection method.

6) Least Cluster Change Algorithm (LCC)

LCC algorithm has a huge enhancement over lowest ID and highest degree algorithm if the cost of continuance is concerned. In this the clustering procedure is not executed from time to time. Hence re-clustering is not as numerous as in other algorithms. In highest degree algorithm clustering scheme is performed from time to time check if cluster head is the node with highest degree [12]. If not than cluster head has to pass over its role to the node with degree higher than itself and in the least cluster it change clustering process is separated into two stages that are cluster structure and cluster maintenance. Cluster formation is done by using lowest ID. Re- clustering is invoked in only one of the following two cases-

- In case of two cluster heads come into the transmission range of each other.
- Another one is that, cluster member is not able to access its cluster head it invokes reformation

7) Clustering for Energy Conservation

This the method that assumes two types of nodes: master and slave. A master node can have a predefined number of slaves apart from one slave node can only be connected to one master node only [13]. A master node starts operation as a cluster head after establishing connection with the slave node. This method reduces the transmission energy utilization by making the cluster head to serve as many slaves as possible.

IV. Identifier Neighbor Based Clustering

In identifier neighbor based clustering, a unique ID is allocated to each and every node in the network. Node ID of neighbors is known to all nodes in the network. The cluster head election is based on criteria involving these IDs such as lowest ID, highest ID etc.

A clustering algorithm called Linked Cluster Algorithm (LCA). In the early stage, all nodes are ordinary nodes; from time to time each node broadcasts its neighbors IDs along with its own ID in the network. Thereafter, the node with smallest ID is selected as cluster head. A node which is a part of two or more cluster heads is a gateway node. The process ends when every node belongs to at least one cluster. Nodes with a small ID are selected as cluster heads [14] [15].

1) Location Based Clustering

In the location-based routing protocol, the location information of mobile nodes is used to enclose routing space into a smaller range. It decreases routing overhead and broadcast storm. A Core Location-Aided Cluster-based Routing protocol (CLACR). The attributes of CLACR are stated as the whole network breaks up into individual clusters. In each cluster, cluster election algorithm is used for selecting cluster head. The number of nodes accountable for routing and data transfer is decreased considerably by the usage of clustering mechanism. It also minimizes the routing overhead and increases the route lifetime tremendously. The path is computed using Dijkstra algorithm on a cluster-by-cluster basis by the CLACR [16].

2) Topology Based Clustering

In the topology based clustering, the cluster head is chosen based on a metric computed from the network topology like node connectivity. Some of the existing topology based clustering algorithms are explained below. A protocol called High-Connectivity Clustering (HCC) which is based on the degree of connectivity. The cluster head selection process chooses the node which has highest number of neighbors. The node with the lowest ID is elected as a cluster head if two or more nodes have the same degree of connectivity. HCC generates a limited number of clusters. But this algorithm increases the number of re-affiliations of cluster head. [7]

3) Mobility Based Clustering

In mobility based clustering, the cluster head is chosen based on the mobility of an individual node with respect to its neighboring nodes. A node should not be elected as a cluster head if it has higher mobility relative to its neighbors. Mobility-based d-hop clustering algorithm (MobDHop) [17] divides the network into d-hop clusters based on relative mobility metric. The objective of creating d-hop clusters is to support larger than one-hop radius clusters which reduces the number of cluster heads. The relative mobility is estimated based on the signal strengths of received packets. The distance between any two nodes is estimated using the signal strengths of the received packets exchanged. The cluster formation process is divided into two stages namely Discovery Stage and Merging Stage. During the discovery stage, mobile nodes with similar speed and direction are grouped into the same cluster. The merging phase is invoked in order to either merge clusters together or join individual nodes to a cluster. The cluster maintenance process is invoked when a node switches on and joins the network or a node switches off and leaves the network.

4) Power Based Clustering

In power based clustering, the cluster head is chosen based on the battery power of a node with respect to its neighboring nodes. A node should not be elected as cluster head if it has a low battery power because low battery power of a particular node affects the network lifetime. A well organized clustering algorithm that can initiate a stable clustering architecture by keeping a host with delicate battery power from being elected as a cluster head. In their proposed new clustering algorithm, a stable clustering architecture is formed by defining a bottleneck node to be a node with battery power lower than a predefined threshold value. Bottleneck cluster head refers to the bottleneck node elected as a cluster head. The proposed clustering algorithm is based on the assumption that if the clustering architecture has fewer bottlenecks then the cluster heads would have a longer lifetime [18].

5) Weight Based Clustering

In Weight based clustering, the cluster head is chosen based on combined weighted metrics such as transmission power, degree of the node, distance between the nodes, battery power, mobility of the

mobile node and so on. Weight of each node can be calculated as Wi = w1di + w2Di + w3Si + w4Pi. Where, d = Degree difference of each node, D = Sum of distance with all neighbors, S = Speed of node, P = Battery Power consumed. w1 + w2 + w3 + w4 = 1

A Weighted Clustering Algorithm which relies upon both absolute and relative attributes of the mobile nodes. Steps for clustering formation for WCA require a communication round for attributes such as the sum of distances and degree difference. One round of communication to find number of neighbors along with the position of the mobile node in the neighborhood can help in finding sum of distances. Whereas mobility and power consumed do not require a communication round. They choose to apply a greedy approach for cluster head selection and absolute weighted information for clustering to reduce the communication round which results in fast clustering formation process [19].

V. Comparison of the Clustering Techniques

S. No	Name of the Scheme	Basis	Cluster head Election Criterion	Advantage	Overall Overhead
1	Linked Cluster Algorithm	Neighbor based	Lowest ID	Simplest	High
2	Least Cluster Change	Neighbor based	Lowest ID	Limited number of clusters	High
3	Core Location-Aided Cluster-Based Routing	Location based	Location	Increased route time; Decreased routing overhead	Low
4	High Connectivity Clustering	Topology based	Highest Degree	Limited number of clusters	High
5	3-Hop between Adjacent CHs	Topology based	Highest Degree	Reduced number of CH	Very High
6	Mobility-based D-hop Clustering Algorithm	Mobility based	Lowest mobility	Reduced number of CH	Low
7	A Stable Clustering Algorithm based On Battery Power	Power based	High battery power	Better performance; High stability; Minimum battery Power; Enhanced network lifetime	Low
8	Modification in Weighted Clustering Algorithm	Weight based	Combined weight metric (Mobility, Entropy ,Power Consumed)	Faster and effective clustering; Reduced communication overhead; Minimum delay	Low
9	Entropy based Weighted Clustering Algorithm	Weight based	Combined weight metric (Node Distance, Mobility , Transmission Range)	Strengthened network; Reduced re-affiliation; Increased Battery life; Reduced computation cost	Low
10	Stable and Flexible Weight based Clustering	Weight based	Combined weight metric (Number of neighbors in 1-hop and 2-hop)	Reliable for cluster formation; Average cluster head change; Performs better then WCA and Lowest ID and Highest degree algorithm	Low
11	Enhancement on Weighted Clustering Algorithm	Weight based	combined weight metric (High transmission range, Transmission power, Mobility, Battery power and Energy)	Reduced Cluster formation	High

12	Mobility Aware Loose clustering	Weight based	A combined weight metric (Mobility , Transmission power)	Reduced number of clusters; Improved Stability of the cluster	High
13	Forecast Weighted Clustering	Weight Based	combined weight metric (Mobility, Battery power consumed , Distance b/w nodes, Degree Difference)	Right Cluster head Selection; Better then WCA	Yes

Table 1. Comparison of the Clustering Techniques

VI. Conclusion

There are many clustering algorithms are reviewed which helps to found MANETs in a hierarchical approach and their main properties are accessible. After the analysis it is seen that a cluster-based MANET has many major issues to observe, such as like the cluster structure stability, the regulate overhead of cluster construction and conservation, the energy utilization of mobile nodes with different cluster-related status, the traffic load supply in clusters. Hence there should be a solution needed which confirms the selection of a consistent cluster head, which can handle intense traffic and sustain stability of cluster head.

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