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A Survey on Clustering to Improve the Network Lifetime in MANETs

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ABSTRACT*:* Mobile Ad Hoc networks are a type of networks that can be deployed quickly without any pre-existing infrastructure. As the communication technology evolves user requires more improvement in network lifetime and bandwidth efficiency. This can be done by forming the cluster of nodes using various cluster approaches. MANETs has several drawbacks due to the sharing of transmission medium, low bandwidth and routing protocols. Bandwidth efficiency and Network life time can be maintained by forming the clusters. Many clustering algorithms has emerged, these algorithms allow the network structure in to group of entities called clusters. In this paper we present a study and analyze several clustering approaches for MANETs that's recently appeared in literature.

KEYWORDS: Mobile Ad-hoc Networks (MANETs),Clustering ,Cluster Head

I.INTRODUCTION

Mobile Ad Hoc network is a group of devices that can communicate with the wireless links. Due to the development of wireless communication technologies, ad hoc networks have gained worldwide attention in recent years. Without any infrastructure it allows the mobile terminals to form a temporary network for instant communication. An ad hoc network consists of several nodes that have an ability to exchange the information with other nodes. Dynamic routing is the major issue in MANETs. Routing is the process of selecting the path to transform the traffic. Routing can be done either in the flat structure or in the hierarchical structure. In flat structure, all the nodes which are present in the network, are in the same level and have a same role. This approach is suitable only for small networks, as the nodes in the network increases it fails to allow scalability. Hierarchical routing approach has been developed to overcome the disadvantages of the flat routing structure. In this approach Clubbing of several nodes is called cluster, it minimize the dissimilarities of object to their closest selected objects. Hierarchical structure has been used in the network topology to improve the routing efficiency.Structuring a network is needed to simplify the routing operations in MANETs. Several clustering algorithm has been proposed in the literature. Clustering techniques allows the routing protocol to operate more efficiently by reducing the traffic and simplifying the data routing [1]. Clusters are formed by clubbing together nodes along the wireless links. A node inside the cluster that coordinates the cluster activities is cluster head, it is used to communicate with other nodes that it can cover under its communication range. The ordinary nodes which are present in the cluster also have a direct access to cluster head and gateways. Gateways are also the nodes that have an ability to hear two or more cluster heads. Ordinary nodes send the packets to their cluster head (CH) to forward in to the respective destination nodes. If the destination node is outside the cluster then it is forwarded to the gateway node.

Several clustering schemes have been proposed to improve the network lifetime.

II.CLUSTERING ALGORITHMS IN MANETS

The process of clubbing together nodes along the wireless links is called cluster. Each cluster has a particular node elected for cluster head based on mobility, degree and density. Cluster is composed of cluster head, gateways and member nodes.CH acts as a temporary base station with in the clusters and is used to communicate with the other cluster head. Gateway node is the common node between several clusters. Suppose the ordinary node needs to forward the packet to the sink node which is present in the other cluster in this scenario gateway node helps to forward the packets from one cluster to another cluster. Member nodes are the ordinary nodes which is present inside the cluster, neither the cluster head nor the gateway node. A node which is present in the network has a transceiver unit required for transmitting and receiving the packets. Nodes are not able to transmit and receive the packets simultaneously. A

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cluster structure ease the special reuse of resources to improve the system capacity. Fig. 1 shows the structure of the cluster [2].

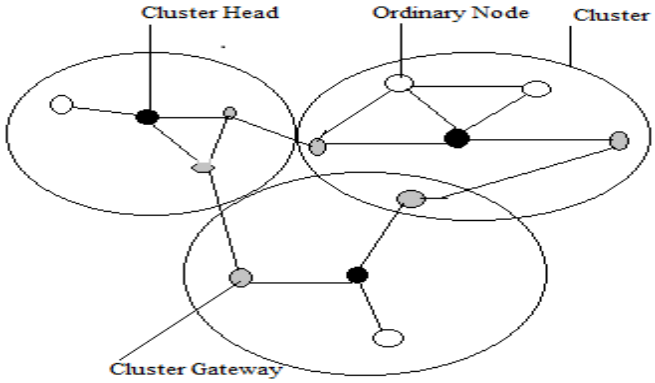

Fig. 1 Cluster Structure

Classification of clustering algorithm can be done based on their objective and cluster head selection criteria:
1. Identifier Based Clustering: A unique ID is given to each node; each node in the network knows the IDs of the neighbouring nodes. The node with lowest ID is selected as a CH. Neighbours have the highest IDs than that of the CH. The process repeats until every node belongs to any one of the clusters. A node which lies within the transmission range of two or more clusters is considered as a gateway node. The concept of forming the cluster based on their IDs is called Linked Cluster Algorithm (LCA) [3]. This scheme concentrates on the nodes of lowest id without considering any other qualification of the nodes for cluster head selection. The main drawback of this scheme is that certain number of nodes will be inactive because of less power due to serving as a cluster head for longer period of time. Least Cluster Change (LCC) algorithm is the improved version of LCA algorithm, which integrates a maintenance step to minimize the cost of re-clustering. The reconstruction of clusters is called only in the following two cases.(1) If two CHs are neighbours, then the node with highest ID gives up the role of CH. (2) If a ordinary node moves outside its cluster and does not join a subsisting cluster then it will become cluster head composing an incipient cluster. LCC ameliorates the stability of clusters but the cost of re-clustering is expensive.Adaptive Clustering algorithm has been proposed by Lin & Gerla [4]. All the nodes presents in the network plays the same role. The concept of CH disappears inside the cluster.LCA concept is used for the election of CH. If the distance between the nodes which is present within the clusters are 3-hops then cluster maintenance is invoked.

Max-Min D-cluster formation algorithm [5] says that clustering is a collection of nodes that are up to d-hops away from a CH. Based on the node IDs CH is selected. Each node broadcast its IDs to the neighbouring nodes which are present within S-hops, collect their IDs and choose the highest ID nodes which it will broadcast in the second phase. During second phase, after receiving the highest id, each node saves the lowest IDs as the highest ids.CH is elected based on IDs saved in the previous phases. The duration of the cluster formation is more and exchanging of information before the election of CH is more in this algorithm.
2. Connectivity Based Clustering: Highest Connectivity Clustering Algorithm [1]: Each nodes share their ID to the nodes present in its communication range. The node which is surrounded by maximum number of nodes gets an opportunity to become cluster head (CH) and can no longer able to participate in a election process. Neighbours of a CH become member of that corresponding cluster. Each cluster assigns certain resources to share among the members. As the number of nodes in the cluster increases, throughput drops. Due to the movement of nodes, re-association rate of nodes is high and the current CH cannot be able to re-elect for a CH even if it loses its one of the neighbours. This approach doesn't provide any restrictions that this number of nodes should be present in the cluster. K-hop connectivity ID clustering algorithm (K-CONID) [1]: It is the combination of lowest id and highest degree algorithm. To select a CHs several criterions has to be consider, first-connectivity, second-Lower id. If any one of the criteria is used it leads to the generation of more clusters than necessary. Clusters in this approach are generated by CHs and nodes that are at the distance more than k-hops. K-CONID generates a link which is generalizes for a K-hop neighbourhood [1], If the node has a highest connectivity then the node is selected as a CH, In case of uniform connection, a node has CH priority if it has lowest id.

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3. Mobility Based Clustering (MOBIC): MOBIC algorithm [6] is based on the LCA algorithm but it includes relative mobility of the nodes as a criterion for CH selection. The main aim of this algorithm is to choose the node with low mobility as a CH. Unnecessary selection of CH can be avoided by using Cluster Contention Interval (CCI). After the CCI time is expired, if the CHs are neighbours then the node with highest id gives up the role of CH. This algorithm reduces the maintenance of the CH; limitations of the LCC algorithm are not completely eliminated.A novel cluster algorithm [2] guarantees the longer lifetime of the clusters. The main idea of this approach is to choose the node which is having the lowest mobility as a CH. Combining the mobility prediction scheme with the highest order clustering technique authors proposed a distributed algorithm. The node with highest weight is considered as a CH. This algorithm allows a node to join other cluster without starting a re-clustering phase. Mobility Prediction Based Clustering (MPBC) [2] scheme has been proposed by Ni et al for MANETs. All Nodes broadcast the "Hello" message to form the list of neighbours. Each node calculates its average relative speed with respect to its neighbours based on exchanging the message. Nodes with the lowest relative mobility are selected as CHs. This algorithm is used to solve the problems caused when a node moves out of communication range and when two CHs moves within the reach of each other, one is required to give up the role of CH. This approach improves the network lifetime.

Mobility based D-hop clustering algorithm(MobDHop) algorithm partitions the network in to D-hop clusters based on relative mobility to support the clusters having the radius more than one-hop, this intern reduces the number of CHs. Relative mobility is calculated based on strength of the received packets. Clustering process is divided in to two stages i.e. Discovery and Merging stages. In Discovery stages, nodes with similar speed and directions are grouped to form a cluster. Merging phase is to merge clusters together or to consider individual nodes to a cluster.

4. Energy Based Clustering Algorithm: Mobile nodes in a MANET depend on battery power supply during network operations. Reduction in energy consumption plays an important role to improve the network life span.Multicast Power greedy clustering (MPGC) [2] algorithm is mainly to reduce the energy consumption. Each node sends a beacon signals with the highest power to inform its presence to its neighbours and simultaneously collects the information about its neighbors. Later each node sends a CH declaration with power level required to reach its nearest nodes and then it increases the power level until it reaches to all the nearby nodes. Each node contains the residual power of its neighbors. The node with highest residual power gets the chance to become a CH. This algorithm improves the network life span, but more number of steps is required to construct the cluster structure which increases the traffic. Flexible Weighted Clustering Algorithm based on Battery Power (FWCABP) is proposed to maintain stable clusters avoiding nodes with low battery power from being elected as a CH and to reduce the number of clusters. During cluster formation, each node sends a beacon message to the neighboring nodes in order to inform its status and build neighbours list.CH is elected based on the distance to its neighboring nodes, mobility and residual battery power. The node with the smallest degree is selected as CH.Enhance Cluster based Energy Conservation (ECEC) algorithm is the improved version of Cluster based Energy Conservation algorithm (CEC) [1]. During cluster formation, nodes with highest energy values are elected as CHs. Later ECEC elects gateways in order make connections with clusters. This algorithm reduces the power consumption which increases the network life span.

5. Weight based clustering Algorithm: It is mainly based on the use of a combined weight metric that consists of several node parameters such as node degree, distances, node speed and the time spent as a CH.CH selection is based on the weight of each node. If a node present in the region which is not covered by any CH, then the procedure for cluster formation is invoked throughout the whole system. To prevent overloading of CHs a predefined threshold value is defined which indicates the capacity of the CH. All the nodes must know the weight of all the other neighbouring nodes. The weight associated to the node can be calculated by using the formula (1)

$$W_x = w1\ \Delta x + w2\ Dx + w3\ Mx + W4\ Px \quad (1)$$

Where $\Delta x = |d_x - \alpha)$, Mx is the measure of mobility obtained by computing the running average speed of every node during the particular time T. Δx is the degree difference obtained by calculating the number of neighbours of each node. α is the predefined threshold, Dx is the distance. Px is the cumulative time of a node being a CH. It is a measure of how much battery power has been consumed.Flexible Weight Based Clustering Algorithm (FWCA) is based on weights of the nodes to build clusters. Several parameters have been used in the election of CH such as transmission power, remaining battery power, node degree and mobility. During cluster maintenance, FWCA uses the capacity of the clusters and life time instead of mobility because stability metric affects the election of CH with the same weight as the node mobility metric. The main aim of this algorithm is to yield less number of clusters, maintaining the stable clusters and improving the network life time.

Enhanced Weighted clustering Algorithm (EWCA) [1] CH is invoked based on the distance between the nodes and its neighbours. Election process is repeated until every node become a member of any cluster or CH. Load balancing has

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been done based on the predefined threshold value of the nodes that a CH can cover ideally. This properly distributes the workloads among the clusters. Stability can be maintained by reducing the number of nodes detachment from its current cluster and connect to other existing clusters.

III.RESULTS and DISCUSSION

By considering the residual energy available in the particular node and distance between the nodes and CH. Energy consumption can be reduced and network life time can be improved. In Fig. 2 and Fig. 3 Red and green solid line indicates the result in the absence and presence of weight based clustering algorithm respectively

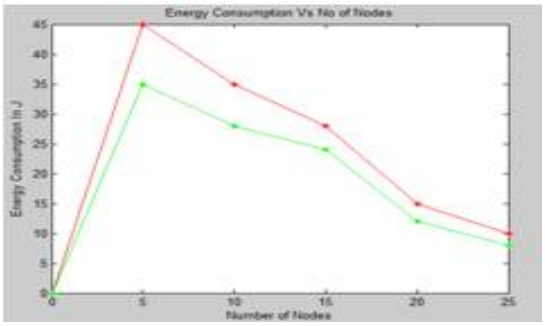

Fig. 2 Energy comparisons with and without using weight based clustering algorithm

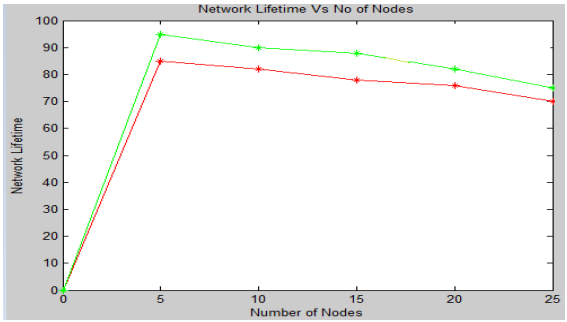

Fig. 3 Network life time with and without using weight based clustering algorithm.

.VI.CONCLUSION

In this paper, we have reviewed several clustering algorithms. Most of the clustering schemes are based on the fundamental issues of MANETs such as improving the network life time, load balancing and reducing energy consumption and maintenance. From all the revealed schemes weight based clustering algorithms is better because it improves the network lifetime by reducing energy consumption.

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