# A Survey on Load Balanced Clustering Algorithms

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***Abstract— The Ad Hoc network is defined by the mobile nature of the nodes and the removal of the requirement for an infrastructure based network i.e. the use of routers and gateways. Ad Hoc networks generally work in clusters i.e. the grouping of wireless mobile devices (computers or embedded devices which is based on efficient communication between all the nodes). Clusters are formed by clubbing together nodes along the wireless links. Cluster Heads are the nodes which communicate with the other nodes that it can cover under its communication range. Cluster Heads form a virtual backbone and may be used to route packets for nodes in their cluster. Nodes, being in an Ad Hoc network, are presumed to have a non-deterministic mobility pattern. Different heuristics employ different policies to elect Cluster Heads. Many of these policies are biased in favor of some nodes. As a result, these nodes shoulder greater responsibility which may deplete their energy faster due higher number of communication made, causing them to drop out of the network. Therefore, there is a need for load-balancing among Cluster Heads to allow all nodes the opportunity to serve as a Cluster Head. A Survey on various clustering algorithms for load balancing is presented in this paper.***

***Keywords—ad hoc, cluster, Communication, MANETs***

## I. INTRODUCTION

Ad hoc networks consist of a set of homogeneous nodes (computers or embedded devices) that move in an independent fashion and communicate with the other node in the topology over a wireless channel. Such networks are logically realized as a set of clusters by grouping together nodes which are in close proximity with one another or through another wireless node. The infrastructure is auto generated by converting the all ready existing nodes into routers,repeaters or gateways.

A general Ad Hoc network will have the following features

**Mobility**: The nodes can reposition themselves in matter of seconds, making the mobility pattern of the nodes non deterministic. This mobility pattern had a major effect on the formation of clusters within the network. This mobility and wireless nature is one of the major features of the Ad Hoc networks and helps it to be deployed in any kind of terrain.

**Multi hop Network**: Since the nodes work as group, a multi hop network is created so that even if a node is not in direct contact with the cluster head it can still get the information via the intermediate nodes by forwarding the same data. This multi hop networks is generated by the conversion of a normal node to a router or gateway.

**Multiple roles for a node**: The Ad Hoc networks should be able to organize itself by generating routers, gateways etc. to maintain communication with all the other nodes. This is done by converting a normal node to a router or a gateway.

**Energy Constraints**: In an Ad Hoc network the nodes are mobile and communicate over a wireless channel. Being mobile the power is used from a battery and the size needs to be kept at a minimum. Hence there is a need to manage the battery power consumption, so that they do not drop out of the network prematurely due to low power.

Out of these the greatest challenge for an Ad Hoc network is resource management and that too particularly the battery life.

Balanced clustering is the key to increasing the network lifetime. Also the Cluster Head consumes the maximum of its battery as compared to the rest of the nodes. Hence, if the number of nodes under one Cluster Head is more as compared to the rest of the Cluster Heads, then this node will prematurely drop out of the network. This dropping out of the cluster head drastically reduces the network life time. Hence the energy consumed in communicating with the different nodes in the networks, formation of the cluster, checking for living nodes etc. must be kept at a minimum. One way of doing this is to optimize the number of communications made by the Cluster Head. This can be done by balancing the number of nodes under all the Cluster Head i.e. making each Cluster Head have almost the same number of nodes under every Cluster Head.

The paper is Organised as follows: Survey On Various Clustering Algorithms is presented in Section II.Conclusion is presented in Section III.

## II. VARIOUS CLUSTERING ALGORITHMS

In cluster based systems , network nodes are partitioned into several groups. In each group, one node is elected to be the cluster-head while the rest of the nodes become ordinary nodes. The cluster size is controlled by the cluster-head's transmission power i.e. its communication range. The ClusterHead coordinates transmissions within the cluster, handles inter-cluster traffic and delivers all packets destined to the cluster; it may also exchange data with nodes that act as gateways to the wired networks. The cluster-based network architectures, the lifetime of the network is strongly related to Cluster Head's failure. Cluster Heads therefore experience high energy consumption and exhaust their energy resources more quickly than ordinary nodes do.

The procedure of cluster formation consists of two phases:

- Cluster-head election
- Assignment of nodes to cluster-heads.

This assignment of nodes to a ClusterHead is one of the major deciding factors for the life of a network. Also after the assignment of these, the balancing of load in terms of the number of nodes serviced by the Cluster-head is important. Many clustering algorithms are proposed till date.

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In this paper we first present the study of some of the popular clustering algorithms which include HC [Highest Connectivity Algorithm], LID[Lowest ID Algorithm] Least cluster change algorithm (LCC), Load balancing clustering (LBC) and Fuzzy Logic Based approach,Max-Min d-cluster formation algorithm, K-hop connectivity ID clustering algorithm (KCONID),Mobility-based d-hop clustering algorithm,Adaptive multihop clustering

## III. HIGHEST CONNECTIVITY ALGORITHM

The Highest Connectivity algorithm chooses a cluster head based on the degree of connectivity with the other node.The degree of a node is computed based on its distance from others. Each node broadcasts its id to the nodes that are within its transmission range. The node with maximum number of neighbors (i.e., maximum degree) is chosen as a clusterhead. The neighbors of a clusterhead become members of that cluster and can not longer participate in the election process.

One major flaw of this election algorithm is that the no of nodes under one cluster head is relatively high as compared to others. Also on increasing the number of nodes in the sample area, this effect is worsened. Since the probability of nodes being close to one another increases. There is also a probability of the same node becoming the ClusterHead again and again.

## IV. LOWEST ID CLUSTER ALGORITHM

Lowest ID cluster algorithm (LIC) is an algorithm in which a node with the minimum id is chosen as a clusterhead. Thus, the ids of the neighbors of the clusterhead will be higher than that of the clusterhead. A node is called a gateway if it lies within the transmission range of two or more clusterheads. Gateway nodes are generally used for routing between clusters. Each node is assigned a distinct id. Periodically, the node broadcasts the list of nodes that it can hear (including itself ).

•A node which only hears nodes with id higher than itself is a clusterhead.

•The lowest-id node that a node hears is its clusterhead, unless the lowest-idspecifically gives up its role as a clusterhead (deferring to a yet lower id node)

.A node which can hear two or more clusterheads is a gateway. Otherwise, a node is an ordinary node.

The Lowest-ID scheme concerns only with the lowest node ids which are arbitrarily assigned numbers without considering any other qualifications of a node for election as a clusterhead. Since the node ids do not change with time, those with smaller ids are more likely to become clusterheads than nodes with larger ids.

## V. LEAST CLUSTER CHANGE ALGORITHM (LCC)

This algorithm is a bit better than the HC algorithm because this allows different nodes to become the ClusterHead.. Thus, drawback of lowest ID algorithm is that certain nodes are prone to power drainage due to serving as clusterheads for longer periodLeast cluster change algorithm (LCC) has a significant improvement over LIC and HCC algorithms as for as the cost of cluster maintenance is consider. Most of protocols executes the clustering procedure periodically, and re-cluster the nodes from time to time in order to satisfy some specific characteristic of cluster-heads. In HCC, the clustering scheme is performed periodically to check the "local highest node degree" aspect of a cluste r-head. When a clusterhead finds a member node with a higher degree, it is forced to hand over its clusterhead role. This mechanism, involves frequent re-clustering.

In LCC the clustering algorithm is divided into two Steps:cluster formation and cluster maintenance.

The cluster formation simply follows LIC, i.e. initially mobile nodes with the lowest ID in their neighborhoods are chosen as clusterheads.

Re-clustering is event-driven and invoked in only two cases:

- When two clusterheads move into the reach range of each other, one gives up the clusterhead role.
- When a mobile node cannot access any clusterhead, it rebuilds the cluster structure for the network according to LIC.

Hence, LCC significantly improves cluster stability by relinquishing the requirement that a cluster-head should have some special features in its local area. But the second case of re-clustering in LCC indicates that a single node's movement may still invoke the complete cluster structure recomputation and thus results in large communication overhead.

## VI. LOAD BALANCING CLUSTERING (LBC)

Load balancing clustering (LBC) provide a nearby balance of load on the elected clusterheads. Once a node is elected a clusterhead it is desirable for it to stay as a clusterhead up to some maximum specified amount of time, or budget. The budget is a user defined restriction placed on the algorithm and can be modified to meet the unique characteristics of the system, i.e the battery life of individualnodes. In this algorithm each mobile node has a variable, virtual ID (VID), and the value of VID is set as its ID number at first. Initially, mobile nodes with the highest IDs in their local area win the clusterhead role. LBC limits the maximum time units that a node can serve as a clusterhead continuously,so when a clusterhead exhausts its duration budget, it resets its VID to 0 and becomes a non-clusterhead node. When two clusterheads move into the reach range, the one with higher VID wins the clusterhead role.when a clusterhead resigns, a non-clusterhead with the largest VID value in the neighborhood can resume the clusterhead function. The newly chosen mobile node is the one whose previous total clusterhead serving time is the shortest in its neighborhood, and this should guarantee good energy level for being a new clusterhead.

However, the drawback is that the clusterhead serving time alone may not be a good indicator of energy consumption of mobile node.

## VII. FUZZY LOGIC BASED CLUSTERING ALGORITHM

The Clustering is divided into three phases: Election of the ClusterHead, Selection of the ClusterHead, and Load Transfer from one ClusterHead to another .

***Election of the ClusterHead***

The election of the ClusterHead is done using the LID algorithm.

***Selection of the ClusterHead***

The selection of the ClusterHead is based on a Fuzzy decision made by the nodes that will be coming under different ClusterHead.

***Load Transfer***

This part of the enhancements is done to reduce the effect of increased load when a new node gets admitted into the cluster. The above algorithm works well, but if the node tries to join at alater stage, the ClusterHeads tends to transfer this node to another ClusterHead which is relatively under loaded.

## VIII. MAX-MIN D-CLUSTER FORMATION ALGORITHM

Max-Min d-cluster formation algorithm generalizes the cluster definition to a collection of nodes that are up to d-hops away from a clusterhead. Due to the large number of nodes involved, it is desirable to let the nodes operate asynchronously. The clock synchronization overhead is avoided, providing additional processing savings. Furthermore, the number of messages sent from each node is limited to a multiple of d-the maximum number of hops away from the nearest clusterhead, rather than generalizes the cluster definition to a collection of nodes that are up to d-hops away from a clusterhead. Due to the large number of nodes involved, it is desirable to let the nodes operate asynchronously. The clock synchronization overhead is avoided, providing additional processing savings. Furthermore, the number of messages sent from each node is limited to a multiple of d-the maximum number of hops away from the nearest clusterhead, rather than n,the number of nodes in the network. This guarantees a good controlled message complexity for the algorithm. Additionally, because d is an input value to the heuristic, there is control over the number of clusterheads elected or the density of clusterheads in the network. The amount of resources needed at each node is minimal, consisting of four simple rules and two data structures that maintain node information over 2d rounds of communication. Nodes are candidates to be clusterheads based on their node id rather than their degree of connectivity. As the network topology changes slightly the node's degree of connectivity is much more likely to change than the node's id relative to its neighboring nodes. If a node A is the largest in the d-neighborhood of another node B then node A, Awill be elected a clusterhead, even though node A may not be the largest in its d-neighborhood. This provides a smooth exchange of clusterheads rather than an erratic exchange. This method minimizes the amount of data that must be passed from an outgoing clusterhead to a new clusterhead when there is an exchange.

## IX. K-HOP CONNECTIVITY ID CLUSTERING ALGORITHM (KCONID)

K-hop connectivity ID clustering algorithm (KCONID) combines two clustering algorithms: the Lowest-ID and the Highest-degree heuristics. In order to select clusterheads connectivity is considered as a first criterion and lower ID as a secondary criterion. Using only node connectivity as a criterion causes numerous ties between nodes On the other hand, using only a lower ID criterion generates more clusters than necessary. The purpose is to minimize the number of clusters formed in the network and in this way obtain dominating sets of smaller sizes. Clusters in the KCONID approach are formed by a clusterhead and all nodes that are at distance at most k-hops from the clusterhead.

At the beginning of the algorithm, a node starts a flooding process in which a clustering request is send to all other nodes.

In the Highest-degree heuristic, node degree only measures connectivity for 1-hop clusters. K-CONID generalizes connectivity for a k-hop neighborhood. Thus, when k = 1connectivity is the same as node degree.Each node in the network is assigned a pair did = (d, ID). D is a node's connectivity and ID is the node's identifier. A node is selected as a clusterhead if it has the highest connectivity. In case of equal connectivity, a node has clusterhead priority if it has lowest ID. The basic idea is that every node broadcasts its clustering decision once all its k-hop neighbors with largerclusterhead priority have done so.

## X. MOBILITY-BASED D-HOP CLUSTERING ALGORITHM

Mobility-based d-hop clustering algorithm partitions an ad hoc network into d-hop clusters based on mobility metric. The objective of forming d-hop clusters is to make the cluster diameter more flexible. This algorithm is based on mobility metric and the diameter of a cluster is adaptable with respect to node mobility. This clustering algorithm assumes that each node can measure its received signal strength. In this manner, a node can estimate its distance from its neighbors. Strong received signal strength implies closeness between two nodes. This algorithm requires the calculation of five terms: the estimated distance between nodes, the relative mobility between nodes, the variation of estimated distance over time, the local stability, and the estimated mean distance. Relative mobility corresponds to the difference of the estimated distance of one node with respect to another, at two successive time moments. This parameter indicates if two nodes move away from each other or if they become closer. The variation of estimated distances between two nodes iscomputed instead of calculating physical distance between two nodes. This is because physical distance between two nodes is not a precise measure of closeness. For instance, if a node runs out of energy it will transmit packets at low power acting as a distanced node from its physically close neighbor. The variation of estimated distance and the relative mobility between nodes are used to calculate the local stability. Local stability is computed in order to select some nodes as clusterheads. A node may become a clusterhead if it is found to be the most stable node among its neighborhood. Thus, the clusterhead will be the node with the lowest value of local stability among its neighbors. partitions an ad hoc network into d-hop clusters based on mobility metric. The objective of forming d-hop clusters is tomake the cluster diameter more flexible. This algorithm is based on mobility metric and the diameter of a cluster is adaptable with respect to node mobility. This clustering algorithm assumes that each node can measure its received signal strength. In this manner, a node can estimate its distance from its neighbors. Strong received signal strength implies closeness between two nodes. This algorithm requires the calculation of five terms: the estimated distance between nodes, the relative mobility between nodes, the variation of estimated distance over time, the local stability, and the estimated mean distance. Relative mobility corresponds to the difference of the estimated distance of one node with respect to another, at two successive time moments. This parameter indicates if two nodes move away from each other or if they become closer.The variation of estimated distances between two nodes is computed instead of calculating physical distance between two nodes. This is because physical distance between two nodes is not a precise measure of closeness. For instance, if a node runs out of energy it will transmit packets at low power acting as adistanced node from its physically close neighbor. The variation of estimated distance and the relative mobility between nodes are used to calculate the local stability. Local stability is computed in order to select some nodes as clusterheads. A node may become a clusterhead if it is found to be the most stable node among its neighborhood. Thus, the clusterhead will be the node with the lowest value of local stability among its neighbors.

## XI. ADAPTIVE MULTIHOP CLUSTERING

Adaptive multihop clustering is is a multihop clustering scheme with load-balancing capabilities. Each mobile node periodically broadcasts information about its ID, Clusterhead ID, and its status (clusterhead/member/gateway) to others within the same cluster. With the help of this broadcast,each mobile node obtains the topology information of its cluster. Each gateway also periodically exchanges information with neighboring gateways in different clusters and reports to its clusterhead. Thus, a clusterhead can know the number of mobile nodes of each neighboring cluster. Adaptive multihop clustering sets upper and lower bounds (U and L) on the number of clustermembers within a cluster that a clusterhead can handle.When the number of clustermembers in a cluster is less than the lower bound, the cluster needs to merge with one of the neighboring clusters. In order to merge two clusters into one cluster, a clusterhead always has to get the cluster size of all neighboring clusters. It prevents that the number of clustermembers in the merged cluster is over the upper bound. On the contrary, if the number of clustermembers in a cluster is greater than the upper bound, the cluster is divided into two clusters.However, Adaptive multihop clustering does not address how to select a proper node to serve as the clusterhead for the newly detached cluster. The upper and lower bounds are decided by network size, mobility etc.

## XII. CONCLUSION

We have reviewed several clustering algorithms which help organize mobile ad hoc networks in a hierarchical manner and presented their main characteristics. With this survey we see that a cluster-based MANET has many important issues to examine, such as the cluster structure stability, the control overhead of cluster construction and maintenance, the energy consumption of mobile nodes with different cluster-related status, the traffic load distribution in clusters, and the fairness
of serving as clusterheads for a mobile node.

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