IOSR Journal of Computer Engineering (IOSR-JCE)
e-ISSN: 2278-0661,p-ISSN: 2278-8727, Volume 18, Issue 6, Ver. II (Nov. - Dec. 2016), PP 38-47
www.iosrjournals.org

A Survey of Clustering Scheme for Manets

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Abstract: *Mobile adhoc network is a network in which nodes are dynamic in nature and has limited bandwidth and battery power. They are used in different situations such as military services, medical or embedded applications. For providing the scalable routing the nodes are divided into clusters, in clusters there should be a cluster head which contains all the information of nodes of its cluster, as in the flat routing every node perform the same role therefore network lifetime is less. The different schemes in clustering are based on different criteria. A cluster head is selected according to specific combination or metric such as identity, degree, energy, weight, mobility etc. clustering is useful to increase life time of network, this survey paper gives a survey of different clustering schemes based on connectivity, dominating set, maintenance, load balancing, weight based, power, identifier, mobility and energy.*

Keywords: *Algorithms, Cluster head, Mobile Ad hocNETworks.*

I. Introduction

In A wireless connection, the mobile nodes of independent system are connected without any infrastructure, and can communicate via radio waves is called MANET(Mobile Ad hoc Network).
Main features of ad hoc network:

- Decentralized
- Preexisting infrastructure is meaningless for new communication
- Each node act as a router by forwarding data to neighbor nodes
- Fast network topology does change due to nodes' movement.

A Mobile Ad Hoc Network is an infrastructure less, self-organized network with hastily changing topology causing the wireless links to be broken and a new path will available. A key issue is the necessity that the Routing Protocol should be able to respond quickly to the topological changes in the network. In ad-hocnetworks, each node must be capable of acting as a router. Due to the availability of limited bandwidth of thenodes, the source and destination node used to communicate via intermediate nodes. The main problems in routing are Routing Overhead, Interference, Asymmetric links, and Dynamic Topology[1].

MANET, now a topic of commercial research, was initially used in military projects, including in tactical networks and Defence Advanced Research Projects Agency (DARPA) projects. Some uses 4G network and other wireless systems as examples of a potential topology for a mobile adhocnetwork(MANET), while others refer to a (VANET)vehicular ad-hoc network, where the free network nodes are installed in cars and other vehicles[2].

The research area of MANETs has to face a lot of challenges: like limited bandwidth, dynamic topology, routing expense, hidden terminal problem, packet loss, route change due to mobility, battery constraints and security threats.

1.1 Routing in MANET

Routing in a network is the process of selecting paths to send network traffic. Routing can be done by two ways either in a flat structure or in a hierarchical structure. In a flat structure, all the nodes have the same role as they are in the same hierarchy level. Although this approach is beneficial for small networks as scalability is the major issue,when the number of nodes in the network is more. In large networks, the flat routing structure can create a problem in the network as it produces excessive information flow in the network. Hierarchical routing protocols remove this problem by making a cluster of some of the nodes of network. [3]

II. Overview

Section 3 describes why do clustering is needed in MANET. Different clustering schemes are described here. The advantages and disadvantages of every algorithm are described in section 4. Fifthsection, the last one concludes the paper.

III. Clustering in MANET

The hierarchical approach of the network can also be called clustering. Different routing schemes are used within clusters (intra- cluster) and between clusters (inter-cluster).Cluster head maintains the whole knowledge of nodes within its cluster but fractional knowledge about the nodes of other clusters. Clustering is akey to handle the scalability in a network in which only selected nodes will take the responsibility of data routing. However, continual topology changes occur in hierarchical approach. Thus, topology management plays a spirited role former to the actual routing in MANET.

With increase in capacity of network clustering also reduce routing overhead which brings more effective plus efficient routing in MANET. Two mechanism s are main for clustering these are cluster formation and cluster maintenance. In cluster formation the process of formation of cluster will be done and CH is selected. Then cluster maintenance procedure will be invoked. A typical cluster structure is shown in fig. 1.

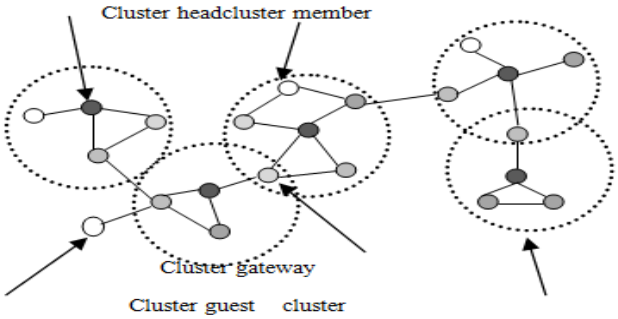

Fig.1. Example of clustered network

The nodes in the cluster can be categorises according to their role performed, these are:
Cluster Head: consists of information of all nodes of that cluster.
Cluster member: all the members of cluster other than cluster head.
Cluster guest: a node which can't directly participate in cluster but can access the cluster headthrough any of cluster member.
Cluster gateway: a node which can access more than one cluster head.

3.1 Clustering Schemes

According to the different functionalities of cluster head the clusters are being classified into different schemes. Ten clustering schemes are defined here. There pros and cons are discussed and then a table is given which capsule their main properties.

1. Connectivity based clustering

1) Highest connectivity clustering algorithm(HCC)[4]

Highest connectivity clustering clusters are constructed on the basis of degree of connectivity. Degree of node is obtained by computing its distance from others. Each node broadcast its id to every node which is in its transmission range. And the node with the highest degree of connectivity would be the cluster head. Any two nodes will be at most two hopes away in the cluster. The neighbors of the cluster head will become members of that clusters, which are up to two hops away.[4] In case, if there are more than two nodes have same match in degree then the tie will be broke by lowest ID.[5]

2) 3-hop between adjacent cluster heads algorithm (3hBAC) [5]

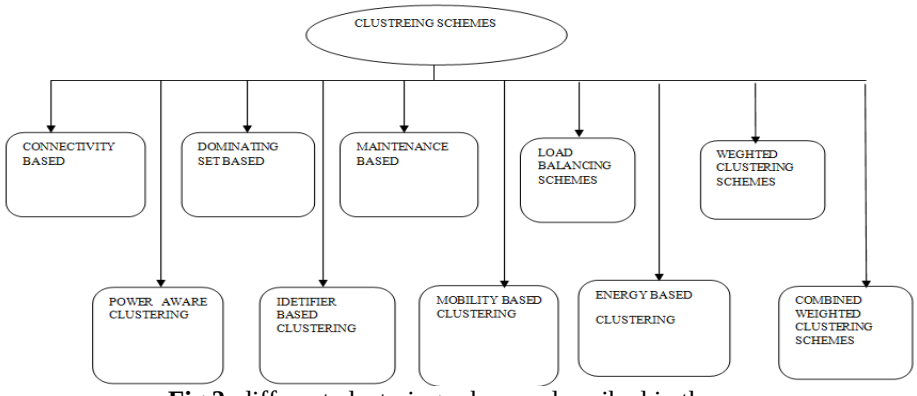

Fig.2. different clustering schemes described in the paper

Creates a 1-hop non overlapping clusters structure.A new node cluster guest is introduce here, which is three hops between neighboring CHs. Cluster guest is a mobile node which cannot get access of cluster head directly but can get the access with the help of member node of that cluster.The node with the highest degree will declare as a CH.For cluster maintenance the procedure will be follow as in LCC algorithm, which decreasesthe number of cluster heads present in the network and also reduces small unnecessary clusters[5]. In this algorithm neighbor table and a member table are maintained by each node. CHs and a member node keep their status for long period [3].

3) K-hope connectivity ID clustering(KCONID)[4]

It combines two clustering algorithms: lowest ID and highest degree heuristics. Cluster head is chosen by taking the first priority to highest connectivity and then lowest ID. Its main focus is to obtain less number of clusters. At the beginning of algorithmnode floods a packet, requesting to form cluster, to all other nodes. K hop connectivity means generalizes the connectivity for K-hop neighborhood. The 1 value of k means that connectivity is same as the node degree.

Every node is have to maintain a pair did: (d,ID) d is the node's connectivity and ID is node's identifier.

4) Adaptive cluster load balance method(ACLBM)[4]

It is an improvement over HCC. To balance the load on cluster head, a new approach is given, by creating an "option" item in HELLO message format. In"option" value CH sets the number of itsdominated member node. In case if the sender is non CH node "option" item will be reset to 0. When the value in the option item of cluster head exceeds the threshold value no new node is allowed to participate in cluster. Hence load is balanced between various clusters.

5) Adaptive multihop clustering (AMC)[4]

AMC is a load balancing scheme. Here the three parameters are maintained by every node these are node's ID, CHID and its status, which every node periodically broadcasts to other nodes within the same network. Cluster members that the cluster head can handle is givenan upper and lower limit, which is set by calculating network size, mobility etc. If the ordinary node in the clusters is less than the lower limit then the cluster have to merge with one of the neighboring clusters. The CH got to know about the size of neighboring clusters through gateway. Each gateway periodically exchange information with neighboring gateways and then reports it to CH. If the cluster size exceeds from its upper limit, the cluster is divided into two clusters.But the main problem with this algorithm is it does not give any criteria to select cluster head.

2. Dominating set based clustering algorithm

1) Connected dominating set algorithm(CDS)[6]

A DS is called connected DS if all the dominating nodes are directly connected with each other. Initially neighbor list is exchanged with every node. If the node has at least two unconnected neighbors then that node will be declared as dominating node or CH. This is called marking process then some rules are applied to reduce the size of cluster generated by marking processwhen two CHs come to the range of each other then node with smaller ID will be deleted.

Main advantage of this algorithm is that number of frozen rounds is less. Cluster can be constructed in just two rounds. One round for marking process and other for extension rules which are used to reduce the size of dominating ser. But cluster maintenance is very costly due to periodically exchange of messages on movement of any node. As a single mobile movement may overpower many mobile nodes to transmit and receive their own packets.Therefore it is not suitable in dynamic environment.

2) Weakly connected dominating sets(WCDS)[6]

Main objective of these two DS based clustering schemes is to select small number of mobile nodes as dominating nodes to form a dominating set.

WCDS works on the idea to relax the direct connection of neighboring dominating nodes. Hence the number of dominating nodes in WCDS is less then CDS. There is size difference between WCDS and CDS. WCDS is smaller than CDS.There is no maintenance algorithm in WCDS.

3. Low maintenance clustering

1) Least cluster change(LCC)[6][4]

It is enhancement over least ID clustering(LIC) andhighest connectivity clustering.[6] it works mainly on the selection of cluster head, and add maintenance step i.e.

- If there are two cluster heads in a cluster then one have to give up its role on the basis of its ID, but in HCC whenever a CH finds a node better than it, it immediately leave its role and handover to that one this procedure leads to re-clustering, and here the cluster head change is invoked only in maintenance phase not in formation phase.
- And when a mobile node cannot getaccess ofany nearby CH then it rebuilds the cluster structure according to LIC algorithm.

With reducing the flaw of HCC it improves the stability of cluster. But it may lead to large computation overhead due to re-clustering is done when any of the node cannot able to access any CH.

2) 3-hop Between Adjacent Cluster head(3hBAC)[6]

Assume a mobile node M. The cluster construction always begins with the neighborhood of M with lowest ID. The node with highest degree between the closed neighborhood set of M will be chosen as CH. 3hBAC forms 1 hop non clustering structure by introduction of new form of node called cluster guest having distance of three hops away from neighboring cluster heads. A mobile node that can access the CH of neighboring clusters without being a member of cluster is called cluster guest. When a node is away from cluster range it can able to join the cluster as a cluster guest if it is possible to reach any of the cluster members. It works better in dense scenario and ripple effect is also low.

3) Lin's algorithm[6]/ Adaptive clustering for mobile wireless network(ACMWN)[4]

If there is no cluster head in the network then there will be no bottleneck of network. Lin's algorithm works on this idea. At first the CH is elected on accounting lowest ID. Every node will have a set contains its own ID plus direct neighbors ID called CID set. If the node will have the lowest ID as compared to its neighbors then it will broadcast its ID claiming to be CH. When it receives any message from other node then at first it will match its ID with itself if its ID is lower than it will delete that node from its CID packet, otherwise that node will be the new CH. This process will be repeated until the formation of cluster. After the formation of cluster CH status will be removed.

4) Passive clustering(PC)[6]

In PC the mobile nodes can be in four states: initial, CH, gateway and ordinary node. The mobile node with initial state can be CH. It will broadcast a message by which every node in the cluster can got that. Any extra message for cluster maintenance is not send. The main point of this algorithm is that not every node which got more than two messages of cluster head will behave as cluster gateway, it has to be chosen by checking the distance between the CH and CG(cluster gateway), is beyond some range, but which node will better to select as a cluster gateway is not been addressed. PC is suitable for network where the nodes move frequently and not suitable for burst network. In this algorithm each node will set a timer to update its own cluster status[6]. Neighbors can get the knowledge about cluster head by monitoring the cluster state in the message and update the CH_ID while receiving. When any node does not receive any packet from its CH in a given interval of time, itreverts its cluster state to initial[4].

4. Load balancing schemes

1) Adaptive multihop clustering(AMC)[6]

In AMC load is balanced by setting U upper and L lower limit, which is decided by network size, bandwidth, mobility, energy and so on. For cluster maintenance a packet is exchanged between nodes having CID and ID and status by which every mobile node gets the topology information of the cluster it belongs. If the number of nodes are less than L then merge mechanism will be appealed, and the CH with more member node will continue with CH role. If the nodes in the cluster extend the limit U then divide that cluster. In one cluster the CH is same and in the other cluster how to select optimal CH is not addressed. A cluster can be enough large.

2) Degree load balancing clustering(DLBC)[6]

In DLBC the CH uses a parameter 'max_delta' which is the difference between ED and number of nodes a CH currently serve. And ED is the value of number of nodes that the CH can serve. If 'max_delta' exceeded some value then the CH have to give up its role. Here also how to elect the CH is not addressed. Here CH change is low because CH has not to give up its role even if there are nodes present in the cluster which have higher node degree.

5. Weighted clustering schemes

1) Weighted clustering algorithm(WCA)[5]

The parameters used in this algorithm are: node distance with all neighbors,node degree, node speed and time spent as a cluster head. Before making a cluster all the nodes have to know the weights of each node, causes a lot of overhead. Election of CH is based on the basis of weight of each node. A threshold is set that indicate the value of nodes that should be supported by CH, so that the CH should not overloaded but there is no parameter which limits the under load of cluster.If a node is does not come under the range of any CH then the whole procedure of cluster formation will be invoked in the whole system, again a lot of overhead[5,3].

Parameters used here: number of nodes it can handle, mobility, transmission power and battery power. And the weight associated with node v is described as: Wv =w1_v+w2Dv+w3Mv+w4Pv. The node which has minimum weight will be elected as CH. The weighting factors are chosen so that w1+w2+w3+w4=1, the factor is related to energy consumption. Details of the factors used in CH selection are given in[4]. A threshold will be set to ensure that a CH will not be overloaded.

1.1 WCA with mobility prediction

This algorithm was proposed for the mobility prediction during cluster maintenance after the cluster formation process. In mobility prediction to predict whether a node is moving along with all its 1-hop neighbors, a quantity is applied.At first every node broadcast a beacon message showing the status of that node. After receiving the beacon message every node makes the neighbors list and the node which has lowest weight in the cluster will be selected as CH. Its main aim is to reduce communication overhead by predicting mobility of node [7].

1.2 improved WCA (iWCA)

This is the improved version of WCA, the main difference is to avoid a node with low battery to being selected as CH. Minimize the clusters present in the network and minimize the overhead for cluster formation and maintenance. It improves the performance of clusters present in the network and re affiliation frequency[7].

2) A flexible weight clustering algorithm(FWCA)[5]

It uses node mobility, node degree, transmission power, remaining battery power to elect CH. Cluster size should be limited to a threshold value.During cluster maintenance phase cluster capacity and link lifetime is used to yield low number of clusters.

3) Enhancement of weighted clustering algorithm(EWCA)[5]

Enhancement is based on two factors, load balancing by setting up a threshold, determine the number of nodes that CH can cover and improving the stability by detach the mobile nodes from a cluster and attach to the another cluster. The selection of CH is on the basis of mobility of mobile nodes or changing the distance between nodes and CH.

4) Score based clustering algorithm(SBCA)[3]

SBCA uses four parameters specified as: battery remaining, node degree, number of members and node stability. It aims to give the minimum number of clusters and increase the life spans of mobile nodes. On the basis of these four parameters the score will be calculated by every node and broadcast to its neighbors. That node which has highest score will be elected as cluster head. In this algorithm the overhead is high.

5) Efficient weight based clustering algorithm(EWBCA)[3]

Four parameters are used here: number of neighbors, battery residual power, stability and variance of distance. Each node calculates combined weight and broadcast the packet to its neighbor nodes. Node which has highest combined weight will be selected as CH. Here the nodes can be in four states: NUL, CH, gateway node, member node. At initial, all the nodes are in NULL state. Its main aim is to improve the usage of bandwidth, energy by making the clusters stable, minimize routing overhead, increasethe throughput. The main disadvantage of this algorithm is it requires more information during cluster construction[12].

6) Robust clustering algorithm(PMW)[7]

Parameters used here: power, mobility and workload. To compute the three parameters locally cover the major cause of re-clustering.This algorithm produce more stable clusters by solving scalability and mobility issues.

7) CMBD [7]

Parameters used here: connectivity(C), residual battery power(B), average mobility(M), distance of nodes(D). These four parameters are used to select CH. A predefined threshold is defined number of nodes a cluster head can handle so that there isno degradation in MAC function and improve load balancing. Main aim is the stability of clusters with lowest number of clusters formed, minimize overhead of maintain and construct cluster and maximize the life spans. Clusters are formed on the basis of these different parameters.

6. Combined weight clustering

1) Entropy based weighted clustering algorithm(EBWCA)[4]

EBWCA uses entropy based model to elect CH. WCA produce high re-affiliation, which causes highly unstable network. This algorithm overcomes the drawback of WCA. EBWCA presents uncertainty and is a measure of chaos of system. That is why it produces stable networks.

2) Vote based clustering algorithm(VBCA)[4]

The clusters are made by transmitting the 'hello' message. 'Hello' message format is given as:

MH_ID	CH_ID	Vote	Option

MH_ID is the mobile host ID, CH_ID is mobile host CH ID. Making use of node location information and power information the vote field is introduced. MH vote value i.e., weighted sum of number of valid neighbors and remaining battery time. Vote=w1x(n/N)+w2x(m/M)…… Option item is used to realize cluster load balance.

Each mobile host send 'hello' message randomly. If a mobile node is new, it resets its 'CH-ID' item. Now each mobile host counts how many hello messages it receives during hello cycle and add that to the 'n' value of vote field. Each mobile host sends another HELLO message, in which vote item is set to its own vote value and got from equation. Now according to the value of second hello message the vote value is updated and the node with the highest value is selected as CH. when there are two CHs presents the higher priority given to is the node with lower ID. Hence in this algorithm in just two rounds every mobile node gets to know about their CH.

3) Weight based adaptive clustering algorithm(WBACA)[4]

Parameters used here: transmission power, transmission rate, mobility, battery power, degree. The clustering approach in WBACA is based on availability of position information which can be obtained via a Global Positioning system(GPS). Each node is assigned a weight according to given parameters, and the node whose weight is minimum will be selected as CH.The weight of node P is defined as

WP=w1*M+w2*B+w3*Tx+w4*D+w5/TR

Details are given in [4].

7. Identifier neighbor based clustering

1) Lowest ID clustering(LIC)

Also called linked cluster algorithm (LCA), each node is assigned a distinct ID. Every node broadcast its neighboring list that it can hear, periodically. A node with the lowest ID will be a CH of cluster. In LIC only the lowest ID is considered as the variable for election, no other parameter is considered here, therefore the nodes with lowest ID are used loose there power early.[4]

2) Min max d-hop

When the cluster is 1-hop it creates large number of CHs in the network causes congestion problem. Max-min d-hop limits the cluster to d-hop and reduces congestion to some extent. But the presence of large number of nodes may perform asynchronously. CH election is based on their ID.If a node A is largest in the d-neighborhood of another node B then node A,A will be elected as clusterhead, even though A may not be the largest in its d-neighborhood.This also minimizes the data to be transfer when CHs have to exchange[4].

Three phases of this algorithm are defined in[4], during the selection of CH. first is each node broadcast its ID make a list and find the highest ID. In the second phase, broadcast that highest ID and the lowest among those highest ID. At last CH is chosen based on the IDs saved previously.

In spite these LCC, ACA, HCC discussed above, are the algorithms which works according to ID.

8. Mobility based clustering

1) Mobility based metric

This algorithm elects the CH on the basis of mobility. The cluster is formed at most two-hops in diameter. The variance of each mobile node is calculated, relative to each of its neighbors. The node with low variance will be selected as CH. To avoid re clustering, when two CHs come into contacts of each other, a timer

is set for a CH. But during cluster maintenance mobility is not always consider as main parameter so it cannot be guaranty that CH will have low mobility compared to its neighbors during maintenance phase. Mobility is ignored respective to the time. Mobility of mobile nodes affects the performance. [4]

2) Mobility based d-hop

Five parameters are used here: estimated distance between nodes, the relative mobility between nodes, variation of estimated distance over time, estimatedmean distance and the local stability. The cluster formation is divided into two stages: discovery stage and merging stage. The cluster with same speed and direction will form a cluster, merging is done to merge the clusters if they can listen to one another through gateways, only if they could achieve the required level of stability. The node with the lowest value of local stability will be the CH. The cluster is more flexible due to the formation of d-hop clusters[4].

3) Mobility prediction based

MPBC works on the relative speeds estimation for every node in the whole network. Each node periodically broadcast its HELLO packet and build their neighbor lists and calculates its average relative speed among its neighbors. Node with lowest mobility will be elected as CH. This algorithm improves the lifetime of cluster and builds stable clusters.

9. Power aware clustering schemes

1) Load balancing clustering(LBC)[4]

It balance the load on elected CH. in this algorithm each node should have a variable, virtual ID(VID) which is given the ID of node at first. The CH will be selected according to their higher degree, but upto some limit or budget. In LBC a node cannot serve as CH continuously. It bounds the limits on CH. When the CH exhaust or limit extends then it will set its VID to 0 and become a nonCH node.The node whose total clusterhead serving time is less among the neighbors and will guarantee a good CH in case of energy level.

2) Power aware connected dominated set(PACDS)[4]

More energy is consumed by unnecessary nodes in DS. It is necessary to minimize the energy consumption of DS that is why the unnecessary nodes should be deleted from the cluster. When a mobile node's closed neighbor set is covered by one or two dominating neighbors and that mobile node have less residual energy then those dominating neighbors, then the mobile node will be deleted from set . But here the main disadvantage is, this scheme cannot balance the energy consumption between DN and non DN as it aims to minimize DS. Hence mobile nodes can deplete their energy at very fast rate.

3) Clustering for energy conservation(CEC) [4]

In this algorithm it is assumes the two types of nodes are there: master and slave. A slave is connected to only one master, no two slaves are directly connected. The area of cluster is determined by the farthest node between the slave node and master node in the cluster. Number of slaves the master can serve is limited. Its main aim is to serve as many slaves as possible by minimizing transmission energy consumption by summed by all master and slaves pairs. Two schemes, single-phase clustering and double-phase clustering, are proposed in [8]. In single-phase clustering,initially every master node page slave nodes with the allowed maximum energy. Each slave receives one or multiple signals sends acknowledgement to that master it receives the strongest signal. If a salve does not receive any channel from master will drop for further communication phase, this mechanism reduce the call drop rate.

Hello message is send periodically during cluster formation such that every node will build their neighbors list, and calculate their speed relative to their neighbors. The node with lowest relative mobility will be selected as CH. During the cluster maintenance phase, due to the movements of nodes the problems are created which are resolved by prediction based method. This algorithm increases the lifetime of CH. [5]

4) Clustering through neighborhood stability based(MobHiD) or Novel clusters algorithm [5]

Combination of highest degree technique with mobility prediction of mobile host by information theory based technique. Cluster head is two hop s away. Involves accurate prediction of future mobility based on neighborhoods stability.If a mobile host has same set of neighbors for a long time, it will create more stable structure. And hence this algorithm predicts mobility of mobile node as stability of neighborhood. A mobile host having the highest degree will be selected as CH. Main objective is to provide stability of cluster structure.

5) Mobility based frame work for adaptive(MBFWA)/ Distributed clustering algorithm(DCA)[6][4]

Cluster formation is done on the basis of (a,t) criteria.Where 't' is the time limit that a path will be available from 'a' node to other node with a probability, regardless to the hop distance between them. The

relation of path availability with time andthe choiceof the values of a and t is given in [9]. By bound the path availability the routing overhead can be reduced. This algorithm is very effective and responsive when the at low mobility and very efficient when at high mobility. This algorithm supports dynamic environment.In DDCA the routing schemes are implemented as table driven scheme for intra cluster routing and on demand scheme for inter cluster routing.

10. Energy based clustering schemes

1) Flexible weighted clustering based(FWCABP)[5]

Parameters used here are weight of degree of nodes, mobility, remaining battery power and sum of its distance to its neighborhood. The node with minimum weight will be selected as CH. It prevents the node with low battery for being selected as CH. when a node reached to its predefined threshold then maintenance process is invoked. But the network performance will degrade during the selection of CH as the network traffic increases.

2) Enhanced cluster based energy conservation(ECEC)[5]

It is enhancement over cluster based energy conservation(CEC)[10]. Here a new topology control protocol is being presented used to extend the lifetime of large adhoc networks during ensuring minimum connectivity of network, the availability for nodes to reach each other and conserve energy by identifying redundant nodes and turning their radios off.The node with highest degree will be elected as CHs. Then the gateways are selected. The procedure for the selection of gateways is given in [11]. This algorithm is used to increase the life time of cluster. But during the election of CHs and gateways the overhead is more.

3) Max heap tree algorithm based on energy efficient clustering[5]

Small clusters are formed in max heap tree algorithm. The root node of max heap tree will be selected as CH. during cluster maintenance tree balancing is needed, because it violates the property of max heap. This algorithm minimizes power consumption and maximize network lifetime.

4) Multicast power greedy clustering(MPGC)[5]

This algorithm consists of three phases: beacon phase, greedy phase and recruiting phase. In beacon phase each node sends its highest power to every node and received beacon also from other nodes. During greedy phase, each node sends CH declaration with necessary level of power required reaching its neighbors and then it increases its power level step by step until it reaches all its neighbors. And in third phase the node with highest residual power will be elected as CH.

IV. Advantages And Disadvantages of Clustering Algorithms

Clustering algorithm	Classification	CH election	Advantages	Disadvantages
Connectivity based	HCC	Highest connectivity	1. Generate limited number of clusters 2. Low rate of cluster head change 3. No overlapping clusters 4. Changing of clusters is low	1. High movements of nodes cause re-affiliation. 2. Degrades throughput, as it does not restrict on upper limit of number of nodes in the cluster 3. Cluster number is high 4. Low stability 5. Total overhead is high
	3hBAC	Highest degree	1. Cluster number can be reduce because cluster topology does not change 2. Eliminate small unnecessary clusters 3. No overlapping clusters 4. Reduce number of cluster heads.	1. Unnecessary overhead due to dynamically change of network 2. High rate ofcluster head change 3. Each node maintains two tables 4. Total overhead is very high
	KCONID	Highest degree lowest ID	1. Minimize number of clusters	1. Overhead of maintaining parameters i e..,(d,ID) 2. Overlapping clusters may possible
	ACLBM	Highest connectivity	1. Balance load between various clusters by giving a threshold value to the cluster heads. 2. Improvement over HCC. 3. Resource consumption and information is transferred to all clusters instead of few.	The movement of only one mobile node causes re-clustering
	AMC	Have not determined	Load is balanced by setting upper and lower limit	Does not give any criteria how to select the cluster head
Dominating set	CDS	*Marking process*	1. Less number of rounds for constructing cluster. 2. Reduce size by checking and comparing ids.	1. Not suitable for dynamic environment 2. Cluster maintenance is expensive 3. Cluster head change is high 4. During movement of any node, it will send a packet so a single node movement may suppress. Many mobile nodes have to receive and transmit their own packets.
	WCDS	*Marking process + relaxing the directly connected dominated nodes*	Less number of dominating sets thenCDS	Needs larger or non-constant no. of rounds for constructing clusters
Maintenance based	LCC	ID	1. Cluster head change is invoked only in maintenance phase not in formation 2. Improves stability	1. Single node movement cause re-clustering 2. Cost of re-clustering is a bit expensive
	3Hbac	Highest node degree	1. Cluster headupdate in very limited cases and no ripple effect 2. Overlapping clusters is low 3. cCHluster head change is low 4. High stability 5. Works better in dense scenario.	for cluster formation stationary assumption is required
	Lin	No CH	1. Low communication complexity as cluster can be formed just by exchanging only one message. 2. No bottleneck as no overhead	During the maintenance phase, it is possible that cluster size decreases and no. of clusters increases.
	PC	Initial node	1. Cluster formation and cluster head selection is done with less exchange of packets. 2. Packet flooding is low. As ordinary nodes are not allowed to flood a packet	1. How to select the optimal range for the selection of CH is not addressed. 2. Not suitable for a network with bursty traffic.
Load balancing schemes	AMC		1. No ripple effect 2. Maintains good stability	1. Can't say about cluster formation at initial. 2. During partition how to select the optimal cluster head is problem in either of cluster.
	DLBC	Null	Does not need to change cluster head even when other node is optimal	1. How to select CH is not addressed. 2. Not suitable for dynamic environment

Clustering algorithm	Classification	CH election	Advantages	Disadvantages
Weighted clustering schemes	WCA	Weight	1. Weight is determined based on multiple parameters 2. Optimize battery, load functionality and MAC functionality 3. Cluster head change is low	1. Overhead is high as a lot of packets are exchanged before cluster formation 2. Re-clustering is required.
	FWCA	Combined weight metric	FCA uses cluster capacity and link lifetime, instead of node mobility, during cluster maintenance, because link stability metric effects the election ofcluster head with same weight the node mobility metric.	Re-clustering is needed on the arrival of new node
	EWCA	Combined weight metric	1. Improve stability and load balancing 2. Number ofcluster head change is less	Weight calculation takes time
	SBCA	Combined weight metric	1. Minimize number of clusters maximize lifespan 2. Maximize lifespans of mobile nodes 3. Generates fewer clusters than WCA	Total overhead is very high
	EWBCA	Combined weight metric	1. Improve the usage of bandwidth and energy, minimizing routing overhead, increasing end to end throughput. 2. Produce stable clusters 3. Total overhead is low 4. Cluster head change is low 5. Cluster number is low 6. Low overlapping clusters	It requires more information during cluster construction.

Clustering algorithm	Classificatio n	CH election	Advantages	Disadvantages
Combined weighted clustering	EBWCA		1. Overcome the drawback of WCA and form stable network. 2. Produce stable clusters.	Presents uncertainty and is a measure of chaos of system. Communication overhead is high
	VBCA		1. In just two rounds every mobile node gets the knowledge of cluster head. 2. Improves stability of cluster structure by introducing battery information	The movement of only one mobile node causes re-clustering
	WBACA		Remove the drawbacks of WCA	The movement of only one mobile node causes re-clustering
Power aware clustering	LBC	Initially at ID then remaining power	1. Cluster heads are elected on the basis of power aware 2. Balance load on cluster heads	The cluster head serving time alone may not be the good indicator of energy consumption of a mobile node.
	PACDS		1. Unnecessary mobile nodes are excluded from dominating set to save their energy consumed for serving as cluster heads	This scheme is not able to balance the energy consumption between dominating nodes and non dominating nodes because it aims to minimize dominated set.
	CEC	Not specified	The cluster will have longer battery time and better performance	Master node election is not adaptive and how to select master node is not specified
Identifier based clustering	LIC	Lowest ID	1. The nodes transfer the information of only IDs. 2. Traffic is low	Early power drainage, When a node serve as cluster head for long time
	Min max d-hop	Minimum ID	1. Amount of resources needed at each node is minimal. Produces robust structure. 2. This algorithm reduces the congestion to some extent.	More information is to be exchange before electing cluster head
Mobility based metric clustering algorithm	MBM	Lowest ID+ timer	Effective for MANETs in which mobile nodes are moving with similar speed and direction.	Mobility is not always considered in cluster maintenance, so a cluster head is not guaranteed to bear low mobility characteristics relative to its member during maintenance phase.
	mobDhop	Lowest mobility	Forms less cluster	Only mobility metric is main parameter
	MPB	Node stability	Able to avoid some unnecessary cluster merges, based on mobility prediction	cluster head Average lifetime is long
	MobHiD	Highest degree+mobili ty prediction	1. Provide longer lifetime of cluster structure 2. Provide stability of cluster structure	Only suitable for small networks
	MBFWAC	a,t criteria	1. Support dynamic environment 2. This algorithm is more efficient when mobility is low and more efficient when mobility is high 3. cluster head change is low	1. In highly mobile network its cluster size diminishes 2. It forms multi-hop clusters so cluster head have to maintain information about more mobile nodes and their status change update causes more control overhead
Energy based	FWCABP	Minimum weight	Clustering overhead is low	Increase traffic during the election of cluster head
	ECEC	Highest energy	1.Increase lifetime of cluster 2.Reduce power consumption	During selection of cluster heads and Gateway overhead is more
	Max heap tree	Highest energy level	1. Minimize power consumption and 2. maximize cluster lifetime 3. cluster head change is low	1. It has high overhead 2. Overlapping clusters are possible
	MPGC	Highest energy	Increase network lifetime	Increase network traffic and bandwidth consumption

V. Conclusion

MANETs is a good field for research area, a lot of works have already done on MANET and still a lot of researches arebeing addressedon this field. MANET is a good area for research as it aims to provide a quality of service across the network. In this survey we first describe the fundamental concepts about clustering, why it is needed. Then the different schemes of cluster, how the clusters are divided according to their different functionalities. We have presented the basic ten schemes of cluster. And on the basis of their categories we have presented the selection of CH, formation of cluster. Different schemes have different objectives. A table is given that distinguish their advantages and disadvantages. This paper is for giving the basic idea about how the clusters are formed and on what basis we can categories the clusters for further studies.

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