Clustering Schemes In Mobile Ad-Hoc Network (MANET): A Review

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Abstract: Mobile Ad-hoc Networks (MANETs) are inherently wireless networks organized without pre-existing topology. MANETs are effectively deployed in different environments such as: Armed Forces, Disaster Management, Medical and other similar Integrated Applications. However, it is observed that newer challenges and applications come up in MANETs every short period of time. In large deployments MANETs can have a huge number of mobile nodes creating new problems. In order to overcome such challenges, clustering algorithms are invariably used which allow the structuring of network into group of entities or cluster. In each cluster there is a particular node acting as Cluster Head (CH). In a cluster individual node has different values for parameters like node mobility, degree of the node, identity or energy of node, etc. Clustering is s process, identifying the number of nodes to be grouped together and an associated cluster head. This process plays an indispensable role in enhancing network performance and resource management. In this paper, analysis of many existing clustering algorithms of MANETs to classify such as: Identity based, Mobility based, Topology based, Energy based, Weight based and artificial intelligence based clustering is done. Further features of clustering like definition, cost, advantages and disadvantages, review of existing techniques and their evaluation are also done. Suggestion for the best clustering scheme has also been put forth.

Index Terms: Clustering, Cluster Head, Energy Based, Mobile Ad hoc Networks, MANET, Routing Protocol, Weight Based

1 Introduction

Anetwork, which consists of network devices that have self-configuring capability and are connected with other nodes wirelessly, forms Mobile Ad-hoc Network. It can be stated that the devices in MANET can easily link with other nodes. These nodes can move anywhere, in any direction (See Figure-1).

Each device used in the MANET contains complete information of the relevant network traffic and thus can act as a router to forward the packets in a reliable manner. The device can operate on its own or interconnect to a large network. This property is quite useful and has led to rapid growth in the usage of the MANET.

A node is a mobile host connected wirelessly to other nodes. While communicating transmission from such devices is received by all other nodes that lie within the transmission range.. However, if both sender & receiver nodes are out of range of each other, in MANET, then the intermediate mobile nodes have the ability to construct the communication path effectively and thereafter forward the packets usually under the supervision of Cluster Head (CH).

Owing to its nature of mobility, each host has to function independently. Moreover, the host is capable of moving anywhere randomly and has to adapt to its dynamic topology. Application of such technology is witnessed in educational, military and industrial sector.

In MANET routing can be done through Flat Structure topology or Hierarchical structure topology. For large Ad-hoc networks flat structure topology is quite ineffective as it is quite complicated and unsteady due to node mobility.

Looking to the other option, the researchers have proposed hierarchical topology structure, to overcome the above stated problem. In this approach, nodes are notionally put in groups called Cluster. Every node maintains whole information of its cluster and part information of other clusters, resulting in improved routing efficiency of the dynamic network.

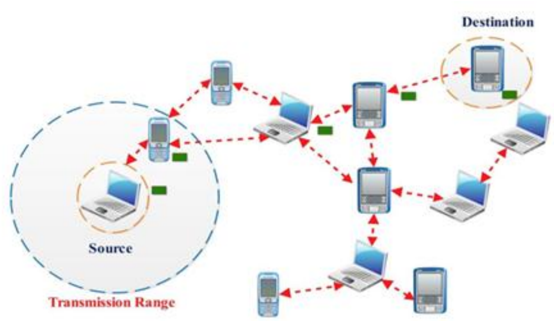

Figure-1 Simple MANET

2 CLUSTERING IN MOBILE AD-HOC NETWORK (MANET)

For organizing wireless networks in large scale topology, it is pertinent to create and maintain distributed nodes in distinct structures such as spanning graphs, dominating sets and clusters with the intention to make system efficient, reliable and robust from communication point of view. This also leads to desirable cooperation among nodes in an ever changing environment. Amongst aforementioned approaches, most familiar approach is clustering. In networks with dynamic topology, in clustering spatially neighboring nodes are grouped together by partitioning the network. These clusters of nodes are identified by a cluster heads which is also a node in the cluster. All nodes in a cluster are connected to each

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other directly or via neighbor nodes. Most of the reported clustering algorithms [1] are based on heuristic approaches for forming cluster and choosing a cluster head [2]. This is mainly because the cluster optimal cluster and cluster head problem is NP-complete.

For facilitating effective communication amongst nodes Clustering is one of the important methods. This is so because mobile nodes have only a limited battery power, which cannot be replaced on will discharged so node goes out of action. This affects the network's performance in general. There is a need to conserve the energy of mobile nodes at all times. This necessitates optimization of communication range and also minimization of the energy usage.

In several research papers standard protocols and their abilities, have been evaluated assuming deployment configurations such as varying degrees of node mobility within a limited space, implying that all nodes lie within a few hops of each other. For performance evaluation of protocols, parameters namely the packet drop rate, end-to-end packet delays, network throughput, the overhead introduced by the routing protocol, etc. are used.
The limited bandwidth ad-hoc network makes it imperative to construct a virtual network with the subset of nodes and there from identifying the route for forwarding packets for good puts. Nodes belonging to neighboring clusters communicate via boundary nodes. As such grouping the nodes into distinctive clusters for form proper clusters is one of the hot spot and biggest challenges MANET research areas.. Optimal clustering solutions can greatly enhance the practicability and performance of MANETs [3].

Direct node to node communication happen amongst those nodes which are within radio range of each other. Outside of radio range nodes communicate with the assistance of intermediate nodes to route their packets. Thus, MANETs can work at any place in any topography. This gives a distinctive edge to MANET and makes it highly robust. Nodes A and C in Figure-2 must trace the route through node B to communicate with each other. The nominal radio range of each node is depicted by circles. Node A and C are not in direct transmission range.

Proper Clustering can improve the network management save battery power. Creation and subsequent maintenance of clusters are the two vital phases important to facilitate smooth functioning of the network over its lifetime. In MANET creation of Cluster refers to forming groups of nodes at the beginning in a structure called cluster for organizing wireless network. Cluster regularly updates the route tables and occasionally reselects the CH in the network. At all times within a cluster mobile nodes must be aware of any neighborhood node changes. As such cluster maintenance necessitates frequent updating of clusters and cluster heads.

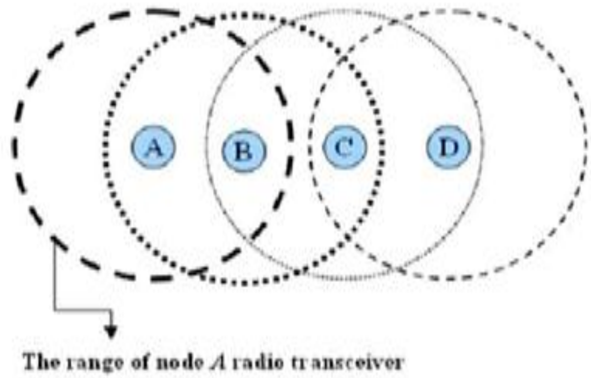

Figure-2 Simple Network Model for MANETS

The random mobility of the nodes, cause unpredictable changes in network topology over a period of time. Nodes are identified as most significant for the MANET system [4] are cluster heads. These nodes are termed as cluster heads within each cluster to act as the local coordinator for other nodes in that cluster. CH primarily initiates process frequently to sort recent routing information. Clustering solutions [5][6][7] consider different node characteristics and perceive different weight parameters as a priority criterion in selecting cluster heads.

It is of paramount importance that quality attributes for targeted applications for which MANET is deployed must also be satisfied as a set of predetermined QoS requirements. More so, because MANETs are utilized for complex application like military/policing and commercial purpose also.

Clustering nodes characterized into 3 different categories, are as follows:

Cluster-Head (CH): One of the nodes in every cluster is chosen as CH which monitors and controls communication routes for all other nodes with its own domain.

Cluster –Gateway (CG): This type of node exists in more than one cluster and act as a bridge between CH of that clusters. Cluster Head and Cluster Gateway nodes are the backbone of the network.

Normal Node: This type of node sends the information to CH which in turn forwards the gathered information to the next hop.

2.1 Advantage of Clustering

The cluster design ensures well-ordered performance with regard to huge dense ad-hoc networks. The benefit of cluster is as below:

1) It permits the protocol for the better execution at MAC layer by increasing the throughput and versatility.

2) It decreases the scale of routing tables, and enhances the routing.
3) Updating the routing tables due to topological change results in reduction of transmission overheads.
4) It helps to reduce the bandwidth requirement and energy utilization in ad-hoc networks

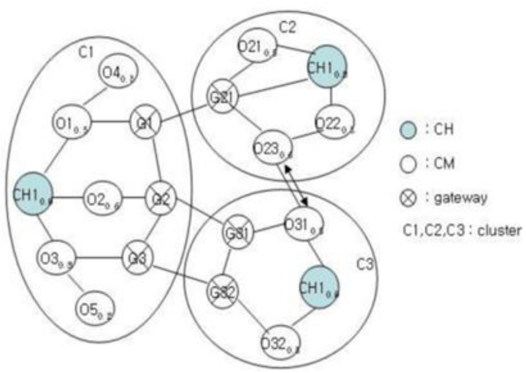

Figure-3 Clustering of Nodes

2.2 Disadvantage of Clustering

1) Clustering related data interchange increases overhead on the network.
2) Reconstruction of Cluster Structure in case of network structure change is resource consuming.
3) Communication Complexity increases due to control message exchange.
4) There is no general solution for clustering.

2.3 Cost of Clustering

The clustering structure requires additional cost for development and maintenance in contrast with normal (Flat) MANET. A quantitative or qualitative analysis of the costs of clustering is performed to recognize the pros and cons of clustering

1) The data related to the cluster vary drastically due to gradual changes in the cluster structure as the topology of the network continues to change. The resulting message packet exchange consumes generous bandwidth and drains the energy that mobile nodes possess.

2) Re-clustering can occur due to sudden local circumstances in some cluster policy, like moving of the node into another cluster or demise of a node, or even closing the heads of clusters that makes the cluster heads to be re-selected. This is known as the re-clustering effect,

3) The plan is split into two phases: formation and maintenance of the clusters. The stage of creation assumes that nodes are static. Each mobile node can acquire exact information from neighboring nodes with frozen time of motion, which may not be applicable in real time.

3 MOBILE AD-HOC NETWORK: CLUSTERING SCHEMES

Classification of various Clustering algorithms is based on the nature of algorithms and criteria for cluster head selection (Figure-4)

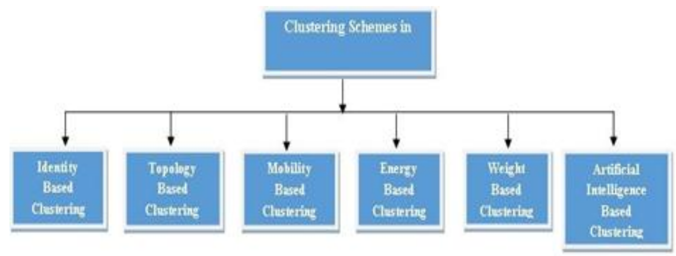

Figure-4 Various Clustering Schemes in MANET

3.1 Identity Based Clustering

In this scheme, every node is assigned a unique ID. In this type of clustering, every node is aware of neighboring node ID's. CH selection is based on condition involving their ID's like Highest ID, Lowest ID etc.

In this paper, a clustering algorithm known as LCA (Linked Cluster Algorithm) [8] is proposed where every node is a CH, either Gateway Node or Normal Node. At initiation stage, all nodes will be normal node. In a preset time interval, every node in the network will broadcast its ID to its neighbor nodes. The node with the lowest Id is elected as the CH.

In this paper, the Least Cluster Change (LCC) [9] algorithm is put forth, wherein algorithm maintenance steps are added to optimize the re-clustering cost. The re-formation of cluster is done only in two conditions: first, when two cluster heads are neighbor nodes, the node with utmost id will be selected as CH. Second, if a member node moves into another cluster then the node leaving the cluster will be a CH. And process to select a new cluster will be initiated.

In the paper [10], an algorithm called "An optimized stable clustering algorithm for mobile ad-hoc network" (OSCA) has been proposed. In this algorithm, an extra mobile node by the name backup node is introduced. Within a cluster a backup node is the ones which has been nominated as second cluster head using LID algorithm. This is done to create stable and more consistent cluster. This means that immediate selection of CH is not needed if an existing CH moves out from its own cluster, as backup node now acts as new cluster head. This algorithm minimizes cluster head changes. Thus cluster becomes relatively more stable and clustering overhead is also reduced.

In "Adaptive Clustering Algorithm" (ACA) [11] researchers have proposed that after formation of clusters, the concept of cluster head should be dissolved and all the nodes in the cluster should play identical roles. The Lowest-Id metric is used for cluster head selection. For cluster maintenance, each node has to be aware of its neighbors up to two-hop. Any time the spatial distance between two or more nodes becomes 3-hops apart, immediately cluster maintenance process is imitated.

Researchers proposed a novel vote-count (VC) based clustering algorithm for MANET [12] which uses node location, id and remaining battery power. Each node counts "Hello" message received from neighbors. The node with receives higher "Hello" messages from its neighbors gets identified as cluster head. In cases where the number of mobile host as cluster head, exceeds the threshold number, more new coming nodes are not discounted. When compared with LID and HD algorithms. Simulation result shows that VC method improves the cluster structure.

Based on heuristics approach researchers have also proposed a "Max-Min Leader Election" algorithm [4] for selecting cluster head in MANET. In this algorithm CH selection is done based on node ID. There are three steps in this algorithm. Each node broadcasts its ID to its neighbors within D-hops in the first step. IDs of responding nodes are preserved. In the second step from the remaining nodes, a node with highest ID is permitted to broadcast. This process continues till all the nodes are exhausted. The third step is involved in selection of CH based on preserved IDs in the two earlier steps. Authors claim that structure created by this algorithm robust but the overhead; however, computational over heads for CH formation is significant since a large amount of information is exchanged in the process.

3.2 Topology Based Clustering

In this scheme network topology based parameter calculation are used to form cluster. CH is selected based on node connectivity parameter.

In a paper [13], the authors have proposed a clustering based new link state routing algorithm called CLSR for MANET. It is claimed that the size of the routing table and routing overhead are deduced. The redundant information on different control packet types is eliminated by this algorithm and traffic control is reduced. Two types of control messages HELLO and CTC are used in CLSR. For clustering process each node send "Hello" message and the responses are used for computation of the 2-hops local routes. The CH initiates CTC message which is broadcast throughout the whole network. This allows nodes to compute inter-cluster routes. The simulation result shows the best performance of this algorithm in terms of routing overhead and the data packet delivery ratio.

A novel algorithm for clustering is proposed in a paper, 3hBAC [14]. This algorithm uses status of new mobile node and cluster guest. The algorithm considers 3-hop distance between adjacent cluster heads to reduce the number of small size cluster formation. Authors claim that the proposed algorithm also reduces frequent cluster head changes thereby improving the CH life time, average node membership time which in turn improves the cluster maintenance efficiency, overall computational efforts for CH management thus resulting in relatively less maintenance requirement and relatively more stable cluster.

In this paper, they had presented an algorithm called "Associativity based cluster formation and management protocol"[15]. This algorithm deals the spatio-temporal stability and the optimal location of the cluster head in a cluster. They had explained the mechanism by which the nodes interacted within the cluster and select a cluster head. They had also presented the different issues that may arise in the management of cluster. Through simulation result this protocol improved the bandwidth usage of the network and the cluster stability.

In this paper, they had proposed an algorithm for cluster head selection called Highest Connectivity Clustering [16]. In this algorithm the node will be selected as CH which has highest number of neighbors (degree of nodes). In cases where two nodes have the same degree of nodes, then the node with the lowest-id is selected as cluster head. Due to node mobility, the re-affiliation of cluster head increases.

3.3 Mobility Based Clustering

In this approach, mobility for cluster formation is taken into account, so that the mobile node with similar moving patterns can be grouped to achieve maximum stability. MOBIC, Mob-Dhop, etc. are some of them.

In their paper W.Su et al [17] have incorporated the mobility prediction for anticipating changes in network topology for rerouting prior to route breaks. In some of the popular algorithms such as on demand unicast routing protocol, multicast routing protocol and distance vector routing protocol, authors have used their mobility prediction mechanism. Their enhancement delivers more numbers of packets at the destination node.

In this paper they proposed, a new mobility metric for nodes in a Mobile Ad-hoc Networks. It is easy to calculate and does not require any knowledge of fixed locations. They proposed mobility based clustering algorithm called MOBIC [18]. Based on simulation results, they deduced that relative mobility is better parameter for clustering the nodes rather than plain IDs which are not representative of node mobility in MANETs.

D-hop clustering algorithm (MobDHop) proposed in [19] is based on mobility. Depending on the mobility pattern, the proposed algorithm forms a variable-diameter cluster in MANETs. Authors have also introduced a new parameter to compute the deviation of distance between two nodes over time in order to calculate the relative mobility of cluster nodes. The diameter of the cluster is flexible based on the cluster stability. MobDHop is able to provide a basic hierarchical routing structure and it is also able to address the scalability issues of routing protocol.

Mobility aware clustering scheme is proposed in [20]. For consistently estimating the future mobility authors have used good information theoretic, techniques on mobile hosts. The correct mobility prediction is applied to form clusters which are significantly robust to topological changes in MANET due to high mobility of the nodes. To compute the mobility of node, it is suggested not to use GPS device. The mobility of each node is computed indirectly by computing the changes in the neighborhood of the mobile host over time. Future host mobility is accurate estimated, by keeping a watch on the movements of mobile hosts. The proposed distributed algorithm combines mobility prediction technique with the highest IDs, clustering technique and builds a robust virtual backbone for MANET.

In the paper [21], for network with high mobility nodes, authors have proposed Mobility prediction-based clustering algorithm (MPBC). The proposed algorithm has two phases initial clustering phase and cluster maintenance phase. The algorithm depends on the estimates about mobility information. Thereafter its working becomes independent of external device (e.g. GPS). Simulation results show effective performance in terms of network lifetime, reduced re-affiliation rate and re-association time.

In the MAR algorithm [22], remaining battery power and mobility are used as parameter for selecting cluster heads. The mobility values of the intermediate node are transmitted via the RREQ packet during the setup of route between source and destination node. After the receiving of a RREQ packet at the destination node, there is a minimum mobility value for a particular path. The path found by this algorithm remains mostly steady. In MAR the energy drain is somewhat higher in the beginning because of the high utilization for selecting the cluster heads.

In this paper, the authors proposed a new modified ad-hoc routing algorithm based on Link-Prediction technique [23].Due to frequent topology changes as a result of nodes mobility in the ad-hoc network, the link path get dissociated frequently. Using Link Prediction technique, this algorithm does a local repair of link failure and also identifies malicious node with the association of a reliability measure while performing route discovery. This algorithm has mainly targeted to improve the network performance and energy consumption model on the network.

3.4 Energy Based Clustering

Node battery energy has a direct effect on the network lifetime. The energy limitation puts up a severe network performance challenge. Specific tasks like routing and excess energy consumption are carried out in Cluster Head.

J.J.Y.Liu et al [24] in there paper had proposed a "Multicast Power Greedy Clustering Algorithm" (MPGC). In the proposed algorithm cluster hierarchy is introduced in ad-hoc network with large number of nodes. Such hierarchy is achieved by partitioned known as greedy heuristic clustering. In this cluster nodes are adoptively used so as to make them power efficient. By acting as agents to transmit and receive communications the cluster heads can lower the consumption of bandwidth and also effectively reduce the complexity of mesh structures. Reduction in battery power usage and improvement in cluster lifetime is achieved by implementing proper mechanism for cluster maintenance. In this regard a multicasting Power aware protocol based on ODMRP acts favorably on the super-nodes topology formed by cluster heads. In simulation studies of this algorithm better performance with regard to cluster lifetime and network scalability is achieved.

In this paper, researchers had proposed an algorithm called "Flexible weighted Clustering Algorithm based on Battery Power" (FWCABP) [25]. This algorithm is functional only when demand is present due to node movement resulting in changes the relative distance between cluster-head and a node. Weights are assigned to a node based on values of some. Maintenance and selection of CH are done based on the information about neighboring nodes. Role of ordinary node and CH is switched to check battery power consumption. Simulation studies of algorithm shows improvement in degree of stability in the network, optimizing clusters and reduction in computational overhead in formation of clusters.

Transmission Range based algorithm by the name Enhanced Sectorized Clustering Scheme is proposed in [26]. This algorithm focuses on suitable node selection for cluster and cluster head formation. This algorithm uses calculations based on residual energy along with transmission range of the CH. Simulation studies indicate that network robustness is increased and frequency of cluster formation are reduced to some extent.

Some authors have proposed algorithms to select CH and along with it the Super CH [27]. Their algorithm uses Communication range, Hop Count, Battery Energy Power, Relative Velocity and Fairness for CH selection. The node is an efficient node that passes all five criterions. Such node is selected as CH. Once CH is selected, super CH is selected by excluding selected CH and using remaining nodes through same election process. The important condition for Super CH selection is that battery should possess maximum power and it should not be a CH. Because of low battery power consumption this algorithm enhances the network life.In this paper, the author proposed a new algorithm called "Enhance Cluster Based Energy Conservation" (ECEC) [28]. In this algorithm Cluster based Energy Conservation is modified. A new protocol for topology control is proposed which enhances the MANET lifetime. During clustering a node having highest estimated battery power is chosen as CH for the neighborhood. Once CHs are selected ECEC starts the process for selection of gateways to connect other clusters. ECEC focuses on power consumption resulting in longer network lifetime.

3.5 Weight Based Clustering

Combination of different parameters are effectively implemented in Weight based clustering techniques, such as degree of node, power of battery, distance difference, node mobility etc. The weighing factors of each metric will be acclimatized according to scenario.

Extensive research has been conducted in MANET on Weight based clustering algorithms. Few algorithms based on the weighted clustering algorithm are stated as under:

The researchers in this paper they had proposed a "Flexible Weight Based Clustering Algorithm" (FWCA) [29]. This algorithm was developed to minimize the number of clusters in the network. The additional focus is to make clusters stable and to maximize node lifetime. It provides flexibility he to assign different weights and brings on record a combined metric to form cluster automatically. They have further, restricted the number of nodes in the cluster and the algorithm is functional only when there is a requirement for the same.

Enhancement on weighted clustering algorithm (EWCA) is proposed in [30]. Authors claim that the proposed algorithm brings a high degree of stability in MANET ultimately resulting in improved load balancing. The key to this is the assumption of a predefined threshold value for the number of nodes to be associated to a CH. These results in low control overhead bringing down the MAC activities thus improving the load balancing.

A framework has been proposed in [31] to organize the mobile nodes into clusters, where it is essential to provide strength during topological changes occurring due to node movement, and in the event of insertion or removal. The authors had mathematically deduced two models which were thereafter combined to get benefit. They modified several node degree based formula reported in the literature related to Quality of Clustering as parameter for stability and load balancing in clustering.

A robust weighted clustering algorithm called PMW (Power, Mobility and Workload) is proposed in [32]. In this, every node weight is calculated using three parameters such as battery power, mobility and workload. Thus, in PMW, there is sparse re-clustering overhead during maintenance of cluster. The lifetime of a cluster was prolonged by PMW.

Authors have extended the WCA algorithm for cluster stability [33]. This parameter is used to quantify the cluster stability. This factor in turn depends on various other parameters such as distance between the farthest node, battery power of cluster head, velocity, and number of nodes. For efficient routing, fuzzy logic is used commonly. If there is more than one route between source and destination, it is implemented to select the optimal route by taking into consideration the energy & velocity on nodes in the path.

A new clustering algorithm for Mobile Ad-hoc Network based on node weight [34] was dealt by them in their research they referred to four parameters for calculating node weight such as: relative speed, stability, number of nodes moving towards a node and remaining battery. The purpose of this algorithm is to decrease the number of cluster formation, enhance cluster stability and stretch the lifespan of mobile nodes.

An "Efficient Weight Based Clustering Algorithm" (EWBCA) [35] has been proposed for MANETs the motive of this algorithm is to conserve the existing cluster as far as possible, minimizing routing overhead, enhancing the end-to-end throughput and optimizing the resource usage such as bandwidth, energy. Each node has characteristics to indicate its suitability as cluster head. This quality is measured using the following features: Remaining Power of Battery, Number of Neighbors, and Variance of distance with all neighbors and Stability.

In this paper, the authors have proposed an "On-demand Weighted Clustering Algorithm" (ODWCA)[36], that can adapt itself dynamically during a change in the topology of ad-hoc network. The WCA assigns different weights and takes into consideration the effect of the degree, transmission power, and mobility and the nodes battery power. The stated algorithm is executed only when need arises.

Weight Based Distributed Clustering algorithm [37] was proposed by the researchers. This algorithm can adapt itself due to change in topology of MANET. The proposed algorithm limits the number of nodes to be handled by a cluster head, so that the MAC is not overloaded. In this algorithm, the load is distributed to quite some extent. A pattern in the changes of LBF in the load distribution is observed. A gradual increase is observed in the LBF due to node mobility in the clusters.

In this paper, authors have presented another new algorithm "Forecast Weighted Clustering Algorithm" (FWCA) [38] to elect the cluster head. In cluster based routing algorithm, a CH controls routing process and also maintains the information of cluster links and cluster membership. Based on this information it is possible to explore dynamically the inter cluster routes. So FWCA facilitates selection of most eligible node as CH and in the process reducing calculation overheads.

In "Flexible Weight Based Clustering" [39] proposed by researchers the algorithm for MANETs. Authors have proposed 2-hop clustering, which is quite stable and flexible against topology changes. For this clustering algorithm various attributes and different coefficients are taken for the weight function, which is suited for various applications in different network topologies.

Trust based cluster routing algorithm (TEBACA) [40], determines the trust value of each node within a cluster. If the trust value of a node is above pre-specified threshold value, then the node will be considered as malicious. Other nodes are included in the trust node list. The algorithm ensures that the nodes in the trust node list only are entitled for CH selection.

In this paper the authors have proposed a trust value updating algorithm, to check the trust value in a given time interval and update the friend list since the dynamic network continuously changes.

A new weight based algorithm called VLWBC is described in [41]. In this paper authors have proposed the virtual links weight for each node which is computed based on links' weight to deduce the final weight of node. This calculation also includes features of neighbor nodes. Four parameters energy, stability, neighborhood and the links' length determine weight value. Value of links and load balancing factor are important for calculation. Proposed algorithm is shown to improve the networks stability, and the lifetime of the clusters at the same time decreasing the consumed energy.

Density based clustering algorithm is proposed in [42] to improve the stability and efficiency in mobile networks. In this algorithm the following parameters are considered such as degree, transmission range, and distance and battery power. Election is involved on-demand basis, to reduce the overheads and packet delivery delay cost of mobile nodes chooses on the basis of its neighbors density, so they apply density based clustering algorithm at mobile ad-hoc network and selected cluster head node in cluster.

M. Ashwin et al in their paper [43], have proposed a cluster based model which dynamically and efficiently maintains the trust relationship in MANETs. In this paper, authors have also investigated the impact of maliciousness and cluster head selection algorithm. Simulation results show that without malicious nodes the proposed algorithm improves the packet delivery ratio and reduces end to end delays as well as cluster number.

"Score Based Clustering Algorithm" (SBCA) has been proposed in [44]. The proposed algorithm minimizes the number of clusters and maximizes the lifespan of nodes. The algorithm uses parameters - remaining battery energy, node degree, and node stability to calculate the node score:. While forming cluster individual node calculates its own score and transmits the same to neighboring nodes. The node with the highest score is made CH.

3.6 Artificial Intelligence Based Clustering

The proposed work is valid for every mobile node in the network. On the mobile node, Fuzzy model [45] along with weight correction model is implemented to select the best cluster head for the MANET. Weight correction model is dependent on supervised learning; Overall network combining the fuzzy model and supervised learning indicates matching behavior with the feed forward supervised learning based model.

In the proposed algorithm [46], each node produces its score using parameters based on fuzzy score calculation like: Remaining battery, Number of neighbor nodes, Number of nodes, Stability. Each node selects a neighbor node independently with the uppermost score as its cluster head. This algorithm gives a better end-to-end performance, longer service life and less clusters.

4 CONCLUSION

In this literature review, we have covered the basic concepts about clustering, its definition, cost, objectives & goals of clustering schemes along with pros & cons of clustering. After that we have tried to classify the clustering schemes into six categories based on their features and objectives as: Identity based clustering, Topology based clustering, Mobility based clustering, Energy based clustering Weight based clustering and Artificial Intelligence based clustering. For evaluation of these schemes various parameters are considered. Based on the review study, a summary of the evaluation is tabulated (Table-1). The review results show that weight based clustering schemes performs better among all the schemes. In cluster head selection, the most commonly implemented technique is weight based clustering schemes. It utilizes combined weight metrics such as battery power, mobility, node degree, transmission range, etc. It improves clustering by achieving the targets of increasing the lifespan of nodes in the network, reducing the number of clusters, decreasing the number of re-affiliation, improving the cluster stability and ensuring a good resource management.

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S.No	Algorithm	Clustering Schemes	Cluster Head Selection	No-of Hops	Overlapping of Clusters	Cluster Number	Cluster Head Change	Cluster Stability
1	LCA	ID-Neighbor	Lowest ID	1	Possible	High	Very High	Very Low
2	LCC	ID-Neighbor	Lowest ID	1	Possible	High	High	Low
3	ACA	ID-Neighbor	Lowest ID	1	No	High	Moderate	Low
4	Max-Min D-Cluster	ID-Neighbor	Node ID	K	No	High	Moderate	Low
5	OSCA	ID-Neighbor	Lowest ID	1	No	Moderate	Morderate	High
6	Vote-Based Clustering	ID-Neigbor	Lowest ID	1	No	Moderate	Moderate	High
5	HCC	Topology	Highest Degree	1	No	High	Very High	Very Low
7	3hBAC	Topology	Highest Degree	1	No	Moderate	Relatively High	Low
8	Associativity based Cluster	Topology	Associativity and node Degree	K	Yes	Moderate	Relatively Low	High
9	CLSR	Topology		2	Yes	Moderate	Low	Relatively High
9	MOBIC	Mobility	Lowest Mobility	1	Possible	Relatively High	Low	Relatively High
10	Stability Based mobility prediction	Mobility	Node Stability	1	Yes	Relatively Low	Low	Relatively High
11	MPBC	Mobility	Lowest Mobility	1	Yes	Relatively Low	Low	High
12	MobDHop	Mobility	Lowest Mobility	K	No	Low	Low	Very High
13	MAR	Mobility	Lowest Mobility	1	No	Low	Relatively Low	High
14	Based on Link-Prediction technique.	Mobility	Mobility and Link Prediction	1	No	Low	Low	High
15	Distributed algorithm.	Mobility	Lowest Mobility	1	No	Low	Low	High
16	MPGC	Energy	Highest Energy	1	Yes	Moderate	Relatively Low	High
17	FWCABP	Energy	Lowest Weight	1	Possible	Low	Low	High
18	ECEC	Energy	Highest Energy	1	Yes	Moderate	Low	Relatively High
19	ESCS	Energy	Highest Energy	1	No	Moderate	Low	High
20	Clustering based on Super Cluster Head	Energy	Energy &	1	No	Low	Low	High
21	FWCA	Weight	A combined Weight Metric	1	Possible	Low	Low	High
22	SBCA	Weight	A combined Weight Metric	1	No	Low	Low	High
23	EWBCA	Weight	A combined Weight Metric	1	No	Low	Low	Very High
24	EWCA	Weight	A combined Weight Metric	1	No	Low	Low	High
25	NQCA	Weight	A combined Weight Metric	1	No	Low	Low	Very High
26	PMW	Weight	A combined Weight Metric	1	No	Low	Relatively Low	Relatively High
27	ODWCA	Weight	A combined Weight Metric	1	No	Moderate	Relatively Low	Relatively High
28	Forecast Weighted Clustering Algorithm	Weight	A combined Weight Metric	1	No	Low	Low	Relatively High
29	TEBACA	Weight	A Combined Weight Metric	1	No	Low	Relatively Low	Relatively High
30	Density Based Clustering Algorithm	Weight	A Combined Weight Metric	1	No	Low	Low	High
31	Weighted Clustering Trust Model	Weight	A Combined Weight Metric	1	No	Low	Low	High
32	VLWBC	Weight	A Combined Weight Metric	1	No	Low	Low	Very High
33	Dynamic Weight Adjustment Using Fuzzy Logic	AI	Fuzzy Score	1	No	Low	Relatively Low	Relatively High
34	Distributed Fuzzy Score-based Clustering	AI	Fuzzy Score	1	No	Low	Low	High

Table-1 Evaluation of Clustering Schemes