Review of Mobility Aware Clustering Scheme in Mobile Adhoc Network

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ABSTRACT
In Mobile Adhoc Network (MANET), hierarchical network architecture is created for improving the performance parameters like scalability and stability. Clustering is one of the typical hierarchical network structures which groups the geographically adjacent nodes into same cluster. By creating such kind of basic clustering structure, scalability can be improved, but high mobile nodes in the network may change the topology dynamically, which may affect the clustered network structure and decreases the stability of the network. For creating more stable and scalable network, clustering must accounts mobile node's mobility behavior for clusterhead selection, cluster formation and cluster maintenance. In mobility aware clustering scheme, the mobile node's mobility behaviors (distance, speed, acceleration, and relative velocity) are estimated first at regular intervals of time. By using this estimated mobility behavior geographically adjacent mobile nodes are grouped into a cluster, and node having the low mobility or low relative velocity is selected as a clusterhead. This mobility aware clustering structure improves the network stability by reducing the least clusterhead change, number of re-affiliation, and association loss. Most of the recent research papers in MANET are focused on mobility concerned clustering algorithm, and hence this paper focuses only on mobility aware clustering instead of various clustering scheme available. This paper comprises of comprehensive survey of mobility aware clustering algorithms for MANET.

General Terms
Algorithms, mobility

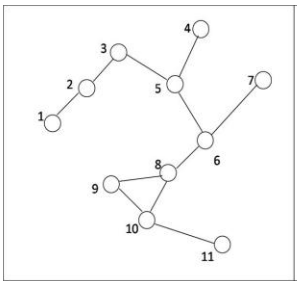
Keywords
MANET, clustering, mobility prediction, scalability.

1. INTRODUCTION
Mobile adhoc network (MANET) is a self organizing and self-configuring infrastructureless network of mobile nodes connected by wireless media links. Every node can act as a mobile router and able to reconfigure themselves. Without using any infrastructure source node can forward packets to destination through multi-hop relaying. In flat network structure, all the nodes in the network are considered equal; hence for finding a path to any other node in the network each node has to create and maintain a routing table. It involves excess of control packet broadcasting and it floods the network by sending the excess of control packets for the routing process. Changes in a single node may affect the entire network topology. The problem of flooding and impact of single node changes on the entire network topology can be reduced significantly by creating a clustering like hierarchical structure. In a clustered adhoc network, cluster members (CMs) locally communicate with their associated clusterheads (CHs), and the CHs are responsible for routing and data forwarding, Control packets are forwarded only between the CHs. It also improves the scalability of the network. High mobile nodes in the clustered network structure may changes the topology of the network frequently and dynamically.

As the topology changes, high mobility nodes in the cluster may disband with current CHs and associate with new a cluster. This instant is called as re-association. If CHs itself is high mobility node then, cluster must be re-organized and clusterhead should be selected for this re-organized cluster. This clusterhead change is referred as CH-rotation. The problem of CH-rotation and re-association become serious if nodes are highly mobile. For creating more stable network, clustering must concern mobility of the nodes for creating and maintaining the clustering structure. In mobility concerned clustering algorithm mobility information are used for creating the more stable network. Mobility information can be estimated from the knowledge of GPS location of the mobile nodes or from the knowledge signal strength of HELLO packets broadcasted by each node at regular interval of time. This paper addresses the following: Definition of Cluster, mobility model, mobility prediction and classification of mobility concerned clustering algorithm based on the objective.

1.1 Clustering
In mobile adhoc network, clustering means a national grouping of mobile nodes into different virtual groups; it can also be defined as the division of whole network into number of virtual groups. During clustering, geographically adjacent nodes are grouped into virtual groups based on their node's behavior or node's resources with some specified rules. In a cluster, nodes may take any one of status as clusterhead(CH), clustermember(CM), clustergateway(CG) or may be on orphan node.

Based on clustering algorithm, particular node in the cluster is selected as a custerhead, which act as a local coordinator for that cluster with certain responsibility such as intra-cluster transmission, data forwarding. Clustering algorithm may consider one or more factors for clusterhead selection. Some of the factors considered during cluster formation are energy, mobility behavior, degree, distance and spreading degree of the nodes. A typical flat network structure is shown in fig 1.(a) and clustering network structure of mobile nodes is shown in fig 1.(b). Flat network structure does not provide scalable architecture, in which single node joins or leaves network may affect the entire network topology and it may floods the network by sending excess of control packets for routing purposes.



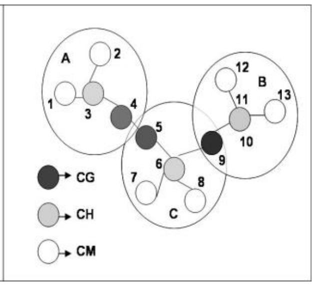


Fig 1.(a):Flat Network **Fig 1.(b): Clustered Network**

In clustered network structure, changes occur only in local topology of the network if any node joins or leaves the network; hence it provides scalable network architecture. It avoids flooding by forwarding the pockets only between the CHs for routing purposes.

1.2 Mobility aware clustering

Mobility of the nodes is the predominant character in MANET. High mobile nodes in the network may change the network topology frequently and it makes the network unstable. Though scalability can be achieved through clustering, stability may be a issue if the mobility of the nodes are not considered while clustering. Mobility aware clustering scheme consider this mobility behavior of the node while clustering and hence it make the network more stable.

2. MOBILITY AWARE CLUSTERING SCHEMES

Clustering algorithm can be classified into six categories [1]. As mobility is the predominant character in MANET, this review concentrates only on mobility aware clustering algorithm. In this section, various mobility-aware clustering algorithms are studied based on mobility prediction approach and clustering model.

2.1 Mobility Based Metric for Clustering (MOBIC)

[2] proposed a weight based new clustering algorithm, which uses mobility metrics for nodes in MANET for selection of clusterhead and formation of clusters of two-hop in diameter. MOBIC is a distributed, lowest mobility clustering algorithm, uses Aggregate Relative Mobility (ARM) for the cluster formation.

2.1.1 Cluster Formation stage

MOBIC follows the following steps for cluster formation.

1. Every node in the network periodically broadcasts a "Hello" message to its neighboring nodes. Upon receiving the two successive "Hello" message from the same neighboring node, each node can calculates its relative mobility metric by using the formula

$$M_Y^{rel} = 10 \log_{10} \frac{Rx\,\mathrm{Pr}_{X->Y}^{new}}{Rx\,\mathrm{Pr}_{X->Y}^{old}} \quad (2.1)$$

   Then each node calculates its aggregate relative mobility value M_Y with its entire neighboring node from the following formula

$$M_Y = \mathrm{var}(M_Y^{rel}(X_1), M_Y^{rel}(X_2), ...M_Y^{rel}(X_m)) \quad (2.2)$$

2. Every nodes broadcasts its ARM value M to its 1-hop neighboring nodes at every Broadcast Interval (BI). From the broadcasting message, each node having the aware about its neighboring nodes..
3. Each node compares its own ARM value with its neighboring node's ARM values. A node has the largest value of M assumes its status itself as Clusterhead, and other nodes are declared as cluster member.
4. If mobility of two clusterhead nodes is same, then clusterhead is selected based on Lowest-ID algorithm

2.1.2 Cluster Maintenance Stage

Mobility metrics are no longer used for cluster maintenance stage. In cluster maintenance stage, if two clusterhead nodes are move into each other node's range, then it waits for CCI interval. After CCI timer has expired, re-clustering of nodes is performed if nodes within the same transmission range. It reduces the accidental re-clustering of nodes for incidental contacts of two moving CHs.

2.2 Modified Weighted Clustering Algorithm with mobility prediction (MWCA)

[3] proposed a clustering algorithm, which involves two clustering stages. In initial clustering stage it uses WCA algorithm [4] for cluster formation. In cluster maintaining stage it uses mobility prediction approach for node management. Mobility prediction involves estimation future position of the nodes. By linear auto-regression [3], future position of the node can be estimated from the past locations it visited, the main objective of MWCA is to reduce the amount of energy, and bandwidth wasted for update the positional information by efficient mobility prediction approach. It assumes that each node must have only one clusterhead. Optimal number nodes in a cluster is 8, co-efficients used for the weight calculation must take the following values
1. $W_1 = 0.7$, $W_2= 0.2$, $W_3 = 0.05$, $W_4 = 0.05$ and
2. $W_1+W_2+W_3+W_4 = 1$.

2.2.1 Cluster Formation

MWCA uses WCA algorithm for cluster formation. Four common factors used for cluster formation are i) *Spread degree* ii) *sum of node's distance from all of its neighbors* iii) *mobility* iv) *Battery Power*

Spread Degree: It is the measure of variation of optimal cluster size 'α' with real value R(V)

$$\Delta sp = 1 - (| \alpha - R(V) | / \alpha). \quad (2.3)$$

Sum of node's distance from all of its neighbors (D_V): It is the measure of sum of its distance with all of its neighbors. It is represented as

$$D_V = \sum dist(v, v') . \quad (2.4)$$

Mobility (M_V): It is the measure of average speed of a mobile node. It can be estimated from the positional information of the node at different time instance.

Battery Power (P_V) : It is the measure of consumed battery power of the node.

Weight of the each node can be calculated from the formula

$$W_V = W1\times\Delta sp + W2\times D_V + W3\times M_V + W4\times P_V \quad (2.5)$$

Node having lowest W_V is selected as a clusterhead(CH), and neighbors of CHs is selected as a cluster member for that corresponding cluster.

2.2.2 Cluster Maintenance

Cluster maintenance in MWC is initiated by two distinct operations such as i) *Node movement* and ii) *Battery Power threshold*

Node Movement:

Any node joining or leaving a cluster will initiate the cluster maintenance stage. In cluster maintenance stage, MWCA uses the linear auto-regression method for finding the future position of the node. By auto-regression each node can predict the future values from the knowledge of previous values. It represented as

$X_{\tau} = X_{\tau-1} +(\sum ((X_{\tau-i}) - (X_{\tau-j})) / N).$ (2.6)

By using this future location prediction, MWCA avoids the beacon message transmission between the nodes for updating the positional information. It conserves the energy and bandwidth usage of the nodes.

Battery Power Threshold:

If CH battery power is less than some threshold, then CH no longer can exist if power becomes null. For maintain a stable cluster new CH is selected if batter power of current CH below threshold value.

2.3 Mobility based d-Hop Clustering Algorithm (MobDHop)

[5] proposed a clustering scheme, which forms a clusters of two-hop distance at initial discovery stage and forms a clusters of variable-diameter in the cluster merging stage based on the mobility pattern of the nodes. The main goals of creating variable-diameter (d-hop) cluster are to reduce the number of cluster in the network, to reduce the cluster formation and cluster maintenance overhead and to make the network more stable. MobDHop assumes that each node in the network can measure its received signal strength and two nodes are connected by bi-directional link. MobDHop involves three stages for creating the more stable network such as *initial discovery stage*, *merging stage* and *maintain stage*

2.3.1 Discovery Stage

MobDHop needs following five parameters for forming a two-hop cluster at discovery stage such as distance between two nodes, relative mobility, variation of estimated distance over time, local stability and Estimated mean of distance(EMD).

Distance between two node: Based on the received signal strength, each node can estimate the distance from its neighbor. Distance between two nodes (A & B) can be estimate the from the formula

$$E[D_{AB}] = \frac{k}{\sqrt{P_r}} \quad (2.7)$$

Relative Mobility: Relative mobility between two nodes can be measured from the differences in distance between two nodes at unit time interval. Relative mobility of Node A with respect to node B is estimated from the formula.

$$M_{AB} = E_t[D_{AB}] - E_{t-1}[D_{AB}] \quad (2.8)$$

***Variation of estimated distance between two nodes*:** Variation of estimated distance over time is used for find the local stability of the node. It is the measure of changes in estimated distance two nodes over a predefined time period. It is calculated from the formula

$$VD_{AB} = \sigma(\left|E[D_{AB}]_1 - E[D_{AB}]_0\right|, \left|E[D_{AB}]_2 - E[D_{AB}]_0\right|, ..., \left|E[D_{AB}]_n - E[D_{AB}]_0\right|) \quad (2.9)$$

Local Stability: Local stability of node A represents the degree of stability at node A w.r.t all of its neighbors. Local stability can be estimated from the formula

$$St_A = \sigma(VD_{AB_1}, VD_{AB_2}, .., VD_{AB_3}) \quad (2.10)$$

Estimated Mean of Distances (EMD): It indicates the diameter of a cluster (hop distance from Clusterhead) determined by its clusterhead. It is calculated from the formula.

$$EMD_{C1} = \mu(E[D_{CH1N1}], E[D_{CH1N2}], .., E[D_{CH1Nn}])$$

(2.11)

2.3.2 Merging Stage:

Discovery stage partitions the network into two-hop clusters. Variable-diameter clusters are formed in the merging stage. Merging process may initiate by a non clustered node or by two neighboring gateways. Merging of two neighboring gateway nodes must satisfy the following conditions

(1). $VD_{G1G2} \le \min\{St_{C1}, St_{C2}\}$ and

(2.12)

(2). $\mu(E[D_{G1G2}]) \le \max\{EMD_{C1}, EMD_{C2}\}$

(2.13)

2.3.3 Maintaining Stage

Any node which joins or leaves the network can change the network topology, and it invokes the cluster maintenance stage. When a node is switches ON and joins into a network, it will initiate merging stage and calculate all the factors for merging. If any node leaves the network (switches OFF) is a clusterhead then the immediate neighbors of the clusterhead will initiate the discovery stage to find the new clusterhead.

2.4 Distributed Group mobility Adaptive Clustering Algorithm (DGMA)

[6] proposed a group mobility model based clustering scheme, which uses linear distance based spatial dependency(LDSD) as a mobility metric. Instead of instantaneous speed and direction, LDSD uses linear distance for estimate the node's movement. The main objective of DGMA algorithm is to form stable clusters by increase the cluster life time and no of re-clustering. This algorithm uses the following approaches for clustering.

1.Linear distance based spatial dependency

2.Distributive Group Mobility Adaptive Clustering Algorithm

2.4.1 Linear distance based spatial dependency

In LDSD, node's movement can be estimated from linear distance D. linear distance of a node can be estimated from the formula

$$D = \sqrt{\Delta X_{Ti}^{\ 2} - \Delta Y_{Ti}^{\ 2}} \quad \&$$

(2.14)

$\Delta X_{Ti} = X_{ti} + X_{Ti}$, $\Delta Y_{Ti} = Y_{ti} + Y_{Ti}$

Where x_{ti} , y_{ti}, x_{Ti} , y_{Ti} are co-ordinates position of the node i at time t & T.

Speed and direction of the node can be estimated from the formula

$\hat{S} = D / (t-T_i)$

$$\theta_i = \begin{cases} \varphi.\mathrm{sgn}(\Delta y_{Ti}), \Delta x_{Ti} > 0 \\ \pi / 2.\mathrm{sgn}(\Delta y_{Ti}), \Delta x_{Ti} = 0 \\ (\pi - \varphi).\mathrm{sgn}(\Delta y_{Ti}), \Delta x_{Ti} < 0 \end{cases}$$

(2.15)

From the following steps each node can find their LDSD value from the above factors.

1. Each node broadcasts, its recent speed and direction from its history information to its directly connected neighbor.
2. Based on received speed and direction of the neighbors, each node can calculates its relative speed and direction from the formula.

$$RD(i,j,t) = \cos(\tilde{\theta}_i(t) - \tilde{\theta}_j(t) \quad (2.16)$$

$$SR(i,j,t) = \frac{Min(\tilde{S}_i(t), \tilde{S}_j(t))}{Max(\tilde{S}_i(t), \tilde{S}_j(t))} \quad (2.17)$$

3. From the estimated relative speed and relative direction node can finds its LDSD value from the following formula.

$$LDSD(i,j,t) = RD(i,j,t) * SR(i,j,t) \quad (2.18)$$

4. From sum of all LDSD value of a node LDTSD can be calculated from the formula

$$LDTSD(i,t) = \sum_{j=1}^{n} LDSD(i,j,t) \quad (2.19)$$

Higher the LDTSD value of a node implies that node i has more number of neighbor set and follows similar mobility pattern with its neighbors.

2.4.2 Distributed Group Mobility Adaptive Clustering Algorithm

DGMA needs the following parameters for clustering
T: Duration over which two nodes are connected directly.
n_1: Ratio of 1-hop white neighbors to the no of all the 1-hop neighbors for whitenodes
n_2: Ratio of 1-hop white neighbors to the number of all the 1-hop neighbors for Red nodes
n_{1_input}, n_{2_input} : Input threshold value for n_1 , n_2.
DGMA can be implemented by applying coloring to the nodes in the network, where initial node, clusterheads, and cluster members are represented by white, red and yellow color respectively. DGMA involves two main processes as *nomination process* and cluster *maintenance process*.

Nomination process: Nomination process involve following steps for cluster formation
Initially all the nodes are white in color. All the white nodes, which are not connected to any neighboring red node broadcasts a request to its directly connected neighbors and initiate the nomination process. In response to request, each white node sends the LDTSD value to the applicant, then node compares it own value of LDTSD value with its neighboring node's LDTSD value. Node having the highest LDTSD value is selected as clusterhead and turns into red color. After receiving the invitation message from red color node, neighboring white nodes turns into yellow color.

Cluster Maintenance: Node's Color only decides the cluster maintenance responsibility of that node.
Red node:
Red node updates its neighboring information table regularly.
If two red nodes are connected directly over the time interval T, the red with largest LDTSD value maintains its color and other red changes its color to yellow.
If $n_1 > n_{1\_input}$ then it turns into white color.
Yellow nodes:
A yellow node with largest LDTSD value is turned into red color.
If yellow node doesn't find any red node as neighboring node then it turns into white color.
White nodes:
White node with neighboring red node having largest LDTSD value can turns into yellow color.
If $n_2 > n_{2\_input}$ then nodes will initiate a new cluster nomination process.

2.5 Clustering through neighborhood stability-based mobility prediction (MobHiD)

[7] proposed a novel mobility aware clustering model, which combines the highest degree technique with mobility prediction of mobile host (MH) by information theory based technique. Mobility prediction in MobHiD involves accurate prediction of future mobility of MH based on neighborhood's stability. The main objective of this algorithm is to provide longer life time of the clustering structure. Hence this clustering structure involves two ingredients such as mobility prediction approach and mobility-aware highest degree (MobHiD) technique.

2.5.1 Mobility prediction approach

A MH with same set of neighbors over a long duration will create a more stable clustering structure. Using this idea, MobHiD predict the mobility of a MH as stability of neighborhood. Probability of MH i having same neighboring MHs over the time t is presented by

$$P(ngh_{i,t}) = p(h_0)p(h_1)p(h_2)\ldots p(h_{nh-1}) \quad (2.20)$$

Where $p(h_i)$ represents the probability of neighboring MH h_i constantly present over the time t of MH i. Estimation of $P(ngh_{i,t})$ needs prediction of movement of MHs after any given movement. This involves complex computation.

One of data compression method, context-modeling technique is used for estimation of $P(ngh_{i,t})$. By creating digital trie, MH can identify the neighboring MHs using context-modeling technique. Digital trie of a MH contains information about its neighboring MH and a counter for measuring number of time the particular MH has been met during the periodic time. LZ78 algorithm[8] is used for updating the digital trie dictionary. From the compression based method, each MH can predict the number of neighbors at any time and its neighboring probability $P(ngh_{i,t})$.

2.5.2 Mobility-aware highest degree (MobHiD) technique

Inside the cluster, routing is straightforward, if nodes in the cluster are connected one hop with its clusterhead. One such clustering scheme is Highest Degree(HD) clustering algorithm[9] which creates one-hop clusters of a small size-size virtual backbone, and MH having a highest degree compared to its neighbor as selected as clusterhead. It also avoids the frequent routing update by one-hop clustering. MobHiD combines HD with data compression based mobility prediction approach [7], where each node in the network can estimate its weight from the formula

$$w_i = a_1.P(neigh_i).d_i + a_2.avgd_i \quad (2.21)$$

Where di is the degree of MH i. Avg a_i is the average degree of figure neighborhoods of MH i.a_1 and a_2 are the weight co-efficient

A larger value of W_i indicates MH having many neighbors for a longer time with high probability. MH with largest W_i is selected as a CH, which create a small-size virtual backbone and stable clustering.

2.6 Stable Clustering Through Mobility Prediction--(p,t,d)

[10] proposed a framework for organizing the nodes in large-scale mobile ad-hoc network dynamically. The main objective of (p,t,d) model is to produce scalable multi-hop network structure by introducing the concept of virtual clustering in MANET. By using this virtual cluster approach (p,t,d)- model can estimate the mobility pattern of the nodes in the network.This model involves three main ingredients such as i) Virtual Clusters ii) Mobility Prediction iii) Clustering algorithm

2.6.1 Virtual Clusters:

(p,t,d)- model introduces the idea of virtual clusters for making the clustering mechanism more scalable. In virtual clustering, geo-graphical area is divided into circular shape of equal regions in a systematic way. Each virtual cluster having center called as Virtual Cluster Center(VCC). If any mobile having its location information, then it can identify the virtual cluster it resides. Each node in the network maintains its node ID as well as virtual cluster ID it resides for mobility estimation.

2.6.2 Mobility Prediction Model

In (p,t,d)-model, movement history of Mobile Node(MN) is represented by set of symbols as follows $V = \{v_1,v_2,v_3,v_4, \ldots\}$ Where V is the movement history and v_1,v_2,v_3,v_4, are virtual clusters visited by that MN. This movement history can be estimated from time-based and movement based tracking schemes. Each node can create a mobility trie dictionary by Zim-lemper algorithm for data compression method. This mobility trie of a MN can be generated from the past movement history of that node. MN uses this mobility trie for mobility prediction.

2.6.3 Clustering Algorithm and Protocol

Each node can initiate the clustering process after estimating the three important parameters for cluster formation such as p,t,d.

Distance Estimation (d_{xk}): Any node x can calculates its distance from respective VCC of virtual cluster k it resides from the formula

$$d_{x,k}(t) = \sqrt{(x_{xk}(t) - x_{ck})^2 - (y_{xk}(t) - y_{ck})^2} \qquad (2.22)$$

Probability Estimation: The probability of next possible VIDs visited by any node x can be estimated from the recursive formula[10]

Stay time in virtual cluster: From the mobility trie, node x can predict the stay time for present virtual cluster k represented as t_{xk}.

Cluster Formation: From the calculated p,t,d value, each node can calculate the clustering co-efficient. Clustering co-efficient can be calculated from the formula.

$$\Omega_K = \begin{cases} p_{xk}\left[\dfrac{t_{xk} - t_{th}}{d_{xk}(t)}\right] \forall d_{xk}(t) \neq 0 \\ p_{xk}\left[\dfrac{t_{xk} - t_{th}}{d_{\min}}\right] otherwise \end{cases} \qquad (2.23)$$

MN with highest Ω value is selected as a clusterhead. Cluster members are associated with corresponding neighboring CH by sending the HELLO packet messages.

2.7 Mobility and Energy Aware Clustering Algorithm (MEACA)

[11] proposed a distributed near-optimal clustering algorithm to generalize the lowest –ID algorithm which stabilizes the clusters better than Lowest ID algorithm [12], [13]. The main objective of MEACA is to quantitatively increase the clusterhead life time and cluster membership time. It forms the stable clusters using node mobility and energy as the attribute for select the clusterhead. It stabilizes the communication path and maximizes the path lifetime. It assumes that every node has unique address and every link is symmetric. Every node in the network is assigned with a priority value. In Lowest-ID algorithm, each node has some predefined priority value, but in MEACA, priority value is assigned to each node in the network based on its mobility attribute (A_m) and energy attribute (A_e) value. Mobility attribute is the measure of node’s mobility and energy attribute is the measure of remaining time of that node before its energy is used up completely. Priority value may changes with time based on the energy and mobility attribute. MEACA follows the following four stages for making a more stable network.

2.7.1 Advertisement of Attributes

Each node in the network periodically broadcast their priority value to its neighbors by advertisement message. The advertisement message contains the updated priority value based on its mobility end energy attributes. Based on the received advertisement message, each node can maintain a neighbor table containing A_m, A_e and node ID of its neighbors.

2.7.2 Formation of Cluster

Each node in the network can determine its role from the neighbor table information. In neighbor table, nodes are sorted from highest value to lowest value of A_m. Nodes having A_m value less than the threshold value $A^*_m = \alpha.\max(A_m)$ is eliminated from the sorted table. Node having Highest A_e value in the sorted table is selected as a clusterhead. All other nodes in the neighbor table associated with that clusterhead.

2.7.3 Finalization of Cluster Roles

Selected node in the cluster formation stage is finalized with clusterhead (CH) role. All other nodes in the neighbor table is finalized with cluster member role after completing the registration process with selected node (CH).

2.7.4 Reformation of Cluster:

After completion of finalization of each node’s cluster roles. Each node maintains a registration table. CH‘s registration table keeps IDs of all its neighbors. Cluster member’s registration table keeps the ID of its Clusterhead., Nodes are re-clustered only when registration table becomes empty.

2.8 Mobility Based Clustering (MBC)

[14] proposed a clustering scheme, which creates clusters of adaptively-variable- size based on mobility pattern of the mobile nodes. The main objective of MBC is to create a stable clustered topology by combining both physical and logical partition of the network. It assumes the nodes having GPS cards mounted on it for finding their location. MBC follows the following five steps for clustering

2.8.1 Mobility Information Dissemination

Each node in the network can identify its position from GPS card mounted on it. Change in position value gives the distance traveled by that node. From distance each node can estimate its velocity from the formula. V(n,t) = Distance traveled by the node m in unit time / time taken(t). After estimating the V(n,t) value, each node broadcasts its velocity information to its neighbors

2.8.2 Calculation of Relative Mobility
Based on received velocity information, any node m can calculates its relative velocity between its and node n from the formulaV(m,n,t) = V(m,t)- V(n,t), then node m can calculate the relative mobility from the formula

$$M(m,n,t) = \frac{1}{N}\sum_{i=1}^{N} V(m,n,t) \qquad (2.24)$$

2.8.3. Initial clustering Stage
Calculated M value is also broadcast at periodic time interval. Each node m form a set Sm, which contains node m and all of its neighboring nodes. From Sm node having lowest-Id and $M_{m,i,T} < Th_{mob}$ is selected as a Tentative clusterhead(TCH), then node m request TCH for clustering.

2.8.4. Cluster Merging
Two tentative clusterheads(TCH_1, TCH_2) will merge if it statisfy the L-hops boundary condition. After merging of two TCH, the parent TCH is selected as clusterhead and other becomes a cluster member.

2.8.5 Cluster Maintenance
The node m in cluster Ci moves into another cluster cj, having node n and satisfies the condition $M_{m,n,T} < Th_{mob}$,then node n is the clusterhead of cluster Cj.

2.9 Mobility based cluster formation Algorithm
[15] proposed a learning automata based weighted cluster formation algorithm MCFA, in which mobility parameters are assumed to be a random variable with unknown distribution. The main objective of MCFA is to increase the number of clusters, cluster life time and re-affiliation time, and to reduce the control message overhead. In MCFA, each mobile host H_i calculates its relative velocity with neighboring mobile host H_j by using the formula

$$RM^{t}_{(i,j)} = \sqrt[2]{\begin{matrix}(v_i^t)^2 + (v_j^t)^2 - \\ [2v_i^t v_j^t \cos(\theta_i^t - \theta_j^t)]\end{matrix}} \qquad (2.27)$$

Then expected relative velocity between two the hosts H_i and H_j is be calculated from the formula

$$ERM^{T}_{(i,j)} = \frac{1}{k}\sum_{t=1}^{k} RM^{T}_{(i,j)} \qquad (2.28)$$

Then each host I calculates the expected relative mobility with its entire neighboring host from the formula

$$ERM^{T}_{i} = \frac{1}{|N_i|}\sum_{\forall Hj \in Nj} ERM^{T}_{(i,j)} \qquad (2.29)$$

The calculated ERM_i value indicates the weight of the mobile host i. clustering of mobile host uses learning automation algorithm which selects the optimal action from a set of allowed action. In MCFA, action stands for selection of optimal clusterhead based on ERM value of the hosts. After CHs selection, Neighboring host of CHs are associated with corresponding CH by sending the RERM messages.

3. CONCLUSION
Clustering is one of the typical hierarchical network structure. It provides more stable network structure, if clustering of nodes accounts the mobility behaviors of the nodes. This paper briefly presented the various mobility aware clustering algorithms in MANET, by clearly explaining the mobility prediction strategies and clustering approaches used in each algorithm. With this review, researchers can have comprehensive understanding of mobility aware clustering schemes in MANET. We hope this review may facilitate researchers to provide more scalable and stable network structure for MANETs.

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