SCAMP-An enhanced Stable Clustering Algorithm in MANETs based on Mobility Prediction

Seema Ruhil, Ajay Dureja

Abstract— Mobile adhoc network faces significant challenges due to the high mobility and dynamic nature of network topologies. Several mobility prediction schemes are being used to make sectorized cluster structure to enhance stability of network. The dissociation and association of the nodes to and from the clusters disturbs the stability of network and thus reconfiguration of the network is not possible. So here we make use of the on-demand clustering algorithm to update the network topology if needed. In this paper, we aim to propose a new stable clustering algorithm based on random direction mobility model. Simulation experiments are conducted to evaluate performance of our algorithm and results shows that our algorithm produces more stable network structure.

Index Terms— MANETs, mobility, clustering, random direction mobility model

I. INTRODUCTION

In recent years, the changing technologies in wireless communication and the excessive use of the handheld and mobile devices has resulted in increasing the popularity of MANETs. A mobile ad hoc network[1] is a collection of wireless mobile nodes that dynamically form a network which needs no pre-existing network infrastructure. Each mobile node in the network acts as a router and chooses the best path to forward data to other nodes in the same transmission range. When the mobile nodes are in an area which is not being covered by any existing infrastructure, then one of the best solutions is to self-organize themselves into small cluster based network architecture. Ad-hoc networks do not use specialized routers for the traffic routing and path discovery mechanisms. This means that certain nodes must be selected to form the backbone to stabilize the network. This can be achieved by building a cluster based network architecture and partitioning ad hoc networks into clusters. Certain nodes, known as *cluster-heads*, plays a key role in adhoc networks.

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They are responsible for the formation of cluster and maintenance of the entire network topology, and also for resource allocation to all the nodes which belongs to their clusters. The clustering algorithm is being performed in two phases: clustering formation and clustering maintenance. In the clustering formation phase, the cluster head selection process is being processed and certain algorithm is being followed to elect a node to be a cluster head. The main objectives of cluster heads are relaying routers to deliver the data packets and to coordinate among several clusters. Due to the dynamic mobility of the nodes these mobile nodes keeps on changing their positions and are free to leave or join any cluster any time. So, it leads to the second phase, namely, clustering maintenance since it becomes difficult for the cluster head to maintain the cluster information.. This paper aims to avoid excessive computation in the cluster maintenance phase, and current cluster structure should be stable and preserved as much as possible.

In this paper, we propose an enhanced Stable Clustering Algorithm based on Mobility Prediction (SCAMP) which is an enhancement of a weighted clustering algorithm (WCA)[6] by maintaining more stabilized clusters. In this algorithm, a node is selected to be the cluster-head if it has the minimum weighted sum of four indices: degree of a node, the sum of the distances to other neighboring nodes, the nodes mobility and the battery lifetime of the node. The high mobility of nodes causes a high frequent re-affiliations, which increases the network overhead. To solve this problem, we propose an algorithm using mobility prediction model. This can enhance the stability of the network by considering the relative mobility of each node and its neighbors for the cluster formation and maintenance, by predicting the mobility of a node using the random direction mobility model. This model is used to predict the direction and the movement of the mobile nodes and thus improves the stability of the network topologies. The Random Direction Mobility Model was invented to prevent the behavior of density waves created by clustering at the centre and to promote a semi-constant number of neighbors. The mobile node selects a particular direction and travels to the border of the simulation area. If the boundary is reached, the node takes a pause for a specific interval of time and then chooses

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the direction to further proceed to complete the simulation process.

II. Related Work and current motivaition

A number of clustering algorithms have been proposed to choose cluster-heads based on several factors like speed, direction, mobility, position, and the number of neighbors of a given node. These efforts have advantages but also have some disadvantages as well, like the high computation overhead for both clustering algorithm execution as well as the update operations.There are mainly two categories of the clustering schemes[2] which are: single metric and the multiple metric based clustering.
In single metric based clustering only one performance factor is being considered and it consists of algorithms.

In *Lowest ID Clustering algorithm (LIC)* the node having the minimum id is elected as the cluster head. In this each node broadcasts the list of nodes it is able to hear thus if a node is able to hear the nodes with id higher than itself then it is selected to be the cluster head otherwise it is an ordinary node.
In *Highest Connectivity Clustering algorithm (HCC* algorithm the node which is having maximum number of neighbors (i.e. maximum degree) is selected to be a cluster head.
Adaptive multi-hop clustering algorithm [7] sets an upper bound (U) and lower bound (L) on the number of cluster members within a cluster that can be managed and handled by the cluster head.

In multiple metrics based clustering more than one metrics are considered and there are also several algorithms in this clustering scheme.

In *WCA: A Weighted Clustering Algorithm for Mobile Ad Hoc Networks* [5] the high mobility of the nodes leads to the often dissociation and association of the nodes to and from the clusters which affects the stability of the network topology. Due to this reconfiguration of the network is unavoidable. The cluster heads forming the dominant set leads to determine the stable network topologies. So depending upon the specific applications a number of parameters like degree, transmission power, mobility, energy, battery power of nodes etc. are considered to elect a node to be a cluster head.

In *Weight Based Adaptive Clustering in Wireless Ad Hoc Networks*[10] each node is assigned a weight based on a generalized formula that takes into account different parameters. The node having smallest weight is chosen to be a cluster head.

An Adaptive Weighted Cluster Based Routing (AWCBRP) Protocol for Mobile Ad-hoc Networks[9] approach assigns weight to the nodes based on the factors stability, energy level and connectivity. Cluster head is selected on the basis of the following weighted sum:-

$$W = w1D1 + w2D2 + w3D3$$

Where D1 is the stability index, D2 is the energy level of the node and D3 is the connectivity factor and w1, w2 and w3 are the weighting factors. And the node having minimum weight value is selected to be the cluster head.

Thus we make use of the weighted clustering algorithm to select a node to be a cluster head and thus enhance this algorithm by predicting the mobility of the nodes and thus establishing a more stabilized network architecture.

III. Proposed Work

In this section, we present the proposed Enhanced Stable Clustering Algorithm using mobility prediction scheme (SCAMP). SCAMP consists of the clustering formation and clustering maintenance phases.

A. Phase-I: Clustering Formation

In WCA[8], the goal is to minimize the value of the sum of all the weight costs of the cluster heads. Here a node is selected as cluster head when it minimize a function of four criteria such as degree, sum of distance between cluster head and the other nodes, mobility of nodes and battery power of the nodes.

The running average speed for each node till current time *T*, it is computed is

$$M_i = \frac{1}{T} \sum_{t=1}^{T} ((X_t - X_{t-1})^2 + (Y_t - Y_{t-1})^2)^{\frac{1}{2}}$$

where (X_t, Y_t) and (X_{t-1}, Y_{t-1}) are the coordinates of node i at time t and (t -1), respectively. It is the absolute mobility of node and cannot indicate information of stability between node and its neighbors. Therefore we present an improved parameter of the average speed which leads to find the cluster head based on the four parameters.

Algorithm for defining a network of clusters.

```
Define a Clustered Network with N Nodes and M Clusters.
For I=1 to M
[Process all clusters]
For j=1 to N
[Process all nodes]
Dist=CalDistance (Node(j),Cluster(i))
If (Dist<SensingRange)
{
Cluster(i).Add(Node(j))
}
```

B. Phase-II: Clustering Maintenance Using Random Direction Mobility Model

The high mobility of nodes coupled with the transient nature of wireless media results in a highly dynamic network topology. Due to this high mobility some nodes will attach itself to a cluster and detach itself to some other cluster. Thus, this reduction of re-affiliation is necessary in ad hoc networks to provide more stability of the network structure. To prevent this we make use of the mobility prediction model called the random direction mobility model. Random Direction Mobility Model [11] was developed to alleviate the behavior of mobile nodes to converge at the centre of the cluster, disperse and converge again. In this model, mobile nodes choose a random direction in which it wants to travel instead of a random destination. After choosing a random direction, a mobile node travels to the border of the simulation area in that direction only. As soon the mobile node reaches the boundary it stops for a certain period of time, chooses another angular direction (between 0 and 180 degrees) and then continues the same process. An example of path of a mobile node, which begins at the center of the simulation area using the Random Direction Mobility Model is shown by the following fig.

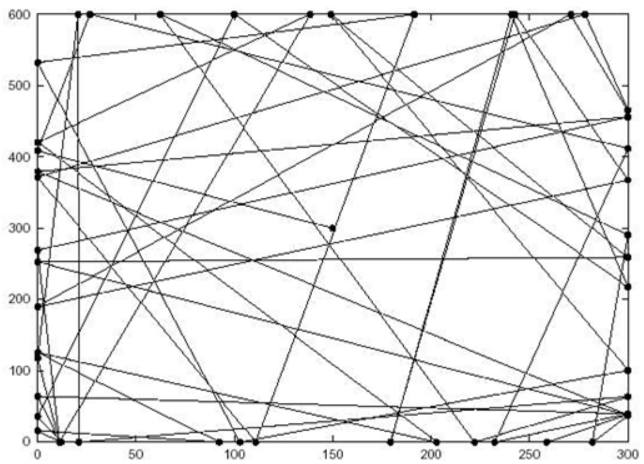

Fig. 1.Traveling pattern of an mobile node using the Random Direction Mobility Model.

The random direction mobility model set up is being depicted in the following algorithm and the communication among different nodes is being shown here by sending randomized source (src) and destination (dst) nodes. Due to this model the network becomes more stabilized and the packet dropping by the nodes stops and thus this model is effective in making the entire network to be stabilized. In this work, the system will consist of a different kind of network with the several assumptions.The clustered network is defined where each cluster is controlled by the cluster head called controller node.The network includes the inter cluster and intra cluster communication and the communication is performed via cluster head.The location of all nodes and coordinators is dynamic.If the coordinator nodes is present, it will control a set of nodes.A network can have one or more coordinator depending on the network size and density.Thus the random direction mobility model plays a key role in enhancing the stability of the network topology by predicting the mobility patterrn and direction of the mobile nodes and thus creating more stable clusters over the network.Thus the network becomes less dynamic and the packet loss during communication among the different nodes decreases and the intra cluster communication becomes more easy and efficient.

IV.RANDOM DIRECTION MOBILITY MODEL IMPLEMENTATION ALGORITHM

```
Algorithm for Setup Random Directional Mobility Model for
each node over the network and sending the randomized
communicating Nodes called Src and Dst

[Perform Communication within Cluster]
{ Set CommunicationType="Intra-Cluster"
Set Communication(Src, Src.Cluster)
Set Communicaiton(Src.Cluster,Dst.Cluster) }
Else
```


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[Perform Inter Cluster Communication]

{ Set CommunicationType="Inter-Cluster"

Set Communication (Src,Src.Cluster)

Set Communication (Src.Cluster,Dst.Cluster)

Set Communication (Dst.Cluster,Dst) }

For i=1 to N

{If (Dist (Node (i), Node (i).Cluster)>SensingRange)

{For j=1 to M

[Identify the Effective Cluster in range)

{If (Dist (Node (i), Cluster (j)) <SensingRange)

{Perform Throughput, IdleRate and Effective Rate Analysis called Performance Vector

If (PerformanceVector>MaxPerformanceVector)

{MaxPerformanceVector=PerformanceVector

Index=j}}}

Set Node (i).Cluster=Index}

Perform the Communication with new cluster head

Analyze the network under different communication vectors}

Thus the above algorithm shows the communication among the different nodes and the random direction mobility model is implemented effectively.If there is any re-affiliation then the communication begins with the new cluster head and we can analyze the network under various communication vectors.

V. EXPERIMENTAL SETUP AND RESULTS

In this, we present the performance of the AODV (Adhoc on-demand distance vector routing protocol) in the proposed SCAMP algorithm simulated by NS2.We simulate a system of N nodes on an 900 m × 900 m area. The value of N is varied between 10 and 50 and the simulatiion time is 100 seconds.

Scenario:-

Parameters	Values
Number of Nodes	50
Protocol	AODV
Simulation Time	100 Sec
Packet Size	512
MAC protocol	802.11
Coverage Range	990x990
Network Type	Clustered
Mobility Model	Random Directional
Number of Clusters	5

The random directional model has been implemented here and the nodes move randomly in any direction with a maximum speed varied between 20m/s and 50 m/s and then takes a pause for a while after reaching the simulation area boundary and then decides the next direction to be taken by it to proceed further to complete the simulation process. The cluster member selection is here defined under the distance parameter. The network nodes represent the inter cluster communication over the network. Mobility is an important parameter which is being analyzed using this simulation in an effective way.Here, due to the use of the random direction mobility model the movement and the direction of nodes can be predicted and thus the network can be made more stabilized.
The following xgraphs shows how the use of random direction mobility prediction model is being analyzed to show the stability of the network topologies

Fig.2 showing the packet communication analysis over the network. Here X axis represents the simulation time and y axis represents the packet loss over the network. Figure shows that the communication is being increased over the networks. total number of data packets being delivered during the different intervals of simulation time.Fig.3 shows the packet delay rate at different intervals of the simulation time.Fig.4 shows the bitrate that is the number of bits transferred during the simulation time.Fig.5 shows the packet loss rate and the Fig. 6 shows the total number of actually lost packets during simulation and the packet loss decreases as the simulation proceeds further and tye network becomes more stabilized.

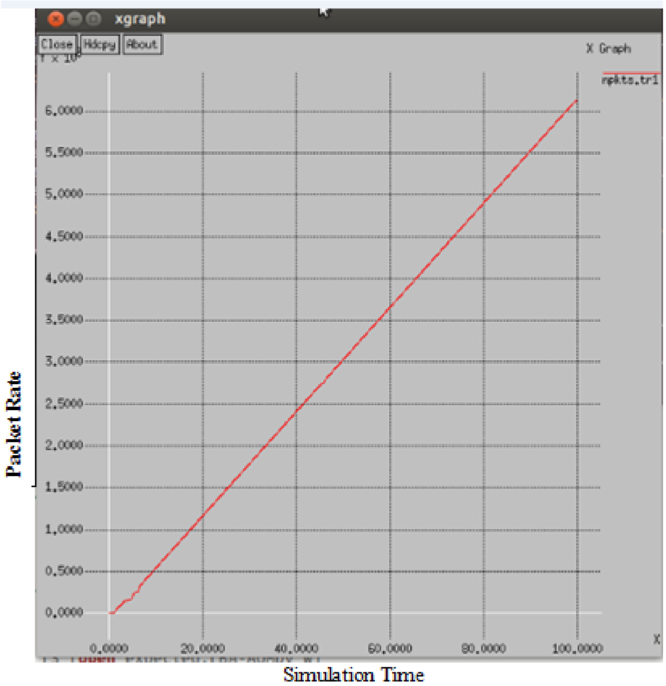
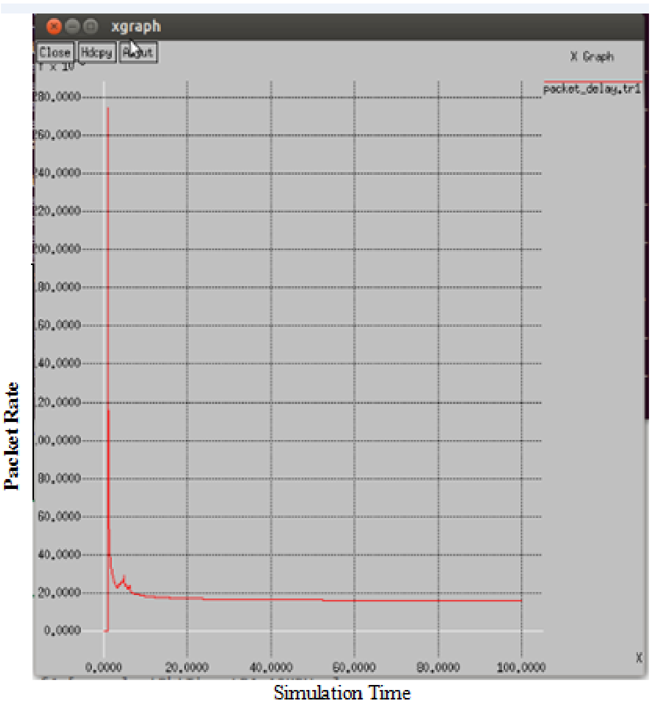


Fig. 2 Packet Transmission Analysis



* Fig.3 Packet delay analysis

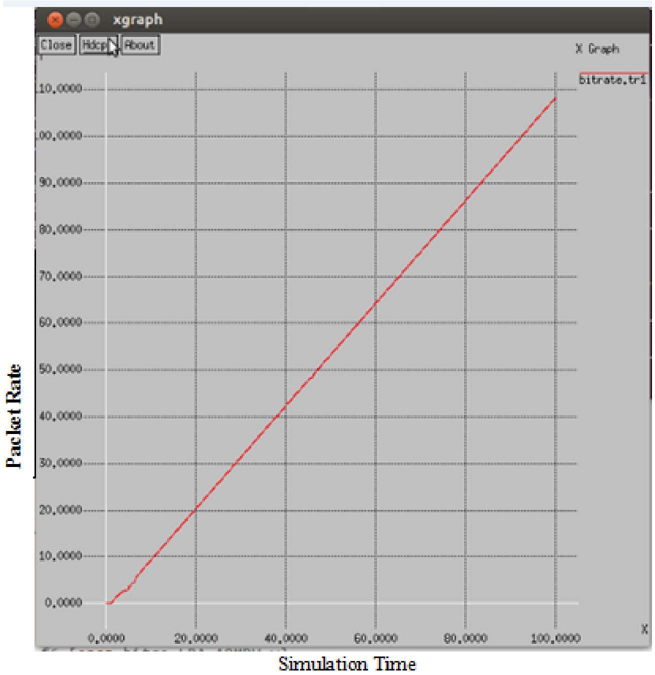


Fig. 4 Bitrate with delay analysis

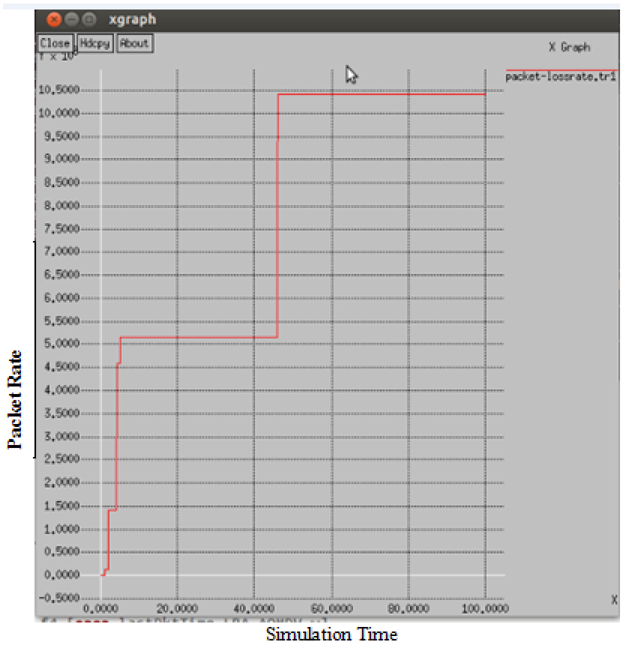


Fig. 5 Packet loss rate analysis

Therefore,the above all xgraphs clearly depicts that as the simulation begins the packet loss rate decreases as we apply here the random direction mobility model to predict the future locations of different nodes which results in better and more stable network structures.

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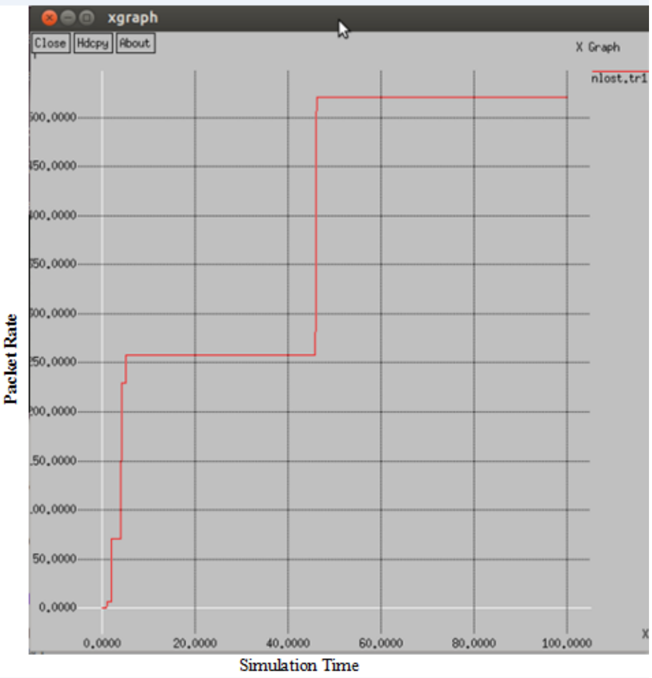

Fig. 6 Lost packet analysis

VI. CONCLUSION

In this paper we have presented an enhanced stable clustering algorithm based on mobility prediction (SCAMP) that can be applied in MANETs to enhance their stability and to reduce the frequent re-affiliation of the nodes. SCAMP mainly focuses on reducing the instability caused by high speed dynamically moving nodes, by taking into account the relative mobility of node and its neighbors. Since SCAMP algorithm supports the stable cluster head election to maintain properly the cluster information and the frequent re-affiliation of nodes is being reduced by mobility prediction model called random direction mobility model which results in stable clustering. The performance of the proposed SCAMP demonstrates that it enhances the stability of the entire network by forming the stable clusters.

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