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Survey on Mobility Prediction Schemes in MANET with clustering techniques

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***Abstract*— Mobile Ad-Hoc Network is a self-organizing multi-hop adhoc network of independent devices in which the topology keeps on changing due to the dynamic mobility of nodes. The nodes in the network have very limited bandwidth and battery power so, due to this challenging environment clustering has to be done to achieve stability. Since the mobile nodes follows different mobility patterns in an arbitrary manner so it causes high uncertainty in the network topologies. In this paper, a survey is carried out on different schemes being proposed to dynamically identify and maintain the hierarchical structure called clusters in MANETs. It also focuses on comprehensive survey of different mobility prediction schemes to enhance the stability of the network and optimize the energy consumption in MANETs.**

***Index Terms*— MANETs, mobility, clustering, mobility prediction schemes.**

I. Introduction

A mobile ad hoc network is composed of independent nodes with equal networking capabilities which are able to function as mobile routers i.e., to forward packets and maintain routes to several destinations. Packets can be forwarded in multi-hops from the source nodes to the destination nodes without any need for the underlying fixed network infrastructure (e.g. routers and base stations). MANETs are self-organizing and multi-hop wireless network of nodes which is capable of adaptive reconfiguration when they are being affected by dynamic mobility of nodes. In addition to the bandwidth optimization and transmission quality enhancement there are several new issues like ad hoc addressing, increased energy constraints, self-configuration and adaptive reconfiguration as network topology is affected by node mobility. Clustering offers an efficient hierarchical structure organization by partitioning mobile hosts into disjoint groups of hosts called clusters. The problem of dynamic topology is recurring and it's a challenge to build stable clusters despite the host mobility. Clustering can also be defined as the division of large network into small number of virtual disjoint groups. In a cluster, a node can be a cluster head (CH), cluster member (CM), cluster gateway (CG) or may be on orphan node.

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A cluster head (CH) acts as an manager to the cluster since it is responsible for the resource allocation and keeps track of the intra-cluster data transmission process. A flat network structure (a) and a lustered network structure (b) is shown in fig.1 ,flat network is not scalable and if any node joins or leave the network then

entire network topology is being affected but this is not in the case of clustered network since it changes only local topology instead of the entire network topology so it provides the scalability to the network.

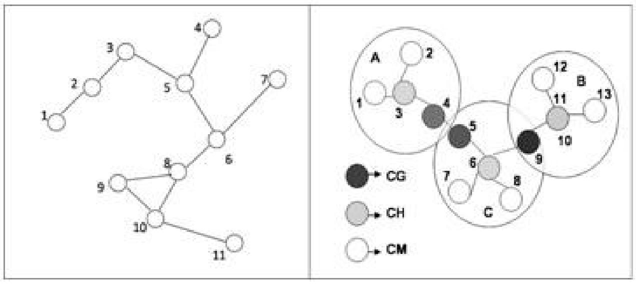

Fig 1.(a) Flat Network Fig 1 (b) Clustered Network

Clustering mechanism considers several factors like energy, mobility, distance and spreading degree, power etc.

II. Types of the Clustering Techniques

A. Single metric based clustering

This scheme considers only one performance factor for making clustering decisions.

Lowest ID Clustering algorithm (LIC)

In this algorithm [2] the node having the minimum id is elected to be the cluster head. Each node is assigned with a unique id and thus in this algorithm the neighbors of the cluster head will have the higher id as compared to the cluster head. In this each node broadcasts the list of nodes it can hear thus if a node is able to hear the nodes with id higher than itself then it is a cluster head otherwise it is an ordinary node. The main disadvantage of this algorithm is that nodes are prone to power drainage due to the cluster heads which serves for a longer period of time.

Highest Connectivity Clustering algorithm (HCC)

In this algorithm [2] the node having maximum number of neighbors (i.e. maximum degree) is selected as an cluster

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head. Each node broadcasts its id to the nodes within its transmission range & thus degree of a node is computed on the basis of its distance from other nodes. But it has a drawback that if the number of nodes in a cluster increases then the throughput decreases.

Adaptive multi-hop clustering

It sets an upper bound (U) and lower bound (L) on the number of cluster members within a cluster [3] that can be managed and handled by the cluster head. If the number of cluster members is less than the lower bound then the cluster needs to be merged with another neighboring cluster. And if the number of cluster members is greater than the upper bound then the cluster is divided into two disjoint sets of clusters.

A. Multiple metrics based clustering

Weight based or combined metric clustering scheme [4] considers more than one metrics into account for cluster formation, including node spreading degree, residual energy capacity, mobility, and so on.

WCA: A Weighted Clustering Algorithm for Mobile Ad Hoc Networks

The high mobility of the nodes leads to the often association and dissociation of 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 [5] a number of parameters like degree, transmission power, mobility, battery power of nodes etc. are considered to elect a node to be a cluster head.

Weight Based Adaptive Clustering in Wireless Ad Hoc Networks

It considers important parameters [6] of a node for cluster head selection which includes mobility, degree, battery power, transmission power and transmission rate. Each node is assigned a weight based on a generalized formula that takes into account all the parameters. The node having smallest weight is chosen as a cluster head.

An Adaptive Weighted Cluster Based Routing (AWCBRP) Protocol for Mobile Ad-hoc Networks

This approach [7] assigns weight to the nodes based on the factors energy level, connectivity and stability. Cluster head is selected on the basis of the following weighted sum:-

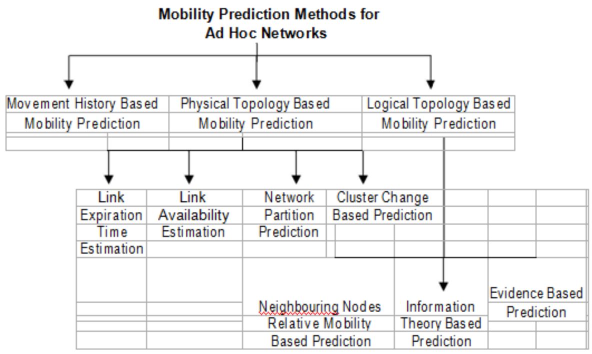
W = w1D1+ w2D2 + w3D3

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

III. Related Work

Mobility Prediction Schemes

Mobility Prediction affects positively the application oriented and service oriented aspects of ad hoc networks.



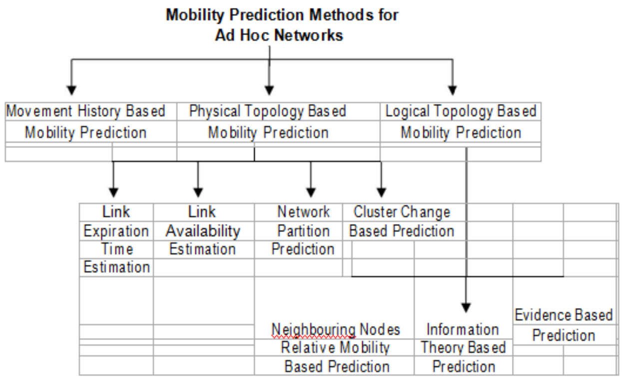


Fig. 2 classification of mobility prediction schemes

A. Movement history based mobility prediction

A number of algorithms has been proposed which predicts the future location of a node based on node's previous movement patterns. Different mobility models are being used to model the node's mobility behavior. This scheme (Liu and Maguine,1996) consists of the regularity pattern recognition algorithm and motion prediction algorithms. Due to this the future location of a node can be predicted according to its movement history and thus required resources can be pre-allocated, routing mechanism can be pre-arranged and all the services may be pre-assigned at new location before the node move into it. But this method is not always feasible due to the highly dynamic topology of the network.

B. Physical topology based mobility prediction

Link expiration time estimation

The route reconstruction can be done before the link breaks by predicting the future state of network topology. A wireless link exists(Su & Gerla,1999) between two nodes p and q of a MANET, if and only if p and q are within a transmission range r of each other. So this method predicts a expiration time of wireless link between two adjacent nodes on a route R. The least link expiration time values(Sue et al,2001) of all links on R is estimated to be the route's R expiration time. Let (xi,yi) and (xj,yj) be the location of nodes i and j, respectively. Let also vi and v j be the speeds, θi and θj to be the moving directions of nodes i and j, respectively, and TX is transmission range. The amount of time T the mobile nodes i and j will stay connected is given by:

$$T = \frac{-(ab+cd)+\sqrt{(a^2+c^2)TX^2-(ad-cb)^2}}{(a^2+c^2)}$$

where a = vi cos θi – vj cos θj, b = xi - xj, c = vi sin θi – vj sin θj, d = yi - yj.The exact location and mobility information of each mobile node can be provided by a GPS device.

Link availability estimation

A probabilistic link availability model(Mc Donald & Znabi,1999(a)), is used to define the probability that there is an active link available between two mobile nodes at time t+T given there is an active link at time t.An estimation T of expiration time(Jiang et al. 2001) for an active link {v,u} between two nodes v

and u at time t, the availability L(T) of link {v,u} is defined as

L(T)=Pr { the link {v,u} lasts from time t to time t+T given that the link is available at time t}

It shows the probability of link {v,u} availability from time t to time t+T.

Group mobility and network partition prediction

When a network is separated into disjoint sub networks due to the diverse mobility pattern of mobile nodes then it leads to network partition .And the prediction of occurrence and timing of network partition(Wang & Li,2002) improves performance and prevents disruption caused by network partition. Consider a network consisting of two mobility groups Ci and Cj each moving with velocities Vi=(vxi,vyi) and Vj= (vx j, vy j)respectively. The relative mobility between them is obtained by fixing one group, say Ci, as stationary. Then the effective velocity Vij at which Cj is moving away from Ci is given by:

Vij = Vj +(- Vi), where Vij = (vxij, vyij) = (vxj-vxi, vyj-vyi)

Assuming two groups cover a region of diameter D, wherein the nodes are distributed uniformly. If we assume both the groups to be perfectly overlapped, then for the two groups to separate, Cj must move past a distance of the diameter D of Ci 's coverage area. Therefore the total time taken for the two groups to change from total overlap to complete separation is given as:

Tij = D/ (vx2ij + vy2ij)1/2

Cluster change based prediction

This method introduces the sectorized cluster structure(Chellapa-Doss et al,2003, Chellapa-Doss et al,2004) i.e. cluster is divided into two sectors called C-type cluster sector which are adjacent to neighbor cluster and S-type cluster sector that are not. Clusters are divided into three regions with respect to the probabilities of cluster change i.e. No-cluster change(No-CC),Low-cluster change (Low-CC) and High-cluster change(Hi-CC).

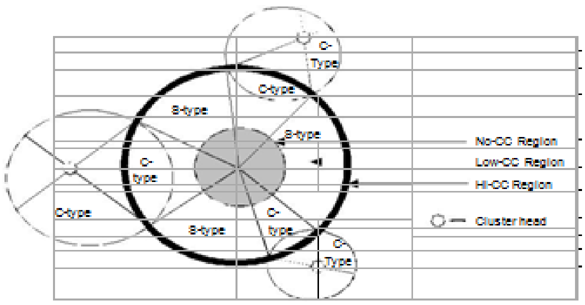


Fig. 3 The sectorized cluster structure

C. Logical Topology Based Mobility Prediction

Neighboring Nodes Relative Mobility Based Prediction

Authors in (McDonald and Znatti, 1999b) propose the (a,t) clustering scheme, according to which mobile nodes are able to form the clusters according to a path availability criterion. The entire network is partitioned into disjoint sets of clusters of mobile nodes, that are being reachable mutually along cluster internal paths that are available for a period of time t with a probability of at least a. The parameters used in this model are predefined. MOBIC in (P. Basu, N. Khan, and T. D. C. Little,2001) introduced an algorithm which selects mobile nodes as an CHs which exhibit the lowest mobility in their neighborhood. Each node compares the strength of the receiving signal from its neighbors over a definite period of time and uses the variance in these values as to indicate that how fast any mobile node is moving in relation to its neighboring nodes. MOBIC uses only the current mobility for the determination of the CHs.

Information theory based mobility prediction

A mobility-aware technique for the formation and maintenance of clusters is being proposed. The main idea behind this technique (Bhattacharya & das,2002) is to estimate the future mobility of nodes to select CH which exhibit lowest predicted mobility as compared to other mobile nodes. To measure node's mobility rate it finds the probability of a mobile node which is having same mobile nodes for a sufficiently long time in its neighborhood. Since a high probability value indicates either the node to be relatively immobile or existence of group of nodes that exhibits same mobility pattern around it. Thus in this technique [11],[12] the mobile node having highest degree among all its neighbors is elected to be a clusterhead.

Evidence based mobility prediction

The Dempster-Shafer (DS) theory of evidence

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developed by A. Dempster (Dempster,1968) and extended by G. Shafer (Shafer, 1975) has stated the DS theory according to which if a probability p is assigned to any event then 1-p represents the confidence not being assigned to the event.1-p represents ignorance and uncertainty and it is not necessarily assigns to the opposite event. In (Dekar and Kheddouci, 2008) a mobility prediction scheme is proposed according to which the DS theory of evidence can be used to predict the future position of mobile nodes. The DS theory of evidence can be exploited by this scheme to represent the main characteristic of mobility prediction. Mobility prediction process is performed by a prediction-agent which works on a cluster based topology, its role is to predict the future clusters of mobile nodes before they leave their current cluster. The cluster nodes are being organized into three categories-(a) central nodes, which are either cluster head or have a link whose strength is greater than a certain value with another central node (b) border nodes, having a neighbor which belongs to another cluster (c) intermediate node ,which is neither central node nor border node. The prediction process is performed only by border nodes, because these nodes have neighbor which belongs to another cluster and thus it joins another cluster and leave their cluster easily.

IV. CONCLUSION

This paper presents a brief survey on different clustering schemes which are used to partition the large network into small disjoint sets of nodes called clusters. Several parameters like battery power, connectivity, mobility etc. are being used to select the cluster head and derive the performance of the mobile nodes. Mobility Prediction methods provides a way to find the different trajectories of the mobile nodes and also predict their future positions in order to create more stable network structures. And also with this review of different mobility prediction schemes researchers can have better comprehensive understanding of creating more stable and scalable networks in MANETs.

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