A Review on Mobility Prediction Schemes in MANET with Clustering Techniques

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Abstract

A Mobile Ad hoc Network (MANET) is an accumulation of wireless portable nodes shaping a system without utilizing any current infrastructure. Every single portable node work as mobile routers that find and keeps routes to other portable nodes of the network and therefore, can be associated dynamically in a self-assertive way. The mobility characteristic of MANETs is an extremely critical one. The mobile nodes may follow different mobility patterns that may affect connectivity and performance. Mobility prediction may positively influence the service oriented feature as well as the application-oriented feature of ad hoc networking. At the network level, precise node mobility might be difficult tasks, for example, call admission control, reservation of network assets, pre-setup of services and QoS provisioning. At the application level, user mobility prediction in combination with user's profile may given to user with enhanced location-based wireless services, such as route guidance, local traffic information etc. In this paper we introduce the most imperative Mobility Prediction schemes for MANETs and concentrating on their fundamental outline standards and qualities.

Keywords: *MANET, QoS, Mobility*

I. INTRODUCTION

A MANET is an autonomous system of mobile nodes. The nodes may be located in or on cars, trucks, ships and anywhere on earth. The MANET nodes are equipped with wireless transmitters and receivers using an antenna that is used to communicate with each node. At a given point of time depending on the nodes' positions and their transmitter and receiver coverage patterns transmission power levels and co-channel interference levels a wireless connectivity in the form of a random i.e. ad hoc network exists between the nodes. This ad hoc topology may change with time as the nodes move or adjust their transmission and reception parameters. MANET has several characteristics such as dynamic topology (free to move in multi-hop), bandwidth constrains, energy constrained, limited physical security, etc.

MANET does not require the Access Point or Base Stations for communication between the nodes. The only possibility of communication is through the neighbouring nodes. One of the most interesting features is the possibility of multi-hop communication [1]. Thus, it is essential to construct virtual network with the subset of nodes that is responsible for forwarding packets. The nodes can be grouped into distinctive clusters. Scalability is of particular interest to ad hoc network designers and users and is an issue with critical influence on capability and capacity.

In general topologies include large numbers of nodes, routing packets will demand a large percentage of the limited wireless bandwidth. To successfully overcome such barriers and to address the issues of scalability and maintenance of MANETs, it is essential to build hierarchies among the nodes, such that the network topology can be abstracted with minimal research. This process is commonly referred to as Clustering [2].Clustering provides a hierarchical MANET system that helps to maintain the routing information. For instance, when a group of people come together and use wireless communication for some computer based on collaborative activities; which is also referred to as spontaneous networking [3].

Many academic papers evaluate protocols and their abilities, assuming varying degrees of mobility within a bounded space, usually with all nodes within a few hops of each other. Different protocols are then evaluated based on measure such as the packet drop rate, the overhead introduced by the routing protocol, end-to-end packet delays, network throughput etc. Since the bandwidth is limited in the ad-hoc network, it is essential to construct virtual network with the subset of nodes that is responsible for forwarding packets. The nodes are grouped into distinctive clusters. Clustering of nodes is one of the biggest challenges that MANETs are facing with and it is a hot topic in the research areas nowadays. Proper clustering solutions can greatly enhance the practicability and performance of MANETs [4].

The mobile nodes can directly communicate to those nodes that are in radio range of each other, whereas others nodes need the help of intermediate nodes to route their packets. These networks are fully distributed and can work at any place without the aid of any infrastructure. This distinctive advantage makes these networks highly robust.

Clustering can improve the network management and energy saving. Normally, cluster formation and cluster maintenance are the two phases that exists in clustering. Since the mobile nodes may not be aware of changes in their neighbourhood, cluster maintenance is initiated to have frequent updating of clusters and cluster heads to maintain the accurate network topology.

Due to the unpredictable mobility of the nodes, it leads to the arbitrary changes of network topology over a time. Therefore, some of the nodes are elected to be most significant for the MANET system [5]. These nodes are called Cluster Heads (CH). The Cluster Heads within each cluster acts as the local coordinator for its cluster member. The cluster heads manage and stores recent routing information. Clustering solutions [6] consider different node characteristics and perceives different weight parameters as a priority criterion in electing cluster heads.

II TYPES OF THE CLUSTERING METHODS

1) ***Single metric based clustering:*** This scheme considers only one performance factor for making clustering assessment.

i) ***Lowest ID Clustering algorithm (LIC)*****:** In Lowest ID Cluster method (LIC) [7], a node with the least ID is picked as a Cluster Head(CH). To every node a unique ID is allotted. Intermittently, the node telecasts the list of nodes that it can listen. A node with least ID will act as a CH. Disadvantage of this algorithm is that certain nodes are disposed to power drain out because of serving as CHs for longer period of time.

ii) ***Highest Connectivity Clustering algorithm (HCC):*** In this algorithm [8] the node having highest number of neighbours (i.e. maximum degree) is selected as a cluster. 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.

iii) ***Adaptive multihop Clustering algorithm*** [7] sets upper bound and lower bound on the number of cluster members within a cluster that a Cluster Head can deal with. At the point when the number of cluster members in a cluster is not exactly the lower bound, the cluster needs to converge with one of the neighboring cluster. Furthermore, if the number of cluster members in a clustering is more noteworthy than the upper bound, the cluster is separated into two clusters

2) ***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.

i) ***WCA: A Weighted Clustering Algorithm:*** 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 [9] 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.

ii) ***Weight Based Adaptive Clustering:*** It considers important parameters [10] of a node for cluster head selection which includes mobility, degree, battery power, transmission power & 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.

iii) ***An Adaptive Weighted Cluster Based Routing (AWCBRP)*** This approach [11] 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

We classify the mobility prediction methods for mobile ad hoc networks into three categories as follows:

1) ***Movement history based prediction*** methods, which forecast the "future" location of a mobile user based on his past movement (i.e., previous user movement patterns).

2) ***Physical topology based mobility prediction*** methods, which base their prediction on the use of the features of MANET's physical topology and therefore, require the use of a Global Positioning System (GPS) to obtain precise node location and mobility information.

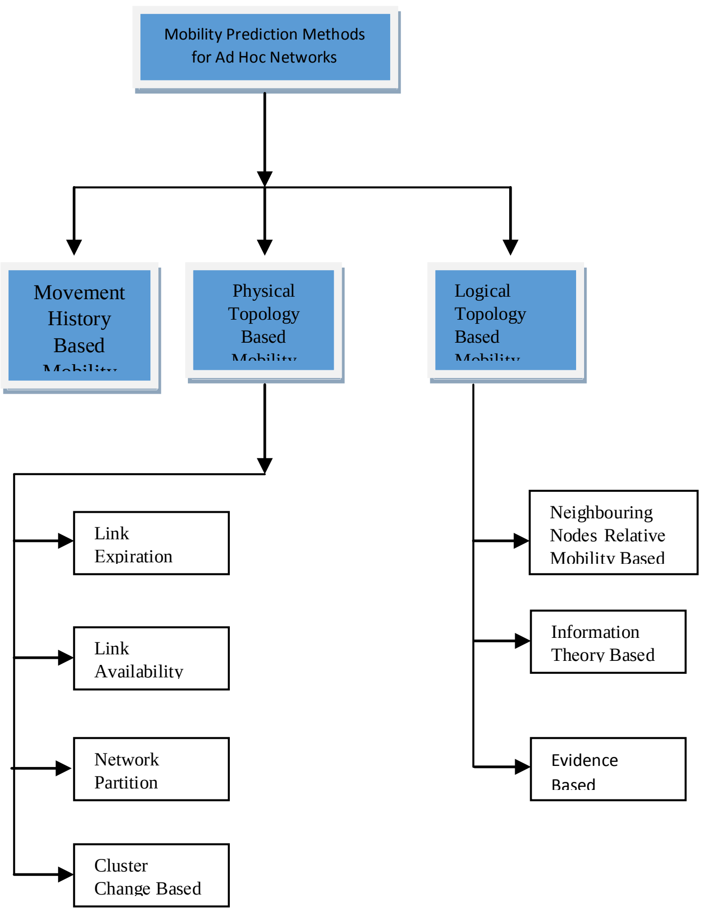

Figure 1: Classification of the mobility prediction methods

3) ***Logical topology based mobility prediction*** methods, which choose a logical topology of the MANET (e.g. a clustering structure) over which they apply their prediction process. On the contrary to the previous category, they do not require exact location and mobility information and thus they do not make use of a GPS. Estimated values of node location and mobility information may be obtained by other means (e.g. using signal attenuation versus travelled distance to estimate inter node distances, or inferring the mobility of each node from how different is the neighbourhood of the node over time).

Mobility prediction methods and their applications

i) ***Movement History Based Mobility Prediction*** A number of motion prediction algorithms mainly for fixed wireless networks, (12,13) have been proposed which predict the "future" location of a mobile user based on the user's movement history (i.e, previous user movement patterns). The algorithms use different mobility models (e.g., the movement circle model, the movement track model, the Markov chain model) to model the user mobility behavior, exploiting the fact that the movement of a mobile user consists of a random and a regular movement part. The regularity in human movement behavior derives from certain activities that are repeated within a defined period of time (e.g., going to work every day or visiting a family member every week). By predicting the future location of a mobile user according to his/her movement history, routing may be pre-arranged, recourses may be pre-allocated, services may be pre-assigned at the new location before the user moves into it. The above methods fail in the case that there are unpredictable changes in user's behavior. Also, there are additional problems when these methods are applied in MANETs because of the nature of those networks applications (military environments, emergency search and rescue operations). Due to dynamic topology and non regular requirements in such applications node mobility prediction based on the movement history is not always feasible and/or efficient.

ii) ***Physical Topology Based Mobility Prediction***

Link expiration time estimation: By exploiting the fact that in real world situations, usually, a mobile node's movement is not completely random but the node travels in a predictable manner, we can predict the future state of the network topology. Through this, the route reconstruction can be done effectively prior to route breaks and without generating excessive control overhead. We say that there exists a wireless link between two nodes p and q of a MANET if and only if p are q are within the transmission range, say r, of each other, i.e., the distance between their placement is smaller than r. In [14] a mobility prediction method is presented for estimating the expiration time of the wireless link between two adjacent ad hoc nodes as a way to enhance various unicast and multicast routing protocols. By predicting the link expiration time for any link on a route R, the route's R expiration time is estimated as the least of the link expiration time values of all links on R. Based on this prediction, routes are reconfigured before they disconnect. The estimation of the link expiration time or in other words, the time period T that two ad hoc nodes remain connected, is done as follows. Let (xi,yi) and (xj,yj) be the positions of nodes i and j, respectively. vi and vj be the speeds, θi and θj be the moving directions of nodes i and j, respectively, and TX their transmission range. The amount of time T the mobile nodes i and j will stay connected is given by

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

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 which can forecast the future status of a wireless link is proposed in (15). The link accessibility is defined as the probability that there is an active link between two mobile nodes at time t+T given that there is an active link between them at time t. Note that a link may experience one or more failures and recoveries in the time interval between t and t+T. The link availability criterion is useful during the clustering process as it can be used by mobile nodes to select more reliable neighbours to form more stable clusters.

In a prediction-based link availability estimation and a routing metric in terms of path reliability based on the link availability estimation are presented. The basic idea of this estimation is as follows:

Given an estimation T of the expiration time (i.e., the continuously available time) for an active link {v,u} between two nodes v and u at time t (computed e.g., by using the link expiration time algorithm of presented above), 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} which indicates the probability that the link {v,u} will be continuously available from time t to time t+T

Group mobility and network partition prediction

Network partition occurs when groups of mobile nodes follow diverse mobility patterns, which cause the separation of the network into disconnected sub networks. Predicting the occurrence and the timing of network partitioning allows MANET applications to improve their performance by acting in advance and preventing disruptions caused by the partitioning. A method for network partition prediction which exploits group mobility patterns to compute the remainder time before separation is proposed in (17).

In order to describe the basic idea of the method, we consider a simple case of a network consisting of two mobility groups Ci and Cj each moving with velocities Vi = (vxi, vyi) and Vj= (vxj, vyj) 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)

Assume that the two groups cover a circular region of diameter D, wherein the nodes are uniformly distributed. Assume also that the groups are in perfect overlap. Then, in order for the two groups to separate, Cj must move past a distance of the diameter D of Ci 's coverage area. Hence, the time taken for the two groups to change from total overlap to complete separation is given by:

Tij = D/ (vx2 ij + vy2 ij) ½

Cluster change based prediction

In a clustered ad hoc network each mobile node belongs to a cluster while the position of each mobile node is defined with respect to the cluster head of the cluster it belongs to. A mobile node changes the cluster it belongs to as affected by mobility. The sectorized ad hoc mobility prediction algorithm is based on the principle that in order to achieve maximum prediction accuracy the prediction process should be restricted to areas of the network with nodes of high cluster change probability (18). The algorithm introduces the sectorized cluster structure i.e., the cluster is divided into three regions with respect to the probability of cluster change as follows:

(i) The No-Cluster Change (No-CC) region of each cluster, which contains the nodes of the cluster that are within communication range of each other and they do not satisfy the requirements for membership to any neighbouring cluster. Thus, for the nodes in the No-CC region cluster change is not possible.

(ii) The Low-Cluster Change (Low-CC) region of each cluster, which contains the nodes of the cluster that are reachable by all nodes in the No-CC region, either directly, or through other intermediate nodes belonging to the No-CC region. Thus, for the nodes in Low-CC region the probability of cluster change is fairly low.

(iii) (The High-Cluster Change (Hi-CC) region of each cluster, which contains the nodes of the cluster that are not reachable by any node in the No-CC region, either directly, or through other intermediate nodes belonging to the No-CC region. The nodes in the Hi-CC region are reachable only through the nodes in the Low-CC region and the probability of cluster change for a node in this region is higher than for nodes in the Low-CC region.

iii) ***Logical Topology Based Mobility Prediction***

Neighbouring Nodes Relative Mobility Based Prediction Many researchers have acknowledged the importance of node mobility estimation for building clustering schemes more stable and less reactive to topological changes of ad-hoc networks. Authors in (McDonald and Znatti, 1999b) propose the clustering scheme, where mobile nodes form clusters according to a path availability criterion. The network is partitioned into clusters of mobile nodes, that are mutually reachable along cluster internal paths which are expected to be available for a period of time t with a probability of at least a. The parameters of this model are predefined. In addition, it is assumed that the movement of each mobile node is random and entirely independent of the movements of other mobile nodes. However, this random walk model cannot always capture some node mobility patterns occurring in practice in MANETs.

MOBIC in (19) elects as CHs the mobile nodes which exhibit the lowest mobility in their neighbourhood. Each node compares the receiving signal strength from its neighbours over the time and uses the variance in these values as an indication of how fast this mobile node is moving in relation to the neighbouring nodes. MOBIC uses only the current mobility to determine the most suitable mobile nodes for CHs. As an extension of MOBIC, MobDHop (20) also uses the variability in receiving signal strength as a hint of neighbourhood mobility and builds variable-diameter clusters. It uses more samples of receiving signal than MOBIC to estimate the predicted mobility, while the prediction model is based on the assumption that the future mobility patterns of mobile nodes will be exactly the same as those of the recent past.

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 (21) 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 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 developed by A. Dempster (22) and extended by G. Shafer 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 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 neighbour 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 neighbour

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 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. Various 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.

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