SPATIOTEMPORAL DATA MINING FOR MOBILITY PREDICTION IN WIRELESS NETWORK

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Abstract. Handover latency in Mobile IPv6 is the time interval during which a mobile node can not send or receive any packets. Predicting mobility of mobile node to improve the latency is one of the critical solutions that has attracted several research interests. Various approaches to mobile prediction have been proposed such as Hidden Markov models, machine learning, data mining, etc. The approach in data mining focuses on investigating the log file of node mobility history to predict the next move of mobile node. In the context of wireless network, the spatial attributes of a mobile node are changing over time, therefore time constraints between locations play an important role in studying its mobility. However, in our knowledge, most conventional studies do not consider simultaneously spatial and temporal attributes of data. In this paper, we propose a data mining based approach that utilizes spatio-temporal attributes to predict the movement of mobile node

Keywords: Data mining, prediction, handover, mobile node, wireless network

1 Introduction

In the recent years, the need of Internet connection "everywhere and at any time" has become more and more popular with IEEE 802.11 wireless local area networks (WLAN) Standards. In 802.11 WLAN components, Access Points (AP) (also known as Base Stations) are stations providing services of distributed systems and they are connected to each other via a fixed wired network. APs with parameters such as name of networks and the channel used by AP, etc., offer wireless connection with the mobile nodes such as laptops, Personal digital assistants (PDAs) or mobile phones. A handover (handoff) is the transfer of a communication from one AP to another AP as the mobile node moves [1]. During a handover, a mobile node (MN) can not send or receive any packets thus the packet loss may occur as well [2]. There has been a considerable amount of research on handover latency to reduce the delay in handover in order to achieve a seamless handover with the meaning that the user is unaware of such status [3].

In 802.11 WLAN, the mobile nodes gain access to the network through an AP by scanning all available channels with active or passive types to find an AP to associate with [3]. This task takes a lot of time and becomes the main factor contributing to the handover latency [1]. One way to solve this problem is to guess the next AP of the mobile node so as to take active scanning. Predicting the next location of the mobile node can reduce the handover delay mainly by detecting the identity of the future AP prior to the actual handover [3]. The information of the future AP can be used in

handover preparation such as providing the channel information required to reduce the scanning delay. Moreover, the prior knowledge of the future network can be utilized to reduce the handover delay such as the fast mobile IPv6 protocol. Therefore, movement prediction of a MN plays a key role in optimizing handovers.

The wireless network consists of a number of APs which are called cells. Each AP transmits on one assigned channel and periodically broadcast a beacon frame on this channel. Therefore, the MN which is currently in this cell and listening to the broadcast channel will know in which cell they are now. The movement of a MN from his current cell to another cell will be recorded in a database which is called the log file of mobility history [4]. Each mobility history contains the identity (ID) of the cell which the MN is connected and the timestamp of this connection. According to [1] [3] [4] [5], data mining has been a useful approach to mobility prediction based on the log file of node mobility history. However, in our knowledge, the conventional studies do not consider spatial and temporal attributes of data simultaneously. In the context of wireless network, the spatial attributes of a mobile node are changing over time, therefore time constraints between locations need to be considered in predicting the mobility.

In this paper, we propose a data mining based approach that utilizes spatio-temporal attributes to predict the movement of mobile node. The remainder of this paper is organized as follows. Section 2 is the related works on mobility prediction. Section 3 presents the problem and its model. Section 4 introduces the mobility prediction based on spatio-temporal data mining. Section 5 is experimental results. Finally, Section 6 is conclusions and further work.

2 Related Works

Various data mining techniques have been used widely to implement the prediction algorithms. Sequential pattern mining is one of the most important techniques in discovering the trends [4] [5] and used widely to predict customer behavior in business [6] or user behavior in web systems [7], as well as to determine the location of moving objects [8] or to guess the next location of a mobile node in mobile environments [4]. It is the process of extracting certain sequential patterns whose support values exceed a predefined minimal support threshold ($supp_{min}$) [9]. The $supp_{min}$ is a pruning mechanism that is used to reduce the number of sequences to a certain level of interest and make the process more efficient [5].

Xiaobai Yao [10] indicates the need of temporal extensions of the most spatial data mining techniques. According to the work, knowledge extracted from spatio-temporal data will help us to have better prediction of spatial processes or events. The utility of spatio-temporal data mining to predict the user movement is presented in [4] [6] [8] [11] [12]. J. Kang [8] proposed a prediction model in order to improve the quality of location based services (LBS) such as traffic management or route finding system. In [12], a Moving Pattern mining algorithm for predicting individual user movement was proposed. They define the individual user as a moving object and represent the spatial location of a moving object in coordinate system with x- and y-axis. In this work, the spatial

operation is used to transform moving objects' location into area for discovering significant information. And then, they apply time constraints between locations of moving objects to make valid moving sequences. Finally, the frequent moving patterns are extracted from the generated moving sequences.

Yavas et. al. [4] presented a three stage prediction algorithm based on the Apriori algorithm for predicting user movements in a PCS (Personal Communication Systems) network. They define the mobility pattern as a sequence of cells and mine frequent paths based on sequential pattern mining. According to simulation results, moderate prediction accuracy was achieved, decreasing only minimally with an increase in random mobility.

In the work [6], Taniar et. al. open up a new future for the prediction of the movement for the individual mobile user based on user movement database (UMD). Each cell in the UMD represents a coordinate which identifies the current position of a mobile user at the given time. They transform UMD into location movement database (LMD) which details the movement sequences. They uses Apriori-like algorithm and movement tree algorithm to mine movement patterns from the LMD in order to determine how mobile users travel through the location of interest from base location to another base location via multiple intermediate locations.

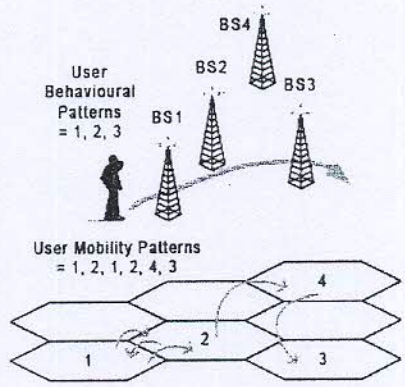

Fig. 1. Differences between user behaviour patterns and user mobility patterns [13]

However, these proposed approaches focus on the physical movements of users but do not really pay attention to user mobility from the perspective of a wireless network. What required in a wireless networks is for the mobility prediction scheme to predict the next AP through which the MN will connect to the network. In an ideal environment, the handover would be to the closest AP. However, AP overloading and anomalous propagation effects frequently result in handovers to APs other than those adjacent to the current cell. The differences between user behavior patterns and user mobility patterns are illustrated in Figure 1. The data mining based approaches [4] [6] [8] [11] [12] can be successfully utilized for location prediction of other types of moving objects, e.g., vehicles or even human but are unsuitable for location prediction for MN in wireless networks. In this paper, we determine a user's movement patterns in wireless networks through a sequence of