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## A data mining approach for location prediction in mobile environments <sup>☆</sup>

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### Abstract

Mobility prediction is one of the most essential issues that need to be explored for mobility management in mobile computing systems. In this paper, we propose a new algorithm for predicting the next inter-cell movement of a mobile user in a Personal Communication Systems network. In the first phase of our three-phase algorithm, user mobility patterns are mined from the history of mobile user trajectories. In the second phase, mobility rules are extracted from these patterns, and in the last phase, mobility predictions are accomplished by using these rules. The performance of the proposed algorithm is evaluated through simulation as compared to two other prediction methods. The performance results obtained in terms of *Precision* and *Recall* indicate that our method can make more accurate predictions than the other methods. © 2004 Elsevier B.V. All rights reserved.

*Keywords:* Location prediction; Data mining; Mobile computing; Mobility patterns; Mobility prediction

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## 1. Introduction

Personal Communication Systems (PCSs) are becoming more popular by the help of the recent developments in the computer and communication technologies. In the near future, PCSs will support a huge user population and offer services that will allow the users to access various types of data such as video, voice and images. A PCS allows dynamic relocation of mobile users since these systems are based on the notion of wireless access. Mobility of the users in PCSs gives rise to the problem of mobility management.

Mobility management in mobile computing environments covers the methods for storing and updating the location information of mobile users who are served by the system. A hot topic in mobility management research field is mobility prediction. Mobility prediction can be defined as the prediction of a mobile user's next movement where the mobile user is traveling between the cells of a PCS or GSM network. The predicted movement can then be used to increase the efficiency of PCSs. By using the predicted movement, the system can effectively allocate resources to the most probable-to-move cells instead of blindly allocating excessive resources in the cell-neighborhood of a mobile user. Effective allocation of resources to mobile users would improve resource utilization and reduce the latency in accessing the resources. Broadcast program generation can also benefit from predicted mobility patterns, since the data items can be broadcast to the cell where the users are moving [16]. Accurate prediction of location information is also crucial in processing location-dependent queries of mobile users. When a user submits a location-dependent query, the answer to the query will depend on the current location of the user [17]. Many application areas including health care, bioscience, hotel management, and the military benefit from efficient processing of location-dependent queries. With effective prediction of location, it may also be possible to answer the queries that refer to the future positions of users.

Up until now, there has been a considerable amount of research on mobility management. Most of the research has focused on the problem of location update, which is concerned with the reporting of the up-to-date cell locations by the mobile users to the PCS network [4]. Location update should be performed whenever a mobile user moves to another cell in the network to be able to track the exact location of each mobile user. When an incoming call arrives, the network simply routes the call to the last reported location of the mobile user. Compared to the amount of work performed on location update, little has been done in the area of mobility prediction [1,6–8,10,11]. These works have some deficiencies, which are explained in the following:

- Some of these works do not attempt to find mobility patterns. Instead, the patterns are assumed to be already available. These patterns are then used for mobility prediction.
- In some of these works, prediction is based on the probability distribution of the speed and direction of the mobile user. For collecting such information, highly sophisticated and expensive tools such as GPS (Global Positioning System) are needed.
- Most of the methods studied in these works are highly sensitive to a change in a mobile user's path. For this reason, the prediction accuracy drops in case of noisy data. These methods do not consider the difference between the randomness and the regularity in users' paths (i.e., they do not distinguish a random movement and a regular movement of a user). In general, users

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