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Link Prediction in Temporal Mobile Database

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Abstract: ***The rapid development of wireless and web technologies has allowed the mobile users to request various kinds of services by mobile devices at anytime and anywhere. The services which are provided to the wireless mobile devices (such as PDAs, Cellular Phones, and Laptops) from anywhere, at any time using ISAP (Information Service and Application Provider) are enhanced by mining and prediction of mobile user behaviors. Given a snapshot of a mobile database, can we infer which customers are likely to access given services in the near future? We formalize this question as the link prediction problem and develop approaches to link prediction based on measures for analyzing the probability of different service access by each customer. Differentiated mobile behaviors among users and temporal periods are not considered simultaneously in the previous works. User relations and temporal property are used simultaneously in this work. Improving the performance of mobile behavior prediction helps the service provider to improve the quality of service. Here, we propose a novel data mining method, namely sequential mobile access pattern (SMAP-Mine) that can efficiently discover mobile users' sequential movement patterns associated with requested services. CTMSP-Mine (Cluster-based Temporal Mobile Sequential Pattern - Mine) algorithm is used to mine CTMSPs. In CTMSP-Mine requires user clusters, which are constructed by Cluster-Object-based Smart Cluster Affinity Search Technique (CO-Smart-CAST) and similarities between users are evaluated by Location-Based Service Alignment (LBS-Alignment) to construct the user groups. The temporal property is used by time segmenting the logs using time intervals. The user cluster information resulting from CO-Smart-CAST and the time segmentation table are provided as input to CTMSP-Mine technique, which creates CTMSPs. The prediction strategy uses the patterns to predict the mobile user behavior in the near future.***

Keywords: mining, mining methods and algorithms, mobile environments

1. Introduction

Link prediction systems have been largely adopted to recommend new friends in online social networks using data about social interactions. With the soaring adoption of location- based services it becomes possible to take advantage of an additional source of information: the places people visit, the product people purchase at different places, the different service people access at different places. Effectively modeling the behavior patterns of users in the mobile web systems benefits not only the users in smart access by caching or prefacing but also the mobile service (m service) providers in financial profit like advertising .The link prediction problem is the problem of predicting links in a mobile transaction database which may form in the future between the location and service.

The tremendous growth of wireless communication technique has changed people to do business in mobile commerce environment**.** Mobile commerce is the buying and selling of goods and services through wireless handheld devices such as cellular telephone and Personal Digital Assistant (PDA). MC is expected to be as popular as e-commerce in the future and it is based on the cellular network composed of several base stations. The communication coverage of each base station is called a cell as a location area. The average distance between two base stations is hundreds of meters and the number of base stations are usually more than 10,000 in a city. When users move within the mobile network, their locations and service requests are stored in a centralized mobile transaction database. Mobile Commerce provides leading solutions which optimize search monetization and advertising on mobile devices. The products and services of mobile commerce are mobile banking, mobile browsing, location-based services, mobile ATM, content purchase and delivery, mobile ticketing. One of the major products and new services involved is location based services.

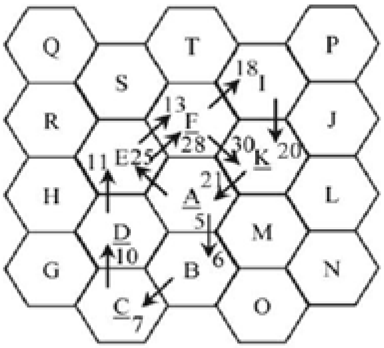

Figure 1: Mobile transactions

a) Moving Sequence

Time	Cell	Services
5	A	S1
6	B	
7	C	S3
10	D	S2
11	E	
13	F	S3,S4
18	I	
20	K	S5
21	A	S1
25	E	
28	F	
30	K	S2

(b) Mobile Transaction Table

Fig. 1 shows an MC scenario, where a user moves in the mobile network and requests services in the corresponding cell through the mobile devices. Fig. 2a shows a moving sequence of a user, where cells are underlined if services are requested there. Fig.2b shows the record of service transactions, where the service S1 was requested when this user moved to the location A at time 5. In fact, there exists insightful information in these data, such as movement and transaction behaviors of mobile users. Mining mobile transaction data can provide insights for various applications, such as prediction of subsequent locations visited by user and user's service requests and service recommendations.

2. Analysis

A. Existing System

In a mobile network consisting cells with a base station for each, users of wireless mobile devices move from one location to another in a random manner. The mobile users are served by ISPs and ISAP to access the World Wide Web, to get necessary information in their daily life. When user's movement and their service requests are predicted in advance, it helps to provide customized and efficient service to the users. Efficiency is increased to help mobile users experience the usage of web applications and web pages as if they access from a PC. The Existing system for prediction uses the moving paths of users or the time a user requests for a service. This system does not consider groups of users in mining, but it considers only individual users. This did not provide efficient Prediction of mobile user behavior and it consumes more time to predict and also it lacks in accuracy. Therefore a new system is proposed to solve the problems in prediction.

B. Limitations of Existing System

- The prediction results are inefficient.
- Prediction process consumes more time.
- No precise prediction of mobile user behavior

C. Proposed System

Here, we propose a novel data mining method, namely sequential mobile access pattern (SMAP-Mine) that can efficiently discover mobile users' sequential movement patterns associated with requested services. A novel method, named Cluster-based Temporal Mobile Sequential Pattern Mine (CTMSP-Mine), for discovering CTMSPs in LBS environment is proposed. In addition, novel prediction strategies are proposed to predict the subsequent user mobile behaviors using the discovered CTMSPs. When mobile users move within the mobile network, the information which includes time, locations, and service requests will be stored in the mobile transaction database. In the data mining mechanism, two techniques and the CTMSP-Mine algorithm are designed to discover the knowledge. First, the CO-Smart-CAST algorithm is proposed to cluster the mobile transaction sequences. In this algorithm, the LBS-Alignment is used to evaluate the similarity of mobile transaction sequences. Second, the temporal property is used by time segmenting the logs using time intervals. After clustering and segmentation, a user cluster table and a time interval table are generated, respectively. Third, the CTMSP-Mine algorithm is used to mine the CTMSPs from the mobile transaction database according to the user cluster table and the time interval table which are essential in discovering the complete information concerning personal mobile behaviors. The entire procedure of CTMSP-Mine algorithm can be divided into three main steps: 1) Frequent-Transaction Mining, 2) Mobile Transaction Database Transformation and 3) CTMSP Mining.

There are three prediction strategies for selecting the appropriate CTMSP to predict the mobile behaviors of users: 1) the patterns are selected only from the corresponding cluster a user belongs to; 2) the patterns are selected only from the time interval corresponding to current time and 3) the patterns are selected only from the ones that match the user's recent mobile behaviors. If there exist more than one pattern that satisfies the above conditions, we select the one with the maximal support.

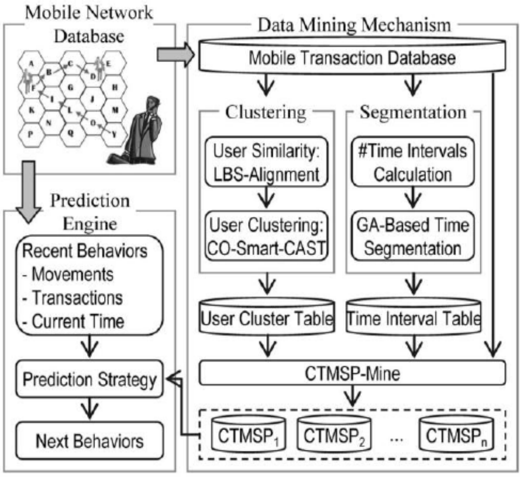

Figure 2: Overall Proposed System

D. Proposed System Benefits

- It is very precise and efficient
- It consumes less time.
- Considering User clusters and time segmentation simultaneously, complete information concerning personal mobile behaviors is predicted.

3. Materials and Methods

The objective is to predict the mobile user behavior in the near future, to improve the quality of service provided by the Information Service and Application Provider to the wireless mobile device.

System Implementation

The implementation consists of four modules. The Mobile transactions and behavior generation module logs the complete transactions of mobile users. The clustering and segmentation modules generate the required patterns. The final module uses the new mining technique to predict the future behavior of the mobile users. The modules are described below.

1) Mobile Transactions and Behavior Generation: A mobile network of cells is created with a base station in each cell. Multiple mobile users are created in several cells. The

mobile users move in random from one location to another and access more services from the Web through ISAP. The user's movement from one cell to another, their requested services and the current time are monitored and logged into huge databases. Such logs make the Mobile transaction database and it is used in the next two modules.

2) Usage of Clustering Method: Users in the different user groups may have different mobile transaction behaviors. Location-Based Service Alignment (LBS-Alignment) technique measures the similarity among multiple users and provides it to CO-Smart-CAST technique. Clustering method named Cluster Object-based Smart Cluster Affinity to Search Technique (CO-Smart-CAST) builds a cluster model.

3) Usage of Segmentation Method: In a mobile transaction database, similar mobile behaviors exist under some certain time segments. To discriminate the different time segments, where the user's behaviors are found to be similar the temporal property is used by time segmenting the logs using time intervals. The segmented time intervals and the corresponding users' mobile transactions are made as entries in the time segmentation table. The output of this module and the second module are provided as input for the fourth module.

4) Applying CTMSP-Mine Technique: User cluster from the second module and time interval table from the third module are used as input in this module. User clustering and temporal property are considered simultaneously, such that the complete mobile sequential patterns are discovered. This module generates patterns called CTMSPs. The patterns and recent behavior of users with current time are provided to the Prediction Strategy. The prediction methods provide the mobile user's behavior in the near future. The Cluster Temporal Mobile Sequential Pattern-Mine algorithm can be divided into three main steps:

- Frequent-Transaction Mining,
- Transaction-Database Transformation
- CTMSP Mining.

5) Prediction Technique: The CTMSPs are selected from the corresponding user cluster and time interval. Three prediction strategies are proposed for selecting the appropriate CTMSP to predict the mobile behaviors of users: 1) the patterns are selected only from the corresponding cluster a user belongs to 2) the patterns are selected only from the time interval corresponding to current time; and 3) the patterns are selected only from the ones that match the user's recent mobile behaviors.

Whenever a user submits a service request at some place, the user's information including current location, currently requested service and the recent behavior (sequential movement associated with requested services) are input to the prediction component.

4. Results

For the proposed CTMSP-Mine (Cluster-based Temporal Mobile Sequential Pattern - Mine), CO-Smart-CAST, LBS-Alignment algorithmswe evaluated the performance under different system conditions by varying the parameters in terms of number of users, support threshold and length of simulated events.

Study on performance of CTMSP-Mine, CO-Smart-CAST and LBS-Alignment

In the experiments, we study the effects by varying the parameters in terms of number of users, support threshold and length of simulated events. For each experiment, CTMSP Mine, CO-Smart-CAST and LBS-Alignment areevaluated.

i) Effects of varying the number of users

This experiment measures the execution time and the number of discovered frequent patterns when the number of users is altered from 100 to 500 and other parameters fixed as the default values. As shown in Fig 3it is obvious that theexecution time increases linearly with the number of users increased. This demonstrates the scalability of the mining methods under different scales of user numbers.

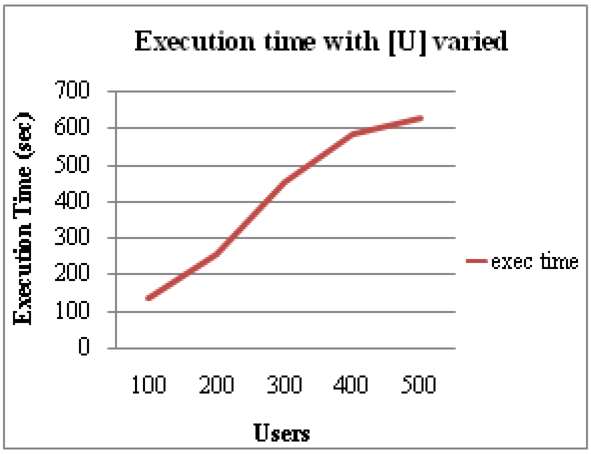

Figure 3: Execution Time

Fig.4also indicates that the number of frequent patterns increases with the increase in the number of users. Through examination on the dataset, we found that more dispersive user behaviors exhibit when there are more users in the network. Consequently, there exist more kinds of user patterns under a larger number of users. This phenomenon results in the increased number of frequent patterns.

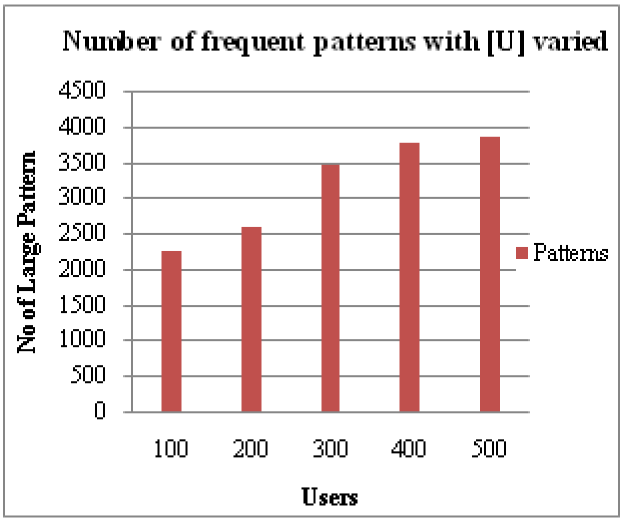

Figure 4: Frequent pattern with U Varied

Study on proposed prediction strategies

Here we have set a different input parameter for predicting links in temporal mobile database shown in fig 5, after setting different input parameter we have to generate the HLR and VLR records then we have to process the generated data records. The generated processed dataset is used as an input for generate ordered pair algorithm. This algorithm is used to find the popular services at each location on a particular time mean we get the pair of location and services In Generate order Pair we find the different services access on different location by users at a particular time. Then we used LBS Alignment algorithm for finding the different services access by mobile users on different location at a particular time along with users. Then we used output of Generate order Pair as input to Smart Cluster Affinity for forming the clusters of location and services. After that we used Time Segmenting Point algorithm for forming the clusters of user and services which he accessed. Fig 6 shows the output of CTMSP-mine. Fig 7 shows the output of prediction system where we predict which user will access which service on which location and at what time.

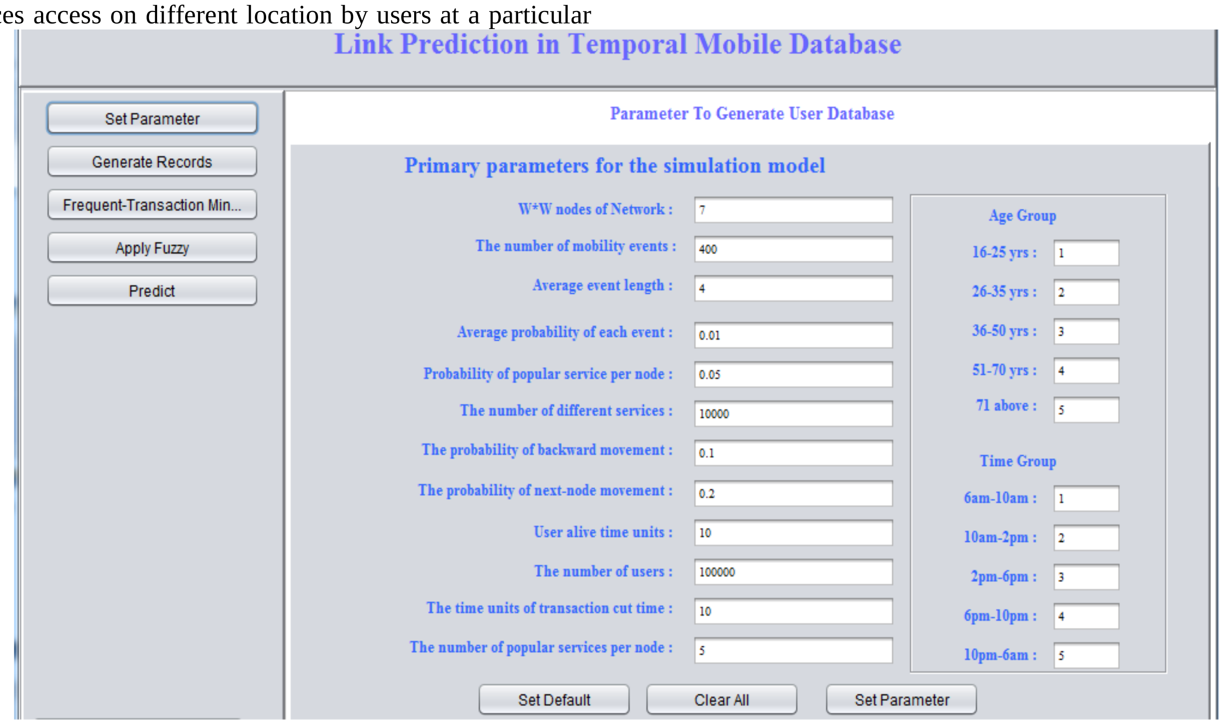

Figure 5: Setting Parameter

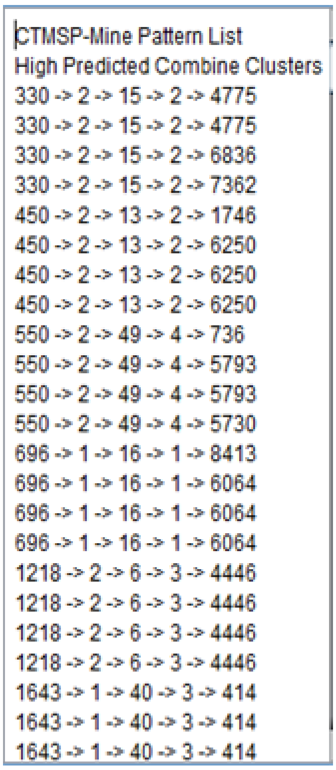
CTMSP-Mine Pattern List
High Predicted Combine Clusters
330 -> 2 -> 15 -> 2 -> 4775
330 -> 2 -> 15 -> 2 -> 4775
330 -> 2 -> 15 -> 2 -> 6836
330 -> 2 -> 15 -> 2 -> 7362
450 -> 2 -> 13 -> 2 -> 1746
450 -> 2 -> 13 -> 2 -> 6250
450 -> 2 -> 13 -> 2 -> 6250
450 -> 2 -> 13 -> 2 -> 6250
550 -> 2 -> 49 -> 4 -> 736
550 -> 2 -> 49 -> 4 -> 5793
550 -> 2 -> 49 -> 4 -> 5793
550 -> 2 -> 49 -> 4 -> 5730
696 -> 1 -> 16 -> 1 -> 8413
696 -> 1 -> 16 -> 1 -> 6064
696 -> 1 -> 16 -> 1 -> 6064
696 -> 1 -> 16 -> 1 -> 6064
1218 -> 2 -> 6 -> 3 -> 4446
1218 -> 2 -> 6 -> 3 -> 4446
1218 -> 2 -> 6 -> 3 -> 4446
1218 -> 2 -> 6 -> 3 -> 4446
1643 -> 1 -> 40 -> 3 -> 414
1643 -> 1 -> 40 -> 3 -> 414
1643 -> 1 -> 40 -> 3 -> 414

Figure 6: Working of CTMSP- Mine

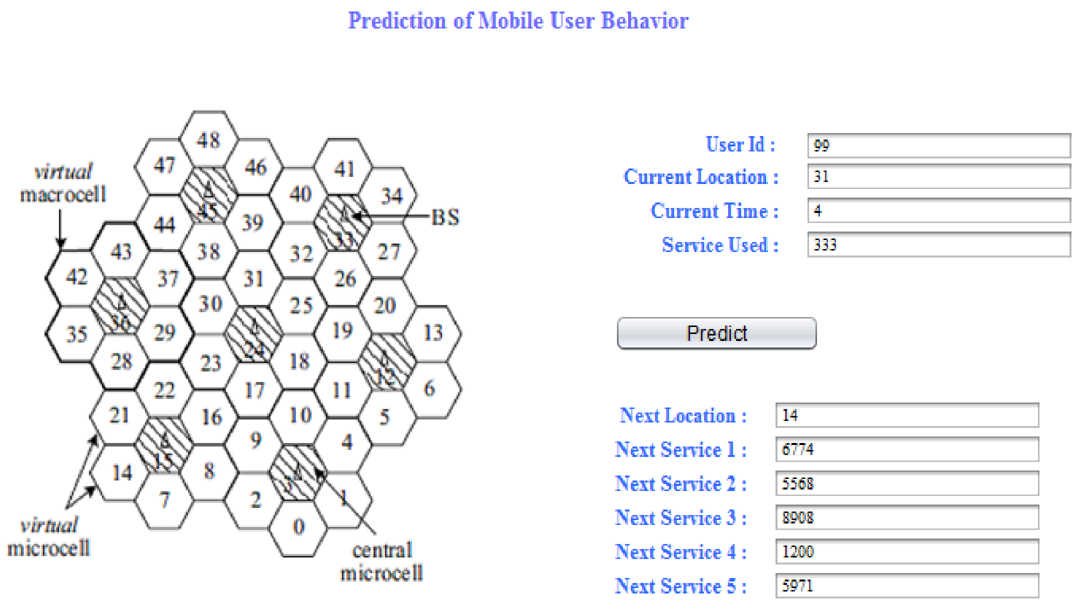

Figure 7: Final prediction of Mobile User Behavior

5. Conclusion

In this paper, we propose a novel data mining method, namely sequential mobile access pattern (SMAP-Mine) that can efficiently discover mobile users' sequential movement patterns associated with requested services. A new method is proposed and named as CTMSP-Mine, for discovering CTMSPs in LBS environments. Further, prediction strategies to predict the subsequent user mobile behaviors using the discovered CTMSPs are introduced. In CTMSP-Mine technique, transaction clustering algorithm named CO Smart-CAST is used to form user clusters, based on the mobile transactions using the proposed LBS-Alignment similarity measurement. Using temporal periods and user clusters simultaneously for prediction, enhances the prediction results. Such prediction results are used by the corresponding mobile service providers to enhance their services.

6. Future Work

By implementing prioritization, it is possible to provide priorities for selected users among the complex user behavior. Many users utilize the mobile services every day but their interest and priorities are different from other user. Such users are prioritized over other mobile users. These prioritized services help to satisfy the needs of mobile users completely when resources are limited. Further, this could be implemented for group behavior too.

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