An Efficient Indexing Technique for Location Prediction of Moving Objects

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Abstract. The necessity of the future index is increasing to predict the future location of moving objects promptly for various location-based services. However, the prediction performance of most future indexes is lowered by the heavy load of extensive future trajectory search in long-range future queries, and their index maintenance cost is high due to the frequent update of future trajectories. Thus, this paper proposes the Probability Cell Trajectory-Tree (PCT-Tree), a cell-based future indexing technique for efficient long-range future location prediction. The PCT-Tree reduces the size of index by building the probability of extensive past trajectories in the unit of cell, and predicts reliable future trajectories using information on past trajectories. Therefore, the PCT-Tree can minimize the cost of communication in future trajectory prediction and the cost of index rebuilding for updating future trajectories. Through experiment, we proved the superiority of the PCT-Tree over existing indexing techniques in the performance of long-range future queries.

Keywords: Moving Objects, PCT-Tree, Future Index, Future Trajectory, Cell, Probability Matrix.

1 Introduction

These days the advance of wireless communication technology and location information technology has brought the development of various location-based services (LBSs) [4,7,8]. In LBS, each moving object, which is a client, transmits information about its location to the server, and the server collects and indexes location information for moving objects and searches necessary location information. Such location indexing of moving objects for LBS is getting more important and research is being made actively on the future index for the fast information service about the present and future location of vehicles in logistics, car tracking and emergent situations [1,2,6].

The future index is a spatio-temporal index for querying present and future locations of moving objects. That is, the future index is used to obtain the future location of moving objects by processing present and future time queries such as "Which taxi will pass the city hall after 10 minutes?" and "Where will a moving object be after 10 minutes?" [6]. The range of future query time to be indexed has a
significant effect on the size of the index and its performance. In general, the longer the query time is, the larger the index is and the lower the accuracy of queries is.

Future indexes are divided into network-based ones and non-network-based ones according to whether or not a road network is used. In the road network environment, a network-based future index is more effective [4,5]. With regard to network-based future indexes, there have been researches on the segment tracking technique [2] that predicts the location of moving objects using information on the road segment, the road network modification technique [1] that modifies road network by extending road segments in order to reduce segment changes, PLM (Prediction Location Model) [6] that generates future trajectories through probability-based prediction of road segments, etc. However, segment tracking has low reliability in the prediction of the future location and increases the communication cost between the server and the client. The road network modification technique changes many road segments in actual situations. PLM has many probability tables and generates an extensive probability search tree in long-range future location prediction.

To solve these problems in future indexes, this paper proposes the Probability Cell Trajectory (PCT)-Tree, an efficient future trajectory indexing technique for predicting the location of moving objects. The PCT-Tree is a future index that can support future trajectory prediction to solve the problem of slow prediction of future location in long-range future queries. The PCT-Tree manages past information on moving objects' entrance into and exit from cells and, by doing so, makes more reliable prediction of the future location of the moving objects. In addition, the PCT-Tree can guarantee faster future trajectory prediction by traversing the probability variables in long-range future location prediction.

This paper is organized as follows. Chapter 2 analyzes existing network-based future index techniques. Chapter 3 explains the PCT-Tree in detail and Chapter 4 discusses the results of performance evaluation through experiment. Finally, Chapter 5 draws conclusions.

2 Network-Based Future Index

This chapter analyzes existing network-based future index techniques that can predict the future location of moving objects. The basic intention of segment tracking is utilizing information on the road network when a client is moving. The server knows what segment of the road network the client is on using information sent by the client and, for this, the server uses the map matching technology. In segment tracking, a client's future location can be predicted as a point moving at a constant speed along a segment represented as a polyline [2]. Here, the speed is what has been reported most recently. However, segment tracking has a problem in that it cannot predict future location at the end of the segment and has to be switched to point or vector tracking and the client has to report to the server whenever it moves from the present segment to another segment.

The road network modification technique changes the road network by extending road segments in order to reduce segment changes. The purpose of road network modification is to connect segments in a way of minimizing segment changes when