Analyzing Spatio-Temporal Data Using Bluetooth for Sales Strategy

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Abstract. Bluetooth beacons can be used to provide location based service by utilizing near distance communication. In order to notice velocity and direction of a moving object, the TPR-Tree can be used for analyzing spatio-temporal data effectively. In this paper, we propose a technique for analyzing spatio-temporal data using Bluetooth for sales strategy. To analyze spatio-temporal data effectively, a technique accumulates spatio-temporal data obtained from the Bluetooth beacons and analyzes the data utilizing the TPR-Tree. The proposed system consists of servlet, DB based on the TPR-Tree and mobile application.

Keywords: Spatio-Temporal Index, TPR-Tree, Bluetooth beacon

1   Introduction

There have been many researches about indoor positioning methods. Some researchers have focused on using Bluetooth beacons. The Bluetooth beacons send ID of beacon from installation place. There are attempts to utilize the Bluetooth beacon such as experiment for indoor position presumption and video prompting and indoor wayfinding[1][2]. Though, studies for spatio-temporal data by using the Bluetooth beacon have not been processed. In order to make an index for spatio-temporal data, the TPR-Tree or the TPR*-Tree[4] are mostly used. This paper proposes that making an index for spatio-temporal data by using the TPR-Tree. This paper is organized as follows. Chapter 2 introduces the Bluetooth beacon and the TPR-Tree. Chapter 3 describes the proposed technique for indexing and analyzing spatio-temporal data. Finally, Chapter 4 presents conclusion and future work.

2   Related Works

2.1   Bluetooth Beacon

Bluetooth beacon is a device that sends a Bluetooth signal at close range[6]. It is similar to NFC (Near Field Communication). But there is a difference about signal range between the Bluetooth beacon and NFC. NFC communication is possible within 20cm. However, the signal range of the Bluetooth beacon is up to 70m. In order to reduce power waste, the Bluetooth beacon utilizes BLE (Bluetooth Low Energy) technology. The Bluetooth beacon does not receive Bluetooth signal and process by itself. The Bluetooth beacon just sends Bluetooth signal within specific range. Therefore, the location information should be obtained by the handheld devices to store it in the database.

2.2   TPR-Tree

The TPR-Tree is a data structure based on the R*-Tree[3][5]. It extends the R*-Tree to process spatio-temporal data for moving object. It is available to search a future position of objects through updating at regular intervals for objects of variable position or size. There is a possibility that errors occur to assume the distant future if the velocity of the object changes more frequently than the periodic update. The error can be solved through more frequently updating, but it may cause a reduction in overall system performance.

3   Analyzing Spatio-Temporal Data Using Bluetooth Beacon

In this section, we propose a technique that analyzing spatio-temporal data by using beacon, mobile application, and server. Fig. 1 shows overall architecture which utilizing the Bluetooth beacon and spatio-temporal data. Installed beacons send Bluetooth signal which contains own ID information. The mobile application is connected to the Bluetooth beacon and receives its ID. After connection, it sends the beacon's ID to the server to obtain the installed location of the beacon. The server consists of beacon DB, spatio-temporal DB and management servlet. The beacon DB stores list of the beacon's ID and information about installation location. The servlet constructs and stores the TPR-Tree index with the location and direction of the moving object in the spatio-temporal DB. The servlet also provides the various functions for requests from the mobile application.
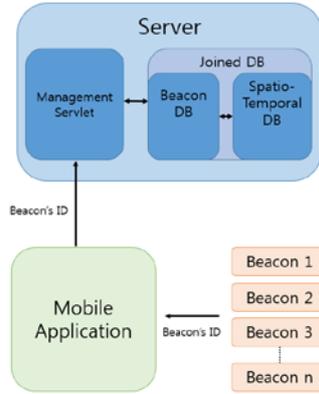
Fig. 1. Overall Architecture

Fig. 2 shows the graph that spatio-temporal data are stored in the spatio-temporal DB by a certain time(t). The circles represent location and ID of the beacons. The rectangle represents the number of users who access the beacons. The dotted lines which connect each circle represent paths which user can move. The arrows which are next to the paths represent the number of users who are moving and direction of movement. As can be seen in Fig. 2, the most crowded beacon is beacon No.2 from t = 0 to t = 2. Fig.2 shows that no one moves to other beacons from beacon No.2. Users who are in the range of beacon No.4 at t = 1 move to beacon No.6. The eight users move to the beacon No.4 from beacon No.3 and 2 users come from beacon No.1. Thus, the place near the beacon No.4 is the most crowded area. Fig. 2 shows that any users do not access to the beacon No.5. The technique that we propose can be utilized in the department store. The manager of the department store may want to know the most crowded place for advertisement. If the actual result is less than the expected sales figures, than the manager has to analyze the problem. This technique can be useful for the manager to decide the sales strategy. In order to improve the profit, the manager could prepare some events near the beacons No.2, 4, and 6 because there are many customers.
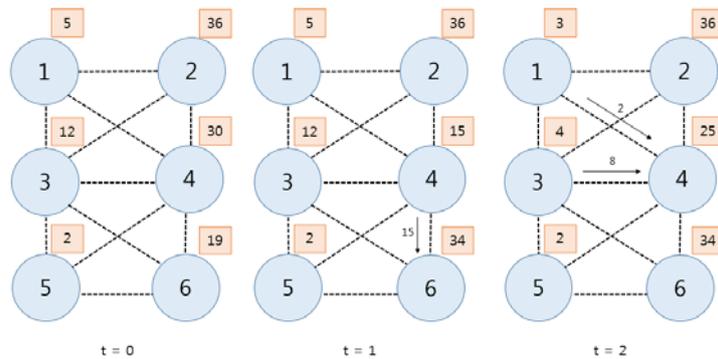

Fig. 2. User's moving by the certain time(t)

4   Conclusion

This paper proposed a technique for analyzing spatio-temporal data by using Bluetooth beacon and TPR-Tree for making the sales strategy. In general, data structures for using spatial data such as R-Tree or R*-Tree do not consider time variation of moving object. To solve this problem, this paper applied the TPR-Tree to process moving object and analyzed the location for advertisement in indoor environment using the Bluetooth beacons. The proposed method can be used to predict user's movement. The manager may exploit the information for advertisement to maximize the sales figures. Our future work could focus on processing the Big Data that collected by many customers.

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