Chapter 84

A New Spatial Transformation Scheme for Preventing Location Data Disclosure in Cloud Computing

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ABSTRACT

Because much interest in spatial database for cloud computing has been attracted, studies on preserving location data privacy have been actively done. However, since the existing spatial transformation schemes are weak to a proximity attack, they cannot preserve the privacy of users who enjoy location-based services in the cloud computing. Therefore, a transformation scheme is required for providing a safe service to users. We, in this chapter, propose a new transformation scheme based on a line symmetric transformation (LST). The proposed scheme performs both LST-based data distribution and error injection transformation for preventing a proximity attack effectively. Finally, we show from our performance analysis that the proposed scheme greatly reduces the success rate of the proximity attack while performing the spatial transformation in an efficient way.

INTRODUCTION

Due to the recent developments of wireless positioning capabilities, such as GPS-equipped smart phones and PDA, location-based services (LBSs) are popular (Taniar, 2011; Safar, 2009; Xuan, 2011). In LBSs, mobile users are usually getting location information combined with traffic information, friend finder, and adjacent neighbor. However, the users can make use of these kinds of services by revealing their exact location to a location-based service provider. So, the users may meet a privacy violation problem (Xiong, 2007). Recently, database outsourcing (Singh, 2008; Singh, 2009) has been one of the most

popular trends in cloud computing. Due to the rapid advancements in LBSs, the speed of transmitting a terabyte of data over long distance has significantly increased and the amount of information generated in our daily lives has grown rapidly over the past decade. This large amount of information requires sophisticated management systems that are beyond the capabilities of individuals or small business. Thus, database outsourcing boosts up its popularity. Because database is separated from a data owner (DO) in database outsourcing, a service provider (SP) is responsible for data storage and performs query processing for the authorized query issuer. However, because the data owner does not want to disclose the original data to the service provider, privacy issues for the database outsourcing have been actively studied (Xiong, 2007; Qiu, 2008; Yi, 2009; Haber, 2009; Yang, 2009; Sachridis, 2010; Jiang, 2010; Ciriani, 2011; Zhou, 2012; Anil, 2013).

For the sake of data protection from an adversary, there have been few transformation techniques in database outsourcing. However, spatial transformation and distance-based conversion techniques are widely used. The distance-based transformation method basically calculates the distance between the actual spatial data and converts them into the transformed data. The most popular distance-based transformation method is Metric Preserving Transformation (MPT) that is proposed by Yiu (2010; 2012). The method maintains the order of the encryption by using Order Preserving Encryption Scheme (OPES) (Agrawal, 2004). Because this kind of method calculates the distance between the spatial data, an attacker cannot infer the original coordinates from the transformed data. However, MPT includes a large numbers of false matches since it is focusing on the preservation of distance value while performing query processing. In addition, MPT can support only nearest neighbor (NN) queries, while it does not such typical queries as range and k-NN queries. For spatial transformation techniques, Gutscher (2006) first proposed a parallel transformation technique in which data points are transformed based on an axis. If an attacker is able to find out one precise transformed point, he/she can easily reveal other points as well. Secondly, Yiu (2010) proposed a spatial transformation technique that re-distributes the location space. By changing the spatial distribution and using SHA-512 secure hash functions, the spatial transformation techniques can make it impossible to disclose the transformed data. However, they do not protect against a proximity attack which is one of the most important attack models in the outsourced databases.

To solve these problems, we propose a new spatial coordinate transformation technique which re-distributes data and inserts some error with the original data. Because the proposed method makes use of line symmetric based transformation, it can effectively protect against proximity attacks. In addition, the proposed method can support both k-NN and range queries. Our contributions can be summarized as follows:

- We present a framework for providing the confidentiality of spatial data that is outsourced to a service provider;
- We provide a proximity attack model for assessing spatial transformation methods and present k-NN and range query processing algorithms for the transformed data;
- We also present an extensive experimental evaluation of our technique by using real data set (e.g., North East USA).

The rest of this paper is organized as follows. In Section 2, we briefly review related works. In Section 3, we discuss typical system architecture for database outsourcing and propose a line symmetric based transformation technique. An empirical evaluation is presented in Section 4. Finally, Section 5 concludes our work with future research direction.

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