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SPATIAL QUERY VERIFICATION OF LOCATION BASED SERVICES IN OUTSOURCED SPATIO TEMPORAL DATABASES

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ABSTRACT

Increased smart phone usage and GPS-enabled devices enlarged the popularity of location based services. The necessity of outsourcing spatial data has also grown hastily. In this paradigm we need to believe a third-party service provider but is not always reliable. Therefore, ensuring spatial query integrity is critical. In this dynamic world, frequent updates from spatial road network, which is a critical update, must also be handled. This paper mainly focuses on the Outsourced Spatial Database (OSDB) model and an efficient k-nearest query verification algorithm, which allows a client to verify the correctness and completeness of the result set in dynamic environment. This approach is based on neighborhood information derived from the voronoi diagram of the essential spatial data set and can handle fundamental spatial query types, like k NN query, shortest path query. In order to handle frequent network changes in dynamic environment, an enhanced representation model of Time Aggregated Graph (TAG) has been used. TAG is capable of holding the dynamic edge change say, traffic density change along with different time instances. Integrating both these techniques may lead to improvement in the efficiency of the system in dynamic and real world environment.

Keywords: Outsourced Spatio temporal database, Voronoi diagram, Time Aggregated graph.

1. INTRODUCTION

In this Internet age, the usage of smart phones and GPS- enabled devices for location based services is growing enormously over the past few years. At present, the navigation technologies in electronic devices like mobile phones, tablets etc., brought in the location-based services with new opportunities. It helps the users to identify their location relative to services, amenities and other people. The amount of digital spatial information available for day-to-day use has grown at an exceptional pace. The Data Owners (DO) are in the need for outsourcing their spatial data to third party Service Provider (SP). This helps the data owners to reduce their maintenance cost along with the
Operational cost. The SP is responsible for processing the data and answering client queries.

In the Outsourced Spatial Database model (OSDB), the clients will be the mobile users. They submit their location based queries in order to discover the points of Interest (POIs) in their neighborhood, for e.g., "Finding nearest vehicle to the current location”. Now the SP has to process the query and return the result to the Client. There exist two major points in this outsourced database model. First, as the SP is not the real owner, they may return incorrect results. Second, the query results might be replaced with fake ones by some malicious attackers. Query integrity in the sense the trustworthiness of hosting environment needs to be assured. When a client receives the query results from the service provider, then it must be able to verify that the data is originated from DO and the result set is correct and complete. The framework commonly used for query integrity assurance is based on public key crypto system, RSA and to solve query verification problem is kNN query verification technique. The database outsourcing system architecture is shown in the Fig 1. It describes the working of the system.

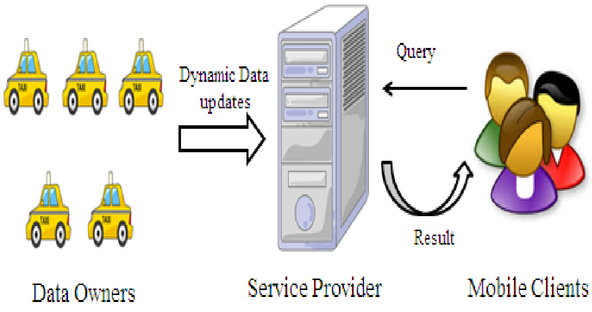

Fig 1. Database outsourcing architecture.

For ensuring the integrity of query results, the generic framework used is based on Digital signatures. This uses public key cryptosystem, such as RSA. The DO digitally signs the data by using signatures. Then it transmit the data to the SP. SP will build the necessary data structure for efficient query processing. When SP receives a query from the client, it generates a verification object (VO) that holds the result set along with the corresponding authentication information. Finally, SP sends VO to the client using which client can verify the results. Additionally, this paper concentrates on handling frequent updates. In case of spatial road network, the location of objects moving around like vehicles change dynamically. This leads to high volume of updates. Concurrently some network updates are also dynamic like traffic density changes or directions (one way, two ways). Those updates must be also handled for effective results. The dynamic nature of the road network is handled by an enhanced form of Time Aggregated Graph (TAG). In order to effectively improve the performance of the system which considers both dynamic nature of road network and the integrity verification, kNN query verification technique with TAG is used.

The remainder of this paper is organized as follows. Section 2 reviews related work and Section 3 discusses on query integrity assurance. Section 4 describes briefly about handling frequent updates Section 5 discusses about the experimental results and Finally, Section 6 is the conclusion.

2 RELATED WORKS

In this section, we review previous works related to k- NN query authentication methods and handling frequent and dynamic network updates.

2.1 Nearest Neighbor Computation

A commonly used query in real time spatial application for searching is the k-nearest- neighbor query [1]. There are algorithms for supporting queries on spatial networks. MR Tree and MR* Tree are some efficient authenticated data structures with respect to space hold up for fast query processing and verification. It was proposed by Y. Yang et al. [3] but it performs well for low selectivity query. It does not support for high selectivity query and also the size of VO is large. The concept of outsourcing was proposed by Y. Yang et al. [4]. The first approach based on the network Voronoi diagram was introduced in [5] for evaluating NN queries on spatial networks. Hu et al. [6] designed the VN-Auth scheme, which is both efficient and deterministic. The main aim of the VN Auth is separating the authentication information from the spatial index. It provides the efficient query results to the users. Ling hu, cyrus shahabi(2010) [7] proposed kNN query verification technique which utilizes the network Voronoi diagrams and neighbors to prove the integrity of the query result. This concept, unlike previous work that verifies *k*-nearest-neighbor results in the Euclidean space, our approach validates both the distance and the shortest path from the query point to its *k*NN result on the road network. VN^3 was proposed by Mohammad Kolahdouzan and Cyrus Shahabi[8] is to partition a large network in to smaller or more manageable regions. Each cell of this Voronoi diagram is pinpointed by one object (e.g., a restaurant or schol) and contains the nodes that are closest to that object in network distance (and not the Euclidian distance). It uses road network distance.

2.2 Graph representation for dynamic road network

A lot of strategies have been implemented related to road network representation. Given a spatial network, it varies over time (e.g., time-varying traffic densities on road networks). Representing the temporal environment of spatial networks would possibly allow us to raise fascinating questions and find effective solutions. It is often necessary to develop a model that handle both the time dependence of the data and the its connectivity of the locations. The model needs to balance storage efficiency and communicative power and provide acceptable support for the algorithms that process the data. There are many ways to represent the spatio temporal road network like snapshot model, Time Extended Graph, Time Aggregated Graph(TAG) as specified by Michael R. Evans and et al.(2015),[9] . Time aggregated graphs (TAG), at their simplest, show a network with a time series of attributes on nodes, edges or both. These time series represent the state of an object at each time step. If we were to compare it to a more familiar temporal geography idea, such as space-time paths, we can easily represent the travel of one person over time in a TAG.

B. George et al.,(2013) [10] and shashi et al.,(2008) [11] proposed Time Aggregated Graphs (TAG). When compared to Time Extended Graph (TEG), TAG do not replicate nodes and edges across time; rather they allow the properties of edges and nodes to be modeled as a time series. The model does not replicate the entire graph for every instant of time. Hence it uses less memory and the algorithms for common operations are computationally more efficient than for time expanded networks.

2.3 Authentication of kNN queries

For authentication, the system uses a digital signature based public key cryptosystem such as RSA [12]. The private key is kept secret at DO, whereas the public key is accessible by all clients. Using its private key, the DO digitally signs the data by generating a signatures. Then, it sends encrypted data to SP which constructs the necessary data structure for efficient query processing. When SP receives a query from a client, it generates a verification object (VO) that contains the result set along with the corresponding authentication information. Finally, SP sends the VO to the client, which can verify the results using the public key of the DO.

Wei-Shinn Ku, Ling Hu et al., [13] proposed a one-way spatial transformation method based on Hilbert curves, which encrypts the spatial data before outsourcing and hence ensures its privacy. Next, by probabilistically replicating a portion of the data and encrypting it with a different encryption key This approach is also applicable for both *k*-nearest-neighbour and spatial range queries, the building blocks of any LBS application. But this technique has a drawback, it is prone to attacks.

III EXISTING SYSTEM

The spatial dataset contains large volume of data objects. The Data owner cannot handle all data. Hence DO outsource its database (dynamic data) to third party Service Provider (SP). The service providers are not actual data owners. To check the correctness and completeness of the result set, k-NN Query verification technique is used. The overall system architecture is shown in the Fig 3. This technique ensures integrity by verifying the authentication and neighborhood information [1].

3.1 Voronoi Diagrams

Voronoi neighbor technique is used to find the nearest neighbors for each POI. Given a set of objects P={V_1,V_2,……V_n} in R, the Voronoi diagram of P is denoted as VD(P) as shown in the Fig 2. The region R is partitioned into n distinct regions. Each object V_i in P belongs to only one region and every point in that region is closer to V_i than to any other object. It follows four properties. [1][5].

1) For a given set of points, the each point belongs to individual Voronoi cell.
2) The average number of Voronoi edges per Voronoi polygon does not exceed 6.
3) Given the Voronoi diagram of P, the nearest neighbor of a query point q is p, iff q ϵ VC (p).
4) Consider k points in the Voronoi diagram, if one point belongs to the query then at least one of the k-1 points is nearest neighbor of the point which belong to query.

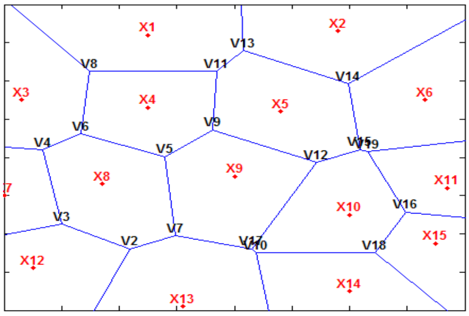

Fig 2 Voronoi Diagram sample

3.2 kNN Query Processing

In outsourced database environment the client post the query to the SP and the SP will process the query on behalf of data owner. As result, the SP will send the verification objects (VO) to the requested users. The VO contains query results along with authentication information which is used for checking the authentication of DO and for the geometric verification that are can be done by the client. On receiving a query from the client, the SP starts processing. The SP will use TAG to hold the dynamic changing parameter and process the query to retrieve kNN query results effectively. Subsequently, the SP also constructs a Verification object (VO) for the KNN query result. This VO contains the query result along with the authentication information. This information is used by client for verifying the integrity. The existing system architecture is shown in fig.3

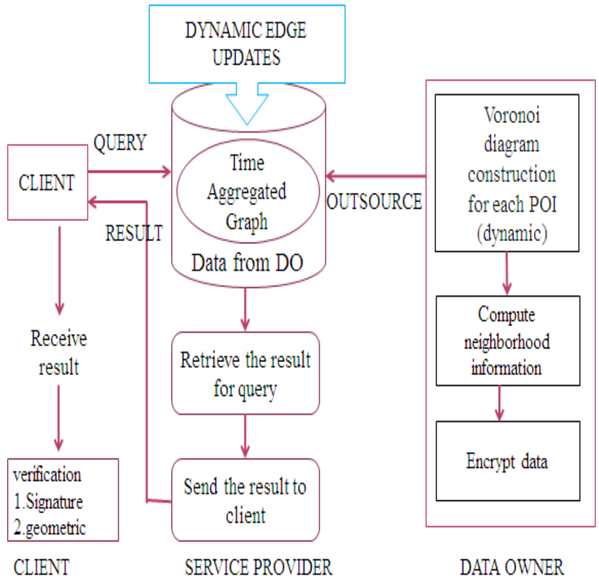

Fig 3 System Architecture

3.3 Verification of Query result

The Query verification process consists of two steps. When the Client receives the Verification Object from the SP, it need to perform 1) Signature verification. 2) Geometric verification. During signature verification, it ensures for the aggregated signature using some signature verification mechanisms such as batch RSA to ensure that the result set is originated from DO and it is not falsified by attackers or SP. Next, it verifies geometric property of the query result. The result set contains the neighborhood information for the requested query. For eg, “Find the most nearest taxi to my current location”. Then the kNN algorithm is used to find out the nearest neighbor for that particular location. Then it compares the result set with the result generated by the SP using kNN verification technique. During comparison it checks the nearest neighbor details and the distance information for particular time instance t generated by both the client and the SP. If the information in both the result set match exactly then the query integrity is verified. Hence the result set generated by the service providers is correct and complete and privacy and integrity of the query result is ensured.

IV PROPOSED SYSTEM

The problem in the moving object databases is that location of DO changes typically from time to time. It is assumed that the DO updates his location and Nearest Neighbours once in 30 minutes. Hence the update becomes dynamic. In the real world scenario, dynamic updates are most welcome as the Service Provider can retrieve recent update from the DO and satisfy the client. And additionally traffic updates like density changes in an edge (road segment) is also one of the important dynamic update that must be handled during a nearest neighbor query. First, the road segments change dynamically says, some routes may be one way during peak hours. Second, even though the cab is near to the query point, if the density is high then it may increase the time. Time Aggregated Graph is chosen to represent this dynamic spatio temporal road network. It might efficiently manage the database and handles frequent updates.

There are two different dynamic updates considered in this work. One is the updates from the Data Owner. Second, the edge update is a dynamic update. Edges are the road segments. Edge update can be the cost between the particular edges.

The cost parameter can be distance, travel time, traffic density etc., Here the cost is considered as traffic density. The density keeps changing say, during peak hours like morning 8AM density may be very high. At 12PM the density of edge can be reduced. Or the edge can be changed one way during peak hours and may be two ways at leisure time. However the scenario is, the traffic density update is a dynamic update. Hence Time Aggregated Graph (TAG) is chosen to solve this problem.

4.1 Time Aggregated Graph

The cost of the edges (traffic density) changes at various time instances. We require a model to hold the traffic density along with the time between different nodes. This parameter is considered to be important because even though the cab is nearby to the client, because of high traffic density the cab may be delayed. To improve the efficiency of the system we choose an enhanced form of Time Aggregated Graph [9][10][11] such that it holds both the density along with different time instances. Fig 4 illustrates the TAG. A person at node A is indicated as Person during time instance t=1. At t=2 there is no person at node A and hence is left blank. But Person reached node B at t=2 hence at t=2 node B is marked Person. The connection between nodes indicates the cost at three time instances. During t=1, the cost between node A and node C is 2. And during t=2, 3 it remains constant 1. So, it is concluded that Time Aggregated Graph is suited for representing the dynamic edge updates.

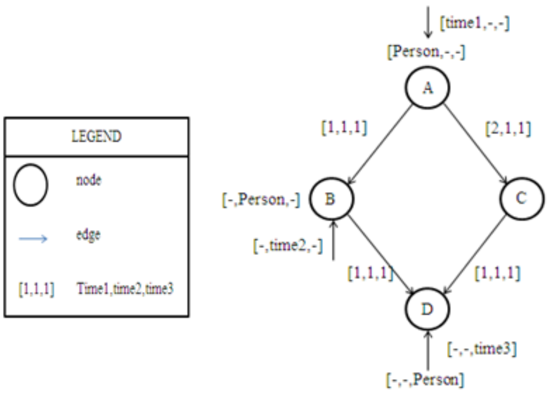

Fig 4 Illustration of Time Aggregated Graph (TAG)

V EXPERIMENTAL RESULTS

The dataset consists of location name, latitude, longitude information. Vehicle updates it current location information along with the time stamp that is used for nearest neighbor computation. Here, the nearest neighbor computation is done using voronoi diagram and the result set is encrypted using RSA algorithm using private key. The public key is announced as public for the client to use it for decryption.

The Voronoi diagram used in nearest neighbor computation. It takes the latitude and longitude information of vehicles and the locations and finds the Euclidian distance between them. Then it uses voronoi diagram for finding the nearest neighbor as shown in Fig 5. Then this data is encrypted and outsourced to service provider environment. The service provider uses this information to respond query posted by user for Eg. “Find nearest Taxi to my current location”. It retrieves this information from the outsourced data and send verification object to the client. The client uses the verification object to verify the integrity of the query result.

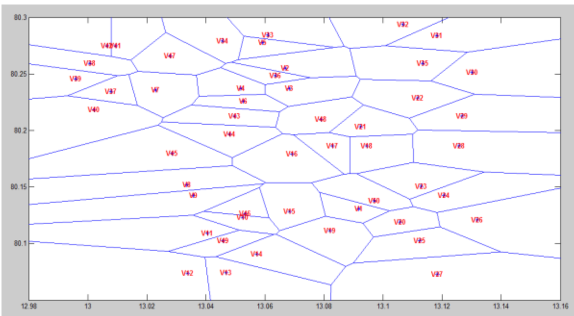

Fig 5 Voronoi diagram at time 9.30 AM

VI CONCLUSION

In this paper, query verification problem for *k*-nearest-neighbor queries on road networks and how to handle updates generated from moving objects is studied. The existing system cannot handle updates of moving objects and. As an enhancement, this work combines the two approaches, k-Nearest neighbor query verification technique and Time Aggregated Graph along with the verification of query result integrity.

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