International Journal of Advances in Computer and Electronics Engineering
Volume: 1 Issue: 1, May 2016, pp. 13–17

Travel Time Computation on Live Road Network over Outsourced Spatio Temporal Databases

[1]A.Suganya, [2]R.Chandrasekar
[1]PG Scholar, Department of Computer Science and Engineering,
Dr. Mahalingam College of Engineering and Technology, Tamil Nadu, India
[2]Assistant Professor, Department of Computer Science and Engineering,
Dr. Mahalingam College of Engineering and Technology, Tamil Nadu, India
[1]suganya.jo92@gmail.com, [2]sekar.vrc@gmail.com

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 fast moving world, the patience of the customer really means a lot. When a NN query is projected, obviously the clients expect the vehicles to reach them very shortly, where travel time comes into focus. Also, in this dynamic world, frequent updates from spatial road network, which is a critical update, must also be handled. In order to handle frequent network changes in dynamic environment, an enhanced representation model called 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. This paper mainly focuses on the Outsourced Spatial Database (OSDB) model, Nearest Neighbor query and an efficient Shortest Path Time Aggregated Graph (SP-TAG) for shortest path and travel time computation 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. Integrating these techniques may lead to improvement in the efficiency of the system in dynamic and real world environment.*

Keyword: *Outsourced Spatio temporal database; Time Aggregated graph; SP-TAG, Voronoi diagram;*

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) is in the need for outsourcing their spatial data to third party Service Provider (SP). This helps the data owners to reduce their maintenance and 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 eg, "Finding nearest vehicle to the current location”. Now the SP has to process the query and return the result to the Client. In static environment, greedy algorithms like Dijkstra’s, A* algorithm etc., works well. But the real world is dynamic. A representation model for representing the dynamic road network is Graph. Many representation models like Snapshot model, Time Extended Graph (TEG), Time Aggregated Graph (TAG) are in existence among which TAG is chosen. Now, a suitable algorithm must replace the shortest path algorithms like Dijkstra and A*. The algorithm must produce the shortest path and travel time. In search, Shortest Path Time Aggregated Graph (SP-TAG) is found to be a better replacement which not only act as replacement to those shortest path algorithms but also capable of accommodating the temporal and dynamic behavior of the road network.

In outsourcing environment, there exist two major points. The correctness and completeness of the query result provided by the service provider. Correctness indicates all datareturned by SP originate from DO without any falsificationand the query result is identical to that computed by DO. Completeness indicates all eligible results have been included by SP in the result set. When a client receives the query results

International Journal of Advances in Computer and Electronics Engineering
Volume: 1 Issue: 1, May 2016, pp. 13–17

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. Also the result provided by the service provider should be the shortest path and shortest time to reach client. The database outsourcing system architecture is shown in the Figure 1.

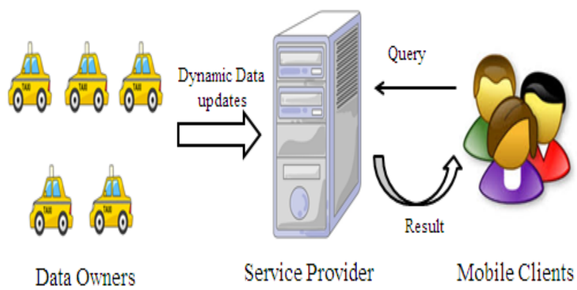

Figure 1 Database outsourcing architecture.

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. LITERATURE SURVEY

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. 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, cyrusshahabi(2010)[7] proposed kNNquery 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 networkdistance (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. B. George et al.,(2007) proposed Shortest Path Time Aggregated Graph shortly called SP-TAG [15] for identifying shortest path from the starting time. It use TAG for representing the road network and is a greedy algorithm to find the shortest path. SP-TAG not only computes the shortest path but also calculates the travel time to reach from the source to destination.

2.3 Authentication of kNN queries

For authentication, the system uses a digital signature based public key cryptosystem such as RSA [12]. The private

International Journal of Advances in Computer and Electronics Engineering
Volume: 1 Issue: 1, May 2016, pp. 13–17

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 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.

3. 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.

3.1 Voronoi Diagrams

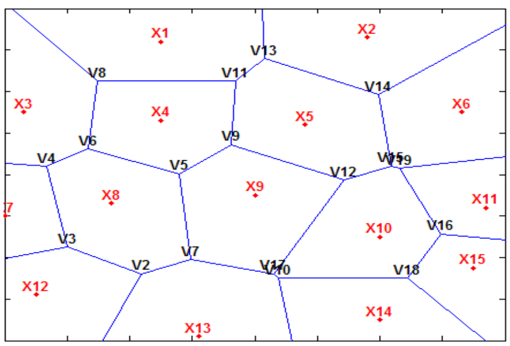

Figure 2 Voronoi Diagram sample

Voronoi neighbor technique is used to find the nearest neighbors for each POI. Given a set of objects $P=\{V_1,V_2,\ldots\ldots V_n\}$ 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) 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 $q \in VC(p)$.
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.

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. In static scenario of road network, the SP will retrieve data given by the DO and apply shortest path algorithms like Dijkstra to compute shortest path. Subsequently, the Verification Object (VO) for the KNN query result is constructed by the client.. This VO contains the query result (NN) along with the authentication information. This information is used by client for verifying the integrity.

3.3 Verification of Query result

On receiving the query result the client performs verification on it to ensure the correctness and completeness of the data. Those verifications are called signature and geometric verification where client will ensure it.

4. 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 edge. 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. SP-TAG algorithm is used for identifying shortest path among the nodes and it might be very easy for making the vehicle to reach the client as soon as possible and at less time. Fig 3 shows the entire system architecture.

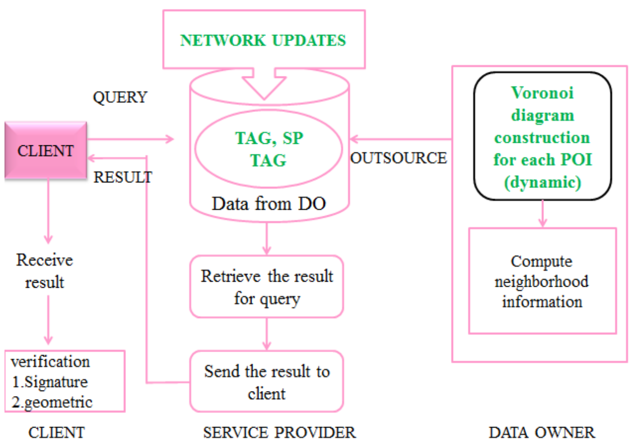

Figure 3 System Architecture

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 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 P during time instance t=1. At t=2 there is no person at node A and hence is left blank. But P reached node B at t=2 hence at t=2 node B is marked P. 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 from this Time Aggregated Graph is suited for representing the dynamic edge updates.

4.2 SP-TAG

Shortest Path Time Aggregated Graph computes shortest path for a given start time in a time dependent network. To represent the network SP-TAG makes use of Time Aggregated Graph (TAG). It follows a greedy strategy to find the shortest path for a given start time. Every node has a cost associated with it which represents the traveltime to reach the node from the source node. The algorithm picks the node withthe least cost and updates the costs of its adjacent nodes.The travel times areassumed to follow the FIFO property. The algorithm of SP-TAG [15] is shown below.

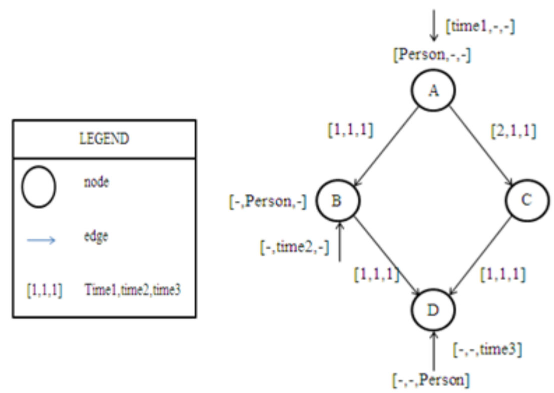

Figure 4 Illustration of Time Aggregated Graph (TAG)

Input:
1) $G(N,E)$: a graph G with a set of nodes N and a set of edges E;
   Each node $n \in N$ has a property:
      Node Presence Time Series : series of positive integers;
   Each edge $e \in E$ has two properties:
      Edge Presence Time Series,
      Travel_time series : series of positive integers;
   $\sigma_{u,v}(t)$ - travel time of edge uv at time t.
2) s: Source node, $s \subseteq N$; 3) d: Destination node, $d \subseteq N$;
4) t_{start}: Start Time;

Output: Shortest Route from s to d for t_{start}

Method:

$c[s] = t_{start}; \forall v \neq s, c[v] = \infty;$
// $c[u]$ is the cost at the node u.
Insert s in priority queue Q.
while Q is not empty do {
  $u = extract\_min(Q)$;
  for each node v adjacent to u do {
    $t = min\_t((u,v), c[u])$;
    if $t + \sigma_{u,v}(t) < c[v]$ {
      $c[v] = t + \sigma_{u,v}(t)$; $parent[v] = u$;
      if v is not in Q, insert v in Q;
    }
  update Q;
  }
 }
}
Output the route from s to d.

Algorithm 1 SP-TAG [15]

5. 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, apply dijkstra, encrypt it and send verification object to the client. The client uses the verification object to verify the integrity of the query result.

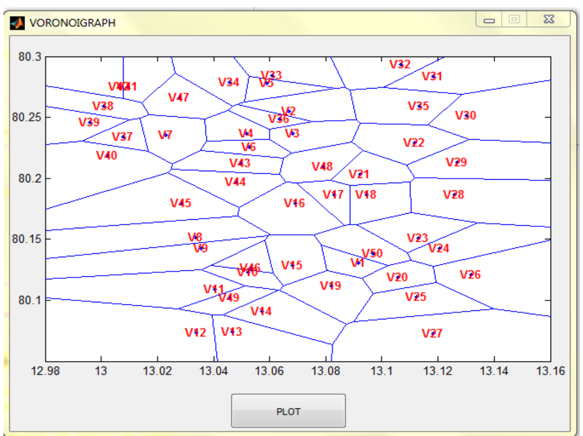

Figure 5 Voronoi diagram at time 9.30 AM

6. CONCLUSION

In this paper, the shortest path and travel time computation fork-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. As an enhancement, this work combines the two approaches, k-Nearest neighbor computation and SP-Time Aggregated Graph for shortest path and travel time computation along with the verification of query result integrity.

REFERENCES

[1] Yinan Jing, Member, IEEE, Ling Hu, Wei-Shinn Ku, Senior Member, IEEE, and Cyrus Shahabi, (2014)“Authentication of k Nearest Neighbor Query on Road Networks” IEEE Transactions of knowledge and data Engineering, vol. 26, NO. 6 June.

[2] Hacigumus,H.Mehrotra,S. and Iyer, B. R.(2002),‘Providing database as a a service’, in Proceeding of 18th International Conference on Data and Engineering, San Jose, California, USA, pp. 29–38.

[3] Yang,Y.Papadopoulos,S. Papadias,D. and G. Kollios (2009), ‘Authenticated indexing for outsourced spatial databases’, International Journal on Very Large Databases, vol. 18, no. 3, pp. 631–648.

[4] Yang,Y. Papadopoulos,S. Papadias,D. and G. Kollios (2008), ‘Spatial outsourcing for location-based services’, in Proceedings of IEEE 24th International Conference on Data and Engineering, Cancún, Mexico, pp. 1082–1091.

[5] Hu,L. Ku,W.S.Bakiras,S. and Shahabi,C.(2013), ‘Spatial query integrity with voronoineighbors’,IEEE Transactions on Knowledge and Data Engineering., vol. 25, no. 4, pp. 863–876.

[6] L Hu, Y Jing,Wei-Shinn ku, Cyrus Shahabai (2012) “Enforcing k nearest neighbor query integrity on road networks”**,** Proceedings of the 20th International Conference on Advances in Geographic Information Systems Pages 422-425.

[7] Hu,L. Ku,W.S. Bakiras,S. and Shahabi,C.(2010), ‘Verifying spatial queries Using voronoineighbors’, in Proceeding of 18th Geographical Information System, San Jose, California ,USA, pp. 350–359.

[8] Mohammad Kolahdouzan and Cyrus Shahabi,(2004) “Voronoi-Based K Nearest Neighbor Search for Spatial Network Databases” in Proceedings of the 30th VLDB Conference, Toronto, Canada.

[9] Michael R. Evans, KwangSoo Yang, ViswanathGunturi, Betsy George, and ShashiShekhar (2015)“Spatio-temporal Networks: Modeling, Storing, and Querying Temporally-Detailed Roadmaps” Springer Science+Business Media Dordrecht M.-P. Kwan et al. (eds.), Space-Time Integration in Geography and GIScience.

[10] B. George and S. Kim,(2013) “Time Aggregated Graph: A Model For Spatio-temporal Networks, Spatio-temporal Networks”, 7 SpringerBriefs in Computer Science.

[11] B.George and shashishekar (2008),“Time Aggregated graph for modeling Spatio-Temporal networks”. http://www.spatial.cs.umn.edu

[12] Fiat, A. (1997), ‘Batch RSA’,Journal on Cryptology, vol. 10, no. 2, pp. 75–88.

[13] Ku,W.SHu,L.Shahabi,C.andWang,H. (2009), ‘Query integrity assurance of location-based services accessing outsourced spatial databases’, in Proceedings of 11th International Symposium on Spatial and Temporal Databases, Aalborg, Denmark, pp. 80–97.

[14] Yiu,M.LLin,Y. and Mouratidis,K.(2010),‘Efficient verification of shortest path search via authenticated hints’, In Proceedings of International Conference on Data and Engineering, Long Beach, California, USA, pp. 237–248.

[15] Betsy George, Sangho Kim, and ShashiShekharSpatio-temporal Network Databases andRouting Algorithms: A Summary of Results, SSTD 2007, LNCS 4605, pp. 460–477, 2007, Springer-Verlag Berlin Heidelberg 2007.

[16] Spatialdatamining-Data Mining Concepts and Techniques 2 edition Hankamber.