Location Based Authentication of KNN Queries with Location and Query Privacy

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Abstract – In mobile communication, spatial queries pose a serious threat to user location privacy because the location of a query may reveal sensitive information about the mobile user. In this paper, study approximate k nearest neighbor (kNN) queries where the mobile user queries the location-based service (LBS) provider about approximate k nearest points of interest (POIs) on the basis of his current location. Proposed a basic solution and a generic solution for the mobile user to preserve his location and query privacy in approximate kNN queries. The proposed solutions are mainly built on the Paillier public-key cryptosystem and can provide both location and query privacy. To preserve query privacy, this basic solution allows the mobile user to retrieve one type of POIs, for example, approximate k nearest car parks, without revealing to the LBS provider what type of points is retrieved. Proposed generic solution can be applied to multiple discrete type attributes of private location-based queries. Compared with existing solutions for kNN queries with location privacy, the proposed solution is more efficient. Experiments have shown that the solution is practical for kNN queries.

Index Terms – ***Location and*** **Query privacy, security, integrity, nearest neighbor and protection.**

1. INTRODUCTION

Location-Based service providers (LBS) offer remote mobile clients with querying services on points-of-interest (e.g., restaurants, cafes, gas stations). A mobile client q issues a moving k nearest neighbor (kNN) query [14] in order to find k points-of-interest closest to q continuously while traveling. Such queries have numerous mobile applications. For example, a tourist may issue a moving kNN query to obtain k nearest restaurants continuously when walking in a city. A driver issues a moving kNN query to find k nearest gas stations continuously while driving.LBS that offer kNN querying services often return mobile clients a safe region [14] in addition to the query results. Given a moving client q, its safe region contains all possible query locations that have the same results as q. In other words, the client only issues a new query to the LBS (for the latest results) when she leaves the safe region. This optimization significantly reduces the communication frequency between the service provider and the clients. Unfortunately, the query results and safe regions returned by LBS may not always be accurate. For instance, a hacker may have infiltrated the LBS's servers so that results of kNN queries all include a particular location (e.g., the White House). Furthermore, it is possible that the LBS is self-compromised, and thus ranks sponsored facilities higher in its query results. The LBS may also return an overly large safe region to the clients for the sake of saving computing resources and communication bandwidth [17], [21]. On the other hand, the LBS may opt to return overly small safe regions so that the clients have to request new safe regions more frequently, if the LBS charges fee for each request, or if the LBS wish to boost its request rate.

Recently, techniques for authenticating query results have received a lot of attentions [9], [10], [16], [17], [18], [19], [20]. Most authentication techniques are based on Merkle tree [13], which is an authenticated data structure (ADS) for ensuring the correctness of query results on a data set. Recently, Yang et al. developed an ADS called Merkle R-tree (MR-tree) for authenticating queries on a spatial data set, and also an improved tree called MR*-tree. Upon receiving a query issued by a mobile client, the LBS not only retrieve the query results but also compute a verification object from the tree. Specifically, the VO consists of certain tree entries that can be later utilized by the client to verify the correctness of results. The issue of authenticating moving kNN queries, however, has not been addressed yet. Existing authentication techniques for static spatial queries [5], [19] have their authentication target as the query results, being a subset of the data set. In contrast, the authentication target of moving queries includes the safe region, which is a geometric shape computed by the LBS at runtime but not part of the data set. Since a safe region is defined based on both query results as well as points not in the query results, the missing of a non-result point in the VO may also fail the authentication of the safe region. Thus, the above techniques cannot help in authenticating moving kNN queries. This paper is devoted to addressing this challenging issue of authenticating moving kNN queries. In this paper, we improve the best authentication method and prove that it achieves VO-optimality. This optimality notion guarantees that the VO contains the minimum data points and tree entries (with respect to the given tree). We also present new optimization techniques for reducing the computation cost and the communication cost of our authentication method. It is especially important to minimize the mobile client's total communication cost as it translates to the client's money (paid to the mobile network provider).

2. RELATED WORK

Authentication techniques have been developed for a variety of queries, including relational queries, sliding window queries, spatial queries, text similarity queries, shortest path queries, moving kNN queries, moving range queries, and subgraph search. However, all existing Authenticated Data Structures (ADS) are either inapplicable or inefficient, since the authentication of *k*NN queries involves verifying both spatial proximity and text relevance. Moreover, authenticating an *k*NN query includes verifying both the top-k result and the accompanying safe zone. The safe zone is calculated based on both the objects in the top-k result and the objects not in the top-k result, so that missing a non-result object may cause a safe zone to fail in the authentication. Although authentication techniques for moving kNN queries and moving range queries involve safe zone verification, the safe zone of an *k*NN query is very different.

Authentication Framework

Authentication consists of two phases, i.e., initialization and query processing & authentication. In the initialization phase, the DO first gets a private key from a key distribution center. Next, it signs the ADS constructed on the data set using the private key and transfers the ADS and signatures to the SP. A client downloads a public key from the key distribution center and the signatures from the SP. In the query processing and authentication phase, the client first issues an *k*NN query. Upon receiving the query, the SP computes the top-k result, the safe zone, and a verification object (VO) that encodes the query result and its safe zone. The client gets the VO from the SP. The top-k result RS and its safe zone _k(RS) are obtained from the VO. The correctness of the top-k result and the safe zone can be verified by the client using the VO, the signatures, and the public key. The client needs to send a new request to the SP only when it leaves the safe zone. When the query moves across the boundary of a safe zone, it requests an updated top-k result and corresponding safe zone. Therefore, authenticating an *k*NN query is equivalent to verifying the correctness of both the top-k result RS and the corresponding safe zone. Moreover The SP is the potential adversary. The SP is outside the administrative scope of the DO and thus cannot be trusted. With the exception of the DO's private key, adversaries are assumed to know all information, including the public key for the secure-hash function, the ADS, the signatures, and the authentication algorithms. They may alter the data set or the ADS, and they may tamper with the search result.

3. PROPOSED SYSTEM

This paper is devoted to addressing this challenging issue of authenticating moving kNN queries. This paper, improve the best authentication method and prove that it achieves VO-optimality. This optimality notion guarantees that the VO contains the minimum data points and tree entries (with respect to the given tree) .Also present new optimization techniques for reducing the computation cost and the communication cost of our authentication method. It is especially important to minimize the mobile client's total communication cost as it translates to the client's money (paid to the mobile network provider).

Advantages of Proposed System

1) Computation optimization that reduces the server and the client CPU time

2) VO compression that reduces the size of each VO

3) Authentication method achieves low communication cost and CPU overhead

4. SYSTEM DESIGN

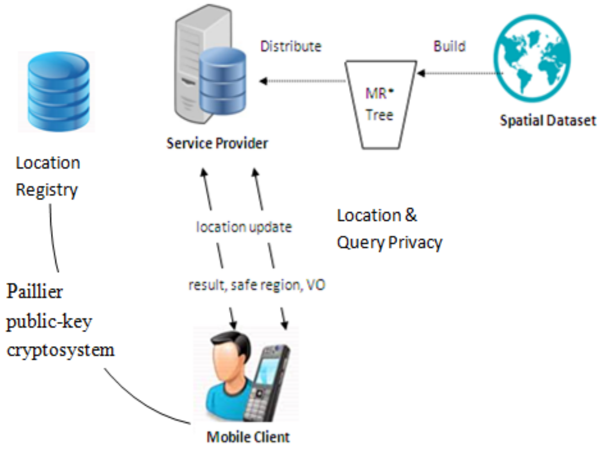


Fig:1 System Architecture

Optimization

Vertex-Based Method (Server)

Algorithm 1. Vertex-Based Method (Server)

```
Receive from client: (Query point q, Integer k)
Using MR-tree/MR*-tree $T_D$(on data set D)
1: S := compute the kNN of q from the tree $T_D$;
2: compute $V_K(S,D)$ from the tree $T_D$;
3: $\gamma := \max_{p \in S} dist(q,p)$; authenticate kNN
4: KVR := $\odot(q, \gamma)$;
```

```
$\psi$ := set of vertices of $V_K(S,D)$  ; authenticate safe region
SRVR := $\cup_{\psi \in \psi} \odot(\psi, \max_{p \in S} dist(\psi,p))$
$\Gamma$ := KVR U SRVR;
VO := DepthFirstRangeSearch($T_D$.root, $\Gamma$);
send VO to the client;
```

Algorithm 1 is the pseudo-code of the server algorithm. Upon receiving the client location q and the number k of required NNs, it computes the kNN result S from an MRtree/MR*-tree. Then, it computes the safe region. Next, it defines verification region G so as to identify useful k points for verifying the kNN result and the safe region, and puts these points into the VO. Specifically, the verification region G is defined as the union of (i) the kNN query result verification region (KVR)and(ii)the kNN safe region verification region (SRVR).

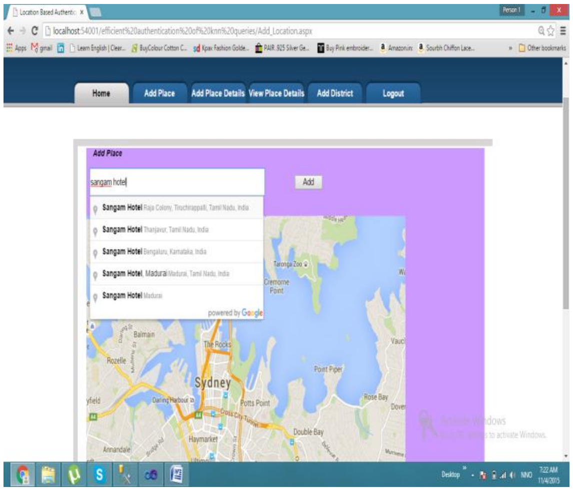
Vertex-BasedMethod (Client)

Algorithm 2. Vertex-Based Method (Client)

```
Receive from server: (Verification object VO)
h'root := reconstruct the root digest from VO;
verify h'root against the tree root signature;
if h'root is correct then
    D':= the set of data points extracted from VO;
    R':= the set of non-leaf entries extracted from VO;
    S':= compute the kNN of q from D';
    $\gamma'$ := max p∈S' dist(q,p);
    if $\forall$e ∈ R' , e n$\odot$(q, $\gamma'$) = θ then
        V := compute $V_K$(S',D')  ;
        $\psi$ := set vertices of V;
        SRVR := $\cup_{\psi \in \psi} \odot(\psi, \max_{p \in S'} dist(\psi,p))$;
        if $\forall$e∈R',e n SRVR= θ then
            return kNN result S'and safe region V;
return authentication failed;
```

Algorithm 2 is the pseudo-code of the client algorithm. Upon receiving the verification object VO from the server, it first reconstructs the root digest from the VO and verifies it against the tree root signature signed by the map provider.If the verification is successful, the VO is guaranteed to contain only entries from the original tree (i.e., no fake entries). Next, it proceeds to verify the correctness of the kNN result and the safe region provided by the VO. It extracts from the VO (i) a set D' of data points, and (ii) a set R'of non-leaf entries, and then computes the kNN result S'from D'.

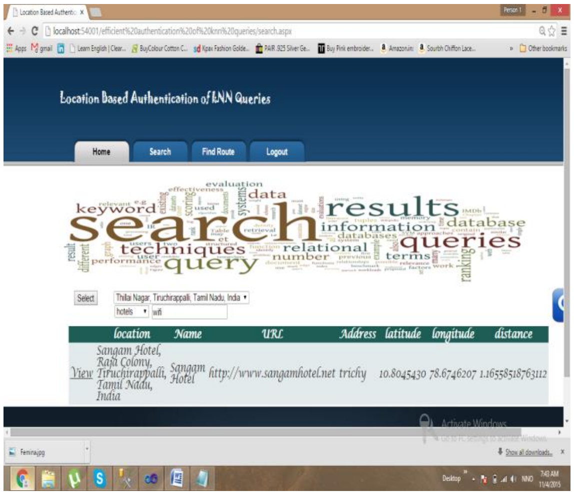
5. OUTPUT SCREENSHOTS



sangam hotel

Sangam Hotel Raja Colony, Tiruchirappalli, Tamil Nadu, India
Sangam Hotel Thanjavur, Tamil Nadu, India
Sangam Hotel Bengaluru, Karnataka, India
Sangam Hotel, Madurai Madurai, Tamil Nadu, India
Sangam Hotel Madurai

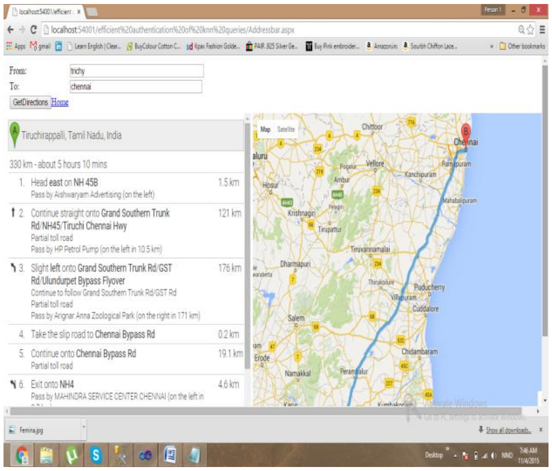
Fig:2 Adding Location Details



Thillai Nagar, Truchirappalli, Tamil Nadu, India
hotels wifi

	location	Name	URL	Address	latitude	longitude	distance
View	Sangam Hotel, Raja Colony, Tiruchirappalli, Tamil Nadu, India	Sangam Hotel	http://www.sangamhotel.net	trichy	10.8045430	78.6746207	1.16558518763112

Fig:3 Location Based Search



From: trichy
To: chennai

Tiruchirappalli, Tamil Nadu, India

330 km - about 5 hours 10 mins

1. Head east on NH 45B 1.5 km
Pass by Aishwaryam Advertising (on the left)

2. Continue straight onto Grand Southern Trunk Rd/NH45/Tiruchi Chennai Hwy 121 km
Partial toll road
Pass by HP Petrol Pump (on the left in 10.5 km)

3. Slight left onto Grand Southern Trunk Rd/GST Rd/Ulundurpet Bypass Flyover 176 km
Continue to follow Grand Southern Trunk Rd/GST Rd
Partial toll road
Pass by Arignar Anna Zoological Park (on the right in 171 km)

4. Take the slip road to Chennai Bypass Rd 0.2 km

5. Continue onto Chennai Bypass Rd 19.1 km
Partial toll road

6. Exit onto NH4 4.6 km
Pass by MAHINDRA SERVICE CENTER CHENNAI (on the left in

Fig:3 Google Map View

6. EXPERIMENTAL EVALUATION

Evaluate all methods on spatial real data. Each point-of-interest stores a lat-long coordinate (16 bytes) and a full geographic name (250 bytes).For dataset, MR*-tree for it with the page size as 4 Kbytes is build. Clients issue kNN queries with the default value of k as 10.

All experiments were run on a 2.5 GHz Intel PC running Windows with 2 GB of RAM. In each experiment, the average performance measure (e.g.server and client CPU time) per client journey per timestamp is reported.

Server Cpu Time

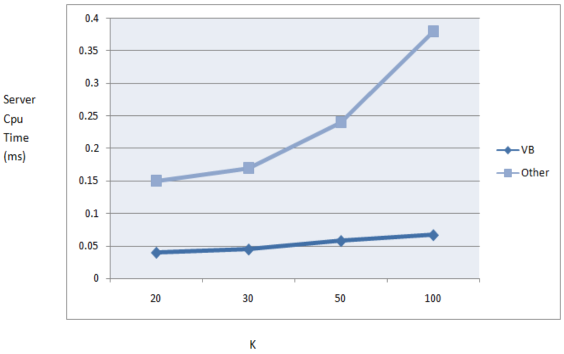


Fig:4 cpu time (server)

Client Cpu Time

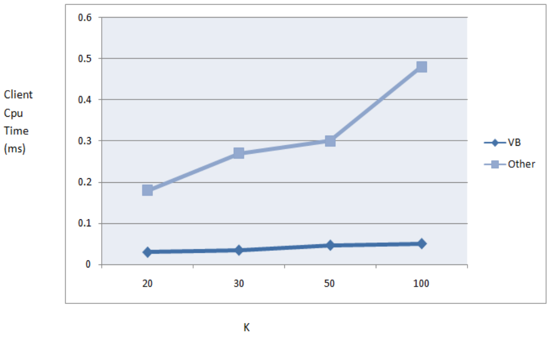


Fig:5 cpu time (client)

7. CONCLUSION

In this project, proposed a basic and a generic approximate k-NN query protocol. Security analysis has shown that the protocol have location privacy, query privacy and data privacy. Performance has shown that the basic protocol performs better than the existing PIR based LBS query protocols in terms of both parallel computation and communication overhead. Experiment evaluation has shown that the basic protocol is practical. Future work is to implement this protocol on mobile devices.

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