Location Dependent Query Processing in Mobile Environment

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***Abstract*—With advancement in Location Based Service and GPS enabled mobile devices, different types of queries to obtain location based information exist in mobile environment. Location based queries or spatial queries are the backbone of Location Based Services. LBS is gaining more popularity in today's world, as they enable the mobile users to obtain location information or location based information. Spatial Query Processing as a tool for Location Based Services is one branch of mobile query processing. In Location dependent query processing, the location information of mobile user is revealed to obtain location based information. Many research works are focusing on privacy protection of mobile users. Many other research works focus on reducing the workload of server while processing mobile queries. Though there exist a lot of research papers that discuss different approaches for doing efficient spatial query processing, this paper propose a novel integrated approach for solving several issues that arise while doing spatial query processing. This paper deals with spatial query processing and has proposed a framework for processing spatial queries efficiently. Both static and dynamic aspect of location dependent query is discussed in this paper.**

***Keywords*-Spatial query processing; Location dependent query; Location based services; Mobile Queries; GPS;**

I. Introduction

With the advancement in hardware technology and wireless communication network, mobile computing applications are in boom[1]. Location based services is one such research area in mobile computing domain that underline this boom. Examples of LBS include emergency services, navigation services, billing services etc. Location dependent data access is an important feature of LBS. In LBS, mobile users with location aware mobile devices are able to make queries about their surrounding anywhere and at any time[2].Spatial query processing or context aware query processing as a backbone of LBS is also gaining more popularity with advancement in LBS technology. Spatial query processing is an important area of research because future of LBS depends how efficiently researcher's device new strategies to process spatial queries considering all issues that arise in spatial query processing. There are two types of spatial queries: *Location dependent queries* and *Location aware queries*. In Location dependent queries, result retrieved by the query depends on location of query issuer[3,4]. Location information is explicitly or implicitly specified in query. As an example, consider the query *"Retrieve closest medical shop near to my current location"*, this query retrieve a list of medical shops depending upon the location of query issuer. In the given example, location information is implicitly specified. Location aware queries are used to retrieve location information of mobile units. Consider the query, *"Where is car x"*, this query retrieve location of car x and is an example of location aware queries. This paper discusses a novel approach to process such spatial queries. The proposed approach can overcome drawbacks like heavy workload to server, Privacy issues, Power consumption of client etc that we face in current spatial query processing. Rest of the paper is organized as follows.In section 2, we discuss spatial query processing with special focus on classification of location dependent queries. Proposed solution is discussed in section 3. Finally section 4 concludes the paper.

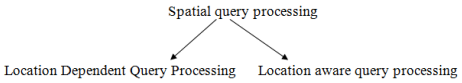

Figure 1. Classification of Spatial Query Processing

II. Spatial Query Processing

Spatial query processing deals with processing of location information of mobile devices. Location is an important piece of information that relates to mobility. Mobility is an important feature of mobile environment. Better support for spatial query processing is given by GPS enabled mobile devices. As a foundation for Location based services, processing of spatial queries is gaining more relevance in mobile computing domain and is an important area of research. Spatial queries are mobile queries that operate on the location information of mobile devices. In spatial queries, either location information is explicitly or implicitly specified in the query or query is used to retrieve location information of mobile device. Accordingly we classify spatial queries into two: *Location dependent query* and *Location aware query*[5,6]. Thus processing of spatial queries involves processing of location dependent and location aware queries. Location dependent query can be targeted to static object or dynamic object. Example of query targeted to static

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object is ”Retrieve cinema theaters in cochin”. In this query, result set contain static object like list of cinema theater names. Example of query targeted to dynamic object is ”Retrieve closest taxis near to my location”. In this query, result set include dynamic object like list of moving taxis whose position changes continuously. As the location of query issuer changes, the result retrieved by queries also changes accordingly. Such queries are called continuous queries.[6,7] We need to continuously refresh the results retrieved by such queries. Location dependent query is an example of continuous queries. We can classify location dependent query basically into spatial queries and temporal queries[8]. While spatial queries focus on location information, temporal queries focus on time. Query like ”Retrieve taxis that crosses cross cut road within two minutes from now” is an example of spatial-temporal location dependent query which specify spatial location like cross cut road and temporal information like two minutes from now. Both spatial and temporal queries can be continuous or non-continuous queries. Range query that retrieve mobile objects within a specified range, Nearest neighbor query that retrieve closest objects nearest to specified location, Navigation query that obtain best route to specified destination etc are different variants of location dependent query.[9]

III. Proposed Approach

We present an integrated approach to spatial query processing that consider heavy workload of server as well as high power consumption of mobile client. Privacy issue of mobile client is also considered in proposed approach. We follow a different approach for processing of spatial queries targeted to static object from processing of queries targeted to dynamic object. In proposed approach both server and client goes through several operating modes while processing spatial queries. The operating modes are as follows:

Sending mode: Client/Server sends query/result in this mode
Receiving mode: Client/Server receive results in this mode
Broadcasting mode: Server broadcast location updates in this mode
Redirecting mode: Server/client redirect query to other clients
Caching mode: Client cache result in this mode
Processing mode: Client/Server process query in this mode

A. Processing of query targeted to static data

A client wants to retrieve result for a query like *”Retrieve me the hospitals near M.G road cochin”*. The client proceeds as follows: Client when it is in the active *sending mode*, send the client id and query to cloak agent. To ensure privacy of client, cloak agent will cloak location specified in query into a cloaking region. Location based query is thus converted into region based query. Client id along with query is then sent to server on behalf of client by the cloak agent. Cloak agent is a middleware between client and server that act as a privacy protector. After obtaining the query, server checks whether the received query is already processed or not. If the query is already processed and there is a nearest active client with query result in its cache, it will switch to *redirect mode*. Redirection of query can be done in two ways. Either server redirect query(refer figure 3) or client redirect query(refer figure3). In server redirection mode, it will redirect the query to that nearest active client that has query result in its cache. In client redirect mode, server sends the client id of nearest active client that has cached result to client who issued the query. After obtaining the client id, query issuer then switch to client redirection mode and redirect the query to the client with obtained client id. In both client redirection mode or server redirection mode, when the redirected query reaches the client, client look up in cache and response back with cached result to client who issued query (in client redirection mode) or server(in server redirection mode). In server redirection mode, received result set is then send to client who issued the query and cached at the client side.

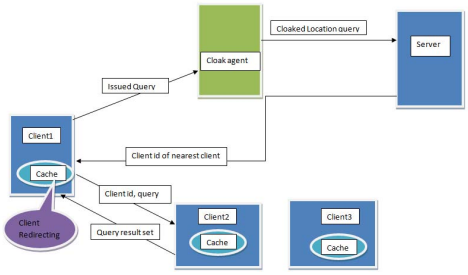

Figure 2. Client in Redirect Mode

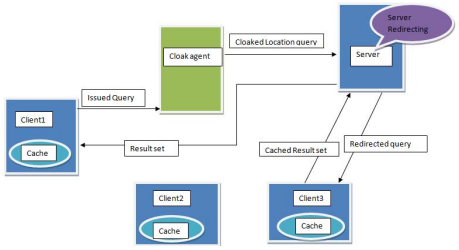

Figure 3. Server in Redirect Mode

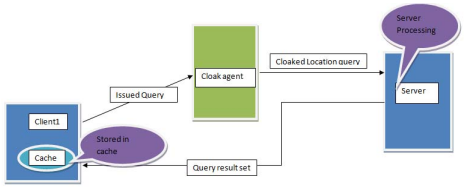

Figure 4. Server in Processing Mode

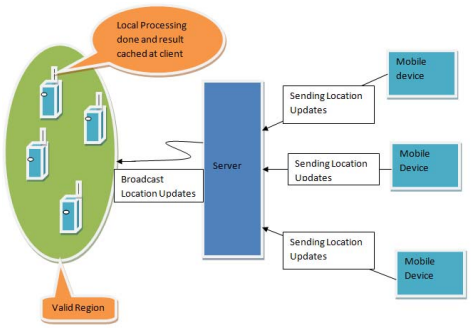

Figure 5. Processing of Query targeted to Dynamic Data

If the query is not already processed, server will then switch to processing mode and will process the query as shown in figure 4. Query is processed in such a way that result superset set has the query results for all possible location in the cloaking region. The result set is then sent to query issuer which refines the result to produce exact result set for specified location in query. Refined result is finally cached for future reference.

B. Processing of query targeted to Dynamic data

Consider a client issued a query like *"Retrieve the closest taxis nearest to my location"*. This query is an example for query that is targeted to dynamic data (List of taxis in the give example) because each time when user location changes, the result of the query changes accordingly. To process such queries, location broadcasting with local processing approach is proposed. In the proposed approach, targeted mobile object (taxis in the specified query) will always update their location information with server. The updated location information is then broadcasted by server when it is in *broadcast mode*. Client who needs to get the result of the query will tune to broadcast channel and listen to broadcasted location information to obtain the needed location updates. After getting the needful, client will switch to local *processing mode* and will process the query and cache the result locally. The cached result is valid until client crosses the valid region. Valid region of a query is an area beyond that result for that query is no more valid. Valid region can be founded out based on the speed of the mobile object. Before switching to local processing mode, it makes sure that it has not processed this query before. If the query is already processed before, then it makes sure that it crosses the valid region so that result cached is no more valid. Only then it has to switch to processing mode and process the query.

IV. Conclusion

In this paper we propose a novel approach to spatial query processing. Previous approaches in query processing were aimed either to reduce the workload of server or workload of client. But our objective is to reduce the workload of both server and client and to obtain the query result with minimum response time. The approach proposed in this paper is an integrated approach which considers protection of privacy of mobile client and reduction of workload. To the best of our knowledge this is the first study that considers privacy protection and reduction in workload together while processing spatial query. Our future direction is to implement this approach and does a comparison study on performance of spatial query processing with previous approaches

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