Unified Performance Analysis of Multihop Wireless Communication Link over Multi-channels

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Abstract. With the rapid increasing of wireless request, user mobility is a critical influence on system performance of mobile environments. Unlike conventional distributed systems, the mobility of users is the major characteristic in a mobile computing environment so that the value of data may depend on location, and processing of a query at one site may give different results than that at another. In this paper, we present the broadcast-based location dependent data delivery scheme for location-based queries. In the approach, broadcasted data objects are dynamically adjusted based on their locations, and the server broadcasts the location dependent data along with access popularity. Then, we present a data evaluation scheme, designed to reduce the query response time. Simulation experiments are conducted to compare the performance of our method with other issues. The results show that our schemes outperform the conventional strategies.

Keywords: location-dependent data, mobile computing environment, broadcast-based data delivery.

1 Introduction

Multi-hop transmission in wireless networks such as cellular and ad hoc networks has been researched in the recent period due to its advantages over traditional networks in terms of deployment and connection. In this scenario, both mobile and stationary clients have the ability to issue spatial requests. The broadcasting of spatial data is an effective way of disseminating data in mobile environments, since this method can be scaled up without any penalty being incurred, when the number of clients grows. However, the system performance obtained with the broadcasting method is highly dependent on the mechanism in which the data is broadcasted [1].

Considering access latency [2], many management schemes designed for mobile environments are based on periodical broadcasting. However, the approach suffers from long query latency and inefficiently utilizes the broadcast bandwidth. Relatively, spatial-dependent request is based on client-initiated. The scheme increases network

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traffic overload substantially due to the expensive uplink checking. In a mobile computing environment, mobile clients may submit queries to mobile centers and wait for responses respectively while they roam between different wireless service areas. To maintain service quality and access accuracy of data items, it is an important issue to manage location dependent data whose value determined by the geographical location of data storage and the geographical location of the mobile unit where the query originated [3]. The rest of this paper is organized as follows. Section 2 gives the related work of this paper.

The proposed method to deal with location-dependent queries is described in section 3. Performance evaluation on varies parameters is conducted in Section 4. Finally, Section 5 concludes this paper.

2 Preliminary and Problem Description

Numerous algorithms exist for answering the queries of specific location [4], motivated by the importance of these queries in fields including geographical information systems (GIS), pattern recognition, document retrieval, and learning theory. Almost all of these algorithms, many of them from the field of computational geometry such as Voronoi diagram [5], are for points in a d-dimensional vector space, but some allow for arbitrary spatial objects, although most are still limited to a point as the query object.

Many of the above algorithms require specialized search structures, but some employ commonly used spatial data structures. For example, algorithms exist for the k-d tree, quad-tree related structures, the R-tree [6], the LSD-tree, and others. In addition, many of the algorithms can be applied to other spatial data structures. For spatial indexing, R-tree provides the better strategy of location distribution. If the query objects cluster around some point, the indexing structure will result in skewed tree. The closer different query objects are, the higher update cost is and the lower efficiency of location division is.

We assume that the data server with a database containing data items, which are all of equal size. A mobile client can cache data values on its local storage. Form mobile users' view, data values are assumed to be of fixed sizes and read-only [7]. In location-dependent services, there are three factors such as data distance, valid scope area and access probability, which can be considered in cache replacement strategy. The definitions of important factors are as follows:

- Data distance (D): the server responds to a query with the suitable value of the data item according to the client's current location.
- Valid scope area (V): data values for a data item depend on geographical locations.
- Access probability (P): hit ratio of the value for a data item depends on the client's current location.

3 Valid Scope and Proposed Method

In view of data caching, precision and dissemination cost are two major issues in the mobile environments [8][9]. Valid scope information has a great influence on performance of location dependent data [10][11]. Hence, the main issue addressed in this paper provides a value function to balance the precision and dissemination cost. The value function for cache items is typically based on access history, such as least recently used (LRU) or a most recently used (MRU) strategy. There are three factors such as data distance, valid scope area and access probability, which can be considered in cache invalidation strategy. We provide the value function below the formula to determine which data item being invalidated in cache.

$$E(I_j) = \frac{P(I_j)}{V(I_j)} \times \frac{1}{D(I_j) \times (T_i - T(I_j))} \quad (1)$$

The value function $E(I_j)$ is denoted as the efficiency of data item I_j, which is defined as individual data item, such as I_A, I_B, etc. Let $P(I_j)$ be the access probability of I_j, $V(I_j)$ be the valid scope area of I_j, and $D(I_j)$ be the data distance of I_j. Besides the three factors, Time-stamp has an impact on caching efficiency. T_i is the current system time and $T(I_j)$ gives a time-stamp for each data item. $(T_i - T(I_j))$ denotes the time difference of recent reference time for a data item. In view of broadcasting time-stamp scheme, if $(T_i - T_j) > (W \times L)$, then the cache item firstly discarded. For temporal locality, the lower value of $(T_i - T(I_j))$ is, the higher the cache item referred. By contrast with spatial locality, $P(I_j)/V(I_j)$ is the cost ratio for referring a cache item. The bigger value of the cost ratio is, the better quality of the location dependent service is.

Combining the features above the discuses, we can derive the value function to measure the efficiency of data item in cache. The bigger value of $E(I_j)$ is, the higher priority of data item with $E(I_j)$ is. The data item with lowest priority is firstly dropped when the cache replacement occurs. The snapshot illustrates the situation below the figure 1. For example, the access sequences of data items are $P(I_A) = 0.3$, $V(I_A) = 6$, $D(I_A) = 3$, $T(I_A) = 1$, $P(I_B) = 0.2$, $V(I_B) = 5$, $D(I_B) = 4$, $T(I_B) = 2$,and $P(I_C) = 0.4$, $V(I_C) = 6$, $D(I_C) = 4$, $T(I_C) = 3$. I_C locates between two valid scopes, so that $P(I_C^1) = 0.2$, $V(I_C^1) = 5$, $D(I_C^1) = 3$, $T(I_C^1) = 4$ should be attached. We assume that the current system time T_i is 6. Based on the above descriptions, we have $E(I_A) = 0.0033$, $E(I_B) = 0.0025$, $E(I_C) = 0.0056$, and $E(I_C^1) = 0.0067$. IB has the lowest priority. When cache replacement occurs, I_B should be a victim.

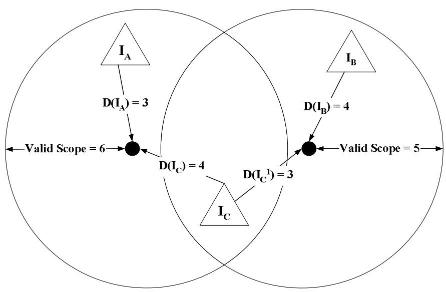

Fig. 1. An example of value function in mobile environments

4 Experimental Results and Performance Analysis

The proposed simulation model does not explicitly model bandwidth instead of similar to previous research [8]. We assume that the requests generated by mobile clients are read only, and no update requests are allowed. A simulated request generator generates requests with exponential inter-arrival time. Each request includes request *id*, arrive-time, and valid scope. We assume that data demand probabilities p_i follow the Zipf [12] distribution:

$$p_i = \frac{\left(\frac{1}{i}\right)^{\theta}}{\sum_{i=1}^{M}\left(\frac{1}{i}\right)^{\theta}}, \left(i = 1, 2, 3, \ldots, M\right) \tag{2}$$

where p_i represents the i'th most popular page. The Zipf distribution allows the pages requested to be skewed. In all the following analysis, the default value of θ is 0.5. This study also uses data distributions to investigate the impact of data access patterns. Figure 2 shows the valid scope with the Zipf parameter ranging from 0.0 to 1.0. If θ equals 0, the distribution corresponds to the uniform distribution.

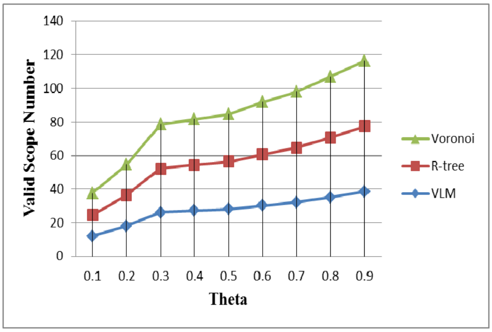

Fig. 2. Valid Scope Under Location Distribution

The proposed method (VLM) outperforms the aforementioned strategies shown as figure 2. Figure 3 illustrates the valid scope under different locations. We vary the number of locations to compare the performance of various speeds. Figure 2 shows that the proposed function evaluates the valid scope in a wide range of settings. The bandwidth utility is an important parameter in the heterogeneous settings. Therefore, this study also investigates the sensitivity of the function to this parameter. The experiments in this study fix the data size and mobility speed. Figure 3 shows that, in general, the function is sensitive to the data size and mobility speed, and the relative order of performance for the function is consistent with previous experiments. The proposed method (VLM) outperforms the other strategies shown as figure 3. We implemented the simulation model described in the section using C++. Each experiment ran the simulation for 30 time units, using an average of 20 runs of each simulation as the final result. Table 1 summarizes the parameters used in this simulation.

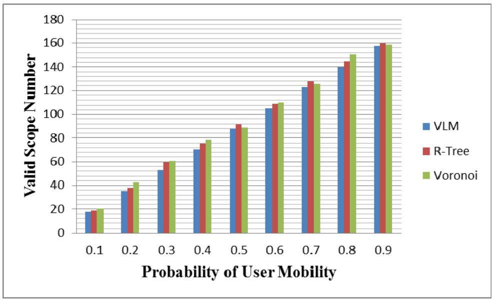

Fig. 3. Valid Scope Under User Mobility

Table 1. Simulation Parameters

Symbol	Default	Range
DBSIZE	100	100-1000
λ	20	2-50
θ	0.5	0.0-1.0
MinSlack	1.0	1-100
MaxSlack	100	1-100
λscope	10	10-300

DBSIZE: Total number of data pages stored in server

λ : Mean request arrival rate (exponential)

θ : Request skewness (Zipf)

MinSlack: Minimum slack time

MaxSlack: Maximum slack time

λ_{scope} : Parameter of exponential scope distribution

5 Conclusion

Network connectivity affects the quality of service (QoS) in a mobile network. Broadcasting is a promising data dissemination method to improve system scalability and deal with dynamic data access pattern. This paper presents an measuring function and a simulation model for valid scope of location dependent data. The proposed approach generally outperforms existing strategies with different location distributions. A series of simulation experiments evaluates the performance of the proposed scheme. The results demonstrate that this approach outperforms other methods for performance metrics such as user mobility, waiting time, and stretch. In the future, we plan to improve the measuring strategy by reducing its time complexity.

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