A Spatio-Temporal Cache Replacement Policy for Location Dependent Data in Mobile Environments

Mary Magdalene Jane, F, P.S.G. College of Technology, India
R. Nadarajan, P.S.G. College of Technology, India
Maytham Safar, Kuwait University, Kuwait

ABSTRACT
Data caching in mobile clients is an important technique to enhance data availability and improve data access time. Due to cache size limitations, cache replacement policies are used to find a suitable subset of items for eviction from the cache. In this paper, the authors study the issues of cache replacement for location-dependent data under a geometric location model and propose a new cache replacement policy RAAR (Re-entry probability, Area of valid scope, Age, Rate of Access) by taking into account the spatial and temporal parameters. Mobile queries experience a popularity drift where the item loses its popularity after the user exhausts the corresponding service, thus calling for a scenario in which once popular documents quickly become cold (small active sets). The experimental evaluations using synthetic datasets for regular and small active sets show that this replacement policy is effective in improving the system performance in terms of the cache hit ratio of mobile clients.

Keywords: Data Caching, Data Management, Location Based Services, Location Dependent Information Services, Mobile Computing

INTRODUCTION
Seamless mobility and ability to gather information about the users’ immediate surroundings has contributed to the growing popularity of a new kind of information services, called Location-Dependent Information Services (Balamash, 2004; Cheverst, 2000; Dunham, 1996; Lee, 2002). By including location as a part of user’s context information, many value-added applications targeted specifically at mobile users especially in geographic, traffic, logistics, tourist, emergency and disaster management systems can be provided. LDIS, being wireless in nature are plagued by mobility constraints like limited bandwidth, client power and intermittent connectivity. Acharya, Alonso, Franklin, and Zdonik (1995), and Zheng and Lee (2001) have
observed that data caching at mobile clients is an effective antidote for the above cited limitations. A data replication mechanism in which copies of data are brought to a mobile unit as a response to a query and retained at the cache for possible use by subsequent queries drastically improves data accessibility and minimizes the access costs. Limited memory of mobile devices poses a restriction on the cache size, making it impossible to retain all the accessed data items in the cache. A cache replacement policy thus becomes inevitable in order to utilize the available cache effectively.

In this paper, we propose a new cache replacement policy called RAAR for Location-Dependent data under geometric location model. It is different from the conventional policies because it takes the spatial and temporal factors into consideration. It is different from PAID and its variants because RAAR considers the re-entry probability and age of data items which are critical in deciding the item to be evicted. To evaluate the performance of proposed Location-Dependent data caching strategy, a simulator is designed and a series of experiments were conducted. The experiment results show that the proposed strategy outperforms the next best policy PAID proposed by Zheng, Xu, and Lee (2002) significantly. In this paper, we study the issues of cache replacement for location-dependent data under a geometric location model and we have proposed a new cache replacement policy RAAR Mobile queries experience a popularity drift where the item loses its popularity after the user has used up the corresponding service. Some of such stale items may never be accessed again because the user has exhausted the service. This age factor has been taken into serious consideration along with access frequency and spatial factors which are re-entry possibility, and area of valid scope.

Cache hit ratio is employed as the primary performance metric. Cache hit ratio can be defined as the ratio of number of queries answered by the client’s cache to the total number of queries generated by the client. Specifically, the higher the cache hit ratio, the higher the local data availability, the less the uplink and down-link costs, and the less the battery consumption.

**LOCATION - DEPENDENT CACHE REPLACEMENT POLICIES**

Several location-aware cache replacement policies have been proposed for LDIS over the past few years and the most predominant ones are explained in this section. In summary, the existing cache replacement polices can be classified into three groups.

Temporal-based cache replacement strategies, such as LRU (least recently used) has been studied by Balamash and Krunz (2004) with respect to web caching, LFU (least frequently used) and LRU-K by O’Neil and O’Neil (1993) have been studied widely in the past. Lam, Chan, and Yuen (2000) proposed a policy called invalid-LRU. They argue that the validity of the current values of data items depends on the temporal constraints and they may become out-dated and useless with the passage of time. The policy selects the invalid items in cache for replacement. In case all the items are valid and there is no invalid cache item, replacement is done using the original LRU principle.

The cache replacement issues for wireless data dissemination were studied in the Broadcast Disk (Bdisk) project by Acharya et al. (1995) in which the cached data item with the minimum value of p/x was evicted for cache replacement, where p is the item access probability and x is its broadcast frequency. Thus, a cached item has a high access probability or has a long broadcast delay. Their simulation based study showed that this strategy could significantly improve the access latency over the traditional LRU and LFU policies.

The first group of policies mentioned above are based on the assumption that clients’ access patterns exhibit temporal locality that is recently accessed objects are likely to be accessed again in the near future. The Manhattan Distance-based cache replacement policy by Jung, You, Lee, and Kim (2002) was designed to support location dependent queries in urban environ-
Spectrum Sensing Using Principal Components for Multiple Antenna Cognitive Radios
www.igi-global.com/chapter/spectrum-sensing-using-principal-components-for-multiple-antenna-cognitive-radios/123565?camid=4v1a

Fractional Reuse Partitioning Schemes for Overlay Cellular Architectures
www.igi-global.com/chapter/fractional-reuse-partitioning-schemes-overlay/62769?camid=4v1a