Chapter 7.33
Mobile Caching for Location-Based Services

Jianliang Xu
Hong Kong Baptist University, Hong Kong

INTRODUCTION

Location-based services (LBS) are services that answer queries based on the locations with which the queries are associate; normally the locations where the queries are issued. With a variety of promising applications, such as local information access (e.g., traffic reports, news, and navigation maps) and nearest neighbor queries (e.g., finding the nearest restaurants) (Barbara, 1999; Ren & Dunham, 2000; D. L. Lee, Lee, Xu, & Zheng, 2002; W. C. Lee, Xu, & Zheng, 2004), LBS is emerging as an integral part of daily life.

The greatest potential of LBS is met in a mobile computing environment, where users enjoy unrestricted mobility and ubiquitous information access. For example, a traveler could issue a query like "Find the nearest hotel with a room rate below $100" from a wireless portable device in the middle of a journey. To answer such a query, however, three major challenges have to be overcome:

- **Constrained Mobile Environments:** Users in a mobile environment suffer from various constraints, such as scarce bandwidth, low-quality communication, frequent network disconnections, and limited local resources. These constraints pose a great challenge for the provision of LBS to mobile users.
- **Spatial Data:** In LBS, the answers to a query associated with different locations may be different. That is, query results are dependent on spatial properties of queries. For a query bound with a certain query location, the query result should be relevant to the query as well as valid for the bound location. This requirement adds additional complexity to traditional data management techniques such as data placement, indexing, and query processing (D. L. Lee, 2002).
- **User Movement:** The fact that a mobile user may change its location makes some tasks in LBS, such as query scheduling and cache management, particularly tough. For example, suppose that a mobile user issues a query "Find the nearest restaurant" at loca-

tion *A*. If the query is not scheduled timely enough on the server, the user has moved to location *B* when he or she gets the answer *R*. However, *R* is no longer the nearest restaurant at location *B*.

Caching has been a commonly used technique for improving data access performance in a mobile computing environment (Acharya, Alonso, Franklin, & Zdonik, 1995). There are several advantages for caching data on mobile clients:

- It improves data access latency since a portion of queries, if not all, can be satisfied locally.
- It helps save energy since wireless communication is required only for cache-miss queries.
- It reduces contention on the narrow-bandwidth wireless channel and off-loads workload from the server; as such, the system throughput is improved.
- It improves data availability in circumstances where clients are disconnected or weakly connected because cached data can be used to answer queries.

However, as discussed above, the *constrains* of mobile computing environments, the *spatial* property of location-dependent data, and the *mobility* of mobile users have opened up many new research problems in client caching for LBS. This chapter discusses the research issues arising from caching of location-dependent data in a mobile environment and briefly describes several state-of-the-art solutions.

BACKGROUND

Location Model

Location plays a central role in LBS. A location needs to be specified explicitly or implicitly for

any information access. The available mechanisms for identifying locations of mobile users are based on two models:

- **Geometric Model:** A location is specified as an *n*-dimensional coordinate (typically, $n = 2$ or 3); for example , the latitude/longitude pair returned by the global positioning system (GPS). The main advantage of the geometric model is its compatibility across heterogeneous systems. However, providing such fine-grained location information may involve considerable cost and complexity.
- **Symbolic Model:** The location space is divided into disjointed zones, each of which is identified by a unique name. Examples are the Cricket system (Priyantha, Chakraborty, & Balakrishnan, 2000) and the cellular infrastructure. The symbolic model is in general cheaper to deploy than the geometric model because of the lower cost of employing a coarser location granularity. Also, being discrete and well-structured, location information based on the symbolic model is easier to manage.

For ease of illustration, two notions are defined: *valid scope* and *valid scope distribution*. A dataset is a collection of data instances. The *valid scope* of a data instance is defined as the area within which this instance is the only answer with respect to a location-dependent query. With the symbolic location model, a valid scope is represented by a set of logical zone ids. With the geometric location model, a valid scope often takes the shape of a polygon in a two-dimensional space. Since a query may return different instances at different locations, it is associated with a set of valid scopes, which collectively is called the *scope distribution* of the query. To illustrate, consider a four-cell system with a wireless-cell-based location model. Suppose that the nearby restaurant for cell 1 and cell 2 is instance *X*, and the nearby restaurant for cell 3 and cell 4 is instance *Y*. Then,

Related Content

A Distributed Least-Squares Algorithm in Wireless Sensor Networks With Unknown and Limited Communications
Jing Wang, In Soo Ahn, Yufeng Lu, Tianyu Yangand Gennady Staskevich (2017). *International Journal of Handheld Computing Research (pp. 15-36).*
www.irma-international.org/article/a-distributed-least-squares-algorithm-in-wireless-sensor-networks-with-unknown-and-limited-communications/196257

Mobile Decision Support for Time-Critical Decision Making
Frada Bursteinand J. Cowie (2009). *Mobile Computing: Concepts, Methodologies, Tools, and Applications (pp. 3552-3560).*
www.irma-international.org/chapter/mobile-decision-support-time-critical/26741

Web Algorithms for Information Retrieval: A Performance Comparative Study
Bouchra Frikhand Brahim Ouhbi (2014). *International Journal of Mobile Computing and Multimedia Communications (pp. 1-16).*
www.irma-international.org/article/web-algorithms-for-information-retrieval/113770

Reversible Data Hiding for Encrypted Image Based on Interpolation Error Expansion
Fuqiang Di, Minqing Zhang, Yingnan Zhangand Jia Liu (2018). *International Journal of Mobile Computing and Multimedia Communications (pp. 76-96).*
www.irma-international.org/article/reversible-data-hiding-for-encrypted-image-based-on-interpolation-error-expansion/214044

Mobile Communications and Mobile Commerce: Conceptual Frames to Grasp the Global Tectonic Shifts
Nikhilesh Dholakia, Morten Raskand Ruby Roy Dholakia (2009). *Mobile Computing: Concepts, Methodologies, Tools, and Applications (pp. 27-37).*
www.irma-international.org/chapter/mobile-communications-mobile-commerce/26486