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Database Support for M-Commerce and L-Commerce

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INTRODUCTION

M-commerce (mobile commerce) applications have evolved out of e-commerce (electronic commerce) applications, riding on recent advancement in wireless communication technologies. Exploiting the most unique aspect inherent in m-commerce, namely, the mobility of customers, l-commerce (location-dependent m-commerce) applications have played an increasingly important role in the class of m-commerce applications. All e-commerce, m-commerce, and l-commerce applications rely on the provision of information retrieval and processing capability. L-commerce applications further dictate the maintenance of customer and service location information. Various database systems are deployed as the information source and repository for these applications, backed by efficient indexing mechanisms, both on regular data and location-specific data.

Bean (2003) gave a good report on supporting Web-based e-commerce with XML, which could be easily extended to m-commerce. An m-commerce framework, based on JINI/XML and a workflow engine, was defined by Shih and Shim (2002). Customers can receive m-commerce services through the use of mobile devices such as pocket PCs, PDAs, or even smart phones. These mobile devices together with their users are often modeled as mobile clients. There are three types of entities central to m-commerce and l-commerce applications: mobile device, wireless communication, and database. In this article, we focus our discussion on mobile-client enabled database servers, often referred to as mobile databases. Mobile databases maintain information for the underlying m-commerce and l-commerce applications in which mobile devices serve as the hardware platform interfacing with customers, connected through wireless communication.

Location is a special kind of composite data ranging from a single point, a line, a poly-line, to a shape defining an area or a building. In general, locations are modeled as spatial objects. The location of a static point of interest, such as a shop, is maintained in a database supporting spatial features and operations, often a spatial database (Güting, 1994). The location of a moving object, like a mobile customer, needs to be maintained in a moving object database (Wolfson, Sistla, Xu, Zhou, & Chamberlain, 1999), a database that supports efficient retrieval and update of object locations. To enable l-commerce, both spatial databases and moving object databases need to support location-specific query processing from mobile clients and location updates they generated.

The two major types of data access requirements for a mobile database are data dissemination and dedicated data access. Data dissemination is preferred, since it can serve a large client population in utilizing the high bandwidth downlink channel to broadcast information of common interest, such as stock quotations, traffic conditions, or special events. On the other hand, dedicated data access is conveyed through uplink channels with limited bandwidth. To disseminate database items effectively, the selected set of hot database items can be scheduled as a broadcast disk (Acharya, Alonso, Franklin, & Zdonik, 1995). Proper indexes can be built to facilitate access to broadcast database items (Imielinski & Badrinath, 1994). Redundancy can be included in data (Leong & Si, 1995) and index (Tan & Ooi, 1998) to combat the unreliability of wireless communication.

For dedicated data access, queries and updates to databases are transmitted from the client to the server. L-commerce services involve processing of location-dependent queries (Madria, Bhargava, Pitoura, & Kumar, 2000). The high frequency of updates to the location of moving objects calls for special indexing technique. The call-to-mobility ratio serves as a good indicator on the tradeoff of indexing mechanisms. The moving object databases should enable efficient execution of queries such as k-nearest neighbor, reversed nearest neighbor (Benetis, Jensen, Karĉiauskas, & Ŝaltenis, 2006), and nearest surrounder search (Lee, Lee, & Leong, 2006). In addition, they should support continuous queries (Prabhakar, Xia, Kalashnikov, Aref, & Hambrusch, 2002), such as continuous k-nearest neighbor, being executed continuously and returning location-dependent results (Lee, Leong, Zhou, & Si, 2005). Reversing the role of query and data, it is equally important to process data streams effectively (Babu & Widom, 2001) such as incoming sensor data streams (Mokbel, Xiong, Hammad, & Aref, 2005) for traffic monitoring in navigational applications.

A related and interesting research problem is the location privacy of a mobile client. For instance, the application server should not be able to deduce the exact location of Alice, when she raises a query to look for a nearest restaurant on the State Street. Yet, the information returned to Alice should enable her to determine the nearest restaurant. Location cloaking technique (Gedik & Liu, 2005) and location anonymizer (Mokbel, Chow, & Aref, 2006) would be used to ensure a form of k-anonymity, such that Alice is indistinguishable from other k-1 clients around the State Street.

BACKGROUND

The three fundamental elements for m-commerce applications, namely, mobile device, wireless communication, and database support can be considered orthogonal. First, the variety of mobile devices differs vastly in computational power, ease of programming, interoperability of operating environments, and support for auxiliary devices. Some mobile clients are based on high-end laptops, while others are based on low-end PDAs or cellular phones. Second, wireless communication offers varying bandwidth and reliability, based on low-bandwidth and unreliable GSM connections, medium-bandwidth GPRS/EDGE and Bluetooth connections, or high-bandwidth 802.11g and WCDMA/CDMA2000 connections. Third, the database may be as primitive as a file system or simple relational database like MS Access, or as complex as the high performance Oracle with transactional and spatial data support. Transactions ensure a sequence of database operations to be executed consistently. This leads to a "cube"-like taxonomy as shown in Figure 1. The support of l-commerce requires a new location maintenance module at the database. However, for most practical applications involving the location of moving objects, transactional access is not required on the location, owing to the inherent imprecise nature of the changing location over time.

In Figure 1, the taxonomy for m-commerce and l-commerce support is displayed. Planes LP and HP represent the low computing power equipment and high computing power equipment respectively, whereas planes LB and HB reflect the availability of low and high communication bandwidth. With the availability of transactions in the TXN plane, this gives rise to eight different regions.

Region zero represents the support of standard file or simple database access from PDA connecting through low-speed modem or phone. Processing is basically performed at the server, since it is too expensive for clients to support complex mechanism. To reduce bandwidth consumption, information distillation/extraction (Cowie & Lehnert, 1996) may be performed to reduce the amount of information transmitted. Simple client/server data access paradigm suffices. Region one assumes an improved wireless network, with large scale WCDMA/CDMA2000 (3G) or small scale 802.11g (WiFi). Recent 802.16 (WiMAX) development and deployment lead to improved bandwidth in medium scale mobile environment. As a result, data access is more effective and conventional client/server data processing techniques can be adopted in a rather straightforward manner.

Region two corresponds to a mobile client with higher computational power. Information transmitted can be transcoded to reduce the bandwidth consumption. Interactive and intelligent mechanisms such as multi-resolution browsing (Leong & Si, 2005) can be employed. Database items are cached to combat the low communication bandwidth, unreliable communication, and frequent disconnection. Research work addressing this issue was pioneered by the Coda file system in 1992 (Satyanarayanan, 2002), in which files are cached by clients and updates made during client disconnection are reintegrated upon reconnection. Caching in an object-oriented database was studied by Chan, Leong, Si, and Wong (1999). Configurations in region three allow

Figure 1. Taxonomy on m-commerce and l-commerce support