Guest Editorial: Special Section on Data Management Systems and Mobile Computing

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The need for “information anywhere anytime” has been a driving force for the increasing growth in Web and Internet technology, wireless communication, and portable computing devices. Mobile computing is the merger of recent advances in computing and communication technologies with the aim of providing a seamless and ubiquitous computing environment to mobile users. In such mobile environments, database applications are enhanced with useful features of wireless technology. For example, users are allowed to establish a mobile office where they can communicate with other users (mobile or stationary), access information from various sources, and manage their work while staying mobile. This feature is important for enabling of mobile workforces supporting ubiquitous services such as weather and forecasting services, financial market reporting, yellow pages, road maps and directions, telematics, point-of-sale applications, in-field work dispatch, law enforcement, military, and the like. By nature, mobile computing environments are characterized by severe resource constraints and unstable operating conditions; this adds a new dimension to the technical challenges for database systems and management.

Many software problems associated with data management, transaction management, and data recovery have their origin in distributed database systems. In mobile computing, however, these problems become more difficult to solve, mainly because of the narrow bandwidth of the wireless communication channels, the relatively short active life of the power supply of mobile units, and the changing locations of required information (sometimes in cache, sometimes in air, sometimes at the server). Further, in many mobile database applications, data changes very rapidly (or even constantly). Users need to receive timely information in order to make critical decisions (e.g., stock market information and trading). Thus, response time becomes a much more key performance metric. In addition to the traditional response time, the active life of the user’s battery is also an important performance merit. Wireless networks differ from wired networks in many ways. Database users over a wired network remain connected not only to the network but also to a continuous power source. In a wireless network, however, both the response time and the active life of the user’s battery are important. In order to conserve energy and extend battery life, clients can slip into doze mode. Clients can be awakened from the doze mode when the server needs to communicate with the client.

Mobile applications can be categorized as 1) vertical applications and 2) horizontal application. In vertical applications, users access data within a specific cell and access is denied to users outside of that cell. For example, users can obtain information on the location of doctors or emergency centers within a cell or parking availability data at an airport cell. In horizontal applications, users cooperate on accomplishing a task and they can handle data distributed throughout the system. The market for horizontal applications is growing; two types of applications that fall in this category are mail-enabled applications and information services to mobile users. These two types of applications differ in the type of data they manage. Public data is primarily managed by vertical applications, while shared data is used by horizontal applications, possibly with some replication. Copies of shared data may be stored both in base and mobile stations. This presents a variety of difficult problems in transaction management consistency, as well as in the integrity and scalability of the architecture.

Data management is concerned with the modeling, efficient storage, retrieval, and manipulation of information. From a data management standpoint, mobility of the clients/nodes provides an interesting variation to distributed computing. Mobile databases can be distributed under two possible scenarios: 1) The entire database is distributed mainly among the wired components, possibly with full or partial replication. A base station manages its own database with a DBMS-like functionality, with additional functionality for locating mobile units and additional query and transaction management features to meet the requirements of mobile environments. 2) The database is distributed among wired and wireless components. Data management responsibility is shared among base stations and mobile units. In this environment, traditional distributed database techniques may not work. These different ways of managing data in mobile environments entail additional considerations and variation with regard to distributed database management.

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The purpose of this special section is to focus on the novel ways in which architecture and mechanisms of data management systems can be adapted to mobile environments. There are eight regular papers and four short papers (selected from among 51 outstanding papers submitted) that deal with issues concerning 1) data distribution, replication, and dissemination, 2) transaction processing and recovery, 3) query processing and 4) location management.

Location management plays a significant role in mobile computing systems and applications. In recent years, location services have received a lot of attention due to the FCC's mandatory requirement on wireless E-911. Many location aware applications will become feasible with the technology that facilitates E-911. This special section includes four papers covering various aspects of location management. The paper “Query Indexing and Velocity Constrained Indexing: Scalable Techniques for Continuous Queries on Moving Objects” by S. Prabhakar et al. addresses efficient evaluation of concurrent continuous queries over a large number of moving objects that is critical for location aware applications. The authors combine query indexing and velocity constrained indexing techniques to enable scalable execution of concurrent continuous queries with acceptable response time. The next paper, “Cache Invalidation and Replacement Strategies for Location-Dependent Data in Mobile Environments” by B. Zheng et al., addresses performance aspects of location services; it proposes location-dependent cache invalidation and replacement strategies based on the principle of semantic caching and studies the performance of the proposed strategies. The paper “Implementing Automatic Location Update for Follow-Me Database Using VoIP and Bluetooth Technologies” by Y. Lin et al. discusses location updates of an automatic follow-me service for small areas using Bluetooth and VoIP and provides an analytic study of the impact of polling frequency for Bluetooth devices. The fourth paper in this category, “General Modeling and Performance Analysis for Location Management in Wireless Mobile Networks” by Y. Fang, develops a new approach to carry out cost analysis for location management in wireless networks and analyzes two well-known location management schemes.

Mobile query processing is an important aspect of mobile database management, yet not much work has yet appeared in the literature. In this special section, the paper “Processing Distributed Mobile Queries with Interleaved Remote Mobile Joins” by C. Lee and M. Chen proposes two algorithms based on divide-and-conquer and remote mobile joins, respectively, to reduce data transmission cost required for mobile query processing.

Transaction management has been a core component of modern database systems. To ensure the ACID properties in an environment where failure can frequently occur, new transactional concepts and processing and recovery techniques have been proposed. The next four papers in this special section address several transaction processing and recovery issues. The paper “On Transaction Processing with Partial Validation and Timestamp Ordering in Mobile Broadcast Environments” by V. Lee et al. deals with processing and validation of “real-time” transactions in wireless broadcast environments. The authors combine partial validation at the mobile client with a dynamic timestamp ordering protocol to improve performance, which is validated by simulation results. The paper “TCOT—A Timeout-Based Mobile Transaction Commitment Protocol” by V. Kumar et al. proposes a “timeout”-based transaction commit protocol to minimize communications between base stations and the mobile hosts and thus improve the throughputs of transaction processing. The next paper, “Support for Recovery in Mobile Systems” by C. Pedregal-Martin and K. Ramamritham, introduces a formal method for defining guarantees and protocols for transactional recovery in mobile systems. The fourth paper in this category, “Multiversion Data Broadcasting” by E. Pitoura and P. Chrysanthis, studies the issues of maintaining multiple versions of data items such that concurrency can be increased for read-only transactions in the presence of updates.

Wireless data broadcast channel is a scalable medium for disseminating data to an unlimited number of mobile clients. Various research issues on efficiently utilizing this medium, such as broadcast scheduling, caching, indexing, have been studied over the years. Three papers addressing multiple channel scheduling and semantic caching of wireless data broadcast are included in the special section. The paper “Efficient Data Allocation over Multiple Channels at Broadcast Servers” by W. Yee et al. shows how to allocate data among a given set of broadcast channels in order to minimize the average response time for queries of single data items. Applying a similar idea of allocating data over multiple channels, the next paper, “Data Allocation on Wireless Broadcast Channels for Efficient Query Processing” by G. Lee et al., aims at optimizing the performance of complex queries that process multiple broadcast data items. The authors propose an algorithm, based on optimal linear ordering, to place the frequently coaccessed data not only close to each other but also in a particular order to optimize the processing of complex queries. The paper “Semantic Data Broadcast for a Mobile Environment Based on Dynamic and Adaptive Chunking” by K. Lee et al. describes a chunk-based scheme to broadcast data for mobile clients. By including the semantics information with data, the clients can deduce whether the results of their queries are completely, partially, or not contained in a chunk and thus can lower their energy consumption by shorten the tuning time.

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