The VLDB Journal (2011) 20:641–642
DOI 10.1007/s00778-011-0250-x

GUEST EDITORIAL

Special issue on data management for mobile services

Ralf Hartmut Güting · Nikos Mamoulis

Published online: 9 August 2011

Small, GPS-enabled and wireless networked mobile devices such as mobile phones, personal digital assistants, or car navigation systems have become powerful, affordable, and wide-spread. Not only do these devices interact with the environment such as local services and facilities, searching for useful information, but they are also capable of collecting and transmitting position data. There is a need for addressing both aspects, of supporting online services by managing the locations of large sets of currently moving users, and of analyzing enormous volumes of captured trajectory data. The latter may in particular be useful for improving mobile services.

This special issue focuses on managing information about moving objects in space and time, both for online applications and for analysis of 'historical' trajectory data. The complex form of trajectory data obtained from objects (typically moving in road networks) calls for specialized methods for indexing, in order to meet the demands of online query evaluation. In addition, the limited resources of the mobile devices that sense and transmit the locations of the moving objects call for techniques that minimize the communication cost of location updates, without sacrificing too much accuracy. Specialized data analysts and common users need effective and efficient tools for querying and mining the large volume of the mobile data that are collected. These include systems that allow the identification of complex forms of data patterns, support aggregate queries, proximity, and direction queries and even consider the uncertainty of the tracked information (e.g., due to GPS errors or signal delays) in probabilistic query evaluation.

R. H. Güting
Faculty of Mathematics and Computer Science,
University of Hagen, 58084 Hagen, Germany
e-mail: rhg@fernuni-hagen.de

N. Mamoulis (✉)
Department of Computer Science, University of Hong Kong,
Pokfulam Road, Hong Kong, China
e-mail: nikos@cs.hku.hk

This special issue presents six papers that are at the forefront of research on data management for mobile services. The issue includes one paper on trajectory indexing, one paper on mobile data tracking, one paper on mining a database of trajectories, and three papers on evaluating complex queries over mobile object databases.

The paper *Indexing in-Network Trajectory Flows*, by Iulian Sandu Popa, Karine Zeitouni, Vincent Oria, Dominique Barth, and Sandrine Vial, proposes a new access method for the efficient retrieval of objects that move in road networks. This approach employs an adaptive graph partitioning to the underlying network and a set of local B^+-tree indexes, one for each partition. The authors present a cost model that allows tuning correctly the index structure for a given query load. The cost model is also used to predict whether on-line updates (e.g., new positions in the trajectory data flows of the moving objects) have degraded the index quality; in this case, the index is rebuilt in order to meet the requirements of the current data.

The paper *Efficient Real-Time Trajectory Tracking*, by Ralph Lange, Frank Dürr, and Kurt Rothermel, deals with the problem of tracking an object's trajectory in real-time, over a wireless network. The authors propose a family of tracking protocols that allow trading off between communication cost and tracked data accuracy. The goal is to obtain a simplified trajectory that does not deviate by more than a certain accuracy bound from the actual movement. The protocols include techniques for bounding space consumption and computational cost at the mobile object's side; this is achieved by an effective compression technique for real-time line simplification.

The paper *Unveiling the Complexity of Human Mobility by Querying and Mining Massive Trajectory Data*, by Fosca Giannotti, Mirco Nanni, Dino Pedreschi, Fabio Pinelli, Chiara Renso, Salvatore Rinzivillo, and Roberto Trasarti, exposes the analytical power that collections of trajectory data have in unveiling the complexity of human mobility. The authors analyze the trajectories of a large number of private cars in Milan and Pisa and demonstrate how it is possible to find answers to challenging analytical questions about mobility behavior, which are not supported by the current generation of commercial systems. In addition, they present M-Atlas, an integrated querying, and mining system for trajectories, which supports SQL-like queries for the discovery of complex mobility knowledge.

The paper *Sequenced Spatiotemporal Aggregation for Coarse Query Granularities*, by Igor Timko, Michael Böhlen, and Johann Gamper, defines a new query operator for spatio-temporal data. Sequenced spatiotemporal aggregation (SSTA) divides the space and time domains into coarse granules (e.g., 100-m road segments, 10-s intervals) and summarizes mobility information (e.g., total number of cars) at each granule. The result can be used for traffic analysis (e.g., identify segments and periods that correspond to jammed traffic). An efficient algorithm for SSTA queries, based on the plane sweep paradigm, is proposed.

The paper *Direction-Based Surrounder Queries for Mobile Recommendations*, by Xi Guo, Baihua Zheng, Yoshiharu Ishikawa, and Yunjun Gao, proposes a new spatial query, which retrieves nearest neighbors of a given query object, which are at diverse directions. Object a is 'directionally close' to object b, with respect to query object q, if the included angle $\angle aqb$ is small. In addition, a dominates b if they are directionally close and a is closer to q than b. Given a query object q, the objective is to find the objects, called 'direction-based surrounders' (DBSs), which are not dominated by others. Compared with classic nearest neighbor search, the new query retrieves objects that are located in different directions of q and hence it provides a better overview of the surrounding area. The main application is location-based recommendation, where a mobile user is interested in points of interest that are close to her current location. Direction diversification in this case may be desirable. The authors present evaluation techniques for this query both in the Euclidean space and in road networks (in this case, a is 'directionally close' to object b if their shortest paths to q overlap). In addition to snapshot DBS queries, they also consider the case where the query point q is moving and q's DBSs should be incrementally maintained.

The paper *Ranking Continuous Nearest Neighbors for Uncertain Trajectories*, by Goce Trajcevski, Roberto Tamassia, Isabel F. Cruz, Peter Scheuermann, David Hartglass, and Christopher Zamierowski, addresses the problem of answering nearest neighbor queries in a database that stores uncertain object trajectories. Uncertainty brings special challenges to the problem of query evaluation, since for each time instant in the query time interval, we should rank the uncertain trajectories based on their probabilities to be nearest neighbors; in addition, for each trajectory with a non-zero probability to be a query result, we should identify the corresponding time intervals for which it qualifies. The authors identify the mathematical properties that enable the ranking of uncertain trajectories to be results of the probabilistic nearest neighbor query and formalize the declarative semantics of query results; based on this, they propose efficient algorithms for query evaluation, with a special focus on the case where objects are moving along road networks.

The papers presented in this special issue were carefully selected after evaluation through peer review. In mid-2010, we issued a call for papers, in response of which we received 21 submissions; these submissions were reviewed by 75 reviewers and, after two rounds of reviews, we accepted 6 papers for publication. In response to the review comments, the authors of the published papers significantly improved their work. We would like to thank both the authors and their reviewers for their outstanding efforts.

Ralf Hartmut Güting
Nikos Mamoulis
Guest Editors