

Data Always and Everywhere — Management of Mobile, Ubiquitous, Pervasive, and Sensor Data

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Abstract

This report summarizes the important aspects of the workshop on “Management of Mobile, Ubiquitous, Pervasive, and Sensor Data,” which took place from October 16th to October 21st, 2005. Thirty-seven participants from thirteen countries met during that week and discussed a broad range of topics related to the management of data in relation to mobile, ubiquitous, and pervasive applications of information technology. The wealth of the contributions is available at the seminar page at the Dagstuhl server. Here, we provide a short overview.

Classification

Data Bases, Networks, Optimization, Interdisciplinary

Keywords

Mobile Data Management, Ubiquitous Computing, Pervasive Computing, Streaming Data, Middleware, Data Integration, Data Placement, Ad-hoc Networking, Micro DBMSs, Context-Aware Applications

1. Goals and Structure of the Workshop

Following decades of rapid and sustained advances in computing and communication technologies, we have reached a stage where it is becoming feasible to embed computing and communication functionality in the physical objects that surround us. For example, such functionality may be embedded into dishwashers, refrigerators,

coffee machines, heating systems and even clothing and jewelry. Other, perhaps more mundane examples include PDAs, mobile phones, MP3 players, and car navigation systems. Many of these computationally enabled objects are small and mobile. As they are also able to communicate with their surroundings, e.g., via low-cost transceivers that allow them to spontaneously interconnect with other objects or via a cellular network, they will have access to the Internet and will be accessible from the Internet. Put differently, their data will be part of a global information space, and they will be able to exploit this space.

As a consequence, data is spread all over, which offers a host of new challenges to data management technology. In particular, data synchronization and consistency become substantial challenges. This is also true for data placement that comprises replication techniques as well as caching technology. This situation is further complicated by these data stores most likely being inherently heterogeneous in terms of data models, storage formats, and access technologies.

This development makes it worthwhile to rethink whether the currently available data management solutions are appropriate for these new scenarios, and how data management technologies that support the whole spectrum would look like. It is exactly the focus of this seminar to discuss issues related to the management of mobile, ubiquitous, and pervasive data.

The seminar brought together representatives from different communities (researchers, software vendors, and users) from different areas (mobile application, middleware, sensor systems, distributed systems, database systems) for joint, in-depth discussions of emerging data management challenges, key objectives being to identify research challenges and standardization needs, and to better understand open problems.

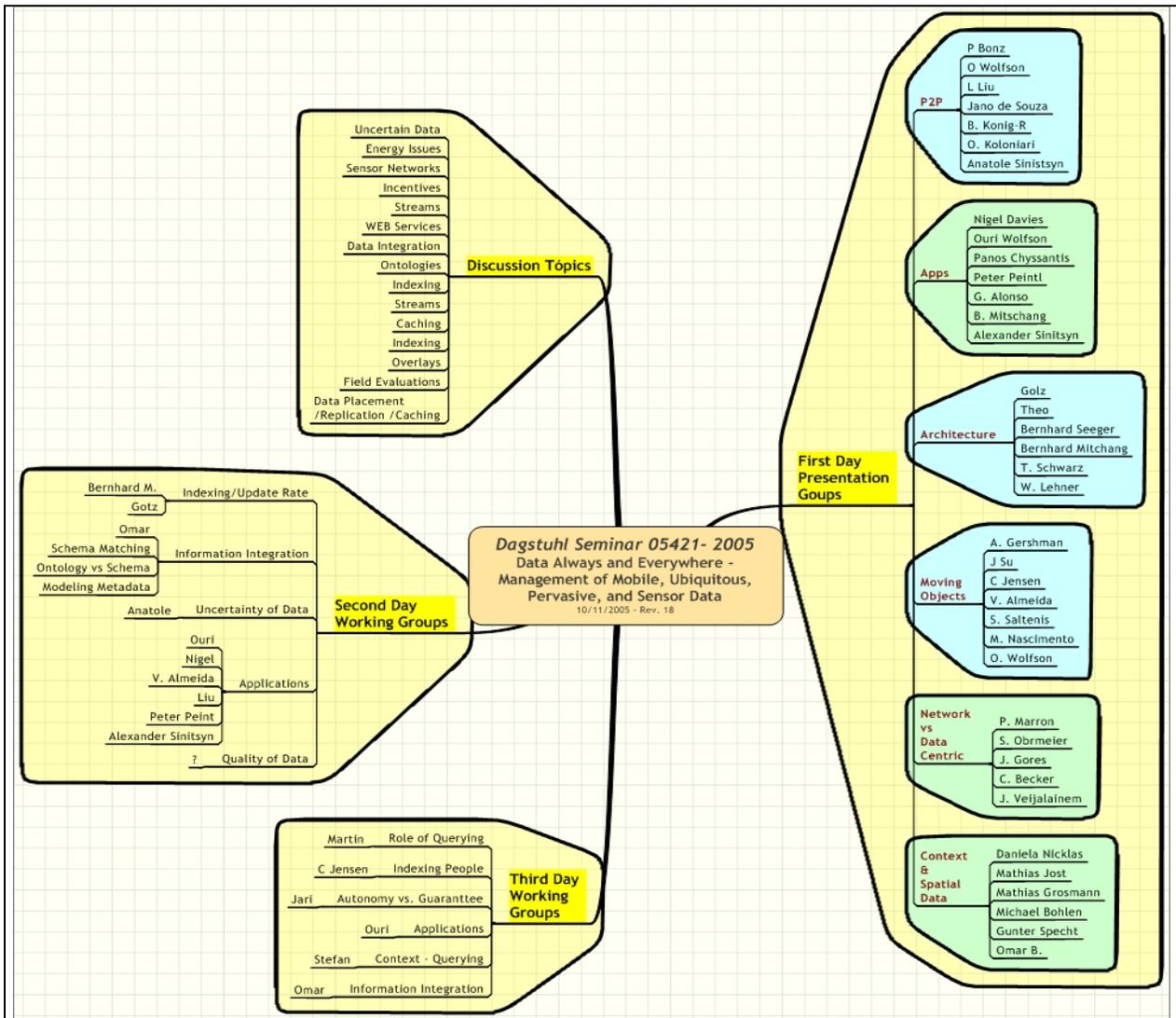
2. Workshop Itinerary

The seminar started with the following list of potential discussion points phrased as questions and given to the participants up front:

- How to synchronize the data and how to achieve consistency?
- How to integrate the data?
- Where to place the data and what technology to use?

- How to manage, store, and access the data?
- What does a suitable processing model look like?
- What kind of communication technology is needed?
- What about a platform approach?
- How to build these kinds of applications?
- What are the killer applications?
- How would a comprising technology for moving objects look like?

The five days were filled with discussions, workgroup meetings, and presentations. The organizers decided on purpose to leave substantial room for discussions and workgroup meetings, to enable the participants to cover new problems and topics that emerged as the seminar progressed and that were considered important for the development of the field. A good overview of the organization of the seminar is given in the Mind Map diagram that follows (prepared by Prof. Jano Moreira de Souza, UFRJ, Rio de Janeiro).



Mind Map: Dagstuhl Seminar 05421 at a Glance

3. Participants

The following researchers participated in the workshop. The titles of their talks are given in parentheses.

- Gustavo Alonso, ETH Zürich (Data from sensor networks)
- Christian Beckerr, Universität Stuttgart Manage
- Peter A. Boncz, CWI - Amsterdam (AmbientDB: P2P database middleware for ubiquitous computing)
- Omar Boucelma, LSIS - Marseille (Building a Spatial Data Integration System: Lessons Learned)
- Michael H. Böhlen, Free University - Bozen
- Panos Kypros Chrysanthis, University of Pittsburgh (Data in Crisis Management: An Exercise for Mobile databases, Sensor databases and Peer-to-Peer databases)

- Nigel Davies, Lancaster University (Content Management for Mobile and Ubiquitous Computing)
- Stefan Dessoth, TU Kaiserslautern
- Anatole Gershman, Accenture Labs - Chicago (Probabilistic Fusion of Sensor Data for Mobile Object Tracking)
- Goetz Graefe, Microsoft Research (B-tree indexes for high update rates)
- Matthias Großmann, Universität Stuttgart (Efficiently Managing Context Information for Large-scale Scenarios)
- Jürgen Göres, TU Kaiserslautern (PALADIN: Pattern-based Approach to Large-scale Dynamic Information Integration)
- Theo Härder, TU Kaiserslautern (Web and Database Caching – Accelerating the Entire User-to-Data Path in the Internet)
- Christian S. Jensen, Aalborg University (Data Management for Moving Objects)
- Matthias Joest, Europ. Media Lab. - Heidelberg (Is the deployment of context- and user-aware technologies necessary to proof their concepts and success?)
- Martin Kersten, CWI - Amsterdam (MonetDB/DataCell: database technology for the ambient home)
- Georgia Koloniari, University of Ioannina (Adaptive Workload-Aware Overlay Networks in Pervasive Environments)
- Birgitta König-Ries, Universität Jena (Incentives for Cooperation: Why do we need them? How can they be engineered?)
- Wolfgang Lehner, TU Dresden (QoS-based Processing of Sensor Data)
- Ling Liu, Georgia Institute of Technology (Location Privacy in Mobile Location-based Services)
- Pedro Jose Marron, Universität Stuttgart (Data Management Frameworks for Sensor Networks)
- Bernhard Mitschang, Universität Stuttgart (Federating Location-based Data Services)
- Jano Moreira de Souza , UFRJ - Rio de Janeiro (Knowledge Applications on P2P)
- Mario A. Nascimento, University of Alberta (RDBMS Support for Indexing of Historical Spatio-Temporal Data)
- Daniela Nicklas, Universität Stuttgart (Data, Context and Situation: Interpretation Layers of Context Models)
- Sebastian Obermeier, Universität Paderborn (Transferring Database Technology to Mobile Ad-Hoc Networks)
- Peter L. Peinl, Fachhochschule Fulda (Autonomic Sensor Network for Ecological Waters Supervision)
- Evaggelia Pitoura, University of Ioannina
- Simonas Saltenis, Aalborg University (Indexing the Past, Present and Anticipated Future Positions of Moving Objects)
- Thomas Schwarz, Universität Stuttgart (Efficient Domain-Specific Information Integration for Context-Aware Applications)
- Bernhard Seeger, Universität Marburg (Data Streams Always and Everywhere)
- Alexander Sinitsyn, Philips Research - Eindhoven (Media Management in CE Environments)

- Günther Specht, Universität Ulm (Processing of Ontologies in Mobile Environments)
- Jianwen Su, Univ. California - Santa Barbara (Conceptual Modeling of Moving Objects: Why Is It Still A Hard Problem?)
- Victor Teixeira de Almeida, FernUniversität in Hagen (Modeling and Querying Moving Objects in Networks)
- Jari Veijalainen, University of Jyväskylä (Autonomy versus guarantees in Mobile P2P environment and Energy consumption tradeoffs for compressed wireless data at a mobile terminal)
- Ouri Wolfson, Univ. of Illinois - Chicago (MOBI-DI: MOBIle DIsccovery of Knowledge about local resources in peer-to-peer wireless networks).

4. Workshop Résumé

At the end of the seminar, the participants categorized the issues that were considered during the presentations and discussions throughout the seminar week. The following list of general topics resulted. These topics capture well the breadth of the seminar. The topics were considered to be particularly interesting by the participants, primarily due to research challenges they embody or their potential relevance for future practice.

- Location-based and moving-objects-based applications
- Data/content integration, federation, and management
- Context management and context-aware services
- Data in sensor networks, data streams, and sensor fusion
- Modeling and querying of mobile and spatial databases
- Indexes for high update rates, including the indexing of the past, current, and near-future positions of moving objects
- Replication and caching
- P2P database middleware
- Privacy Issues

It is our belief that the seminar has improved the participants' understanding of the seminar's topic area in general and of the abovementioned topics in particular, has built new collaborations among the seminar participants, and will stimulate further collaborations among members of the different communities involved.