

Commenced Publication in 1973

Founding and Former Series Editors:

Gerhard Goos, Juris Hartmanis, and Jan van Leeuwen

Editorial Board

David Hutchison

Lancaster University, UK

Takeo Kanade

Carnegie Mellon University, Pittsburgh, PA, USA

Josef Kittler

University of Surrey, Guildford, UK

Jon M. Kleinberg

Cornell University, Ithaca, NY, USA

Alfred Kobsa

University of California, Irvine, CA, USA

Friedemann Mattern

ETH Zurich, Switzerland

John C. Mitchell

Stanford University, CA, USA

Moni Naor

Weizmann Institute of Science, Rehovot, Israel

Oscar Nierstrasz

University of Bern, Switzerland

C. Pandu Rangan

Indian Institute of Technology, Madras, India

Bernhard Steffen

University of Dortmund, Germany

Madhu Sudan

Microsoft Research, Cambridge, MA, USA

Demetri Terzopoulos

University of California, Los Angeles, CA, USA

Doug Tygar

University of California, Berkeley, CA, USA

Gerhard Weikum

Max-Planck Institute of Computer Science, Saarbruecken, Germany

Stefano Spaccapietra Esteban Zimányi
Il-Yeol Song (Eds.)

Journal on Data Semantics XIII

Volume Editors

Stefano Spaccapietra
École Polytechnique Fédérale de Lausanne
EPFL-IC
Database Laboratory
1015 Lausanne, Switzerland
E-mail: stefano.spaccapietra@epfl.ch

Esteban Zimányi
Université Libre de Bruxelles
Department of Computer and Decision Engineering
50 av. F.D. Roosevelt, 1050 Bruxelles, Belgium
E-mail: ezimanyi@ulb.ac.be

Il-Yeol Song
Drexel University
College of Information Science and Technology
Philadelphia, PA 19104, USA
E-mail: song@drexel.edu

CR Subject Classification (1998): H.3, H.4, H.2, C.2, D.3, F.3, D.2

ISSN 0302-9743 (Lecture Notes in Computer Science)
ISSN 1861-2032 (Journal on Data Semantics)
ISBN-10 3-642-03097-1 Springer Berlin Heidelberg New York
ISBN-13 978-3-642-03097-0 Springer Berlin Heidelberg New York

This work is subject to copyright. All rights are reserved, whether the whole or part of the material is concerned, specifically the rights of translation, reprinting, re-use of illustrations, recitation, broadcasting, reproduction on microfilms or in any other way, and storage in data banks. Duplication of this publication or parts thereof is permitted only under the provisions of the German Copyright Law of September 9, 1965, in its current version, and permission for use must always be obtained from Springer. Violations are liable to prosecution under the German Copyright Law.

springer.com

© Springer-Verlag Berlin Heidelberg 2009
Printed in Germany

Typesetting: Camera-ready by author, data conversion by Scientific Publishing Services, Chennai, India
Printed on acid-free paper SPIN: 12660797 06/3180 5 4 3 2 1 0

The LNCS Journal on Semantics of Data

Computerized information handling has changed its focus from centralized data management systems to decentralized data exchange facilities. Modern distribution channels, such as high-speed Internet networks and wireless communication infrastructure, provide reliable technical support for data distribution and data access, materializing the new, popular idea that data may be available to anybody, anywhere, anytime. However, providing huge amounts of data on request often turns into a counterproductive service, making the data useless because of poor relevance or an inappropriate level of detail. Semantic knowledge is the essential missing piece that allows the delivery of information that matches user requirements. Semantic agreement, in particular, is essential to meaningful data exchange.

Semantic issues have long been open issues in data and knowledge management. However, the boom in semantically poor technologies, such as the Web and XML, has boosted renewed interest in semantics. Conferences on the Semantic Web, for instance, attract big crowds of participants, while ontologies on their own have become a hot and popular topic in the database and artificial intelligence communities.

Springer's *LNCS Journal on Data Semantics* aims at providing a highly visible dissemination channel for remarkable work that in one way or another addresses research and development on issues related to the semantics of data. The target domain ranges from theories supporting the formal definition of semantic content to innovative domain-specific application of semantic knowledge. This publication channel should be of the highest interest to researchers and advanced practitioners working on the Semantic Web, interoperability, mobile information services, data warehousing, knowledge representation and reasoning, conceptual database modeling, ontologies, and artificial intelligence.

Topics of relevance to this journal include:

- Semantic interoperability, semantic mediators
- Ontologies
- Ontology, schema and data integration, reconciliation and alignment
- Multiple representations, alternative representations
- Knowledge representation and reasoning
- Conceptualization and representation
- Multimodel and multiparadigm approaches
- Mappings, transformations, reverse engineering
- Metadata
- Conceptual data modeling
- Integrity description and handling
- Evolution and change
- Web semantics and semi-structured data

- Semantic caching
- Data warehousing and semantic data mining
- Spatial, temporal, multimedia, and multimodal semantics
- Semantics in data visualization
- Semantic services for mobile users
- Supporting tools
- Applications of semantic-driven approaches

These topics are to be understood as specifically related to semantic issues. Contributions submitted to the journal and dealing with semantics of data will be considered even if they are not from the topics in the list.

While the physical appearance of the journal issues resembles the books from the well-known Springer LNCS series, the mode of operation is that of a journal. Contributions can be freely submitted by authors and are reviewed by the Editorial Board. Contributions may also be invited, and nevertheless carefully reviewed, as in the case for issues that contain extended versions of the best papers from major conferences addressing data semantics issues. Special issues, focusing on a specific topic, are coordinated by guest editors once the proposal for a special issue is accepted by the Editorial Board. Finally, it is also possible that a journal issue be devoted to a single text.

The Editorial Board comprises an Editor-in-Chief (with overall responsibility), a Co-editor-in-Chief, and several members. The Editor-in-Chief has a four-year mandate. Members of the board have a three-year mandate. Mandates are renewable and new members may be elected anytime.

We are happy to welcome you to our readership and authorship, and hope we will share this privileged contact for a long time.

Stefano Spaccapietra
Editor-in-Chief
<http://lbd.epfl.ch/e/Springer/>

JoDS Volume XIII – Special Issue on Semantic Data Warehouses

Data warehouses have been established as a fundamental and essential component of current decision-support systems. Many organizations have successfully used data warehouses to collect essential indicators that help them improve their business processes. Furthermore, the combination of data warehouses and data mining has allowed these organizations to extract strategic knowledge from raw data, allowing them to design new ways to perform their operations.

In recent years, research in data warehouses has addressed many topics ranging from physical-level issues, aiming at increasing the performance of data warehouses in order to deal with vast amounts of data, to conceptual-level and methodological issues, which help designers build effective data warehouse applications that address the needs of decision makers better.

Nevertheless, globalization and increased competition pose new challenges to organizations, which need to dynamically and promptly adapt themselves to new situations. This brings new requirements to their data warehouse and decision-support systems, particularly with respect to (1) heterogeneity, autonomy, distribution, and evolution of data sources, (2) integration of data from these data sources while ensuring consistency and data quality, (3) adaptability of the data warehouse to multiple users with multiple and conflicting requirements, (4) integration of the data warehouse with the business processes of the organization, and (5) providing innovative ways to interact with the data warehouse, including advanced visualization mechanisms that help to reveal strategic knowledge. In addition, data warehouses are increasingly being used in non-traditional application domains, such as biological, multimedia, and spatio-temporal applications, which demand new requirements for dealing with the particular semantics of these application domains.

Therefore, building next-generation data warehouse systems and applications requires enriching the overall data warehouse lifecycle with semantics in order to support a wide variety of tasks including interoperability, knowledge reuse, knowledge acquisition, knowledge management, reasoning, etc.

The papers in this special issue address several of the topics mentioned above. They all provide different insights into the multiple benefits that can be obtained by envisioning data warehouses from a new semantic perspective. As this is a relatively new domain, these papers open many new research directions that need to be addressed in future work. This research will definitely have a huge impact on the next generation of data warehouse applications and tools.

Referees for the Special Issue

We would like to thank all the reviewers for their excellent work in evaluating the papers. Without their committment the publication of this special issue of JODS would not have been possible.

Alberto Abelló, Universitat Politècnica de Catalunya, Spain

Omar Boussaïd, Université du Lyon 2, France

Matteo Golfarelli, University of Bologna, Italy

Panagiotis Kalnis, National University of Singapore, Singapore

Jens Lechtenbörger, University of Münster, Germany

Wolfgang Lehner, Dresden University of Technology, Germany

Tok Wang Ling, National University of Singapore, Singapore

Sergio Luján Mora, University of Alicante, Spain

Elzbieta Malinowski, Universidad de Costa Rica, Costa Rica

Svetlana Mansmann, University of Konstanz, Germany

Rokia Missaoui, Université du Québec en Outaouais, Canada

Ullas Nambiar, IBM India Research Lab, India

Torben Bach Pedersen, Aalborg University, Denmark

Mario Piattini, Universidad de Castilla La Mancha, Spain

Stefano Rizzi, University of Bologna, Italy

Markus Schneider, University of Florida, USA

Alkis Simitsis, Stanford University, USA

Dimitri Theodoratos, New Jersey Institute of Technology, USA

Juan-Carlos Trujillo Mondéjar, Universidad de Alicante, Spain

Panos Vassiliadis, University of Ioannina, Greece

Robert Wrembel, Poznan University of Technology, Poland

Previous Issues of the Journal

- JoDS I Special Issue on Extended Papers from 2002 Conferences, LNCS 2800, December 2003
Co-editors: Sal March and Karl Aberer
- JoDS II Special Issue on Extended Papers from 2003 Conferences, LNCS 3360, December 2004
Co-editors: Roger (Buzz) King, Maria Orlowska, Elisa Bertino, Dennis McLeod, Sushil Jajodia, and Leon Strous
- JoDS III Special Issue on Semantic-Based Geographical Information Systems, LNCS 3534, August 2005
Guest Editor: Esteban Zimányi
- JoDS IV Normal Issue, LNCS 3730, December 2005
- JoDS V Special Issue on Extended Papers from 2004 Conferences, LNCS 3870, February 2006
Co-editors: Paolo Atzeni, Wesley W. Chu, Tiziana Catarci, and Katia P. Sycara
- JoDS VI Special Issue on Emergent Semantics, LNCS 4090, September 2006
Guest Editors: Karl Aberer and Philippe Cudre-Mauroux
- JoDS VII Normal Issue, LNCS 4244, November 2006
- JoDS VIII Special Issue on Extended Papers from 2005 Conferences, LNCS 4830, February 2007
Co-editors: Pavel Shvaiko, Mohand-Saïd Hacid, John Mylopoulos, Barbara Pernici, Juan Trujillo, Paolo Atzeni, Michael Kifer, François Fages, and Ilya Zaihrayeu
- JoDS IX Special Issue on Extended Papers from 2005 Conferences (continued), LNCS 4601, September 2007
Co-editors: Pavel Shvaiko, Mohand-Saïd Hacid, John Mylopoulos, Barbara Pernici, Juan Trujillo, Paolo Atzeni, Michael Kifer, François Fages, and Ilya Zaihrayeu
- JoDS X Normal Issue, LNCS 4900, February 2008

- JoDS XI Special Issue on Extended Papers from 2006 Conferences,
LNCS 5383, December 2008
Co-editors: Jeff Z. Pan, Philippe Thiran, Terry Halpin,
Steffen Staab, Vojtech Svatek, Pavel Shvaiko, and John
Roddick
- JoDS XII Normal Issue, in press, March 2009

JoDS Editorial Board

Editor-in-Chief Stefano Spaccapietra, EPFL, Switzerland
Co-editor-in-Chief Lois Delcambre, Portland State University, USA

Members

Carlo Batini	Università di Milano Bicocca, Italy
Alex Borgida	Rutgers University, USA
Shawn Bowers	University of California Davis, USA
Tiziana Catarci	Università di Roma La Sapienza, Italy
David W. Embley	Brigham Young University, USA
Jerôme Euzenat	INRIA Alpes, France
Dieter Fensel	University of Innsbruck, Austria
Fausto Giunchiglia	University of Trento, Italy
Nicola Guarino	National Research Council, Italy
Jean-Luc Hainaut	FUNDP Namur, Belgium
Ian Horrocks	University of Manchester, UK
Arantza Illarramendi	Universidad del País Vasco, Spain
Larry Kerschberg	George Mason University, USA
Michael Kifer	State University of New York at Stony Brook, USA
Tok Wang Ling	National University of Singapore, Singapore
Shamkant B. Navathe	Georgia Institute of Technology, USA
Antoni Olivé	Universitat Politècnica de Catalunya, Spain
José Palazzo M. de Oliveira	Universidade Federal do Rio Grande do Sul, Brazil
Christine Parent	Université de Lausanne, Switzerland
Klaus-Dieter Schewe	Massey University, New Zealand
Heiner Stuckenschmidt	University of Mannheim, Germany
Pavel Shvaiko	Informatica Trentina, Italy
Katsumi Tanaka	University of Kyoto, Japan
Yair Wand	University of British Columbia, Canada
Eric Yu	University of Toronto, Canada
Esteban Zimányi	Université Libre de Bruxelles, Belgium

Table of Contents

Multidimensional Integrated Ontologies: A Framework for Designing Semantic Data Warehouses	1
<i>Victoria Nebot, Rafael Berlanga, Juan Manuel Pérez, María José Aramburu, and Torben Bach Pedersen</i>	
A Unified Object Constraint Model for Designing and Implementing Multidimensional Systems	37
<i>François Pinet and Michel Schneider</i>	
Modeling Data Warehouse Schema Evolution over Extended Hierarchy Semantics	72
<i>Sandipto Banerjee and Karen C. Davis</i>	
An ETL Process for OLAP Using RDF/OWL Ontologies	97
<i>Marko Niinimäki and Tapio Niemi</i>	
Ontology-Driven Conceptual Design of ETL Processes Using Graph Transformations	120
<i>Dimitrios Skoutas, Alkis Simitsis, and Timos Sellis</i>	
Policy-Regulated Management of ETL Evolution	147
<i>George Papastefanatos, Panos Vassiliadis, Alkis Simitsis, and Yannis Vassiliou</i>	
Author Index	179