

Stefano Ceri Katsumi Tanaka
Shalom Tsur (Eds.)

Deductive and Object-Oriented Databases

Third International Conference, DOOD '93
Phoenix, Arizona, USA, December 6-8, 1993
Proceedings



Springer-Verlag

Berlin Heidelberg New York
London Paris Tokyo
Hong Kong Barcelona
Budapest

Series Editors

Gerhard Goos
Universität Karlsruhe
Postfach 69 80
Vincenz-Priessnitz-Straße 1
D-76131 Karlsruhe, Germany

Juris Hartmanis
Cornell University
Department of Computer Science
4130 Upson Hall
Ithaca, NY 14853, USA

Volume Editors

Stefano Ceri
Politecnico di Milano, Dipartimento di Elettronica
Piazza Leonardo da Vinci, 32, I-20133 Milano, Italy

Katsumi Tanaka
Kobe University, Department of Computer and Systems Engineering
Rokkodai, Nada, Kobe 657, Japan

Shalom Tsur
The University of Texas, System Ctr. for High Performance Computing
Balcones Research Center
10100 N. Burnett Road, Austin, TX 78758-4497, USA

CR Subject Classification (1991): H.2.3, D.1.5-6, I.2.4, F.4.1

ISBN 3-540-57530-8 Springer-Verlag Berlin Heidelberg New York
ISBN 0-387-57530-8 Springer-Verlag New York Berlin Heidelberg

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-Verlag. Violations are liable for prosecution under the German Copyright Law.

© Springer-Verlag Berlin Heidelberg 1993
Printed in Germany

Typesetting: Camera-ready by author
Printing and binding: Druckhaus Beltz, Hemsbach/Bergstr.
45/3140-543210 - Printed on acid-free paper

Preface

The Third International Conference on Deductive and Object-Oriented Databases is a continuation of the two previous conferences in this area. Its central tenet is the continuing belief that the object-oriented and deductive paradigms for the modeling, organization, and processing of data complement each other rather than competing, and that the solution of problems involving massive volumes of complex data can best be attempted by utilizing the best of both approaches in an integrated fashion.

Central questions in this area are therefore: "How do we design a tool that presents the best of the object-oriented and declarative ideas, blended into one seamless form? How can the users of this tool express their problems in a combination of declarative and procedural features as their needs dictate it?" The search for answers to these issues forms a continuing quest and we have attempted to include papers in this volume that contribute towards this goal.

This volume contains twenty-nine papers. Three invited papers (David Maier, Kotagiri Ramamohanarao, Rainer Manthey) well represent the current efforts towards establishing the technology of deductive and object-oriented databases though concrete prototyping and product-oriented project experiences: Proxies, Aditi, and IDEA.

Twenty-six regular papers were selected out of a total of seventy submissions. Eleven of them were selected by the European Program Committee after a Program Committee meeting held in Milan on June 30; ten were selected by the American Program Committee; and five were selected by the Far East Program Committee. The outcome of the Far East and American Committee was solely based on the referee reports received for each paper and the discussions among the members of the committees. As a noteworthy feature it should be mentioned that the global evolution of electronic mail made it possible to conclude the discussions among the different chairs without ever having to physically gather at one place.

The editors wish to thank all of those who committed their time and efforts towards the success of this conference, either by submitting papers and/or by reviewing them.

December 1993

Stefano Ceri
Katsumi Tanaka
Shalom Tsur

Message of the General Conference Chairperson

It gives me great pleasure to welcome the Third International Conference on Deductive and Object-Oriented Databases (DOOD93) to the Valley of the Sun in Scottsdale, Arizona. This is the first time the DOOD conference has been held in the Americas. The notable success of the first two conferences in Kyoto, Japan, and Munich, Germany, established a challenging benchmark for us to meet. Judging from the quality of the papers that were accepted, I feel confident that this tradition of success is being continued. The original goal of the DOOD conference was to bring together researchers and practitioners who are dealing with two of the most promising areas of database research, deductive logic and object-orientation. This goal is still valid, especially as it appears that there will be industrial DOOD systems emerging in the near future.

The high quality of the papers presented at the conference is a direct result of the hard work and diligence of the three program committees and external reviewers under the supervision and guidance of the Program Chairs: Prof. Stefano Ceri, Prof. Katsumi Tanaka and Dr. Shalom Tsur. I would like to express my sincere thanks for their efforts in selecting twenty-six high quality papers and to the authors. I also want to express my thanks to the three invited speakers, Prof. David Maier, Prof. Kotagiri Ramamohanarao and Prof. Rainer Manthey. In recognition of the movement of DOOD out of the research laboratory and into industrial environments, the conference is also featuring two panels, one devoted to DOOD research directions and the other exploring potential application domains for DOOD.

An interesting innovation for this conference is that several papers have been nominated for inclusion in a special issue of the *Journal of Intelligent Information Systems*, dedicated to DOOD topics, that is to appear in 1994.

The conference also includes several special activities for spouses and attendees that are intended to allow participants to gain a deeper appreciation of the Arizona locale. This includes an all-day tour to the Grand Canyon, immediately following the conference.

An undertaking of this magnitude cannot succeed without the assistance of numerous dedicated people who give unselfishly of their time and efforts. I would especially like to thank the chair of the organizing committee, Dr. Forouzan Golshani, for his extensive contributions. Thanks also are due to Prof. Robert Meitz, the treasurer, Ms. Robin Fulford, chair of publications and publicity and to Mr. Ted Karren, chair of registration.

I would like to express my gratitude to the chair of the DOOD Steering Committee, Dr. Jean-Marie Nicolas, and to each of the Steering Committee members. Finally, I would like to thank Prof. Jack Minker, Steering Committee Chair Emeritus, who remains one of the most important driving forces behind the success of this conference.

General Chairperson

Oris Friesen (Bull HN)

Steering Committee Chairperson

Jean-Marie Nicolas (Bull SA)

Steering Committee Chairperson Emeritus

Jack Minker (University of Maryland)

Program Committee Chairpersons

America

Shalom Tsur (University of Texas)

Europe

Stefano Ceri (Politecnico di Milano)

Far East

Katsumi Tanaka (Kobe University)

Far East Coordinator

Shojiro Nishio (Osaka University)

Organizing Committee Chairperson

Forouzan Golshani (Arizona State University)

Treasurer

Robert Meitz (Arizona State University)

Publicity and Publications Chairperson

Robin Fulford (Bull HN)

Registration Chairperson

Ted Karren (Bull HN)

Sponsors:

- Arizona State University/Intelligent Information Systems Laboratory
- Bull Worldwide Information Systems
- American Express

Supporting Organizations:

- European Computer-Industry Research Centre (ECRC)
- Advanced Software Technology and Mechatronics Research Institute of Kyoto (ASTEM RI/Kyoto)

Cooperating Organizations:

- American Association for Artificial Intelligence (AAAI)
- Commission of the European Communities, DGXIII

Program Committee Members

America

Anthony Bonner
(Univ. of Toronto)
Suzanne Dietrich
(Arizona State Univ.)
Sumit Ganguly
(Rutgers Univ.)
Narain Gehani
(ATT Bell Laboratories)
Michael Kifer
(SUNY Stony Brook)
Jean-Louis Lassez
(IBM TJWatson Res.Ctr.)
Jack Orenstein
(Object Design Inc.)
Raghu Ramakrishnan
(Univ. of Wisconsin)
Ken Ross
(Columbia Univ.)
Jehoshua Sagiv
(Hebrew Univ.)
Olivia Sheng
(Univ. of Arizona)
Oded Shmueli
(Technion, Haifa)
Ouri Wolfson
(Univ. of Illinois, Chicago)
Clement Yu
(Univ. of Illinois, Chicago)
Carlo Zaniolo
(UCLA)

Europe

Serge Abiteboul
(INRIA, Paris)
Peter Apers
(Univ. of Twente)
Elisa Bertino
(Univ. of Genova)
Francois Bry
(ECRC, Munich)
Georg Gottlob
(Tech. Univ. Wien)
Peter Gray
(Univ. of Aberdeen)
Klaus Dittrich
(Univ. of Zurich)
Giorgio Ghelli
(Univ. of Pisa)
Rainer Manthey
(Univ. of Bonn)
Jan Paredaens
(Univ. of Antwerp/UIA)
Joachim Schmidt
(Hamburg Univ.)
Marc Scholl
(Univ. of Ulm)
Letizia Tanca
(Politecnico di Milano)
Patrick Valduriez
(INRIA, Paris)
Fernando Velez
(O2 Technology)
Laurent Vieille
(Bull SA)
Roberto Zicari
(J.-W. Goethe Univ.)

Far East

Qiming Chen
(Tsing-Hua Univ.)
Kazuhiko Kato
(Univ. of Tokyo)
Tok-Wang Ling
(Natl. Univ. of Singapore)
Hongjun Lu
(Natl. Univ. of Singapore)
Akifumi Makinouchi
(Kyushu Univ.)
Nobuyoshi Miyazaki
(Oki)
Shojiro Nishio
(Osaka Univ.)
Atsushi Ohori
(Oki)
Maria Orlowska
(The Univ. of Queensland)
Ron Sacks-Davis
(RMIT, Univ. Melbourne)
Toshihisa Takagi
(Univ. of Tokyo)
Kyu-Young Whang
(KAIST)
Kazumasa Yokota
(ICOT)
Masatoshi Yoshikawa
(Kyoto Sangyo Univ.)

Contents

Object-Oriented Database Technology

Treating Programs as Objects: The Computational Proxy Experience (INVITED PAPER)	1
<i>D. Maier, J.B. Cushing</i>	

Language Semantics I

Foundations of Aggregation in Deductive Databases	13
<i>A. V. Gelder</i>	
The Differential Fixpoint Operator with Subsumption	35
<i>G. Köstler, W. Kießling, H. Thöne, U. Güntzer</i>	
Datalog with Non-Deterministic Choice Computes NDB-PTIME	49
<i>L. Corciulo, F. Giannotti, D. Pedreschi</i>	

Applications and Usage of Logic

A Deductive and Object-Oriented Approach to a Complex Scheduling Problem	67
<i>Y. Caseau, P-Y. Guillo, E. Levenez</i>	
On the Logical Foundations of Schema Integration and Evolution in Heterogeneous Database Systems	81
<i>L.V.S. Lakshmanan, F. Sadri, I.N. Subramanian</i>	
Explaining Program Execution in Deductive Systems	101
<i>T. Arora, R. Ramakrishnan, W.G. Roth, P. Seshadri, D. Srivastava</i>	

Query Optimization

A Logic for Rule-Based Query Optimization in Graph-Based Data Models	120
<i>N.Coburn, G.E. Weddell</i>	
Specifying Rule-Based Query Optimizers in a Reflective Framework	146
<i>L.Fegaras, D. Maier, T. Sheard</i>	
Semantic Query Optimization in Deductive Object-Oriented Databases ...	169
<i>J.P. Yoon, L. Kerschberg</i>	

Panel 1

Research in Deductive and Object-Oriented Databases	183
<i>R. Ramakrishnan (MODERATOR)</i>	

Deductive Logic Database Technology

An Implementation Overview of the Aditi Deductive Database System (INVITED PAPER)	184
<i>K. Ramamohanarao</i>	

Language Semantics II

Negation and Aggregates in Recursive Rules: The LDL++ Approach	204
<i>C. Zaniolo, N. Arni, K. Ong</i>	
ISALOG \neg : A Deductive Language with Negation for Complex-Object Databases with Hierarchies	222
<i>P. Atzeni, L. Cabibbo, G. Mecca</i>	
On Efficient Reasoning with Implication Constraints	236
<i>X. Zhang, Z.M. Ozsoyoglu</i>	

Query Processing

Bottom-Up Query Evaluation with Partially Ordered Defaults	253
<i>S. Brass, U.W. Lipeck</i>	
An Extension of Path Expressions to Simplify Navigation in Object-Oriented Queries	267
<i>J. Van den Bussche and G. Vossen</i>	
Query Classes	283
<i>M. Staudt, M. Jarke, M.A. Jeusfeld, H.W. Nissen</i>	

Updates

Database Updating Revisited	296
<i>D. Laurent, V. Phan Luong, N. Spyratos</i>	
Super-Key Classes for Updating Materialized Derived Classes in Object Bases	310
<i>S. Konomi, T. Furukawa, Y. Kambayashi</i>	

Panel 2

Applications of Deductive and Object-Oriented Databases	327
<i>S.W. Dietrich (MODERATOR)</i>	

Deductive and Object-Oriented Database Technology

Beyond Data Dictionaries: Towards a Reflective Architecture of Intelligent Database Systems (INVITED PAPER)	328
<i>R. Manthey</i>	

Extensions to Object-Orientation

A Deductive and Typed Object-Oriented Language	340
<i>R. Bal, H. Balsters</i>	
Noodle: A Language for Declarative Querying in an Object-Oriented Database	360
<i>I.S. Mumick, K.A. Ross</i>	
Tracking Causal Dependencies in an Active Object-Oriented Database ...	379
<i>D.Mattox, K. Smith, S.C.Y. Lu</i>	

Object-Oriented Concepts

Automatic Class and Method Generation for Object-Oriented Databases	395
<i>R. Elmasri, S. James, V. Kouramajian</i>	
Modeling Multilevel Entities Using Single Level Objects	415
<i>E.Bertino, S. Jajodia</i>	
A Model Using Classes as a Basic Organization Tool	429
<i>T.W. Koh, B.C. Ooi, Y.S. Ho</i>	

Data and Knowledge Modelling Concepts

Knowledge Base Revision Using Circumscription	444
<i>L.Y. Yuan, J-H. You</i>	
Versioning of Objects in Deductive Databases	459
<i>F.N. Kesim, M. Sergot</i>	
A Model for Sets and Multiple Inheritance in Deductive Object-Oriented Systems	473
<i>G. Dobbie, R. Topor</i>	