

Proceedings

Seventh International Conference on

DATA ENGINEERING



April 8-12, 1991
Kobe, JAPAN



IEEE Computer Society Press



The Institute of Electrical and Electronics Engineers, Inc.

Proceedings

Seventh International Conference on
DATA ENGINEERING

1951 - 1991
40 YEARS OF SERVICE

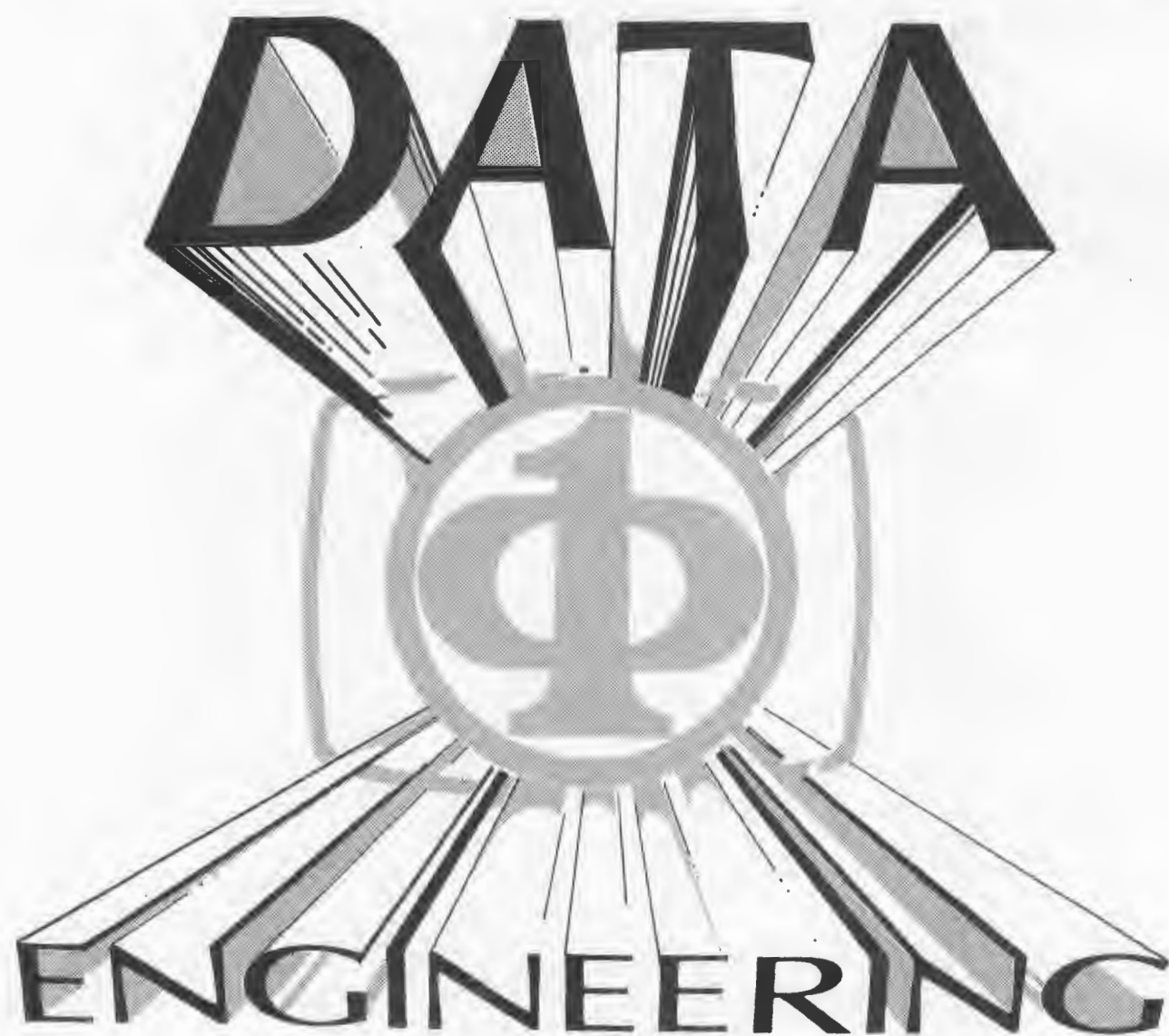


IEEE COMPUTER SOCIETY

Proceedings

Seventh International Conference on

DATA ENGINEERING



April 8-12, 1991
Kobe, JAPAN



IEEE Computer Society Press



The Institute of Electrical and Electronics Engineers, Inc.

Proceedings

Seventh International Conference on
DATA ENGINEERING

April 8-12, 1991
Kobe, JAPAN

Supported by:

ASCII Corporation
Daikin Industries, Ltd.
Digital Equipment Corporation, Japan
Fujitsu, Ltd.
Hitachi, Ltd.
IBM Japan, Ltd.
Kao Corporation
Kawasaki Steel Corporation
KDD Company, Ltd.
Kozo Keikaku Engineering Inc.
Matsuda Motor Corporation
NEC Corporation
Nihon Unisys, Ltd.
Nippon Timeshare Company, Ltd.
NTT Corporation
Oki Electric Industry Company, Ltd.
OMRON Corporation
Ricoh Company, Ltd.
Seiko Instrument and Electronics, Ltd.
Sharp Corporation
Sumitomo Electric Industries, Ltd.
The Japan Research Institute, Ltd.
Toshiba Corporation
Yokogawa Electric Corporation



IEEE Computer Society Press
Los Alamitos, California

Washington ● Brussels ● Tokyo

The papers in this book comprise the proceedings of the meeting mentioned on the cover and title page. They reflect the authors' opinions and are published as presented and without change, in the interest of timely dissemination. Their inclusion in this publication does not necessarily constitute endorsement by the editors, the IEEE Computer Society Press, or The Institute of Electrical and Electronics Engineers, Inc.

Published by



IEEE Computer Society Press
10662 Los Vaqueros Circle
P.O. Box 3014
Los Alamitos, CA 90720-1264

Copyright © 1991 by the Institute of Electrical and Electronics Engineers, Inc.

Cover designed by Jack I. Ballestero

Production Editor Wally Hutchins

Printed by Edwards Bros., in the United States of America

Copyright and Reprint Permissions: Abstracting is permitted with credit to the source. Libraries are permitted to photocopy beyond the limits of U.S. copyright law for private use of patrons those articles in this volume that carry a code at the bottom of the first page, provided the per-copy fee indicated in the code is paid through the Copyright Clearance Center, 29 Congress Street, Salem, MA 01970. Instructors are permitted to photocopy isolated articles for noncommercial classroom use without fee. For other copying, reprint or republication permission, write to Director, Publishing Services, IEEE, 345 East 47th Street, New York, NY 10017. All rights reserved.

IEEE Computer Society Press Order Number 2138

Library of Congress Number 90-85782

IEEE Catalog Number 91CH2968-6

ISBN 0-8186-2138-9 (paper)

ISBN 0-8186-6138-0 (microfiche)

ISBN 0-8186-9138-0 (case)

Additional copies can be ordered from:

IEEE Computer Society Press
Customer Service Center
10662 Los Vaqueros Circle
P.O. Box 3014
Los Alamitos, CA 90720-1264

IEEE Computer Society
13, avenue de l'Aiglon
B-1200 Brussels
BELGIUM

IEEE Computer Society
Ooshima Building
2-19-1 Minami-Aoyama,
Minato-Ku
Tokyo 107, JAPAN

IEEE Service Center
445 Hoes Lane
P.O. Box 1331
Piscataway, NJ 08855-1331



THE INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS, INC.

General Co-Chairpersons' Message

We would like to welcome you to Kobe, Japan, and the Seventh International Conference on Data Engineering (ICDE-7). This is the first time the ICDE is being held outside of the United States since its inception in 1984. Given the dramatic advances in computer technologies during the past decade in Asia, Kobe is a very exciting place to host ICDE-7. We hope that you will find both the tutorials and technical program useful and stimulating, and that you will take advantage of this opportunity to engage in social and technical dialog with your colleagues from other parts of the world. This year we received 260 submissions from 25 countries, making ICDE-7 a truly international conference.

An international conference of this size and diversity requires a tremendous amount of work and coordination from many people and organizations. First of all, we would like to acknowledge the support we have received from the city of Kobe and 26 companies from Japanese industry (see the list appearing on page iii). Without their generosity, the conference would not be as successful as we anticipated.

As General Co-Chairpersons, our primary responsibility is to coordinate various tasks carried out by other willing and talented volunteers. We would like to take this opportunity to express our sincere appreciation to Nick Cercone and Mas Tsuchiya, Program Co-Chairpersons, and their 70-member Program Committee for doing an excellent job in selecting 78 high-quality papers for presentation at the conference. We would also like to thank Koichi Furukawa for organizing the Industrial Track sessions. Thanks are due to Amit Sheth and Ryohei Nakano for arranging eight excellent tutorials and to David Cohen and Yuzuru Tanaka for selecting the best paper of the conference. Special thanks go to Akihiko Yamada and Masaru Kitsuregawa for coordinating with Japanese industry. Last, but not least, we would like to express our thanks to the ICDE Steering Committee for their vote of confidence in us for running this conference, and to Wally Hutchins for editing the proceedings.

We would also like to express our appreciation to both Professor C.V. Ramamoorthy and Professor Hisashi Kobayashi for accepting our invitation to be the keynote speakers. Both of them are world-class researchers and educators, and have made tremendous contributions to many areas of computer science and engineering. Finally, we would like to thank all the attendees of ICDE-7, and hope that you will find time to enjoy both the conference and the city of Kobe to the utmost extent.

Ming T. (Mike) Liu
Tadao Ichikawa
General Co-Chairpersons

Program Co-Chairpersons' Message

We extend a hearty greeting in welcoming you to Kobe, Japan, and to the Seventh IEEE International Conference on Data Engineering. This year, with the Conference being held outside of Los Angeles for the first time, we mark a new beginning for the Data Engineering Conference. Its increased importance and continued strong interest worldwide are reflected in the large number of papers that were submitted. The quality of the technical program continues to improve making Data Engineering a most highly regarded conference.

We received 260 submissions from 25 countries from all parts of the world. The quality of these papers was outstanding. Due to limited space, however, the program committee applied stringent standards to select 77 papers on interesting, timely, and important subjects, ranging from query processing to object-oriented databases. Selected papers were organized into three tracks of 18 technical sessions to be presented over three days. In addition to these regular sessions, we have added an industrial track on the second day consisting of two paper sessions and one panel session. Our intent for organizing the Industrial Track is to provide a forum for sharing practical industry experience among those who have more applied problems and needs as well as those researchers who are insulated from the "real world" engineering problems. We believe panel sessions provide an important opportunity to interact in an informal way with the leading experts in specific subject areas. We have included six panel sessions.

Tutorial sessions offer informative, current topics; we encourage your attendance. After surveying the needs of the data engineering community, the tutorial chair then carefully chose the speakers who were best qualified to present these topics. We are privileged to have two outstanding keynote speakers. Professor C.V. Ramamoorthy, of the University of California, Berkeley, is world renowned for his prolific contributions to a variety of areas in computer science. Professor Hisashi Kobayashi, Dean of Engineering at Princeton University, is an experienced technology manager and has made important contributions to computer performance measurement.

It is impossible to individually thank all of the persons who contributed to the success of this Conference. We would like to mention a few of them. We thank all of the members of the Program Committee for their selfless dedication in reviewing and selecting papers. The Advisory Committee in Japan, especially organized for this conference, was instrumental in soliciting a large number of papers from Japan and encouraging conference participation from the Japanese computer industry. Our special thanks go to the members of the Data Engineering Steering Committee; the Co-general Chairpersons, Tad Ichikawa and Mike Liu; the Vice Chairpersons, M. Ahuja, A. Elmagarmid, K. Furukawa, R. Goebel, F. Golshani, R. King, M. Kitsuregawa, R. Liuzzi, A. Makinouchi, E. Neuhold, K. Whang, and C. Yu; Tutorials Chair, A. Sheth; Industrial Coordinator, A. Yamada; European Coordinator, W. Litwin; Awards Chair, D. Cohen; Publicity Chair, T. Sparr; the Treasurers, T. Lien and T. Kikuno; and all of the helpful members of the IEEE Computer Society and Graphic Tuna. We would also like especially to thank Ms. Carolyn Seely-Morrison, Ms. Sandra Johnson, and Ms. Gail Brow, of the Centre for Systems Science at Simon Fraser University, for their heroic efforts to conceal our disorganization from authors, reviewers, and program committee members. Their day-to-day effort to ensure that a productive program committee meeting take place required much hard work and dedication. The Simon Fraser University Centre for Systems Science also made invaluable contributions to the success of this Conference.

Finally we would like to thank all of you, the participants, for your attendance and hope that you benefit from attending this Conference.

Nick Cercone and Mas Tsuchiya
Program Co-Chairpersons

Committee Members

Steering Committee

C.V. Ramamoorthy
University of California, Berkeley, USA

P. Bruce Berra
Syracuse University, USA

Benjamin W. Wah
University of Illinois, USA

John Carlis
University of Minnesota, USA

Joseph E. Urban
Arizona State University, USA

General Chairpersons

Ming T. (Mike) Liu
Ohio State University, USA

Tadao Ichikawa
Hiroshima University, Japan

Program Chairpersons

Nick J. Cercone
Simon Fraser University, Canada

Mas Tsuchiya
Sypex International, USA/Japan

Program Vice-Chairpersons

Mohan Ahuja
Ohio State University, USA

Ahmed K. Elmagarmid
Purdue University, USA

Kuichi Furukawa
ICOT, Japan

Randy Goebel
University of Alberta, Canada

Forouzan Golshani
Arizona State University, USA

Roger King
University of Colorado, USA

Masaru Kitsuregawa
University of Tokyo, Japan

Raymond Liuzzi
USAF RADC, USA

Akifumi Makinouchi
Kyushu University, Japan

Erich Neuhold
GMD, Germany

Kyu-Young Whang
IBM Watson Research Center, USA

Clement T. Yu
University of Illinois at Chicago, USA

Tutorials Chairpersons

Amit P. Sheth
Bellcore, USA

Ryohei Nakano
Japan

Industrial Coordinator

Akihiko Yamada
NEC Corporation, Japan

Advisory Committee

Chairperson

Masaru Kitsuregawa
University of Tokyo, Japan

Members

Yunosuke Haga
Oki Electric Industry Co., Ltd., Japan
Takaya Ishida
Mitsubishi Electric Corporation, Japan
Tohru Kawata
Sharp Corporation, Japan
Tsutomu Kawada
Toshiba Corp., Japan

Tsukasa Kawaoka
NTT Corporation, Japan
Kaname Kobayashi
Fujitsu, Ltd., Japan
Masao Managaki
NEC Corporation, Japan
Takayuki Sagishima
*Matsushita Electric Industrial Co., Ltd.,
Japan*
Norihisa Suzuki
IBM Japan, Ltd., Japan
Seiichi Yoshizumi
Hitachi, Ltd., Japan

European Coordinator

Witold Litwin
INRIA, France

Awards

David Cohen
Sente Corporation, USA

Yuzuru Tanaka
Hokkaido University, Japan

Publicity

Ted M. Sparr
Univ. of New Hampshire, USA

Masahito Hirakawa
Hiroshima University, Japan

Treasurers

Yao-Nan Lien
AT&T Bell Labs, USA

Tohru Kikuno
Osaka University, Japan

Local Arrangements

Masatoshi Yoshikawa
Kyoto Sangyo Univ., Japan

Program Committee Members

- Amr El Abbadi, *University of Calif., Santa Barbara, USA*
Altair Bancilhgon, *Demaine de Voluceau, France*
François Bancilhgon, *INRIA, France*
Jonathan Bein, *University of Colorado, USA*
Bharat K. Bhargava, *Purdue Univ., USA*
Dr. Bocca, *ECRC, Germany*
François Bry, *ECRC, Germany*
Stefano Ceri, *Politecnico di Milano, Italy*
Sharma Chakravarthy, *Univ. of Florida, USA*
Peter Dadam, *University of Ulm, Germany*
S. Misbah Deen, *University of Keele, England*
David DeWitt, *University of Wisconsin, Madison, USA*
Klaus Dittrich, *University of Zurich, Switzerland*
Shinya Fushimi, *Mitsubishi Electric Corp., Japan*
Hector Garcia-Molina, *Princeton Univ., USA*
Georg Gottlob, *Technical Univ. Vienna, Austria*
Goetz Graefe, *University of Colorado, USA*
K.C. Guh, *Univ. of Wisconsin, Milwaukee, USA*
Jiawei Han, *Simon Fraser University, Canada*
Sandra Heiler, *Xerox Corporation, USA*
Yoshio Izumida, *Fujitsu Labs Ltd., Japan*
H.V. Jagadish, *AT&T Bell Labs, USA*
Nabil Kamel, *University of Florida, USA*
Iris Kamney, *Rand Corporation, USA*
Yutaka Kasahara, *NEC Corporation, Japan*
Charles Kellogg, *Lockheed AI Research, USA*
Larry Kerschberg, *George Mason University, USA*
Yashushi Kiyoki, *University of Tsukuba*
Robert R. Korfhage, *Univ. of Pittsburgh, USA*
Eva Kuhn, *Univ. of Technology Vienna, Austria*
Dik Lee, *Ohio State University, USA*
Stanley Lee, *University of Florida, USA*
Robert Levinson, *Univ. of Calif., Santa Cruz, USA*
Yao-Nan Lien, *AT&T Bell Labs, USA*
Wo-Shun Luk, *Simon Fraser Univ., Canada*
Peter Lyngbaek, *Hewlett-Packard Labs, USA*
William Mansfield, *Bellcore, USA*
Masanobu Matsuo, *Twin Sun, Inc., USA*
Gordon McCalla, *University of Saskatchewan, Canada*
Takao Miura, *Sangyo Noritsu Univ., Japan*
Nobuyoshi Miyazaki, *Oki Electric Ind., Japan*
Song-Chun Moon, *Korea Advanced Institute of Sci. & Tech., Korea*
Dan Moore, *US West Advanced Tech., USA*
Ali Morfeq, *King Abdulaziz Univ., Arabia*
Amihai Motor, *University of Southern California, USA*
Marguerite C. Murphy, *San Francisco State University, USA*
Masaya Nakayama, *Toyohashi University of Technology, Japan*
Peter A. Ng, *New Jersey Institute of Technology, USA*
Shojiro Nishio, *Osaka University, Japan*
Z. Meral Ozsoyoglu, *Case Western Reserve University, USA*
M. Tamer Ozsu, *GTE Labs Inc., USA*
D. Scott Parker, *Univ. of California, Los Angeles, USA*
Antonio Pizzarello, *Bull HN Info. Systems, USA*
Ing. Radu Popescu-Zeletin, *Nat'l Research Corp. for Math. & Data Proc., Germany*
Sakti Pramanik, *Michigan State Univ., East Lansing, USA*
M.V. Ramakrishna, *Michigan State Univ., East Lansing, USA*
David Reiner, *Lotus Dev. Corp., USA*
Arnie Rosenthal, *Xerox Corporation, USA*
Market Rusinkiewicz, *Univ. of Houston, USA*
Ron Sacks-Davis, *Royal Melbourne Institute of Technology, Australia*
G. Schlageter, *Fern Universitat, Germany*
Mike Stonebraker, *Univ. of California, Berkeley, USA*
Stanley Y.W. Su, *University of Florida, USA*
Katsumi Tanaka, *Kobe University, Japan*
Minoru Tanaka, *Hiroshima Univ., Japan*
Yuzuru Tanaka, *Hokkaido University, Japan*
Amin Tjoa, *University of Vienna, Austria*
Susan Urban, *Arizona State University, USA*
Ralph Wachter, *Naval Research, USA*
Jerry Yan, *NASA Ames, USA*
Kazumasa Yokota, *ICOT, Japan*

List of Reviewers

Adachi, J.
Afsarmanesh, H.
Agrawal, R.
Ahad, R.
Ahmed, R.
Ahuja, M.
Al-Qasimi, A.
Almajid, R.
Alonso, R.
Altinkemer, K.
Amano, H.
Analyti, A.
Arikawa, M.
Armstrong, W.
Bancilhon, F.
Barker, K.
Baron, R.
Bayle, A.J.
Beeri, C.
Bein, J.
Berra, J.B.
Böhnlein, P.
Boloix, G.
Boudriga, N.
Bouguettaya, A.
Breitbart, Y.
Brieteder, C.
Brocca, J.
Bry, F.
Buchmann, A.
Bukhres, O.
Burg, B.
Capraro, G.T.
Carey, M.J.
Carlis, J.
Cavano, J.
Cerccone, N.
Ceri, S.
Chakravarthy, S.
Chaturvedi, A.
Chen, J.-C.
Chen, M.-S.
Chen, Q.
Chiang, K.
Chou, H.-T.
Collet, C.
Cortes-Rello, E.
Crowter, J.J.
Dadam, P.
Dandamudi, S.
Dar, N.
Datta, A.
Dayal, U.
Delcambre, L.
Dietrich, S.W.
DiMarco, C.
Dimitrova, N.
Dittrich, K.R.
Dobosiewicz, W.
Dorn, J.
Draxler, C.
Drew, P.
Drosten, K.
Du, W.
Eiter, T.
El Abbadi, A.
El Mallah, E.
Elmagarmid, A.
Etherington, D.W.
Fankhauser, P.
Fass, D.
Fayek, A.M.
Fisher, D.G.
Fomaggi, Z.
Fotouhi, F.
Frestno, M.W.
Friesen, O.
Fujita, M.
Furukawa, K.
Fushimi, S.
Gadia, S.
Gahlot, A.
Gangopadhyay, D.
Gaudeot, J.-L.
Gburzynski, P.
Georgakopolous, D.
Gherfal, F.
Goebel, R.
Golshani, F.
Goodwin, S.
Goyal, P.
Graefe, G.
Green, M.
Groeneboer, C.
Guh, K.C.
Guh, K.G.
Gupta, R.
Hall, G.
Han, J.
Haniuda, H.
Haphard, J.
Harada, L.
Harashima, S.
Hasan, W.
Hasse, C.
Hayashi, K.
Heddaya, A.
Heiler, S.
Hernandez, H.J.
Hiraoka, A.
Hirony, A.
Hoebel, L.
Hong, J.-K.
Hong, K.-H.
Hoover, H.J.
Hsu, M.
Hu, Y.
Hurang, A.
Ibaraki, T.
Iida, T.
Ikeda, H.
Ikeda, T.
Inoue, U.
Ishida, T.
Ishikawa, H.
Ishizuka, M.
Jagadish, H.V.
Kalliss, F.
Kambayashi, Y.
Kamel, N.
Kamel, U.
Kanasaki, K.
Kaneda, Y.
Kaneko, A.
Kappel, G.
Kato, K.
Kato, T.
Katoh, N.
Katsuno, H.
Kaul, M.
Kawagoe, K.
Kifer, M.
Kim, C.
Kimura, Y.
Kishimoto, M.
Kitagawa, H.
Kiyoki, Y.
Klas, W.
Kobayashi, S.
Kogan, B.
Koo, R.
Korfhage, R.
Kounoe, M.
Krishnamurthy, R.
Krueger, P.
Kuhn, E.
Kumagai, N.
Kung, C.
Kunifuji, S.
Kunii, H.S.
Kuroki, S.
Laasch, C.
Lakshman, T.V.
Lazzara, A.V.
Lee, D.
Lee, H.-S.
Lee, H.-Y.
Lee, R.-C.
Lee, Y.S.
Lefebvre, A.
Leichner, S.
Lemmer, J.
Leu, Y.
Levinson, R.
Lieberherr, K.
Lien, Y.-N.
Lin, D.
Litwin, W.
Liu, C.
Liuzzi, R.
Lockemann, P.
Lohman, G.M.
Lomet, D.
Long, D.
Luk, W.S.
Lum, V.
Lyngback, P.
Makinouchi, A.
Malhotra, A.
Managaki, M.
Manning, M.
Manoh, F.
Mansfield, W.
Manthey, R.
Martin, T.P.
Masukuchi, Y.
Masunaga, Y.
Matherson, J.
Matsuo, F.
Matsuo, M.
McFetridge, P.
McIver, W.J.
Meng, W.
Mercer, R.

Merz, U.
 Millard, B.R.
 Minker, J.
 Miranker, P.
 Missaoui, R.
 Miura, T.
 Miyazaki, J.
 Miyazaki, N.
 Moerkotte, G.
 Monkeberg, A.
 Mono, S.C.
 Moore, D.
 Morfeq, A.
 Morimoto, Y.
 Morishita, S.
 Morita, Y.
 Moriya, K.
 Murata, M.
 Murphy, M.
 Muth, P.
 Nakano, M.
 Nakayama, H.
 Nakayama, M.
 Neimat, M.-A.
 Nguyen, D.
 Nigam, A.
 Nishio, S.
 Nitta, K.
 Ogawa, Y.
 Oheimer, M.
 Ohmori, T.
 Ohsato, H.
 Osborn, S.
 Ouksel, M.A.
 Ozkarahan, E.
 Ozsoyoglu, M.
 Ozsu, T.
 Parker, D.S.
 Perrizo, W.
 Pizarello, A.
 Popescu-Zeletin, R.

Potter, W.D.
 Pramanik, S.
 Pu, C.
 Punch, W.F.
 Quinlan, R.
 Quinn-Jacobs, D.
 Rafii, A.
 Raghavan, V.
 Rakow, T.C.
 Ramakrishna, M.V.
 Ramamohanarao, K.
 Ramamritham, K.
 Rao, K.R.
 Reiner, D.
 Renter, A.
 Richardson, J.
 Robinson, J.T.
 Rosenthal, A.
 Rubinovitz, H.
 Rusinkiewicz, M.
 Sacks-Davis, R.
 Saisho, Keizo
 Sakabe, T.
 Sakai, H.
 Sakakibara, Y.
 Sakama, C.
 Sakamoto, A.
 Sakauchi, M.
 Sakauti, M.
 Salem, K.
 Salzberg, B.
 Satoh, T.
 Sattar, A.
 Satyanarayanan, O.T.
 Sbattella, L.
 Schrefl, M.
 Schultz, J.W.
 Scott, W.
 Shaffer, C.
 Shan, M.
 Shaw, C.

Shekar, B.
 Shimojo, S.
 Shin, D.-G.
 Shioya, I.
 Shirazi, B.
 Silberchatz, A.
 Singhal, M.
 Snodgrass, R.
 Sohn, A.
 Soloninka, J.
 Sorenson, P.
 Sripada, S.M.
 Sticken, J.
 Stonebraker, M.
 Stumptner, M.
 Su, S.
 Sun, W.
 Sunderraman, R.
 Suzuka, T.
 Suzuki, K.
 Takagi, T.
 Takahashi, C.
 Takizawa, M.
 Tambe, M.
 Tanaka, K.
 Tanaka, Y.
 Tanaka, Y.
 Tang, J.
 Tanimoto, S.
 Thomas, M.
 Thomasian, A.
 Tirri, H.
 Toogood, R.
 Tout, W.
 Traff, J.
 Troy, D.J.
 Trudel, A.
 Tsuchiya, M.
 Tsuga, K.
 Tsukamoto, M.
 Tsuruoka, K.

Turau, V.
 Uchinami, S.
 Udagawa, Y.
 Ueshima, S.
 Unemi, T.
 Urban, S.
 Valduriez, P.
 Valduriez, R.
 van Beek, P.
 Vemuri, R.
 Vineyard, D.R.
 Wachter, R.
 Wah, B.
 Watanabe, T.
 Watari, S.
 Weddell, G.
 Weikum, G.
 Whang, K.-Y.
 Woelk, D.
 Wolf, J.
 Wolski, A.
 Wong, S.K.M.
 Xu, H.
 Yahalom, R.
 Yamane, Y.
 Yang, Q.
 Yaseen, R.
 Yokata, H.
 Tokota, K.
 Yokotsuka, M.
 Yoon, D.-K.
 Yoshikawa, M.
 You, J.
 Young, H.
 Yu, C.
 Yuan, L.Y.
 Zhang, W.
 Zhao, K.
 Zicari, R.

Table of Contents

General Co-Chairpersons' Message	v
Program Co-Chairpersons' Message	vi
Conference Committee	vii
Reviewers	x

Session 1: Object-Oriented Database Systems

Chair: S. Urban, Arizona State University

A Framework for Schema Updates in an Object-Oriented Database System	2
<i>R. Zicari</i>	
How Spacey Can They Get? Space Overhead for Storage and Indexing with Object-Oriented Databases	14
<i>M.J. Willshire</i>	
An Association Algebra for Processing Object-Oriented Databases	23
<i>M. Guo, S.Y.W. Su, and H. Lam</i>	

Session 2: Distributed Database Systems

Chair: M. Rusinkiewicz, University of Houston

Efficiently Maintaining Availability in the Presence of Partitionings in Distributed Systems	34
<i>P. Triantafiliou and D. Taylor</i>	
Processing of Multiple Queries in Distributed Databases	42
<i>A.Y. Lu and P.C.-Y. Sheu</i>	
Determining Beneficial Semijoins for a Join Sequence in Distributed Query Processing	50
<i>M.-S. Chen and P.S. Yu</i>	

Session 3: Design and Human Interfaces

Chair: R. Goebel, University of Alberta

Interactive Manipulation of Object-oriented Views	60
<i>J.-C. Mamou and C.B. Medeiros</i>	
Implementation and Evaluation of a Browsing Algorithm for Design Applications	70
<i>Y. Udagawa</i>	
A Knowledge-Based Subsystem for a Natural Language Interface to a Database That Predicts and Explains Query Failures	80
<i>S.W. Joseph and R. Aleliunas</i>	

Session 4: Panel 1: Practitioner Problems in Need of Database Research

Chair: G. Thomas, Bellcore

Panelists: TBA

Session 5: Data Engineering Techniques I

Chair: A. Sheth, Bellcore

Wait Depth Limited Concurrency Control	92
<i>P.A. Franaszek, J.T. Robinson, and A. Thomasian</i>	

Efficient Implementation Techniques for the Time Index	102
<i>R. Elmasri, Y.-J. Kim, and G.T.J. Wu</i>	
Voting with Regenerable Volatile Witnesses	112
<i>J.-F. Pâris and D.D.E. Long</i>	

Session 6: AI and Knowledge-Based Systems—Reasoning

Chair: R. Aleliunas, Simon Fraser University

Modeling Uncertainty in Databases	122
<i>F. Sadri</i>	
Natural Joins in Relational Databases with Indefinite and Maybe Information	132
<i>K.-C. Liu and L. Zhang</i>	
Meta-Reasoning: An Incremental Compilation Approach	140
<i>R. Goebel</i>	

Session 7: Access Methods and File Structures

Chair: A. Kaneko, NEC Corporation

DOT: A Spatial Access Method Using Fractals	152
<i>C. Faloutsos and Y. Rong</i>	
An Indexing Technique for Object-Oriented Databases	160
<i>E. Bertino</i>	
An Efficient Hybrid Join Algorithm: A DB2 Prototype	171
<i>J. Cheng, D. Haderle, R. Hedges, B.R. Iyer, T. Messinger, C. Mohan, and Y. Wang</i>	
Navigation and Schema Transformations for Producing Nested Relations from Networks	181
<i>M. Iwaihara, T. Furukawa, and Y. Kambayashi</i>	

Session 8: Parallel Query Processing

Chair: S. Fushimi, Mitsubishi Electric Corporation

Parallel Computation of Direct Transitive Closures	192
<i>Y.-N. Huang and J.-P. Cheiney</i>	
An Effective Algorithm for Parallelizing Hash Joins in the Presence of Data Skew	200
<i>J.L. Wolf, D.M. Dias, P.S. Yu, and J. Turek</i>	
Scheduling Batch Transactions on Shared-Nothing Parallel Database Machines: Effects of Concurrency and Parallelism	210
<i>T. Ohmori, M. Kitsuregawa, and H. Tanaka</i>	
The Software Architecture of a Parallel Processing System for Advanced Database Applications	220
<i>Y. Kiyoki, T. Kurosawa, K. Kato, and T. Masuda</i>	

Session 9: Deductive and Extensive Databases

Chair: D.S. Reiner, Lotus Development Corporation

Semantic Query Reformulation in Deductive Databases	232
<i>S.-G. Lee, L.J. Henschen, and G.Z. Qadah</i>	
Design Overview of the Aditi Deductive Database System	240
<i>J. Vaghani, K. Ramamohanarao, D.B. Kemp, Z. Somogyi, and P.J. Stuckey</i>	

A Rule-Based Query Rewriter in an Extensible DBMS	248
<i>B. Finance and G. Gardarin</i>	
Constraint-Based Reasoning in Deductive Databases	257
<i>J. Han</i>	

Session 10: Distributed Database Control

Chair: Y. Izumida, Fujitsu Laboratory

Locking Granularity in Multiprocessor Database Systems	268
<i>S. Dandamudi and S.-L. Au</i>	
Request Order Linked List (ROLL): A Concurrency Control Object for Centralized and Distributed Database Systems	278
<i>W. Perrizo</i>	
Unilateral Commit: A New Paradigm for Reliable Distributed Transaction Processing	286
<i>M. Hsu and A. Silberschatz</i>	

Session 11: Heterogeneous, Federated or Multidatabase Systems

Chair: S. Nishio, Osaka University

Atomic Commitment for Integrated Database Systems	296
<i>P. Muth and T.C. Rakow</i>	
Data Sharing in a Large Heterogeneous Environment	305
<i>R. Alonso, D. Barbará, and S. Cohn</i>	
On Serializability of Multidatabase Transactions Through Forced Local Conflicts	314
<i>D. Georgakopoulos, M. Rusinkiewicz, and A. Sheth</i>	

Session 12: Query Languages and Processing—Optimization

Chair C. Yu, UICC

An Efficient Semantic Query Optimization Algorithm	326
<i>H.H. Pang, H.J. Lu, and B.C. Ooi</i>	
Query Processing Algorithms for Temporal Intersection Joins	336
<i>H. Gunadhi and A. Segev</i>	
Optimization of Generalized Transitive Closure Queries	345
<i>S. Dar, R. Agrawal, and H.V. Jagadish</i>	

Session IND-1

Chair: W. Havens, Simon Fraser University

Speakers: S. Shinoaki, Tokyo Gas Company; G. Jonsson, IBM Nordiska Lab; R. Loesh, Jet Propulsion Labs

Session 13: Panel 2: Genomic Databases: New Opportunities In Database Research and Development

Chair: S. Pramanik, Michigan State University

Panelists: S. Pramanik, Michigan State University; R. Percher, GenBank, Los Alamos National Lab.; T. Marr, Cold Spring Harbor Lab.; D. Benton, National Center for Human Genome Research, NIH; W. Grosky, Wayne State University; B. Robbins, NSF

Session 14: Data Engineering Techniques II

Chair: *K. Tanaka, Kobe University*

Maintaining Quasi Serializability in Multidatabase Systems	360
<i>W. Du, A.K. Elmagarmid, and W. Kim</i>	
Object-Centered Constraints	368
<i>L.M.L. Delcambre, B.B.L. Lim, and S.D. Urban</i>	
Interval Assignment for Periodic Transactions in Real-Time Database Systems	378
<i>H. Nakazato and K.-J. Lin</i>	

Session 15: AI and Knowledge Based Systems—Rule Processing

Chair: *K. Yokota, ICOT*

Compiling a Rule Database Program into a C/SQL Application	388
<i>G. Kiernan and C. de Maindreville</i>	
Using Type Inference and Induced Rules to Provide Intensional Answers	396
<i>W.W. Chu, R.-C. Lee, and Q. Chen</i>	
Evaluation of Rule Processing Strategies in Expert Databases	404
<i>A. Segev and J.L. Zhao</i>	

Session IND-2

Chair: *W. Mansfield, Bellcore*

Speakers: *W. Havens, Centre for Systems Science; V.M. Markowitz, Computer Science Research Department; T. Takagi, Educational Center for Information Processing*

Session 16: Performance Evaluation

Chair: *S.-C. Moon, KAIST*

Performance Evaluation of Functional Disk System (FDS-R2)	416
<i>M. Kitsuregawa, M. Nakano, and M. Takagi</i>	
Performance Limits of Two-Phase Locking	426
<i>A. Thomasian</i>	
Performance Measurement of Some Main Memory Database Recovery Algorithms	436
<i>V. Kumar and A. Burger</i>	

Session 17: Applications and Application Systems

Chair *N. Miyazaki, Oki Electric*

Object Versioning in Ode	446
<i>R. Agrawal, S. Buroff, N. Gehani, and D. Shasha</i>	
Query Pairs As Hypertext Links	456
<i>K. Tanaka, N. Nishikawa, S. Hirayama, and K. Nanba</i>	
Perfect Hashing Functions for Hardware Applications	464
<i>M.V. Ramakrishna and G.A. Portice</i>	

Session 18: Query Processing

Chair: *M. Tanaka, Hiroshima University*

An Object-Oriented Query Processor That Produces Monotonically Improving Approximate Answers	472
<i>S.V. Vrbsky and J.W.S. Liu</i>	

Divide and Conquer: A Basis for Augmenting a Conventional Query Optimizer with Multiple Query Processing Capabilities	482
<i>S. Chakravarthy</i>	
Domain Vector Accelerator (DVA): A Query Accelerator for Relational Operations	491
<i>W. Perrizo, J. Gustafson, D. Thureen, D. Wenberg, and W. Davidson</i>	

Session 19: Data Engineering Techniques III

Chair: Y. Tanaka, Hokkaido University

Spatial Join Indices	500
<i>D. Rotem</i>	
Optimal Buffer Partitioning for the Nested Block Join Algorithm	510
<i>J.L. Wolf, B.R. Iyer, K.R. Pattipati, and J. Turek</i>	
Spatial Database Indices for Large Extended Objects	520
<i>O. Günther and H. Noltemeier</i>	

Session 20: Panel 3: Today and Tomorrow of DE Technology In Japan

Chair: Kamijo

Panelists: TBA

Session 21: Database Design and Modelling

Chair: M.C. Murphy, San Francisco State University

Object/Behavior Diagrams	530
<i>G. Kappel and M. Schrefl</i>	
Modeling Transition	540
<i>G. Hall and R. Gupta</i>	
ESQL: A Query Language for the Relation Model Supporting Image Domains	550
<i>R. Ahad and A. Basu</i>	

Session 22: AI and Knowledge-Based Systems—Systems

Chair: V. Kumar, University of Missouri—Kansas City

Preserving and Generating Objects in the LIVING IN A LATTICE Rule Language	562
<i>A. Heuer and P. Sander</i>	
The Architecture of <i>BrAID</i> : A System for Bridging AI/DB Systems	570
<i>A.P. Sheth and A.B. O'Hare</i>	
Inferential Modeling Technique for Constructing Second Generation Knowledge-Based Systems	582
<i>C.W. Chan, R.E. Jennings, and P. Tontiwachwuthikul</i>	

Session 23: Benchmarks and Performance Evaluation

Chair: R. Wachter, Office of Naval Research

Performance Characteristics of Protocols with Ordered Shared Locks	592
<i>D. Agrawal, A. El Abbadi, and A.E. Lang</i>	
Read Optimized File System Designs: A Performance Evaluation	602
<i>M. Seltzer and M. Stonebraker</i>	
A Methodology for Benchmarking Distributed Database Management Systems	612
<i>C.U. Orji</i>	

Session 24: Database Management I

Chair: M.V. Ramakrishna, Michigan State University

Optimal Buffer Allocation in a Multi-Query Environment 622
P.S. Yu and D.W. Cornell

Conflict-driven Load Control for the Avoidance of Data-Contention Thrashing 632
A. Moenkeberg and G. Weikum

Incremental Restart 640
E. Levy

Session 25: Panel 4: Multimedia Database Systems

*Chairs: F. Golshani, Arizona State University, and
A. Pizzarello, Bull HN Information Systems*

Panelists: D. Boyd, *Kodak*; G. Martin, *University of Warwick*; W. Grosky, *Wayne State University*; G. Gates, *Syntellec*; G. Weiderhold, *Stanford University*; P. Hall, *SEP, France*; N. Young, *Logica, UK*; R. Martinex, *University of Arizona*

Session 26: Object-Oriented Environments

Chair: T. Sparr, University of New Hampshire

Precomputation in a Complex Object Environment 652
A. Jhingran

Exploiting Parallelism in the Implementation of AGNA, a
Persistent Programming System 660
R.S. Nikhil and M.L. Heytens

An Evaluation Framework for Algebraic Object-Oriented Query Models 670
L. Yu and S.L. Osborn

Session 27: Query Languages and Processing

Chair: K.C. Guh, University of Wisconsin, Milwaukee

A Polymorphic Relational Algebra and Its Optimization 680
D. Eichmann and D. Alton

Real Time Retrieval and Update of Materialized Transitive Closure 690
K.-C. Guh, C. Sun, and C. Yu

Execution Plan Balancing 698
M.C. Murphy and M.-C. Shan

Session 28: Panel 5: Cooperating Knowledge-Based Systems

Chair: S.M. Deen, University of Keele

Panelists: TBA

Session 29: Database Management II

Chair: D. Cohen, Sente Corporation

A Semantic Integrity Framework: Set Restrictions for Semantic Groupings 710
E.A. Rundensteiner, L. Bic, J. Gilbert, and M.-L. Yin

ARIES-RRH: Restricted Repeating of History in the ARIES Transaction Recovery Method	718
<i>C. Mohan and H. Pirahesh</i>	
An Analysis Technique for Transitive Closure Algorithms: A Statistical Approach	728
<i>S. Ganguly, R. Krishnamurthy, and A. Silberschatz</i>	
Session 30: AI and Databases	
<i>Chair: K. Furukawa, ICOT</i>	
L_k : A Language for Capturing Real World Meanings of the Stored Data	738
<i>D.G. Shin</i>	
First-Order Logic Reducible Programs	746
<i>K. Wang and L.Y. Yuan</i>	
Distributed Query Optimization by One-Shot Fixed-Precision Semi-Join Execution	756
<i>C. Wang, V.O.K. Li, and A.L.P. Chen</i>	
Author Index	765