

# Lecture Notes in Computer Science

951

Edited by G. Goos, J. Hartmanis and J. van Leeuwen

Advisory Board: W. Brauer D. Gries J. Stoer

Max J. Egenhofer John R. Herring (Eds.)

# Advances in Spatial Databases

4th International Symposium, SSD '95  
Portland, ME, USA, August 6-9, 1995  
Proceedings



Springer

## Series Editors

Gerhard Goos, Universität Karlsruhe, Germany

Juris Hartmanis, Cornell University, NY, USA

Jan van Leeuwen, Utrecht University, The Netherlands

## Volume Editors

Max J. Egenhofer

National Center for Geographic Information and Analysis  
Department of Spatial Information Science and Engineering  
and Department of Computer Science, University of Maine  
5711 Boardman Hall, Orono, ME 04469-5711, USA

John R. Herring

Oracle Corporation

3 Bethesda Metro Center, Suite 1400, Bethesda, MD 20814, USA

Cataloging-in-Publication Data applied for

## Die Deutsche Bibliothek - CIP-Einheitsaufnahme

**Advances in spatial databases** : 4th international symposium ;  
proceedings / SSD '95, Portland, ME, USA, August 6 - 9, 1995.  
Max J. Egenhofer ; John R. Herring (ed.). - Berlin ; Heidelberg  
; New York : Springer, 1995

(Lecture notes in computer science ; Vol. 951)

ISBN 3-540-60159-7

NE: Egenhofer, Max J. [Hrsg.]; SSD <4, 1995, Portland, Me.>; GT

CR Subject Classification (1991): H.2-3, H.5, I.4, I.5, J.2

ISBN 3-540-60159-7 Springer-Verlag 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-Verlag. Violations are liable for prosecution under the German Copyright Law.

© Springer-Verlag Berlin Heidelberg 1995

Printed in Germany

Typesetting: Camera-ready by author

SPIN 10486460 06/3142 - 5 4 3 2 1 0 Printed on acid-free paper

## Message from the Chairs

These proceedings contain the technical papers selected for presentation at the Fourth International Symposium on Large Spatial Databases (SSD '95) held in Portland, Maine, August 6-9, 1995. With the conferences in Santa Barbara (1989), Zurich (1991), and Singapore (1993), the International Symposium on Large Spatial Databases has become the premier meeting for researchers, developers, and practitioners focusing on the integration between database management systems and geographic information systems. SSD '95 brought together computer scientists and GIS experts to explore advances in modeling, storage, and retrieval of massive spatial data sets, and to discuss the requirements from new, demanding application domains.

From among sixty submissions of full papers by authors from sixteen countries, the program committee selected twenty-three outstanding papers for inclusion in this volume. The acceptance rate at SSD continues to be highly competitive, which we believe is a sign of an active research community.

The papers included in this volume show that we are on the verge of a new generation of spatial database management systems motivated by the needs of digital spatial libraries, interoperable systems and Open GIS, and the World-Wide Web. Discussions have moved away from the design of new spatial access methods, more SQL extensions, or yet another object-oriented spatial data model. This is not to say that the problems of spatial query languages and conceptual modeling for spatial data have been solved, but rather the attention for innovative advancements has shifted. New, exciting topics have come up, such as data mining in large spatial databases. Other areas have been established as topics with great potential for advanced use such as spatial joins and spatial reasoning for intelligent access to spatial data.

The conference included two tutorials on spatial databases (by Hanan Samet) and spatio-temporal information systems (by Mike Worboys). Also two panels on Open GIS and New Applications of Spatial Databases were included to stimulate discussion of emerging issues. For the first time at SSD, we offered a software demonstration session.

We are in debt to the many people who made this event happen. The program committee and the external referees provided invaluable assistance with their reviews. Hanan Samet deserves special thanks for hosting the program committee meeting at the University of Maryland. The conference would have been impossible without the local organization of Kathleen Hornsby. We also very much appreciated the assistance of Eileen Herring and Blane Shaw.

We are very grateful for the support given by our corporate sponsors: Environmental Systems Research Institute, Inc., Lockheed Martin, Management & Data Systems, and Oracle Corporation. Cooperation with ACM SIGMOD and the National Center for Geographic Information and Analysis is also gratefully acknowledged.

Max J. Egenhofer  
General Chair

John R. Herring  
Program Chair

Portland, Maine, USA, August 1995

## Acknowledgments

In Cooperation with ACM SIGMOD

### **Sponsors:**

Environmental Systems Research Institute, Inc.  
Lockheed Martin, Management & Data Systems  
National Center for Geographic Information and Analysis  
Oracle Corporation

# Conference Organization

## **General Chair:**

Max J. Egenhofer, University of Maine

## **Program Committee Chair:**

John R. Herring, Oracle Corporation

## **Local Arrangements:**

Kathleen Hornsby, University of Maine

## **Program Committee:**

David Abel, CSIRO, Australia

Walid Aref, Matsushita Information Technology Laboratory, Panasonic Technologies, Inc.

Mark Ashworth, Unisys Corporation

Renato Barrera, Intergraph Corporation

Gilberto Camara, Instituto Nacional de Pesquisas Espaciais (INPE), Brazil

Marco Casanova, IBM Brazil

Eliseo Clementini, Università de l'Aquila, Italy

Umesh Dayal, Hewlett-Packard Laboratories

Jim Farley, University of Arkansas

Robin Feagus, US Geological Survey

Leila de Floriani, Università de Genoa, Italy

Andrew Frank, Technical University Vienna, Austria

Randolph Franklin, Rensselaer Polytechnic Institute

Kenn Gardels, University of California - Berkeley

Mike Goodchild, University of California - Santa Barbara

Oliver Günther, Humboldt Universität, Germany

Ralf Hartmut Güting, Fernuniversität Hagen, Germany

Klaus Hinrichs, Universität Münster, Germany

Erland Jungert, Swedish Defense Establishment, Sweden

Curt Kolovson, Hewlett-Packard

Hans-Peter Kriegel, Universität München, Germany

Gail Langran Kucera, Intergraph Corporation

Ron Lake, MDA, Canada

Scott Morehouse, ESRI, Inc.

John O'Callaghan, CSIRO, Australia

Beng Chin Ooi, University of Singapore

Peter van Oosterom, TNO Physics and Electronics Laboratory,  
The Netherlands

Dimitris Papadias, University of California - San Diego

Niki Pissinou, University of SW Louisiana

Hanan Samet, University of Maryland

Hans Schek, ETH Zürich, Switzerland  
Michel Scholl, INRIA, France  
Timos Sellis, National Technical University Athens, Greece  
Cliff Shaffer, Virginia Polytechnic Institute and State University  
Terry Smith, University of California - Santa Barbara  
Mark Sondheim, Ministry of Environment, Lands and Parks, Canada  
Agnès Voisard, Freie Universität Berlin, Germany  
Gio Wiederhold, Stanford University  
Mike Worboys, University of Keele, UK

**Additional Reviewers:**

Chuan Heng Ang  
Stefan Berchtold  
Thomas Brinkhoff  
Michael Dillencourt  
Claudio Esperanca  
Martin Ester  
Gabriel Kuper  
Kia Makki  
Enrico Puppo  
Alan Saalfeld  
Michael Schiwietz  
Thomas Seidl  
Jayant Sharma  
Emmanuel Stefanakis  
Yannis Theodoridis  
Tom Vijlbrief

# Contents

## Spatial Data Models

Lossless Representation of Topological Spatial Data Bart Kuijpers, Jan Paredaens, Jan Van den Bussche.....	1
On the Desirability and Limitations of Linear Spatial Database Models Luc Vandeurzen, Marc Gyssens, Dirk Van Gucht.....	14
The Quad View Data Structure — A Representation for Planar Subdivisions Ulrich Finke, Klaus H. Hinrichs.....	29

## Spatial Data Mining

Discovery of Spatial Association Rules in Geographic Information Databases Krzysztof Koperski, Jiawei Han.....	47
Knowledge Discovery in Large Spatial Databases: Focusing Techniques for Efficient Class Identification Martin Ester, Hans-Peter Kriegel, Xiaowei Xu.....	67

## Spatial Query Processing

Ranking in Spatial Databases Gísli R. Hjaltason, Hanan Samet.....	83
Optimal Redundancy in Spatial Database Systems Volker Gaede.....	96
Accessing Geographical Metafiles through a Database Storage System Stephen Blott, Andrej Vckovski.....	117
Extending a Spatial Access Structure to Support Additional Standard Attributes Andreas Henrich, Jens Möller.....	132



## Multiple Representations

Towards a Formal Model for Multiresolution Spatial Maps Enrico Puppo, Giuliana Dettori.....	152
--	-----

Multi-Scale Partitions: Application to Spatial and Statistical Databases Philippe Rigaux, Michel Scholl.....	170
--	-----

## Open GIS

Specifying Open GIS with Functional Languages Andrew U. Frank, Werner Kuhn.....	184
--	-----

## Geo-algorithms

Load-Balancing in High Performance GIS: Declustering Polygonal Maps Shashi Shekhar, Sivakumar Ravada, Vipin Kumar, Douglas Chubb, Greg Turner.....	196
---	-----

Implementation of the ROSE Algebra: Efficient Algorithms for Realm-Based Spatial Data Types Ralf Hartmut Güting, Thomas de Ridder, Markus Schneider.....	216
--	-----

A 3D Molecular Surface Representation Supporting Neighborhood Queries Thomas Seidl, Hans-Peter Kriegel.....	240
---	-----

## Reasoning about Spatial Relations

An Inferencing Language for Automated Spatial Reasoning about Graphic Entities Paul Scarponcini, Daniel C. St. Clair, George W. Zobrist.....	259
--	-----

Inferences from Combined Knowledge about Topology and Directions Jayant Sharma, Douglas M. Flewelling.....	279
--	-----

2D Projection Interval Relationships: A Symbolic Representation of Spatial Relationships Mohammad Nabil, John Shepherd, Anne H.H. Ngu.....	292
--	-----

Topological Relations between Discrete Regions Stephan Winter.....	310
---	-----

## **Spatial Joins**

Generating Seeded Trees from Data Sets Ming-Ling Lo, Chinya V. Ravishankar.....	328
--	-----

Spatial Join Strategies in Distributed Spatial DBMS David J. Abel, Beng Chin Ooi, Kian-Lee Tan, Robert Power, Jeffrey X. Yu.....	348
--	-----

## **Benchmarks**

Comparison and Benchmarks for Import of VPF Geographic Data from Object-Oriented and Relational Database Files David Arctur, Eman Anwar, John Alexander, Sharma Chakravarthy, Miyi Chung, Maria Cobb, Kevin Shaw.....	368
--	-----

Compressing Elevation Data Wm. Randolph Franklin.....	385
--	-----

<b>Author Index</b> .....	405
---------------------------	-----