

**Lecture Notes in Computer Science**  
Edited by G. Goos, J. Hartmanis and J. van Leeuwen

**1984**

**Springer**

*Berlin*

*Heidelberg*

*New York*

*Barcelona*

*Hong Kong*

*London*

*Milan*

*Paris*

*Tokyo*

Joe Marks (Ed.)

# Graph Drawing

8th International Symposium, GD 2000  
Colonial Williamsburg, VA, USA, September 20-23, 2000  
Proceedings



Springer

Series Editors

Gerhard Goos, Karlsruhe University, Germany  
Juris Hartmanis, Cornell University, NY, USA  
Jan van Leeuwen, Utrecht University, The Netherlands

Volume Editor

Joe Marks  
Mitsubishi Electric Research Laboratories  
201 Broadway, Cambridge, MA 02139, USA  
E-mail: marks@merl.com

Cataloging-in-Publication Data applied for

Die Deutsche Bibliothek - CIP-Einheitsaufnahme

Graph drawing : 8th international symposium ; proceedings / GD 2000,  
Colonial Williamsburg, VA, USA, September 20 - 23, 2000. Joe Marks  
(ed.). - Berlin ; Heidelberg ; New York ; Barcelona ; Hong Kong ;  
London ; Milan ; Paris ; Singapore ; Tokyo : Springer, 2001  
(Lecture notes in computer science ; Vol. 1984)  
ISBN 3-540-41554-8

CR Subject Classification (1991):G.2, I.3, F.2

ISSN 0302-9743

ISBN 3-540-41554-8 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 New York  
a member of BertelsmannSpringer Science+Business Media GmbH  
© Springer-Verlag Berlin Heidelberg 2001  
Printed in Germany

Typesetting: Camera-ready by author, data conversion by PTP Berlin, Stefan Sossna  
SPIN:10781412 06/3142 - 5 4 3 2 1 0 - Printed on acid-free paper

## Preface

This year's meeting marked the Eighth International Symposium on Graph Drawing. The organizing and program committees worked hard to make this year's symposium possible, and we were delighted that so many people came to Colonial Williamsburg, Virginia, for three days of the latest results in the field of graph drawing.

As in previous years, the review process was quite competitive. We accepted 30 out of 53 regular-length submissions, and 5 out of 15 short submissions, for a total acceptance ratio of 35 out of 68, or 51%. This year's program featured several new developments in the field. Four different approaches for handling very large graphs were presented in a session on force-directed layout. Two sessions were devoted to the latest advances in orthogonal graph drawing. And alongside the usual mix of theory and practice papers we had several contributions based on empirical studies of users and of systems.

Our invited talks were given by two speakers who were new to most members of the GD community, but who work in areas that are closely related to graph drawing. Professor Colin Ware of the University of New Hampshire told us how knowledge of human visual perception is useful for the design of effective data visualizations. And Professor David Jensen of the University of Massachusetts at Amherst talked about the process of knowledge discovery from graphs, a process that involves more than just graph drawing and visualization.

In addition to the program proper, we also had two additional events associated with the symposium. Uli Brandes organized a workshop on data-exchange formats for graph drawing, and Franz Brandenburg took charge of the annual graph-drawing contest. Reports on both of these events are included in the proceedings.

Finally, I would like to thank the members of the organizing and program committees for their hard work and dedication: their names are listed on the following pages. Special thanks goes to Kathy Ryall, the chair of the organizing committee, who chose the site and, with the aid of her able assistants, made sure that everything went smoothly throughout the symposium. I would also like to thank the sponsors of the graph-drawing contest: AT&T Research Laboratories, Daimler-Chrysler, and Tom Sawyer Software. And finally I would like to acknowledge the general and generous symposium sponsorship from MERL-Mitsubishi Electric Research Laboratories.

# Organization

## Program Committee

Therese Biedl, University of Waterloo  
Peter Eades, University of Newcastle  
Wendy Feng, Tom Sawyer Software  
Ashim Garg, SUNY Buffalo  
Michael Goodrich, Johns Hopkins  
Michael Kaufmann, University of Tübingen  
Jan Kratochvíl, Charles University  
Giuseppe Liotta, University of Perugia  
Joe Marks (chair), MERL  
Stephen North, AT&T Research  
Kathy Ryall, University of Virginia  
Kozo Sugiyama, JAIST  
Roberto Tamassia, Brown University  
Robin Thomas, Georgia Institute of Technology  
Dorothea Wagner, University of Konstanz  
Stephen Wismath, University of Lethbridge

## Organizing Committee

Renee Carabajal, MERL  
Karen Dickie, MERL  
Joe Marks, MERL  
Janet O'Halloran, MERL  
Kathy Ryall (chair), University of Virginia / MERL

## Sponsoring Institutions

AT&T Research Laboratories  
Daimler-Chrysler  
MERL–Mitsubishi Electric Research Laboratories  
Tom Sawyer Software

## VIII Organization

### **Steering Committee**

Franz Brandenburg, University of Passau  
Giuseppe Di Battista, University of Rome  
Ioannis G. Tollis, University of Texas, Dallas  
Jan Kratochvíl, Charles University  
Joe Marks, MERL  
Pierre Rosenstiehl, EHESS  
Roberto Tamassia, Brown University  
Takao Nishizeki, Tohoku University  
Petra Mutzel, Technical University of Vienna

### **External Referees**

François Bertault  
Ulrik Brandes  
Broňa Brejová  
Sabine Cornelsen  
Walter Didimo  
Ugur Dogrusoz  
Markus Eiglsperger  
Irene Finocchi  
Arne Frick  
Seok-Hee Hong  
Mike Houle  
Stephen Kobourov  
Wei Lai  
Annegret Liebers  
Anna Lubiw  
Hugo A.D.Do Nascimento  
Maurizio Patrignani  
Maurizio Pizzonia  
Aaron Quigley  
Chris Riley  
Tomáš Vinař  
Thomas Willhalm  
David Wood

# Table of Contents

## Invited Talk

The Visual Representation of Information Structures .....	1
<i>Colin Ware</i>	

## Empirical Studies and Standards

User Preference of Graph Layout Aesthetics: A UML Study .....	5
<i>Helen C. Purchase, Jo-Anne Alder, and David Carrington</i>	
A User Study in Similarity Measures for Graph Drawing .....	19
<i>Stina Bridgeman and Roberto Tamassia</i>	
Interactive Partitioning (System Demonstration, Short) .....	31
<i>Neal Lesh, Joe Marks, and Maurizio Patrignani</i>	
An Experimental Comparison of Orthogonal Compaction Algorithms (Extended Abstract) .....	37
<i>Gunnar W. Klau, Karsten Klein, and Petra Mutzel</i>	
GraphXML – An XML-Based Graph Description Format .....	52
<i>Ivan Herman and M. Scott Marshall</i>	

## Theory I

On Polar Visibility Representations of Graphs .....	63
<i>Joan P. Hutchinson</i>	
A Linear Time Implementation of SPQR-Trees .....	77
<i>Carsten Gutwenger and Petra Mutzel</i>	
Labeling Points with Rectangles of Various Shapes .....	91
<i>Shin-ichi Nakano, Takao Nishizeki, Takeshi Tokuyama, and Shuhei Watanabe</i>	
How to Draw the Minimum Cuts of a Planar Graph (Extended Abstract) .....	103
<i>Ulrik Brandes, Sabine Cornelsen, and Dorothea Wagner</i>	

## Applications and Systems

2D-Structure Drawings of Similar Molecules .....	115
<i>J.D. Boissonnat, F. Cazals, and J. Flötotto</i>	

X Table of Contents

Fast Layout Methods for Timetable Graphs . . . . .	127
<i>Ulrik Brandes, Galina Shubina, Roberto Tamassia, and Dorothea Wagner</i>	

An Algorithmic Framework for Visualizing Statecharts . . . . .	139
<i>R. Castelló, R. Mili, and I. G. Tollis</i>	

Visualization of the Autonomous Systems Interconnections with HERMES . . . . .	150
<i>Andrea Carmignani, Giuseppe Di Battista, Walter Didimo, Francesco Matera, and Maurizio Pizzonia</i>	

Drawing Hypergraphs in the Subset Standard (Short Demo Paper) . . . . .	164
<i>François Bertault and Peter Eades</i>	

## Invited Talk

Knowledge Discovery from Graphs (Invited Talk) . . . . .	170
<i>David Jensen</i>	

## Force-Directed Layout

A Multilevel Algorithm for Force-Directed Graph Drawing . . . . .	171
<i>C. Walshaw</i>	

A Fast Multi-scale Method for Drawing Large Graphs . . . . .	183
<i>David Harel and Yehuda Koren</i>	

FADE: Graph Drawing, Clustering, and Visual Abstraction . . . . .	197
<i>Aaron Quigley and Peter Eades</i>	

A Multi-dimensional Approach to Force-Directed Layouts of Large Graphs . . . . .	211
<i>Pawel Gajer, Michael T. Goodrich, and Stephen G. Kobourov</i>	

GRIP: Graph dRawing with Intelligent Placement . . . . .	222
<i>Pawel Gajer and Stephen G. Kobourov</i>	

## k-Level Graph Layout

A Fast Layout Algorithm for $k$ -Level Graphs . . . . .	229
<i>Christoph Buchheim, Michael Jünger, and Sebastian Leipert</i>	

Graph Layout for Displaying Data Structures . . . . .	241
<i>Vance Waddle</i>	

$k$ -Layer Straightline Crossing Minimization by Speeding Up Sifting . . . . .	253
<i>Wolfgang Günther, Robby Schönfeld, Bernd Becker, and Paul Molitor</i>	

## Orthogonal Drawing I

Lower Bounds for the Number of Bends in Three-Dimensional Orthogonal Graph Drawings .....	259
<i>David R. Wood</i>	
Orthogonal Drawings of Cycles in 3D Space (Extended Abstract) .....	272
<i>Giuseppe Di Battista, Giuseppe Liotta, Anna Lubiw, and Sue Whitesides</i>	
Three-Dimensional Orthogonal Graph Drawing with Optimal Volume ....	284
<i>Therese Biedl, Torsten Thiele, and David R. Wood</i>	

## Orthogonal Drawing II

A Linear-Time Algorithm for Bend-Optimal Orthogonal Drawings of Biconnected Cubic Plane Graphs (Extended Abstract) .....	296
<i>Shin-ichi Nakano and Makiko Yoshikawa</i>	
Refinement of Three-Dimensional Orthogonal Graph Drawings .....	308
<i>Benjamin Y. S. Lynn, Antonios Symvonis, and David R. Wood</i>	

## Theory II

$\omega$ -Searchlight Obedient Graph Drawings .....	321
<i>Gill Barequet</i>	
Unavoidable Configurations in Complete Topological Graphs .....	328
<i>János Pach and Géza Tóth</i>	
Minimum Weight Drawings of Maximal Triangulations (Extended Abstract) .....	338
<i>William Lenhart and Giuseppe Liotta</i>	
A Layout Algorithm for Bar-Visibility Graphs on the Möbius Band .....	350
<i>Alice M. Dean</i>	

## Symmetry and Incremental Layout

An Algorithm for Finding Three Dimensional Symmetry in Trees .....	360
<i>Seok-Hee Hong and Peter Eades</i>	
On Maximum Symmetric Subgraphs .....	372
<i>Ho-Lin Chen, Hsueh-I. Lu, and Hsu-Chun Yen</i>	
Clan-Based Incremental Drawing .....	384
<i>Fwu-Shan Shieh and Carolyn L. McCreary</i>	
The Marey Graph Animation Tool Demo .....	396
<i>Carsten Friedrich and Peter Eades</i>	

**Workshop and Contest**

Graph Data Format Workshop Report ..... 407  
    *Ulrik Brandes, M. Scott Marshall, and Stephen C. North*

Graph-Drawing Contest Report ..... 410  
    *Franz Brandenburg, Ulrik Brandes, Michael Himsolt, and  
    Marcus Raitner*

**Author Index ..... 419**