Graph-Drawing Contest Report

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Abstract. This report describes the Sixth Annual Graph Drawing Contest, held in conjunction with the 1999 Graph Drawing Symposium in Prague, Czech Republic. The purpose of the contest is to monitor and challenge the current state of the art in graph-drawing technology [2, 3, 5, 6, 4].

1 Introduction

Text descriptions of the four categories for the 1999 contest are available via the World Wide Web (WWW) [7]. Eighteen separate submissions were received (one more than last year), containing 57 different graph drawings (a record number), and one live demonstration. The winners for Categories A–C were selected by the contest organizers. The winners for Category D were ranked by the vote of all the symposium attendees. Conflicts of interest were avoided on an honor basis. The winning entries are described below.

2 Winning submissions

2.1 Category A

The graph for Category A was unusually complex for the contest. It represents the characters in the long-running German soap opera, *Lindenstrasse*. This show started 14 years ago on ARD (one of the main public TV stations); every week about seven million people watch it. The data in the graph have been extracted from a poster in a popular book [8]. The following data are associated with

each character node in the graph: the character's name and gender, the numbered episodes in which the character appears, the dates of the character's birth and death (if known), and the character's current status in the show (active, inactive, dead, or unknown). In addition, the importance of the character is also indicated, and the most important characters have pictures associated with them. The edges that relate characters are also typed to indicate the nature of the relationship: business, friendship, partnership, family, or hostility.

Three visualization tasks for this graph were mandated:

1. To depict the current situation.
2. To visualize the whole graph, including both current and past characters and relations.
3. To show the development of the graph over some time interval.

Only one submission was received for Tasks 1 and 3; none was received for Task 2. Nevertheless, the quality of the single submission was such that the committee decided to award the first-place prize to its creators, Vladimir Batagelj and Andrej Mrvar ([Vladimir.Batagelj, Andrej.Mrvar]@uni-lj.si) from the University of Ljubljana, Slovenia. The drawing in Figure 1 illustrates the current situation in the show.[5] It was drawn using the "Pajek" system [10]. An initial layout was computed using the Kamada-Kawai force-directed algorithm; this layout was subsequently edited by hand to arrange the nodes on a rectangular net. The dynamic drawings (not shown) were also computed using an incremental force-directed method.

2.2 Category B

Category B was this year's "theory surprise." It consisted of a directed graph whose edges were colored blue or green. No further information was provided. The 10 submissions received included an astonishing 49 different drawings of the graph!

The graph is the six-bit shift-register graph. It also occurs as the state graph of the minimal deterministic finite state automaton that recognizes the regular set $\{0|1\}^*1\{0|1\}^6$. Thus, the nodes are labeled most meaningfully as six-bit numbers from 000000 to 111111. The blue edges describe the left shifts from nodes with labels 0x. They define a binary tree with a self-loop at the root 000000. Similarly, the green edges describe the left shifts from nodes with labels 1x; they define a binary tree with a self-loop at the root 111111. These two trees are glued together. Conversely, the shift register graphs can be partitioned into two edge-disjoint trees. However, it is a bad strategy to draw shift-register graphs using a common tree-drawing algorithm for one of these trees, and then to insert the remaining edges. The shift-register graphs are highly symmetric and some symmetry should be displayed in any reasonable drawing.

[5] The original version of this drawing is in color, as are all of the winning drawings. A copy of this report with color drawings can be obtained from Joe Marks, marks@merl.com.

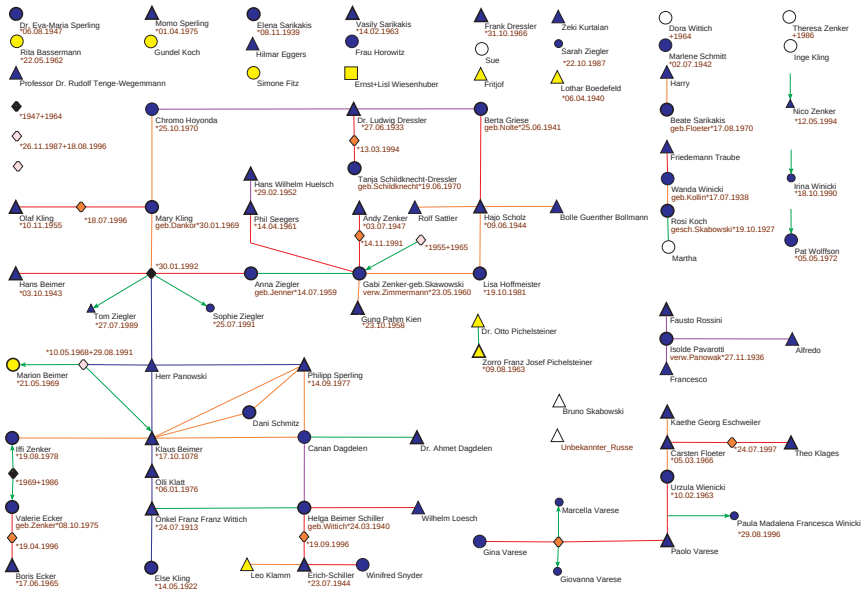

Fig. 1. First place, Category A (original in color).

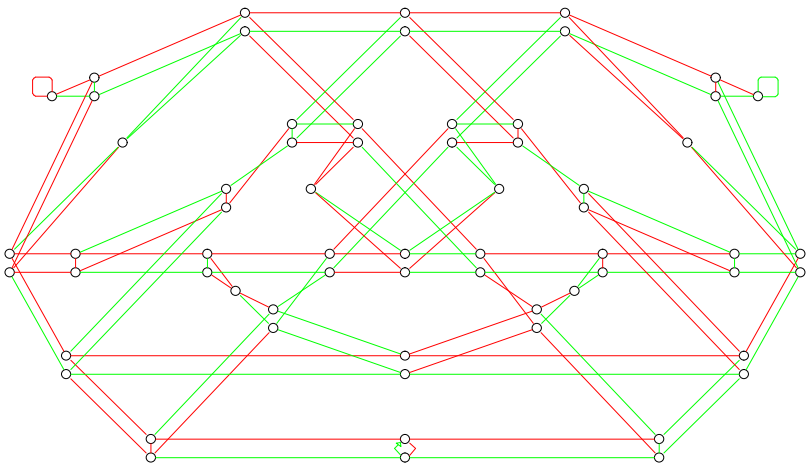

Fig. 2. Joint third place, Category B (original in color).

Symmetry is indeed visible in the joint third-prize winners, shown in Figures 2–4. The drawing in Figure 2 was submitted by Karlis Freivalds and Paulis Kikusts (karlisf,paulis@cclu.lv), from the University of Latvia, Latvia. It was generated using the ActiveX Graphical Diagramming Engine (`http://www.-gradetools.com/`). The structure of the graph was discovered using a variant of barycentric layout, and subsequent refinement of node and edge positions was done by hand. Note the resemblance to a "smiley face"!

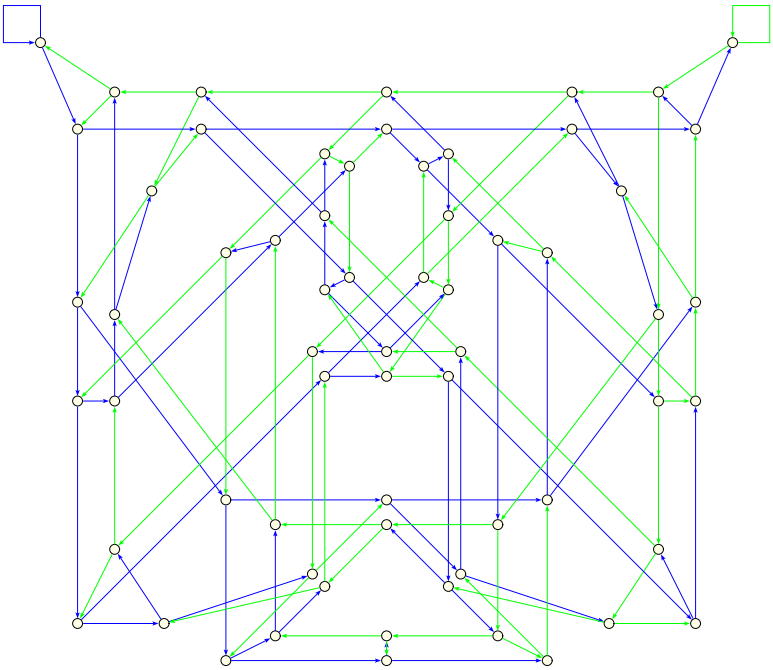

Fig. 3. Joint third place, Category B (original in color).

Ago Kuusik (Ago.Kuusik@ul.ie), from the University of Limerick, Ireland, submitted the drawing in Figure 3. An initial layout was computed using the 3D spring embedder of LEDA GraphWin. The layout was then refined manually.

The drawing in Figure 4 is called "Fool's Crown" by its author, Roland Wiese (wiese@informatik.uni-tuebingen.de), from the Universität Tübingen. The drawing was generated in the following steps:

- First the two nodes with self-loops were moved manually to opposite sides and fixed there.
- Then the GEM spring embedder was applied to the graph.
- Finally, the drawing was beautified via manual adjustment.

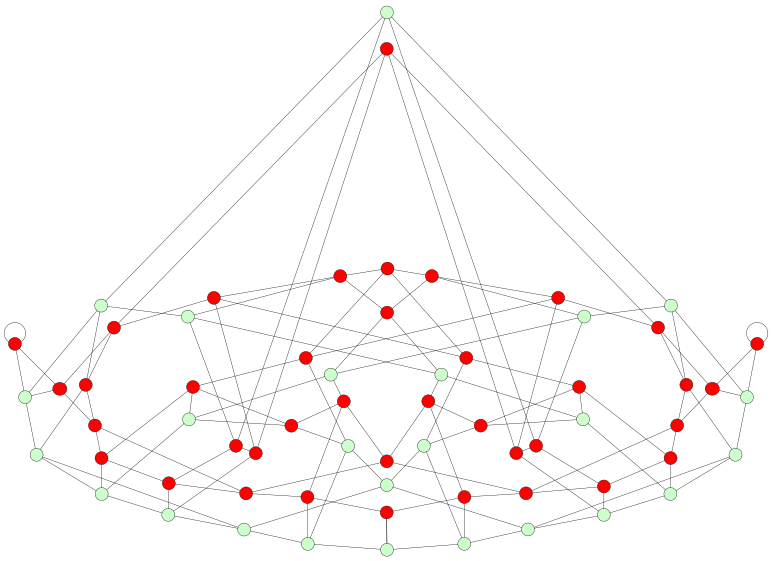

Fig. 4. Joint third place, Category B (original in color).

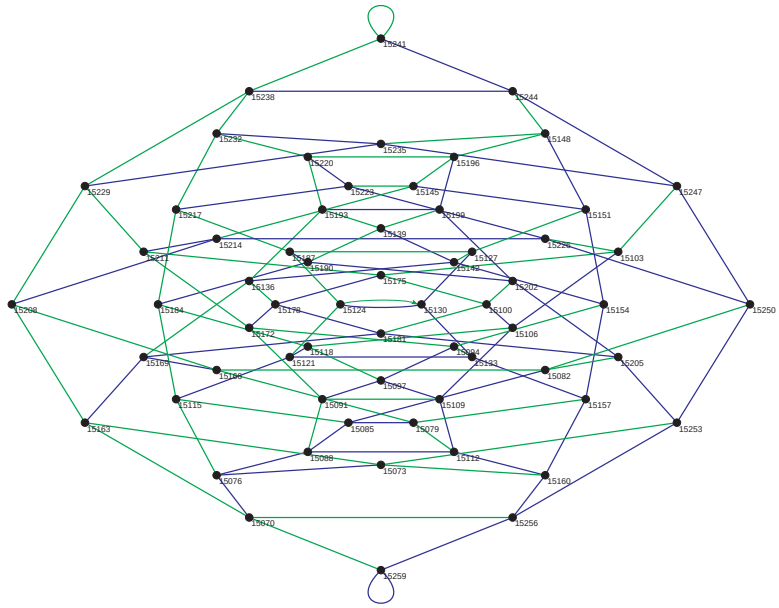

Fig. 5. Second prize, Category B (original in color).

The third-place winners all required some manual editing to produce their final drawings. The second-place drawing for Category B required no manual adjustment, and is shown in Figure 5. It was produced by Vladimir Batagelj and Andrej Mrvar ([Vladimir.Batagelj, Andrej.Mrvar]@uni-lj.si) from the University of Ljubljana, Slovenia, using the "Pajek" system [10]. The layout was computed using a kind of Principal Components' Analysis: the first, second, and fifth eigenvectors of the Laplacian matrix were used to generate a 3D embedding, and then a suitable projection was selected to generate the final 2D drawing.

The winning entry for Category B was submitted by Ulrik Brandes (ub@cs.brown.edu), from Brown University. He was the only contestant to determine the true underlying structure of the graph and its origin. In addition to awarding first place to Brandes's submission, the judges felt that the written account of his investigation was of such high quality as to warrant publication in full. It can be found elsewhere in this volume, and contains several drawings of the contest graph [1].

2.3 Category C

Biochemistry is becoming an important application area for graph drawing. Biochemical pathways represent the complex interconnections between reactants, products, and enzymes in cells. In graph-theoretic terms they are hypergraphs. The contest hypergraph comes from the "Biochemical Pathways" atlas [9], and represents the main biochemical reactions of cells. For the contest it is modeled as a regular graph with additional unlabeled white nodes representing hyperedges of high degree. The nodes in the graph are labeled, and colored according to type, e.g., green for carbohydrates, blue for amino acids, etc. The graph edges are also typed: edges can be undirected, unidirectional, or bidirectional.

The drawing in Figure 6 was awarded joint first place in this category. It was submitted by Karlis Freivalds and Paulis Kikusts (karlisf,paulis@cclu.lv), from the University of Latvia, Latvia. It was generated using the ActiveX Graphical Diagramming Engine (`http://www.gradetools.com/`). The structure of the graph was discovered using a variant of barycentric layout, and subsequent refinement of node and edge positions was done interactively.

The other first-place drawing (Figure 7) was submitted by Rowena Mankelow (c9514915@studentmailbox.newcastle.edu.au), from the University of Newcastle, Australia. An initial layout was computed using a force-directed method. Nodes were then repositioned by hand to emphasize important biochemical pathways, such as the tricarboxylic acid cycle.

2.4 Category D

The only requirement for submissions in this category is that they be some form of artistic expression inspired by or related to graph drawing. There were only two entries in this category, but both were deemed worthy of prizes.

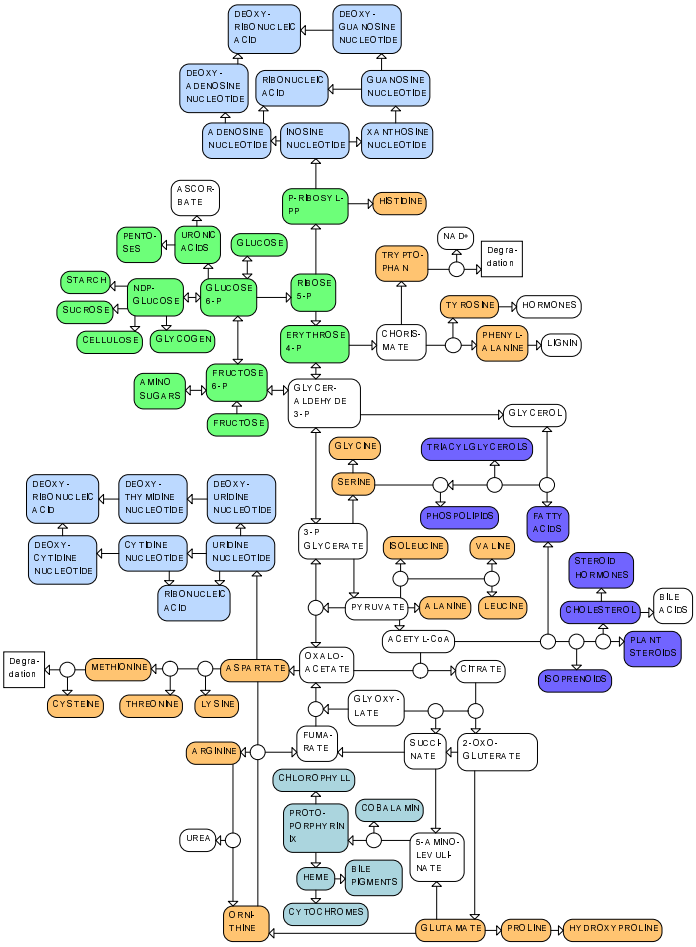

Fig. 6. Joint first place, Category C (original in color).

Second place was awarded to Michael Goodrich (goodrich@jhu.edu) for the remarkable image of a seashell shown in Figure 8. The pattern on the shell, reminiscent of tree layouts, was generated naturally.

First place in Category D went to Ulrik Brandes (ub@cs.brown.edu), from Brown University. This drawing, called "Shiftset," depicts the state-transition diagram of an eight-bit shift register, arranged circularly according to binary states. In the original, edges are colored to indicate the insertion of 0 (yellow) or 1 (orange), respectively. Further details can be found in Brandes's account of his Category B submission [1], on which this graph and drawing are based.

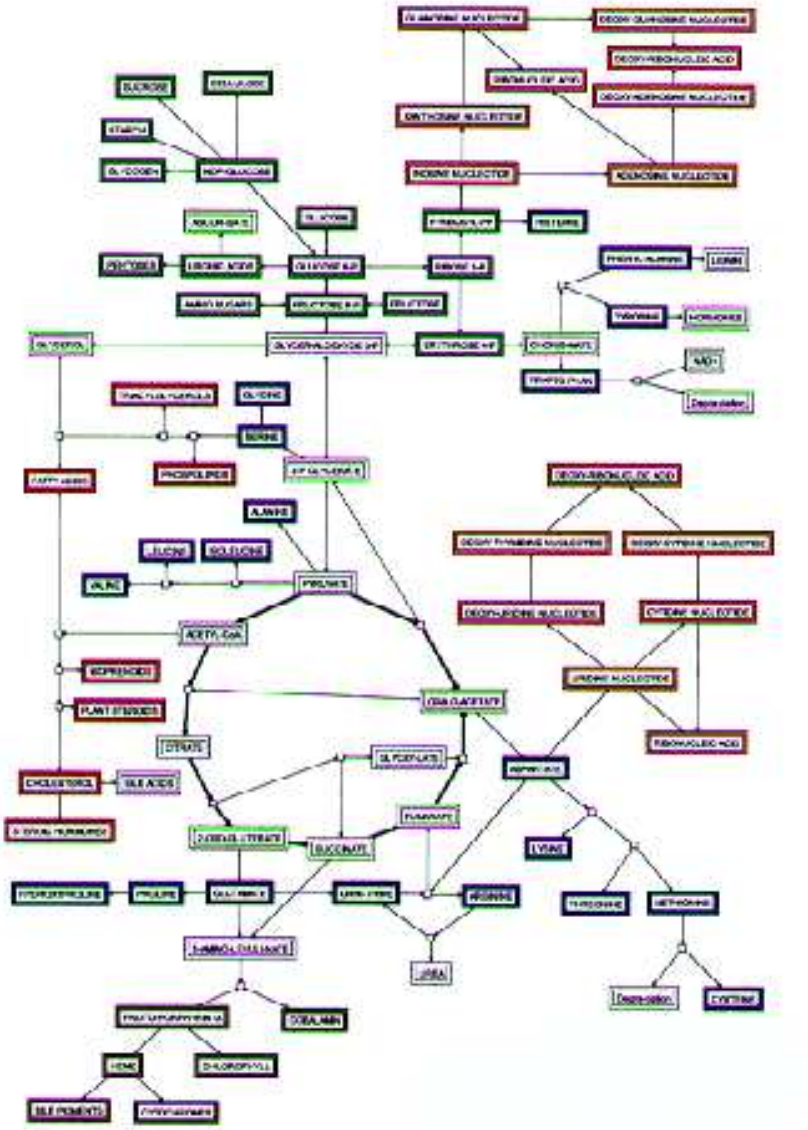

Fig. 7. Joint first place, Category C (original in color).

Fig. 8. Second place, Category D (original in color).

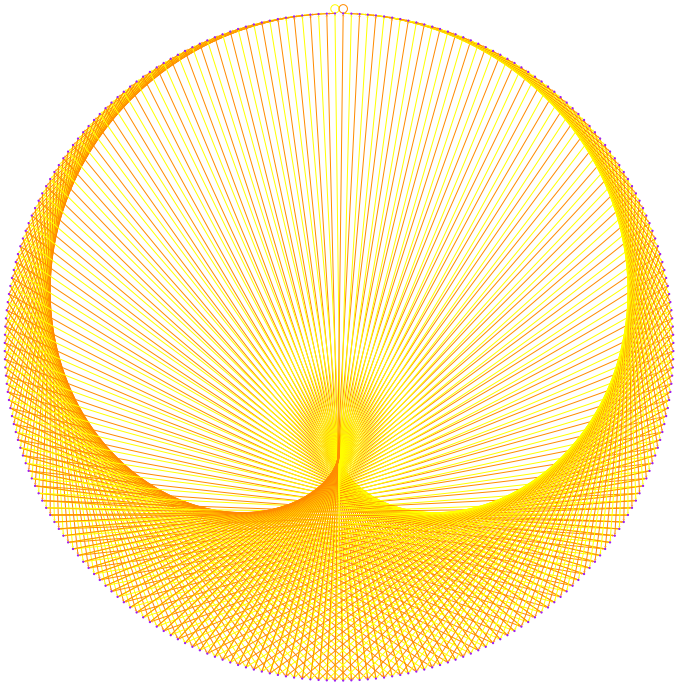

Fig. 9. First place, Category D (original in color).

3 Observations and Conclusions

As in past years, most of the winners combined automated and manual techniques to great effect. Given this distinct pattern in how graph-drawing software is used, it is perhaps surprising that few systems have been designed to give explicit support to this kind of human-computer cooperative design. A future graph-drawing contest may therefore include an interactive-editing category.

Another trend that continued from previous years is that of using graph drawing as an analysis tool. No submission exemplifies this approach better than the first-place winner in Category B.

Category D, the artistic category, received fewer submissions this year, but made up in originality and beauty what was lacking in numbers.

4 Acknowledgments

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References

1. U. Brandes. Hunting down graph B. In this volume.
2. P. Eades and J. Marks. Graph-drawing contest report. In R. Tamassia and I. G. Tollis, editors, *Lecture Notes in Computer Science: 894 (Proceedings of the DIMACS International Workshop on Graph Drawing '94)*, pages 143–146, Berlin, October 1994. Springer.
3. P. Eades and J. Marks. Graph-drawing contest report. In F. J. Brandenburg, editor, *Lecture Notes in Computer Science: 1027 (Proceedings of the Symposium on Graph Drawing GD '95)*, pages 224–233, Berlin, September 1995. Springer.
4. P. Eades, J. Marks, P. Mutzel, and S. North. Graph-drawing contest report. In S. H. Whitesides, editor, *Lecture Notes in Computer Science: 1547 (Proceedings of the Symposium on Graph Drawing GD '98)*, pages 423–435, Berlin, August 1998. Springer.
5. P. Eades, J. Marks, and S. North. Graph-drawing contest report. In S. North, editor, *Lecture Notes in Computer Science: 1190 (Proceedings of the Symposium on Graph Drawing GD '96)*, pages 129–138, Berlin, September 1996. Springer.
6. P. Eades, J. Marks, and S. North. Graph-drawing contest report. In G. DiBattista, editor, *Lecture Notes in Computer Science: 1353 (Proceedings of the Symposium on Graph Drawing GD '97)*, pages 438–445, Berlin, September 1997. Springer.
7. `http://www.ms.mff.cuni.cz/acad/kam/conferences/GD99/contest/rules.-html`.
8. J. C. Huth, editor. *Das Lindenstrasse-Universum.* Köln, 1998.
9. G. Michal. *Biochemical Pathways.* Spektrum Akademischer Verlag, Heidelberg, 1999.
10. `http://vlado.fmf.uni-lj.si/pub/networks/pajek/`.