Graph-Drawing Contest Report

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Abstract. This report describes the Seventh Annual Graph Drawing Contest, held in conjunction with the 2000 Graph Drawing Symposium in Williamsburg, Virginia. The purpose of the contest is to monitor and challenge the current state of the art in graph-drawing technology [3,4, 6,7,5,2].

1 Introduction

Text descriptions of the four categories for the 2000 contest were available via the World Wide Web (WWW) [10]. Eight separate submissions were received, containing 33 different graph drawings, and one live demonstration. Moreover there were four spontaneous mobiles of space clusters. The winners for the Categories were selected by the contest organizers and Joe Marks. Conflicts of interest were avoided on an honor basis. The winning entries are described below.

2 Winning Submissions

2.1 Category A

The graph given for Category A has been generated with DaimlerChrysler's C++ Analyzer. The C++ Analyzer is a tool for static analysis of C and C++ software. It supports visualization of software with graphs, browsing and cross referencing as well as computation of metrics.

This particular graph is a real world example and visualizes the class relationships in the C++ Analyzer itself. The graph consists of a large number of individual components and contains several high degree nodes. The challenge for this particular contest entry was not to visualize any interesting graph properties (there probably aren't any), but to find a nice and comprehensible layout for a rather large graph.

Among the submitted entries the winner Nikola S. Nikolov from the University of Limerick gave the best analysis and display of the underlying structure.

J. Marks (Ed.): GD 2000, LNCS 1984, pp. 410–418, 2001.

His drawings were made with an ILP-based system developed by the Graph Drawing research group at the University of Limerick

The first step was to separate the 26 connected components of the graph. Then each component was drawn separately by using the ILP-based algorithms for layering and crossing minimization. All the drawings have minimum number of dummy nodes for the layering algorithm (subject to the given input parameters) and minimum number of edge crossings for the resulting layering. The final drawings of the five big components were chosen among alternative solutions made with different input parameters to the layering algorithm. It was tried to keep the dimensions of the drawing within reasonable bounds and to achieve as few edge crossings as possible. Manual editing was needed to tune the position of the nodes and to tidy the labels.

In the two biggest components the arrows of the edges were removed to achieve a clearer drawing. All the edges without arrows point downwards.

The nodes of component 2 are colored in three colors: white, yellow (grey in the print), blue (black in the print). Each yellow node is connected by an edge to the blue node with label "SCPos". These edges were removed to achieve a better drawing. All these edges have a yellow source node and the blue node "SCPos" as a destination node. Figure 1 shows this component.

2.2 Category B

In the analysis of social networks, graph drawing is increasingly recognized as a tool to effectively support visual exploration and communication of findings. The graphs given for Category B addressed one of the major challenges in this area, namely the comparison of networks of similar type.

The data for Category B were provided by Maryann M. Durland, an independent business consultant. Within a sizeable corporation, two teams working in similar projects were asked how frequent they would be in contact with other members of their team, with their clients, and with domain experts external to their team. The data thus consists of two directed graphs, each with three types of vertices (team members, clients, external experts) and integer edge weights ranging from 1 to 4 (indicating quarterly, monthly, biweekly, and weekly contact, respectively).

As in many graph drawing contests before, the winning entry was submitted by Vladimir Batagelj and Andrej Mrvar from the University of Ljubljana, Slovenia. Figure 2 shows their circular layouts of the two networks, where team members, clients, and experts are located on the inner, middle, and outer circle, respectively. Essentially, the circular ordering is determined by the mutual overlap of pairwise vertex neighborhoods, namely by applying a heuristic for the Traveling Salesperson Problem to a complete graph with edge weights that quantify neighborhood similarity. Edge weights are depicted by different gray scales.

These images clearly show how both teams divide into a client/expert interface and a group working internally. However, the teams also differ quite visibly in both their internal and external communication. The drawings thus readily enable comparison and interpretation of the way these teams have organized their contacts.

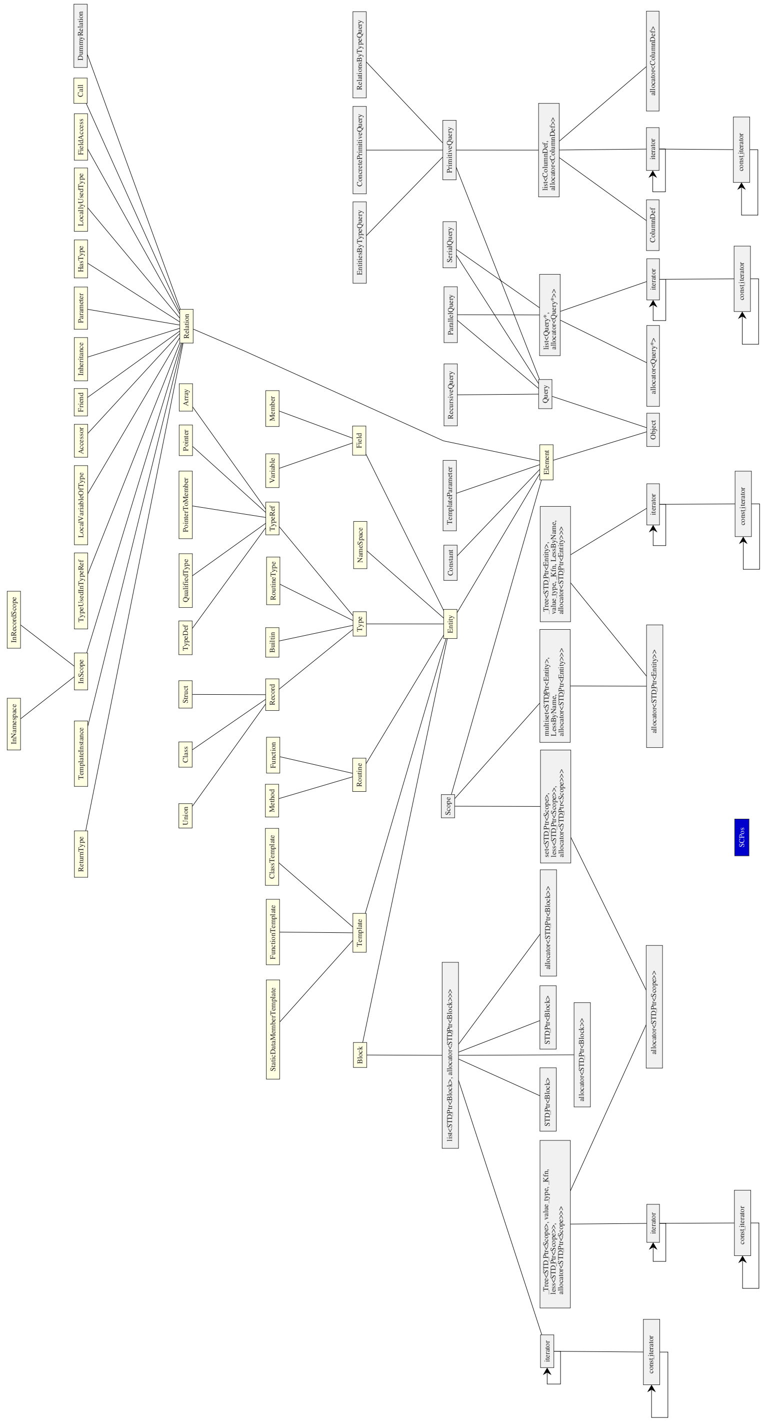
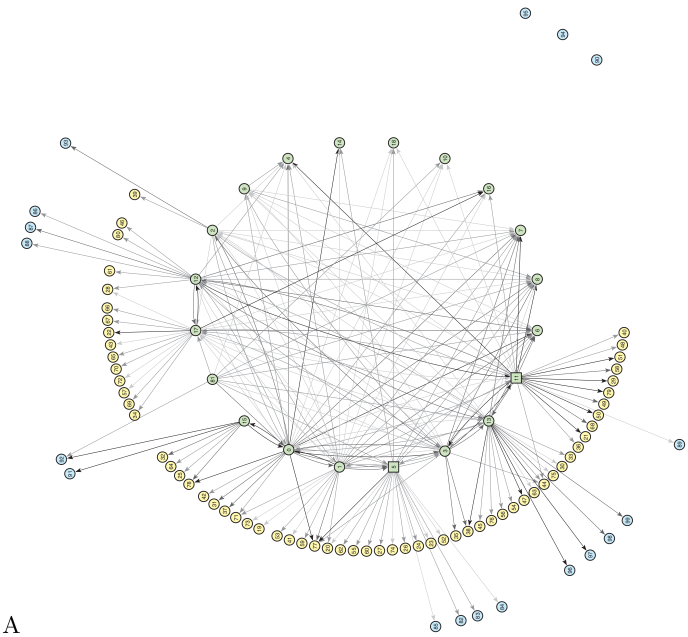
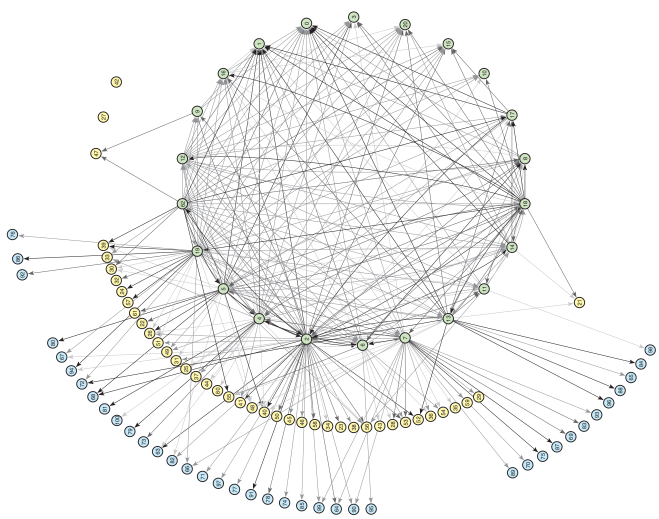


Fig. 1. Winning entry for Category A (original in color)



Team A



Team B

Fig. 2. Winning entry for Category B (original in color)

2.3 Category C

The data for the Category C graph were provided by John Carlis of the University of Minnesota and John Hanna of US West in Minneapolis. The graph describes a real in-use data-model, although all the labels were changed to Xs to protect the intellectual investment.

A data model is a technology-independent statement of the kinds of data to be remembered by a database management system. For this contest we have simplified the drawing to include just entities, attributes, and binary relationships. Graphically, each entity appears as a box (a rectangle), each attribute appears as text within an entity's box, and each relationship appears as a line between two (not necessarily distinct) entities. The quality of the graph significantly impacts the design process. A poorly drawn graph means an unreadable model.

Unfortunately there were no entries for graph C and it is kept for future competitions.

2.4 Category D

Category D is the free or artistic category. There is no explicit challenge graph but a framework to combine arts and graphs. The entries to category D were divided into three sub-categories

D1. Jan Adamec from Charles University, Prague took a composition of Miró and converted the painting into a graph by putting vertices at intersection points and adding some vertices and edges.

Each of its nine components was drawn separately using a modified spring algorithm. No further manual editing (except of adding colors) was done.

D2. Christian A. Duncan, Pawel Gajer, Michael T. Goodrich and Stephen G. Kobourov submitted a stereo-graphic hologram of the graph corresponding to the Sierpinski pyramid of order 7, see Fig. 4 for a 2-D drawing of their 3-D model.

The Sierpinski pyramid is a classic fractal [11]. Whereas traditionally the image is defined with fixed vertices and edges, they made theirs a fractal graph with no specific embedding. They used a graph embedder to embed the representation of the graph producing interesting and beautiful results.

The Sierpinski pyramid graph is created by a recursive procedure, parametrized on the order of the recursion. As in the 2-D case, at each iteration, every pyramid is divided into five congruent smaller pyramids with the central pyramid removed. In a Sierpinski pyramid of order k the number of vertices is $|V_k| = \frac{4^k}{2} + 2$ and the number of edges is $|E_k| = 6(|V| - 4) + 12 = 3 \times 4k$. in their example the Sierpinski pyramid of order 7 has 8,194 vertices and 49,152 edges.

Given the parameter k the adjacency matrix of a graph which corresponds to the Sierpinski pyramid of order k was generated. The graph is then drawn using the Grip system [9] without any modification to the resulting drawing. The drawing method of the Grip system uses a multi-dimensional algorithm

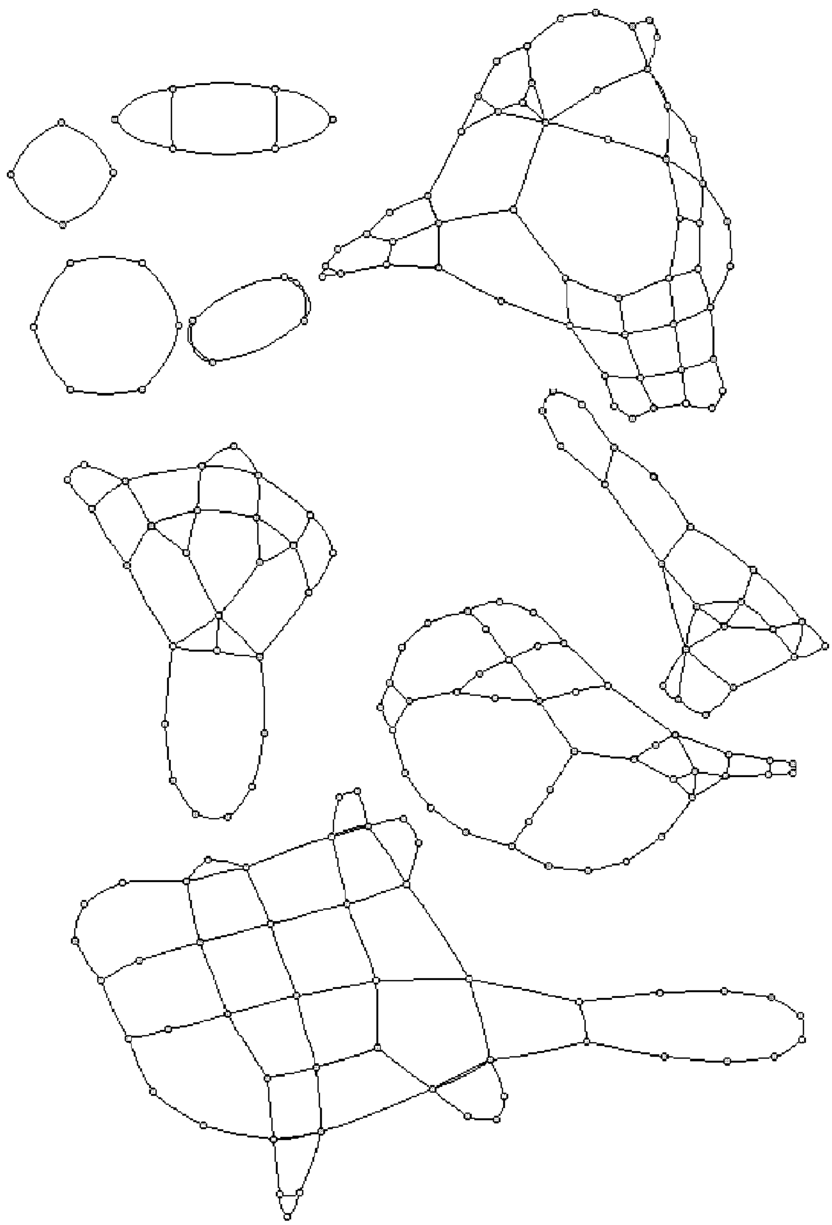


Fig. 3. Jan Adamec's version of Miró's painting (original in color)

for drawing large graphs [8]. The algorithm takes advantage of the symmetric nature of the Sierpinski pyramid to quickly produce a final drawing. Altogether, the generation of the graph, the preprocessing, and final 3-D drawing took 22 seconds on a 550Mhz Pentium II with 128MB of RAM.

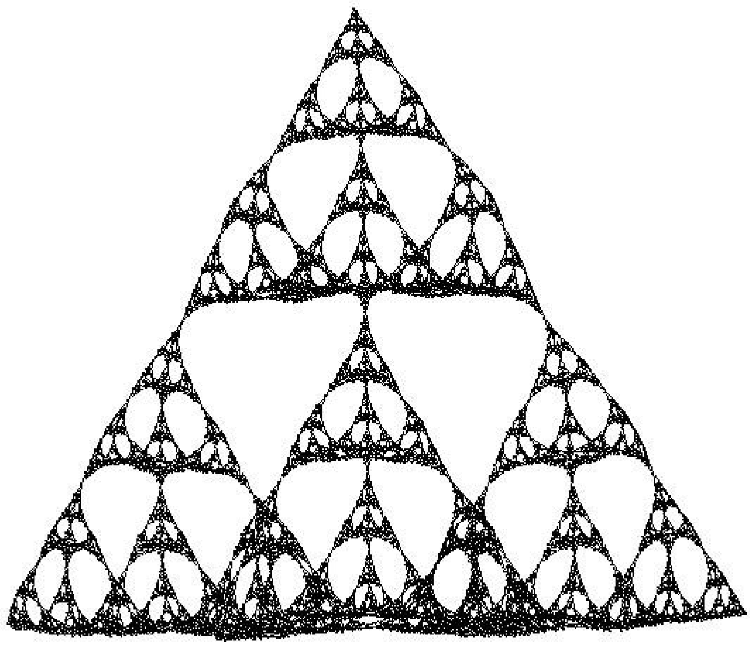


Fig. 4. 2-D drawing of the 3-D hologram of the Sierpinski pyramid of order 7.

The hologram of the drawing was created using the stereo-graphic image method [1]. The hologram captures the 3-D nature of the drawing to produce an effect similar to that of rotation of the original 3D model in OpenGL. The hologram itself was presented at the conference and is exhibited at the University of Arizona.

D3. was Joe Marks' surprise for the participants of the symposium. They found a space cluster in their GD'2000 bag. A space cluster consists of 72 elastic rods and 24 plastic intersections. The participants were encouraged to construct three dimensional graphs. There were sharp time restrictions: three breaks and one night session. Four teams submitted their assemblies, which were aesthetically nice 3D graphs.

The winner is "The Rose" by Robby Schönfeld from the University of Halle, Germany and Nikola S. Nikolov, from the University of Limerick, Ireland. Figure 5 shows the photo. This is the largest finite graph which is both maximal planar and regular.

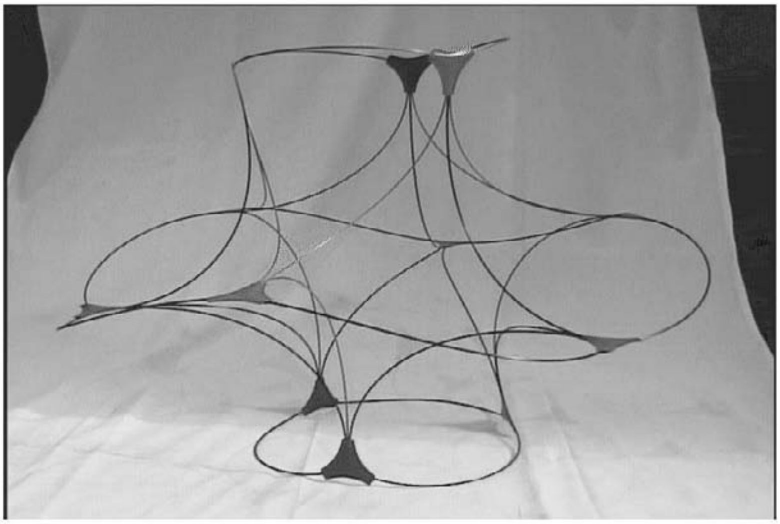


Fig. 5. The “Rose”

3 Observations and Conclusions

The organization of this year’s graph drawing competition had been shifted from its initiator Joe Marks to Franz Brandenburg. Confronted with the three tasks of collecting challenge graphs, raising money from sponsors and finally ranking the entries, the first one was the hardest.

As in the past years, the graph drawing competition had a scientific and a fun category. Several times the posted challenge graphs have served to initiate research or give a push in a particular direction. Winning entries are referenced in several papers. This year, the data were taken from real life problems. Using well-founded approaches the winners made the underlying meaning of the data visible.

Unfortunately, the number of contributions to the graph drawing competitions has reached a low point. We’ll try to attract more members inside and outside the graph drawing community to contribute to the graph drawing competition.

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