Graph Drawing Contest Report

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Abstract. This report describes the 23rd Annual Graph Drawing Contest, held in conjunction with the 24th International Symposium on Graph Drawing (GD'16) in Athens, Greece. The purpose of the contest is to monitor and challenge the current state of graph-drawing technology.

1 Introduction

This year, the Graph Drawing Contest was divided into two parts: the *creative topics* and the *live challenge*.

The creative topics had two graphs: the first one was a graph about country relations in the Panama papers, and the second one was a family tree of figures in Greek mythology. The data sets for the creative topics were published months in advance, and contestants could solve and submit their results before the conference started. The submitted drawings were evaluated according to aesthetic appearance, domain-specific requirements, and how well the data was visually represented.

The live challenge took place during the conference in a format similar to a typical programming contest. Teams were presented with a collection of challenge graphs and had one hour to submit their highest scoring drawings. This year's topic was to minimize the number of crossings in book layouts with a fixed number of pages.

Overall, we received 15 submissions: 6 submissions for the creative topics and 9 submissions for the live challenge.

2 Creative Topics

The two creative topics for this year were a graph about the Panama papers, and a Greek mythology family tree. The goal was to visualize each graph with complete artistic freedom, and with the aim of communicating the data in the graph as well as possible.

We received 2 submissions for the first topic, and 4 for the second. For each topic, we selected up to three contenders for the prize, which were printed on large poster boards and presented at the Graph Drawing Symposium. Finally,

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out of those contenders, we selected the winning submission. We will now review the top three submissions for each topic (for a complete list of submissions, refer to http://www.graphdrawing.de/contest2016/results.html).

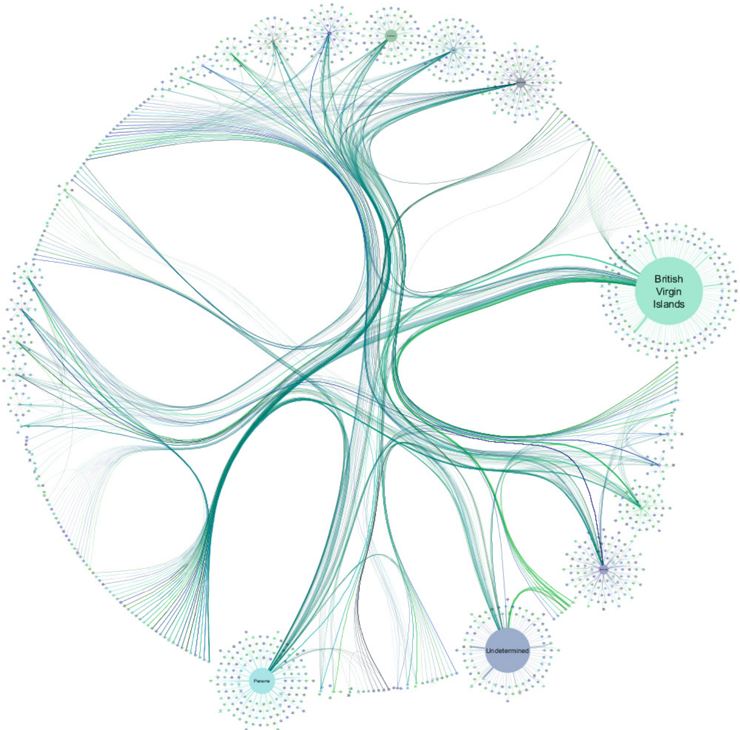
2.1 Panama Papers

The *International Consortium of Investigative Journalists* (ICIJ)[1] is a global network of more than 190 investigative journalists in more than 65 countries who collaborate on in-depth investigative stories. Recently, the ICIJ released an *Offshore Leaks Database*[2] of almost 320,000 offshore companies and trusts from the Panama papers and the Offshore Leaks investigations.

For the first creative topic, we processed the database to create a weighted directed graph that shows the relationships between countries. A directed edge from country A to country B with weight w means that there are w Offshore Entities in country B that are linked to a company in country A.

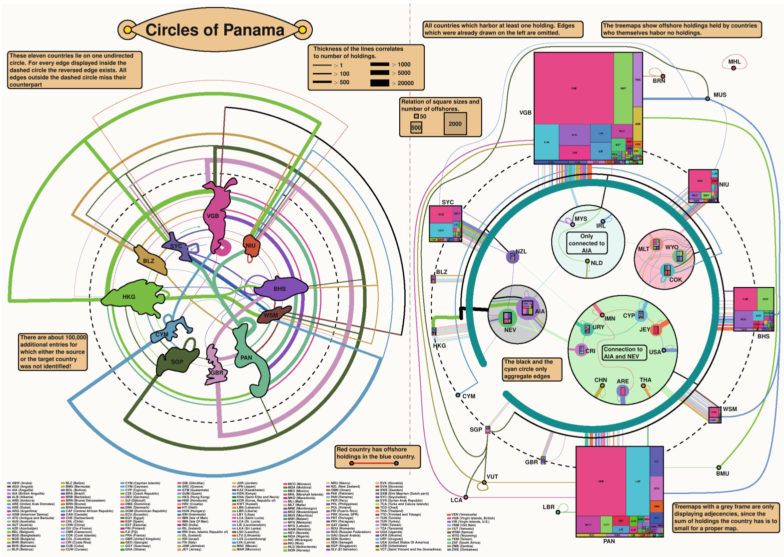
The resulting layout of the graph should contain the names of the countries and should give a good overview on their correlation.

Runner-Up: Evmorfia Argyriou, Anne Eberle, and Martin Siebenhaller (yWorks). The committee likes the combination of clustering with radial layouts and organic edges, and a circular layout for the clusters that are connected with bundled edges. The representation of edge weights and (weighted) in-degrees via edge thickness and node sizes help a lot to grasp the underlying data.



[1] https://www.icij.org/.
[2] https://offshoreleaks.icij.org/.

Winner: Fabian Klute (TU Wien). The committee likes the approach of this submission that derivates severely from standard approaches. The drawing is split into two parts. On the left, a highly connected subgraph consisting of eleven nodes is represented with different drawing styles depending on whether an edge exists in both directions or only in one. On the right, nodes without incoming edges are placed in treemaps that also represent vertices and are connected by various edge styles. The problem of label sizes was solved by using three-letter country codes and a different color for each country.



2.2 Greek Mythology Family Tree

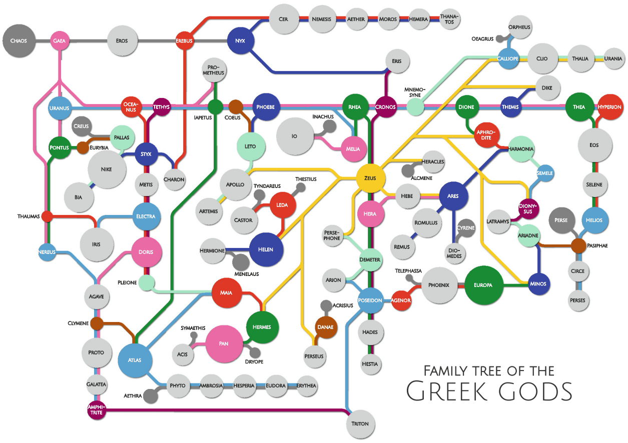
The following data comes from the *Greek Mythic Genealogy Project*[3].

> Greek myth contains a large amount of genealogical information. Various characters are related to each other in ways that are difficult for the non-specialist to keep track of, if for no other reason than that there are such a large number of gods, heroes, and other characters who appear in the various myths, epics, lyrics, legends, comedies, and other material. The Greek Mythic Genealogy Project is a fragmentary attempt to keep track of some of these relationships.

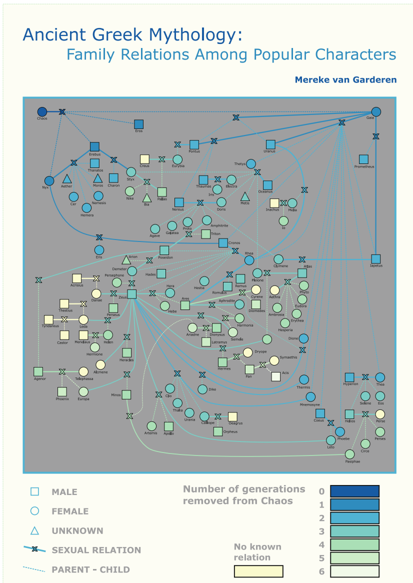
For the second creative topic, participants were asked to draw a family "tree" of popular characters in Greek Mythology. We created a subgraph of the large database by extracting only the most popular (by the number of Google results) names and their parents. This reduced the number of nodes to 118.

[3] http://patrickbrianmooney.nfshost.com/~patrick/greek-myth/greek-genealogy.html.

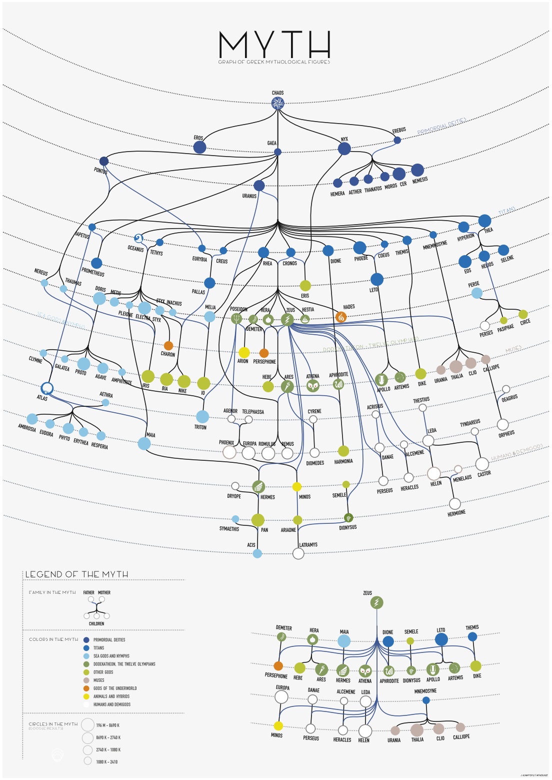
Runner-Up: Thom Castermans, Tim Ophelders, and Willem Sonke (TU Eindhoven). The first runner-up used a very interesting strategy to lay out siblings in order to reduce the complexity of the drawing: instead of drawing one edge from a parent to each of its children, a single (bundled) path is used that connects the childrin with the parent; in some cases (e.g., if there are too many children), more than one bundled path was used. The edges are colored by with the same color as the parent, which makes it easy to find the relationship between two nodes. The committee especially likes the metro map style of the drawing and the non-standard way of visualizing siblings.



Runner-Up: Mereke van Garderen (University Konstanz). The second runner-up drew the graph completely manually without using existing algorithms. The vertices are nicely layed out and both keep the number of crossings small and keep immediate family members close together. The edges are drawn with a mix of straight lines (with few slopes) and splines. In order to still show the hierarchical layout of the graph, the nodes and edges are colored by their generation with respect to the goddess Chaos. The committee finds the visual appearance, the colors, and the edge styles very appealing.



Winner: Jonathan Klawitter and Tamara Mchedlidze (Karlsruhe Institute of Technology). The committee was impressed by the aesthetic appeal of this submission. The layout is very nicely done and clearly shows the hierarchy in the family tree. The nodes are carefully placed on several circular arcs and the edges are drawn as curves; in order to represent families, the father–children and the mother–children edges form bundles. The committee especially liked the coloring of the vertices that represent different types of entities in the Greek myth, such as titans, sea gods, or muses. Similar types are grouped closely together. For the twelve Olympian gods (and some other important figures), the authors also added their symbols inside the nodes. Below the drawing of the whole graph, there is a second drawing that only shows the partners and children of Zeus.



3 Live Challenge

The live challenge took place during the conference and lasted exactly one hour. During this hour, local participants of the conference could take part in the manual category (in which they could attempt to solve the graphs using a supplied tool), or in the automatic category (in which they could use their own software to solve the graphs). At the same time, remote participants could also take part in the automatic category.

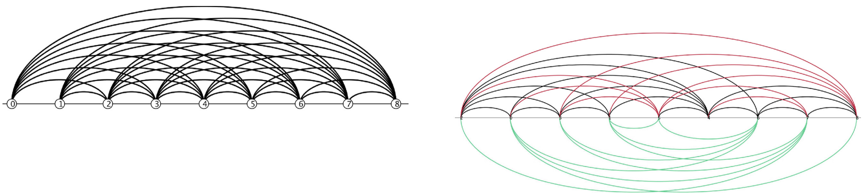
The challenge focused on minimizing the number of crossings in a book embedding with k pages. The input graphs are arbitrary undirected graphs and a maximum number of pages that may be used.

A book with k pages consists of k half-spaces, the pages, that share a single line, the spine of the book. A k-page book embedding of a graph is an embedding of a graph into a book with k pages such that all the vertices lie at distinct positions of the spine and every edge is drawn in one of the pages such that only its endpoints touch the spine.

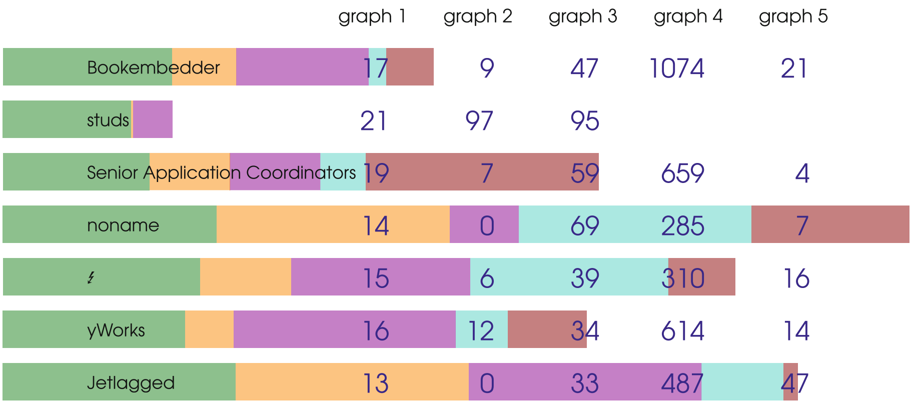
Note that edges may only cross if they are assigned to the same page. We are looking for drawings that minimize the number of crossings. The results are judged solely with respect to the number of crossings; other aesthetic criteria are not taken into account. This allows an objective way to evaluate a drawing.

3.1 Manual Category

In the manual category, participants were presented with five graphs. These were arranged from small to large and chosen to highlight different types of graphs and graph structures. For illustration, we include the first graph in its initial state and the best manual solution we received (by team JetLagged). For the complete set of graphs and submissions, refer to the contest website.



We are happy to present the full list of scores for all teams. The numbers listed are the number of crossings in each graph; the horizontal bars visualize the corresponding scores.

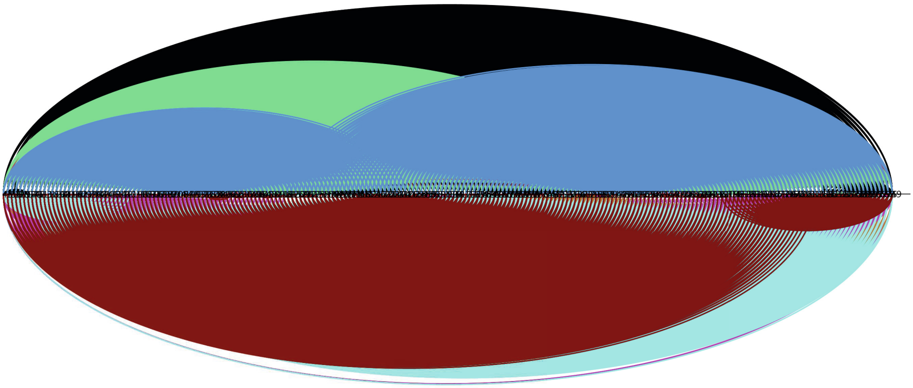


The winning team is team noname, consisting of Michael Bekos, Thanasis Lianeas, and Chrysanthi Raftopoulou!

3.2 Automatic Category

In the automatic category, participants had to solve the same five graphs as in the manual category, and in addition another five—much larger—graphs. Again, the graphs were constructed to have different structure.

Once more, for illustration, we include the best solution (by team Ruhrpott) of the first large graph as it looks in the tool. The graphs themselves can be found on the contest website.



	graph 1	graph 2	graph 3	graph 4	graph 5	graph 6	graph 7	graph 8	graph 9	graph 10
Ruhrpott	8	0	6	71	1	2538783	2630	17009	234238	100343
Johan de Ruiter	8	0	3	56	0	2683608	3	10219	191716	122311

The winning team is team Johan de Ruiter, consisting of Johan de Ruiter!

> “I used a Simulated Annealing approach with a collection of K 2D Fenwick trees as the underlying data structure in which the edges of the graph were stored according to their assigned pages in the book embedding. This allowed for logarithmic time counting of the number of crossings per edge, edge insertion and edge removal. Swapping two vertices, and moving a vertex into an empty spot, were realized by removing and reinserting all the incident edges.”
> *Johan de Ruiter*

Acknowledgments. The contest committee would like to thank the generous sponsors of the symposium, Dennis van der Wals for programming most of the tool for the manual category, and all the contestants for their participation. Further details including all submitted drawings and challenge graphs can be found at the contest website: http://www.graphdrawing.de/contest2016/results.html.