Graph Drawing Contest Report

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Abstract. This report describes the 21st Annual Graph Drawing Contest, held in conjunction with the 2014 Graph Drawing Symposium in Würzburg, Germany. 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 an *offline contest* and an *online challenge*. The offline contest had two categories: the first one dealt with creating a metro map layout from a given bus and tram network, and the second one was a composer's network. The data sets for the offline contest 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 online 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 approximately one hour to submit their highest scoring drawings. This year's topic was the same as last year, namely to minimize the area for orthogonal grid layouts, where we allowed crossings (the number of crossings was not judged, only the area counted).

Overall, we received 24 submissions: 5 submissions for the offline contest and 19 submissions for the online challenge.

2 Metro Map Layout

In this category, the task was to visualize the bus and tram network of Würzburg in a metro map style layout. The data for the network included information about the stops like the name of the stops and their geographic locations, as well as the bus/tram lines with their stops and the distances between stops. We asked for a visualization of the whole network, presenting the connections in a clear way for a possible user of public transport in Würzburg. The data had been kindly provided by the WVV[1].

[1] http://www.wvv.de

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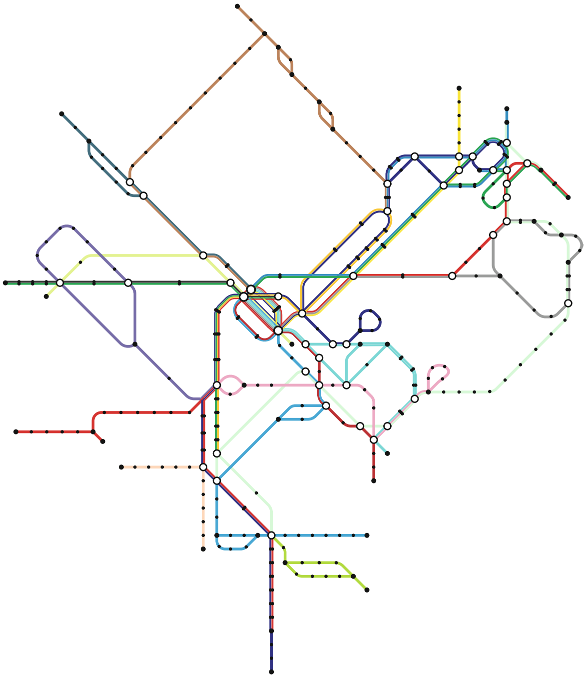
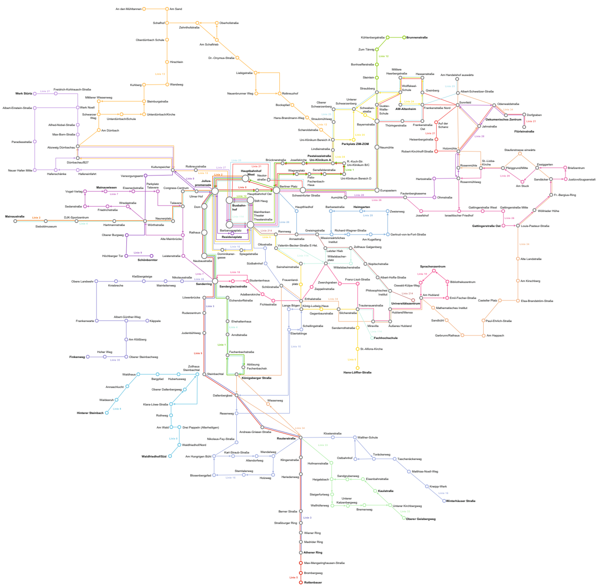


(a) Martin Nöllenburg



(b) Arturs Verza

Fig. 1. Metro map layout of Würzburg's public transport network

We received two submissions in this category, both presenting the network in a very nice way. Martin Nöllenburg's submission (see Fig. 1(a)) is a typical metro map drawing with a very nice routing of lines, created using their ILP-based metro map layout algorithm [1]. Fig. 1(b) shows Arturs Verza's submission, which gives a clear picture of the cluttered city center.

The winner in this category was Martin Nöllenburg from the Karlsruhe Institute of Technology, since we preferred the nicer global layout of his submission, which allows a user of the map to easily figure out possible connections.

3 Composers Graph

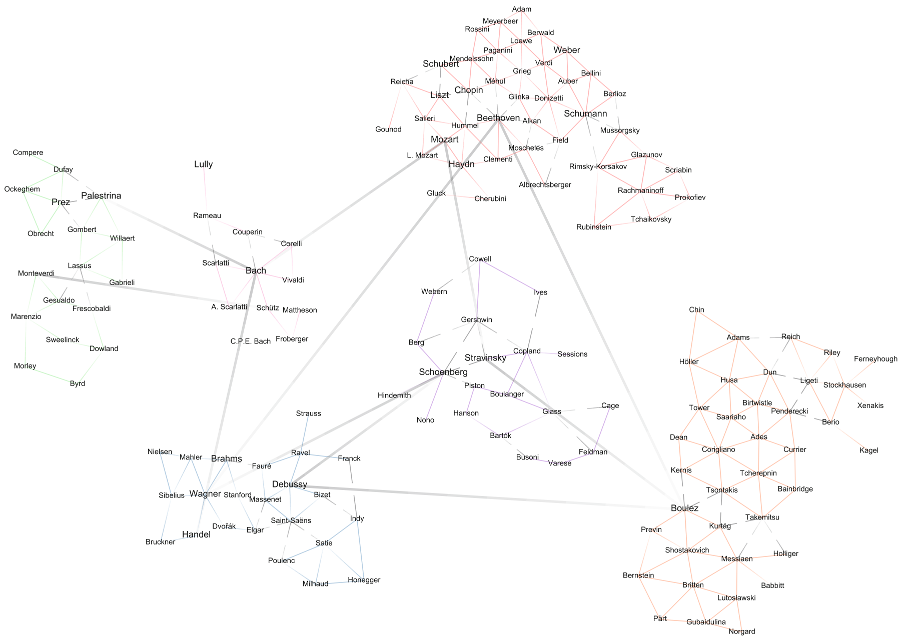
For this category, we used a data set that was already a contest graph in 2011. The *composers graph* is a large directed graph, where its 3,405 nodes represent Wikipedia articles about composers, and its 13,382 edges represent links between these articles. This graph has too many nodes and edges to be effectively presented in a straightforward way. Therefore, this time the task was to select the about 150 most important nodes and to create a drawing of a subgraph containing these nodes. Part of the task was to define *important* in a suitable way. The criterion should only depend on the given graph, not on any other sources or knowledge. It was also allowed to filter out some edges between important nodes using a reasonable criterion for filtering.

We received three submissions for this graph. Fig. 2(a) shows the submission from Remus Zelina et al.; they divided the composers into *influencers* and *influencees* (a composer could appear twice) and then used Girvan Newman modularization to obtain a set of modules. For selecting the most important composers, they used the corresponding factor in the modularity formula as well as the page rank algorithm. They also categorized the edges with respect to the module structure and selected only the most important ones. The final layout was then obtained by applying a layered approach that emphasized the module structure. The submission by Ulf Rüegg (see Fig. 2(b)) used the notion of betweenness to select the most important nodes in the graph; the edges were then selected as a maximum spanning tree, where the edges were weighed using edge betweenness. The resulting tree was laid out with a stress minimization approach. The third submission came again from Arturs Verza. He used centrality for selecting the top 150 composers, removed transitive edges in the subgraph, and finally applied a circular layout algorithm (due to lack of space we omit the drawing; it can be found on the contest web page).

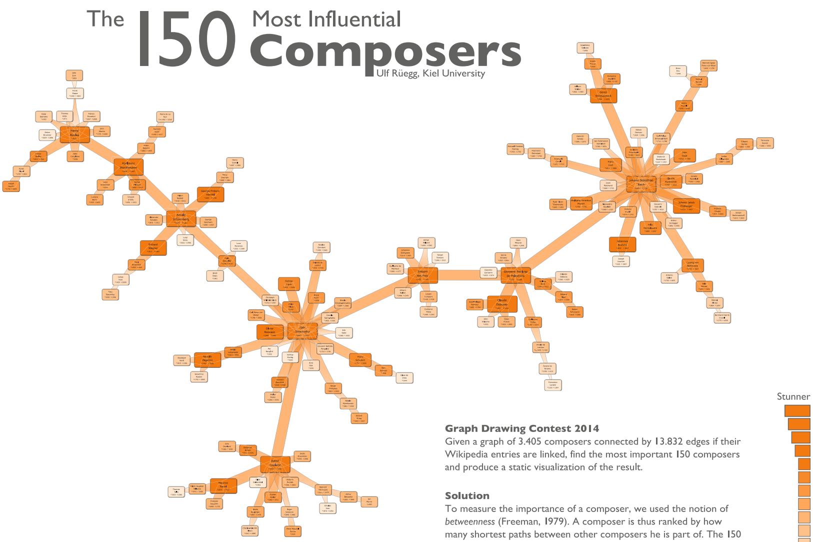
The winner in this category was the team Remus Zelina, Sebastian Bota, Siebren Houtman, and Radu Balaban from Meurs, Romania, for their clear representation of global as well as local structure.

4 Online Challenge

The online challenge, which took place during the conference, dealt with minimizing the area in an orthogonal grid drawing. The challenge graphs were not necessarily planar and had at most four incident edges per node. Edge crossings were allowed and their number did not affect the score of a layout. Since typical drawing systems first try

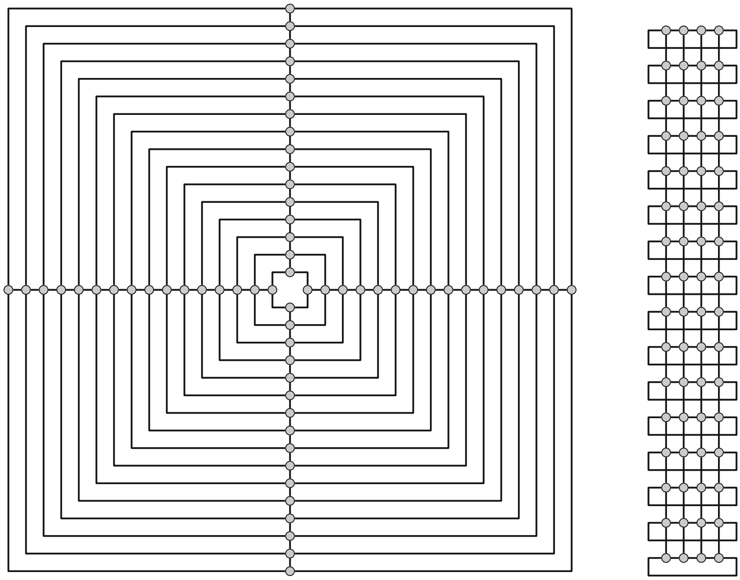


(a) Remus Zelina et al.



(b) Ulf Rüegg

Fig. 2. Composers graph



(a) initial (b) best automatic

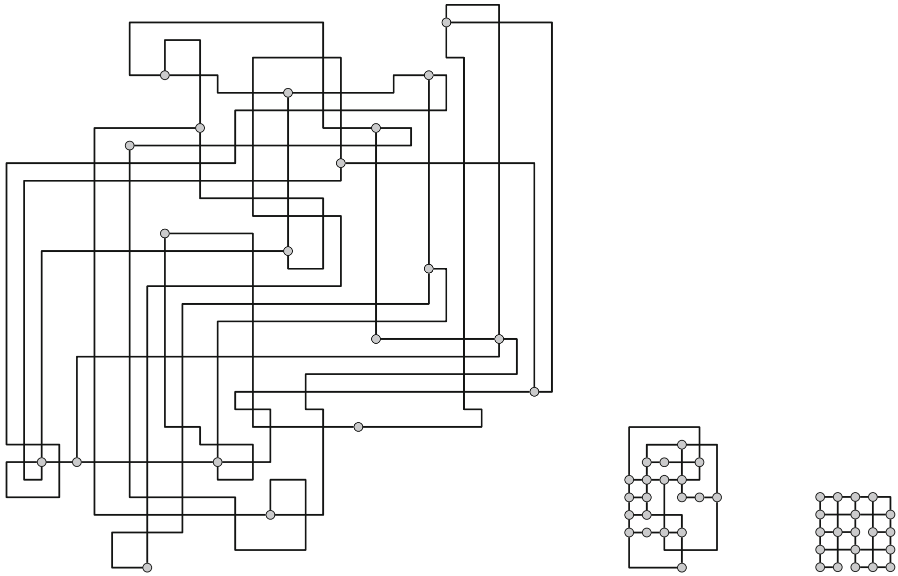
Fig. 3. Challenge graph with 64 nodes and 124 edges: (a) initial layout and (b) best automatic result by the team of Mchedlidze et al

to minimize the number of crossings, which might result in long edges increasing the required area, we were in particular interested in the effect of allowing crossings on the quality of layouts when trying to reduce the area.

The task was to place nodes, edge bends, and crossings on integer coordinates so that the edge routing is orthogonal and the layout contains no overlaps. At the start of the one-hour on-site competition, the contestants were given five graphs with an initial legal layout with a large area. The goal was to rearrange the layout to reduce the area, defined as the number of grid points in the smallest rectangle enclosing the layout. Only the area was judged; other aesthetic criteria, such as the number of crossings or edge bends, were ignored.

The contestants could choose to participate in one of two categories: *automatic* and *manual*. To determine the winner in each category, the scores of each graph, determined by dividing the area of the best submission in this category by the area of the current submission, were summed up. If no legal drawing of a graph was submitted (or a drawing worse than the initial solution), the score of the initial solution was used.

In the automatic category, contestants received six graphs ranging in size from 20 nodes / 29 edges to 100 nodes / 182 edges and were allowed to use their own sophisticated software tools with specialized algorithms. Manually fine-tuning the automatically obtained solutions was allowed. Fig. 3 shows a challenge graph from the automatic category with 64 nodes, 124 edges, and a very bad initial layout. The best obtained result improved the area from 1089 to 192. With a score of 4.964, the winner in the automatic category was the team of Tamara Mchedlidze, Martin Nöllenburg and their



(a) initial (b) best manual (c) optimal

Fig. 4. Challenge graph with 20 nodes and 29 edges: (a) initial layout, (b) best manual result obtained by the team of Will and Jawaherul, and (c) optimal solution

Graph Drawing lecture students Igor, Alexander, and Denis from the Karlsruhe Institute of Technology, who found the best results for four of the five contest graphs.

The 19 manual teams solved the problems by hand using IBM's *Simple Graph Editing Tool* provided by the committee. They received five graphs ranging in size from 6 nodes / 8 edges to 20 nodes / 29 edges. The largest input graph was also in the automatic category. For this graph, both the best automatic and the best manual team could improve the area from initially 1056 to 54, whereas the optimal solution has an area of 25; see Fig. 4. With a score of 4.425, the winner in the manual category was the team of Philipp Kindermann, Fabian Lipp and Wadim Reimche from the University of Würzburg, who found the best results for three of the five contest graphs.

Acknowledgments. The contest committee would like to thank the generous sponsors of the symposium and all the contestants for their participation. Further details including winning drawings and challenge graphs can be found at the contest website:

`http://www.graphdrawing.de/contest2014/results.html`

References

1. Nöllenburg, M., Wolff, A.: Drawing and labeling high-quality metro maps by mixed-integer programming. IEEE Trans. Vis. Comput. Graph. 17(5), 626–641 (2011)