

Algorithms for Graph Visualization

Wrap Up

INSTITUT FÜR THEORETISCHE INFORMATIK · FAKULTÄT FÜR INFORMATIK

Tamara Mchedlidze
6.2.2017



Exams

- Oral Exam (20 Minutes)
 - 13,14 February 2017
 - 20,21 March 2017
 - Room 315
 - Myself + Benjamin (or substitute) taking protocol.
- Language:** English.

Content

- Material from lectures/exercises
- Skript, Slides, Blackboard proofs - only what have been discussed

Goals

- Layout problems (Problem definitions, Aesthetic criteria)
- Algorithms (Proof ideas)

Graph visualization problem

given: Graph $G = (V, E)$

find: (**good**) drawing Γ of G , that

- complies with drawing conventions
- optimizes aesthetics
- satisfies local/partial constraints

- Graph Classes
- Drawing Conventions, Aesthetic Criteria
- Algorithms and their type (D & C, Incremental, LP)
- Techniques

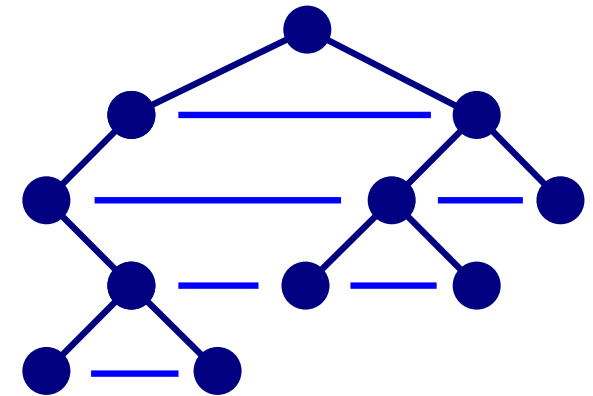
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Let's Draw a Graph!

Topic 1: Trees

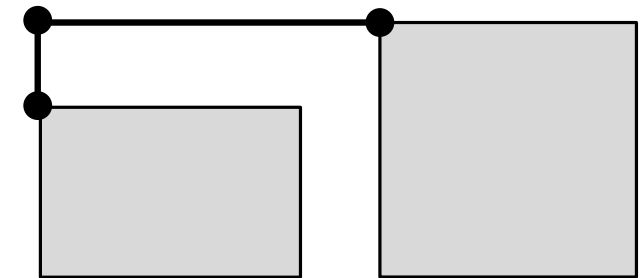
Layered Layout

- **Aesthetics:** symmetry, area
- **Conventions:** planarity, vert. on layers
- **Algorithm:** Divide&Conquer, Time $O(n)$, Area $O(n^2)$



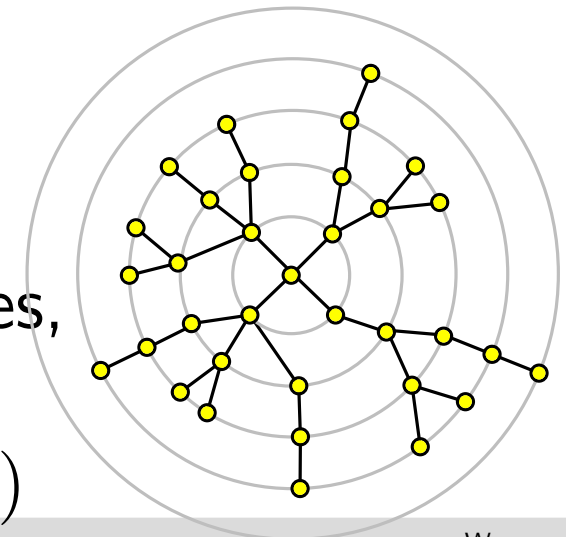
HV-Layout

- **Aesthetics:** symmetry, area
- **Convention:** h/v edges, planarity
- **Algorithm:** Divide&Conquer, Time $O(n)$, Area $O(n \log n)$



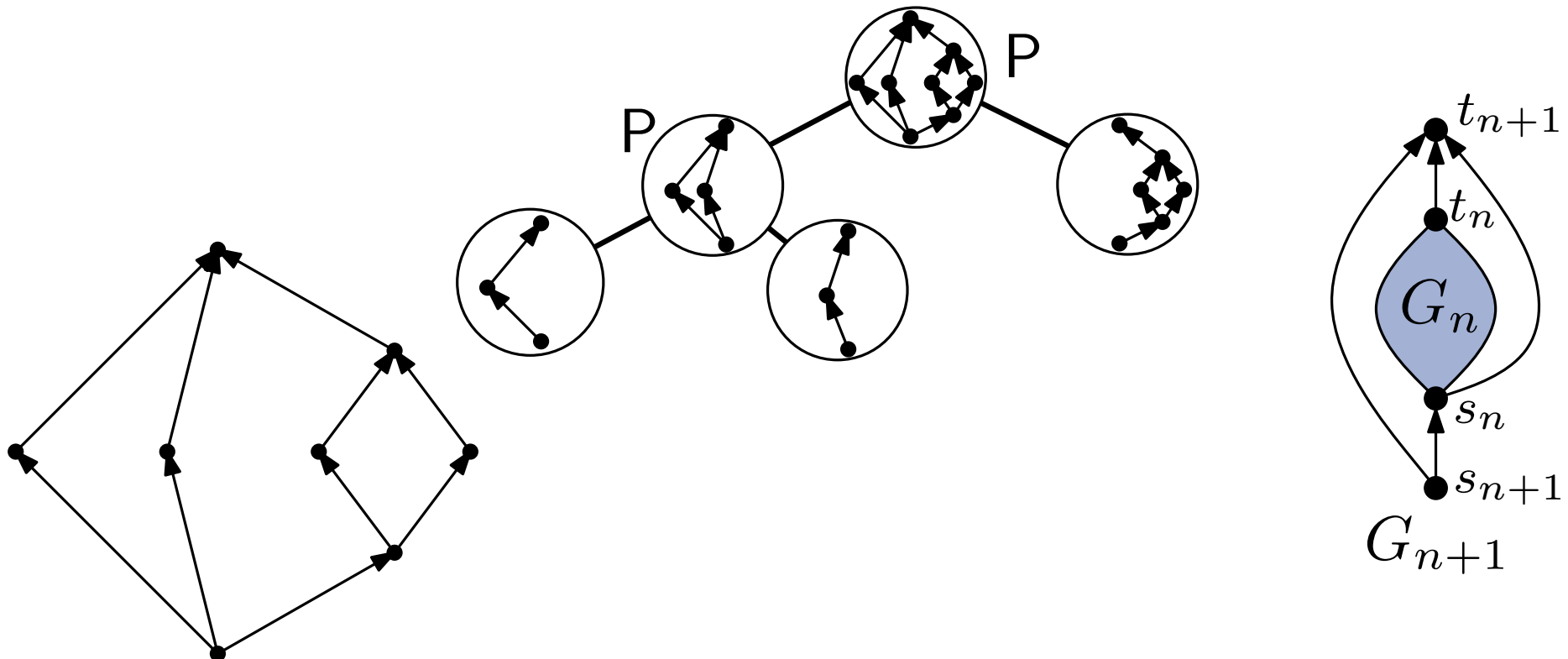
Radial Layout

- **Aesthetics:** vertex distribution
- **Convention:** vertices on co-centric circles, planarity
- **Algorithm:** Divide&Conquer, Time $O(n)$



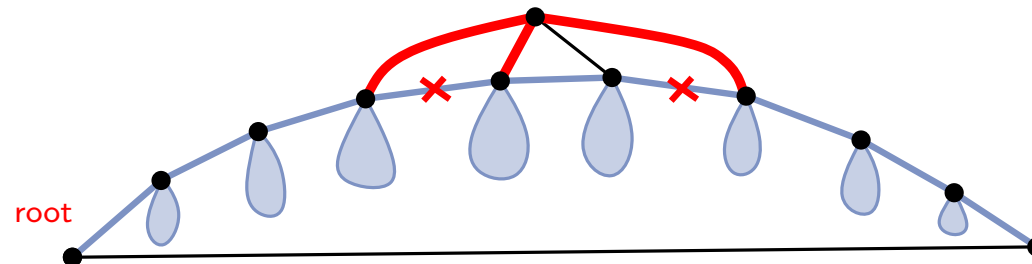
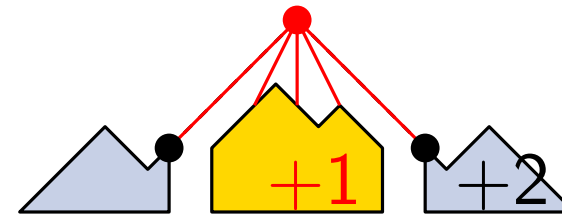
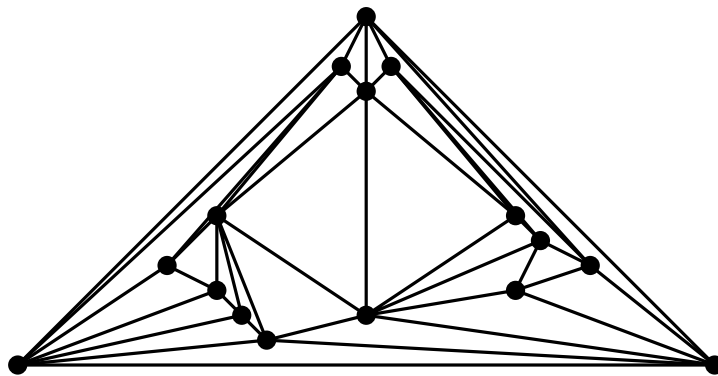
Topic 2: Series-Parallel Graphs

- **Convention:** planarity, upwardness
- **Aesthetics:** symmetry, vertical automorphisms
- **Algorithm:** Divide&Conquer based on SPQ-decomposition, Time $O(n)$, Area $O(n^2)$. Embedding varies.
- **Area lower bound** with fixed embedding $\Omega(4^n)$

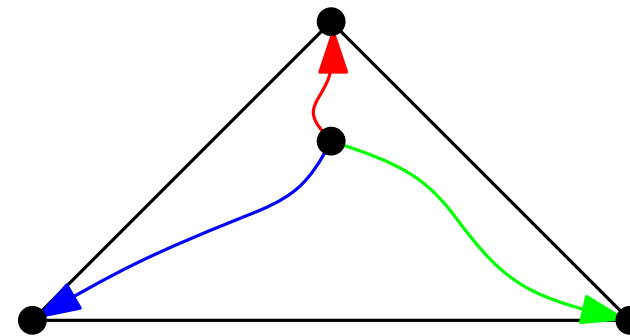
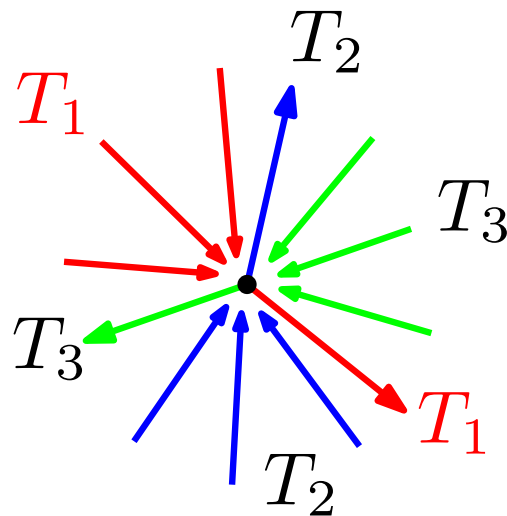


Topic 3: Planar Graphs - Shift Algorithm

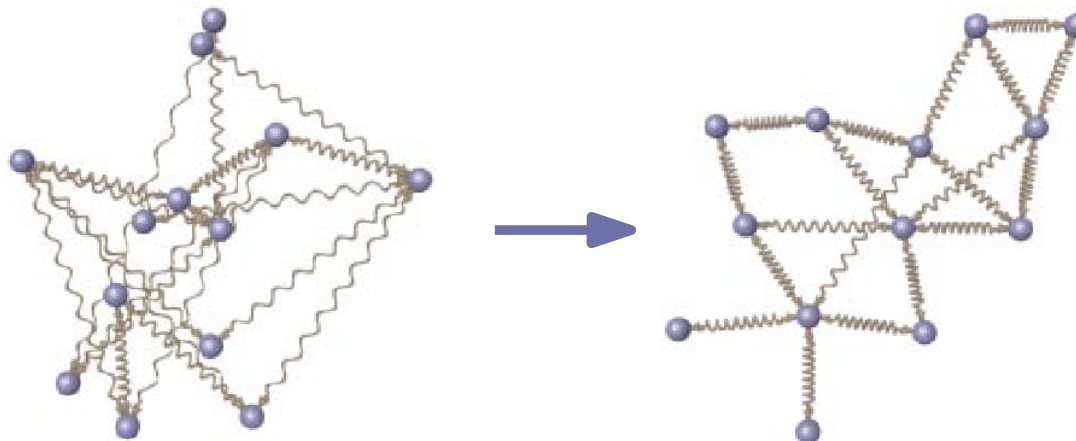
- **Conventions:** planarity
Aesthetics: ... ?
- **Algorithm:** Incremental based on **Canonical Ordering**.
Time $O(n)$, Area $O(n^2)$. Embedding fixed.
- **Highlights:** Proof of planarity, linear time implementation based on relative x -distances



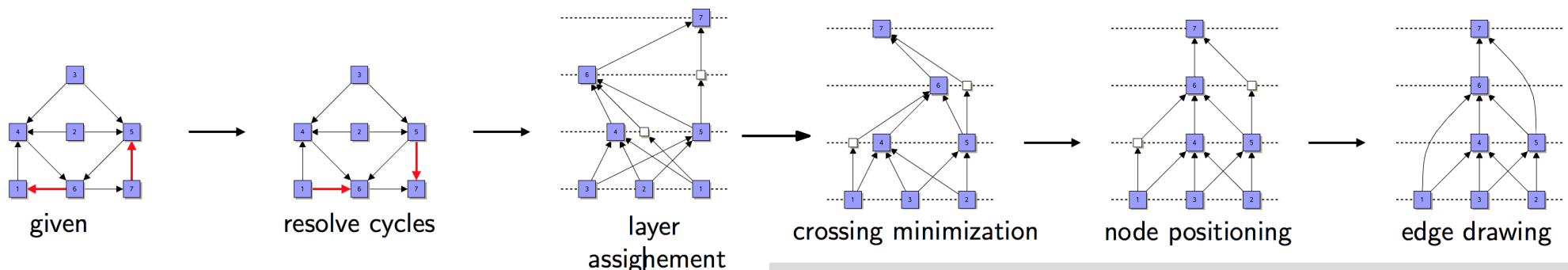
- **Conventions:** planarity
Aesthetics: ... ?
- **Algorithm:** Based on **Barycentric representation**, **Schnyder forest**. Time $O(n)$, Area $O(n^2)$. Embedding fixed.
- **Highlights:** Proof of planarity of barycentric representation, Schnyder forest - useful tool on its own.



- **Conventions:** ...
Aesthetics: edge length
- **Algorithm:** Eades, Fruchteman-Reingold. Time $O(n^2)$ per iteration.
- **Modifications:** Inertia, Gravitation, Magnetic Forces.
Bounded Drawing area.
Adaptive displacement.
Computation of forces using Quad-tree - Time $O(n \log n)$ per iteration. Multilevel approach - Time $O(n \log^2 n)$ overall.

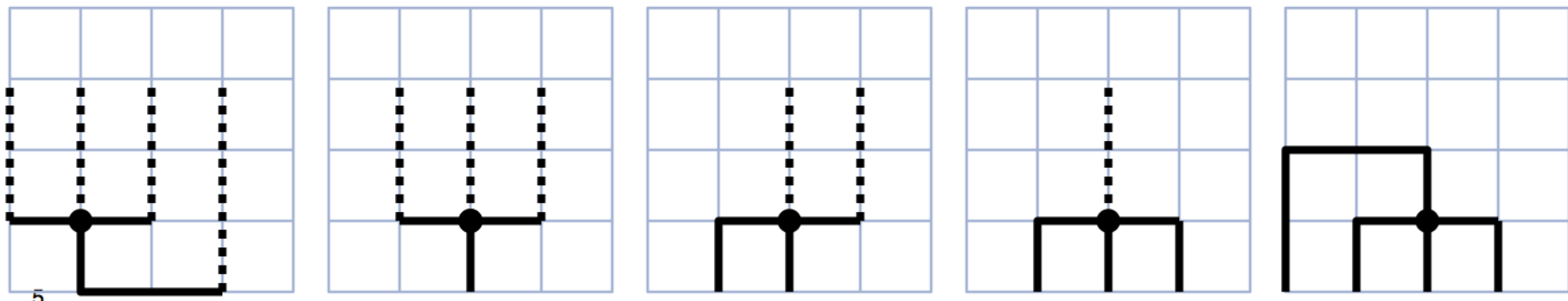


- Conventions:** vertices on layers, edges upward
- Aesthetics:** upwardness, edge length, edge bends, edge straightness, drawing width/ height, crossings.
- Algorithm:** Sugiyama Framework.
 - Resolve cycles** - Heuristic solutions. Time $O(|V| + |A|)$.
 - Layer Assignment** - minimize height: topological numbering ($O(|V| + |A|)$), total edge length: ILP
 - Crossing Minimization** - swap. Two layers: heuristics: barycenter, median (approximation factor) ($O(|V| + |A|)$), ILP.
 - Node Positioning** - edge straightness: quadratic program.

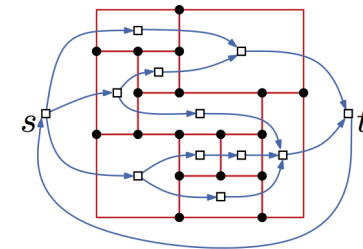
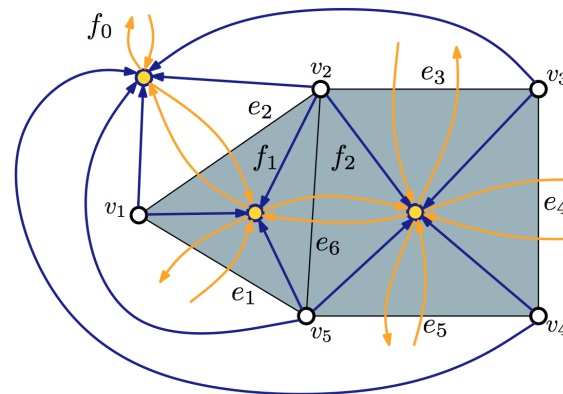
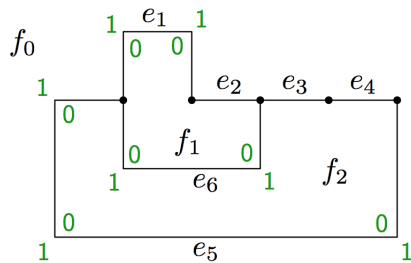


Topic 7: Degree 4 - Orthogonal Drawings

- **Conventions:** Edges on grid.
Aesthetics: Height, Width, Bends
- **Algorithm:** Biedl & Kant: incremental algorithm. Time Uses ear-decomposition, topological ordering. Time $O(n)$. Area $O(n^2)$.
- **Highlights:** Planar Drawing in case of Planar Embedded Graphs

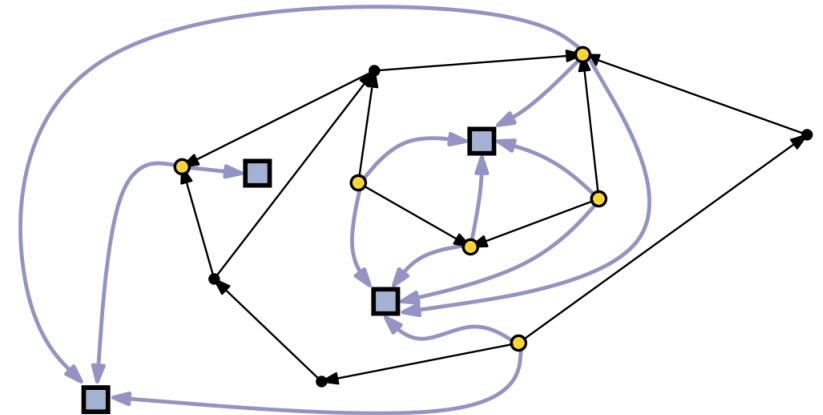
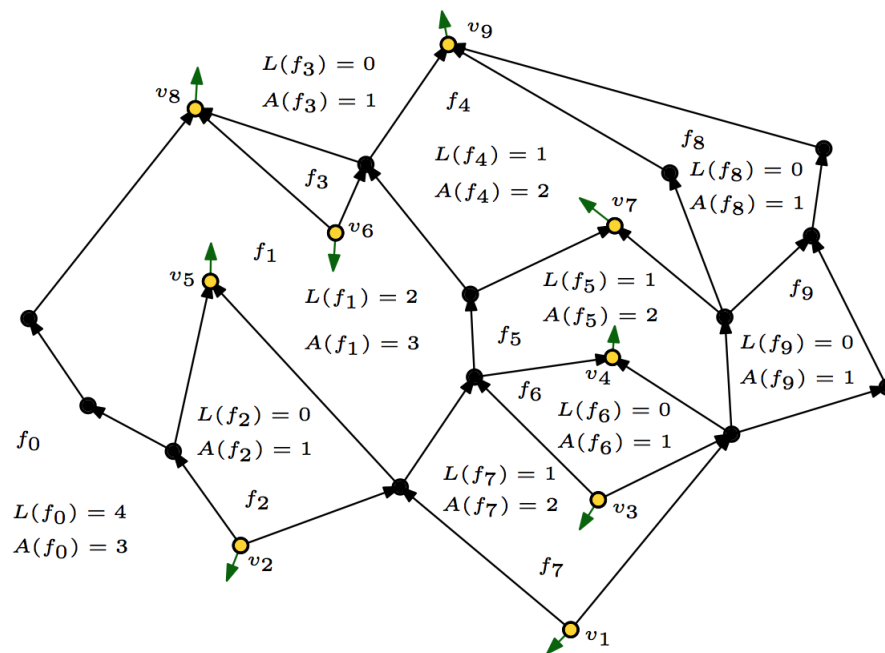


- Conventions:** Edges on grid.
Aesthetics: Height, Width, Bends
- Algorithm:** Topology-shape-metric.
 Crossing Reduction
Bend Minimization: Orthogonal Representation. Flow Network. Time $O(n^{3/2})$
Area Minimization: All faces rectangles: total edge length, area, flow network. Time $O(n^{3/2})$. Topological numbering. Rectilinear faces - face refinement.



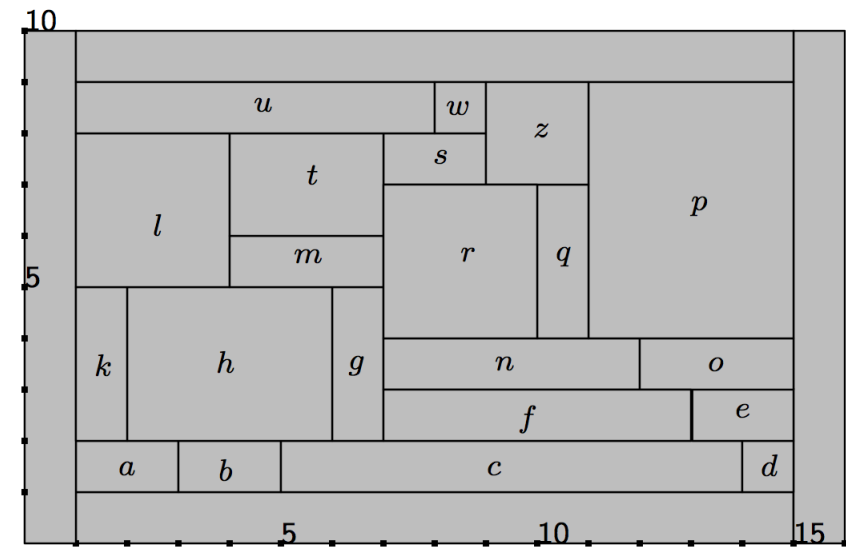
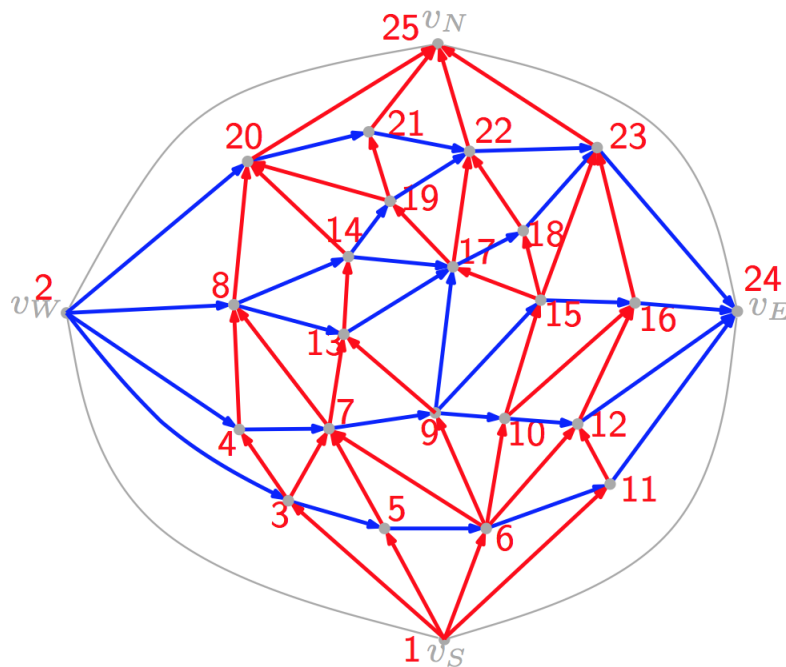
Topic 9: Upward Planarity

- **Conventions:** Planarity, Edges Upward
Aesthetics: ...
- **Algorithm:** Characterization (drawing planar st-digraphs),
Assignment vertices to faces, Flow Network, Face
subdivision. Time $O(n^2)$.



Topic 10: Contact Representations

- **Conventions:** Vertices polygons, Edges-contacts
Aesthetics: Complexity of polygons
- **Algorithm:** Rectangular dual. Characterization. Regular Edge Labeling, Canonical Ordering, st-digraphs, topological ordering. Time $O(n)$.



Visualization of GD Publications

- Graph Drawing Contest holding at Graph Drawing conference each September

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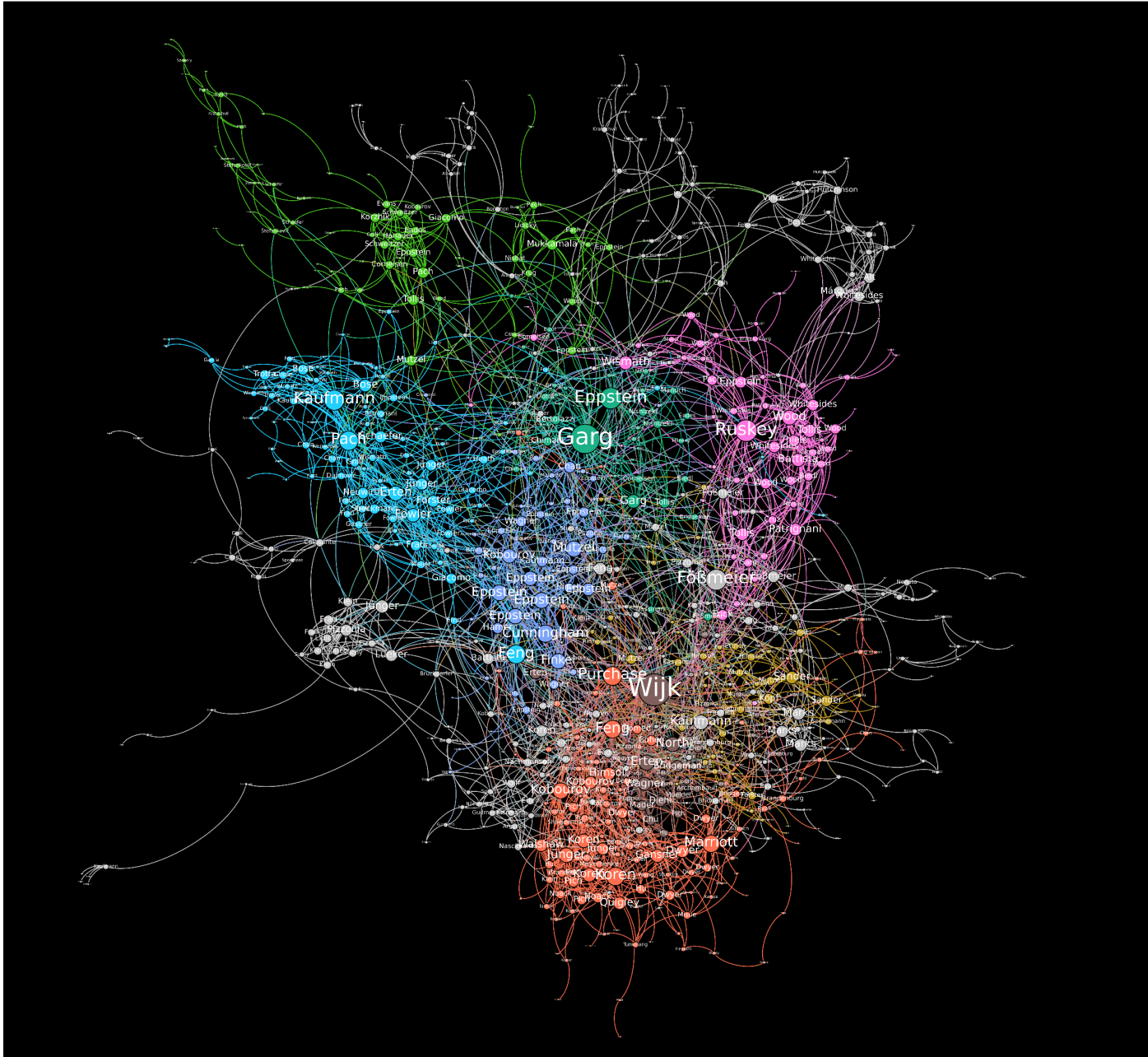
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- 1 Submission: by Sophie von Schmettow

Visualization of GD Publications



Sophie von Schmettow

Practical Course on Graph Visualization

Background: International Symposium on Graph Drawing (GD) and Graph Drawing Challenge



The poster for the 24th International Symposium on Graph Drawing & Network Visualization (GD 16) is centered around a network diagram. The central node is a green circle containing the text "gd 16" in a stylized font, with "19-21 SEPTEMBER" and "ATHENS GREECE" below it. This central node is connected to several other nodes, each containing a different image: a classical building, a modern city street, a landscape with a mountain, a classical building, a classical building, a classical building, and a classical building. The poster also features logos for sponsors like Springer, Microsoft, and Works. Below the central node, there are four columns of text: PROGRAM COMMITTEE, ORGANIZING COMMITTEE, INVITED SPEAKERS, and IMPORTANT DATES.

**24th International Symposium on
GRAPH DRAWING
& NETWORK VISUALIZATION**

gd 16
19-21 SEPTEMBER
ATHENS GREECE

PROGRAM COMMITTEE

Patrizio Angelini	Ian Kyrle
Therese Biedl	Kwan-Liu Ma
Walter Didimo	Tamara Mchedlidze
Cody Dunne	Martin Nöllenburg (co-chair)
David Eppstein	Stephen North
Jean-Daniel Fekete	Maurizio Patrignani
Stefan Felsner	Helen Purchase
Radoslav Fulek	Huamin Qu
Eindhoven Gansner	Günter Rote
Yifan Hu (co-chair)	André Schulz
Karsten Klein	Lei Shi
Stephen Kobourov	Alexandru Telea
Marc van Kreveld	

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Antonios Symvonis (chair)
Ioannis Tollis

CONTEST COMMITTEE

Philipp Kindermann
Maarten Löffler (chair)
Lev Nachmannson
Ignaz Rutter

INVITED SPEAKERS

Daniel Keim
Roger Wattenhofer

IMPORTANT DATES

Paper submission: June 12
Paper notification: July 24
Poster submission: Aug. 17
Poster notification: Aug. 28
Early registration: Aug. 30
Final versions due: Sept. 1
Contest submission: Sept. 11
PhD school: Sept. 22-23

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Task: develop software for a given graph visualization problem



The poster for the 24th International Symposium on Graph Drawing & Network Visualization (GD&NV 2016) is centered around a network graph. The central node is a green circle containing the text "gd16 19-21 SEPTEMBER ATHENS GREECE". It is connected to several other nodes, including logos for National Technical University of Athens, Microsoft, Springer, and other sponsors. The poster also features several circular images of historical Greek architecture and a network graph. Below the central node, there are four columns of text: PROGRAM COMMITTEE, ORGANIZING COMMITTEE, INVITED SPEAKERS, and IMPORTANT DATES.

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2014

- Area Minimization for Orthogonal Drawings
- part of the lecture
- best team won graph drawing contest



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2014

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- best team won graph drawing contest

2015

- Crossing Minimization in Book Embeddings
- separate course
- one team - collaborative work
- second place at the contest
- Best Poster Award in 2016



Practical Course on Graph Visualization

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Task: develop software for a given graph visualization problem

2017

- **Maximizing the Angles Between Crossing Edges in Straight-line Drawings**
- 5 credit points
- 8 participants (registration by email to me)



Topic

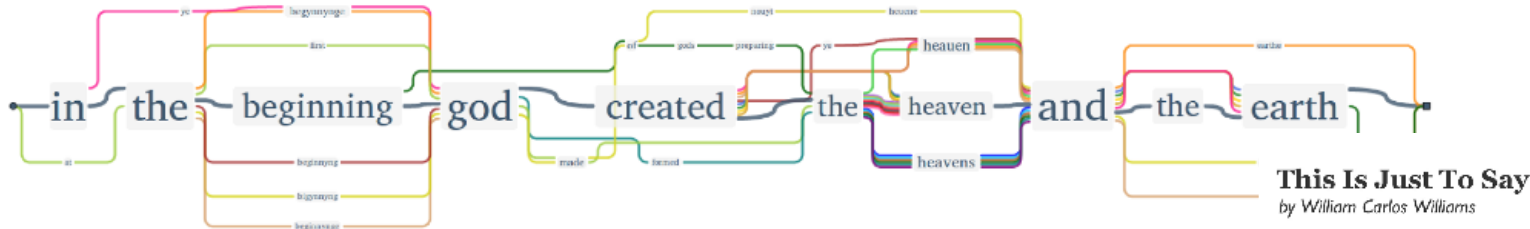
- Visualization of Citation Network of Graph Drawing Publications
 - Target: participate in the GD contest
 - Trying out various layout styles (edge bundling), clustering methods
 - Implementation (D3 or other framework)
 - Clustering Methods
 - Topic Extraction and Labeling Methods

Details

- Up to 40 hours/month
- Send your requests to me

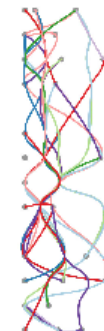
Topics

- Visualization of Text Variant Graphs and Sonic Topology of Poems with Curves
- Basic Computational Geometry Problems: routing curve through obstacles, minimizing curve complexity.
- Text variant: obstacles can move, Sonic Topology: obstacles do not move



This Is Just To Say
by William Carlos Williams

I have eaten
the plums
that were in
the icebox
and which
you were probably
saying
for breakfast
Forgive me
they were delicious
so sweet
and so cold



Details

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