Karlsruhe Institute of Technology

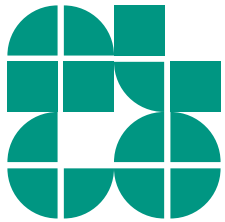
Algorithms for Graph Visualization

Wrap Up

INSTITUT FÜR THEORETISCHE INFORMATIK · FAKULTÄT FÜR INFORMATIK

Tamara Mchedlidze

6.2.2017



Organizational

Exams

- Oral Exam (20 Minutes)
- 13,14 February 2017
- 20,21 March 2017
- Room 315
- Myself + Benjamin (or substitute) taking protocall.
  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)

Layout Problem – General Definition

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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

Material Overview

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

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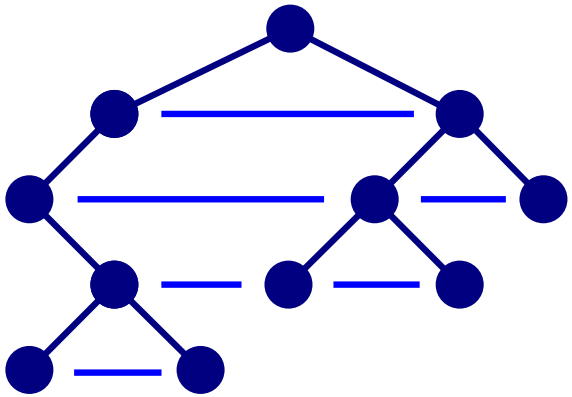
Let's Draw a Graph!

Topic 1: Trees

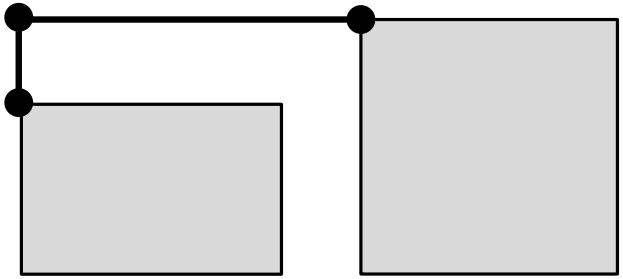
Layered Layout

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



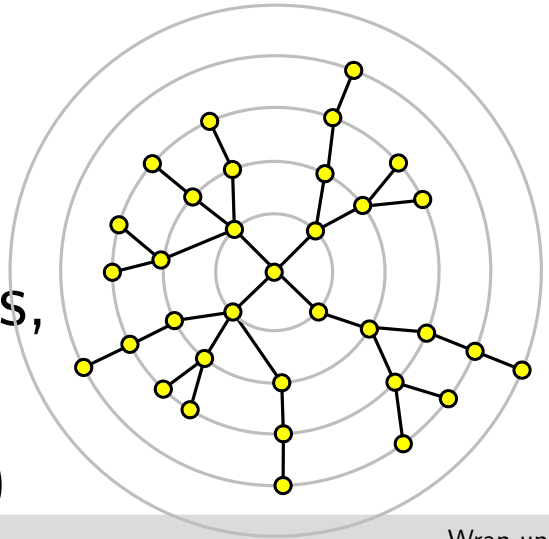
HV-Layout

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



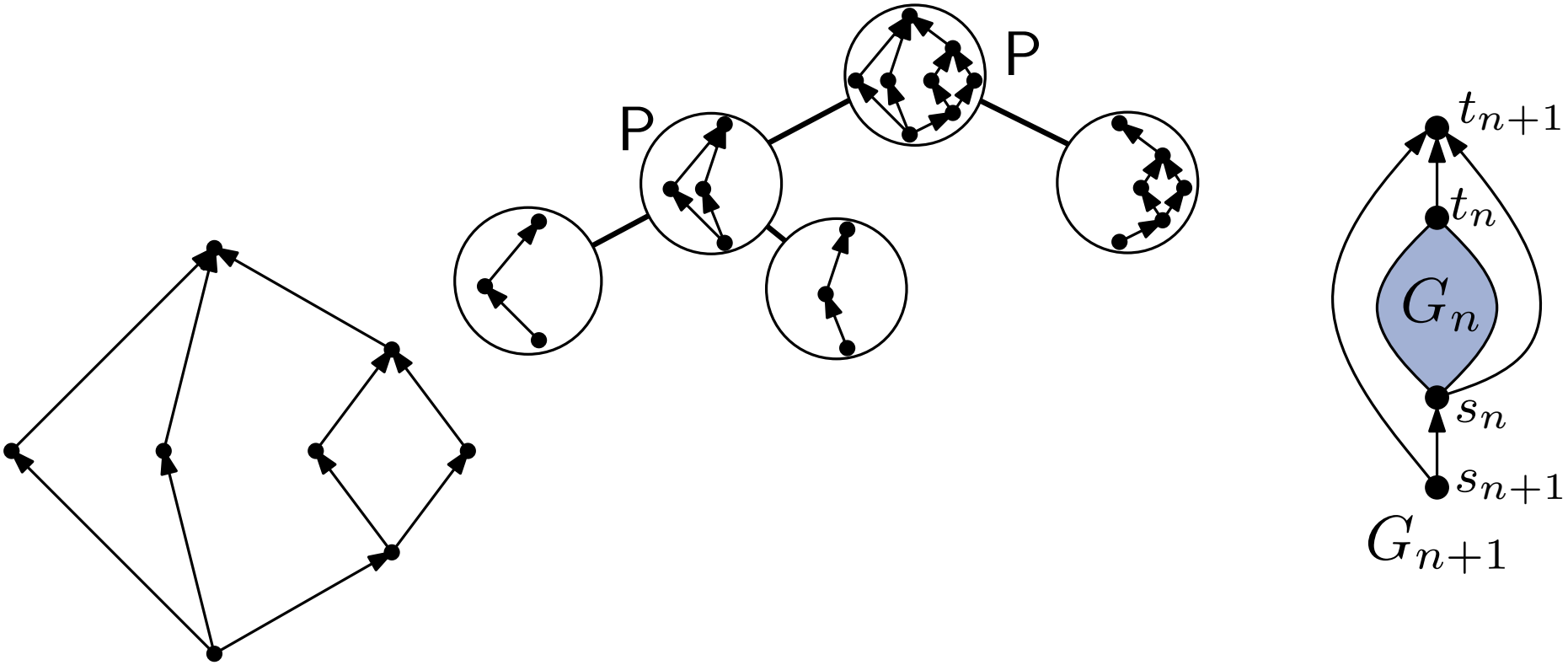
Radial Layout

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



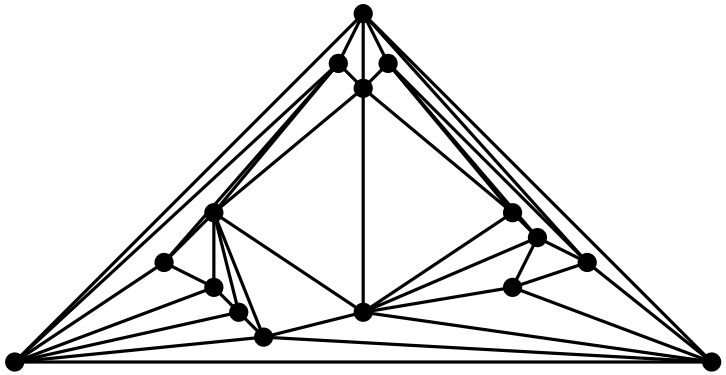
Topic 2: Series-Parallel Graphs

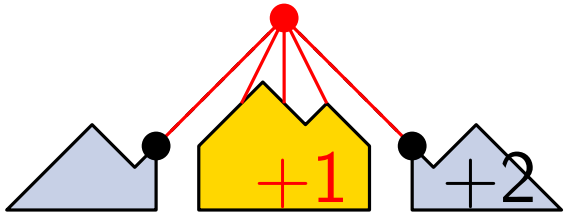
- **Convention:** planarity, upwardness
  Aesthetics: symmetry, vertical automorphisms
- **Algorithm:** Divide&Conquer based on SPQ-decomposition, Time $O(n)$, Area $O(n^2)$. Embedding varies.
- **Area lower bound** with fixed embedding $\Omega(4^n)$

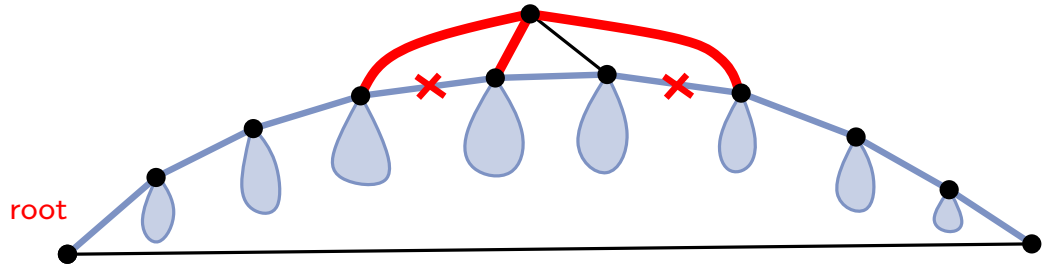


Topic 3: Planar Graphs - Shift Algorithm

- **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

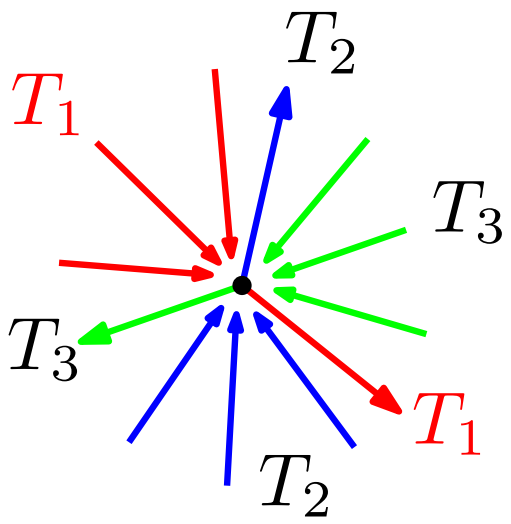


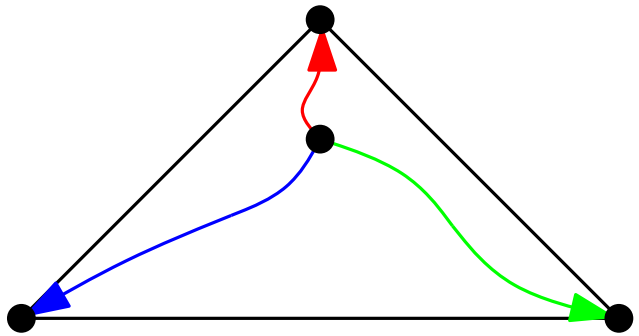




Topic 4: Planar Graphs - Schnyder Realizer

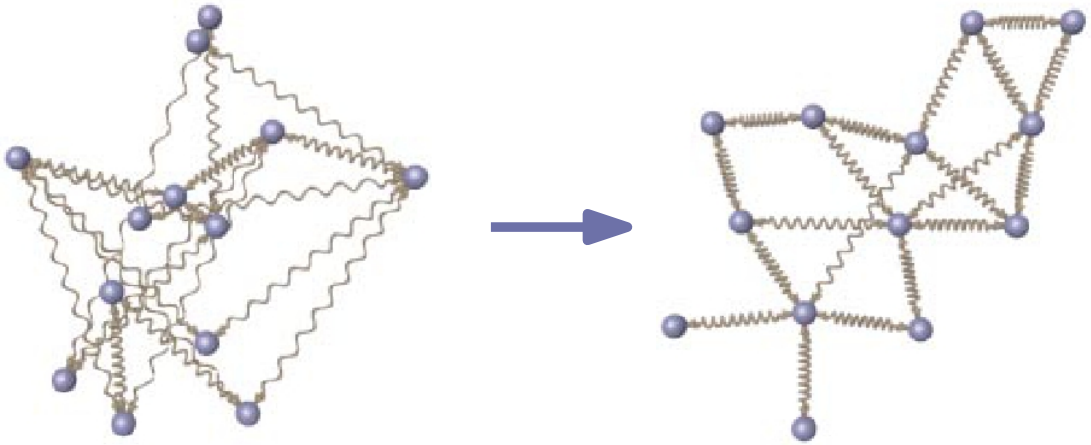
- **Conventions:** planarity
  Aesthetics: ... ?
- **Algorithm:** Based on **Barycentric representation**, **Schnyder forest**. Time $O(n)$, Area $O(n^2)$. Embedding fixed.
- **Highlights:** Proof of planarity of baricentric representation, Schnyder forest - useful tool on its own.





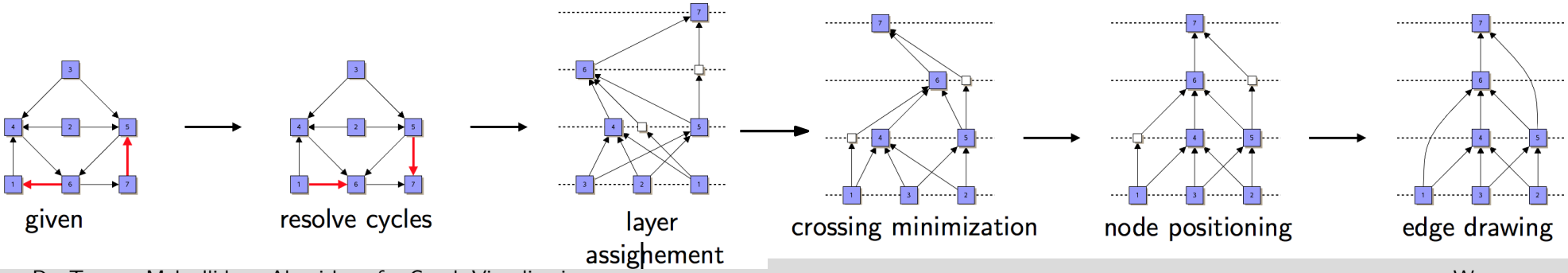
Topic 5: General Graphs - Force Directed

- **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.



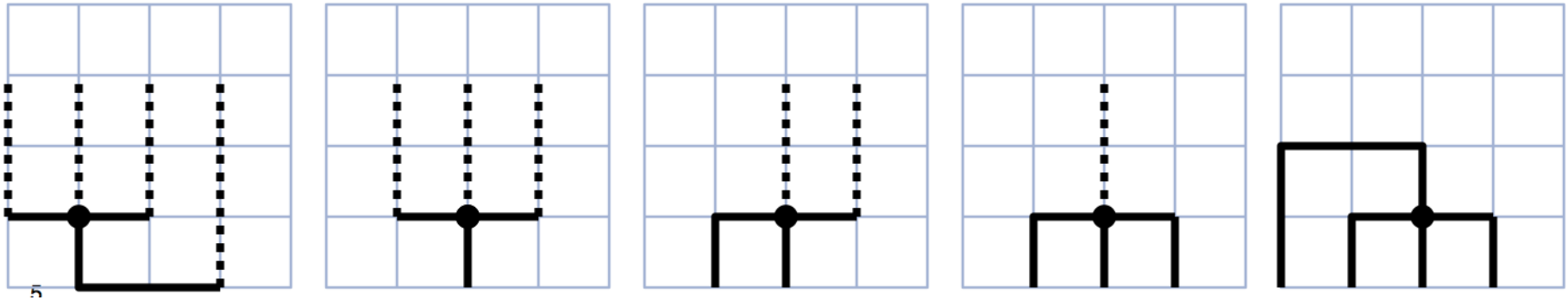
Topic 6: Directed Graphs - Layered Layout

- **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 Assignement - 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.



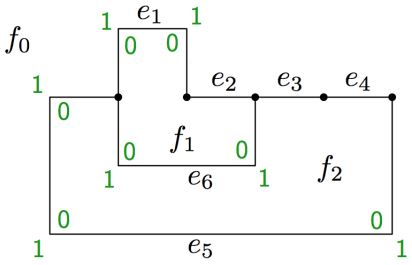
Topic 7: Degree 4 - Orthogonal Drawings

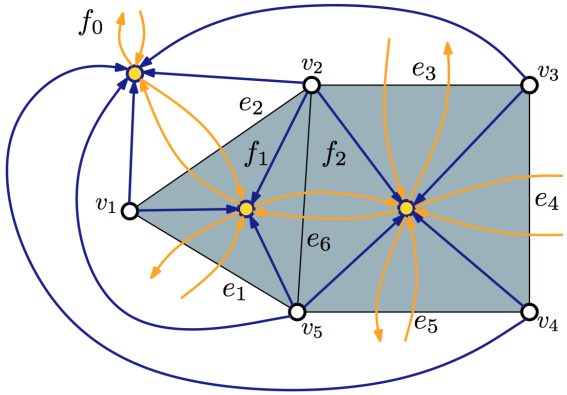
- **Conventions:** Edges on grid.
  Aesthetics: Height, Width, Bends
- **Algorithm:** Biedl& Kant: incremental algorithm. Time Uses ear-decomposition, topological ordering. Time $O(n)$. Area $O(n^2)$.
- **Highlights:** Planar Drawing in case of Planar Embedded Graphs

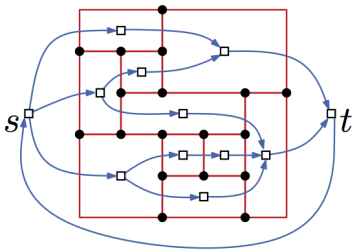


Topic 8: Degree 4 - Orthogonal Drawings - Flow

- **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. Rectlinear faces - face refinement.

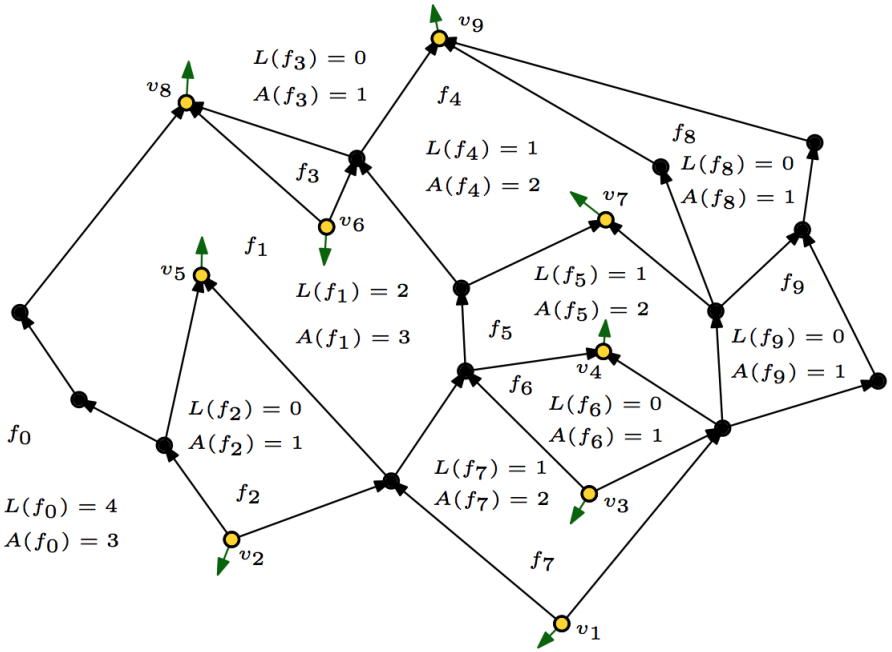


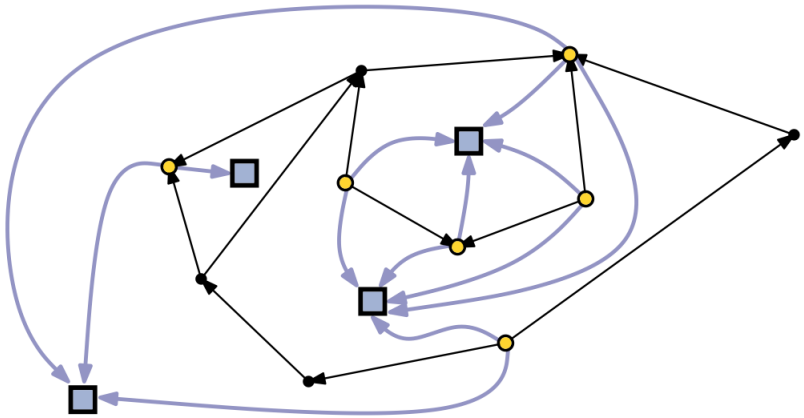




Topic 9: Upward Planarity

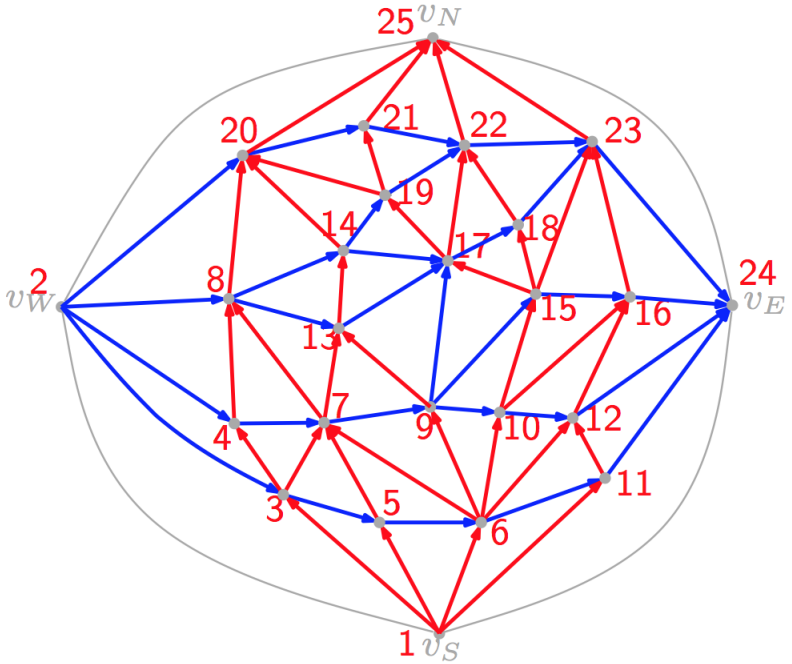
- **Conventions:** Planarity, Edges Upward
  Aesthetics: ...
- **Algorithm:** Characterization (drawing planar st-digraphs), Assignement vertices to faces, Flow Network, Face subdivition. Time $O(n^2)$.

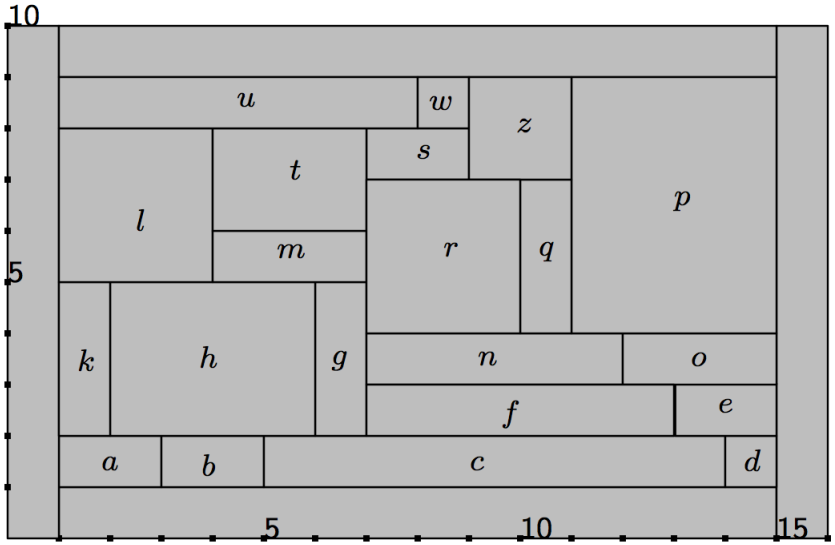




Topic 10: Contact Representations

- **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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- 1 Submission: by Sophie von Schmettow

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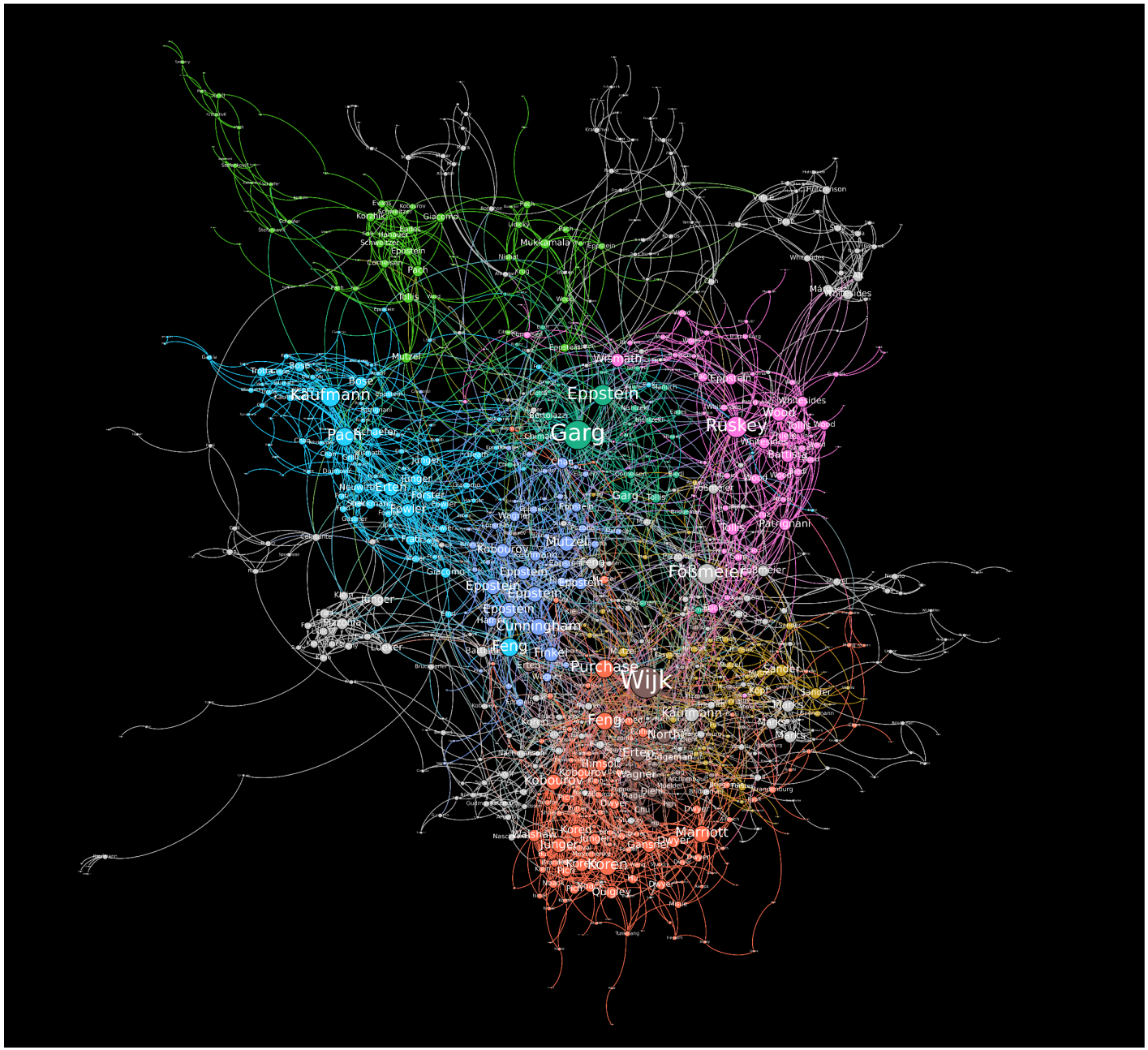

Sophie von Schmettow

Practical Course on Graph Visualization

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

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Task: develop software for a given graph visualization problem

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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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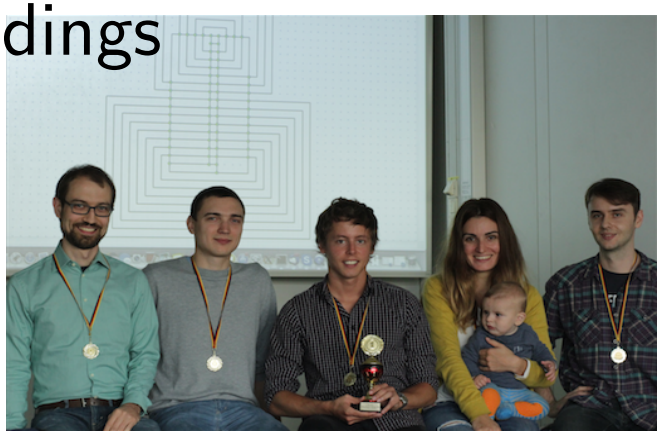
- best team won graph drawing contest

2015

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



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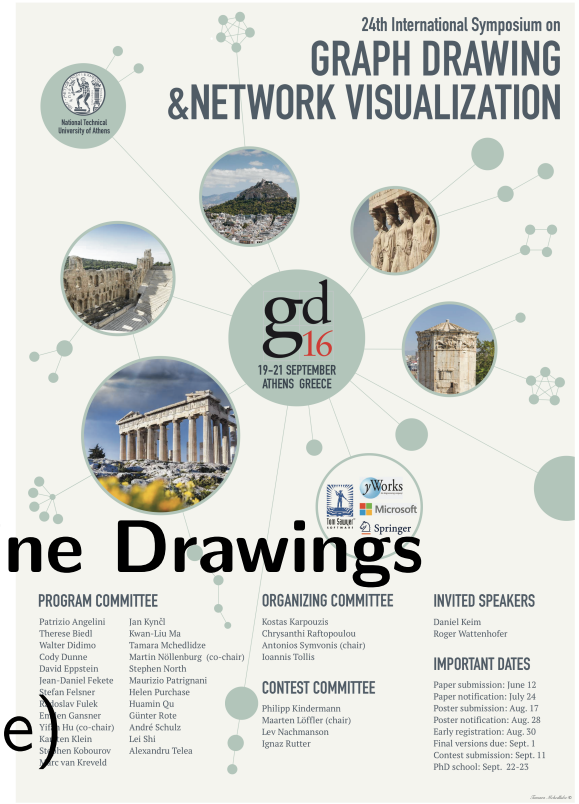


2017

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

HiWi Place

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

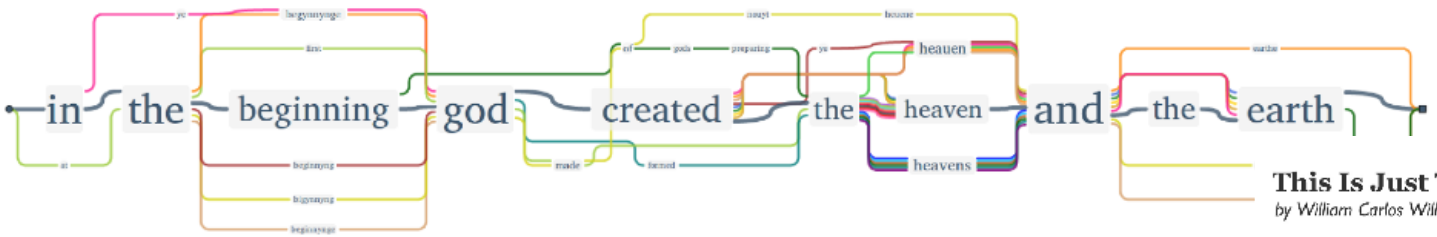
Details

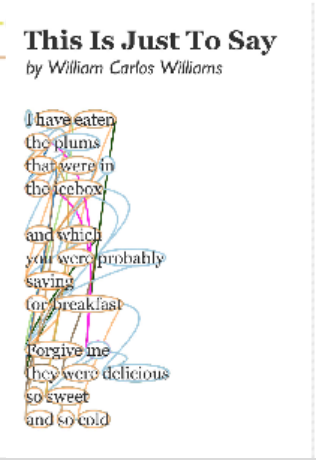
- Up to 40 hours/month
- Send your requests to me

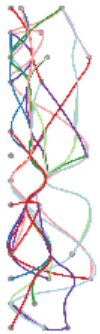
HiWi Place (Master's Thesis possible)

Topics

- Visualization of Text Variant Graphs and Sonic Topilogy 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







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