Lecture 13: Graphs/Trees

Information Visualization
CPSC 533C, Fall 2009

Tamara Munzner

UBC Computer Science

Mon, 31 October 2011

Readings Covered

Graph Visualisation in Information Visualisation: a Survey. Ivan Herman, Guy Melancon, M. Scott Marshall. IEEE Transactions on Visualization and Computer Graphics, 6(1):24-44, 2000.

Online Dynamic Graph Drawing. Yaniv Frishman and Ayellet Tal. Proc EuroVis 2007, p 75-82.

Topological Fisheye Views for Visualizing Large Graphs. Emden Gansner, Yehuda Koren and Stephen North, IEEE TVCG 11(4), p 457-468, 2005.

Further Readings

Animated Exploration of Graphs with Radial Layout. Ka-Ping Yee, Danyel Fisher, Rachna Dhamija, and Marti Hearst, Proc InfoVis 2001, p 43-50.

Cushion Treemaps. Jarke J. van Wijk and Huub van de Wetering, Proc InfoVis 1999, pp 73-78.

Interactive Information Visualization of a Million Items. Jean-Daniel Fekete and Catherine Plaisant, Proc InfoVis 2002, p 117-124.

GrouseFlocks: Steerable Exploration of Graph Hierarchy Space. Daniel Archambault, Tamara Munzner, and David Auber. IEEE Trans. Visualization and Computer Graphics 14(4):900-913 2008.

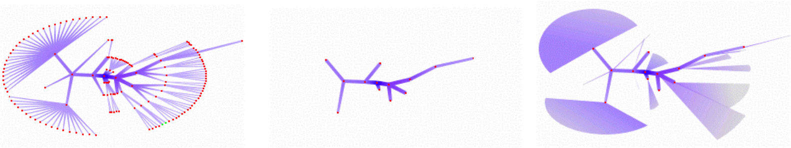
Multiscale Visualization of Small World Networks. David Auber, Yves Chiricota, Fabien Jourdan, Guy Melancon, Proc. InfoVis 2003, p 75-81.

Visual Exploration of Multivariate Graphs. Martin Wattenberg, Proc. CHI 2006, p 811-819.

Hermann Survey

- true survey, won't try to summarize here!

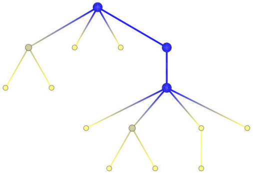
- nice abstraction work by authors themselves
  - derived data: skeletonization via Strahler numbers
  - encoding techniques:
    - ghosting = layering
    - hiding = elision
    - grouping = aggregation



[Fig 22. Herman, Melancon, and Marshall. Graph Visualisation in Information Visualisation: a Survey. IEEE Transactions on Visualization and Computer Graphics, 6(1), pp. 24-44, 2000]

Trees: Basic Node-Link Drawings

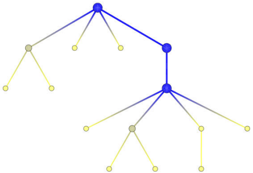
- task/data abstraction
  - understanding detailed topological structure of tree
- visual encoding: layered node-link view
  - vertical position: distance from root node in hops
  - horizontal position: (as much symmetry as possible)



[http://gravite.labri.fr/?Want_to_work_with_us_?:Hiring_puzzles:Tidy_Tree_Layouts]

Trees: Basic Node-Link Drawings

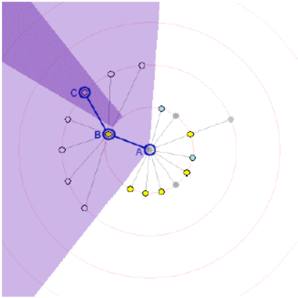
- algorithm level:
  - Wetherell and Shannon 1978, Tidy Drawings of Trees
  - Reingold and Tilford 1981, Tidier Drawing of Trees
  - Walker 1990, A Node-positioning Algorithm for General Trees
  - Buchheim et al 2002, Improving Walker's Algorithm to Run in Linear Time

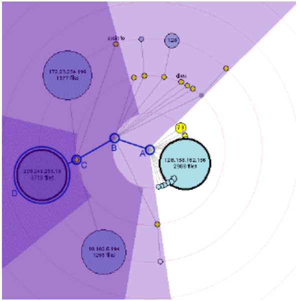


[http://gravite.labri.fr/?Want_to_work_with_us_

Trees: Radial Node-Link Drawings

- data abstraction: data stream, not static file
- encoding technique: radial not rectilinear layout
- interaction technique: animated transitions from old to new layout

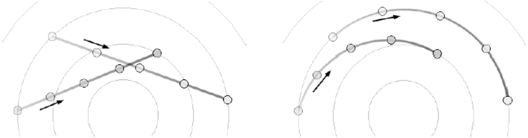




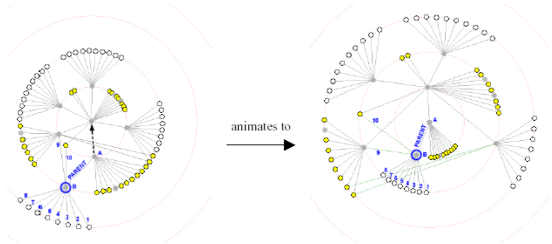
[Figs 3, 5. Yee et al. Animated Exploration of Graphs with Radial Layout. Proc InfoVis 2001.]

Trees: Radial Node-Link Drawings

- animation requirements identified:
  - avoid center collapse/clutter by interpolate polar not rectilinear



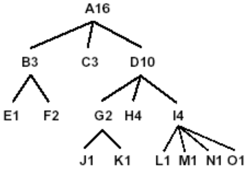
- maintain neighbor order to stabilize (note prefuse bug!)



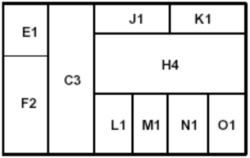
[Fig 2. Yee et al. Animated Exploration of Graphs with Radial Layout. Proc InfoVis 2001.]

Trees: Treemaps

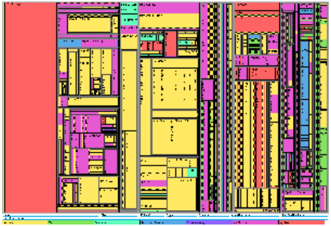
- data abstraction: tree nodes have attributes
- task abstraction: emphasize node attribs, not topological structure
- visual encoding: use containment not connection



Node and link diagram



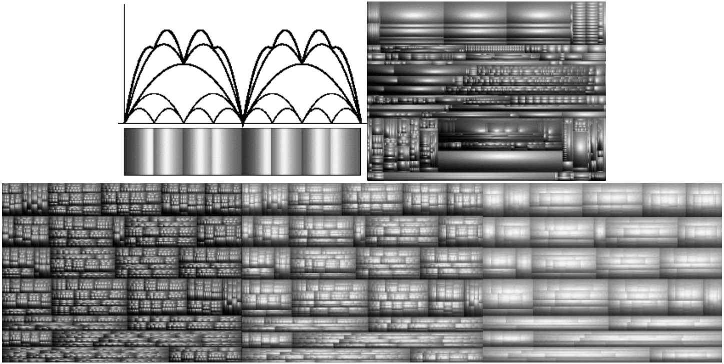
Treemap



[Fig 1. van Wijk and van de Wetering. Cushion Treemaps. Proc InfoVis 1999, pp 73-78.]
[http://www.cs.umd.edu/hcil/treemap-history/treeviz_colorful_scaled.gif]

Cushion Treemaps

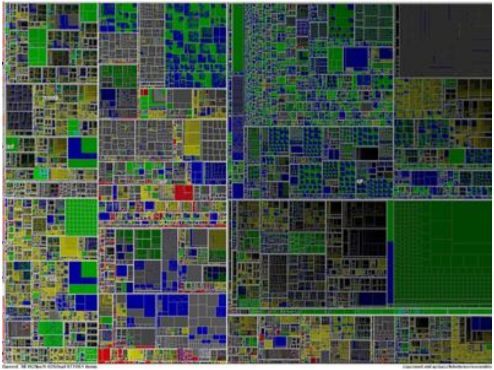
- visual encoding: also show nesting/topo structure more clearly with shading cues
- interaction: scale parameter controls global vs. local



[Figs 4, 5, 6. van Wijk and van de Wetering. Cushion Treemaps. Proc InfoVis 1999, pp 73-78.]

Scaling Up Treemaps: MillionVis

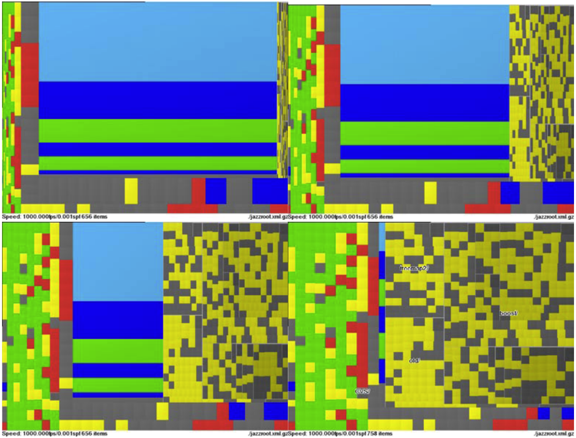
- visual encoding: treemaps, scatterplots
    - darkness shows nesting level
- algorithm: many GPU tricks for speed
    - dynamic queries through Z buffering



[Fig 1. Fekete and Plaisant. Interactive Information Visualization of a Million Items. Proc InfoVis 2002, p 117-124.]

Scaling Up Treemaps: MillionVis

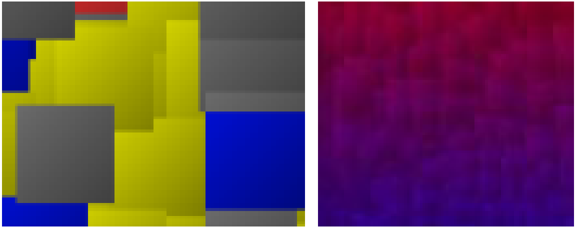
- interaction: animated transitions
  - visenc requirement: stable layout



[Fig 4a. Fekete and Plaisant. Interactive Information Visualization of a Million Items. Proc InfoVis 2002, p 117-124.]

Scaling Up Treemaps: MillionVis

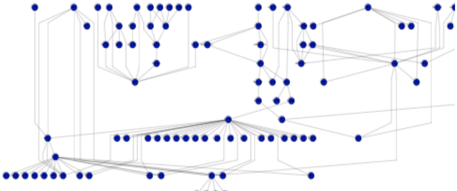
- scalability requires care at visual encoding level
  - not just algorithm level!
  - to visually distinguish with fewer pixels, use shading not outline



[Fig 2. Fekete and Plaisant. Interactive Information Visualization of a Million Items. Proc InfoVis 2002, p 117-124.]

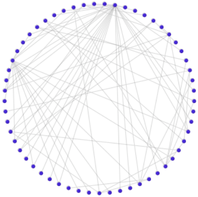
Graphs: Hierarchical Layout

- visual encoding
  - vertical position: distance from root
  - does *not* mean using containment
- algorithms
  - Sugiyama et al 1983, Methods for Visual Understanding of Hierarchical System Structures
  - Gansner et al 1993, A Technique For Drawing Directed Graphs
  - Eiglsperger et al 2005, An efficient implementation of Sugiyama's algorithm for layered graph drawing



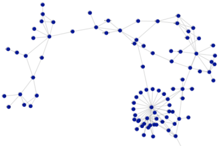
Graphs: Circular Layout

- visual encoding
  - nodes on circle
  - edge crossings minimized
  - algorithms
    - Six and Tollis 1999, A Framework for Circular Drawings of Networks



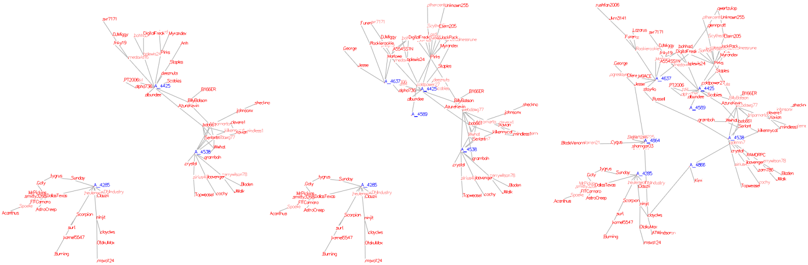
Graphs: Force-Directed Placement

- visual encoding
    - nondeterministic placement
- algorithm
    - spring forces pull together edges, repulsive forces pull apart nodes
    - optimization framework easy to extend, but tends to be brittle
- algorithms
    - Fruchterman and Reingold, 1991, Graph Drawing By Force-Directed Placement
    - Kamada and Kawai, 1989, An Algorithm For Drawing General Undirected Graphs



Online Dynamic Graph Drawing

- data abstraction: streaming data not static file
- task abstraction: dynamic stability (tradeoff)
  - minimize visual changes
  - stay true to current dataset structure



[Fig 1. Frishman and Tal. Online Dynamic Graph Drawing. Proc EuroVis 2007, p 75-82.]

Online Dynamic GD: Algorithm

- static graph layout algs unstable
  - small changes in input can have large changes in output
  - randomness, no constraints on maintaining geometric proximity
- dynamic online algorithm
  - first step: initialize, layout
  - later steps: merge, pin, layout, animate
  - acceleration: partition before GPU force-directed layout

Online Dynamic GD: Validation

- algorithm level
  - complexity analysis
  - benchmarks: running time for CPU and GPU versions
- visual encoding level
  - qualitative discussion of result images/video
  - quantitative metrics:
    - pairwise avg node displacement for stability
    - potential energy for quality
    - compare static, full dynamic, dynamic without pinning

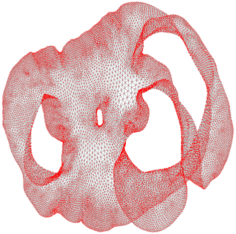
Critique

Critique

- strengths
  - strong algorithmic contribution
    - previous work not scalable
  - very good validation, matches technique contribution
  - best paper award, EuroVis 2007

Critique

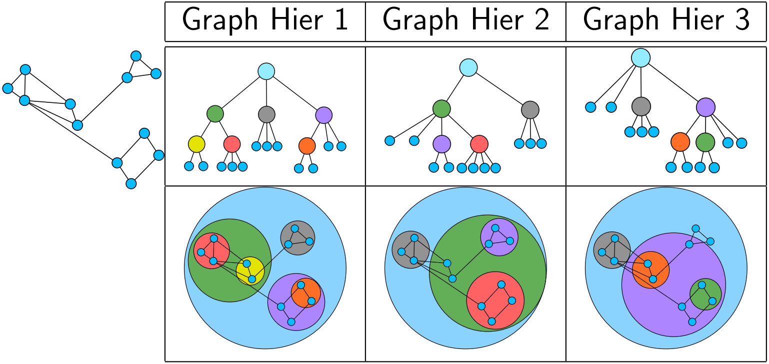
- strengths
  - strong algorithmic contribution
    - previous work not scalable
  - very good validation, matches technique contribution
  - best paper award, EuroVis 2007
- weaknesses
  - using mesh datasets to test graph drawing claims
    - different topological characteristics than typical infovis case



[Fig 3a. Frishman and Tal. Online Dynamic Graph Drawing. Proc EuroVis 2007, p 75-82.]

Multi-level Graphs

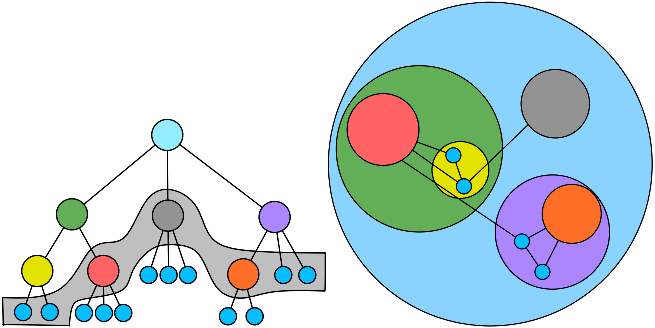
- data abstraction: create cluster hierarchy on top of original graph (coarsening)



[Fig 3. Archambault et al. GrouseFlocks: Steerable Exploration of Graph Hierarchy Space. IEEE Trans. Visualization and Computer Graphics 14(4):900-913 2008.]

Multi-level Graphs: GrouseFlocks

- visual encoding: containment
- interaction: expand/contract metanodes to change graph cut



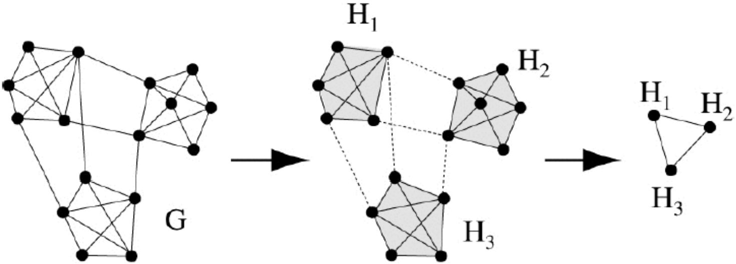
[Fig 2. Archambault et al. GrouseFlocks: Steerable Exploration of Graph Hierarchy Space. IEEE Trans. Visualization and Computer Graphics 14(4):900-913 2008.]

Small-World Networks

- high clustering, small path length
  - vs. random uniform distribution
- examples
  - social networks, movie actors, Web, ...
- multiscale small-world networks
  - exploit these properties for better layout

Small World Coarsening

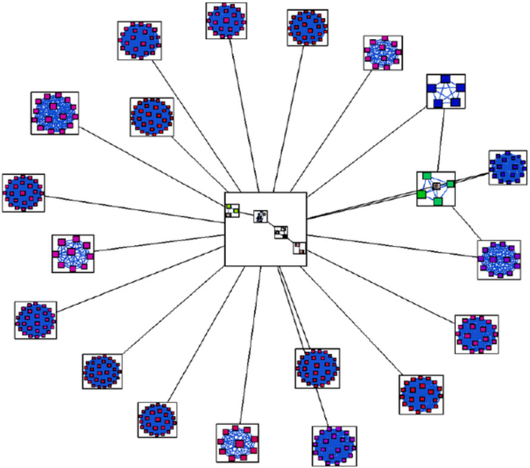
- remove low-strength edges
- maximal disconnected subgraphs
- quotient graph: subgraph = higher-level node



[Fig 2. Auber et al. Multiscale Visualization of Small World Networks. Proc. InfoVis 2003, p 75-81.]

Small World: Nested Quotient Graphs

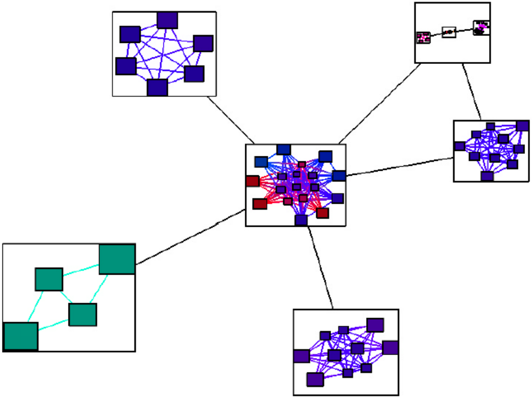
- visual encoding
  - containment: subgraph laid out within metanode



[Fig 3. Auber et al. Multiscale Visualization of Small World Networks. Proc. InfoVis 2003, p.75-81.]

Small World: Nested Quotient Graphs

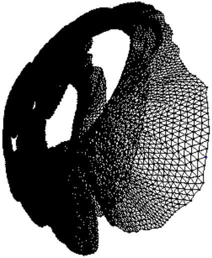
- pro: very evocative of structure
- con: does not scale past 2-3 levels of depth



[Fig 5. Auber et al. Multiscale Visualization of Small World Networks. Proc. InfoVis 2003, p 75-81.]

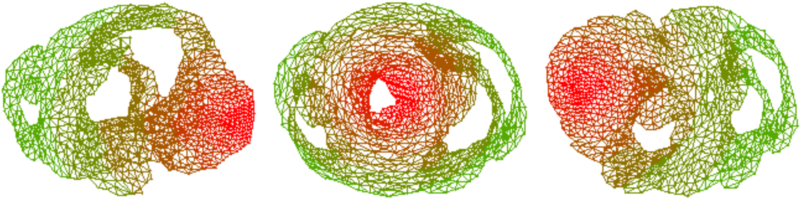
Topological Fisheye Views

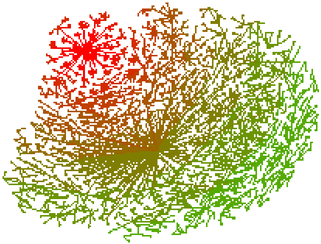
- data abstraction
  - input is laid-out graph
  - construct multilevel hierarchy by coarsening graphs
- interaction: user controls focus point
- visual encoding: show hybrid view made from cut through several levels



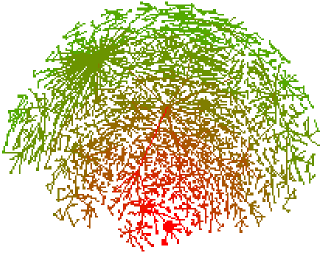
[Fig 2. Gansner, Koren, and North, Topological Fisheye Views for Visualizing Large Graphs. IEEE TVCG 11(4), p 457-468, 2005.]

Topological Fisheye Views





focus on a top-left portion

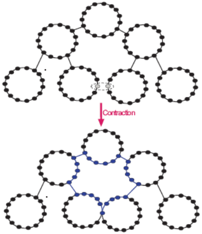


focus on a bottom portion

[Fig 4,7. Gansner, Koren, and North, Topological Fisheye Views for Visualizing Large Graphs. IEEE TVCG 11(4), p 457-468, 2005.]

Topo Fisheye: Coarsening Strategy

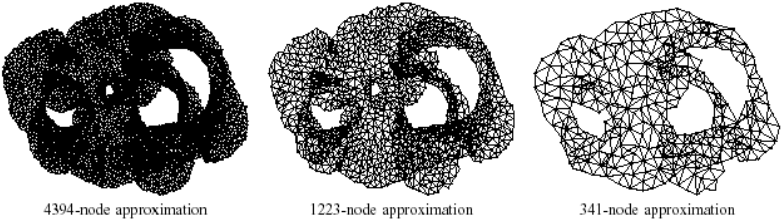
- must preserve graph-theoretic properties
  - topological distance (hops away), cycles
  - cannot just use geometric proximity alone
  - cannot just contract nodes/edges
  - exploit geometric information with proximity graph



[Fig 2. Gansner, Koren, and North, Topological Fisheye Views for Visualizing Large Graphs. IEEE TVCG 11(4), p 457-468, 2005.]

Topo Fisheye: Coarsening Requirements

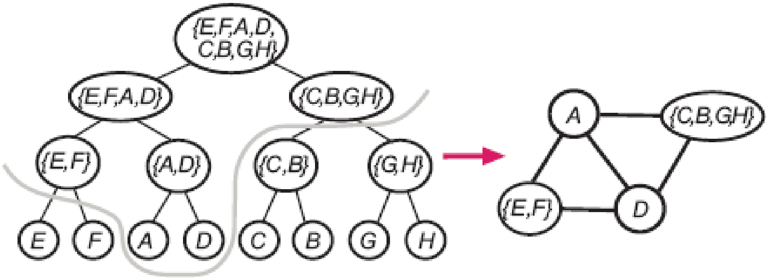
- uniform cluster/metanode size
- match coarse and fine layout geometries
- scalable



[Fig 10. Gansner, Koren, and North, Topological Fisheye Views for Visualizing Large Graphs. IEEE TVCG 11(4), p 457-468, 2005.]

Topo Fisheye: Hybrid Graph

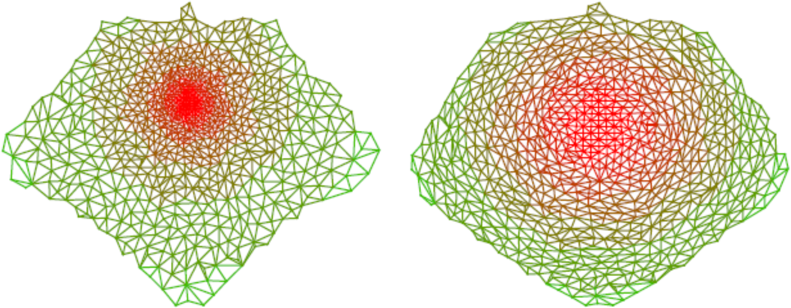
- find active nodes



[Fig 14. Gansner, Koren, and North, Topological Fisheye Views for Visualizing Large Graphs. IEEE TVCG 11(4), p 457-468, 2005.]

Topo Fisheye: Distort For Uniform Density

- visual encoding
  - geometric distortion for uniform density
  - (colorcoded by depth in hierarchy to illustrate algorithm)



(b) default layout of hybrid graph (c) distorted layout of hybrid graph

[Fig 15. Gansner, Koren, and North, Topological Fisheye Views for Visualizing Large Graphs. IEEE TVCG 11(4), p 457-468, 2005.]

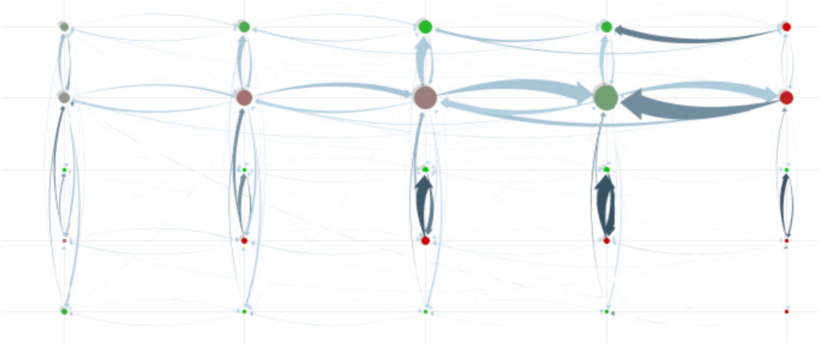
Critique

Critique

- strengths
  - topologically sophisticated, not just geometric distortion
  - rigorous approach
- weaknesses (shared by many approaches)
  - what if mental model does not match coarsening strategy?
  - again, meshes for evaluating infovis claims

PivotGraph

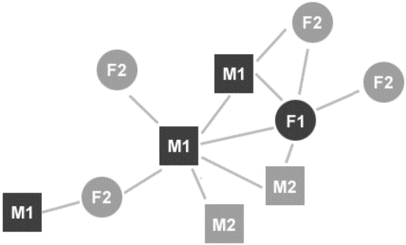
- task abstraction: show relationship between node attributes and connections in multiattribute graph
- data abstraction: rollup and selection transformations



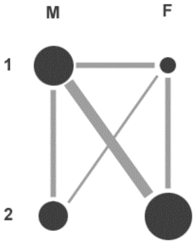
[Fig 1. Wattenberg. Visual Exploration of Multivariate Graphs. Proc. CHI 2006, p 811-819.]

PivotGraph

- visual encoding: line (1D) or grid (2D), area proportional to attribute
  - grid nodes based on attribute count, not original graph node count!
  - scalability through abstraction, not layout algorithms



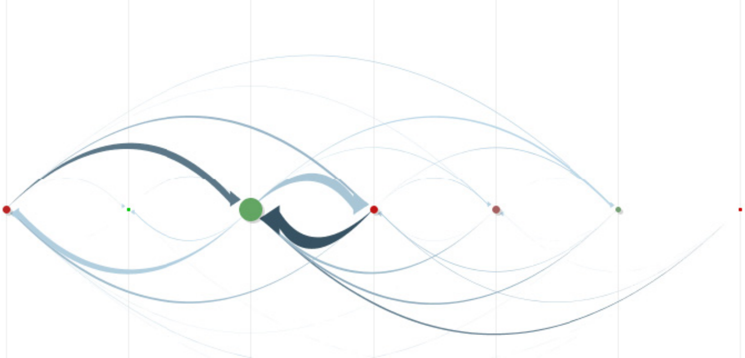
Node and Link Diagram



PivotGraph Roll-up

PivotGraph

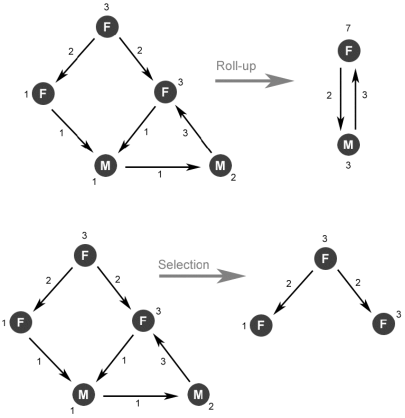
- visual encoding: line for 1D rollup, or grid for 2D case



[Fig 6. Wattenberg. Visual Exploration of Multivariate Graphs. Proc. CHI 2006, p 811-819.]

PivotGraph

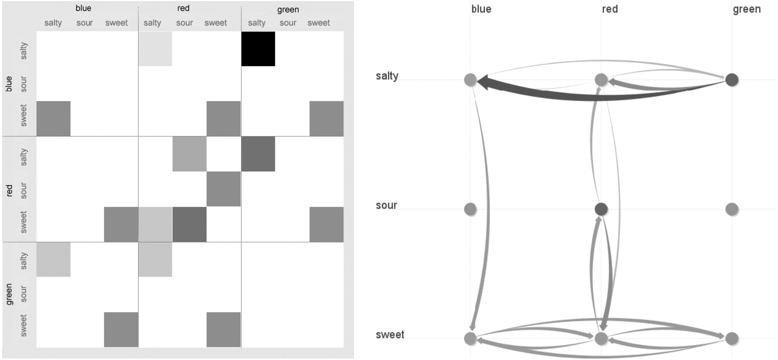
- interaction: changing rollup/selection choices, animated transitions between states



[Fig 2,3. Wattenberg. Visual Exploration of Multivariate Graphs. Proc. CHI 2006, p 811-819.]

PivotGraph

- in general, more compact than matrix view



[Fig 7,8. Wattenberg. Visual Exploration of Multivariate Graphs. Proc. CHI 2006, p 811-819.]

Presentation Topics

- see course page for your day/topic
- seed papers coming soon for Wed Nov 9 folks