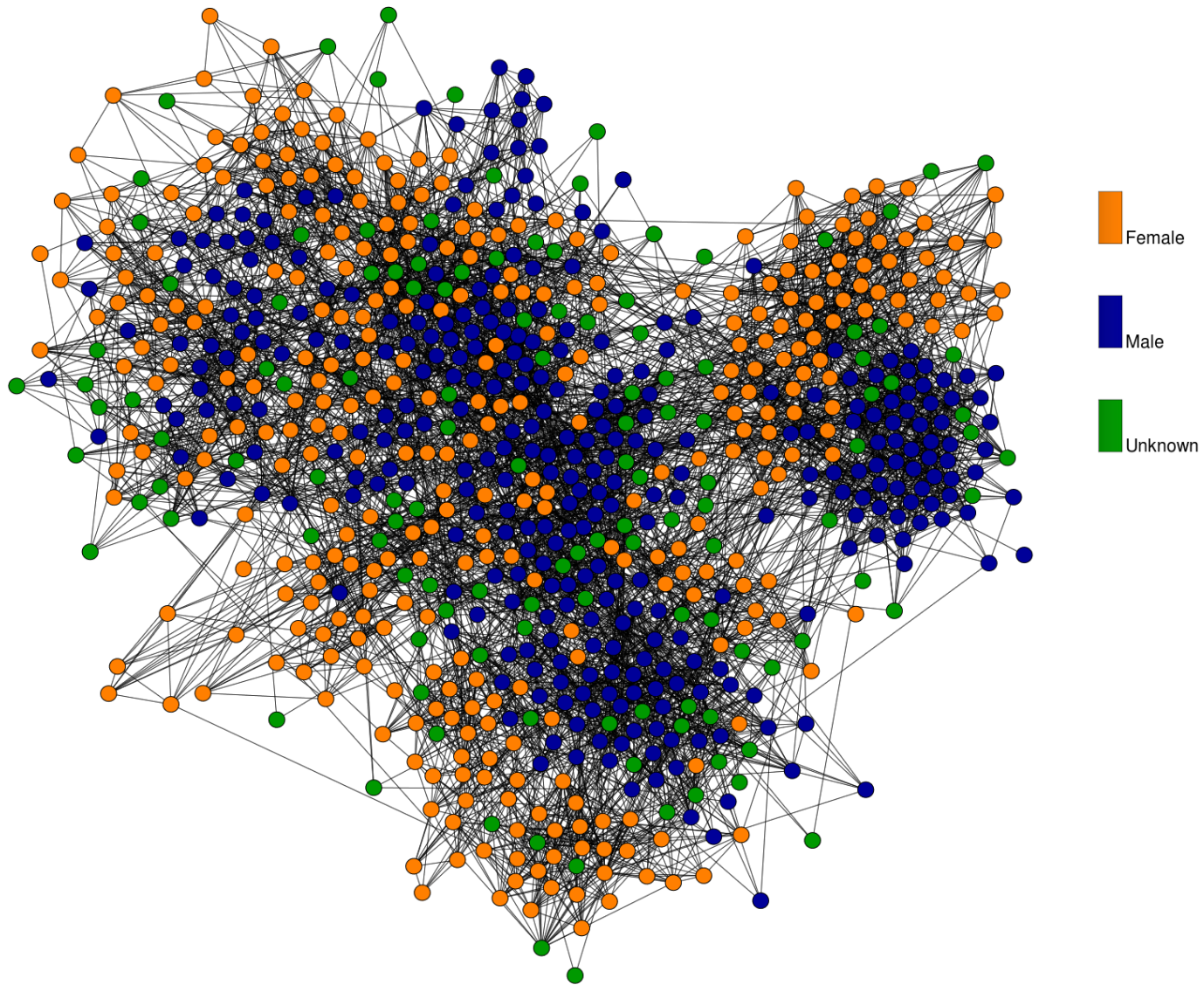
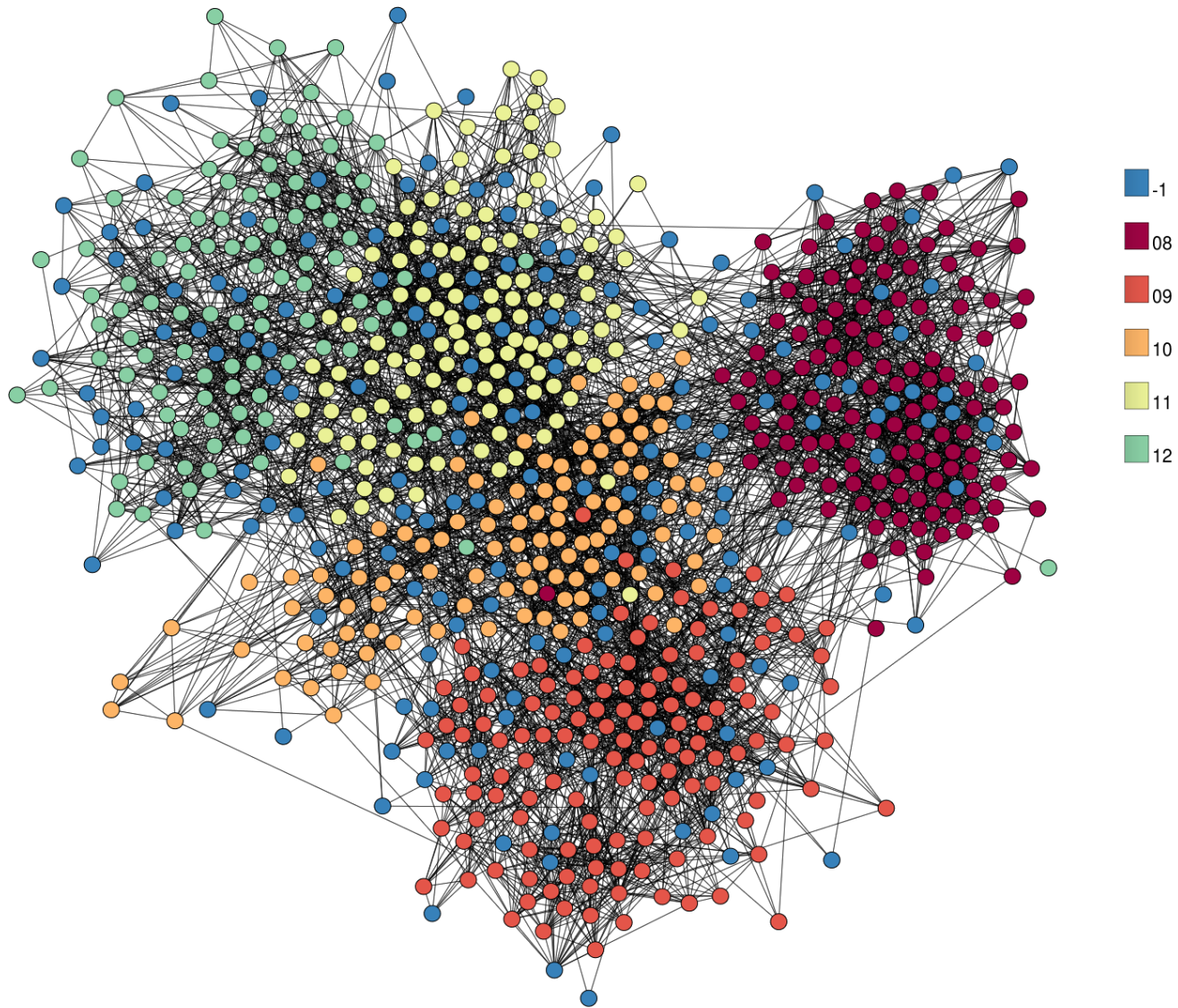


Graph Layouts

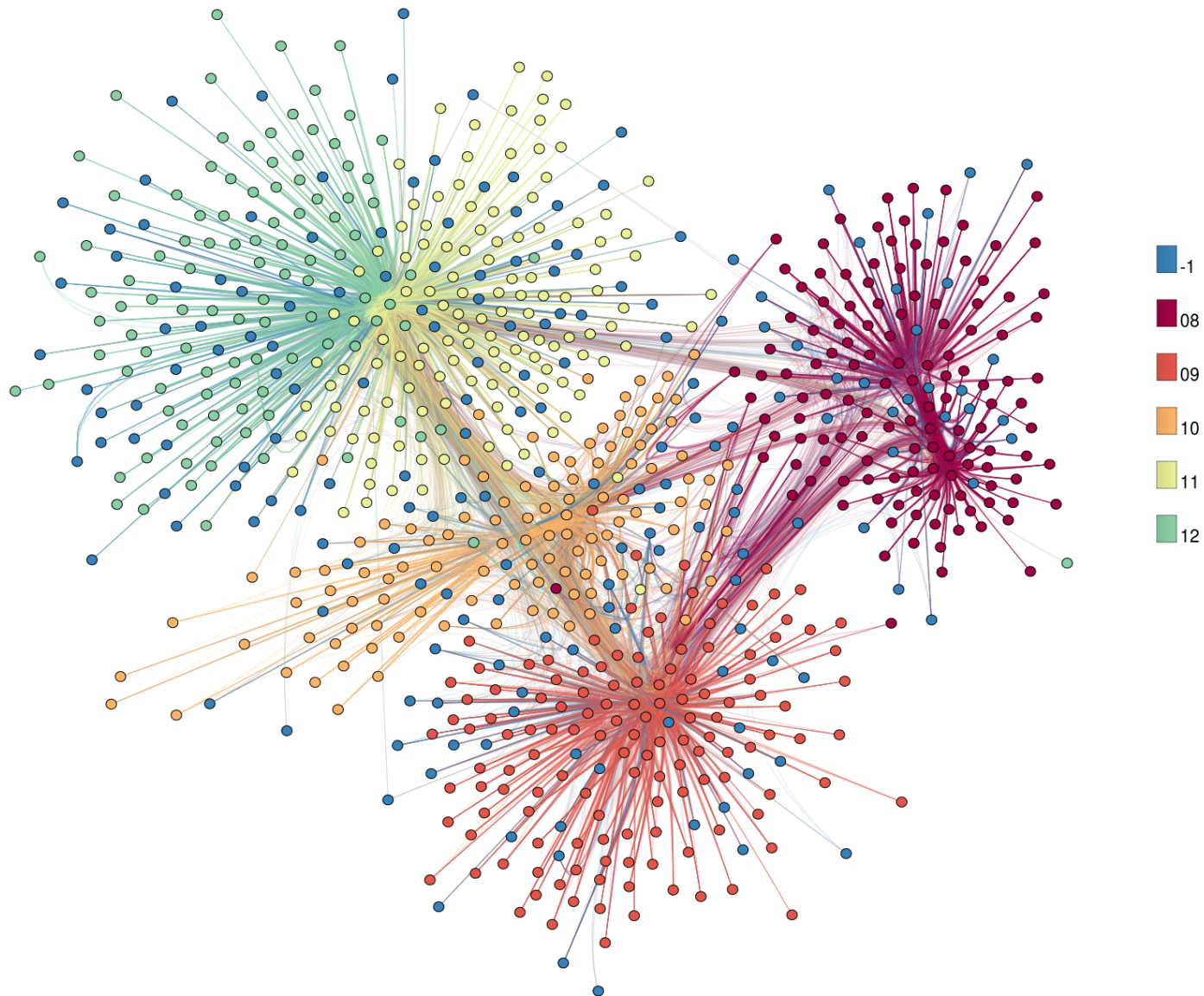
MOTIVATION



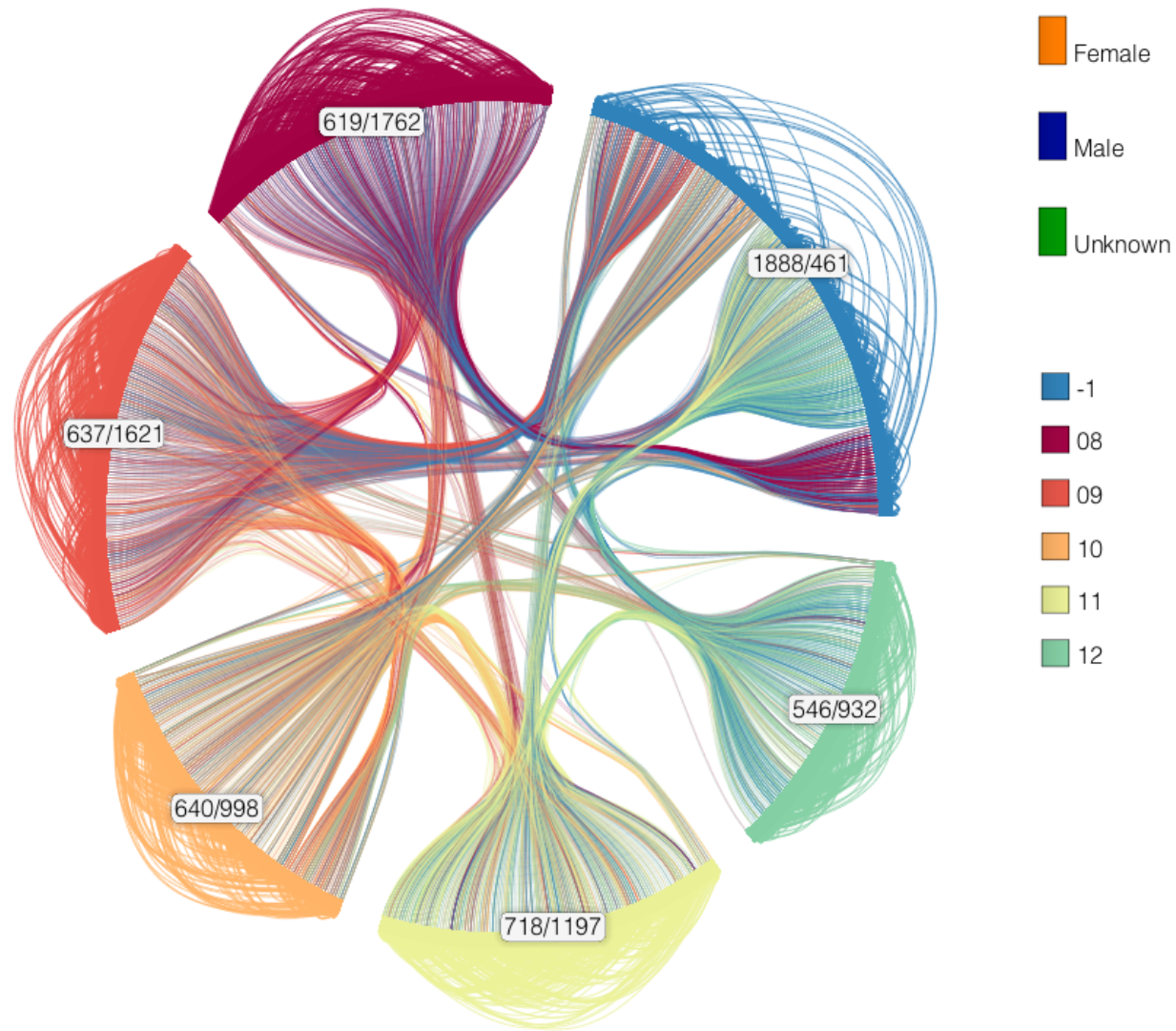
<http://vidi.cs.ucdavis.edu/projects/AggressionNetworks/>



<http://vidi.cs.ucdavis.edu/projects/AggressionNetworks/>



<http://vidi.cs.ucdavis.edu/projects/AggressionNetworks/>

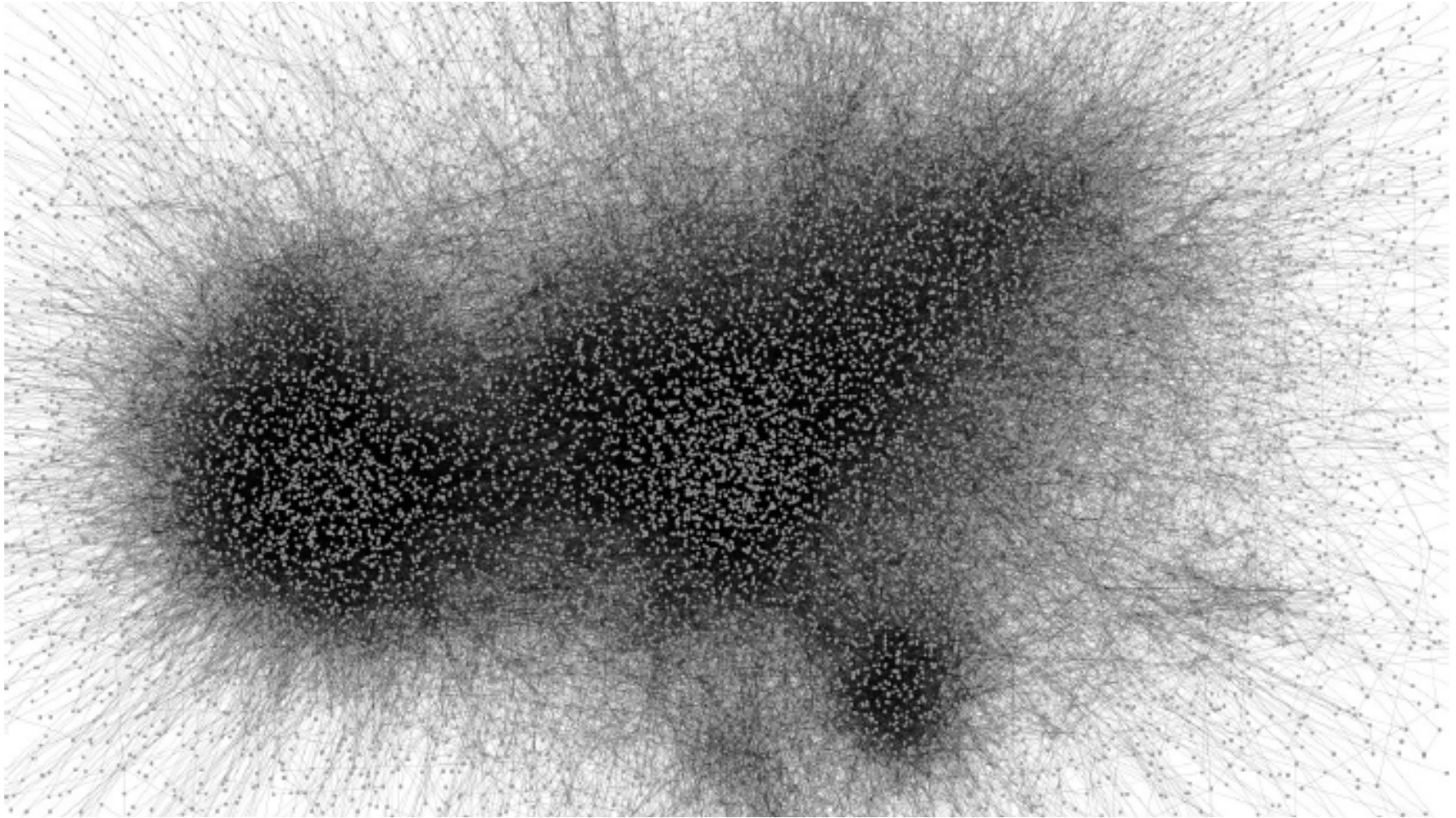


<http://vidi.cs.ucdavis.edu/projects/AggressionNetworks/>

CONSIDERATIONS

What considerations should we make when visualizing graphs?

Hairballs



<http://www.michelecoscia.com/?p=171>

Hairballs



<http://www.nytimes.com/imagepages/2008/11/20/science/20mammoth.ready.html>

Considerations

- Node Layout
 - Place randomly?
 - Place on grid?
 - Place by metric?
 - Place using physics?
- Node Attributes
 - Color?
 - Size?
 - Shape?
- Edge Layout
 - Straight edges?
 - Curved edges?
 - Edge crossings?
 - Edge bundling?
- Edge Attributes
 - Color?
 - Width?
 - Arrows?

Considerations

- Non overlapping nodes?
- Visible labels?
- Minimize edge crossings?
- Minimize distance between nodes?
- View overall structure?
- View connections and connectivity?
- View detailed subgraphs?

MATRIX DIAGRAMS

Matrix Diagrams

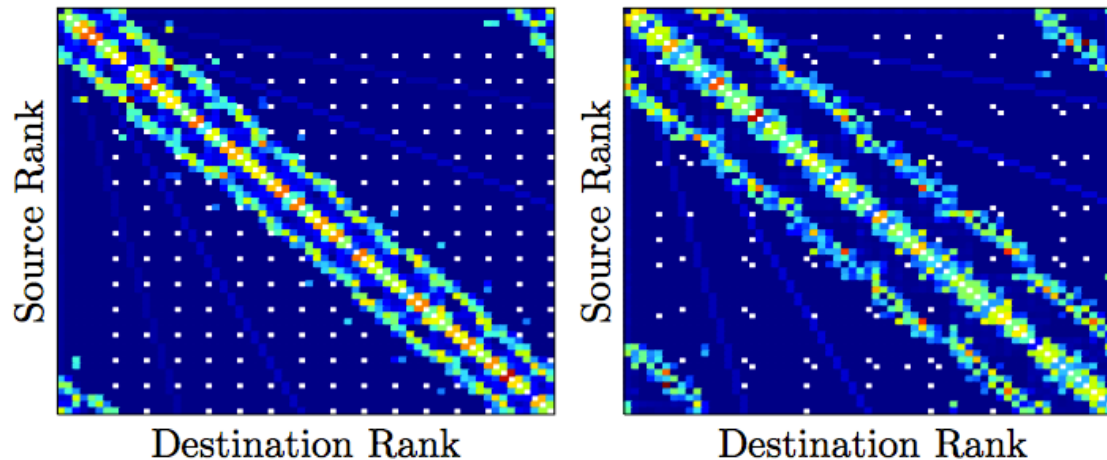
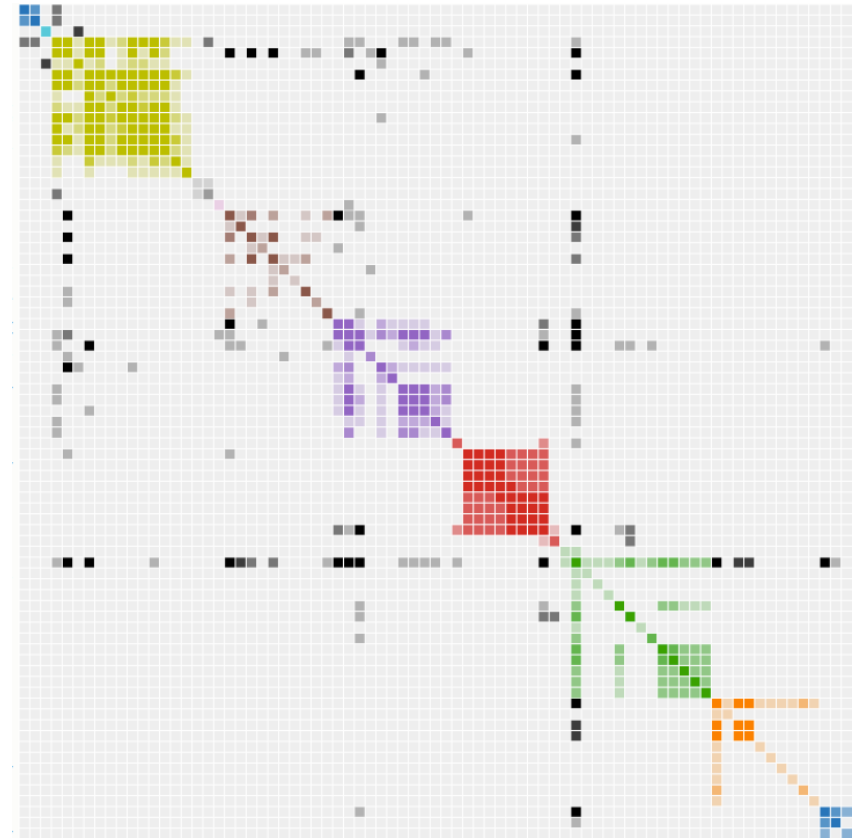
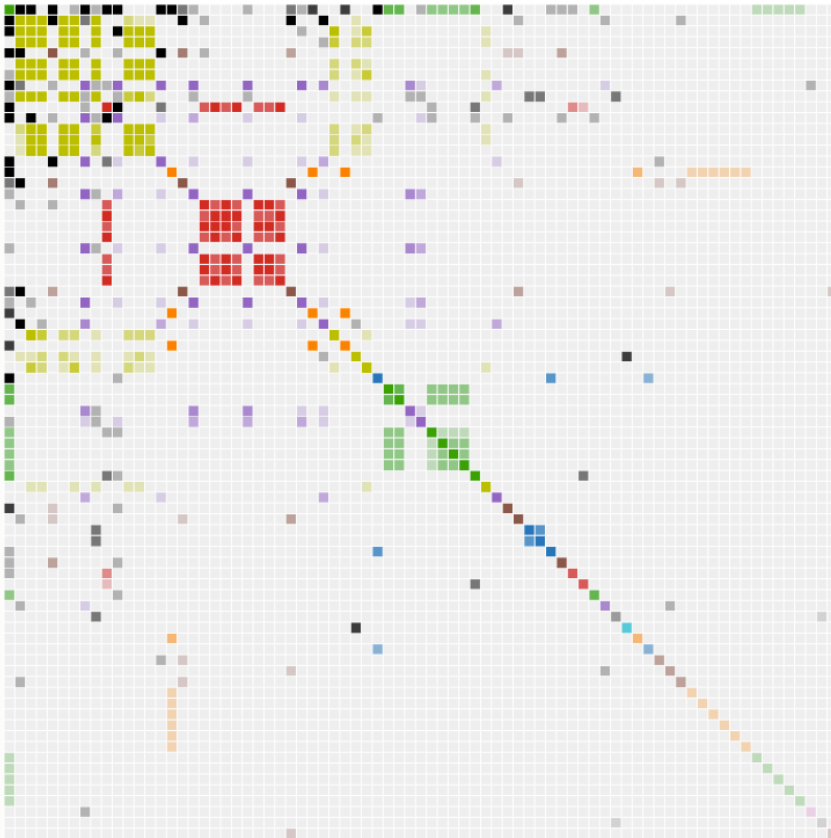


Figure 3: Data dependent topology demonstrated by molecular dynamics simulator NAMD under different molecular arrangements. The number of bytes sent between ranks is linearly mapped from dark blue (lowest) to red (highest), with white indicating an absence of communication.

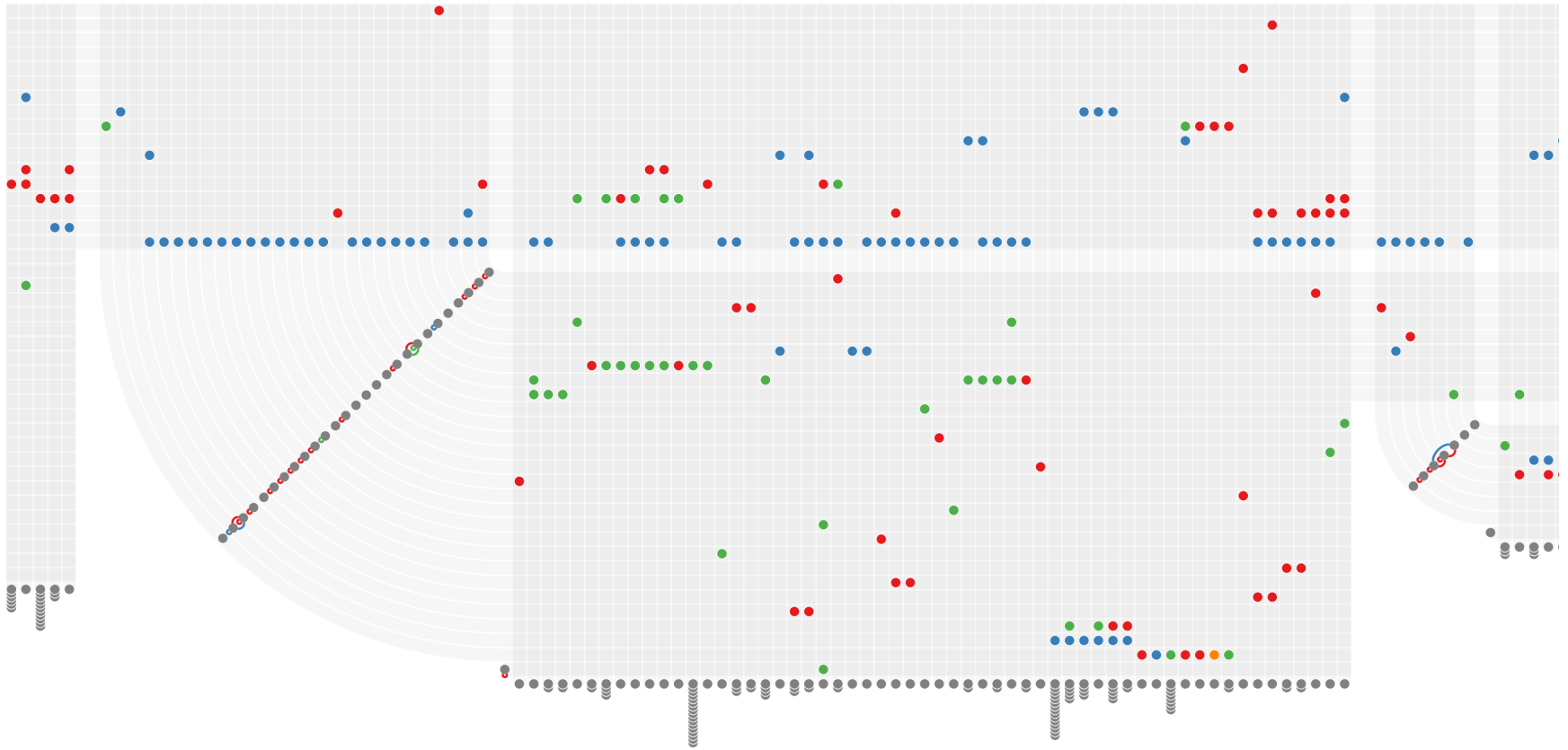
<http://node99.org/papers/ntc-journal.pdf>

Les Misérables Co-Occurrence



<http://bost.ocks.org/mike/miserables/>

Compressed Adjacency Matrix



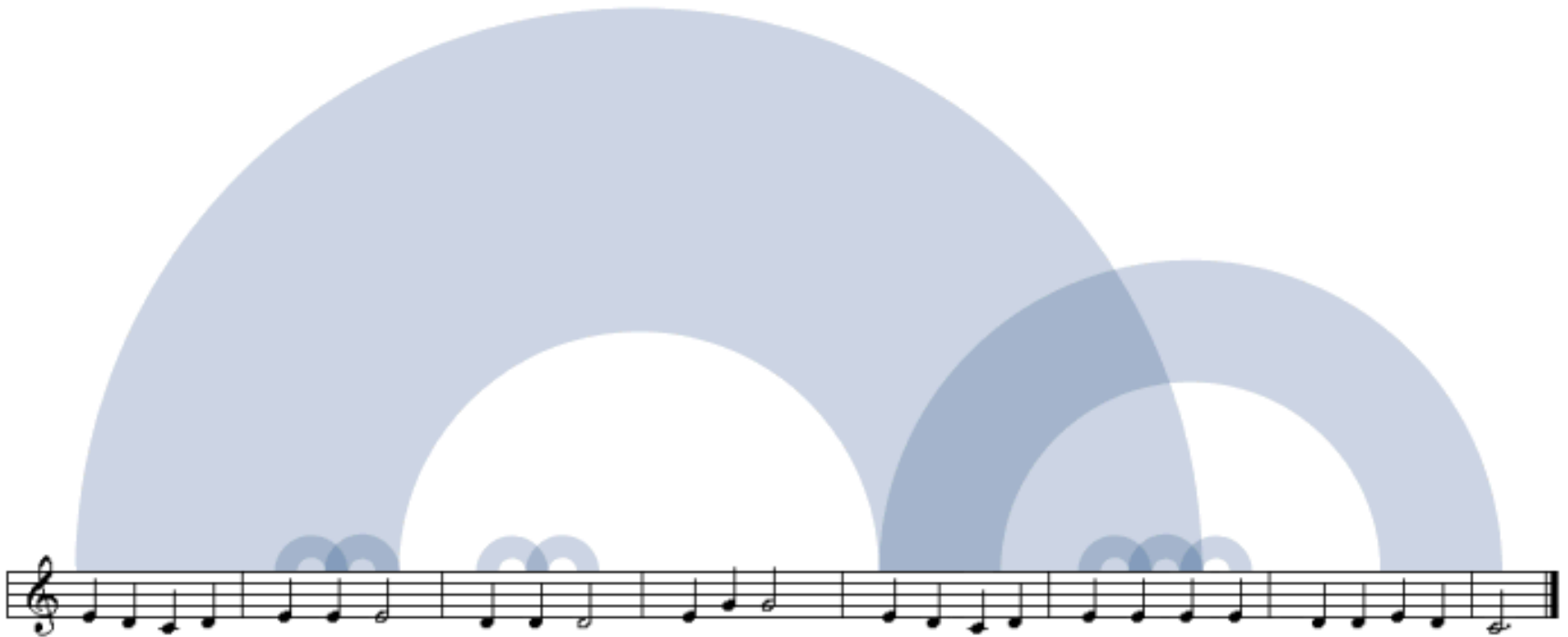
<http://www.computer.org/csdl/trans/tg/2012/12/ttg2012122457-abs.html>

NODE LAYOUT

Common Graph Layouts

- Arc Diagrams
- Circle Layout
- Spring and Force-Directed Layouts
- Self-Organizing Map Layout
- Fruchterman Reingold Layout
- Kamada Kawai Layout
- Hive Plots
- Multi-Level Layouts

Arc Diagram

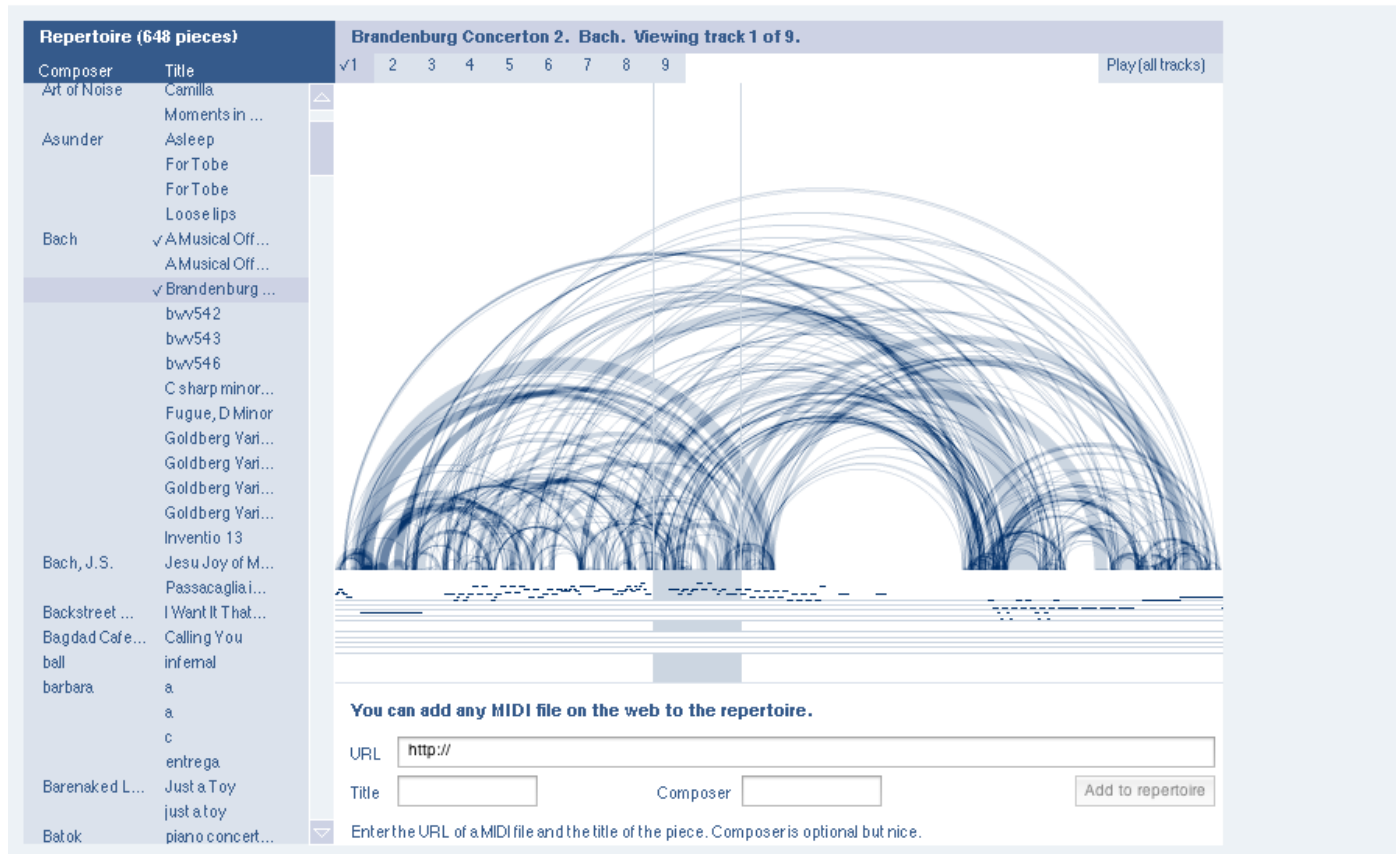


<http://www.turbulence.org/Works/song/method/method.html>

Arc Diagram

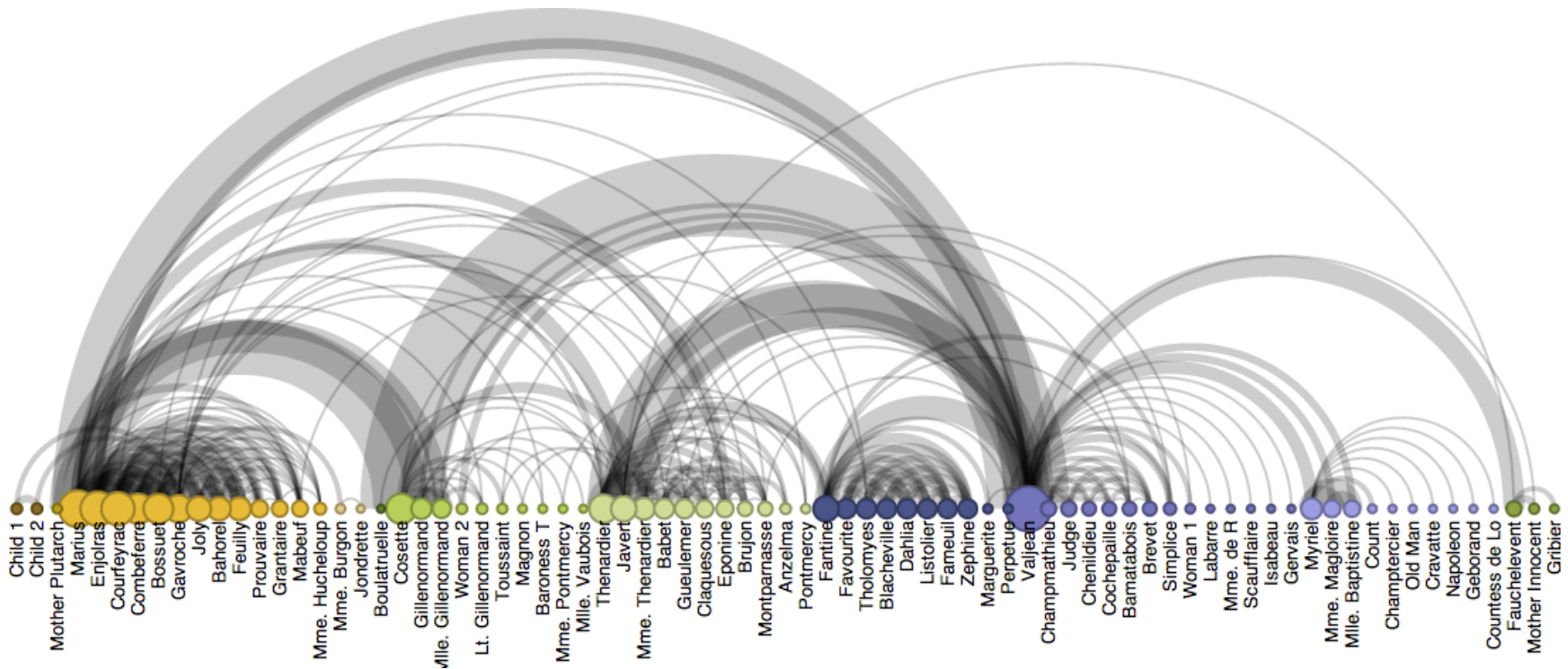
THE SHAPE OF SONG

[What the diagrams mean](#) | [Image gallery](#) | [Home](#) | [Contact](#)



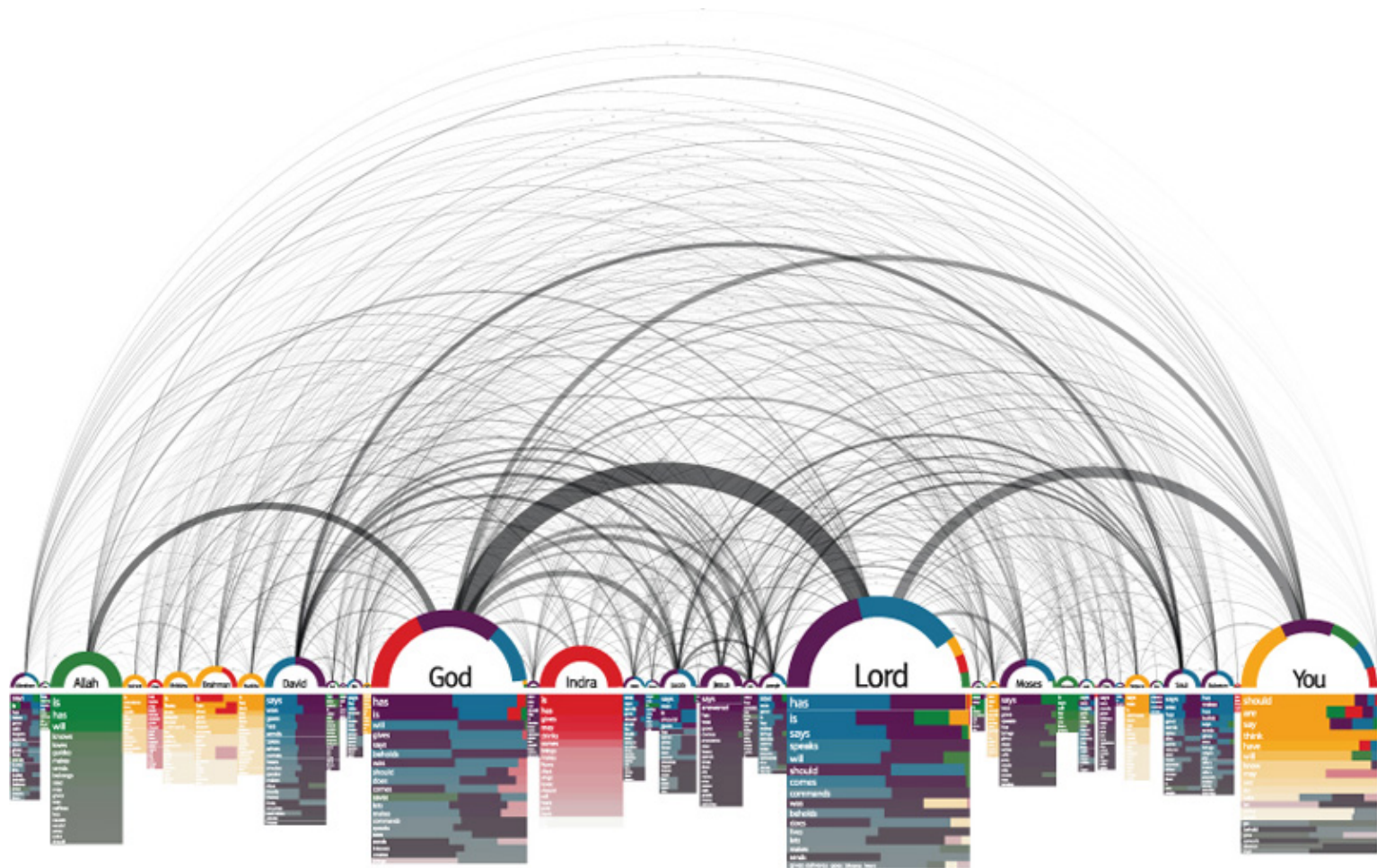
<http://www.turbulence.org/Works/song/mono.html>

Arc Diagram in Protovis



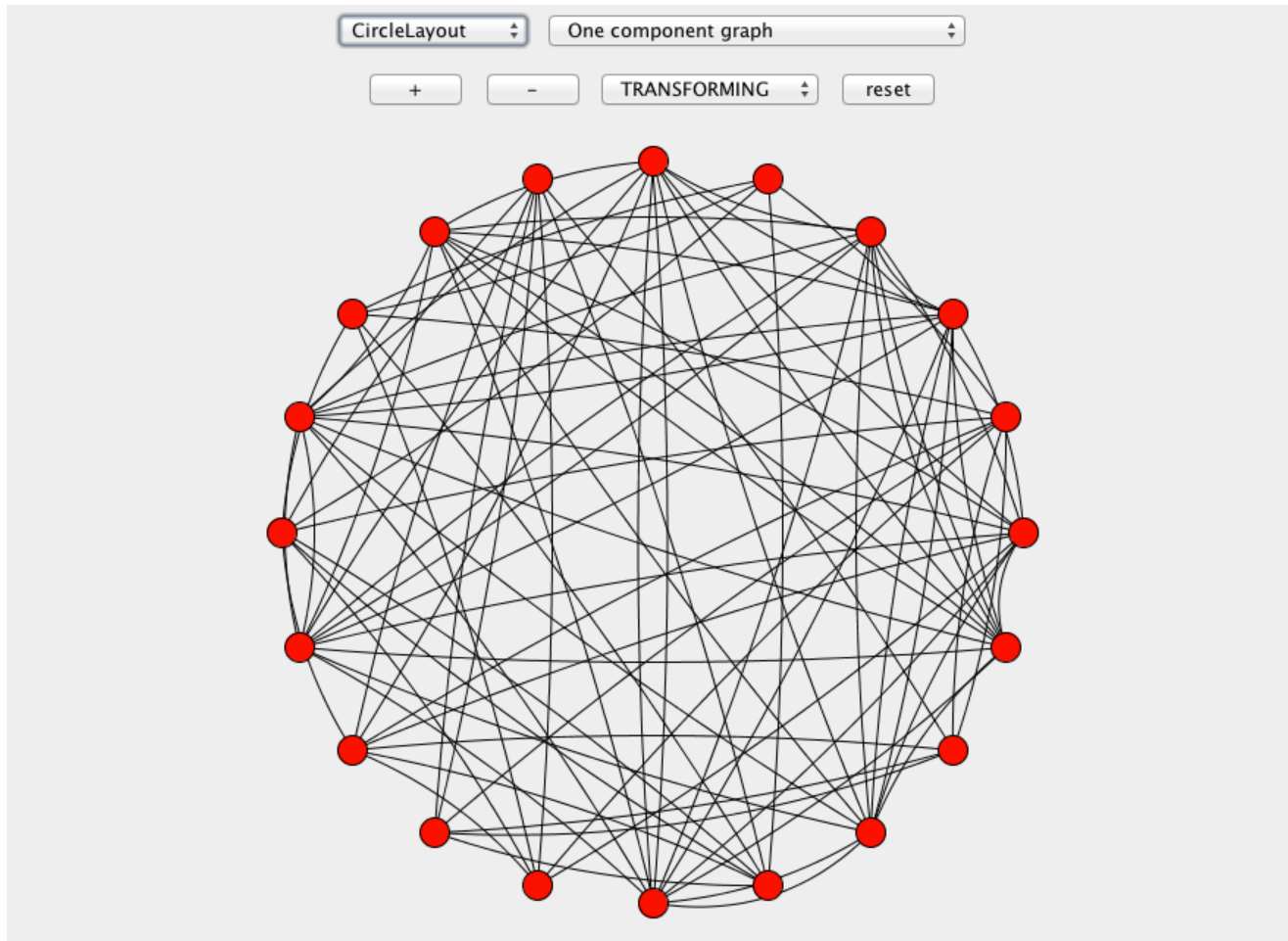
<http://mbostock.github.io/protovis/ex/arc.html>

Similar Diversity



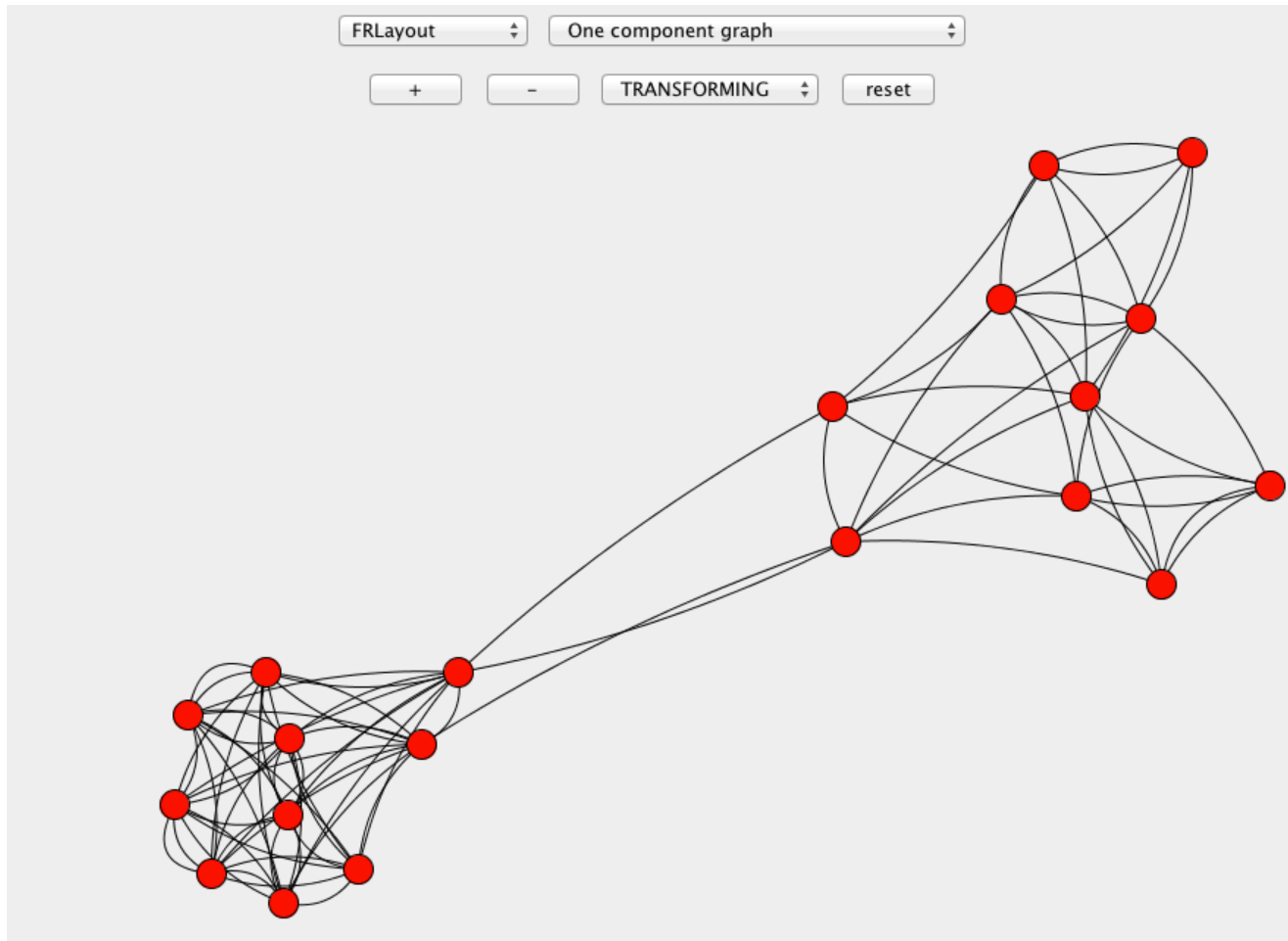
<http://similardiversity.net/about/>

JUNG Layouts



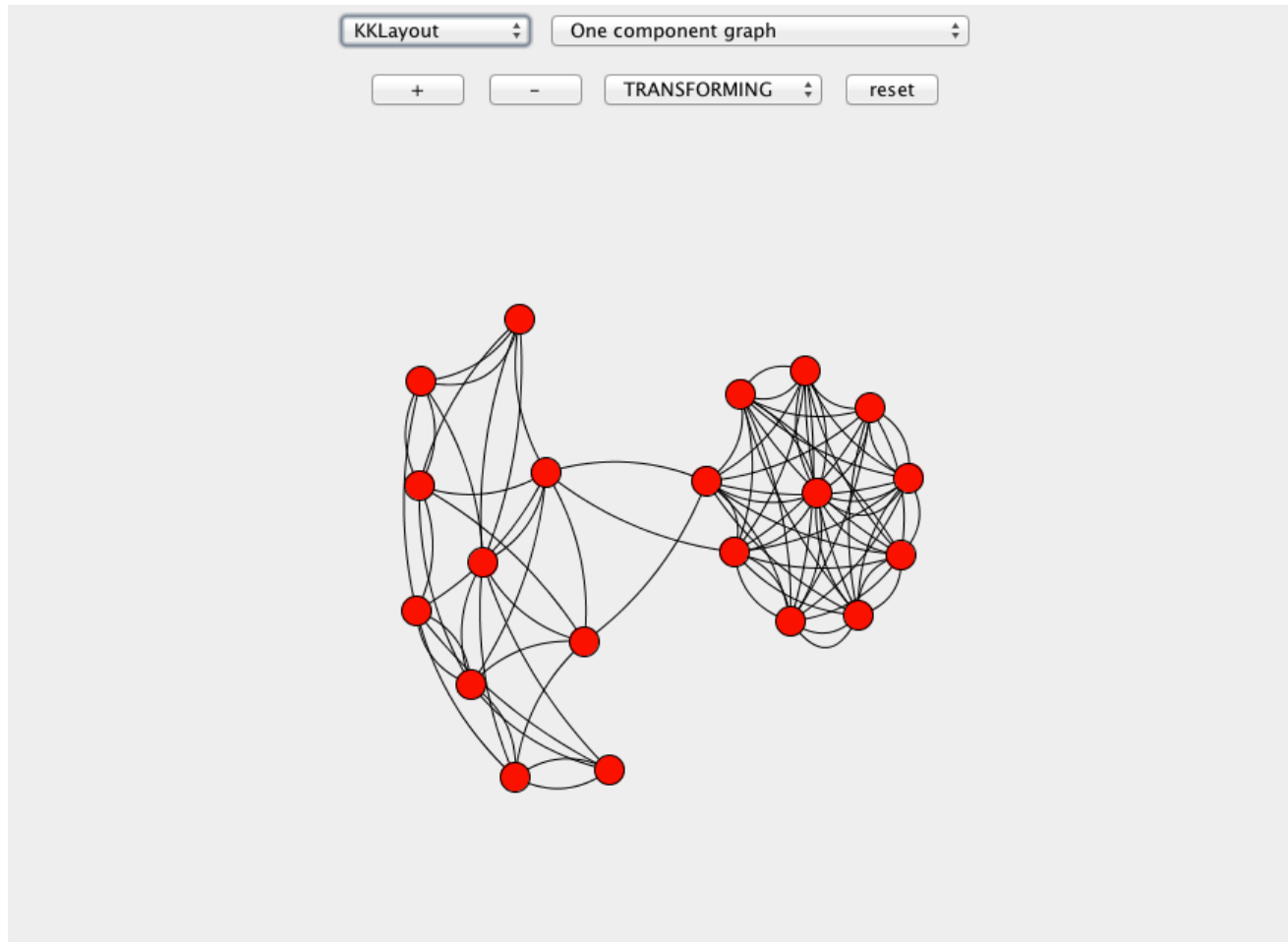
<http://jung.sourceforge.net/applet/showlayouts2.html>

JUNG Layouts



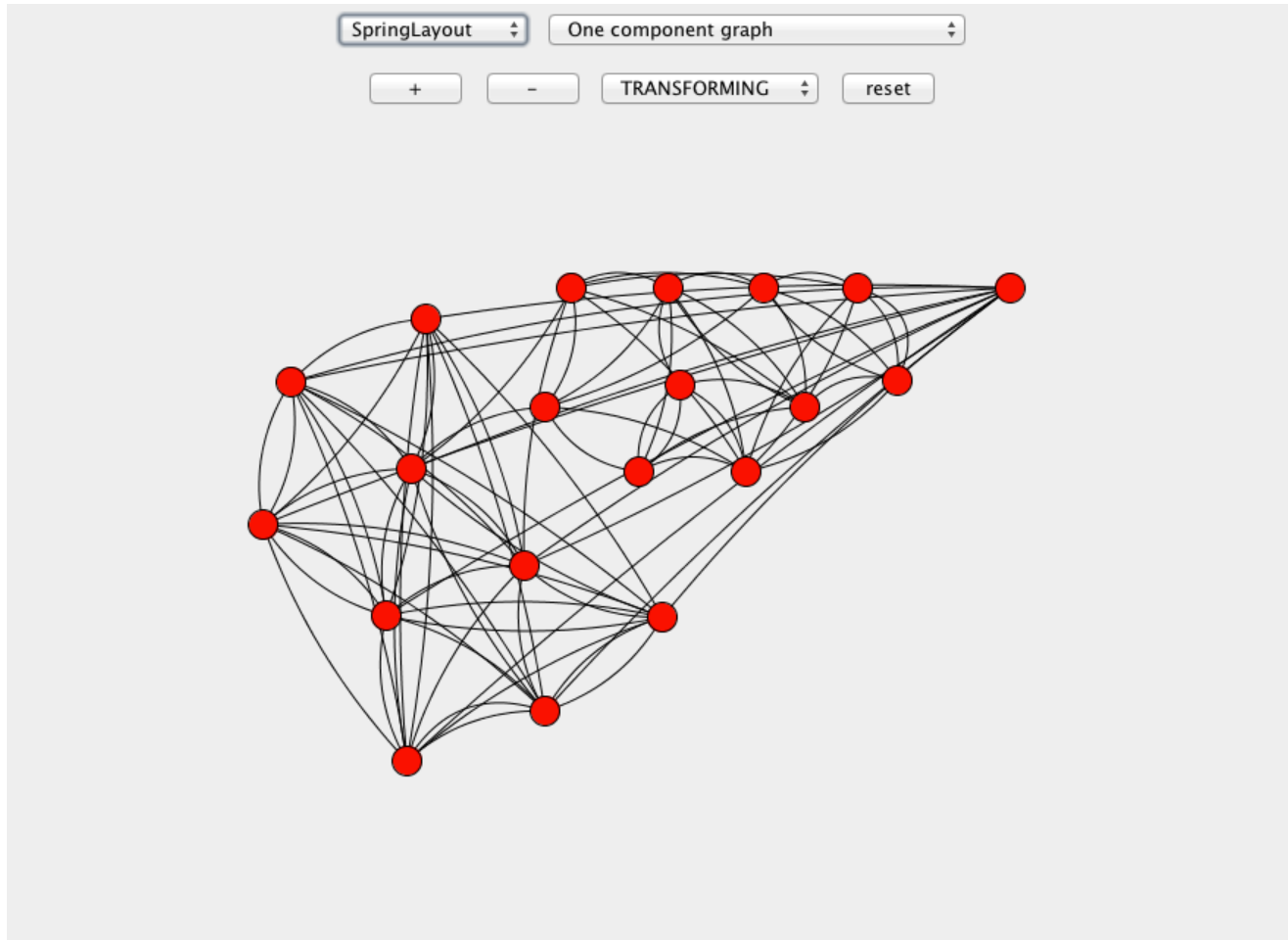
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JUNG Layouts



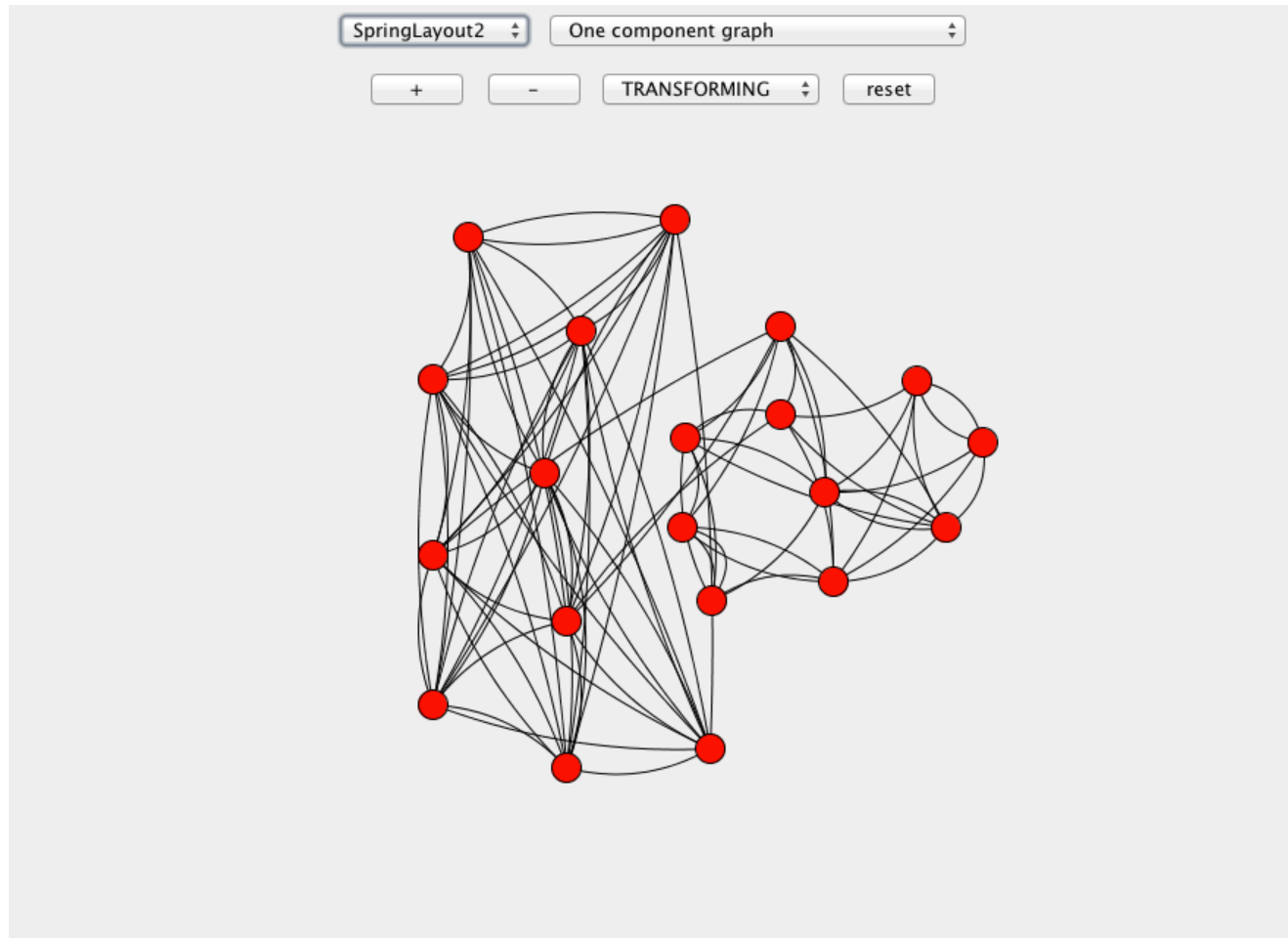
<http://jung.sourceforge.net/applet/showlayouts2.html>

JUNG Layouts



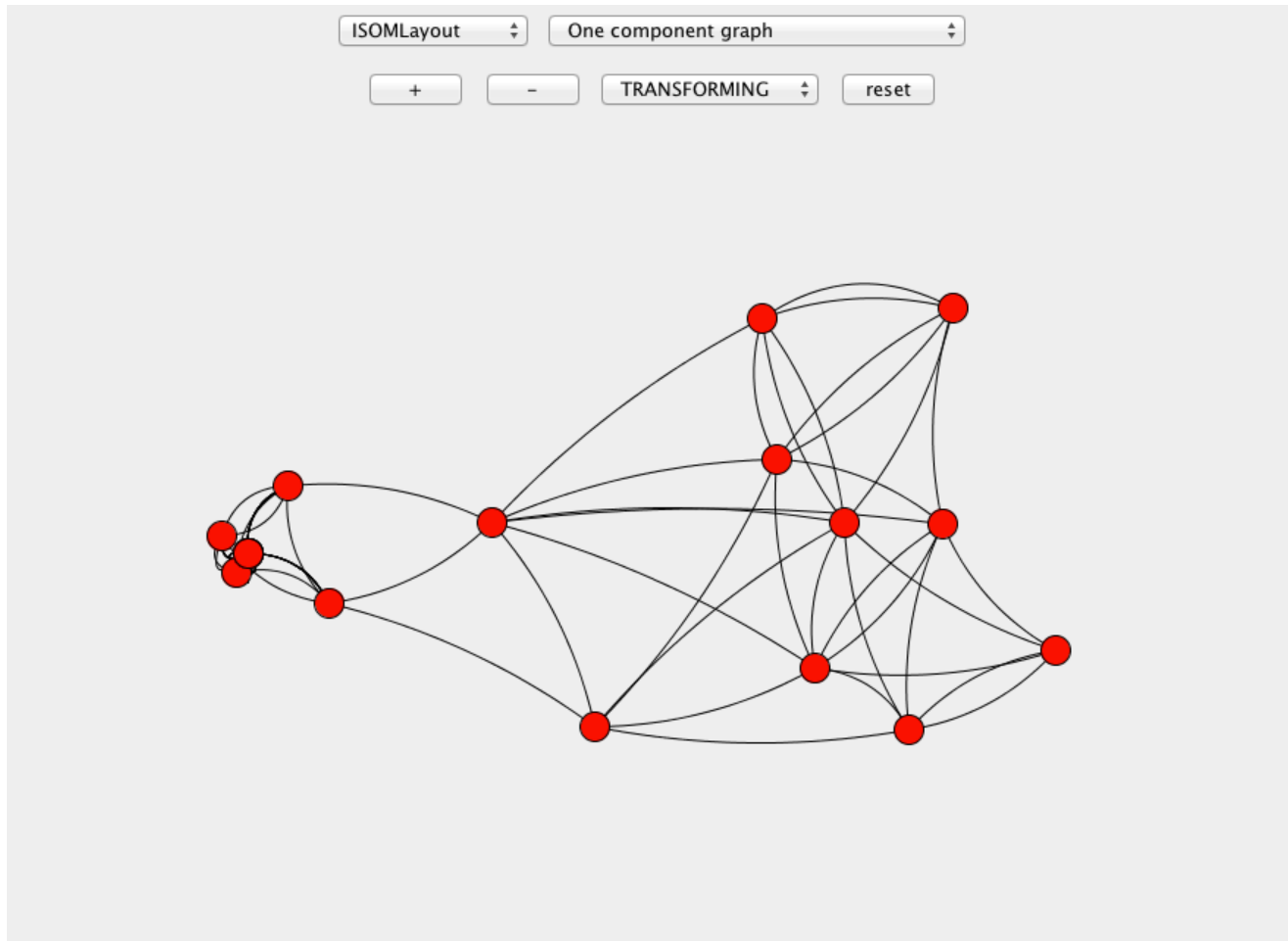
<http://jung.sourceforge.net/applet/showlayouts2.html>

JUNG Layouts



<http://jung.sourceforge.net/applet/showlayouts2.html>

JUNG Layouts



<http://jung.sourceforge.net/applet/showlayouts2.html>

Force Directed Layout in D3



<http://bl.ocks.org/mbostock/4062045>

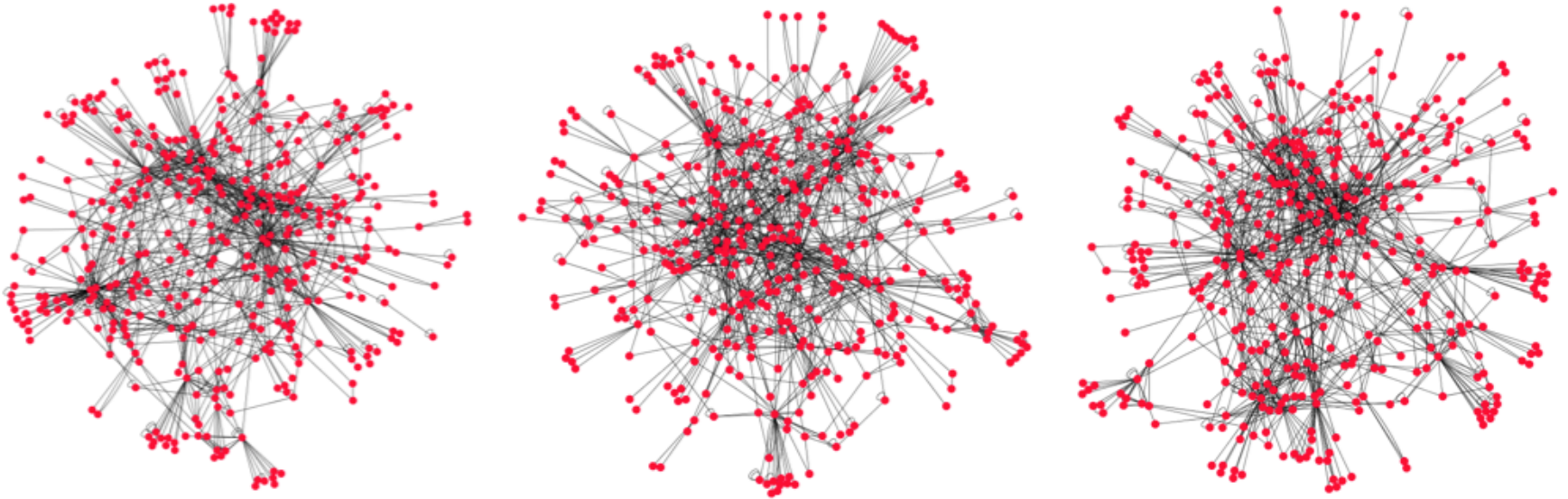
HIVE PLOTS

Hive Plots

- What are hive plots?
 - Network layout algorithm using per-node network properties for node placement
 - A radially-arranged parallel coordinate plot
- Why use hive plots?
 - Repeatable, comparable network layouts
 - Shows network properties with topology

<http://www.hiveplot.net/>

Motivation

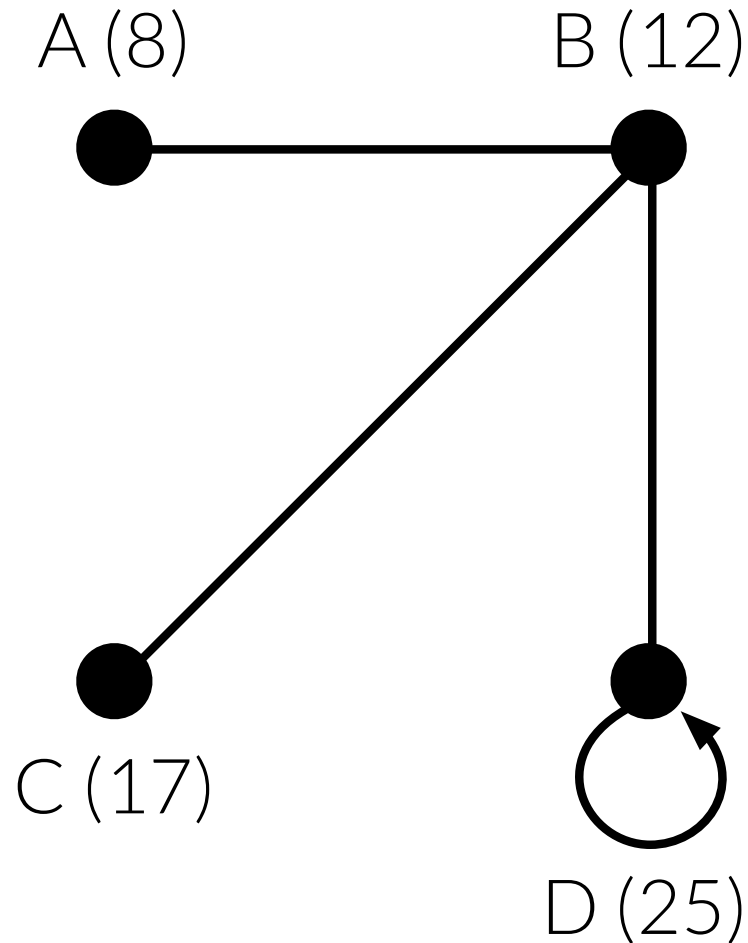


Subset of the human protein-protein interaction network rendered by Cytoscape. Each visualization uses the same layout (spring embedded), using the previous as a starting point.

Rual et al., *Nature* **437**(7062):1173-8.

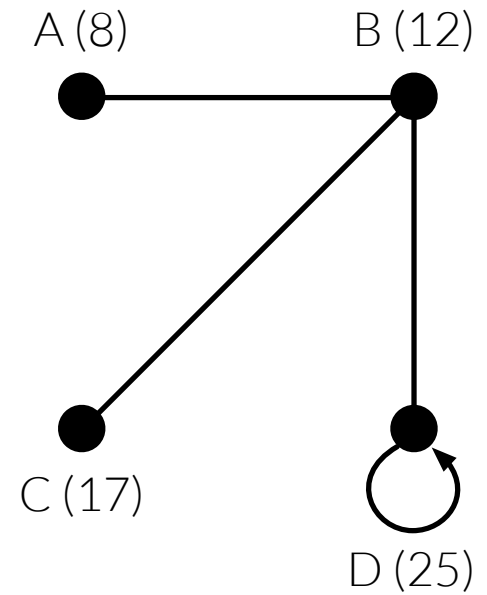
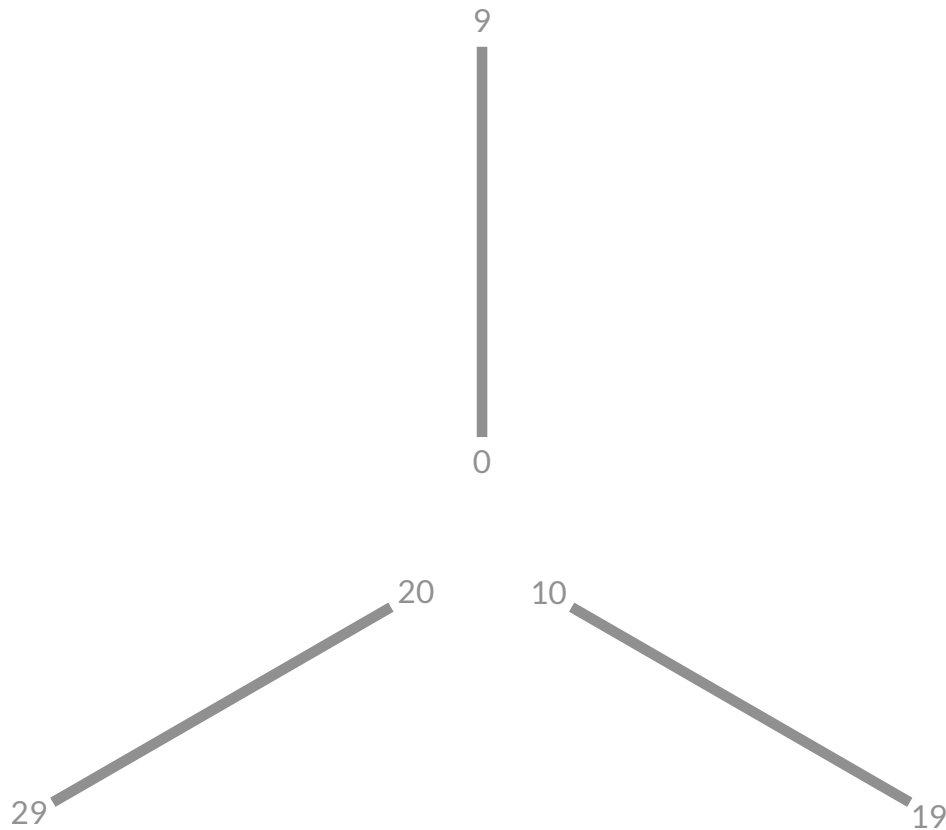
<http://www.hiveplot.net/talks/hive-plot.pdf>

Initial Network



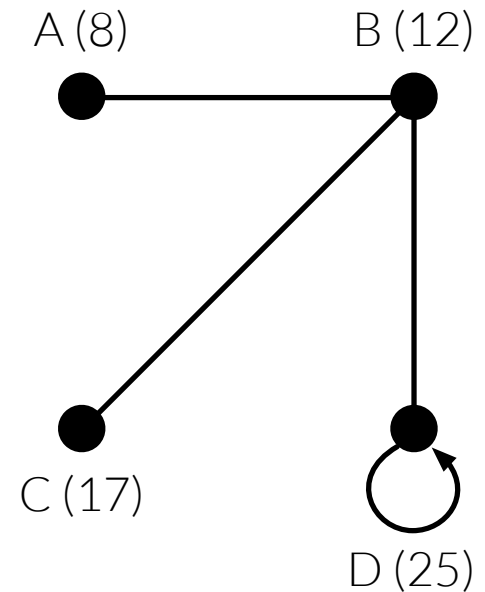
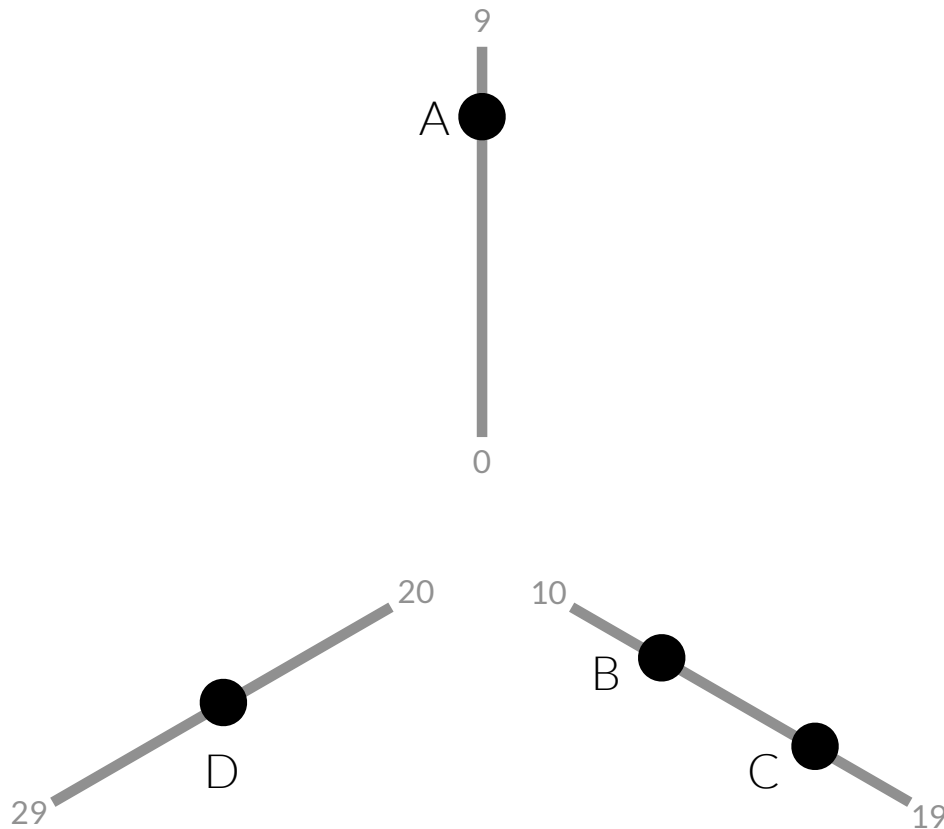
Simple network with node weights and a self-loop.

Axis Layout



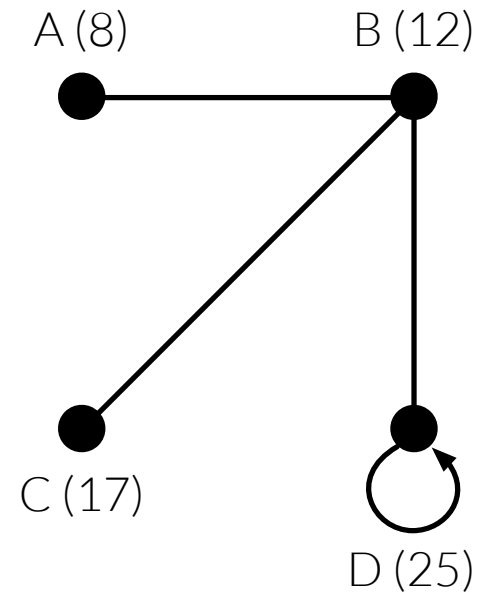
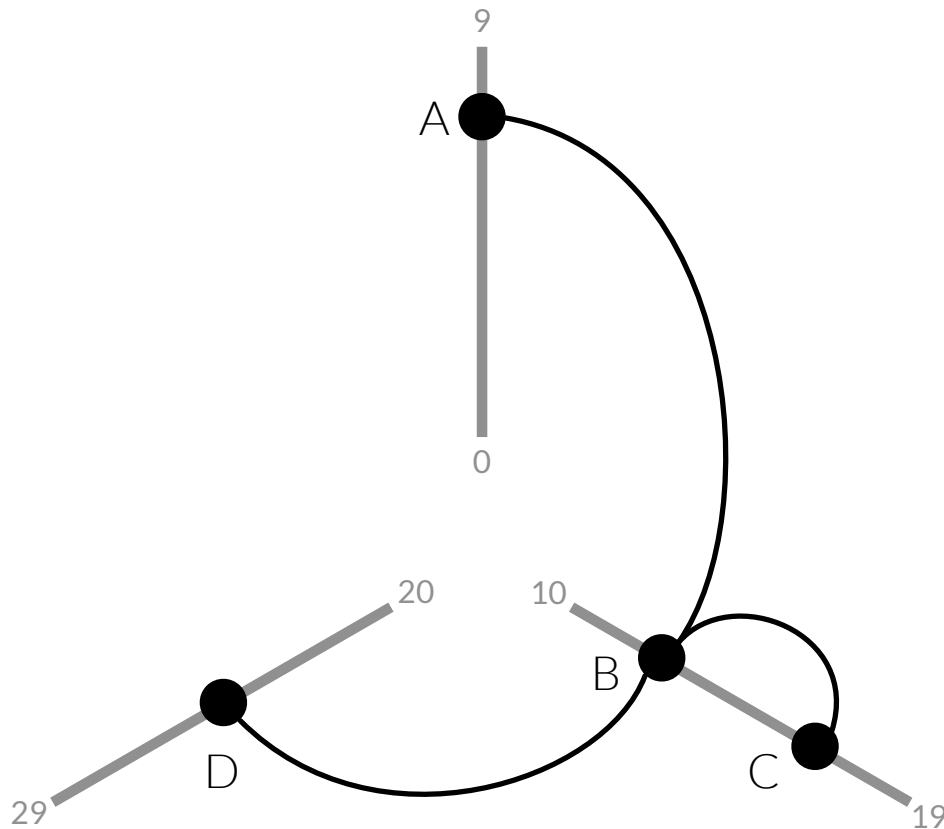
Three axis bars guarantee no edge crossings across axes. Divide node weight range between axes.

Node Layout



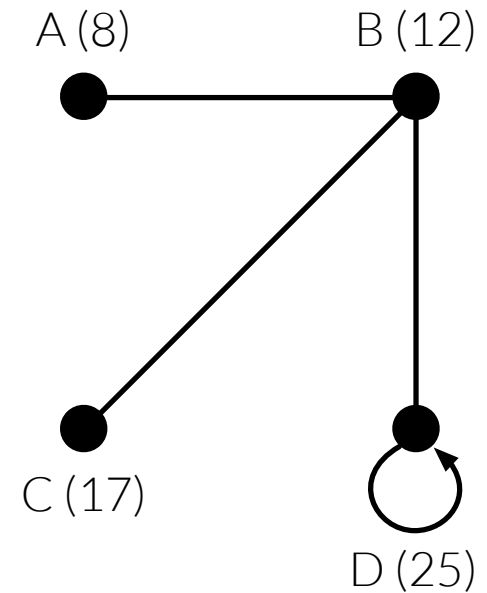
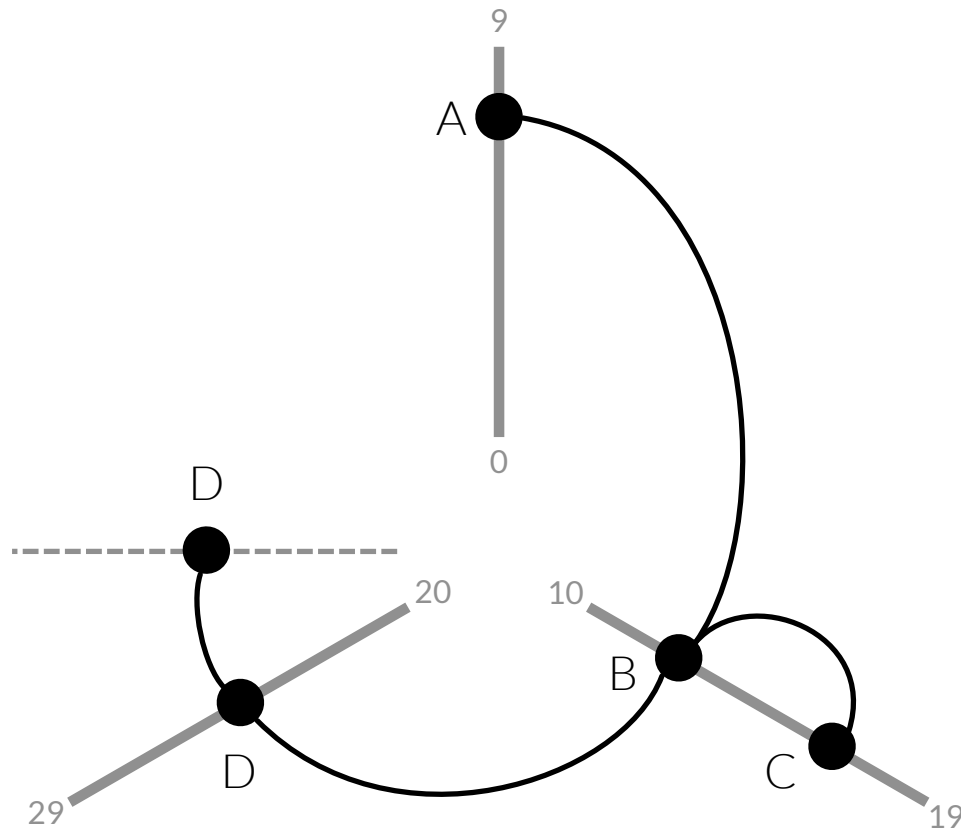
Place nodes on axis lines according to weight.

Edge Layout



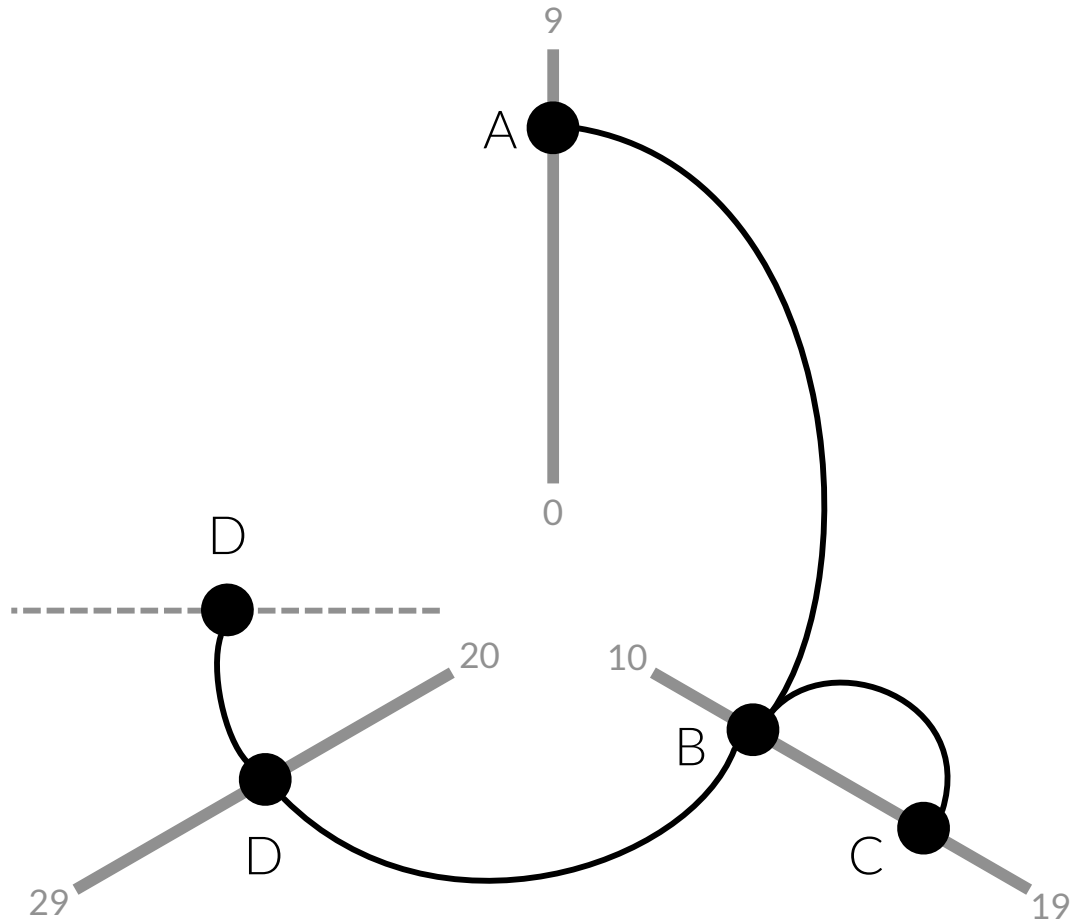
Connect nodes together accordingly.

Self Loops

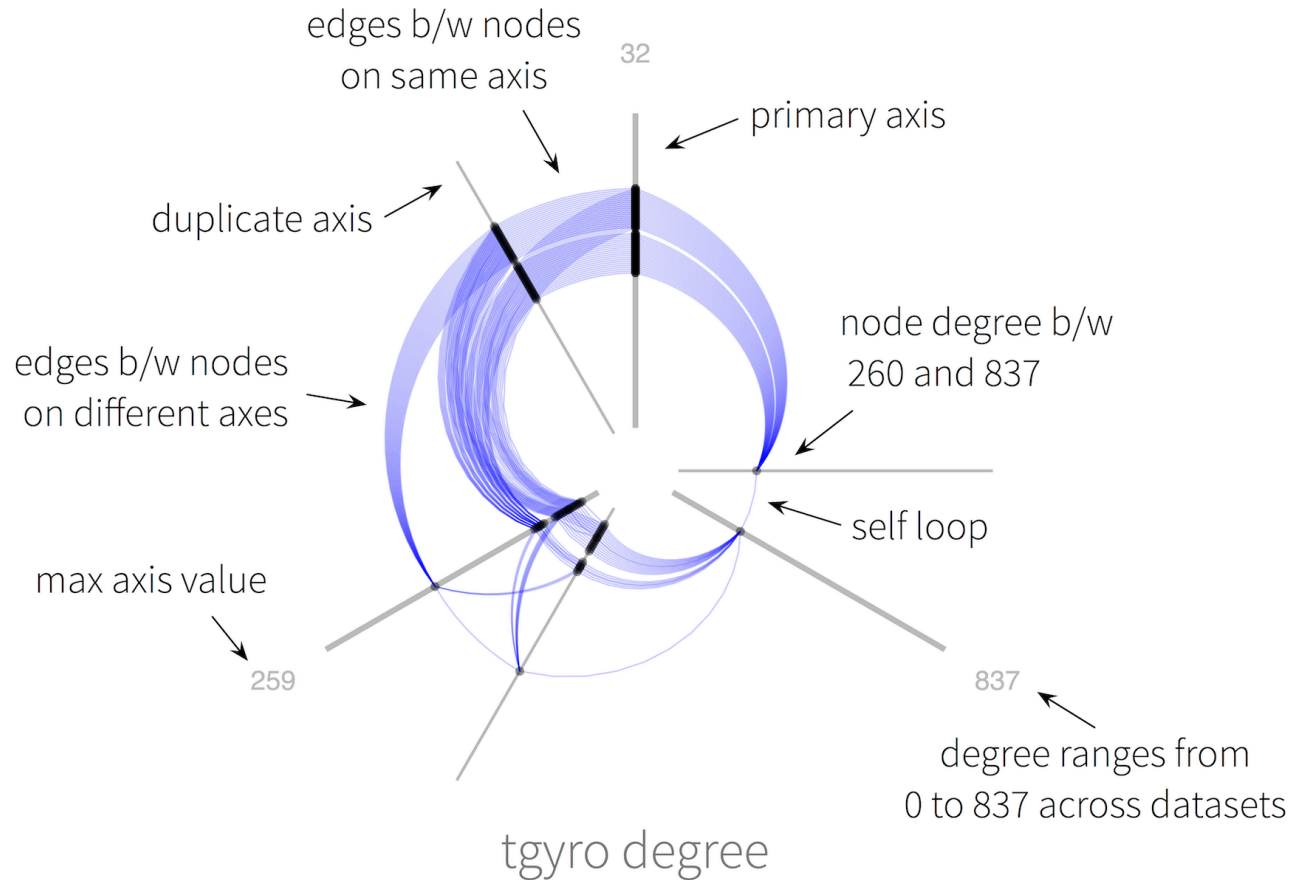


Clone axis lines to show self-loops in network.

Final Layout

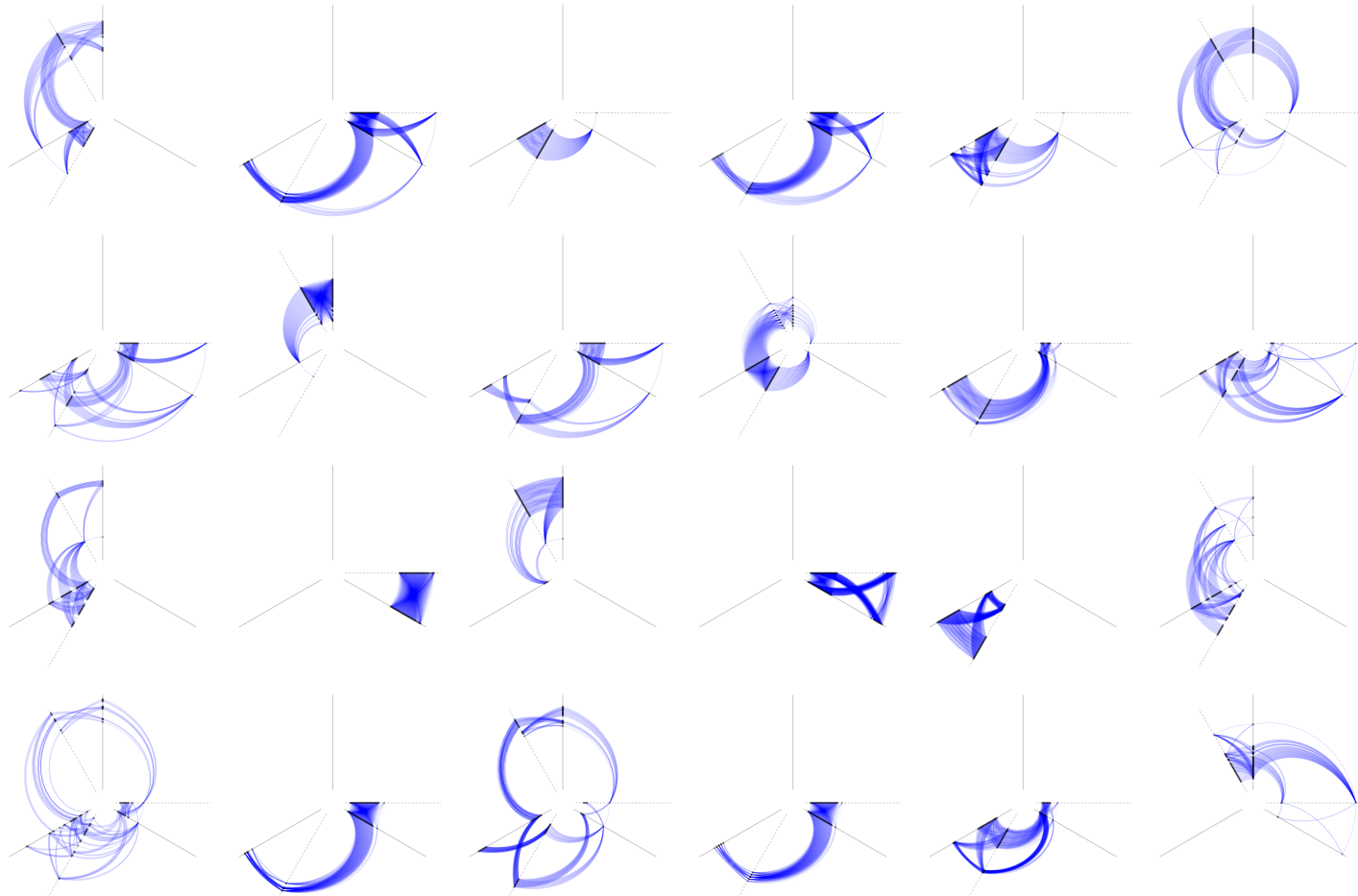


Hive Plots



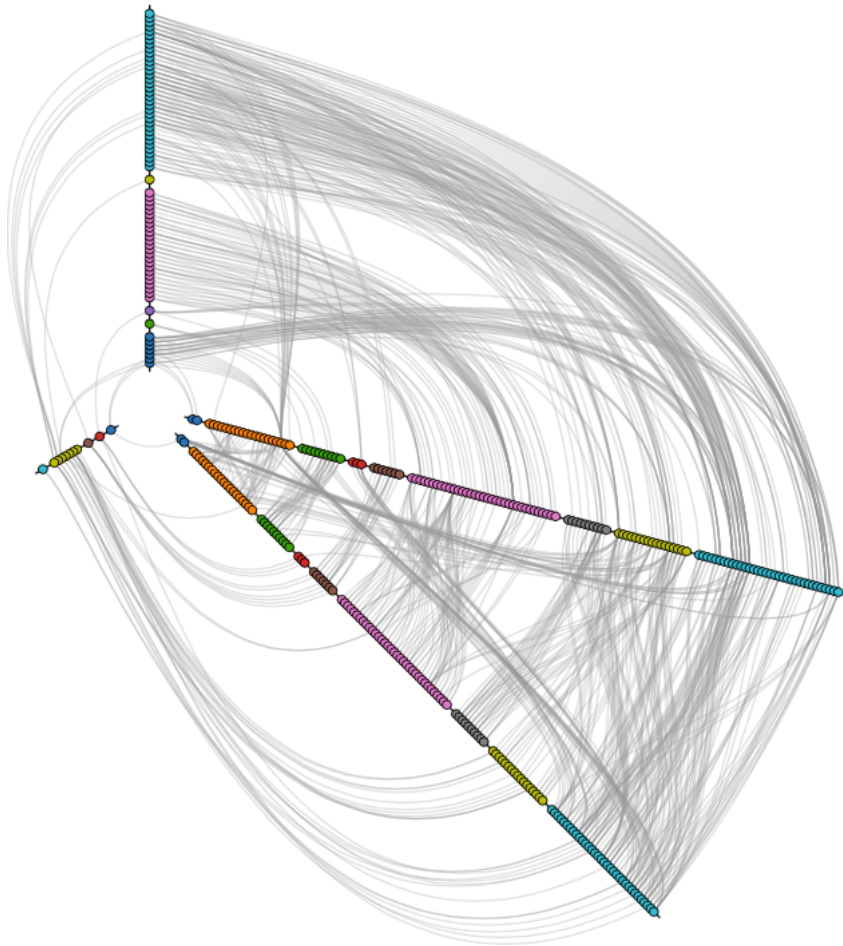
<http://dl.acm.org/citation.cfm?id=2379698>

Hive Panels



<http://dl.acm.org/citation.cfm?id=2379698>

Hive Plots in D3



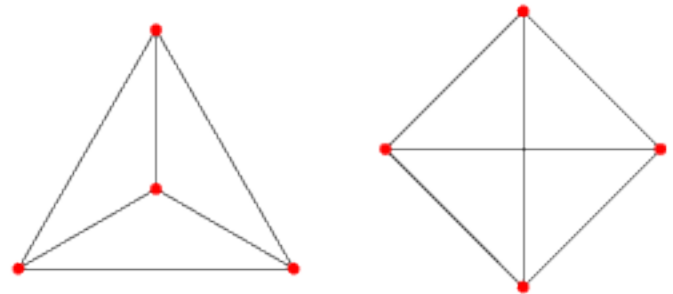
<http://bost.ocks.org/mike/hive/>

EDGE LAYOUT

Edge Crossings

- **Planar Graph**

- "A graph is planar if it can be drawn in a plane without graph edges crossing."
- If the graph is not planar, it is impossible to draw without edge crossings.
- Trees are planar graphs.

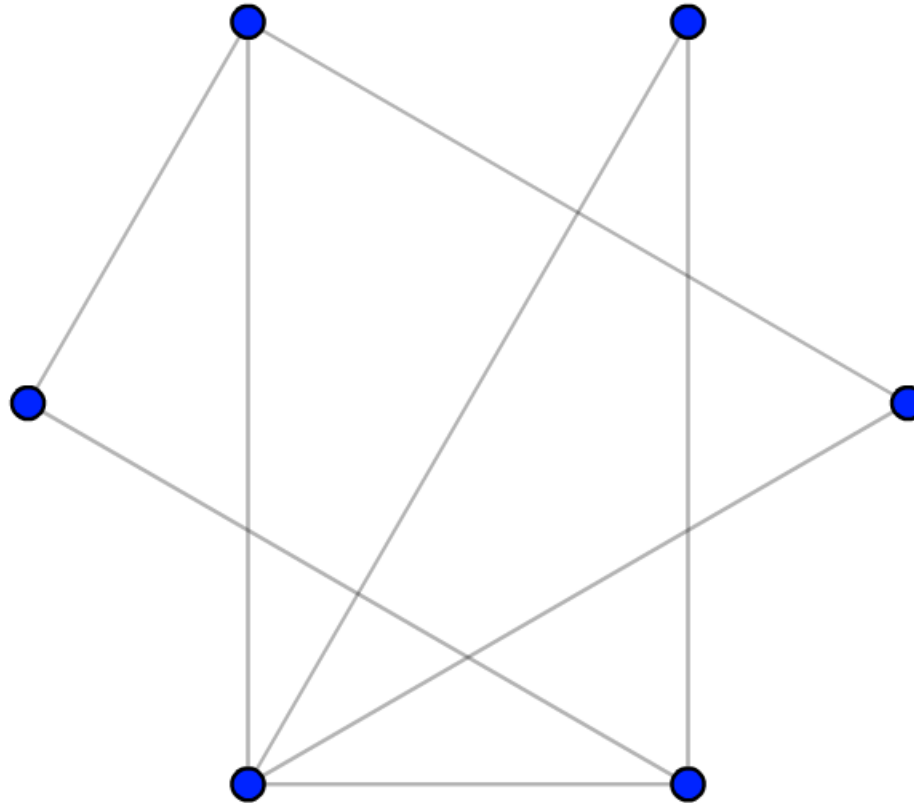


<http://mathworld.wolfram.com/PlanarGraph.html>

Planarity Game

Score: 0

Level: 1

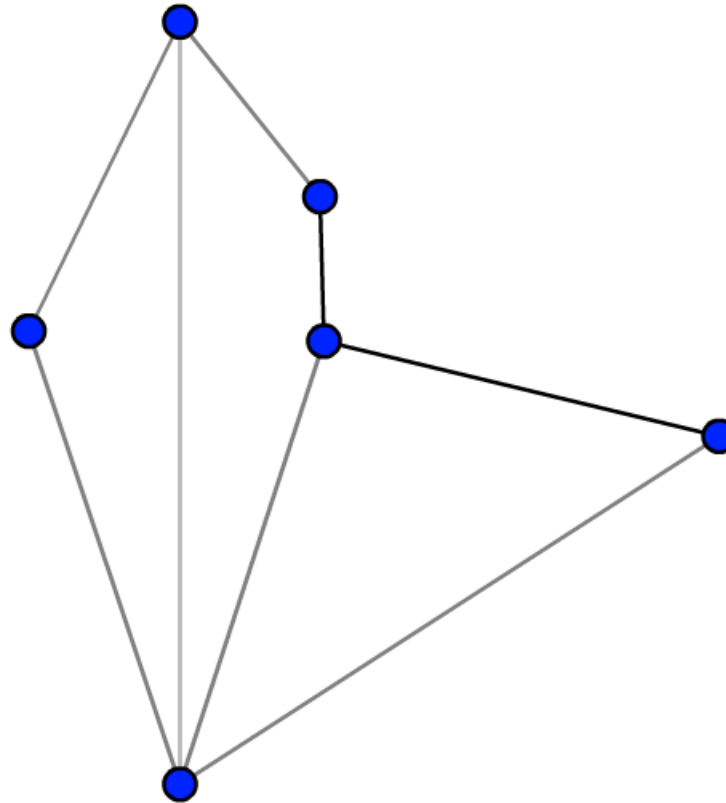


<http://www.planarity.net/>

Planarity Game

Score: 0

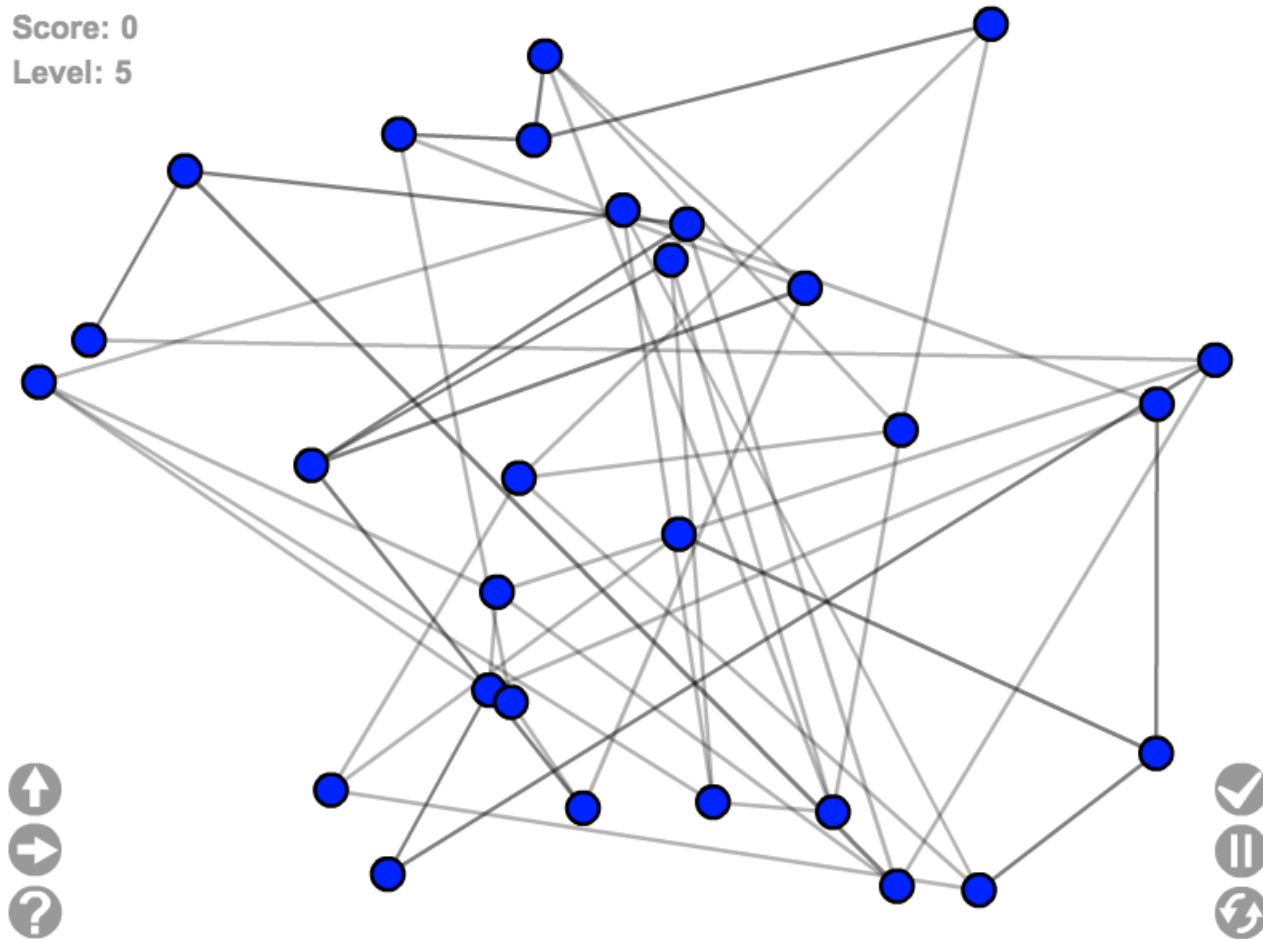
Level: 1



<http://www.planarity.net/>

Planarity Game

Score: 0
Level: 5

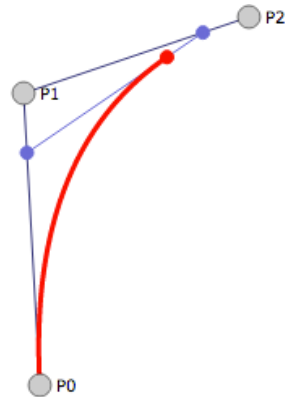


<http://www.planarity.net/>

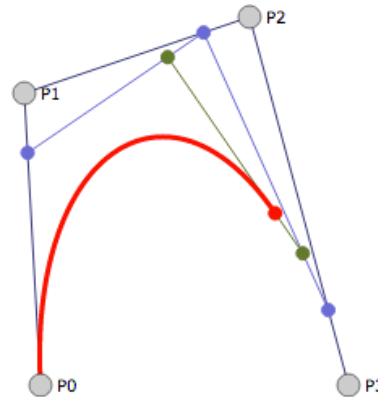
Curved Edges



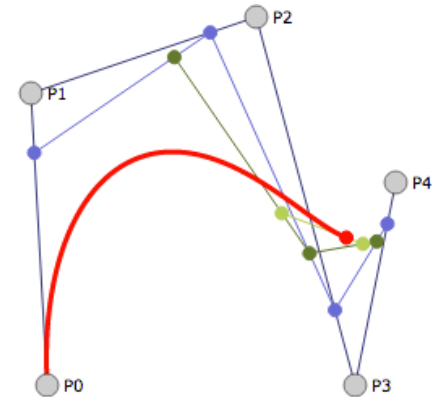
t=0.80



t=0.80



t=0.80



t=0.80

<http://www.jasondavies.com/animated-bezier/>

Edge Bundling

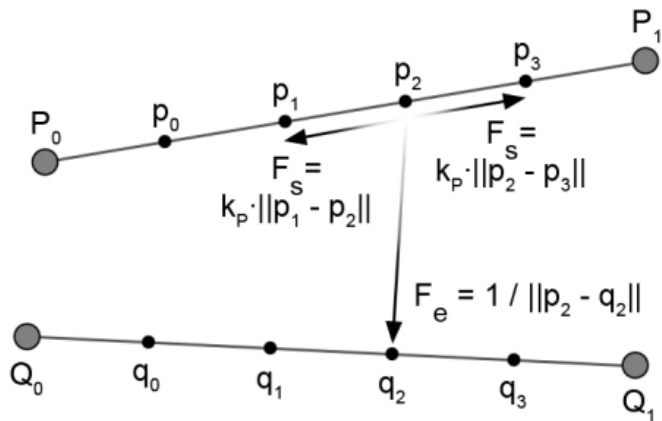


Figure 1: Two interacting edges P and Q . The spring forces $\mathbf{F}_s$ and the electrostatic force $\mathbf{F}_e$ that are exerted on subdivision point p_2 by p_1 , p_3 , and q_2 are shown.

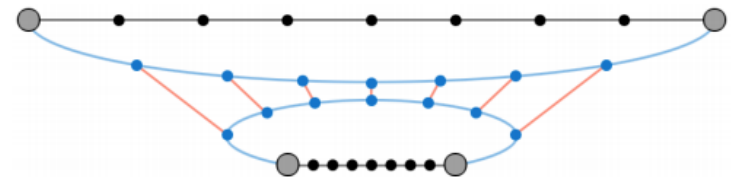


Figure 4: Bundling edges that differ considerably in length can result in noticeable stretching and curving of short edges. Original edges, curved edges and attracting forces are shown in black, blue, and red, respectively.

http://www.win.tue.nl/~dholten/papers/forcebundles_eurovis.pdf

Edge Bundling

Danny Holten & Jarke J. van Wijk / Force-Directed Edge Bundling for Graph Visualization

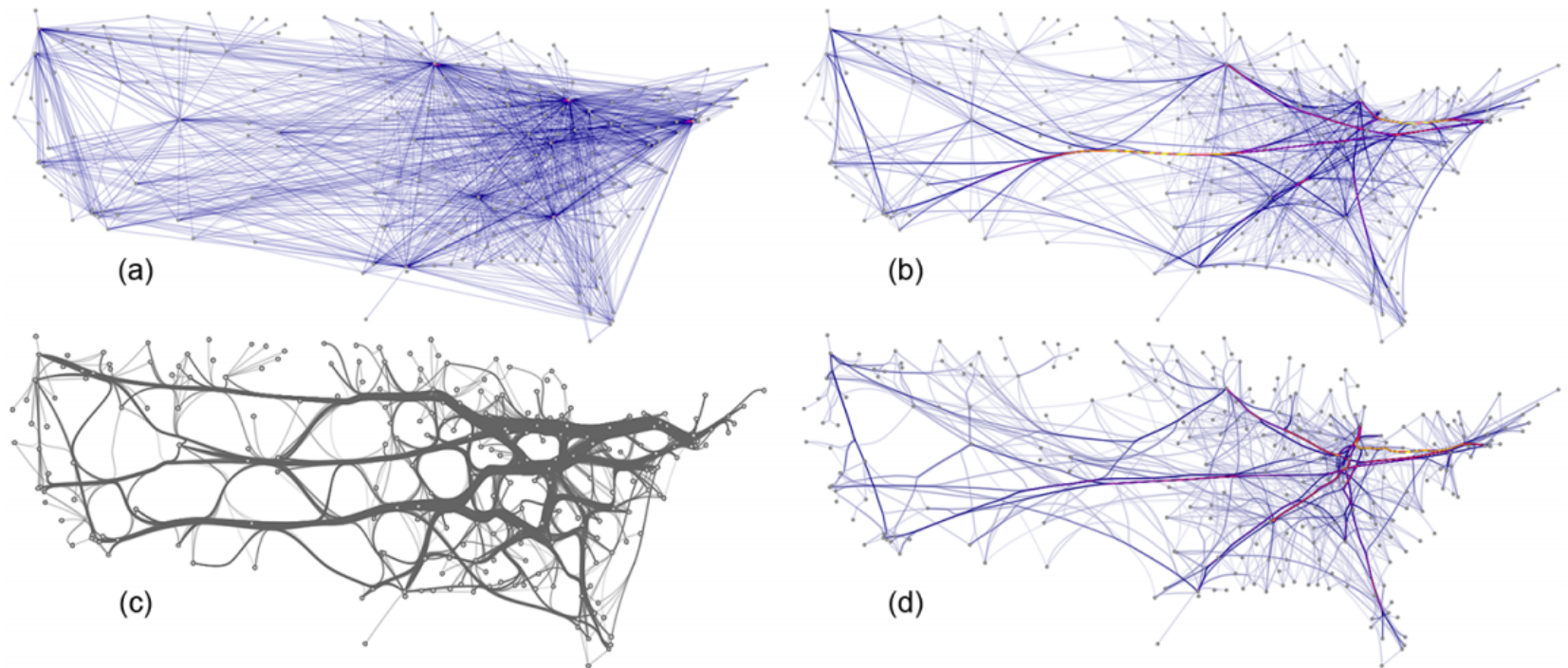
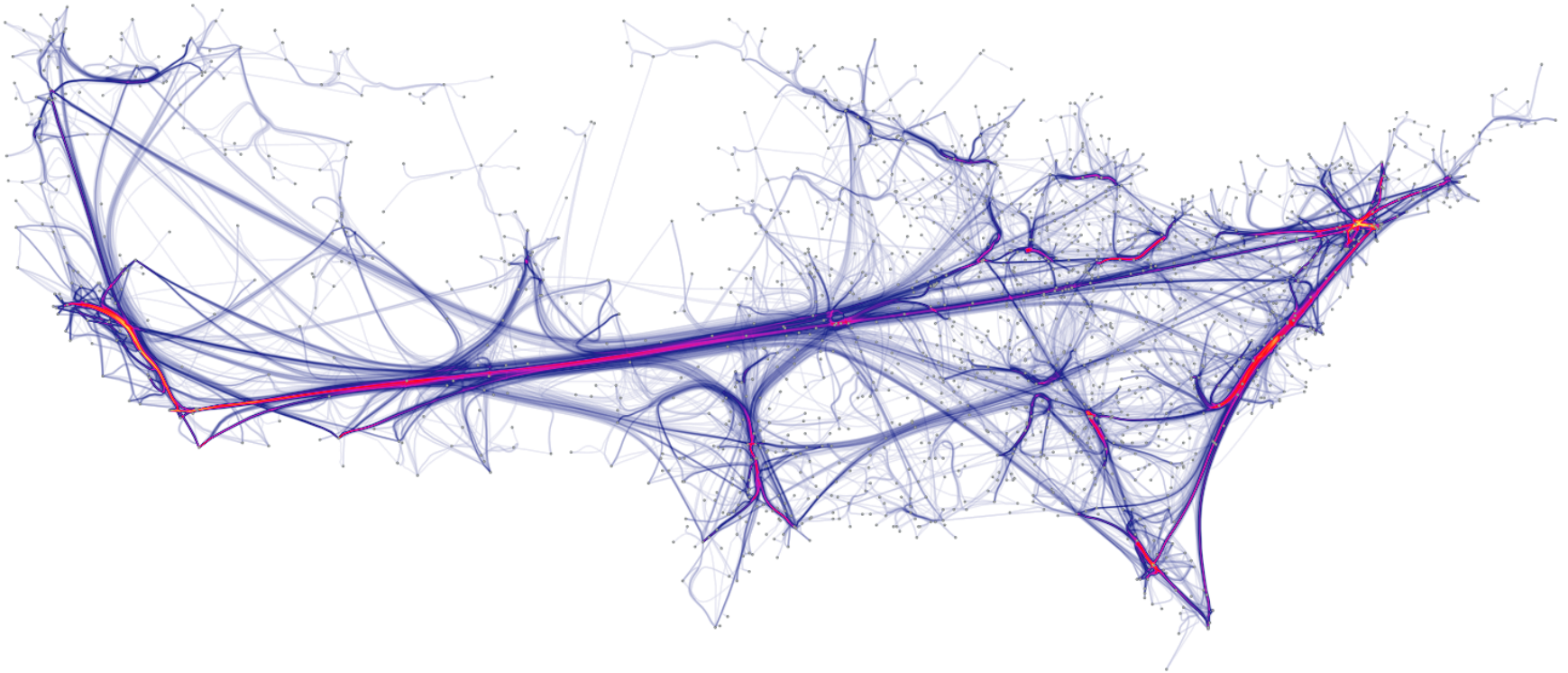


Figure 7: US airlines graph (235 nodes, 2101 edges) (a) not bundled and bundled using (b) FDEB with inverse-linear model, (c) GBEB, and (d) FDEB with inverse-quadratic model.

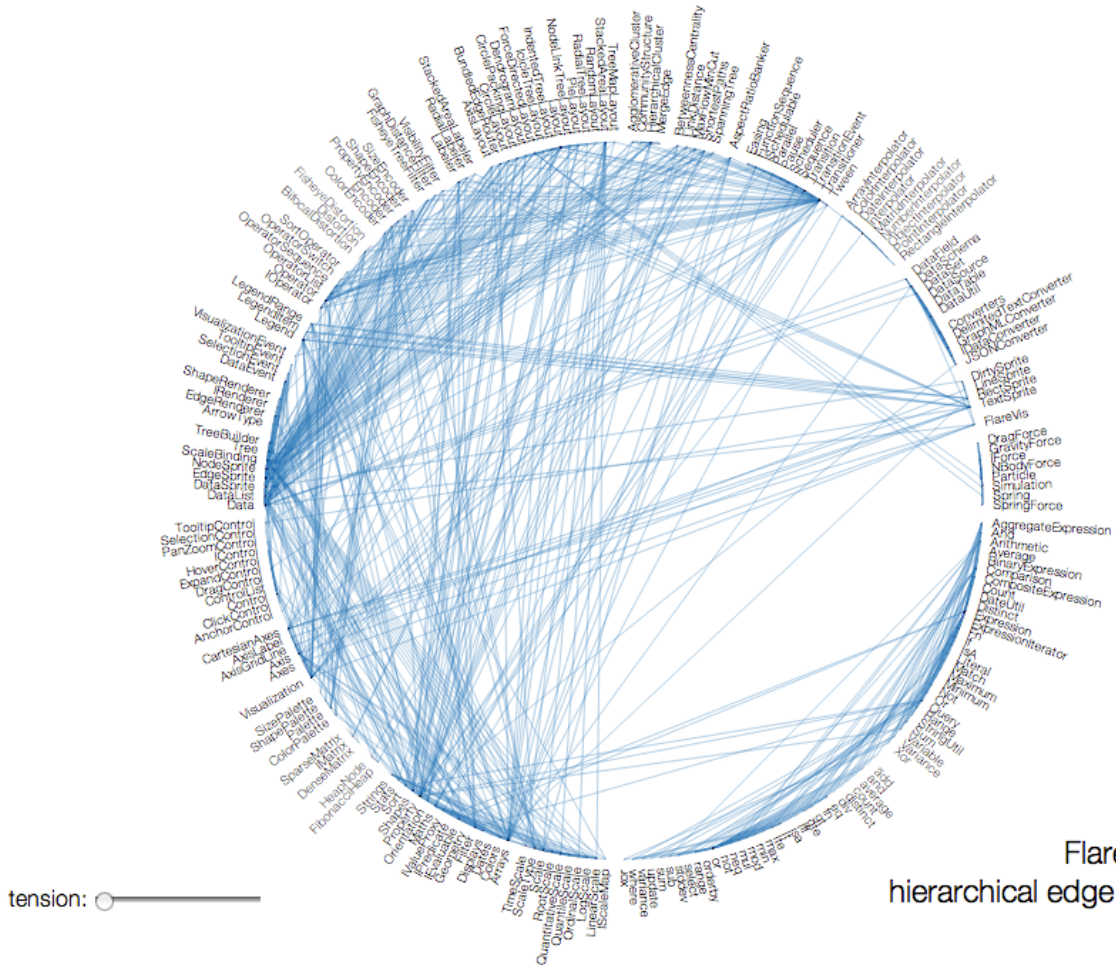
http://www.win.tue.nl/~dholten/papers/forcebundles_eurovis.pdf

Edge Bundling



<http://www.win.tue.nl/~dholten/>

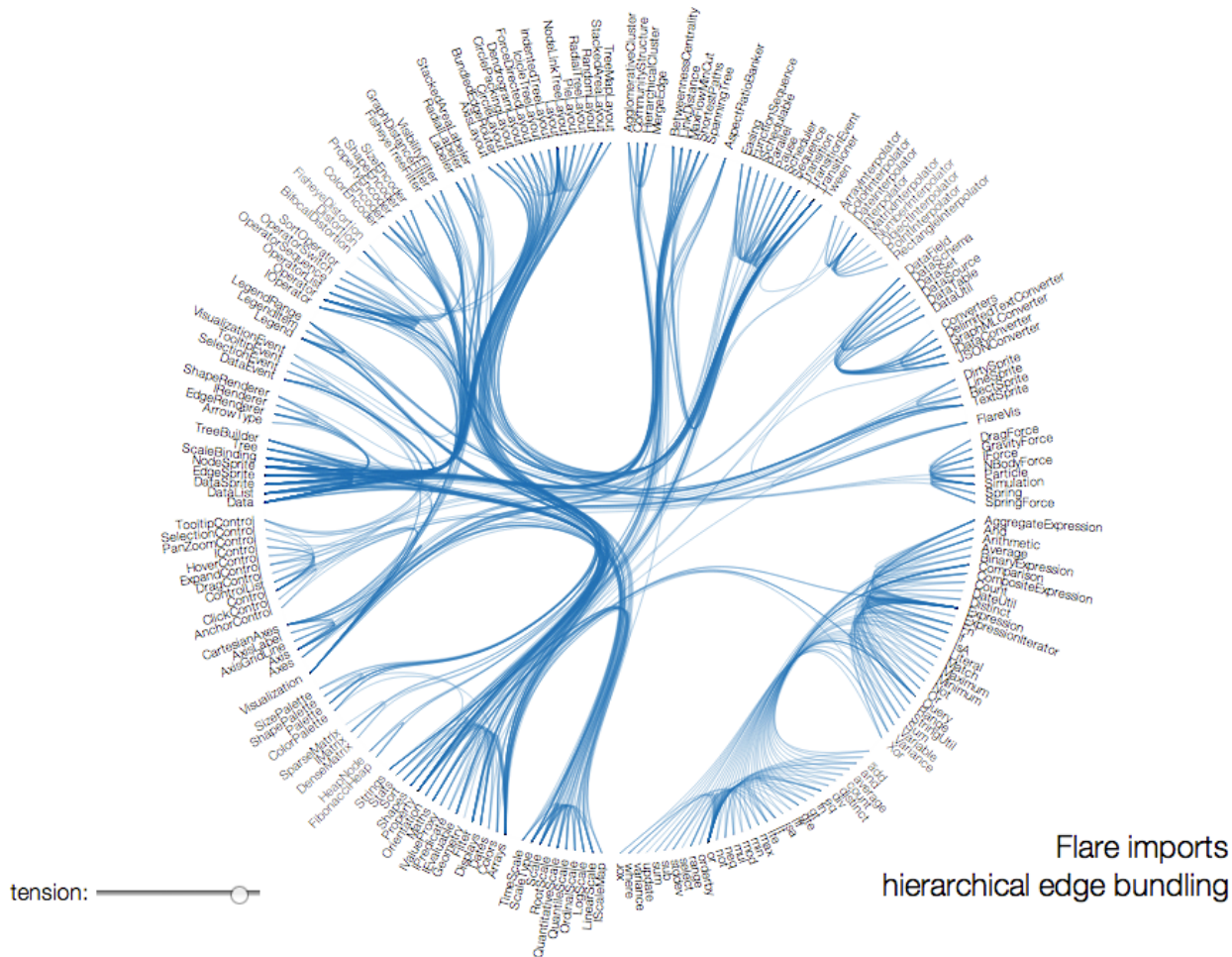
Edge Bundling



Flare imports
hierarchical edge bundling

<http://mbostock.github.io/d3/talk/20111116/bundle.html>

Edge Bundling

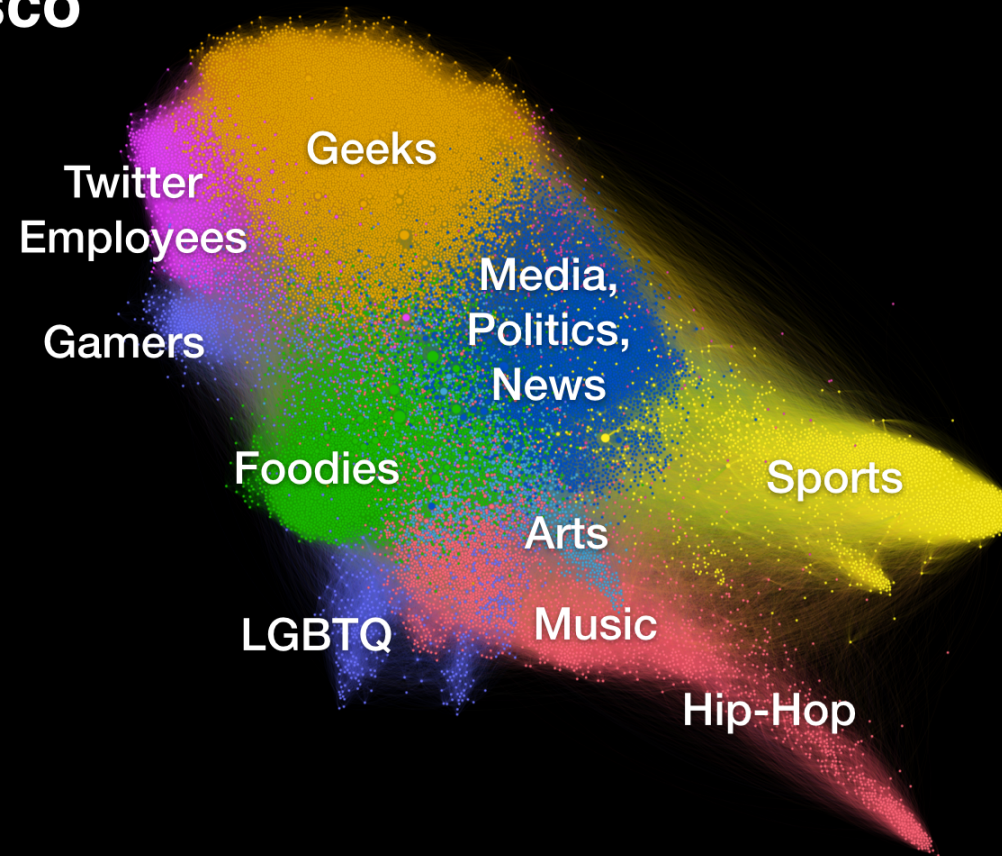


<http://mbostock.github.io/d3/talk/20111116/bundle.html>

RESOURCES

San Francisco

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<http://peoplemaps.org/> • https://www.ted.com/talks/dave_troy_social_maps_that_reveal_a_city_s_intersections_and_separations

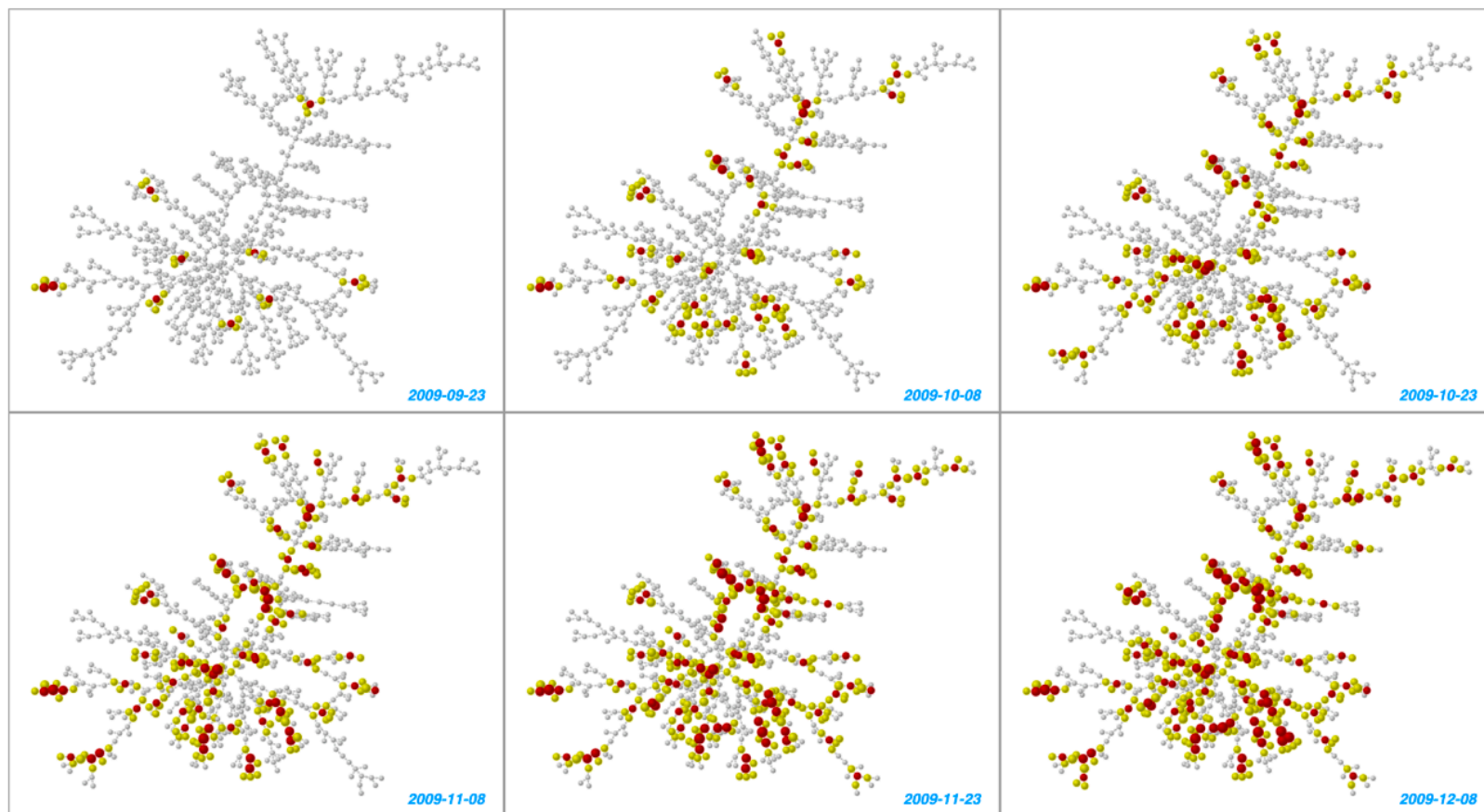


Figure 4. Progression of flu contagion in the friendship network over time. Each frame shows the largest component of the network (714 people) for a specific date, with each line representing a friendship nomination and each node representing a person. Infected individuals are colored red, friends of infected individuals are colored yellow, and node size is proportional to the number of friends infected. All available information regarding infections is used here. Frames for all 122 days of the study are available in a movie of the epidemic posted in the Supporting Information (Video S1). doi:10.1371/journal.pone.0012948.g004

<http://nicholaschristakis.net/> • http://www.ted.com/talks/nicholas_christakis_how_social_networks_predict_epidemics

QUESTIONS?