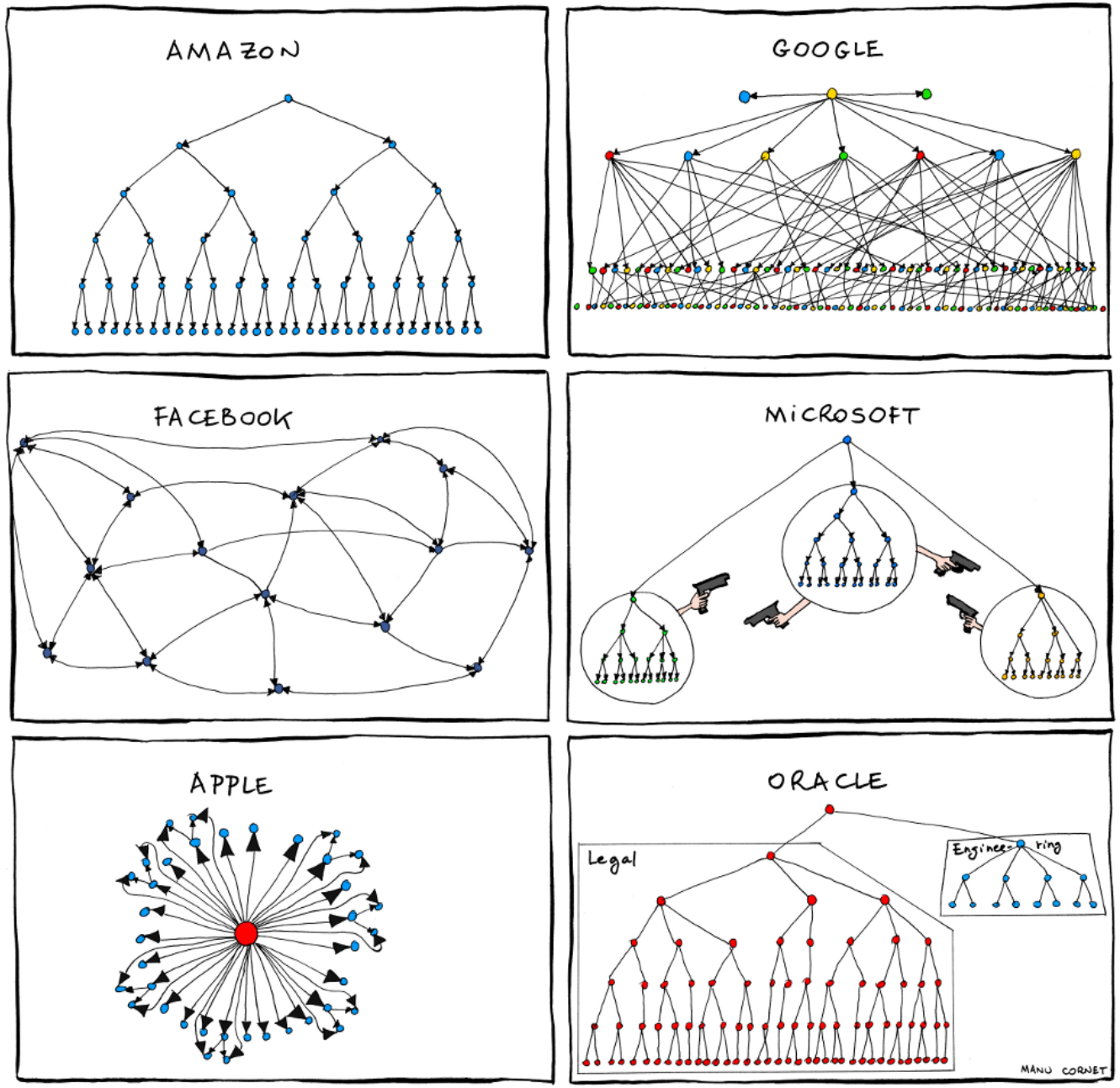
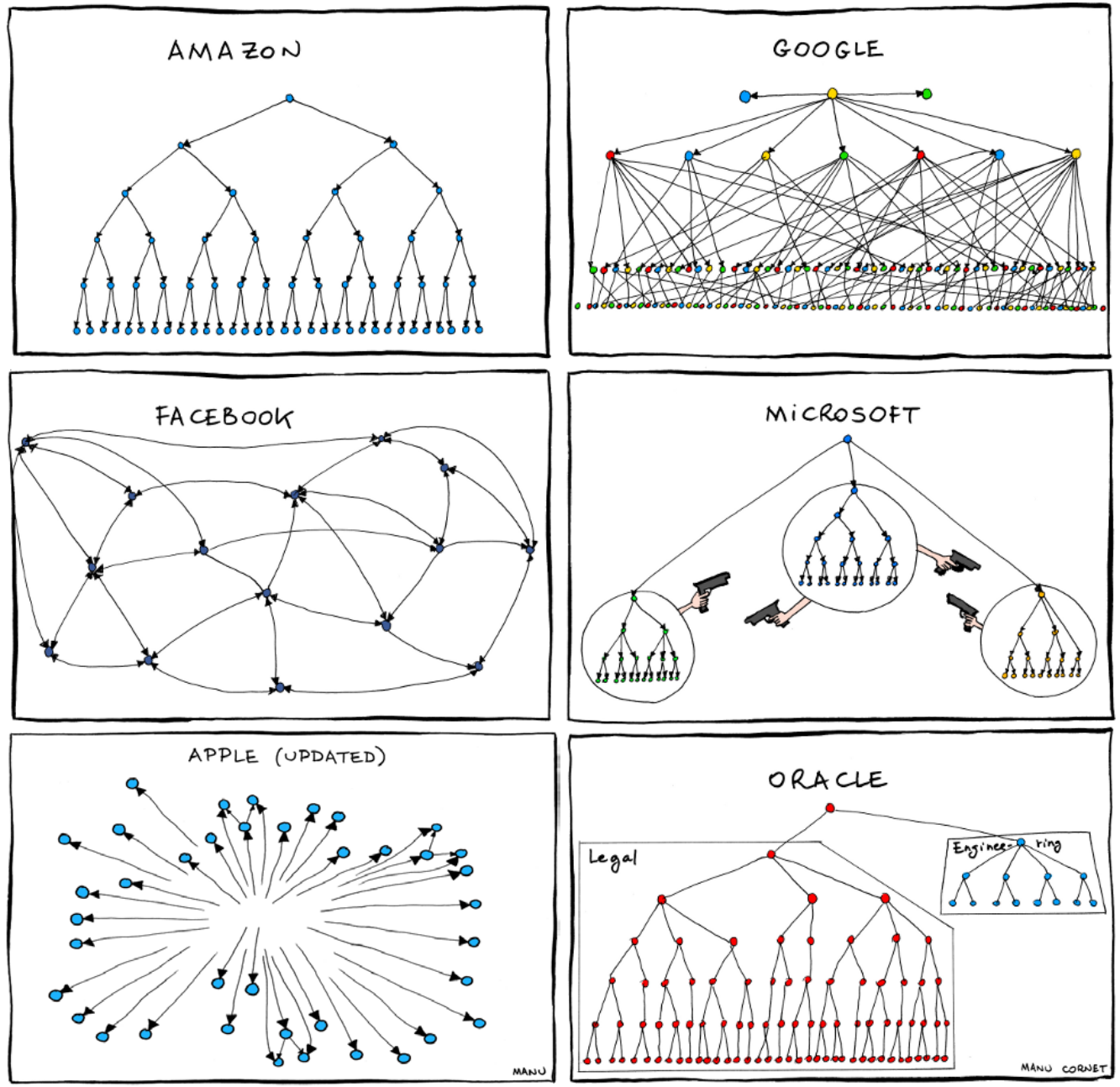
Trees and Networks

Edges and Nodes are Sexy



Organizational Structures by Manu Cornet http://www.bonkersworld.net/organizational-charts/



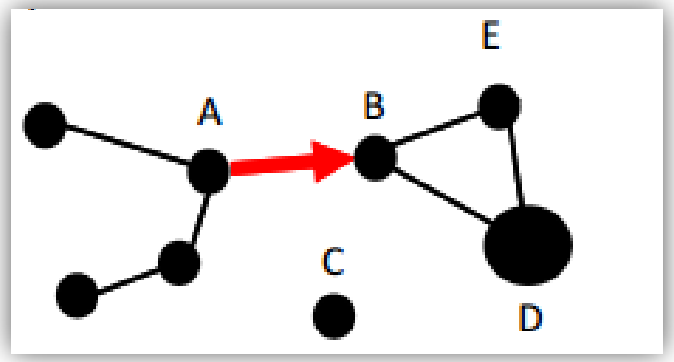
Organizational Structures by Manu Cornet http://www.bonkersworld.net/organizational-charts/

Node & Link Diagrams

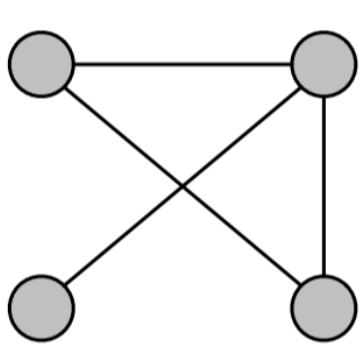
Networks and Trees are made of these…

Some Definitions

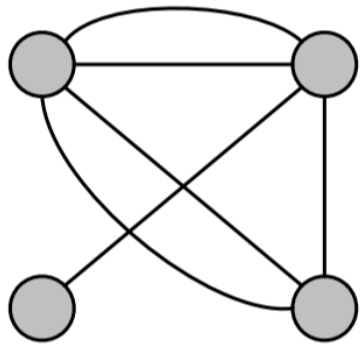
Nodes (or vertices): can be isolated and *not* connected. Can be labeled, have quantitative or qualitative attributes (e.g. node area size)



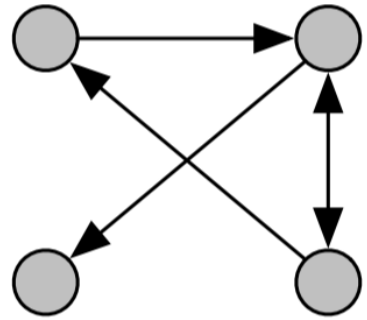
Links (or edges): unidirected or directed, or self loops. Can be labeled and have additional attributes (weight, color, etc). Can be assigned quantitative or qualitative values. Can be signed.



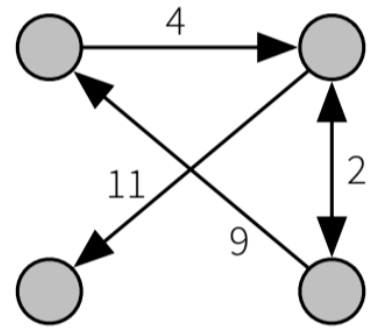
undirected graph



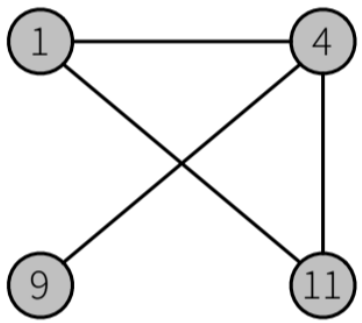
multigraph



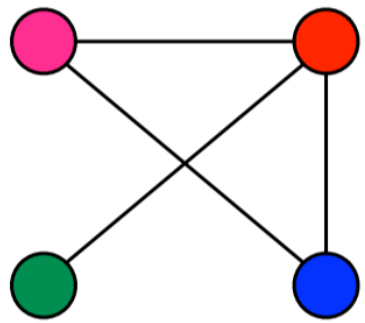
directed graph



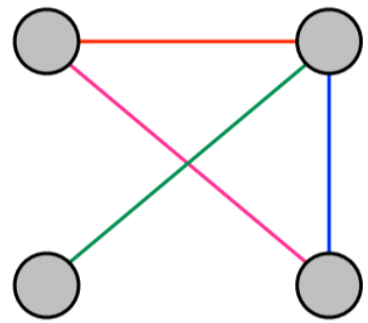
edge-labeled



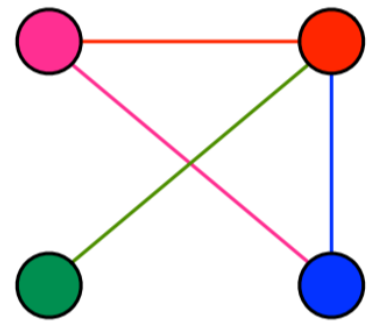
vertex-labeled



vertex-colored



edge-colored



vertex & edge colored

Network and Tree Visualizations

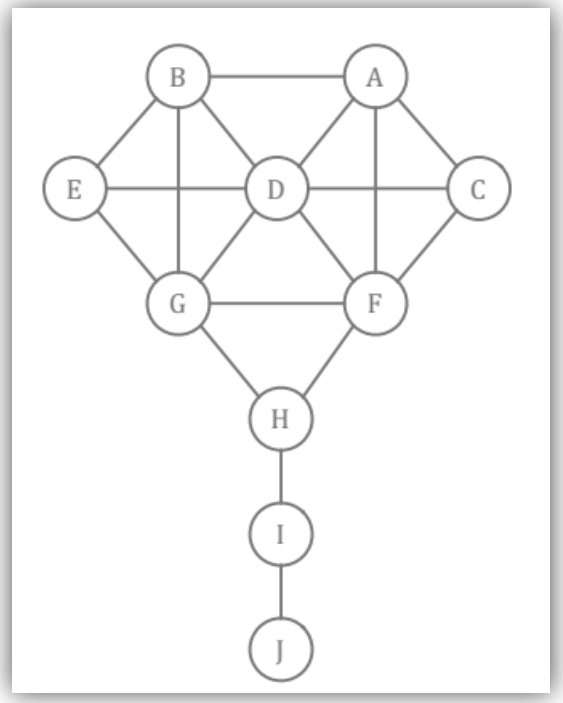
Goal is to use the **spatial organization** and **visual cues** to effectively show:

- Connectivity
- Partitions / Clusters / Communities
- Outliers

Checking a Network Out

Node and Link Properties | Network Properties | Statistics

Node and Link Properties



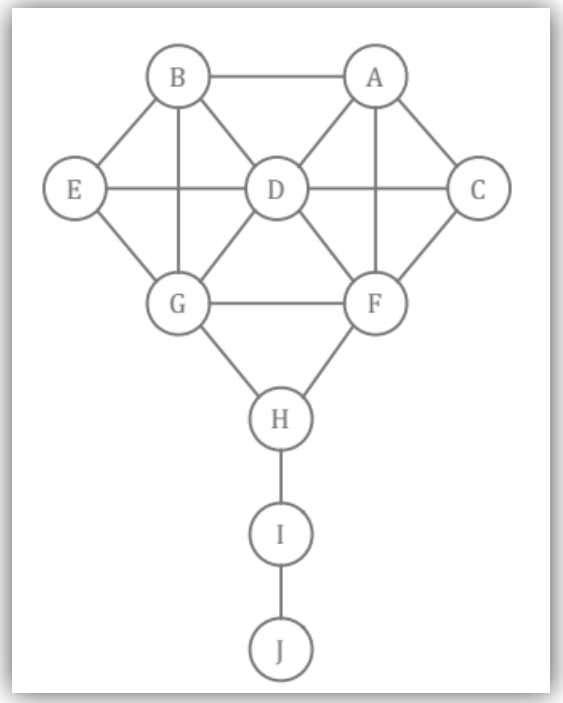
Degree or **Isolation** of a node

Betweenness centrality of a node: Number of shortest paths between pairs of nodes that pass through a given node.

Betweenness centrality of an link: Number of shortest paths among all possible node pairs that pass through a given link.

Shortest path length

Network Properties



Number of

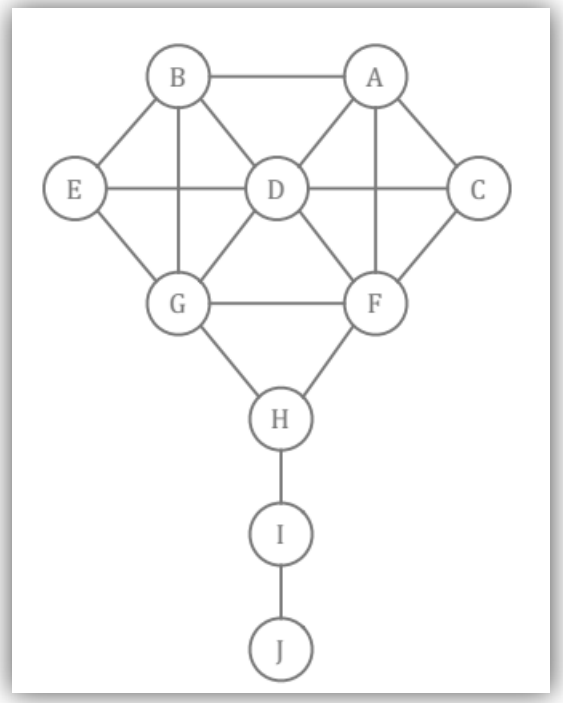
- Nodes, Isolated nodes
- In- and Out-degree
- Edges
- Self-loops

Diameter: Longest of all shortest paths among all possible node pairs in a network

Density: Ratio of the number of edges in the network to the square of the total number of nodes.

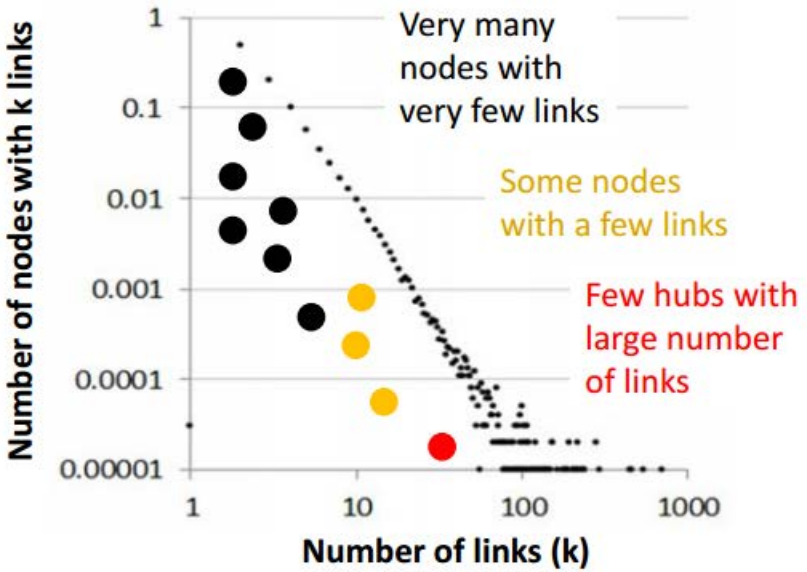
Points of failure, Key Paths, Boundary Spanners, Peripheral Players

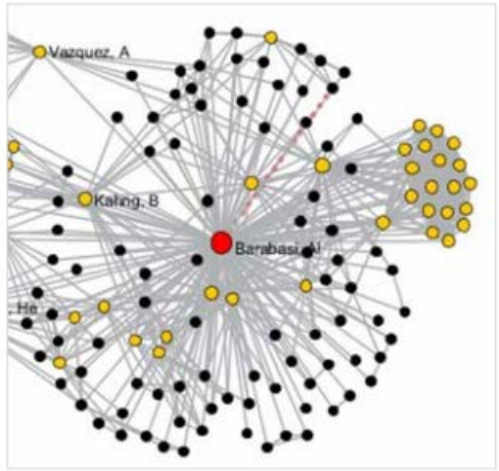
Statistical Network Properties



Clustering coefficient: Measures the average probability that two neighbors of the node i are also connected.

Node degree distribution P(k): probability that any randomly chosen node has degree k.

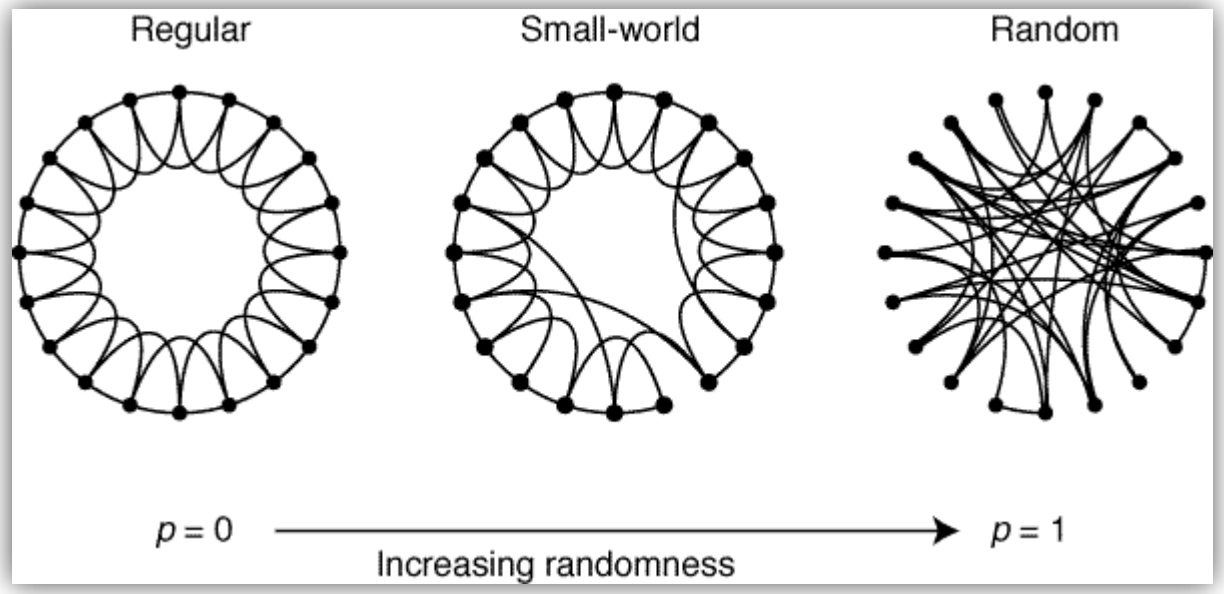




Some Network Properties

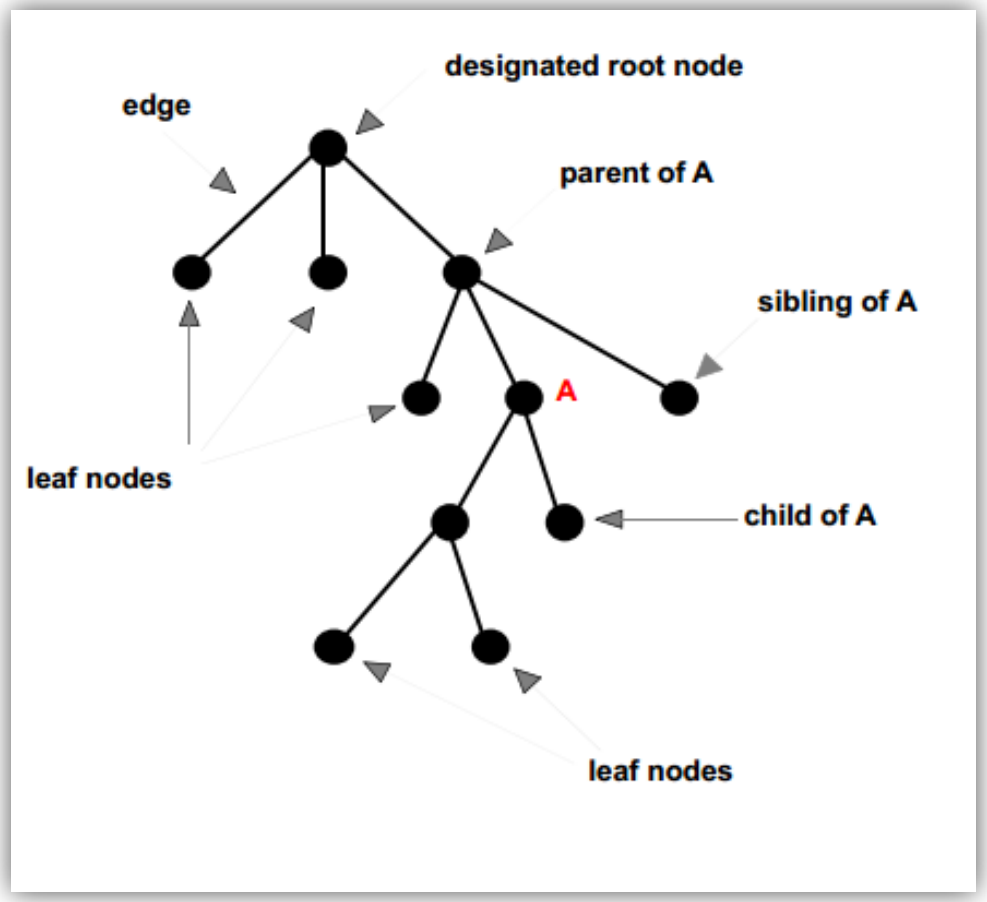
Average clustering coefficient (C):
Average probability that two neighbors of the node *i* are also connected.

Average path length (l):
Average number of steps along the shortest paths for all possible pairs of network nodes.



Duncan J. Watts and Steven H. Strogatz *Nature* **393**, 440-442(4 June 1998)

Trees: A Special Type of Network



Tree Structures are used to model hierarchical data

– acyclic, i.e. has no cycles or loops

– usually undirected

– usually rooted (a single node at top)

– subgraphs are also a trees (subtree)

Ooh, pretty!

Making a Network look good

Aesthetic Considerations

Crossings – minimize towards planar

Total Edge Length – minimize to proper scale

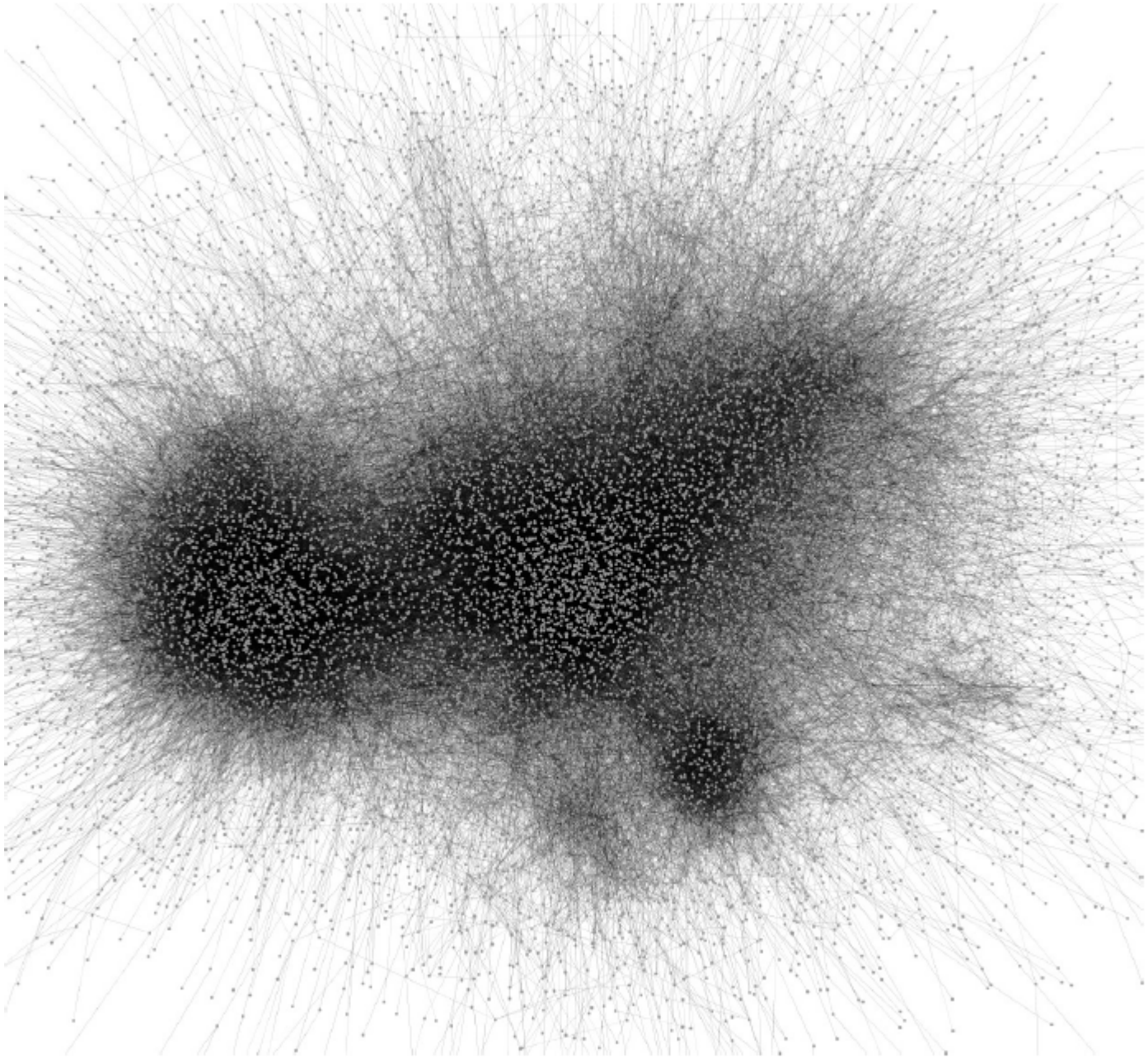
Area – minimize towards efficiency

Max Edge Length vs Uniform Edge Length

Total Bends – minimize orthogonal

Distribution | Symmetry | Flow

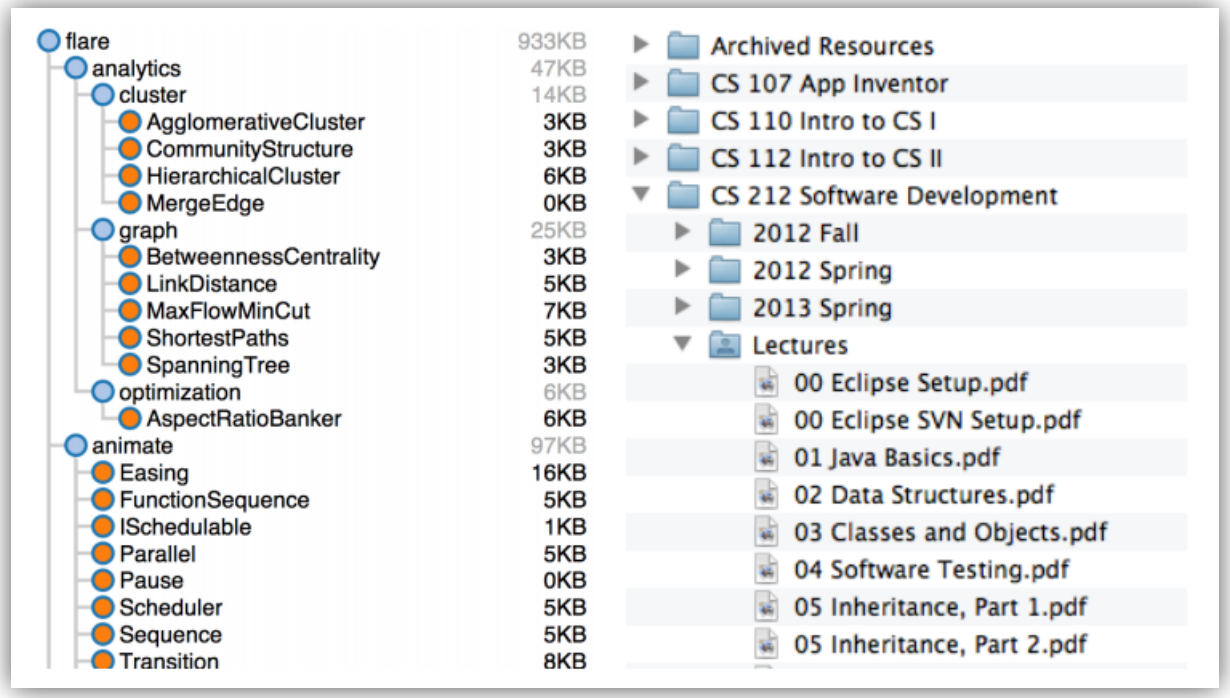
Space



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

Common Layouts

- **Node Link**

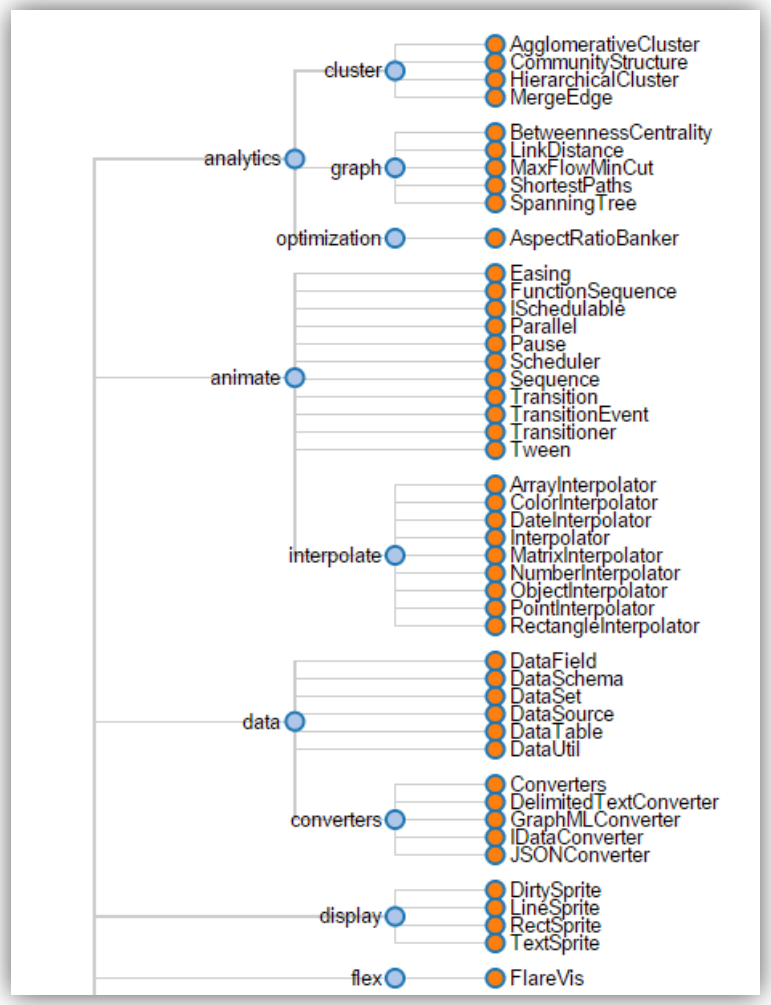


http://mbostock.github.io/protovis/ex/indent.html

Common Layouts

- **Node Link**

  A ***dendrogram*** (or cluster layout) is a node-link diagram that places leaf nodes of the tree at the same depth.

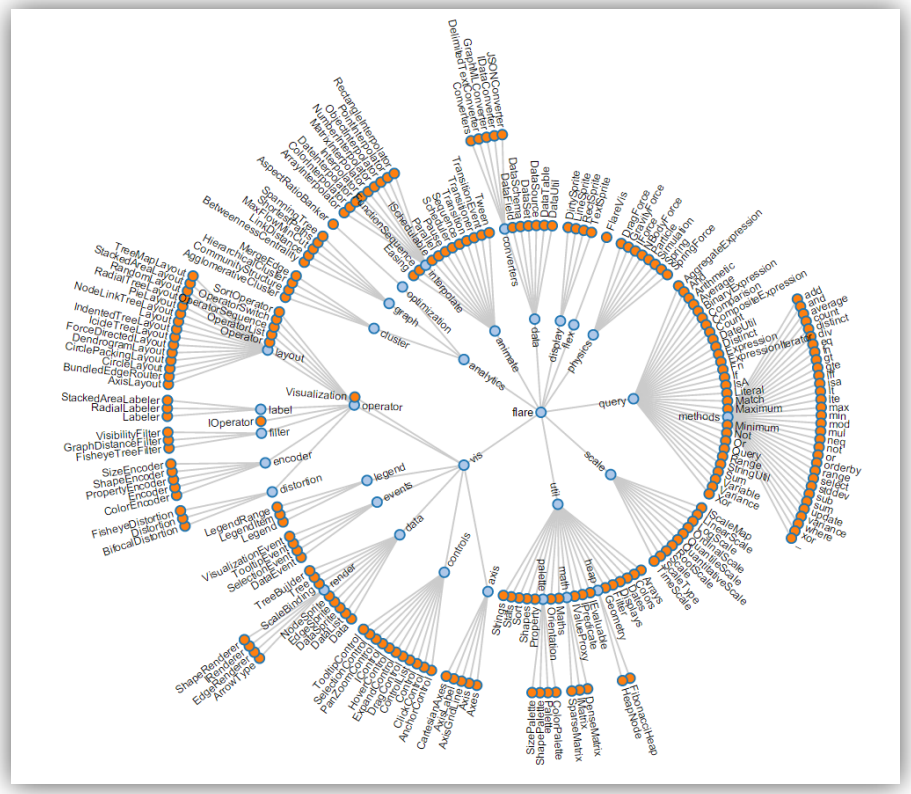


http://mbostock.github.io/protovis/ex/dendrogram.html

Common Layouts

- **Node Link**

  The ***Reingold-Tilford*** algorithm for efficient, tidy and radial arrangement of layered nodes.



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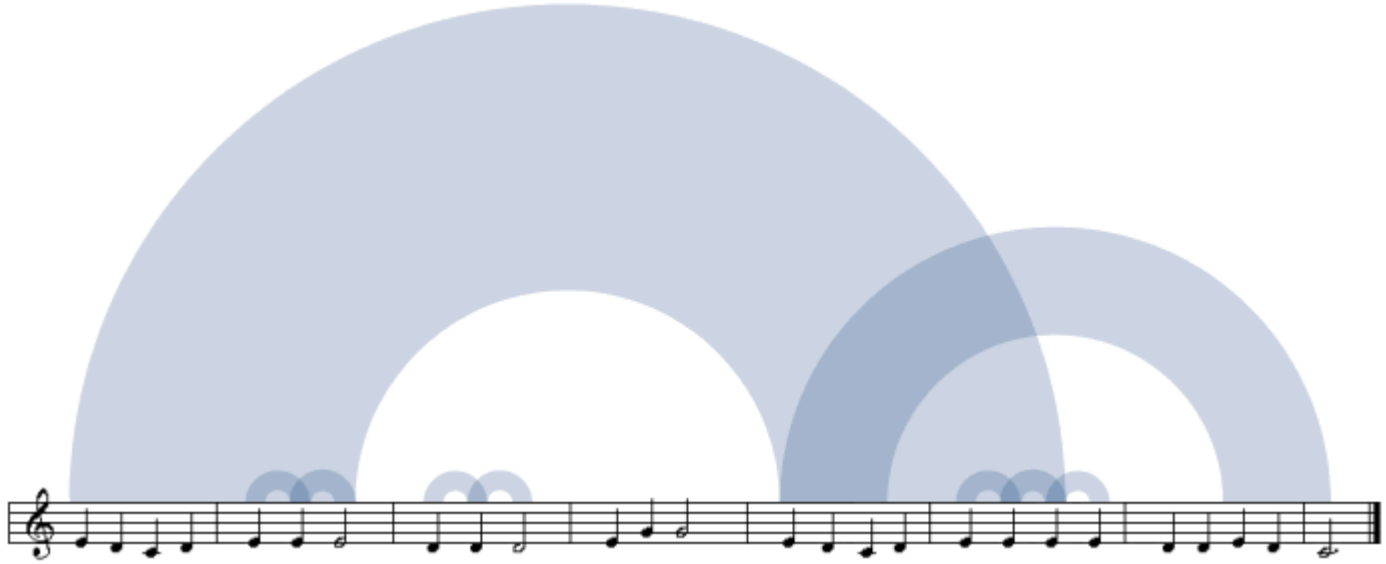
Common Layouts

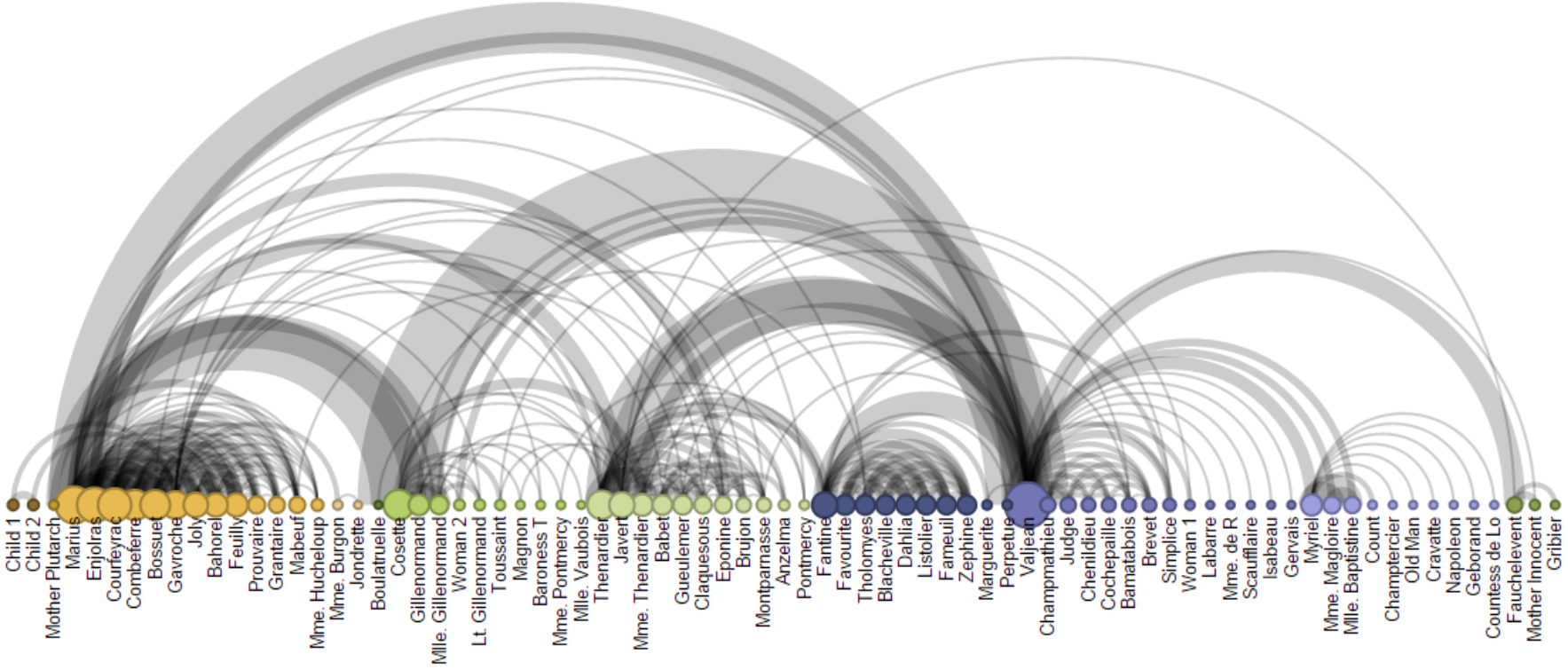
- Node Link
- **Arc Diagrams**



The diagrams in *The Shape of Song* display musical form as a sequence of translucent arches. Each arch connects two repeated, identical passages of a composition. By using repeated passages as signposts, the diagram illustrates the deep structure of the composition.

Common Layouts

- Node Link
- **Arc Diagrams**



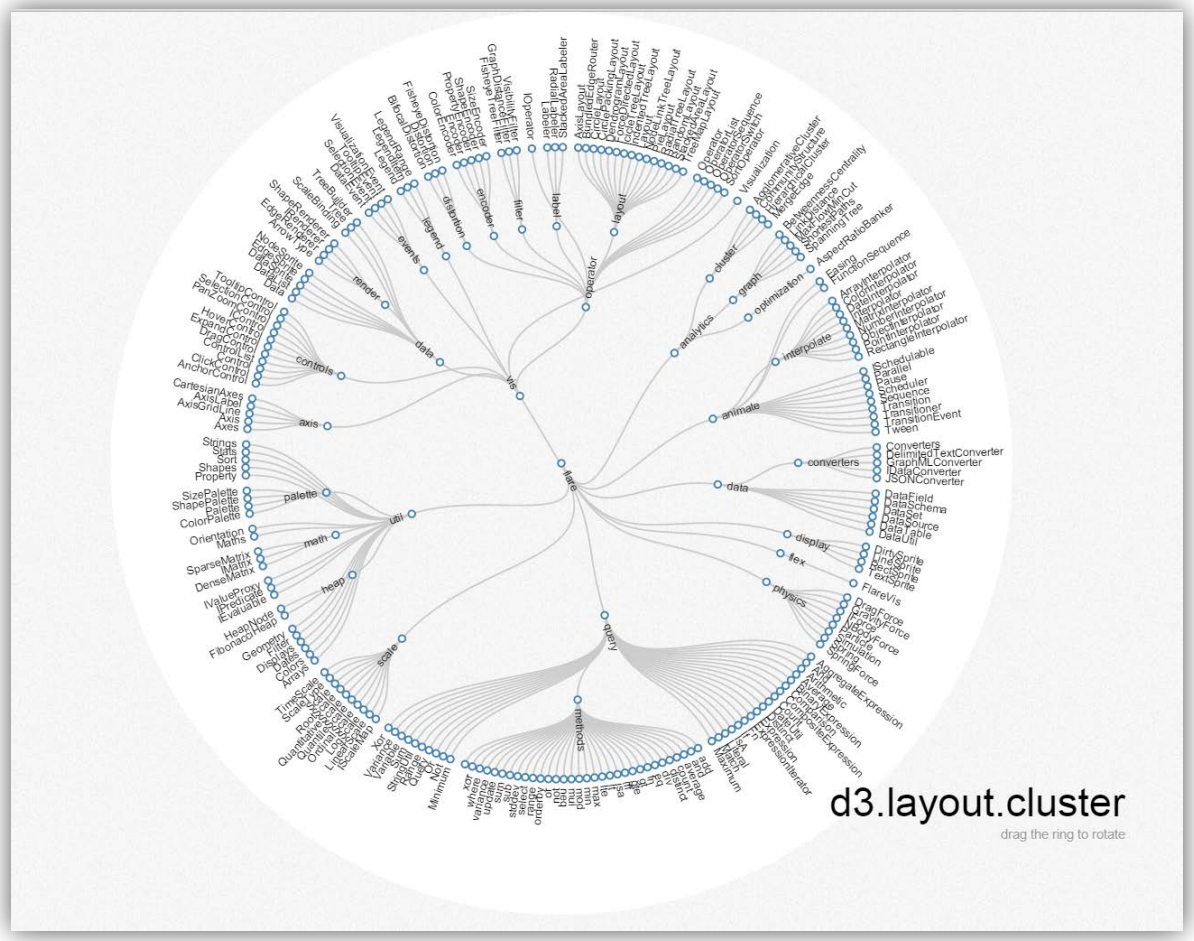
Character co-occurrence in *Les Misérables*. Node colors depict cluster memberships computed by a community-detection algorithm.

Knuth, D. E. 1993. *The Stanford GraphBase: A Platform for Combinatorial Computing*, Addison-Wesley.

Common Layouts

- Node Link
- Arc Diagrams
- **Circle Layout**

  Concentric circles of hierarchy
  - Nodes are evenly distributed
  - Branches do not overlap



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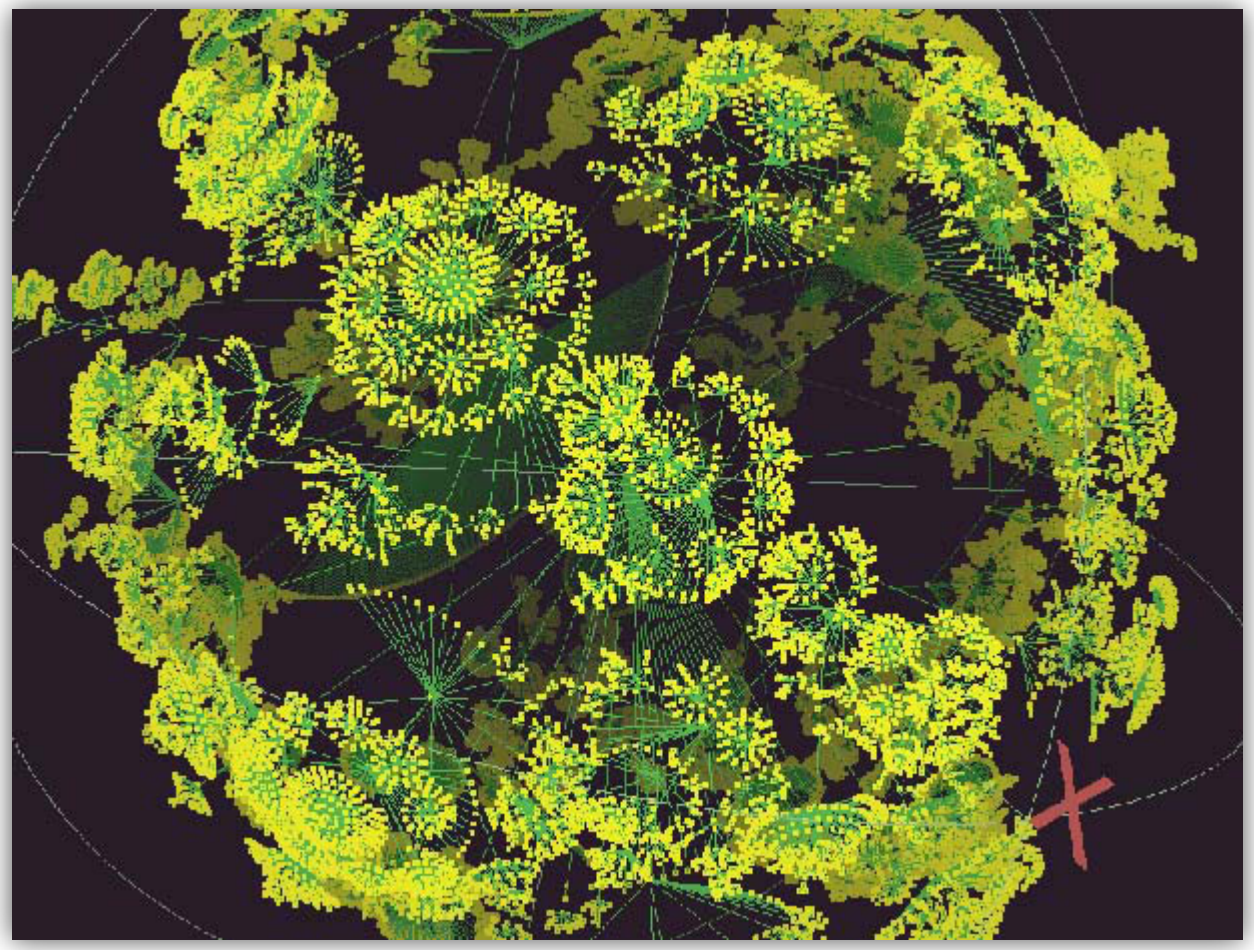

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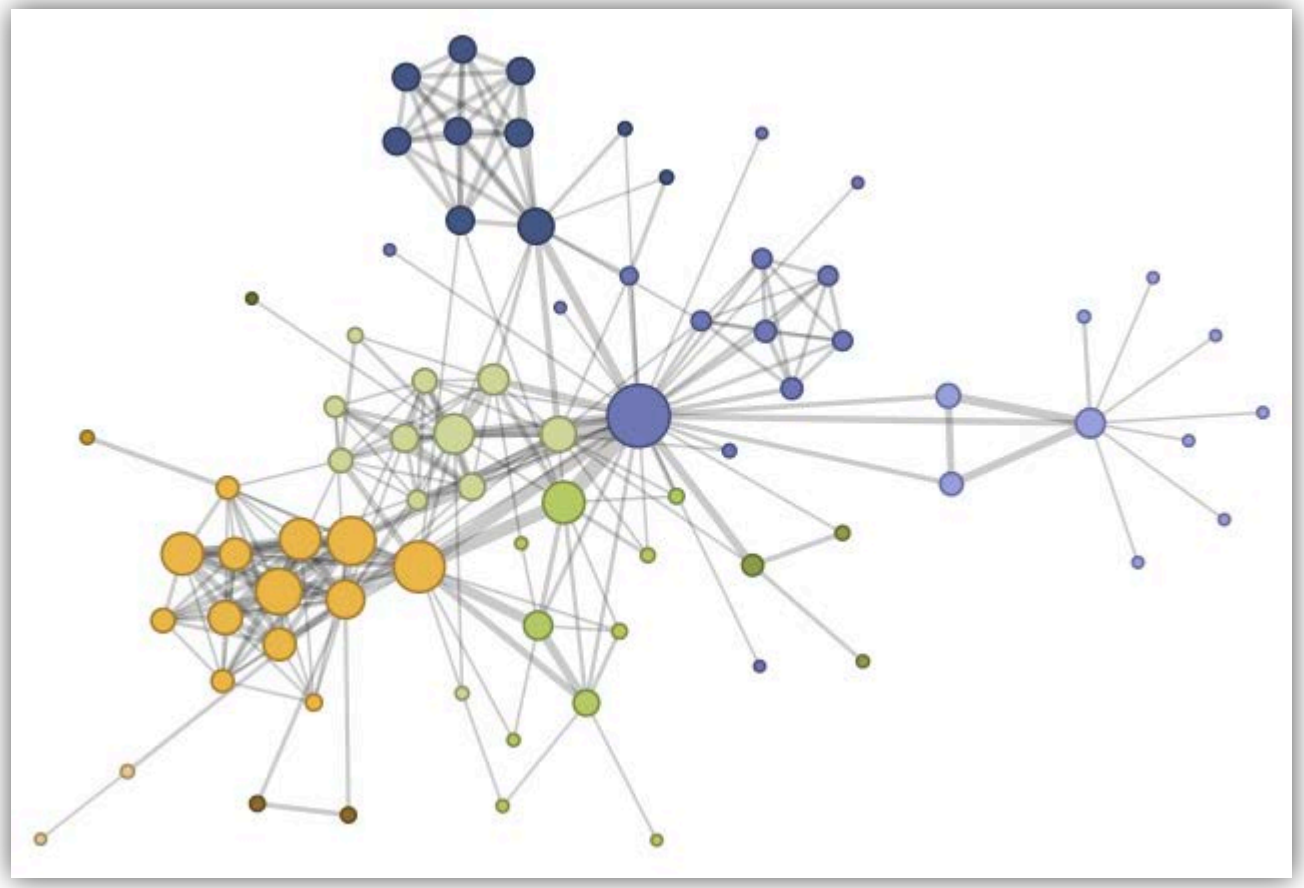
Common Layouts

- Node Link
- Arc Diagrams
- Circle Layout
- **Spring and Force-Directed Layouts**
  - Fruchterman Reingold Layout
  - Kamada Kawai Layout
  - Generalized Expectation Max (GEM)



http://homes.cs.washington.edu/~jheer/files/zoo/

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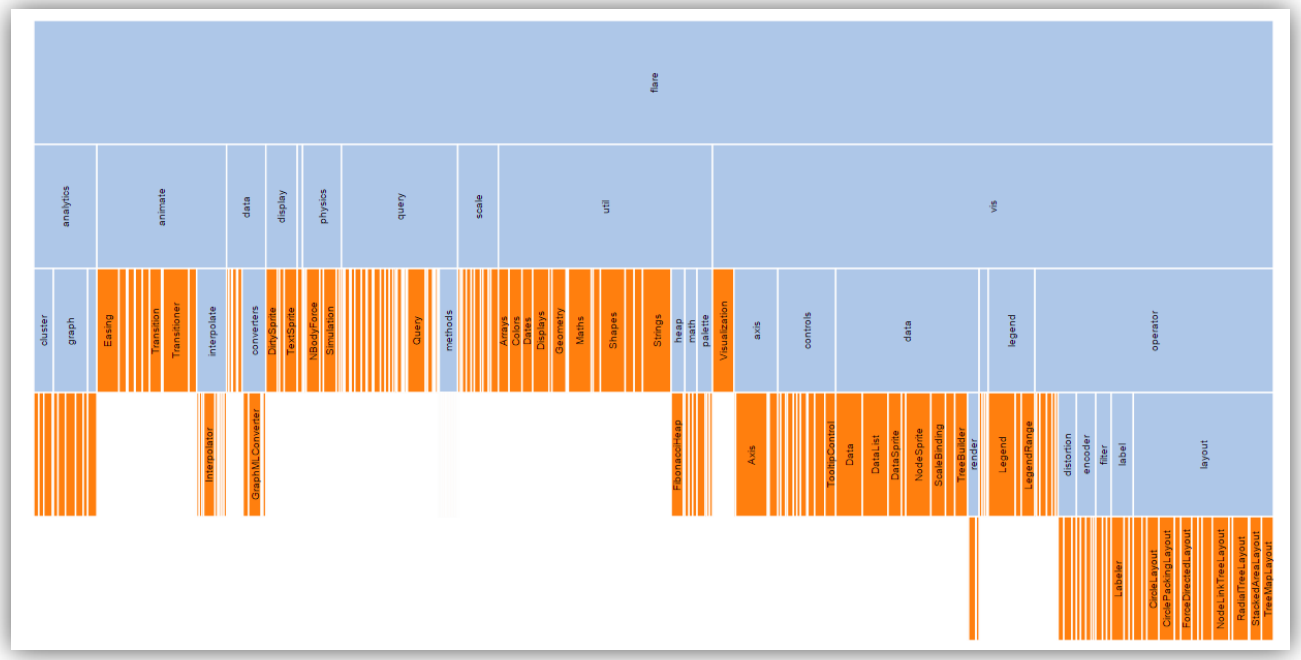
- **Space Filling**
  - Icicle
  - Sunburst
  - Treemap



http://homes.cs.washington.edu/~jheer/files/zoo/ex/hierarchies/icicle.html - Flare Visualization Toolkit

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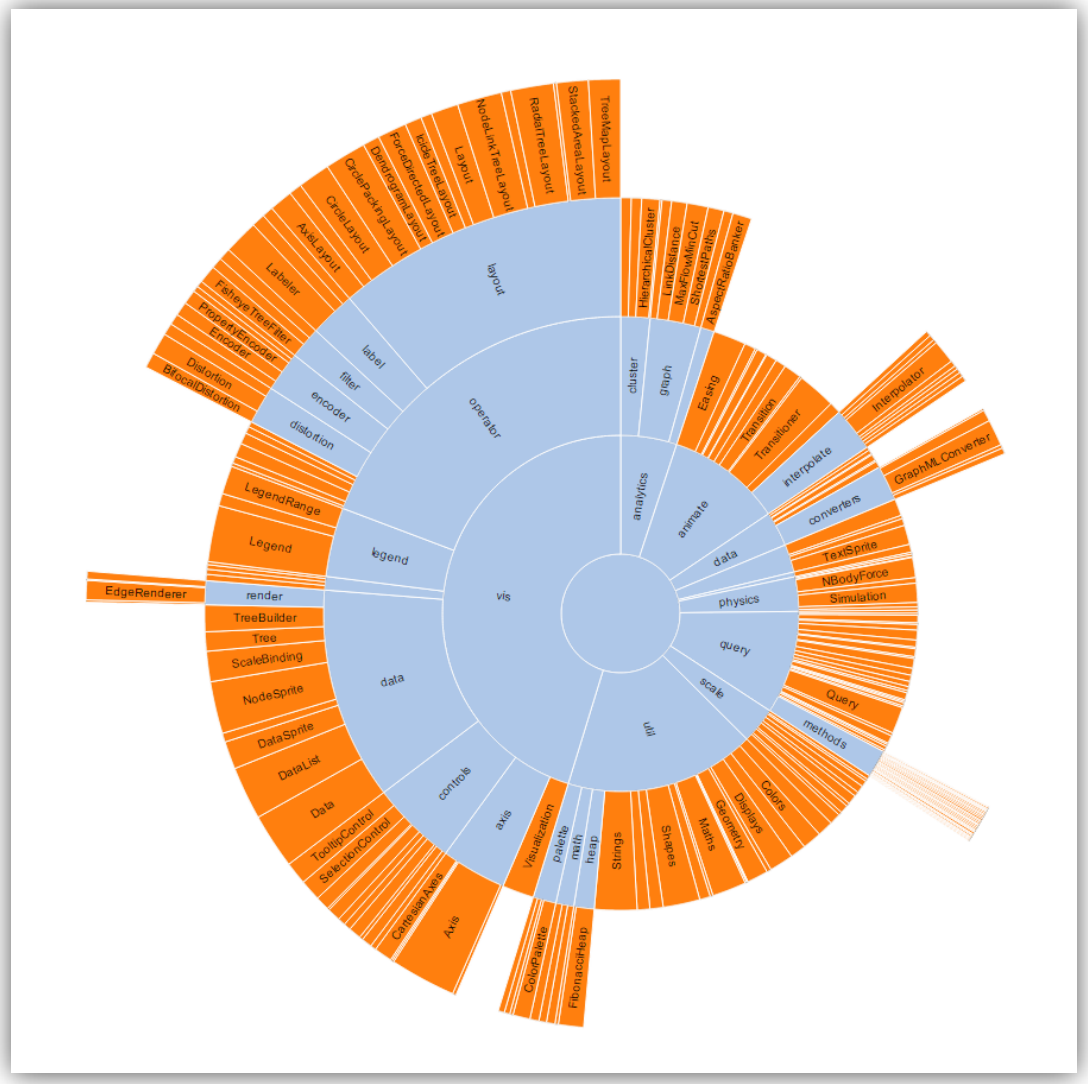

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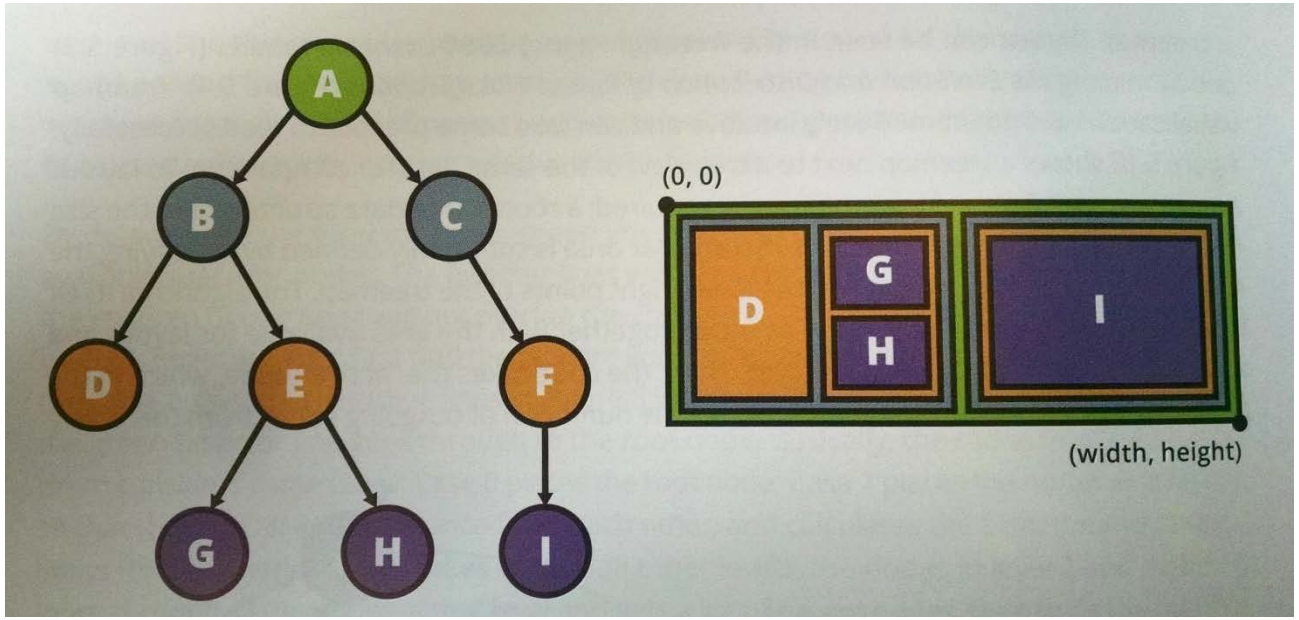


Image from *Visual Insights* by Borner and Polley, 2014

Visual Complexity

Suggestions for design from Manuel Lima

Document | Clarify | Reveal | Expand

Visual Complexity by Manuel Lima, 2011

Willard Brinton
Graphic Methods for Presenting Facts 1914

"Though graphic presentations are used to a very large extent today, there are at present no standard rules by which the person preparing a chart ay know that he is following good practice. This is unfortunate because it permits every one making a chart follow his own sweet will."

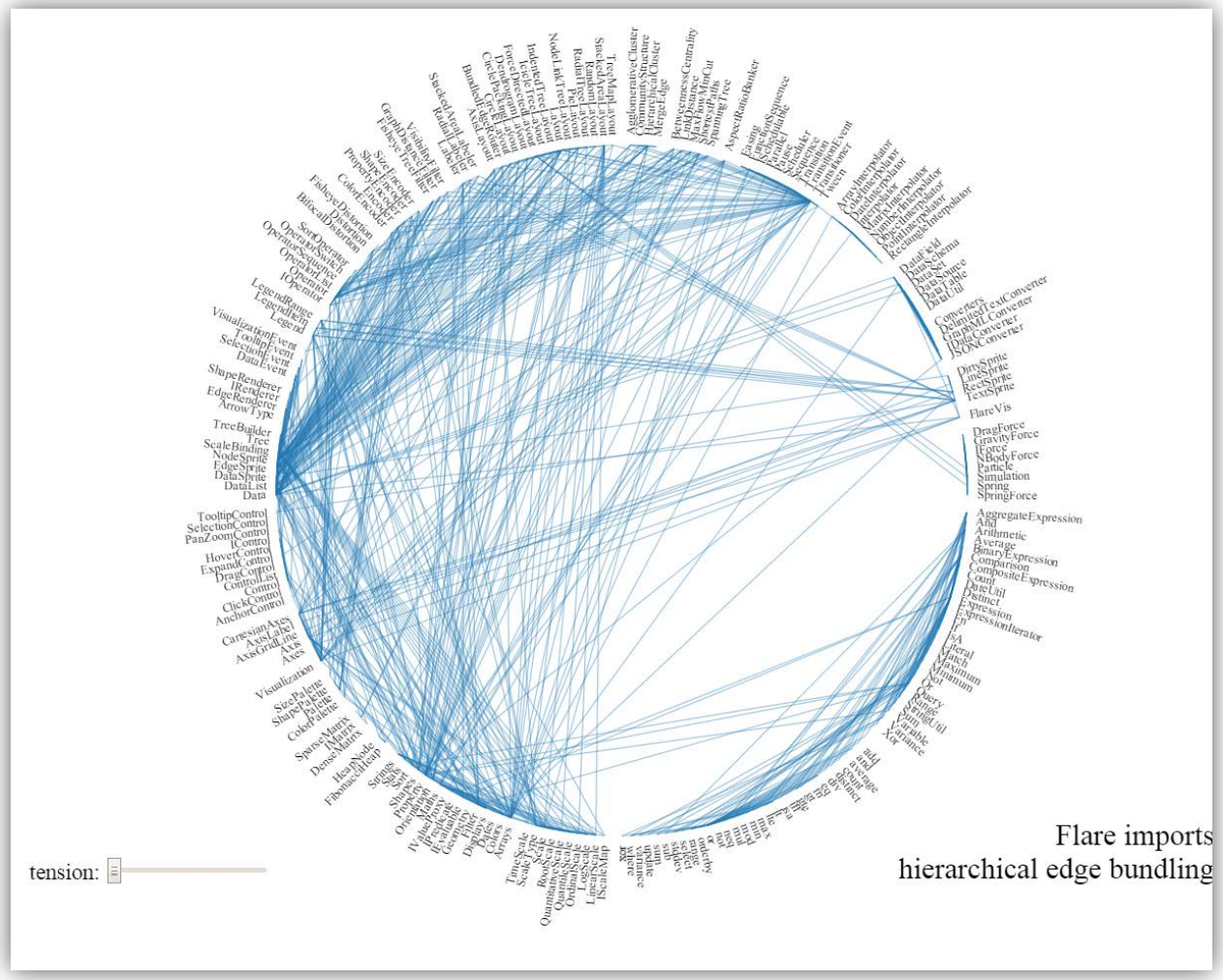
Suggestions for Network Visualization Design

1. Start with a Question
2. Look for Relevancy
3. Enable Multivariate Analysis
4. Embrace Time
5. Enrich your vocabulary: visual encoding
    - Richer nodes
    - Expressive edges
    - Clear visual languages: legen… wait for it…. dary!
6. Expose Grouping
    - Similarity | proximity | common fate (motion)
7. Maximize Scaling:
    - Macro view: pattern
    - Relationship: connectivity, analytics
    - Micro: individual nodes
8. Manage intricacy
    - “Overview first, zoom and filter, then details on demand” – Ben Schneiderman

Special Topics

Technology is cool…

Bundling (more than cable, internet and phone)



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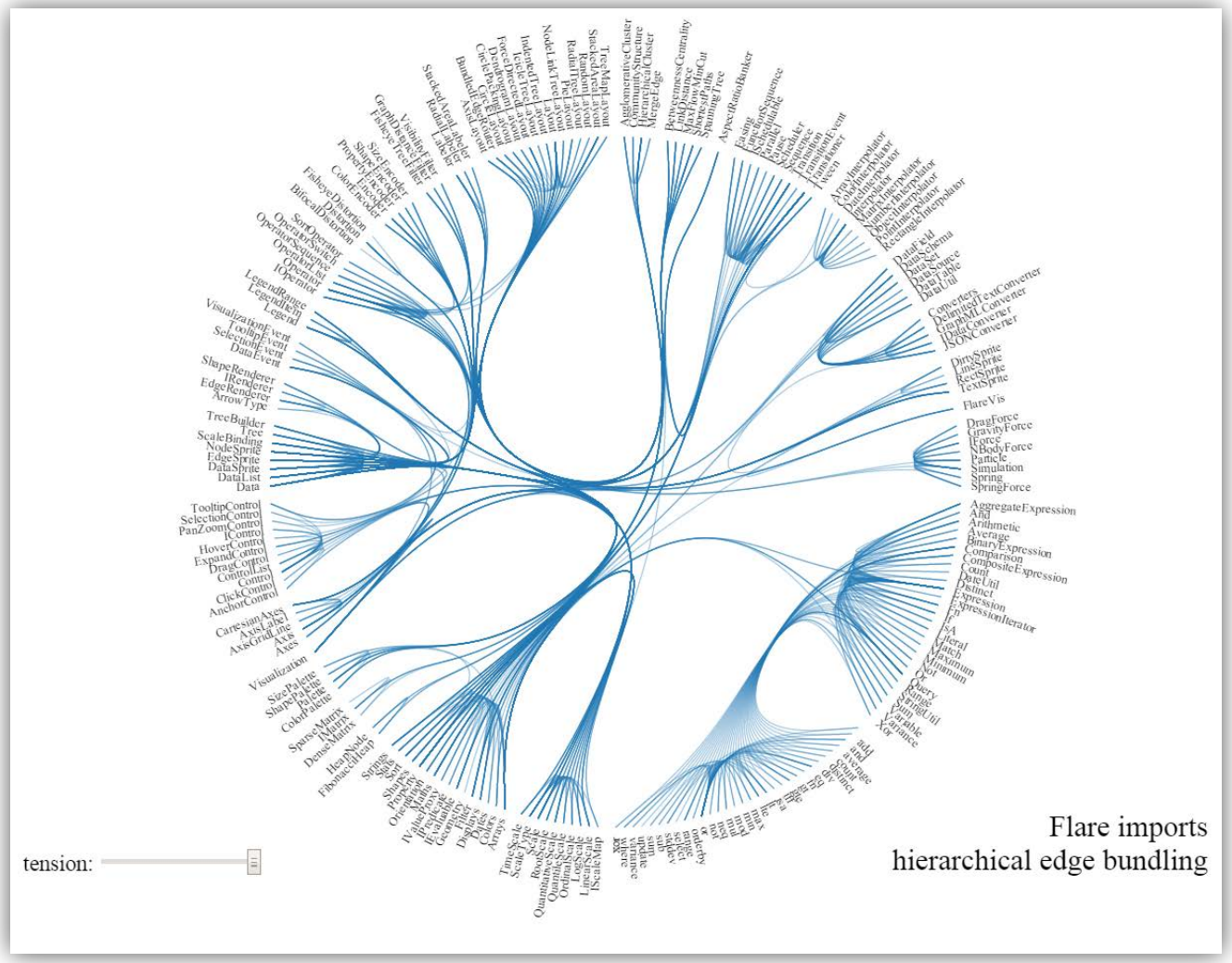

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