Trees and Networks

Edges and Nodes are Sexy
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)

![Diagram of a network with labeled nodes and edges]

**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.
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**

http://www.orgnet.com/sna.html
**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 $k$. 

![Graph with nodes A, B, C, D, E, F, G, H, I, J and a degree distribution plot.](image)
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.

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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**
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.

http://mbostock.github.io/protovis/ex/tree.html
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.
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- **Circle Layout**
  
  Concentric circles of hierarchy
  
  - Nodes are evenly distributed
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- 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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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
“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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