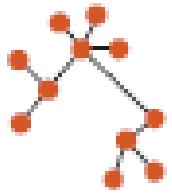
Chapter 9 – Networks and Trees

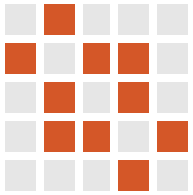
10/27/20

Arrange Networks and Trees

Node–Link Diagrams
Connection Marks
✔ NETWORKS ✔ TREES



Adjacency Matrix
Derived Table
✔ NETWORKS ✔ TREES

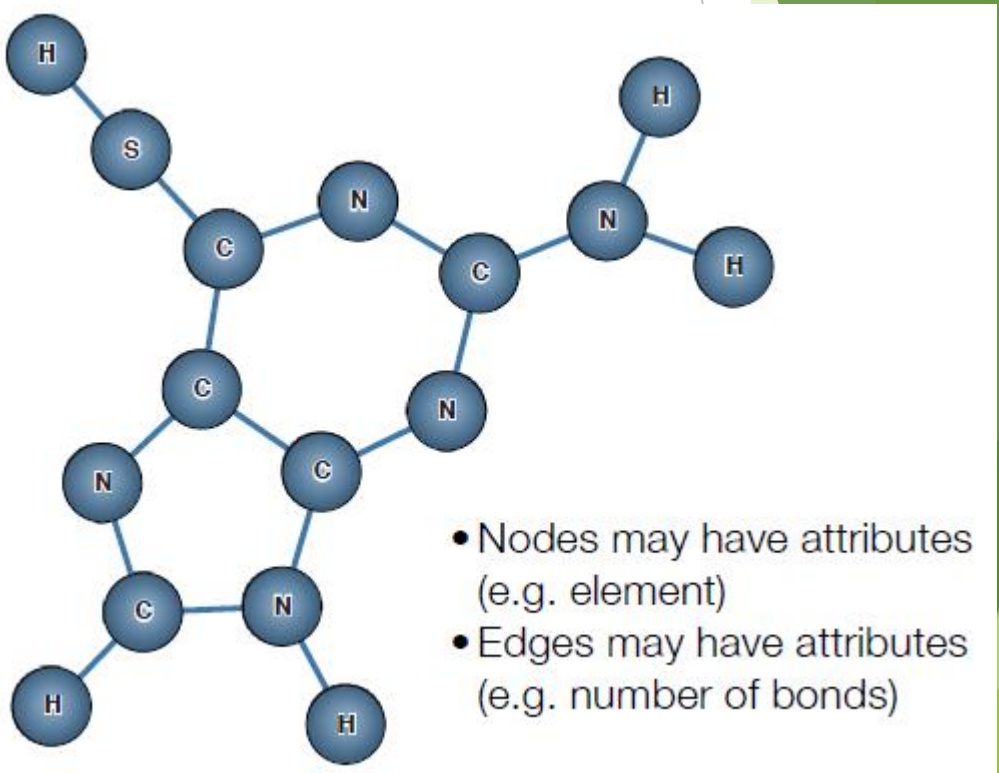


Enclosure
Containment Marks
✘ NETWORKS ✔ TREES

Networks

Node-Link Diagrams

- Data: nodes and edges
- Task: understand connectivity, paths, structure (topology)
- Encoding:
  - nodes as point marks (distributed in space), connections by line marks (straight or curved)
  - space used to communicate hierarchical orientation
- Scalability: hundreds

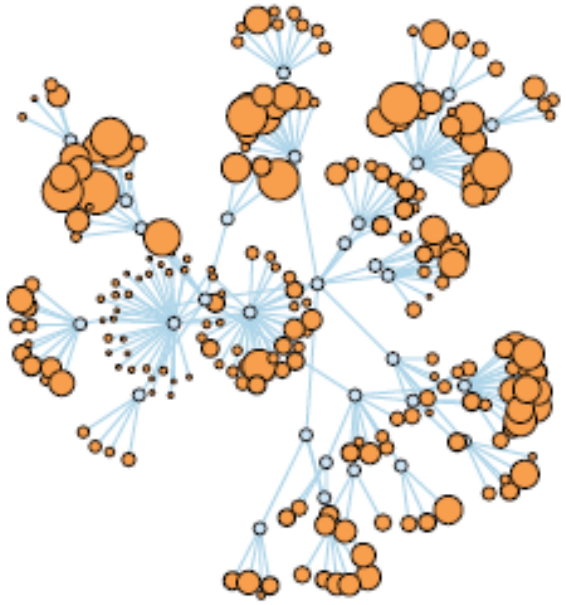


Social Networks

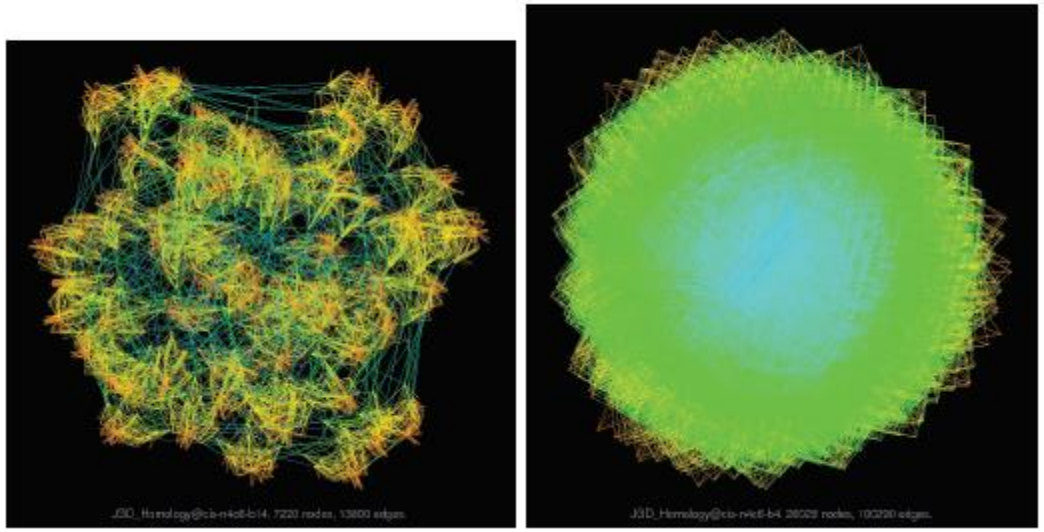
[P. Butler, 2010]

Force-Directed Network Layout

- Algorithm
- Nodes push away from each other but edges are springs that pull them together
- Weakness: nondeterministic, algorithm may produce different results each time it runs
- (Deterministic approaches such as bar charts and scatterplots)

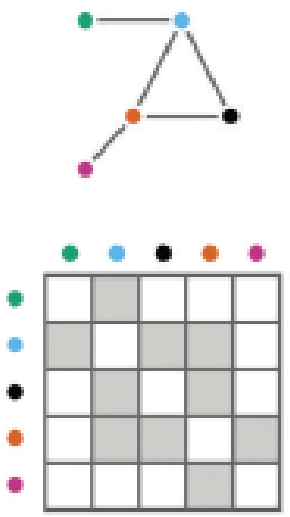


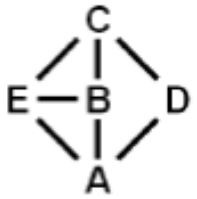
Force-Directed Network Layout Limitations

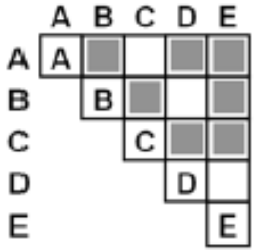


Adjacency Matrix

- Change network to tabular data and use a matrix representation
- Derived data: nodes are keys, edges are Boolean values
- Task: lookup connections, find well-connected clusters
- Scalability: millions of edges







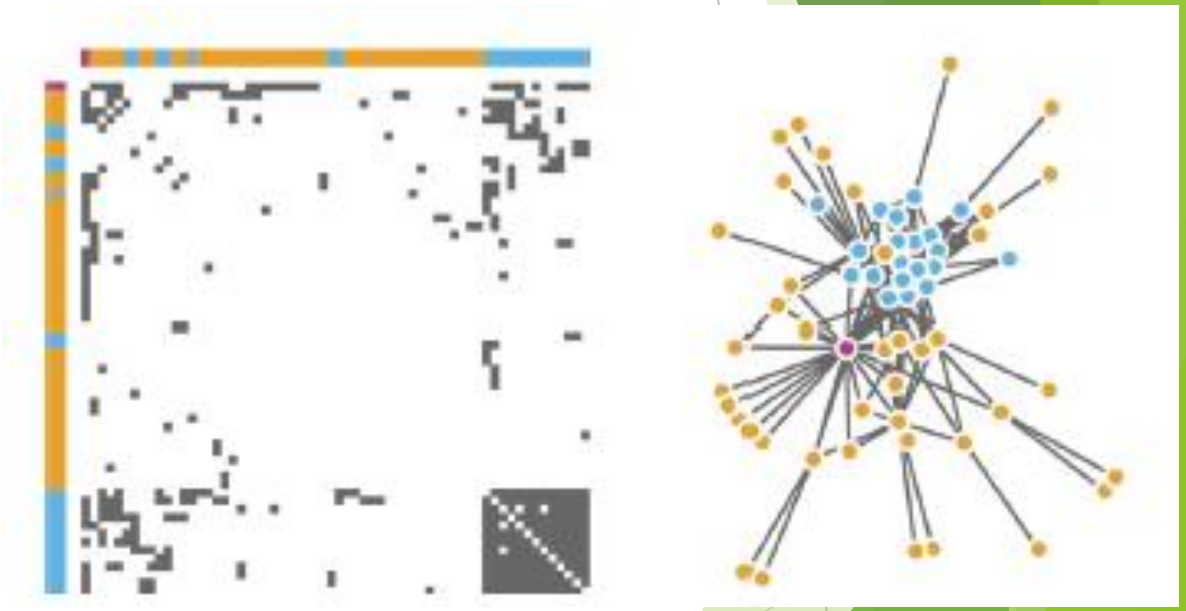
[Henry et al., 2007]

Adjacency Matrix

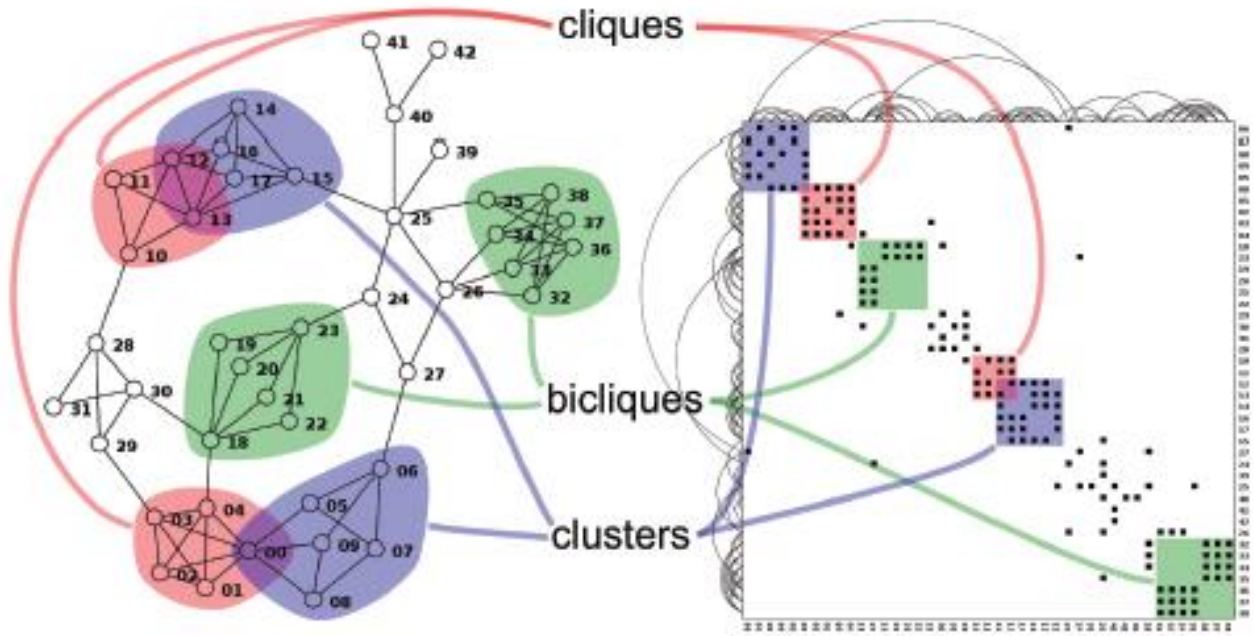
- Encoding of additional information about another attribute:
  - Coloring matrix cells
  - Size coding (limited by pixel availability per cell; typically only a few levels would be distinguishable between largest and smallest size)
  - Show weighted networks; link has an associated quantitative value attribute encoded by an ordered channel such as luminance or size

Node-Link or Adjacency Matrix?

- Empirical study:
  - Node-link better for small graphs; familiarity among audience as well
  - Adjacency better for large graphs; unfamiliarity
- Multi-link paths hard with adjacency matrix
- More familiarity with node-link diagrams
- Link density problematic with node-link but not with adjacency matrices



Structures from Adjacency Matrices

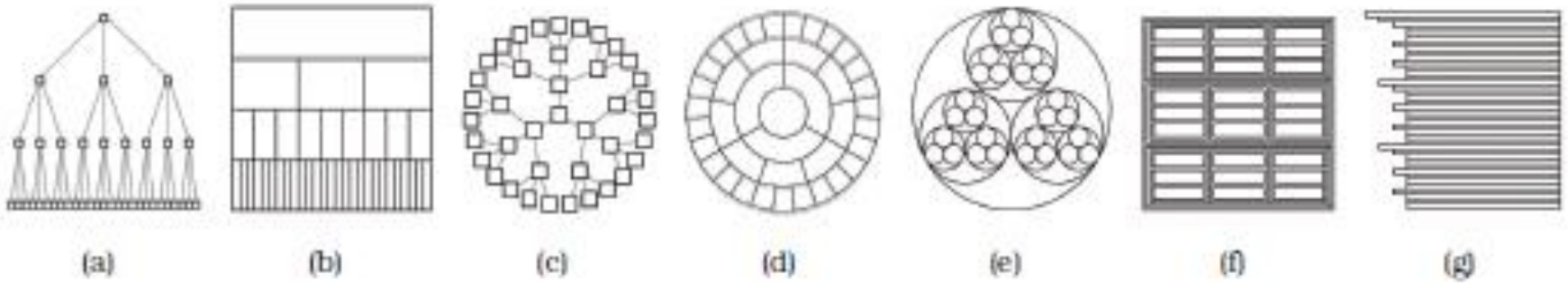


Trees

Trees

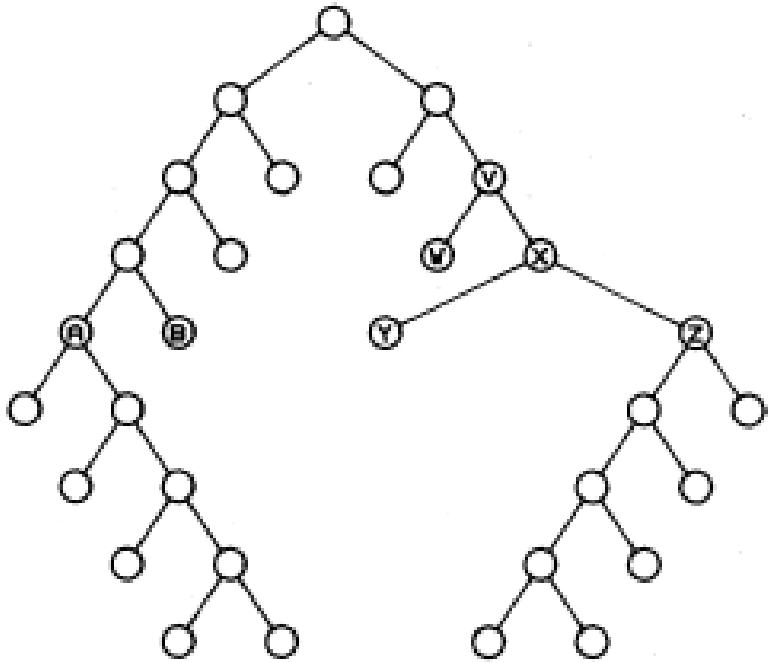
- Directed acyclic graphs
  - Each edge has a direction; origin is the parent, destination is the child
- Has a root and every other node hangs off it
- Can consider enclosure in trees using parent-child relationships
- Primary concern: spatial layout of nodes and edges
- Goal is to effectively depict the graph structure:
  - Connectivity, path-following
  - Network distance
  - Clustering
  - Ordering (e.g. hierarchy level)

Tree Visualizations



Node-Link Diagram

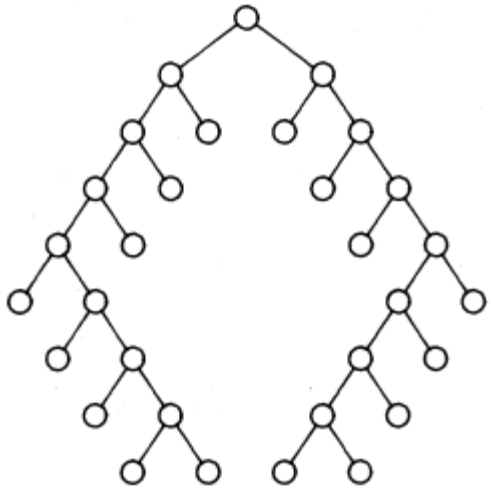
- Trees are graphs, but with more structure
- Horizontal or vertical
- Parent-child relationship



[WS Alg., Reingold and Tilford, 1981]

Reingold-Tilford Algorithm

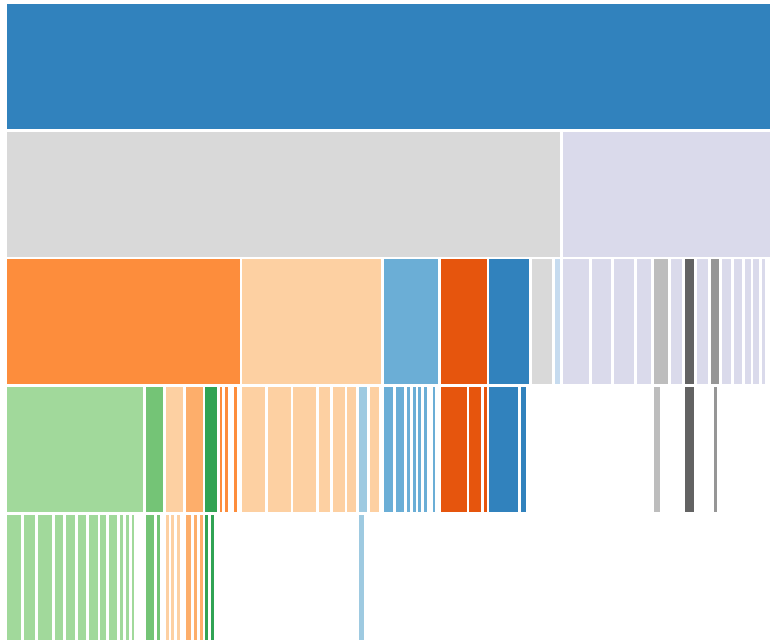
- Goal:
  - Make smarter use of space
  - Maximize density and symmetry
- Design concerns
  - Clearly encode depth level
  - No edge crossings
  - Isomorphic subtrees drawn identically
  - Compact
- Approach
  - Bottom up recursive approach
  - Make sure every subtree is drawn for each parent
  - Pack subtrees as closely as possible
  - Center parent over subtrees



[Reingold and Tilford, 1981]

Icicle Plot

- Line marks
- Depth shown by vertical positioning
- Links and sibling order shown by horizontal positioning



[Bostock, 2011]

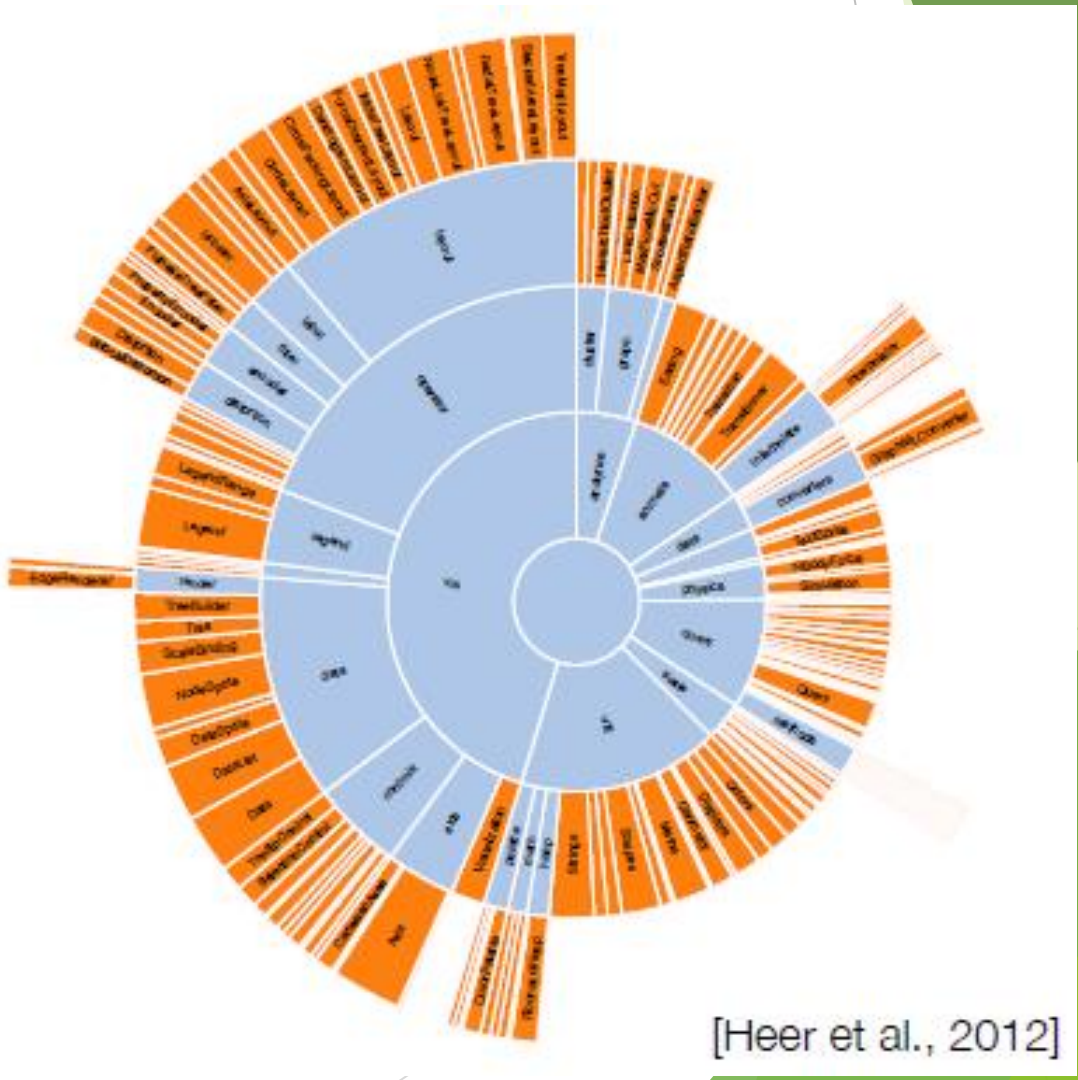
Radial Node-Link

- Use polar coordinates instead of rectilinear
- Same layout algorithm works (e.g. Reingold-Tilford)
- Benefit: space usage, labels

https://observablehq.com/@d3/radial-tidy-t

Sunburst

- Icicle plot in radial layout
- Reading labels?
- Intuitive imagination

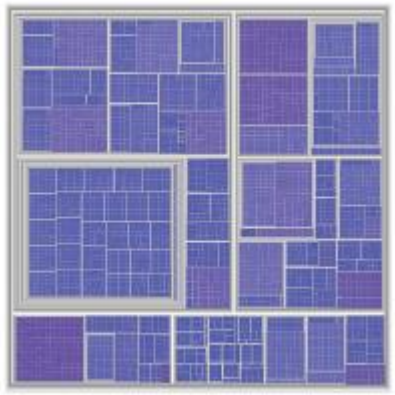


[Heer et al., 2012]

Trees - Containment

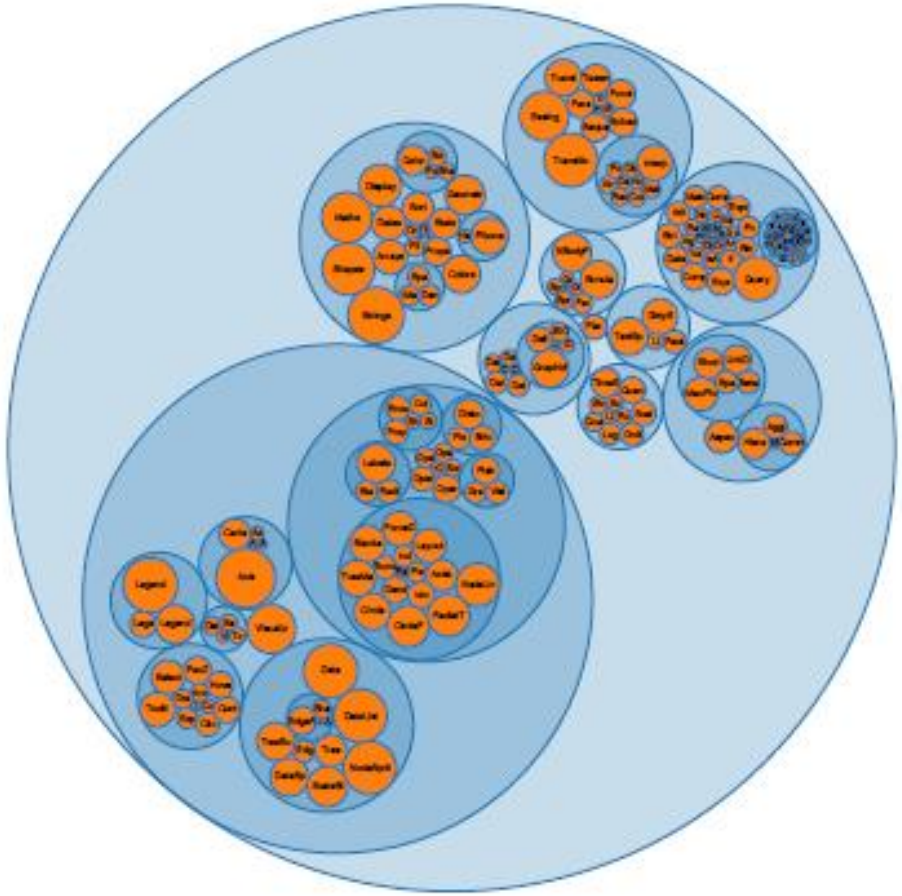
Treemaps

- Containment marks instead of connection marks
- Orientation of division (horizontal/vertical) changes at each step
- Not as easy to see the intermediate rectangles
- Scalability: millions of leaf nodes and links possible



Nested Circles

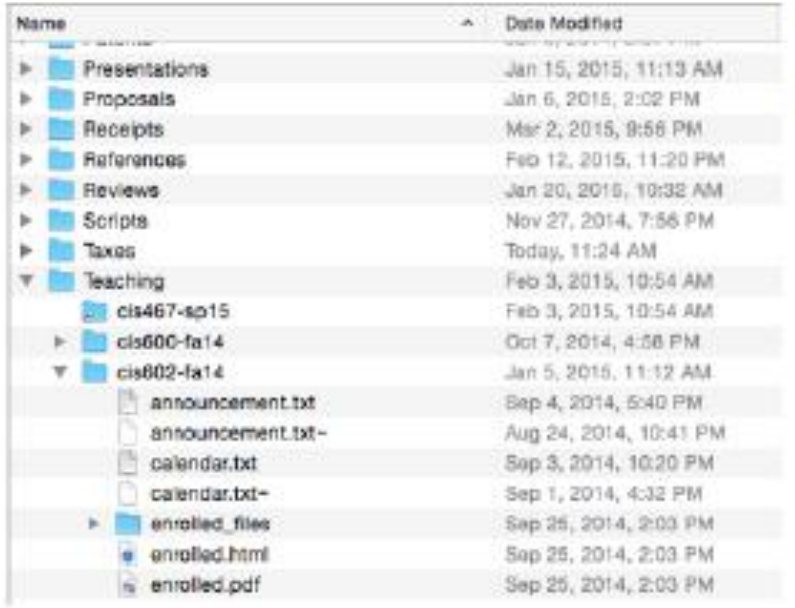
- Looks like a cluster diagram, but shows hierarchy
- Containment shown by layering of semi-transparent circles
- Labeling is more difficult



[Bostock, 2012]

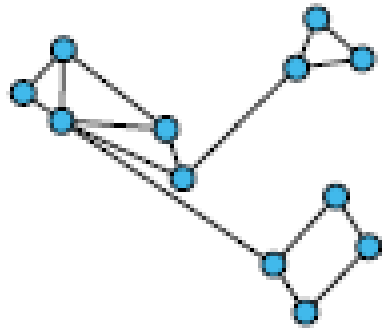
Indented Outline

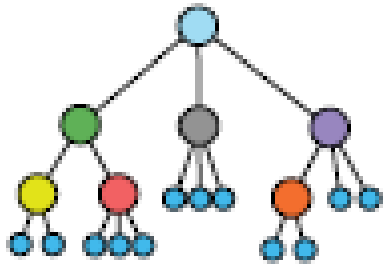
- Similar to a filesystem tree
- Horizontal position shows depth, vertical positions shows sibling/order

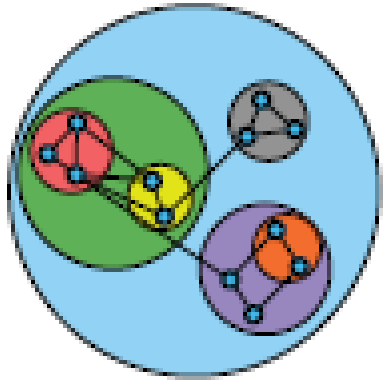


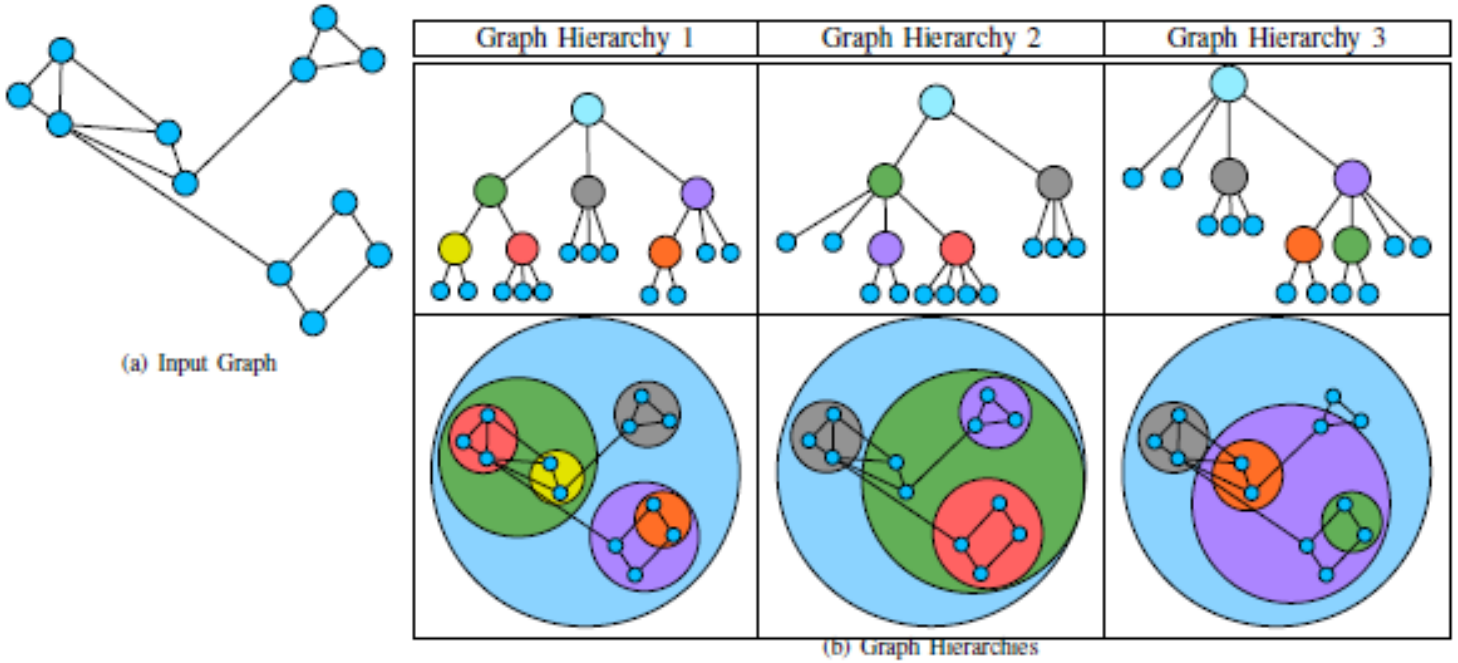
Compound Networks

- Add a hierarchy to the network (e.g. from clustering)
- GrouseFlocks: uses nested circles with colors









(a) Input Graph

(b) Graph Hierarchies

[Archambault et al., 2008]

Sources/Credits

- Tamara Munzner, Visualization Analysis & Design, A K Peters Visualization Series, CRC Press, 2014.
- Utah, Miriah Meyer, Visualization (2014).
- UMass Dartmouth, David Koop, Data Visualization (2015).