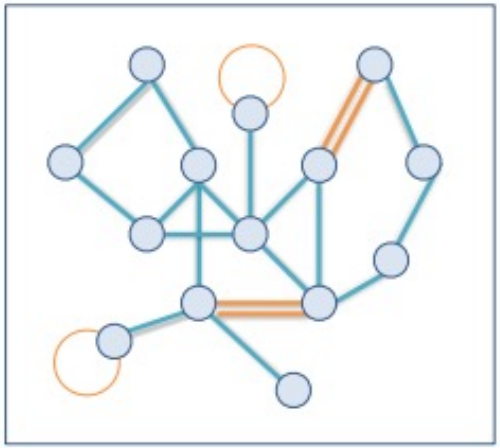
HA NOI UNIVERSITY OF SCIENCE AND TECHNOLOGY
SCHOOL OF INFORMATION AND COMMUNICATION TECHNOLOGY

Lecture 14 - Graph data visualization

Graph data visualization

Graph

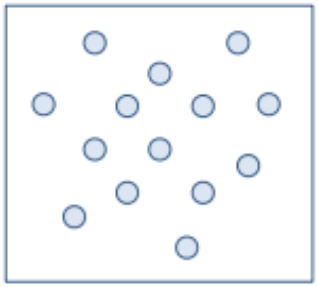
- The graph G(V,E) includes the set of vertices V and the set of edges E
- A simple graph is unweighted, undirected graph containing no graph loops or multiple edges
- Directed graph distinguishes edge AB and edge BA

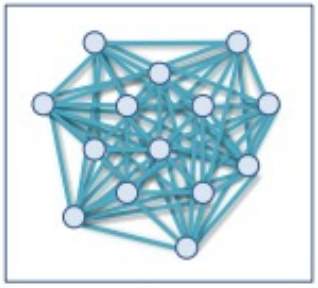


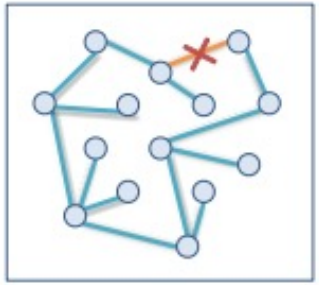
Not a simple graph!
→ A ***general graph***

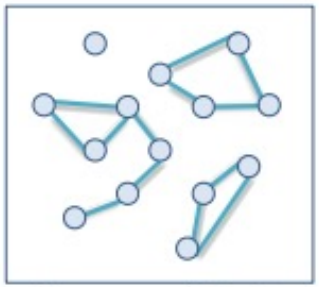
Basic concepts

- **An independent set, stable set, coclique or anticlique** is a set of vertices in a graph, no two of which are adjacent.
- **Clique** is a subset of vertices of an undirected graph such that every two distinct vertices in the clique are adjacent.
- **A graph** is said to be **connected** if every pair of vertices in the graph is connected.
- **A tree** is an undirected graph in which any two vertices are connected by exactly one path, or equivalently a connected acyclic undirected graph.


Independent Set

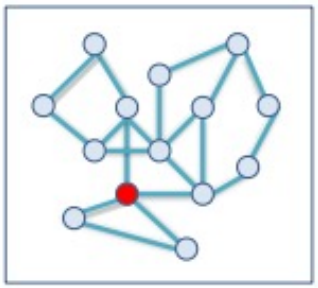

Clique


Tree

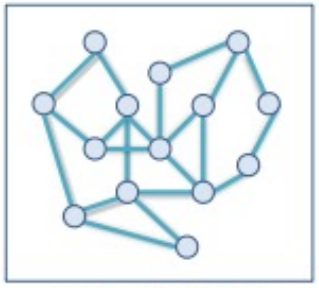

Unconnected Graph

Basic concepts

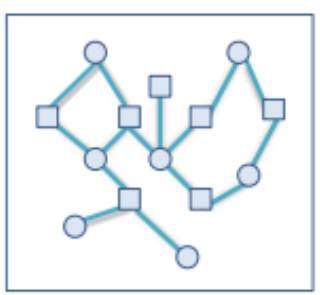
- **An articulation point (or cut vertex) (Điểm khớp)** is defined as a vertex which, when removed along with associated edges, makes the graph disconnected
- **A biconnected graph (đồ thị nối đôi)** is a connected and "nonseparable" graph, meaning that if any one vertex were to be removed, the graph will remain connected.
  - A biconnected graph has no articulation vertices.
- **A bipartite graph (or bigraph) (đồ thị hai phần)** is a graph whose vertices can be divided into two disjoint and independent sets U and V such that every edge connects a vertex in U to one in V

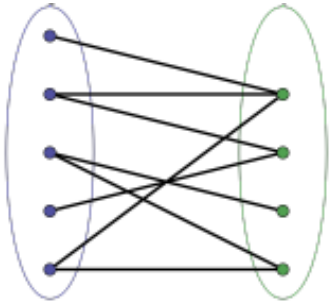


Articulation Point (red)



Biconnected Graph



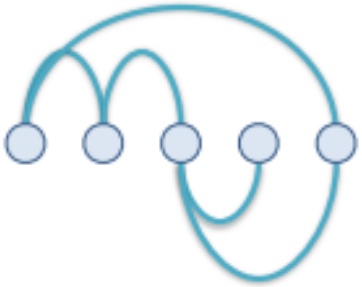


Bipartite Graph

Basic concepts

- Degree (bậc) of a vectex
  - deg(n) is the number of edges that are incident to the vertex
- Graph diameter (đường kính)
  - diam(G) is the greatest distance (shortest parh) between any pair of vertices

Graph visualization

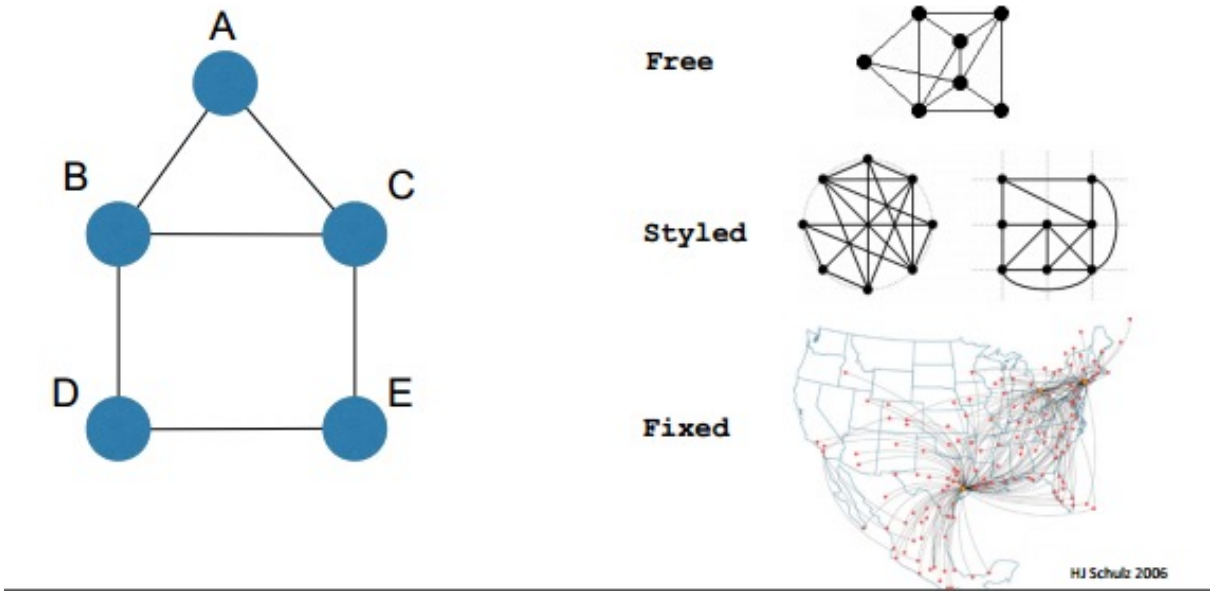


Explicit
(Node-Link)

Matrix

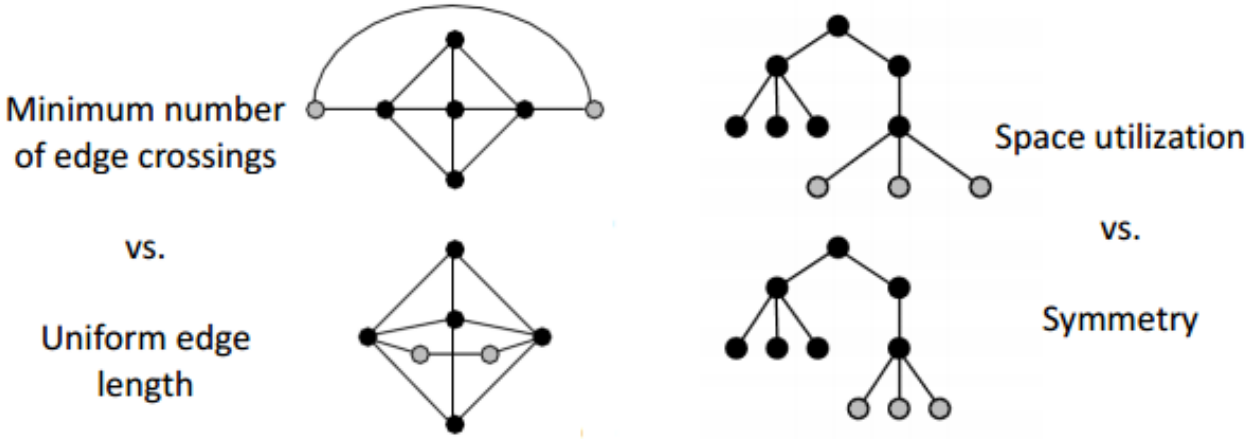
Implicit

Explicit graph visualization (node-link)



Criteria for node-link representation

- Minimizing the intersection edges
- Minimize the distance between the vertices
- Minimize drawing area
- Edges of similar length
- Maximum angle between different edges
- Symmetry (graphs with the same structure must look the same)



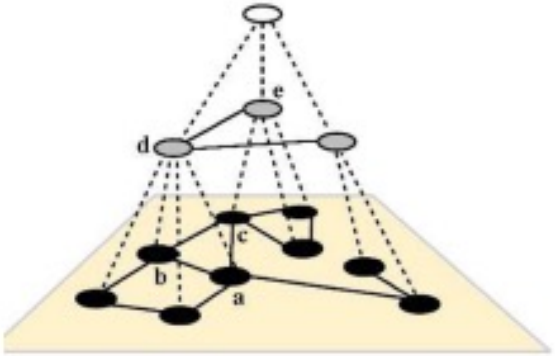
Force-directed graph

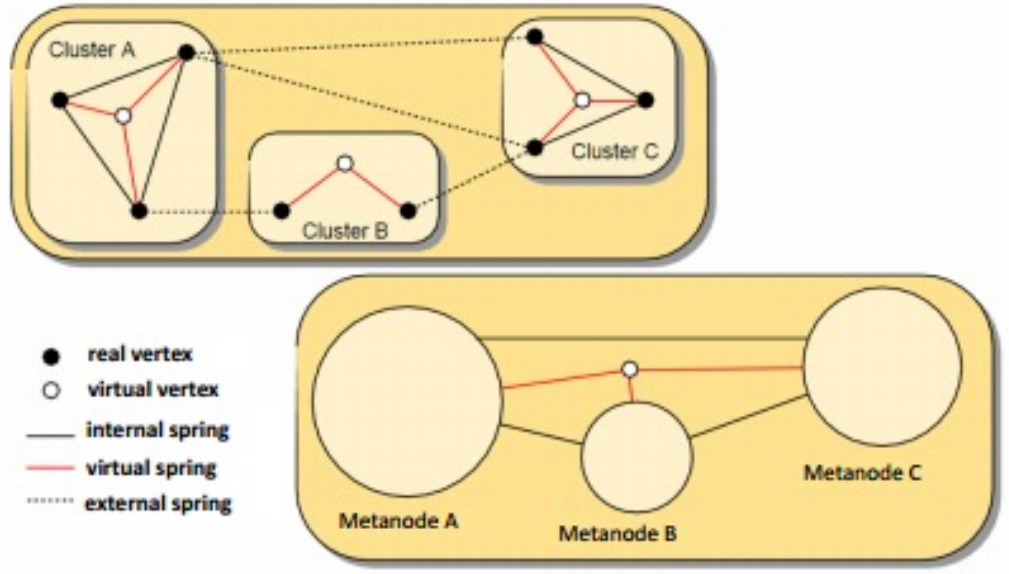
- The forces are applied to the nodes, pulling them closer together or pushing them further apart.
- This is repeated iteratively until the system comes to a mechanical equilibrium state

https://observablehq.com/@d3/force-directed-graph

Multi-level technique

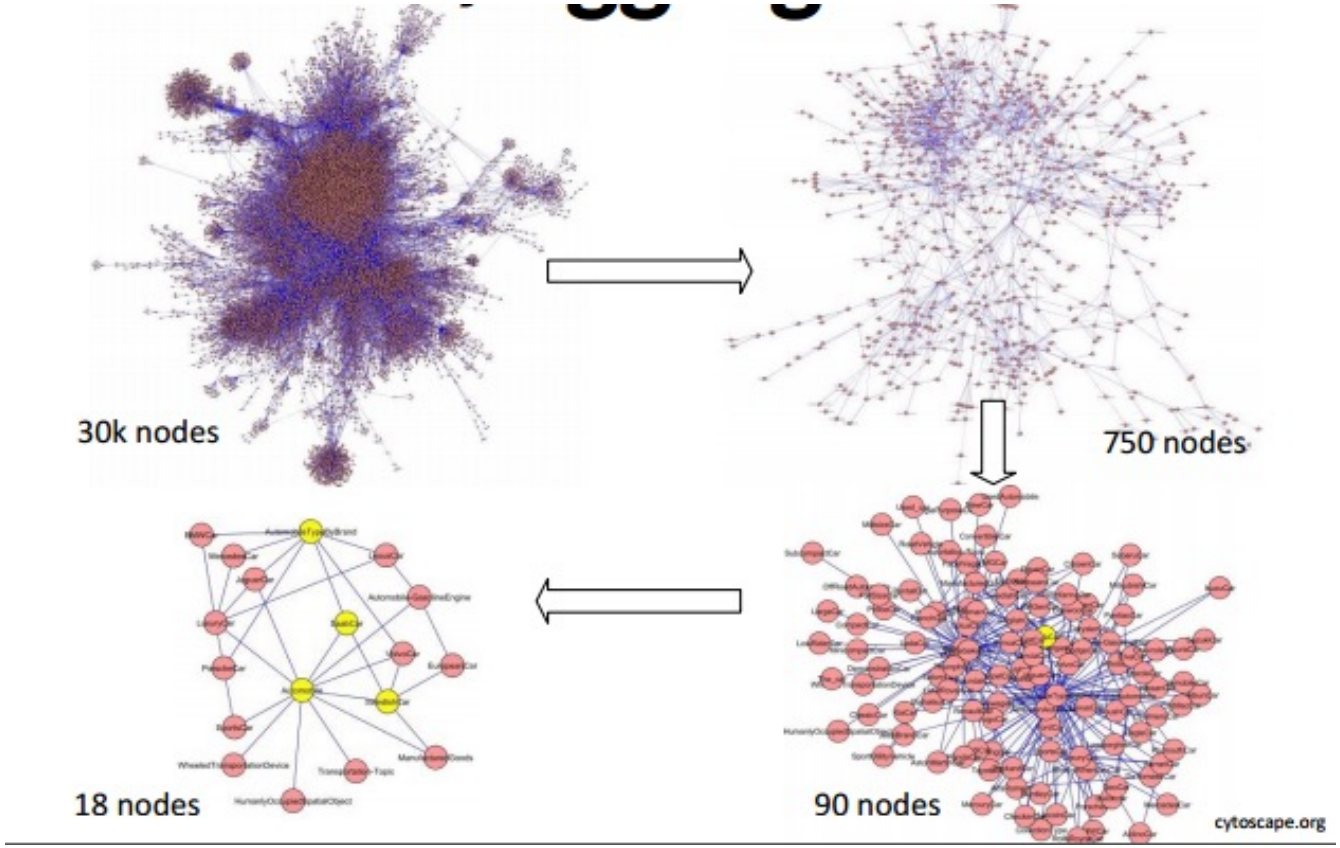
- Reduce the magnitude of a graph by merging vertices together, compute a partition on this reduced graph, and finally project this partition on the original graph.



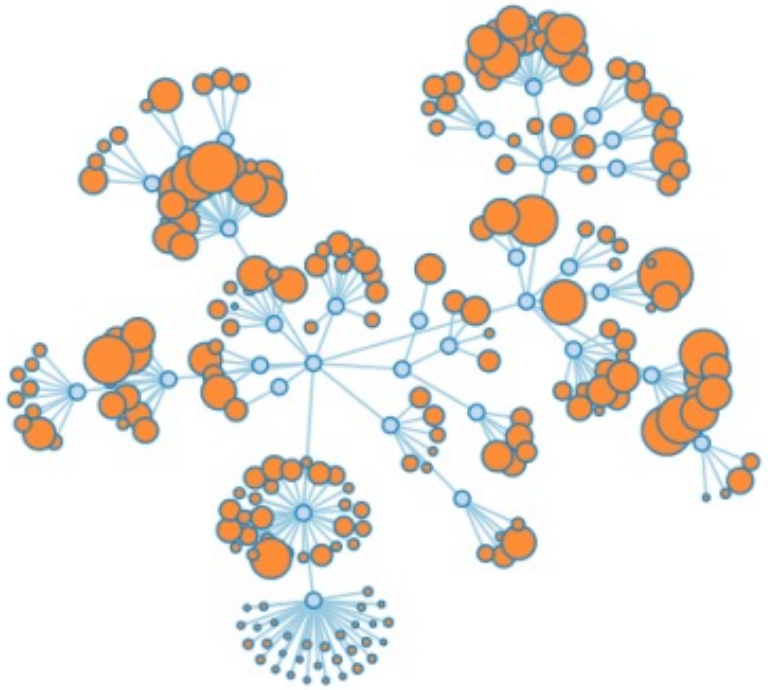


[Schulz 2004]

Sampling



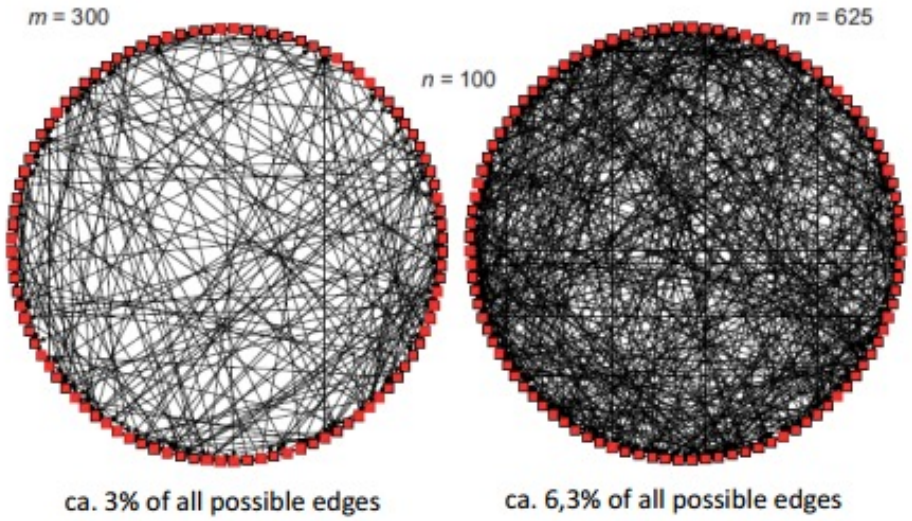
Collapse/Expand



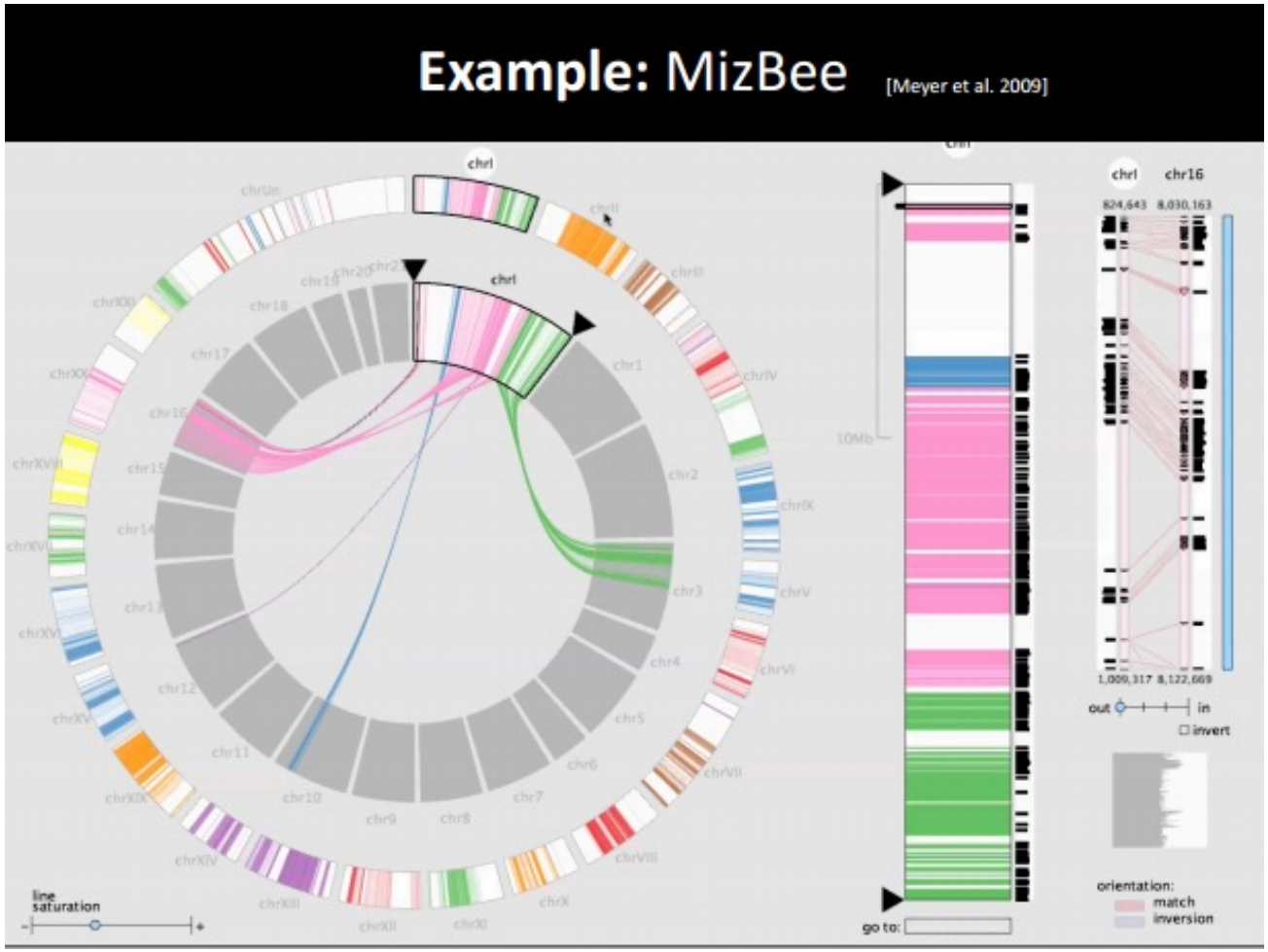
http://bl.ocks.org/mbostock/1062288

Fixed arrangement for graphs

- Circos Layout

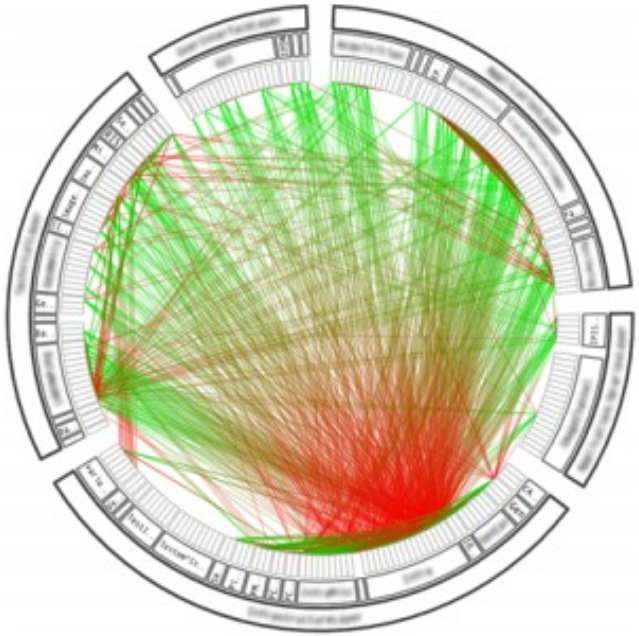


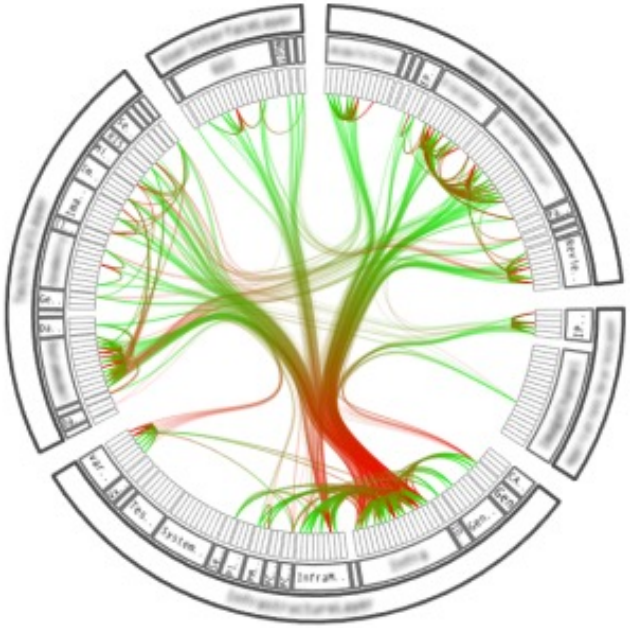
Fixed arrangement for graphs



Fixed arrangement for graphs

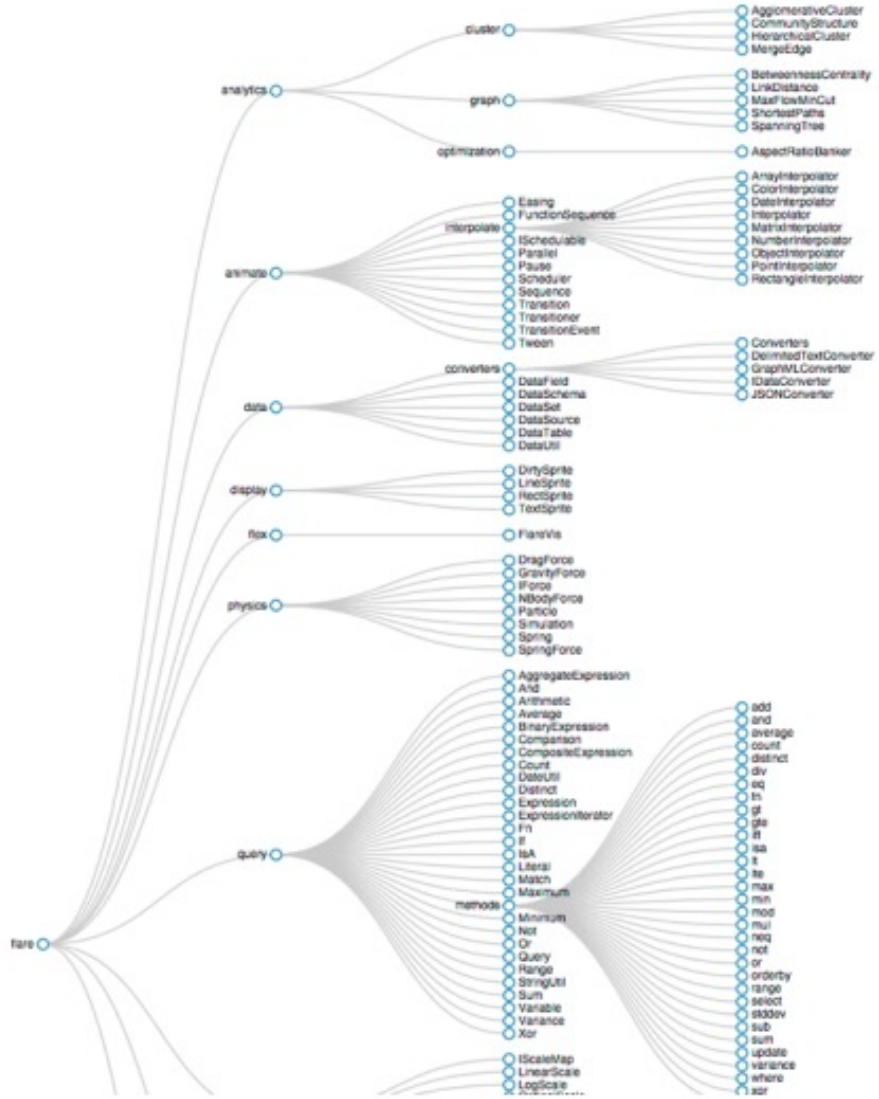
- Edge bundling

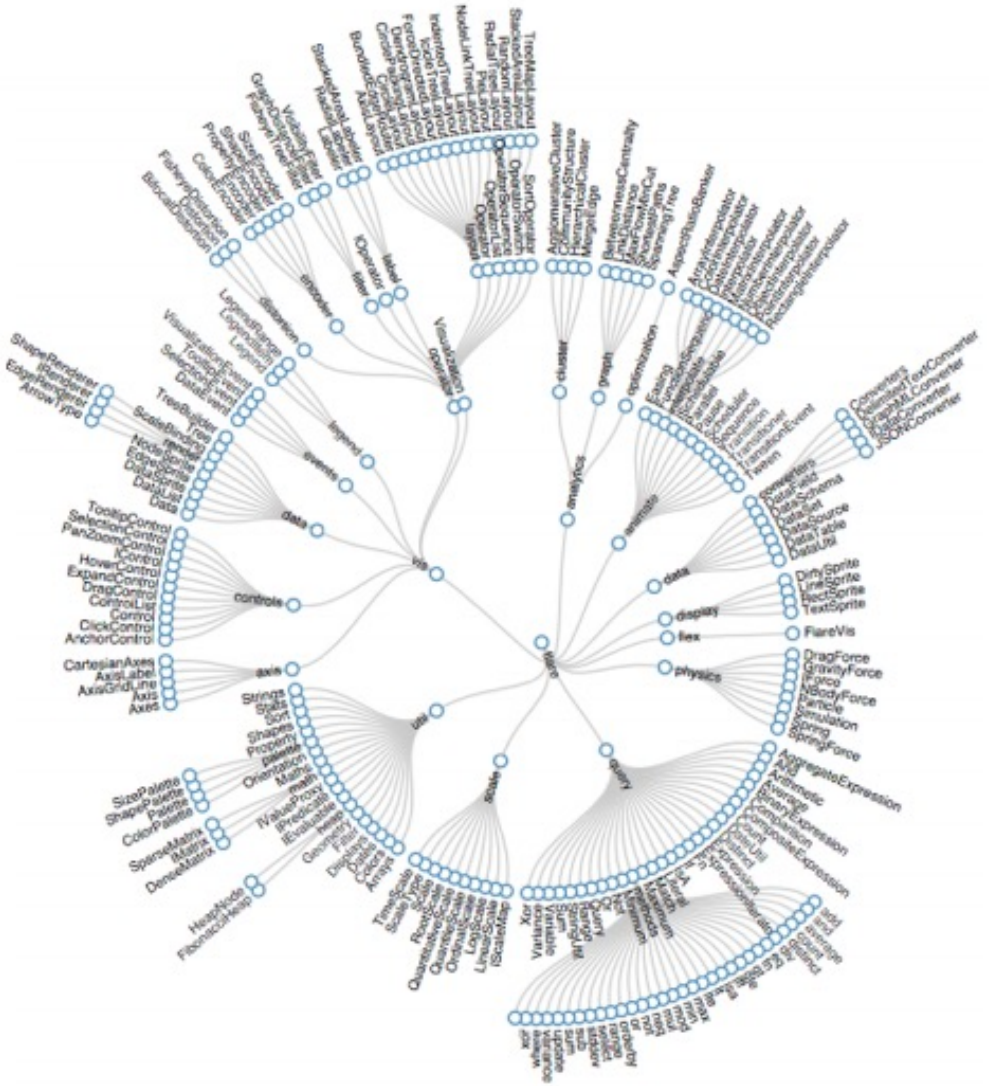




https://observablehq.com/@d3/hierarchical-edge-bundling

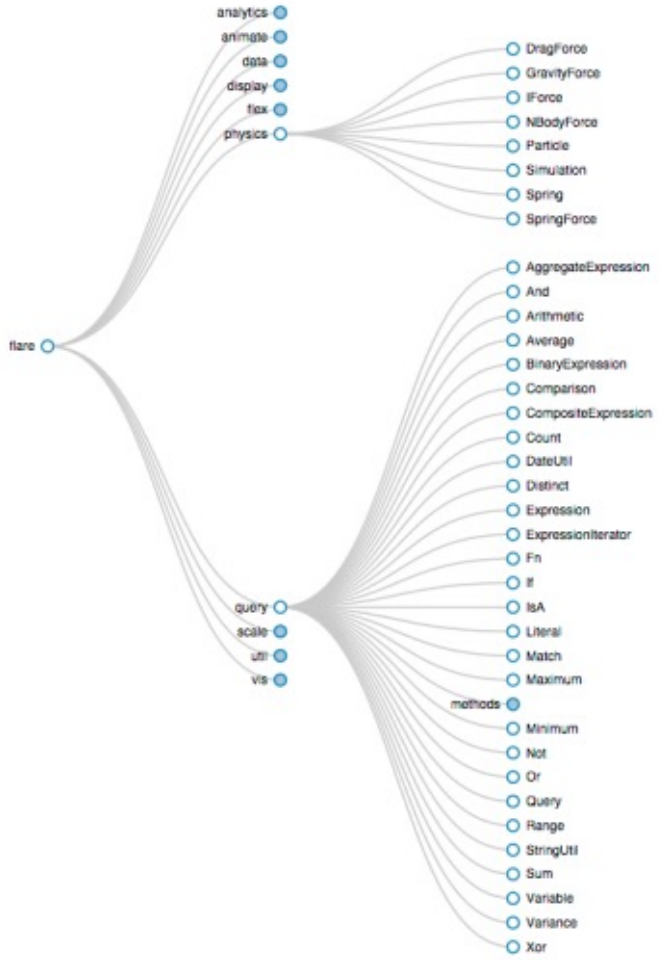
Tree layout

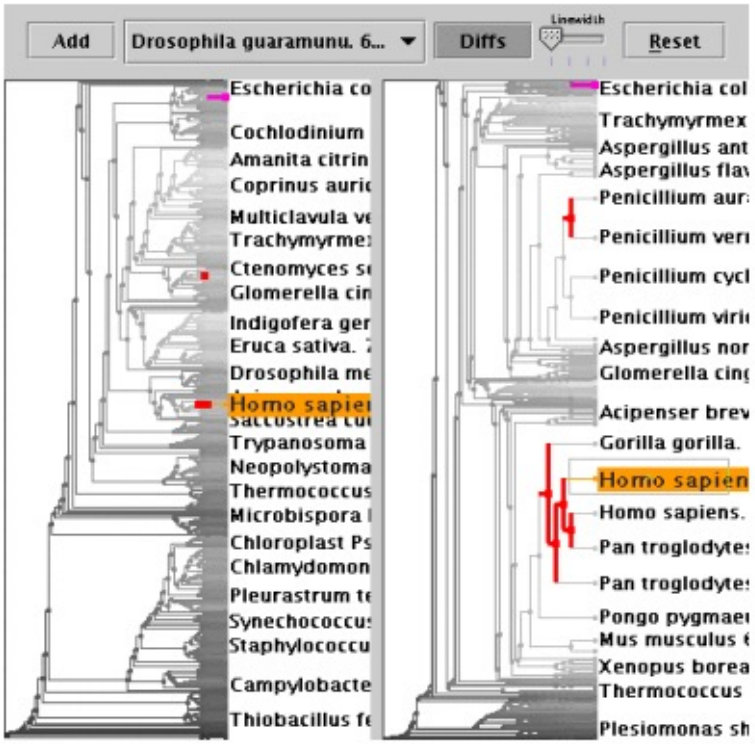




https://observablehq.com/@d3/tree

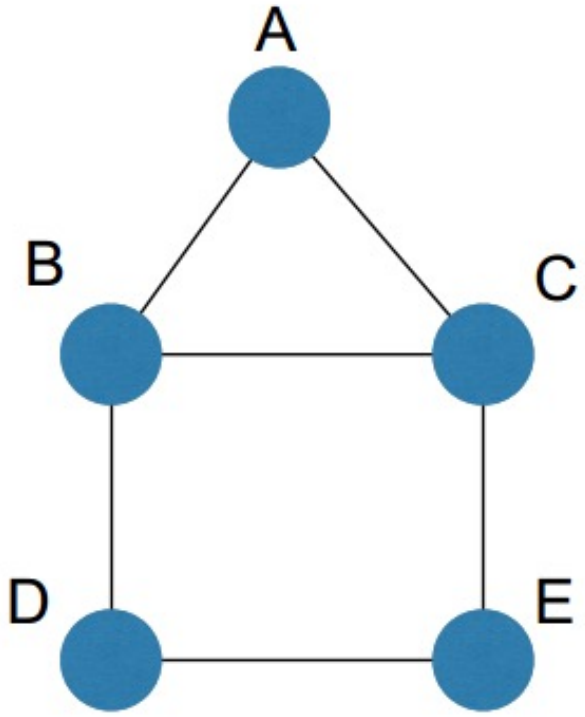
Tree layout





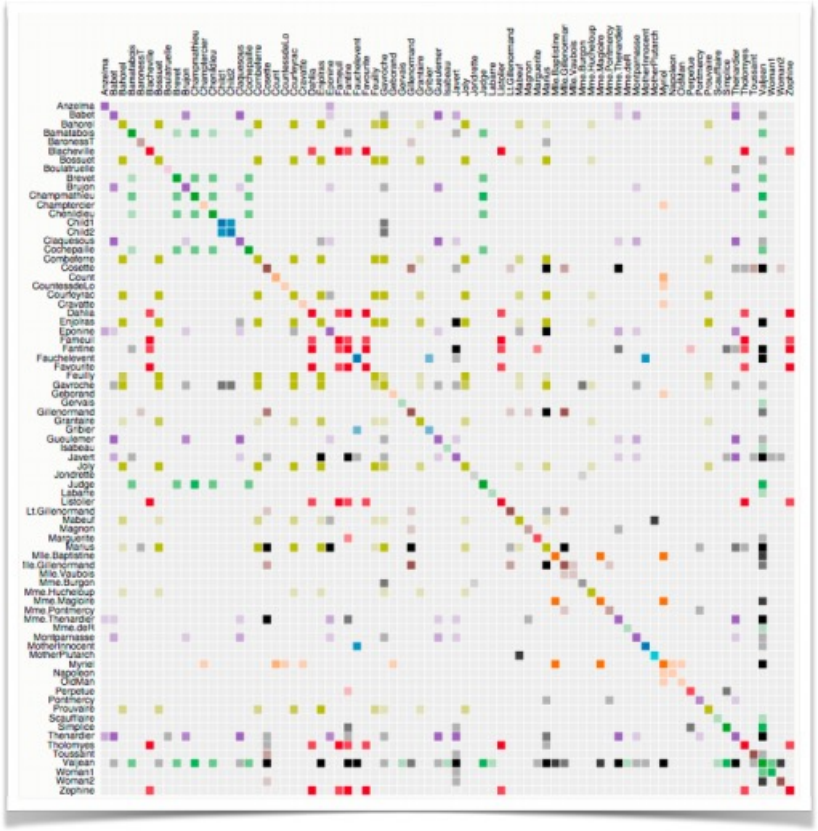
http://bl.ocks.org/mbostock/4339083

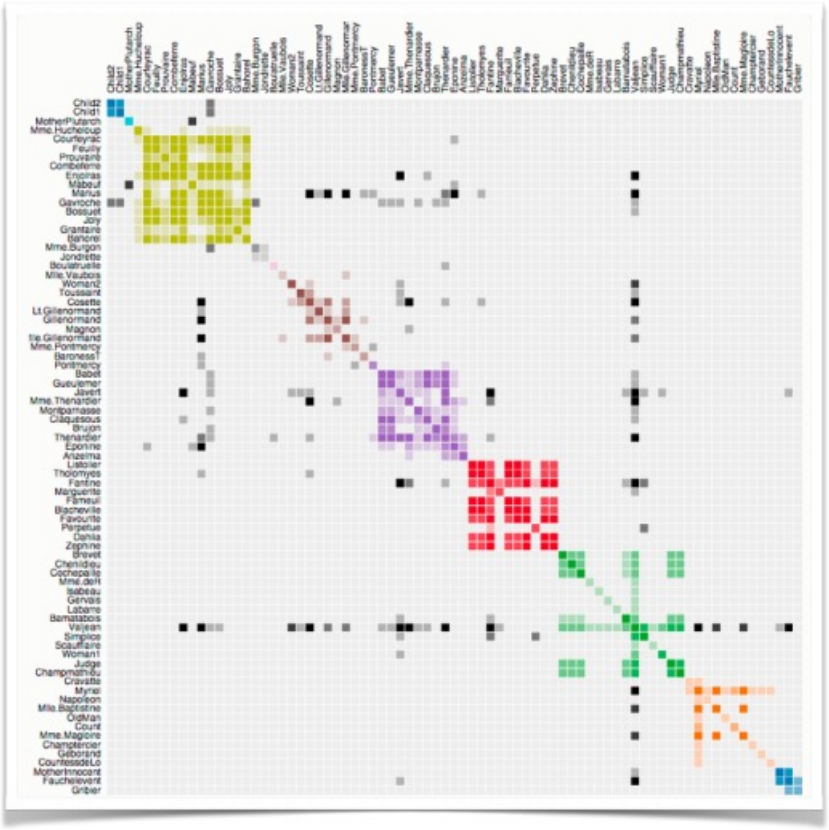
Adjacency matrix



	A	B	C	D	E
A		■	■		
B	■		■	■	
C	■	■			■
D		■			■
E			■	■	

Adjacency matrix

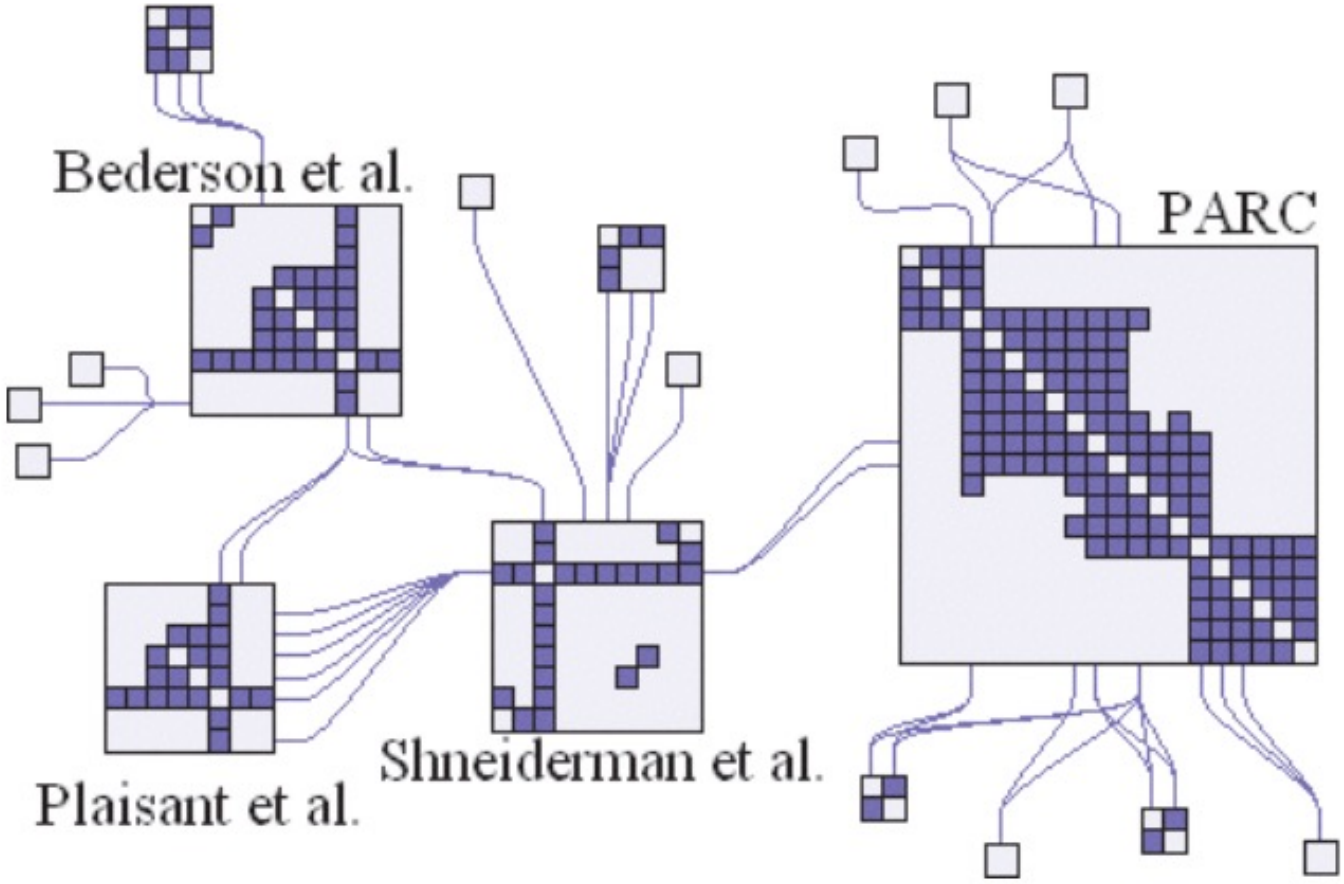




Adjacency matrix

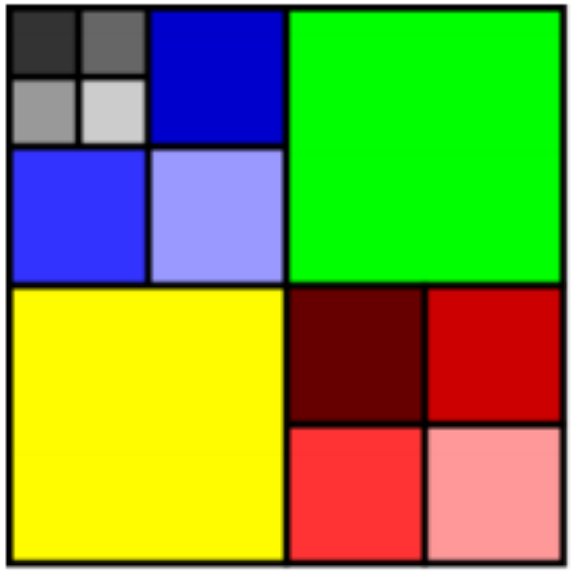
- Advantage
  - Can represent most graphs (except hypergraphs)
  - Focus on edges instead of vertices
  - No need to care about layout
- Disadvantage
  - Difficult to detect relationships such as paths, cycles, etc.

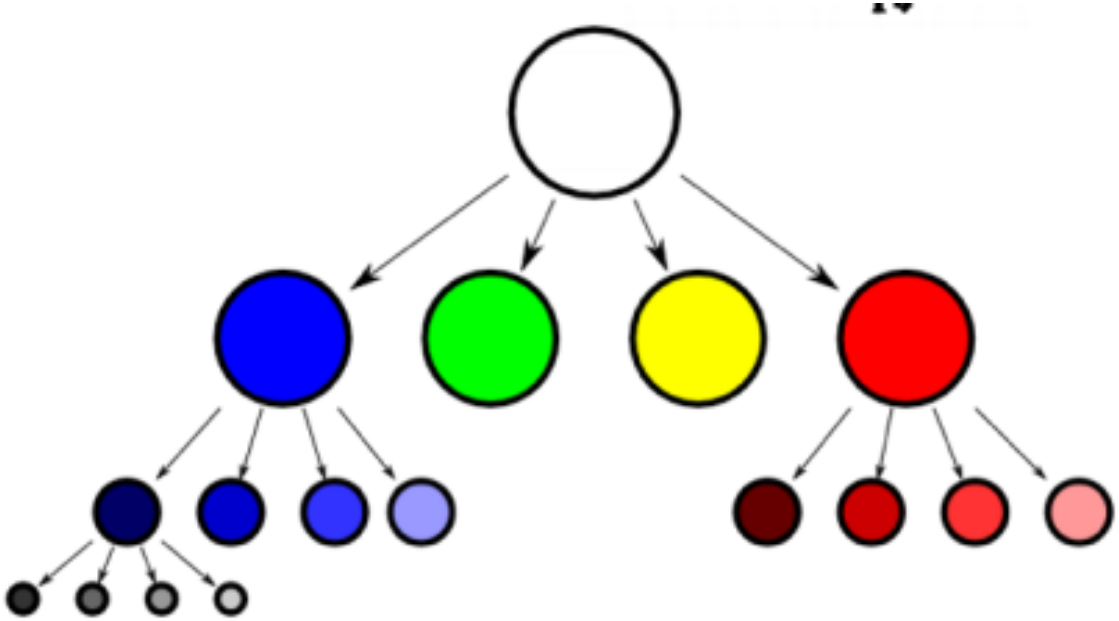
Hybrid layoub



Implicit presentation

- TreeMap





http://www.nytimes.com/packages/html/newsgraphics/2011/0119-budget/

Implicit presentation

- Sunburst

https://observablehq.com/@d3/sunburst
https://observablehq.com/@d3/zoomable-sunburst

- https://observablehq.com/@3cd7d5ec89dc7f68/graph-visualization-introduction

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