HUST

ĐẠI HỌC BÁCH KHOA HÀ NỘI

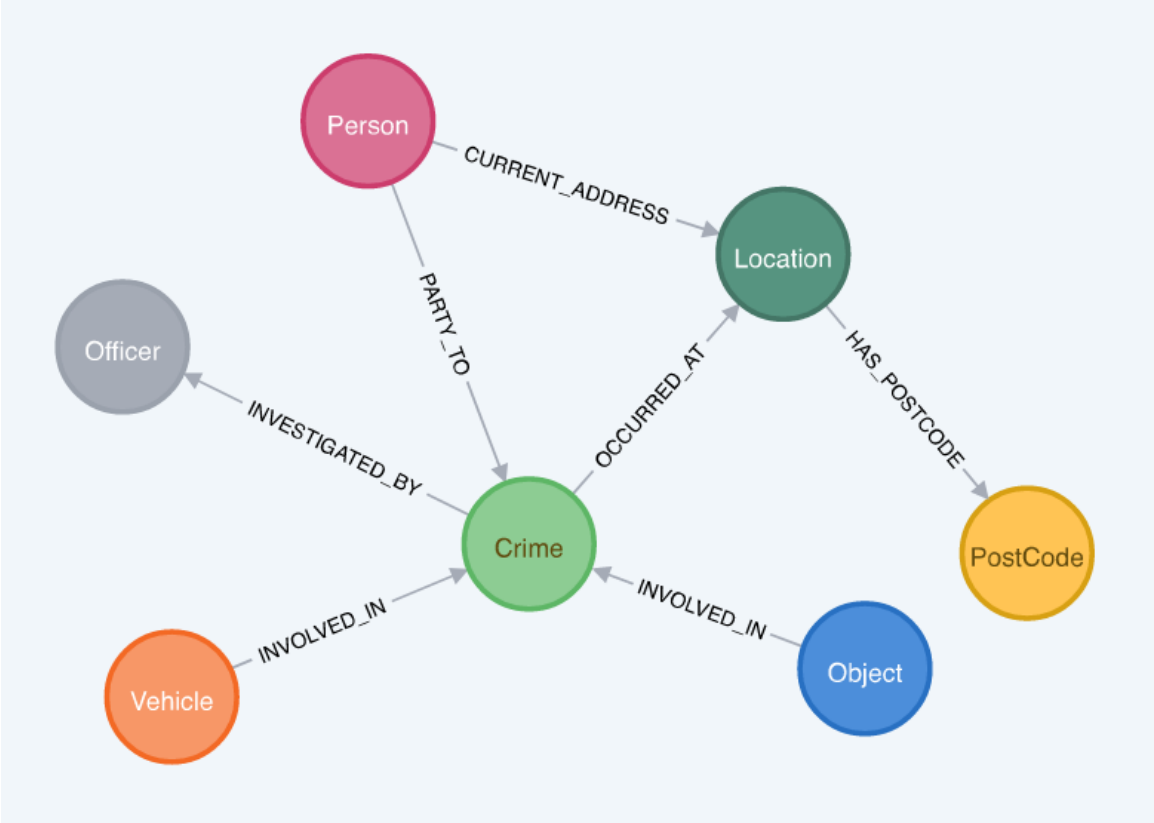
HANOI UNIVERSITY OF SCIENCE AND TECHNOLOGY

ONE LOVE. ONE FUTURE.

Graph data visualization

What is graph data

- Data representing relationships between entities
  - Entities are represented by nodes (vertices or points)
  - Relationships are represented by edges (lines or arcs)
  - The graph G(V.E) includes the set of vertices V and the set of edges E

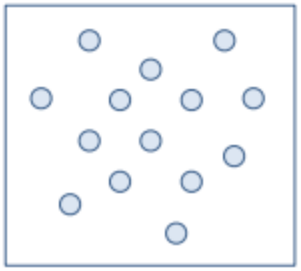


Properties of Graph Data

- Sparsity
  - Not all nodes are connected by edges
  - Number of edges is often much less than the number of possible connections between nodes
- Directionality
  - **Directed edges:** Show a one-way relationship between nodes (e.g., following on Twitter)
  - **Undirected edges:** Show a two-way relationship between nodes (e.g., friendship on Facebook)
- Weights
  - Weights represent the strength or importance of the relationship between nodes
  - Can be numerical values, distances, times, or other quantities

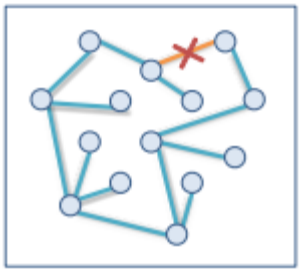
Basic concepts

- **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.

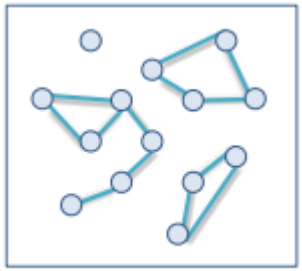


Independent Set

Clique



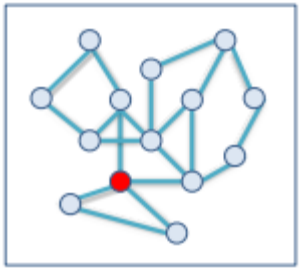
Tree



Unconnected Graph

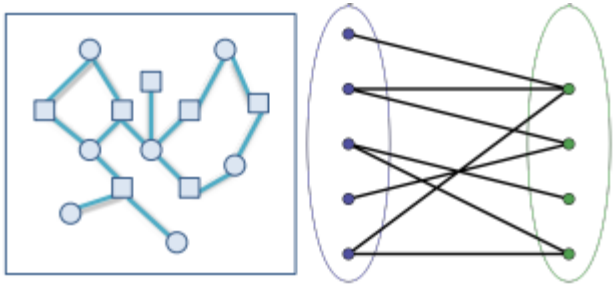
Basic concepts

- **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

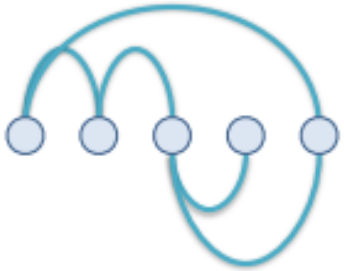


Bipartite Graph

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

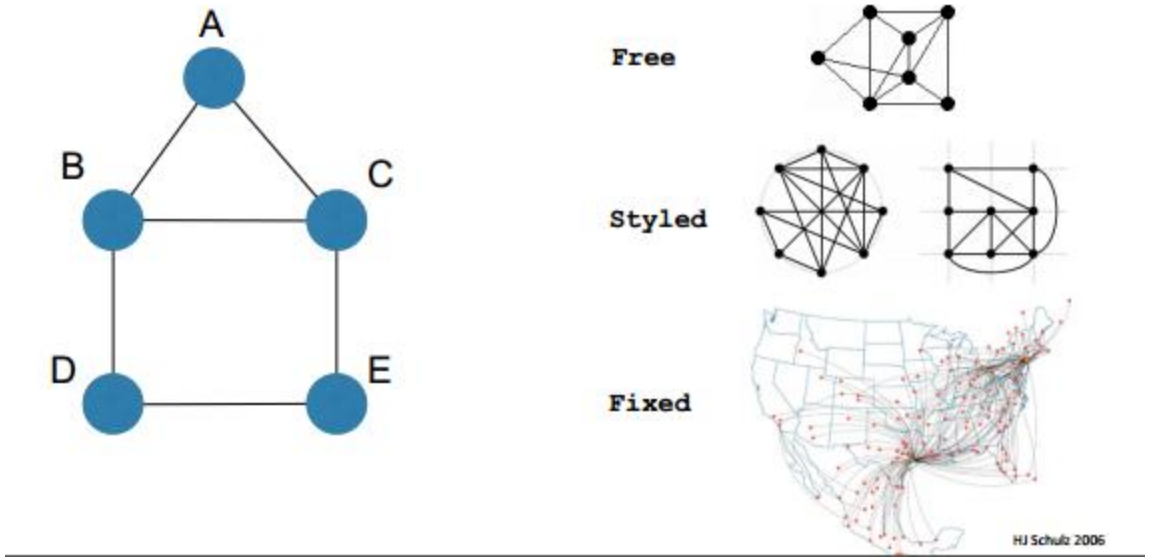


Explicit
(Node-Link)

Matrix

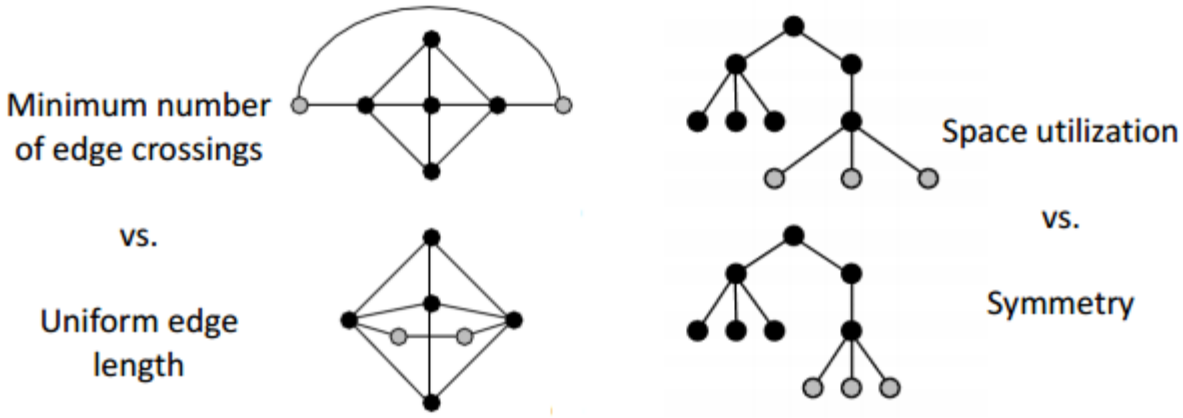
Implicit

Explicit graph visualization (node-link)



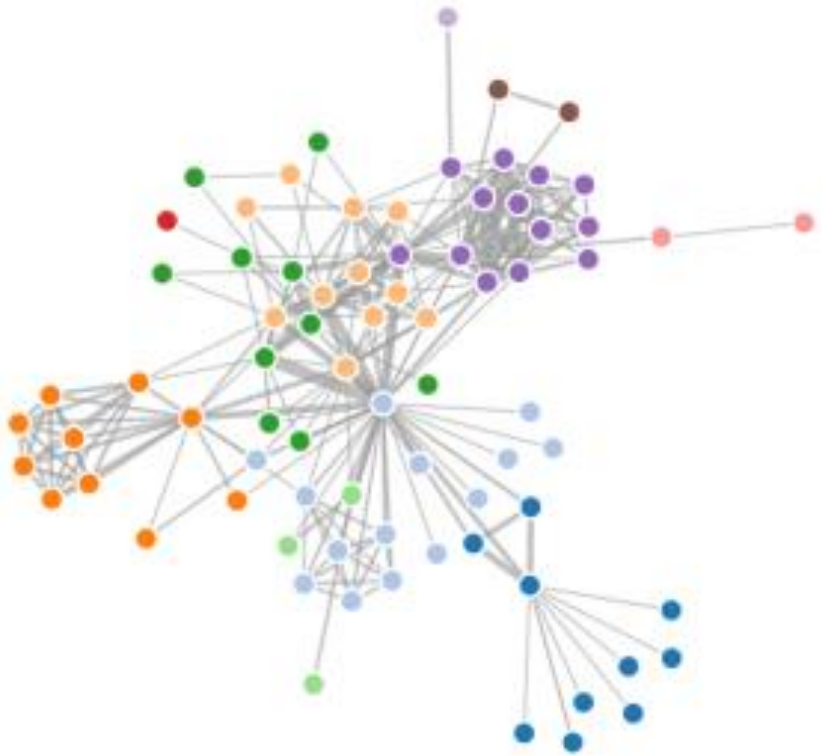
Criteria for node-link representation

- 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

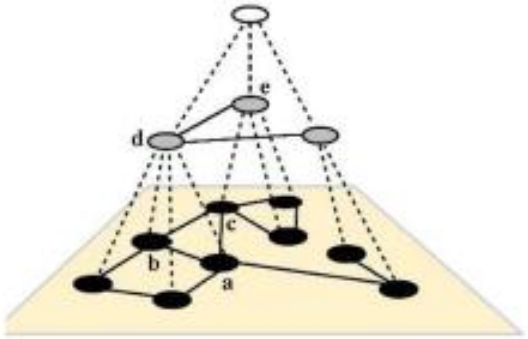
- The forces are applied to the nodes, pulling them closer together or pushing them further apart.
- This is repeated iteratively until the system comes to a mechanical equilibrium state

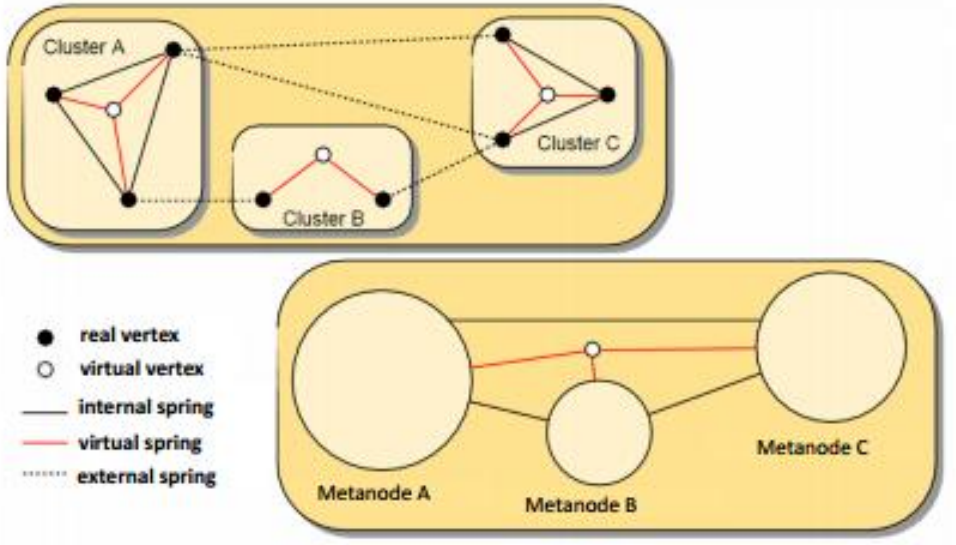


https://observablehq.com/@d3/force-directed-graph

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.

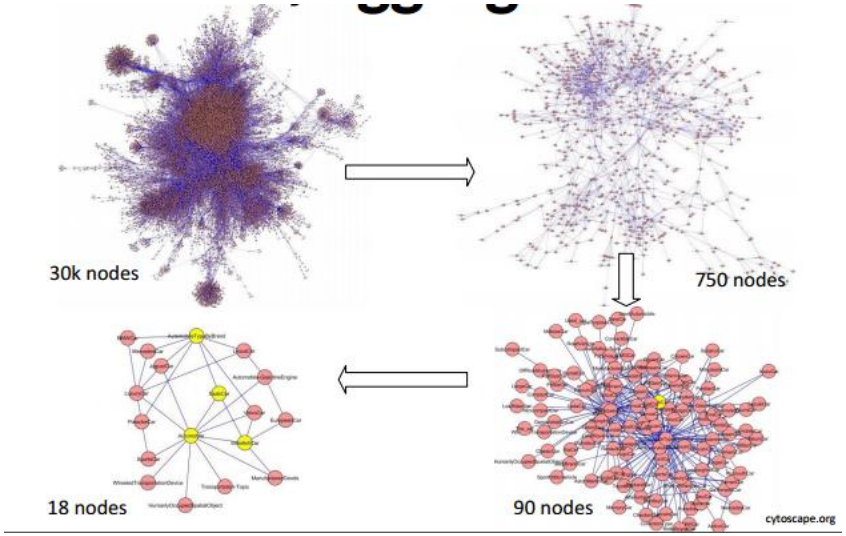




[Schulz 2004]

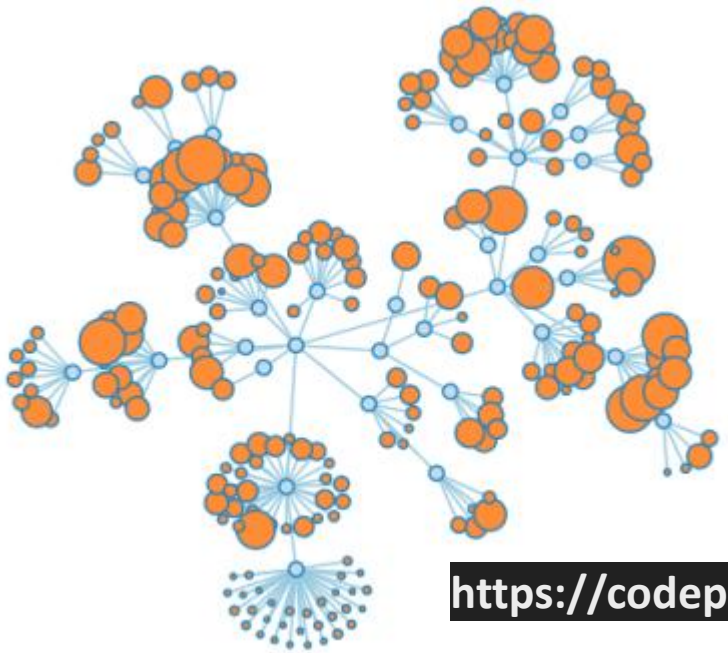
Sampling

- Large graphs can overwhelm visualization tools and viewers.
- Sampling allows us to explore a manageable subset of the data.
- Different sampling techniques highlight various aspects of the graph.
- Key sampling techniques
  - Random Sampling
  - Degree-Based Sampling
  - Ego-Network Sampling
  - Community Sampling



Collapse/Expand

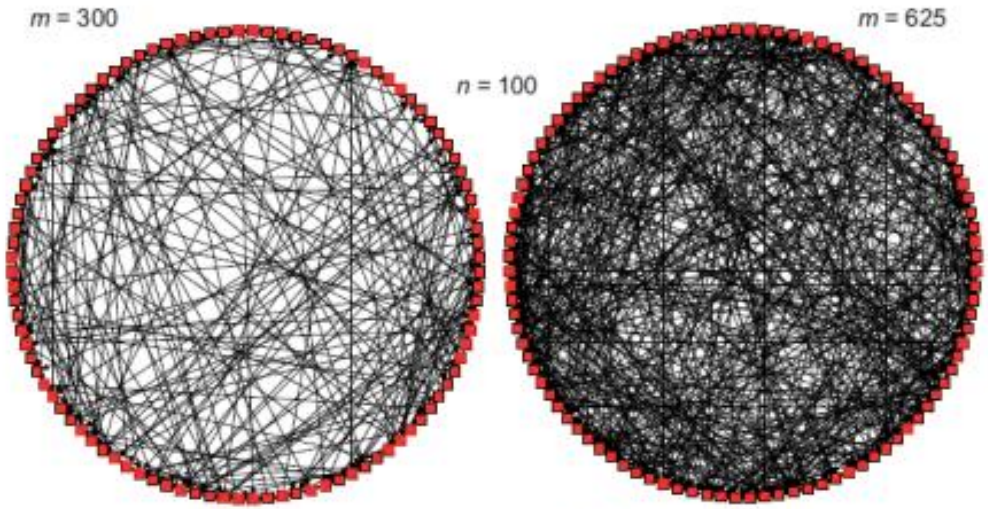
- Particularly useful for hierarchical graphs, where sub-trees can be collapsed or expanded as needed.
- **Clarity:** Reduces visual clutter, making it easier to focus on specific areas of interest.
- **Scalability:** Handles large datasets efficiently by allowing parts of the graph to be hidden.



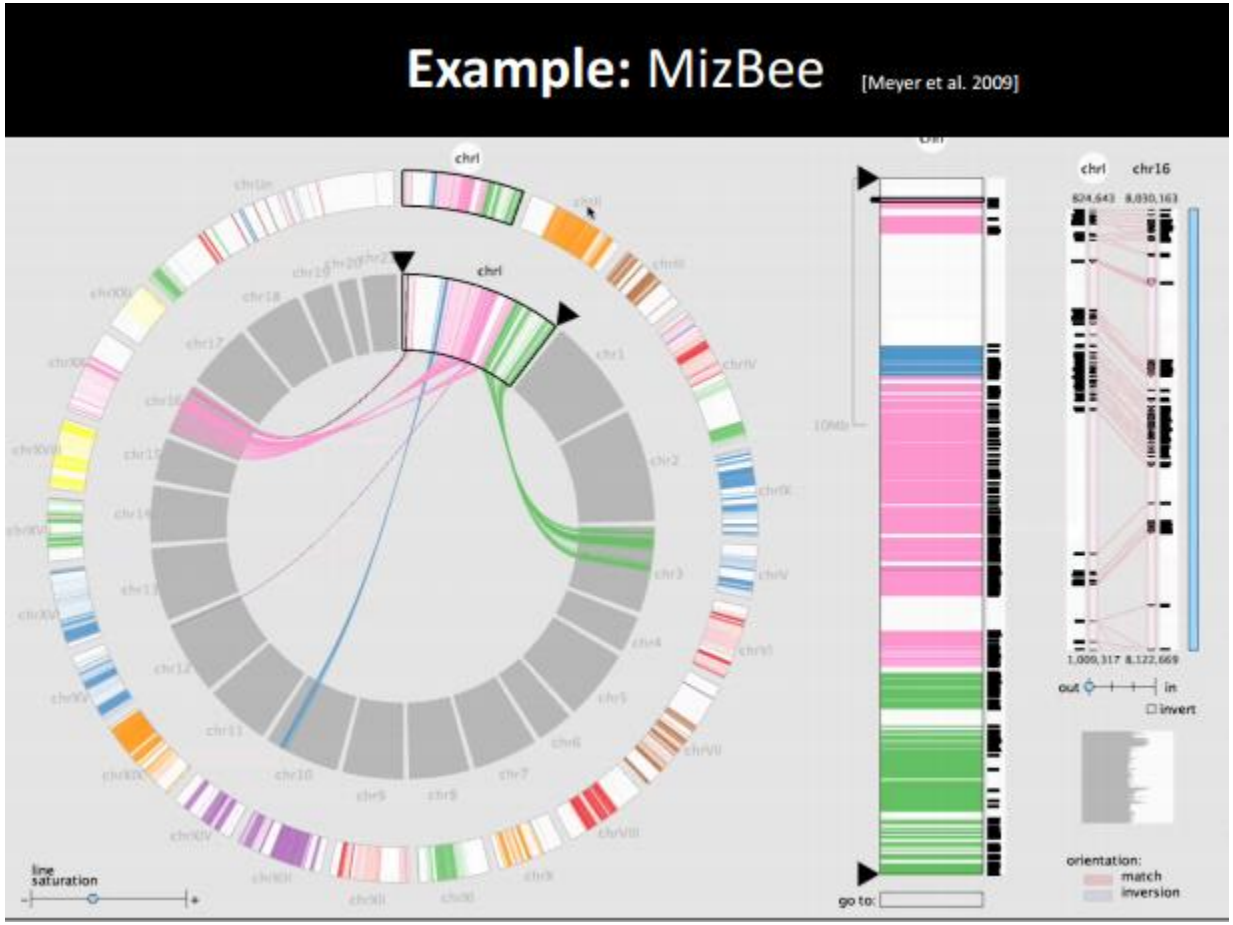
https://codepen.io/gyunee/pen/oNvEoOb

Fixed arrangement for graphs

- Circos Layout
  - **Compact Visualization:** Efficiently uses space to show large, complex datasets.
  - **Pattern Recognition:** Facilitates the identification of clusters, patterns, and relationships.
  - **Aesthetic Appeal:** Attractive and engaging, enhancing the visual storytelling of data.

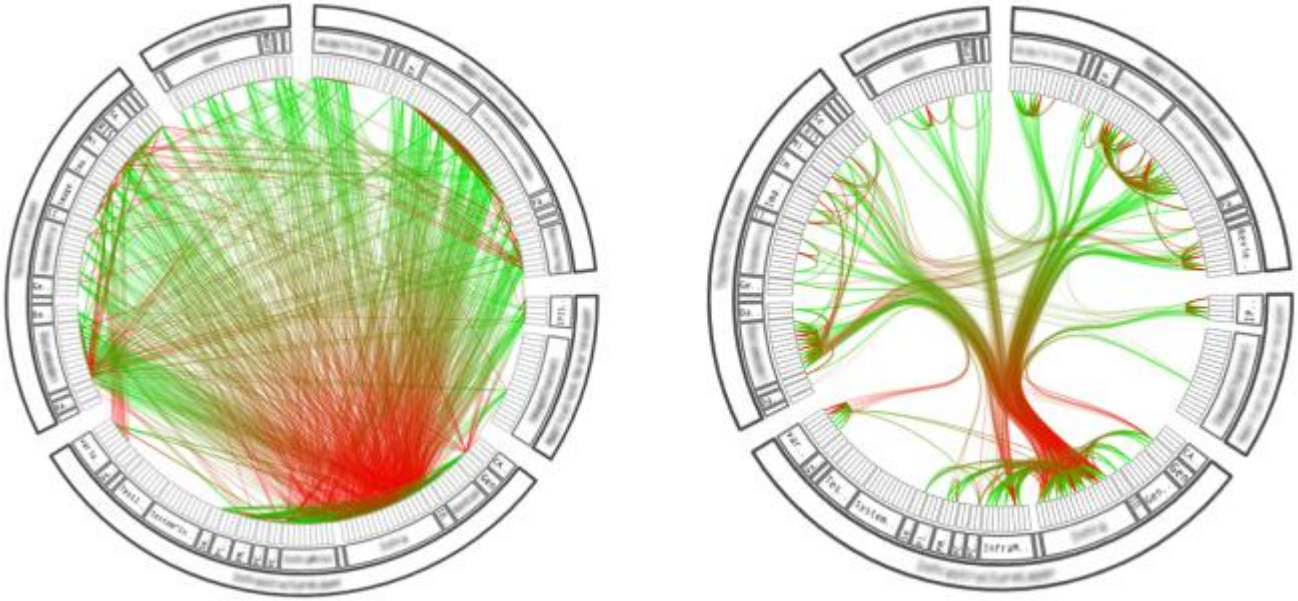


Fixed arrangement for graphs



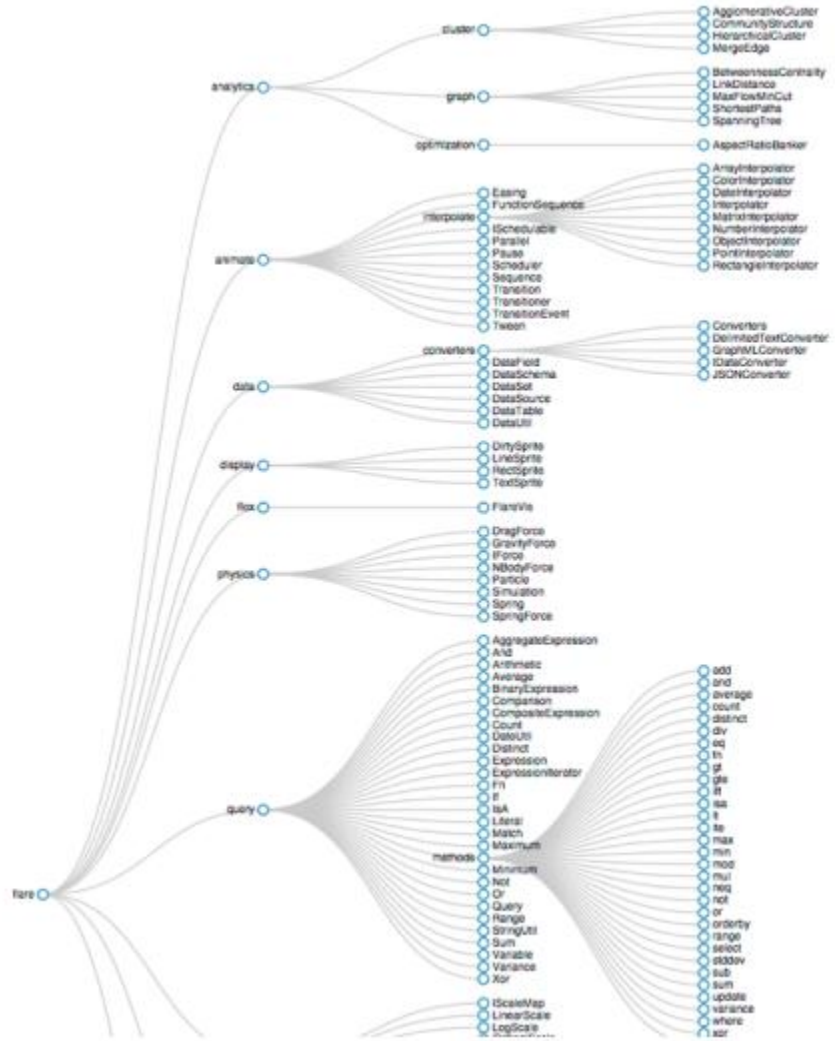
Fixed arrangement for graphs

- Edge bundling



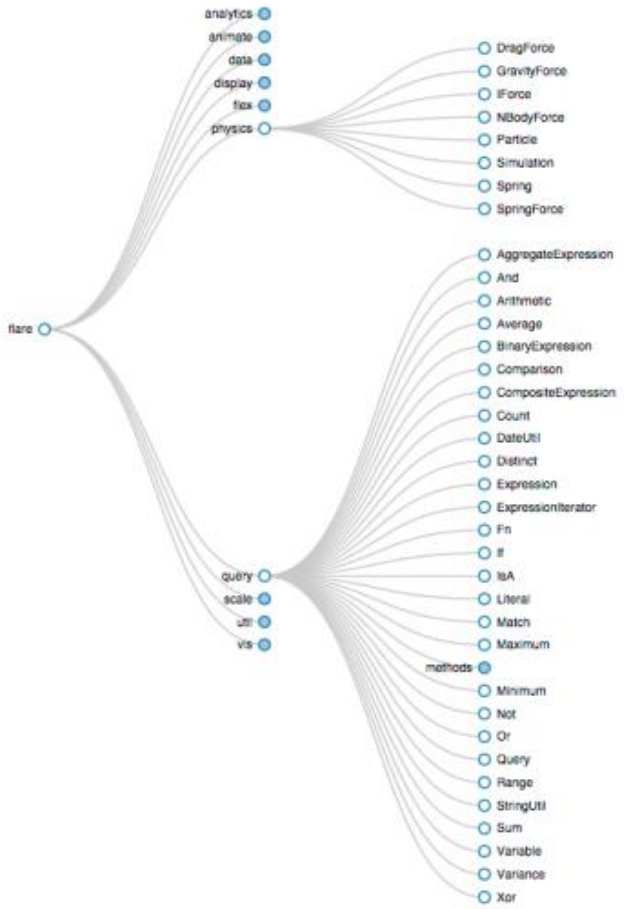
https://observablehq.com/@d3/hierarchical-edge-bundling

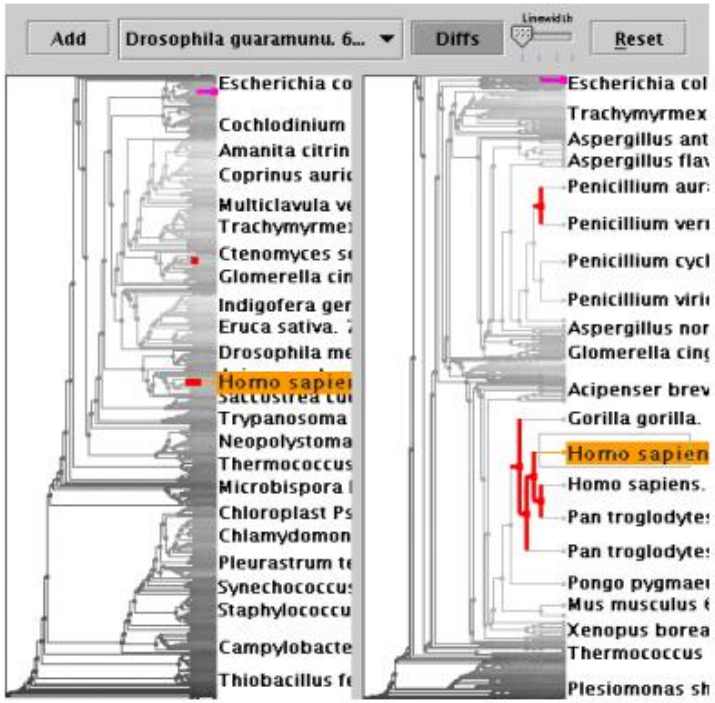
Tree layout



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

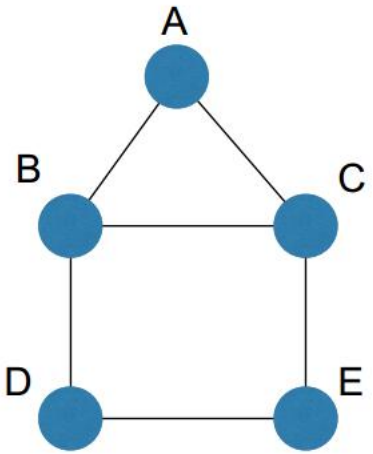
Tree layout





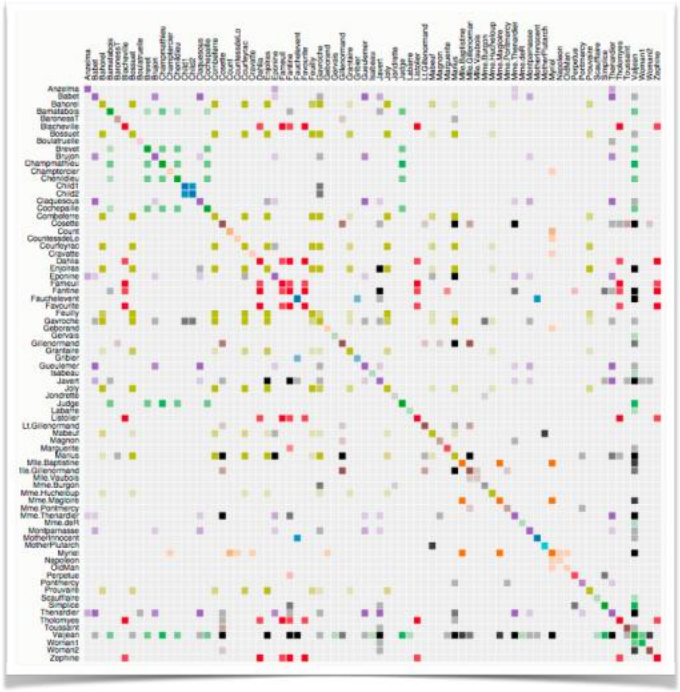
http://bl.ocks.org/mbostock/4339083

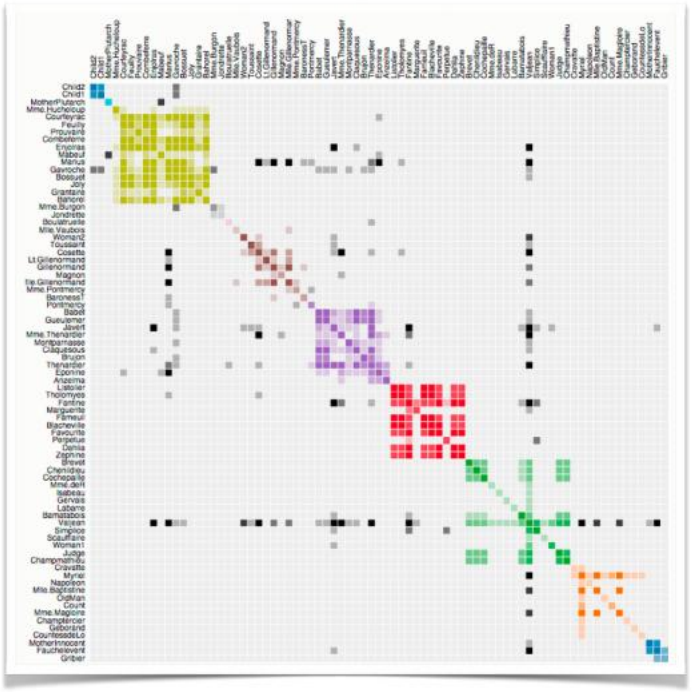
Adjacency matrix



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

Adjacency matrix

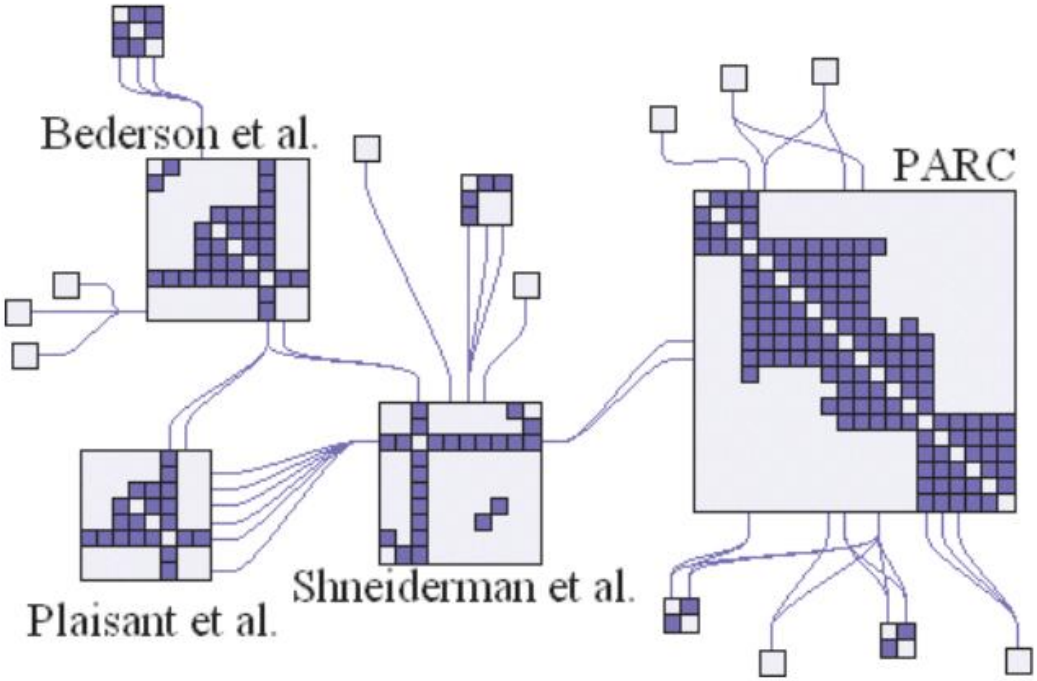




Adjacency matrix

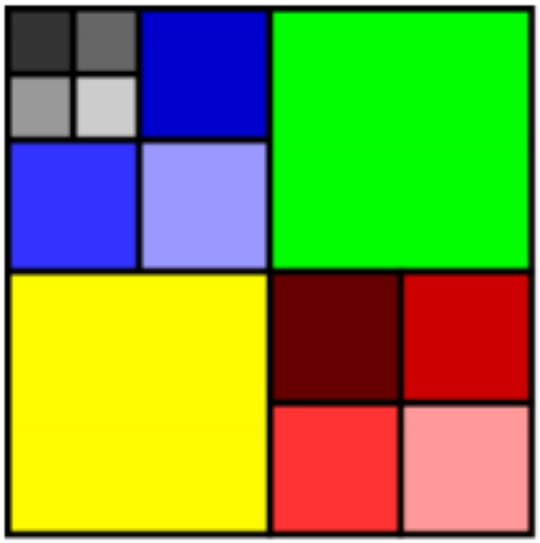
- Advantage
  - Can represent most graphs (except hypergraphs)
  - Focus on edges instead of vertices
  - No need to care about layout
- Disadvantage
  - Difficult to detect relationships such as paths, cycles, etc.

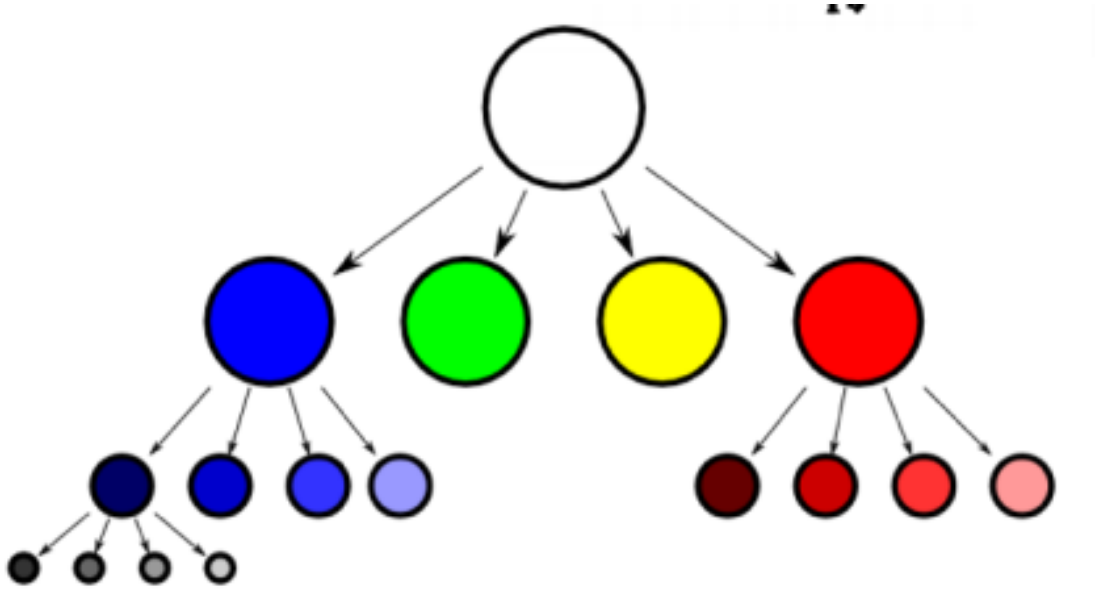
Hybrid layout



Implicit presentation

- A treemap chart is a visualization that displays hierarchical data using nested rectangles.
- Structure
  - The entire chart area represents the root of the hierarchy.
  - Each rectangle (or cell) represents a branch or leaf node.
  - Rectangles are sized and ordered by a quantitative variable.
  - Colors can be used to represent different categories or to encode additional data dimensions.





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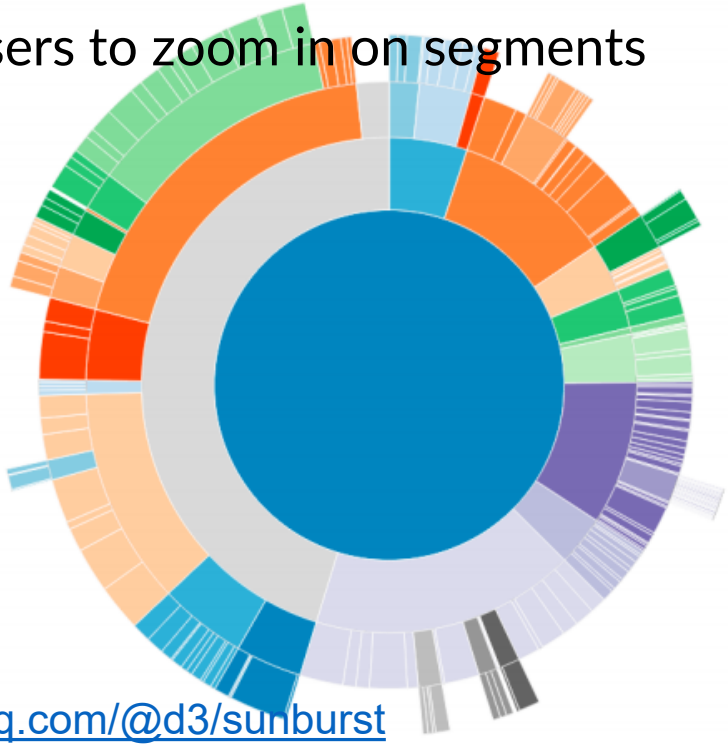
Implicit presentation

- A sunburst chart is a radial visualization that represents hierarchical data using concentric circles.
- Structure
  - The center circle represents the root of the hierarchy.
  - Each subsequent ring represents a level in the hierarchy.
  - Slices are divided into segments representing subcategories.
- Interactive Exploration: Often allows users to zoom in on segments for detailed views.



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