cs6630 | October 21 2014

TREES & GRAPHS

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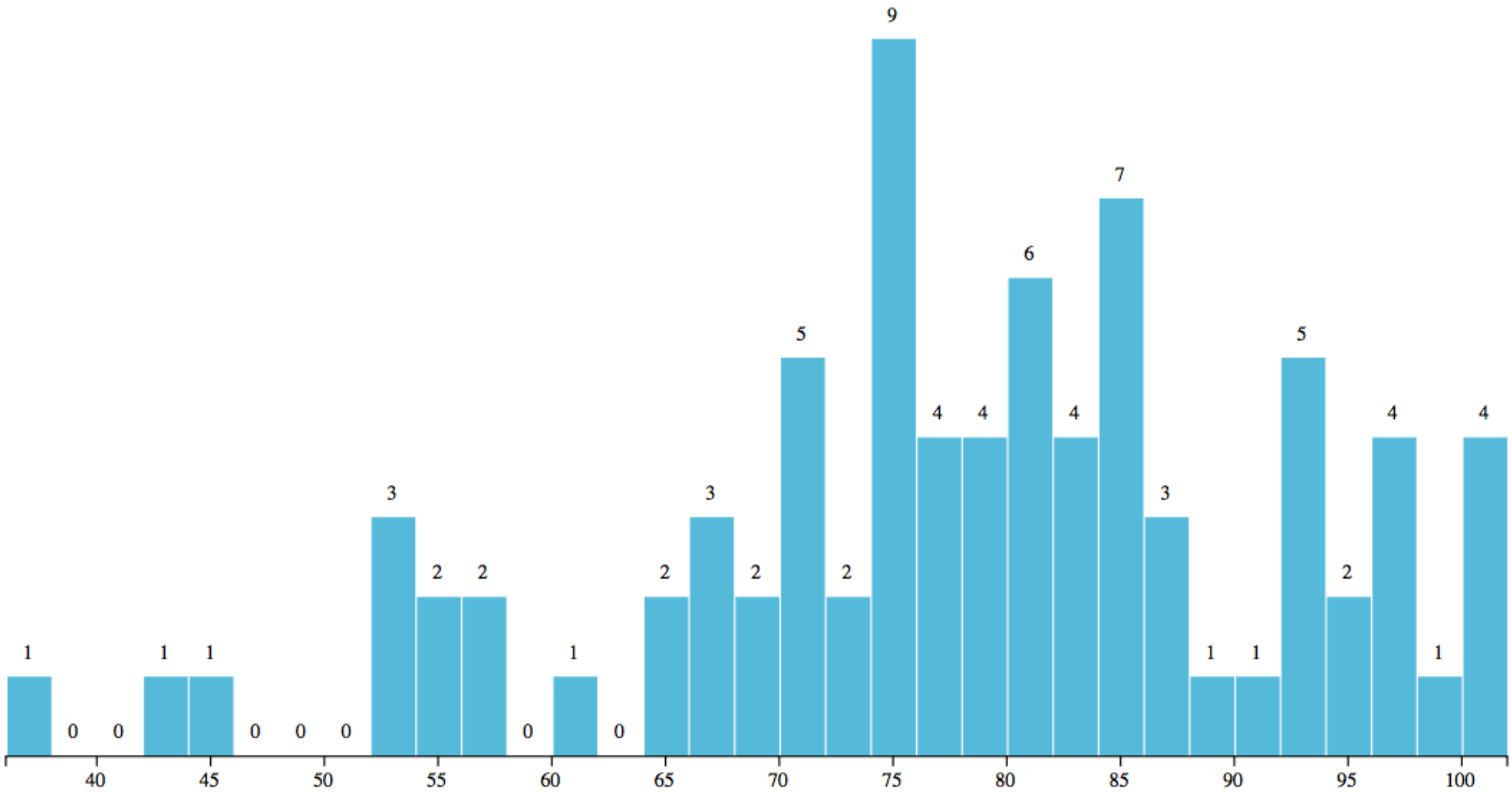
slide acknowledgements:
Miriah Meyer, University of Utah
Hanspeter Pfister, Harvard University
Jeff Heer, Stanford University

administrivia . . .

exam 1



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EXAM REVIEW

last time . . .

Arrange Tables

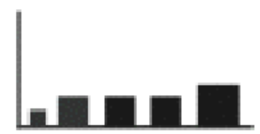
➔ Express Values

➔ Separate, Order, Align Regions

→ Separate

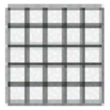
→ Order

→ Align



→ *1 Key*
List

→ *2 Keys*
Matrix

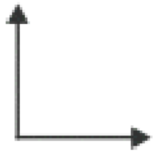


→ *3 Keys*
Volume

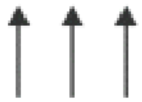
→ *Many Keys*
Recursive Subdivision

➔ Axis Orientation

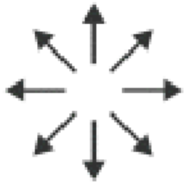
→ Rectilinear



→ Parallel

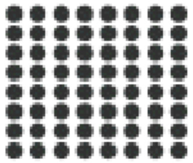


→ Radial



➔ Layout Density

→ Dense

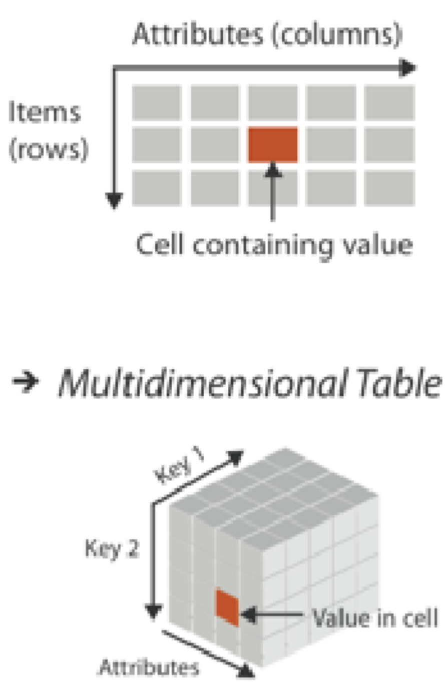


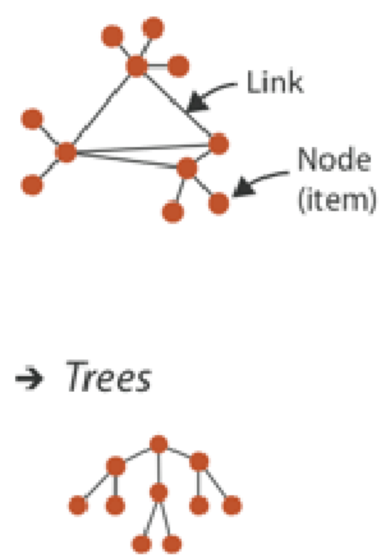
→ Space-Filling

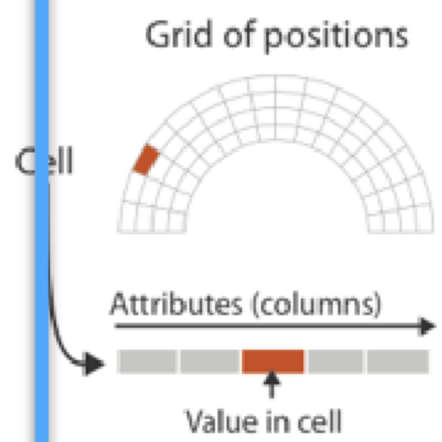
today . . .

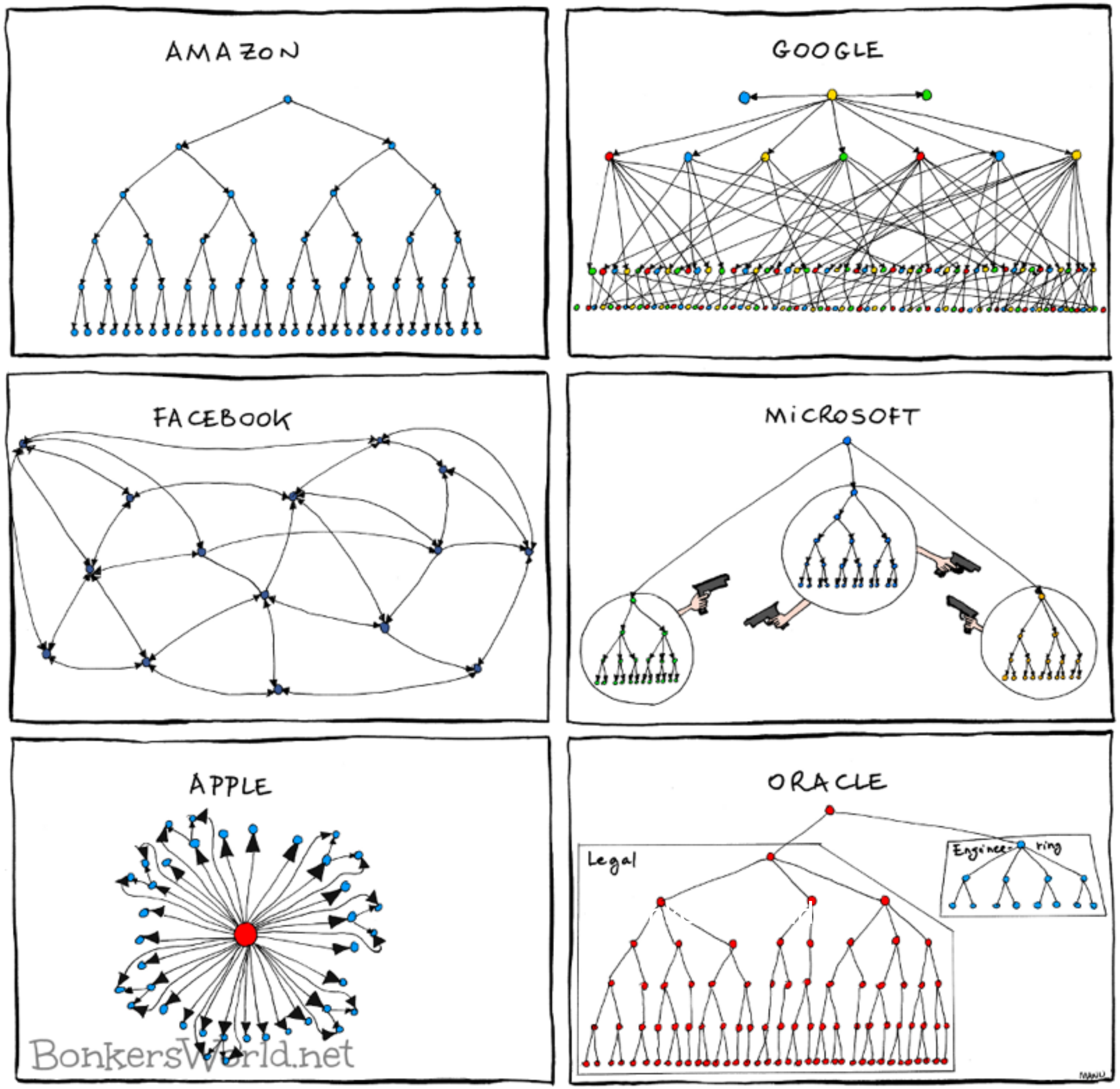
dataset types

Tables	Networks & Trees	Fields	Geometry	Clusters, Sets, Lists
Items	Items (nodes)	Grids	Items	Items
Attributes	Links	Positions	Positions	
	Attributes	Attributes		





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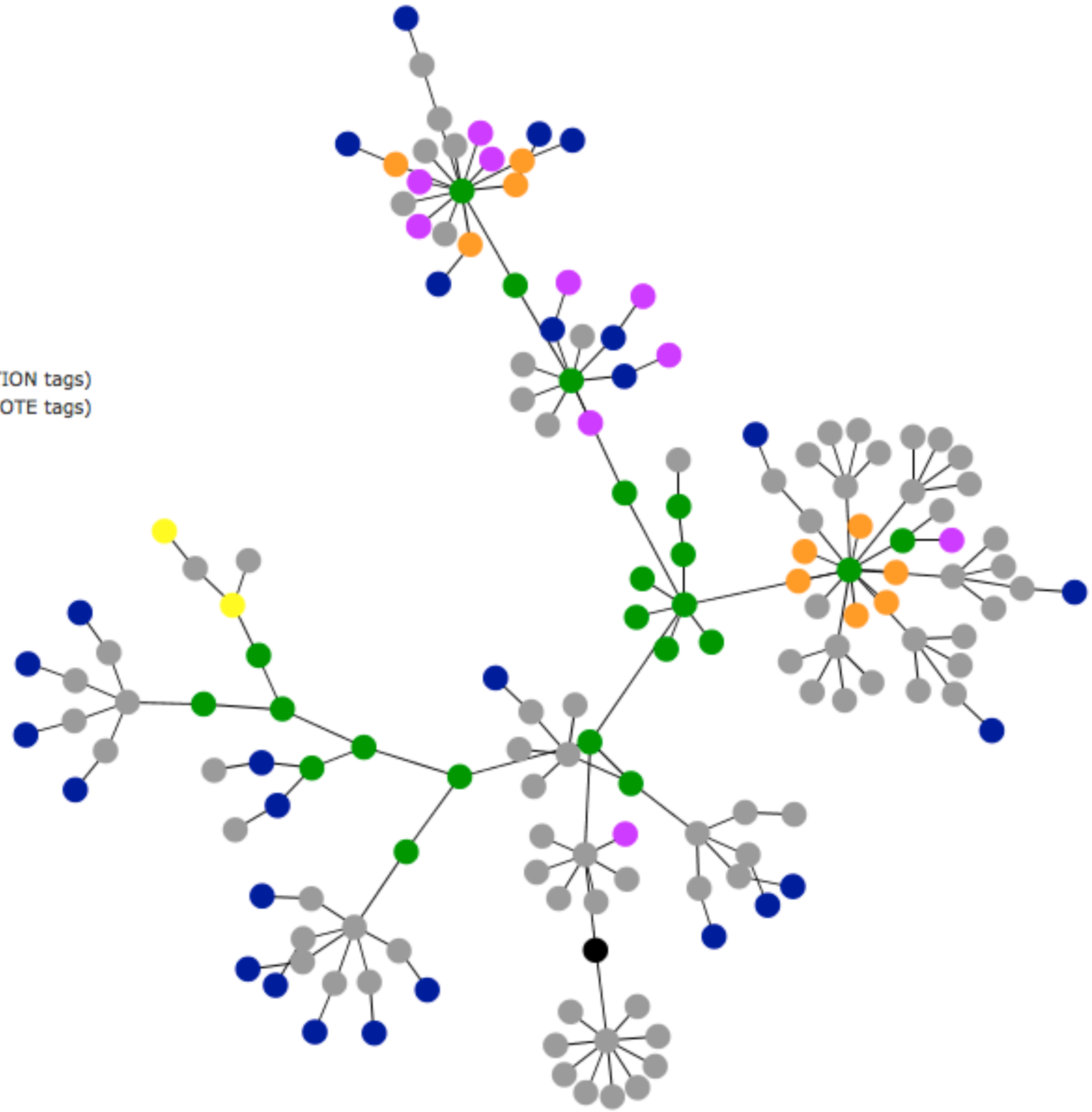
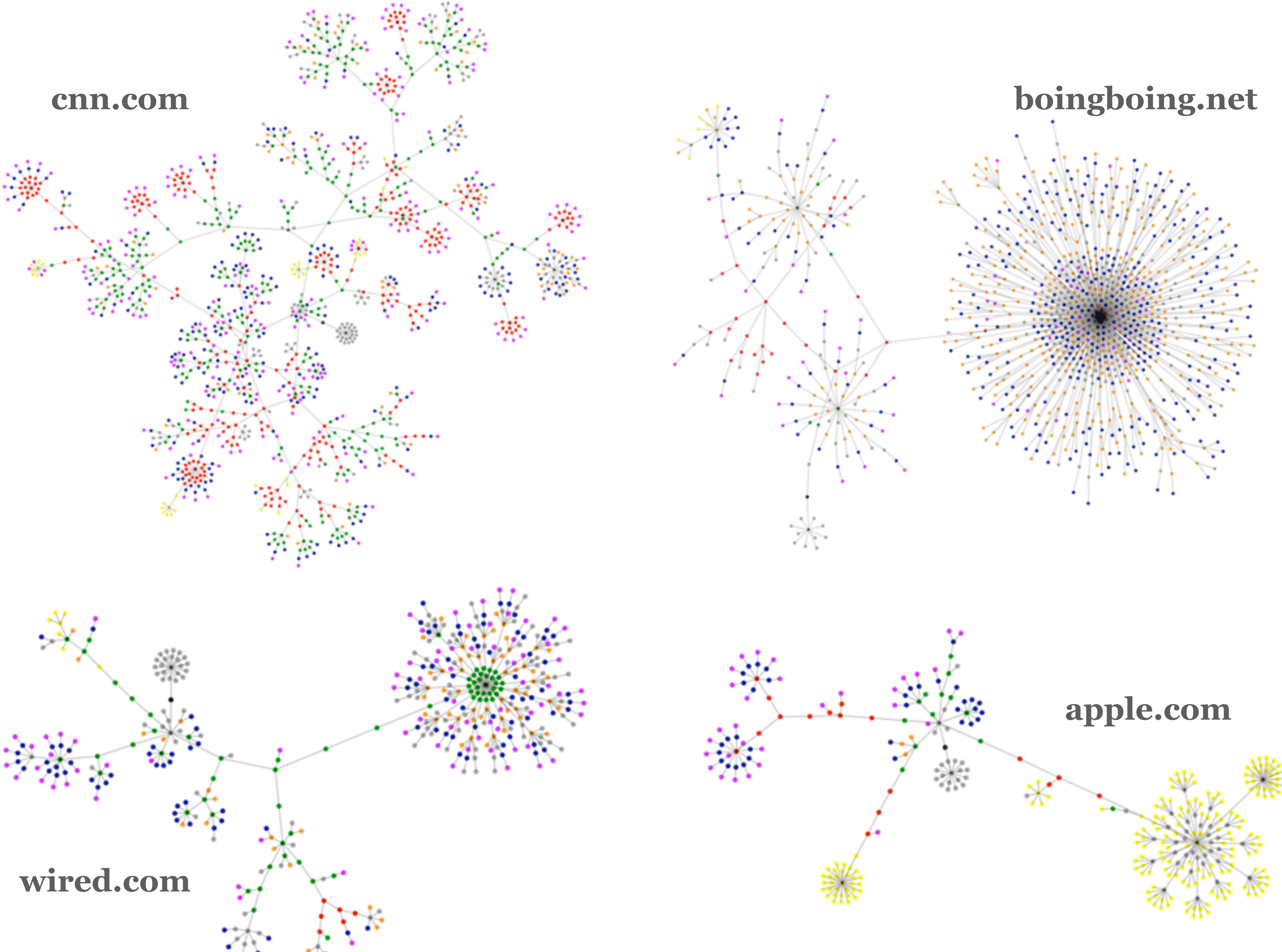
blue: for links (the A tag)
red: for tables (TABLE, TR and TD tags)
green: for the DIV tag
violet: for images (the IMG tag)
yellow: for forms (FORM, INPUT, TEXTAREA, SELECT and OPTION tags)
orange: for linebreaks and blockquotes (BR, P, and BLOCKQUOTE tags)
black: the HTML tag, the root node
gray: all other tags



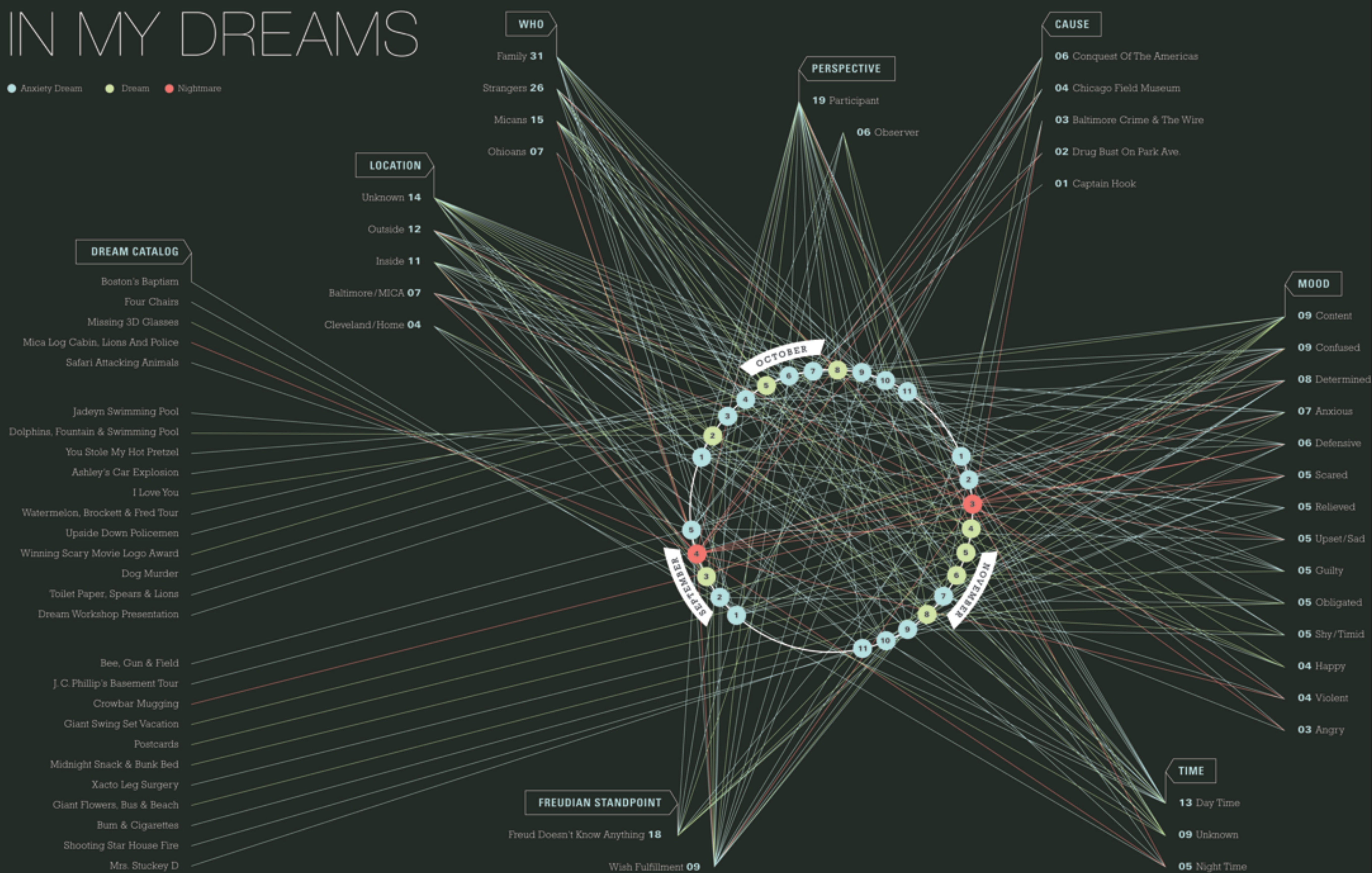
Webpages as Graphs



Webpages as Graphs


facebook


December 2010
Paul Butler

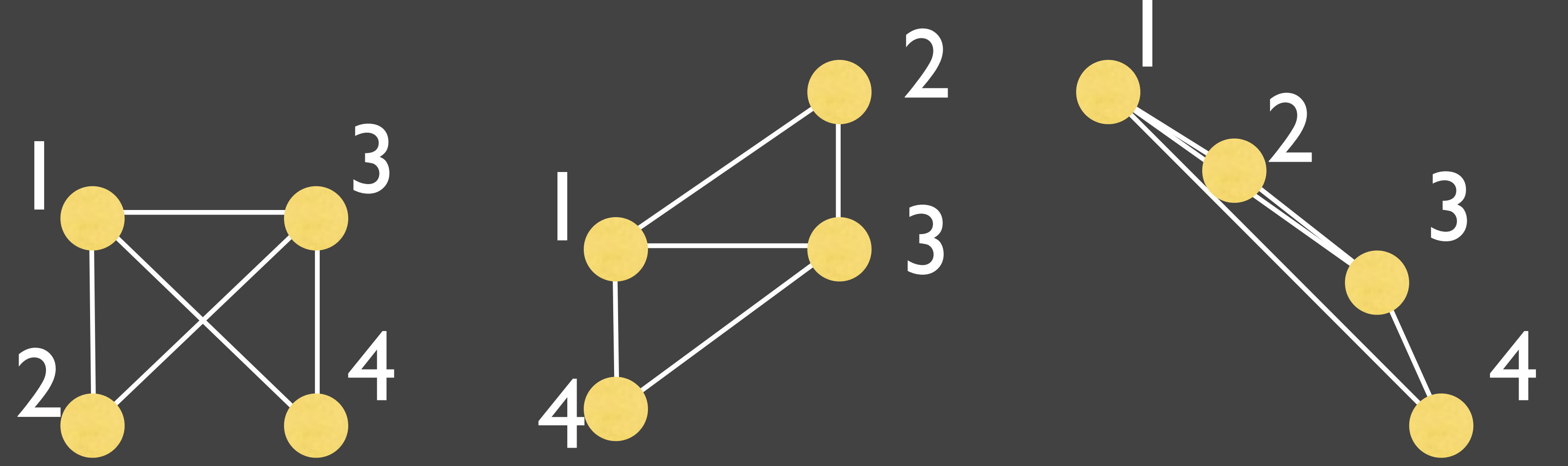


Kailie Parrish

DEFINITIONS

GRAPH

- A graph *G* consists of a collection of vertices (or nodes) *V* and a set of edges *E,* consisting of vertex pairs.
- An edge $e_{xy} = (x,y)$ connects two vertices *x* and *y.*
  - for example: V={1,2,3,4}, E={(1,2),(1,3),(2,3),(3,4),(4,1)}

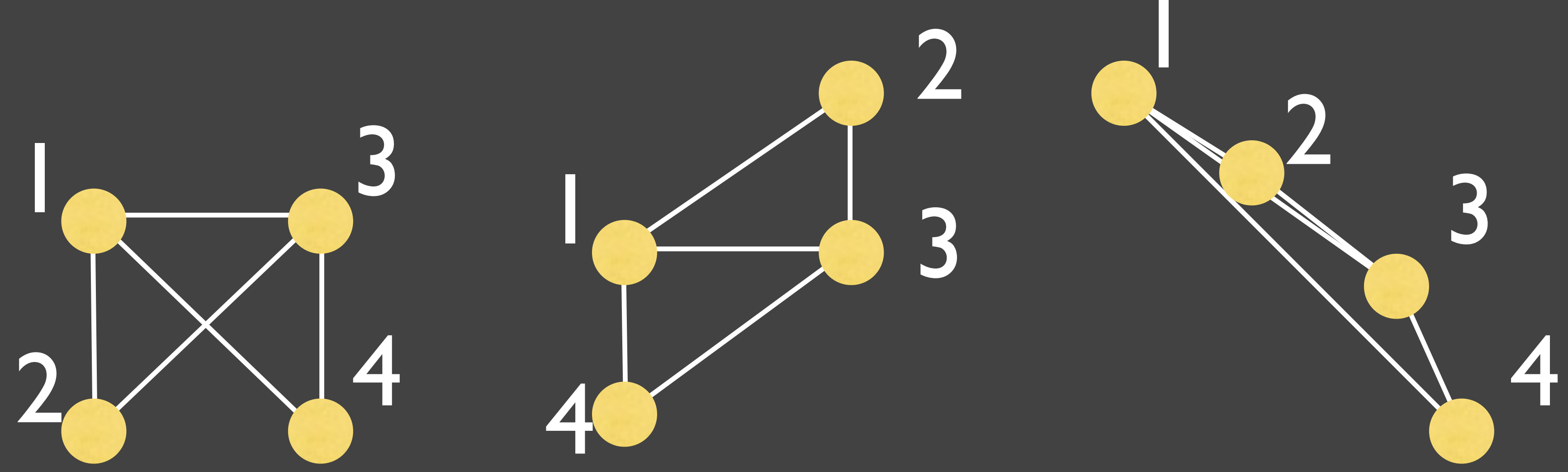


Nodes

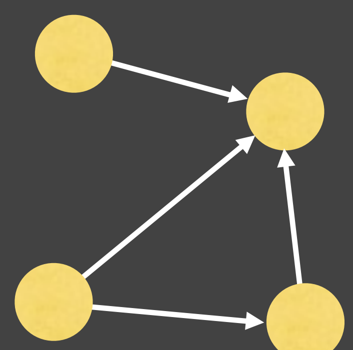
ID	Attribute 1	Attribute 2
1	3.4	Good
2	5.8	Bad
3	1.1	Ugly
4	-3.5	Really Ugly

Edges

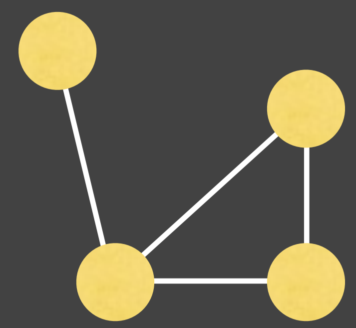
Source	Target	Attribute 3
1	2	100
1	3	200
1	4	50
2	3	150
3	4	250



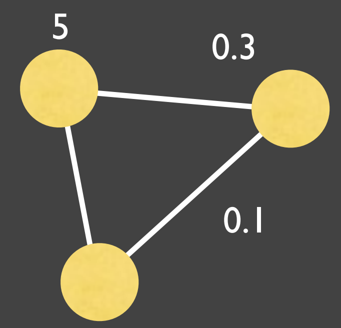
a bunch of definitions



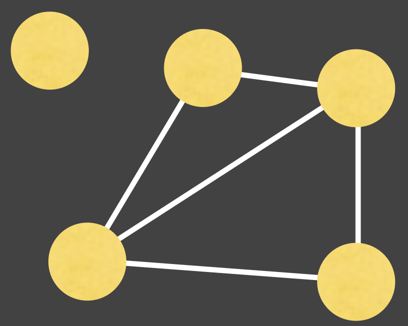
A directed graph



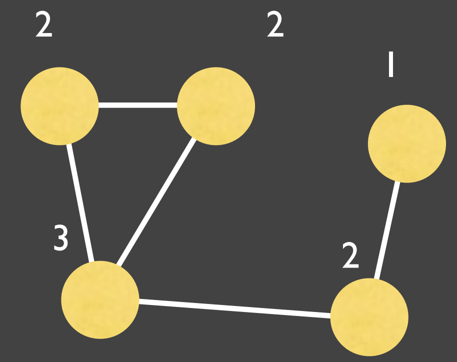
An undirected graph



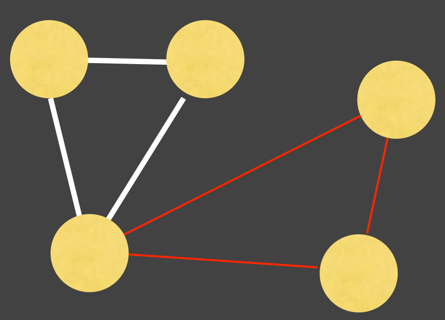
Weighted



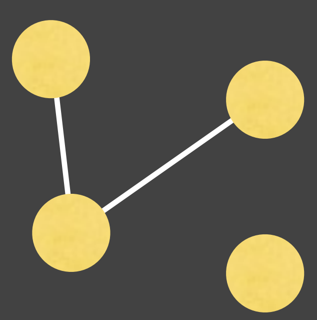
Unconnected



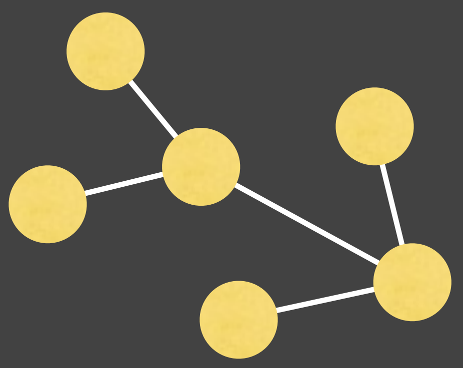
Node degrees



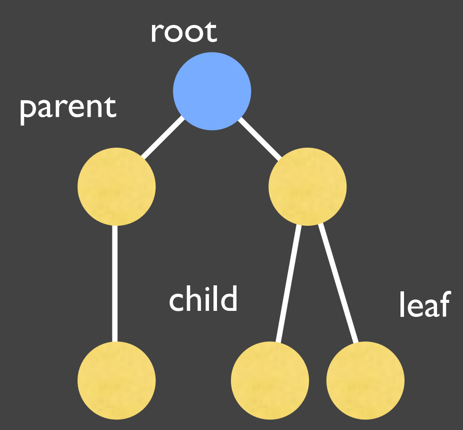
A cycle



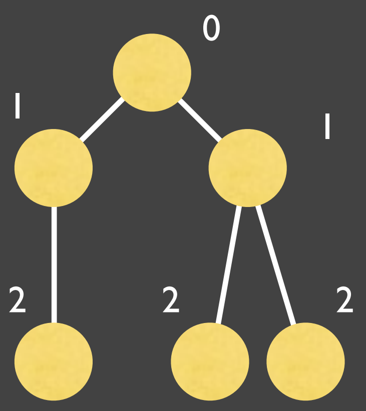
An acyclic graph



A connected acyclic graph,
a.k.a. a **tree**



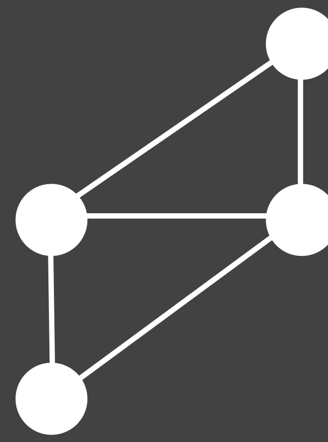
A rooted tree
or hierarchy



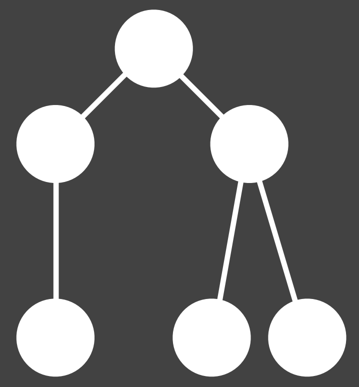
Node depths

GRAPHS & TREES

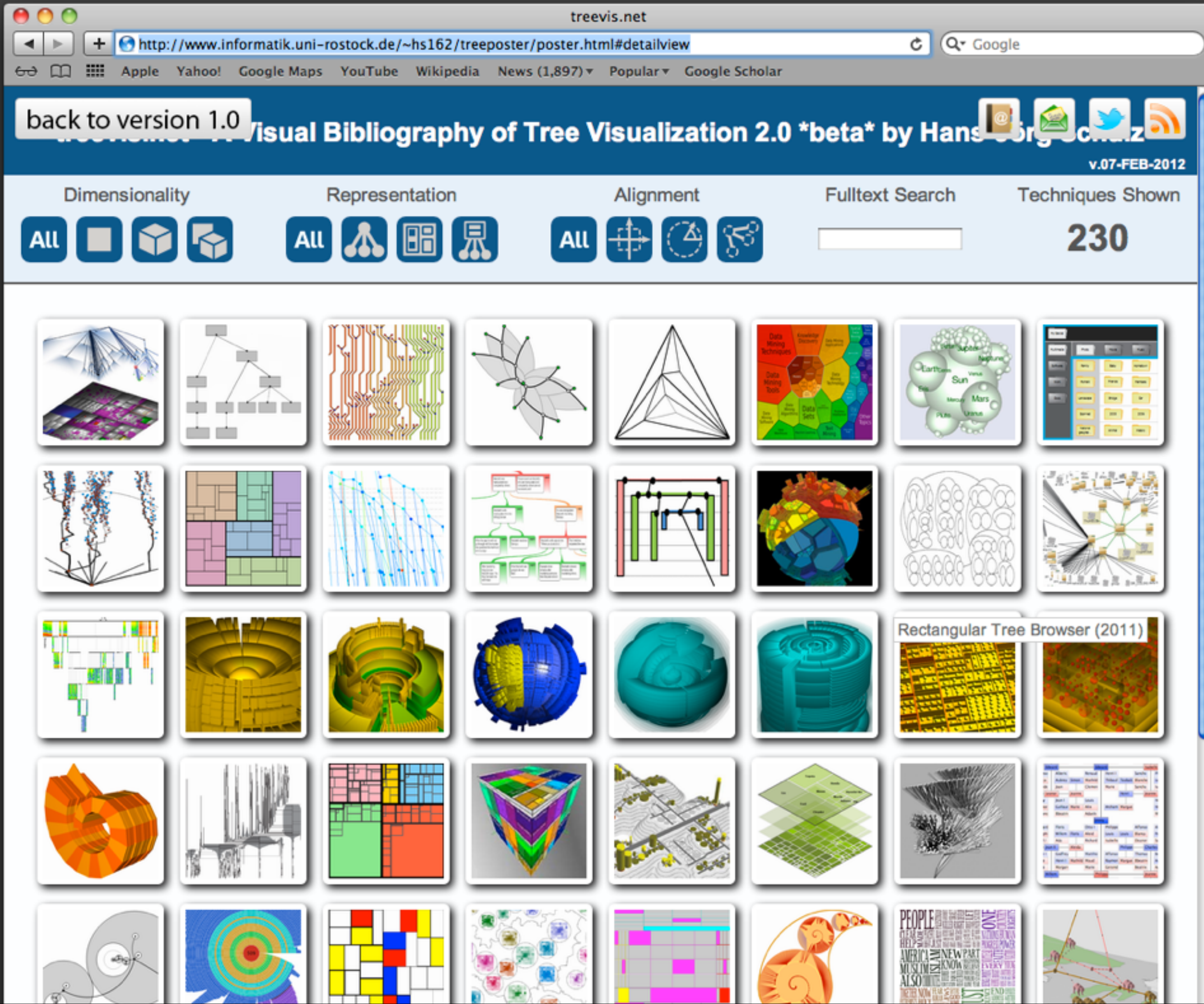
- **graphs**
  - model relations amount data
  - *nodes* and *edges*



- **trees**
  - graphs with hierarchical structure
  - nodes as *parents* and *children*



VISUALIZING TREES



treevis.net
http://www.informatik.uni-rostock.de/~hs162/treeposter/poster.html#detailview
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Yahoo!
Google Maps
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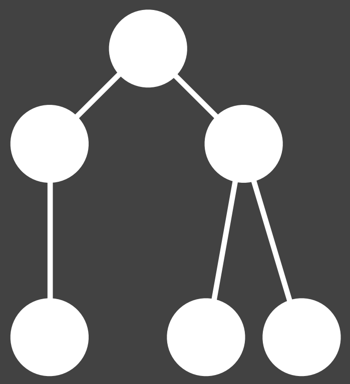
Popular
Google Scholar
back to version 1.0
Visual Bibliography of Tree Visualization 2.0 *beta* by Hans
v.07-FEB-2012
Dimensionality
Representation
Alignment
Fulltext Search
Techniques Shown
All
All
All
230
Rectangular Tree Browser (2011)

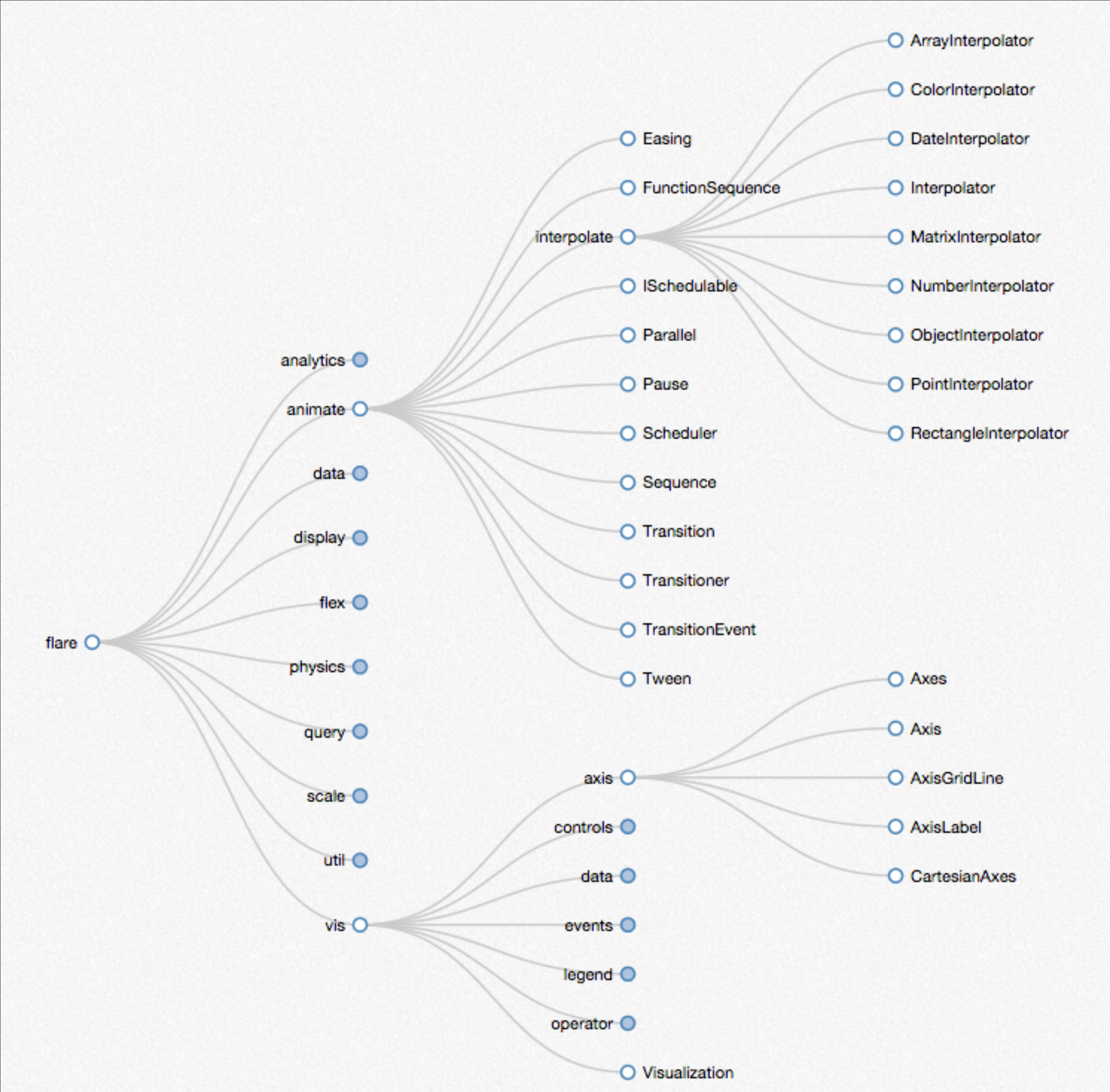
ROOTED TREES

- recursion makes it elegant and fast to draw trees
- approaches:
  - node link
  - layered
  - indentation
  - enclosure

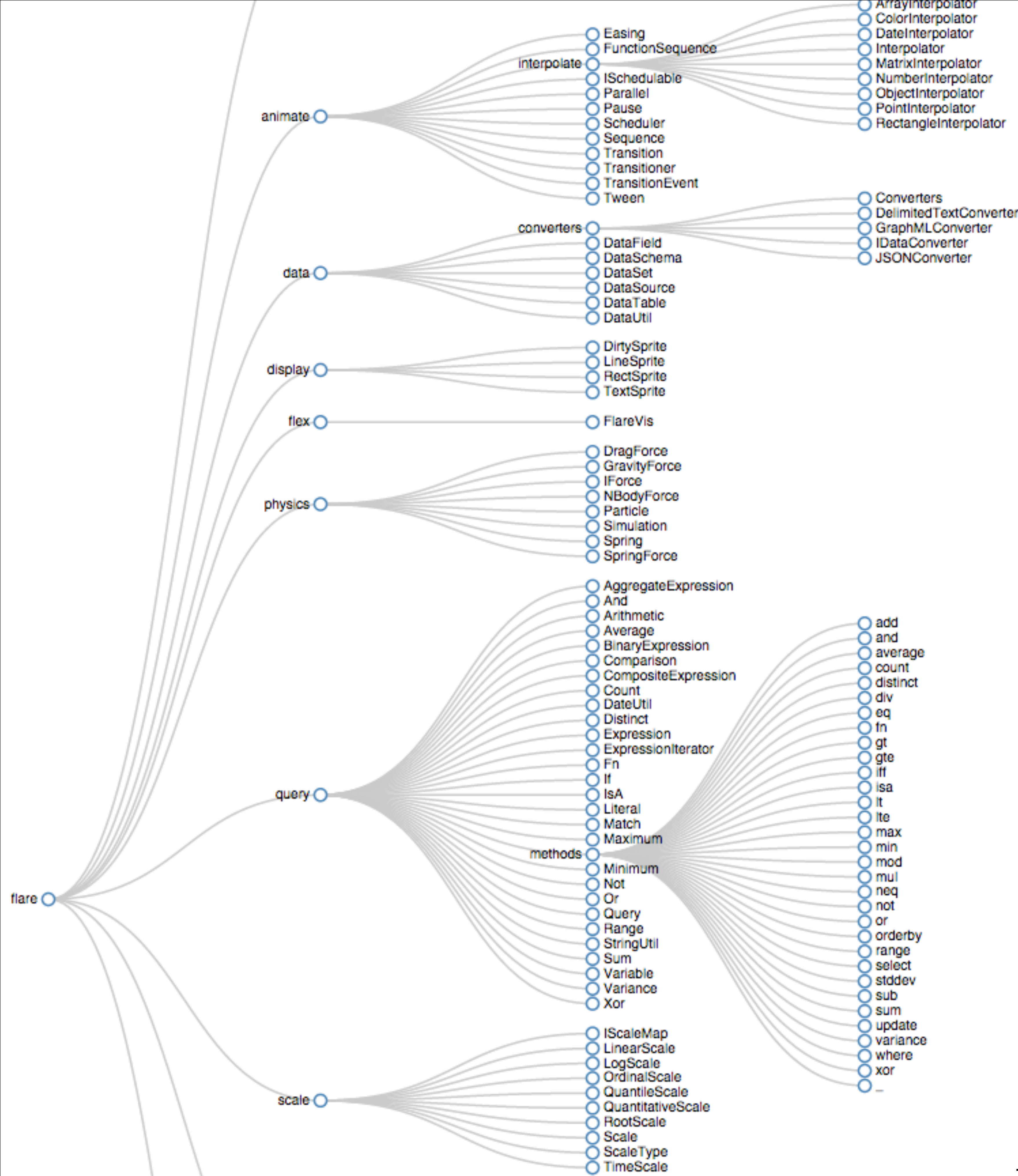
NODE-LINK DIAGRAMS

- nodes are distributed in space, connected by straight or curved lines
- typical approach is to use 2D space to break apart breadth and depth
- often space is used to communicate hierarchical orientation





http://mbostock.github.io/d3/talk/20111018/tree.html

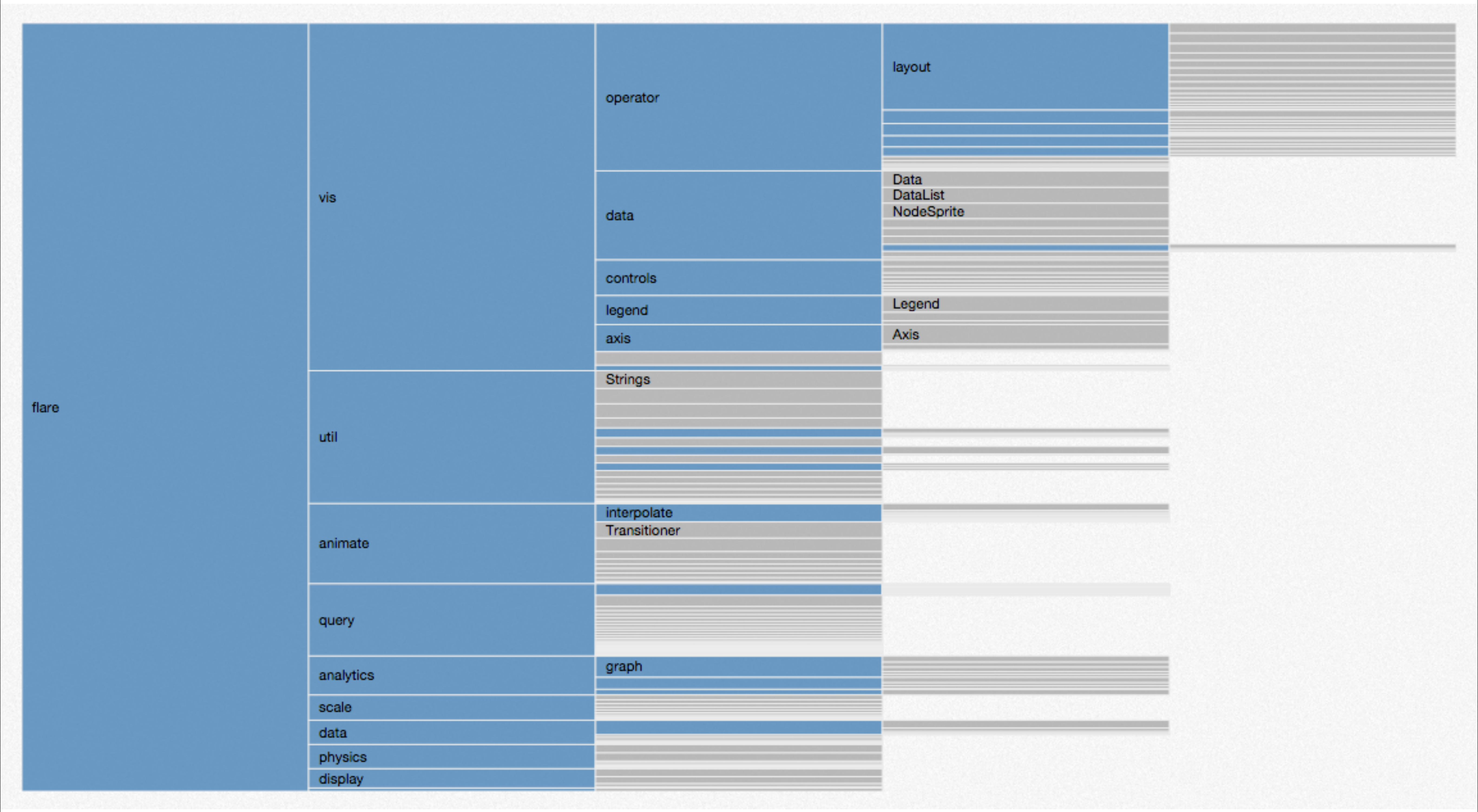


http://bl.ocks.org/mbostock/4339184

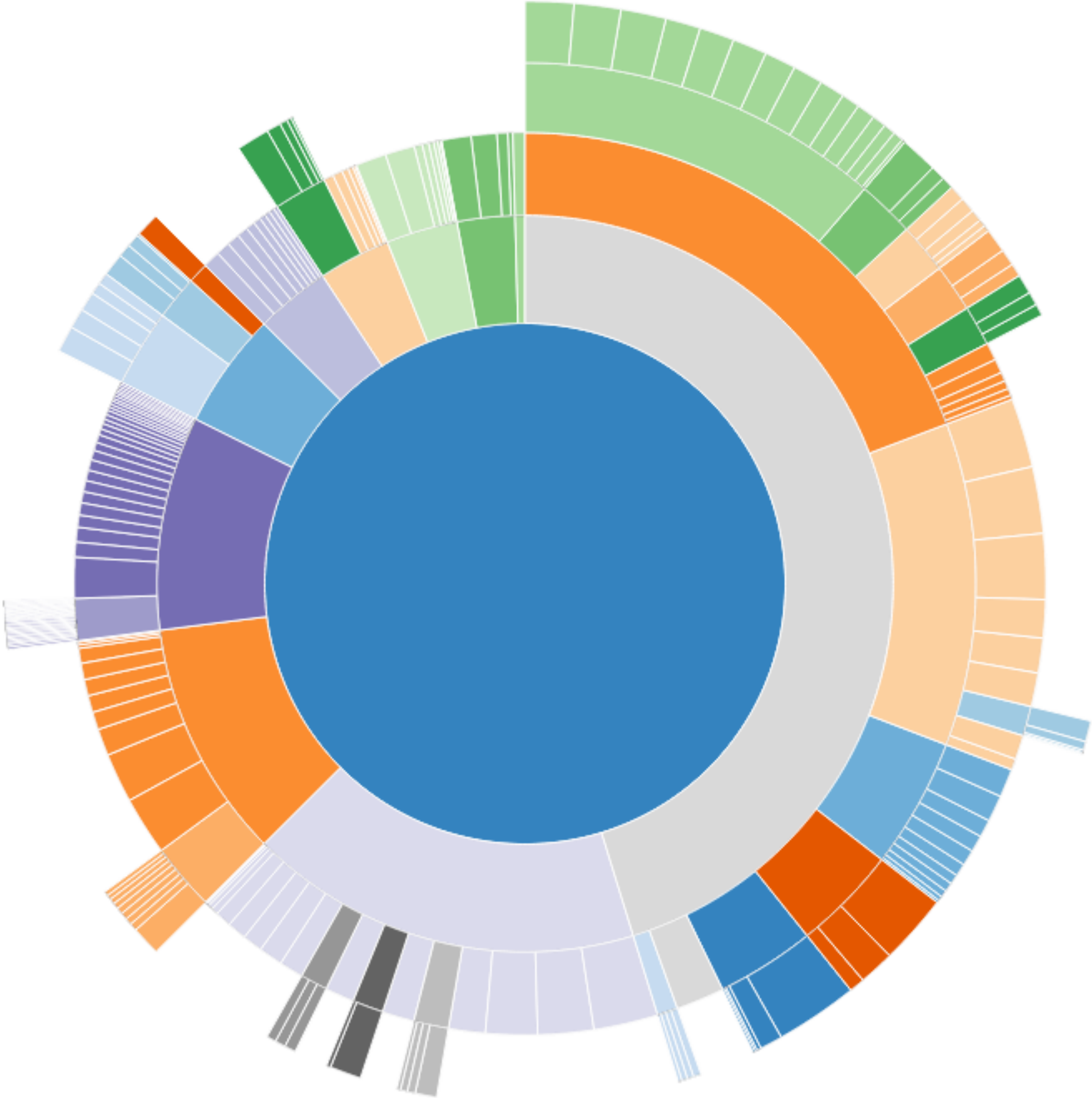
http://bl.ocks.org/mbostock/4063550

LAYERED DIAGRAMS

- recursive subdivision of space
- structure encoded using:
  - layering
  - adjacency
  - alignment



http://mbostock.github.io/d3/talk/20111018/partition.html



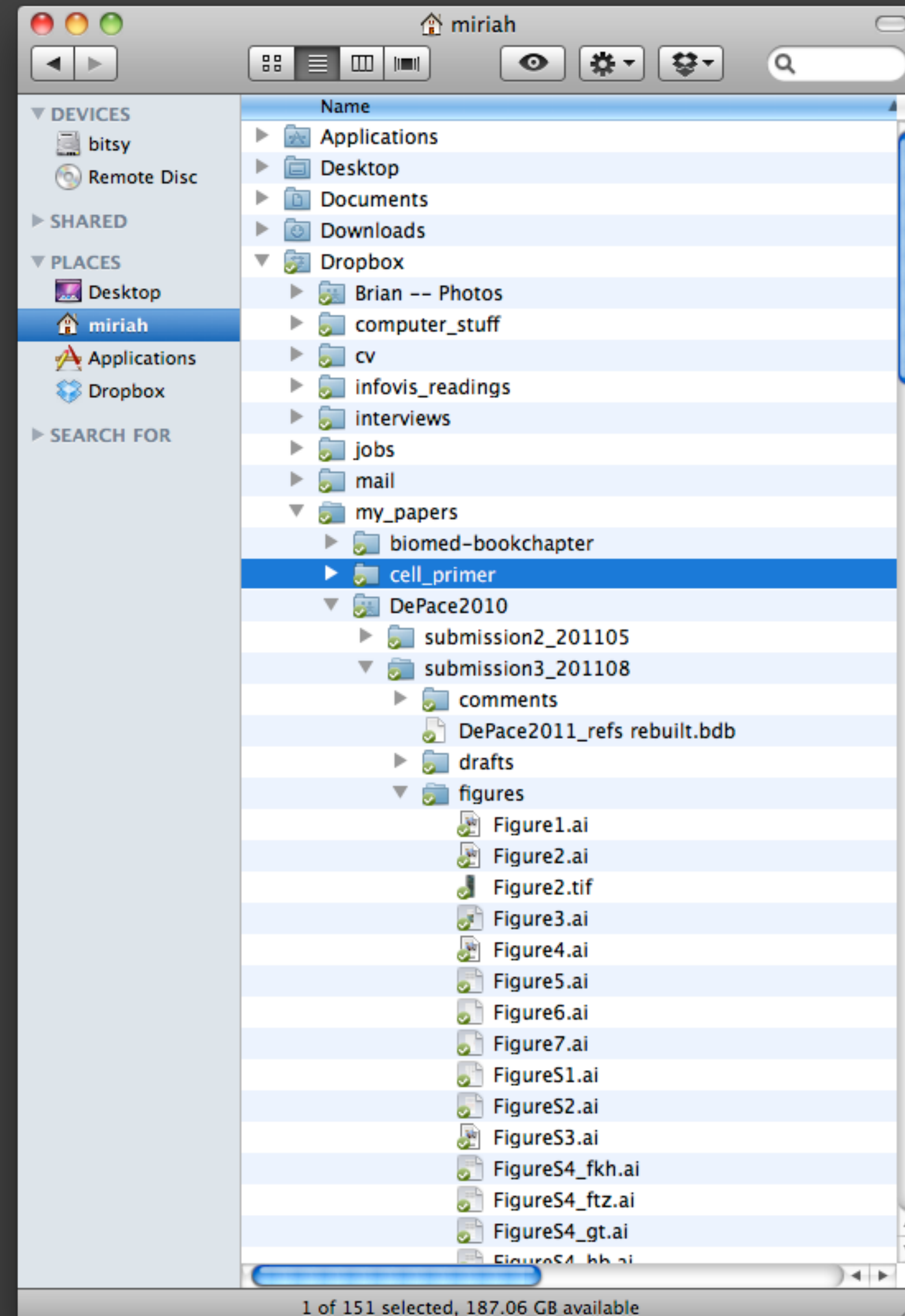
http://bl.ocks.org/mbostock/raw/4348373/

SCALE PROBLEM

- tree breadth often grows exponentially
- quickly run out of space!
- solutions
  - scrolling or panning
  - filtering or zooming
  - hyperbolic layout

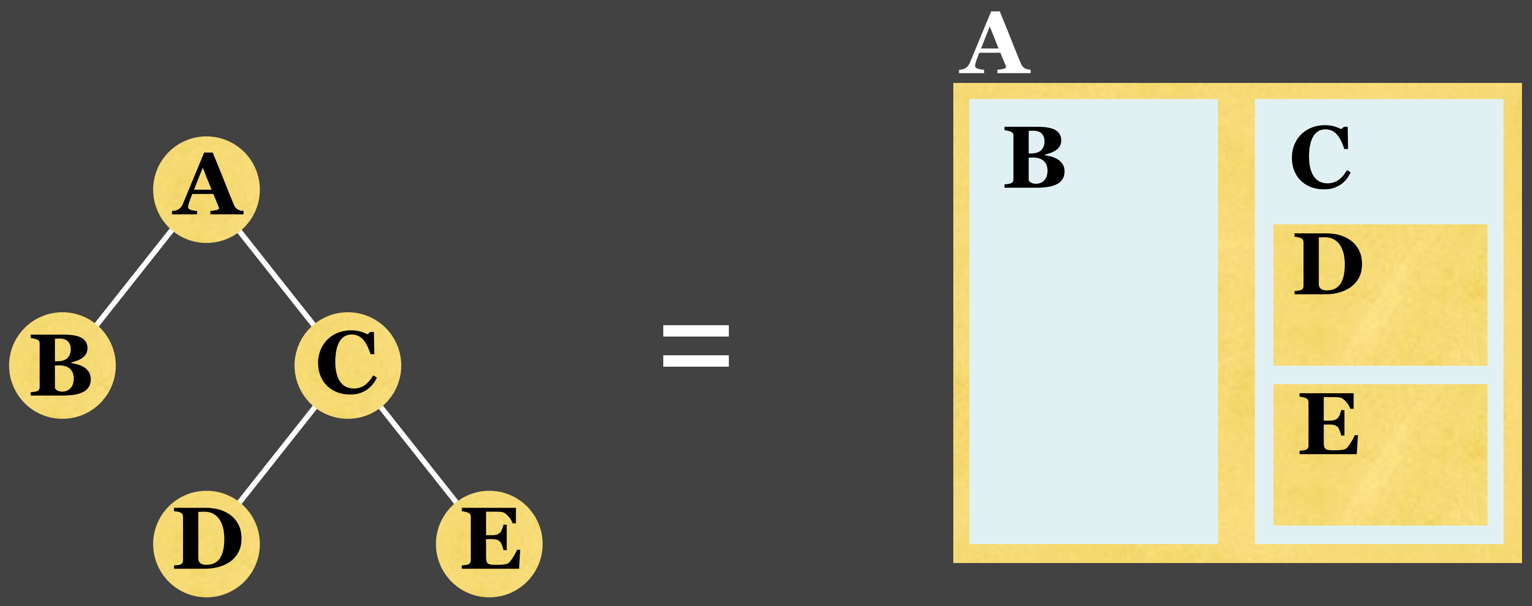
INDENTATION

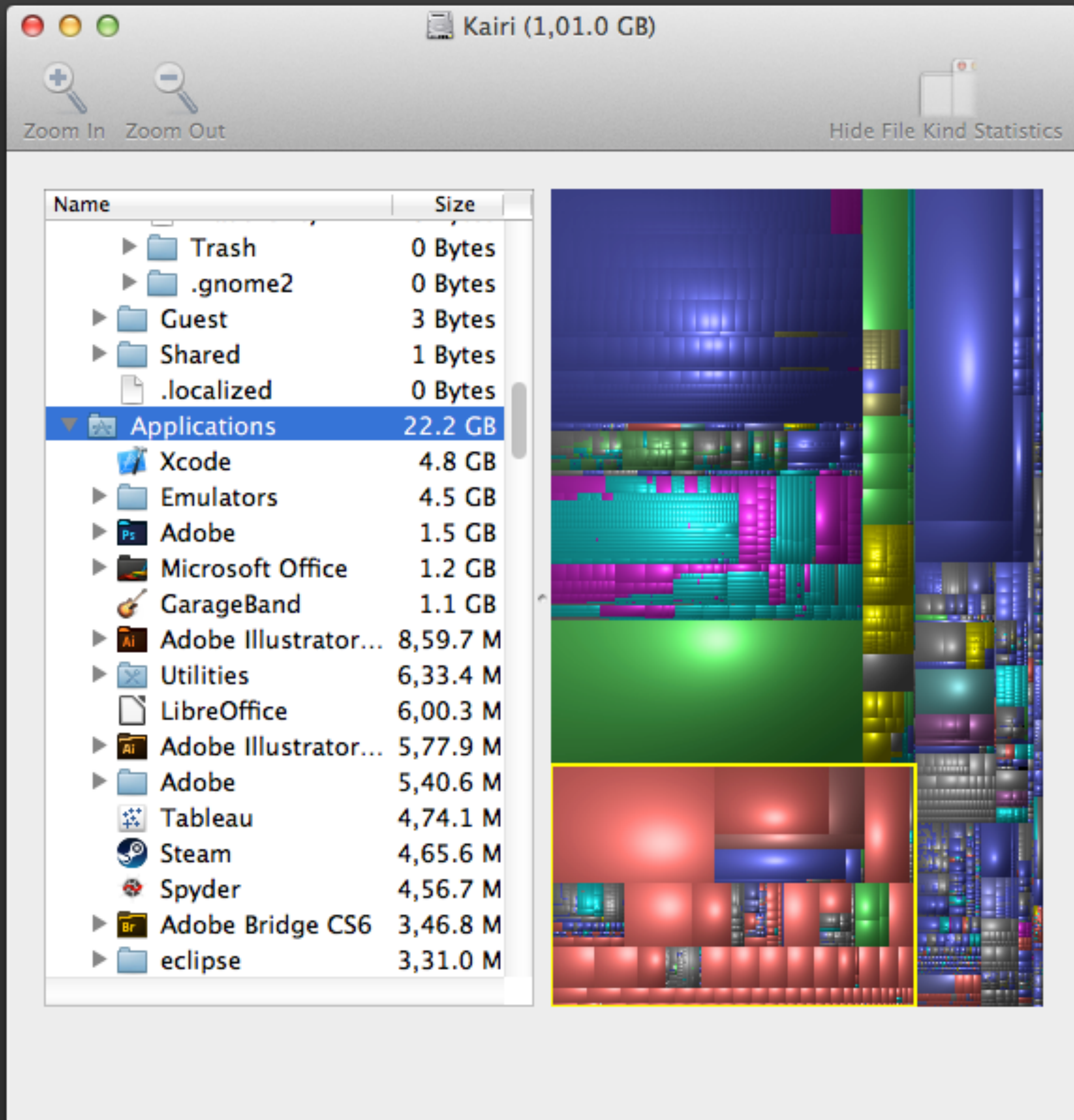
- place all items along vertically spaced rows
- indentation used to show parent/child relationships
- commonly used as a component in an interface
- breadth and depth contend for space
- often requires a great deal of scrolling



ENCLOSURE DIAGRAMS

- **encode structure using spatial enclosure**
  - often referred to as *treemaps*
- **benefits**
  - provides single view of entire tree
  - easier to spot small / large nodes
- **problems**
  - difficult to accurately read depth

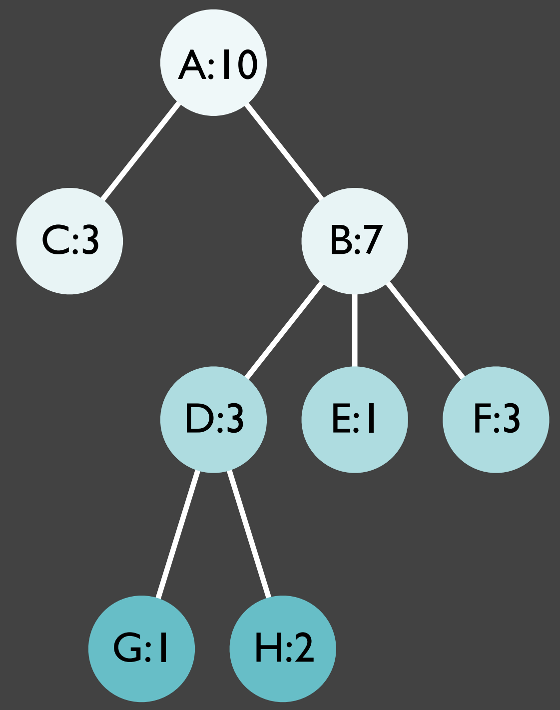


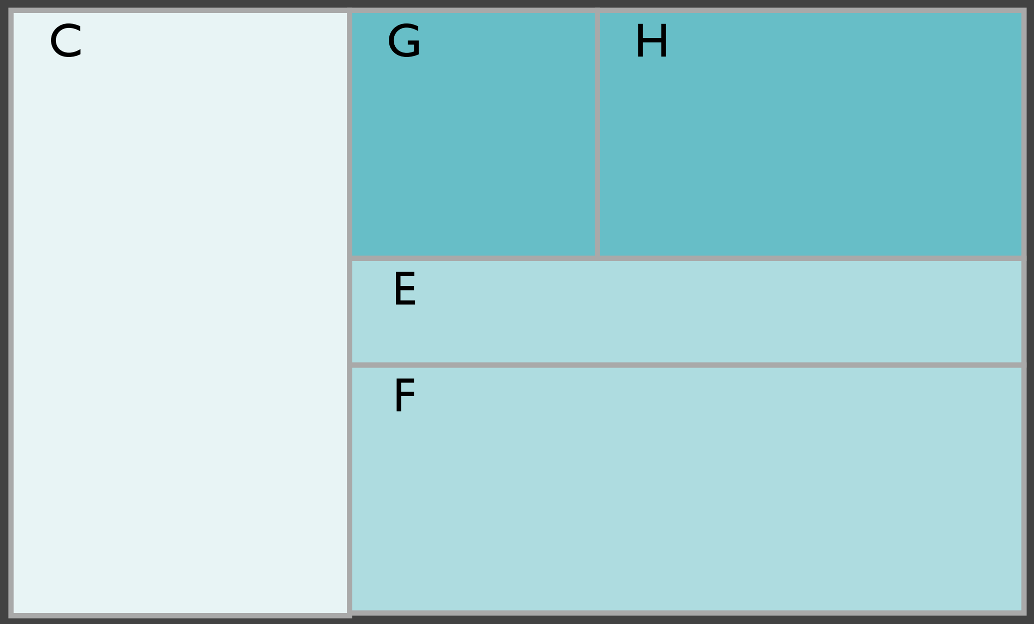


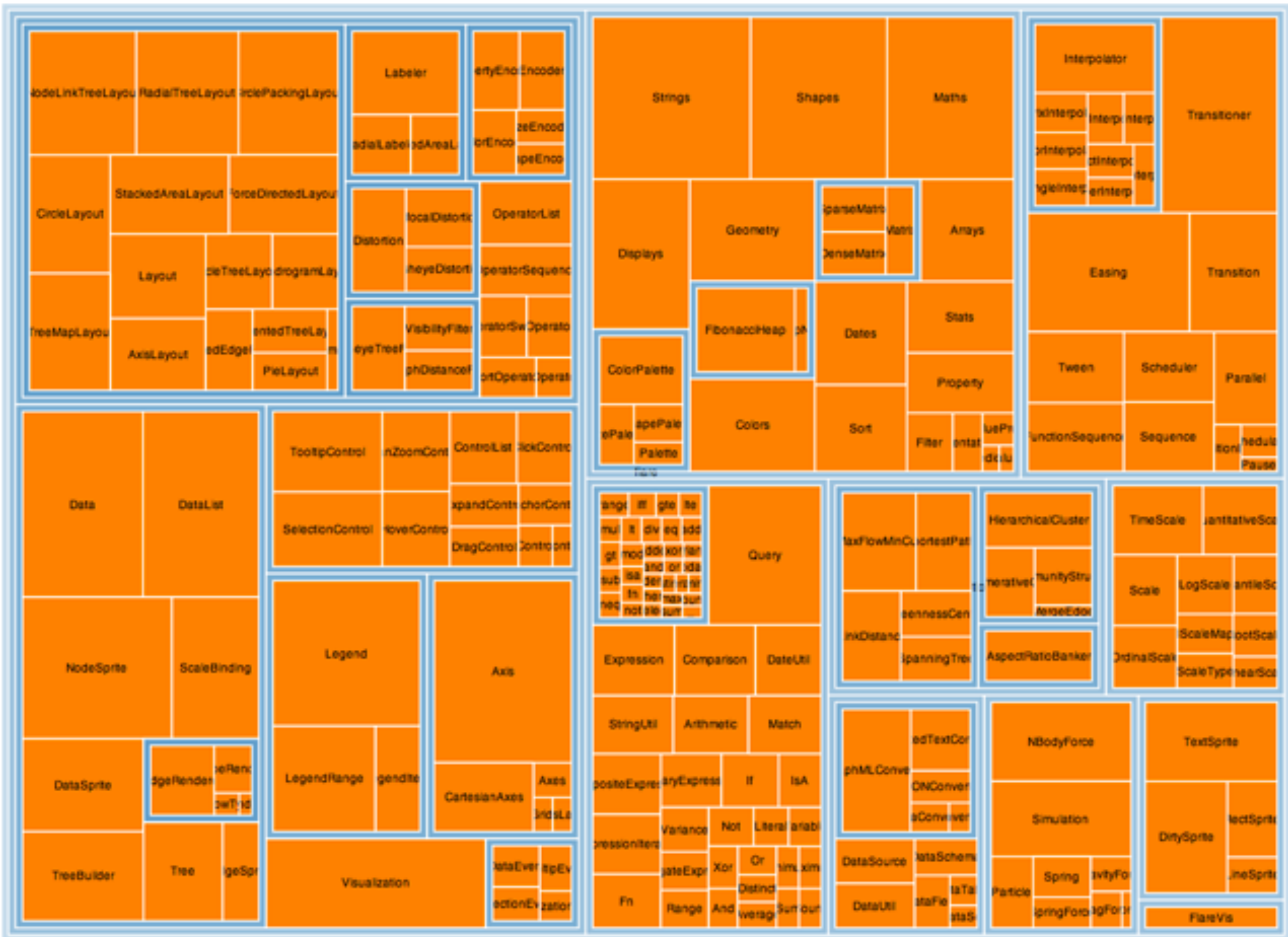
http://www.derlien.com/

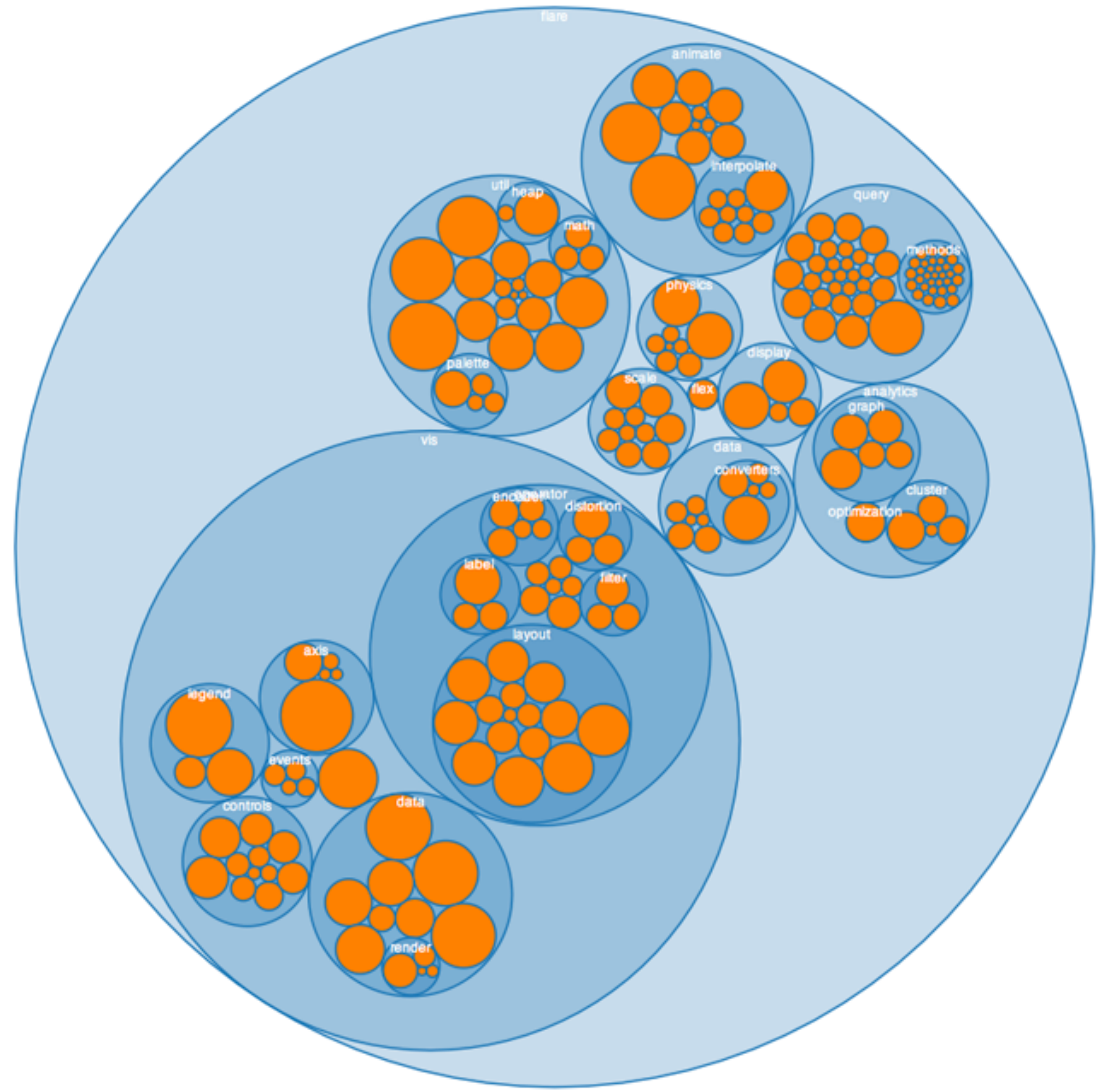
TREEMAPS

- recursively fill space based on a size metric for nodes
- enclosure indicates hierarchy
- additional measures can control aspect ratio of cells
- most often use rectangles, but other shapes possible
  - square, circle, voronoi tessellation



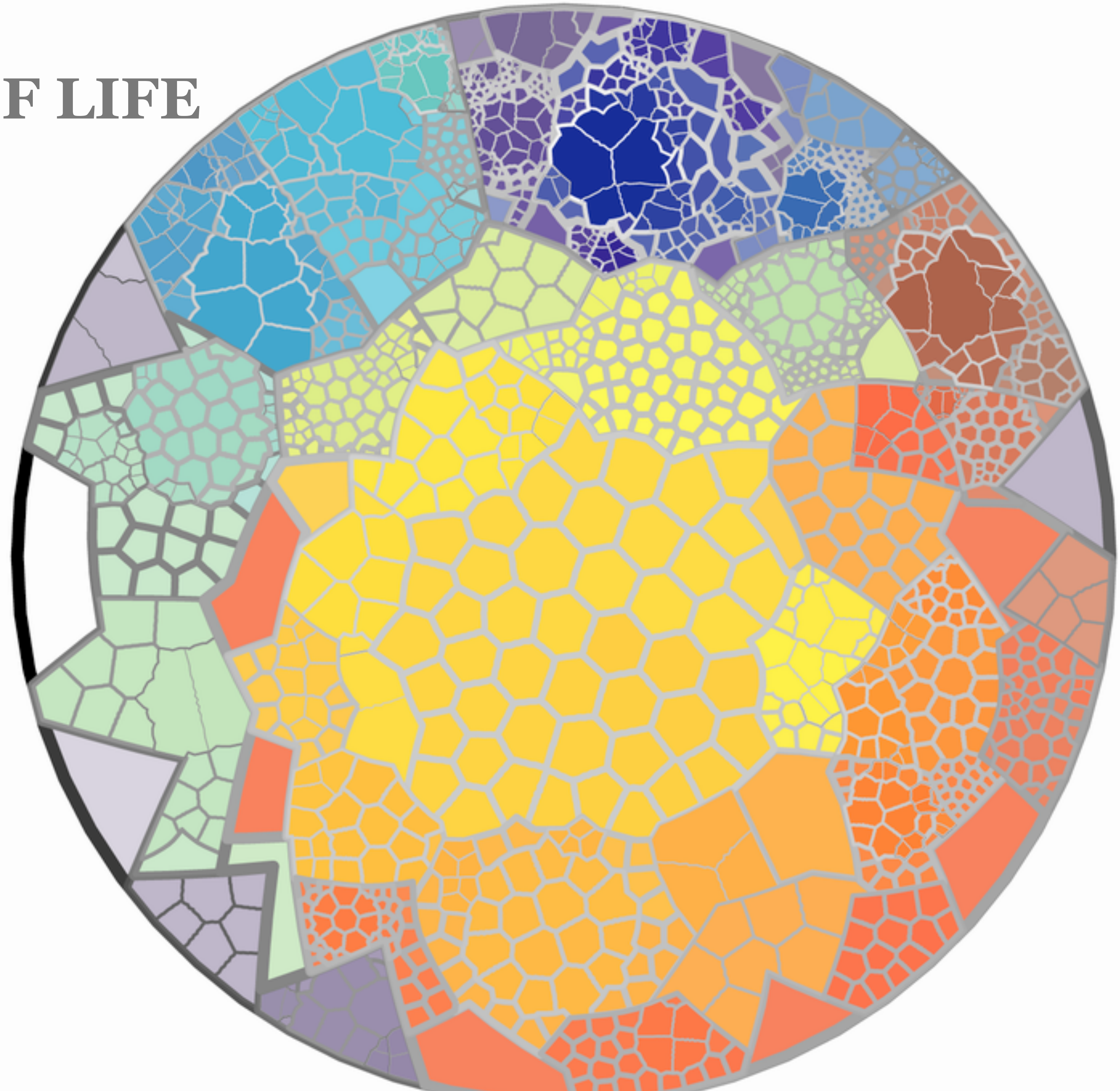






http://hci.stanford.edu/jheer/files/zoo/

TREE OF LIFE
mammals



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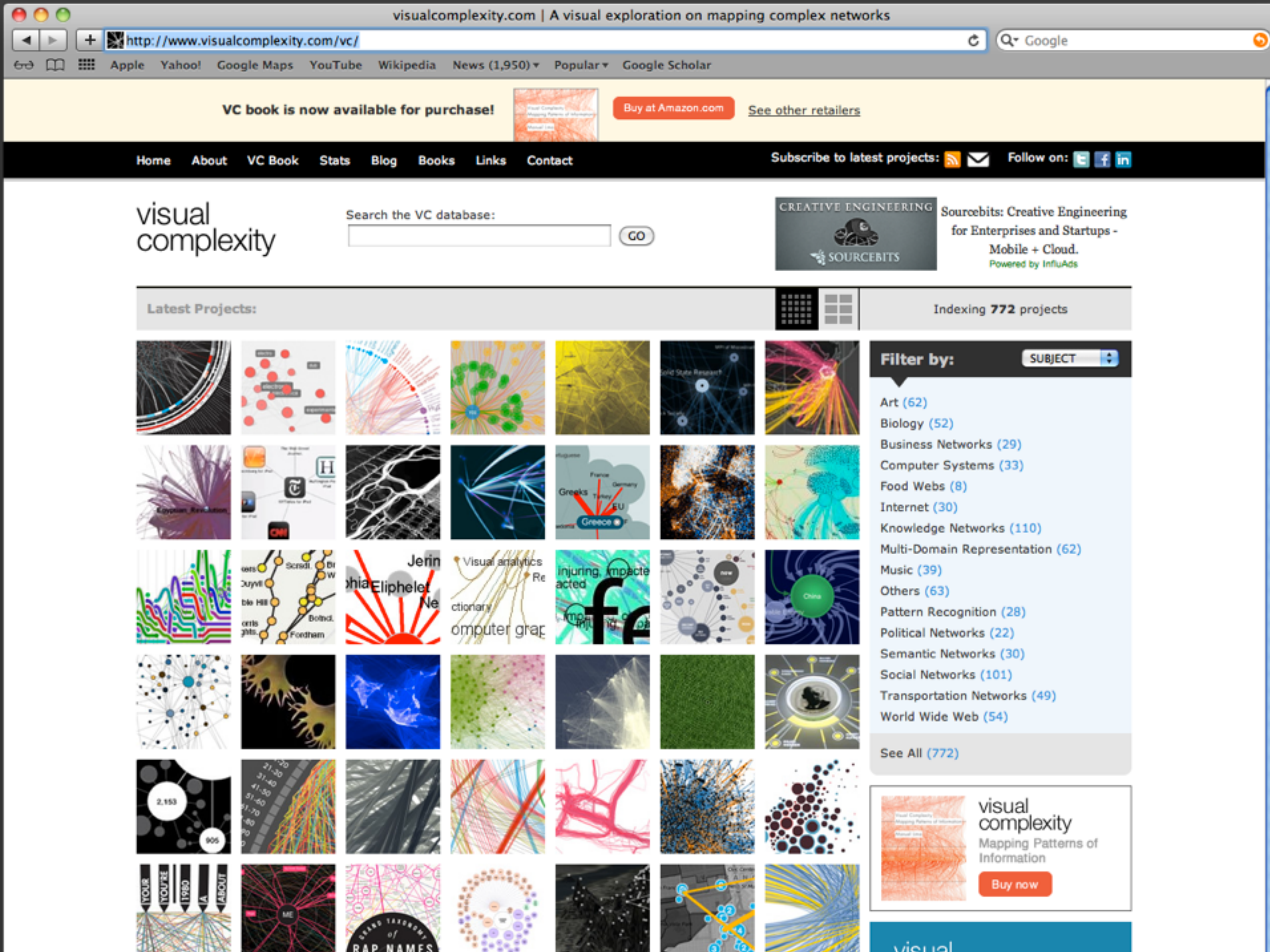
VISUALIZING GRAPHS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Knowledge Networks (110)
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Music (39)
Others (63)
Pattern Recognition (28)
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See All (772)
visual complexity
Mapping Patterns of Information
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RAP NAMES

VISUALIZING GRAPHS

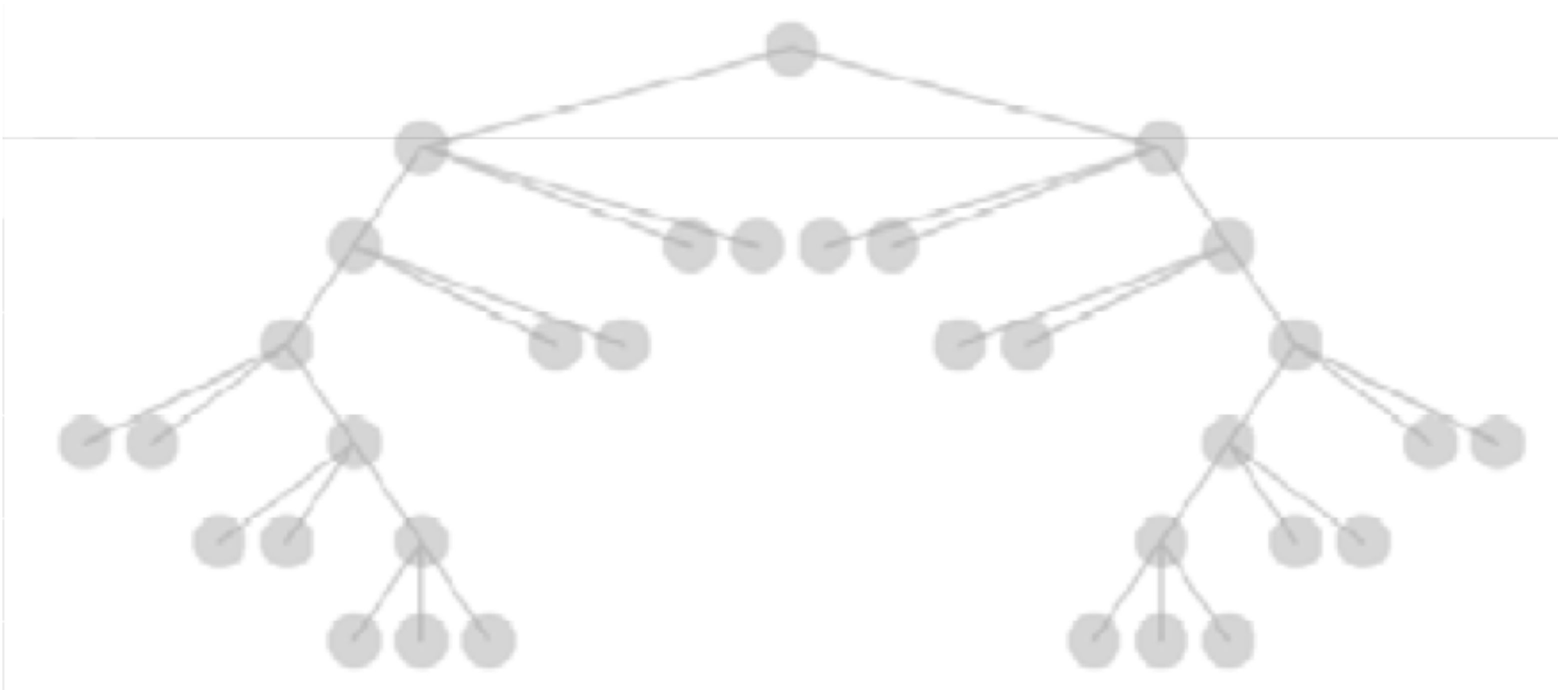
- **node link layouts**
  - Reingold-Tilford (trees only)
  - Sugiyama (directed acyclic graphs)
  - Force directed
  - Attribute-based
- **adjacency matrices**
- **aggregate views**
  - Motif Glyphs
  - PivotGraph

SPATIAL LAYOUT

- primary concern of graph drawing is the spatial layout of nodes and edges
- often (but not always) the goal is to effectively depict the graph structure
  - connectivity, path-following
  - network distance
  - clustering
  - ordering (e.g., hierarchy level)

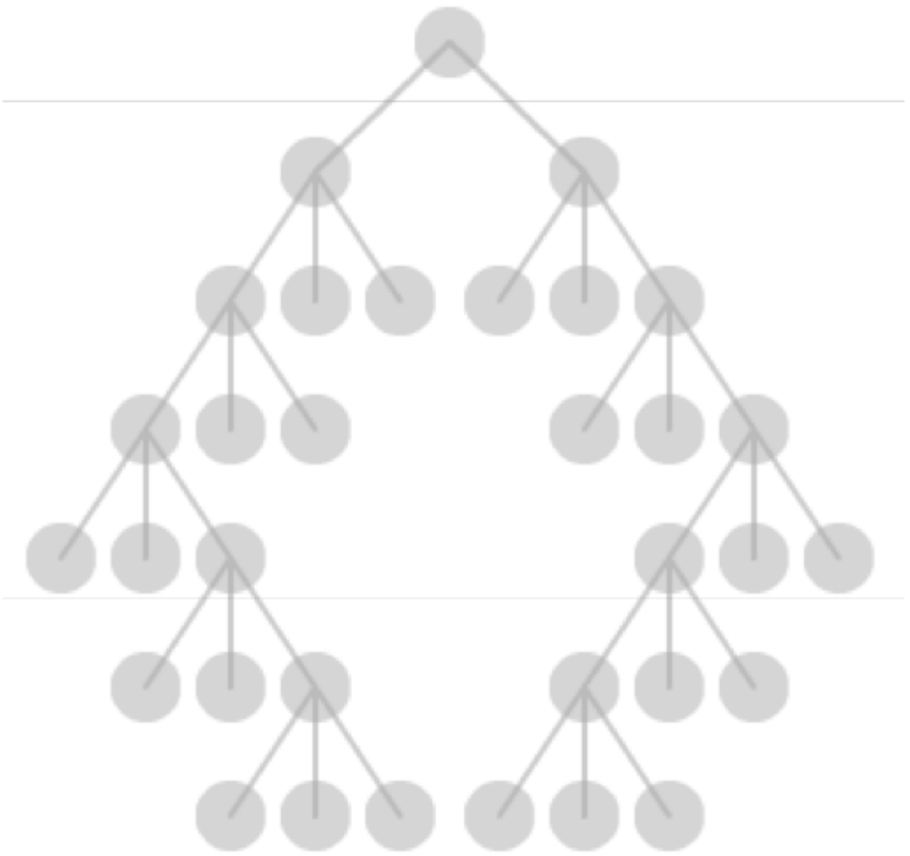
REINGOLD-TILFORD

- **repeatedly divide space for subtrees by leaf count**
  - breadth of tree along one dimension
  - depth along the other dimension



REINGOLD-TILFORD

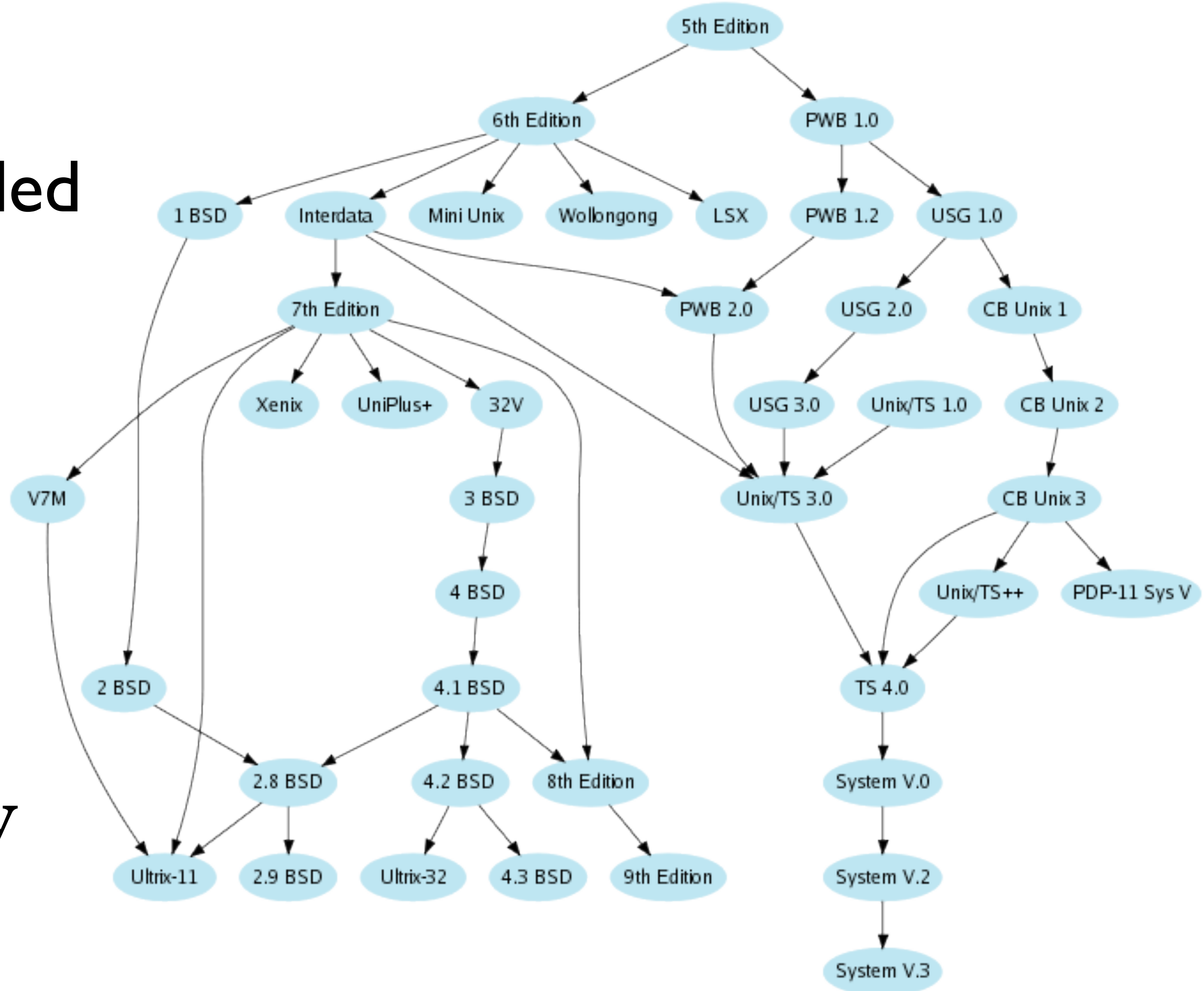
- **goal**
  - make smarter use of space
  - maximize density and symmetry
- **design concerns**
  - clearly encode depth level
  - no edge crossings
  - isomorphic subtrees drawn identically
  - compact
- **approach**
  - bottom up recursive approach
  - for each parent make sure every subtree is drawn
  - pack subtrees as closely as possible
  - center parent over subtrees



SUGIYAMA

- great for graphs that have an intrinsic ordering

- depth not strictly encoded
  - What is the depth of V7M?



UNIX ancestry

SUGIYAMA

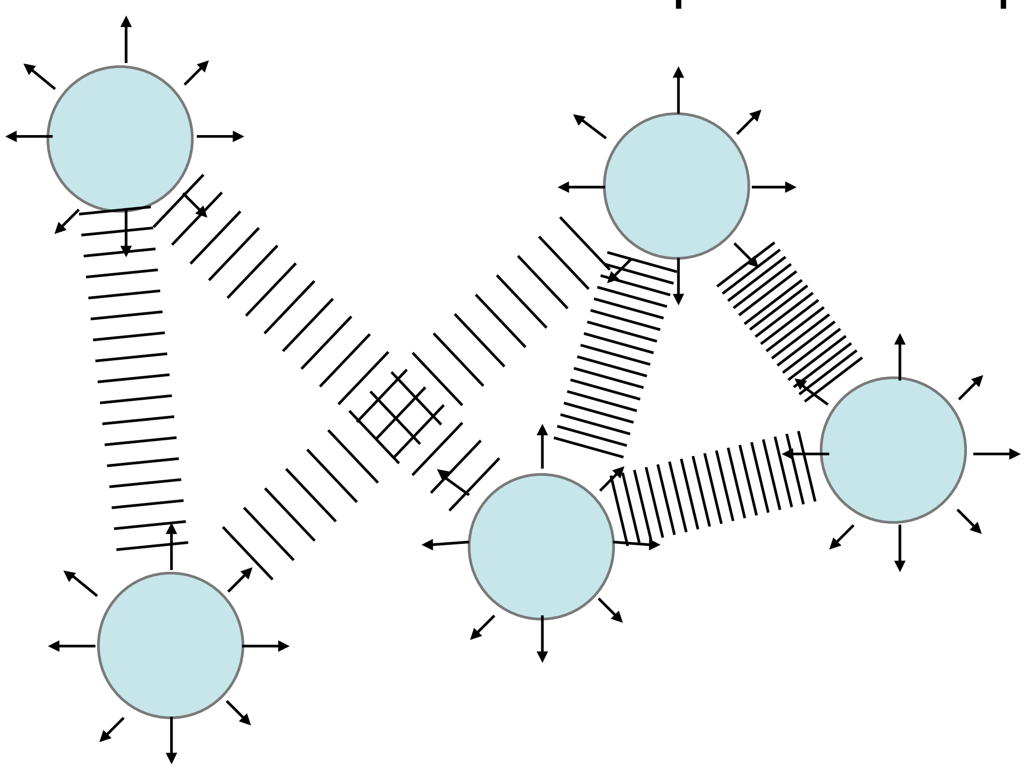
+ nice, readable top down flow
+ relatively fast (depending on heuristic used for crossing minimization)

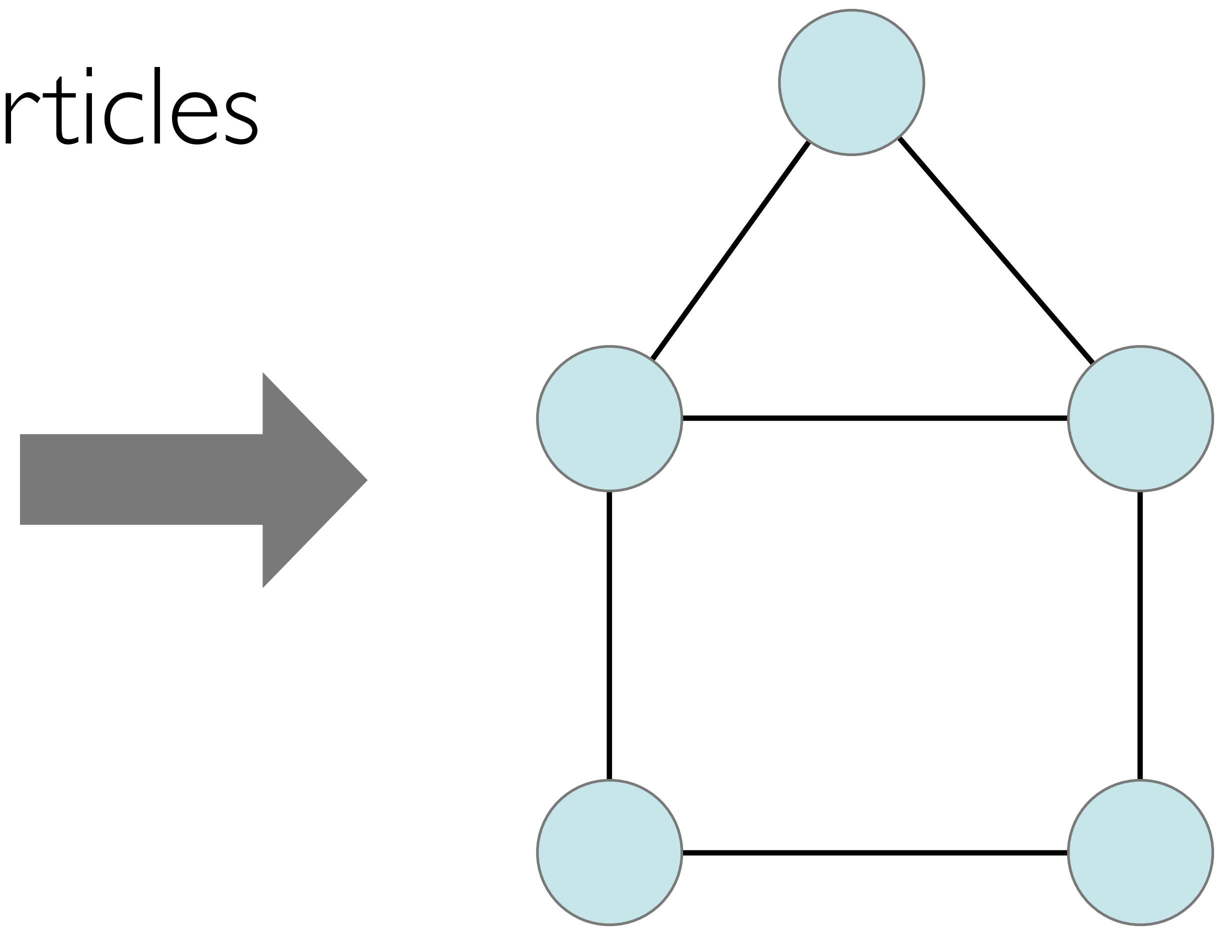
- not really suitable for graphs that don't have an intrinsic top down structure
- hard to implement
  - use free graphviz lib instead: http://www.graphviz.org

FORCE-DIRECTED

- no intrinsic layering, now what?

- physics model
  - edges = springs
  - nodes = repulsive particles





FORCE MODEL

- many variations, but usually physical analogy:
  - **repulsion** : $f_R(d) = C_R * m_1 * m_2 / d^2$
    - *m_1, m_2 are node masses*
    - *d is distance between nodes*
  - **attraction** : $f_A(d) = C_A * (d – L)$
    - *L is the rest length of the spring*
    - *i.e. Hooke's Law*
- total force on a node x with position x'
  - $\sum^{\text{neighbors}(x)} : f_A(||x'-y'||) * (x'-y') + -f_R(||x'-y'||) * (x'-y')$

ALGORITHM

- **start from random layout**
- **(global) loop:**
  - for every node pair compute repulsive force
  - for every edge compute attractive force
  - accumulate forces per node
  - update each node position in direction of accumulated force
- **stop when layout is ‘good enough’**

FORCE DIRECTED

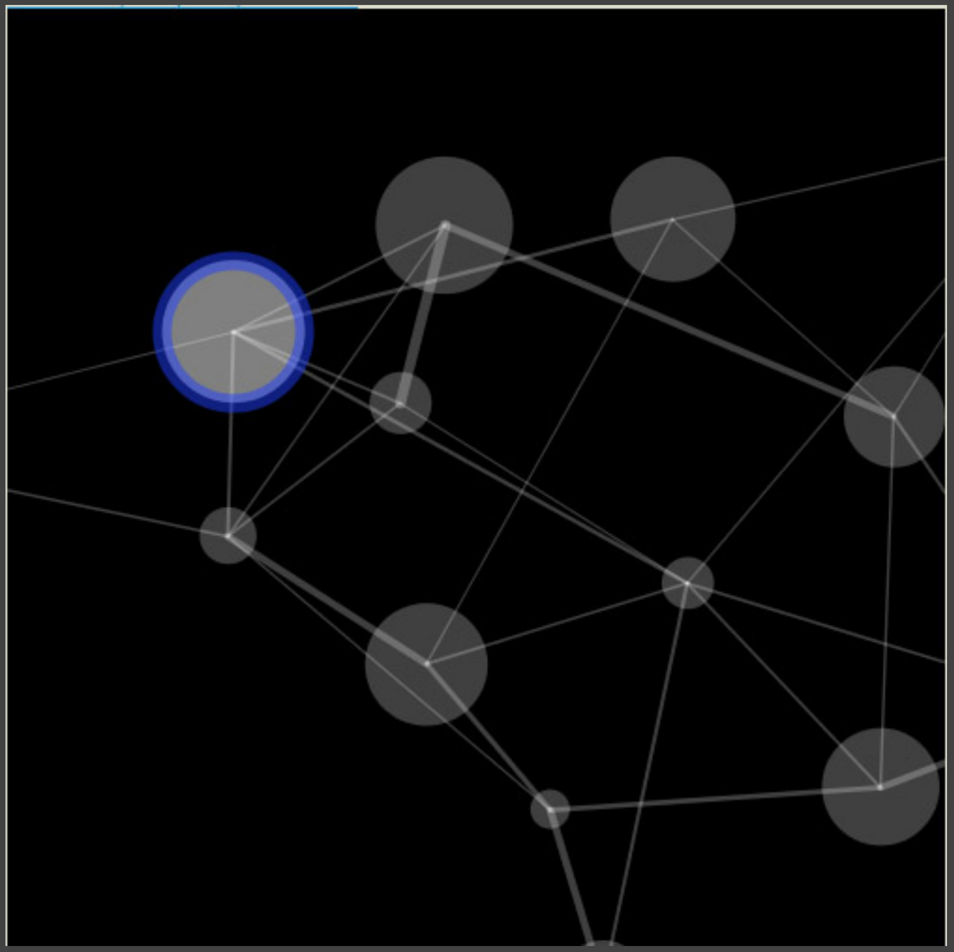
+ very flexible, aesthetic layouts on many types of graphs

+ can add custom forces

+ relatively easy to implement

- repulsion loop is $O(n^2)$ per iteration
  - can speed up to O(N log N) using quadtree or k-d tree

- prone to local minima
  - can use simulated annealing



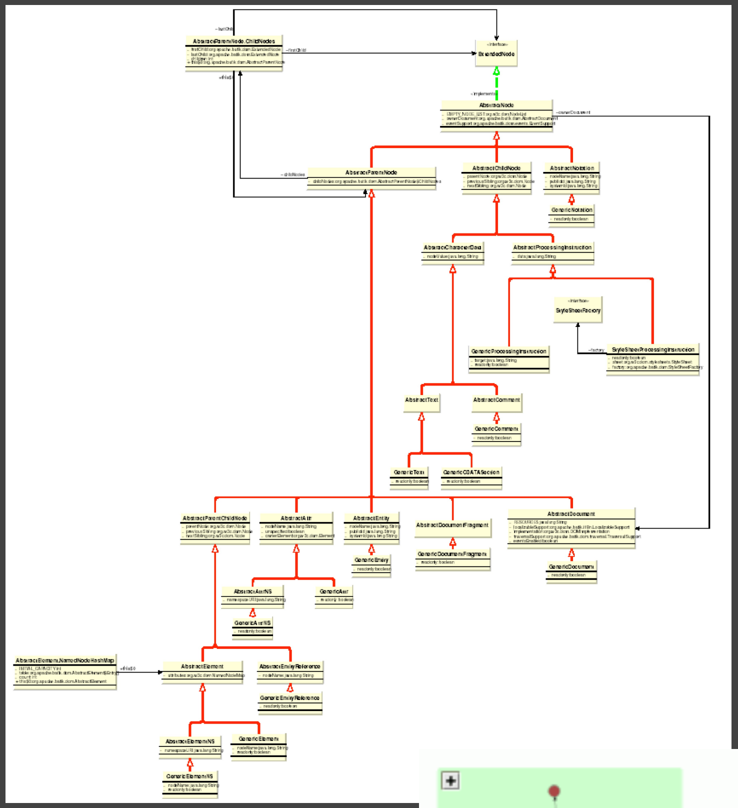
Les Misérables

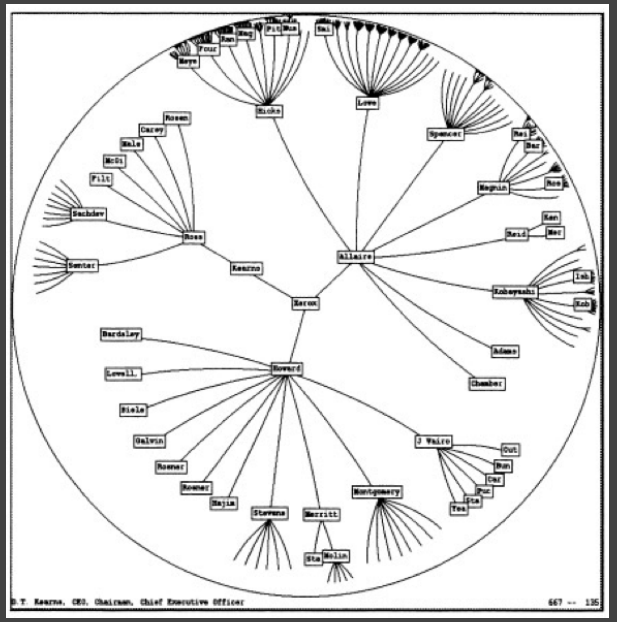
character co-occurrence

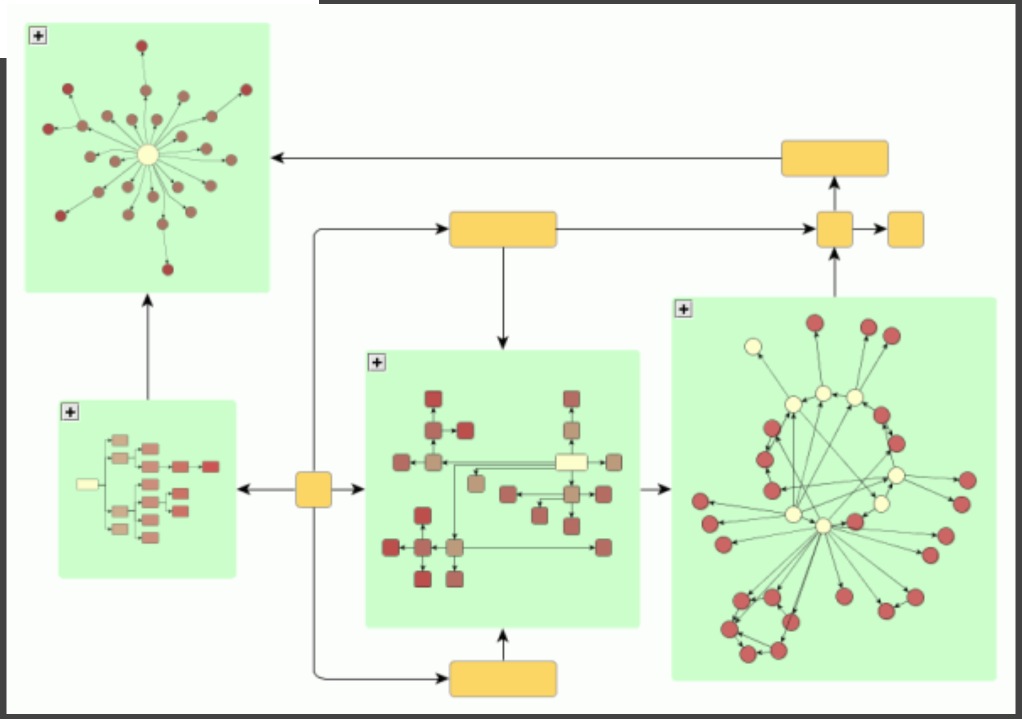
http://bl.ocks.org/mbostock/4062045

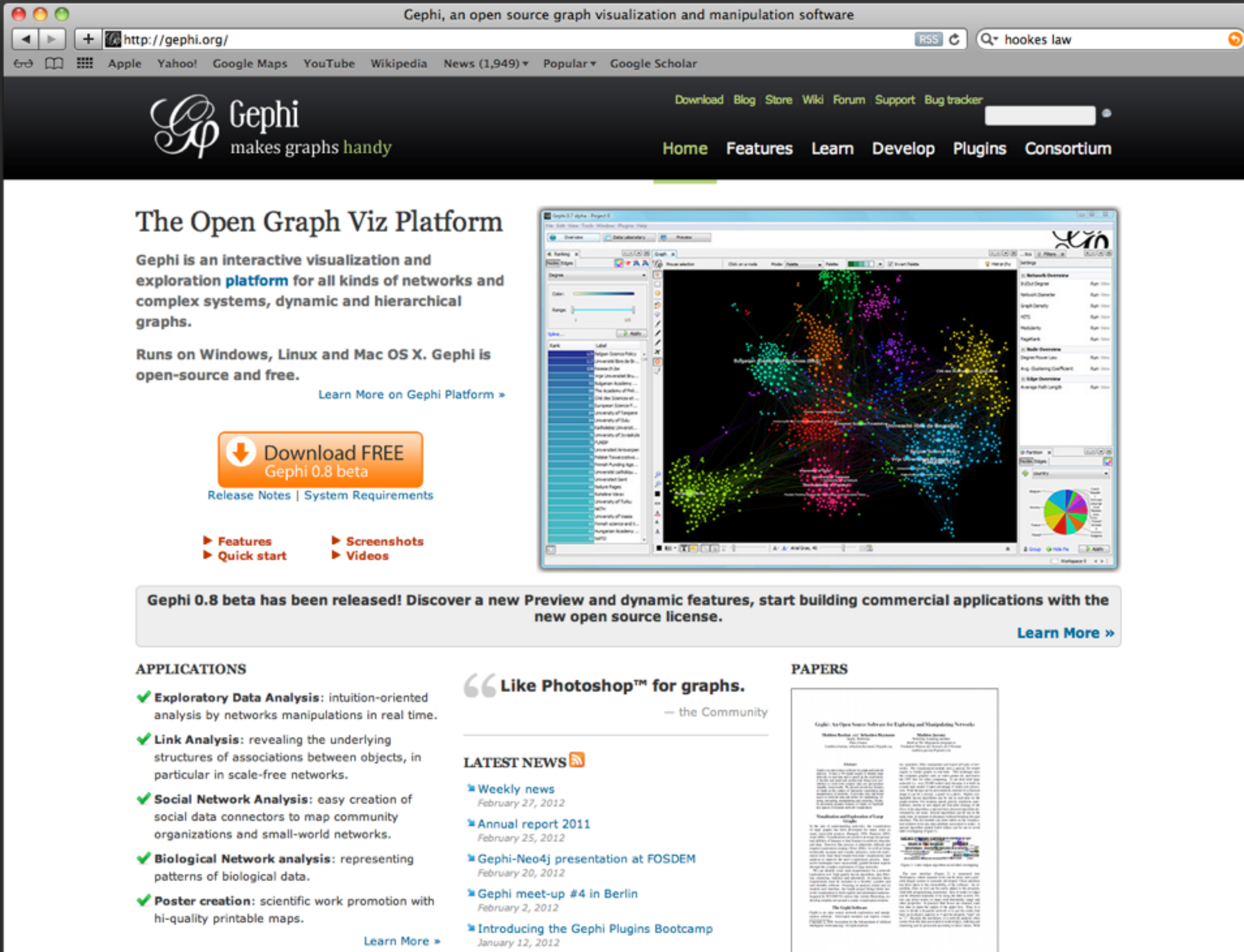
OTHER LAYOUTS

- **orthogonal**
  - great for UML diagrams
  - algorithmically complex
- **circular layouts**
  - emphasizes ring topologies
  - used in social network diagrams
- **nested layouts**
  - recursively apply layout algorithms
  - great for graphs with hierarchical structure








Gephi, an open source graph visualization and manipulation software
http://gephi.org/
hookes law
Apple Yahoo! Google Maps YouTube Wikipedia News (1,949) Popular Google Scholar
Download Blog Store Wiki Forum Support Bug tracker
Gephi
makes graphs handy
Home Features Learn Develop Plugins Consortium
The Open Graph Viz Platform
Gephi is an interactive visualization and exploration platform for all kinds of networks and complex systems, dynamic and hierarchical graphs.
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APPLICATIONS
Exploratory Data Analysis: intuition-oriented analysis by networks manipulations in real time.
Link Analysis: revealing the underlying structures of associations between objects, in particular in scale-free networks.
Social Network Analysis: easy creation of social data connectors to map community organizations and small-world networks.
Biological Network analysis: representing patterns of biological data.
Poster creation: scientific work promotion with hi-quality printable maps.
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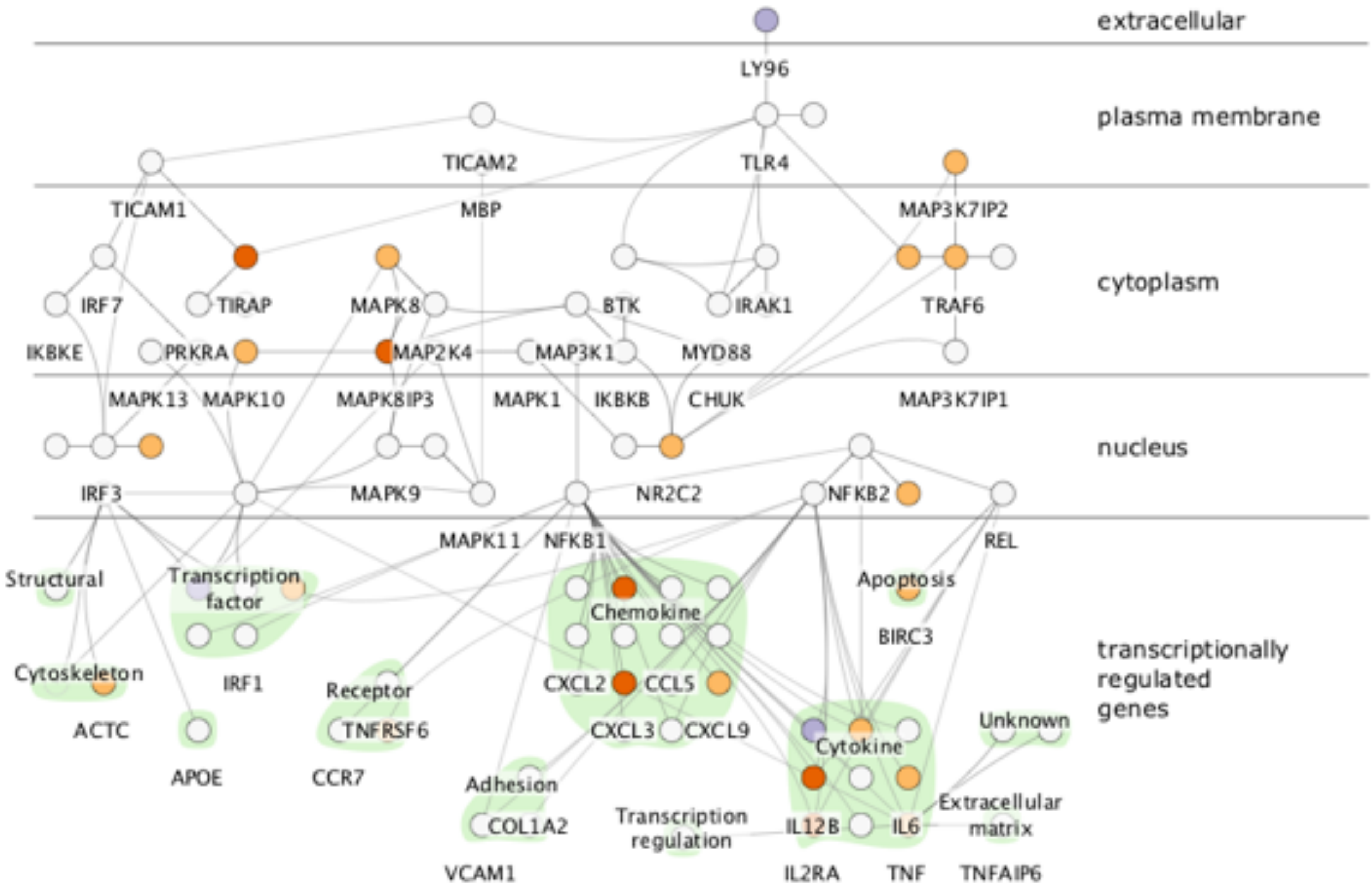
Like Photoshop™ for graphs.
— the Community
LATEST NEWS
Weekly news
February 27, 2012
Annual report 2011
February 25, 2012
Gephi-Neo4j presentation at FOSDEM
February 20, 2012
Gephi meet-up #4 in Berlin
February 2, 2012
Introducing the Gephi Plugins Bootcamp
January 12, 2012
PAPERS

ATTRIBUTE-DRIVEN LAYOUT

- large node-link diagrams get messy!
- are there additional structures we can exploit?

- idea: use data attributes to perform layout
  - e.g., scatterplot based on node values
- dynamic queries and/or brushing can be used to enhance perception of connectivity

cerebral



Barsky 2008

NODE LINK

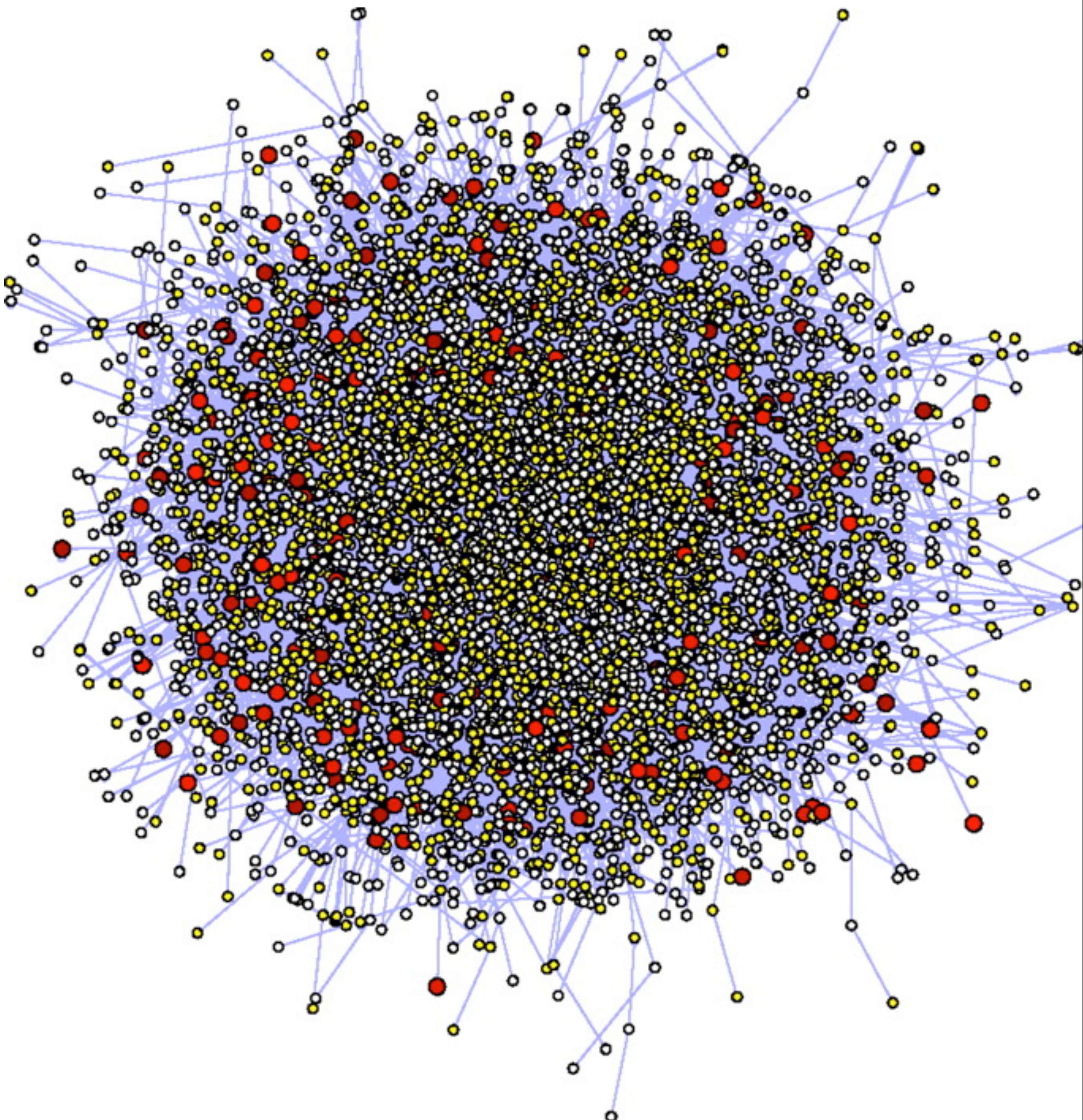
+ understandable visual mapping

+ can show overall structure, clusters, paths

+ flexible, many variations

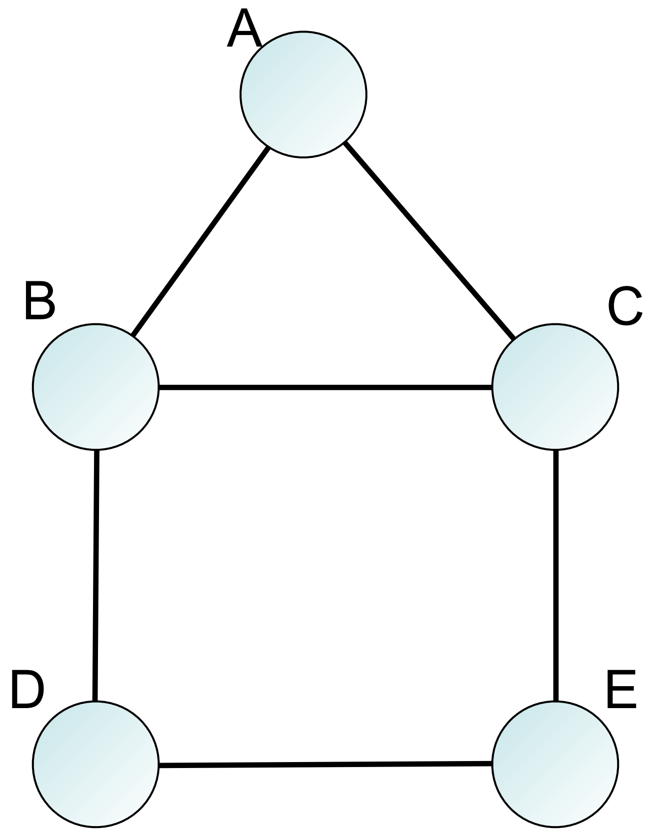
- all but the most trivial algorithms are > $O(N^2)$

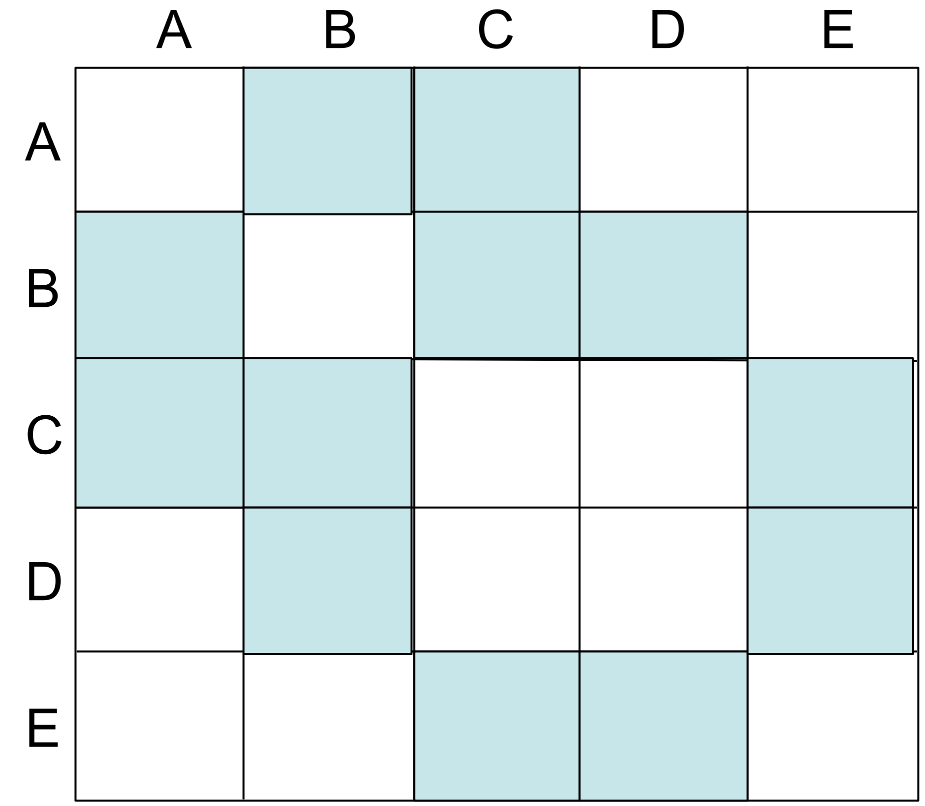
- not good for dense graphs
  - hairball problem!



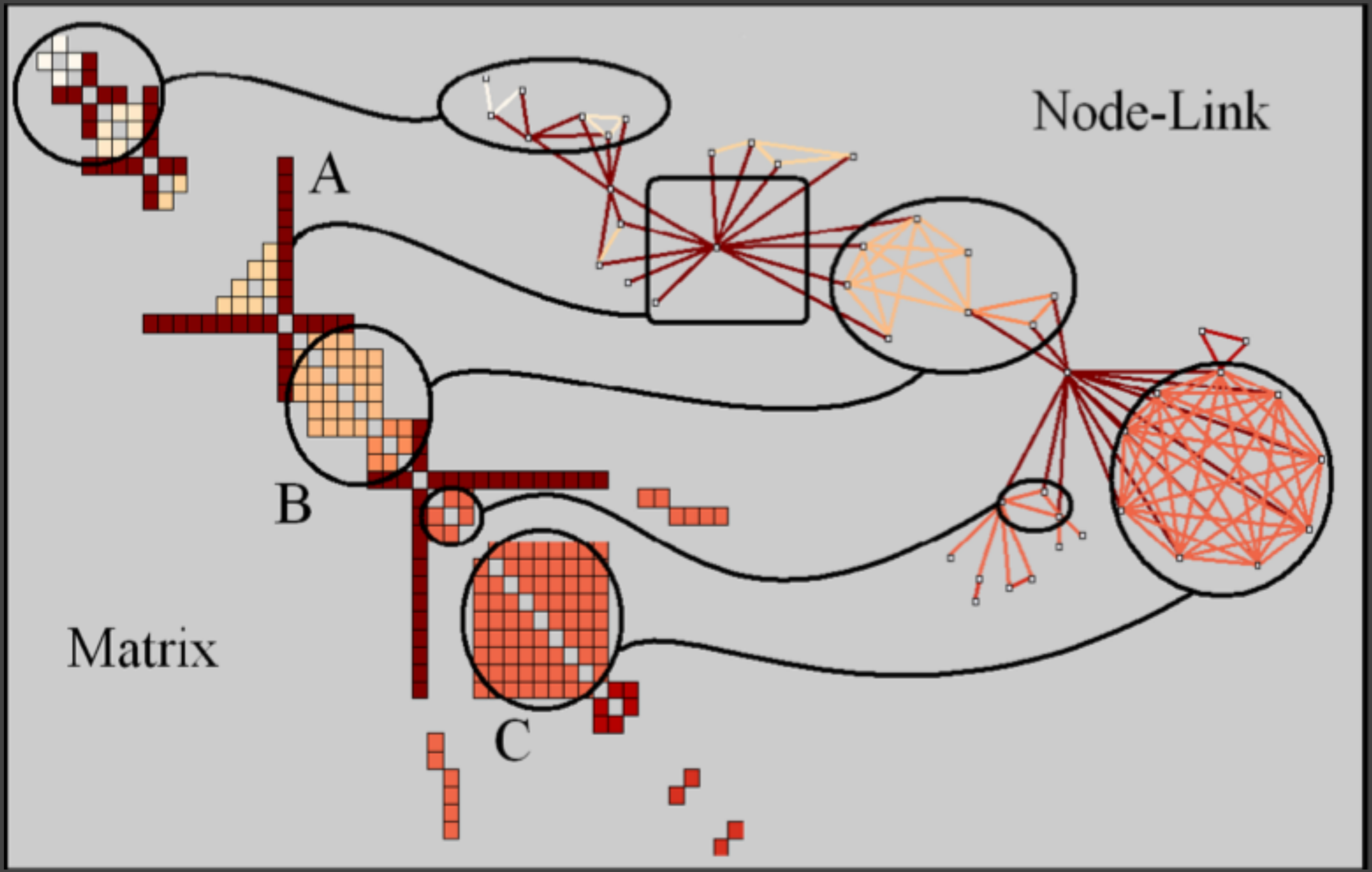
ALTERNATIVE: ADJACENCY MATRIX

- instead of node link diagram, use adjacency matrix representation



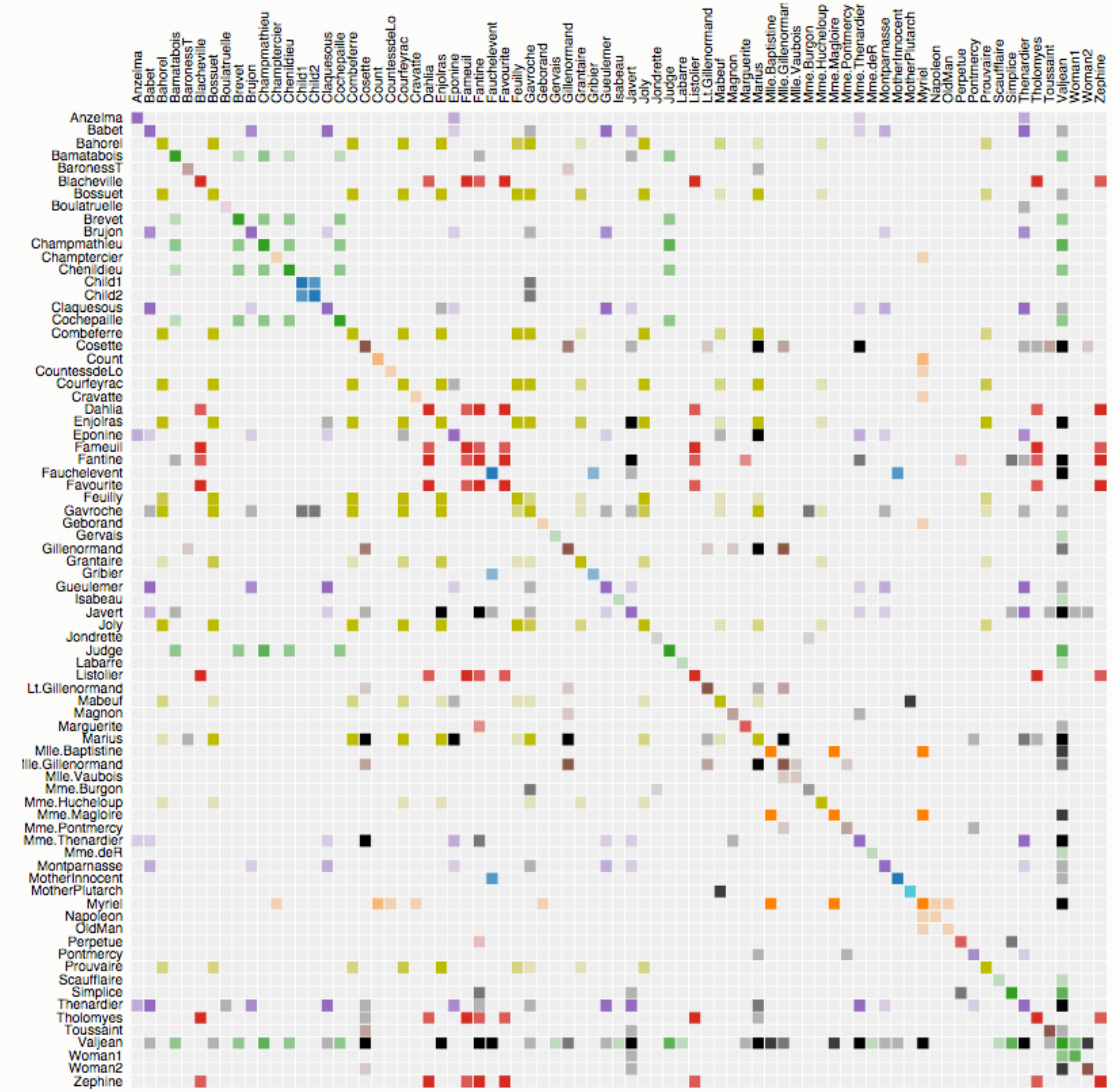


SPOTTING PATTERNS IN MATRICES



Henry 2006

Les Misérables
character
co-occurrence



http://bost.ocks.org/mike/miserables/

+ great for dense graphs

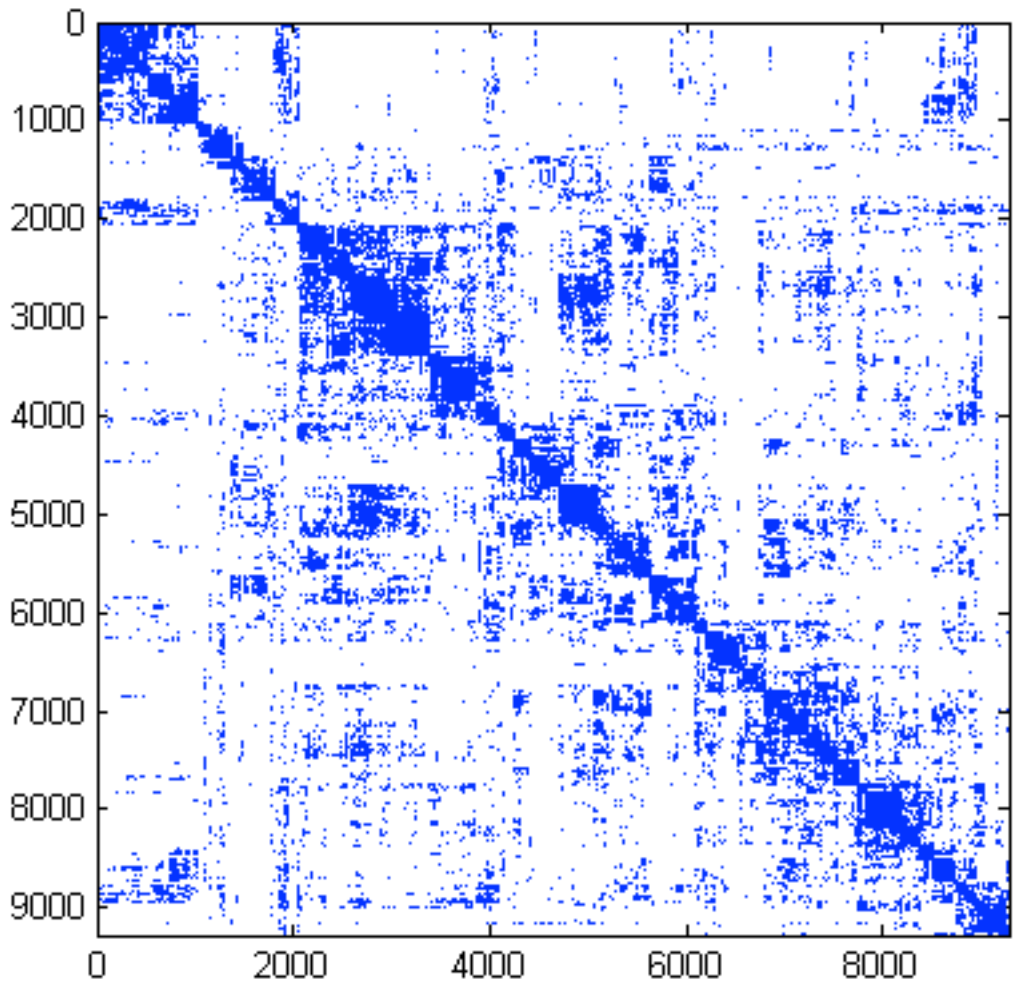
+ visually scalable

+ can spot clusters

- row order affects
  what you can see

- abstract visualization

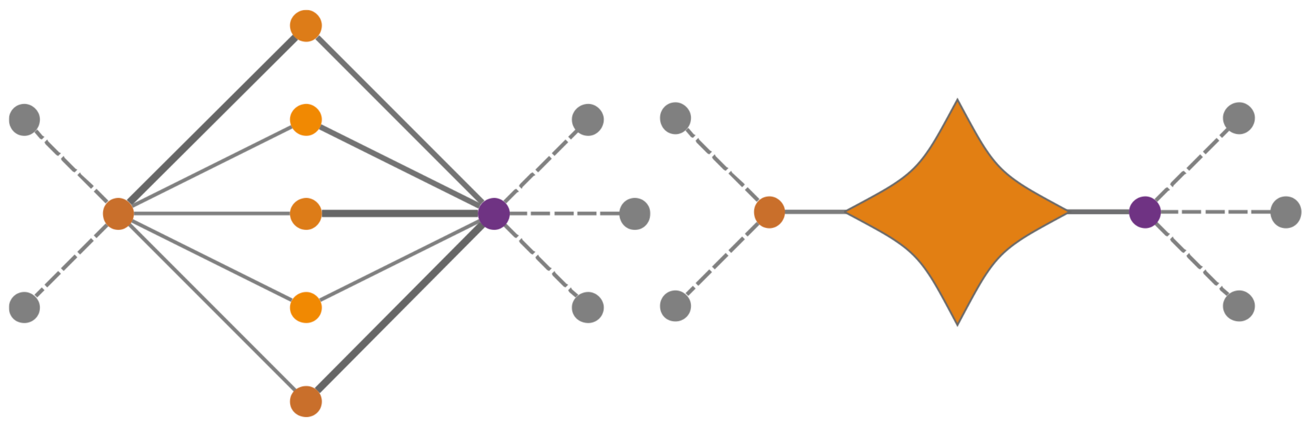
- hard to follow paths



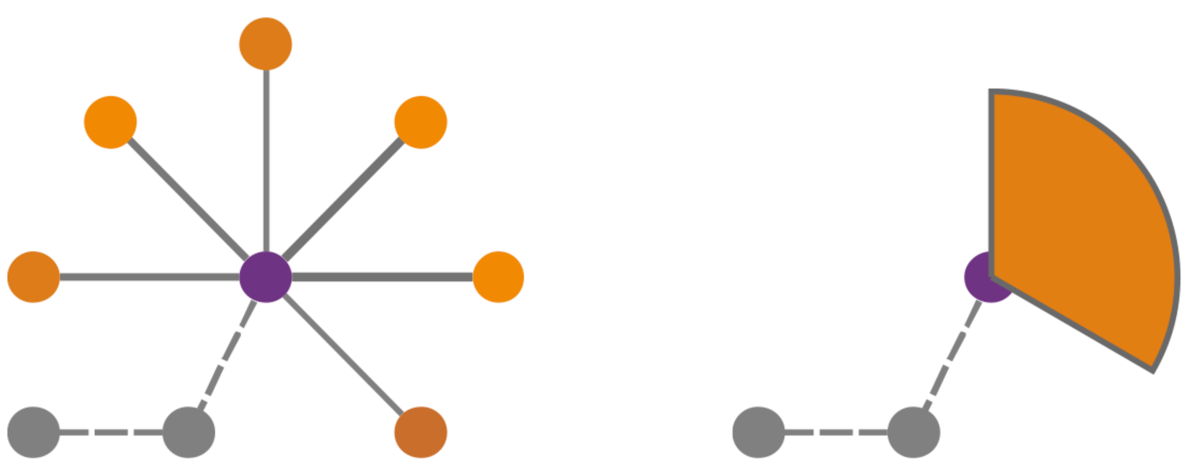
AGGREGATE VIEWS

MOTIF GLYPHS

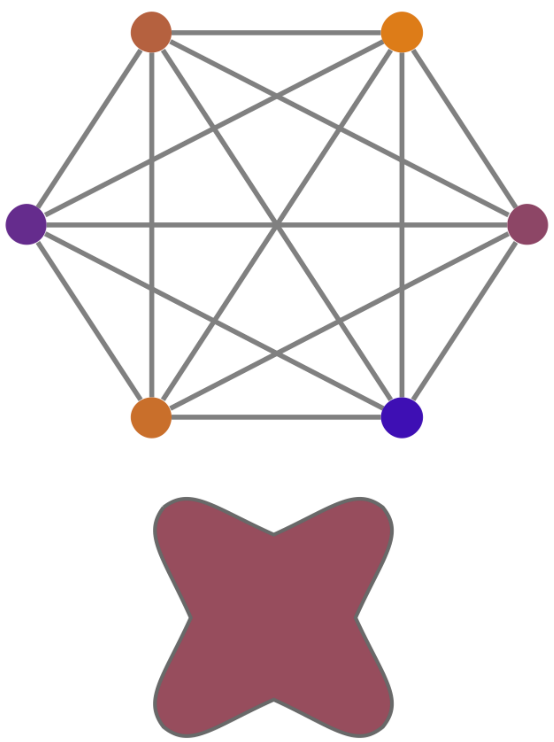
Connector



Fan

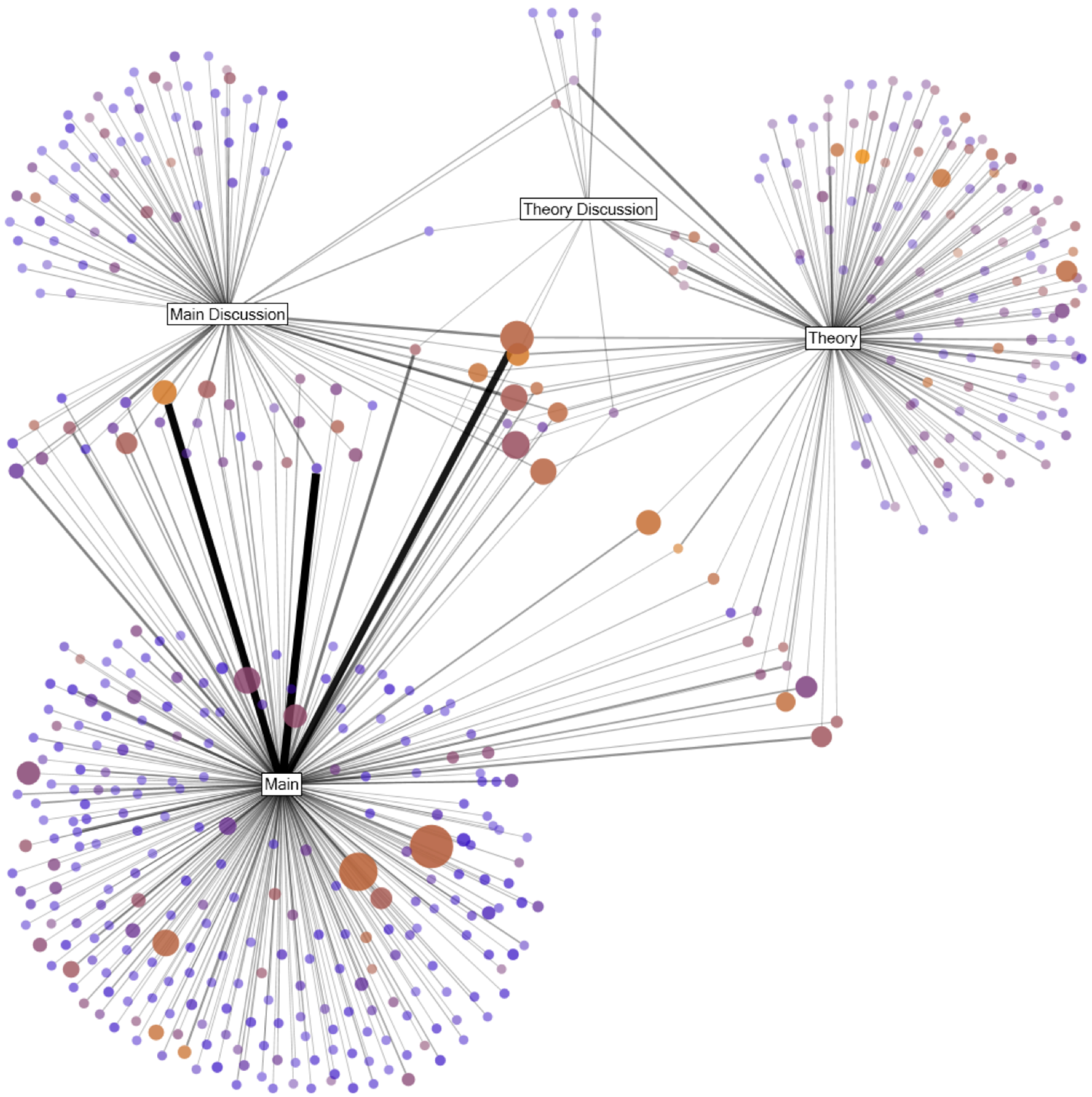


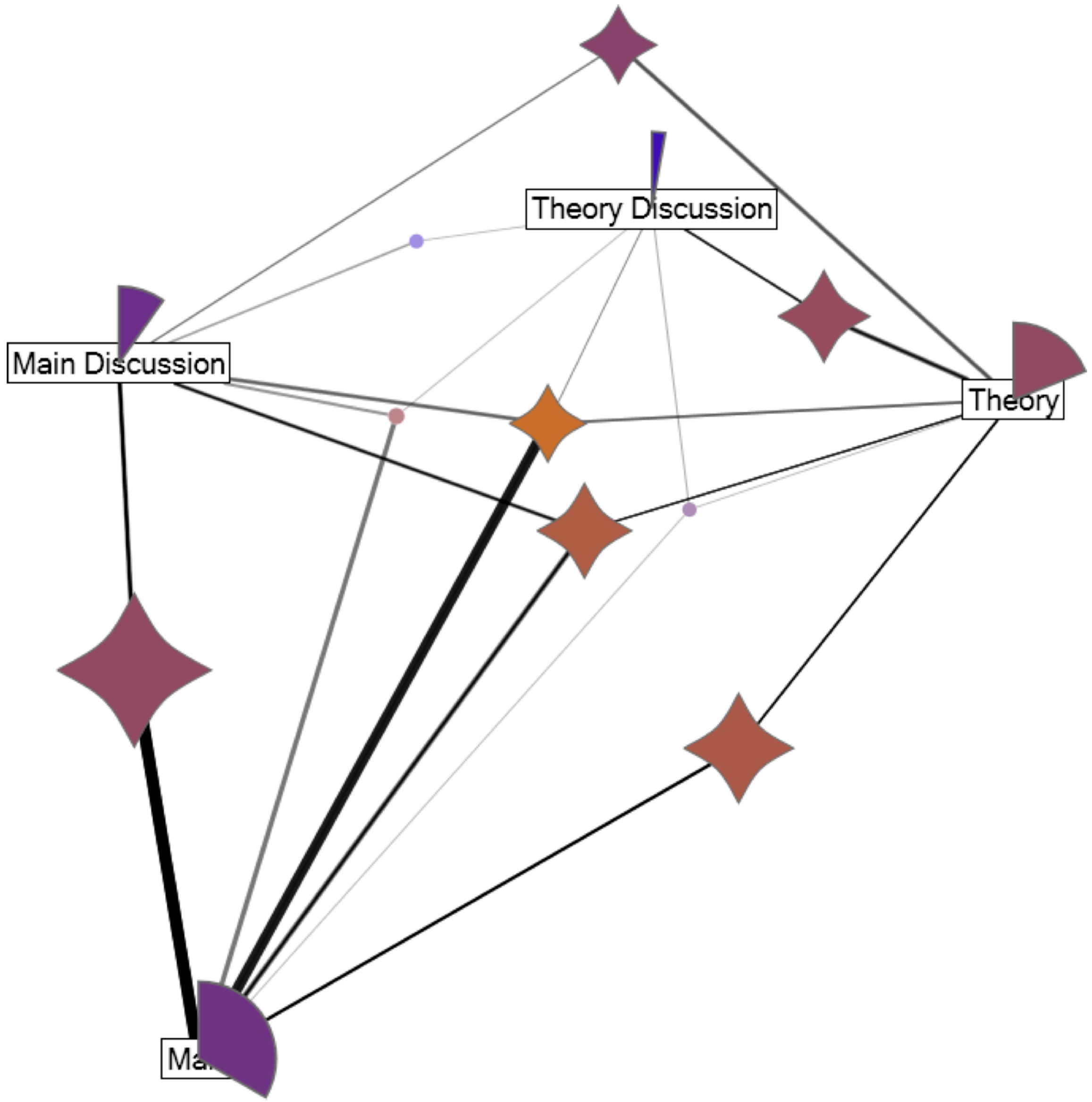
Clique



Dunne 2013

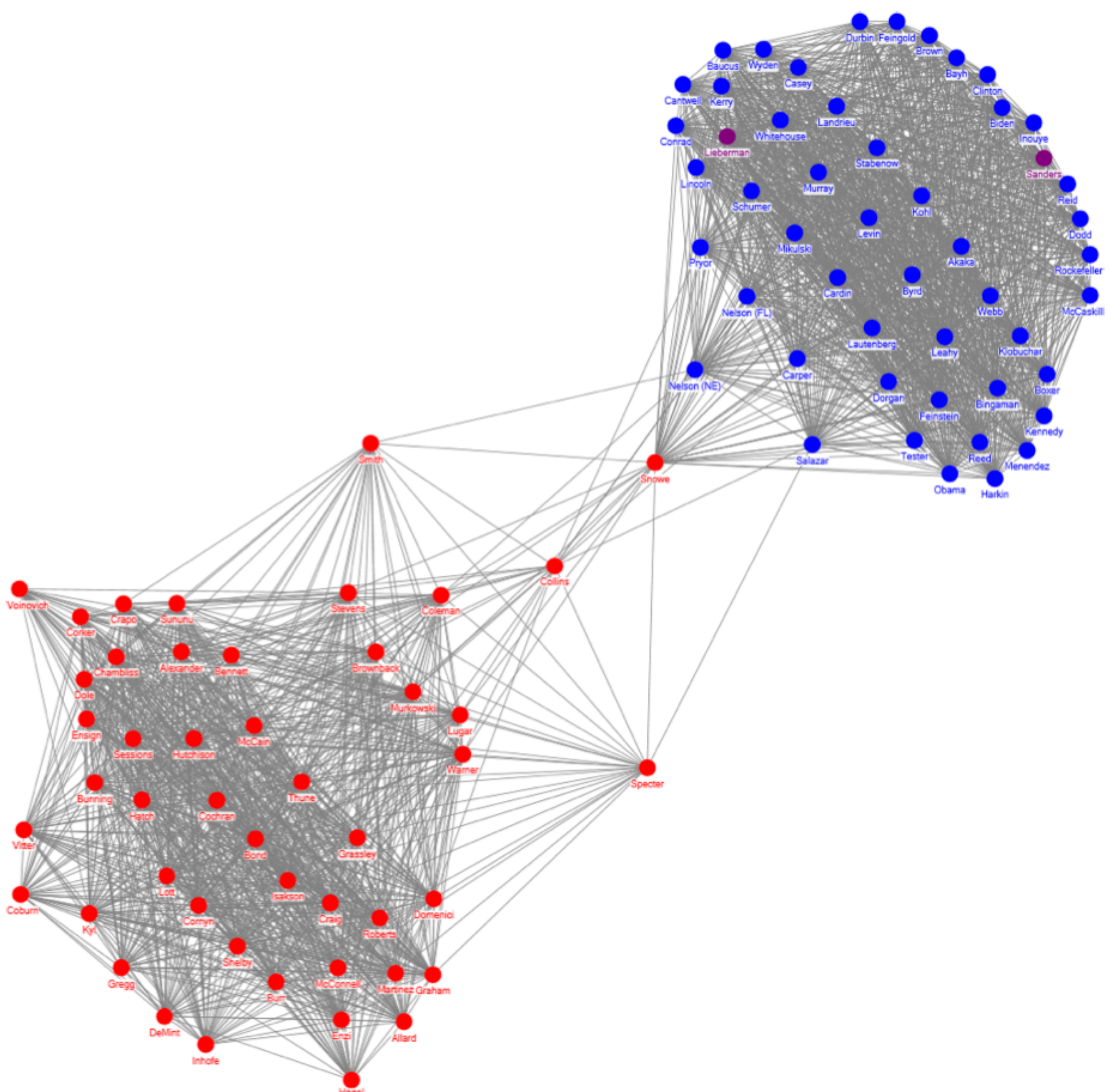
MOTIF GLYPHS

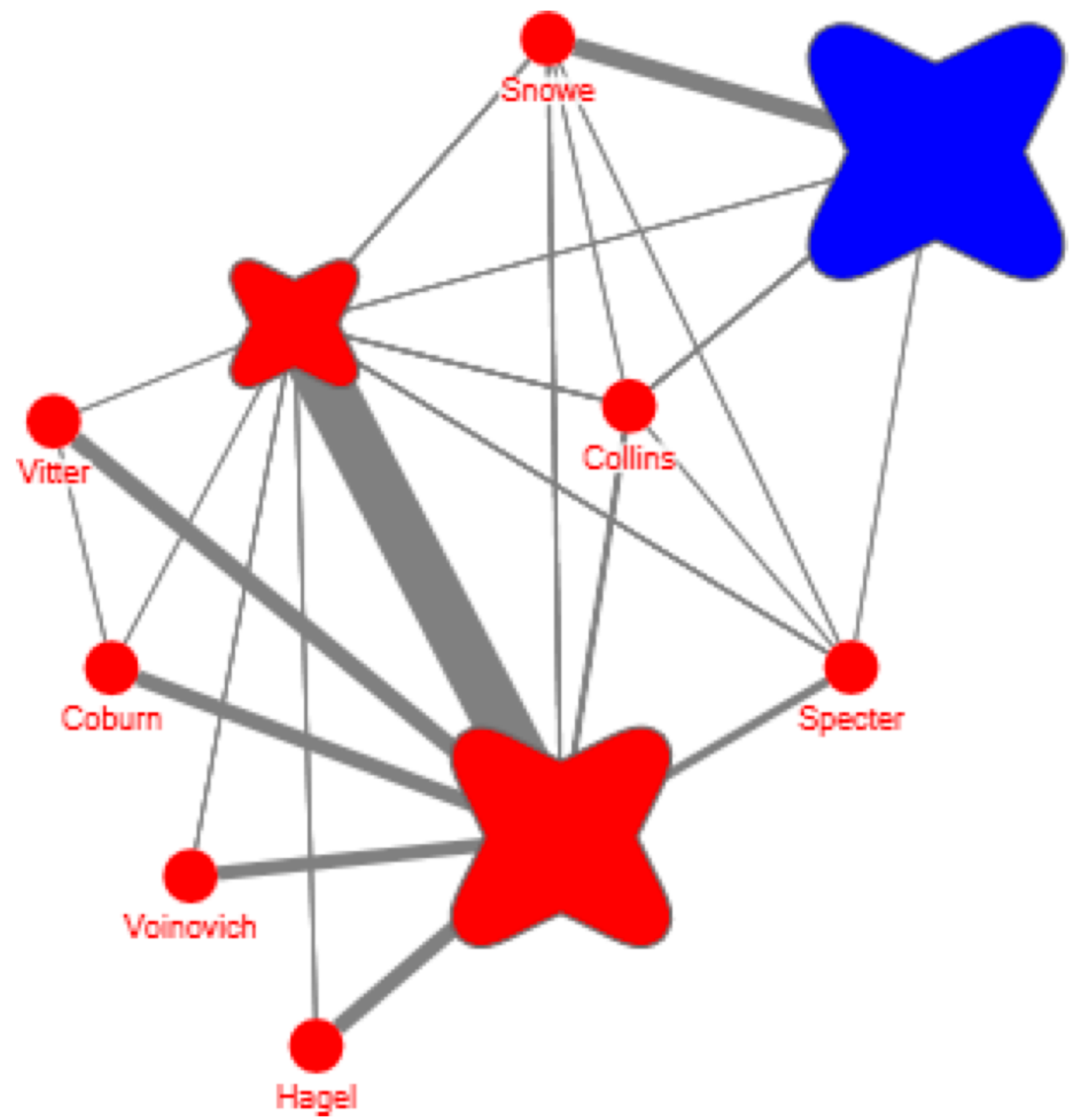




Dunne 2013

MOTIF GLYPHS





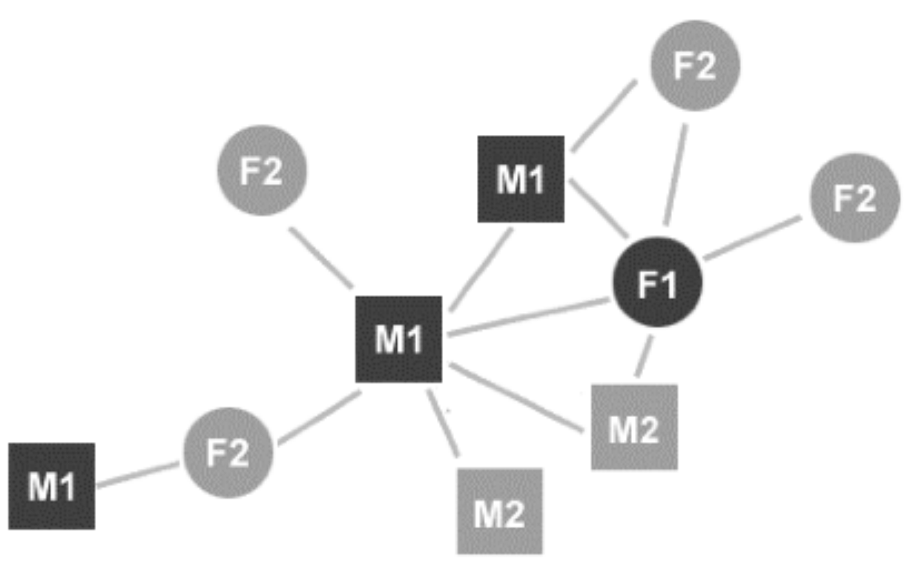
Dunne 2013

CRITIQUE

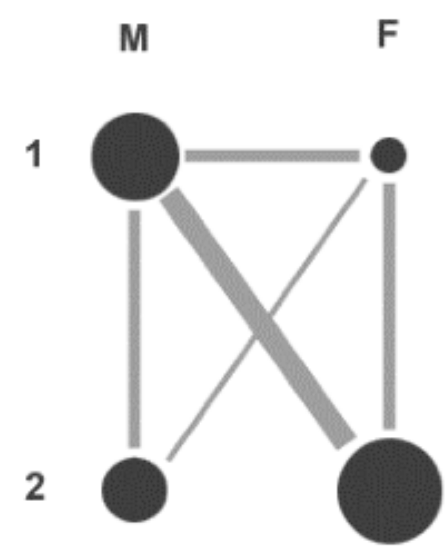
- When *can* you use this technique?
- When *should* you use this technique?

PIVOT GRAPHS

- new graph, derived from categorical node attributes
- 1D or 2D layouts possible
- size of nodes and edges related to number of aggregated original nodes and edges
- scalability through abstraction, not layout algorithm



Node and Link Diagram



PivotGraph Roll-up

CRITIQUE

- When *can* you use this technique?
- When *should* you use this technique?

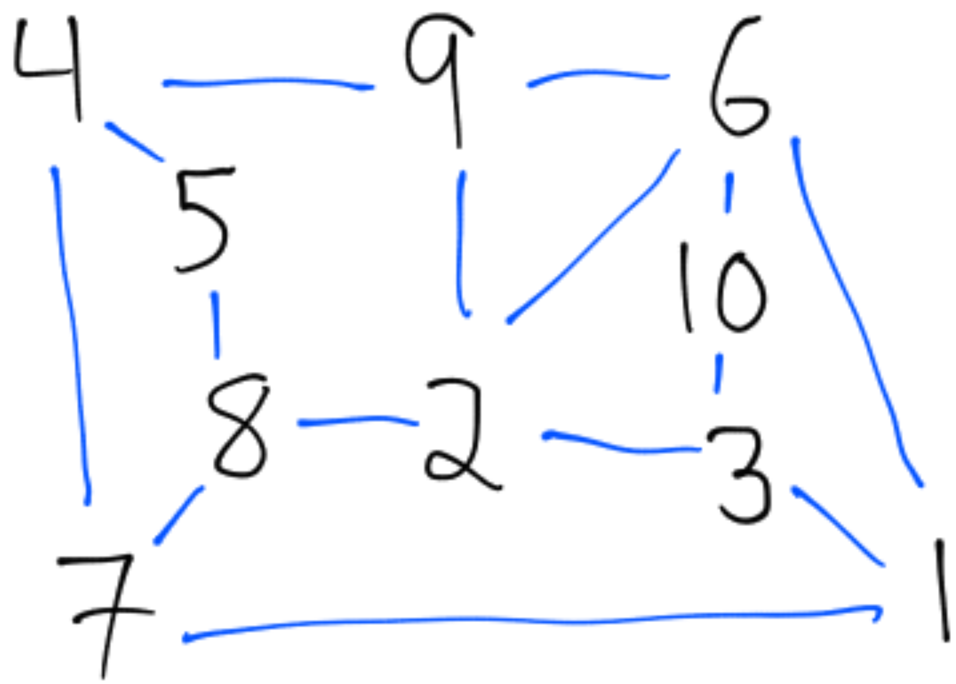
exercise

GRAPH DRAWING EXERCISE

adjacency matrix

	1	2	3	4	5	6	7	8	9	10
1	0	0	1	0	0	1	1	0	0	0
2	0	0	1	0	0	1	0	1	1	0
3	1	1	0	0	0	0	0	0	0	1
4	0	0	0	0	1	0	1	0	1	0
5	0	0	0	1	0	0	0	1	0	0
6	1	1	0	0	0	0	0	0	1	1
7	1	0	0	1	0	0	0	1	0	0
8	0	1	0	0	1	0	1	0	0	0
9	0	1	0	1	0	1	0	0	0	0
10	0	0	1	0	0	1	0	0	0	0

create an aesthetically pleasing
node-link diagram
representation



create an aesthetically pleasing
node-link diagram
representation

RECAP

- TREES
  - **indentation**
    - *simple, effective for small trees*
  - **node link** and **layered**
    - *looks good but needs exponential space*
  - **enclosure** (treemaps)
    - *great for size related tasks but suffer in structure related tasks*

- GRAPHS
  - **node link**
    - *familiar, but problematic for dense graphs*
  - **adjacency matrices**
    - *abstract, hard to follow paths*
  - **aggregation can help**
    - *not always possible, not always appropriate*

- **TAKE HOME MESSAGE: no best solution**

L14: Text and Sets

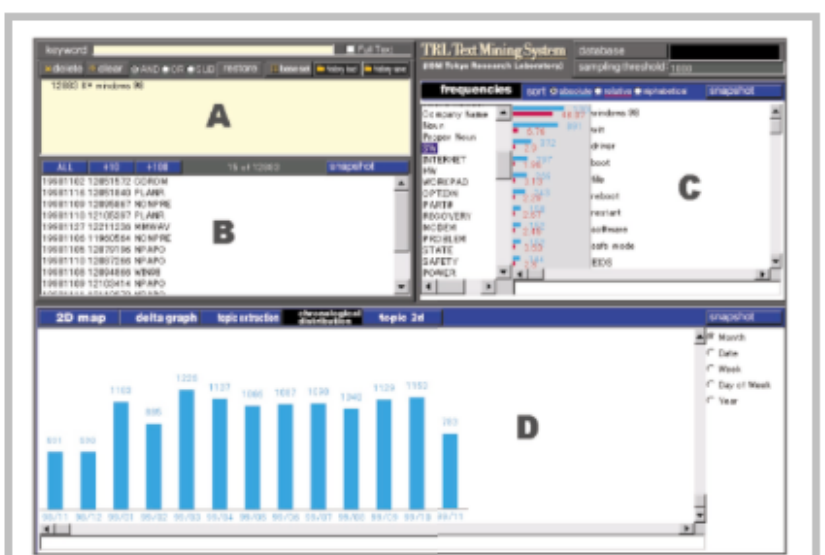
REQUIRED READING

Search User Interfaces

MARTI HEARST | CAMBRIDGE UNIVERSITY PRESS | 2009

CH. 11: INFORMATION VISUALIZATION FOR TEXT ANALYSIS

As discussed in the previous chapter, visualization when applied to text seems to be most effective for specialists doing data analysis. Although this is an exciting field, it is not what most people think of when one talks about search interfaces. Unfortunately, some researchers working on visualization of text conflate search tasks with data analysis tasks. For example, Veerasamy and Heikes, 1997 critique one interface for making it "more difficult than in our tool to gain an overall picture of the query word distribution for a whole set of documents in one glance." It is unclear why a searcher would want to see such a distribution, even though such a view may be of great interest to a computational linguist.



Search

Chapter Contents

Book Contents

Eurographics Conference on Visualization (EuroVis) (2014)
R. Borgo, R. Maciejewski, and I. Viola (Editors)

STAR – State of The Art Report

Visualizing Sets and Set-typed Data: State-of-the-Art and Future Challenges

Bilal Alsallakh[1], Luana Micallef[2,3], Wolfgang Aigner[1,4], Helwig Hauser[5], Silvia Miksch[1], and Peter Rodgers[3]

[1]Vienna University of Technology, Austria [2]Helsinki Institute for Information Technology HIIT, Finland
[3]University of Kent, United Kingdom [4]St. Pölten University of Applied Sciences, Austria [5]University of Bergen, Norway

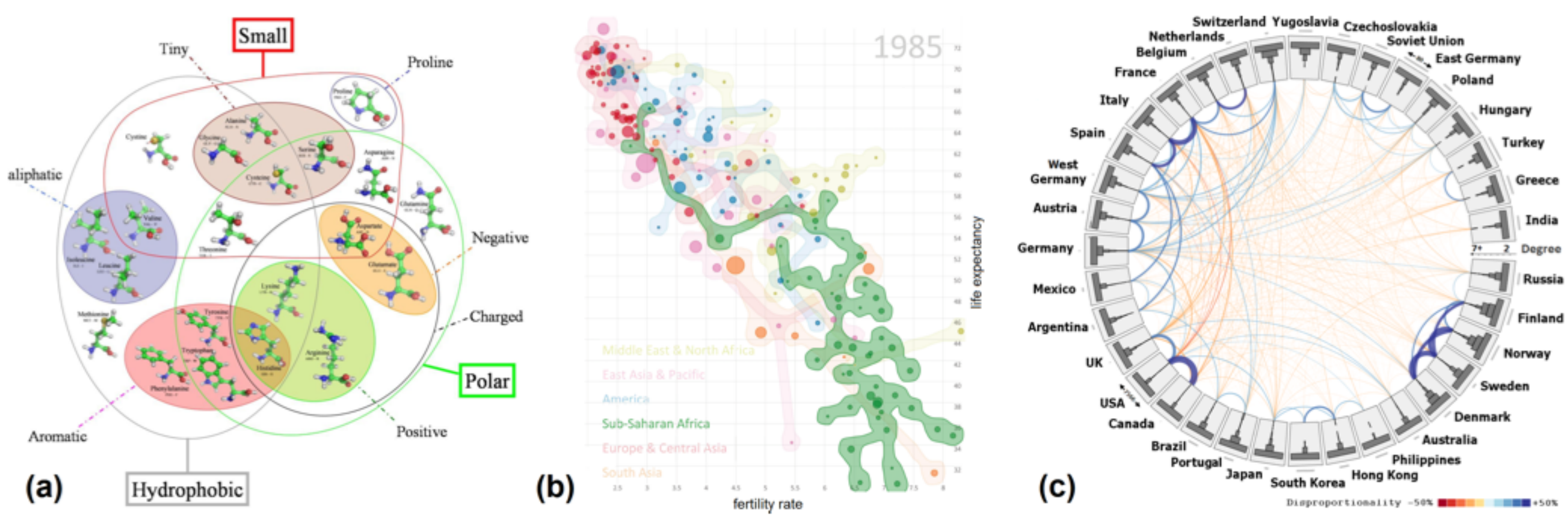


Figure 1: Different set visualizations: (a) An Euler diagram [Pod08], (b) Bubble Sets [CPC09], (c) Radial Sets [AAMH13].

Abstract