CSE 564
Visualization & Visual Analytics

Visualization of Hierarchies

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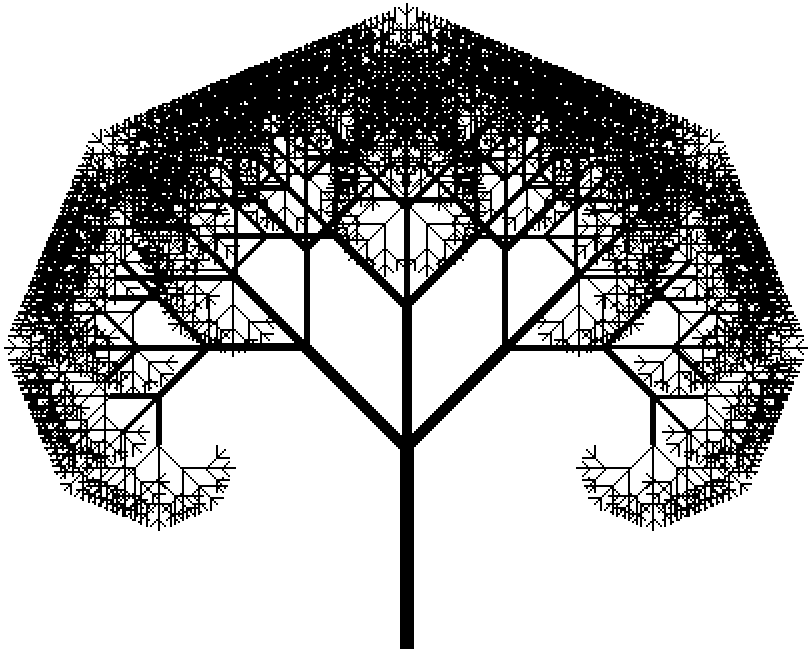
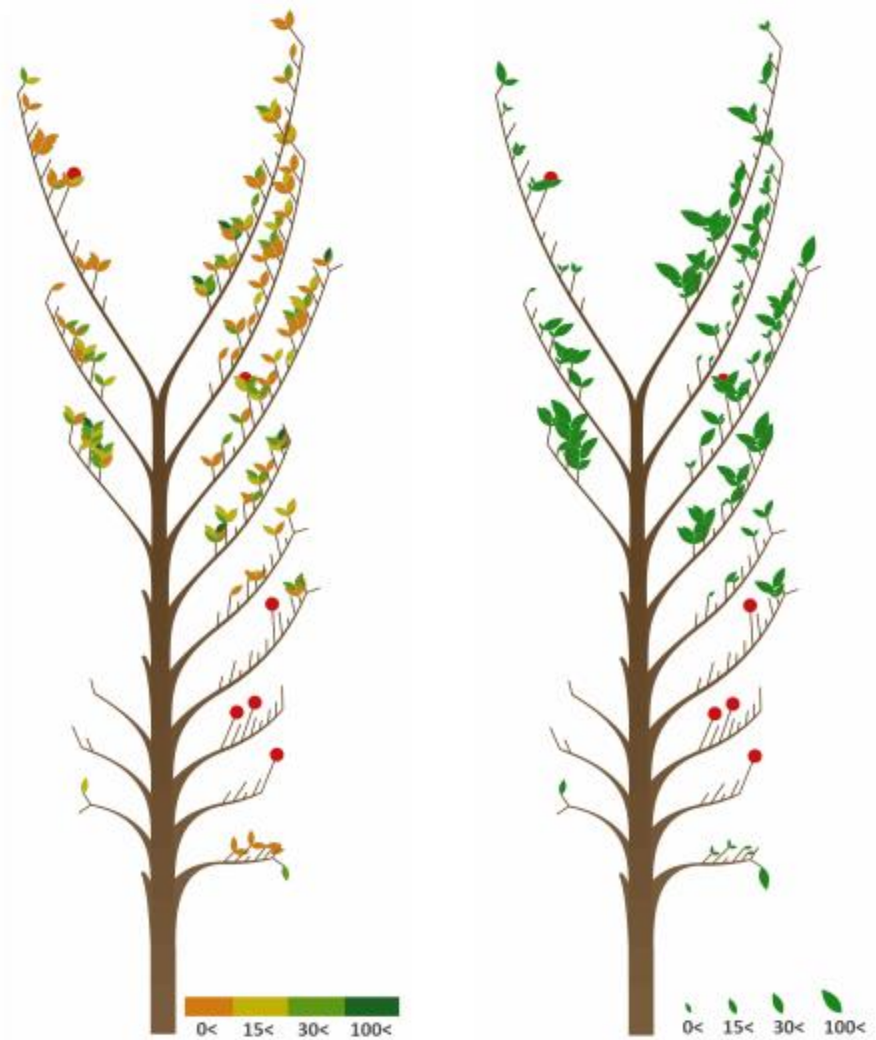
Hierarchies = Trees



Tree – A Natural Metaphor

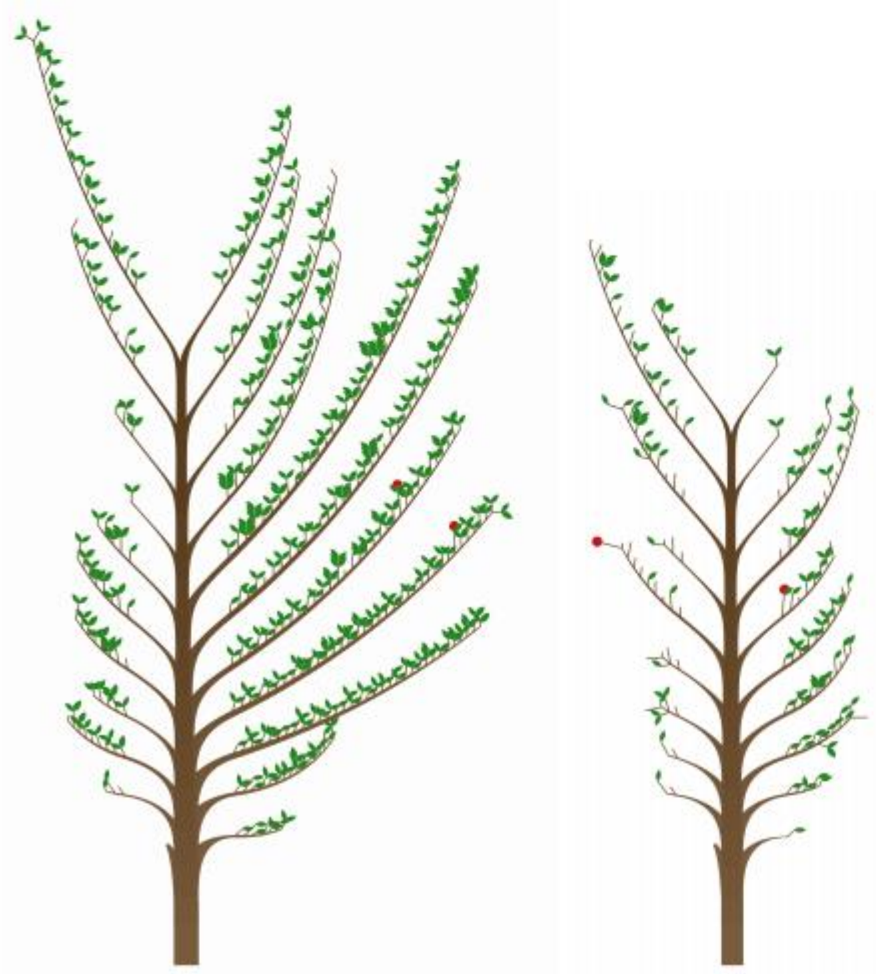
Mapping publications to a tree

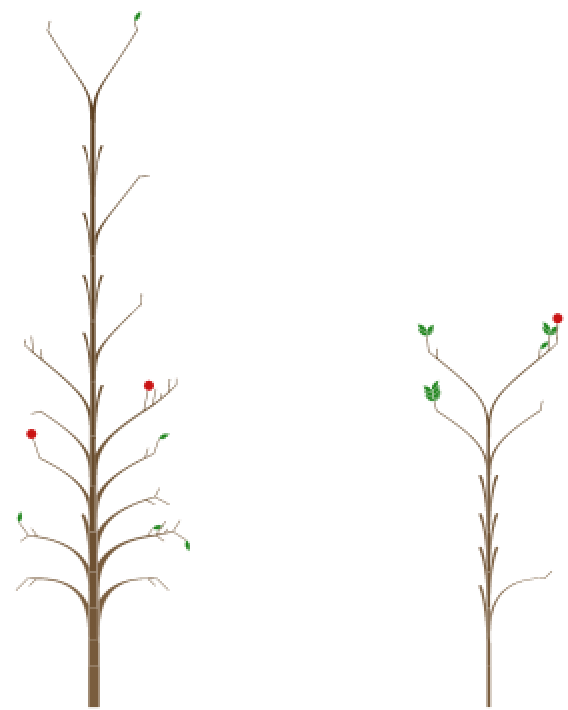
- major leaves are papers
- minor leaves are co-authors
- height is time
- fruit are comments
- size or color is number of paper’s citations
- journal papers on right side
- conference papers left side



Fung and Ma, Personal VIS 2015

Productive vs. Unproductive Researchers



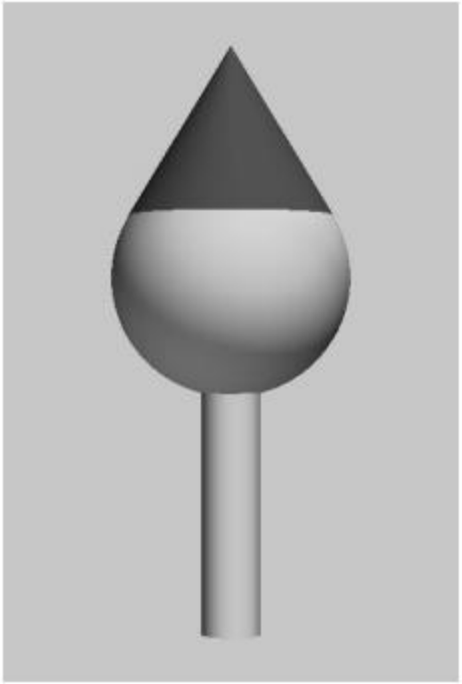


Productive

Unproductive

Botanical-Inspired Visualizations

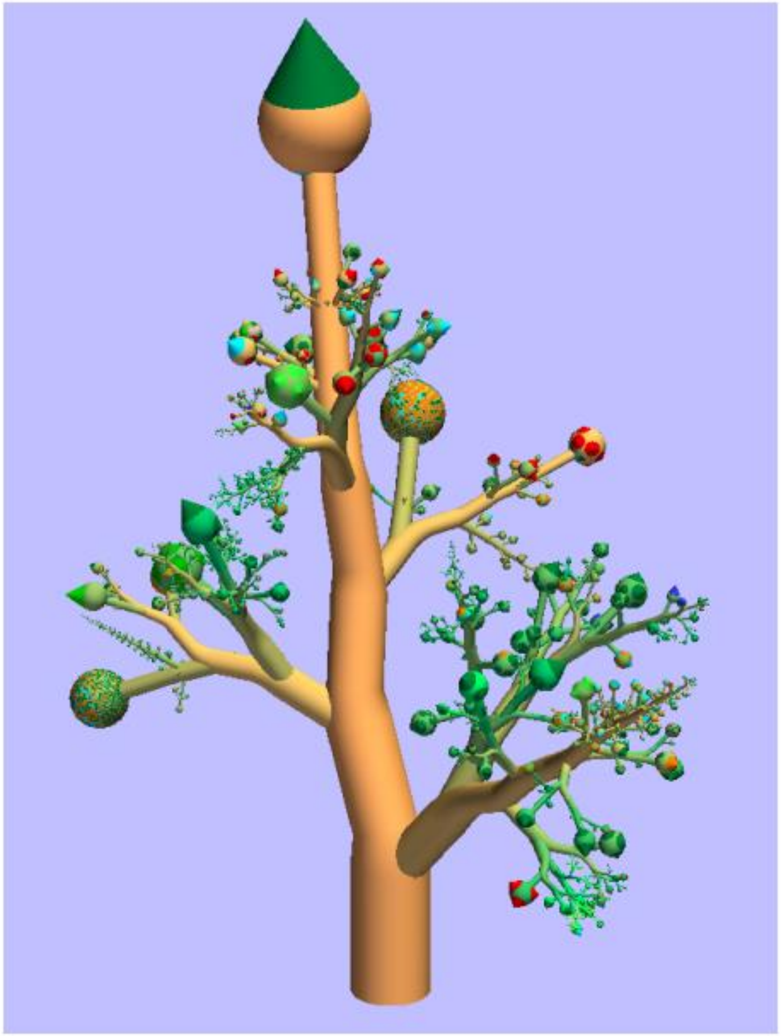
Visualizing hard drives with tree cartoons



one file

many files

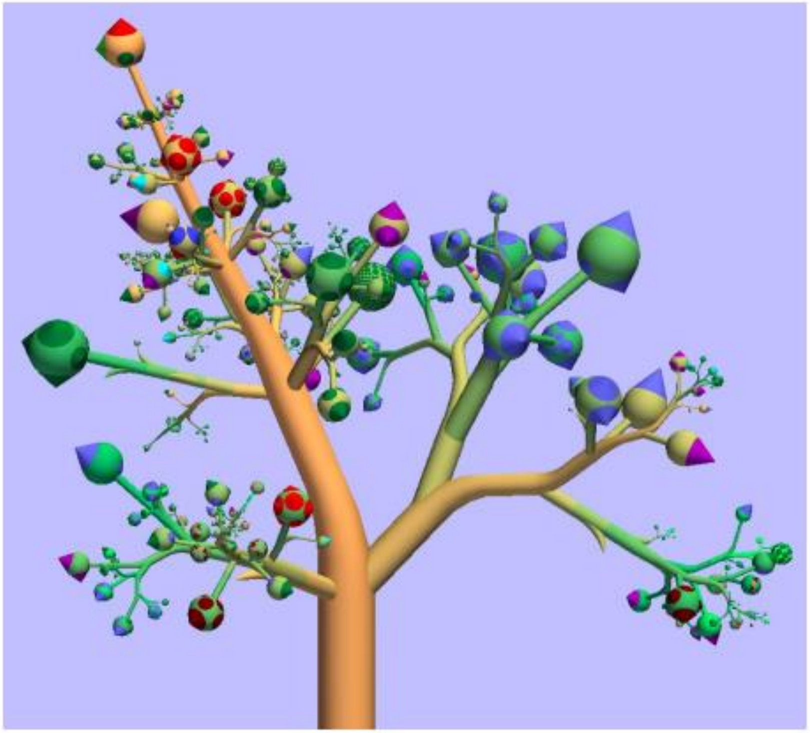
Kleiberg et al., IEEE InfoVis 2001

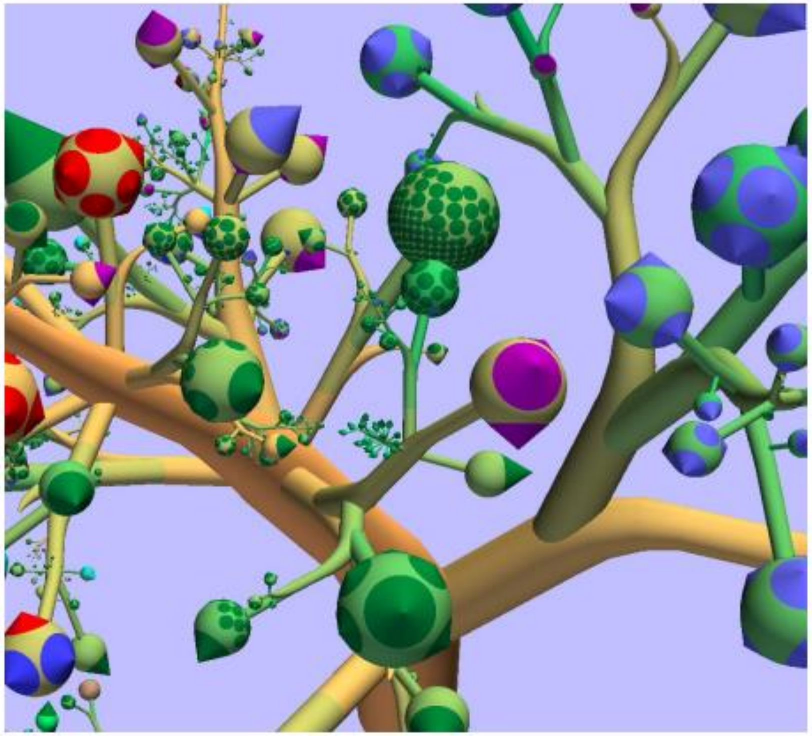


Botanical-Inspired Visualizations

Color maps to file type

- blue are pdf files, red are image files

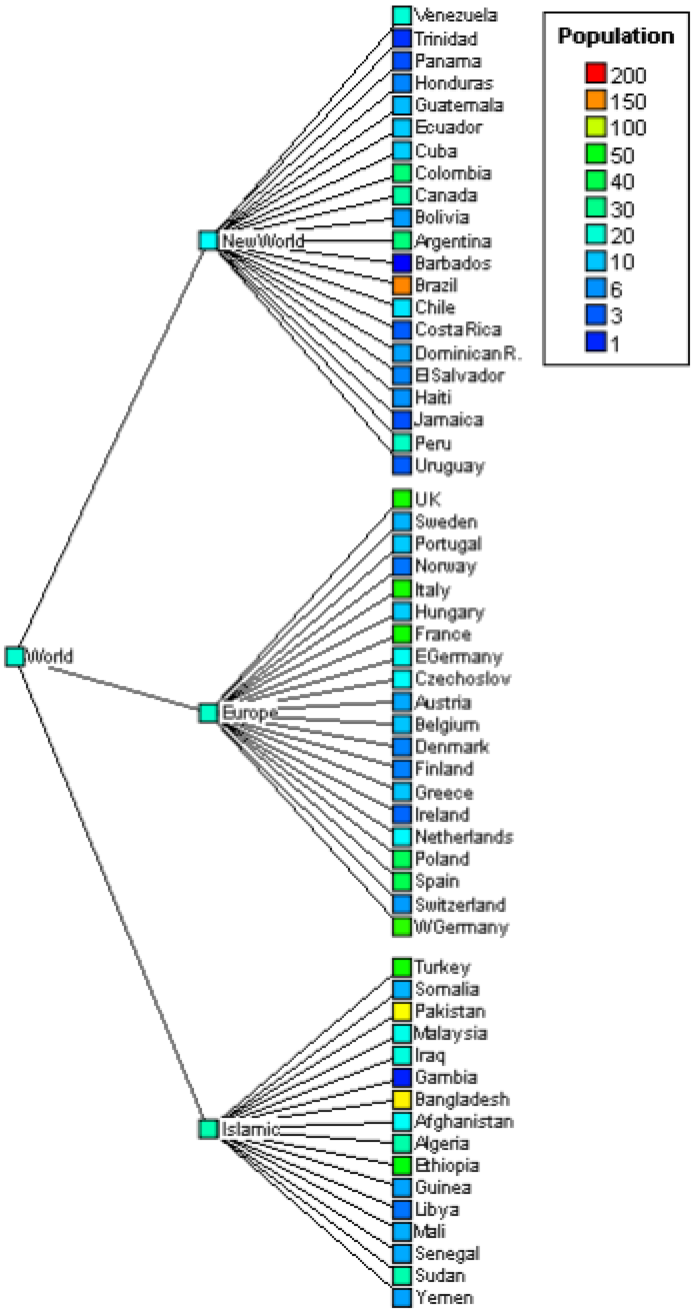




Conventional

Standard Node-Edge layout for a hierarchical network

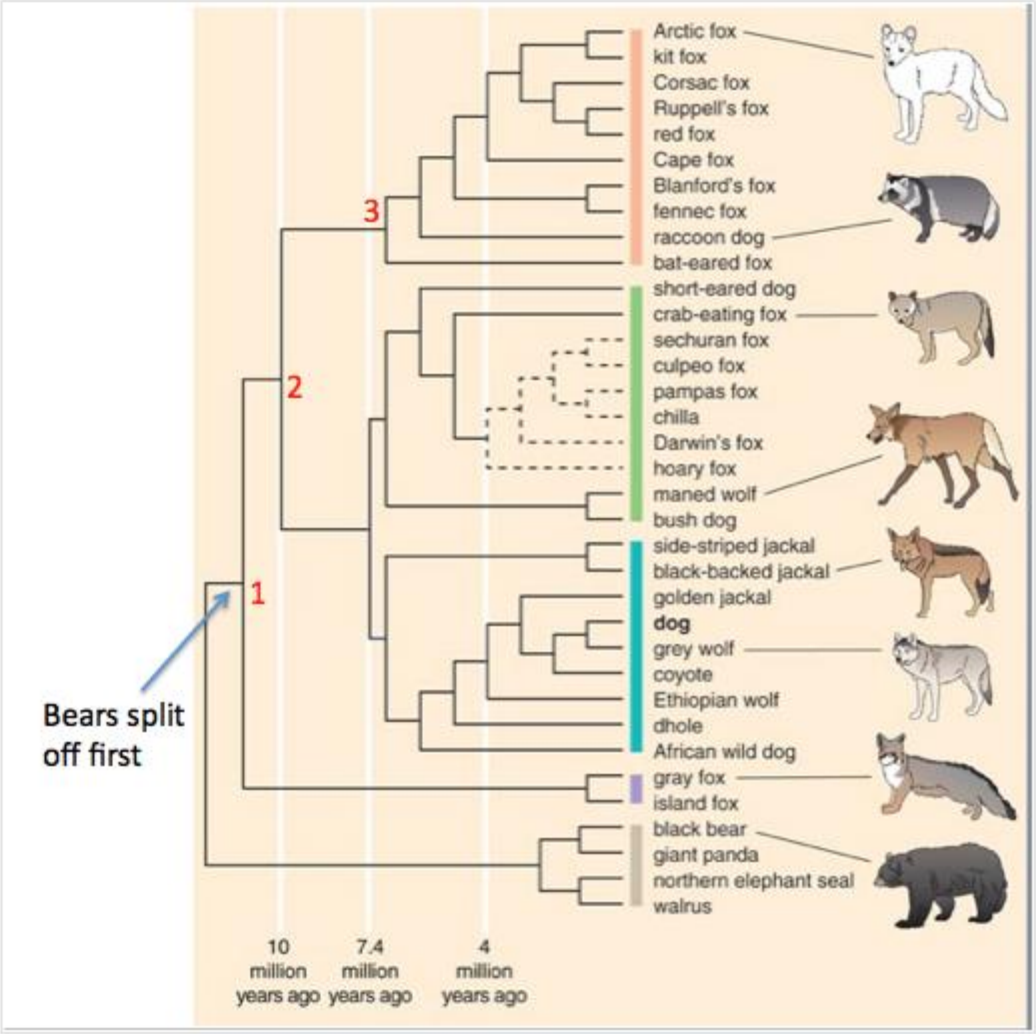
- 3 levels
- color maps to quantitative information (here population)



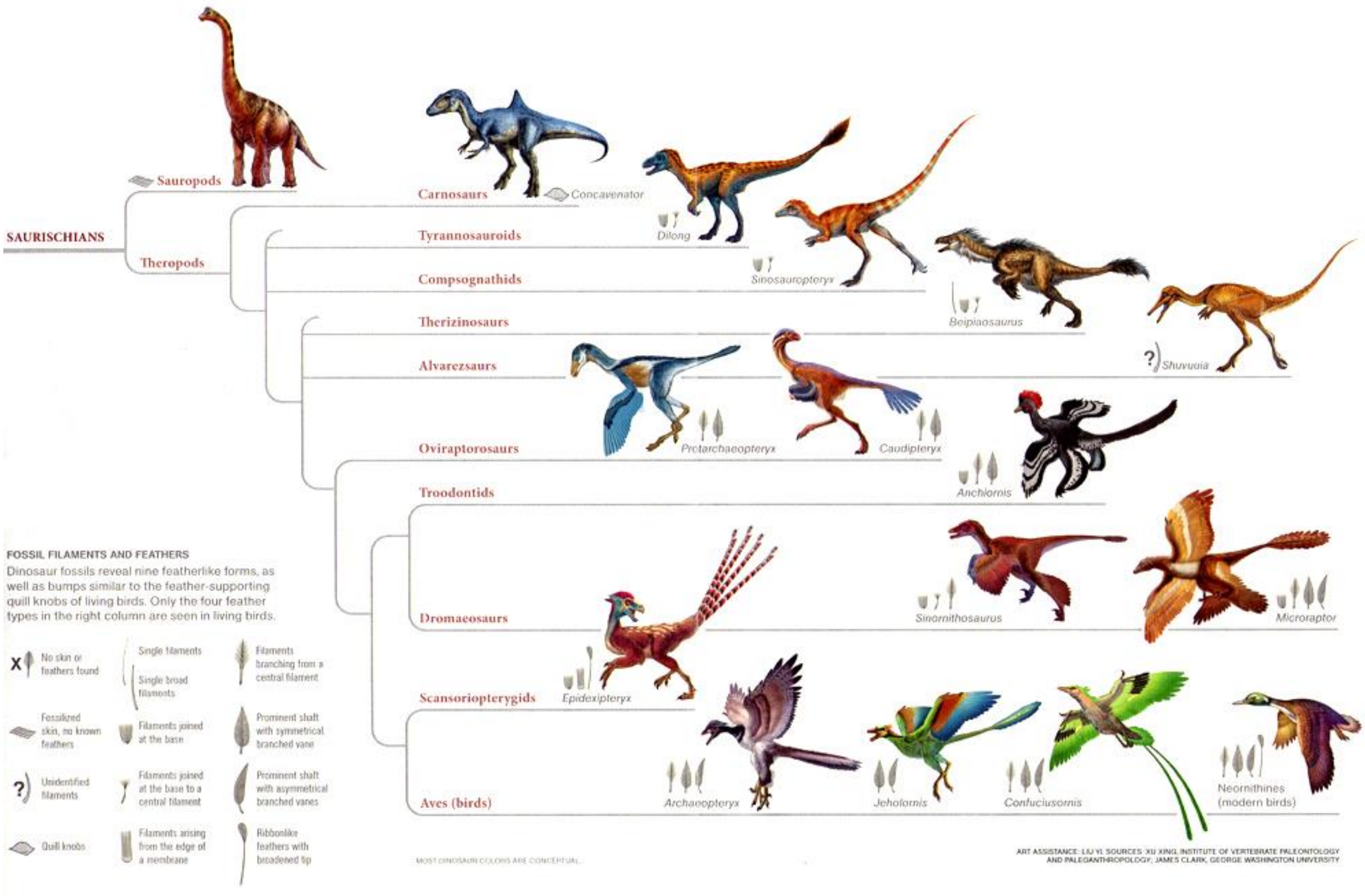
DENDROGRAM

Typically used to depict classification hierarchies

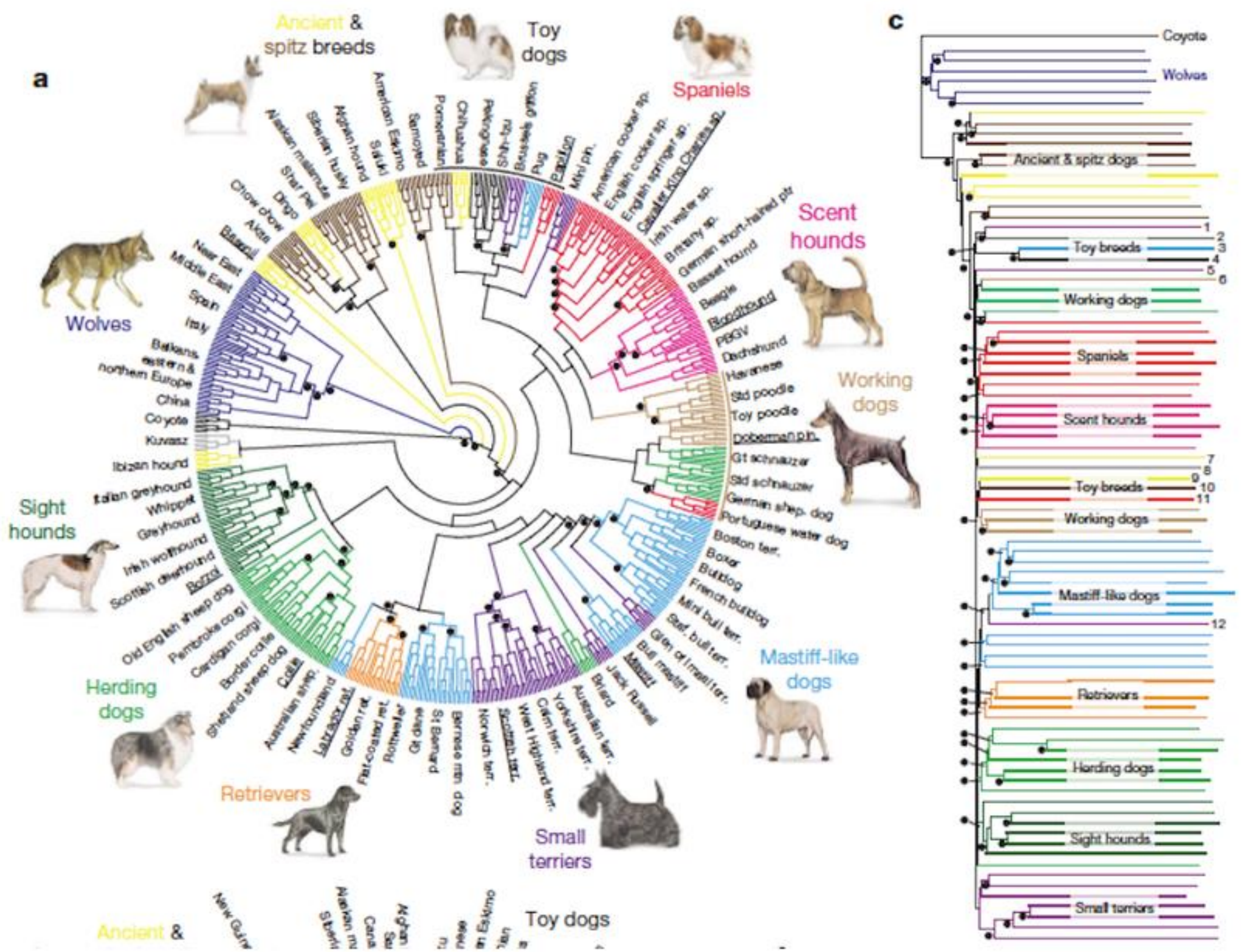
- split-off points visualize proximity



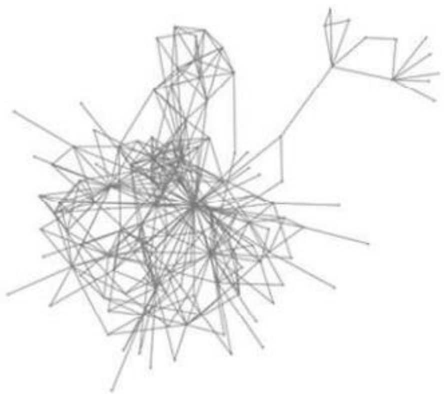
Birds and Dinosaurs



Circles Are More Space-Efficient



Radial Plots and Edge Bundles

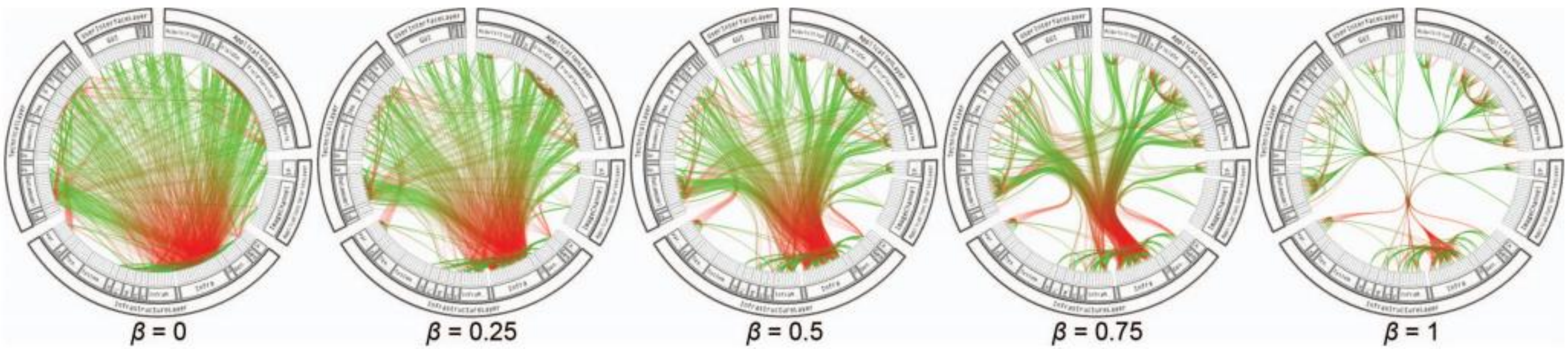


Original Graph

Jia et al., Computer Graphics Forum 2011

Edge Bundling

Edges are represented by splines with tension β



Setting β

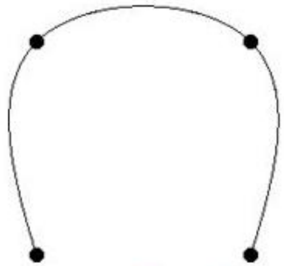
- low values mainly provide low-level, node-to-node connectivity information
- high values provide high-level information

Holten, IEEE TVCG 2006

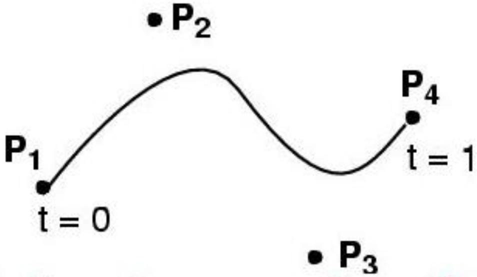
What's A Spline

Smooth curve defined by some control points

Moving the control points changes the curve

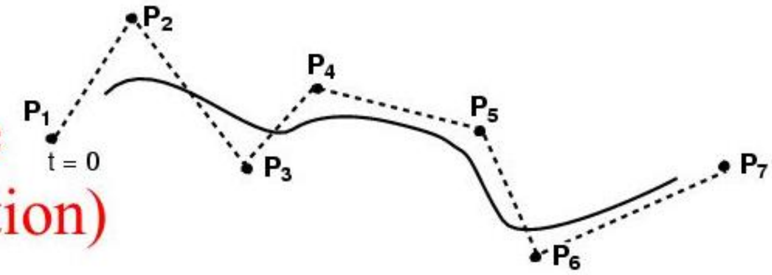


Interpolation



Bézier (approximation)

BSpline (approximation)



Primer: Uniform Cubic B-Spline

A B-Spline curve is defined as follows:

$$X(t) = \sum_{k=0}^{n} P_k B_{k,d}(t)$$

- n is the total number of control points
- d is the order of the curves, $2 \le d \le n+1$, d typically 3 or 4
- $B_{k,d}$ are the uniform B-spline blending functions of degree d-1
- P_k are the control points
- Each $B_{k,d}$ is only non-zero for a small range of t values, so the curve has local control

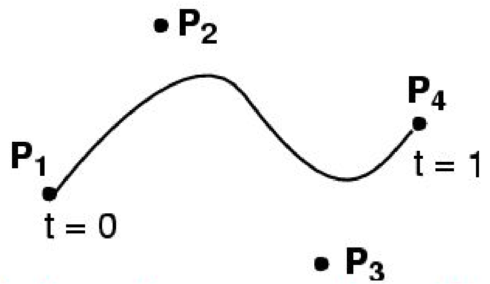
Or in matrix form:

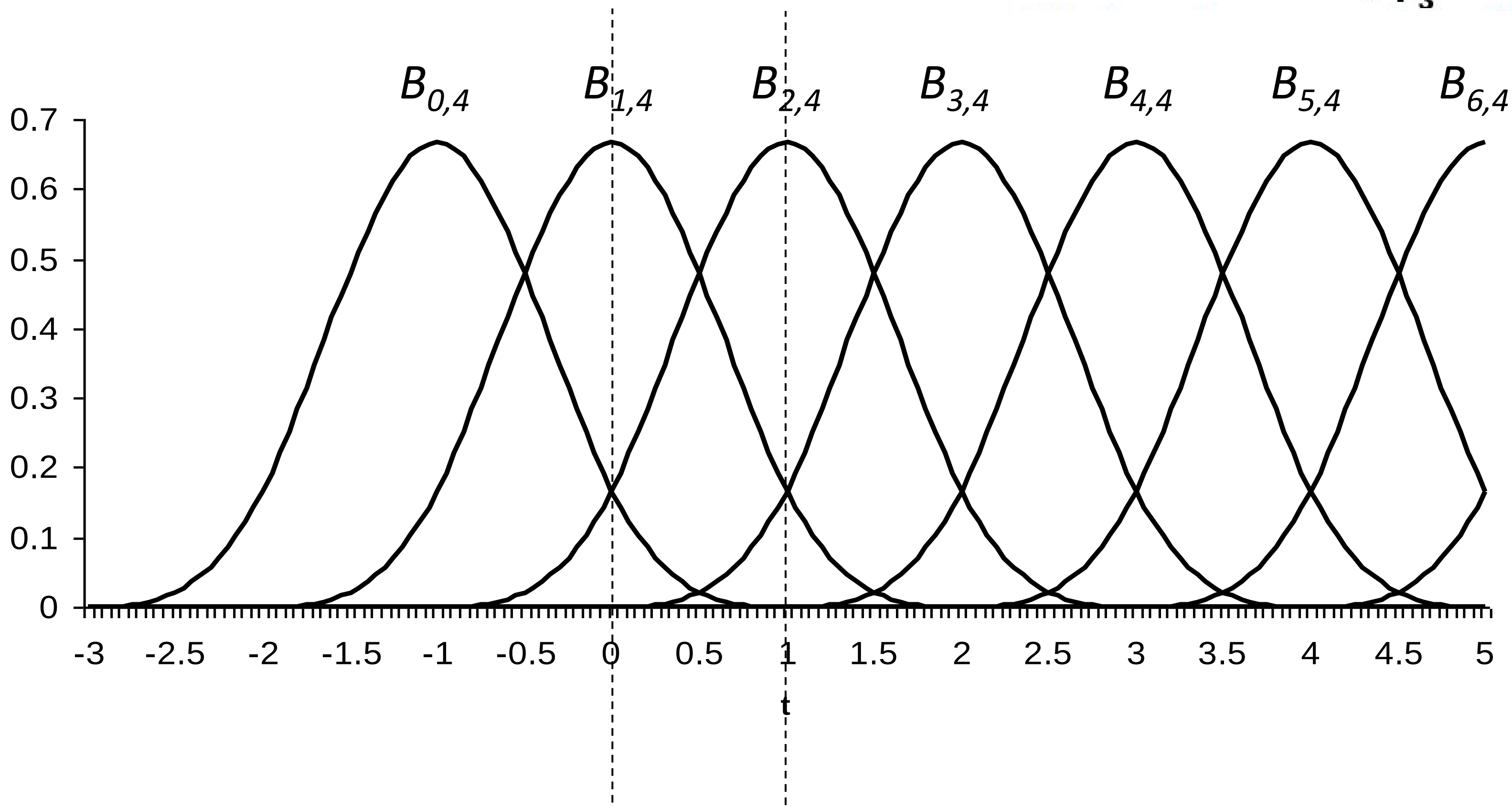
$$x(t) = \frac{1}{6}\begin{bmatrix} P_0 & P_1 & P_2 & P_3 \end{bmatrix} \begin{bmatrix} -1 & 3 & -3 & 1 \\ 3 & -6 & 0 & 4 \\ -3 & 3 & 3 & 1 \\ 1 & 0 & 0 & 0 \end{bmatrix} \begin{bmatrix} t^3 \\ t^2 \\ t \\ 1 \end{bmatrix}$$

- t is the *parametric variable*
- defined on [0,1]

Primer: Uniform Cubic B-Spline

Four basis functions B must be active to define the B-Spline curve



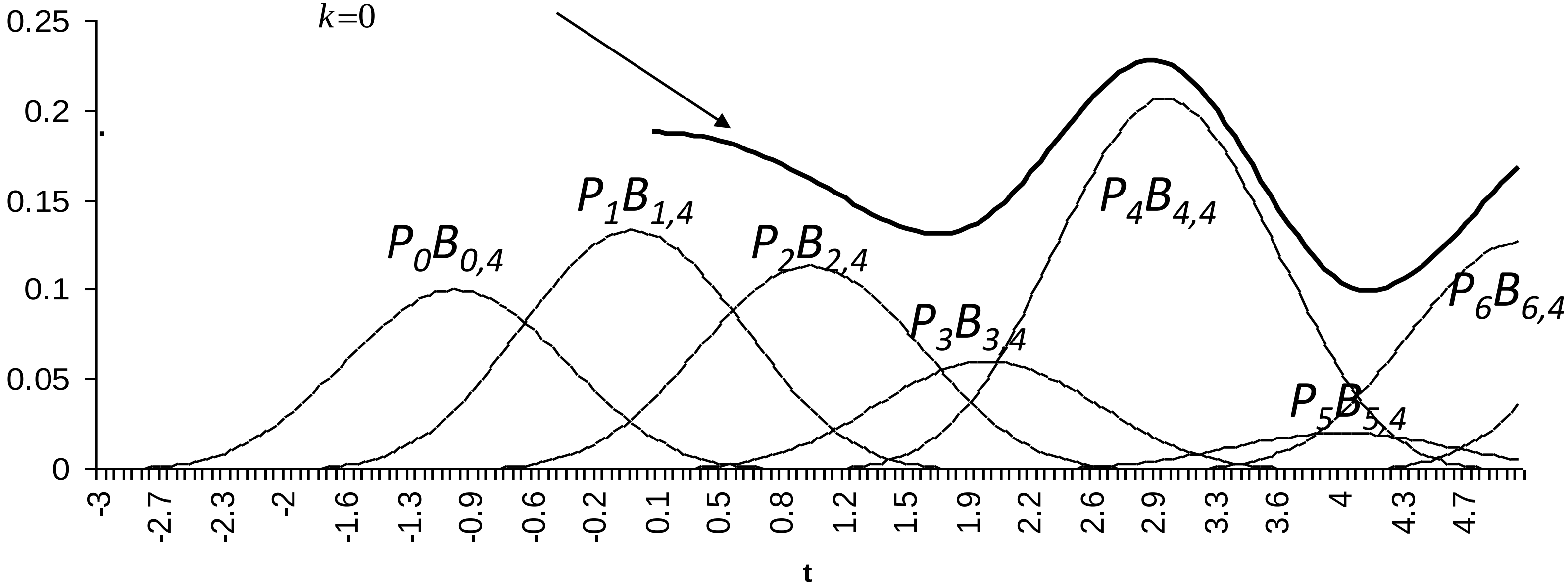


Primer: Uniform Cubic B-Spline

The locations of the control points scale the basis functions

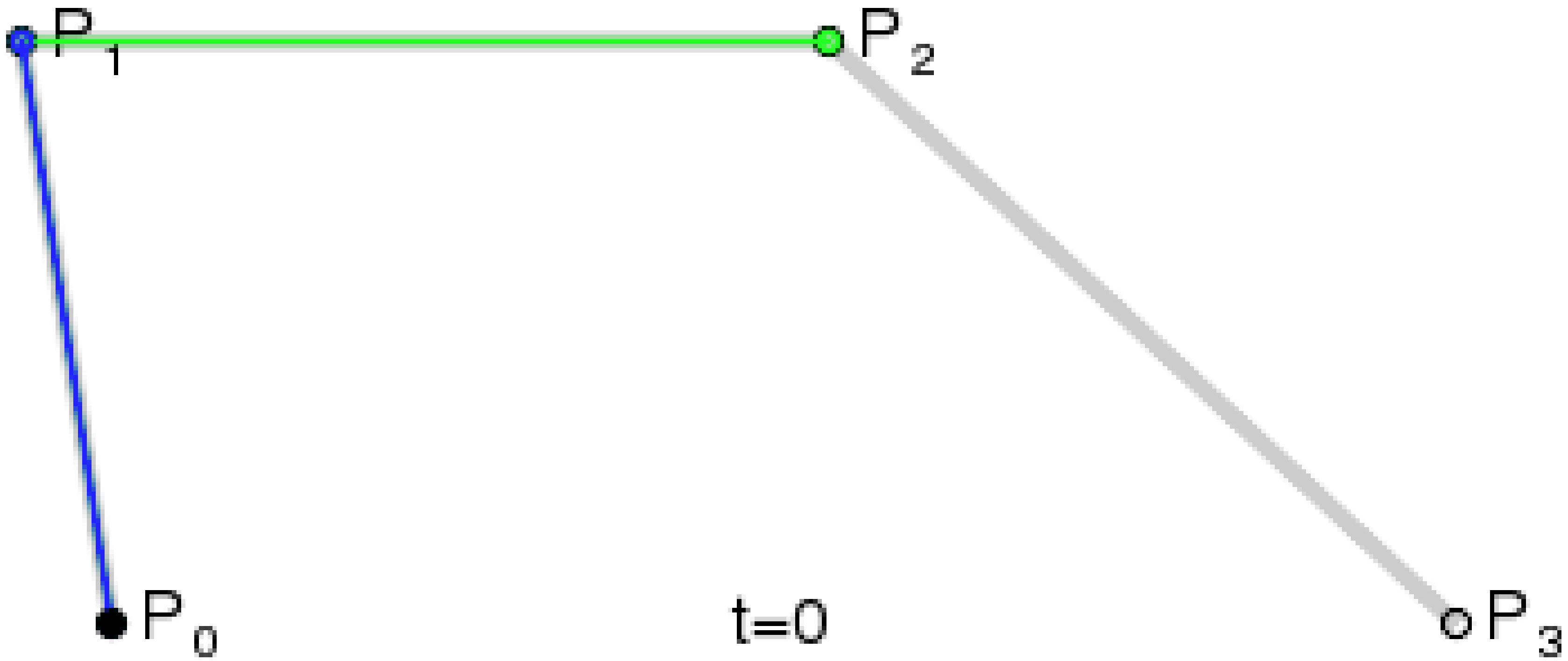
- in this simple example we see a continuous 1D function generated from 6 control points and basis functions

$$X(t)=\sum_{k=0}^{n} P_k B_{k,4}(t)$$



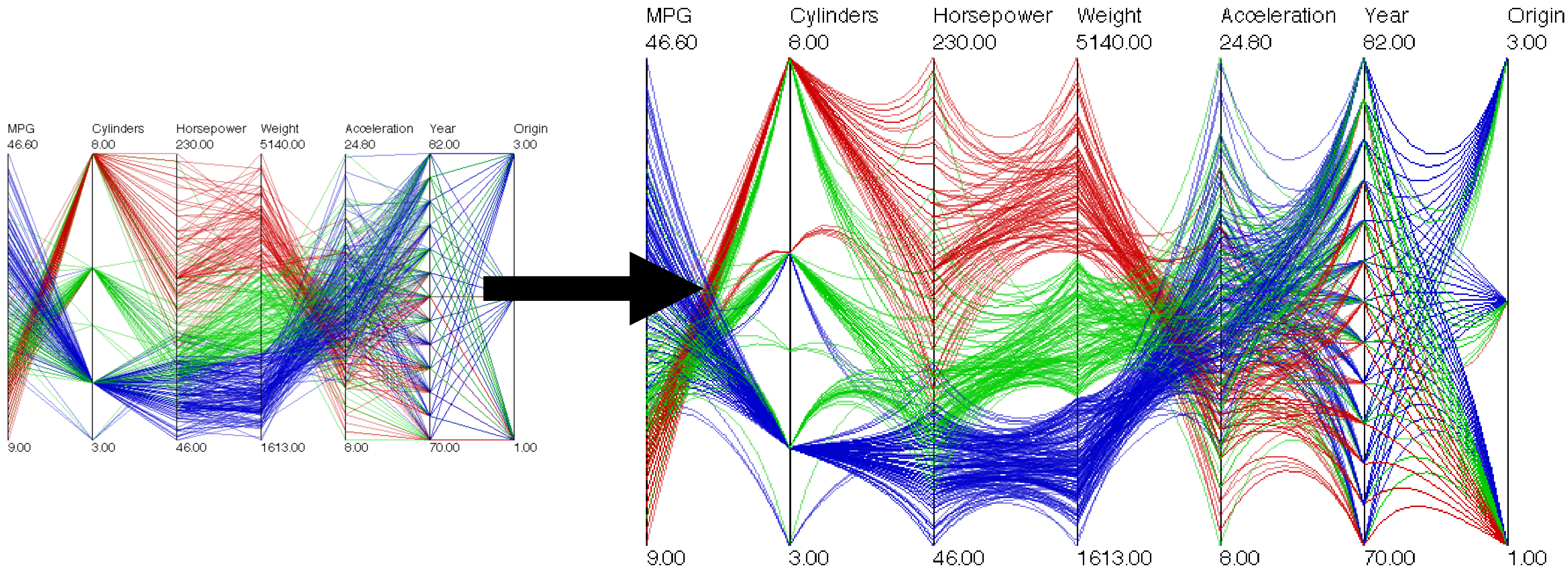
The curve can't start until there are 4 basis functions active

Cubic B-Spline Animated



Application to Parallel Coordinates

One straightforward way of reducing clutter is to replace polylines with polycurves:



Each line segment is replaced with an end-point interpolating, quadratic B-spline. A tension parameter can be controlled by the user.

McDonnell and Mueller, Computer Graphics Forum, 2008

Edge Bundling (cont.)

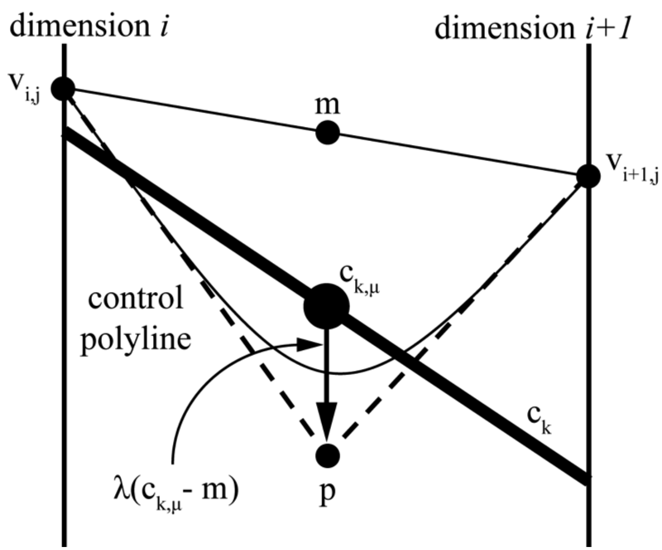
Let m be the mid-point in viewport coordinates of $v_{i,j}$ and $v_{i+1,j}$, end-points of a line segment

Let c_k be the cluster to which this segment belongs and $c_{k,\mu}$ be its mid-point in viewport coordinates

Let λ and β be tension parameters (usually λ = 0.75) and 0 ≤ β ≤ 1 is set by the user

The control points of the spline are given by:

- $(-1, v_{i,j})$
- $(0, \beta m + (1 - \beta)p)$
- $(1, v_{i+1,j})$

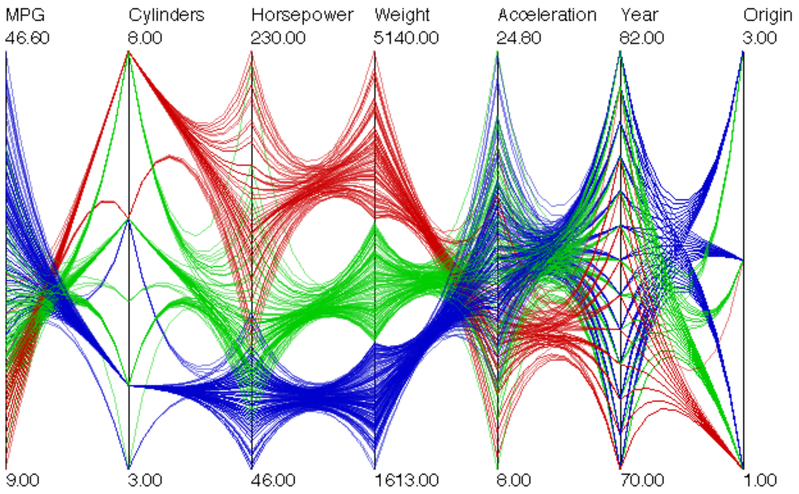


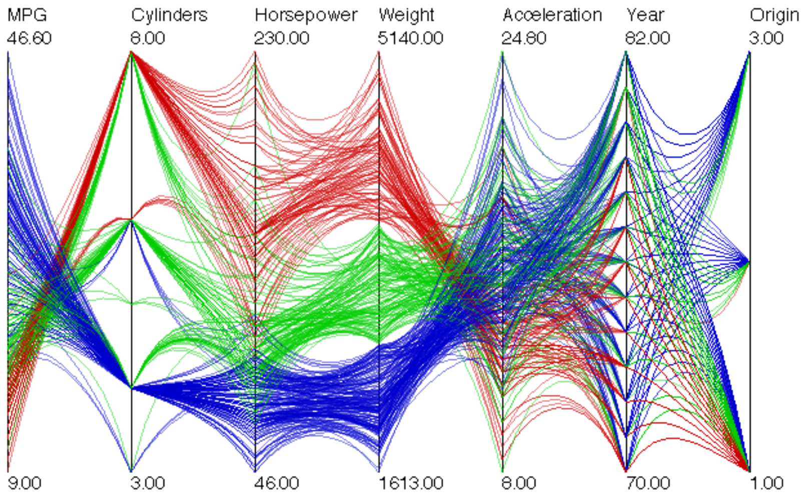
Edge Bundling (cont.)

The tension can be changed to control the amount of clutter reduction

In our implementation, the λ parameter is fixed, but the β parameter can be changed in the GUI

Examples of medium and low tension, respectively:





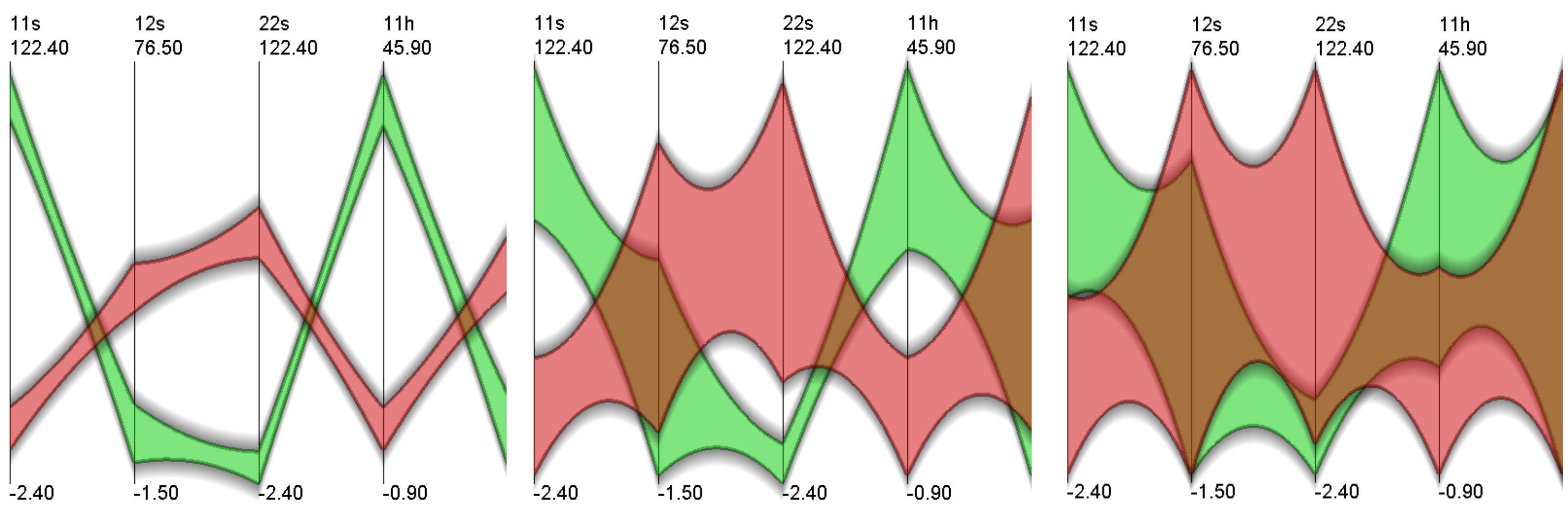
Cluster Rendering

Recall that clusters are often rendered as heavy line segments on top of the dataset

In IPC we render the clusters as polygonal meshes

They help to show the ranges of each cluster along axes

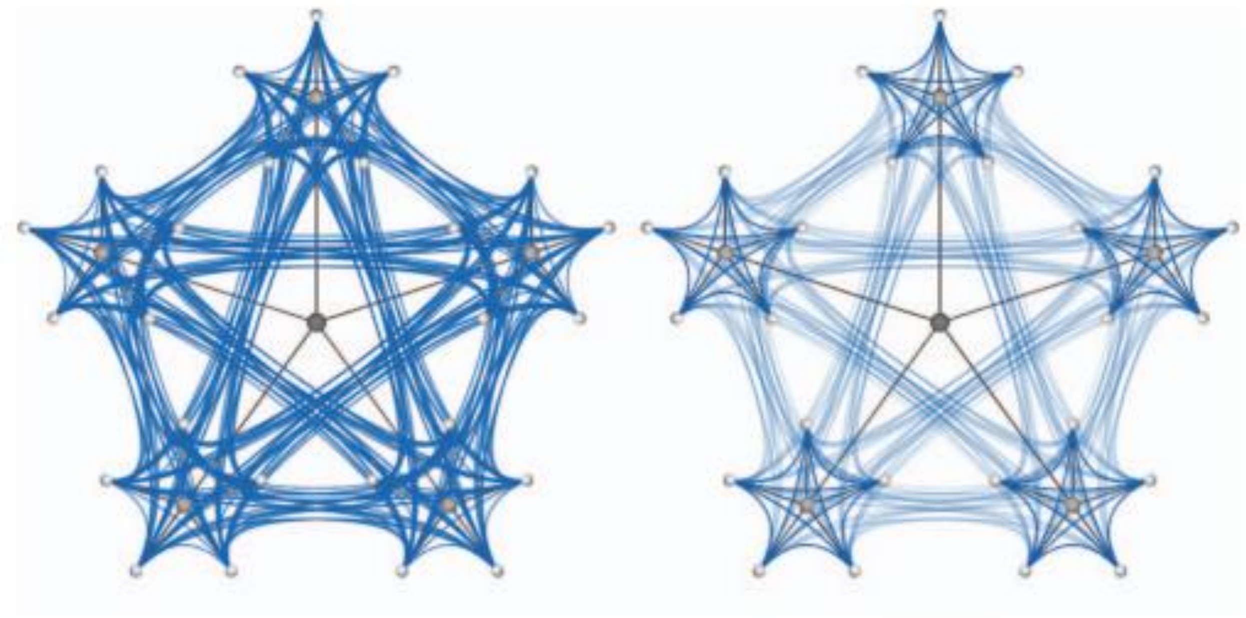
The vertical “spread” can be controlled by the user



Alpha (Opacity) Blending

Draw curves at different opacities

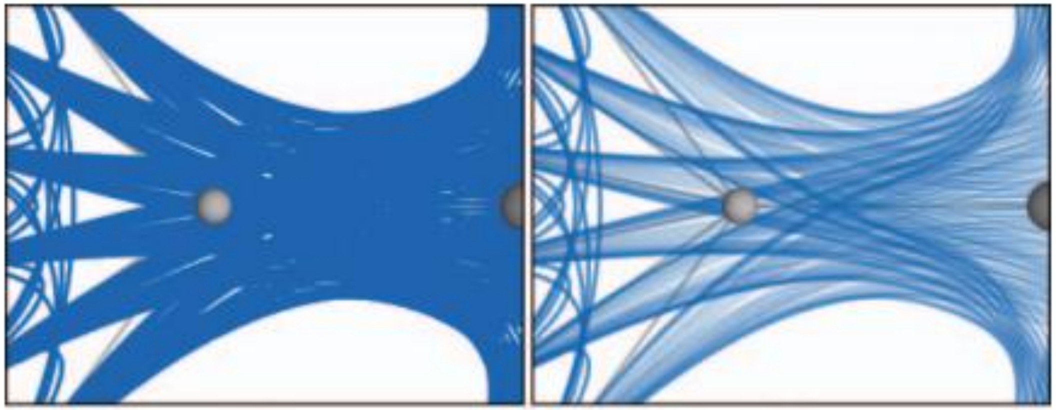
- long curves: low opacities (high transparencies)
- short curves: high opacity (makes short curves visible)



alpha blending disabled   alpha blending enabled

Alpha (Opacity) Blending

Alpha blending also enables visualization of sub-bundles and differentiation of lines

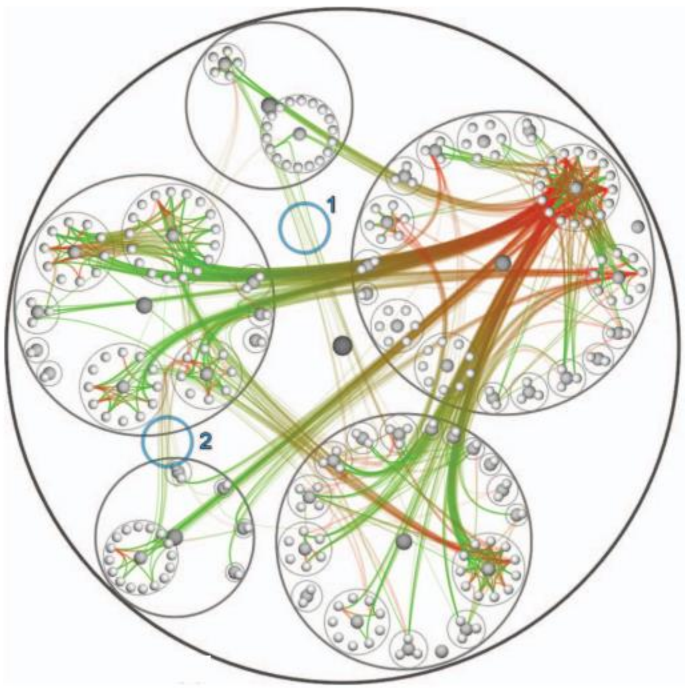


alpha blending disabled alpha blending enabled

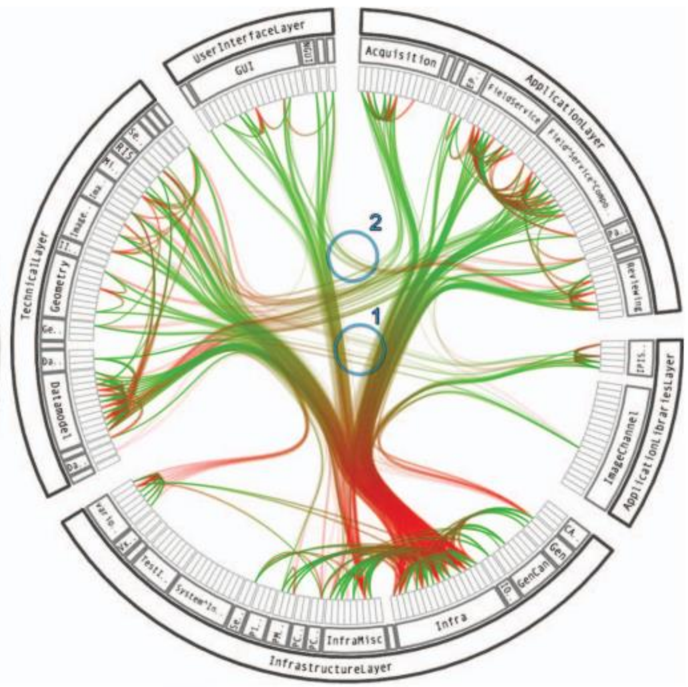
Edge Bundling Example

Software system call graph

- green is caller, red is callee

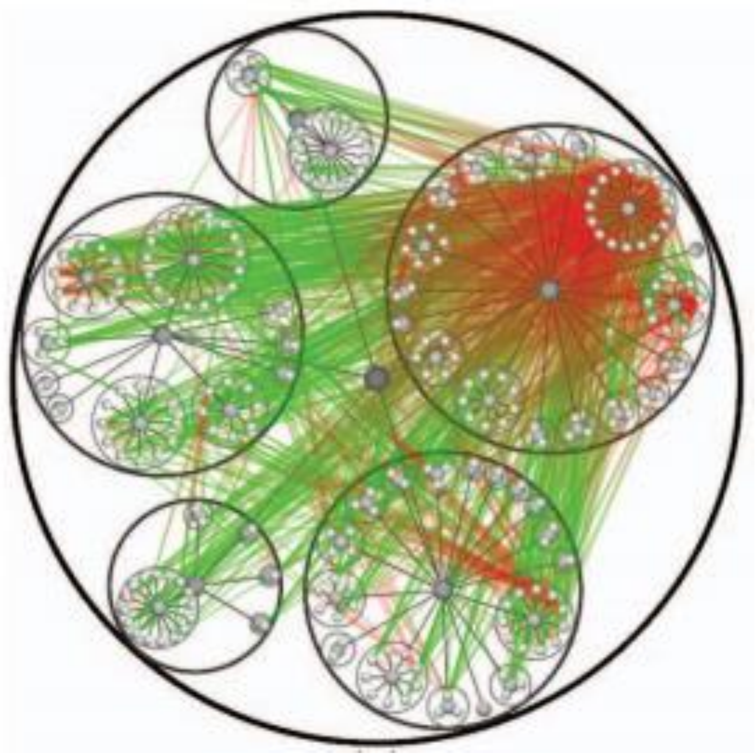


balloon layout (isolated processes)

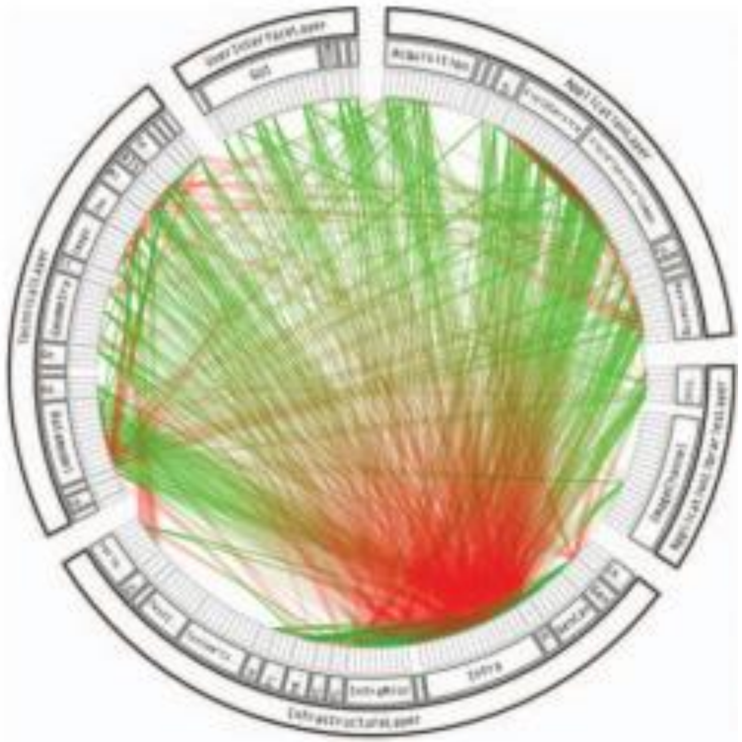


radial layout (more integrated)

Without Edge Bundling



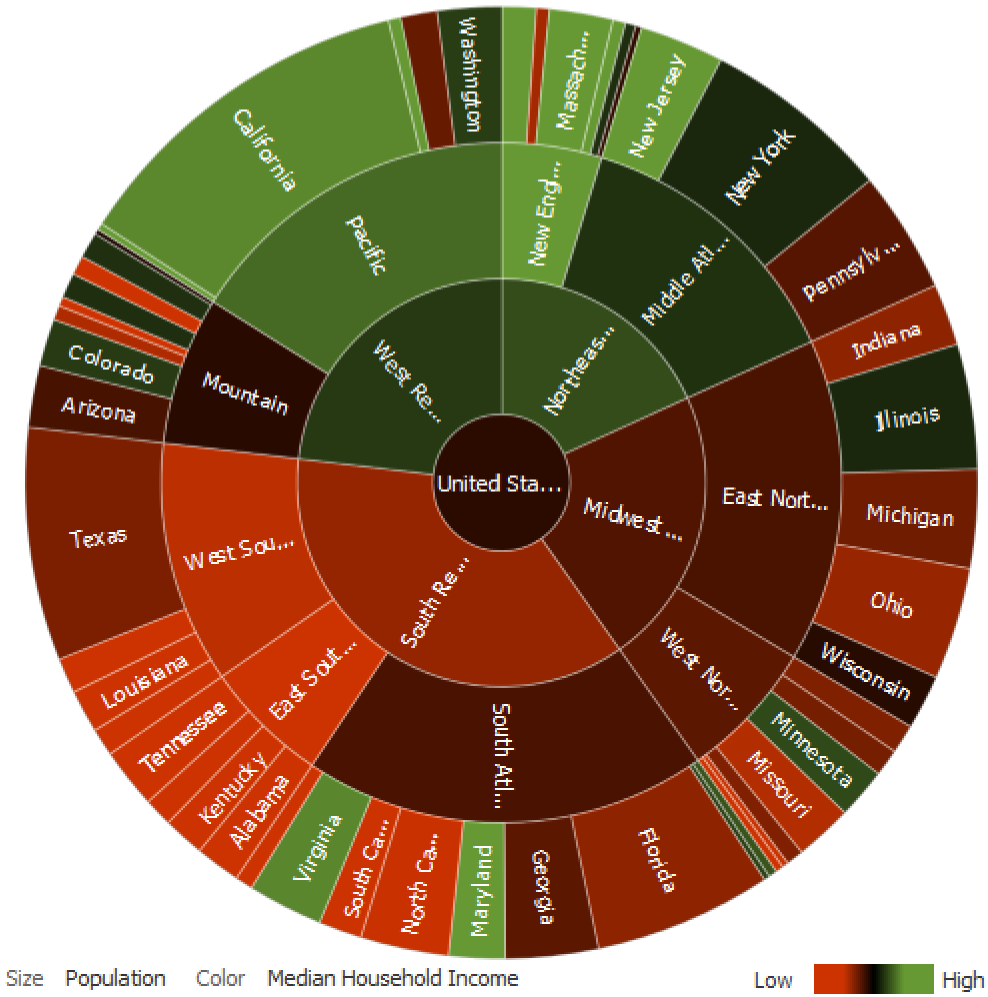
balloon layout



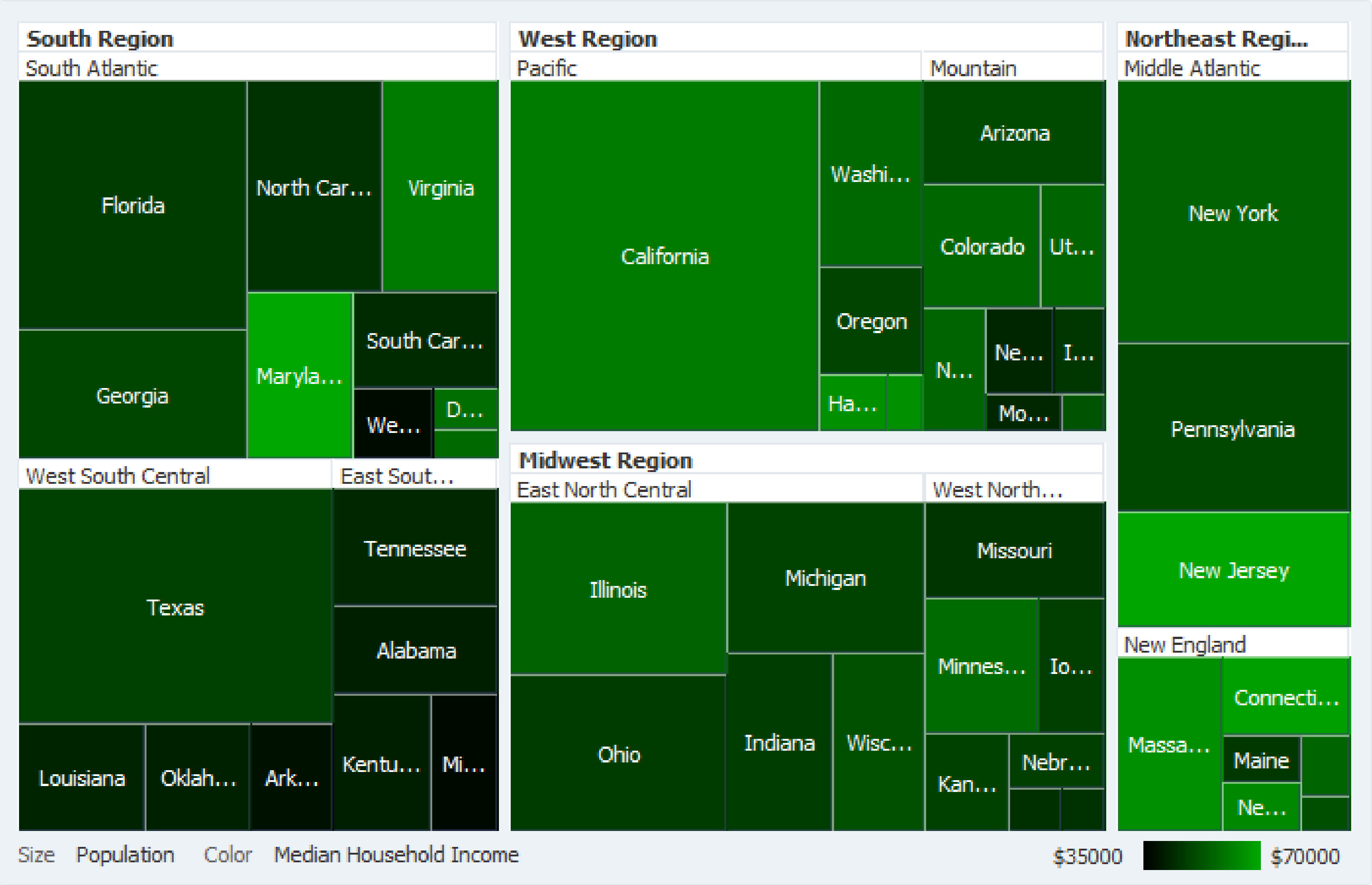
radial layout

Hierarchies with Sun Burst Displays

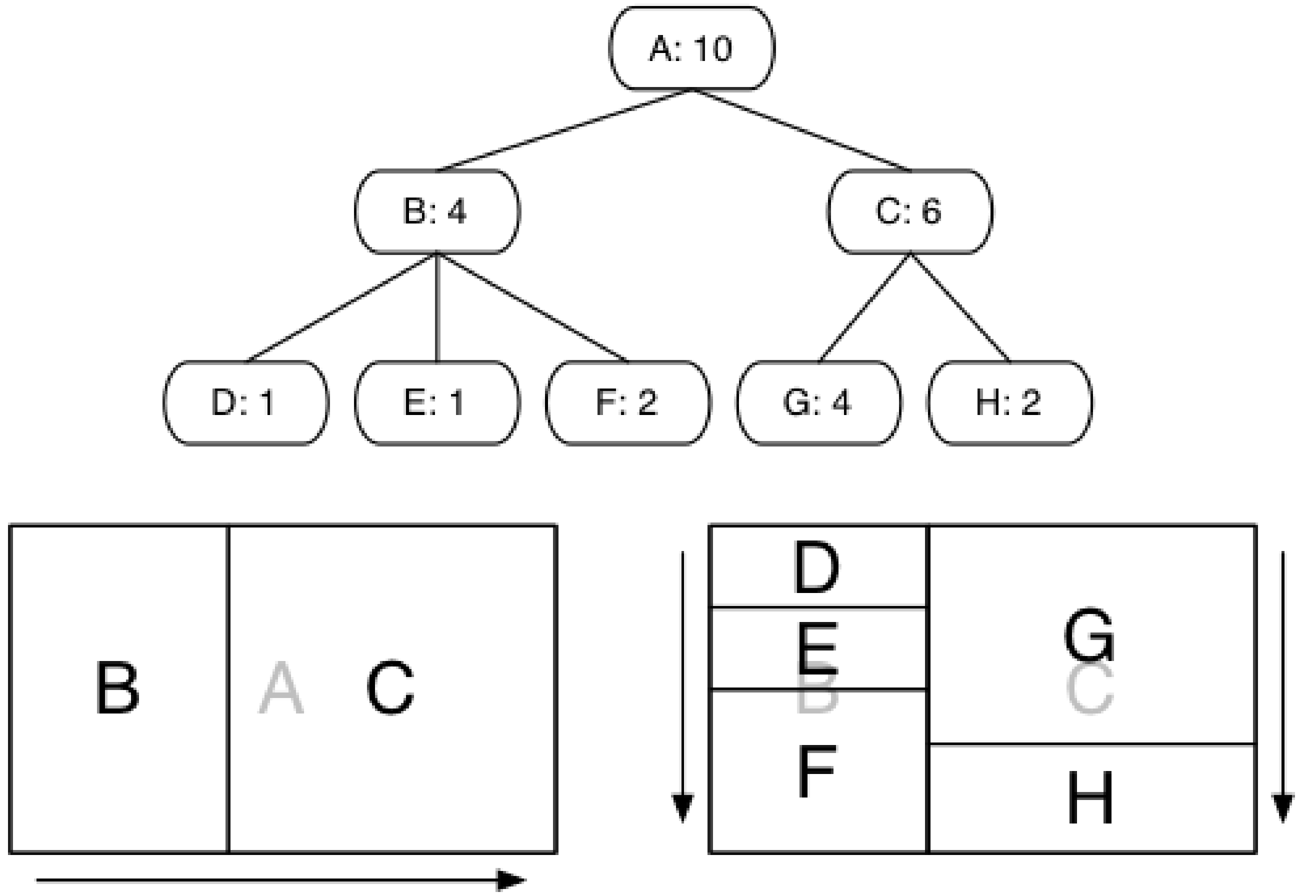
Sunburst with Partition of Unity



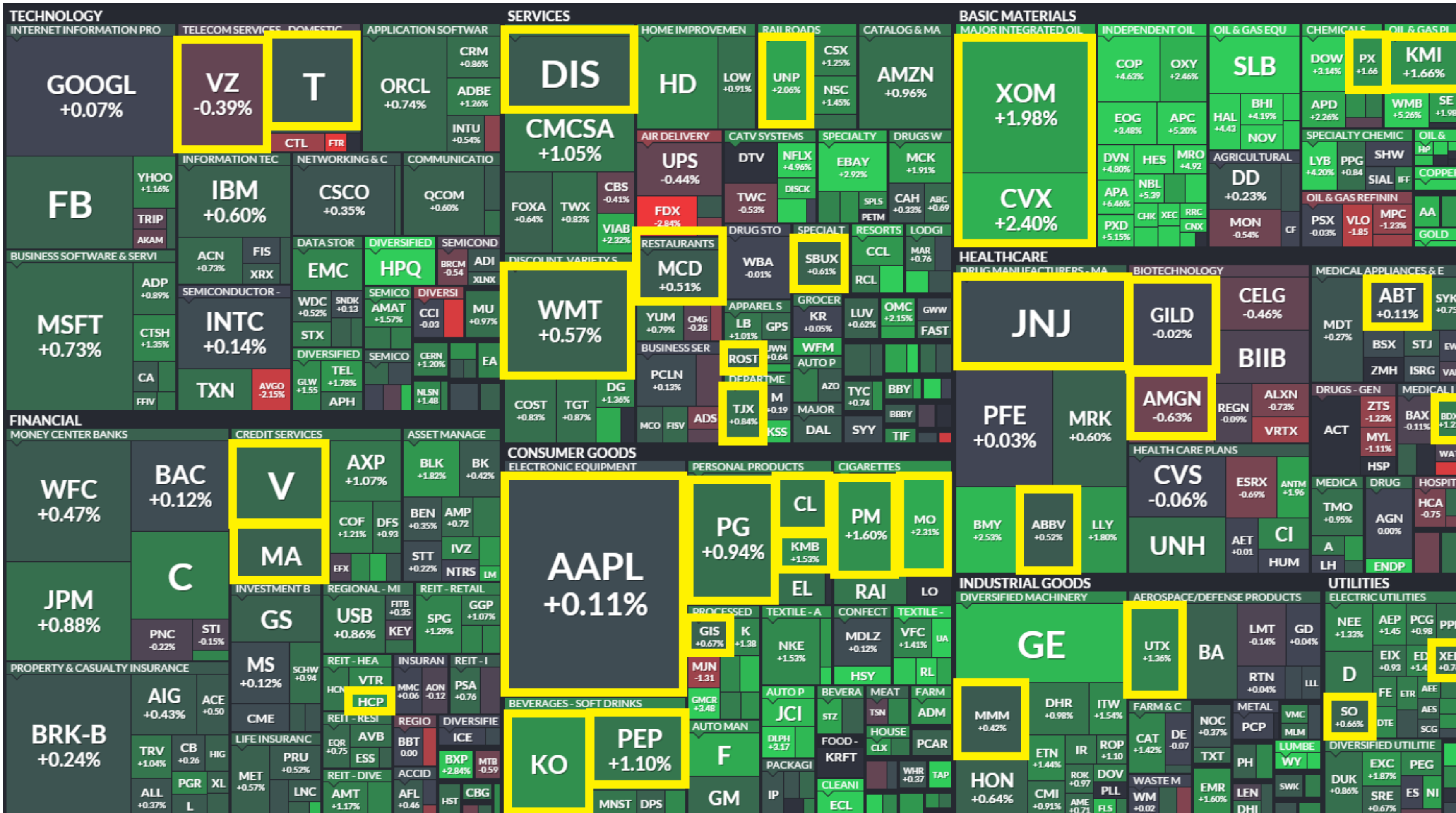
Same Data with Treemap



Treemap Constructon

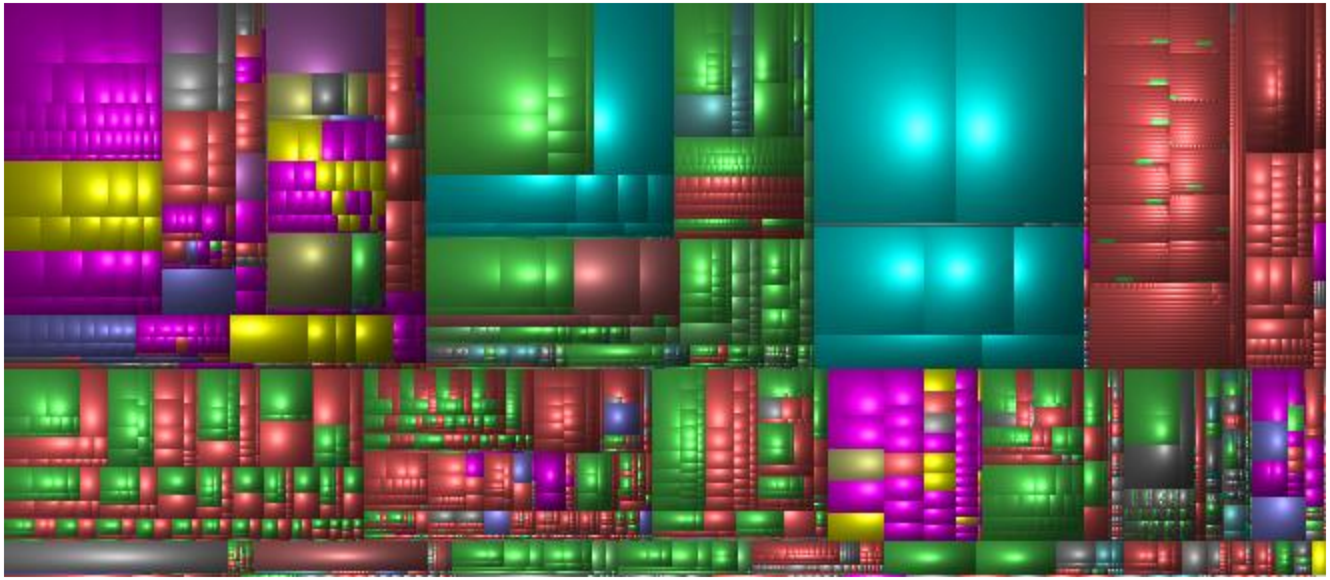


Treemap for Stock Portfolio



Size is mapped to market cap, yellow boxes are investor's holdings

Cushion Treemap



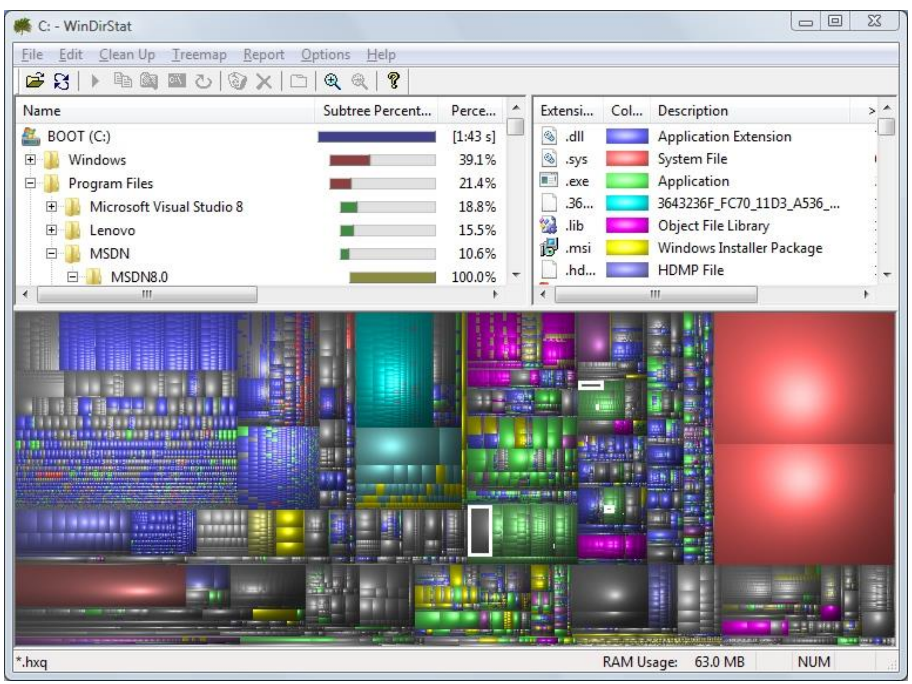
Advantages

- due to perceived discontinuity in texture between nodes, lines are no longer necessary to separate nodes
- more of the space can be used for the actual node display
- much smaller nodes can be shown than in a flat treemap

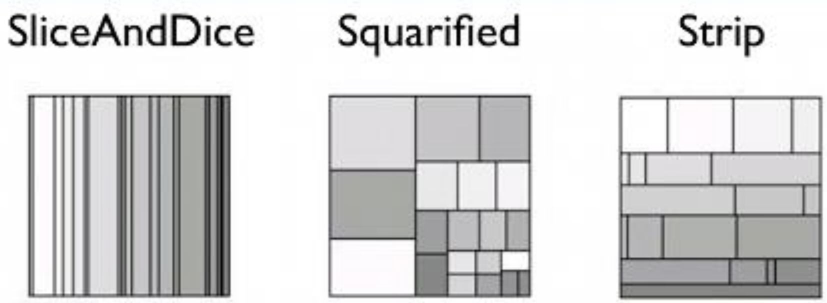
Tree map for Disk Drives

Used in programs like

- WinDirStat (Windows)
- KDirStat (Linux)
- DiskInventory (Mac)



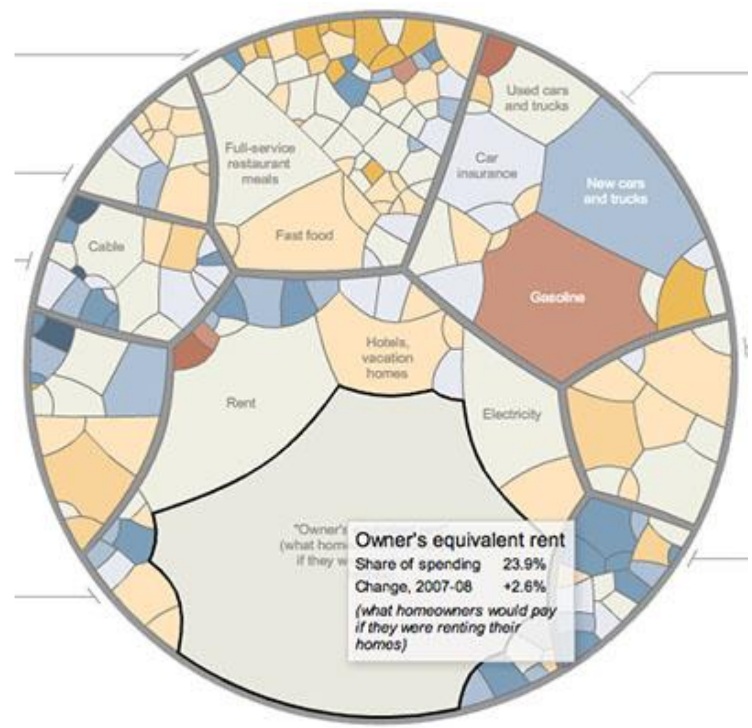
Treemap variations



order	ordered	unordered	ordered
aspect ratios	very high	lowest	medium
stability	stable	medium	medium

Voronoi treemap

- based on Voronoi tesselation



Squarified treemap is preferred

- it's difficult to visually compare long slivery tiles with tiles that have a more even aspect ratio
- a squarified treemap makes the map more globally comparable