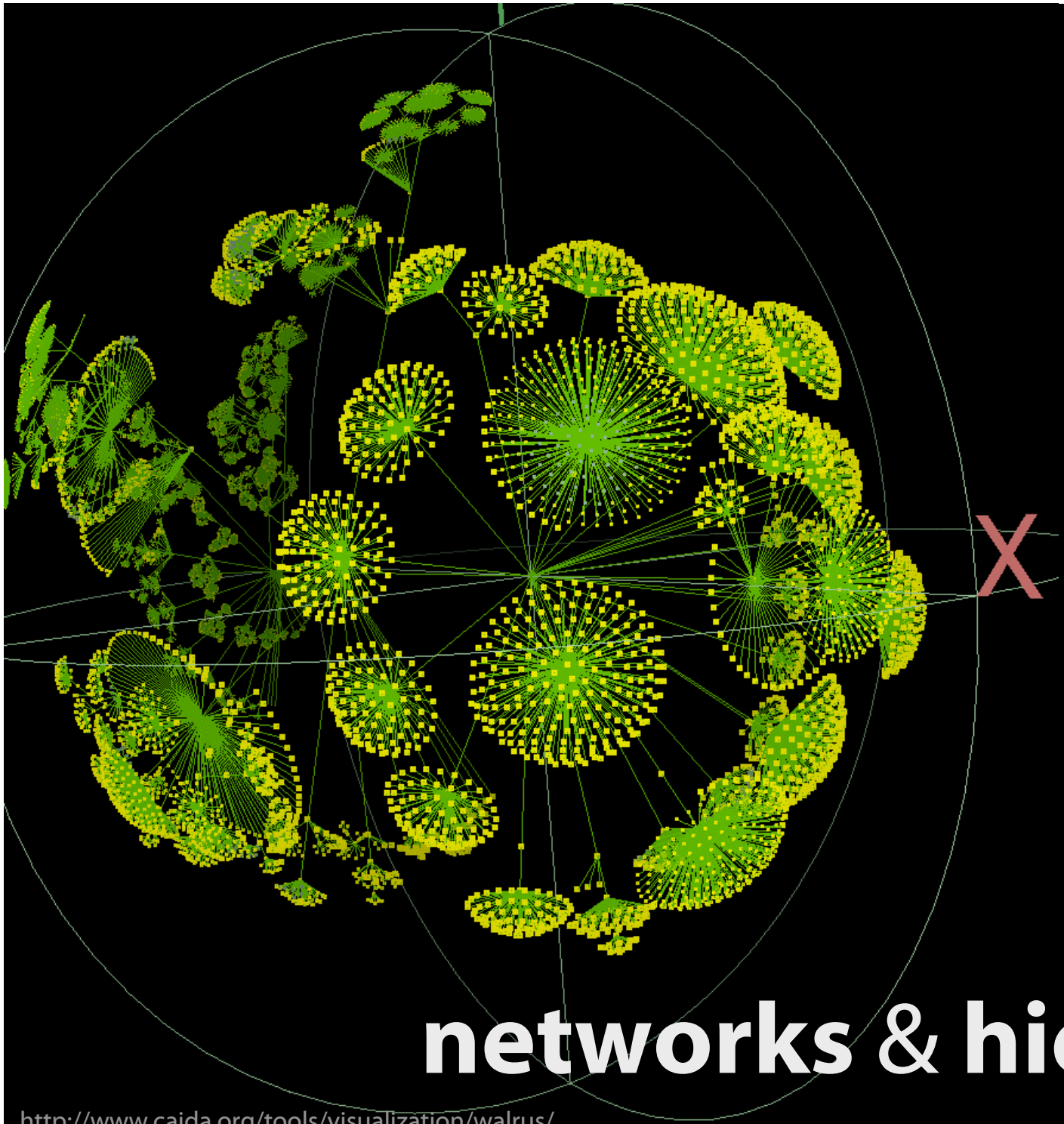


http://www.caida.org/tools/visualization/walrus/

informations-
visualisierung

Wolfgang Aigner

aigner@ifs.tuwien.ac.at
http://ieg.ifs.tuwien.ac.at/~aigner/

Version 2.0

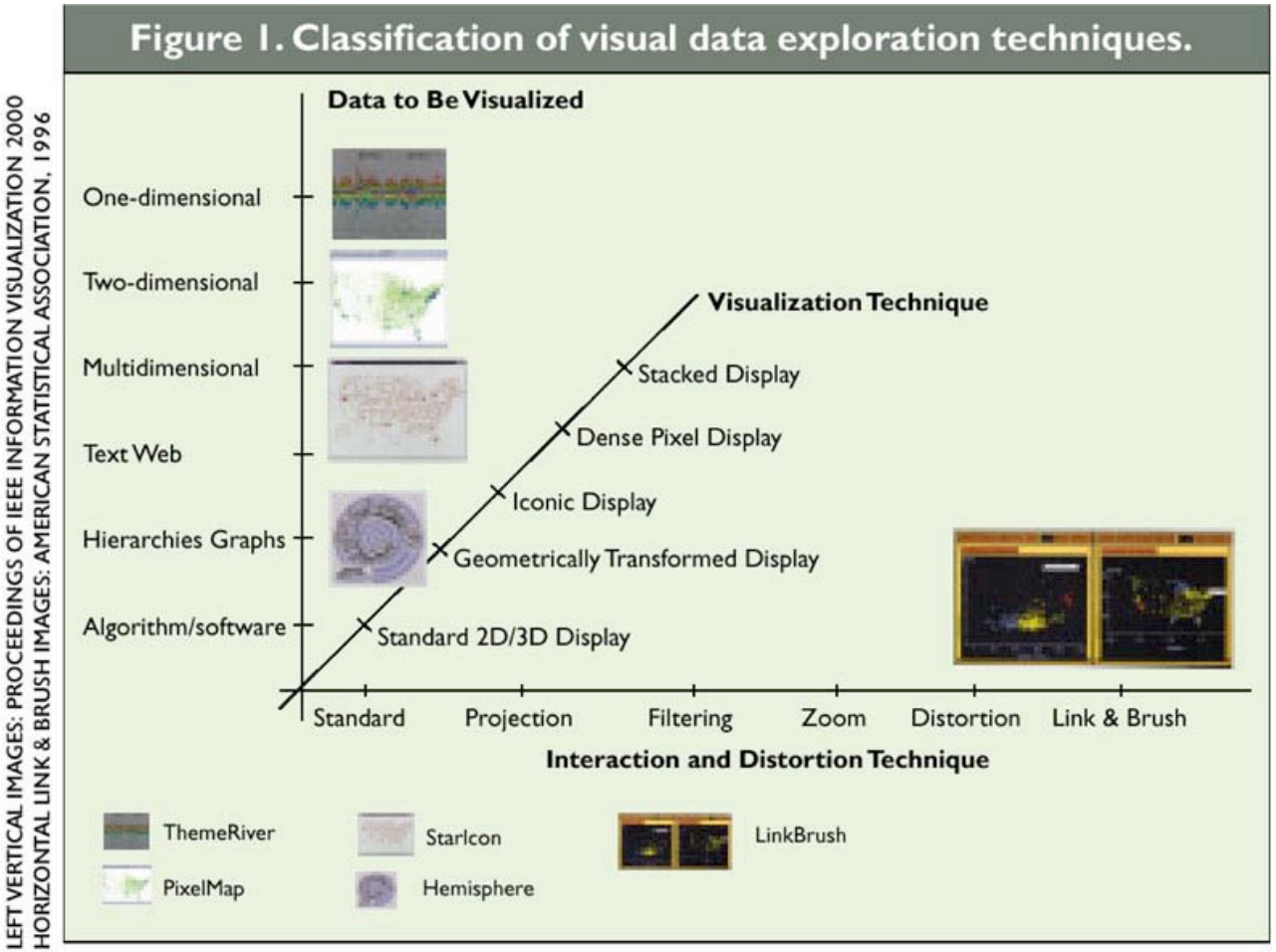
25.11.2010

networks & hierarchies

Overview

A) Hierarchical visualization techniques

B) Visualizing networks & hierarchies



[Keim, 2001]

Part A
hierarchical visualization techniques

Problem

Data

multivariate data (e.g., Movie DB, Car dataset)

Presentation space

display dimensionality constrained to 2D or 3D

Task

meaningful representation of all variables within a single plot

How?

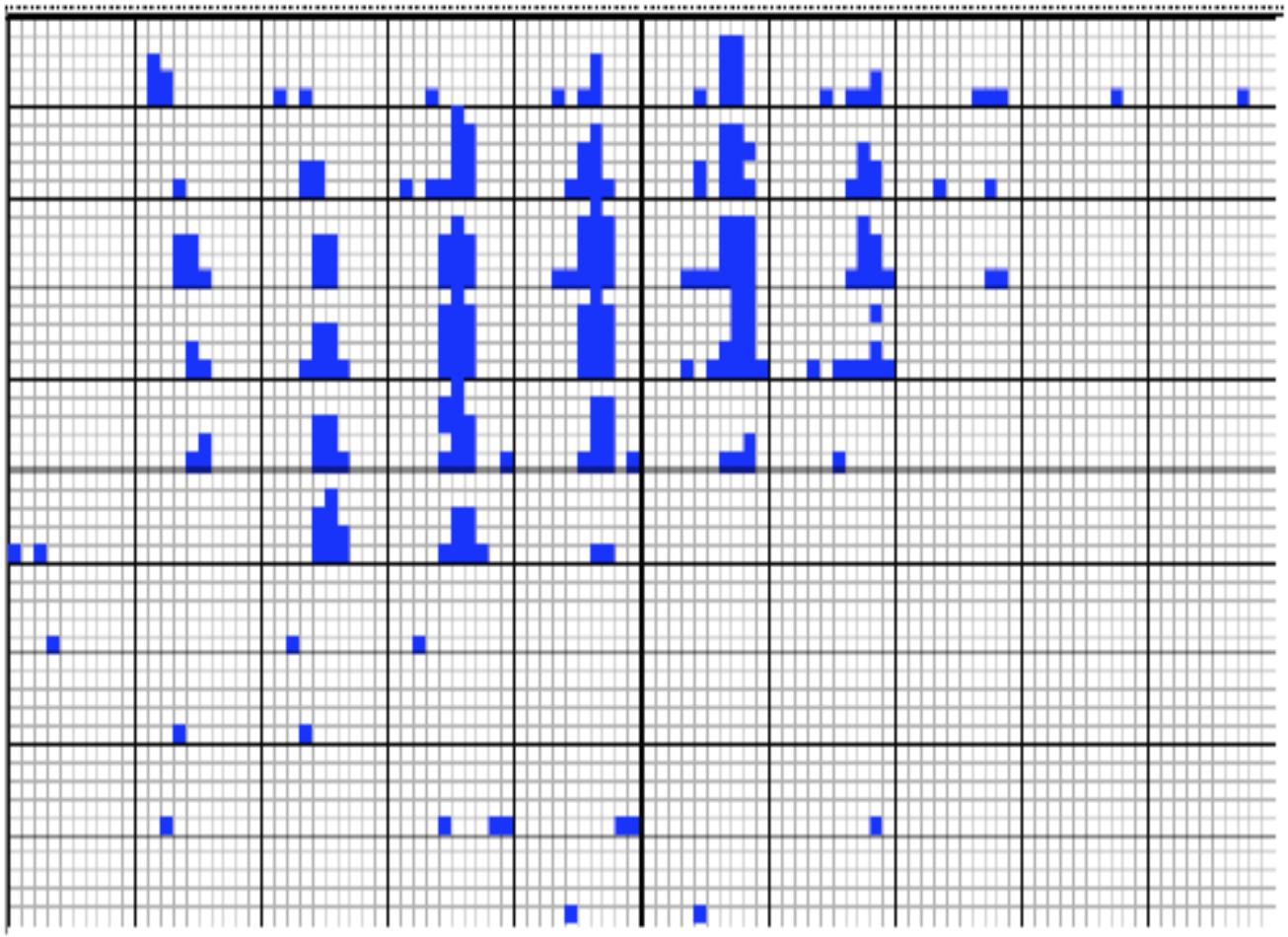
Example

4 variables:

- longitude
- latitude
- ore grade
- depth

Dimensional Stacking

[LeBlance et al. 1990]

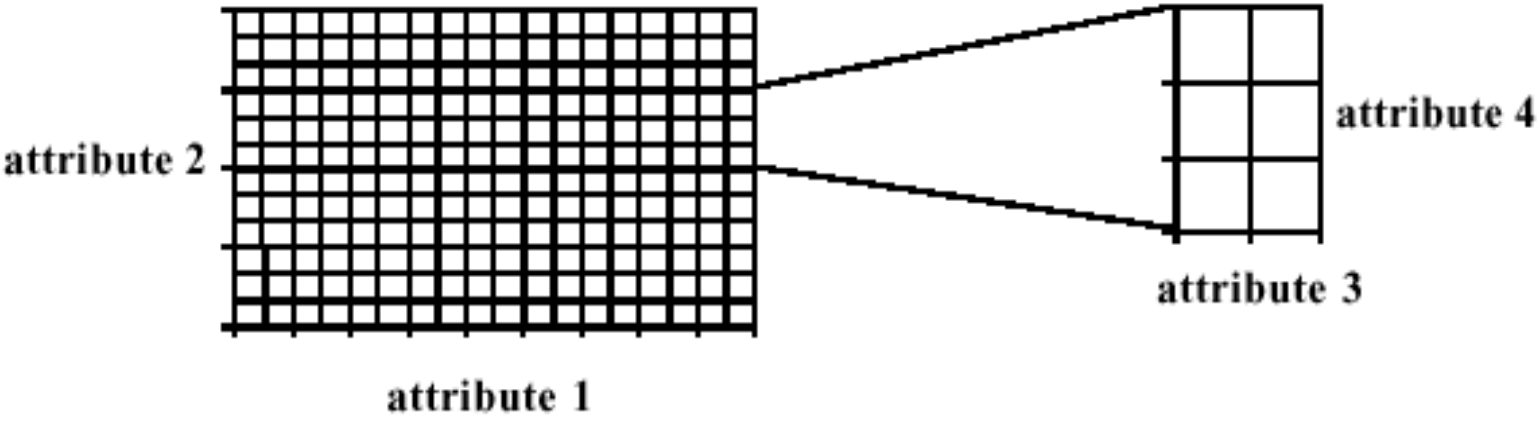


visualization of oil mining data with longitude and latitude mapped to the outer x-, y- axes and ore grade and depth mapped to the inner x-, y- axes

used by permission of M. Ward, Worcester Polytechnic Institute

Dimensional Stacking

[LeBlance et al. 1990]



Partitioning of the n-dim. attribute space in 2-dim. subspace, which are “stacked” into each other

Partitioning of the attribute value ranges into classes

Important attributes should be used on the outer levels

Adequate especially for data with **ordinal** attributes of **low** cardinality

Dimensional Stacking

[LeBlance et al. 1990]

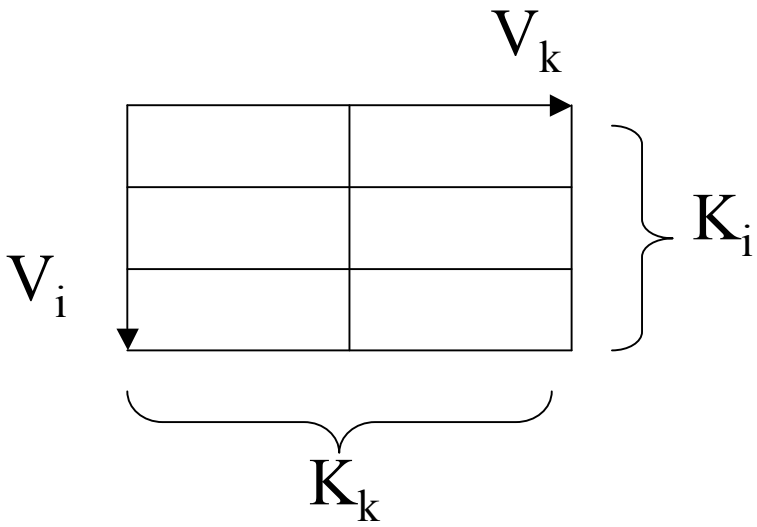
Given

Variables V_1 - V_m

Power of the Domain: Cardinalities K_1 – K_m

Process

2 Variables V_i,V_k → K_i*K_k Grid



Example

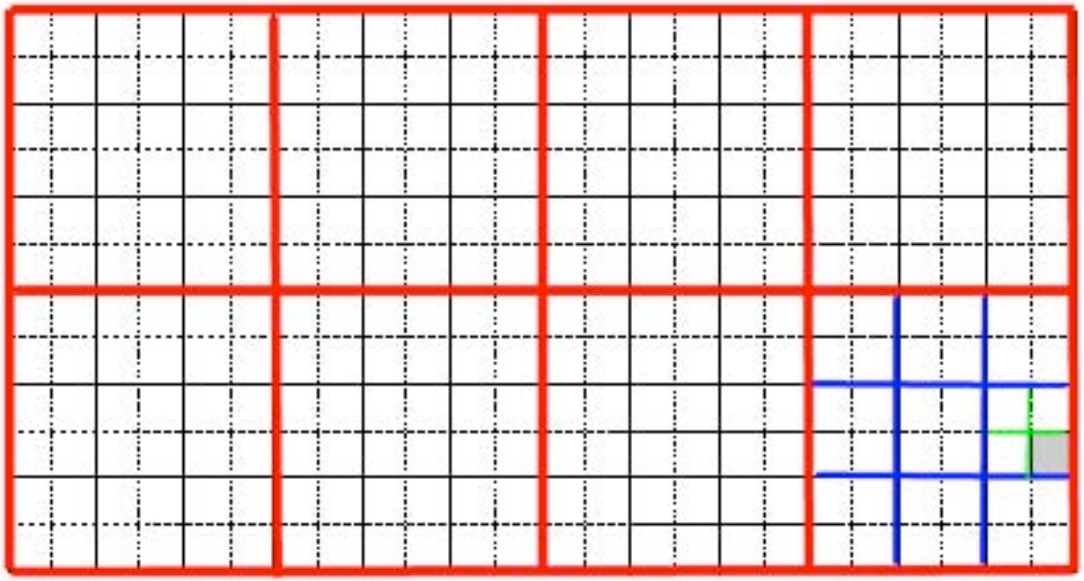
[LeBlance et al. 1990]

Variables: V_1-V_6

Cardinalities: $K_1=4, K_2=2, K_3=2, K_4=3, K_5=3, K_6=2$

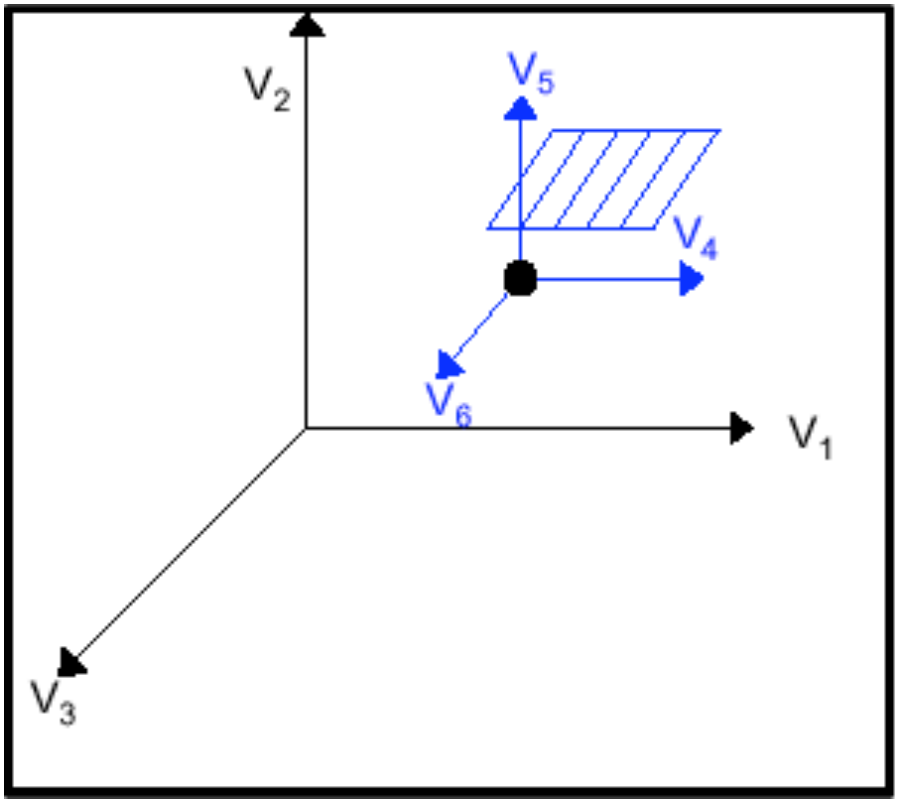
Pairs $P_1(V_1,V_3), P_2(V_4,V_5), P_3(V_2,V_6)$

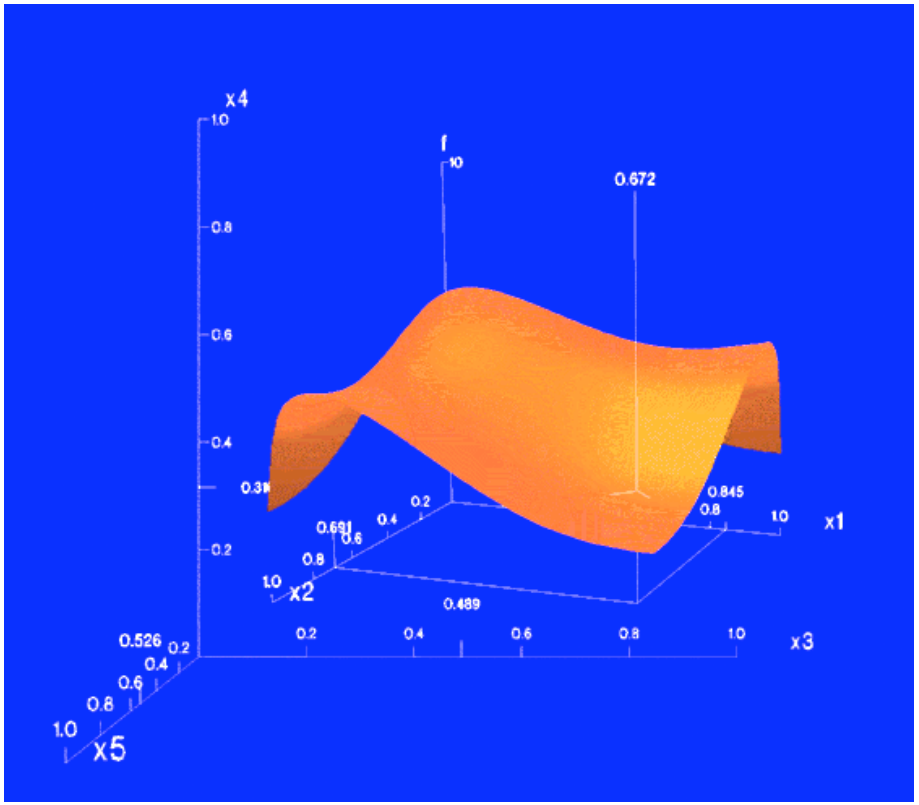
Example - Combination: 4,2,3,2,2,2



Worlds-within-Worlds

[Feiner & Besherss 1990]





Partitioning of the n-dim. Space into 3-dim. Subspace

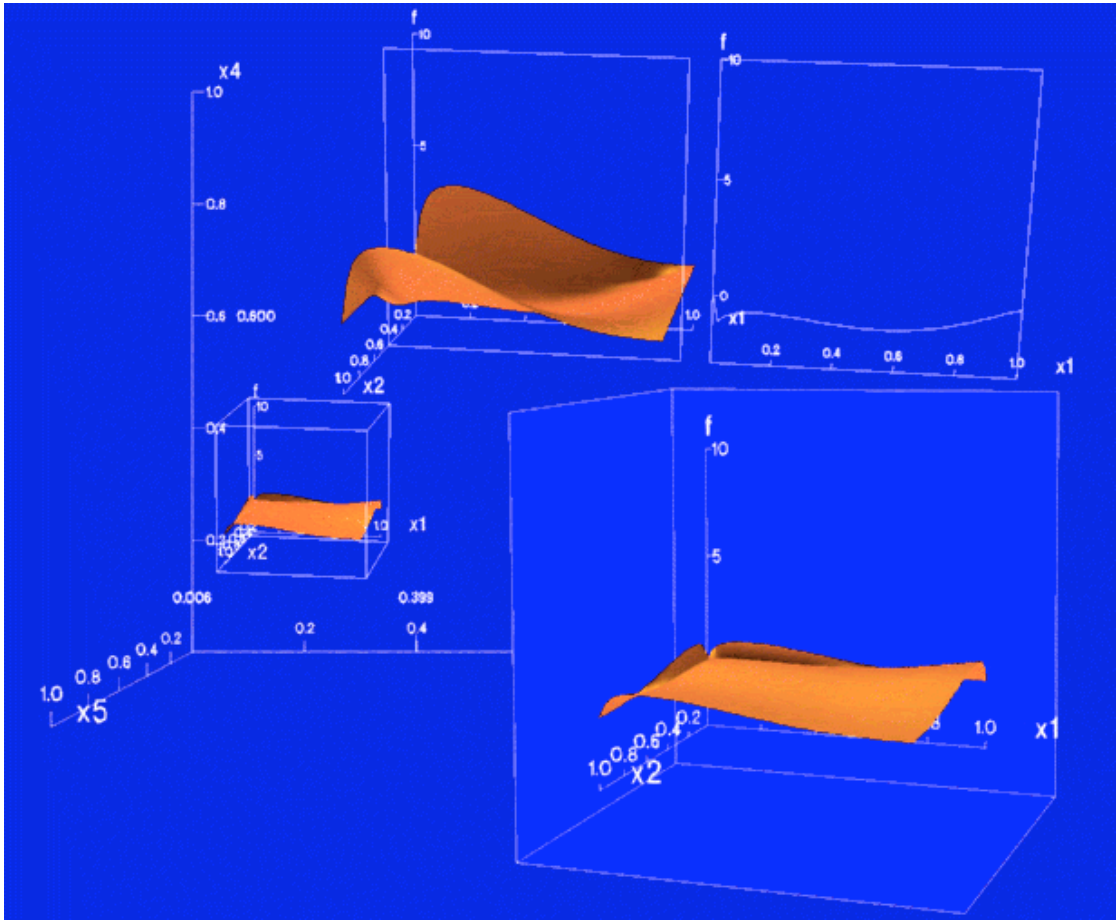
Nested 3-dim coordinates

3-dim coordinate = one property

Selected points --> new coordinates' system

Worlds-within-Worlds

[Feiner & Besherss 1990]



Part B
visualizing networks & hierarchies

Illustrating example

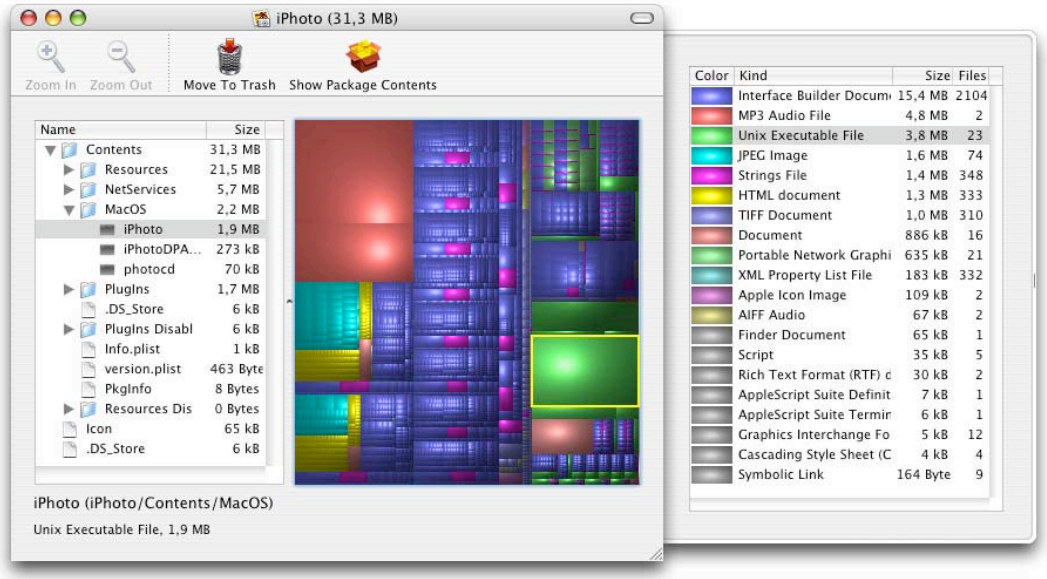
Data: file system

Problem/task: disk is full --> free some space

How?

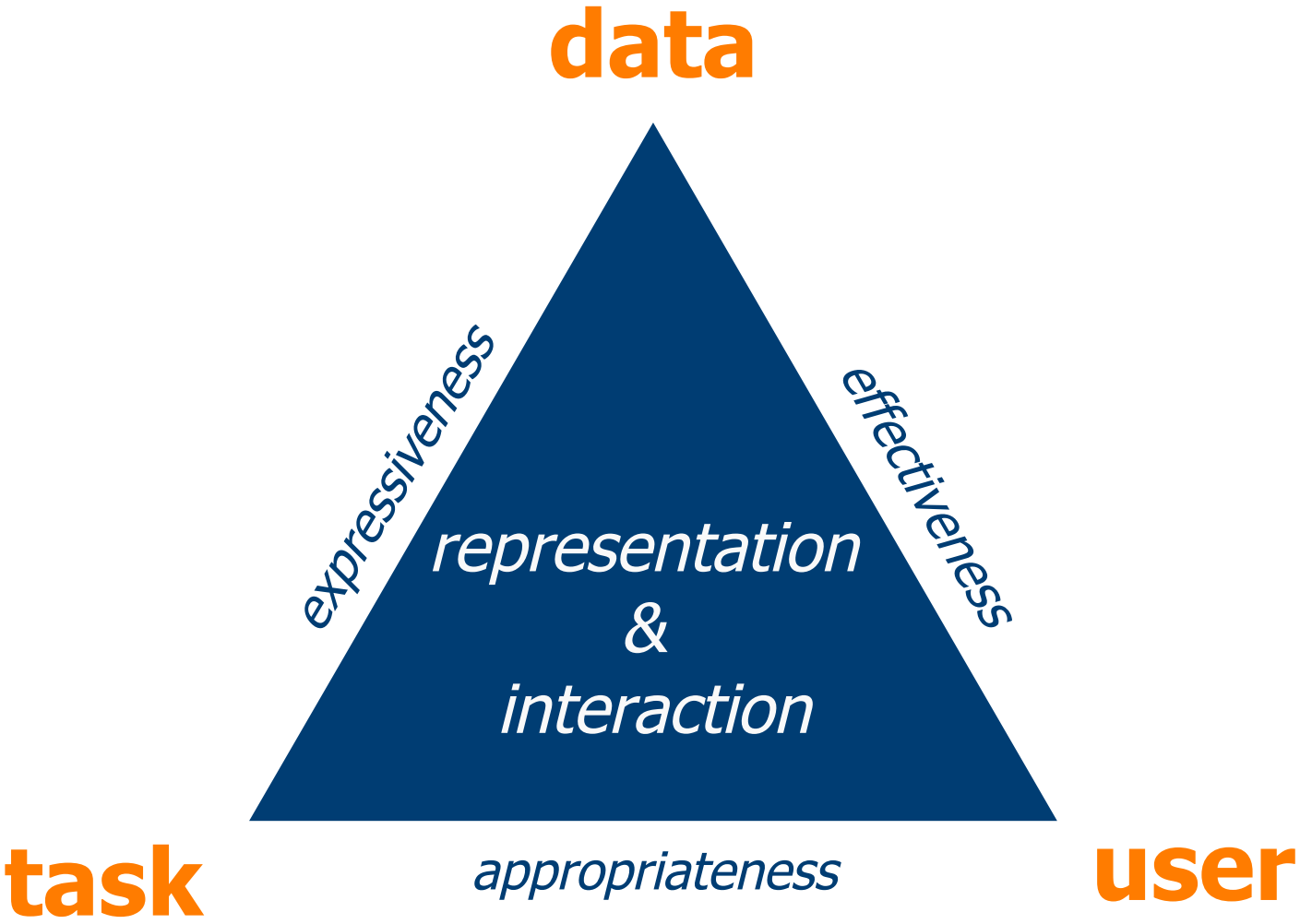
Tool?

Visualization?



Tjark Derlien, Disk Inventory X, 2005. http://www.derlien.com/

Visualization Design



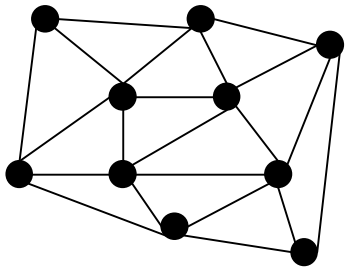
Basic Data Characteristics

network / graph

items (nodes) that have relationships (edges)

G := {N, E}

no inherent hierarchical structure



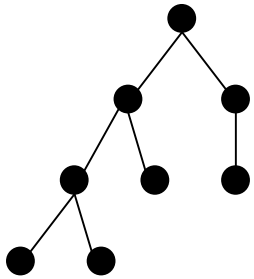
hierarchy / tree

parent - child relationships

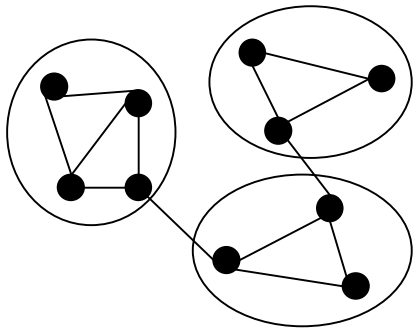
every node has at most one parent

exactly one root node

mostly non-leaf nodes are containers only



hierarchical network



Network examples

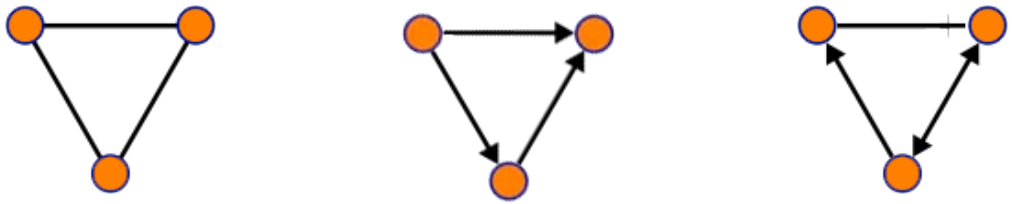
Airline map:=(Cities, Flights)

Team:=(People, Relationships)

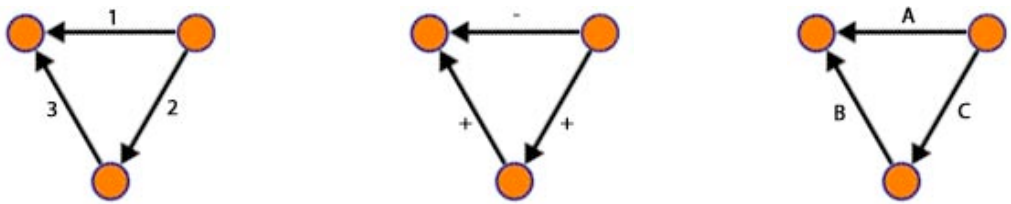
Molecule:=(Atoms, Bonds)

Edges

undirected / directed / mixed

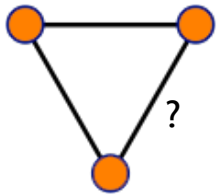


weighted / signed / labeled

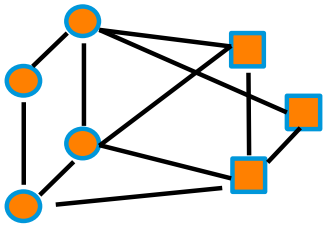


simple / multiplex

certainty / probabilistic

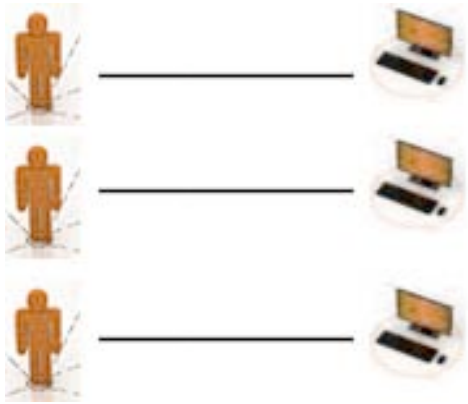


multi-modal



Graph theory

Multi-modal example :: Blogosphere



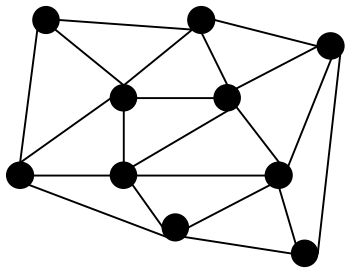
Bloggers know each other (simple, undirected) + Blogs link each other (multiplex, directed) + Bloggers write blogs (bipartite)

= Blogosphere structure (multiplex, mixed, multi-modal)

Basic Data Characteristics

Topology

- Nodes
- Edges



Node attributes

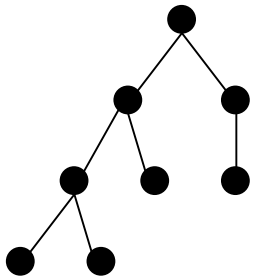
Edge attributes

Node measures (derived)

Edge measures (derived)

Network measures (derived)

Size / number of elements (complexity)



Tree: connected, unweighted, acyclic graph

Hierarchies

Hierarchical data are **very common**

Hierarchies are one of the most prevalent **organizing principles** for coping with information

application examples

organizations, org-charts, taxonomies, table of contents, sitemaps, file system, genealogies, ...

Tasks

What are the tasks the users want to perform? What are users' goals?

reducing complexity

categorization - hierarchies (expand/collapse)

overview of topology

distribution

examine relationships

examine paths

examine elements

identify

locate

distinguish

relate

compare

specific

general

Part B.1
visualizing networks

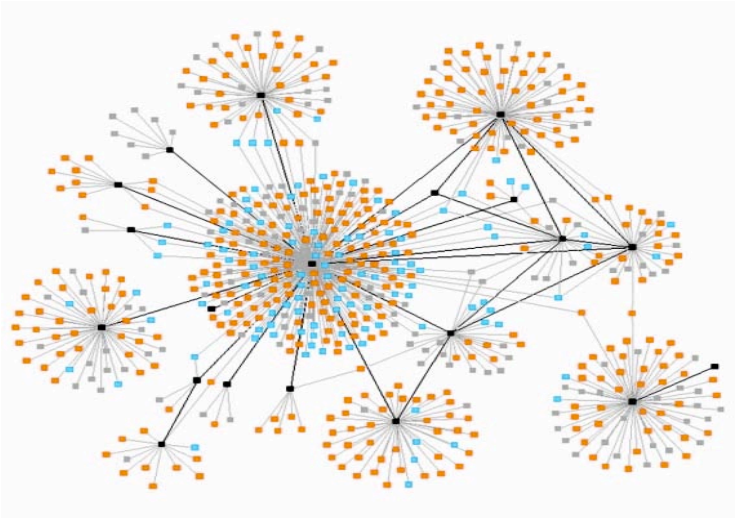
Visual Encodings for Networks

connection / node-link

convention: root mostly on top, leafs on bottom

pros: popular, well-known

cons: occlusion, edge crossing, scales badly



adjacency matrices

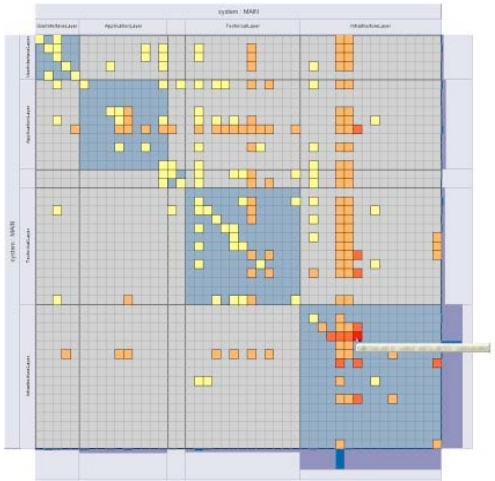
graph as table

nodes as rows/columns

edges as table cells

pros: large graphs, no occlusion, no edge crossing

cons: no path finding

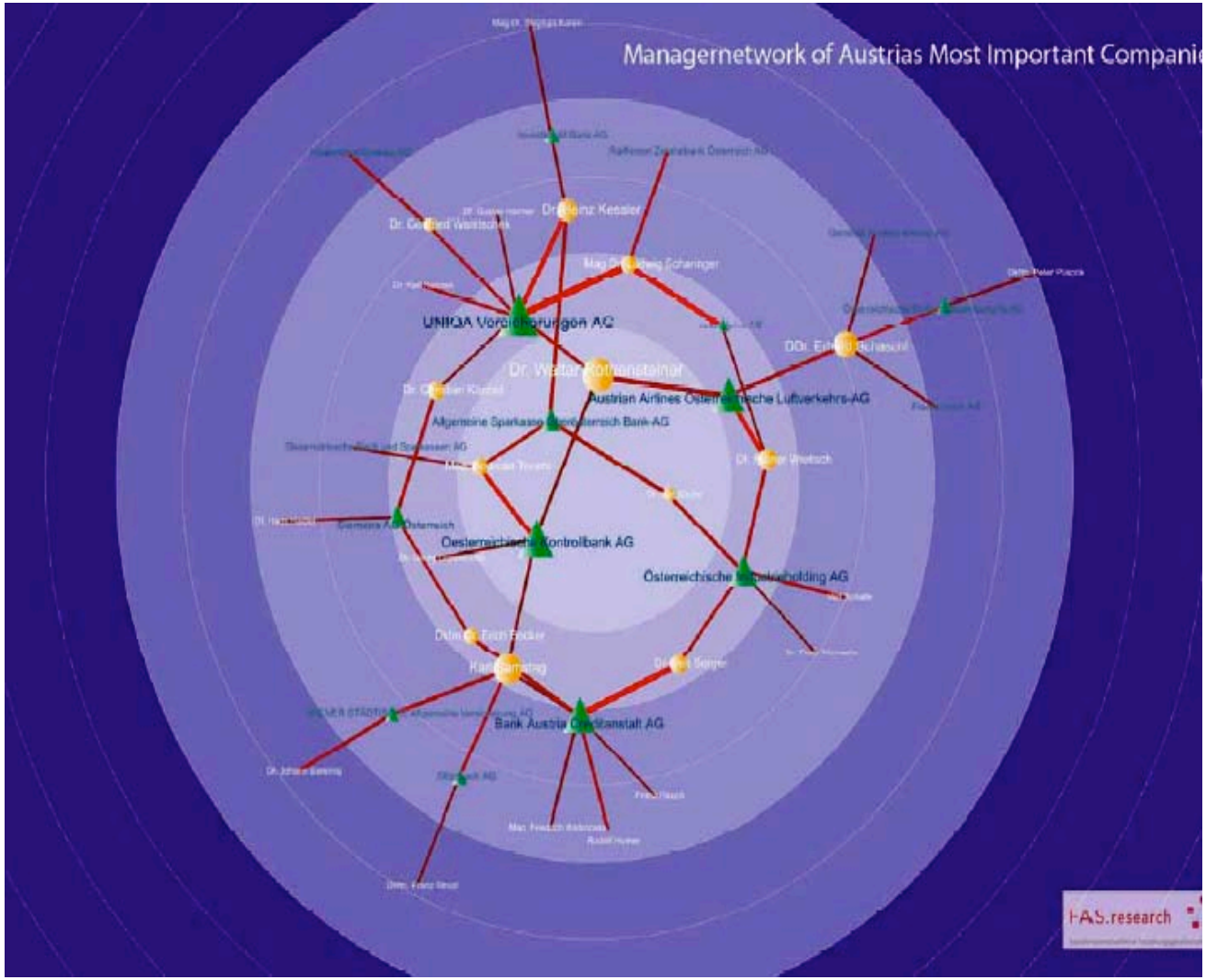


FAS.research

informations-visualisierung

Social Network Analysis

http://www.fas.at/



Issues for representation

Positioning of nodes

- layout

Representation of edges

- e.g., weights

Size / complexity

- High number of nodes & edges

Labeling

Interaction with graphs

Layout: Guiding criteria

drawing conventions

- edges only straight lines, rectilinear lines, or polygonal lines
- placing nodes on a fixed grid
- having all sibling nodes share the same vertical position

constraints

- particular node in the center
- group of nodes close to each other
- links from top to bottom or left to right

aesthetics

- minimize node overlap
- uniform edge length
- minimize line crossings
- maintain pleasing aspect ratio
- minimize total area of drawing
- minimize total length of edges
- minimize number of bends in edges
- minimize the number of distinct angles or curvatures
- symmetry

Layout

Multi-dimensional scaling (MDS)

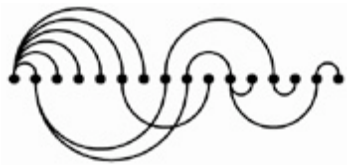
Spring embedder

Force directed

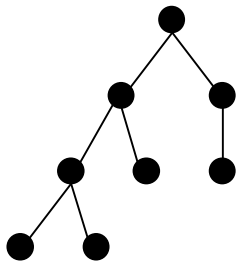
Two forces:

spring between; electrical repulsion

Rectilinear



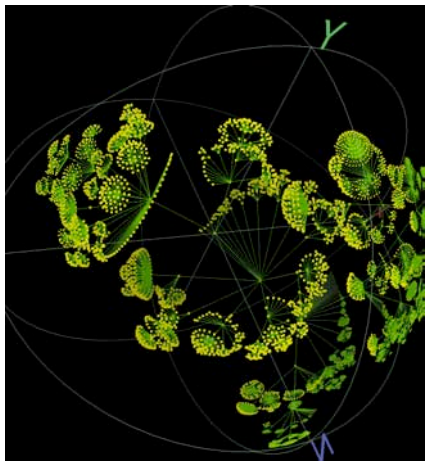
Hierarchical



Radial

HV layout (horizontal vertical)

Images:
- Bernard J. Kerr, Thread Arcs, 2003, http://www.research.ibm.com/remail/threadarcs.html.
- Jeffrey Heer, Tree Visualization, SIMS 247: Information Visualization and Presentation, 2005.
- Max Baker, Netdisco, http://netdisco.net/



Issues for representation

Positioning of nodes

- layout

Representation of edges

- e.g., weights

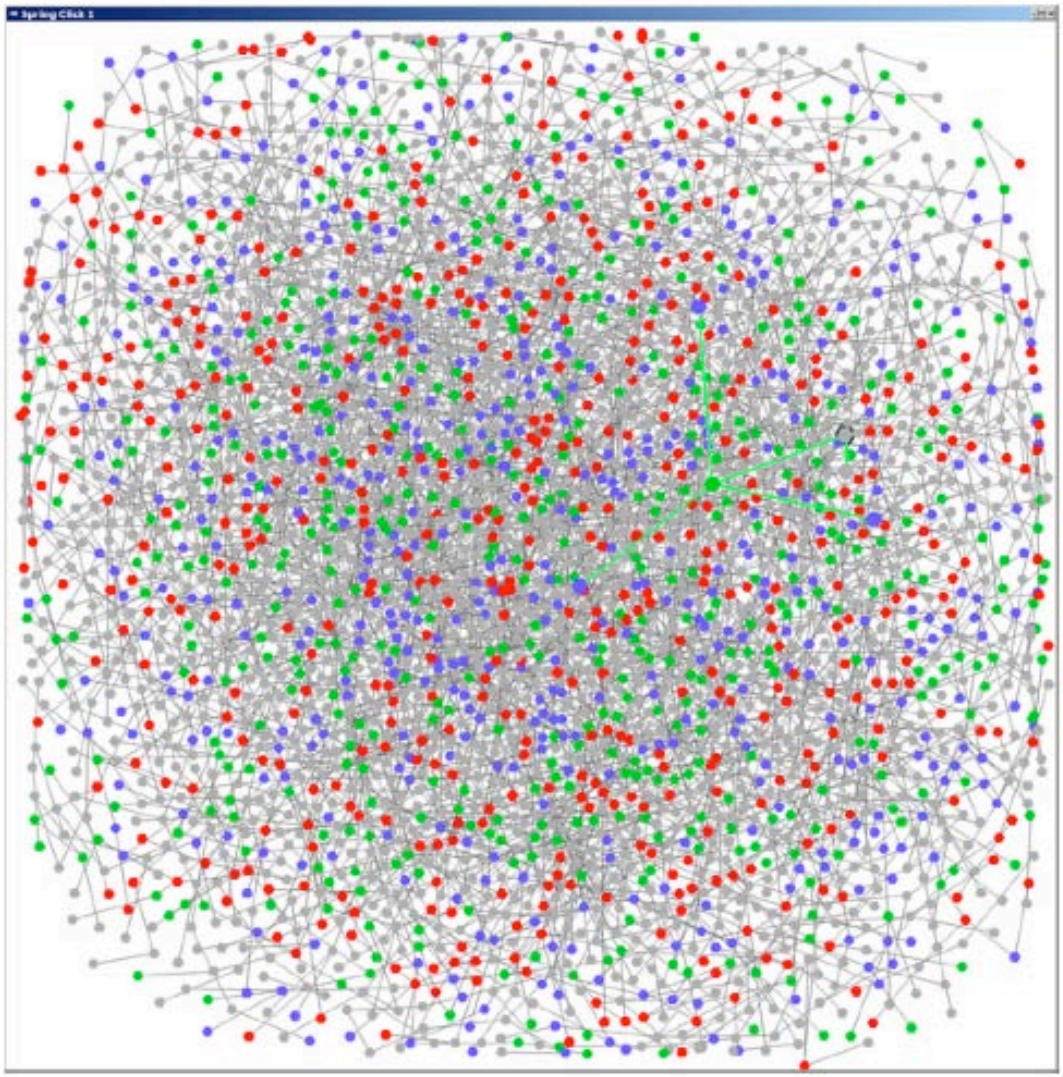
Size / complexity

- High number of nodes & edges

Labeling

Interaction with graphs

Large graph



3200 nodes

force-directed layout

Image by C. Ware from [Görg et al., 2007]

Size / complexity

high number of nodes & edges

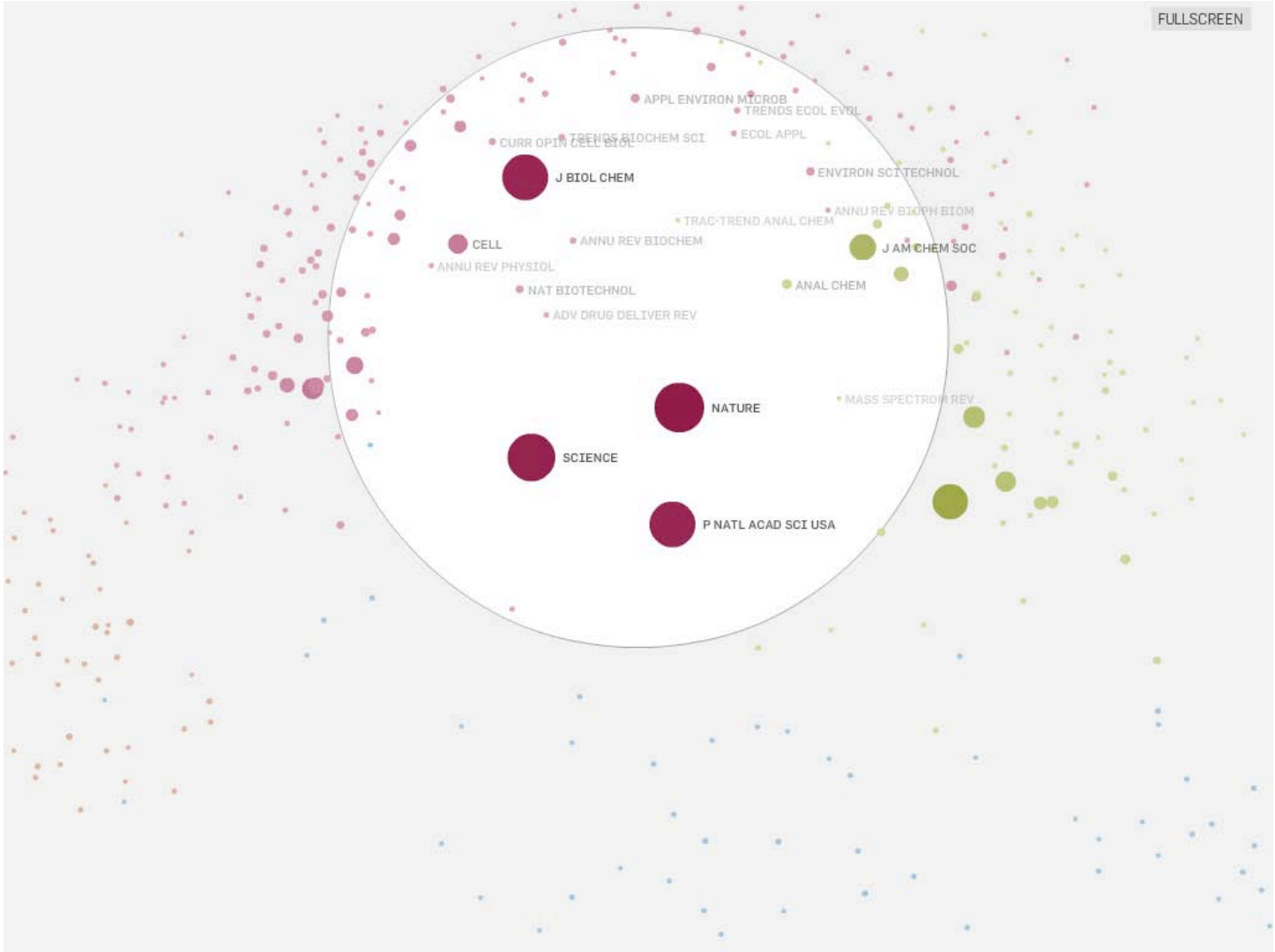
reducing complexity

- edges - link reduction
  - e.g., visualizing only the edges that have weights above a certain value
  - eliminate redundant edges and maintain the most signifikant links
    - minimum spanning trees (MST)
    - pathfinder network scaling (PFNET)
- nodes - node reduction
  - clustering

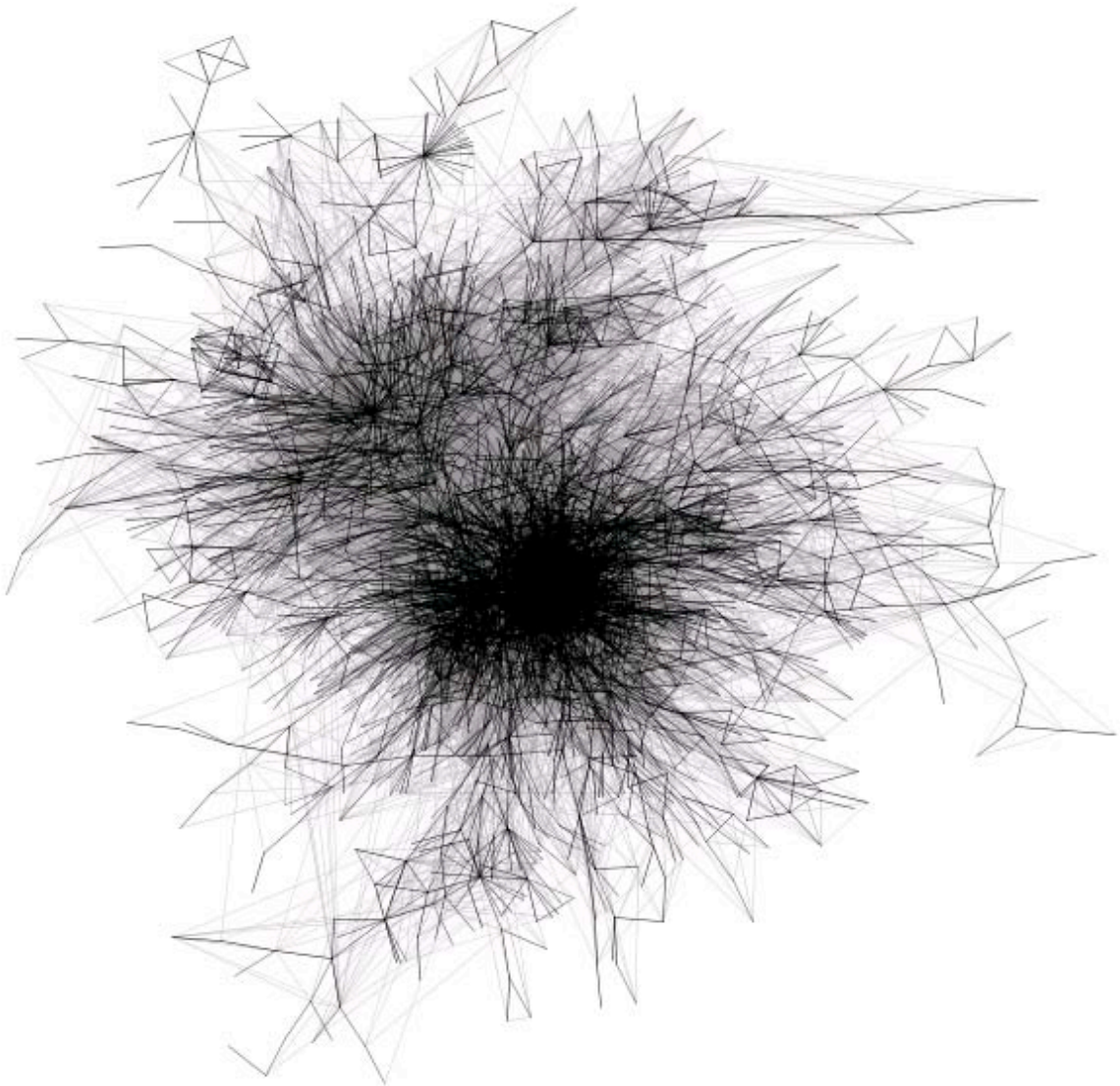
preservation of global structure

Node-only

informations-
visualisierung



Link-only



Clustering

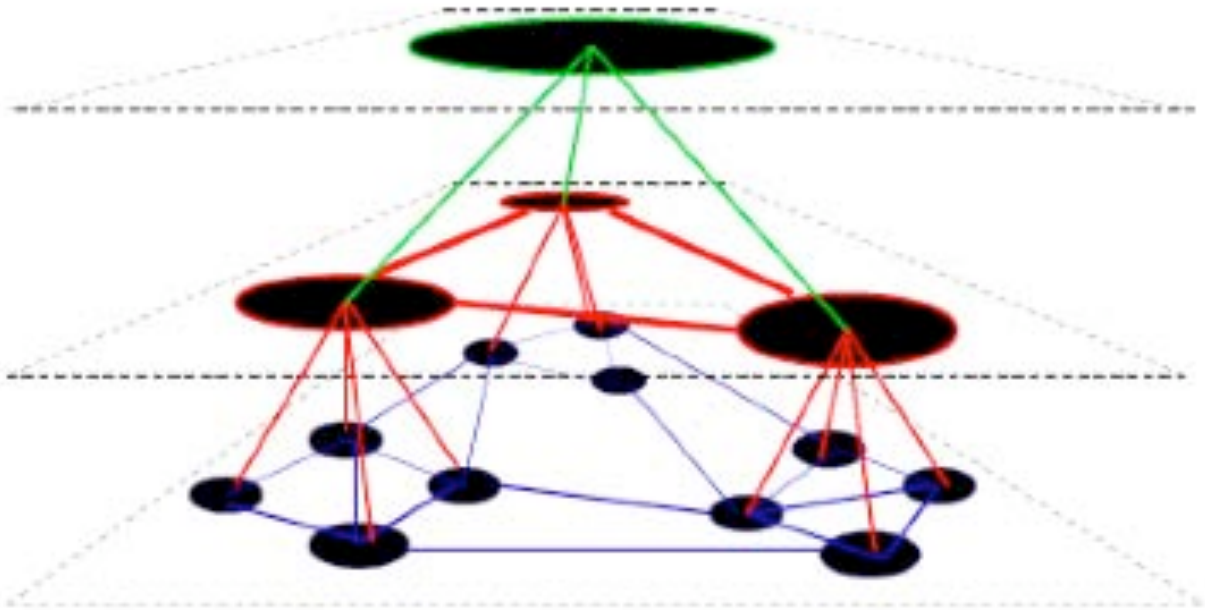


Image by P. Eades from [Görg et al., 2007]

Issues for representation

Positioning of nodes

- layout

Representation of edges

- e.g., weights

Size / complexity

- High number of nodes & edges

Labeling

Interaction with graphs

Labeling

non-trivial problem

non-overlapping

NP-hard problem

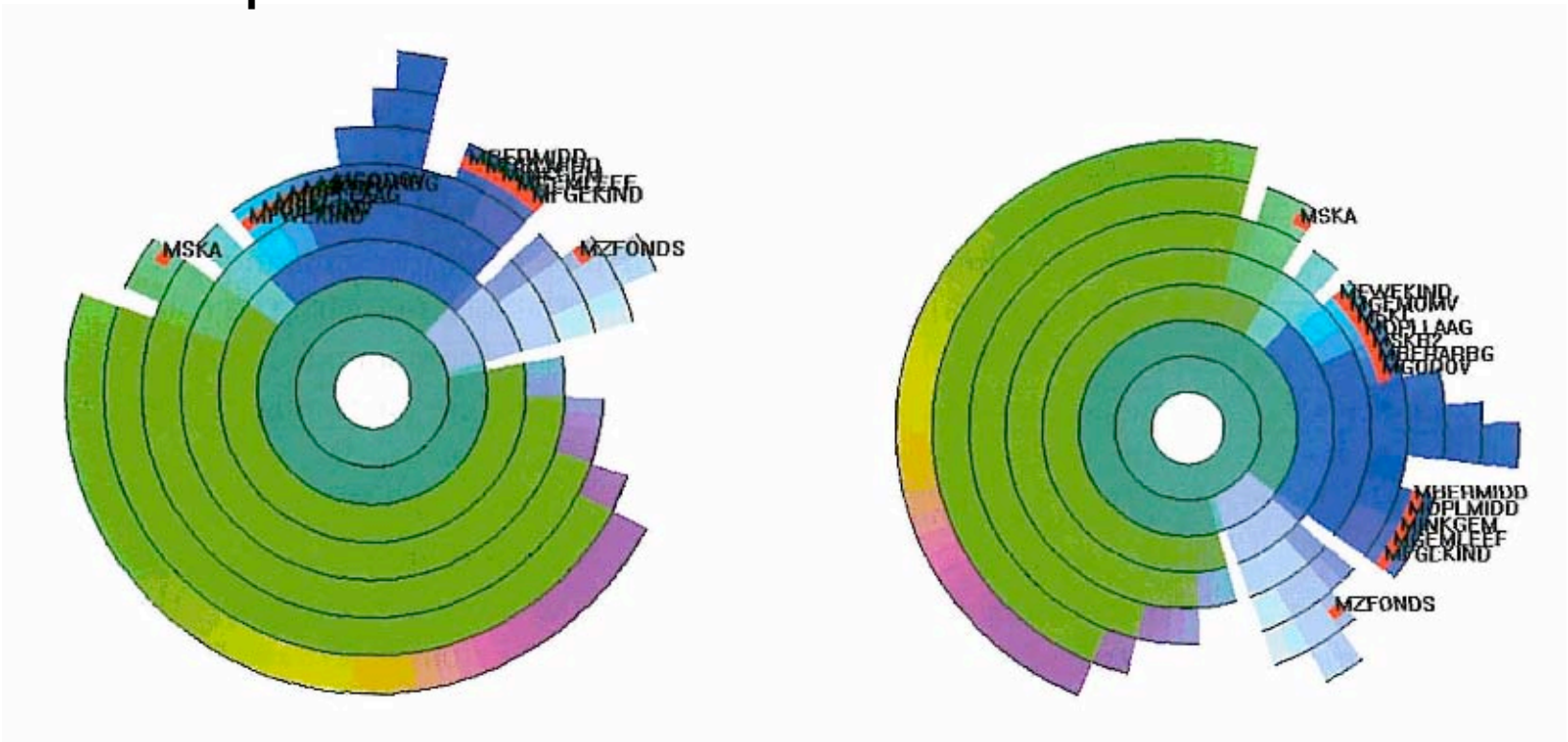


Image from [Ward et al., 2010]

Issues for representation

Positioning of nodes

- layout

Representation of edges

- e.g., weights

Size / complexity

- High number of nodes & edges

Labeling

Interaction with graphs

Interaction with graphs

move nodes

zoom & pan

hide or show edges

selection

focus+context

Video
CGV

Part B.2
visualizing hierarchies

Visual Encodings for Hierarchies

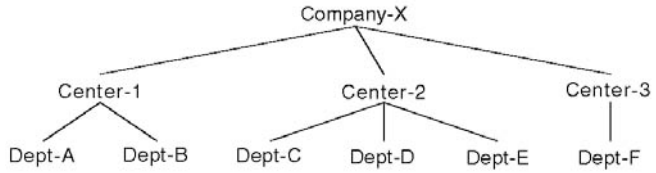
indentation

- representation of hierarchy level via indentation
- focus on linear structure
- pros: well-known, simple, text-based
- cons: aspect ratio

```
Company-X
    Center-1
        Dept-A
        Dept-B
    Center-2
        Dept-C
        Dept-D
        Dept-E
    Center-3
        Dept-F
```

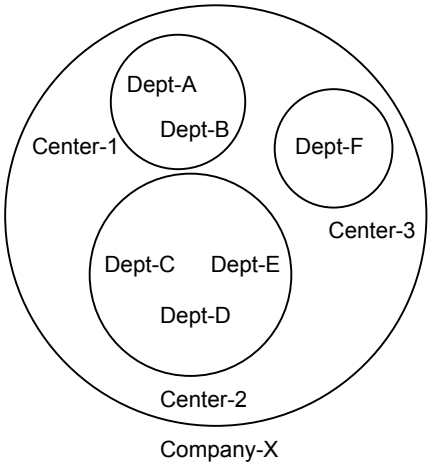
connection / node-link

- convention: root mostly on top, leafs on bottom
- pros: popular, well-known
- cons: scales badly (space usage, aspect ratio)



containment

- summed values
  - propagation through hierarchy
- space-filling graphs
- pros: no occlusion, no edge crossing
- cons: labeling, reading order



Interaction

why?

- aspect ratio
- large information space
- do not fit onto display space
- Problem: large structures that don't fit on a single view/screen

expand / collapse

navigate

focus + context

- *see upcoming lecture for details*

Video CGV

Demo application: Hierarchical Visualization System (HVS)

[Andrews, 2005]

Acedemic prototype

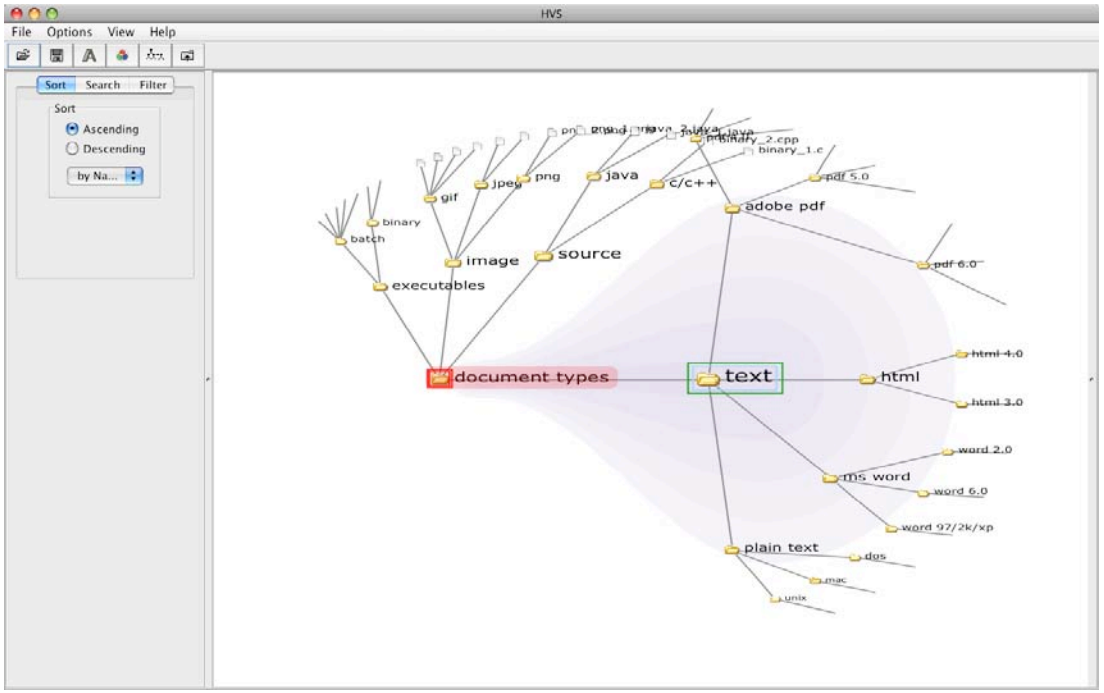
Graz University of Technology, Institute for Information Systems and Computer Media (IICM)

Lead by Prof. Keith Andrews

Extensible InfoVis toolkit for visualizing hierarchically structured data

Visualizations provided:

- Tree View
- Information Pyramids
- Hyperbolic Tree
- Magic Eye
- InfoLens
- TreeMaps
- Sunburst

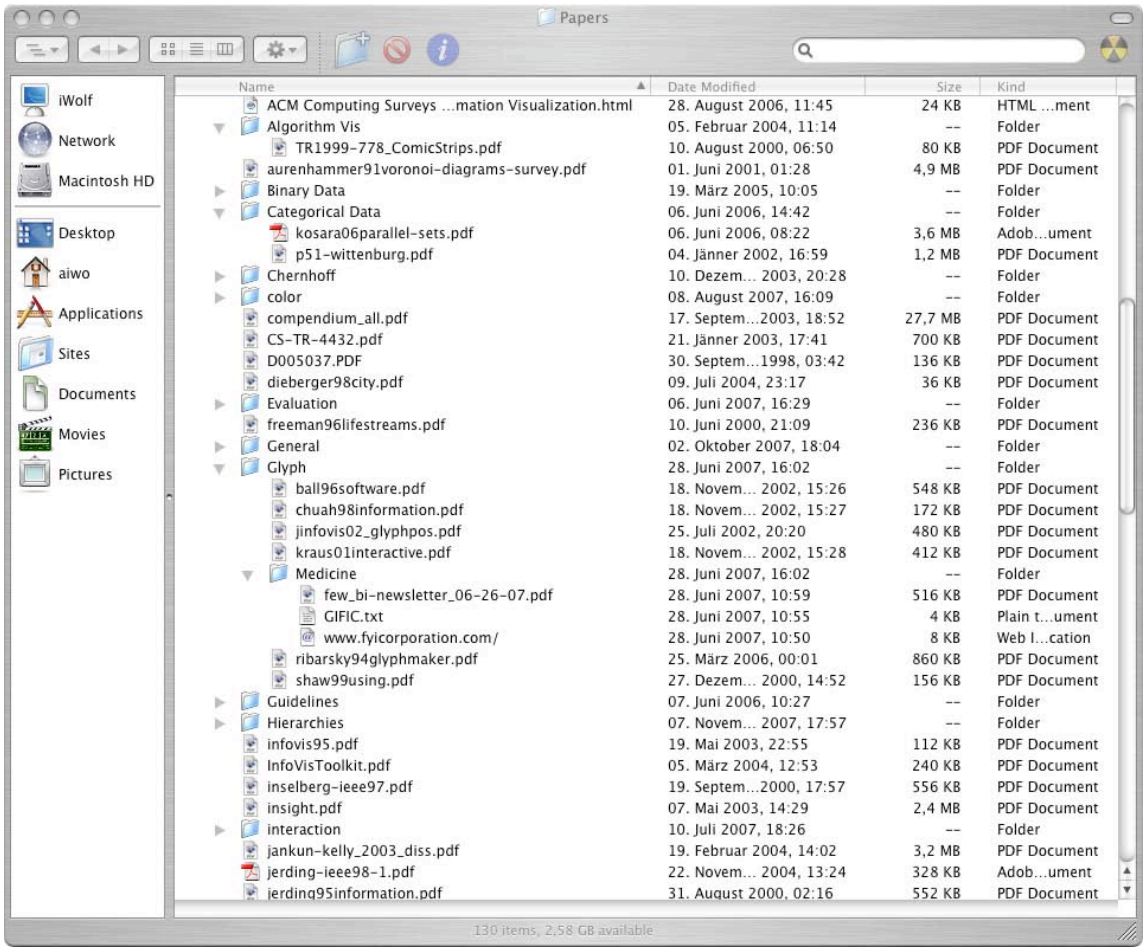


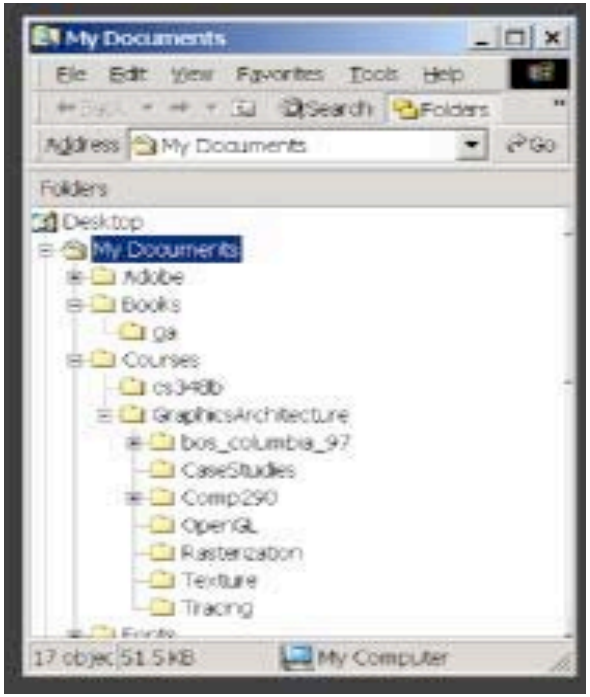
Demo (HVS)

Indented Lists

representation of hierarchy
level via indentation

focus on linear structure

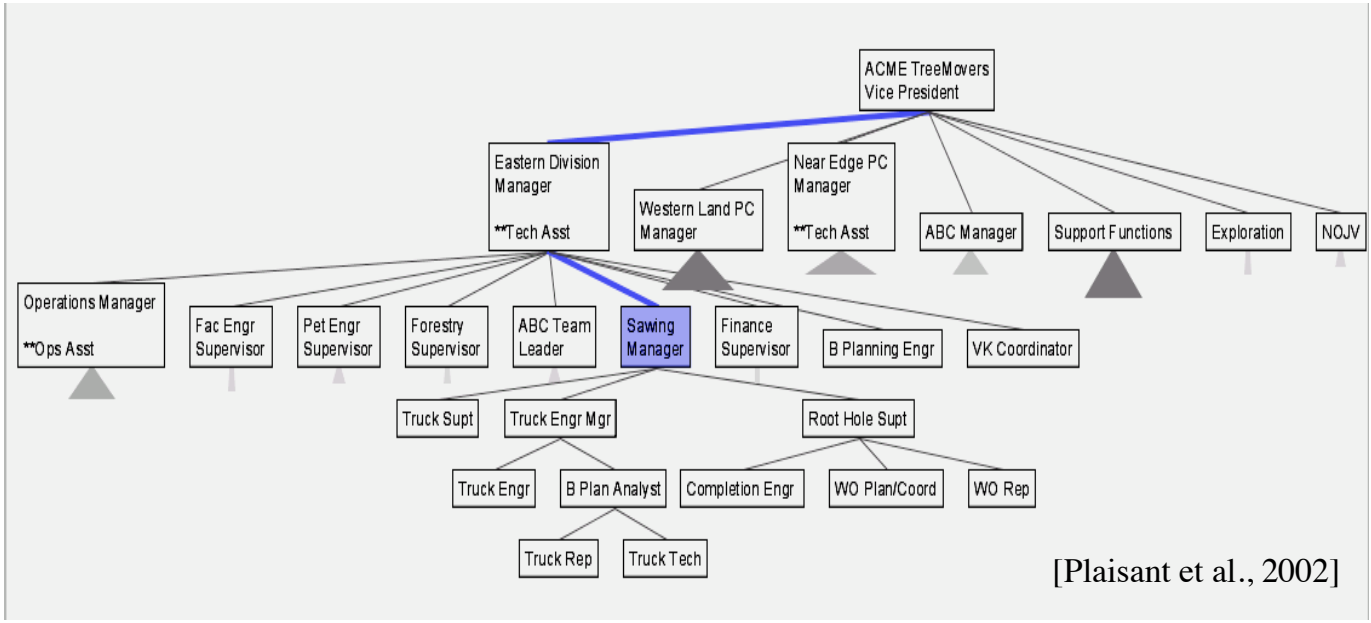




SpaceTree / DOI Tree

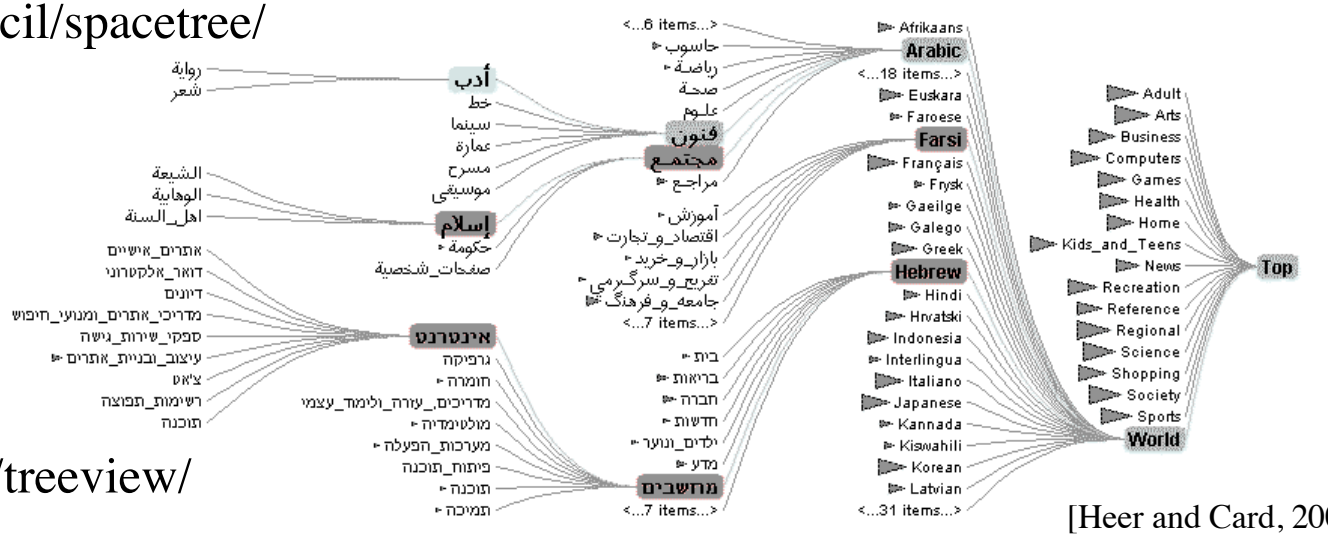
informations-visualisierung

Demo



[Plaisant et al., 2002]

http://www.cs.umd.edu/hcil/spacetree/



http://prefuse.org/gallery/treeview/

[Heer and Card, 2004]

Cone Trees

[Robertson, Mackinlay, Card 1991]

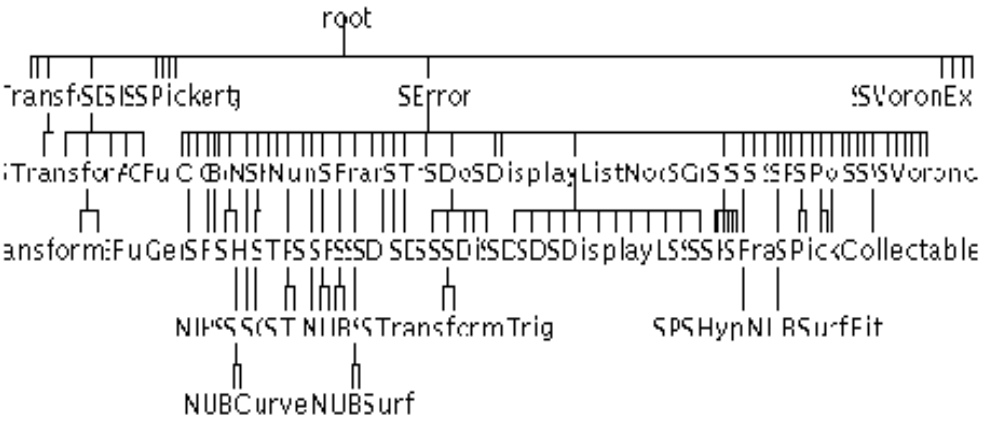


Figure 5: A Standard 2D Tree

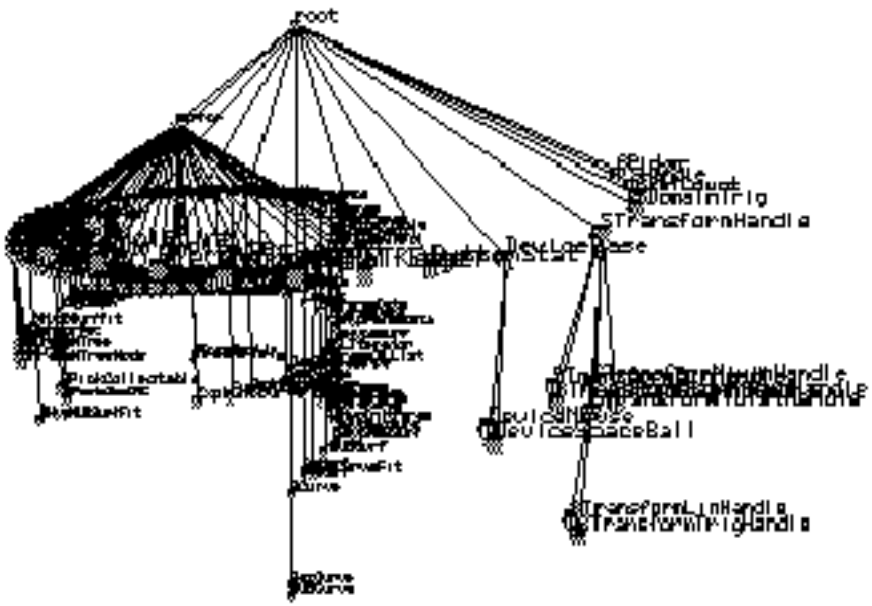
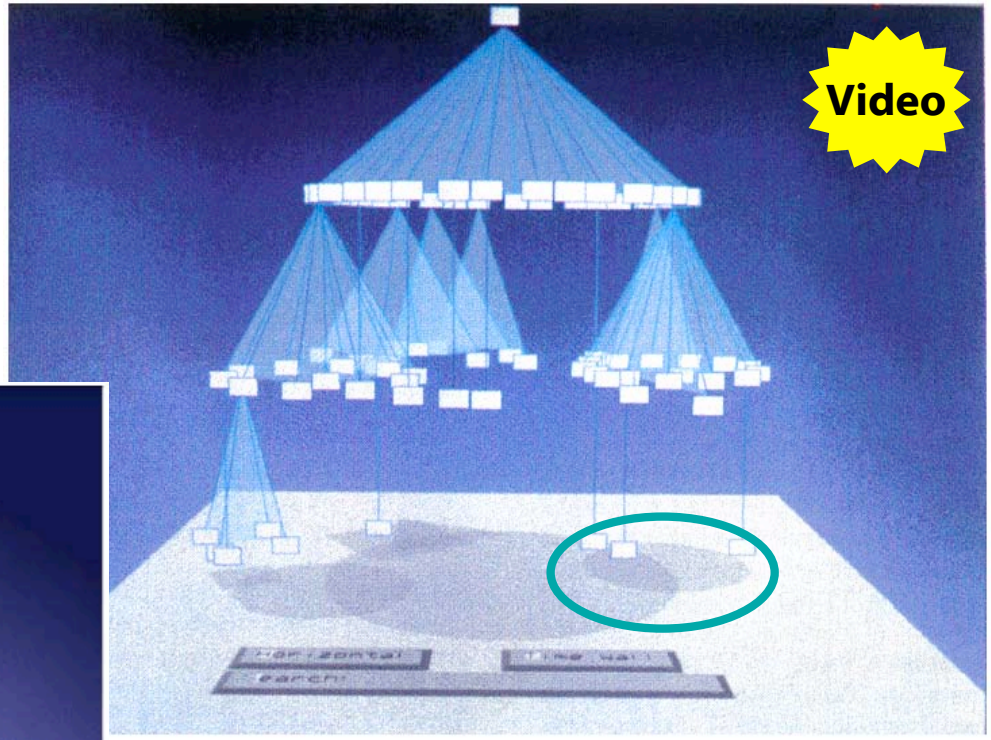


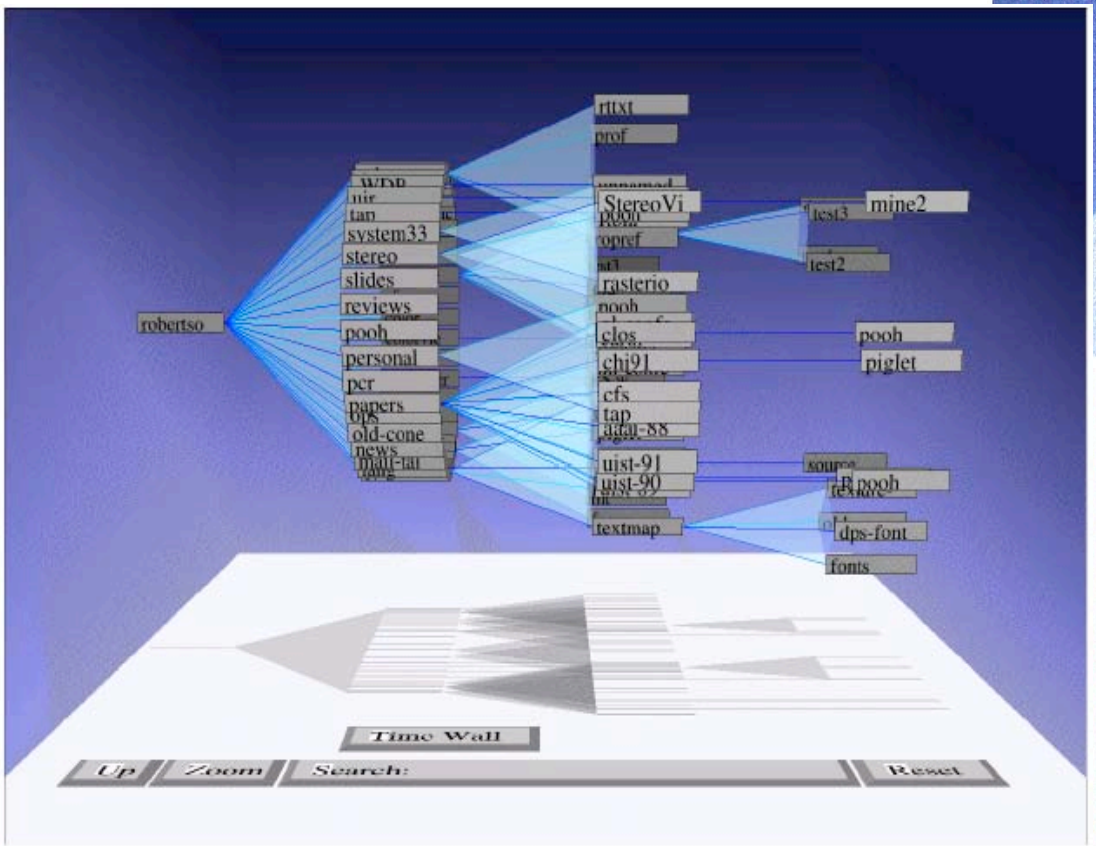
Figure 9: A 3D Cone Tree.

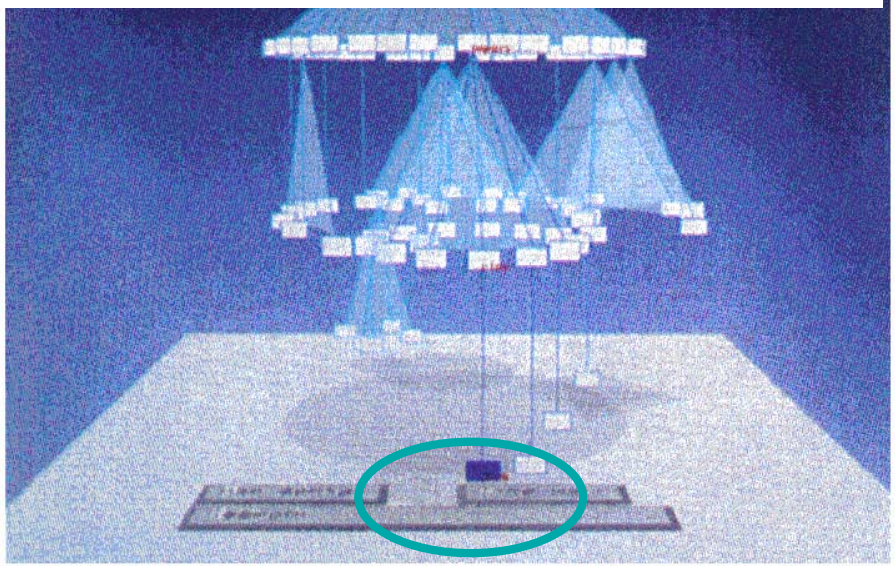
Cone Trees vs. Cam Trees

Vertical (Cone Tree) vs.
Horizontal (Cam Tree)

Shadows provide 2D structure







Cone Trees

[Robertson, Mackinlay, Card 1991]

Important:

Interaction!

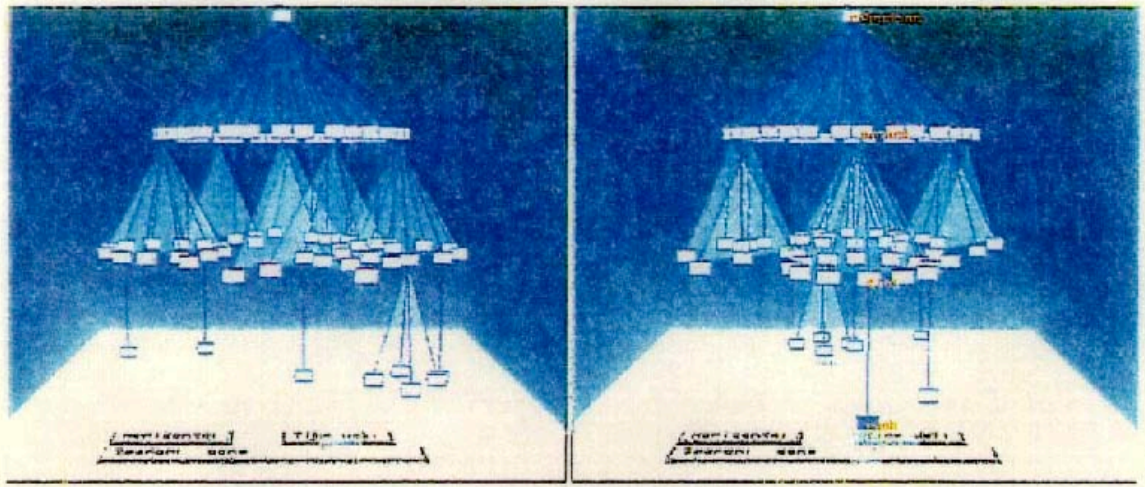


Figure 1: Layout of a simple Cone Tree, before and after selection.

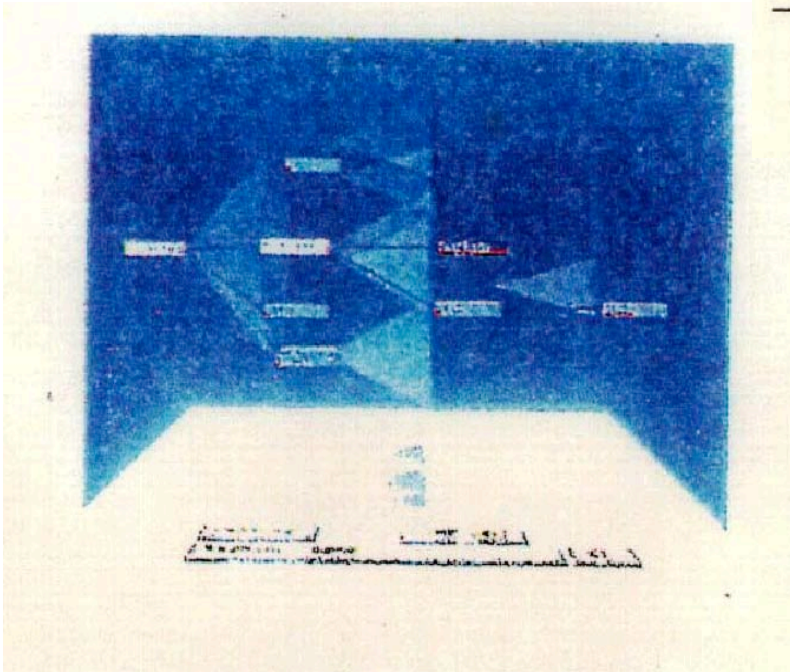


Figure 4: Result of a Search Operation.

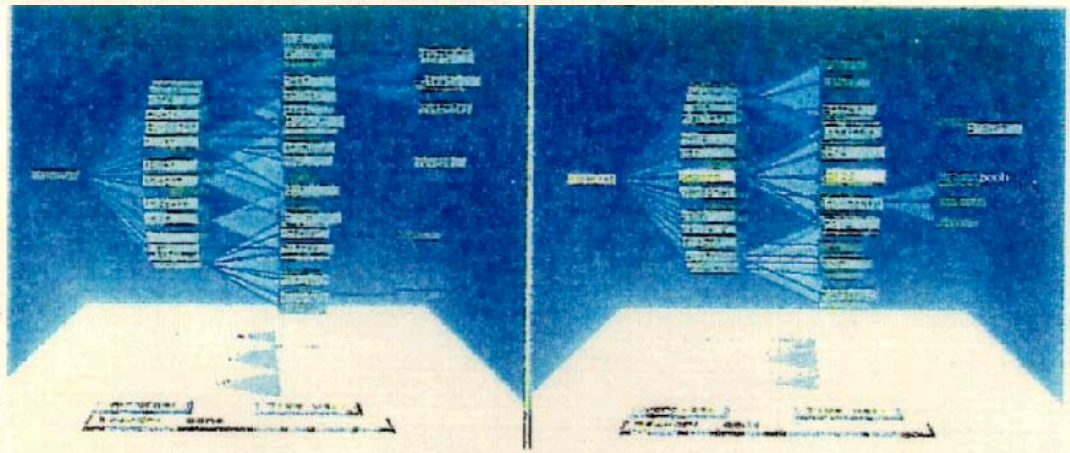
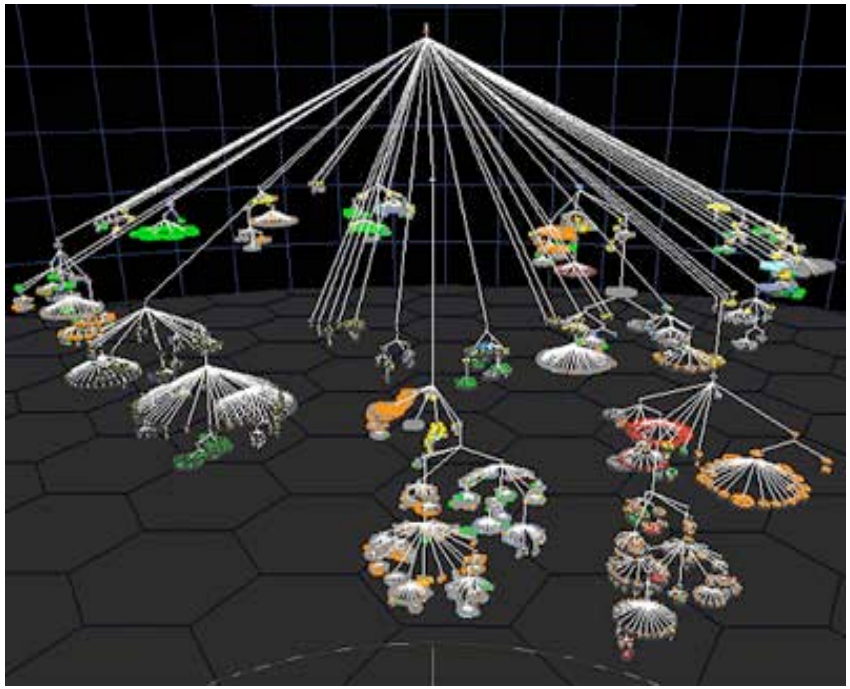
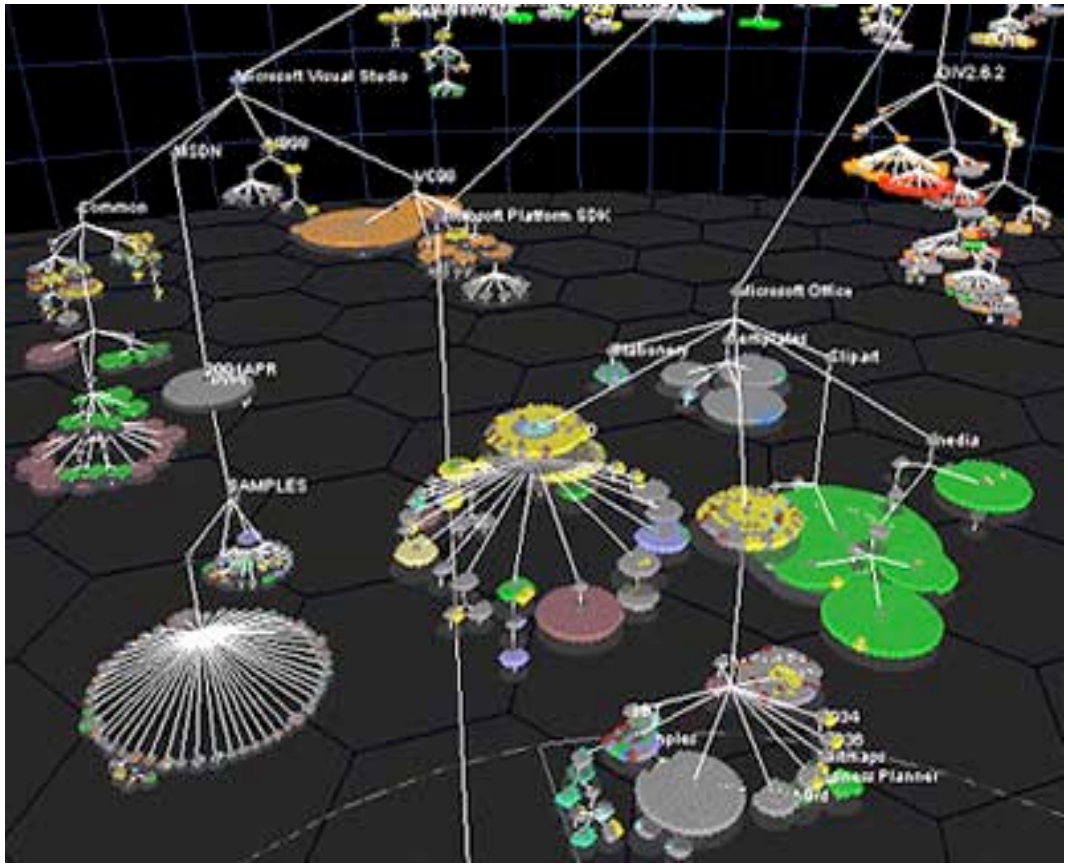


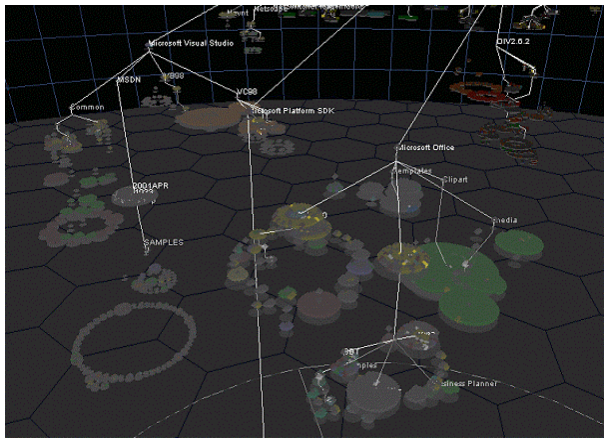
Figure 2: Layout of a simple Cam Tree, before and after selection.

Starlight – File System

[Pacific Northwest National Laboratory – USA]

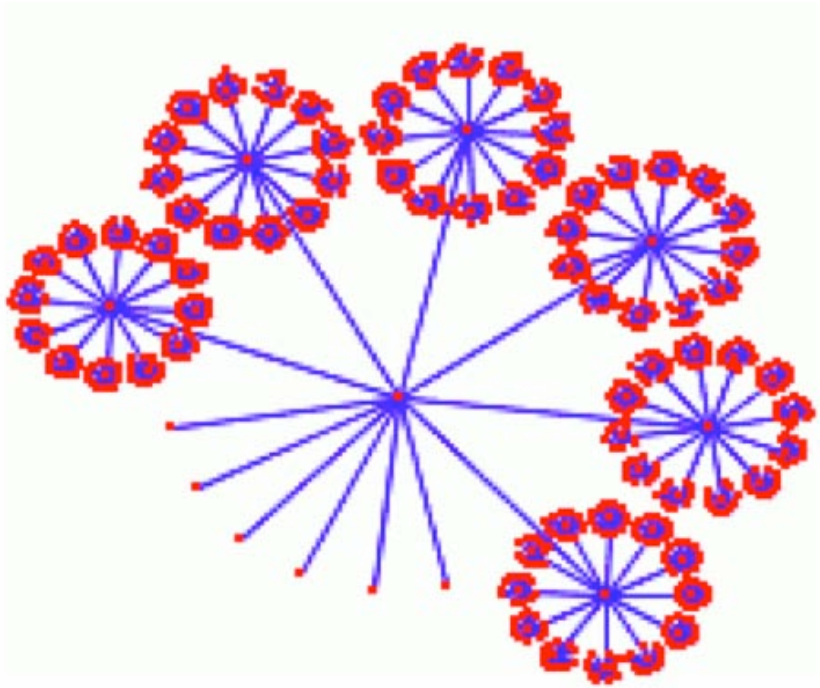






Balloon Trees

Flattened cone trees



[Herman, Melancon, and Marshall, 2000]

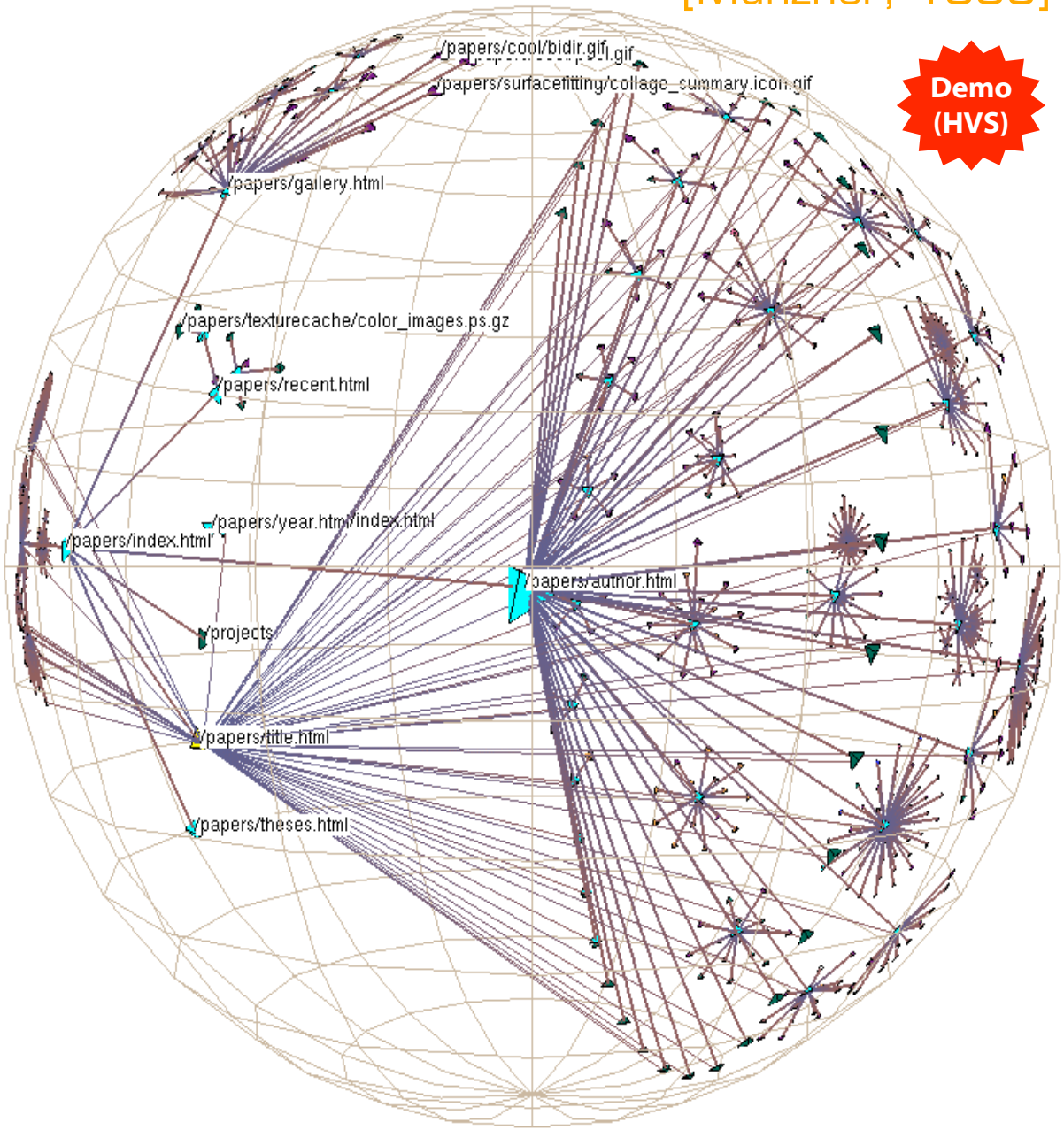
Hyperbolic Trees

[Munzner, 1998]

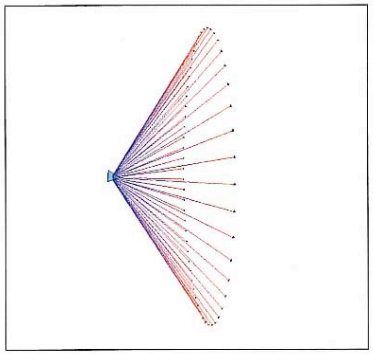
Nodes are placed on hyperbolic geometry (inside of a sphere)

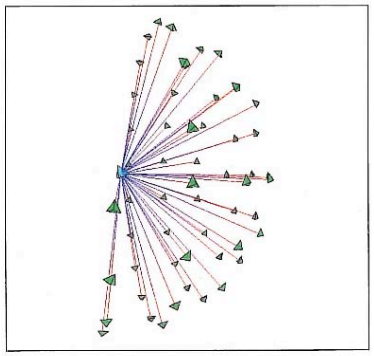
Projection into 2D

F+C



Demo (HVS)

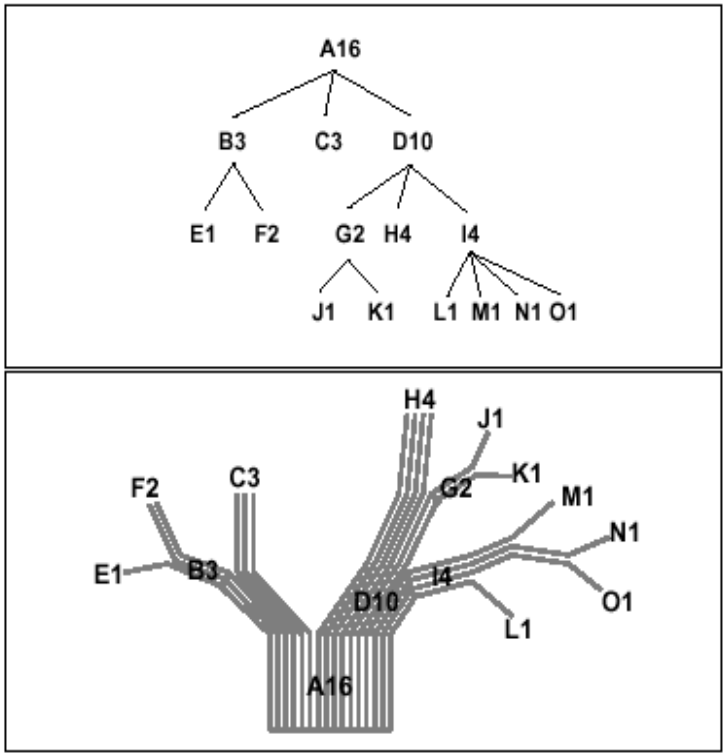




Botanical Visualization of Huge Hierarchies

[Kleiberg, van de Wetering & van Wijk, 2001]

Node and link diagram



Holton's "Strang Modell"

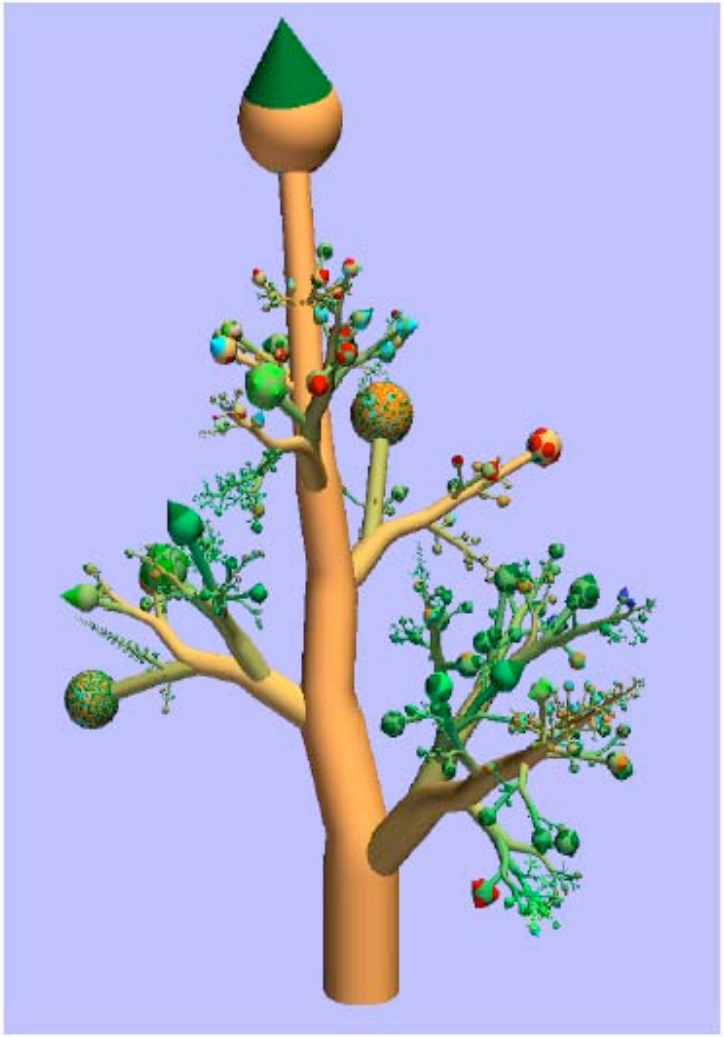


Figure 10. Complete hard disk with $\alpha = 45$ and $\beta = 360/\varphi$.

Botanical Visualization

[Kleiberg, van de Wetering & van Wijk, 2001]

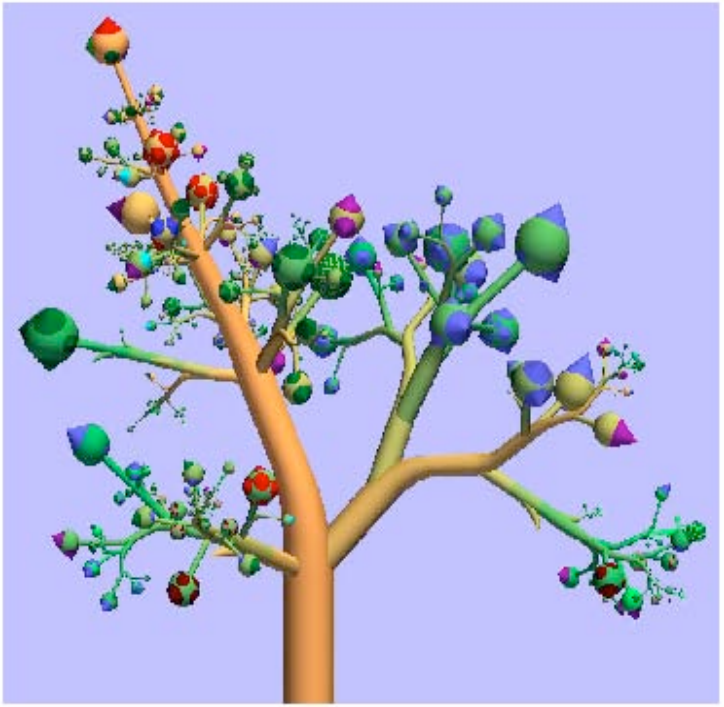


Figure 12. Unix home-directory.

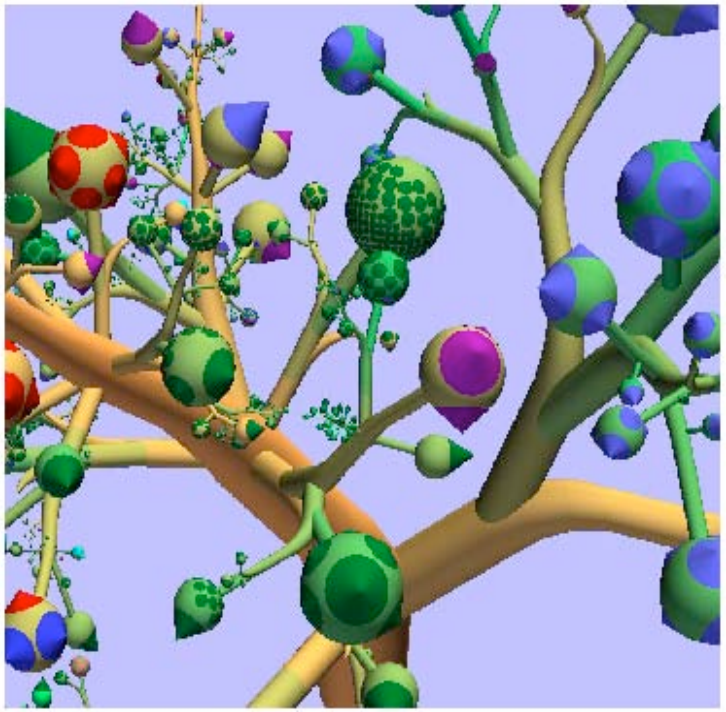


Figure 13. Detail of figure 12.

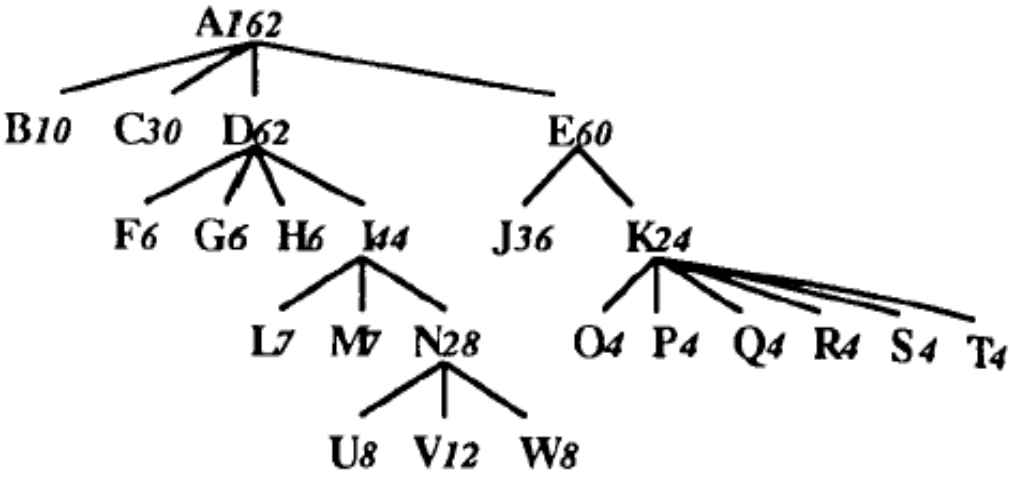
Alternative 3D Visualization to Big Hierachies

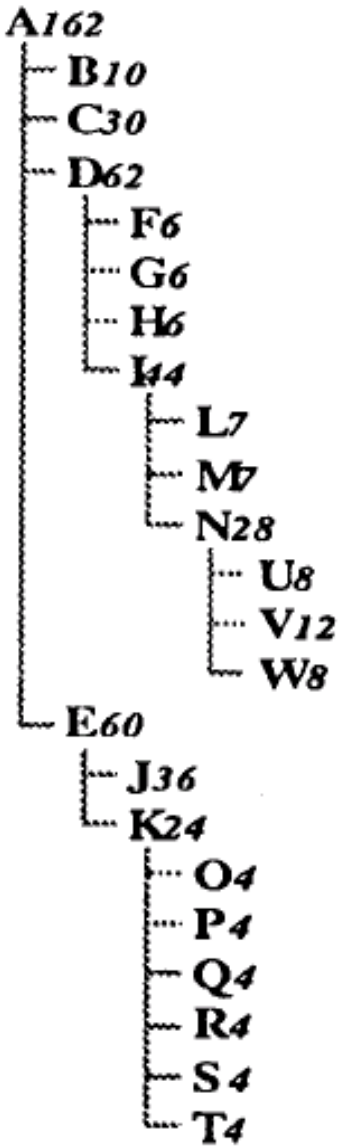
Branches Clash Seldom, Even Though no Particular Algorithm is Included

Adapted Phi-Balls are Appropriate fir Big Files

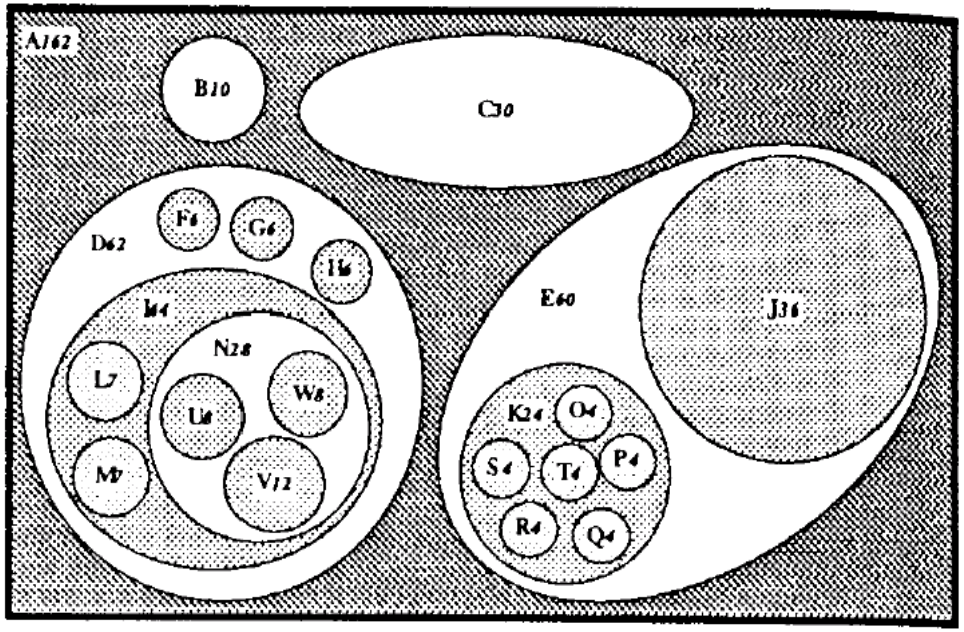
Containment

[Shneiderman 1992; Johnson, 1993]





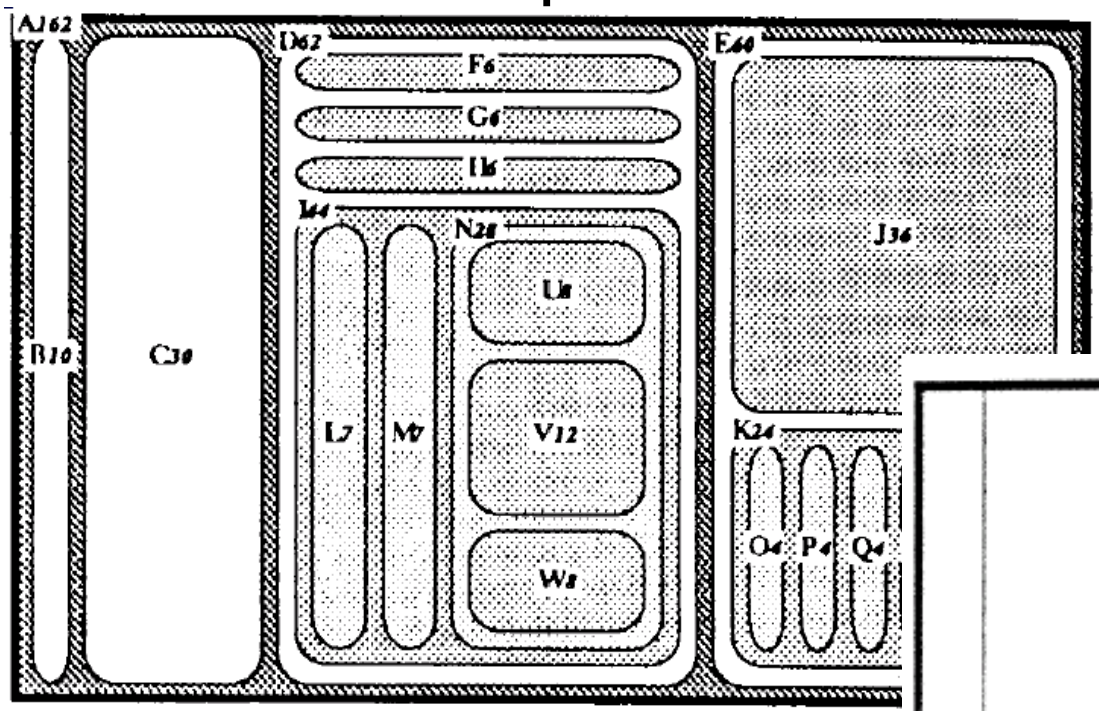
Venn-Diagram



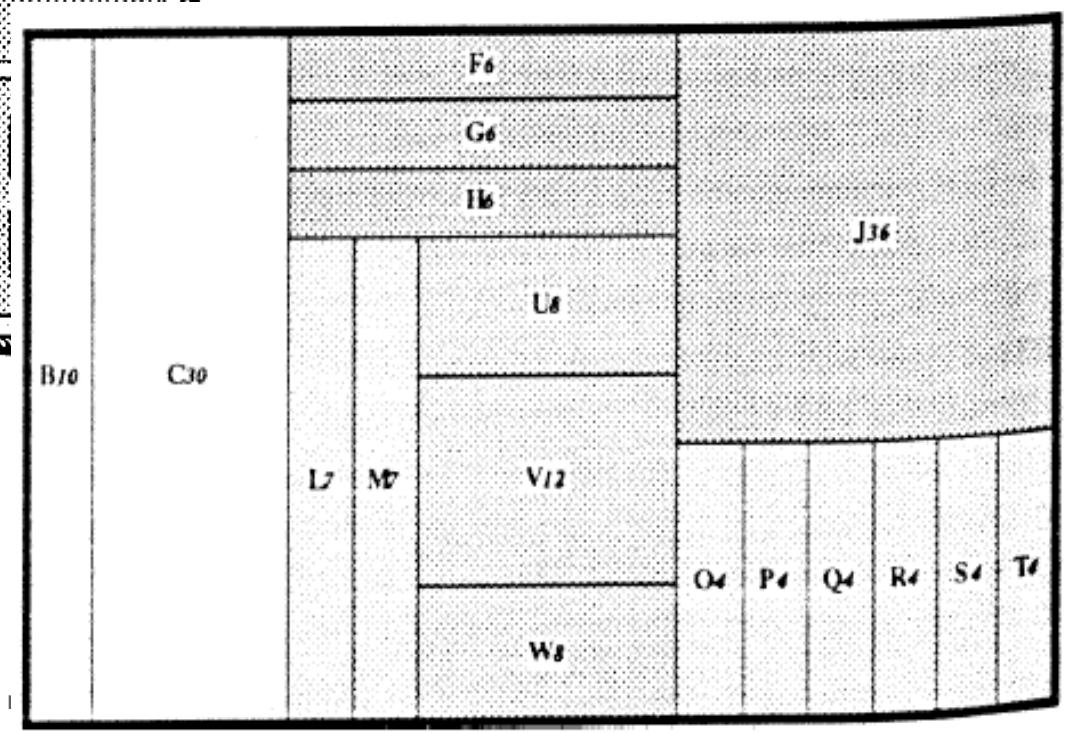
Venn-Diagram --> Treemaps

[Shneiderman 1992; Johnson, 1993]

Nested Treemap



Treemap:



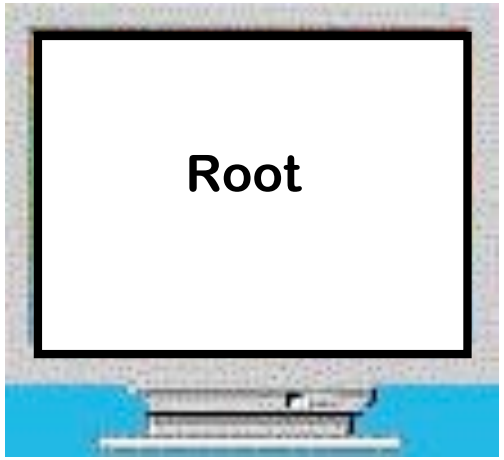
Example: File Structure to Tree

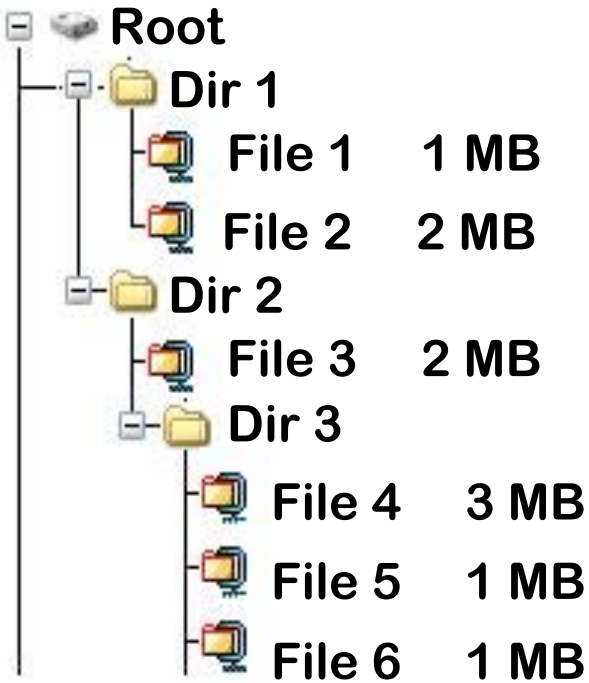
File System:

3 Folders

6 Files

1) Root -> whole Screen





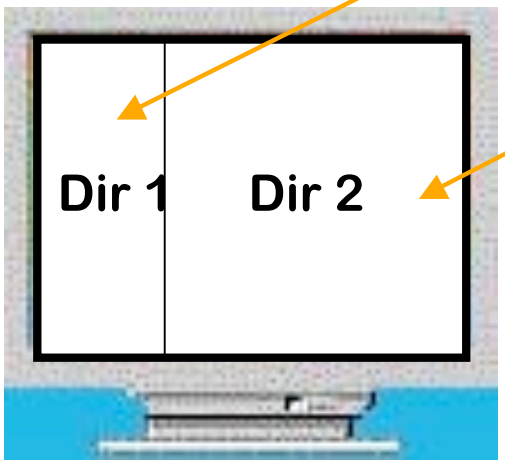
Example: File Structure to Tree

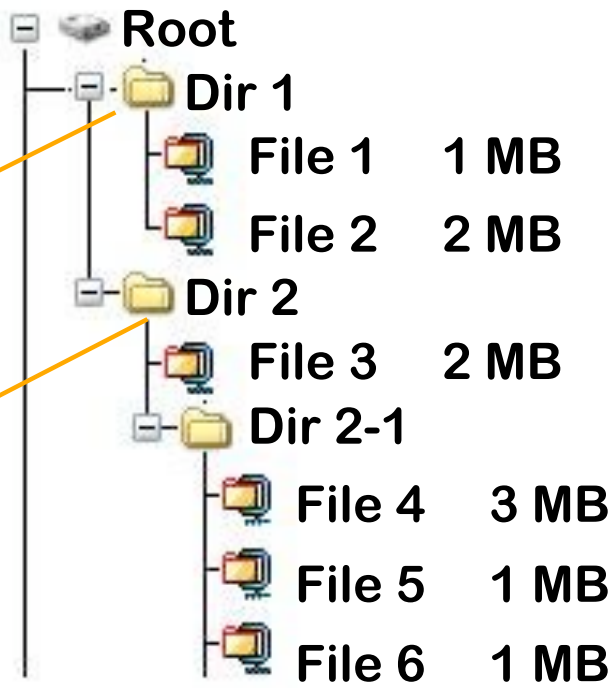
File System:

3 Folders

6 Files

2) Cutting - according to the size (30% and 70% of the space)





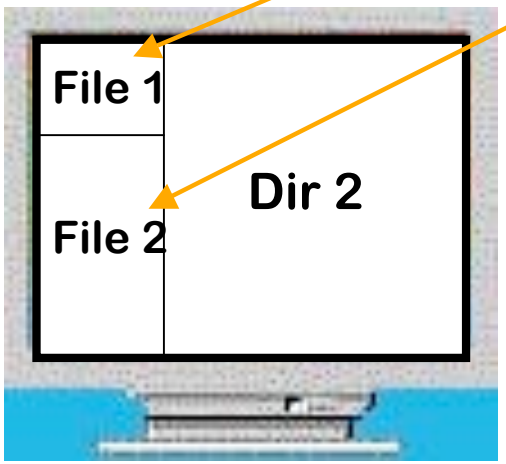
Example: File Structure to Tree

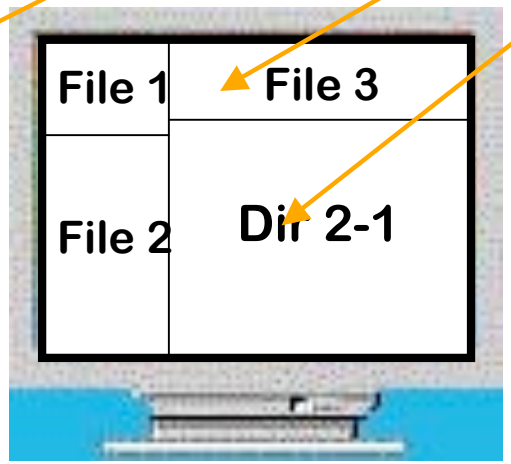
File System:

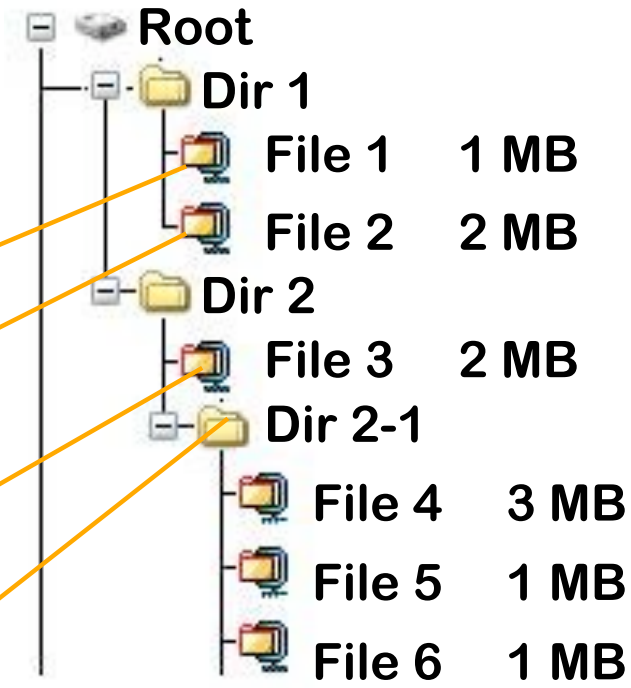
3 Folders

6 Files

3) Iteration: folder and subfolder







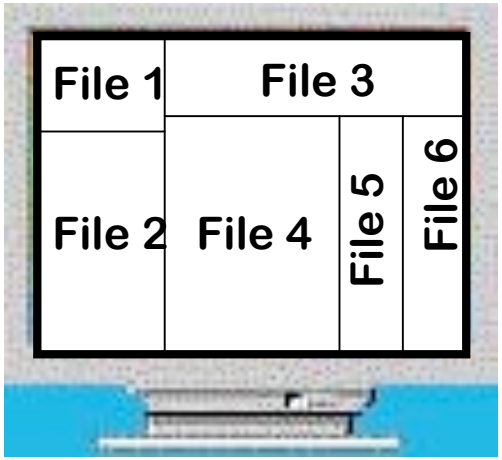
Example: File Structure to Tree

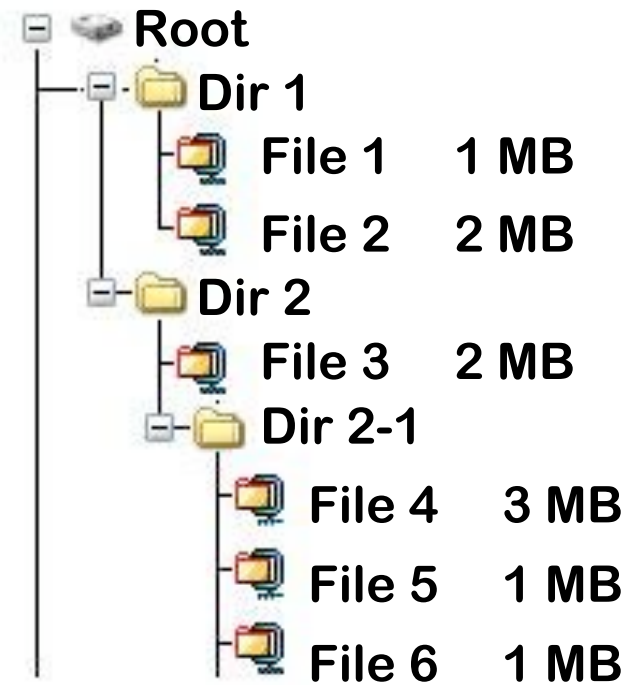
File System:

3 Folders

6 Files

One Solution



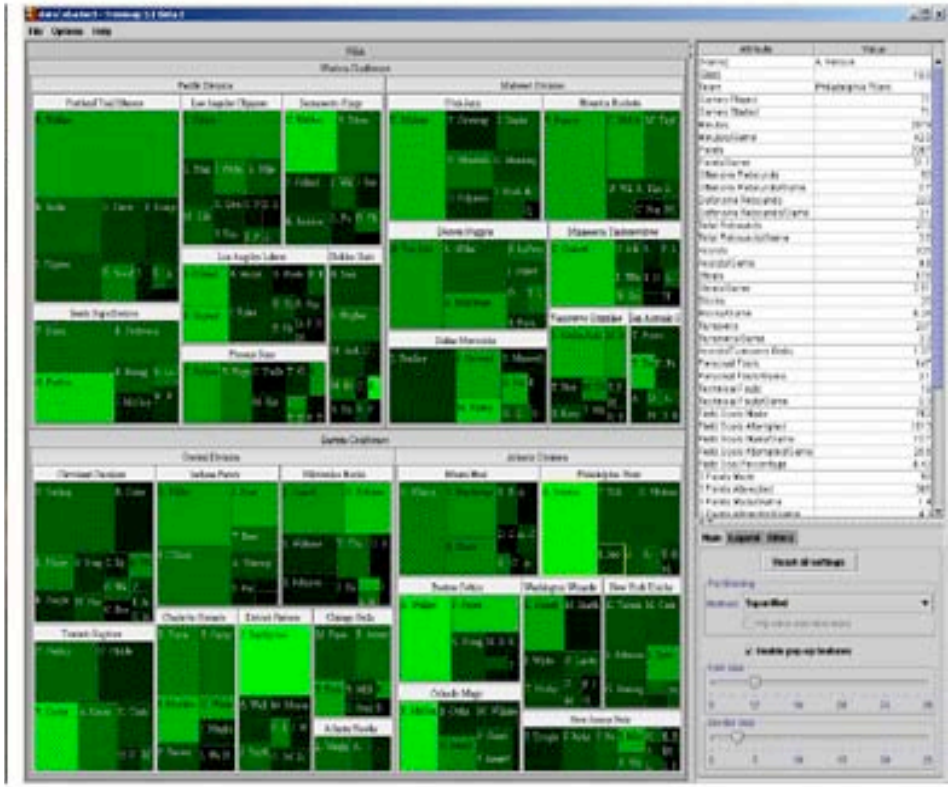


Demo (HVS)

Treemap: View Large Trees with Node Values

[Shneiderman talk]

+ Space filling
+ Space limited
+ Color coding
+ Size coding
- Requires learning



TreeViz (Mac, Johnson, 1992)
NBA-Tree (Sun, Turo, 1993)
Winsurfer (Teittinen, 1996)
Diskmapper (Windows, Micrologic)
Treemap3 (Windows, UMd, 2001)

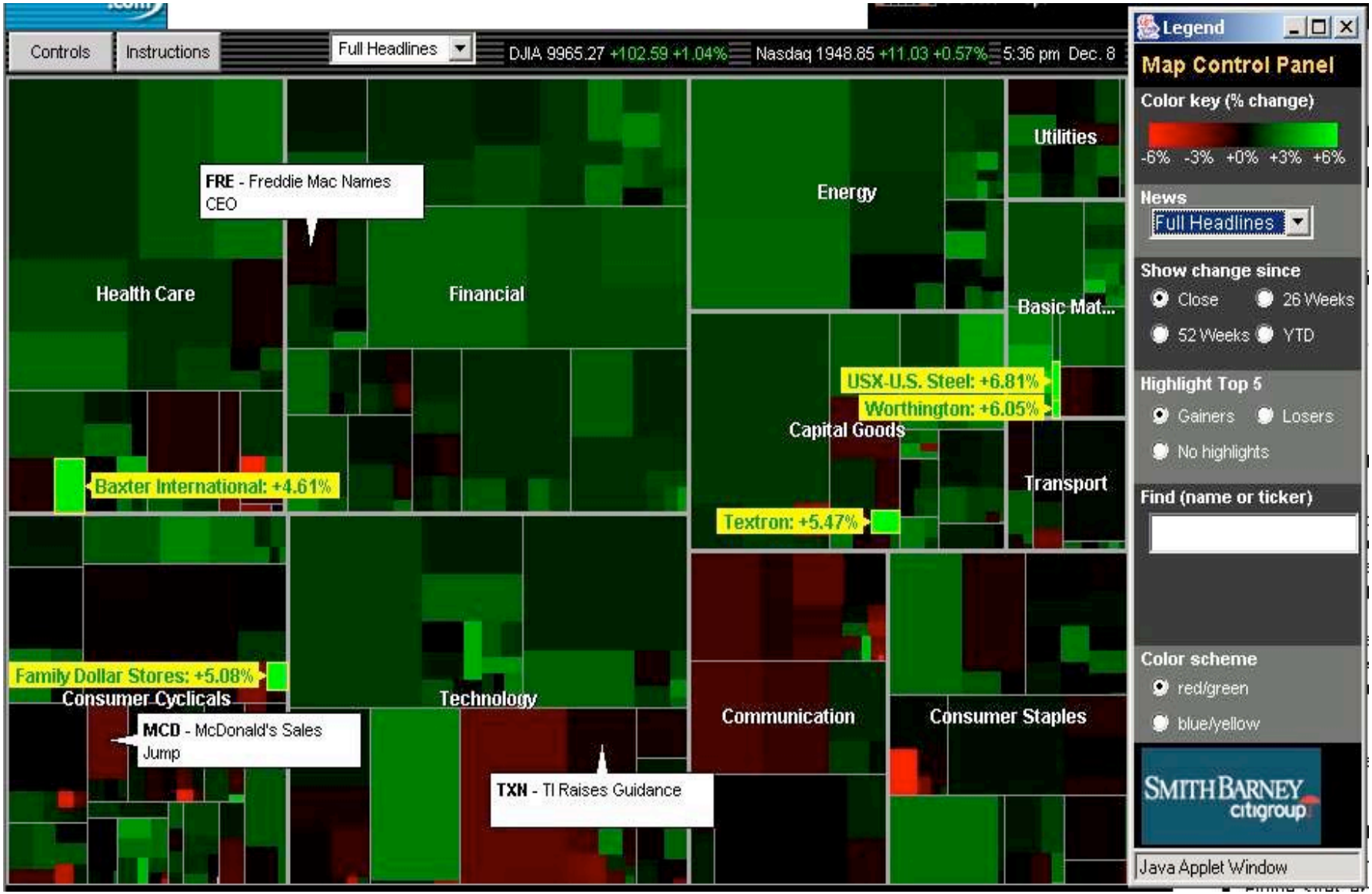
http://www.cs.umd.edu/hcil/treemap/

(Shneiderman, *ACM Trans. on Graphics*, 1992)

Finance Analysis

Gainers (bright green)

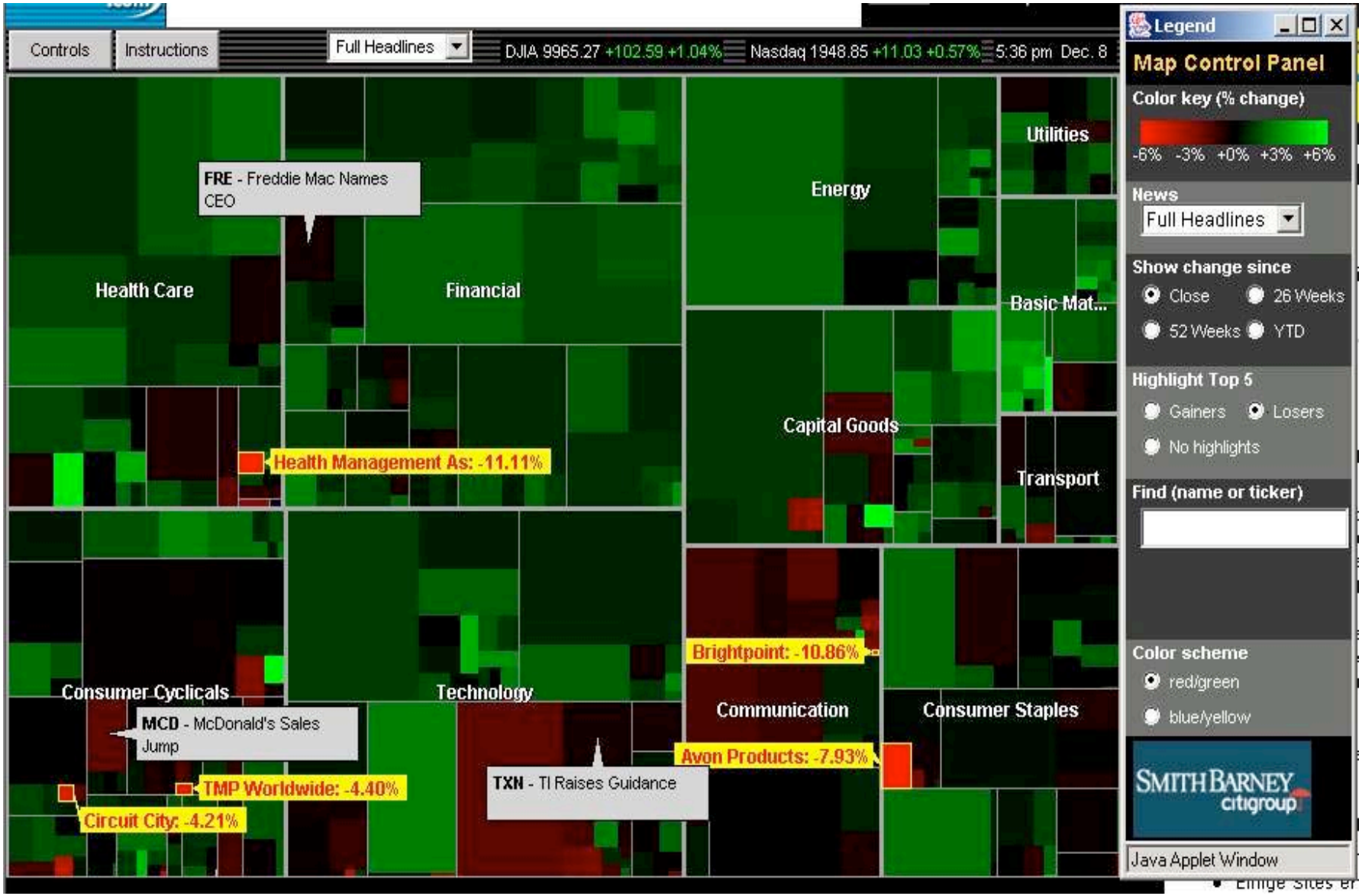
http://www.smartmoney.com/marketmap



Finance Analysis

Losers (bright red)

http://www.smartmoney.com/marketmap



Treemap: Newsmap

http://newsmap.jp

TreeMaps Summary

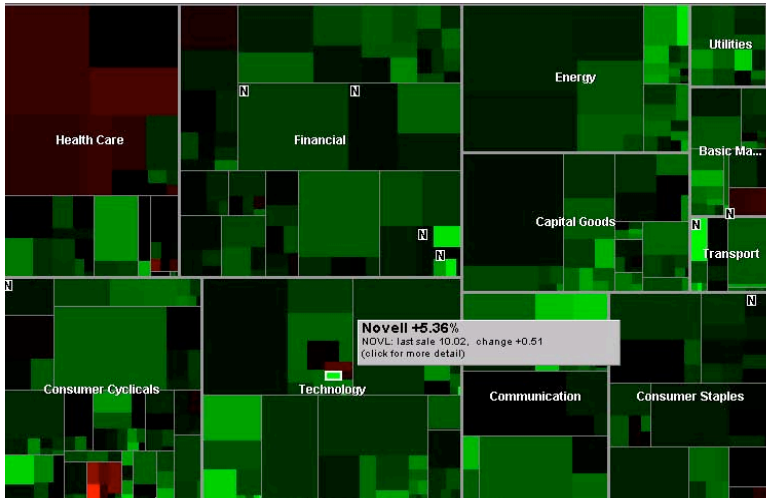
Turning a tree into a planar space-filling map

Capacity to see tens of thousands of nodes in a fixed space and find large areas or duplicate directories is very powerful

Treemap algorithms

- BinaryTree
- Ordered
- SliceAndDice
- Squarified
- Strip

Beamtree

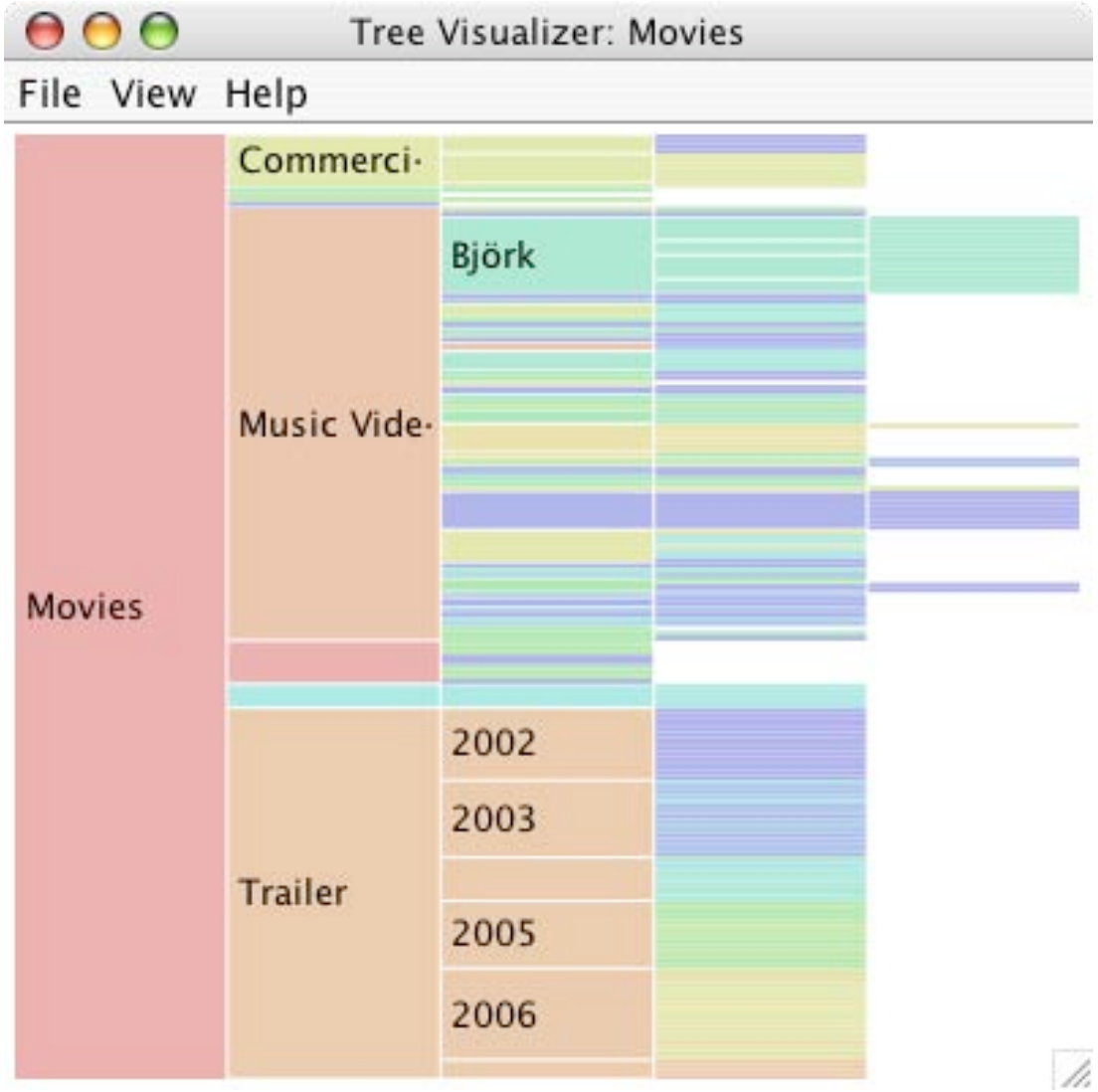


Map of the market [Wattenberg, smartmoney.com]

Icicle Trees

Tree levels side by side horizontal / vertical

Subdivision by size



Demo

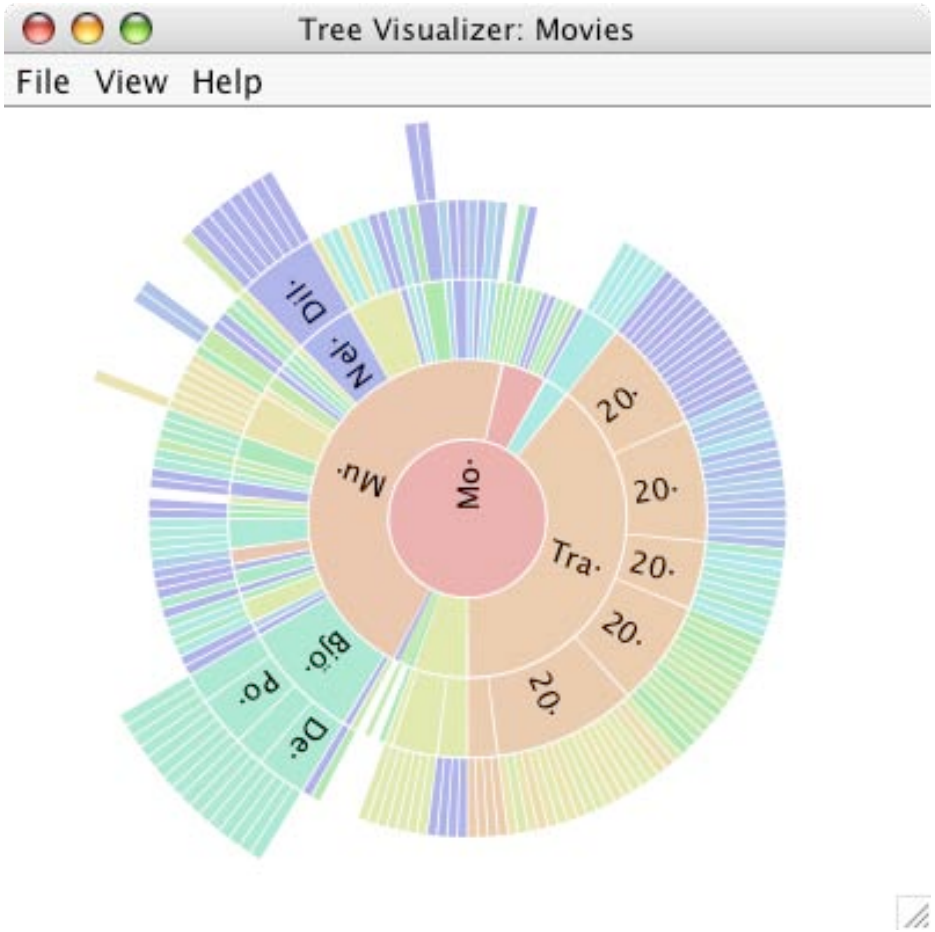
Randelshofer, 2007. http://www.randelshofer.ch/oop/treeviz/index.html

Sunburst Tree

[Stasko]

Radial version of icicle trees

Interaction facilities to navigate / zoom



Demo

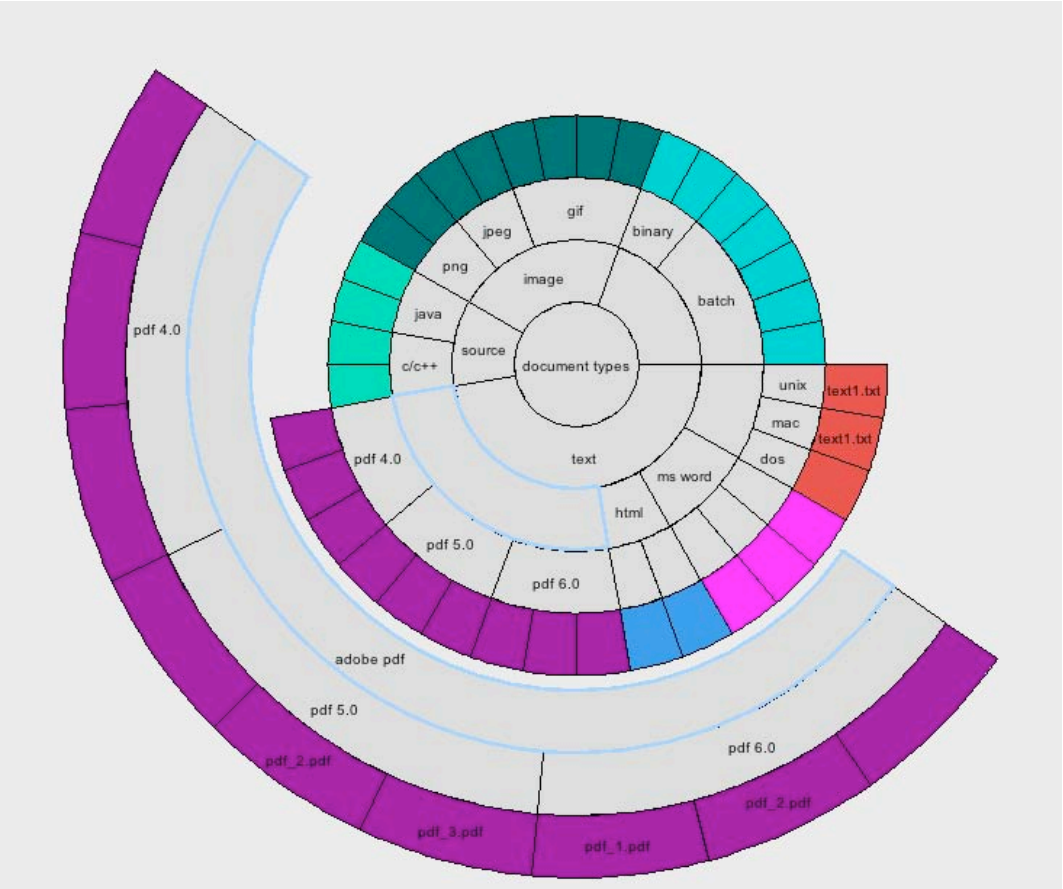
Video

Randelshofer, 2007. http://www.randelshofer.ch/oop/treeviz/index.html

Sunburst Tree: Focus + Context

[Andrews, 2005]

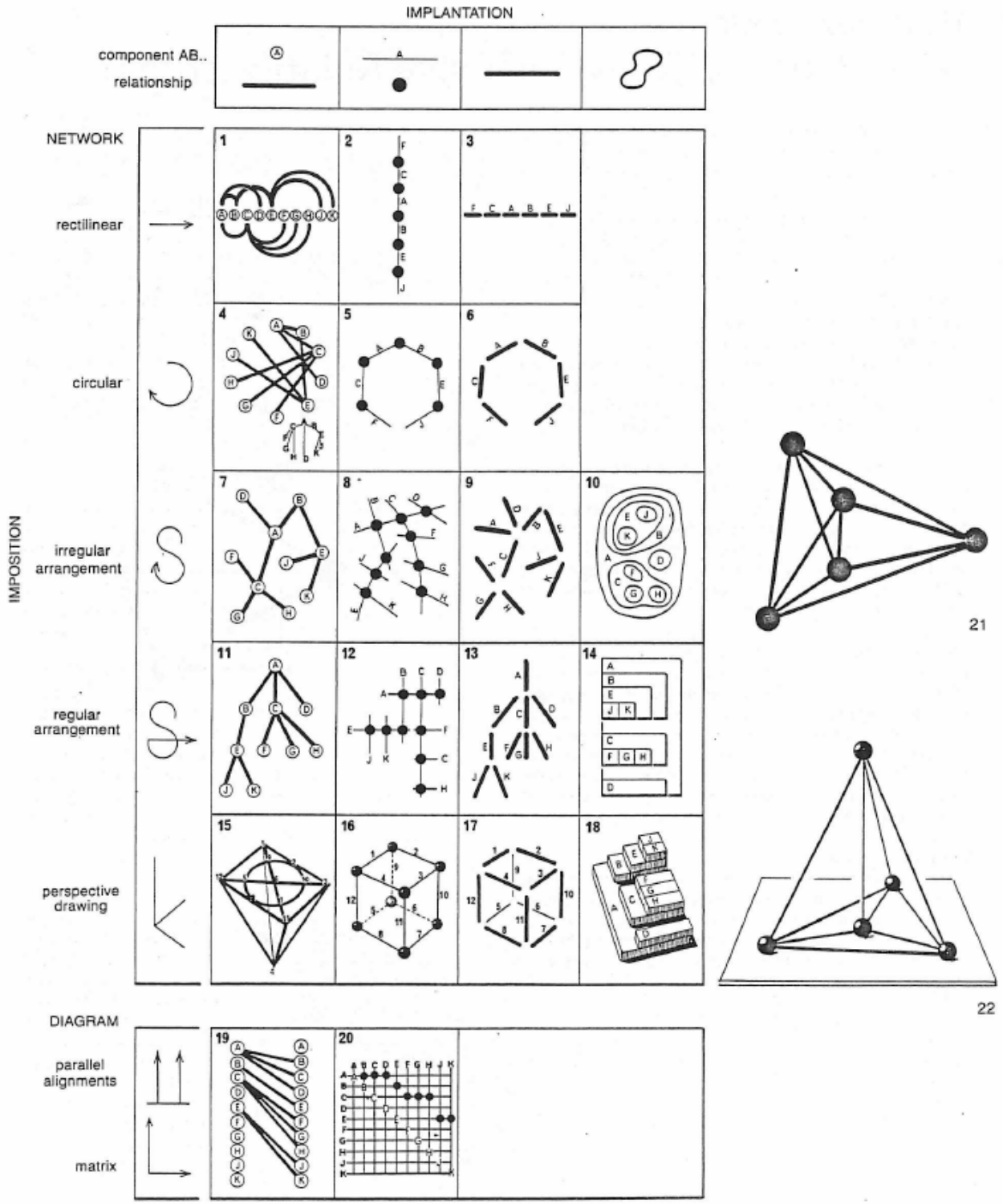
Selected element is redrawn and expanded in outer semi-circle



Demo (HVS)

Bertin's taxonomy

[Bertin, 1983]



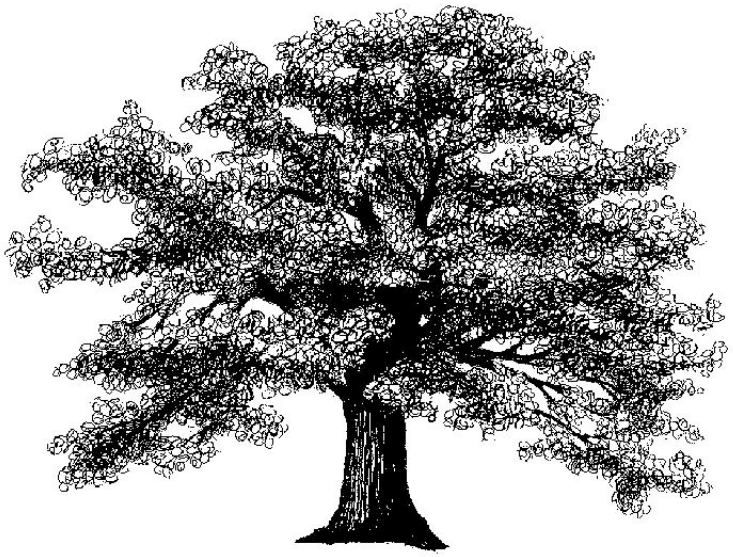
Summary

Hierarchical visualization techniques

- Re-usage of display dimensions

Visualization of networks & hierarchies

- Common data structure in many domains
- Connection & containment
- Representations
  - Indented lists
  - Node-Link diagrams
  - Containment diagrams
  - Adjacency matrices



Useful Stuff

Treemap

- HCIL Treemap Browser <http://www.cs.umd.edu/hcil/treemap>
- Map of the Market <http://www.smartmoney.com/marketmap>
- Newsmap <http://newsmap.jp>
- The Hive Group <http://www.hivegroup.com>
- HyperTree Java Library <http://hypertree.sourceforge.net/>

SpaceTree <http://www.cs.umd.edu/hcil/spacetree>

Tree Visualizer <http://www.randelshofer.ch/oop/treeviz/index.html>

VisualComplexity.com <http://www.visualcomplexity.com>

ManyEyes <http://www.many-eyes.com>

Search Engines / Clustering

- Clusty <http://clusty.com>

Acknowledgements

Thanks to Silvia Miksch and Paolo Federico whose slides form the basis of this presentation.

Ideas have been taken from Katy Börner's, Jeff Heer's, and Jock Mackinlay's presentation slides of their visualization classes.

Literature

[Görg et al., 2007] Görg, C. and Pohl, M. and Qeli, E. and Xu, K.: Visual Representations, in Kerren, A., Ebert, A. and Meyer J. (Eds.): Human-centered Visualization Environments, pp. 189-224, volume 4417 of LNCS Tutorial, Springer, 2007.

[Mazza, 2009] Mazza, R.: Introduction to Information Visualization, Chapter 5 (Networks and Hierarchies), pp. 63-89, Springer-Verlag, London, 2009.

[Ward et al., 2010] Ward, M. and Grinstein, G. and Keim, D.: Interactive Data Visualization: Foundations, Techniques, and Application, Chapter 8 (Visualization Techniques for Trees, Graphs, and Networks), pp. 271-290, A K Peters, 2010.