Hierarchical Data Visualization

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Hierarchical Data

Hierarchical data emphasize the subordinate or membership relations between data items.

- ✓ Organizational Chart
- ✓ Classifications / Taxonomies (Species and subspecies)
- ✓ Information storage (file structure)
- ✓ Logical inference: decision tree
- ✓ Etc.

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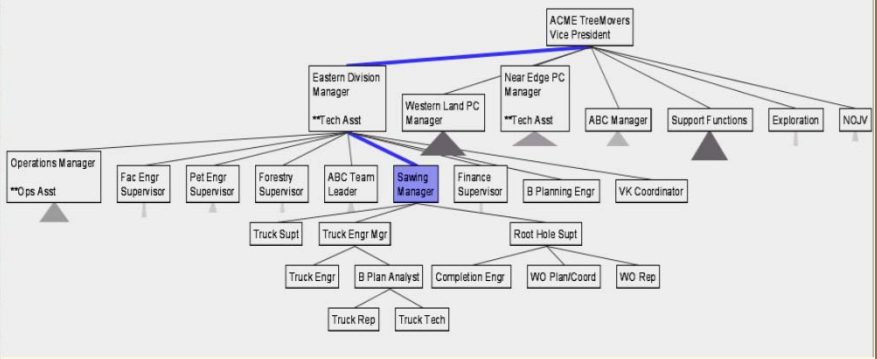
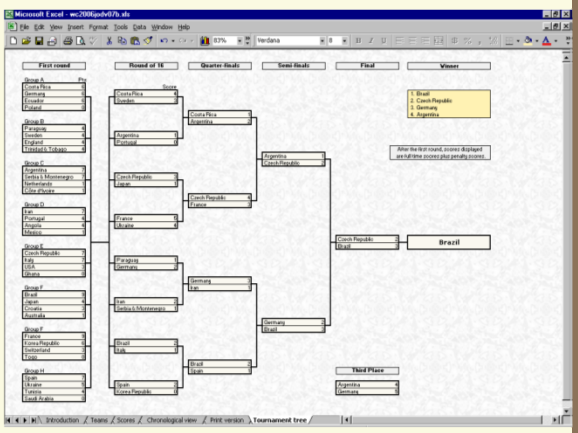
Organizational Chart



Family trees, tournament, etc.



Hierarchical Data Representation

Special type of graph (tree): *G={V,E}*

- Acyclic (no loop or cycle)
- Rooted
- Each sub-graph is also a tree

✓ Challenging for large dataset

- Visual display and spatial layout of edges and nodes.
- Interactivity for data exploration

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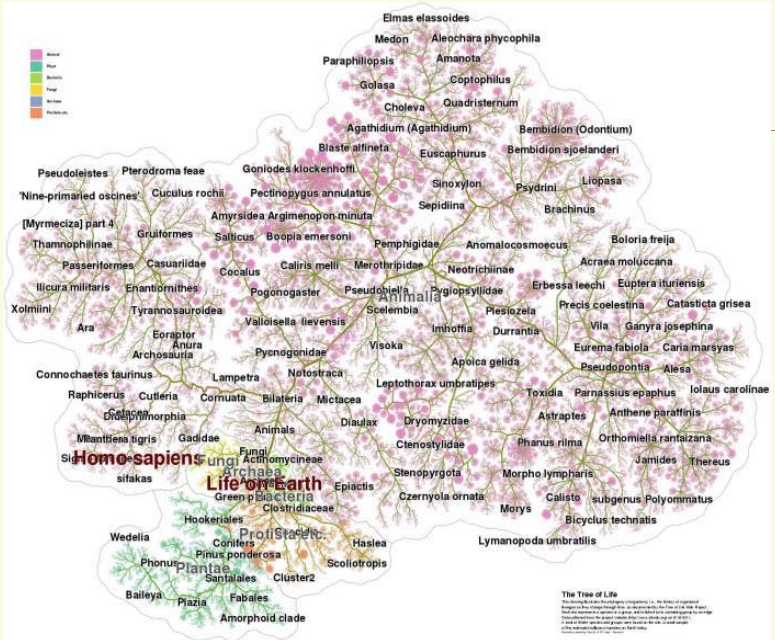

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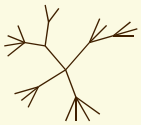
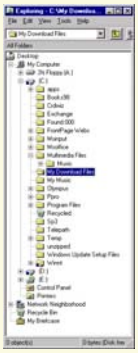
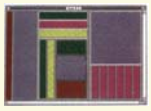
Hierarchical Data Visualization Techniques

- ✓ Node-Link Diagrams
  - – Orthogonal layout
  - – Traditional Layout
  - – Radial Layout
- ✓ Space-Filling
  - – Treemap
  - – Voronoi Treemap
- ✓ Hybrid Techniques







Which technique to use

- ✓ Reading: People read faster by scanning in lines (not arcs!)
- ✓ Convention: Does the application domain have established conventions?
- ✓ Designs with multiple visual components
  - – How much screen real-estate do you give the tree?

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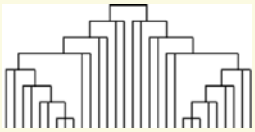
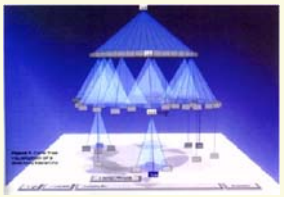
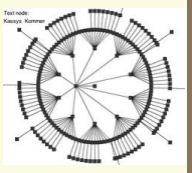
Node-Link Diagrams

- ✓ Orthogonal layout
  - – Indented Layout
  - – Dentrogram
  - – Icicle
- ✓ Traditional Layout
  - – 2D
  - – 3D : ConeTrees
- ✓ Radial layout
  - – Radial diagram
  - – Sunburst diagram
  - – Hyperbolic trees







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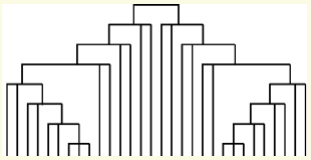
Orthogonal Layout

- ✓ Nodes are horizontally or vertically aligned
- ✓ Easy to implement
- ✓ Visually more intuitive
- ✓ For large dataset, the layout can be imbalanced.



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Indented Layout

- ✓ Child nodes placed below parent and indented
- ✓ Height expands and shrinks
- ✓ Compact width
- ✓ Breadth and depth fight for space resource
- ✓ Often used to navigate file systems
- ✓ Difficult to see all nodes of a specific level: losing context

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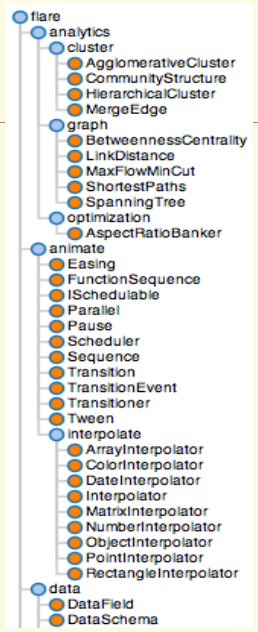
- ✓ Easy to implement
- ✓ Good for Searching, Bad for Structure
- ✓ Can use text file (or html)

```
function draw(node:Node, depth:int) {
    println(<depth spaces> + nodelabel);
    for each child c do
        draw(c,depth+1)
}
draw(root,0);
```



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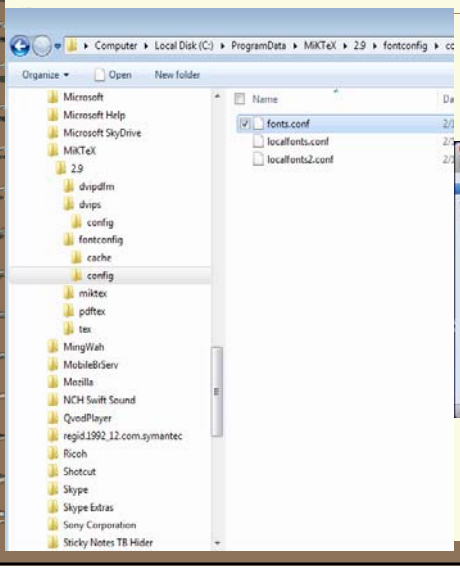
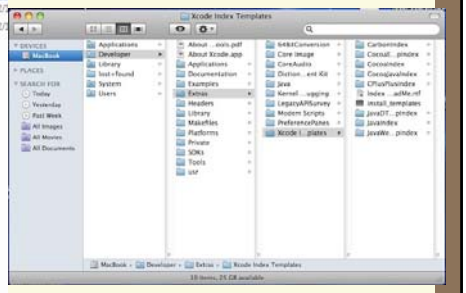
File Systems





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Dendrogram

- ✓ A branching diagram representing a hierarchy of categories based on degree of similarity.
- ✓ All leaves at bottom of diagram
- ✓ Edges usually drawn with sharp corners
- ✓ Often used to illustrate the arrangement of the clusters by hierarchical clustering.

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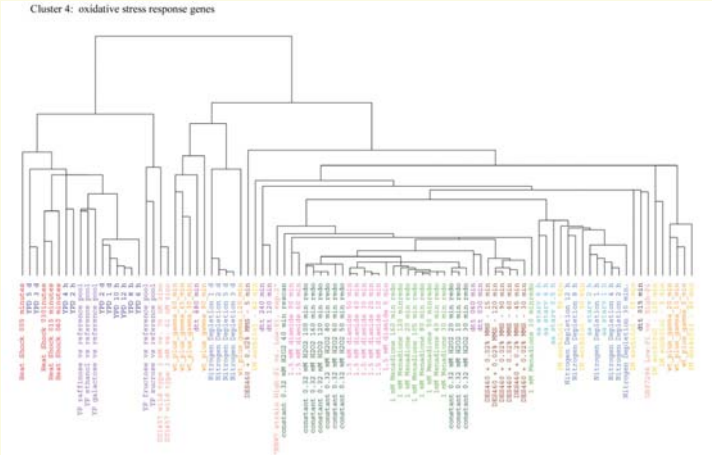
Dendrogram: Gene Clustering



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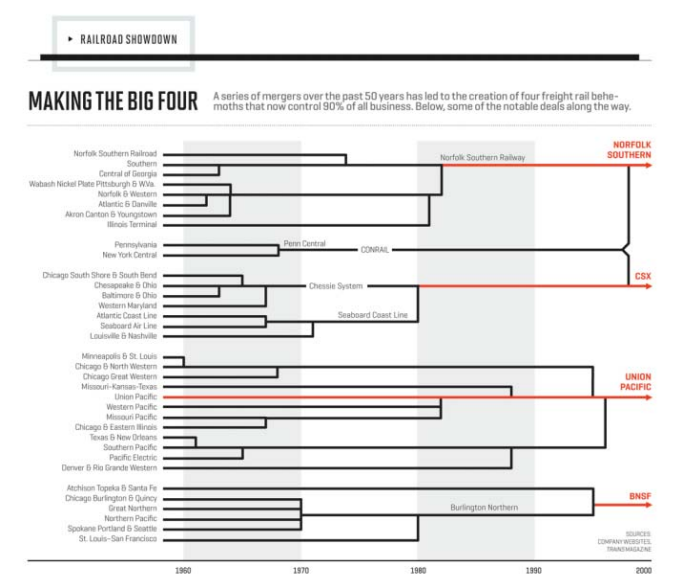

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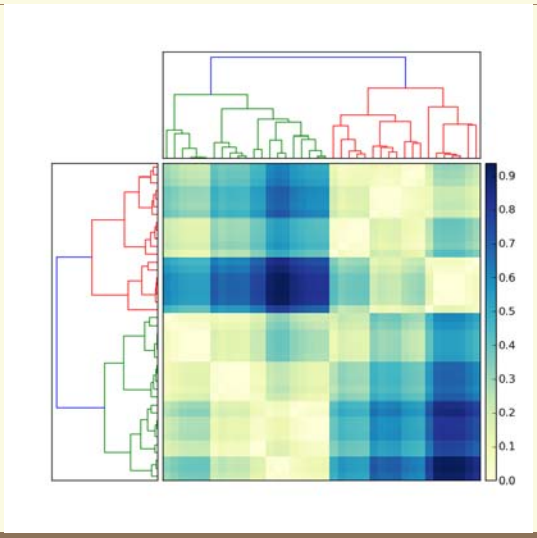
Heatmap and Dendrogram



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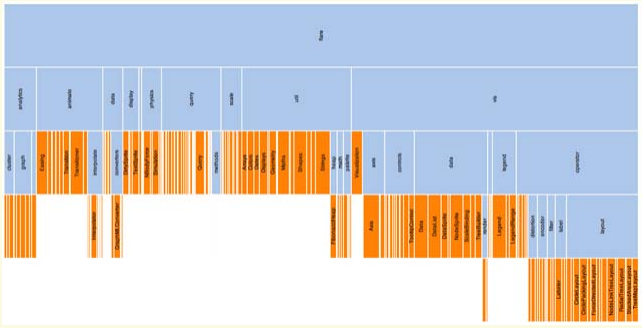
Icicle Tree

Edges implied by adjacency and spatial relationships.



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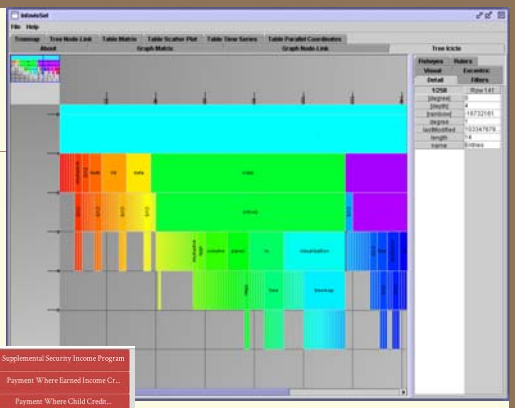
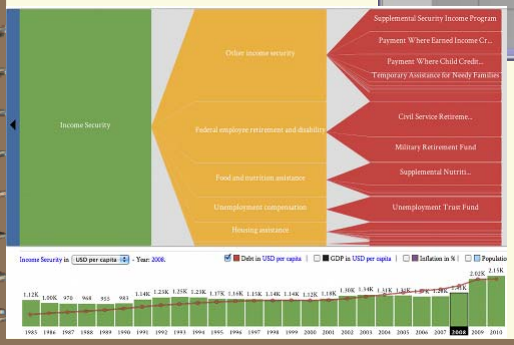
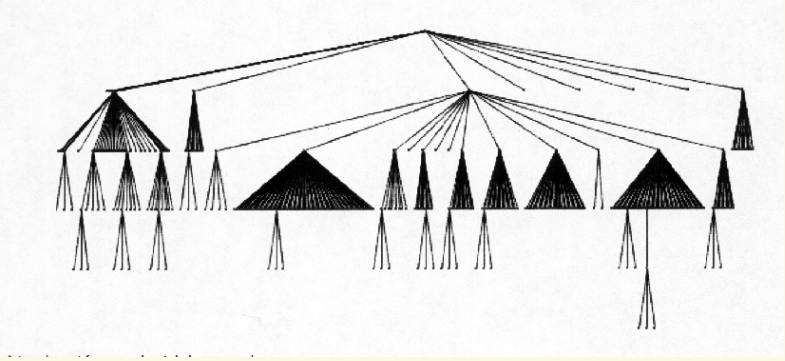
Icicle Trees



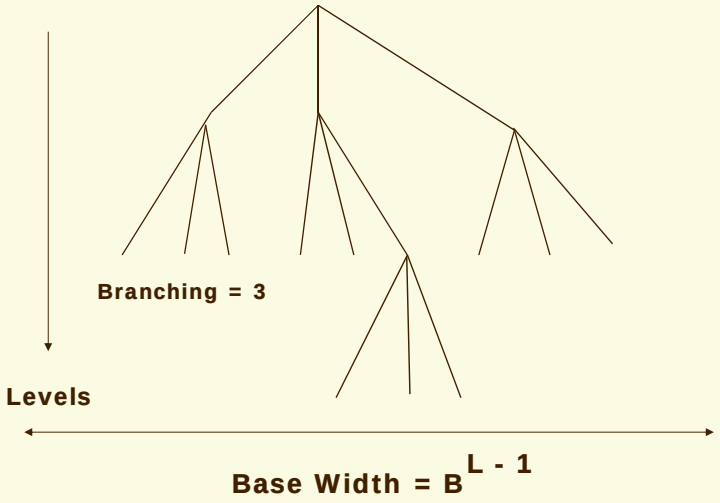


Traditional Node-Link Layout

Allocate Space proportional to # of Children at Different Levels

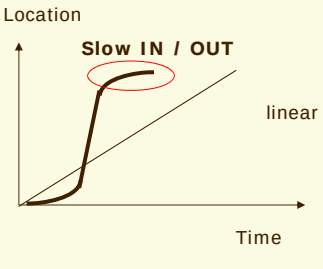


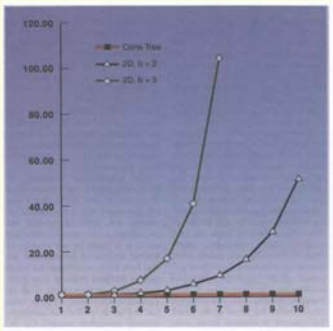
Exponential Growth of Nodes



Manage exponential growth of nodes

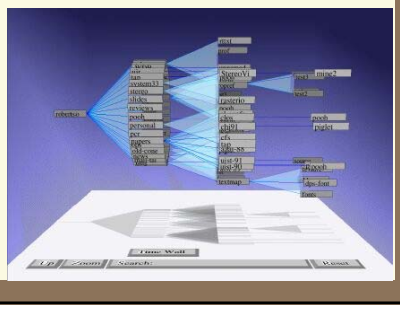
- ✓ Use 3D to "linearize" problem – width fixed
- ✓ Use "Slow IN / OUT" animation of object or point of interest to create "**Object Constancy**"





3D ConeTree

- ✓ Combining 3D display and 2D projection.
- ✓ Extending available viewing space to 3D.
- ✓ 3D Animation to reduce perception cost.
- ✓ Difficult for large trees
- ✓ Need 3D interaction



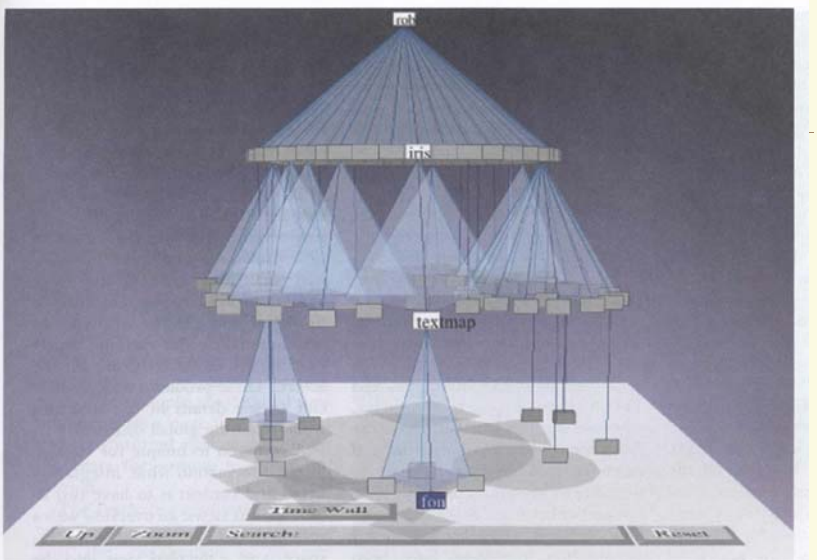
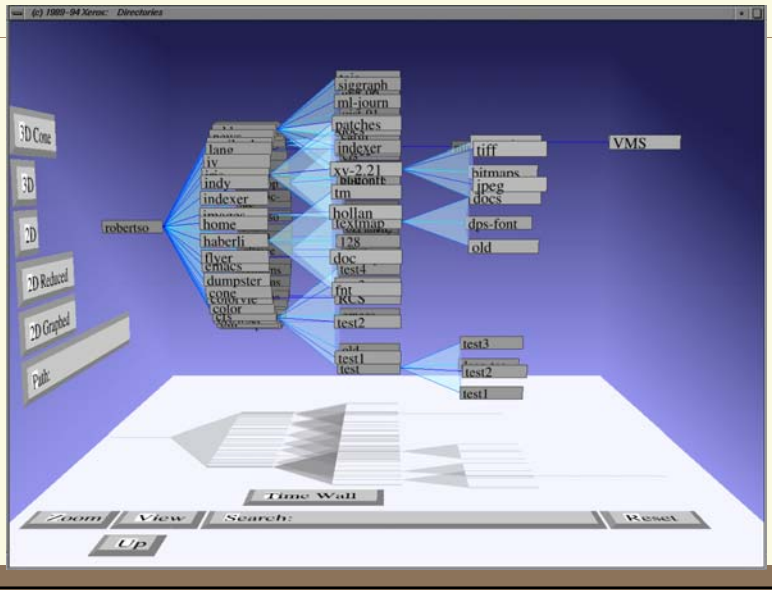


FIGURE 7

Cone Tree visualization of a directory hierarchy

Cone Tree : file system example



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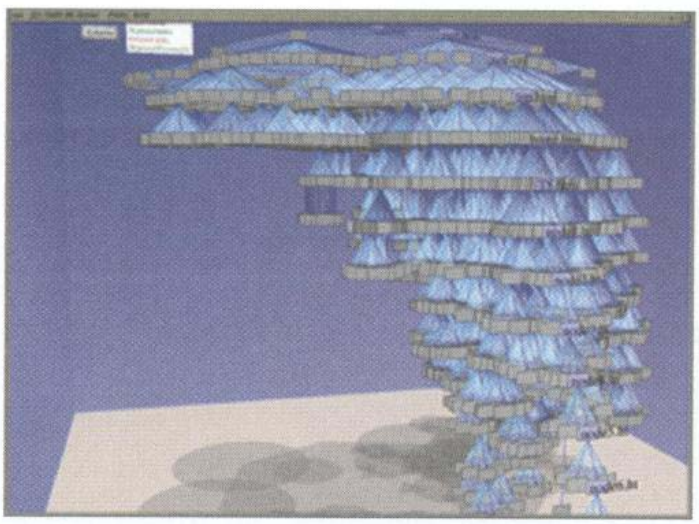

FIGURE **2.13**

Cone tree of 10,000 nodes in the Xerox PARC Web.

Radial Layout

- ✓ Root at the center
- ✓ Nodes of different levels are placed on circles of different radii.
- ✓ More effective use of space: more nodes at deeper levels (hence more space)

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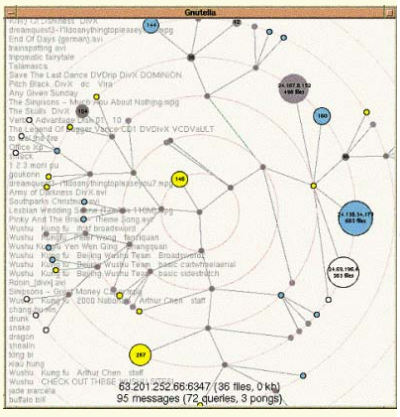
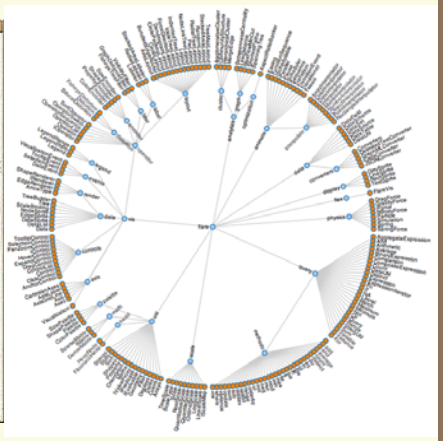
Radial Layout examples





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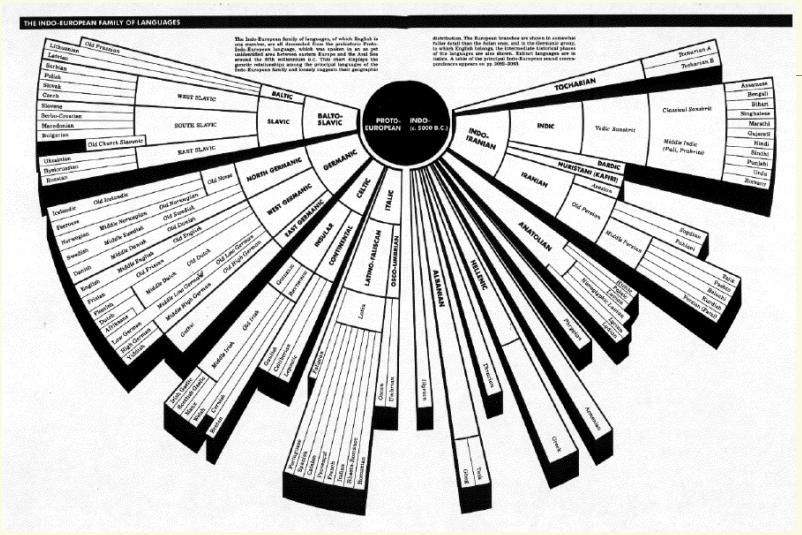
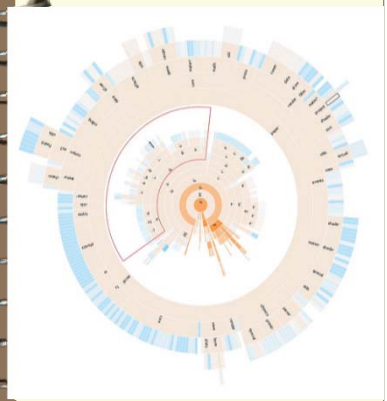
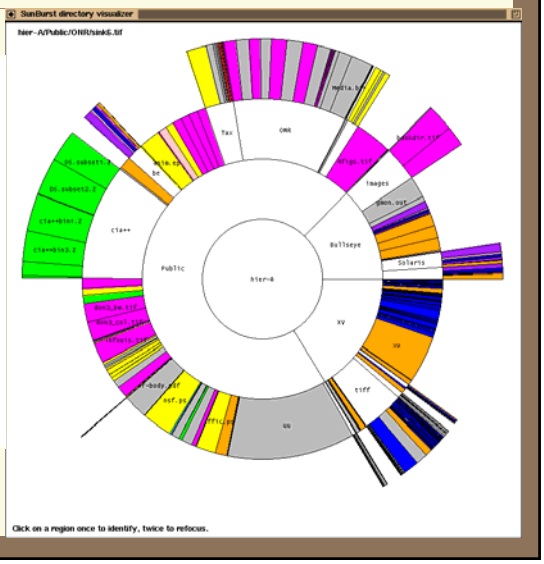


American Heritage Dictionary

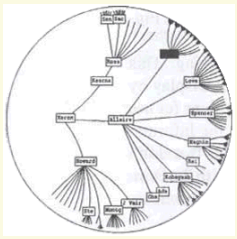
SunBurst: Radial Version of Icicle Tree

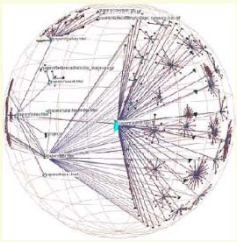


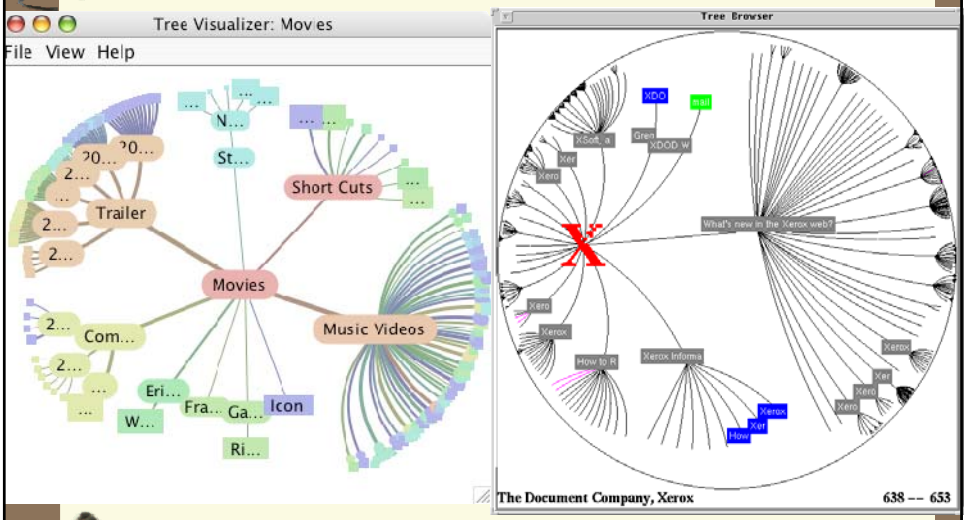


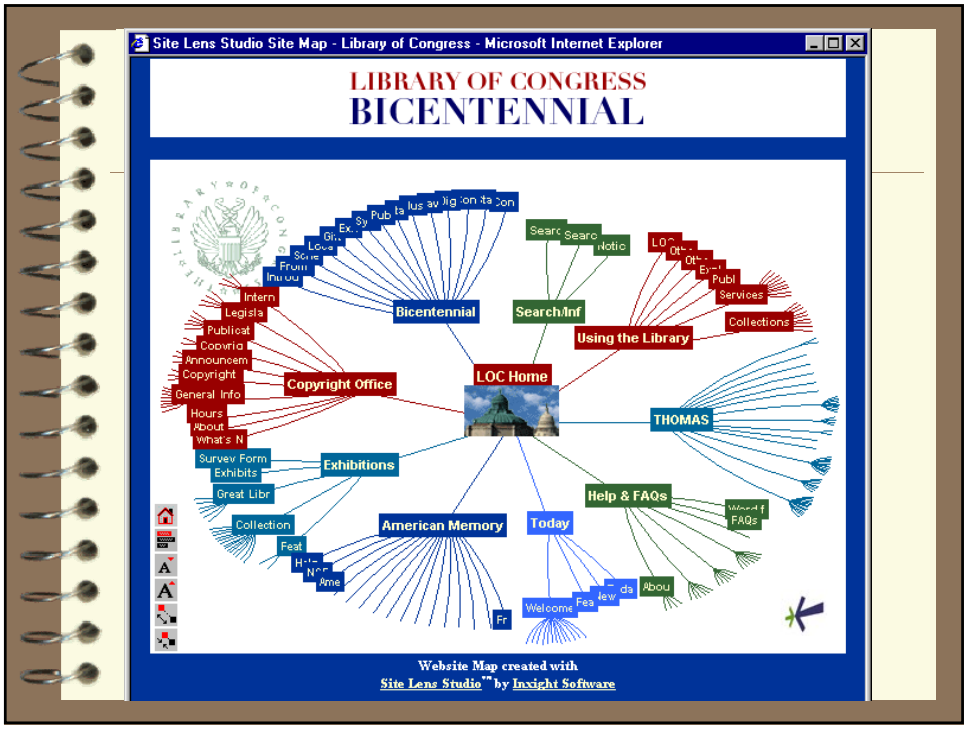
Hyperbolic Trees

- ✓ Employs hyperbolic space, which intrinsically has “more room”
- ✓ Similar to radial layout, but outer levels are shrunk according to a hyperbolic formula.
- ✓ Can re-focus : “focus+context” approach
- ✓ Difficult to accurately place nodes due to the nonlinear hyperbolic mapping

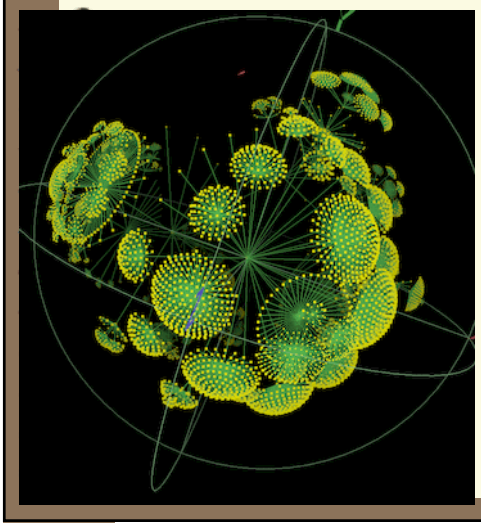


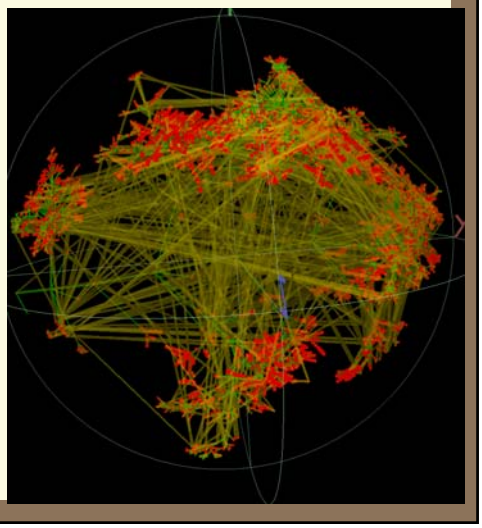


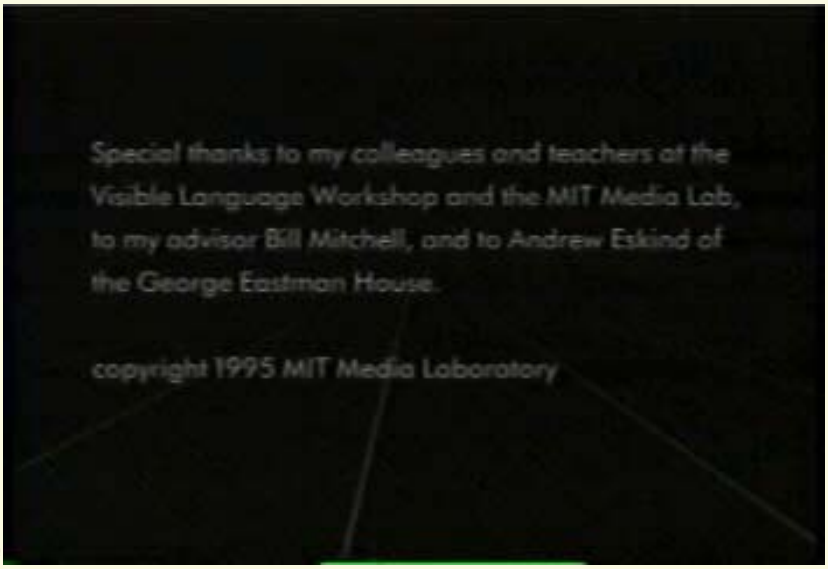




3D Hyperbolic Browser: Walrus







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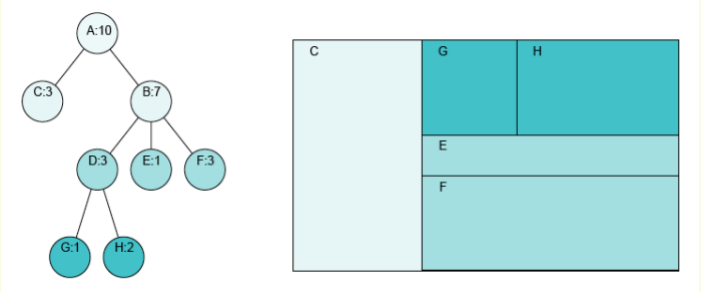
Space Filling Techniques

- ✓ Containment relationship
- ✓ Treemaps, Voronoi Treemaps



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Treemaps: "Slice & Dice"

- ✓ Partition screen space hierarchically.
- ✓ Alternate x- and y-partitions, with important attribute used first.
- ✓ "Content" is represented using Area
- ✓ Color may correspond to an additional attribute
- ✓ Suitable to get an overview over large amounts of hierarchical data (e.g., file system) and for data with multiple ordinal attributes (e.g., census data)

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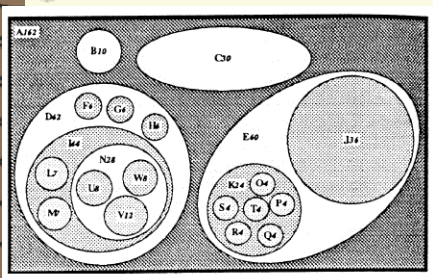
Treemap



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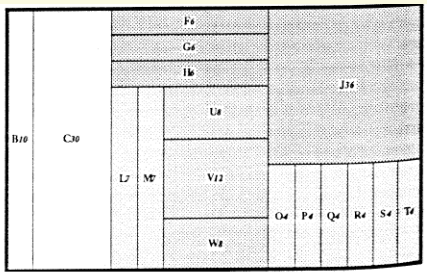
Venn Diagram



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Tree-Map

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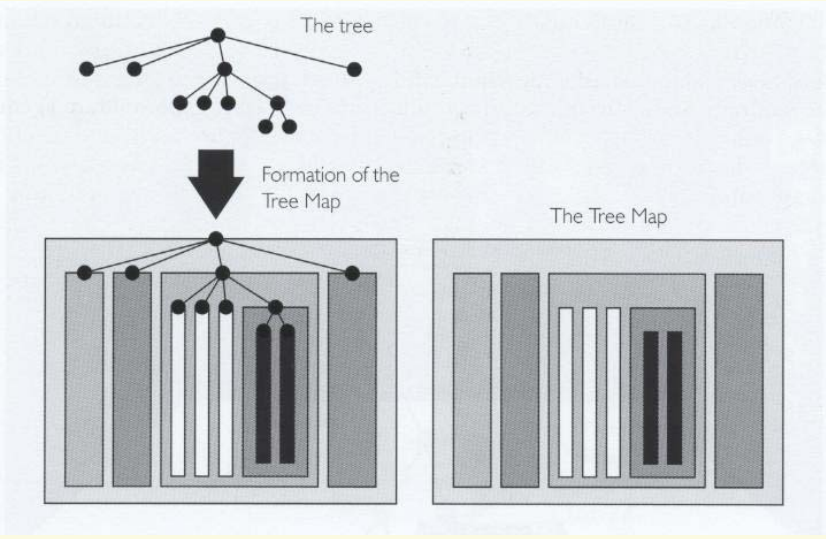
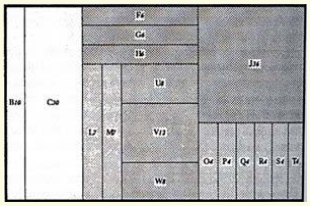
Treemap Algorithm

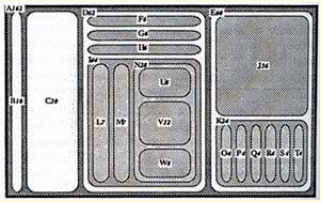
- ✓ Calculate sizes:
  - Recurse to children
  - My size = sum children sizes
- ✓ Draw Treemap (*node*, *space*, *direction*)
  - Draw *node* rectangle in *space*
  - Alternate *direction*
  - For each *child*:
    - Calculate *child space* as % of node *space* using size and *direction*
    - Draw Treemap (*child*, *child space*, *direction*)



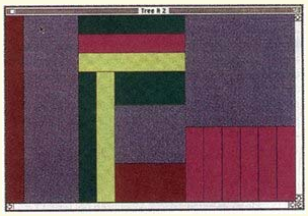
Treemaps – Nested vs. Non-nested

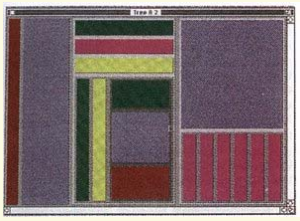


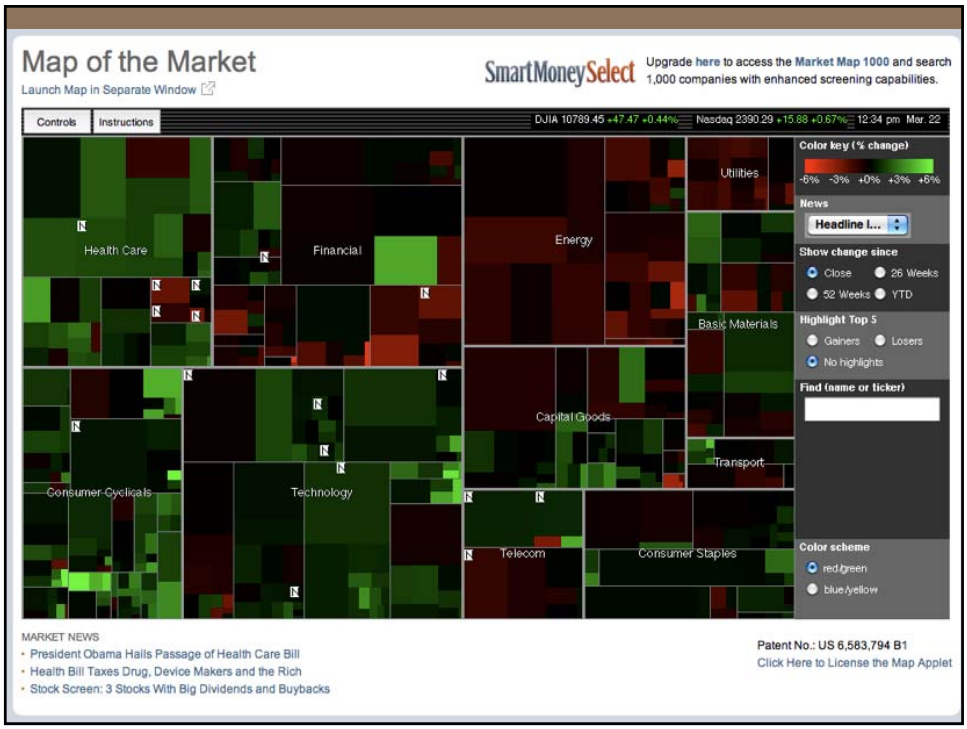
Non-nested Tree-Map



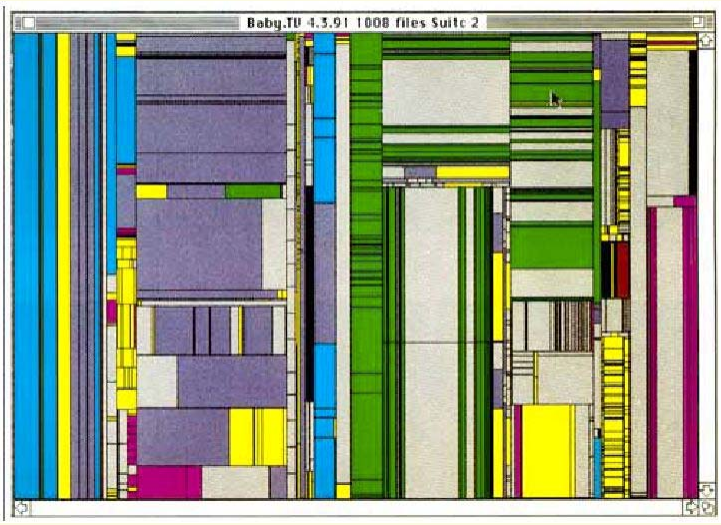
Nested Tree-Map







Treemap : file system



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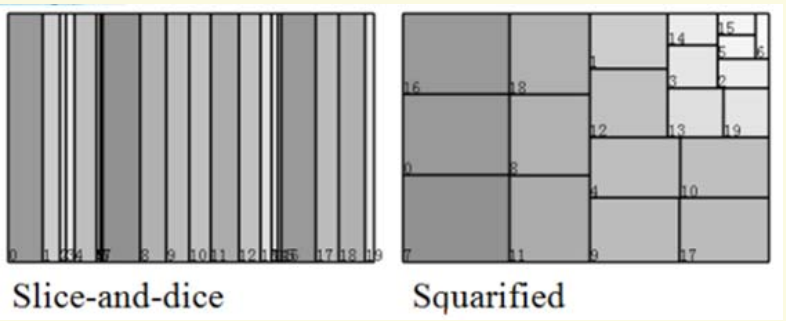
Squarified layout



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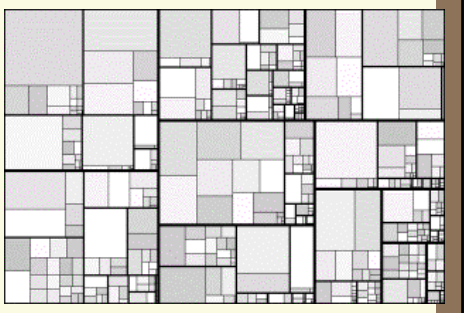
Slice-and-dice

- Ordered,
- very bad aspect ratios



Squarified

- Unordered
- best aspect ratios

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Tree maps for categorical data

- ✓ Categorical data do not have natural hierarchy.
- ✓ Building hierarchy for categories is critical
- ✓ Higher levels in the hierarchy for more important categories
- ✓ Example: Real estate data.
  - – Location, Property Type, Price, etc.

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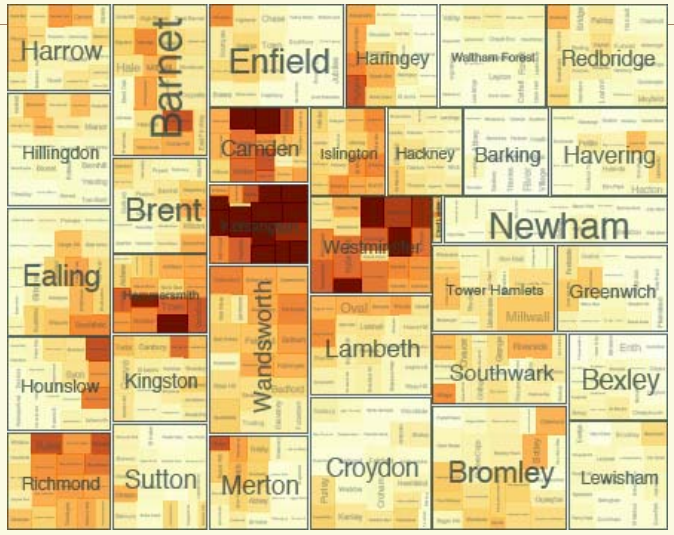
London Real Estate Transaction



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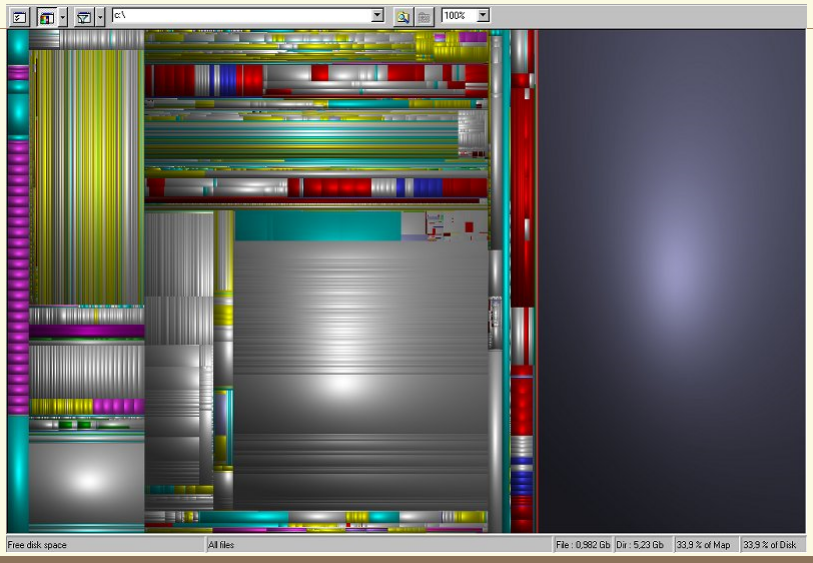
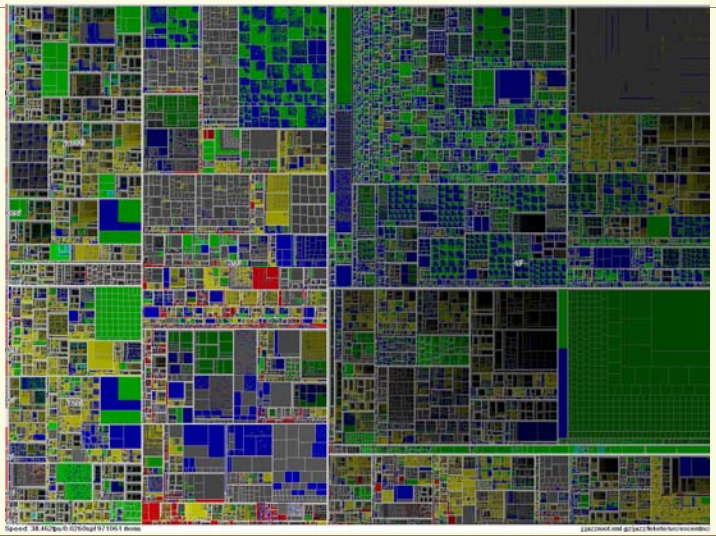
Treemaps – Shading



Treemaps – 1,000,000 items



Interaction Techniques for Zoomable Treemaps

UIST 2006 Demonstration

Renaud Blanch & **Éric Lecolinet**, ENST (GET)
http://www.infres.enst.fr/~elc/

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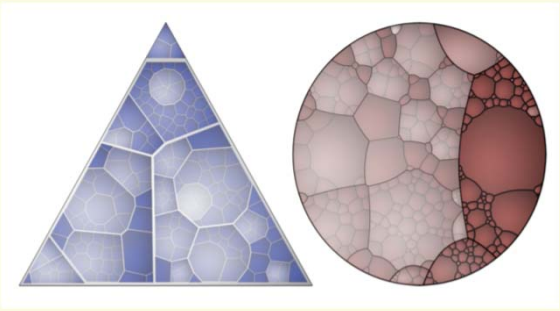
Voronoi Treemaps

- ✓ Dividing space using arbitrary polygons
- ✓ Based on Voronoi tessellations



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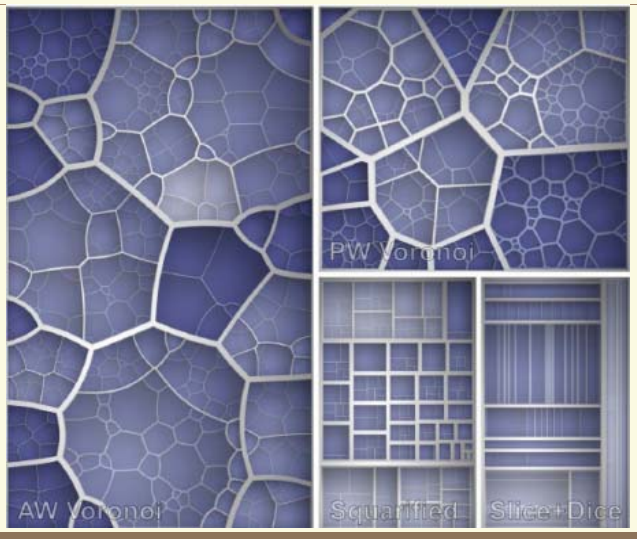
Voronoi vs. Slice-and-Dice vs. Squarified



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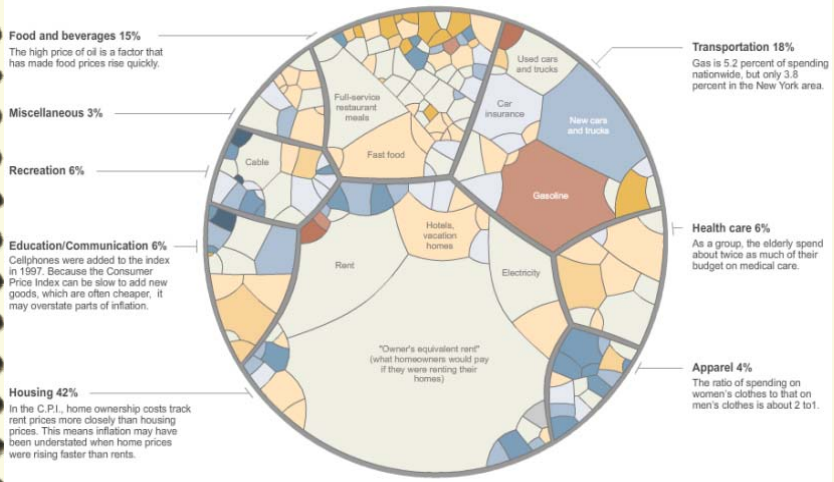
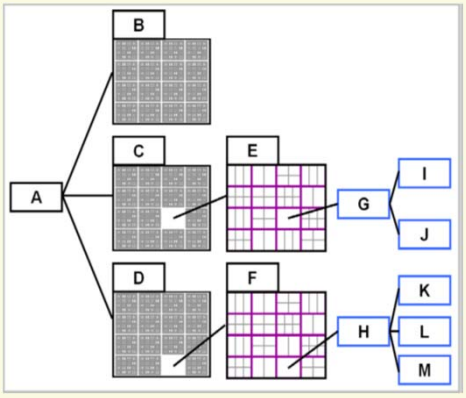
US Consumer Expenditures



Hybrid Techniques: Elastic Hierarchy

Combining Node-link diagrams and treemaps



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Elastic Hierarchies: Combining Treemaps and Node-Link Diagrams

Shengdong Zhao, Michael J. McGuffin, Mark Chignell

University of Toronto

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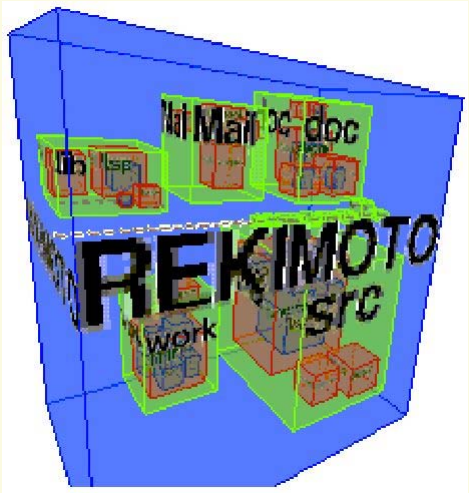
InfoCube : file system example



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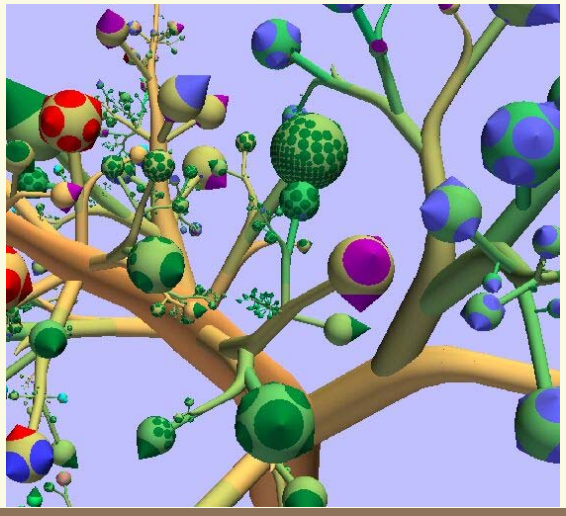
Botanical Visualization of Huge Hierarchies



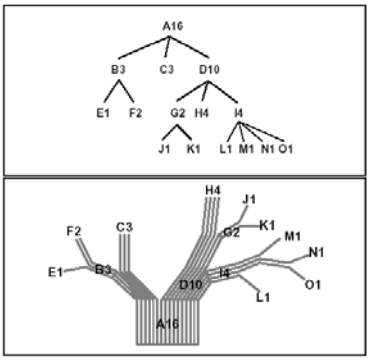


Figure 2. Node and link diagram (t) and corresponding strands model (d).

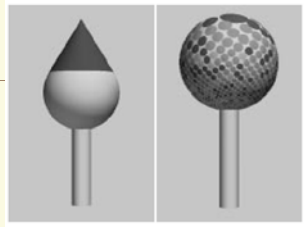


Figure 8. Phi-ball with one (l) and many (r) files.

Figure 9. Final model with contraction, extrusion, and phi-balls.

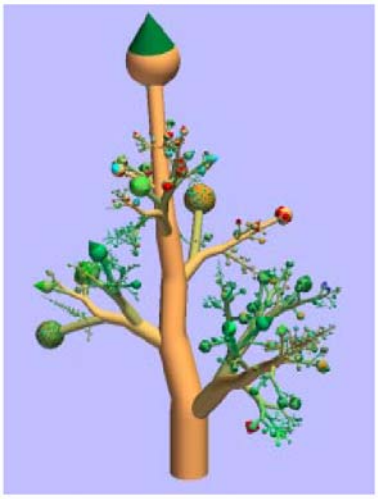


Figure 10. Complete hard disk with $\alpha = 45$ and $\beta = 360/\varphi$.

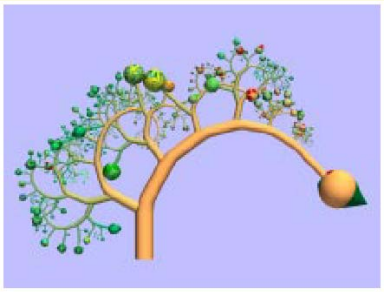
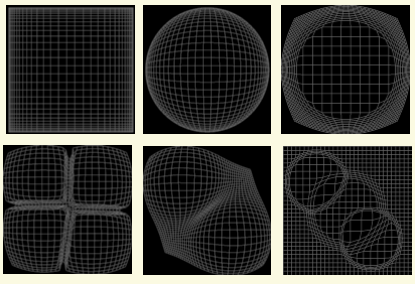


Figure 11. Complete harddisk with $\alpha = 90$ and $\beta = 0$.

Focus+Context Interaction

Nonlinear Magnification

- http://www.cs.indiana.edu/~tkeahey/research/nlm/nlm.html
- Fisheye Views
- Focus+Context



Treemap Interaction