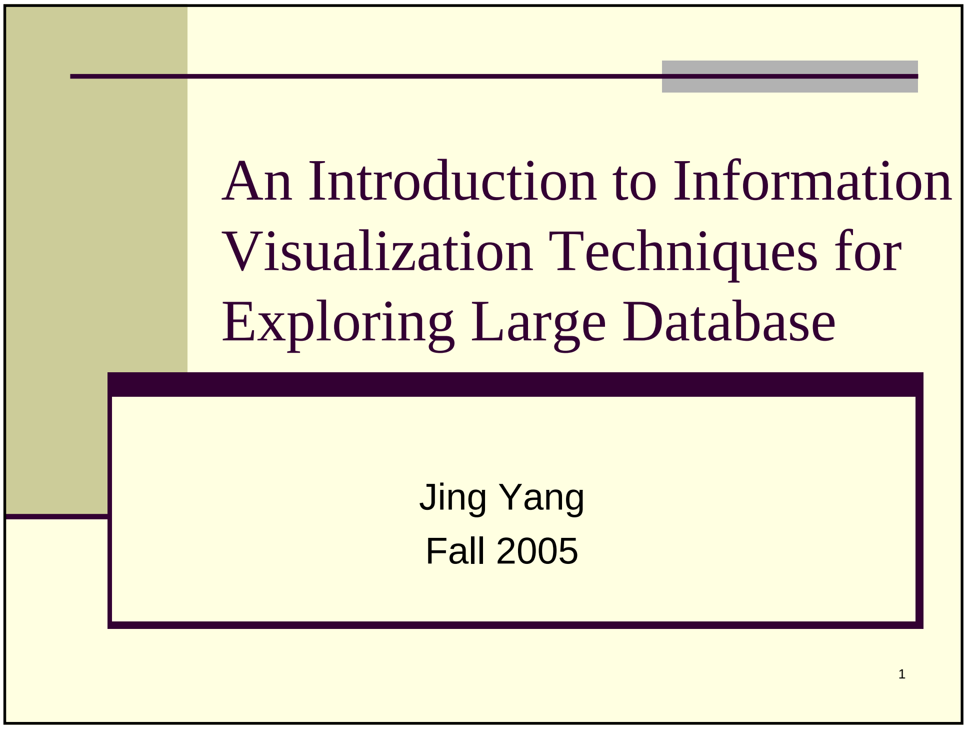
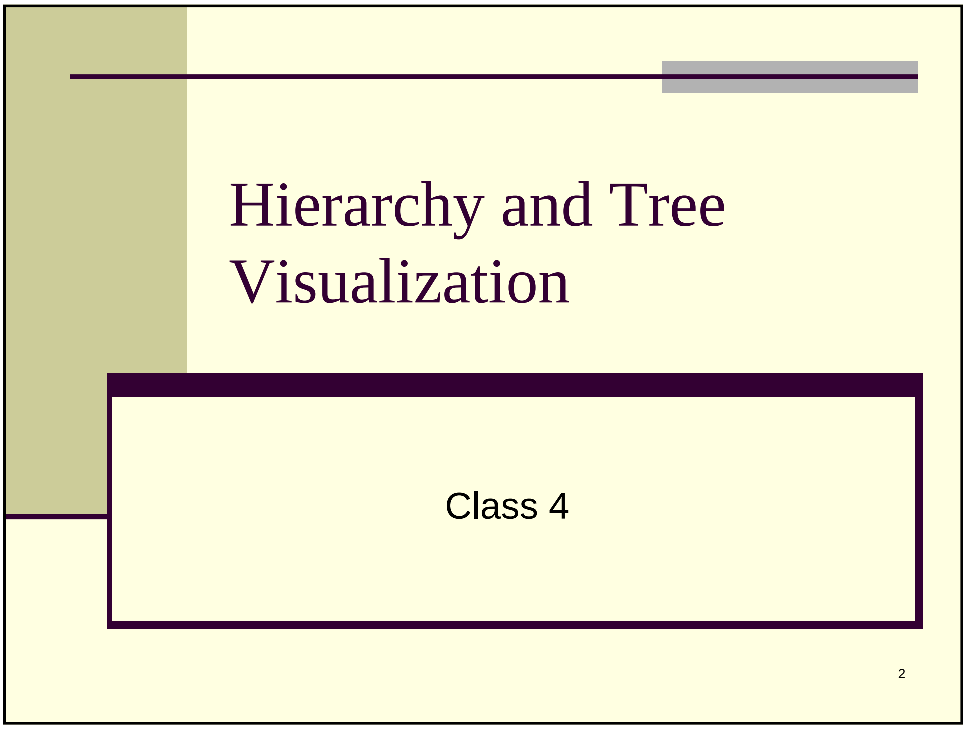


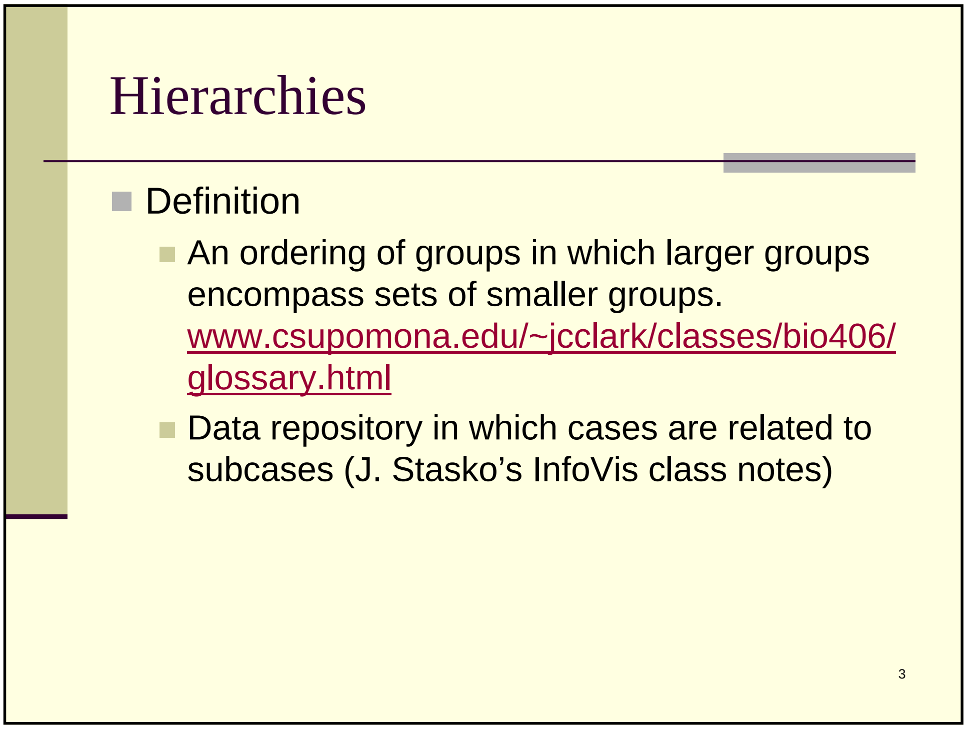
An Introduction to Information Visualization Techniques for Exploring Large Database

Jing Yang
Fall 2005



Hierarchy and Tree Visualization

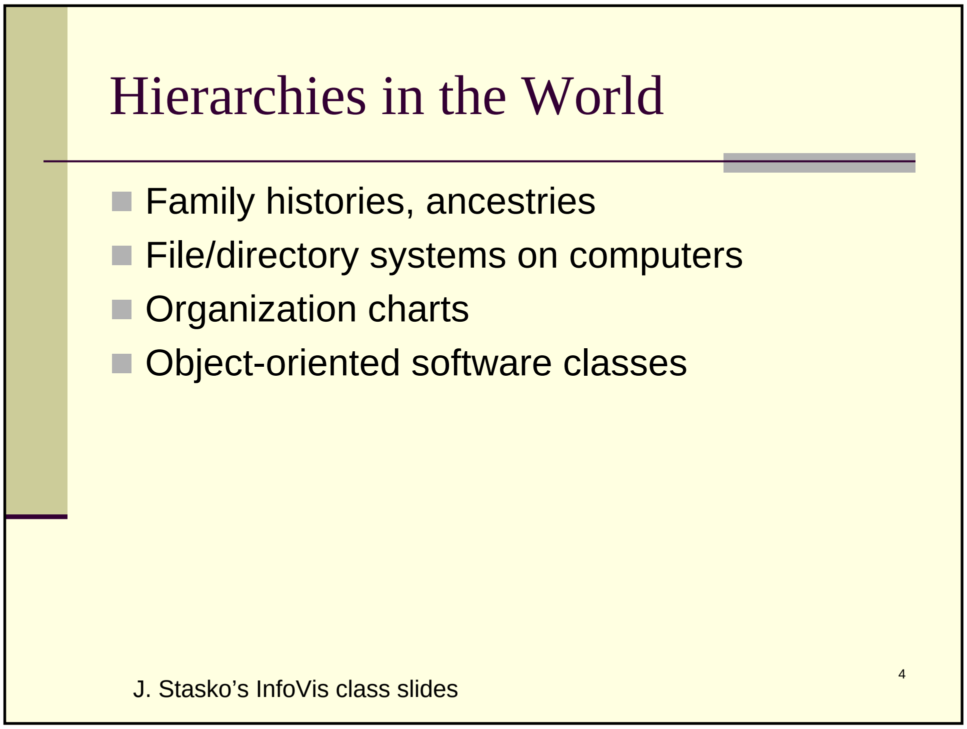
Class 4



Hierarchies

- Definition
  - An ordering of groups in which larger groups encompass sets of smaller groups. www.csupomona.edu/~jcclark/classes/bio406/glossary.html
  - Data repository in which cases are related to subcases (J. Stasko's InfoVis class notes)

3



Hierarchies in the World

- Family histories, ancestries
- File/directory systems on computers
- Organization charts
- Object-oriented software classes

J. Stasko's InfoVis class slides

4

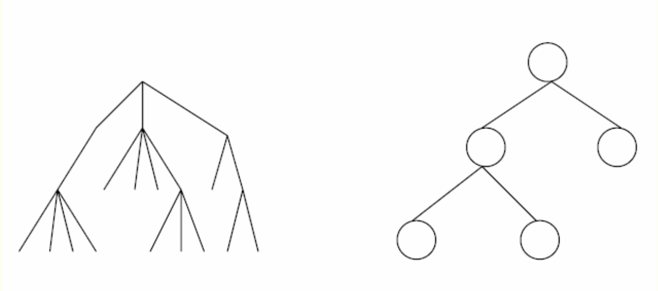
Trees

- Hierarchies are often represented as trees
  - Directed, acyclic graph
- Two major categories of tree vis techniques:
  - Node-link diagram
    - Visible graphical edge from parents to their children
  - Space-filling

Node-Link Diagrams

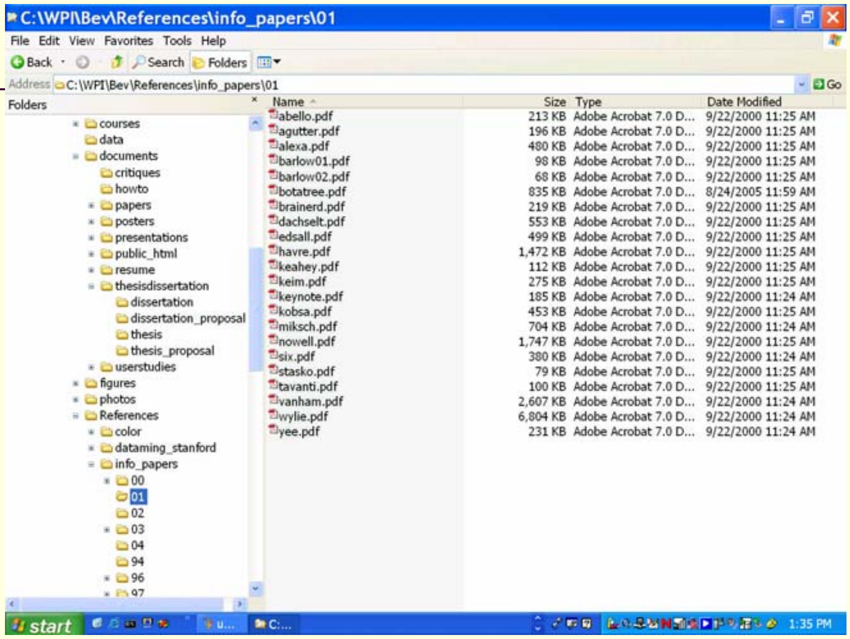
Node-Link Diagrams

- Root at top, leaves at bottom is very common



J. Stasko's InfoVis class slides

Microsoft Explorer



Address C:\WPI\Bev\References\info_papers\01

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wylie.pdf	6,804 KB	Adobe Acrobat 7.0 D...	9/22/2000 11:24 AM
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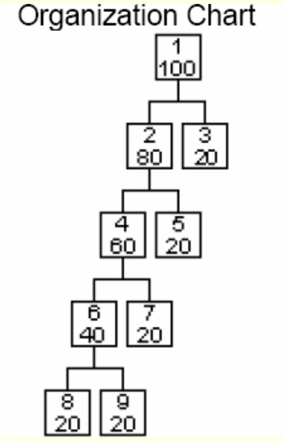
Organization Chart

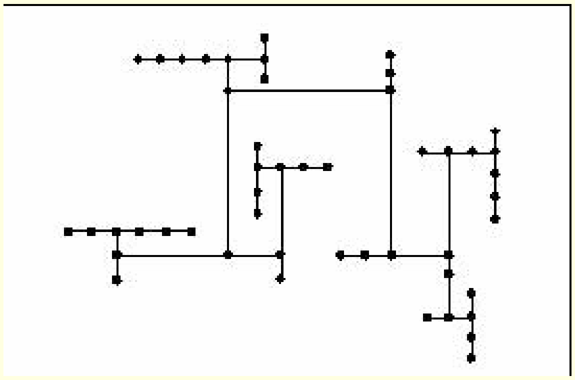


A decision tree

The figure is from Barlow and Neville InfoVis 2001

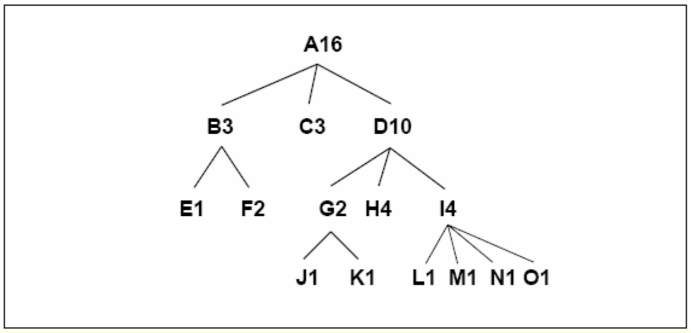
H-Tree Layout

- Work well only for binary trees



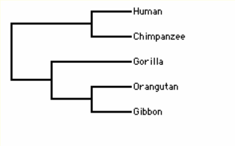
Herman, G. Melançon, M.S. Marshall, “Graph Visualization in Information Visualization: a Survey” In: *IEEE Transactions on Visualization and Computer Graphics*, 2000, pp. 24-44.

A Common Visualization

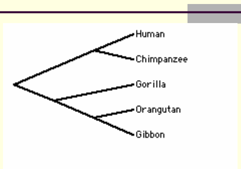


E. Kleiberg et. al. InfoVis 2001

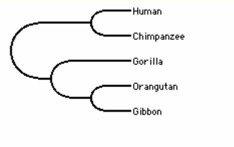
Different Styles



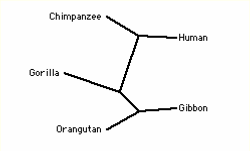
Rectangular: Well suited for displaying labeled/scaled trees.



Straight: Works well only on rooted binary trees.



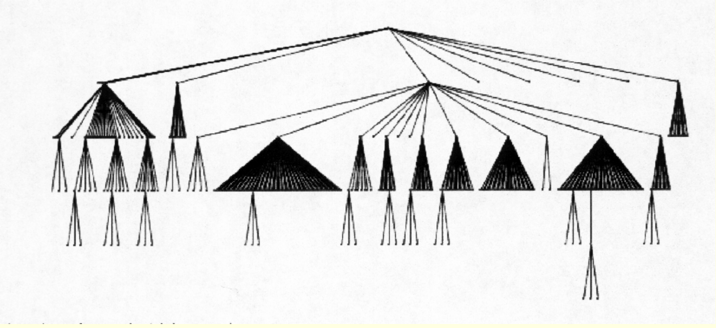
Smooth Edges: Very similar to the rectangular mode



Radial: Works well for visualizing unrooted trees.

http://www.hyphy.org/docs/GUIExamples/treepanel.html

A Classical Hierarchical View



Position children "below" their common ancestors

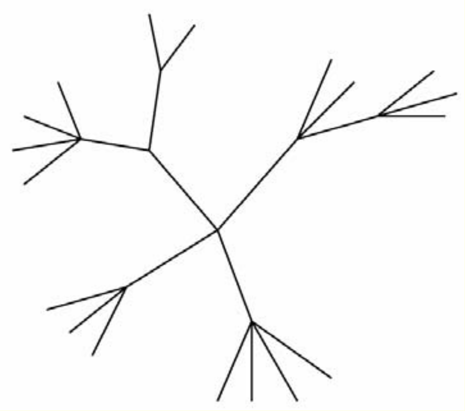
Layout can be top-down, left-to-right and grid like positioning

Fast: linear time

E. Reingold and J. Tilford. *Tidier drawing of trees*. IEEE Trans. Softw. Eng., SE-7(2):223-- 228, 1981

13

Why Put Root at Top (Left)



- Root can be at center with levels growing outward too
- Can any node be the root?

J. Stasko's InfoVis class slides

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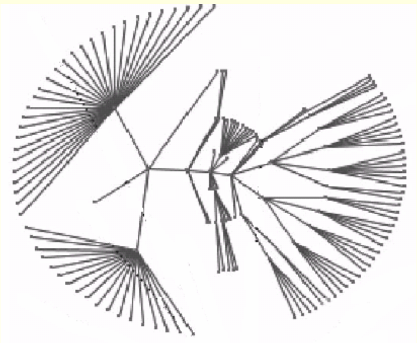
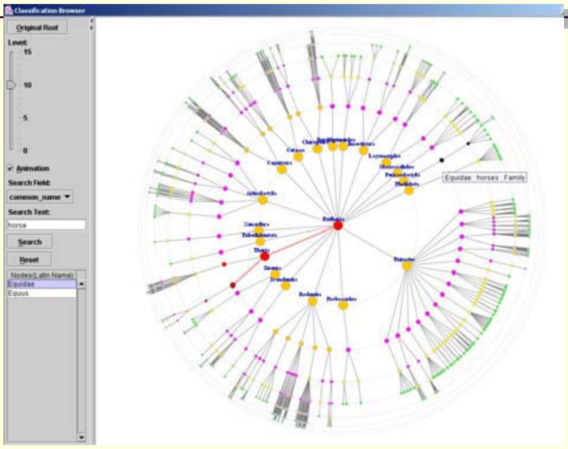
Radial View

- Recursively position children of a sub-tree into circular wedges



P. Eades, “Drawing Free Trees”, *Bulleting of the Institute fro Combinatorics and its Applications,* 1992, pp. 10-36.

Radial View



☑ Animation

Search Field: common_name

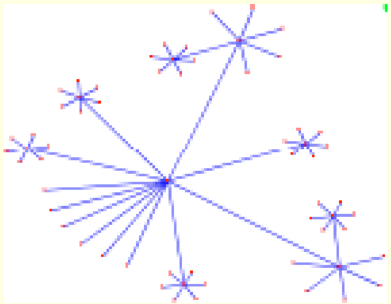
Search Text: horse

Equidae
Equus

Infovis contest 03 Treemap, Radial Tree, and 3D Tree Visualizations
Nihar et. al. Indiana University

Balloon View

- Siblings of sub-trees are included in circles attached to the father node.
- A projection of a cone tree

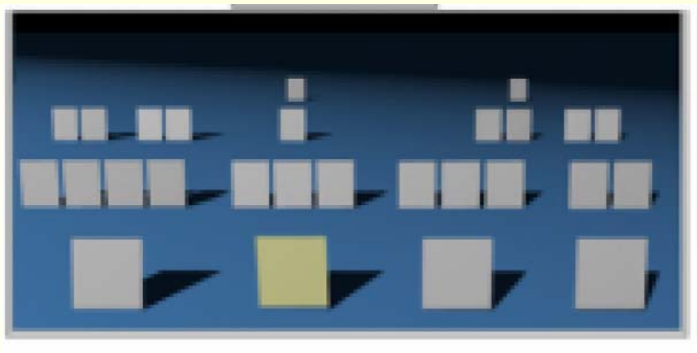


Melancon, G., Herman, I.: Circular drawing of rooted trees. Reports of the Centre for Mathematics and Computer Sciences (CWI), INSR9817,

The Challenges

- Scalability
  - # of nodes increases exponentially
  - Available space increases polynomially (circular case)
- Showing more attributes of data cases in hierarchy or focusing on particular applications of trees
- Interactive exploration

3D Tree



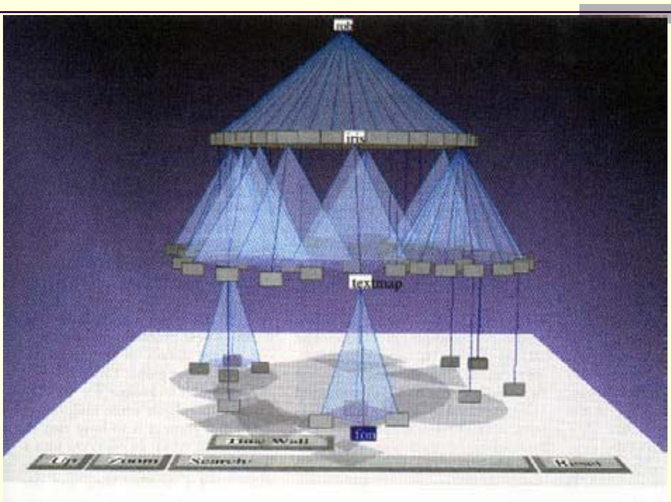
Tavanti and Lind, InfoVis 01

Cone Tree

- Key ideas:
  - Add a third dimension into which layout can go
  - Compromise of top-down and centered techniques mentioned earlier
  - Children of a node are laid out in a cylinder “below” the parent
  - Siblings live in one of the 2D planes

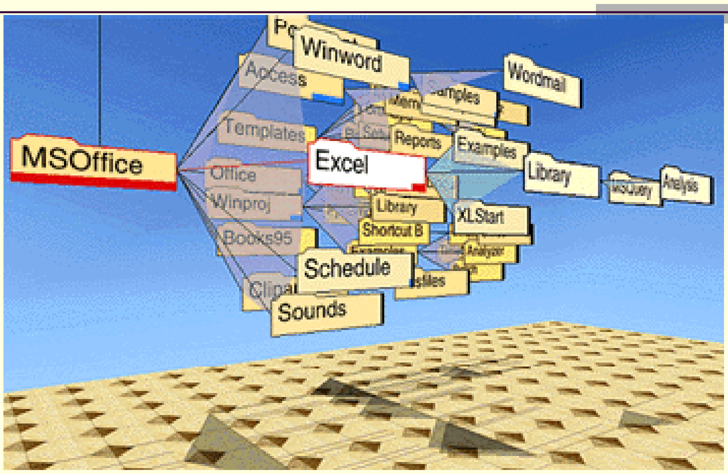
Robertson, Mackinlay, Card CHI ‘91

Cone Tree

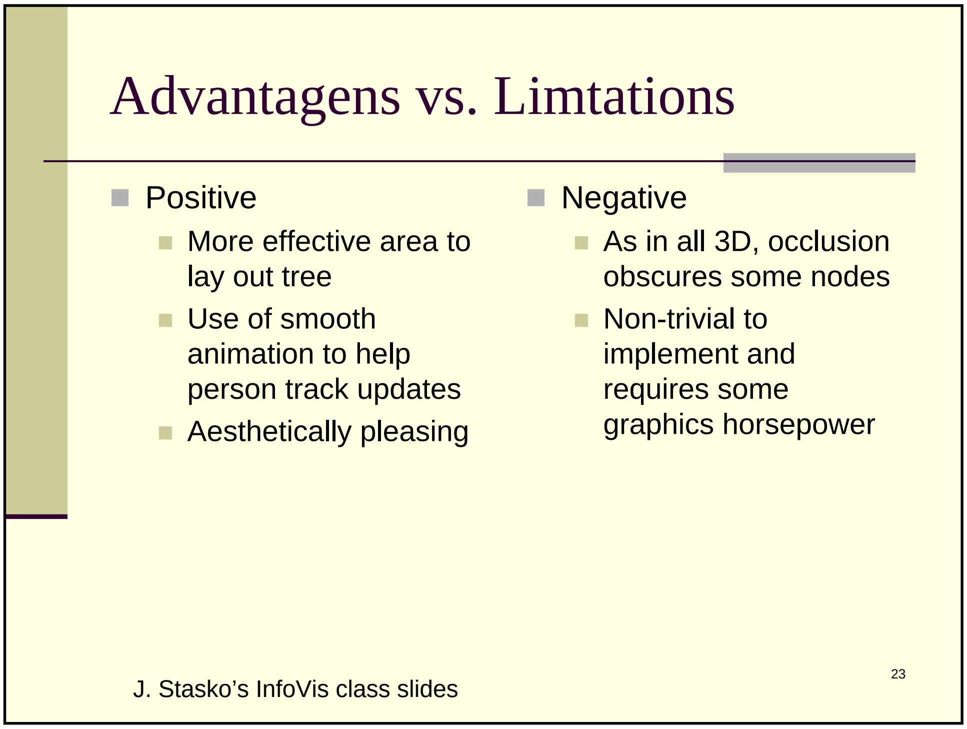


Robertson, Mackinlay, Card CHI ‘91

Alternative Views



Robertson, Mackinlay, Card CHI ‘91



Advantagens vs. Limtations

- Positive
  - More effective area to lay out tree
  - Use of smooth animation to help person track updates
  - Aesthetically pleasing
- Negative
  - As in all 3D, occlusion obscures some nodes
  - Non-trivial to implement and requires some graphics horsepower

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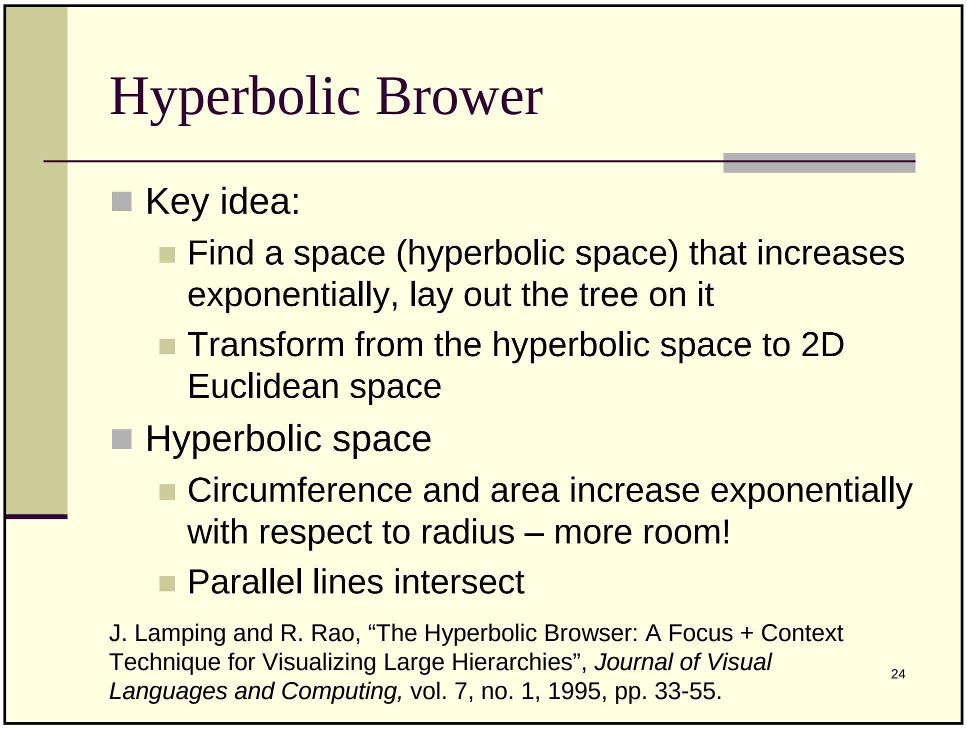

Hyperbolic Brower

- Key idea:
  - Find a space (hyperbolic space) that increases exponentially, lay out the tree on it
  - Transform from the hyperbolic space to 2D Euclidean space
- Hyperbolic space
  - Circumference and area increase exponentially with respect to radius – more room!
  - Parallel lines intersect

J. Lamping and R. Rao, "The Hyperbolic Browser: A Focus + Context Technique for Visualizing Large Hierarchies", *Journal of Visual Languages and Computing,* vol. 7, no. 1, 1995, pp. 33-55.

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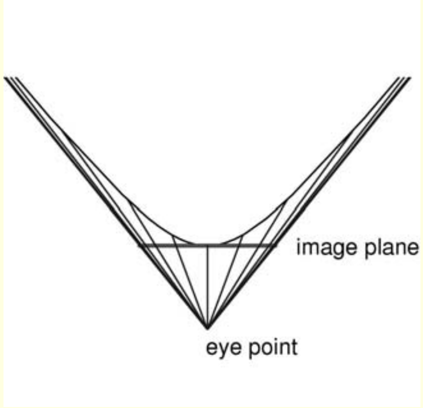
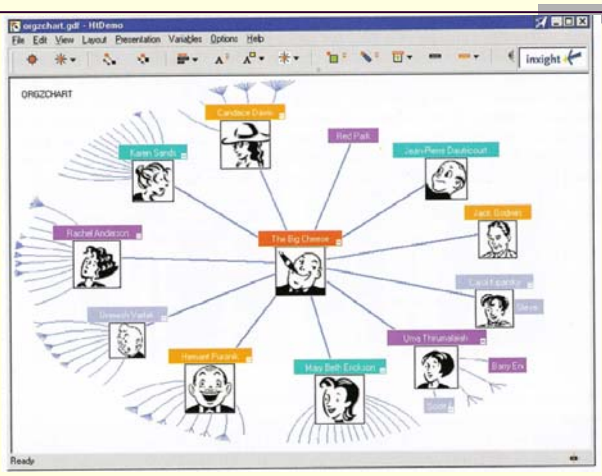
1-D Hyperbolic Projection



An illustration of the projective model for one-dimensional hyperbolic space.

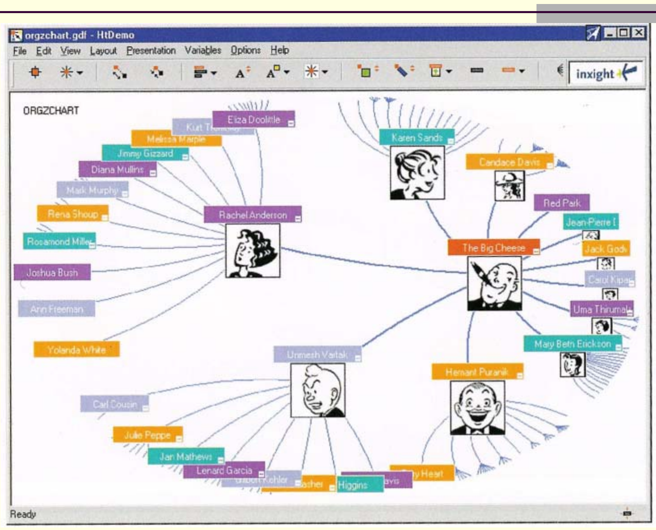
From Tamara Munzner's Ph.D. dissertation

Hyperbolic Brower



R. Spence. Information Visualization

Change Focus



Hyperbolic Brower

- Demo

http://www.inxight.com/VizServerDemos/demo/orgchart.html

Key Attributes

- Natural magnification (fisheye) in center
- Layout depends only on 2-3 generations from current node
- Smooth animation for change in focus
- Don’t draw objects when far enough from root (simplify rendering)

J. Stasko’s InfoVis class slides

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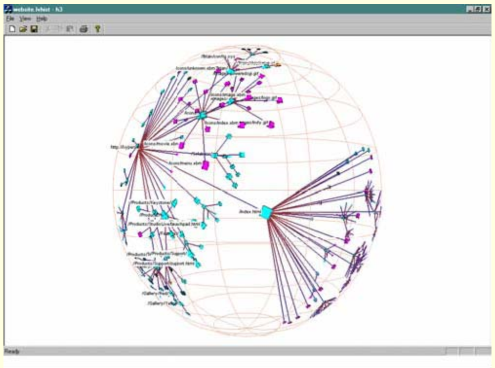
H3 Browser

- Use hyperbolic transformation in 3D space



Demo

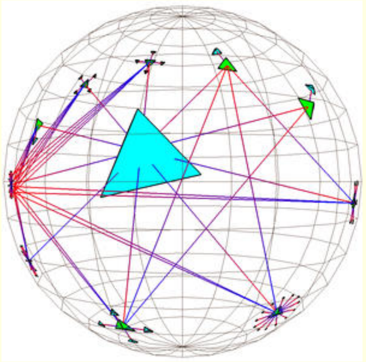
Tamara Munzner: H3: laying out large directed graphs in 3D hyperbolic space. INFOVIS 1997: 2-10

30

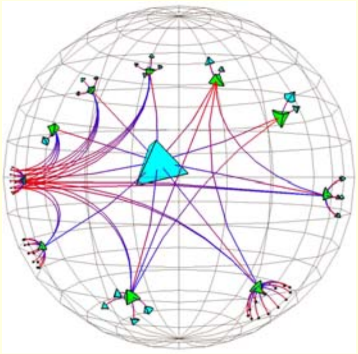
Layout

- Find a spanning tree from an input graph
  - Use domain-specific knowledge
- Layout algorithm
  - Nodes are laid out on the surface of hemispheres
  - A bottom-up pass to estimate the radius needed for each hemisphere
  - A top-down pass to place each child node on its parental hemisphere’s surface

Scalability - Model Selection



Projective model: keeps lines straight but distorts angles.



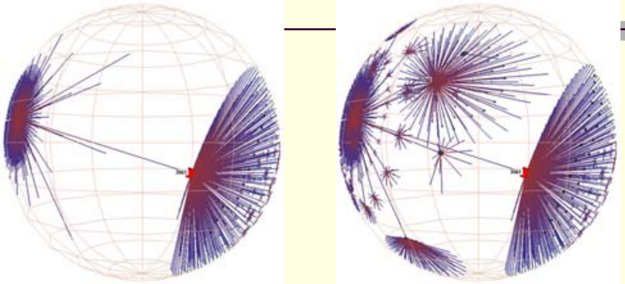
Conformal model: preserves angles but maps straight lines to circular arcs.

From Tamara Munzner’s Ph.D. dissertation

Projective vs. Conformal Model

- Projective model
  - Less aesthetically pleasing ☹
  - Transformation: 4X4 matrices ☺
  - Straight lines ☺
- Conformal model
  - More aesthetically pleasing ☺
  - Transformation: 2X2 complex matrices ☹
  - Curves ☹

Scalability - Adaptive Drawing



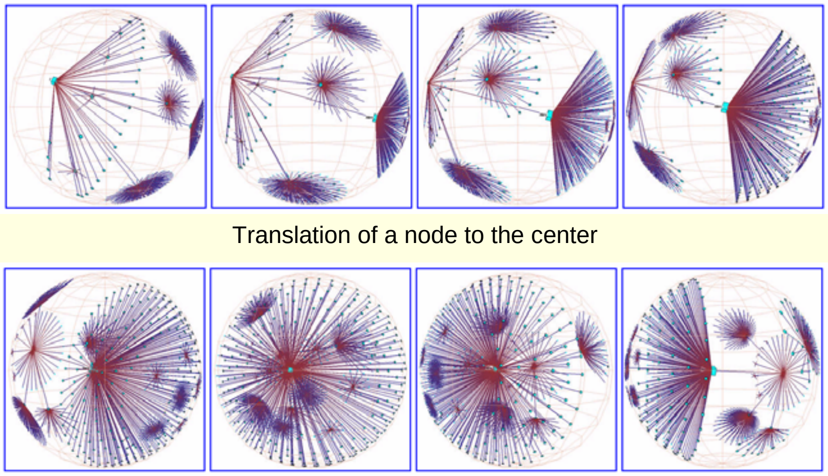
- Maintain a target frame rate
  - Draw only as much of the neighborhood around a center point as is possible in the allotted time
    - Unterminated links
  - Fill in scene fringe using several bounded idle frames when the user is idle
- Question: Why use several idle frames?

Movie 3

Scalability - Other Tricks

- Only draw a local neighborhood of nodes
  - Nodes sufficiently far from the center will project to less than a single pixel – terminate drawing when features project to subpixel areas
- Use front buffer for highlighting

Navigation

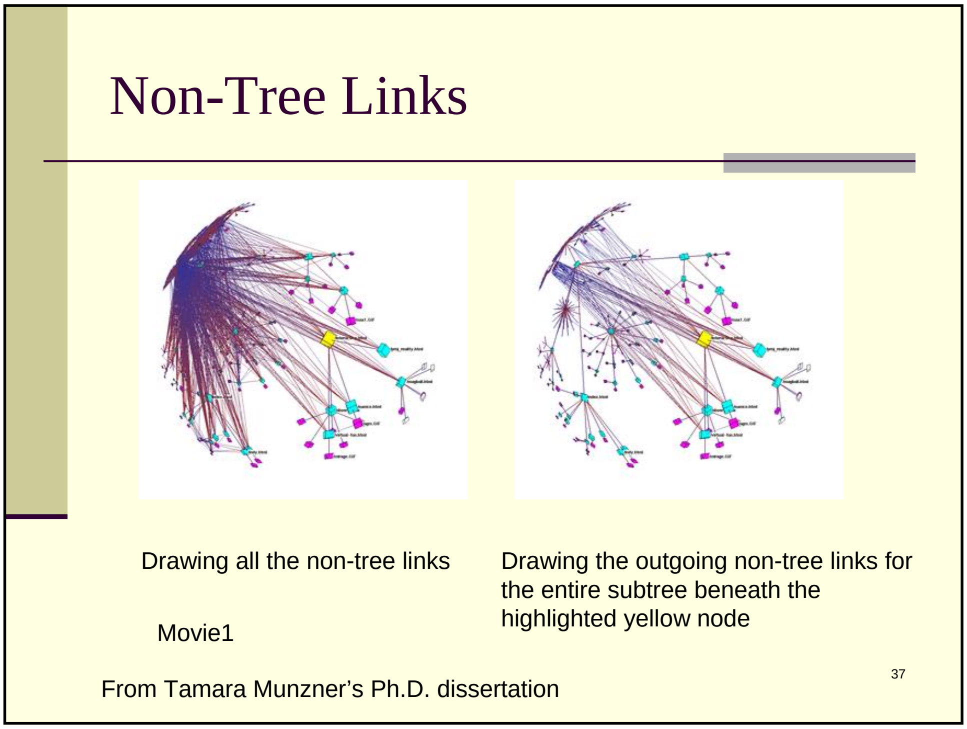


Translation of a node to the center

Movie0

Rotation around the same node

From Tamara Munzner's Ph.D. dissertation



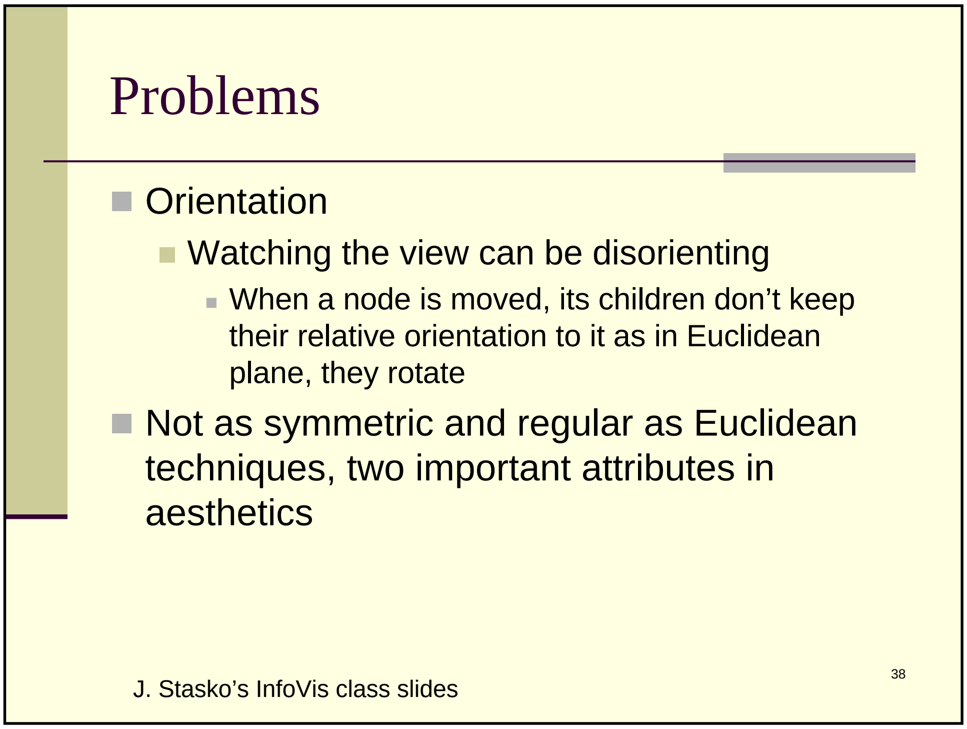
Non-Tree Links

Drawing all the non-tree links

Movie1

Drawing the outgoing non-tree links for the entire subtree beneath the highlighted yellow node

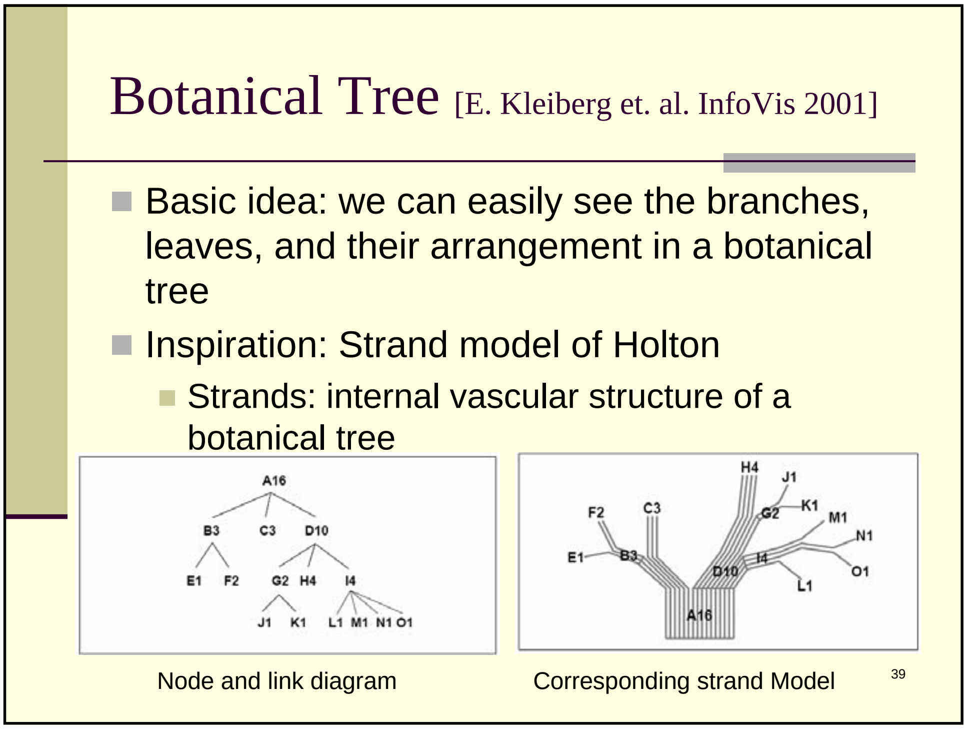
From Tamara Munzner’s Ph.D. dissertation



Problems

- Orientation
  - Watching the view can be disorienting
    - When a node is moved, its children don’t keep their relative orientation to it as in Euclidean plane, they rotate
- Not as symmetric and regular as Euclidean techniques, two important attributes in aesthetics

J. Stasko’s InfoVis class slides

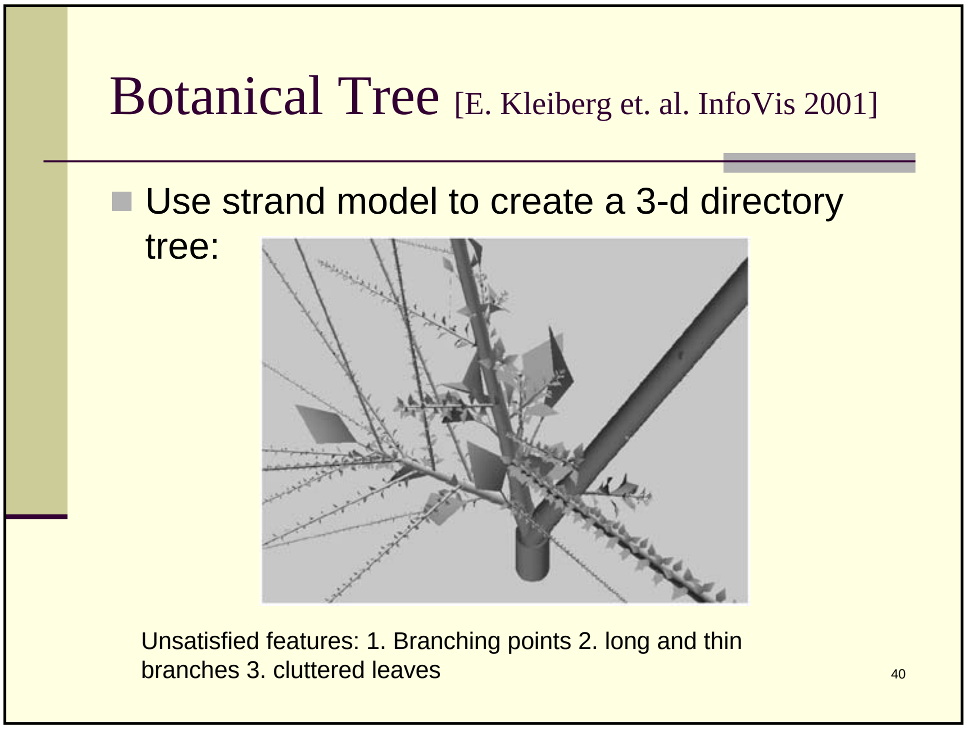


Botanical Tree [E. Kleiberg et. al. InfoVis 2001]

- Basic idea: we can easily see the branches, leaves, and their arrangement in a botanical tree
- Inspiration: Strand model of Holton
  - Strands: internal vascular structure of a botanical tree

Node and link diagram

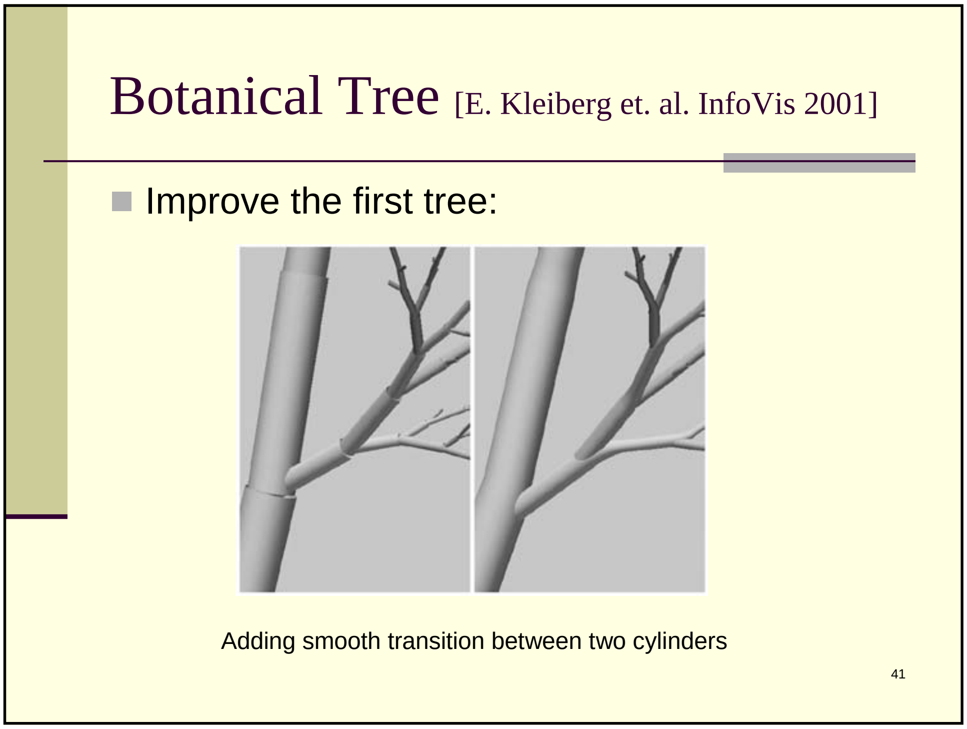
Corresponding strand Model



Botanical Tree [E. Kleiberg et. al. InfoVis 2001]

- Use strand model to create a 3-d directory tree:

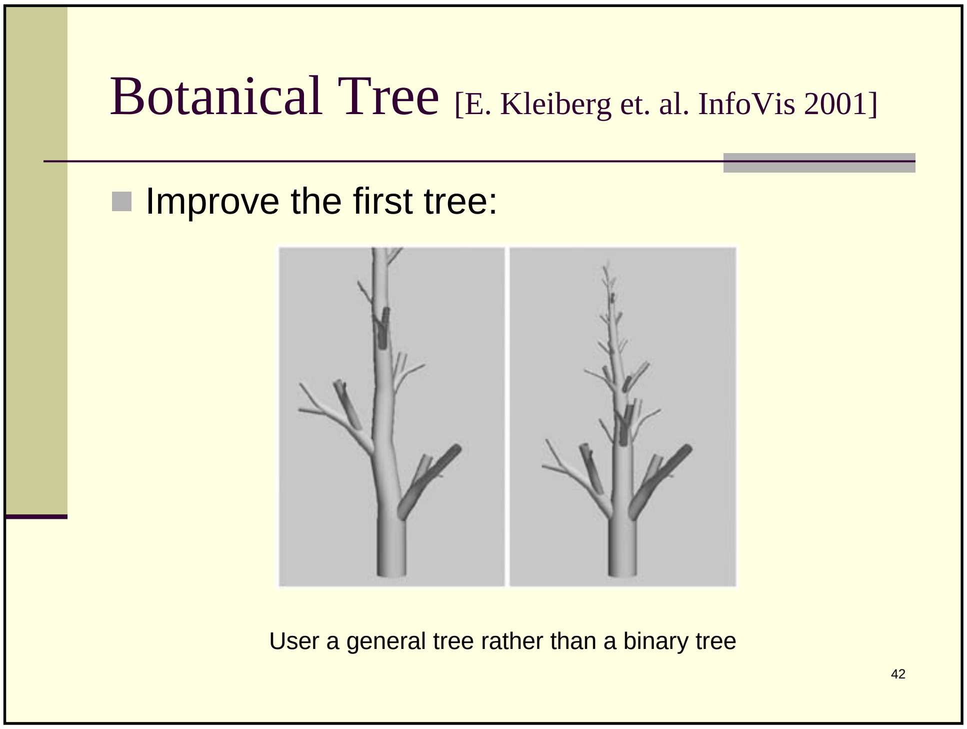
Unsatisfied features: 1. Branching points 2. long and thin branches 3. cluttered leaves



Botanical Tree [E. Kleiberg et. al. InfoVis 2001]

- Improve the first tree:

Adding smooth transition between two cylinders



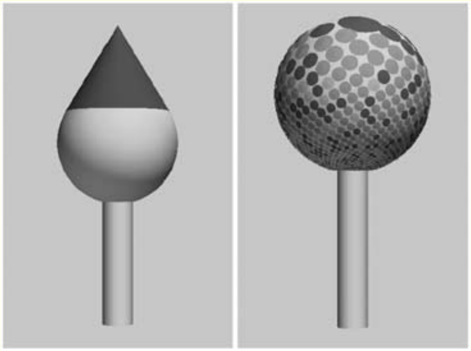
Botanical Tree [E. Kleiberg et. al. InfoVis 2001]

- Improve the first tree:

User a general tree rather than a binary tree

Botanical Tree [E. Kleiberg et. al. InfoVis 2001]

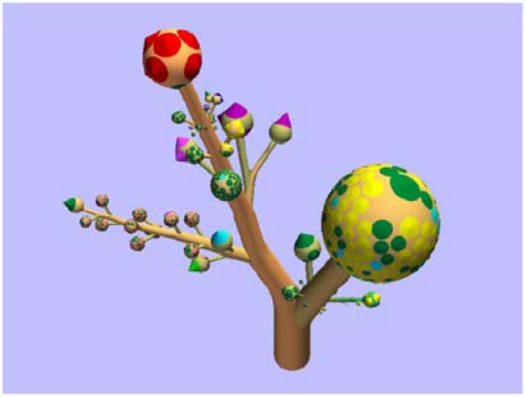
- Improve the first tree:



Phi-ball with one (left) and many (right) files

Botanical Tree [E. Kleiberg et. al. InfoVis 2001]

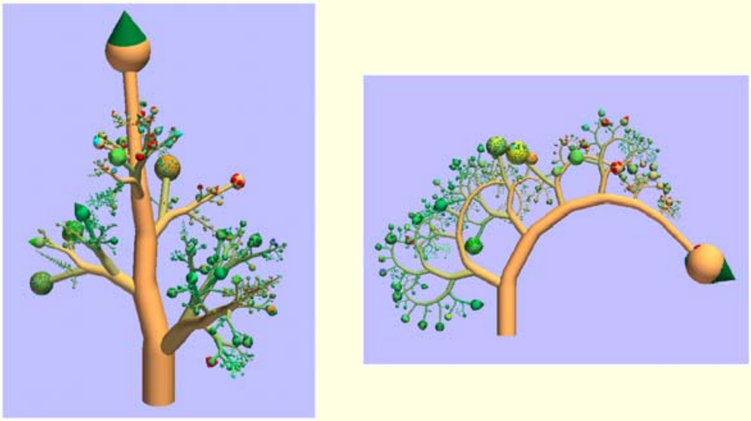
- Botanical tree:



Final model with the improvements

Botanical Tree [E. Kleiberg et. al. InfoVis 2001]

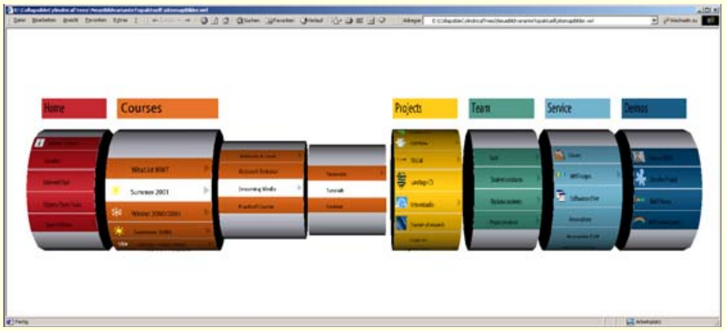
- Botanical tree:



The same directory with different settings

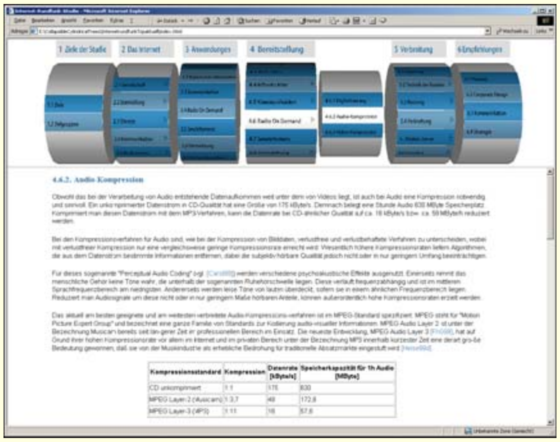
Collapsible Cylindrical Tree [Dachselt & Ebert Infovis 01]

- Basic idea: use a set of nested cylinders according to the telescope metaphor
- Limitation: one path is visible in once
- Interactions: rotation, go down/up



Collapsible Cylindrical Tree [R. Dachselt, J. Ebert Infovis 01]

- Example application: web document browing



4.6.2. Audio Kompression

Obwohl das bei der Verarbeitung von Audio entstehende Datenaufkommen weit unter dem von Videos liegt, ist auch bei Audio eine Kompression notwendig und sinnvoll. Ein unkomprimierter Datenstrom in CD-Qualität hat eine Größe von 175 kByte/s. Demnach belegt eine Stunde Audio 630 MByte Speicherplatz. Komprimiert man diesen Datenstrom mit dem MP3-Verfahren, kann die Datenrate bei CD-ähnlicher Qualität auf ca. 16 kByte/s bzw. ca. 58 MByte/h reduziert werden.

Bei den Kompressionsverfahren für Audio sind, wie bei der Kompression von Bilddaten, verlustfreie und verlustbehaftete Verfahren zu unterscheiden, wobei mit verlustfreier Kompression nur eine vergleichsweise geringe Kompressionsrate erreicht wird. Wesentlich höhere Kompressionsraten liefern Algorithmen, die aus dem Datenstrom bestimmte Informationen entfernen, dabei die subjektiv hörbare Qualität jedoch nicht oder in nur geringem Umfang beeinträchtigen.

Für dieses sogenannte "Perceptual Audio Coding" (vgl. [Card00]) werden verschiedene psychoakustische Effekte ausgenutzt. Einerseits nimmt das menschliche Gehör keine Töne wahr, die unterhalb der sogenannten Ruhehörschwelle liegen. Diese verläuft frequenzabhängig und ist im mittleren Sprachfrequenzbereich am niedrigsten. Andererseits werden leise Töne von lauten überdeckt, sofern sie in einem ähnlichen Frequenzbereich liegen. Reduziert man Audiosignale um diese nicht oder in nur geringem Maße hörbaren Anteile, können außerordentlich hohe Kompressionsraten erzielt werden.

Das aktuell am besten geeignete und am weitesten verbreitete Audio-Kompressions-verfahren ist im MPEG-Standard spezifiziert. MPEG steht für "Motion Picture Expert Group" und bezeichnet eine ganze Familie von Standards zur Kodierung audio-visueller Informationen. MPEG Audio Layer 2 ist unter der Bezeichnung Musicam bereits seit län-gerer Zeit im professionellen Bereich im Einsatz. Die neueste Entwicklung, MPEG Audio Layer 3 [FhG00], hat auf Grund ihrer hohen Kompressionsrate vor allem im Internet und im privaten Bereich unter der Bezeichnung MP3 innerhalb kürzester Zeit eine derart gro-ße Bedeutung gewonnen, daß sie von der Musikindustrie als erhebliche Bedrohung für traditionelle Absatzmärkte eingestuft wird [Heise99d].

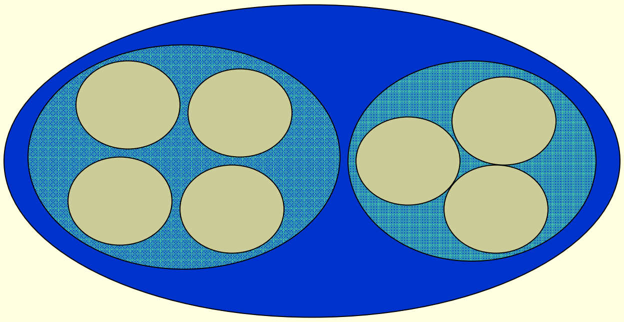
Kompressionsstandard	Kompression	Datenrate [kByte/s]	Speicherkapazität für 1h Audio [MByte]
CD unkomprimiert	1:1	175	630
MPEG Layer-2 (Musicam)	1:3,7	48	172,8
MPEG Layer-3 (MP3)	1:11	16	57,6

Unbekannte Zone (Gemischt)

Space-Filling Techniques

Space-Filling Techniques

- Each item occupies an area
- Children are “contained” within parent



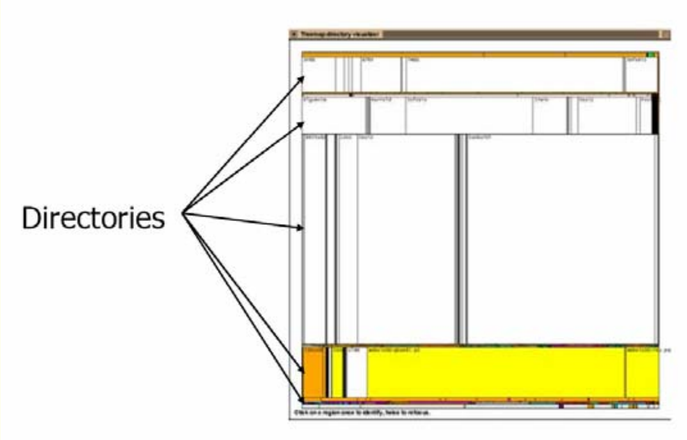
Treemap

- Children are drawn inside their parents
- Alternative horizontal and vertical slicing at each successive level
- Use area to encode other variables of data items

B. Johnson, Ben Shneiderman: Tree maps: A Space-Filling Approach to the Visualization of Hierarchical Information Structures. IEEE Visualization 1991: 284-291

Treemap

- Example



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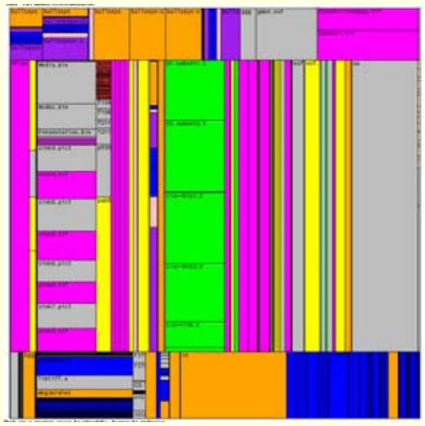
Treemap

- Example



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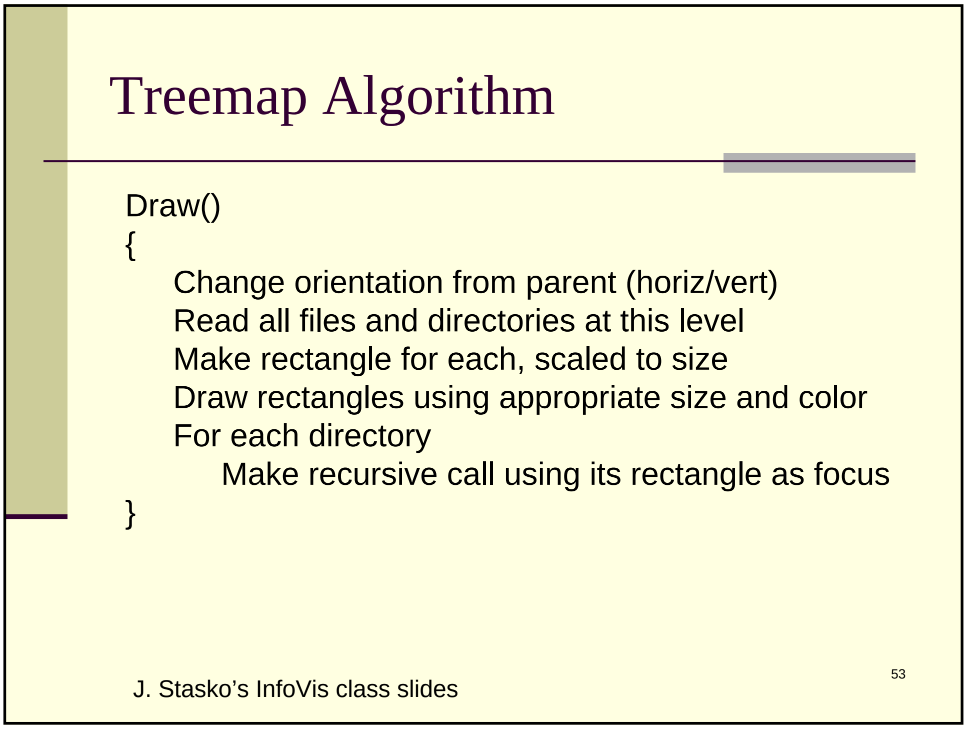

Treemap Algorithm

```
Draw()
{
    Change orientation from parent (horiz/vert)
    Read all files and directories at this level
    Make rectangle for each, scaled to size
    Draw rectangles using appropriate size and color
    For each directory
        Make recursive call using its rectangle as focus
}
```

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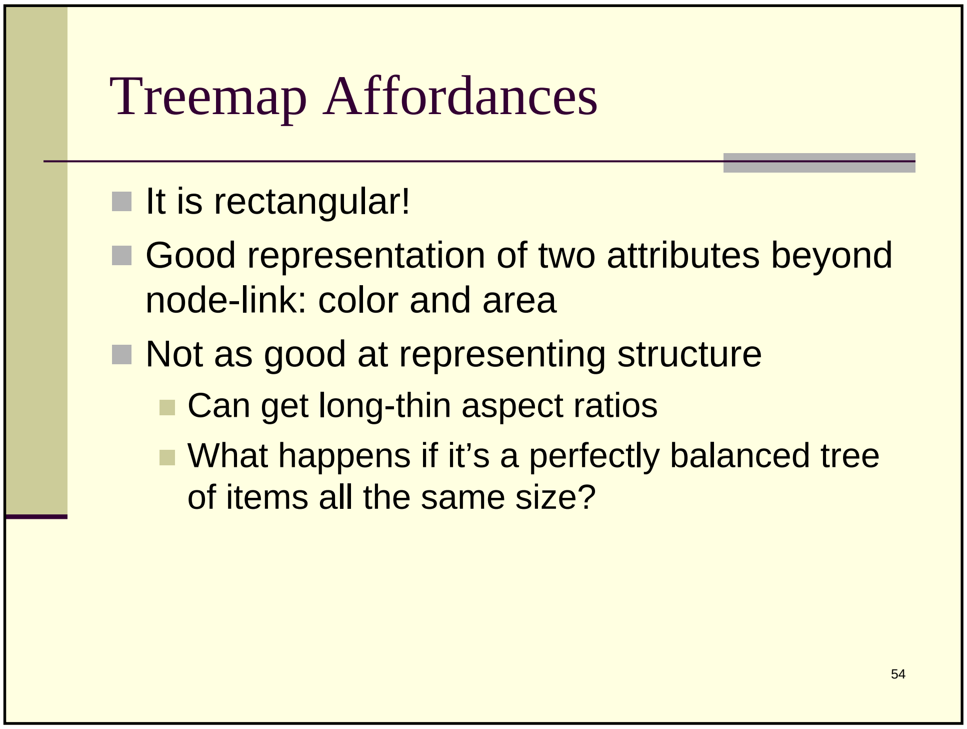
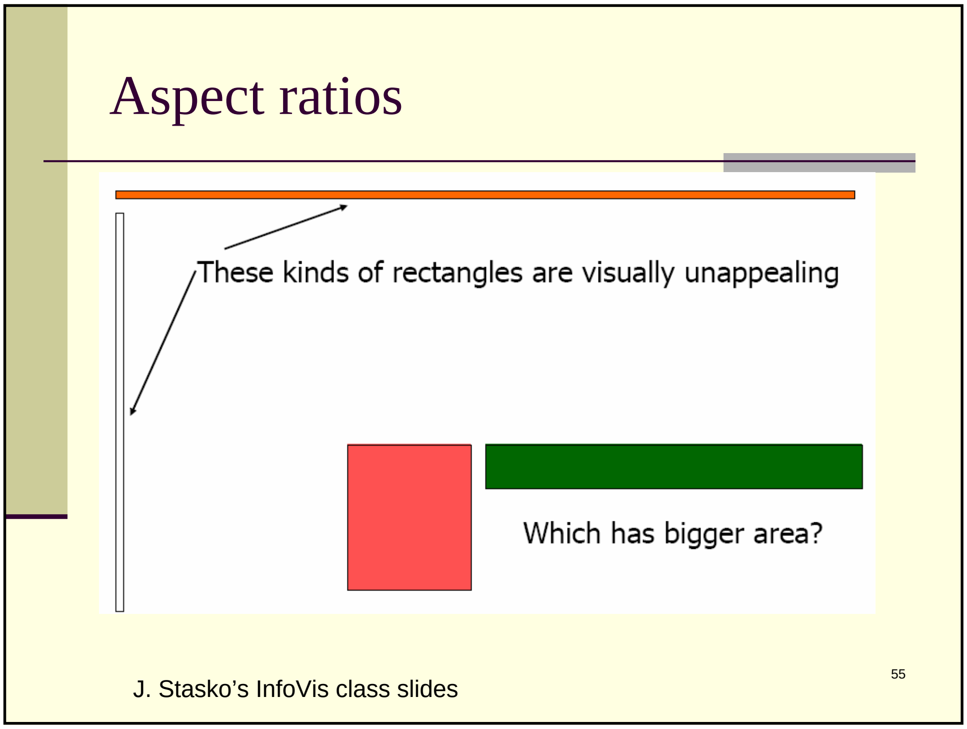


Treemap Affordances

- It is rectangular!
- Good representation of two attributes beyond node-link: color and area
- Not as good at representing structure
  - Can get long-thin aspect ratios
  - What happens if it’s a perfectly balanced tree of items all the same size?



Aspect ratios

These kinds of rectangles are visually unappealing

Which has bigger area?

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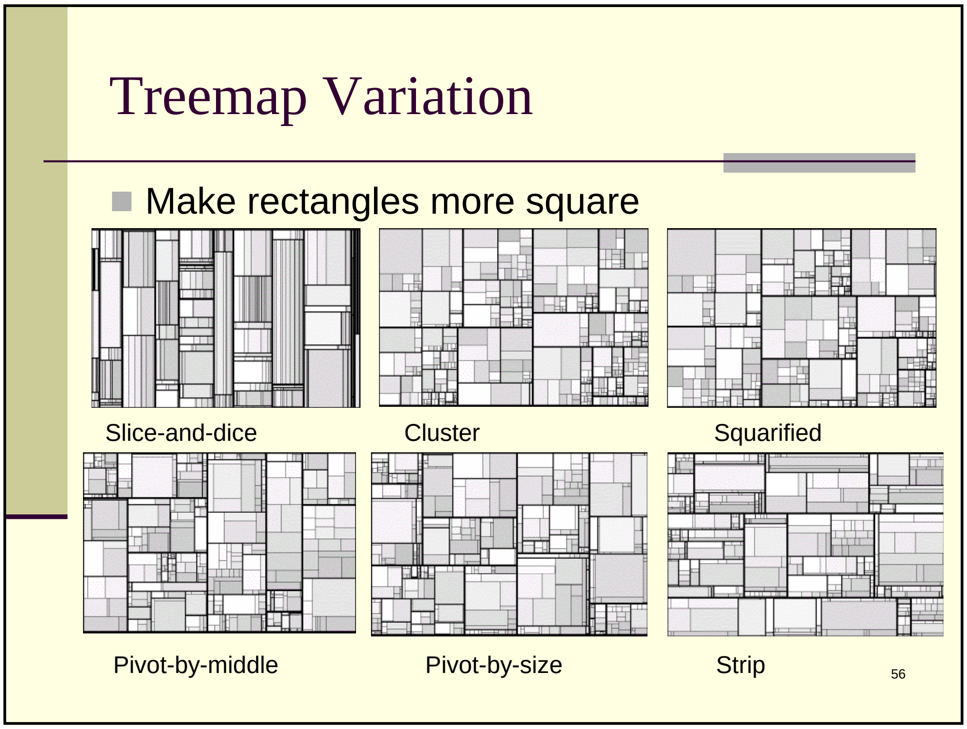

Treemap Variation

- Make rectangles more square

Slide-and-dice

Cluster

Squarified

Pivot-by-middle

Pivot-by-size

Strip

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Showing Structure

- Borderless treemap: hard to discern structure of hierarchy
  - What happens if it's a perfectly balanced tree of items all the same size?
- Variations:
  - Use border
  - Change rectangles to other forms

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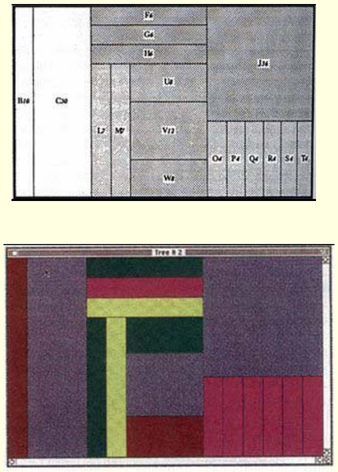
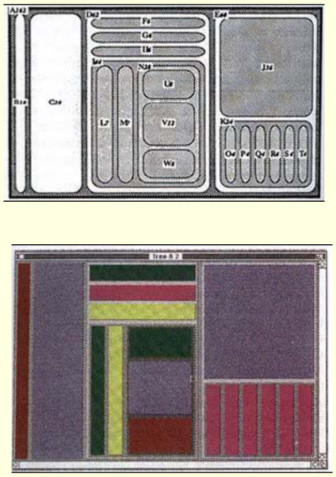
Nested vs. Non-nested



Non-nested Treemap



Nested Treemap

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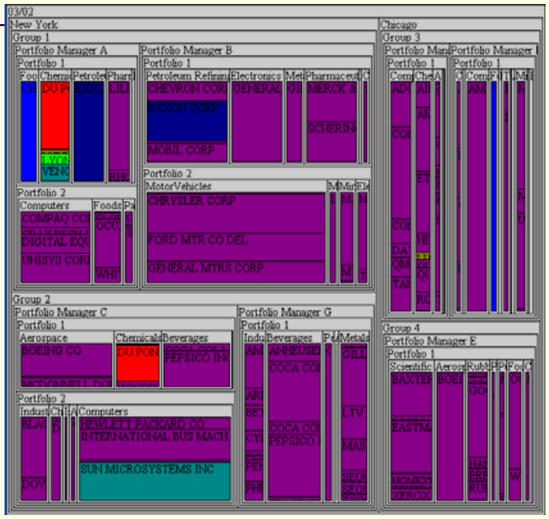
Nested Treemap

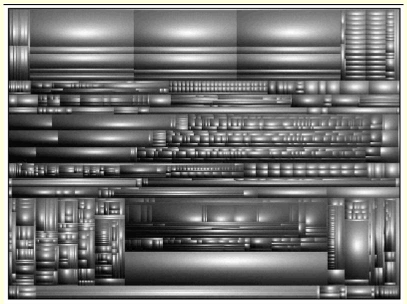
- Borders help on smaller trees, but take up too much area on large, deep ones

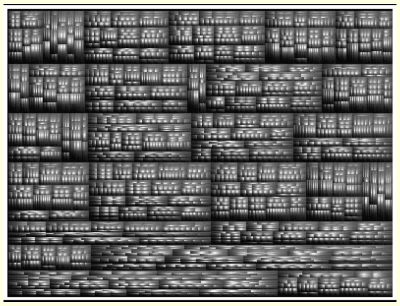


http://www.cs.umd.edu/hcil/treemap-history/treemap97.shtml

Cushion Treemap

- Add shading and texture (Van Wijk and Van de Wetering InfoVis’99)

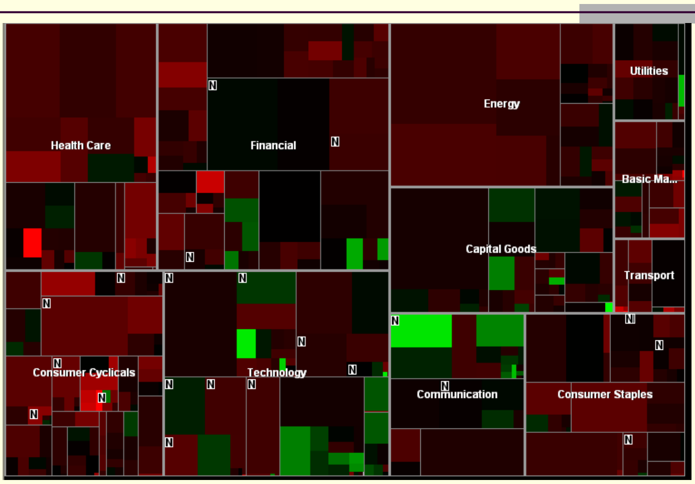




Treemap Applications

- Software visualization
- Tennis matches
- File/directory structures
- Basketball statistics
- Stocks and portfolios

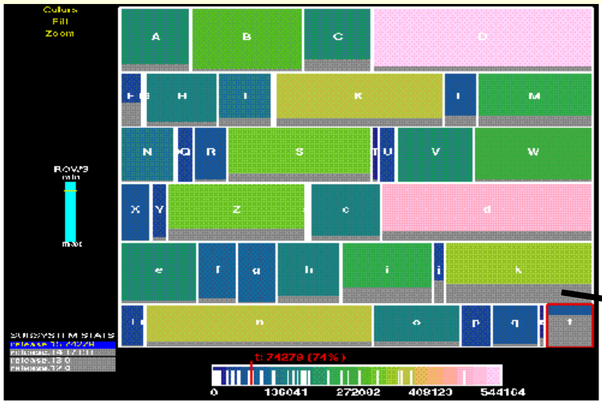
Marketmap



http://www.smartmoney.com/marketmap/

Software Visualization

- SeeSys (Baker & Eick, AT&T Bell Labs)

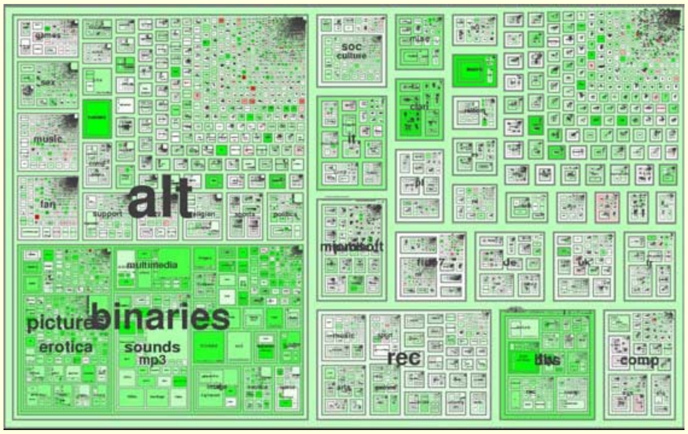


New code in this release

Figure 2: NCSL and new development by subsystem in a recent release.

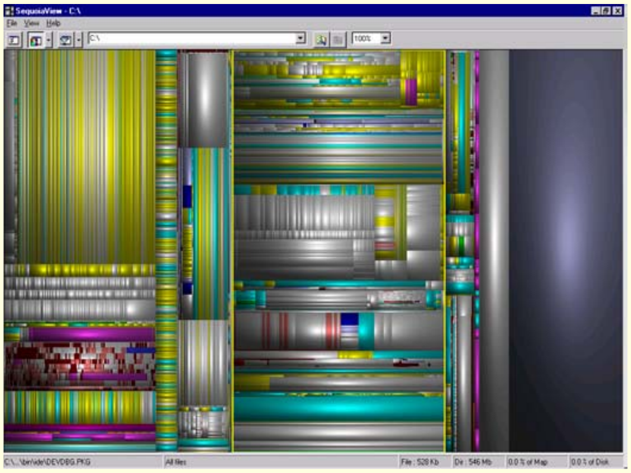
Internet News Groups

- Netscan (Fiore & Smith Microsoft)

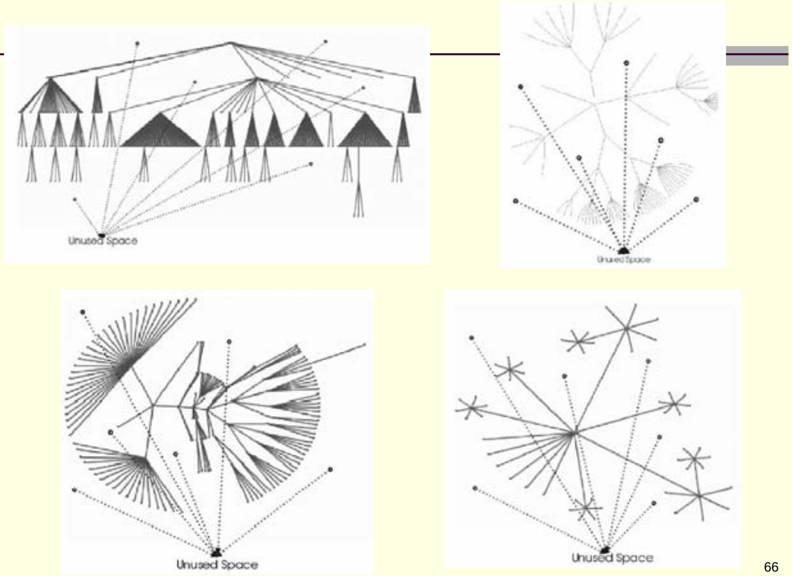


SequoiaView

- File visualizater www.win.tue.nl/sequoiaview/



Space-Optimized Tree - Motivation

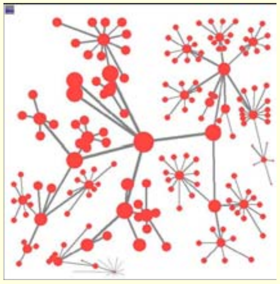


Q. Nguyen and M. Huang Infovis 02

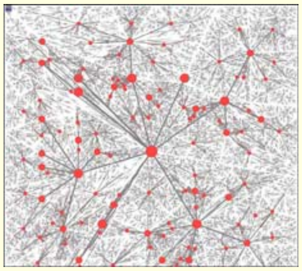
Space-Optimized Tree [Q. Nguyen and M. Huang Infovis 02]

Key idea:

- Partition display space into a collection of geometrical areas for all nodes
- Use node-link diagrams to show relational structure



Example: Tree with 150 nodes



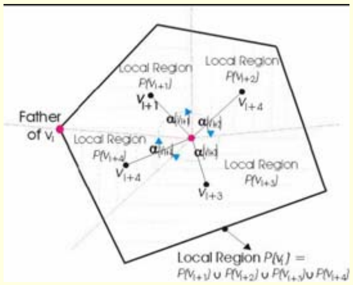
Example: Tree with approximately 55000 nodes

Space-Optimized Tree

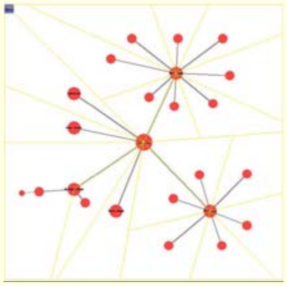
Area division:

$$w(v_i) = 1 + C\sum_{j=0}^{k-1} w(v_{l+j})$$

$$\alpha(v_{l+m}) = A\frac{w(v_{l+m})}{\sum_{j=0}^{k} w(v_{l+j})}$$



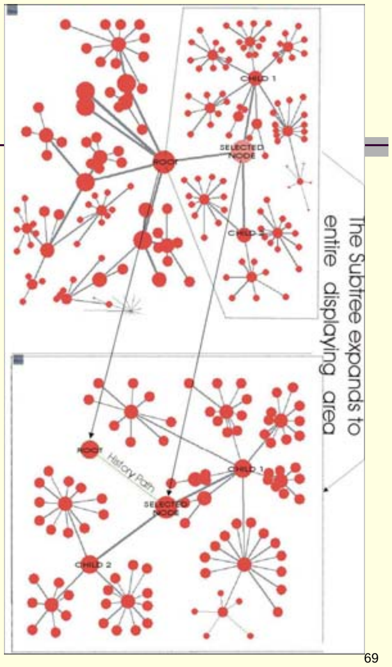
Example of dividing the local region of one node



Example: Tree with approximately 55000 nodes

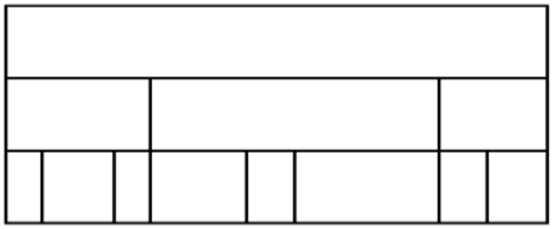
Space-Optimized Tree

- Zooming by mouse clicking
- Animation during zooming



Space-Filling Techniques

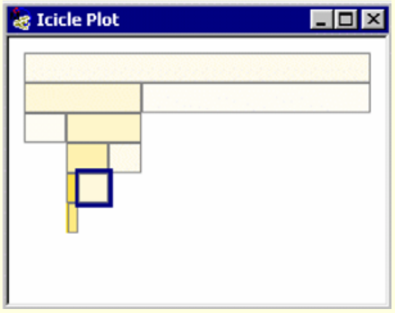
- Each item occupies an area
- Children are “contained” within (under) parent

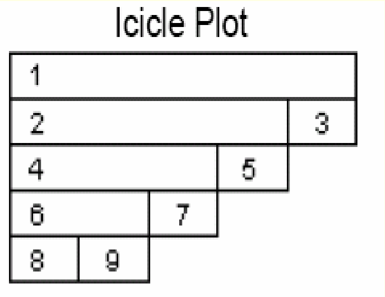


One Example

Icicle Plot

- Icicle plot (similar to Kleiner and Hartigan's concept of castles)
  - Node size is proportional to node width





Barlow and Neville InfoVis 2001

Radial Space Filing Techniques

- InterRing [Yang02]