

Hierarchies and Trees

CS 4460 - Introduction to Information Visualization
Spring, 2019
Alex Endert

last time

- we talked about graphs
- basic terminology
- nodes and edges can have attributes
- examples of graph visualizations
- tables, matrixes

Hierarchies

- Definition
 - Data repository in which cases (data items) are related to sub-cases
 - Can be thought of as **imposing an ordering** in which items are parents or ancestors of other items
 - All nodes have an in-degree = 1, except root node, which does not have an in-degree (in-degree of 0)
 - Leaf nodes have an out-degree = 0
 - Binary tree has out degree maximum = 2

Hierarchies in the World

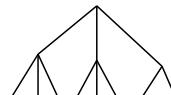
- Pervasive
 - Family histories, ancestries
 - File/directory systems on computers
 - Organization charts
 - Animal kingdom: Phylum,..., genus,...
 - Object-oriented software classes
 - ...

Trees

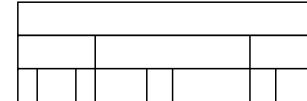
- Hierarchies often represented as trees
 - Directed, acyclic graph
 - Just like graphs, can have attributes on the nodes and/or links

Visualizing Trees – Four Methods

- **Node-link** we will cover these two in more detail



- **Space-filling**



- Connectivity matrix

- For this case, a 12x12 binary matrix (12 nodes in tree)

- Indented list

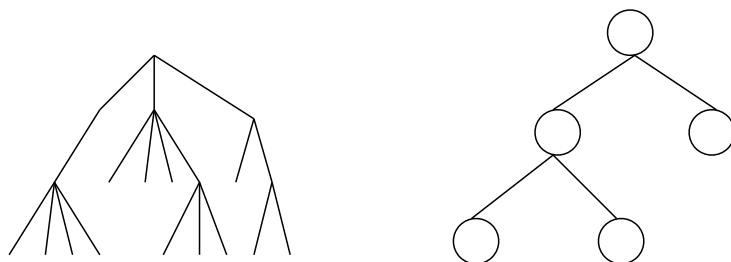
- Many many more, see

- <http://www.informatik.uni-rostock.de/~hs162/treeposter/poster.html>

Node-link approach

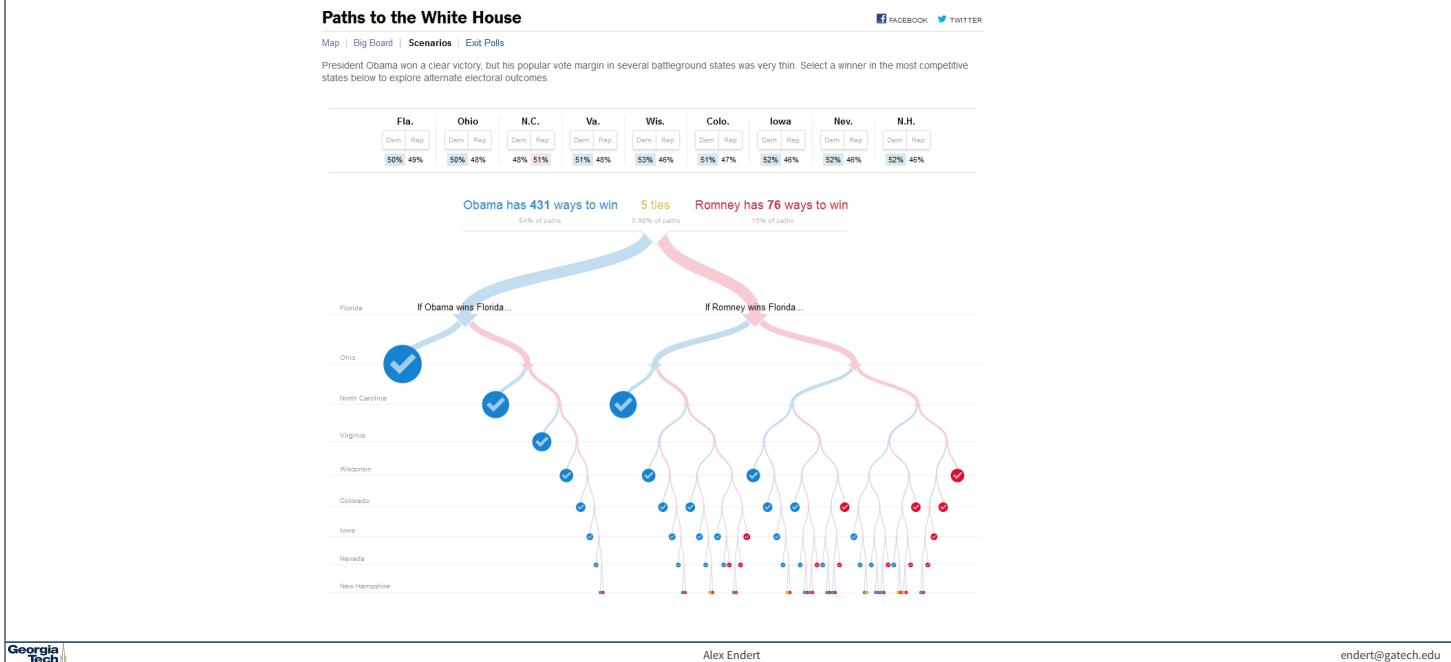
Node-Link Diagrams

- **Root** at top, **leaves** at bottom is very common (but you could lay this out differently)



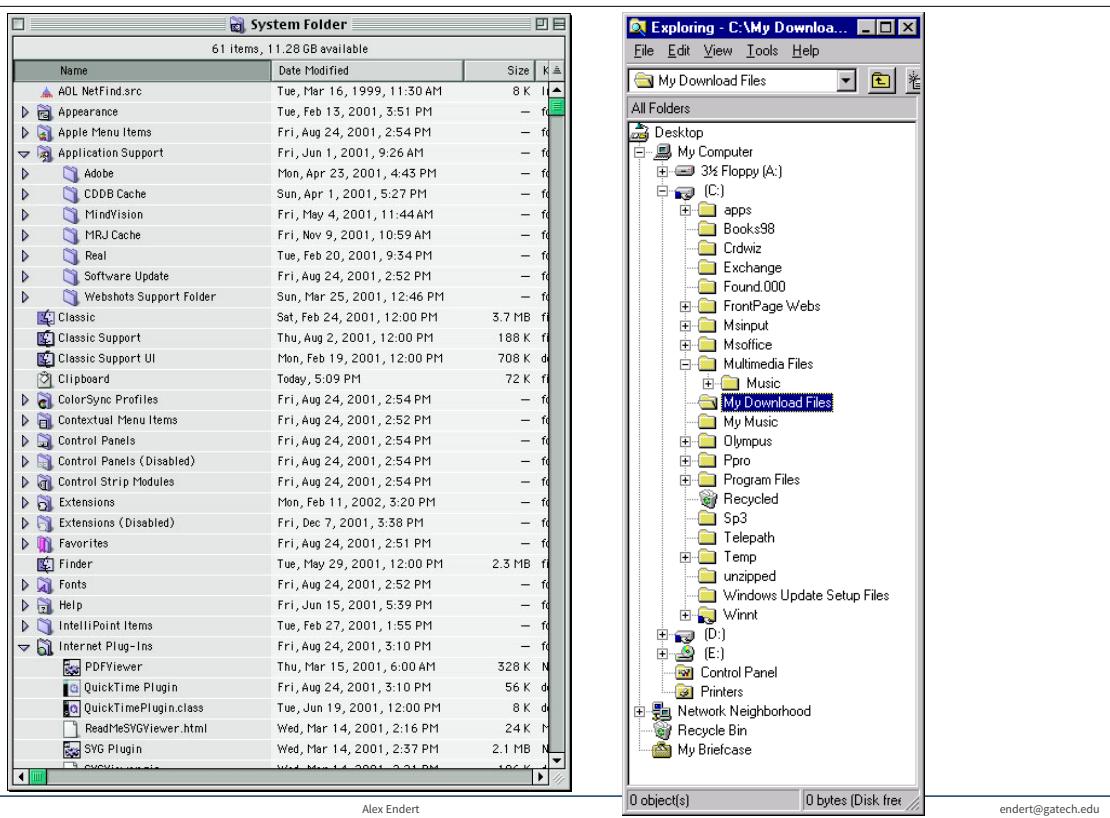
<http://elections.nytimes.com/2012/results/president/scenarios>

Election '12



Georgia Tech | Alex Endert | endert@gatech.edu

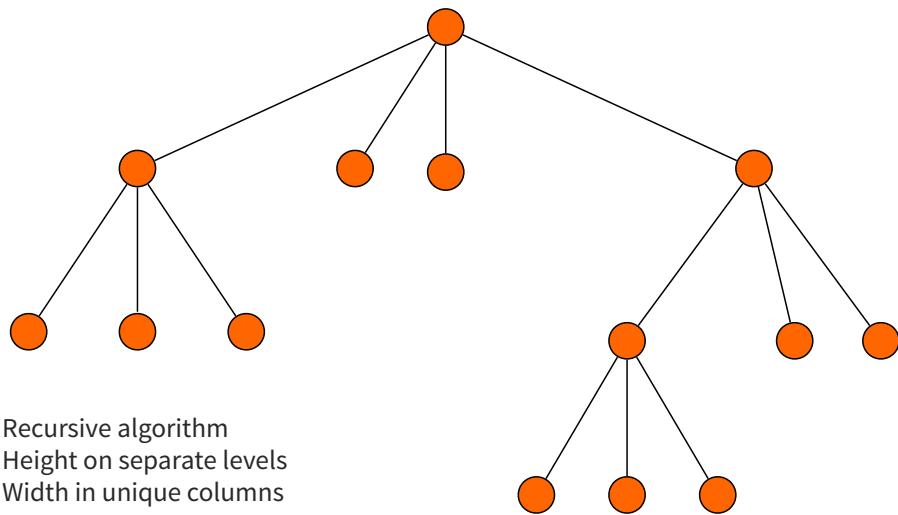
Examples Indented Lists



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Basic Layout Algorithm



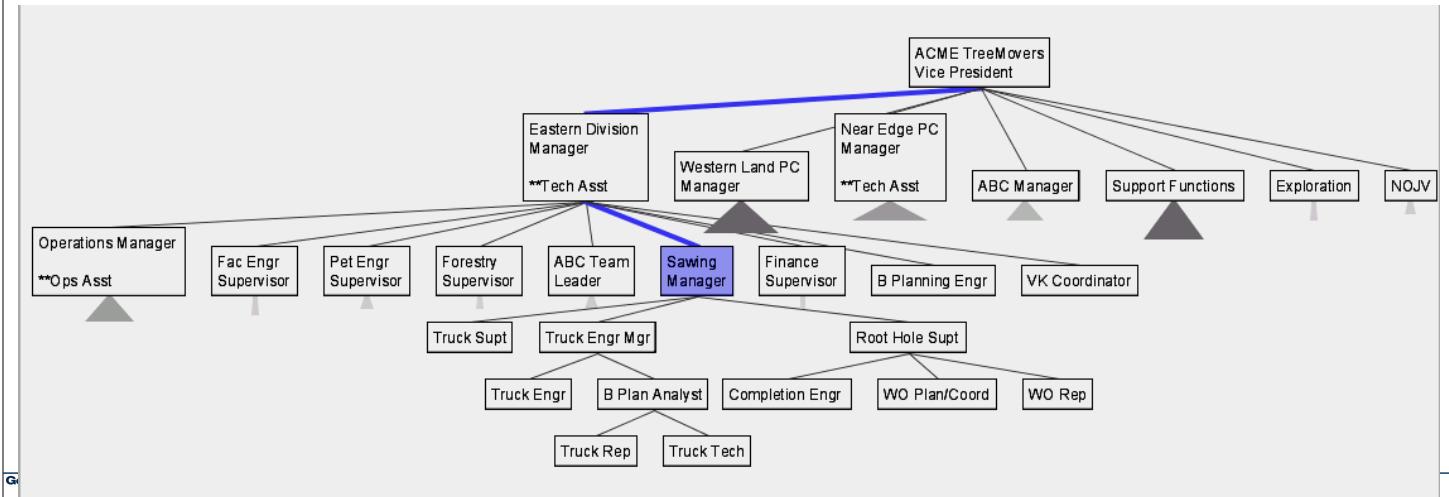
Potential Problems

- For top-down, width of fan-out **uses up horizontal real estate** very quickly
- Tree might **grow a lot along one particular branch**
 - Hard to draw it well in view without knowing how it will branch
- Just like graphs, there are **lots of layout algorithms**. We are not going to go over them in detail.

SpaceTree

Grosjean, Plaisant, Bederson
InfoVis '02

- Uses conventional 2D layout techniques with some clever additions
 - aggregation of sub-trees into triangles (of “fans”)



Characteristics

- Vertical or horizontal
- Subtrees are **triangles**
 - **Size** indicates depth
 - **Shading** indicates number of nodes inside
- Navigate by clicking on nodes
 - Strongly restrict zooming

3D Approaches

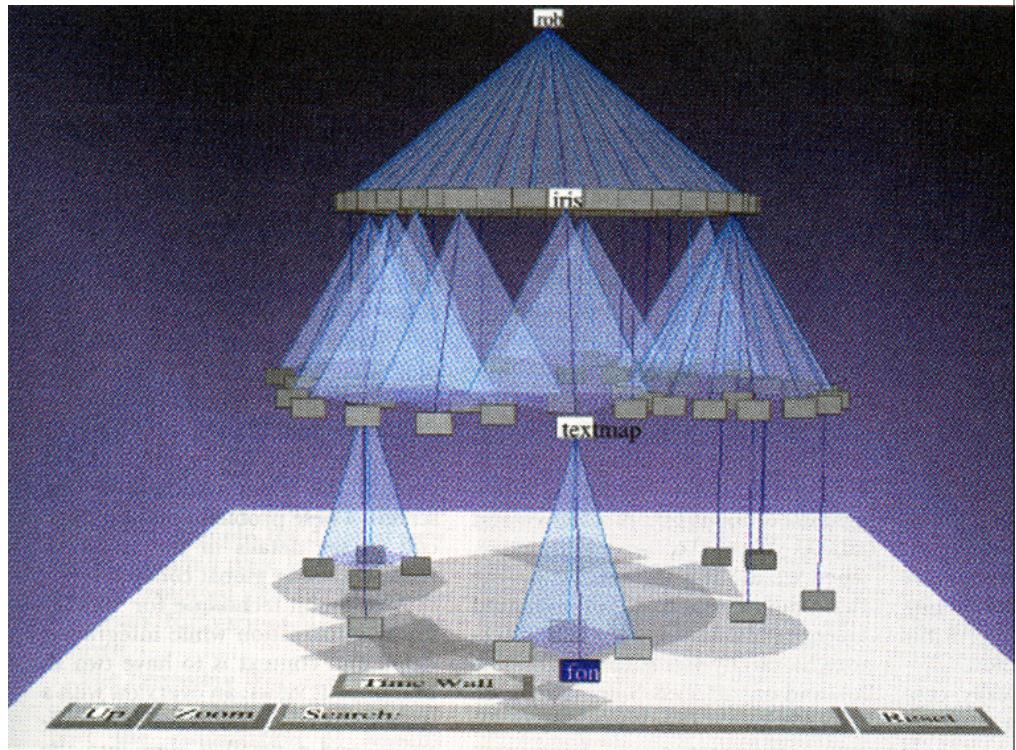
- Add a third dimension into which layout can go
- Compromise of top-down and centered techniques mentioned earlier
- Children of a node are laid out in a cylinder “below” the parent
 - Siblings live in one of the 2D planes

Cone Trees

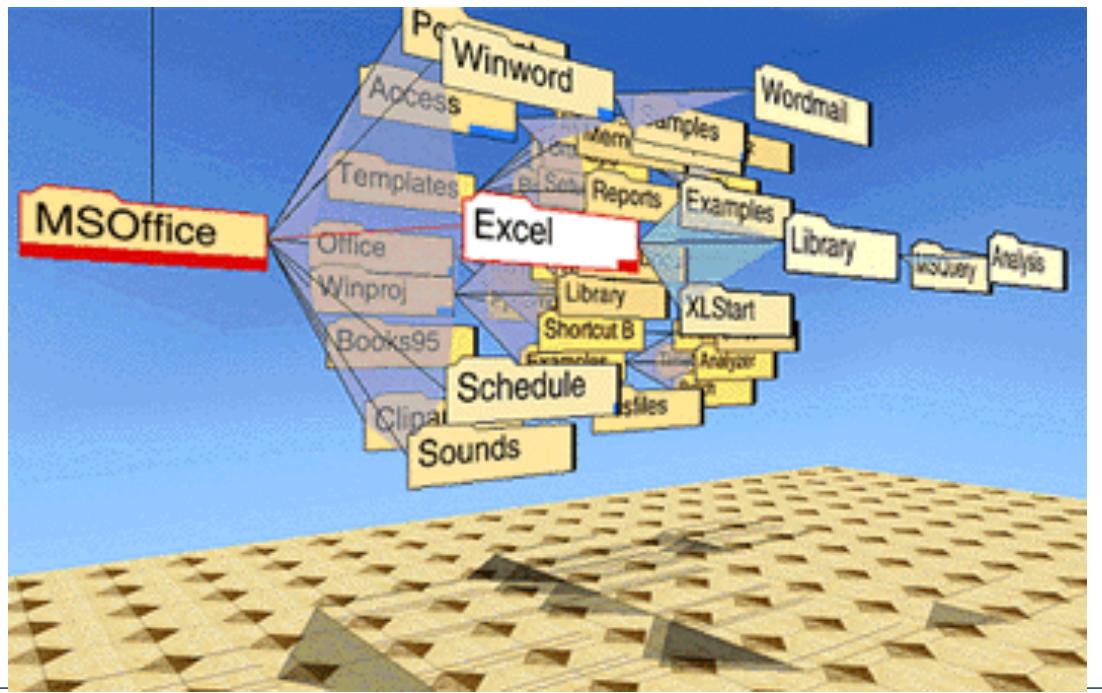
Developed at
Xerox PARC

3D views of
hierarchies
such as file
systems

Robertson, Mackinlay, Card
CHI '91



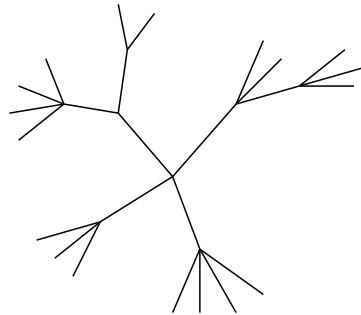
Alternate Views



Cone Trees

- Pros
 - More effective area to lay out tree
 - Use of smooth animation to help person track updates
 - Aesthetically pleasing (if done correctly)
 - Cons
 - As in all 3D, occlusion obscures some nodes
 - Non-trivial to implement and interaction/navigation may lead to usability issues

Why Put Root at Top?



Root can be at center with levels growing outward too

Alternative Solutions

- Change the geometry
- Apply a hyperbolic transformation to the space
- Root is at center, subordinates around
- Apply idea recursively, distance decreases between parent and child as you move farther from center, children go in wedge rather than circle

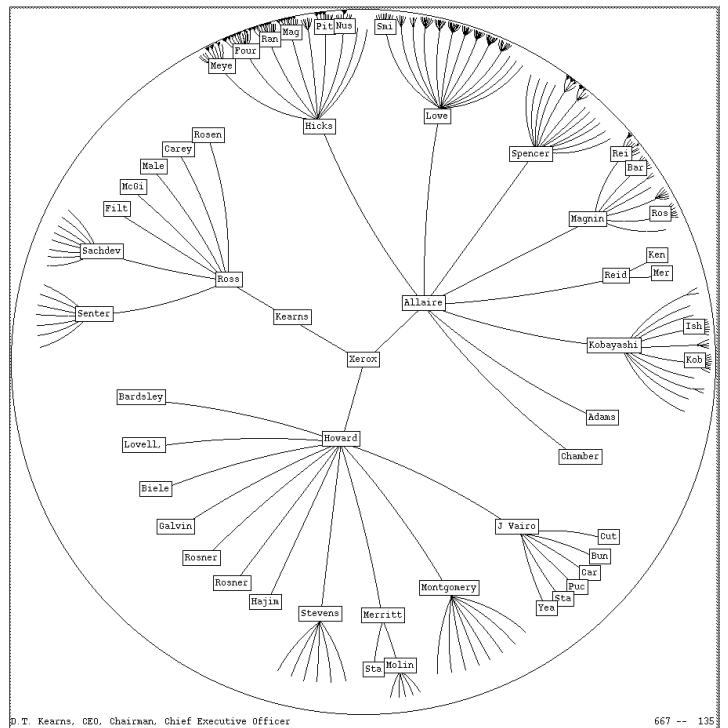
Hyperbolic Browser

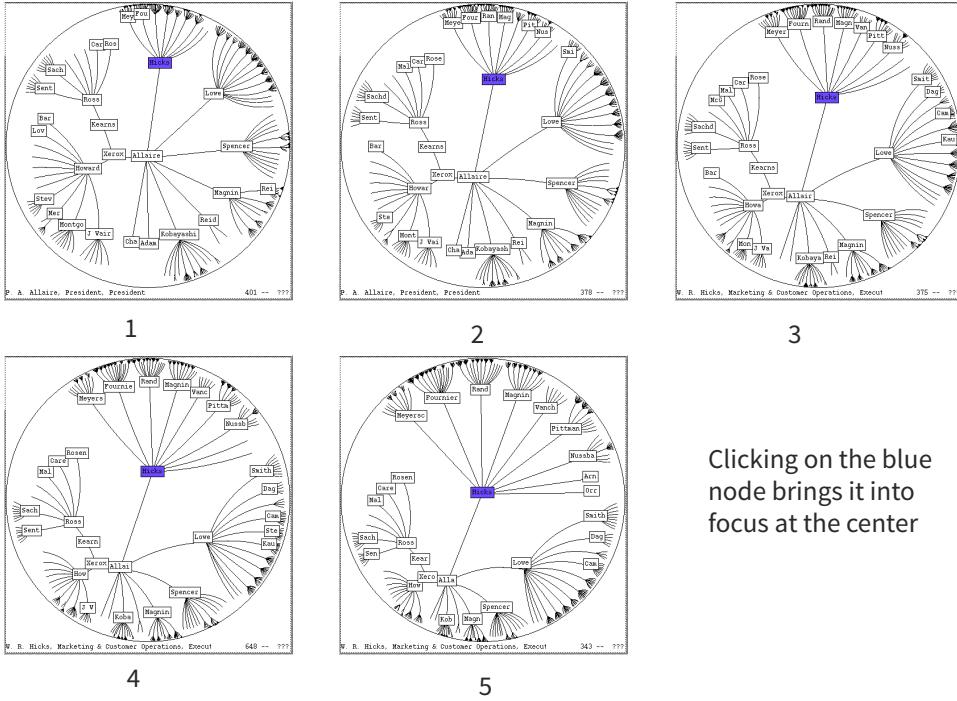
- Focus + Context Technique
 - Detailed view blended with a global view
 - First lay out the hierarchy on the hyperbolic plane
 - Then map this plane to a disk
 - Start with the tree's root at the center
 - Use animation to navigate along this representation of the plane

Lamping and Rao,
JVLC '96

2D Hyperbolic Browser

- Approach: Lay out the hierarchy on the hyperbolic plane and map this plane onto a display region.
 - Comparison
 - A standard 2D browser: 100 nodes (w/3 character text strings)
 - Hyperbolic browser: 1000 nodes, about 50 nearest the focus can show from 3 to dozens of characters





Potential Problems

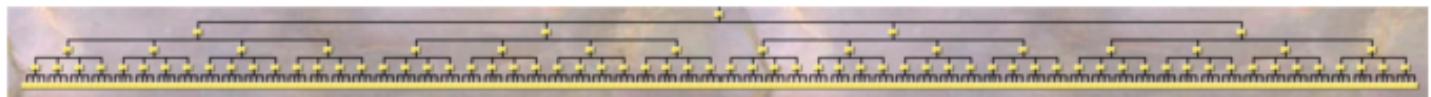
- Orientation
 - Watching the view can be disorienting
 - When a node is moved, its children don't keep their relative orientation to it as in Euclidean plane, they rotate
 - Not as symmetric and regular as Euclidean techniques, two important attributes in aesthetics

Degree-of-Interest Trees

Where else have we talked about degree of interest during this class?

Degree-of-Interest Trees

- Problem: Trees quickly degrade into line



- Approach: Use fisheye-like focus & context ideas to control how a tree is drawn

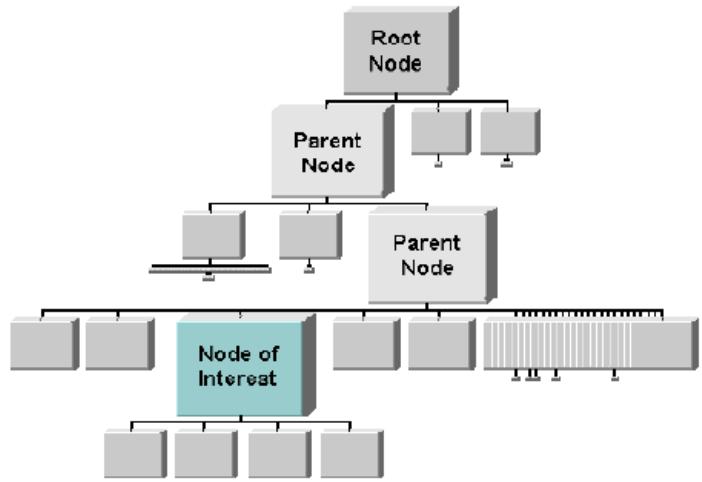
Card & Nation
AVI '02

Approach

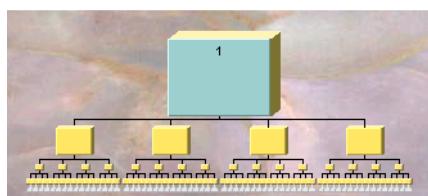
recall DOI from fisheye views. Similar concept here

- Combine multiple ideas:

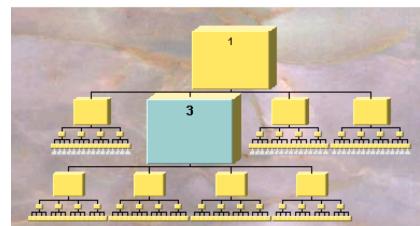
- Expanded DOI computation
- Logical filtering to elide nodes
- Geometric scaling
- Semantic scaling
- Clustered representation of large unexpanded branches
- Animated transition



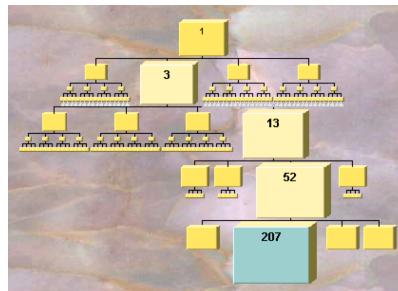
Example Operations



1. Display of a uniform tree of 4 levels

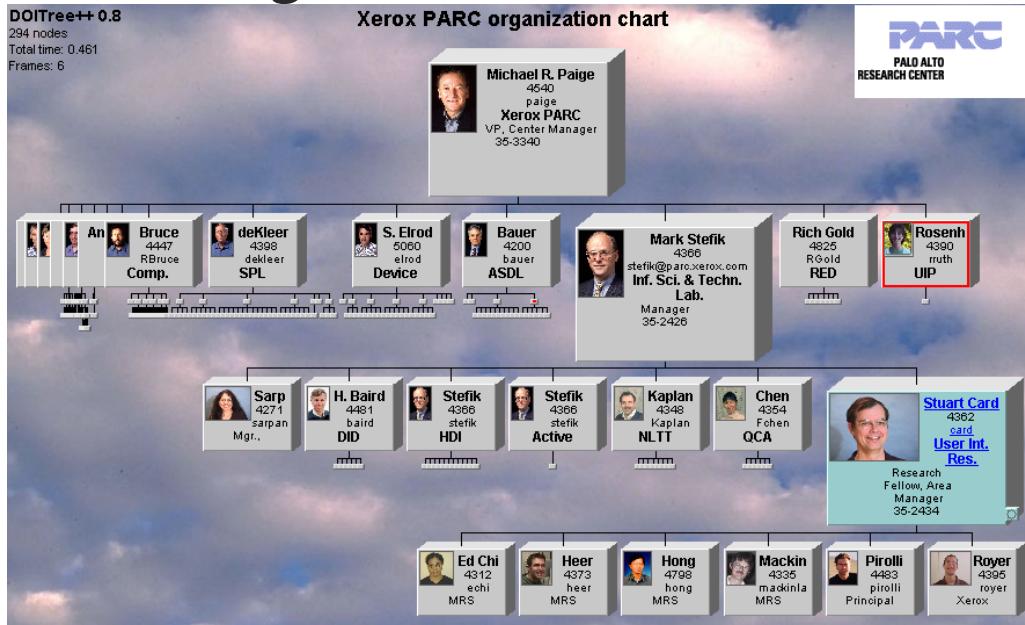


2. Same tree with focus on Node 3



3. Same tree expanded down to a leaf node

Better View of Org Chart



FlexTree

- Horizontally-drawn tree with compression along vertical dimension
- One focus is on showing decision trees well
- Contextual multi-foci view
- Basic idea: Push all nodes down as far as you can

Song, Curran & Sterritt
Information Visualization '04

Example

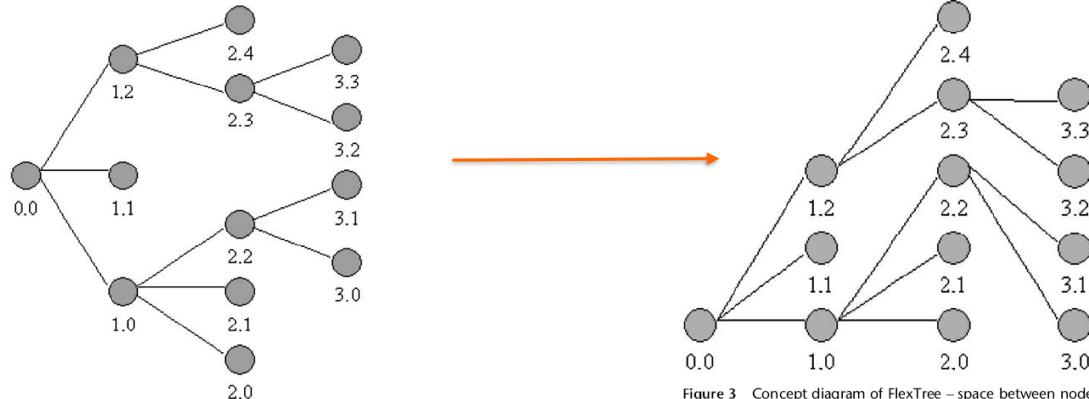
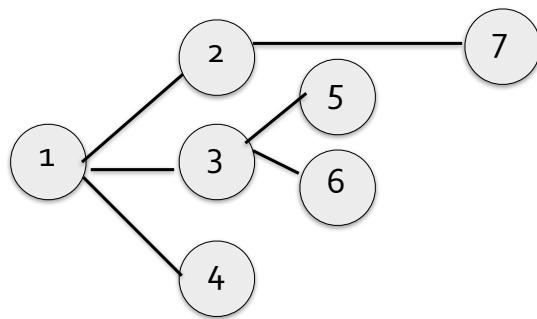
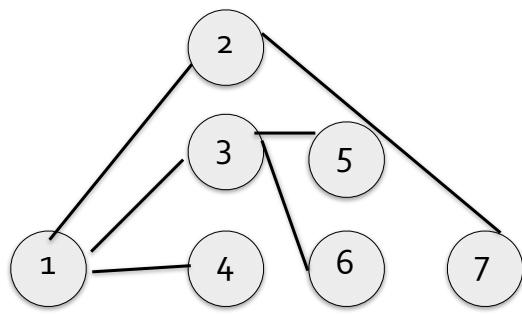


Figure 3 Concept diagram of FlexTree – space between nodes is compressed to achieve a compact view.





Bar Chart / Flex Tree Hybrid

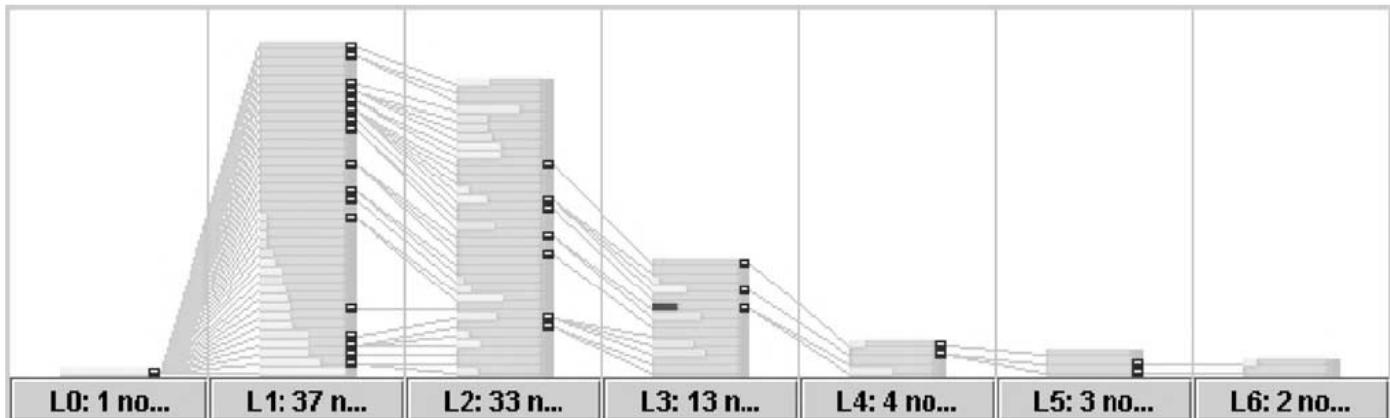
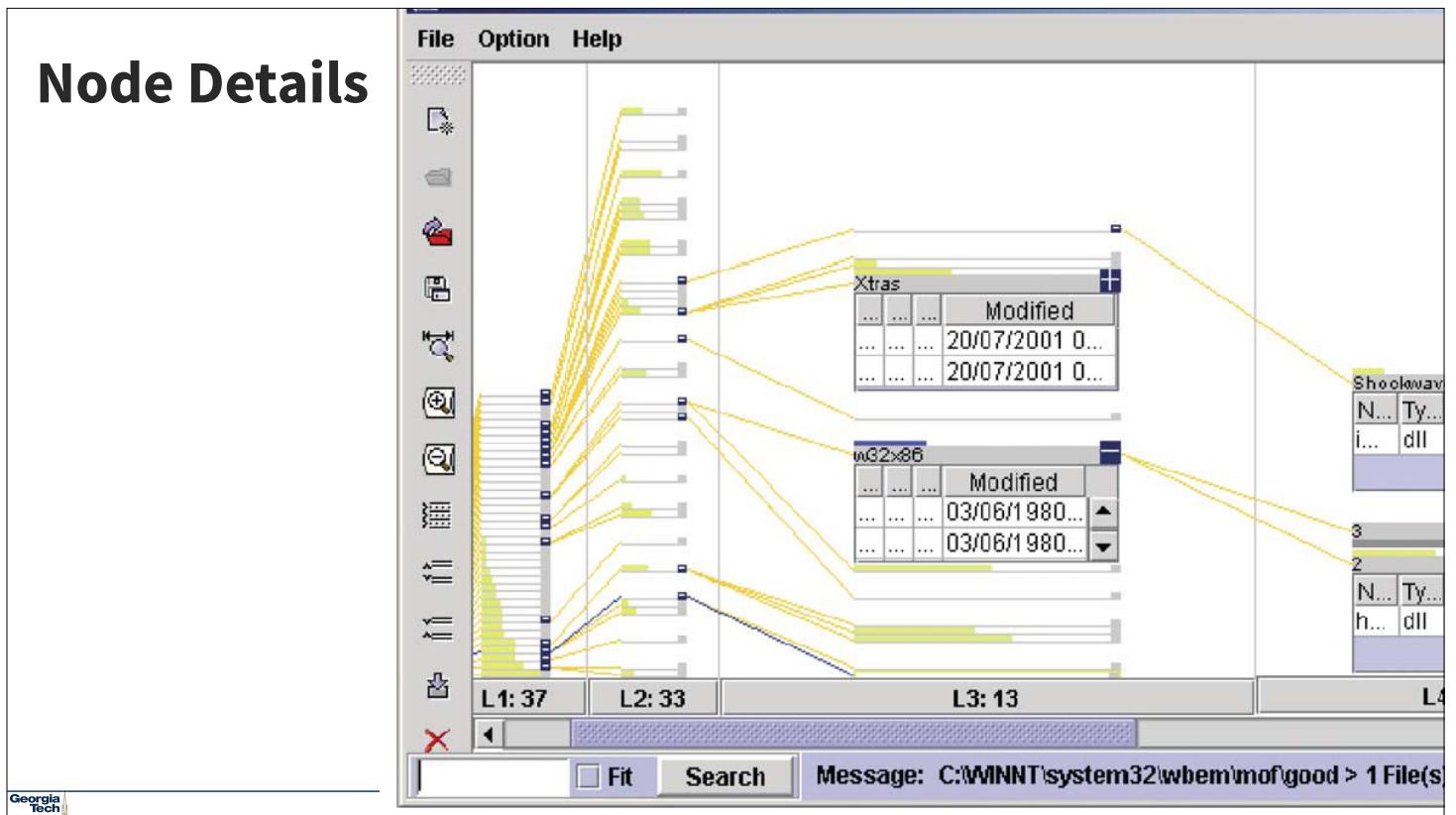


Figure 4 Bar chart view of FlexTree – nodes within the same level stack closely to each other in a space-filling manner.

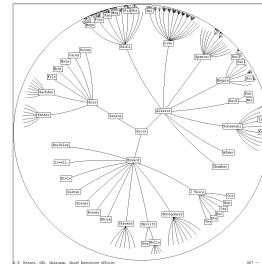
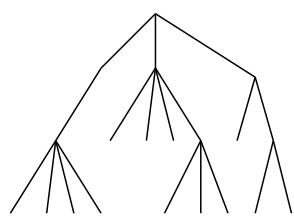
Node Details



Recall: Node-Link Reps

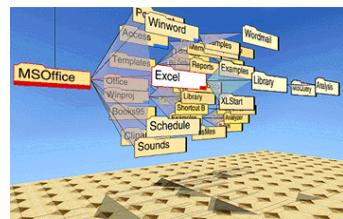
Hyperbolic tree

Traditional



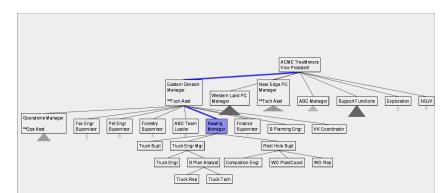
Lamping & Rao

ConeTree



Card, Mackinlay & Robertson

SpaceTree



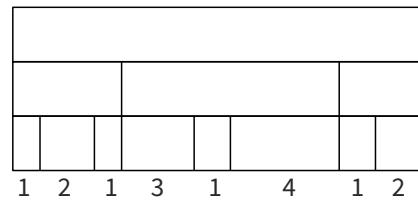
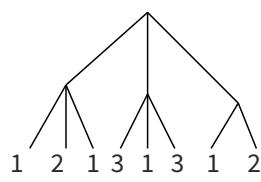
Plaisant, Grosjean & Bederson

On to Space-filling approaches

Space-Filling Representation

Each item occupies an **area**

Children are “contained” under parent

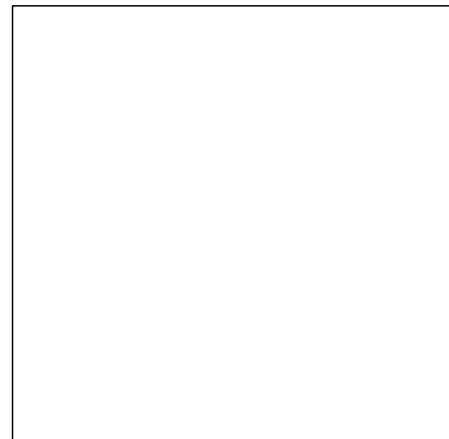
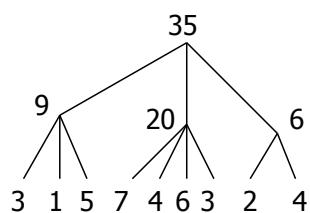


One example: “Icicle plot”

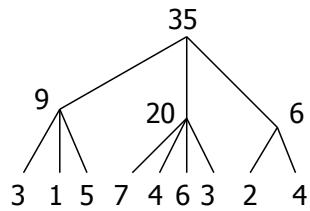
Treemap

- Space-filling representation developed by Shneiderman and Johnson, Vis '91
- Children are drawn **inside their parent**
- Alternate horizontal and vertical slicing at each successive level
- Use **area to encode other variable of data items**
 - e.g., quantity, % of whole, price, ...

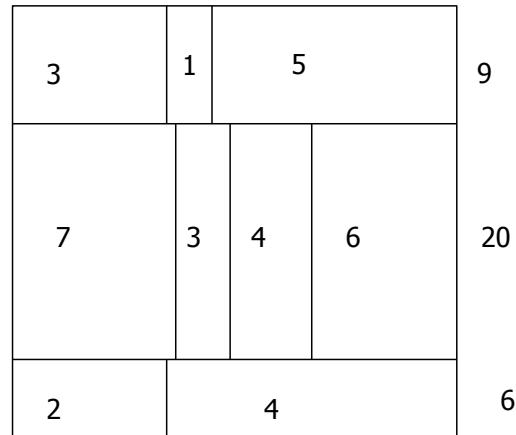
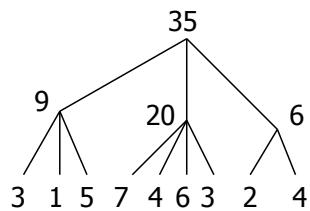
Example



Example

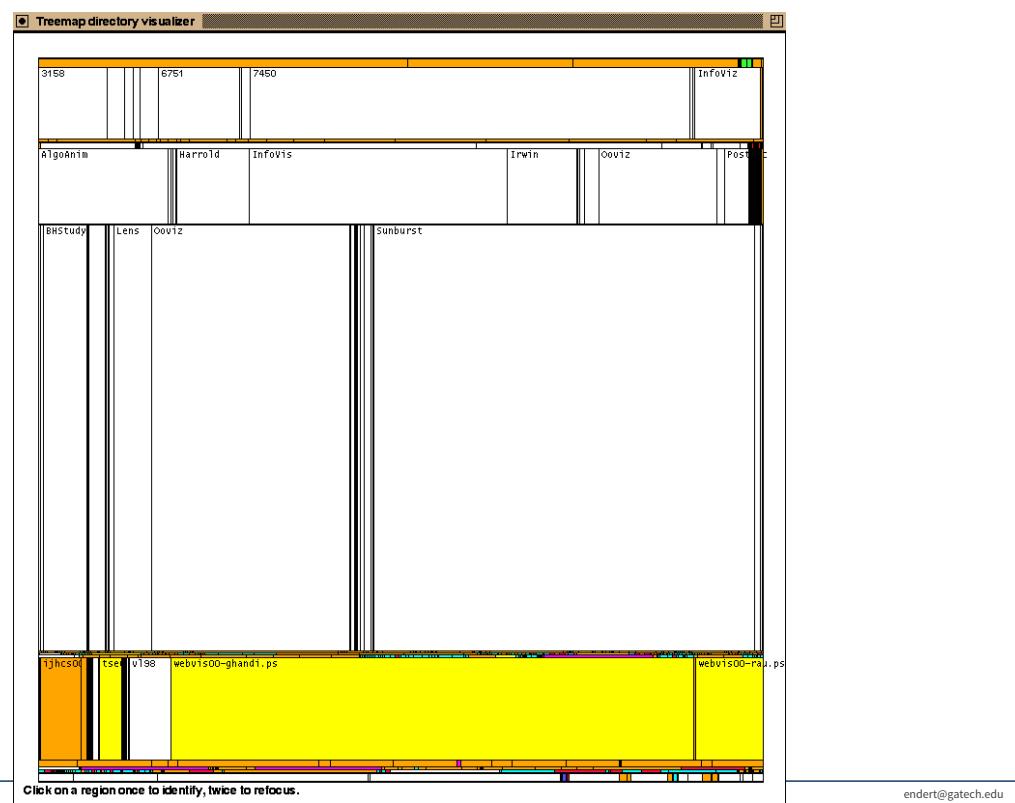


Example

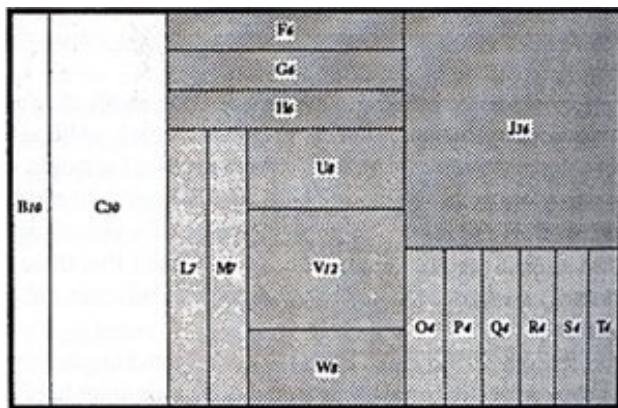


Treemap

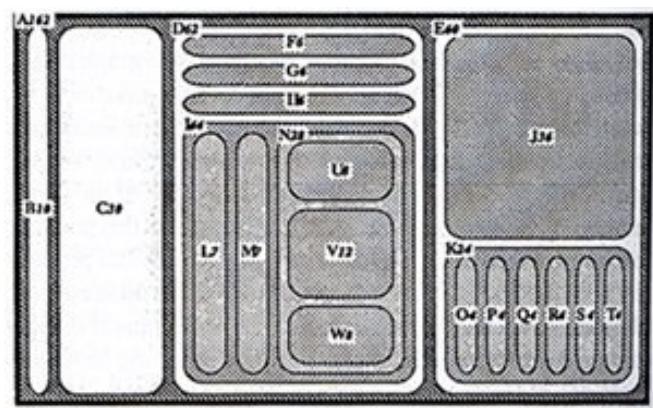
Directories on HDD



Nested vs. Non-nested



Non-nested Tree-Map



Nested Tree-Map

Applications

- Can use Treemap idea for a variety of domains
 - File/directory structures
 - Basketball statistics
 - Software diagrams
 - Tennis matches
 - Code: <https://bl.ocks.org/mbostock/911ad09bdead40ec0061>
 -

Variation

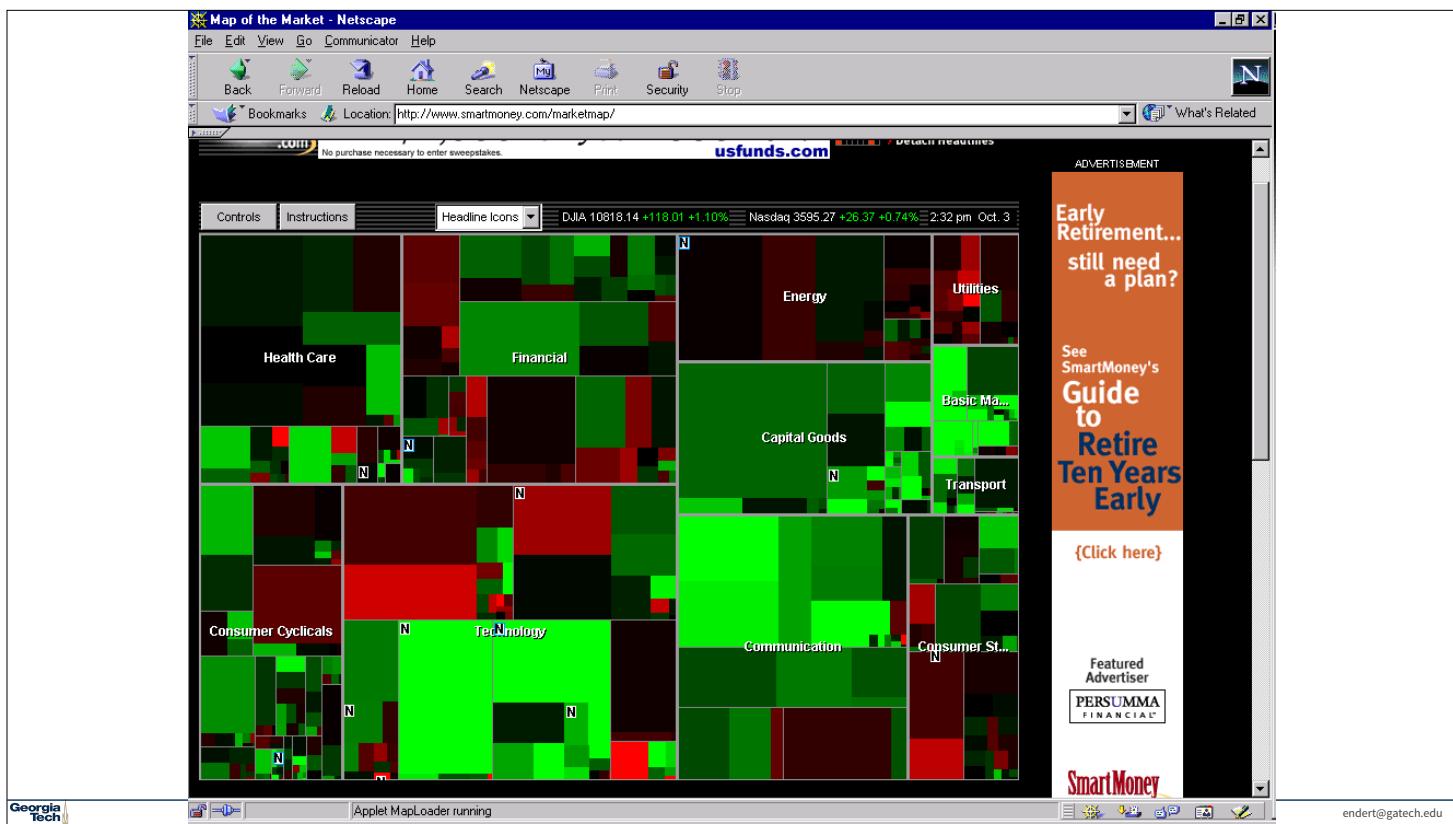
- Can rectangles be made more square?
.....think about it.....
- If area encodes quantity of an attribute, “shape” or “size” is hard to control
- In general, a very hard problem!
- There are other algorithms to optimize for specific characteristics of a tree map.
-

Variation: “Cluster” Treemap

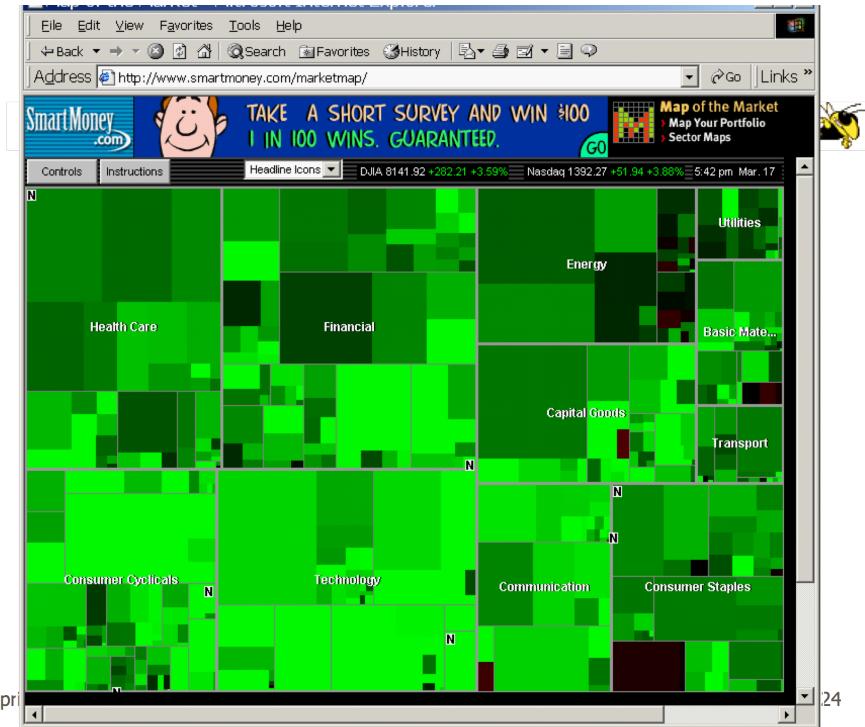
- SmartMoney.com Map of the Market
 - Illustrates stock movements
 - “Compromises” treemap algorithm to avoid bad aspect ratios
 - Basic algorithm (divide and conquer) with some hand tweaking
 - Takes advantage of shallow hierarchy

Image on next slide

Wattenberg
CHI '99



A good
day :^)



More recent times

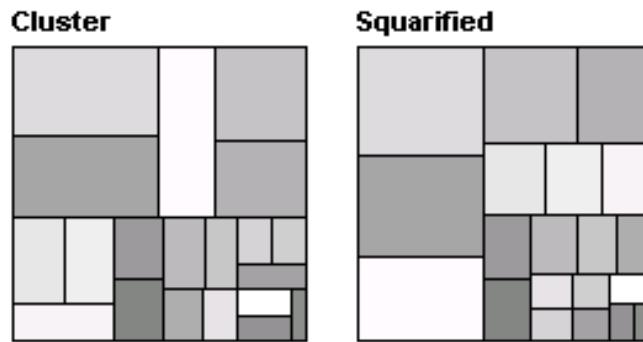
Sept. 29, 2008



Other Treemap Variations

- **Squareified treemap**

- Bruls, Huizing, van Wijk, EuroGraphics '00
- Alternate approach, similar results



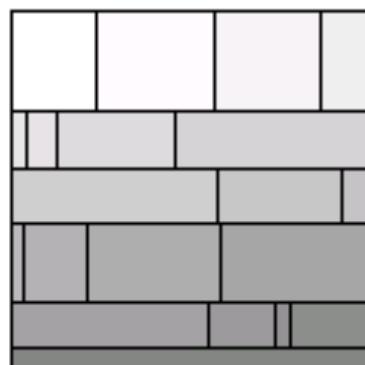
New Variation

- Strip treemap

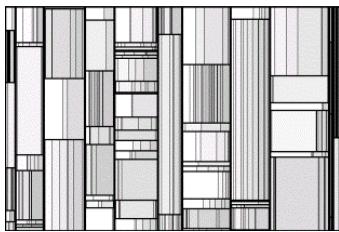
Use strips to place items

Put new rectangle into strip
If it makes **average aspect ratio of all rectangles in strip** go down,
keep it there
If it makes aspect ratio go up, put
it back and move to next strip

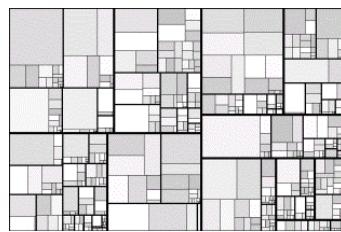
Strip Treemap



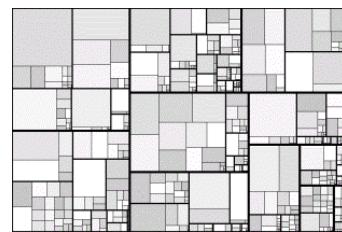
Bederson, Shneiderman & Wattenberg
ACM Trans on Graphics '02



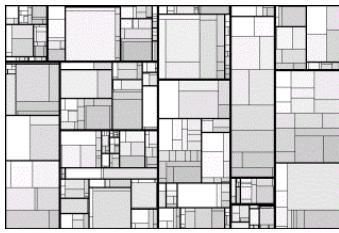
Slice-and-dice



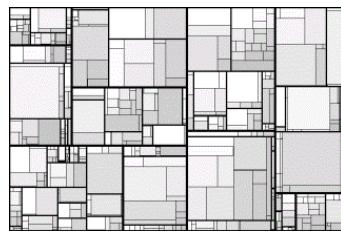
Cluster



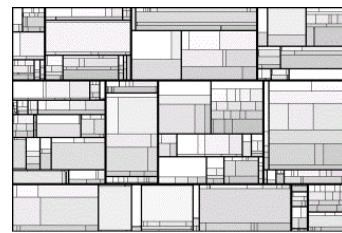
Squarified



Pivot-by-middle



Pivot-by-size

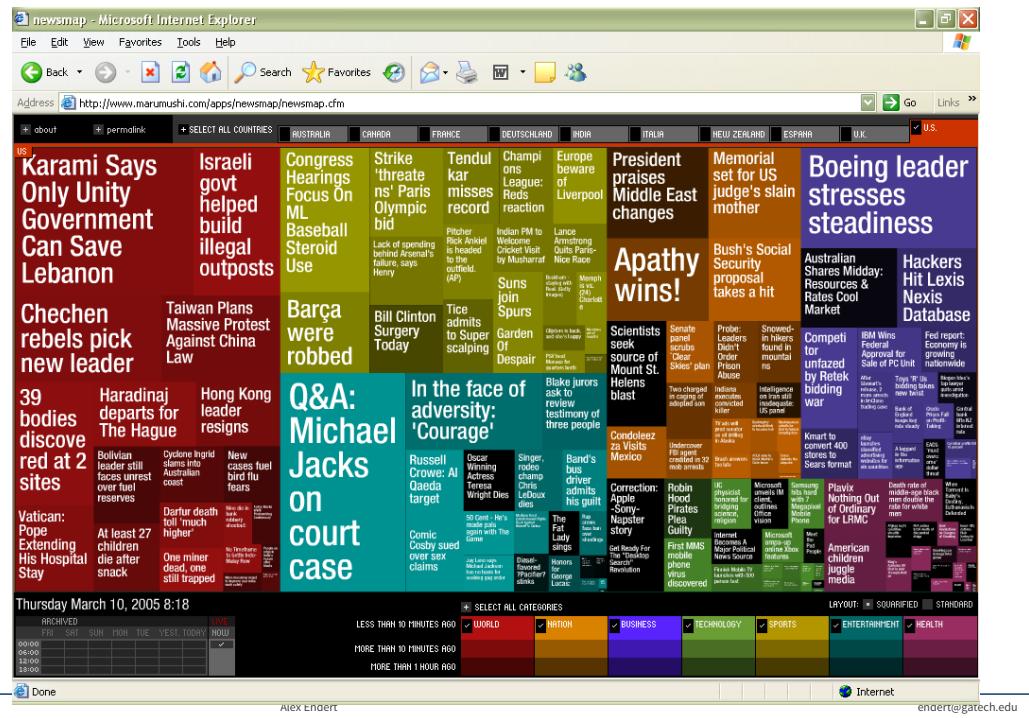


Strip

News Stories

www.marumushi.com/apps/newsmap/newsmap.cfm

Marumushi



Scaling Up

Mansmann & Vinnik
TVCG '06

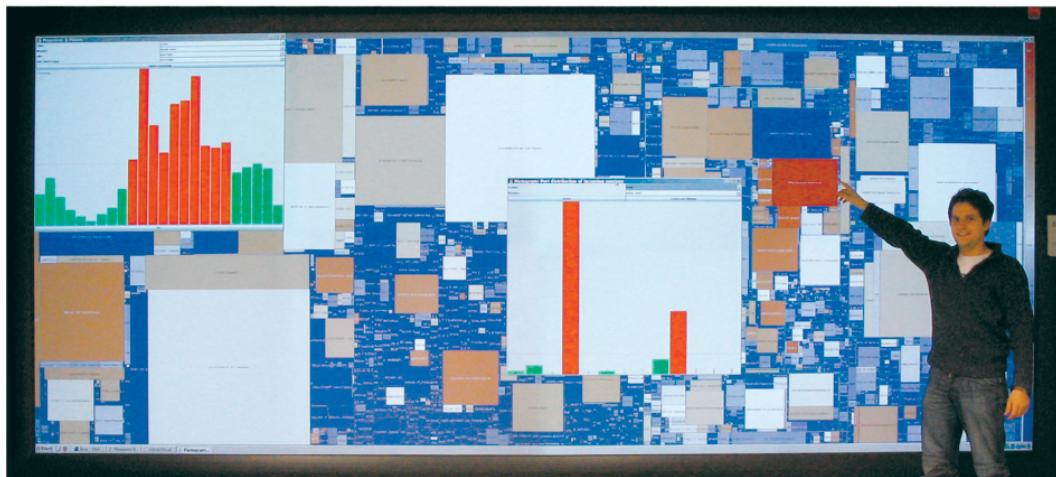


Fig. 5. *Hierarchical Network Map* displaying all 19,731 autonomous systems (one can still zoom in twice for details) on a large display wall (5.20m × 2.15m, 8.9 Megapixels, powered by eight projectors). The query interface on the top left shows the traffic distribution over time and specifies the selected data, in this case the traffic entering the gateway of the University of Konstanz on well-known ports (0-1023) on 29 November 2005 using “transferred bytes” as measure with logarithmic color mapping. One recognizes a heavy traffic load from AS 3320 (red) of “Deutsche Telekom” as well as to neighboring autonomous systems in Germany. A port histogram reveals high activity on the Web ports 80 and 443. For security and privacy reasons, the data was aggregated and sanitized.

Another Problem

- What if nodes with zero value (mapped to area) are very important?
 - Example: Stock or mutual fund portfolios:
Funds you don't currently hold have zero value in your portfolio, but you want to see them to potentially buy them

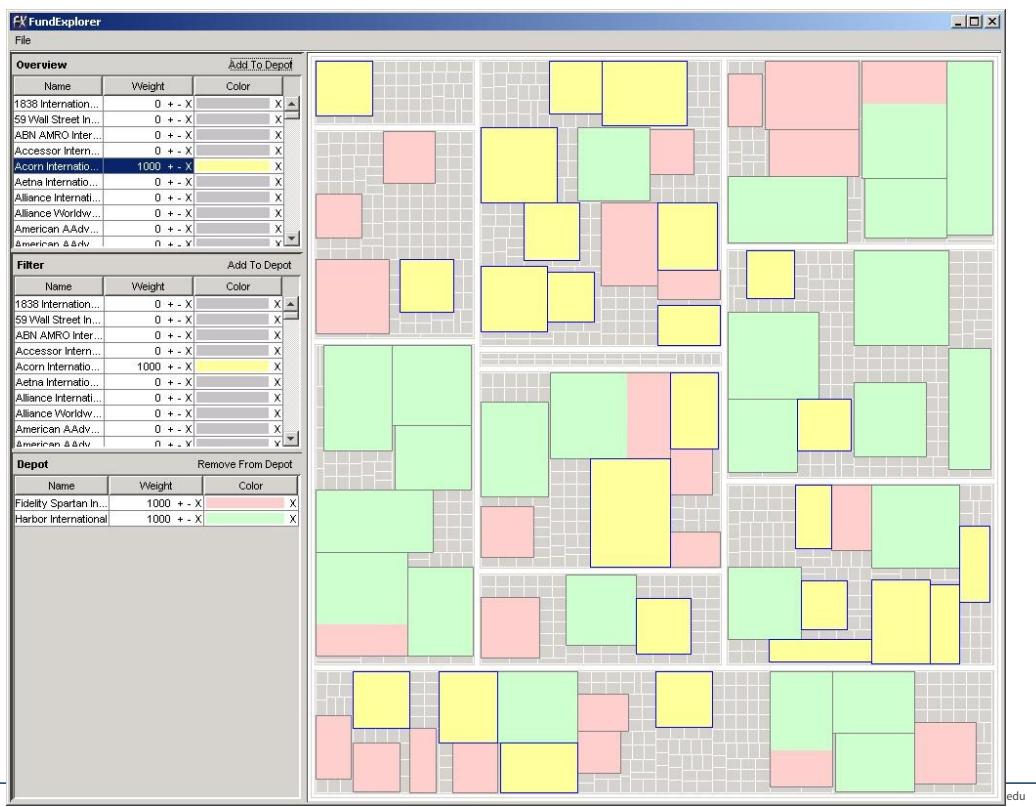
FundExplorer to show example

- Show mutual fund portfolios, including funds not currently held
 - Area maps to your relative investment in fund
- Want to help the user with portfolio diversification as well
 - If I add fund X, how does that overlap with my current fund holdings?

Solution

- **Context Treemap** – Treemap with small distortion
 - Give zero-valued items (all together) some constant proportion of screen area
 - Provide dynamic query capabilities to enhance exploration leading to portfolio diversification

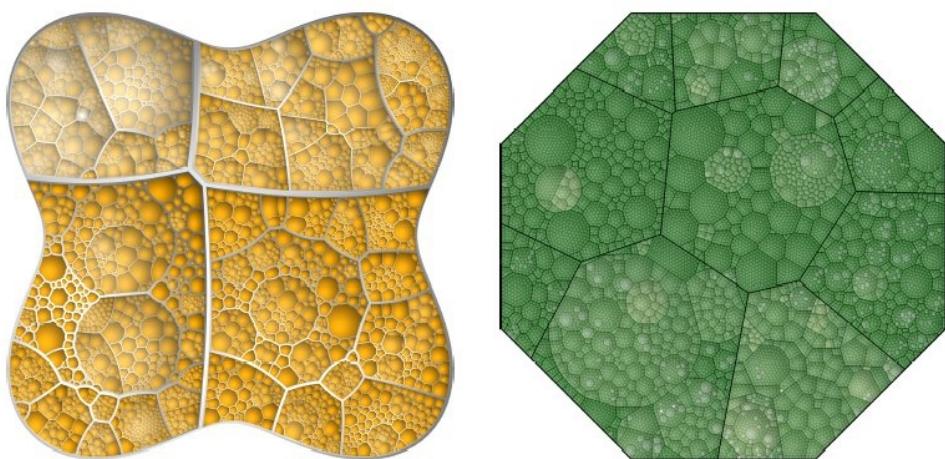
FundExplorer



Georgia Tech

edu

Voronoi Treemaps



Balzer & Deussen
InfoVis '05

Georgia Tech

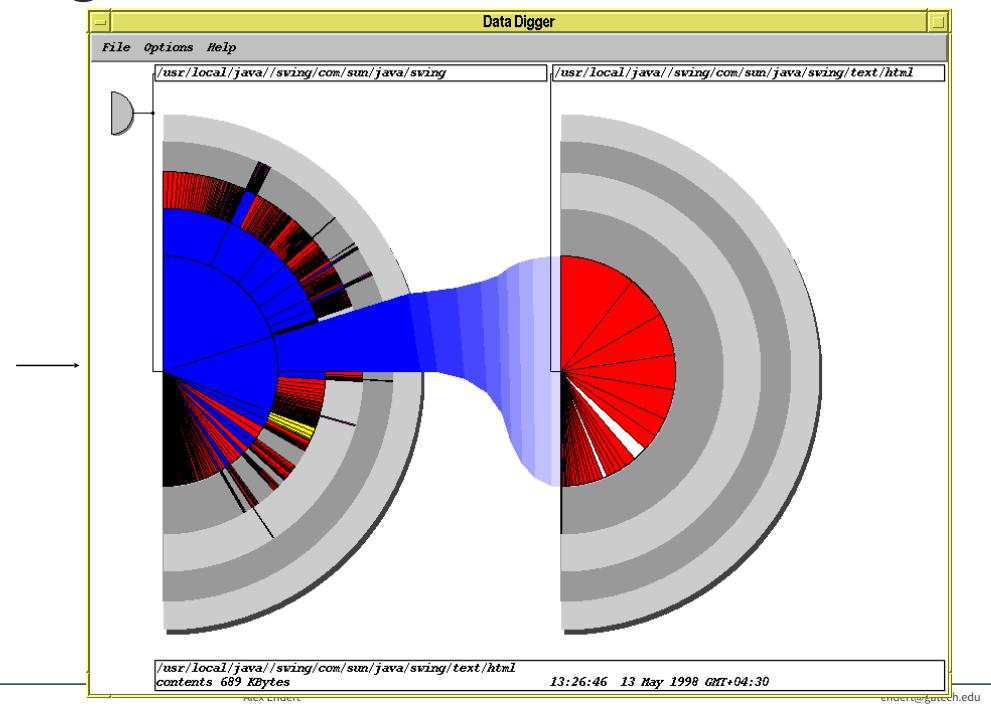
Alex Endert

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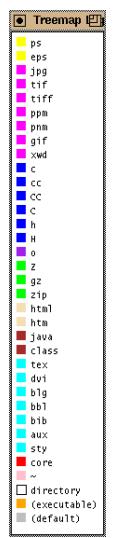
Radial Space-Filling

Chuah
InfoVis '98

Andrews &
Heidegger
InfoVis '98



SunBurst



Stasko, Catrambone, Guzdial &
McDonald
IJHCS '00

Click on a region once to identify, twice to refocus.

SunBurst

- Root directory at center, each successive level drawn farther out from center
- Sweep angle of item corresponds to size
- Color maps to file type or age
- Interactive controls for moving deeper in hierarchy, changing the root, etc.
- Double-click on directory makes it new root

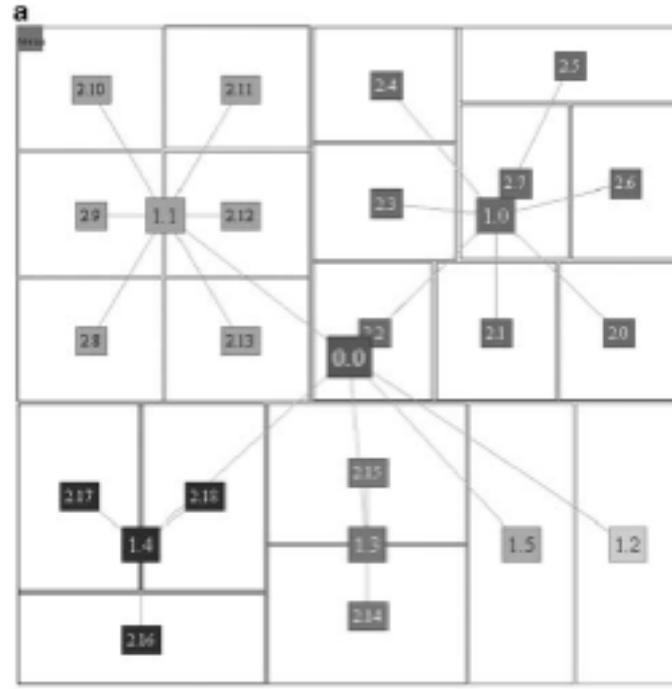
Hybrid Approaches

- Mix node-link and space-filling

EnCon

- Explicit combination of node-link and treemap-like techniques
 - Partition space into hierarchical regions, then draw node link into that

Nguyen & Huang
Information Visualization '05



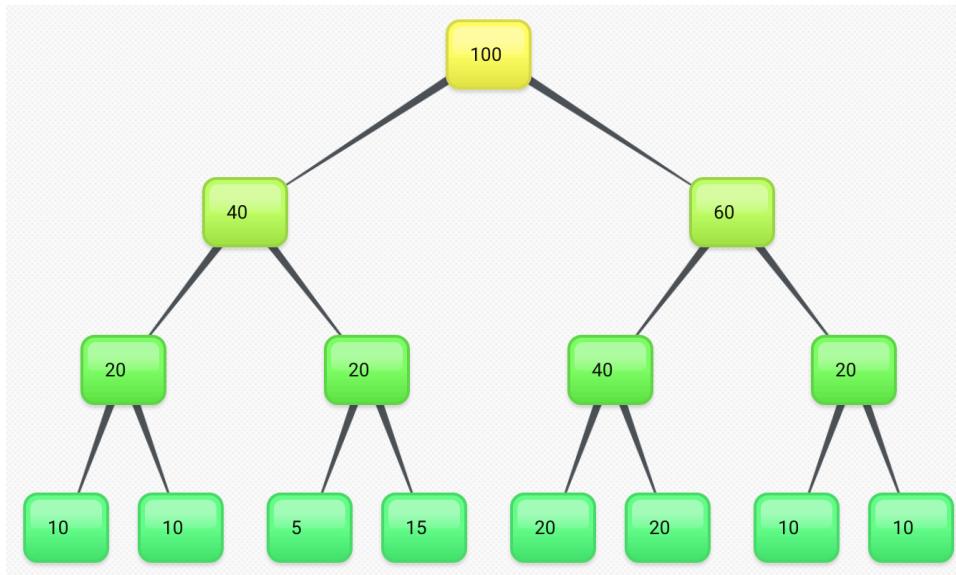
endert@gatech.edu

Summary

- Node-link diagrams or space-filling techniques?
 - It depends on the properties of the data
 - Node-link typically better at exposing structure of information structure
 - Space-filling good for focusing on one or two additional variables of cases

now, let's try one with Hierarchical Data

- Your hierarchy has 4 layers (L1, L2, L3, L4)
- I've used one way to show it (a tree)
- Design an alternative using 1 of the techniques covered today
- again, groups of 2-4, then we'll discuss
- write your names and GT ID's on the back (counts as quiz today)



today, we covered

- hierarchy representation techniques
 - node-link
 - space-filling
 - hybrids