

# Hierarchies and Trees 2 (Space-filling)



CS 7450 - Information Visualization  
November 4, 2015  
John Stasko

## Hierarchies **Recall**

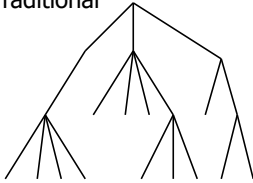


- Definition
  - Data repository in which cases are related to subcases
  - Can be thought of as imposing an ordering in which cases are parents or ancestors of other cases

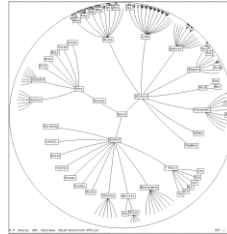
# Last Time: Node-Link Reps



Traditional

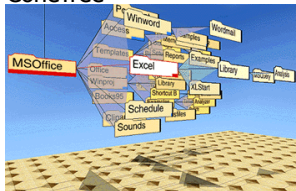


Hyperbolic tree



Lamping & Rao

ConeTree



Card, Mackinlay & Robertson

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SpaceTree



Plaisant, Grosjean & Bederson

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# Node-link Shortcoming?



- Difficult to encode more variables of data cases (nodes)
  - Shape
  - Color
  - Size
  - ...but all quickly clash with basic node-link structure

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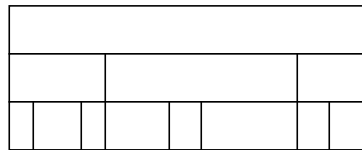
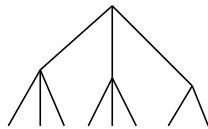
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# Space-Filling Representation



Each item occupies an area

Children are "contained" under parent



One example: "Icicle plot"



## Exercise

# Treemap



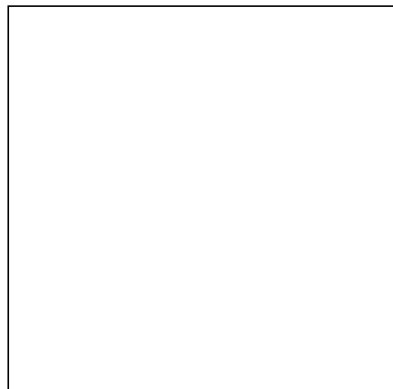
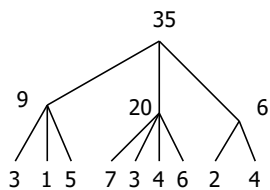
- Space-filling representation developed by Shneiderman and Johnson, Vis '91
- Children are drawn inside their parent
- Alternate horizontal and vertical slicing at each successive level
- Use area to encode other variable of data items

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# Example

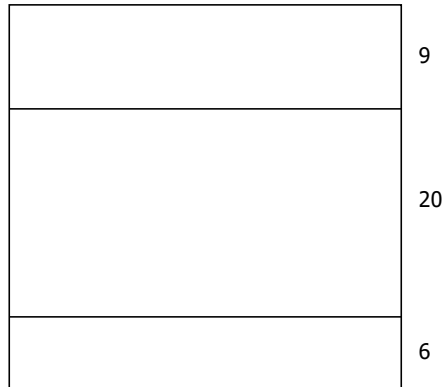
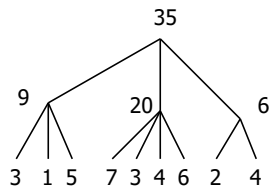


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# Example

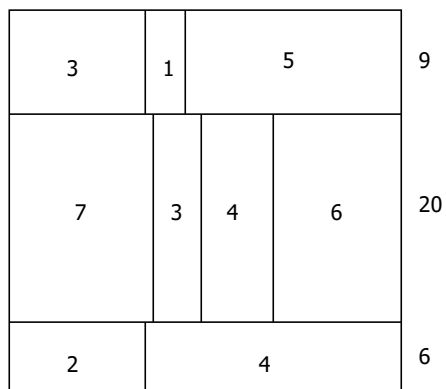
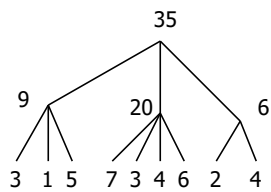


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# Example



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# Treemap



- Example

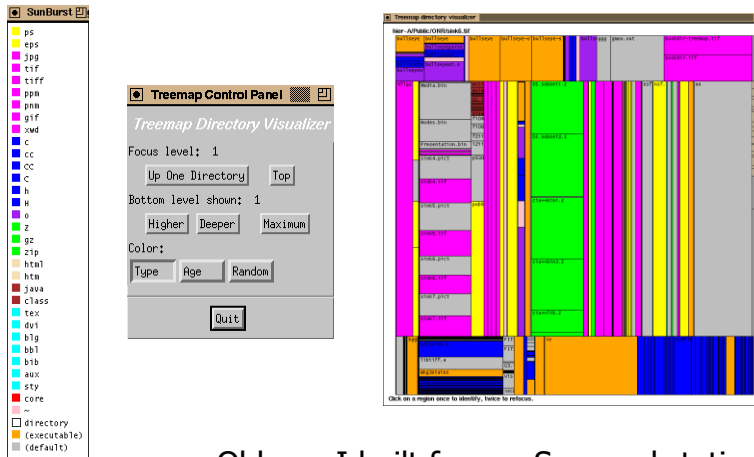


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# Treemap Example



Old one I built for our Sun workstations

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# Treemap Algorithm



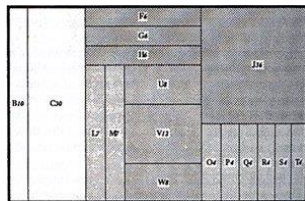
```
Draw()  
{  
  Change orientation from parent (horiz/vert)  
  Read all files and directories at this level  
  Make rectangle for each, scaled to size  
  Draw rectangles using appropriate size and color  
  For each directory  
    Make recursive call using its rectangle as focus  
}
```

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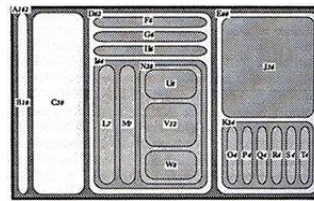
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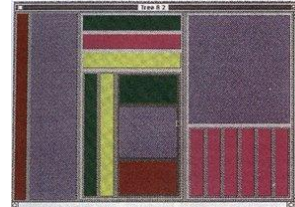
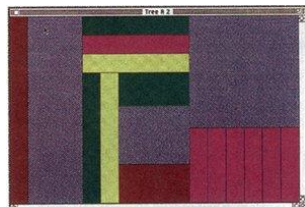
## Nested vs. Non-nested



Non-nested Tree-Map



Nested Tree-Map



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# Applications



- Can use Treemap idea for a variety of domains
  - File/directory structures
  - Basketball statistics
  - Software diagrams
  - Tennis matches

# Software Visualization App



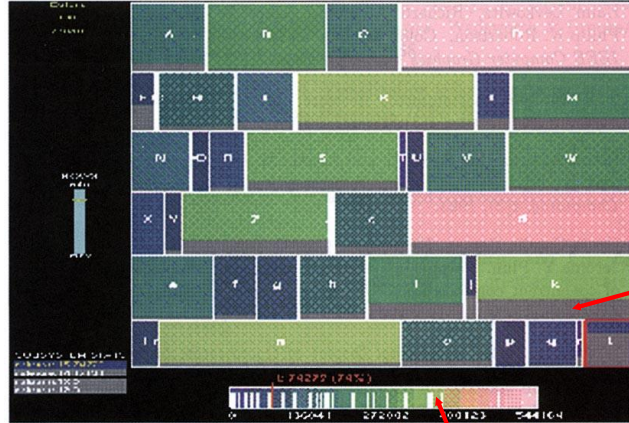
- SeeSys: Software Metrics Visualizing System
- Uses treemap-like visualization to present different software metrics
- Displays:
  - Size
  - Recent development
  - High fix-on-fix rates
  - History and growth



# Sample View 1



Subsystems in a software system. Each rectangle represents the non-comment source code in a subsystem. Area means size



New code in this release

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Size

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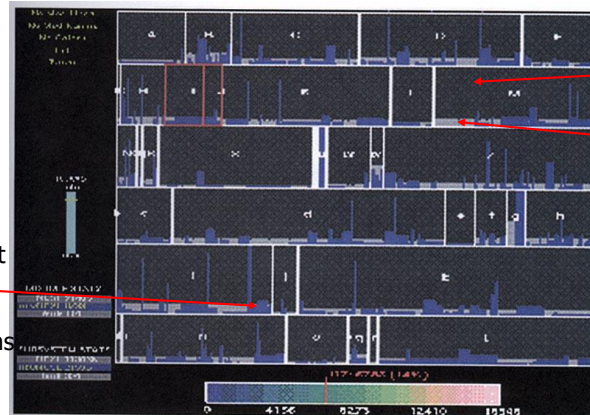
# Sample View 2



Bug rates by subsystem and directory

Represents new code in this release

Bars represent individual directories in the subsystems



Added functionality

Bug fixes

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# Tennis Viewing Application



- Analyze, review and browse a tennis match
- Space-filling/treemap-like hierarchy representation for a competition tree
- Shows match,sets,games,points
- Uses lenses to show shot patterns
- Red/green to encode two players
- Composite colors on top of each other

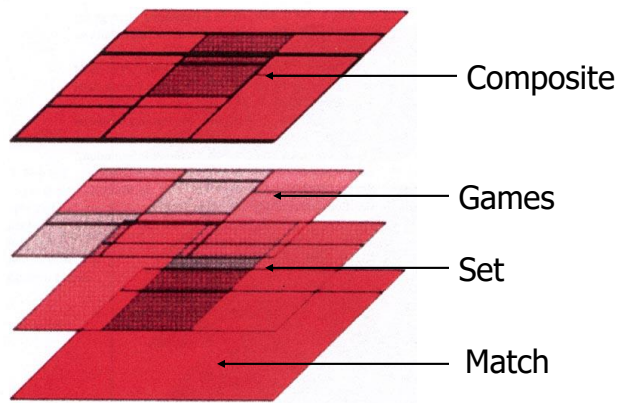
Jin and Banks  
*IEEE CG&A '97*

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# Visualization Make-up



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# Simulated Match Results



Match view

Bond won

Set results

Lens showing ball movement on individual points

Game results



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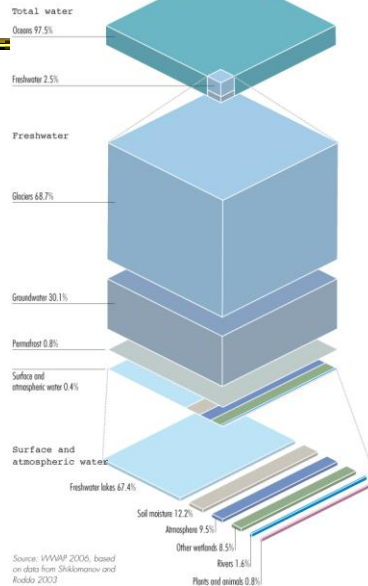
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# Treemap?

Very nice infographic

Figure 4.1 Global distribution of the world's water

Note: see Chapter 3 on water that is easily available to plants.



<http://blog.wired.com/wiredscience/2008/06/awesome-infogra.html>

Source: WWAP 2003, based on data from Shikimanzov and Rodda 2003

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# Treemap Affordances



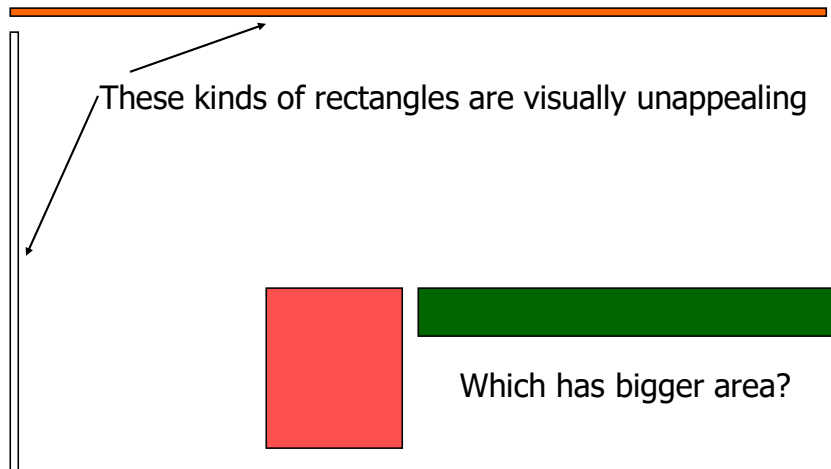
- Good
  - Representation of two attributes beyond node-link: color and area
- Not as good
  - Representing structure
    - ⑩ What happens if it's a perfectly balanced tree of items all the same size?
    - ⑩ Also can get long-thin aspect ratios
    - ⑩ Borders help on smaller trees, but take up too much area on large, deep ones

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# Aspect ratios



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# Variation



- Can rectangles be made more square?  
.....think about it.....
- In general, a very hard problem!

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# 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
  - [www.smartmoney.com/marketmap](http://www.smartmoney.com/marketmap)

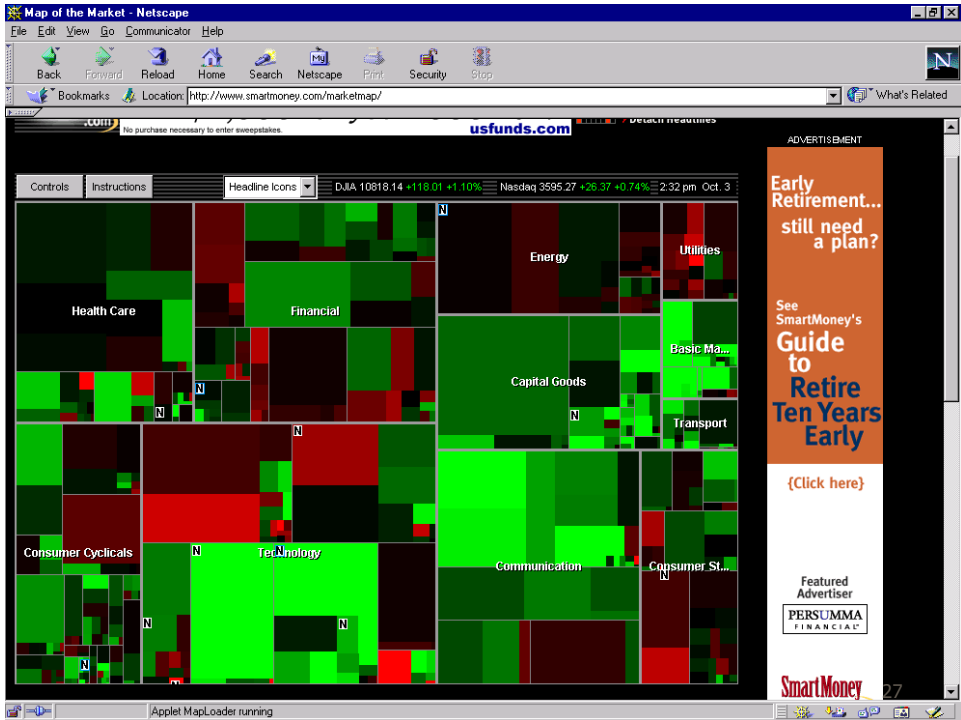
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Image on next slide

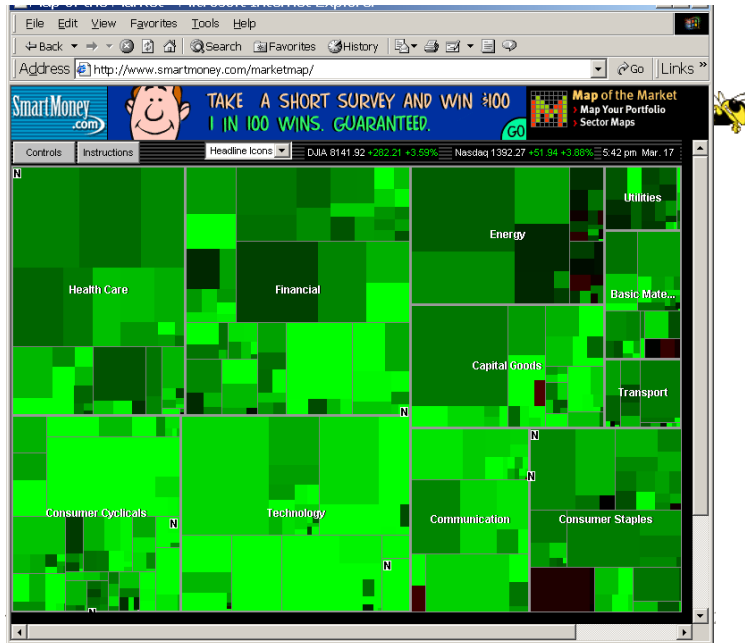
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Wattenberg  
CHI '99

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A good day :^)



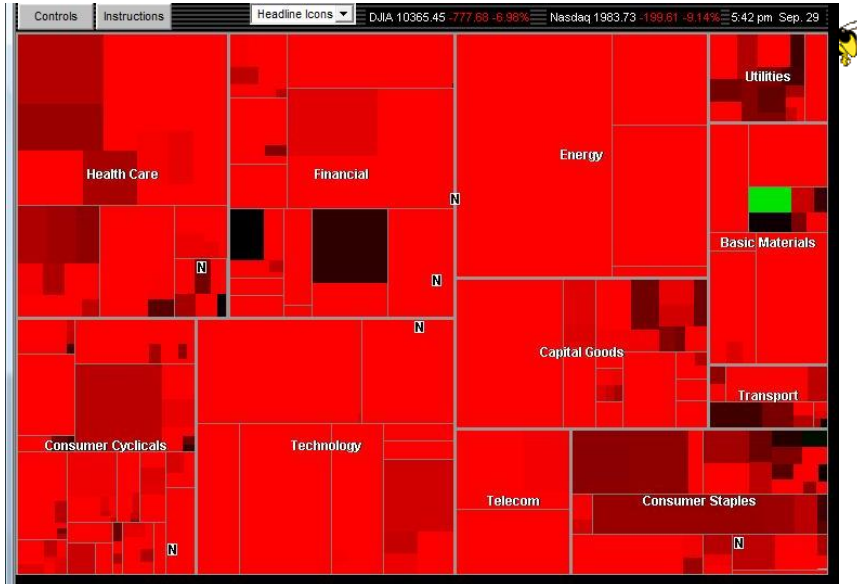
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More recent times

Sept. 29, 2008

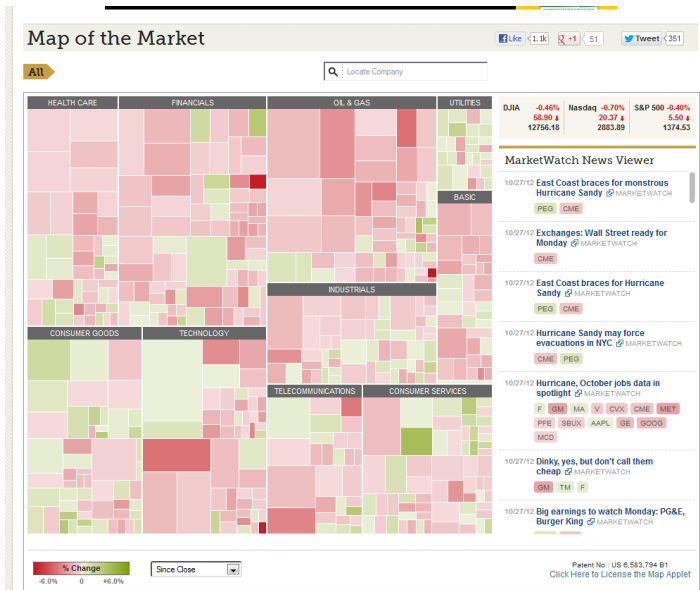


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Newer One (also now defunct)



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I don't like it as much

(Where's the nice control panel?)

A variant

<https://finviz.com/map.ashx>



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## SmartMoney Review



- Tuftesque micro/macro view
- Dynamic user interface operations add to impact
- One of best applications of an InfoVis techniques that I've seen

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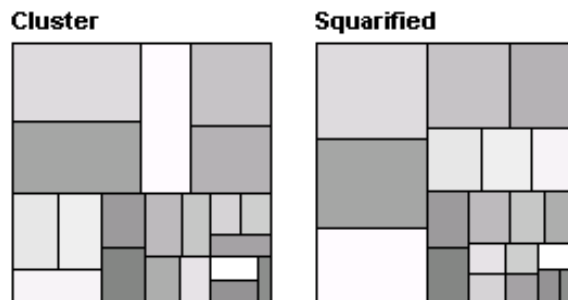
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## Other Treemap Variations



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



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## Square Algorithm Problems



- Small changes in data values can cause dramatic changes in layout
- Order of items in a group may be important

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# New Square Algorithms



- Pivot-by-size and pivot-by-middle

Partition area into 4 regions

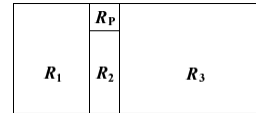
Pick pivot element  $R_p$

Size: Largest element

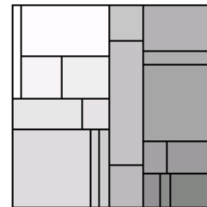
Middle: Middle element

$R_1$  - elements earlier in list than pivot

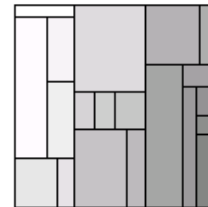
$R_2$  - elements in list before  $R_3$  and also that makes  $R_p$  have aspect ratio closest to 1



Pivot-by-middle



Pivot-by-size



Shneiderman & Wattenberg  
InfoVis '01

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# New Variation



- Strip treemap

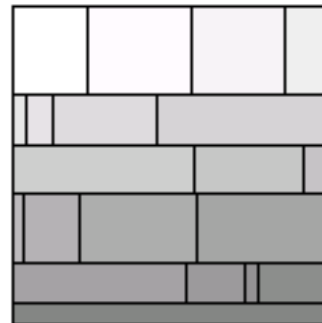
Use strips to place items

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

StripTreemap



Bederson, Shneiderman & Wattenberg  
*ACM Trans on Graphics* '02

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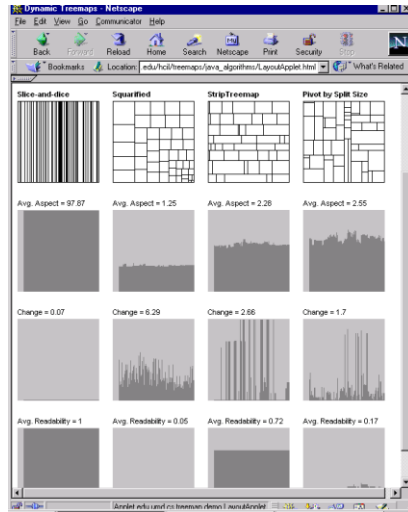
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# Compare results



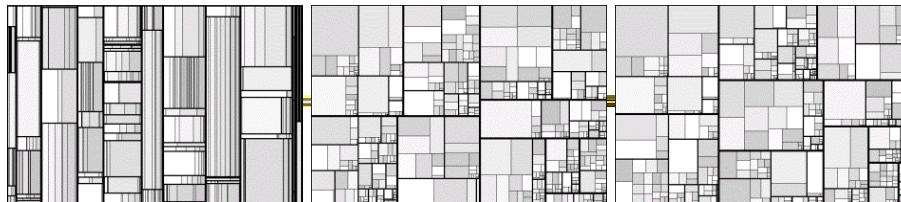
- Compare
  - slice and dice
  - squarified
  - strip
  - pivot
- techniques by
  - aspect ratio
    - width to height
  - structural change
    - metric designed to measure movements of items
  - readability
    - metric based on changes in direction of eye gaze as items scanned



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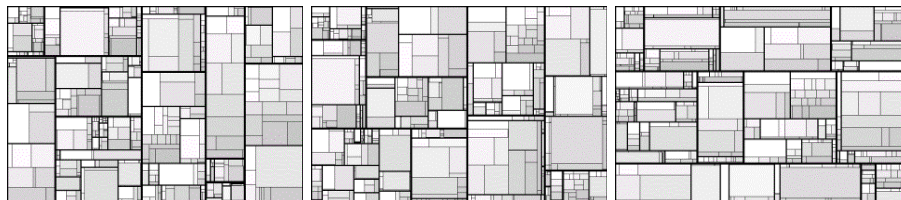
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Slice-and-dice

Cluster

Squarified



Pivot-by-middle

Pivot-by-size

Strip

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# Showing Structure



- Regular borderless treemap makes it challenging to discern structure of hierarchy, particularly large ones
  - Supplement Treemap view
  - Change rectangles to other forms

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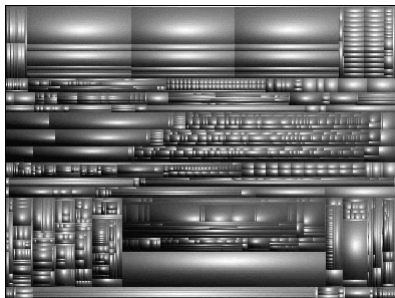
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# Variation: Cushion Treemap



Add shading and texture to help convey structure of hierarchy

Van Wijk & van de Wetering  
InfoVis '99



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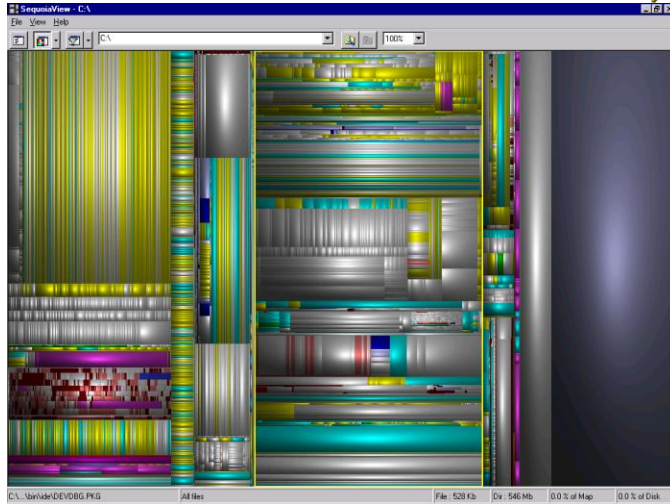
40

# SequoiaView

[www.win.tue.nl/sequoiaview/](http://www.win.tue.nl/sequoiaview/)



File visualizer  
built using  
cushion treemap  
notion



Demo

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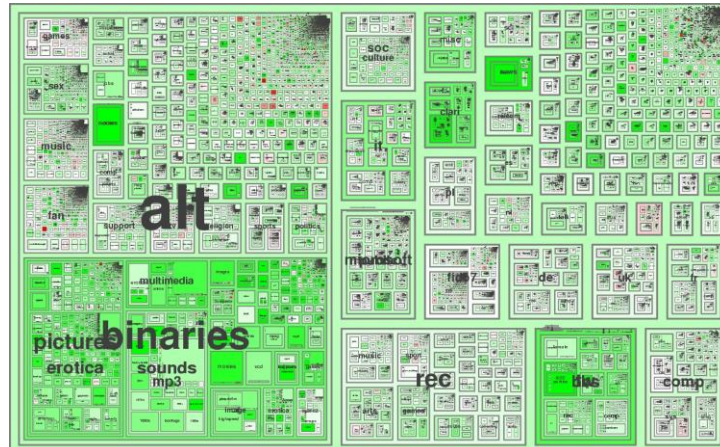
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# Internet News Groups



NetScan

Fiore & Smith  
Microsoft



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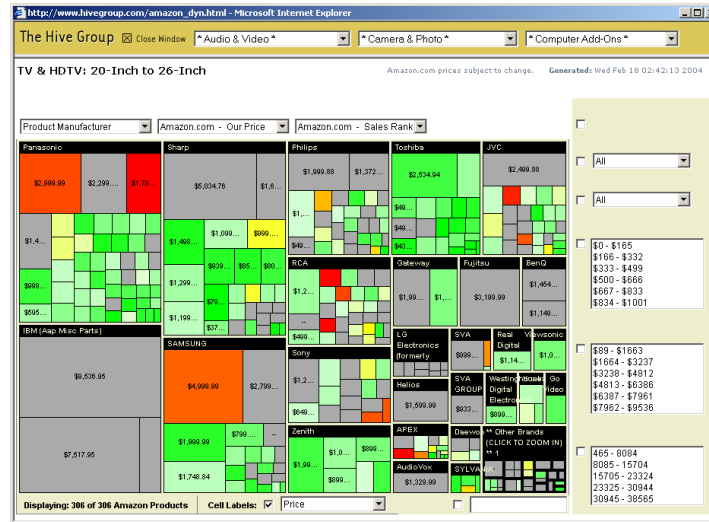
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# Product Sales

www.hivegroup.com/amazon.html

The Hive Group



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# News Stories

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

Marumushi



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# Investment Portfolios



Panopticon

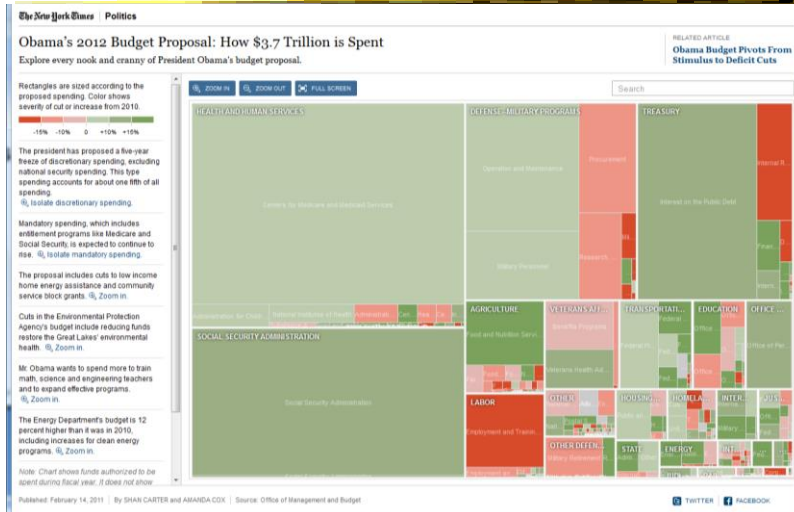


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# Federal Budget

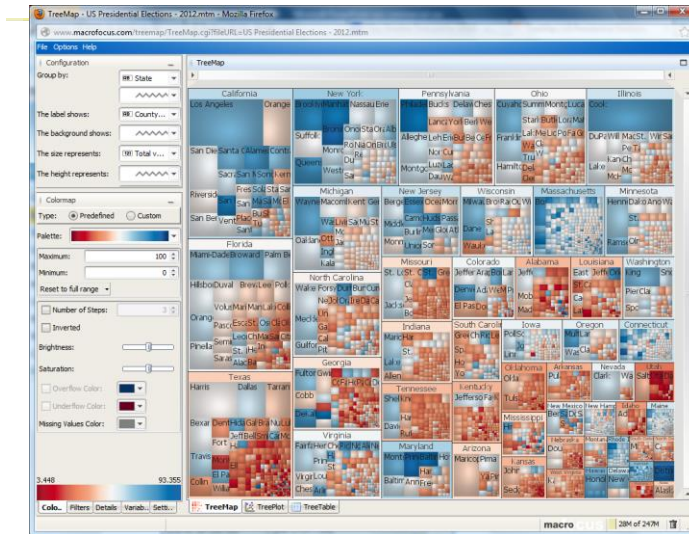


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# 2012 Presidential Election



[http://www.treemap.com/datasets/uselections/?goback=.gde\\_80552\\_member\\_184123140](http://www.treemap.com/datasets/uselections/?goback=.gde_80552_member_184123140)  
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# Scaling Up

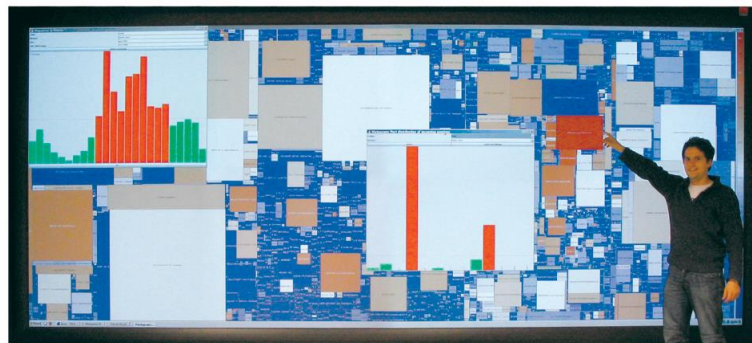


Fig. 5. Hierarchical Network Map displaying all 19,731 autonomous systems (one can still zoom in twice for details) on a large display wall (5.20m × 2.15m, 8.9 Megapixels, powered by eight projectors). The query interface on the top left shows the traffic distribution over time and specifies the selected 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.

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Mansmann & Vinnik  
 TVCG '06

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## 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
- Solutions?

## FundExplorer



- 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

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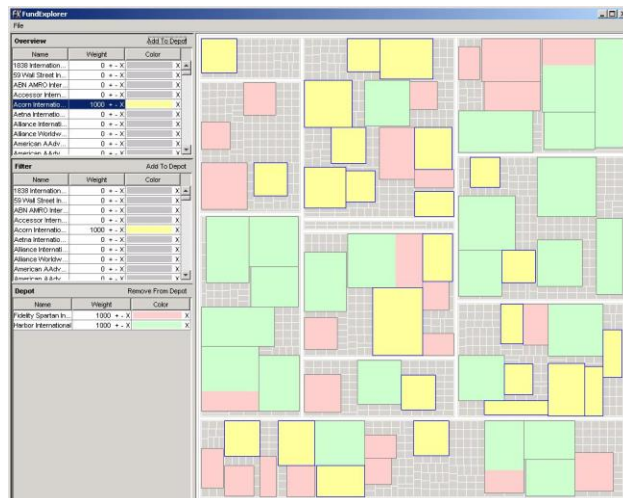
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# FundExplorer



Video  
InfoVis '03

Demo

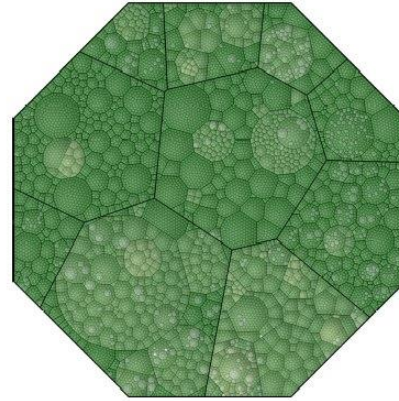
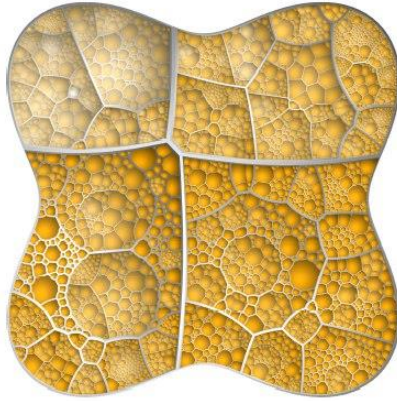


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# Voronoi Treemaps



Balzer & Deussen  
InfoVis '05

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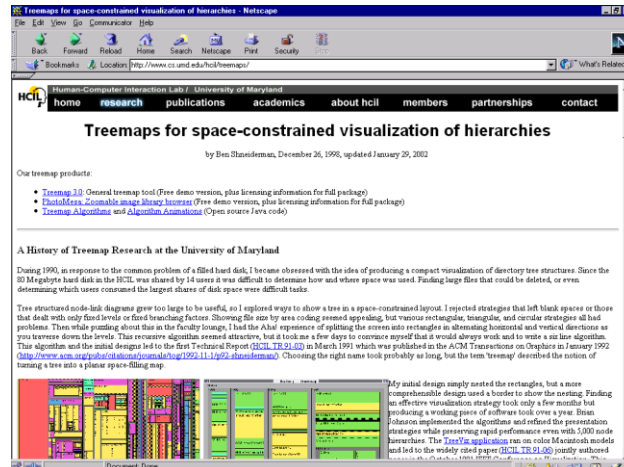
[www.cs.umd.edu/hcil/treemap-history/](http://www.cs.umd.edu/hcil/treemap-history/)

# The World of Treemaps



Maryland HCIL  
website devoted  
to Treemaps

Workshop in  
2001 there on  
topic



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## Limitation?

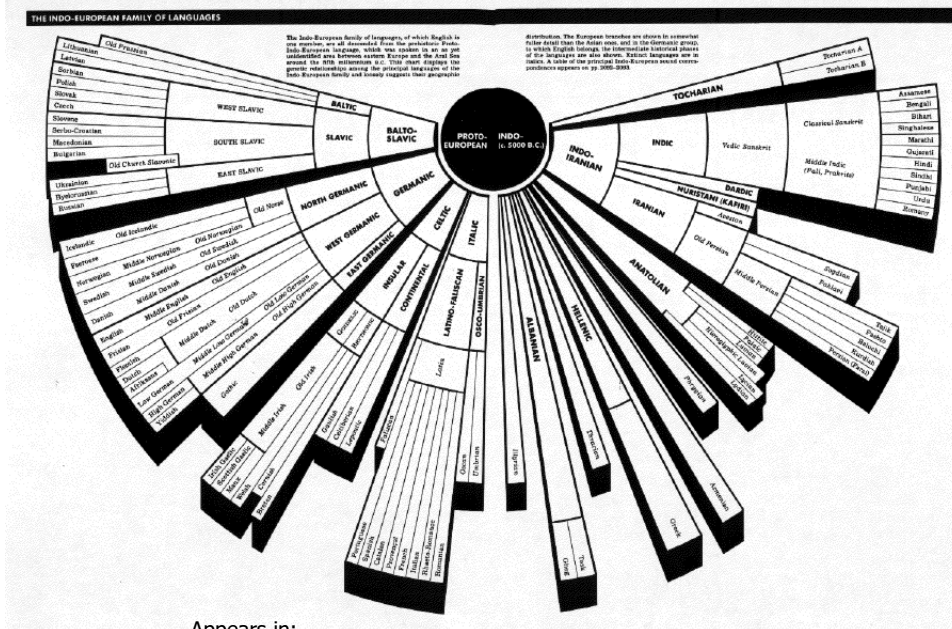


- What is primary shortcoming of treemap as a hierarchical data set representation?
- How could we do better?
  - Keep advantages without incurring disadvantages

## Another Technique



- What if we used a radial rather than a rectangular space-filling technique?
  - We saw node-link trees with root in center and growing outward already...
- Make pie-tree with root in center and children growing outward
  - Radial angle now corresponds to a variables rather than area



Appears in:  
*American Heritage Dictionary*, 3rd Ed. Houghton Mifflin, 1992

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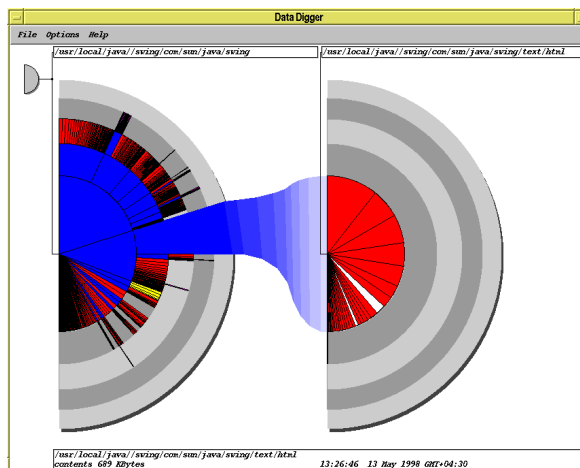
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## Radial Space-Filling



Chuah  
 InfoVis '98

Andrews &  
 Heidegger  
 InfoVis '98

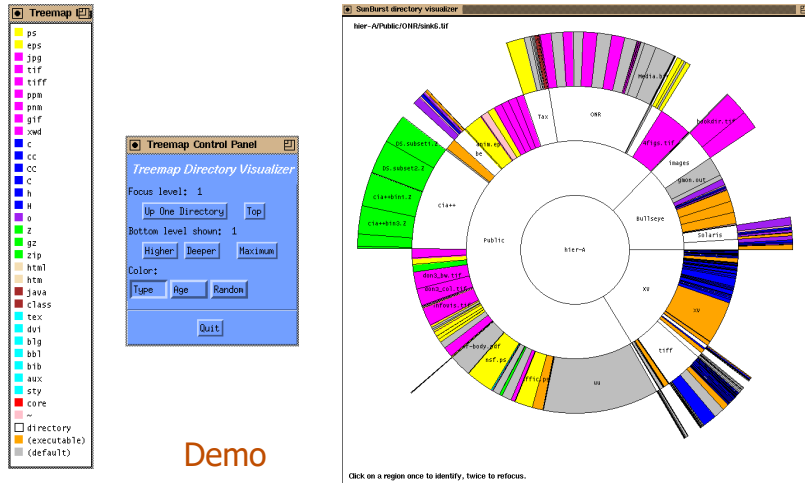


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# SunBurst



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# 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

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# Empirical Study



- Compared SunBurst to Treemap (borderless) on a variety of file browsing tasks
  - SunBurst performed as well (or better) in task accuracy and time
  - Learning effect - Performance improved with Treemap on second session
  - Strong subjective preference (51-9) for SunBurst
  - Participants cited more explicit depiction of structure as an important reason

More to come on evaluation...

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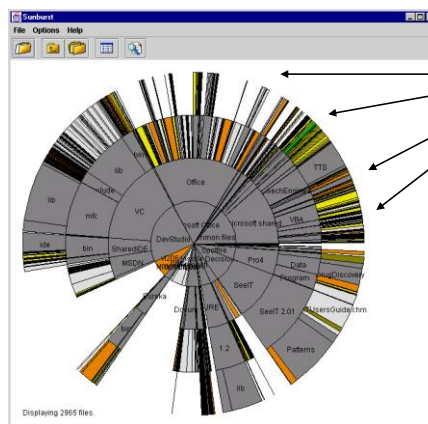
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# SunBurst Negative



- In large hierarchies, files at the periphery are usually tiny and very difficult to distinguish



examples

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## Fix: Objectives



- Make small slices bigger
- Maintain full circular space-filling idea
- Allow detailed examination of small files within context of entire hierarchy
- Don't alter ratios of sizes
- Avoid use of multiple windows or lots of scrollbars
- Provide an aesthetically pleasing interface in which it is easy to track changes in focus

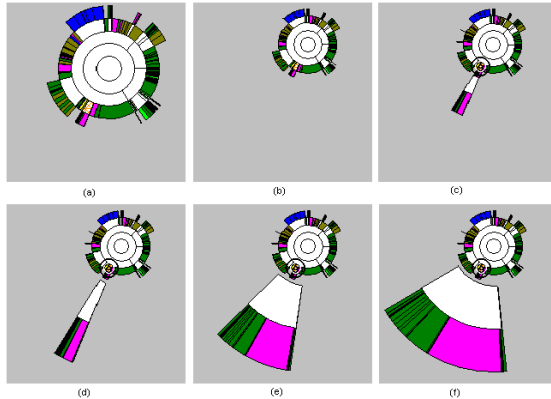
## 3 Solutions



- Three visualization+navigation techniques developed to help remedy the shortcoming
  - Angular detail
  - Detail outside
  - Detail inside



# Angular Detail



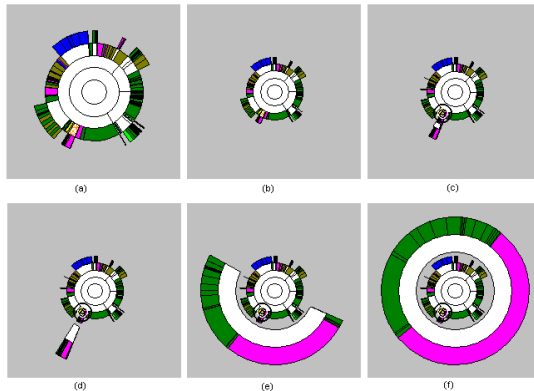
- Most "natural"
- Least space-efficient
- Most configurable by user

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# Detail Outside



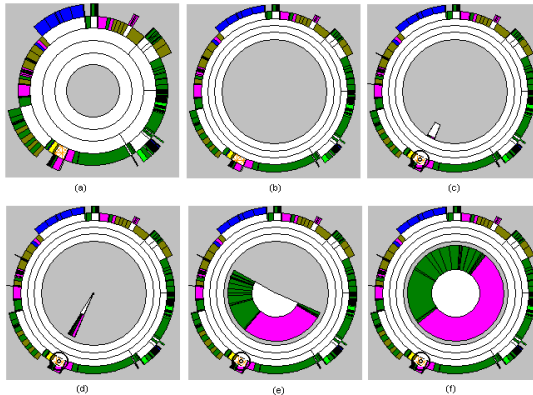
- Exhibits non-distorted miniature of overview
- Somewhat visually disconcerting
- Focus is quite enlarged (large circumference and 360°)
- Relatively space efficient

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# Detail Inside



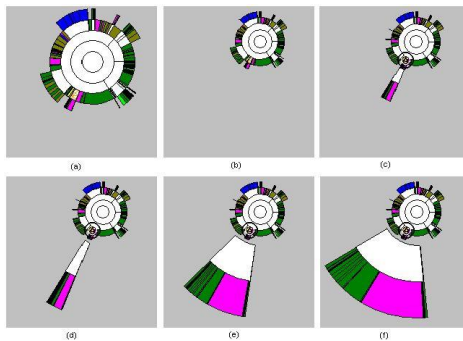
- Perhaps least intuitive and most distorting
- Items in overview are more distinct (larger circumference)
- Interior 360° for focus is often sufficient

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# See in Action



Video

Stasko & Zhang  
InfoVis '00

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## Key Components



- Two ways to increase area for focus region: larger sweep angle and longer circumference
- Smooth transitions between overview and focus allow viewer to track changes
- Always display overview
- Allow focus selections from anywhere: normal display, focus or overview regions

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## Potential Follow-on Work



- Multiple foci
- Varying radii for different levels in hierarchy
- Use quick-keys to walk through neighboring files
- Smarter update when choosing new focus region from existing focus
- Fourth method: expand angle of focus in place by compressing all others

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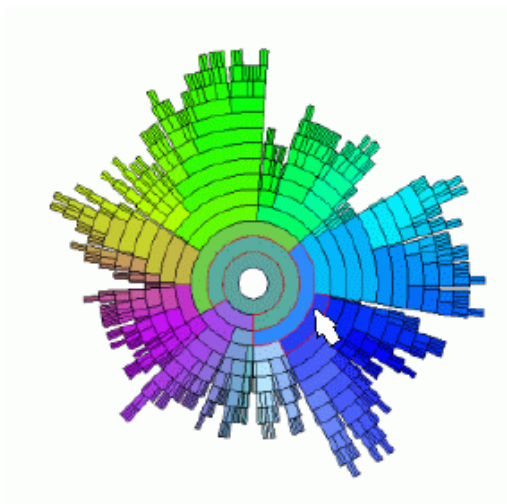
70

# InterRing



Provides many of those follow-on capabilities and new operations

Yang, Ward & Rudensteiner  
InfoVis '02



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# Even Sand Crabs Do It



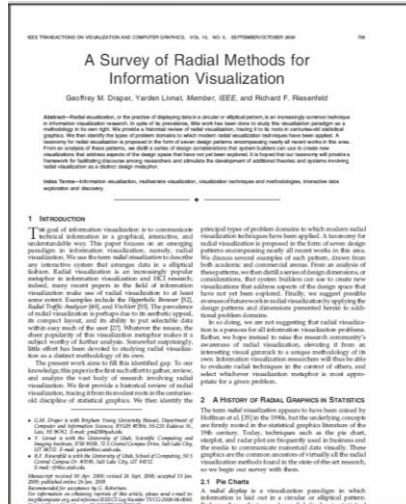
<http://www.flickr.com/photos/jkr1812/2234846316/in/gallery-49563472@N07-72157624817856060/lightbox/>

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# Survey of Radial Techniques



Draper et al  
TVCG '09

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## More Alternatives



- Combine space-filling hierarchy presentations (really nesting) with zooming
- Children drawn inside of parent, but not totally encompassing

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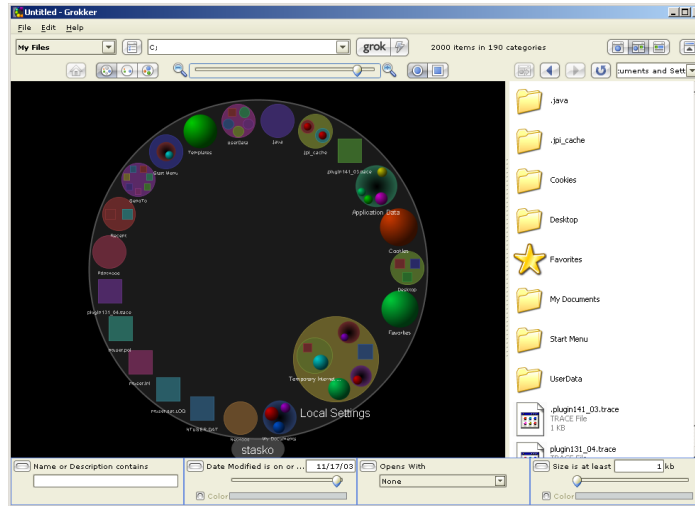
# Grokker

www.groxis.com



Demo

Defunct



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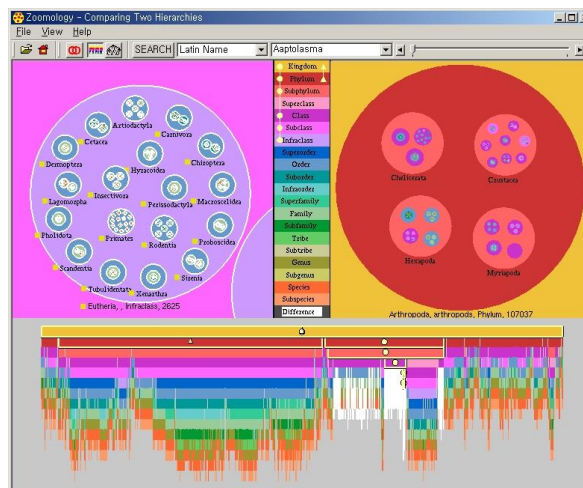
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# Zoomology



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Spring '03  
project

InfoVis '03  
Contest Winner  
Best Student  
entry

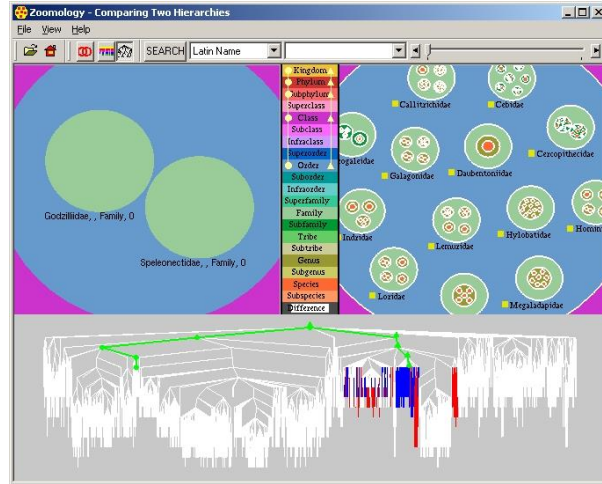


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# Alternate View



Video

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# Circle Packing

Wang, Wang, Dai & Wang  
CHI '06

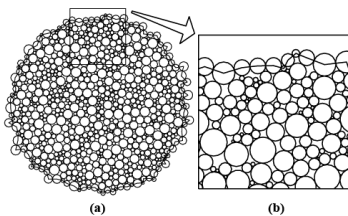


Figure 4. Packing 1000 circles with random radii

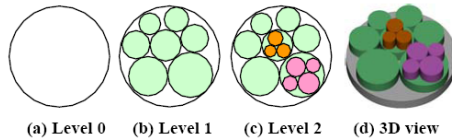
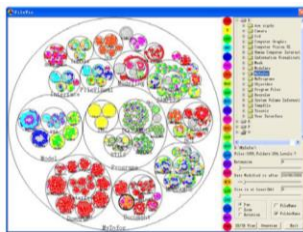
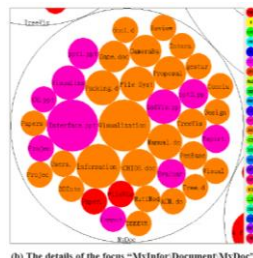


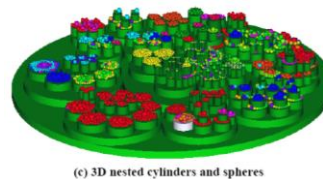
Figure 5. Pack circles into a circle recursively



(a) User interface and the overview of "D:MyInfor"



(b) The details of the focus "MyInfor Document:MyDoc"



(c) 3D nested cylinders and spheres

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# Hybrid Approaches



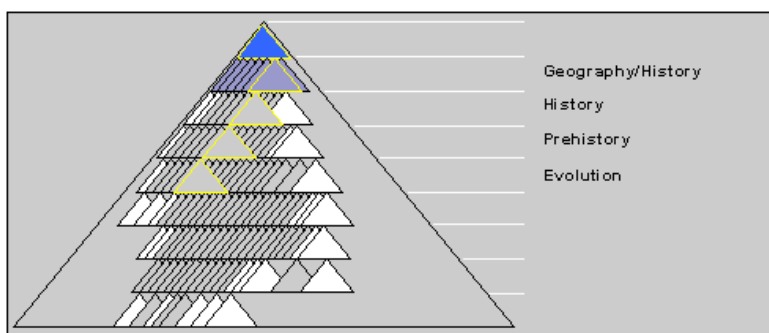
- Mix node-link and space-filling

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# CHEOPS



(Saw last time)

Beaudoin, Parent, Vroomen,  
Vis '96

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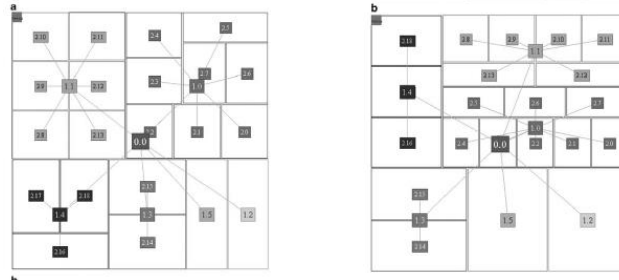
80



# EnCon



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

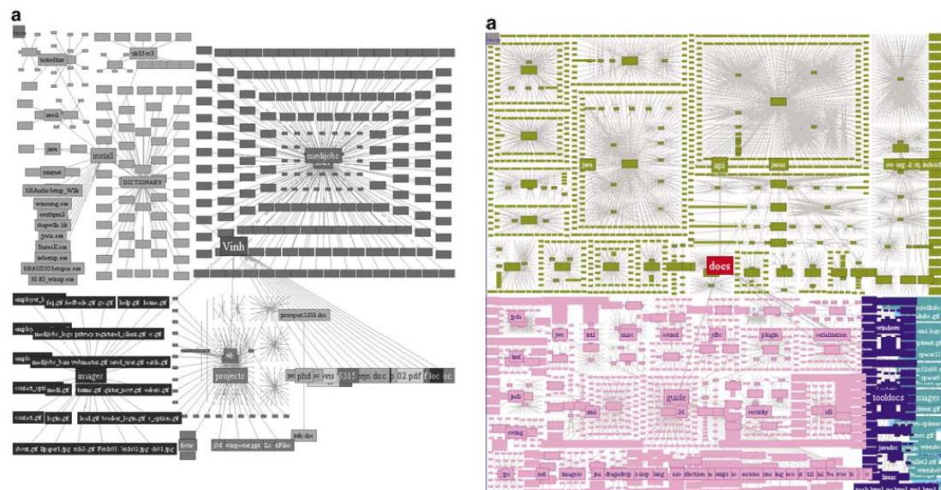


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## EnCon Sample Views



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# 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

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## Great Visual Summary

Downloadable poster



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

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# Zoomed In



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# Version 2

<http://treevis.net>



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## HW 6



- Draw a graph
- 10-vertex abstract graph provided
- You draw a node-link representation
- Follow the directions!
  - Bring one copy
  - Name on back
- Due Monday 9<sup>th</sup> (no late submissions)
- Don't spend a lot of time

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## Upcoming



- Graphs & Networks 1
  - Reading  
Lee et al '06
- Graphs & Networks 2
  - Reading  
Perer & Shneiderman '06

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# References



- Spence and CMS texts
- All referred to papers