Hierarchies and Trees 2 (Space-filling)

CS 7450 - Information Visualization

March 3, 2011
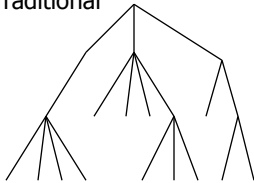
John Stasko

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
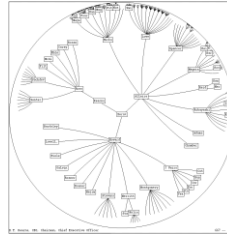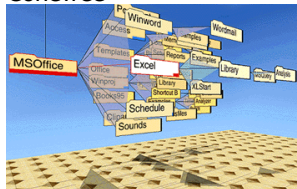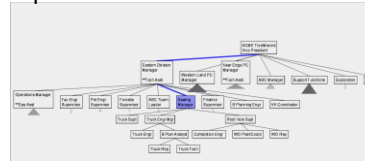
1

Last Time: Node-Link Reps

Hyperbolic tree

Traditional

Lamping & Rao

ConeTree

SpaceTree

Card, Mackinlay & Robertson

Plaisant, Grosjean & Bederson

Node-link Shortcoming

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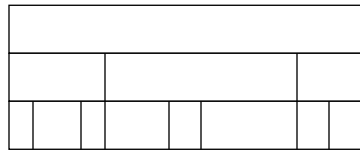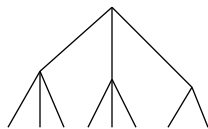 - …but all quickly clash with basic node-link structure

Space-Filling Representation

Each item occupies an area
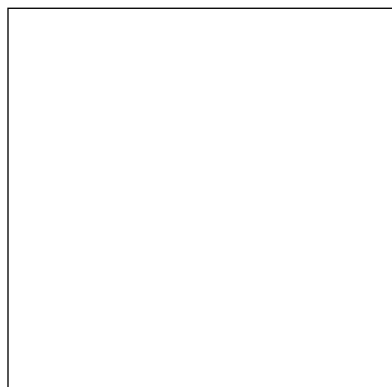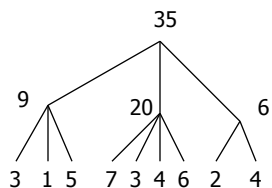
Children are "contained" under parent

One example

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
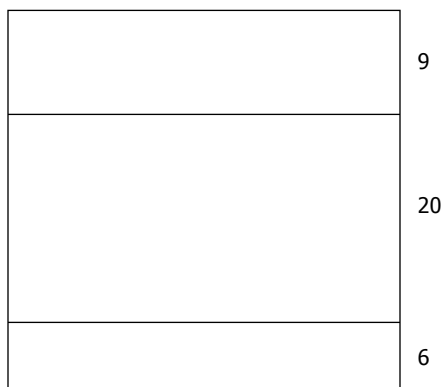- Use area to encode other variable of data items

Example
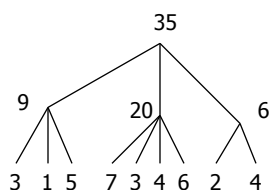
```
            35
     9      20      6
   3 1 5  7 3 4 6  2  4
```

Example

```
            35
     9      20      6
   3 1 5  7 3 4 6  2  4
```

9
20
6

4

Example

```
             35
        /     |     \
       9      20      6
      /|\    /|\\    / \
     3 1 5  7 3 4 6 2   4
```

3	1	5	9
7	3 4	6	20
2	4		6
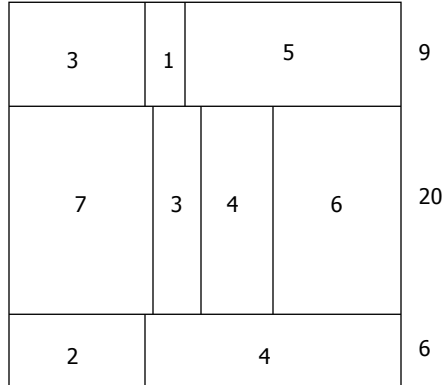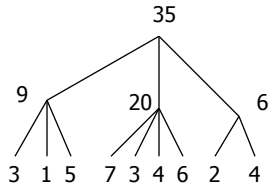
Treemap

- Example

Directories

Treemap Example

Old one I built for our Sun workstations

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
}
```
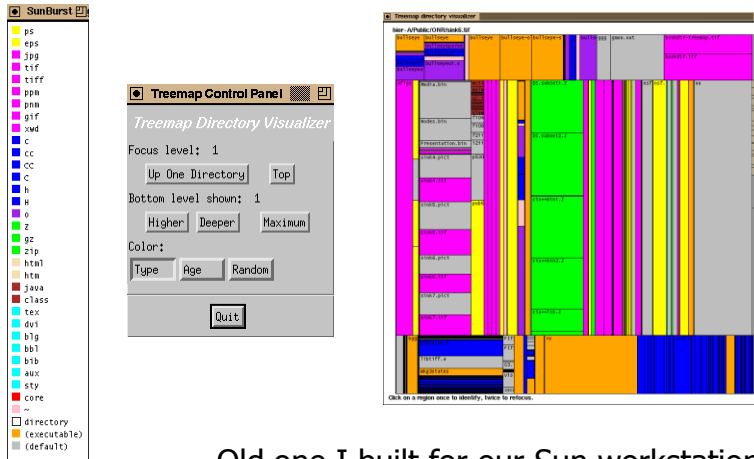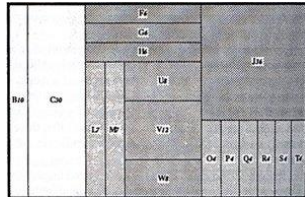
Nested vs. Non-nested

Non-nested Tree-Map
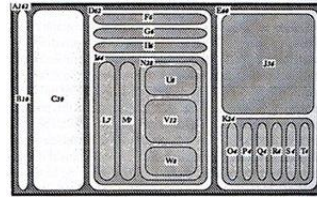
Nested Tree-Map
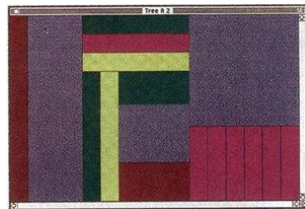
Applications

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

Software Visualization App

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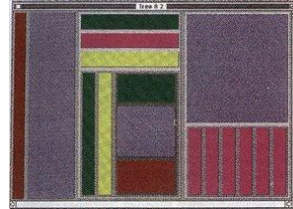- Displays:
  - Size
  - Recent development
  - High fix-on-fix rates
  - History and growth

Baker and Eick
JVLC '95

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

Size

Sample View 2

Bug rates by subsystem and directory

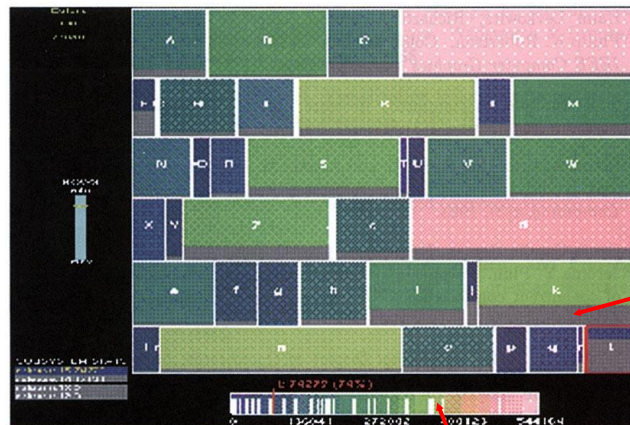Represents
new code
in this
release

Added
functionality

Bug fixes

Bars represent
individual
directories in
the subsystems
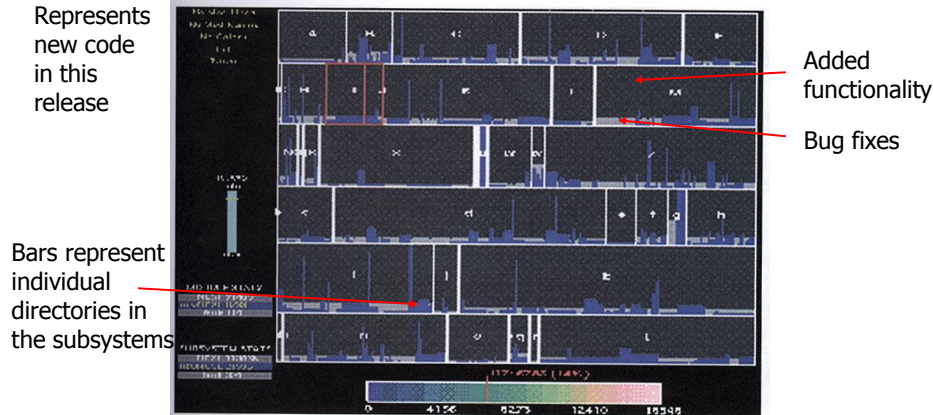
Tennis Viewing Application

- 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

Composite

Games

Set

Match

Simulated Match Results

Match view

Bond won

Set results

Lens showing ball movement on individual points

Game results

Treemap?
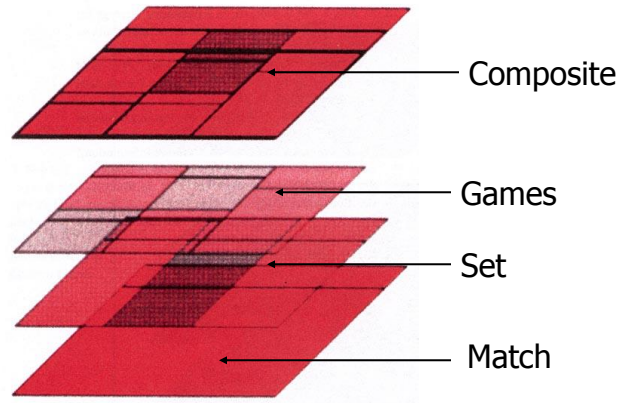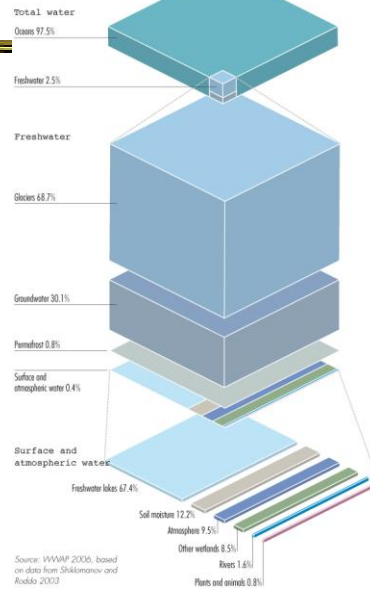
Very nice infographic

Figure 4.1 Global distribution of the world's water
Note: see Chapter 3 on water that is easily available to plants.

Total water
Oceans 97.5%

Freshwater 2.5%

Freshwater

Glaciers 68.7%

Groundwater 30.1%

Permafrost 0.8%

Surface and atmospheric water 0.4%

Surface and atmospheric water

Freshwater lakes 67.4%

Soil moisture 12.2%
Atmosphere 9.5%
Other wetlands 8.5%
Rivers 1.6%
Plants and animals 0.8%

Source: WWAP 2006, based on data from Shiklomanov and Rodda 2003

Treemap Affordances

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

Aspect ratios

These kinds of rectangles are visually unappealing

Which has bigger area?

Variation

- Can rectangles be made more square?
  ……think about it……

- In general, a very hard problem!

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
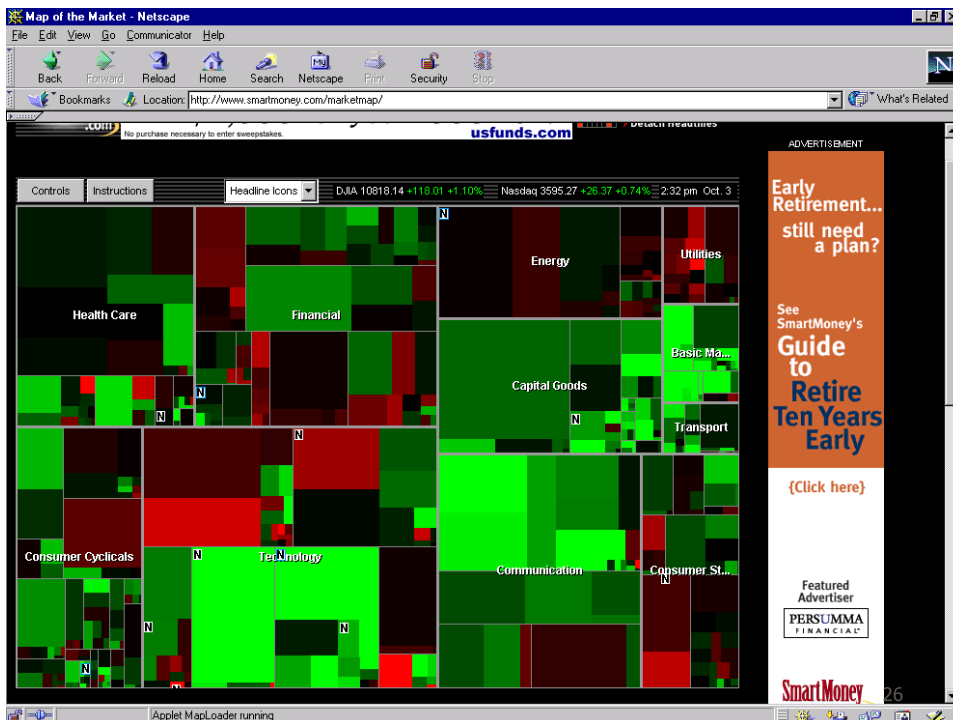 - Takes advantage of shallow hierarchy
  - www.smartmoney.com/marketmap

Image on next slide

Wattenberg
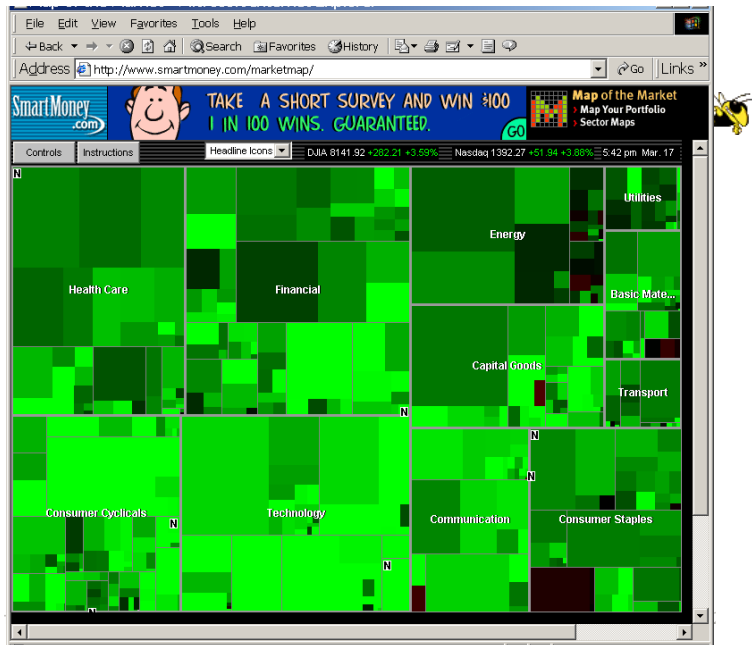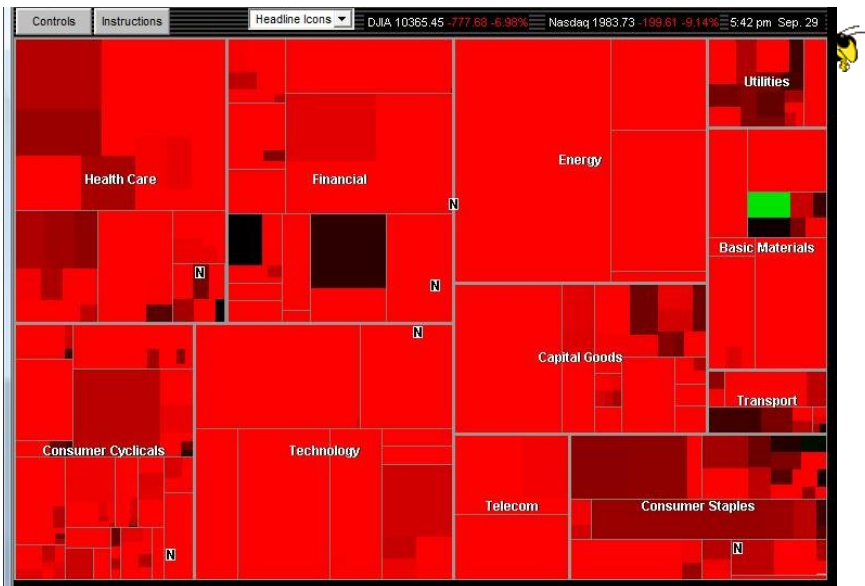CHI '99

A good
day :^)

More recent times   Sept. 29, 2008

14

SmartMoney Review

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

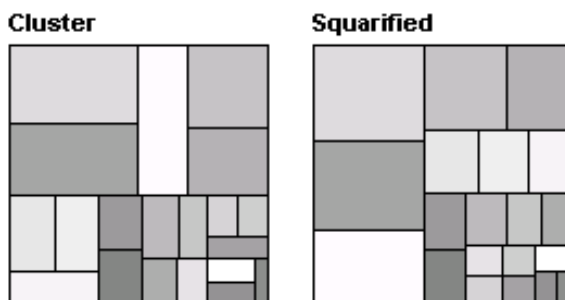# Other Treemap Variations

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

Square Algorithm Problems

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

New Square Algorithms

- Pivot-by-size and pivot-by-middle
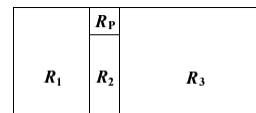
Partition area into 4 regions
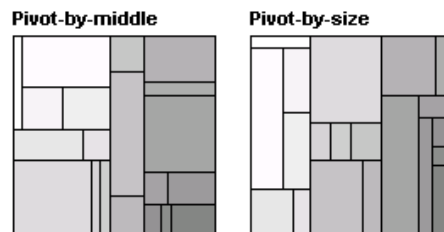Pick pivot element Rp
  Size: Largest element
  Middle: Middle element
R_1 - elements earlier in list than pivot
R_2 - elements in list before R_3 and also that makes Rp have aspect ratio closest to 1

Shneiderman & Wattenberg
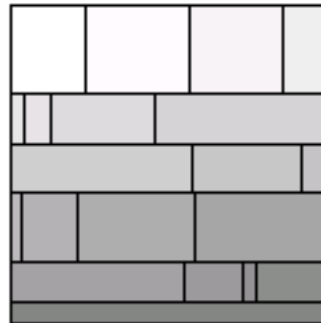InfoVis '01

New Variation

- Strip treemap

StripTreemap

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

Bederson, Shneiderman & Wattenberg
ACM Trans on Graphics `02

www.cs.umd.edu/hcil/treemap-history/java_algorithms/LayoutApplet.html
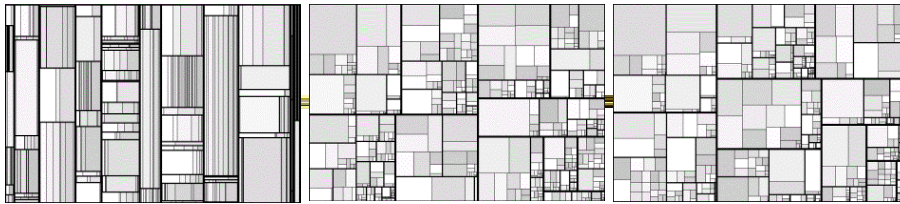
Compare results

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
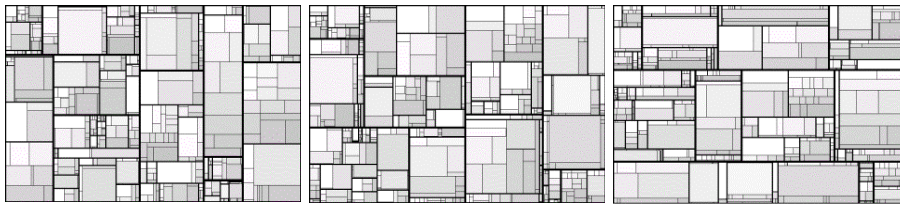   in direction of eye gaze as
     items scanned
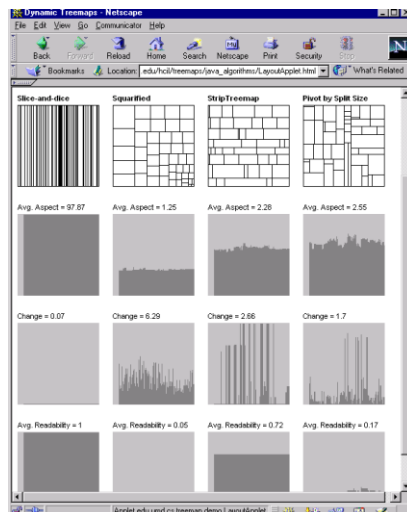
Slice-and-dice   Cluster   Squarified

Pivot-by-middle   Pivot-by-size   Strip

Showing Structure

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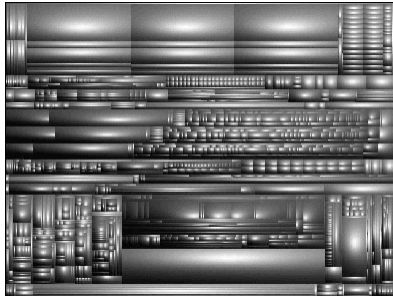 – Supplement Treemap view
  – Change rectangles to other forms

Variation: Cushion Treemap

Add shading and texture
to help convey structure
of hierarchy

Van Wijk & van de Wetering
InfoVis '99

SequoiaView   `www.win.tue.nl/sequoiaview/`

File visualizer
built using
cushion treemap
notion
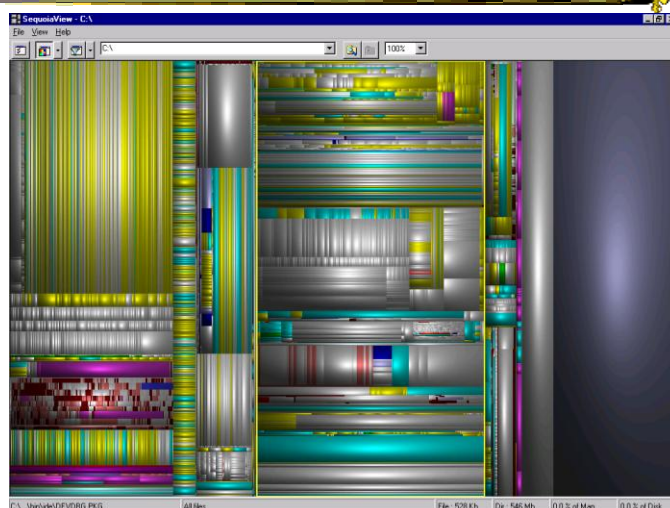
Demo

Internet News Groups

NetScan

Fiore & Smith
Microsoft

Product Sales

www.hivegroup.com/amazon.html

The Hive
Group

News Stories

Marumushi

Investment Portfolios

Panopticon

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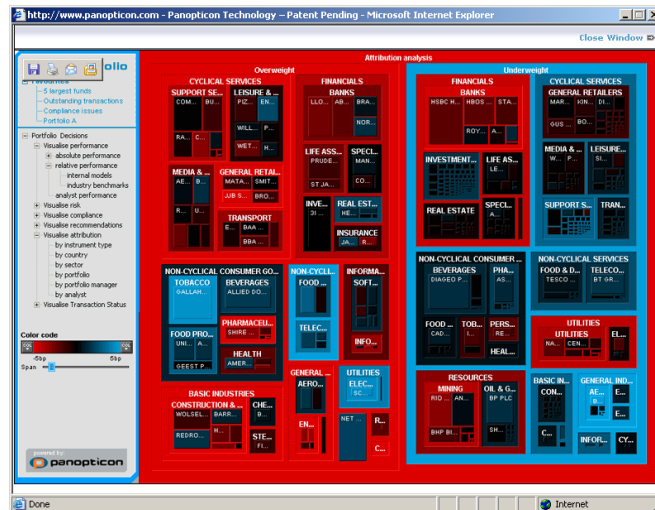
Scaling Up

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.

Mansmann & Vinnik
TVCG '06

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

- 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
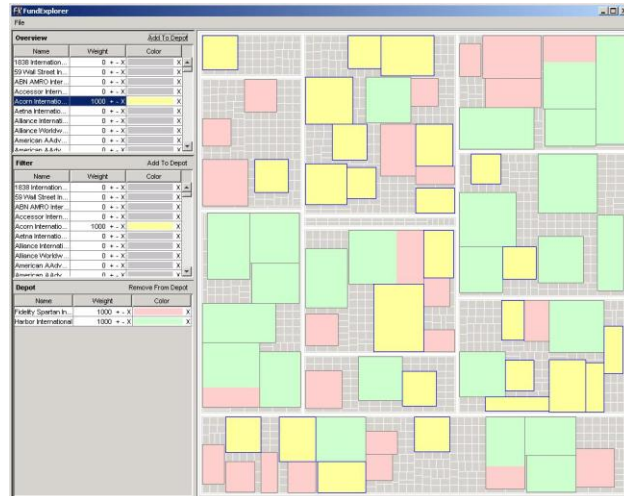   - Provide dynamic query capabilities to enhance exploration leading to portfolio diversification
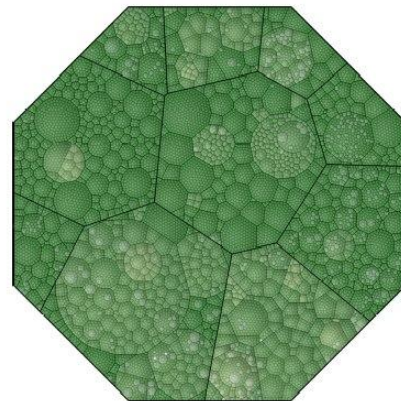
FundExplorer

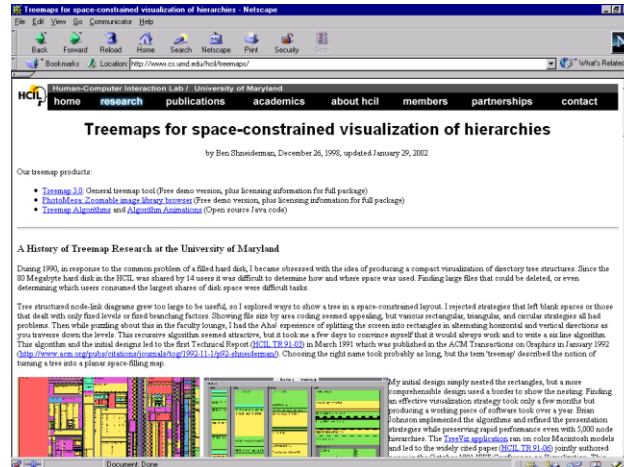Video
InfoVis '03

Demo

Voronoi Treemaps

Balzer & Deussen
InfoVis '05

The World of Treemaps

Maryland HCIL website devoted to Treemaps

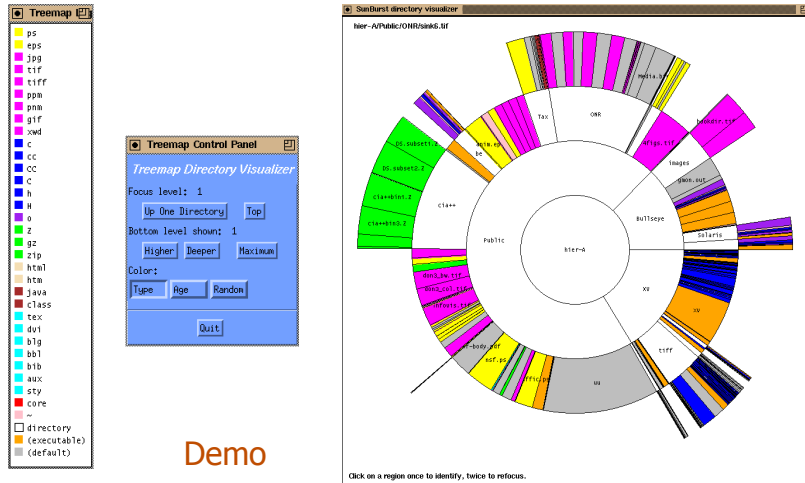Workshop in 2001 there on topic

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

Radial Space-Filling

Chuah
InfoVis '98

Andrews &
Heidegger
InfoVis '98

SunBurst

Demo

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

SunBurst
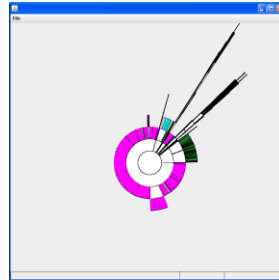
- Demonstration of system

Java version built by Neel Parekh

Stasko, Catrambone, Guzdial & McDonald
IJHCS `00

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...

SunBurst Negative

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

examples

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

Stasko & Zhang
InfoVis '00

Angular Detail
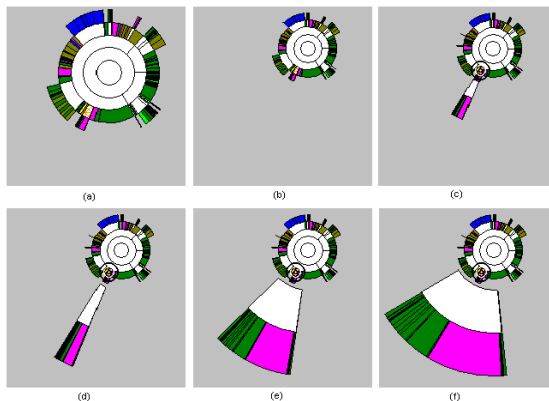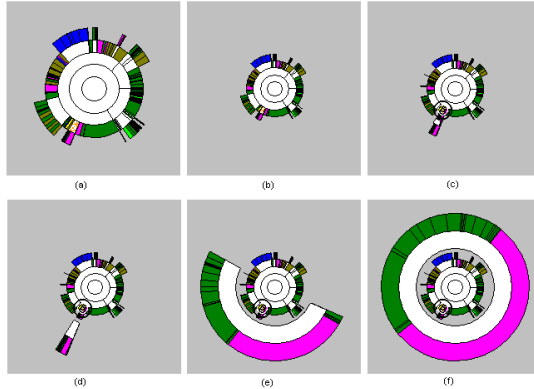

- Most "natural"
- Least space-efficient
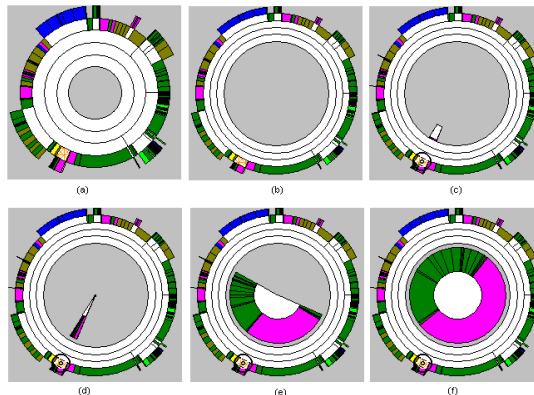- Most configurable by user

Detail Outside

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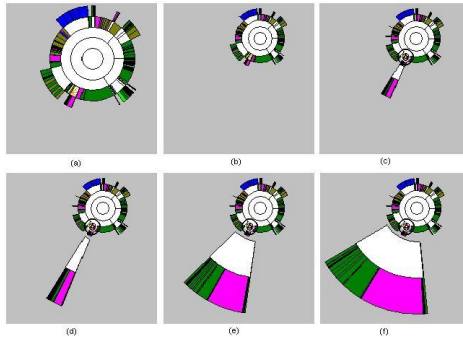- Relatively space efficient

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

(a)   (b)   (c)

(d)   (e)   (f)

Video

Stasko & Zhang
InfoVis '00

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

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

InterRing

Provides many of those follow-on capabilities and new operations
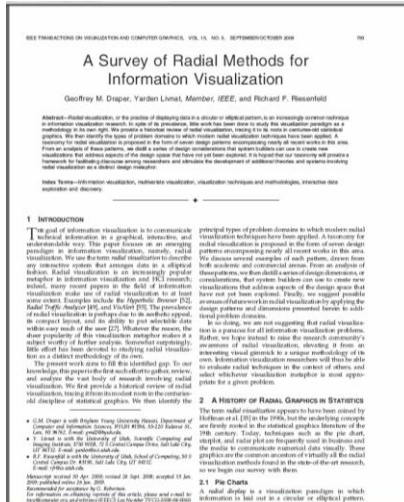
Yang, Ward & Rudensteiner
InfoVis '02
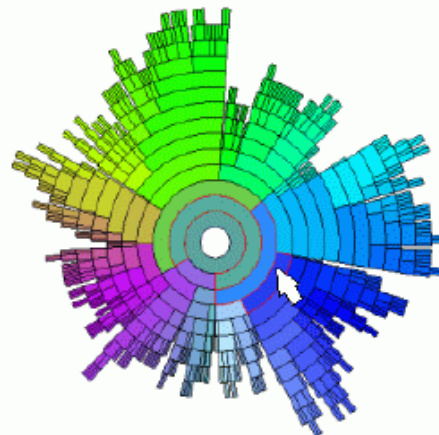
Survey of Radial Techniques

Draper et al
TVCG '09

More Alternatives

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

Grokker

www.groxis.com

Demo
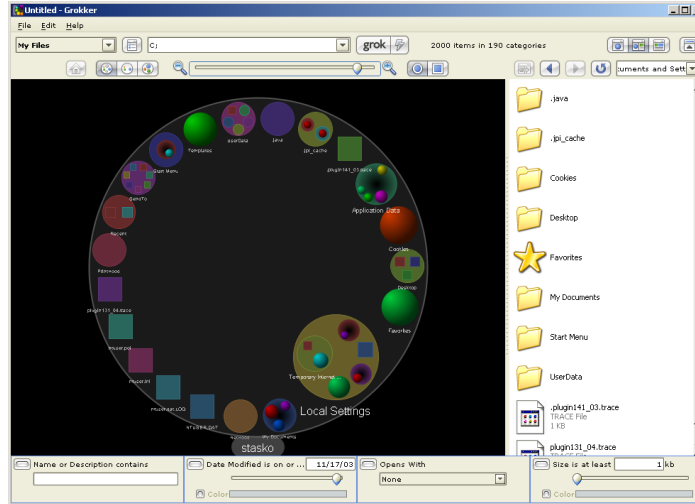
Zoomology

CS 7450
Spring '03
project

InfoVis '03
Contest Winner
Best Student
entry
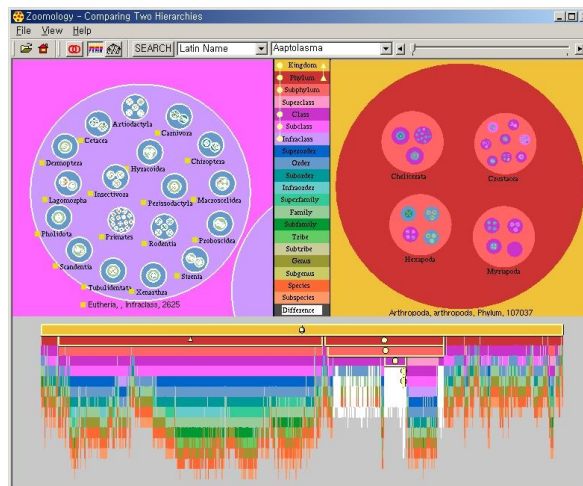
Alternate View

Video

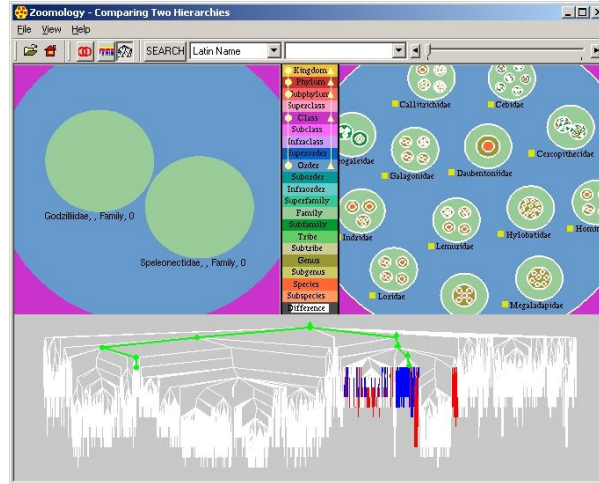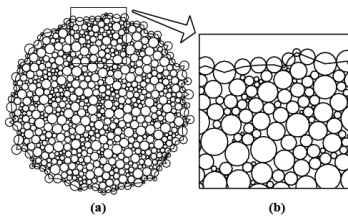# Circle Packing

Wang, Wang, Dai & Wang
CHI '06

(a)   (b)

Figure 4. Packing 1000 circles with random radii

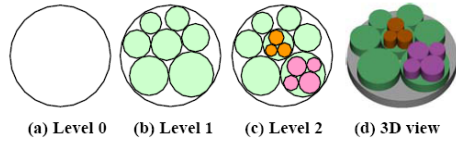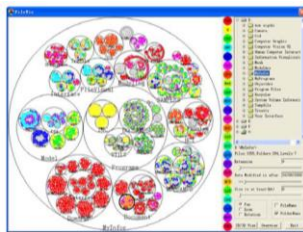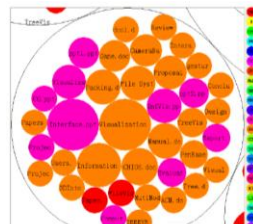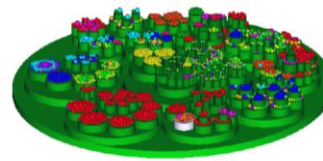(a) Level 0   (b) Level 1   (c) Level 2   (d) 3D view

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

Hybrid Approaches

- Mix node-link and space-filling
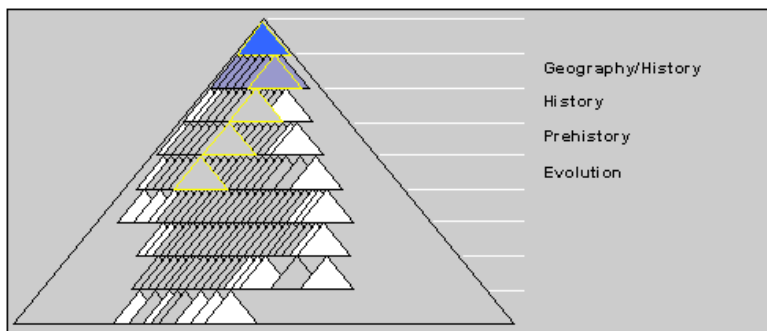
CHEOPS

Geography/History
History
Prehistory
Evolution

(Saw last class)

Beaudoin, Parent, Vroomen, Vis '96

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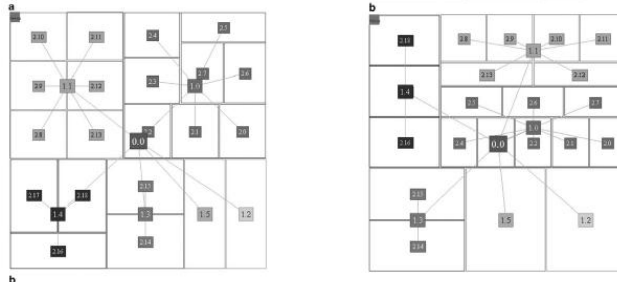
- Explicit combination of node-link and treemap-like techniques
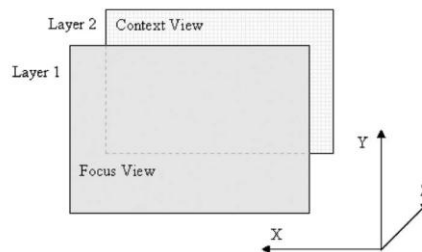- Partition space into hierarchical regions, then draw node link into that

Focus + Context → Zooming + Layering

- Uses 2 Layers with semi-transparency
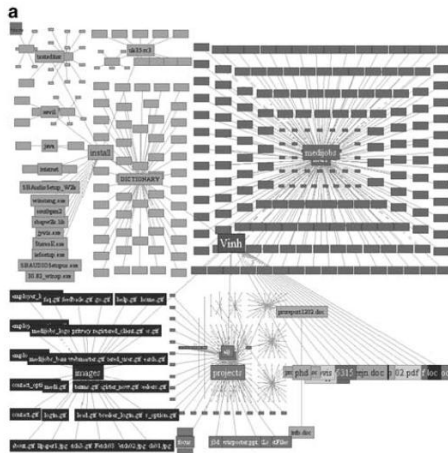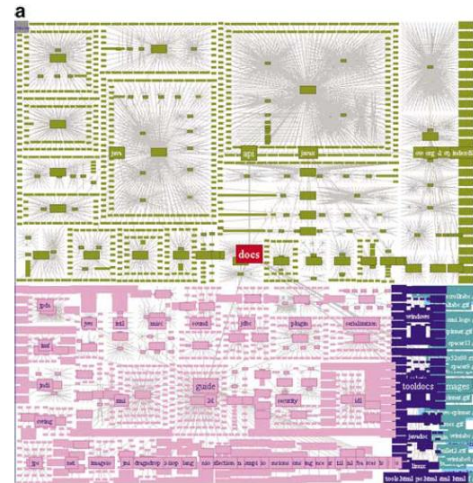- Viewer can zoom and swap
- Provides animated transitions in-between

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EnCon Sample Views

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

HW 6

- Drawing a Graph
  - Given an adjacency matrix for a graph, draw a "nice-looking" node-link representation of it

- Due next Tuesday
- Follow the directions!!!
- Spend about 30 minutes on it

Project

- Midway report due next Thursday
- Key ingredients
  - Clear problem description
  - What is your data? (be explicit)
  - What development tools will you use?
  - Detailed design ideas

Upcoming

- Graphs & Networks 1
  - Reading
    - Ward chapter 8

- Graphs & Networks 2
  - Reading
    - Perer & Shneiderman

References

- Spence and CMS texts
- All referred to papers