CS 53000 Introduction to Scientific Visualization

Information Visualization Primer

December 6, 2011

(Information) Visualization

Problem:

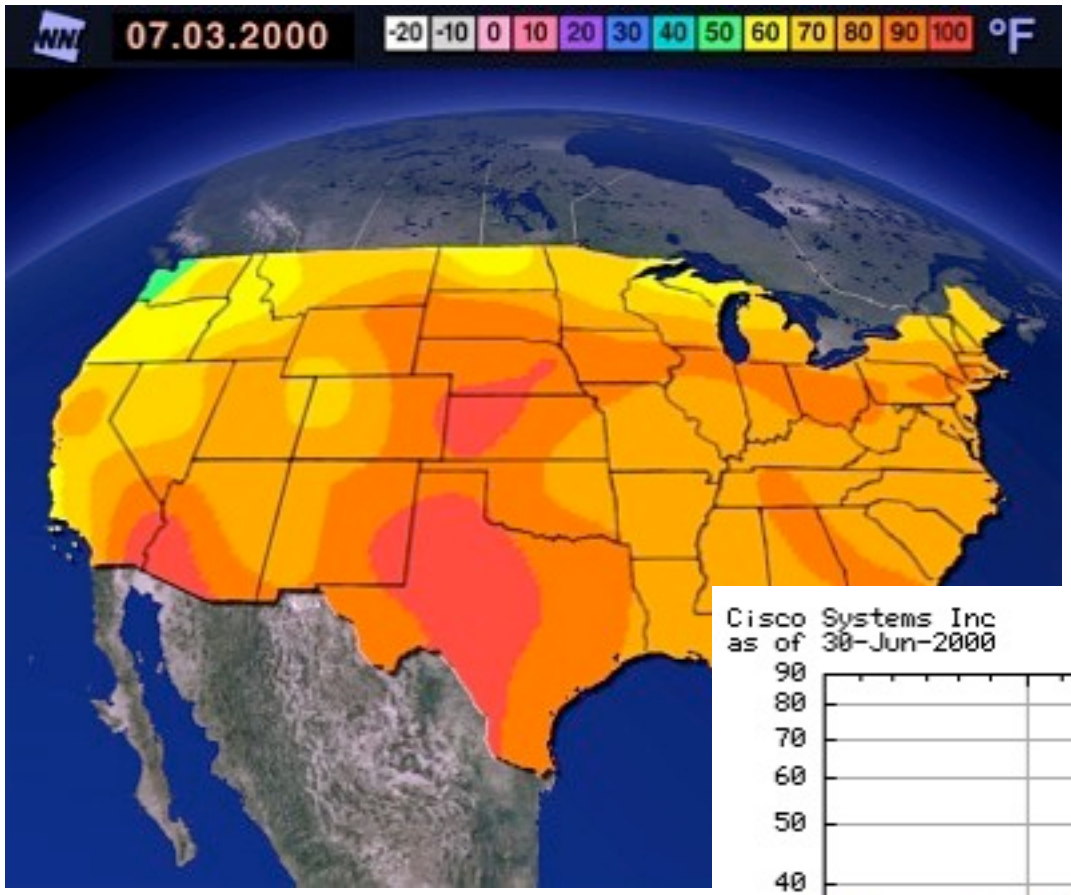
- HUGE Datasets: How to understand them?

Solution

- Take better advantage of human perceptual system
- Convert information into a graphical representation.

Issues

- How to convert abstract information into graphical form?
- Do visualizations do a better job than other methods?



Visualization Success Stories

The Power of Visualization

1. **Start out going Southwest on ELLSWORTH AVE**

Towards BROADWAY by turning right.

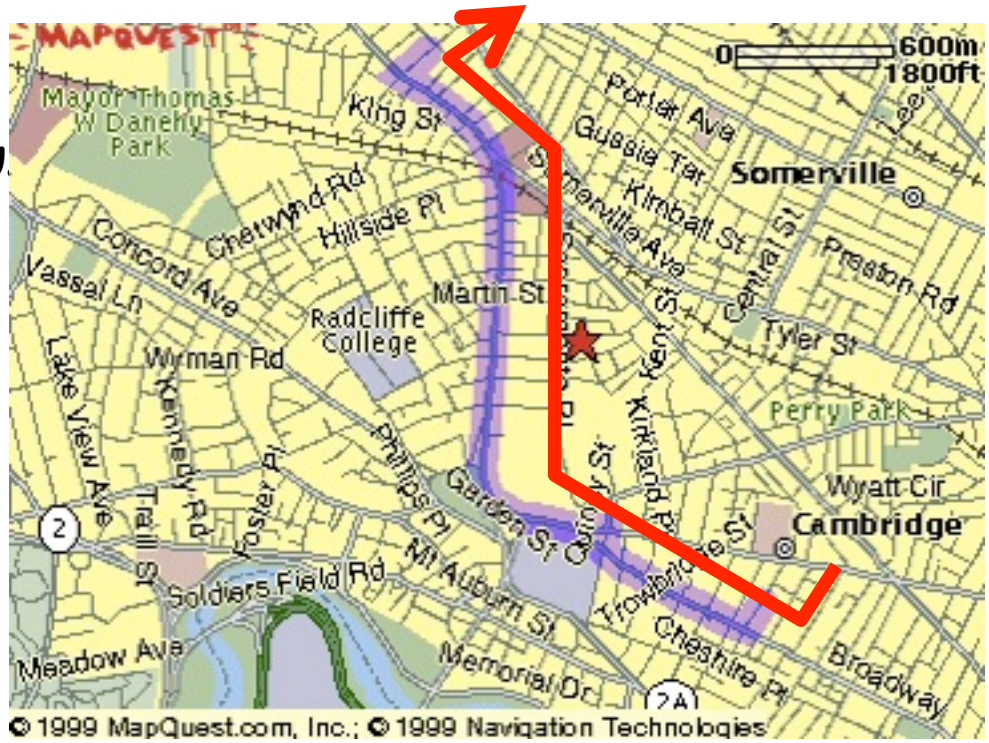
2: **Turn RIGHT onto BROADWAY.**

3. **Turn RIGHT onto QUINCY ST.**

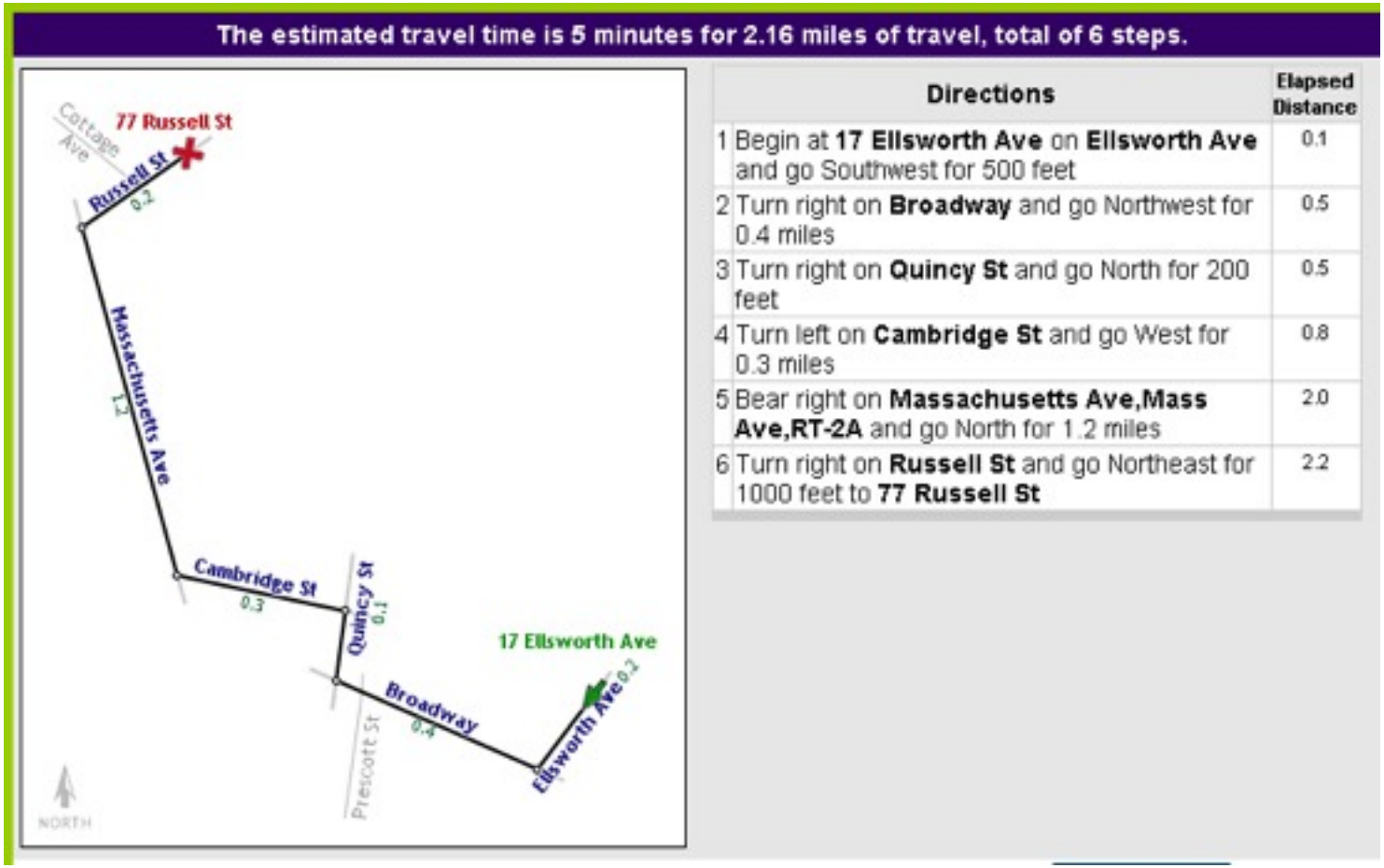
4. **Turn LEFT onto CAMBRIDGE ST.**

5. **Turn SLIGHT RIGHT onto MASSACHU**

6. **Turn RIGHT onto RUSSELL ST.**



The Power of Visualization

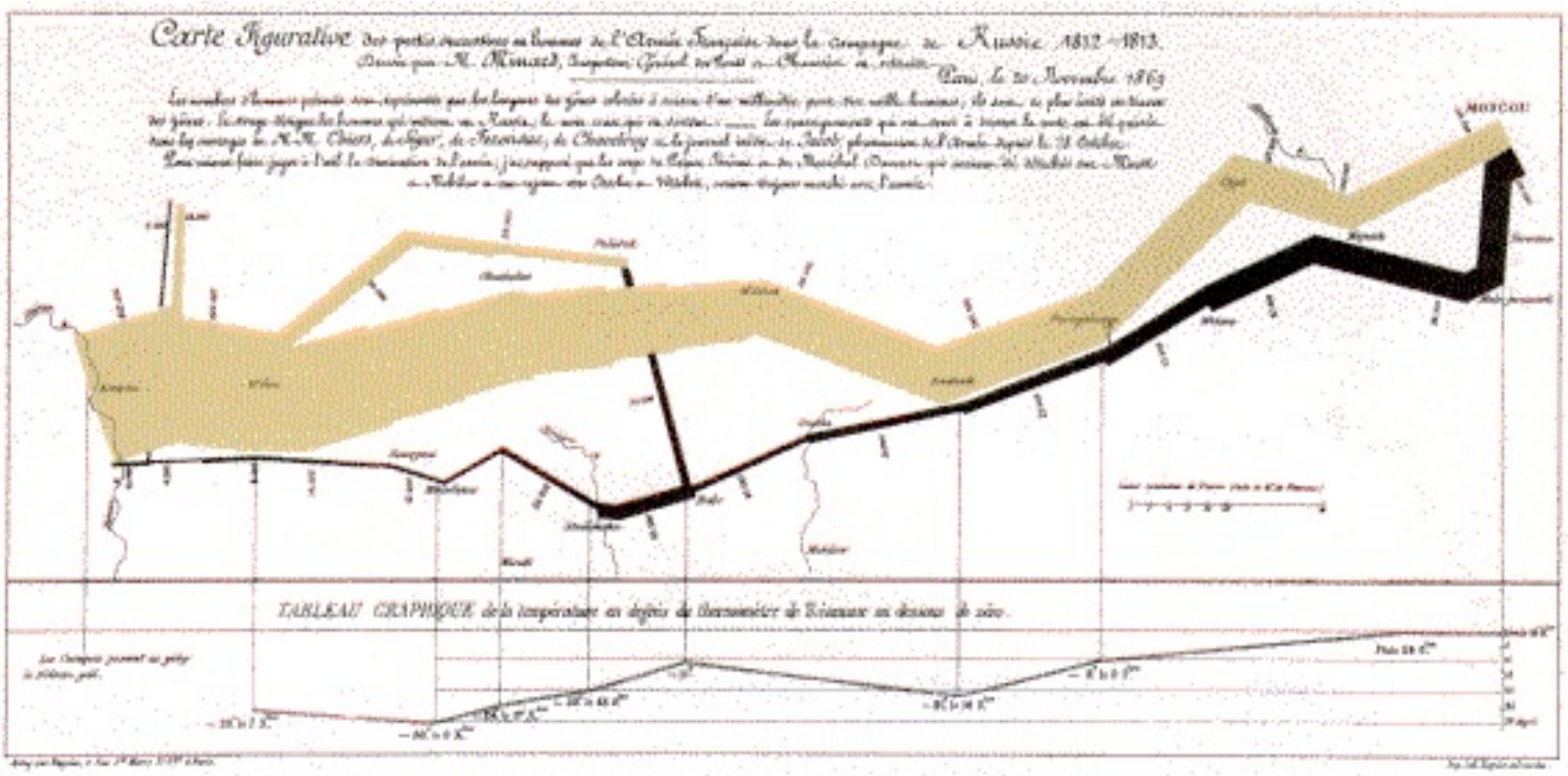


Line drawing tool by Maneesh Agrawala http://graphics.stanford.edu/~maneesh/

London Subway

www.londontransport.co.uk/tube

Napolean's March



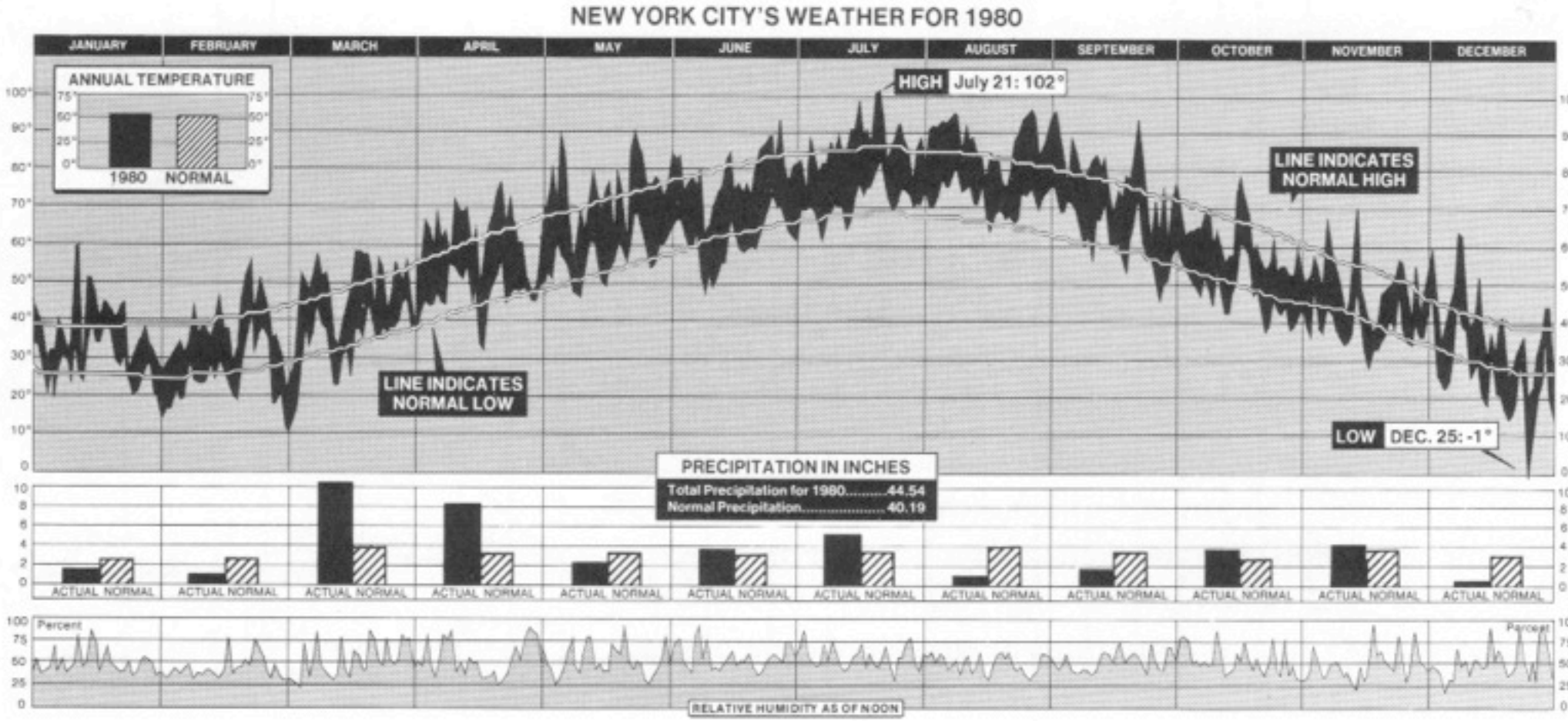
Minard graphic

size of army
direction

latitude
longitude

temperature
date

Example



New York Times, January 11, 1981, p. 32.

Tufte, Vol. 1

Information Visualization

What is "information"?

- Items, entities, things which do not have a direct physical correspondence
- Notion of abstractness of the entities is important too
- Examples: baseball statistics, stock trends, connections between criminals, car attributes...

Information Visualization

What is "Information visualization"?

- The use of computer-supported, interactive visual representations of data to amplify cognition.
  - From [Card, Mackinlay Shneiderman '98]

What It's **Not**

Scientific Visualization

- Primarily relates to and represents something physical or geometric
- Examples
  - Air flow over a wing
  - Stresses on a girder
  - Weather over Pennsylvania

Information Visualization

Components:

- Taking items without a direct physical correspondence and mapping them to a 2-D or 3-D physical space.

- Giving information a visual representation that is useful for analysis and decision-making

Purpose of Information Visualization

To help:

- Explore
- Calculate
- Communicate
- Decorate (browser)

2 Different Primary Goals: 2 Different Types of Vis

Explore/Calculate

- Analyze
- Reason about Information

Communicate

- Explain
- Make Decisions
- Reason about Information

Two Key Attributes

Scale

- Challenge often arises when data sets become very large

Interactivity

- Want to show multiple different perspectives on the data

Key Tools

Using size to indicate quantity

Using color for distinguishing / selection

- NOT FOR QUANTITY!!!!

Brushing and Linking

Animation

Providing multiple views

Domains for Info Vis

- Text
- Statistics
- Financial/business data
- Internet information
- Software
- ...

The Need for Critical Analysis

We see many creative ideas, but they often bomb in use

The hard part:

how to apply it judiciously

- Inventors usually do not accurately predict how their invention will be used

Tasks in Info Vis

Overview, zoom & filter, details on demand

Search

- Finding a specific piece of information
  - How many games did the Braves win in 1995?
  - What novels did Ian Fleming author?

Browsing

- Look over or inspect something in a more casual manner, seek interesting information
  - Learn about crystallography
  - What has Jane been up to lately?

Tasks in Info Vis

Analysis

- Comparison-Difference
- Outliers, Extremes
- Patterns

Assimilation

Monitoring

Awareness

Overview, zoom & filter, details on demand

Knowledge Crystallization

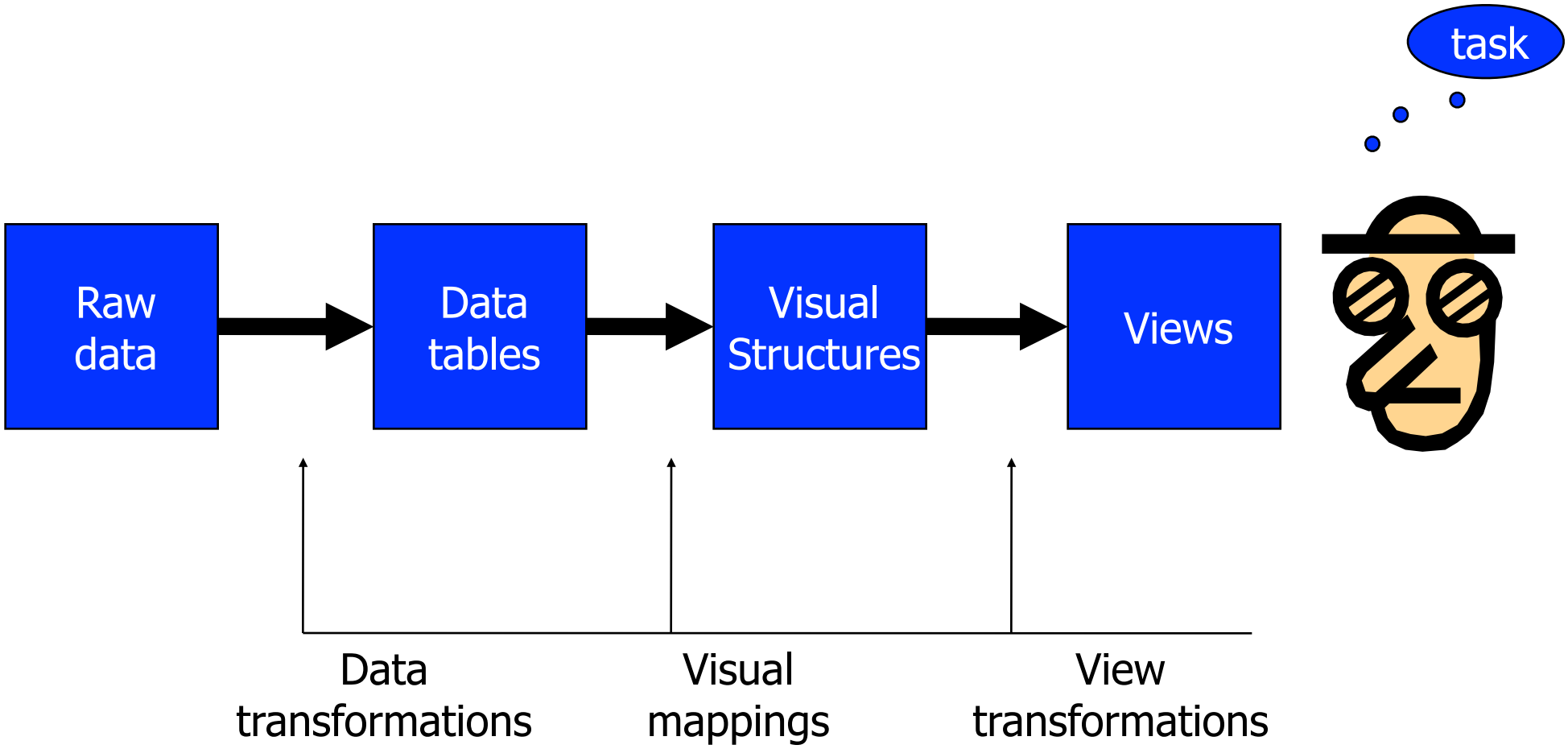
- Information foraging
- Search for schema (representation)
- Instantiate schema
- Problem solve to trade off features
- Search for a new schema that reduces problem to a simple trade-off
- Package the patterns found in some output product

From CMS '98

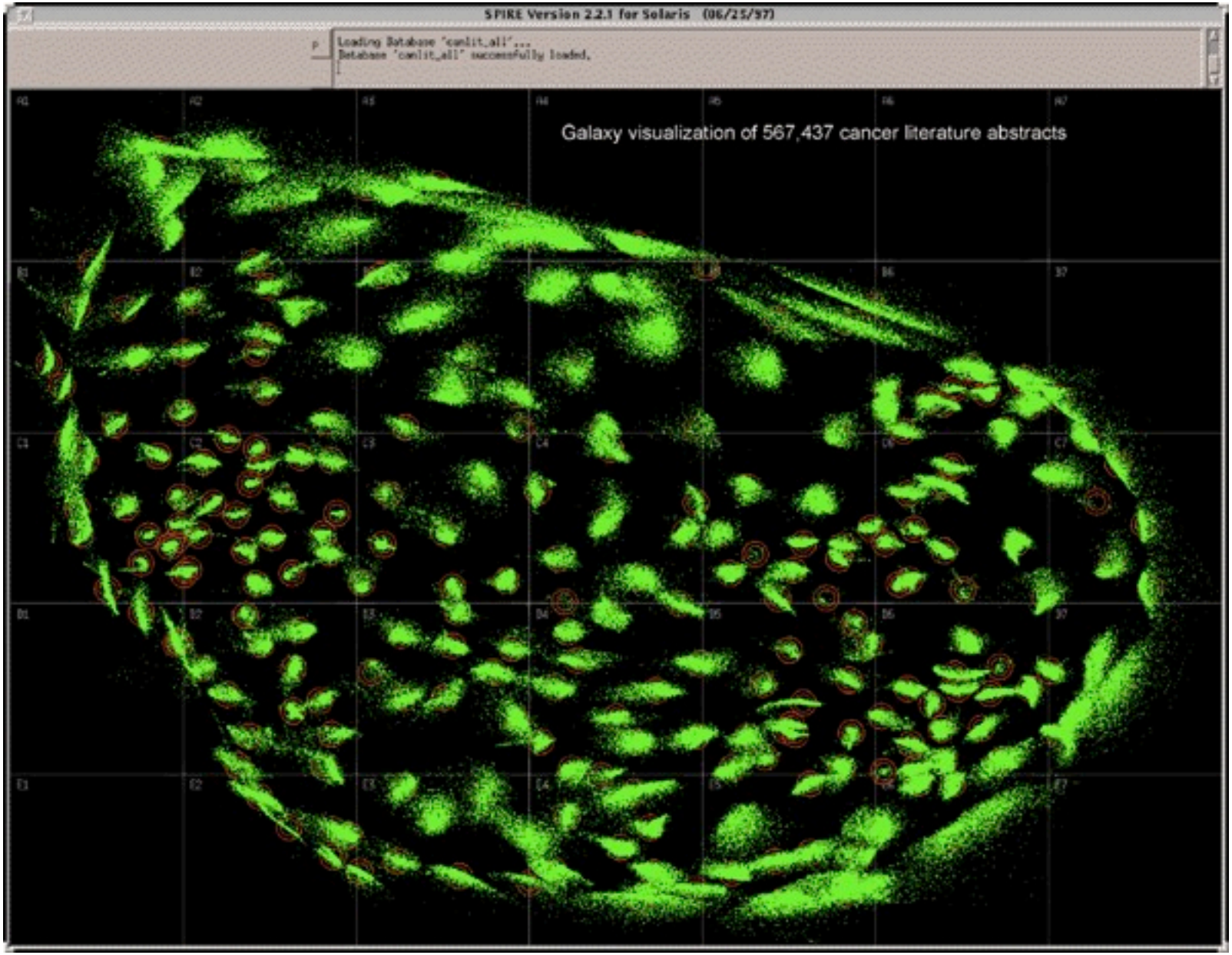
How Vis Amplifies Cognition

- Increasing memory and processing resources available
- Reducing search for information
- Enhancing the recognition of patterns
- Enabling perceptual inference operations
- Using perceptual attention mechanisms for monitoring
- Encoding info in a manipulable medium

Process

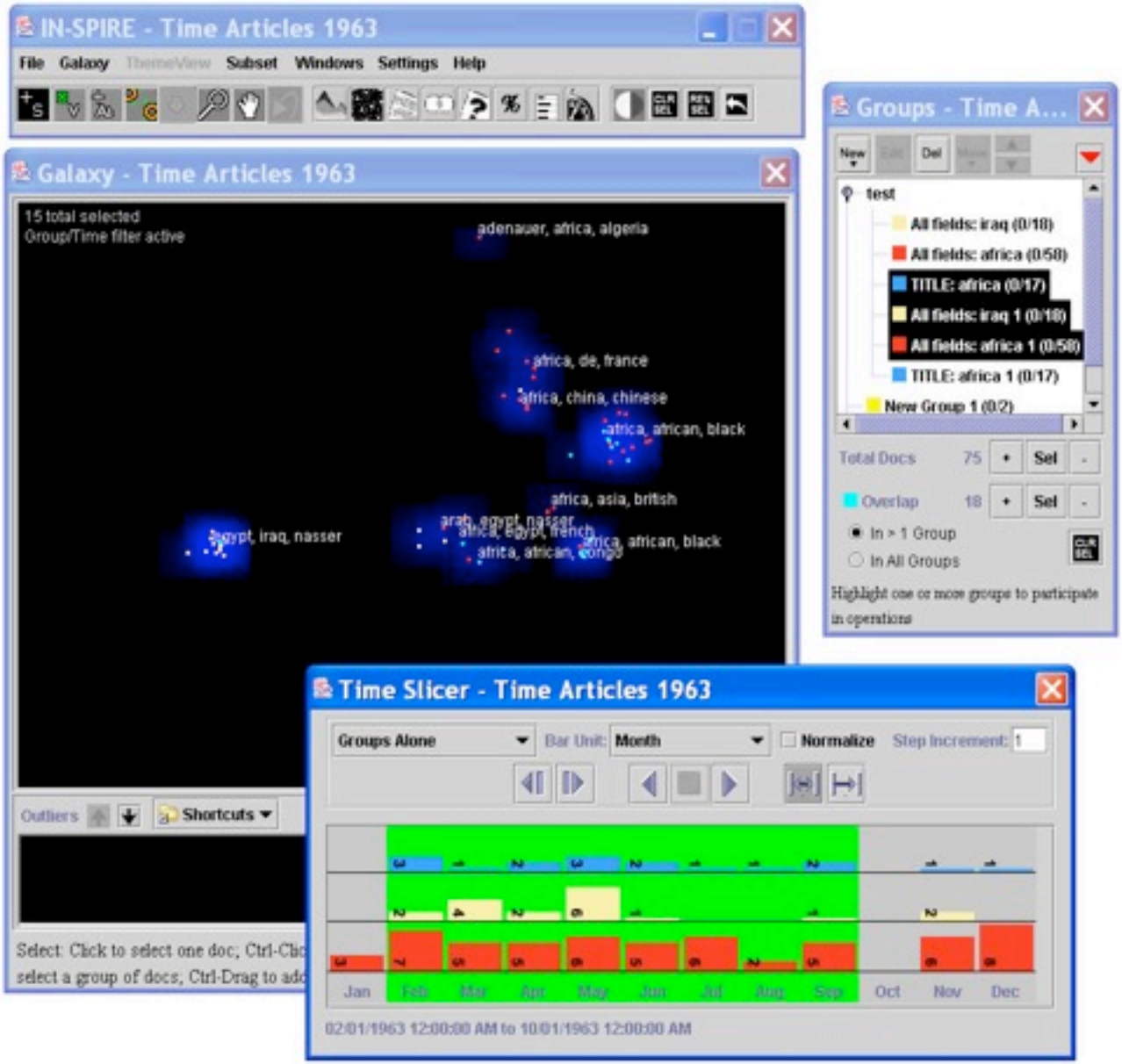

task
Raw data
Data tables
Visual Structures
Views
Data transformations
Visual mappings
View transformations

Galaxy


SPIRE Version 2.2.1 for Solaris (06/25/97)
Loading Database 'canlit_all'...
Database 'canlit_all' successfully loaded.
Galaxy visualization of 567,437 cancer literature abstracts

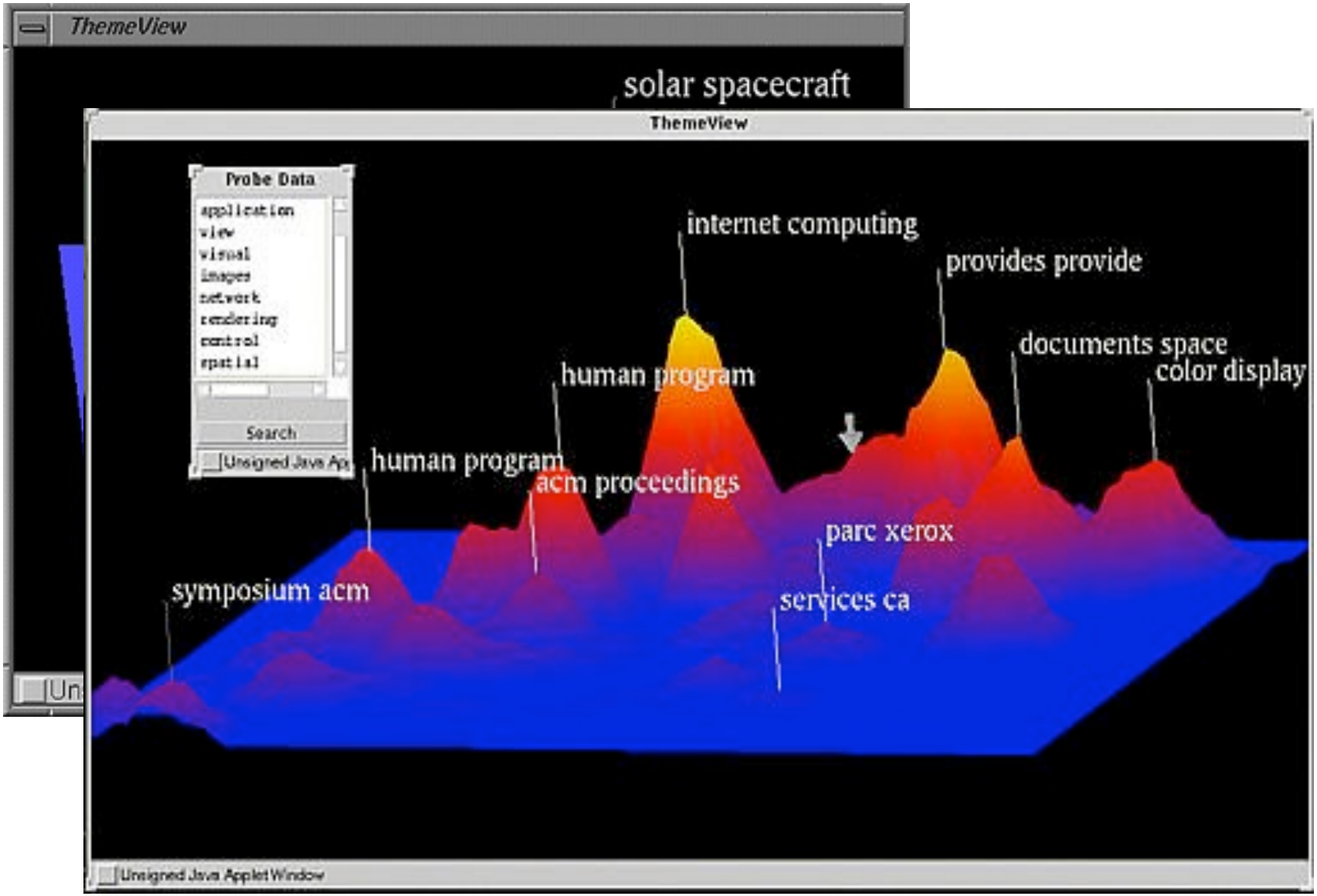
Galaxy

http://in-spire.pnl.gov/2shots/in-spire_tools.jpg



ThemeView

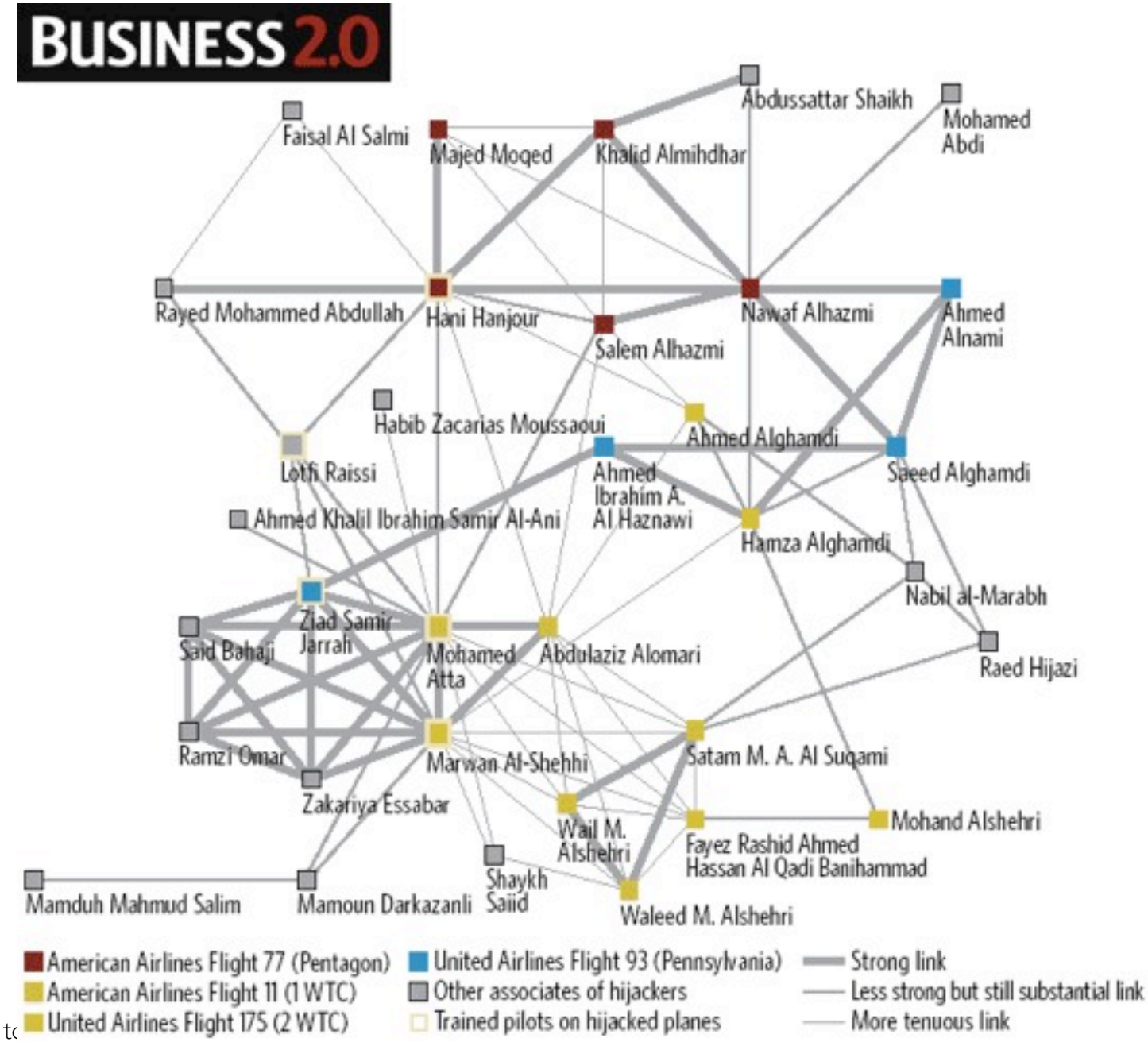
http://picturethis.pnl.gov/picturet.nsf/All/4J5Q3E?opendocument



Visualization in the Aftermath of 9/11

Six Degrees of Mohamed Atta

http://business2.com/articles/mag/0,1640,35253,FF.html



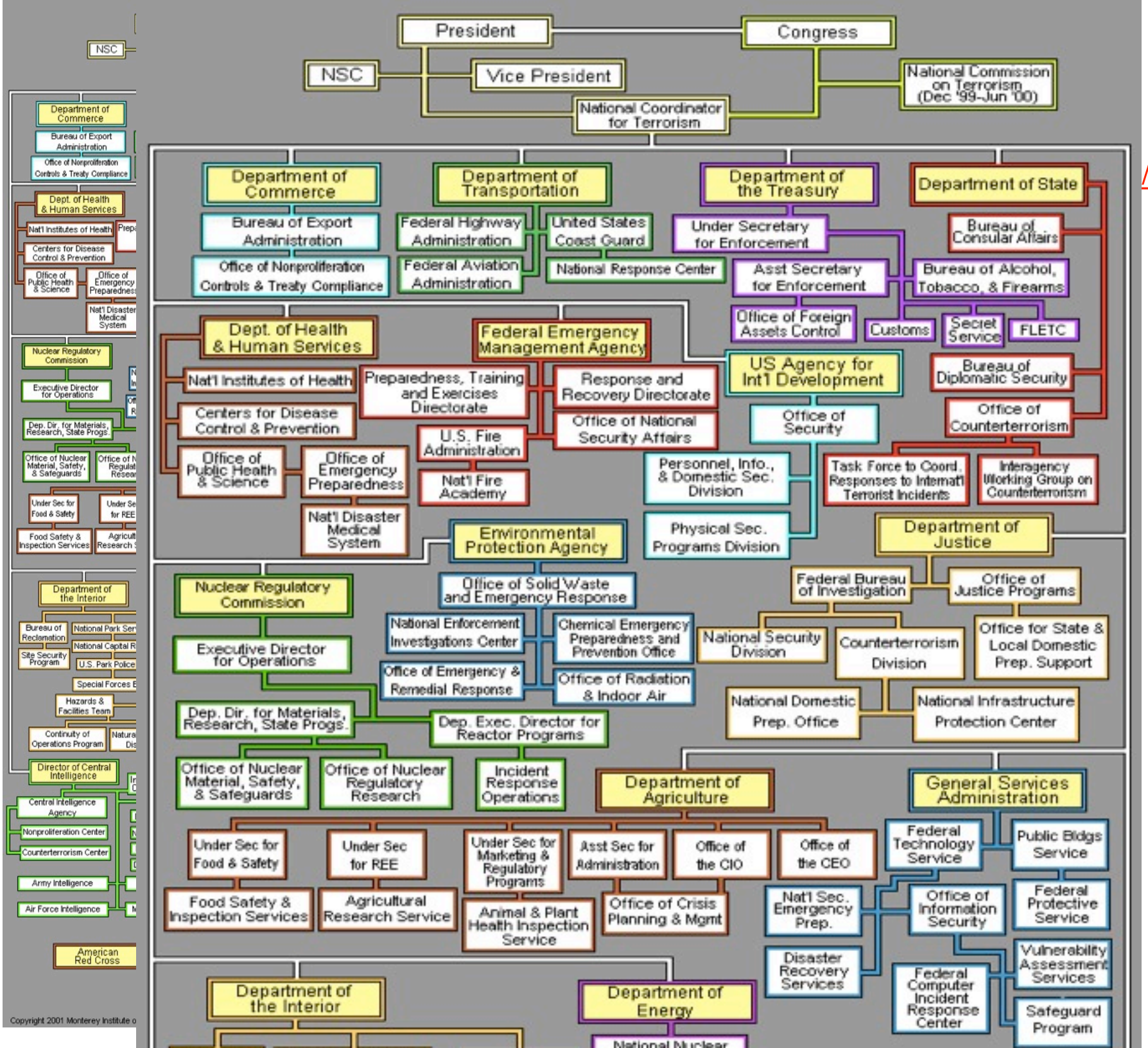

President
Congress
NSC
Vice President
National Commission on Terrorism (Dec '99-Jun '00)
National Coordinator for Terrorism
Department of Commerce
Bureau of Export Administration
Office of Nonproliferation Controls & Treaty Compliance
Department of Transportation
Federal Highway Administration
United States Coast Guard
Federal Aviation Administration
National Response Center
Department of the Treasury
Under Secretary for Enforcement
Asst Secretary for Enforcement
Office of Foreign Assets Control
Customs
Secret Service
FLETC
Department of State
Bureau of Consular Affairs
Bureau of Alcohol, Tobacco, & Firearms
Bureau of Diplomatic Security
Office of Counterterrorism
Task Force to Coord. Responses to Internatl Terrorist Incidents
Interagency Working Group on Counterterrorism
Dept. of Health & Human Services
Nat'l Institutes of Health
Centers for Disease Control & Prevention
Office of Public Health & Science
Office of Emergency Preparedness
Nat'l Disaster Medical System
Federal Emergency Management Agency
Preparedness, Training and Exercises Directorate
Response and Recovery Directorate
Office of National Security Affairs
U.S. Fire Administration
Nat'l Fire Academy
US Agency for Int'l Development
Office of Security
Personnel, Info., & Domestic Sec. Division
Physical Sec. Programs Division
Nuclear Regulatory Commission
Executive Director for Operations
Dep. Dir. for Materials, Research, State Progs.
Office of Nuclear Material, Safety, & Safeguards
Office of Nuclear Regulatory Research
Incident Response Operations
Dep. Exec. Director for Reactor Programs
Environmental Protection Agency
Office of Solid Waste and Emergency Response
National Enforcement Investigations Center
Chemical Emergency Preparedness and Prevention Office
Office of Emergency & Remedial Response
Office of Radiation & Indoor Air
Department of Justice
Federal Bureau of Investigation
Office of Justice Programs
National Security Division
Counterterrorism Division
Office for State & Local Domestic Prep. Support
National Domestic Prep. Office
National Infrastructure Protection Center
Department of Agriculture
Under Sec for Food & Safety
Under Sec for REE
Under Sec for Marketing & Regulatory Programs
Asst Sec for Administration
Office of the CIO
Office of the CEO
Food Safety & Inspection Services
Agricultural Research Service
Animal & Plant Health Inspection Service
Office of Crisis Planning & Mgmt
General Services Administration
Federal Technology Service
Public Bldgs Service
Nat'l Sec. Emergency Prep.
Office of Information Security
Federal Protective Service
Disaster Recovery Services
Federal Computer Incident Response Center
Vulnerability Assessment Services
Safeguard Program
Department of the Interior
Department of Energy
National Nuclear

Chart
/cbw/

Flash Animation of Flight Paths

http://www.washingtonpost.com/wp-srv/nation/graphics/attack/aviation_1.html

Example of finding the right application

The Treemap (Johnson & Shneiderman)

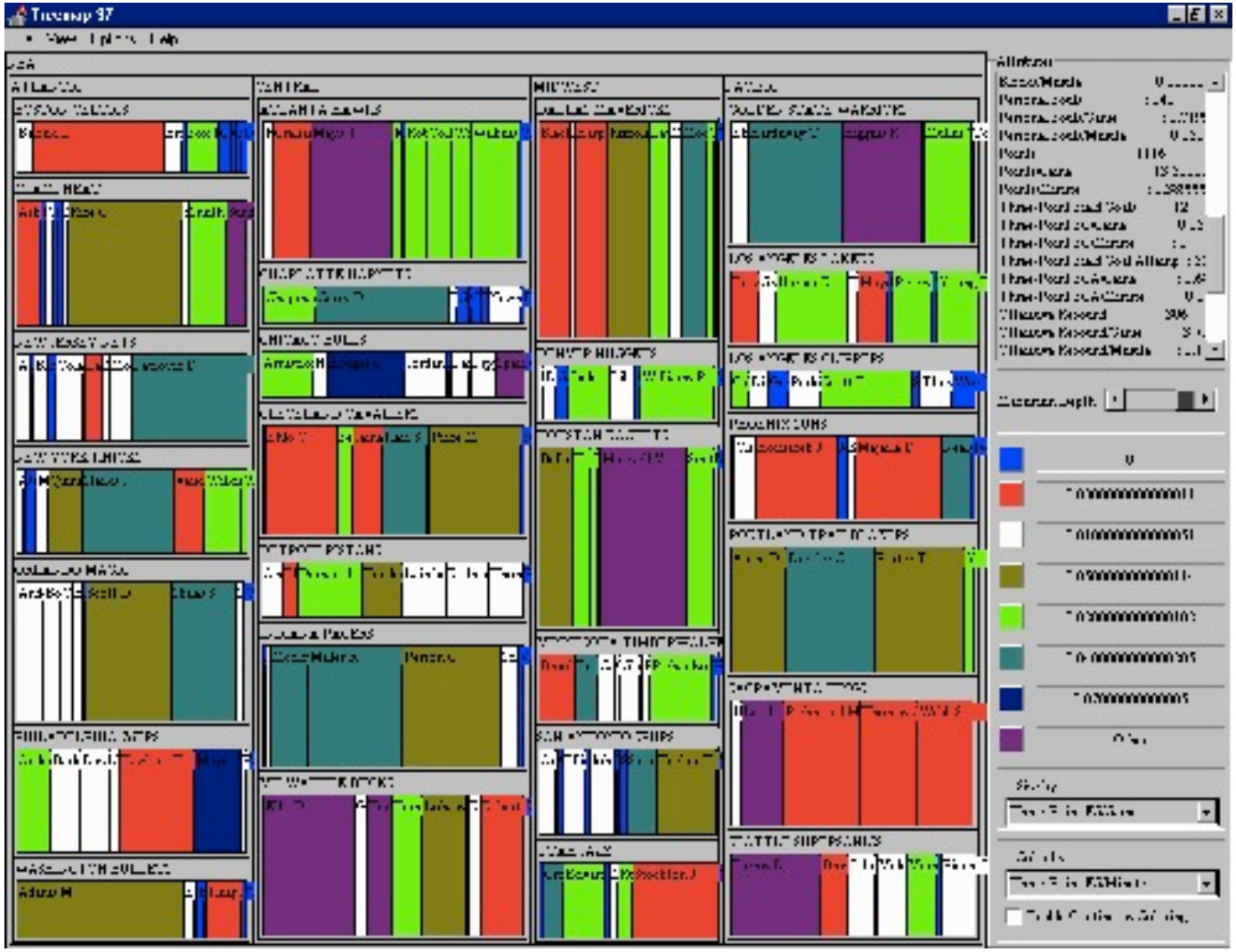
Idea:

- Show a hierarchy as a 2D layout
- Size on screen indicates relative size of underlying objects

Overview, zoom & filter, details on demand

Treemap applied to File System

Overview, zoom & filter, details on demand



Treemap Problems

Too disorderly

- What does adjacency mean?
- Aspect ratios uncontrolled leads to lots of skinny boxes that clutter

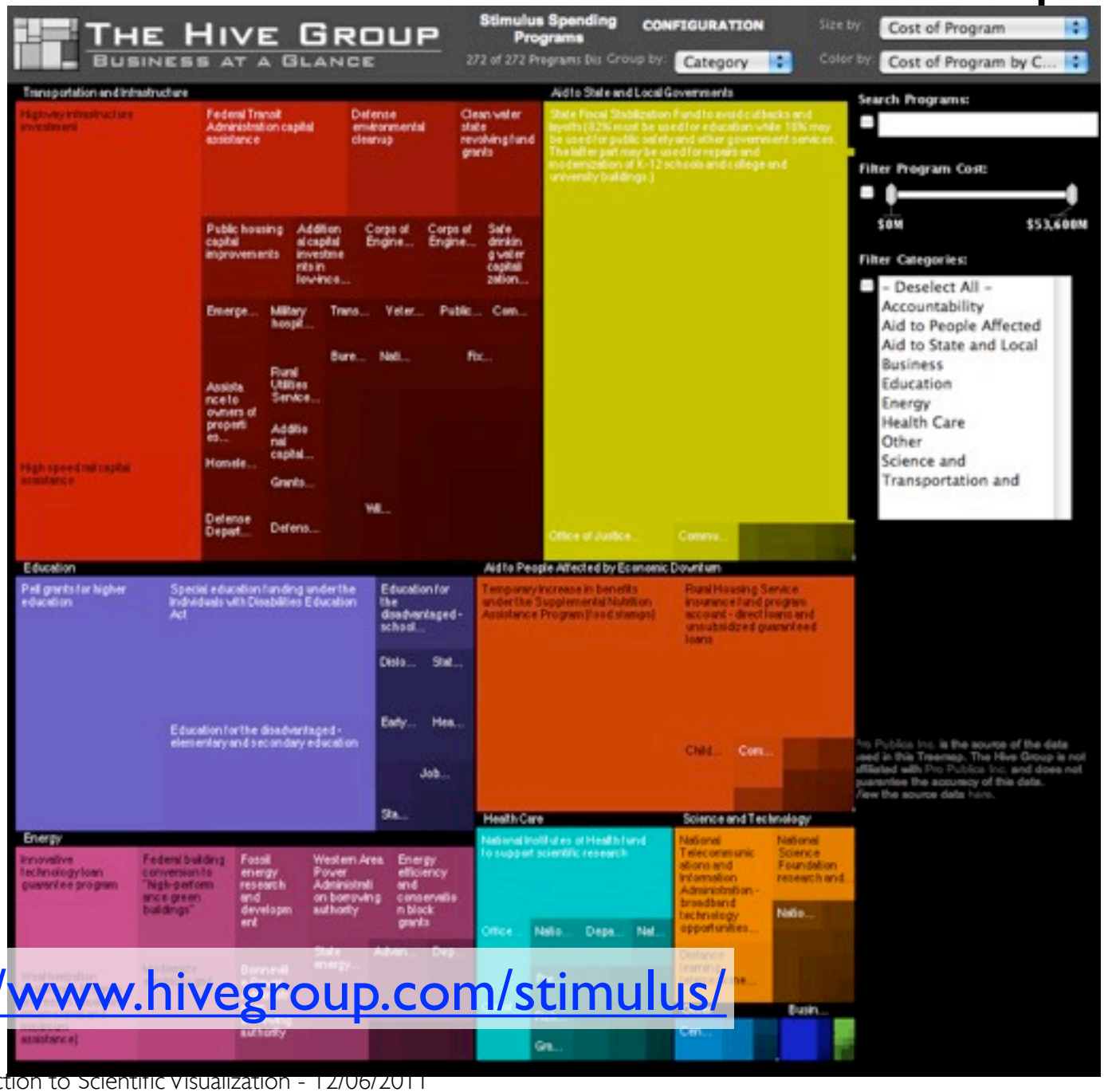
Color not used appropriately

- In fact, is meaningless here

Wrong application

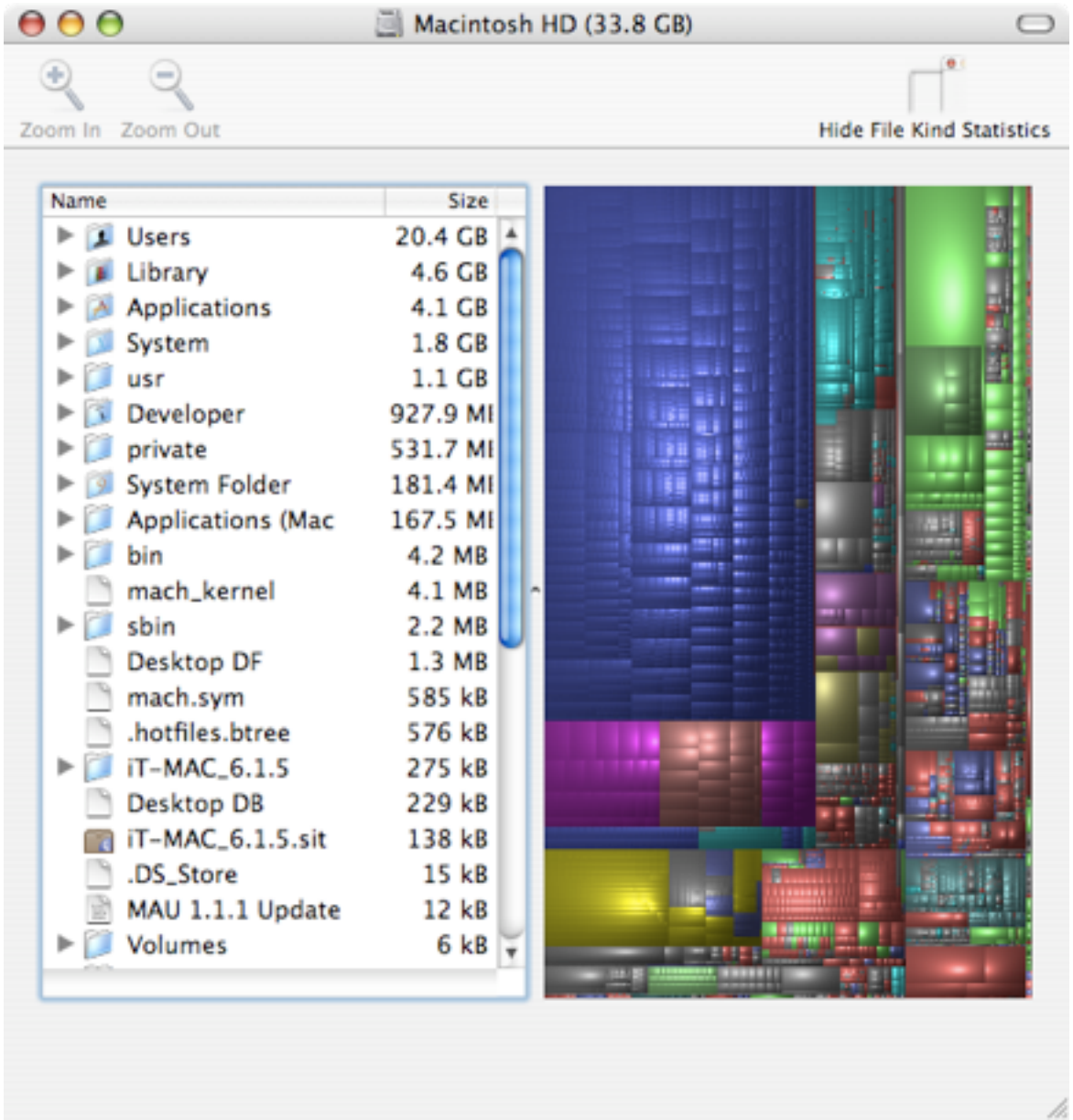
- Don't need all this to just see the largest files in the OS

Stimulus Bill Tree Map



http://www.hivegroup.com/stimulus/

File System Application



Successful Application of Treemaps

Think more about the use

- Break into meaningful groups
- Fix these into a useful aspect ratio

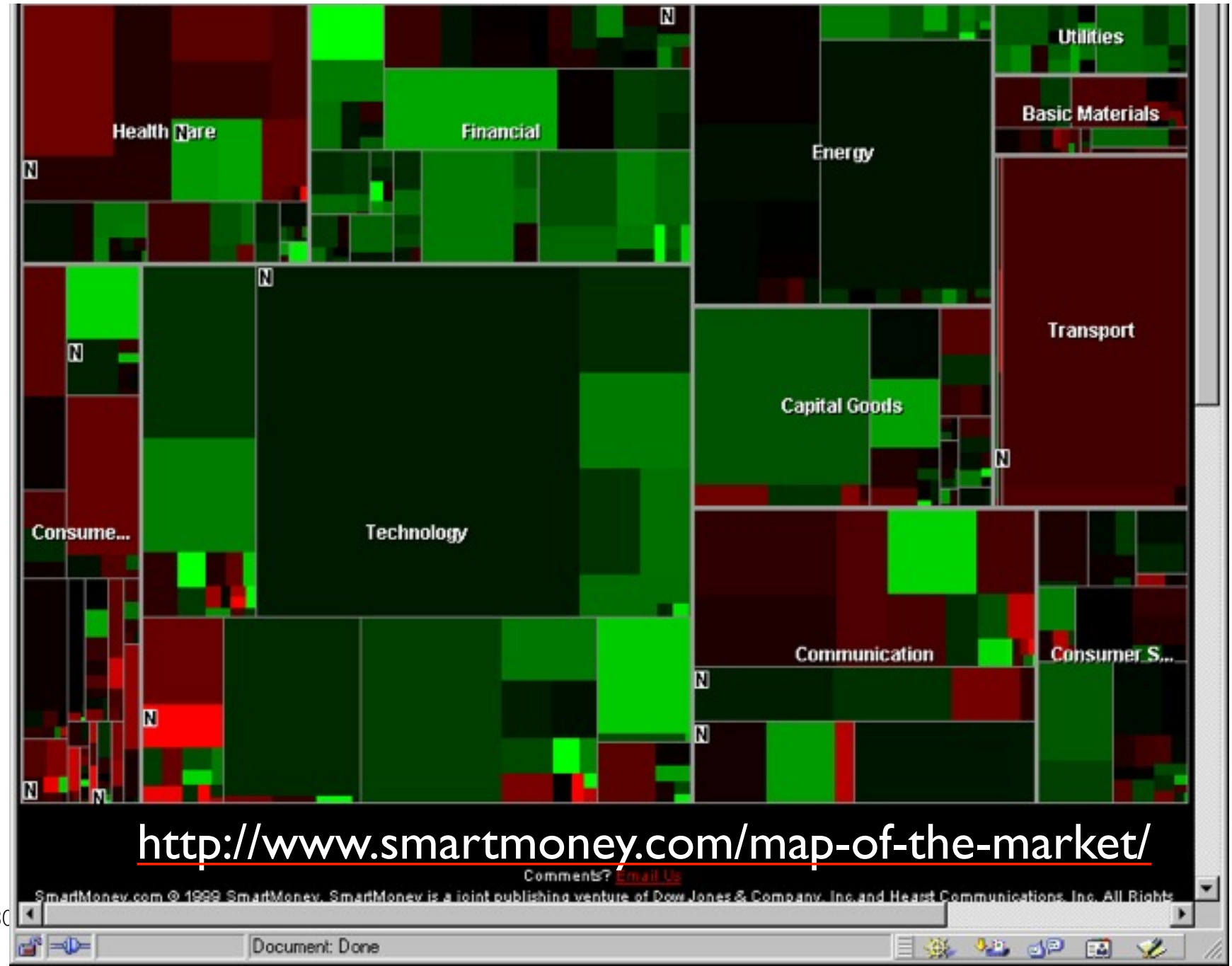
Use visual properties properly

- Use color to distinguish meaningfully
  - Only two colors: can distinguish one thing from another
  - Amount isn't very important

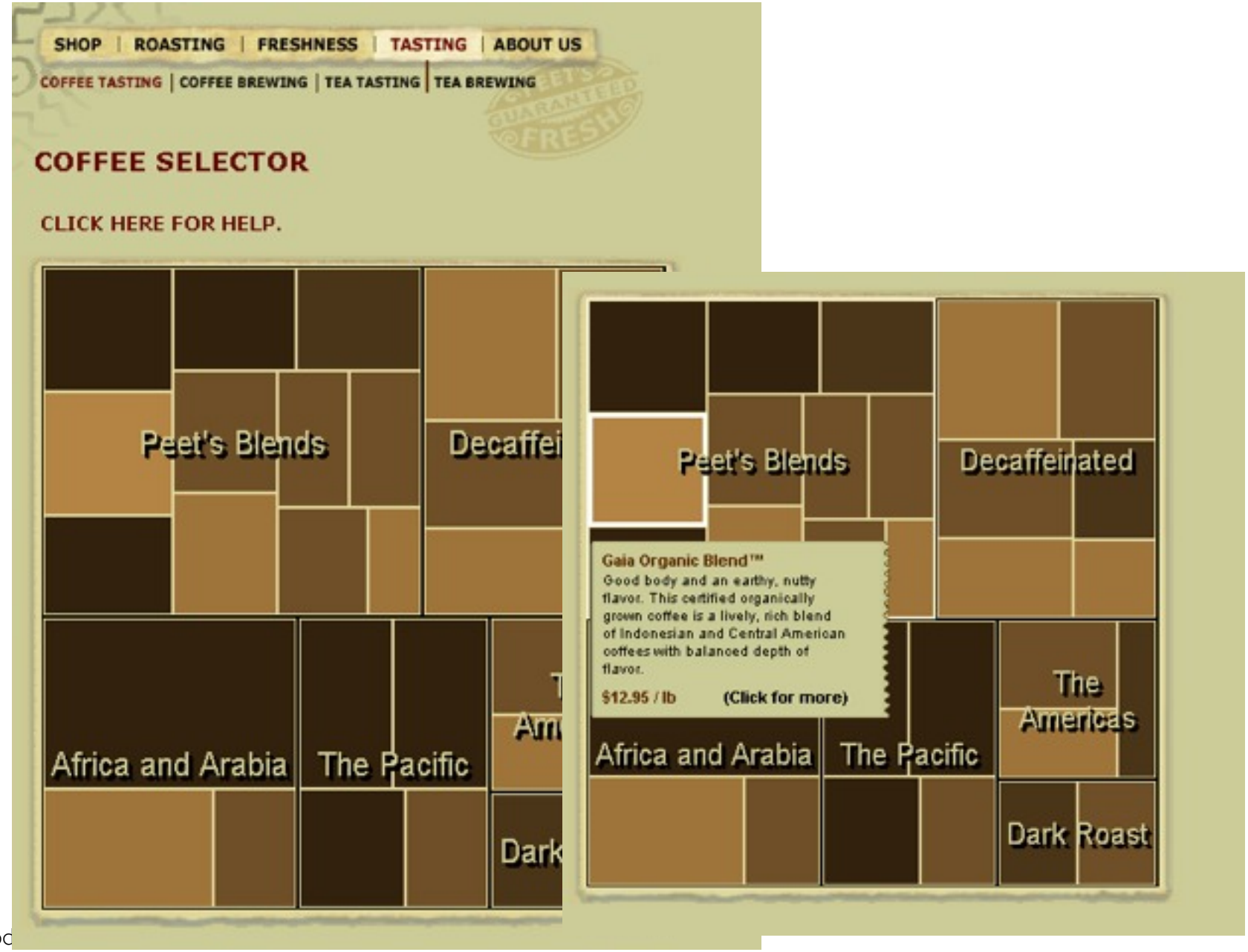
Provide excellent interactivity

- Access to the real data
- Makes it into a useful tool

A Good Use of TreeMaps and Interactivity



Treemaps in Peets site



Analysis vs. Communication

MarketMap use of treemaps allows for sophisticated analysis

http://www.smartmoney.com/map-of-the-market/

Peets use of treemaps is more for presentation and communication

See also:

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

Most Widely Deployed InfoVis?

- What is the most widely deployed information visualization tool (software?)

Example

Baseball statistics

Microsoft Excel - baseball

File Edit View Insert Format Tools Data Accounting Window Help

Arial 10 B I U 100%

A1 = Name

	A	B	C	D	E	F	G	H	I	J	
1	Name	At Bats	Hits	Home Run	Runs	Rbi	Walks	Years In M	Career At I	Career Hits	Car
2	STRING	INT	INT	INT	INT	INT	INT	INT	INT	INT	INT
3	Andy Allanson	293	66	1	30	29	14	1	293	66	
4	Alan Ashby	315	81	7	24	38	39	14	3449	835	
5	Alvin Davis	479	130	18	66	72	76	3	1624	457	
6	Andre Dawson	496	141	20	65	78	37	11	5628	1575	
7	Andres Galarra	321	87	10	39	42	30	2	396	101	
8	Alfredo Griffin	594	169	4	74	51	35	11	4408	1133	
9	Al Newman	185	37	1	23	8	21	2	214	42	
10	Argenis Salaza	298	73	0	24	24	7	3	509	108	
11	Andres Thomas	323	81	6	26	32	8	2	341	86	
12	Andre Thornton	401	92	17	49	66	65	13	5206	1332	
13	Alan Trammell	574	159	21	107	75	59	10	4631	1300	
14	Alex Trevino	202	53	4	31	26	27	9	1876	467	
15	Andy Van Slyk	418	113	13	48	61	47	4	1512	392	
16	Alan Wiggins	239	60	0	30	11	22	6	1941	510	
17	Bill Almon	196	43	7	29	27	30	13	3231	825	
18	Billy Beane	183	39	3	20	15	11	3	201	42	
19	Buddy Bell	568	158	20	89	75	73	15	8068	2273	
20	Buddy Biancala	190	46	2	24	8	15	5	479	102	
21	Bruce Bochte	407	104	6	57	43	65	12	5233	1478	

baseball

Ready

Data Tables

- Often, we take raw data and transform it into a form that is more workable
- Main idea:
  - Individual items are called cases
  - Cases have variables (attributes)

Data Table Format

	$Case_1$	$Case_2$	$Case_3$	...
$Variable_1$	$Value_{11}$	$Value_{21}$	$Value_{31}$	
$Variable_2$	$Value_{12}$	$Value_{22}$	$Value_{32}$	
$Variable_3$	$Value_{13}$	$Value_{23}$	$Value_{33}$	
...				

Dimensions

Think of as a function

$f(case_1) = <Val_{11}, Val_{12},...>$

Example

	Mary	Jim	Sally	Mitch	...
SSN	145	294	563	823	
Age	23	17	47	29	
Hair	brown	black	blonde	red	
GPA	2.9	3.7	3.4	2.1	
...					

People in class

Variable Types

Three main types of variables

- N-Nominal (equal or not equal to other values)
  - Example: gender
- O-Ordinal (obeys < relation, ordered set)
  - Example: fr,so,jr,sr
- Q-Quantitative (can do math on them)
  - Example: age

Metadata

Descriptive information about the data

- Might be something as simple as the type of a variable, or could be more complex
- For times when the table itself just isn't enough
- Example: variable1 is "the current temperature measured on the East side of LWSN". Or variable2 is the computed divergence of the vector field computed with this formula…. Or variable3 is the cost/benefit analysis based on: $Qw = Qw/o + Qp$

How Many Variables?

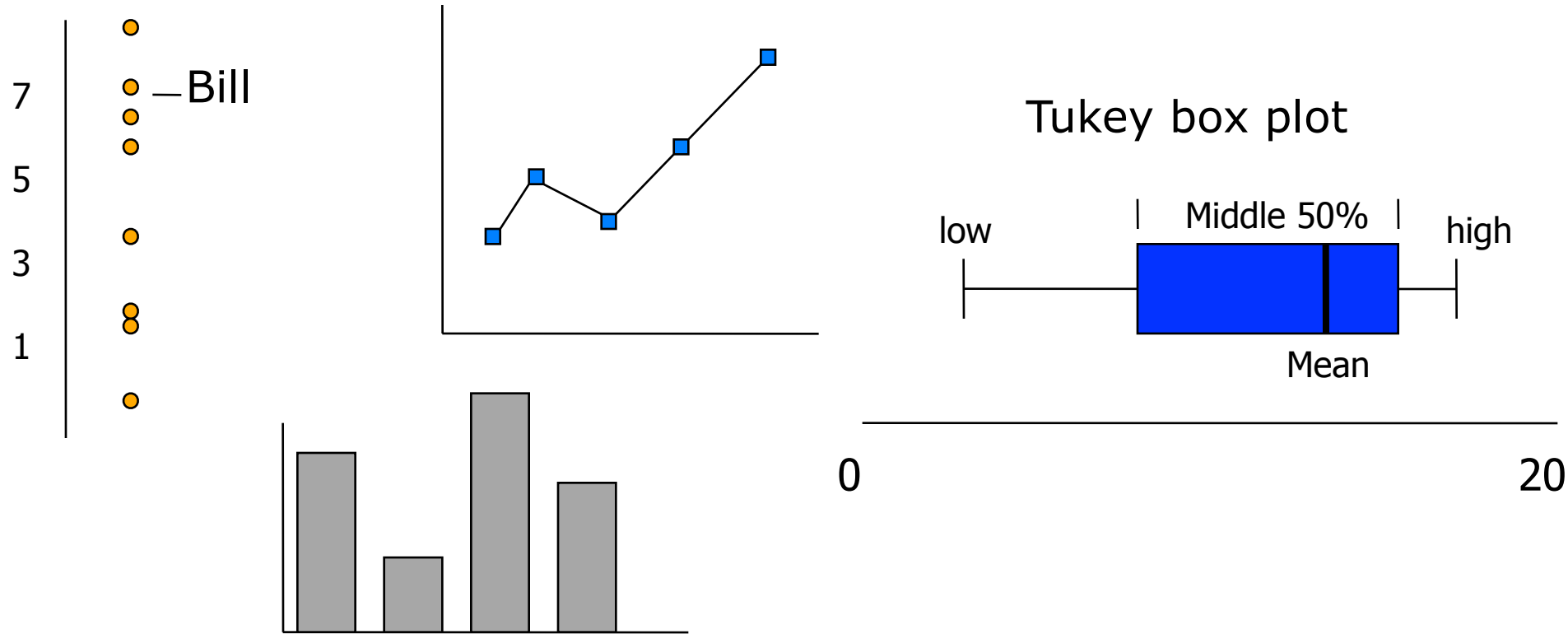
Data sets of dimensions 1,2,3 are common

Number of variables per class

- 1 - Univariate data
- 2 - Bivariate data
- 3 - Trivariate data
- >3 - Hypervariate data

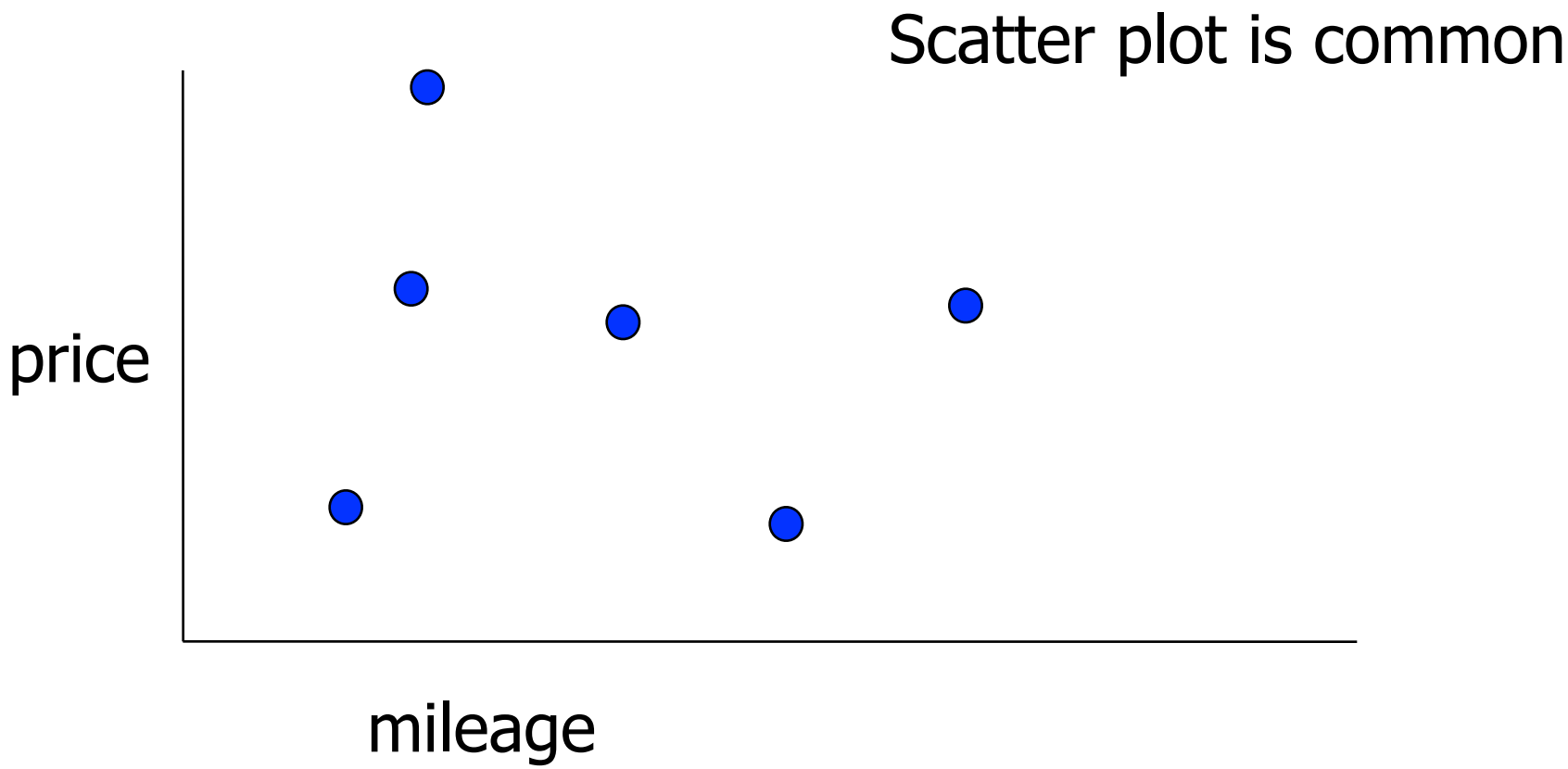
Univariate Data

Representations



Bivariate Data

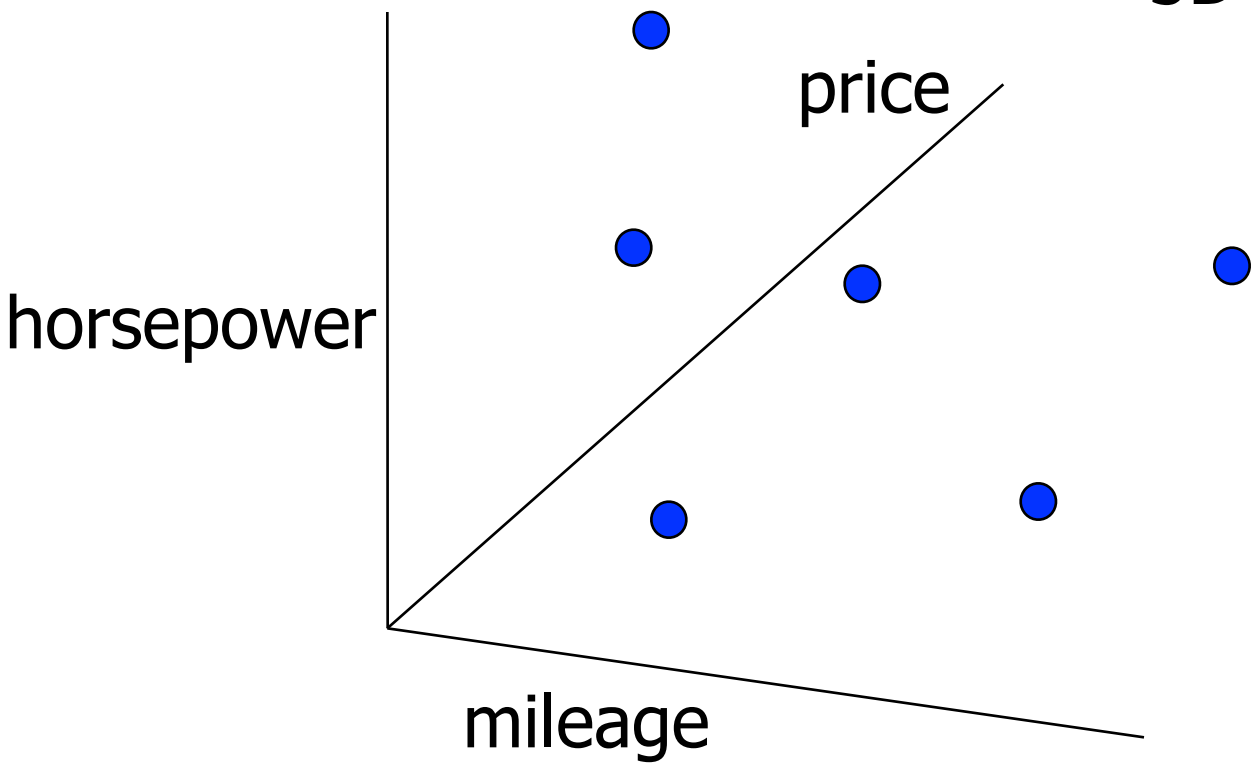
Representations



Trivariate Data

Representations

3D scatter plot is possible



Hypervariate Data

Number of well-known visualization techniques exist for data sets of 1-3 dimensions

- line graphs, bar graphs, scatter plots OK
- We see a 3-D world (4-D with time)

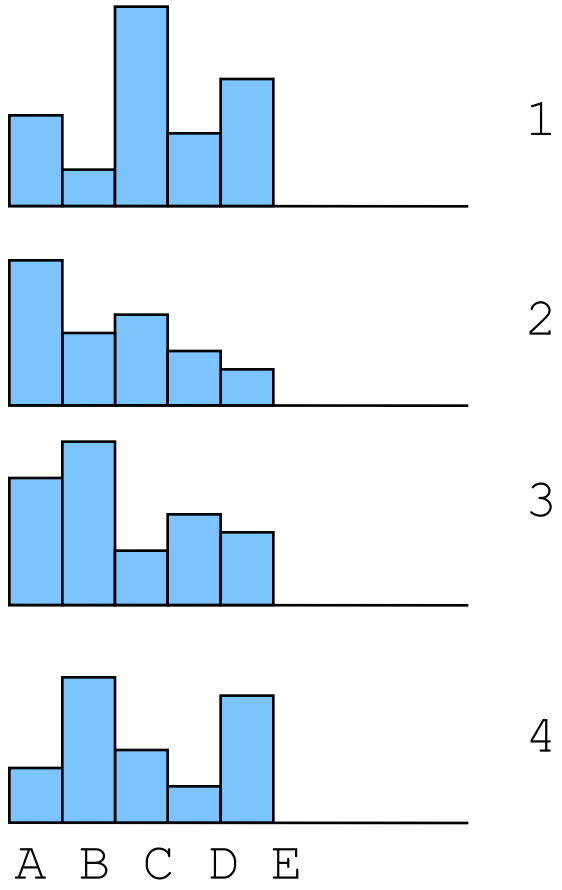
What about data sets with more than 3 variables?

- Often the interesting ones

Multiple Views

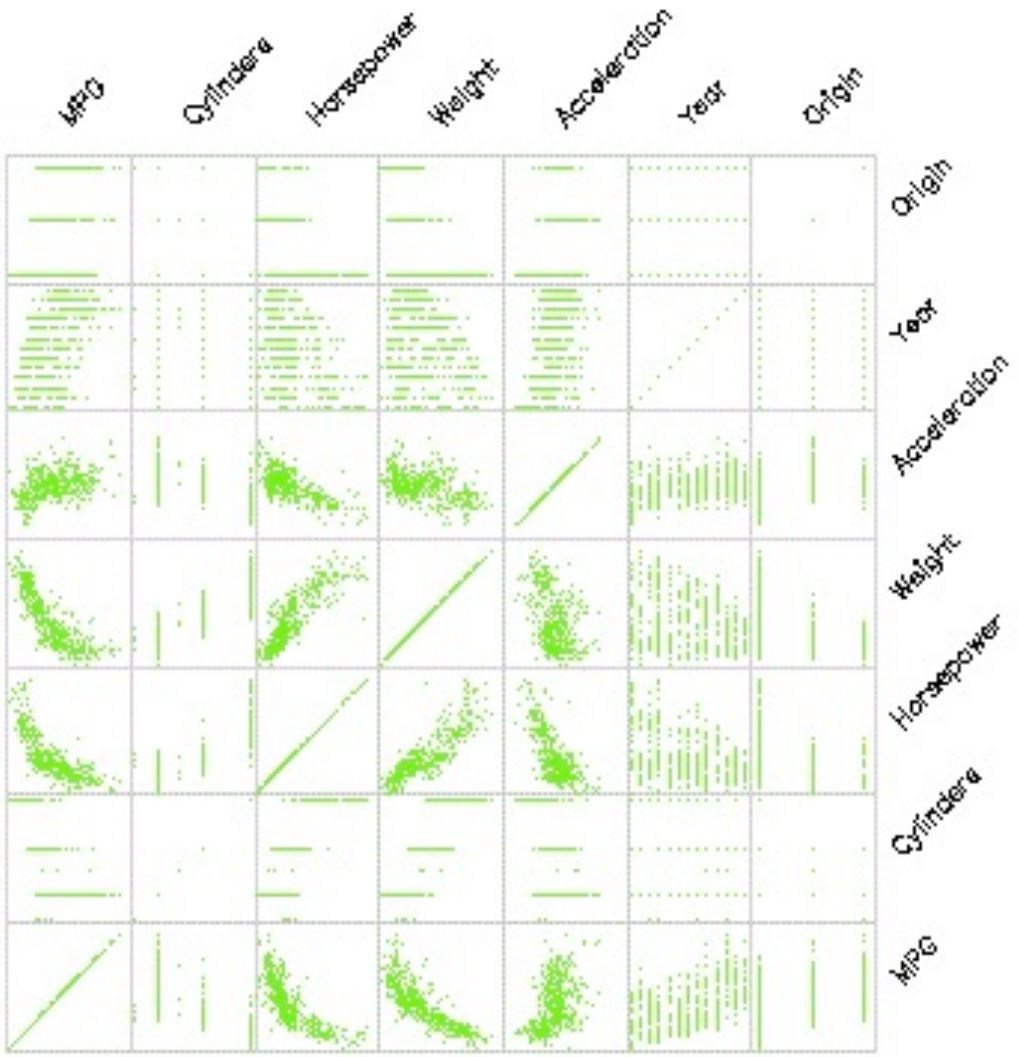
Give each variable its own display

	A	B	C	D	E
1	4	1	8	3	5
2	6	3	4	2	1
3	5	7	2	4	3
4	2	6	3	1	5

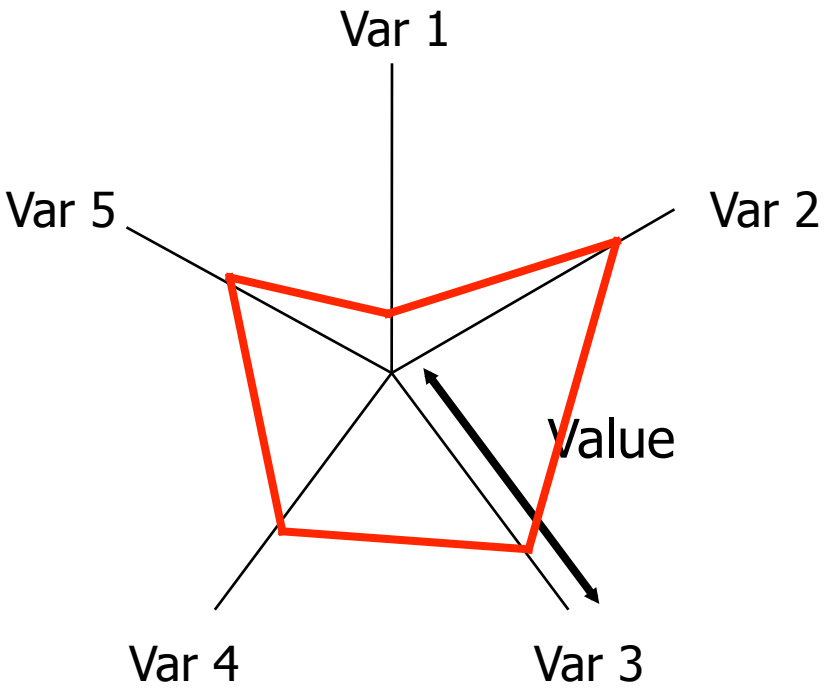


Scatterplot Matrix

Represent each possible pair of variables in their own 2-D scatterplot



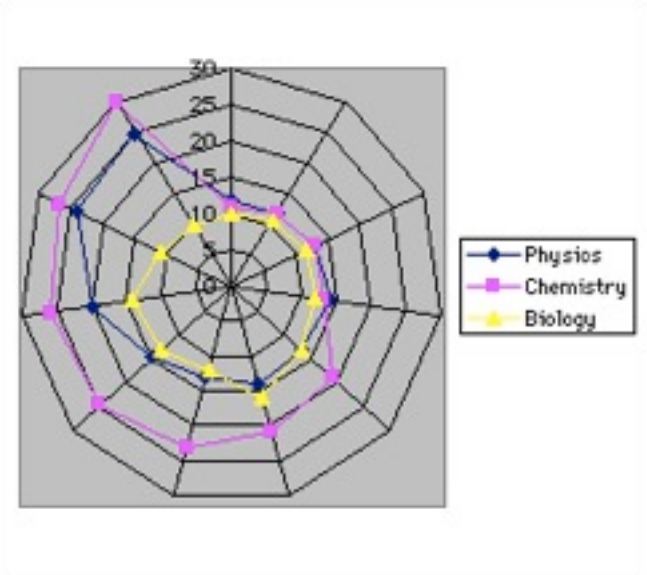
Star Plots

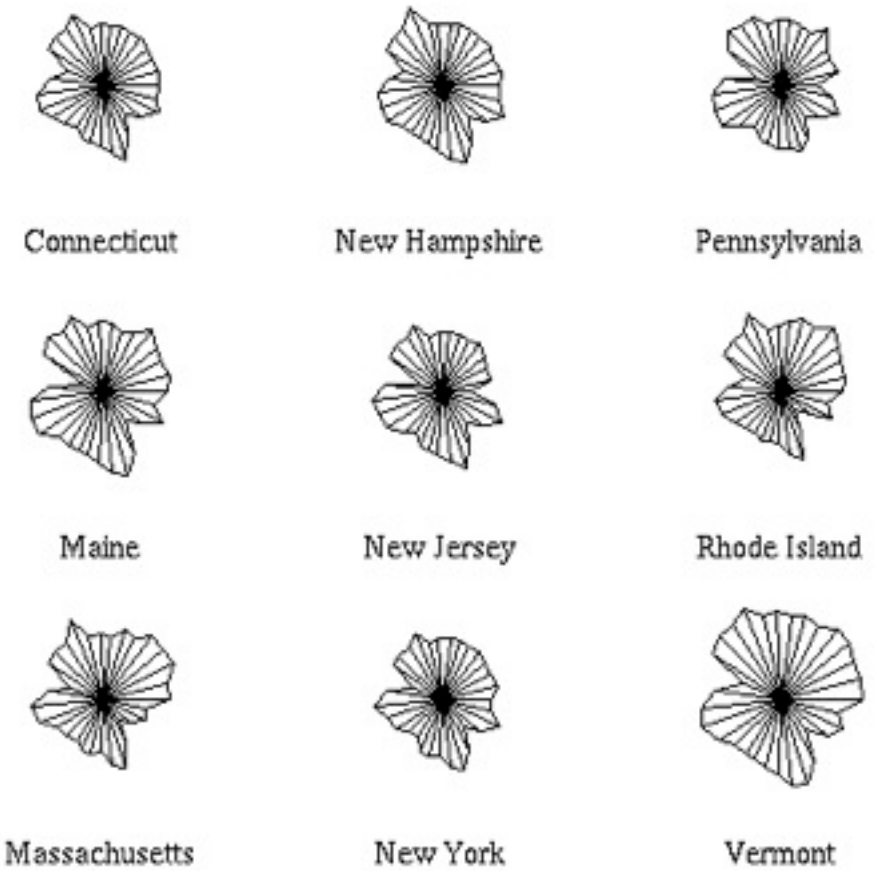


Space out the n variables at equal angles around a circle

Each "spoke" encodes a variable's value

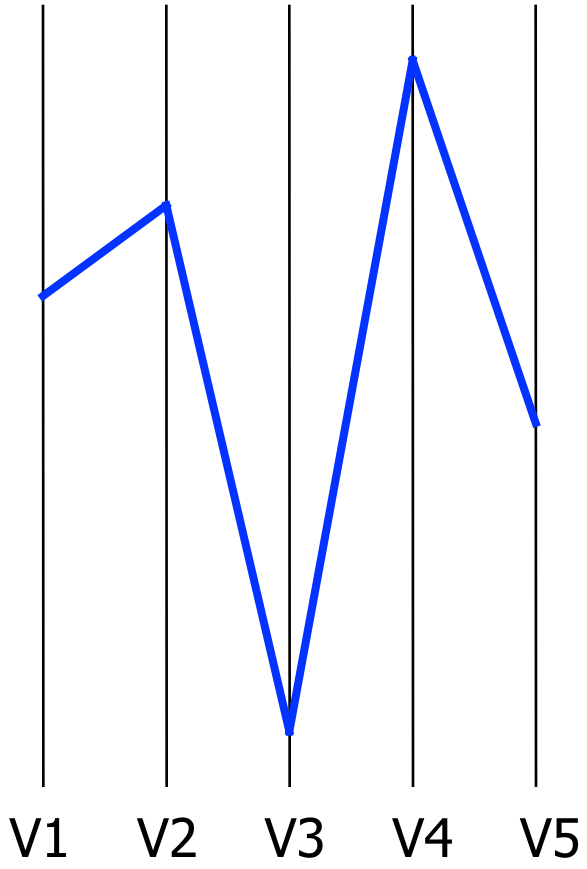
Star Plot examples





http://seamonkey.ed.asu.edu/~behrens/asu/reports/compre/comp1.html

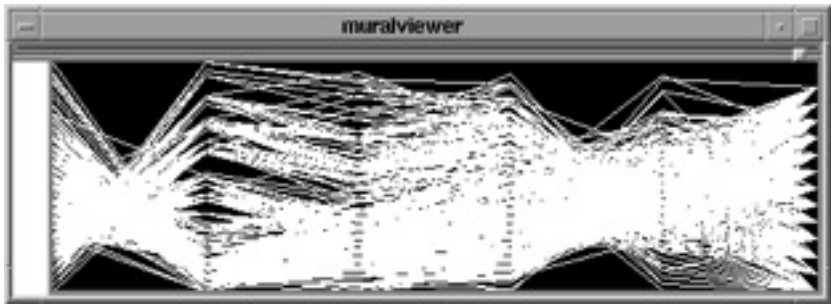
Parallel Coordinates



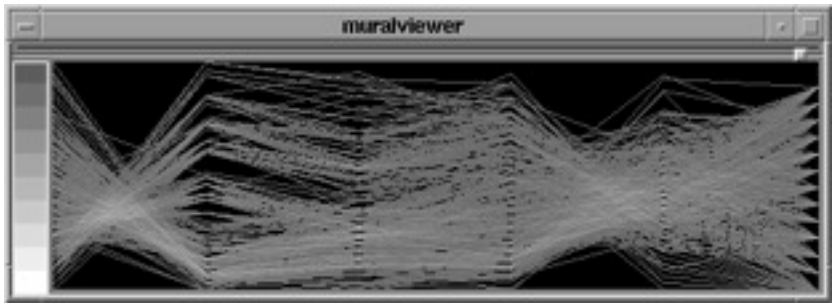
Encode variables along a horizontal row

Vertical line specifies values

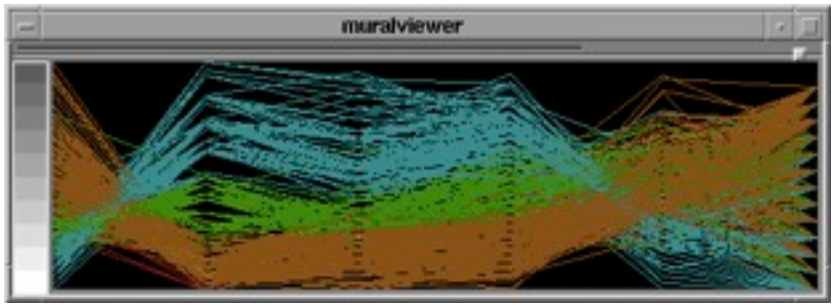
Parallel Coords Example



Basic

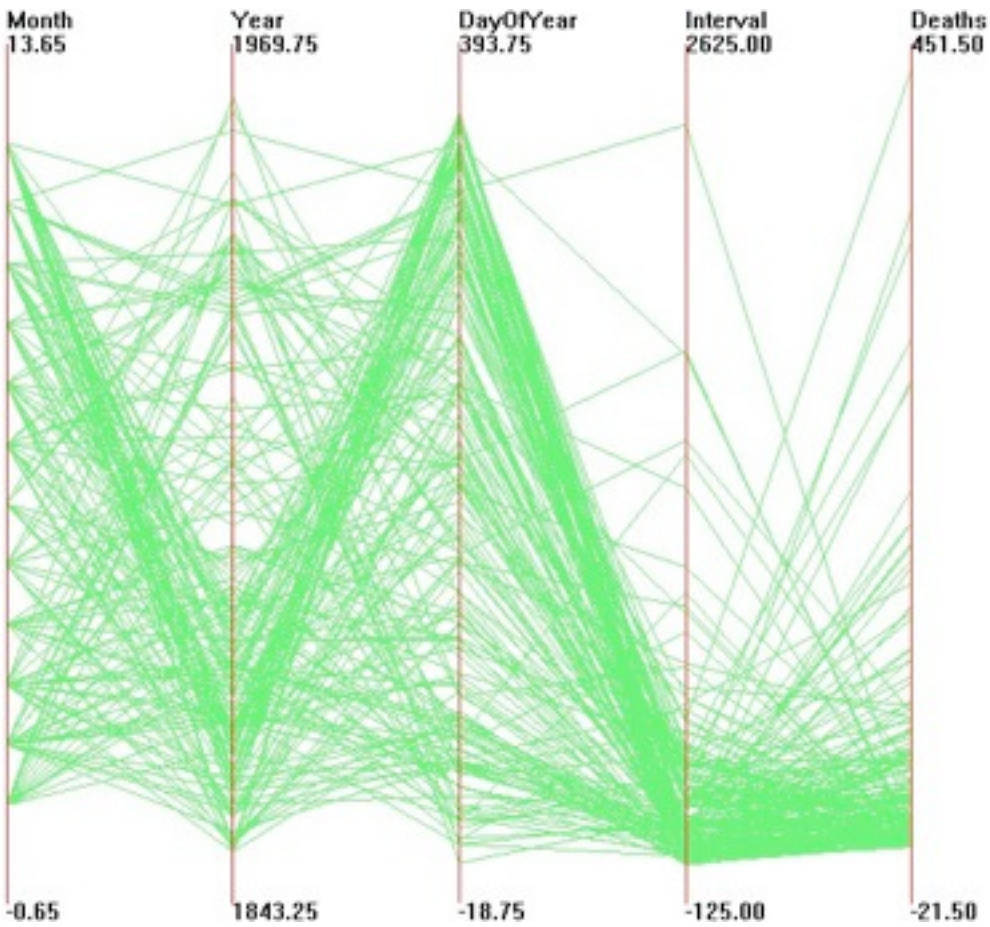


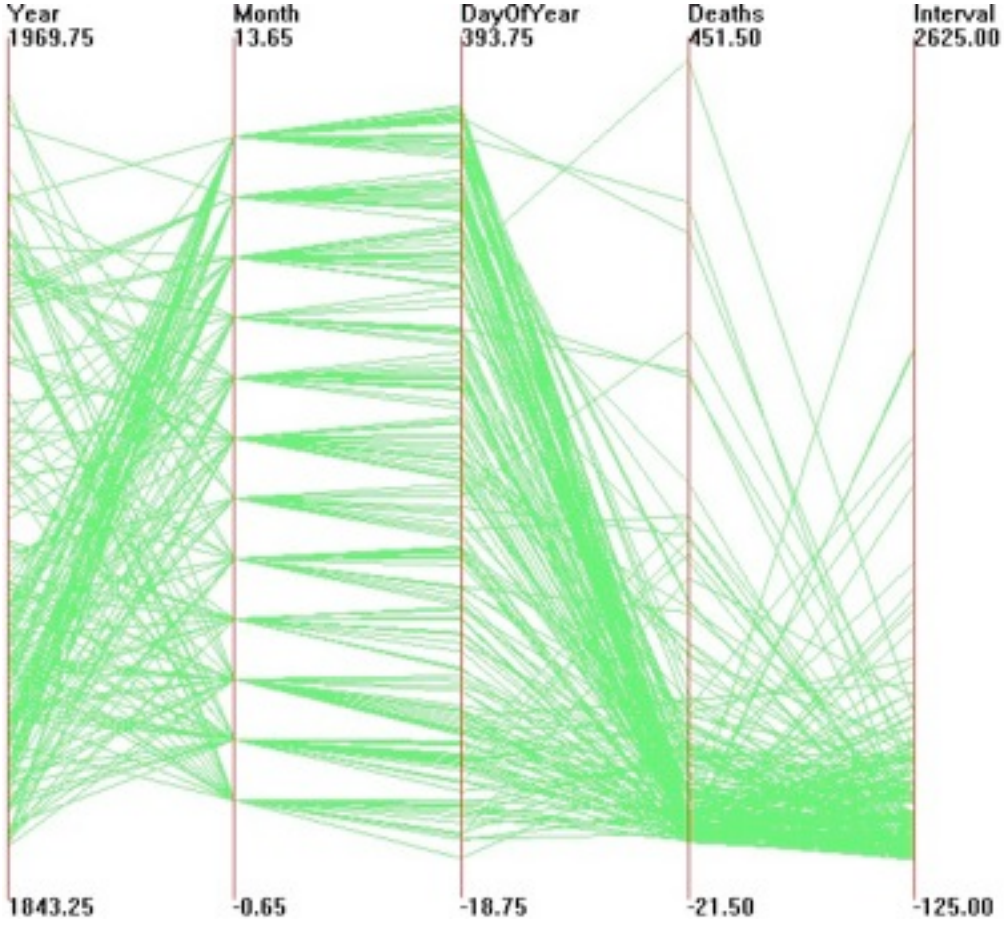
Grayscale



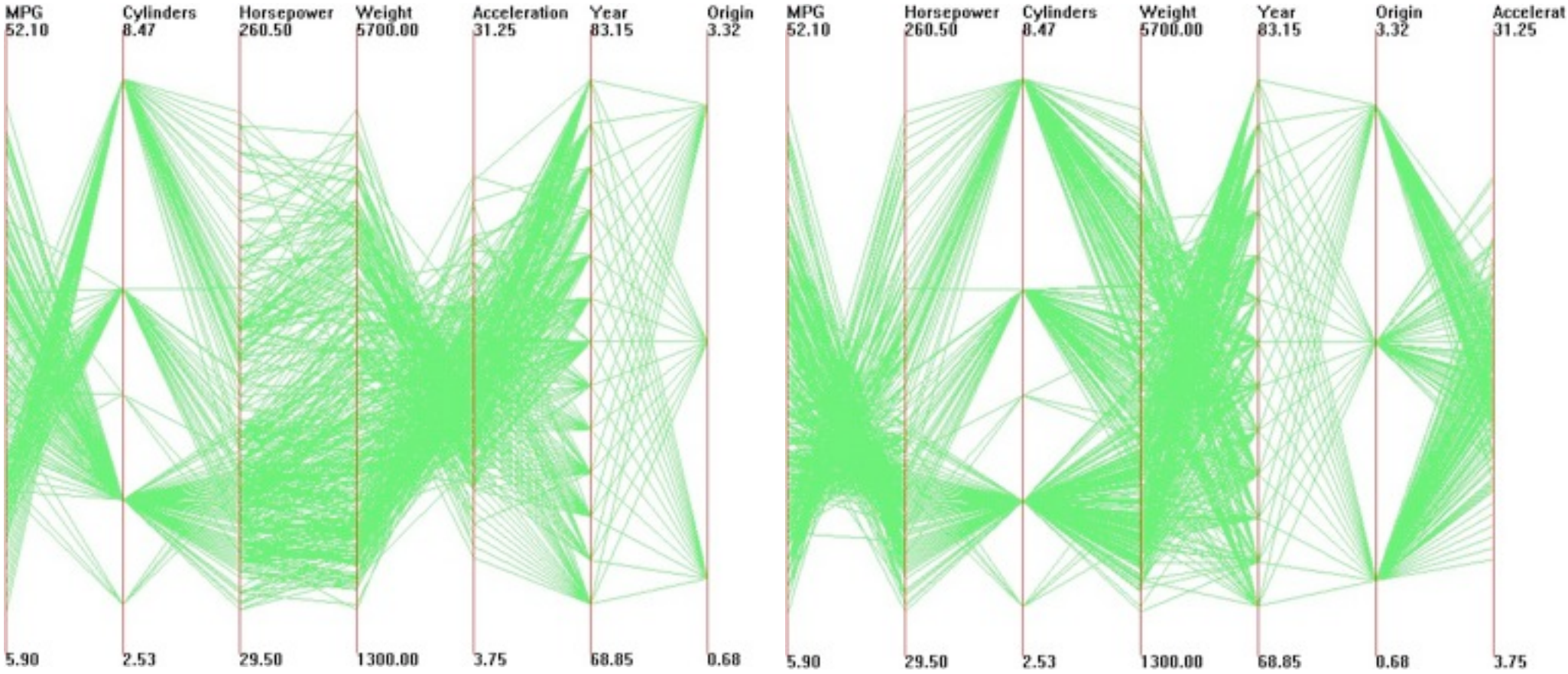
Color

Why Does Order Matter?

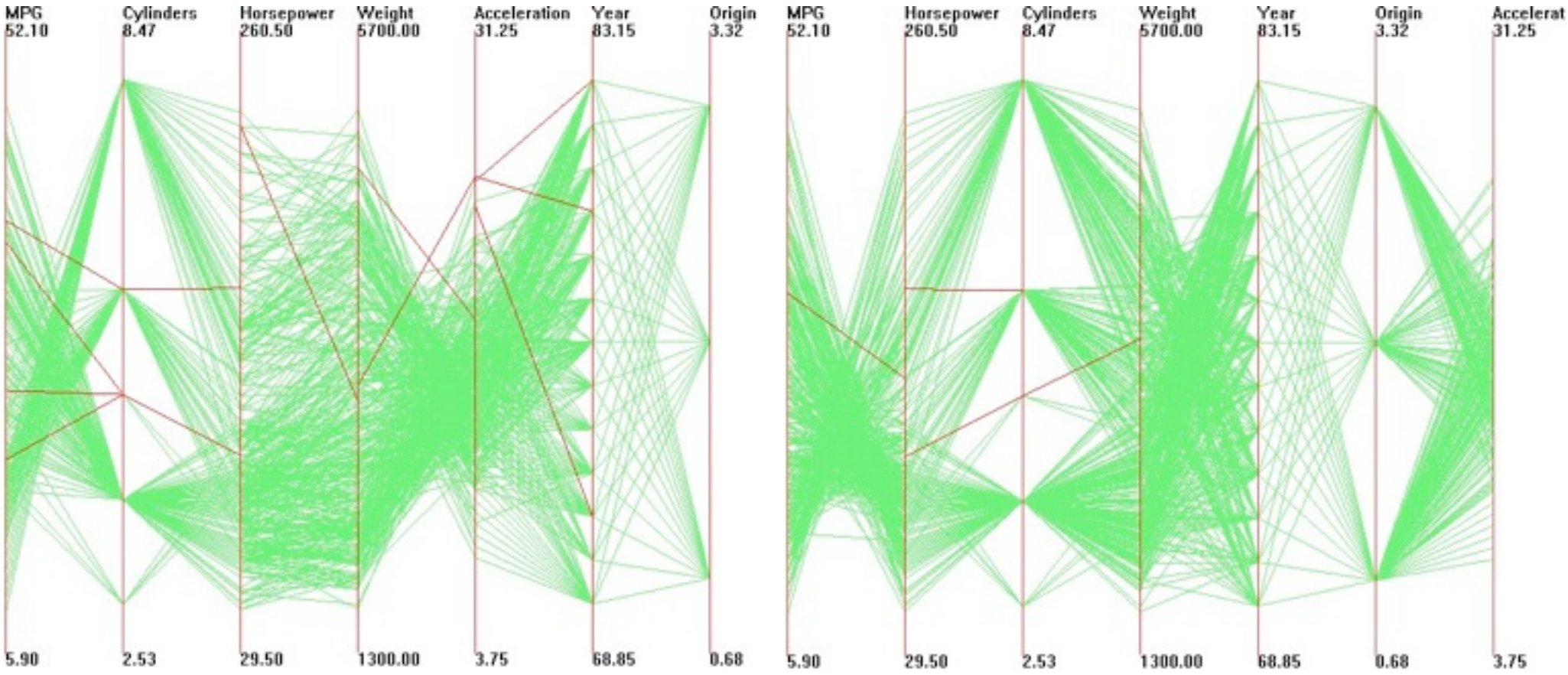




Example

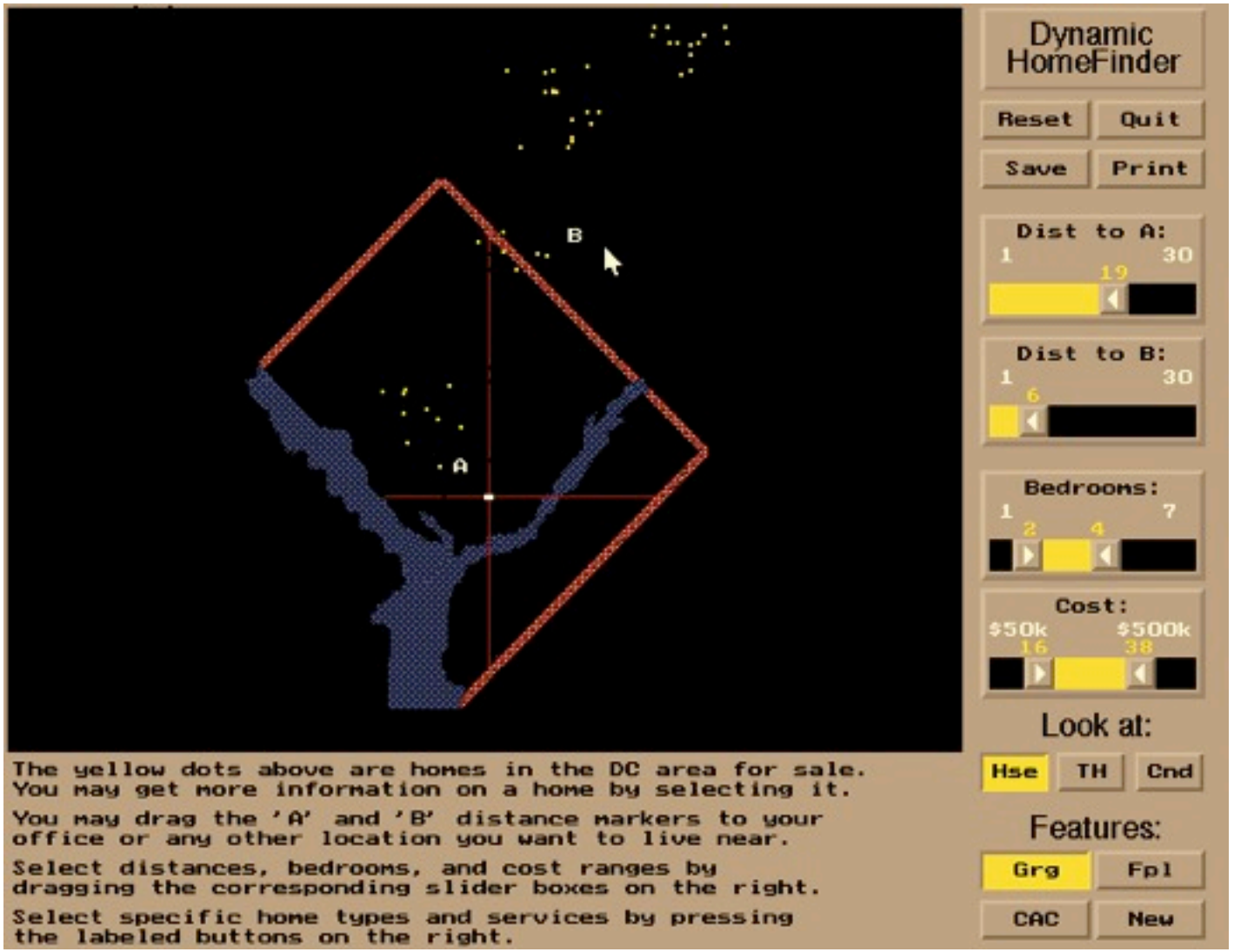

MPG
52.10
Cylinders
8.47
Horsepower
260.50
Weight
5700.00
Acceleration
31.25
Year
83.15
Origin
3.32
5.90
2.53
29.50
1300.00
3.75
68.85
0.68
MPG
52.10
Horsepower
260.50
Cylinders
8.47
Weight
5700.00
Year
83.15
Origin
3.32
Accelerat
31.25
5.90
29.50
2.53
1300.00
68.85
0.68
3.75

Outliers Highlighted



HomeFinder

HCIL
Univ. Maryland



Hierarchies (Trees)

Definition

- Data repository in which cases are related to subcases

Pervasive

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

Trees

Two main representation schemes

- Node-link
- Space-filling

Approaches to scale:

- Complex representation
- Navigation
- Elide (don't show) some nodes
- Show nodes at different sizes

Tasks on Trees

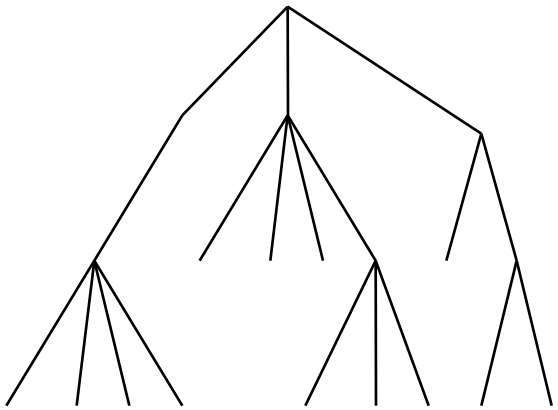
Help understand node characteristics or tree structure?

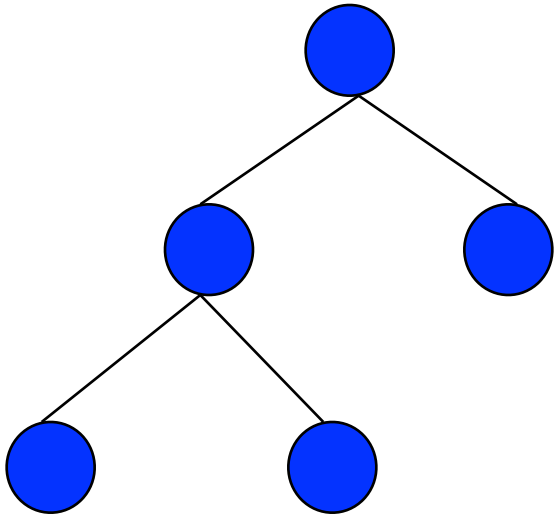
Some kinds of tasks:

- Find a node
- Revisit node
- List node ancestors
- Understand local topology
- Understand global topology

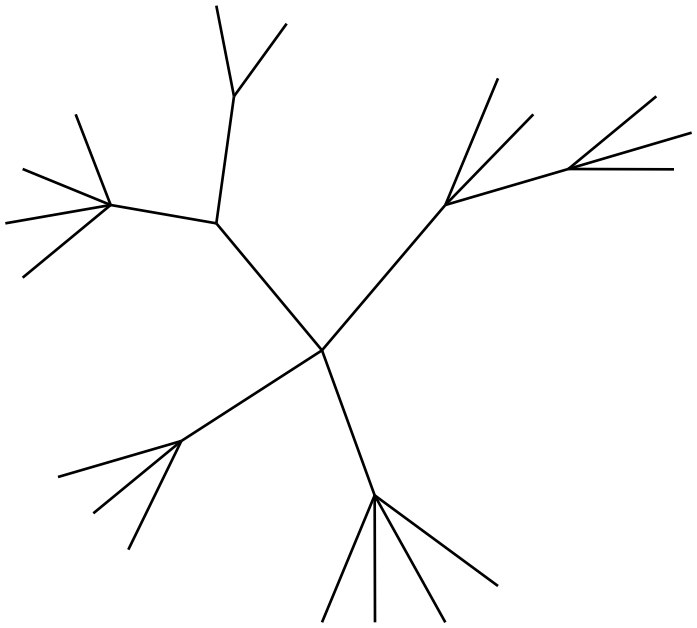
Node-Link Diagrams

Root at top, leaves at bottom is very common





Why Put Root at Top?



Root can be at center with levels growing outward too

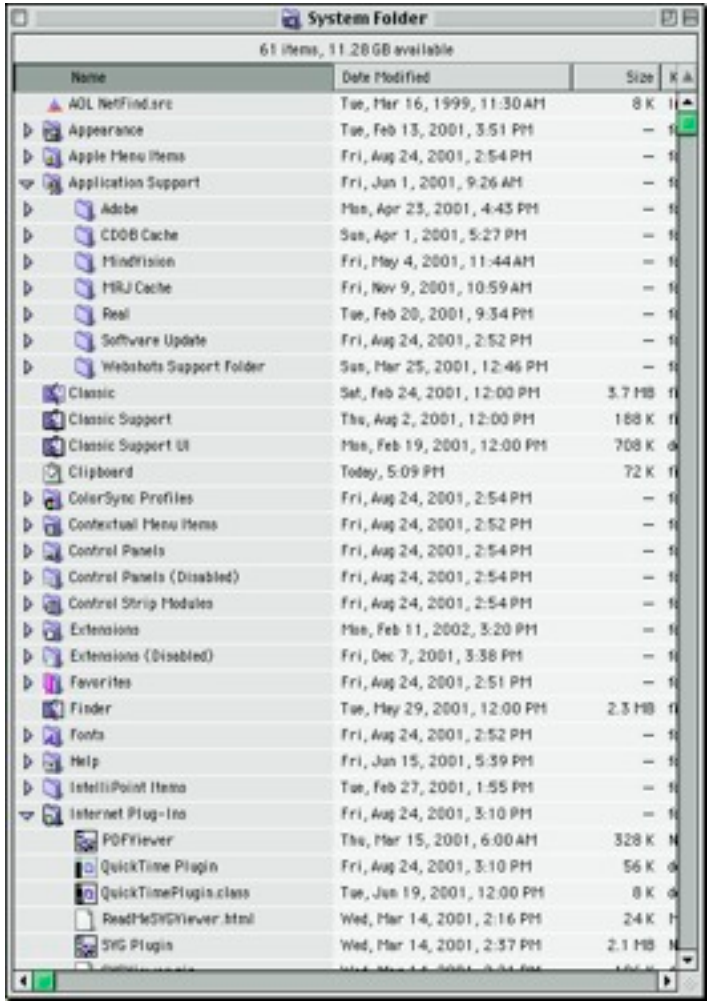
Examples

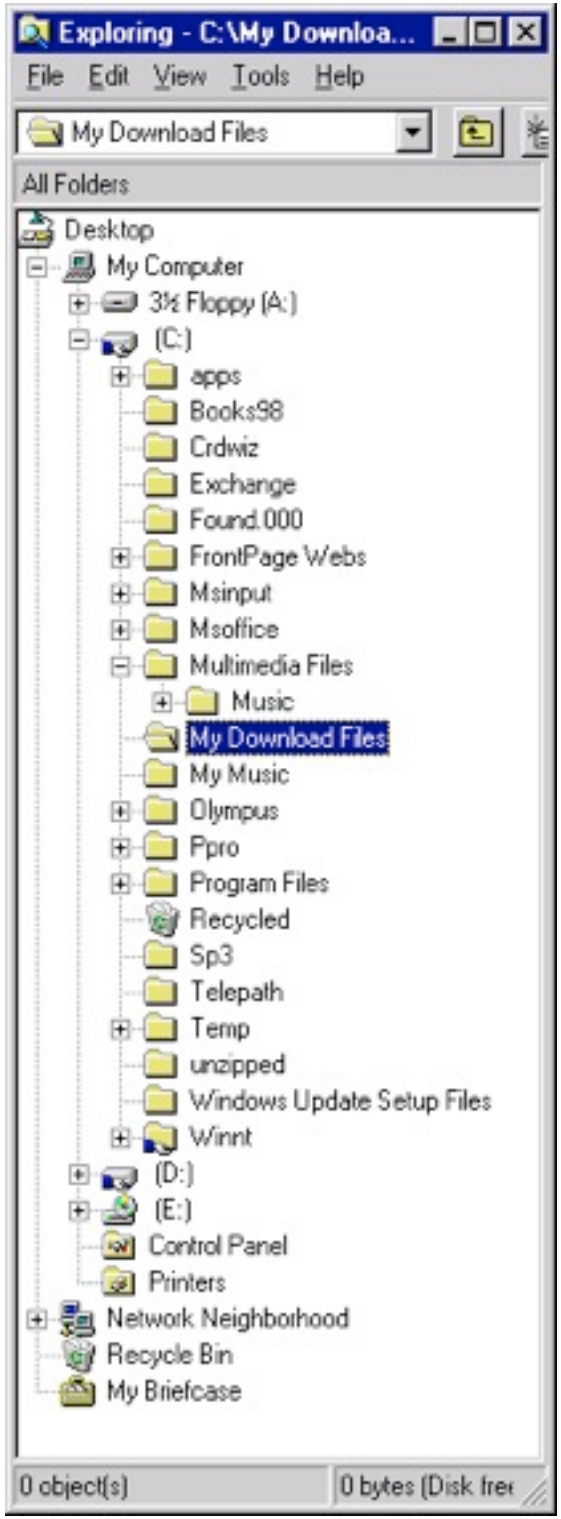
Good for?

Search

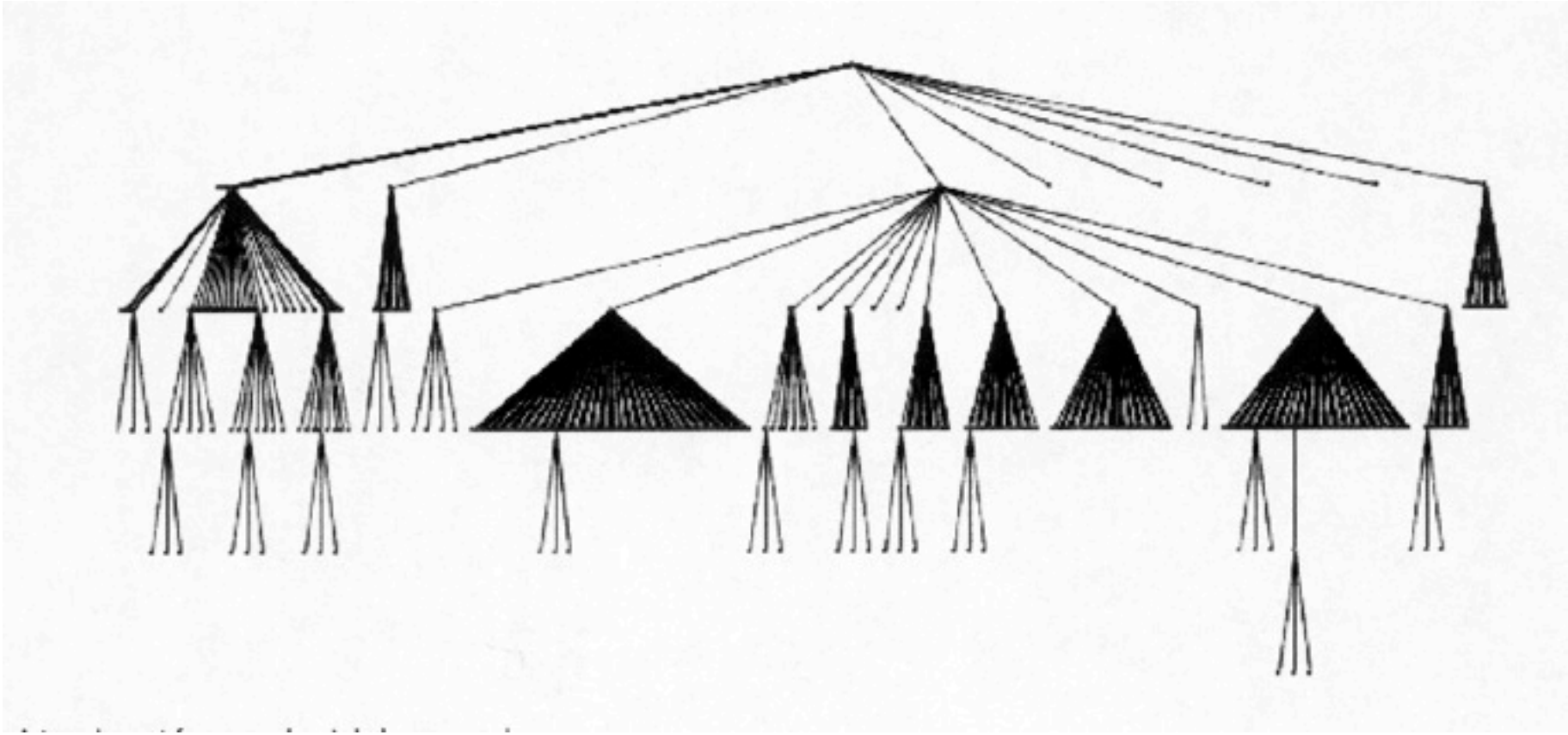
Bad for?

Understanding structure





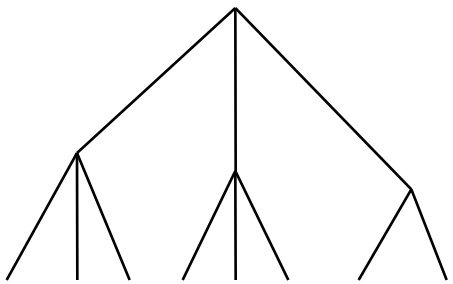
Drawing a Tree

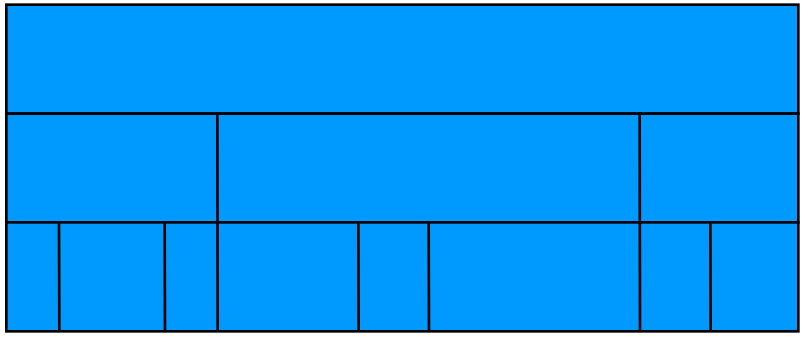


Space-Filling Representation

Each item occupies an area

Children are "contained" under parent





One example

Potential Problems

For top-down, width of fan-out uses up horizontal real estate very quickly

- At level n, there are 2^n nodes

Tree might grow a lot along one particular branch

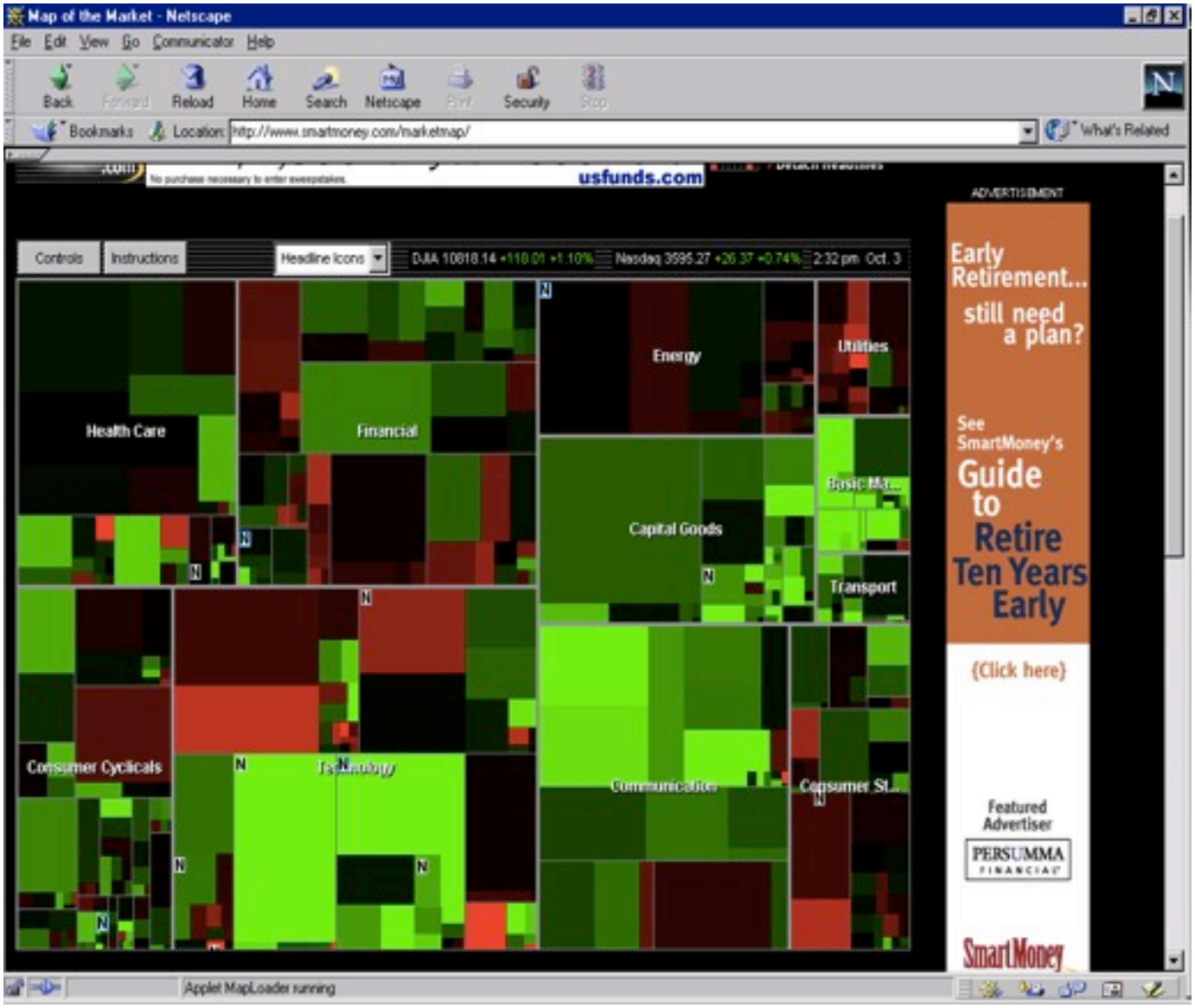
- Hard to draw it well in view without knowing how it will branch

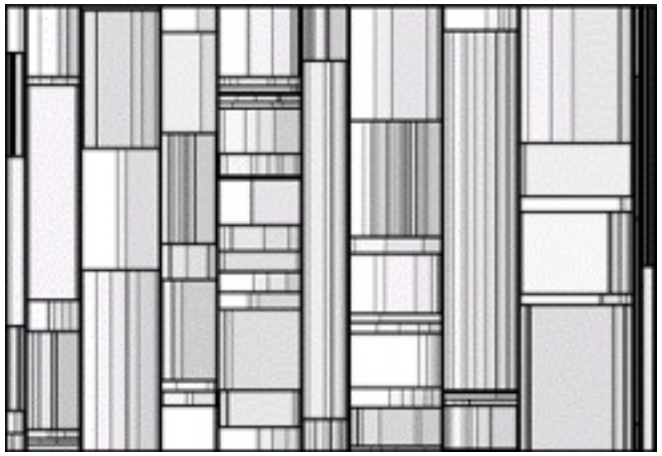
InfoVis Solutions

Techniques developed in Information Visualization largely try to assist the problems identified in the last slide

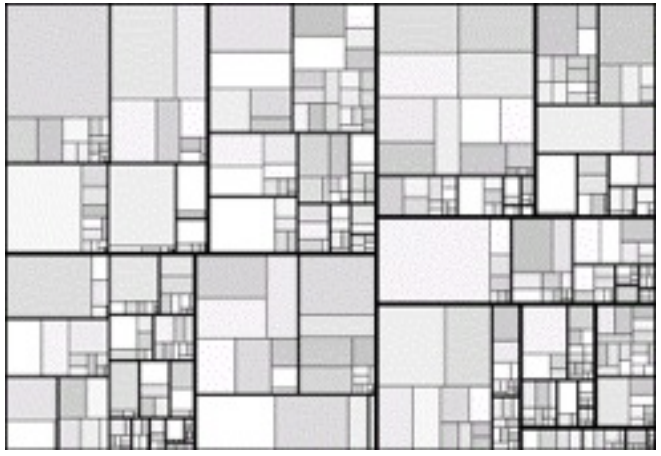
Alternatively, Information Visualization techniques attempt to show more attributes of data cases in hierarchy or focus on particular applications of trees

Treemap – Shneiderman et. al.

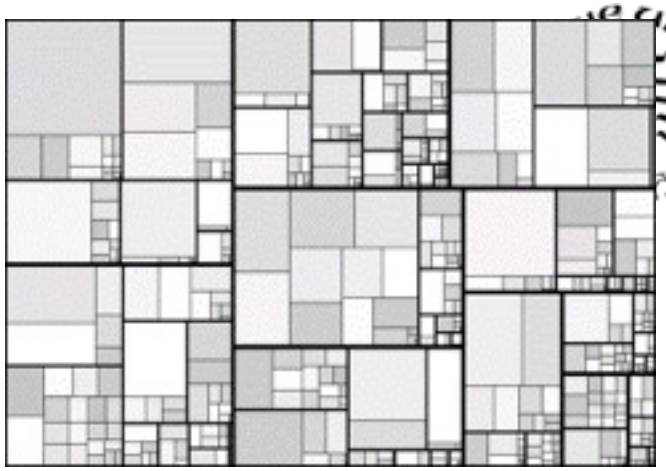




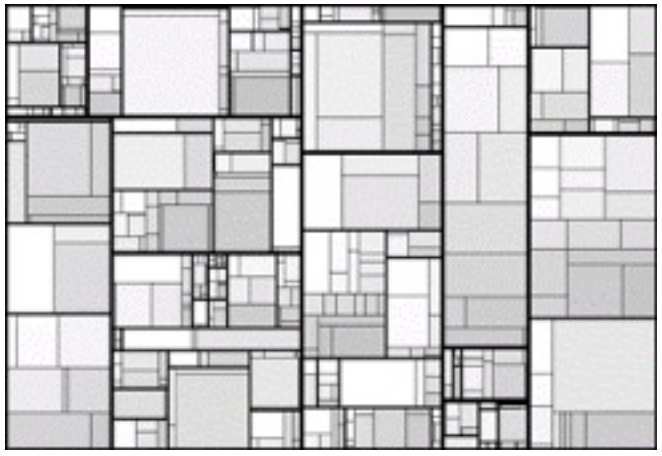
Slice-and-dice



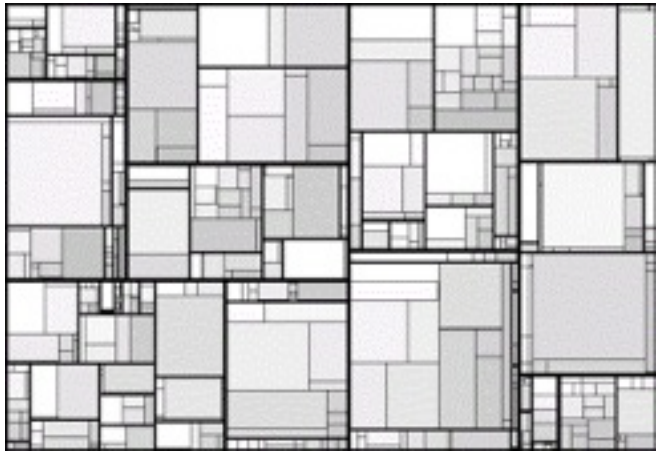
Cluster



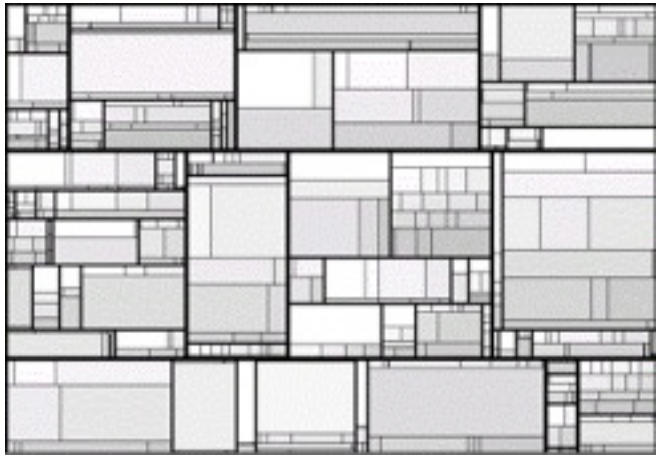
Squarified



Pivot-by-middle



Pivot-by-size

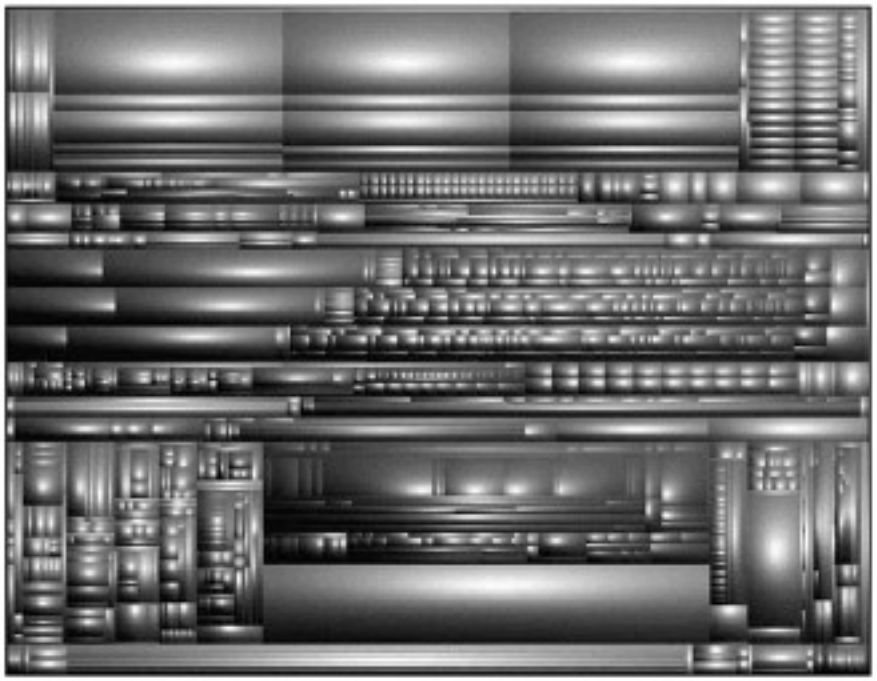


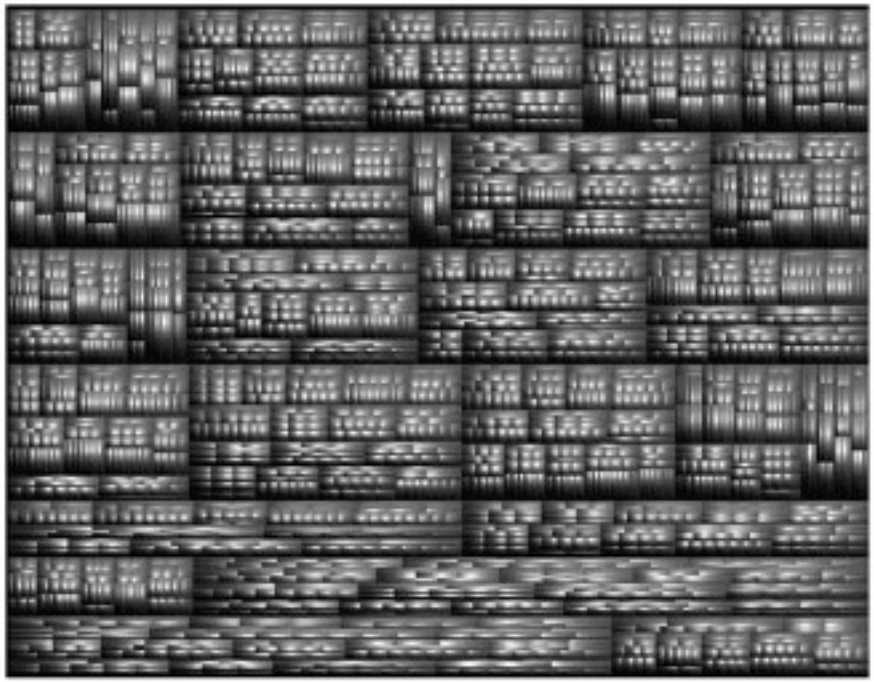
Strip

Variation: Cushion Treemap

Add shading and texture to help convey structure of hierarchy

Van Wijk '99





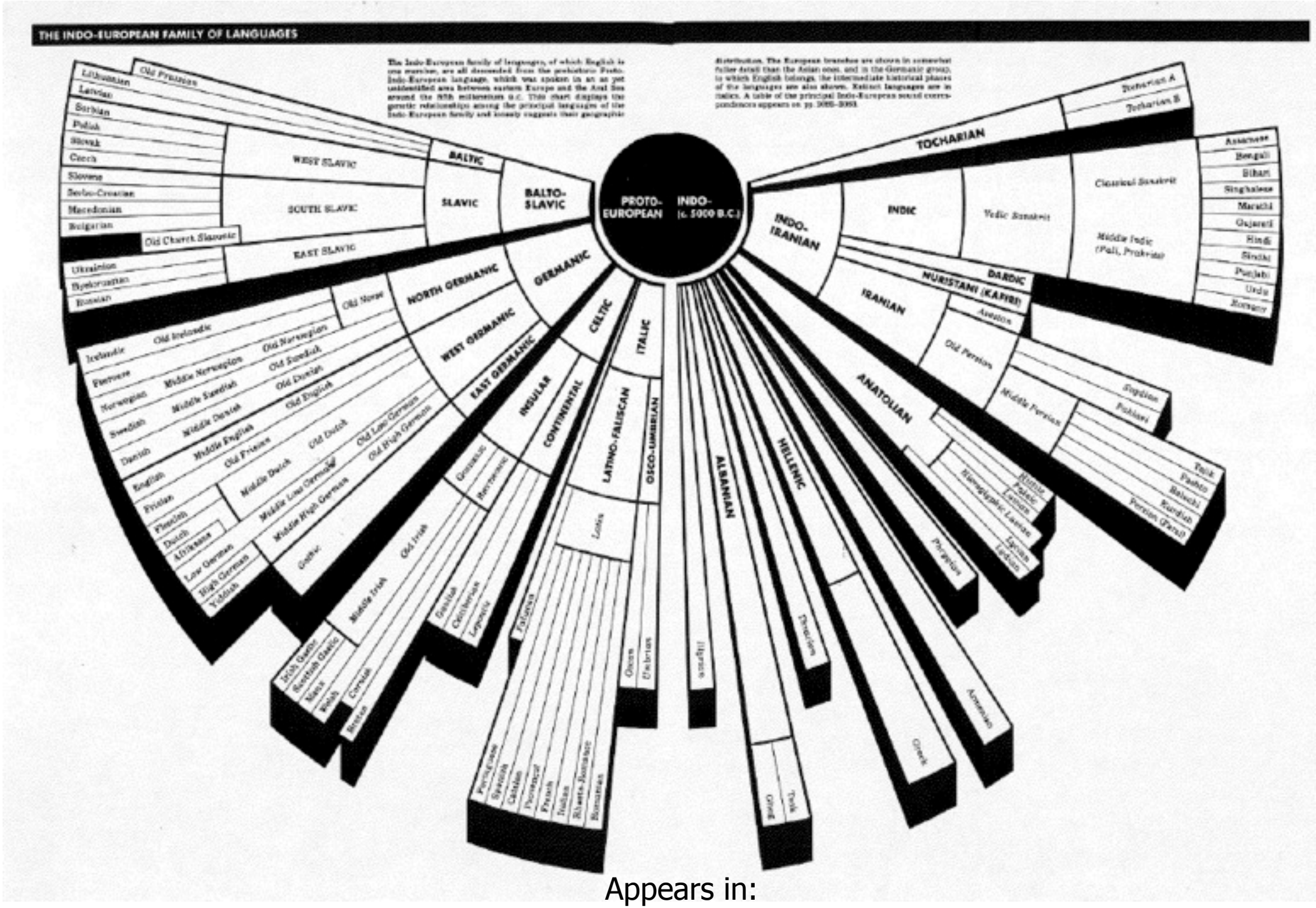
Another Technique

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



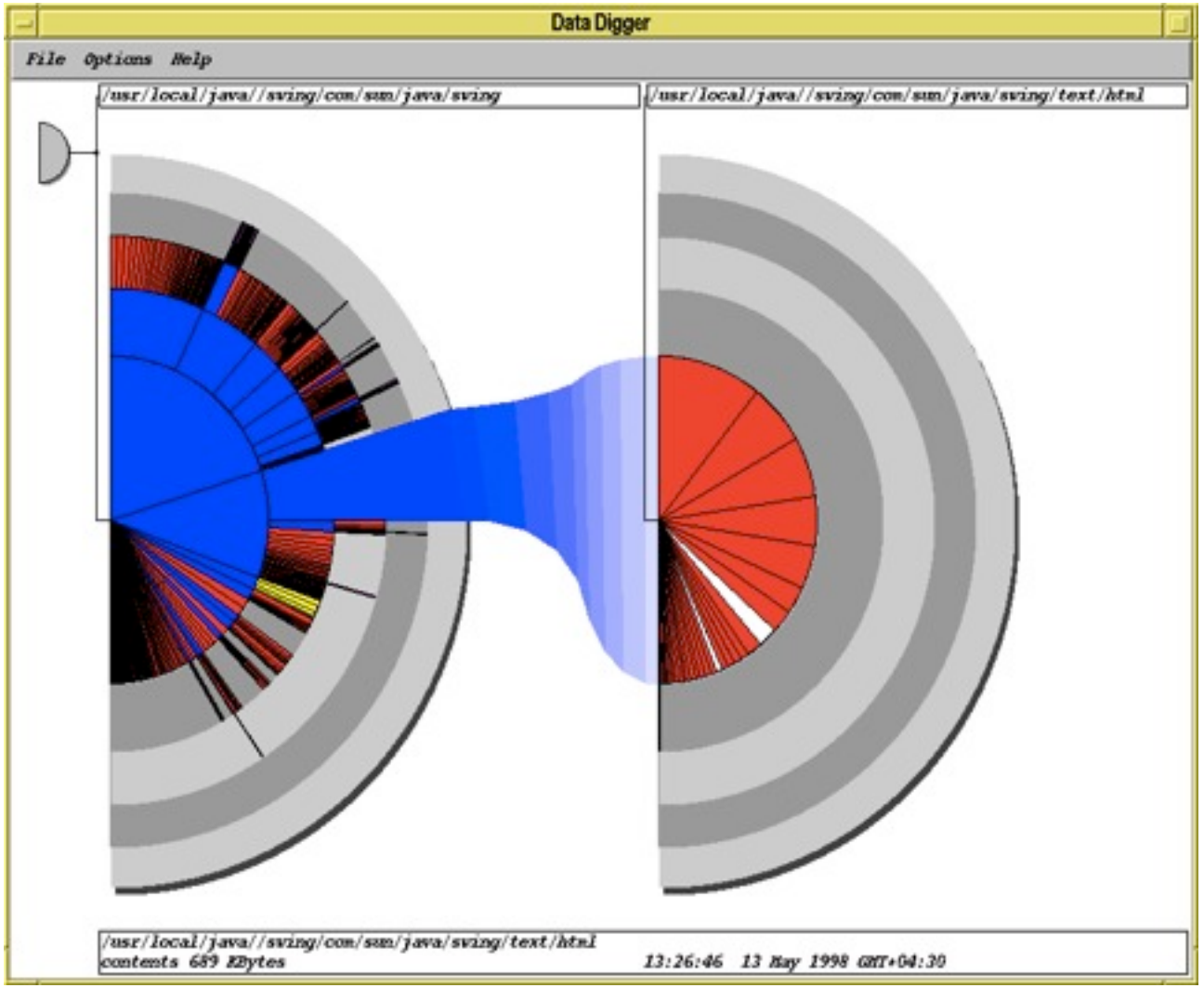
Appears in:
American Heritage Dictionary, 3rd Ed. Houghton Mifflin, 1992

Radial Space-Filling

Chuah

Andrews & Heidegger

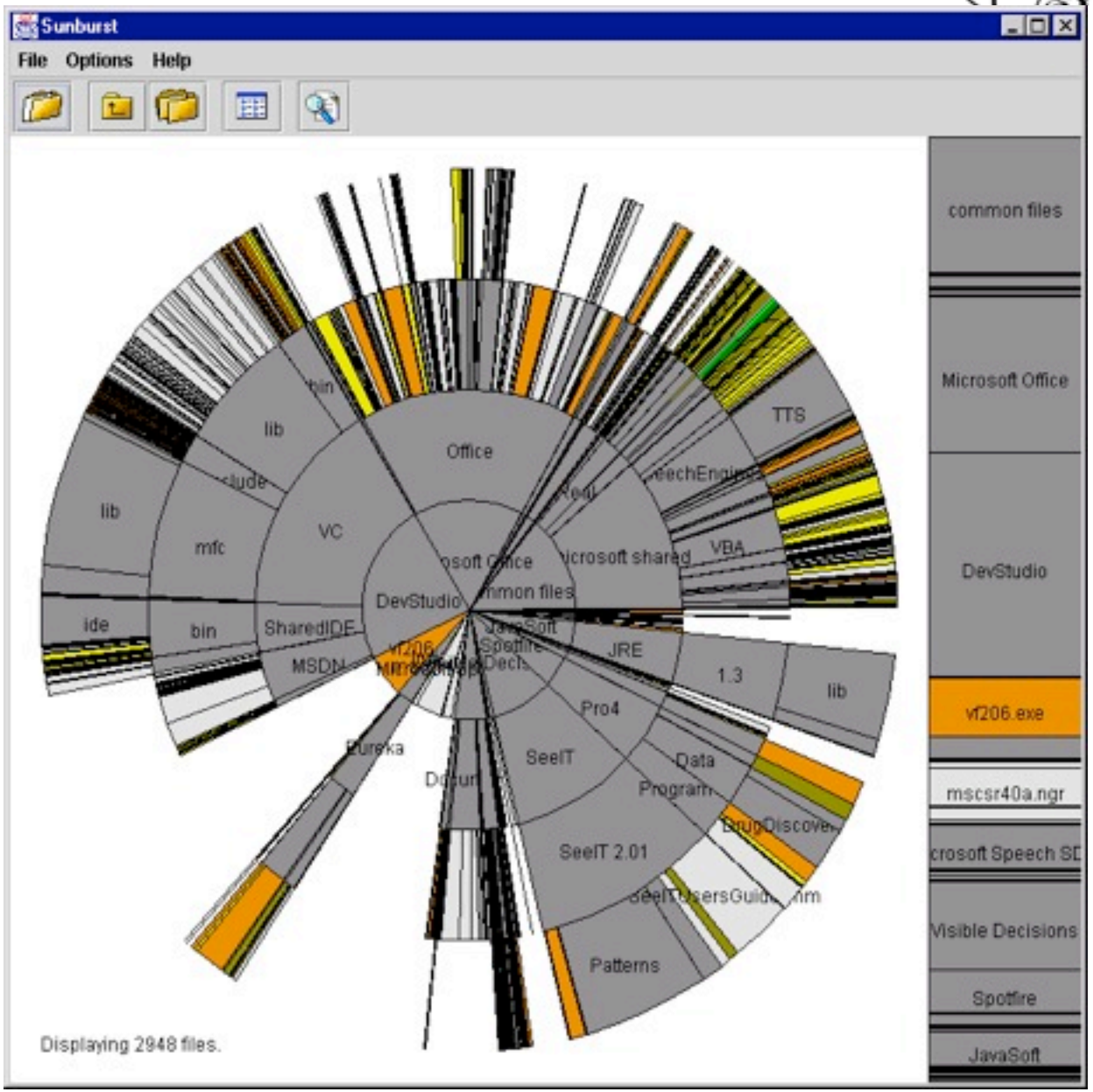
InfoVis '98



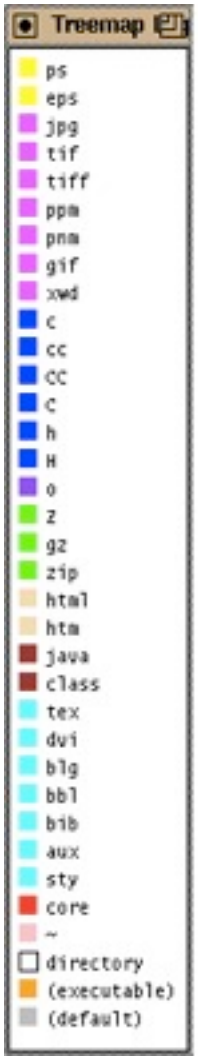
SunBurst

www.cc.gatech.edu/gvu/ii/sunburst

File browser



SunBurst


Treemap
ps
eps
jpg
tif
tiff
ppm
pnm
gif
xwd
c
cc
CC
C
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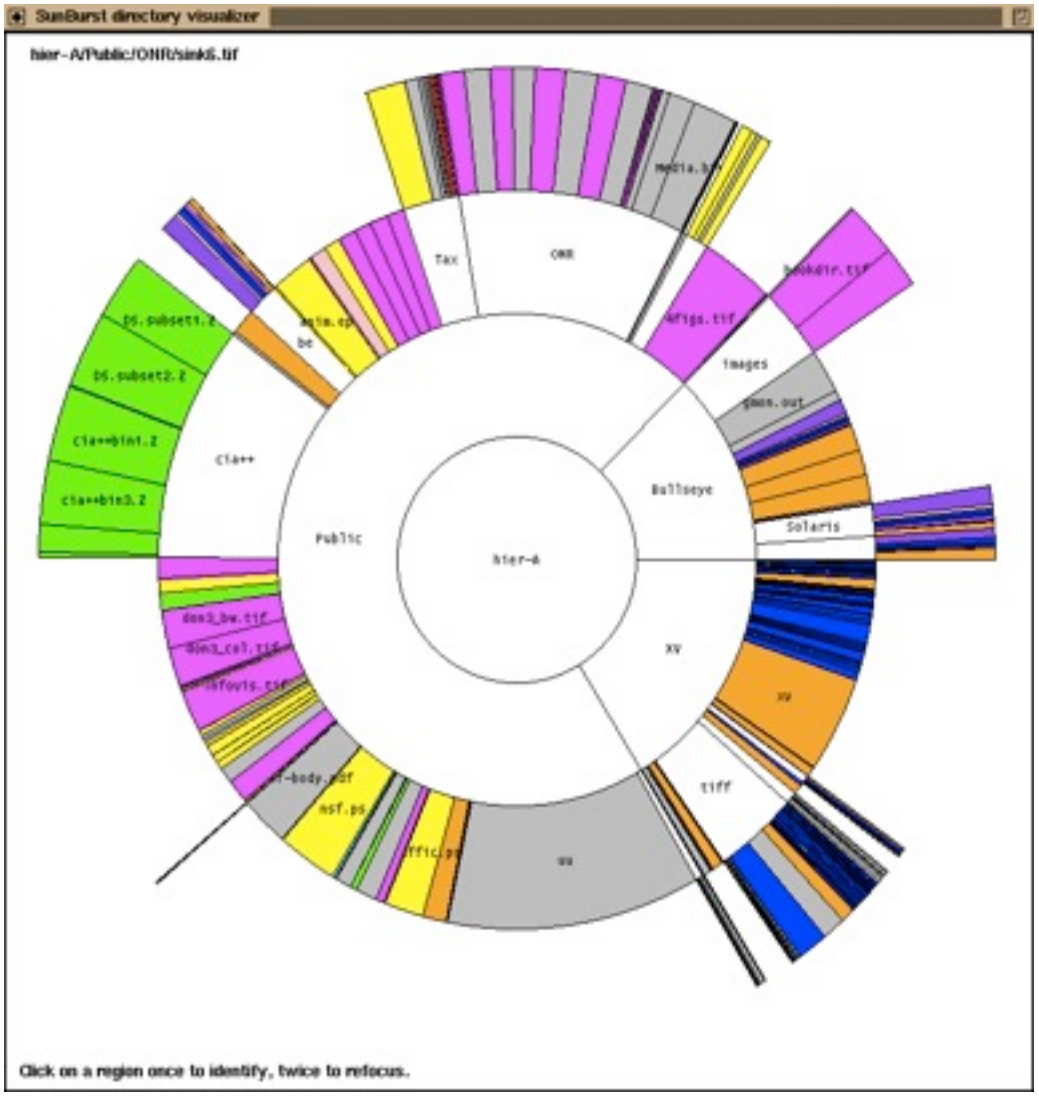
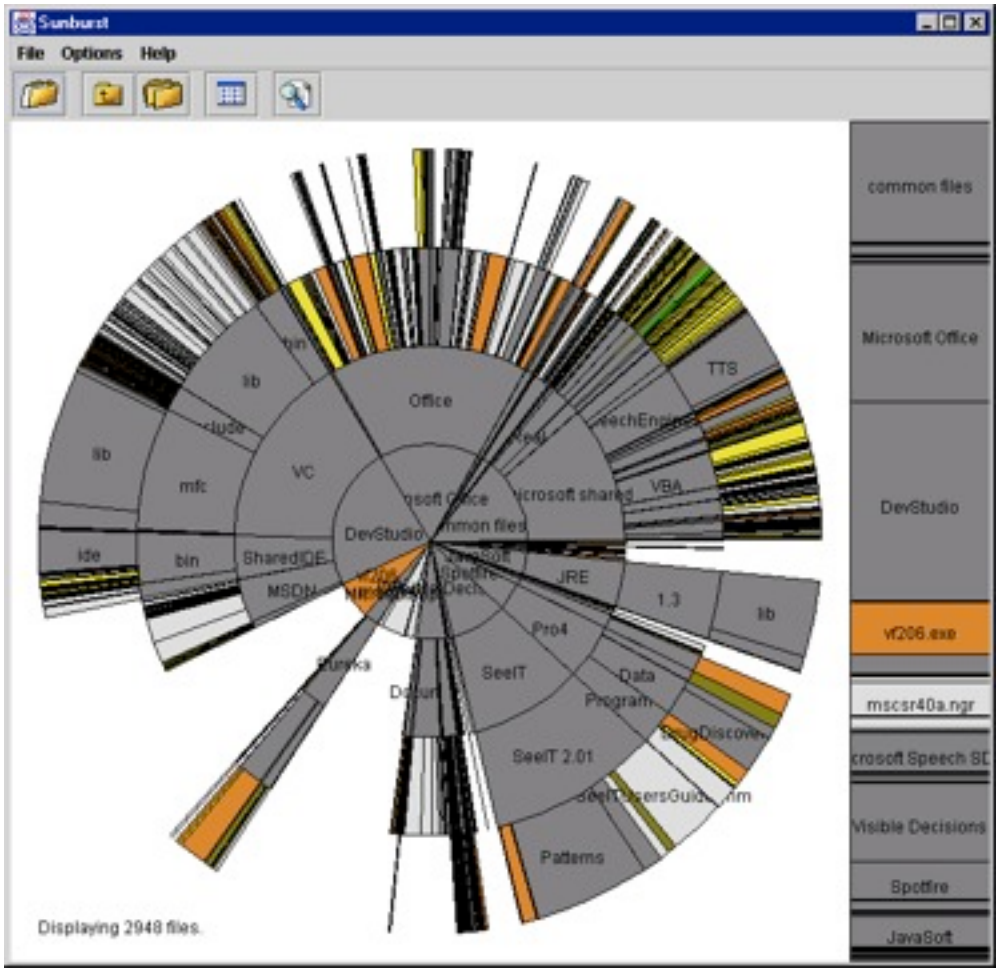
H
o
z
gz
zip
html
htm
java
class
tex
dvi
blg
bbl
bib
aux
sty
core
~
directory
(executable)
(default)


Treemap Control Panel
Treemap Directory Visualizer
Focus level: 1
Up One Directory
Top
Bottom level shown: 1
Higher
Deeper
Maximum
Color:
Type
Age
Random
Quit


SunBurst directory visualizer
hier-A/Public/ONR/sink5.tif
Public
hier-A
cla++
Bullseye
XV
Solaris
images
tiff
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



Empirical Study

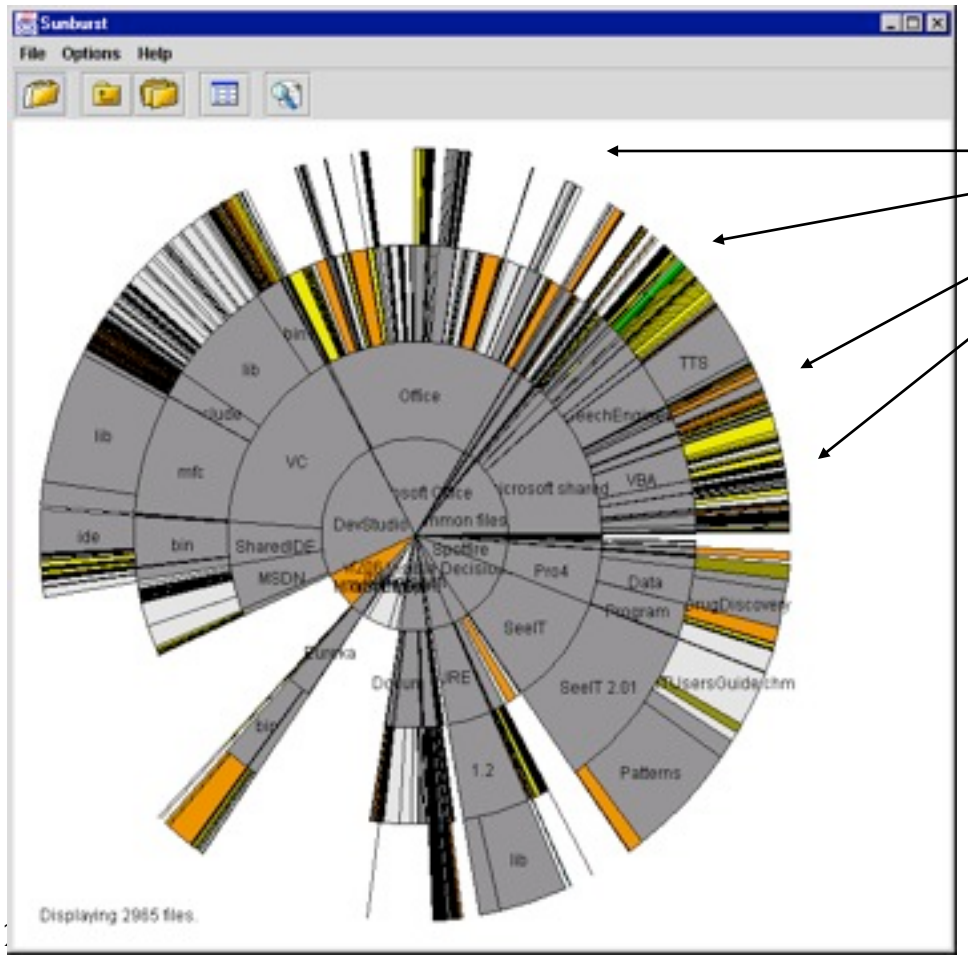
Stasko, Catrambone, Guzdial & McDonald
International Journal of Human-Computer Studies, 2000

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

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

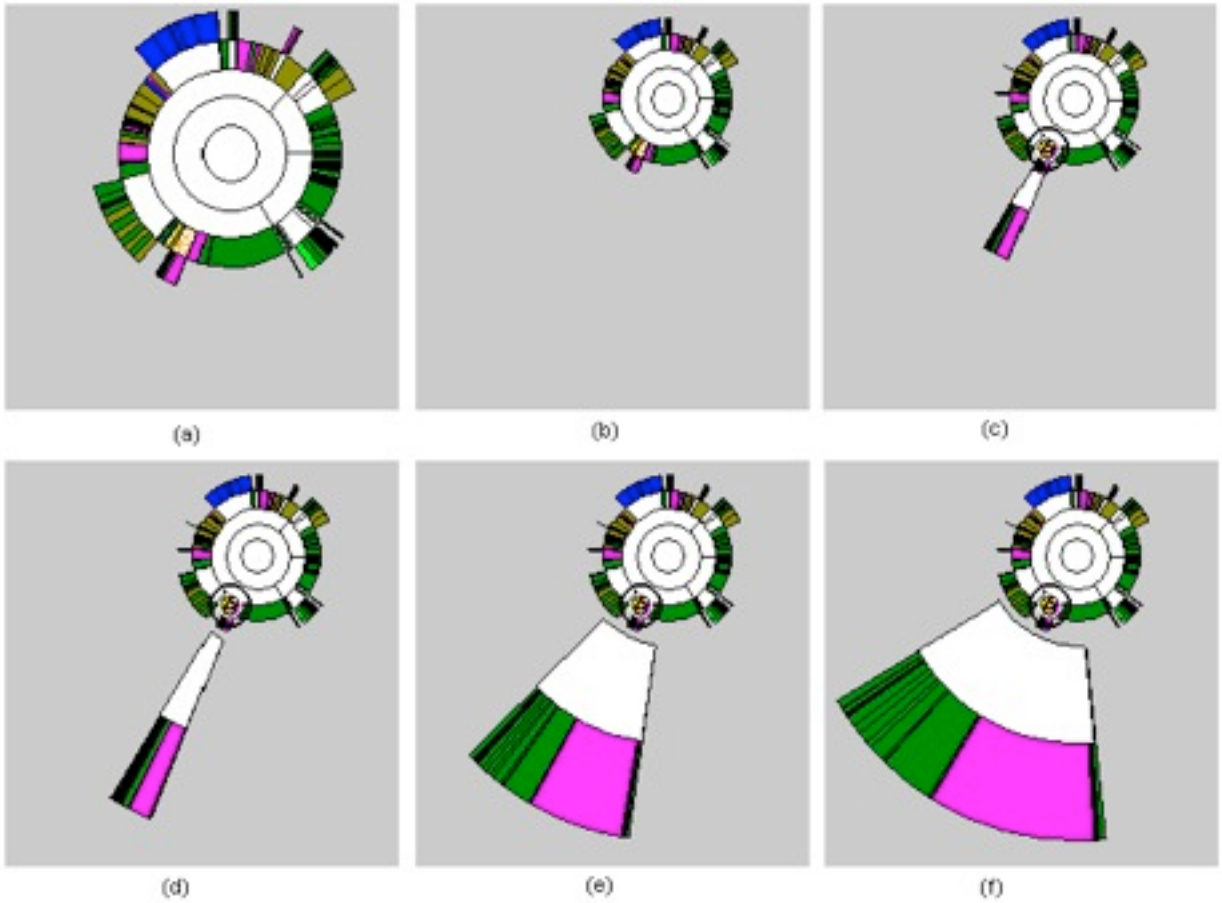
Provide an aesthetically pleasing interface in which it is easy to track changes in focus

3 Attempts

Three visualization+navigation techniques developed to help remedy the shortcoming

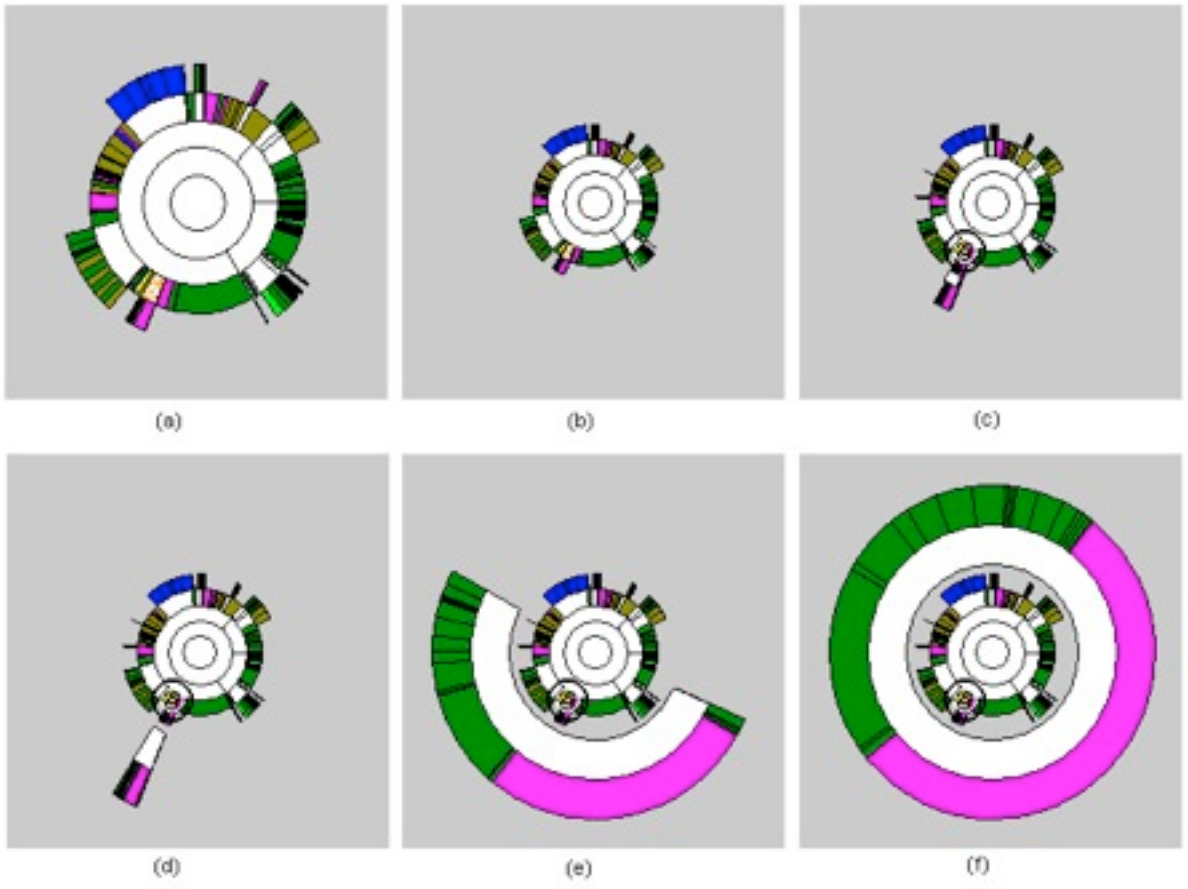
- Angular detail
- Detail outside
- Detail inside

Angular Detail



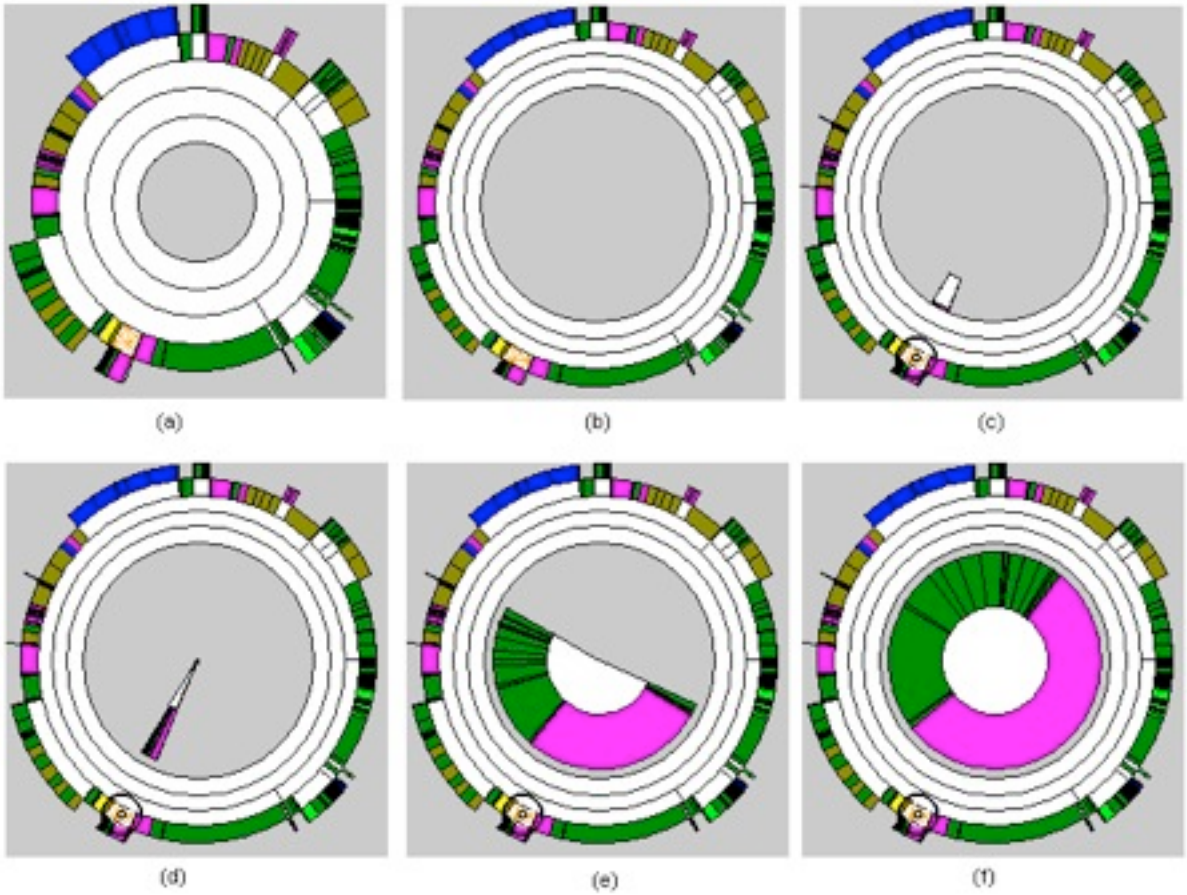
- Most "natural"
- Least space-efficient
- Most configurable by user

Detail Outside



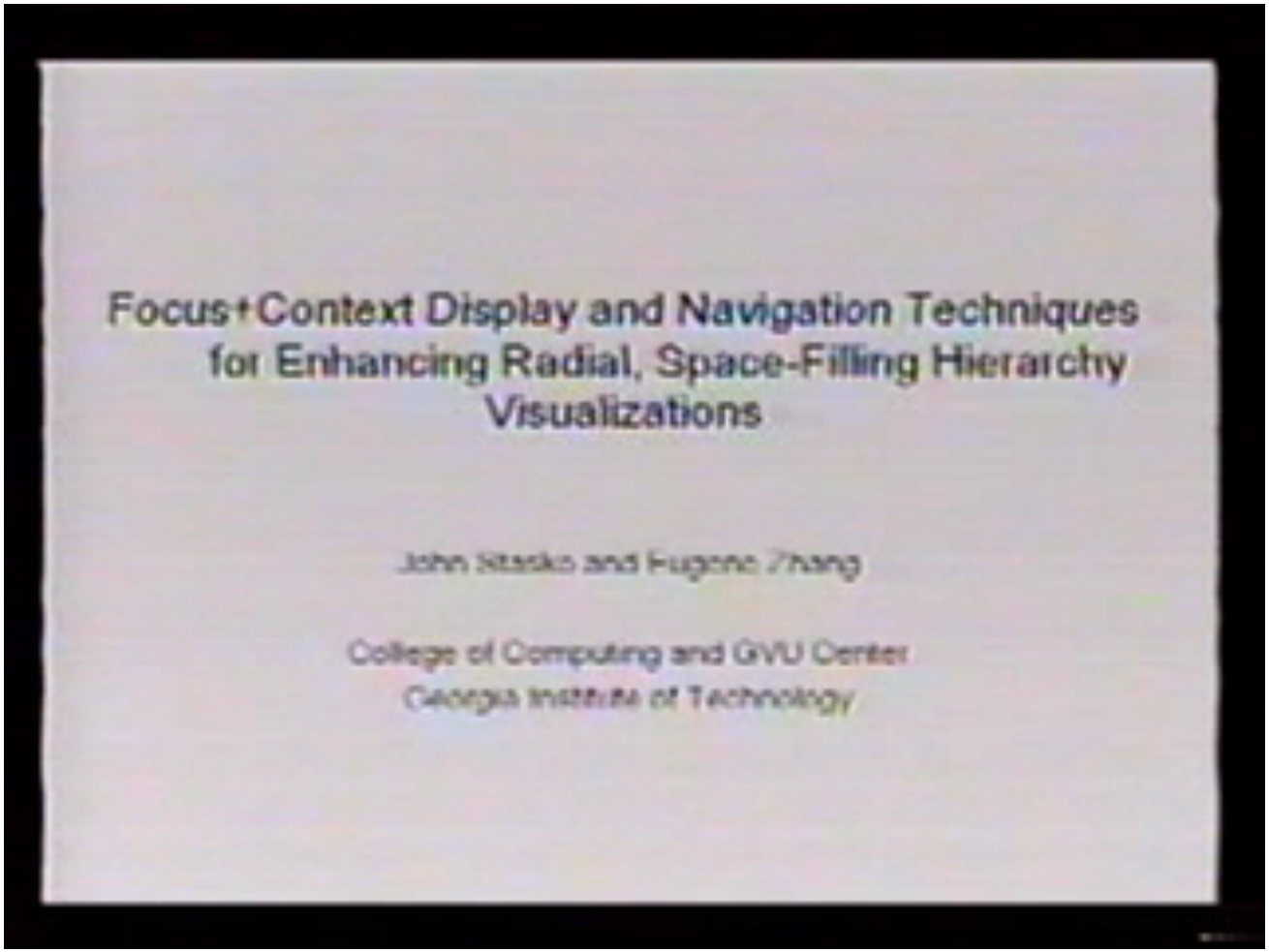
- Exhibits non-distorted miniature of overview
- Somewhat visually disconcerting
- Focus is quite enlarged (large circumference and 360°)
- Relatively space efficient

Detail Inside



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

Sunburst Demo



3D Approaches

Add a third dimension into which layout can go

Compromise of top-down and centered techniques mentioned earlier

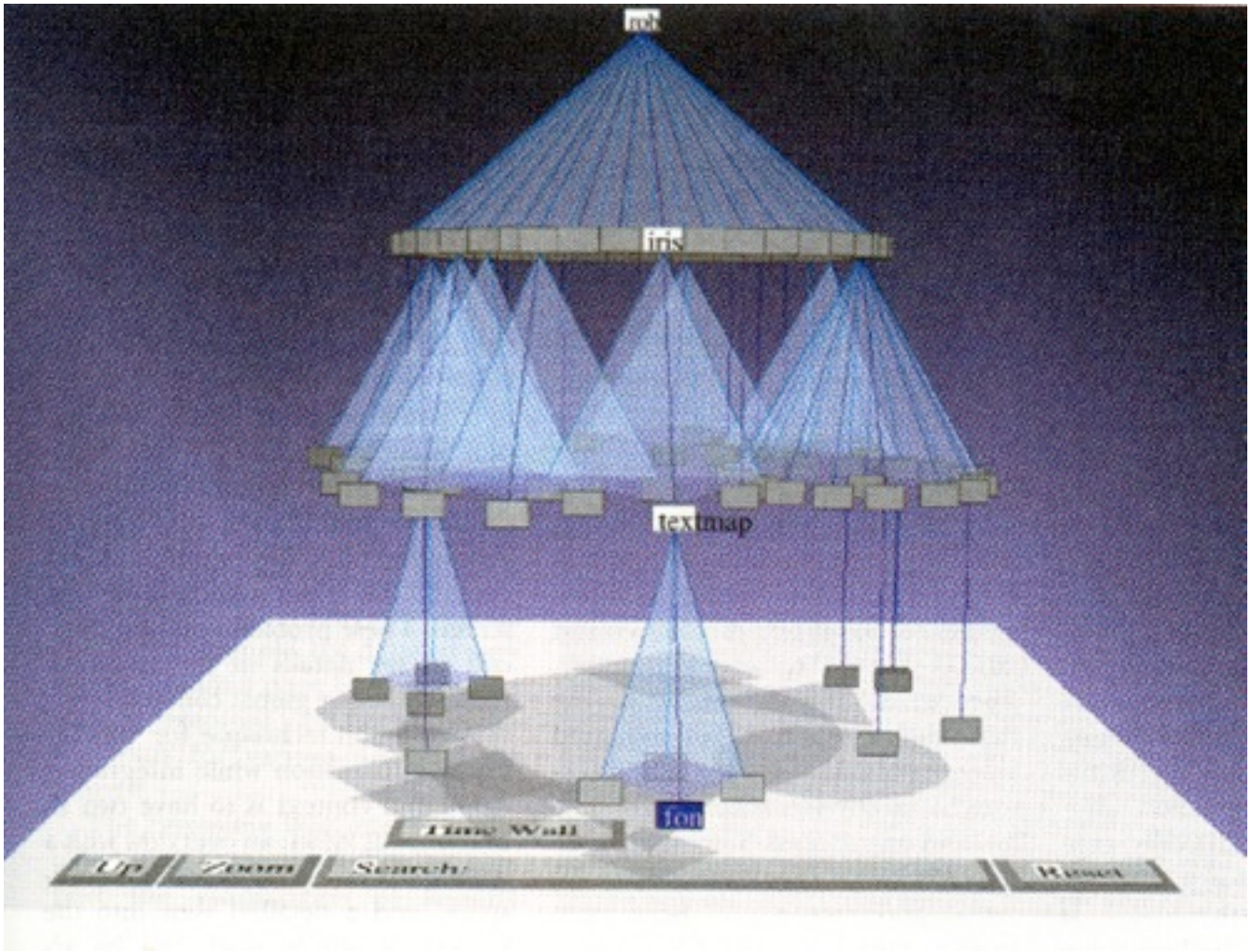
Children of a node are laid out in a cylinder "below" the parent

- 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 '91

Cone Trees

Developed at Xerox PARC

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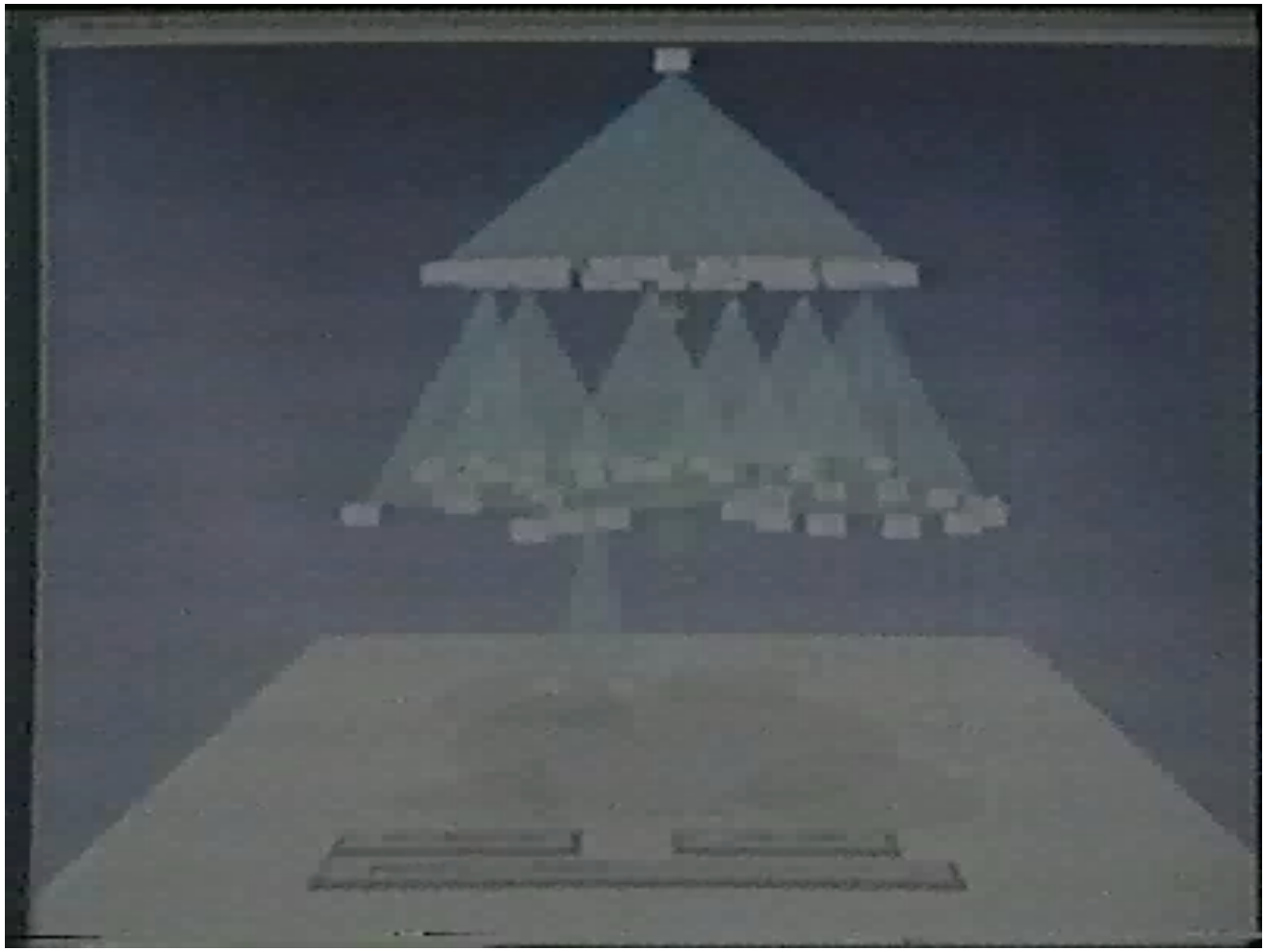
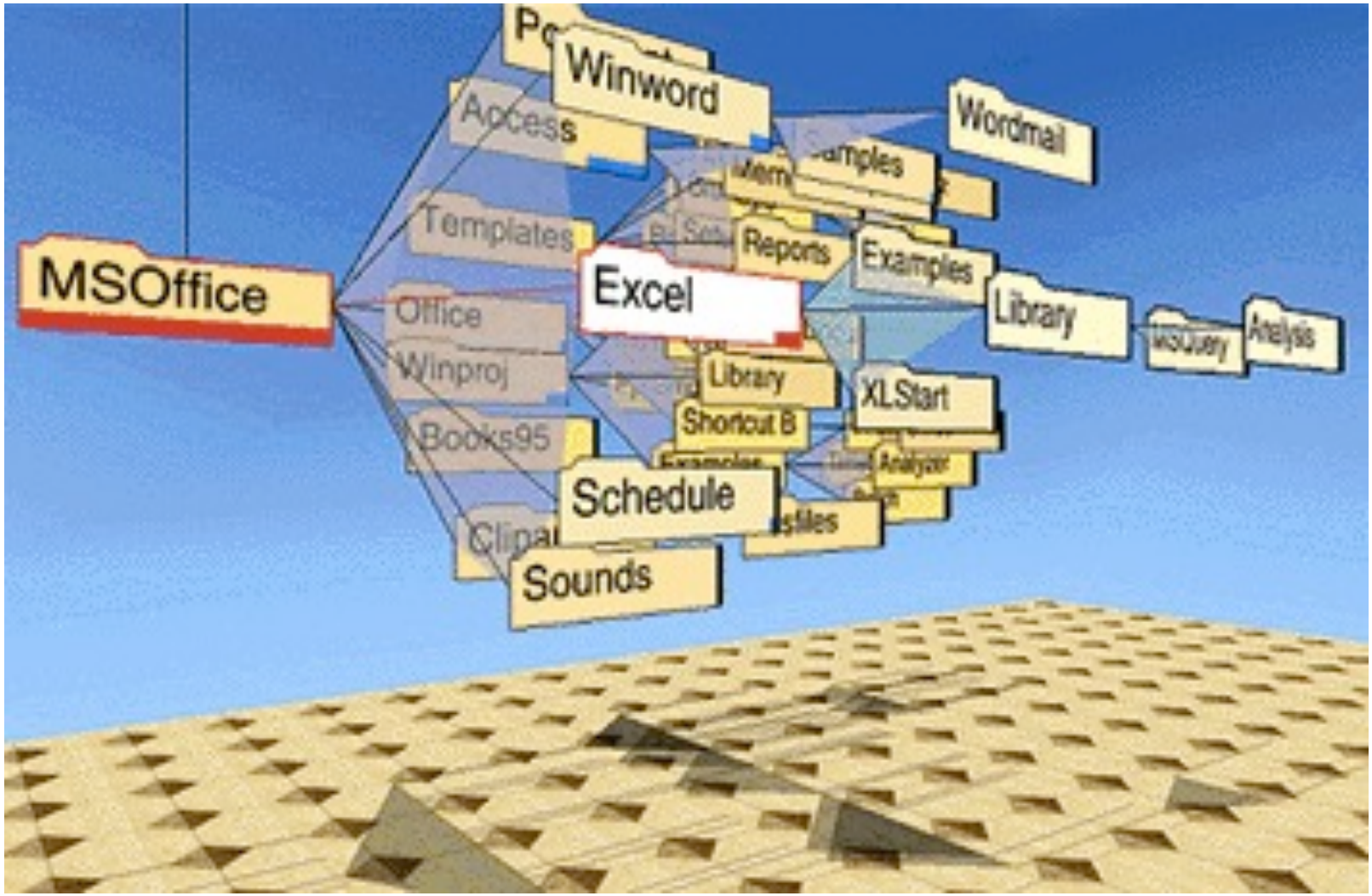


Robertson, Mackinlay, Card '91

Alternate Views



Cone Trees

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**

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

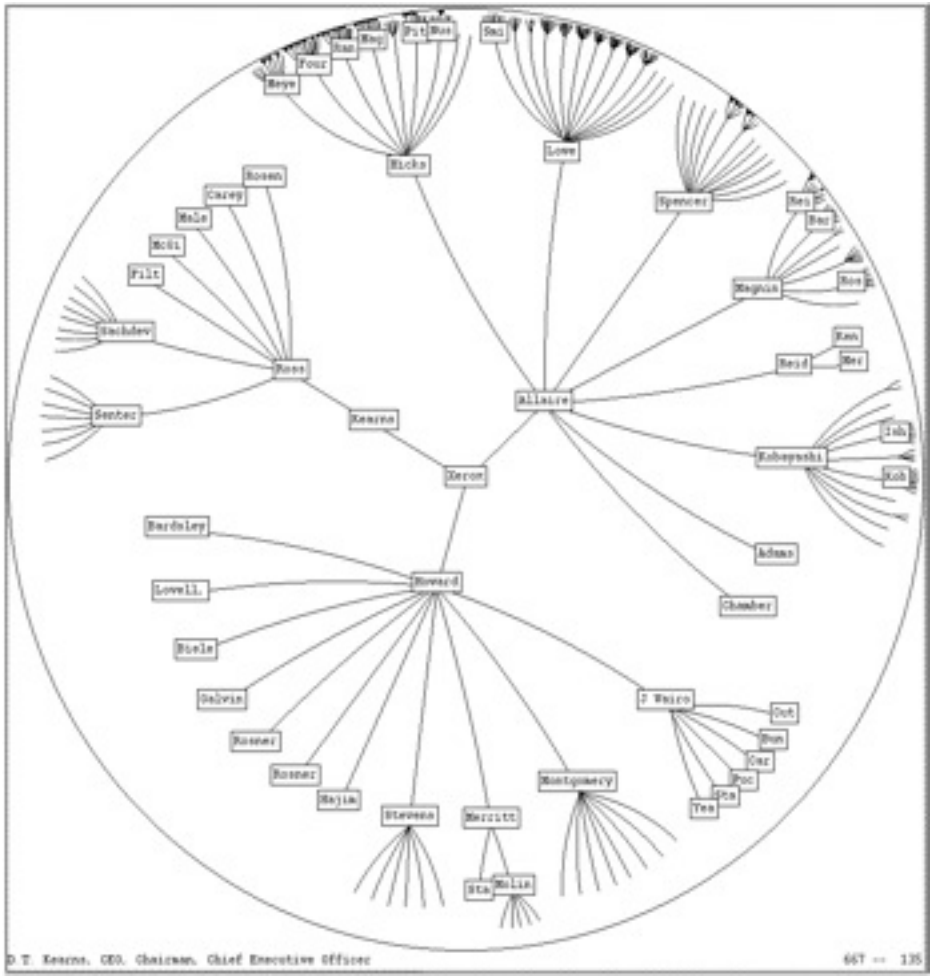
Then map this plane to a disk

Start with the tree's root at the center

Use animation to navigate along this representation of the plane

Lamping and Rao, '94

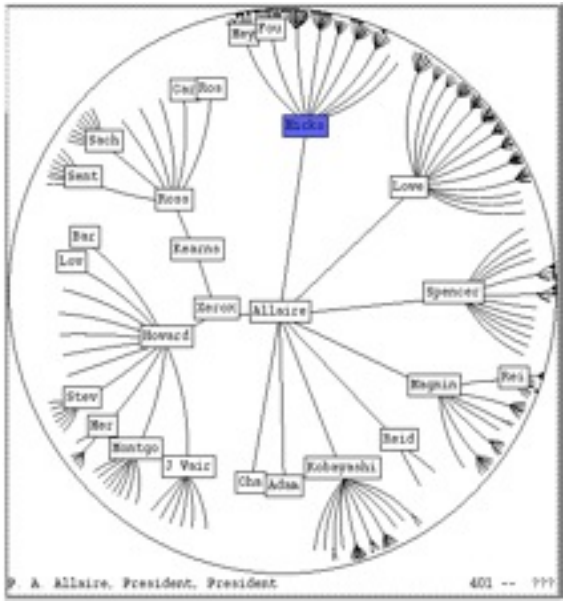
2D Hyperbolic Browser



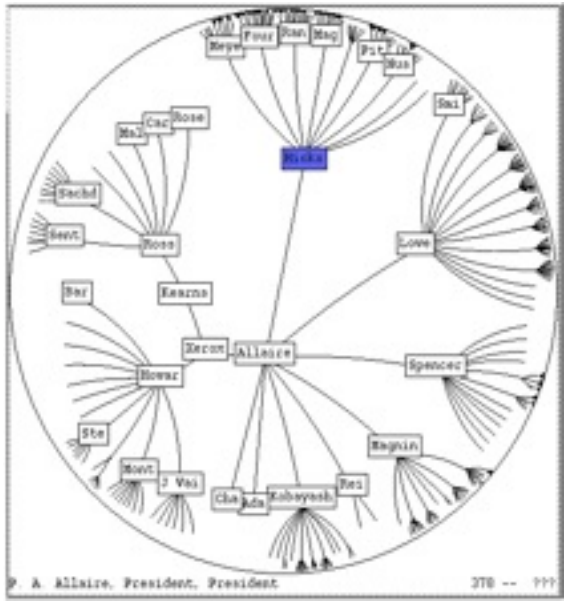
Approach: Lay out the hierarchy on the hyperbolic plane and map this plane onto a display region.

Comparison

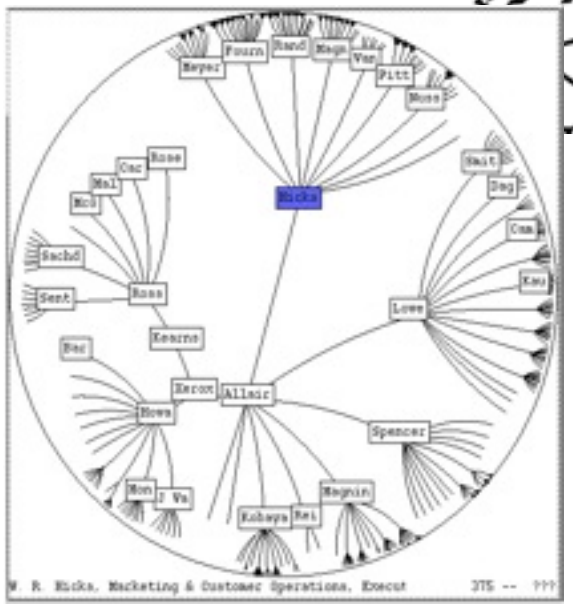
- A standard 2D browser: 100 nodes (w/3 character text strings)
- Hyperbolic browser: 1000 nodes, about 50 nearest the focus can show from 3 to dozens of characters



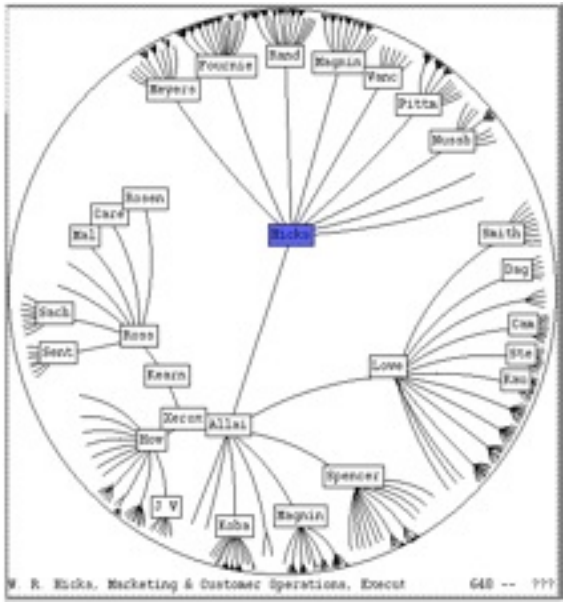
1



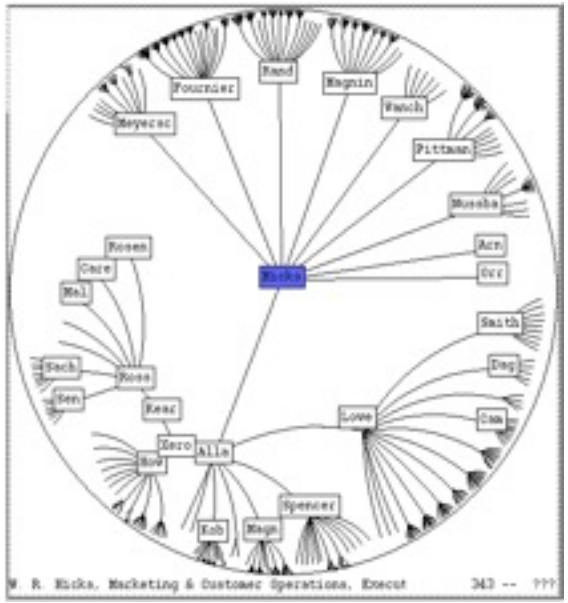
2



3



4



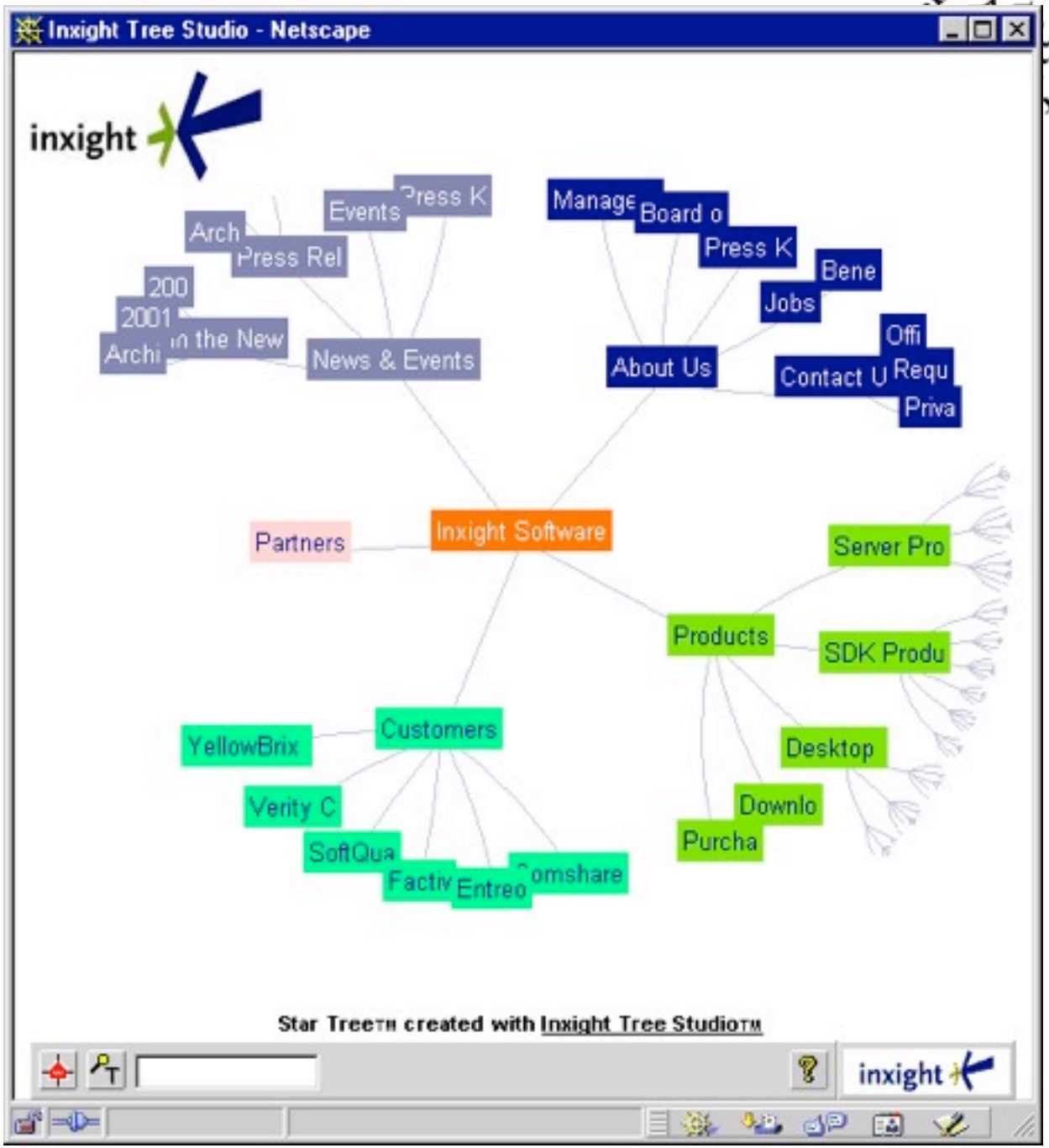
5

Clicking on the blue node brings it into focus at the center

StarTree

Hyperbolic tree

www.inxight.com



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)

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

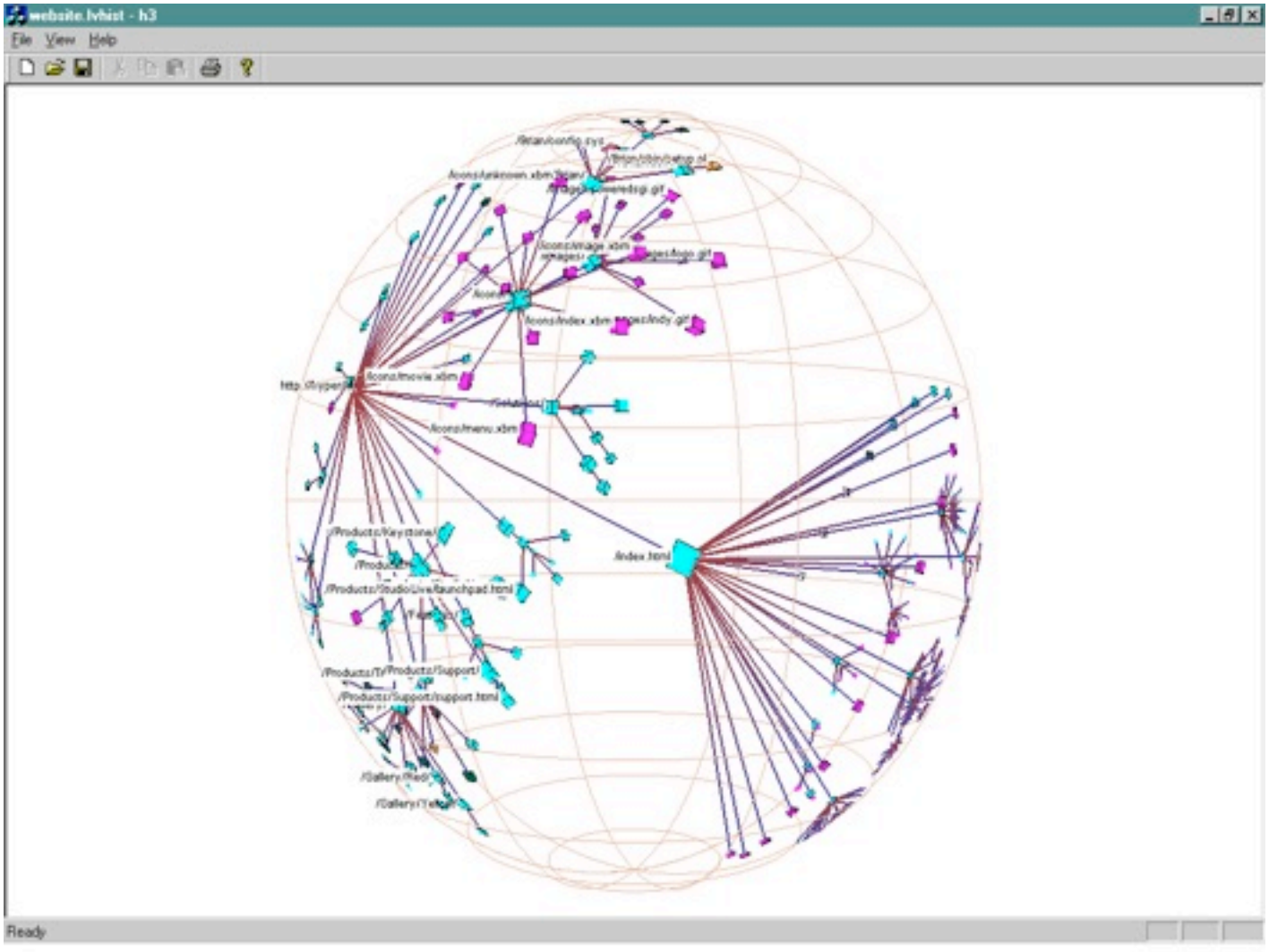
How about 3D?

Can same hyperbolic transformation be applied, but now use 3D space?

Sure can

Have fun with the math!

H3Viewer



Munzner, '98

Layout

Find a spanning tree from an input graph

- Use domain-specific knowledge

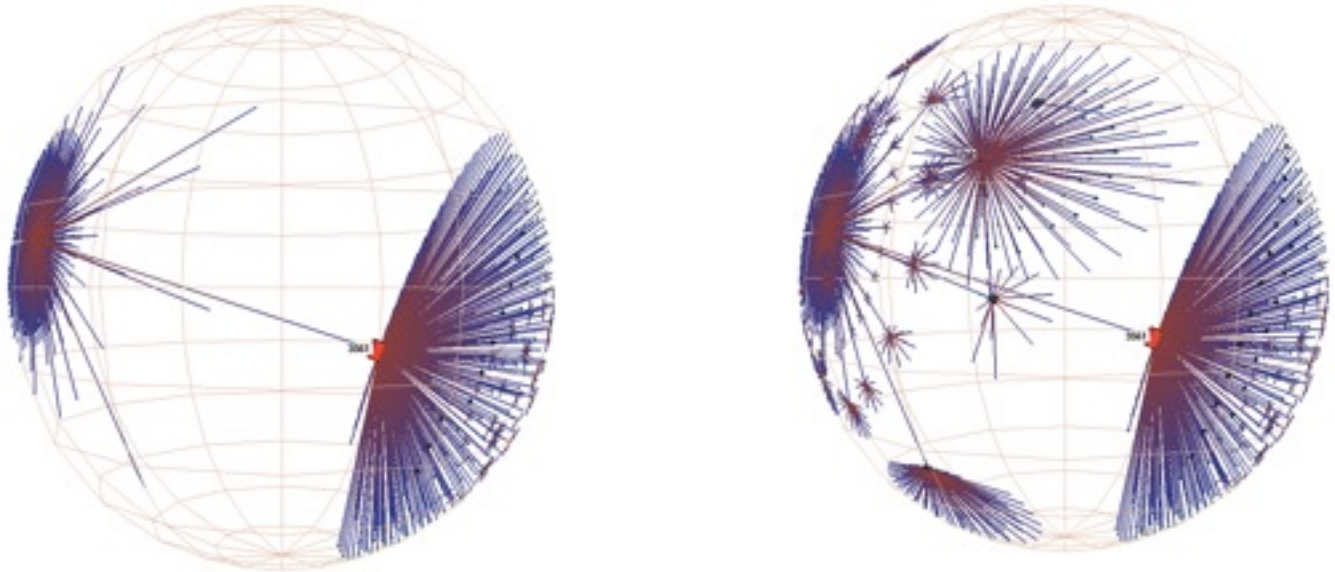
Layout algorithm

- Nodes are laid out on the surface of a hemisphere
- 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

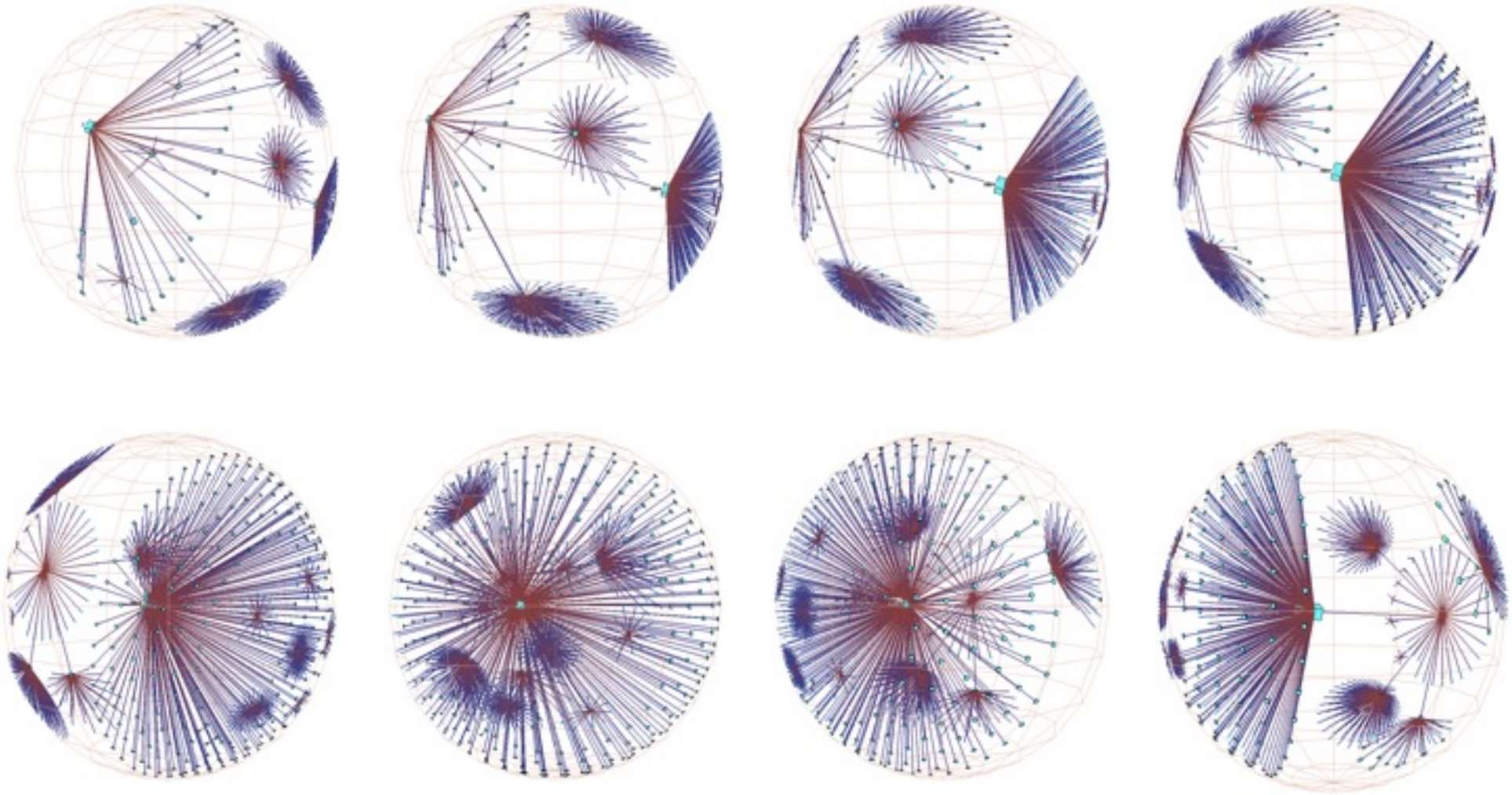
Drawing

Maintain a target frame by showing less of the context surrounding the node of interest during interactive browsing

Fill in more of the surrounding scene when the user is idle



Navigation



Performance

Handle much larger graphs, i.e. >100,000 edges

Support dynamic exploration & interactive browsing

Maintain a guaranteed frame rate

http://graphics.stanford.edu/~munzner/

Focus + Context

Scale - Many data sets are too large to visualize on one screen

- May simply be too many cases
- May be too many variables
- May only be able to highlight particular cases or particular variables, but viewer's focus may change from time to time

Challenge

Have context/overview seamlessly and smoothly co-exist with focus/detail

Why?

- Easier to move between the two, helps assimilate view updates, less jarring, …

Not all overview and detail techniques are good at this

Focus + Context Views

Same idea as overview and detail, with one key difference:

- Typically, the overview and the detail are combined into a single display
- Mimics our natural vision systems more closely

How?

What techniques have we seen so far that would help accomplish focus +context?

Possible Methods

Filtering

Selective aggregation

Micro-macro readings

Highlighting

Distortion

Prototypical Example

When people think about focus+context views, they typically think of the **Fisheye View** (distortion)

Introduced by George Furnas in 1981 report, more famous article is 1986 SIGCHI paper

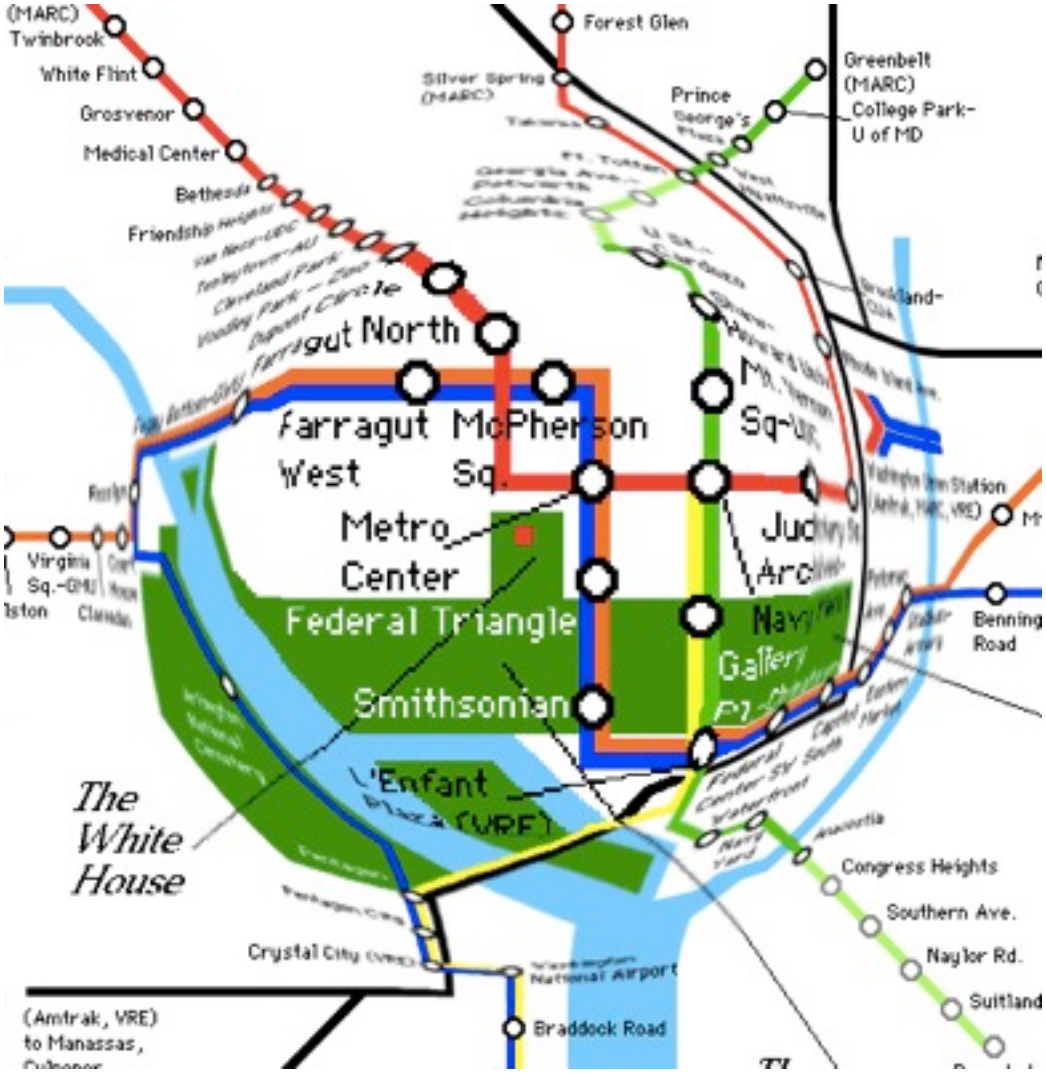
Definition

Fisheye View -

"Provide[s] detailed views (focus) and overviews (context) without obscuring anything…The focus area (or areas) is magnified to show detail, while preserving the context, all in a single display."

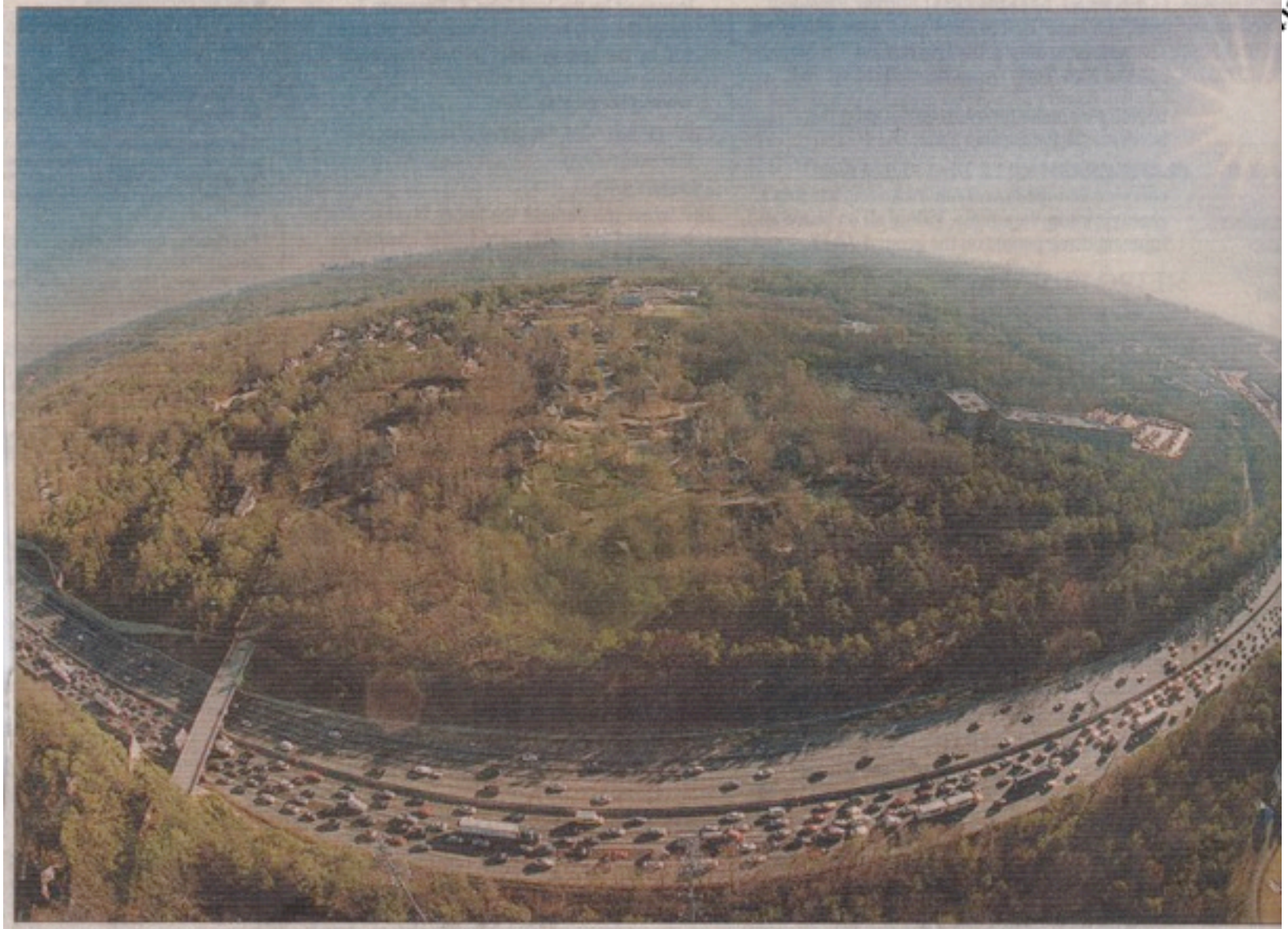
-(Shneiderman, **DTUI**, 1998)

Example


(MARC)
Twinbrook
White Flint
Grosvenor
Medical Center
Bethesda
Friendship Heights
Forest Glen
Silver Spring
(MARC)
Prince
George's
Greenbelt
(MARC)
College Park-
U of MD
Farragut North
Farragut
West
McPherson
Sq.
Metro
Center
Federal Triangle
Smithsonian
Virginia
Sq.-GMU
Benning
Road
The
White
House
L'Enfant
Crystal City
Congress Heights
Southern Ave.
Naylor Rd.
Suitland
(Amtrak, VRE)
to Manassas,
Braddock Road

Everyday Life Example

On I-285, another Perimeter maul



Traffic creeps along I-285 westbound during the evening rush hour Thursday after a hole developed in a bridge over the Chattahoochee River and th
closed. Officials say recent construction work may have caused the problem. This photo, taken with a fisheye lens, is looking south toward downtow

Fisheye Terminology

Focal point

Level of detail

Distance from focus

Degree of interest function

DoI Function

Can take on various forms

- Continuous - Smooth interpolation away from focus
- Filtering - Past a certain point, objects disappear
- Step - Levels or regions dictating rendering
  0<x<.3 all same, .3<x<.6 all same
- Semantic changes - Objects change rendering at different levels

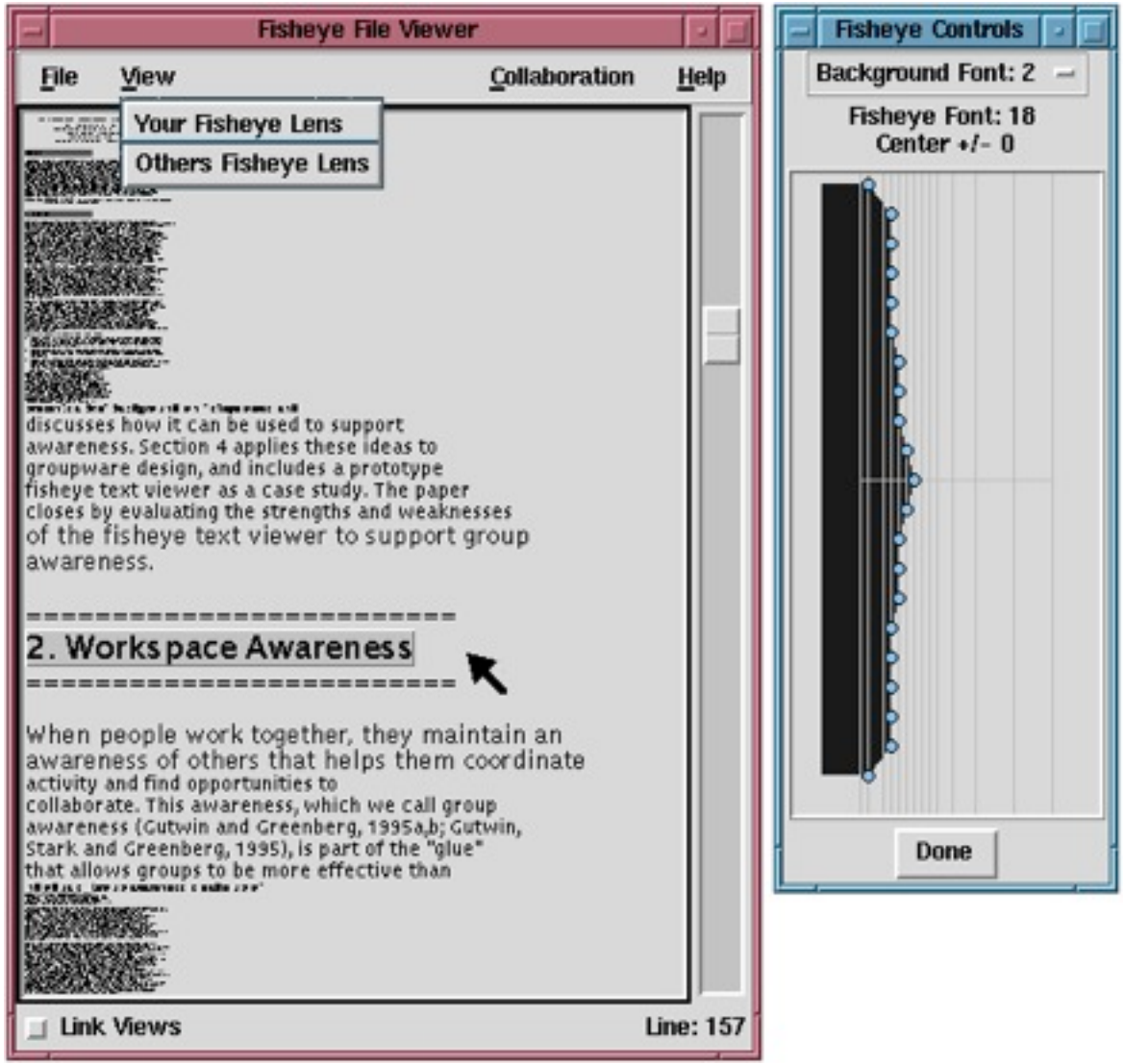
Applications

Text/program viewing

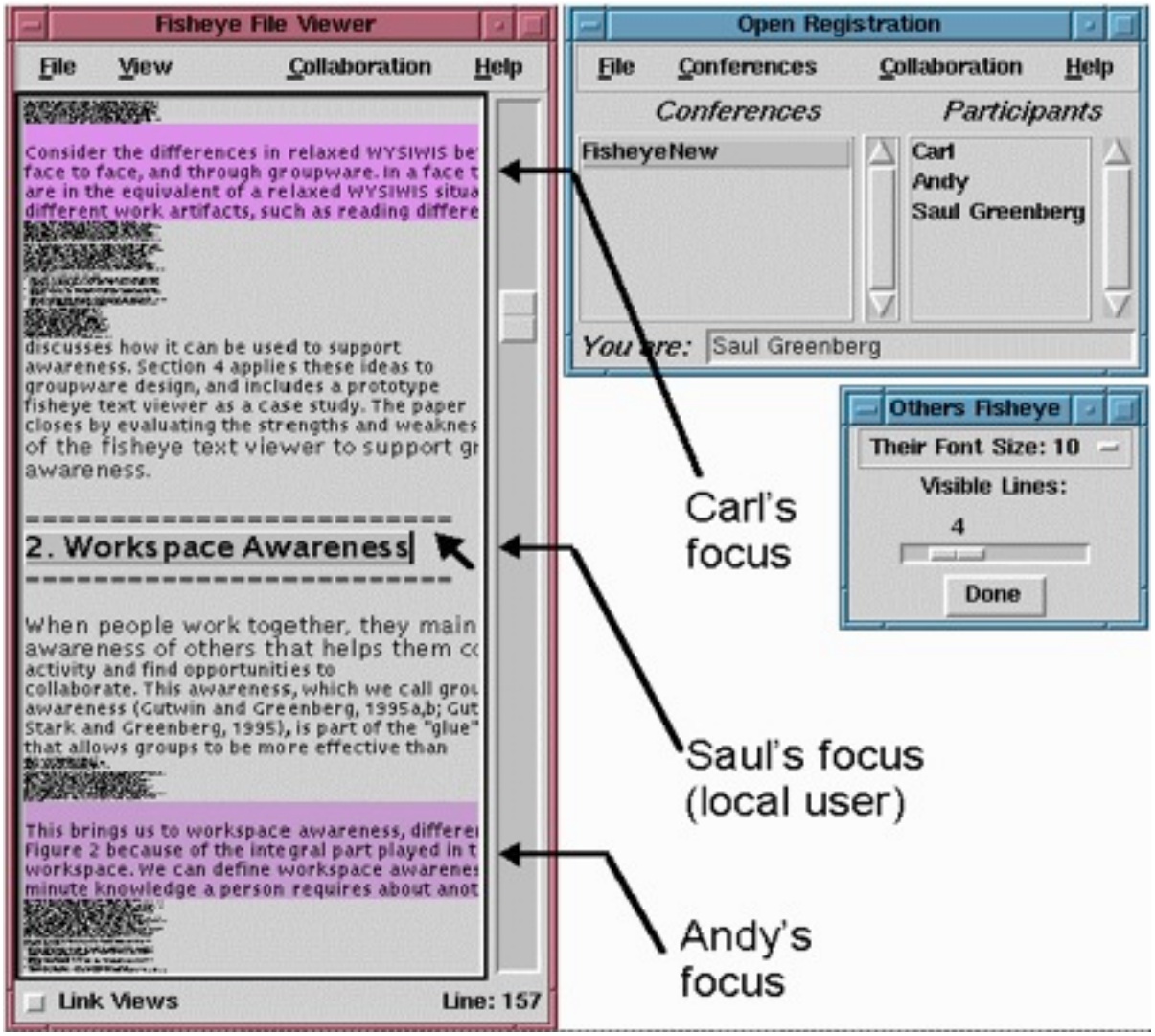
Furnas' original example

Shown here are examples from Gutwin and Greenberg

Step function



Applications



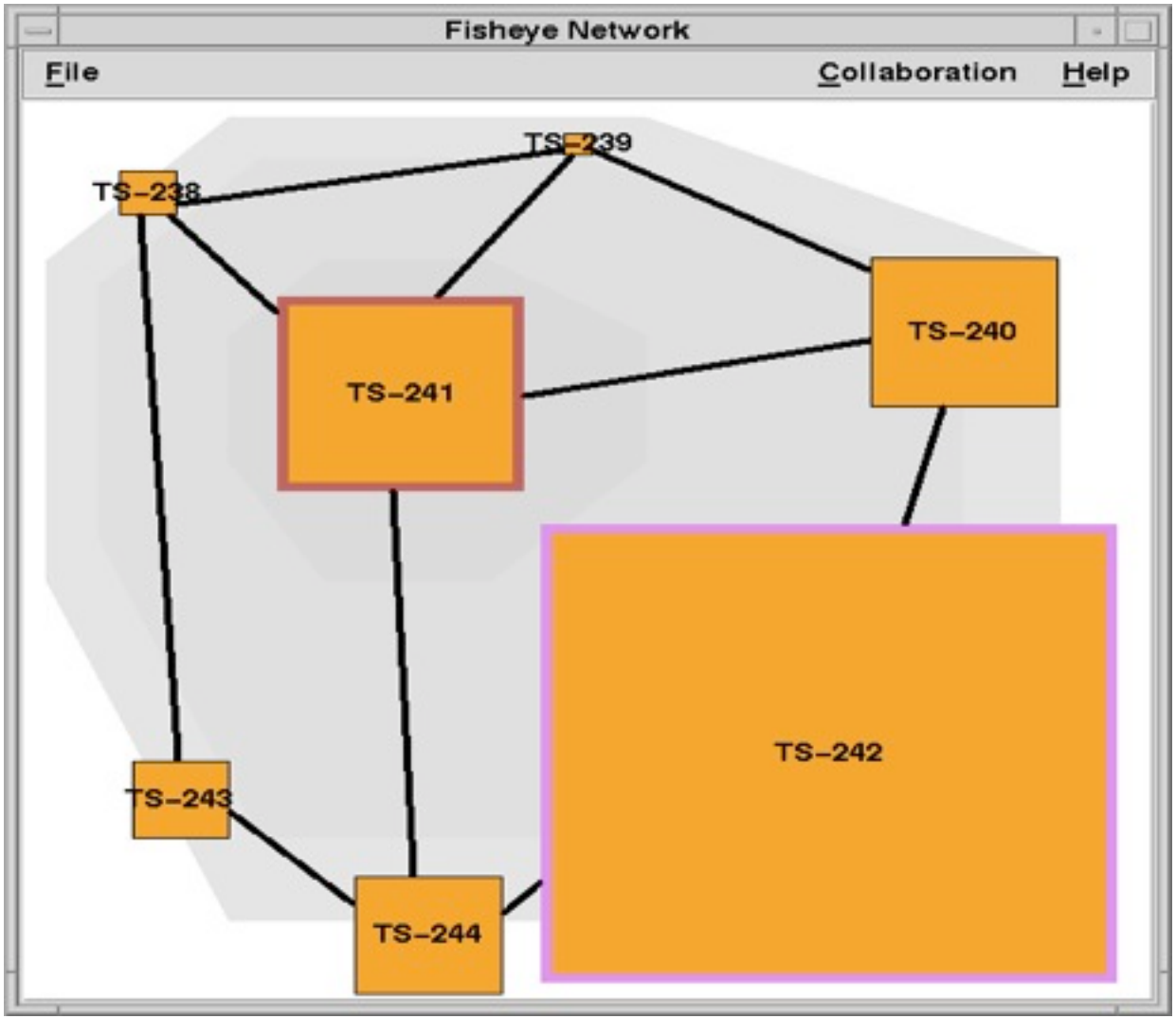
Shared text editor for CSCW

Gutwin and Greenberg, '96

Applications

Viewing nodes in networks

Gutwin and Greenberg



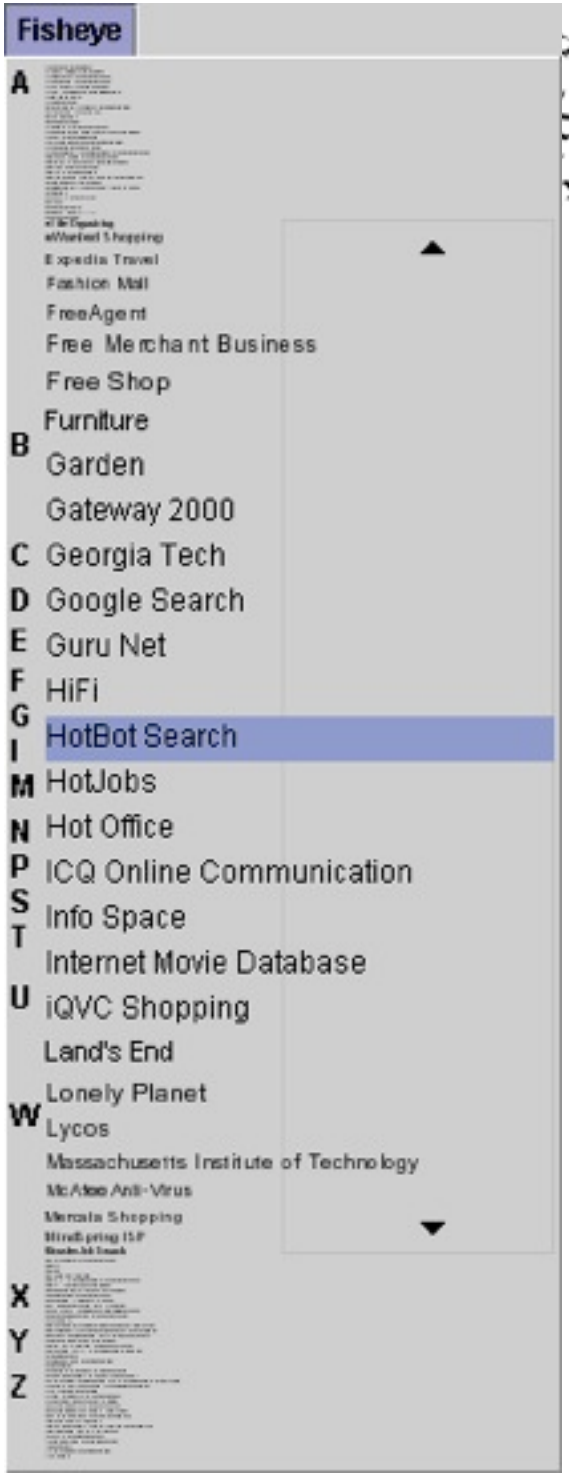
Applications

Fisheye menu

Uses a focus-lock mode
(move cursor to right)

Demo:
`www.cs.umd.edu/hcil/fisheyemenu`

Bederson '00



Graphical Fisheye Views

Apply fisheye techniques to 2D graph

Experiment with a variety of distortion factors

Interactive tool that allows user to browse display and change focus

Sarkar and Brown '94

Graphical Fisheye Views

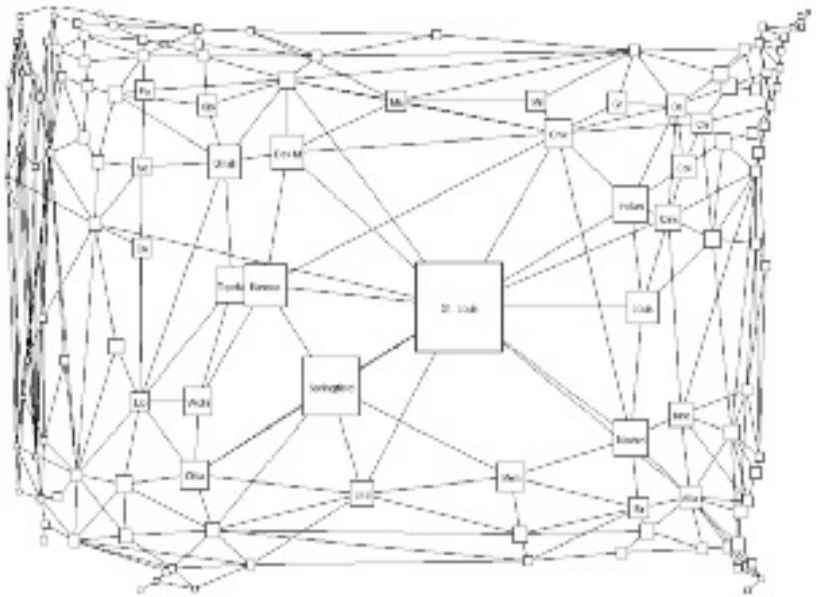


Figure 2: A fisheye view of the graph in Figure 1. The focus is on St. Louis. (The values of the fisheye parameters are d _ 5, r _ 0, c _ 0, $VWcutoff$ _ 0; the meanings of these parameters are explained in Sections 4 and 6.)

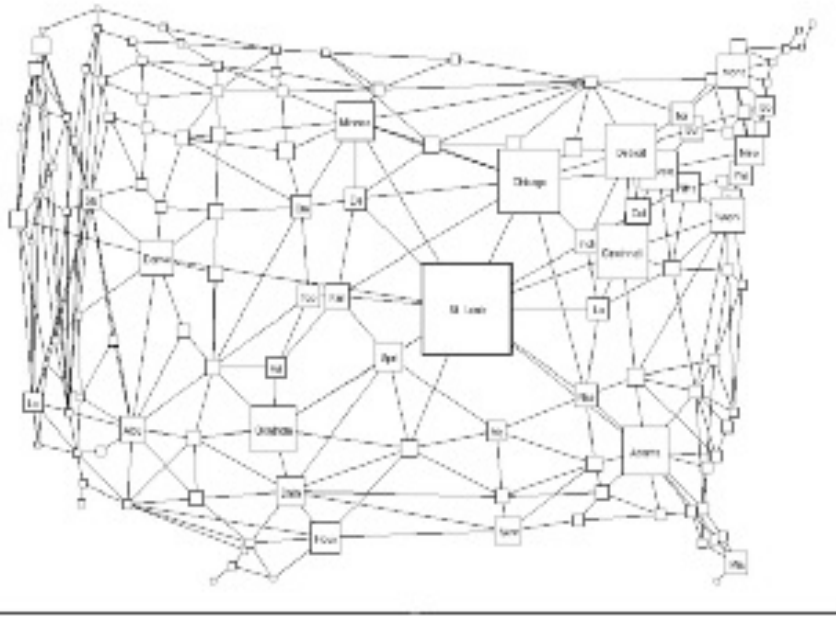
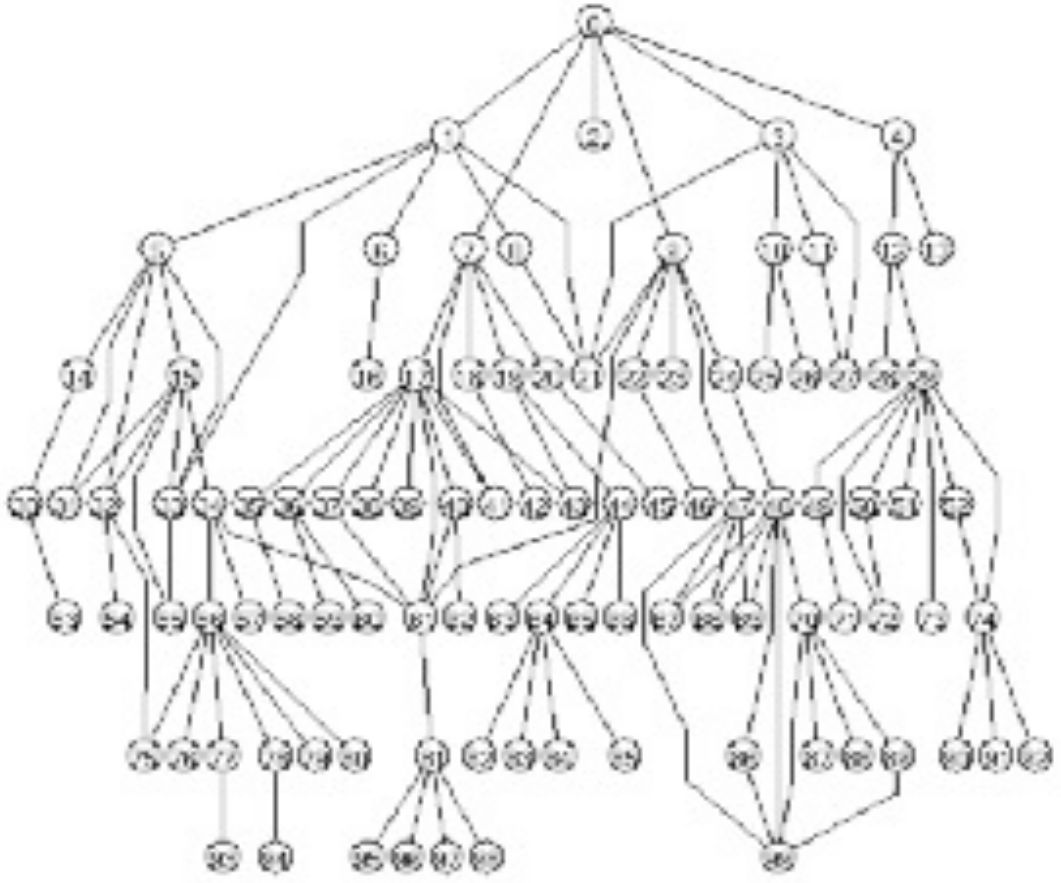


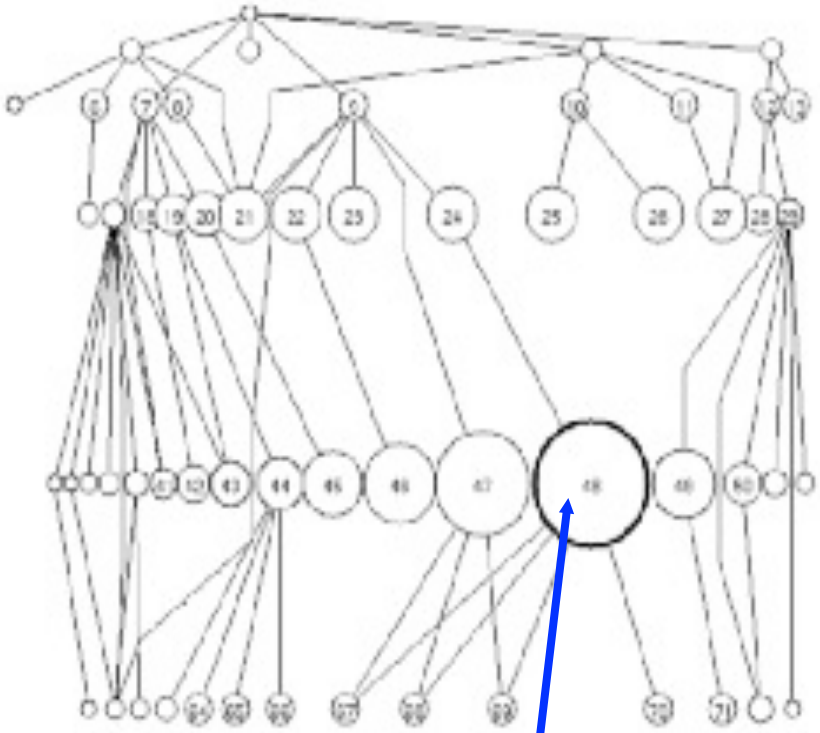
Figure 3: A fisheye view of the graph in Figure 1, with less distortion than in Figure 2. The values of the fisheye parameters are d _ 2, c _ 0.5, c _ 0.5, $VWcutoff$ _ 0.

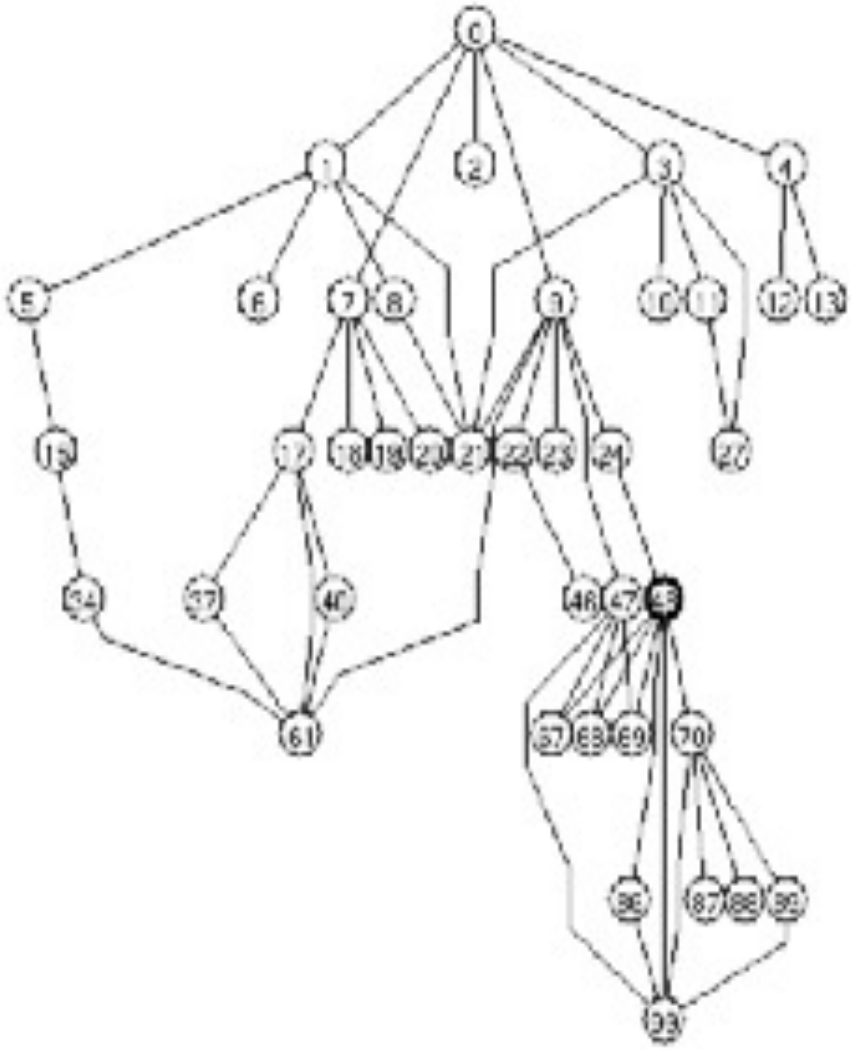
Example



Original

Example





Focal point

Constraining Changes

Continuous zoom

- Can change focal point smoothly in graph
- Other nodes give up space
- Bartram et al '95

Constrained fisheye

- Make transitions in focus more aesthetically pleasing and easier to track
- Storey et al '99

Simon Fraser Univ.

Bifocal Display

Interesting application of fisheye view

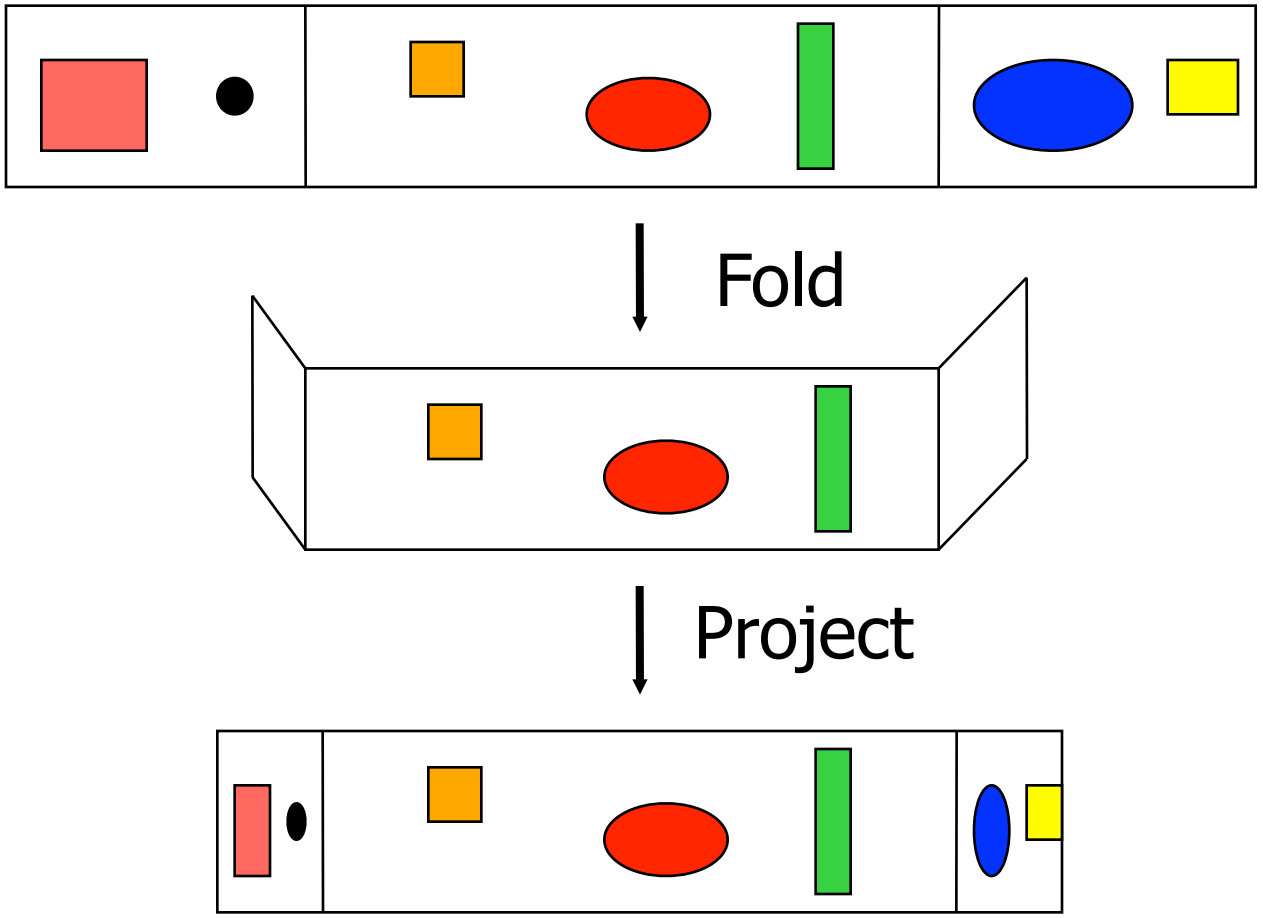
View office documents

Take items in periphery and fold back in 3-space

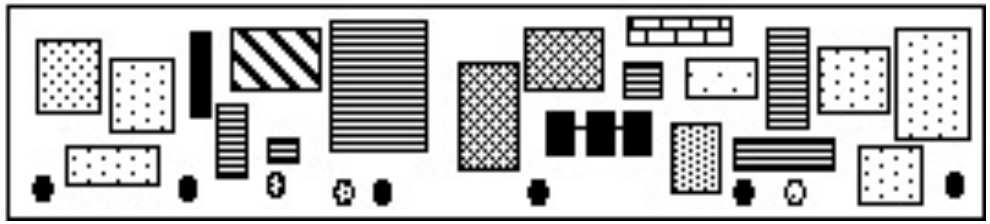
Project onto front viewing screen

Spence & Apperly '82

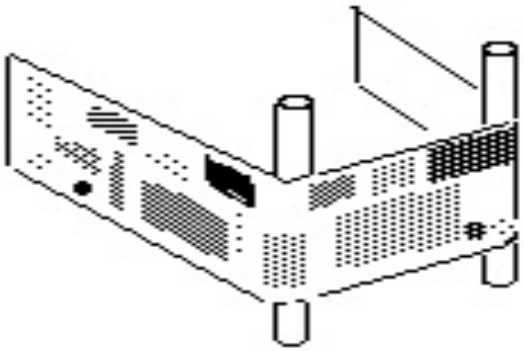
Bifocal Display



Bifocal Display



Fold



Project

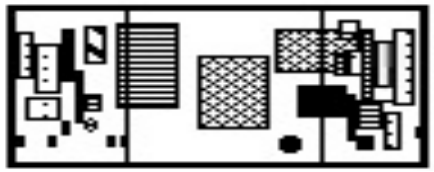
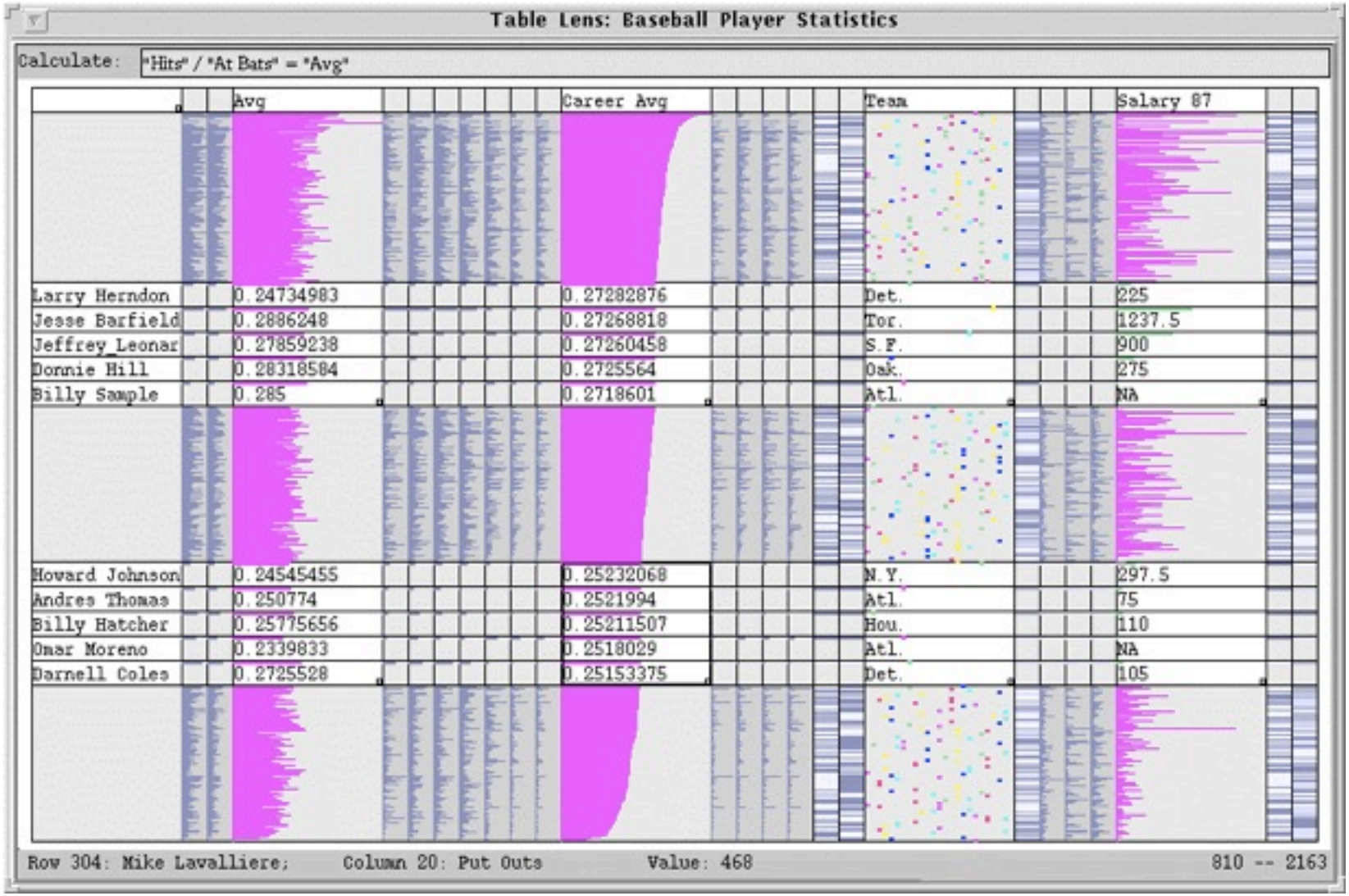


Table Lens



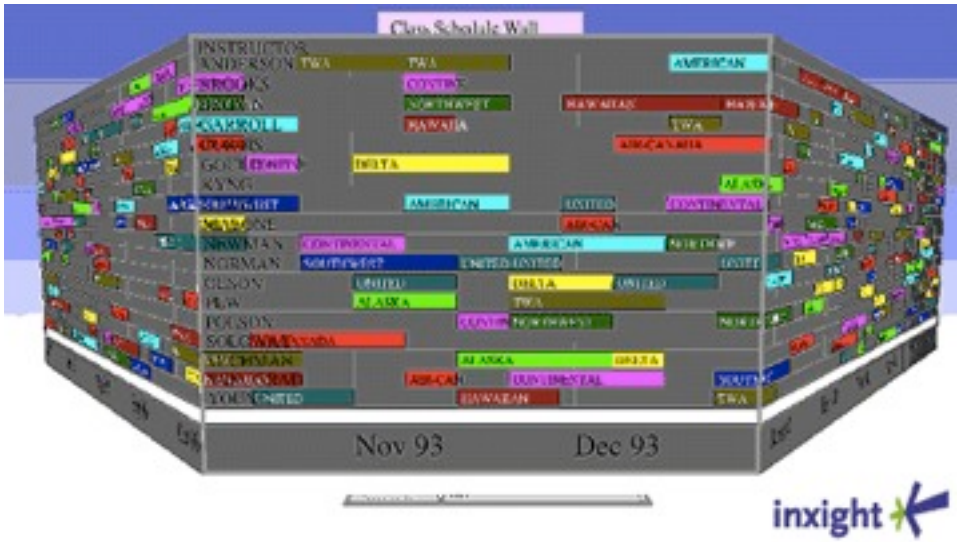
From Xerox PARC and Inxight

A bifocal display

Perspective Wall

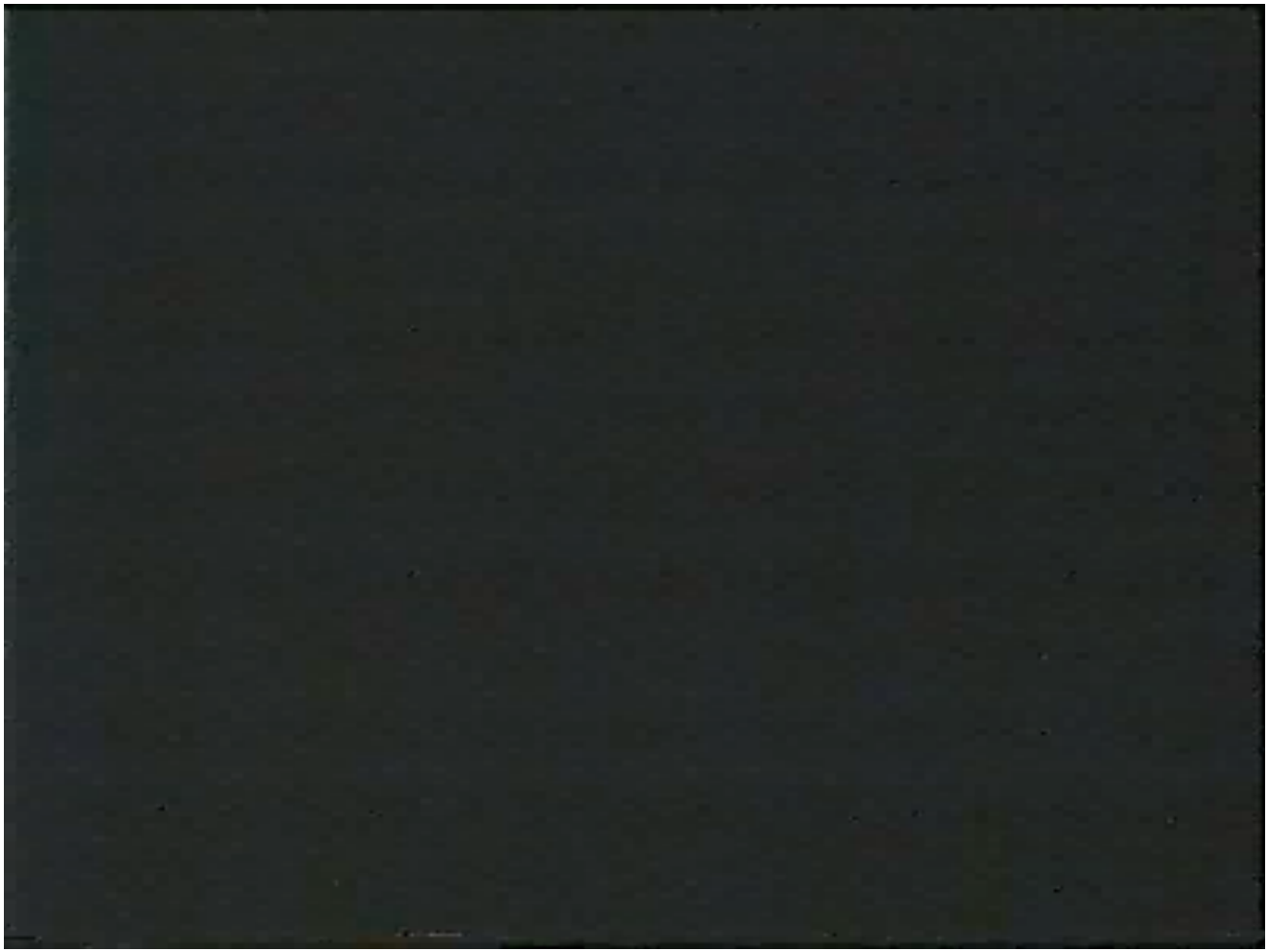
Computerized, automated 3D implementation of Bifocal display

Map work charts onto diagram, x-axis is time, y-axis is project

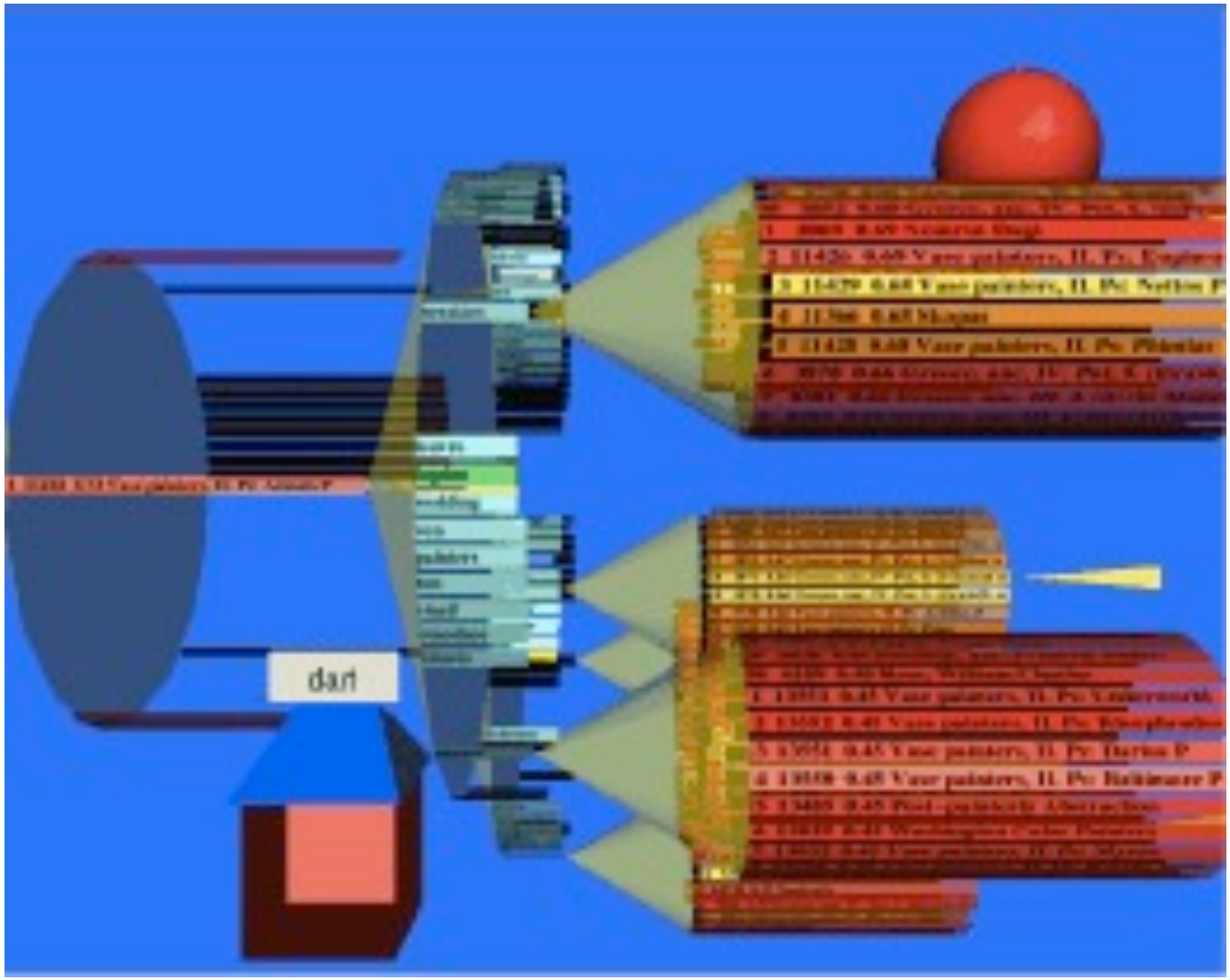


Mackinlay, Robertson, Card '91

Perspective Wall



Another Cone Tree Example



Disadvantages

Distortion can be annoying

Can be very difficult to implement

Any change in focal point potentially requires recalculation of DoI for all objects and hence re-rendering of all objects -> Expensive!

Overview of some methods