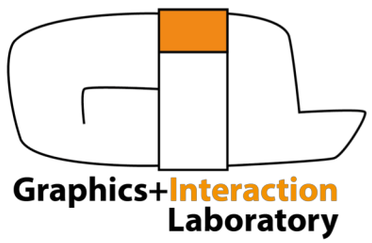
Information Visualization (InfoVis)

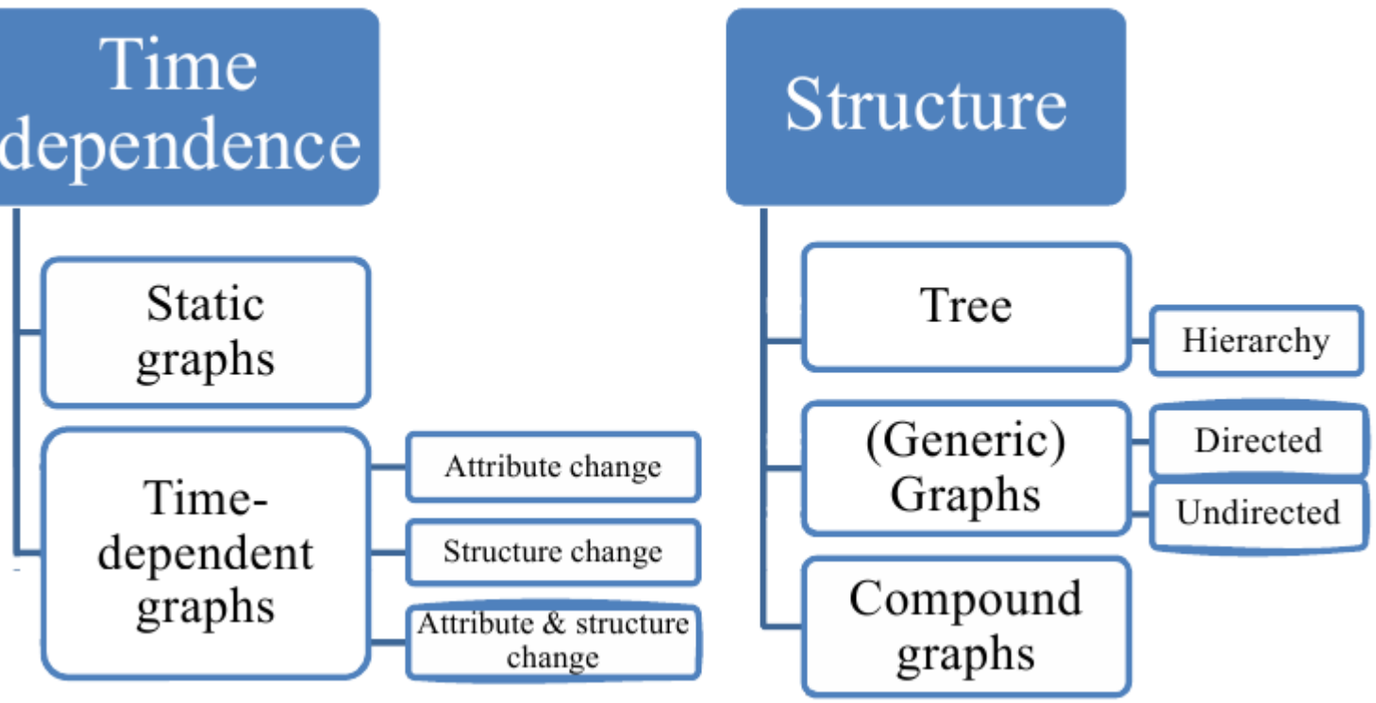
Networks and Graphs



NETWORK (GRAPH)

Prof. Hartmut Seichter, PhD | seichter@fh-sm.de | Schmalkalden University of Applied Sciences

Classification of Graphs



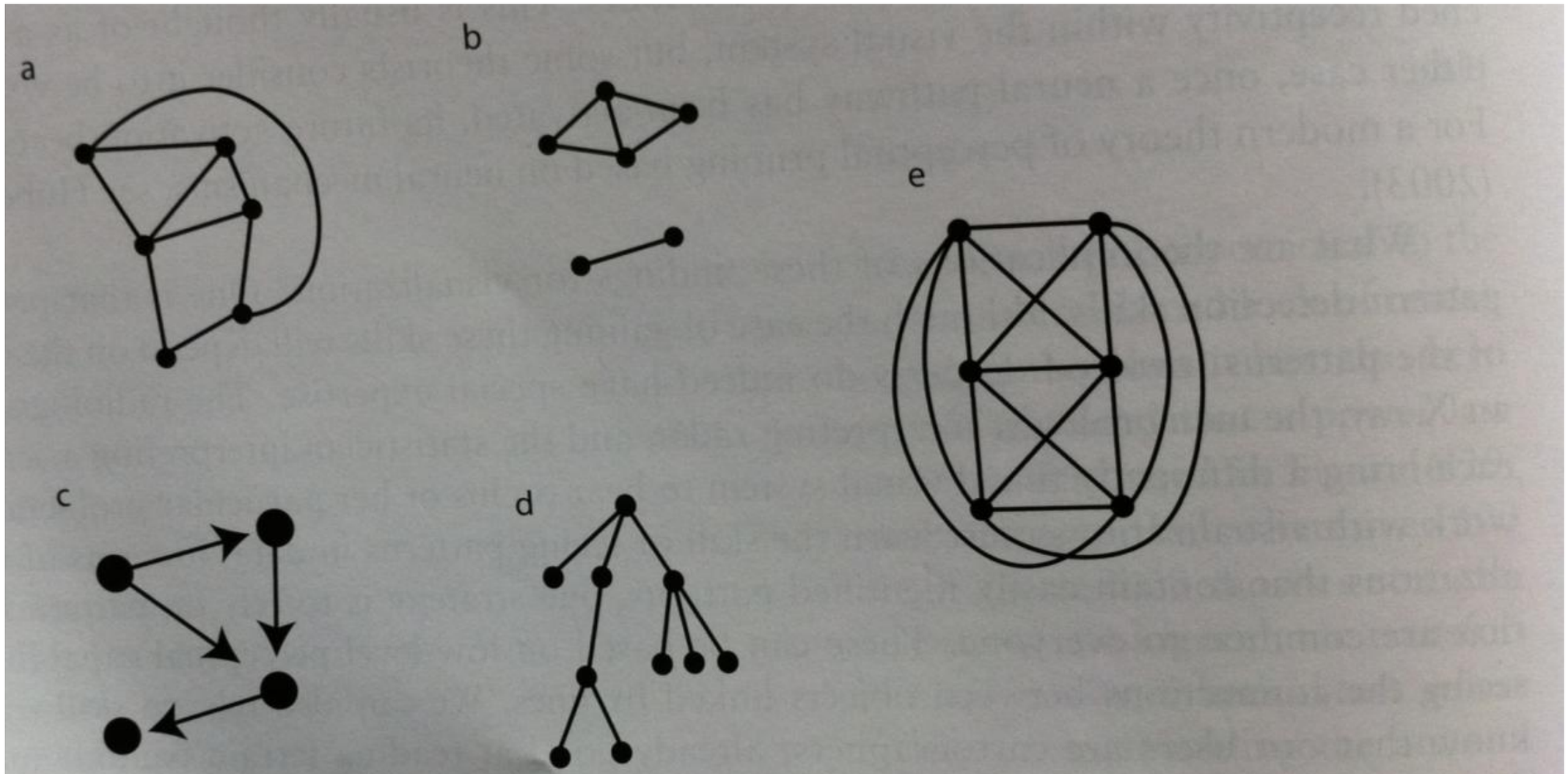
What is a relation?

- Dictionary definition
  - Relation: a logical or natural association between two or more things of one another; connection

- Undirected vs. directed
  - Undirected: Bob and Mary are married
  - Directed: William gives Kate a kiss

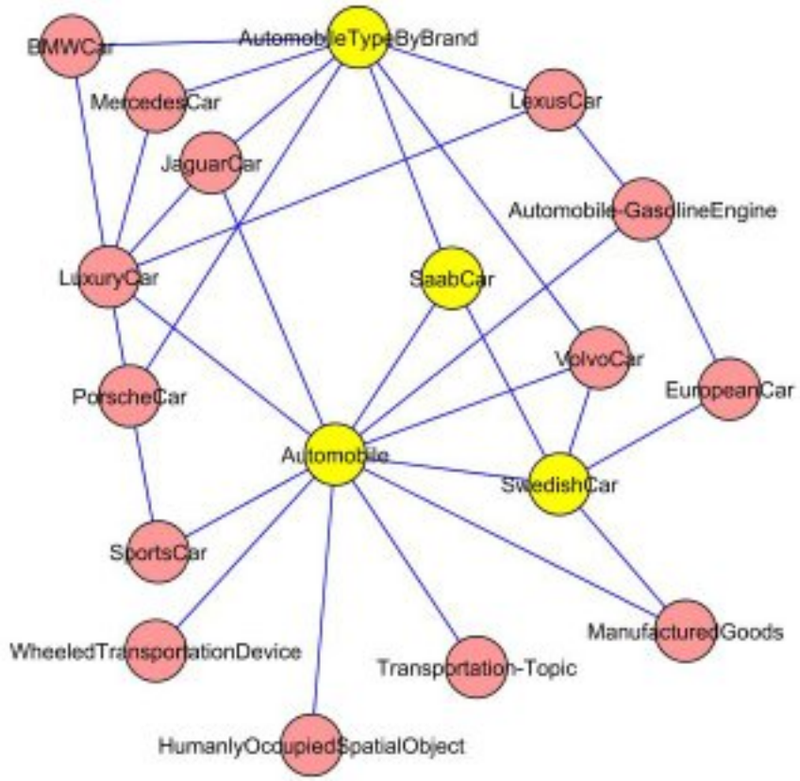
Prof. Hartmut Seichter, PhD | seichter@fh-sm.de | Schmalkalden University of Applied Sciences

Node-Link Diagrams



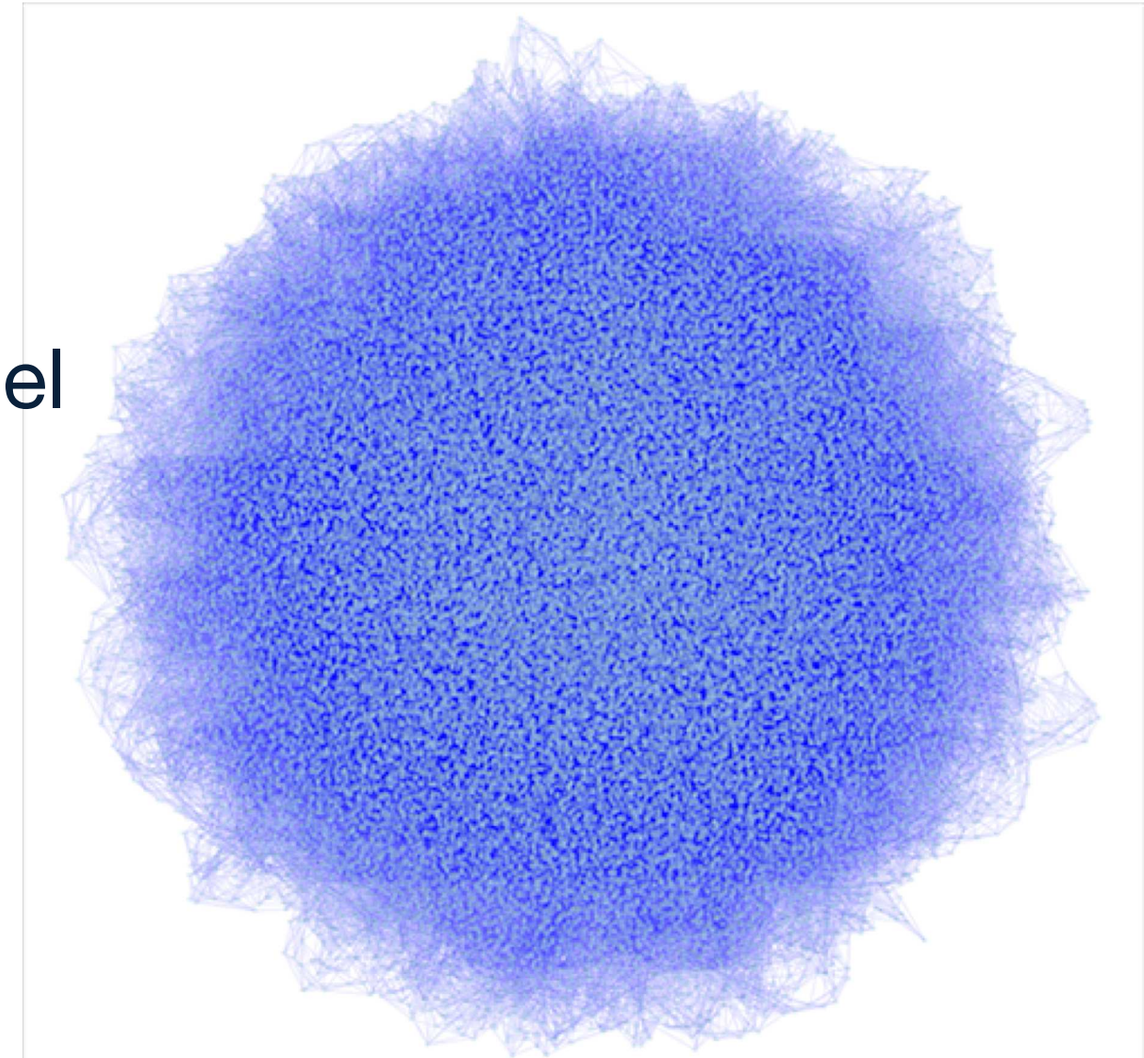
Node–link diagrams, technically called graphs: (a) A graph. (b) A graph with two connected components. (c) A directed graph. (d) A tree structure graph. (e) A nonplanar graph. It cannot be laid out on a plane without links crossing.

Node-Link Diagram Example

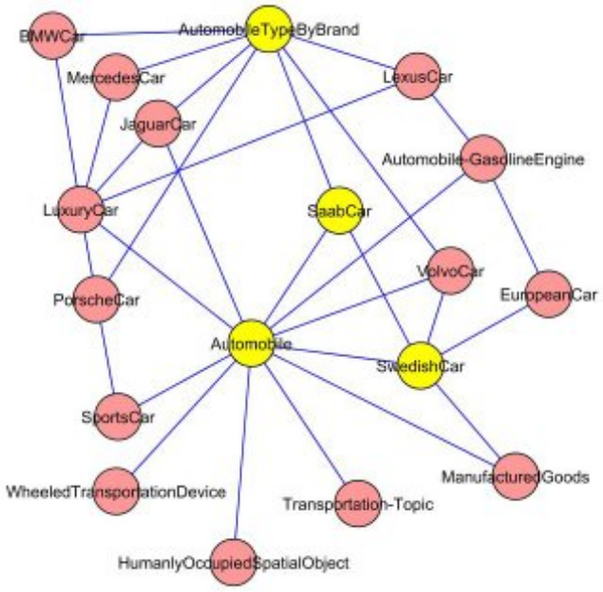


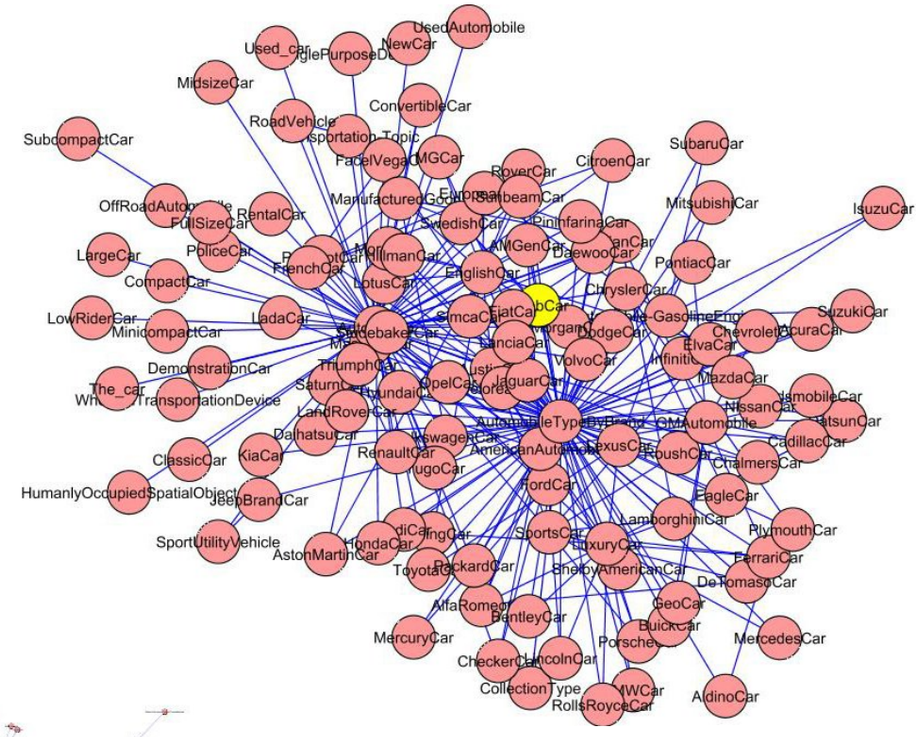
Problem: Giant Hairball

- Example
  - Network generated by igraph's Watts-Strogatz small-world model (**50k nodes** and **250k edges**) visualized by Cytoscape
- Graph problem
- Routing / layout algorithms
  - Minimize crossings
  - Often impossible to find optimal layout



Abstraction



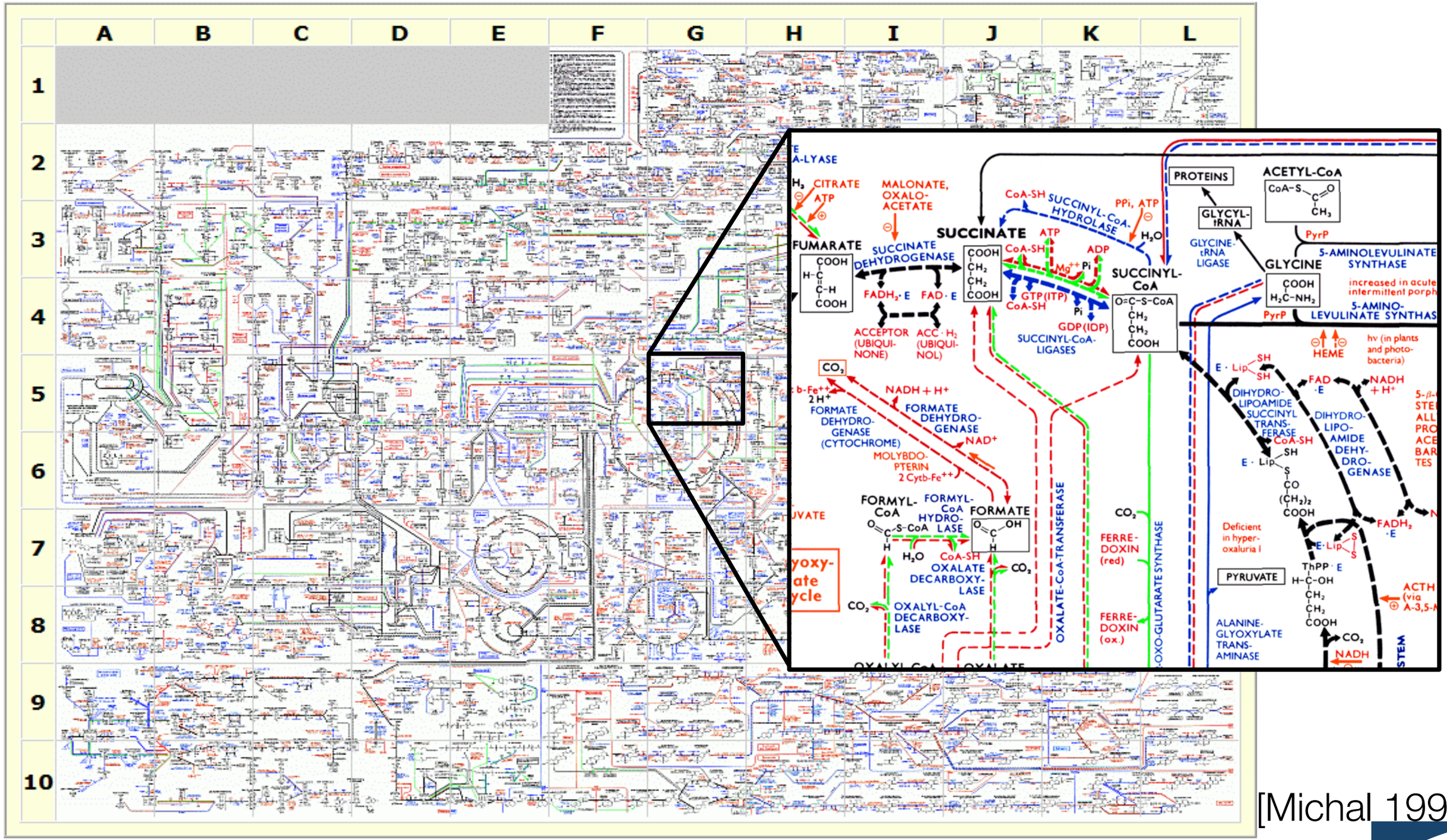


Prof. Hartmut Seichter, PhD | seichter@fh-sm.de | Schmalkalden University of Applied Sciences

3D Network Visualization

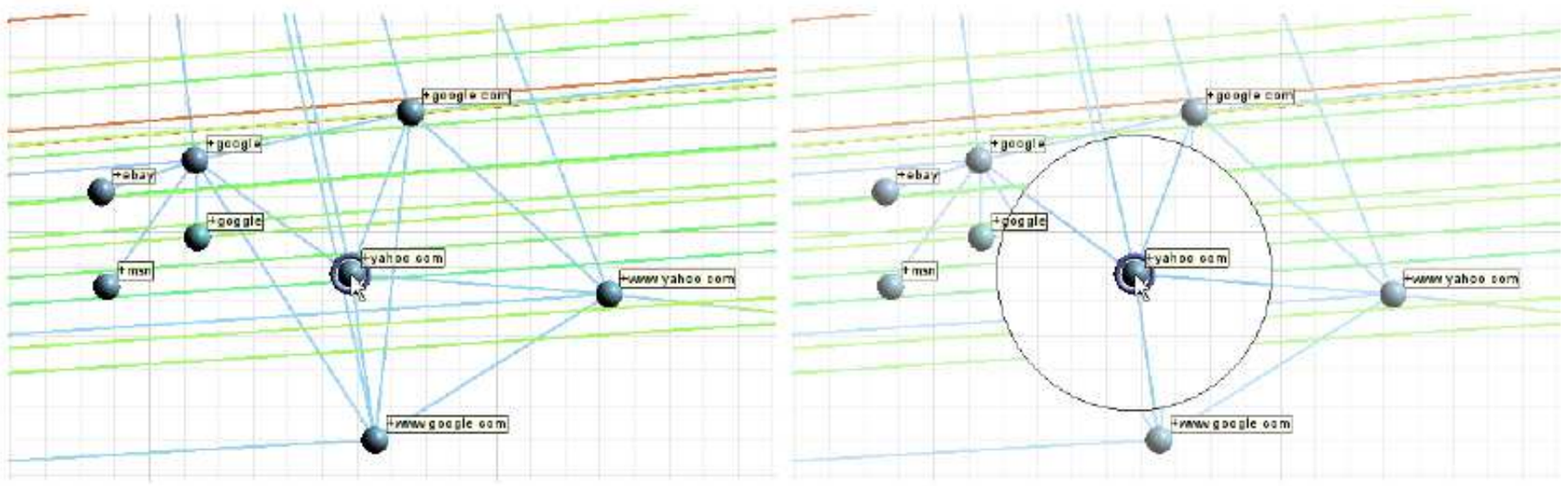
Prof. Hartmut Seichter, PhD | seichter@fh-sm.de | Schmalkalden University of Applied Sciences

Example from Biology: Pathways



[Michal 1999]

Graph Interaction using Lenses



(a) Original view (b) Local edge lens

(c) Bring neighbors lens (d) Composite lens

Trees and Hierarchies

Explicit vs. Implicit Hierarchy Vis

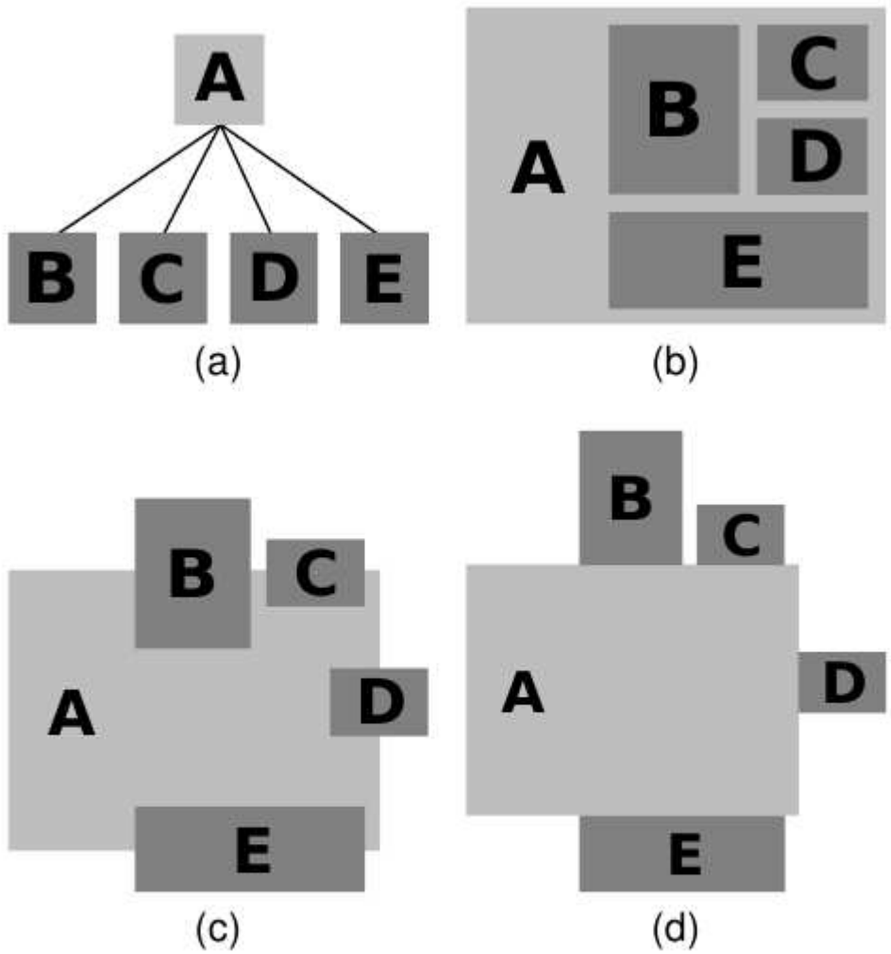
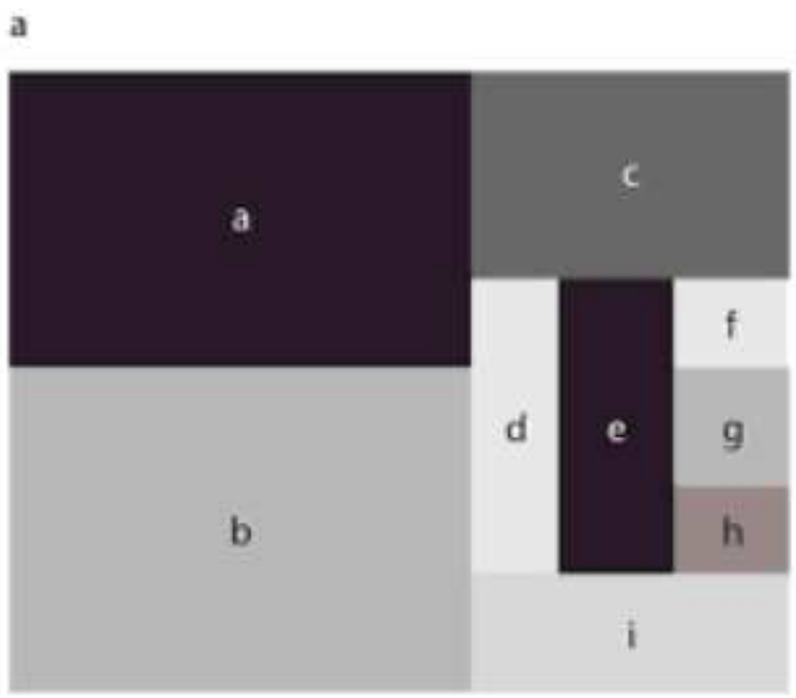
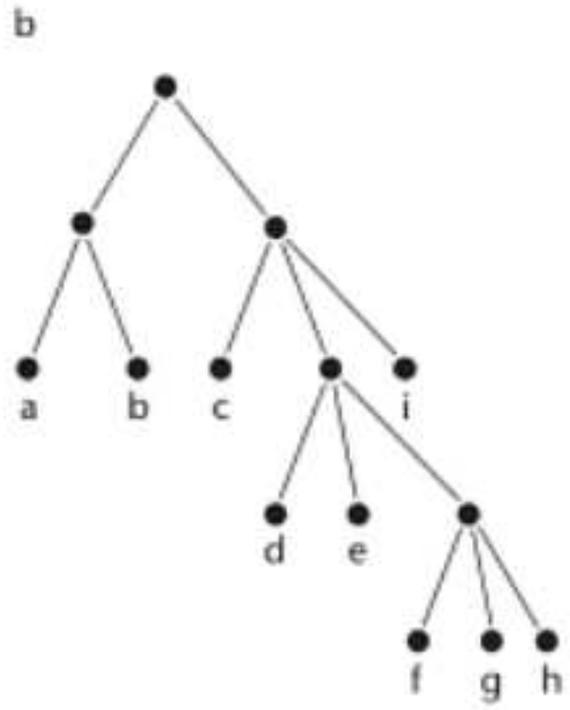


Fig. 2. (a) Explicit, node-link layout, (b) Implicit layout by inclusion, (c) Implicit Layout by overlap, (d) Implicit layout by adjacency.

TreeMap

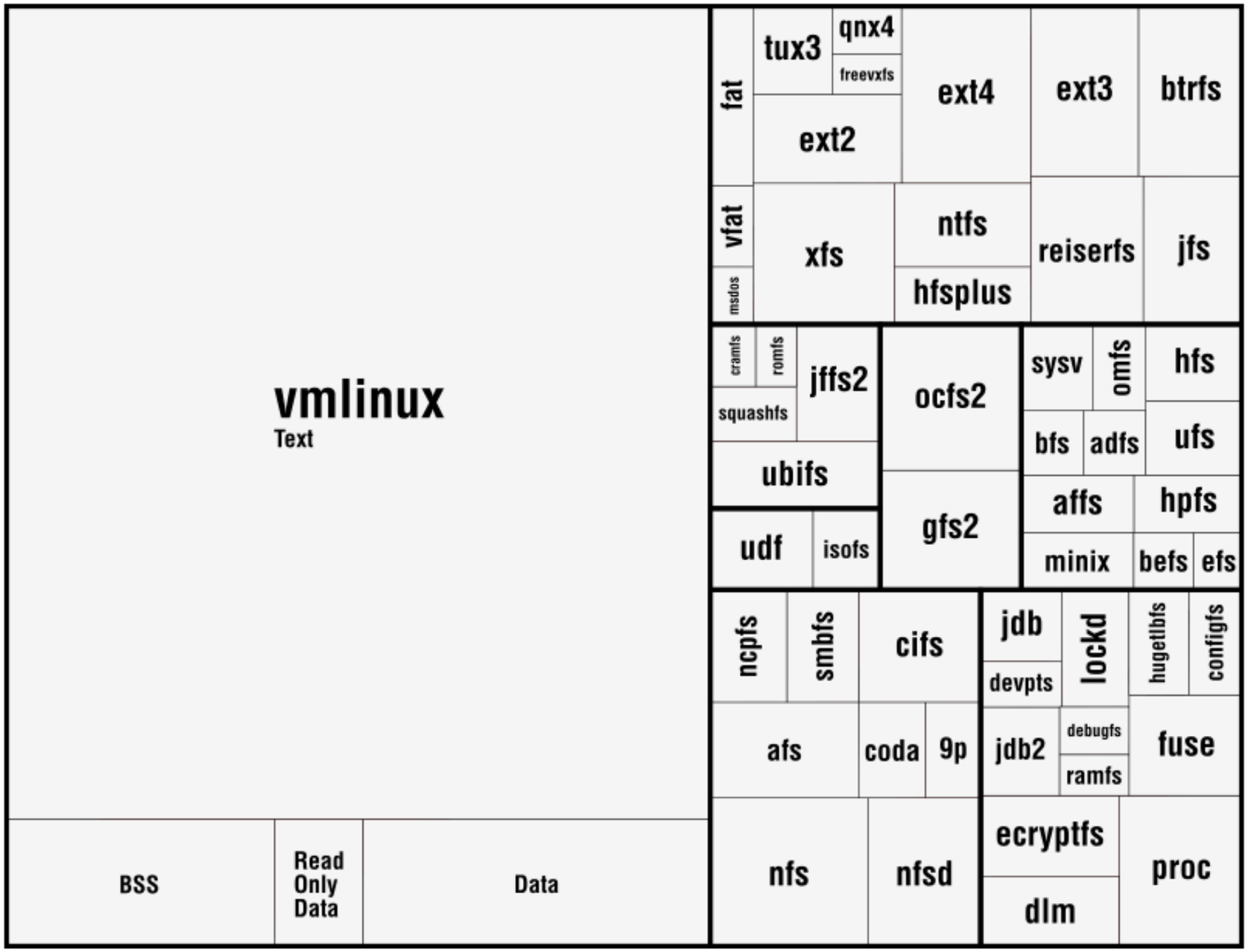
- Tree nodes are embedded
  in the area of their father nodes
- Attributes are mapped to space
- Space filling



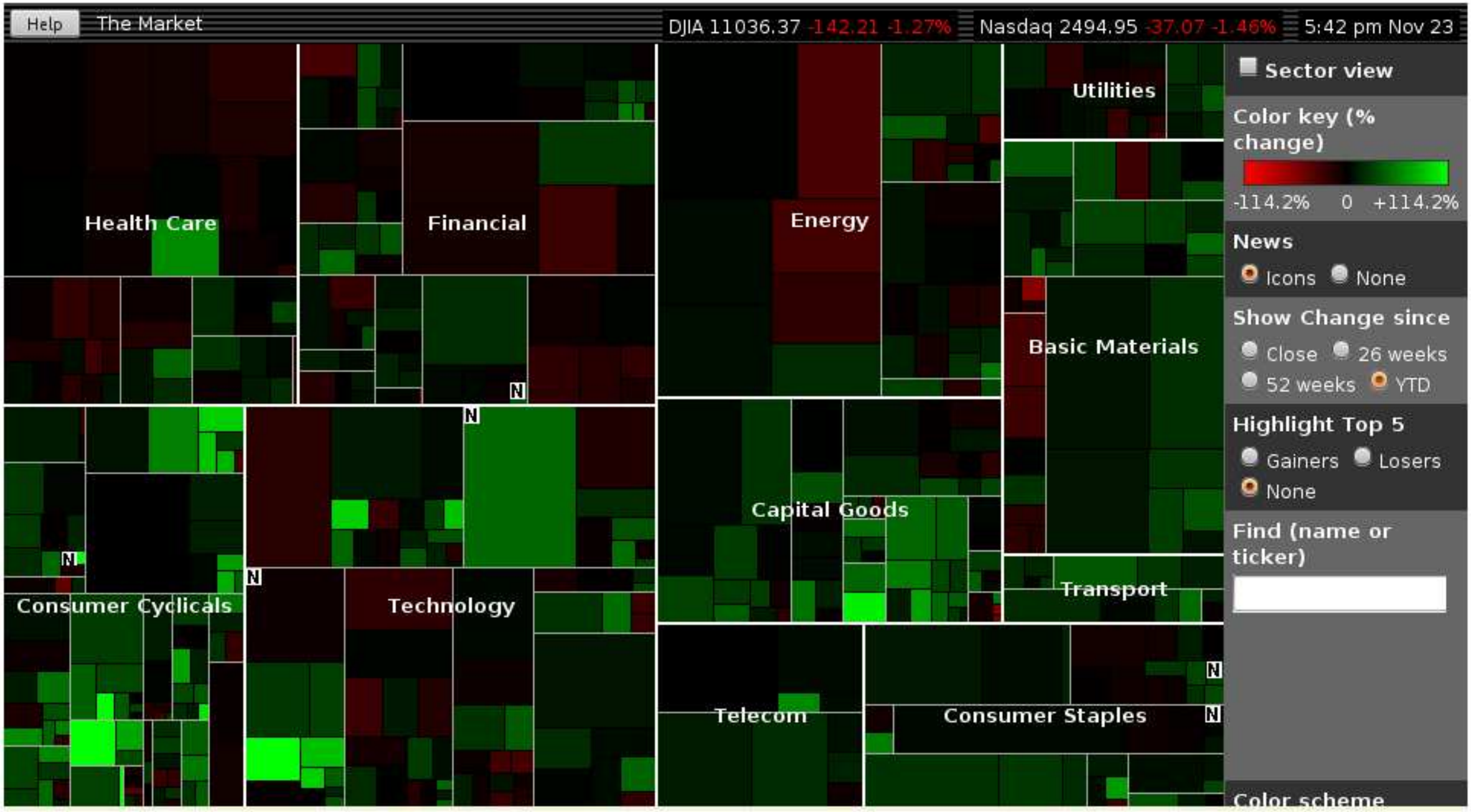


[Ware 2004]

Example: File System Structure

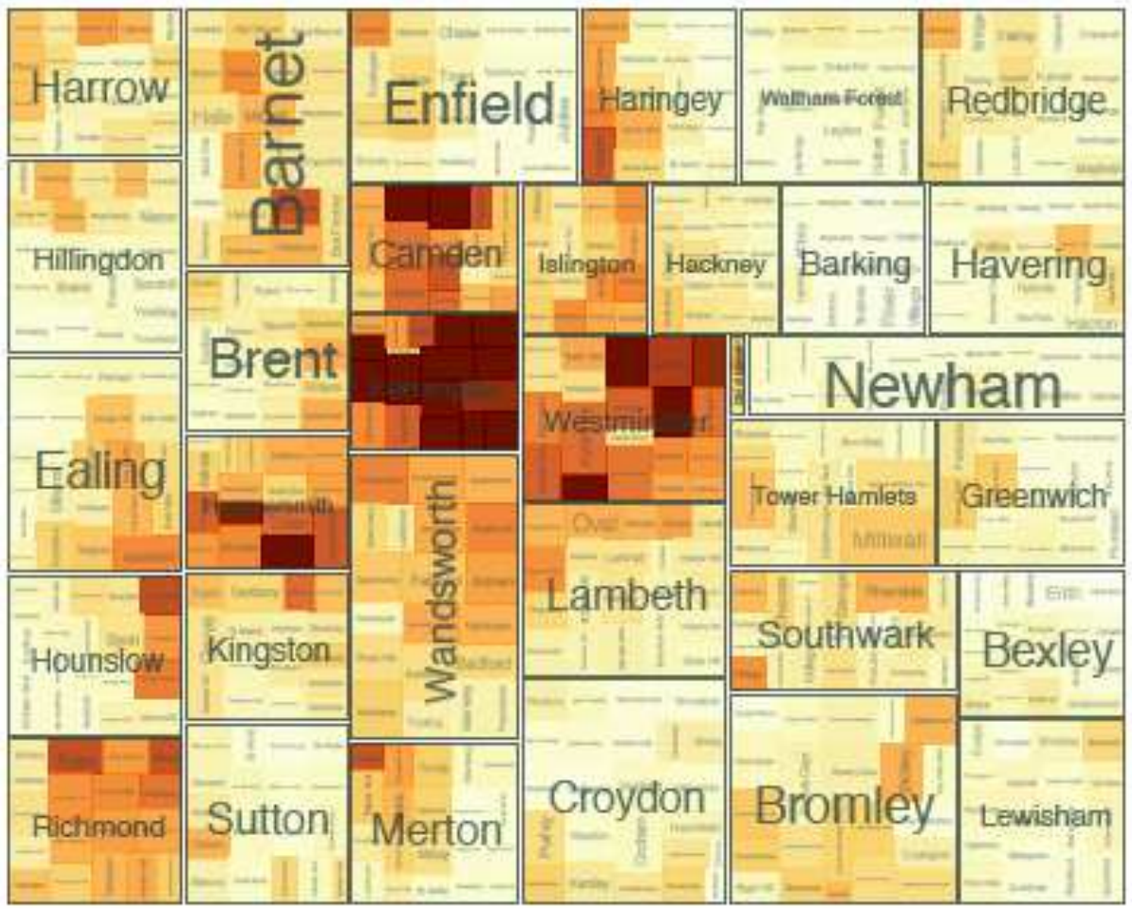


Example: Stock Market TreeMap



Configuring Hierarchical Layouts to Address Research Questions

- Aidan Slingsby, Jason Dykes, Jo Wood
  - City University London



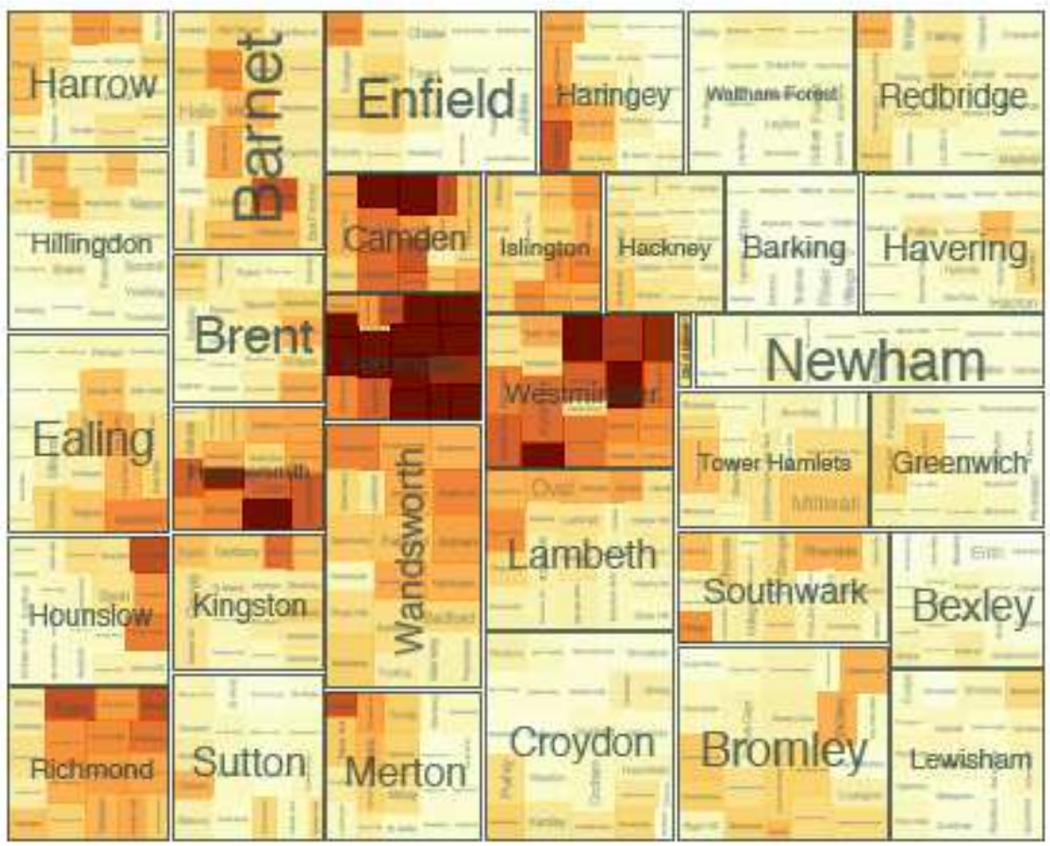
Hierarchical Layouts

- Show multiple aspects of large multi-variate datasets
- Nested graphical summaries of resulting subsets - showing subset properties by
  - size
  - shape
  - color

Prof. Hartmut Seichter, PhD | seichter@fh-sm.de | Schmalkalden University of Applied Sciences

Space-Filling Rectangular Displays

- Ability to tessellate and nest
- Attribute hierarchy (order in which variables are dimensionally stacked) has strong effect on perception of patterns and trends



HiVE

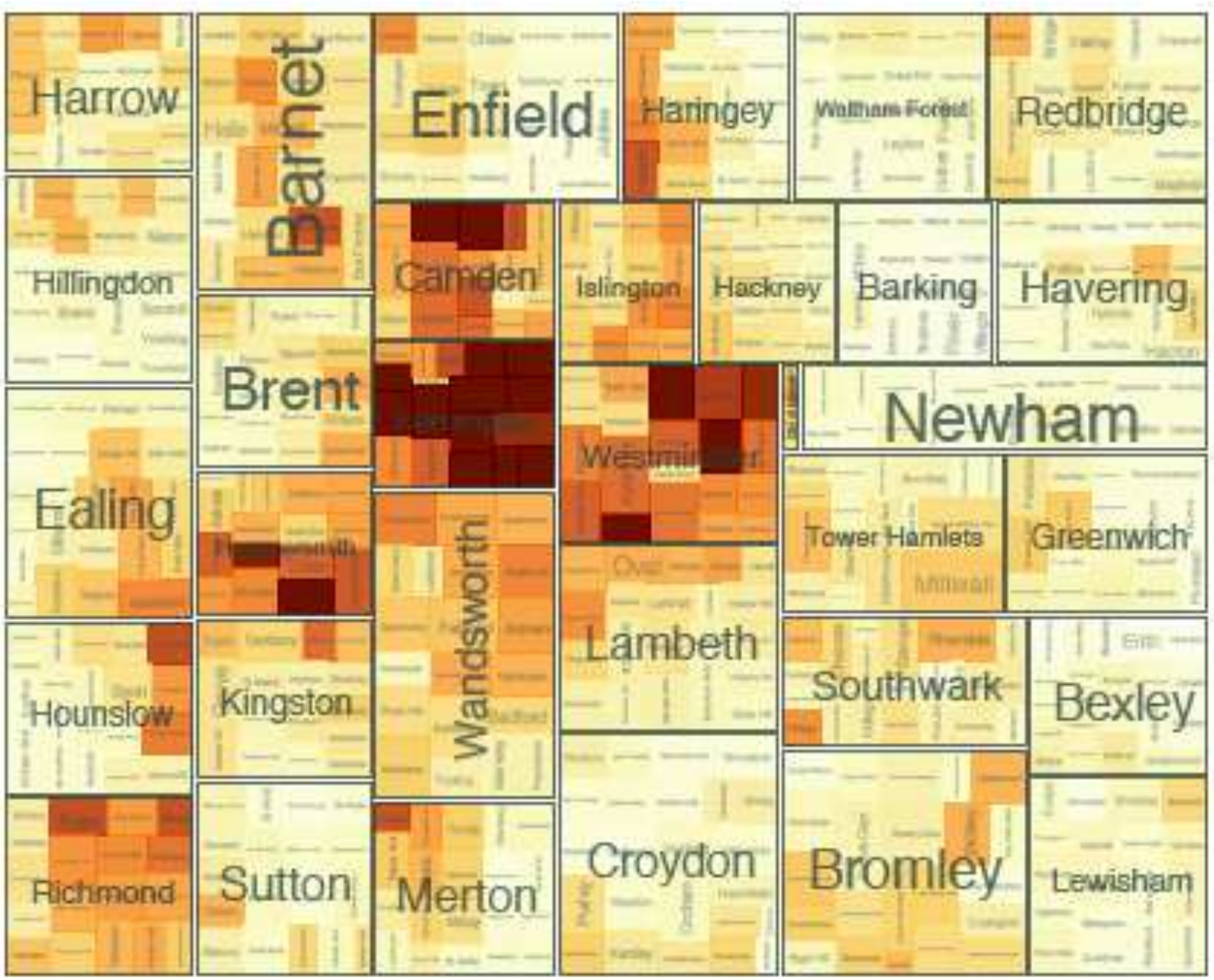
- Notation for describing hierarchical visualization
  - states
  - operators for reconfiguring states
- Control of
  - structure (attribute hierarchy)
  - appearance
    - layout (e.g. “squarified”, “spatially-ordered” ...)
    - size
    - color

Prof. Hartmut Seichter, PhD | seichter@fh-sm.de | Schmalkalden University of Applied Sciences

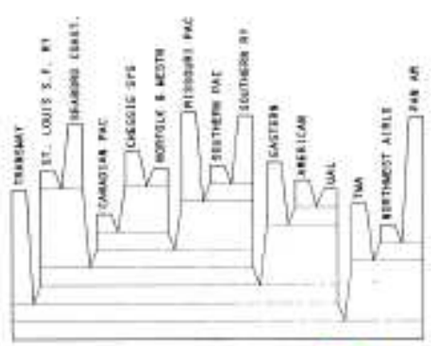
Example


Wandsworth
Croydon
Lambeth
Southwark
Richmond
Haringey
Bromley
Barnet
Ealing
Hillingdon
Sutton
Kingston
Lewisham
Tower Hamlets
Greenwich
Harrow
Redbridge
Enfield
Waltham Forest
Hounslow
Brent
Camden
Hackney
Bexley
Westminster
Newham
Havering
Merton
Barking
Islington

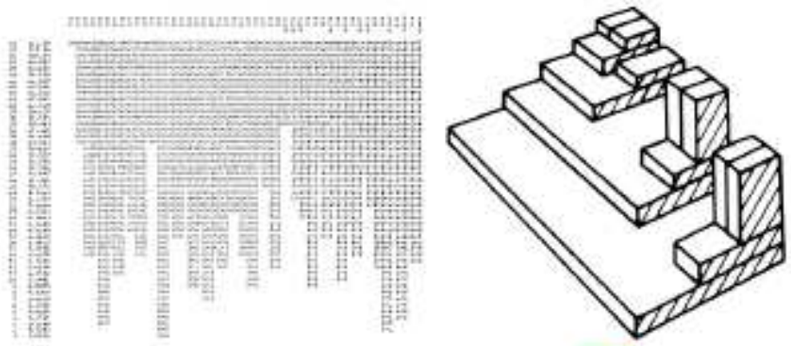
Video!


Harrow
Barnet
Enfield
Haringey
Waltham Forest
Redbridge
Hillingdon
Camden
Islington
Hackney
Barking
Havering
Brent
Newham
Ealing
Tower Hamlets
Greenwich
Wandsworth
Lambeth
Southwark
Bexley
Hounslow
Kingston
Richmond
Sutton
Merton
Croydon
Bromley
Lewisham

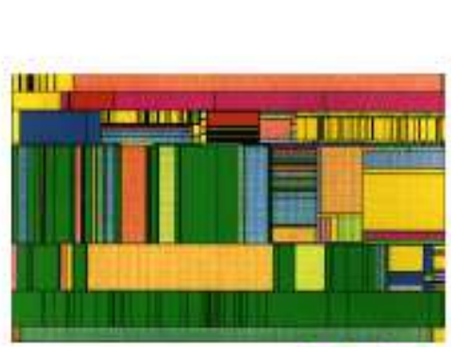
Implicit Hierarchy Visualization Techniques Overview 1981-1997



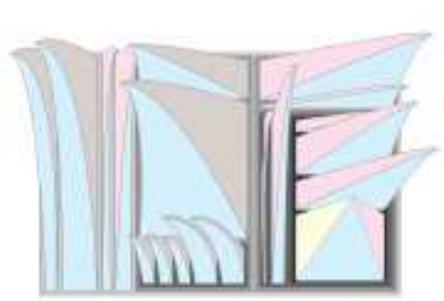
(a) Castles 1981 [17]



(b) 2D+3D Icicle Plots 1983 [12]

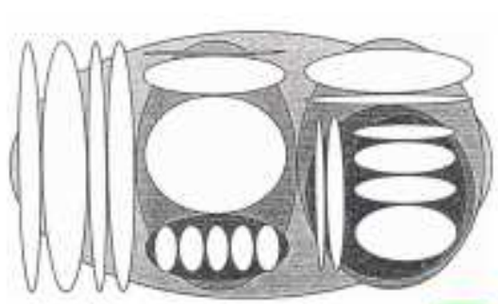


(c) Treemap 1991 [10], [11]

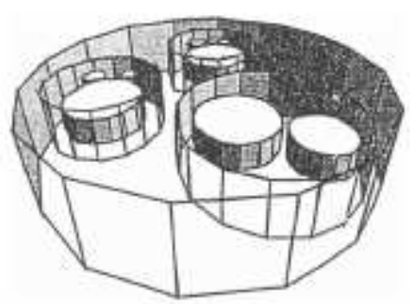


(d) 2 1/2-D Treemap 1992 [65]

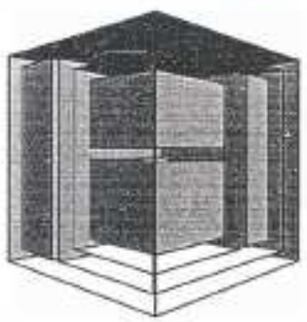
(e) Polar Treemap 1993 [15]



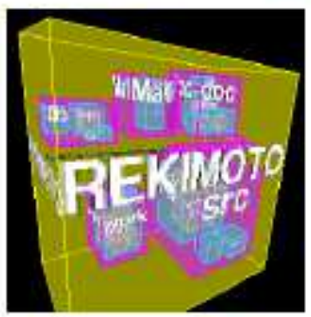
(f) Treemap with Ovals 1993 [15]



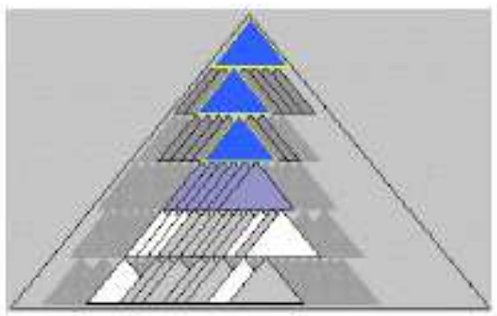
(g) Nested Columns 1993 [15]



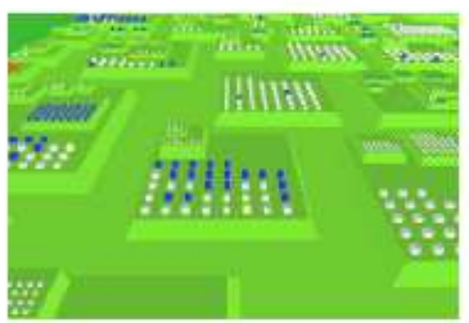
(h) 3D Treemap 1993 [15]



(i) Information Cube 1993 [29]



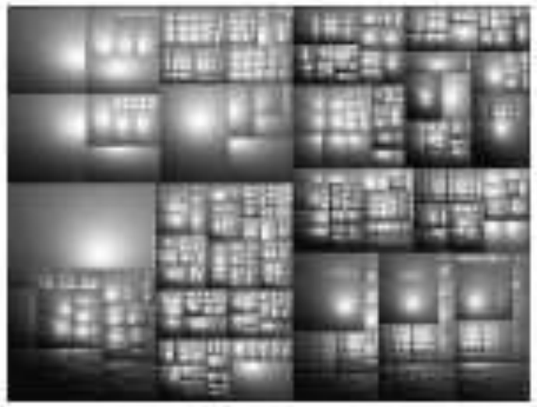
(j) Cheops™ 1996 [50]



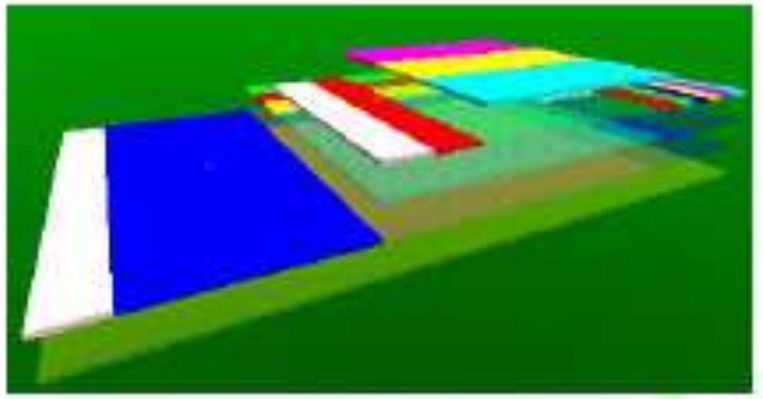
(k) Information Pyramids™ 1997 [28]

Implicit Hierarchy Visualization Techniques Overview 1998-2002

(l) Triangular Aggregated Treemap 1998 [49]

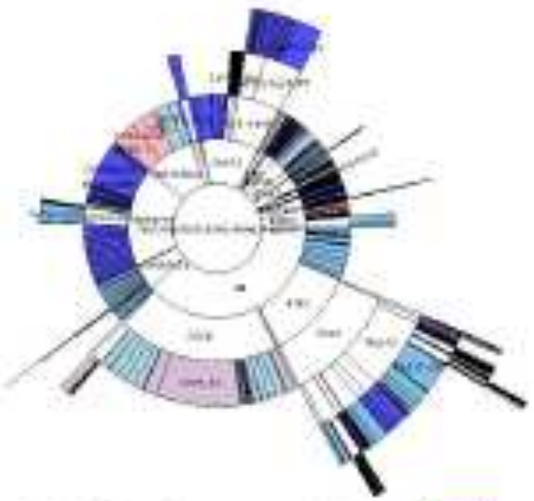


(m) Cushion Treemap 1999 [51]



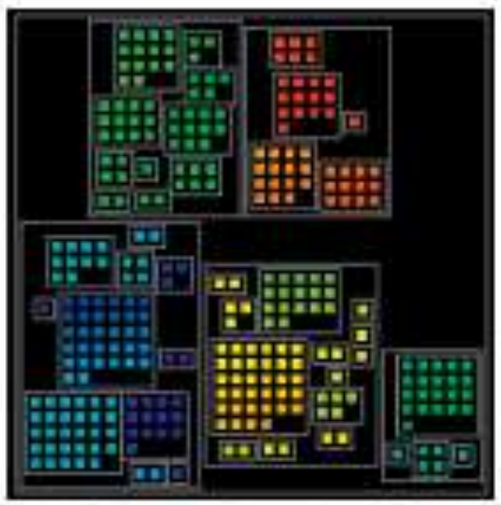
(n) 3D Nested Treemap 1999 [26]

(o) PieTree 2000 [38]

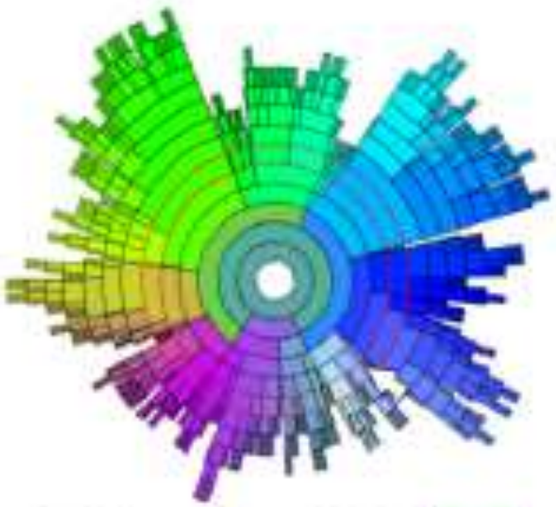


(p) Sunburst 2000 [40]

(q) Quantum Treemap 2001 [66]

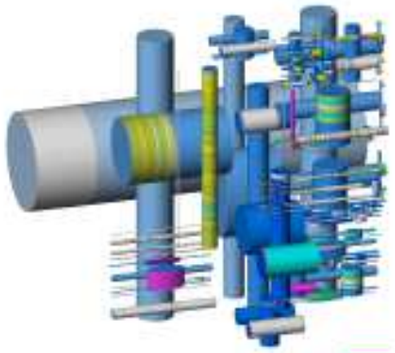


(r) Data Jewelry Box 2002 [58]

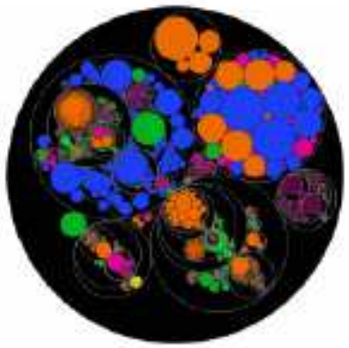


(s) InterRing 2002 [42]

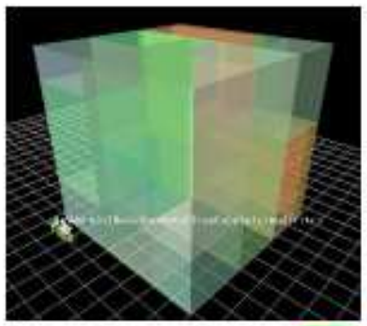
Implicit Hierarchy Visualization Techniques Overview 2002-2006



(a) 3D Beamtree 2002 [23]

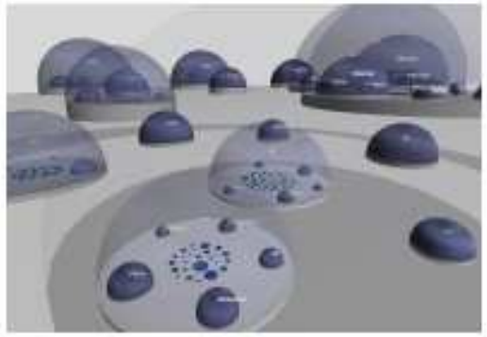


(b) Pebble Map 2003 [36]



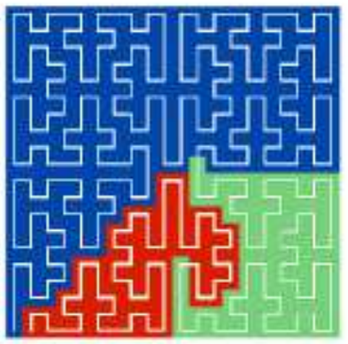
(c) Tree Cube 2003 [30]

(d) StepTree 2004 [20]

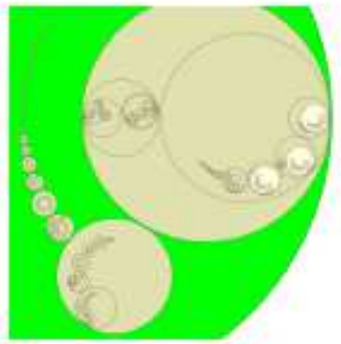


(e) Nested Hemispheres 2004 [27]

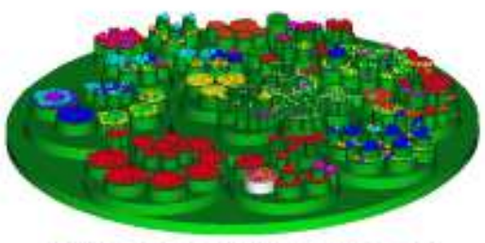
(f) Voronoi Treemap 2005 [44]



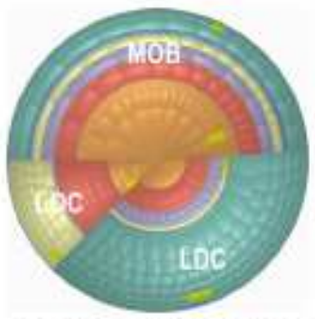
(g) Jigsaw Map 2005 [59]

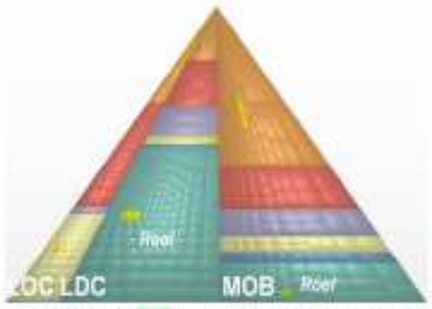


(h) CropCircles 2006 [37]



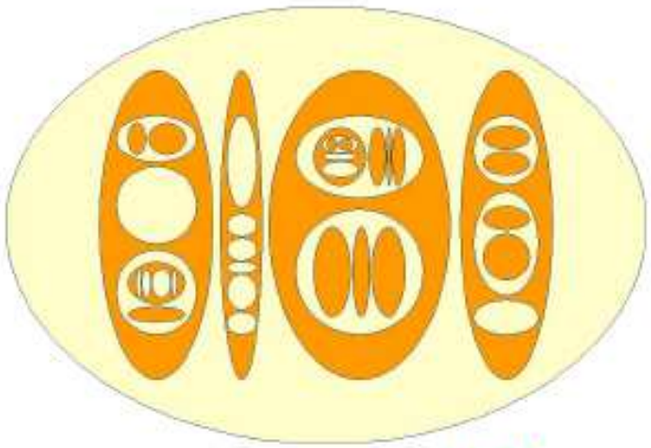
(i) 3D Nested Cylinders and Spheres 2006 [21]



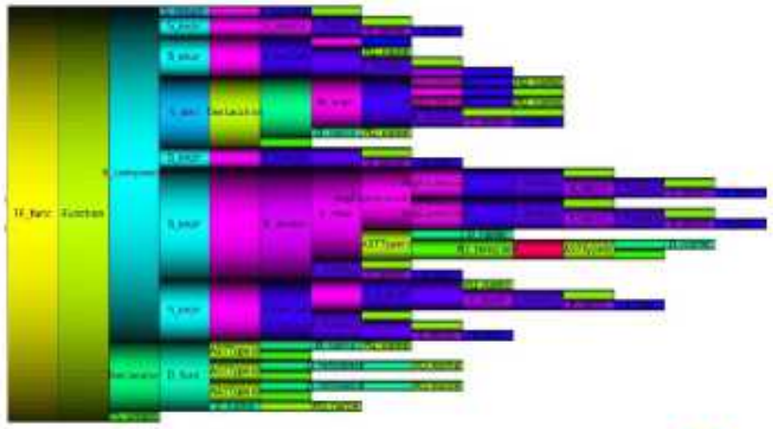


(j) Generalized Treemaps 2006 [8] – pie, pyramid, and combination of both

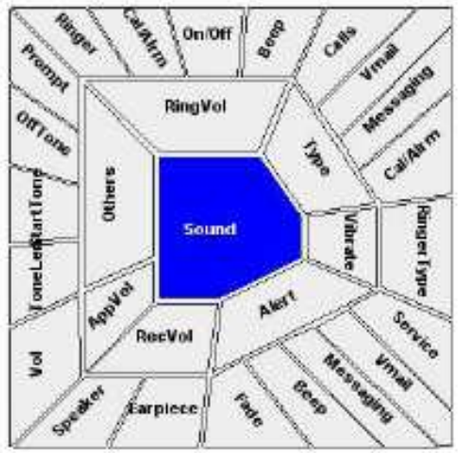
Implicit Hierarchy Visualization Techniques Overview 2006-2009



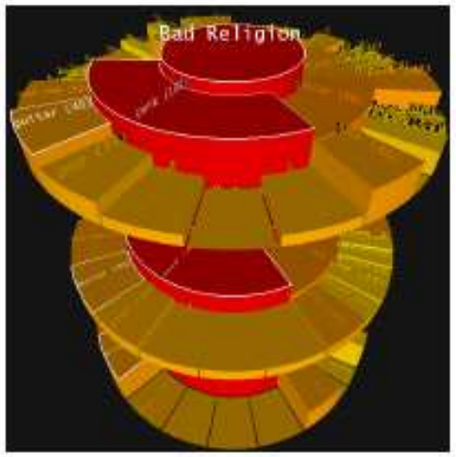
(k) Ellimap 2007 [48]



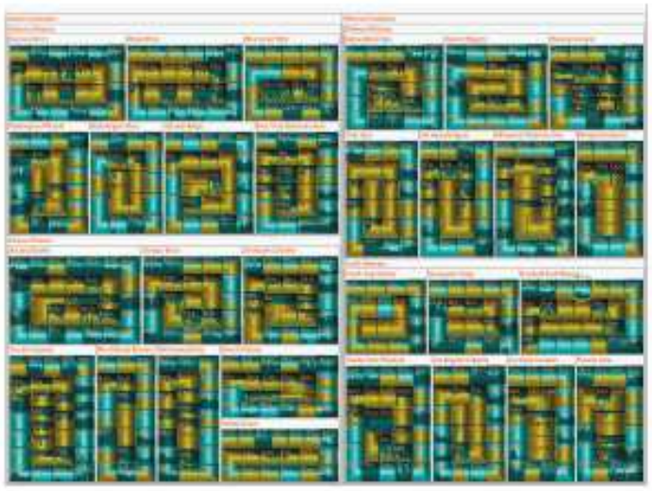
(l) Cushioned Icicle Plot 2007 [52]



(m) Radial Edgeless Tree 2007 [46], [47]

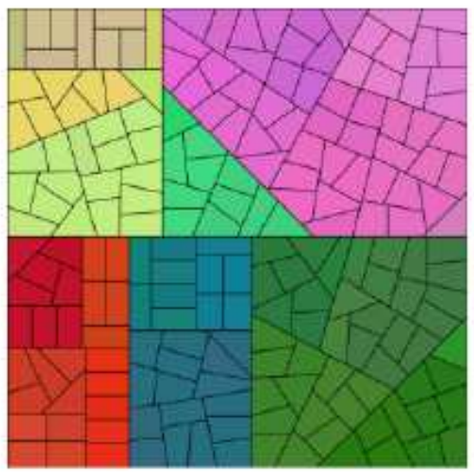


(n) 3D Sunburst 2007 [70]

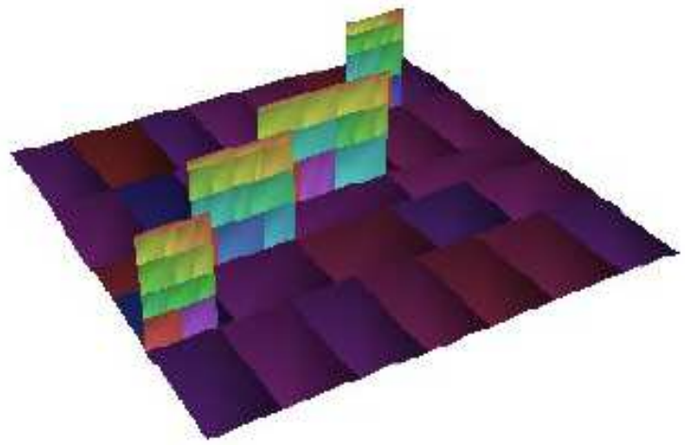


(o) Contrast Spiral Treemap 2007 [53]

(p) Cascaded Treemap 2008 [19]



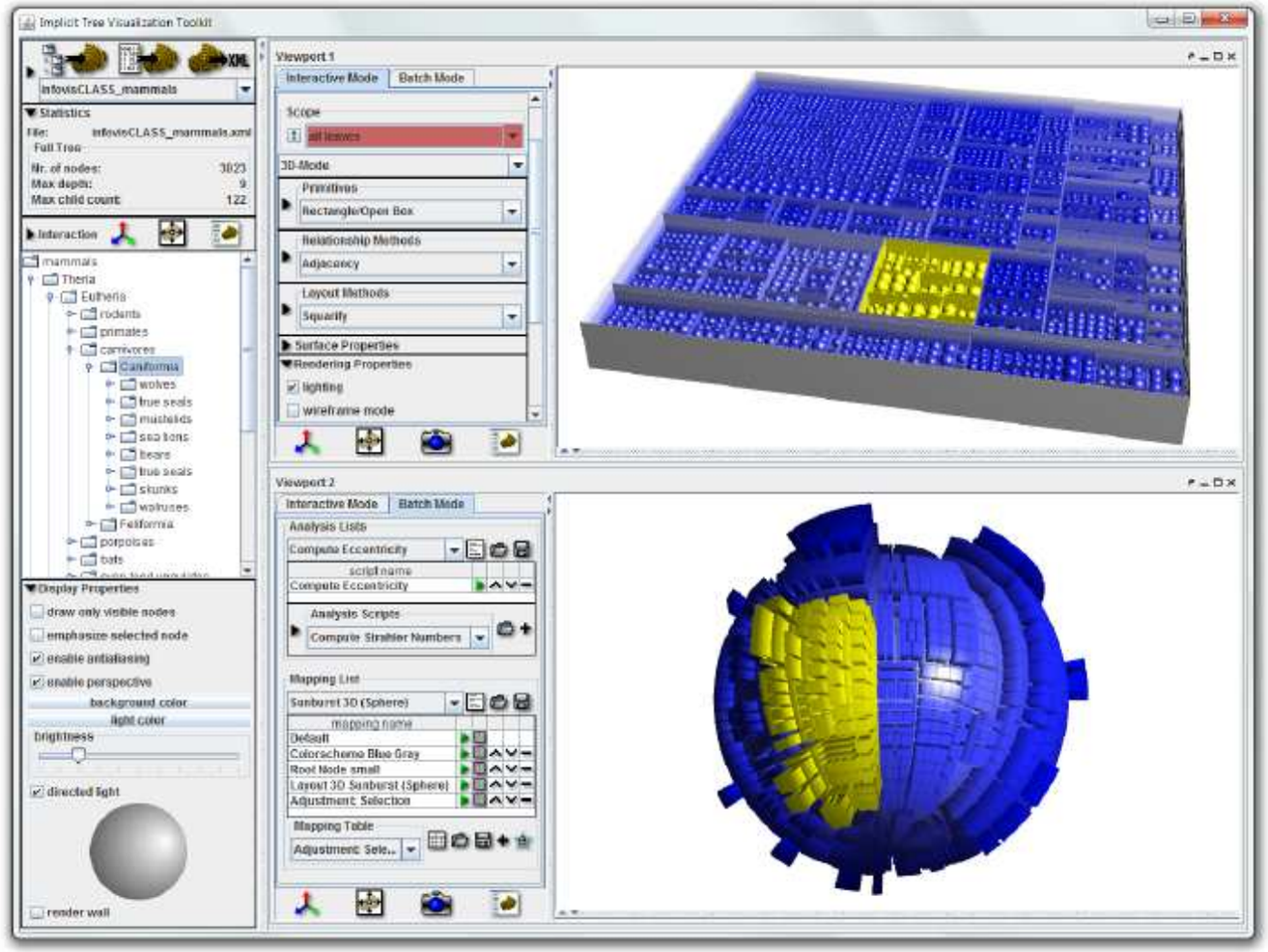
(q) Circular Partitions 2008 [45]



(r) Lifted Treemap 2009 [68]

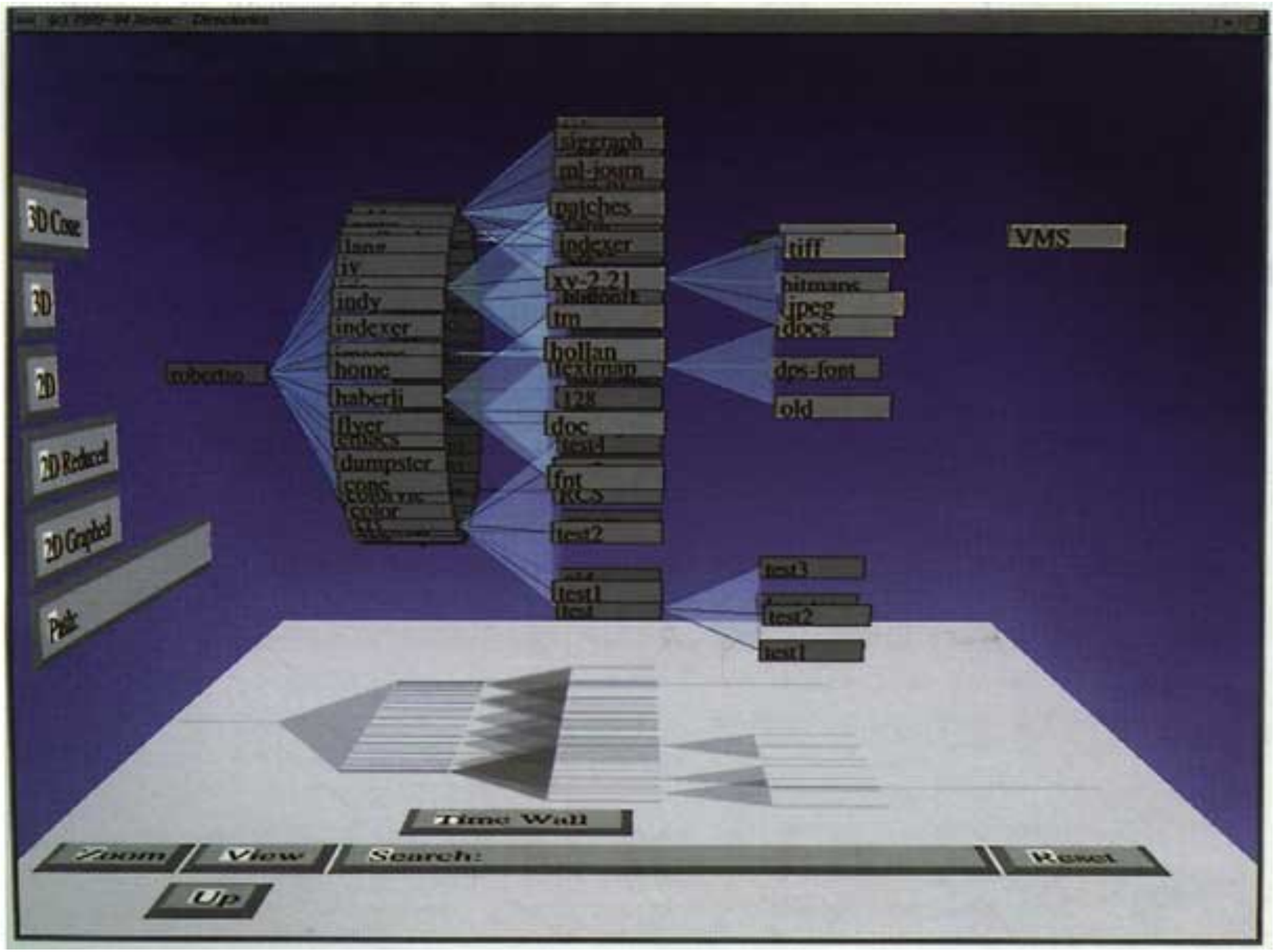
Implicit Tree Visualization Toolkit

- Rapid Visualization Development
- Create published and even unpublished techniques
- Design Space
  - Dimensionality
  - Node Representation
  - Edge Representation
  - Layout



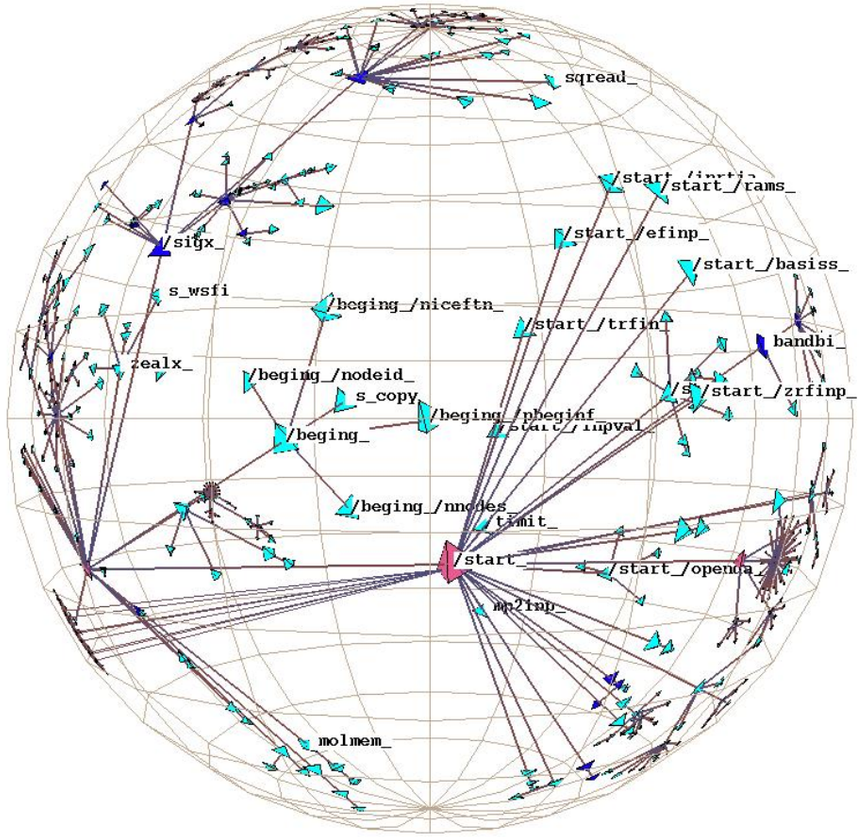
Prof. Hartmut Seichter, PhD | seichter@fh-sm.de | Schmalkalden University of Applied Sciences

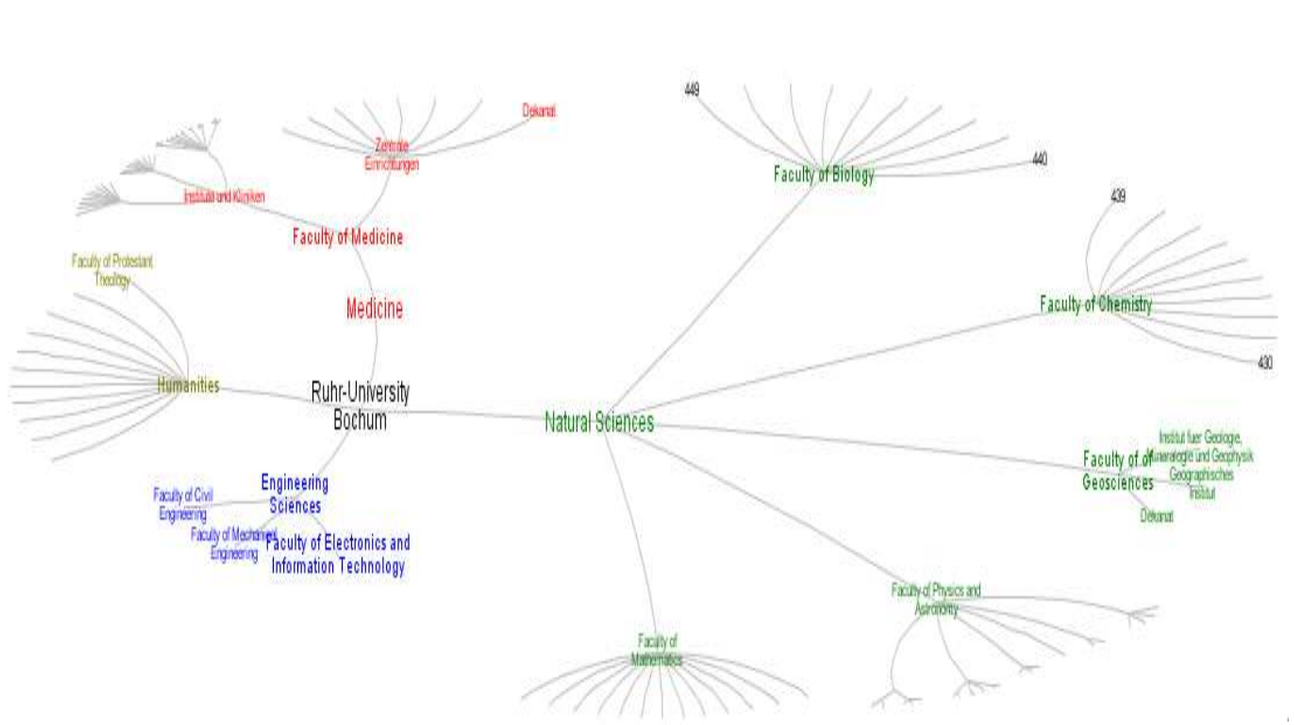
Cone Tree


3D Cone
3D
2D
2D Reduced
2D Graphed
Pick
roberto
iv
indy
indexer
home
haberli
flyer
dumpster
color
ml-josm
matches
indexer
xv-2.21
tm
holjan
doc
fnt
test2
test1
tiff
jpeg
docs
dos-font
old
VMS
test3
test2
test1
Time Wall
Zoom
View
Search:
Reset
Up

Hyperbolic Tree

- Circular display region
- Projection on a sphere
- Root initially in the center



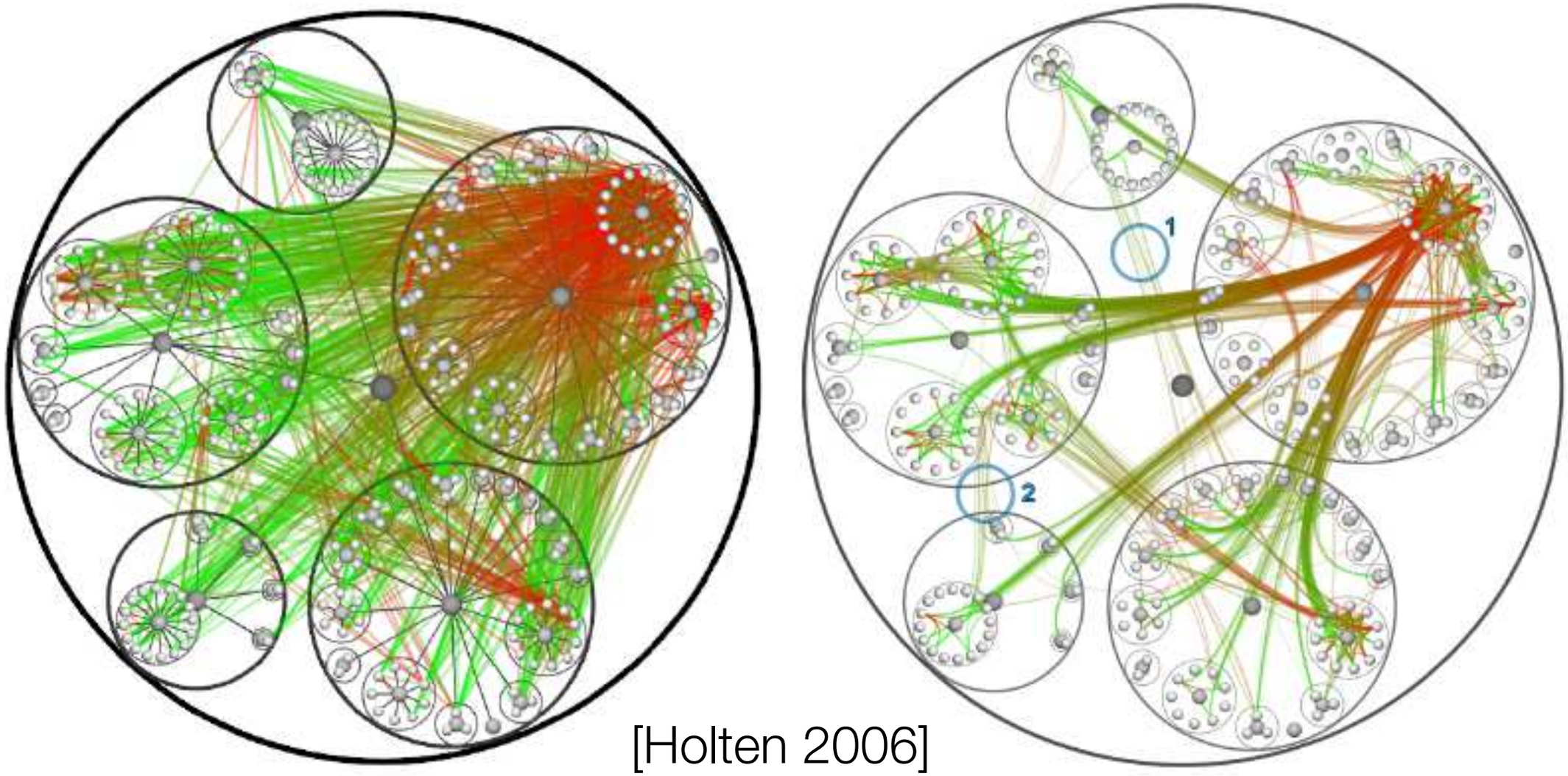


Hybrid Visualization Techniques

Hybrid

- Data sets with mixed characteristics
- Example
  - Primary: multi-dimensional data
  - Secondary: tree structure calculated with clustering algorithm

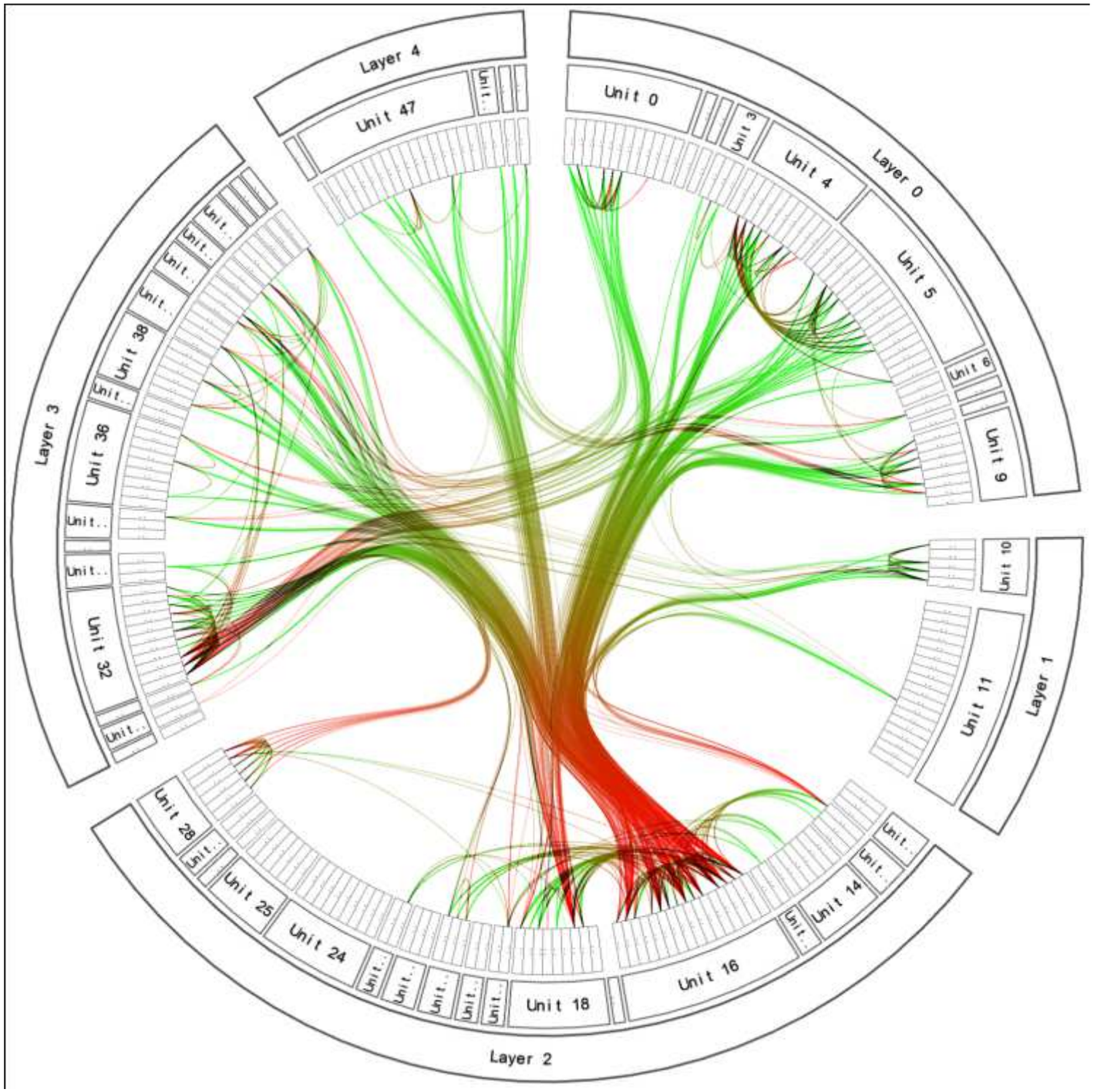
Hierarchical Edge Bundling



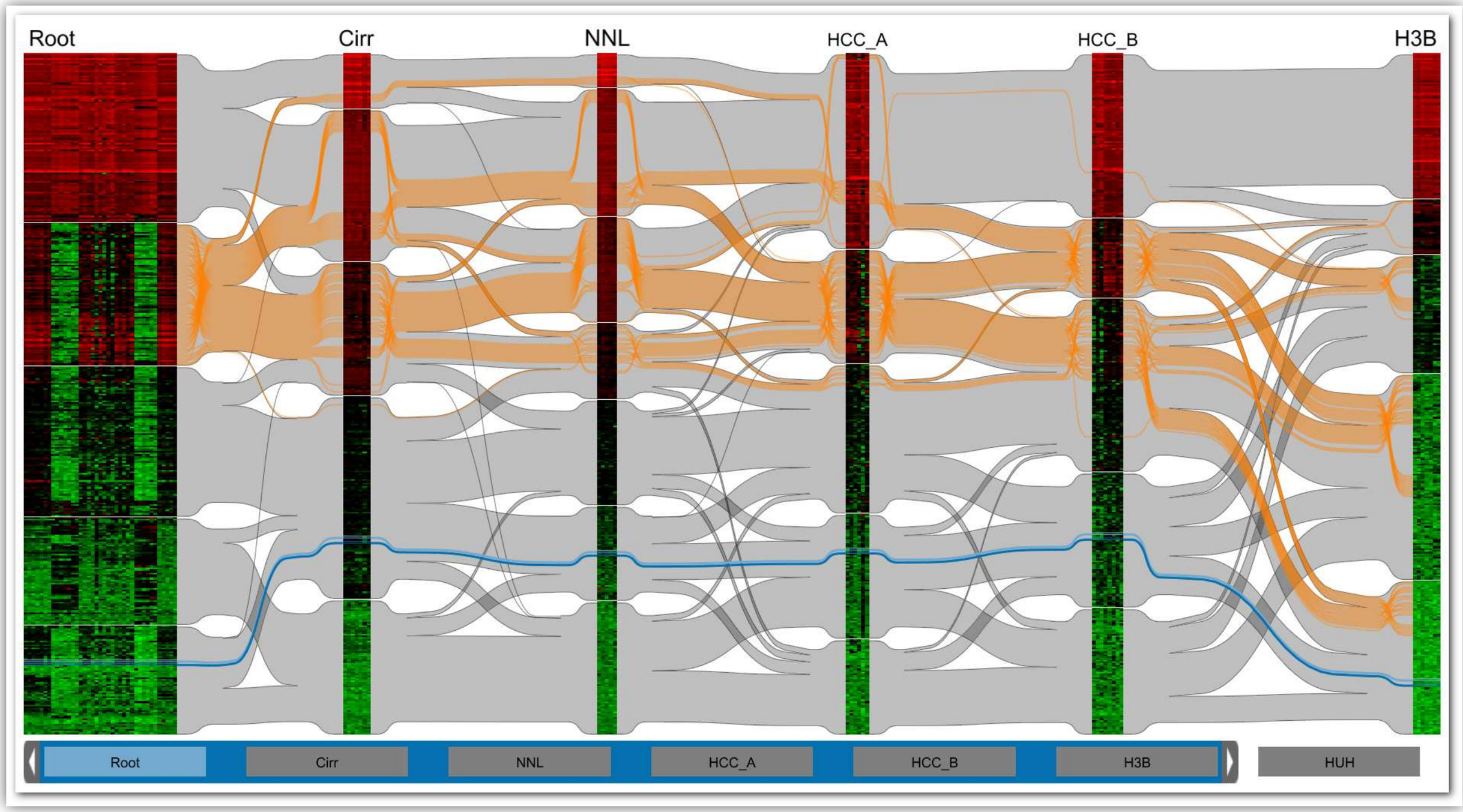
[Holten 2006]

(a) Original graph (b) Edge bundling

Hierarchical Edge Bundling (2)

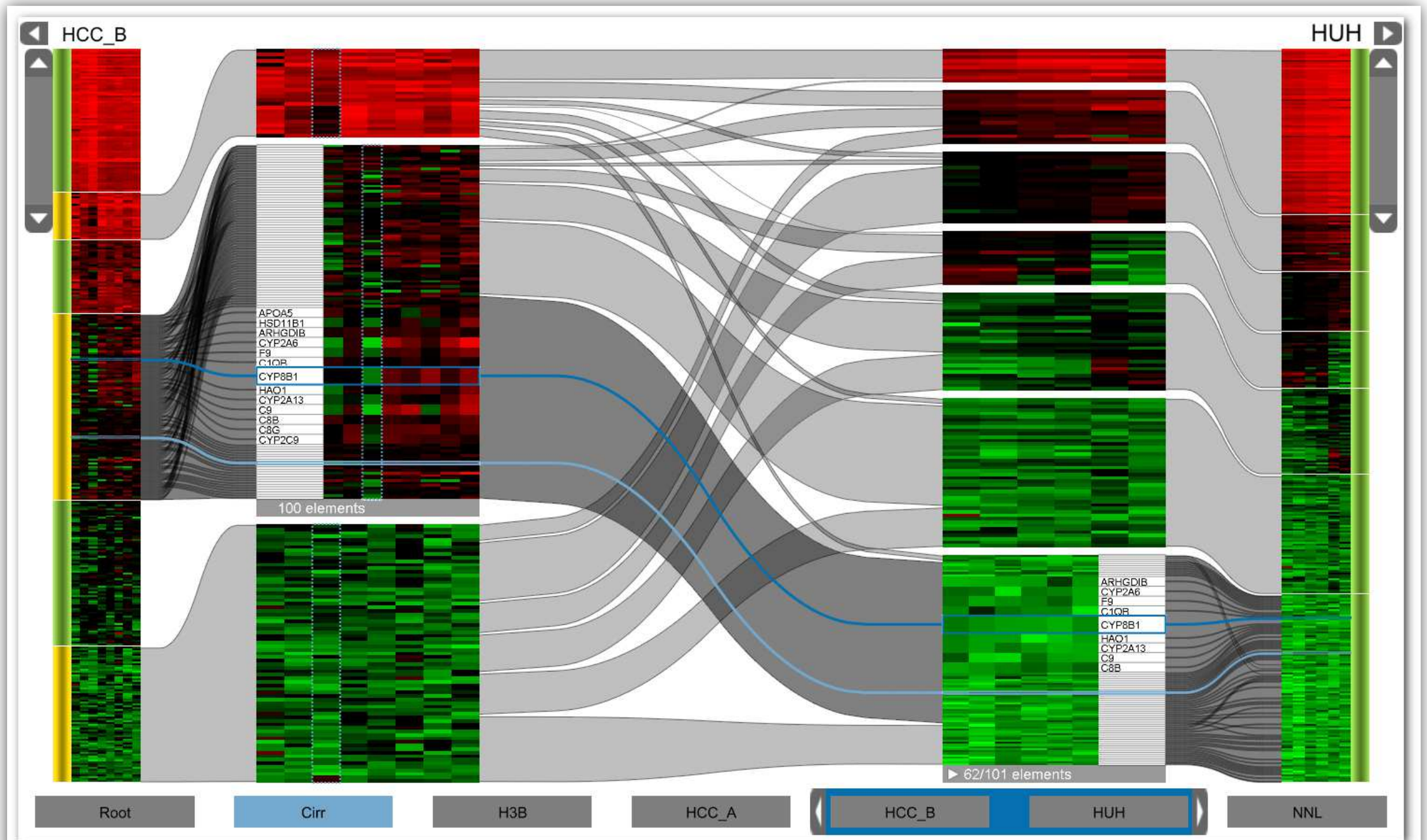


Caleydo Matchmaker



Caleydo Matchmaker: Detail Mode

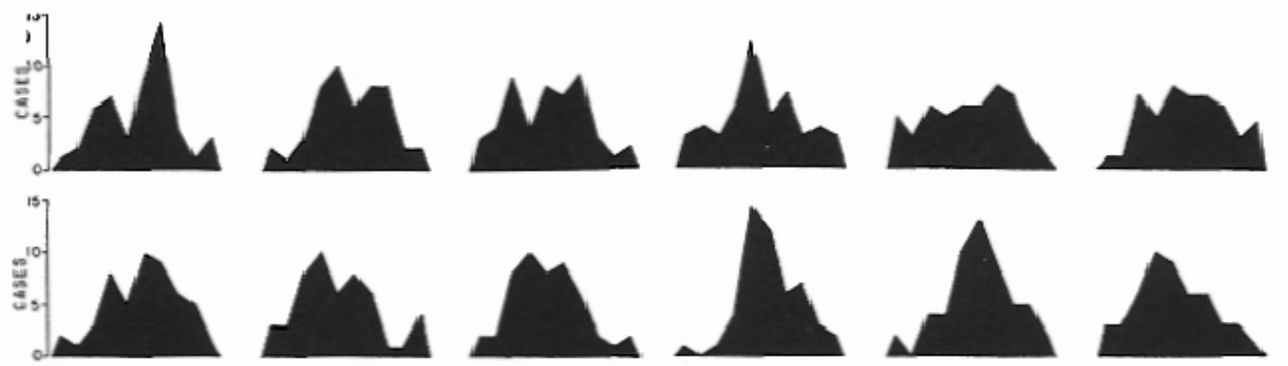
http://www.youtube.com/watch?v=vi-G3LqHFZA



Multiple-coordinated Views, Brushing

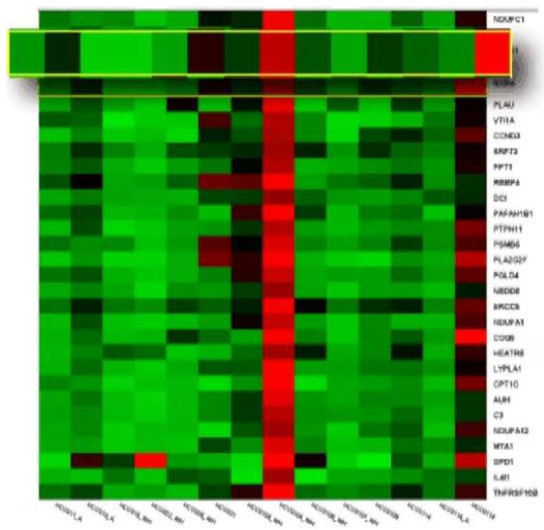
Multiple Views

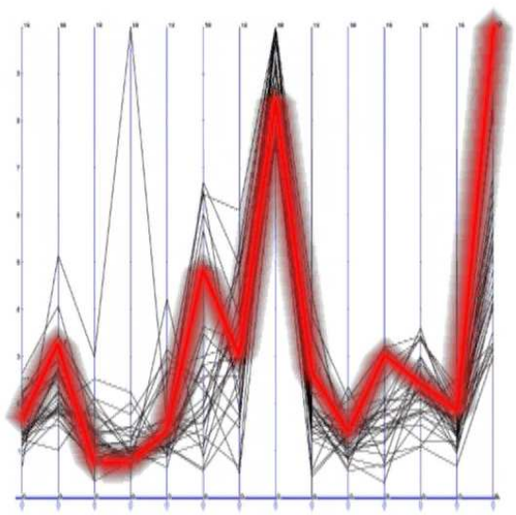
- Multiple data sets using the same visual representation



[Edward Tufte. The Visual Display of Quantitative Information, p 172]

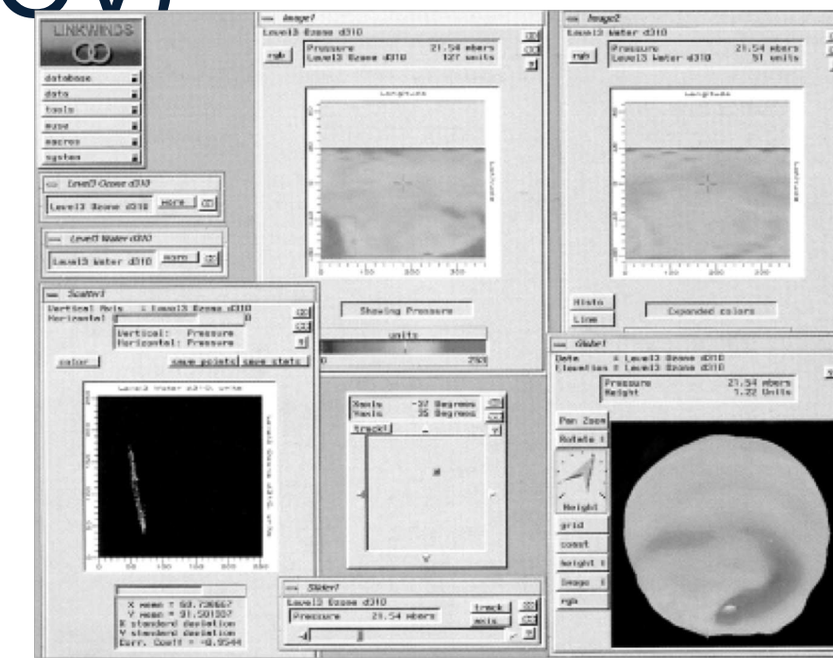
- A single data set in representations



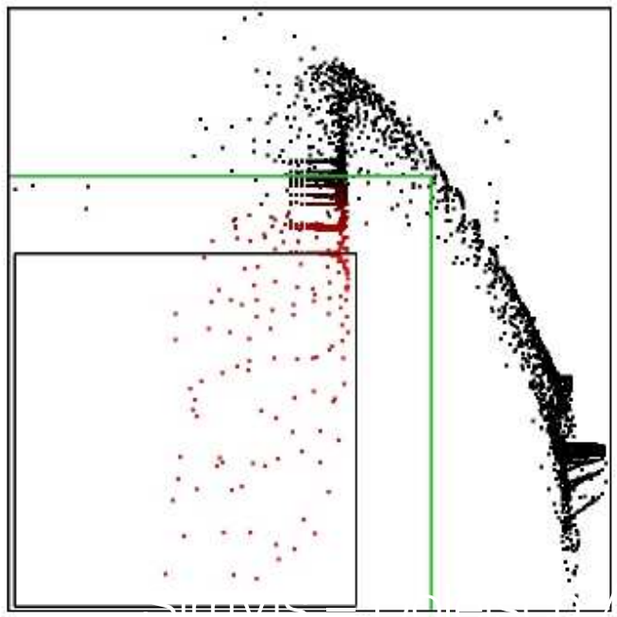


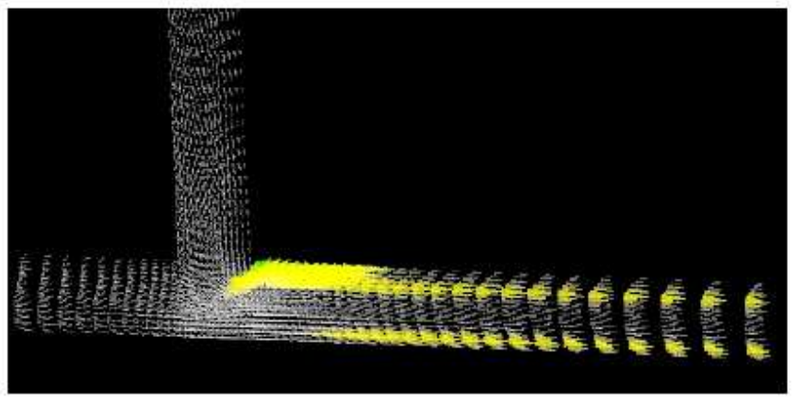
Prof. Hartmut Seichter, PhD | seichter@fh-sm.de | Schmalkalden University of Applied Sciences

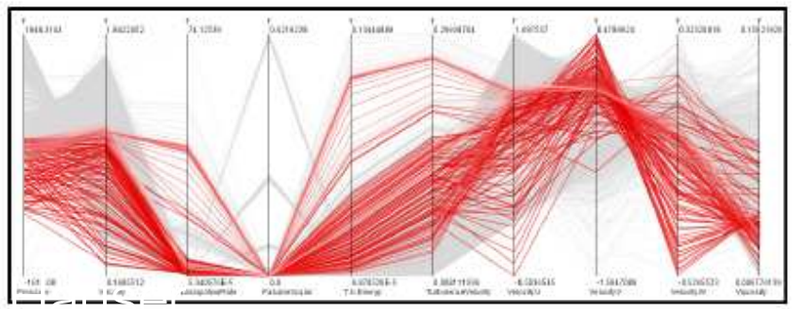
Multiple Coordinated Views (MCV)



- Linking of views
- Kinds
  - Highlighting (brushing)
  - Navigation (overview+detail)
  - Change of parameters

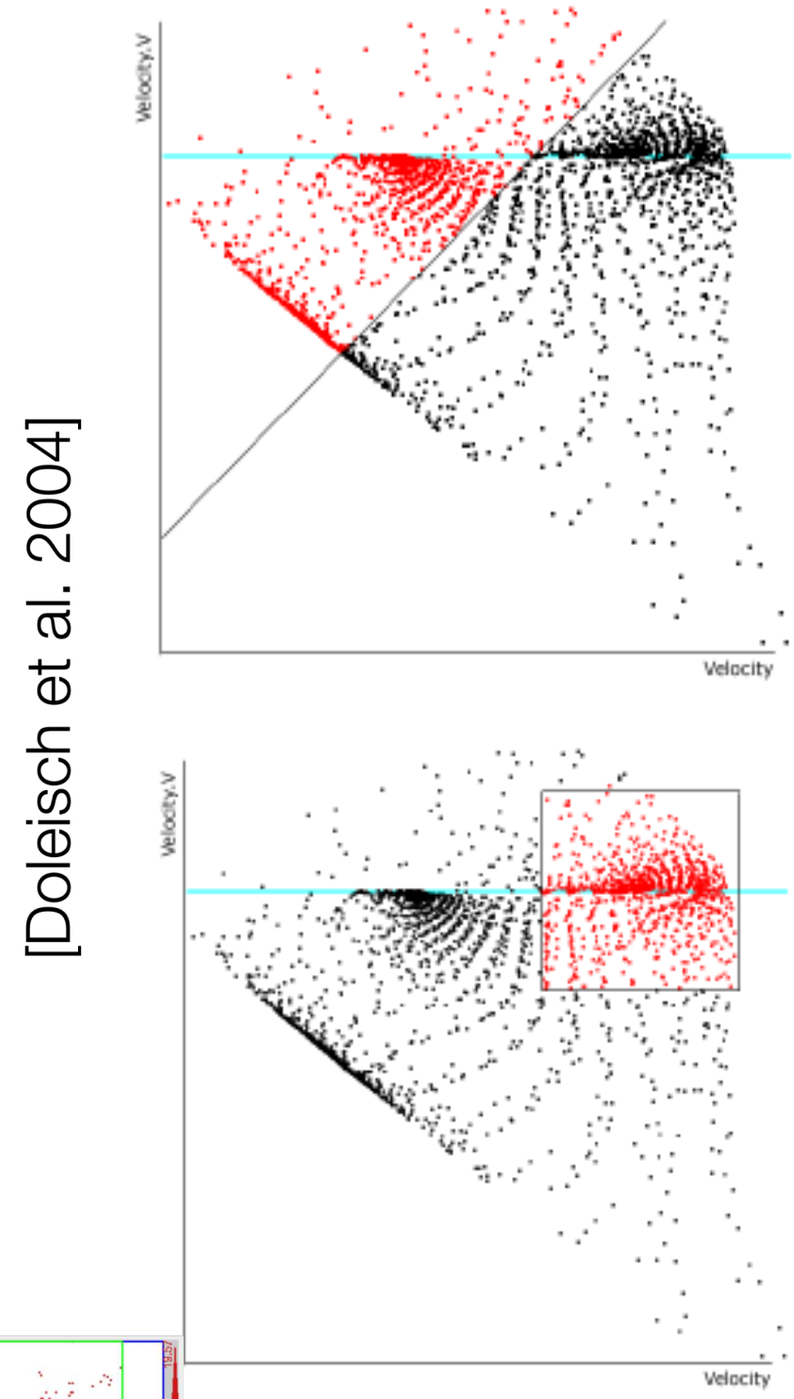




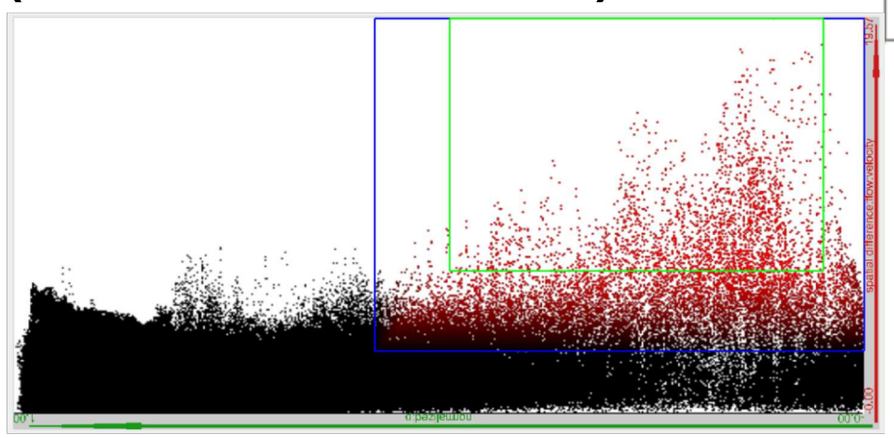


Brushing

- Highlight or select groups of data points
  - geometric functions such as:
    - rectangles, angles, free-form, lassos, etc.
    - query results
- Can be composite (AND, OR)
- Can be continuous (smooth brush)

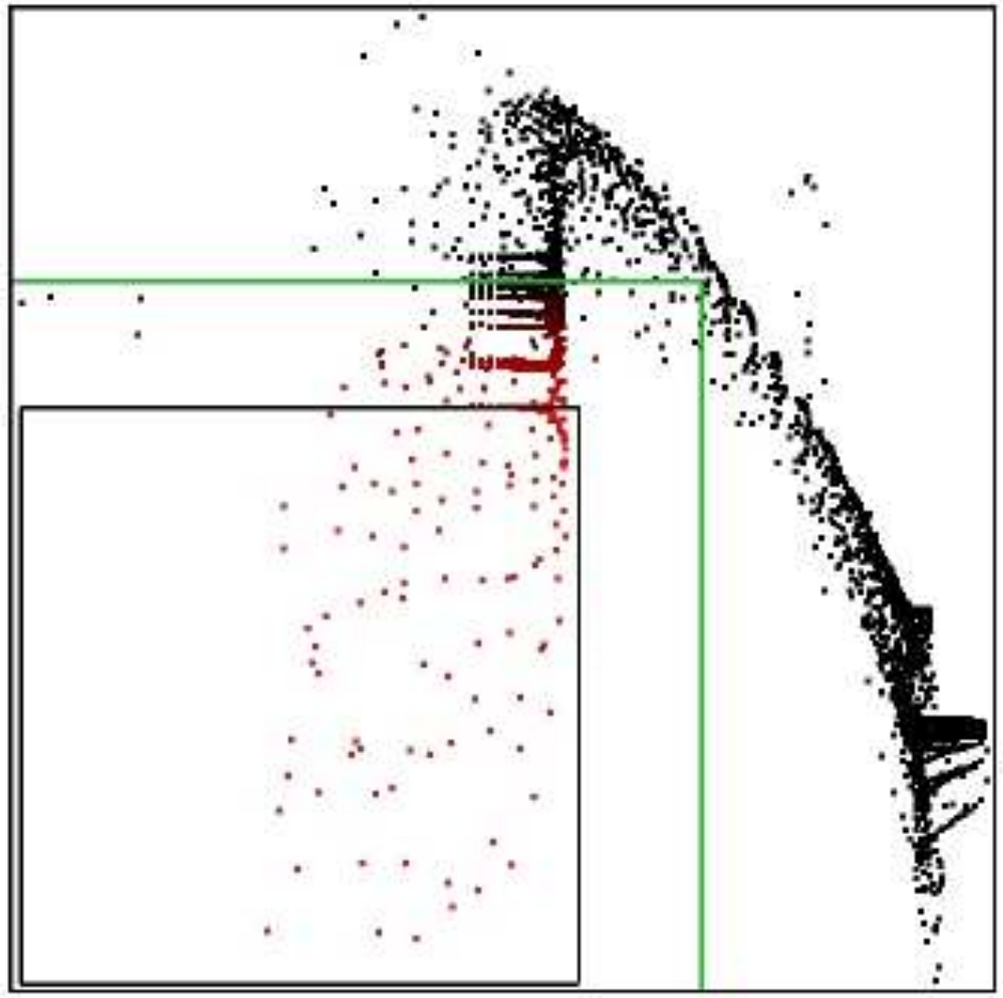


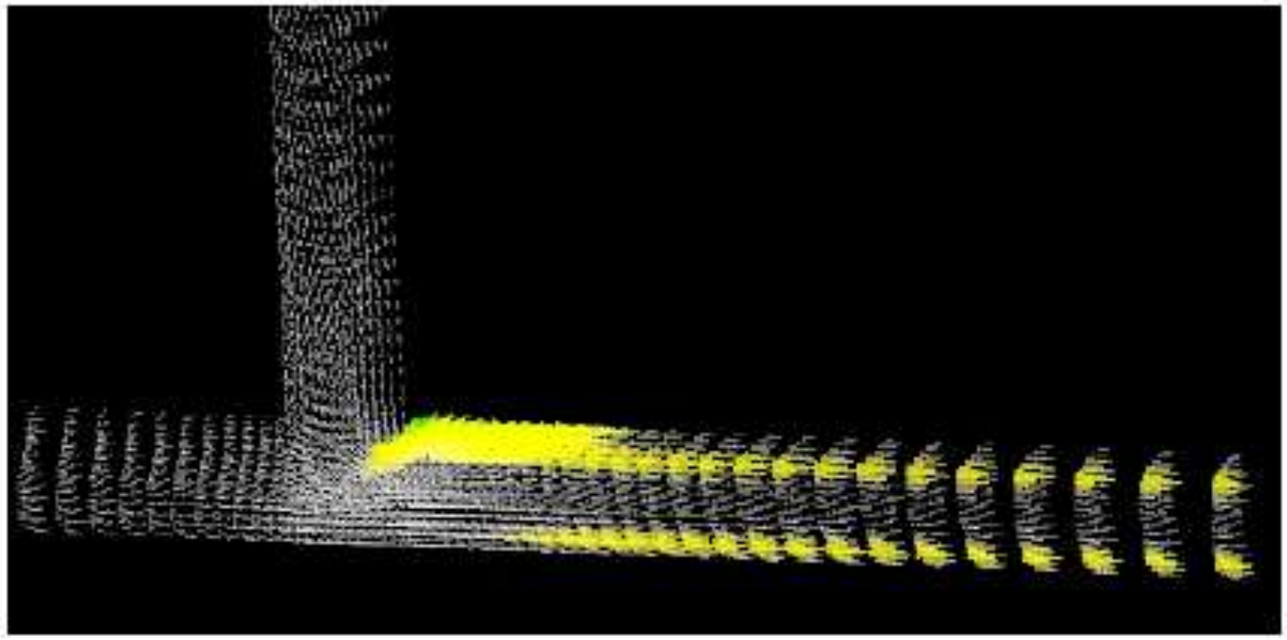
[Doleisch et al. 2004]

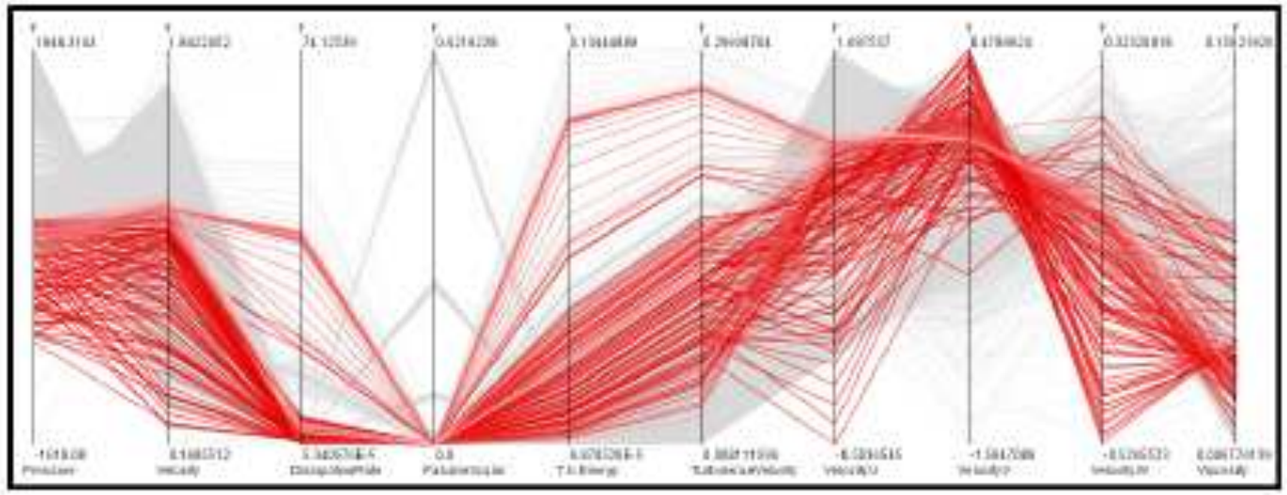


[Hauser et al. 2002]

Linking: Brushing in MCV

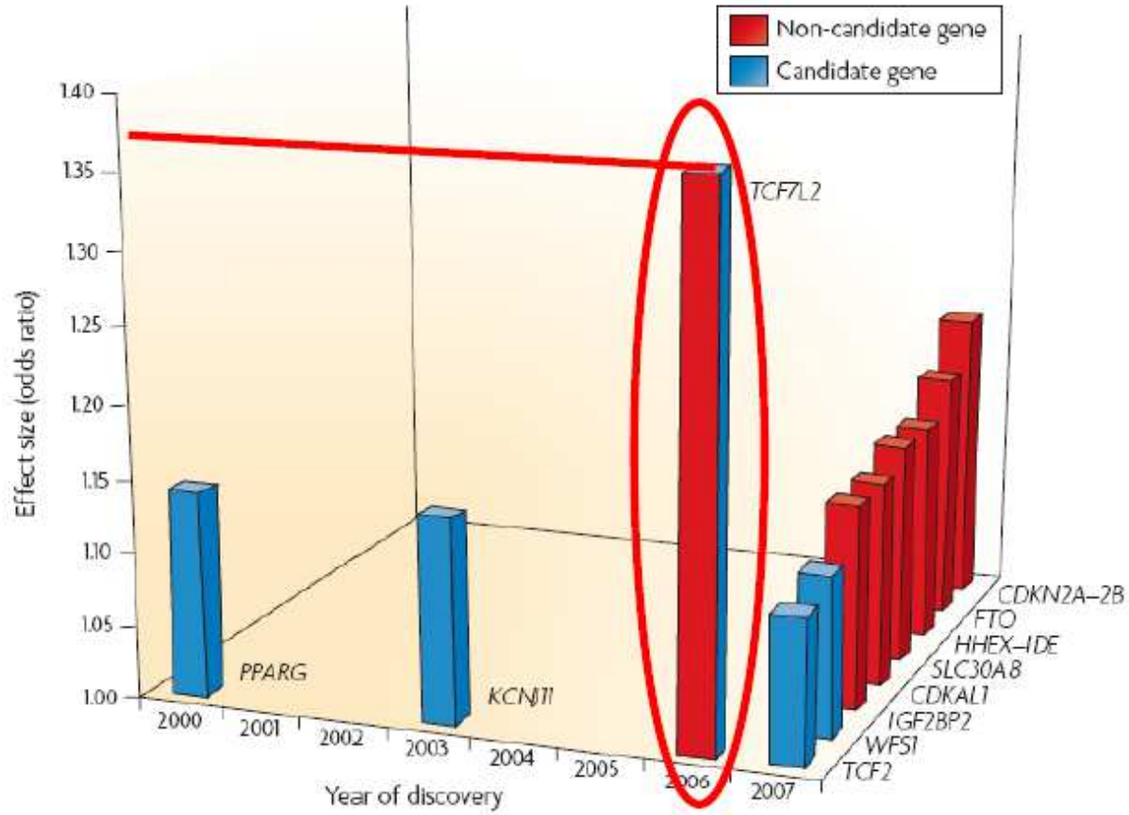






2D vs. 3D

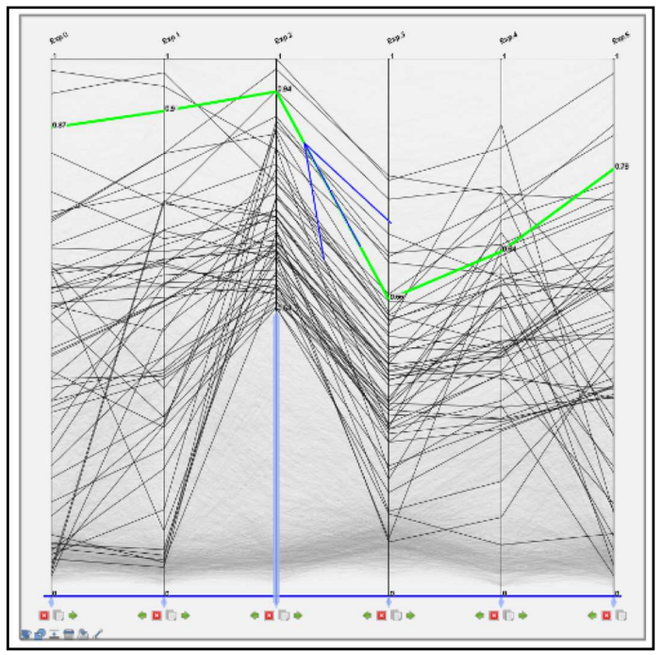
- 2D
  - No projection and visibility calculation needed
  - PRO
    - Easy to understand
    - Concrete data values can be read
    - No extra requirements to soft-/hardware
- 3D
  - More data presentable
  - PRO
    - Natural interpretation
    - Additional possibilities
  - CON
    - Perspective distortion / occlusion
    - 2D output devices (exception: Virtual Reality)



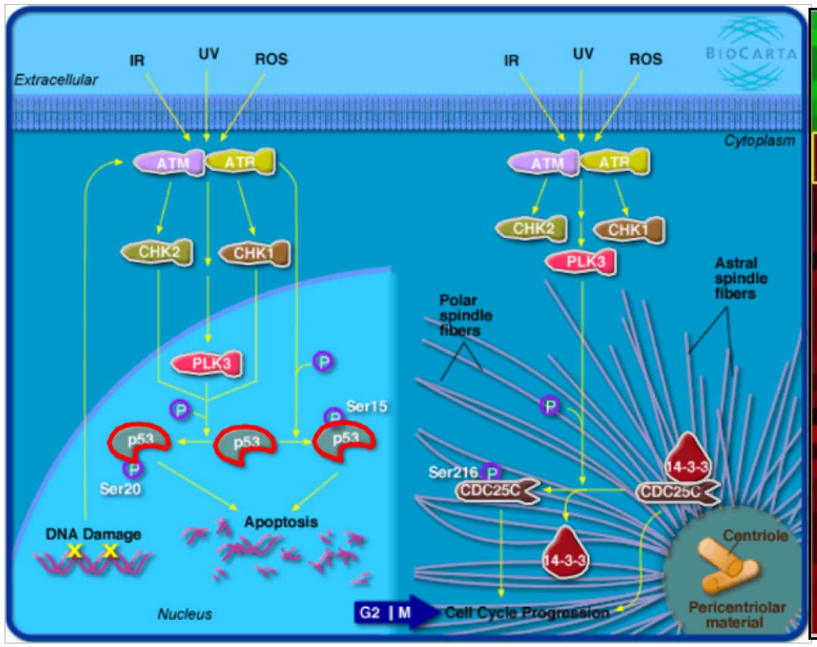
[Lecture Notes Human Genetics 2010, TU Graz]

Problem Statement

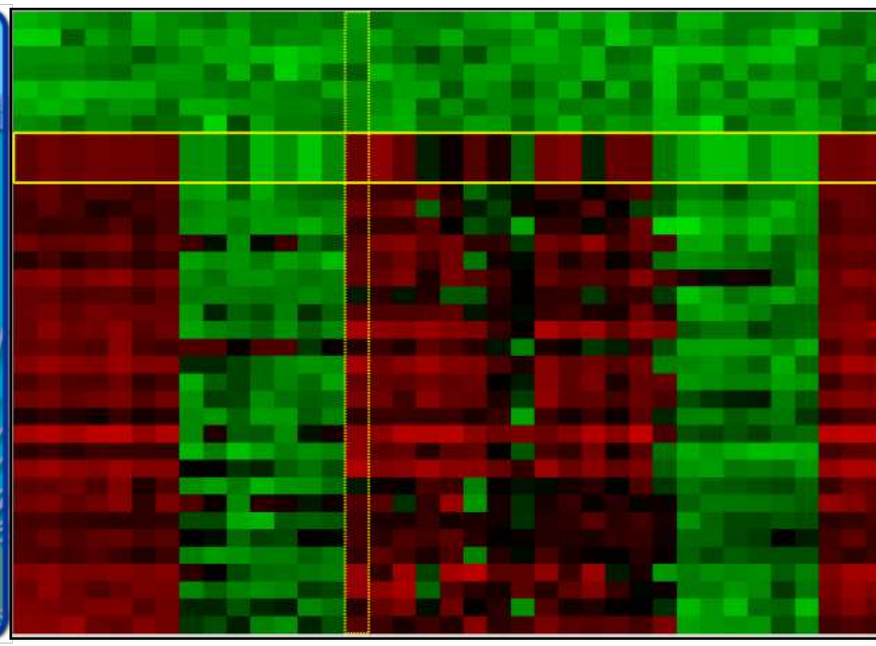
- Multiple 2D views
- Views are linked
- Relations between entities in views



Parallel Coordinates



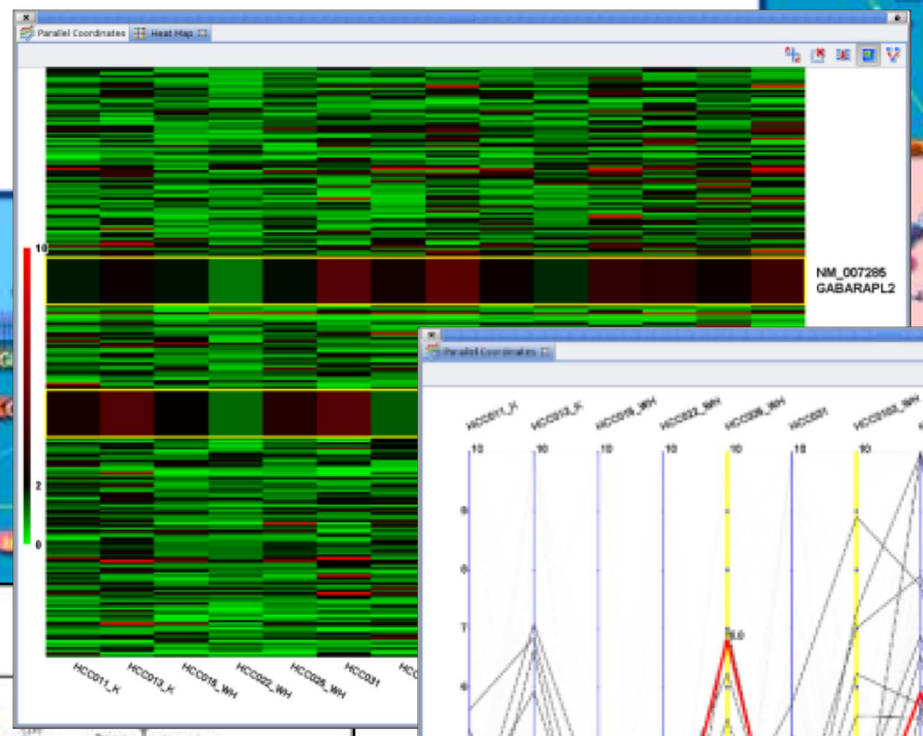
Pathways (>800)

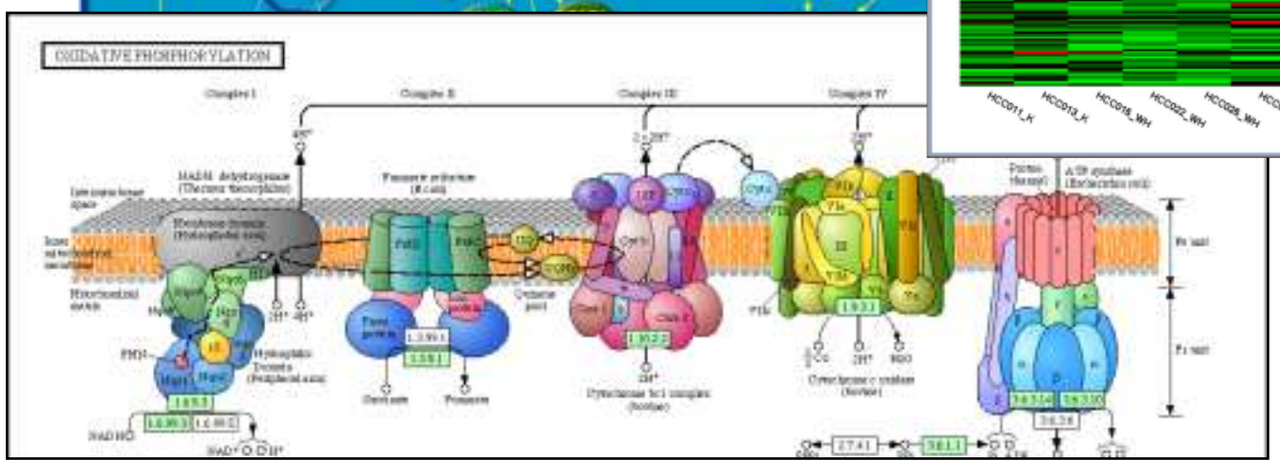


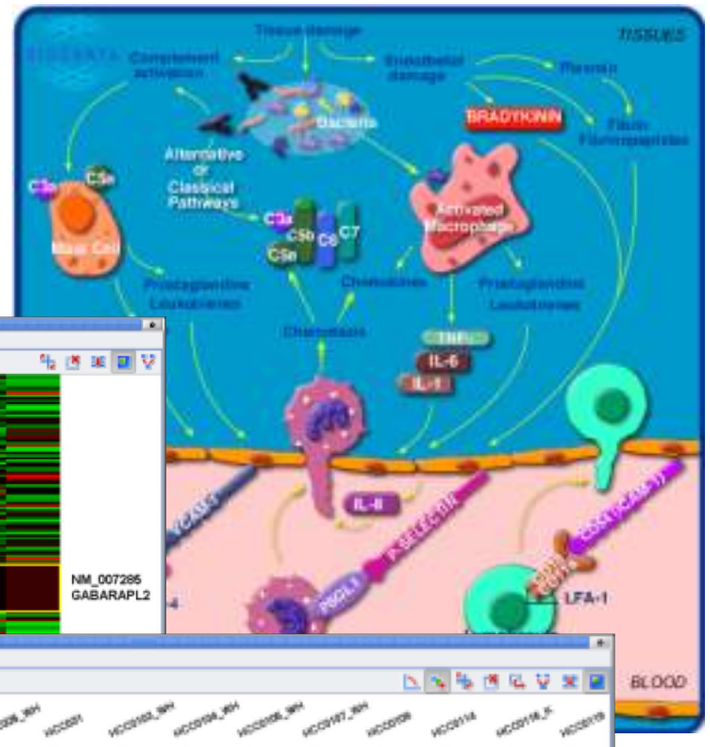
Heat Maps

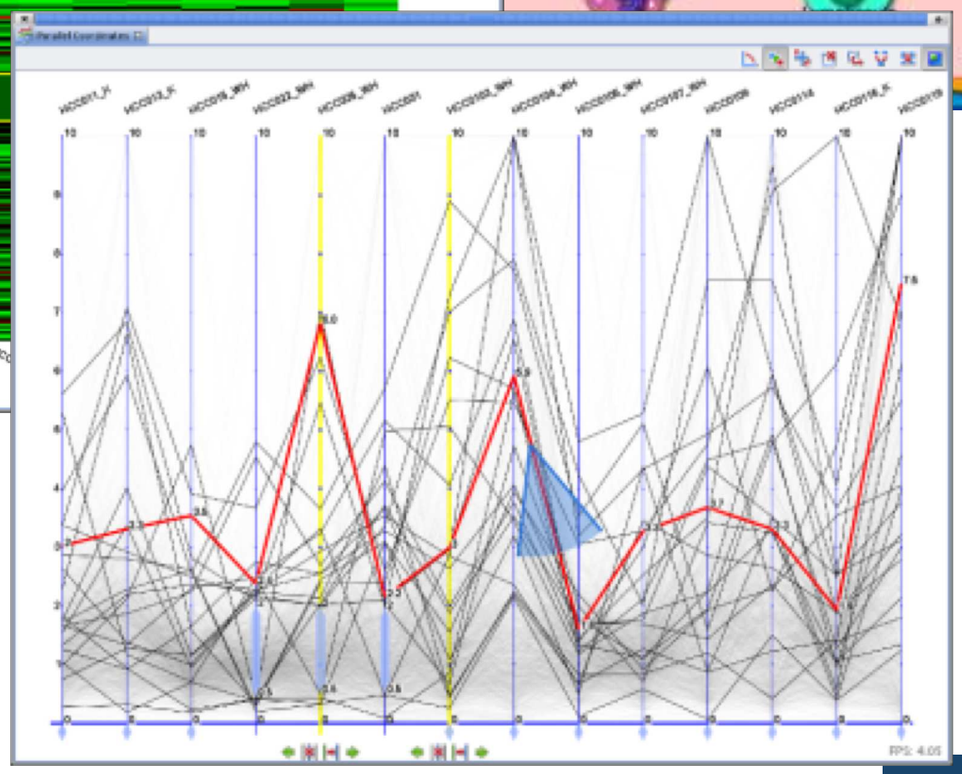
How to handle these views?

- Classic approach
  - Windows side-by-side
  - Tabs

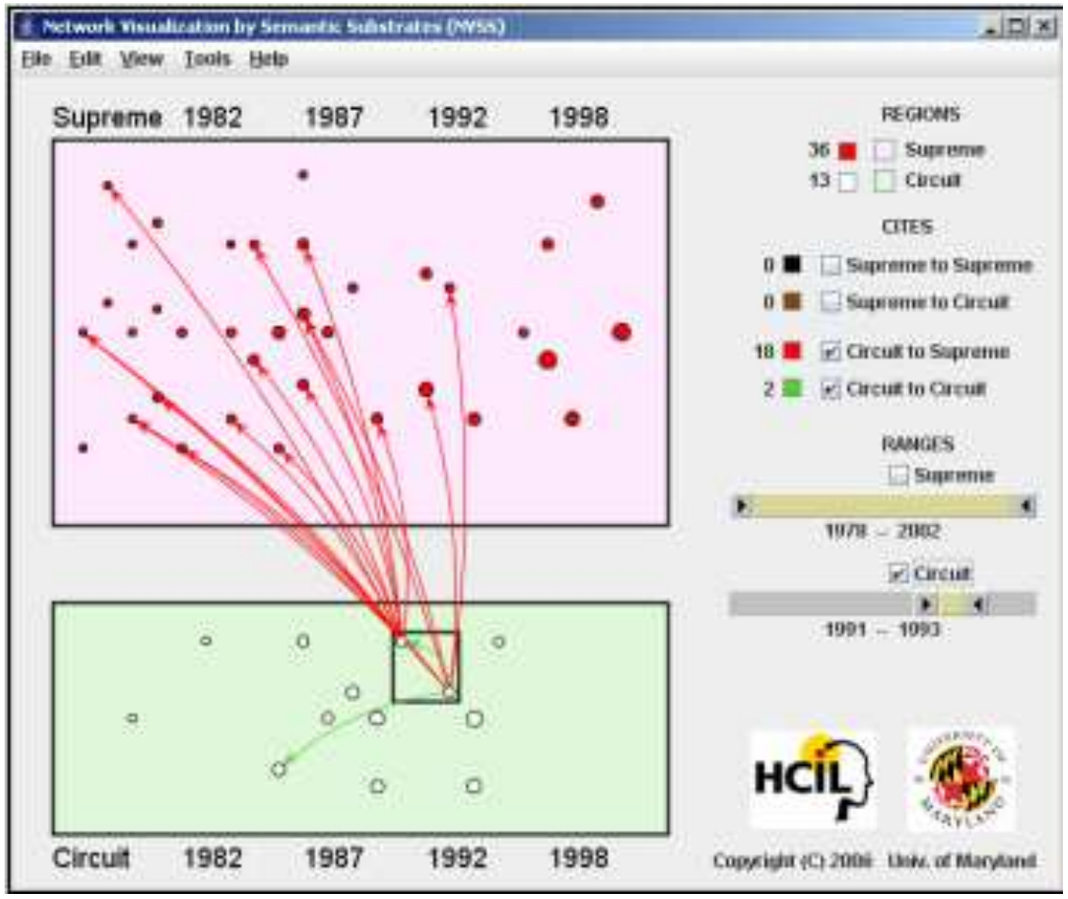








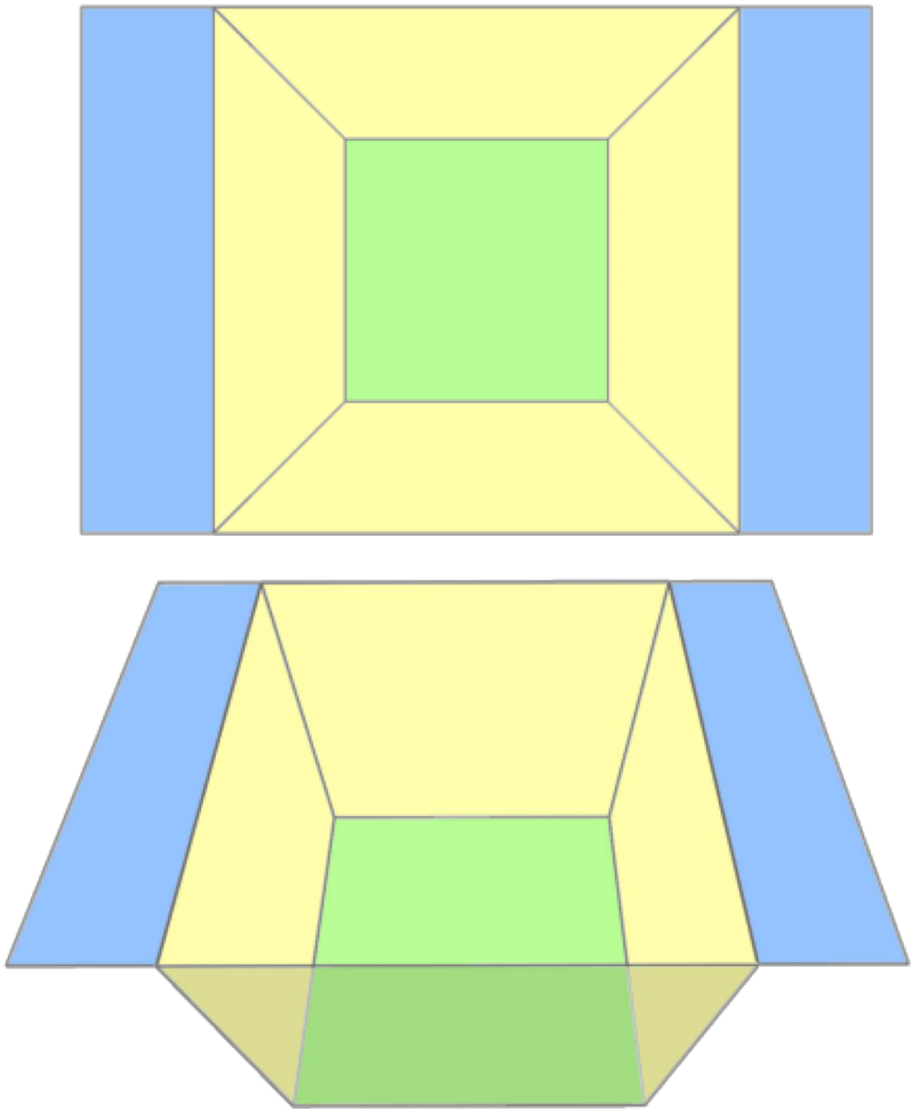
Visual Links

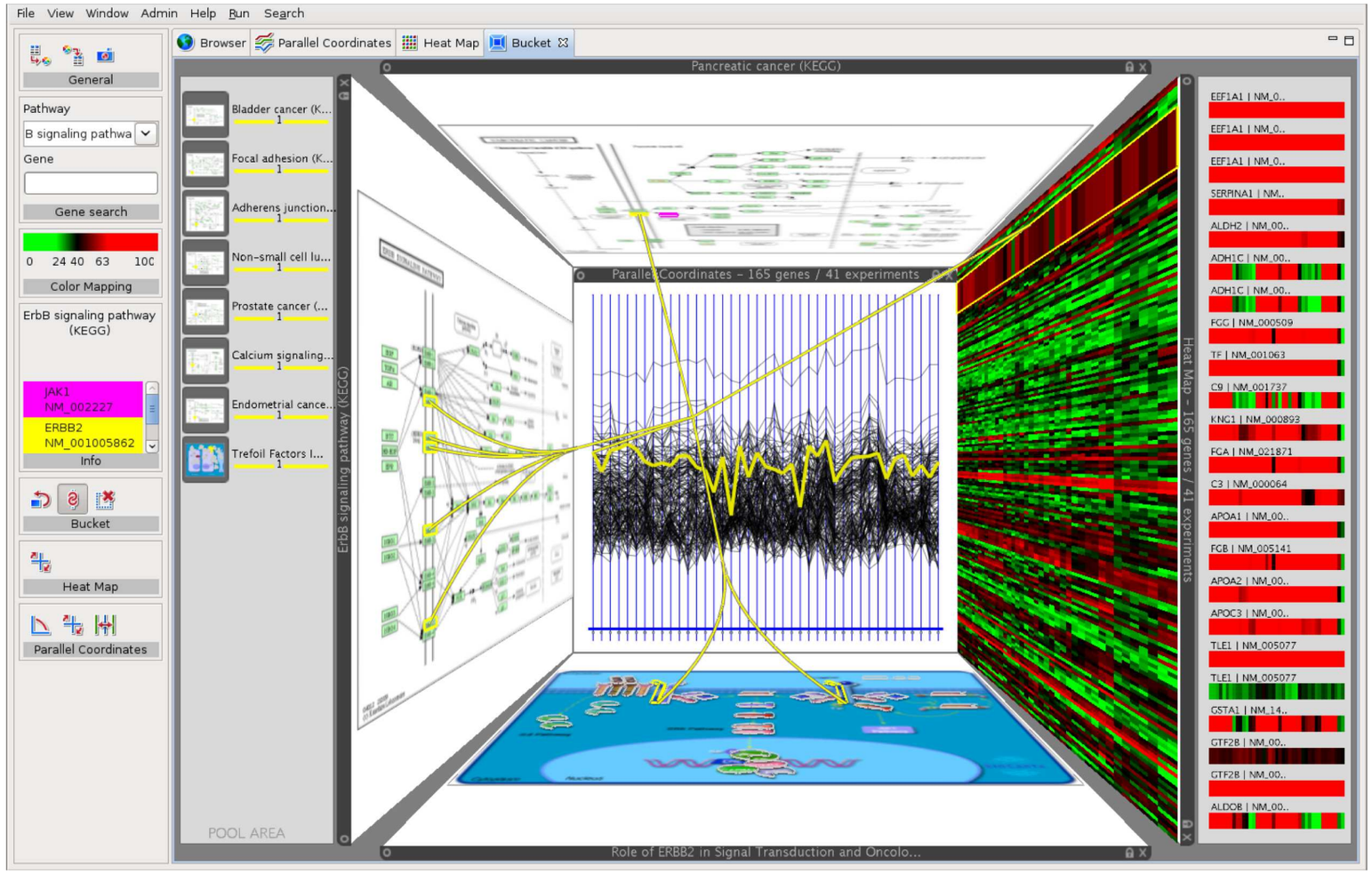


VisLink [Collins and Carpendale 2007]

Bucket

http://www.youtube.com/watch?v=8SV3Id_lvNY



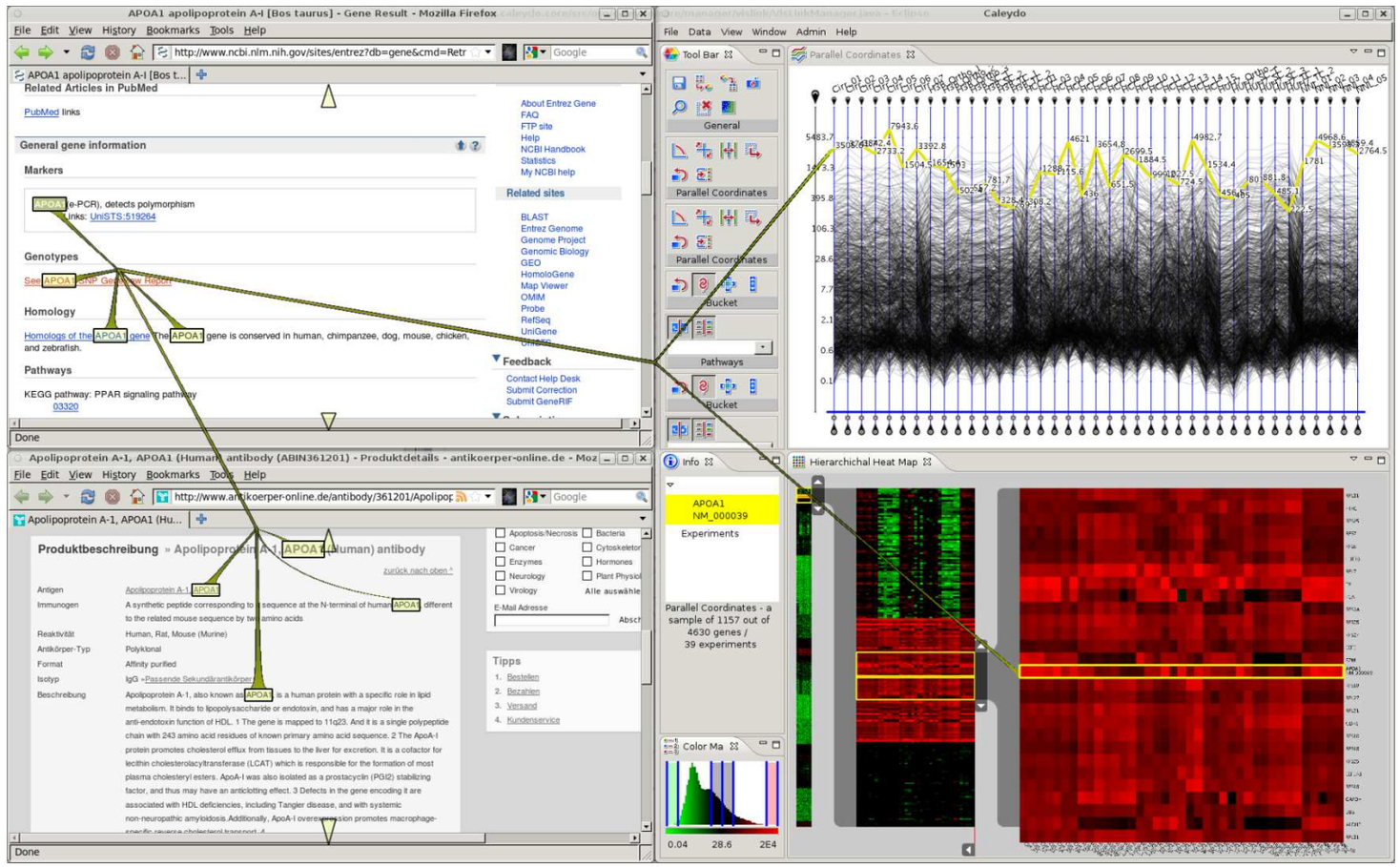


“Super Application”?

- Expects a „Super Application“ that can visualize everything
- Often unfeasible!
- Solution: use existing applications
- Downsides:
  - not integrated
  - no highlighting, linking, etc.

Visual Links across Applications

http://www.youtube.com/watch?v=4uXvxAeb5xA



References

- C. Ware, Information Visualization, Second Edition: Perception for Design, 2nd ed. Morgan Kaufmann, 2004, ISBN-13: 978-1558608191.
- Robert Spence: Information Visualization - Design for Interaction, Pearson Verlag, 2001, ISBN13: 9780132065504