Social Network Analysis

Visualizing Social Networks

Course Outline

- Graph Theory and Social Networks
- **Visualizing Social Networks**
- Information Networks and the World Wide Web
- Game Theory
- Network Dynamics
- Applications of SNA in various domains

Visualizing Social Networks

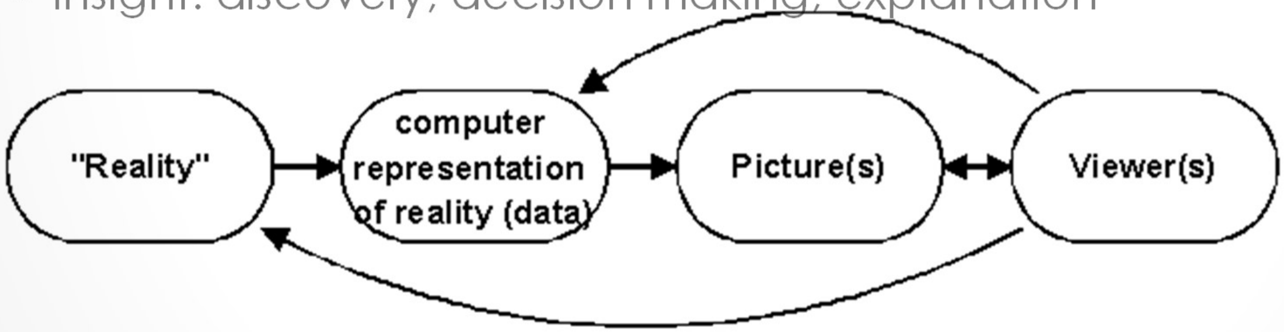
- **Introduction to Visualization**
- Graph Visualization
- Graph Layouts
- Interaction
- Tools

What is Visualization?

- The purpose of visualization is to convey information to
- people through graphical representations of data.
- Visualization has previously been defined as the *"Formation of visual images; the act or process of interpreting in visual terms or of putting into visual form*"
- More recently a new definition has been added: "*A tool or method for interpreting image data fed into a computer and for generating images from complex multi-dimensional data sets*"
- A cognitive process
  - Form a mental image of something
  - Internalize an understanding

Basics of Visualization

- Visualization is essentially a mapping process from computer representations to perceptual representations, choosing encoding techniques to maximize human understanding and communication. The goal of a viewer might be a deeper understanding of physical phenomena or mathematical concepts, but it also might be a visual proof of computer representations derived from such an initial stage.
- "The purpose of visualization is insight, not pictures"
  - Insight: discovery, decision making, explanation

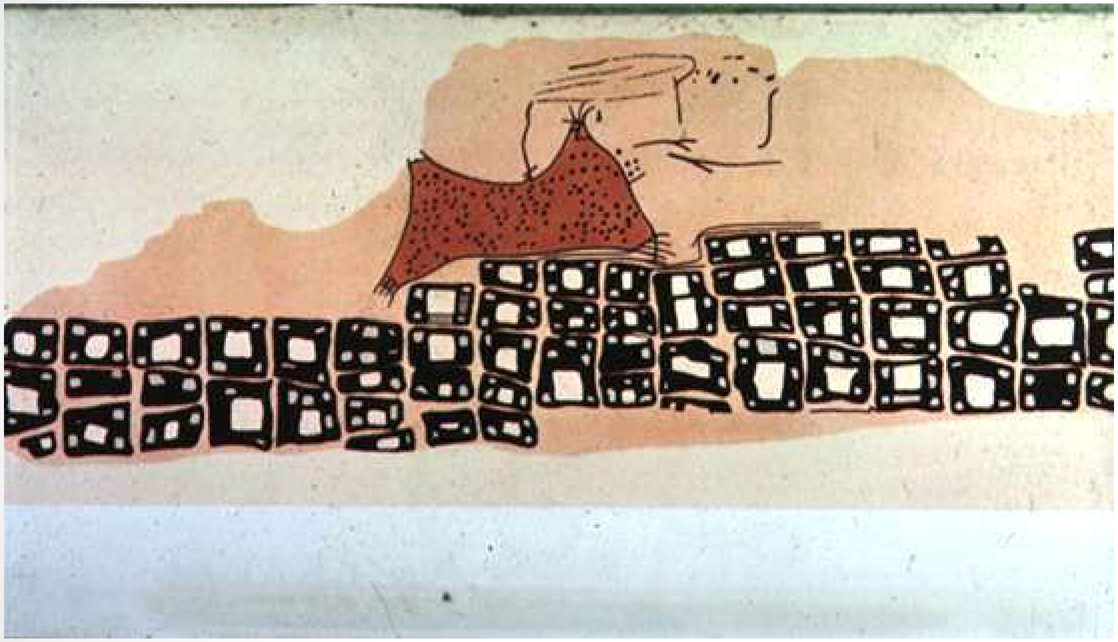


- "Visualization is really about external cognition, that is, how resources outside the mind can be used to boost the cognitive capabilities of the mind." - Stuart Card, Xerox PARC

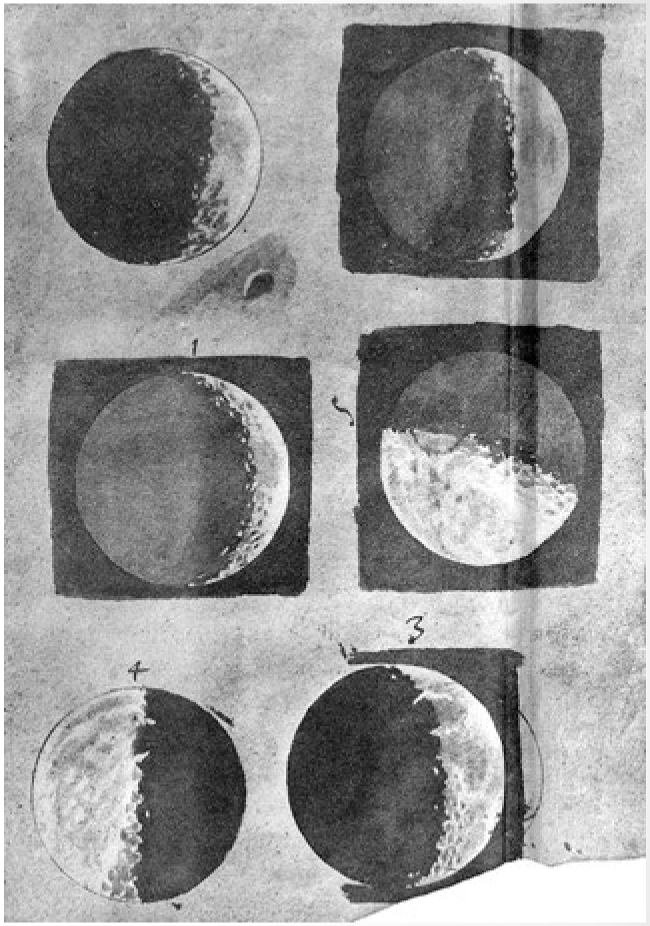
Visualization Goals

- **Record** information
  - Blueprints, photographs, seismographs, …
- **Analyze** data to support reasoning
  - Understand your data better and act upon that understanding
  - Develop and assess hypotheses (visual *exploration*)
  - Find patterns and discover errors in data
- **Communicate** information to others more effectively
  - Share and persuade (visual *explanation*)

Record

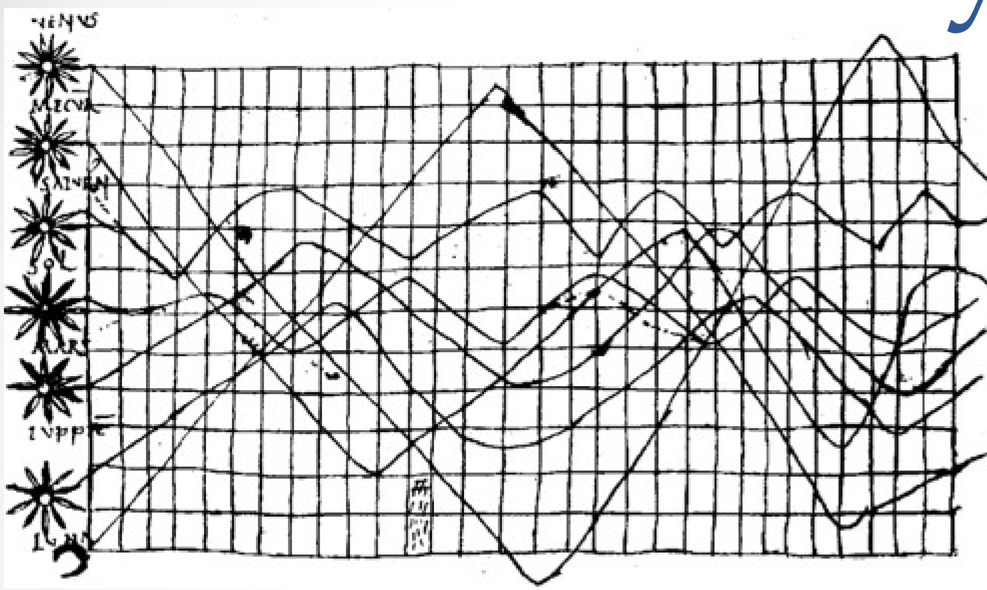


Konya town map, Turkey, c. 6200 BC

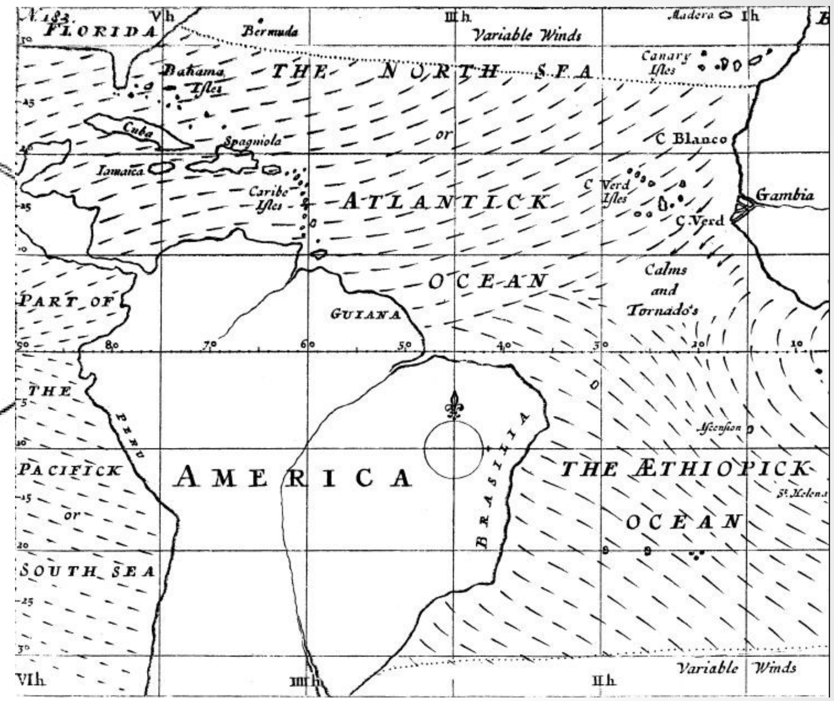


Galileo Galilei, 1616

Analyze

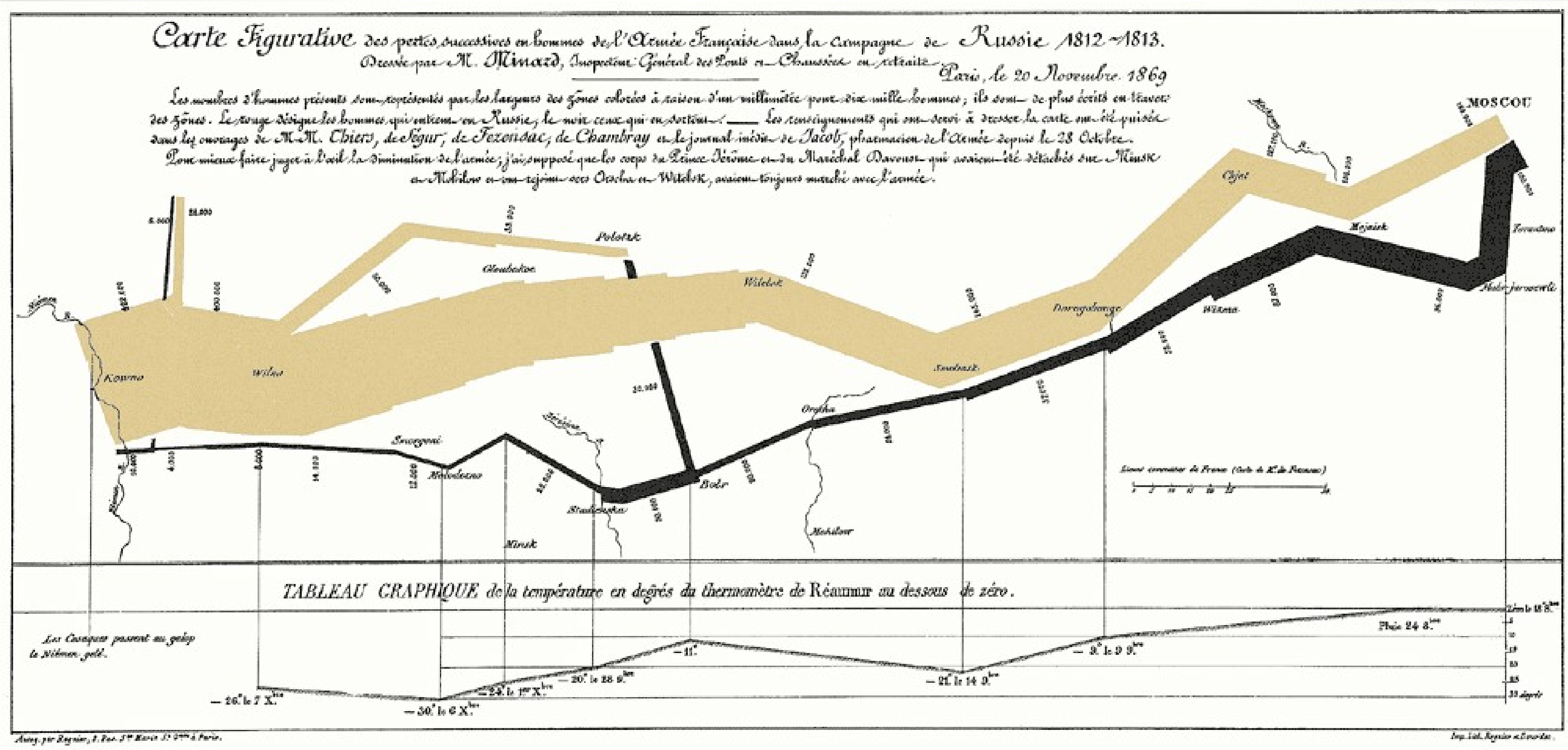


Planetary Movement Diagram, c. 950



Halley's Wind Map, 1686

Communicate



Napoleon's invasion of Russia in 1812, by Jacque Minard

When to apply Visualization?

- Visualization most useful in **exploratory data analysis**
  - Don't know what you're looking for
  - Don't have a priori questions
  - Want to know what questions to ask
- Search (OK)
  - Finding a specific piece of information
- Browsing (Better)
  - Look over or inspect something in a more casual manner, seek interesting information
- Visuals can frequently take the place of many words
- Visuals can summarize, aggregate, unite, explain, …
  - Sometimes words are needed, however

Classification of Visualization

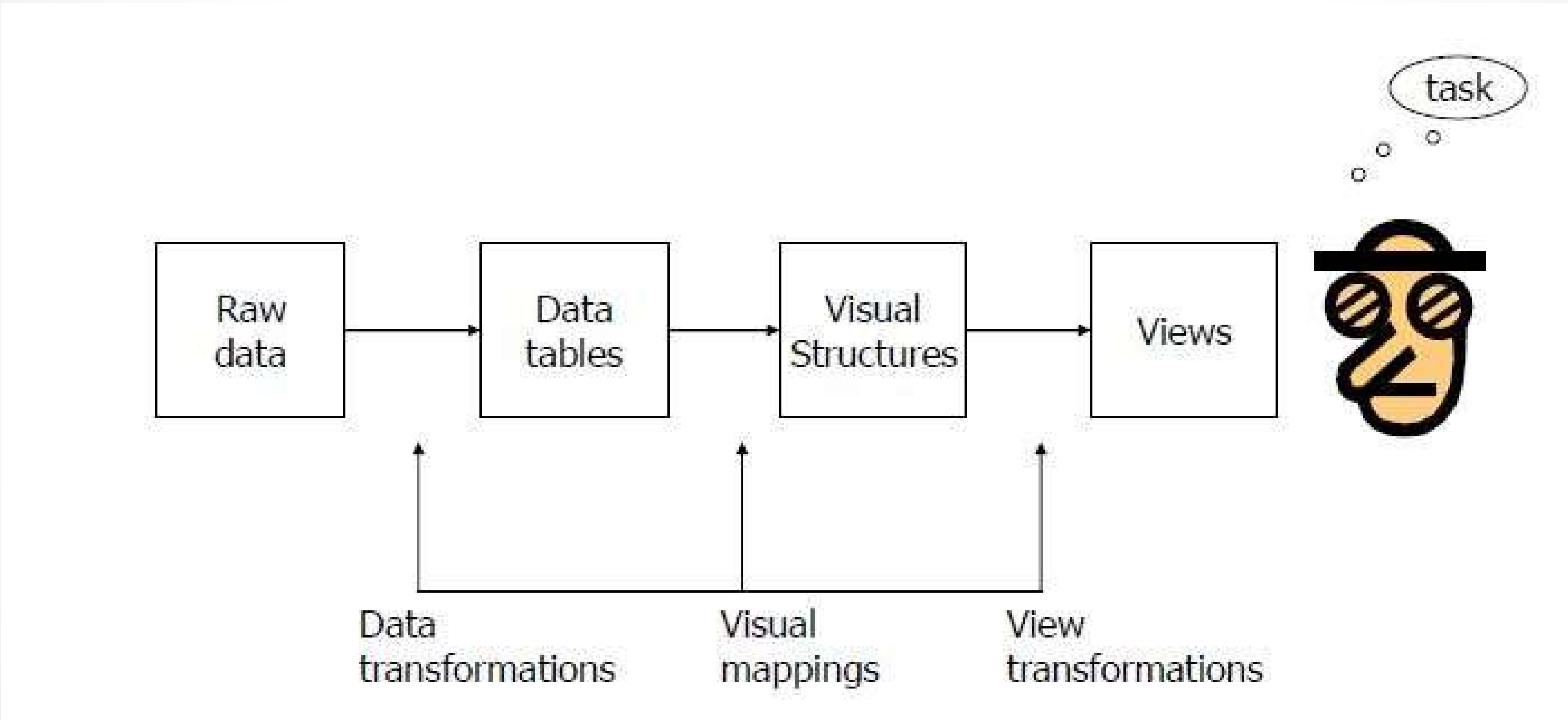
Data Visualization can be classified into 2 major areas:

- **Scientific Visualization**: Primarily relates to and represents something physical or geometric (Often 3-D)
  - Air flow over a wing
  - Stresses on a girder
  - Torrents inside a tornado
  - Organs in the human body
  - Molecular bonding
- **Information Visualization**:
  - 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 presentation

Challenges of Information Visualization

- Visual Representation: Designing a cognitively useful spatial mapping of a dataset that is not inherently spatial and accompanying the mapping by interaction techniques that allow people to intuitively explore the dataset
- Scale of data: Challenge often arises when data sets become large
- Diversity: Data of data types, forms, sizes

Information Visualization Processing Model



Related Areas

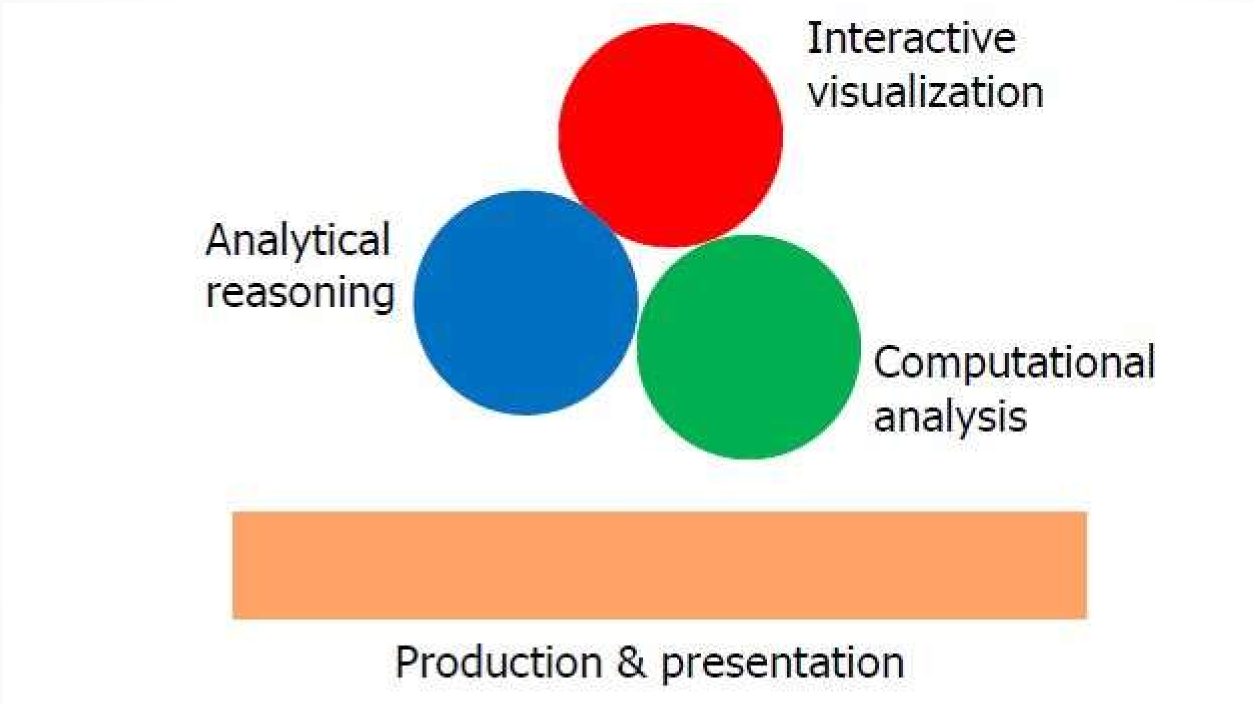
- Many other techniques for data analysis
  - Statistics, DB, Data mining, Machine learning, Information Retrieval

- Visualization is influenced by many other areas
  - Computer graphics, Human-computer interaction, Cognitive psychology, Graphic design, Cartography, Art

New Emerging Area: Visual Analytics

- Visual analytics is the science of analytical reasoning facilitated by interactive visual interfaces
- Visual analytics combines automated analysis techniques with interactive visualizations for an effective understanding, reasoning and decision making on the basis of very large and complex data sets

Visual Analytics – Main Components



Visualizing Social Networks

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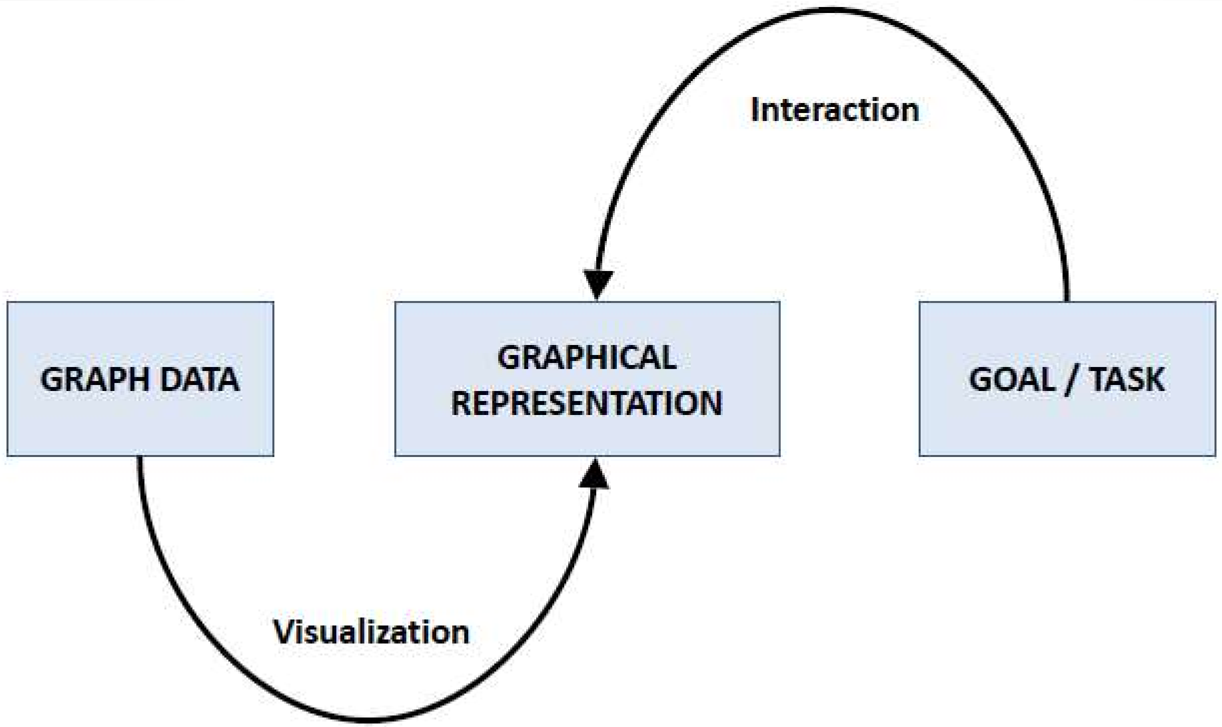
- **Graph Visualization**
- Graph Layouts
- Interaction
- Tools

Graph Visualization



How to decide which **representation** to use for which **type of graph** in order to achieve which kind of **goal**?

Different Kinds of Tasks/Goals

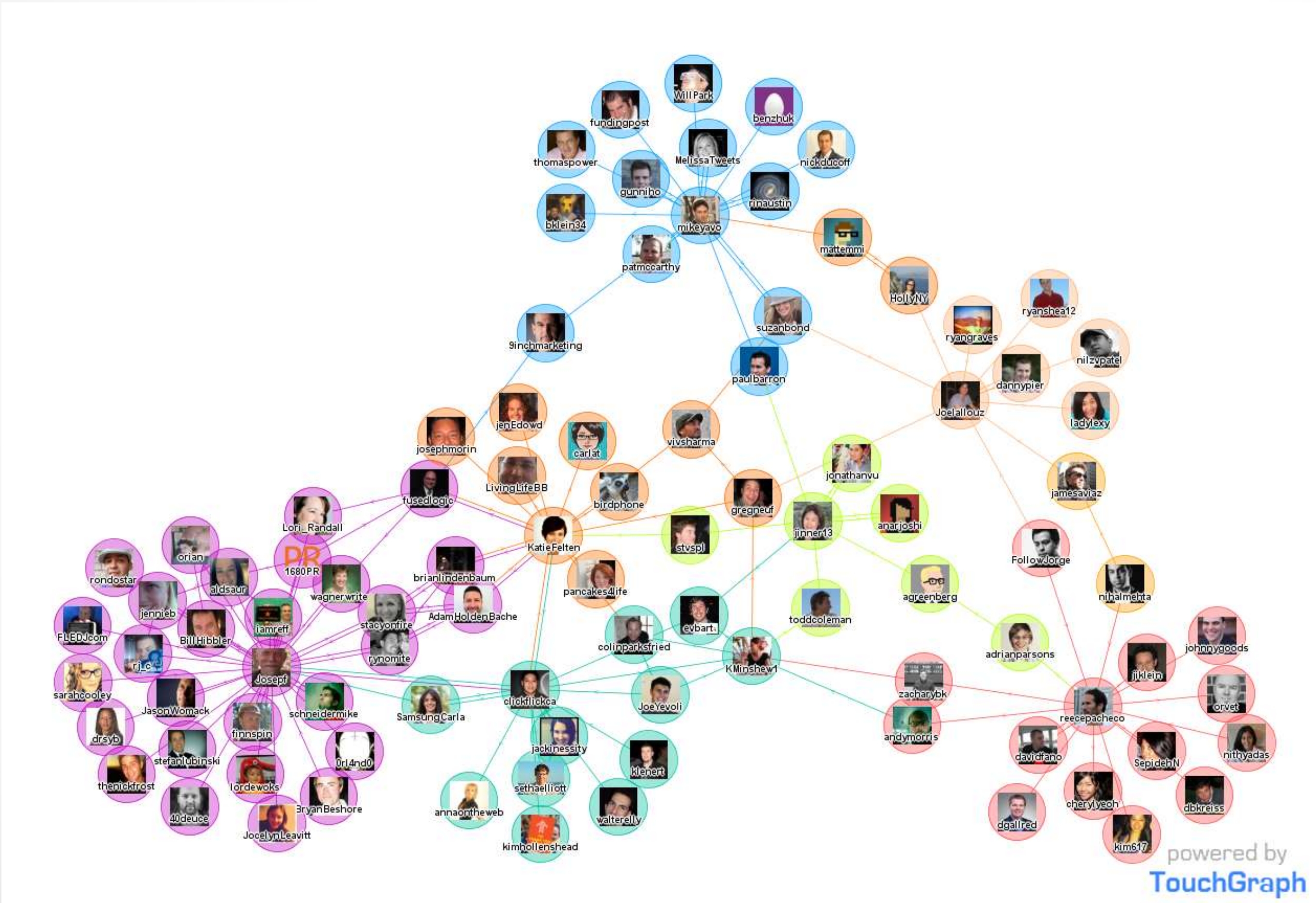
Two principal types of tasks: **attribute-based (ABT)** and **topology-based (TBT)**

- **Localize** – find a single or multiple nodes/edges that fulfill a given property
  - ABT: Find the edge(s) with the maximum edge weight.
  - TBT: Find all adjacent nodes of a given node.
- **Quantify** – count or estimate a numerical property of the graph
  - ABT: Give the number of all nodes.
  - TBT: Give the indegree (the number of incoming edges) of a node.
- **Sort/Order** – enumerate the nodes/edges according to a given criterion
  - ABT: Sort all edges according to their weight.
  - TBT: Traverse the graph starting from a given node.

High-level Tasks

- Are 2 nodes representing the same entity?
  - The same person in a Telecom graph with different SIMs
  - The same author is a co-author graph
- How is the graph changing over time?
- Are there anomalies in the graph?
  - Unusual patterns?

Visualization of a Social Network



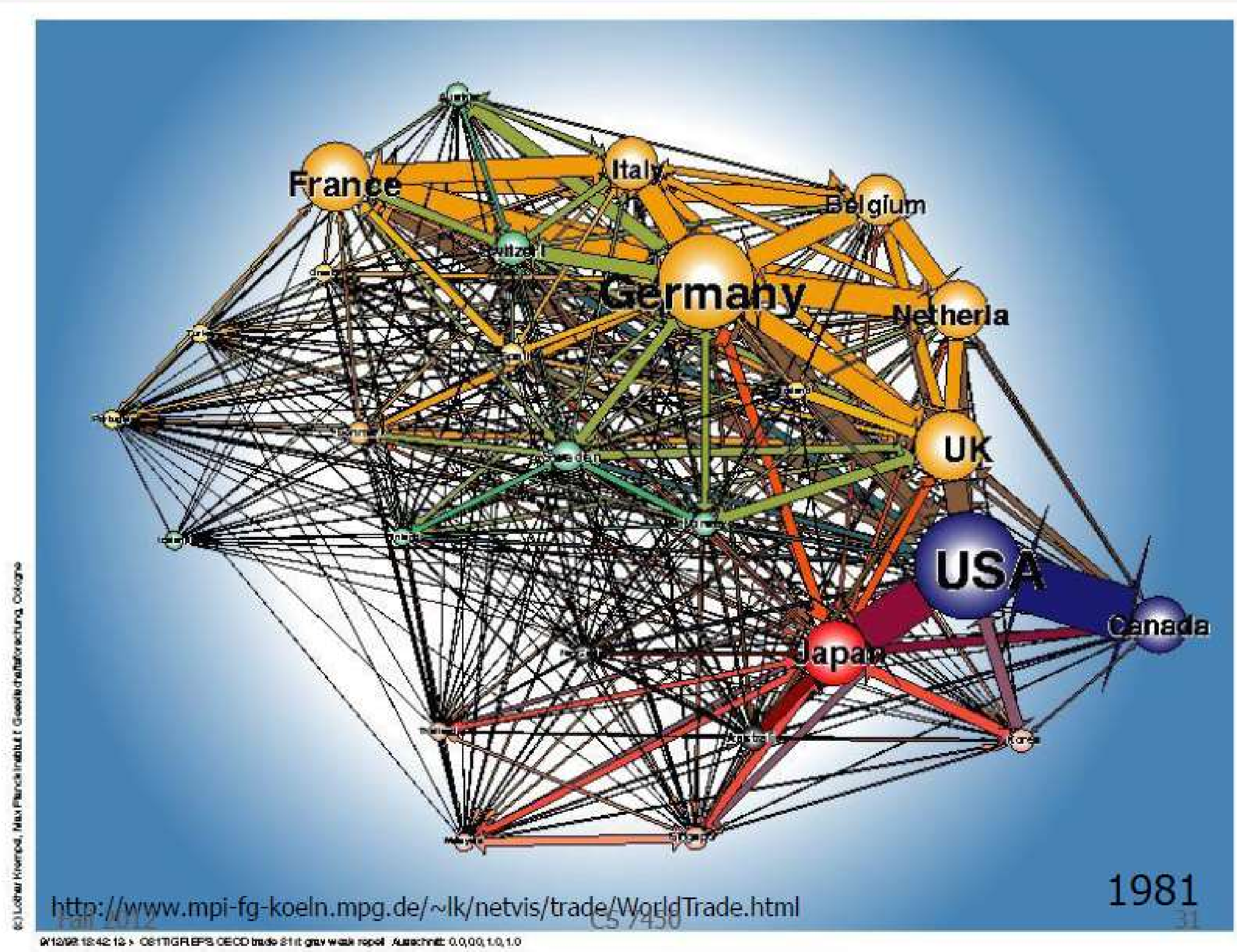
Visualization of Twitter activity data

Graph Visualization Steps

- Decide visual encoding of nodes and link
- Graph layout and positioning
  - Make a concrete rendering of abstract graph
- Navigation/Interaction
  - How to support user changing focus and moving around the graph

- **Challenge of Graph Visualization: Scale**

It is not easy to visualize large graphs!



Shneiderman's Network Visualization Nirvana

- Every node is visible
- For every node you can count its degree
- For every link you can follow it from source to destination
- Clusters and outliers are identifiable

Visualizing Social Networks

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- **Graph Layouts**
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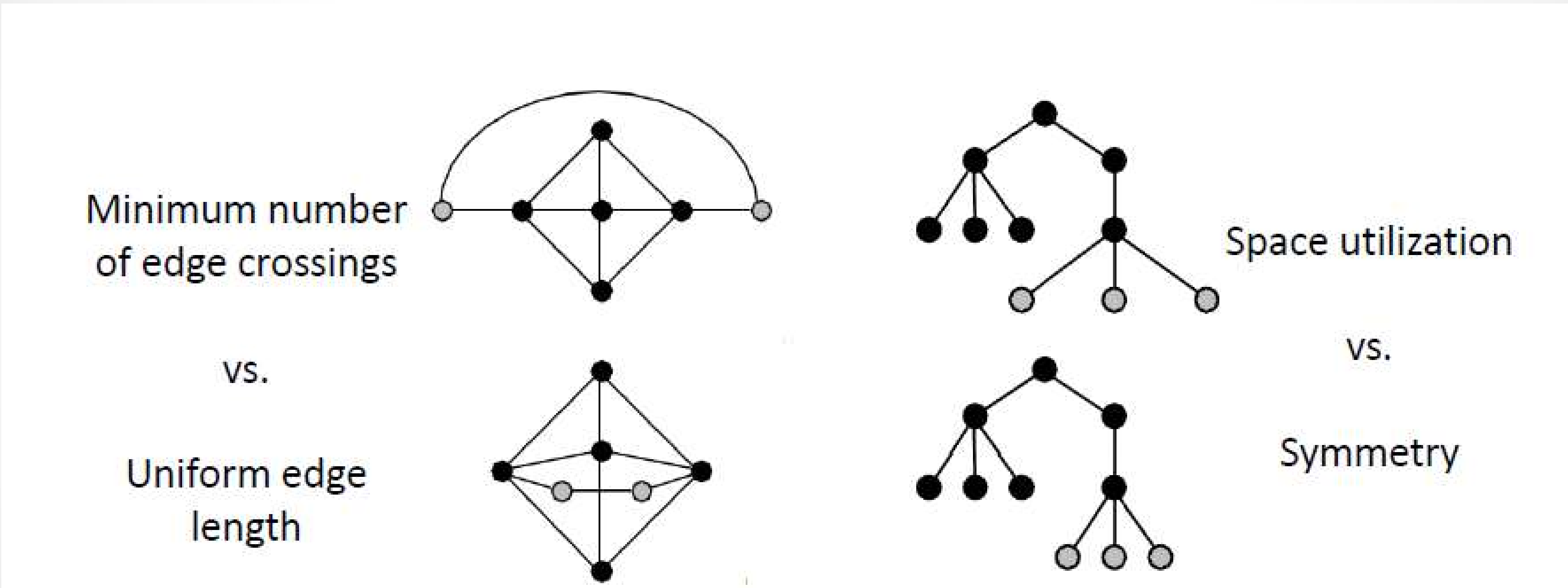
Criteria for Good Node-Link Layout

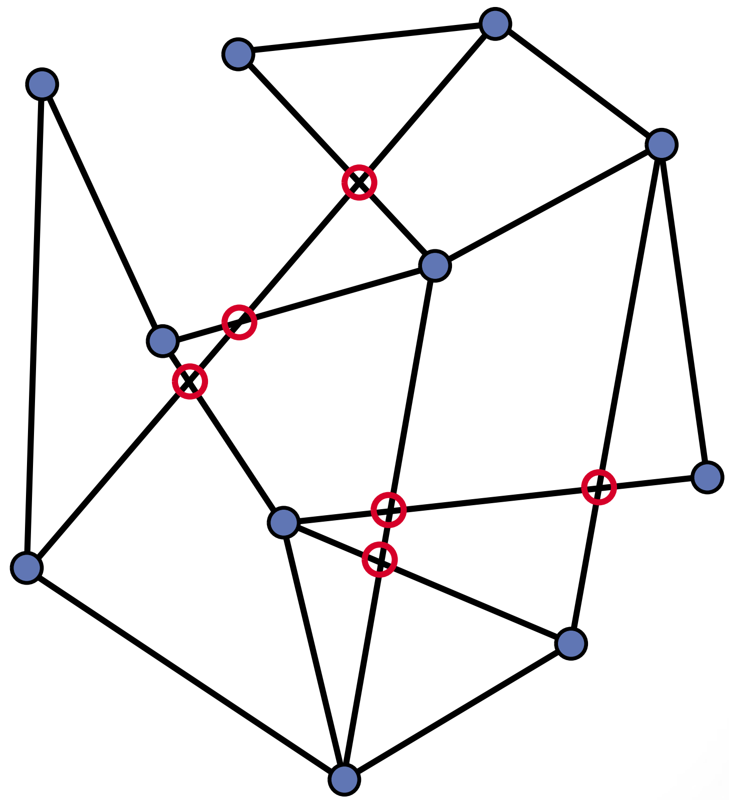
- Minimized **drawing area**
- Aspect ratio about 1 (not too long and not too wide)
- Minimized **distance** of neighboring nodes
- Minimized **edge crossings**
- Edges should have same length
- Edges should be straight lines
- **Symmetry**: similar graph structures should look similar
- Isomorphic substructures displayed equivalently

Conflicting Criteria



Optimization of the graph drawing criteria is a hard problem

Edge Crossing

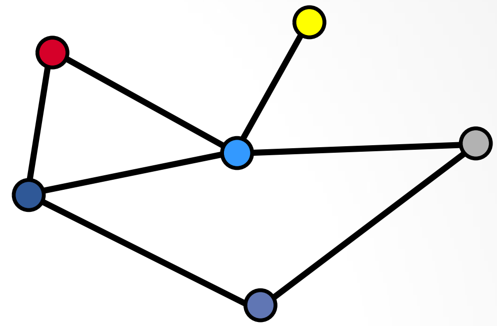


Minimizing edge crossing is NP-hard

Graph - Planarity

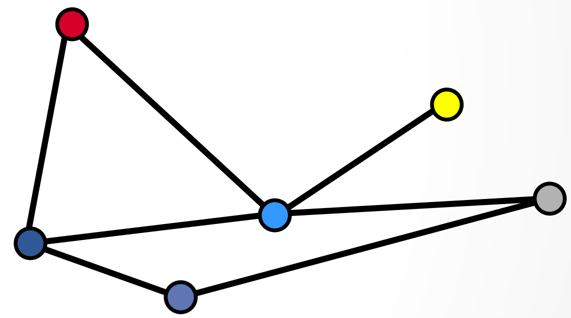
Planar Graph

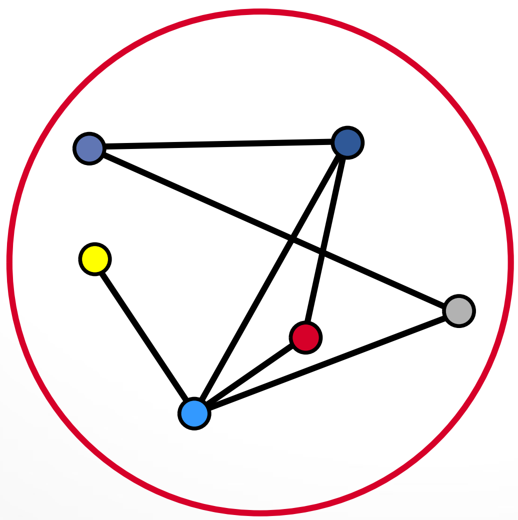
- can be drawn in the plane without crossings

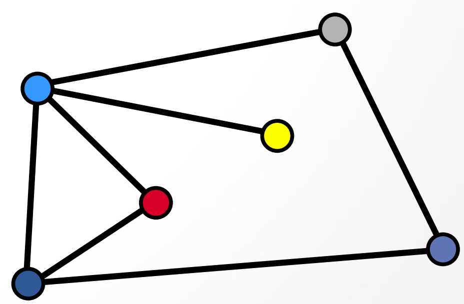


Plane Graph

- planar graph with a fixed embedding

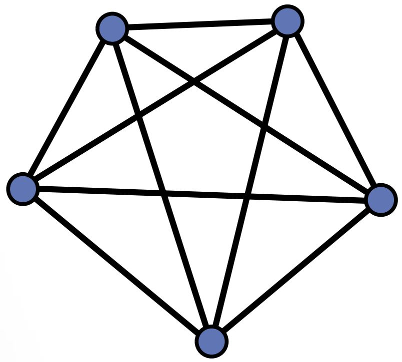




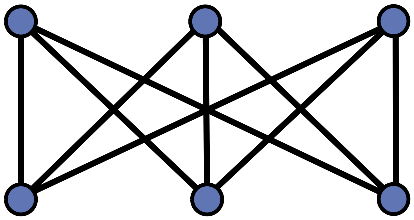


Smallest not-planar graphs

K_5



$K_{3,3}$



Planarity testing

Theorem [Kuratowski 1930 / Wagner 1937]

A graph G is planar if and only if it does not contain K_5 or $K_{3,3}$ as a minor.

Minor

A graph H is a minor of a graph G, if H can be obtained from G by a series of 0 or more deletions of vertices, deletions of edges, and contraction of edges.

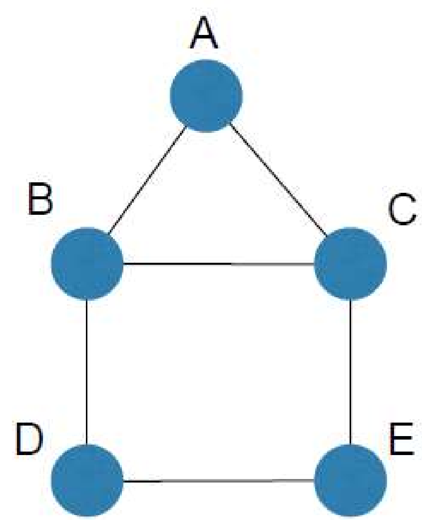
- G = (V, E), |V| = n, planarity testing in O(n) time possible.

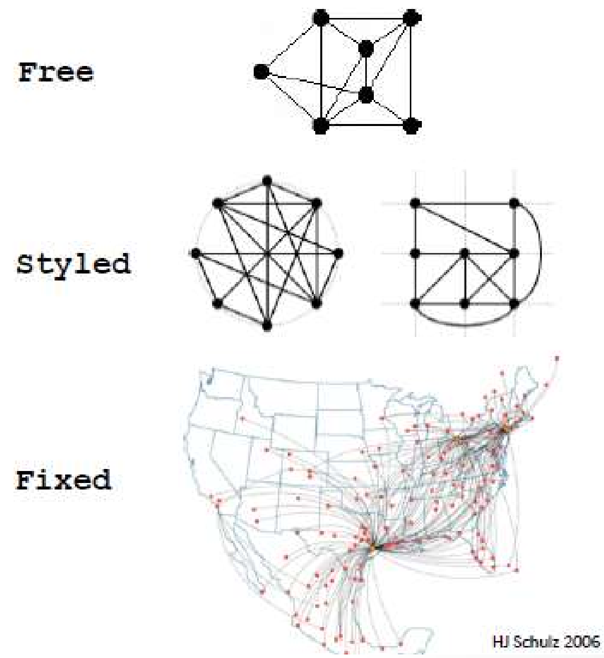
Other Criteria

- Predictability
  - Two different runs on similar graphs should lead to similar results
- Time Complexity
  - Real time interaction

Graph Representation

Node-link diagrams: vertex = point, edge = line/arc

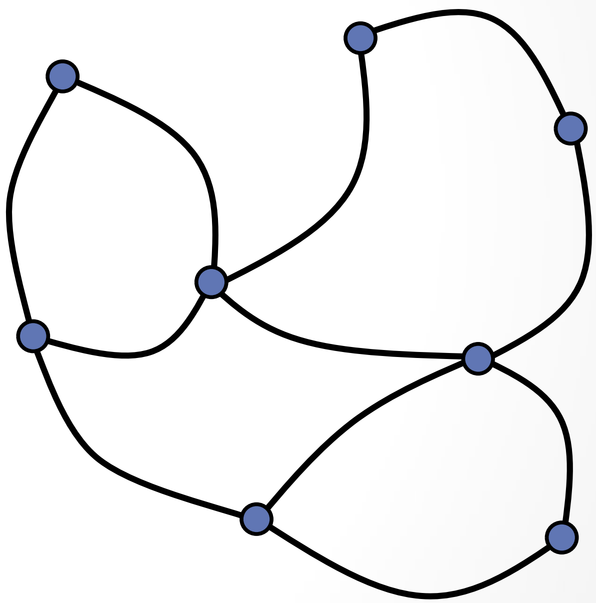




Planar drawings

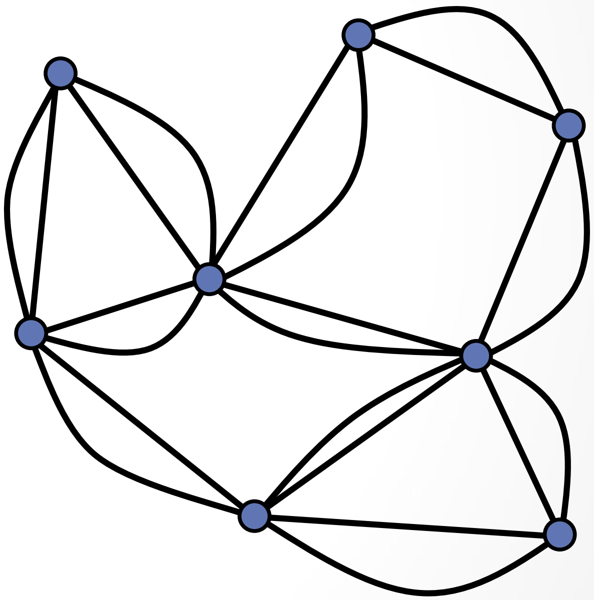
Vertices	points in the plane
Edges	curves

- No edge crossings



Straightline drawings

Vertices	points in the plane
Edges	straight lines



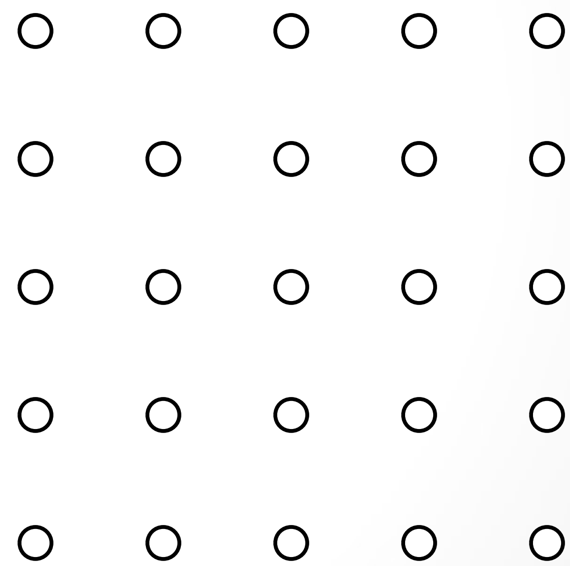
Theorem

Every planar graph has a plane embedding where each edge is a straight line.

[Wagner 1936, Fáry 1948, Stein 1951]

Grid Layout

Vertices	points in the plane on a grid
Edges	polylines, all vertices on the grid



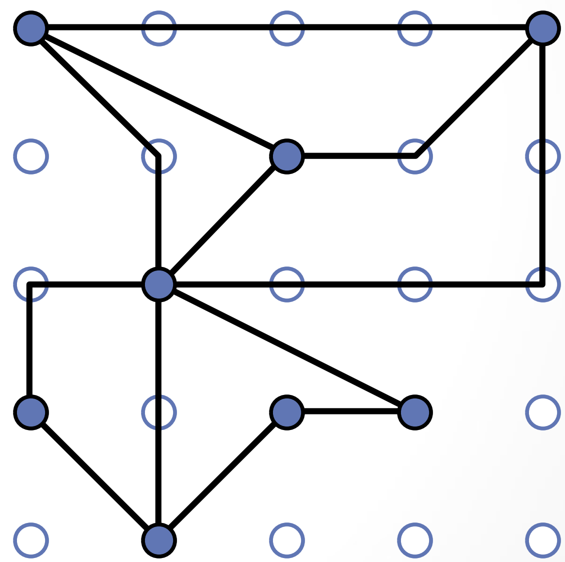
Grid Layout

Vertices — points in the plane on a grid

Edges — polylines, all vertices on the grid

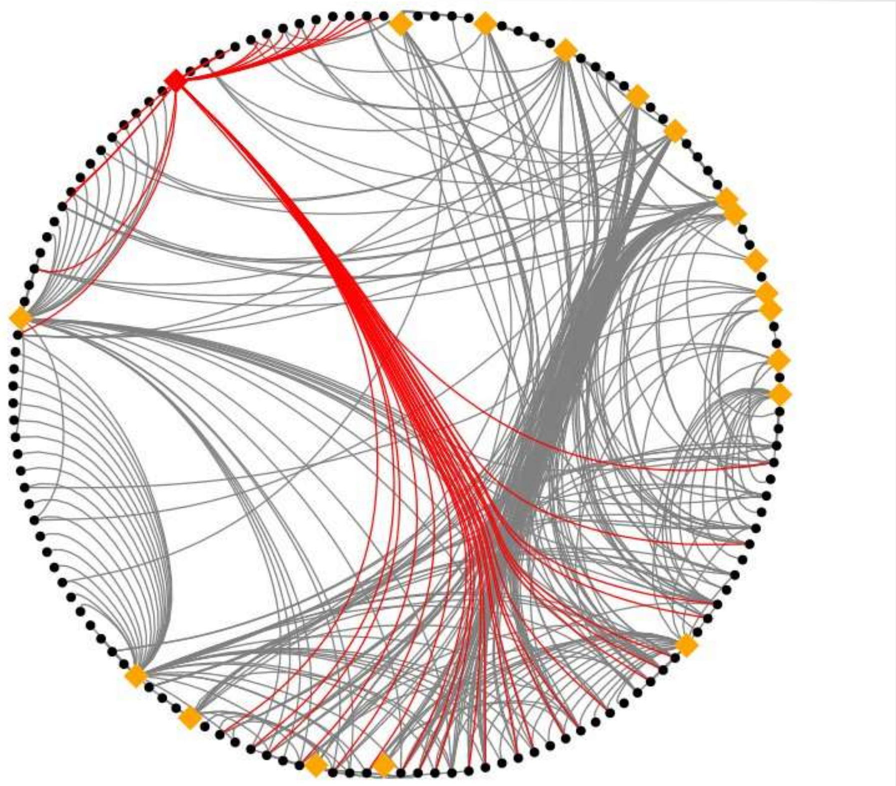
Objective

minimize grid size



Circular Layout

- **Circular layout** is a style of drawing that places the vertices of a graph on a circle, often evenly spaced so that they form the vertices of a regular polygon.
- Draw edges to connect vertices



Hierarchical Layout

Often called Sugiyama layout

Try to impose hierarchy on graph
- Reverse edges if needed to remove cycles
- Introduce dummy nodes

Put nodes into layers or levels
Order l->r to minimize crossings

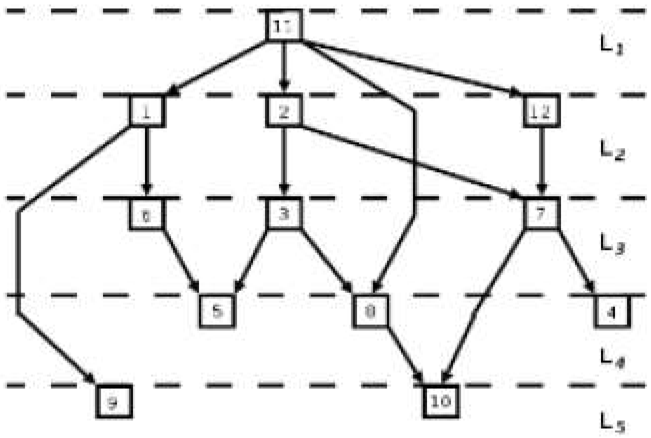


Figure: A graph showing a layered layout, created with the Sugiyama heuristic, with the layers shown. The bends in the edges correspond to dummy nodes.

Geography-based Layout

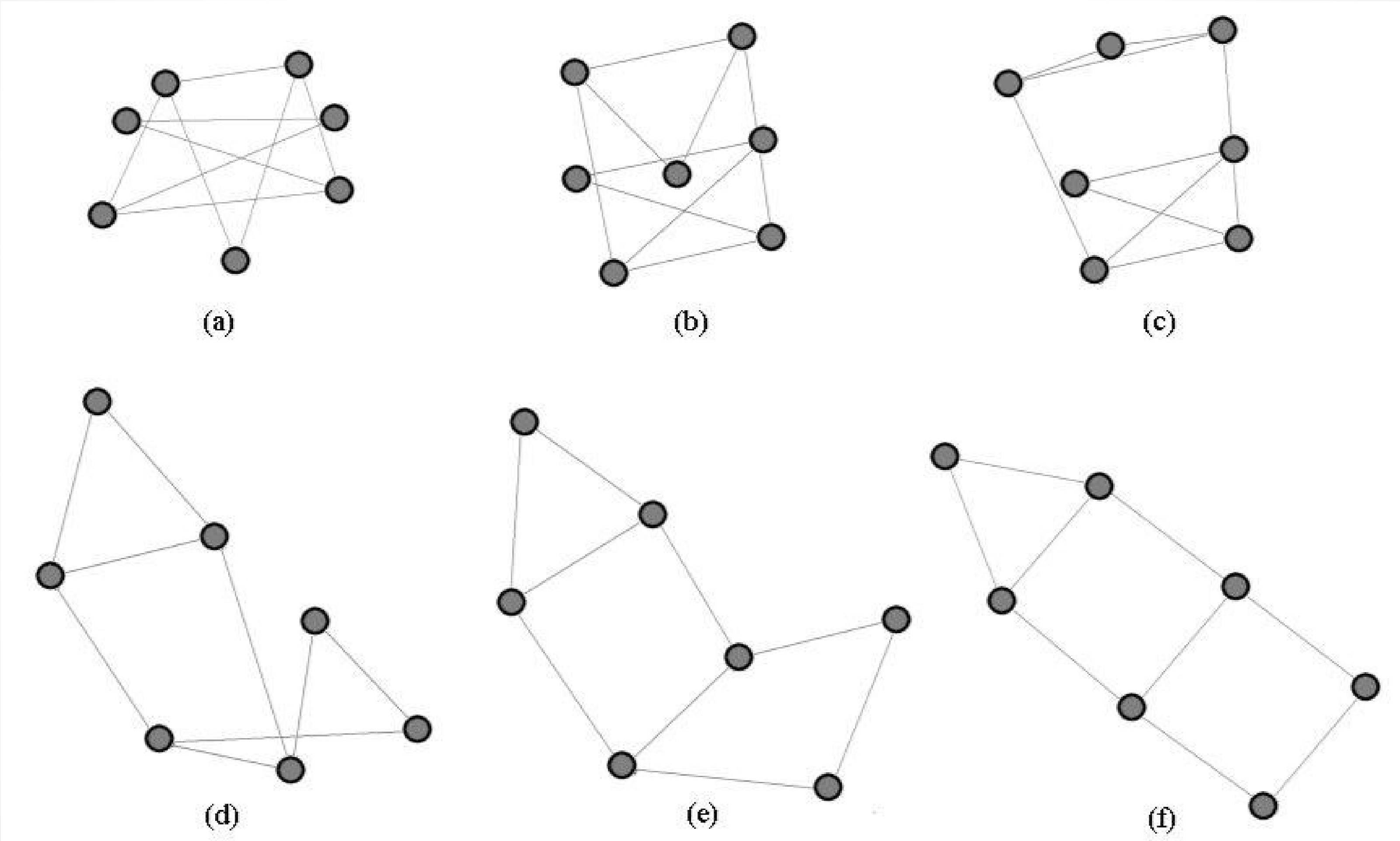
Force-directed Layouts

- Impose constraints (objectives) on layout
  - Shorten edges
  - Minimize crossings
- Define through equations
- Create optimization algorithm that attempts to best satisfy those equations
- Many variations

Spring Layout

- Spring model
  - Edges – Springs (gravity attraction)
  - Vertices – Charged particles (repulsion)
- Equations for forces (Force of attraction f_a & repulsion f_r)
  - $f_a = c_a \log(r)$ (c_a :Attraction factor, r: Distance between nodes)
  - $f_r = c_r / r^2$ (c_r : Replusion factor)
- Iteratively recalculate to update positions of vertices
- Seeking local minimum of energy
  - Sum of forces on each node is zero

Example



Fruchterman Reingold Algorithm

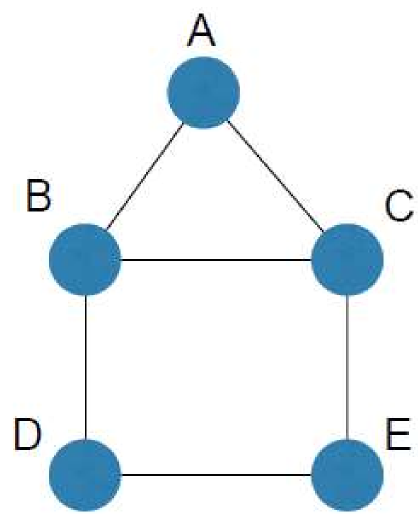
- Add global temperature
- If hot, nodes move further each step
- If cool, smaller movements
- Generally cools over time

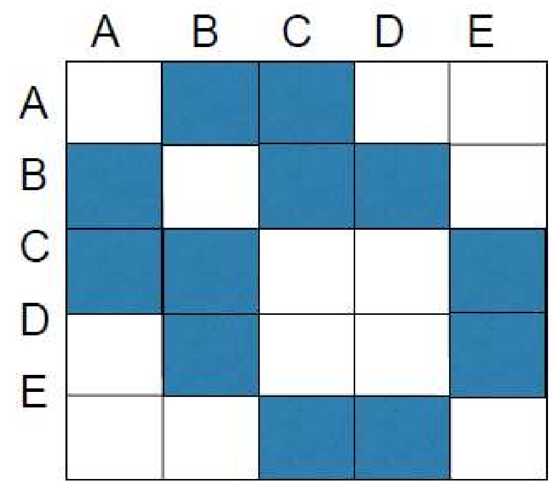
Force-directed Layouts – Evaluation

- Pros
  - Strong theoretical foundations
  - Simplicity: Few lines of code
  - Good results (till graphs of about 1000 nodes)
- Cons
  - Computationally expensive
    - For interactive visualization limit is about 1000 nodes
    - High time complexity: > $O(N^3)$
  - Not predictable

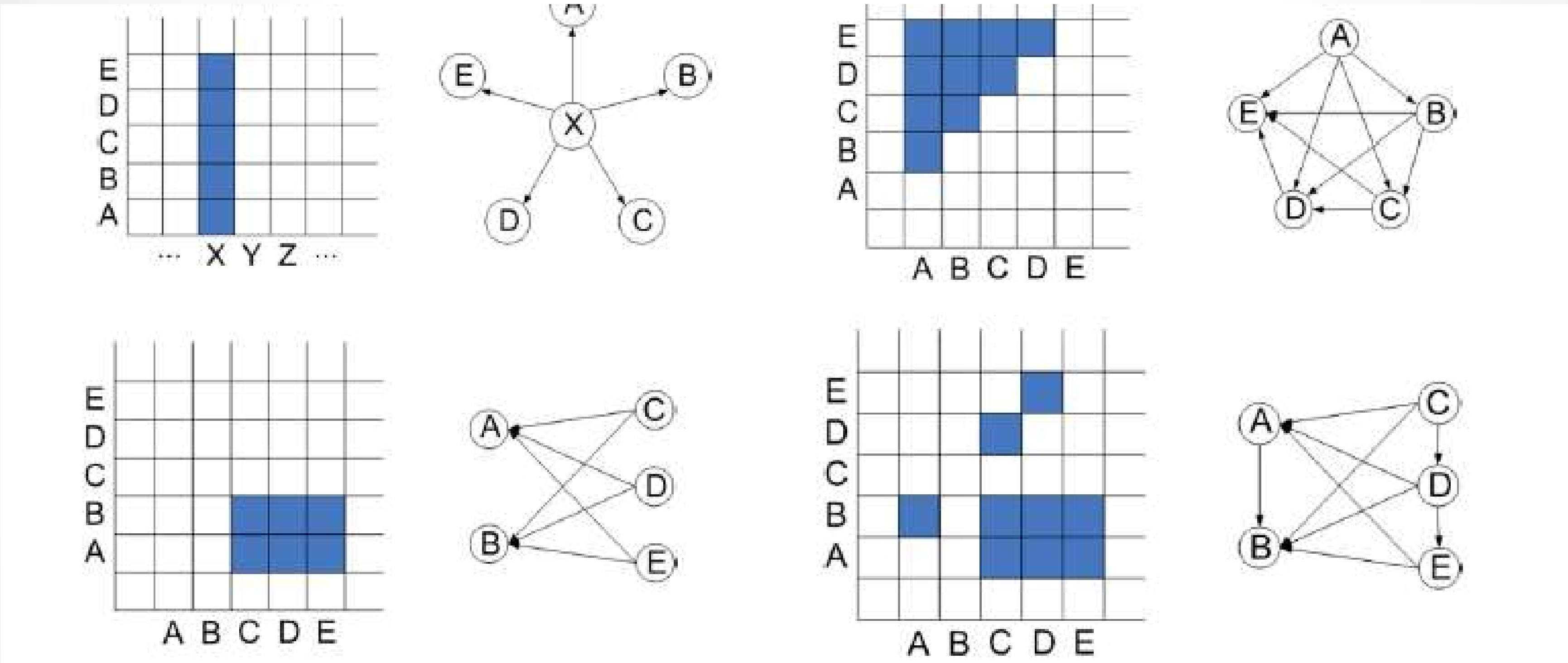
Matrix Representation

Instead of node link diagram, use adjacency matrix

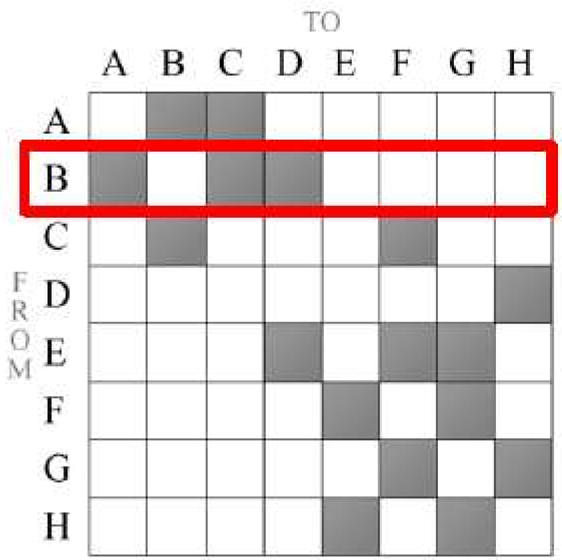




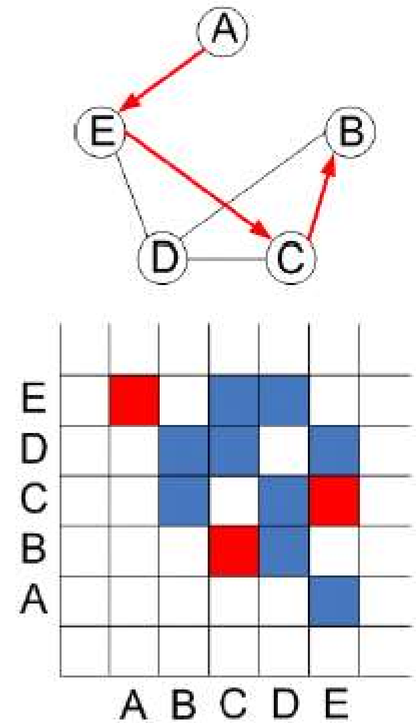
Examples



Matrix Representation - Evaluation

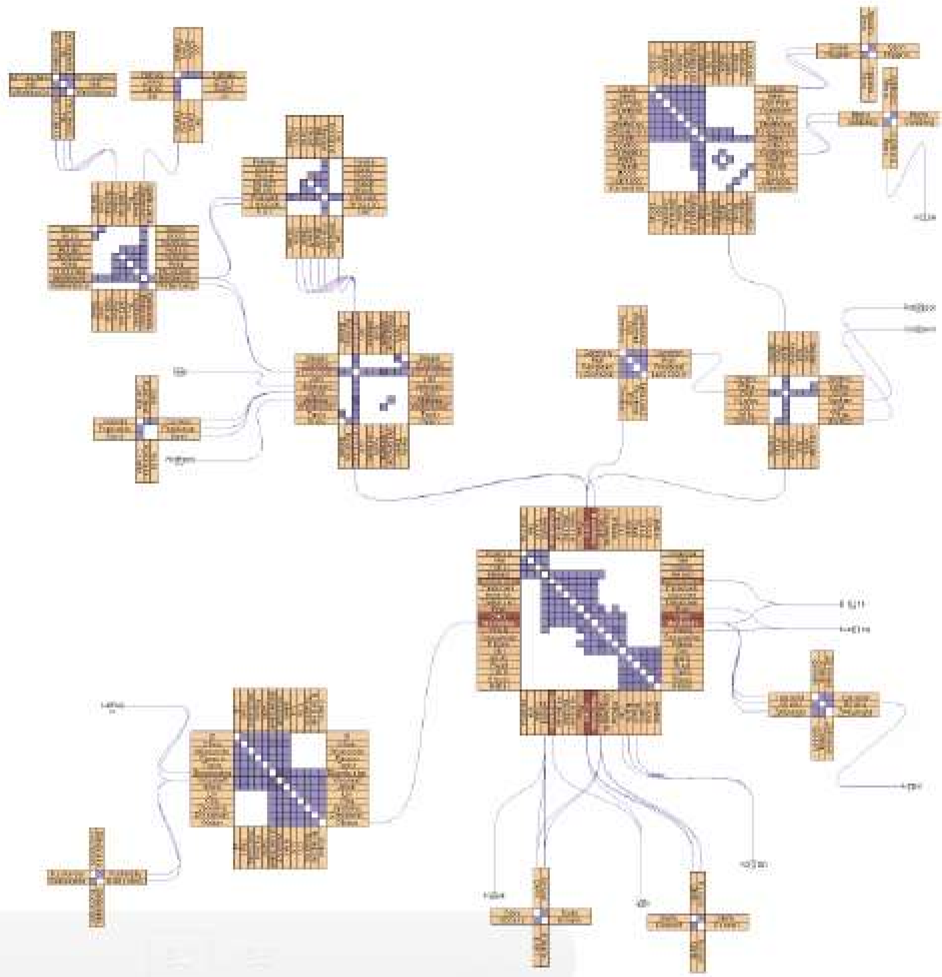


Well suited for
neighborhood-related TBTs



Not suited for
path-related TBTs

NodeTrix



Hybrid of matrix
and node-link

Henry & Fekete
TVCG (InfoVis) '07

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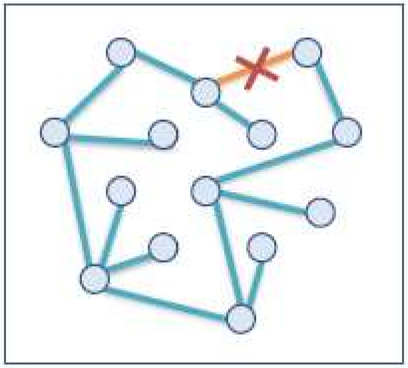
- Graph Layouts
  - **Tree Layout**
- Interaction
- Tools

Spanning Trees

- Graph can be visualized through minimum spanning tree
  - Additional edges added later
  - Very common technique
  - Helps with predictability
  - Visualization depends on starting point

Tree

- A Tree is a graph with no cycles
  - Nodes have parent and children
  - Root: Node with no parent
  - Leaves: Nodes with no children



Tree Visualization Approaches

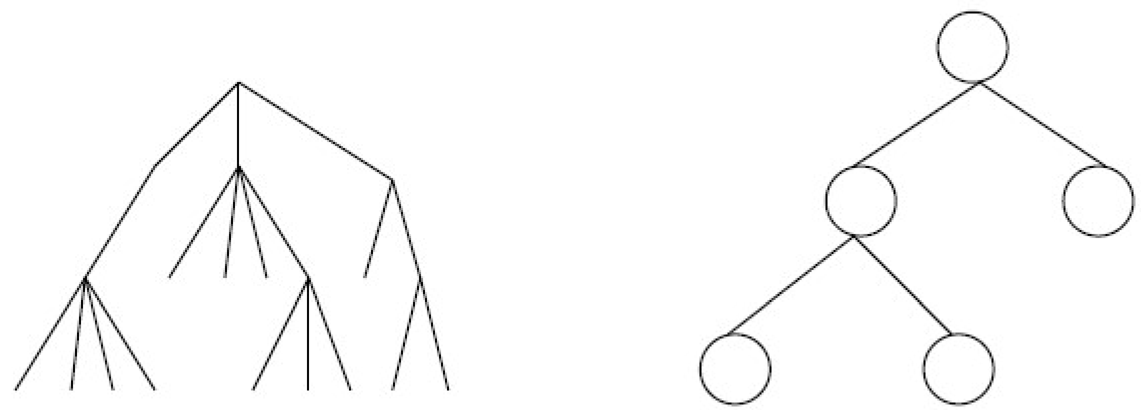
- Node and Link
- Space Filling

Tree Visualization Approaches

- Node and Link
- Space Filling

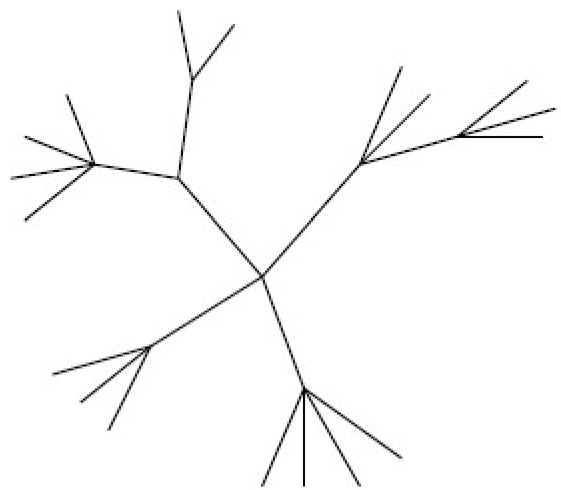
Node link diagram

- Root at top, leaves at bottom is very common

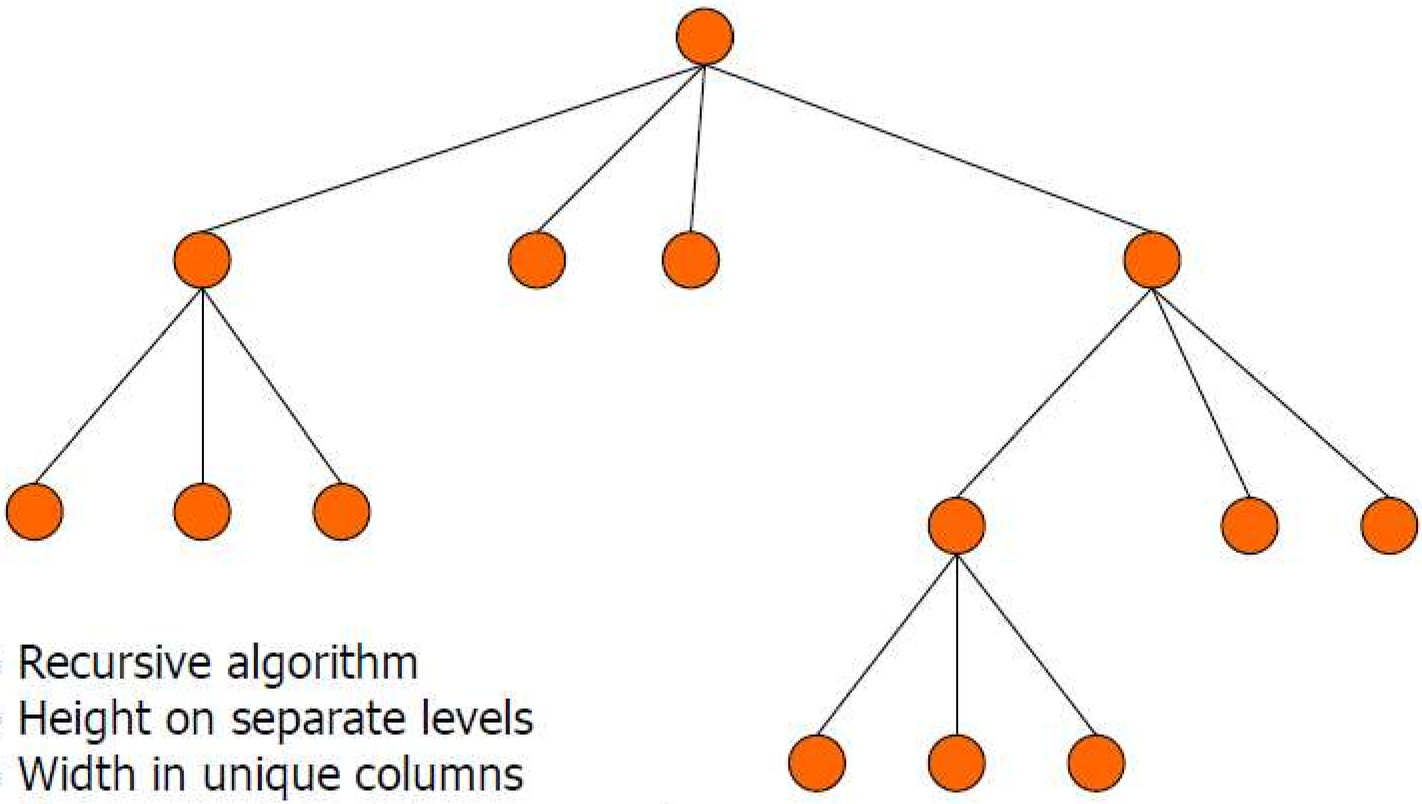


Radial Layout

- Root can be at center with levels growing outward too



Basic Algorithm



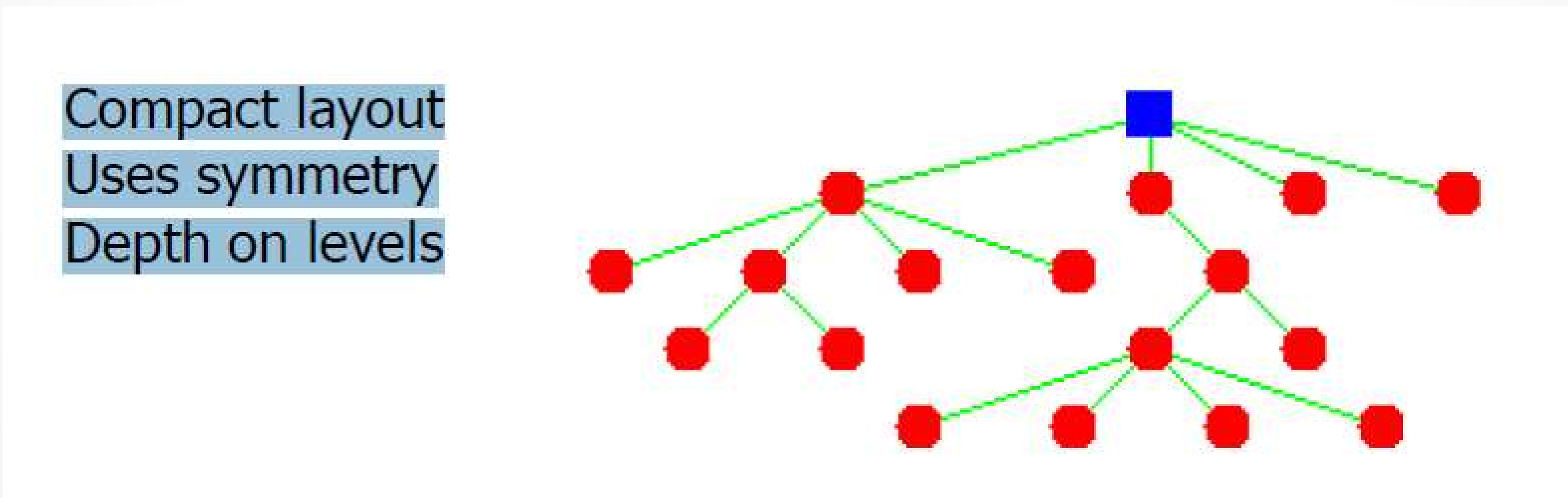
- Recursive algorithm
- Height on separate levels
- Width in unique columns
- Make room for subtrees upwards

Potential Problems

- For top-down, width of fan-out uses up horizontal real estate very quickly
  - At level n, there are 2n nodes
- Tree might grow a lot along one particular branch
  - Hard to draw it well in view without knowing how it will branch

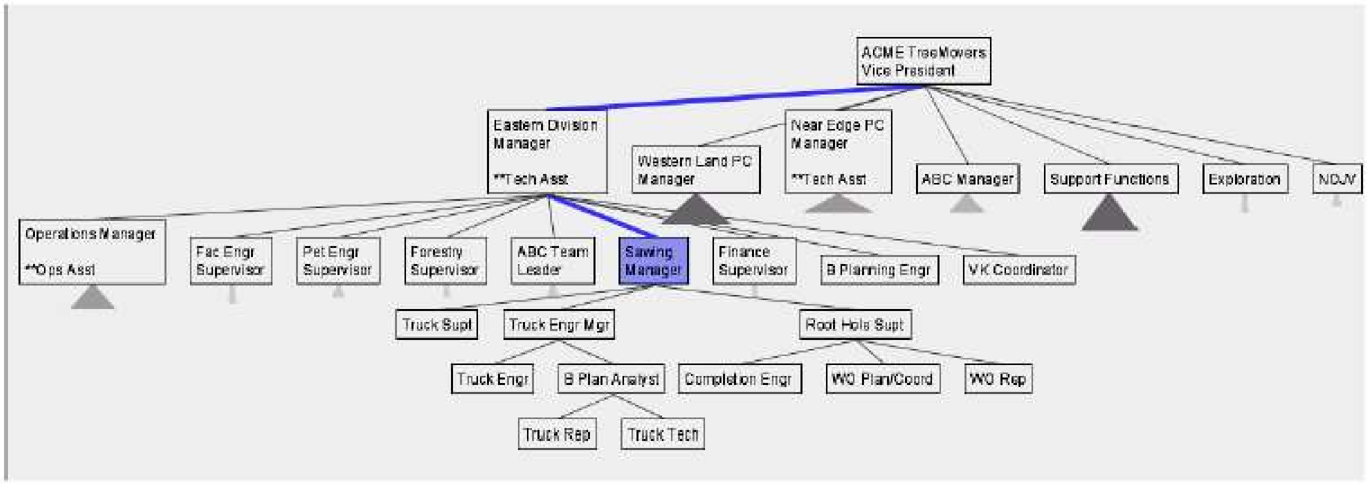
Reingold-Tilford Algorithm

- Recursive algorithm based on Post-order Traversal of Trees
- Isomorphic subtrees laid out in same way



Space Tree

- Uses conventional 2D layout techniques with some clever additions



- Subtrees are triangles
  - Size indicates depth
  - Shading indicates number of nodes inside
- Navigate by clicking on nodes

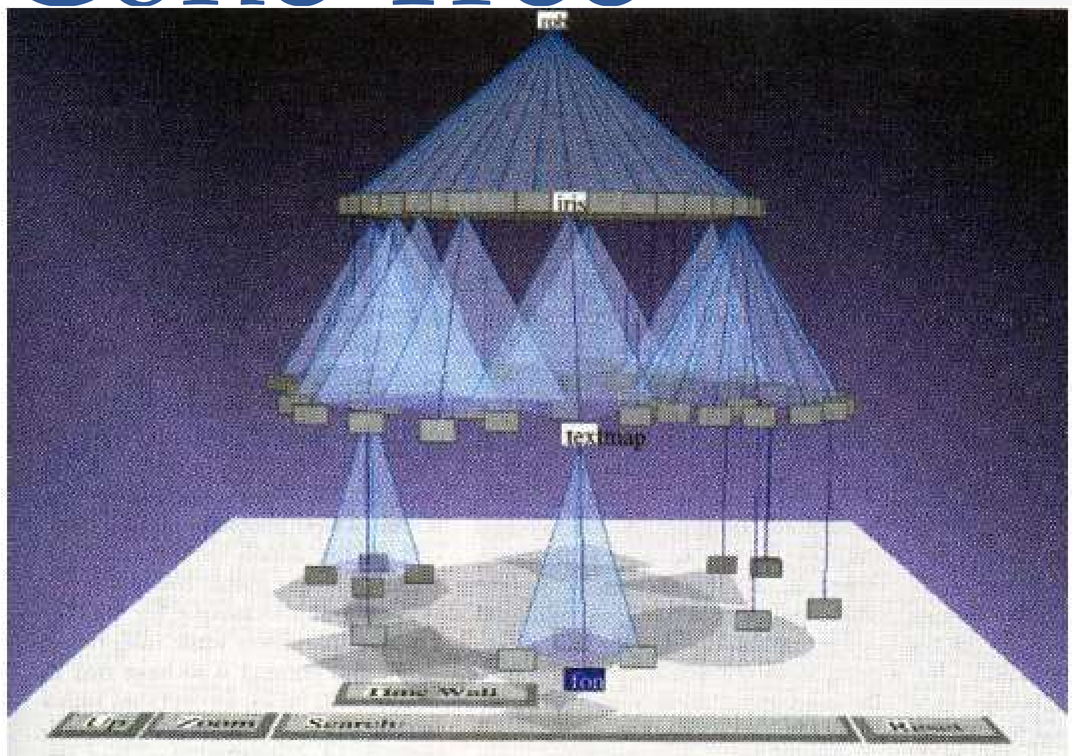
3D Approach

- 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 cone “below” the parent
    - Siblings live in one of the 2D planes

Cone Tree

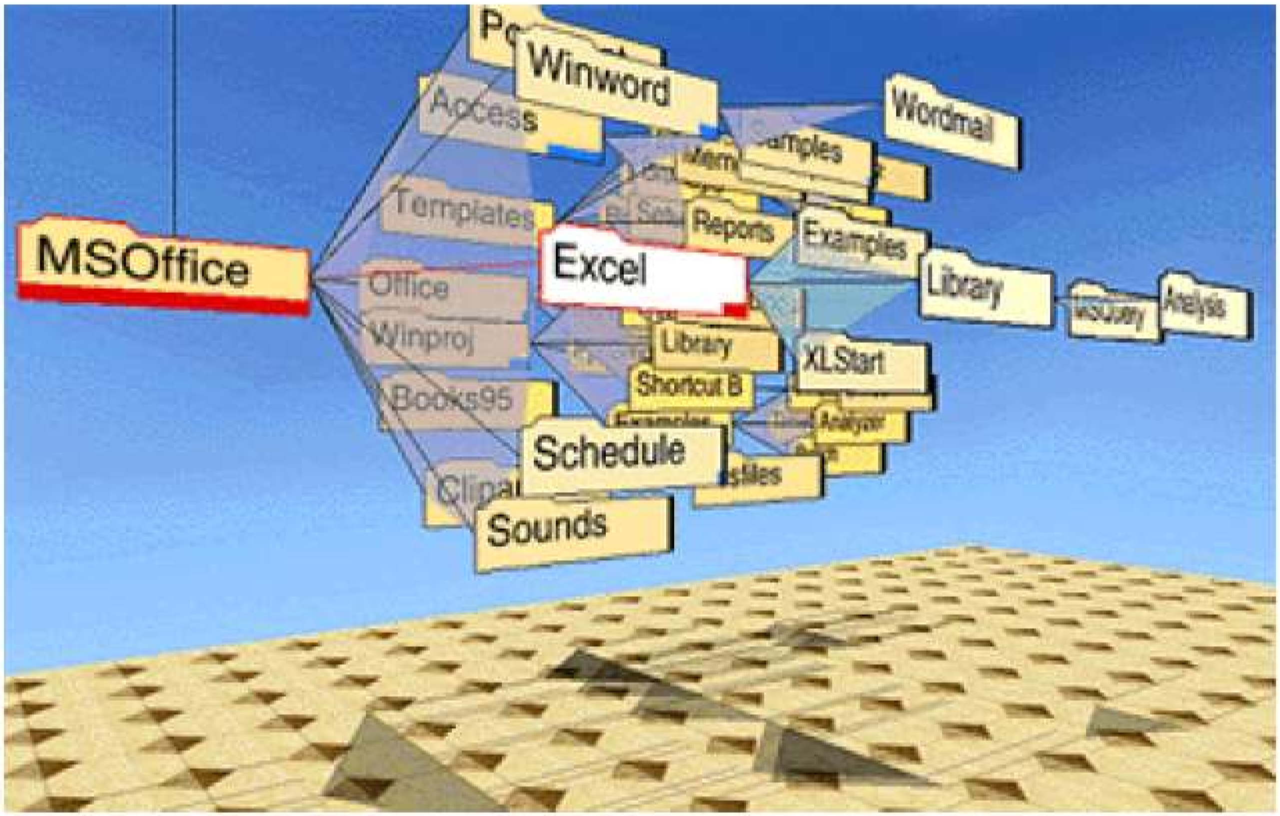
Developed at Xerox PARC

3D views of hierarchies such as file systems



Robertson, Mackinlay, Card

Alternate View



Cone Tree - Evaluation

- Pros
  - More effective area to lay out tree
  - Use of smooth animation to help person track updates
  - Aesthetically pleasing

- Cons
  - As in all 3D, occlusion obscures some nodes
  - Non-trivial to implement and requires some graphics horsepower

Tree Visualization Approaches

- Node and Link
- Space Filling

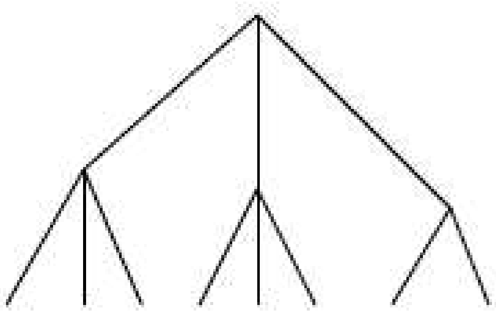
Node-Link Shortcoming

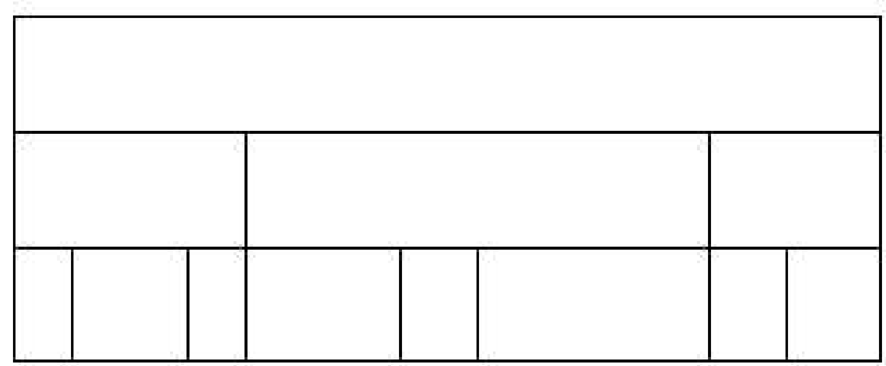
- Difficult to encode more variables of data cases (nodes)
  - Shape
  - Color
  - Size
- …but all quickly clash with basic node-link structure

Space Filling Representation

Each item occupies an area

Children are "contained" under parent

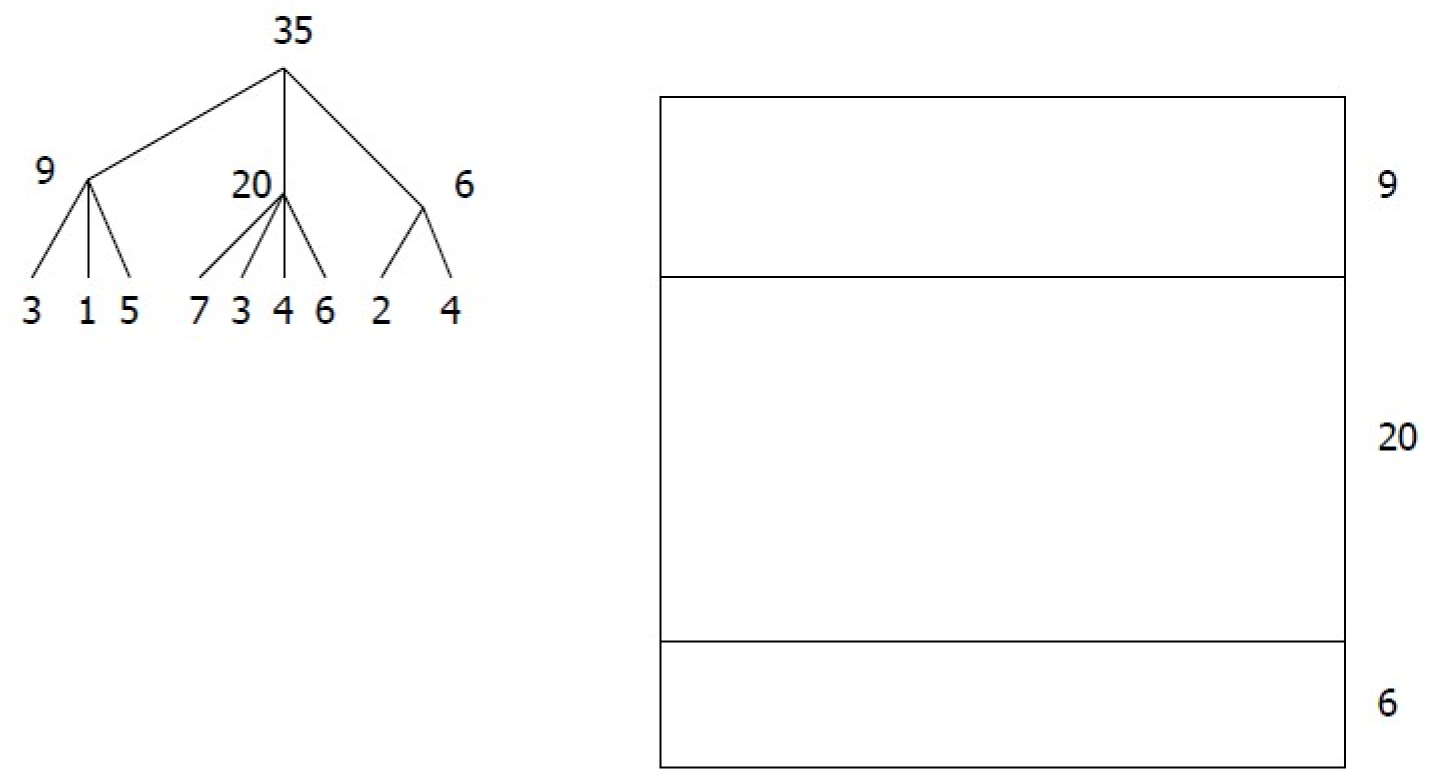




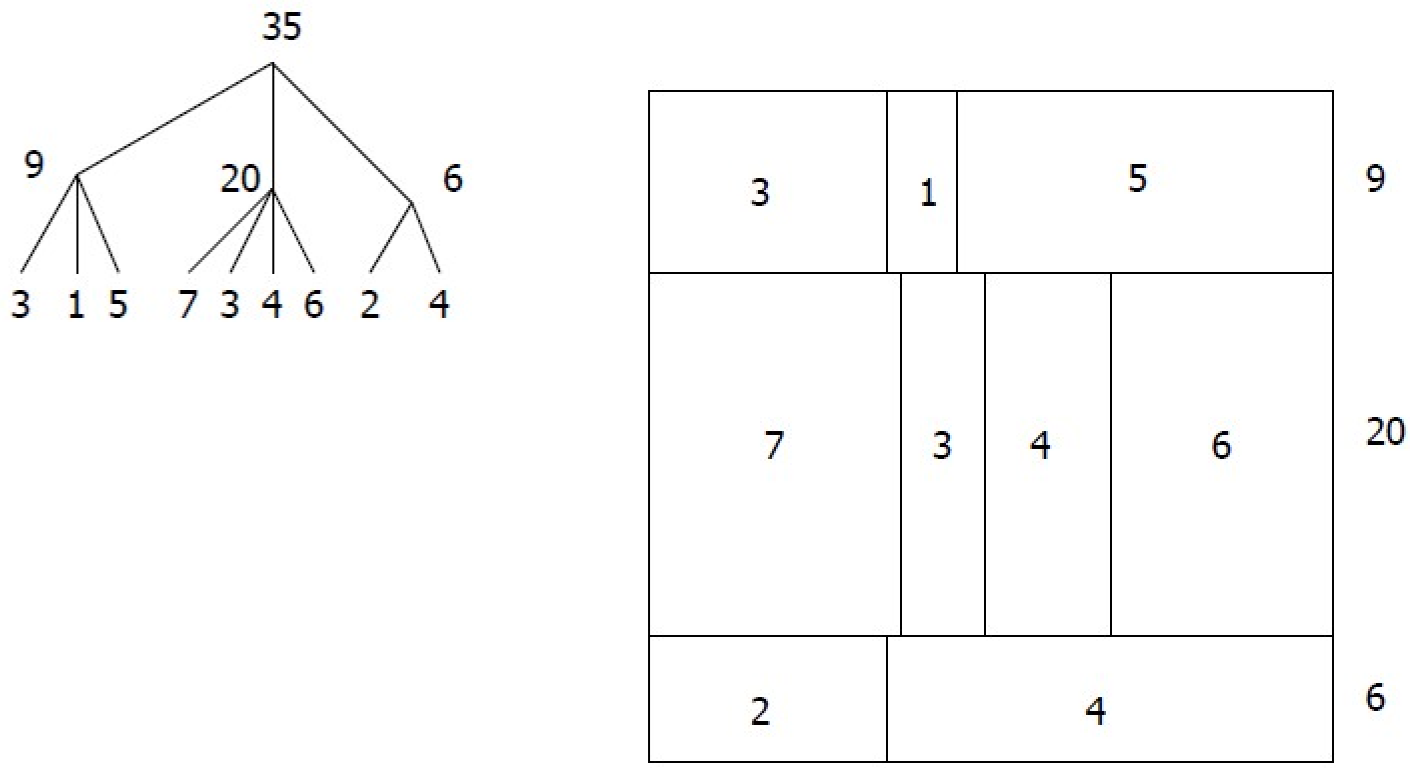
Treemap

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

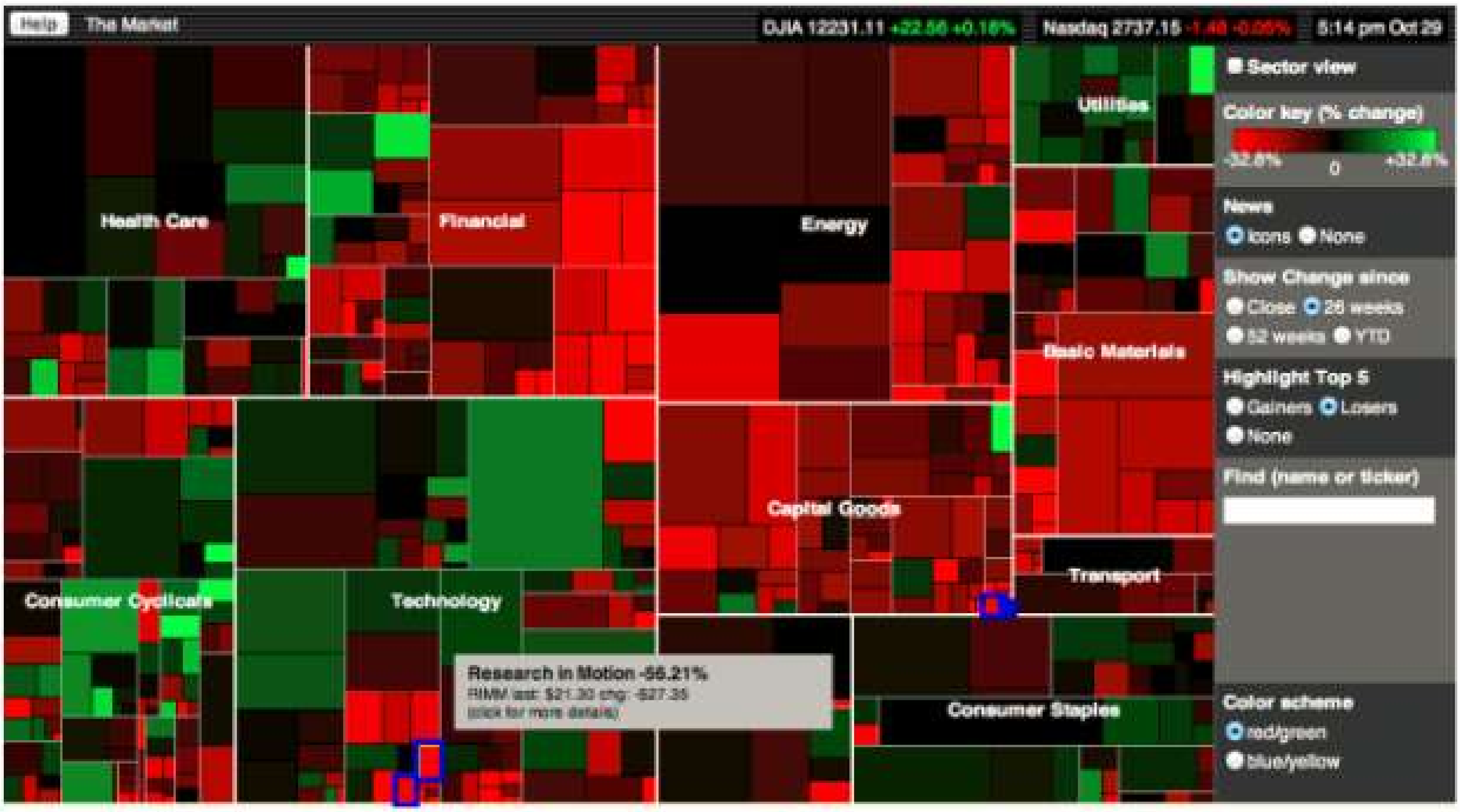
Example



Example

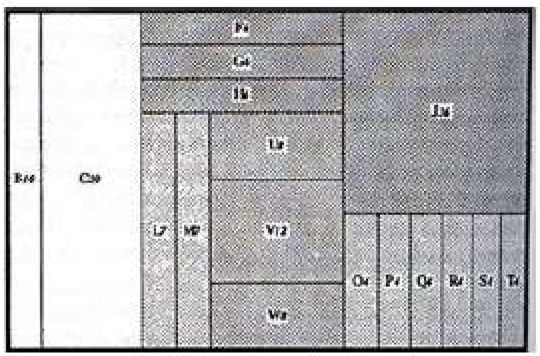


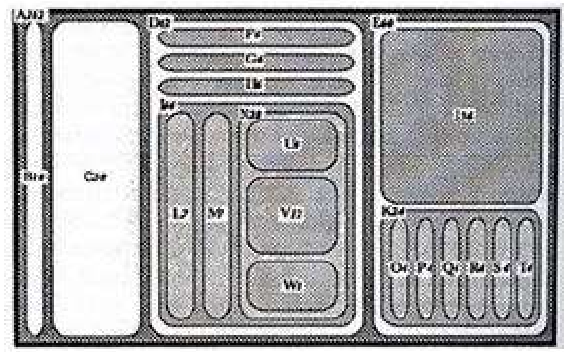
Example



Map Of The Market (Source: SmartMoney website)

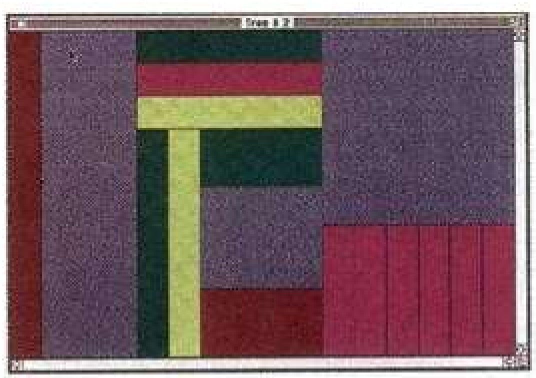
Nested vs Non-nested

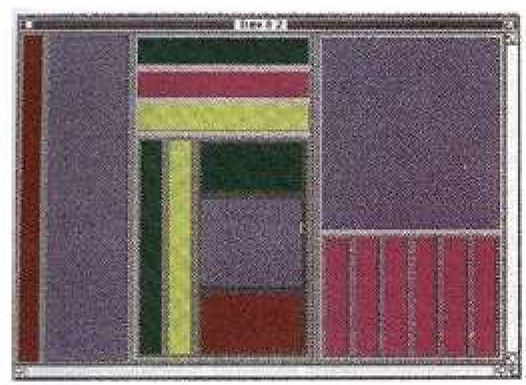




Non-nested Tree-Map

Nested Tree-Map





Treemap - Evaluation

- 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

Node-link or Space filling?

- Node-link typically better at exposing the structure of information space
- Space-filling good for focusing on one or two additional variables of cases

Reading

1. Fruchterman and Reingold: **Graph Drawing by Force-directed Placement** Available at: *http://reingold.co/force-directed.pdf*

2. Henry and Fekete: **NodeTrix: A Hybrid Visualization of Social Networks** Available at: http://research.microsoft.com/en-us/um/people/nath/docs/Henry_infovis07.pdf

3. Reingold and Tilford: **Tidier Drawings of Trees** Available at: http://reingold.co/tidier-drawings.pdf

4. Robertson, Mackinlay and Card: **Cone Trees: Animated 3D visualizations of Hierarchical Information** Available at: http://www2.parc.com/istl/groups/uir/publications/items/UIR-1991-06-Robertson-CHI91-Cone.pdf

5. Johnson and Shneiderman: **Tree Visualization with Tree-maps: 2-d space-filling approach** Available at: https://www.cs.umd.edu/users/ben/papers/Johnson1991Tree.pdf

s

Visualizing Social Networks

- Introduction to Visualization
- Graph Visualization
- Graph Layouts
- **Interaction**
- Tools

Moving beyond Graph Layout

- One of the key ways we move beyond graph layout to graph visualization (InfoVis) is interaction with the graph
- Interaction is essential for understanding large graphs
- We can utilize various techniques

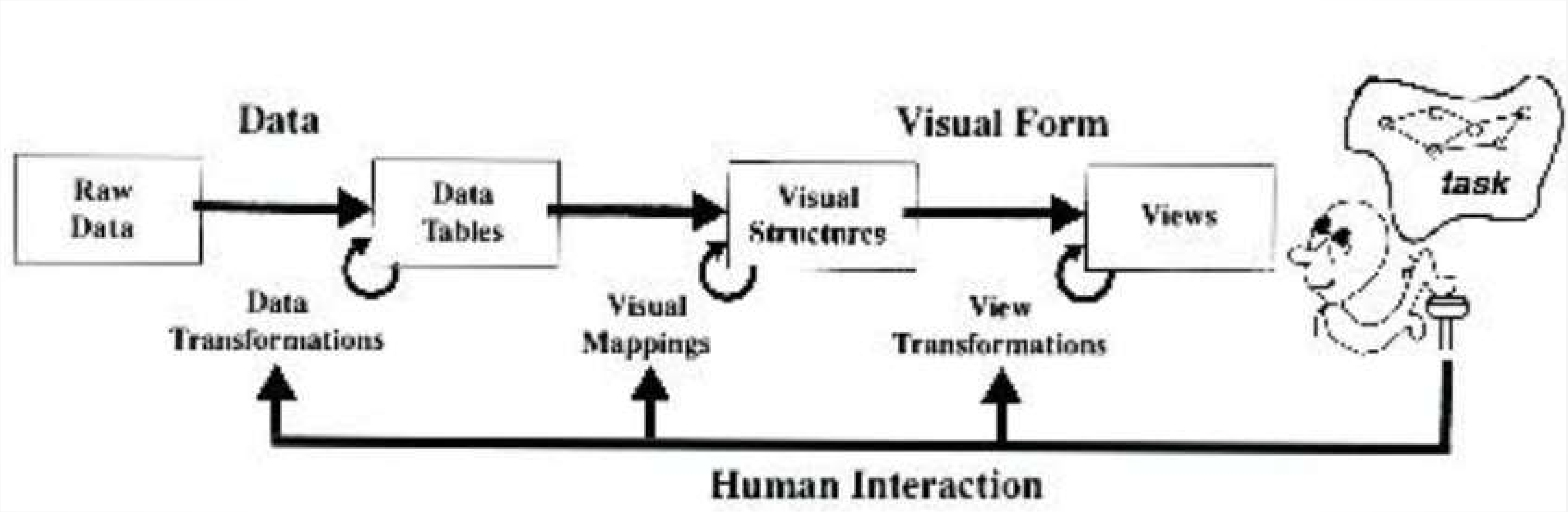
Interaction

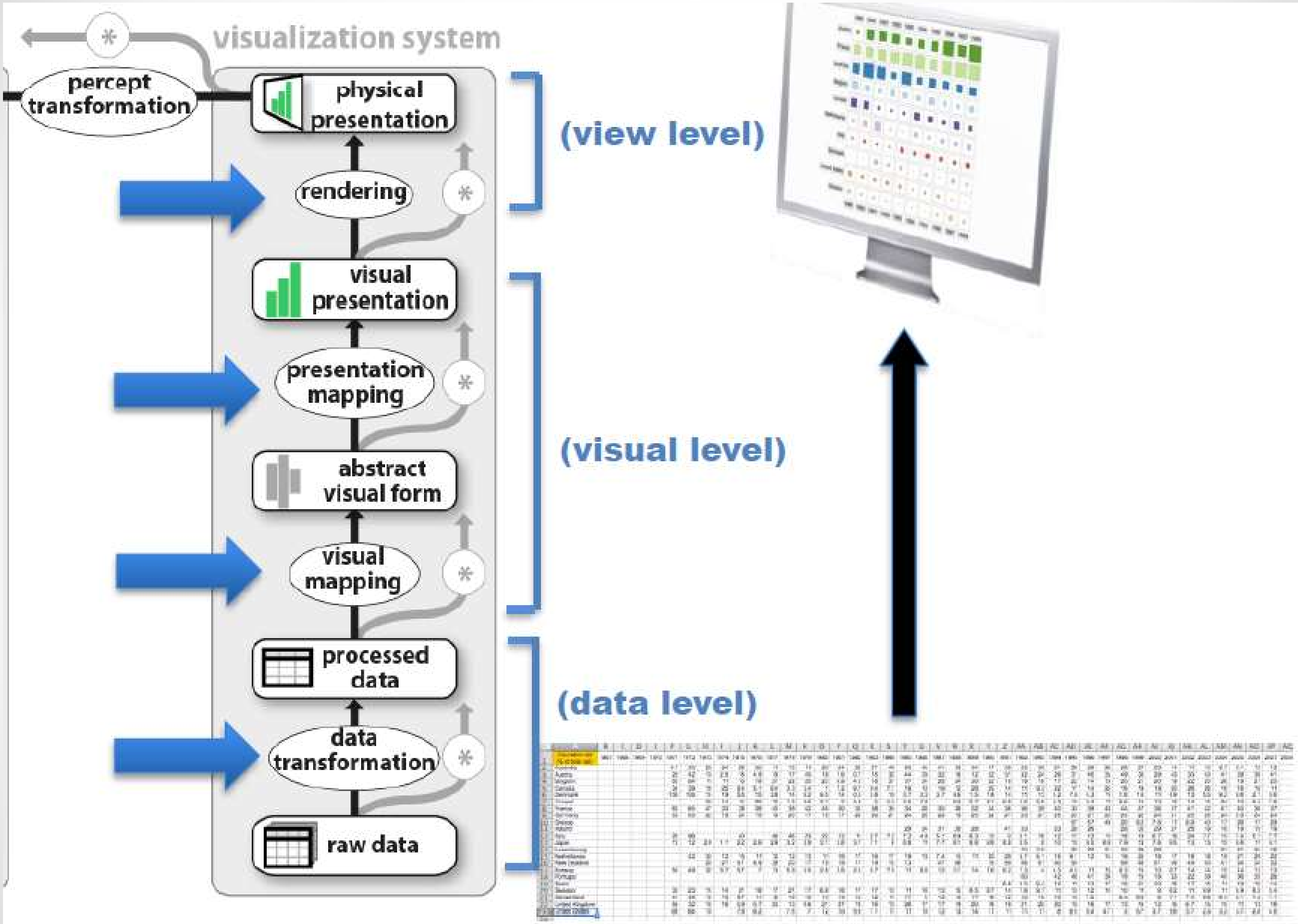
- "The effectiveness of information visualization hinges on two things: its ability to clearly and accurately represent information and our ability to interact with it to figure out what the information means."
  - S. Few Now You See It, p. 55

- What is Interaction?
  - "The communication between user and the system" [Dix et al., 1998]
  - "Direct manipulation and instantaneous change" [Becker et al., 1987]

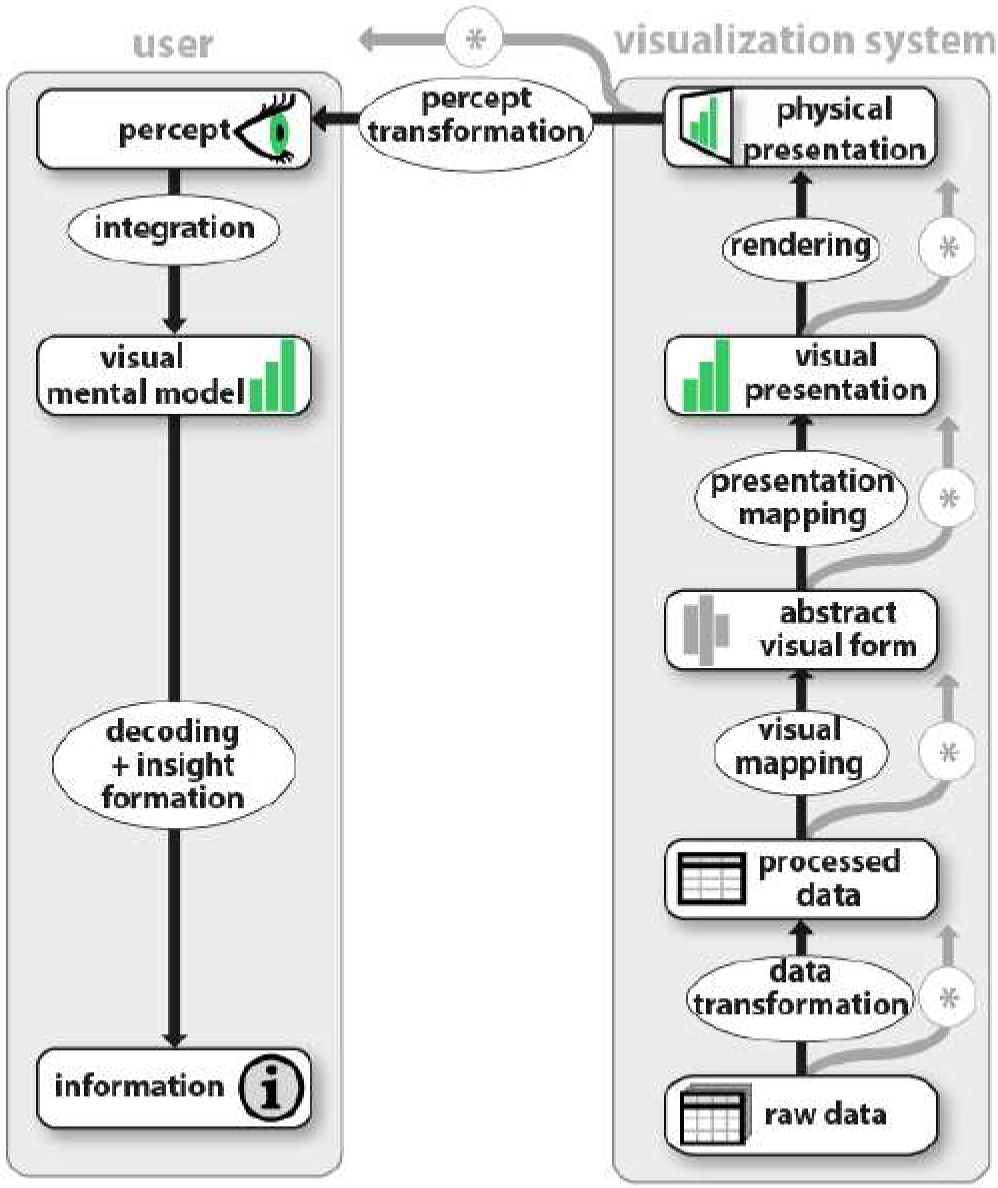
- There is too much to be shown
- There are many ways to show it
  - **Let the user dynamically control what to show and how to show it**

The Visualization Pipeline





visualization system
percept transformation
physical presentation
rendering
visual presentation
presentation mapping
abstract visual form
visual mapping
processed data
data transformation
raw data
(view level)
(visual level)
(data level)



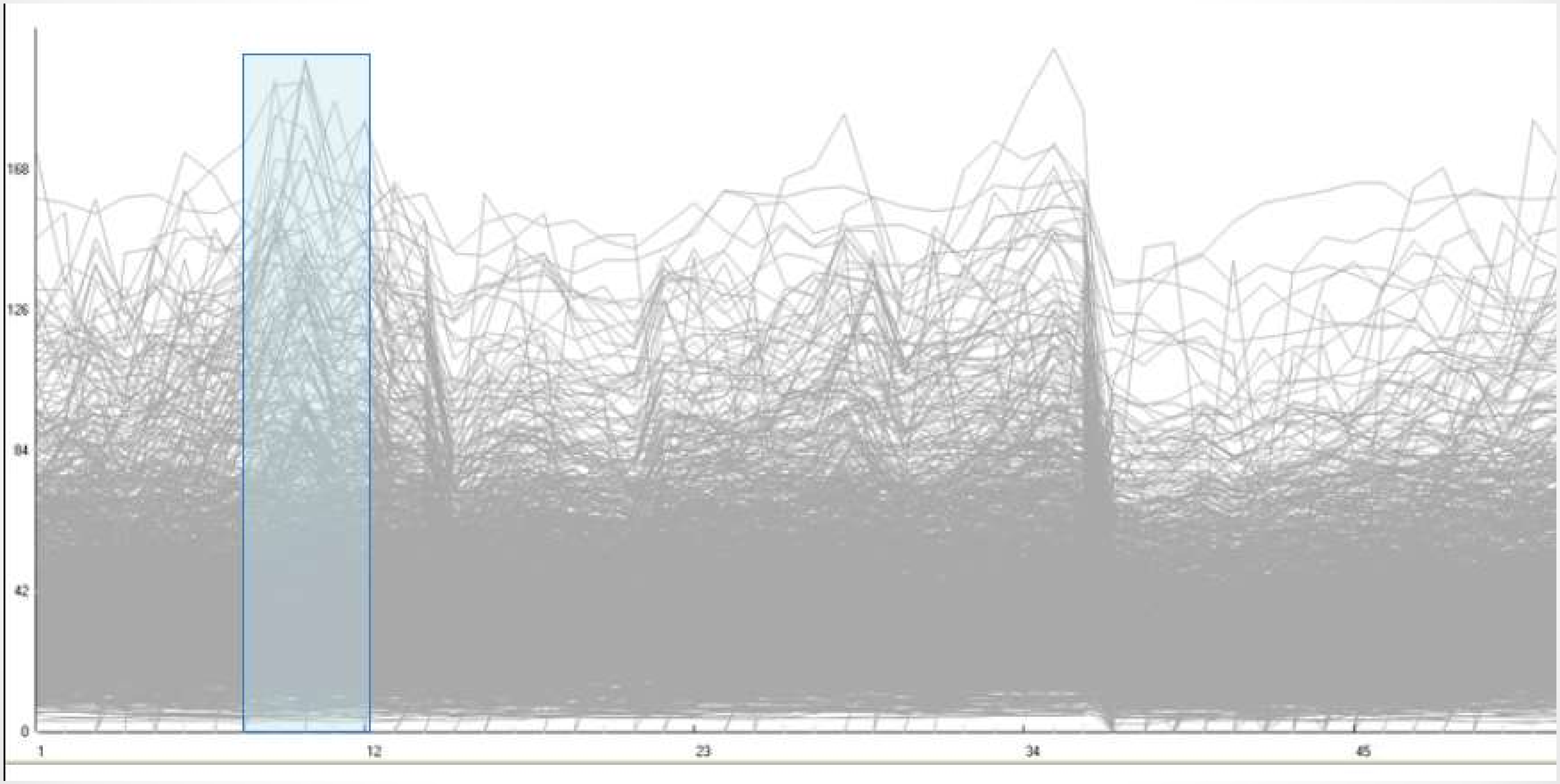
Jansen and Dragicevic 2013 (www.aviz.fr/beyond)

Analytical Tasks

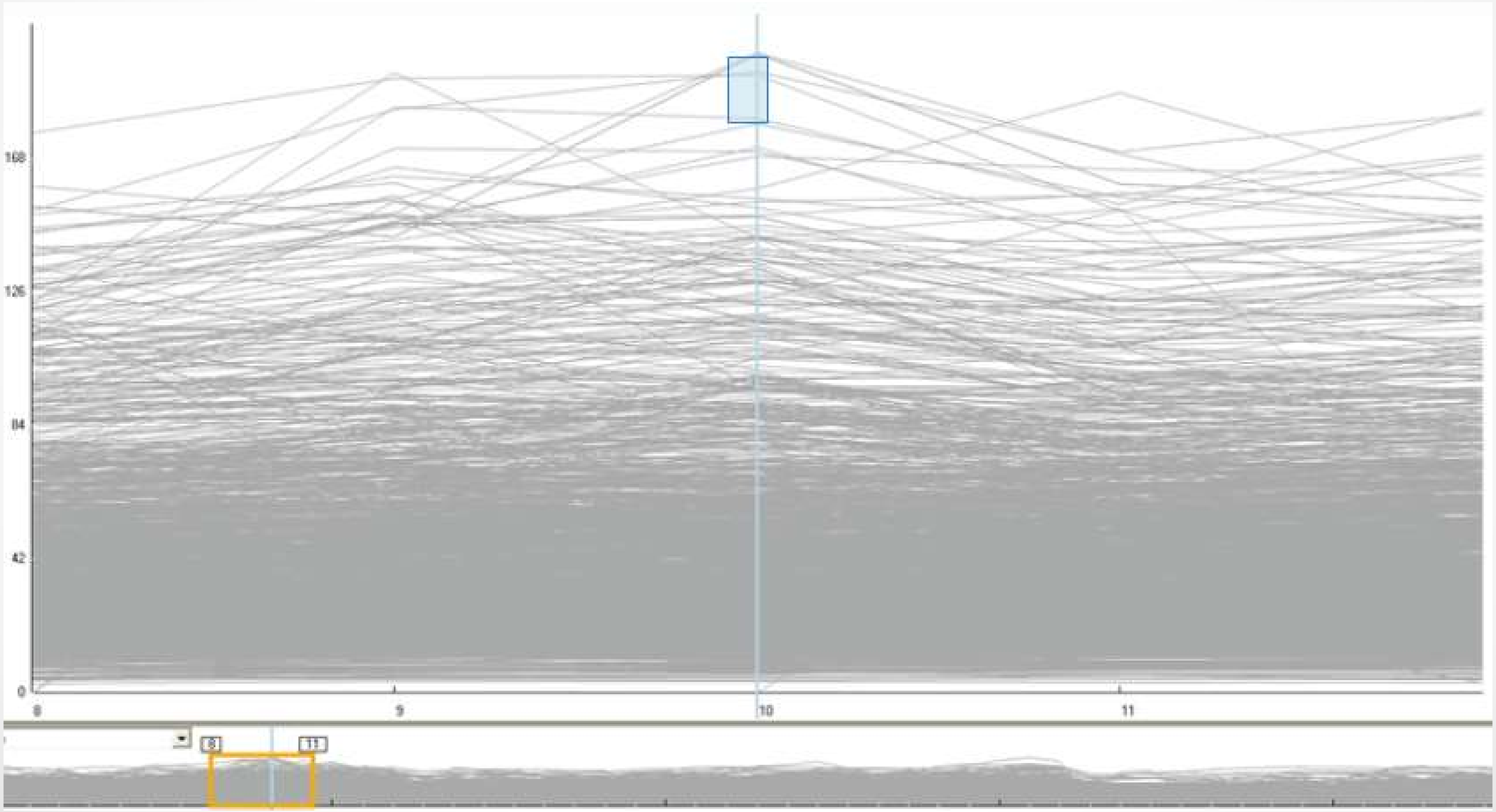
1. **Overview:** Gain an overview of the entire collection
2. **Zoom :** Zoom in on items of interest
3. **Filter:** Filter out uninteresting items
4. **Details-on-demand:** Select an item or group and get details when needed
5. **Relate:** View relationships among items
6. **History:** Keep a history of actions to support undo, replay, and progressive refinement
7. **Extract:** Allow extraction of sub-collections and of the query parameters

- Shneiderman, 1996

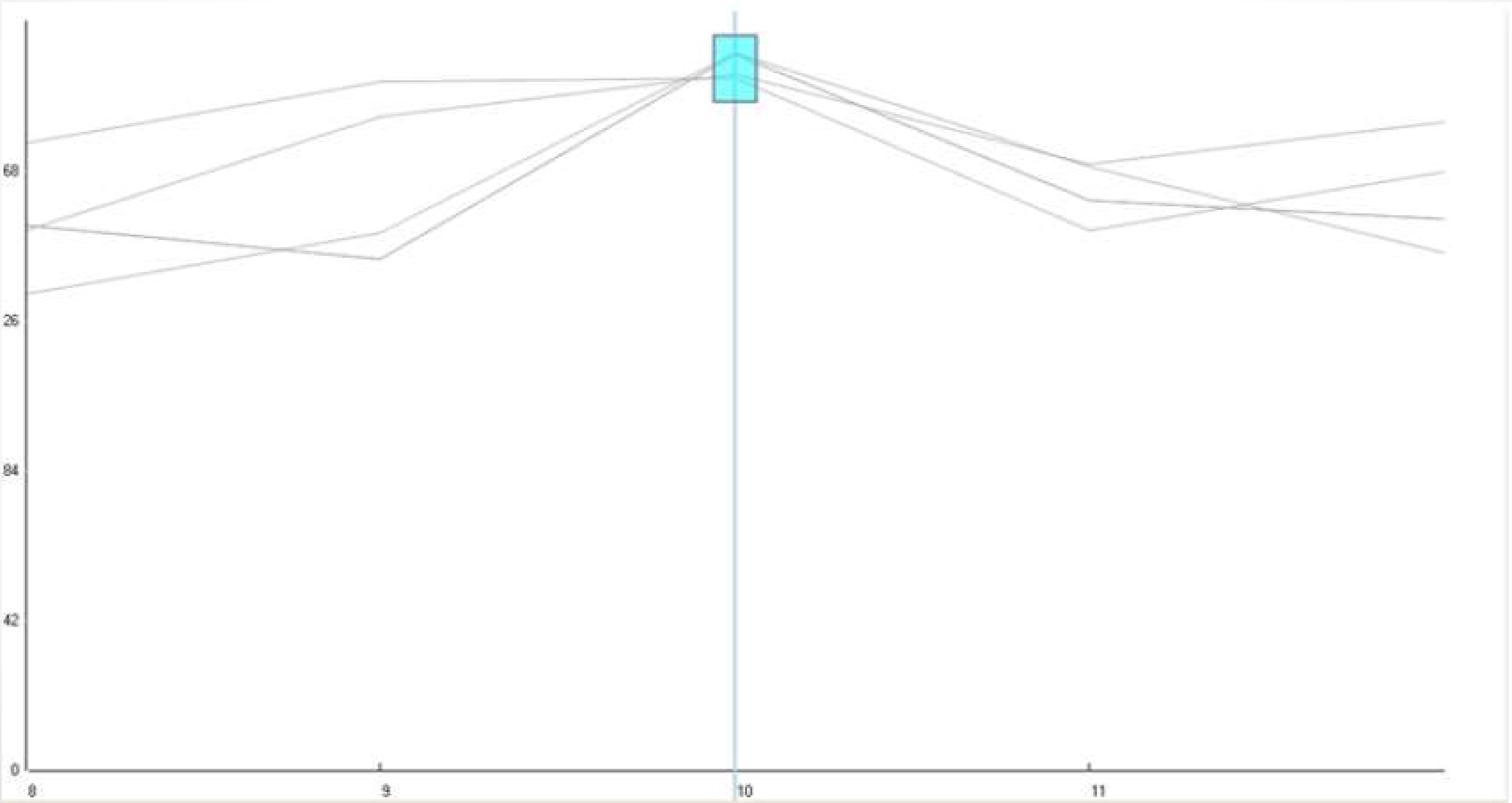
Overview



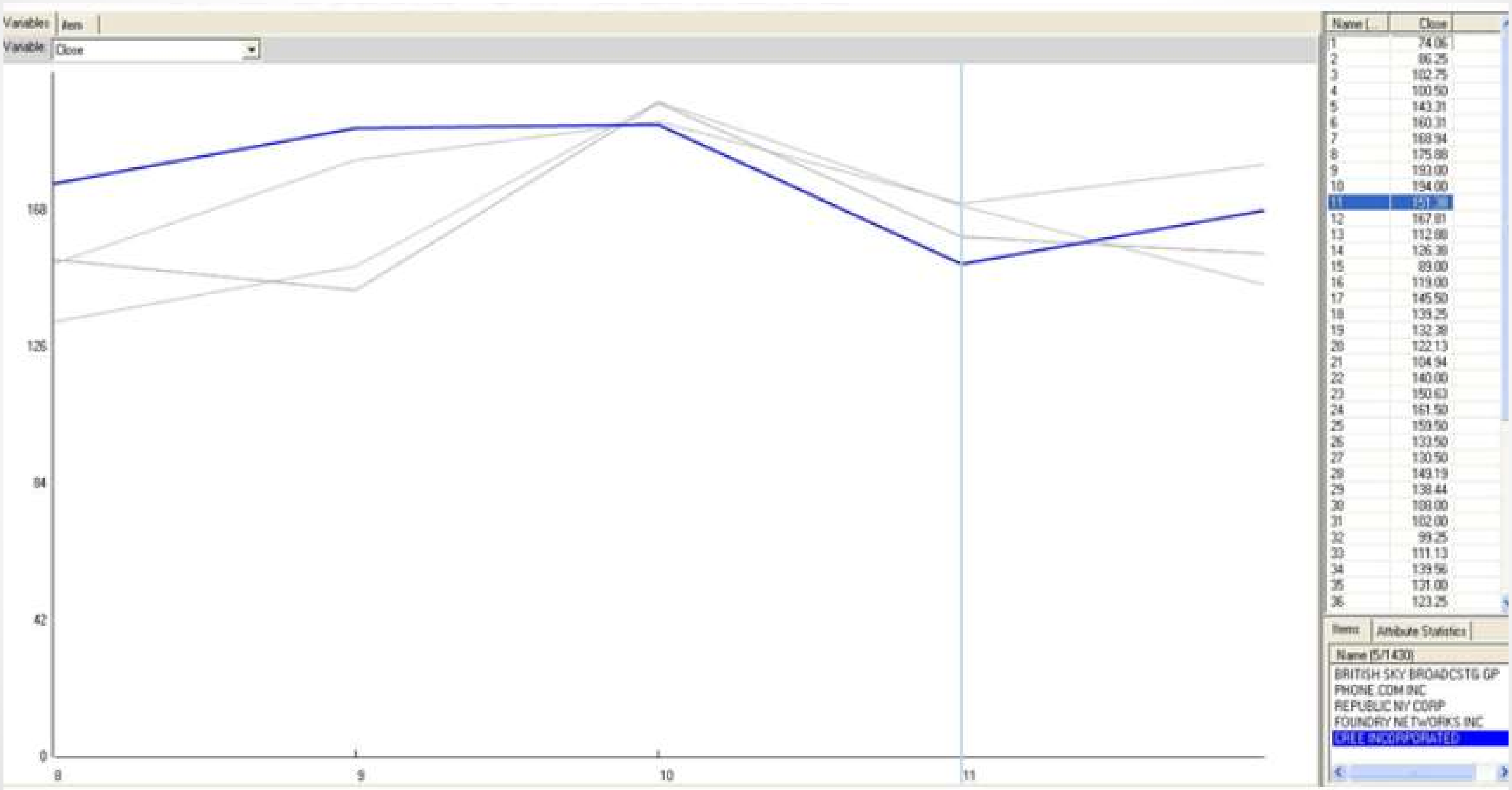
Zoom & Filter



Zoom & Filter



Details on Demand



Interaction Technique

- "An interaction technique is the fusion of **input and output**, consisting of all **software and hardware** elements, that provides a way for the user to accomplish a task"
  - Tucker, 2004

- Types of interaction techniques
  - **Command-line interfaces**
  - **Input**: mouse, touch, keyboard, speech,...
  - Direct manipulation interfaces

Families of Infovis Interaction Techniques

- Selection
- Rearrangement
- Filtering techniques
- Navigation techniques
- Multiple views

Select

- "Mark something as interesting"
- Mark items of interest to keep track
- Seems to often work as a preceding action to subsequent operations.

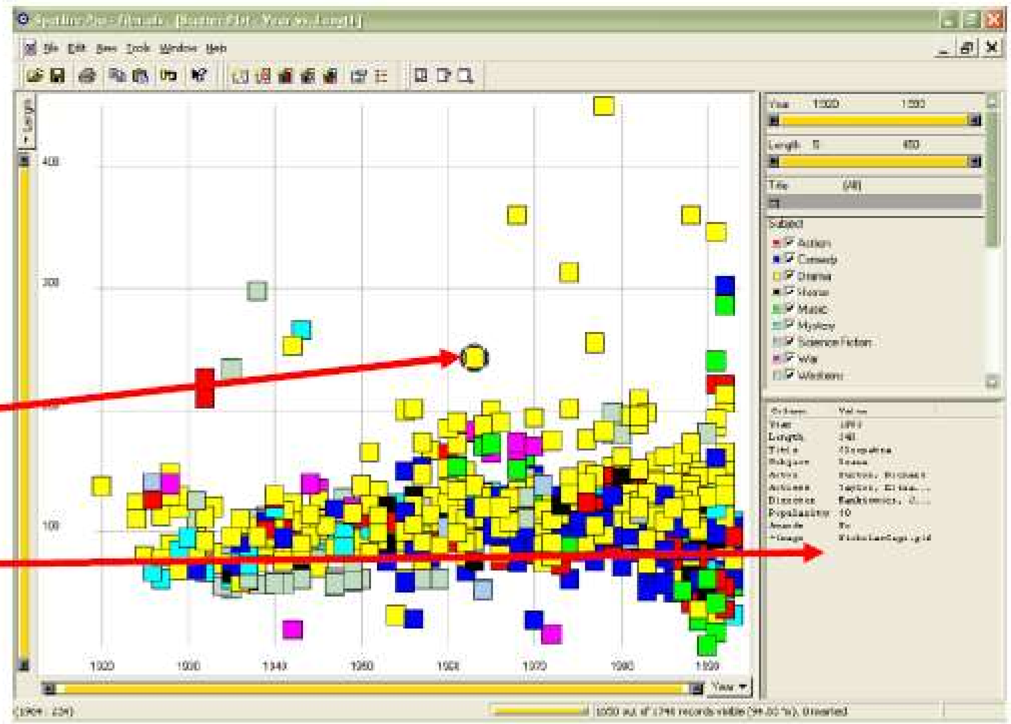
- Example:
  - Selecting a node and seeing all its attributes
  - Selecting a node and creating its Spanning tree

Mouse Selection

Clicking on an item selects it and attributes of the data point are shown

Selected item

Attributes



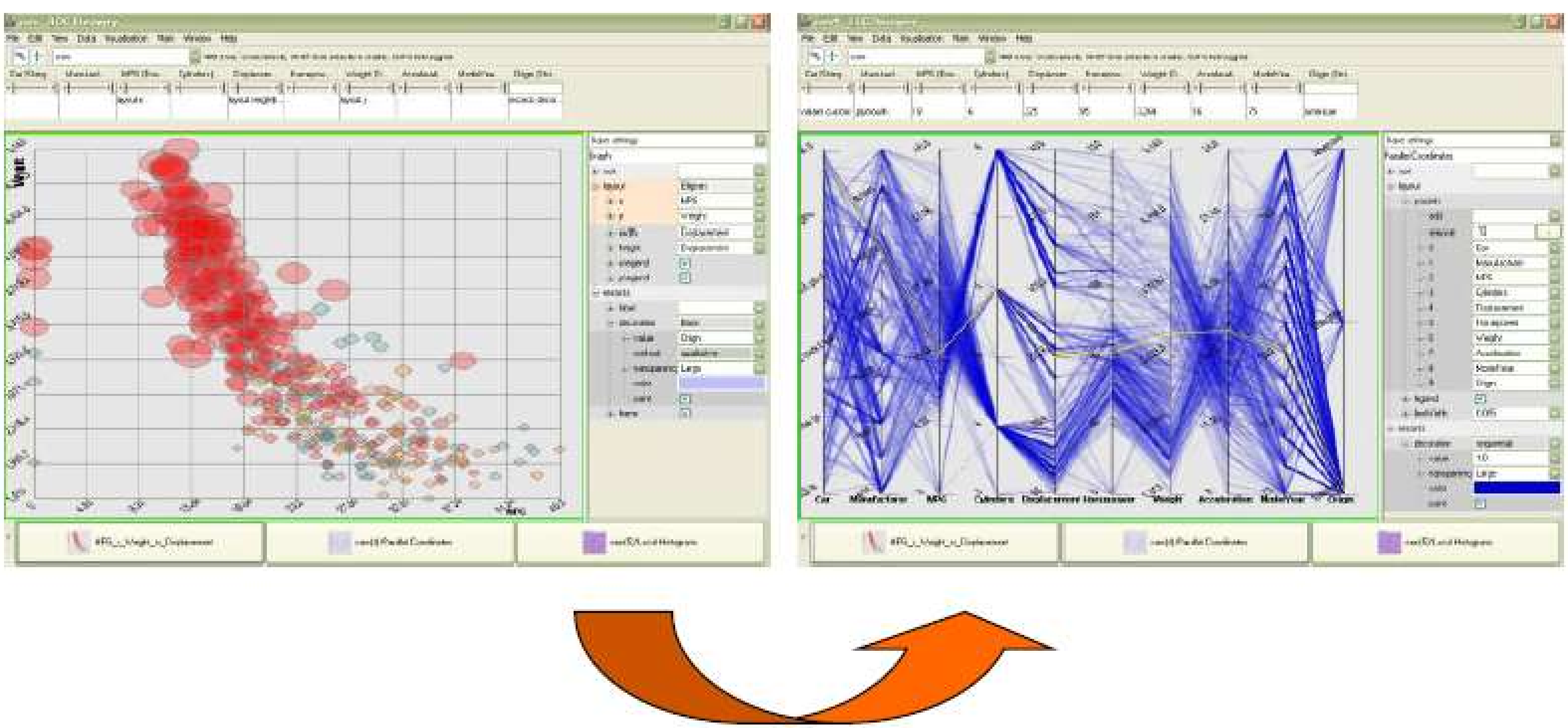
Rearrangement

- "Show me a different arrangement"
- Provide different perspectives by changing the spatial arrangement of representation

- Example
  - Changing data representation (Node & Link => Matrix)
  - Sorting based on attributes of the nodes and links

Changing Representation

- May interactively change entire data representation
  - Looking for new perspective
  - Limited real estate may force change

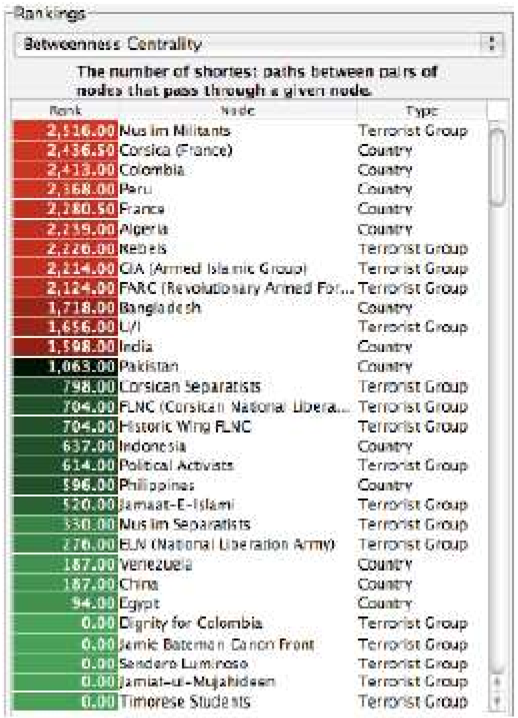


Attribute Ranking

- Choose some attribute and rank all nodes based on the attribute
- Sort the rankings and show in lists and scatterplots
- Allow user to filter based on rankings
- Can aggregate rankings for cohesive subgroups of nodes

Social Network Attributes

- **Bary center** – total shortest path of a node to all other nodes
- **Betweenness centrality** – how often a node appears on the shortest path between all other nodes
- **Closeness centrality** – how close a node is compared to all other nodes
- **Cut-points** – the subgraph becomes disconnected if the node is removed
- **Degree** – number of connections for node
- **HITs** – "hubs and authorities" measure
- **Power centrality** – how linked a node is to rest of network



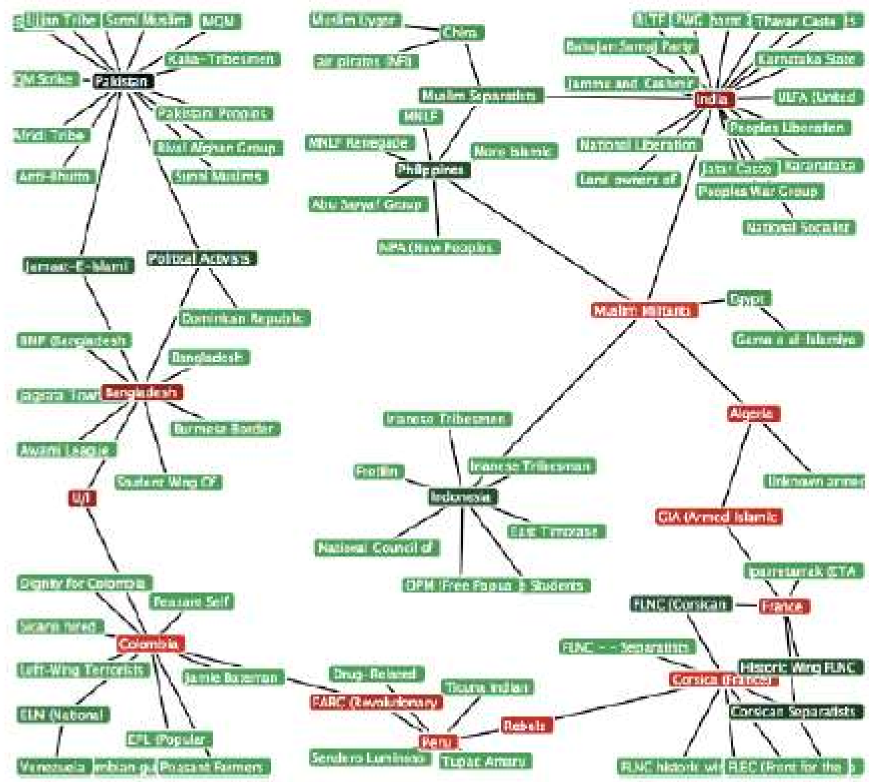
Rankings

Betweenness Centrality

The number of shortest paths between pairs of nodes that pass through a given node.

Rank	Node	Type
2,516.00	Muslim Militants	Terrorist Group
2,436.50	Corsica (France)	Country
2,413.00	Colombia	Country
2,368.00	Peru	Country
2,280.50	France	Country
2,239.00	Algeria	Country
2,226.00	Rebels	Terrorist Group
2,214.00	GIA (Armed Islamic Group)	Terrorist Group
2,124.00	FARC (Revolutionary Armed For...	Terrorist Group
1,718.00	Bangladesh	Country
1,656.00	L/I	Terrorist Group
1,598.00	India	Country
1,063.00	Pakistan	Country
798.00	Corsican Separatists	Terrorist Group
704.00	FLNC (Corsican National Libera...	Terrorist Group
704.00	Historic Wing FLNC	Terrorist Group
637.00	Indonesia	Country
614.00	Political Activists	Terrorist Group
596.00	Philippines	Country
520.00	Jamaat-E-Islami	Terrorist Group
330.00	Muslim Separatists	Terrorist Group
276.00	ELN (National Liberation Army)	Terrorist Group
187.00	Venezuela	Country
187.00	China	Country
94.00	Egypt	Country
0.00	Dignity for Colombia	Terrorist Group
0.00	Jamie Bateman Cayon Front	Terrorist Group
0.00	Sendero Luminoso	Terrorist Group
0.00	Jamiat-ul-Mujahideen	Terrorist Group
0.00	Timorese Students	Terrorist Group

(a) Ordered list of 97 nodes in the largest connected component of the terrorism network in 1996. The nodes are ranked according to their betweenness centrality.



(b) Network visualization of the same 97 nodes, colored according to their ranking. The nodes with highest betweenness rankings, sometimes referred to as "gatekeepers", are painted red.

Figure 1.

Perer & Shneiderman TVCG (InfoVis) '06

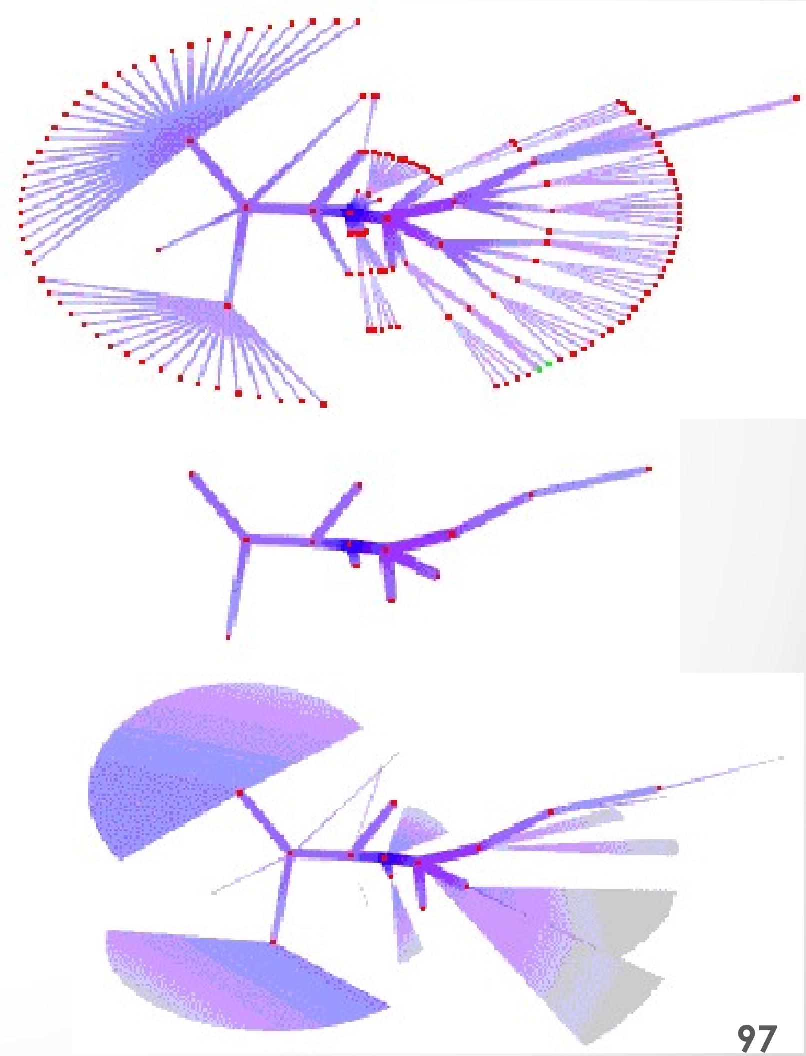
Filtering

- "Show me something conditionally"
- Change the set of data items being presented based on some specific conditions.

- Example
  - Dynamic query
  - Clustering

Methods of representing unselected nodes

- Ghosting
  - De-emphasizing or relegating nodes to background
- Hiding
  - Not displaying at all
- Grouping
  - Grouping under super -node representation



Faceted Metadata

- Attributes of datasets are grouped into multiple orthogonal categories
- Selecting a value from one filters on that value and updates the items in other categories
- User explores data collection by series of selections

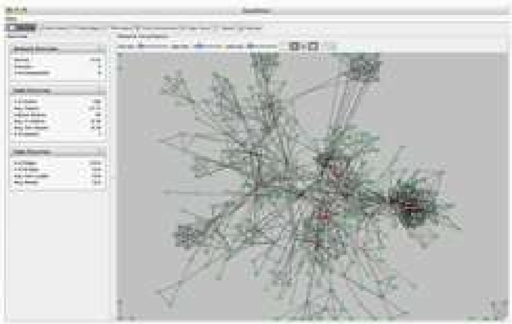
Database Queries

- Pros
  - Powerful, flexible
- Cons
  - Must learn language
  - Only shows exact matches
  - Don't know magnitude of results
  - No helpful context is shown
  - Reformulating to a new query can be slow

Dynamic Queries

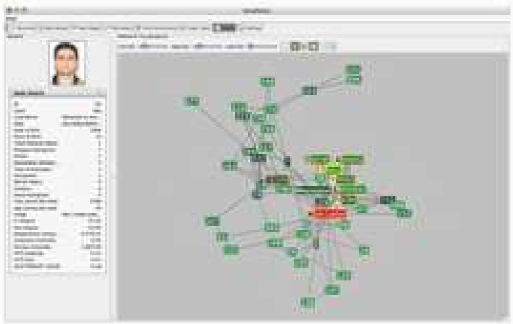
- Probably best-known and one of most useful infovis techniques (Shneiderman IEEE Software '94)
- Visual representation of world of action including both the objects and actions
- Rapid, incremental and reversible actions
- Selection by pointing (not typing)
- Immediate and continuous display of results

Example: Social Action



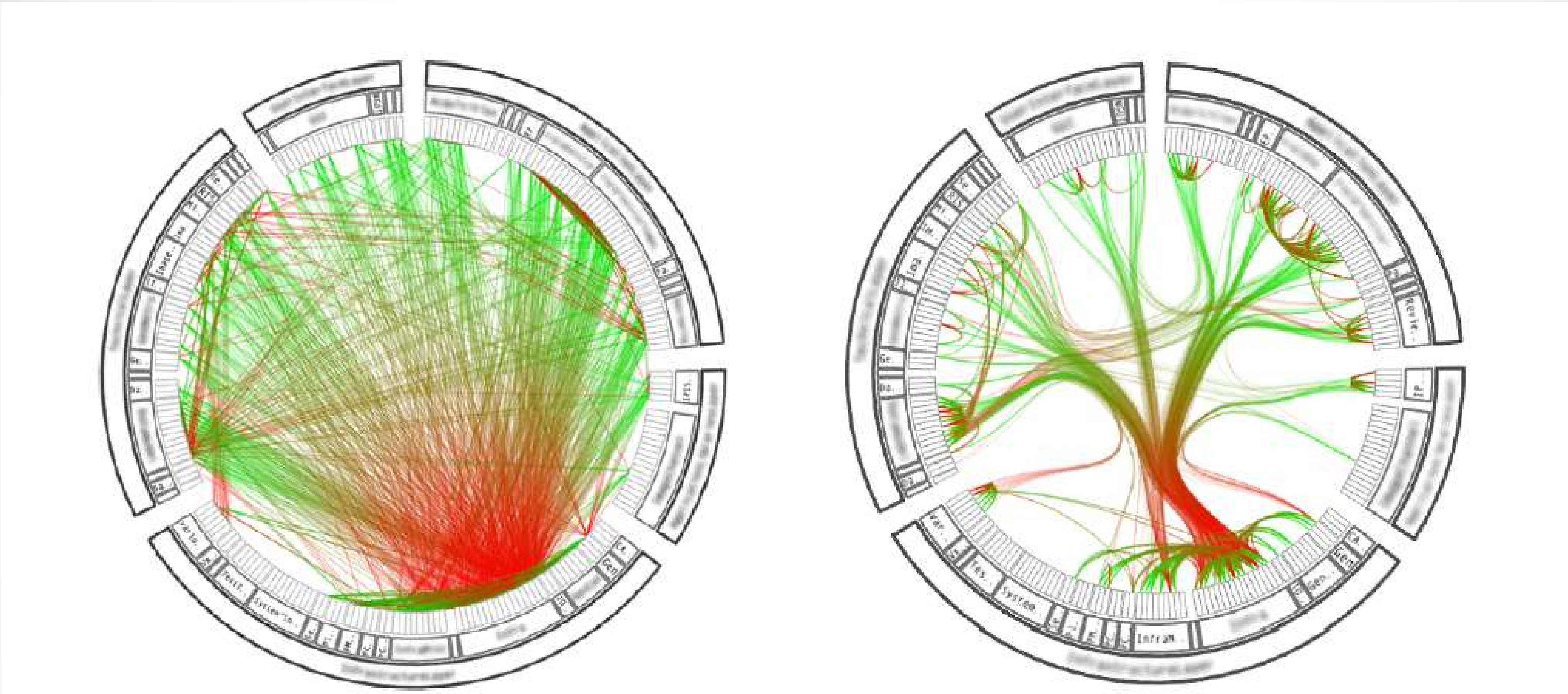
Users begin with an overview of the entire social network. On the left side, overview statistics that describe the overall structure are presented. On the right, the network is visualized using a force directed algorithm.

The gatekeepers are found using a statistical algorithm. Users filter out the unimportant nodes using a dynamic slider which simplifies the visualization while maintaining the node positions and structure of the network.



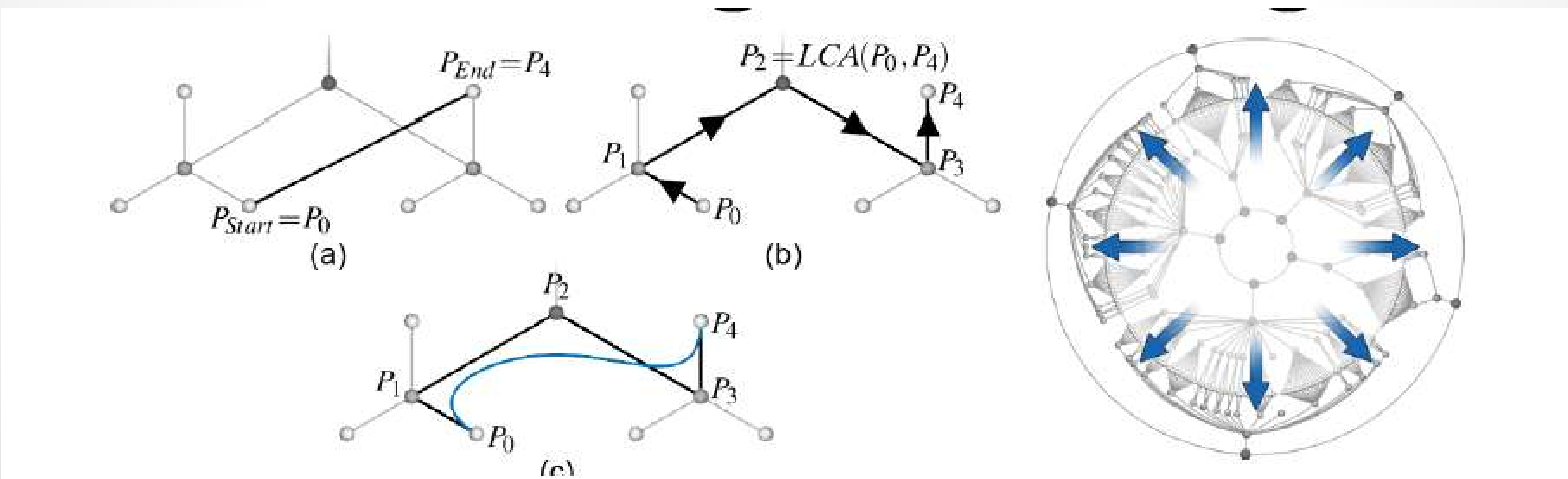
Labels are always given priority so users can understand what the data represents. When user selects a node, neighbors are highlighted and details appear on the left. In order to protect sensitive information, node labels have been anonymized except for those individuals publicly identified in the Zacarias Moussaoui trial.

Reduce Clutter: Edge Bundling



Hierarchical Edge Bundling

- Bundle edges that go from/to similar nodes together
  - Holten TVCG (InfoVis) '06



Clustering

- Structure-based Clustering
  - Most common in graph visualization
  - Often retain structure of graph

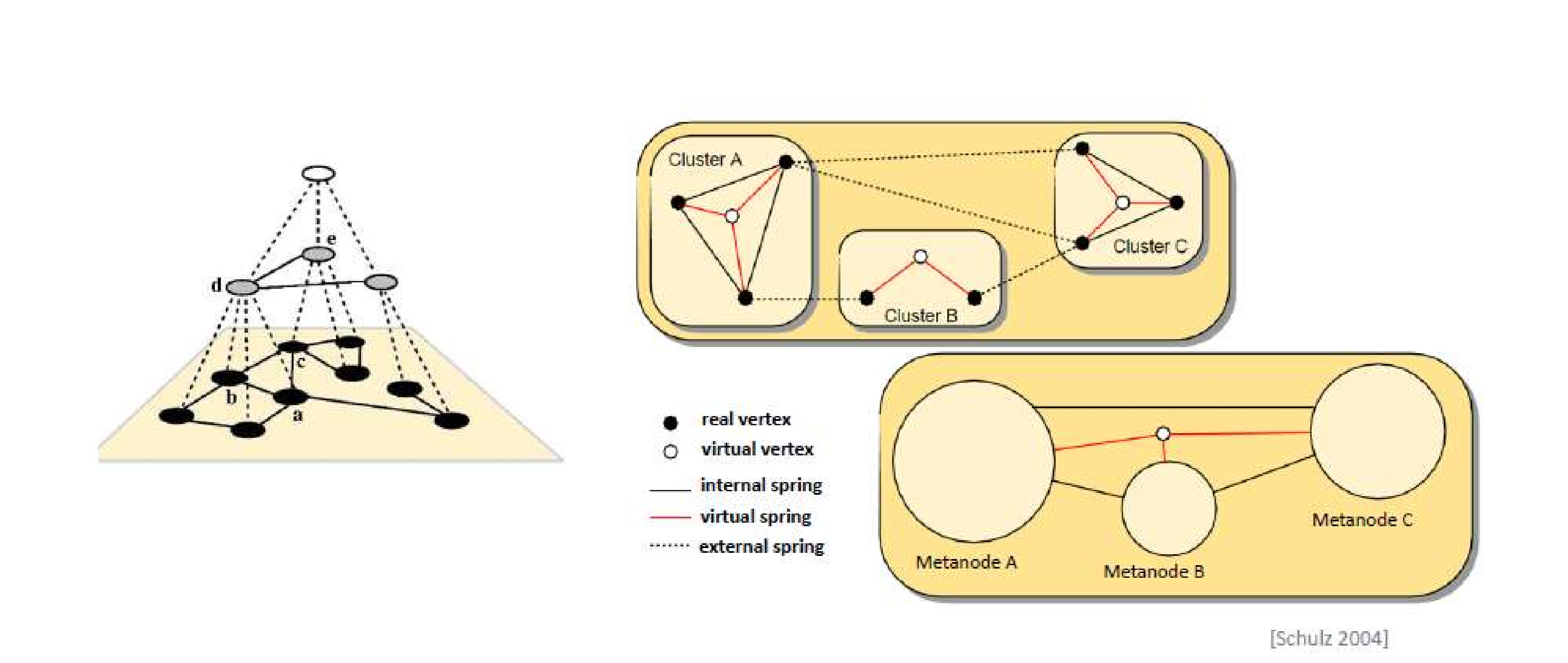
  $\Rightarrow$Useful for user orientation
- Content-based Clustering
  - Application specific
  - Can be used for
    - Filtering: de-emphasis or removal of elements from view
    - Search: emphasis of an element or group of elements

Clustering – Goal & Technique

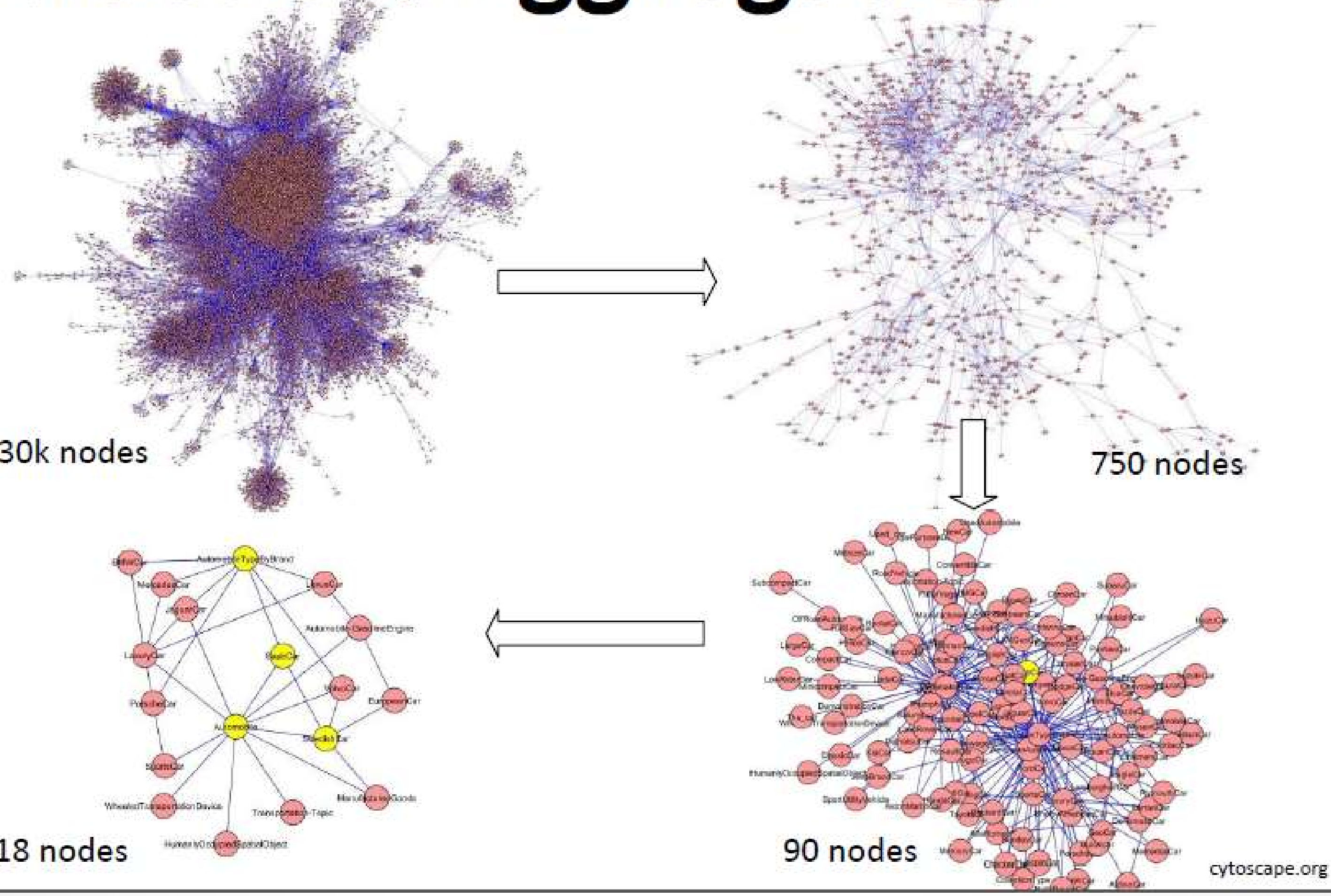
- Common goal
  - Finding disjoint clusters
  - Finding overlapping clusters
- Common technique
  - Least number of edges between neighbors (Ratio Cut technique in VLSI design)

Hierarchical Clustering

- From successive application of clustering process
- Can be navigated as tree



Abstraction/Aggregation



Families of Infovis Interaction Techniques

- Selection
- Rearrangement
- Filtering techniques
- Navigation techniques
  - Pan + Zoom
  - Focus + Context
- Multiple views

Incremental Exploration and Navigation

- For very large graphs (e.g. Internet)
- Small portion displayed
- Other parts displayed as needed
- Displayed graph small

$\Rightarrow$Layout and interaction times may be small

Pan & Zoom

- Zoom and Pan
  - Zoom for graphs exact, not pixel-based (adjustment of screen transformations)
- Geometric Zooming
  - Simple blow-up
- Semantic Zooming
  - Content changes
  - Clustering

Pan & Zoom

Mery-sur-Oise
Cergy
Taverny
Domont
Goussainville
Dammartin-en-Goële
Satellite
Traffic
Jouy-le-Moutier
Conflans-Sainte-Honorine
Sarcelles
Les Mureaux
Andrésy
Garges-lès-Gonesse
Mitry-Mory
Achères
Argenteuil
Saint-Denis
Aulnay-sous-Bois
Claye-Souilly
Poissy
Asnières-sur-Seine
Bobigny
Nanterre
Quincy-
La Villette
Ternes
Château de Bagatelle
Chelles
Lagny-sur-Marne
Paris
Montreuil
Auteuil
Beynes
Torcy
Serris
Nogent-sur-Marne
Le Chesnay
Plaisir
Ivry-sur-Seine
Pontchartrain
Versailles
Clamart
Pontault-Combault
Créteil
Trappes
Robinson
Antony
Ozoir-la-Ferrière
Coignières
Orly
Gretz-Armainvilliers
Massy
Palaiseau
Athis-Mons
Presles-en-Brie
Gif-sur-Yvette
en-Yvelines
Brie-Comte-Robert
Savigny-sur-Orge
Les Ulis
Coubert
5 mi
10 km
Viry-Châtillon
Forêt de Sénart
Soignolles-en-Brie
Limours
Map data ©2013 Google - Edit in Google Map Maker Report a problem

Pan & Zoom

Courbevoie
Levallois-Perret
Neuilly-sur-Seine
Puteaux
Place Charras
Satellite
Traffic
Pantin
Parc Henri Barbusse
Romainville
Les Lilas
Porte de Clignancourt
Porte de la Chapelle
Epinettes
Batignolles
Goutte d'Or
18e
17e
19e
9e
10e
8e
2e
3e
Belleville
Porte Dauphine
Chaillot
Muette
Bois de Boulogne
16e
Musée du Louvre
Paris
11e
20e
Montreuil
Seine-Saint-Denis
Paris
Faubourg Saint-Germain
6e
5e
Jardin Émile Gallé
Vincennes
Auteuil
Boulogne-Billancourt
Javel
15e
Montparnasse
12e
Saint-Mandé
Porte de Saint-Cloud
Bercy
14e
13e
Quartier de la Gare
Bois de Vincennes
Petit-Montrouge
Issy-les-Moulineaux
Parc de Montsouris
Paris Val-de-Marne
Charenton-le-Pont
Meudon
Montrouge
Gentilly
Ivry-sur-Seine
Châtillon
Arcueil
Clamart
Maisons-Alfort
1 mi
2 km

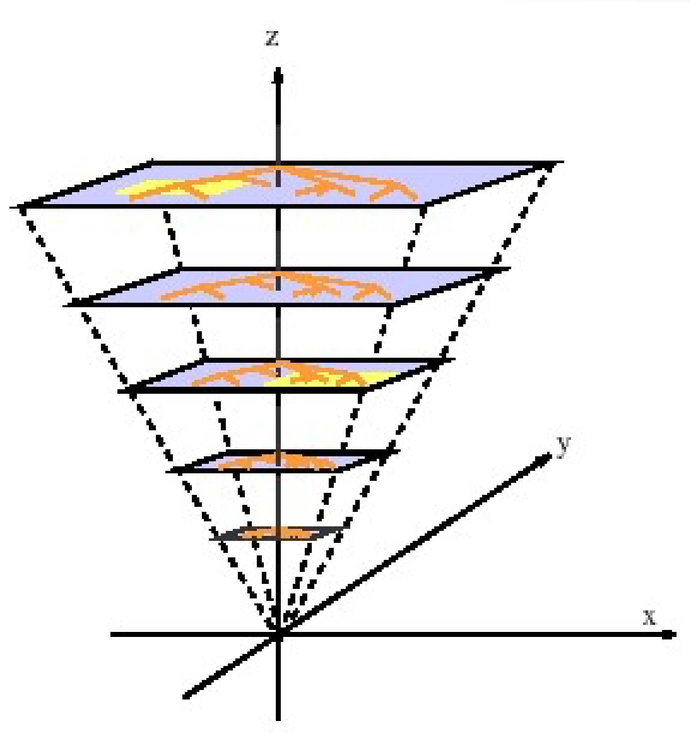
Pan & Zoom

L'annexe
Place Louis Lépine
Elektron
Préfecture de police
Bd du Palais
Rue de Lutèce
Satellite
Traffic
Soc Parisienne Restauration Rapide SP2
Le Soleil d'Or
Paris en Scène
Quai du Marché Neuf
Île de la Cité
Pont Saint-Michel
La Seine
Relais H
Crypte archéologique du parvis Notre-Dame
100 ft
20 m
Quai Saint-M
Saint-Michel
Map data ©2013 Cybercity, Google -
Edit in Google Map Maker
Report a problem

Problem – Where am I?

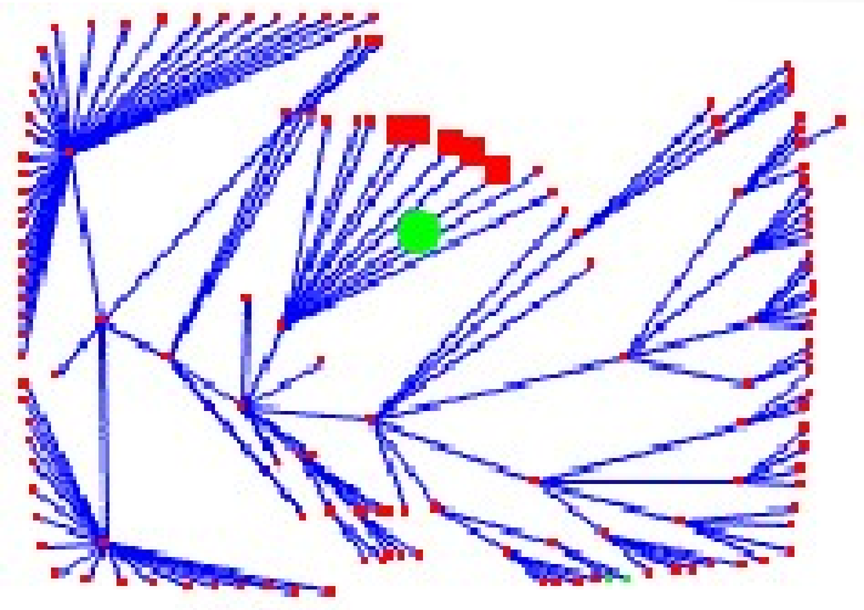
Problem with Combination of Zoom and Pan

- Assume zoom and pan independent
- Objects may temporarily move away
- Semantic Zoom: Picture differs for each level



Focus + Context Techniques

- Zooming looses contextual information
- Focus + Context keeps context
- Example: Fisheye Distortion



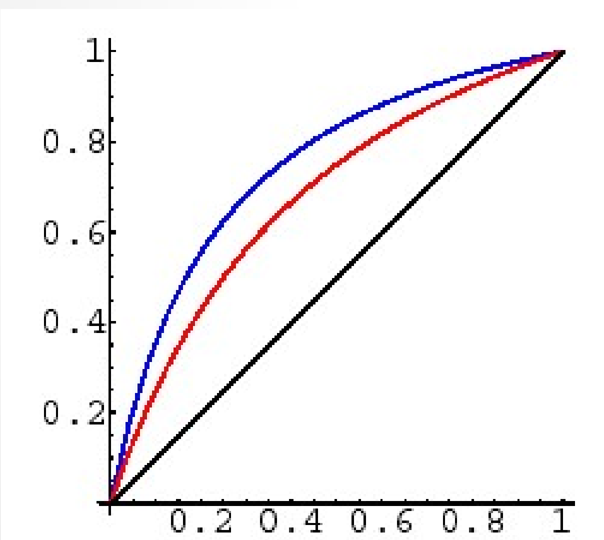
Degree of Interest

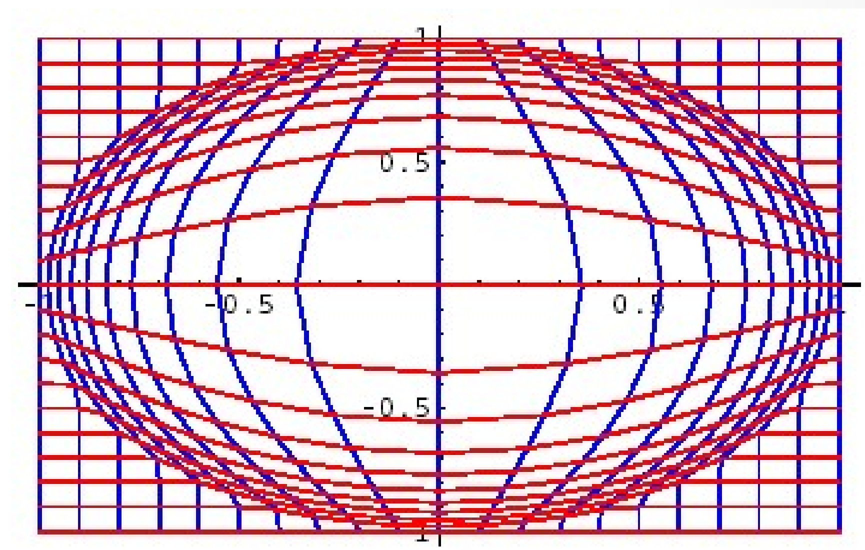
- Concept introduced in classic paper
- "Generalized fisheye views" George Furnas, 1986

- Definition :
- $DOI_{fisheye}(x \mid y) = API(x) - D(x,y)$
  - x is any node
  - y is current point of focus
  - API(x) is the global A Priori Importance
  - D(x,y) is the Distance between x and the current point y

Fisheye Distortion

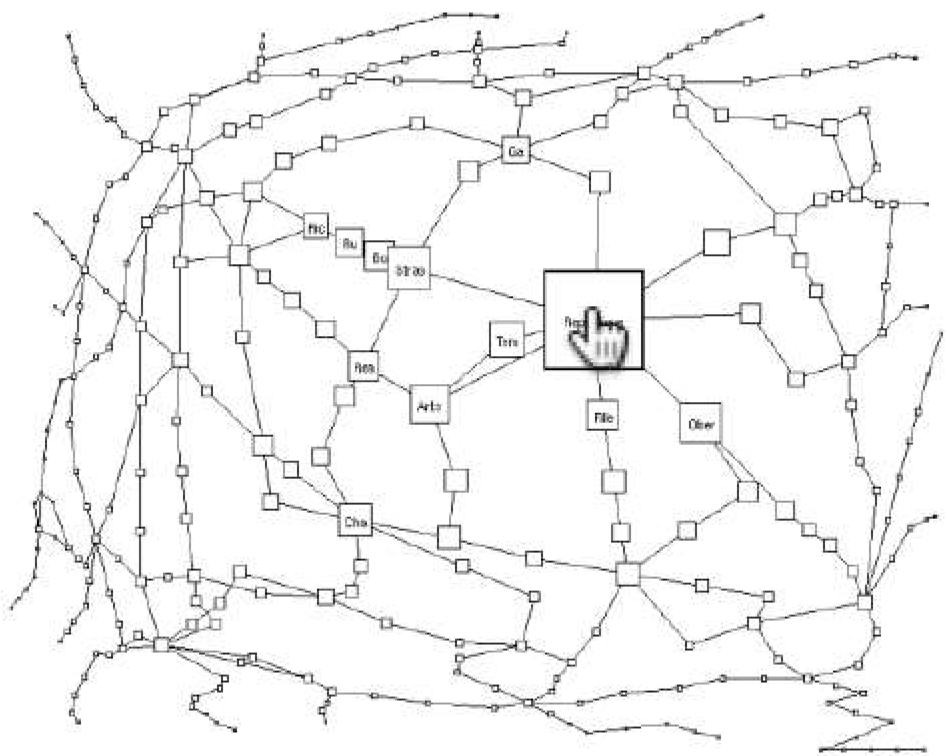
- Process
  - Pick focus point
  - Map points within radius using a concave monotonic function
  - Example: Sarkar-Brown distortion function





Focus + Context

Fisheye View of Graphs



Sarkar and Brown, 1992

Problem with Fisheye

- Distortion should also be applied to links
  - Prohibitively slow (polyline)
- Alternative
  - Continue using lines
  - Can result in unintended line crossings
- Other Alternative
  - Combine layout with focus+context

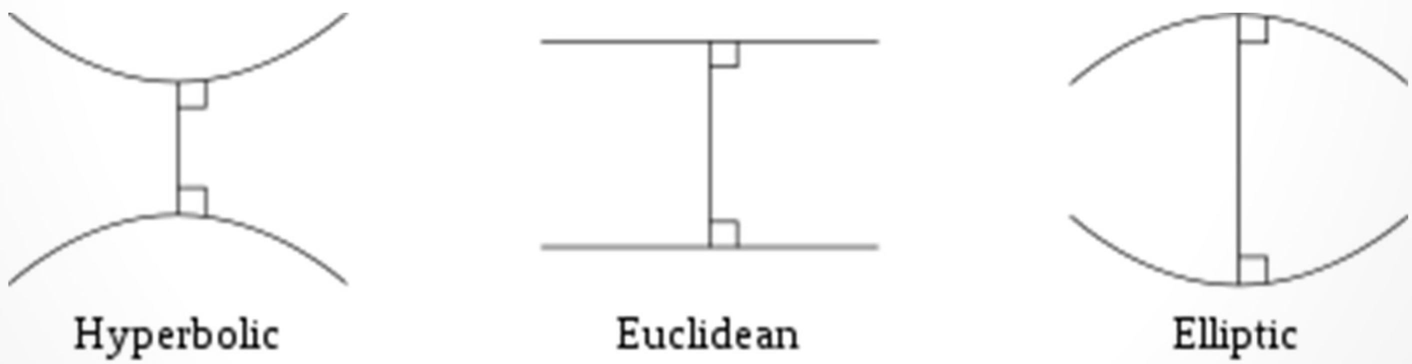
  $\Rightarrow$Hyperbolic viewer

Hyperbolic Browser

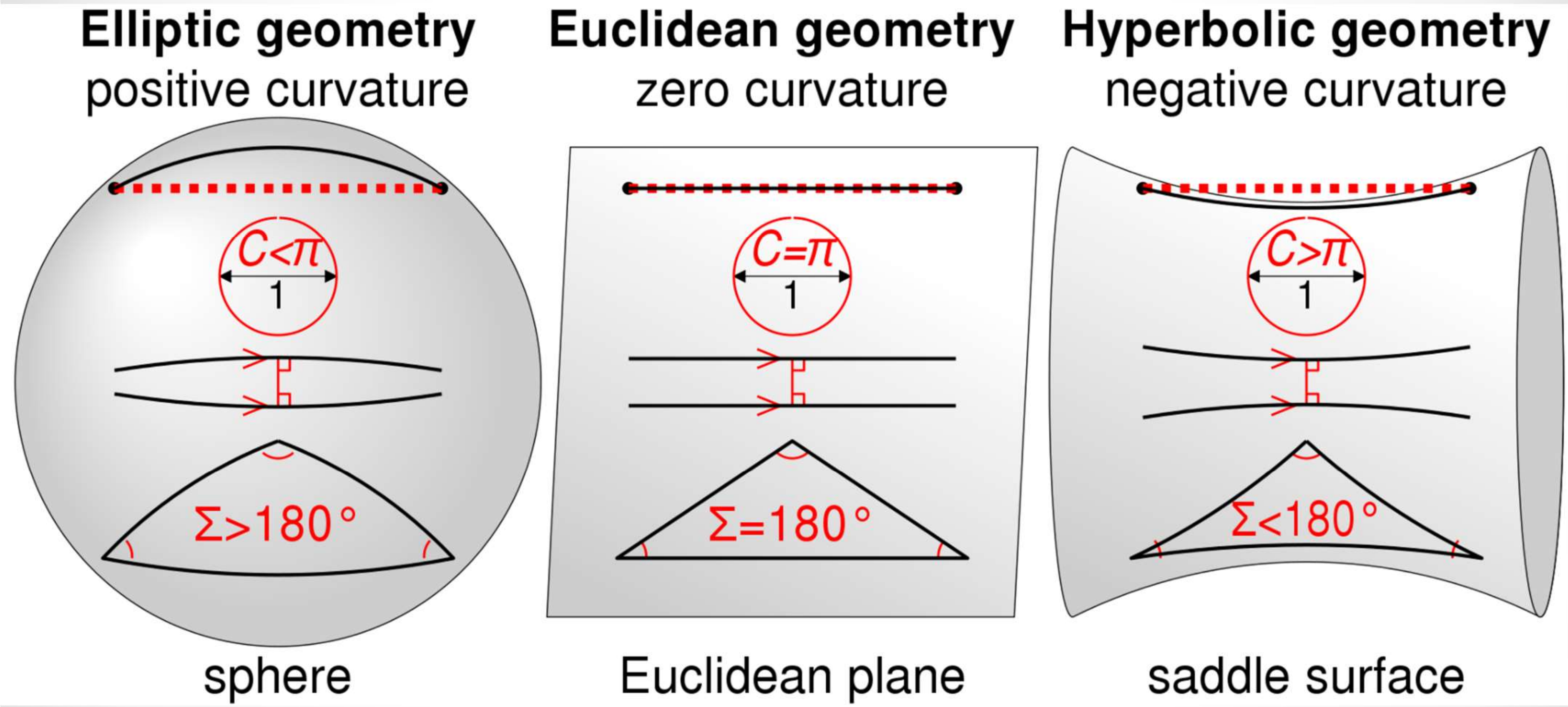
- Focus + Context Technique
- Detailed view blended with a global view
- First lay out the hierarchy on the hyperbolic plane
- Then map this plane to a disk
- Start with the tree's root at the center
- Use animation to navigate along this representation of the plane

Hyperbolic Viewer Concepts

- For a given point and non-intersecting line: many parallel lines through point
- Segments that are congruent in the hyperbolic sense are exponentially smaller in the Euclidean sense when approaching the perimeter



Behavior of lines with a common perpendicular in each of the three types of geometry

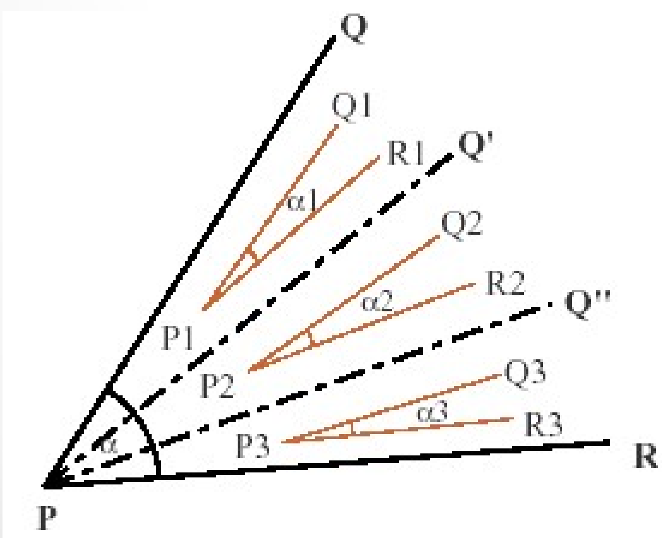


Elliptic geometry
positive curvature
Euclidean geometry
zero curvature
Hyperbolic geometry
negative curvature
C<π
1
C=π
1
C>π
1
Σ>180°
Σ=180°
Σ<180°
sphere
Euclidean plane
saddle surface

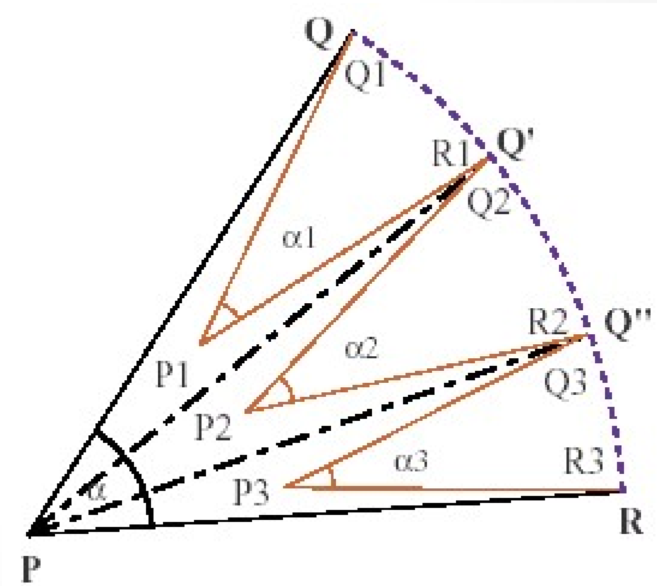
Simple Tree Construction Algorithm

- Node P with with wedge QPR
- Subtrees start at P_1, P_2, and P_3
- The circumference of a circle grow exponentially with its radius

Euclidean



Hyperbolic



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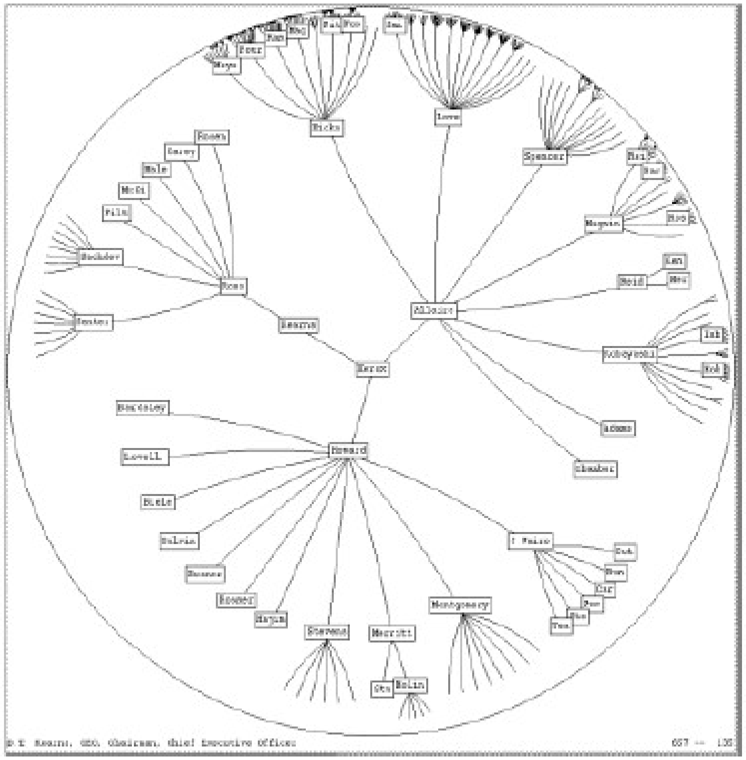
2D Hyperbolic Browser

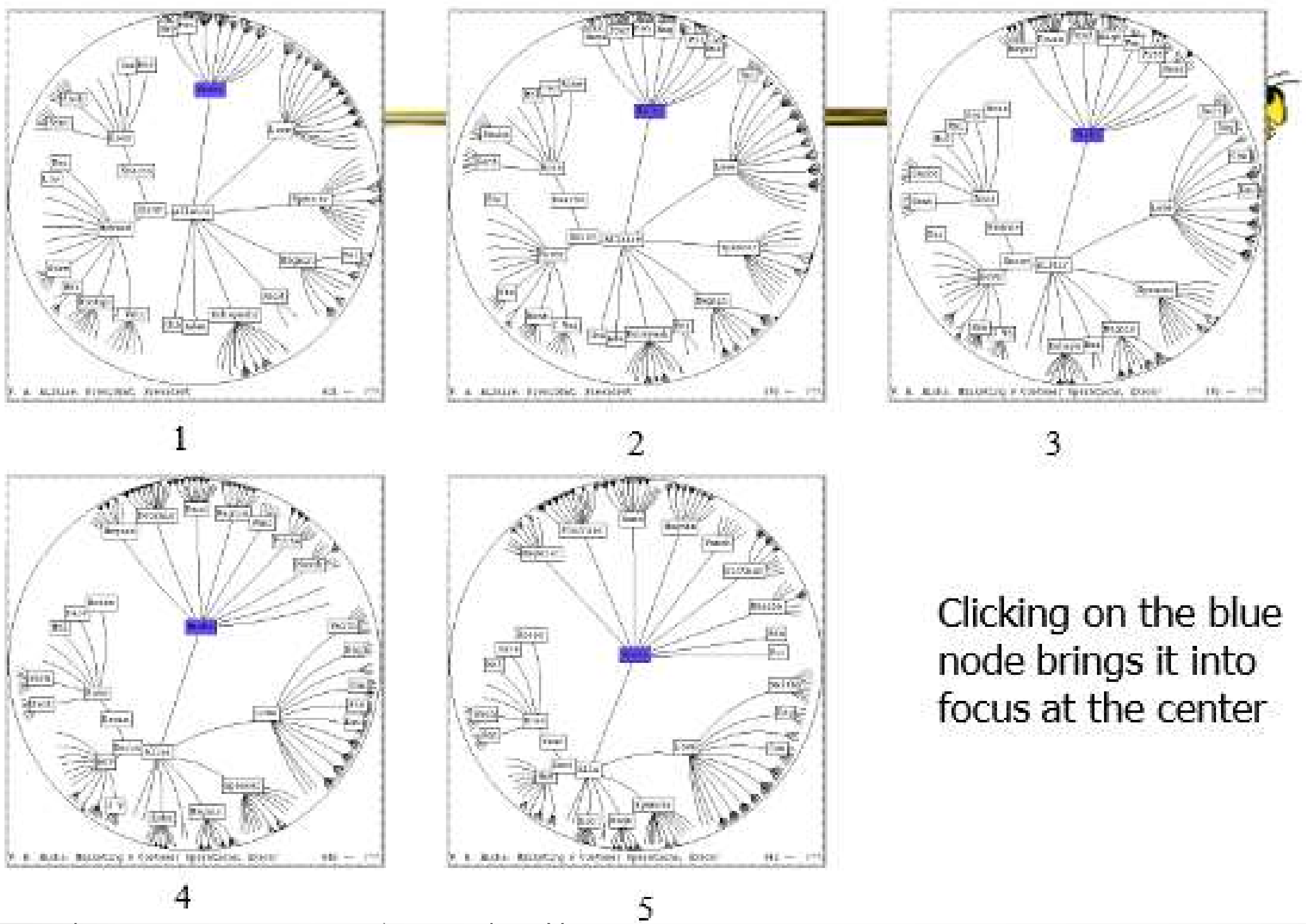
- **Approach:** Lay out the hierarchy on the hyperbolic plane and map this plane onto a display region.
- Comparison
  - A standard 2D browser: 100 nodes (w/3 character text strings)
  - Hyperbolic browser: 1000 nodes, about 50 nearest the focus can show from 3 to dozens of characters



Hyperbolic Browser - Concepts

- 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)

Hyperbolic Browser - Interactions

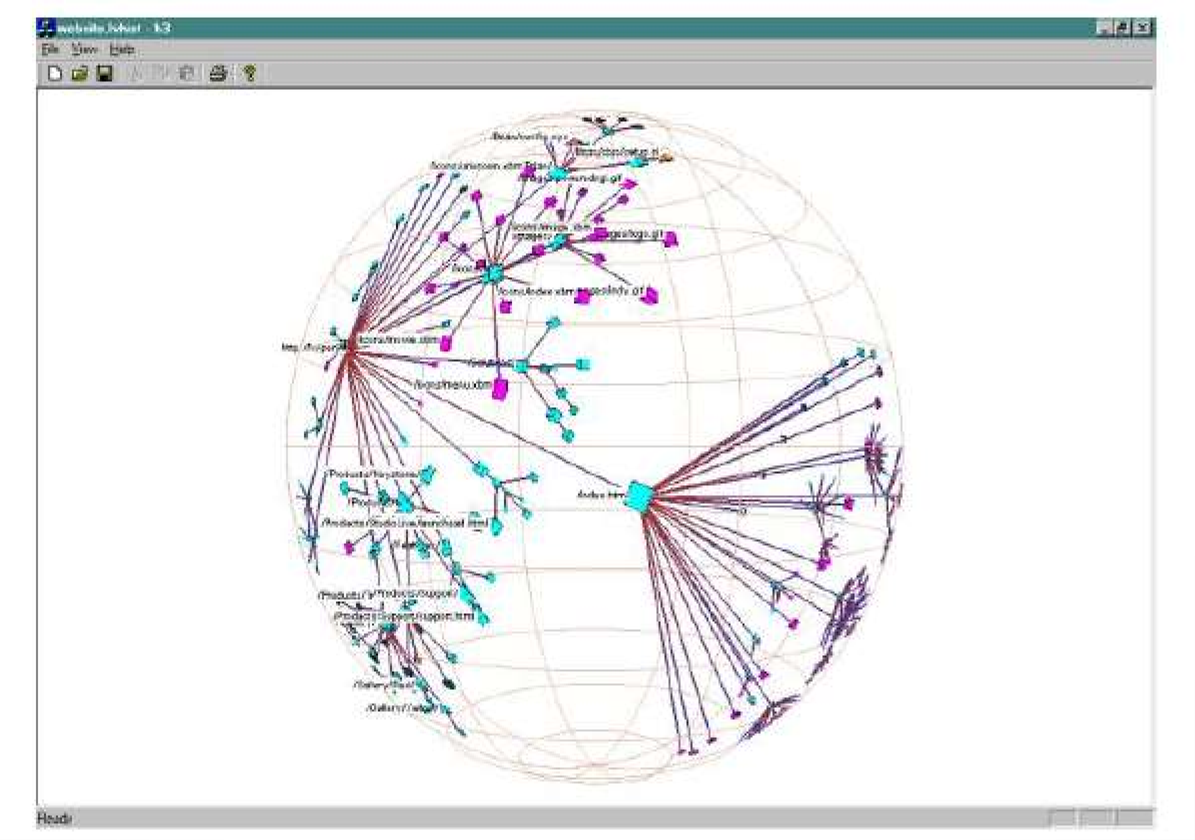


Clicking on the blue node brings it into focus at the center

Hyperbolic Browser - 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

H3Viewer – Viewing Graphs in 3D Hyperbolic Space

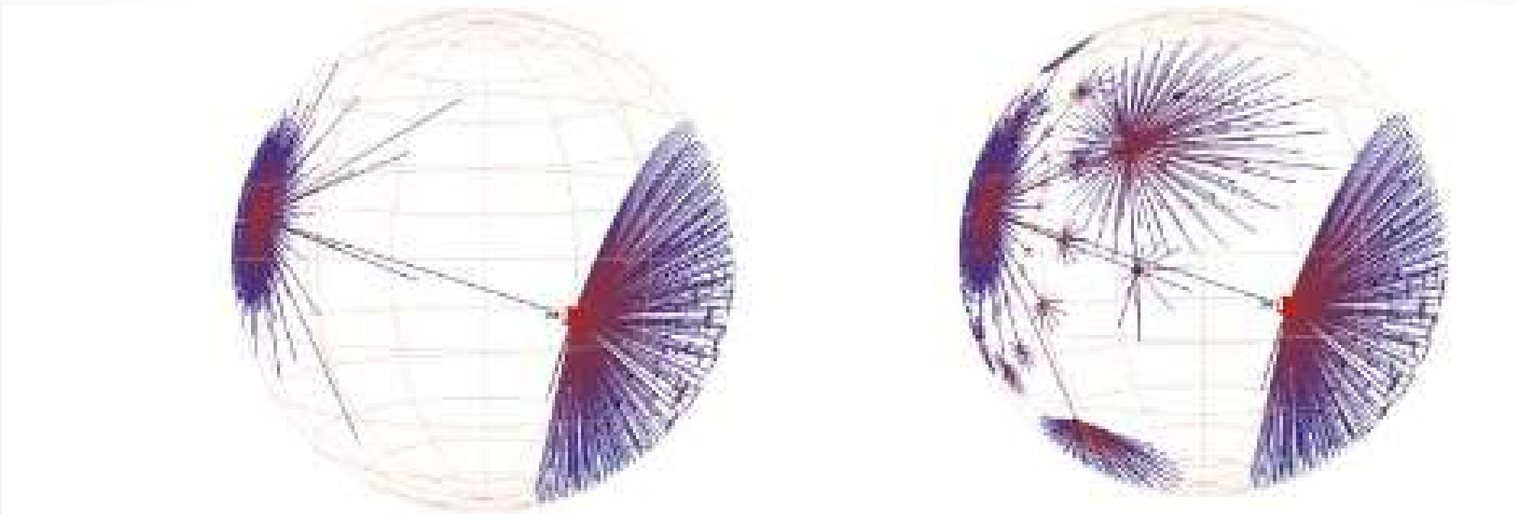


H3 Viewer - Technique

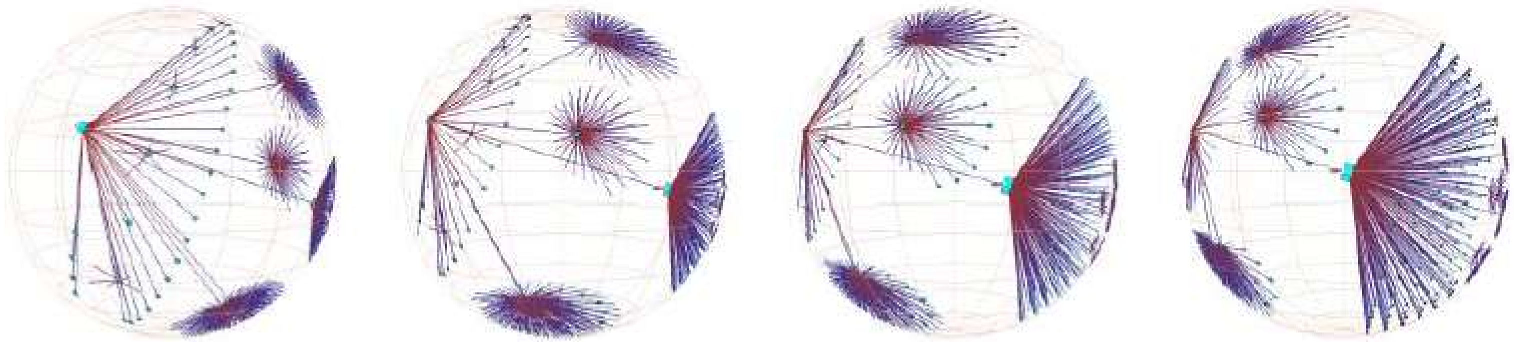
- Find a spanning tree from an input graph
- Layout algorithm
  - Nodes are laid out on the surface of a hemisphere
  - A bottom up pass to estimate the radius needed for each hemisphere
  - A top down pass to place each child node on its parental hemisphere's surface

H3 Viewer - Drawing

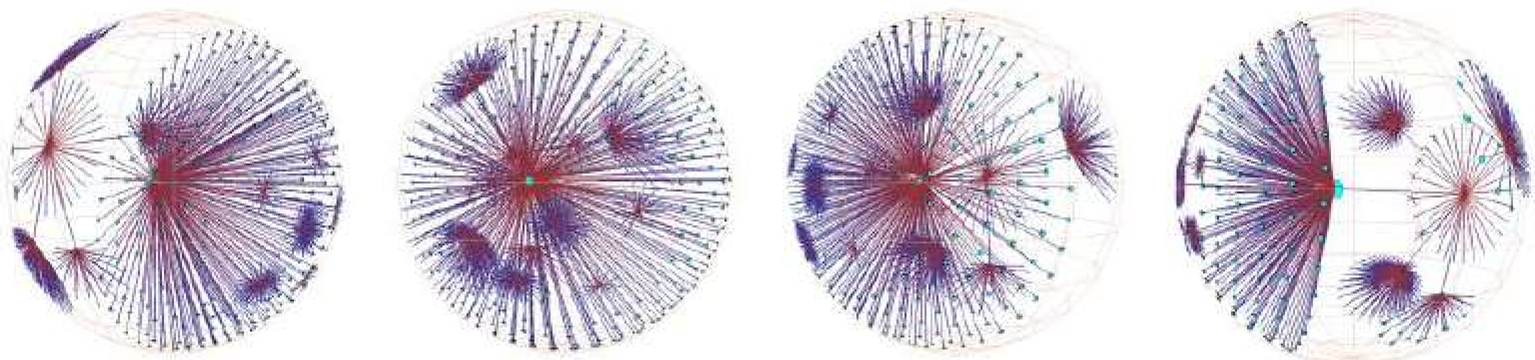
- Showing less of the context surrounding the node of interest during interactive browsing
- Fill in more of the surrounding scene when the user is idle



H3 Viewer - Navigation



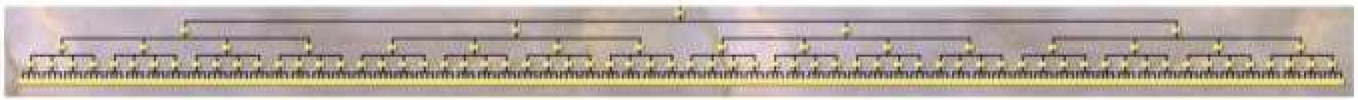
Translation of a node to the center



Rotation around the same node

Degree of Interest Trees

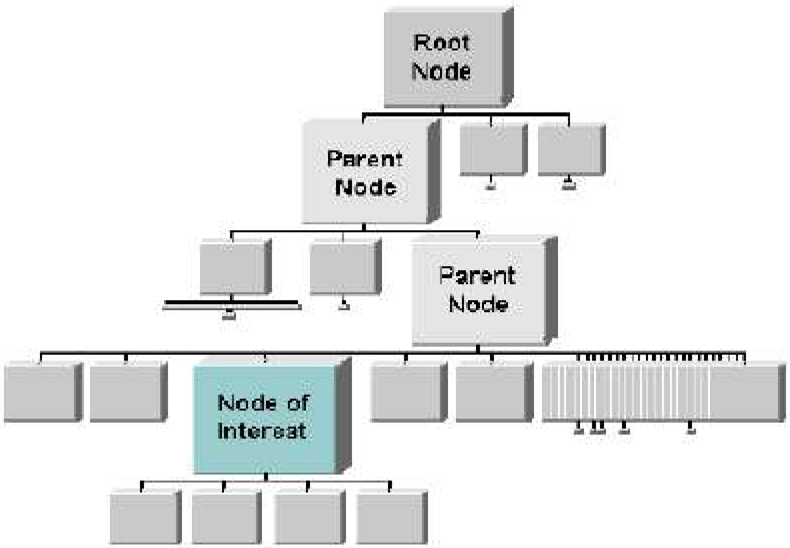
- Problem: Trees quickly degrade into line



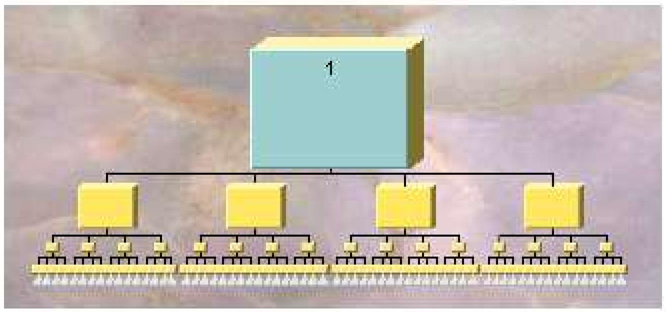
- Approach: Use fisheye-like focus & context ideas to control how a tree is drawn

Approach

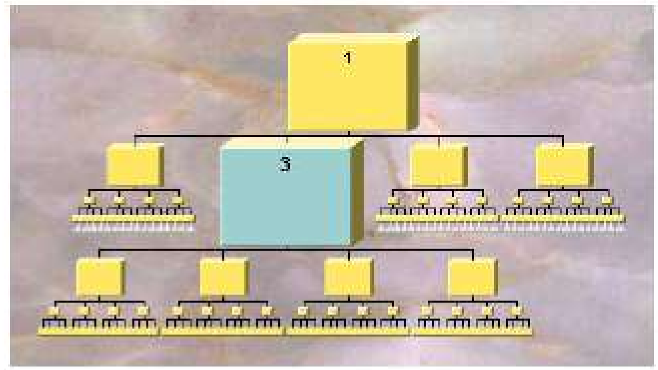
- Combine multiple ideas:
  - Expanded DOI computation
  - Logical filtering to elide nodes
  - Geometric scaling
  - Semantic scaling
  - Clustered representation of large unexpended branches
  - Animated transition



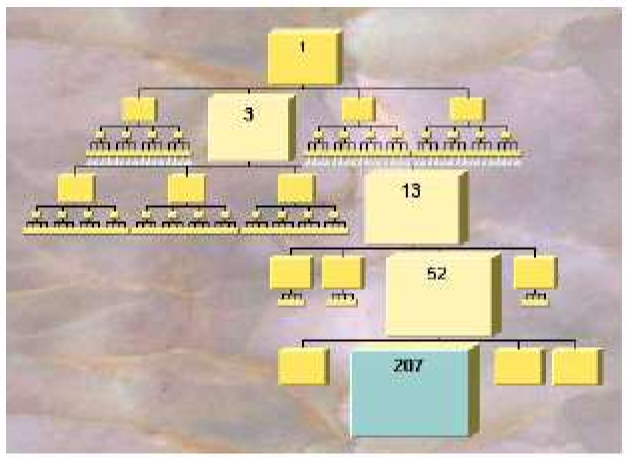
Example



1. Display of a uniform tree of 4 levels



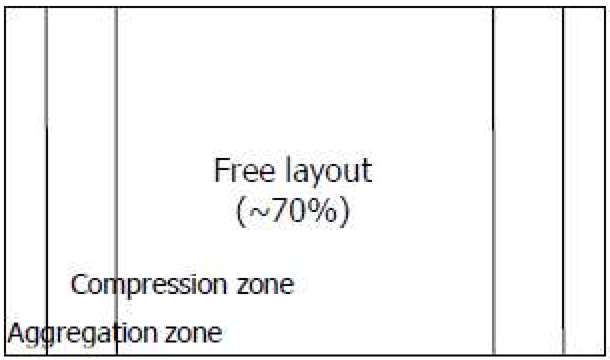
2. Same table with focus on Node 3



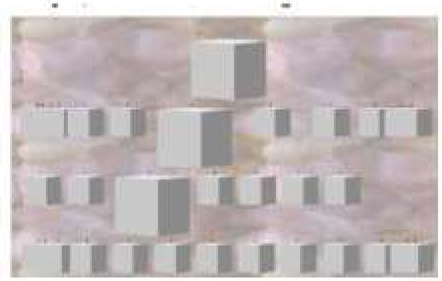
3. Same tree expanded down to a leaf node

Compression

- For nodes: compress to fit (compress in X or in Y)



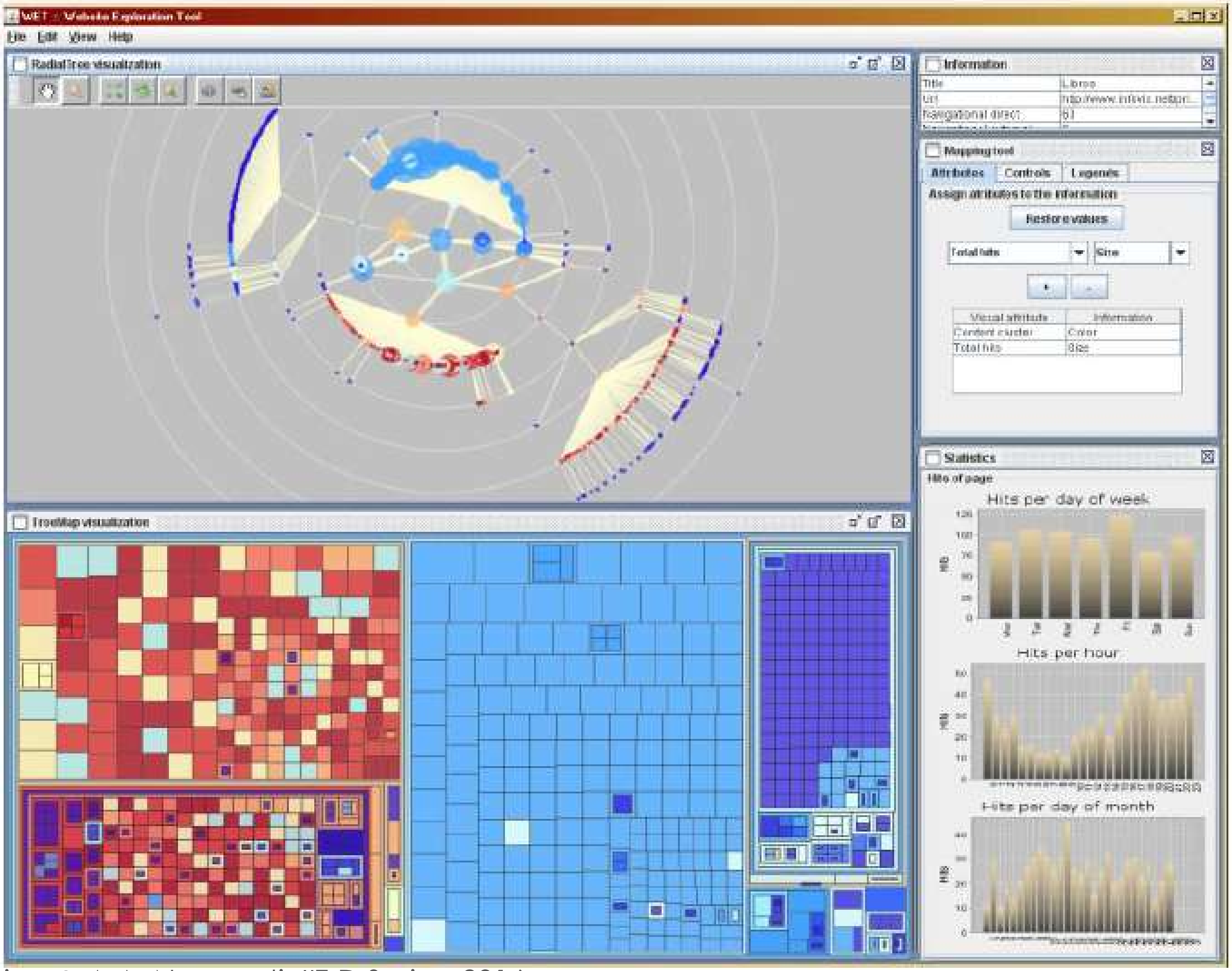
- Within-node compression
  - Data deletion
  - Word abbreviation
  - Node rotation



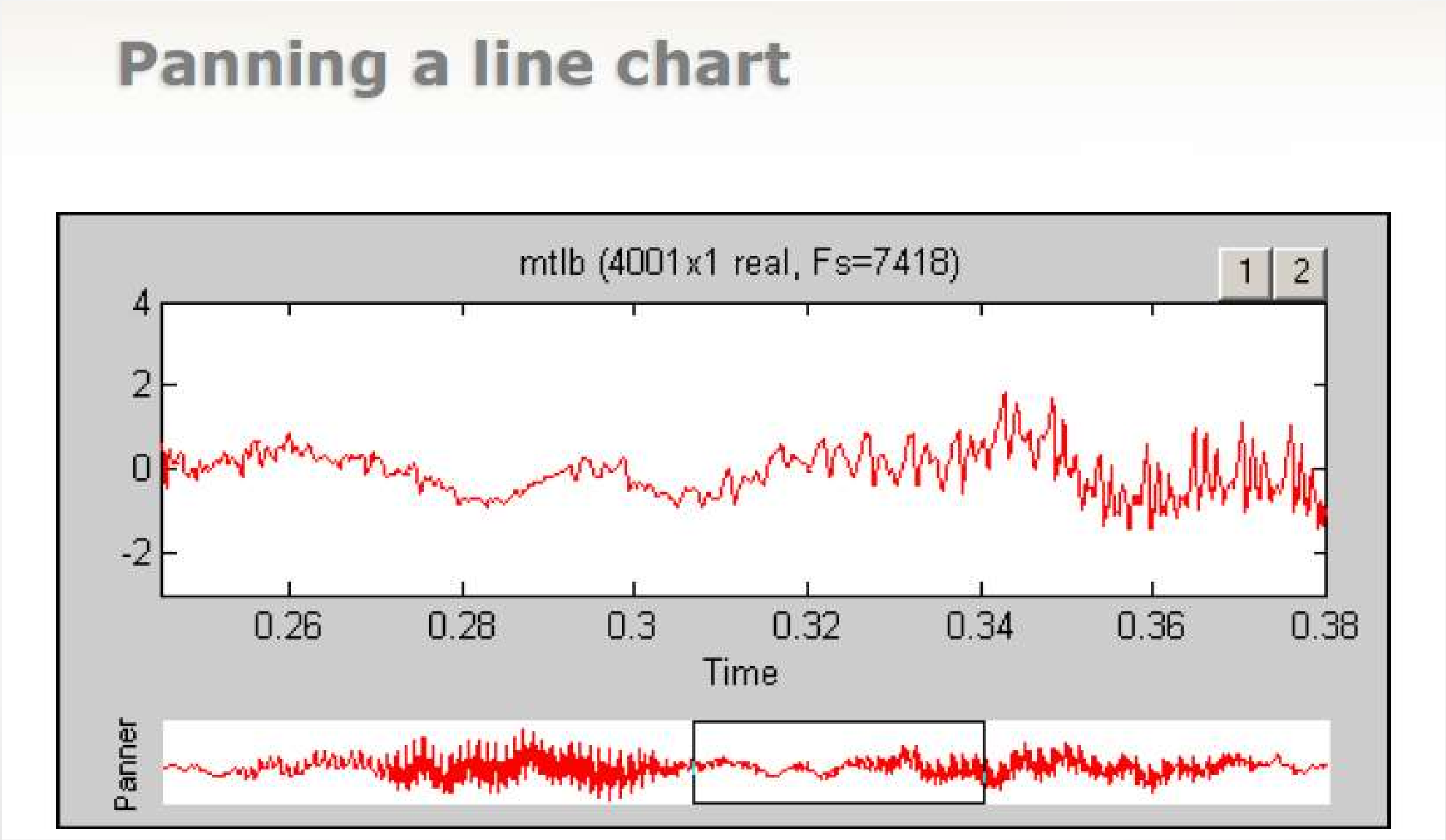
Families of Infovis Interaction Techniques

- Selection
- Rearrangement
- Filtering techniques
- Navigation techniques
- Multiple views
  - Overview + Detail
  - Magic Lens
  - Coordinated Views

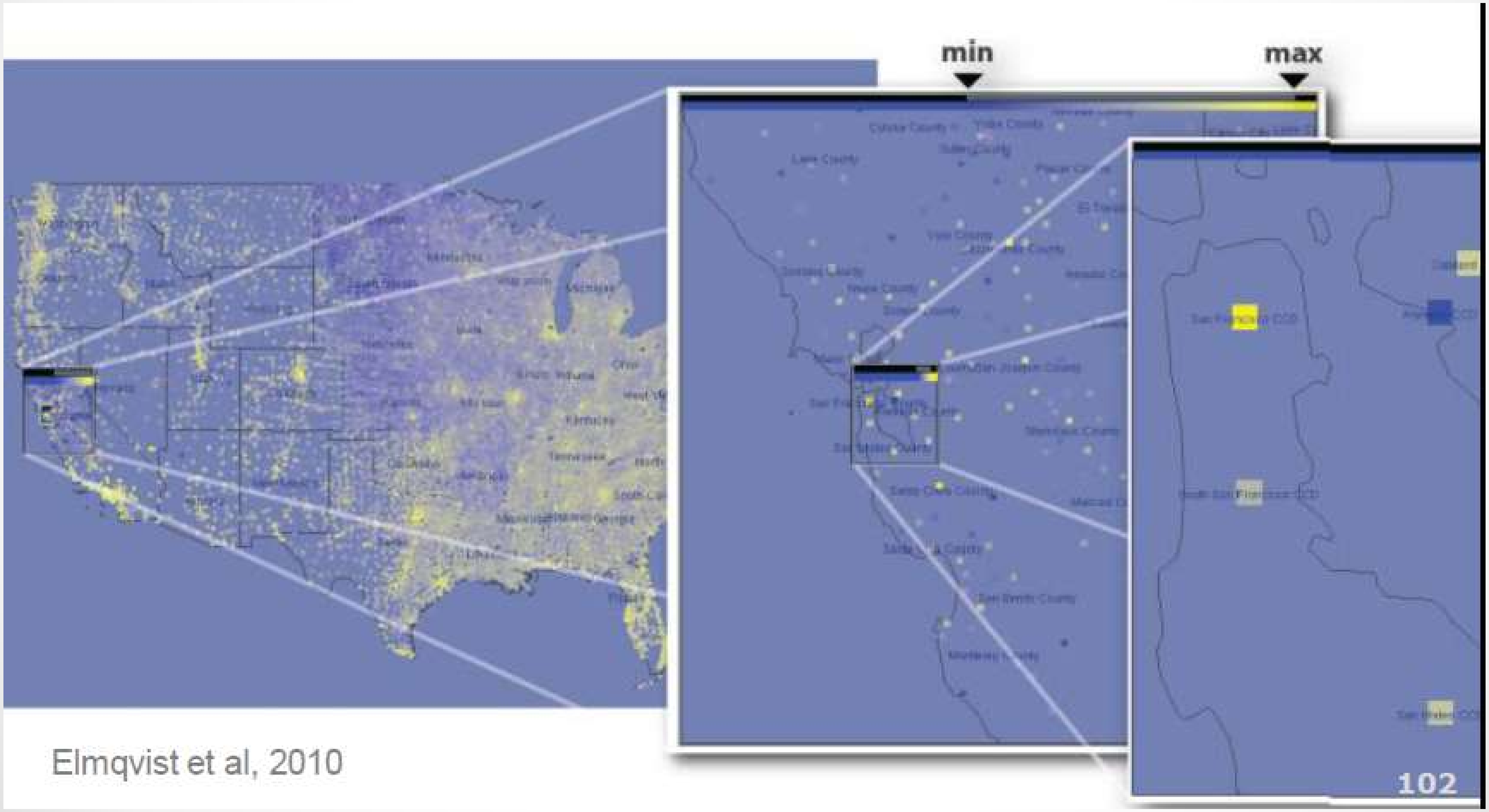
Multiple Views



Overview + Detail



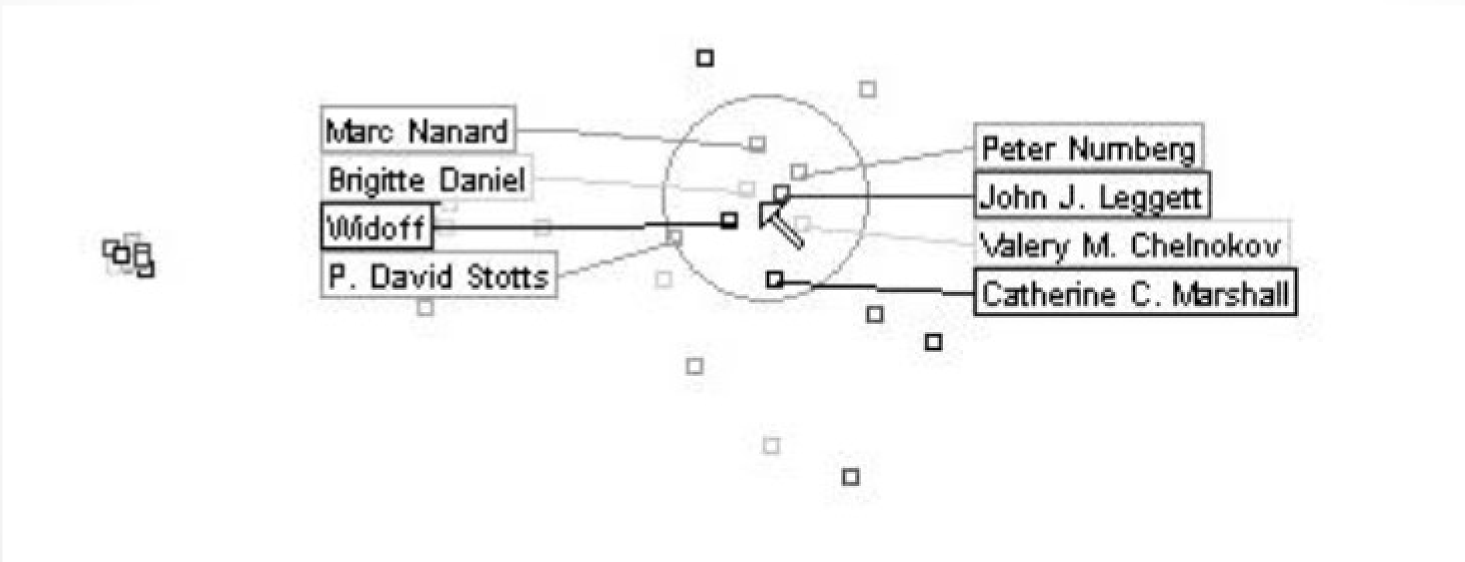
Magic Lens



Elmqvist et al, 2010

Labeling

- Labeling is difficult to do when so many entities exist
- Exentric Labeling: Does not appear until user hovers over data points

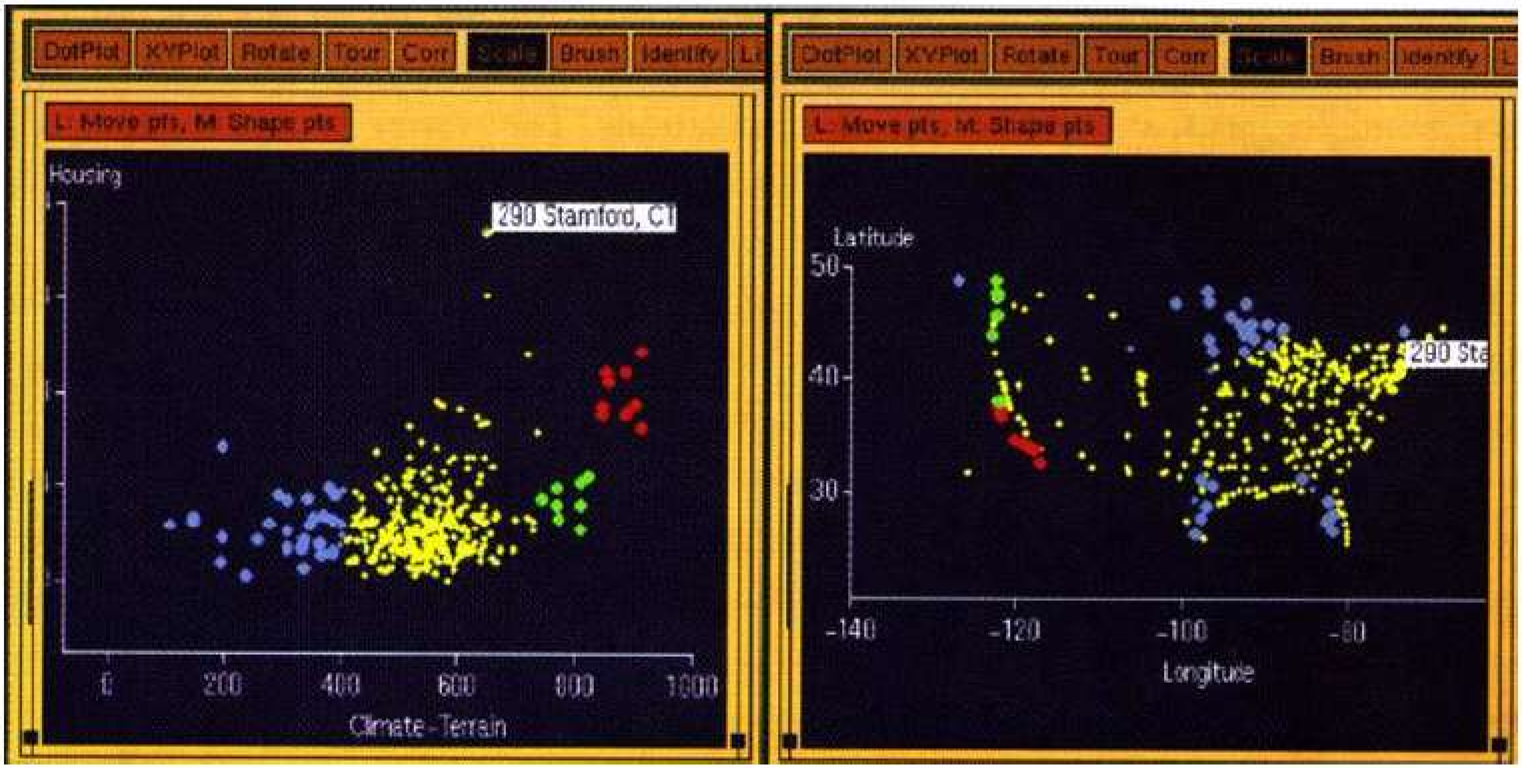


Coordinated Views

- "Show me related items in different views"
  - Highlight associations and relationships
  - Show hidden data items that are relevant to a specified item

- Brushing
  - Selecting or highlighting a case in one view generates highlighting the case in the other views
  - Very common technique in InfoVis

Colored Brushing & Linking



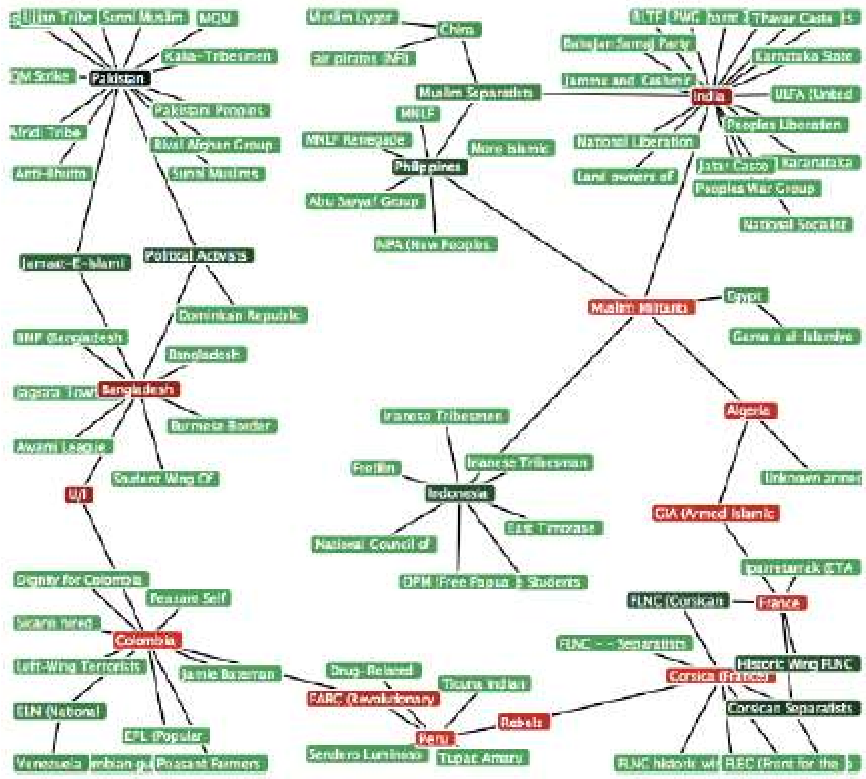
Chris North, 2001

Rankings

Betweenness Centrality

The number of shortest paths between pairs of nodes that pass through a given node.

Rank	Node	Type
2,516.00	Muslim Militants	Terrorist Group
2,436.50	Corsica (France)	Country
2,413.00	Colombia	Country
2,368.00	Peru	Country
2,280.50	France	Country
2,239.00	Algeria	Country
2,226.00	Rebels	Terrorist Group
2,214.00	GIA (Armed Islamic Group)	Terrorist Group
2,124.00	FARC (Revolutionary Armed For...	Terrorist Group
1,718.00	Bangladesh	Country
1,656.00	L/I	Terrorist Group
1,598.00	India	Country
1,063.00	Pakistan	Country
798.00	Corsican Separatists	Terrorist Group
704.00	FLNC (Corsican National Libera...	Terrorist Group
704.00	Historic Wing FLNC	Terrorist Group
637.00	Indonesia	Country
614.00	Political Activists	Terrorist Group
596.00	Philippines	Country
520.00	Jamaat-E-Islami	Terrorist Group
530.00	Muslim Separatists	Terrorist Group
276.00	ELN (National Liberation Army)	Terrorist Group
187.00	Venezuela	Country
187.00	China	Country
94.00	Egypt	Country
0.00	Dignity for Colombia	Terrorist Group
0.00	Jamie Bateman Canon Front	Terrorist Group
0.00	Sendero Luminoso	Terrorist Group
0.00	Jamiat-ul-Mujahideen	Terrorist Group
0.00	Timorese Students	Terrorist Group



(a) Ordered list of 97 nodes in the largest connected component of the terrorism network in 1996. The nodes are ranked according to their betweenness centrality.

(b) Network visualization of the same 97 nodes, colored according to their ranking. The nodes with highest betweenness rankings, sometimes referred to as "gatekeepers", are painted red.

Figure 1.

Perer & Shneiderman TVCG (InfoVis) '06

Multiple Views

MatrixExplorer

- Provides matrix view in combination with node-link and various operations for gaining different perspectives

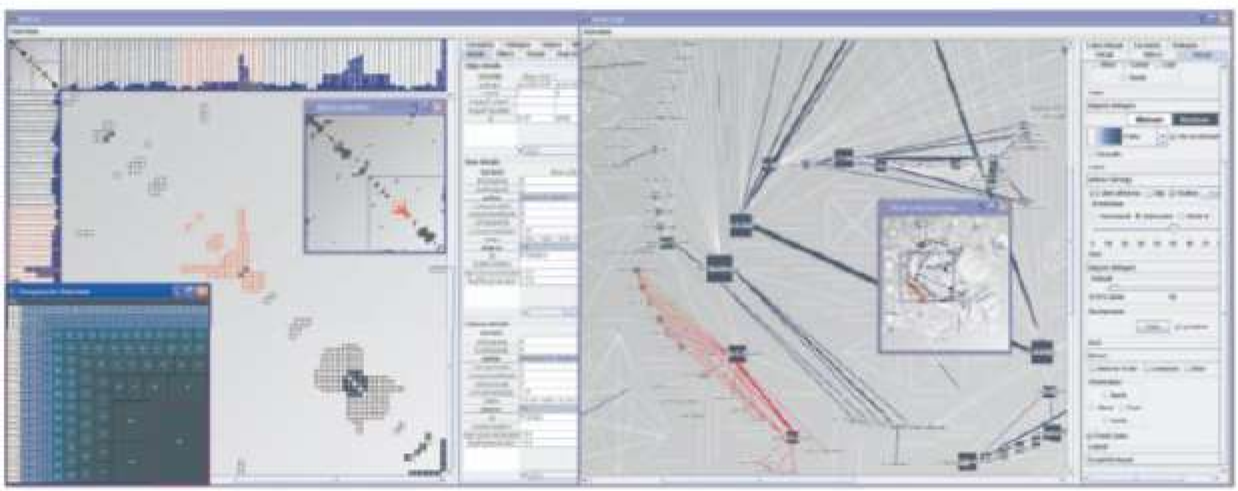


Fig. 1. MatrixExplorer showing two synchronized representations of the same network: matrix on the left and node-link on the right.

Multiple Views – Search & Visualization

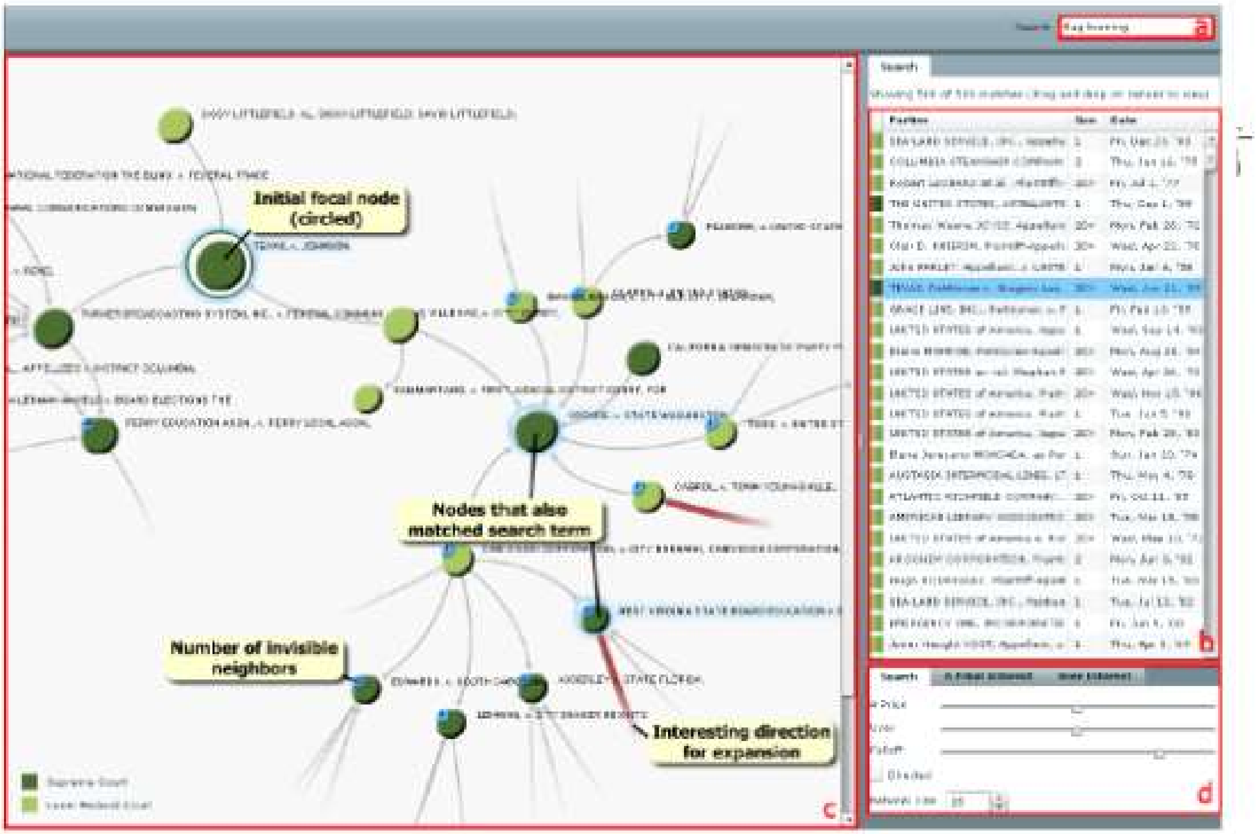


Fig. 3. Basic user interface layout. A user types a query in the searchbox (a) which yields a number of hits presented in tabular form (b). One of these hits can then be dragged to the main screen (c) which shows the subgraph centered on that node. Other nodes that matched the user's search are highlighted in blue. Users can adapt the balance between different components of the DOI function and the size of the subgraph in a separate panel (d).

Alternate Approach for Large Graph Visualization

- "Search, show context, expand on demand"
- van Ham & Perer TVCG (InfoVis) '09

- Show some of the details, rather than high level structure
- Allow users to focus on particular nodes
- Adapt DOI algorithm from trees to graphs
- Rely heavily on interaction

Reading

1. Adam Perer, Ben Shneiderman : Integrating Statistics and Visualization: Case Studies of Gaining Clarity during Exploratory Data Analysis Available at: http://hcil2.cs.umd.edu/trs/2008-03/2008-03.pdf

2. Sarkar and Brown: **Generalized Fish—eye Views of Graphs**Available at: *http://www.hpl.hp.com/techreports/Compaq-DEC/SRC-RR-84A.pdf*

3. Munzer: **H3: Laying Out Large Directed Graphs in 3D Hyperbolic Space** Available at: http://graphics.stanford.edu/papers/h3/html.nosplit/

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