



# Representation- II Encoding relation

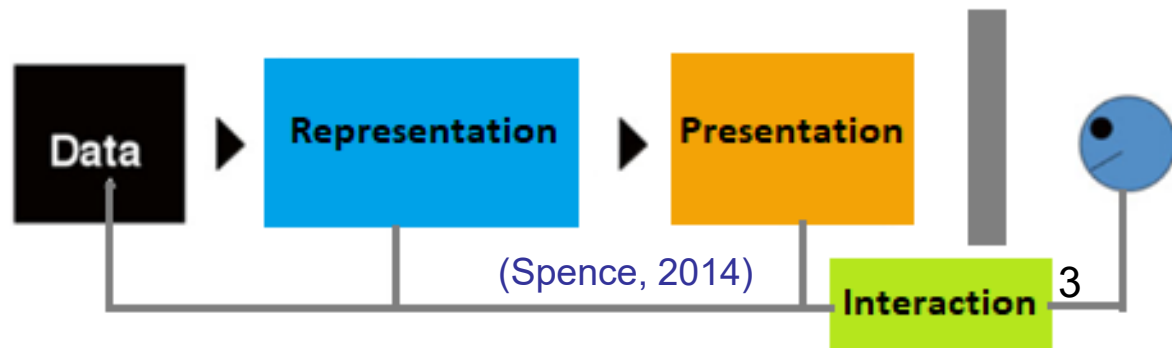


- Two types of data:
  - Value (already addressed)
  - Relation

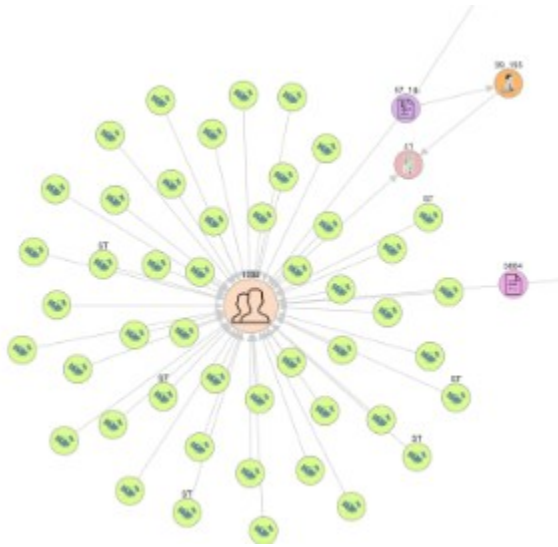
- What is relation?

A logical or natural association between two or more things; relevance of one to another; connection (in dictionary)

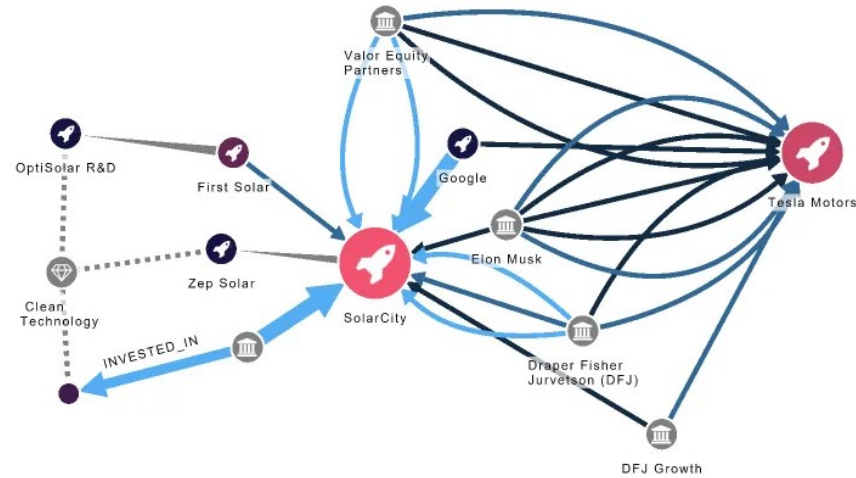
- How to represent relation?



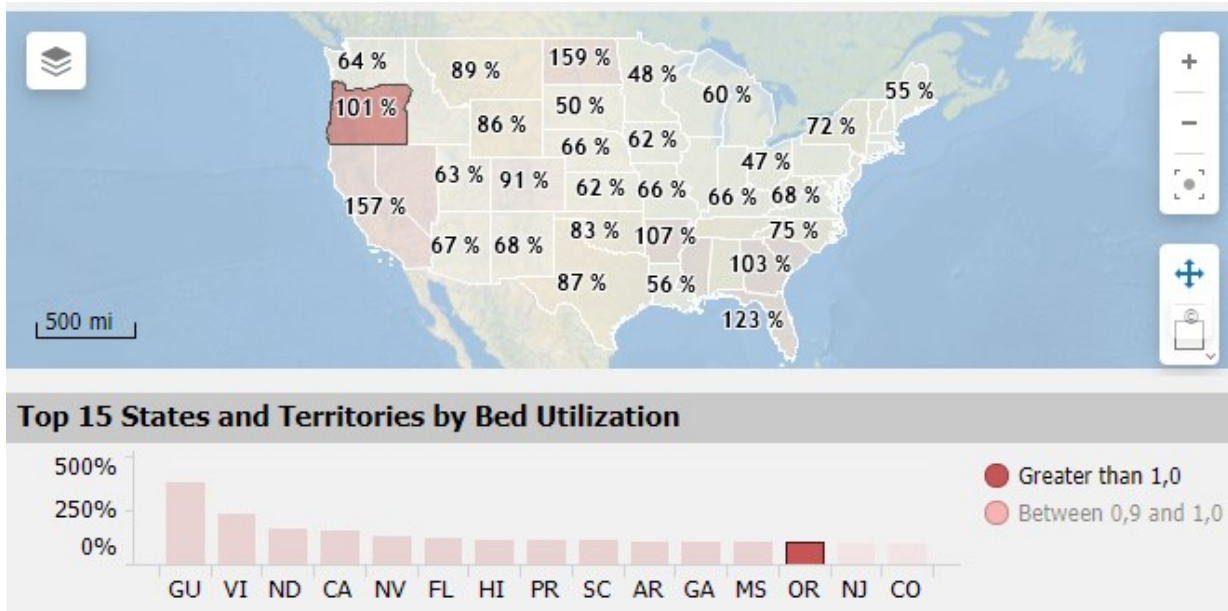
# Several ways to represent relation:



Lines indicate relationship



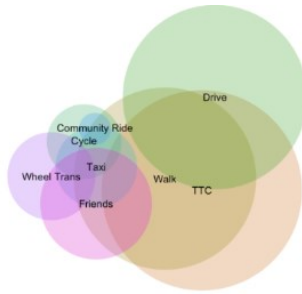
Arrows indicate unique unilateral functional relations



Color indicates a relation between representations

- The nature of relations is different from values
- However, the prime considerations in the choice of a representation are similar:
  - an understanding of the task
  - the insight that is sought
  - what questions might be asked of the relation
- Some representations of relation are very simple, yet powerful

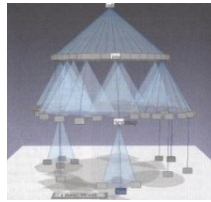
# Encoding relation



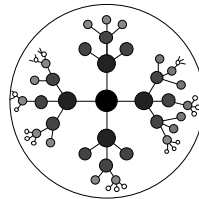
- Diagrams Venn diagrams

- Networks

- Trees Cone trees



- Hyperbolic browser



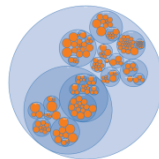
- Treemap



- Sunburst



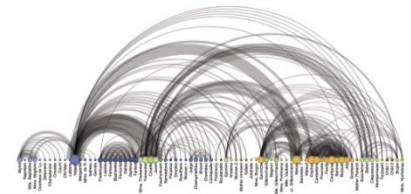
- Nested circles



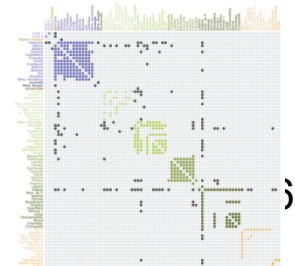
- node-link



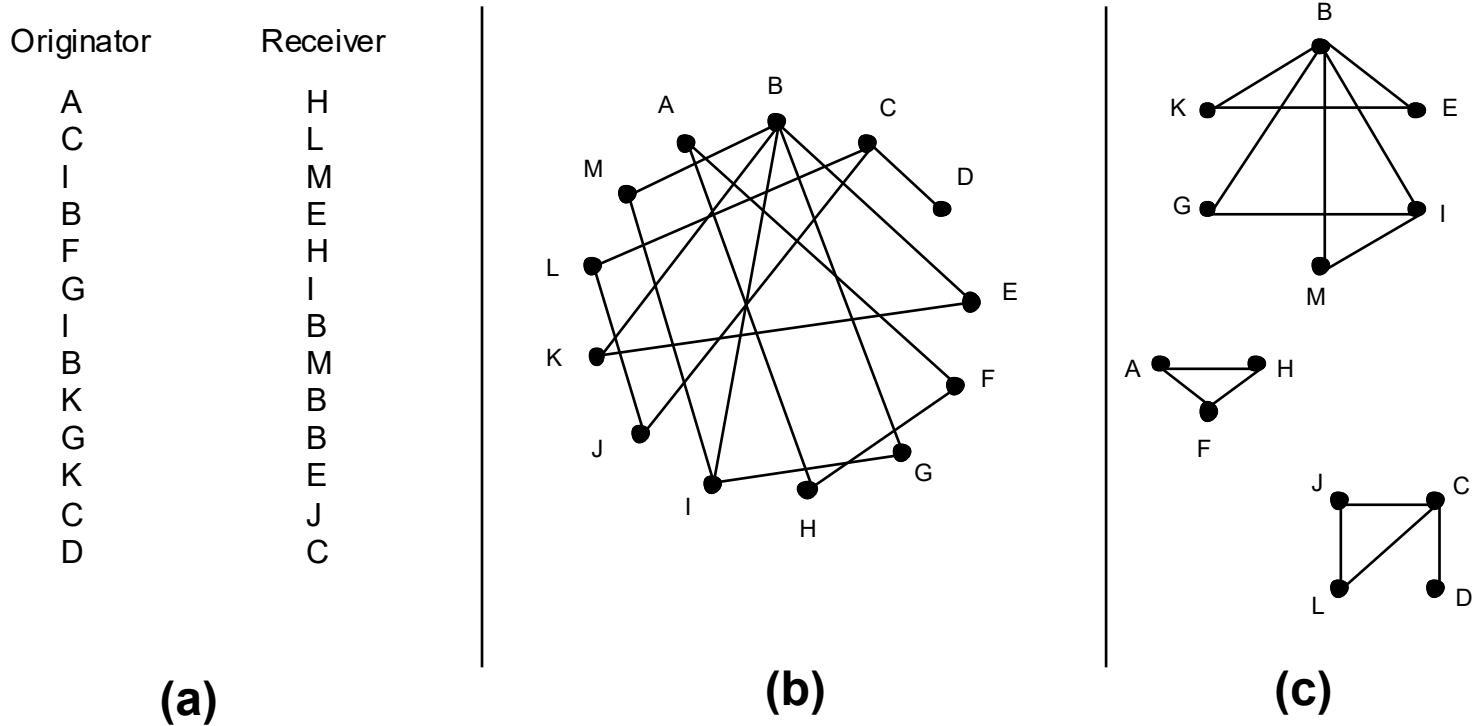
- Arc



- Matrix



- **Lines** are perhaps the simpler way to represent a relation between two entities



Insight into even a short list of telephone calls (a) is enhanced by their node-link representation (b), especially if disconnected subsets can be identified (c).

(Spence, 2007)



Perhaps the most familiar use of lines to represent relations is in transportation maps



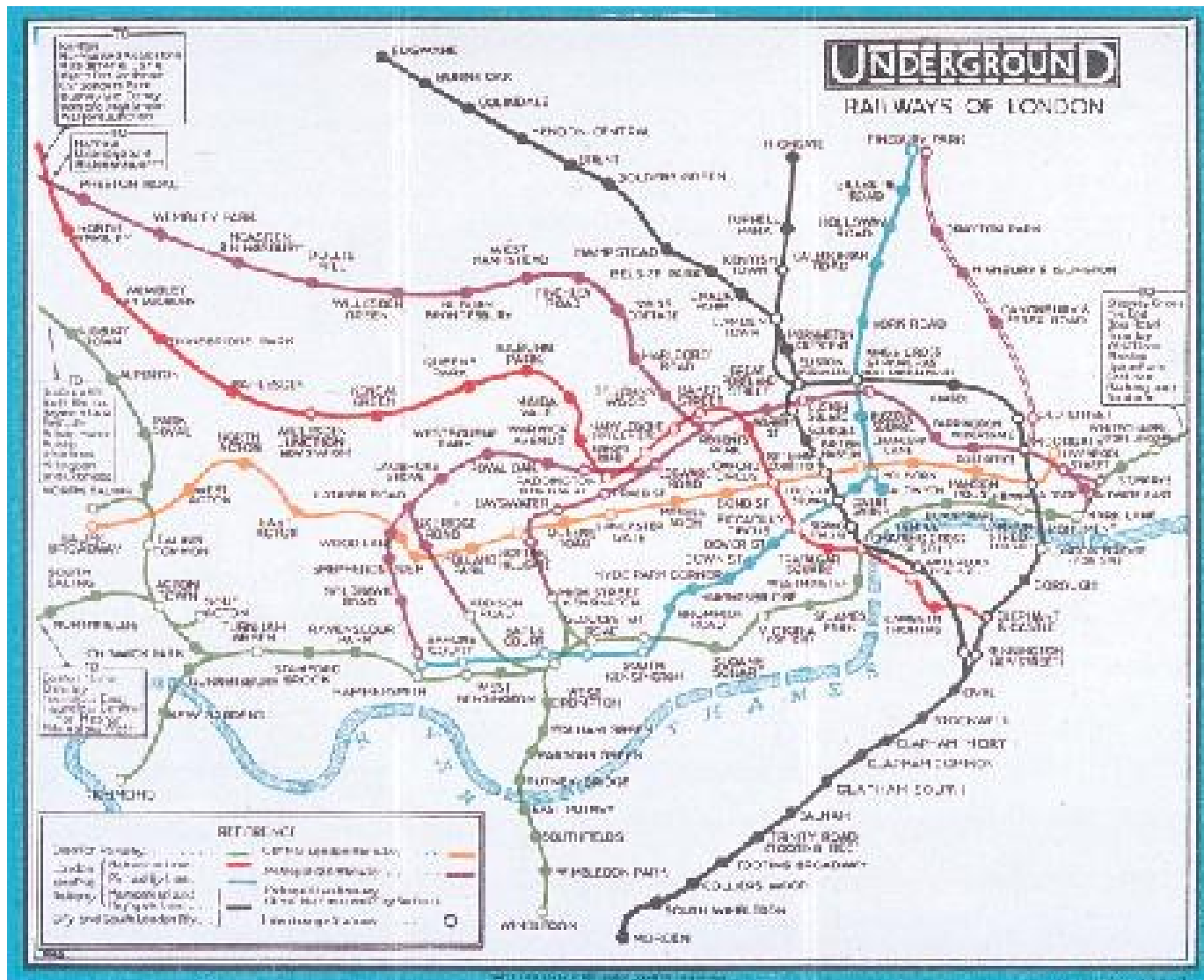
Harry Beck's original London Underground map (1933) (Spence, 2007)

## Topological transportation maps:

- Exploit the shapes into which lines connecting stations are arranged
- Use color to denote different lines
- Use symbols to denote different types of stations
- Have general (but not necessarily) accurate veracity





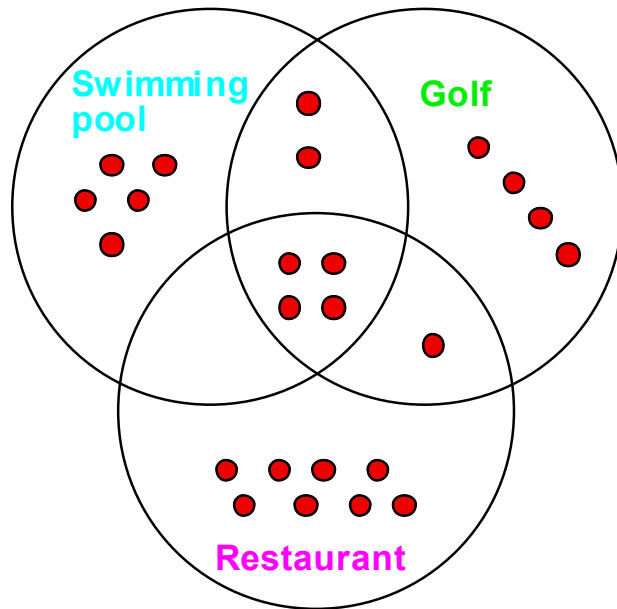


The Underground map in use prior to the introduction of Harry Beck's map

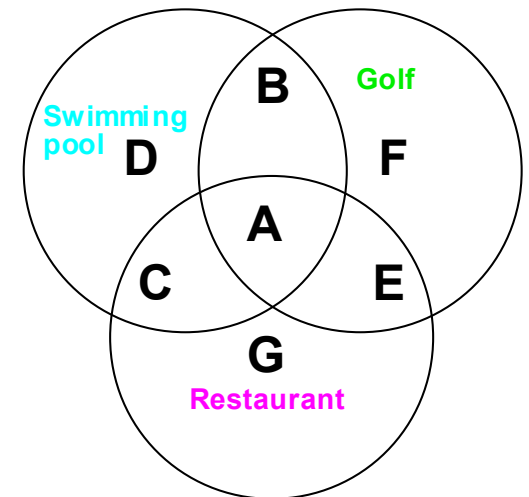
- **Venn diagrams** make easier the search of an object verifying a set of logical relations

	Swimming Pool	Golf Course	Restaurant
A	●	●	●
B	●	●	
C	●		●
D	●		
E		●	●
F		●	
G			●

Facilities offered by eight hotels



A Venn Diagram representation of the attributes of 24 hotels



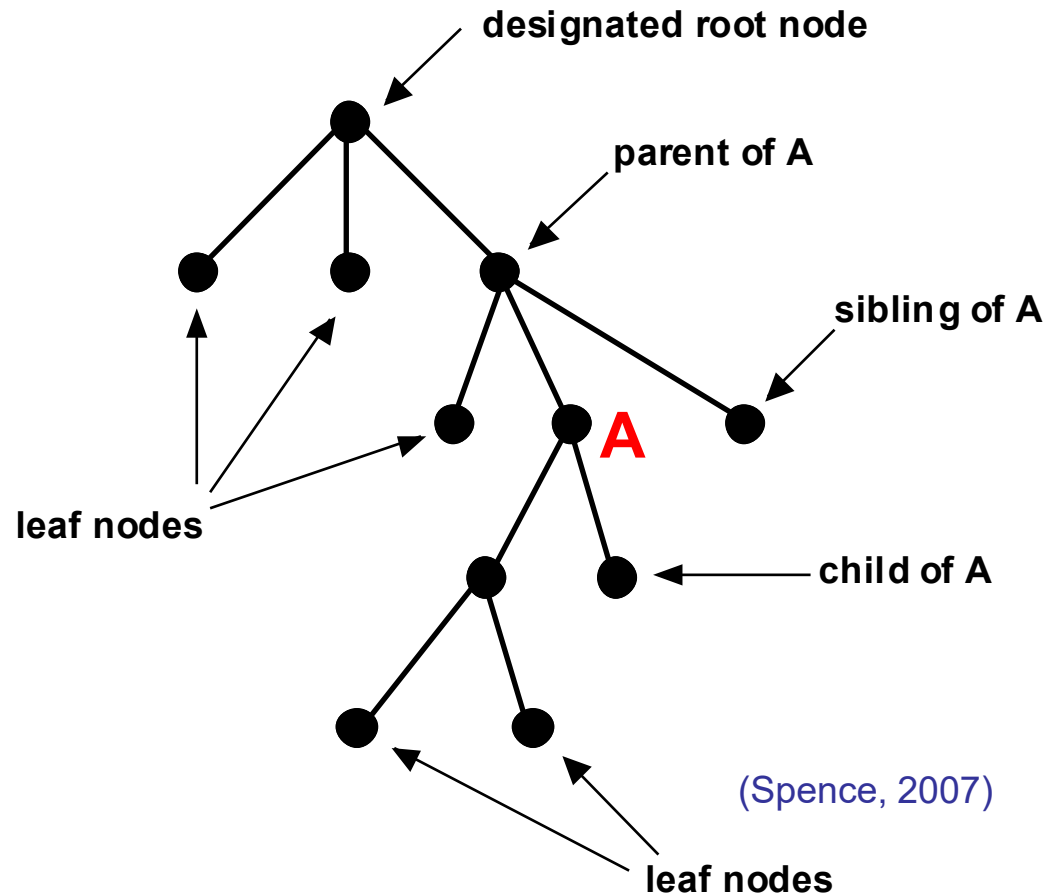
(Spence, 2007)

- The previous representations show relations with no restriction upon what is connected (networks)

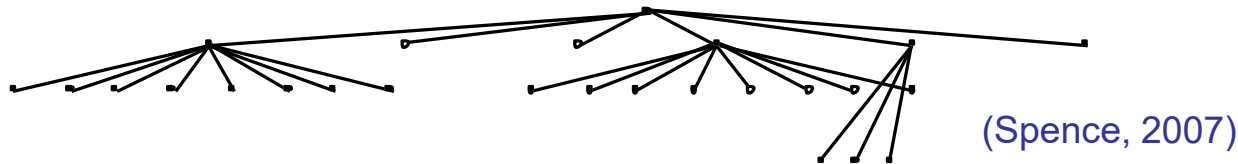
- **Trees** are a class of networks which have no loops

- There are several common representations:

- cone trees
- tree maps
- hyperbolic browser

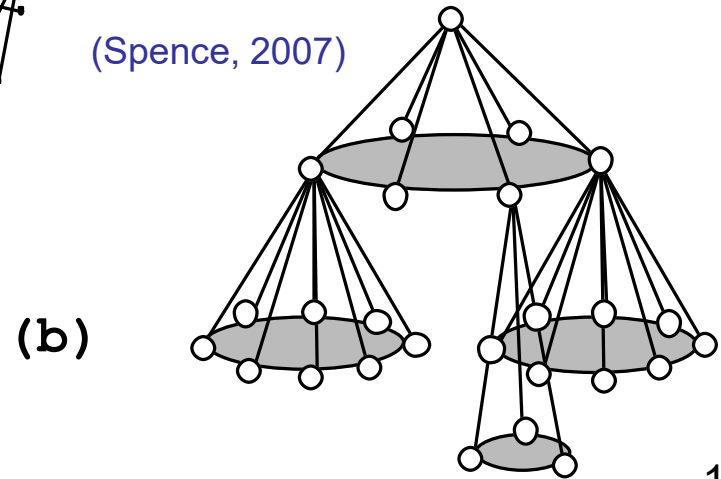


- Representing trees with many levels may occupy much space mainly in the horizontal
- A **Cone tree** (Robertson et al., 1991) corresponds to arrange the nodes subordinate to a given node in a cone
- Cone trees are more compact



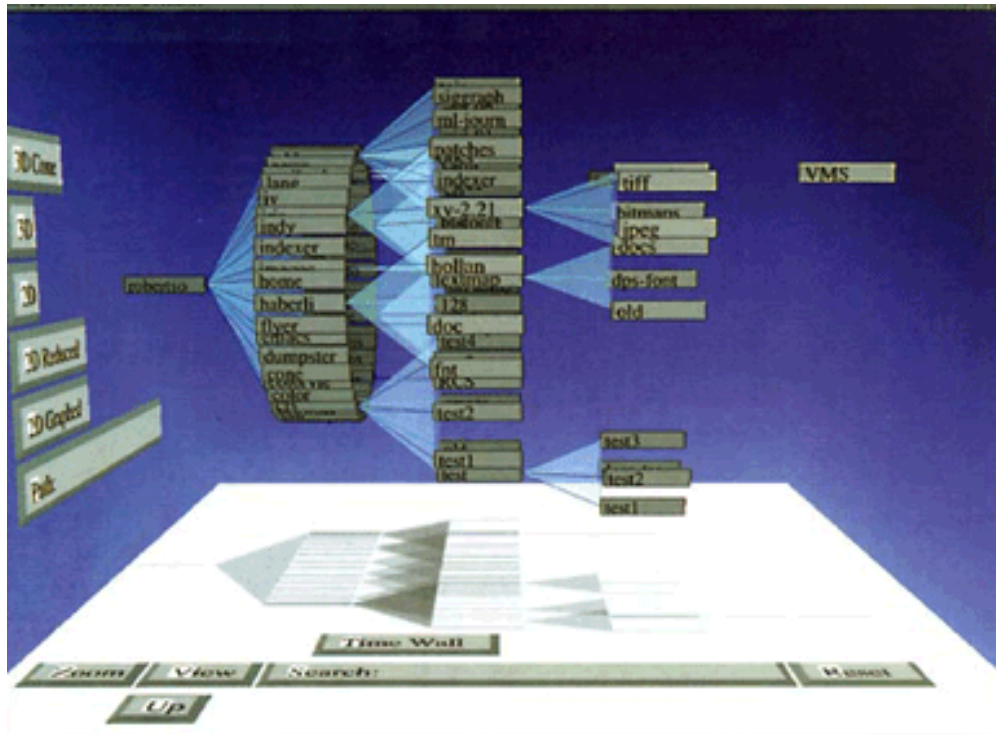
(a)

(a) A tree (b) The corresponding Cone Tree



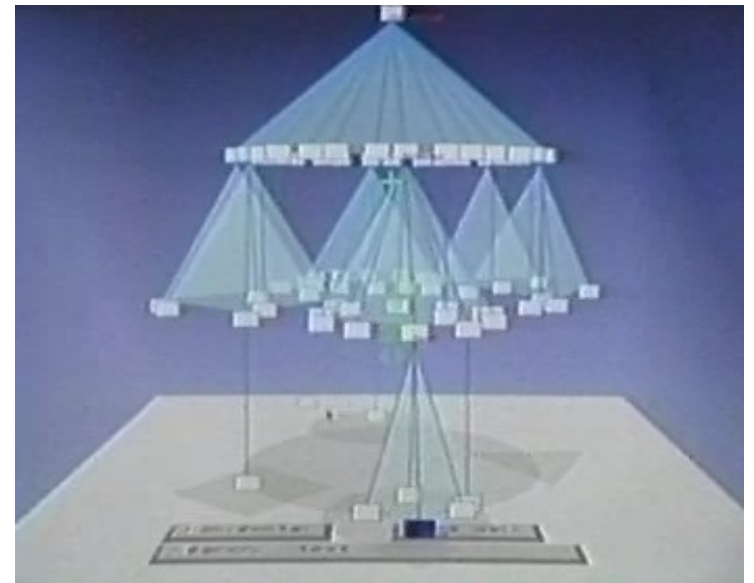
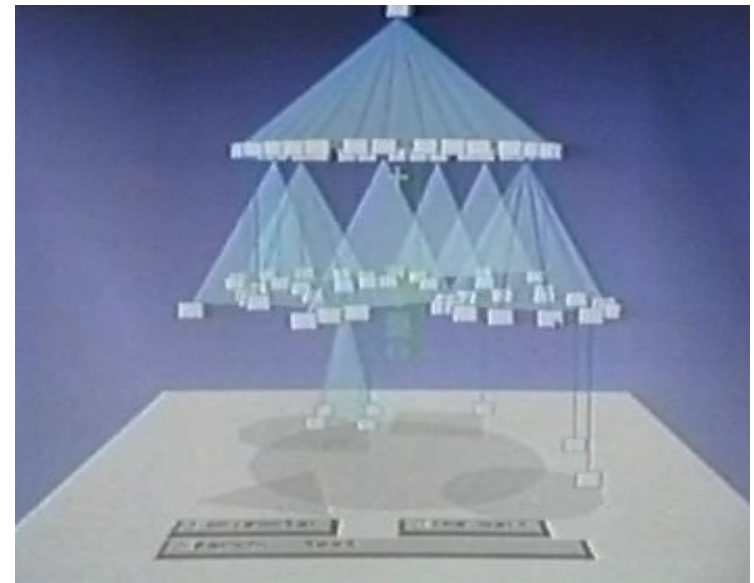
(b)

## Cone trees



A reorientation of the Cone Tree (Cam Tree), more convenient for the textual labeling of nodes

<http://www.youtube.com/watch?v=1eO1pgTVu-g>



(Spence, 2007)



- The **Hyperbolic Browser** (Lamping et al., 1995) represents a tree within a circle

- It is based on a hyperbolic geometric transformation:

- the designated root node is at the center

- its children are distributed around it at a particular distance

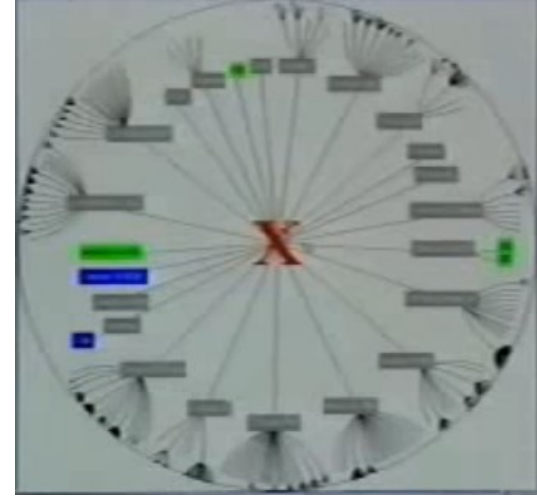
- as the number of levels increase:

- the distance between each node and its parent decreases

- the size of the node also decreases

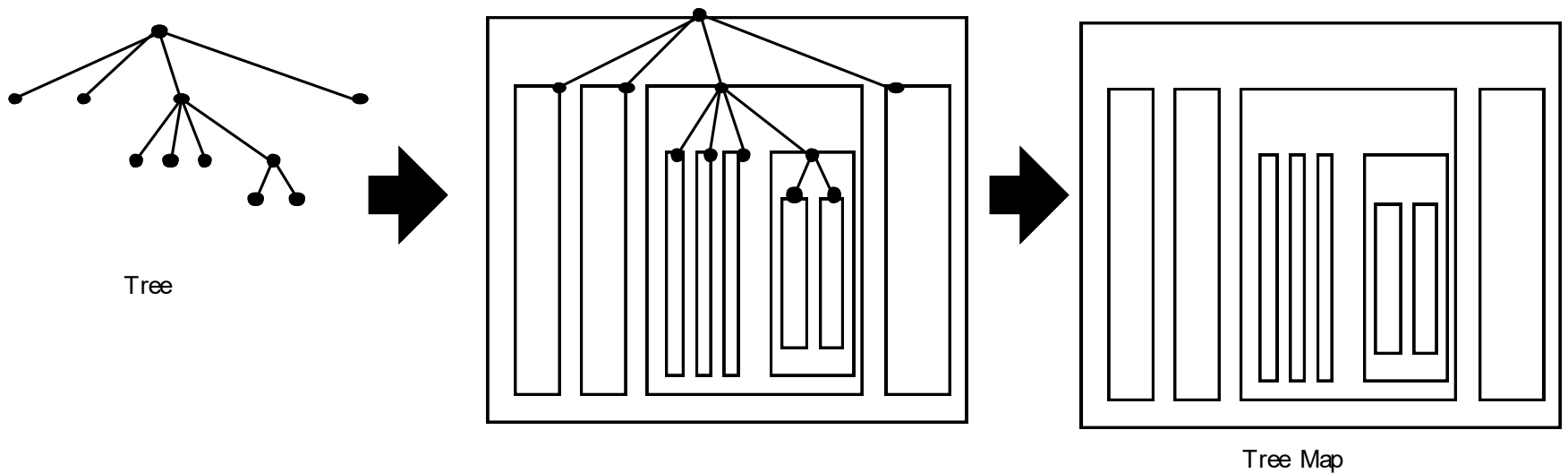
- drawing stops at one pixel resolution

- The principal advantage is its interactive nature: any node of interest can be moved to the center



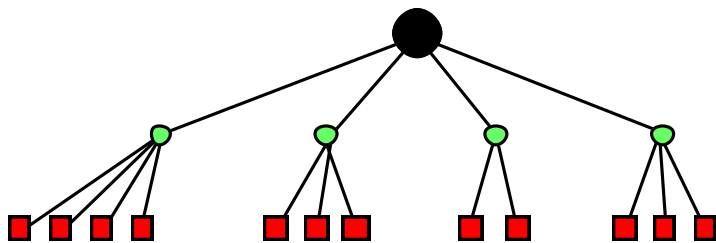
<http://www.youtube.com/watch?v=pwpze3RF55o>

- The **Tree map** (Jonhson and Shneiderman, 1991) is another representation of a tree:
  - the root node is represented by a rectangle (usually as large as possible)
  - within this rectangle there are smaller rectangles (one for each child node)
  - this is repeated until all the nodes are represented



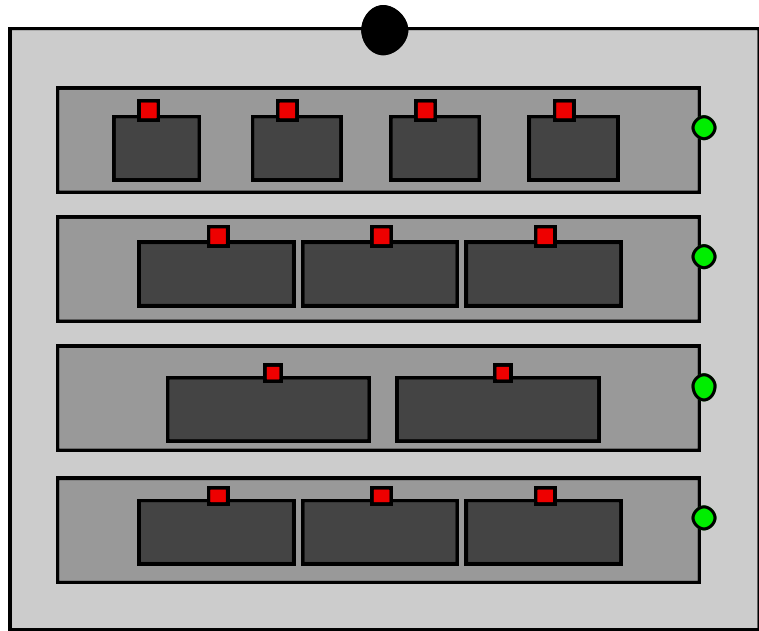
The construction of a Tree Map (Spence, 2007)





Tree

Tree Map

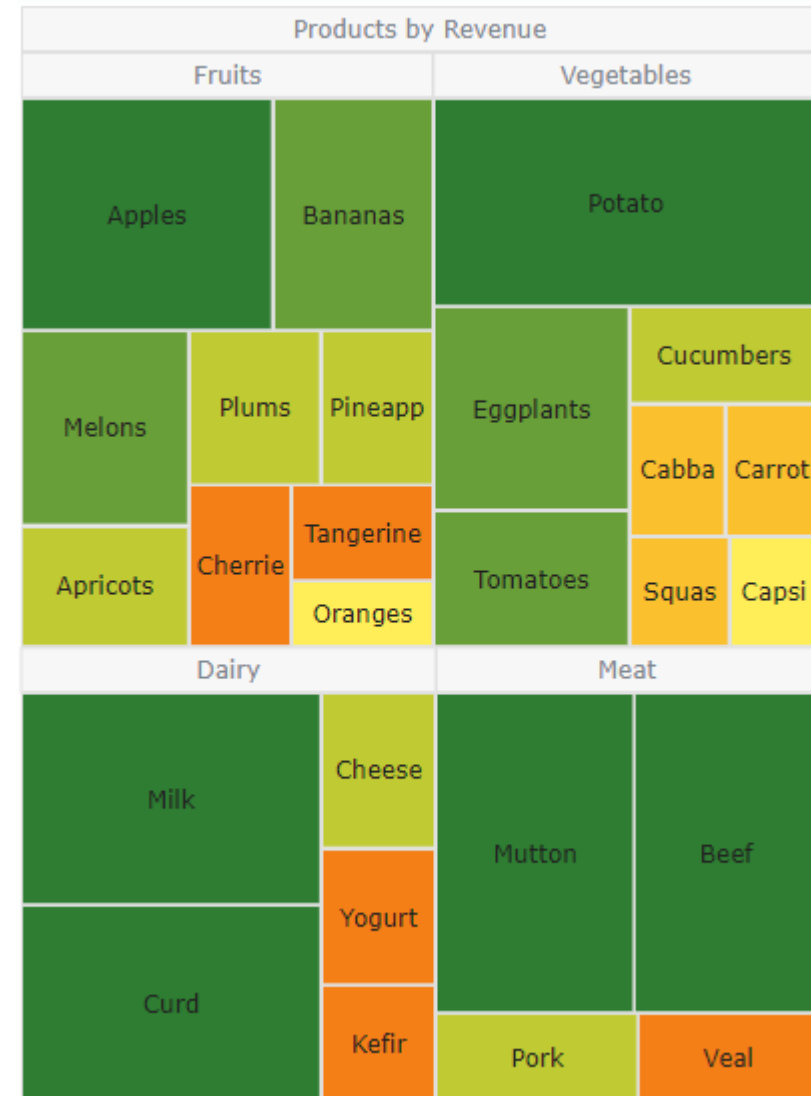


The 'slice-and-dice' construction of a Tree Map to obtain leaf nodes represented by rectangles more suited to the inclusion of text and images (Spence, 2007)

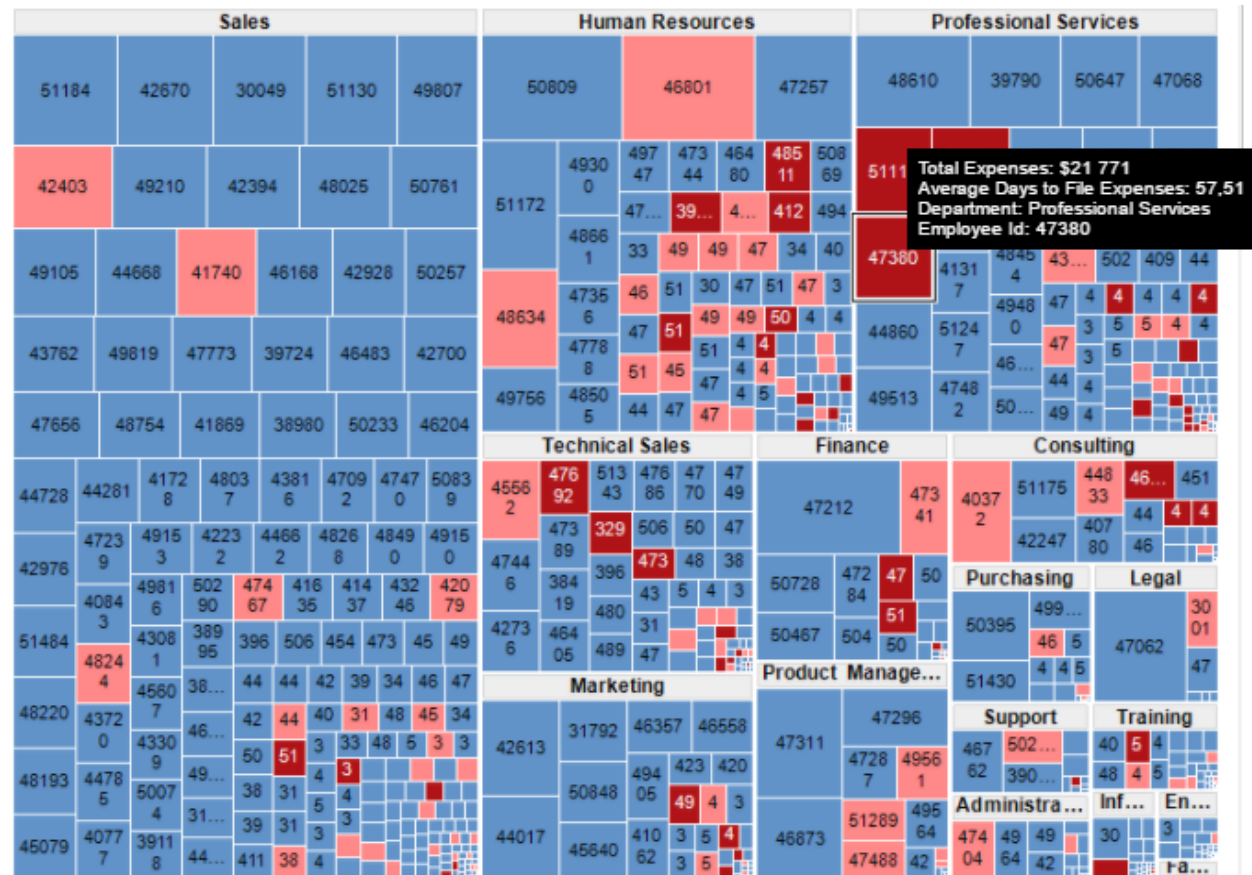
[http://www.youtube.com/watch?v=4tQeQ\\_kzYhA](http://www.youtube.com/watch?v=4tQeQ_kzYhA)

## Main advantages of Treemaps:

- Allow identifying the relationship between two elements in a hierarchy
- optimize the use of space
- accurately display multiple elements together
- show ratios of each part to the whole



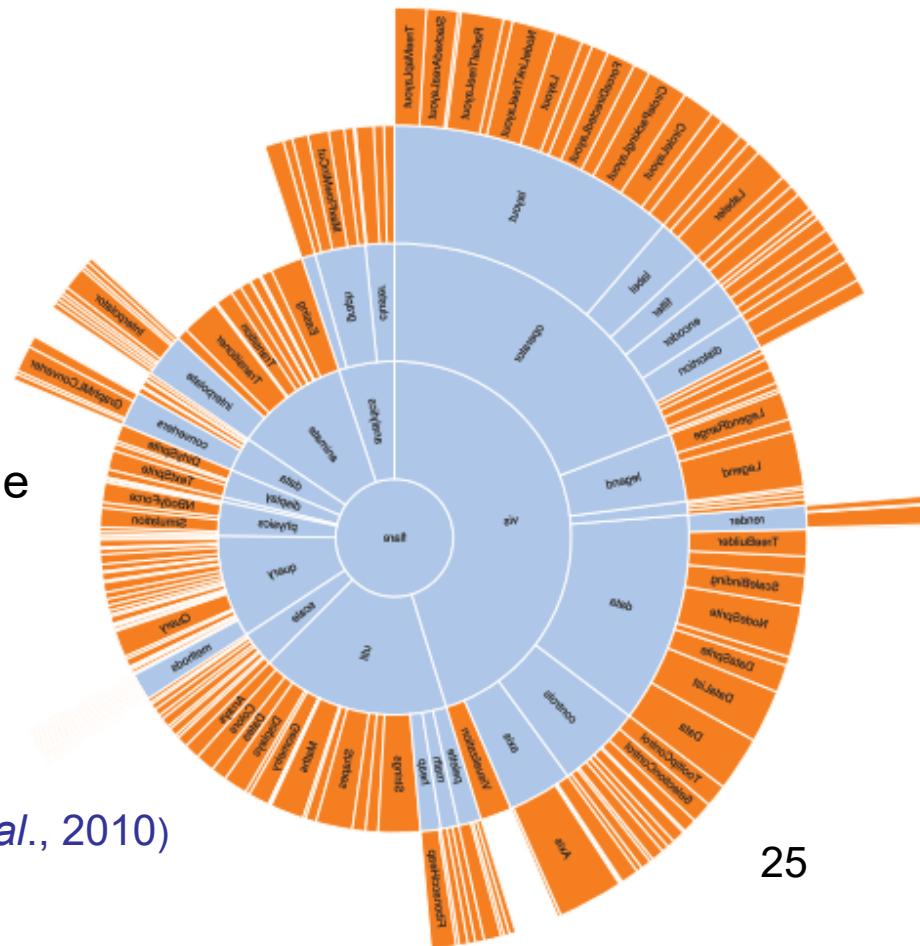
- The treemap offers a lot of opportunities for
  - encoding by color and area
  - interaction by mouse-over and selection of further detail by mouse click



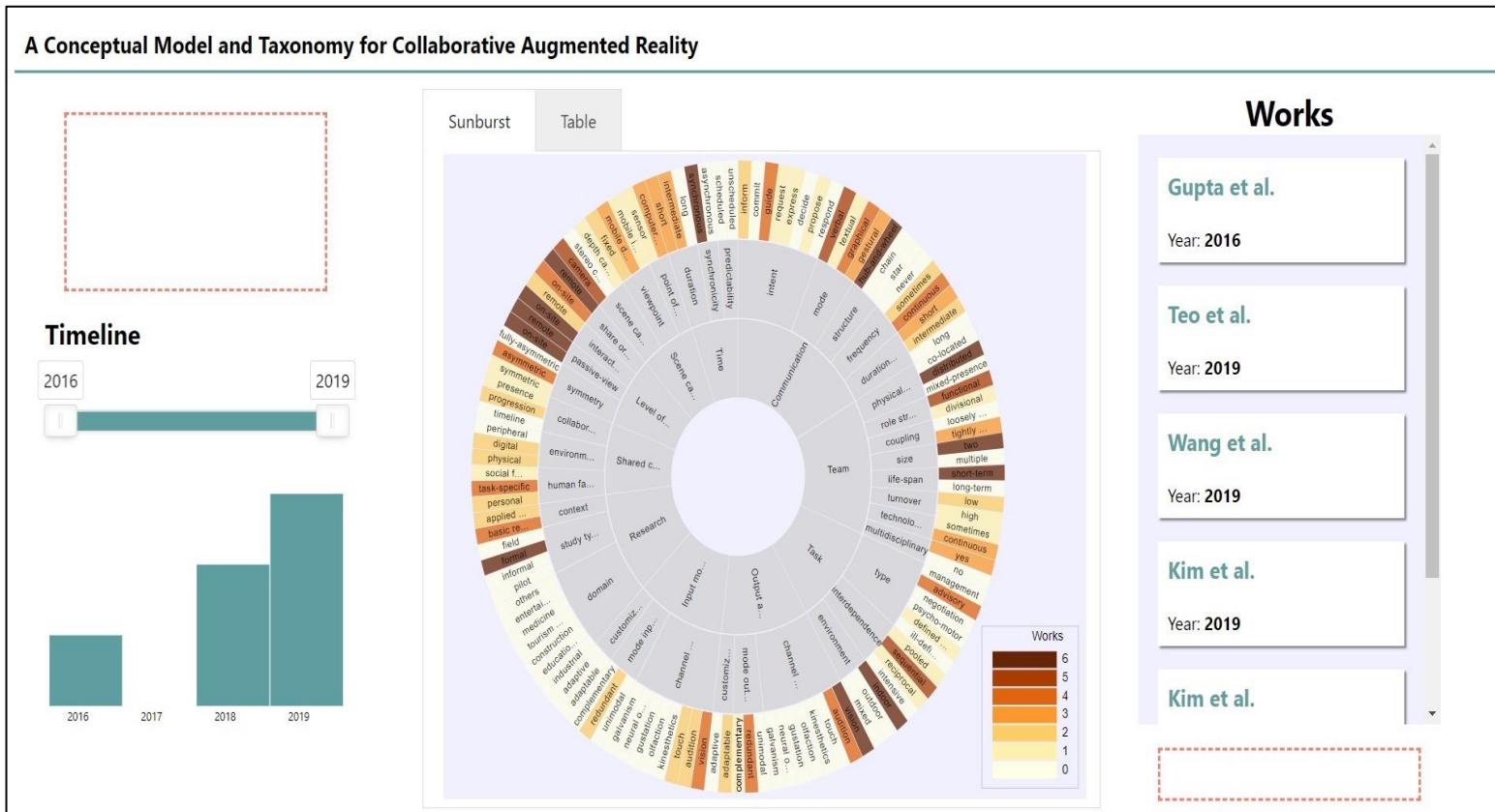
<https://spotfire>

[next.cloud.tibco.com/spotfire/wp/analysis?file=/DemoGallery/SpotfireExpenseAnalyze22r&waid=w0hU-njQ502rG47hpABu3-30030149eftn3l&wavid=0](https://next.cloud.tibco.com/spotfire/wp/analysis?file=/DemoGallery/SpotfireExpenseAnalyze22r&waid=w0hU-njQ502rG47hpABu3-30030149eftn3l&wavid=0)

- The **Sunburst** is another enclosure diagram used to represent a tree
- Also known as Ring Chart, Multi-level Pie Chart, and Radial Treemap
- An inner circle surrounded is by rings of deeper hierarchy levels
- The angle of each segment is:
  - divided equally under its parent node or
  - proportional to a value
- All segments may be colored according to category or hierarchy level (Heer *et al.*, 2010)

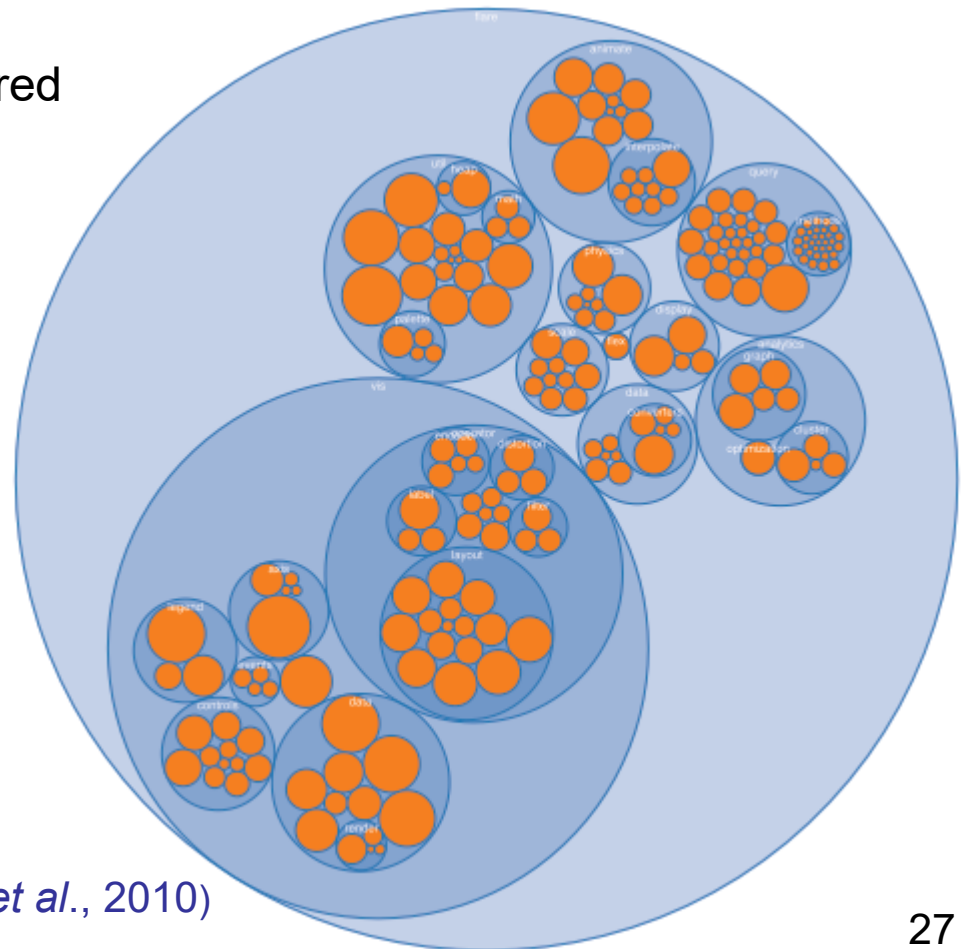


# Using a Sunburst to visualize a taxonomy



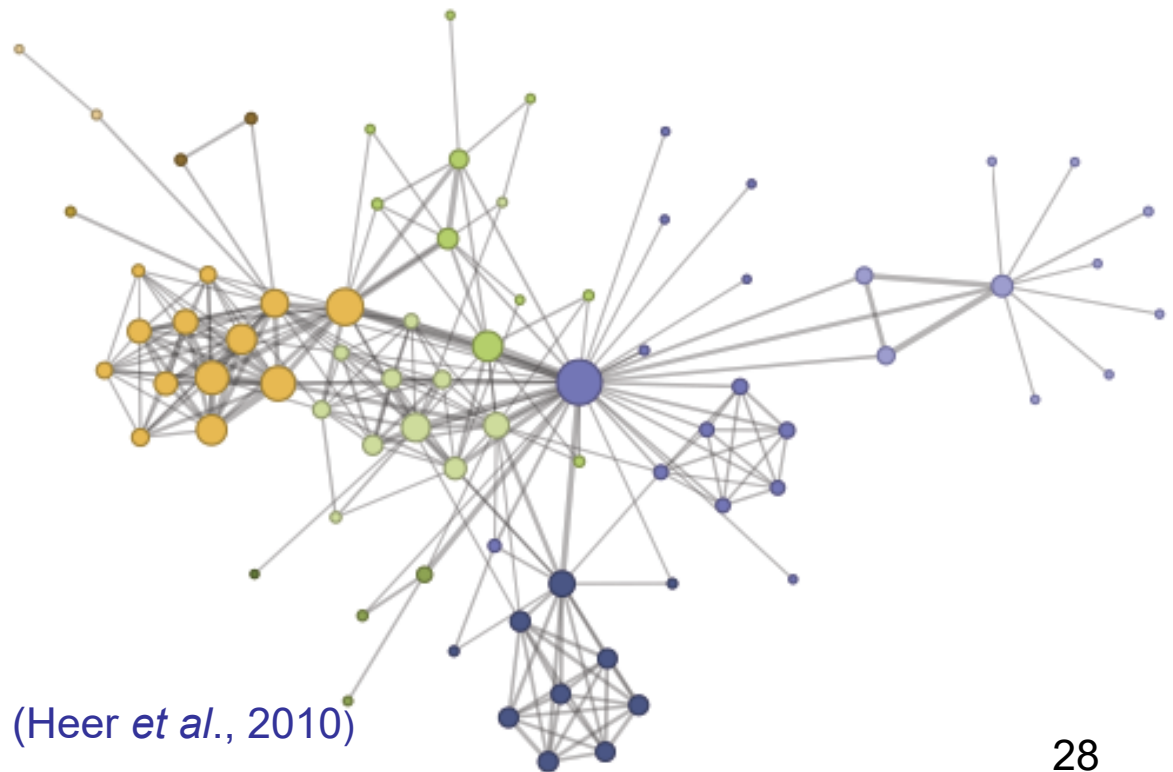
[https://tiagodavi70.github.io/survey\\_viewer/overview.html](https://tiagodavi70.github.io/survey_viewer/overview.html)

- The **nested circles** layout is a different sort of enclosure
- It does not use space as efficiently as a treemap, but it effectively reveals the hierarchy
- Node sizes can be rapidly compared using area judgments.



(Heer *et al.*, 2010)

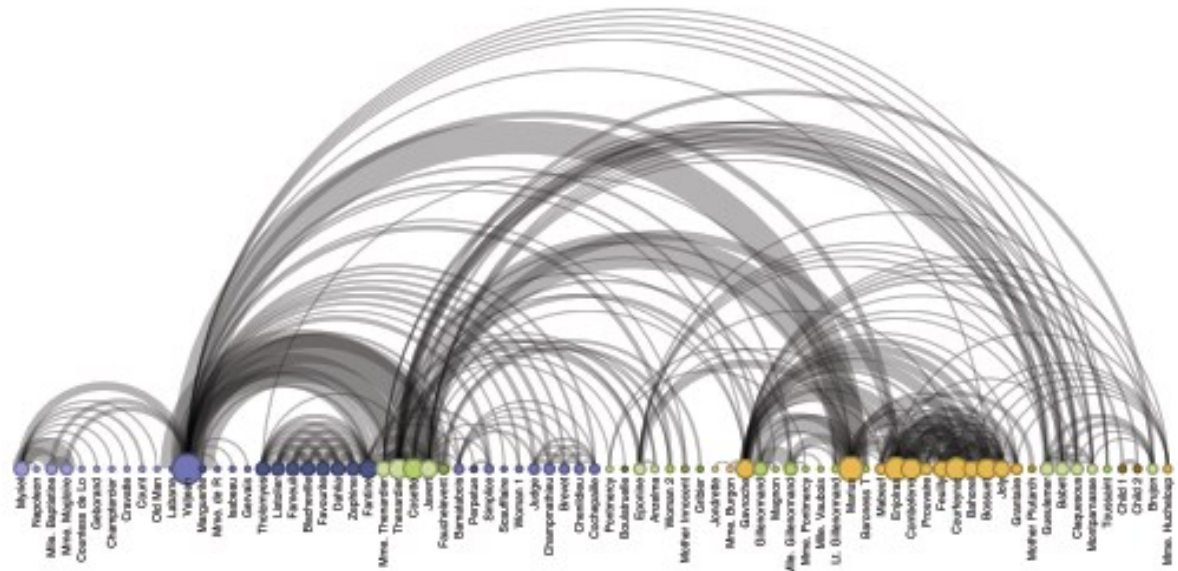
- The **node-link (force directed)** layout is a common and intuitive approach to network layout; it models the graph as a physical system
- Nodes are charged particles that repel each other, and links are dampened springs that pull related nodes together





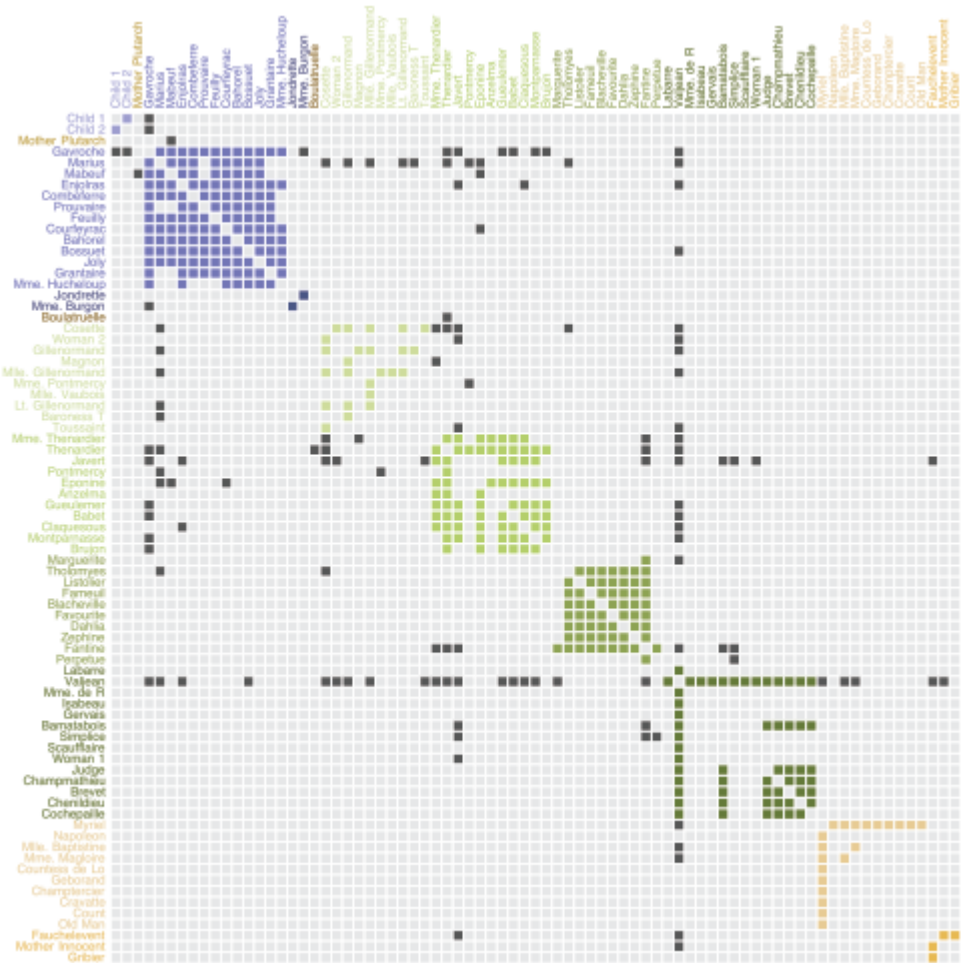
- The **arc diagrams** use a one-dimensional layout of nodes, with circular arcs to represent links
- May not convey the overall structure of the graph as effectively as a two-dimensional layout, with a good ordering of nodes it is easy to identify cliques and bridges
- , Multivariate data can easily be displayed alongside nodes
- Seriation is the problem of sorting the nodes in a manner that reveals underlying cluster structure is formally called seriation

(Heer *et al.*, 2010)



- The **matrix views** represent the adjacency matrix of a graph
- Using color or saturation instead of text allows values associated with the links to be perceived more rapidly

•, The seriation problem also applies



(Heer et al., 2010)

- “ many more ... visualization exist ... Emerging domains such as bioinformatics and text visualization are driving researchers and designers to continually formulate new and creative representations ... the DNA underlying all visualizations remains the same: the principled mapping of data variables to visual features such as position, size, shape and color...” (Heer *et al.*, 2010)

## Word Cloud: simple representation of text

- Used to visualize free form text or tags
- After preprocessing the text the number of occurrences of each word is shown with font size or color

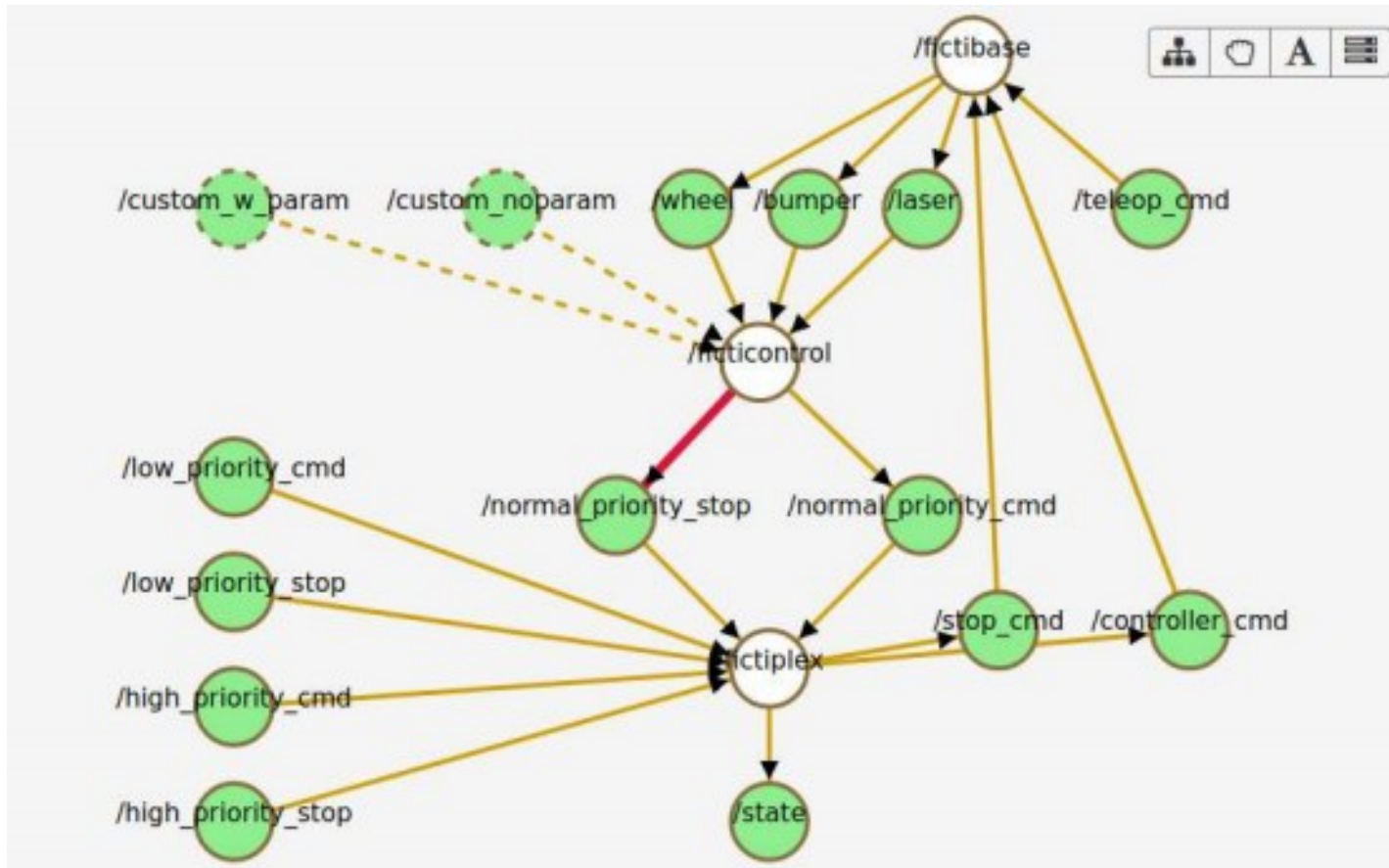


R. Mazza, *Introduction to Information Visualization*, 2004 (chap.1):

“**Data**” was the most often used word

# A graph visualization: The ROS Computation Graph

Computation Graph with query reports (highlighted is a Link with a queue of size 1)



(André Santos, 2021)

# Main bibliography

- Spence, R., *Information Visualization, Design for Interaction*, 2nd ed., Prentice Hall, 2007
- Mazza, R., *Introduction to Information Visualization*, Springer, 2009
- Munzner, T., *Visualization Analysis and Design*, A K Peters/CRC Press, 2014
- Ware, C., *Information Visualization, Perception to Design*, 2nd ed., Morgan Kaufmann, 2004
- Heer, J., Bostock, M., Ogievetsky, V., “A Tour through the Visualization Zoo”, *ACM Queue*, vol. 8, n.5, 2010 <https://queue.acm.org/detail.cfm?id=1805128>
- [http://www.wikiviz.org/wiki/Main\\_Page](http://www.wikiviz.org/wiki/Main_Page)

## Acknowledgement

The author of these slides is very grateful to Professor Robert Spence as he provided the electronic version of his book figures