

Data Visualization (CSCI 627/490)

Trees & Multiple Views

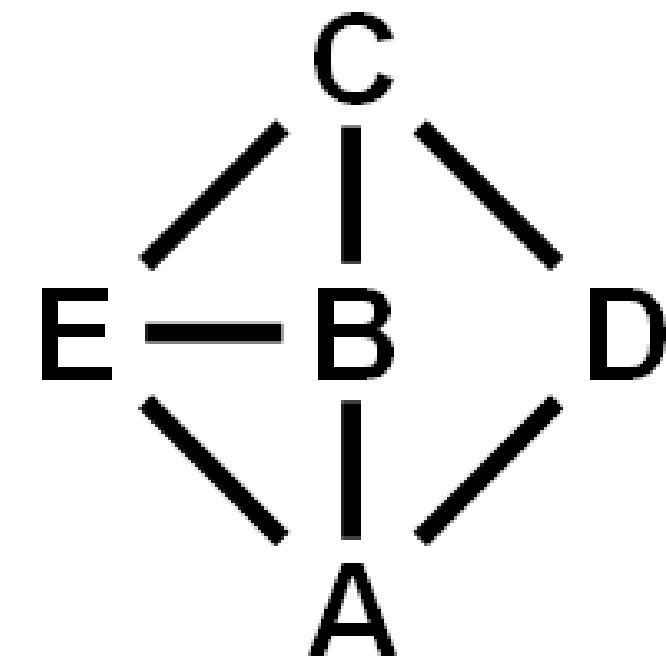
Dr. David Koop

Node-Link Diagrams Need Layouts

- Need to use spatial position when designing node-link visualizations
- Otherwise, nodes can **occlude** each other, links hard to distinguish
- How?
 - With bar charts, we could order using an attribute...
 - With networks, we want to be able to see connectivity and topology (not in the data usually)
- Possible metrics:
 - Edge crossings
 - Node overlaps
 - Total area

Adjacency Matrix

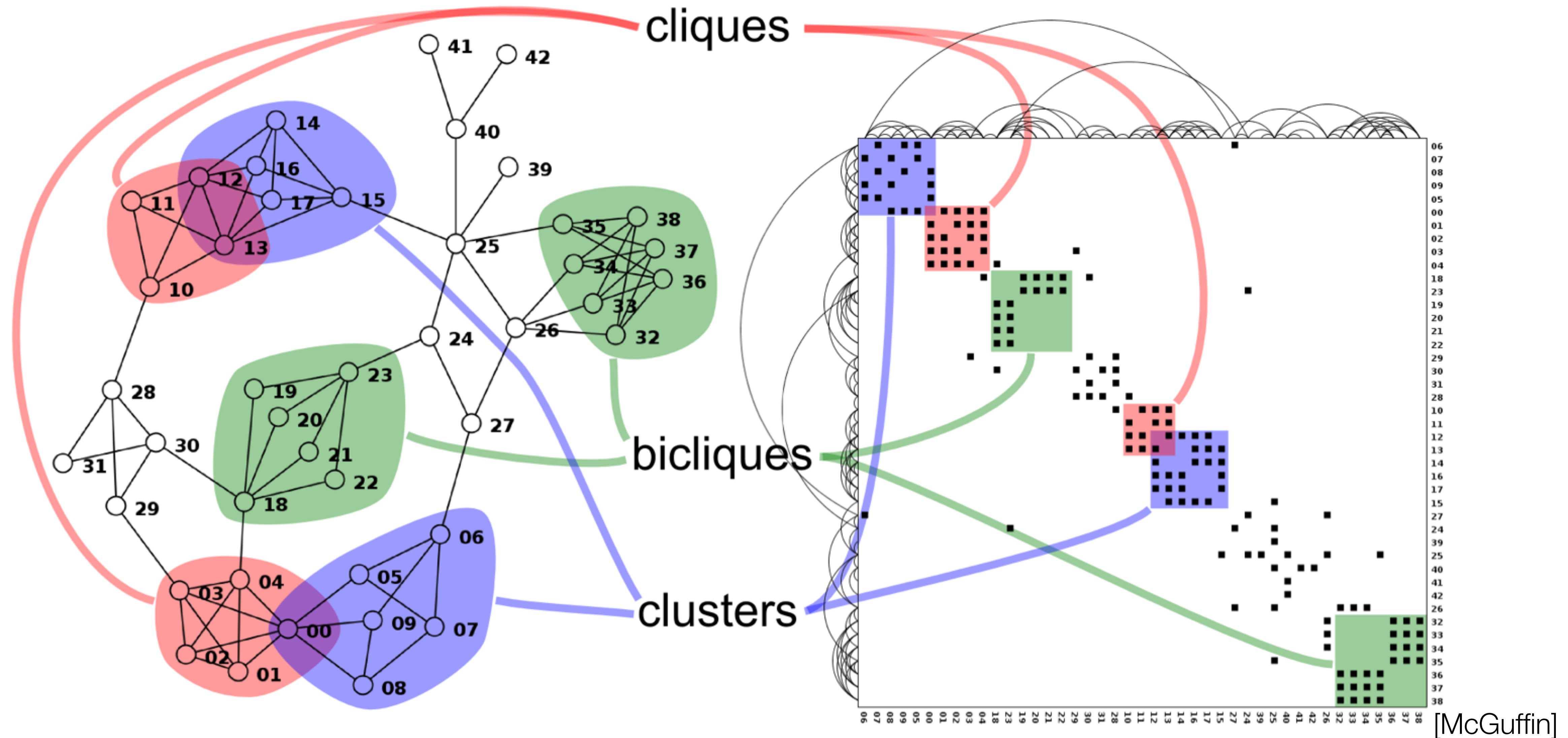
- Change network to tabular data and use a matrix representation
- Derived data: nodes are keys, edges are boolean values
- Task: lookup connections, find well-connected clusters
- Scalability: millions of edges
- Can encode **edge weight**, too



	A	B	C	D	E
A	A	■	□	■	■
B		B	■	□	■
C			C	■	■
D				D	□
E					E

[Henry et al., 2007]

Structures from Adjacency Matrices

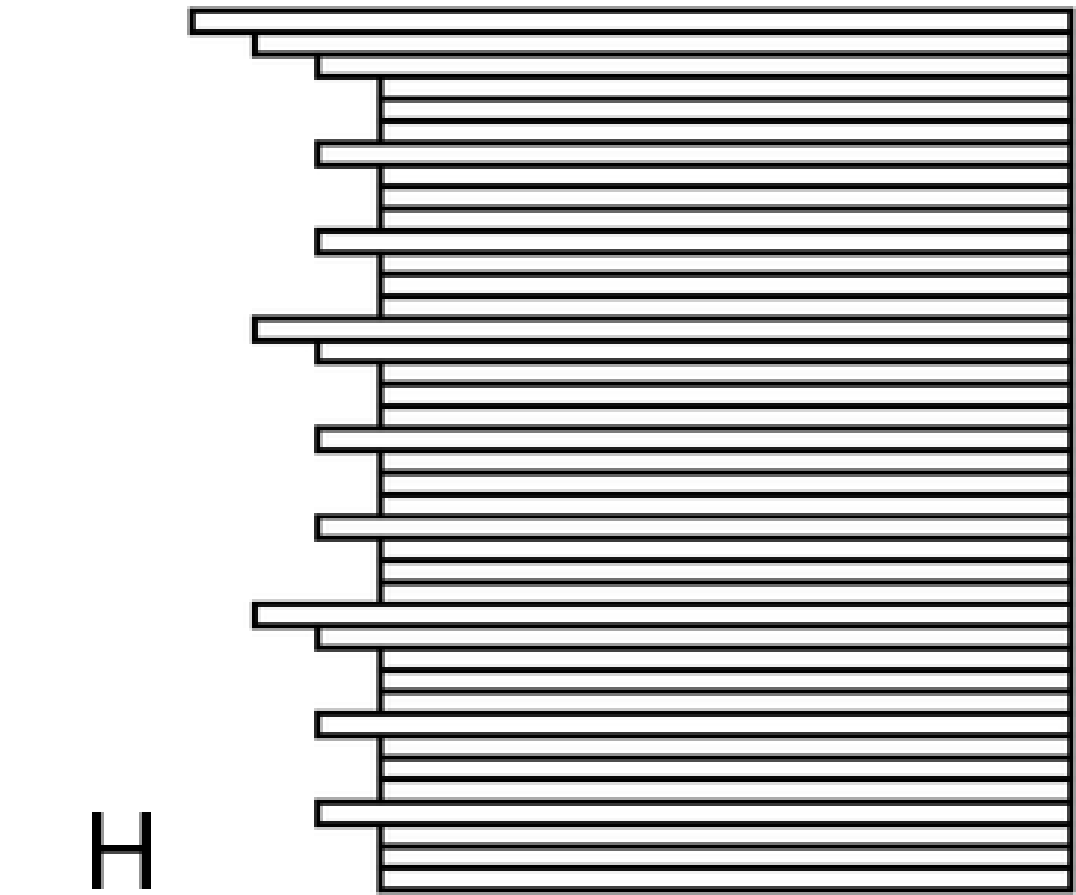
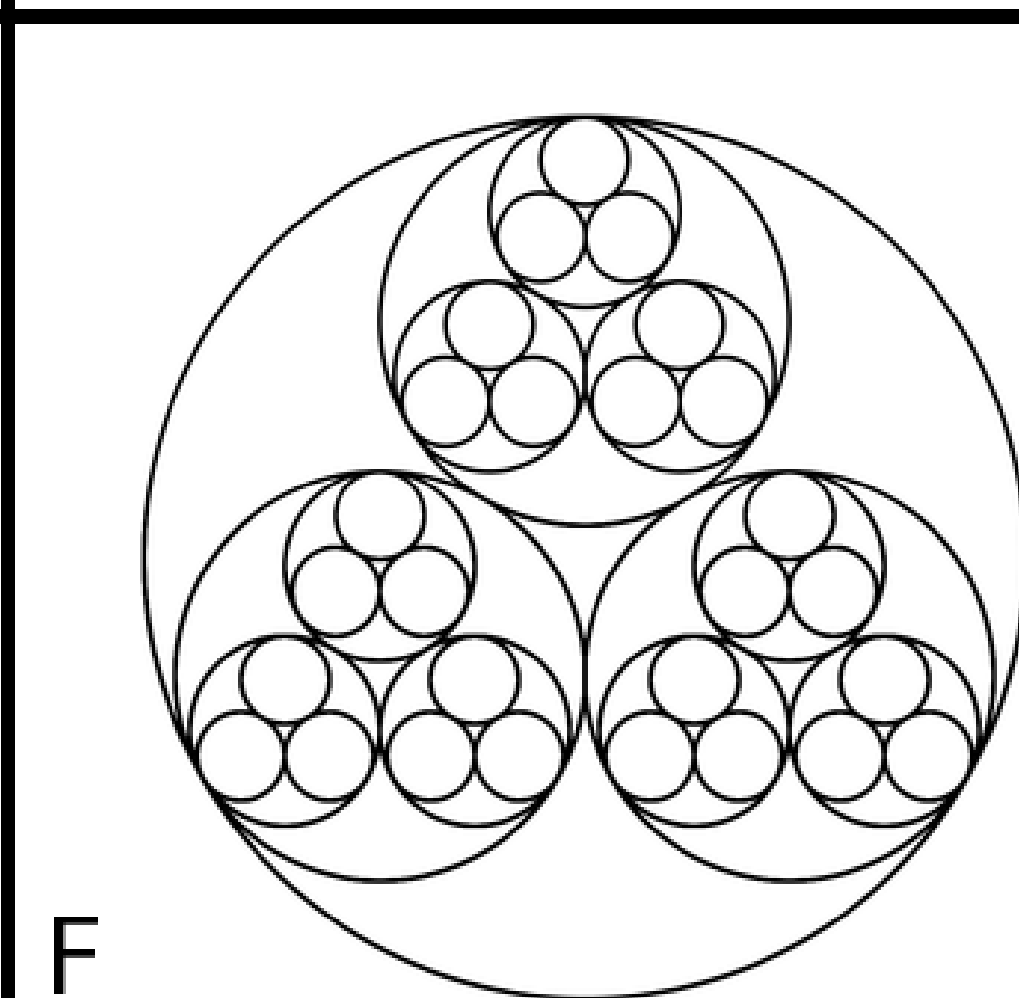
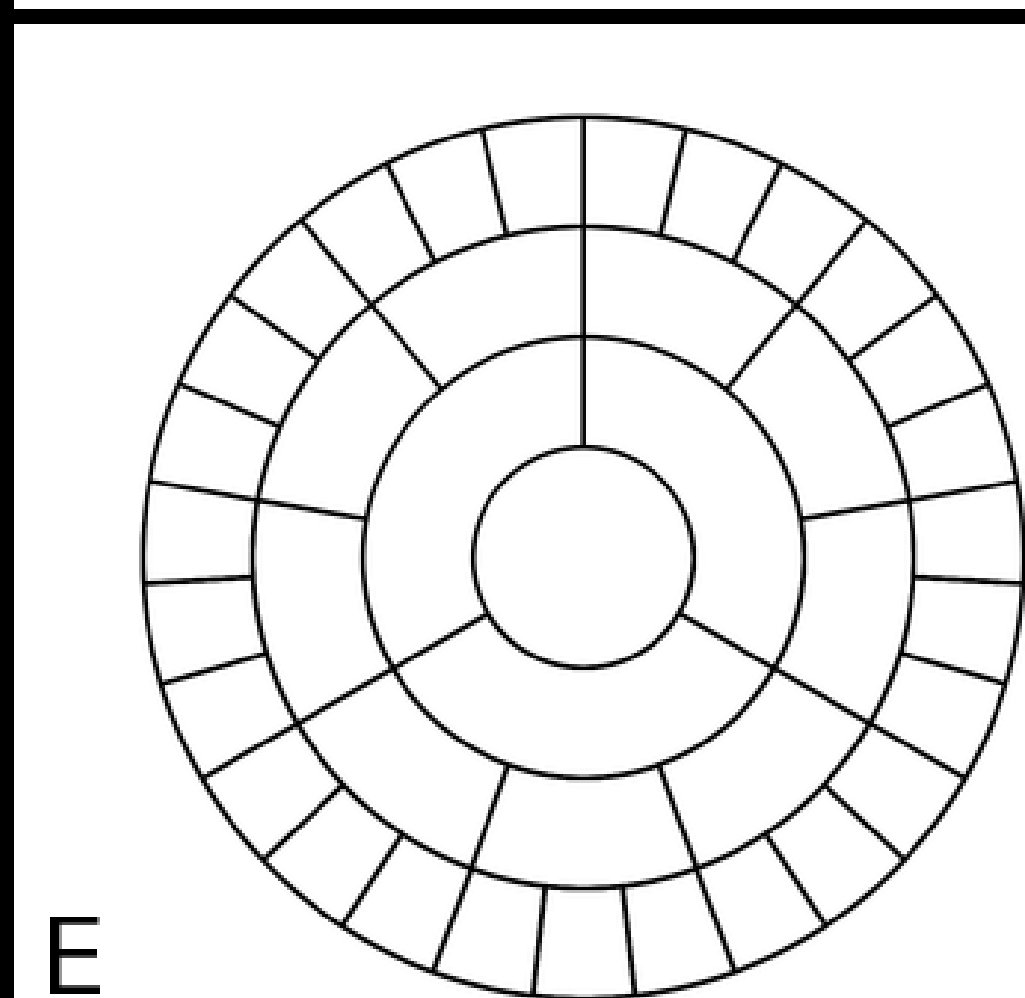
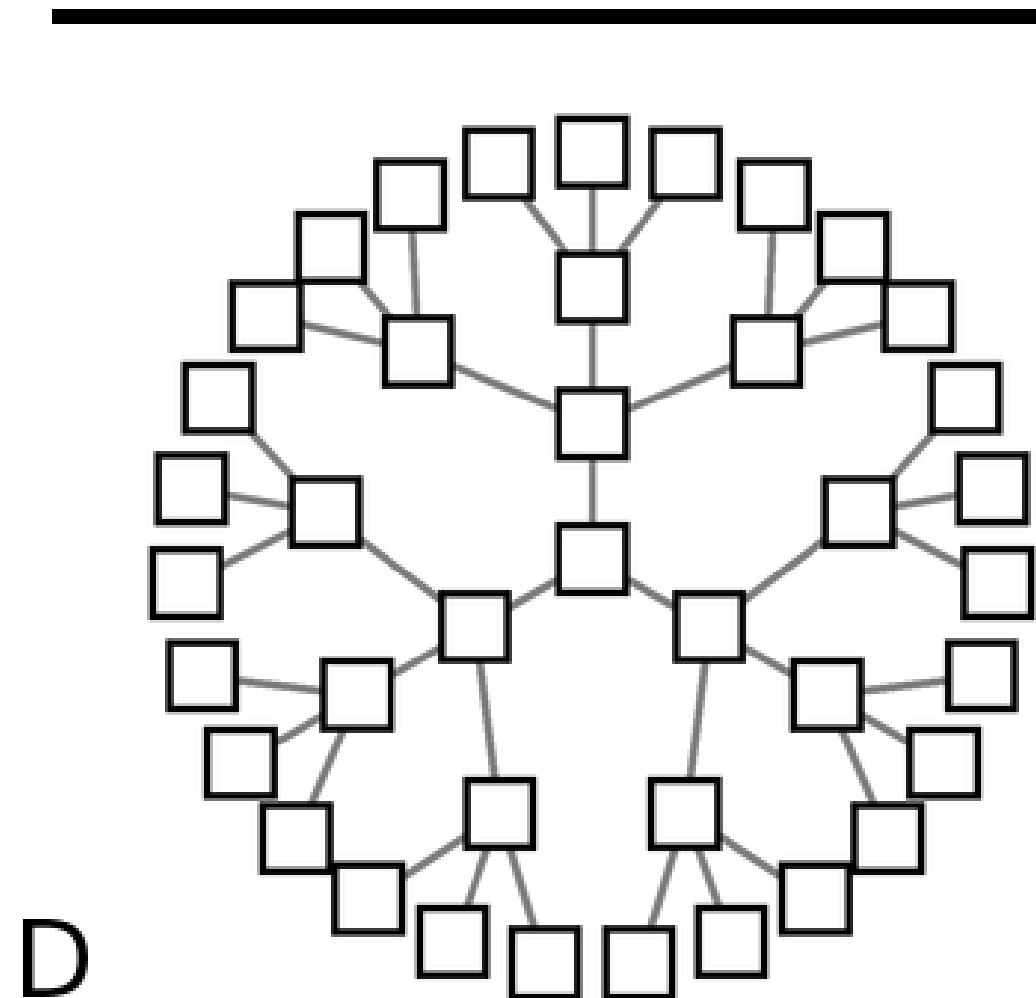
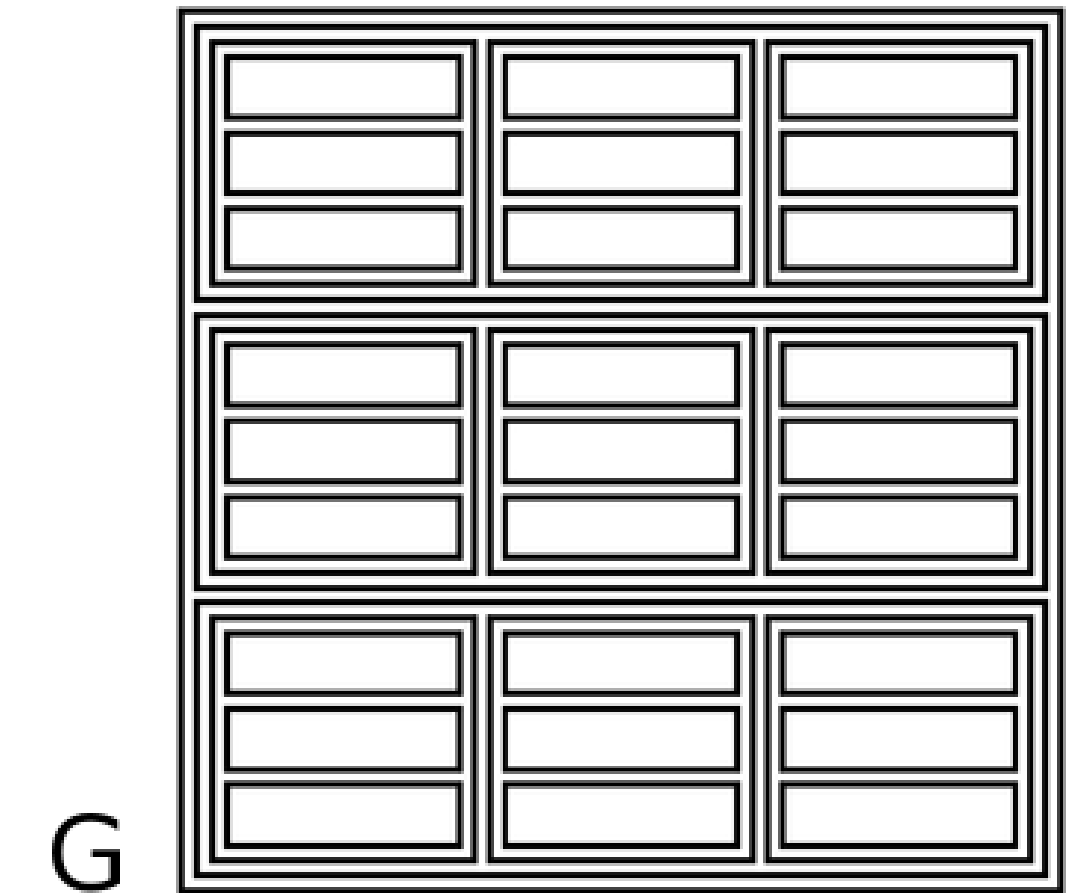
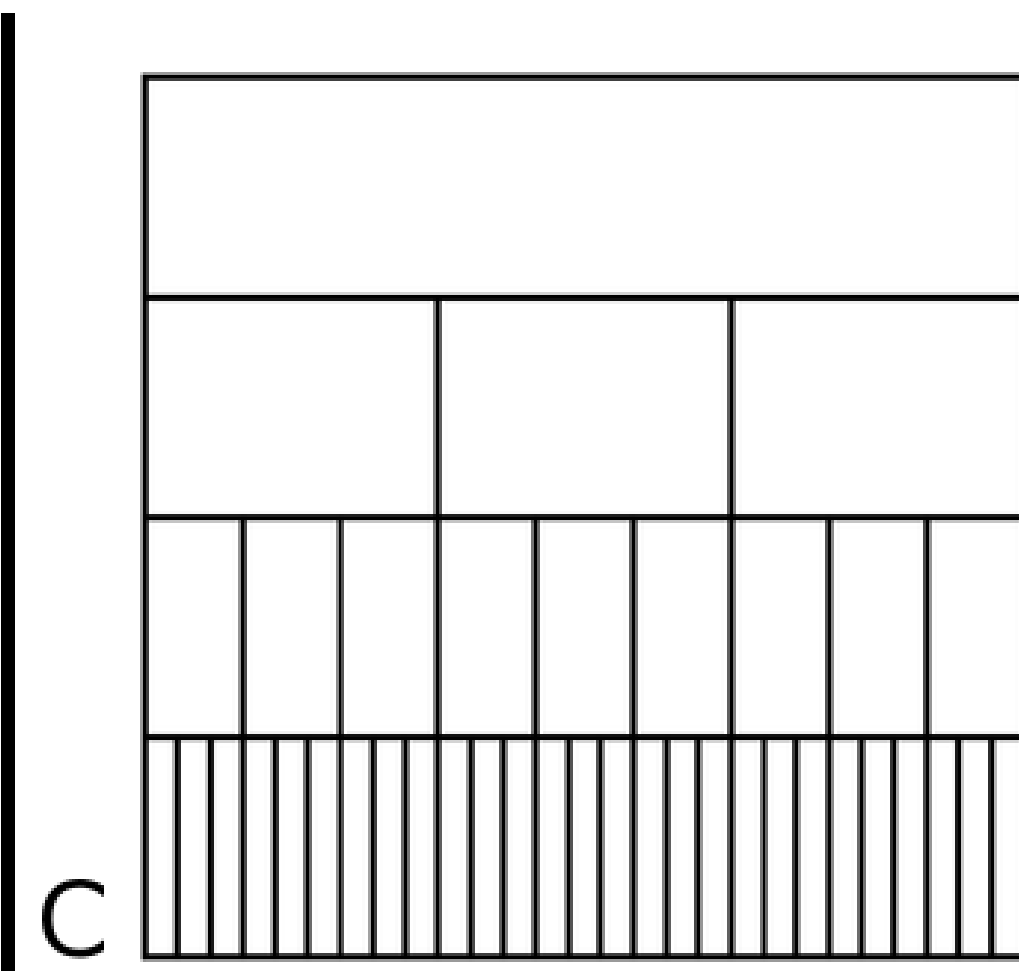
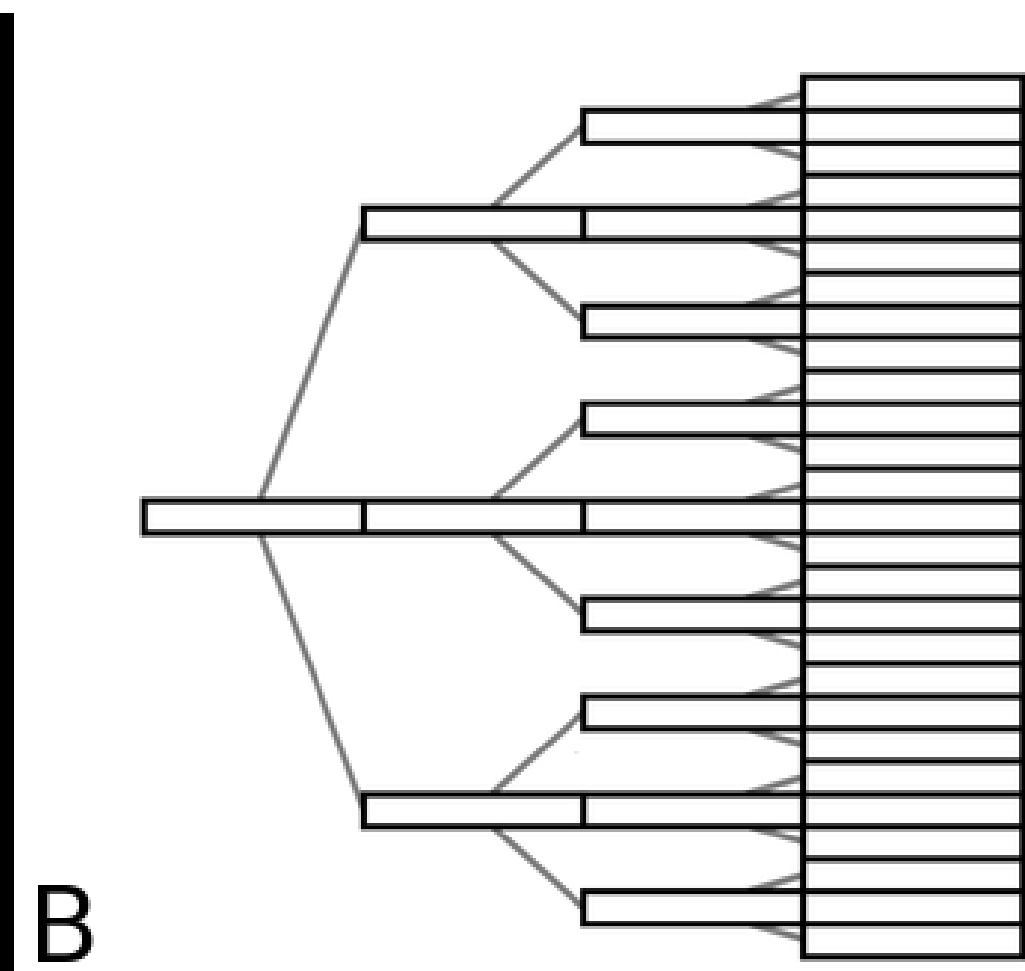
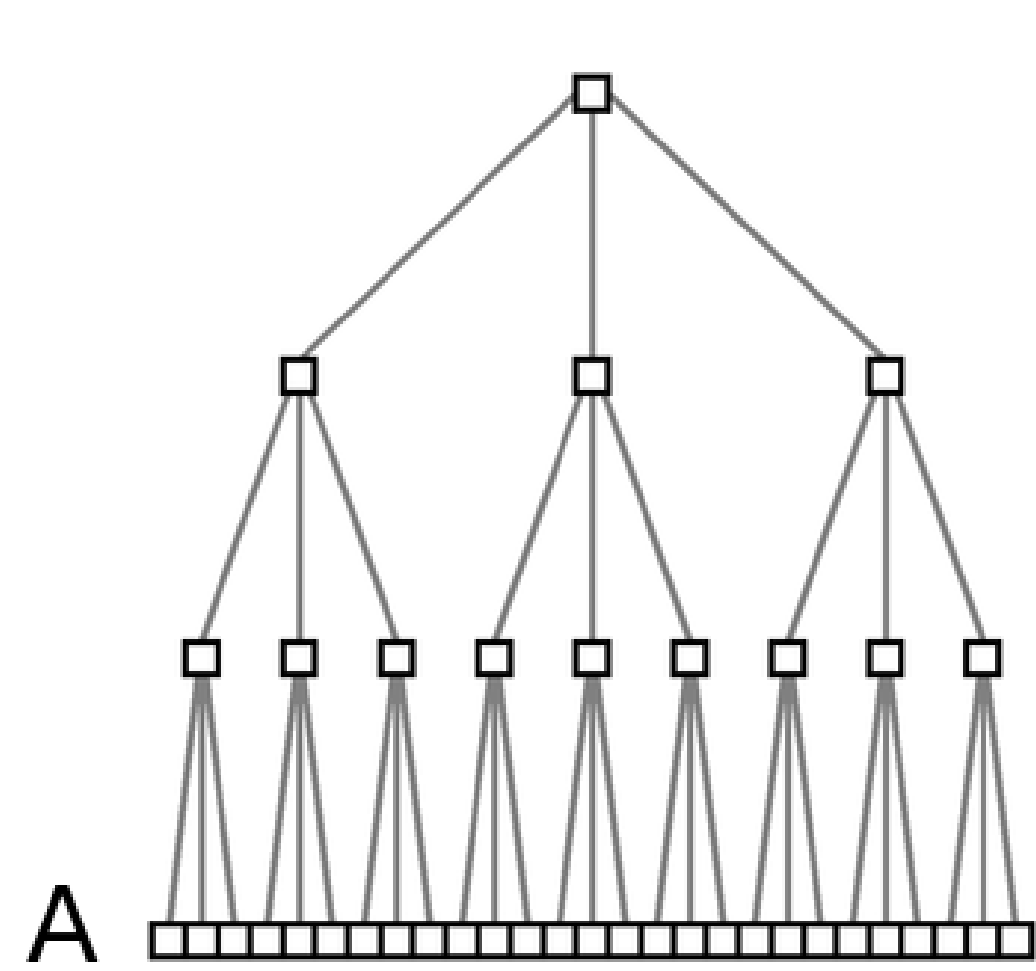


[McGuffin]

Node-Link or Adjacency Matrix?

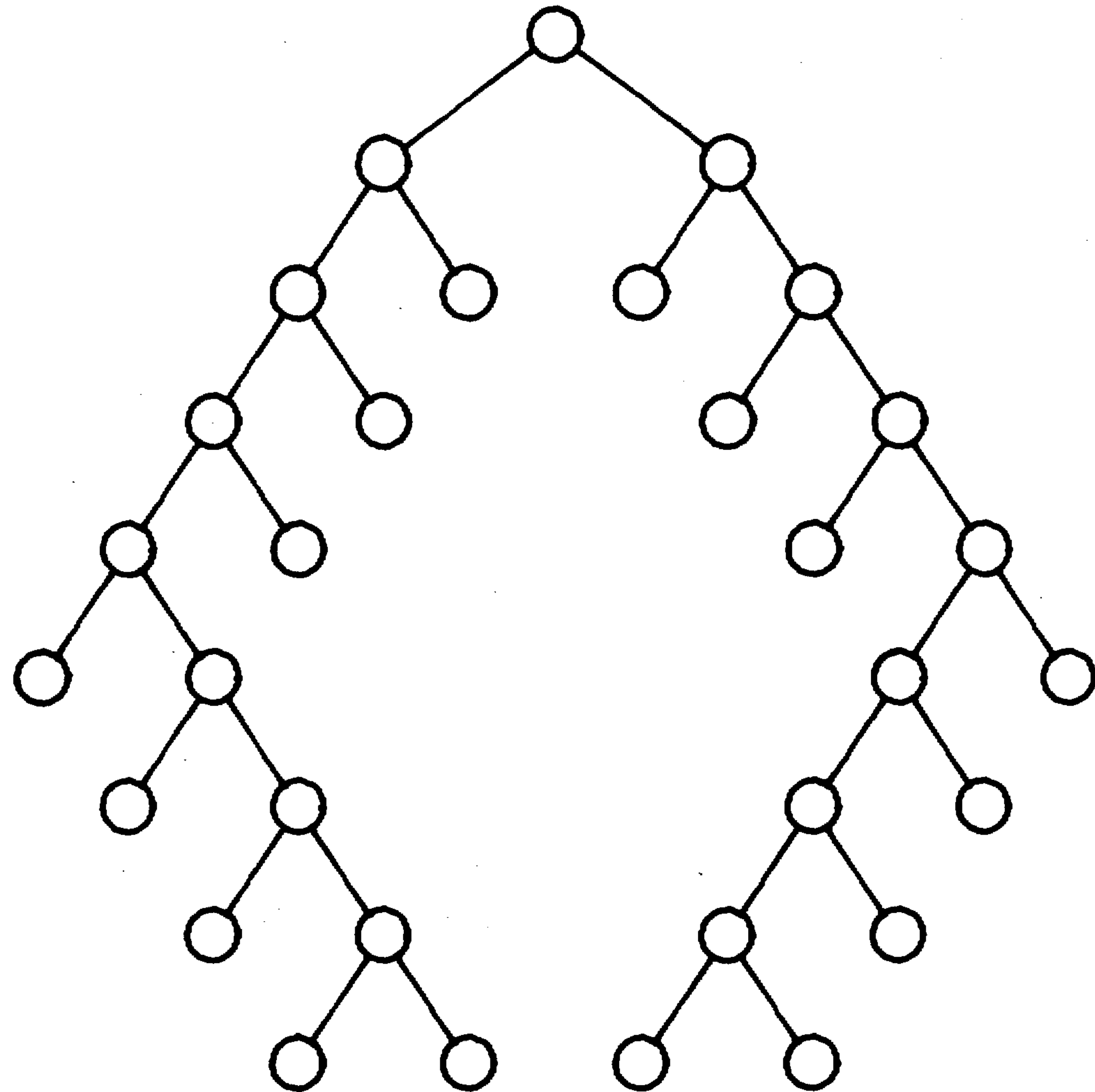
- Empirical study: For most tasks, node-link is better for small graphs and adjacency better for large graphs
- Multi-link paths are hard with adjacency matrices
- Immediate connectivity or neighbors are ok, estimating size (nodes & edges also ok)
- People tend to be more familiar with node-link diagrams
- Link density is a problem with node-link but not with adjacency matrices

Tree Visualizations



[McGuffin and Robert, 2010]

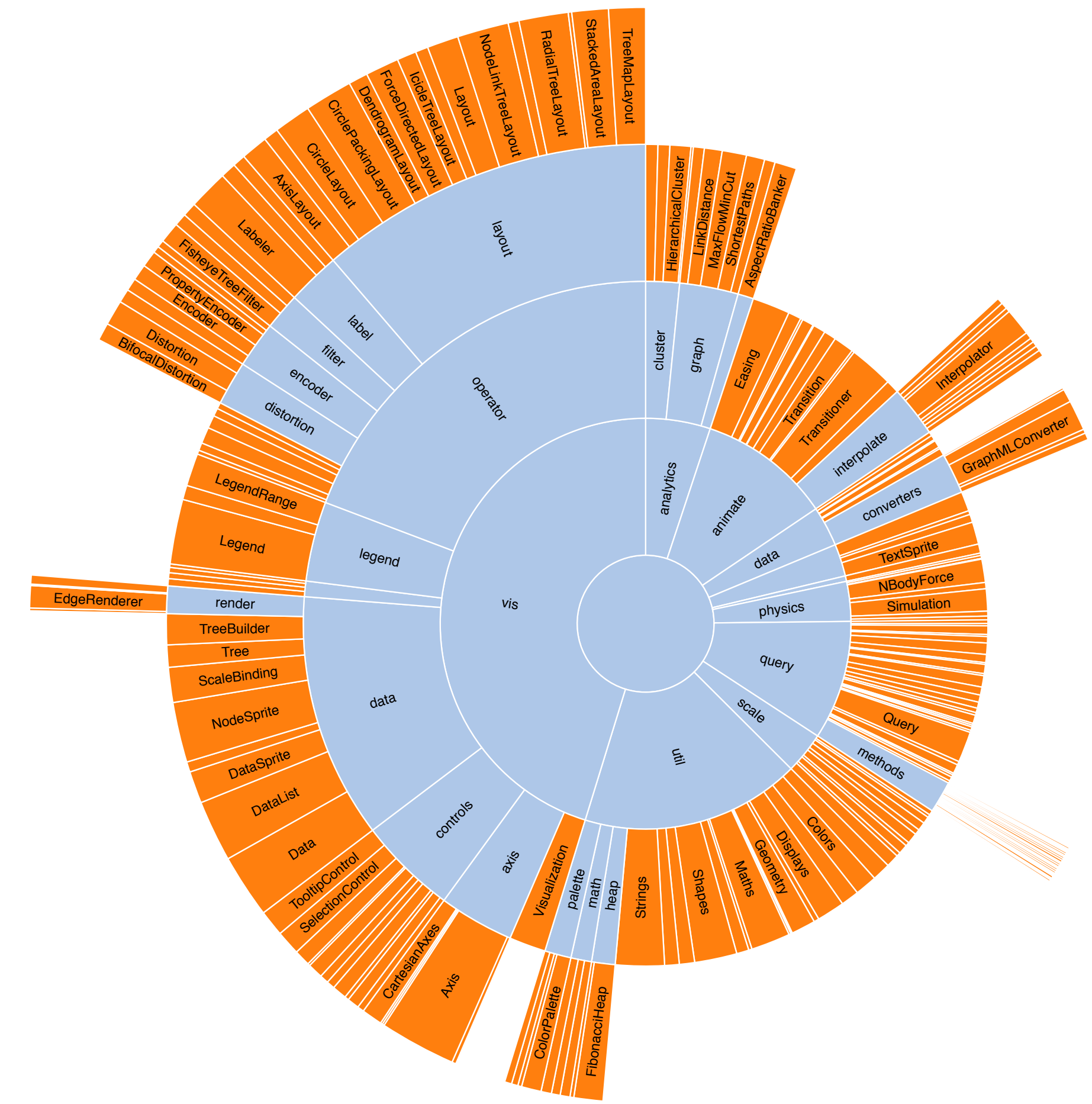
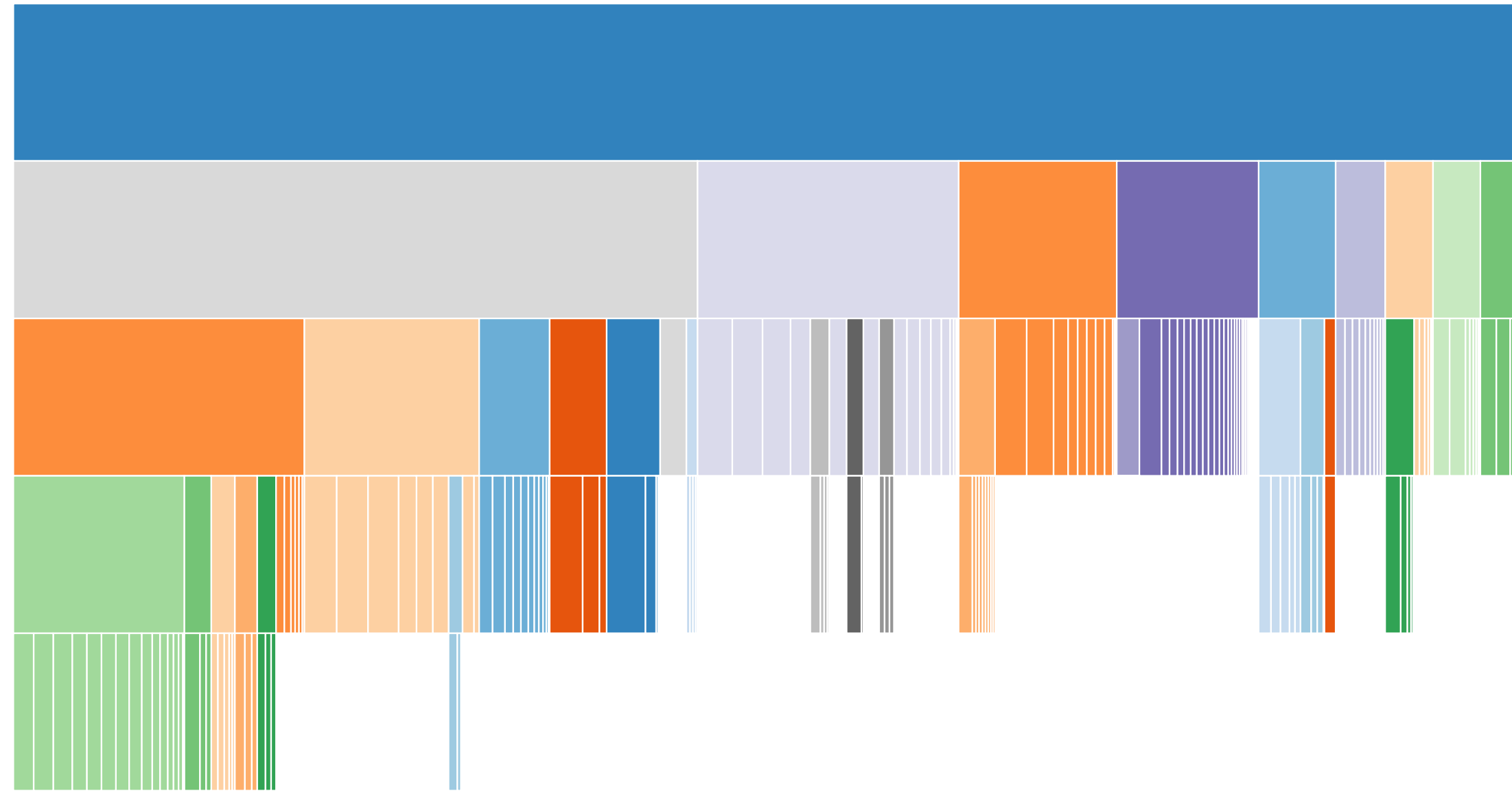
Reingold-Tilford Algorithm



- Recurse on left and right subtrees
- Shift subtree over as long as it doesn't overlap
- Place parent centered above the subtrees
- Originally, only binary trees, extended by Walker

[Reingold and Tilford, 1981]

Icicle & Sunburst Visualizations

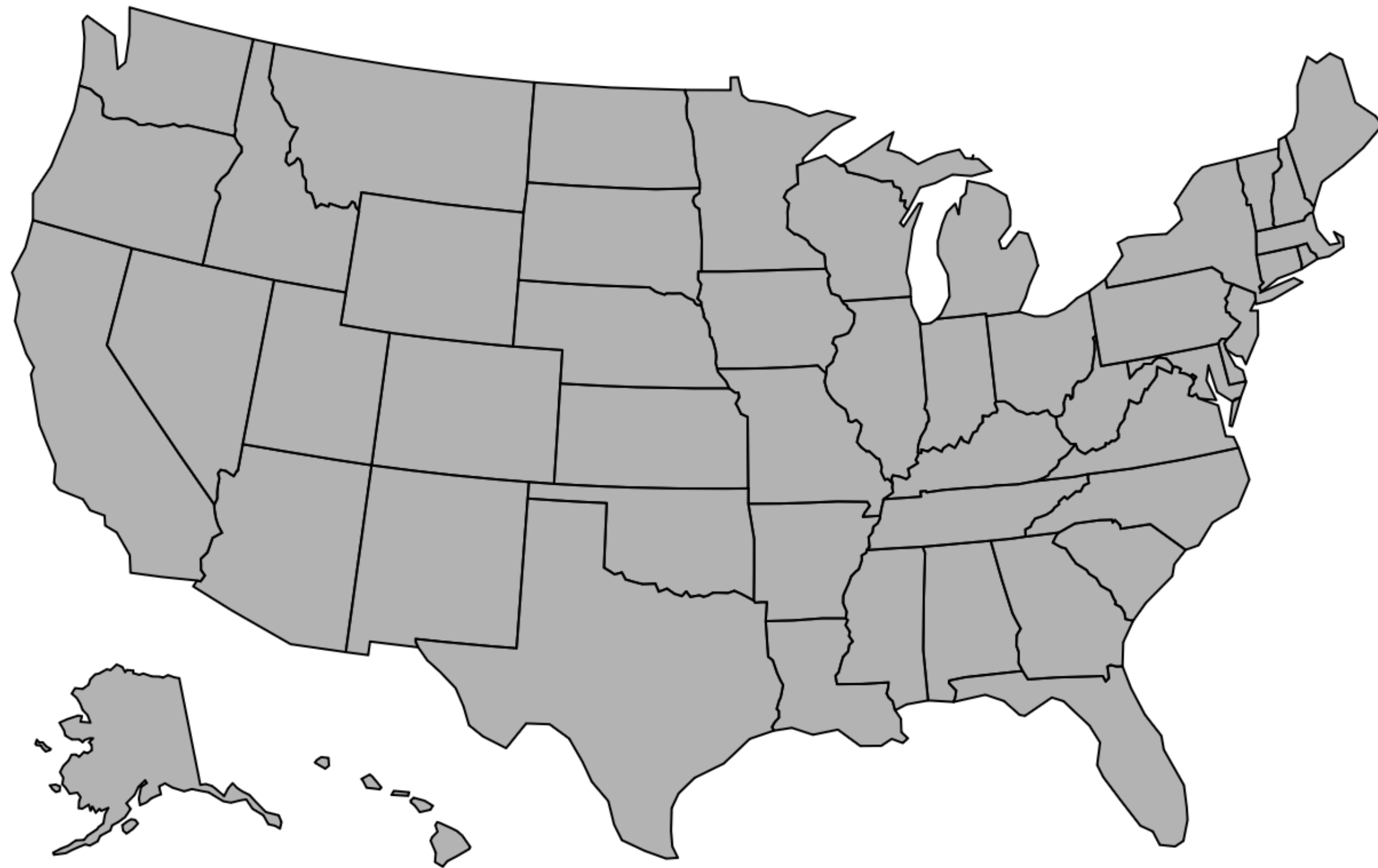


[Bostock (2011), Heer et al. (2012)]

Projects

- Proposal feedback up on Blackboard
 - Be creative: <https://xeno.graphics/>
- Designs:
 - Three different good designs
 - One bad design
 - Sketch these
 - Progress on implementation

Assignment 4



- Choropleth Maps
 - Use D3 for Part 1
 - Can use either D3 or Plot for Part 2
 - Make sure the colormap is appropriate!
- Treemap [627]
- Two resources:
 - Courselet (Plot in python)
 - Observable Notebook on Maps

Treemaps

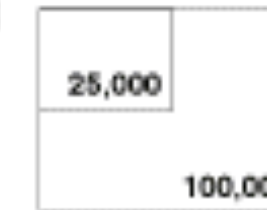
Car/Truck Treemap

Truck Sales Slip, Tripping Up Chrysler

Over the past few years, Chrysler executives said they were following the lead of Toyota and Honda, focusing on vehicles that met the needs of their customers. But as American consumers turned away from large trucks and S.U.V.'s in 2006, Chrysler continued to churn out big vehicles, which are now sitting unsold at dealerships across the country.

READING THE CHART

Boxes are scaled proportionally according to number of cars sold in 2006



Change in sales from 2005 to 2006

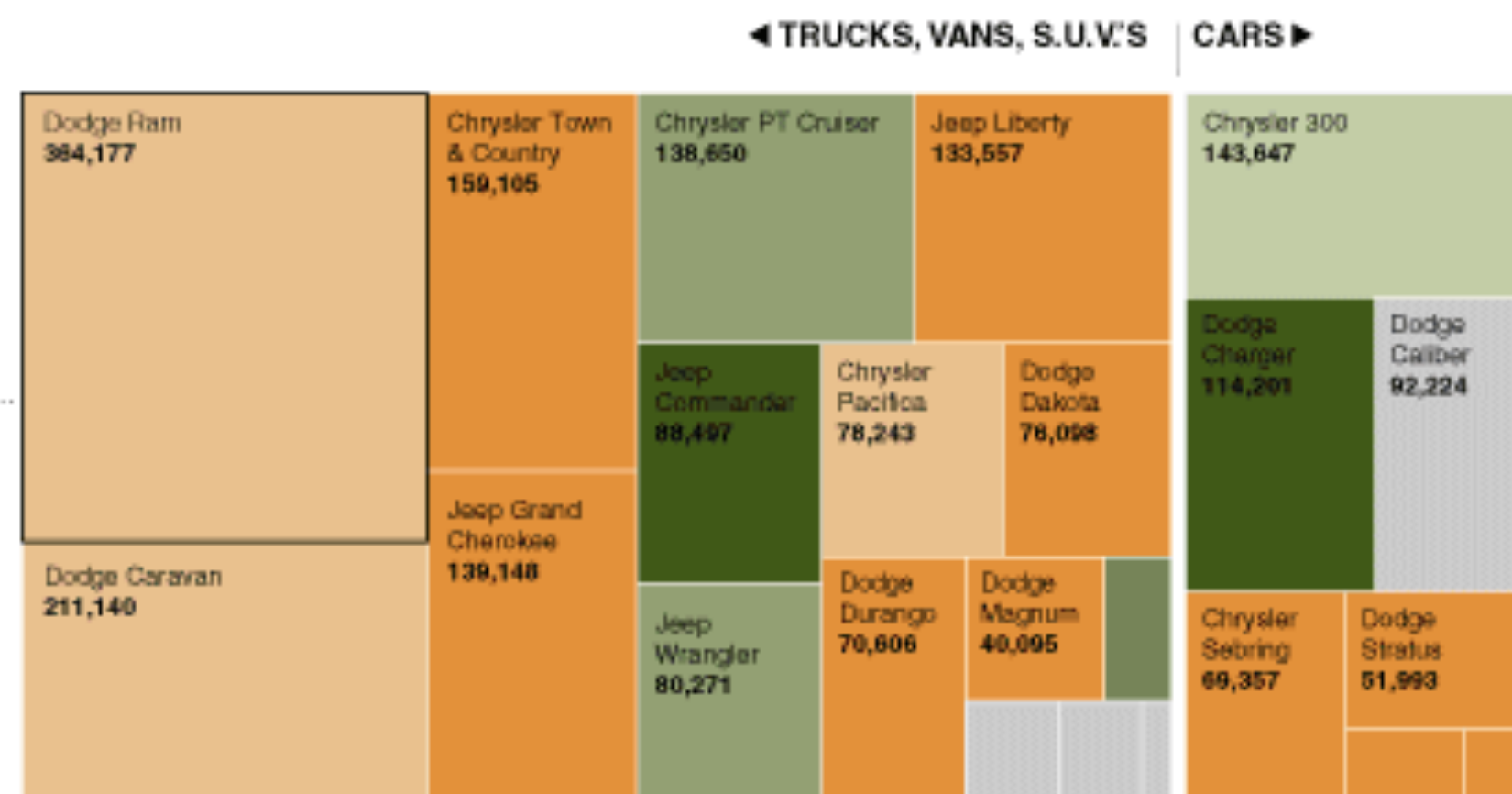


No 2005 sales

Many of these vehicles were introduced in 2005.

Chrysler Group **-7.0%**
Trucks/vans/S.U.V.'s 1.6 million
Cars 0.5 million

Pickups, minivans and S.U.V.'s made up 76 percent of Chrysler's sales, which left it vulnerable when consumers shifted to cars.

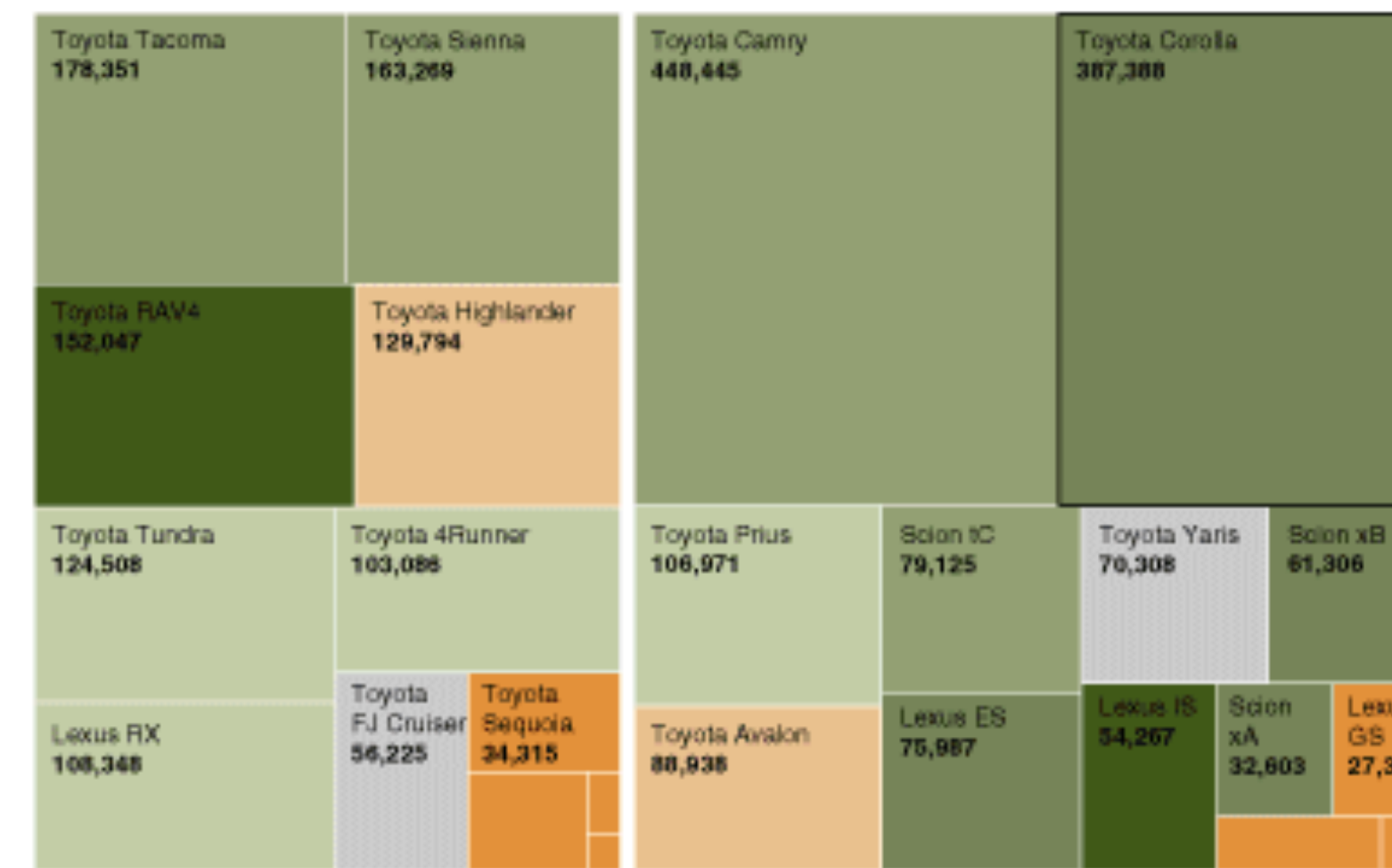


General Motors **-8.7%**
Trucks/vans/S.U.V.'s 2.5 million
Cars 1.6 million

G.M. introduced new versions of its large S.U.V.'s in late 2005, hoping they would bolster sales. Instead, sales of big vehicles were hurt when gas prices climbed. One of the few standouts was the Chevrolet HHR, new in 2005.



TRUCKS, VANS, S.U.V.'S | CARS

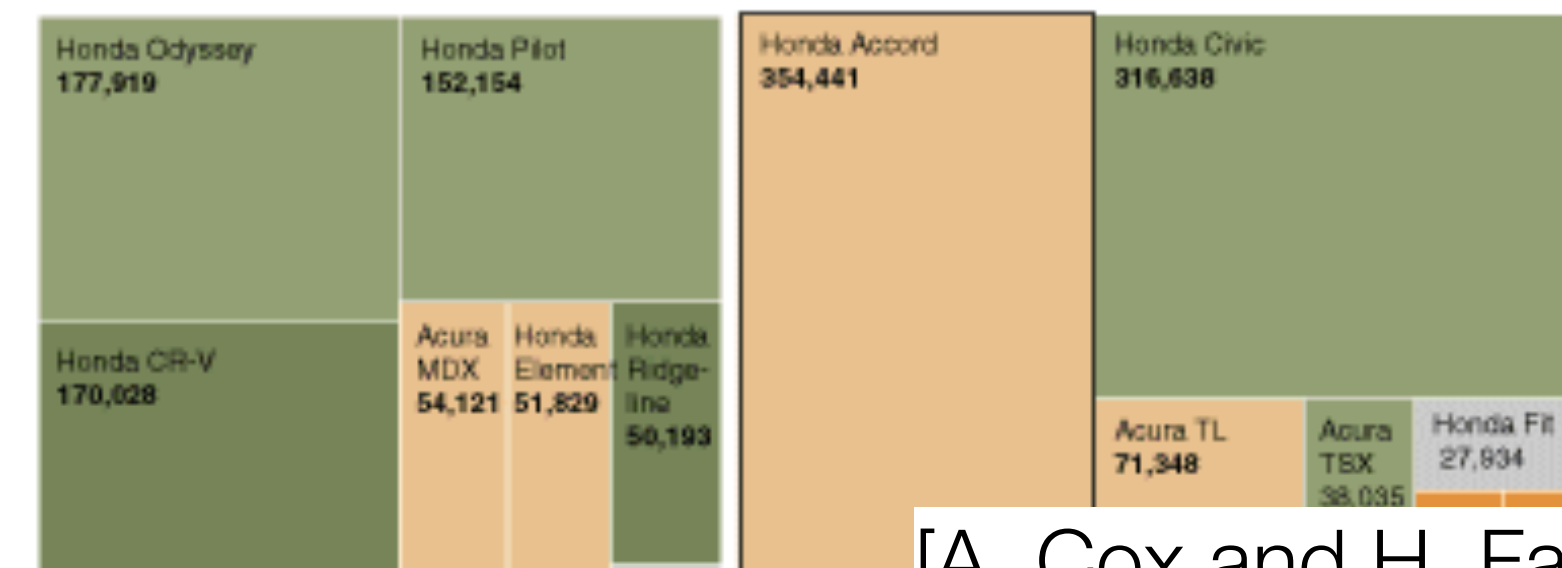


Toyota **+12.5%**
Trucks/vans/S.U.V.'s 1.1 million
Cars 1.5 million

Toyota rolled out a new version of the Camry, and once again it was the country's best-selling car.



Corolla sales also jumped, along with gas prices. Toyota could not escape the decline in sales of supersized S.U.V.'s like its Sequoia.



Honda **+3.2%**
Trucks/vans/S.U.V.'s 0.7 million
Cars 0.8 million

Like the Corolla, the small Honda Civic did well. But the Accord stalled. Buyers, it seems, are waiting for the new version to be released this year.

[A. Cox and H. Fairfield, NYTimes, 2012]

Car/Truck Treemap

shifted to cars.



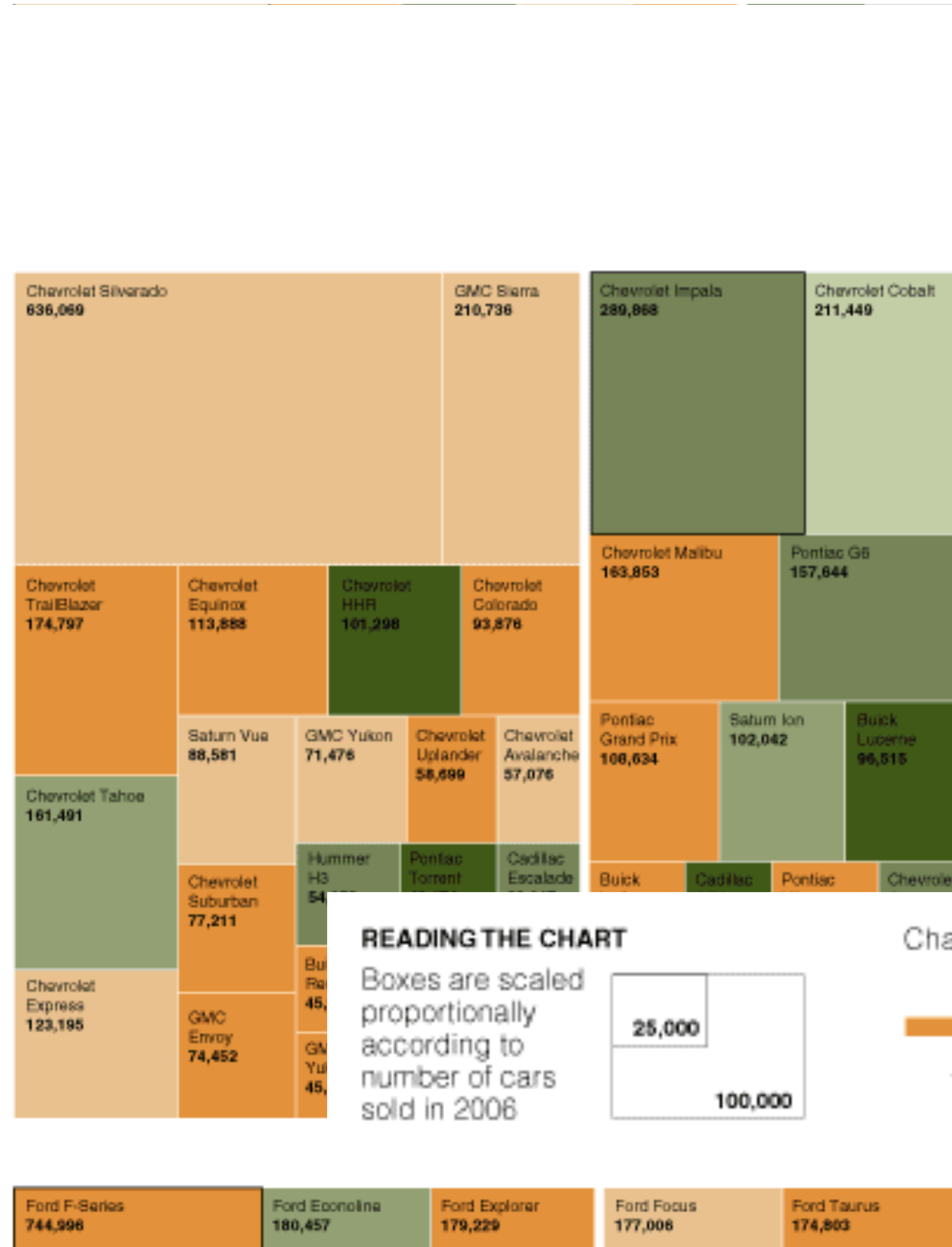
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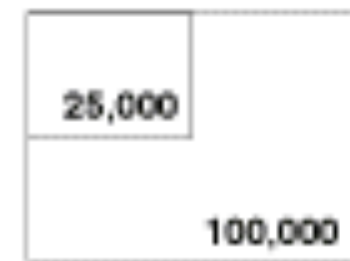
The Chevrolet Impala, with or without flashing lights, did well in 2006, when a redesign came out.

Ford **-8.3%**
Trucks/vans/S.U.V.'s 1.8 million

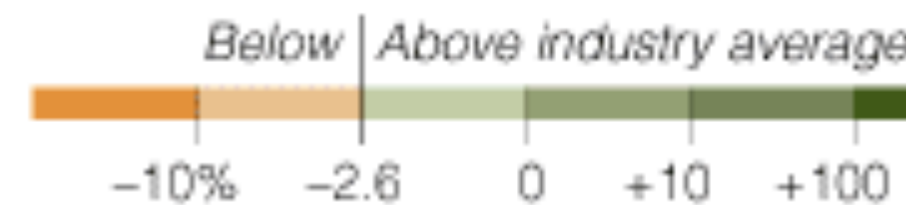


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Nissan **-5.3%**
Trucks/vans/S.U.V.'s 0.5 million
Cars 0.6 million

BMW **+2.1%**
Trucks/vans/S.U.V.'s 0.1 million
Cars 0.3 million

[A. Cox and H. Fairfield, NYTimes, 2012]

Treemap

- Containment marks instead of connection marks
- Encodes some attribute of the items as the **size** of the rectangles
- Not as easy to see the intermediate rectangles
- Scalability: millions of leaf nodes and links possible

- Need a layout algorithm!

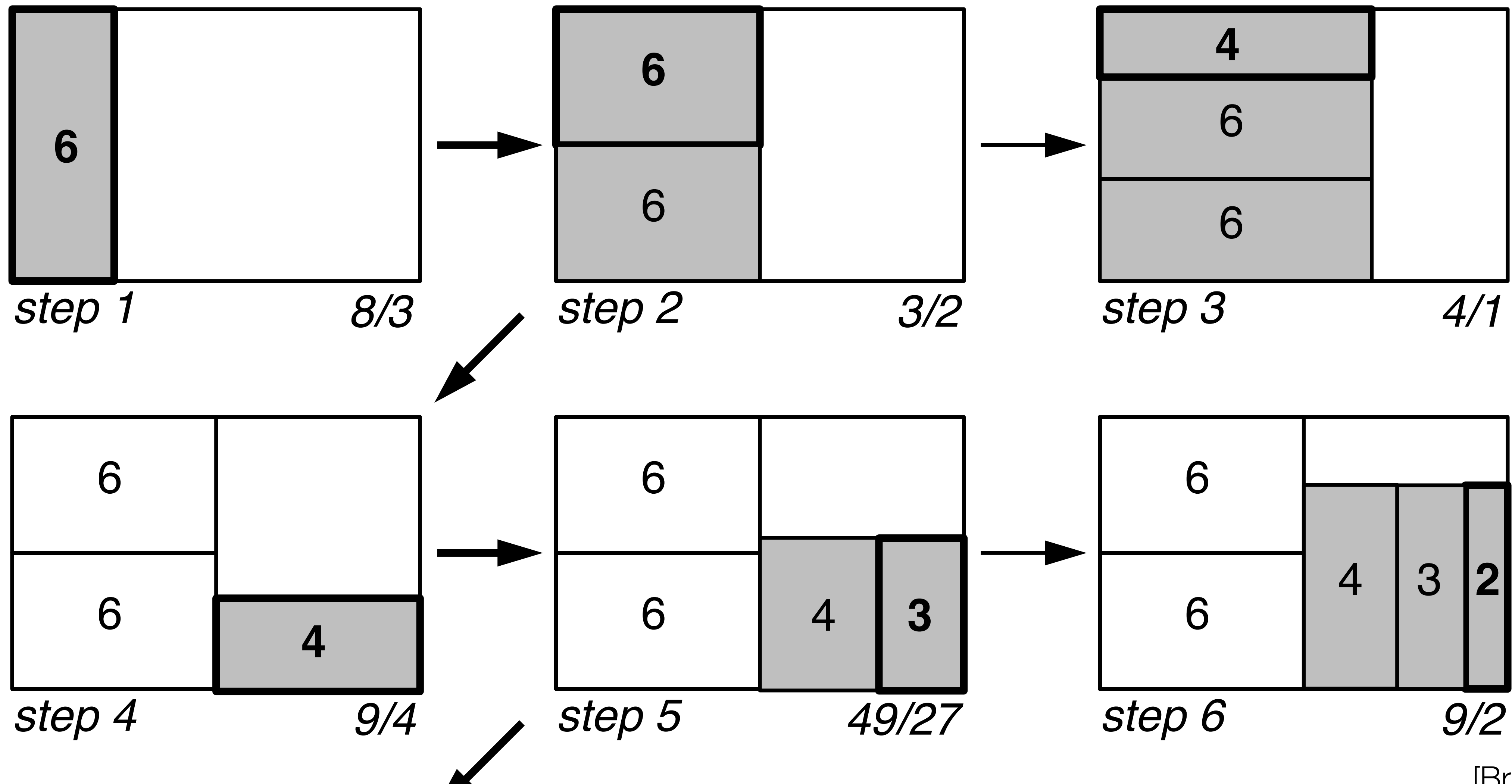
Layout Algorithms

- How do we generate the area marks?
- What considerations should we try to keep in mind?

Layout Algorithms

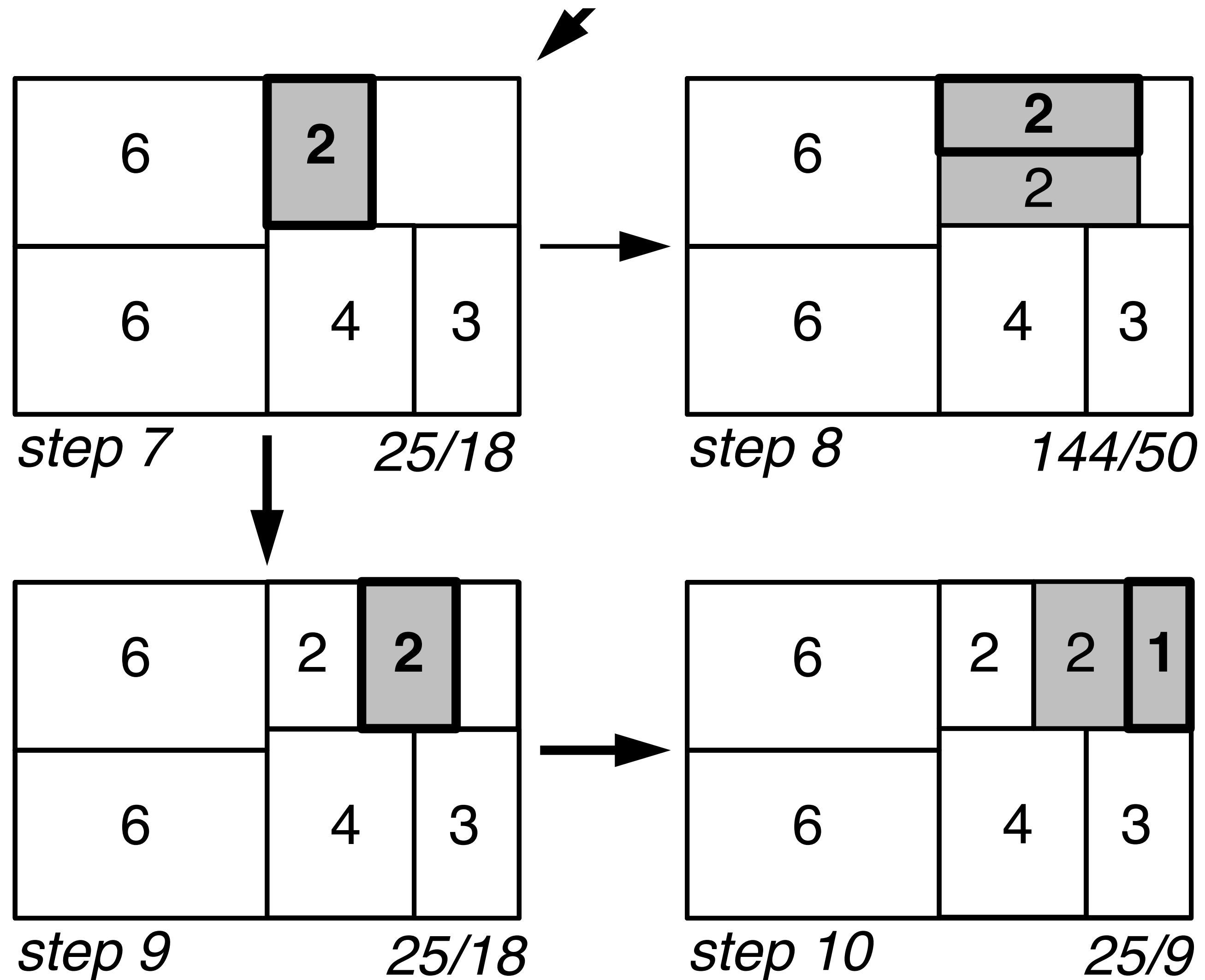
- How do we generate the area marks?
- What considerations should we try to keep in mind?
 - area true to quantitative value
 - show hierarchy
 - aspect ratio
- Also...
 - ordering
 - stability

Squarification Algorithm



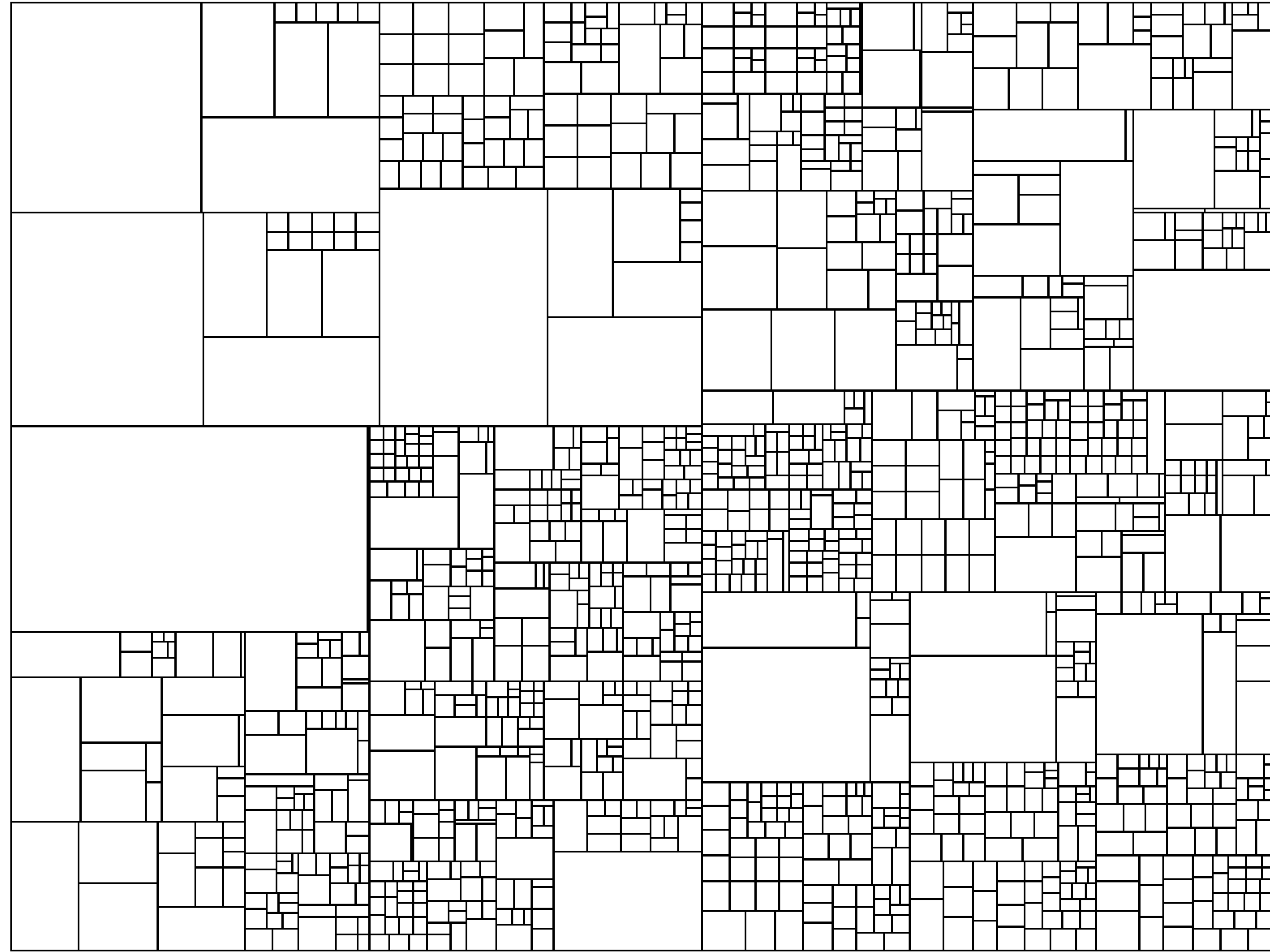
[Brus et al., 1999]

Squarification Algorithm

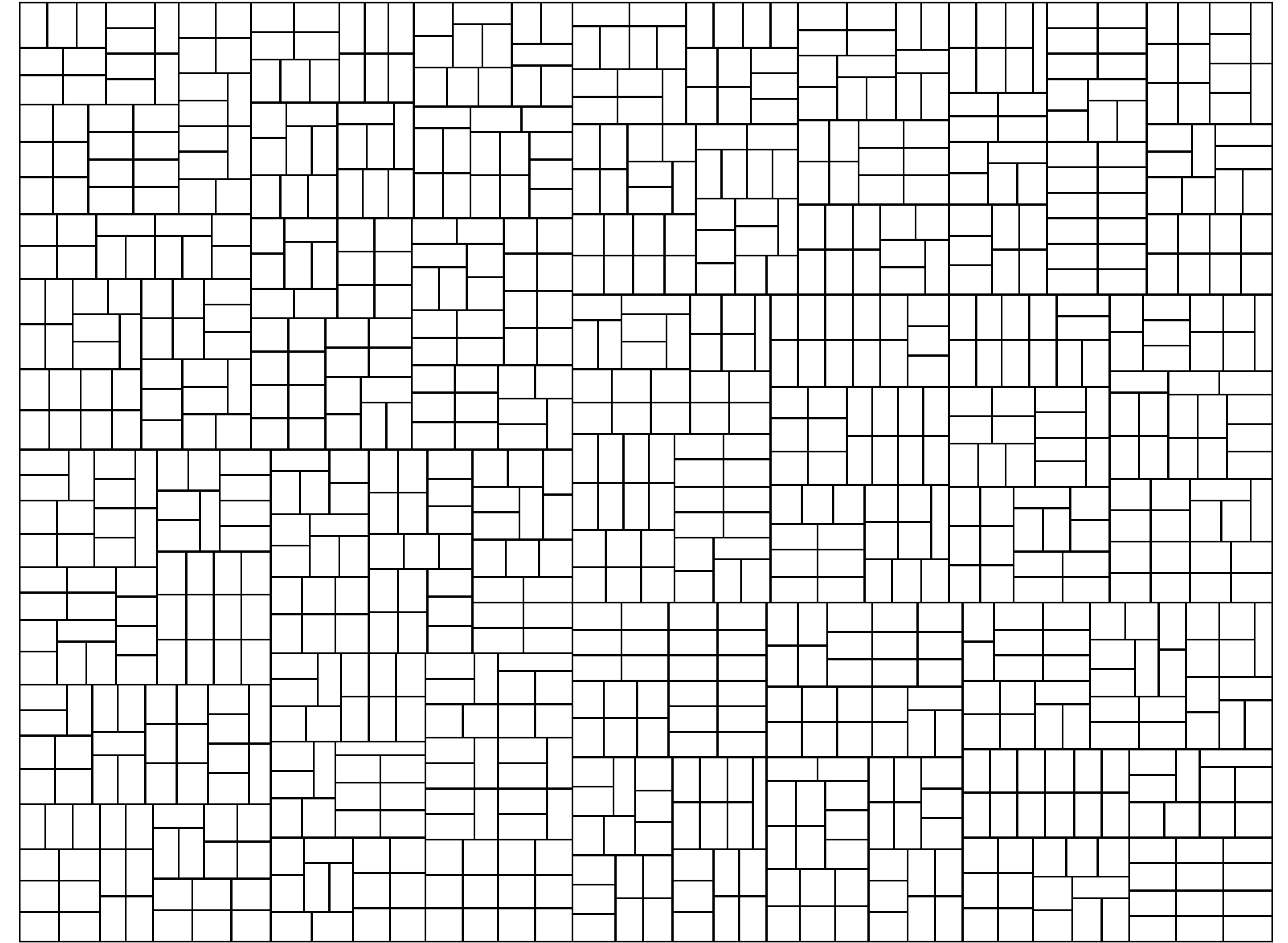


[Brus et al., 1999]

Squarified Treemaps



(a) File system



(b) Organization

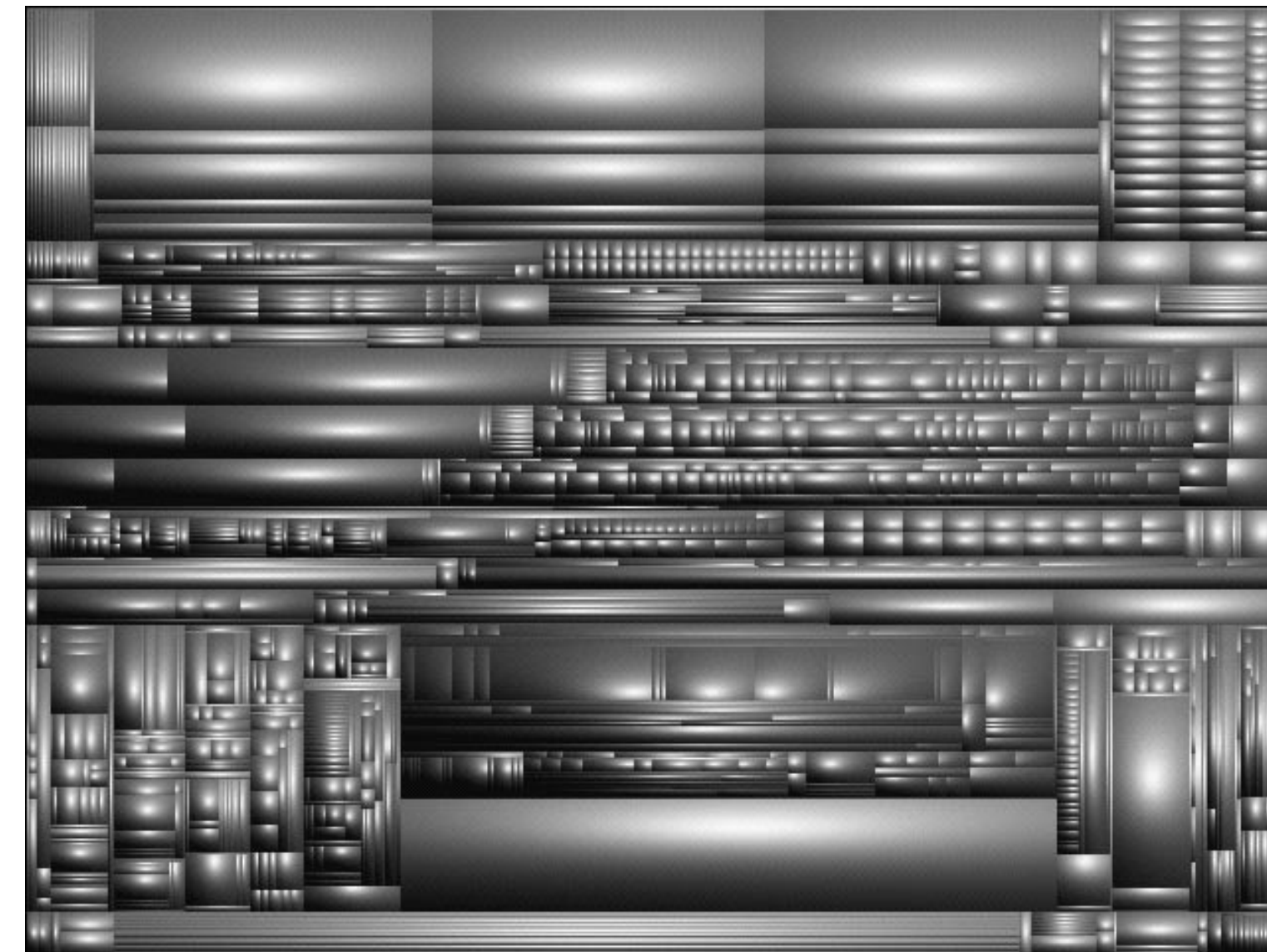
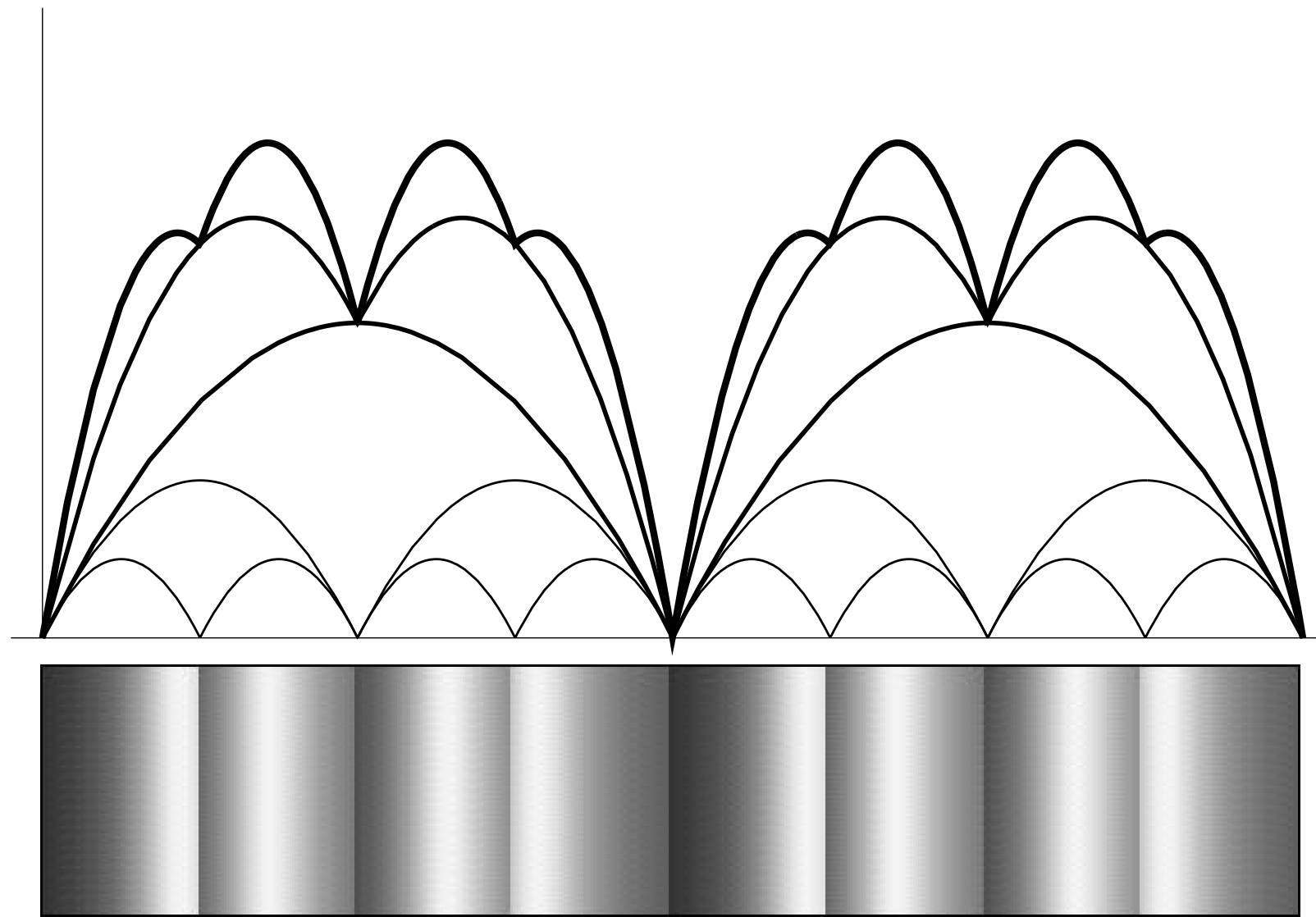
[Brus et al., 1999]

Squarified Layout

- Sort values
- Switch orientation whenever necessary to obtain best aspect ratios

Improving Treemaps (Cushion)

- Leaves are ok, but it can be difficult to find the hierarchy
- Encode this as shading information
- More effective to understand hierarchy



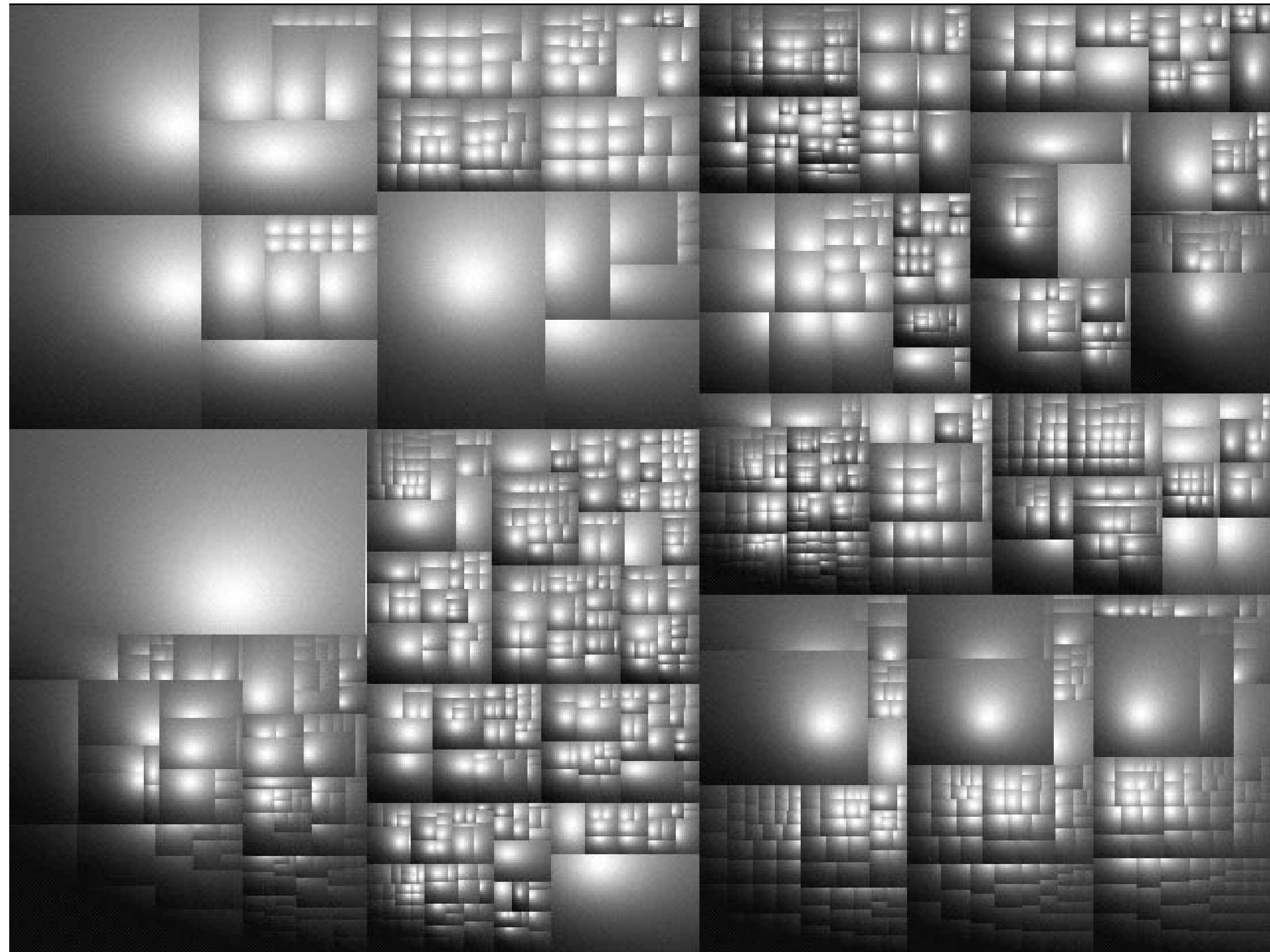
[van Wijk and van de Wetering, 1999]

Disk Inventory

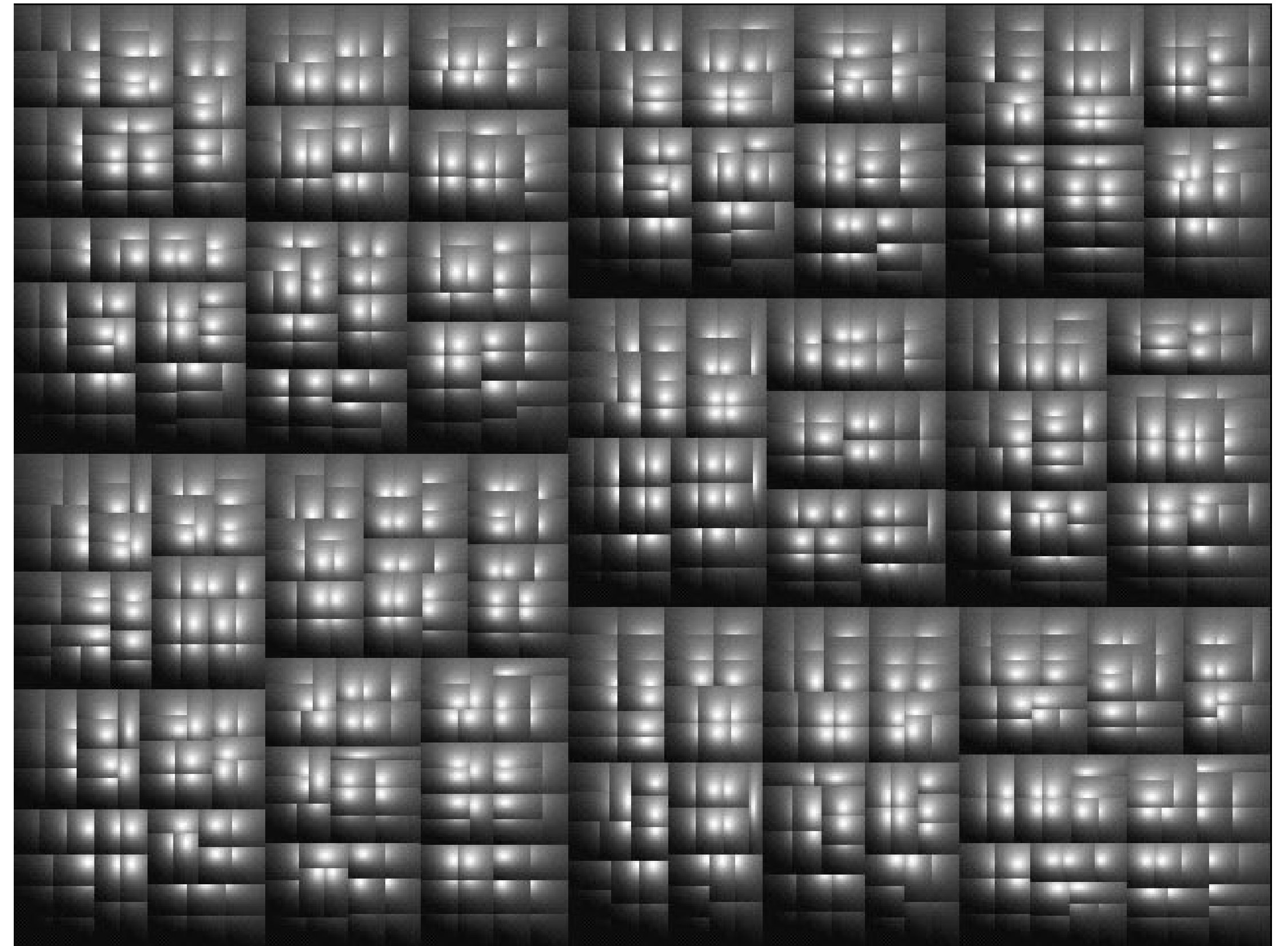
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Blue	Interface Builder Document	15,4 MB	2104
Red	MP3 Audio File	4,8 MB	2
Green	Unix Executable File	3,8 MB	23
Cyan	JPEG Image	1,6 MB	74
Magenta	Strings File	1,4 MB	348
Yellow	HTML document	1,3 MB	333
Dark Blue	TIFF Document	1,0 MB	310
Brown	Document	886 kB	16
Light Green	Portable Network Graphi	635 kB	21
Teal	XML Property List File	183 kB	332
Purple	Apple Icon Image	109 kB	2
Olive	AIFF Audio	67 kB	2
Grey	Finder Document	65 kB	1
Grey	Script	35 kB	5
Grey	Rich Text Format (RTF) d	30 kB	2
Grey	AppleScript Suite Definit	7 kB	1
Grey	AppleScript Suite Termin	6 kB	1
Grey	Graphics Interchange Fo	5 kB	12
Grey	Cascading Style Sheet (C	4 kB	4
Grey	Symbolic Link	164 Byte	9

[Disk Inventory X]

Squarified + Cushioned Treemaps



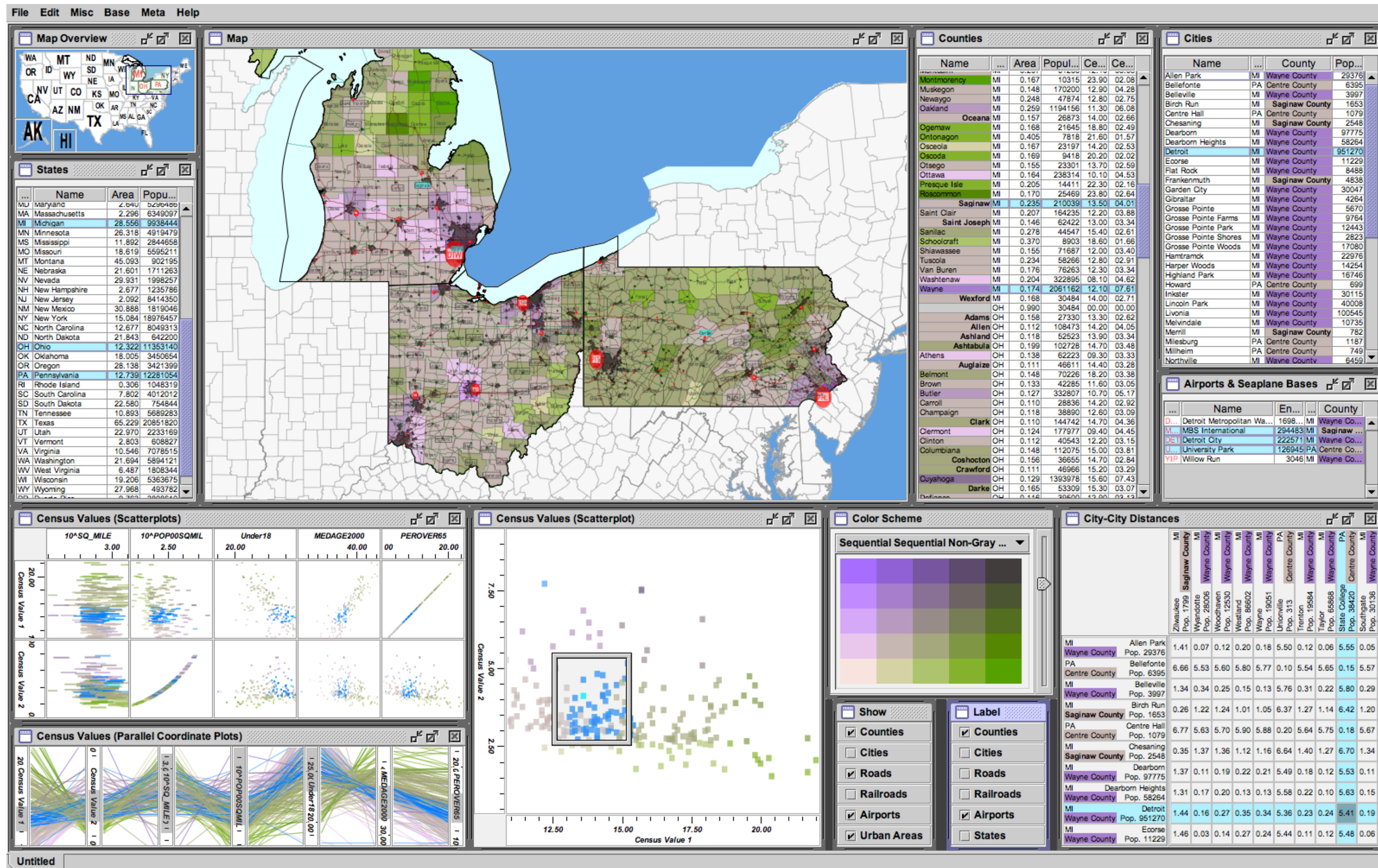
(a) File system



(b) Organization

[Brus et al., 1999]

Multiple Views



[Improvise, Weaver, 2004]

Multiple Views

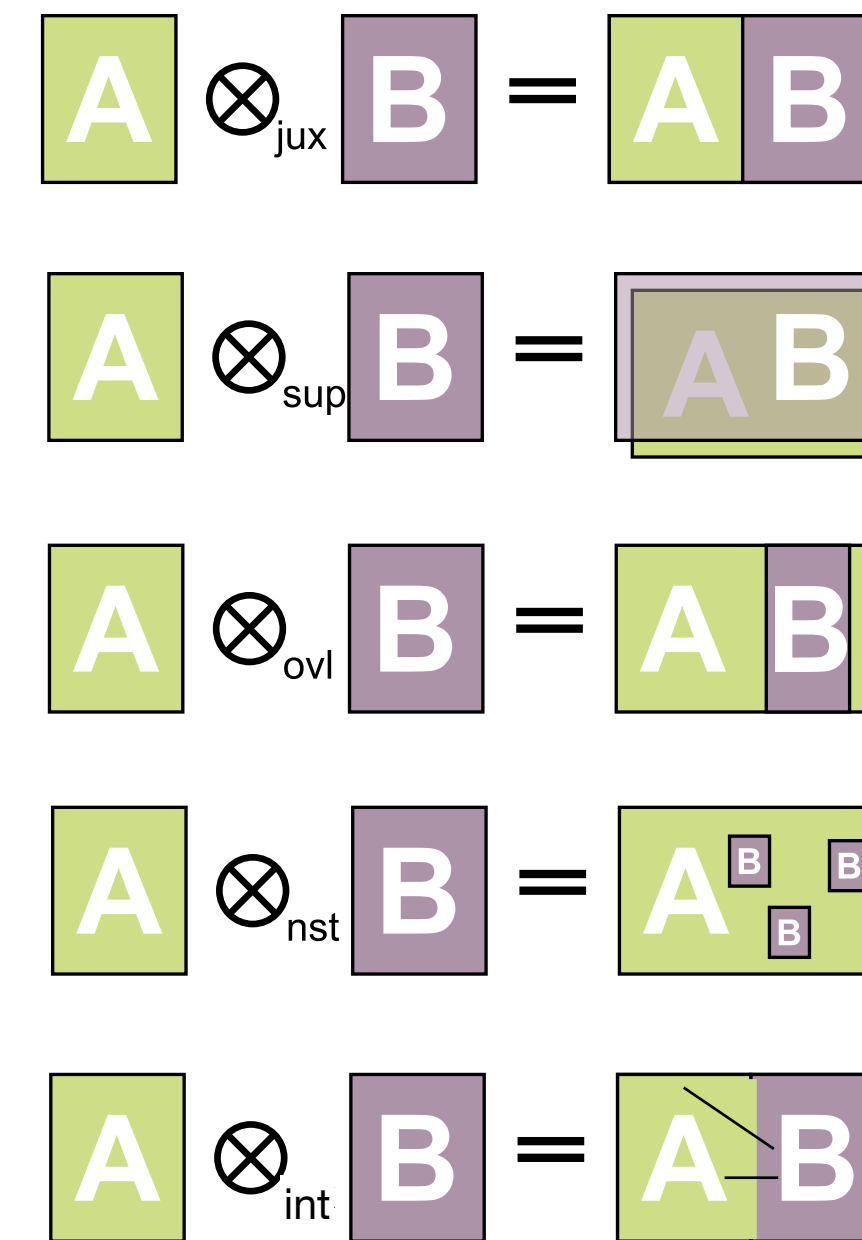
- Why have just one visualization?
- Sometimes data is best examined in more than one view
 - Clutter/visual overload
 - Different attributes (cannot show all attributes in one view)
 - Different scales (task requires overview or detail)
 - Different encodings (no single encoding is optimal for all tasks)
- Eyes Beat Memory (Ch. 6)
 - Aiding working memory:
side-by-side/layers > animated > jump cuts
 - Showing all visual elements at once → don't need to remember

Multiple Views

- Big questions:
 - How to partition display or layer views?
 - How to coordinate views (e.g. navigation, selection)?
 - What data is shared?

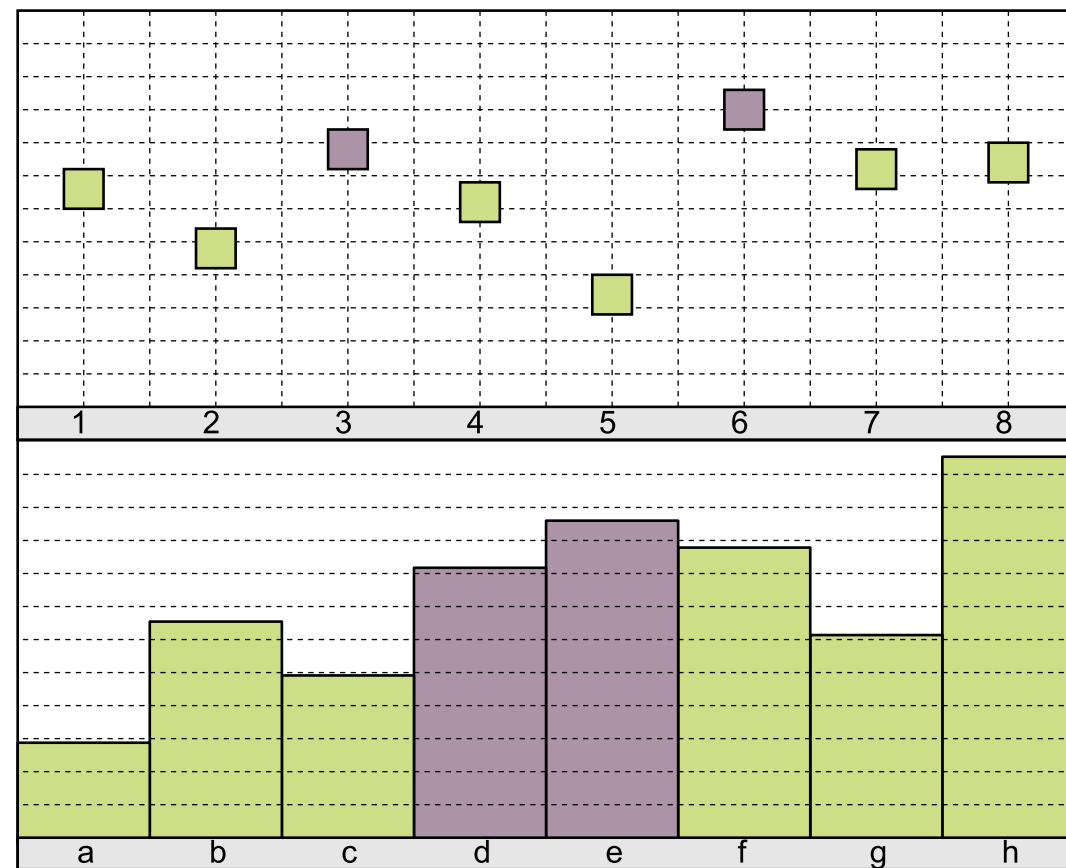
Design Space of Composite Visualization

- Composite visualization views (CVVs)
 - Includes Coordinated multiple views (CMV)
 - + More!
- Design Patterns:
 - Juxtaposition: side-by-side
 - Superimposition: layers
 - Overloading: vis meshed with another
 - Nesting: vis inside a vis (recursive vis)
 - Integration: "merge" views + links

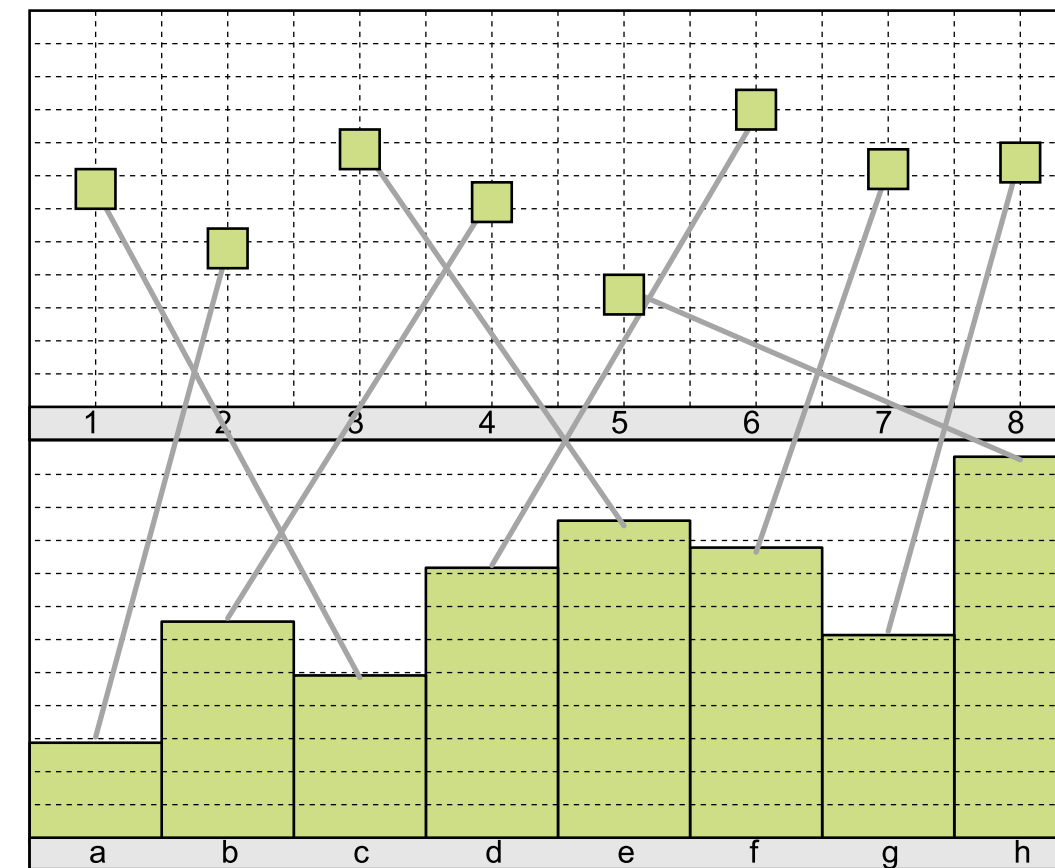


[W. Javed and N. Elmqvist, 2012]

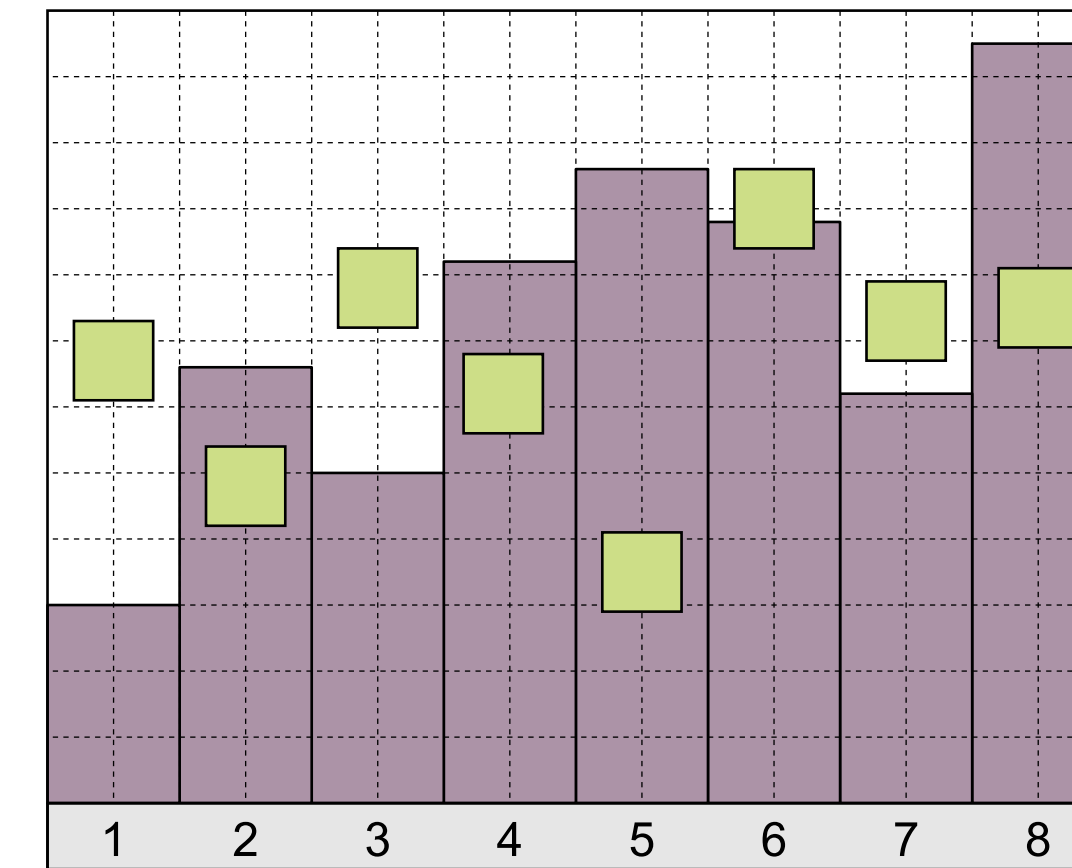
Composite Visualization Techniques



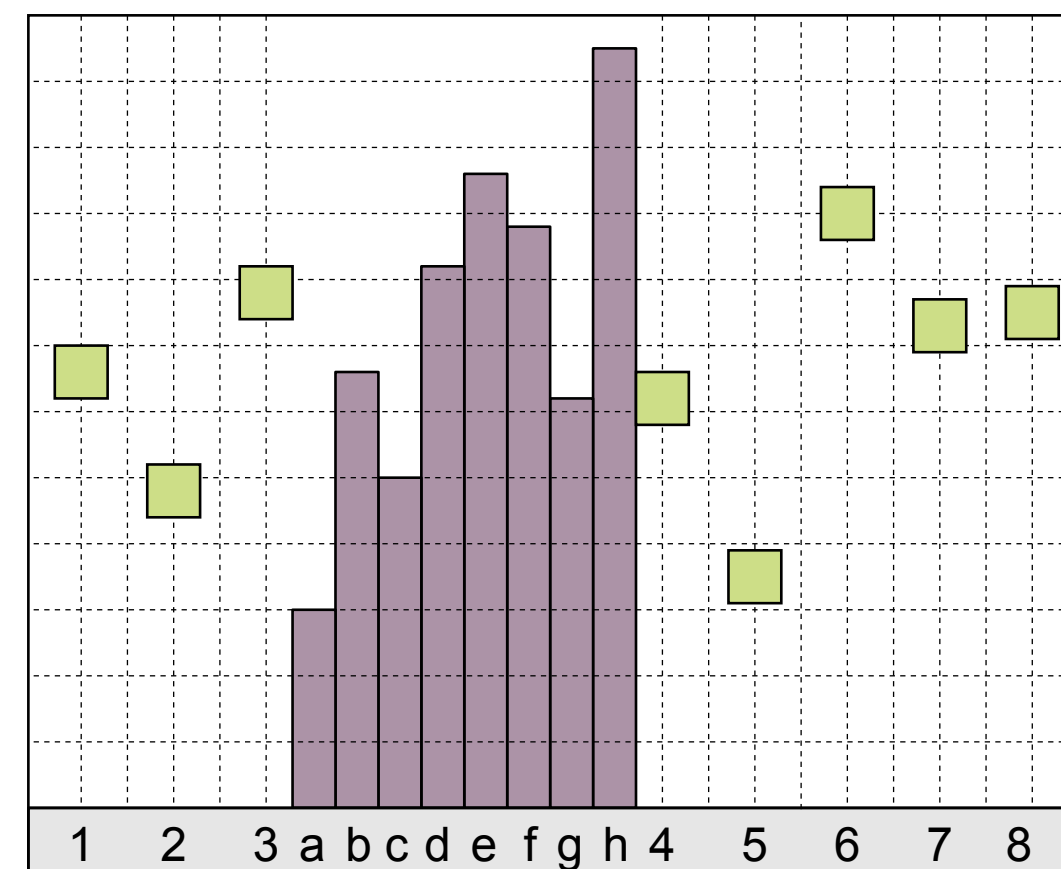
(a) Juxtaposed views.



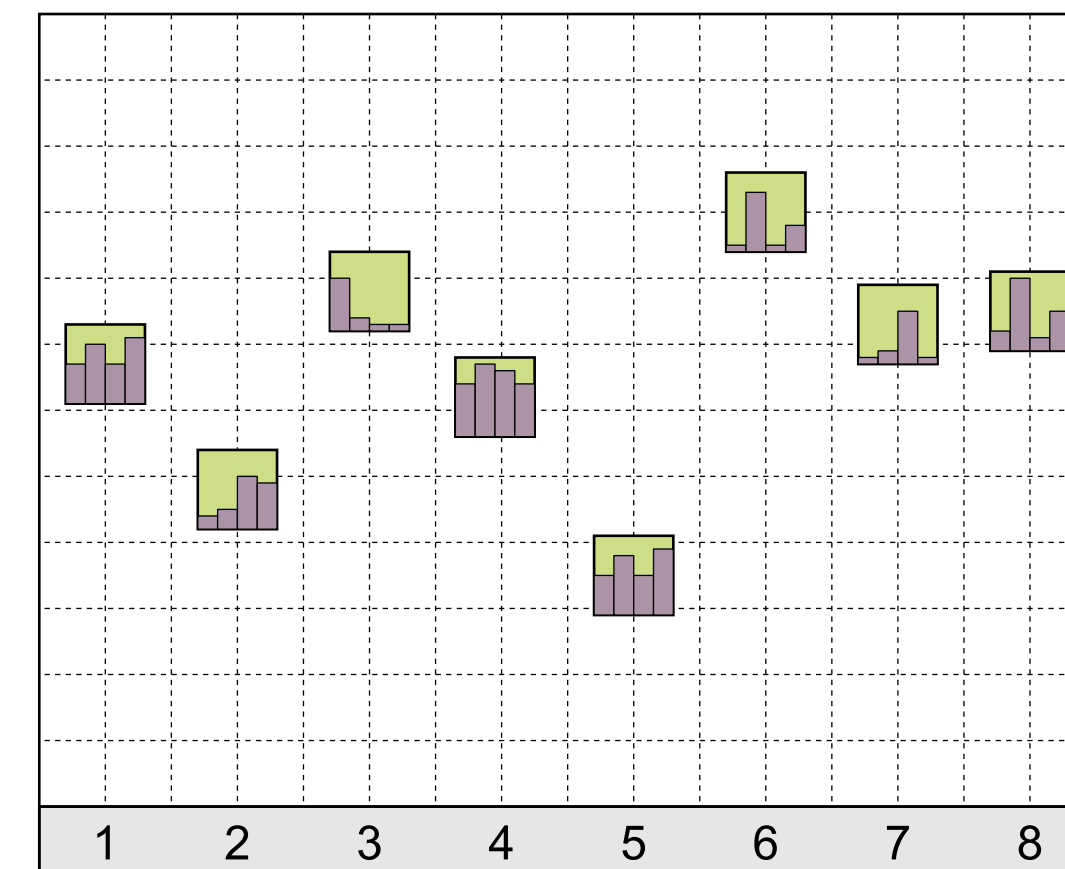
(b) Integrated views.



(c) Superimposed views.



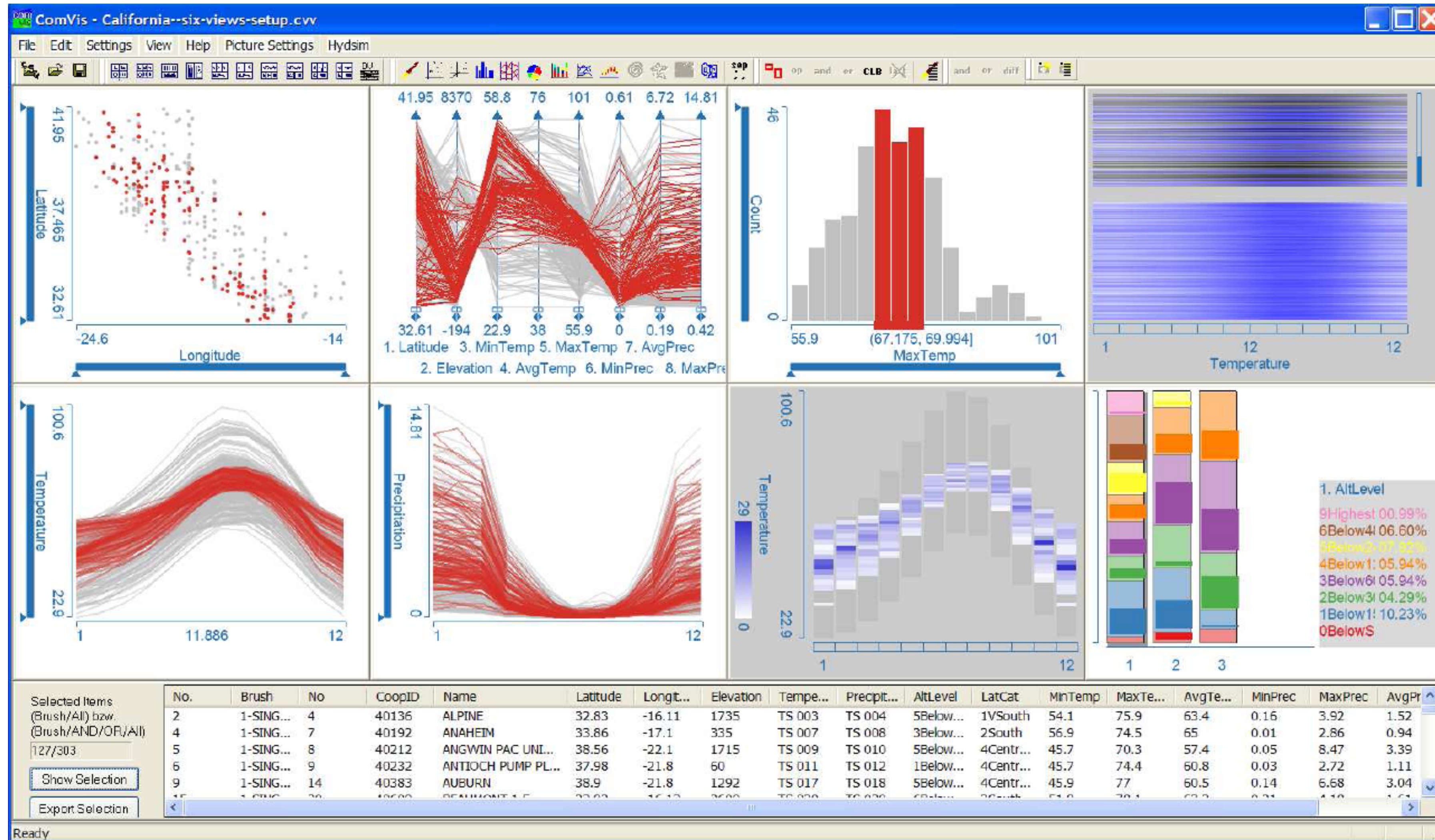
(d) Overloaded views.



(e) Nested views.

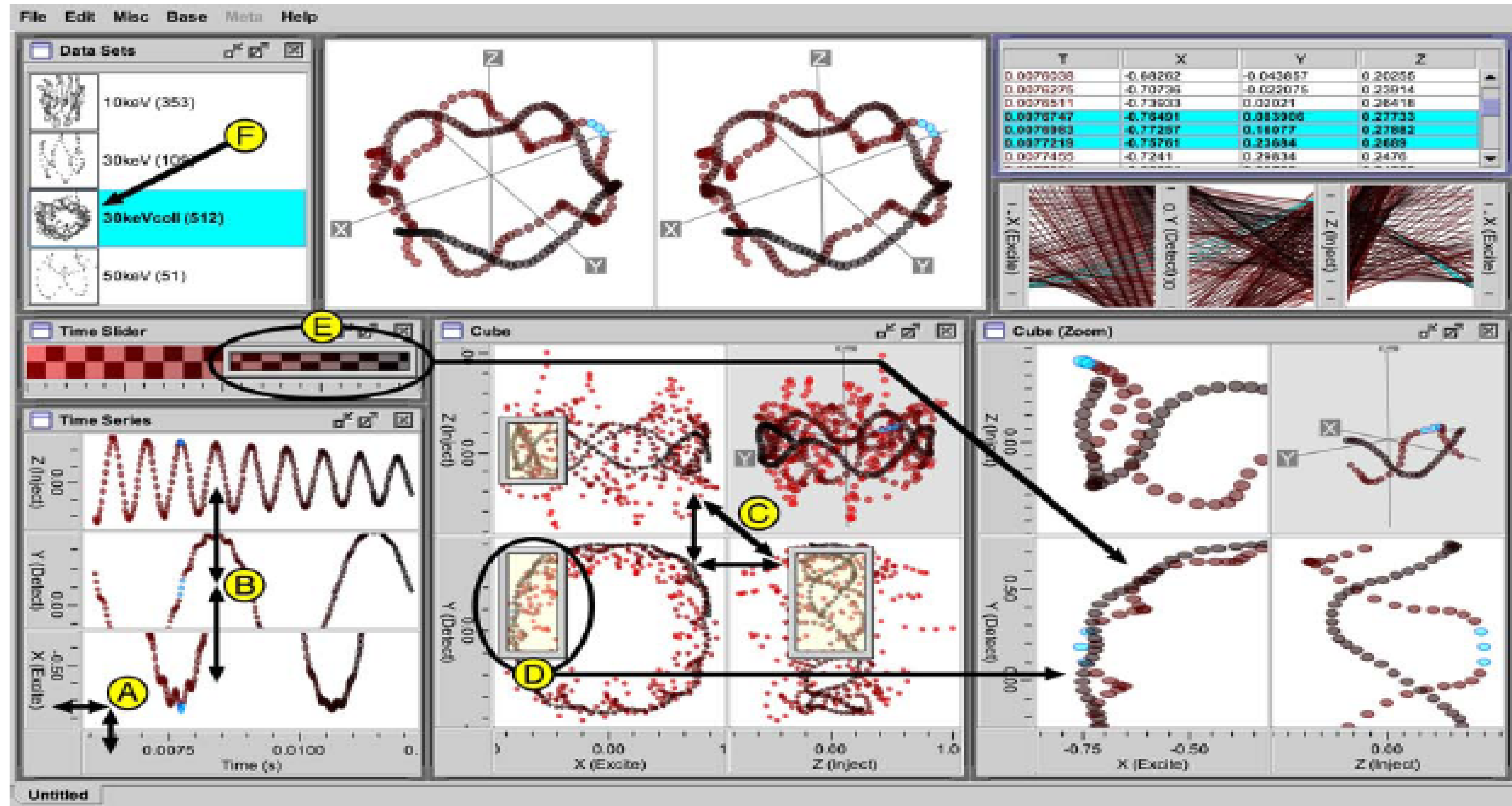
[W. Javed and N. Elmqvist, 2012]

Juxtaposition



[ComVis, K. Matkovic et al., 2008]

Juxtaposition



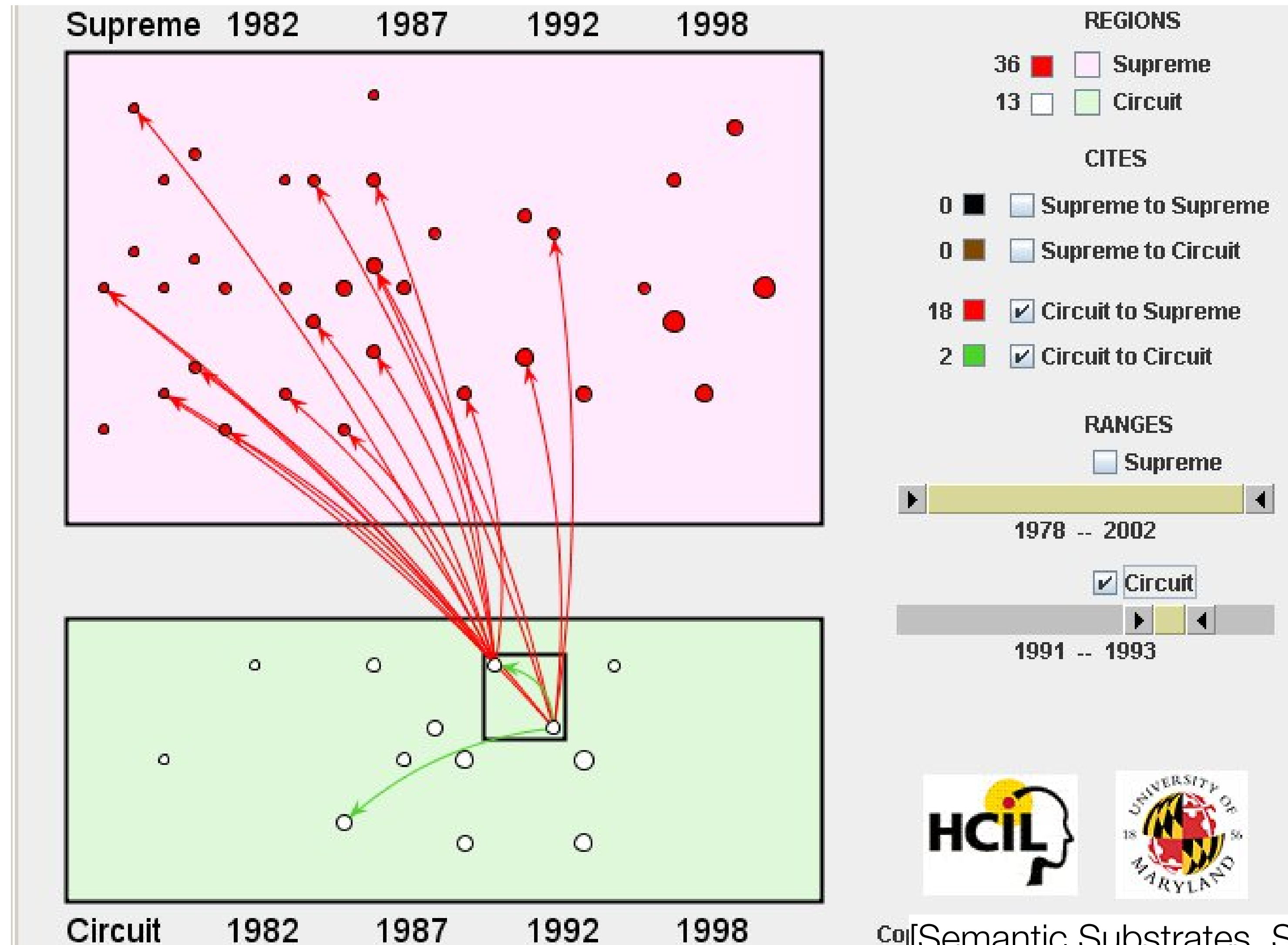
[Improvise, C. Weaver, 2004]

Juxtaposition Guidelines

- Benefits:
 - The component visualizations are independent and can be composed without interference
 - Easy to implement
- Drawbacks:
 - Implicit visual linking is not always easy to see, particularly when multiple objects are selected
 - Space is divided between the views, yielding less space for each view
- Applications: Use for heterogeneous datasets consisting of many different types of data, or for where different independent visualizations need to be combined.

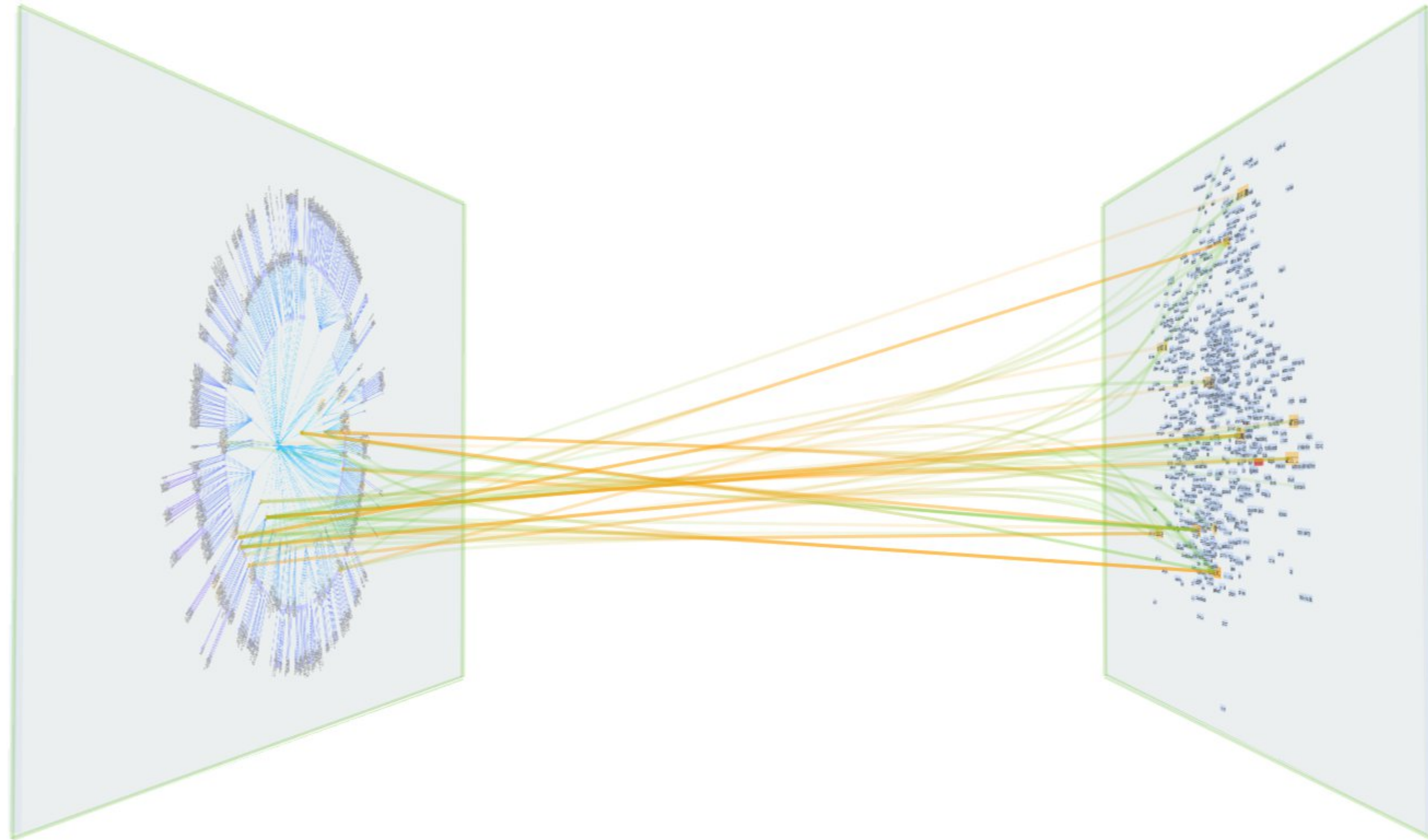
[W. Javed and N. Elmqvist, 2012]

Integration



Co[Semantic Substrates, Shneiderman and Aris, 2006]

Integration



[VisLink, Collins and Carpendale, 2007]

Integration

Carte Figurative des pertes successives en hommes de l'Armée Française dans la campagne de Russie 1812-1813.
 Dressée par M. Minard, Inspecteur Général des Ponts et Chaussées en retraite. Paris, le 20 Novembre 1869.

Les nombres d'hommes présents sont représentés par les largeurs des zones colorées à raison d'un millimètre pour dix mille hommes; ils sont de plus écrits en travers des zones. Le rouge désigne les hommes qui entrent en Russie, le noir ceux qui en sortent. — Les renseignements qui ont servi à dresser la carte ont été puisés dans les ouvrages de M. M. Chiers, de Ségur, de Fezensac, de Chambray et le journal inédit de Jacob, pharmacien de l'Armée depuis le 28 Octobre. Pour mieux faire juger à l'œil la diminution de l'armée, j'ai supposé que les corps du Prince Jérôme et du Maréchal Davoust qui avaient été détachés sur Minsk et Mobilow et ont rejoint vers Orscha et Witebsk, avaient toujours marché avec l'armée.

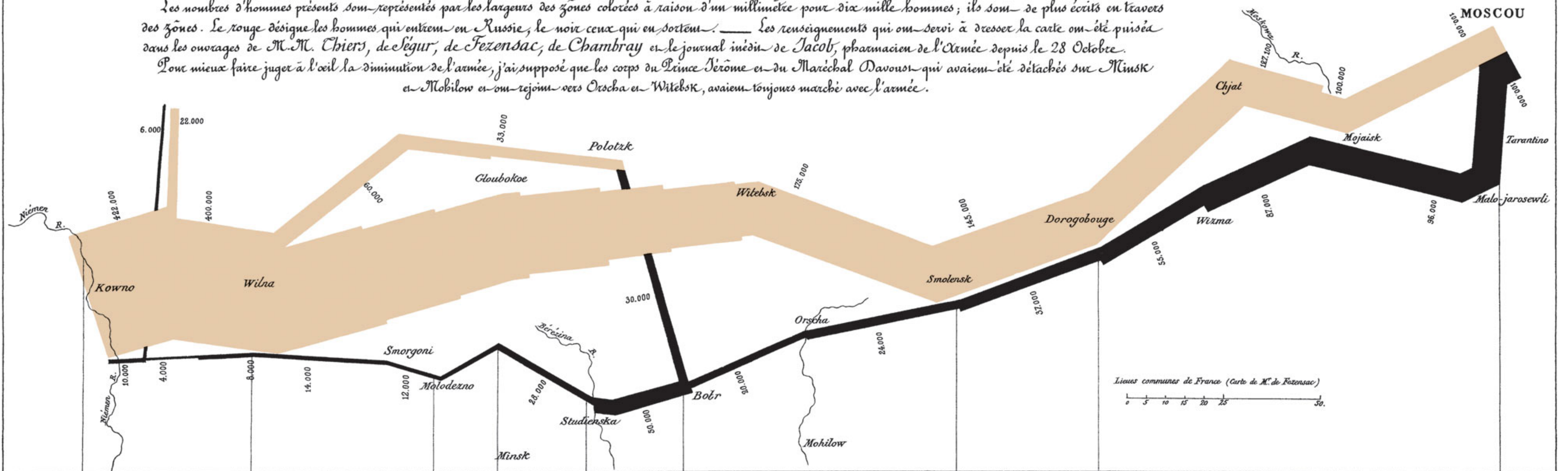
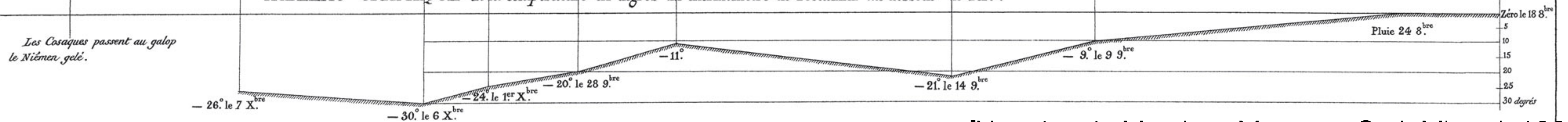


TABLEAU GRAPHIQUE de la température en degrés du thermomètre de Réaumur au dessous de zéro.



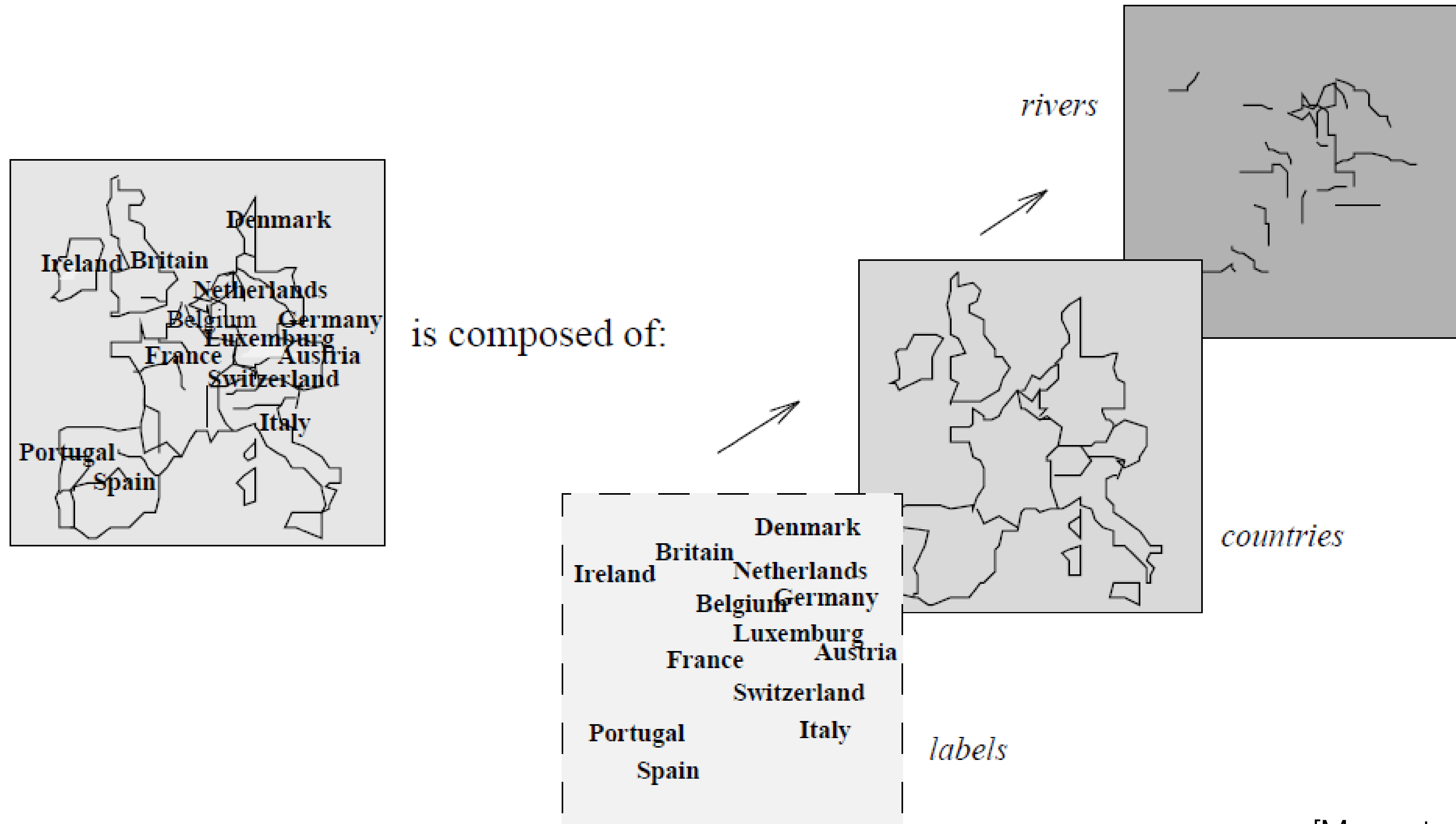
[Napoleon's March to Moscow, C. J. Minard, 1869]

Integration Guidelines

- Benefits:
 - Easy to perceive one-to-one and one-to-many relations between items in components
 - Visualizations are less independent compared to juxtaposed views, but still separate
- Drawbacks:
 - Extra visual clutter added to the overall view
 - Display space is split between the views
 - Some dependencies exist between views to allow for the visual linking
- Applications: Use for heterogeneous datasets where correlation and comparisons between views is particularly important.

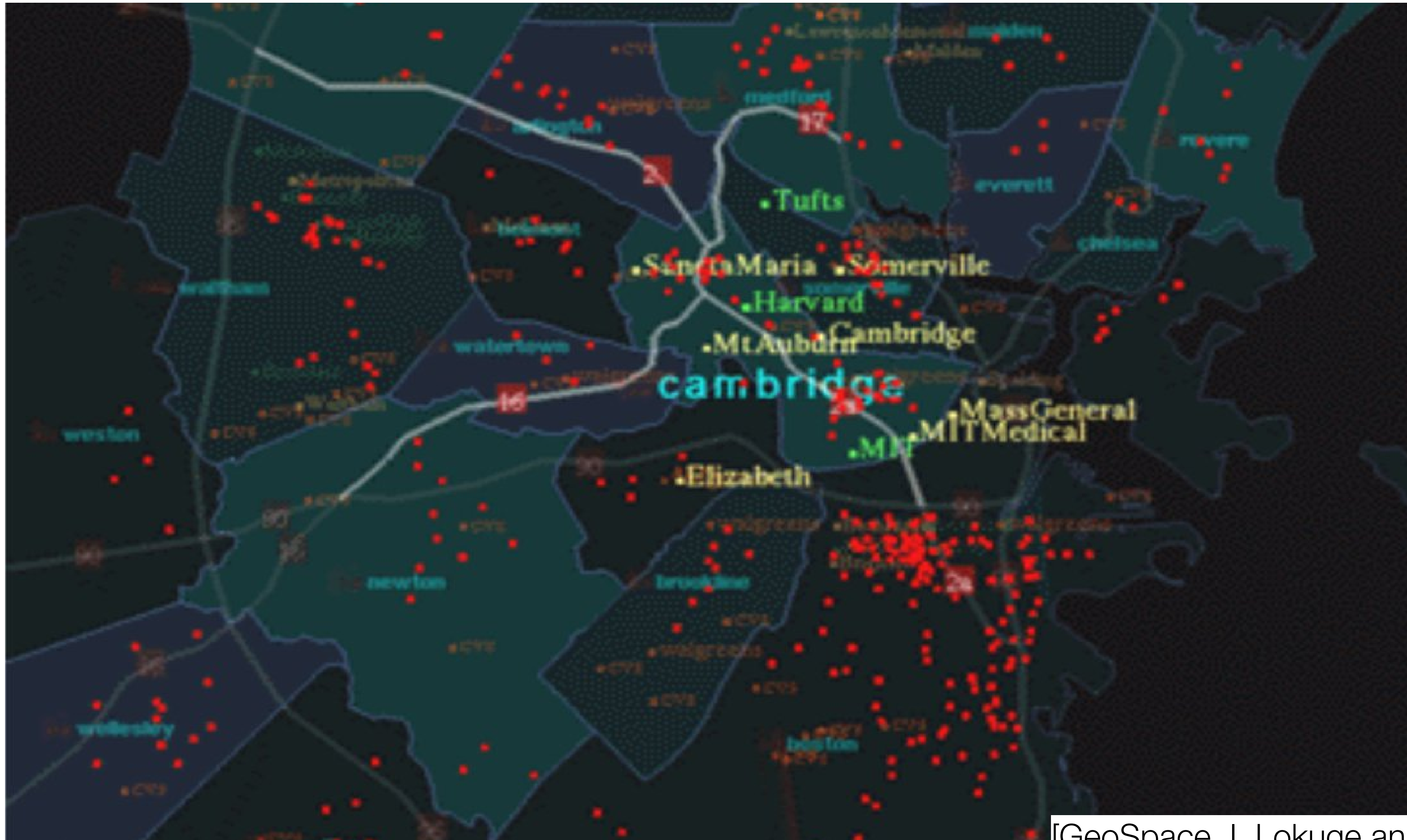
[W. Javed and N. Elmqvist, 2012]

Superimposition



[Mapgets, A. Voisard, 1995]

Superimposition



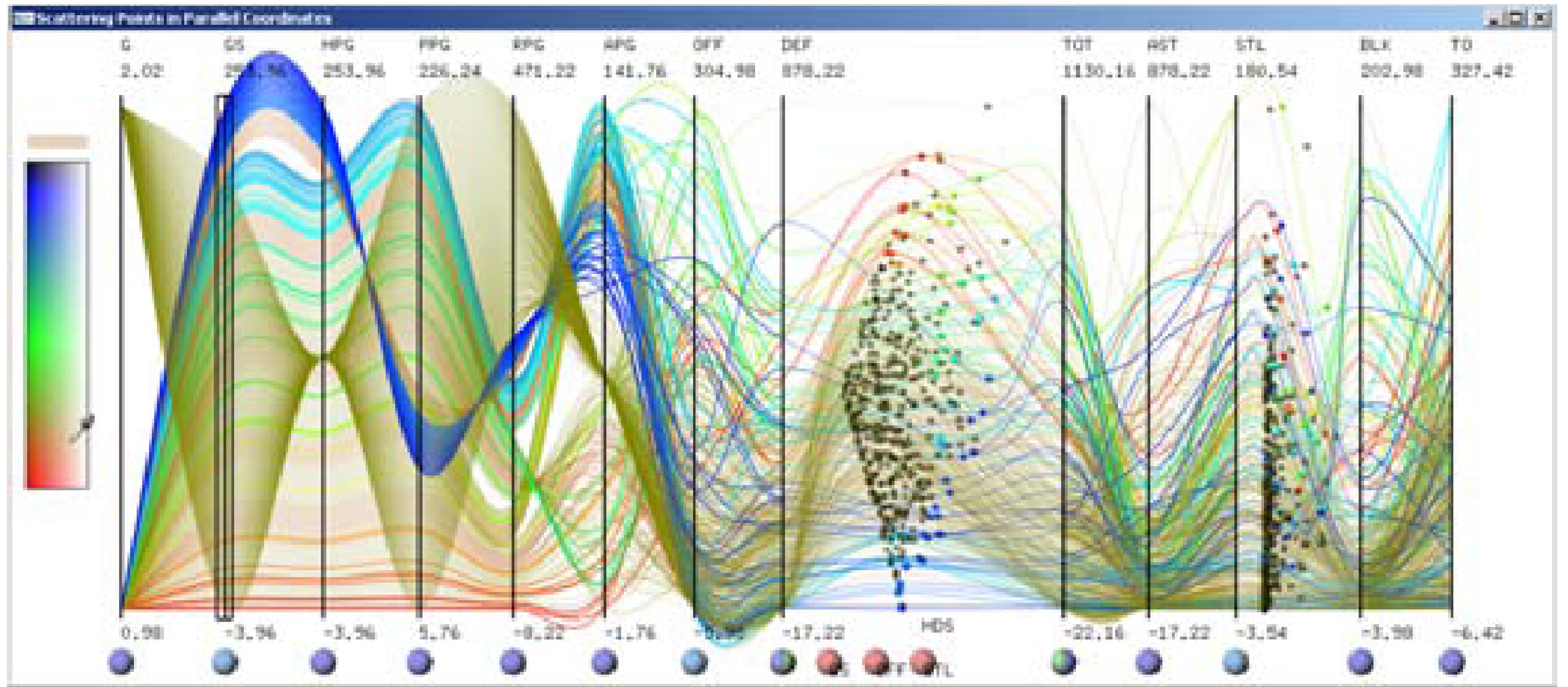
[GeoSpace, I. Lokuge and S. Ishizaki, 1995]

Superimposition Guidelines

- Benefits:
 - Allows direct comparison in the same visual space.
- Drawbacks:
 - May cause occlusion and high visual clutter.
 - The client visualization must share the same spatial mapping as the host visualization.
- Applications: In settings where comparison is common, or where the component visualization views need to be as large as possible (potentially the entire available space).

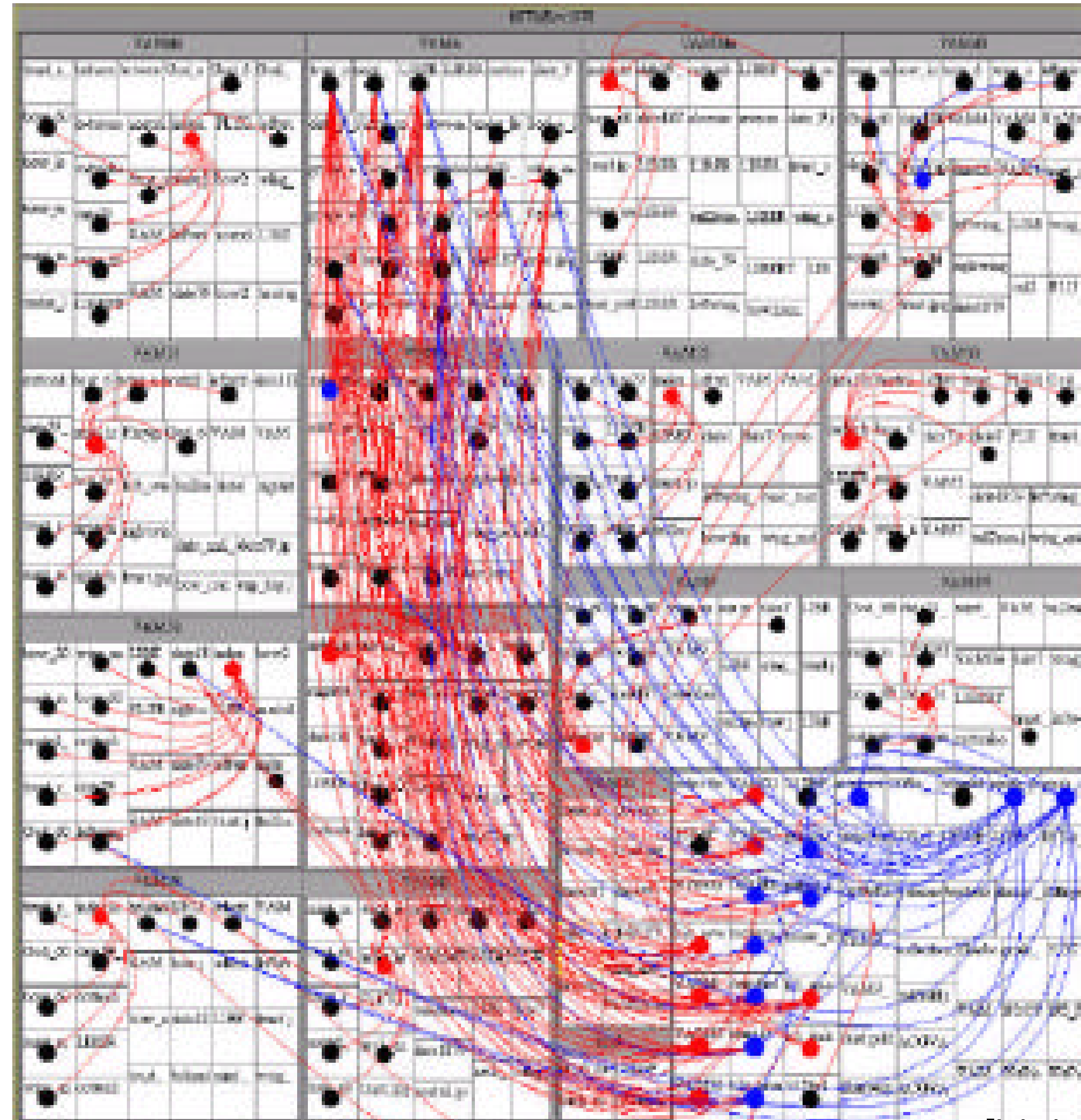
[W. Javed and N. Elmqvist, 2012]

Overloading



[SPCC, X. Yuan et al., 2009]

Overloading



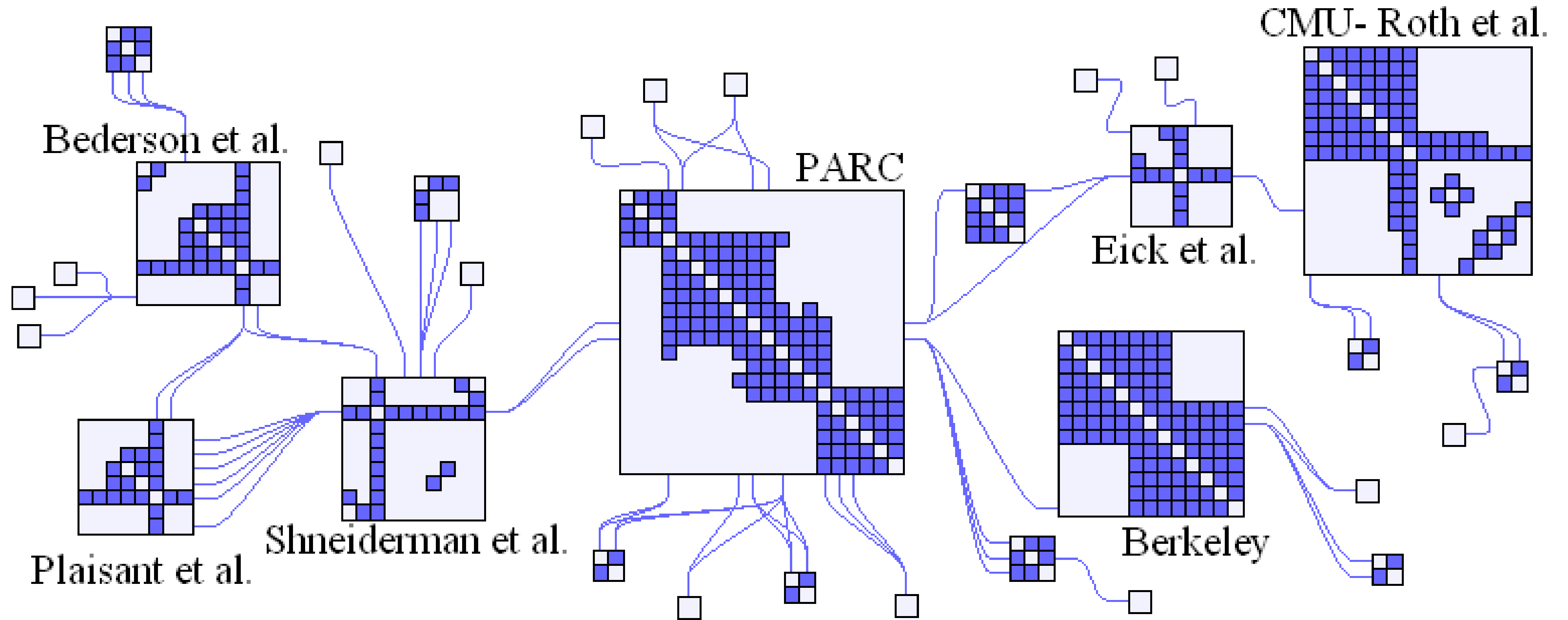
[Links on Treemaps, J.-D. Fekete et al., 2003]

Overloading Guidelines

- Benefits:
 - The client visualization does not have to share the same coordinate space as the host visualization
 - This also yield more flexibility and control over visual clutter
- Drawbacks:
 - Visual clutter is increased
 - Visual design dependencies between components are significant
- Applications: Situations where one visualization can be folded into another to yield a compact (and complex) result.

[W. Javed and N. Elmqvist, 2012]

Nesting



[NodeTrix, N. Henry et al., 2007]

Nesting Guidelines

- Benefits:
 - Very compact representation
 - Easy correlation
- Drawbacks:
 - Limited space for the client visualizations
 - Clutter is high
 - Visual design dependencies are high
- Applications: Situations that call for augmenting a particular visual representation with additional mapping

[W. Javed and N. Elmqvist, 2012]

Design Space

- Visualizations: the techniques or idioms used
- Spatial relation: relationship between visual structures in display space
- Data relation: visual relationship between items in different views
 - None: No relation
 - Item-item: One-to-one
 - Item-group: One-to-many
 - Item-dimension: Item in one view is a **scale** in another

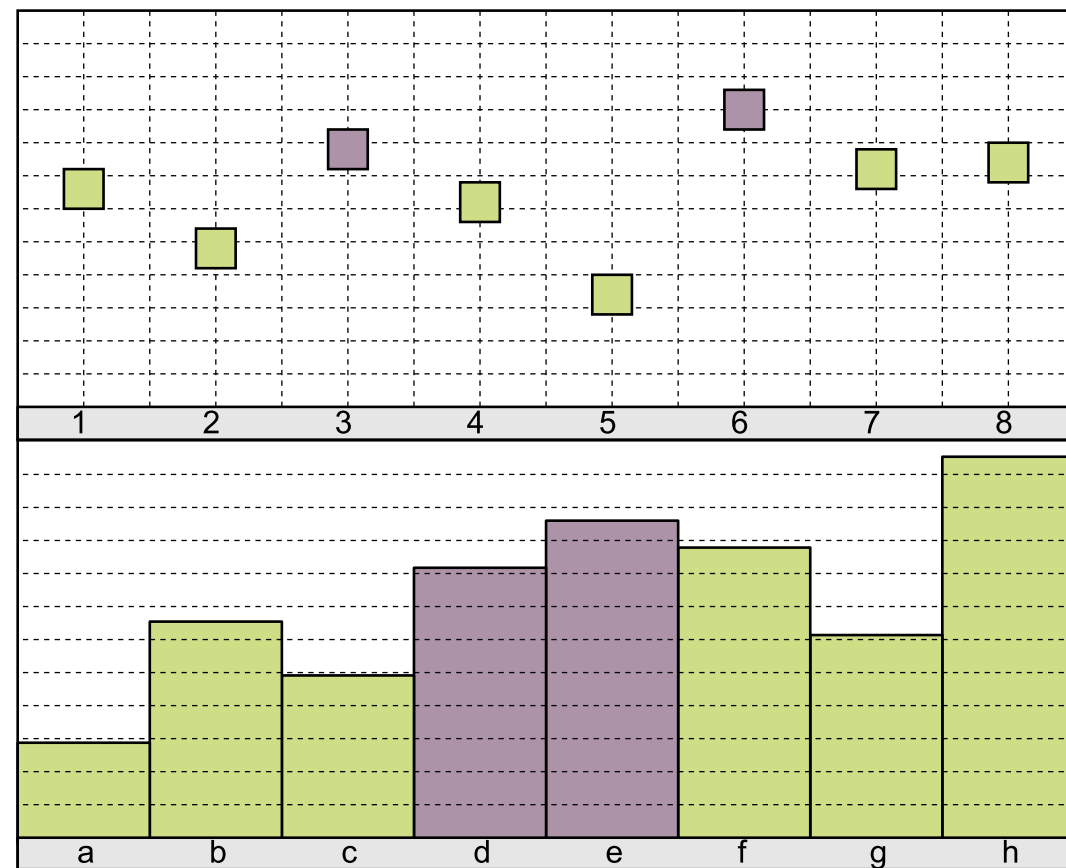
[W. Javed and N. Elmqvist, 2012]

Summary

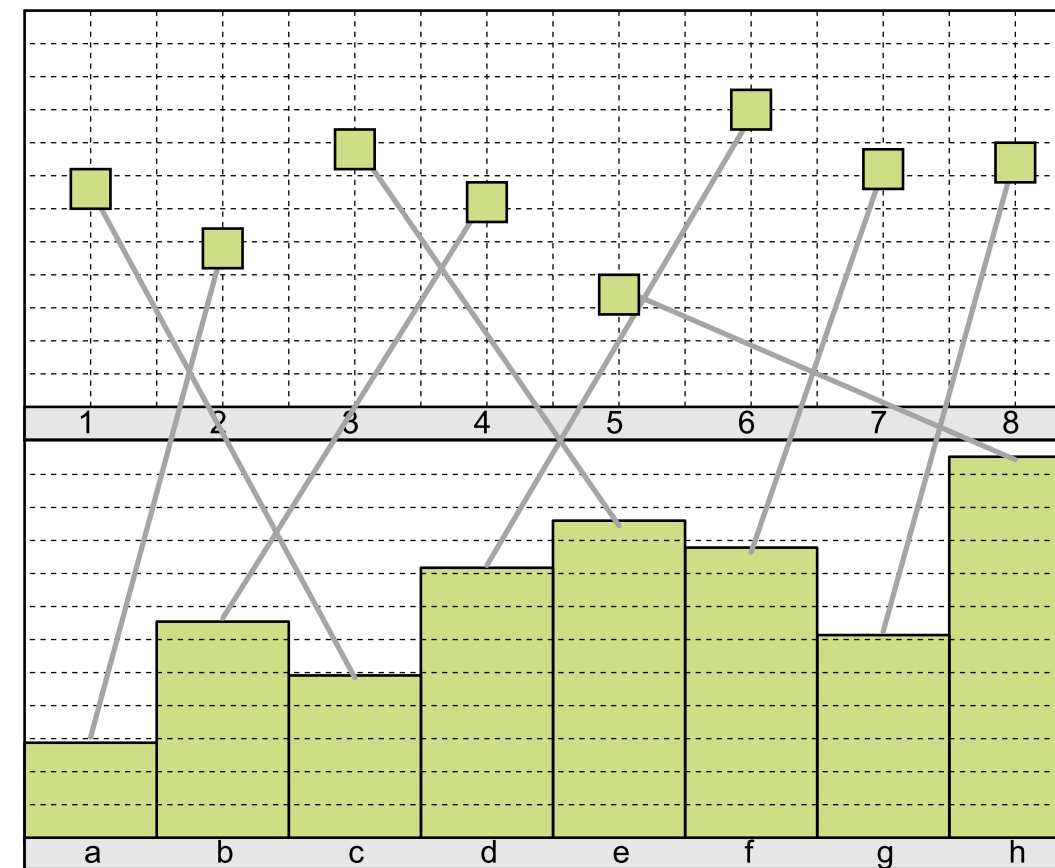
Technique	Visualization A	Visualization B	Spatial Relation	Data Relation
ComVis [24] (Figure 2)	any	any	juxtapose	none
Improvise [39] (Figure 3)	any	any	juxtapose	none
Jigsaw [36]	any	any	juxtapose	none
Snap-Together [30]	any	any	juxtapose	none
semantic substrates [34] (Figure 4)	node-link	node-link	juxtapose	item-item
VisLink [11] (Figure 5)	radial graph	node-link	juxtapose	item-item
Napoleon's March on Moscow [37]	time line view	area visualization	juxtapose	item-item
Mapgets [38] (Figure 6)	map	text	superimpose	item-item
GeoSpace [22] (Figure 7)	map	bar graph	superimpose	item-item
3D GIS [8]	map	glyphs	superimpose	item-item
Scatter Plots in Parallel Coordinates [45] (Figure 8)	parallel coordinate	scatterplot	overload	item-dimension
Graph links on treemaps [14] (Figure 9)	treemap	node-link	overload	item-item
SparkClouds [21]	tag cloud	line graph	overload	item-item
ZAME [13] (Figure 10)	matrix	glyphs	nested	item-group
NodeTrix [17] (Figure 11)	node-link	matrix	nested	item-group
TimeMatrix [44]	matrix	glyphs	nested	item-group
GPUVis [25]	Scatterplot	glyphs	nested	item-group

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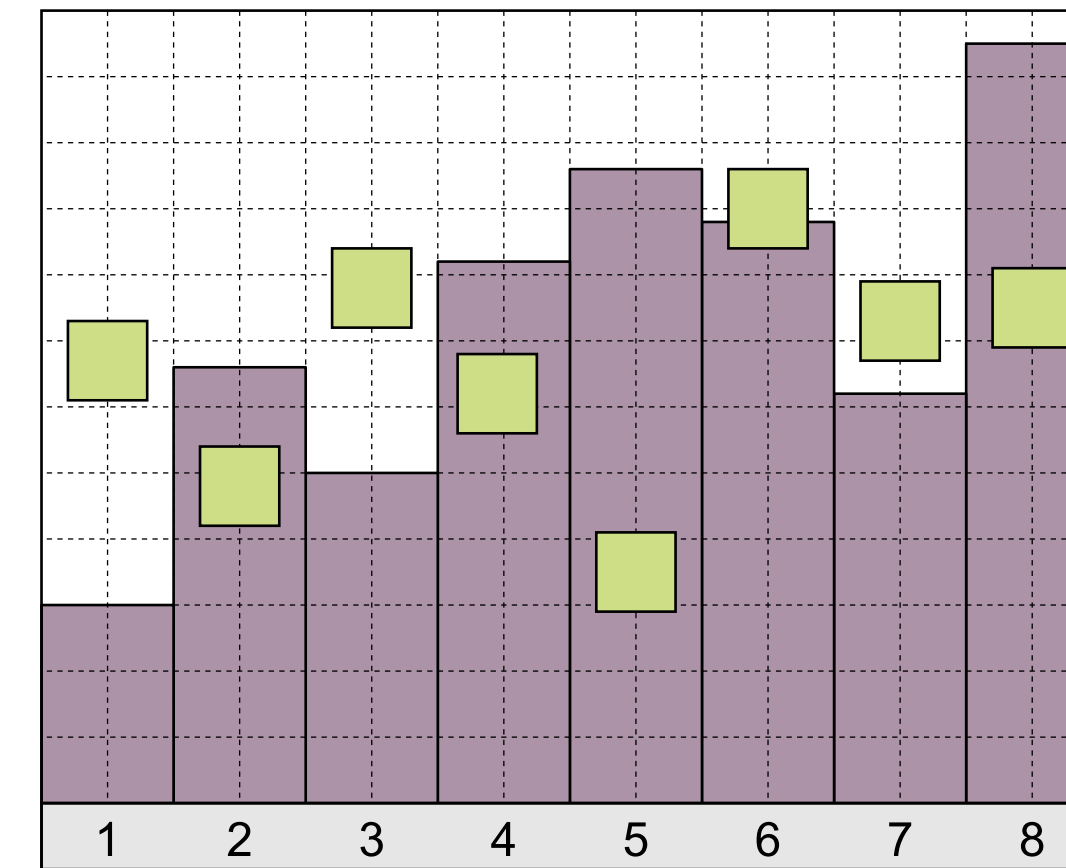
Summary (Scatterplot + Bar Chart)



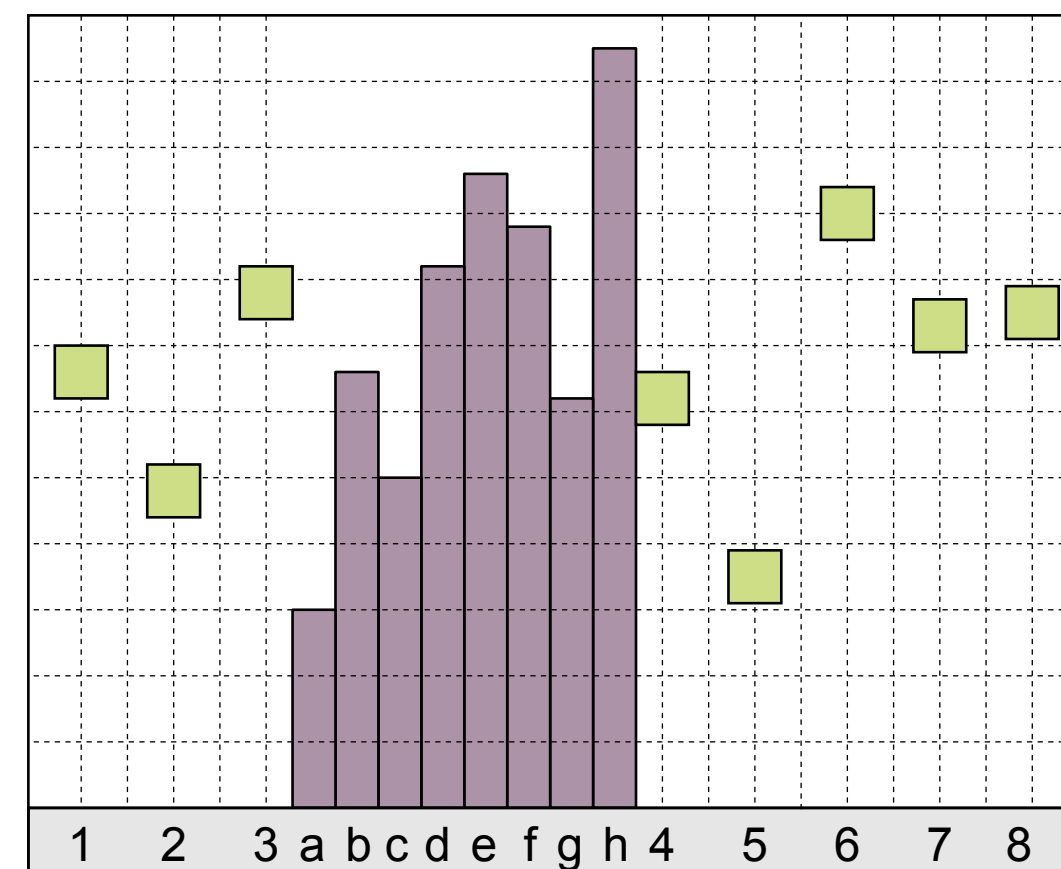
(a) Juxtaposed views.



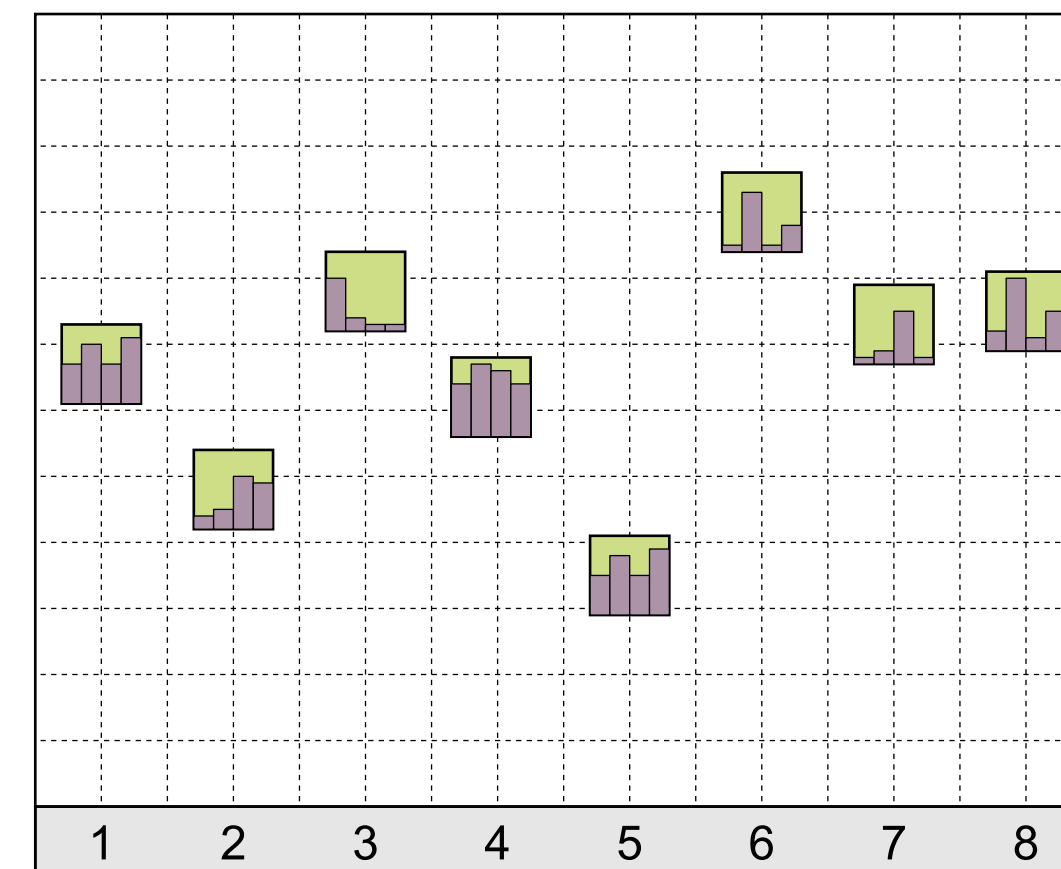
(b) Integrated views.



(c) Superimposed views.



(d) Overloaded views.



(e) Nested views.

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