Data Visualization (CSCI 627/490)

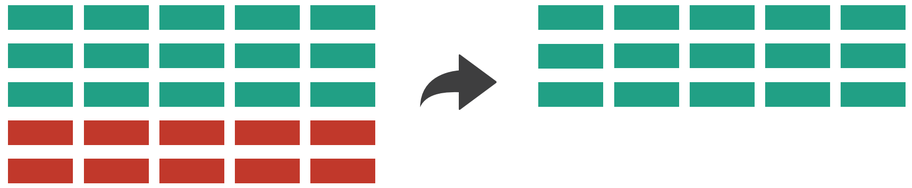
Focus+Context & Data

Dr. David Koop

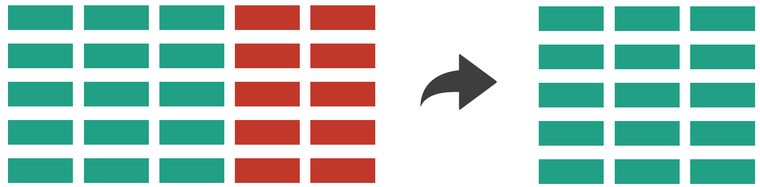
Overview: Reducing Items & Attributes

Filter

- Items

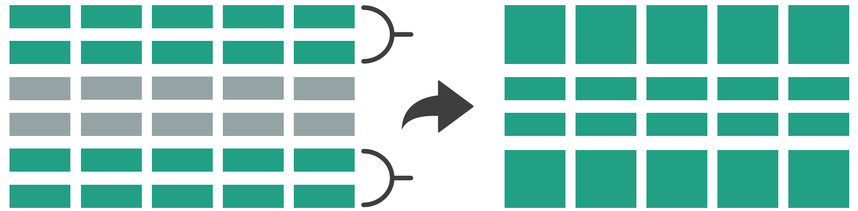


- Attributes

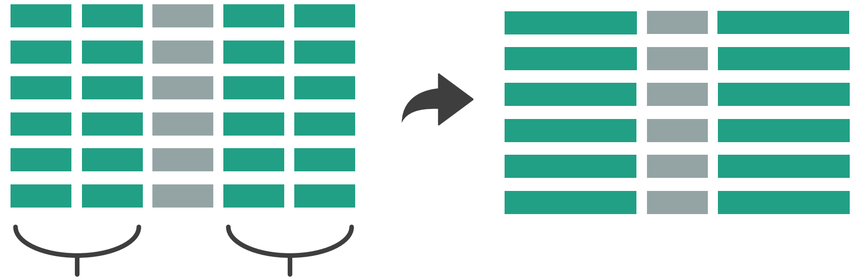


Aggregate

- Items

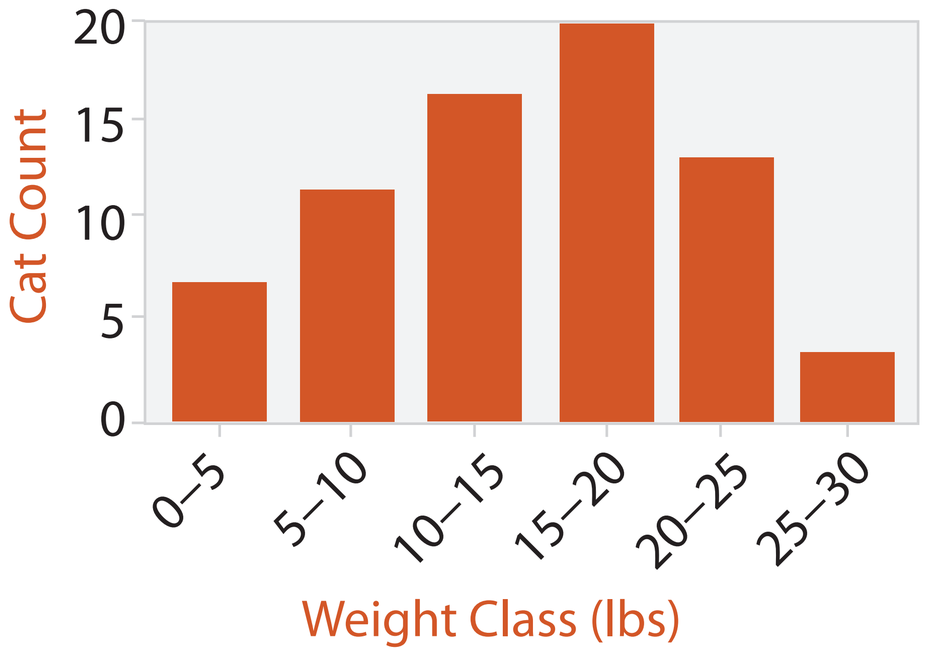


- Attributes



[Munzner (ill. Maguire), 2014]

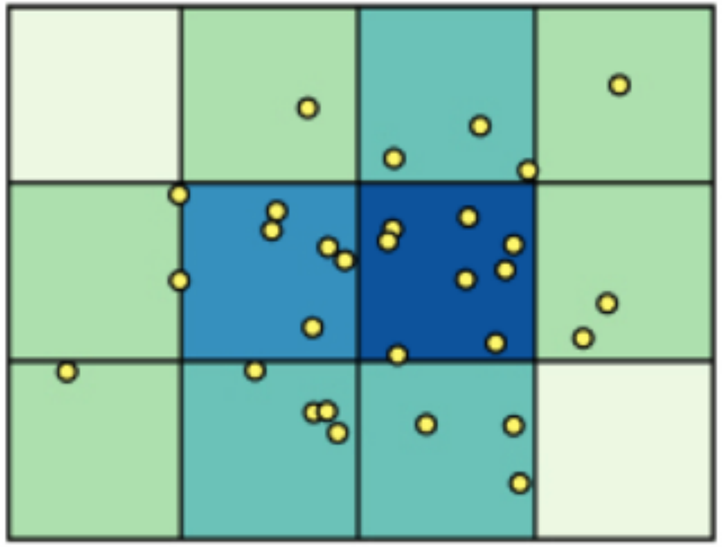
Aggregation: Histograms

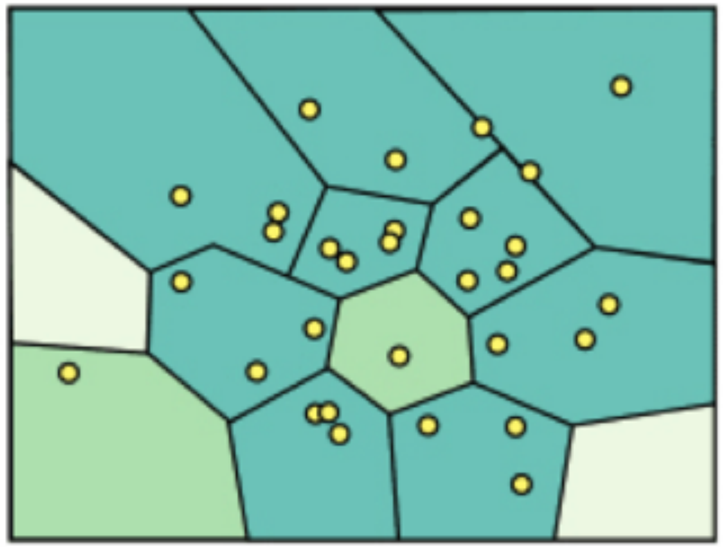


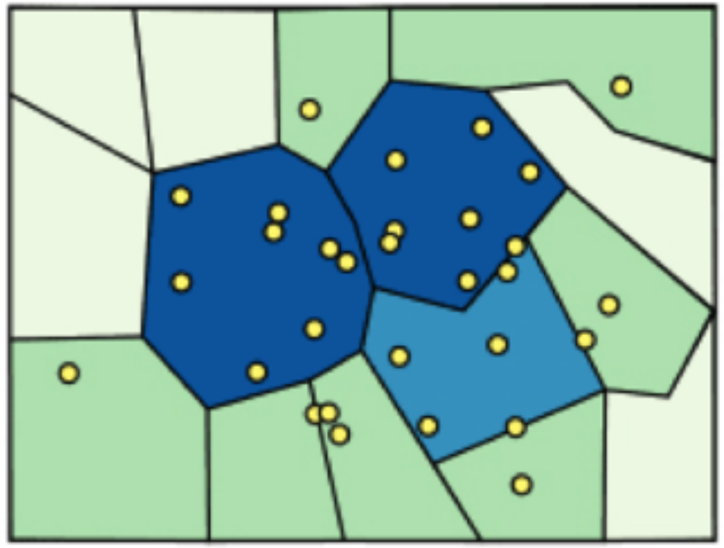
- Very similar to bar charts
- Often shown without space between (continuity)
- Choice of number of bins
  - Important!
  - Viewers may infer different trends based on the layout

[Munzner (ill. Maguire), 2014]

Spatial Aggregation



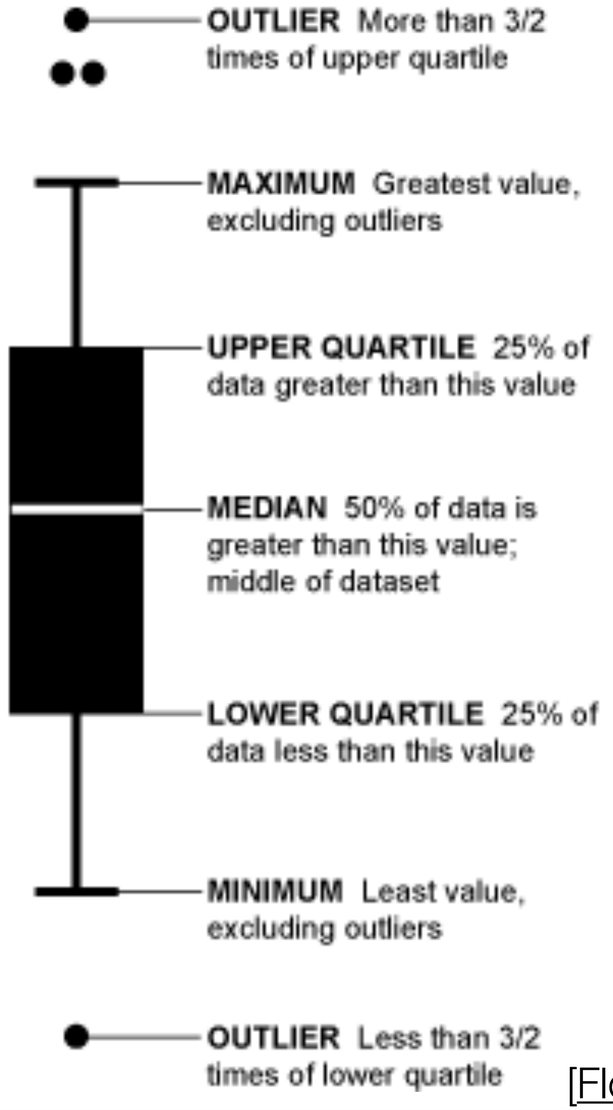




[Penn State, GEOG 486]

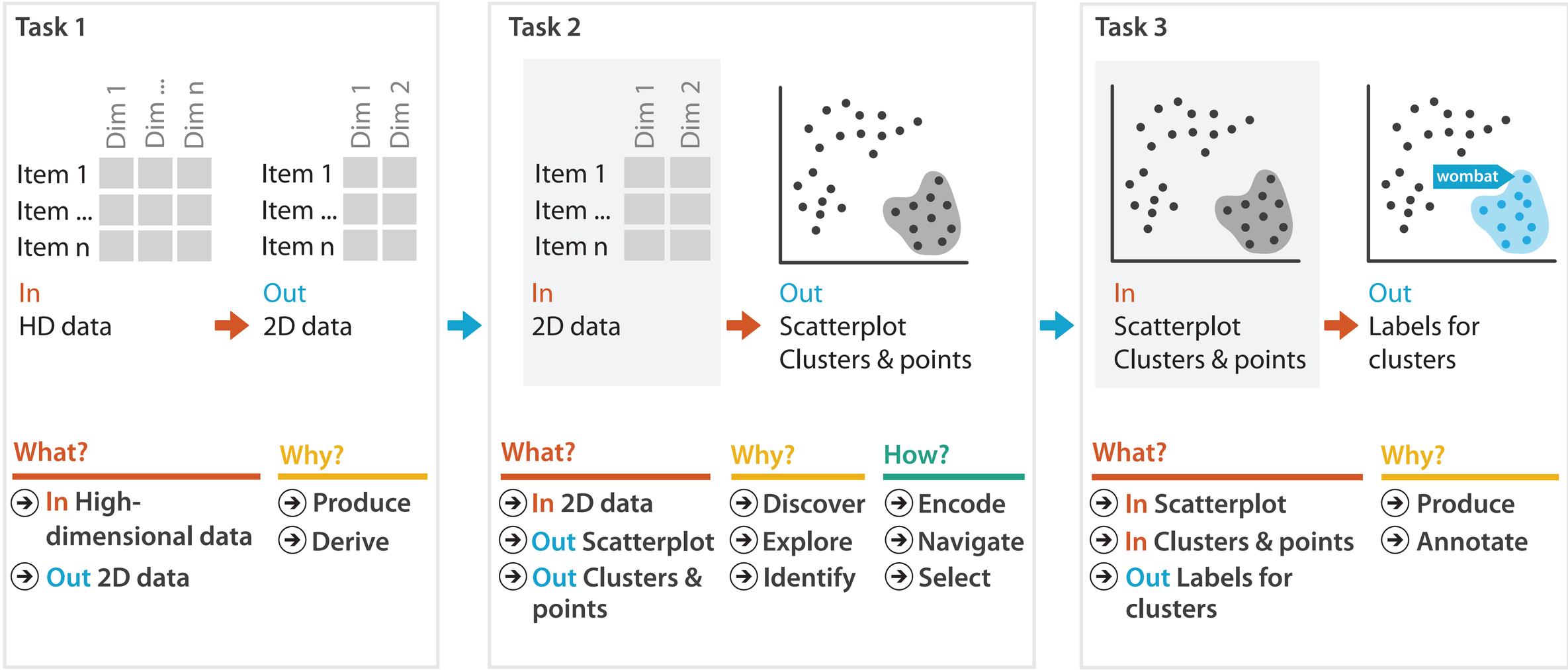
Aggregation: Boxplots

- Show **distribution**
- Single value (e.g. mean, max, min, quartiles) doesn't convey everything
- Created by John Tukey
- Show **spread** and **skew** of data
- Best for **unimodal** data
- Variations like vase plot for multimodal data
- Aggregation here involves many different marks



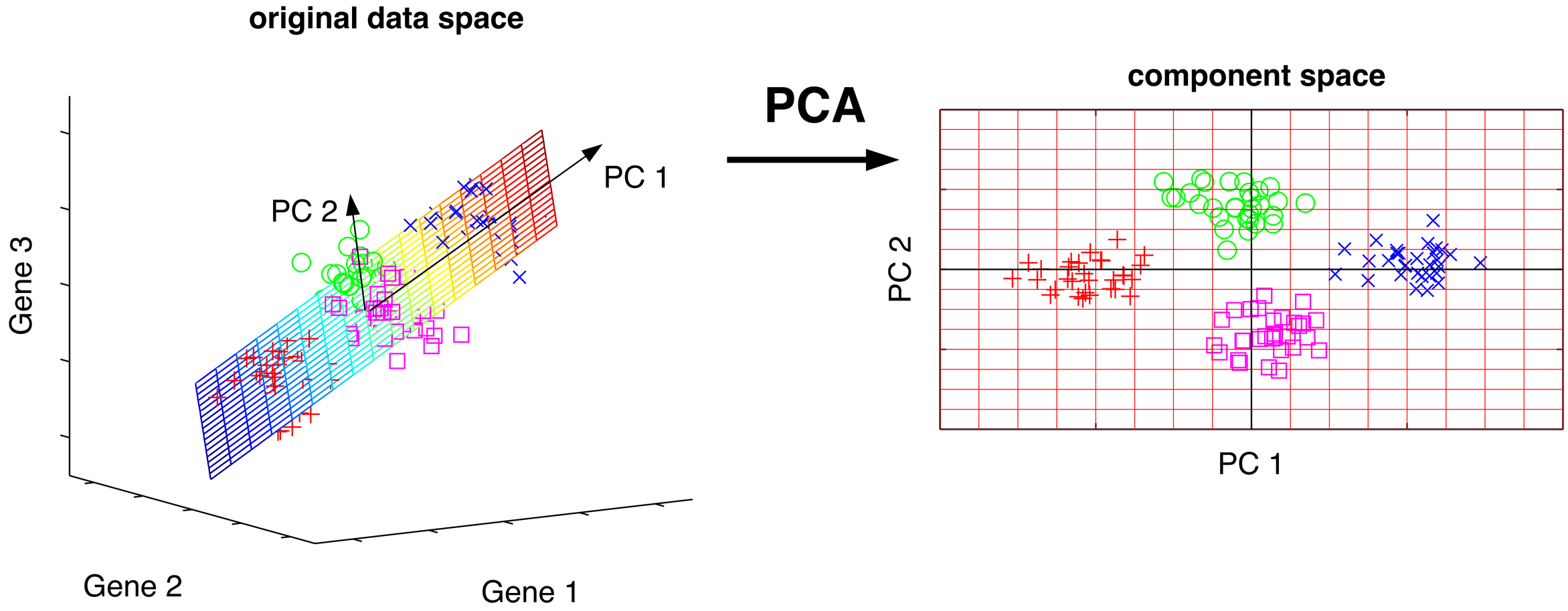
[Flowing Data]

Tasks in Understanding High-Dim. Data



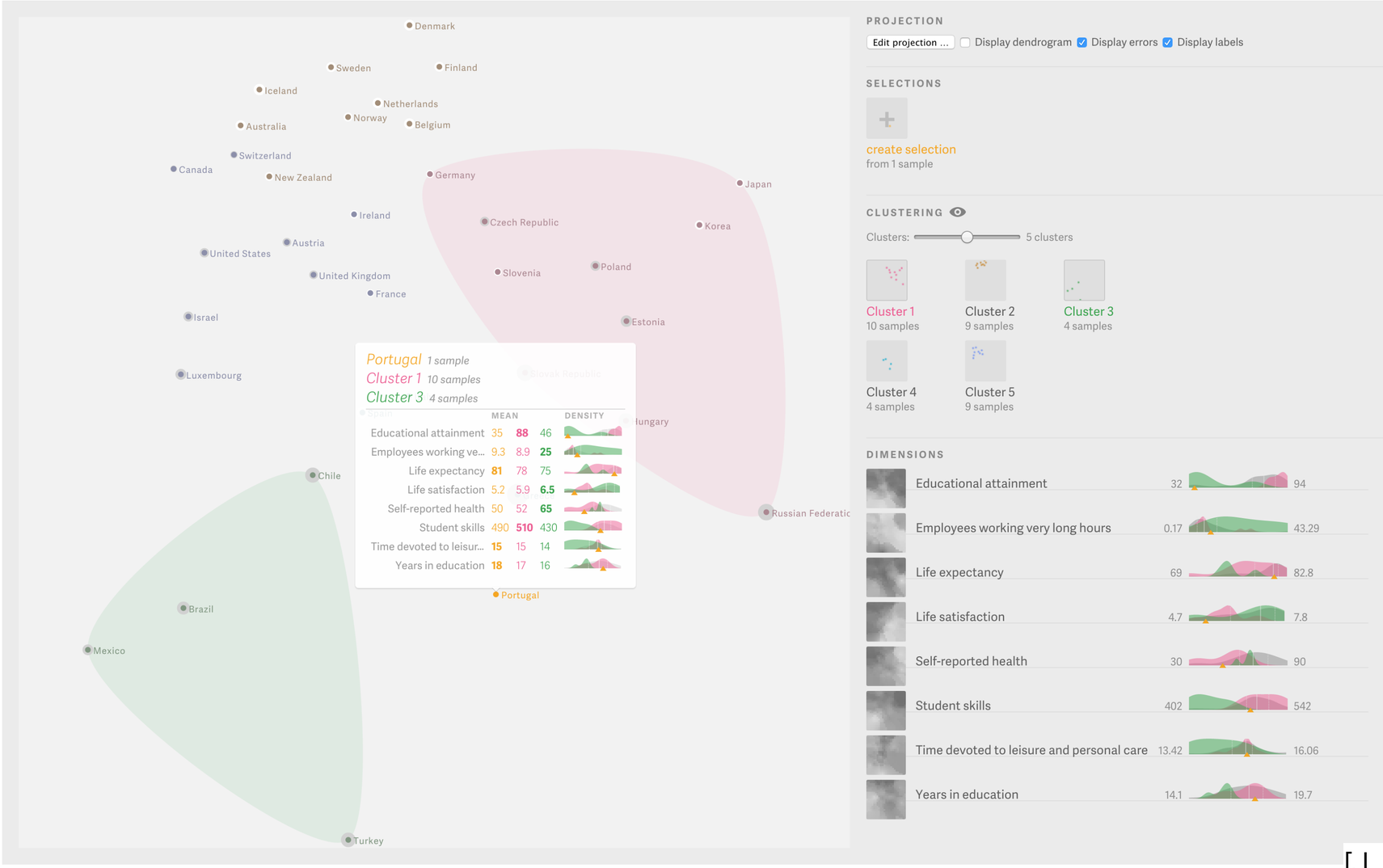
[Munzner (ill. Maguire), 2014]

Principle Component Analysis (PCA)



[M. Scholz, CC-BY-SA 2.0]

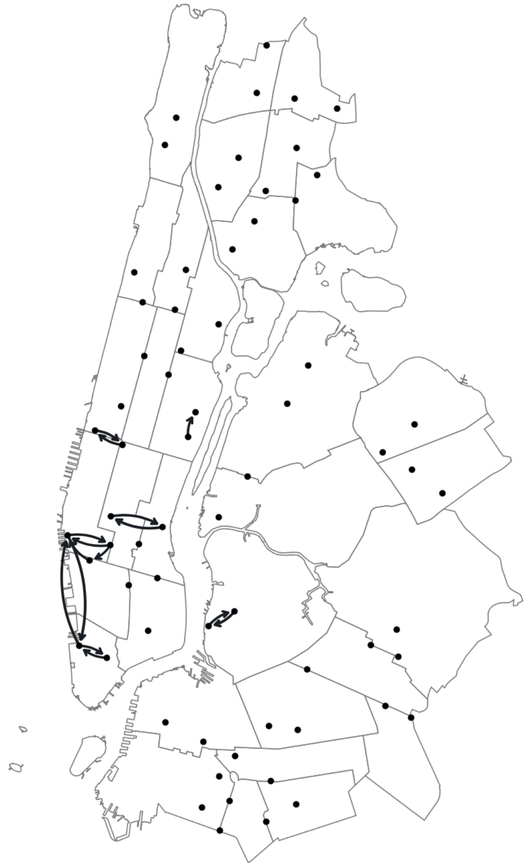
Probing Projections



[J. Stahnke et al., 2015]

Assignment 5

- Create Multiple Views
- Filtering
- Linked Highlighting
- Aggregation



Final Project

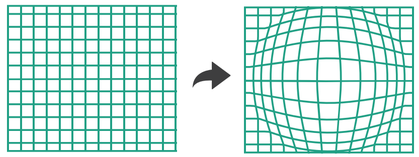
- Designs feedback soon
- Work on implementations
- Presentations will be last week of class
- Reports due at the end of the class

Focus+Context Overview

- **Embed**
  - Elide Data

  - Superimpose Layer

  - Distort Geometry



Reduce

- Filter

- Aggregate

- Embed

[Munzner (ill. Maguire), 2014]

Focus+Context

- Show everything at once but compress regions that are not the current focus
  - User shouldn't lose sight of the overall picture
  - May involve some aggregation in non-focused regions
  - "Nonliteral navigation" like semantic zooming
- Elision
- Superimposition: more directly tied than with layers
- Distortion

Elision

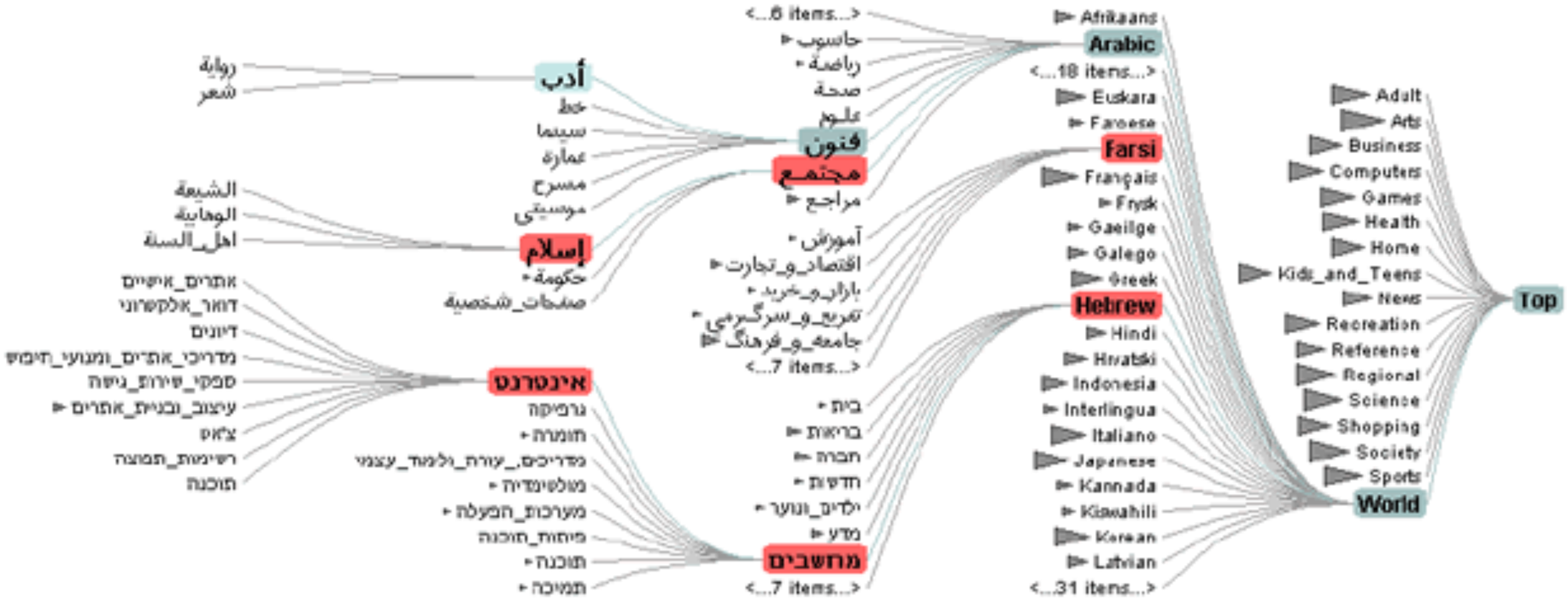
- There are a number of examples of elision including in text , DOITrees, …
- Includes both filtering and aggregation but goal is to give overall view of the data
- In visualization, usually correlated with focus regions

Degree of Interest Function

- DOI = I(x) - D(x,y)
  - I: interest function
  - D: distance (semantic or spatial)
  - x: location of item
  - y: current focus point (could be more than one)
- Interactive: y changes

Elision: DOITrees

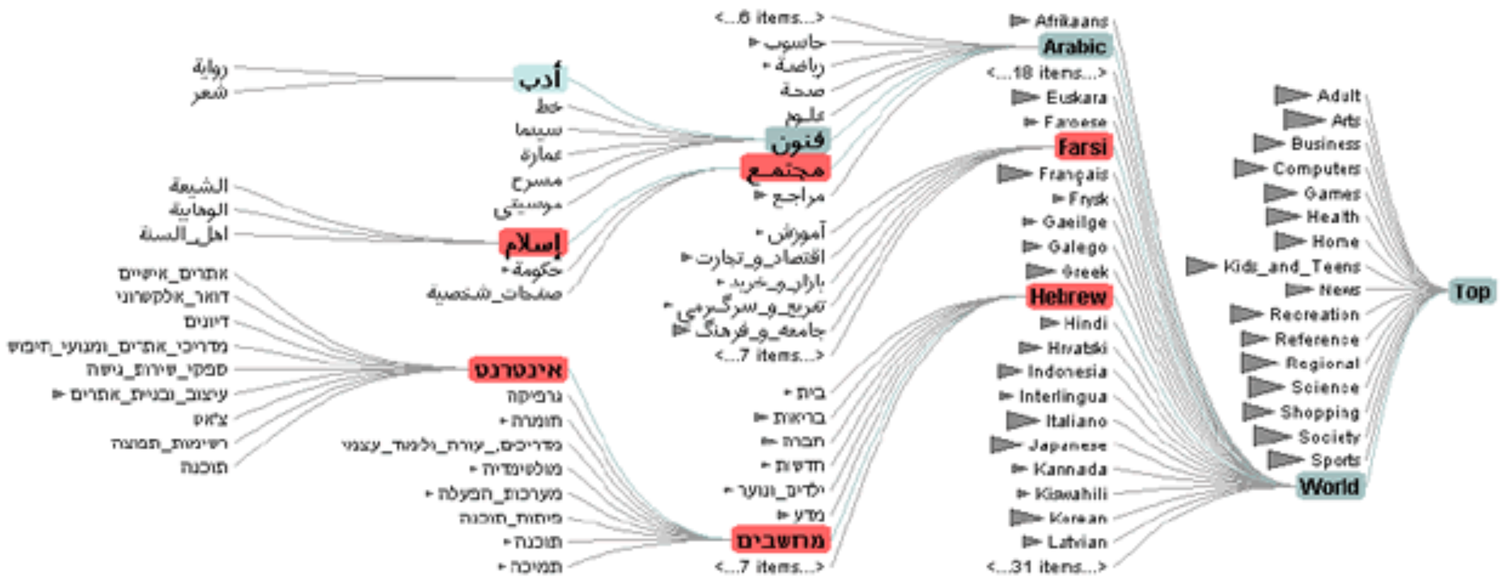
- Example: 600,000 node tree
  - Multiple foci (from search results or via user selection)
  - Distance computed topologically (levels, not geometric)



[Heer and Card, 2004]

Elision & Degree of Interest Function

- DOI = I(x) - D(x,y)
  - I: interest function
  - D: distance (semantic or spatial)
  - x: location of item
  - y: current focus point
  - Interactive: y changes

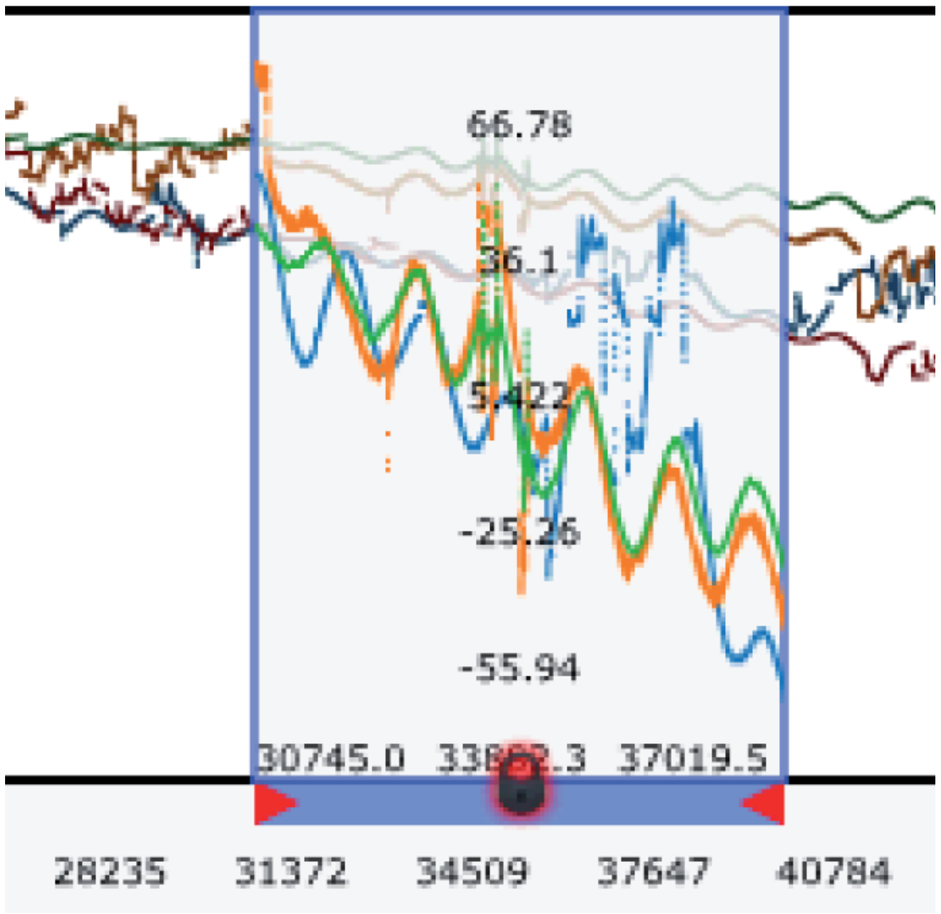


[Heer and Card, 2004]

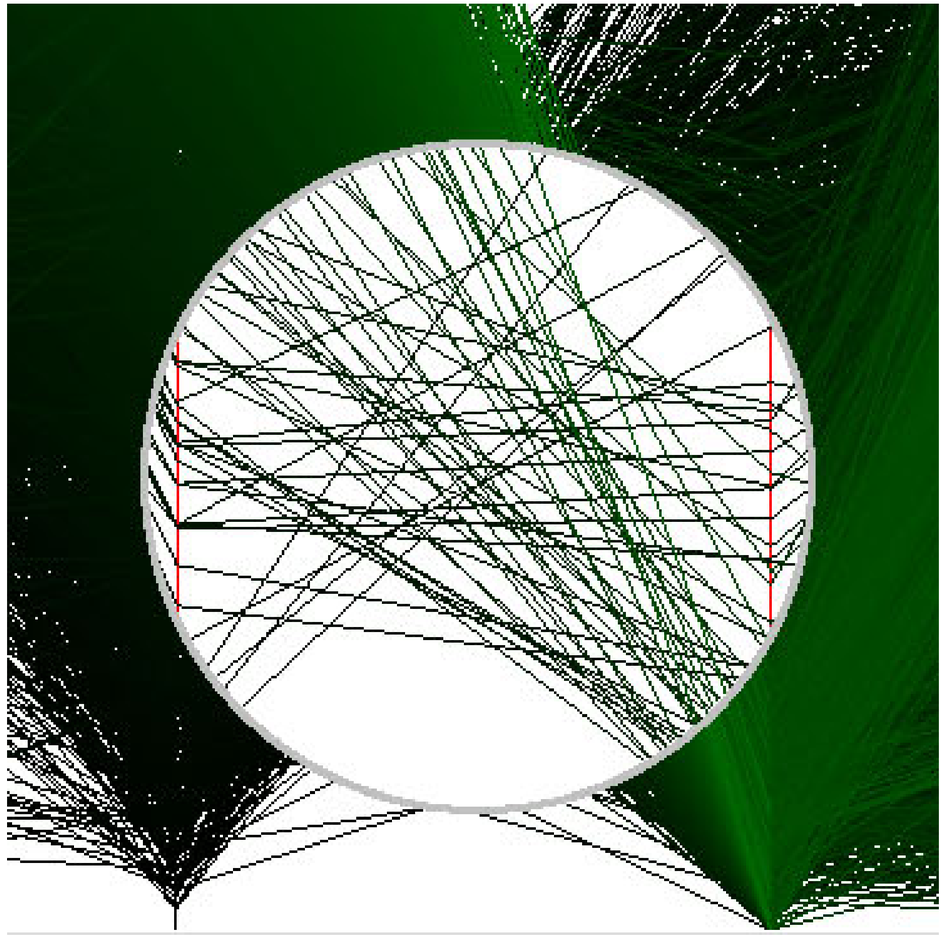
Superimposition

- Different from layers because this is restricted to a particular region
  - For Focus+Context, superimposition is **not global**
  - More like overloading
- Lens may occlude the layer below

Superimposition with Interactive Lenses



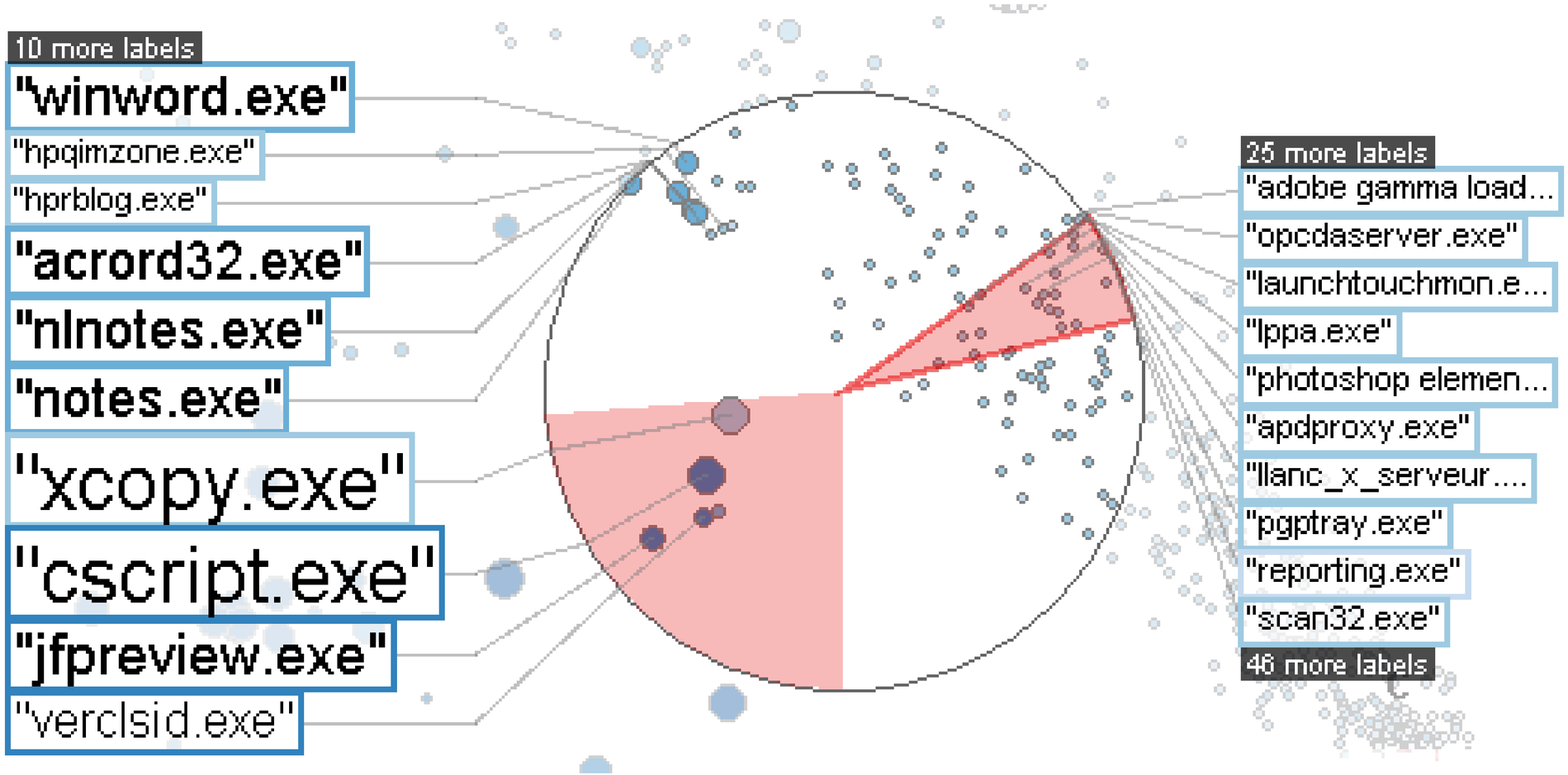
(a) Alteration



(b) Suppression

[ChronoLenses and Sampling Lens in Tominski et al., 2014]

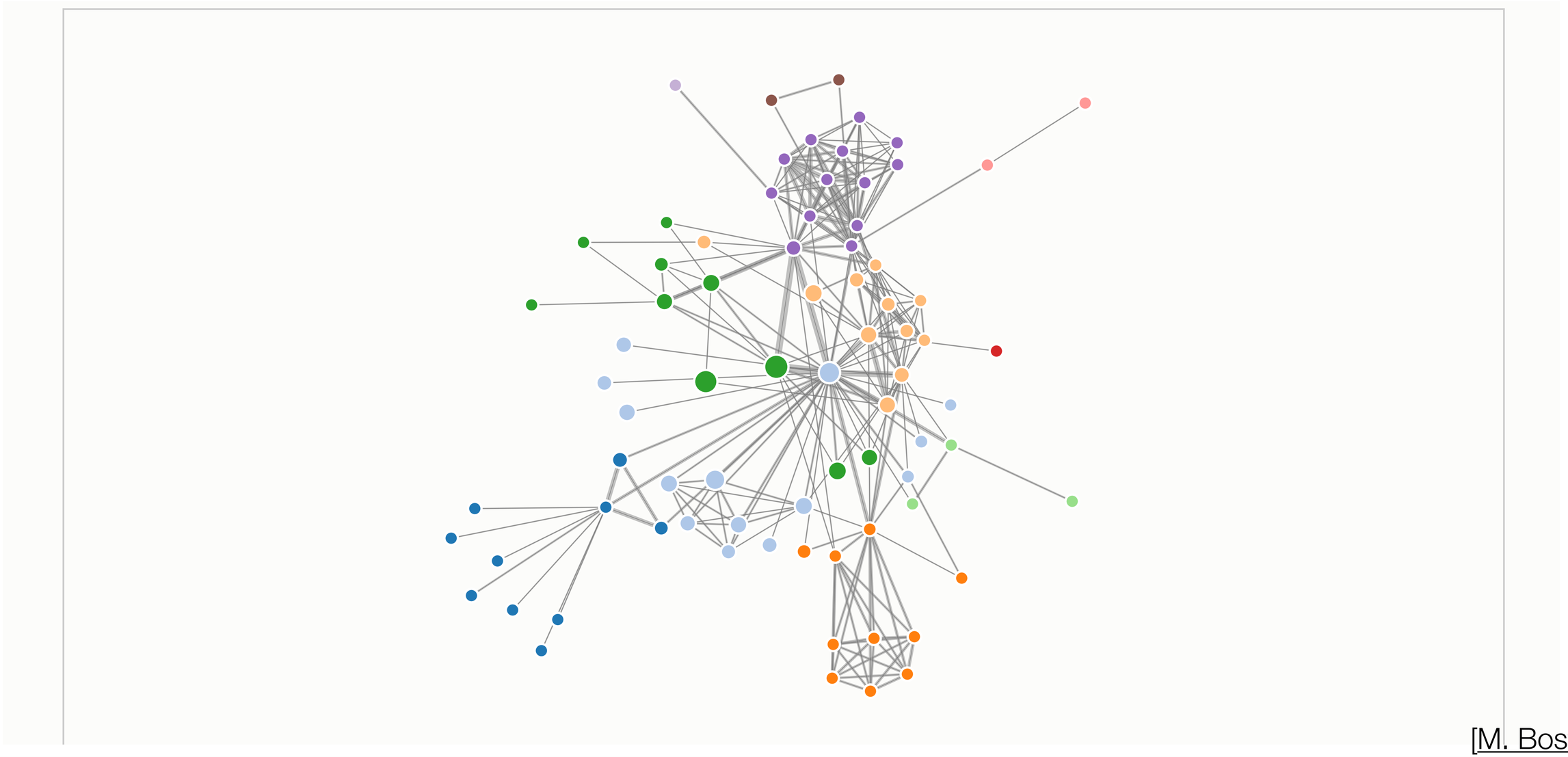
Superimposition with Interactive



(c) Enrichment

[Extended Lens in Tominski et al., 2014]

Distortion

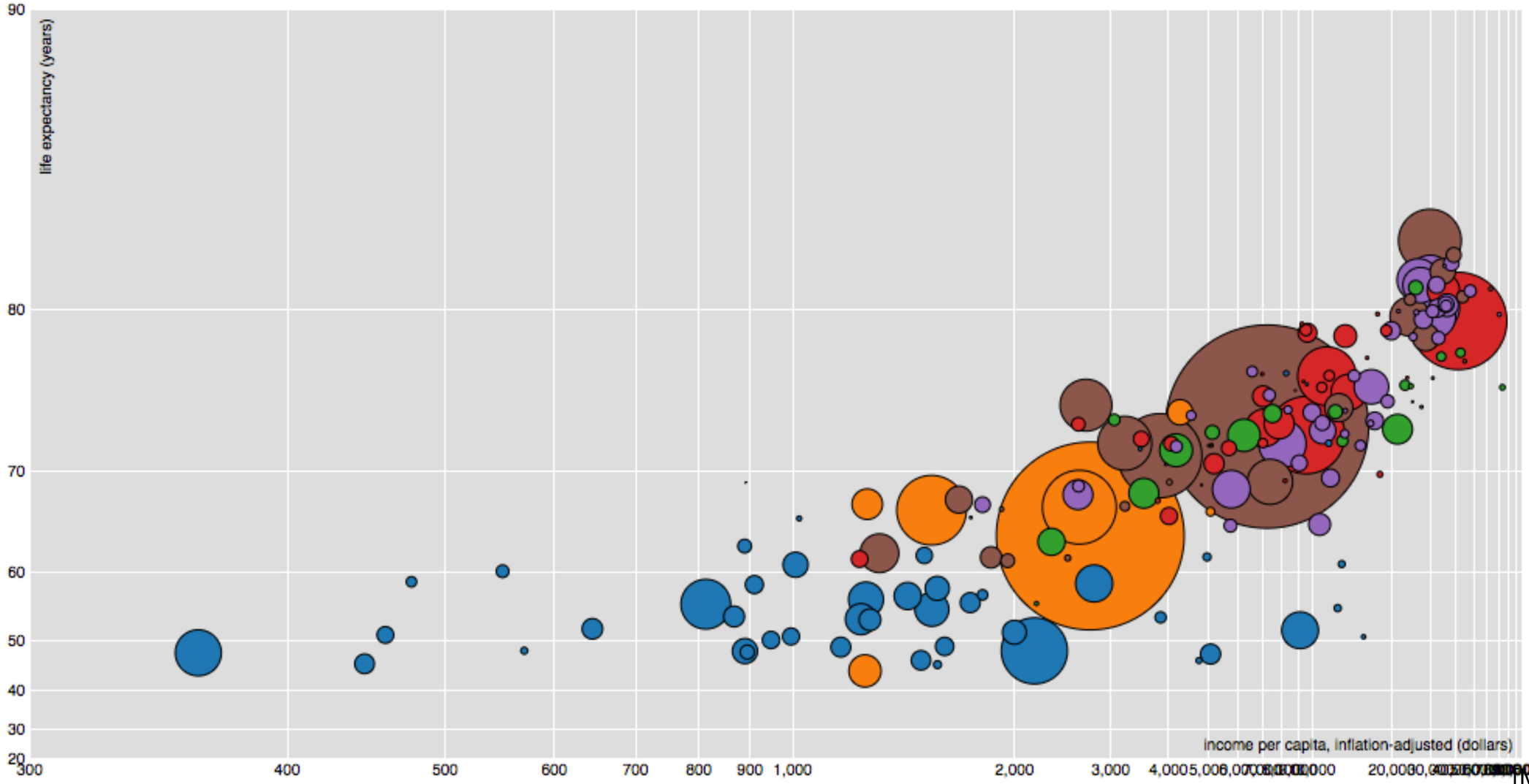


[M. Bostock]

Distortion Choices

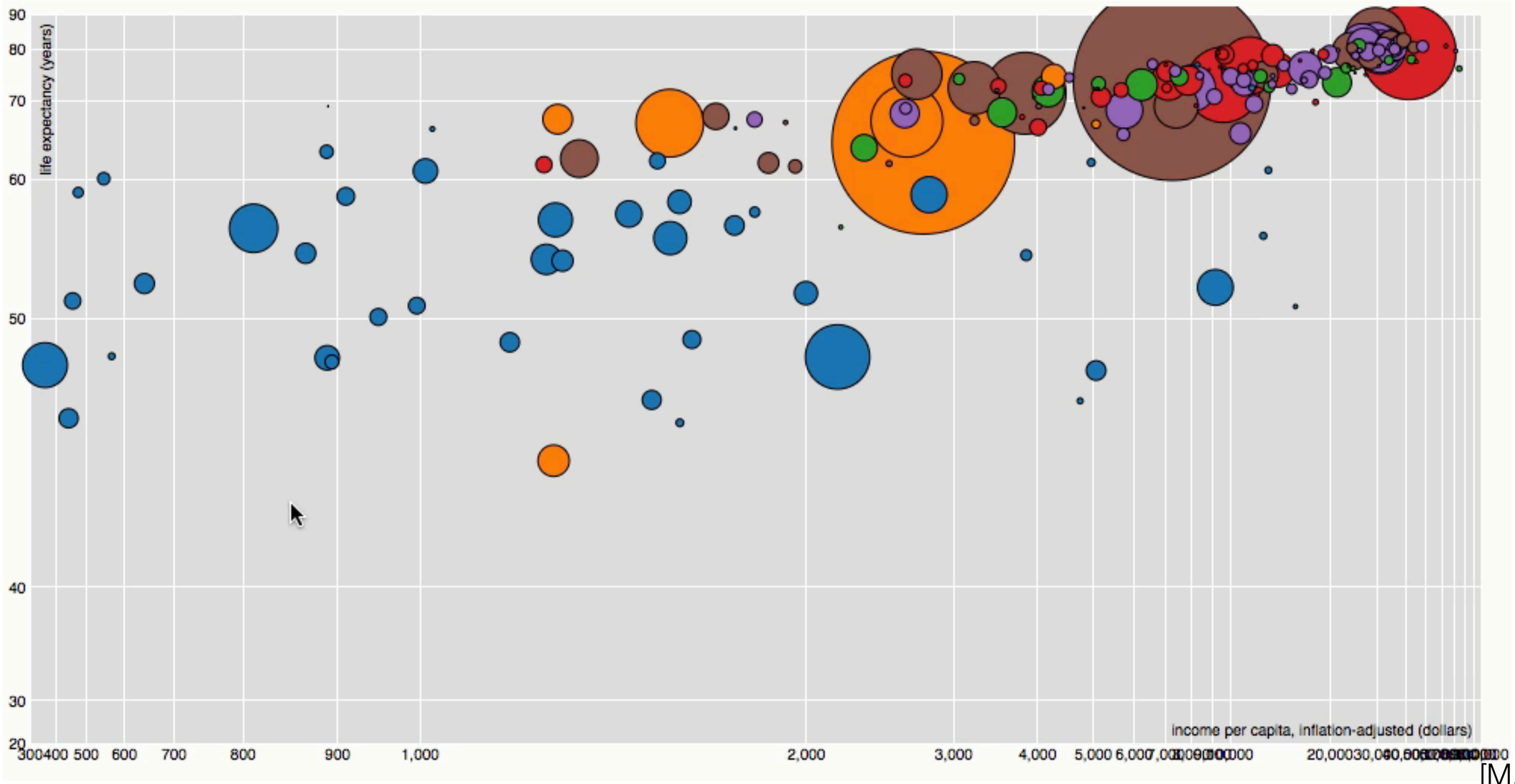
- How many focus regions? One or Multiple
- Shape of the focus?
  - Radial
  - Rectangular
  - Other
- Extent of the focus
  - Constrained similar to magic lenses
  - Entire view changes
- Type of interaction: Geometric, moveable lenses, rubber sheet

Overplotting



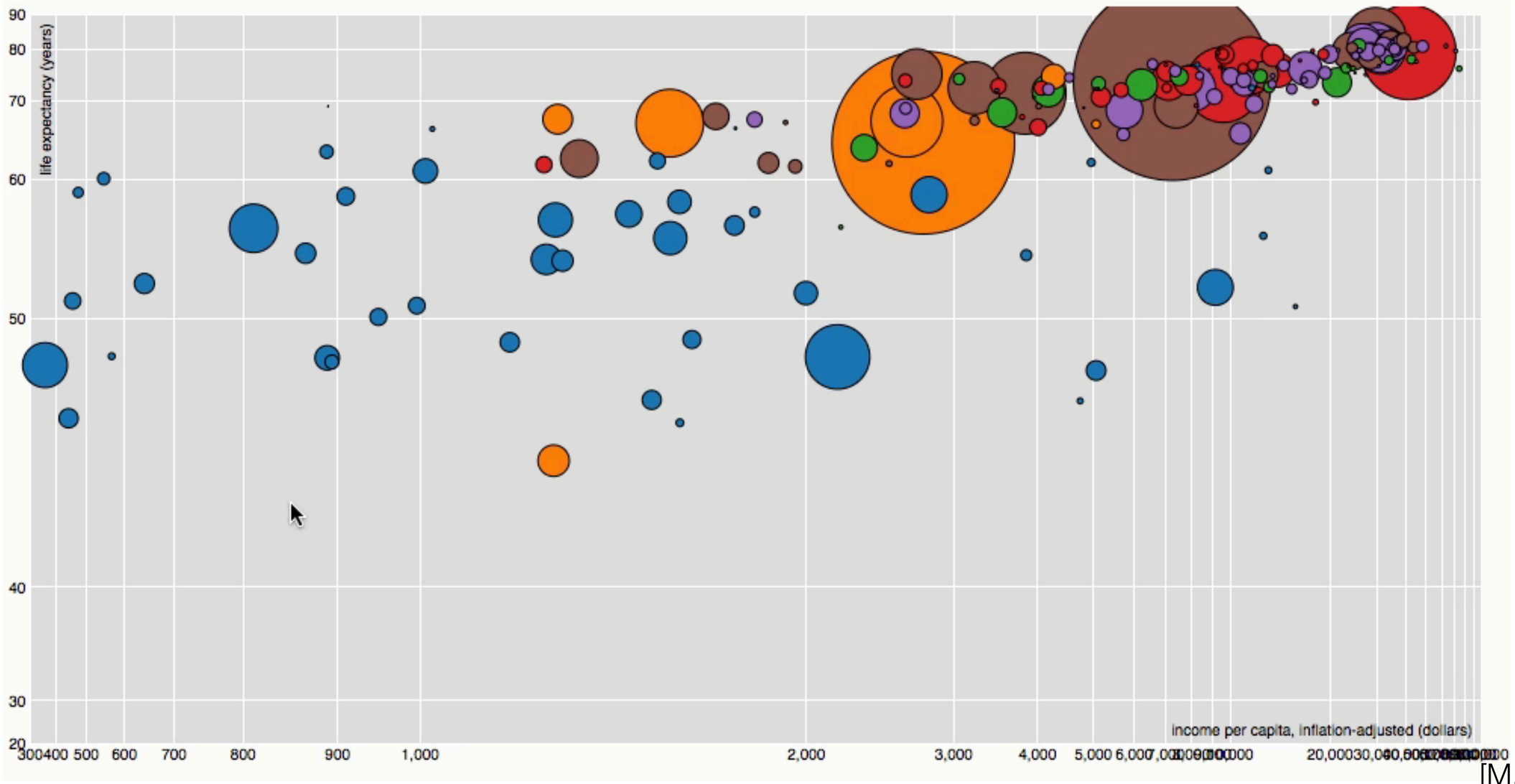
[M. Bostock]

Cartesian Distortion



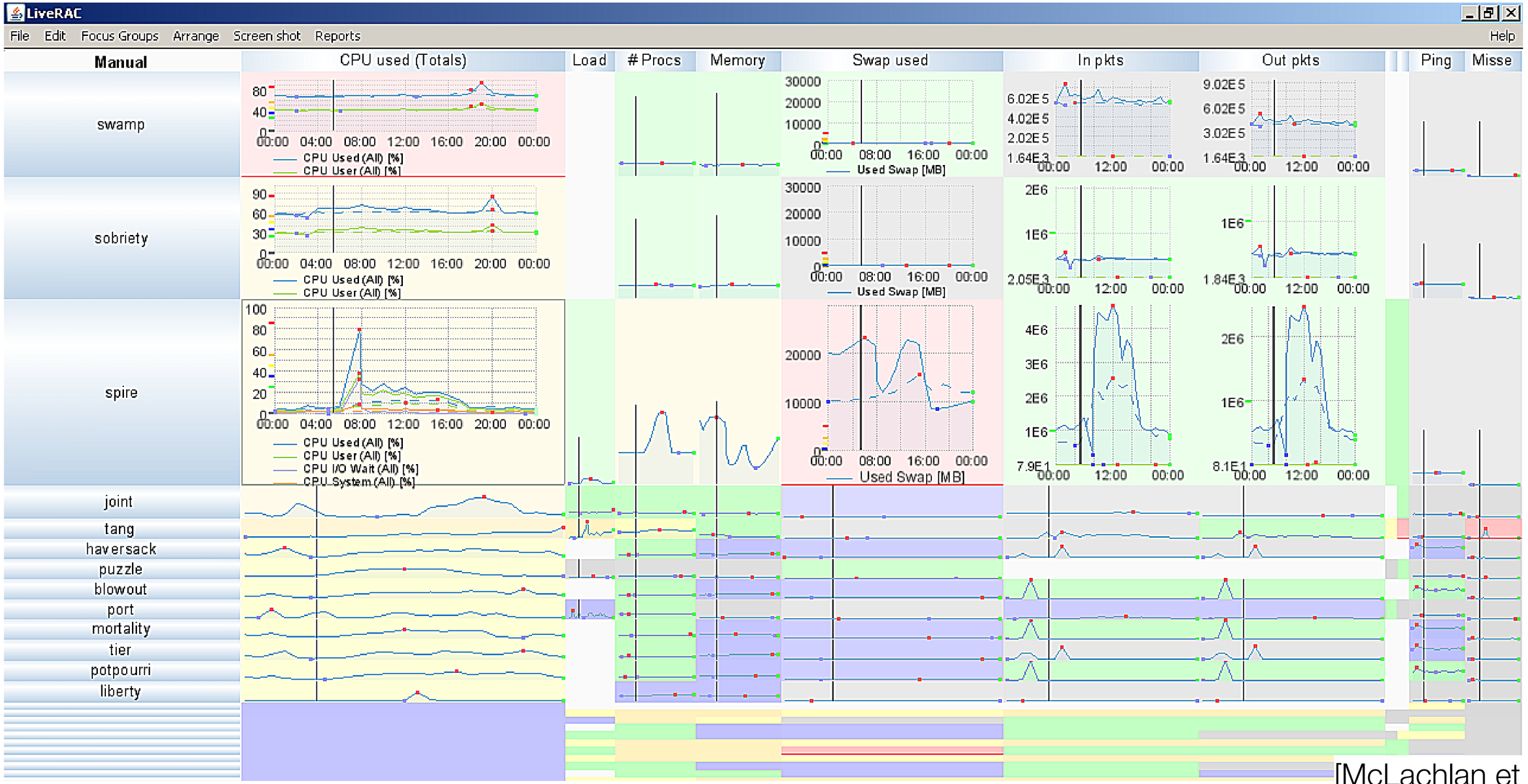
[M. Bostock]

Cartesian Distortion



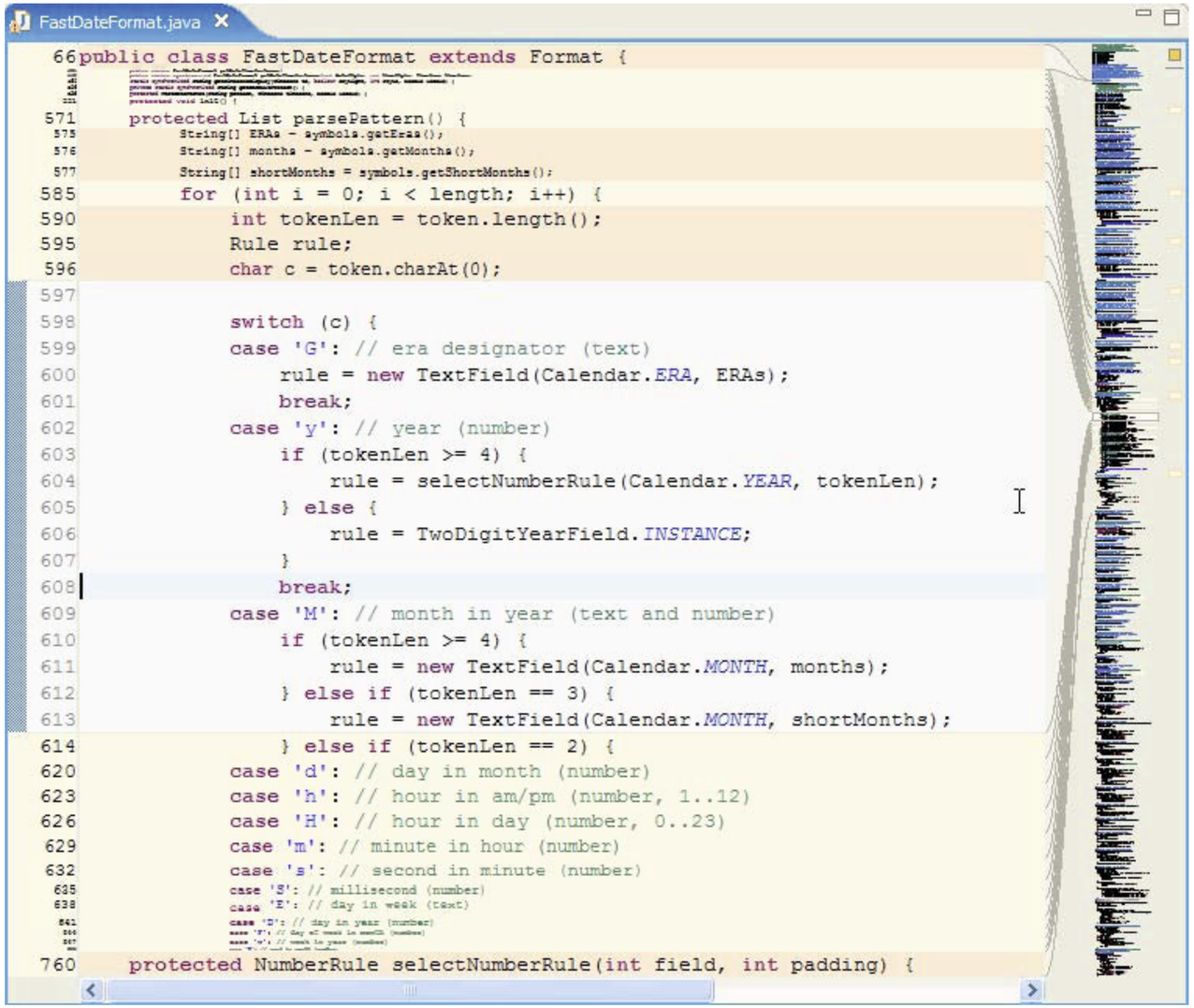
[M. Bostock]

Stretch and Squish Navigation



[McLachlan et al., 2008]

Fisheye Distortion in Programming



[Jakobsen and Hornbaek, 2011]

Distortion vs. Hide

DefaultGalleryItemRenderer.java

```
12  package org.eclipse.nebula.widgets.gallery;
37  public class DefaultGalleryItemRenderer extends Abs
41      boolean dropShadows = false;
78      public void draw(GC gc, GalleryItem item, int i
95          if (itemImage != null) {
100             size = getBestSize(imageWidth, imageHeigh
101
102             xShift = (width - size.x) >> 1;
103             yShift = (useableHeight - size.y) >> 1;
104
105             if (dropShadows) {
106                 Color c = null;
107                 for (int i = this.dropShadowsSize - 1
108                     c = (Color) dropShadowsColors.get
109                     gc.setForeground(c);
110
111                     gc.drawLine(x + width + i - xShif
113                 }
114             }
115         }
152     }
154     public void setDropShadowsSize(int dropShadowsS
```

[Jakobsen and Hornbaek, 2011]

Research Questions

- Is a priori importance useful (and for what)?
- What does the user focus on?
  - predictability of view changes when focus changes
  - how direct user control is
  - task & context
- What interesting information should be displayed
  - degree of interest function may produce varied result sizes
- Do fisheye views integrate or disintegrate?
  - interference with other interactions; allow on-demand use?
- Are fisheye views suitable for large displays?

[Jakobsen and Hornbaek, 2011]

Distortion Concerns

- Distance and length judgments are **harder**
  - Example: Mac OS X Dock with Magnification
  - Spatial position of items changes as the focus changes
- Node-link diagrams not an issue… why?
- Users have to be made aware of distortion
  - Back to scatterplot with distortion example
  - Lenses or shading give clues to users
- **Object constancy**: understanding when two views show the same object
  - What happens under distortion?
  - 3D Perspective is distortion… but we are well-trained for that
- Think about **what** is being shown (filtering) and method (fisheye)

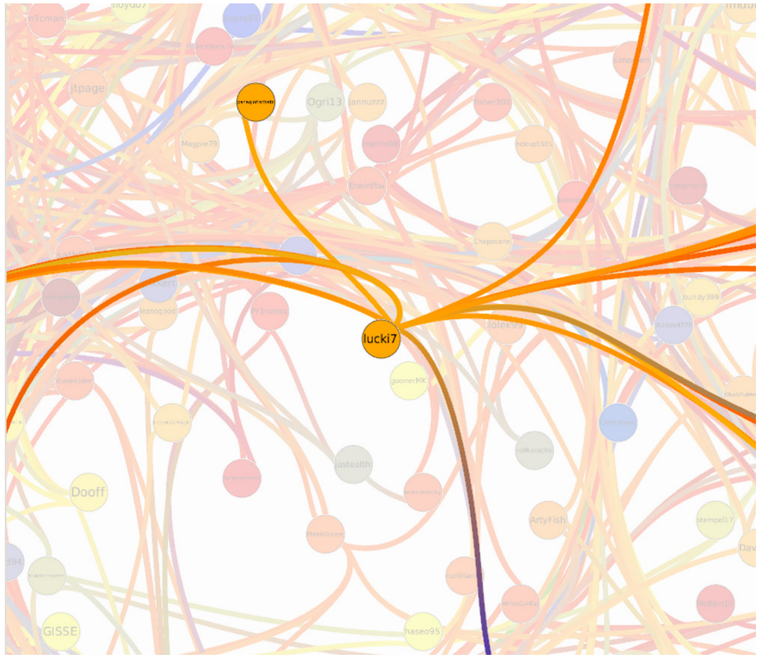
H3 Layout

[T. Munzner, 1998]

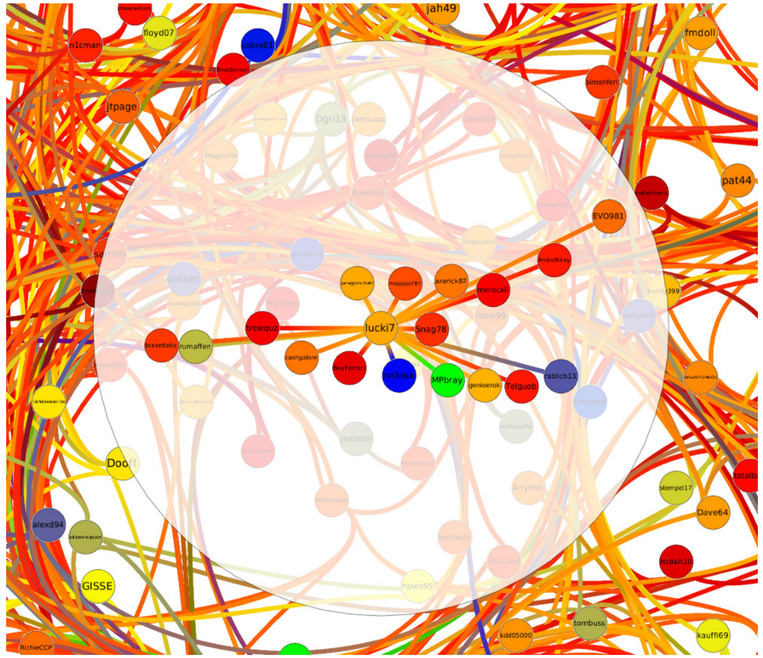
H3 Layout

[T. Munzner, 1998]

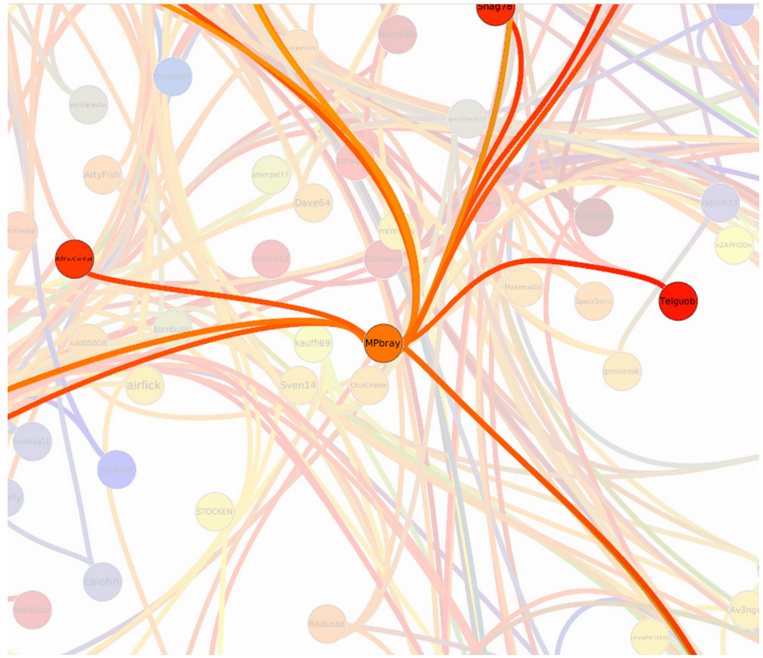
Focus+Context in Network Exploration



(a) Bring (step 1) – Selecting a node fades out all graph elements but the node neighborhood.



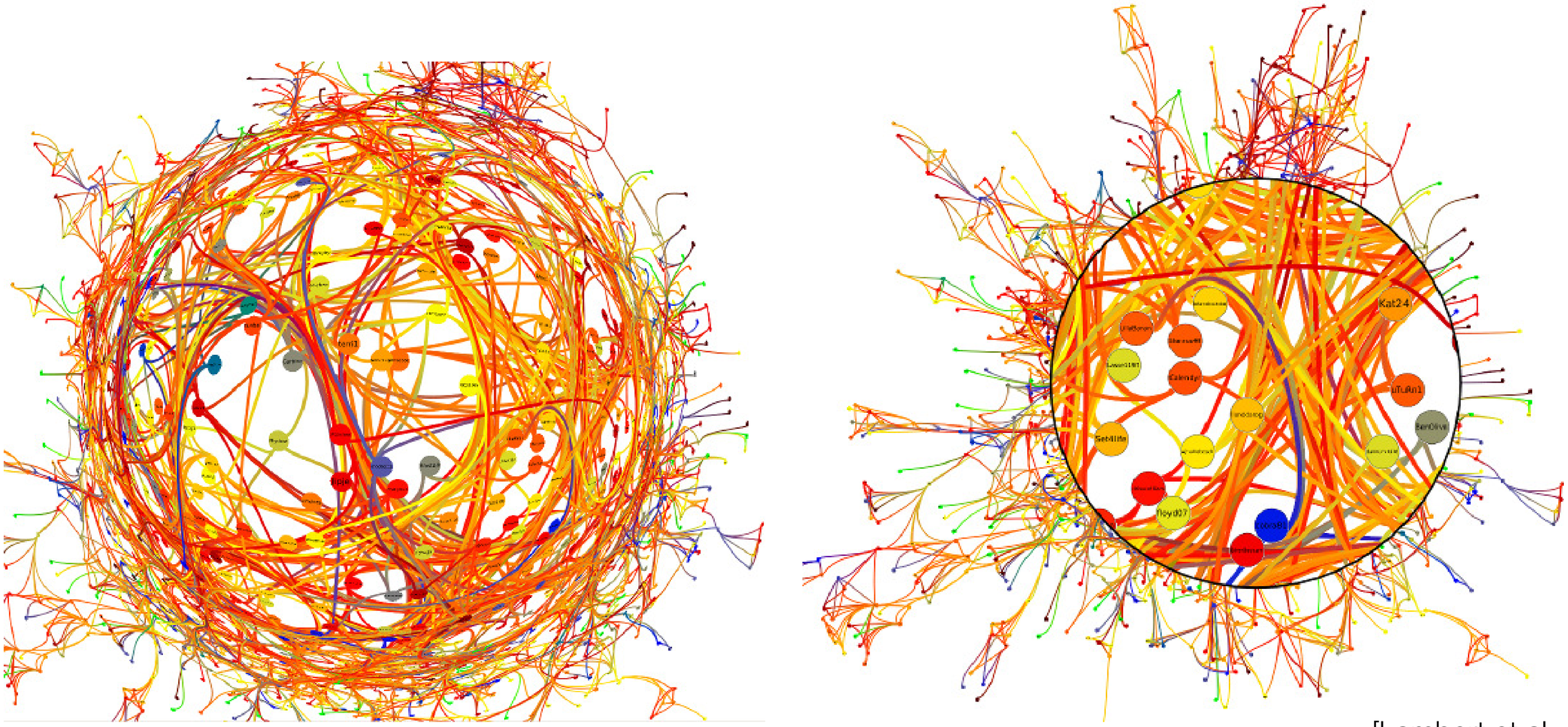
(b) Bring (step 2) – Neighbor nodes are pulled close to the selected node.



(c) Go – After selecting a neighbor (the green node in Fig. 4(b)), a short animation brings the focus towards a new neighborhood.

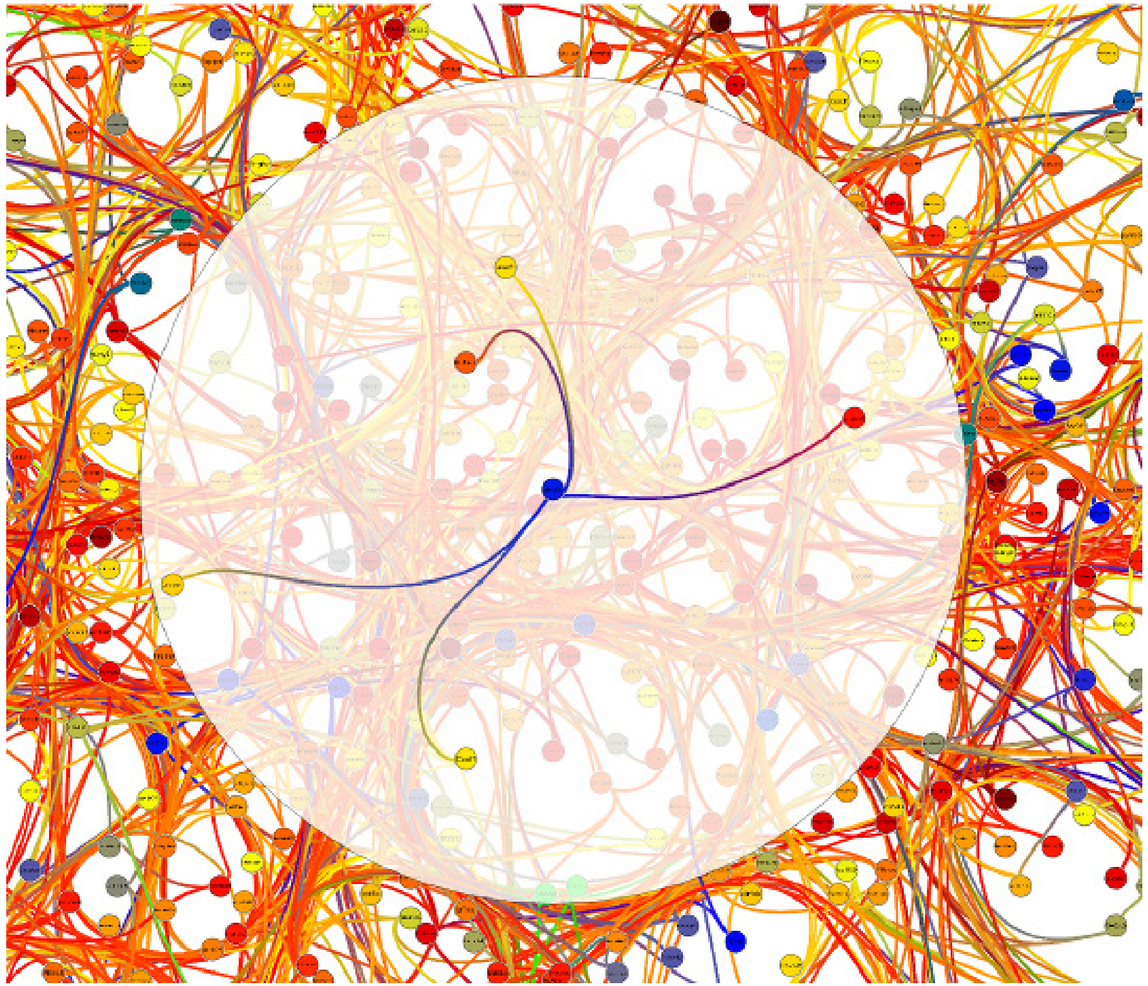
[Lambert et al., 2010]

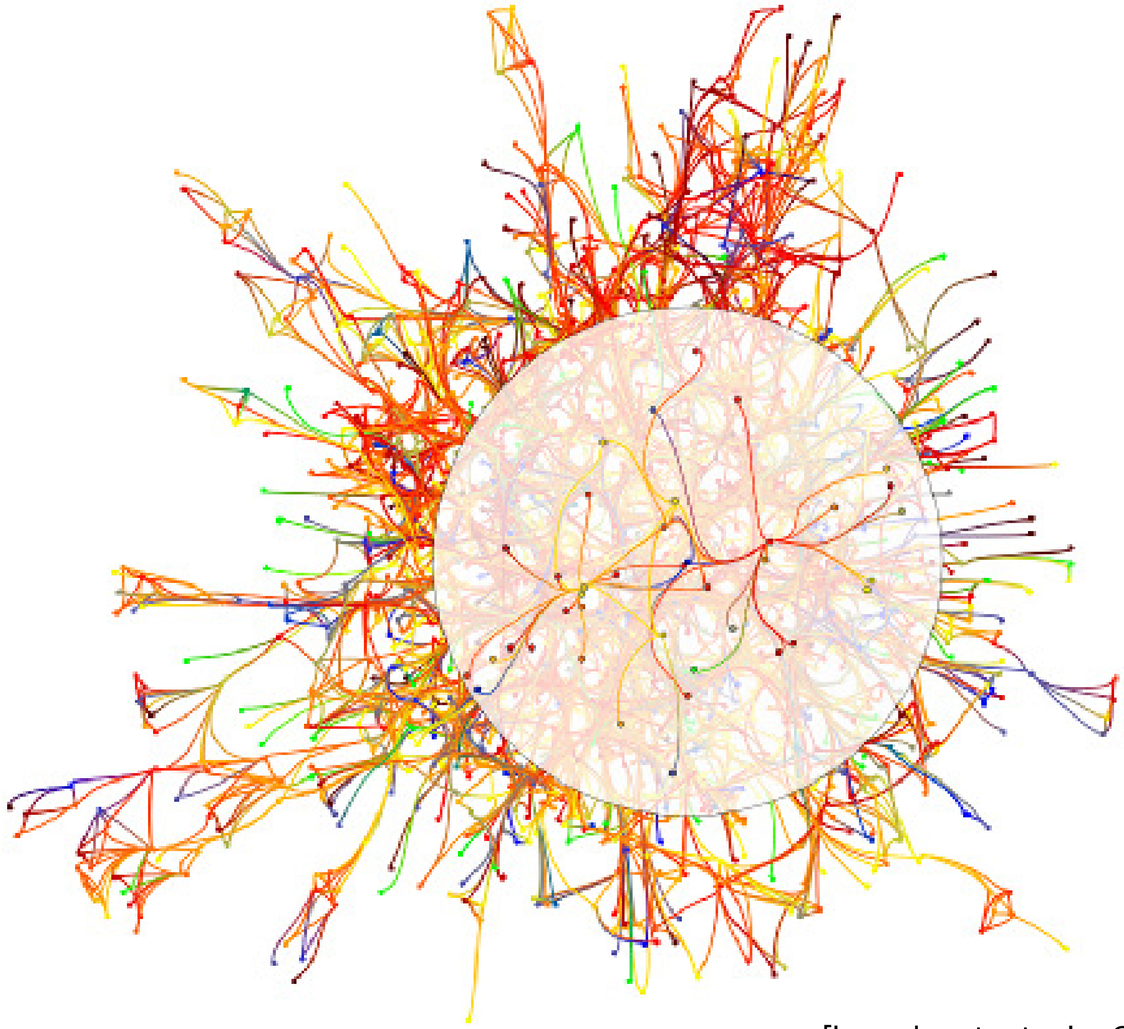
Focus+Context in Network Exploration



[Lambert et al., 2010]

Focus+Context in Network Exploration





[Lambert et al., 2010]

Data

Data Wrangling

- Problem 1: Visualizations need data
- Solution: The Web!
- Problem 2: Data has extra information I don't need
- Solution: Filter it
- Problem 3: Data is dirty
- Solution: Clean it up
- Problem 4: Data isn't in the same place
- Solution: Combine data from different sources
- Problem 5: Data isn't structured correctly
- Solution: Reorder, map, and nest it

Hosting data

- github.com
- gist.github.com
- figshare.com
- myjson.com
- observablehq.com
- Other services

Cross-origin resource sharing (CORS)

- Restricts where data can be loaded from
- If developing locally, can
  - Run a web server locally (`python -m http.server` or npm's `http-server`)
  - Put the data on a website (like github), make sure to use **raw** URLs
- If loading JavaScript, this sometimes requires more help
  - https://www.jsdelivr.com/?docs=gh

Why JavaScript?

- Python and R have great support for this sort of processing
- Data comes from the Web, want to put visualizations on the Web
- Sometimes unnecessary to download, process, and upload!
- More tools are helping JavaScript become a better language

JavaScript Data Wrangling Resources

- Latest version: https://observablehq.com/@berkeleyvis/learn-js-data
- My old version: https://observablehq.com/@dakoop/learn-js-data
- Based on http://learnjsdata.com/
- Good coverage of data wrangling using JavaScript

Comma Separated Values (CSV)

- File structure:

```
cities.csv:

city,state,population,land area
seattle,WA,652405,83.9
new york,NY,8405837,302.6
boston,MA,645966,48.3
kansas city,MO,467007,315.0
```

- Loading using D3:

```
d3.csv("/data/cities.csv").then(function(data) {
  console.log(data[0]);
});
```

- Result:

```
=> {city: "seattle", state: "WA", population: 652405, land area: 83.9}
```

- Values are strings! Convert to numbers via the unary + operator:

```
- d.population => "652405"
- +d.population => 652405
```

[http://learnjsdata.com]

Tab Separated Values (TSV)

- File structure:

```
animals.tsv:

name    type    avg_weight
tiger    mammal    260
hippo    mammal    3400
komodo dragon    reptile    150
```

- Loading using D3:

```
d3.tsv("/data/animals.tsv").then(function(data) {
  console.log(data[0]);
});
```

- Result:

```
=> {name: "tiger", type: "mammal", avg_weight: "260"}
```

- Can also have other delimiters (e.g. '|', ';')

[http://learnjsdata.com]

JavaScript Object Notation (JSON)

- File Structure:

```
employees.json:
[
 {"name":"Andy Hunt",
  "title":"Big Boss",
  "age": 68,
  "bonus": true
 },
 {"name":"Charles Mack",
  "title":"Jr Dev",
  "age":24,
  "bonus": false
 }
]
```

- Loading using D3:

```
d3.json("/data/employees.json".then(function(data) {
  console.log(data[0]);
});
```

- Result:

```
=> {name: "Andy Hunt", title: "Big Boss", age: 68, bonus: true}
```

[http://learnjsdata.com]

Loading Multiple Files

- Use Promise.all to load multiple files and then process them all

```
Promise.all([d3.csv("/data/cities.csv"),
             d3.tsv("/data/animals.tsv")])
  .then(analyze);

function analyze(data) {
  cities = data[0]; animals = data[1];

  console.log(cities[0]);
  console.log(animals[0]);
}
=> {city: "seattle", state: "WA", population: "652405", land area: "83.9"}
{name: "tiger", type: "mammal", avg_weight: "260"}
```

[http://learnjsdata.com]

Filtering Data

- Often useful to filter data before loading into a visualization
- Already seen this with array functions
- ```
  data = [{name: "Two-Egg Breakfast", price: 12.39},
          {name: "Hash Brown", price: 1.99},
          {name: "Eggs Benedict", price: 11.29},
          {name: "Coffee", price: 2.49}]
  data.filter(d => d.price < 5)
  ```
-
  ```

Combining Data

- Suppose given products and brands
- Brands have an `id` and products have a `brand_id` that matches a brand
- Want to join these two datasets together
  - `Product.brand_id` => `Brand.id`
- Use a nested `forEach`/`filter`
- Use a native join command

[http://learnjsdata.com]

Summarizing Data

- d3 has min, max, and extent functions of the form
  - 1st argument: dataset
  - 2nd argument: accessor function
- Example:

```
var landExtent = d3.extent(data, function(d) { return d.land_area; });
console.log(landExtent);
=> [48.3, 315]
```

- Summary statistics, e.g. mean, median, deviation → same format
- Median Example:

```
var landMed = d3.median(data, function(d) { return d.land_area; });
console.log(landMed);
=> 193.25
```

[http://learnjsdata.com]

Grouping Data

- Take a flat structure and turn it into a (potentially nested) map
- Similar to a groupby in databases
- Data

```
var expenses = [{"name":"jim","amount":34,"date":"11/12/2015"},
  {"name":"carl","amount":120.11,"date":"11/12/2015"},
  {"name":"jim","amount":45,"date":"12/01/2015"},
  {"name":"stacy","amount":12.00,"date":"01/04/2016"},
  {"name":"stacy","amount":34.10,"date":"01/04/2016"},
  {"name":"stacy","amount":44.80,"date":"01/05/2016"}
];
```

- Grouping:

```
expensesByName = d3.group(expenses, d => d.name)
```

- Results:

```
Map(3) { "jim" => Array(2) [Object, Object]
         "carl" => Array(1) [Object]
         "stacy" => Array(3) [Object, Object, Object] }
```

Rollup Data

- Data

```
var expenses = [{"name":"jim","amount":34,"date":"11/12/2015"},
  {"name":"carl","amount":120.11,"date":"11/12/2015"},
  {"name":"jim","amount":45,"date":"12/01/2015"},
  {"name":"stacy","amount":12.00,"date":"01/04/2016"},
  {"name":"stacy","amount":34.10,"date":"01/04/2016"},
  {"name":"stacy","amount":44.80,"date":"01/05/2016"}
];
```

- Using d3.rollup:

```
expensesAvgAmount = d3.rollup(
  expenses,
  v => d3.mean(v, d => d.amount), // aggregate by the mean of amount
  d => d.name // group by name
)
```

← the aggregation function (difference from group)

- Result:

```
Map(3) {
  "jim" => 39.5
  "carl" => 120.11
  "stacy" => 30.3
}
```

[http://learnjsdata.com]

groups and rollups

- Both group and rollup return Map objects
- groups and rollups are the same functions but return nested arrays
- More examples: https://observablehq.com/@d3/d3-group

arquero

- Library for query processing and transformation of array-backed data tables
- Similar to database and/or dataframe frameworks
- Integrates with Apache Arrow
- Documentation
- Illustrated Guide to Arquero's Verbs