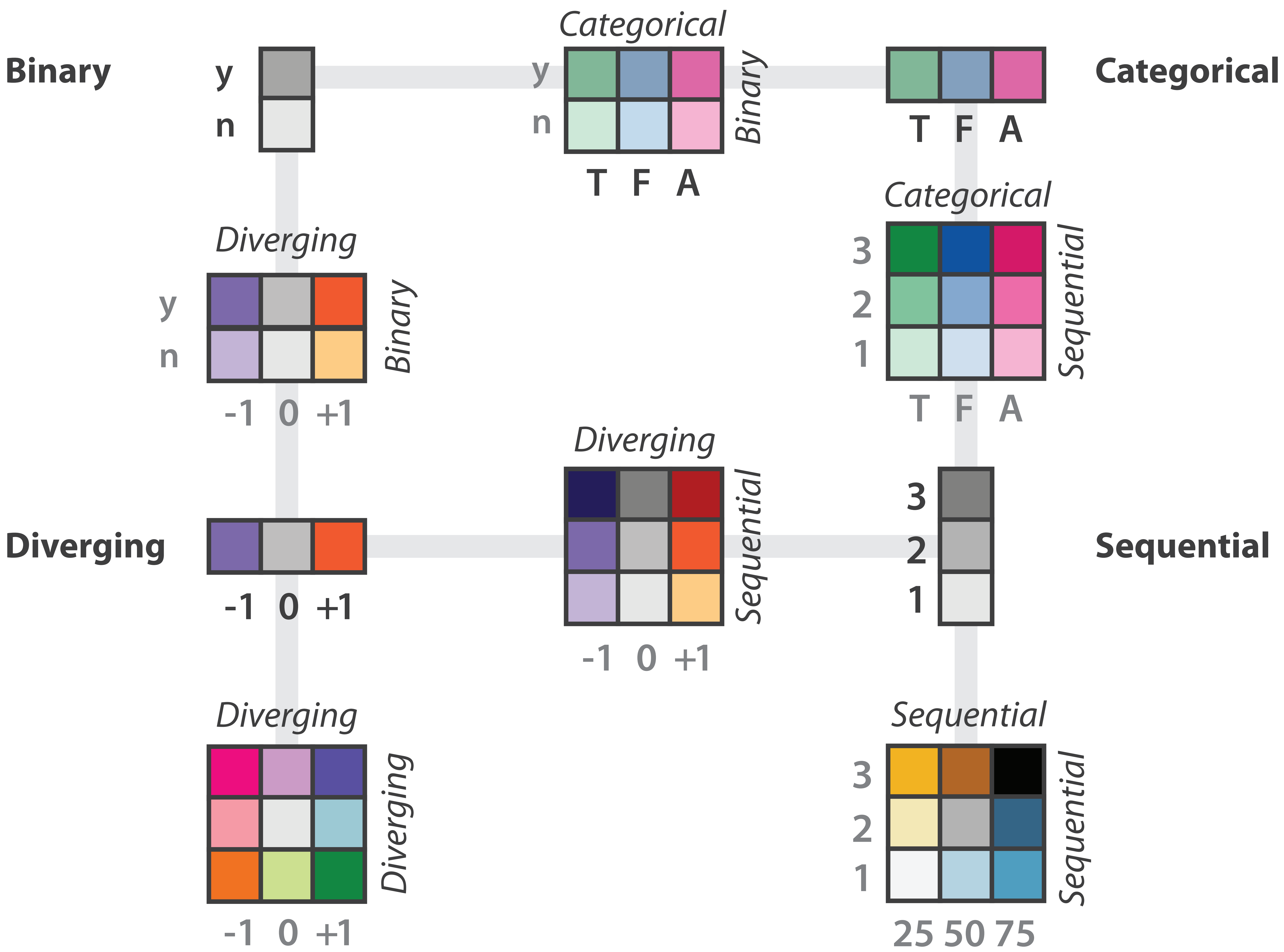
Data Visualization (CSCI 627/490)

Maps & Networks

Dr. David Koop

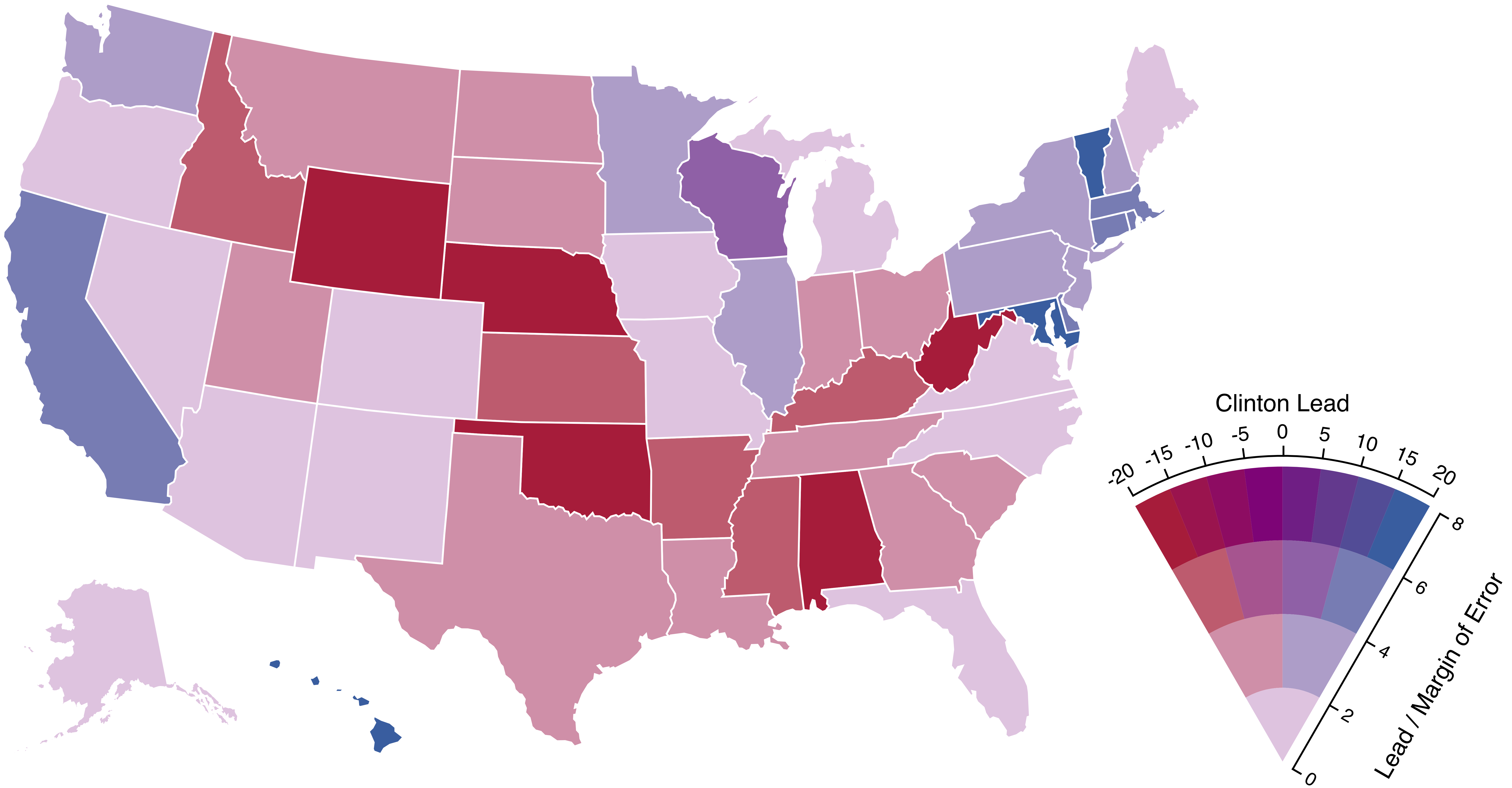
Northern Illinois University

Bivariate Colormaps



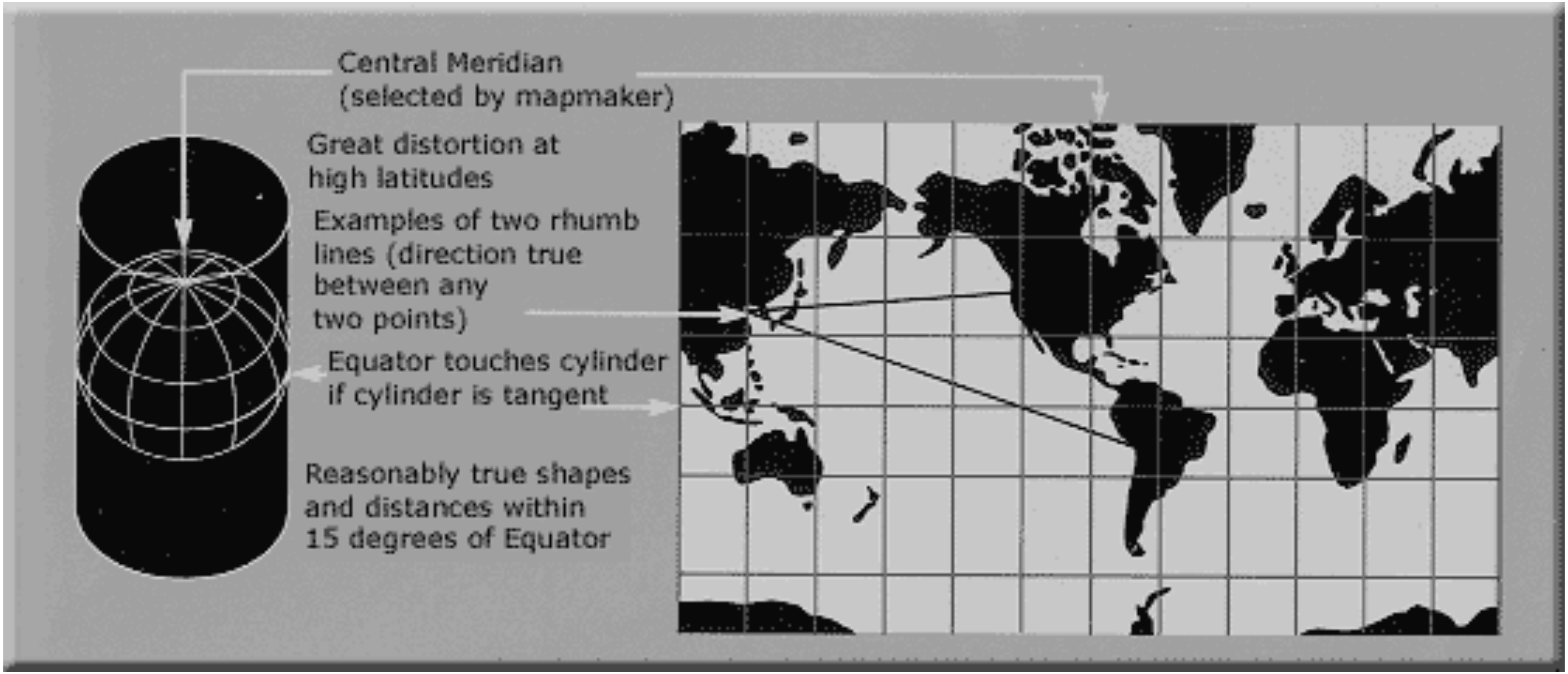
[Munzner (ill. Maguire), 2014]

Value-Suppressing Uncertainty Palette



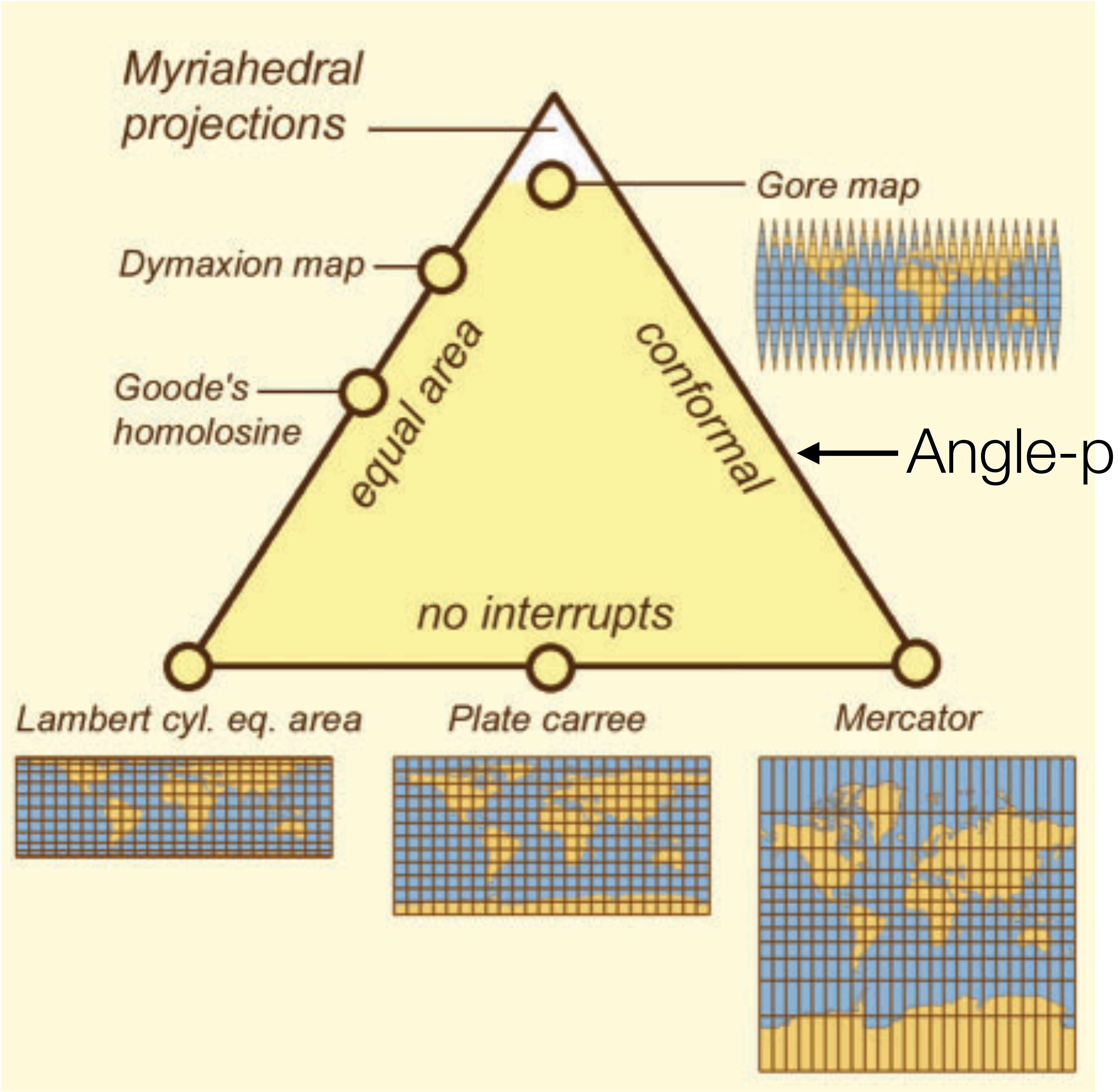
[Correll et al., 2018]

Geographic Data: 3D to 2D: Projection



[USGS Map Projections]

Projection Classification



Angle-preserving

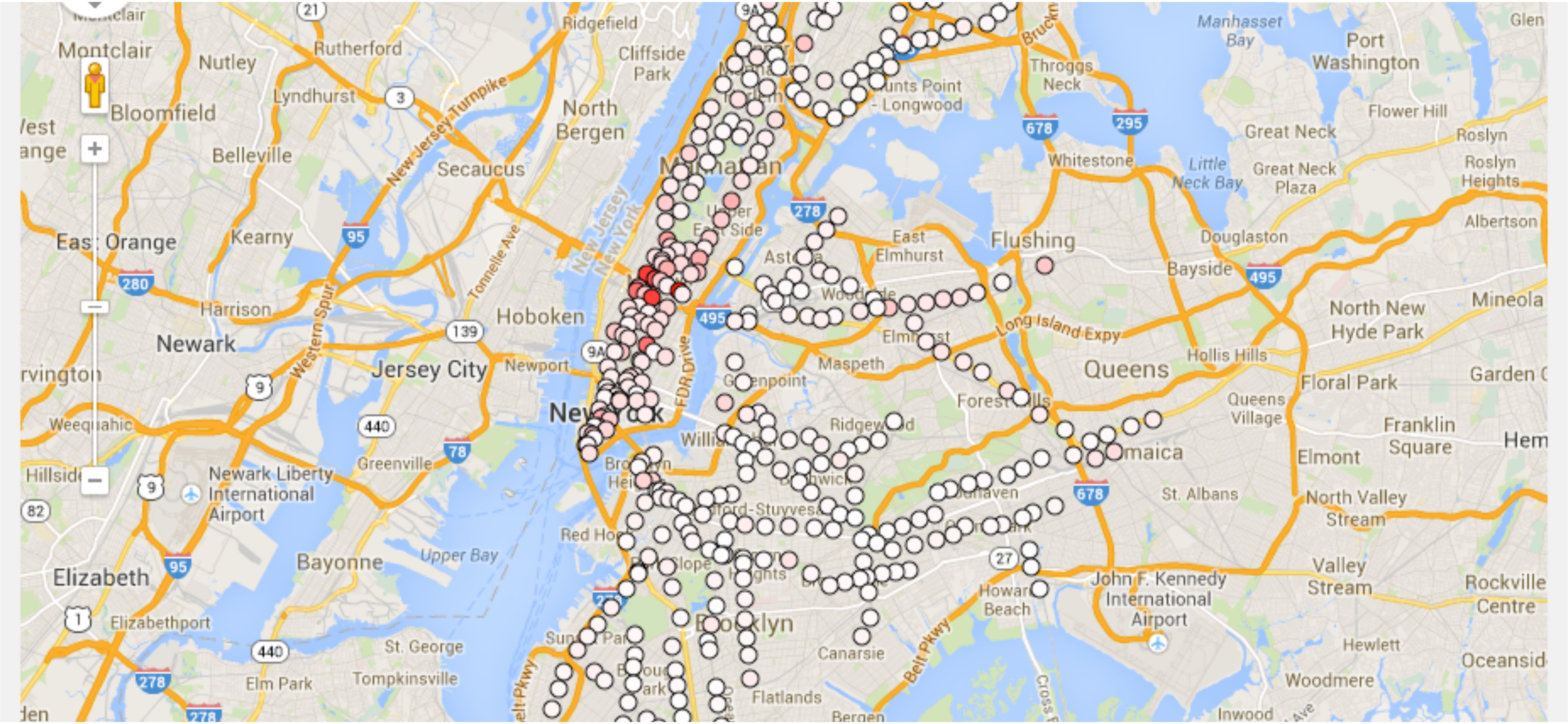
[J. van Wijk, 2008]

Search Tasks

	Target known	Target unknown
Location known	*Lookup*	*Browse*
Location unknown	*Locate*	*Explore*

[Munzner (ill. Maguire), 2014]

Adding Discrete Data to a Map: Quantitative Points



Adding Continuous Data to a Map: Isolines

[USGS via Wikipedia]

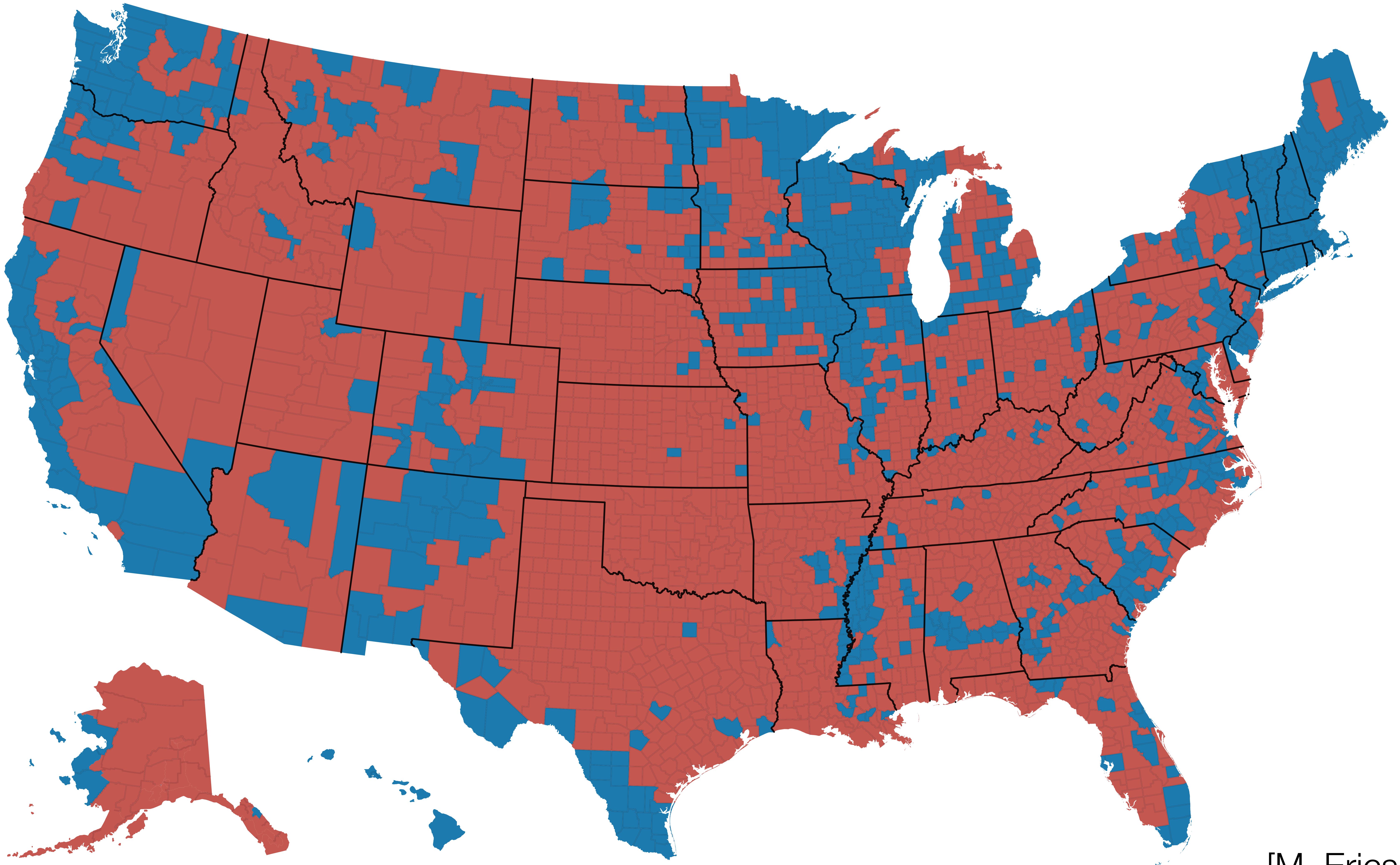
Assignment 4

- To be announced soon
- Colormaps, geospatial vis, networks

Project

- Next Step: Design
  - Given dataset (what) and tasks (why), work on the how
  - Don't do this the other way around: do not start with "I want to make a streamgraph" and then decide what tasks could work with that
  - This includes interactive design

Choropleth (Two Hues)



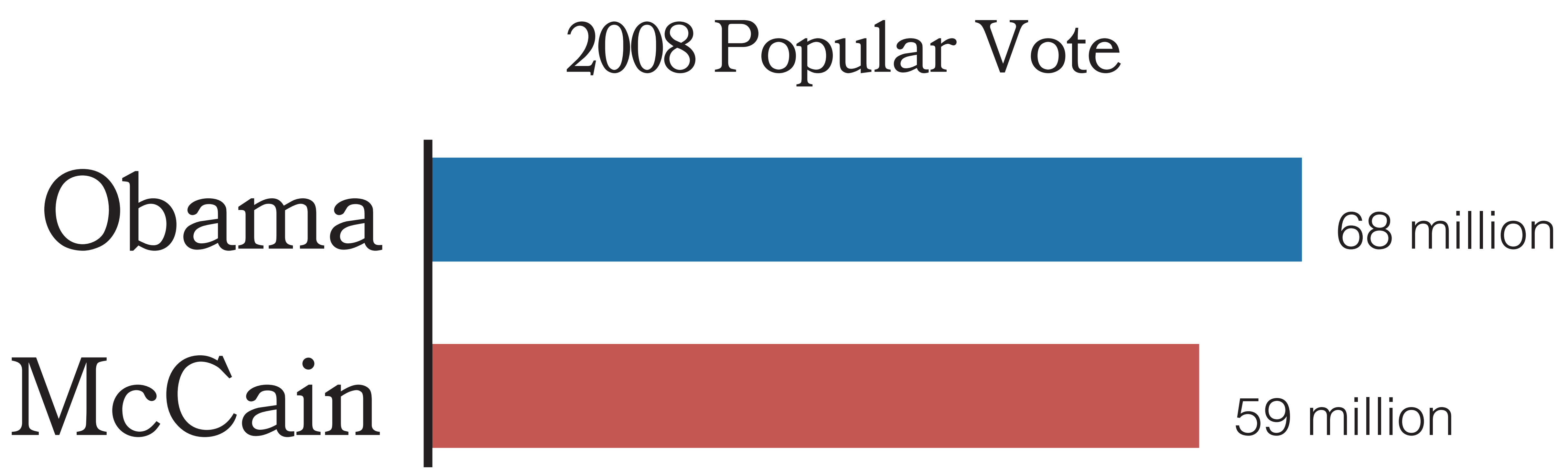
[M. Ericson, New York Times]

Choropleth Map

- Data: geographic geometry data & one quantitative attribute per region
- Tasks: trends, patterns, comparisons
- How: area marks from given geometry, color hue/saturation/luminance
- Scalability: thousands of regions

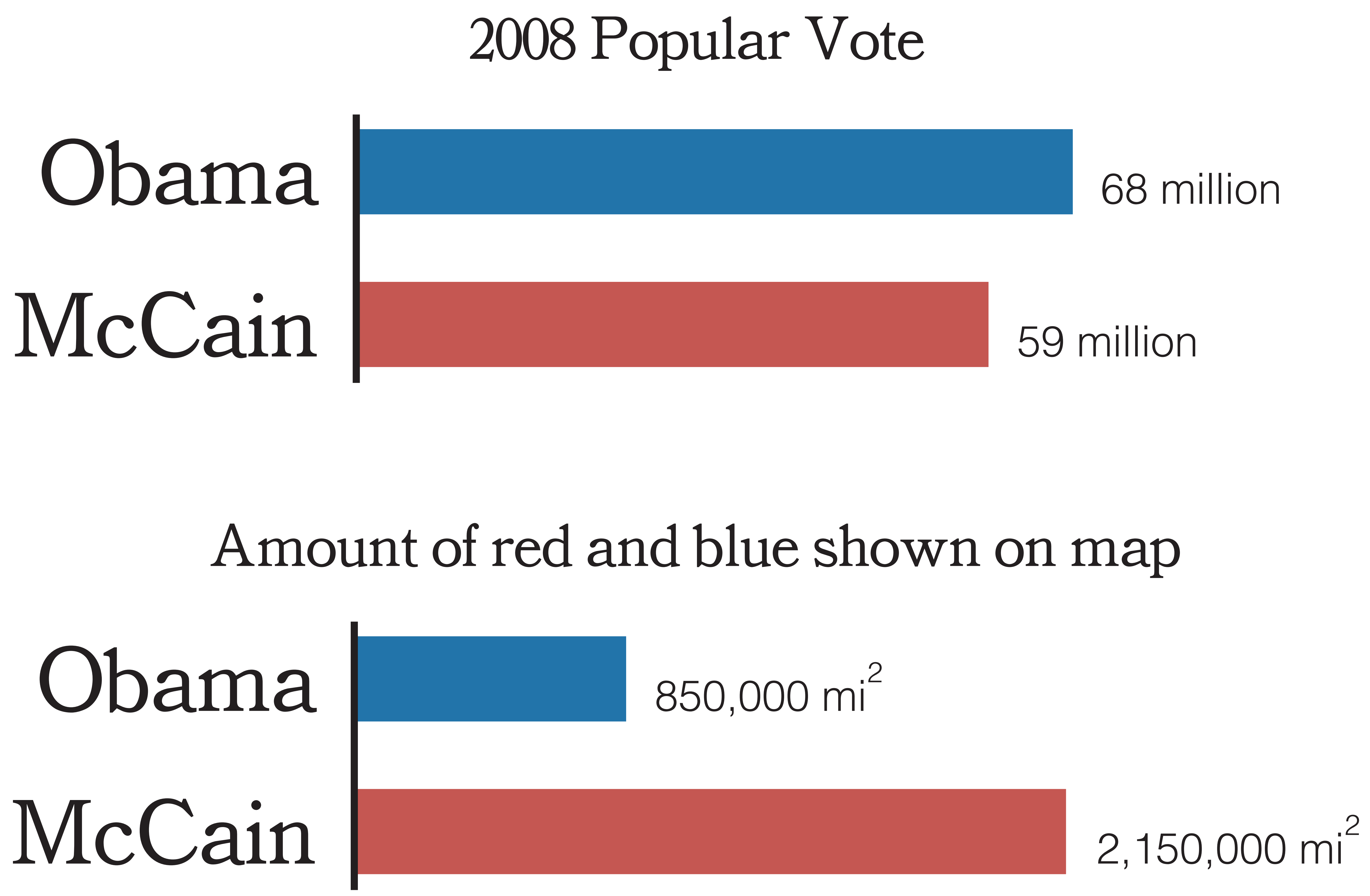
- Design choices:
  - Colormap
  - Region boundaries (level of summarization)

Problem?



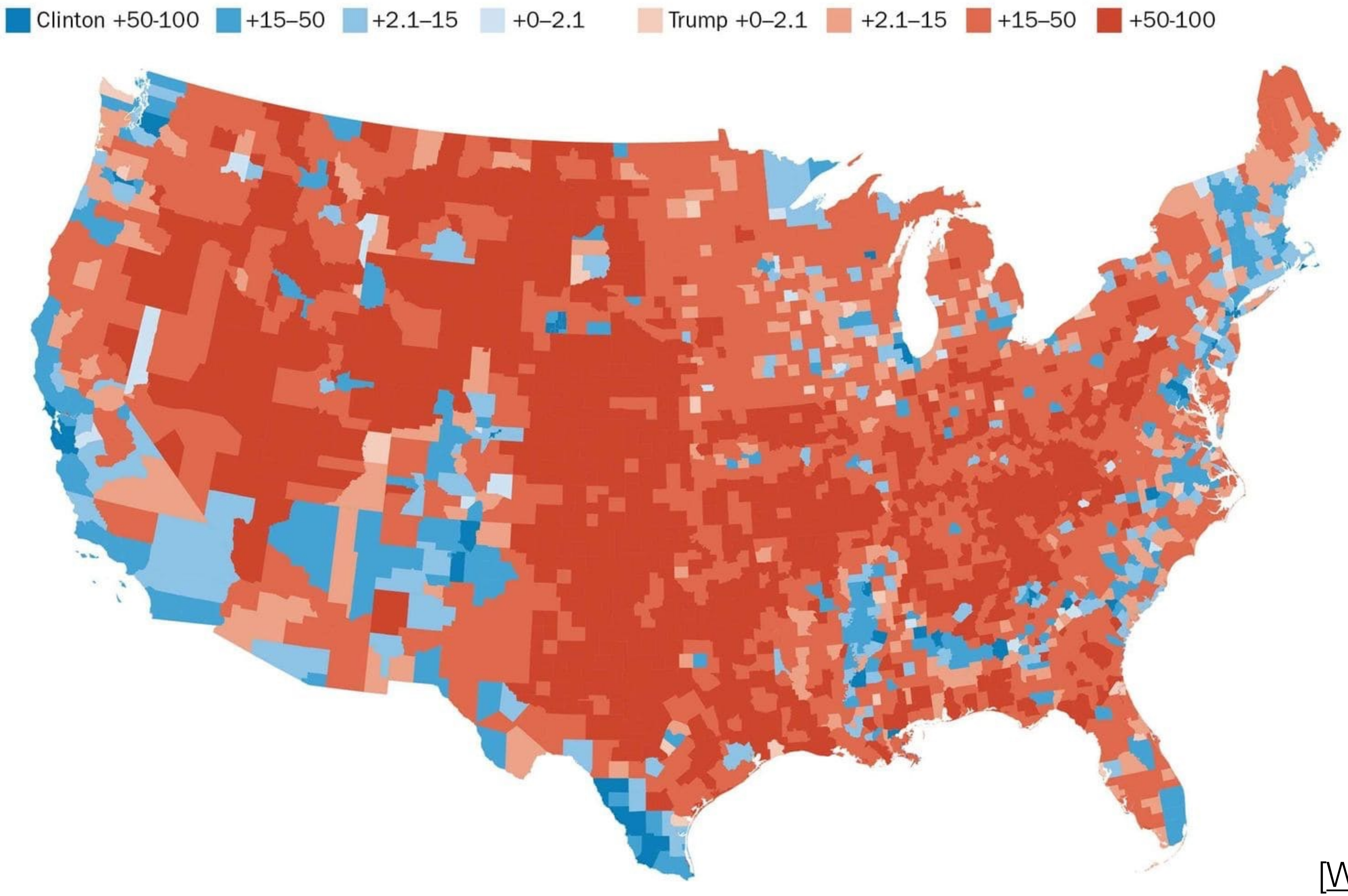
[M. Ericson, New York Times]

Problem?



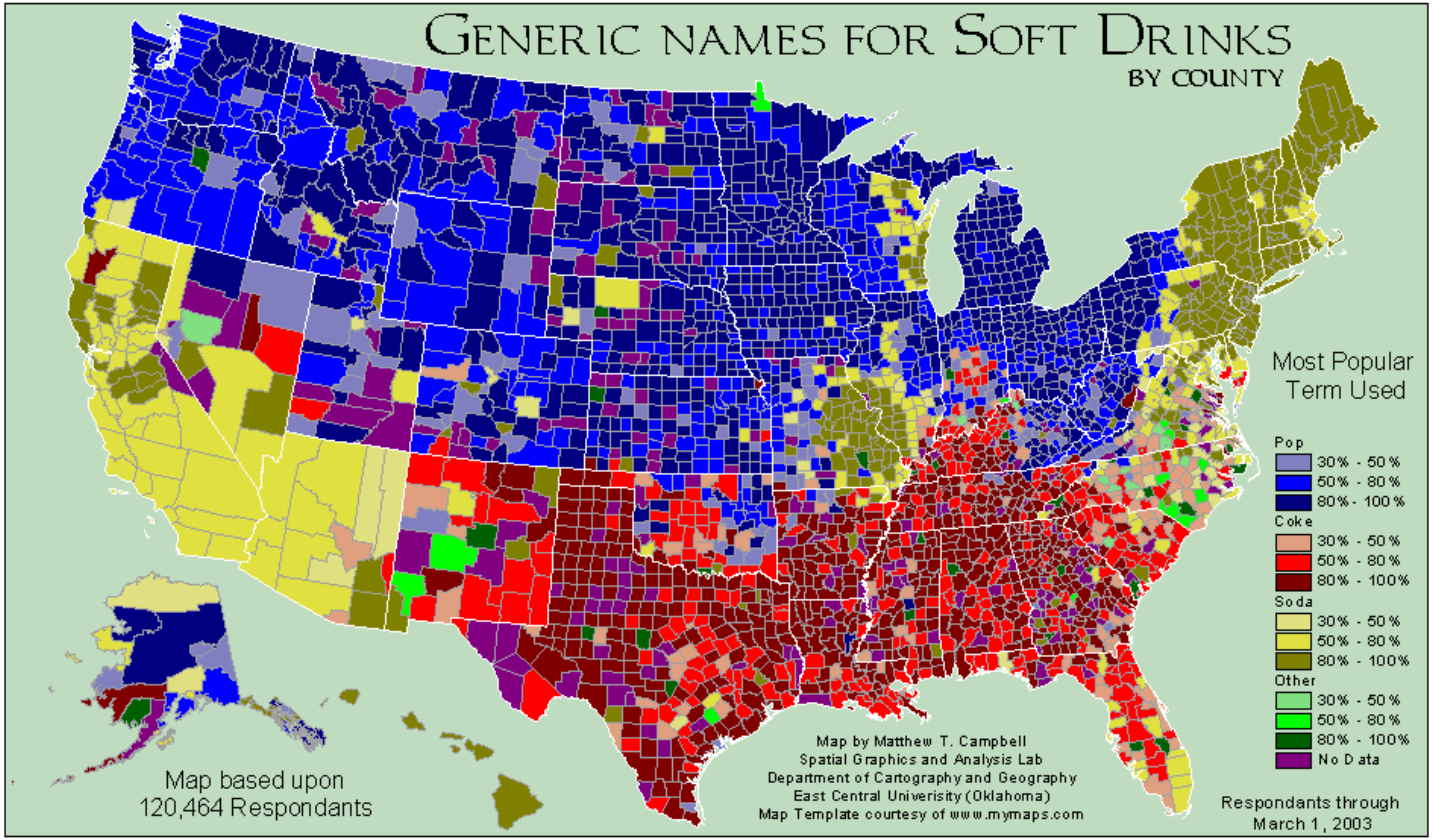
[M. Ericson, New York Times]

Adding Saturation



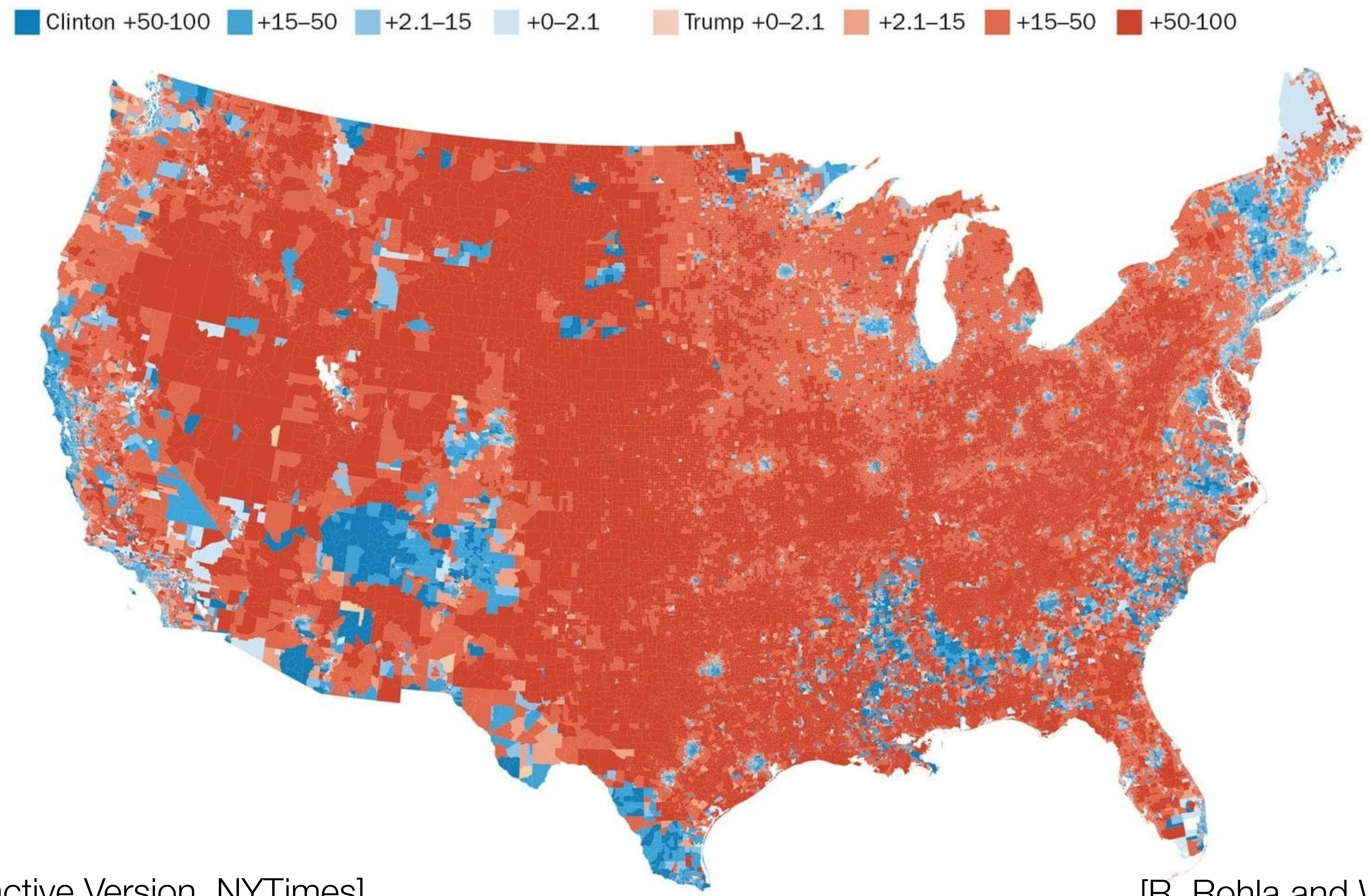
[Washington Post, 2018]

Area Marks and Color Hue & Saturation



[popvssoda.com]

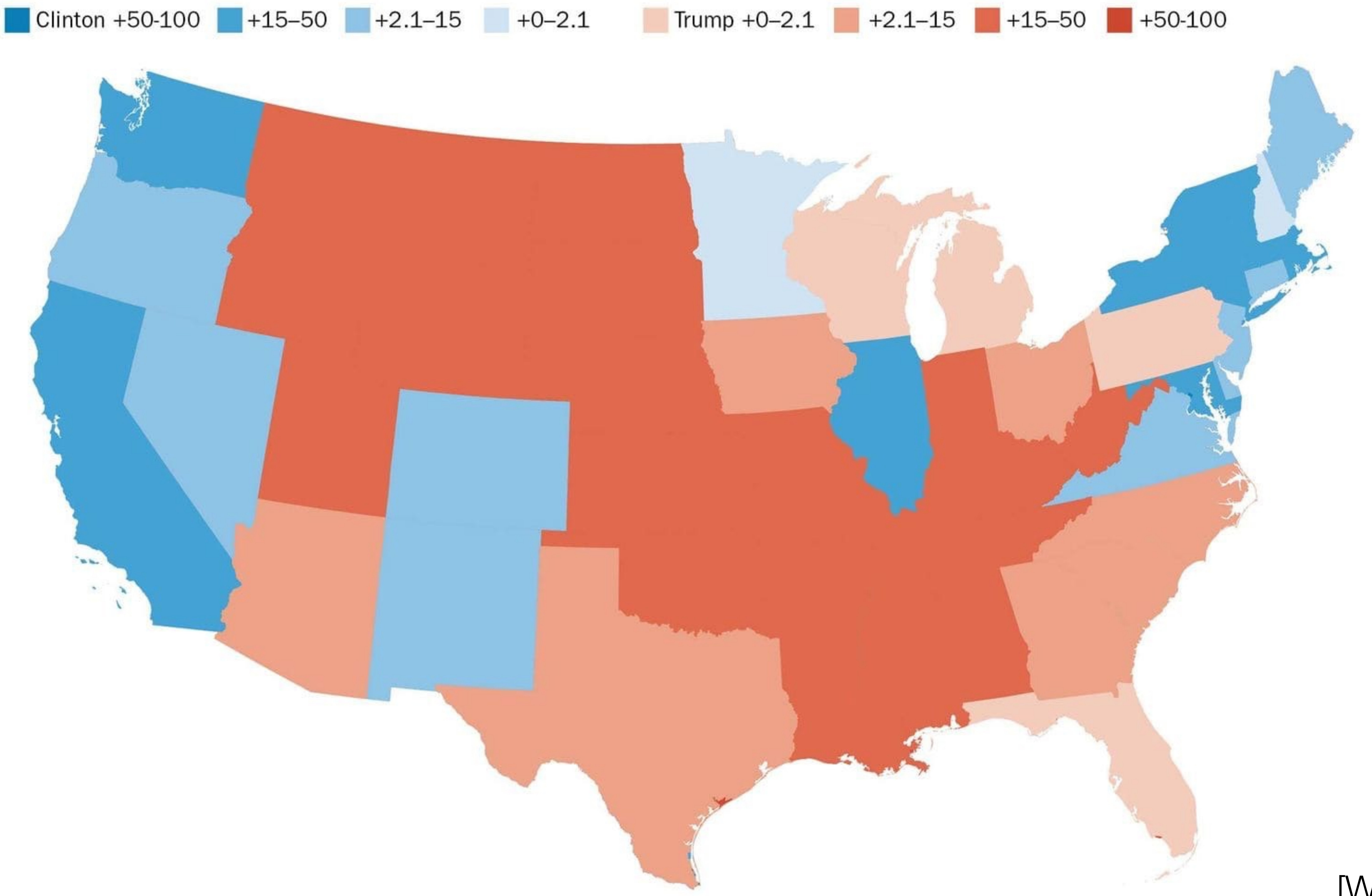
Aggregation: 2016 Election by Precinct



[Interactive Version, NYTimes]

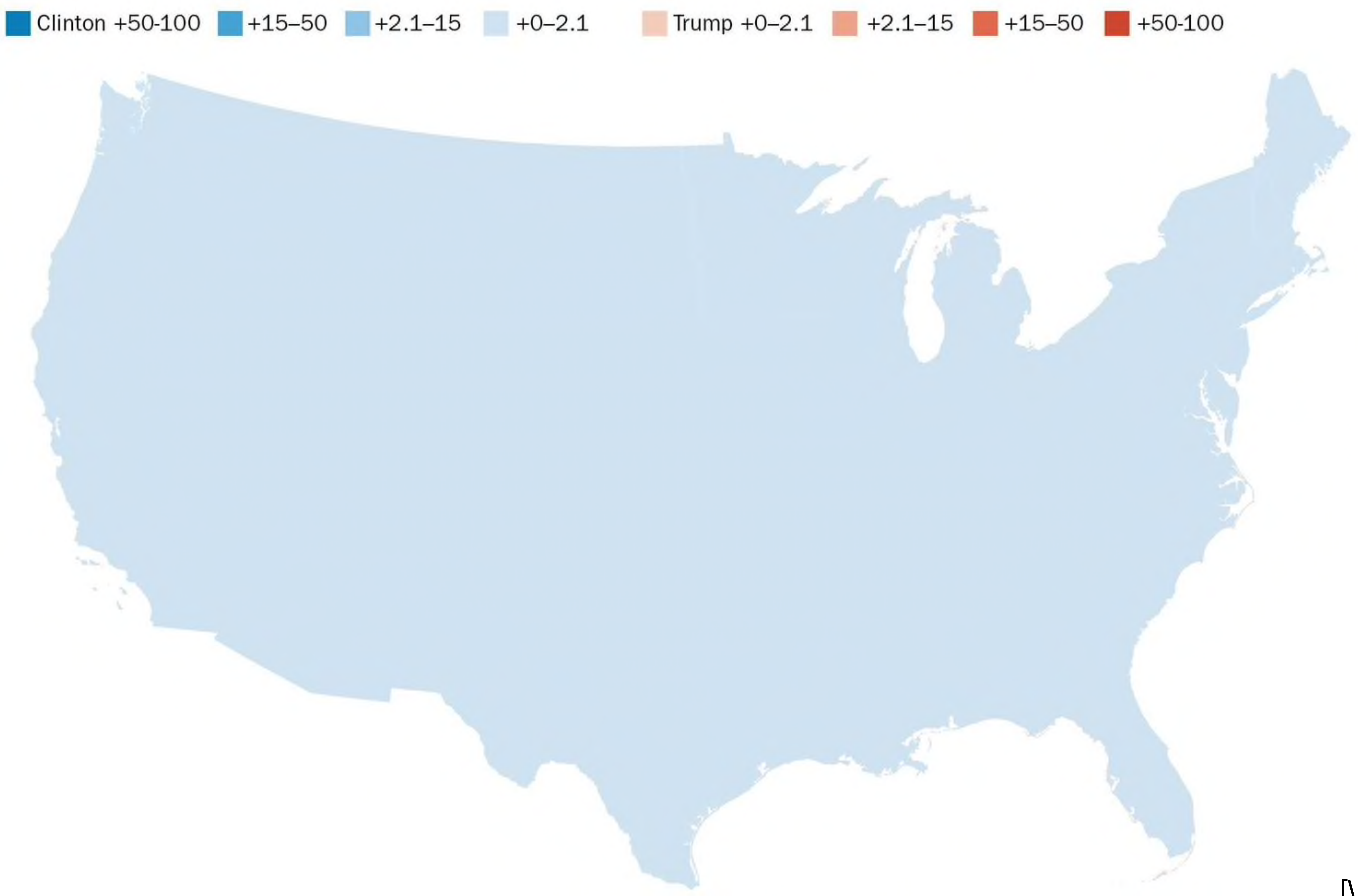
[R. Rohla and Washington Post, 2018]

Aggregation: 2016 Election by State



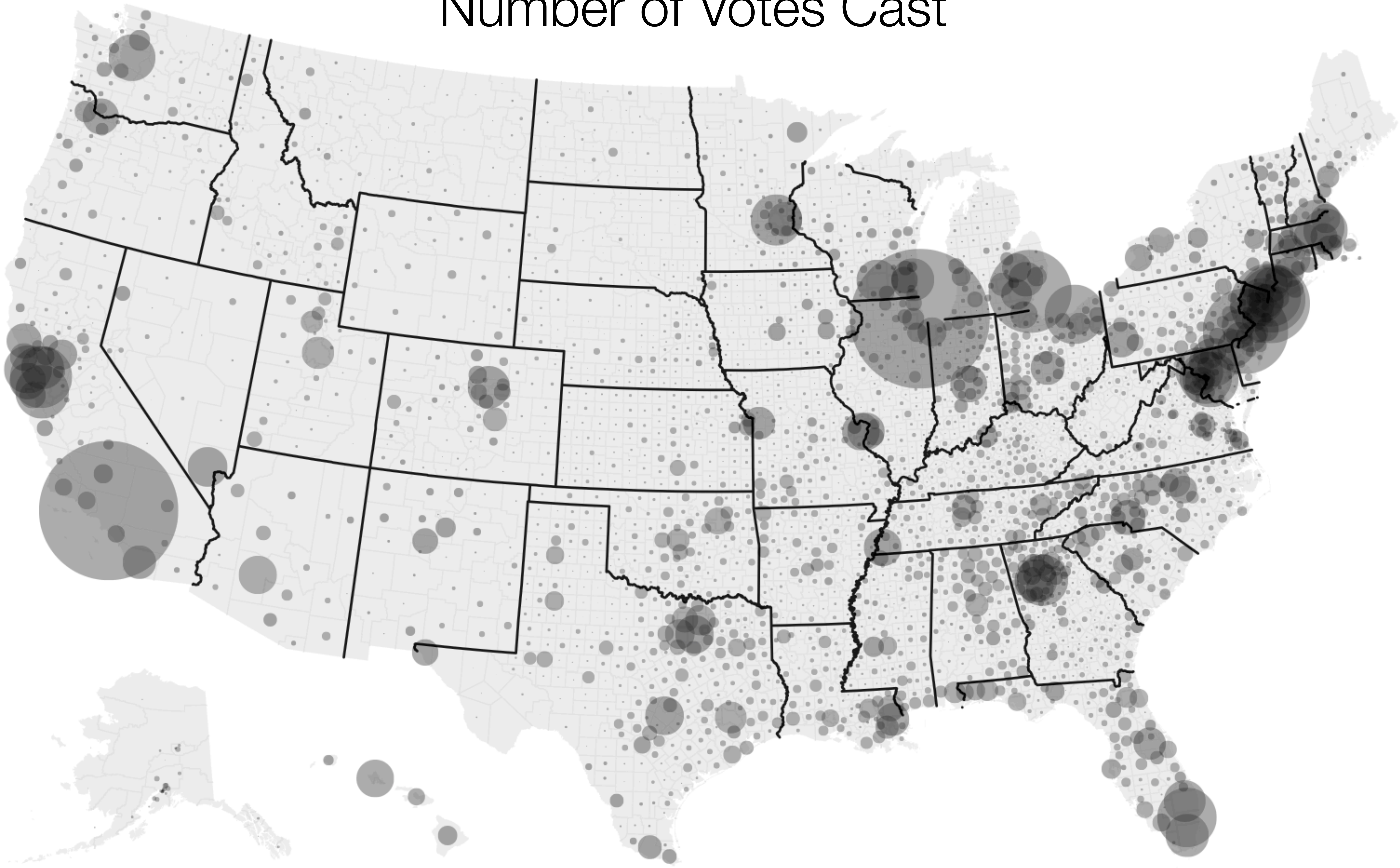
[Washington Post, 2018]

Aggregation: 2016 Election by Country



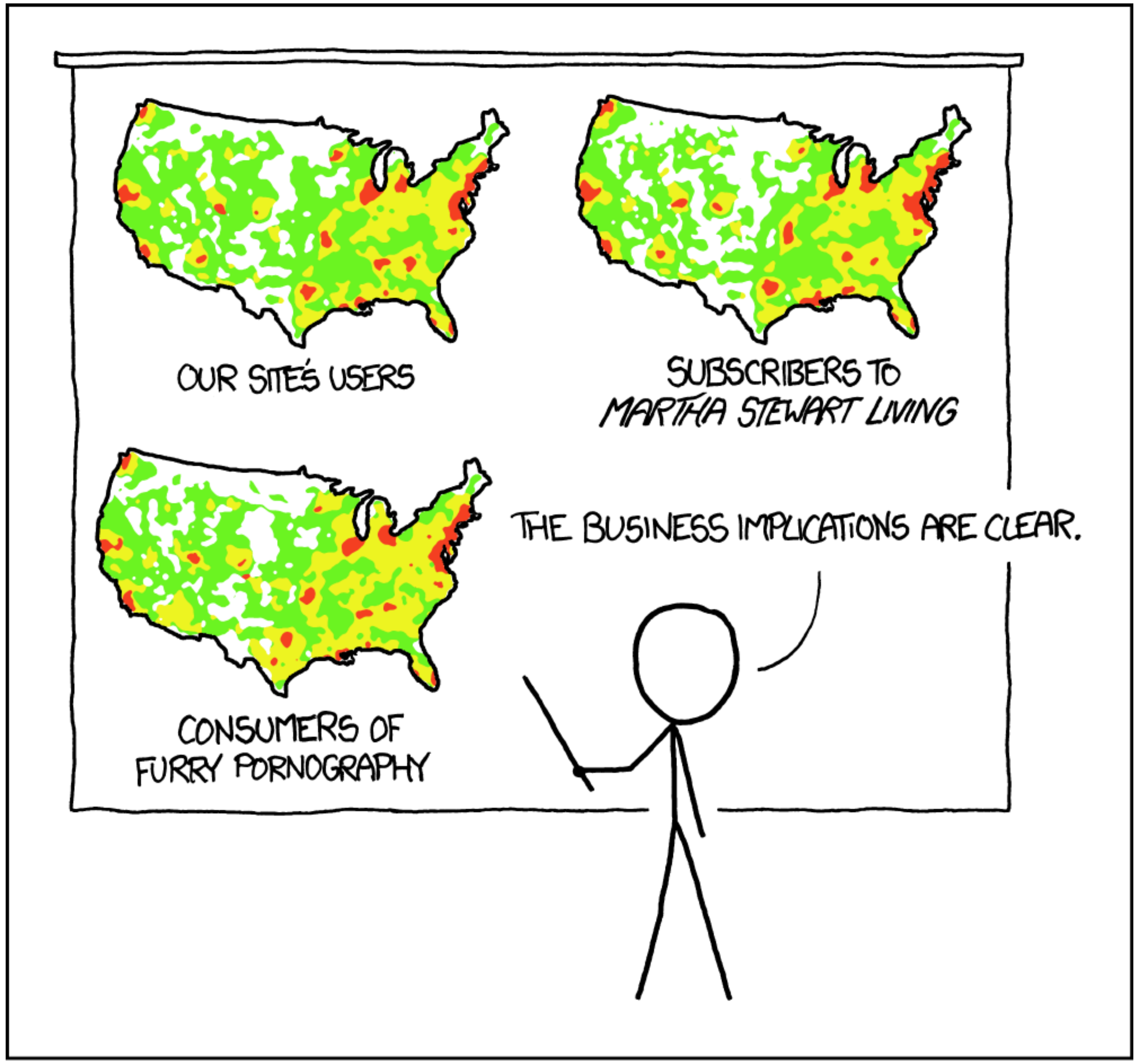
[Washington Post, 2018]

Maps: What trends do you see?



[Desaturated by D. Koop, M. Ericson, New York Times]

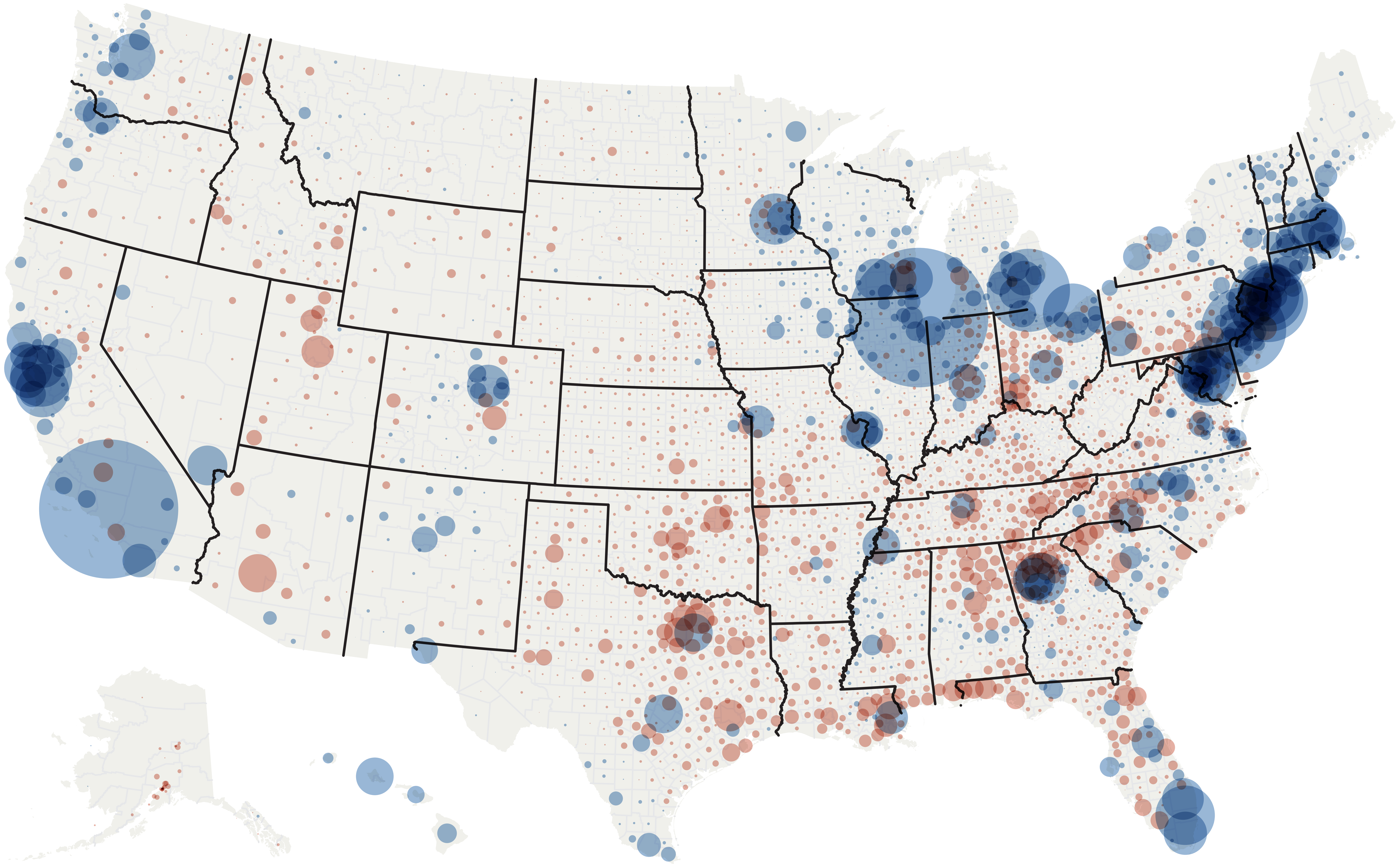
Don't Just Create Population Maps!



PET PEEVE #208:
GEOGRAPHIC PROFILE MAPS WHICH ARE BASICALLY JUST POPULATION MAPS

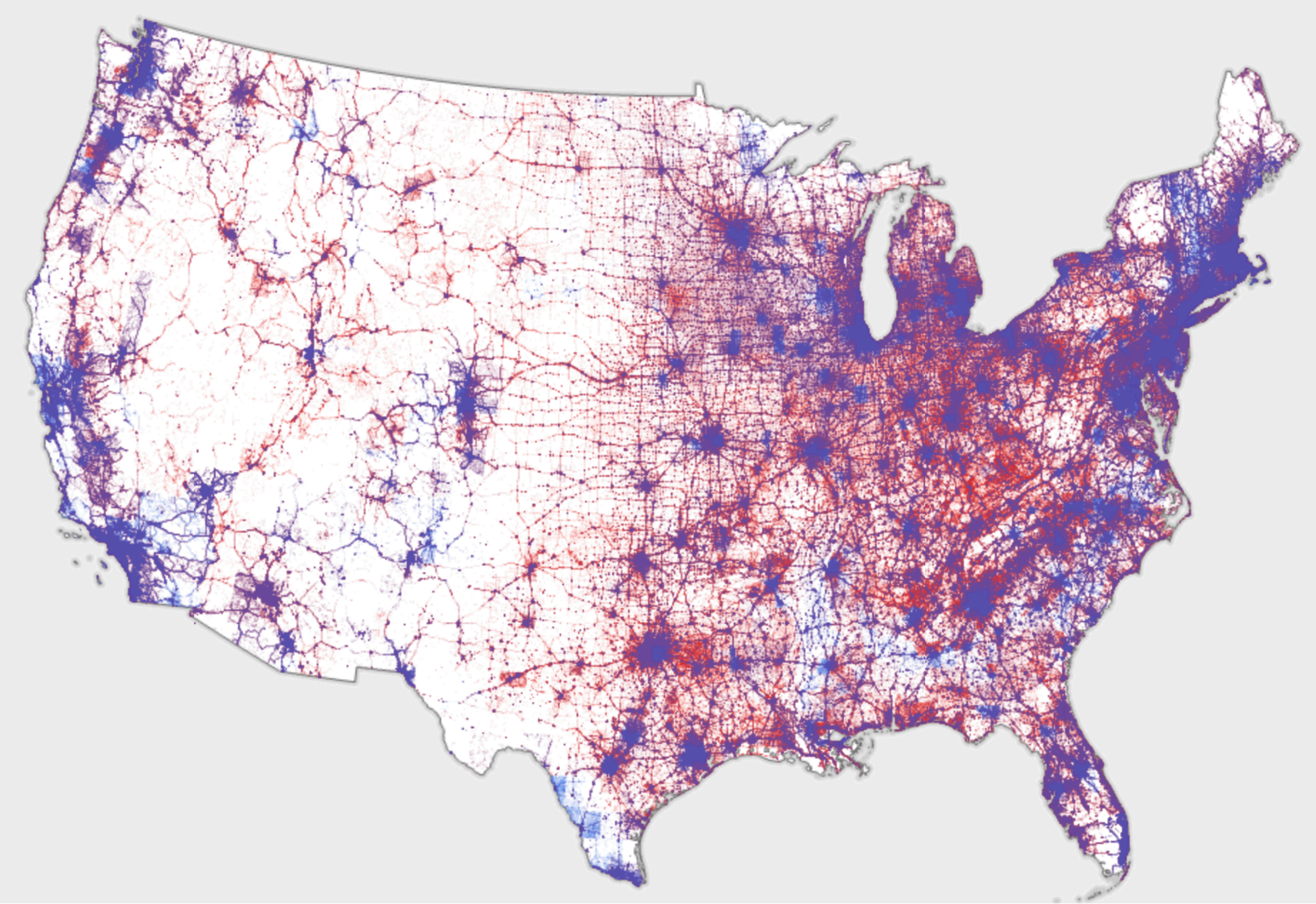
[xkcd]

Size Encoding



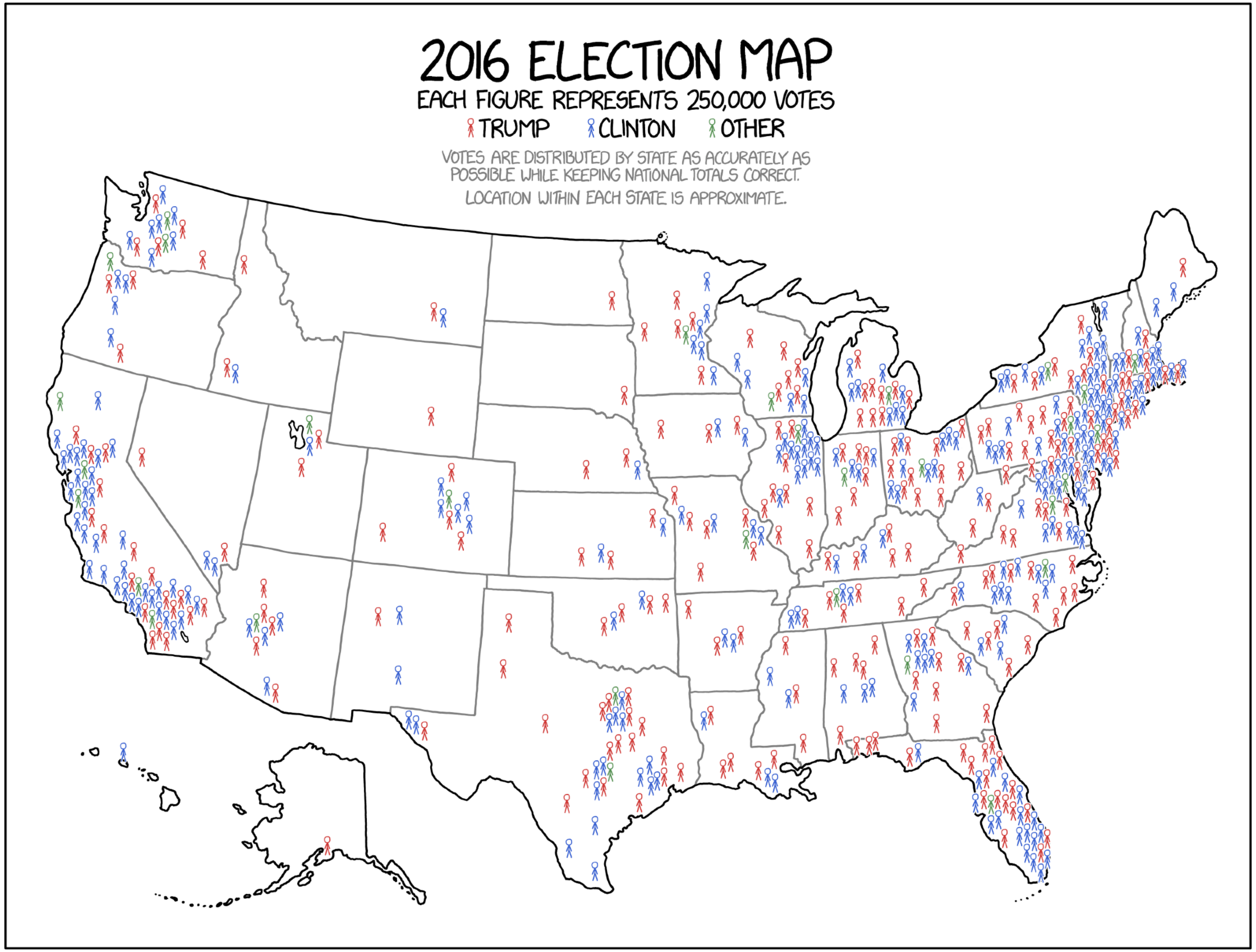
[M. Ericson, New York Times]

Dasymetric Dot Density



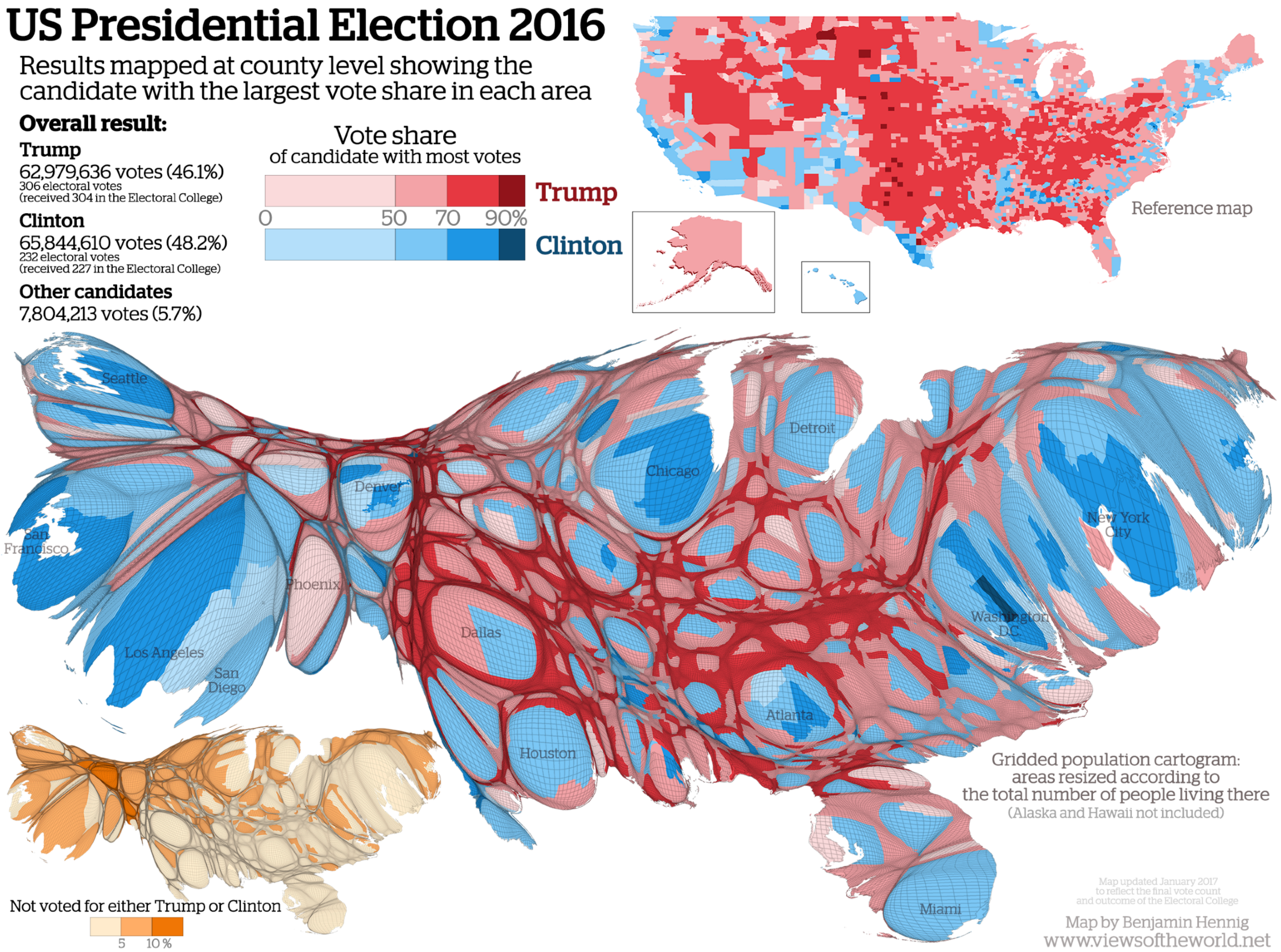
[K. Field]

Glyphs: xkcd's Map



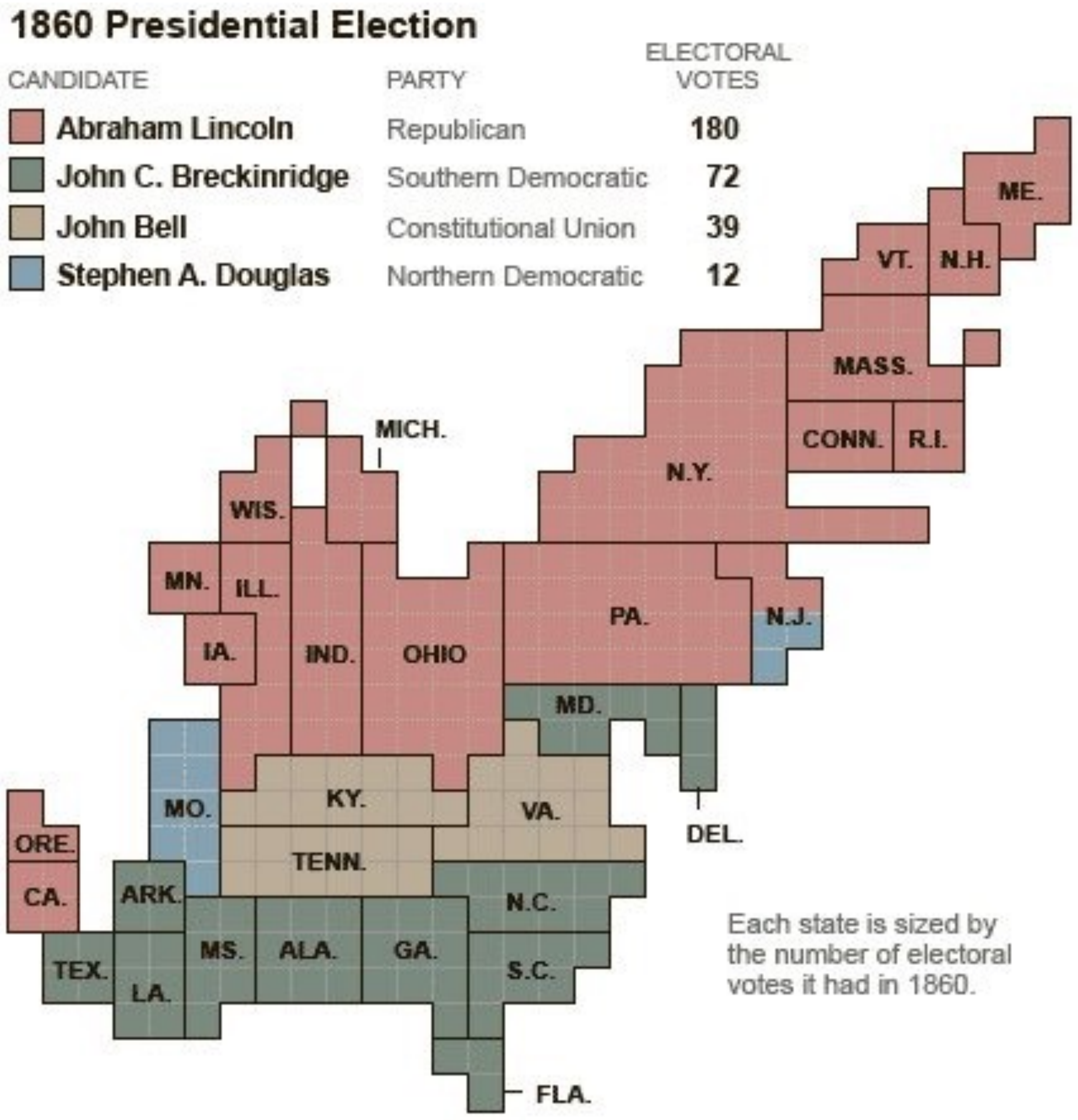
[xkcd]

Cartograms



[B. Hennig]

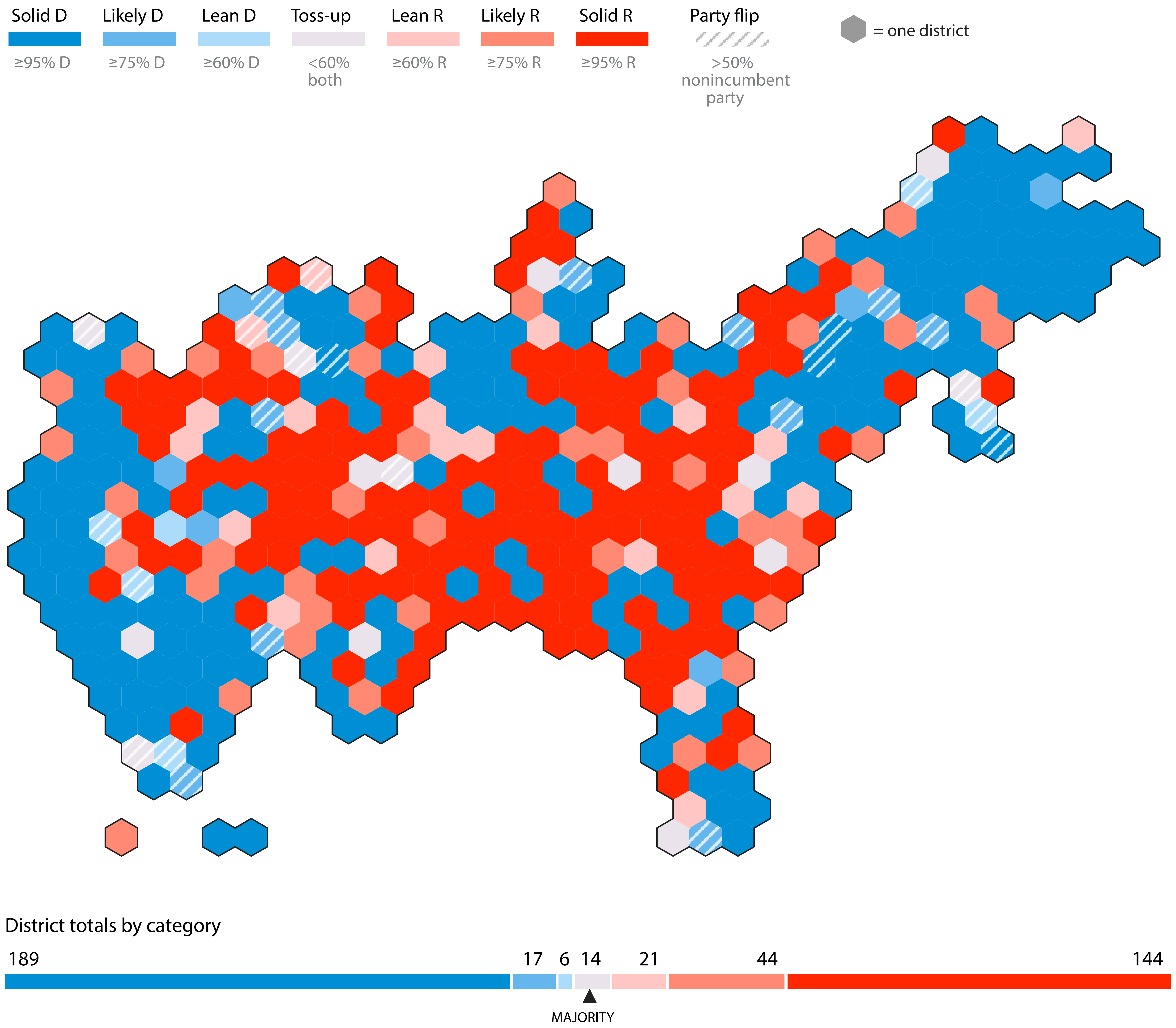
Cartograms



- Data: geographic geometry data & **two** quantitative attributes (one part-of-whole)
- Derived data: new geometry derived from the part-of-whole attribute
- Tasks: trends, comparisons, part-of-whole
- How: area marks from derived geometry, color hue/saturation/luminance
- Scalability: thousands of regions
- Design choices:
  - Colormap
  - Geometric deformation

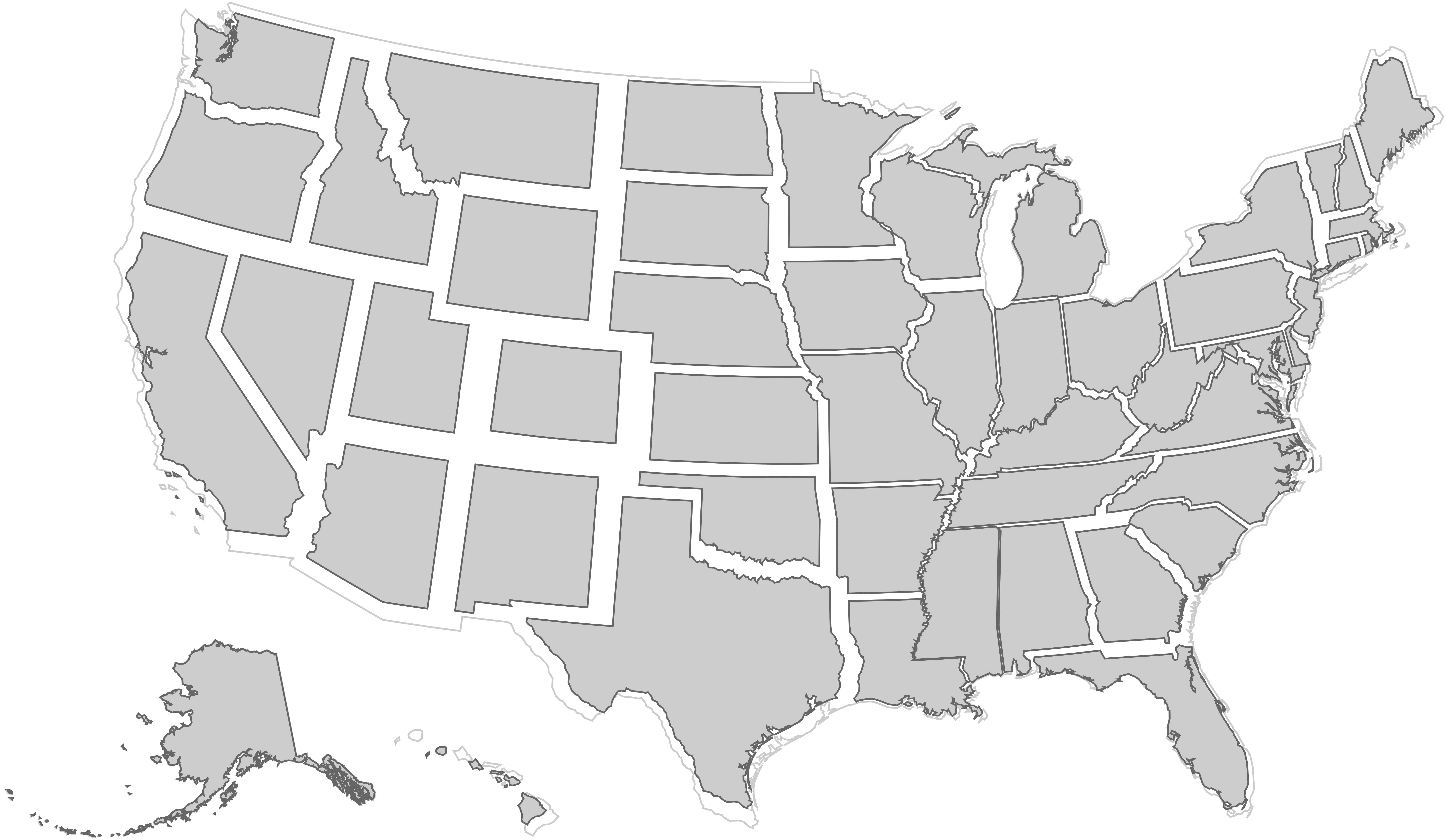
[New York Times]

Hexagonal Cartogram



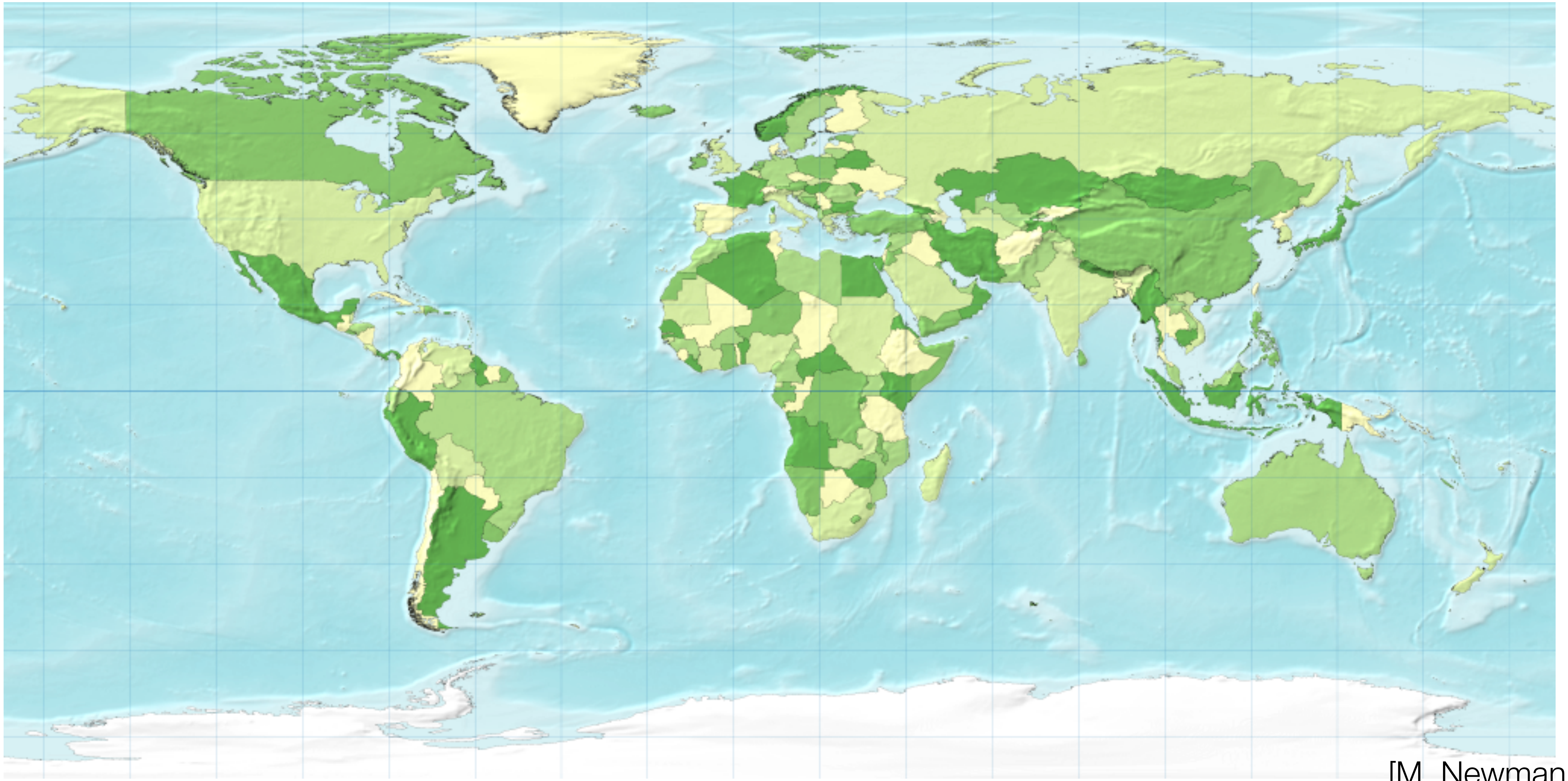
[FiveThirtyEight, 2018]

Non-Contiguous Cartogram



[M. Bostock, 2012]

World Cartograms

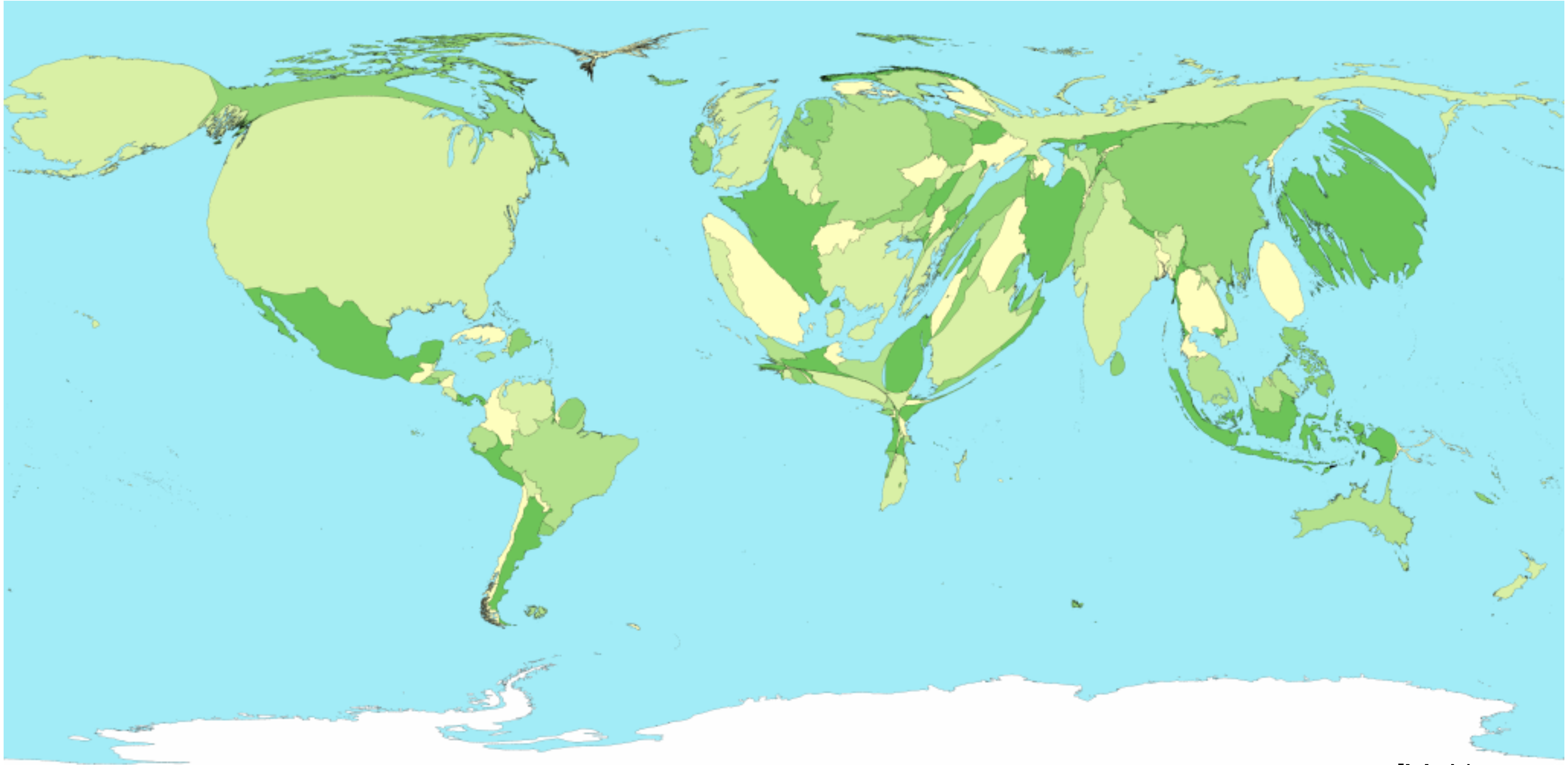


[M. Newman, 2009]

World Population

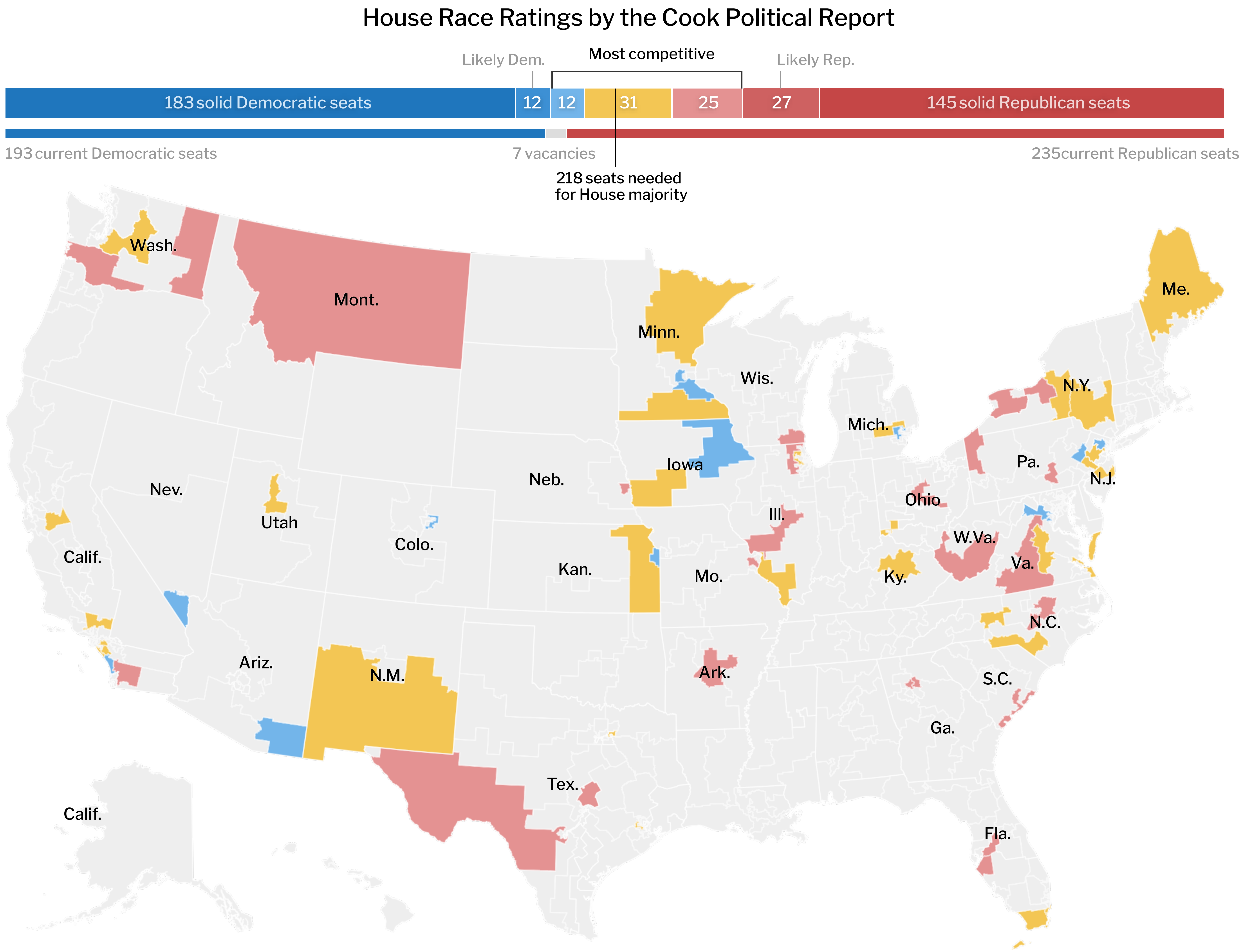
[M. Newman, 2009]

World Energy Consumption



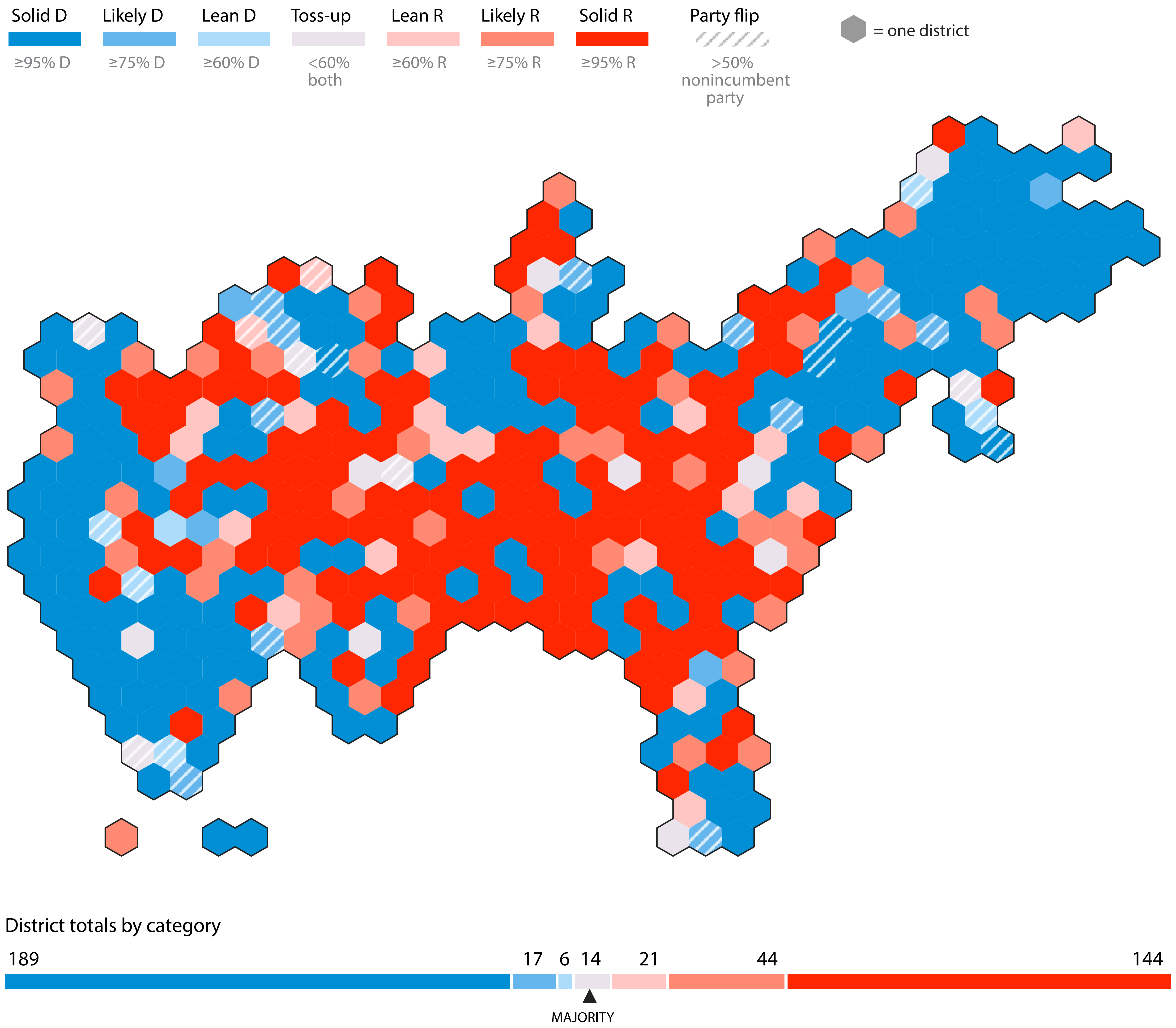
[M. Newman, 2009]

House Races: Map?



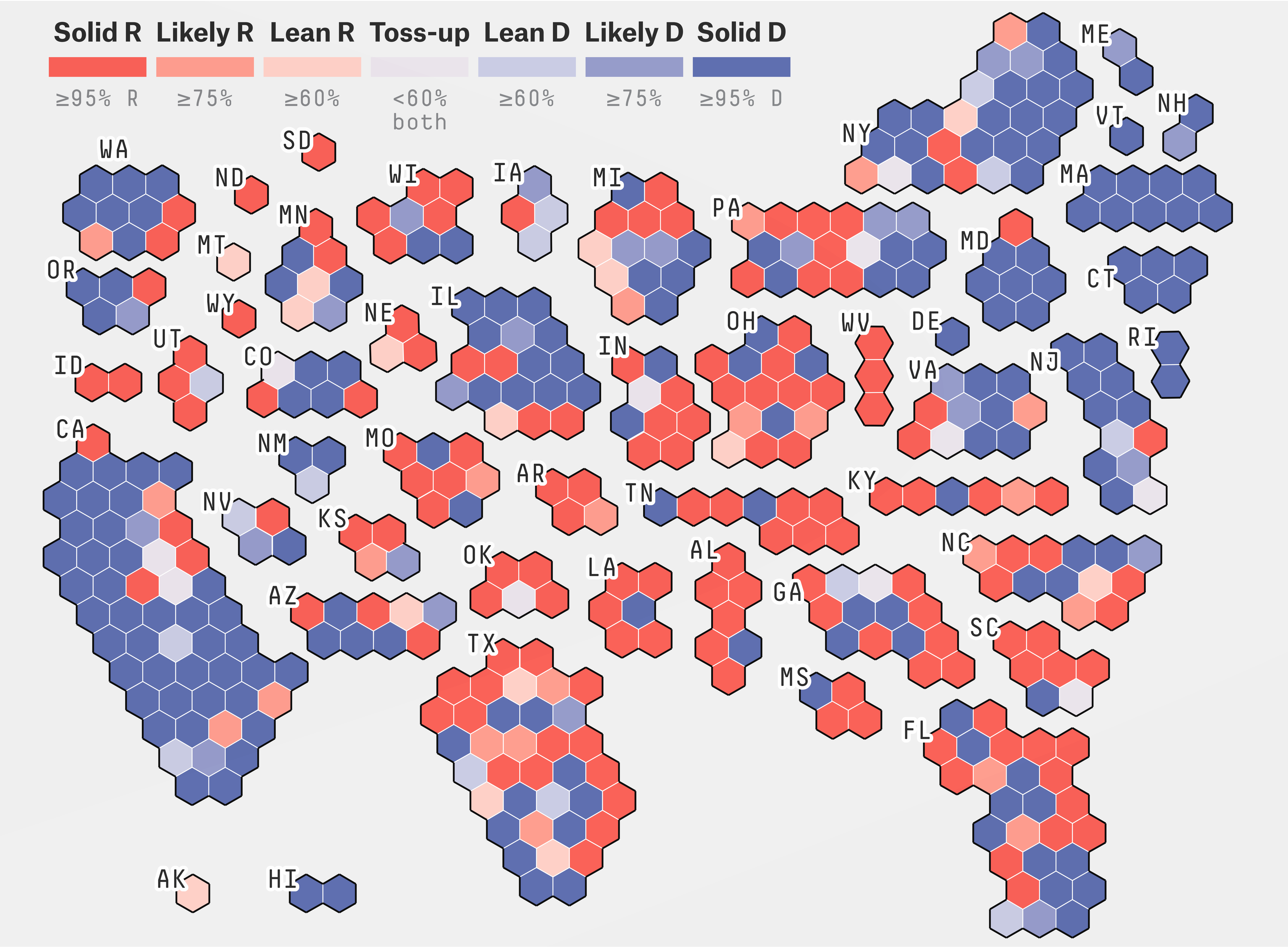
[New York Times, 2018]

House Races: Cartogram?



[FiveThirtyEight, 2018]

House Races: Non-Contiguous "Cartogram"



[FiveThirtyEight, 2020]

Maps Aren't Always Best: Close House Races

12 Lean Democratic

- AZ-02 Open (McSally)
- CA-49 Open (Issa)
- CO-06 Coffman
- IA-01 Blum
- KS-03 Yoder
- MI-11 Open (Trott)
- MN-02 Lewis
- MN-03 Paulsen
- NV-03 Open (Rosen)
- NJ-11 Open (Frelinghuysen)
- PA-07 Vacant (formerly Dent)
- VA-10 Comstock

31 Tossups

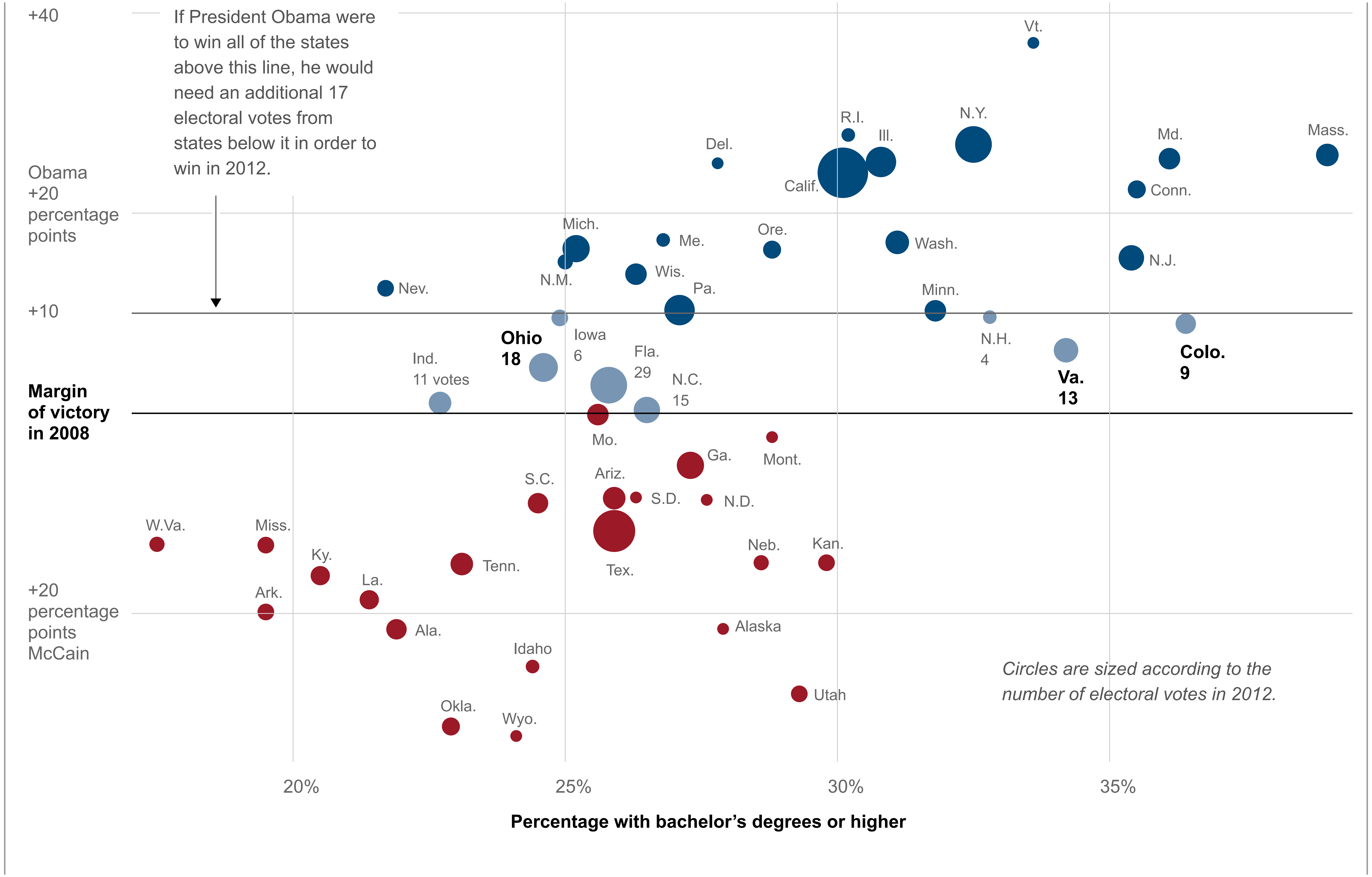
- CA-10 Denham
- CA-25 Knight
- CA-39 Open (Royce)
- CA-45 Walters
- CA-48 Rohrabacher
- FL-26 Curbelo
- FL-27 Open (Ros-Lehtinen)
- IL-06 Roskam
- IL-12 Bost
- IA-03 Young
- KS-02 Open (Jenkins)
- KY-06 Barr

25 Lean Republican

- AR-02 Hill
- CA-50 Hunter
- FL-15 Open (Ross)
- FL-16 Buchanan
- GA-06 Handel
- GA-07 Woodall
- IL-13 Davis
- IL-14 Hultgren
- MO-02 Wagner
- MT-AL Gianforte
- NE-02 Bacon
- NY-24 Katko

[New York Times, 2018]

Maps Aren't Always Best: Obama Targets



[NYTimes]

Networks

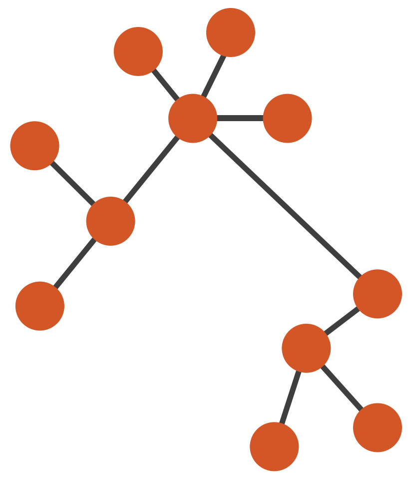
Networks

- Why not graphs?
  - Bar graph
  - Graphing functions in mathematics
- Network: nodes and edges connecting the nodes
- Formally, $G = (V,E)$ is a set of nodes V and a set of edges E where each edge connects two nodes.
- Nodes == items, edges connect items
- **Both** nodes and edges may have **attributes**

Arrange Networks and Trees

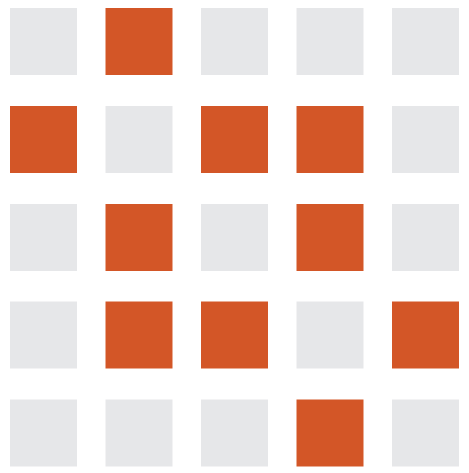
Node–Link Diagrams
Connection Marks

✔ NETWORKS ✔ TREES



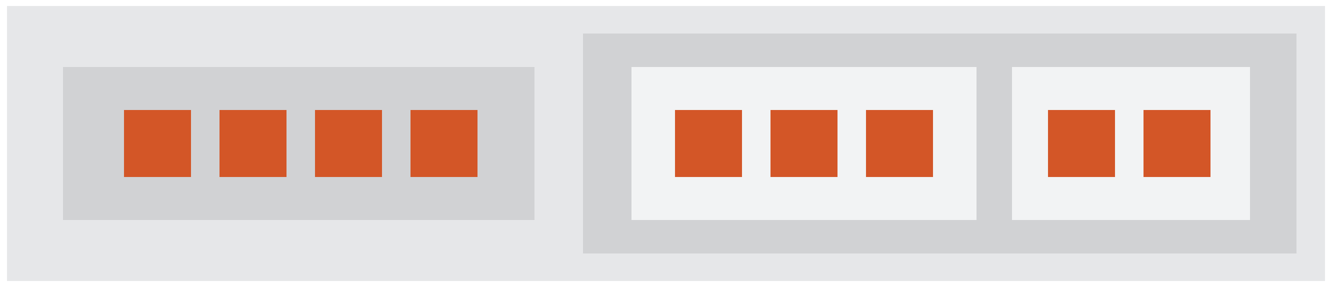
Adjacency Matrix
Derived Table

✔ NETWORKS ✔ TREES



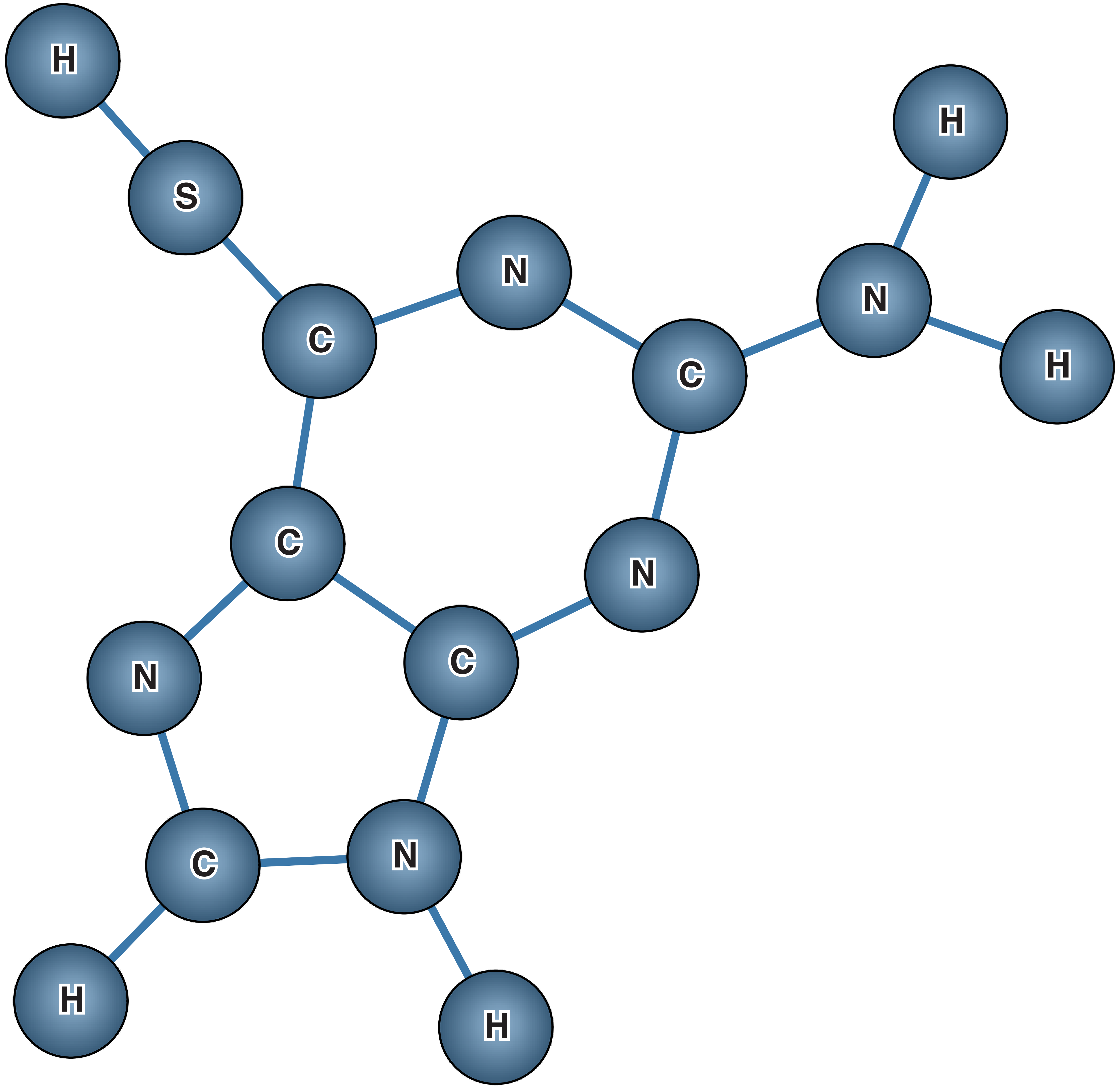
Enclosure
Containment Marks

✕ NETWORKS ✔ TREES

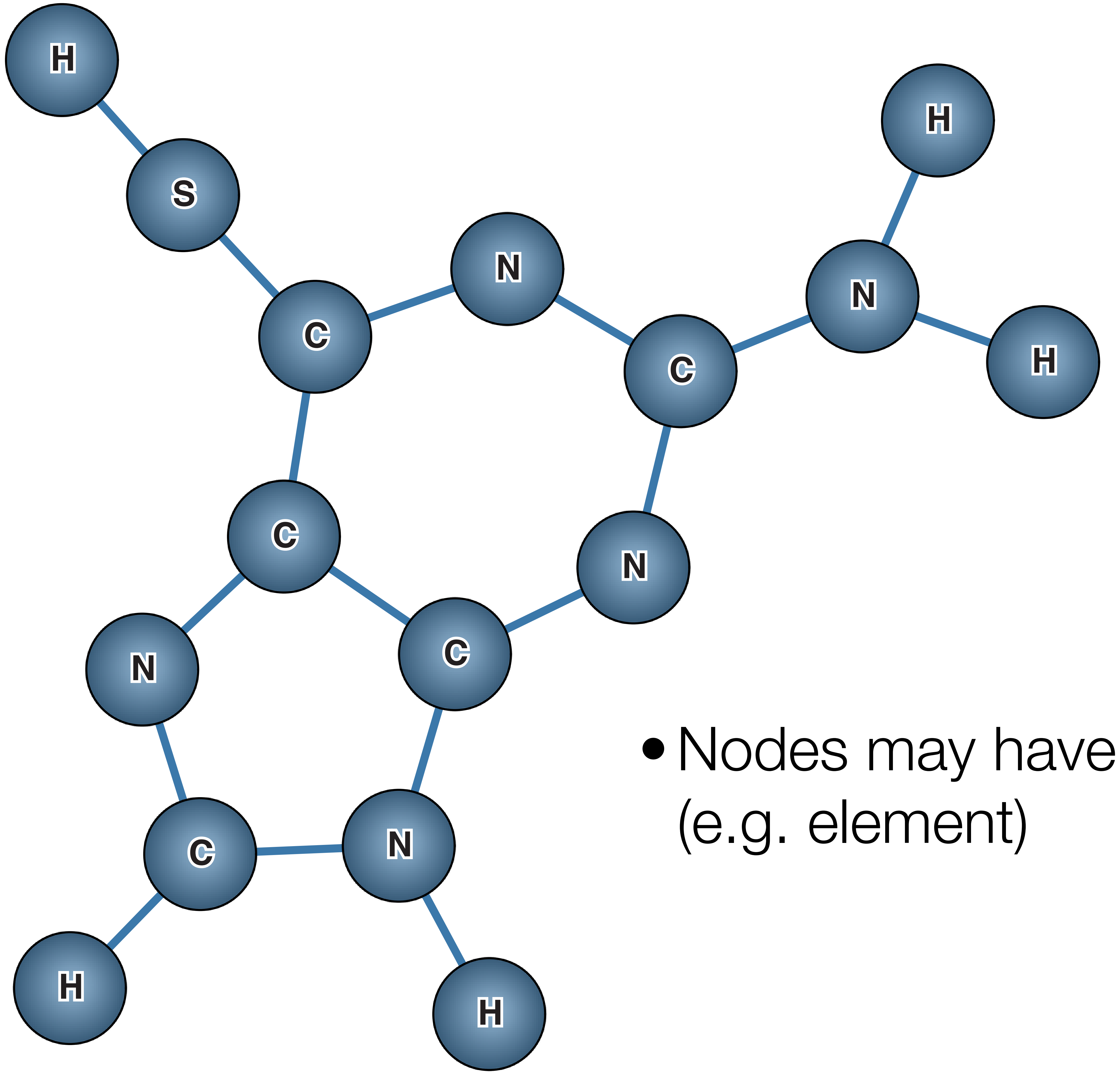


[Munzner (ill. Maguire), 2014]

Molecule Graph

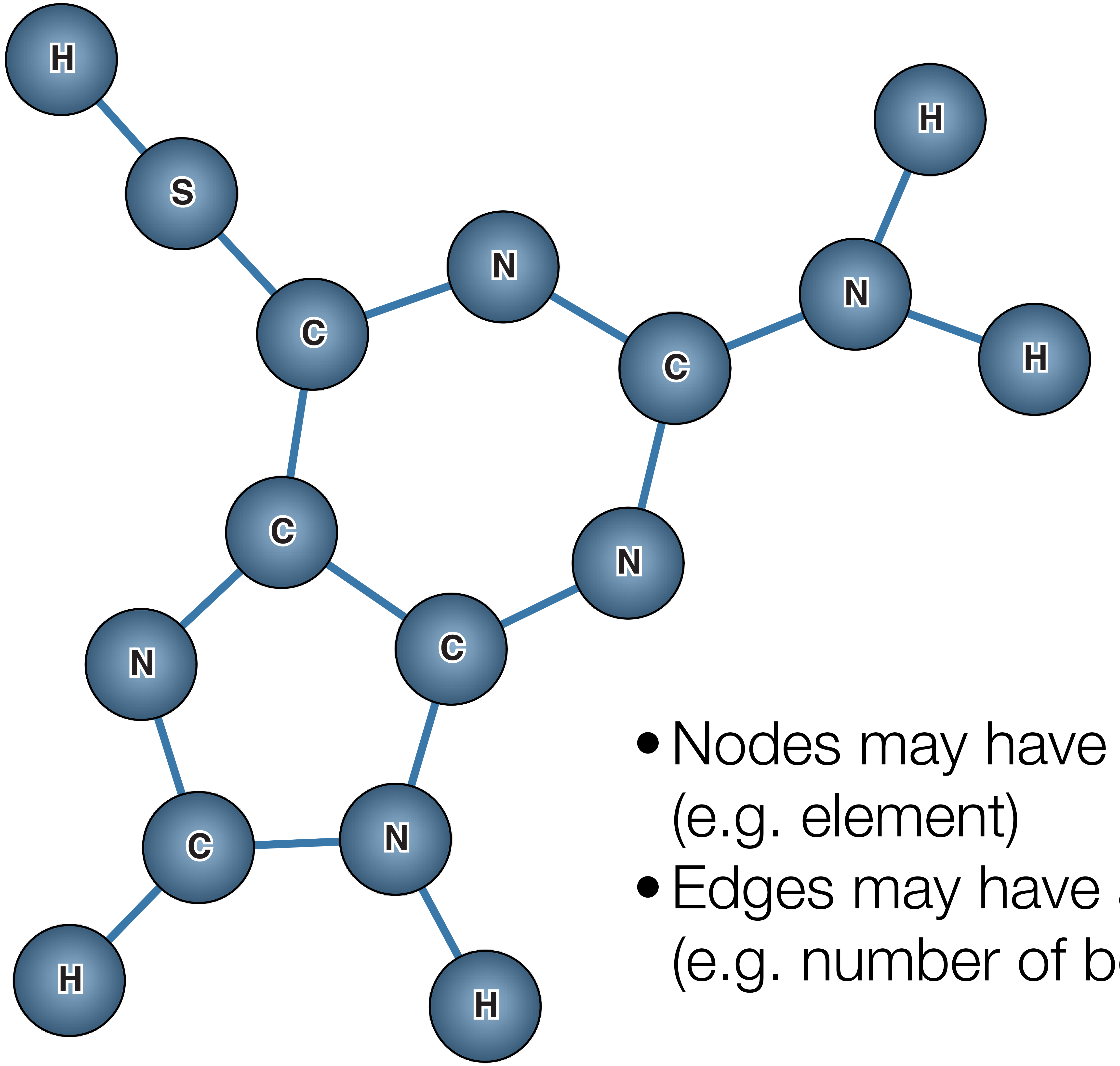


Molecule Graph



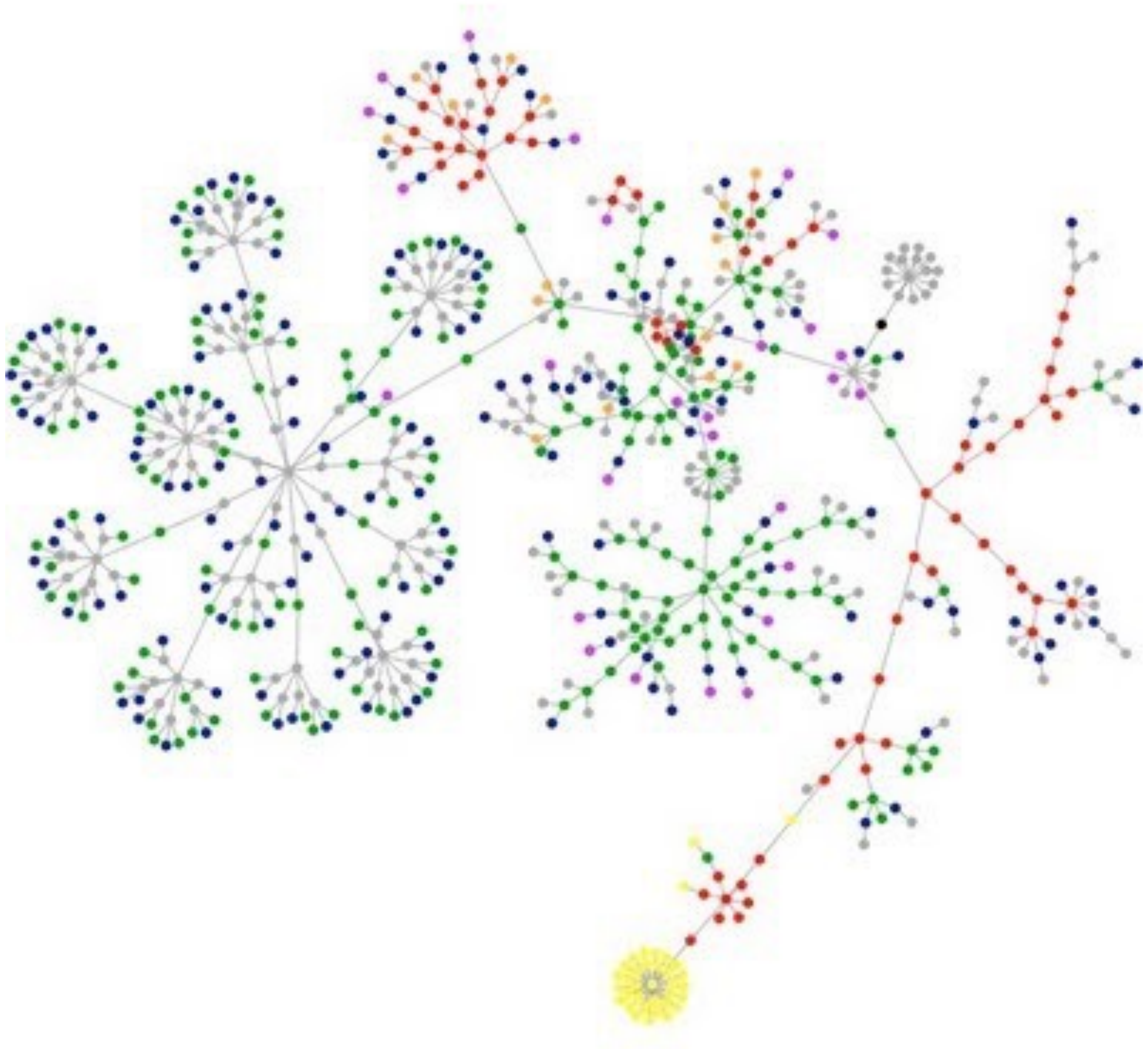
- Nodes may have attributes (e.g. element)

Molecule Graph



- Nodes may have attributes (e.g. element)
- Edges may have attributes (e.g. number of bonds)

Web Sites as Graphs (amazon.com)



[M. Salathe, 2006]

Social Networks

[P. Butler, 2010]

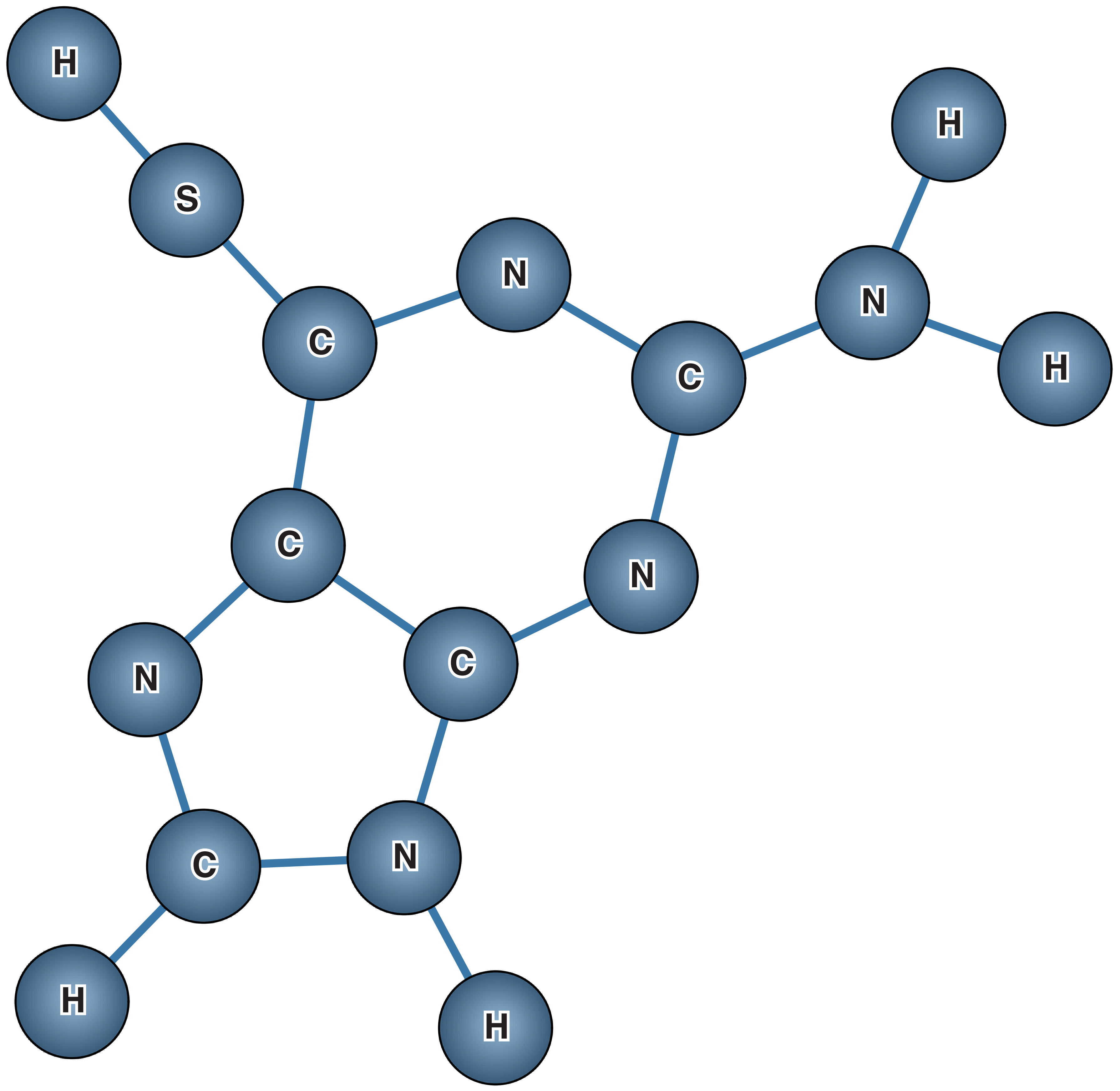
Networks as Data

Nodes

ID	Atom	Electrons	Protons
0	N	7	7
1	C	6	6
2	S	16	16
3	C	6	6
4	N	7	7

Edges

ID1	ID2	Bonds
0	1	1
1	2	1
1	3	2
3	4	1

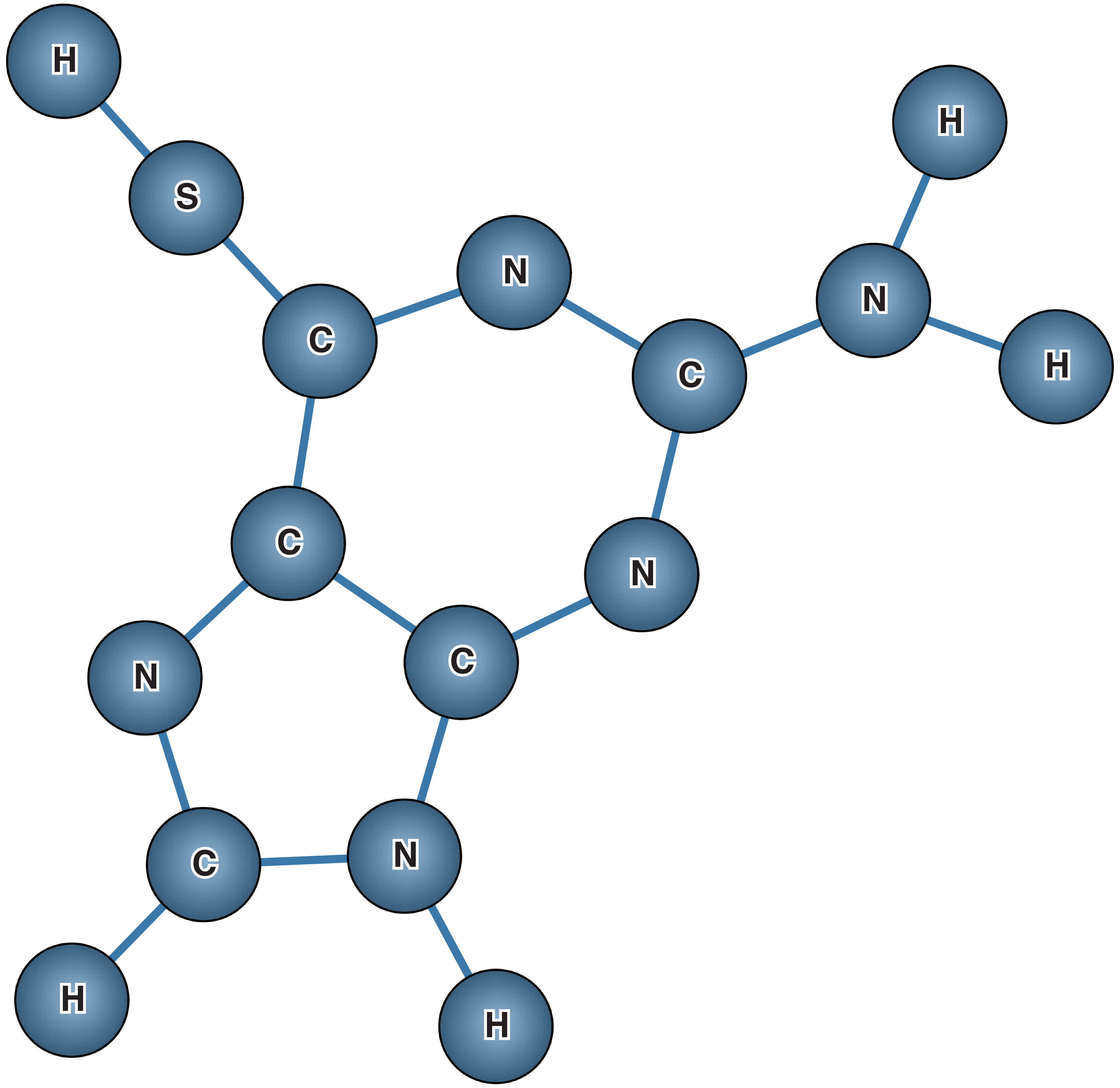


Node-Link Diagrams

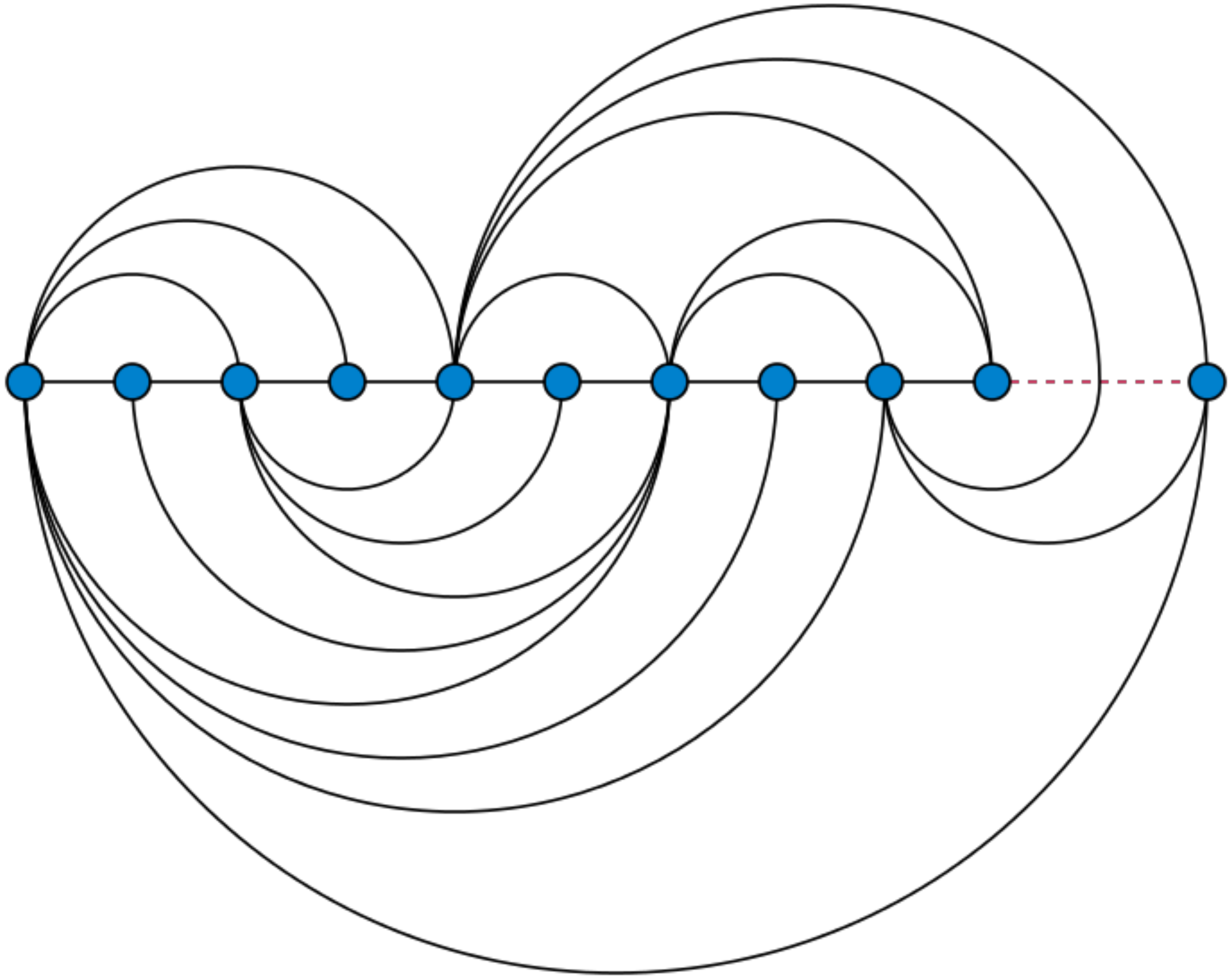
- Data: nodes and edges
- Task: understand connectivity, paths, structure (topology)
- Encoding: nodes as point marks, connections as line marks
- Scalability: hundreds

- …but high **density** of links can be problematic!

- Issue with the encoding?



Arc Diagram



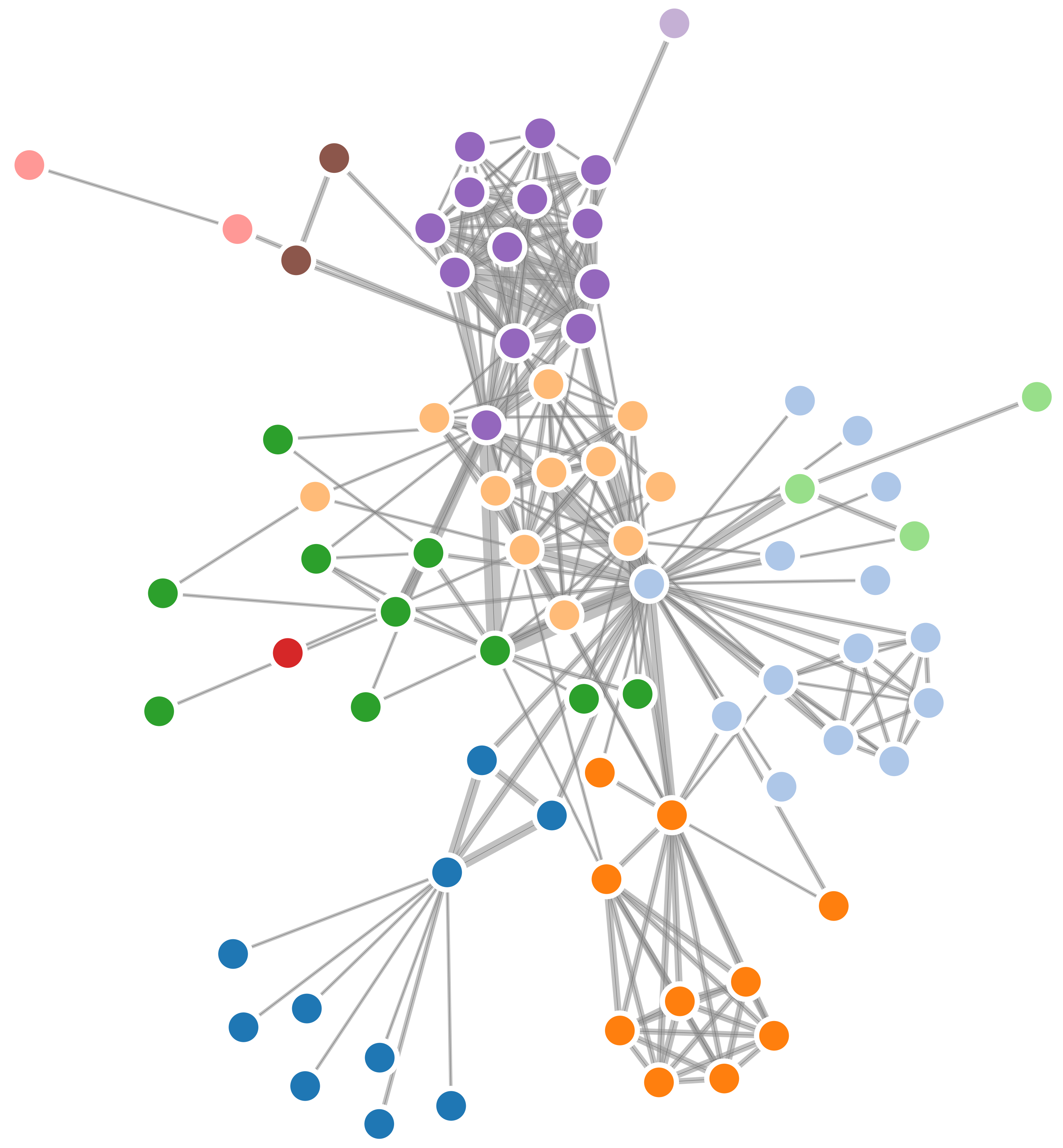
[D. Eppstein, 2013]

Network Layout

- Need to use spatial position when designing network 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

Force-Directed Layout

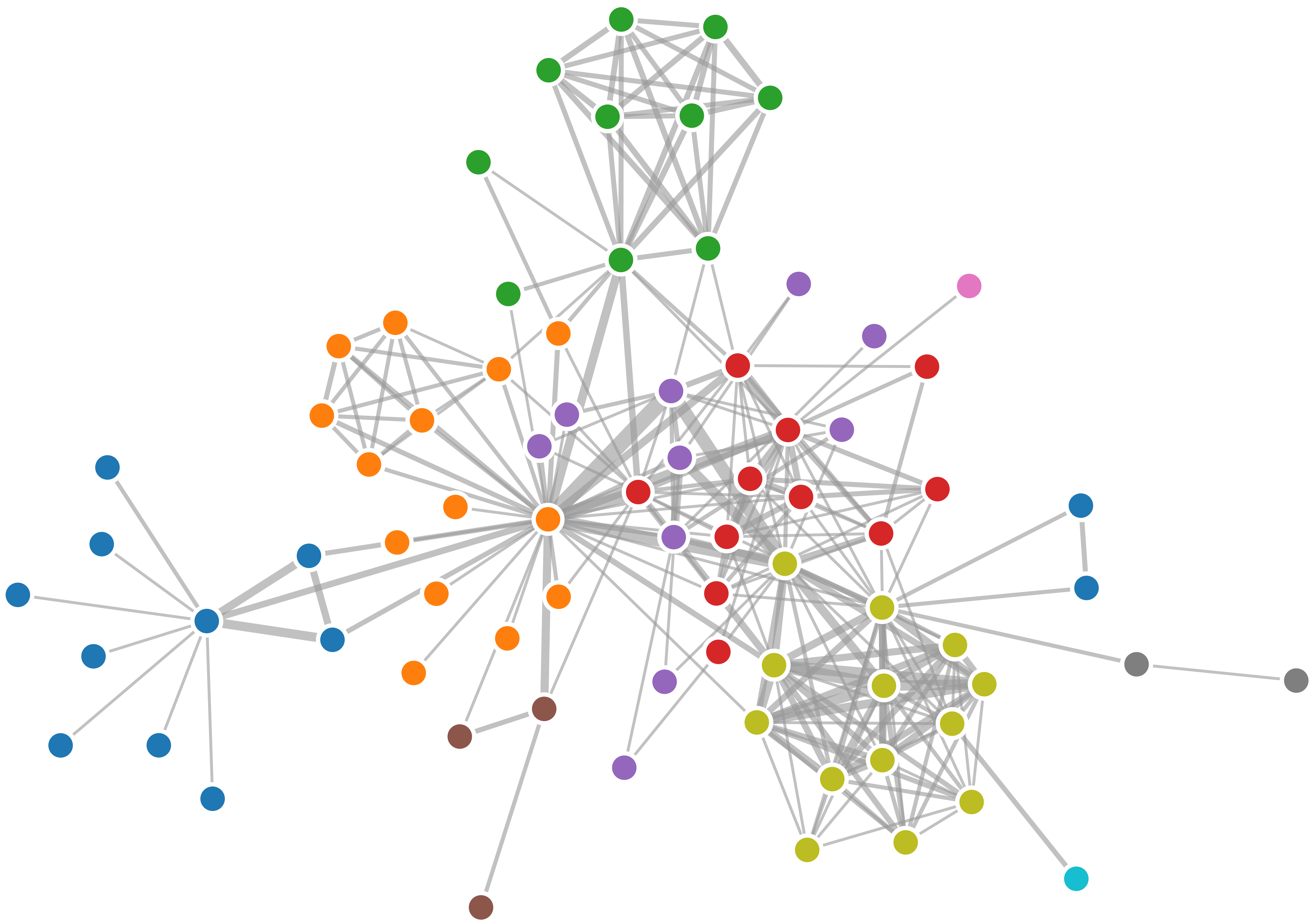
- Nodes push away from each other but edges are springs that pull them together
- Weakness: nondeterminism, algorithm may produce difference results each time it runs



[M. Bostock, 2017]

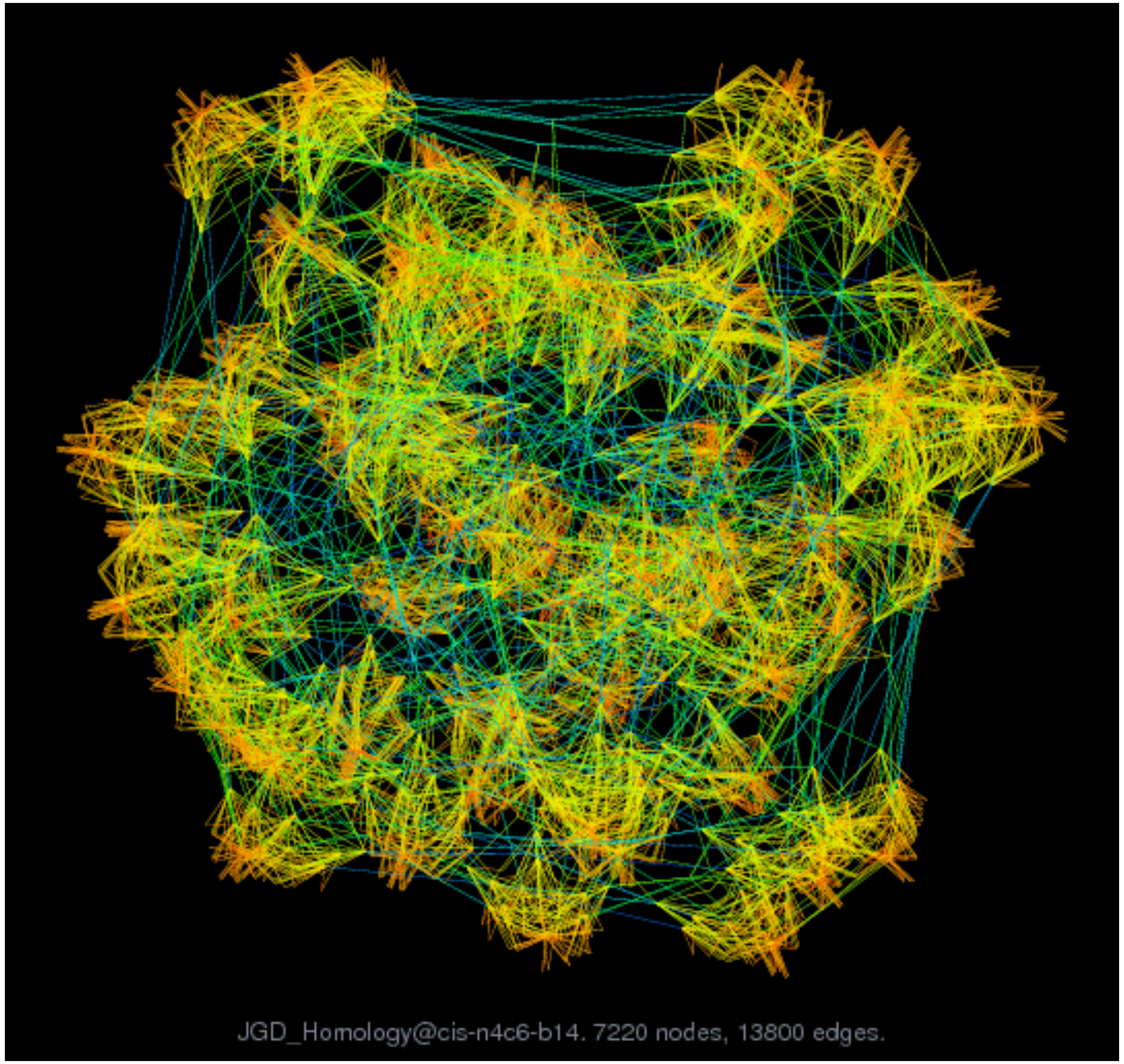
Constraint-Based Optimization (CoLa)

- Higher quality layout
- More **stable** in interactive applications (no "jitter")
- Allows user specified constraints such as alignments and grouping
- Can avoid overlapping nodes
- Provides flow layout for directed graphs
- May be **less scalable** to very large graphs
- Can route edges around nodes



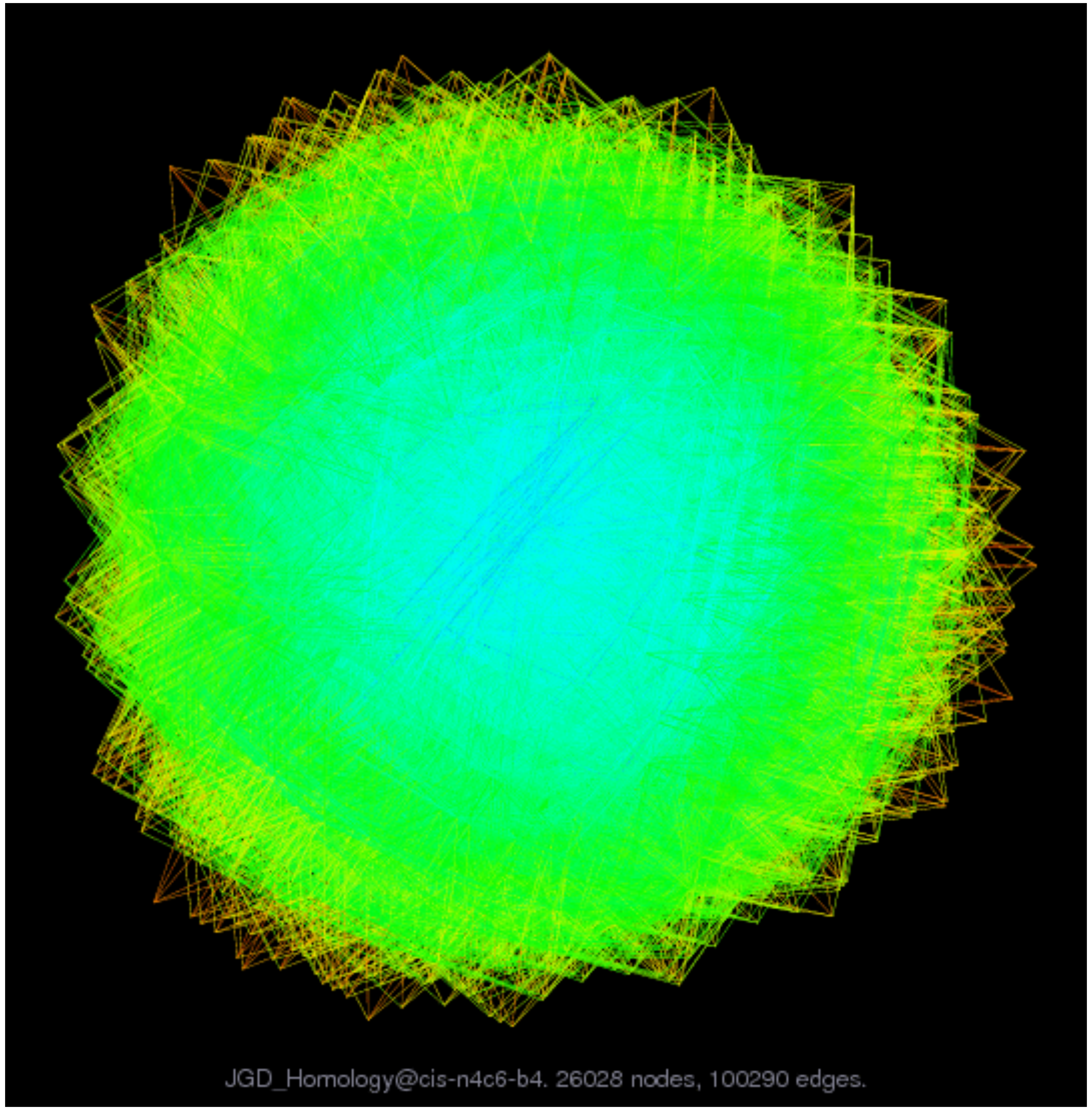
[T. Dwyer et al. (WebCoLa); M. Bostock (Example), 2018]

sfdp



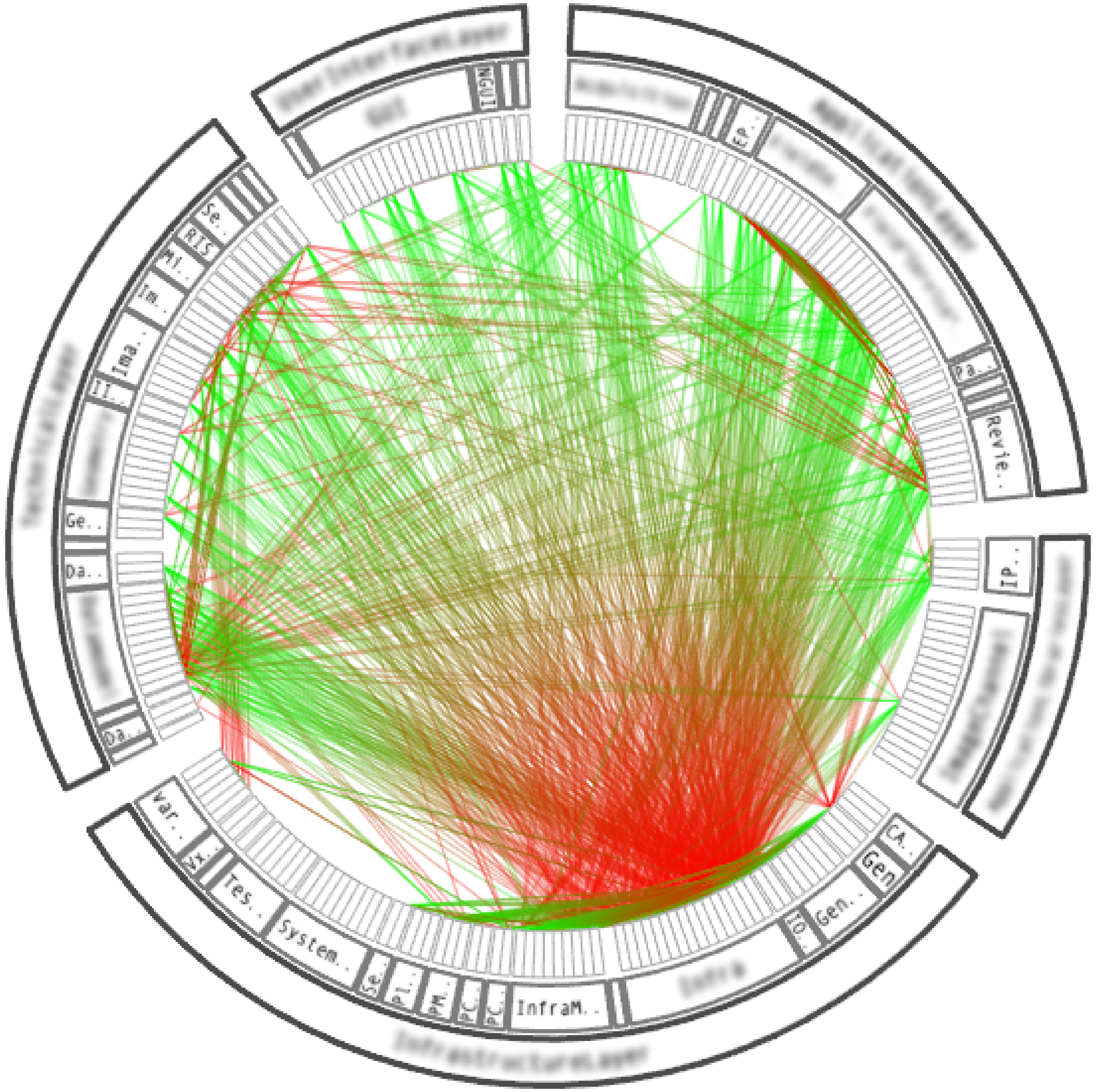
[Hu, 2005]

“Hairball”



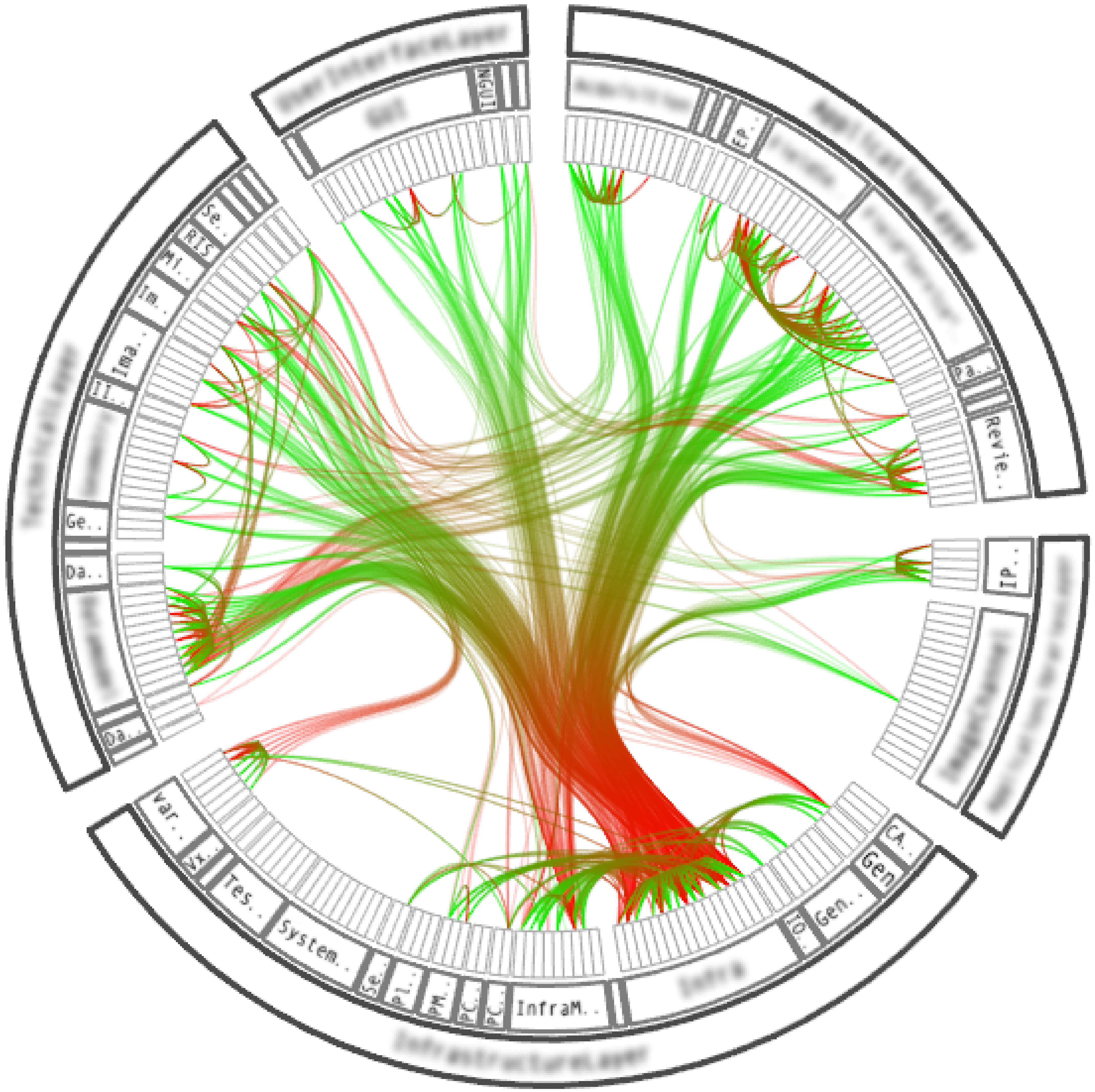
[Hu, 2014]

Hierarchical Edge Bundling



[Holten, 2006]

Hierarchical Edge Bundling



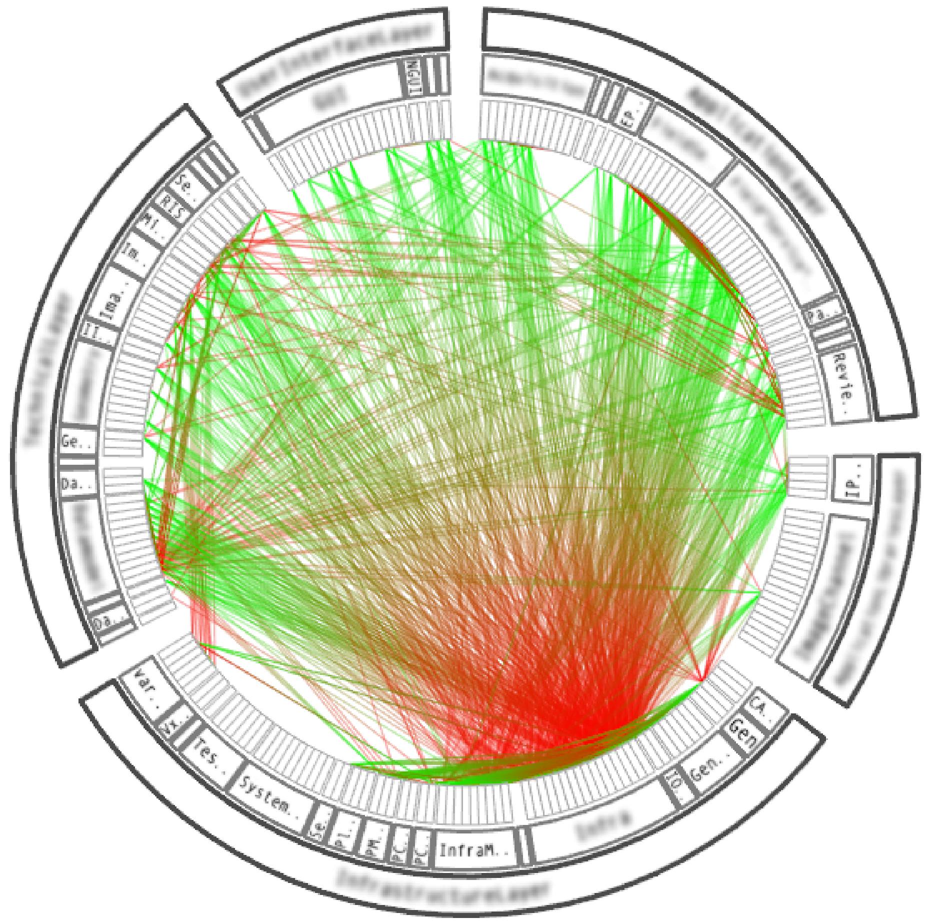
[Holten, 2006]

Hierarchical Edge Bundling

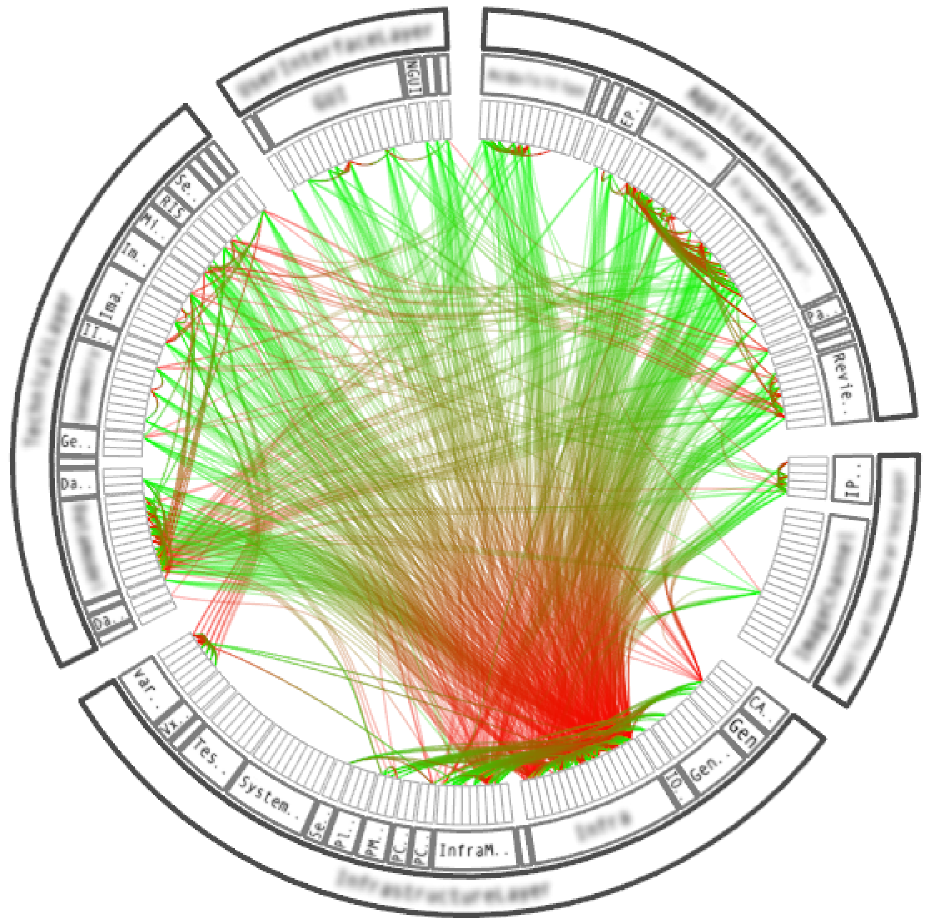
- Flexible and generic method
- Reduces visual clutter when dealing with large numbers of adjacency edges
- Provides an intuitive and continuous way to control the strength of bundling.
  - Low bundling strength mainly provides low-level, node-to-node connectivity information
  - High bundling strength provides high-level information as well by implicit visualization of adjacency edges between parent nodes that are the result of explicit adjacency edges between their respective child nodes

[Holten, 2006]

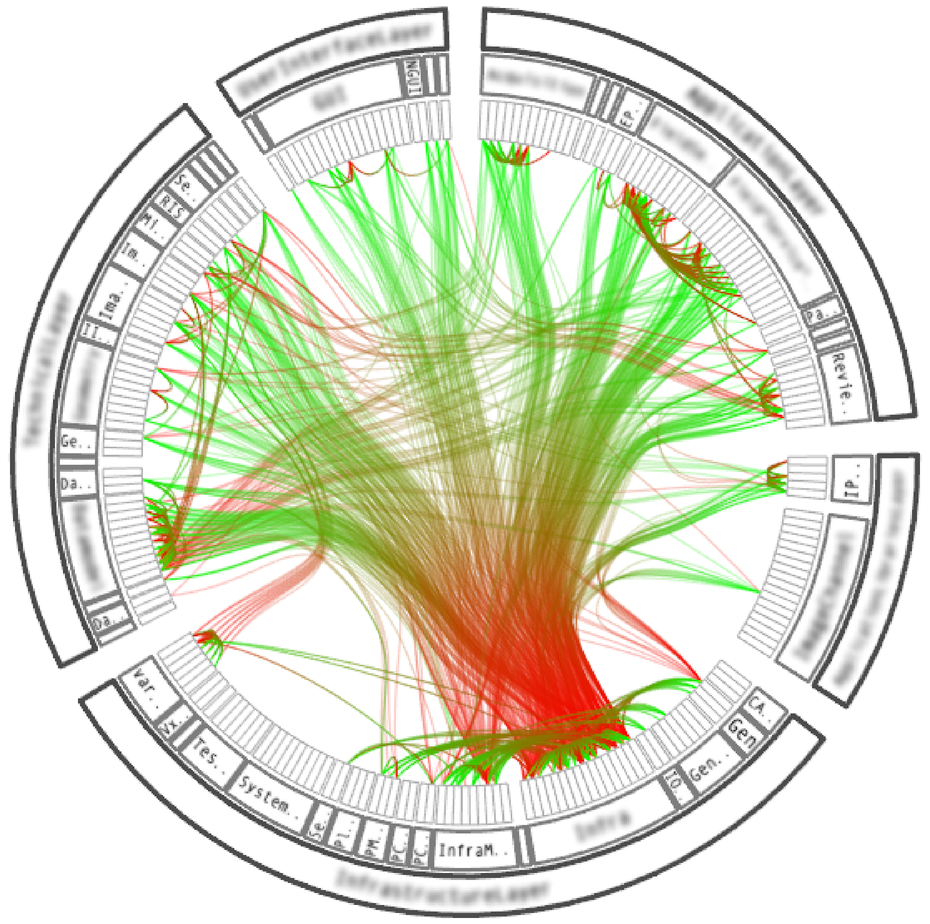
Bundling Strength



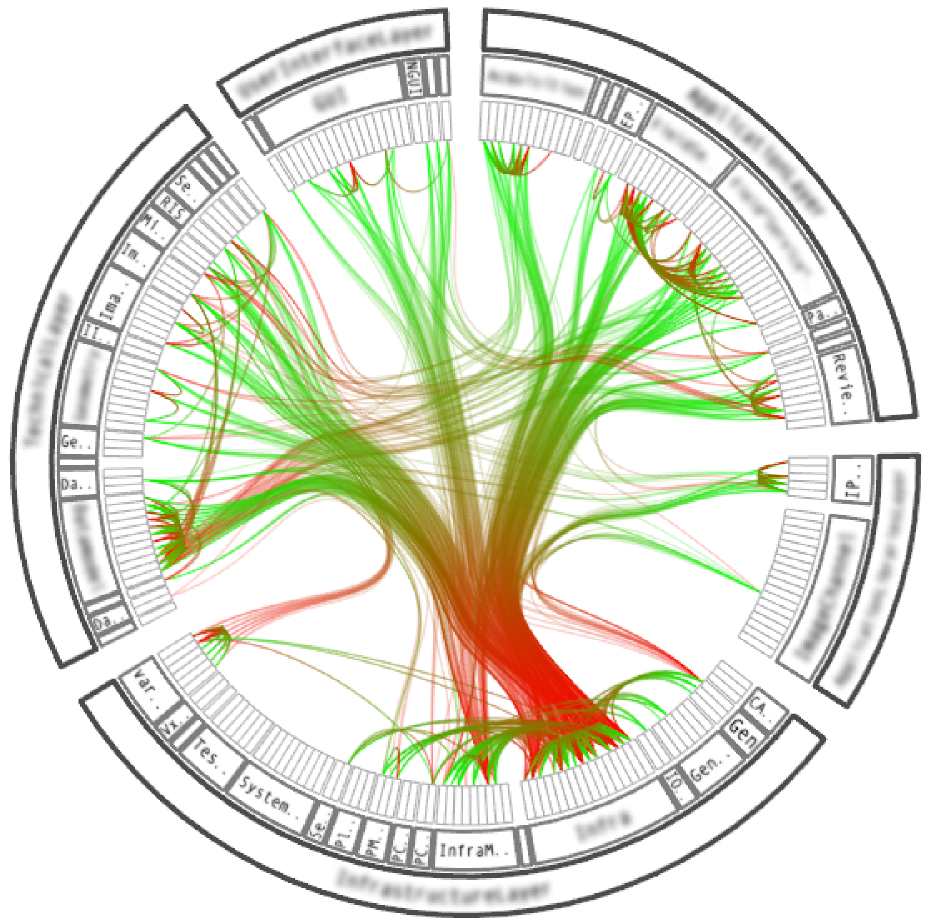
$\beta = 0$



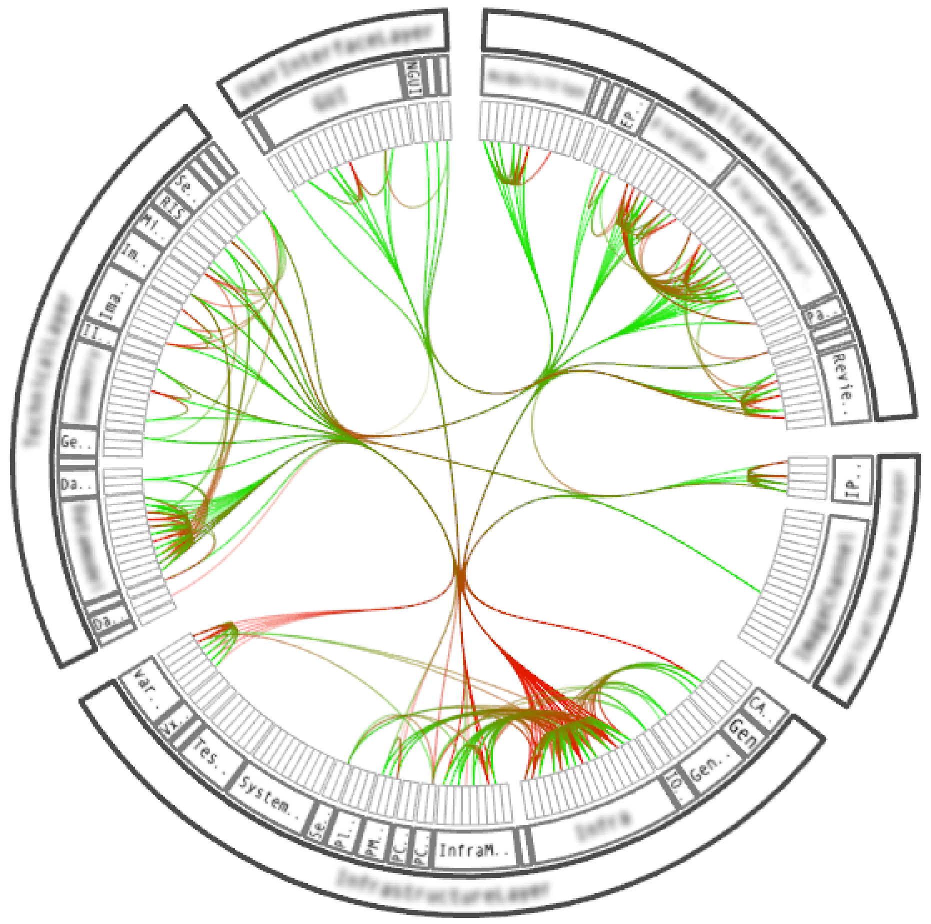
$\beta = 0.25$



$\beta = 0.5$



$\beta = 0.75$



$\beta = 1$

[Holten, 2006]