Network Diagram Workshop

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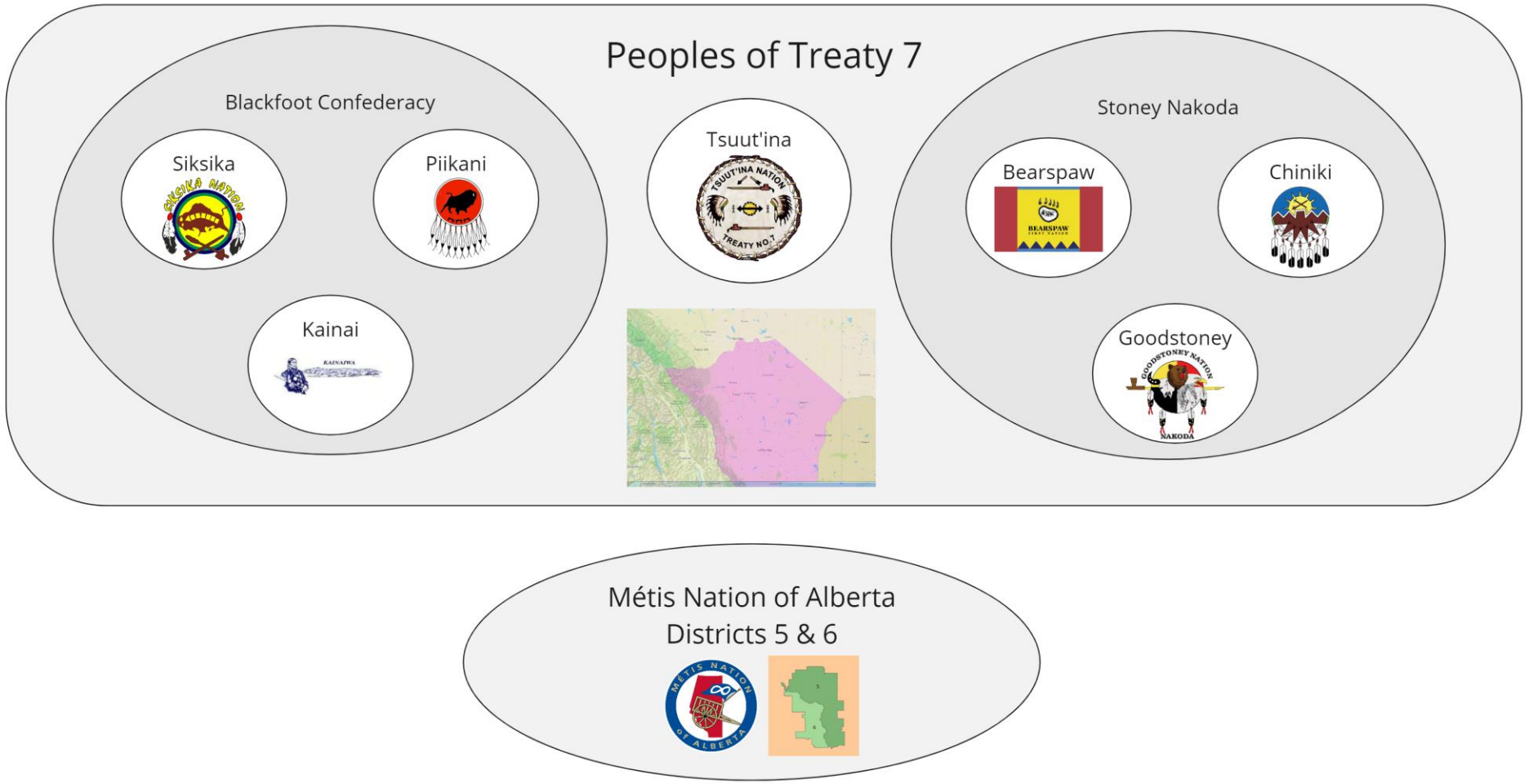
Data and Visualization Curator

Feb 10, 2025

Slides: brosz.ca/slides



The University of Calgary, located in the heart of Southern Alberta, both acknowledges and pays tribute to the traditional territories of the peoples of Treaty 7, which includes the Blackfoot Confederacy (comprised of the Siksika, the Piikani, and the Kainai First Nations), the Tsuut’ina First Nation, and the Stoney Nakoda (including the Chiniki, Bearspaw, and Goodstoney First Nations). The City of Calgary is also home to the Métis Nation of Alberta (Districts 5 and 6).

Today's Plan

What do I mean by a Network Diagram?

Visualizing Relationships

- Types & representations

Node-Link Examples

- Sketch a diagram — Paper & pens

Aesthetics & Layout

- Another sketching exercise

Create a network diagram with Cytoscape

- Data format — https://cytoscape.org
- Automatic layout techniques

Hairballs

Other structures / Beyond Node-Link

Objectives

Varieties of Network Diagram.

Many possibilities beyond Node-Link

Network diagram tools.
Cytoscape

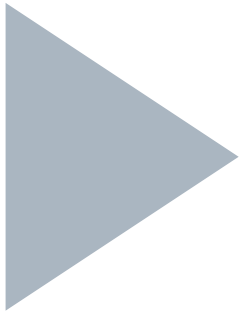
What is a network diagram?
Vocabulary

Aesthetics.
What makes a network diagram good to look at?

Challenges of Network Diagrams.
Not easy!
Hairballs

Take Home Message

No best solution

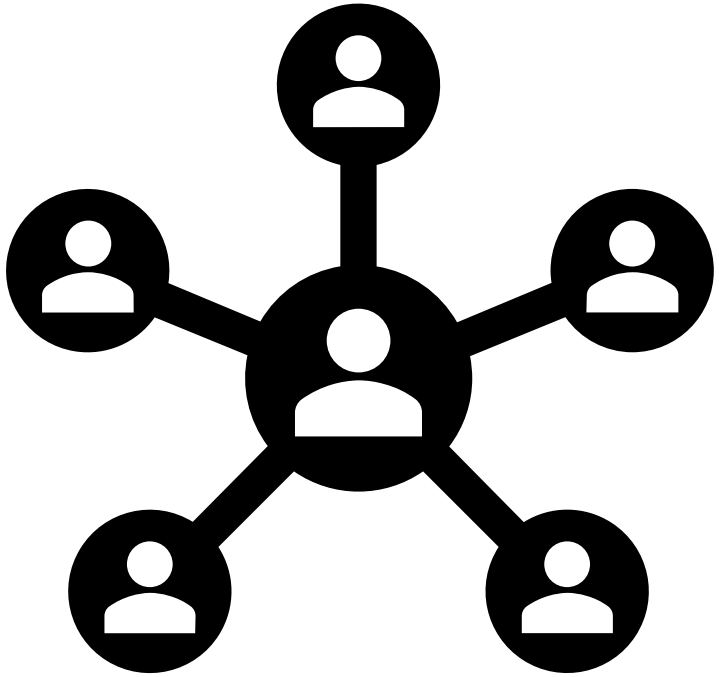


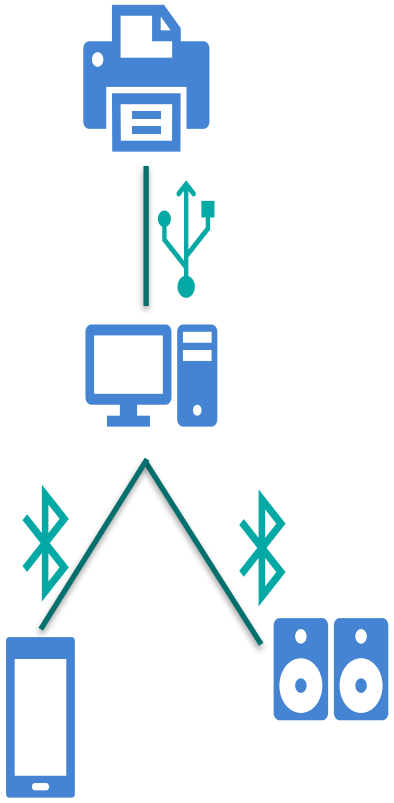
You need to explore and find something that works for your data

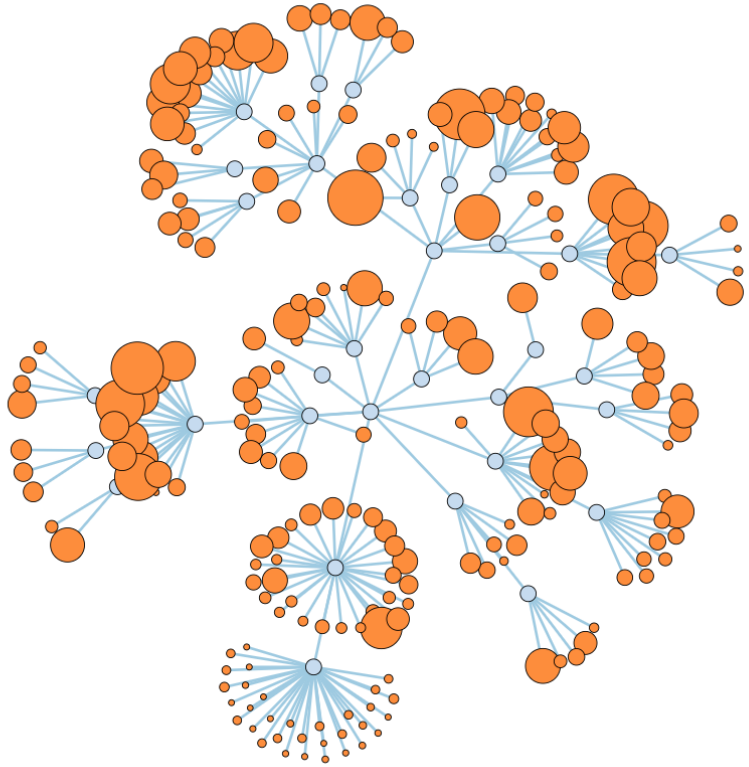
Graphs

aka Networks
aka Node-Link Diagrams

Used for visualizing relationships.

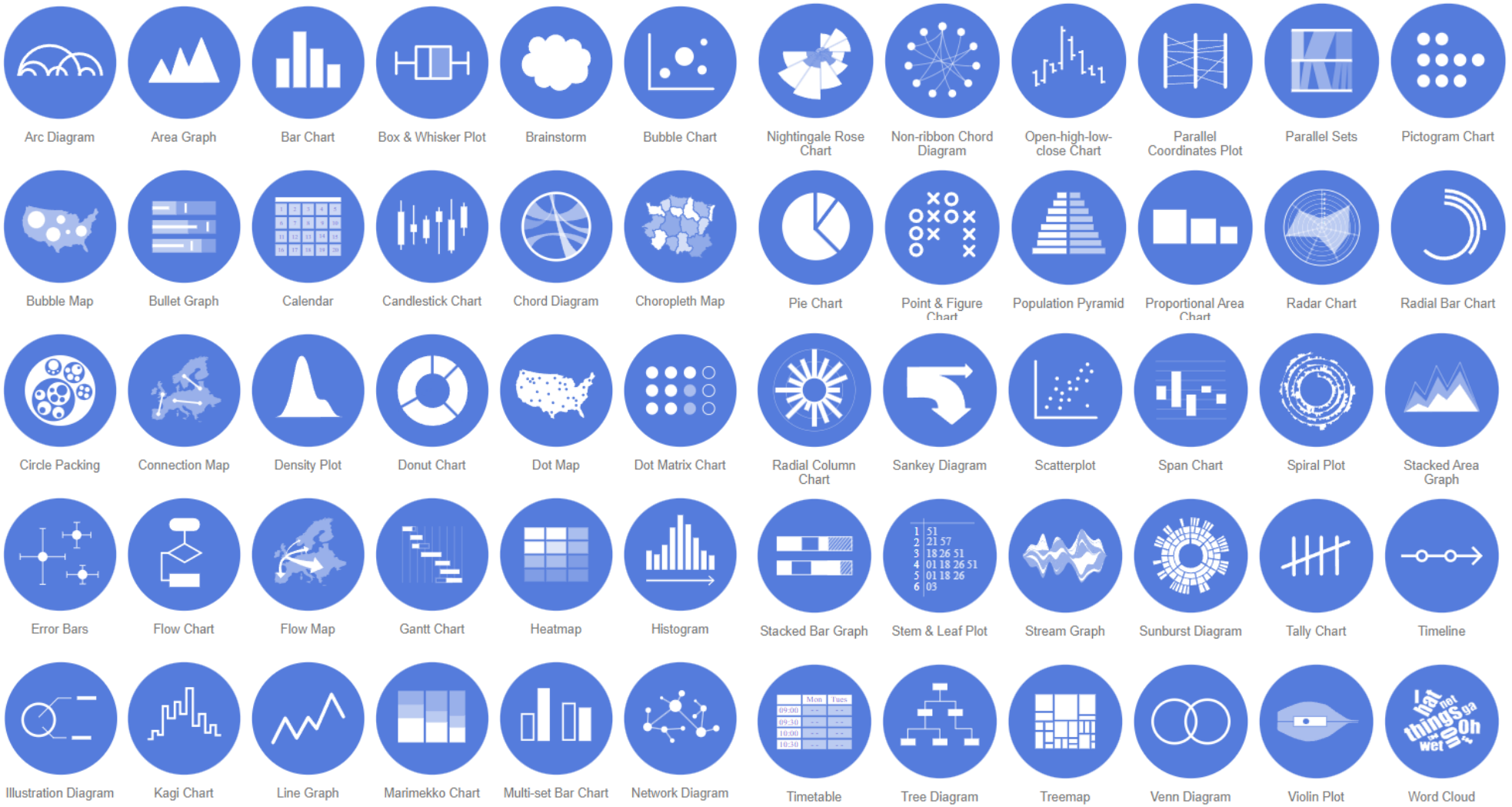






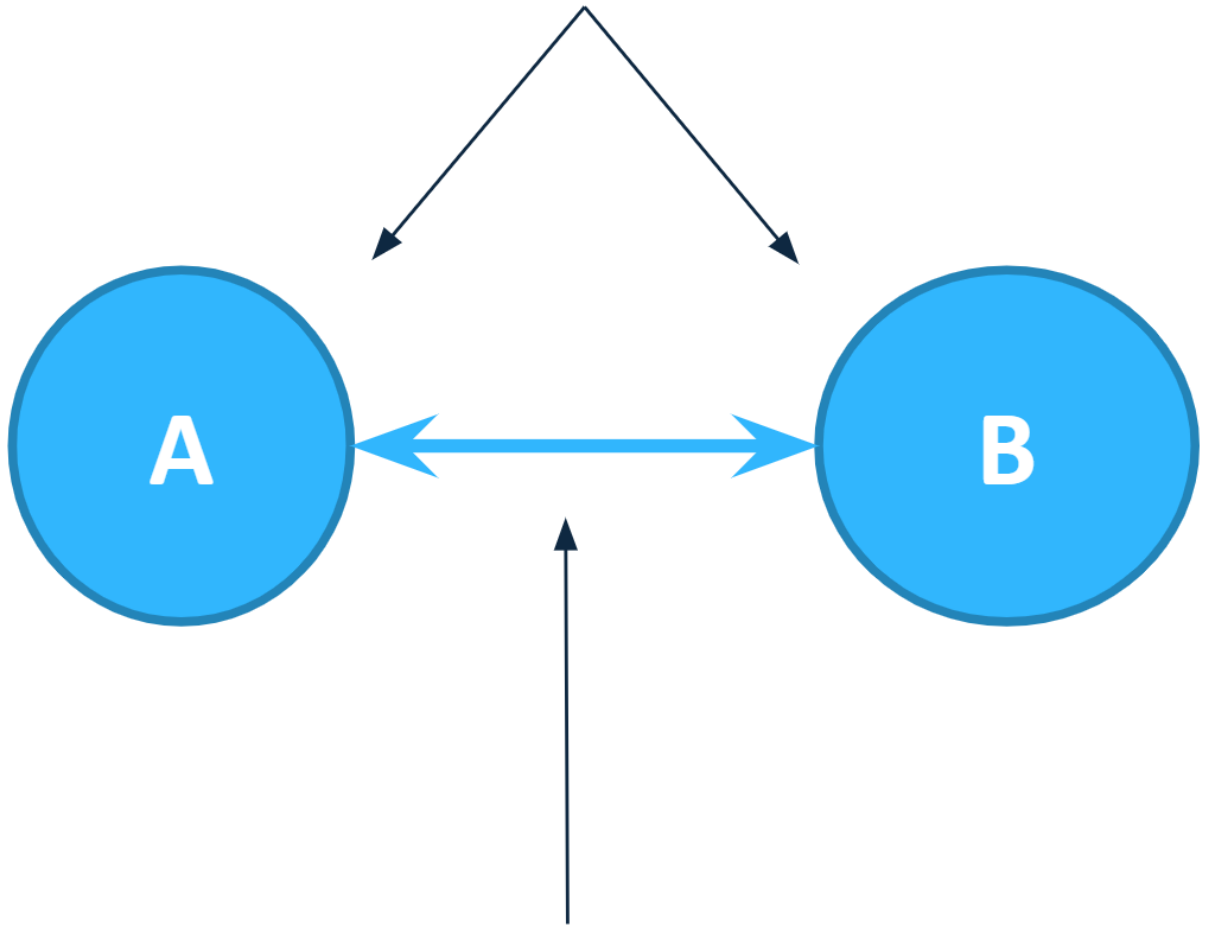
https://mbostock.github.io/d3/talk/20111116/force-collapsible.html

Of All Chart Types – Networks Describe Relationships



Nodes

entities in a network. “Stuff”



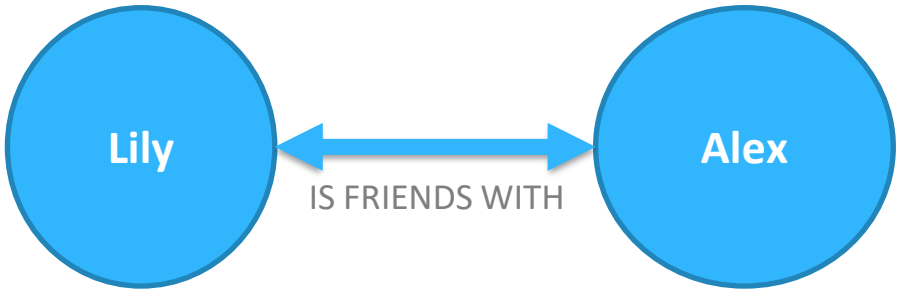
Edge

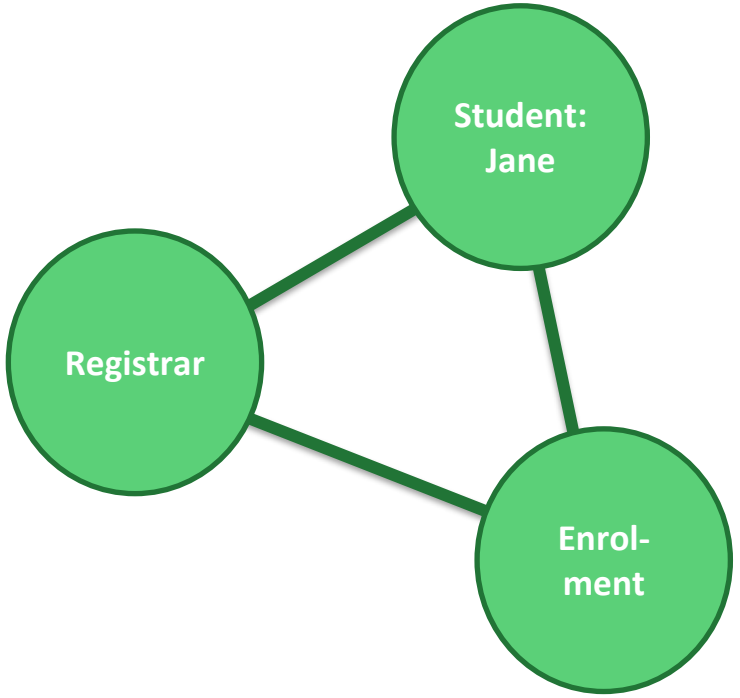
link, relationship, tie, connection

~~Network Diagram Workshop~~

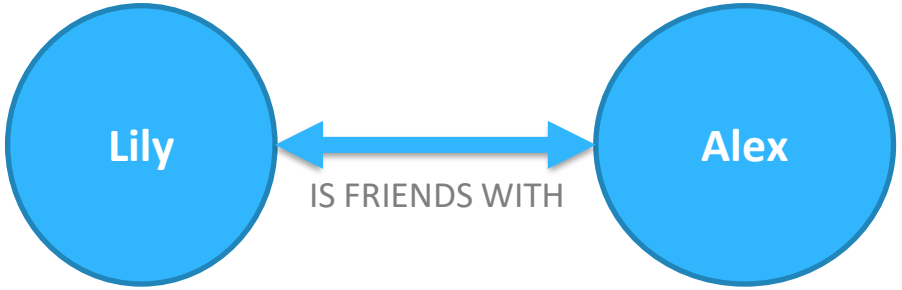
Visualizing Relationships Workshop

Examples of Relationships





Relationships



- Is made up of two (or more) things and the relation between them.
- The relationship is binary - it either exists or it does not.
  - To represent this, we must show the items in the relationship as well as the relationship itself.
- The relationship can also have attributes.

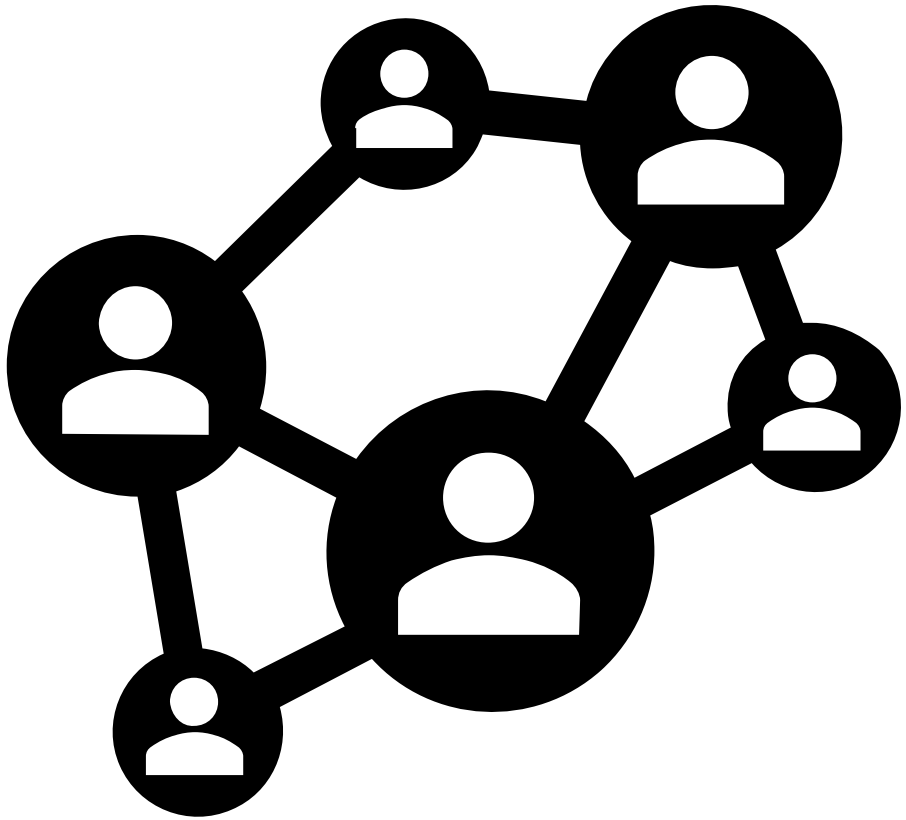
Types of Relations

Connection

Structure:

- Hierarchy
- Derived Form

Similarity



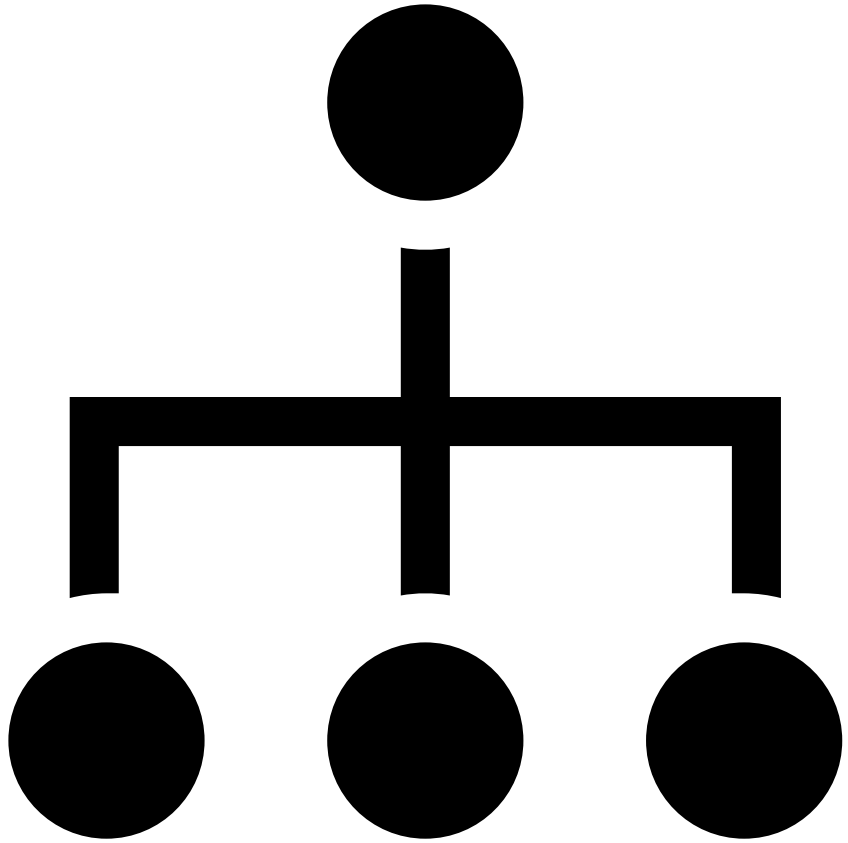
Types of Relations

Connection

Structure:

- **Hierarchy**
- Derived Form

Similarity



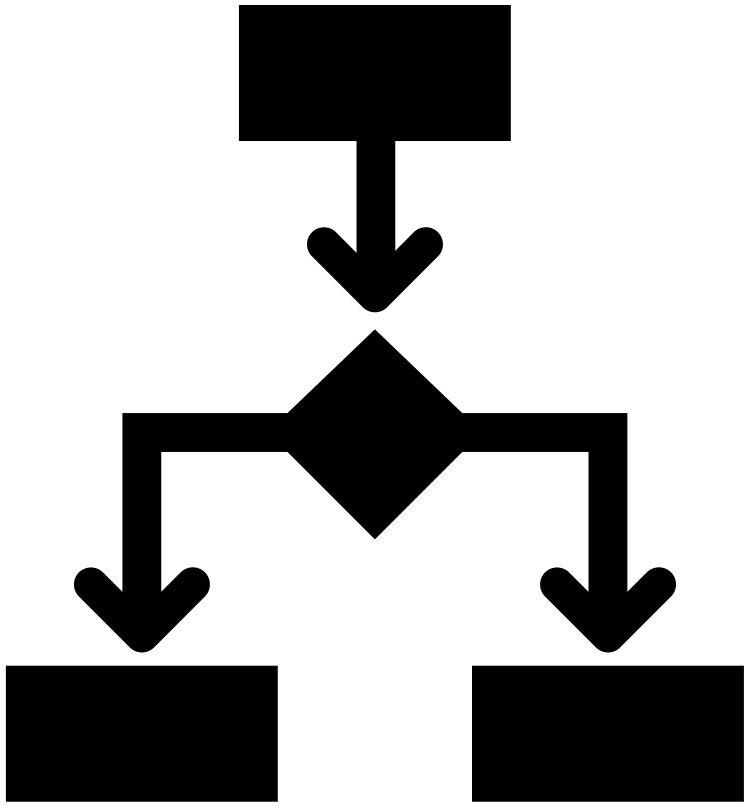
Types of Relations

Connection

Structure:

- Hierarchy
- **Derived Form**

Similarity



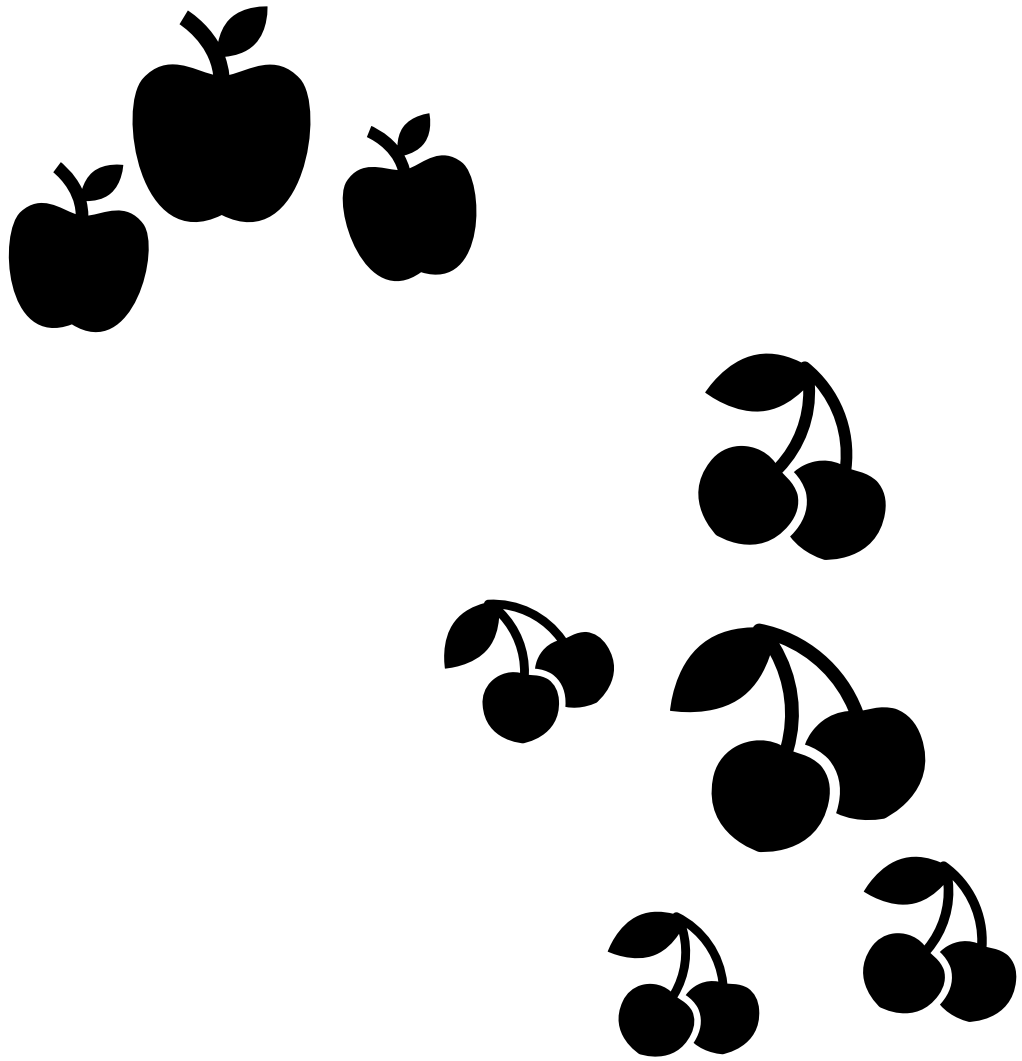
Types of Relations

Connection

Structure:

- Hierarchy
- Derived Form

Similarity



REPRESENTING RELATIONS

SYMBOLIC

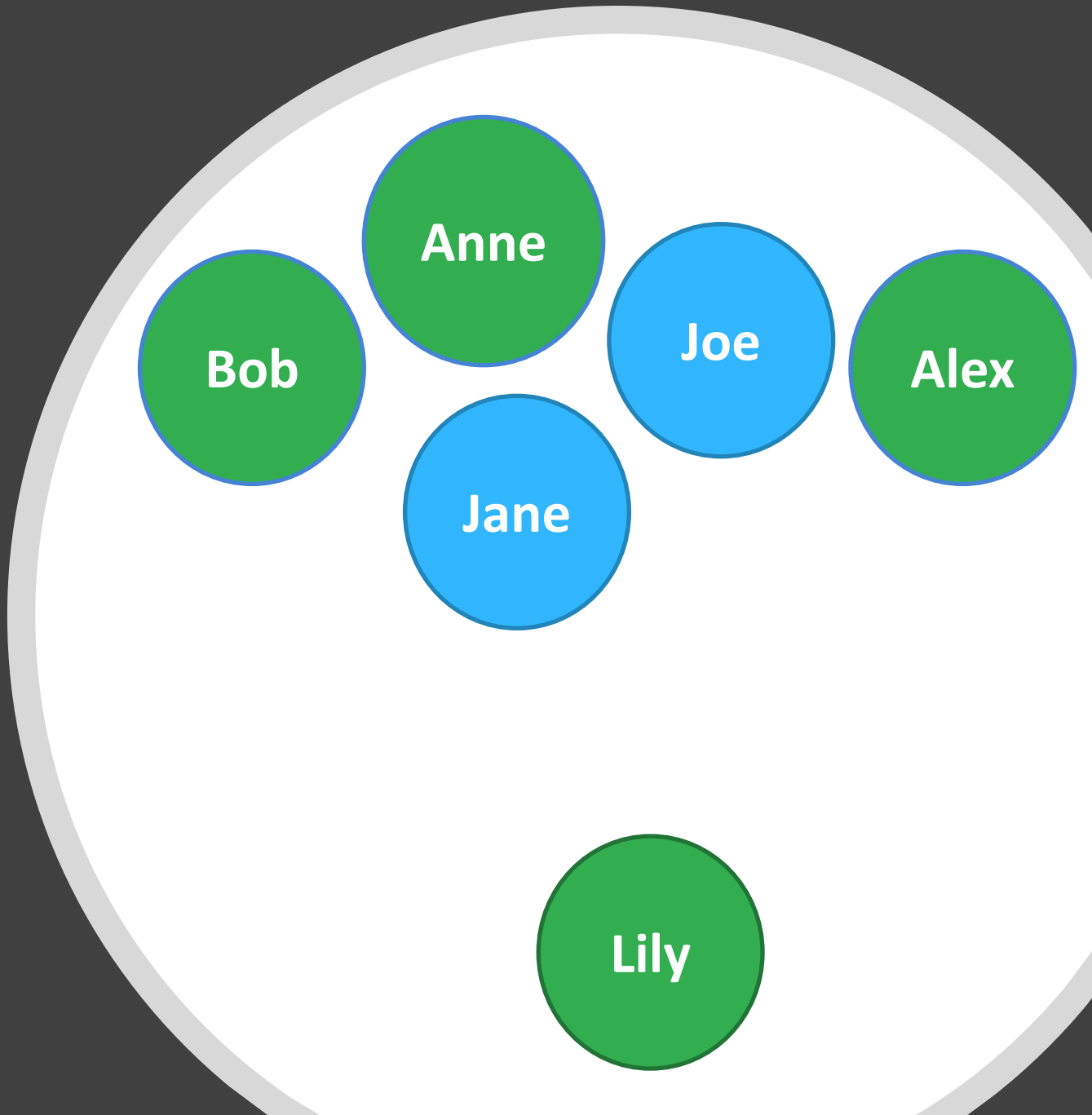
$$y = f(x)$$

REPRESENTING RELATIONS

SIMPLEST

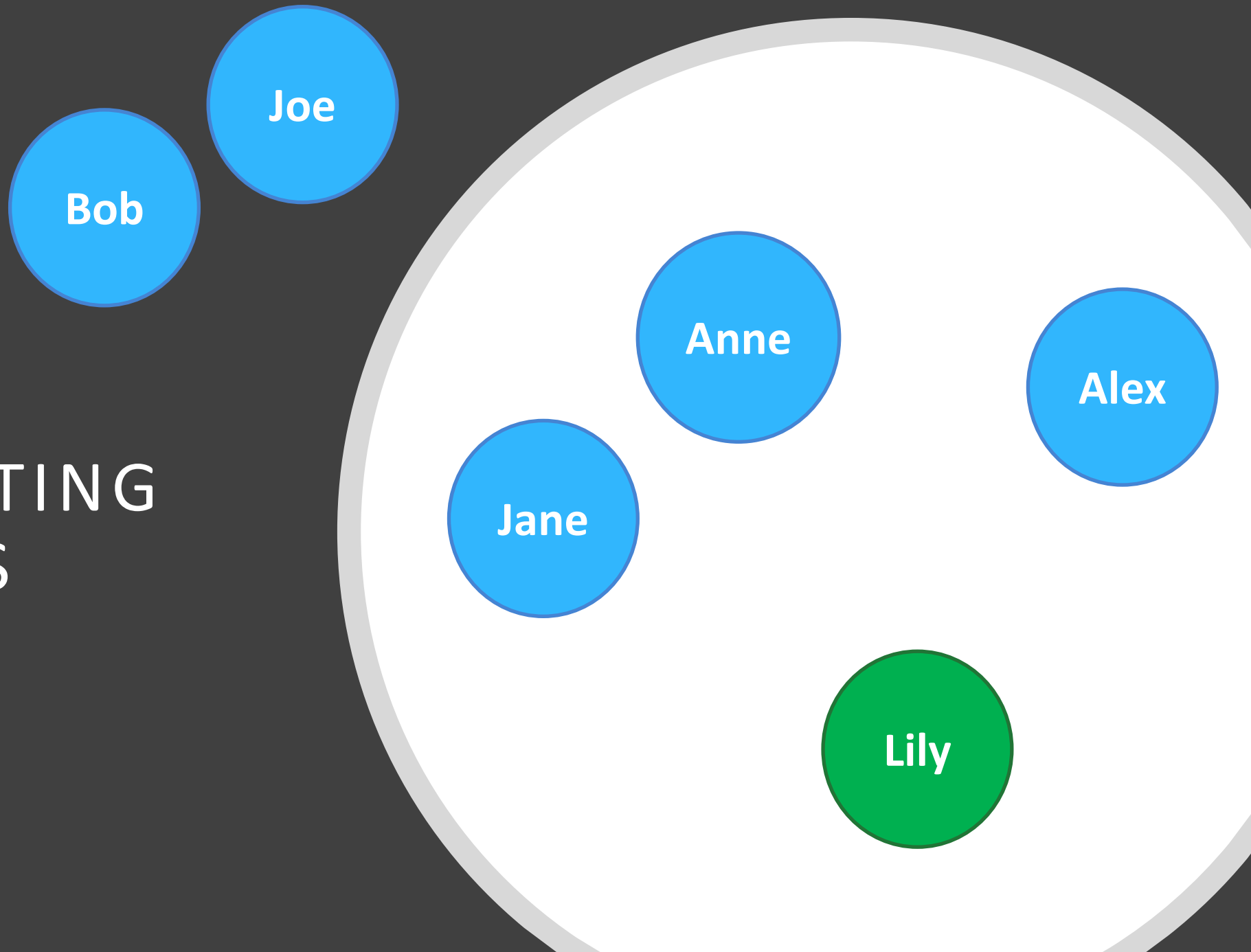
REPRESENTING RELATIONS

COLOUR



REPRESENTING RELATIONS

POSITION



ATTRIBUTES OF RELATIONS

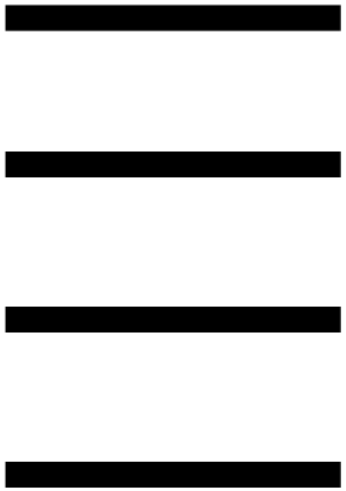
DIRECTIONALITY

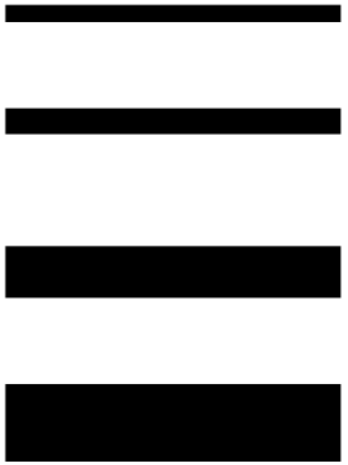
Undirected

Uni-directional

Bi-directional

WEIGHT



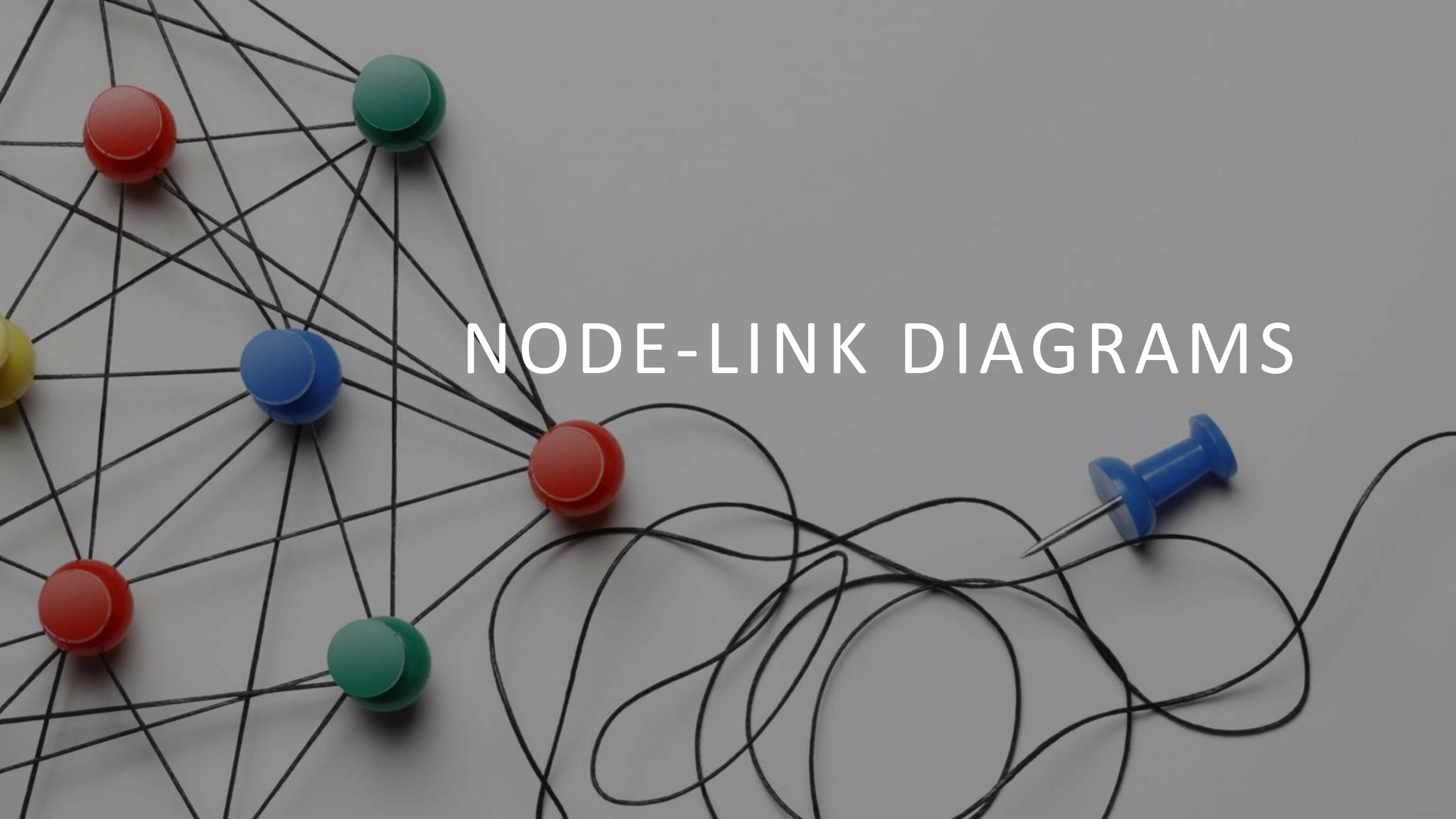


CATEGORY

CERTAINTY

NETWORK TERMS & MEASUREMENTS

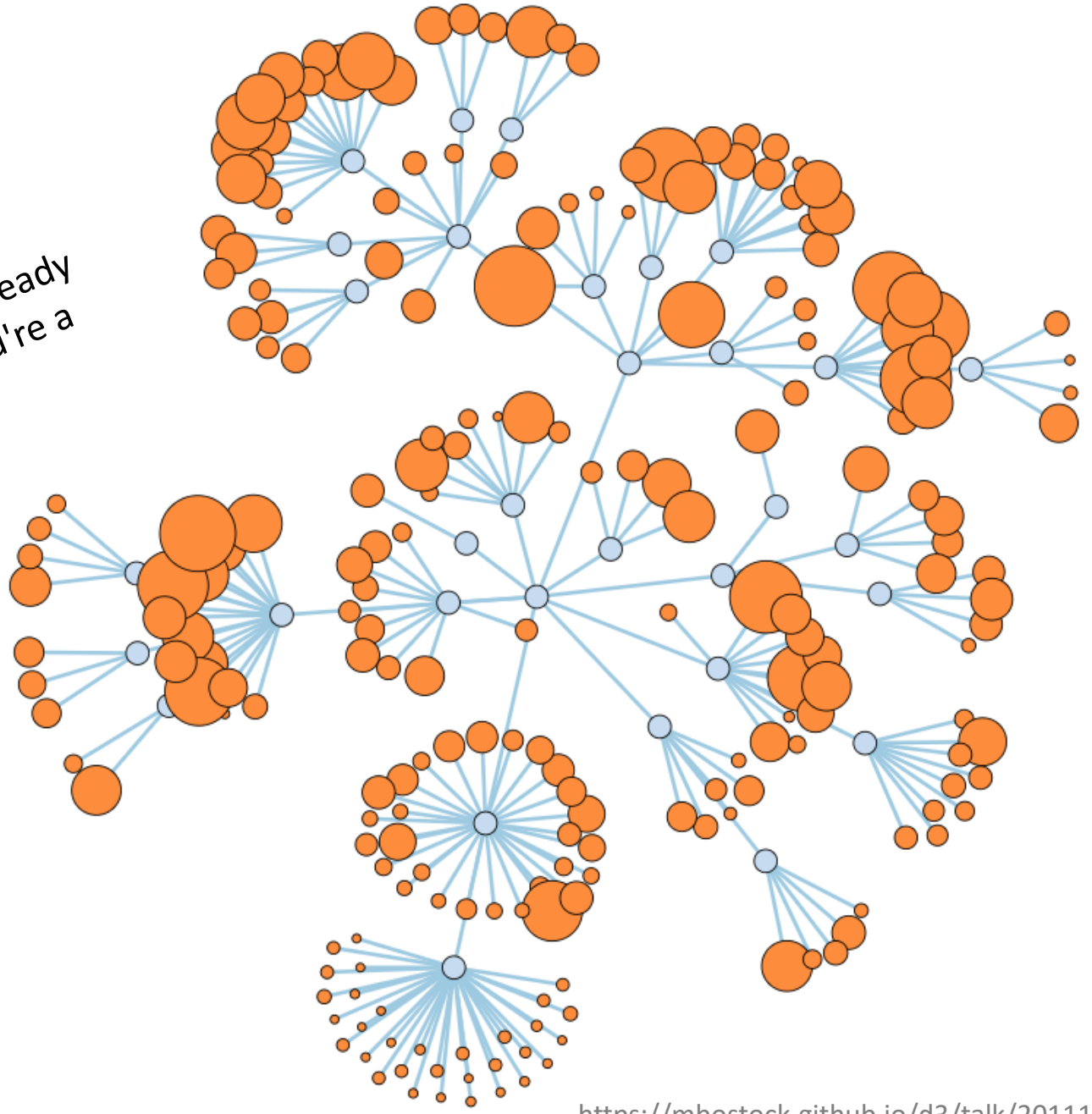
Degree	Number of edges connected to a node (in-degree & out-degree for directed networks).
Density	Number of edges in the network as a fraction of total possible edges.
Distance	The number of edges that exist in a path between nodes.
Tree	A hierarchical network with a root node.
Leaf	A node that is only connected to one other node.
Centrality	A node's importance. Can be measured in different ways: •**Degree**: edge count. •**Eigenvector**: how well connected the node is with other well connected nodes. •**Betweenness**: higher value for nodes that lie on a high proportion of paths between other nodes. •**Closeness**: Average of shortest path to all other nodes.



NODE-LINK DIAGRAMS

NODE-LINK

"When you think of a graph, you likely already think of a node-link diagram - unless you're a mathematician." Robert Kosara (2012)



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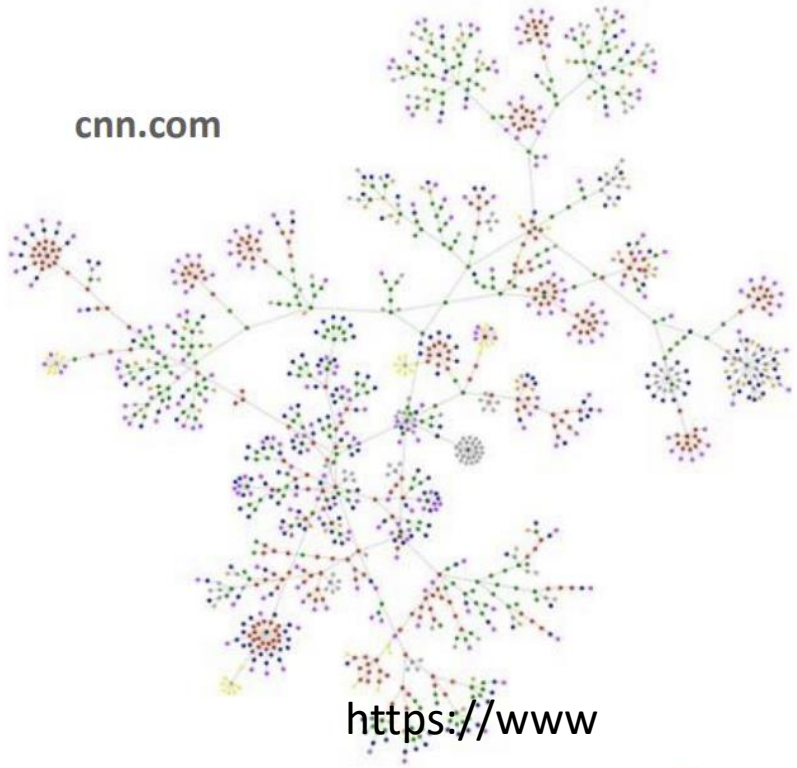
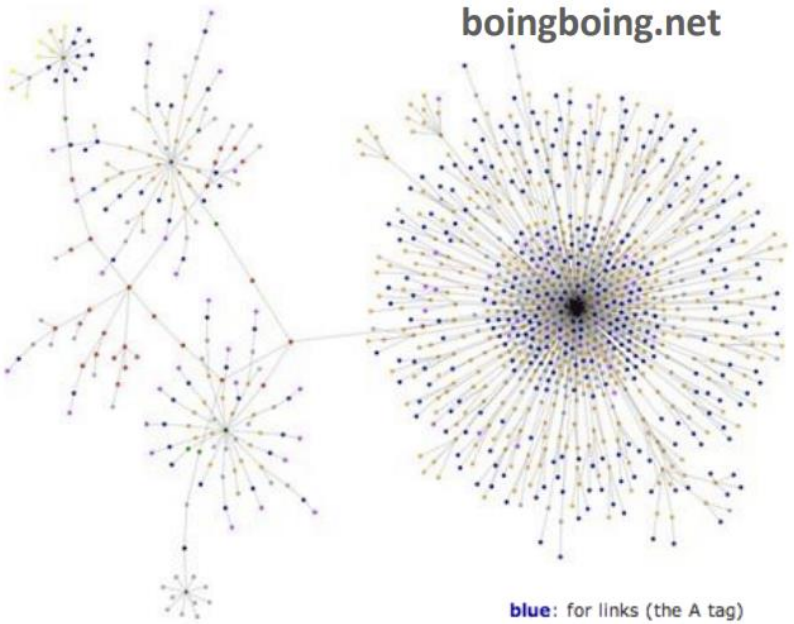
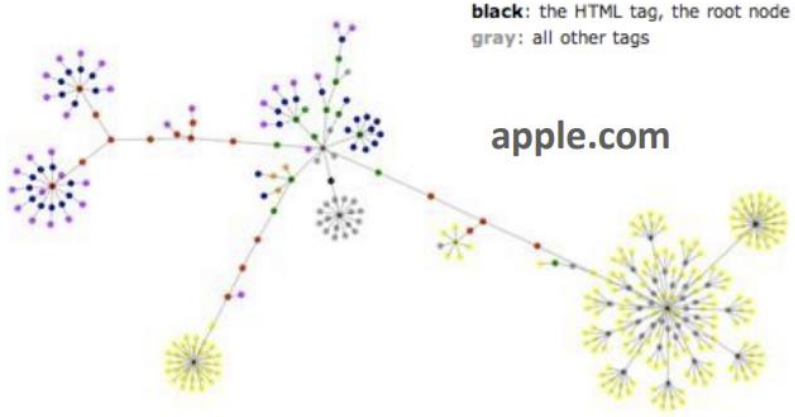




https://www

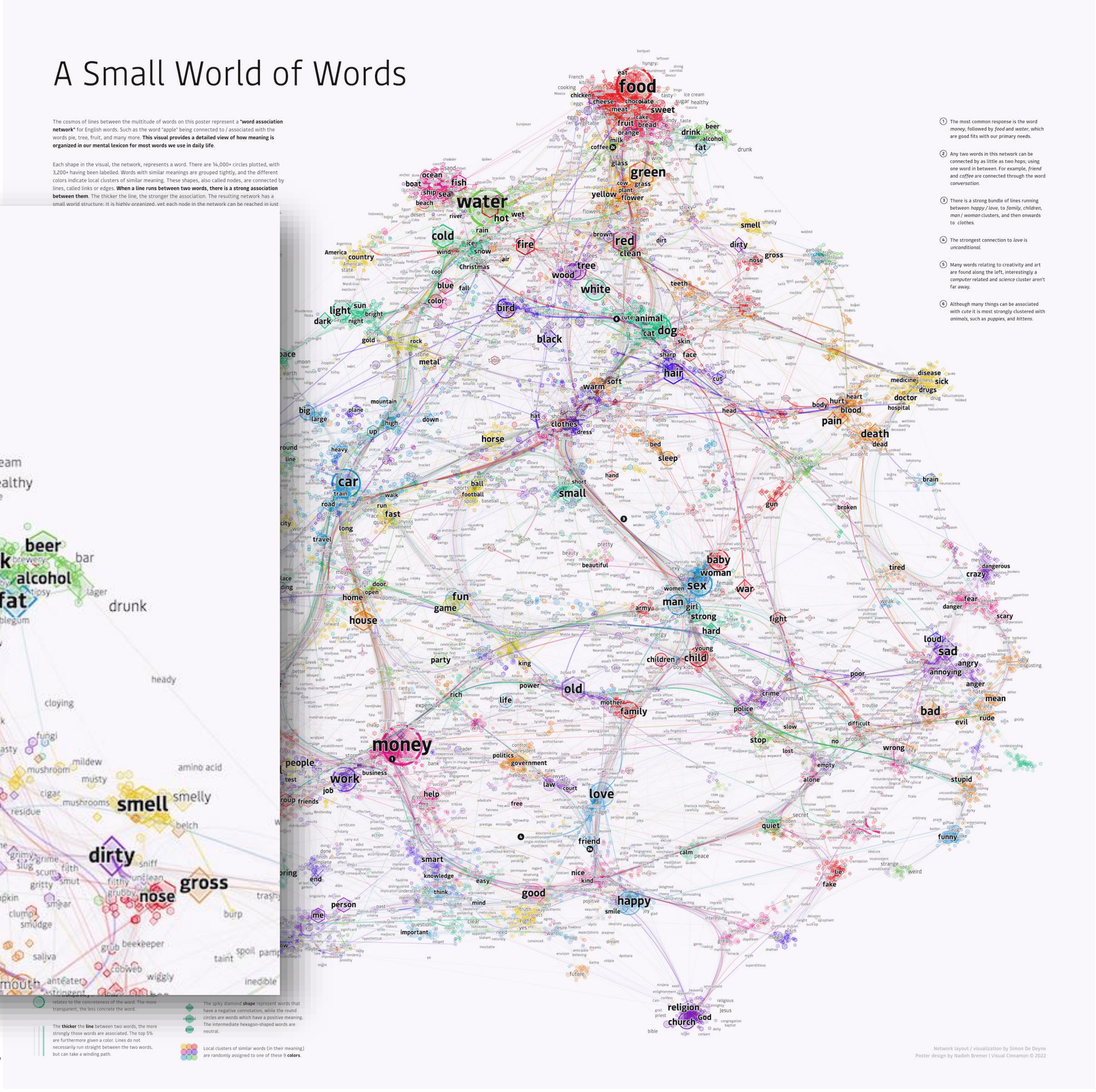
blue: for links (the A tag)
red: for tables (TABLE, TR and TD tags)
green: for the DIV tag
violet: for images (the IMG tag)
yellow: for forms (FORM, INPUT, TEXTAREA, SELECT and OPTION tags)
orange: for linebreaks and blockquotes (BR, P, and BLOCKQUOTE tags)
black: the HTML tag, the root node
gray: all other tags

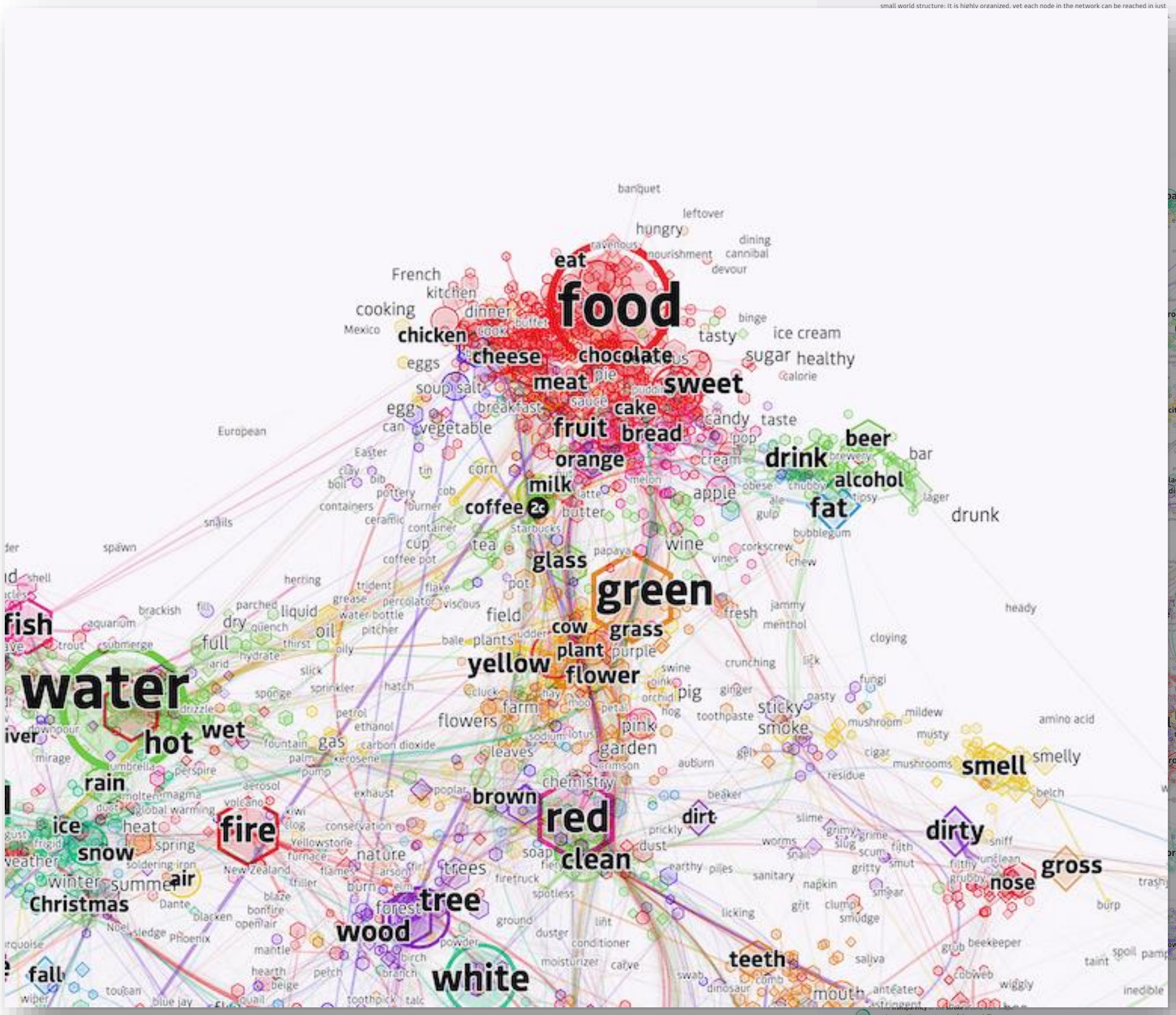


WEBPAGES AS GRAPHS
App by Marcel Salathe

Marcel Salathe - https://www.flickr.com/groups/websites_as_graphs/pool/with/267436177

This research project, led by Simon de Deyne, looks at how people associate words, asking for the first words that come to mind when presented by a specific word, such as “apple”.





Nadieh Bremer https://www.visualcinnamon.com/portfolio/small-world-of-words/

Sketching Exercise 1

Layout

Sketching Exercise 1 Layout

5 Nodes: A, B, C, D, E

In the table, each row describes an edge

Sketch an aesthetically pleasing node-link diagram of this network

A	B
C	D
C	B
A	D
A	C
B	D
D	E
A	E
D	D

Node & Link Aesthetics

What matters?

Node Metrics

- Distribute nodes evenly
- Separate nodes & edges

Edge Metrics

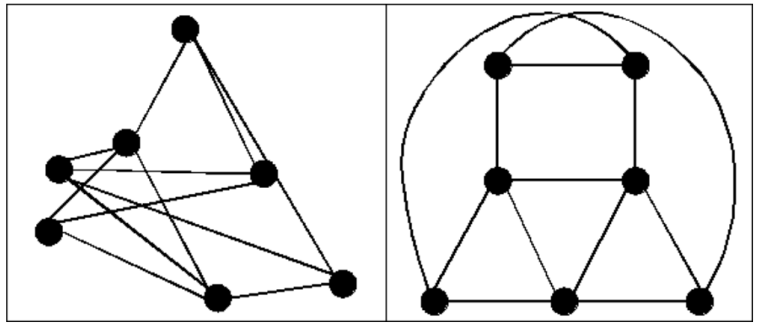
- Minimize crossings
- Uniform length
- Minimize bends / maximize orthogonality

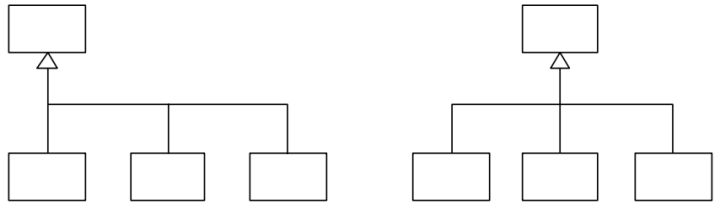
Symmetry

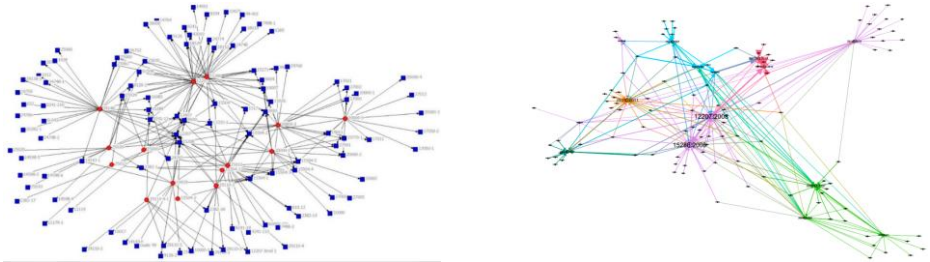
- Global and local

Centrality

- Highest degree nodes in middle
- Degree one nodes outside/surrounding
- Adjust edge length by node centrality







Hua J, Huang ML, Huang W, Zhao C. Applying Graph Centrality Metrics in Visual Analytics of Scientific Standard Datasets. *Symmetry*. 201

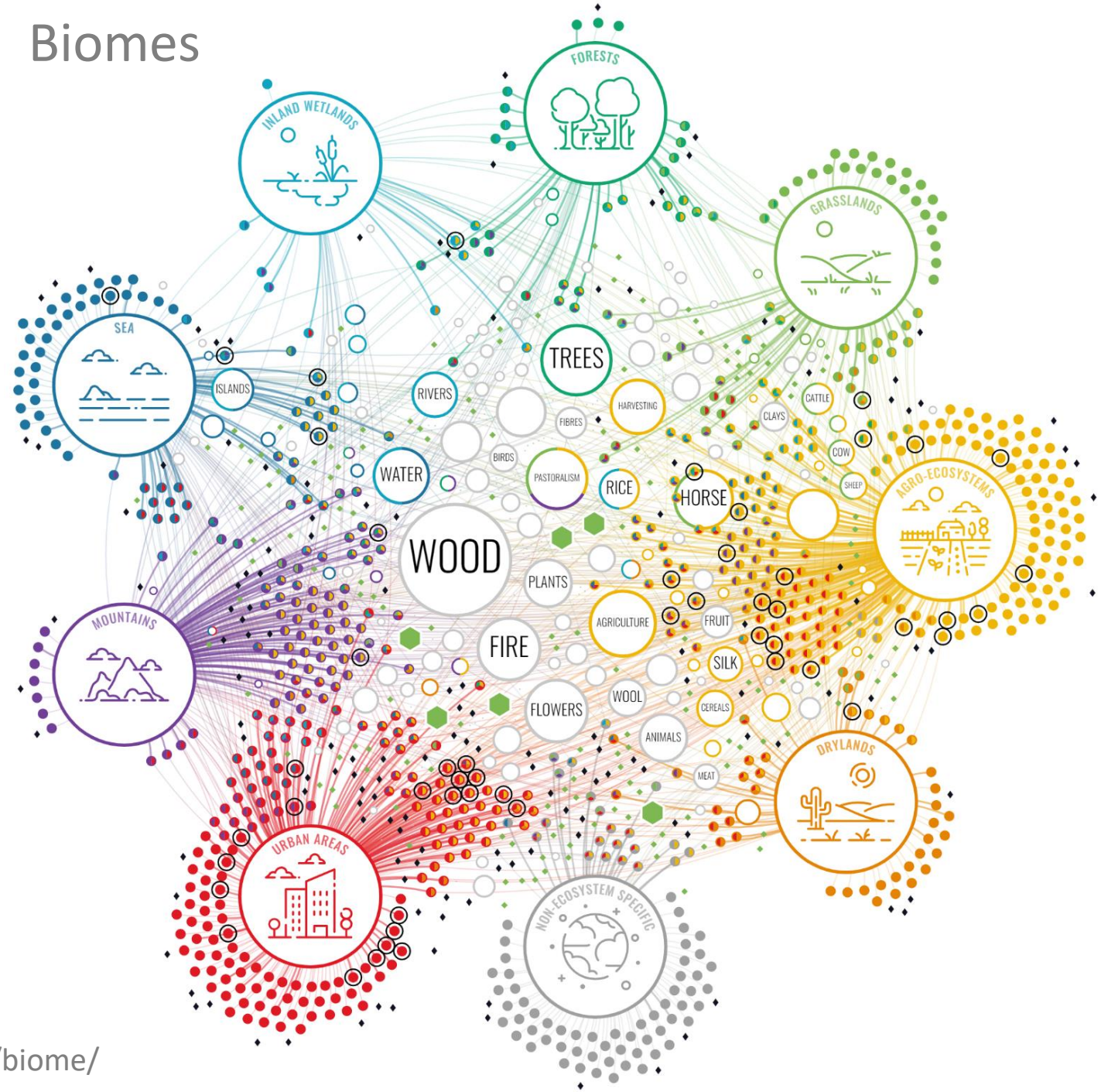
UNESCO Cultural Heritage

2000 elements (intangible cultural heritage items, countries, concepts, and more) and 15K connections between them.

4 network diagrams:

1. Main Constellation
2. Biomes Constellation
3. Domain visual
4. Threats visual.

Biomes



Nadiah Bremer & UNESCO https://ich.unesco.org/dive/biome/

Node & Link Layout

Isn’t that a simple problem?

- Battista et al. list more than **300** publications (1994)
- The Graph Drawing E-print Archives more than **800** publications (2013)

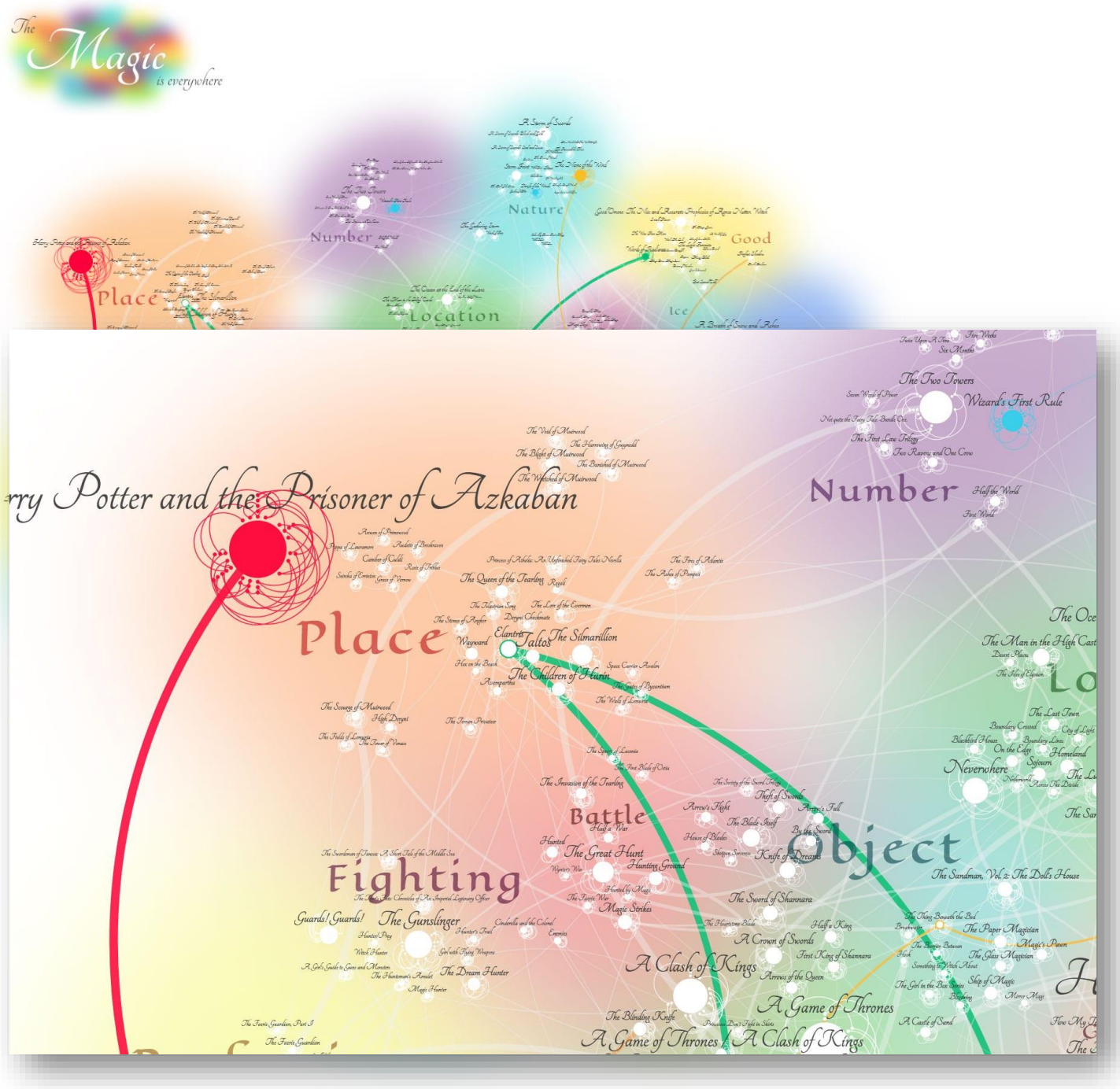
Whether intended or not, viewers will interpret spatial relationships:

- **proximity**: things that are closer are more similar/related
- **centrality**: things in the center are more relevant than those on the periphery
- **direction**: up is good, down is bad, and information flows horizontally (left to right in western cultures)

One Last Node-Link

Data is pulled from the titles of the books focusing on general subjects/terms, such as fire, royal, time, & more. These titles were clustered in a 2-dimensional plane, which placed books with similar themed titles together.

Authors are traced by coloured arcs. Although most authors appear to have their top-10 titles spread over the entire map below, some authors have a clear trend. Such as Charlaine Harris whose 10 books are all situated around death. On the other hand, J.R.R. Tolkien has his books spread from top to bottom.

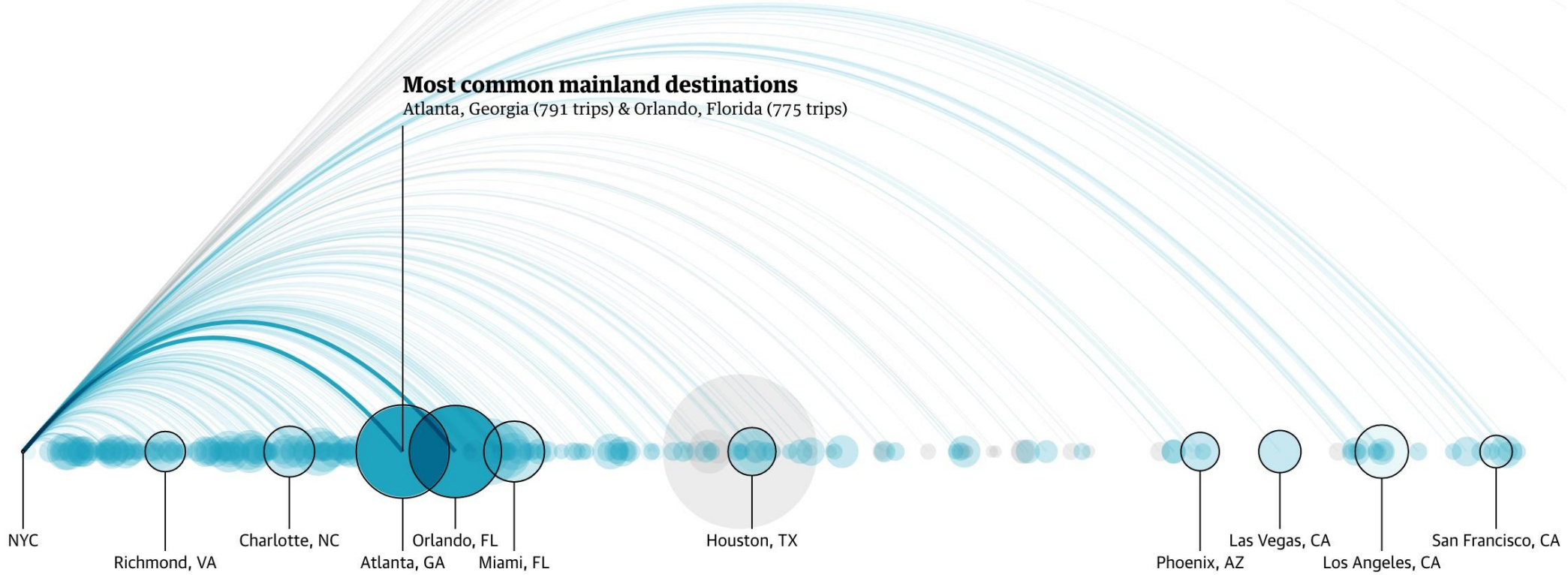


Nadieh Bremer https://magiciseverywhere.visualcinnamon.com/

LAYOUT: ARCS

Homeless relocations from New York City

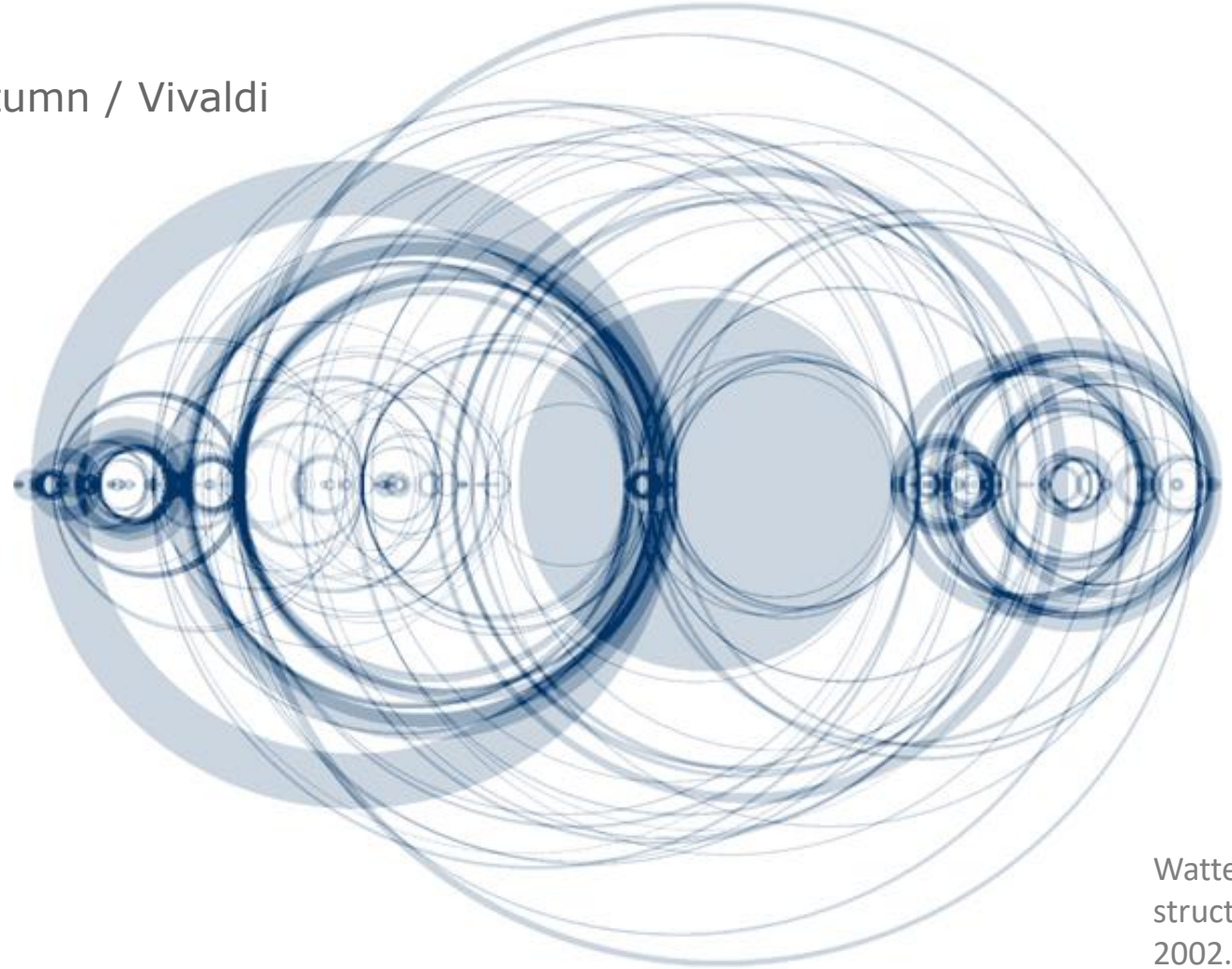
The most popular US mainland destinations were two cities in the South: Orlando, Florida, and Atlanta, Georgia.



https://www.theguardian.com/us-news/ng-interactive/2017/dec/20/bussed-out-america-moves-homeless-people-country-study

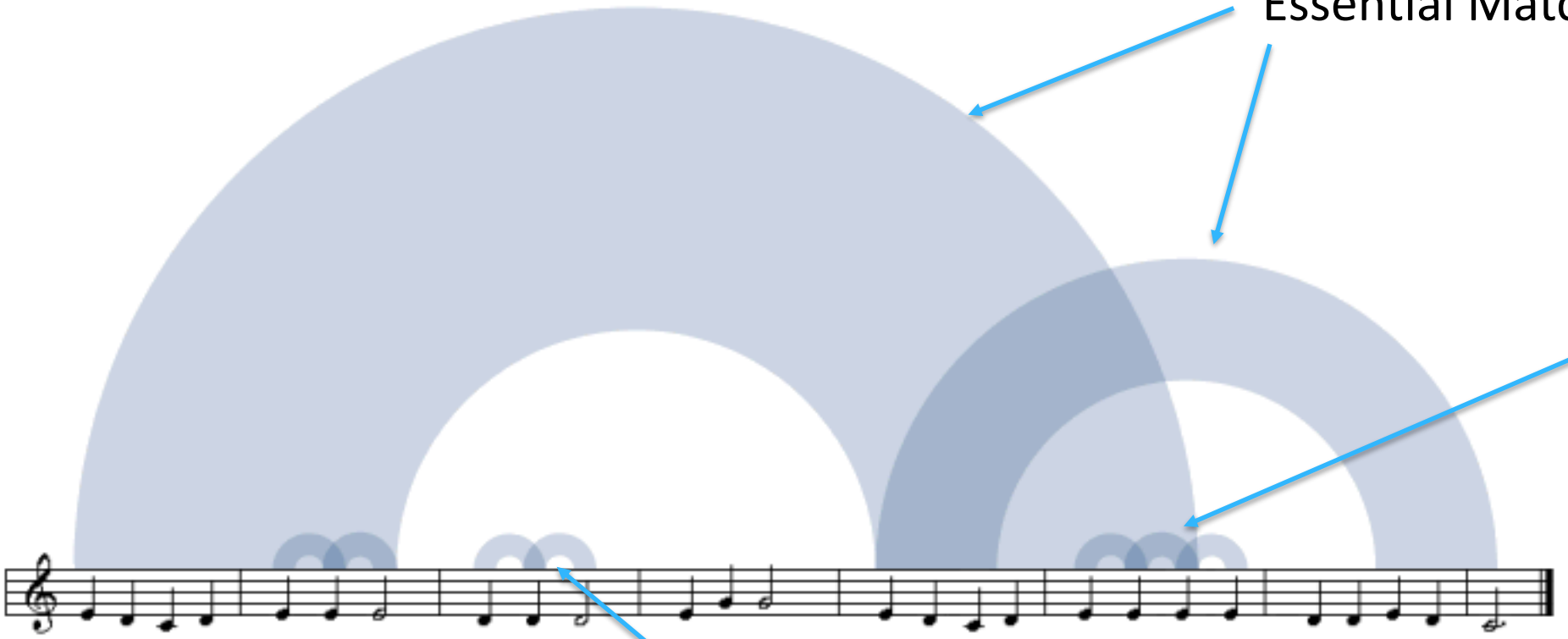
ARC DIAGRAMS

Four Seasons / Autumn / Vivaldi



Wattenberg, M., "Arc diagrams: visualizing structure in strings," Information Visualization, 2002. INFOVIS 2002. IEEE Symposium, 2002

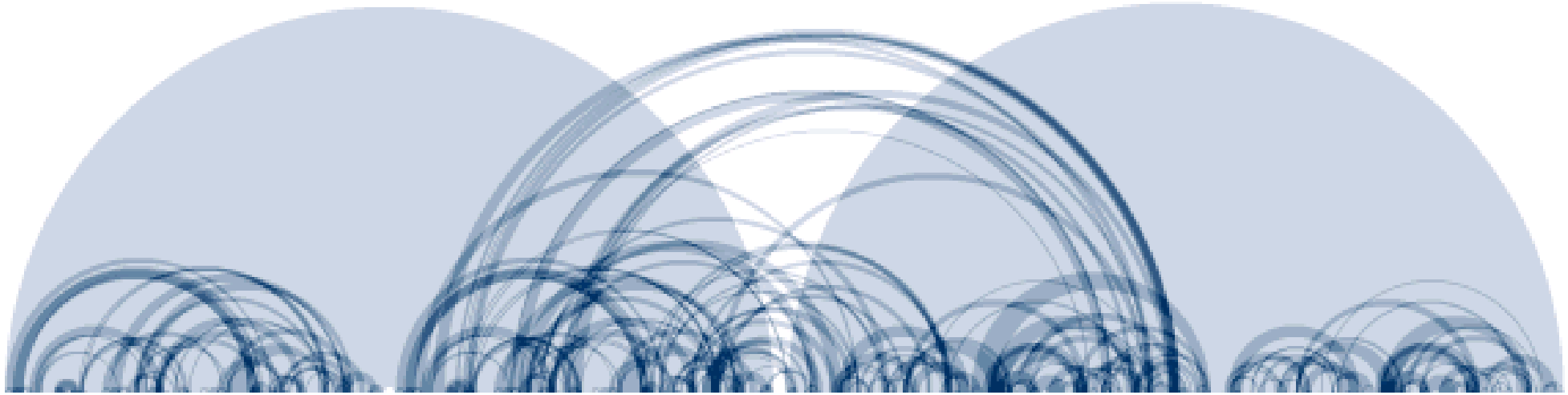
MUSIC – MARY HAD A LITTLE LAMB



https://www.turbulence.org/Works/song/method/method.html

Wattenberg, M., "Arc diagrams: visualizing structure in strings," Information Visualization, 2002. INFOVIS 2002. IEEE Symposium, 2002

MUSIC – GOLDBERG VARIATIONS



This diagram represents one of the Goldberg Variations.

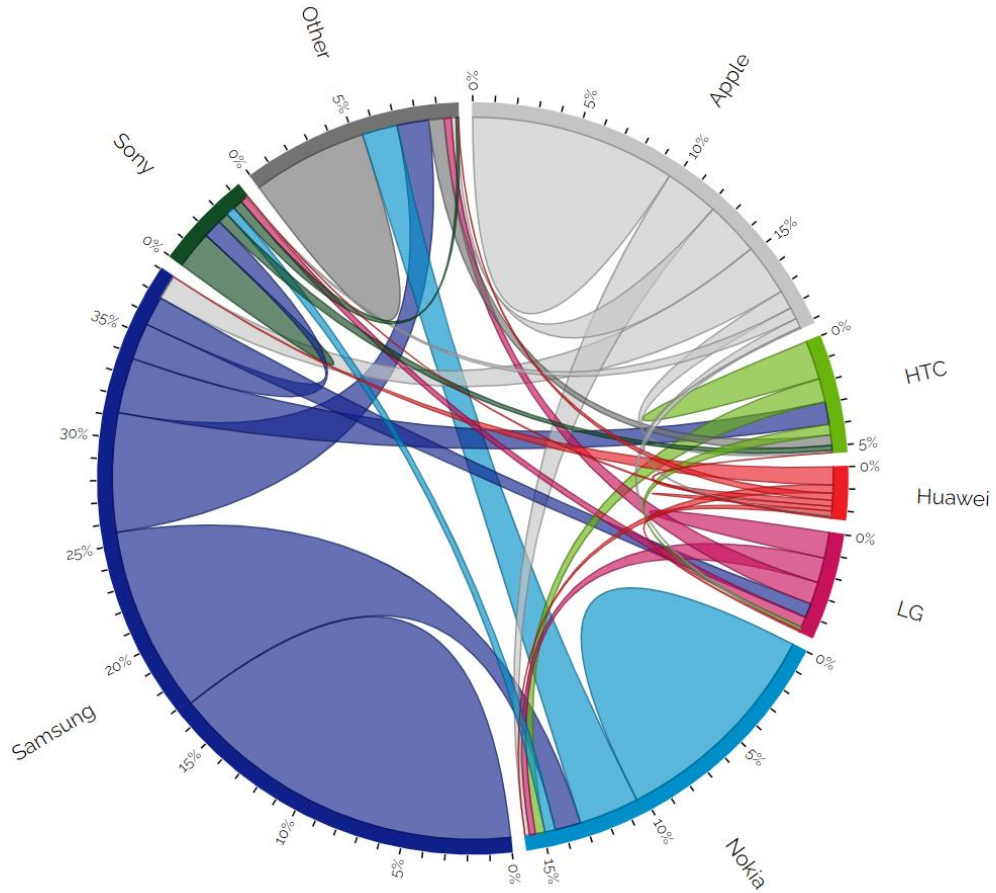
It shows that the piece divides into two main parts, each made of a long passage played twice--or what a musician would call an "AABB" structure.

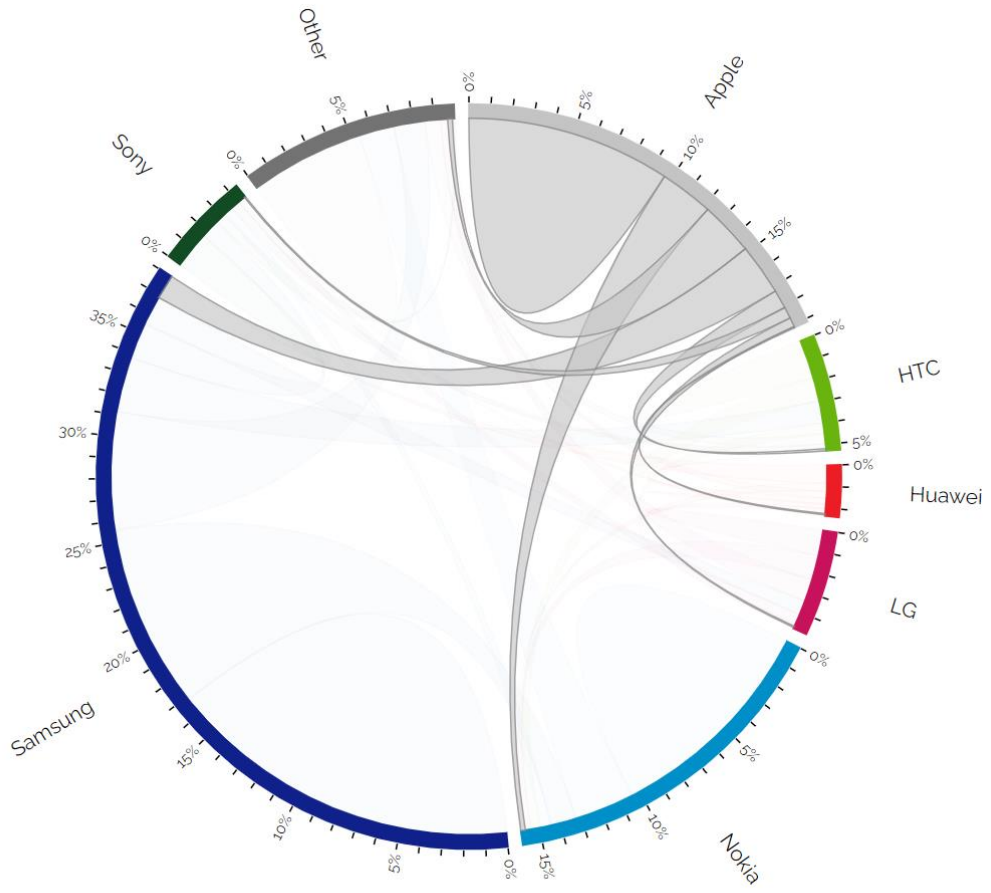
The diagram, however, provides much more detailed information than the simple "AABB" notation. For instance, you can see that the A and B passages are loosely related, as shown by the bundle of thin arcs connecting the two halves of the piece.

https://www.turbulence.org/Works/song/method/method.html

Wattenberg, M., "Arc diagrams: visualizing structure in strings," Information Visualization, 2002. INFOVIS 2002. IEEE Symposium, 2002

Layout: Chord Diagram

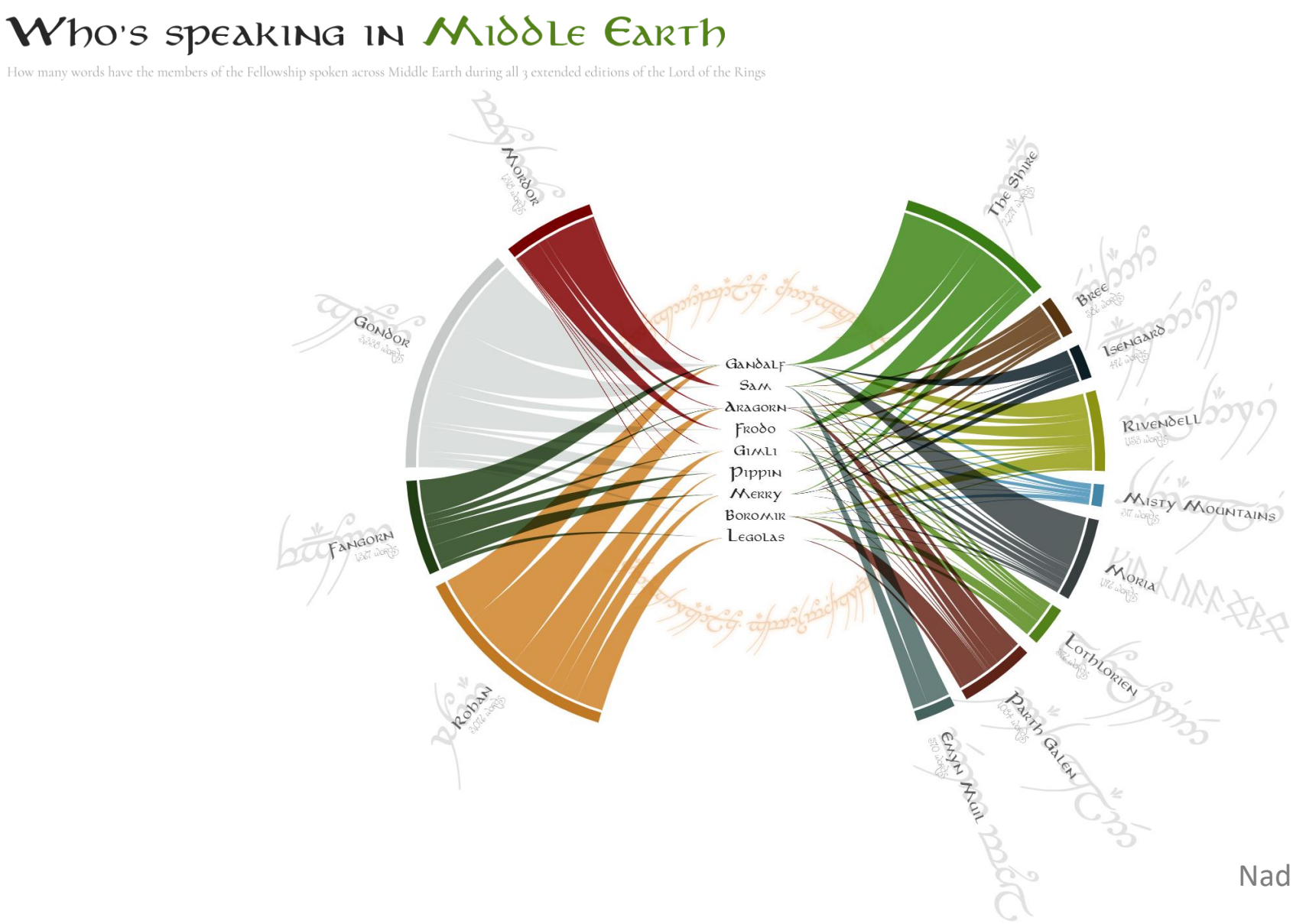




The Deloitte Global Mobile Consumer Survey asked 2000 residents of the Netherlands about the brand of their current phone and the brand of their previous main phone.

https://www.visualcinnamon.com/portfolio/phone-brand-switching/

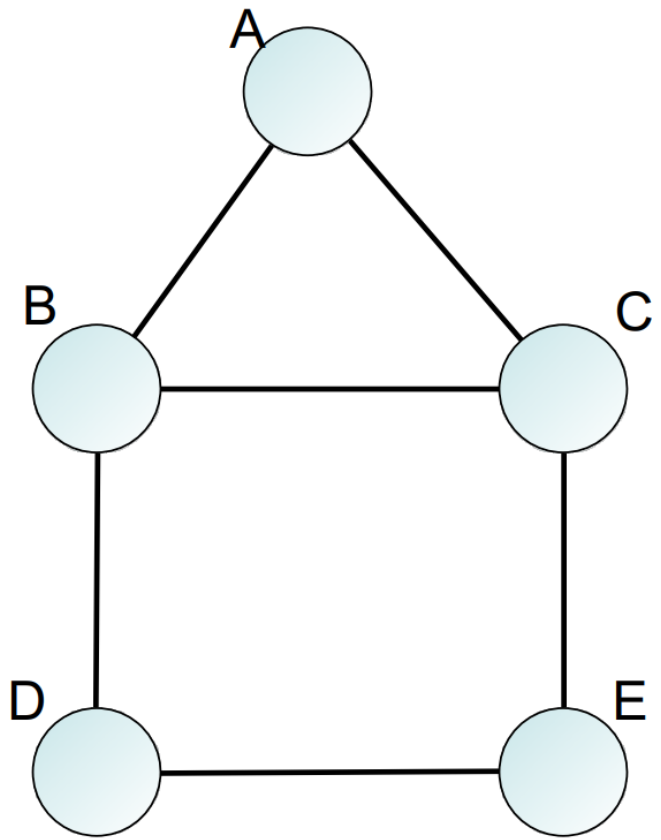
Layout: Chord Diagram



In this visualization you can find out how many words each character has spoken at each general location throughout the Lord of the Rings movies.

Nadiah Bremer https://lotr.visualcinnamon.com/

Layout: Adjacency Matrix

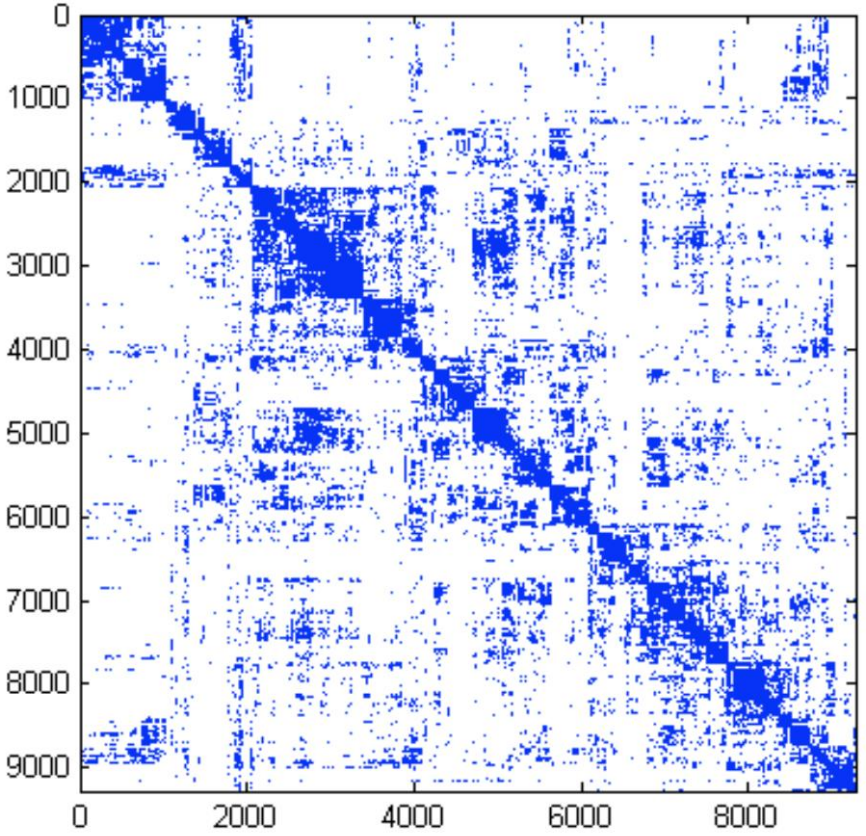


	A	B	C	D	E
A		■	■		
B	■		■	■	
C	■	■			■
D		■			■
E			■	■	

Layout: Adjacency Matrix

+ Great for dense graphs
+ Visually scalable
+ Spot clusters

- Row order has strong effect
- Abstract, more challenging to understand
- Hard to follow paths



Other Layouts

Orthogonal

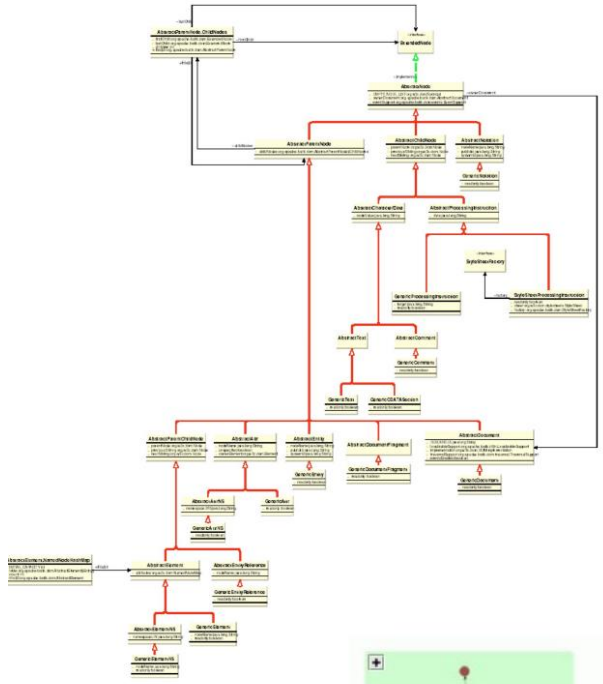
- provides structure to help avoid crossed edges
- hard to do algorithmically

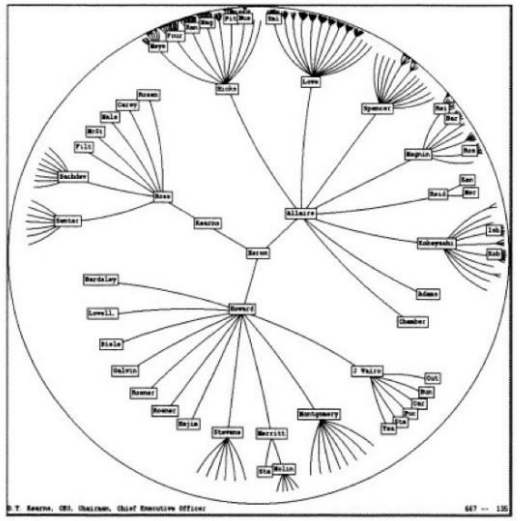
Hyperbolic

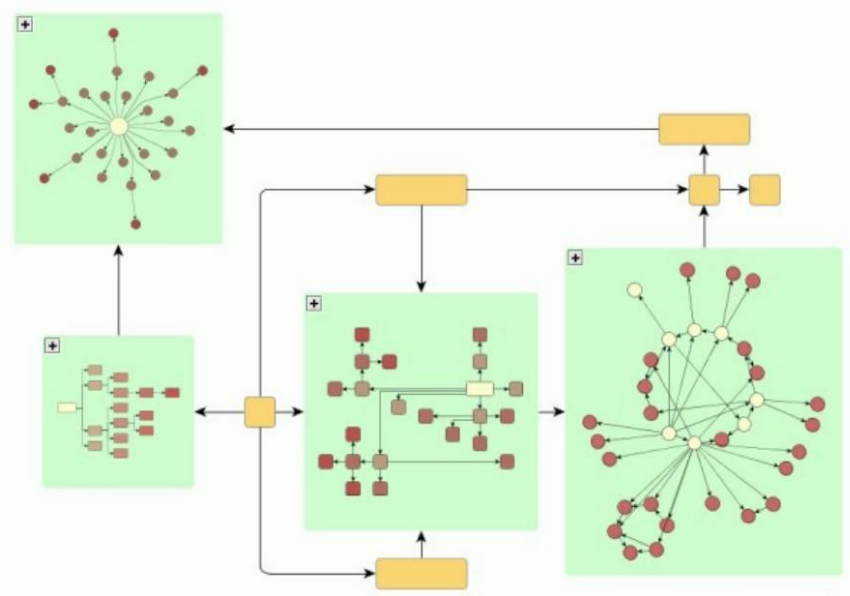
- Interactive, provides focus + context

Nested Layouts

- break graphs into smaller pieces/clusters
- great for hierarchies







Sketching Exercise 2

Edge Properties

Sketching Exercise 2 Edge Properties

Nodes and Node Attributes

Author (# papers)

Carolina (6),

Miriah (42)

Alex (36),

Sean (8),

Marc (40)

Nils (51),

Silvia (110)

Links and Link Attributes

Co-author, co-author - # joint papers

Carolina, Alex - 2

Sean, Miriah - 7

Miriah, Alex - 2

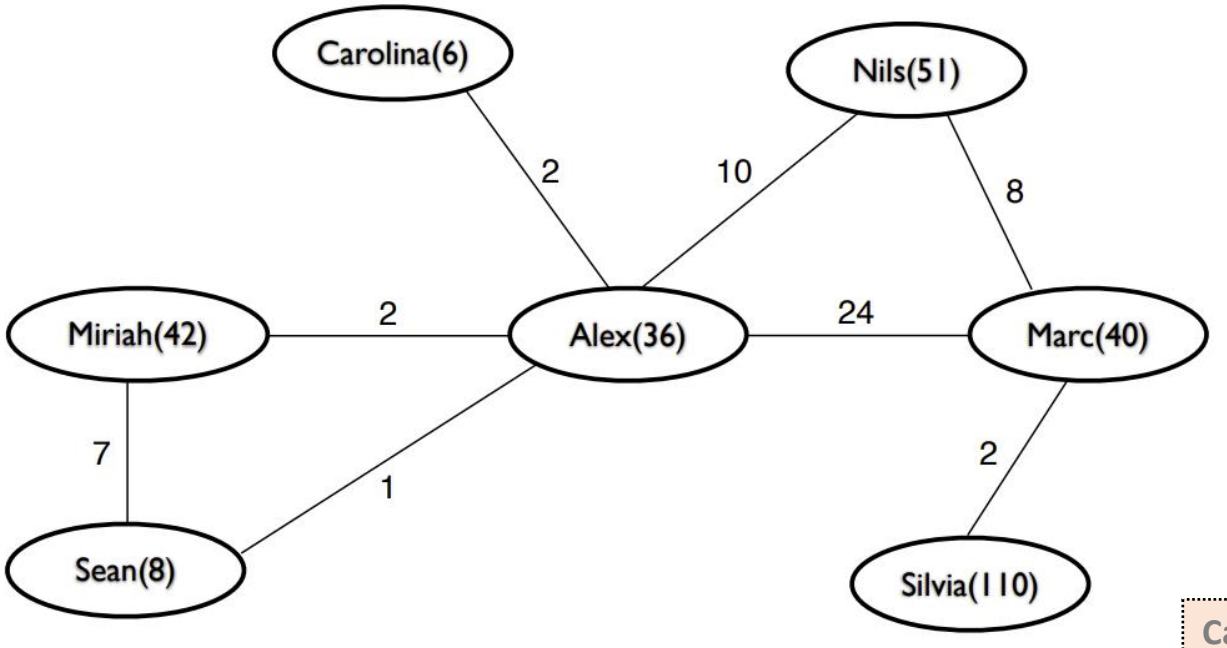
Alex, Sean - 1

Alex, Nils - 10

Alex, Marc - 24

Marc, Silvia - 1

Marc, Nils - 8



	Carolina 6	Miriah 42	Alex 36	Sean 8	Marc 40	Nils 51	Silvia 110
Carolina 6			2				
Miriah 42			2	6			
Alex 8	2	2		1	14	10	
Sean 8		7	1				
Marc 40			14			8	1
Nils 51			10		8		
Silvia 110					1		

Cytoscape Tutorial

Creating a Network Diagram with Software

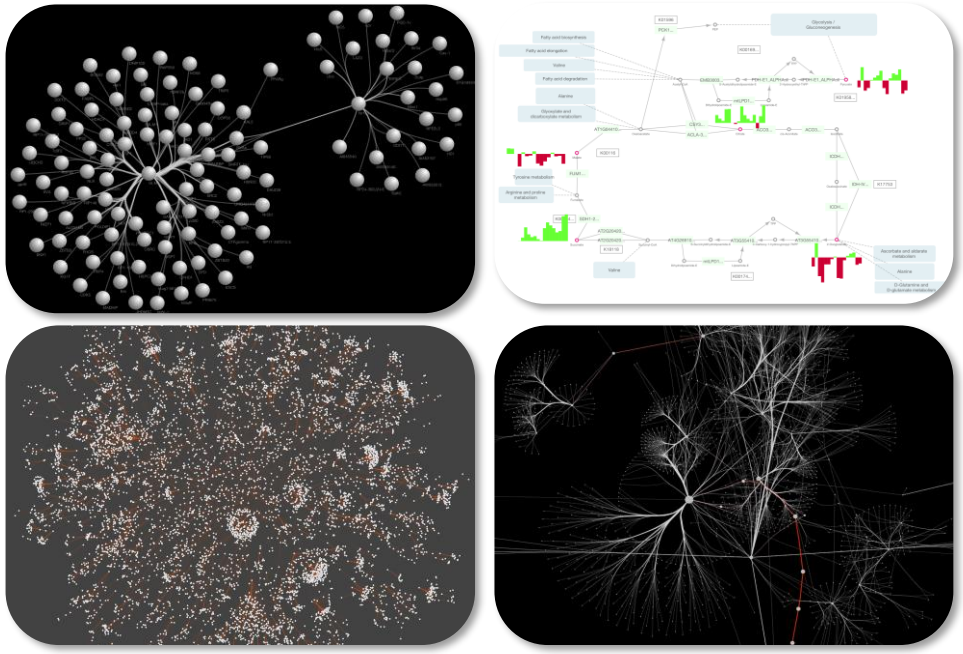
Tools for Creating Graphs (& Trees)

Applications / Webapps	*Gephi*, *Cytoscape*, *Circos*, *NanoHistory*, *Onodo*
Drawing Tools	*Powerpoint, MS Visio, Miro, Adobe Illustrator*
Code Libraries	*D3*, *ggraph*, *p5.js*, *Cytoscape.js*, *sigma.js*, *tldraw*, *Raphael*, *grano*
Treemaps	*Tableau*, *PowerBI*, *Flourish*, *Datawrapper*

* This is a very small selection of the many tools out there, keep searching if these don't meet your needs.

Cytoscape

Network Data Integration, Analysis, and Visualization in a Box



- Open source software for visualizing networks
- Created for bioinformatics and molecular profiling
- Sister-project cytoscape.js, javascript library for showing and interacting with networks online
  - Can create a network diagram in Cytoscape, then export to Cytoscape.js via JSON for an interactive, web version

https://cytoscape.org/

Data Files

Edge Data

Many possible formats:

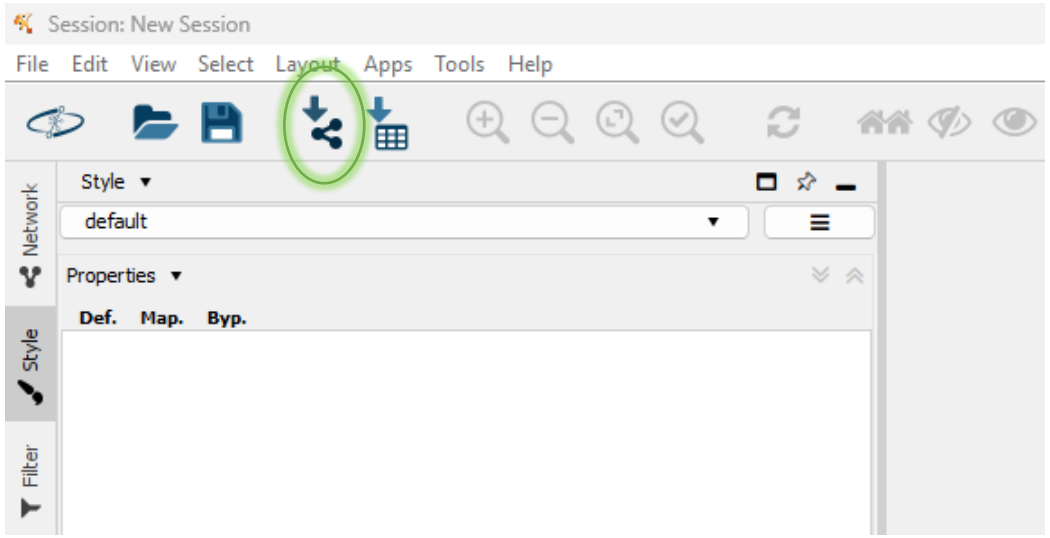
csv, tsv, txt, json, xlsx, xml + more

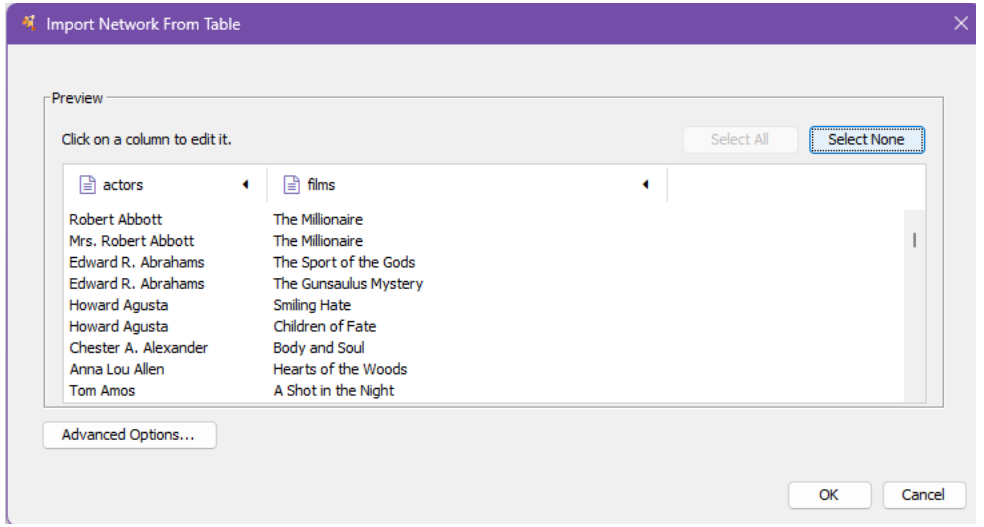
Download and use
edgelist.csv
from brosz.ca/slides

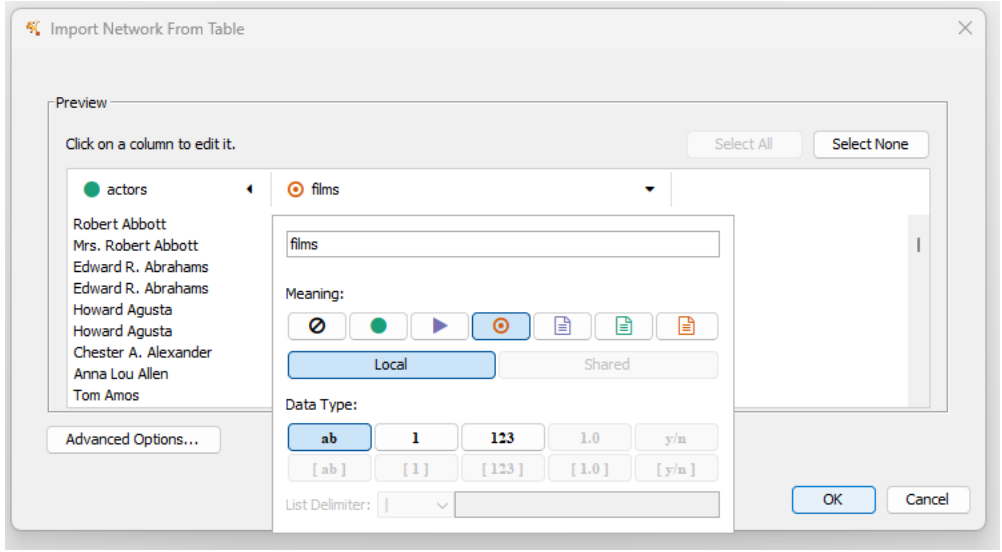
actors	films
Robert Abbott	The Millionaire
Mrs. Robert Abbott	The Millionaire
Edward R. Abrahams	The Sport of the Gods
Edward R. Abrahams	The Gunsaulus Mystery
Howard Agusta	Smiling Hate
Howard Agusta	Children of Fate
Chester A. Alexander	Body and Soul
Anna Lou Allen	Hearts of the Woods
Tom Amos	A Shot in the Night
Charles H. Anderson	Uncle Remus' First Visit to New York
Mrs. Charles H. Anderson	Uncle Remus' First Visit to New York
Ida Anderson	Deceit
Ida Anderson	A Son of Satan
Ida Anderson	The Secret Sorrow
Ida Anderson	Gayety
Ida Anderson	Ghost of Tolson's Manor
A.E Anson	Arrowsmith
Emmett Anthony	A Son of Satan
Emmett Anthony	Ghost of Tolson's Manor
Jean Armour	The Sport of the Gods
Billy Arnett	The Fall of the Mighty
Grace Arnett	The Fall of the Mighty

Tutorial based from https://miriamposner.com/classes/dh201w19/tutorials-guides/network-analysis/create-a-network-graph-with-cytoscape/

Load Edges

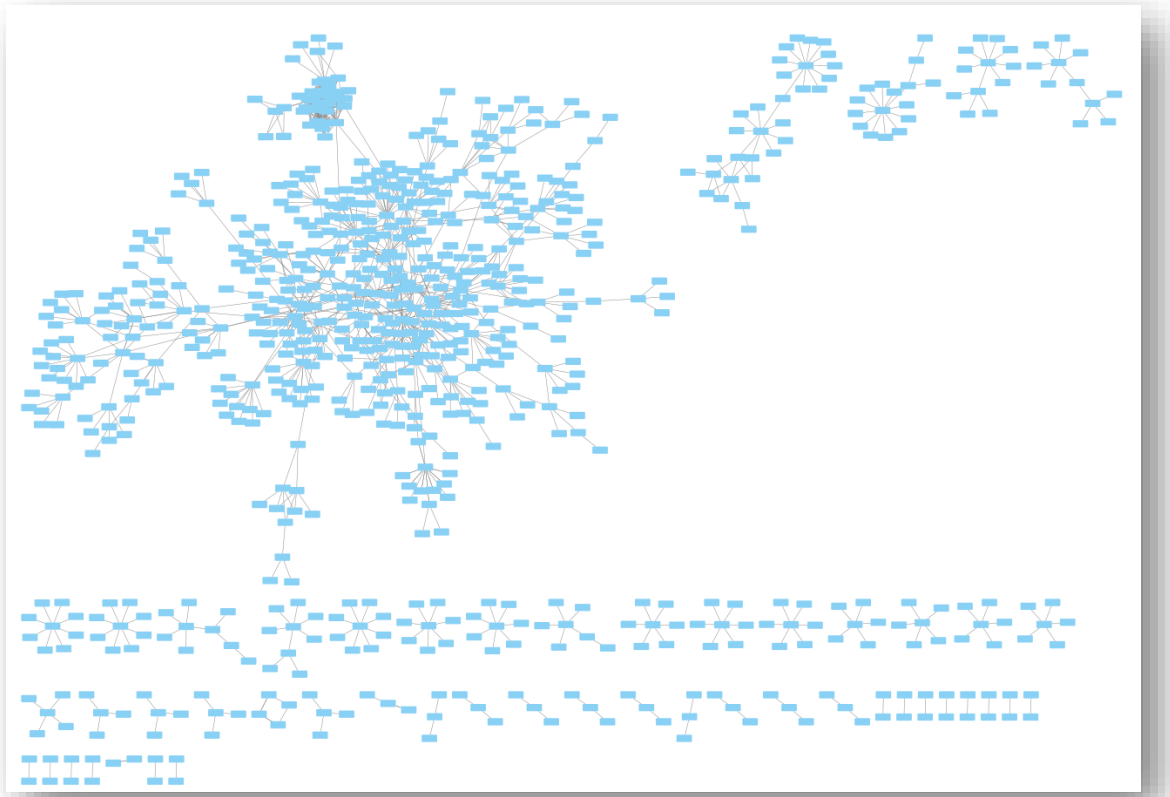




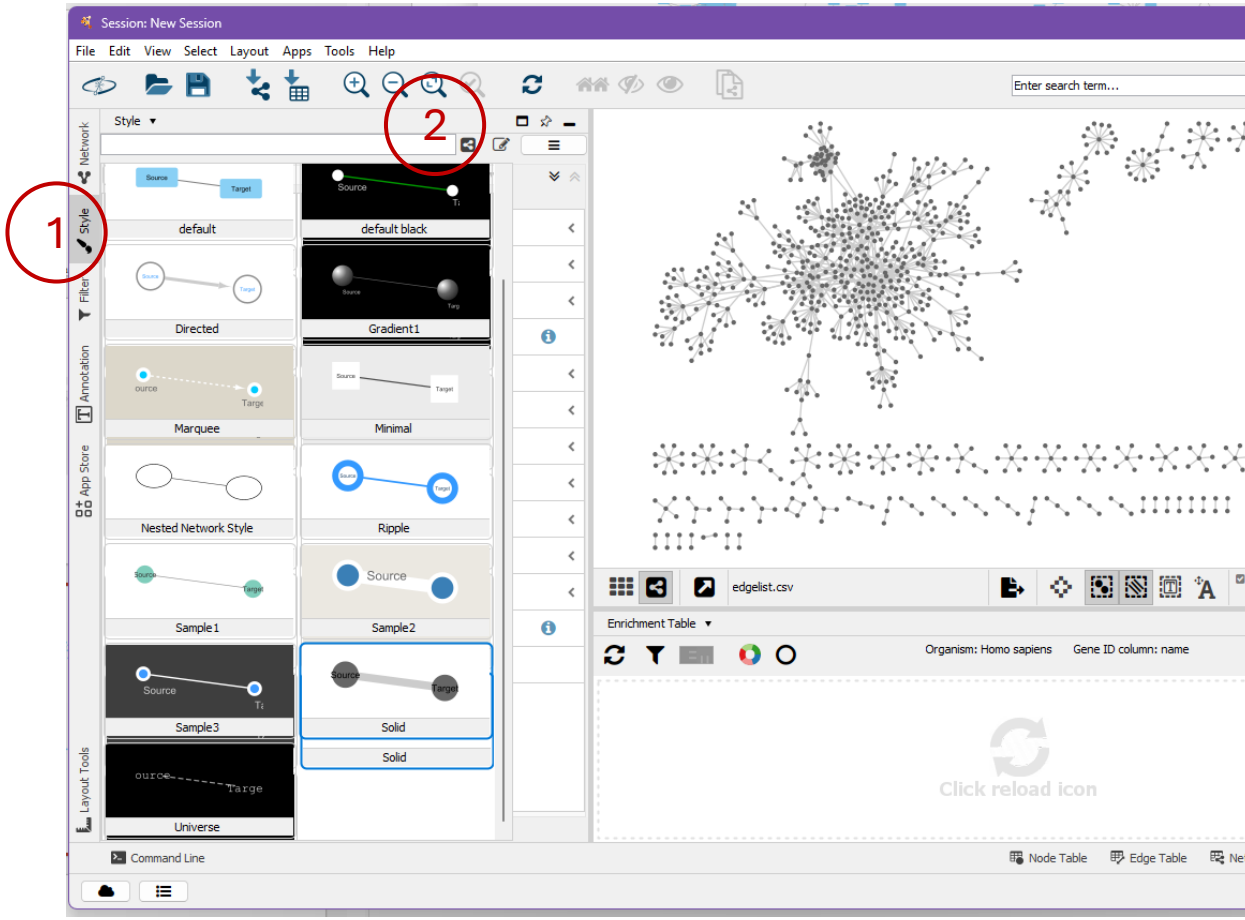


edgelist.csv from https://brosz.ca/slides

Adjust Style

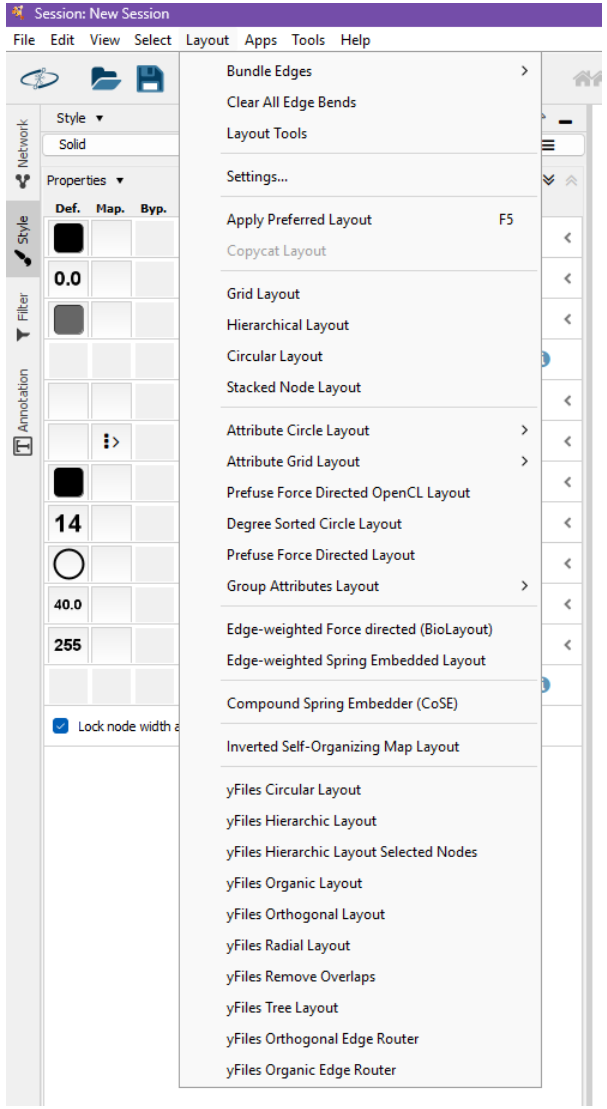


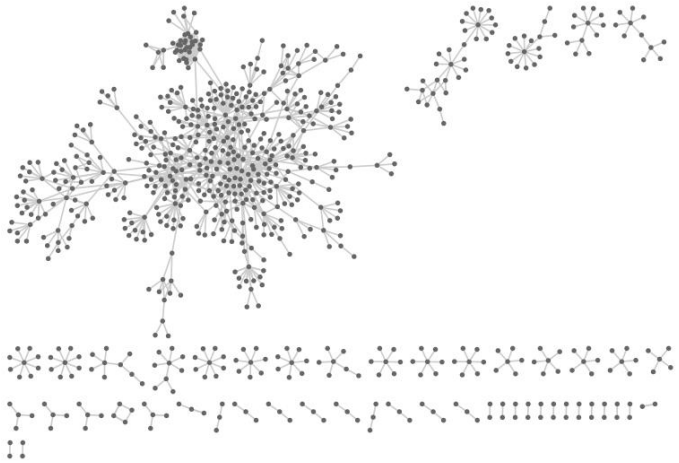
782 nodes, 1114 edges

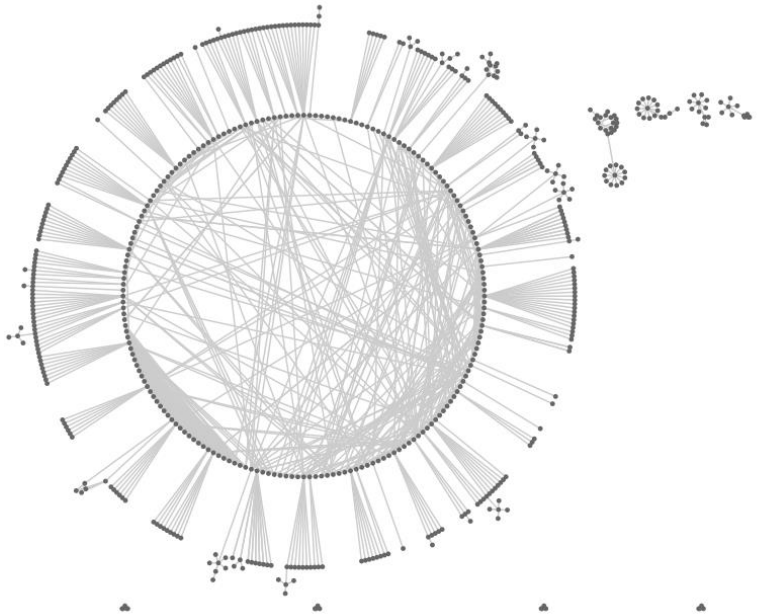


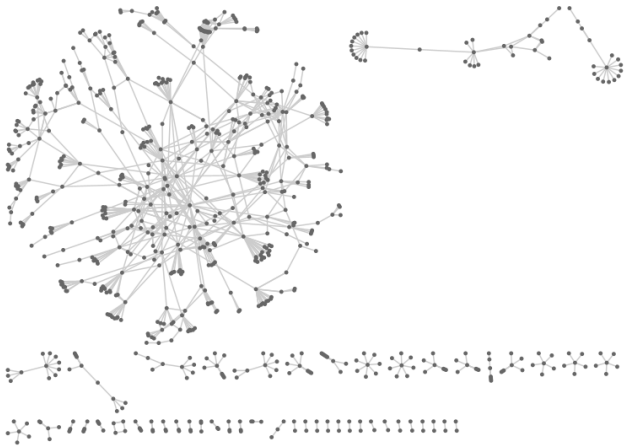
1. Style tab
2. Drop down presets
3. Try different styles

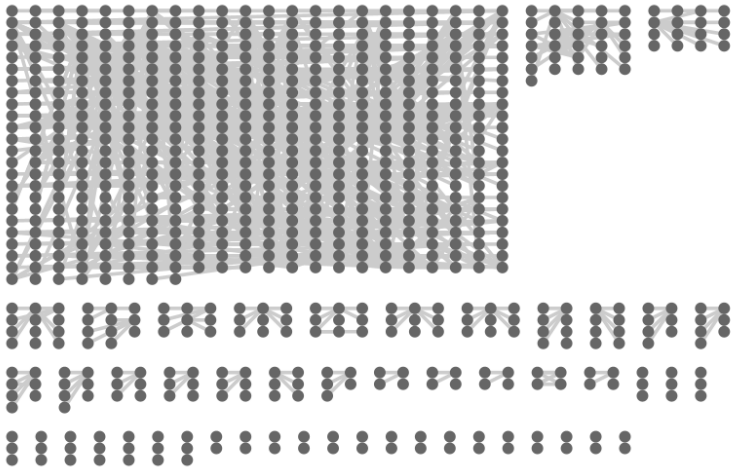
Adjust Layout











Data Files

Node Data

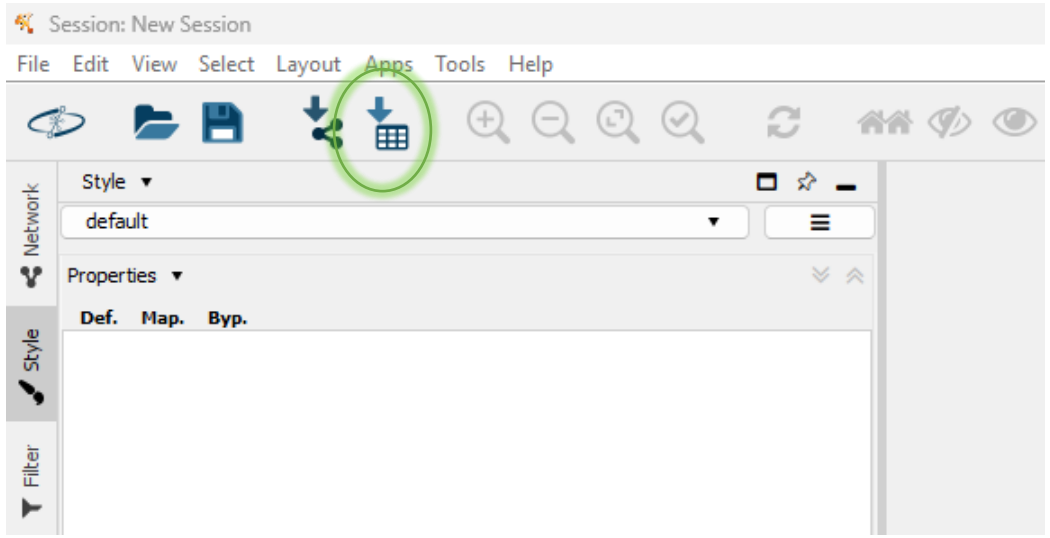
Formats:

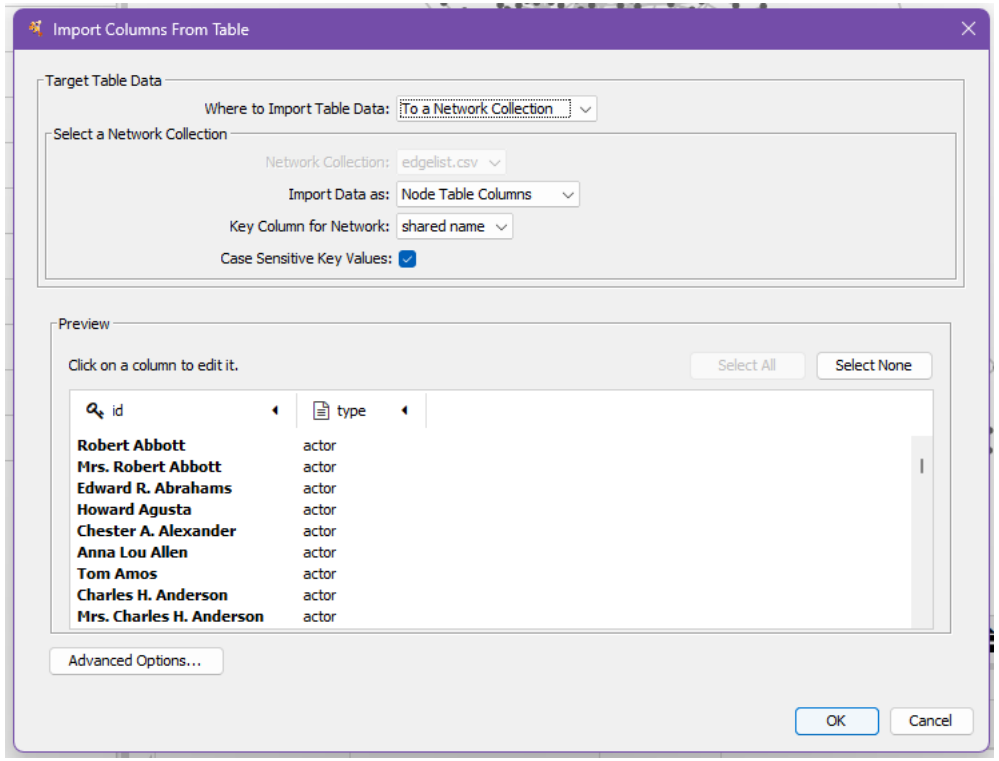
csv, xlsx, txt

Download and use
nodelist.csv
from brosz.ca/slides

id	type
Robert Abbott	actor
Mrs. Robert Abbott	actor
Edward R. Abrahams	actor
Howard Agusta	actor
Chester A. Alexander	actor
Anna Lou Allen	actor
Tom Amos	actor
Charles H. Anderson	actor
Mrs. Charles H. Anderson	actor
Ida Anderson	actor
A.E Anson	actor
Emmett Anthony	actor
Jean Armour	actor
Billy Arnett	actor
Grace Arnett	actor
Sam Arnold	actor
Willie Arnster	actor
Ida Askins	actor
Jack Austin	actor
William Baker	actor
Josephine Baker	actor
Sam Baker	actor
Edna Barr	actor

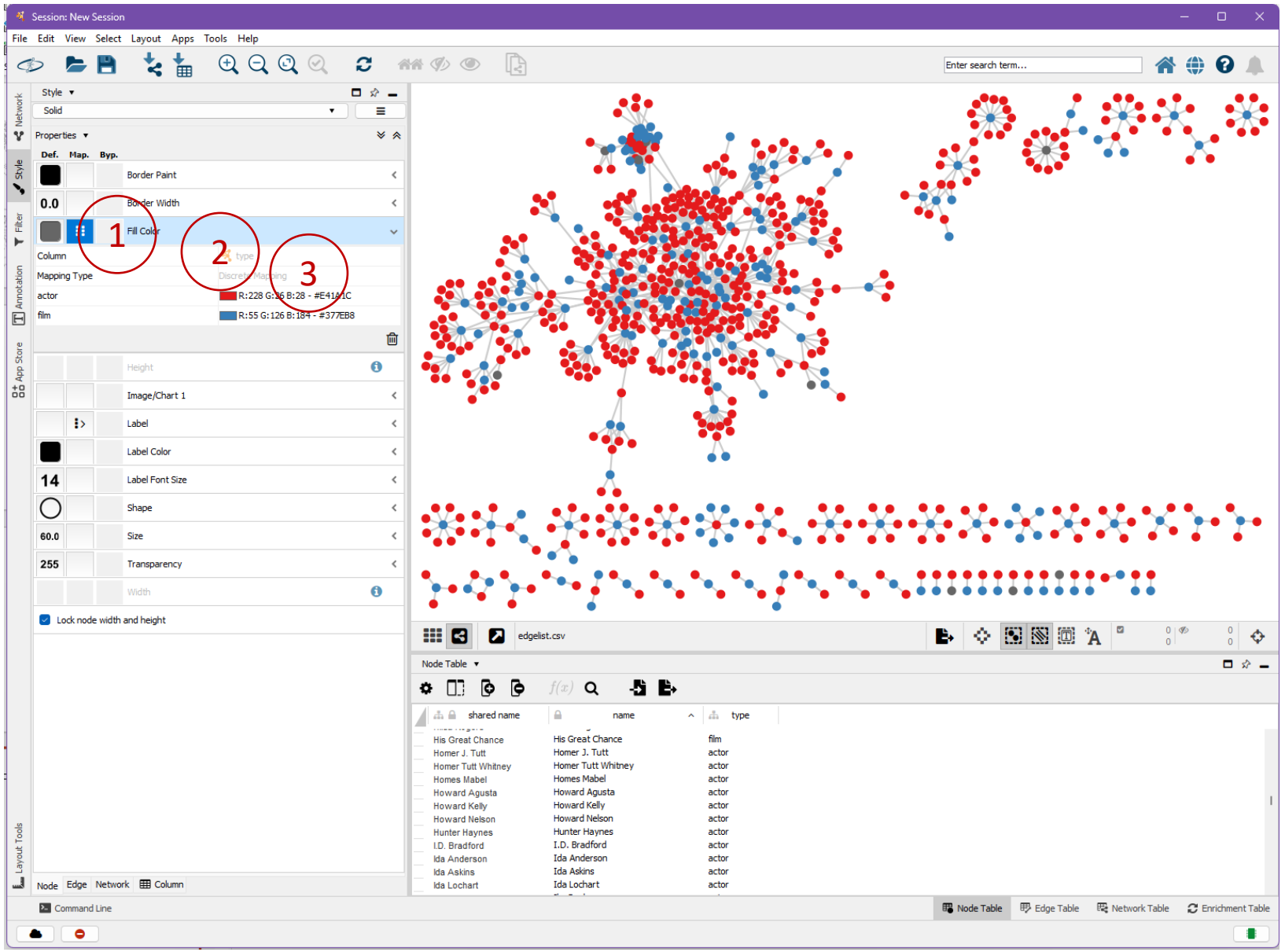
Load Nodes





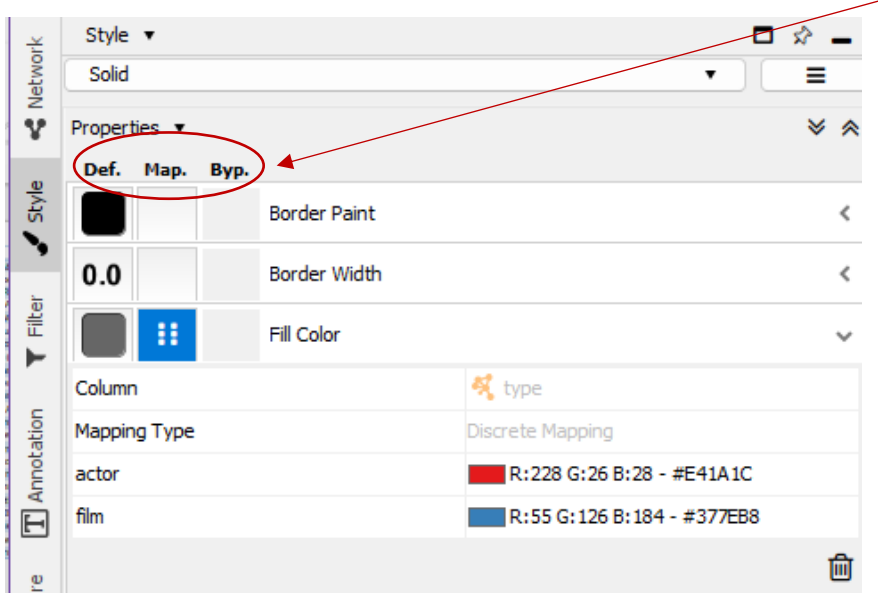
nodelist.csv from https://brosz.ca/slides

Distinguish Actors & Films



1. Select fill colour
2. Change column to “type”
3. Discrete mapping
   - Passthrough is something you’d use if you had a column with colour values
4. Pick the colours for actors and films

More Styles



Def., Map., Byp.

Def. = Default

default visual attribute of a node/edge

Map. = Mapping

change the attribute based on a node/edge property

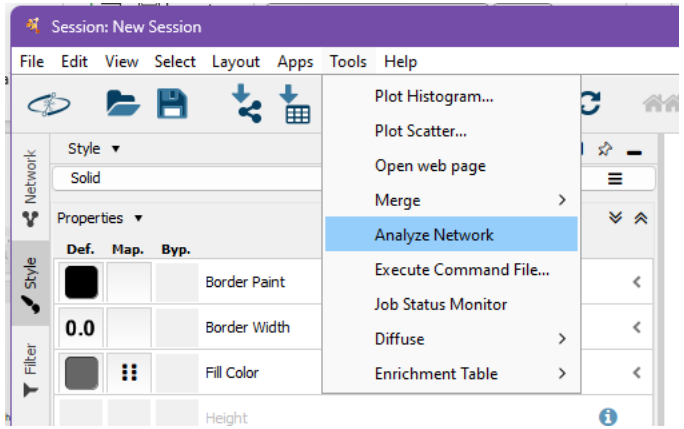
Byp. = Bypass

you can select a group of nodes and use this to apply a different style to those nodes

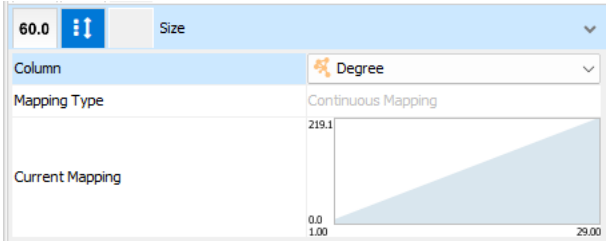
Use Node / Edge / Network to swap between node, edge, and network style attributes.

Use Network Measure to Change Node Size

- Have Cytoscape calculate various measures of your network for you.

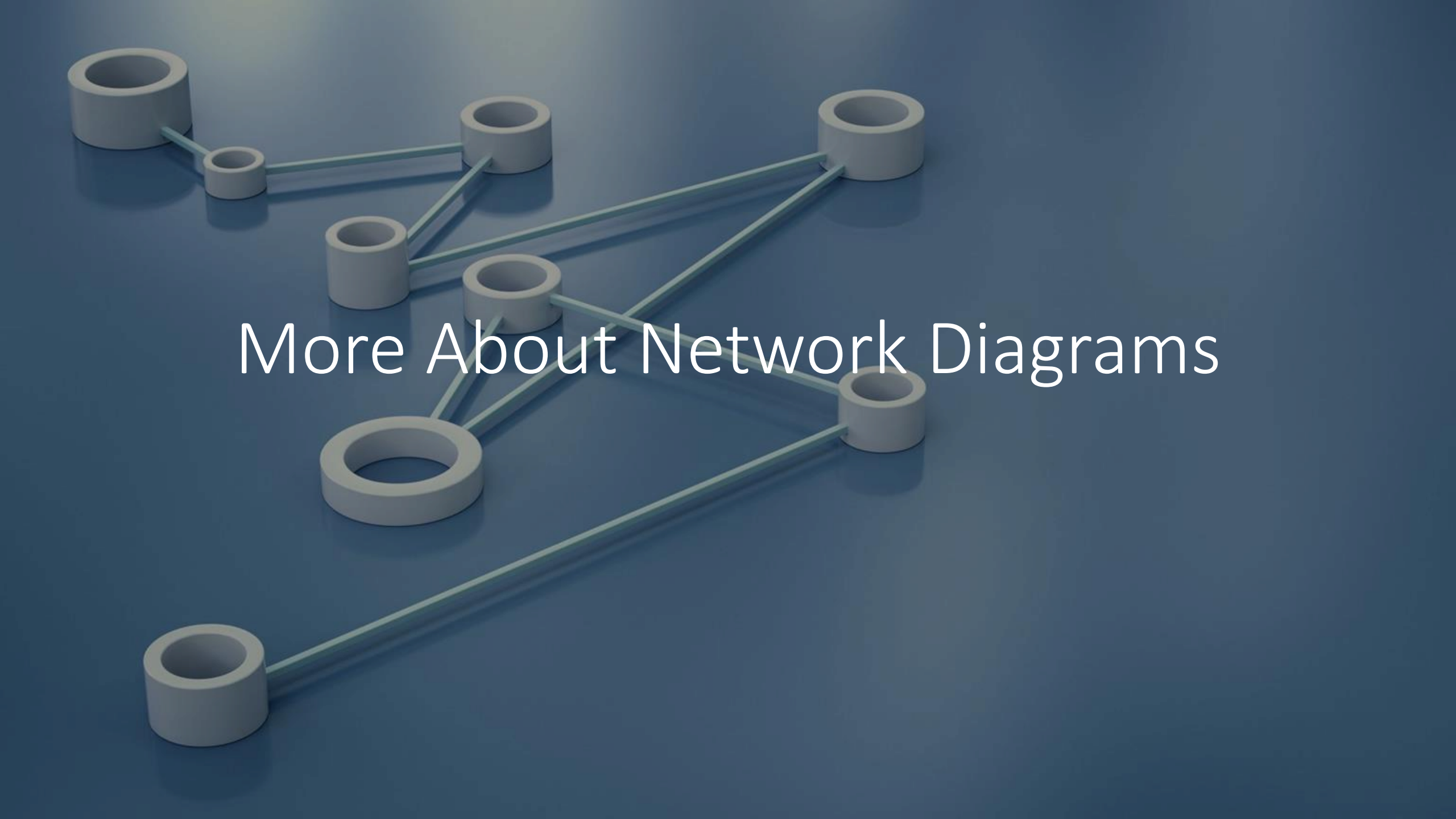


- Now, change node size to map to degree



For more . . .

https://github.com/miriamposner/cytoscape_tutorials/blob/master/working-with-selections.md

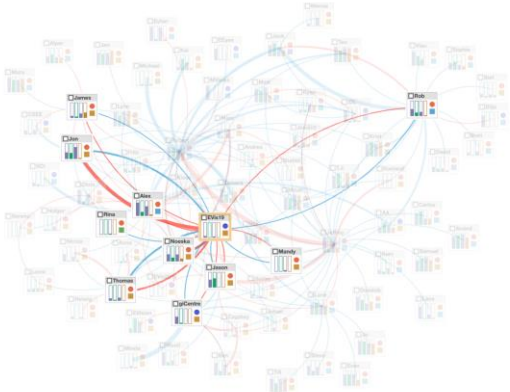


More About Network Diagrams

Networks quickly become overwhelming

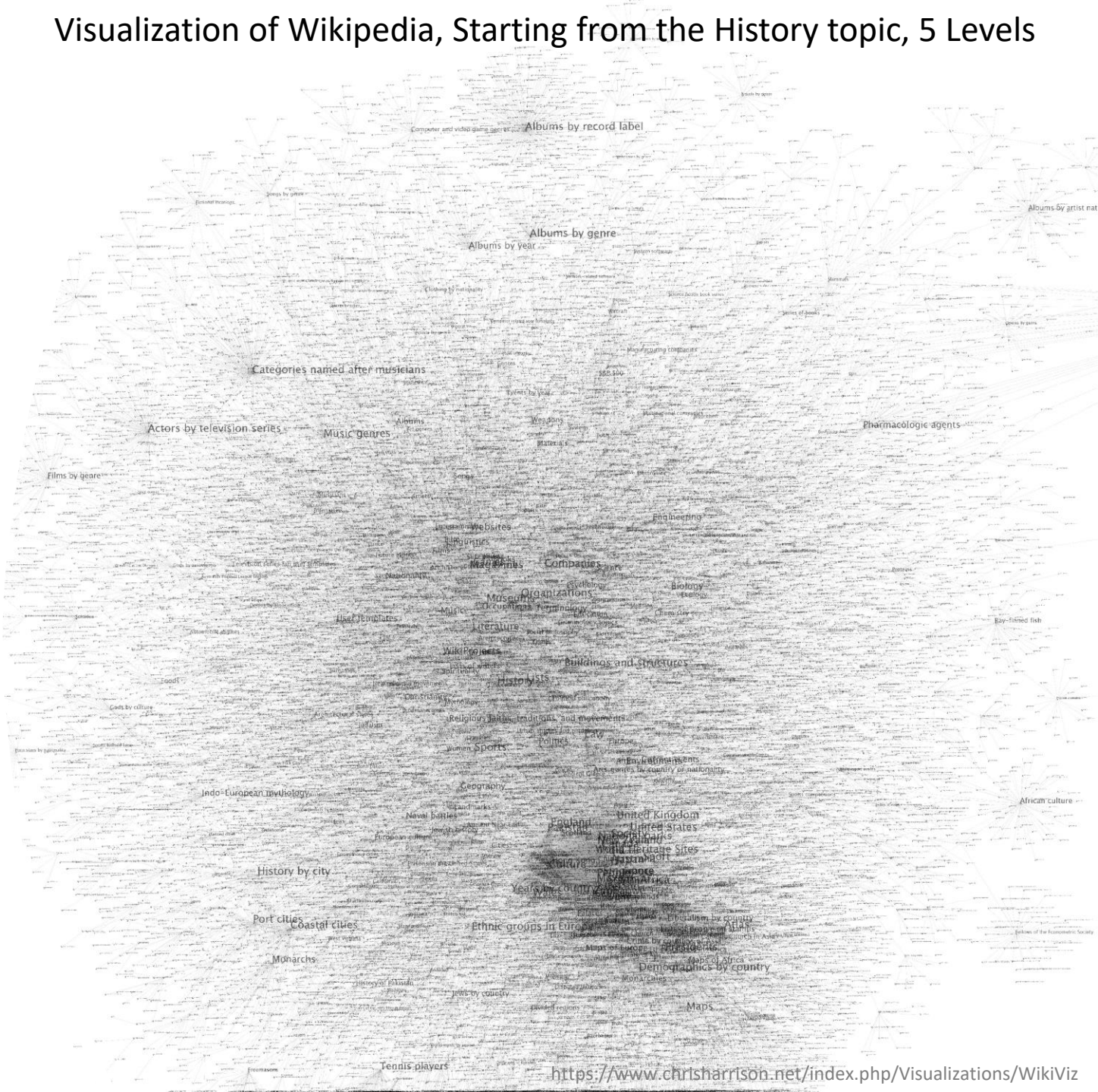
This is the hairball problem

- Layout is critical
- Sometimes can be fixed via interactivity



https://web.cs.wpi.edu/~ltharrison/docs/nobre2020evaluating.pdf

Visualization of Wikipedia, Starting from the History topic, 5 Levels



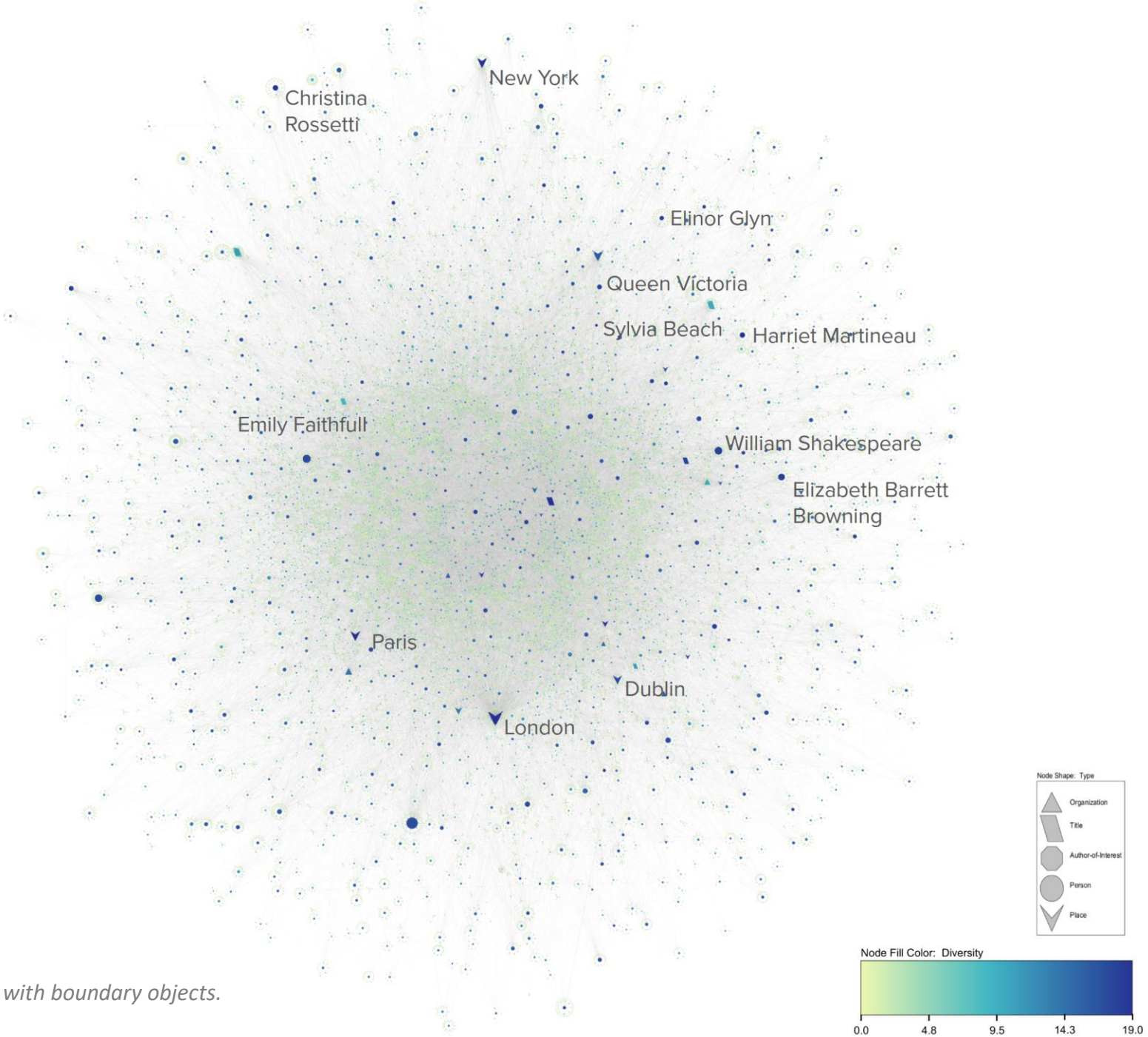
https://www.chrisharrison.net/index.php/Visualizations/WikiViz

The Orlando Project

Feminist Literary History and Digital Humanities

Women's Writing in the British Isles from the Beginnings to the Present

- 56,047 edges
- 37,080 nodes
- 11,870 people
- 19,662 texts
- 2,817 organizations
- 2,649 places



From *Brown, Brosz, Flynn, Mo, Obbard. Making feminist literary history with boundary objects. Rewritings of Literary History w/ Algorithms. Chicago, Nov 2024.*

Hairballs

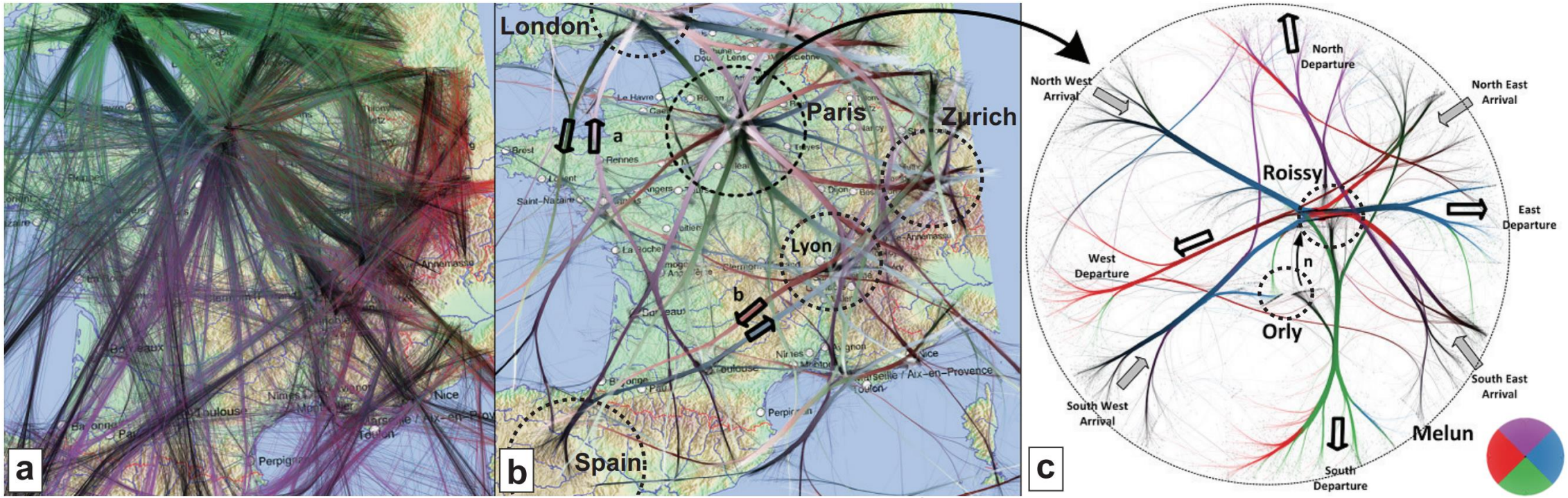
Approaches:

- **Edge bundling**
- **Edge/Node filtering**
- **Hierarchies/groupings**
- Layout algorithms
- Interaction

No perfect approach. Depends on your data and what you want your viewers to see (or do).

Edge Bundling

European flight paths



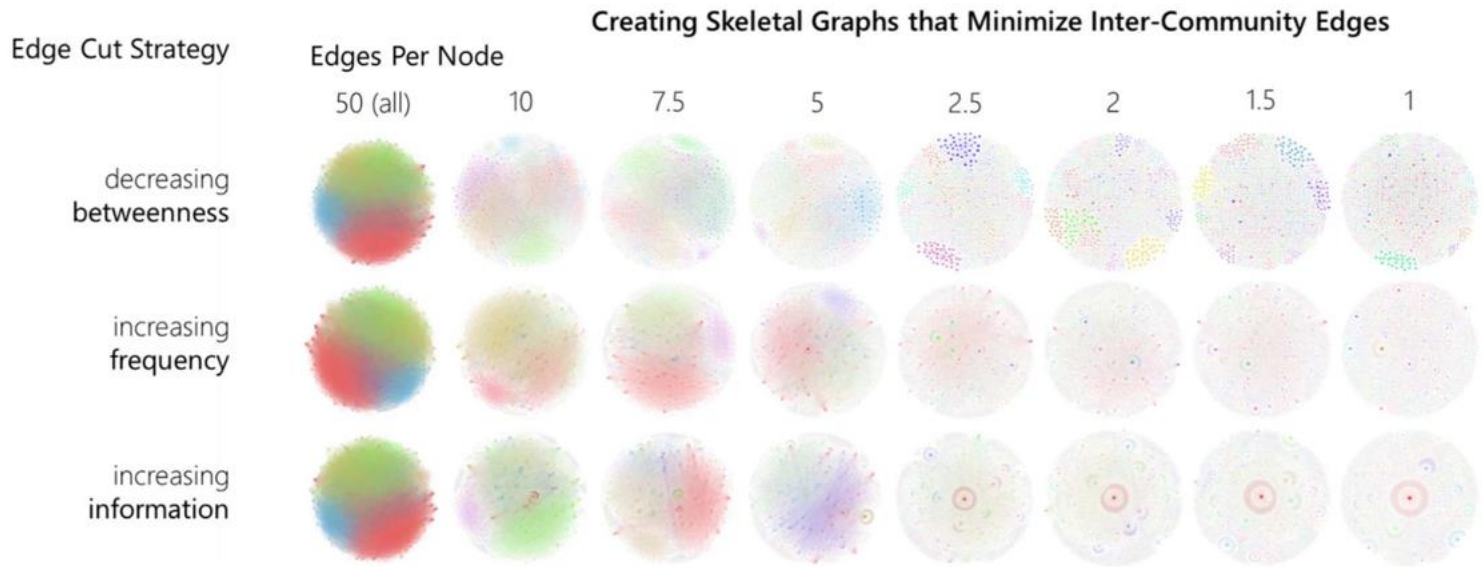
From Peysakhovich, Telea, & Hurter. Attribute-Drive Edge Bundling for General Graphs with Applications in Trail Analysis. 2015

Also Node Bundling!

Can combine nodes or edges based on common properties.

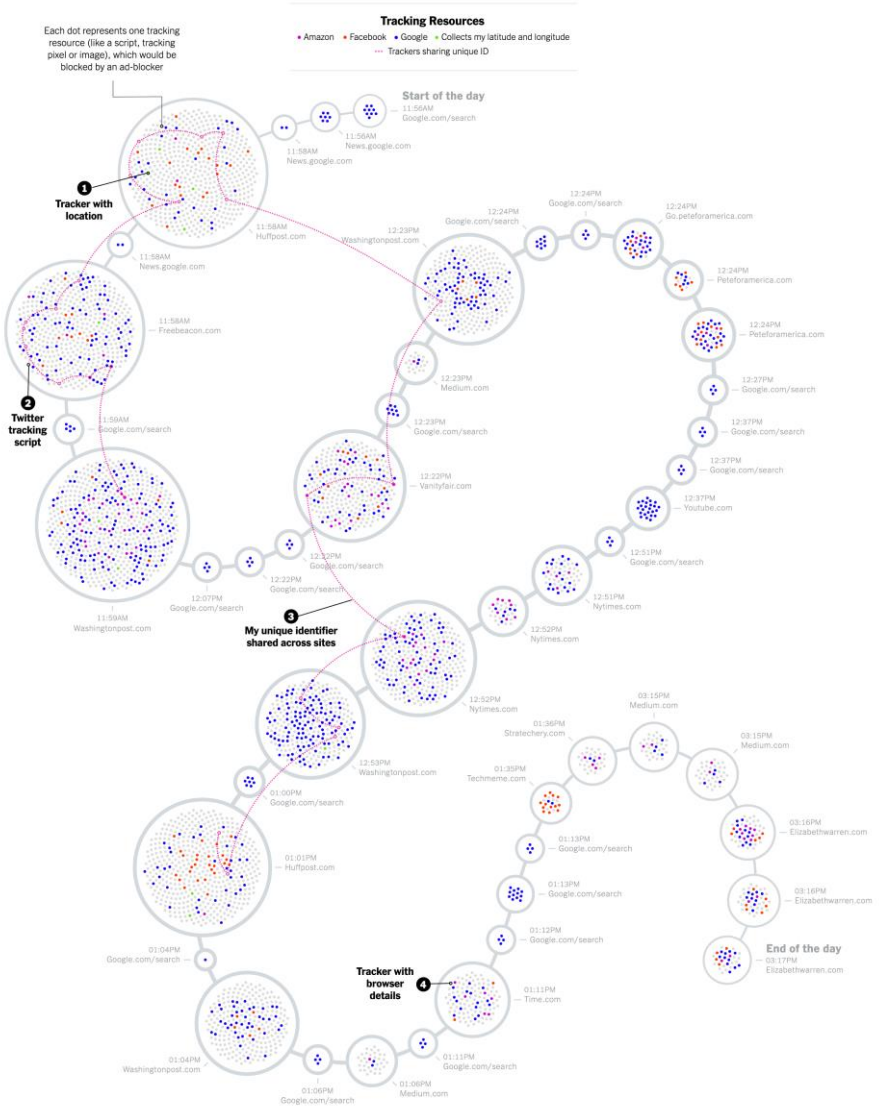
Filtering

- Remove non-critical edges/nodes to reveal important structures
  - Nodes
    - Low degree (fewer connections)
  - Edges
    - Low weight edges, Edges that connect different “communities”

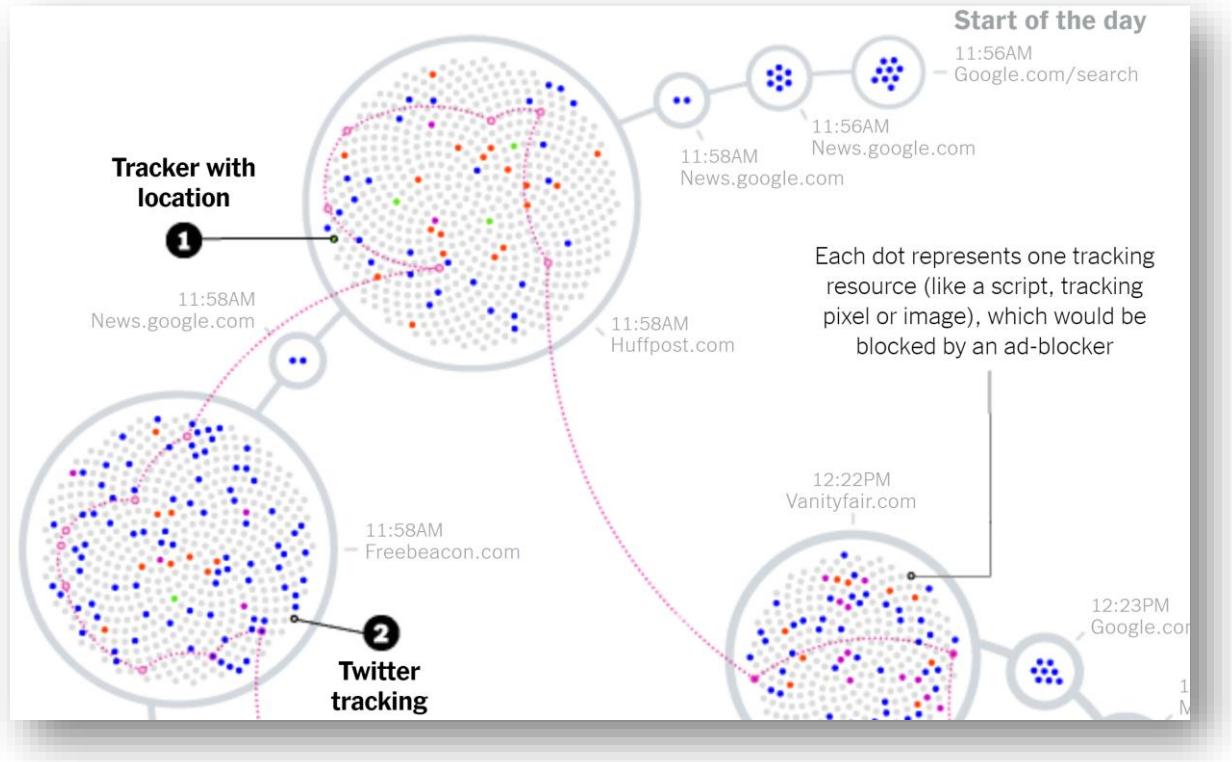


Edge, Larson, Mobius, White. Trimming the Hairball: Edge Cutting Strategies for Making Dense Graphs Usable. IEEE Conference on Big Data, 2018

Hierarchy / Grouping



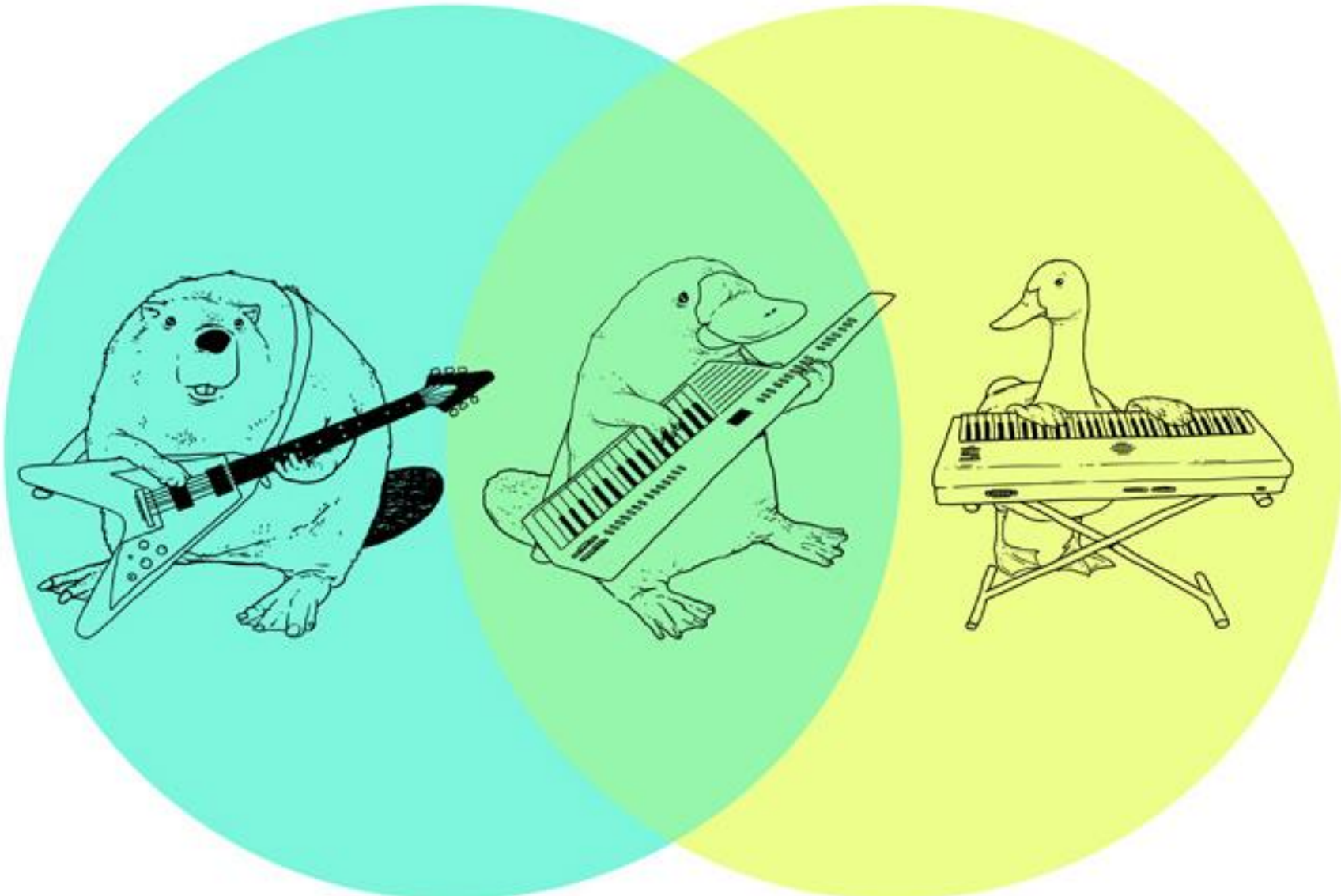
I Visited 47 Sites.
Hundreds of Trackers
Followed Me.



https://www.nytimes.com/interactive/2019/08/23/opinion/data-internet-privacy-tracking.html

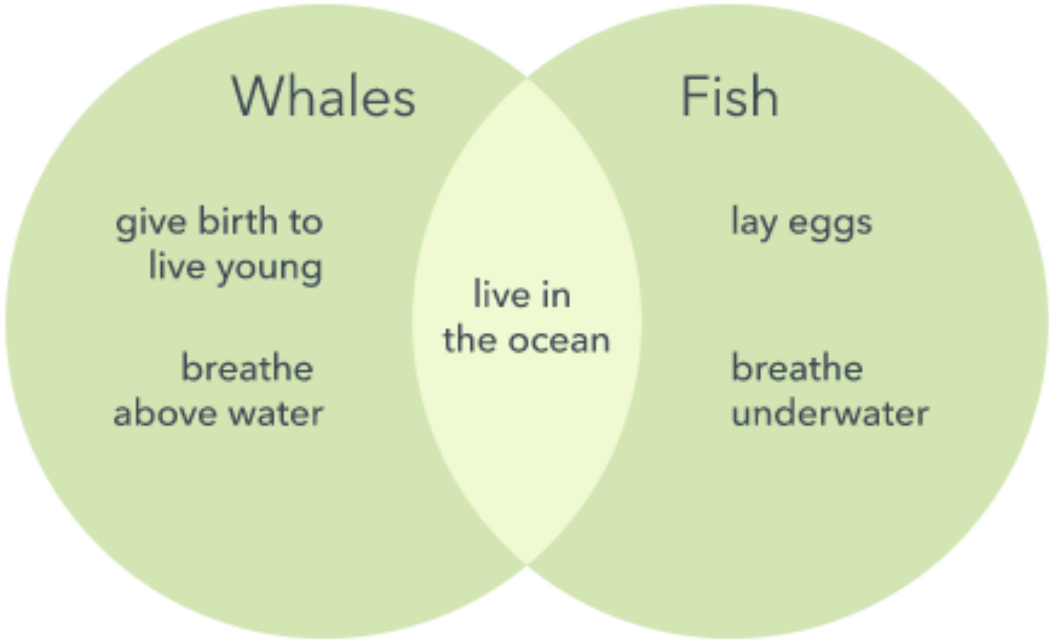
BEYOND NODE-LINK CONNECTIONS

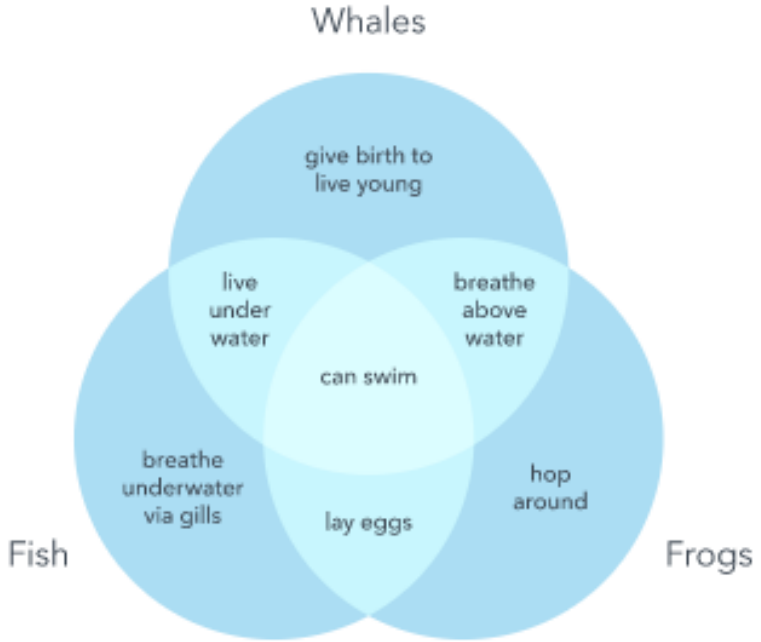
INSTEAD USE USE CONTAINMENT



https://cargocollective.com/tensographics/Math

VENN DIAGRAM

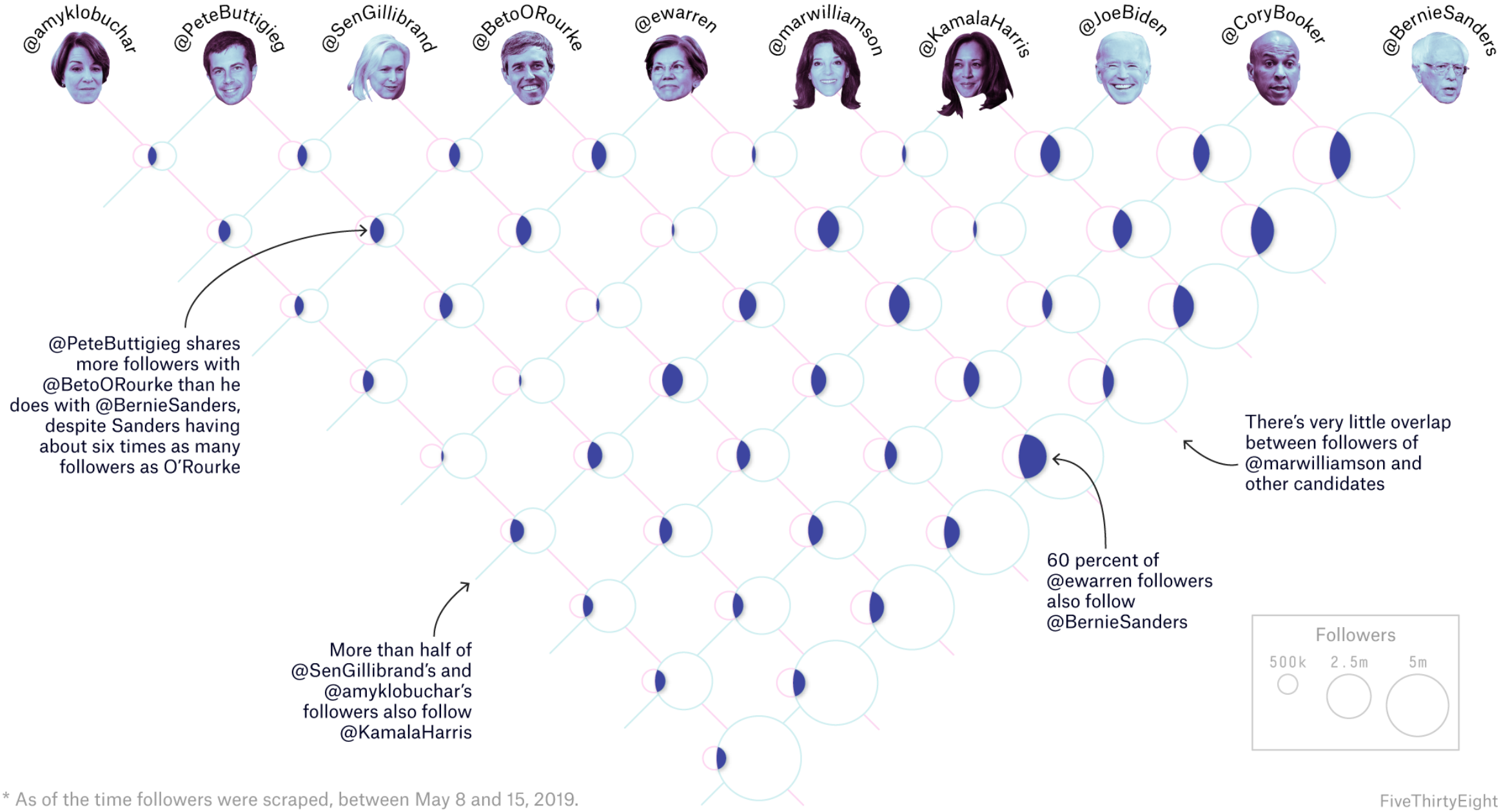




https://www.lucidchart.com/pages/venn-diagram

The Venn diagrams of the 2020 Twitter primary

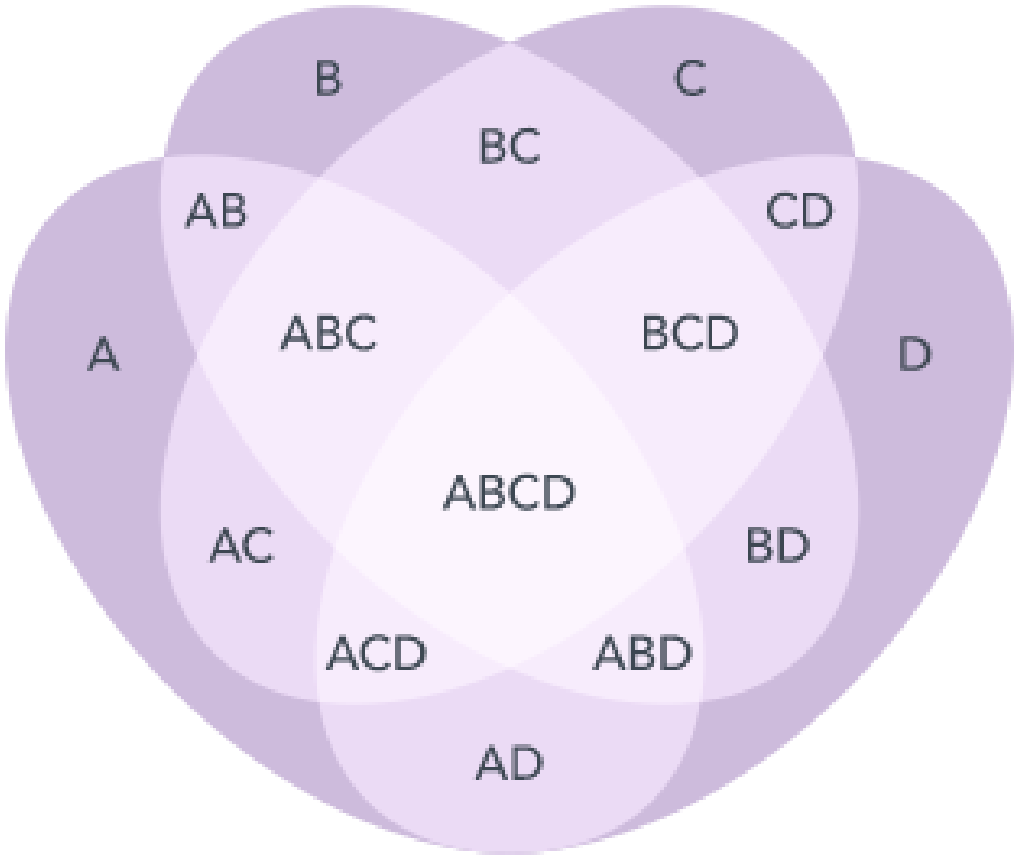
Shared Twitter followers between pairs of Democratic presidential candidates who have more than 500,000 followers*

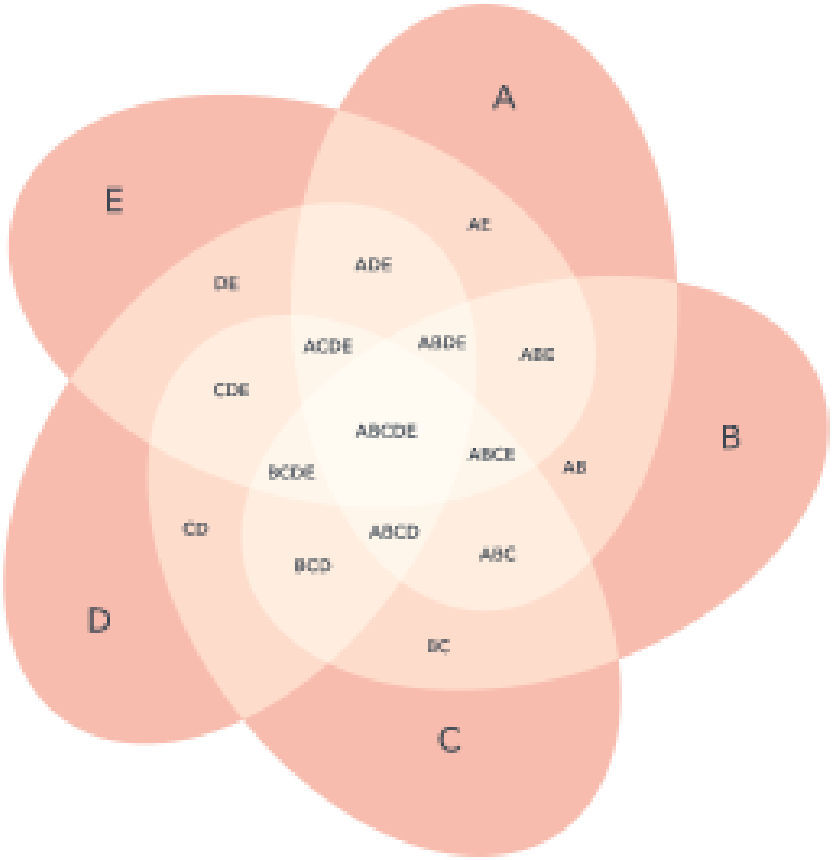


* As of the time followers were scraped, between May 8 and 15, 2019.

FiveThirtyEight

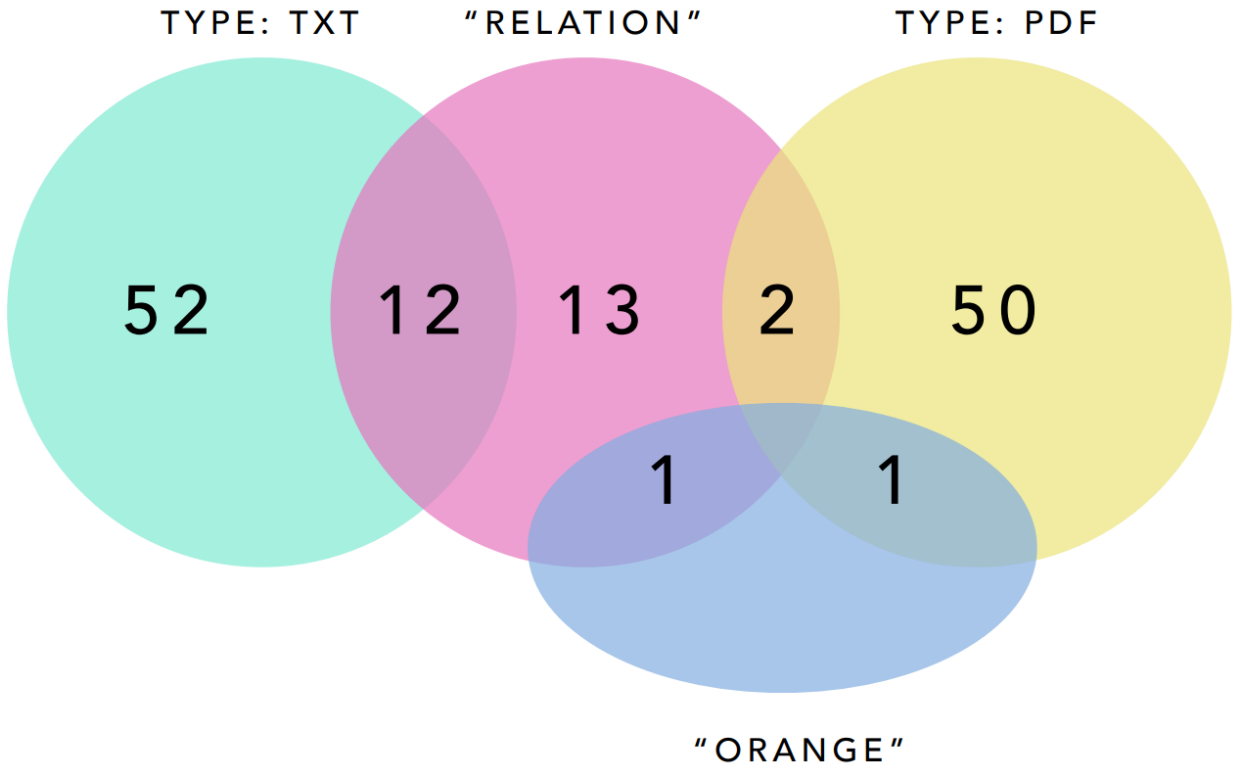
VENN DIAGRAM

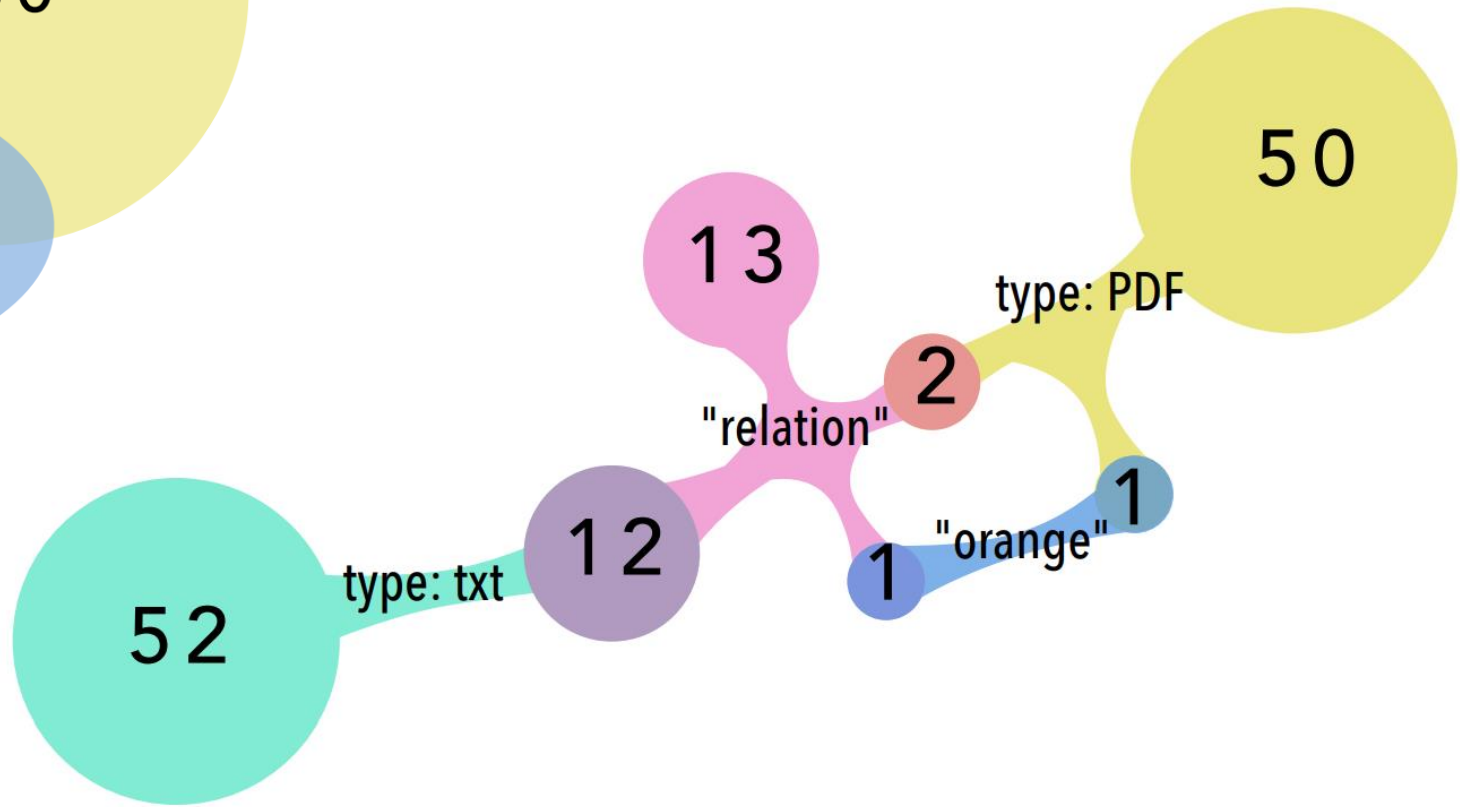




https://www.lucidchart.com/pages/venn-diagram

CLUSTER MAPS

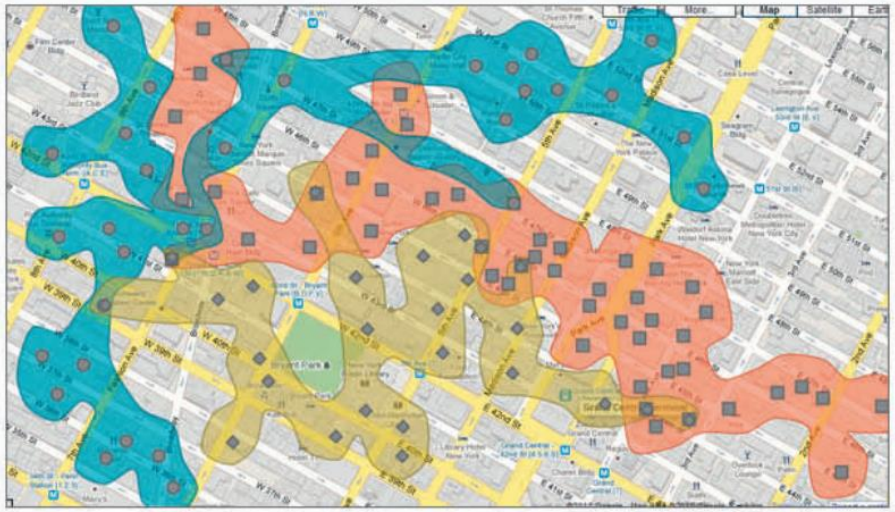


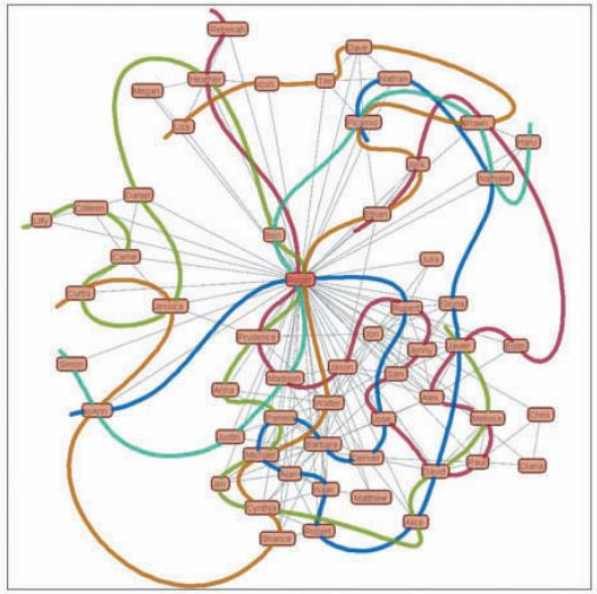


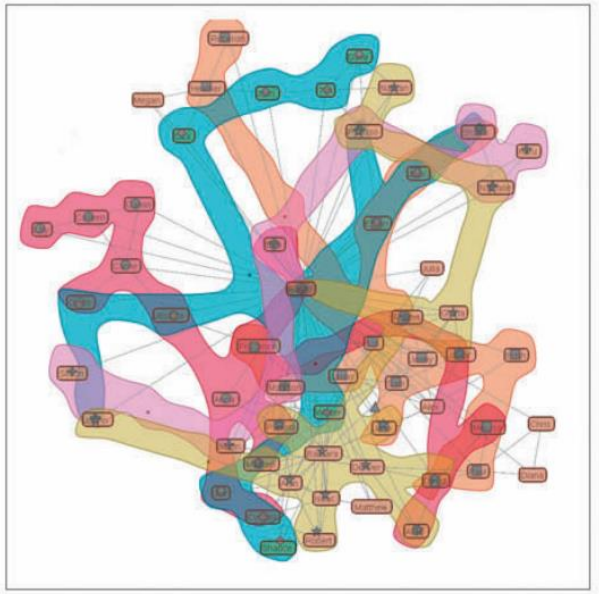
BUBBLE SETS

https://www.youtube.com/watch?v=Ju2hSThmPWA

LINE SETS VS BUBBLE SETS







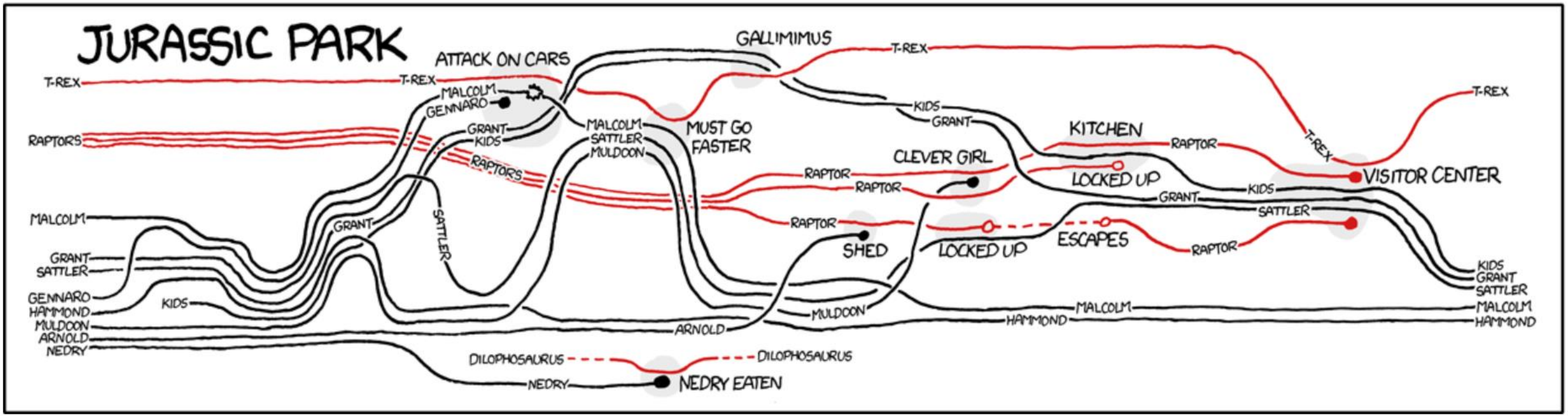
Design Study of LineSets, a Novel Set Visualization Technique

- Basak Alper
- Nathalie Henry Riche
- Gonzalo Ramos
- Mary Czerwinski

IEEE Transactions on Visualization and Computer Graphics | March 2011, Vol 18(5)

USING SPATIAL POSITIONING

https://xkcd.com/657/large/

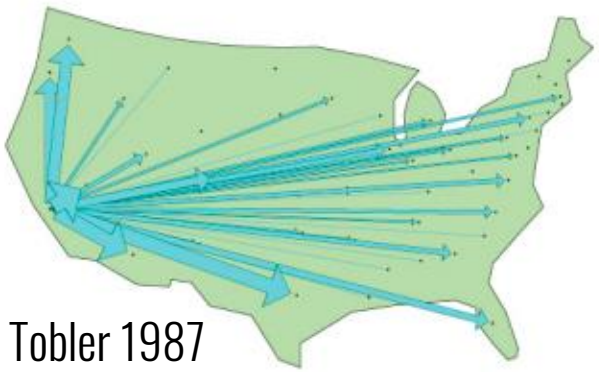


https://xkcd.com/657/large/

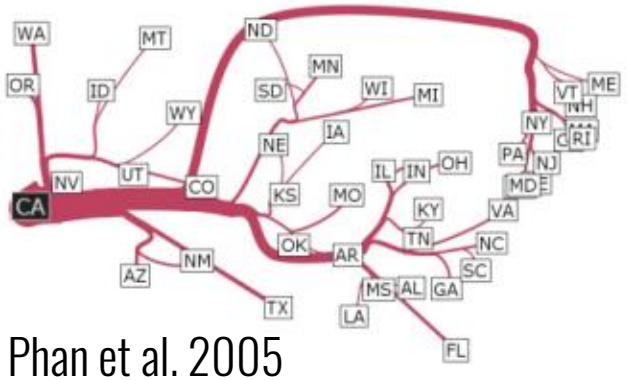
Networks with Map Locations

- Choice: Ignore exact locations or not
- If not, less freedom
  - Focus on adjusting edge properties
- Look into Geography literature

Migration from California

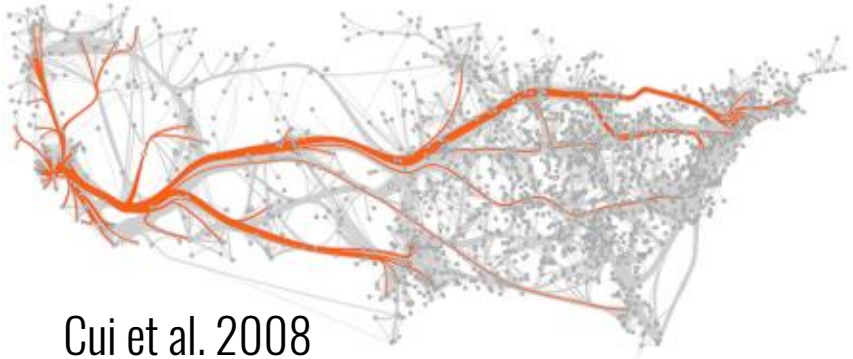


Tobler 1987

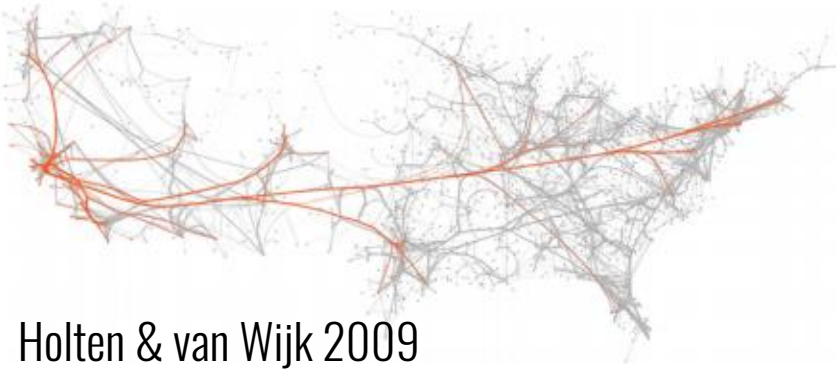


Phan et al. 2005

Verbeek et al. 2011

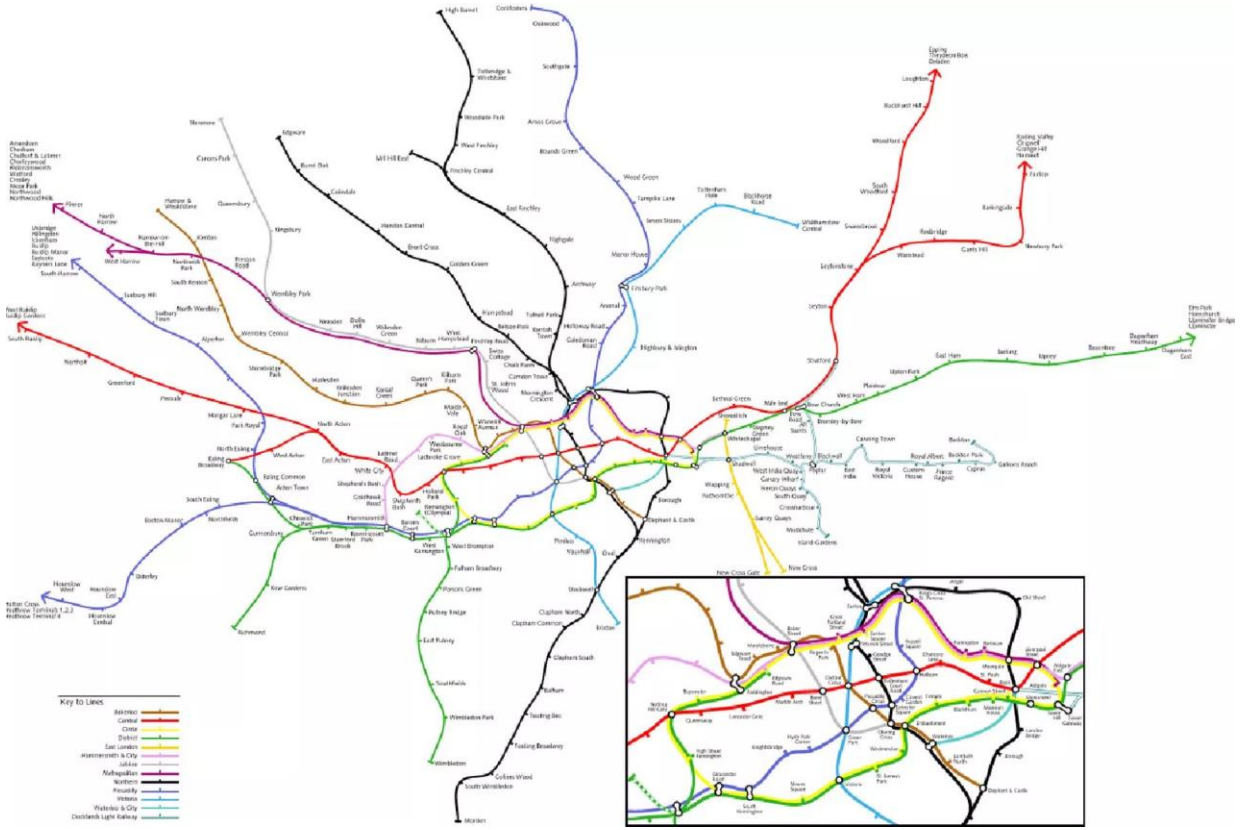


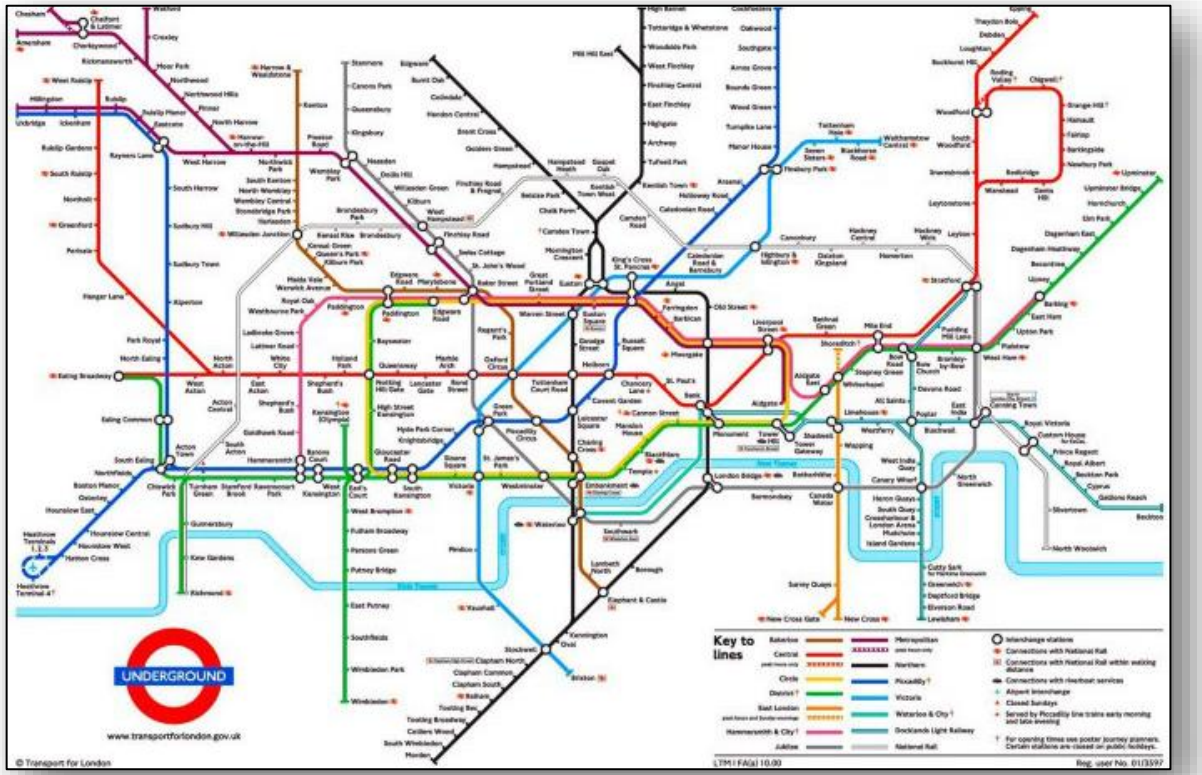
Cui et al. 2008

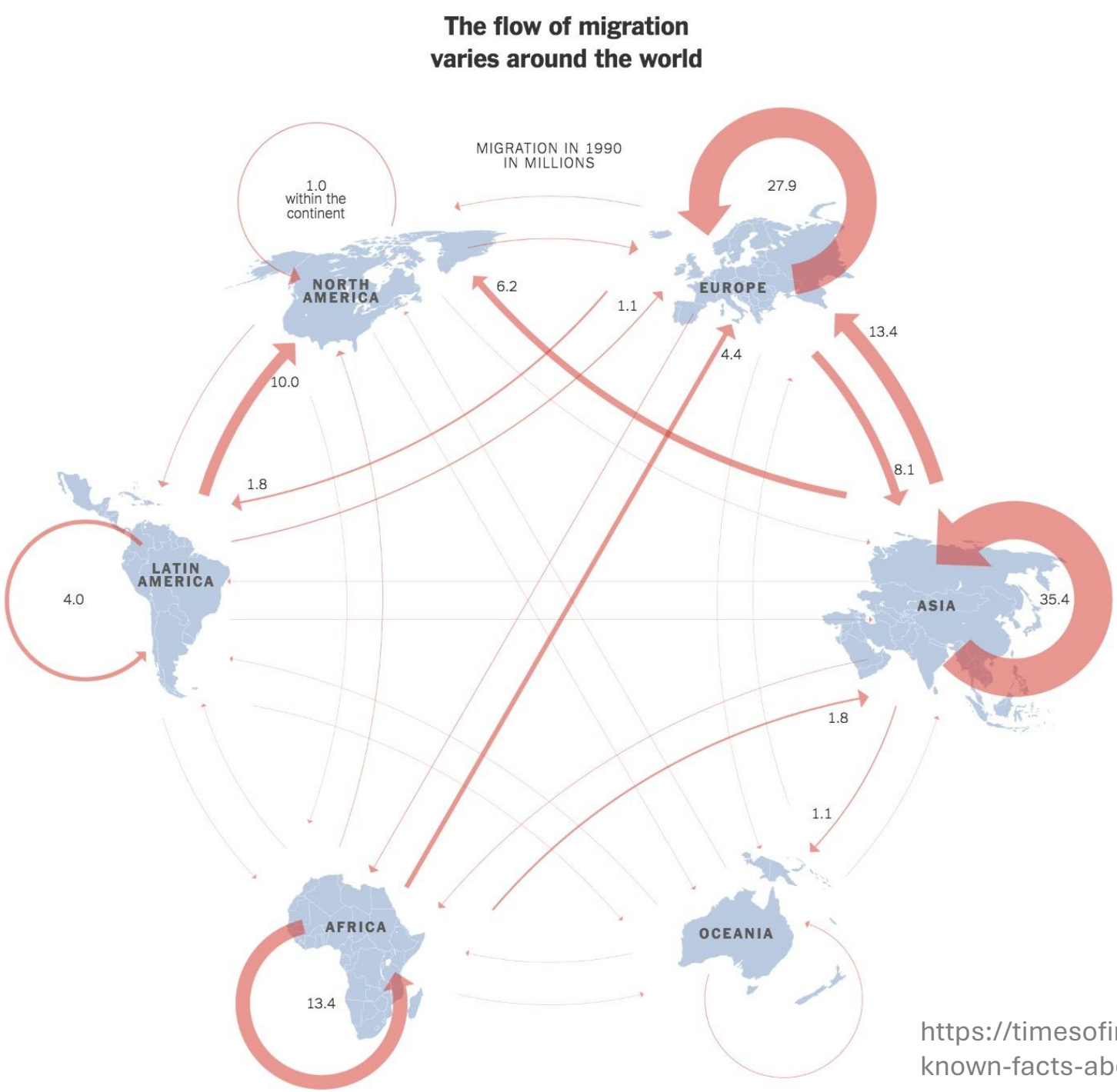


Holten & van Wijk 2009

London Underground Map





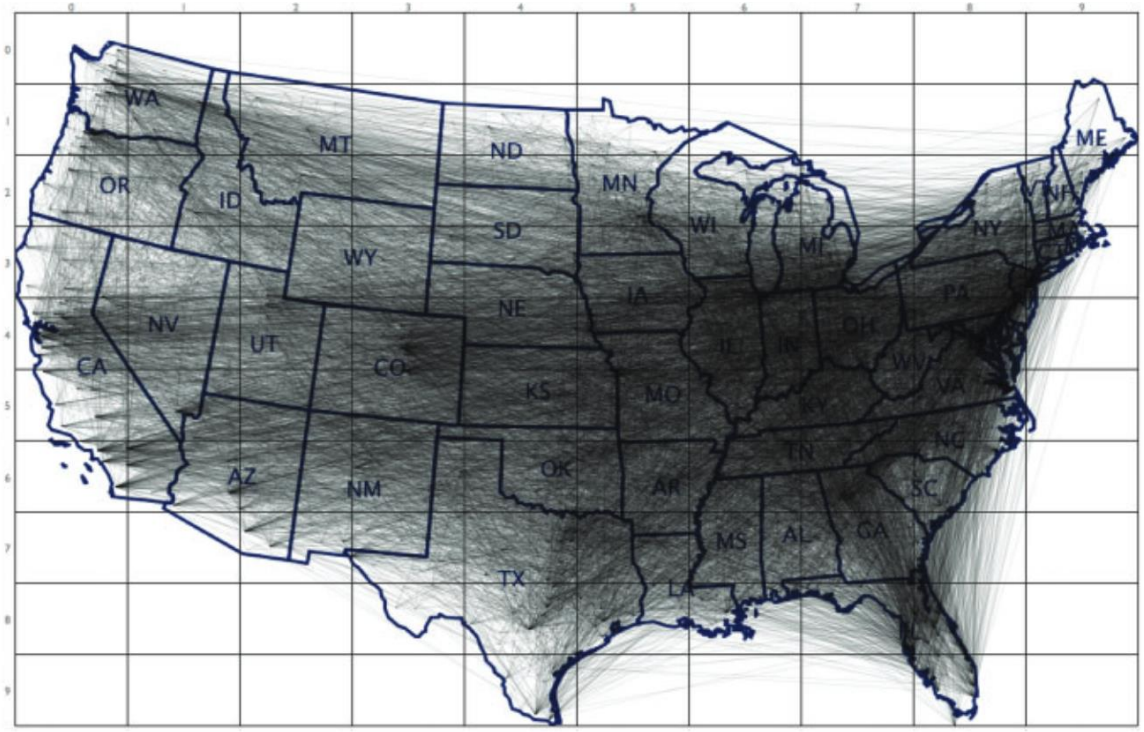


https://timesofindia.indiatimes.com/world/three-lesser-known-facts-about-migration/articleshow/65303606.cms

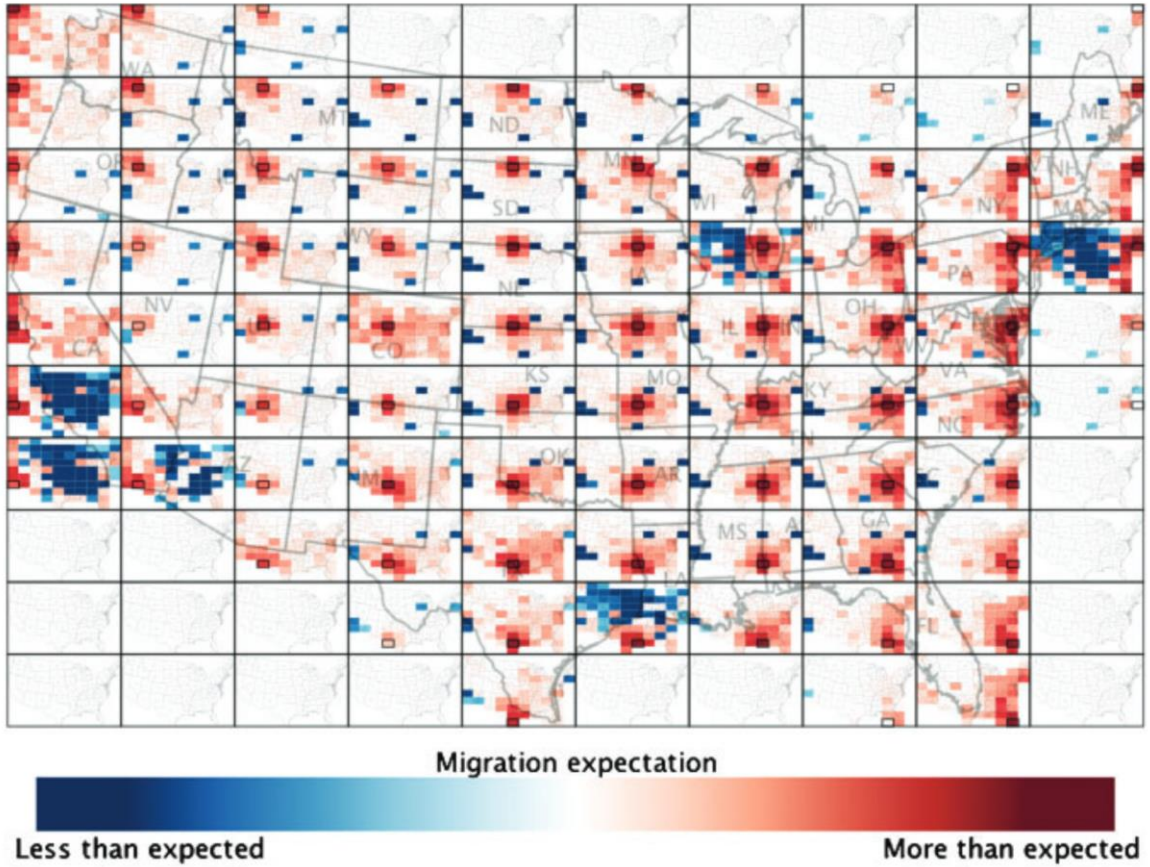
OD MAPS - DIVIDE & CONQUER

FOR MAP FLOWS W/ DIRECTED EDGES

US In-Country Migration (3% Sample)

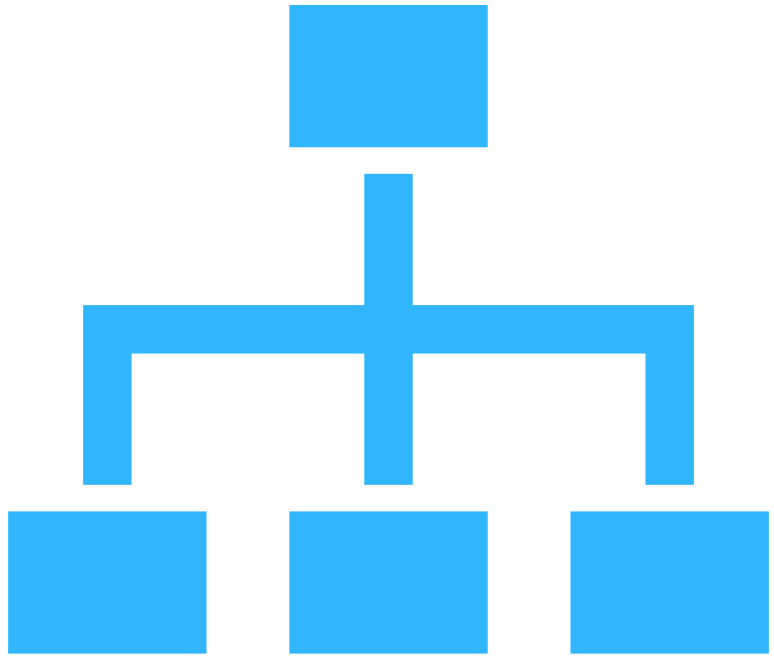


(100% Sample)



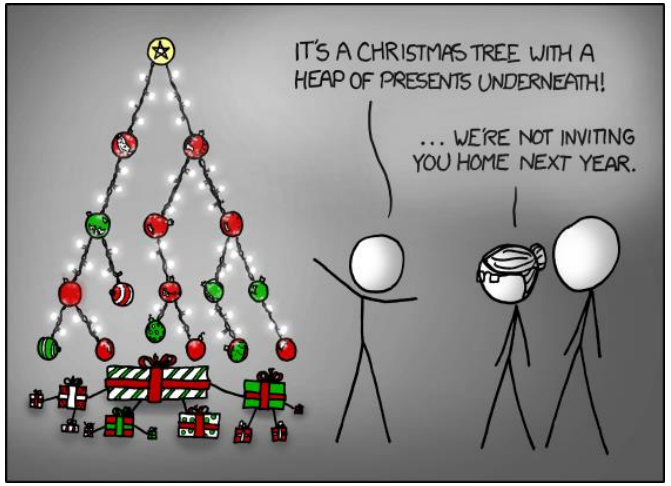
Jo Wood, Jason Dykes & Aidan Slingsby (2010) Visualisation of Origins, Destinations and Flows with OD Maps, The Cartographic Journal

HIERARCHICAL RELATIONS



TREE

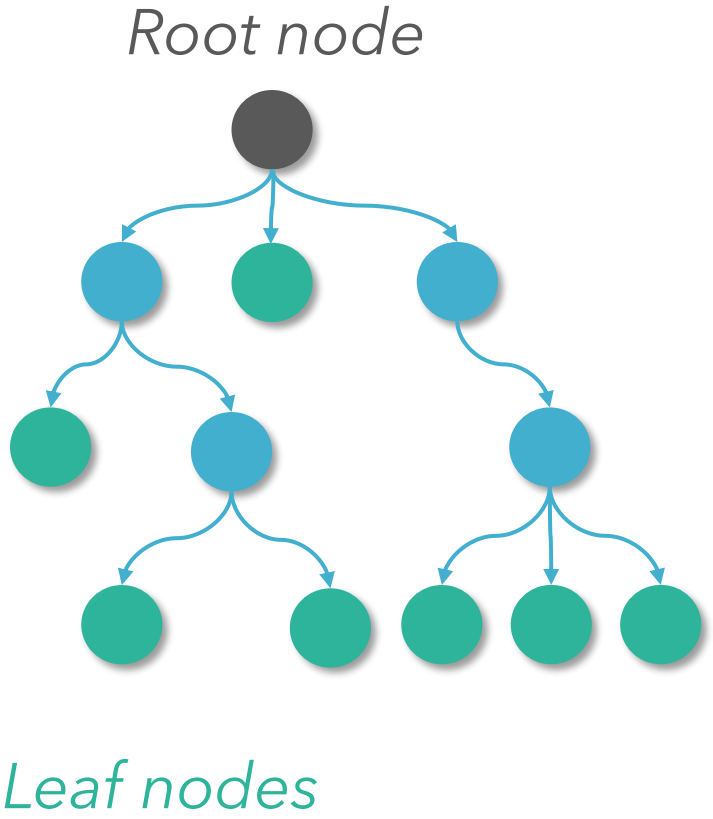
Simple type of graph
Does not have cycles (loops)



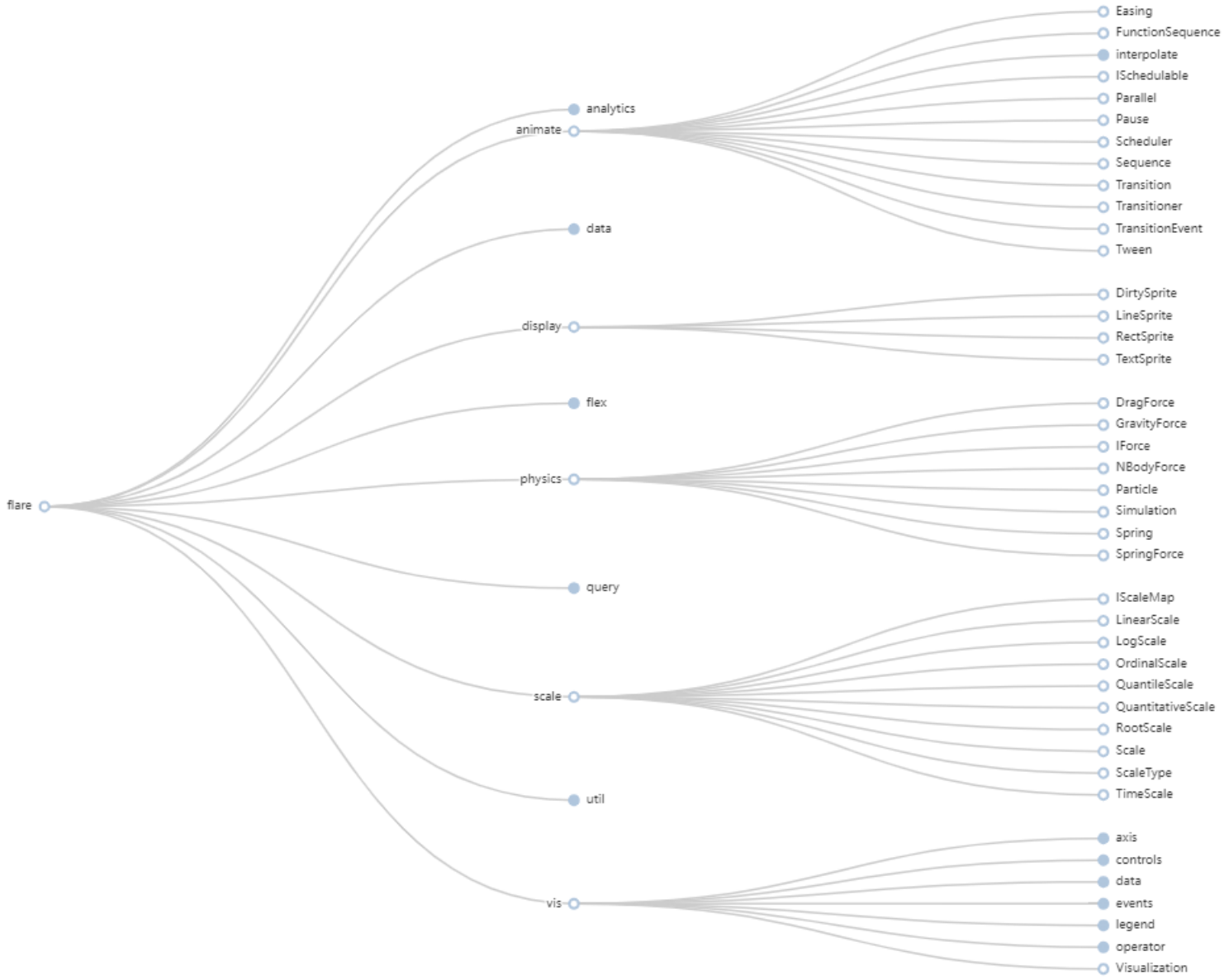
https://xkcd.com/835

Types of nodes:

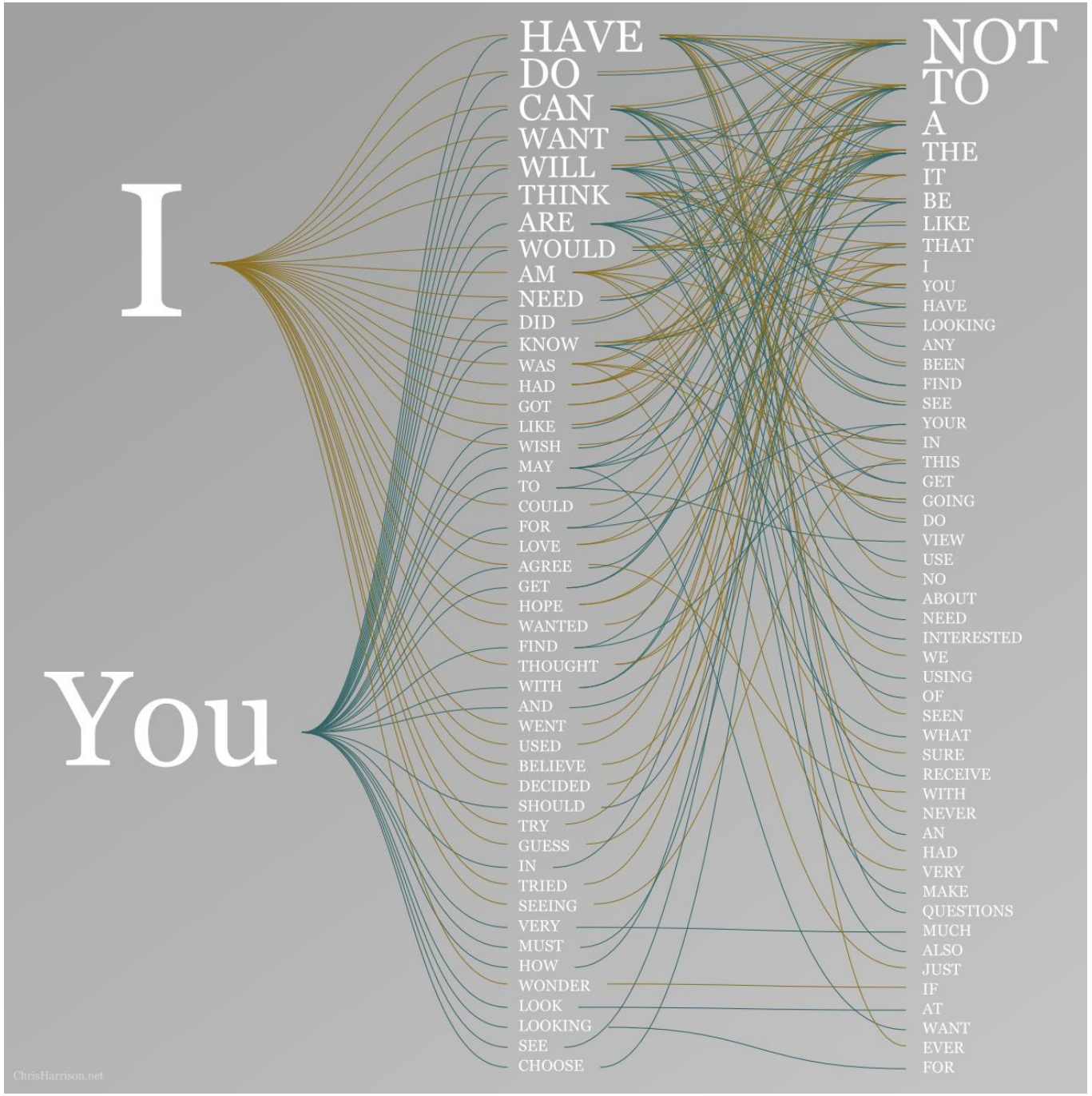
- Root
- Parent/child
- Leaf



LINEAR TREE

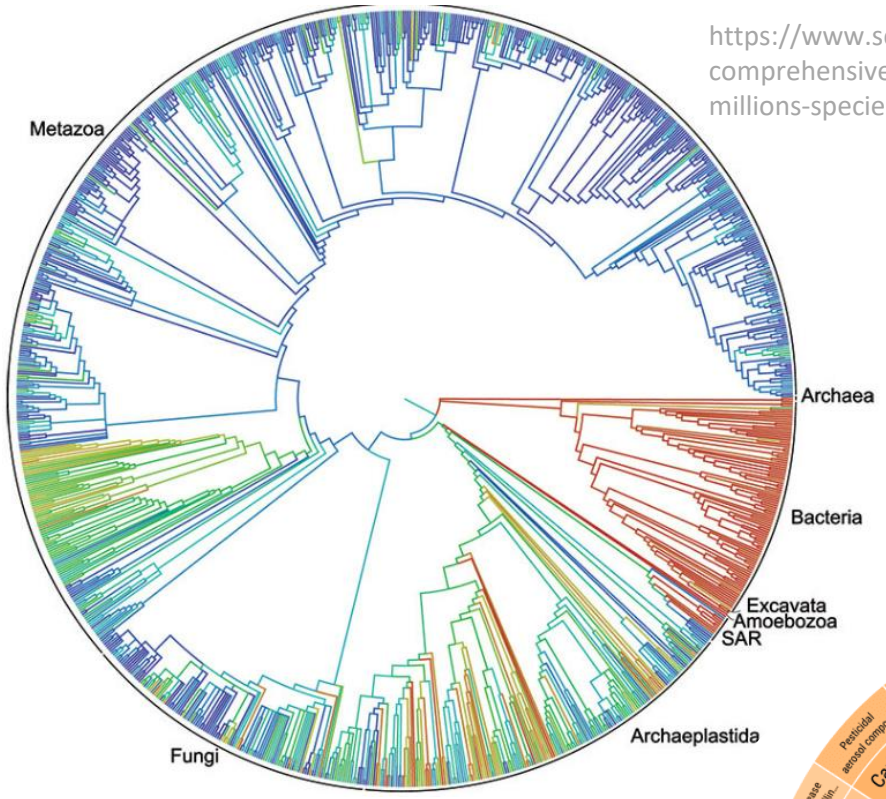

flare
analytics
animate
Easing
FunctionSequence
interpolate
ISchedulable
Parallel
Pause
Scheduler
Sequence
Transition
Transitioner
TransitionEvent
Tween
data
display
DirtySprite
LineSprite
RectSprite
TextSprite
flex
physics
DragForce
GravityForce
IForce
NBodyForce
Particle
Simulation
Spring
SpringForce
query
scale
IScaleMap
LinearScale
LogScale
OrdinalScale
QuantileScale
QuantitativeScale
RootScale
Scale
ScaleType
TimeScale
util
vis
axis
controls
data
events
legend
operator
Visualization

LINEAR TREE

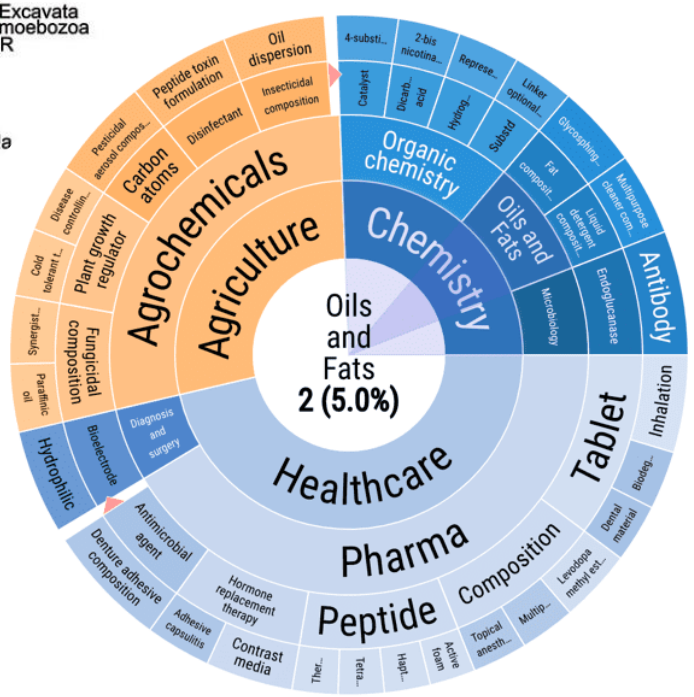


From https://www.chrisharrison.net/index.php/Visualizations/WebTrigrams

RADIAL TREE



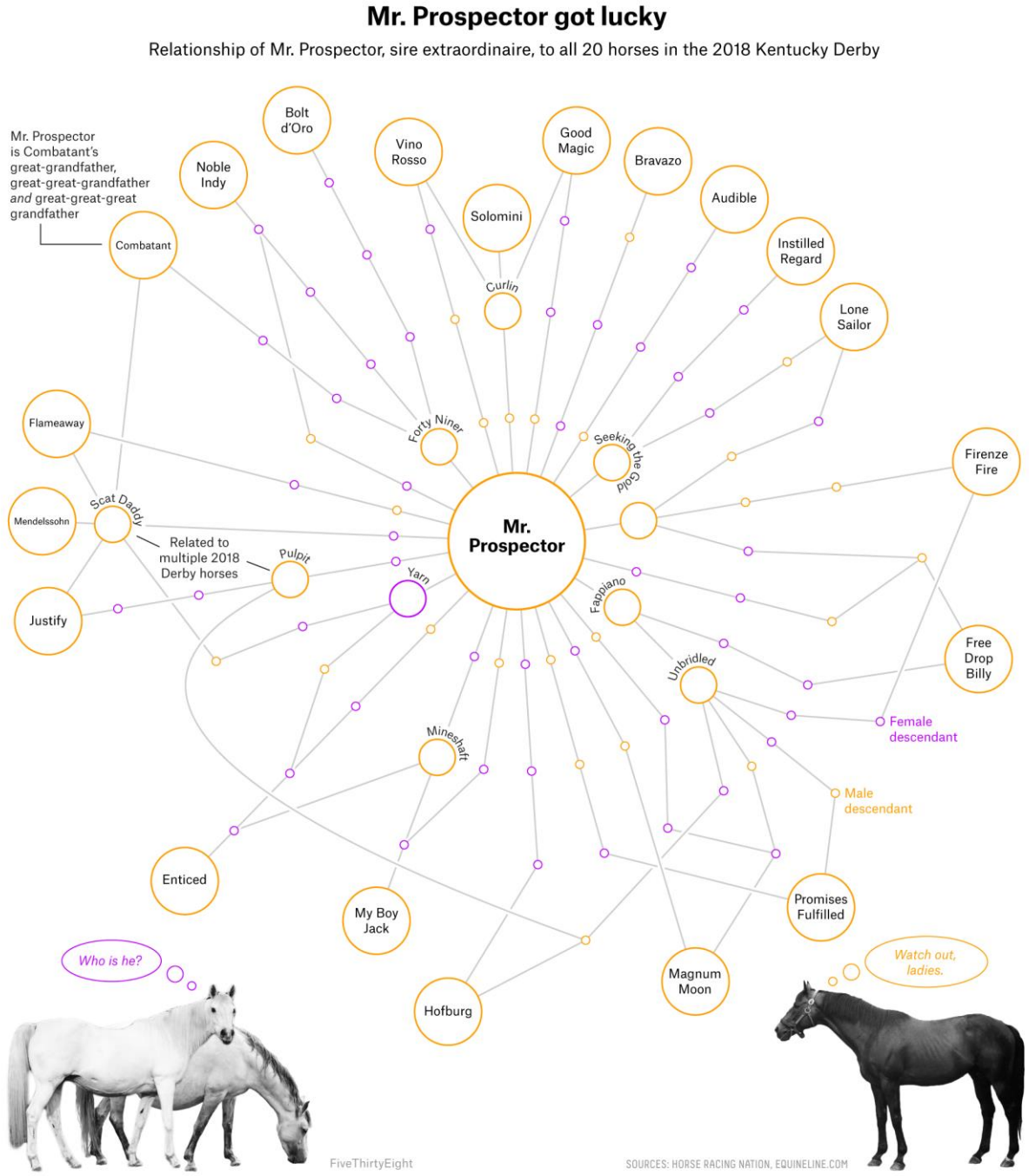
https://www.science.org/content/article/first-comprehensive-tree-life-shows-how-related-you-are-millions-species



https://www.lexisnexisip.com/resources/must-have-patent-visualization-tools/

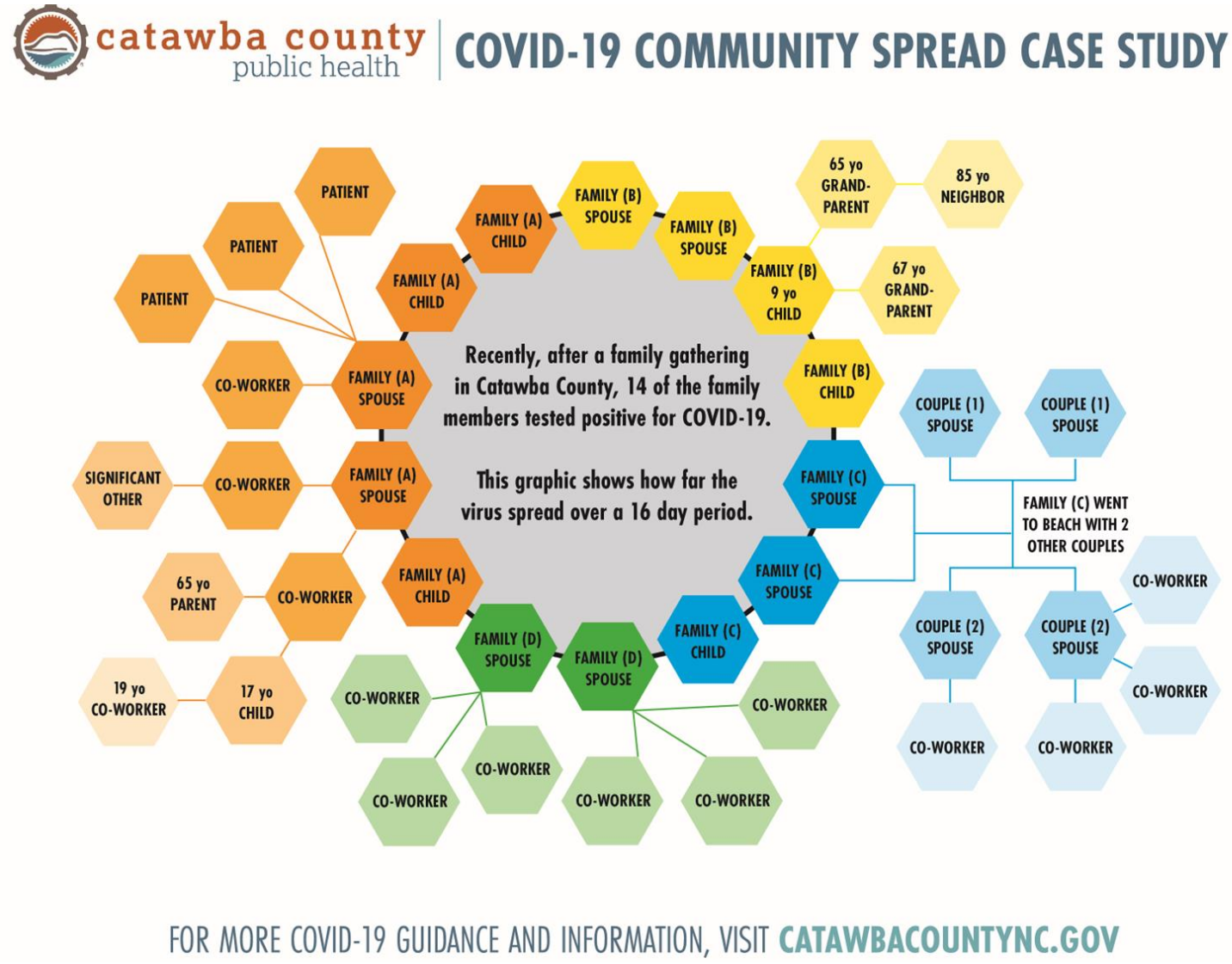
RADIAL TREE

2018 Kentucky Derby

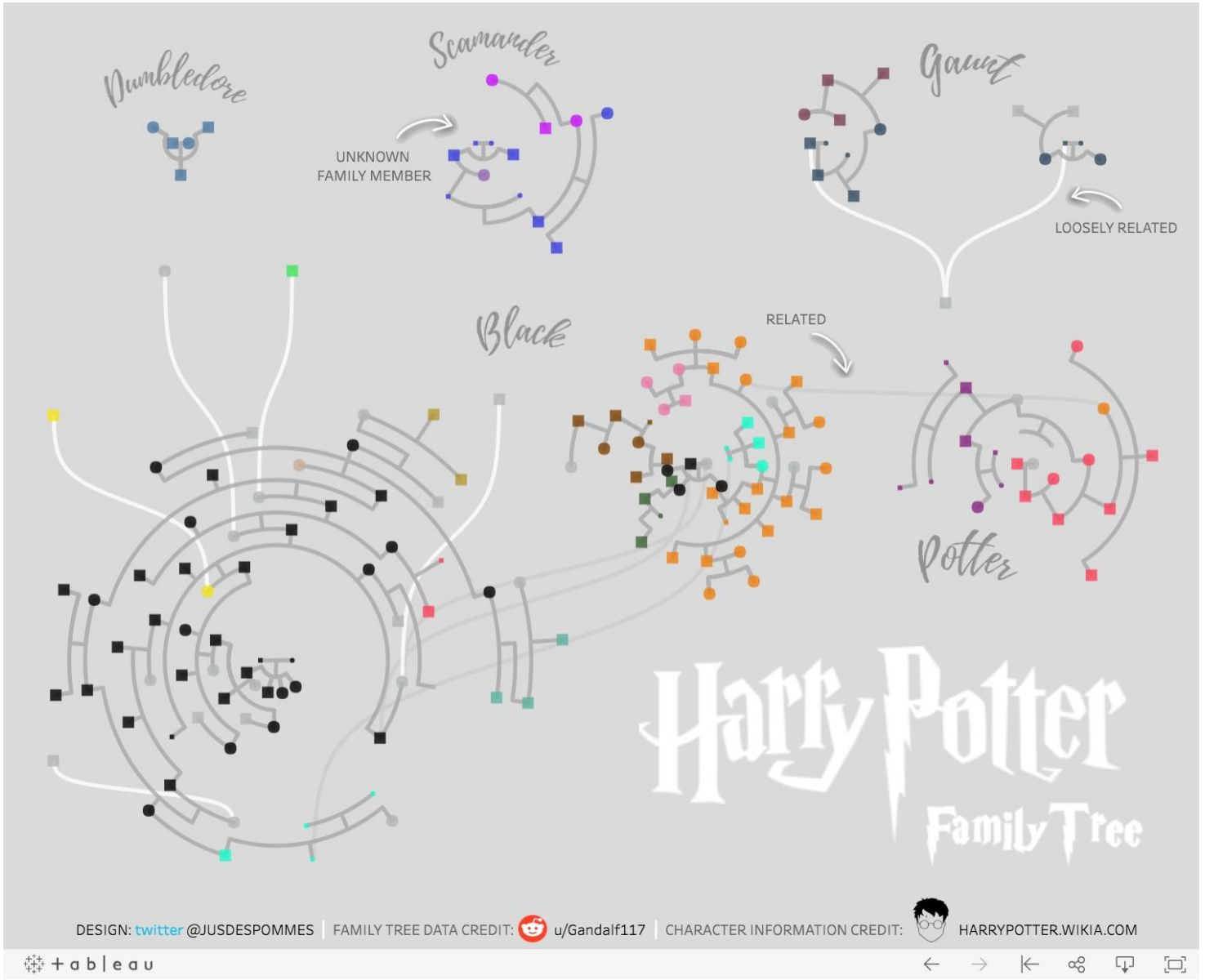


https://fivethirtyeight.com/features/nearly-half-the-kentucky-derby-field-is-racing-against-a-half-brother/

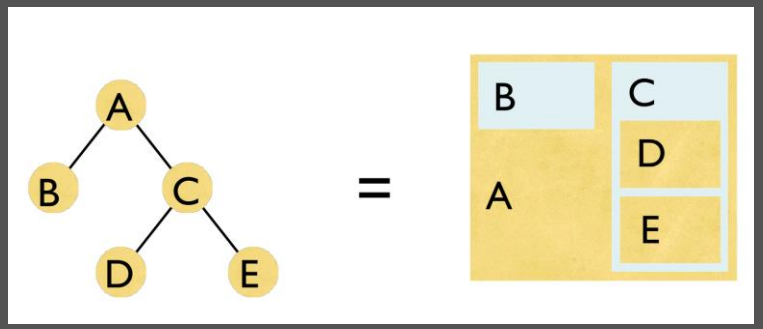
RADIAL TREE

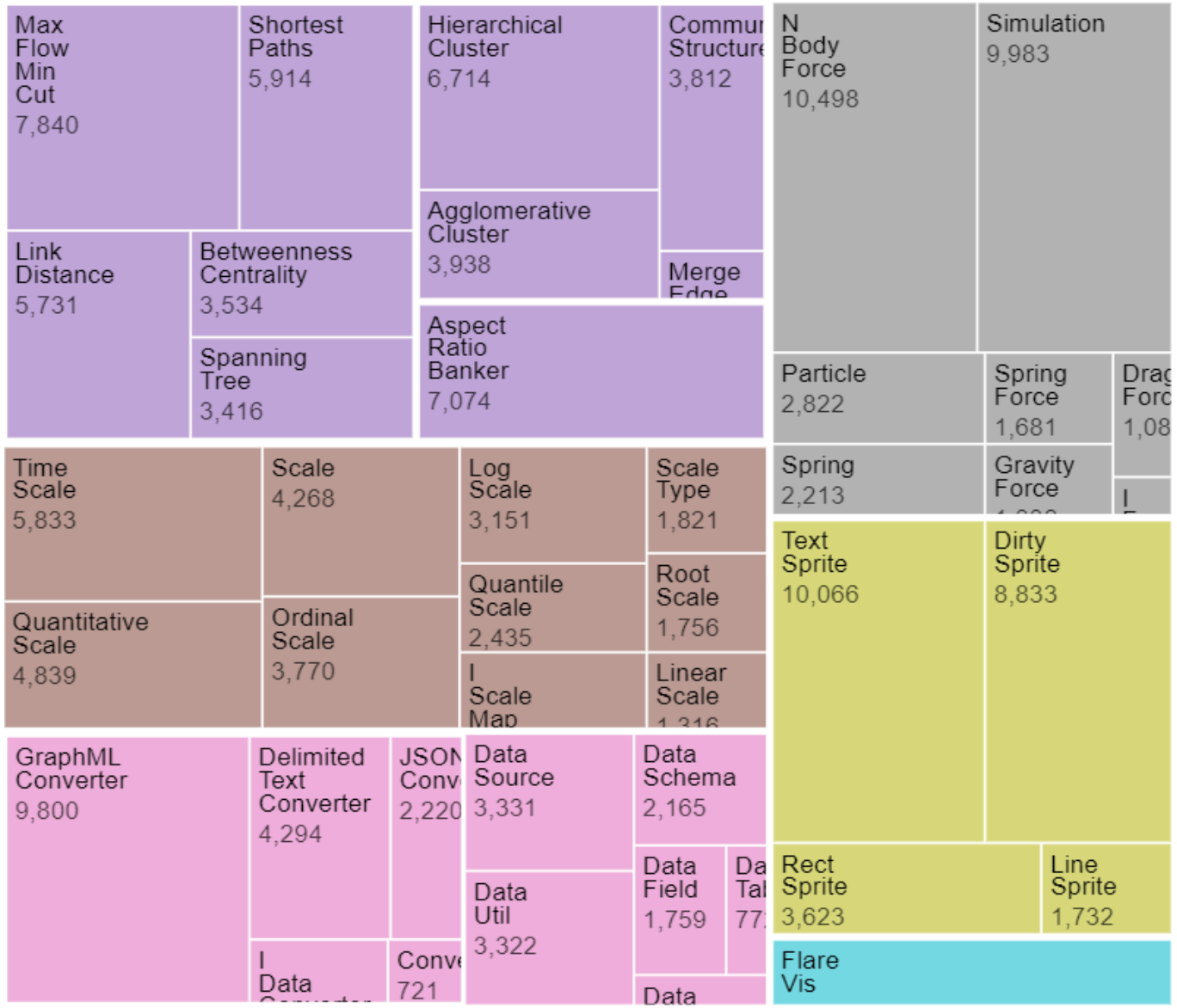

catawba county public health
COVID-19 COMMUNITY SPREAD CASE STUDY
Recently, after a family gathering in Catawba County, 14 of the family members tested positive for COVID-19.
This graphic shows how far the virus spread over a 16 day period.
PATIENT
PATIENT
PATIENT
FAMILY (A) CHILD
FAMILY (A) CHILD
FAMILY (B) SPOUSE
FAMILY (B) SPOUSE
65 yo GRAND-PARENT
85 yo NEIGHBOR
FAMILY (B) 9 yo CHILD
67 yo GRAND-PARENT
FAMILY (B) CHILD
CO-WORKER
FAMILY (A) SPOUSE
SIGNIFICANT OTHER
CO-WORKER
FAMILY (A) SPOUSE
FAMILY (C) SPOUSE
COUPLE (1) SPOUSE
COUPLE (1) SPOUSE
FAMILY (C) WENT TO BEACH WITH 2 OTHER COUPLES
65 yo PARENT
CO-WORKER
FAMILY (A) CHILD
FAMILY (C) SPOUSE
COUPLE (2) SPOUSE
COUPLE (2) SPOUSE
CO-WORKER
19 yo CO-WORKER
17 yo CHILD
FAMILY (D) SPOUSE
FAMILY (D) SPOUSE
FAMILY (C) CHILD
CO-WORKER
CO-WORKER
CO-WORKER
CO-WORKER
CO-WORKER
CO-WORKER
CO-WORKER
CO-WORKER
CO-WORKER
FOR MORE COVID-19 GUIDANCE AND INFORMATION, VISIT CATAWBACOUNTYNC.GOV

RADIAL TREE


Dumbledore
Scamander
UNKNOWN
FAMILY MEMBER
Gaunt
LOOSELY RELATED
Black
RELATED
Potter
Harry Potter
Family Tree
DESIGN: twitter @JUSDESPOMMES | FAMILY TREE DATA CREDIT: u/Gandalf117 | CHARACTER INFORMATION CREDIT: HARRYPOTTER.WIKIA.COM
+ableau

TREEMAP





https://observablehq.com/@d3/treemap

SUNBURST

M. Bostock, “Sunburst Partition”, D3 Gallery, http://bl.ocks.org/mbostock/4063423


How to cite this site?
Check out other surveys!
treevis.net - A Visual Bibliography of Tree Visualization 2.0 by Hans-Jörg Schulz
v.04-SEP-20
Dimensionality
All
Representation
All
Alignment
All
Fulltext Search
Techniques Shown
339

Take Home Message

- Finding the best solution depends on your data and purpose/task
- Explore!!! Iterate
- Use these examples and techniques to inspire you

Network Diagram Workshop

Slides:
https://brosz.ca/slides

Contact:
jdlbrosz@ucalgary.ca