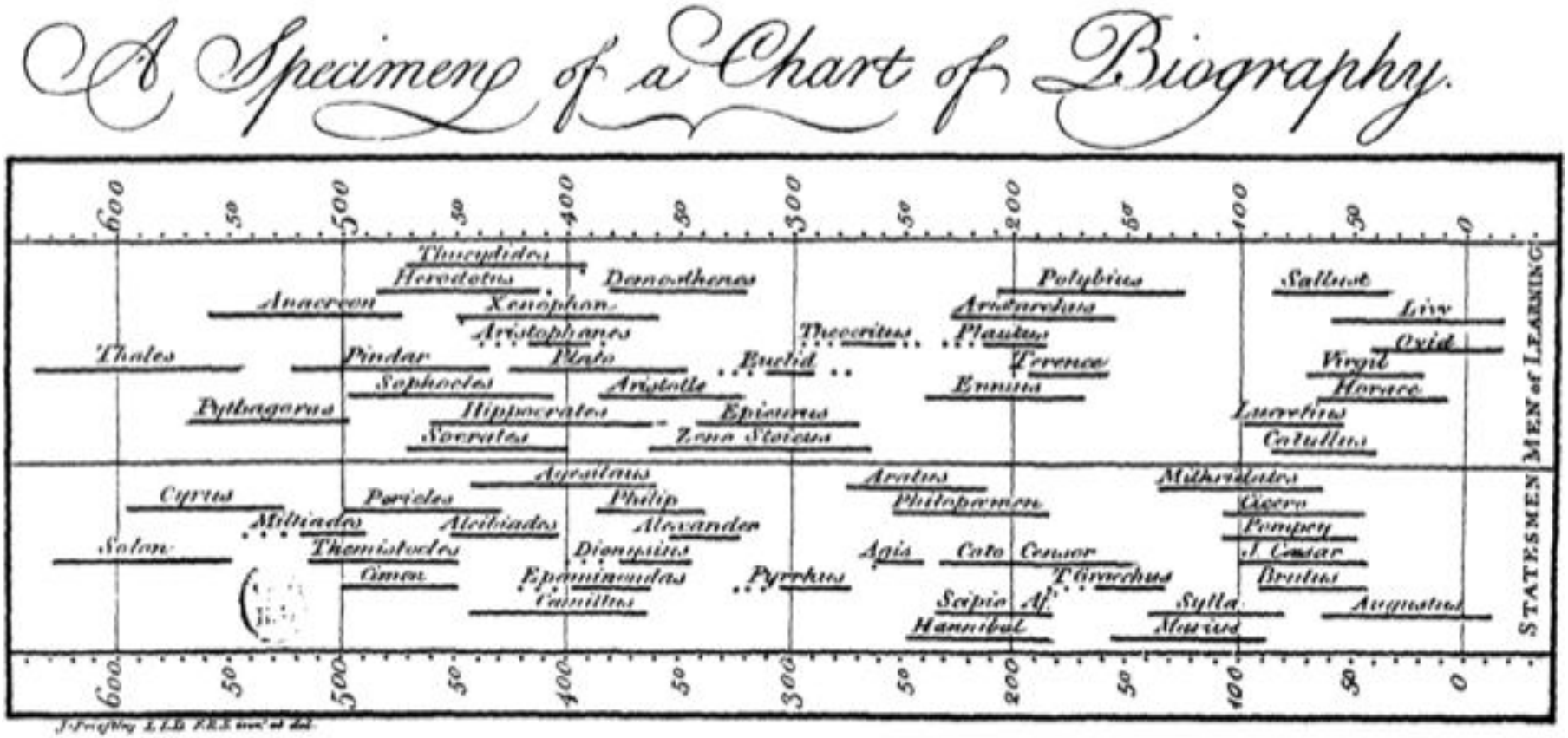
Time

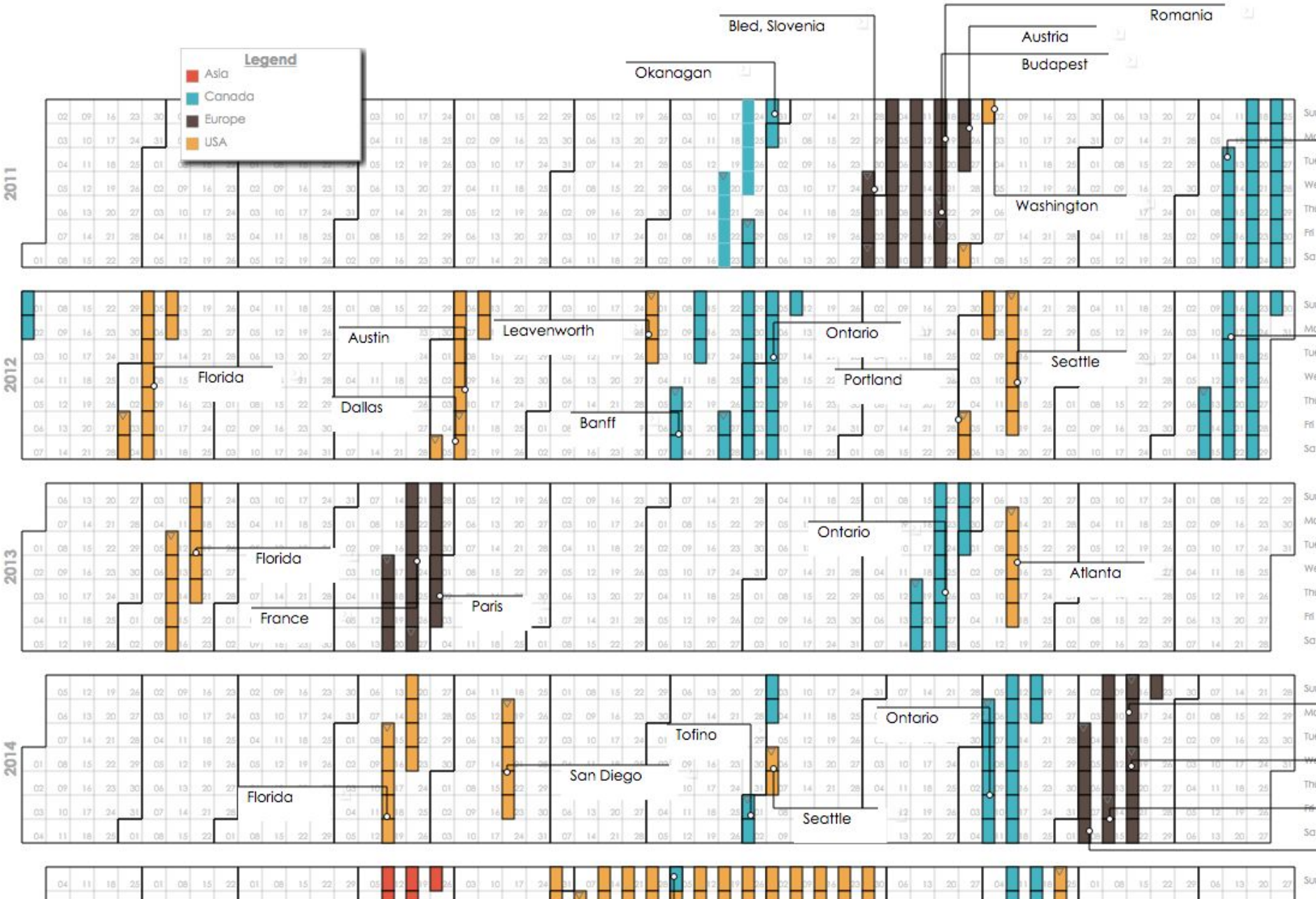
Complexity of Time

- Well known but hard to grasp
- Different scales (min, days, weeks, years...)
- Combination with already complicated problems (maps, networks, nD-data.)

Gantt charts



Calendars

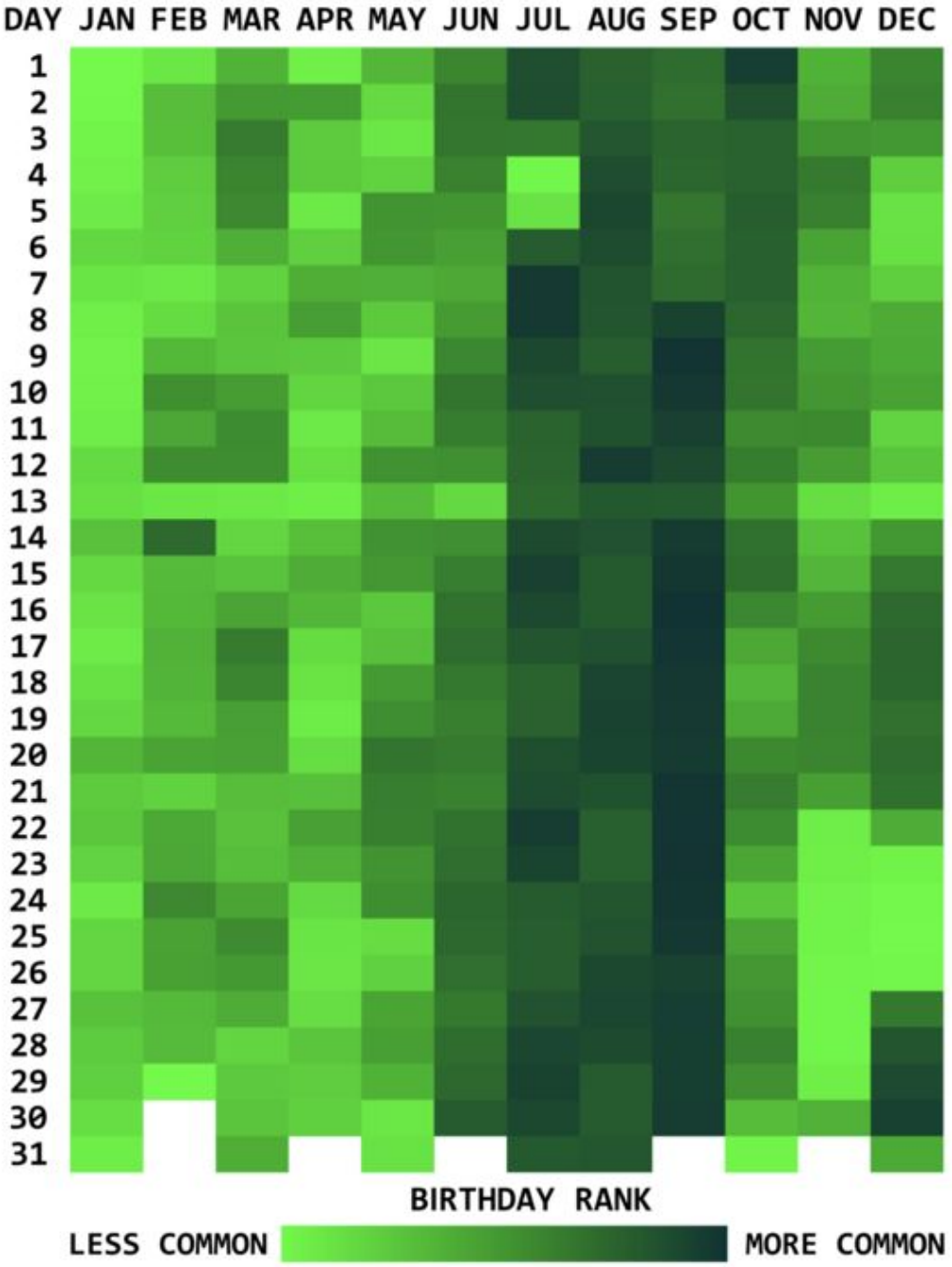

Legend
Asia
Canada
Europe
USA
2011
2012
2013
2014
Bled, Slovenia
Okanagan
Romania
Austria
Budapest
Washington
Florida
Austin
Dallas
Leavenworth
Banff
Ontario
Portland
Seattle
Florida
France
Paris
Ontario
Atlanta
Florida
San Diego
Tofino
Seattle
Ontario

Heatmap

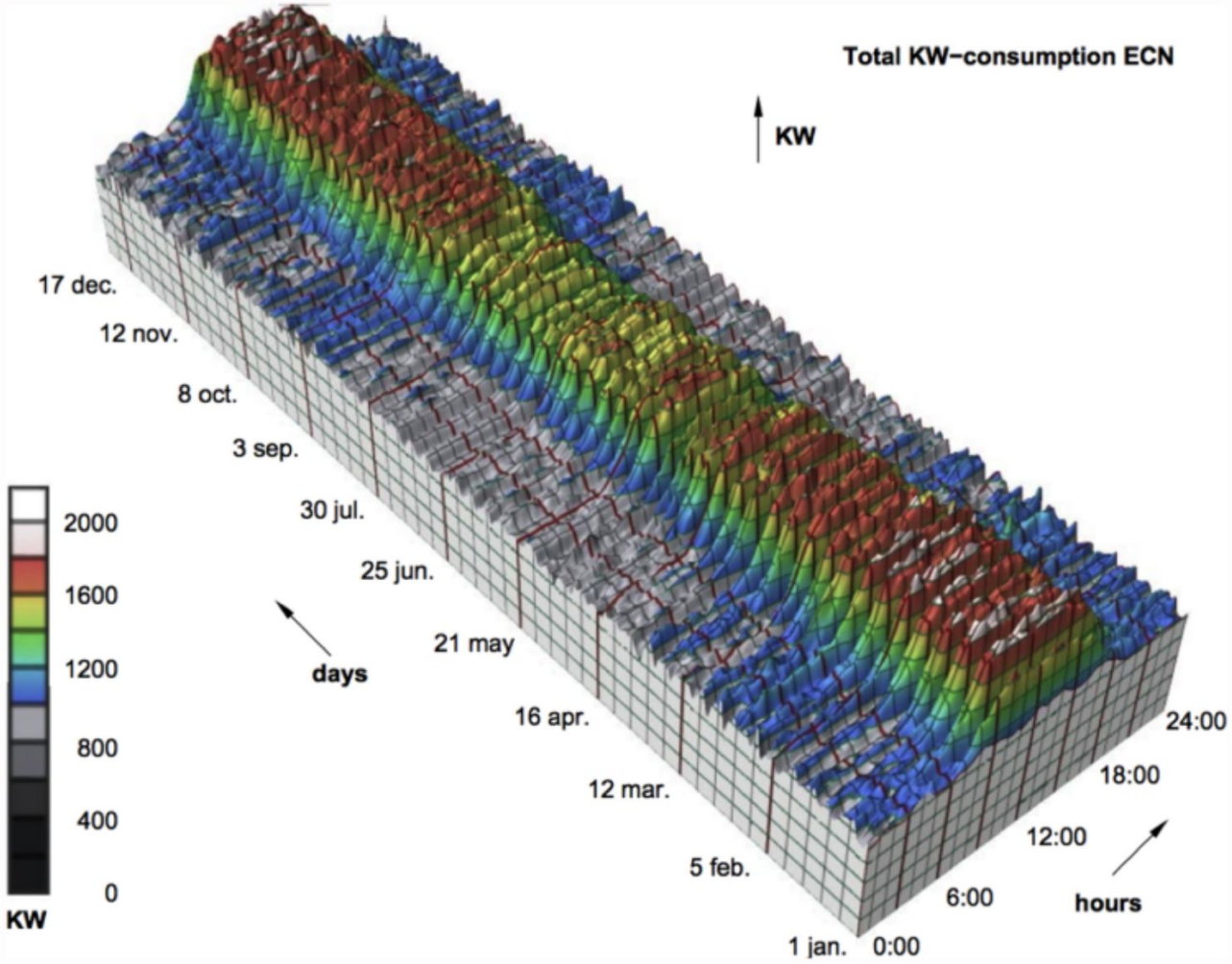
- Calendar data + numerical values

\+ Row and column effects
\+ Easy look up
\+ Space efficient

\- Precise value comparison



3D heatmap matrix



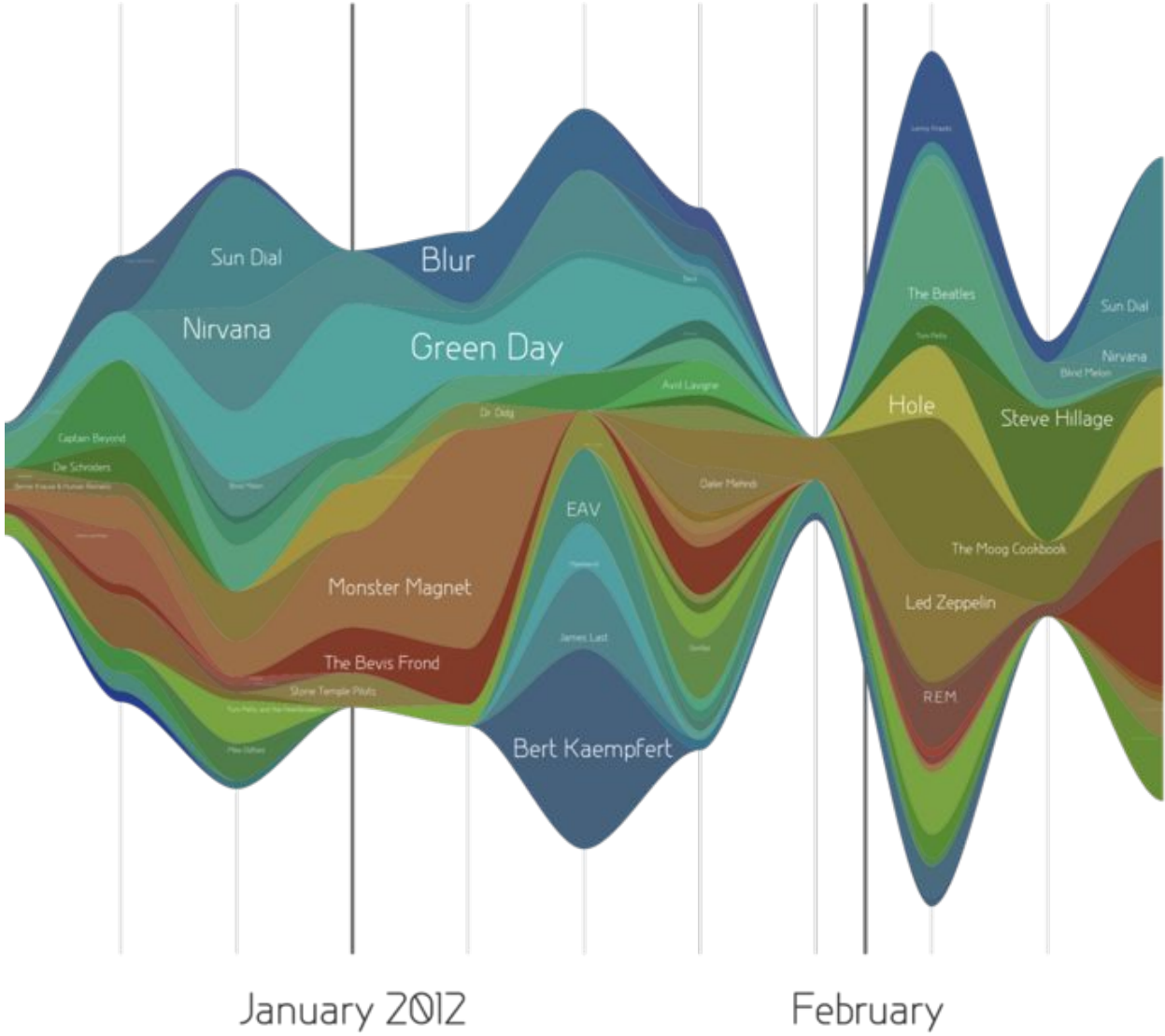
Van Wijk, Jarke J., and Edward R. Van Selow. "Cluster and calendar based visualization of time series data." *Information Visualization, 1999.(Info Vis' 99) Proceedings. 1999 IEEE Symposium on*. IEEE, 1999.

Stream Graph

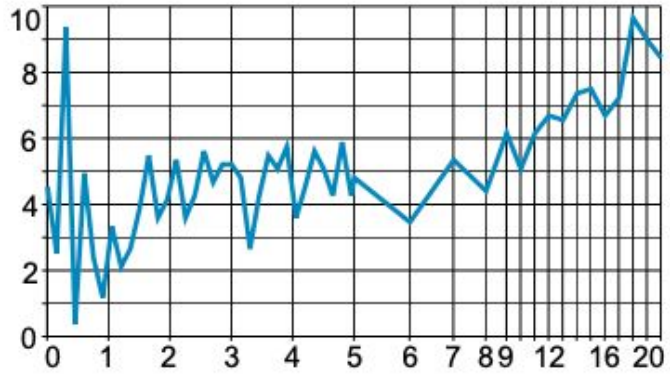
- Multiple quantiative values over time

\+ Accumulated values
\+ Relative values

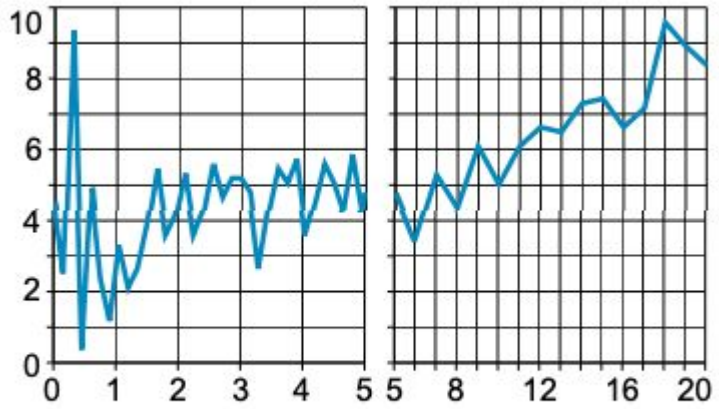
\- Comparison across time is hard
\- Hard to assess individual values



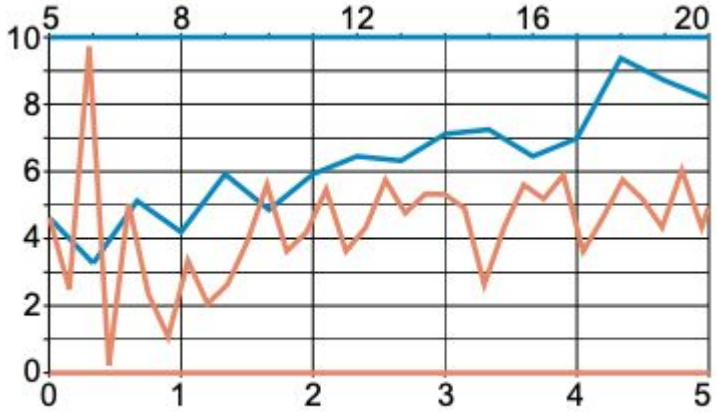
Dual-Scale Data Charts



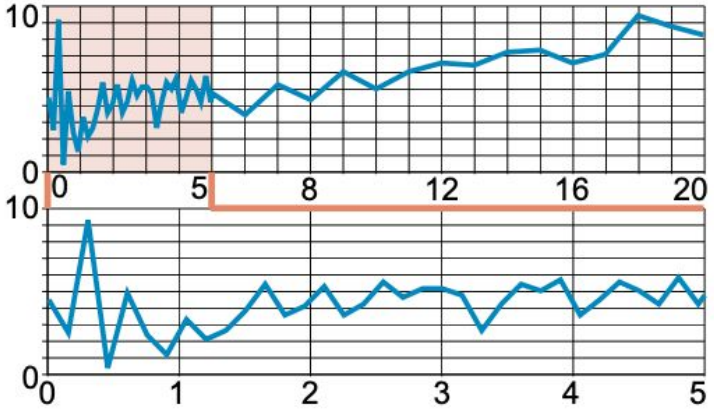
(a) A lens chart.



(a) A broken chart.



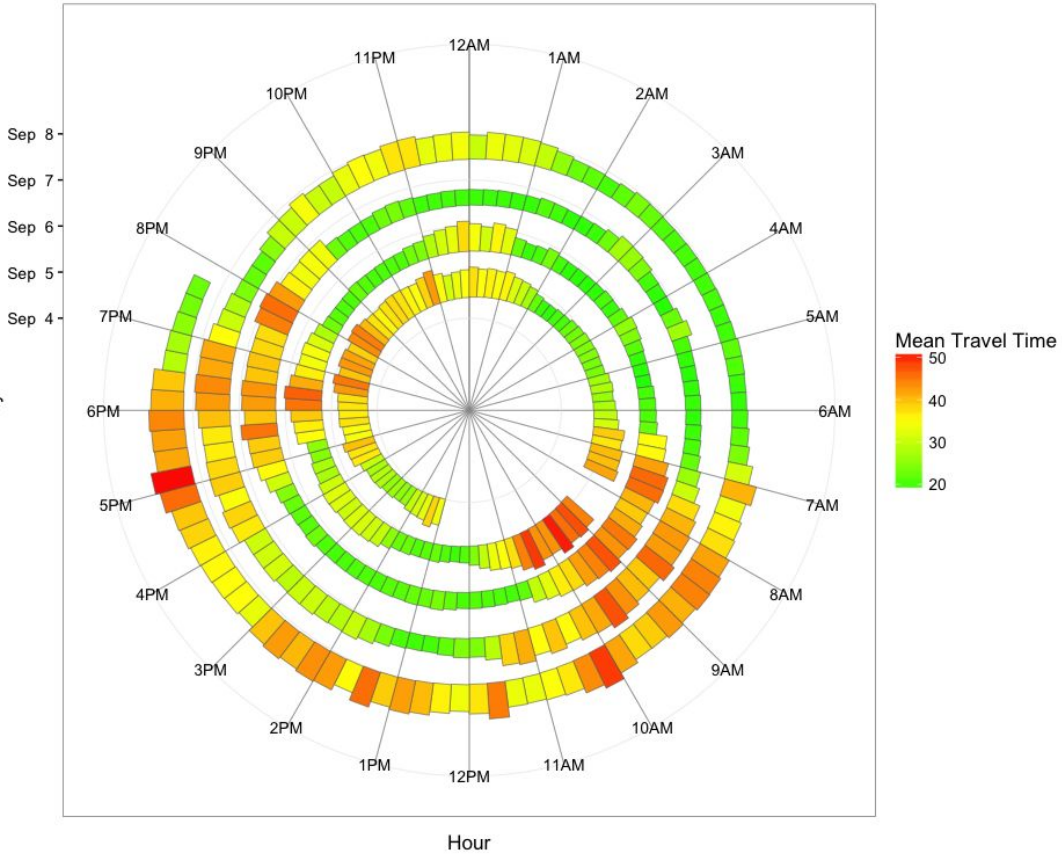
(a) A superimposed chart.

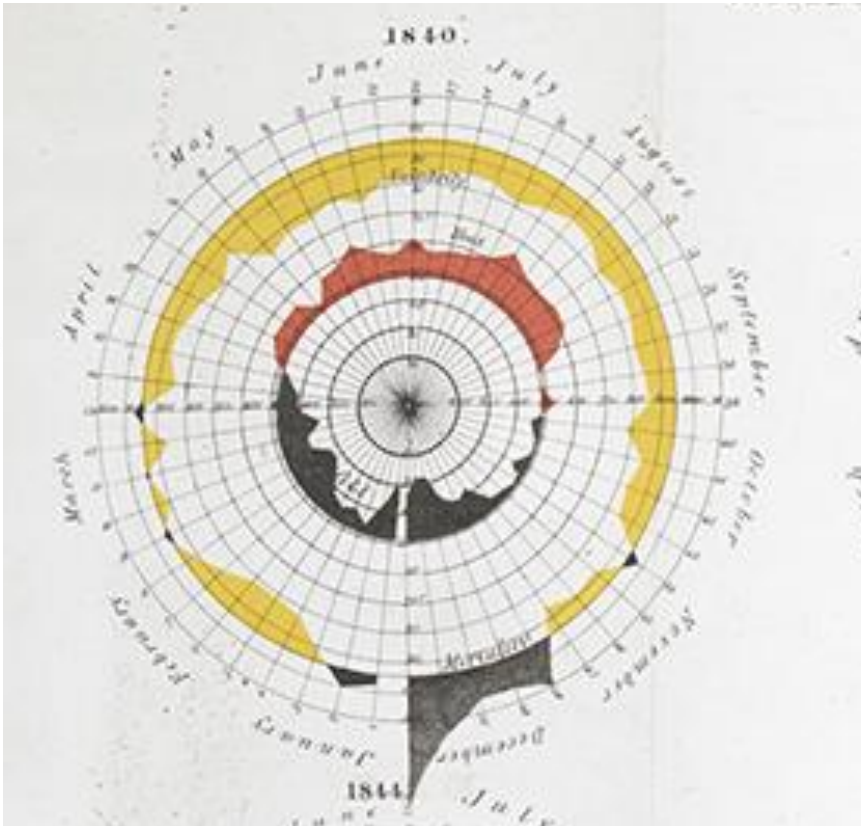


(a) A cut-out chart.

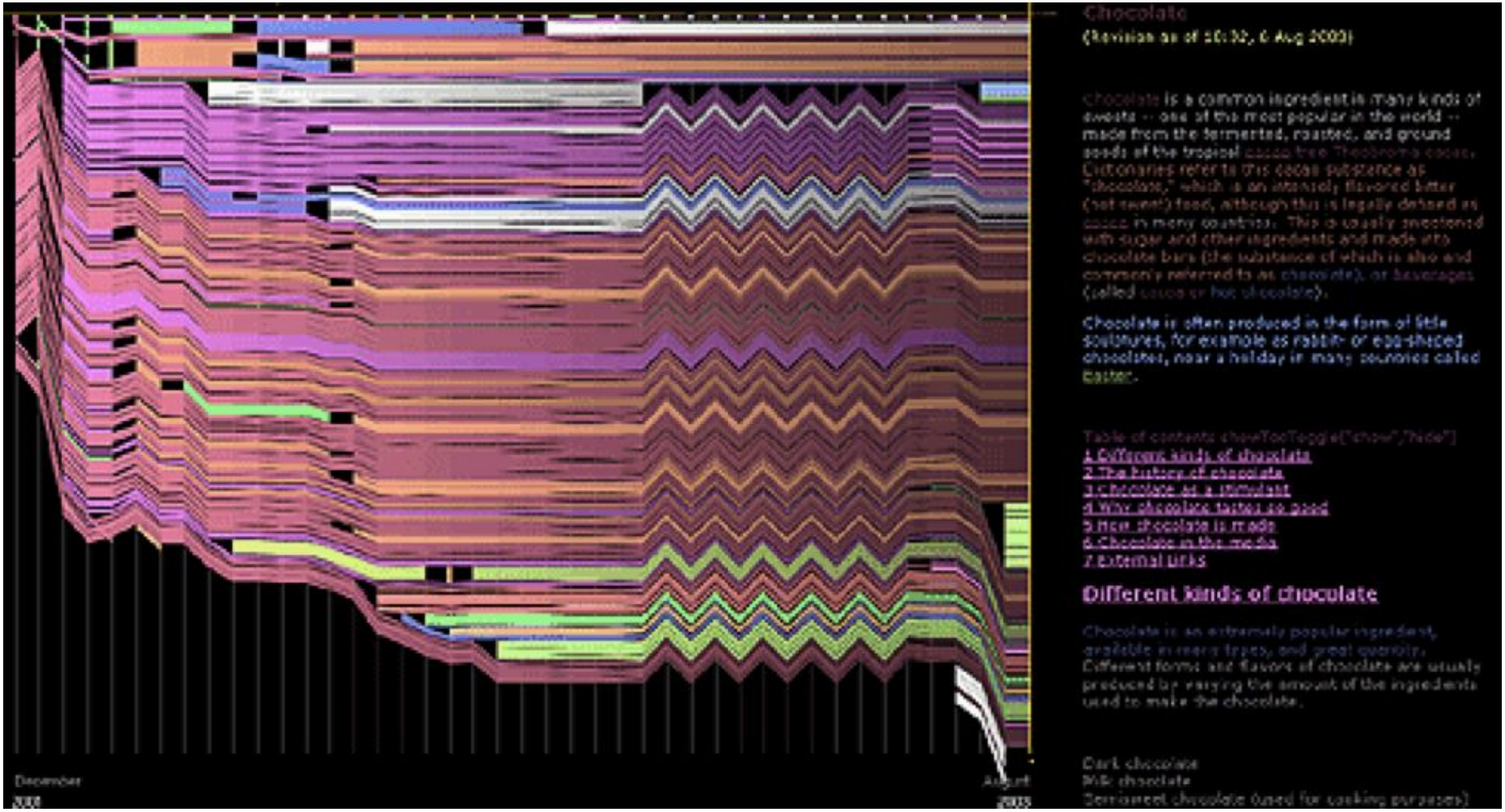
https://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=6065014

Radial time visualizations



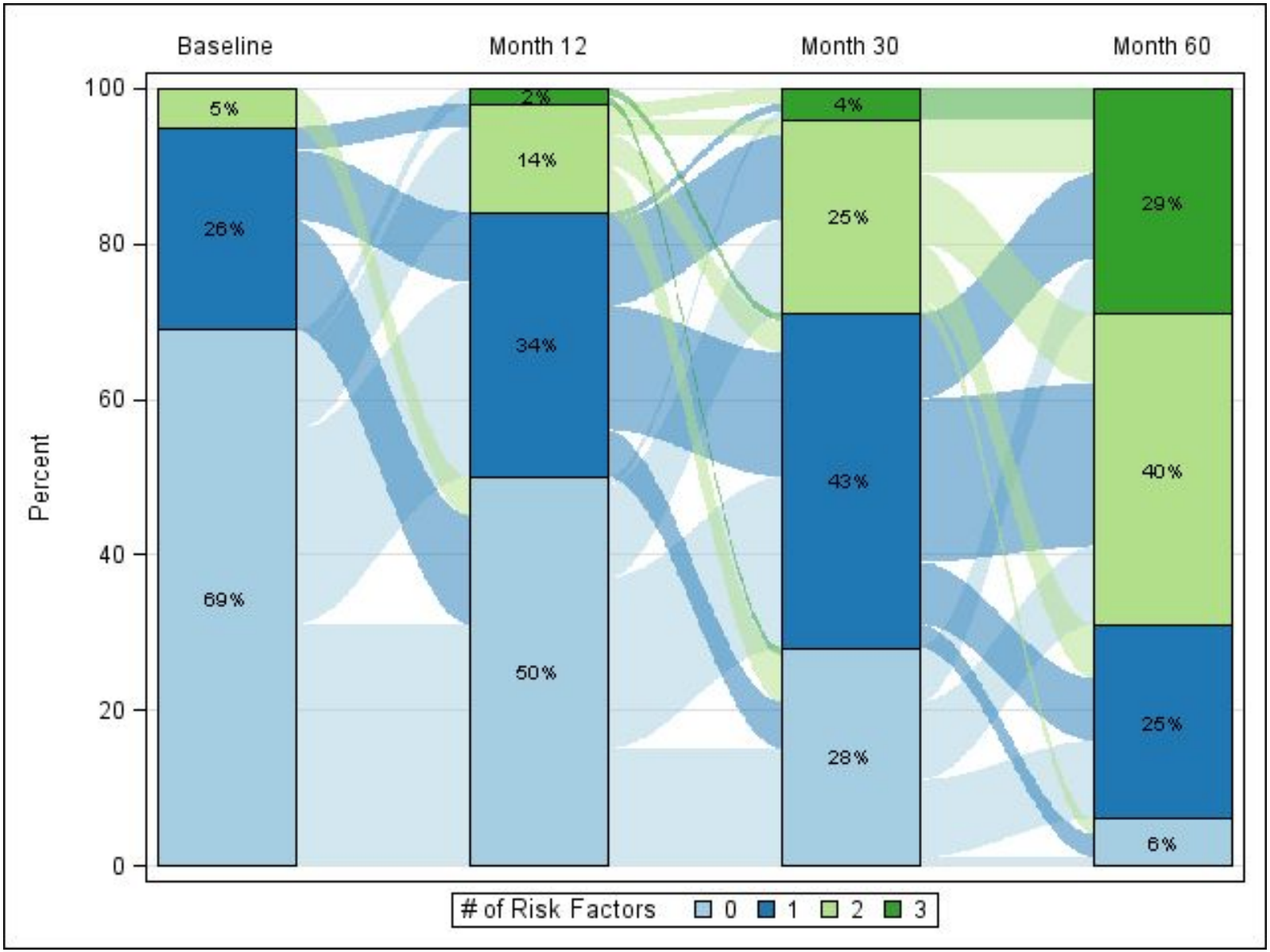


Stackflow



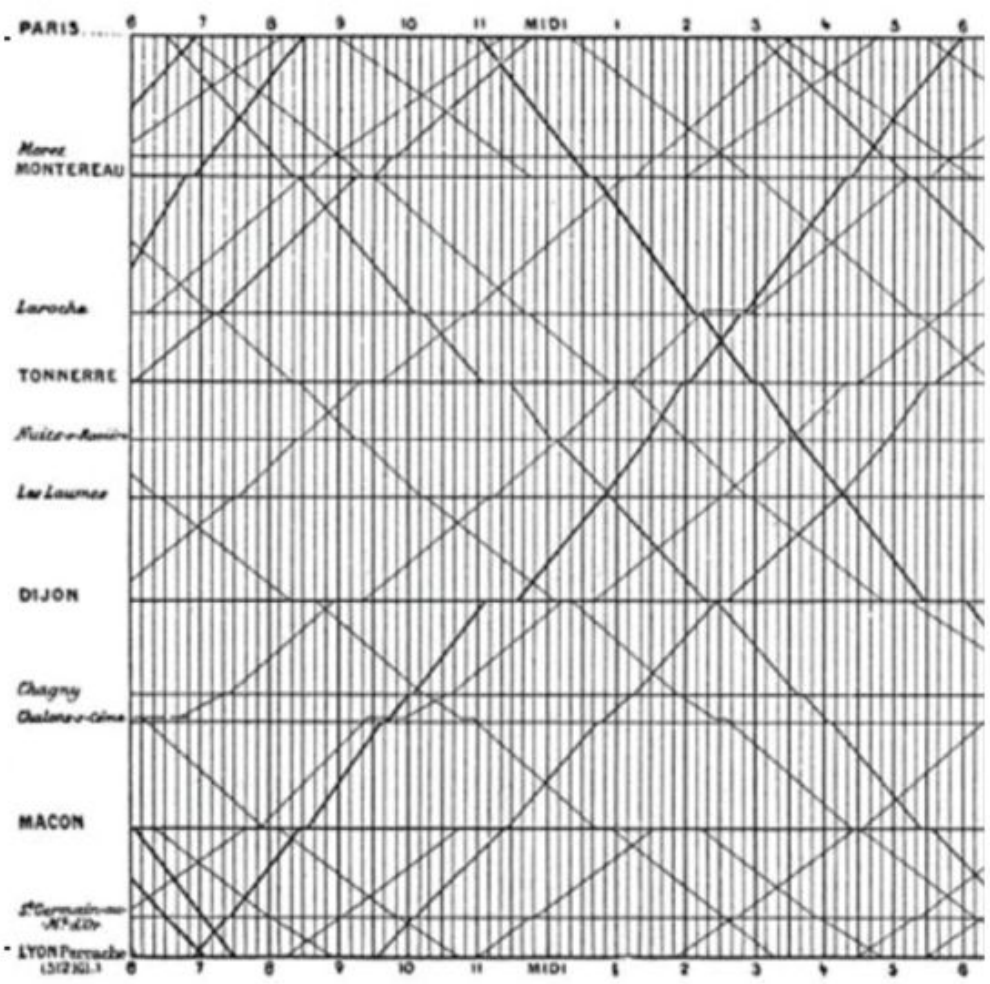
Viégas, Fernanda B., Martin Wattenberg, and Kushal Dave. "Studying cooperation and conflict between authors with history flow visualizations." *Proceedings of the SIGCHI conference on Human factors in computing systems*. ACM, 2004.

Flow Diagram

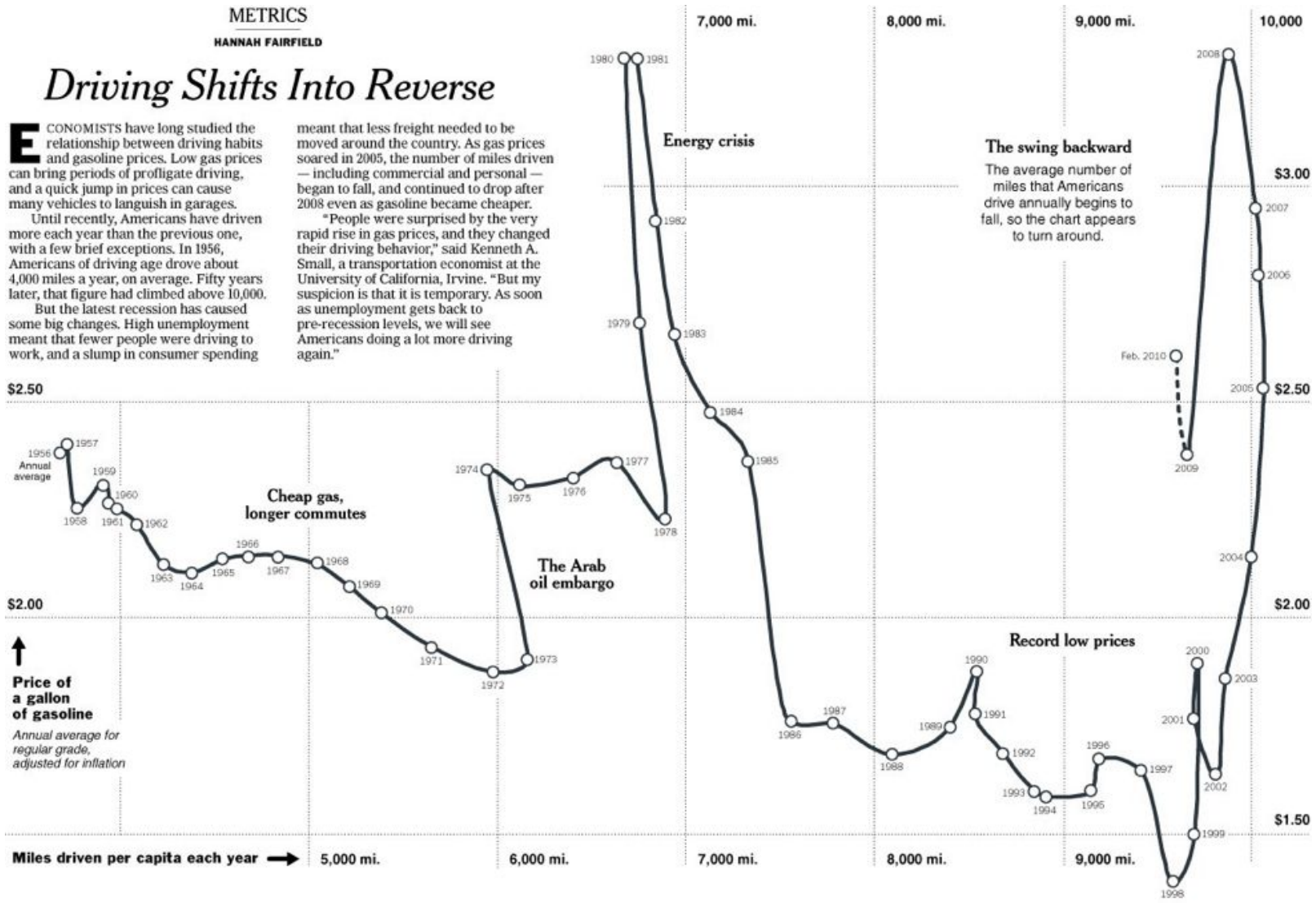


Train Plans


Paris
Versailles
A4
A10
A5
A6
A26
A71
A77
A6
Parc Naturel
Régional
du Morvan
A39
A36
Bourges
A71
France
E62
A6
A39
E62
Vichy
A71
A40
Clermont-Ferrand
A89
A72
A43
Lyon

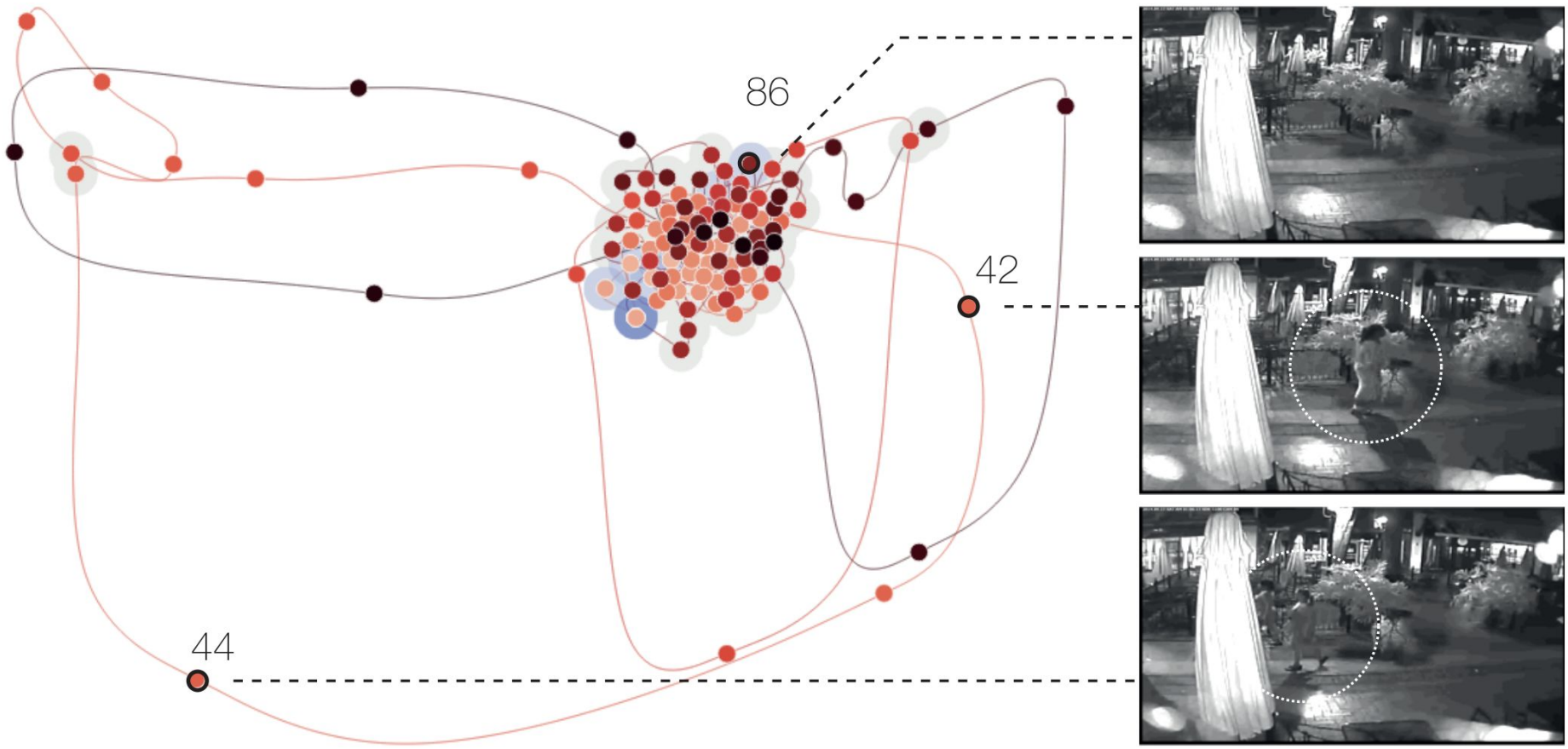

PARIS
MIDI
MONTEREAU
TONNERRE
DIJON
MACON
LYON

Connected Scatterplot



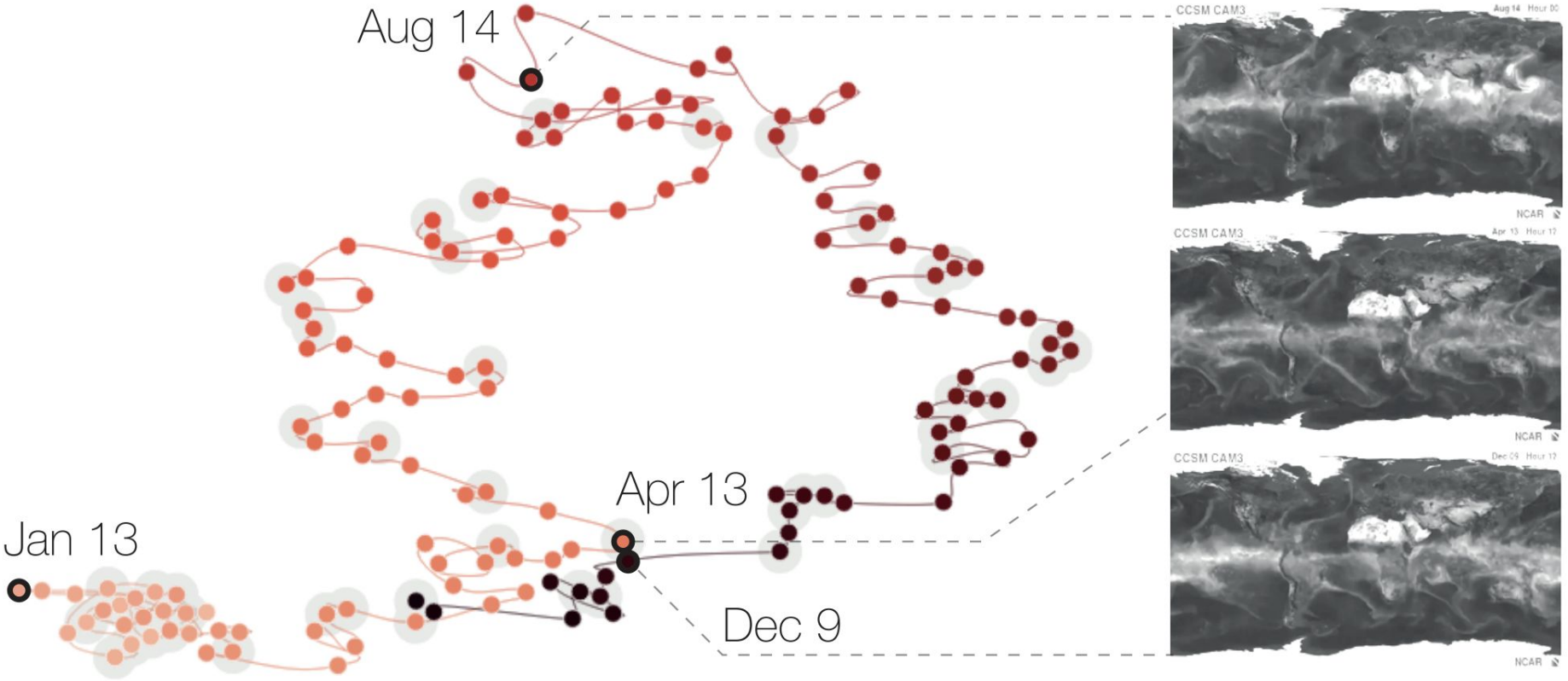
Haroz, Steve, Robert Kosara, and Steve Franconeri. "The connected scatterplot for presenting paired time series." *IEEE Transactions on Visualization & Computer Graphics* 1 (2016): 1-1.

Time Curves



Bach, Benjamin, et al. "Time curves: Folding time to visualize patterns of temporal evolution in data." *IEEE transactions on visualization and computer graphics* 22.1 (2016).

Time Curves

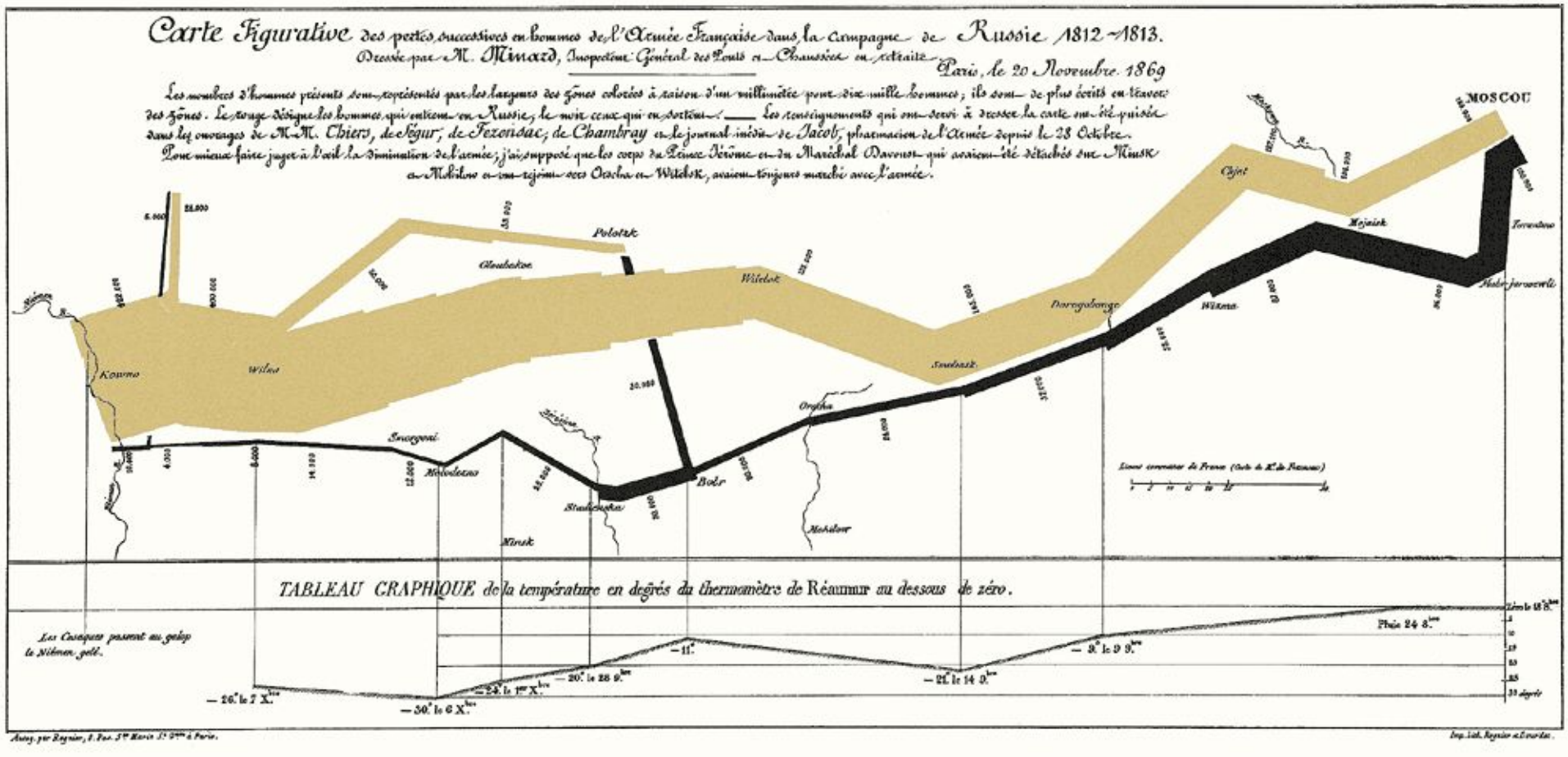

Aug 14
Apr 13
Jan 13
Dec 9
CCSM CAM3
NCAR
CCSM CAM3
NCAR
CCSM CAM3
NCAR

Time Curves

+ Amount of change
+ Signatures
+ Comparision

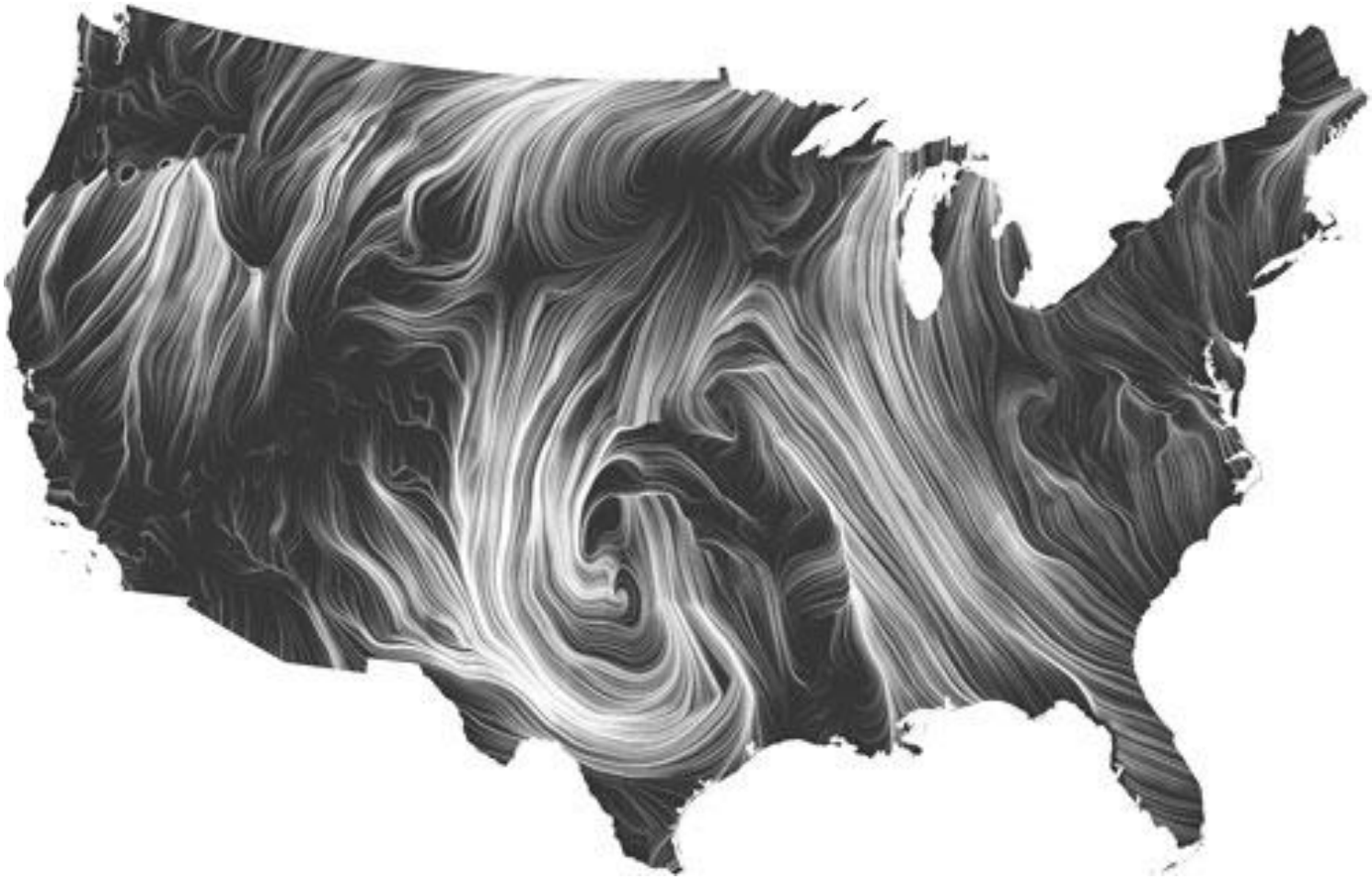
- Details
- Artifacts due to projection

Spatio-Temporal



Charles Joseph Minard (1781–1870)

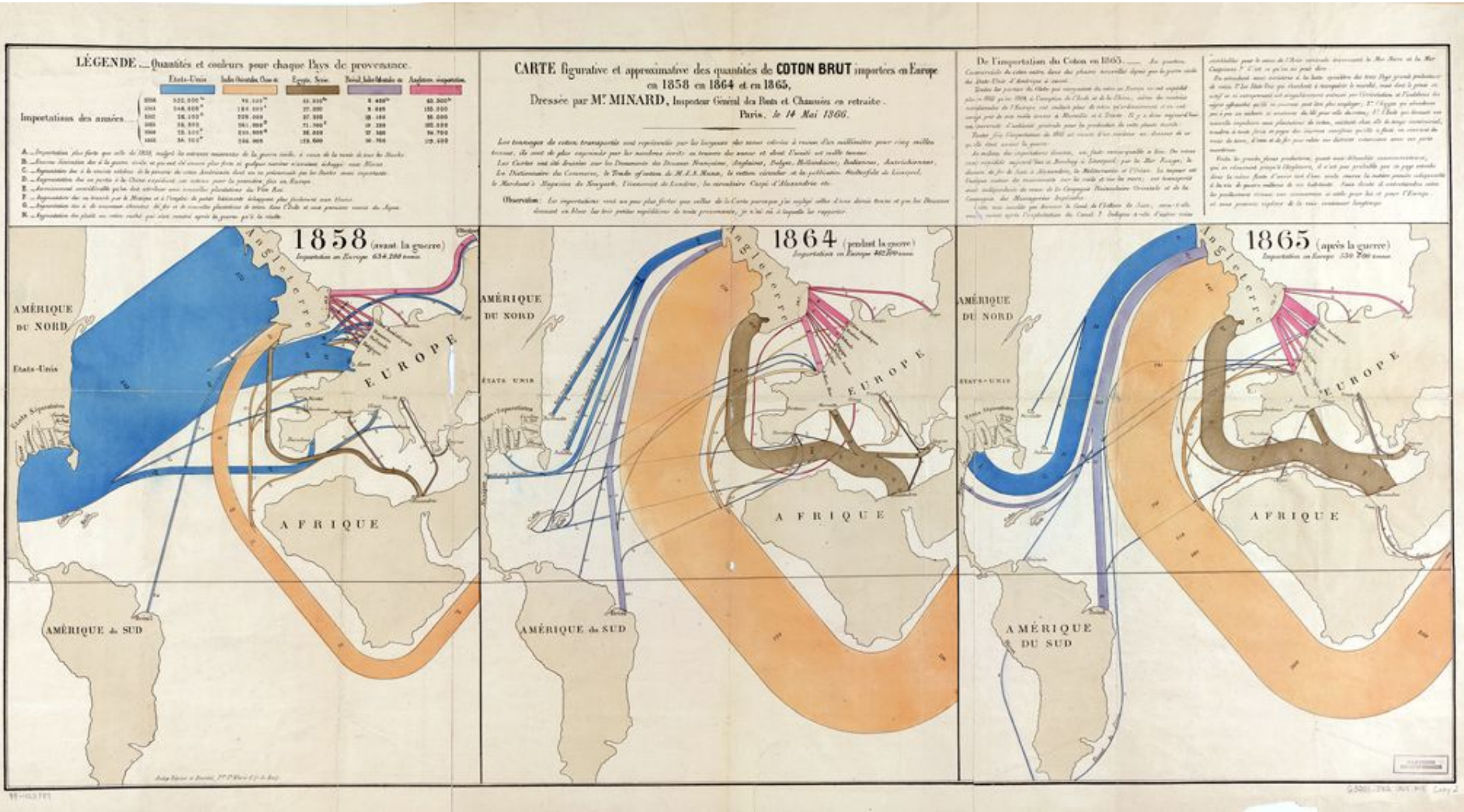
Wind Map



http://www.bewitched.com/windmap.html

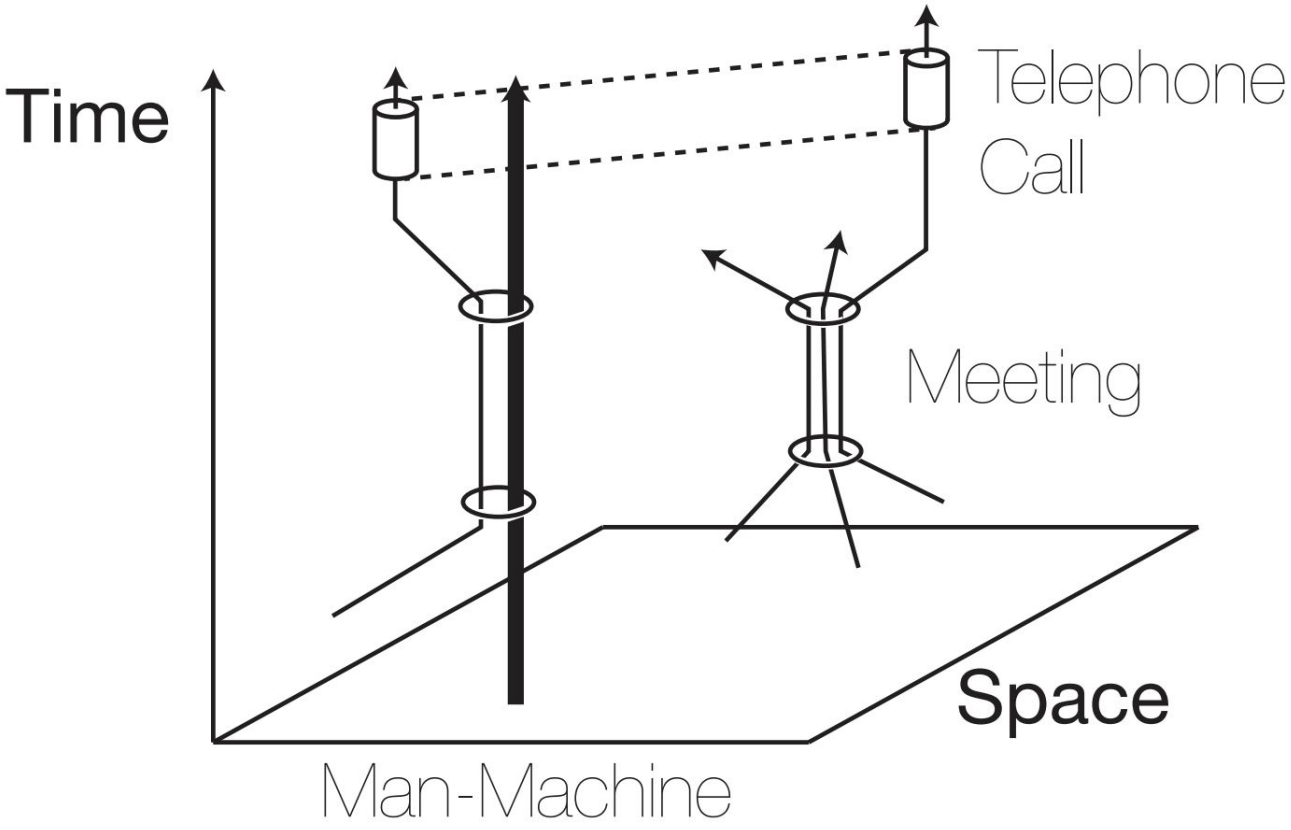
http://hint.fm/wind/

Flow Diagram Small Multiples



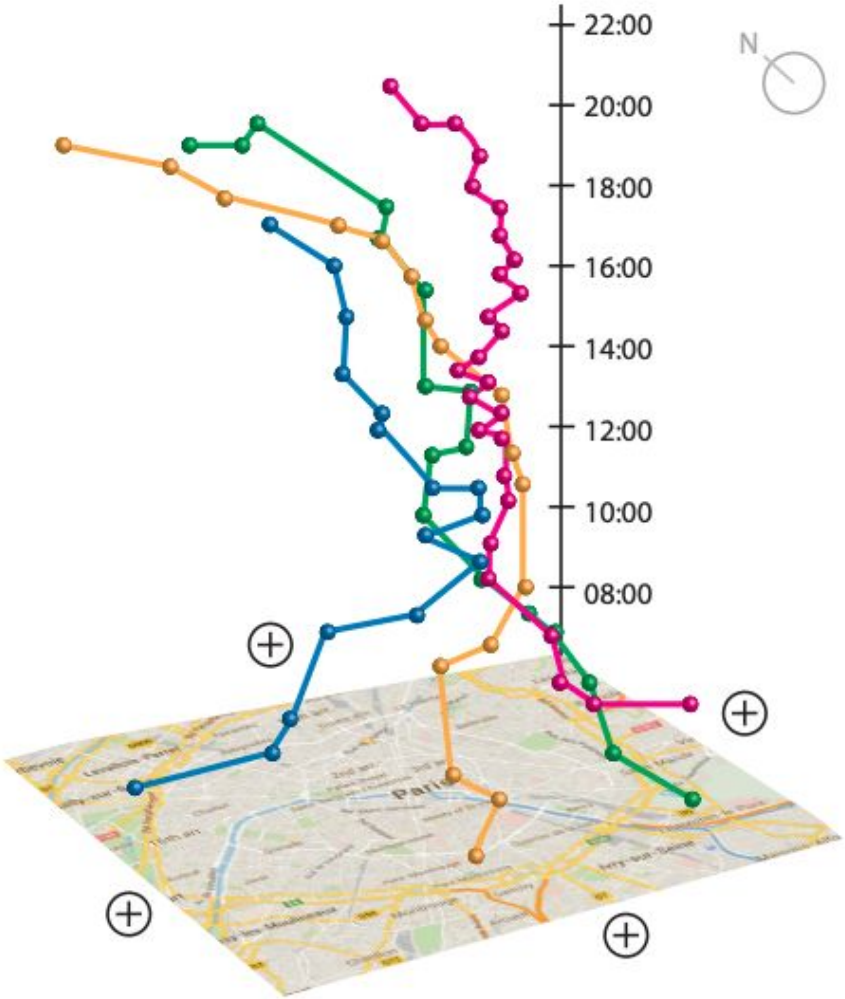
Space-Time Cubes

Space-Time Cubes

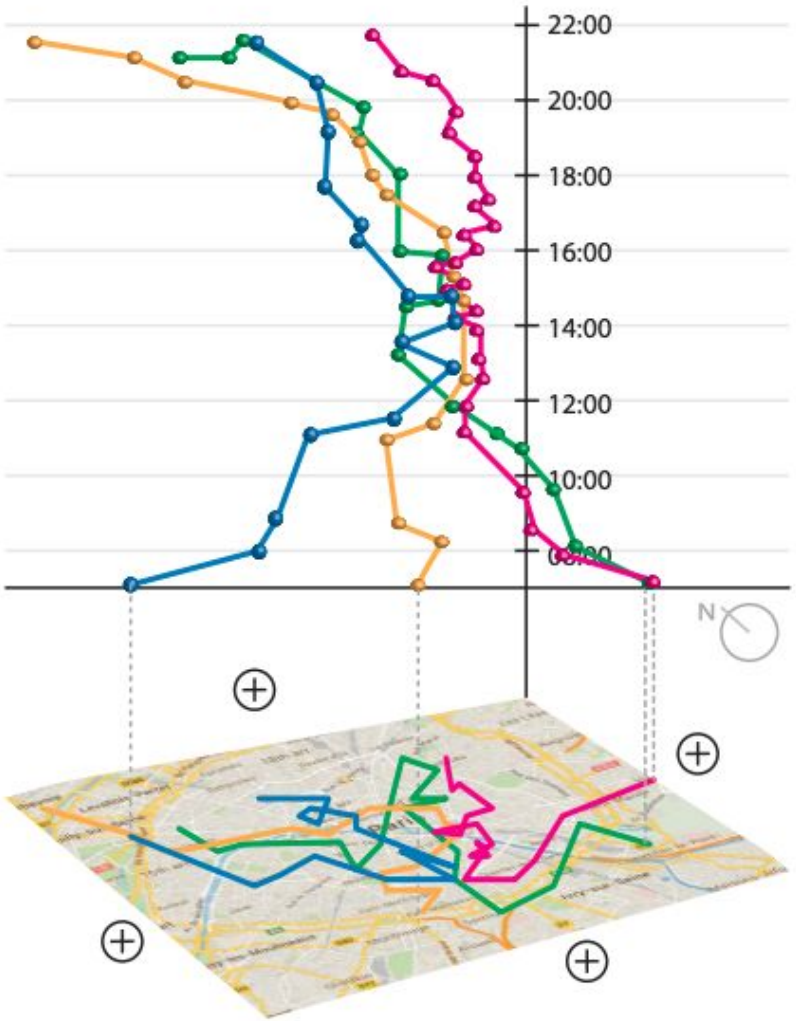


Bach, Benjamin, et al. "A Descriptive Framework for Temporal Data Visualizations Based on Generalized Space-Time Cubes." *Computer Graphics Forum*. Vol. 36. No. 6. 2017.

Space-Time Cubes

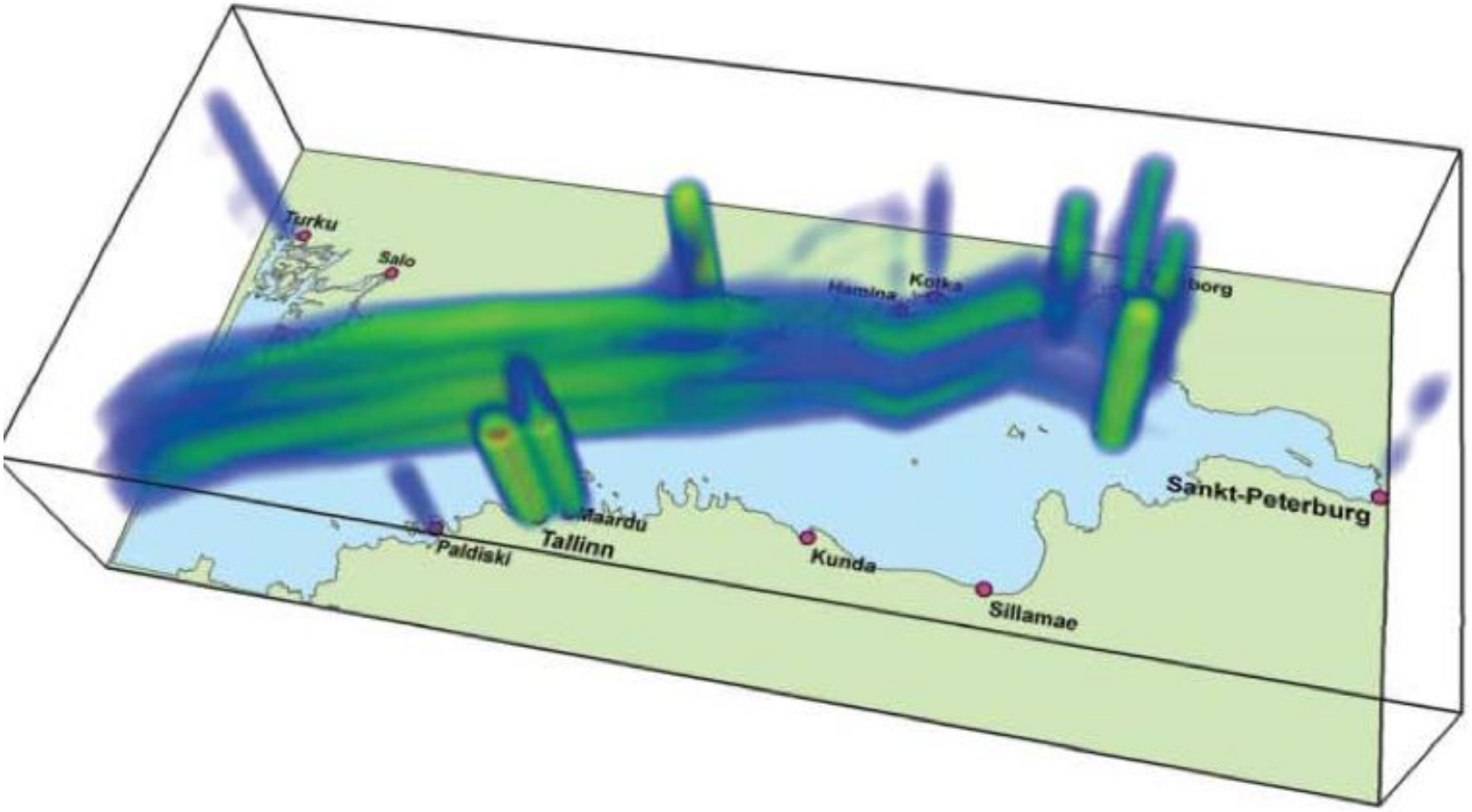


(a) 3D rendering

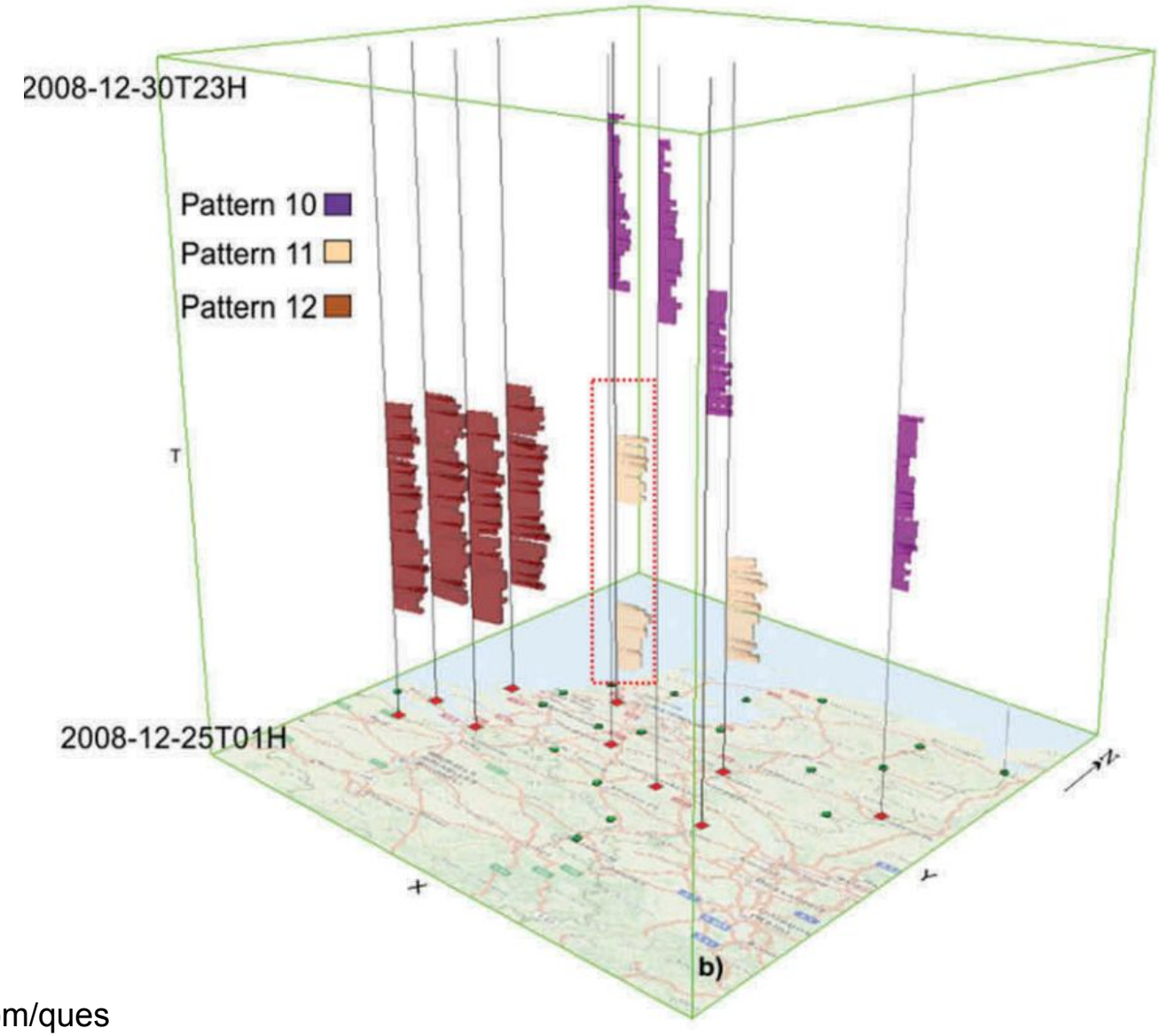


(b) Space flattening (on top)

Space-Time Cubes

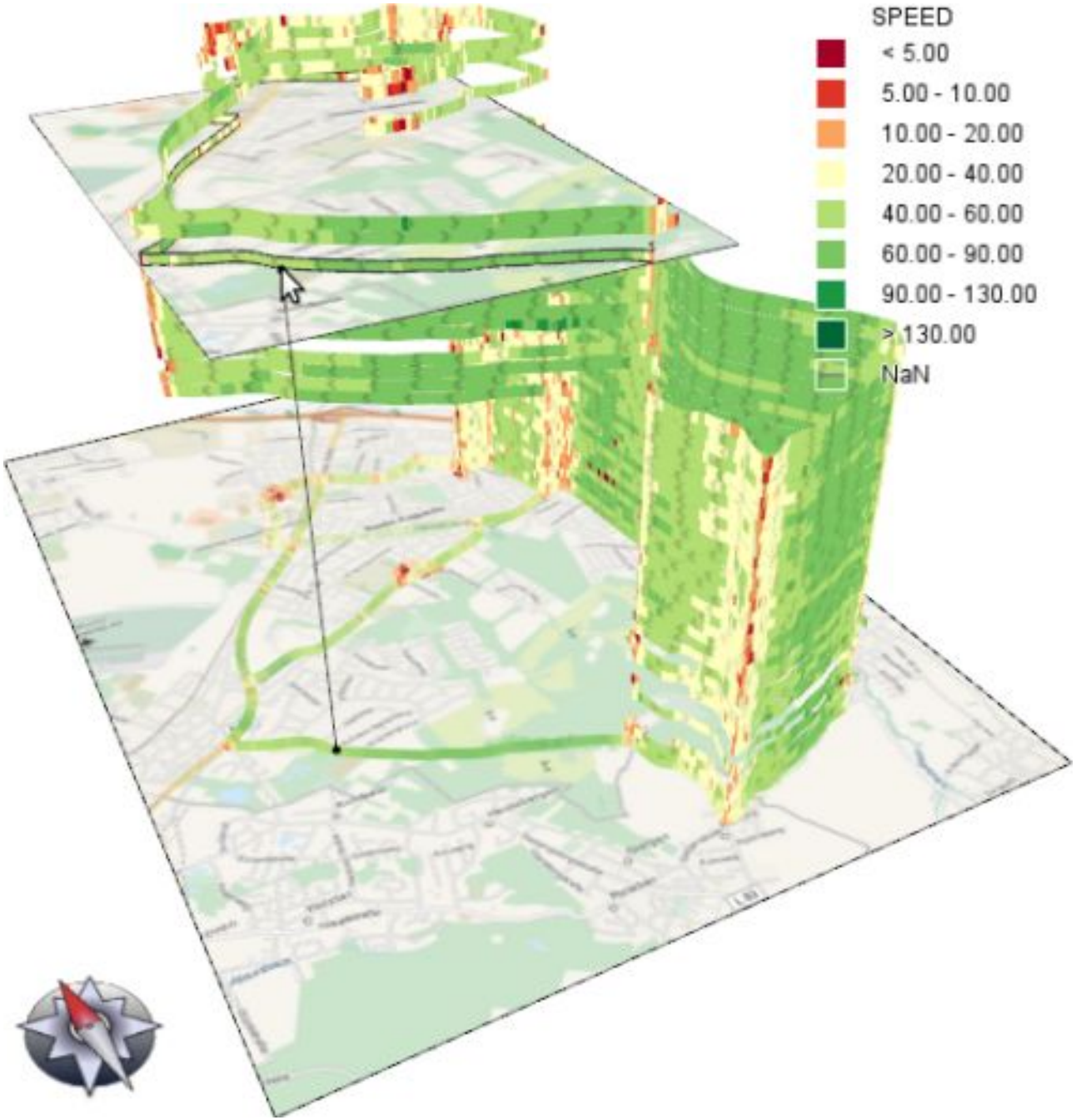


Spatial patterns



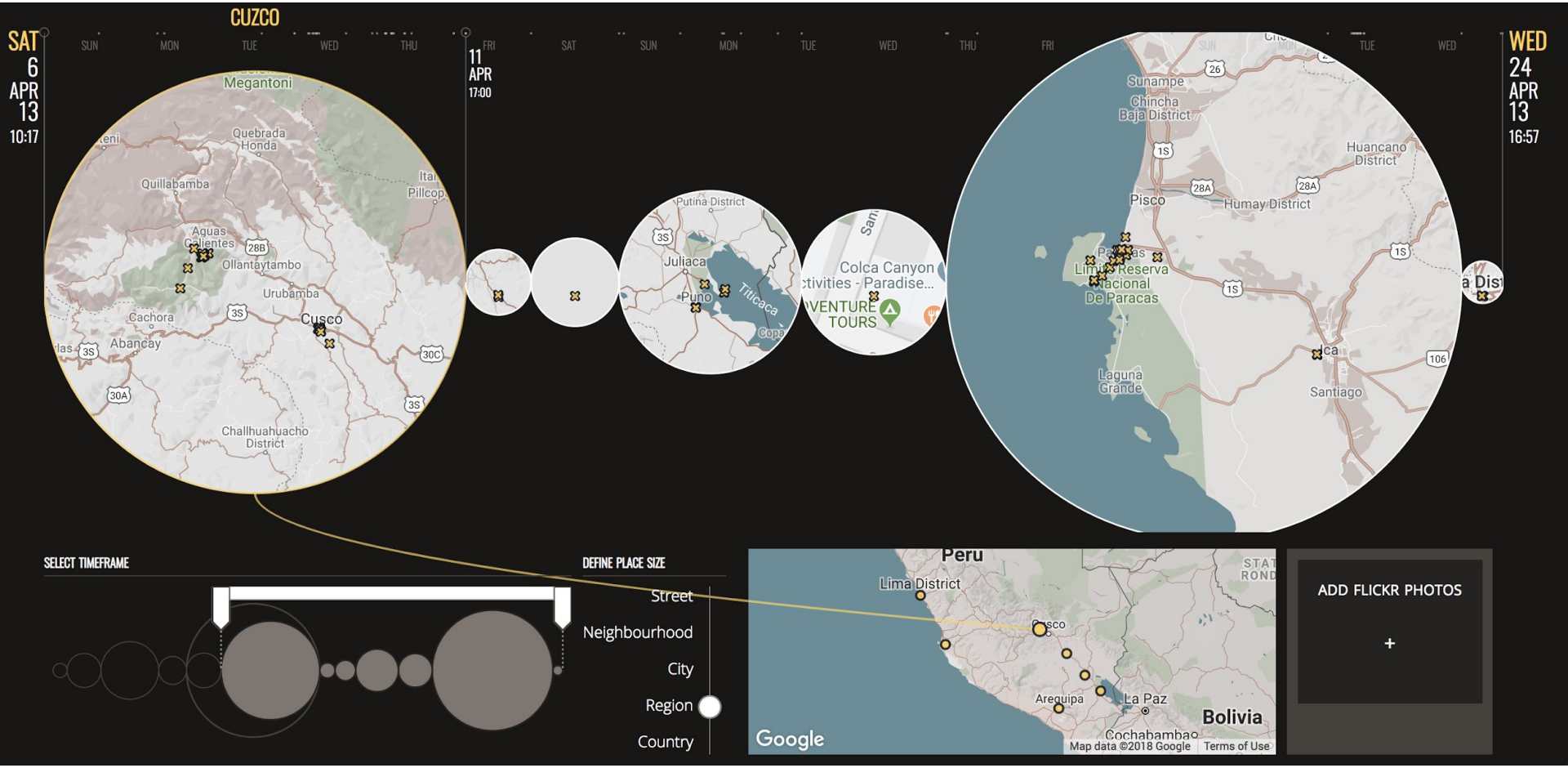
https://gis.stackexchange.com/questions/202882/create-space-time-cube-in-arcgis-for-desktop

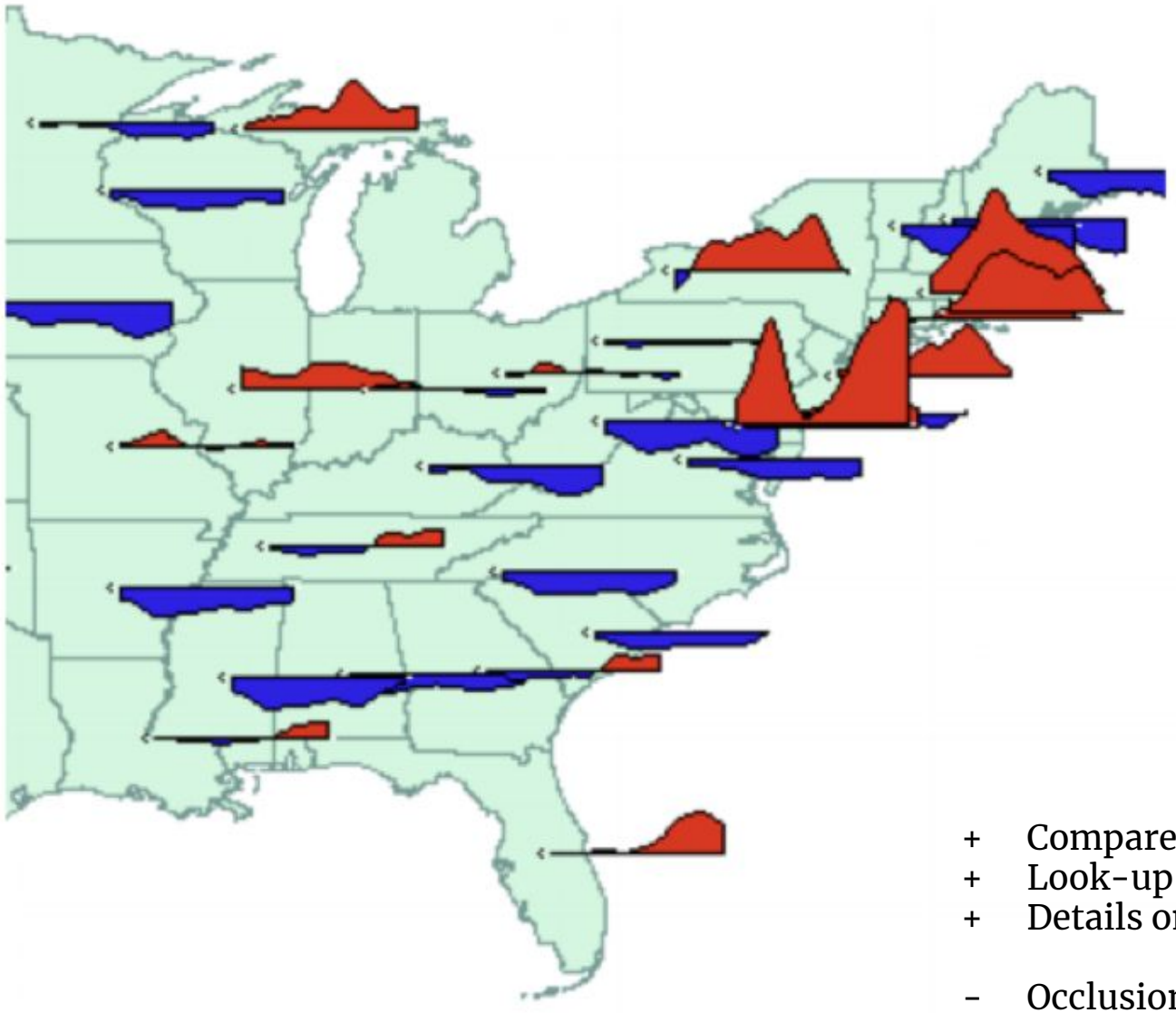
Trajectory Wall



Andrienko, G., Andrienko, N., Schumann, H., & Tominski, C. (2014). Visualization of trajectory attributes in space–time cube and trajectory wall. In *Cartography from Pole to Pole* (pp. 157-163). Springer, Berlin, Heidelberg.

Visits

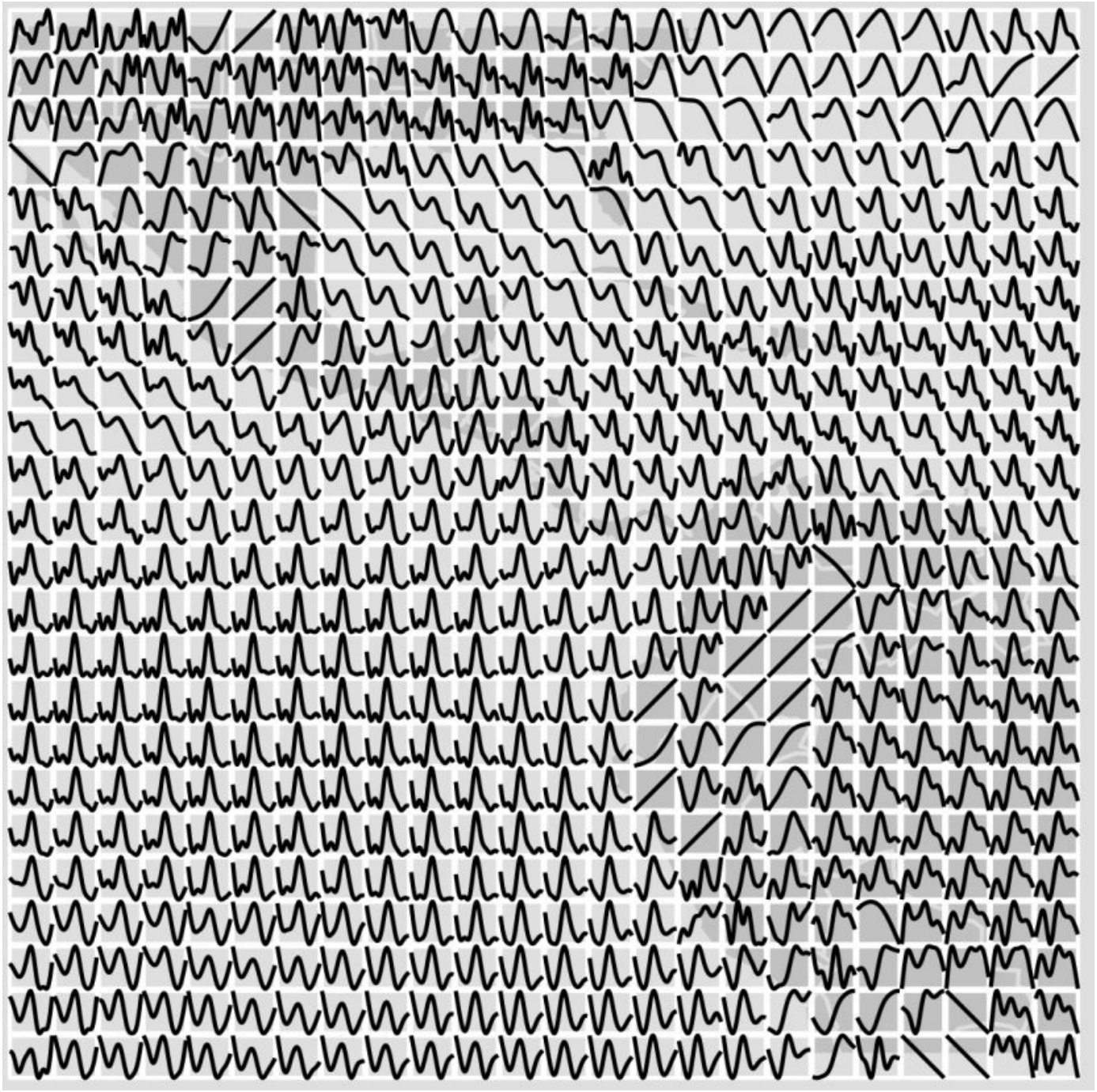

CUZCO
SAT
6
APR
13
10:17
11
APR
17:00
WED
24
APR
13
16:57
SUN
MON
TUE
WED
THU
FRI
SAT
Megantoni
Quebrada Honda
Quillabamba
Aguas Calientes
Ollantaytambo
Urubamba
Cachora
Cusco
Abancay
Challhuahuacho District
Putina District
Juliaca
Puno
Titicaca
Colca Canyon
VENTURE TOURS
Sunampe
Chincha Baja District
Huancano District
Pisco
Humay District
Reserva Nacional De Paracas
Laguna Grande
Santiago
SELECT TIMEFRAME
DEFINE PLACE SIZE
Street
Neighbourhood
City
Region
Country
Peru
Lima District
Cusco
Arequipa
La Paz
Bolivia
Cochabamba
Google
Map data ©2018 Google
Terms of Use
ADD FLICKR PHOTOS
+



+ Compare regions
+ Look-up regions
+ Details on regions

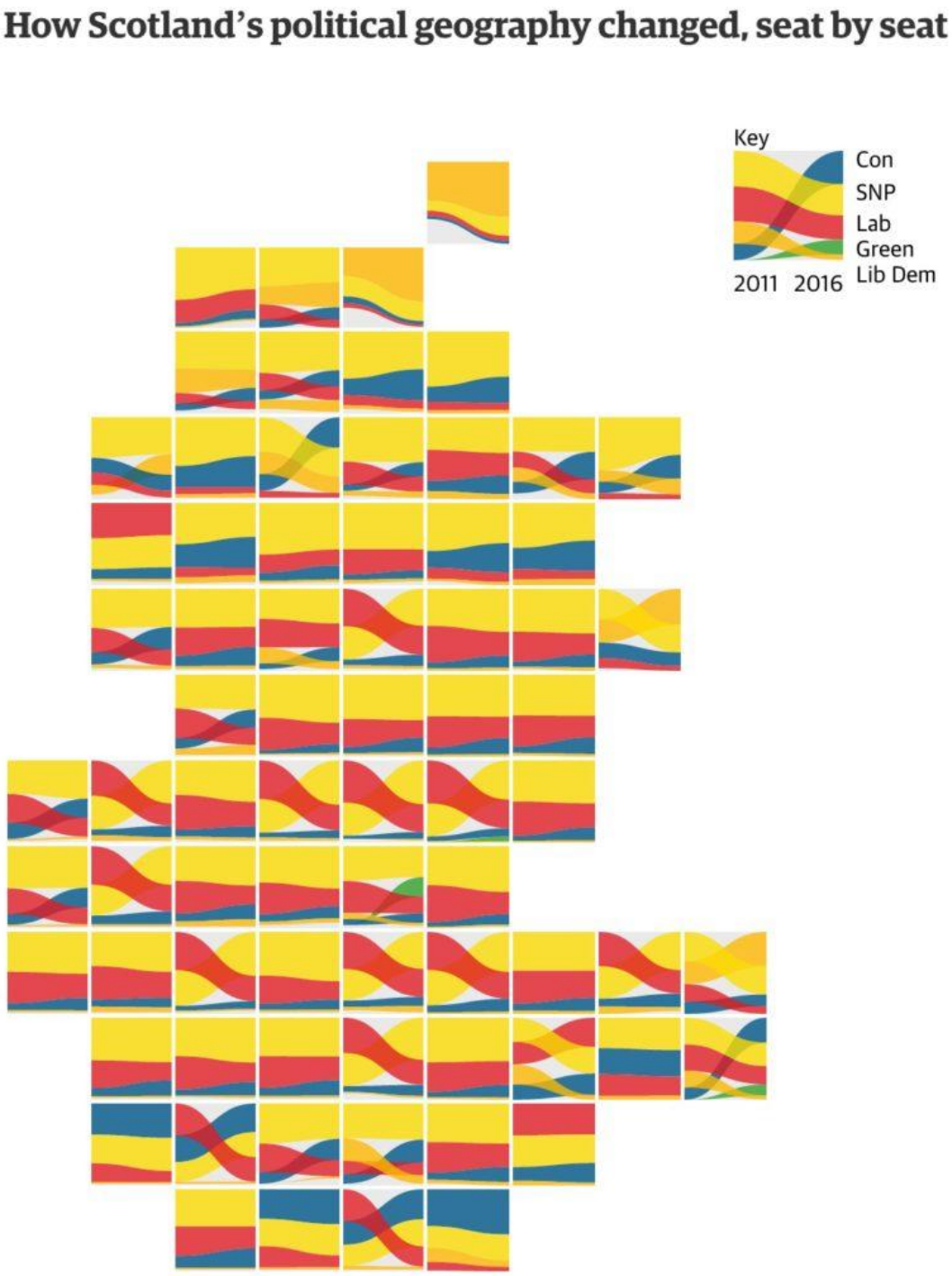
- Occlusion

Glyph Maps



https://vita.had.co.nz/papers/glyph-maps.pdf

Geo-flow

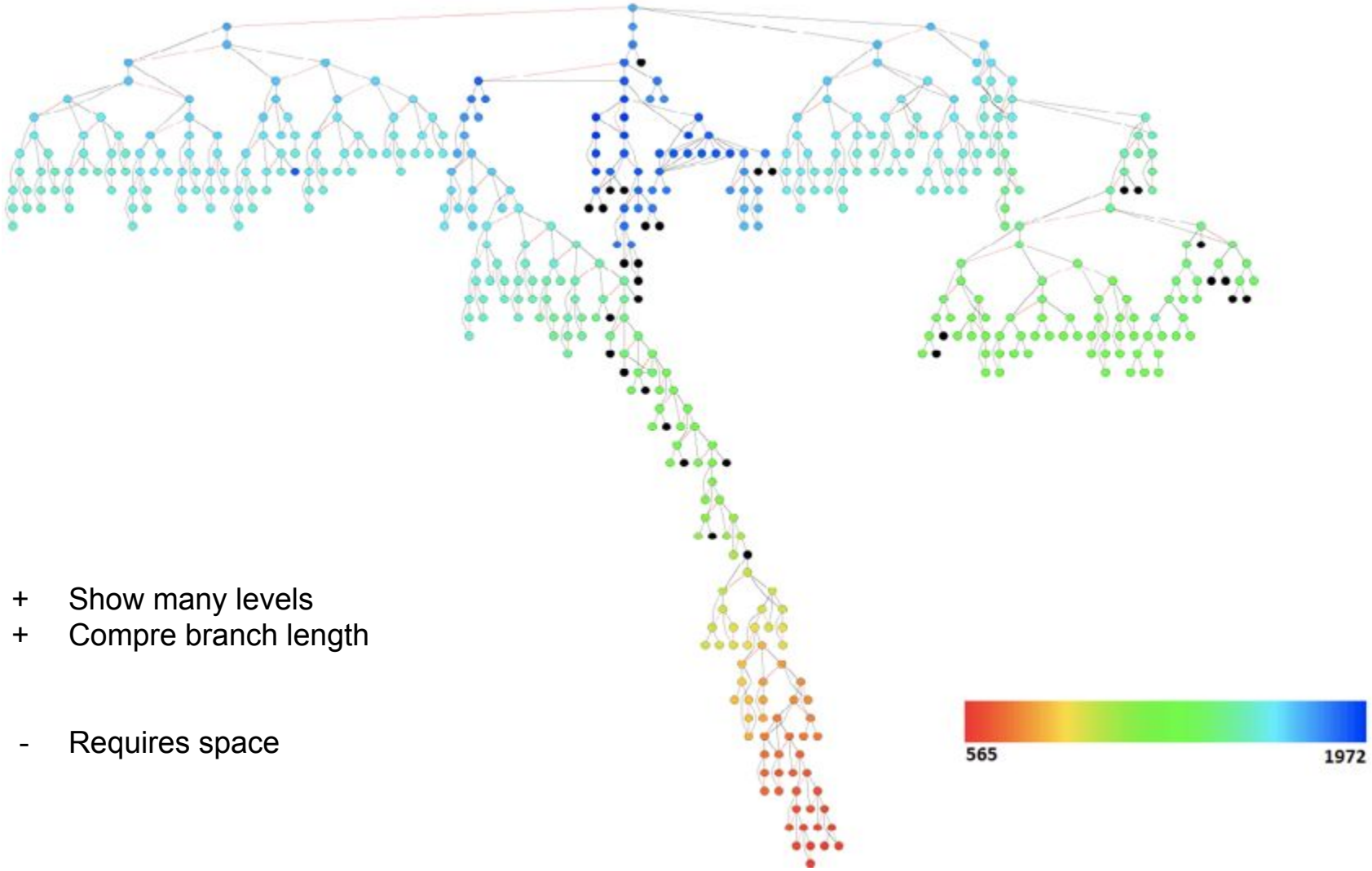


+ Compare regions
+ Look-up regions
+ Details on regions

- Compare far away glyphs
- Glyphs can become small

Trees

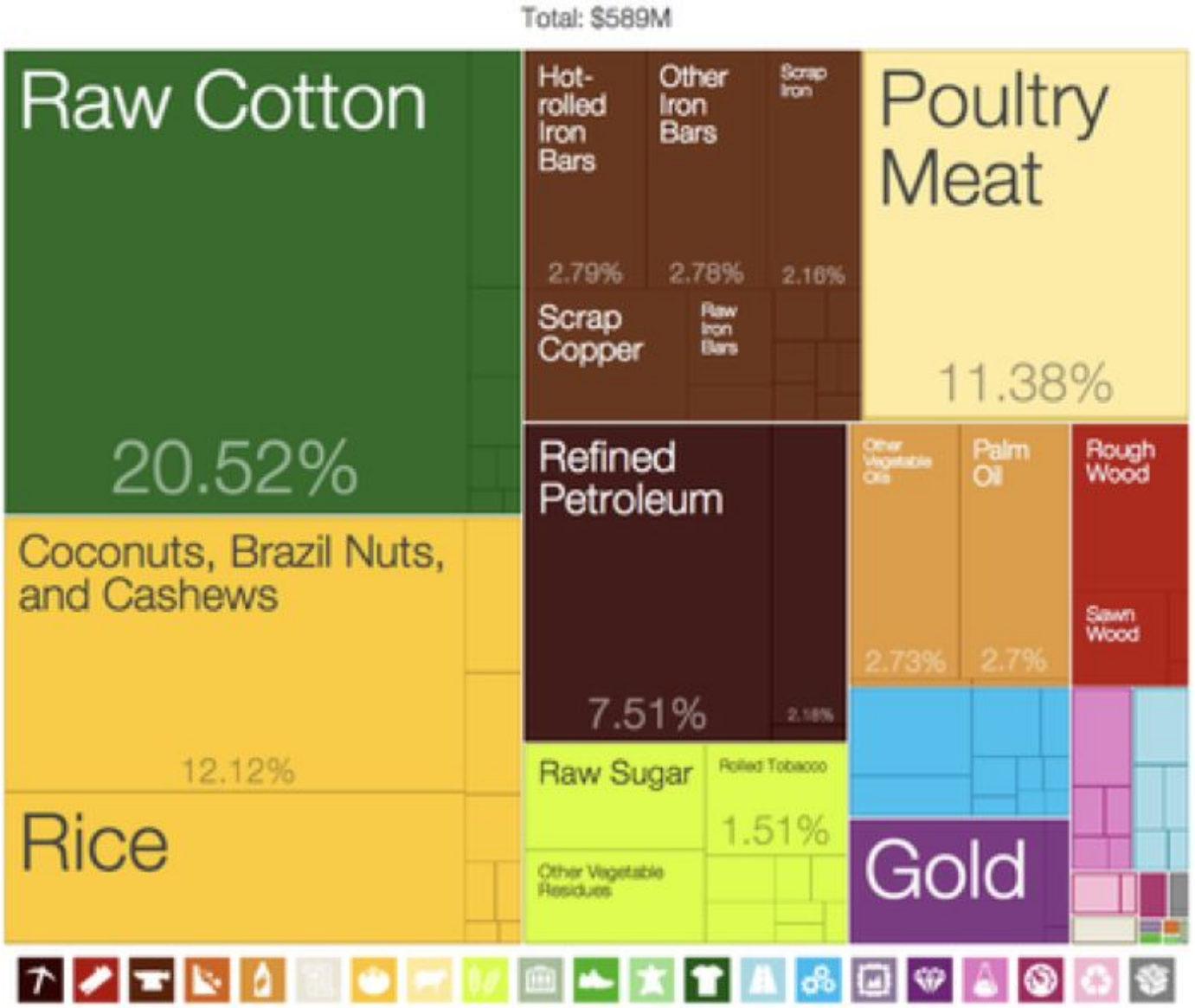
Node-link Diagram



+ Show many levels
+ Compre branch length

- Requires space

Treemap



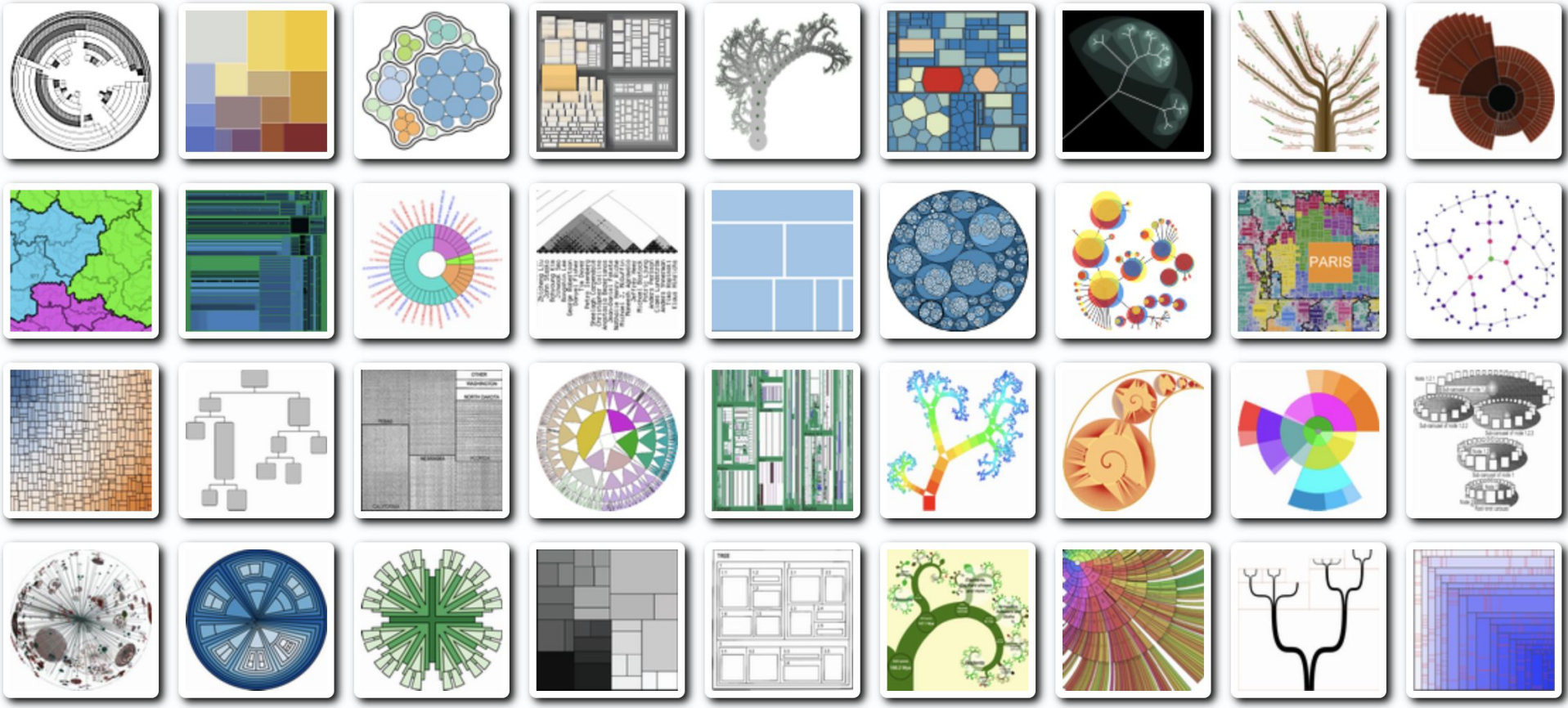
+ Space-filling
+ Relative size encoding
+ Space for additional encoding

- Level comparison
- Precise area comparison
- Can't show many levels

TreeVis.net

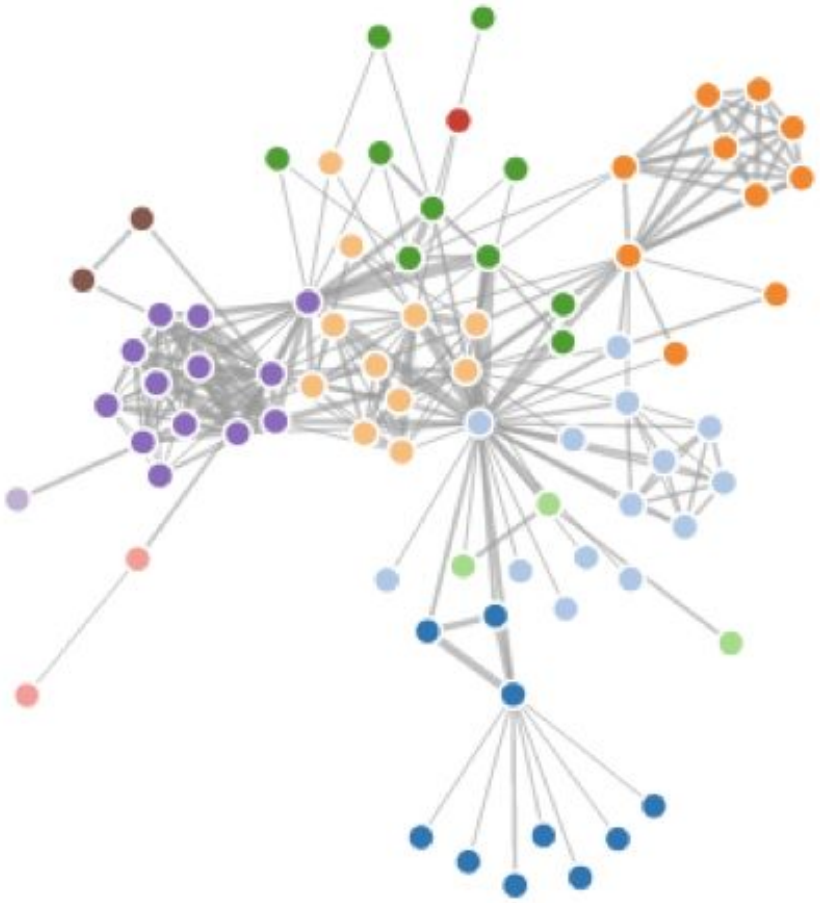
Dimensionality | Representation | Alignment | Fulltext Search | Techniques Shown

All | All | All | 306



Networks

Node-link Diagram



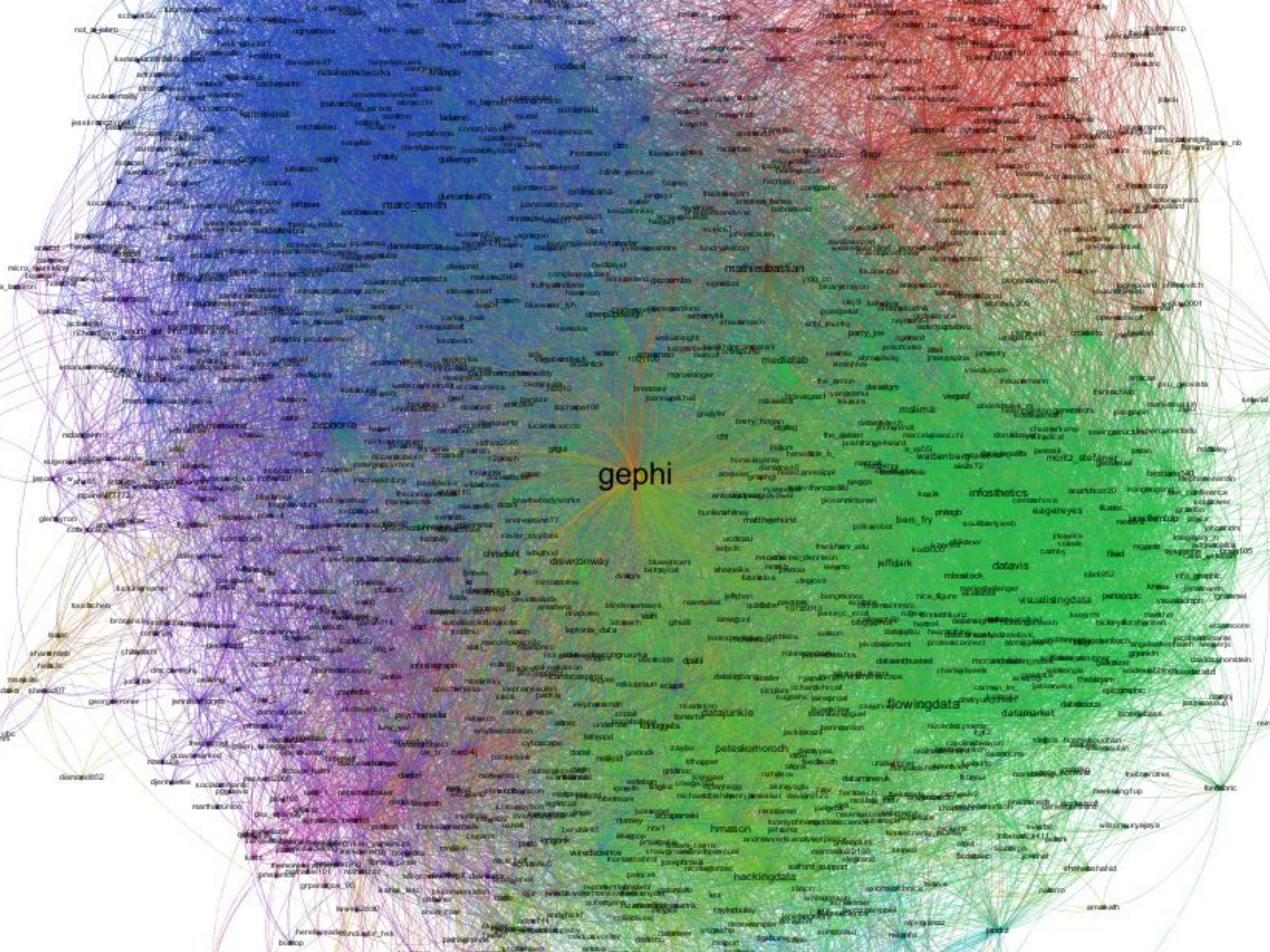
Directed Link

Multiple Links

Link Types

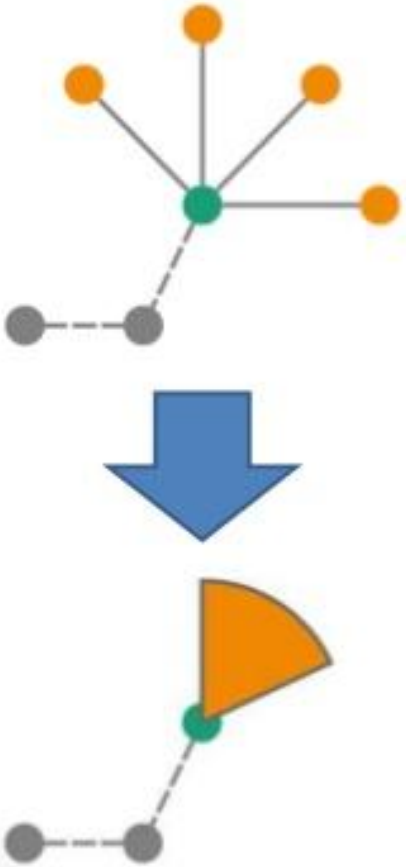
Node type

Weighted link

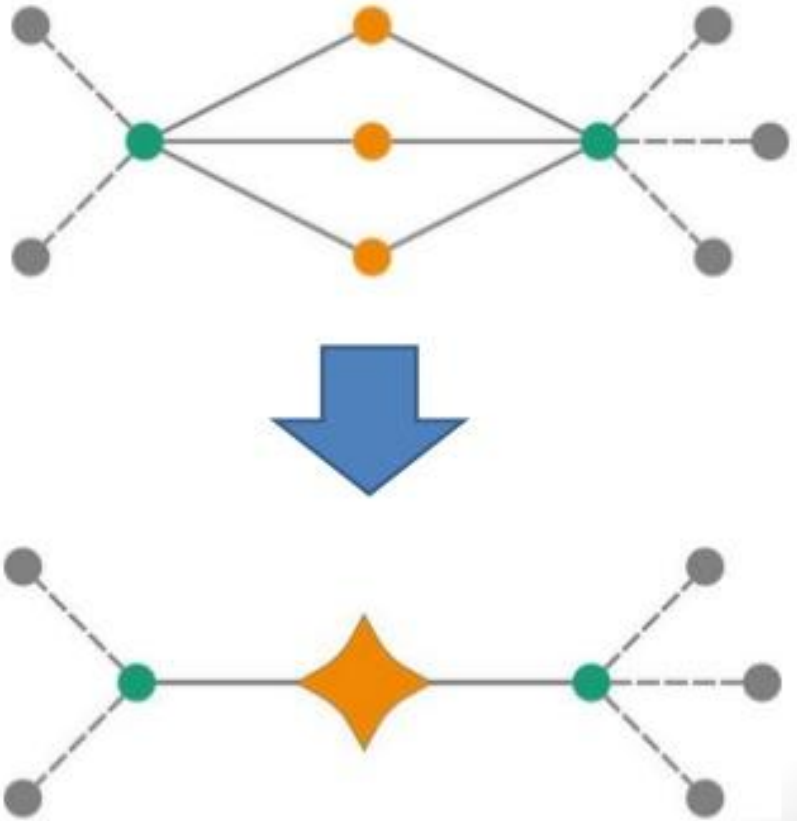

gephi
marc_smith
mathieubastian
medialab
mslima
infosthetics
datavis
visualisingdata
flowingdata
datamarket
datajunkie
petroskomoroch
hmason
hackingdata
jeffclark
drewconway
ben_fry
moritz_stefaner
eaganyas
zephoria

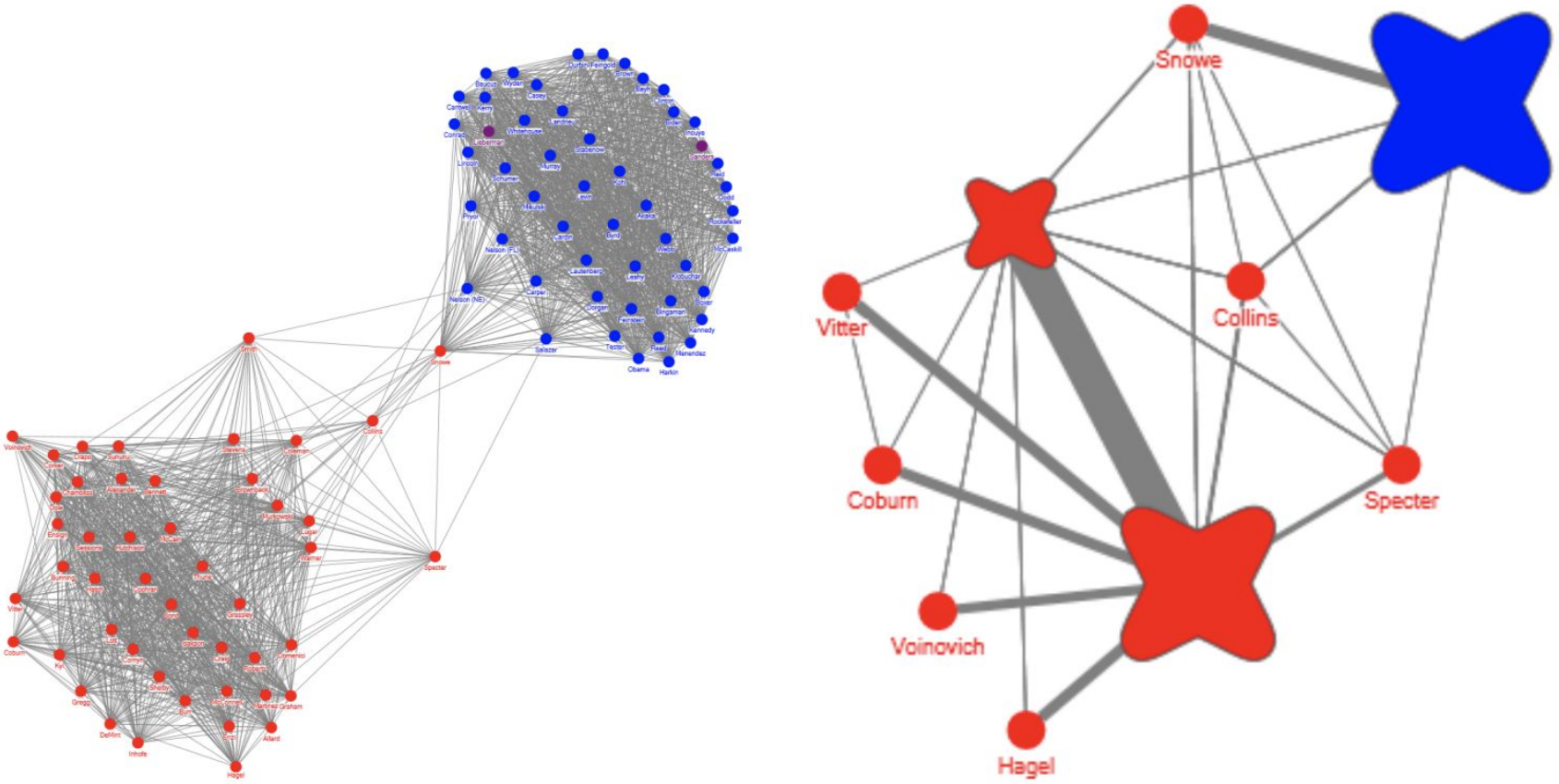
Motif Simplification

Fan Motif



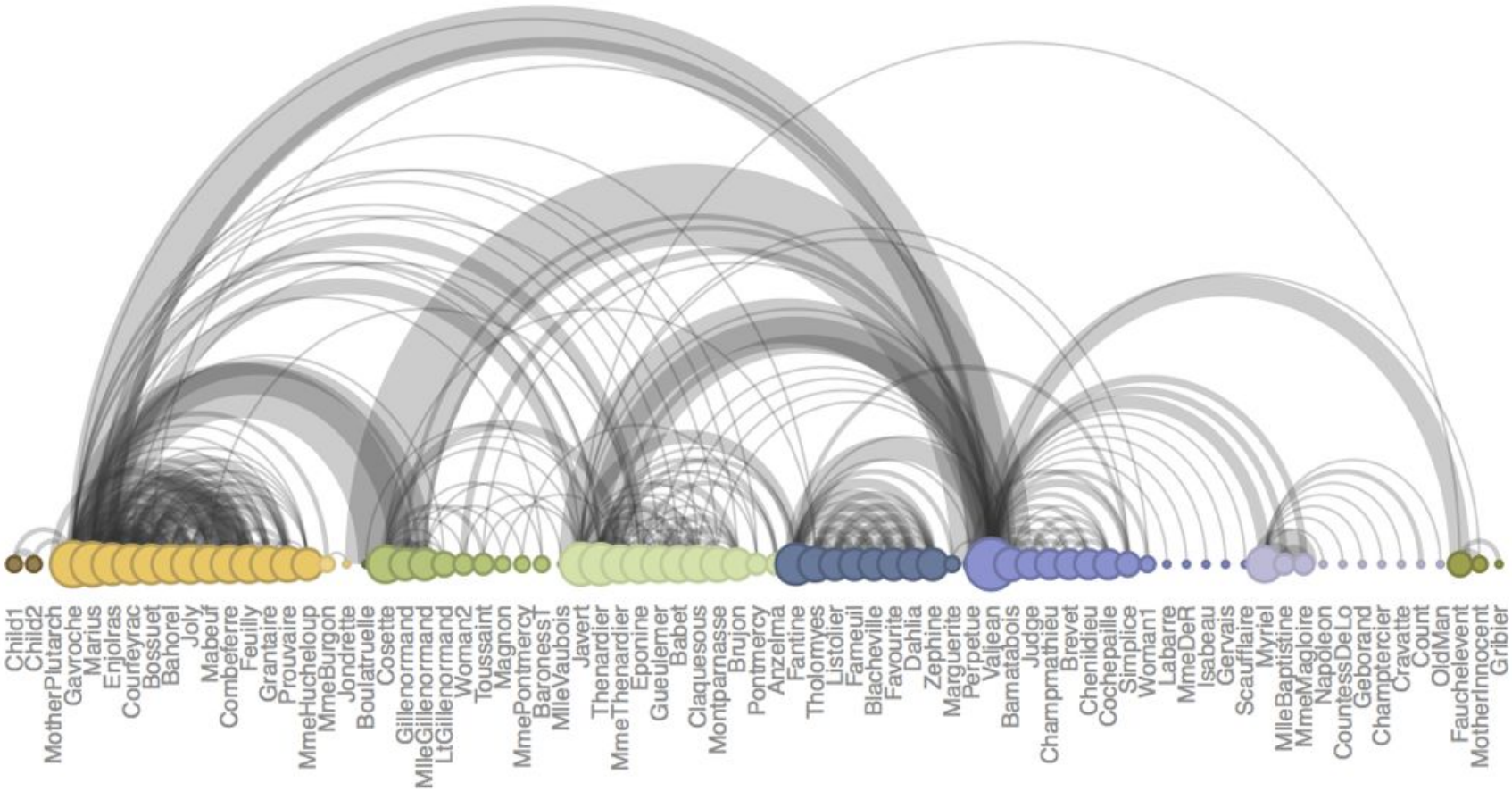
2-Connector Motif





Dunne, Shneiderman: "Motif Simplication",
2014

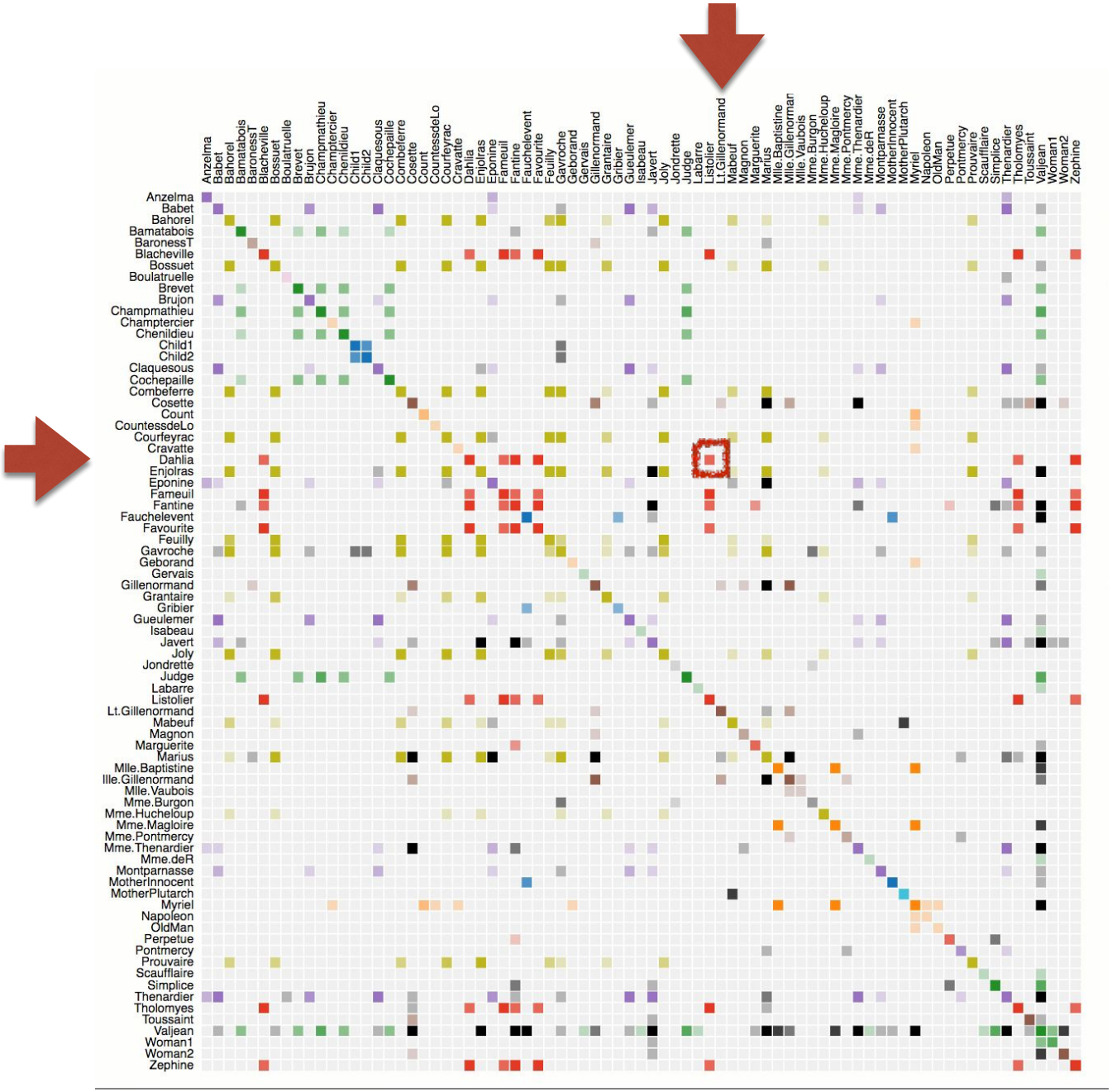
Arc Diagram

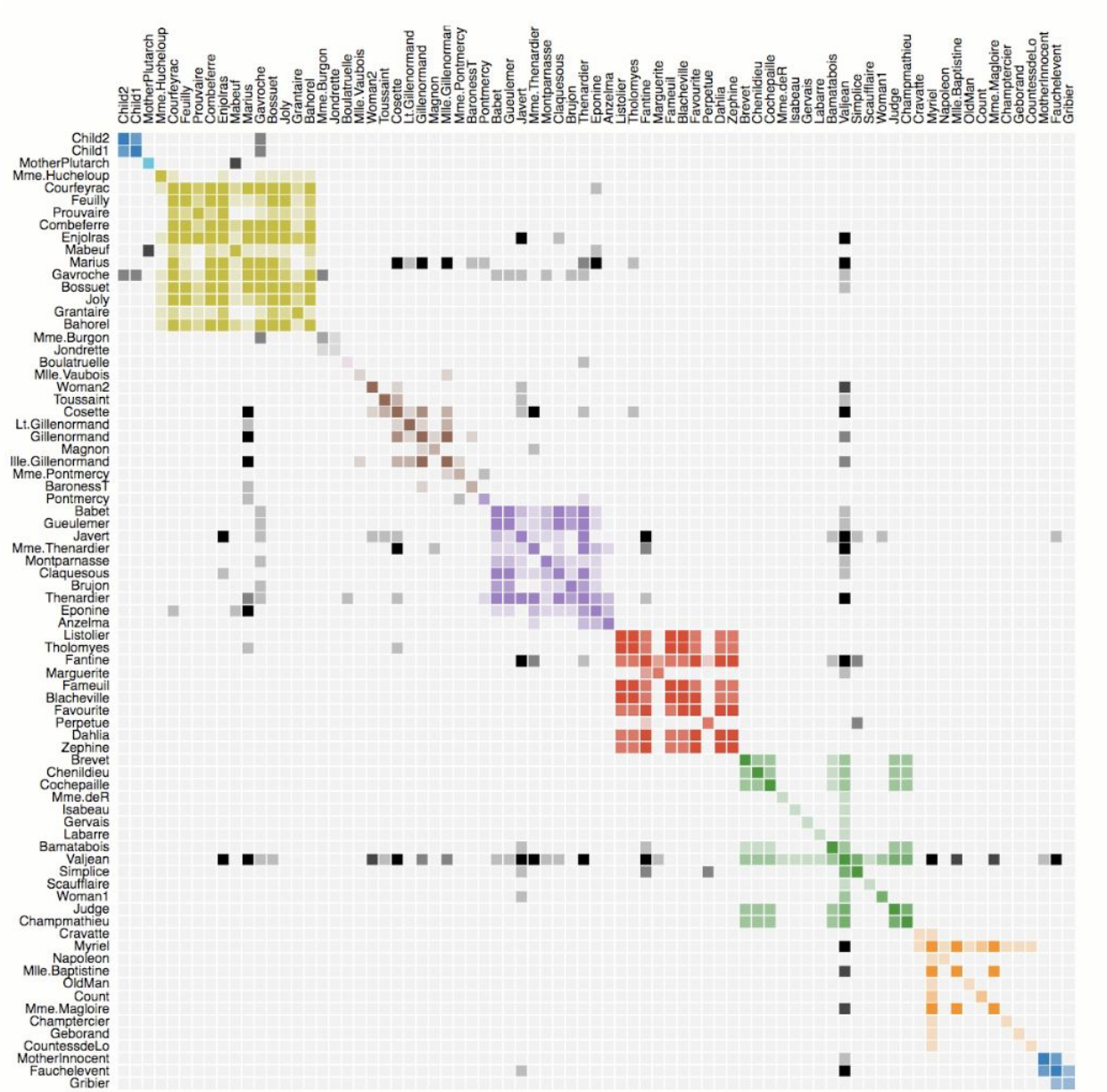


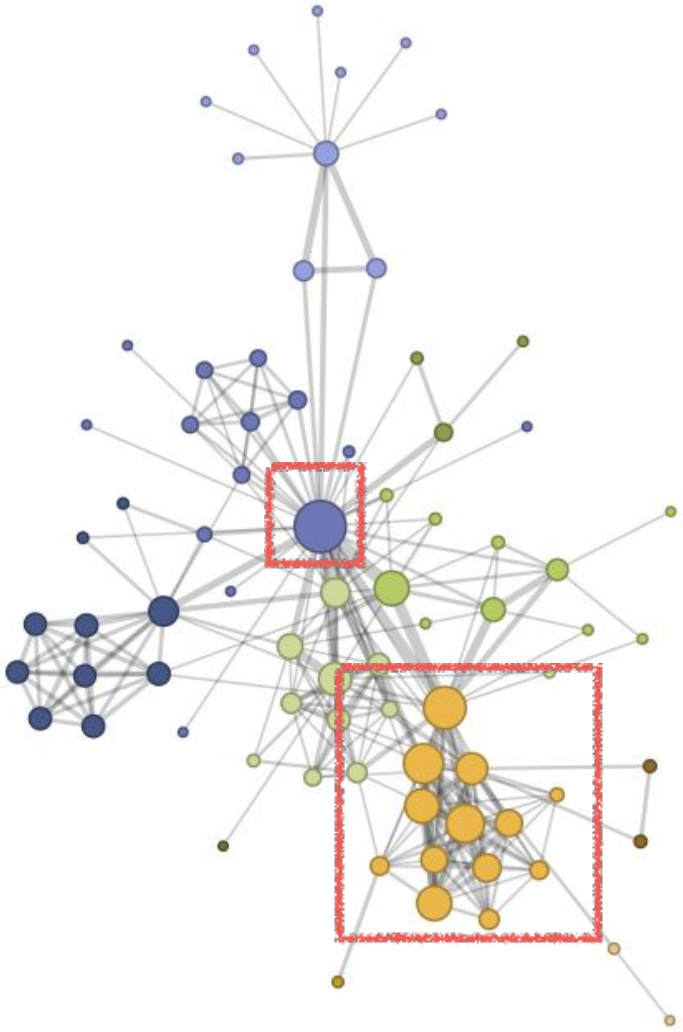
+ Node ordering
+ Node groups

- Requires meaningful ordering
- Does not scale with density

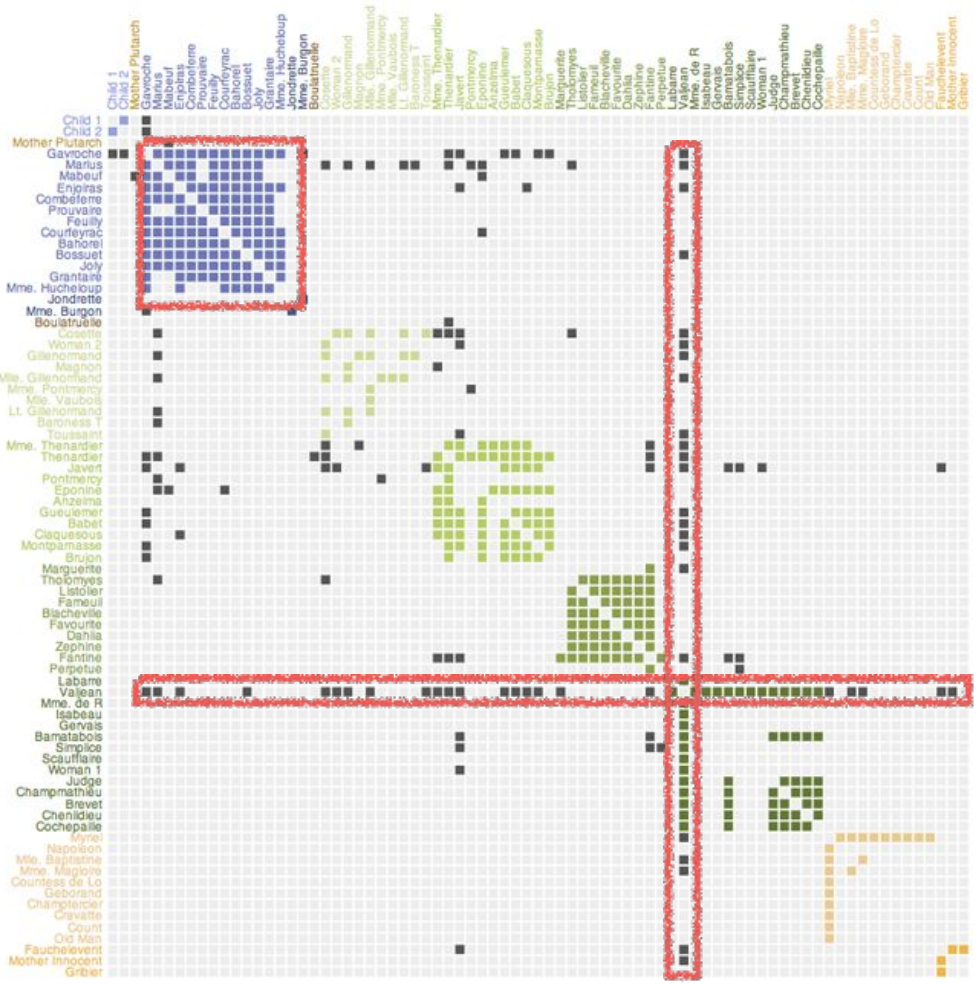
Wattenberg, Martin. "Arc diagrams: Visualizing structure in strings." *Information Visualization, 2002. INFOVIS 2002. IEEE Symposium on*. IEEE, 2002.


Anzelma
Babet
Bahorel
Bamatabois
BaronessT
Blacheville
Bossuet
Boulatruelle
Brevet
Brujon
Champmathieu
Champtercier
Chenildieu
Child1
Child2
Claquesous
Cochepaille
Combeferre
Cosette
Count
CountessdeLo
Courfeyrac
Cravatte
Dahlia
Enjolras
Eponine
Fameuil
Fantine
Fauchelevent
Favourite
Feuilly
Gavroche
Geborand
Gervais
Gillenormand
Grantaire
Gribier
Gueulemer
Isabeau
Javert
Joly
Jondrette
Judge
Labarre
Listolier
Lt.Gillenormand
Mabeuf
Magnon
Marguerite
Marius
Mlle.Baptistine
Mlle.Gillenormand
Mlle.Vaubois
Mme.Burgon
Mme.Hucheloup
Mme.Magloire
Mme.Pontmercy
Mme.Thenardier
Mme.deR
Montparnasse
MotherInnocent
MotherPlutarch
Myriel
Napoleon
OldMan
Perpetue
Pontmercy
Prouvaire
Scaufflaire
Simplice
Thenardier
Tholomyes
Toussaint
Valjean
Woman1
Woman2
Zephine


Child2
Child1
MotherPlutarch
Mme.Hucheloup
Courfeyrac
Feuilly
Prouvaire
Combeferre
Enjolras
Mabeuf
Marius
Gavroche
Bossuet
Joly
Grantaire
Bahorel
Mme.Burgon
Jondrette
Boulatruelle
Mlle.Vaubois
Woman2
Toussaint
Cosette
Lt.Gillenormand
Gillenormand
Magnon
Mlle.Gillenormand
Mme.Pontmercy
BaronessT
Pontmercy
Babet
Gueulemer
Javert
Mme.Thenardier
Montparnasse
Claquesous
Brujon
Thenardier
Eponine
Anzelma
Listolier
Tholomyes
Fantine
Marguerite
Fameuil
Blacheville
Favourite
Perpetue
Dahlia
Zephine
Brevet
Chenildieu
Cochepaille
Mme.deR
Isabeau
Gervais
Labarre
Barnatabois
Valjean
Simplice
Scaufflaire
Woman1
Judge
Champmathieu
Cravatte
Myriel
Napoleon
Mlle.Baptistine
OldMan
Count
Mme.Magloire
Champtercier
Geborand
CountessdeLo
MotherInnocent
Fauchelevent
Gribier

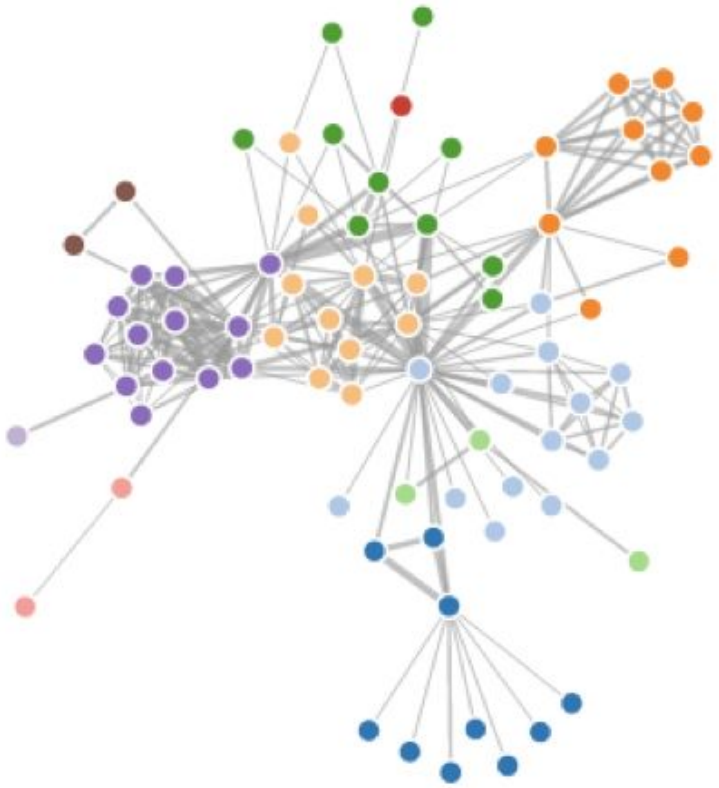


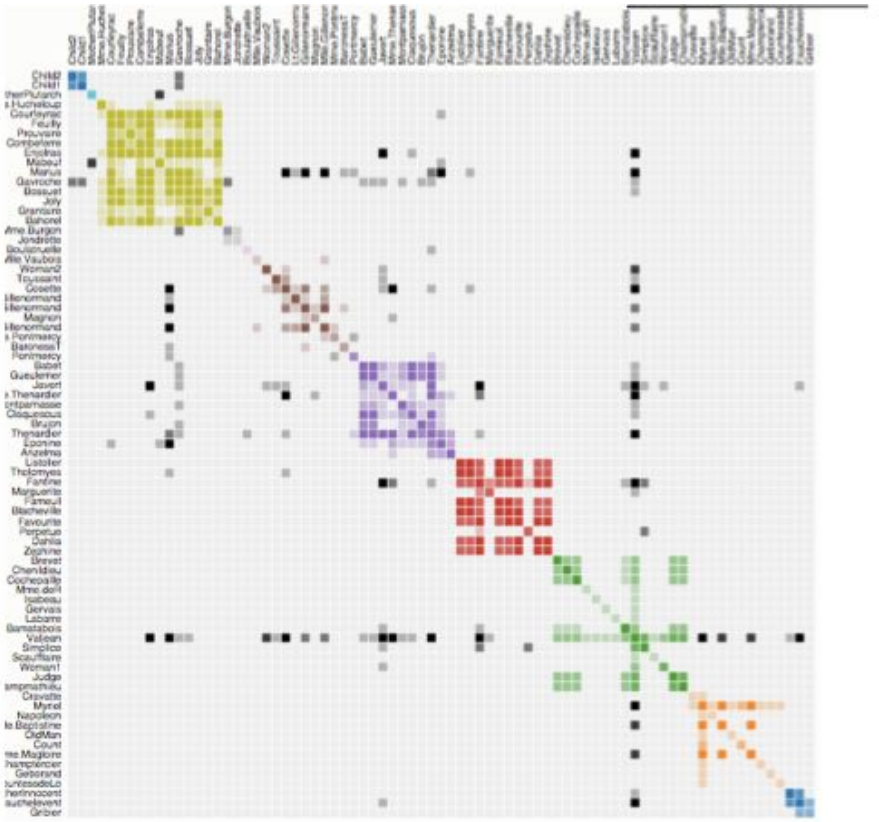
Node
Link



Matrice
s

Adjacency Matrix





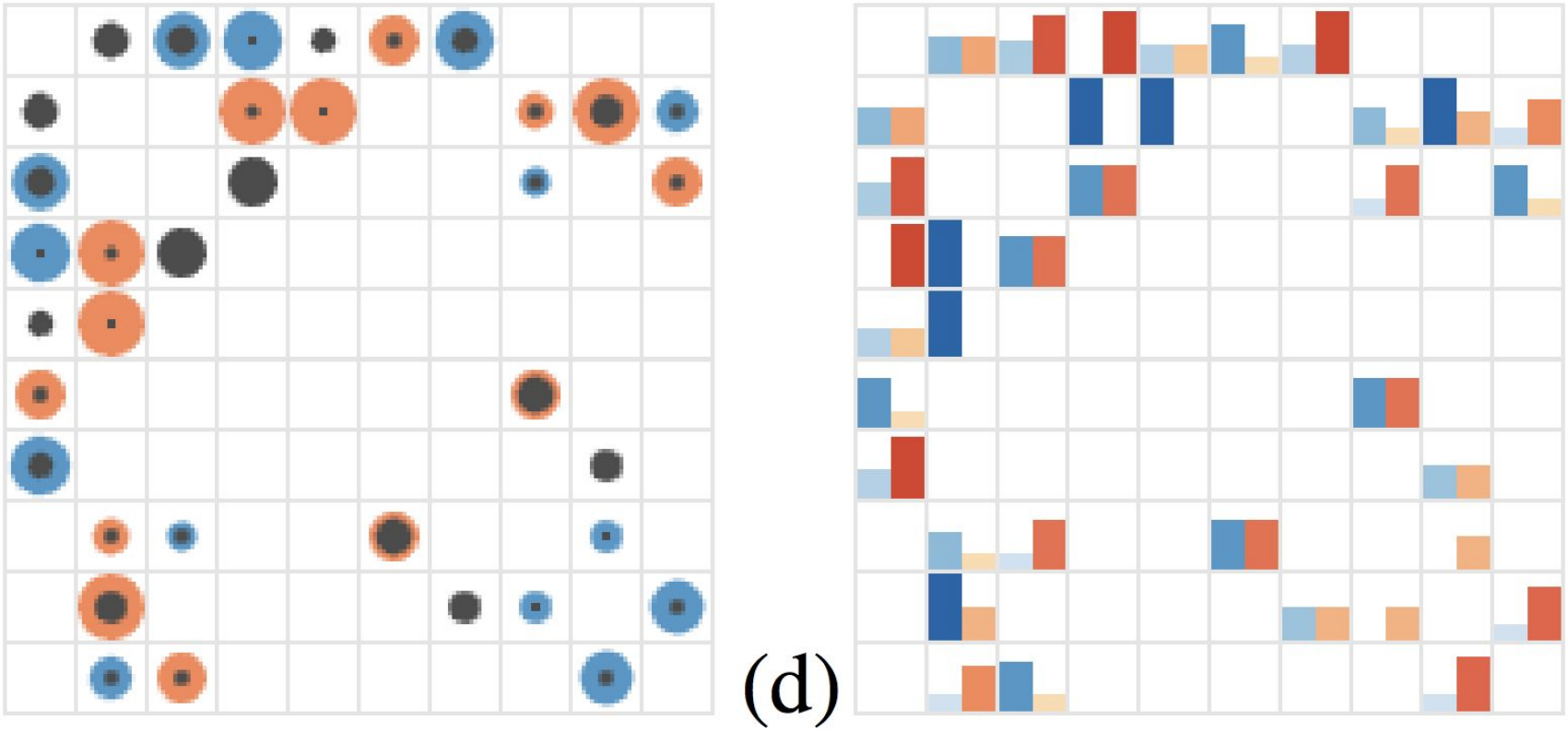
+ Path finding / following
+ Outliers
+ Disconnected components (if sparse)

=> Sparse networks

+ Clusters
+ Missing links in clusters
+ Highly connected nodes

=> Dense networks

Matrix Cells



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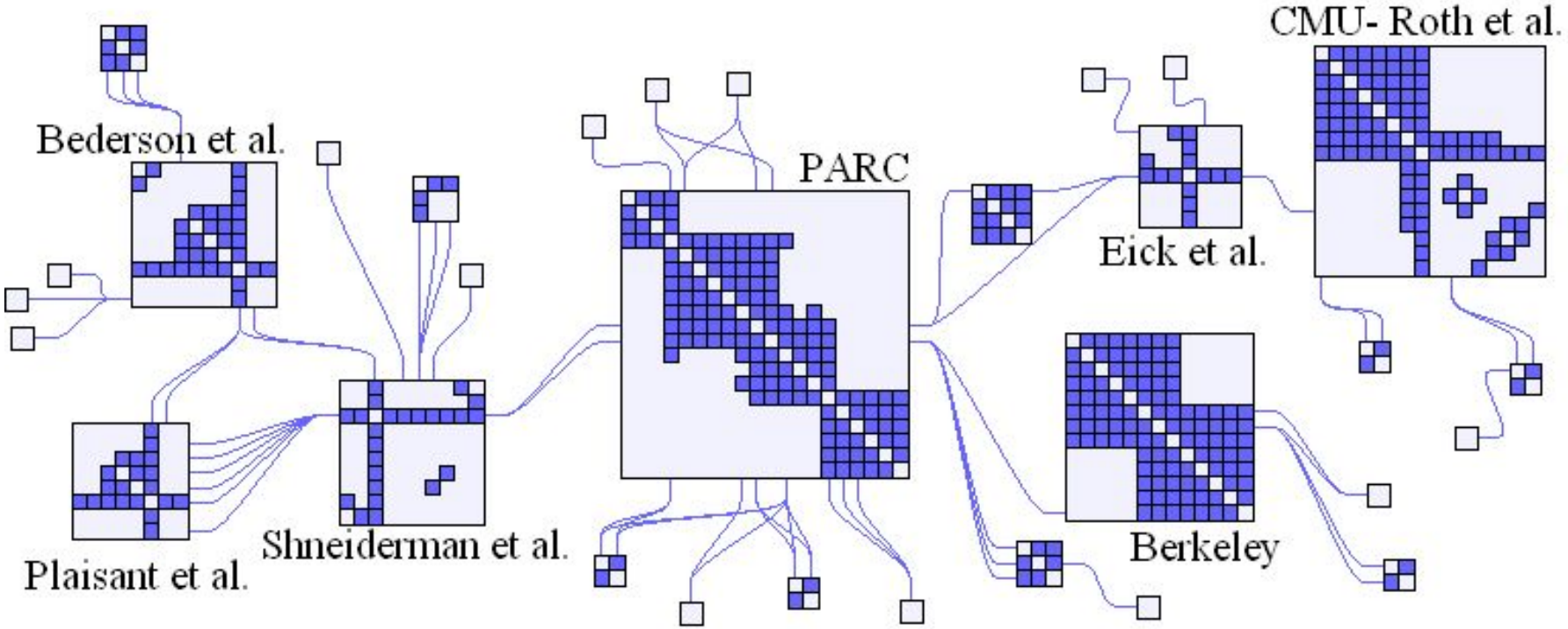
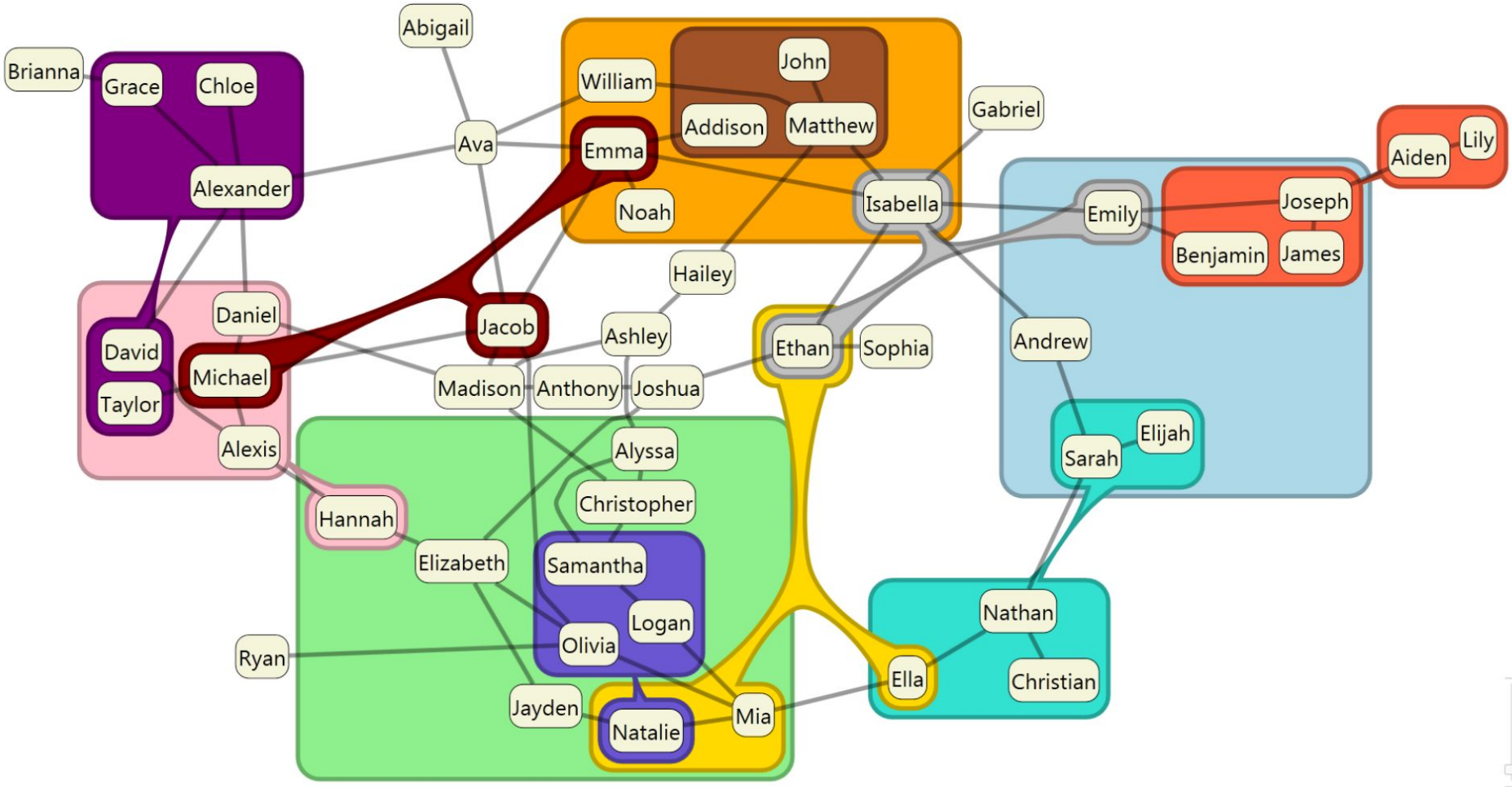
Matrix Cells



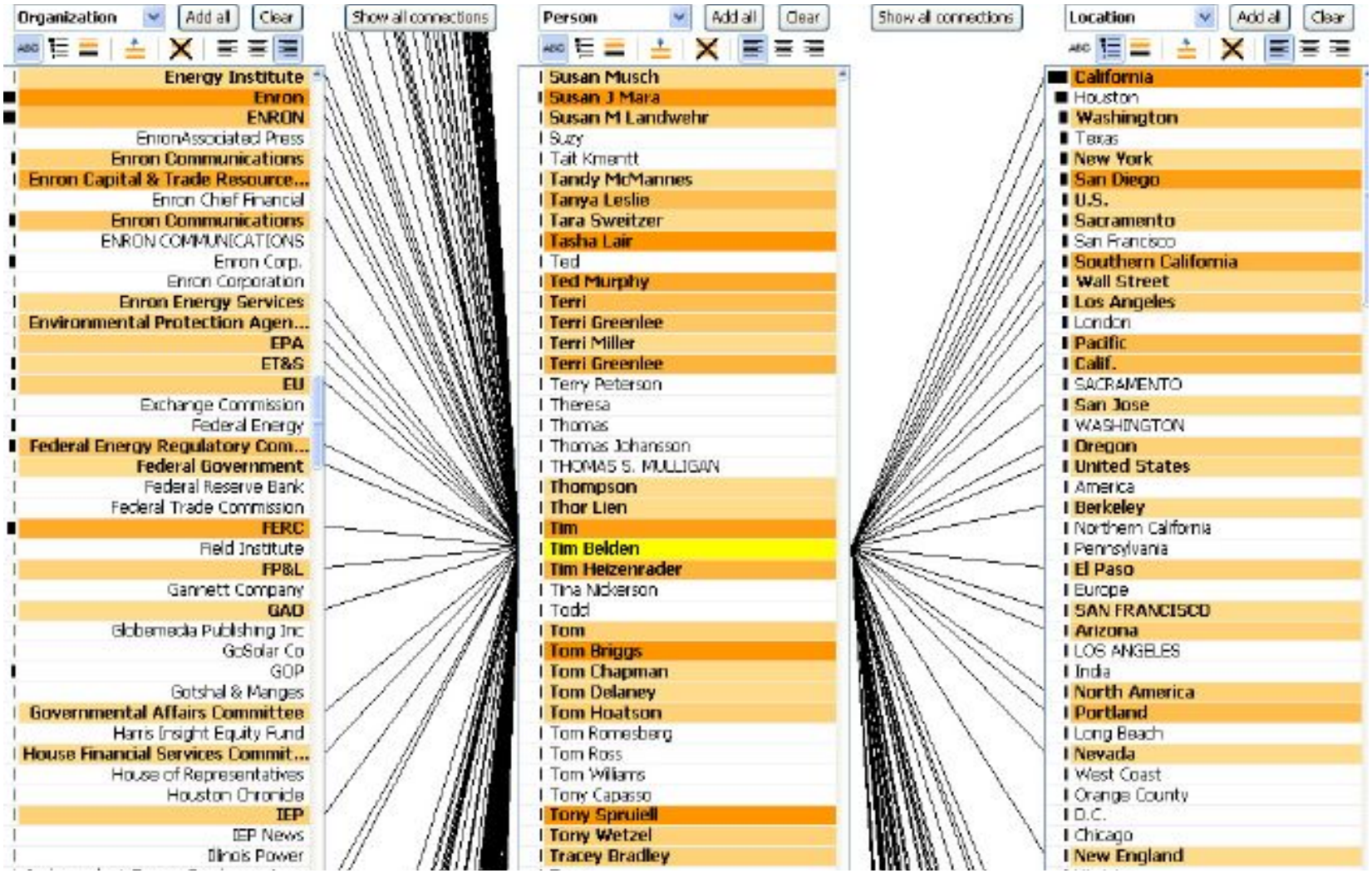
Henry, N., Fekete, J. D., & McGuffin, M. J. (2007). NodeTrix: a hybrid visualization of social networks. *IEEE transactions on visualization and computer graphics*, *13*(6), 1302-1309.

Networks and Sets



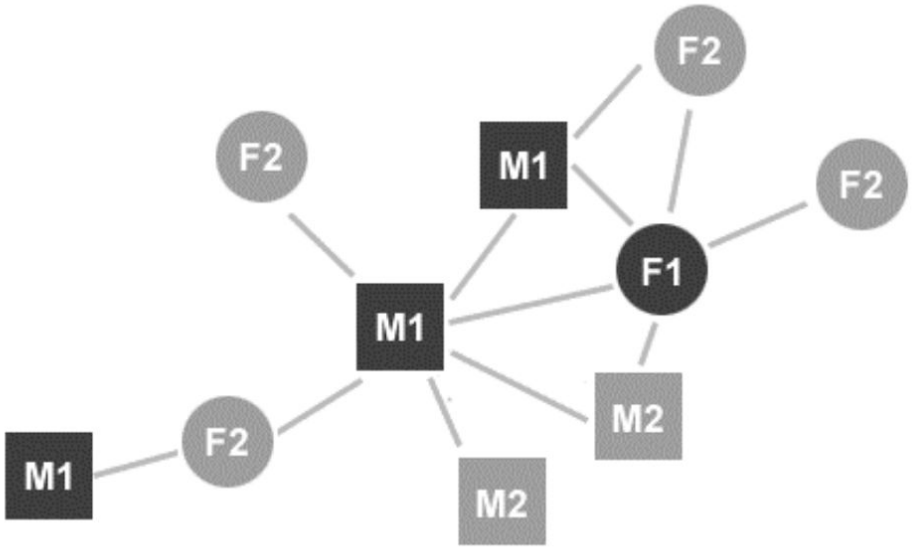
Riche, N. H., & Dwyer, T. (2010). Untangling euler diagrams. *IEEE Transactions on Visualization and Computer Graphics*, *16*(6), 1090-1099.

Jigsaw



Stasko, J., Görg, C., & Liu, Z. (2008). Jigsaw: supporting investigative analysis through interactive visualization. *Information visualization*, *7*(2), 118-132.

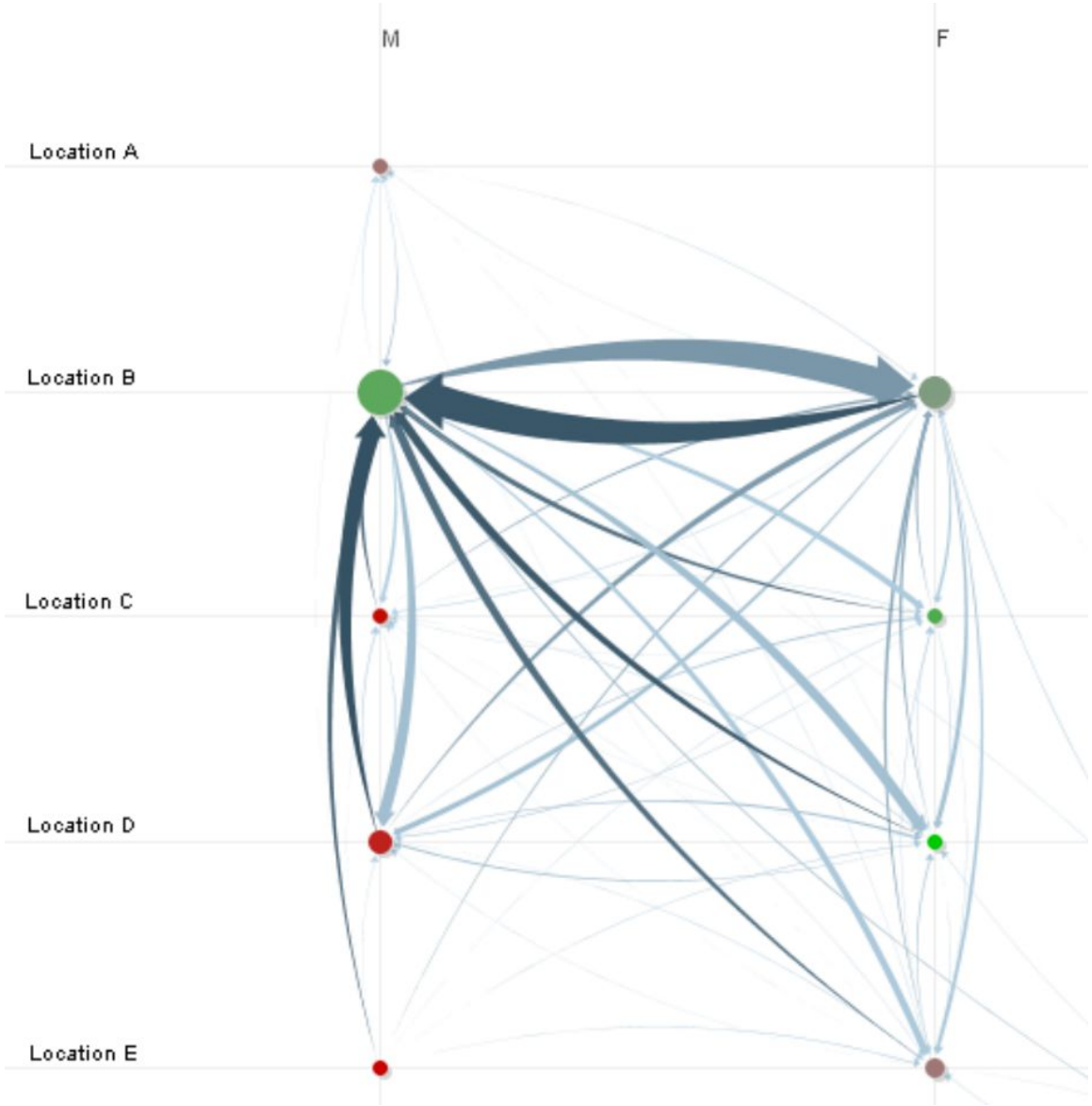
Pivot Graphs



Node and Link Diagram

Wattenberg, M. (2006, April). Visual exploration of multivariate graphs. In *Proceedings of the SIGCHI conference on Human Factors in computing systems* (pp. 811-819). ACM.

Jigsaw



Choosing a Visualization?

Criteria

- How many dimensions does my data set have?
- What is my task?
- What is the information in need?
- How large/dense is my data?

Finding a trade-off

Familiarity ⟷ Power

One Vis ⟷ Multiple Vis

Detail ⟷ Overview

Interaction ⟷ Staticness