Alexander Lex
@alexander_lex
http://alexander-lex.net

THE UNIVERSITY OF UTAH

Layout Adaption Strategies for Visualizing Multivariate Networks

visualization design lab

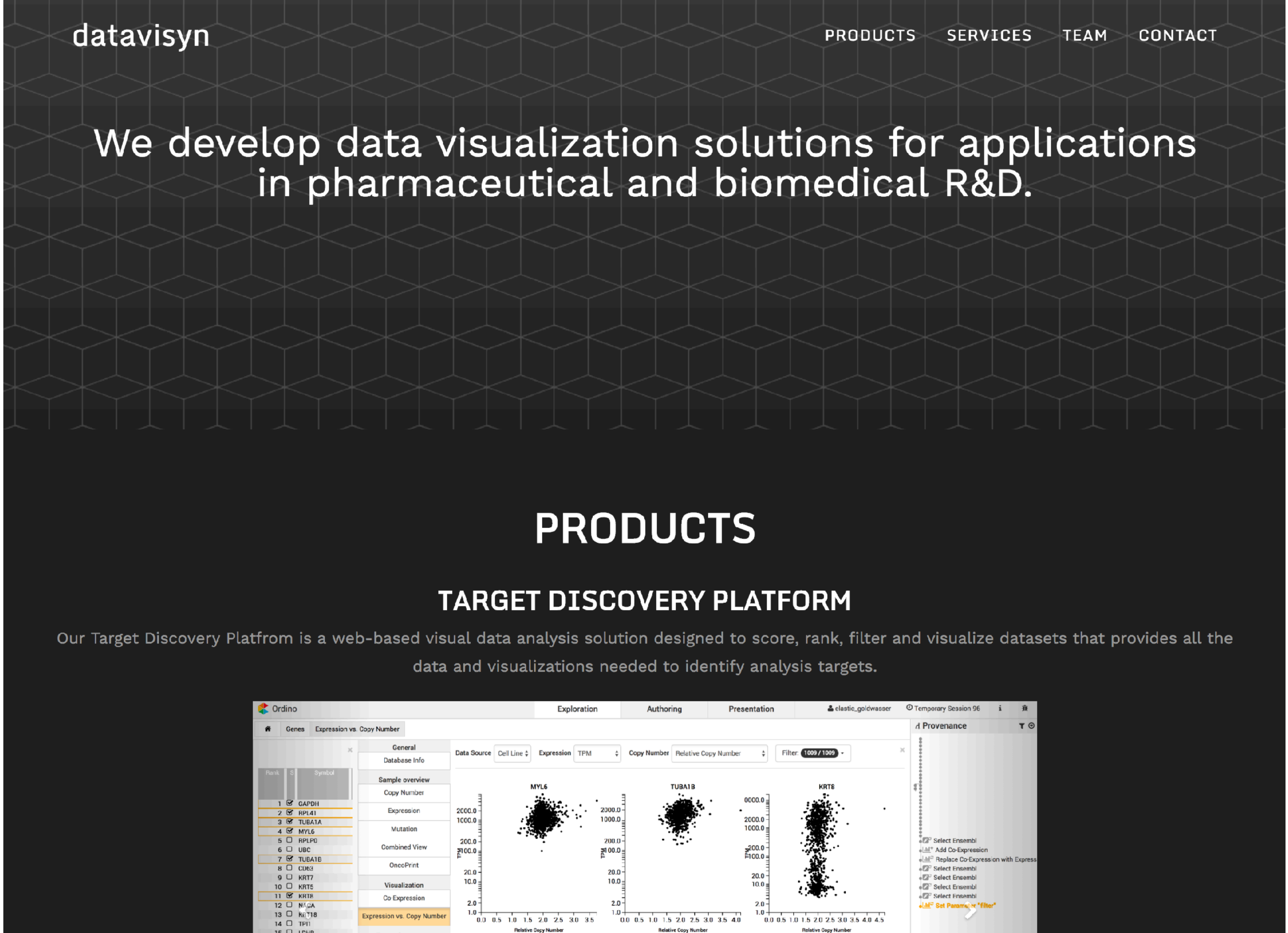
SCI
www.sci.utah.edu

visualization
design lab

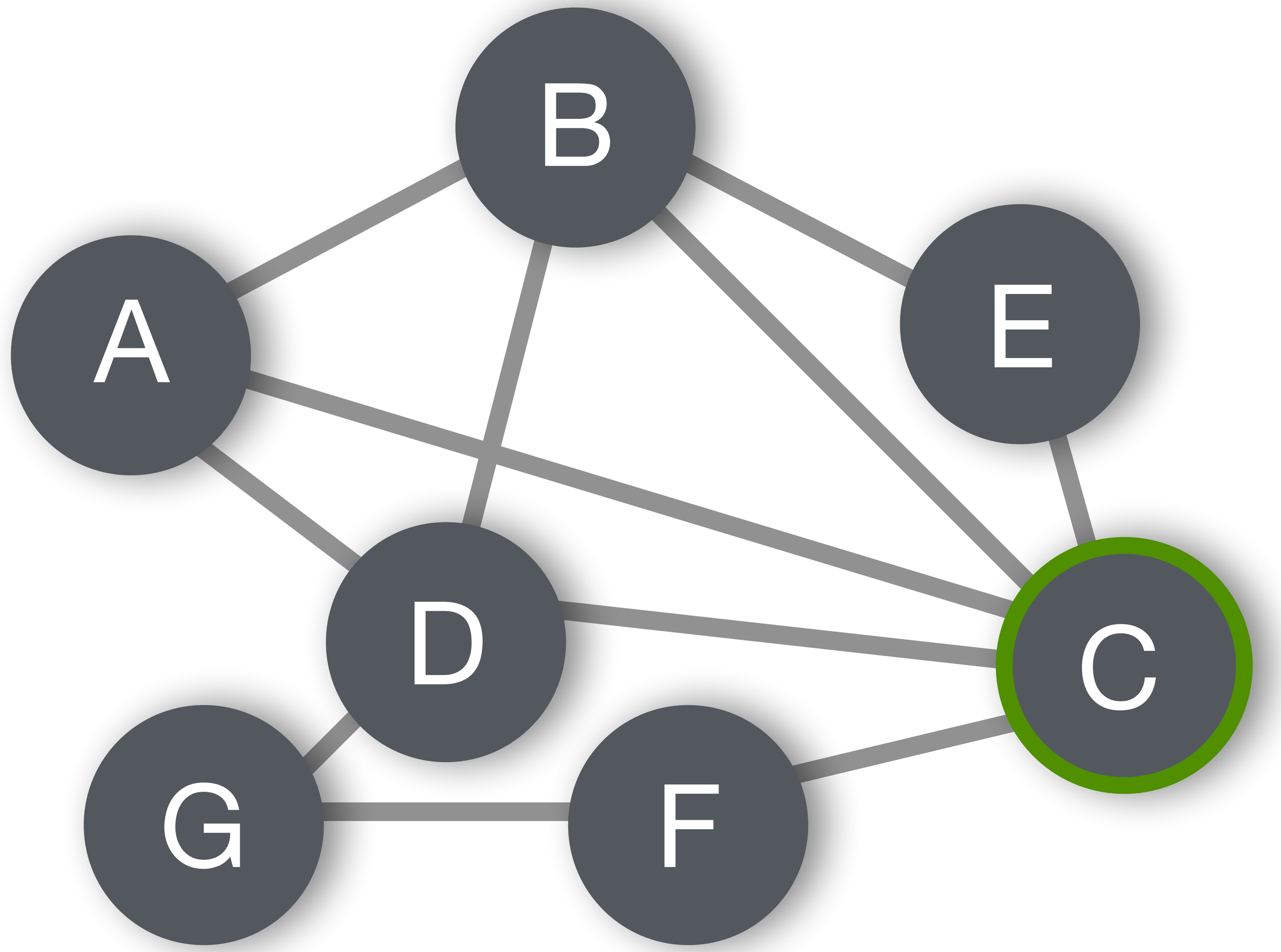
http://vdl.sci.utah.edu/

Sam Quinan · Jennifer Rogers · Miriah Meyer · Aspen Hopkins · Jimmy Moore · Alexander Lex

Nina McCurdy · Alex Bigelow · Carolina Nobre · Ethan Kerzner · Pascal Goffin datavisyn.io



What is a Multivariate Network?



Node	Year	Citations	Type	...
A	2006	13	Journal	...
B	2009	36	Conference	...
C	2017	5	Journal	...
...	...	...	...	

Challenge: Consider topology and attributes simultaneously

Challenge: Graph Size

How can we deal with graphs too large to sensibly render at once?

Scalability problem exacerbated by attributes

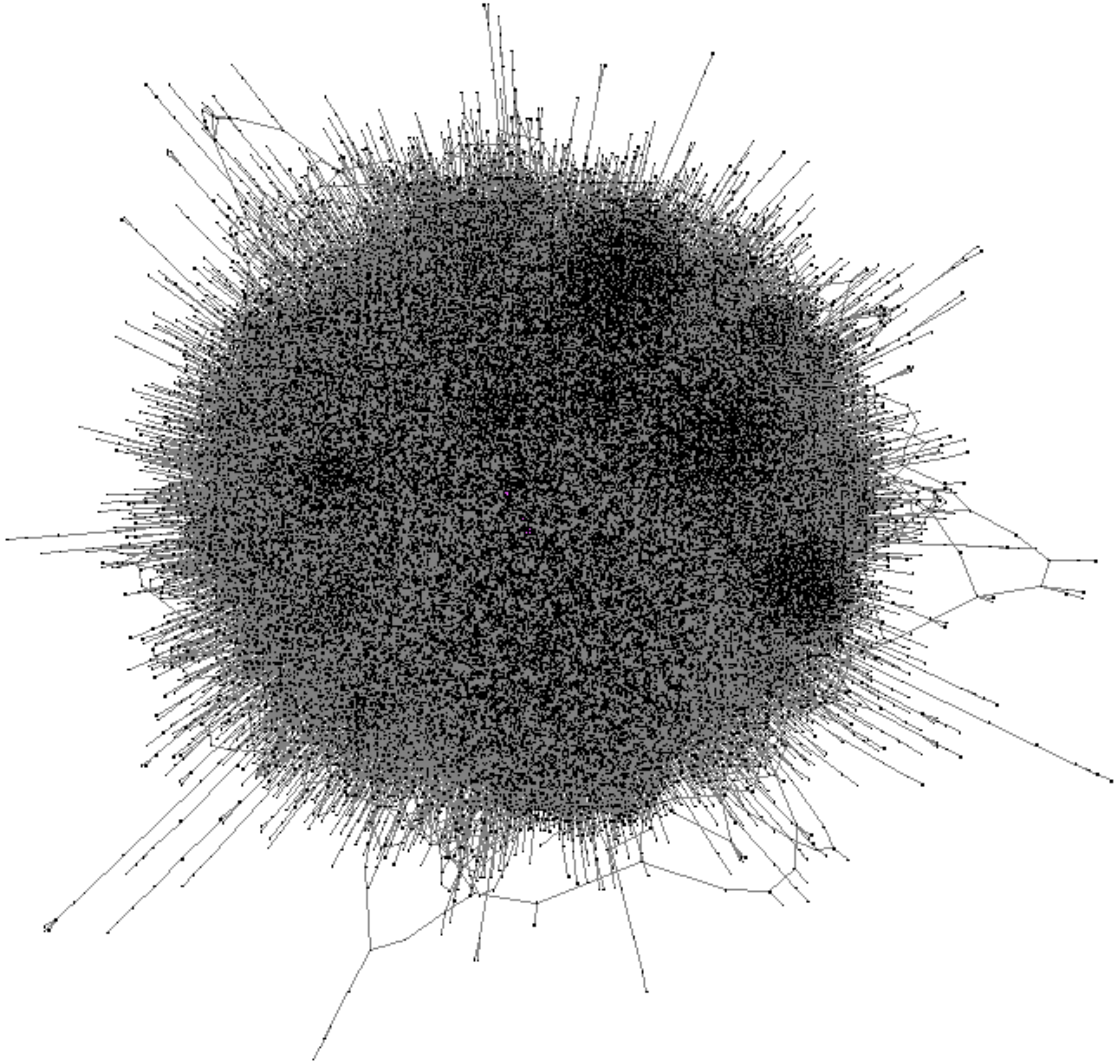


Image Source:
http://www.thenetworkthinkers.com/2013/03/big-data.html

Global and Local Network Analysis Tasks

Based on [Lee et al, 2006]

Task	Examples	Overview / Local	Type
Adjacency	Find the nodes adjacent to a node. Which node has a maximum number of adjacent nodes.	Local	Toplogy
Accessibility	Find the nodes accessible from a node, find nodes accessible from a node with distance X.	Local	Toplogy
Common Connection	Given nodes, find a set of nodes that are connected to all of them.	Local	Toplogy
Connectivity (Local)	Find the shortest path between two nodes.	Local	Toplogy
Connectivity (Global)	Identify Clusters, connected components. Find bridges, articulation points.	Overview	Toplogy
Node Attributes	Find a node with a specific attribute; Inspect attributes of a specific node	Local	Attribute
Link Attributes	Given a node find the nodes connected only by certain types of links; which node is connected by a link having the largest/smallest value.	Local	Attribute
Follow Path		Local	Browsing
Revisit	Return to a previously visited node	Local	Browsing
Overview	Estimate the size of the network	Overview	Topology
Topology-Attribute Interaction	How does an attribute influence the topology of the network	Local	Topology/ Attribute
Query	Retreive all nodes of a property. Retrieve a specific node. Retreive all neighbors.	Either	Topology/ Attribute

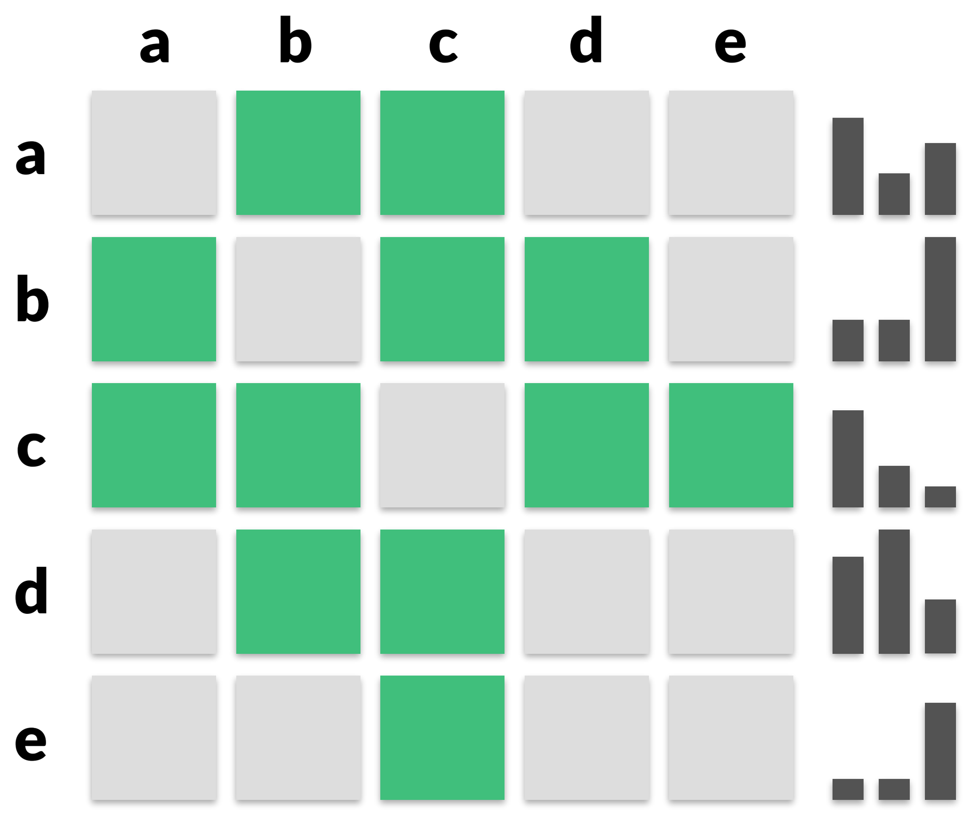
Many Graph Tasks Dont Require Overviews

[van Ham and Perer, 2009]

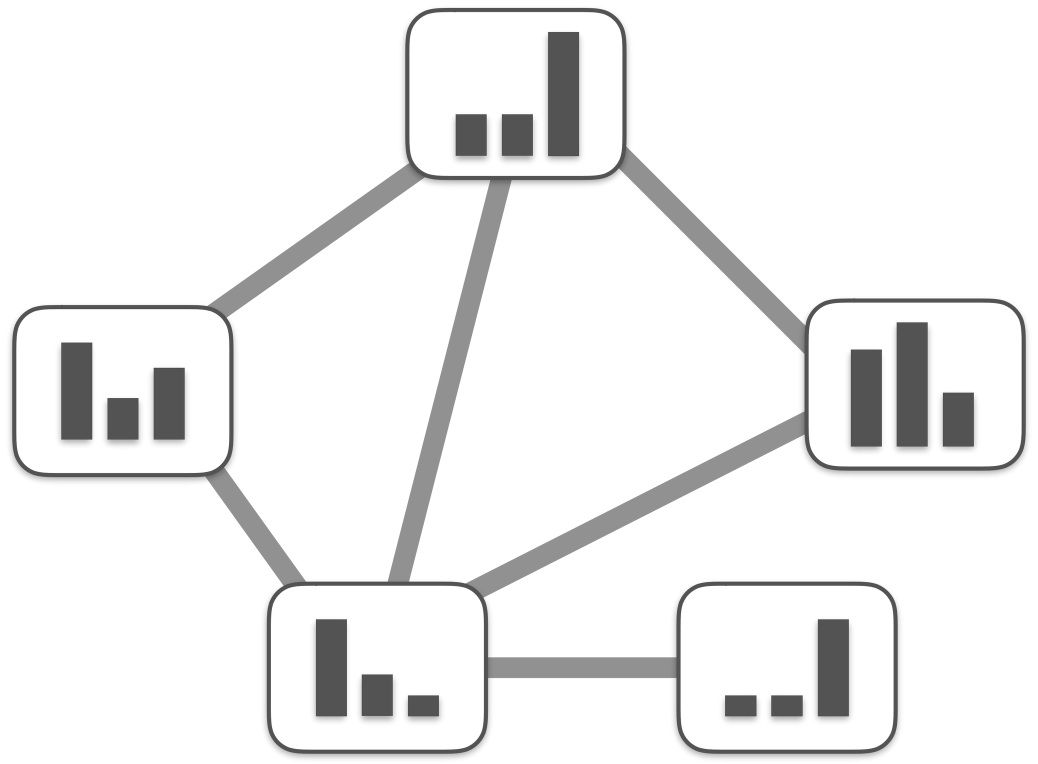
Search, Show Context, Expand on Demand


Show all attributes /
many attributes
Show all nodes /
large network
Show selected
nodes /
small network
Show selected attributes /
few attributes

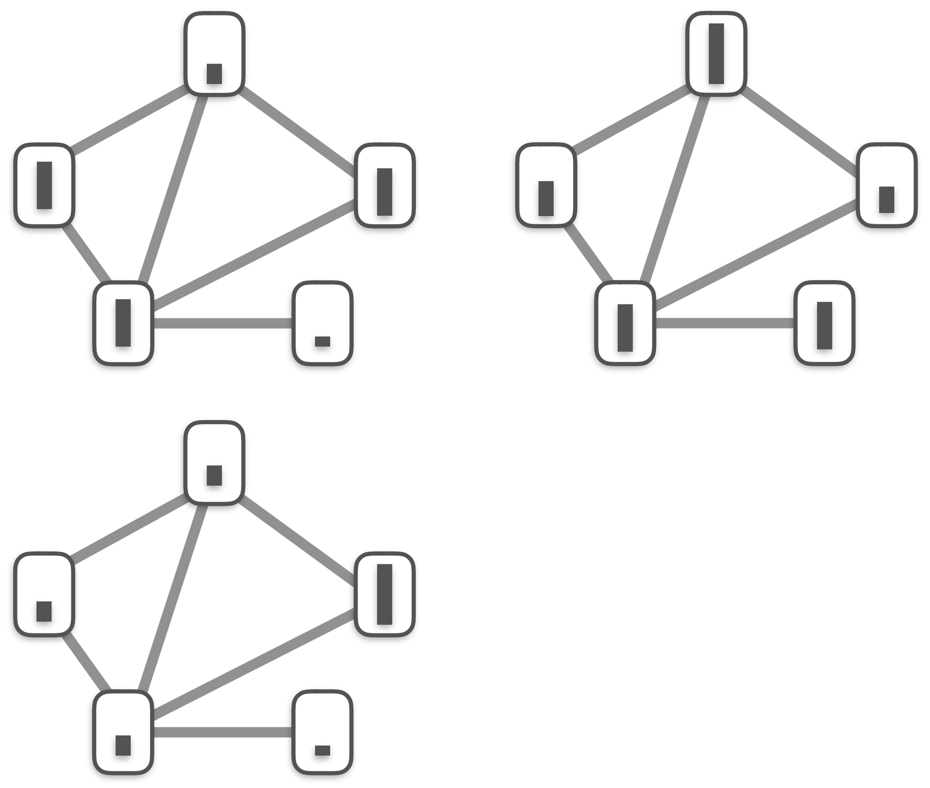
Multivariate Network Visualization Strategies



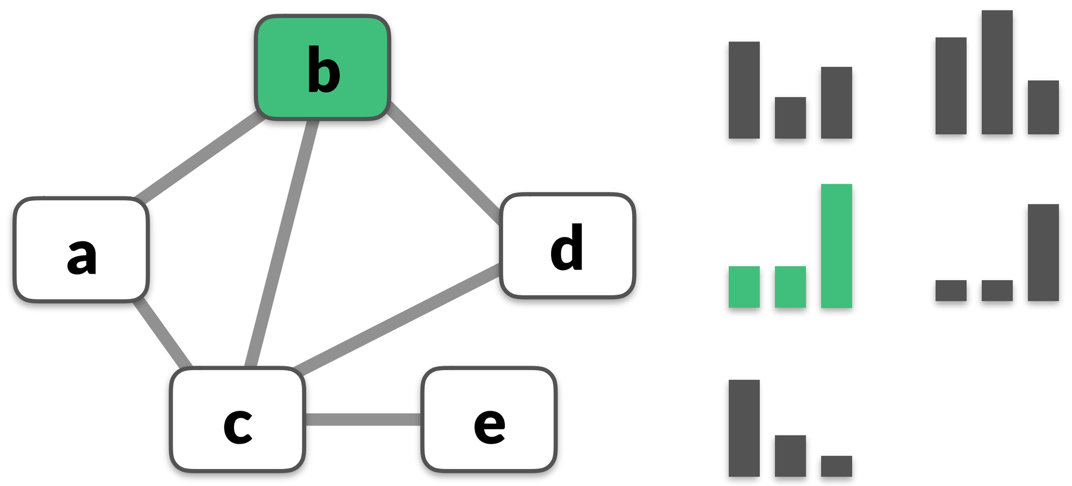
Matrices



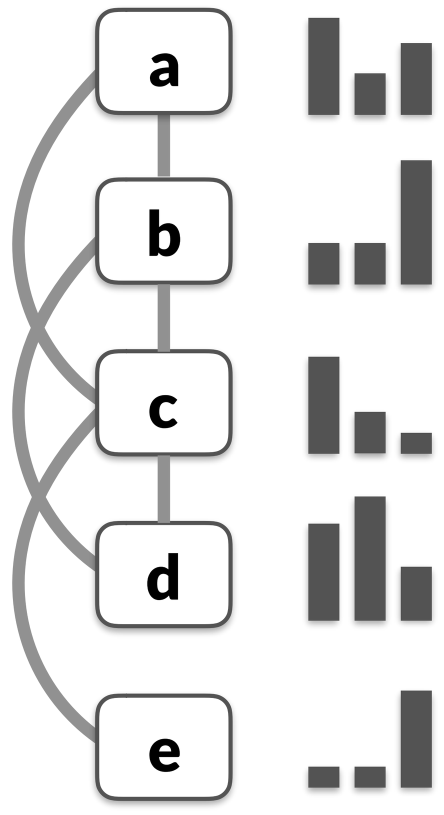
On-Node Encoding



Small Multiples

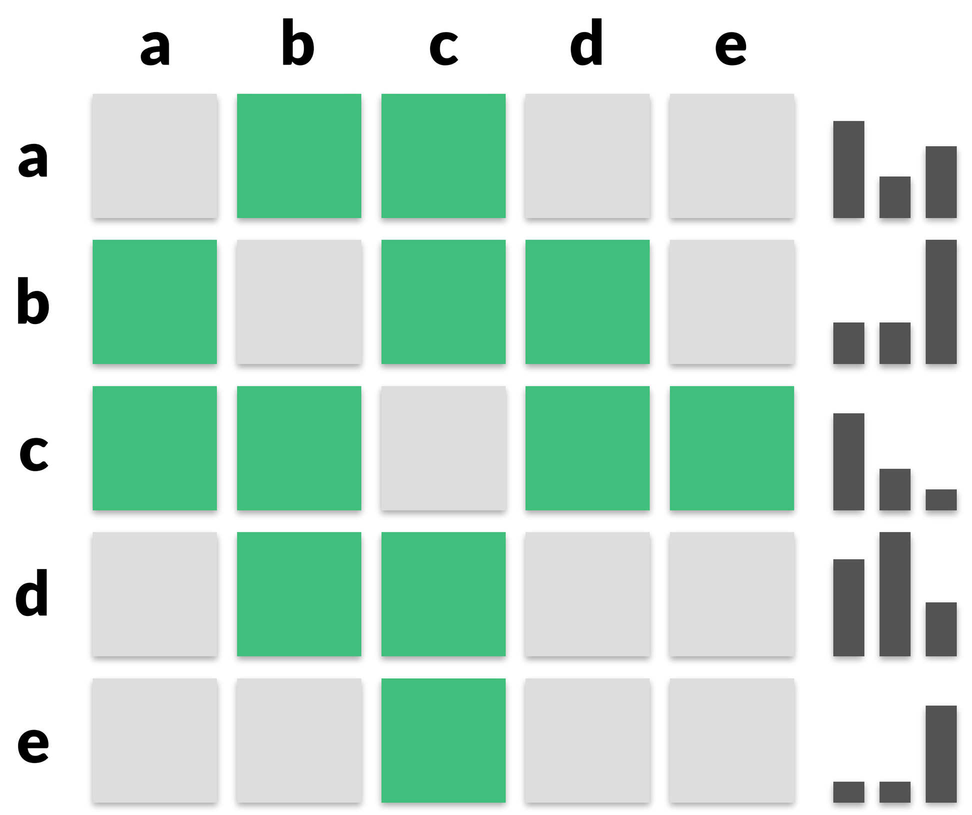


Multiple Coordinated Views



Layout Adaption

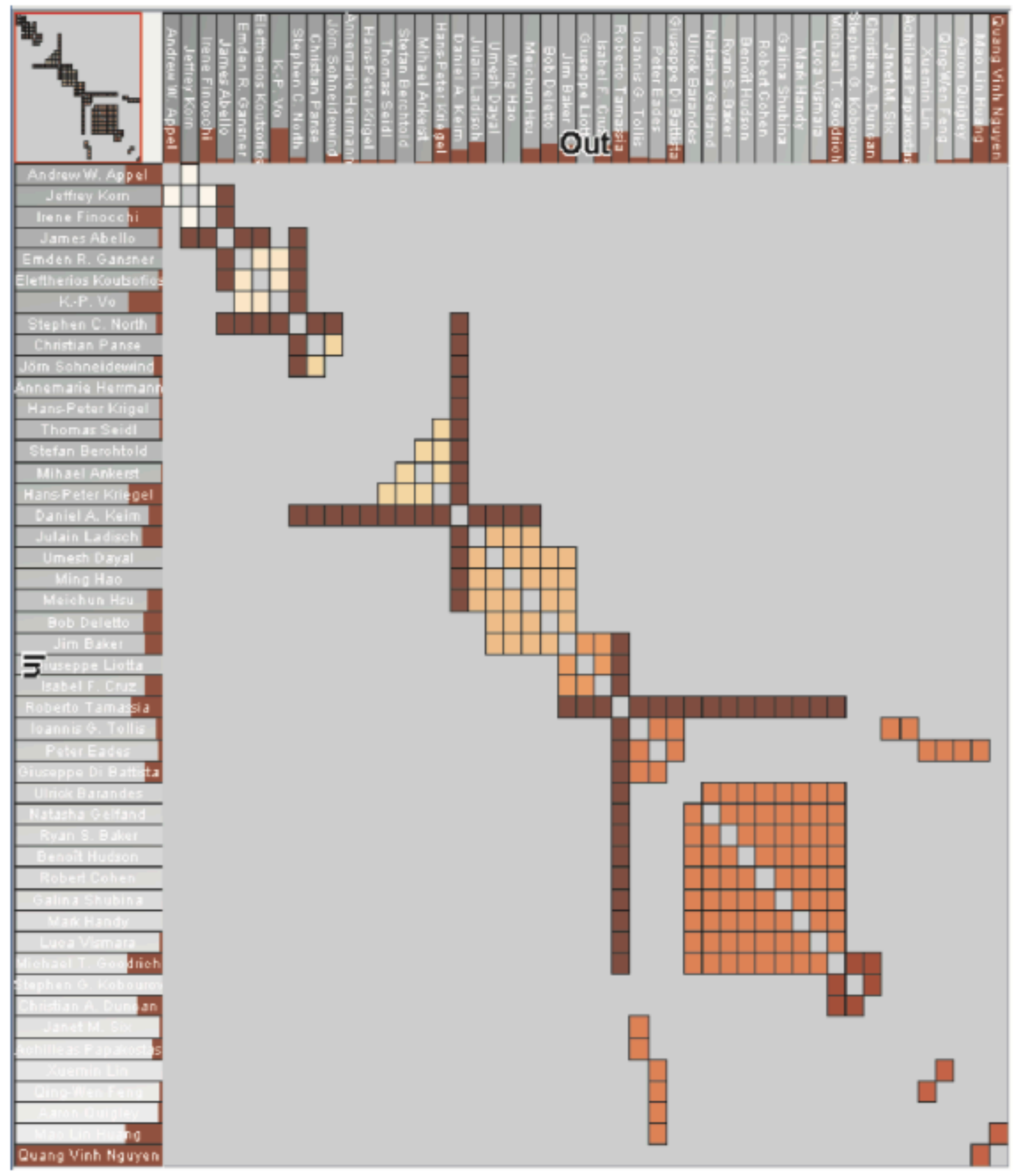
Matrices



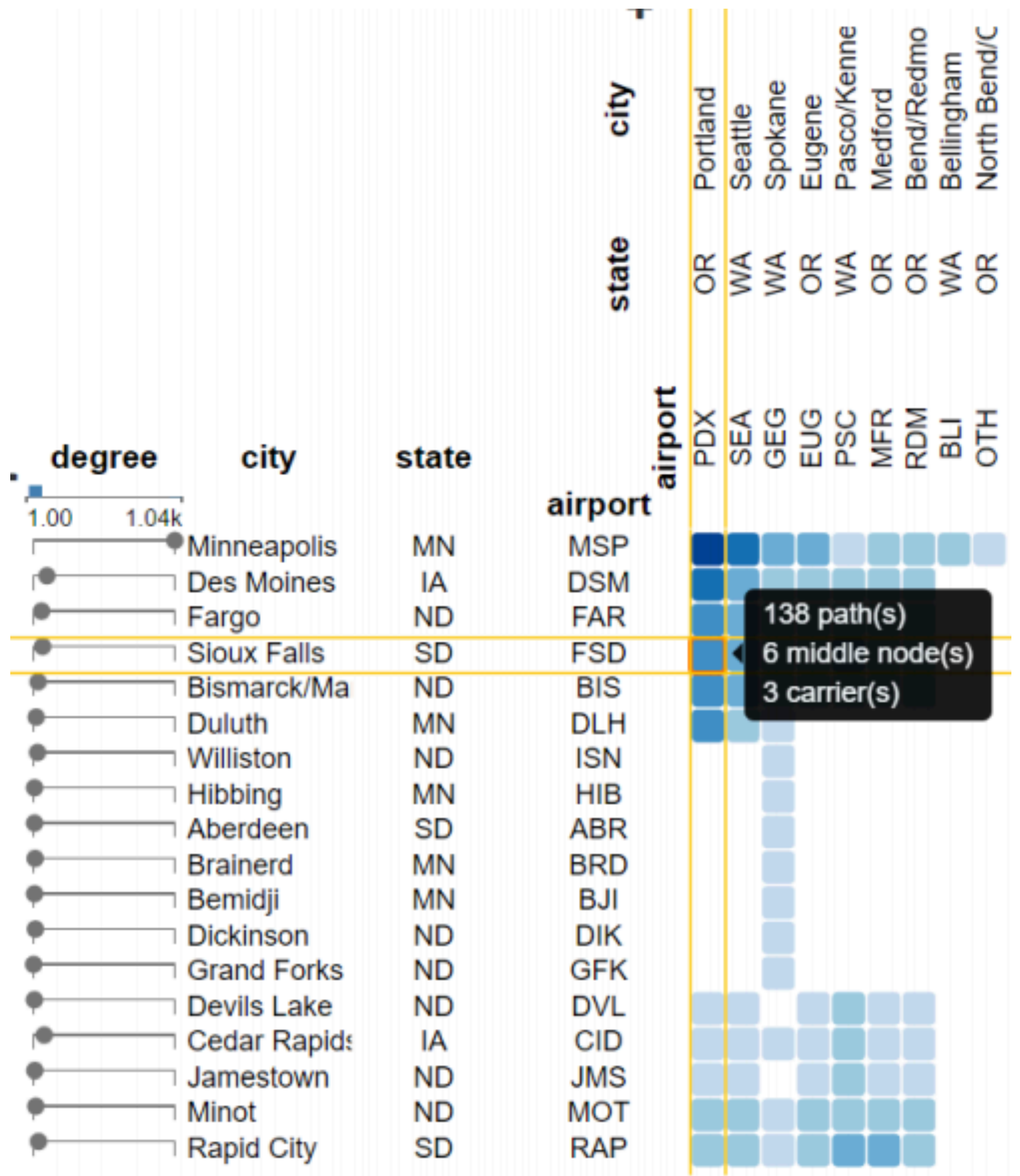
Easy to encode edge attributes in cells

Easy to encode node attributes adjacent to matrix

Common pros and cons of matrices

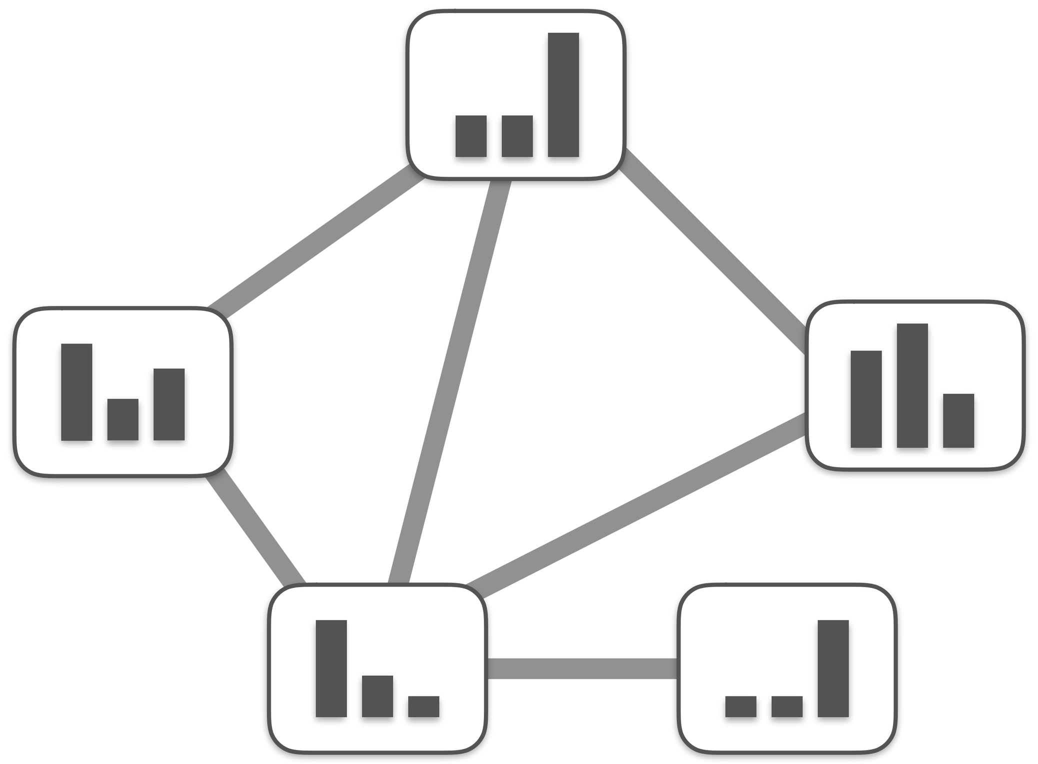


[Henry and Fekete, MatrixExplorer, 2006]



[Kerzner et al., Graffinity, 2017]

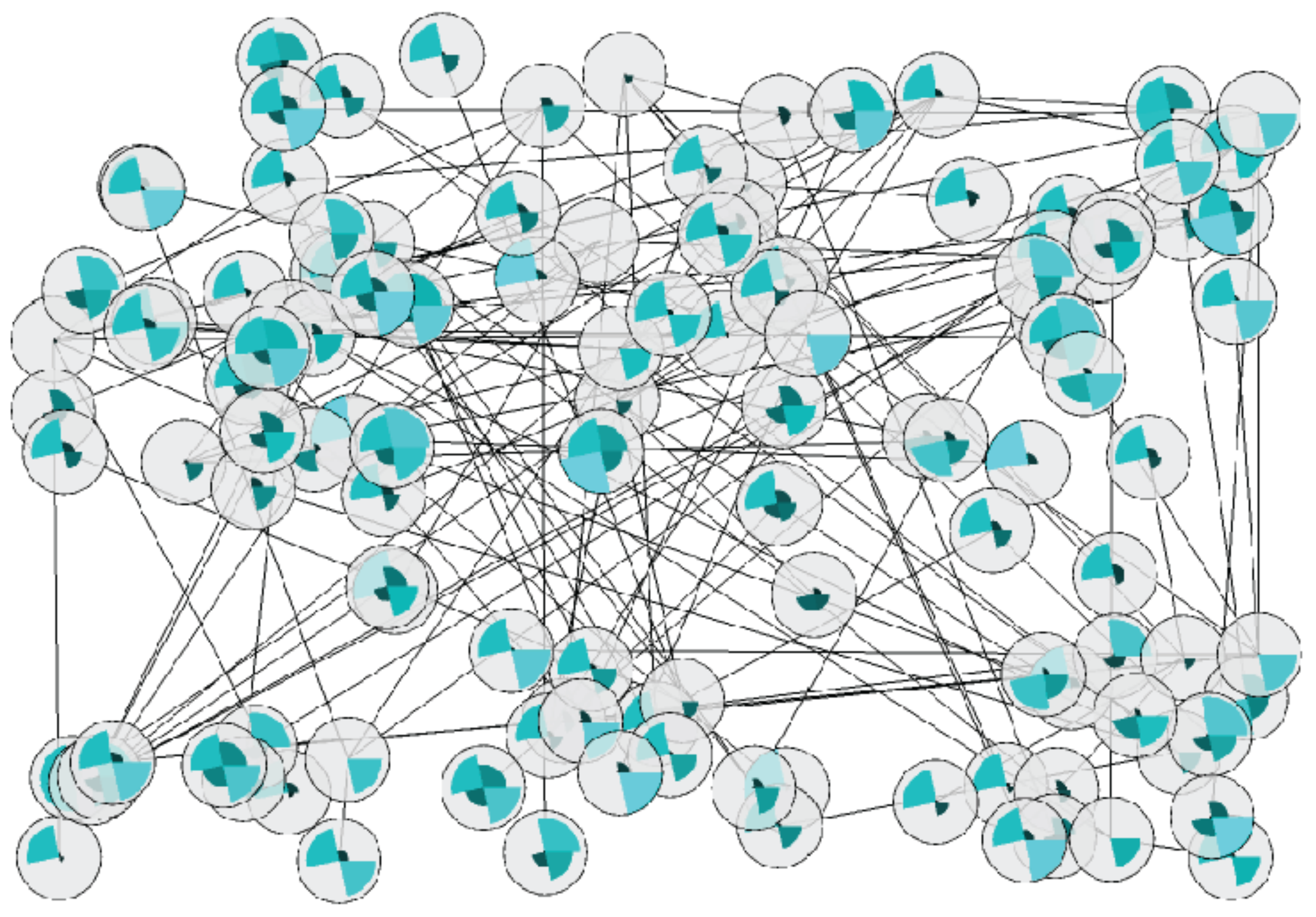
On-Node Encoding



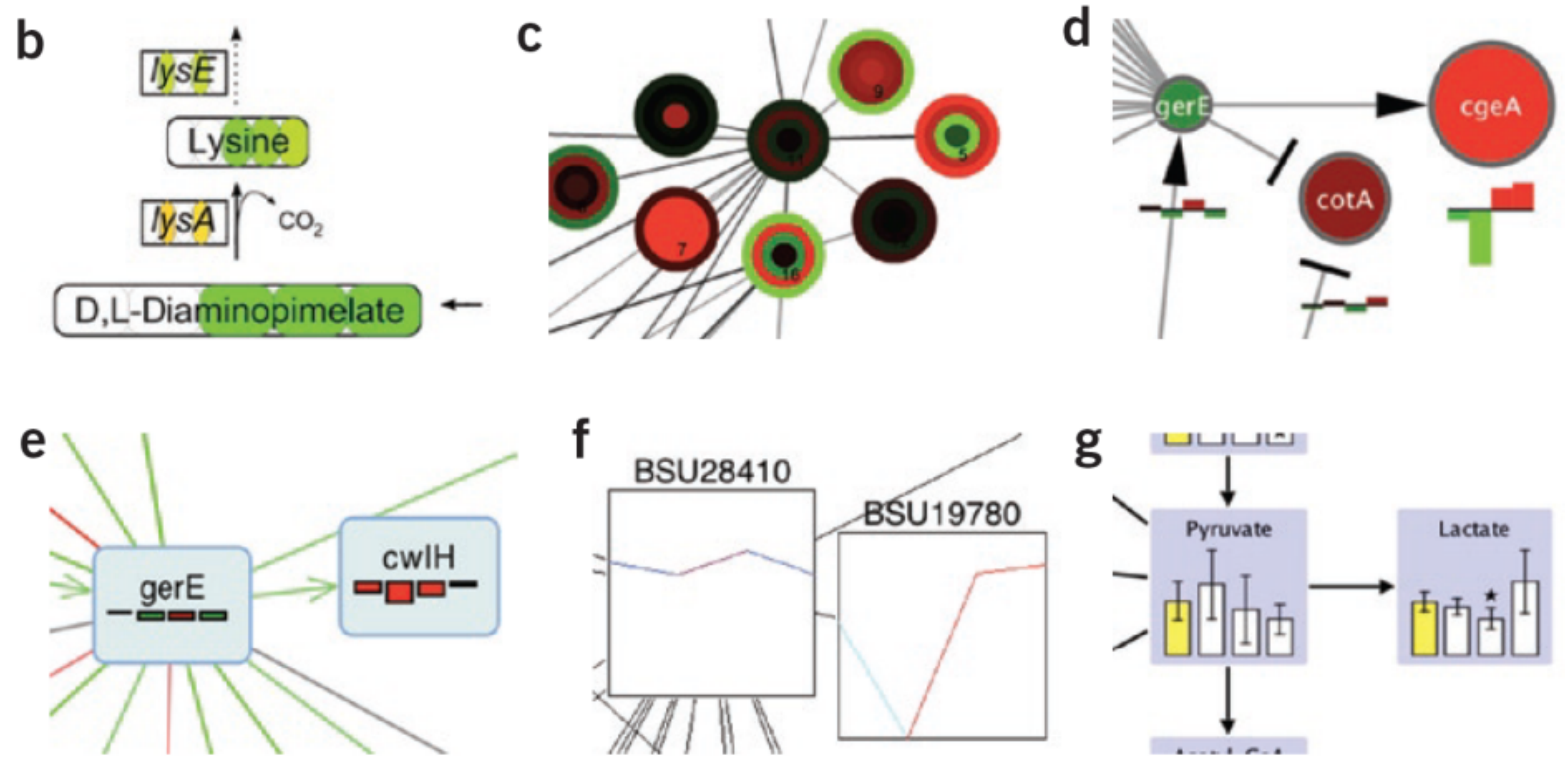
Canonical way to visualize single attribute. Widely supported.

Ideal for topology-attribute interaction

Tricky for multiple attributes

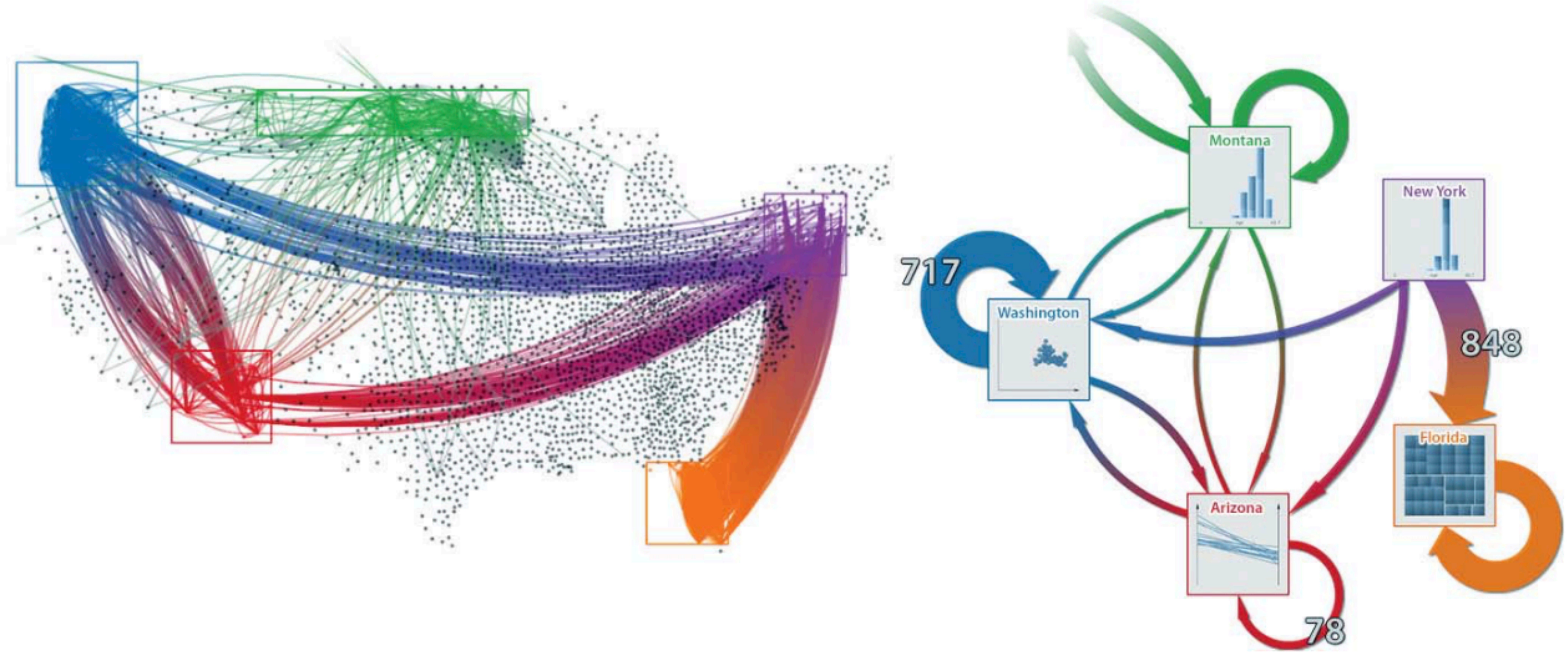


[McDonnel2009]



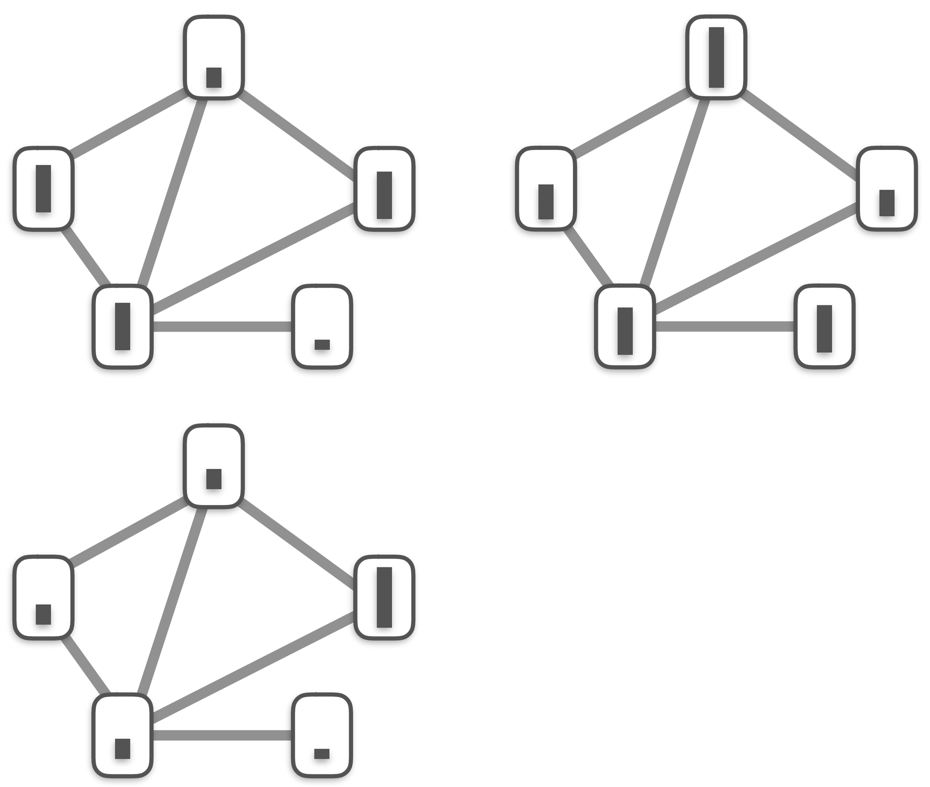
[Gehlenborg2010]

On-Node Encoding for Aggregates



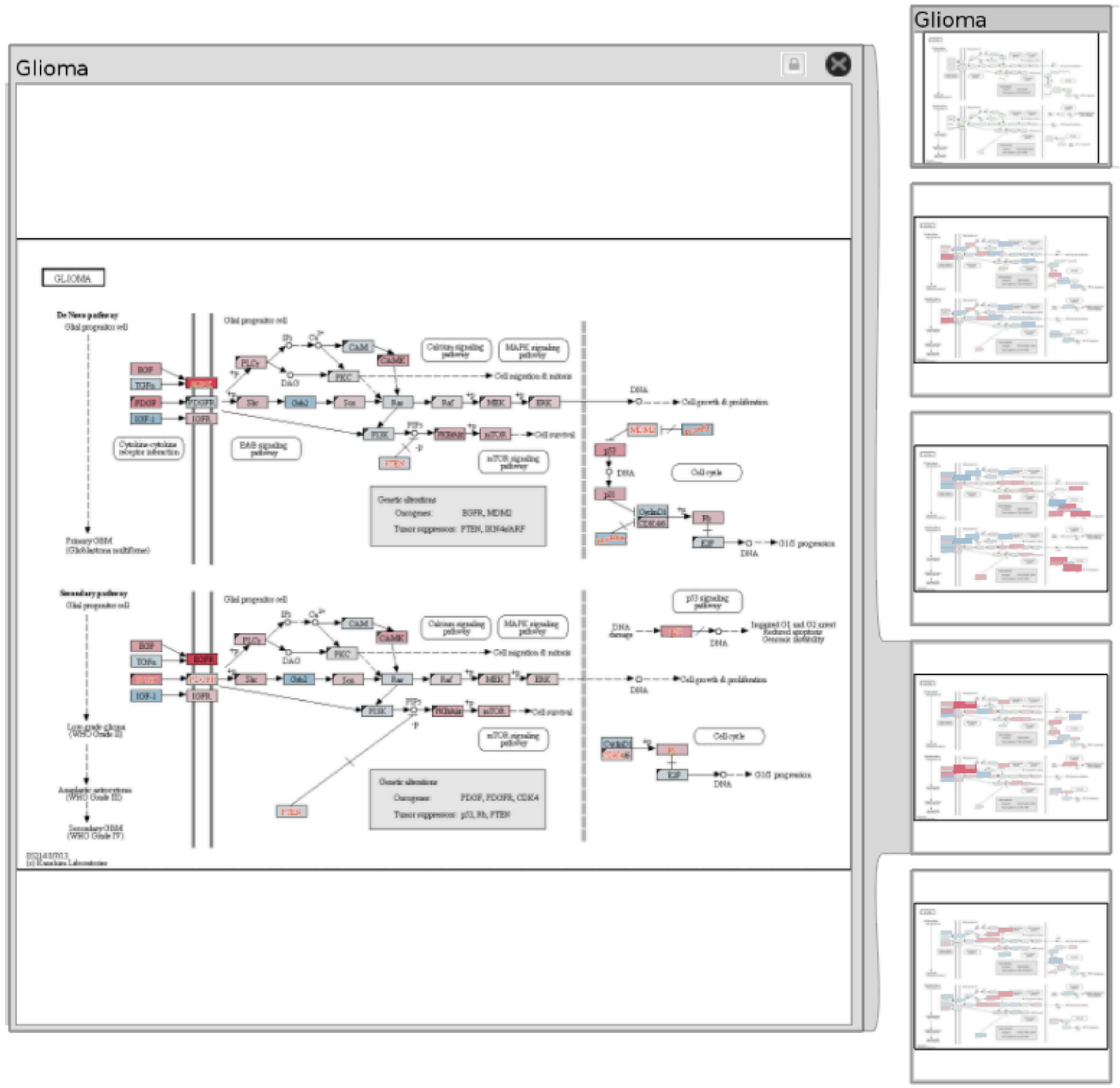
[van den Elzen and van Wijk, 2014]

Small Multiples

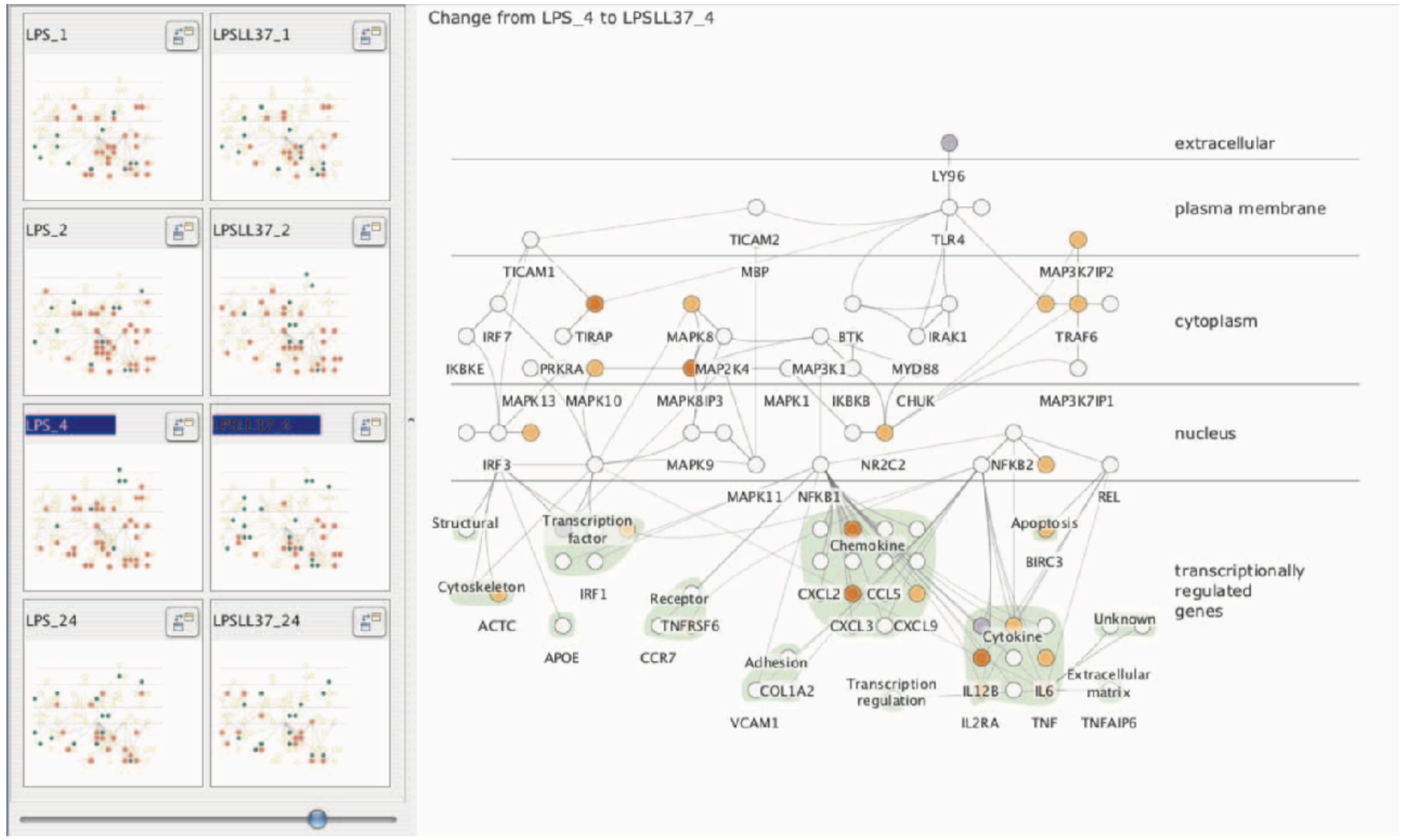


On-node encoding with small multiples

Graphs tend to be small, combine with focus graph



[Lex et al., StratomeX, 2012]

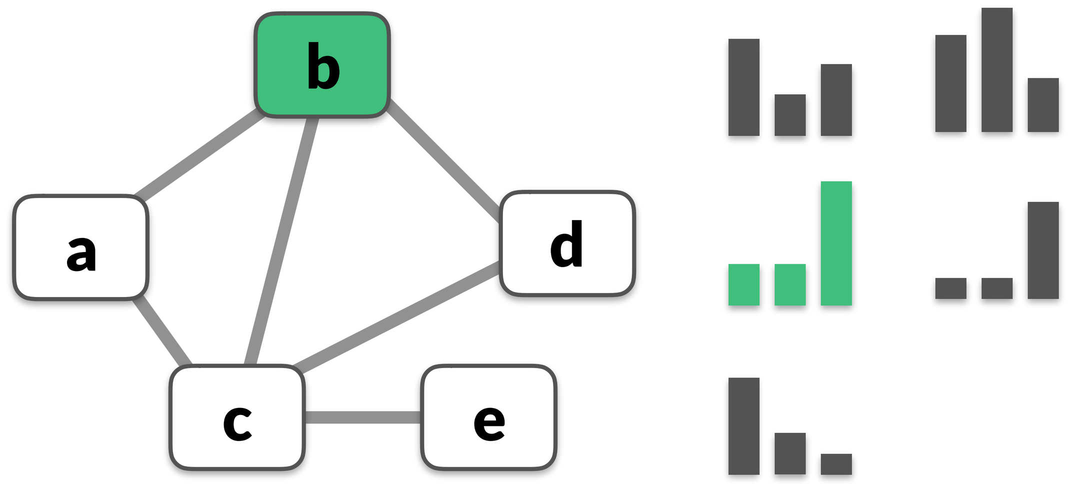


[Barsky et al., Cerebral, 2008]

https://www.sporcle.com/games/Cutthroat/spot-the-difference-i

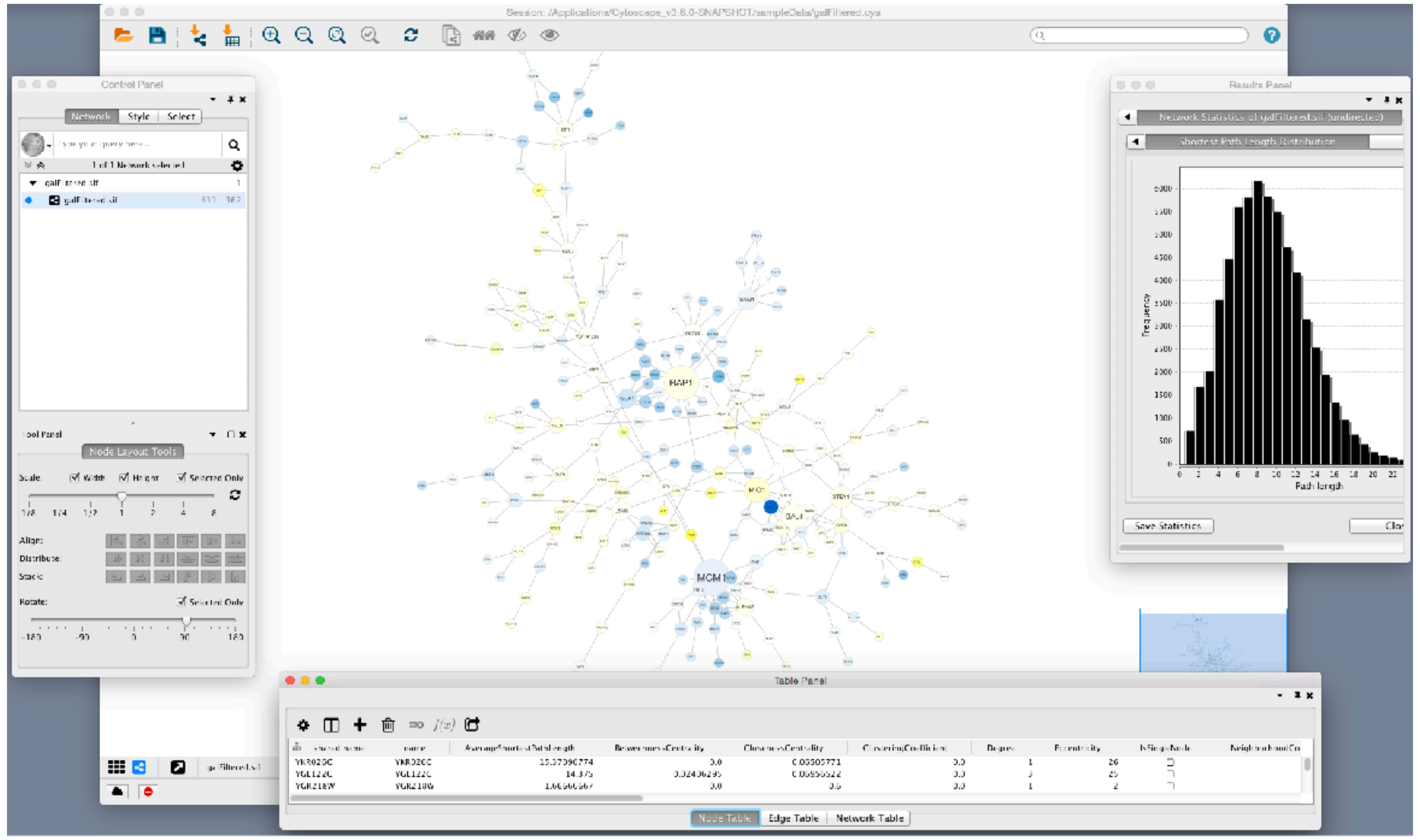
https://www.sporcle.com/games/Cutthroat/spot-the-difference-i

Multiple Coordinated Views

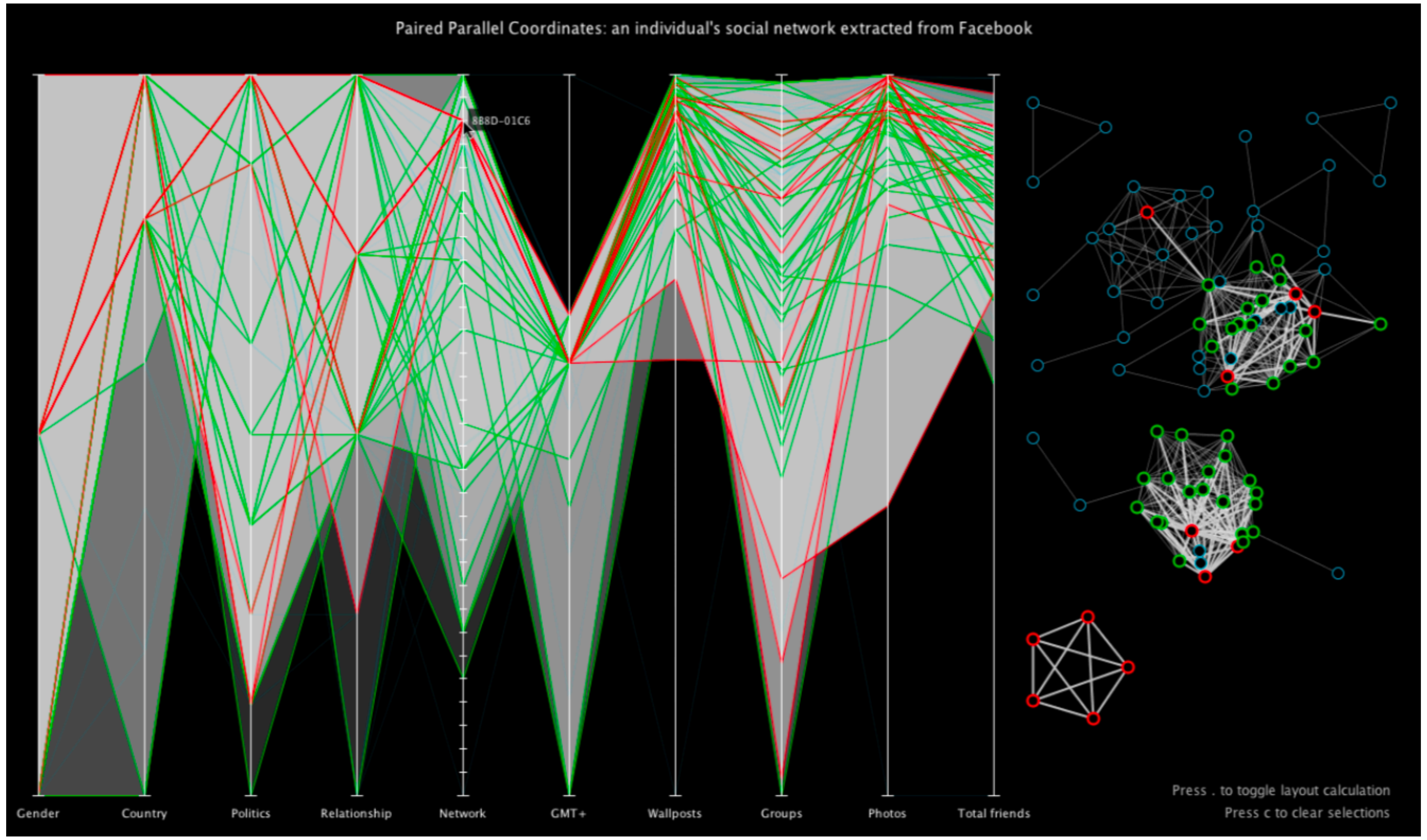


Can optimize for topology and attributes at the same time

Lacking when evaluating interplay

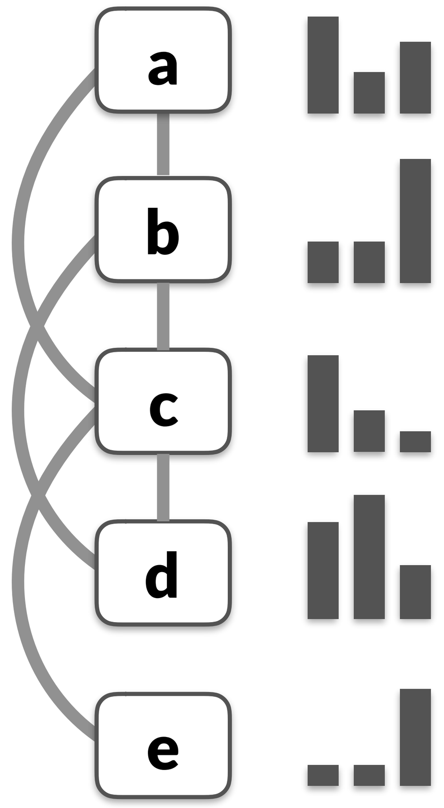


[Shannon et al., Cytoscape, 2003]



[Shannon et al., 2008]

Layout Adaption



Adapt node position in a node-link diagram so that it is well suited for attribute visualization

Layout driven by attributes

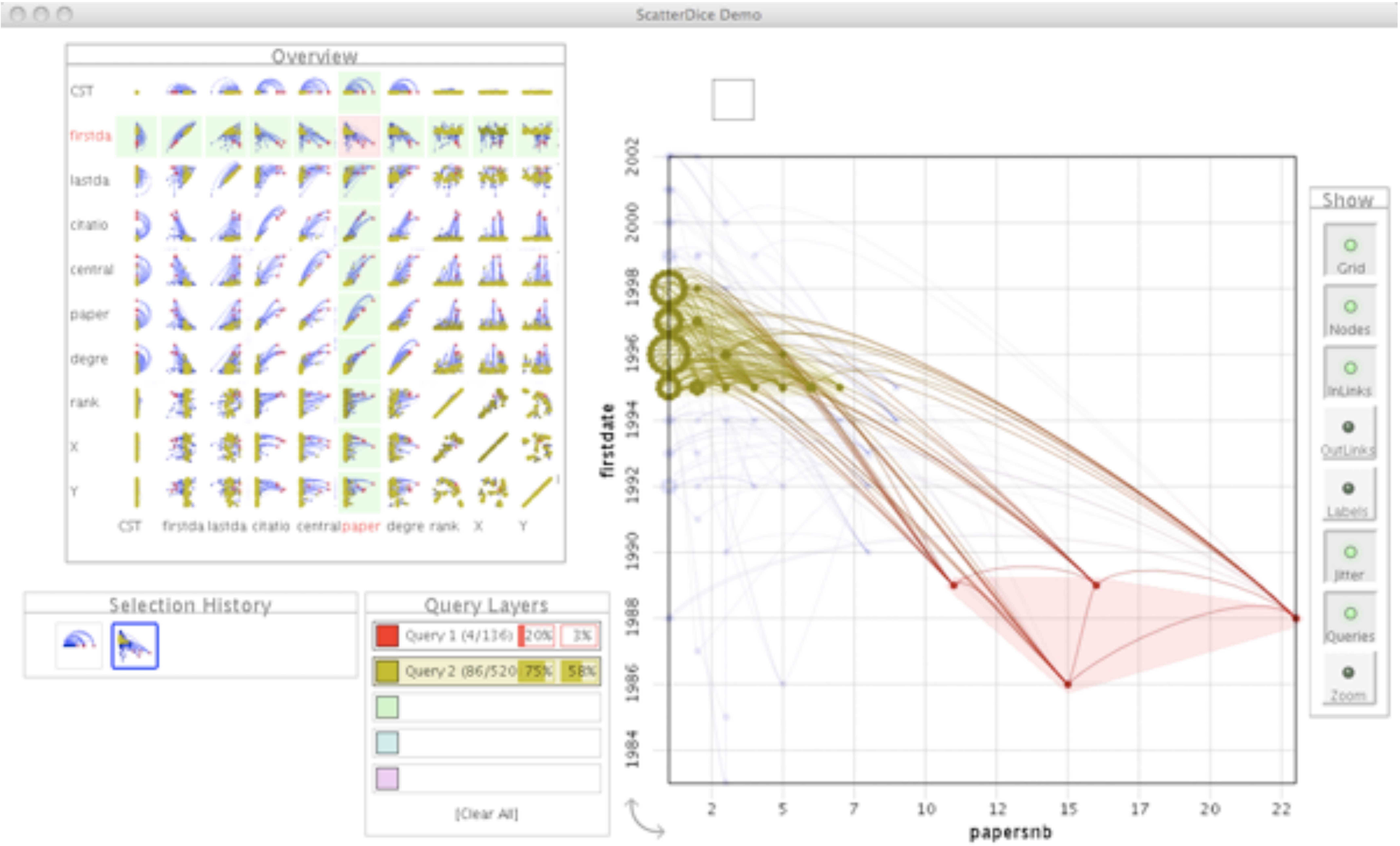
Layout driven by Topology

Fixed Layout

Node position defined by attribute values.

Focus on relationship of limited number of attributes

Topology hard to read



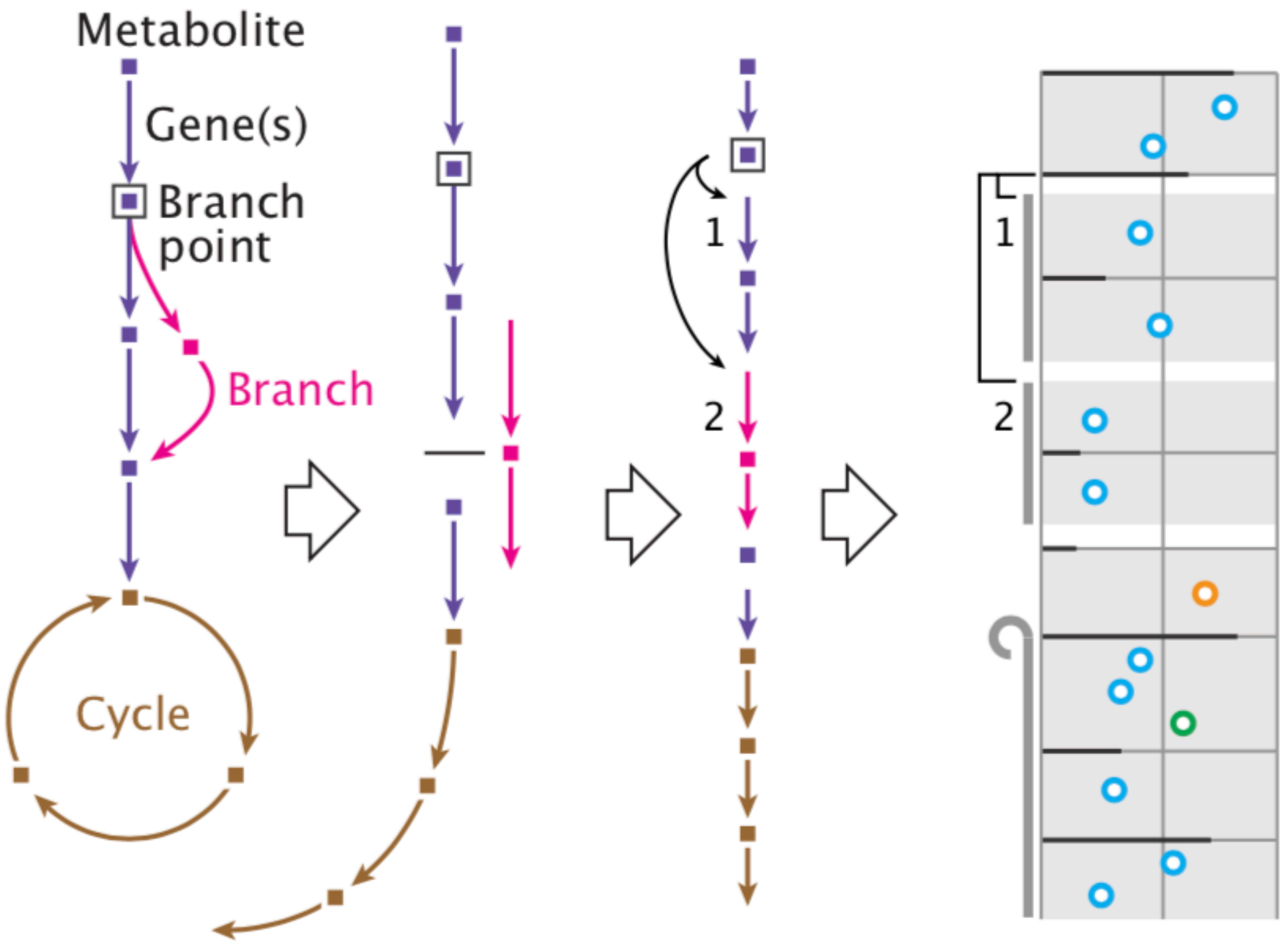
Layout driven by attributes

[Bezerianos et al, 2010]

Layout driven by Topology

Linearization Strategy:
Layout that enables
juxtaposition with attribute
visualizations

Complete Linearization: Pathline



[Meyer et al, Pathline, 2010]

Good solution for smaller graphs

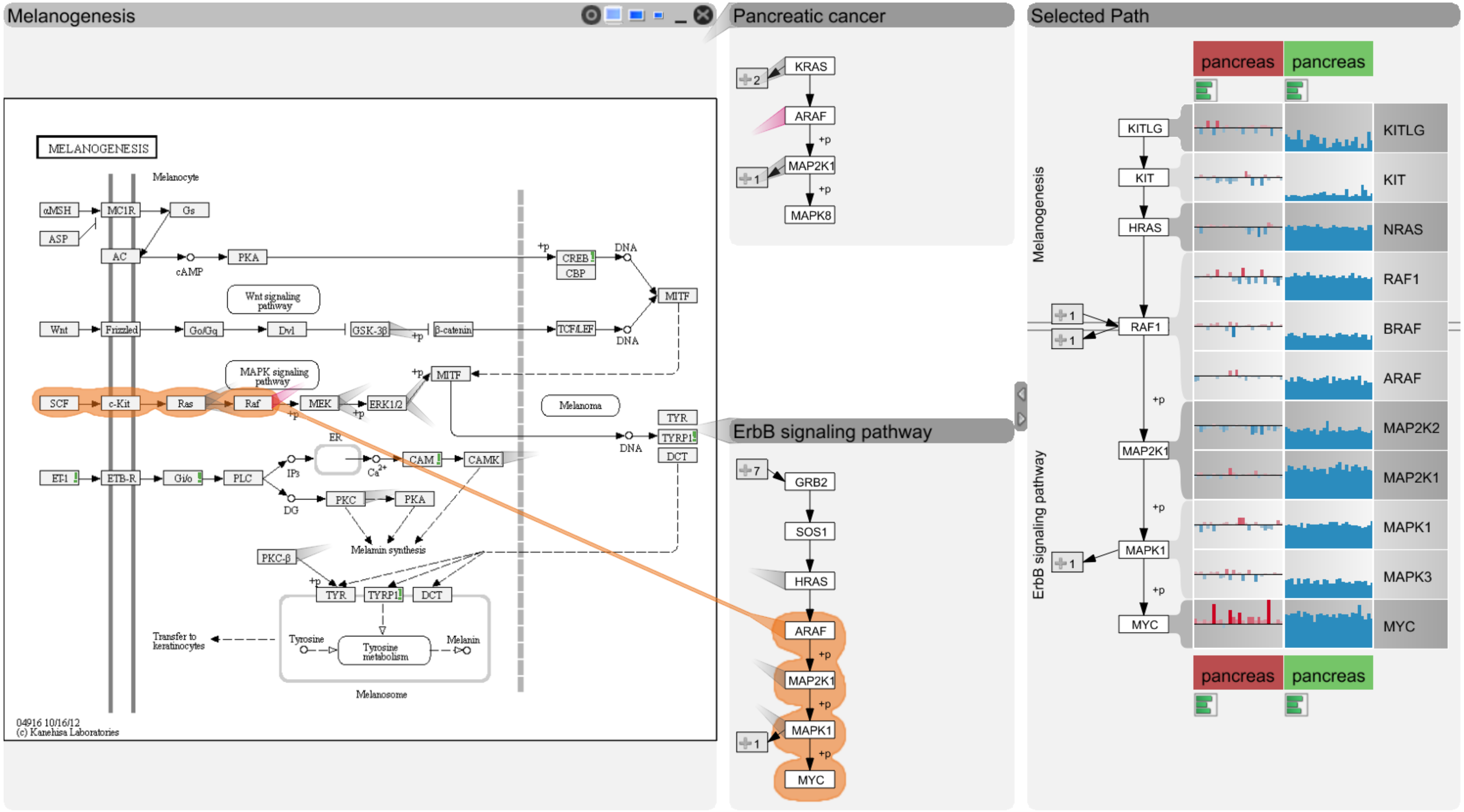
Hard to keep track of topology for complex graphs

Layout driven by attributes

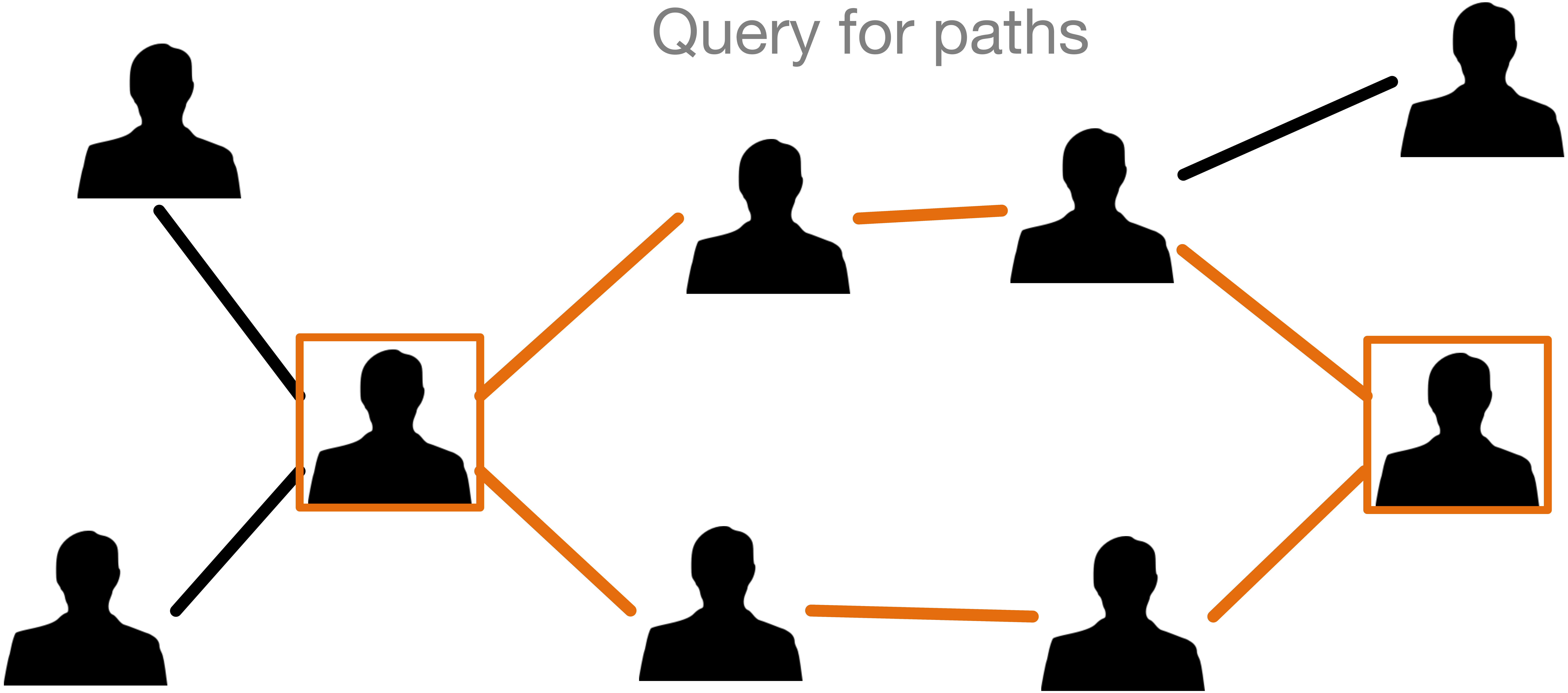
Layout driven by Topology

Selective Linearization: enRoute

enRoute


Melanogenesis
Pancreatic cancer
Selected Path
ErbB signaling pathway
MELANOGENESIS
Melanocyte
KRAS
ARAF
MAP2K1
MAPK8
GRB2
SOS1
HRAS
MAPK1
MYC
pancreas
pancreas
KITLG
KIT
NRAS
RAF1
BRAF
MAP2K2
MAPK3
Melanogenesis
ErbB signaling pathway
04916 10/16/12
(c) Kanehisa Laboratories

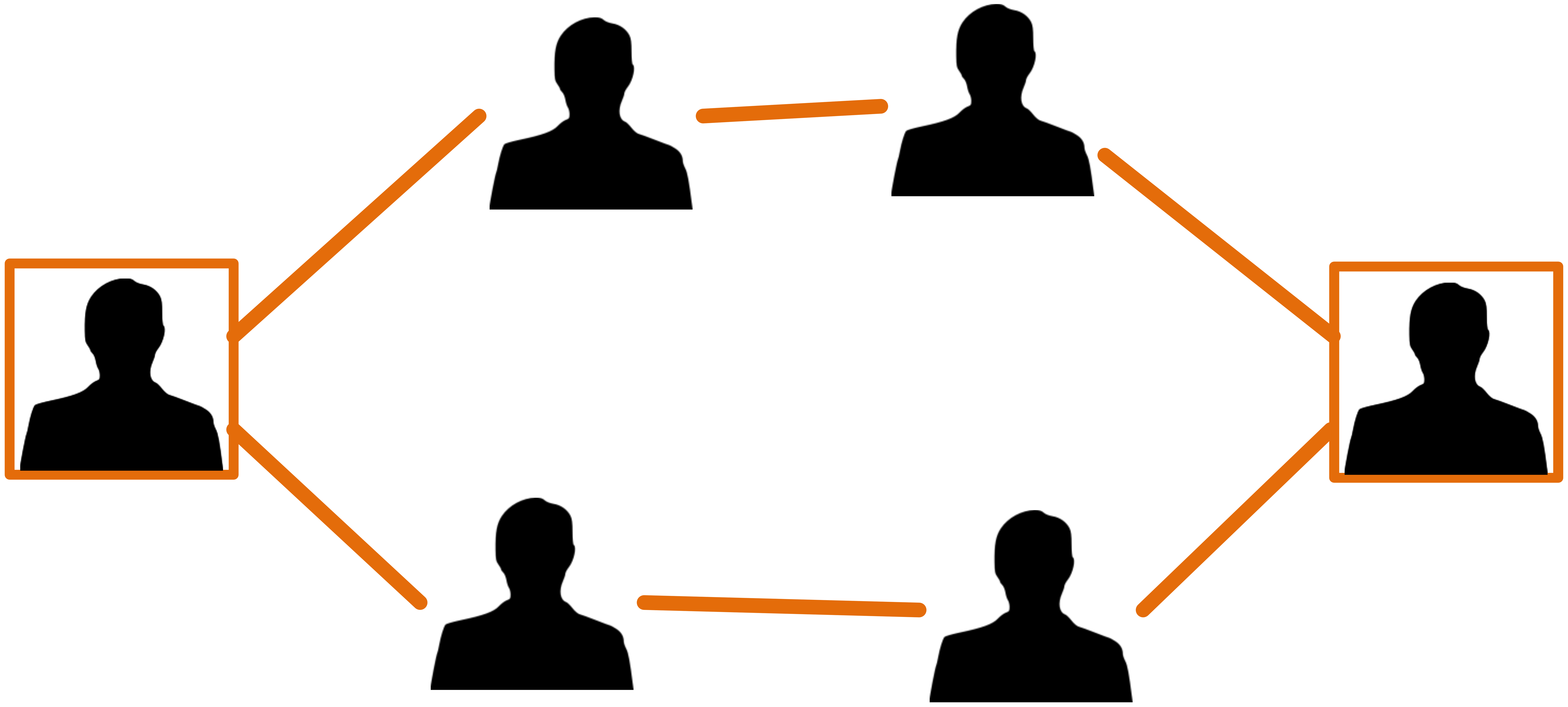
Selective Linearization: Pathfinder



Layout driven by attributes

Layout driven by Topology

Selective Linearization: Pathfinder

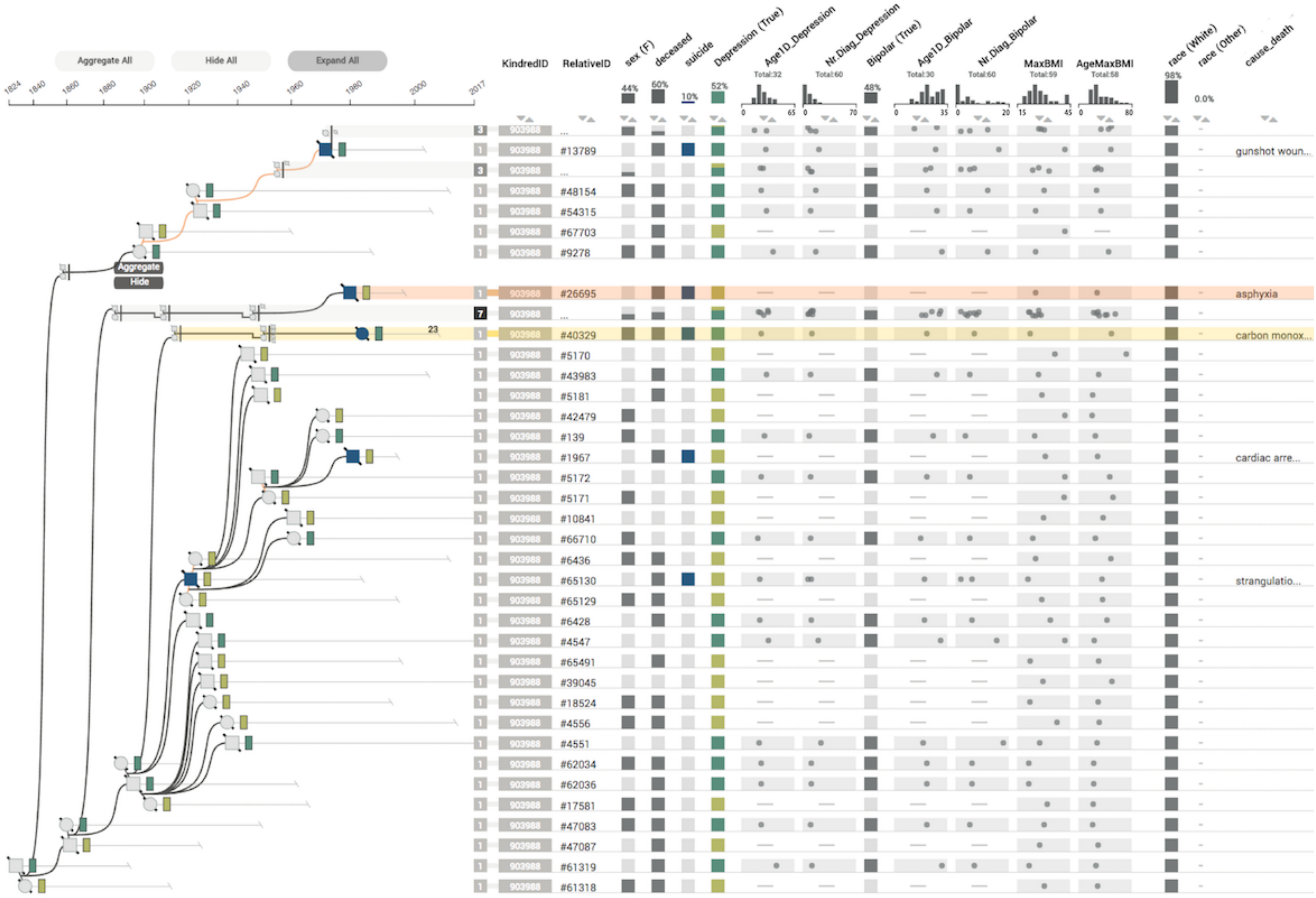


Selective Linearization: Pathfinder

Show paths as ranked list


Pathfinder
Start
End
Advanced Query
Length
Paths
Path Statistics
Path List
Path Topology
Active Page
All
Query Interface

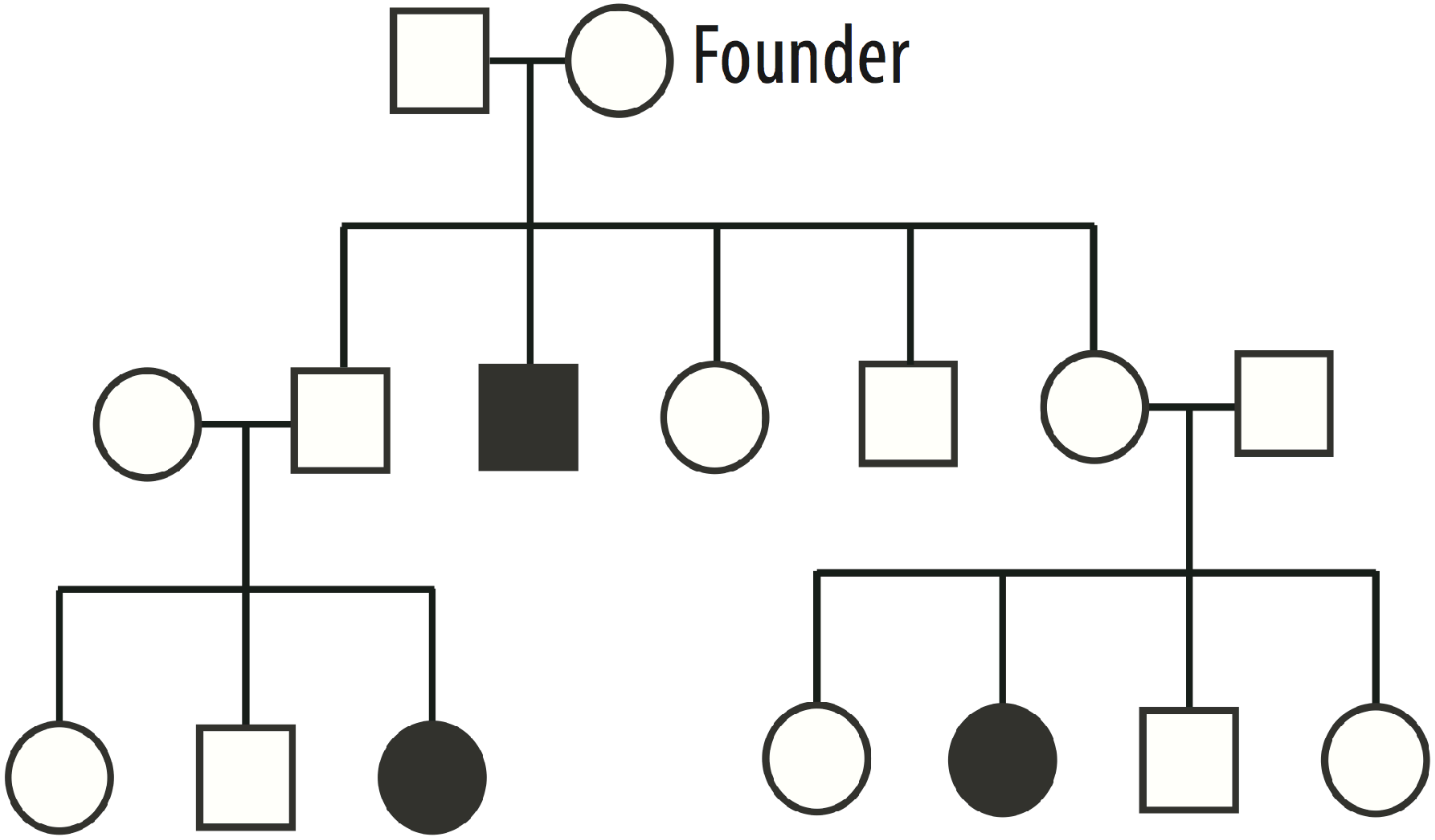
Linearizing a Tree: Lineage

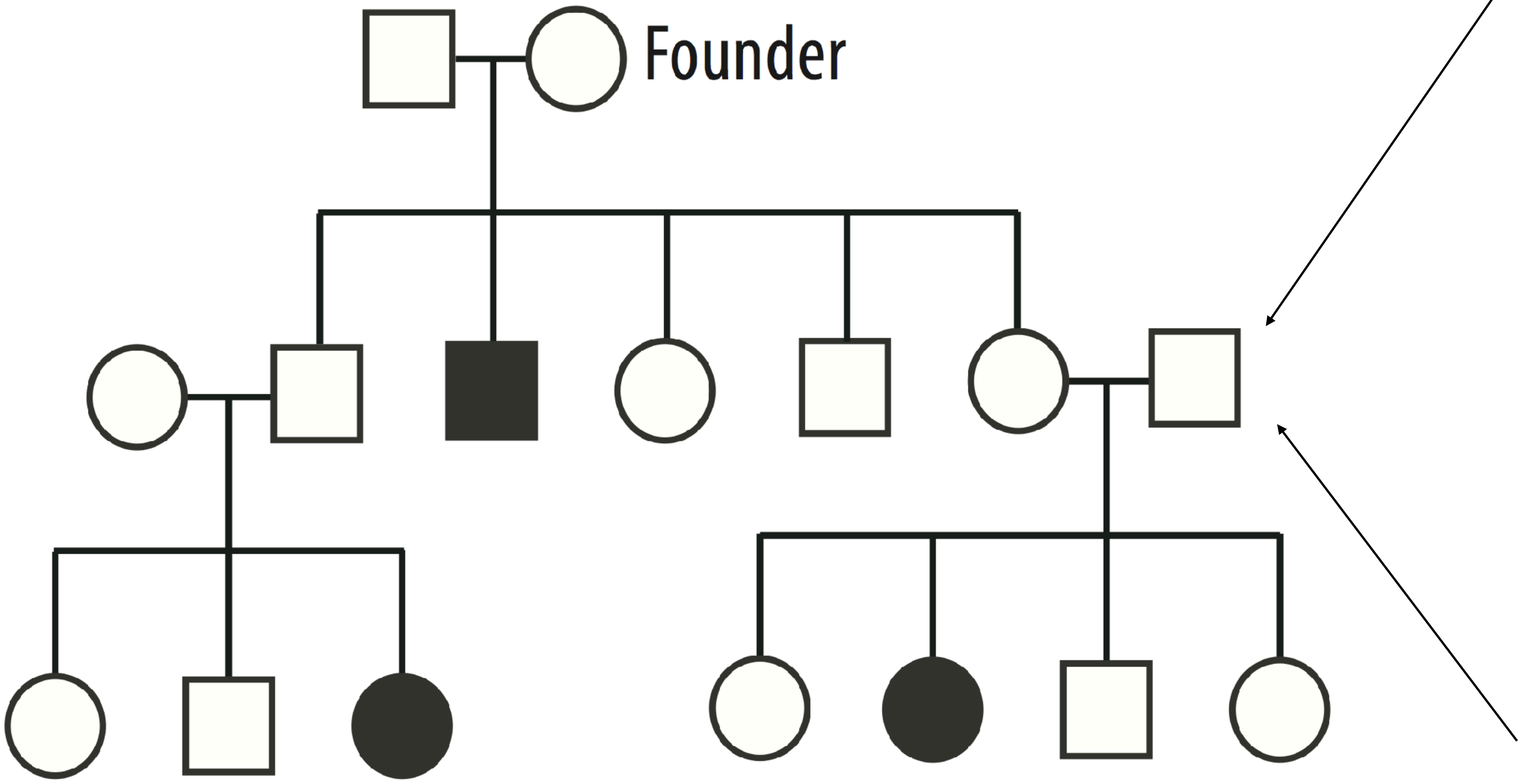


[Nobre et al, Lineage, 2018]

Layout driven by attributes

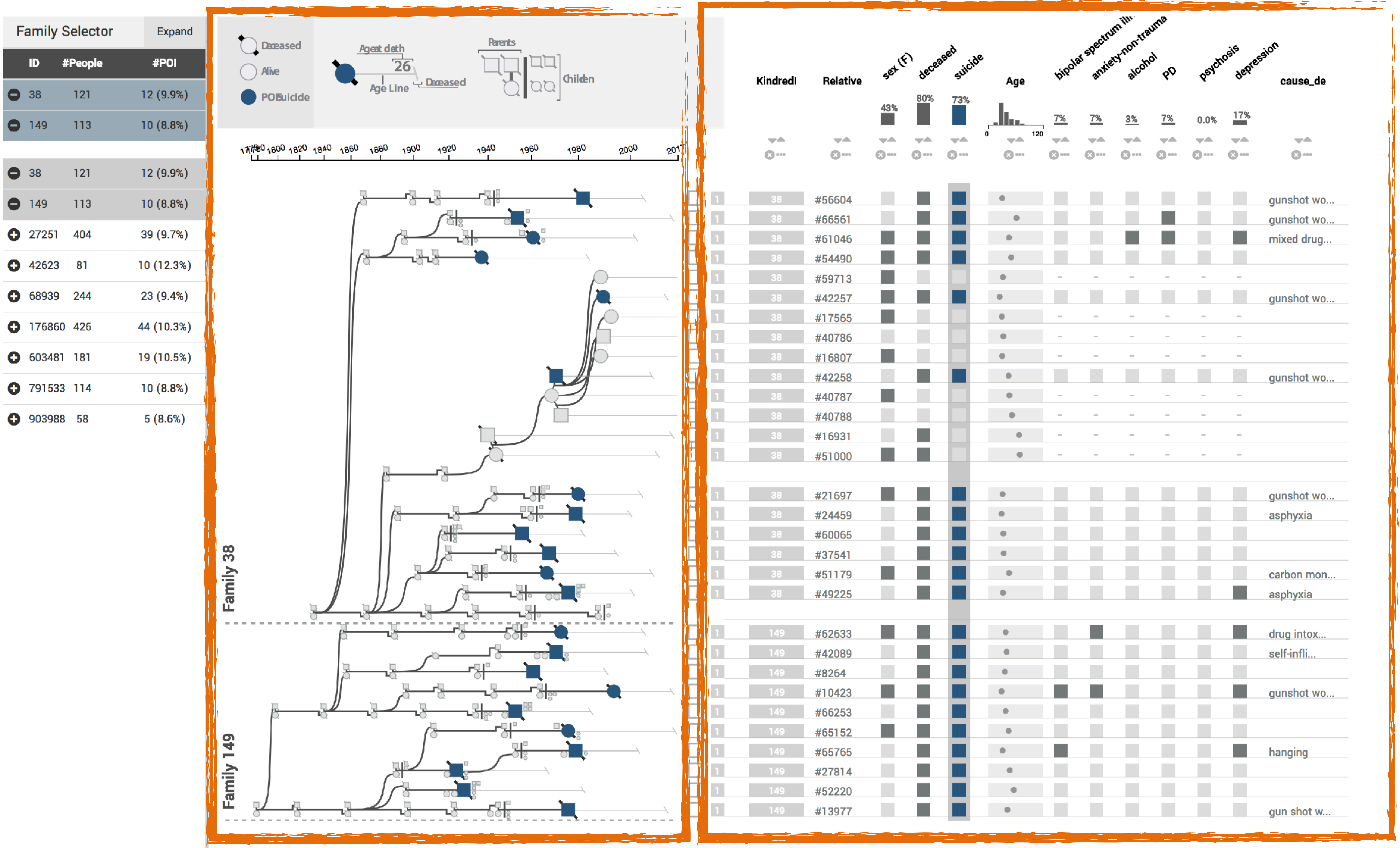
Layout driven by Topology


Founder



Age
Sex
Race
Bipolar
 # diagnosis bipolar
Depression
 # diagnosis depression
Asthma
 # diagnosis asthma
Obesity
Schizophrenia
Cause of Death
Weapon Used

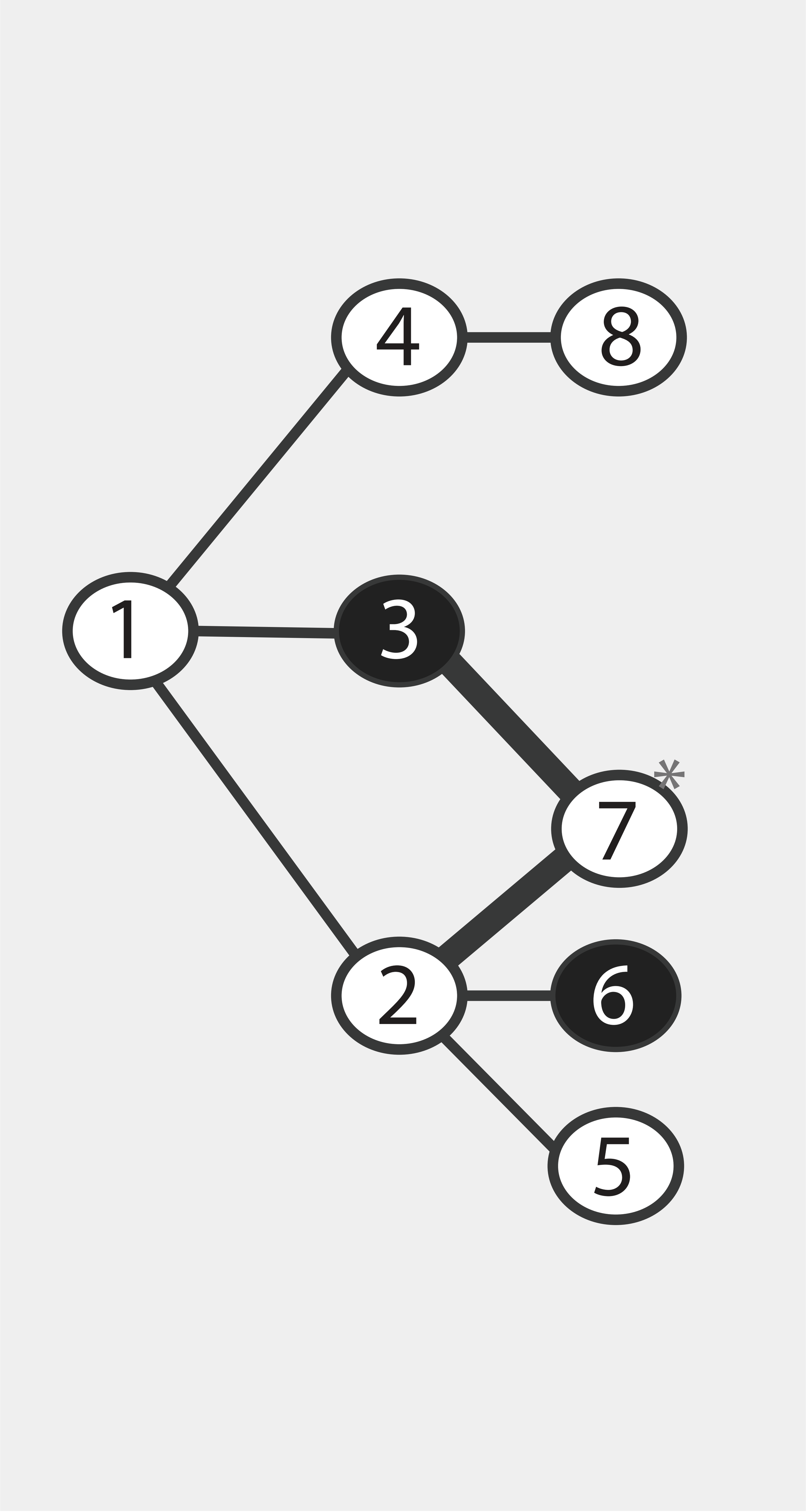
Genealogy with ~400 members rendered with Progeny



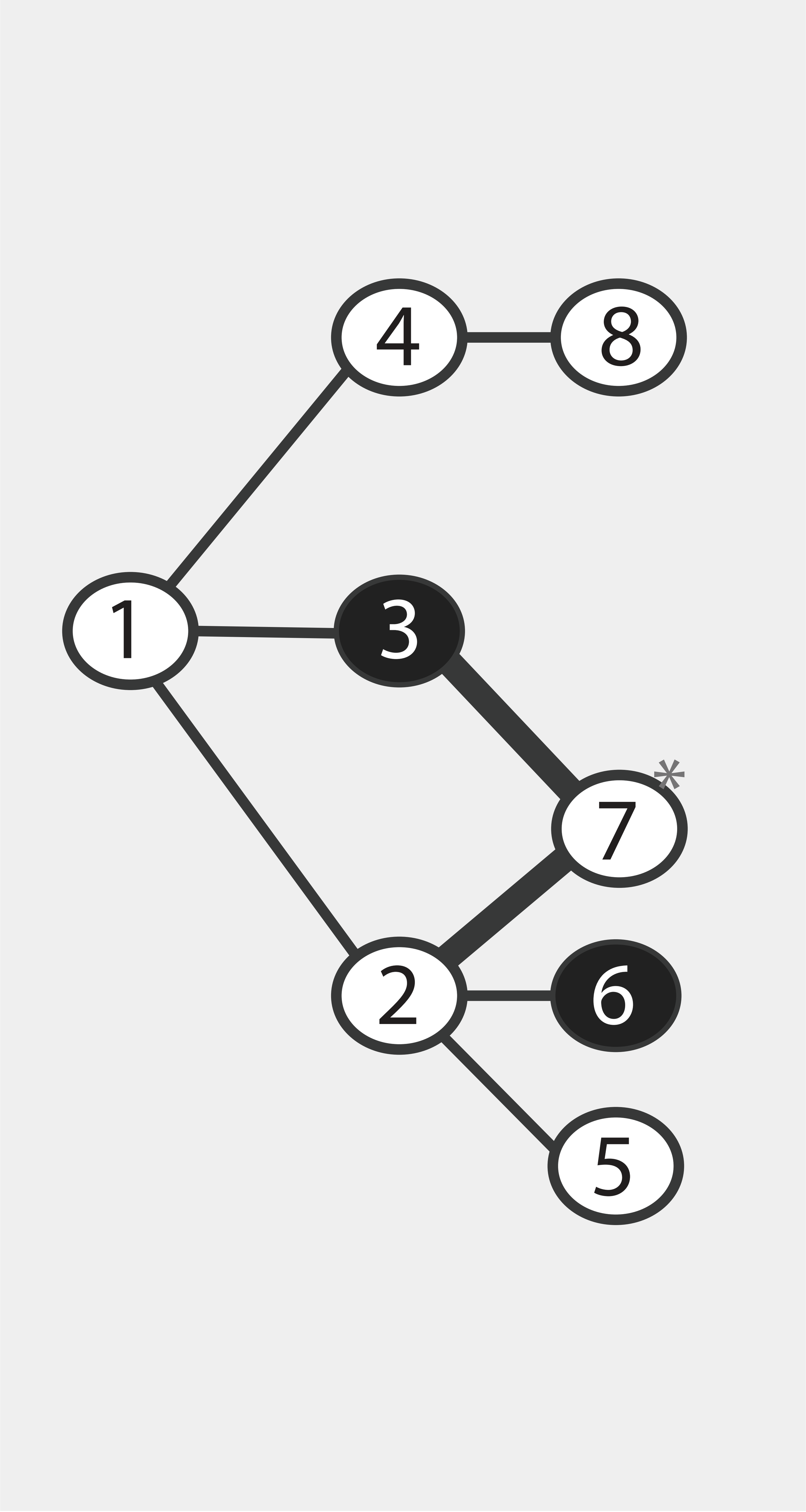
1. De-cycle and linearize graph

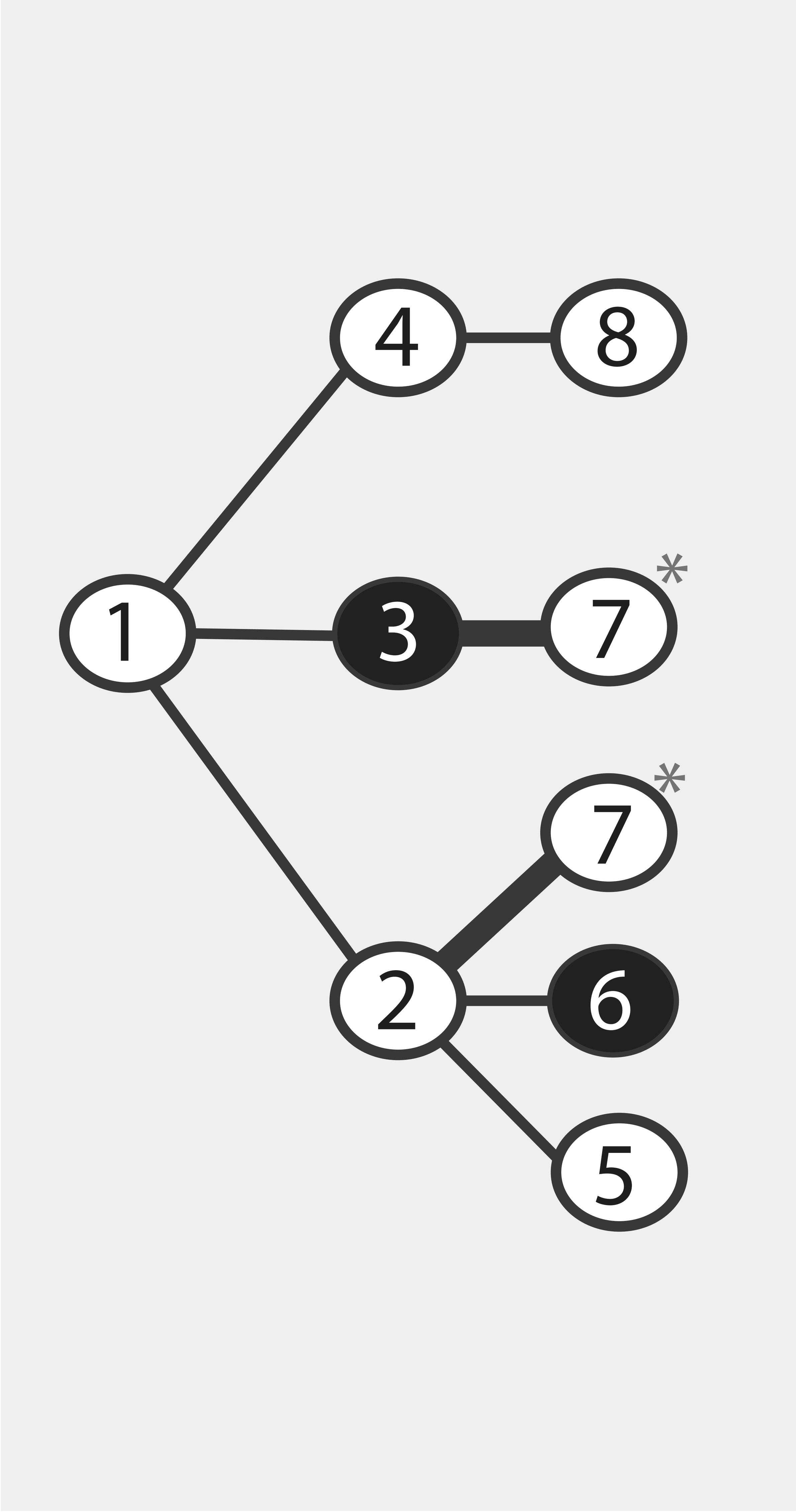
2. Plot attributes in table

De-Cycling

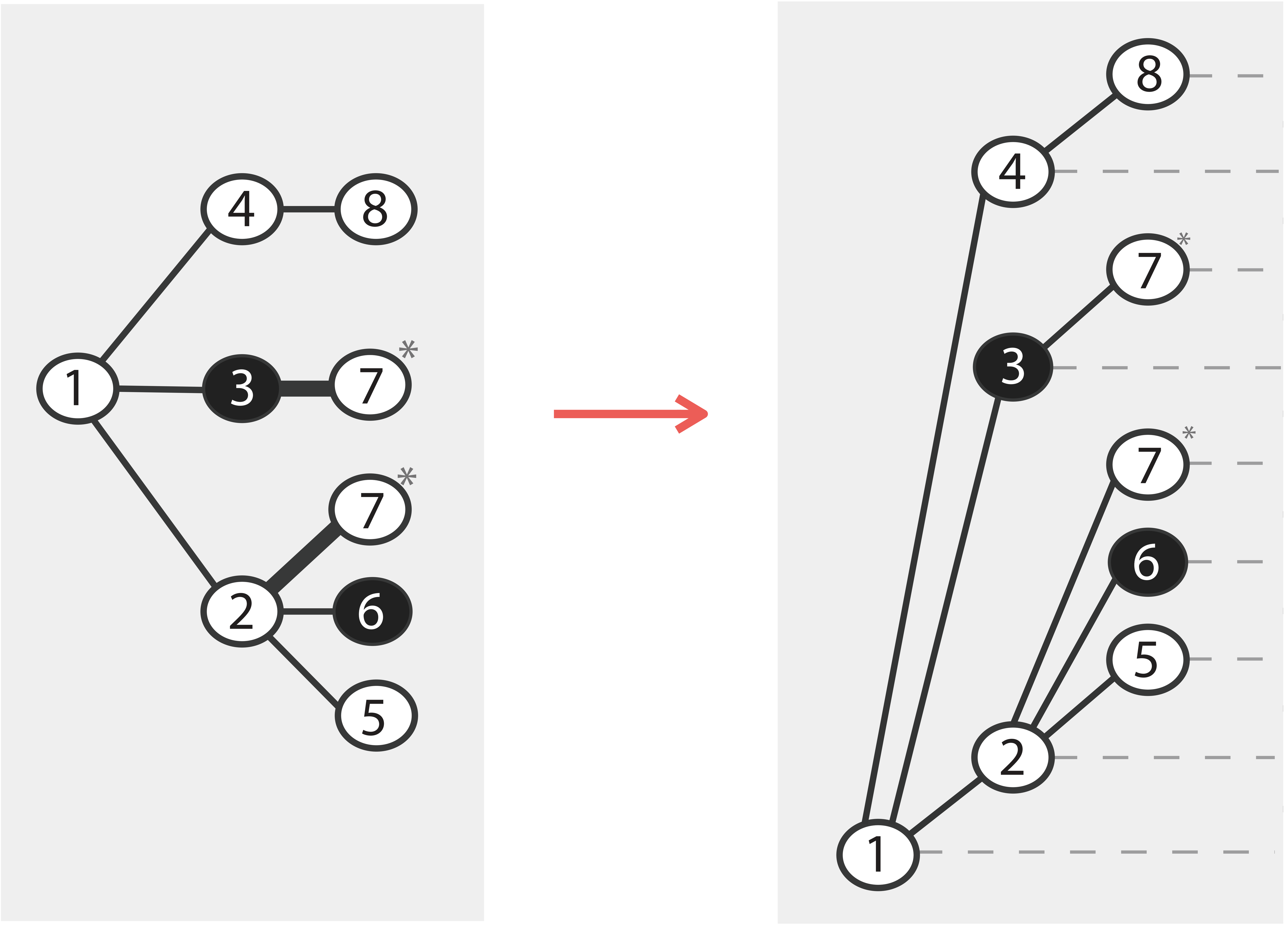


De-Cycling

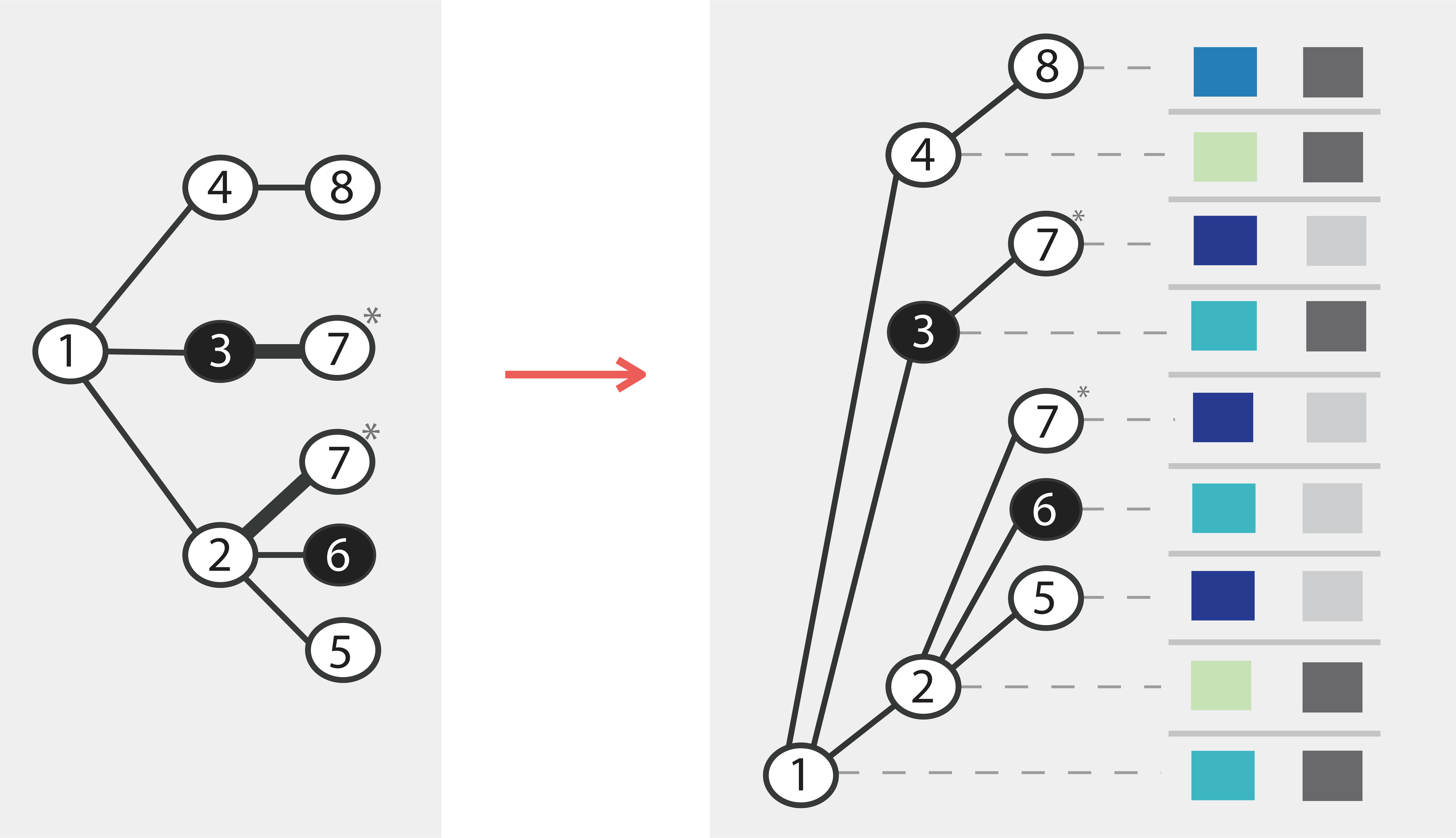


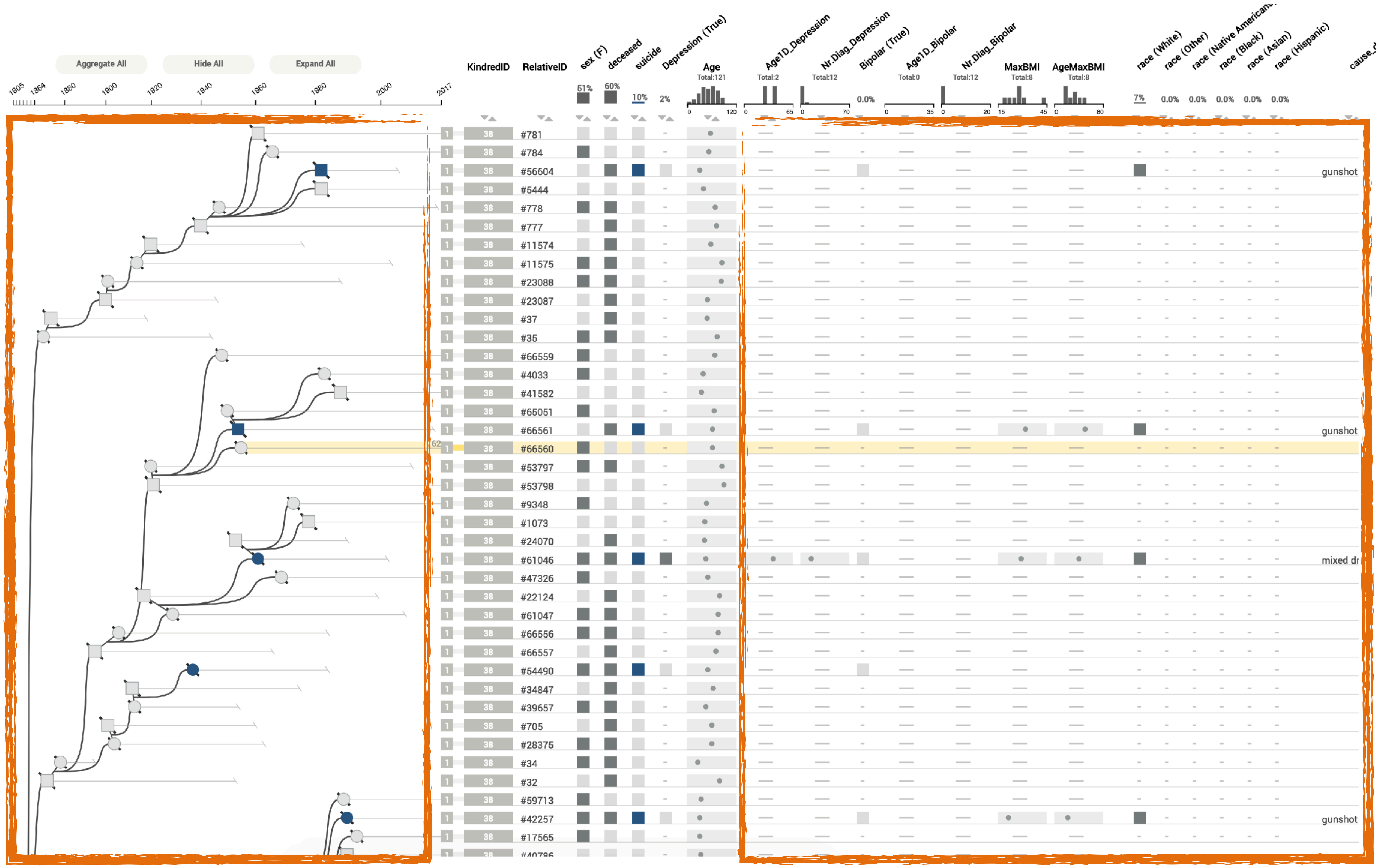


Linearization



Linearization

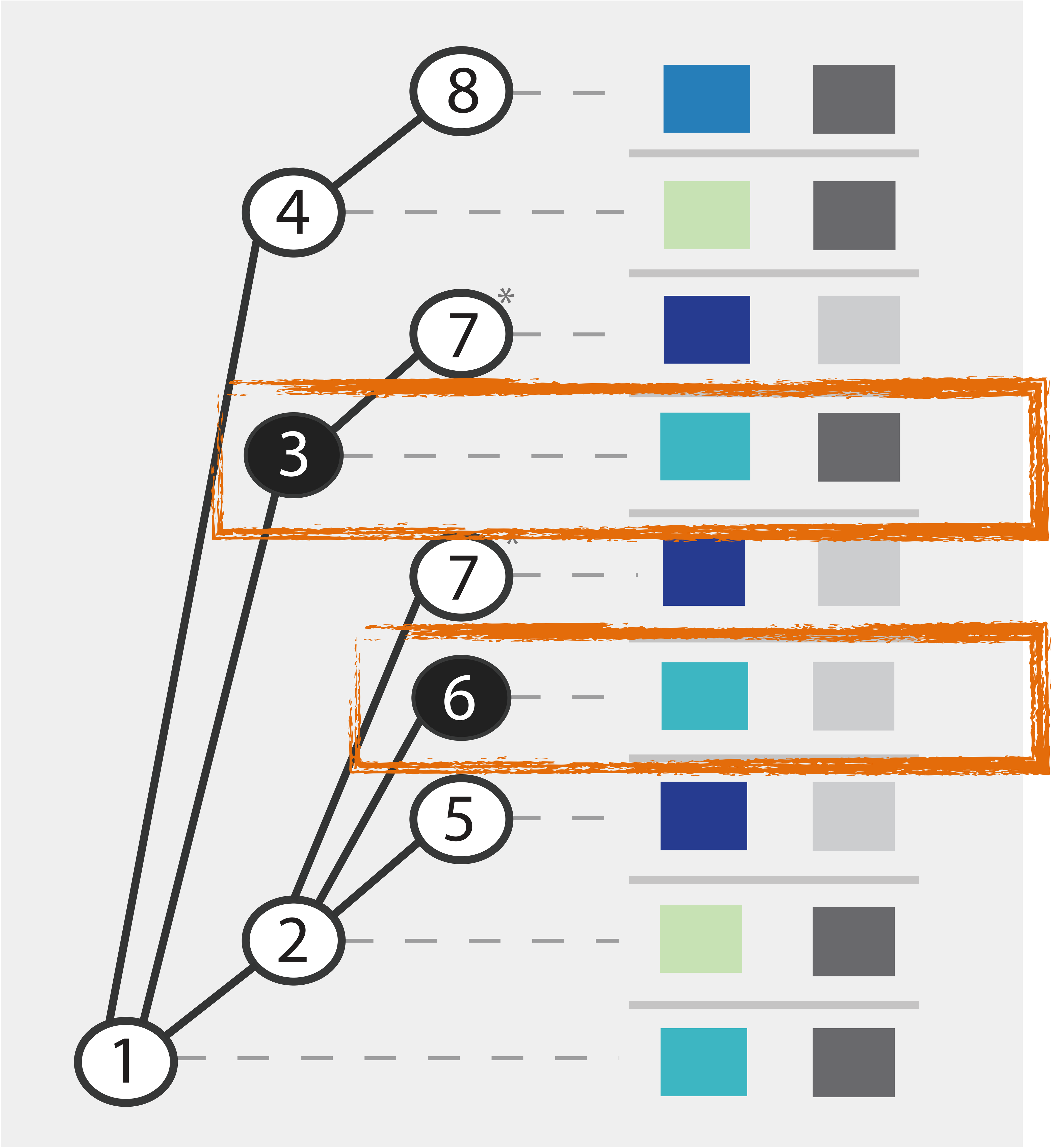




Can’t show many people

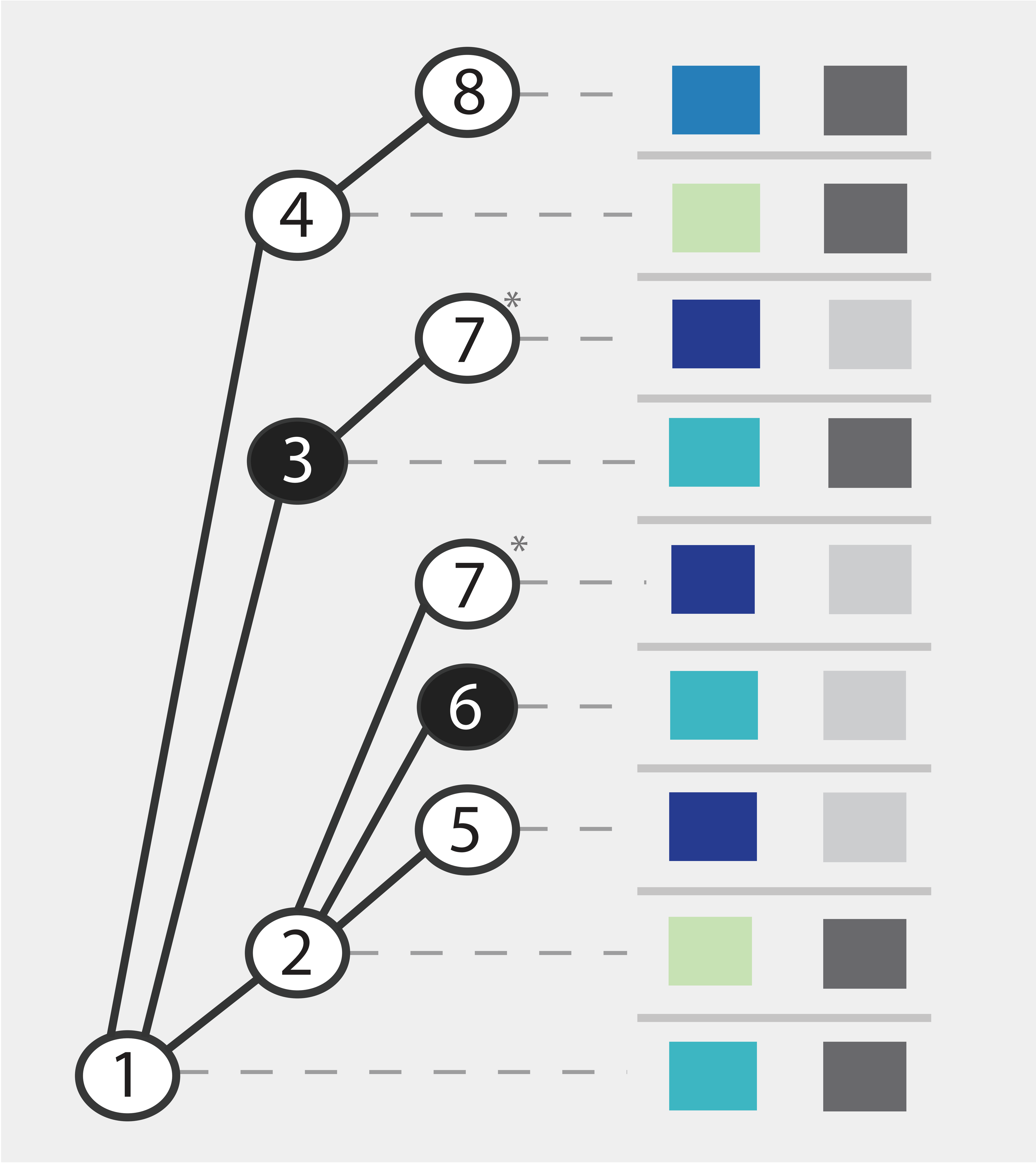
Lots of missing data

Aggregation

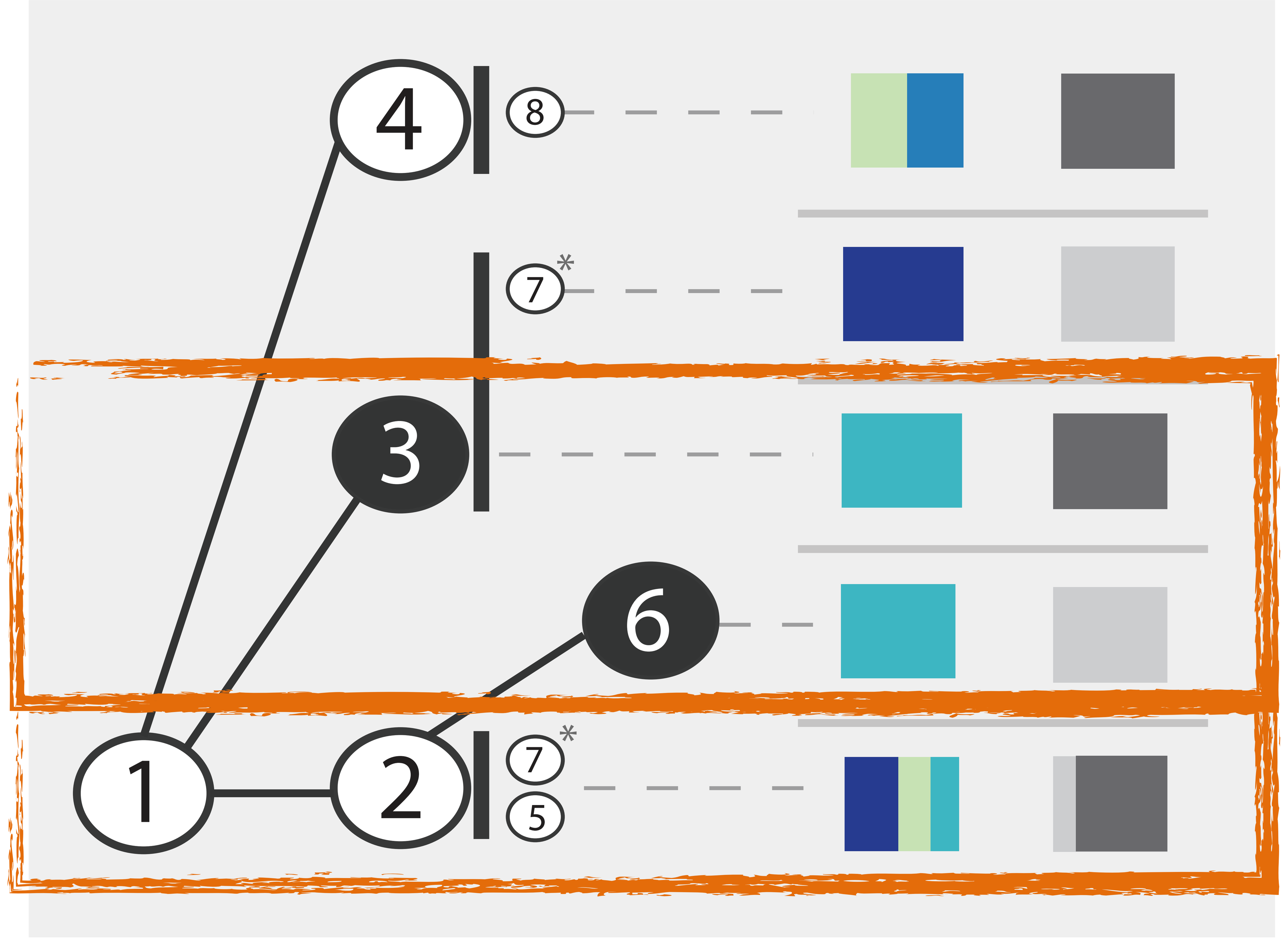


People of Interest

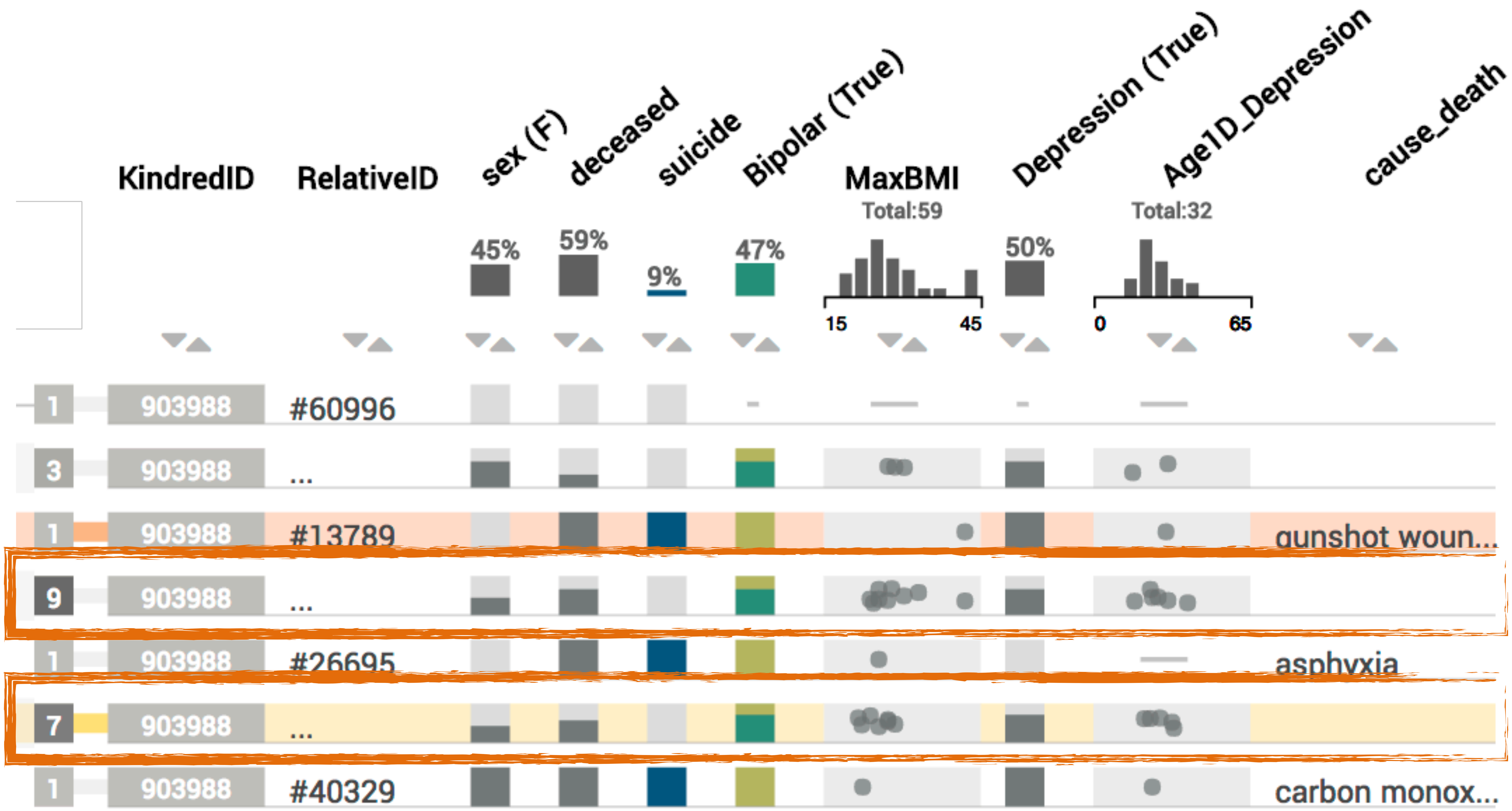
Aggregation



One row for every person of interest

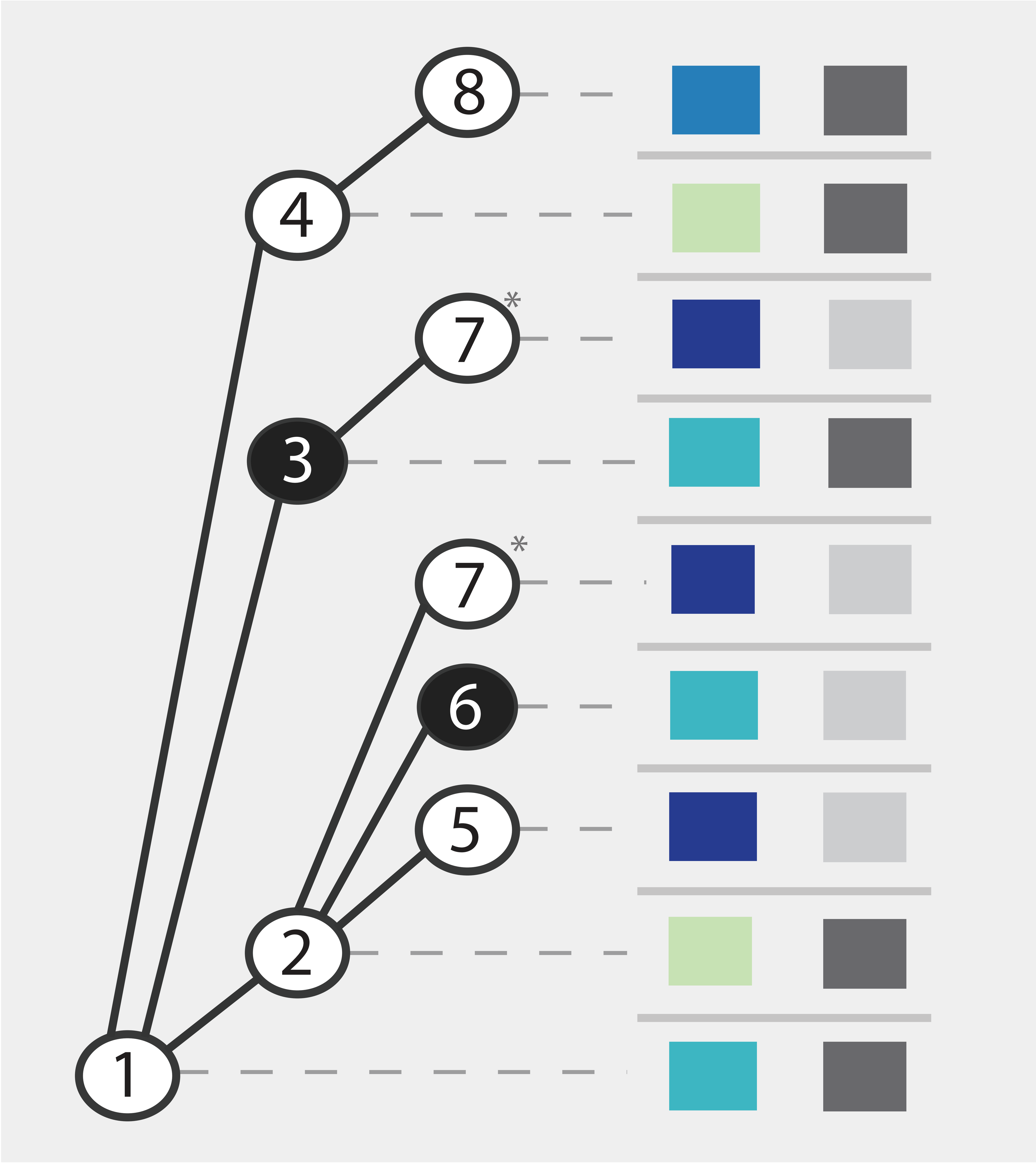


Others have to share a row

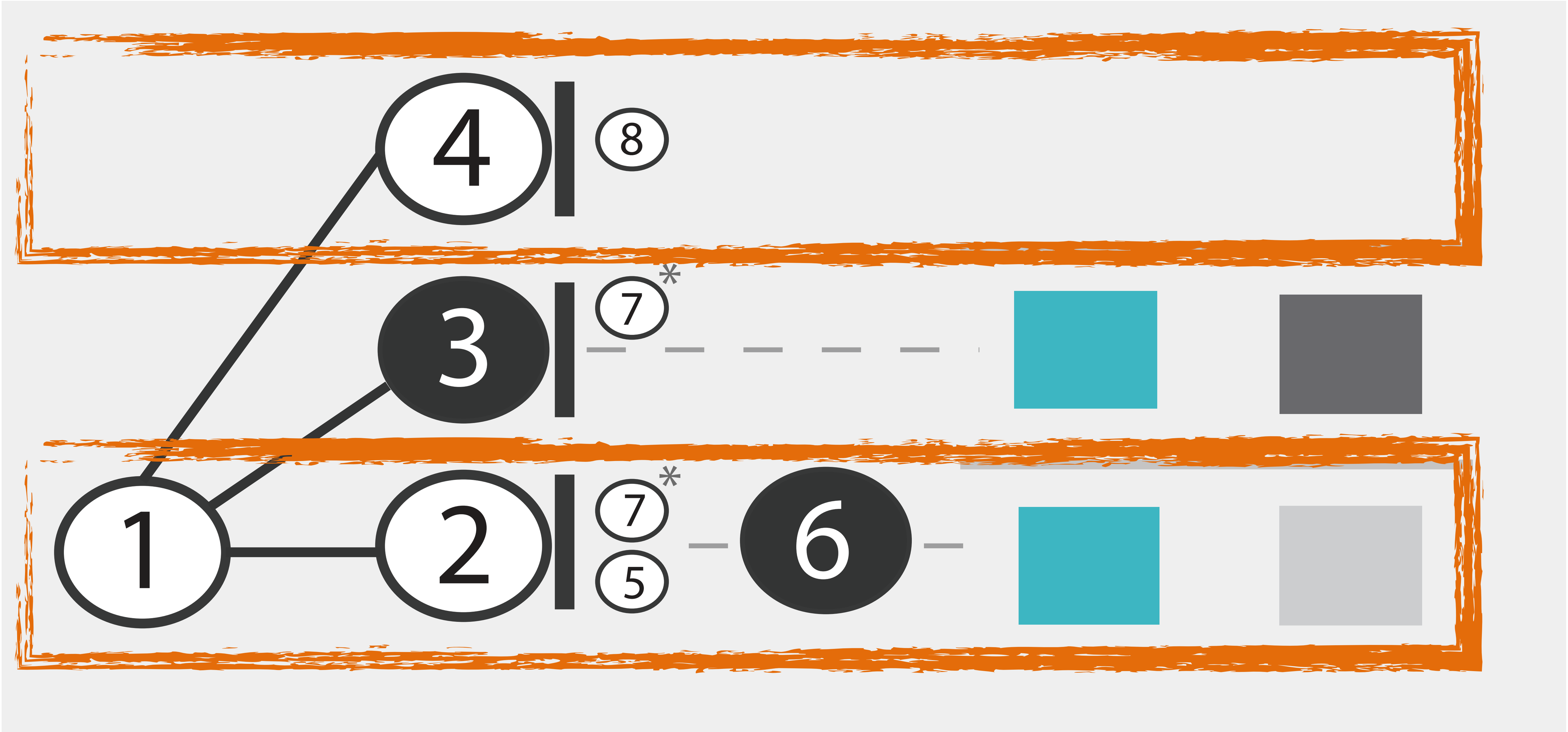


Aggregated Rows

More Aggressive: Hiding



Empty row

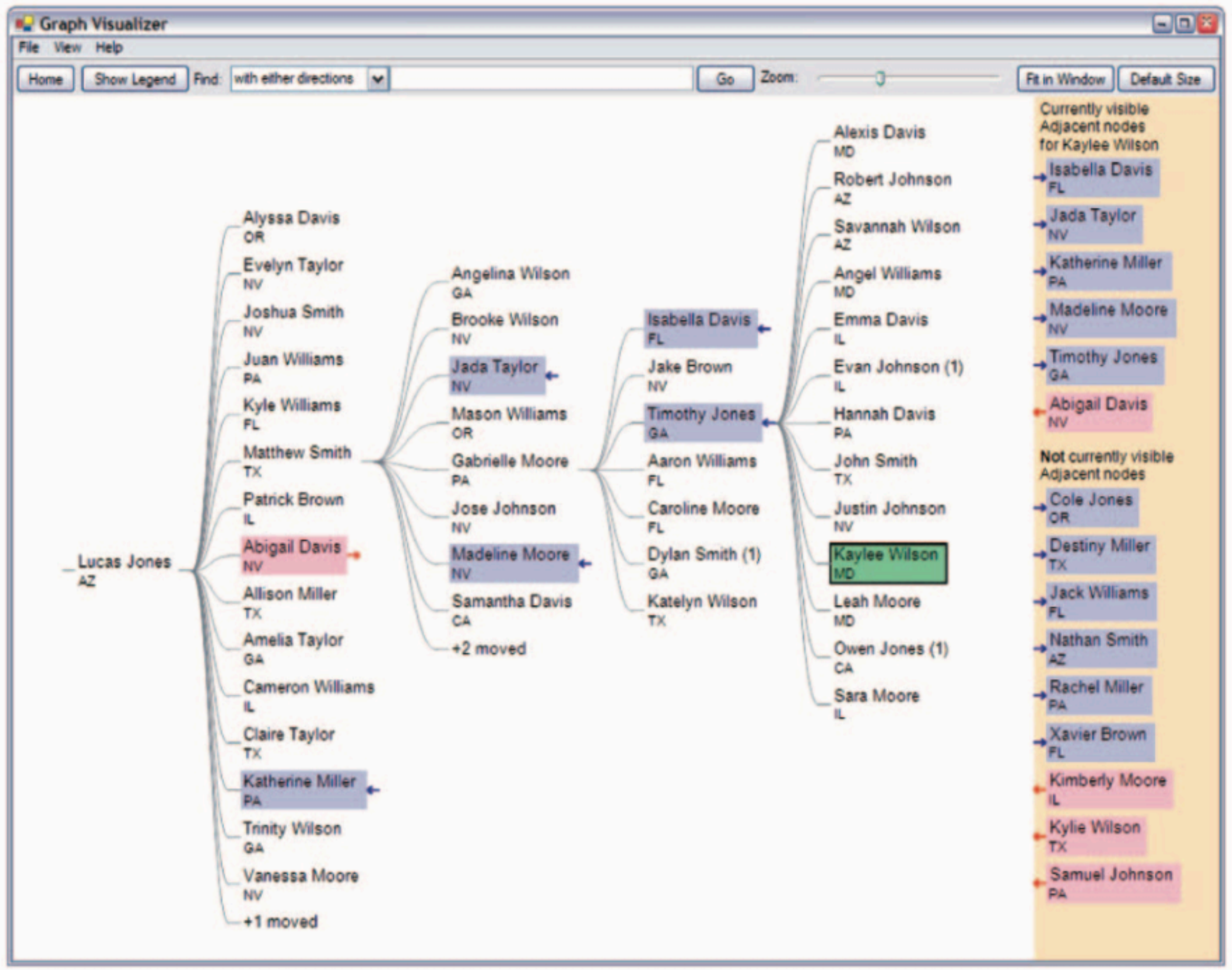


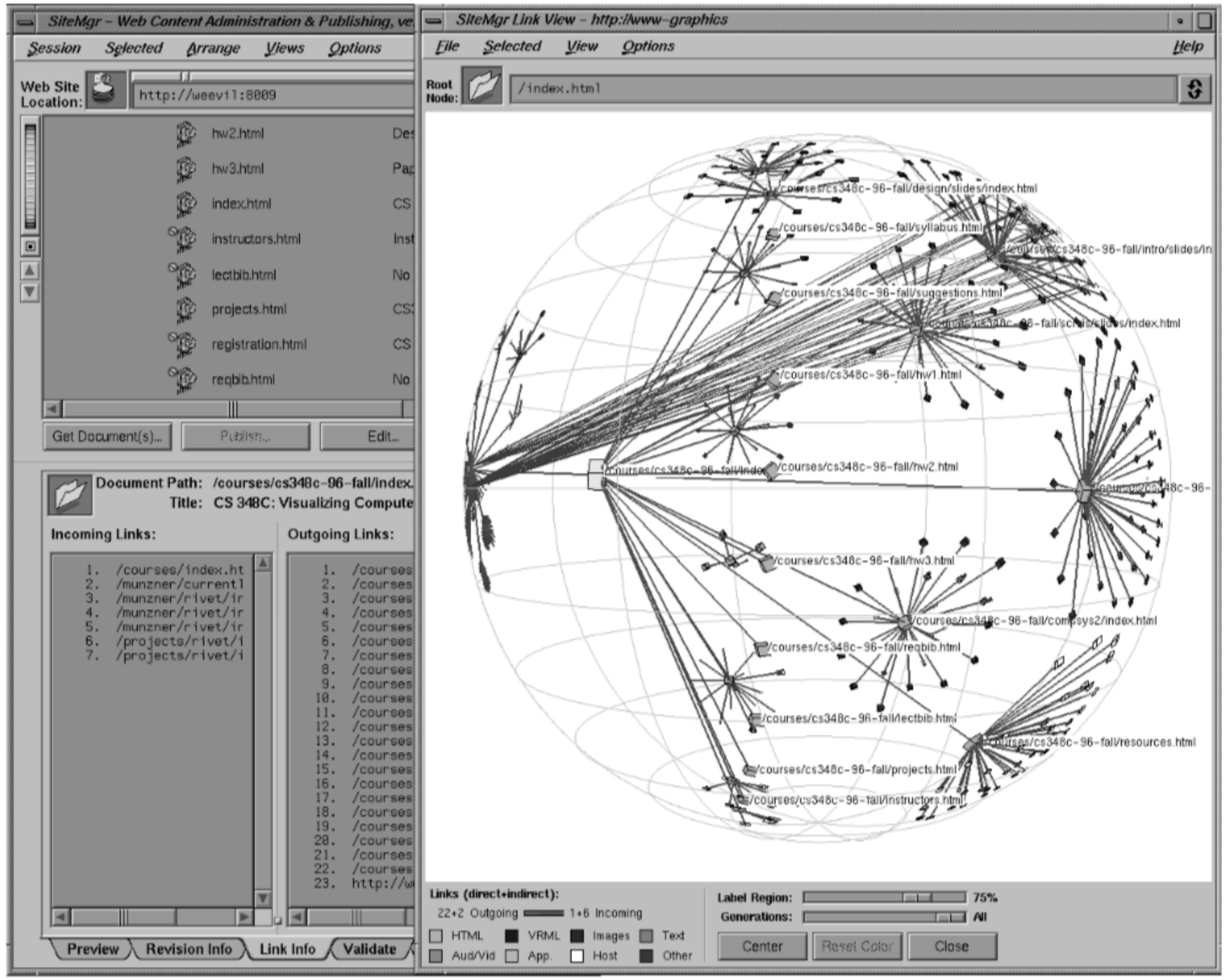
Only data for #6 shown


Family Selector
Expand
ID
#People
#POI
PD
38
121
12 (9.9%)
2 (16.7%)
27251404
39 (9.7%)
6 (15.4%)
149 113
10 (8.8%)
0 (0%)
42623 81
10 (12.3%)
1 (10%)
68939244
23 (9.4%)
4 (17.4%)
17686026
44 (10.3%)
4 (9.1%)
60348181
19 (10.5%)
1 (5.3%)
79153314
10 (8.8%)
0 (0%)
90398858
5 (8.6%)
0 (0%)
Deceased
Alive
POI Suicide
Age at death
26
Age Line
Deceased
Parents
Children
Family 38
1800
1820
1840
1860
1880
1900
1920
1940
1960
1980
2000
2017
KindredI
Relative
sex (F)
deceased
suicide
Age
bipolar spectrum ill...
anxiety-non-trauma
alcohol
psychosis
depression
cause_de
PD
42%
100%
100%
0
120
6%
6%
8%
2%
21%
15%
Age : 17
#66561
#61046
#52789
#16926
#25172
#4039
#48533
#38948
#56604
#54490
#42257
#42258
#21697
#24459
#60065
#37541
#51179
#49225
#25316
#2240
#36629
#66690
#16545
#36257
#14621
#9568
gunshot wo...
mixed drug...
quetiapine...
asphyxia
carbon mon...
self-infli...

Could we use something like Lineage for general Multivariate Networks?

Use a Spanning Tree to Visualize a Graph

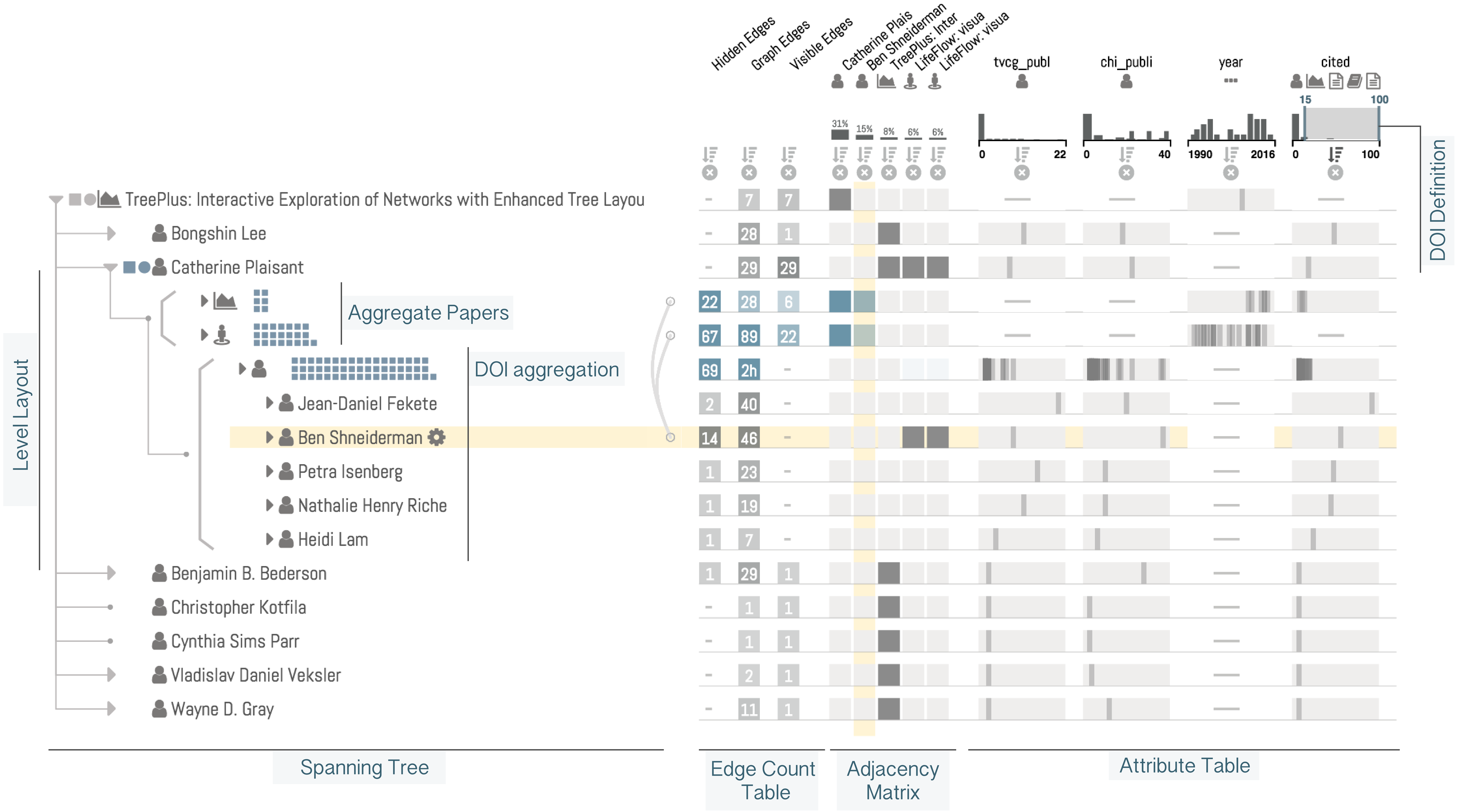




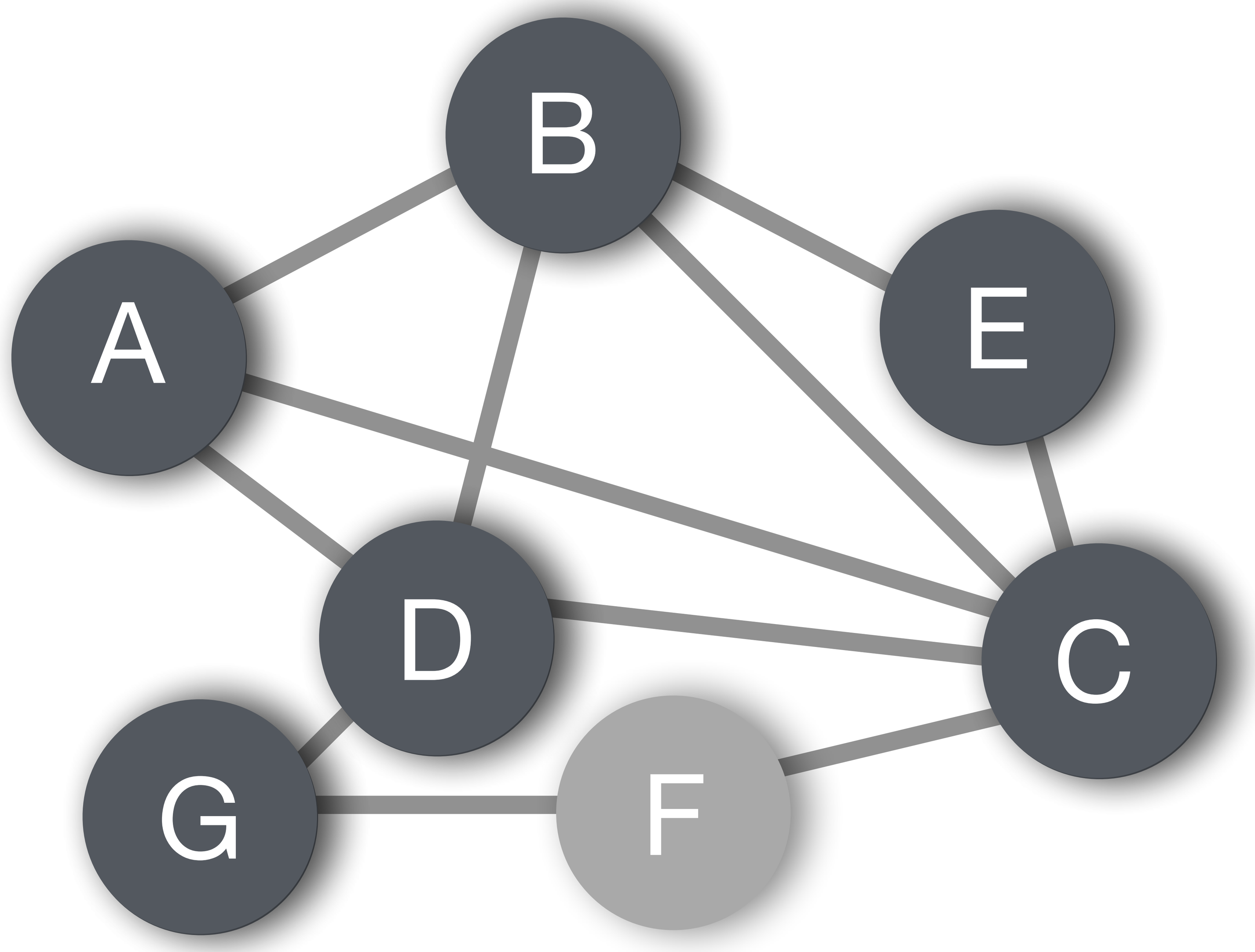
[Lee et al., TreePlus, 2006]

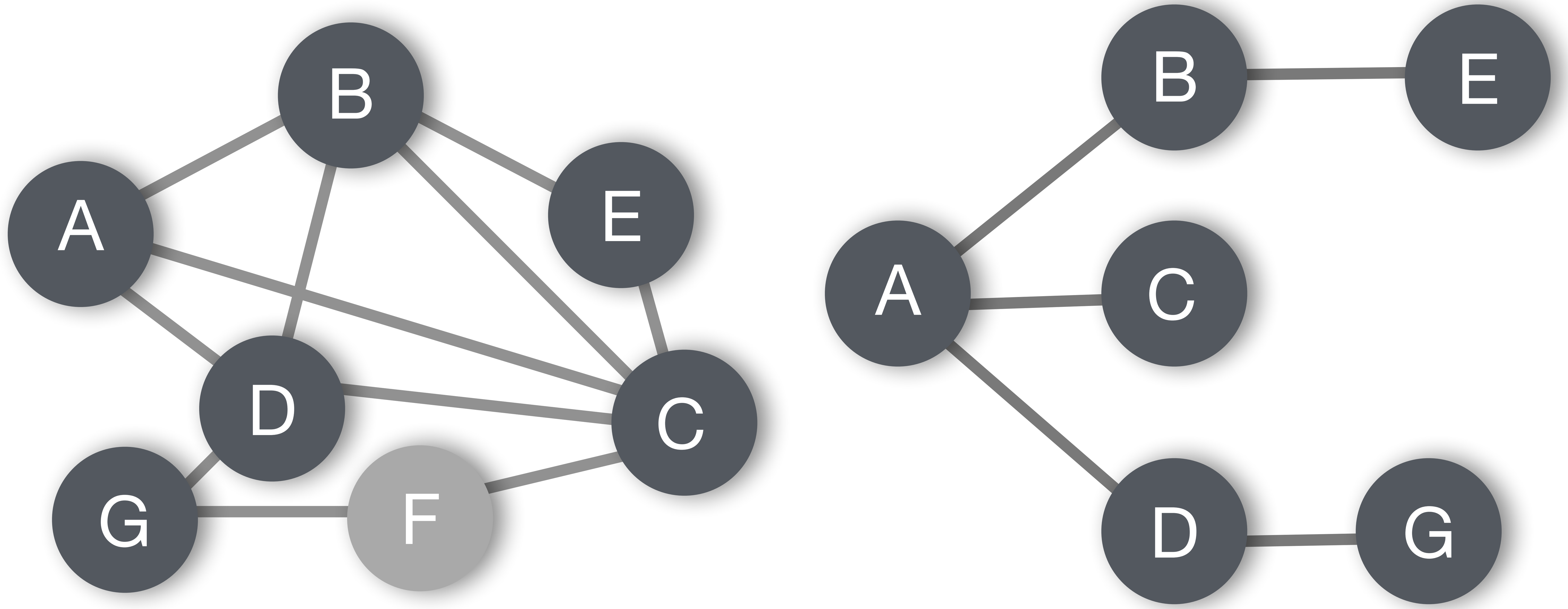
[Munzner, H3Viewer, 1998]

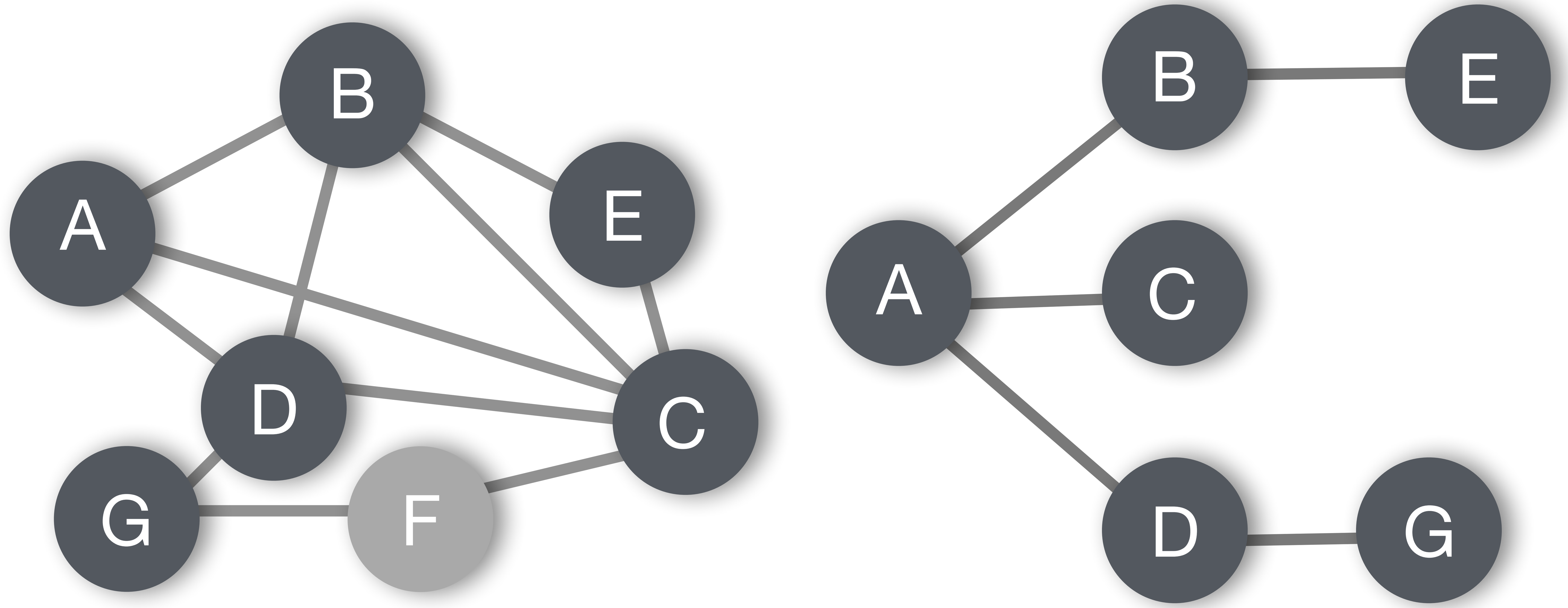
Linearizing a Spanning Tree: Juniper



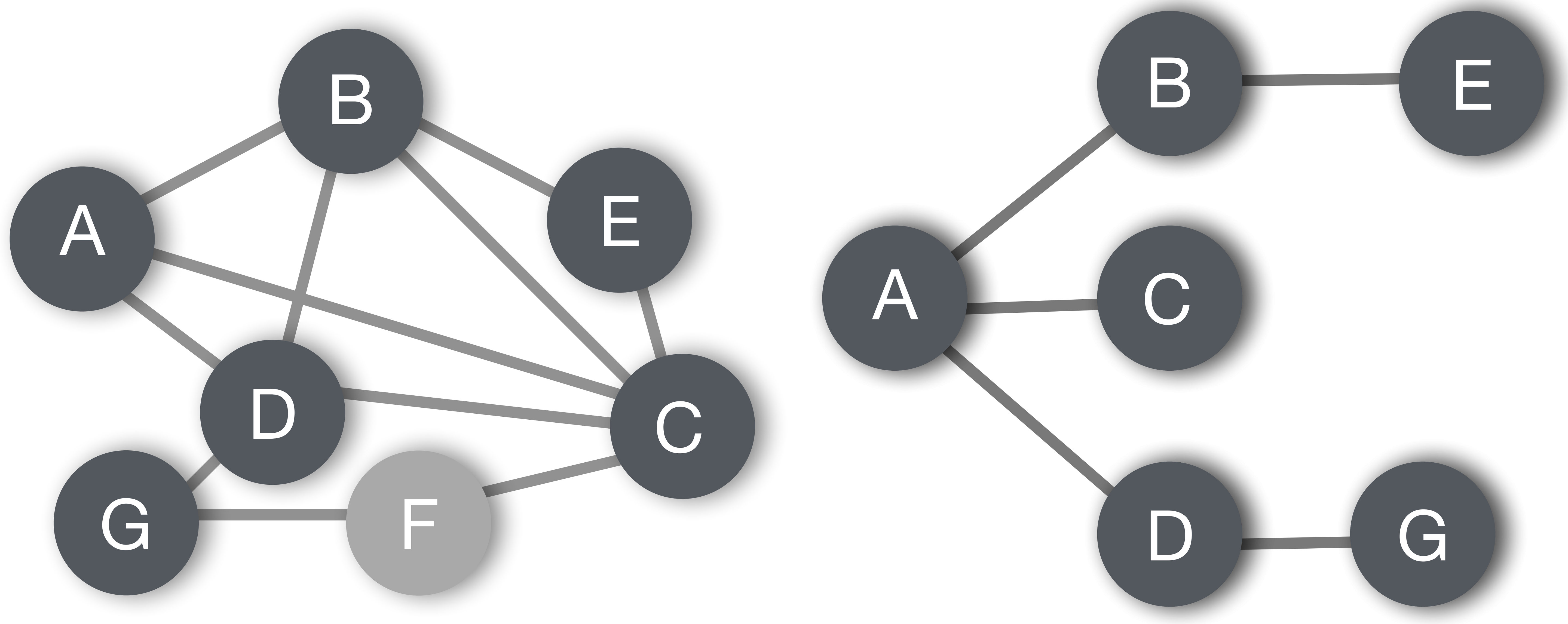
[Nobre et al, Juniper, Preprint 2018]


B
A
E
D
C
G
F

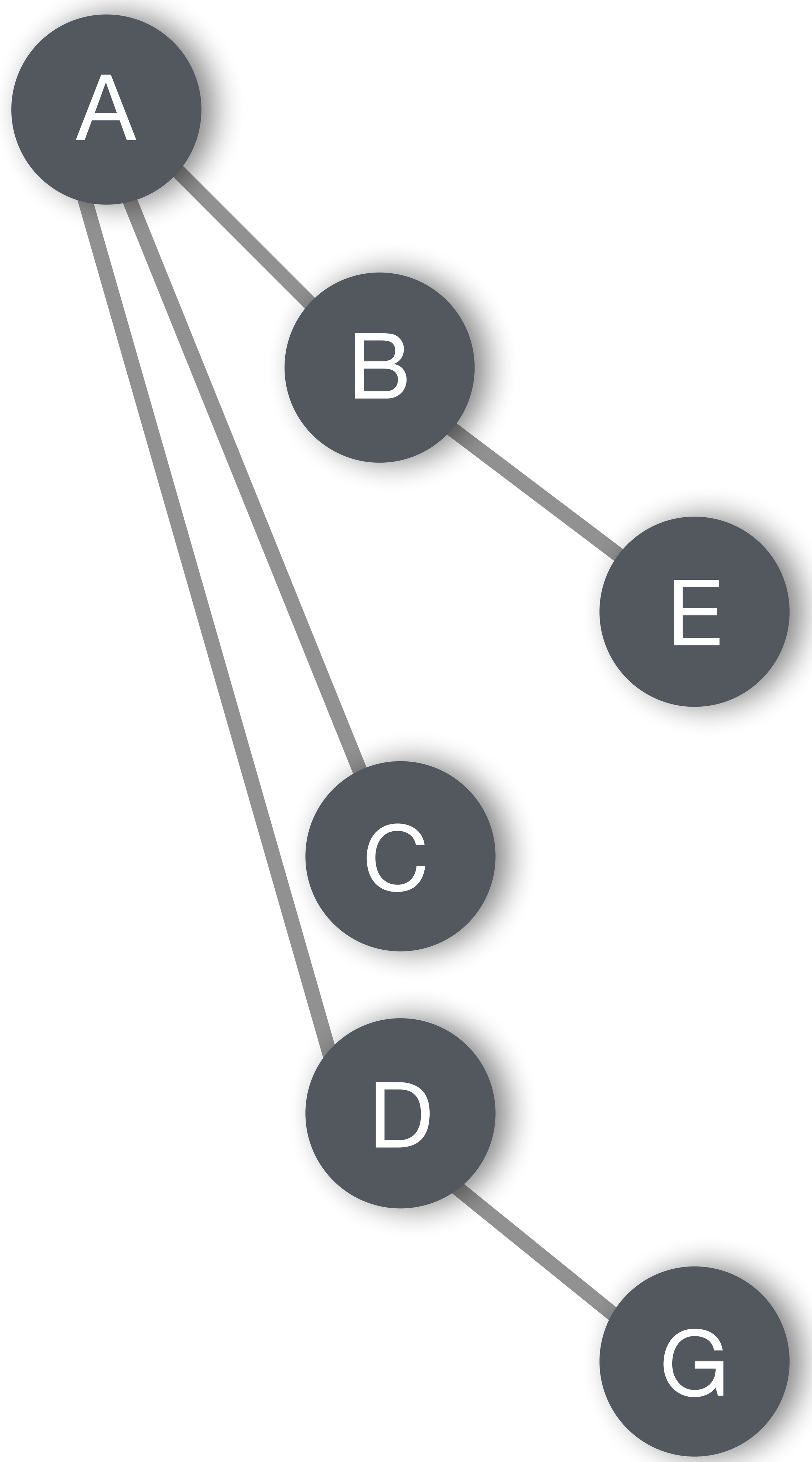

A
B
C
D
E
F
G
A
B
C
D
E
G



B
A
E
D
C
G
F
B
E
A
C
D
G

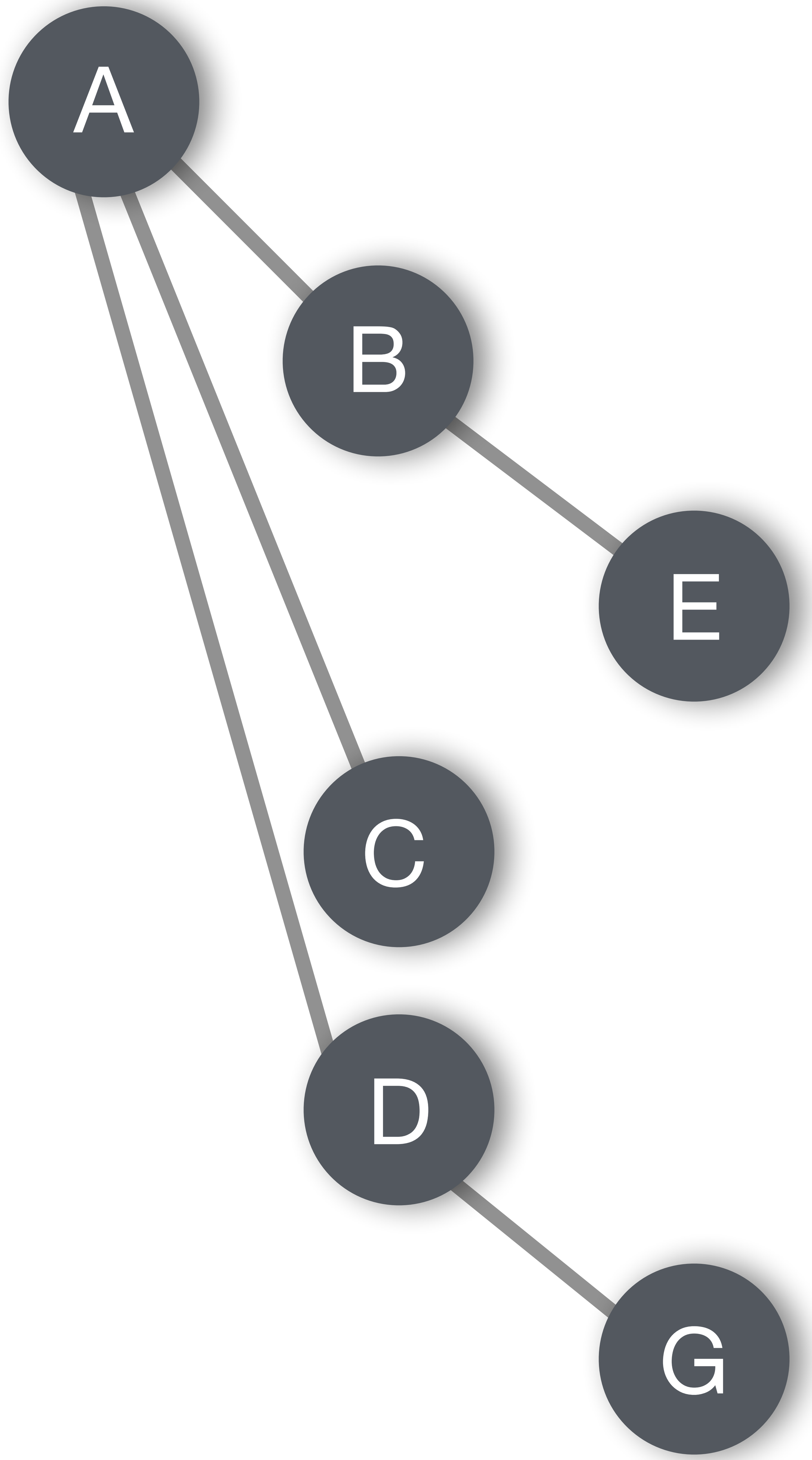

B
A
E
D
C
G
F
B
E
A
C
D
G


A
B
E
D
C
G
F
A
B
E
C
D
G
A
B
E
C
D
G



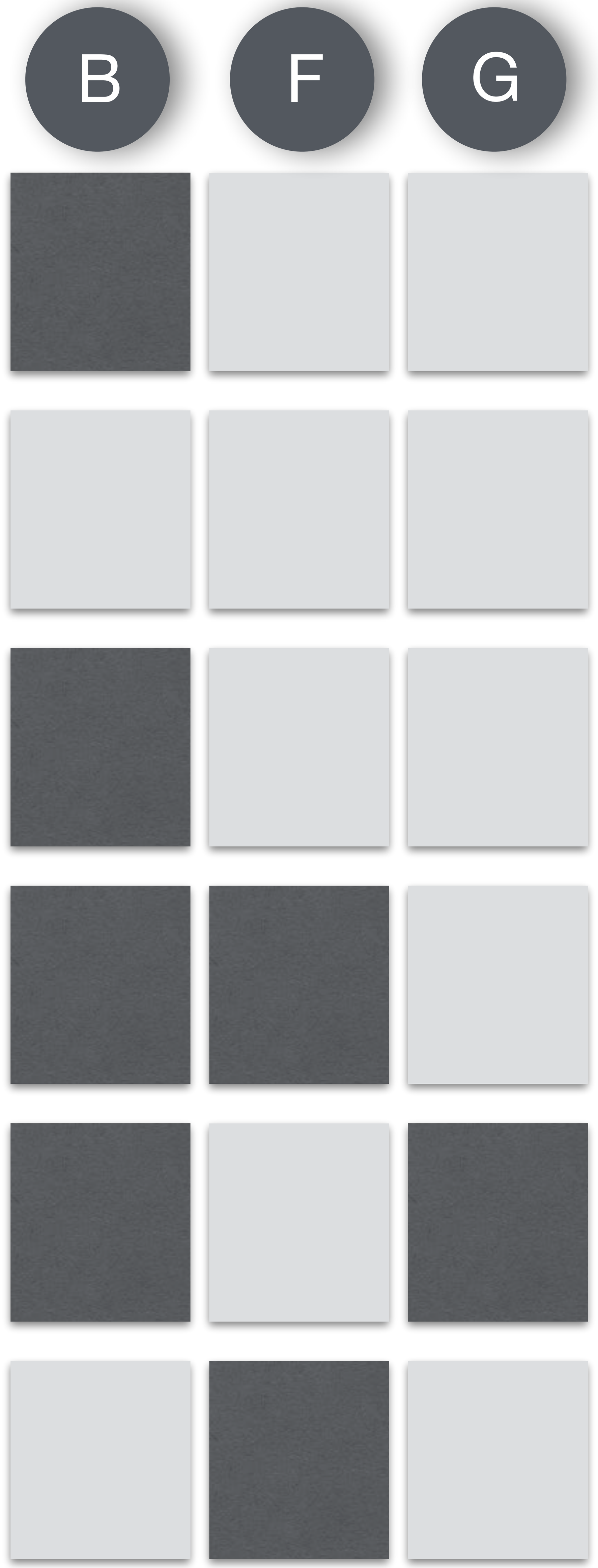
Hidden Edges	Graph Edges
0	3
2	4
1	2
4	5
1	3
0	2

Edges

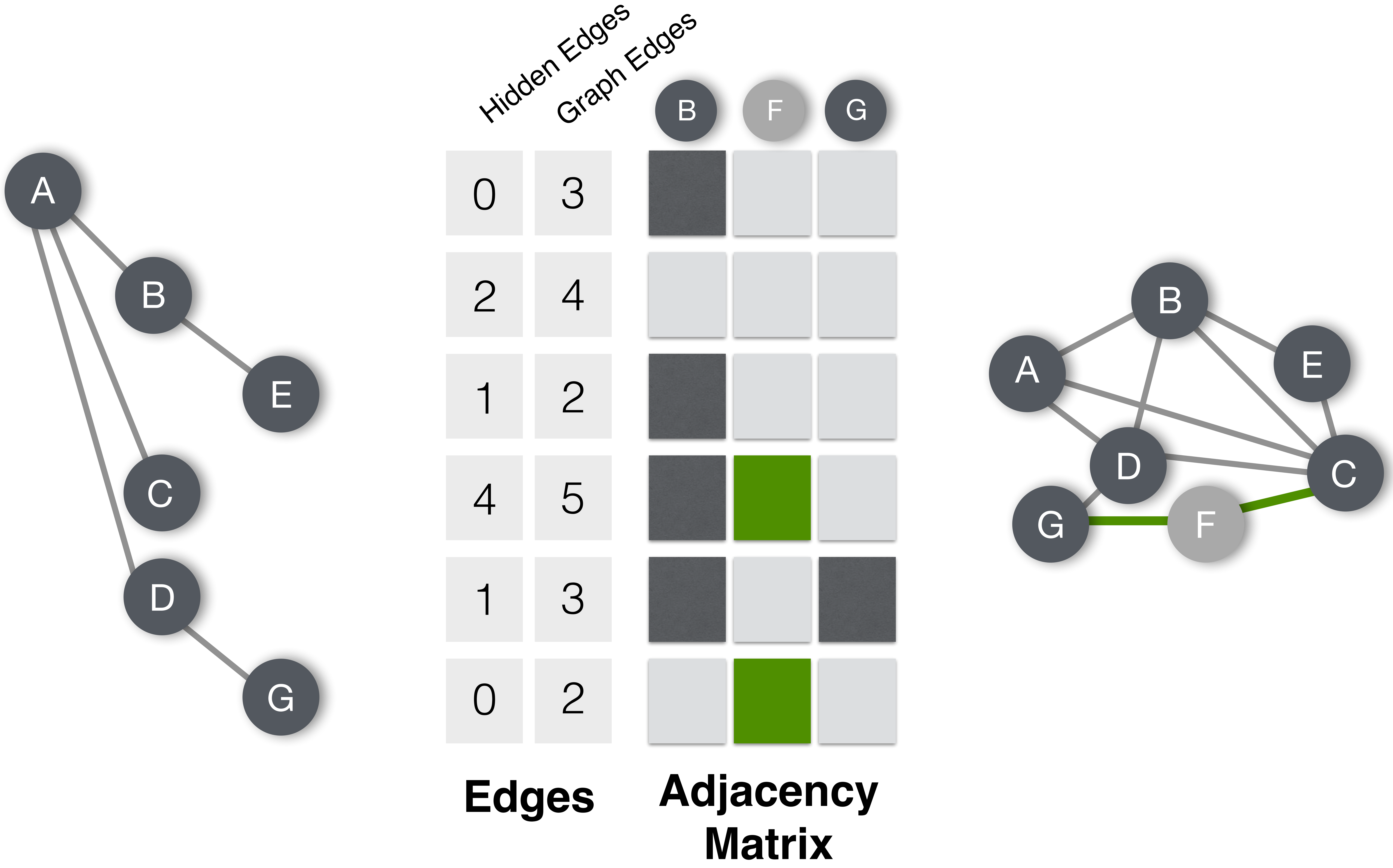


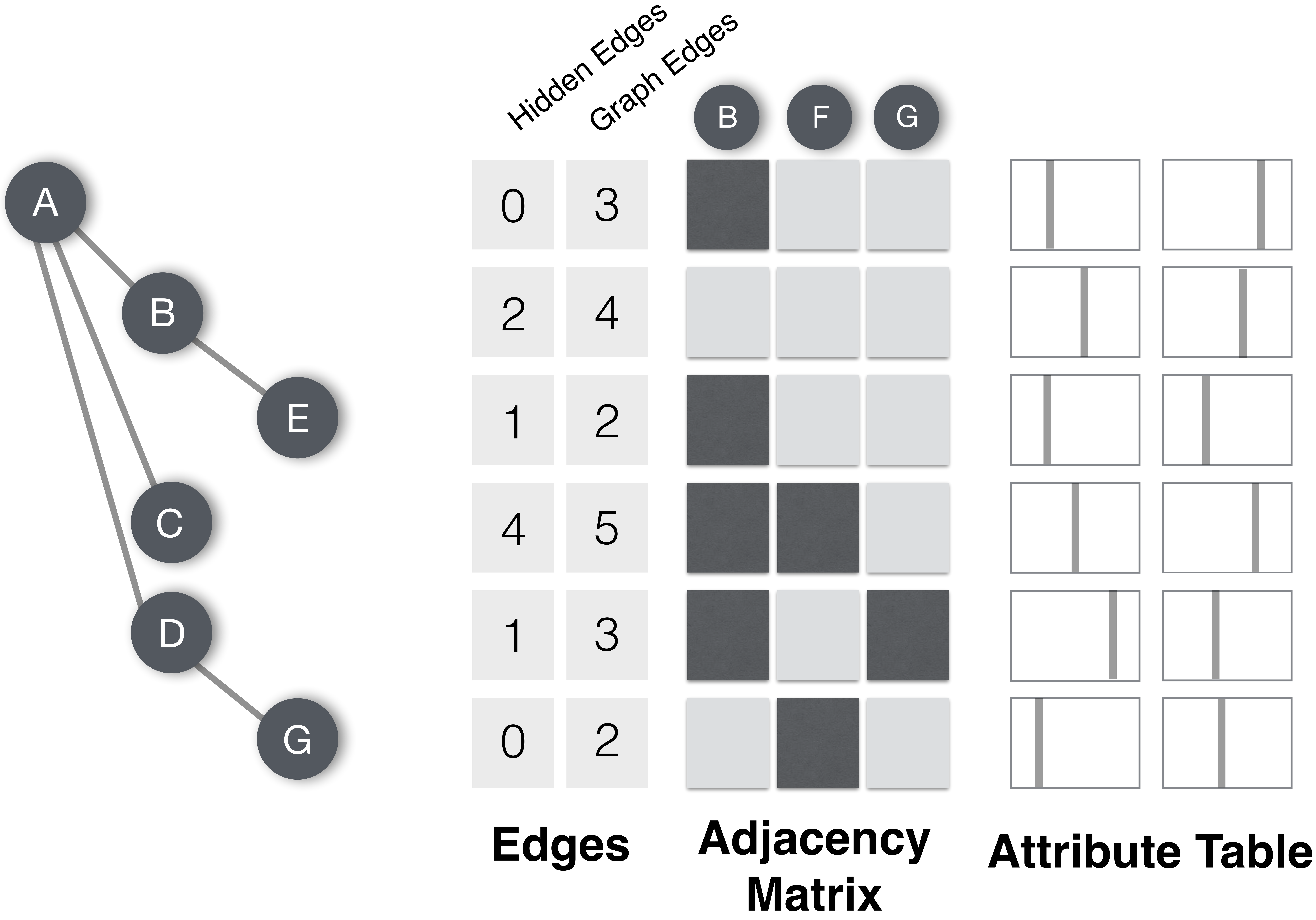
Hidden Edges	Graph Edges
0	3
2	4
1	2
4	5
1	3
0	2

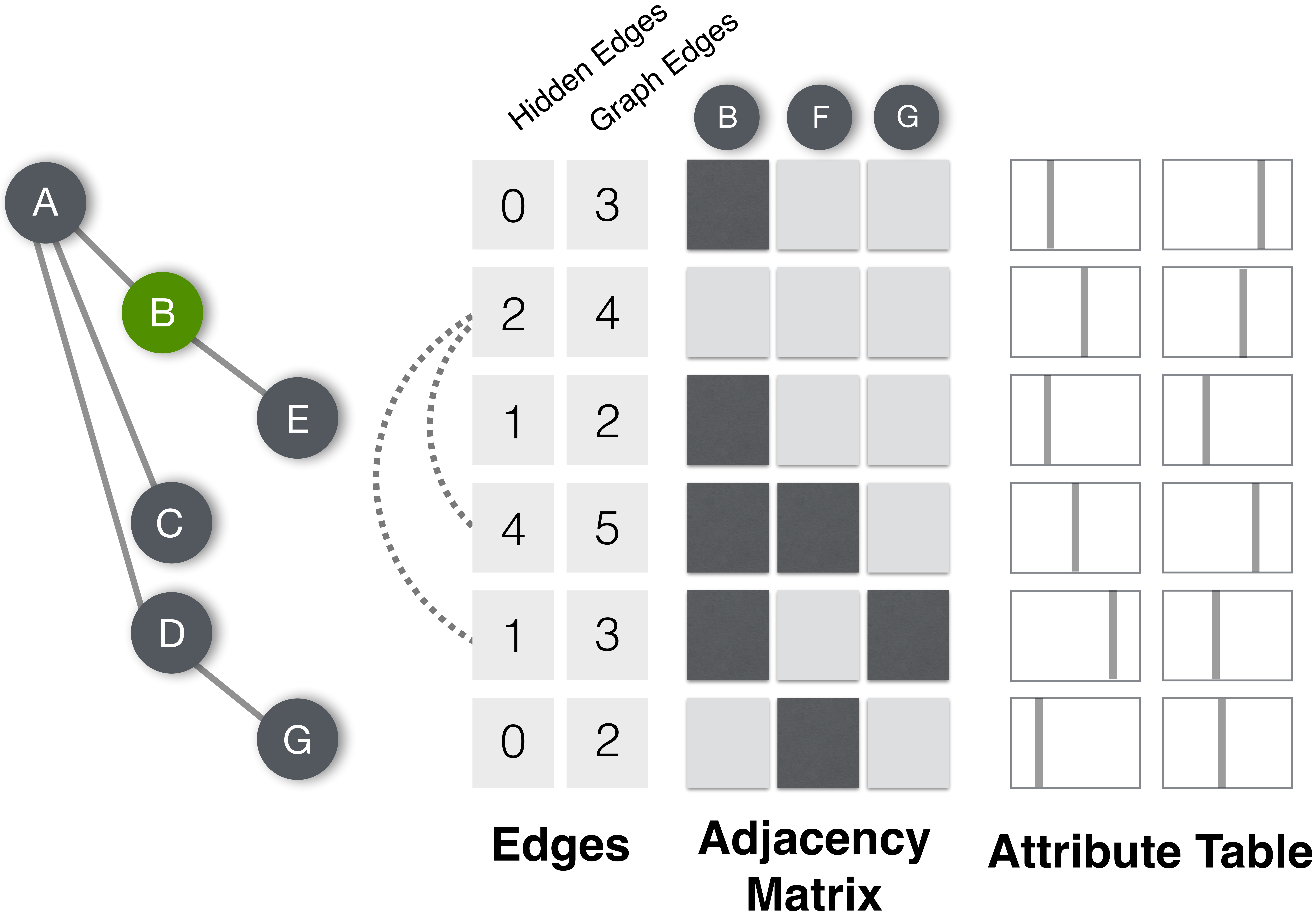
Edges



Adjacency Matrix


A
B
E
C
D
G
Hidden Edges
Graph Edges
B
F
G
0 3
2 4
1 2
4 5
1 3
0 2
Edges
Adjacency Matrix
B
A
E
D
C
G
F


A
B
C
D
E
G
Hidden Edges
Graph Edges
B
F
G
0 3
2 4
1 2
4 5
1 3
0 2
Edges
Adjacency Matrix
Attribute Table


A
B
E
C
D
G
Hidden Edges
Graph Edges
0 3
2 4
1 2
4 5
1 3
0 2
B
F
G
Edges
Adjacency Matrix
Attribute Table

Hidden Edges
Graph Edges
Visible Edges
Catherine Plais
Ben Shneiderman
TreePlus: Inter
LifeFlow: visua
LifeFlow: visua
tvcg_publ
chi_publi
year
cited
TreePlus: Interactive Exploration of Networks with Enhanced Tree Layou
Bongshin Lee
Catherine Plaisant
Aggregate Papers
DOI aggregation
Jean-Daniel Fekete
Ben Shneiderman
Petra Isenberg
Nathalie Henry Riche
Heidi Lam
Benjamin B. Bederson
Christopher Kotfila
Cynthia Sims Parr
Vladislav Daniel Veksler
Wayne D. Gray
Level Layout
DOI Definition
Spanning Tree
Edge Count Table
Adjacency Matrix
Attribute Table

Conclusions

Linearization & Juxtaposition are good options for visualizing Multivariate Graphs

Many tasks are local, leverage the “Search, Show Context, Expand on Demand” principle for multivariate networks

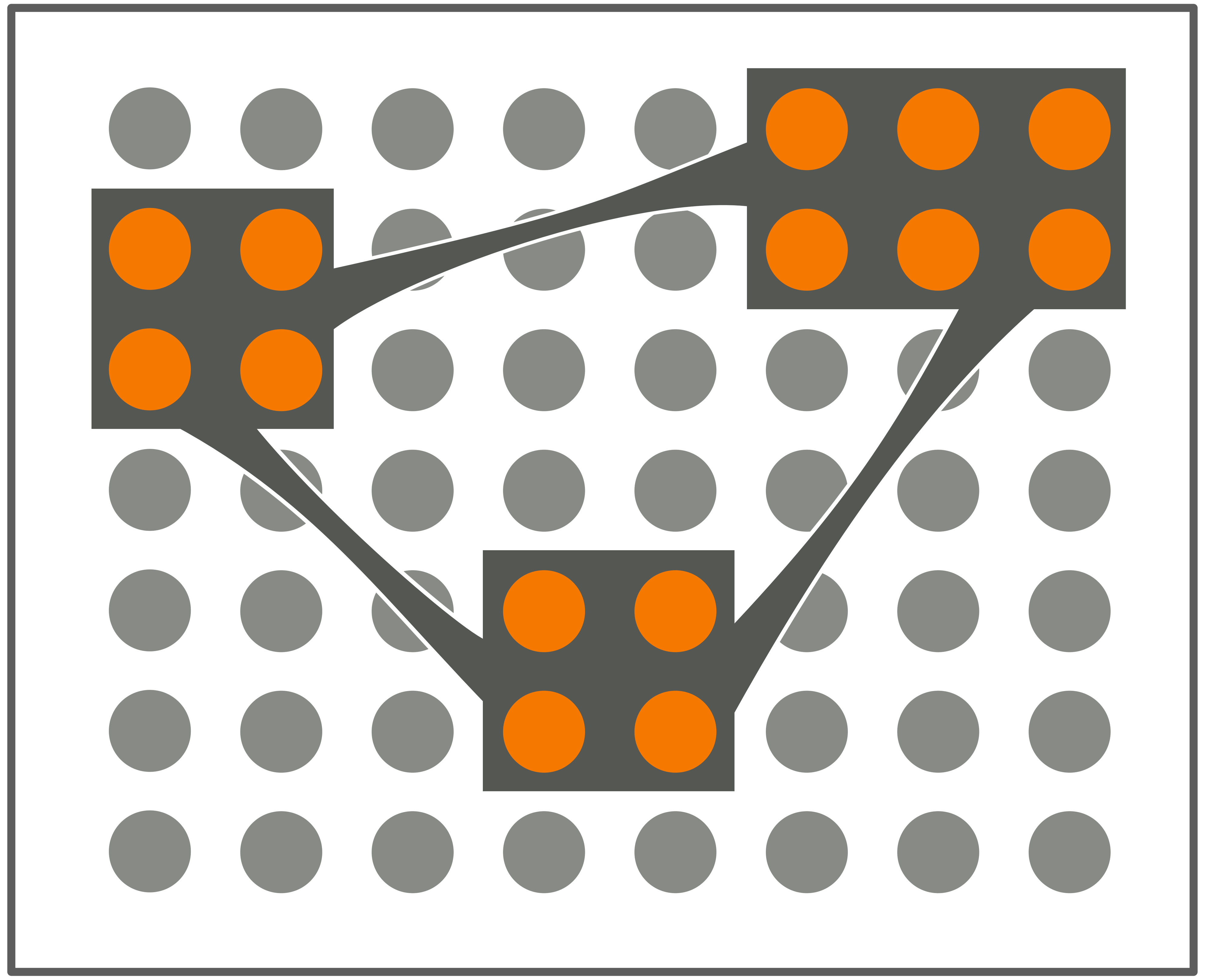

Show all attributes /
many attributes
Show all nodes /
large network
Show selected
nodes /
small network
Show selected attributes /
few attributes

Challenges

Interactivity is key, but that results in challenges:

Coverage

Evaluation



Alexander Lex
@alexander_lex
http://alexander-lex.net

THE UNIVERSITY OF UTAH

Thanks to: Carolina Nobre, Hilary Coon, Marc Streit, Nils Gehlenborg, and many others.
Funded by the Utah Genome Project, NIH, NSF and DoD

HEALTH
UNIVERSITY OF UTAH

visualization
design lab

www.sci.utah.edu