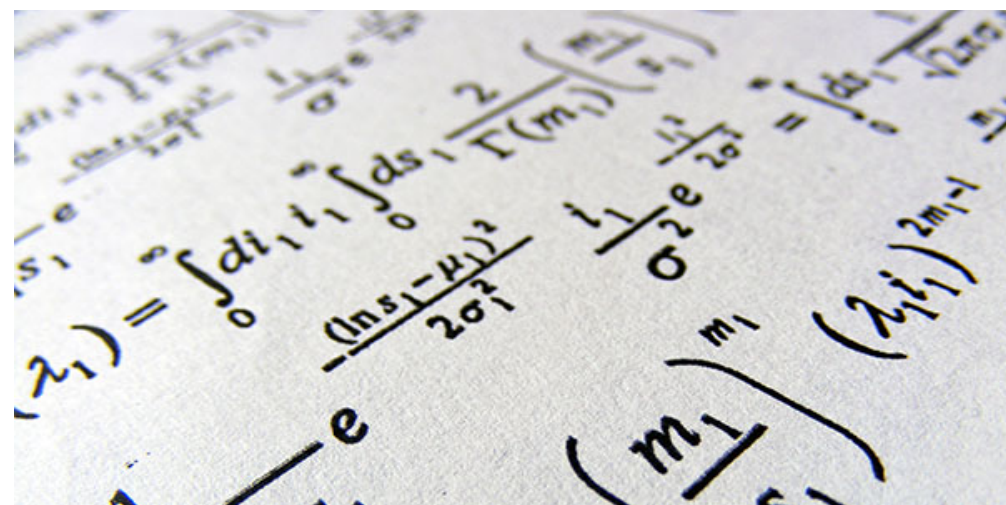


Visualization: The Human Lens to Networks

Michael Sedlmair
Visualization & Data Analysis Group



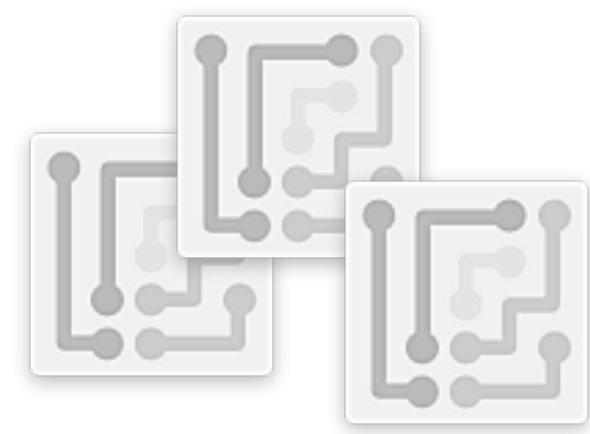
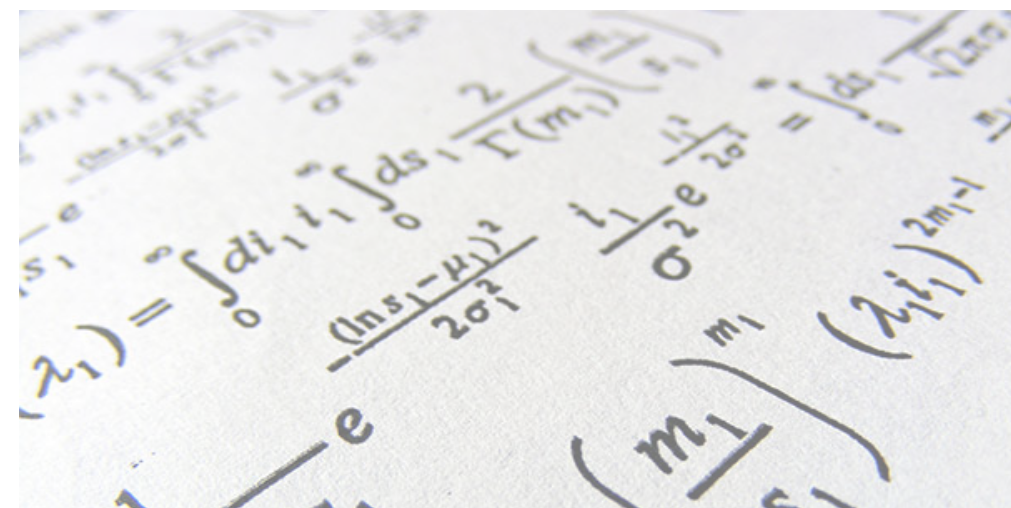
Data



https://www.strath.ac.uk/media/1newwebsite/imagesbysize/600x300/Applied_analysis_600x300.jpg



Visualization



Look at / Interact



Understand patterns

Make decisions

Gain insights

Communicate

Definition: Visualization (Vis)

“Computer-based visualization systems provide visual representations of datasets intended to help people carry out some task more effectively.”

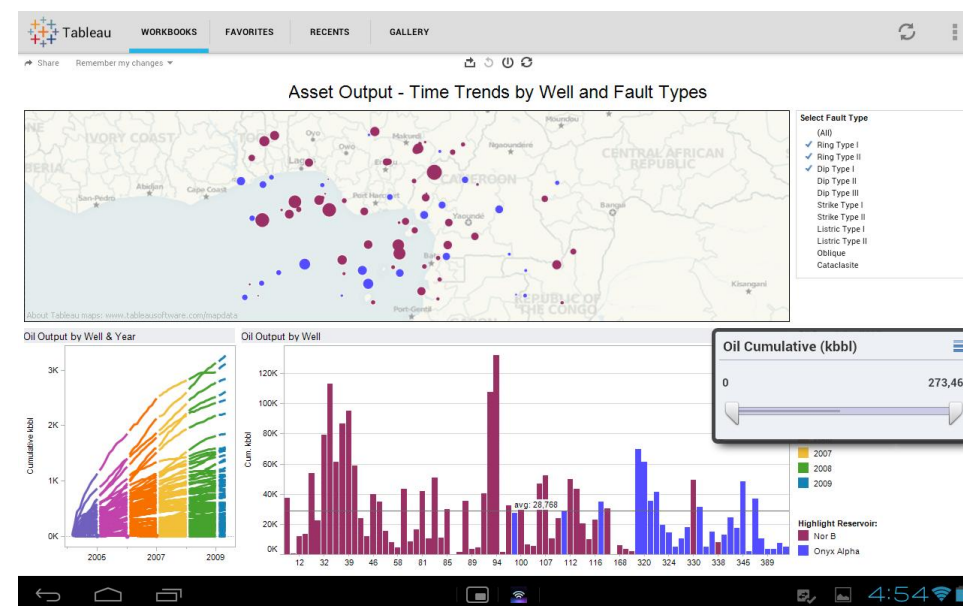
Tamara Munzner.

Visualization Analysis and Design.

A K Peters Visualization Series, CRC Press, 2014.

Interactive visual analysis

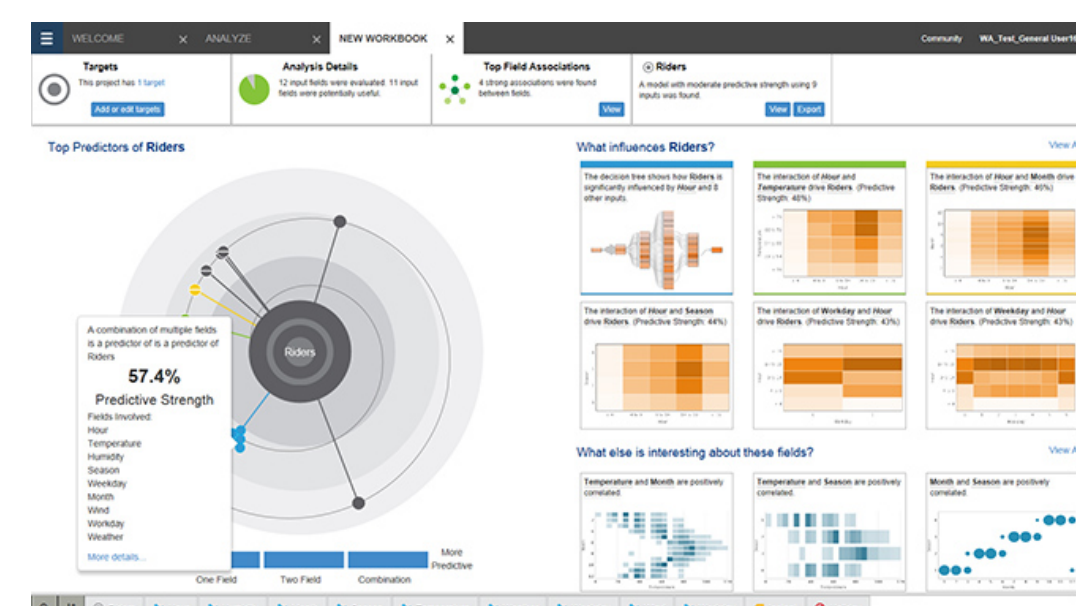
“Computer-based visualization systems provide visual representations of datasets intended to help people carry out some task more effectively.”



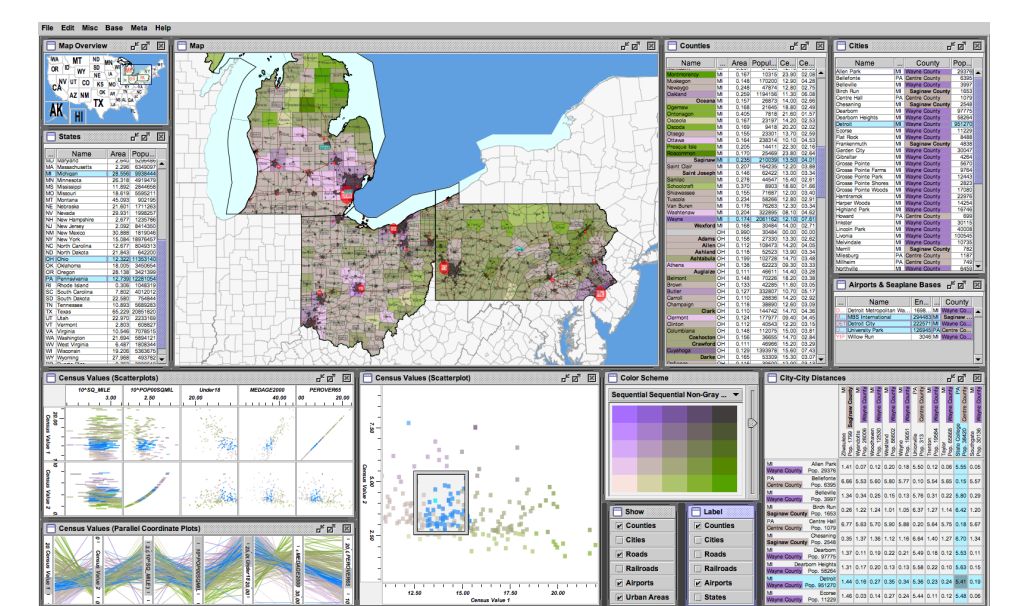
Tableau



SAS



IBM Watson Analytics



Improvise

not pretty pictures

Why a human in the loop?

“Computer-based visualization systems provide visual representations of datasets intended to help people carry out some task more effectively.”



not needed if fully automatic solution exists (and is trusted)

Ill-defined / ill-structured problems:

- no single optimal solution
- no clear objective measures

Herbert A. Simon.
The structure of ill-structured problems.
Artificial Intelligence, 4, 181-204. 1973.

Examples:

- exploratory analysis of scientific problems
- (collaborative) decision-making problems
- model building & validation

Effective support of ill-defined tasks!

*“Computer-based visualization systems provide visual representations of datasets intended to help people carry out some task **more effectively.**”*

Metrics of success:

- Novel — entirely new insights
- Faster — speed up common workflows

Why visual representations?

*“Computer-based visualization systems provide **visual representations** of datasets intended to help people carry out some task more effectively.”*

start



<https://media.holidaycheck.com/data/urlaubsbilder/images/146/1166832900.jpg>

end



<http://www.schoenbrunn.at/en/services/media-center/photo-gallery/great-parterre.html>

U1

- Leopoldau
- Großfeldsiedlung
- Aderklaaer Straße
- Rennbahnweg
- Kagrner Platz
- Kagran
- Alte Donau
- Kaisermühlen - VIC
- Donauinsel
- Vorgartenstraße
- Praterstern
- Nestroyplatz
- Schwedenplatz
- Stephansplatz
- Karlsplatz
- Taubstummengasse
- Südtiroler Platz
- Reumannplatz

U2

- Seestadt
- Aspern
- Hausfeldstraße
- (An den alten Schanzen)
- Aspernstraße
- Donauspital
- Hardeggasse
- Stadlau
- Donaustadtbrücke
- Donaumarina
- Stadion
- Krieau
- Messe Prater
- Praterstern
- Taborstraße
- Schottenring
- Schottentor
- Rathaus
- Volkstheater
- Museumsquartier
- Karlsplatz

U3

- Ottakring
- Kendlerstraße
- Hütteldorfer Straße
- Johnstraße
- Schweglerstraße
- Westbahnhof
- Zieglergasse
- Neubaugasse
- Volkstheater
- Herrngasse
- Stephansplatz
- Stubentor
- Landstraße
- Rochusgasse
- Kardinal-Nagl-Platz
- Schlachthausgasse
- Erdberg
- Gasometer
- Zippererstraße
- Enkplatz
- Simmering

U4

- Heiligenstadt
- Spittelau
- Friedensbrücke
- Roßauer Lände
- Schottenring
- Schwedenplatz
- Landstraße
- Stadtpark
- Karlsplatz
- Kettenbrückengasse
- Pilgramgasse
- Margaretengürtel
- Längenfeldgasse
- Meidling Hauptstraße
- Schönbrunn
- Hietzing
- Braunschweigasse
- Unter St Veit
- Ober St Veit
- Hütteldorf

U6

- Floridsdorf
- Neue Donau
- Handelskai
- Dresdner Straße
- Jägerstraße
- Spittelau
- Nußdorfer Straße
- Währinger Straße
- Michelbeuern - AKH
- Alser Straße
- Josefstädter Straße
- Thaliastraße
- Burggasse
- Westbahnhof
- Gumpendorfer Straße
- Längenfeldgasse
- Niederhofstraße
- Philadelphiabrücke
- Tscherttegasse
- Am Schöpfwerk
- Alterlaa
- Erlaaer Straße
- Perfektastraße
- Siebenhirten

start

end

Why visual representations?

*“Computer-based visualization systems provide **visual representations** of datasets intended to help people carry out some task more effectively.”*



U1
U2
U3
U4
U6

Perception
beats
Cognition!

Visualization research



→
technique-driven

New algorithms

New visualization techniques



←
problem-driven

Understand users & tasks

Design studies

Visualization research



technique-driven

Graph Drawing

**My
research
focus**

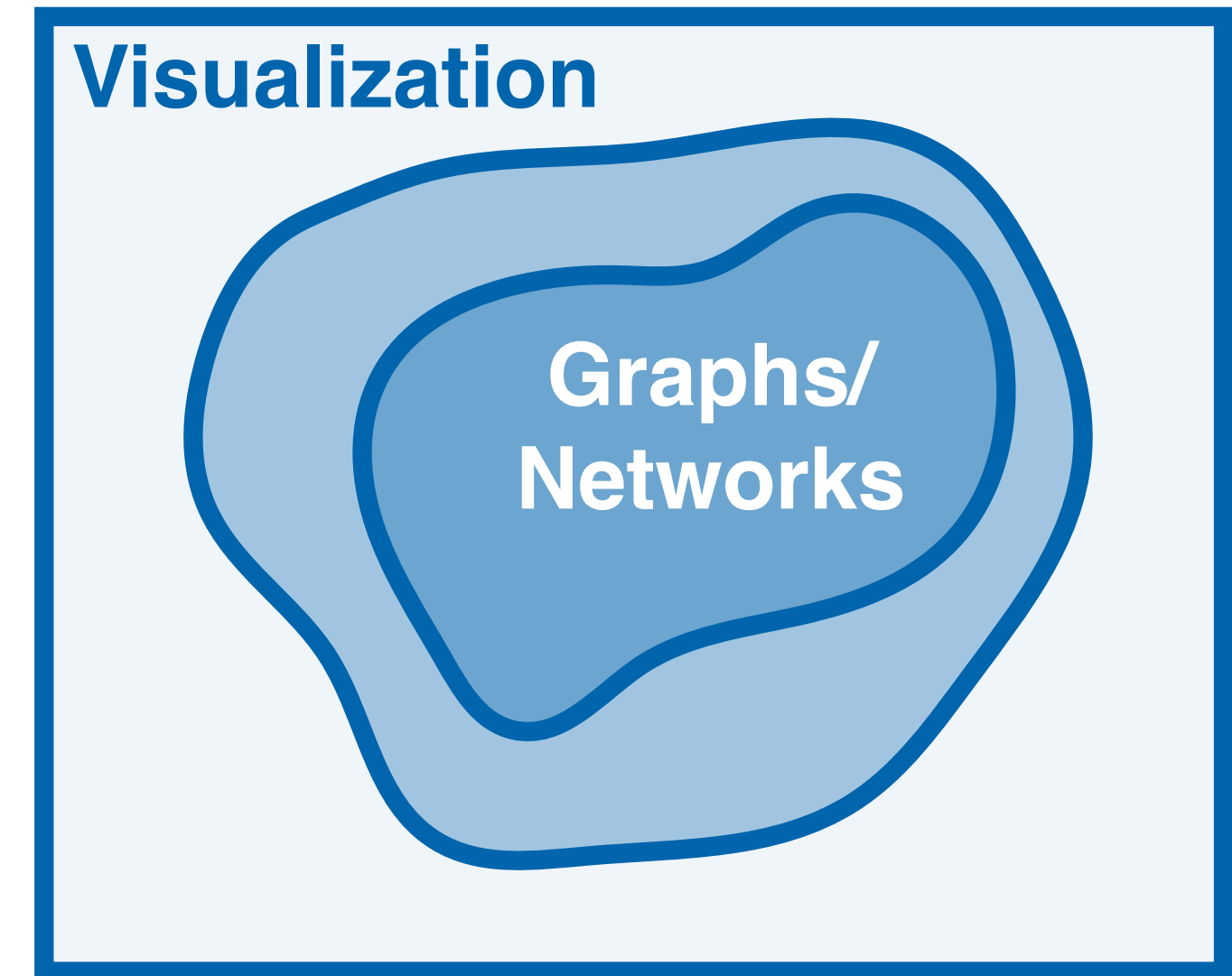


problem-driven

Network Visualization

Today's goal:

Graph/network visualization and around



1. Technique-driven research

- Trends in graph drawing
- Trends in visualization — Related to graph drawing

2. Problem-driven research

- Design Study Example — RelEx: Visualization of overlay networks
- Design Study Methodology — Why care in network science?

Outline

1. Technique-driven research

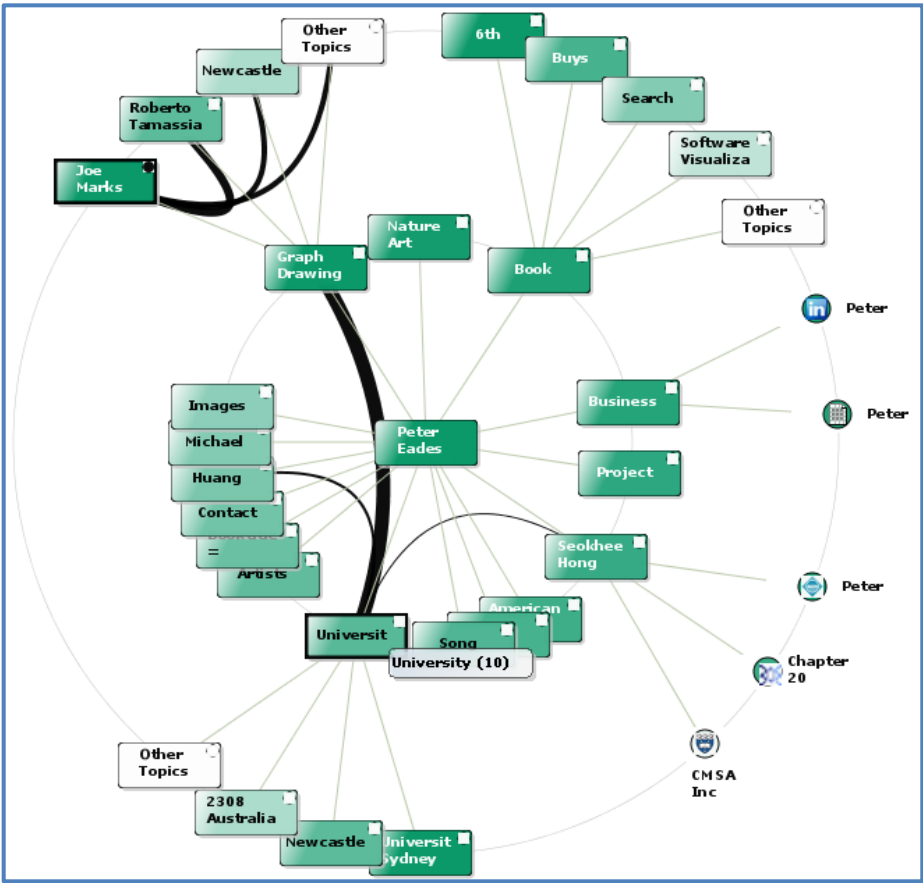
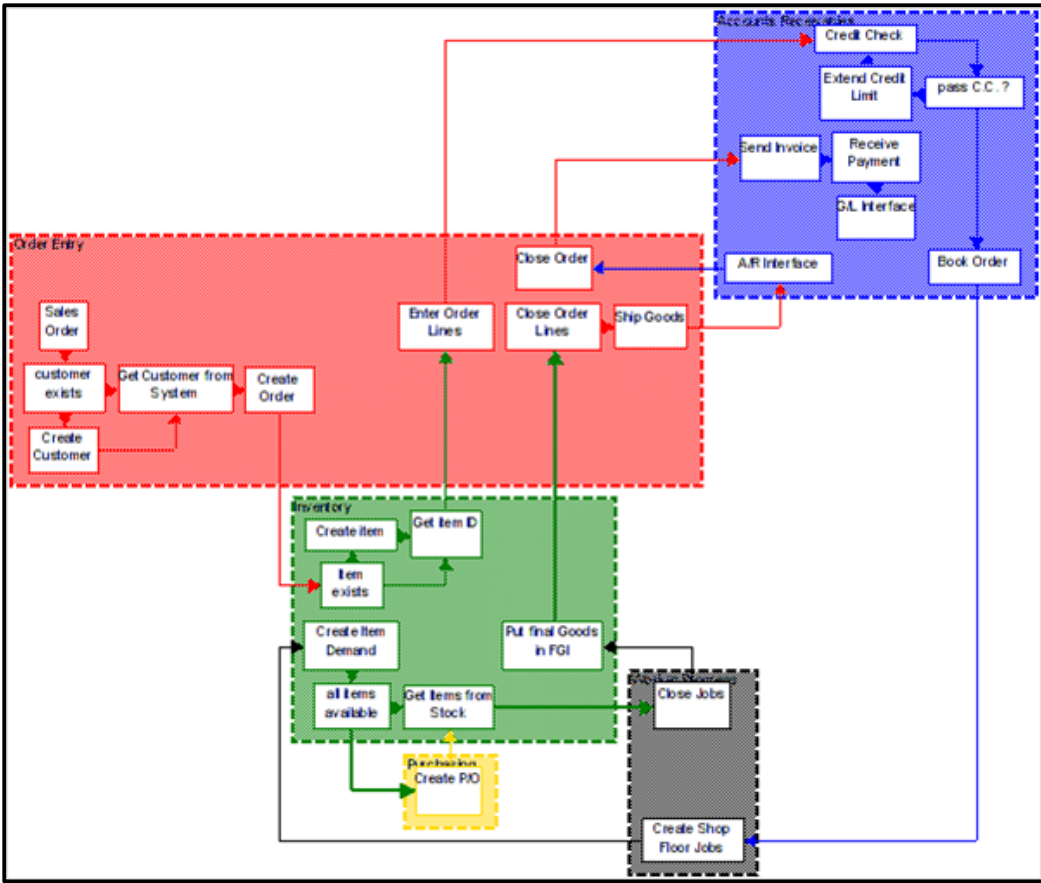
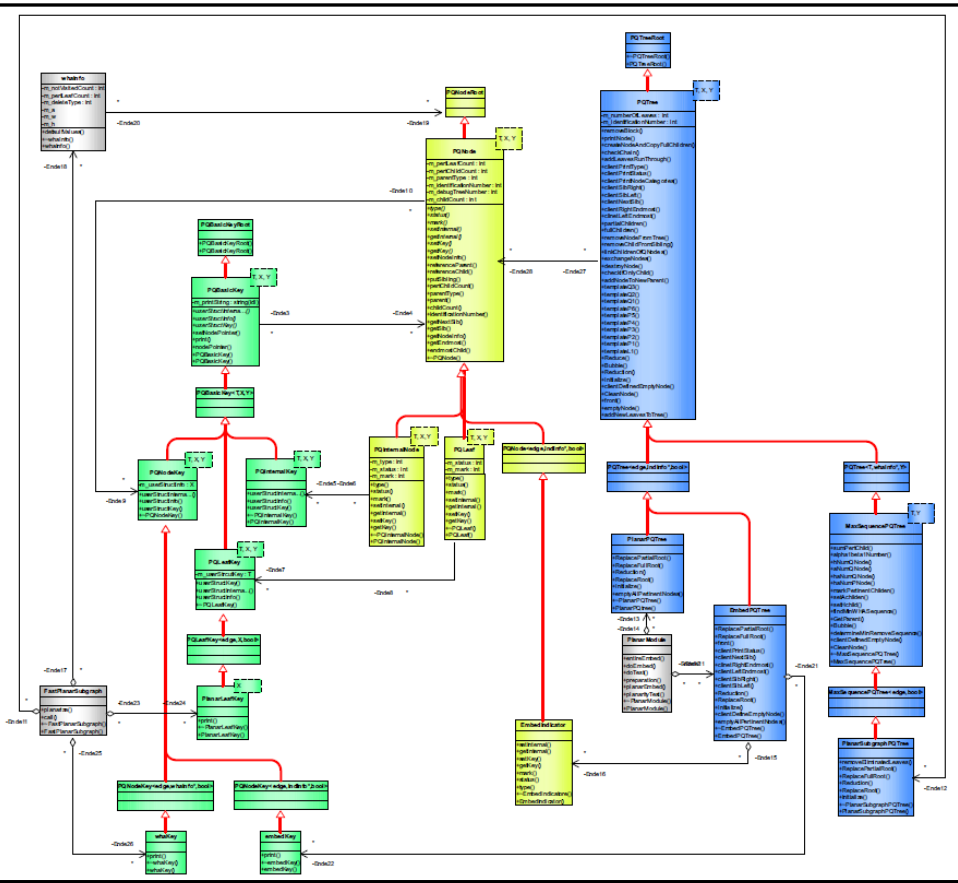
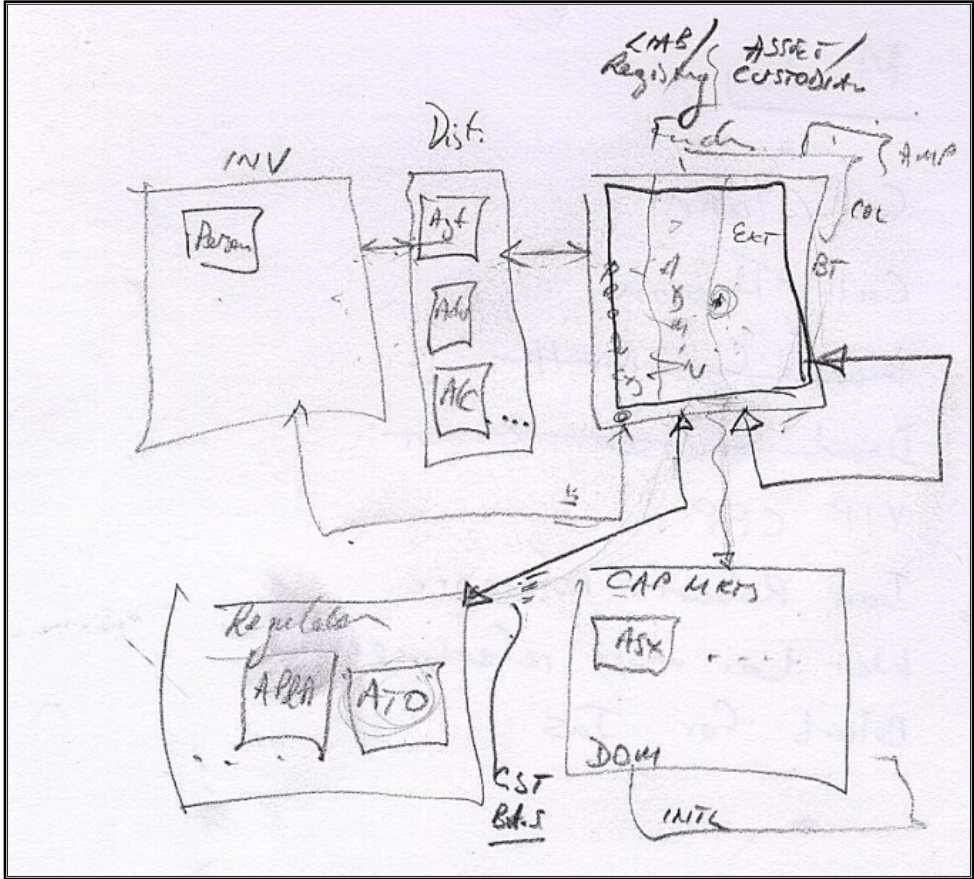
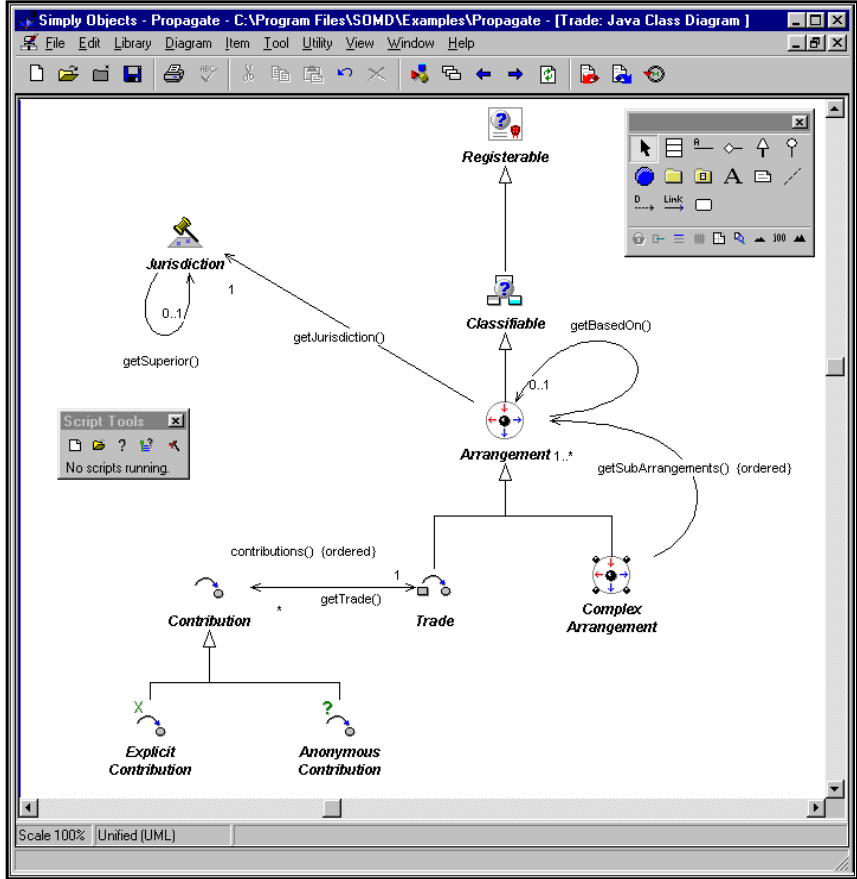
- Trends in graph drawing
- Trends in visualization — Related to graph drawing

2. Problem-driven research

- Design Study Example — RelEx
- Design Study Methodology

3. Summary

Networks & Graphs



etc.

Graph Drawing

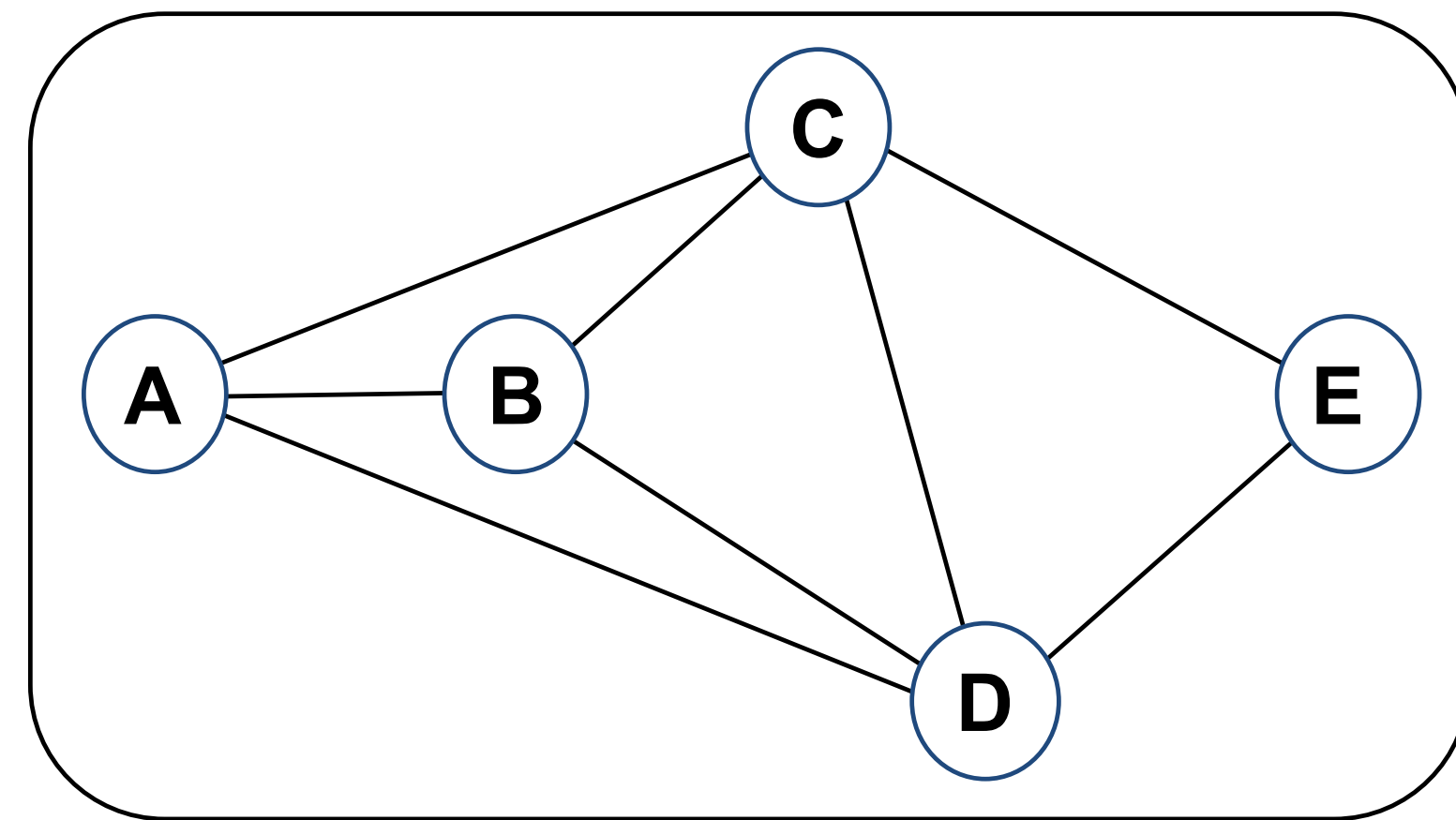
- The classical graph drawing problem is to develop **algorithms to draw graphs nicely.**

graph

A - B, C, D
B - A, C, D
C - A, B, D, E
D - A, B, D, E
E - C, D



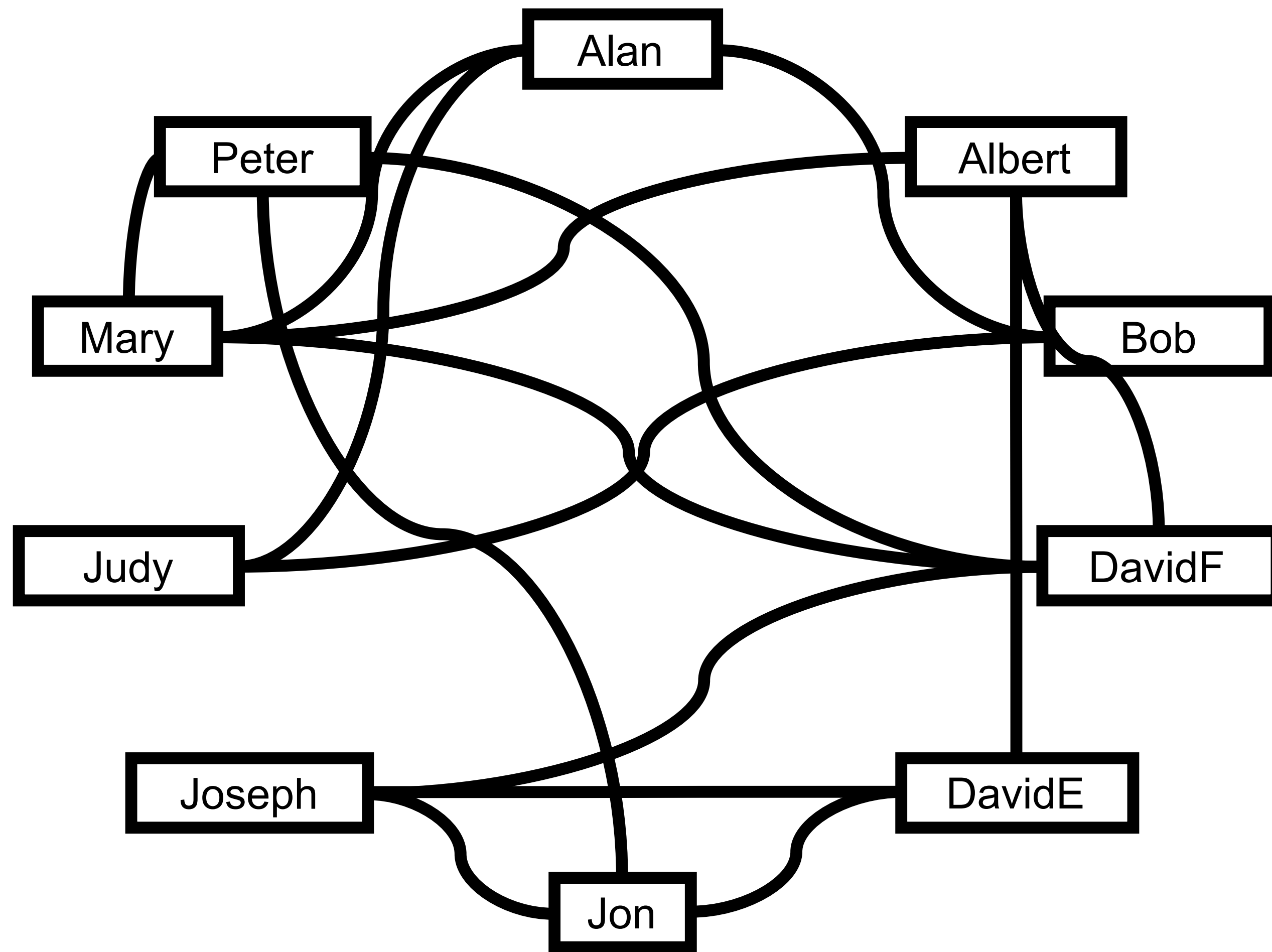
nice graph drawing



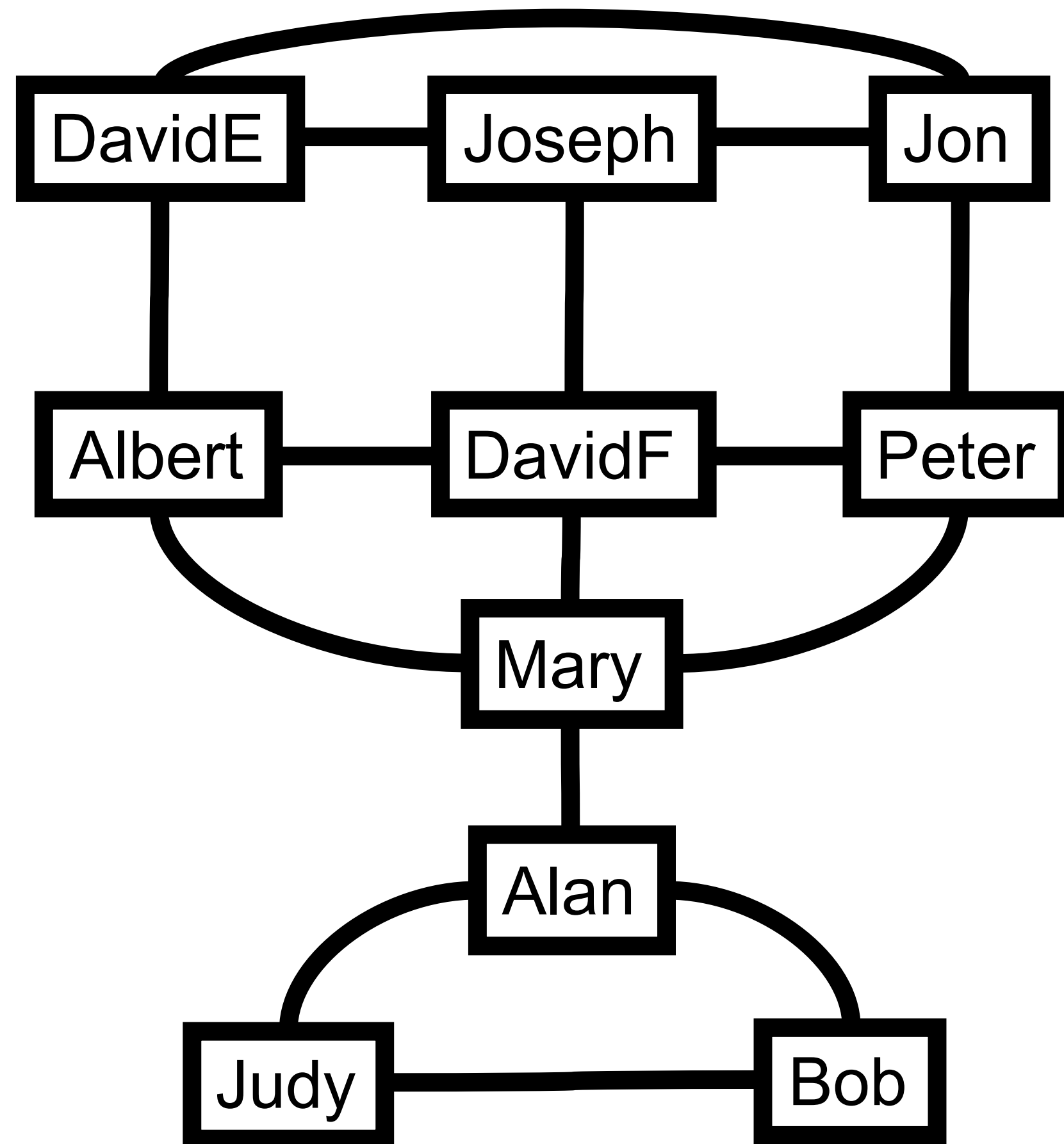
Example

<i>X</i>	<i>Adjacent to X</i>
Mary	Peter, Albert, DavidF, Peter
Judy	Bob, Alan
Peter	Mary, DavidF, Jon
DavidF	Albert, Joseph, Peter, Mary
Jon	Peter, Joseph, DavidE
DavidE	Jon, Joseph, Albert
Joseph	DavidE, Jon, DavidF
Bob	Judy, Alan
Alan	Bob, Mary, Judy
Albert	DavidF, Mary, DavidE

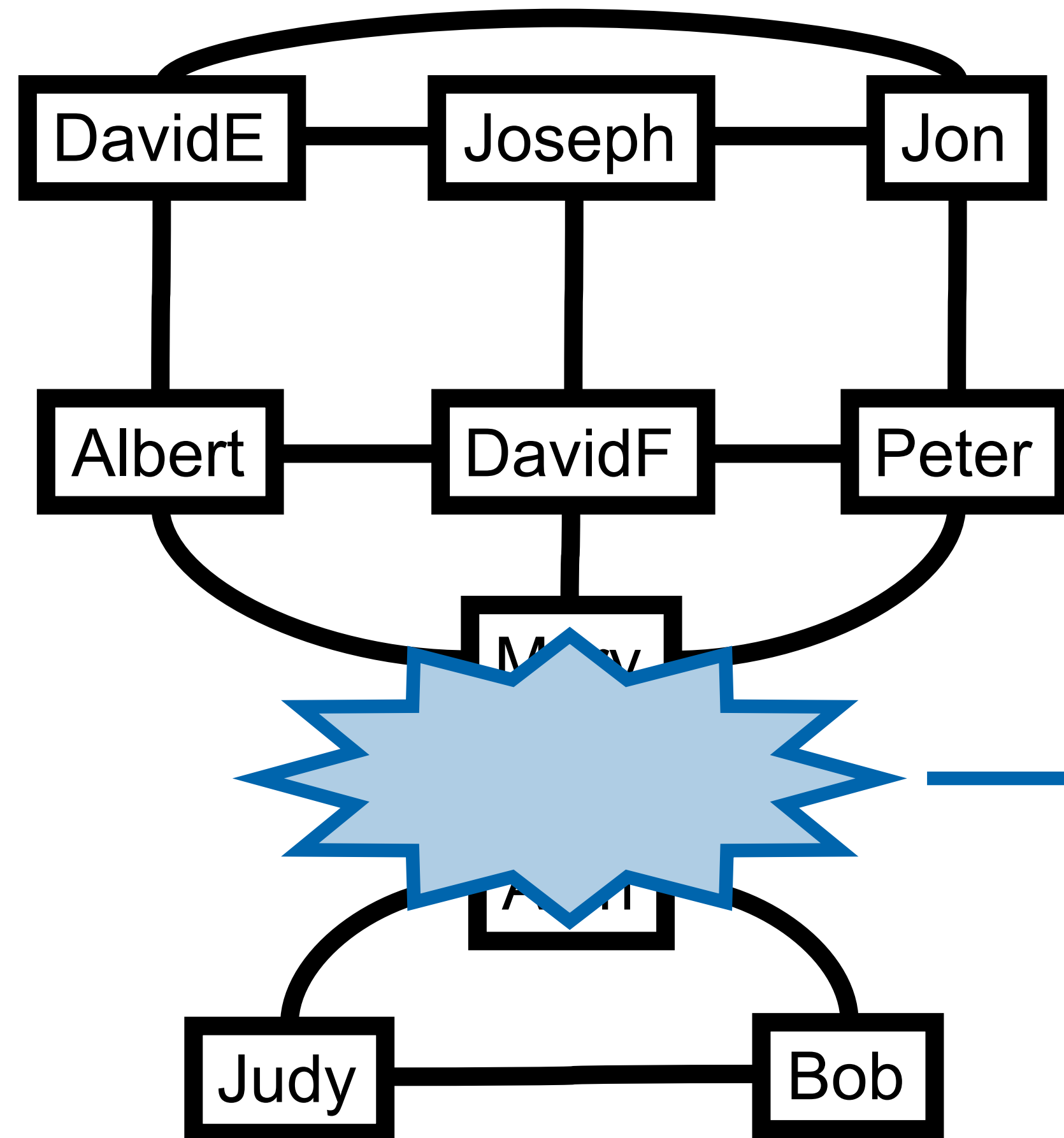
Example



Example



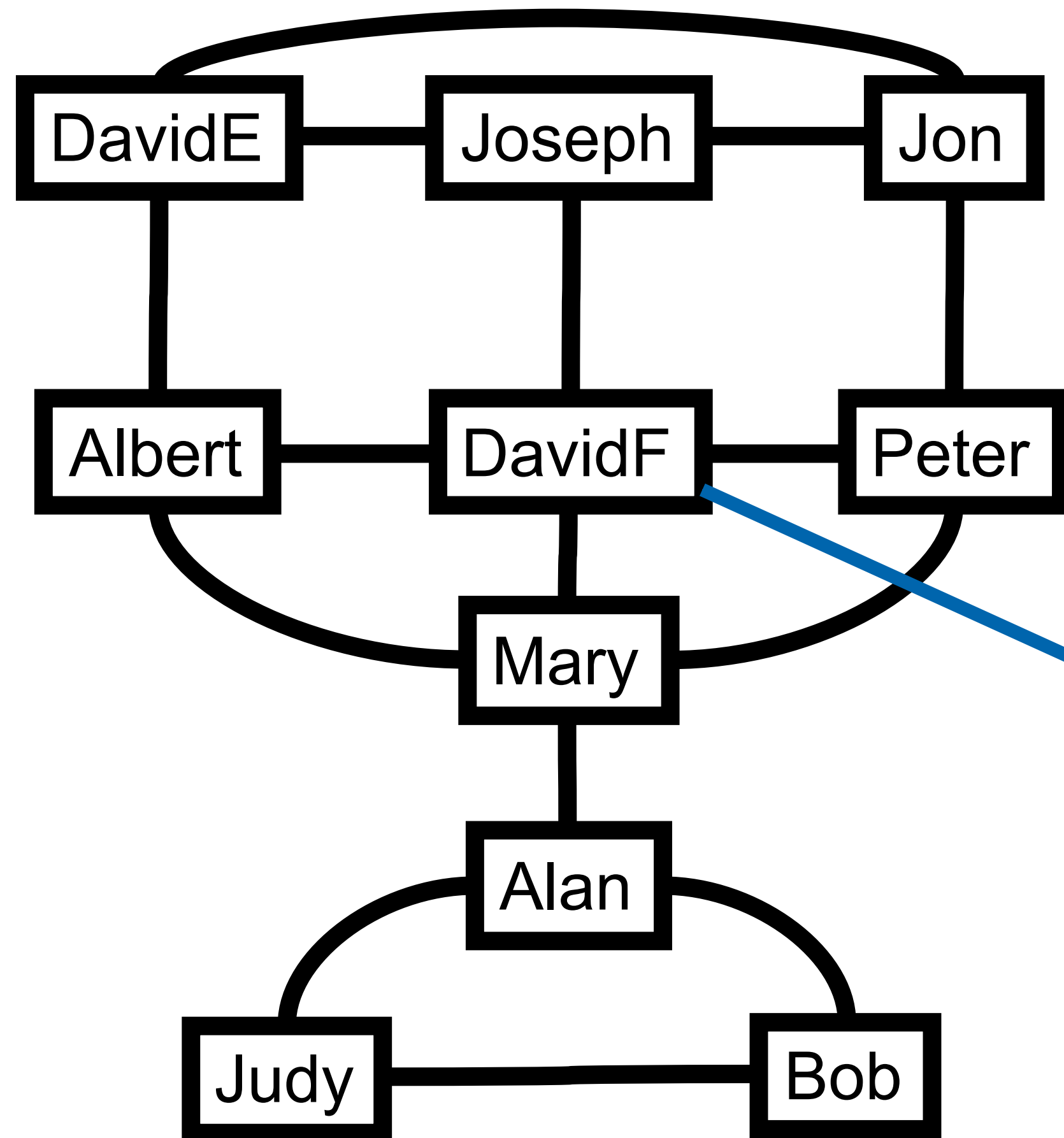
Example



Terrorist network

Eliminate

Example

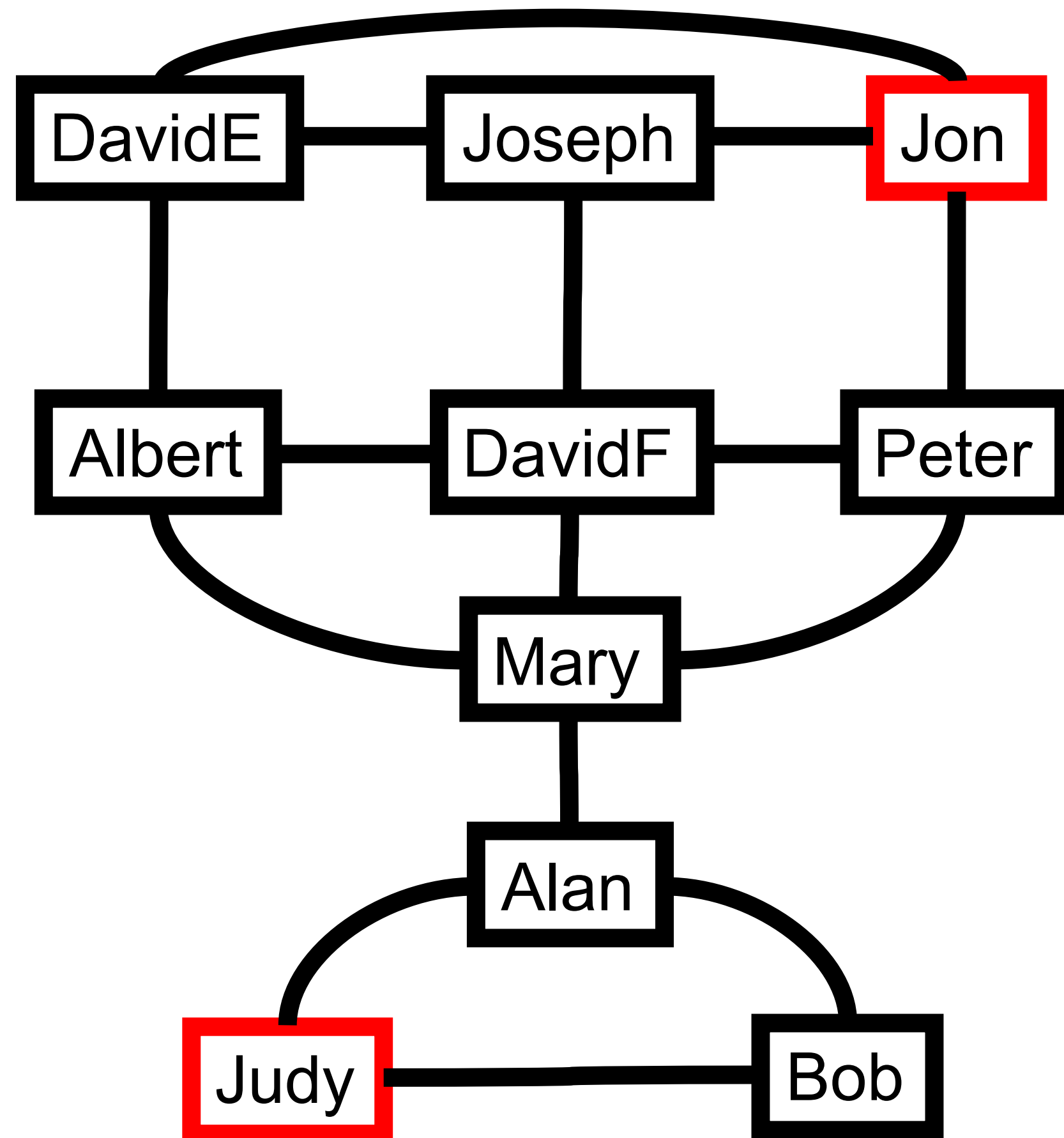


Mobile phone network:

- * **nodes: people**
- * **edges: phone calls**

Good deal \$\$\$\$

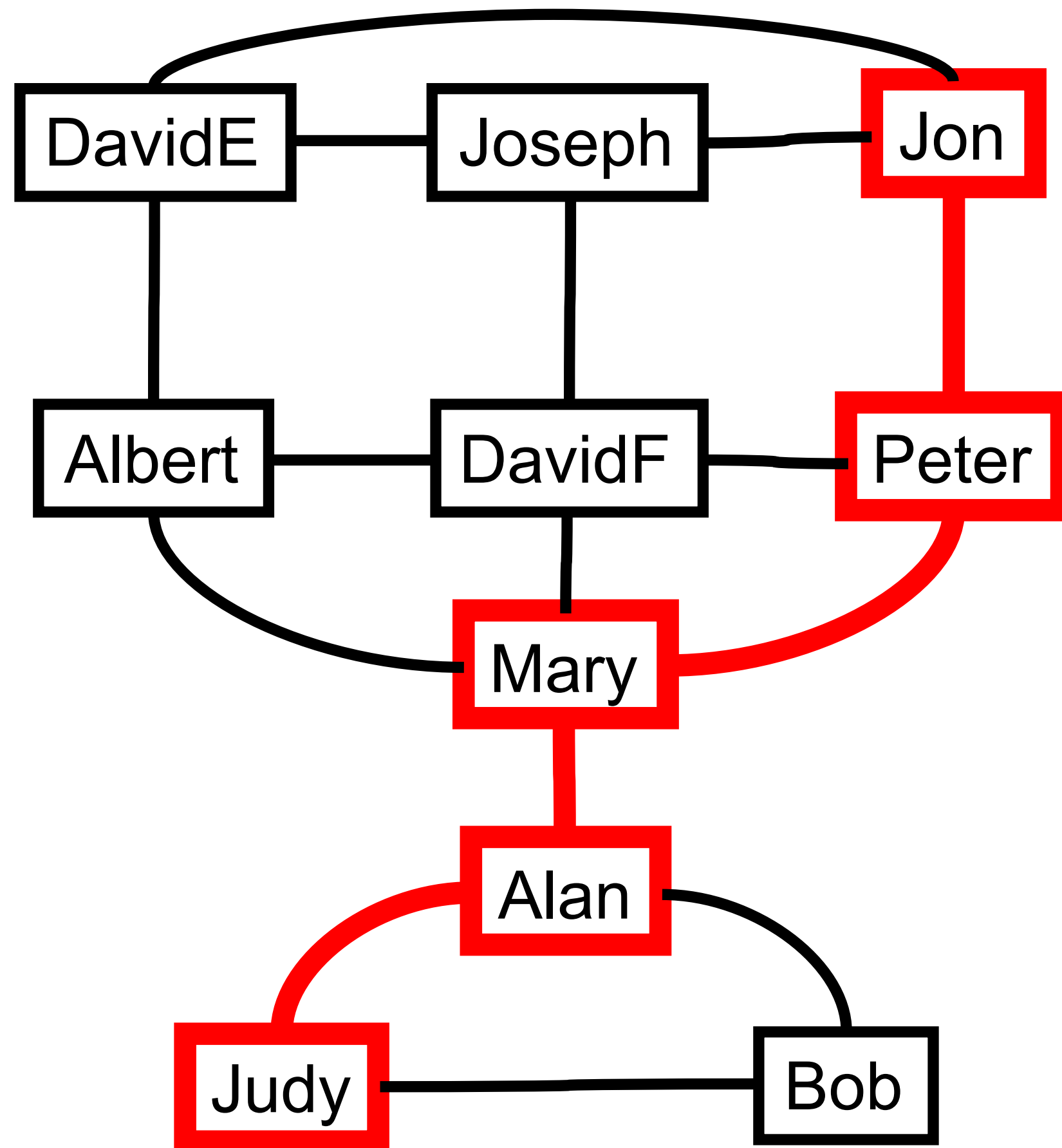
Example



Transport network:

- * **nodes: places**
- * **edges: train lines**

Example

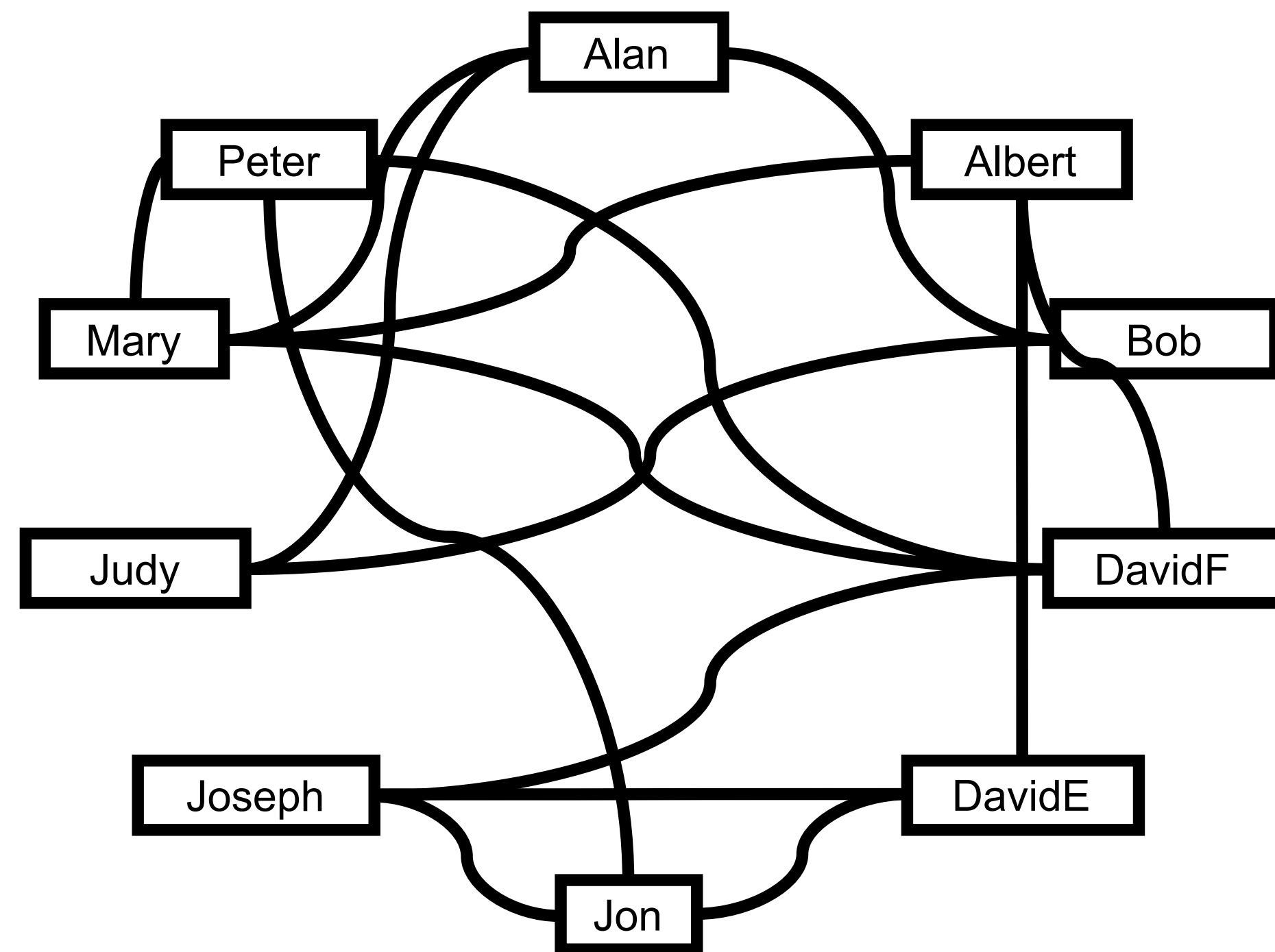


Transport network:

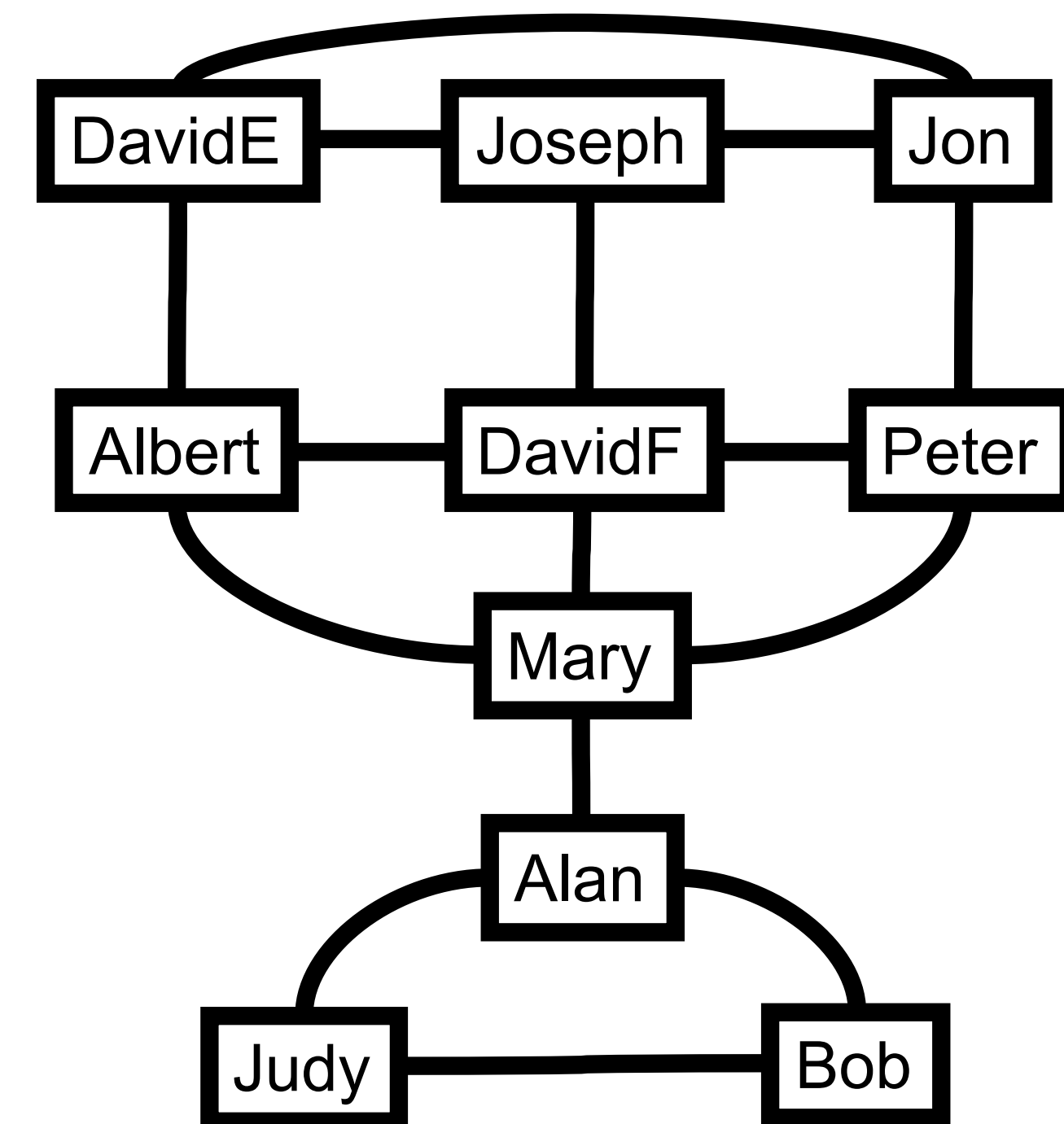
- * **nodes: places**
- * **edges: train lines**

Shortest path?

What algorithm give good drawings of graphs?

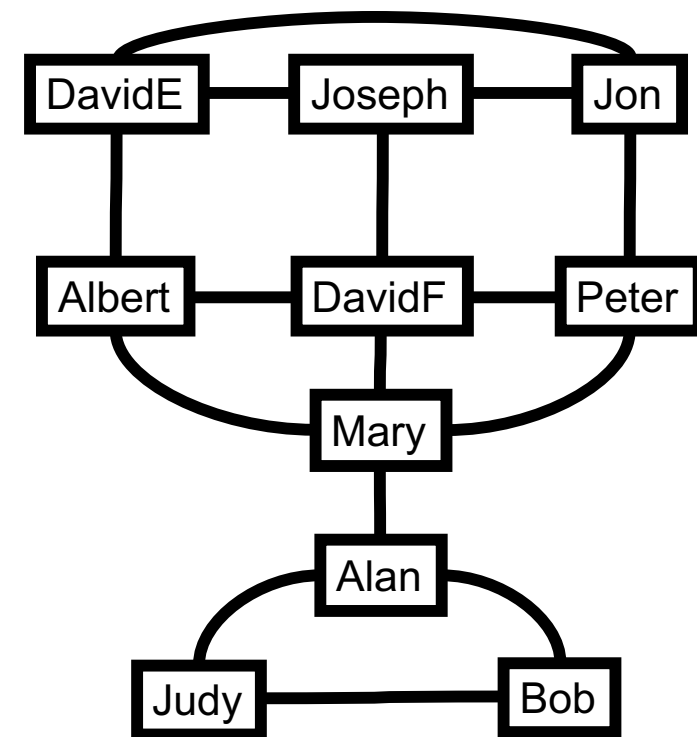
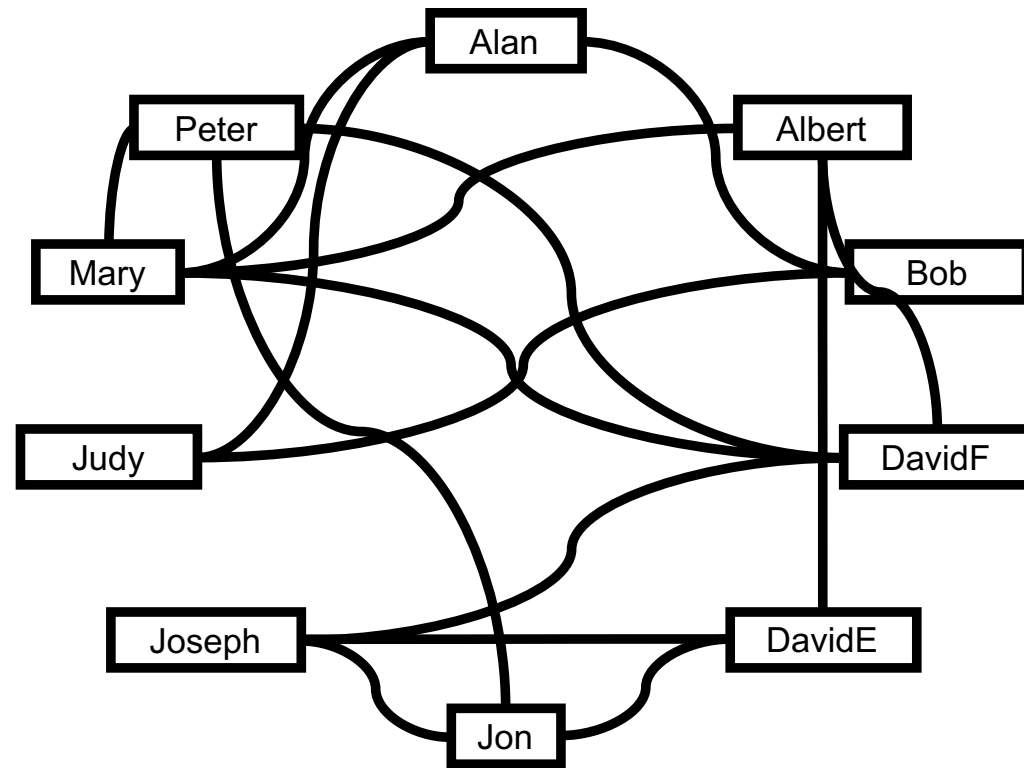


Bad



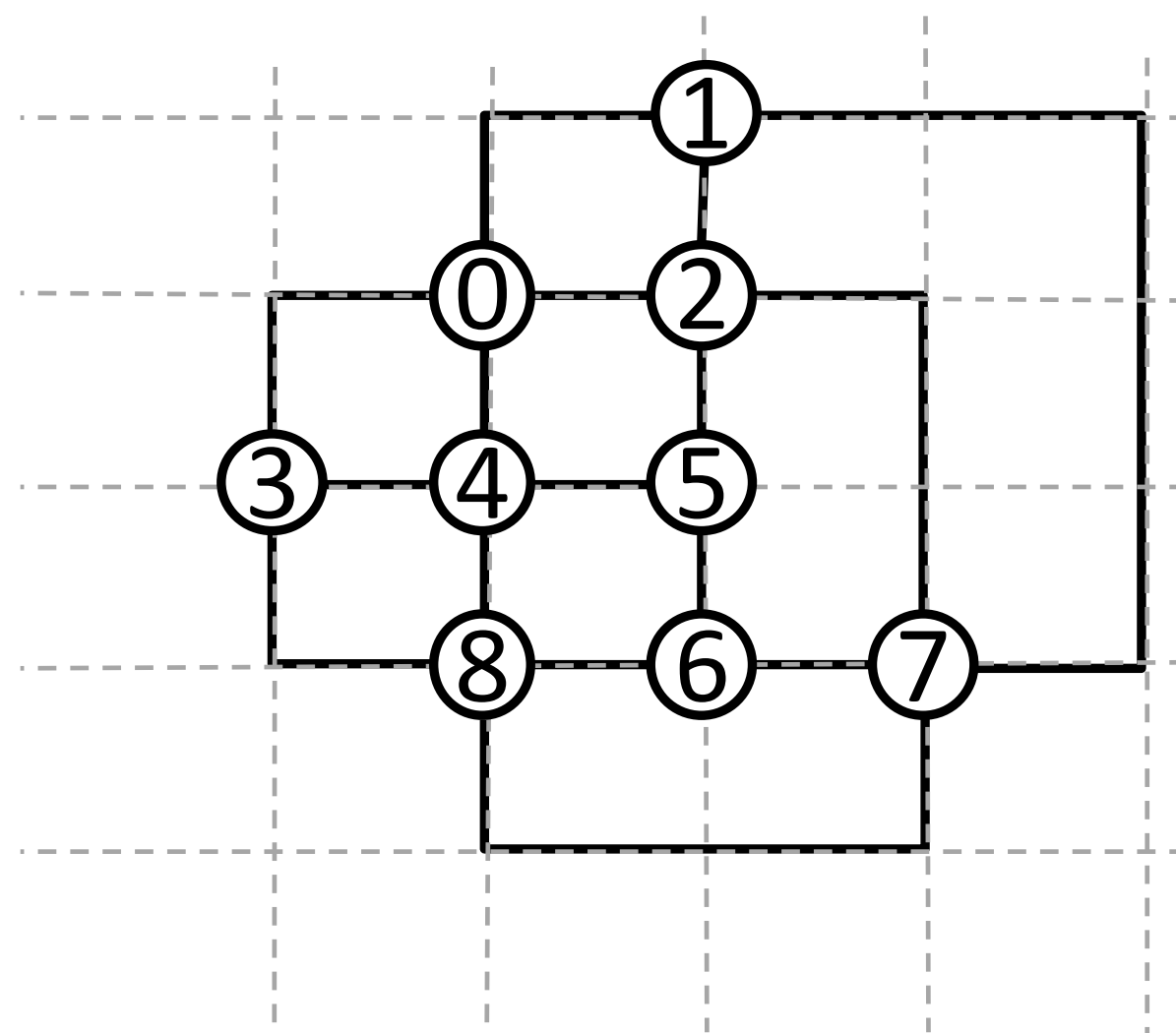
Good

Quality measures for networks

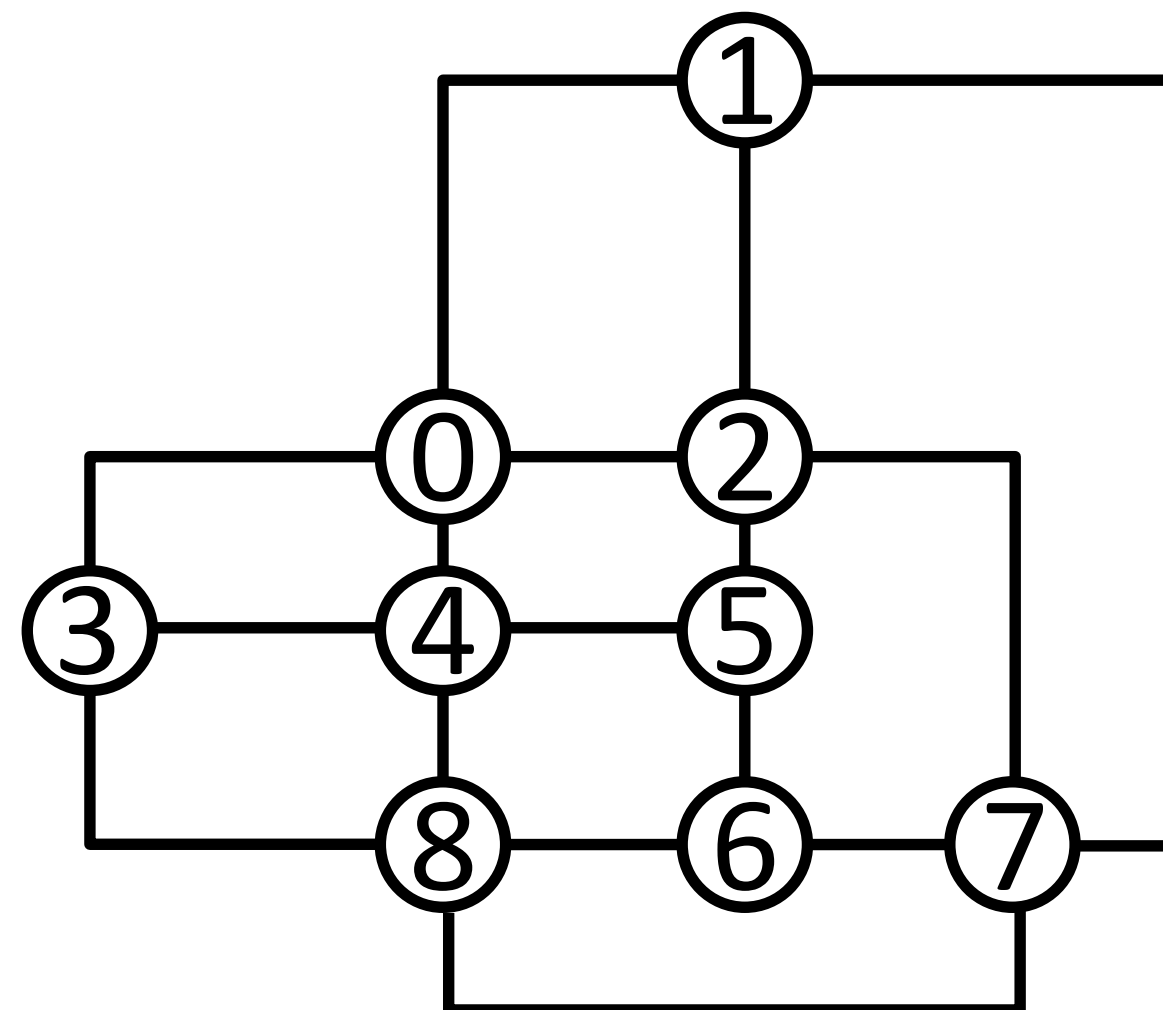


- Classical quality measures
 - minimize edge crossings
 - minimize bends
 - ...
- Human subject experiments found crossings & bends to be most important *wrt* readability
 - Purchase et al., 1997
 - Ware et al 2002
 - Huang et al 2004

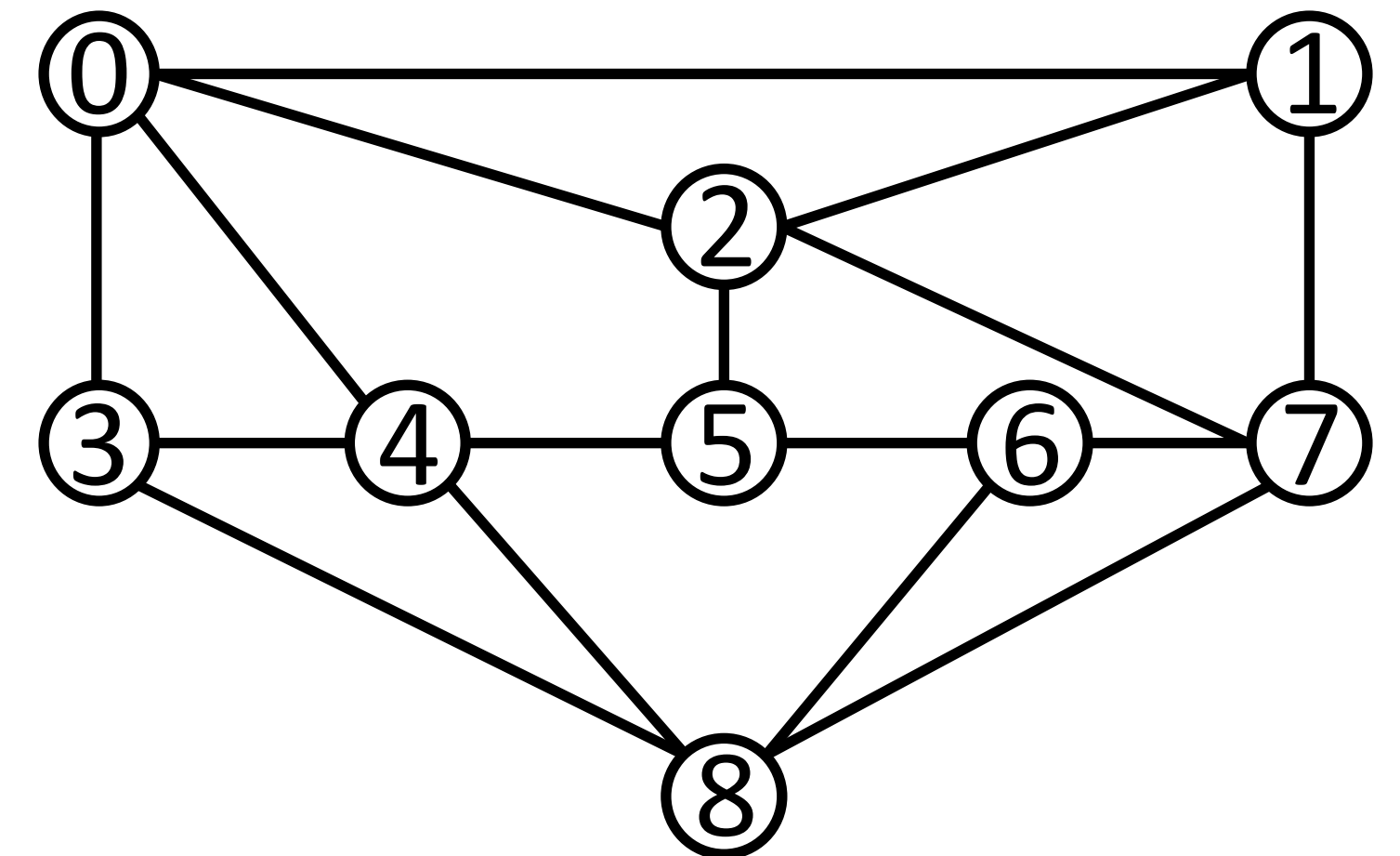
Different kinds of layouts



grid-based



orthogonal

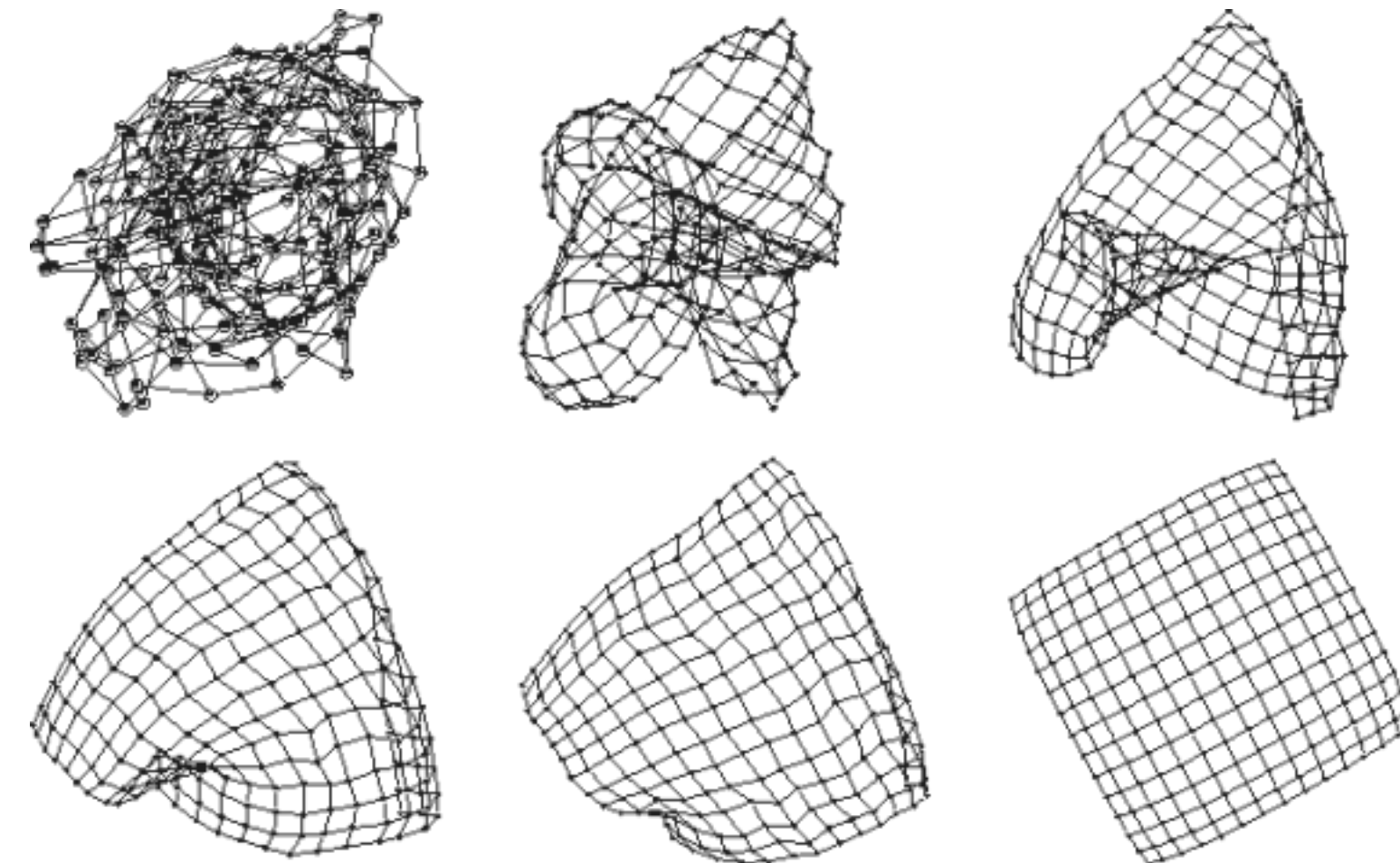


straight-line

Force-directed layouts

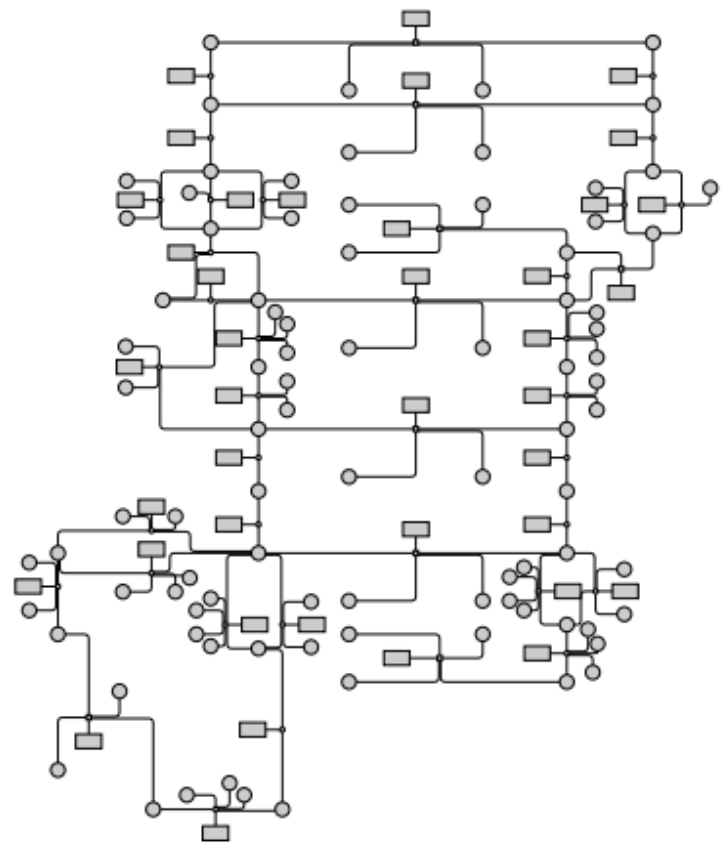


<https://bl.ocks.org/mbostock/4062045>

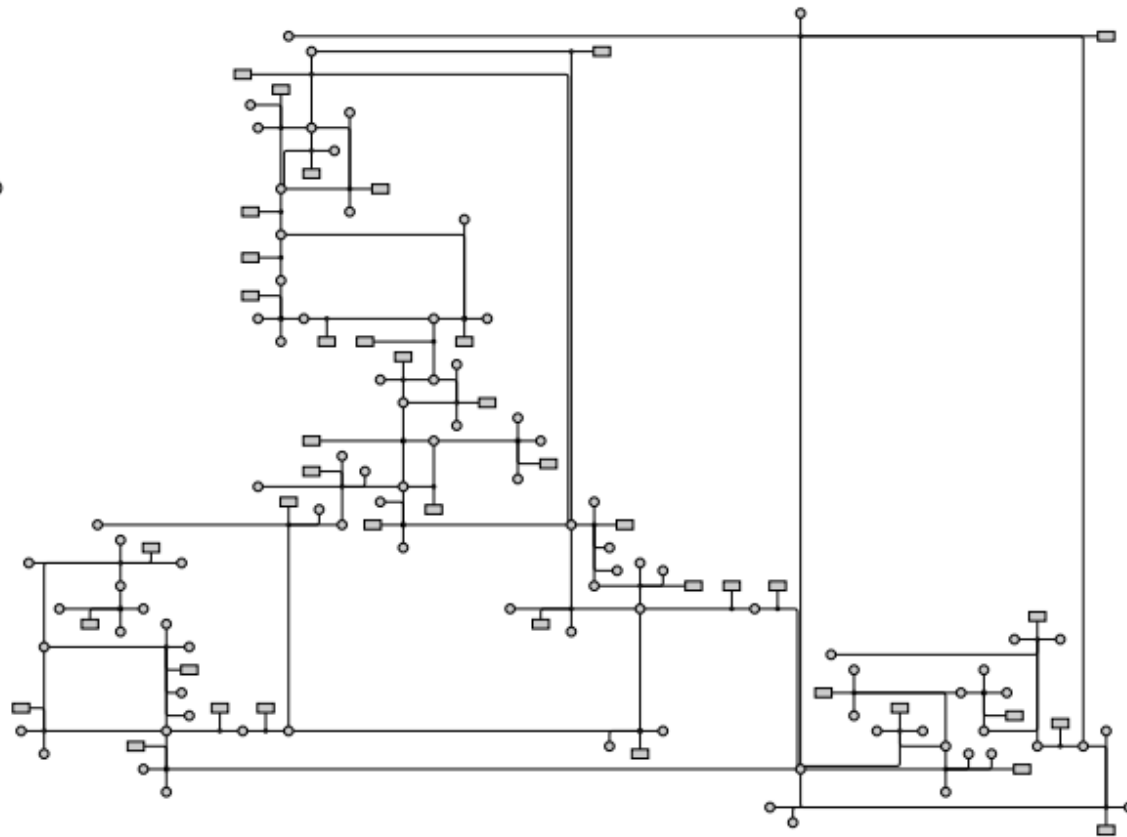


© Sander

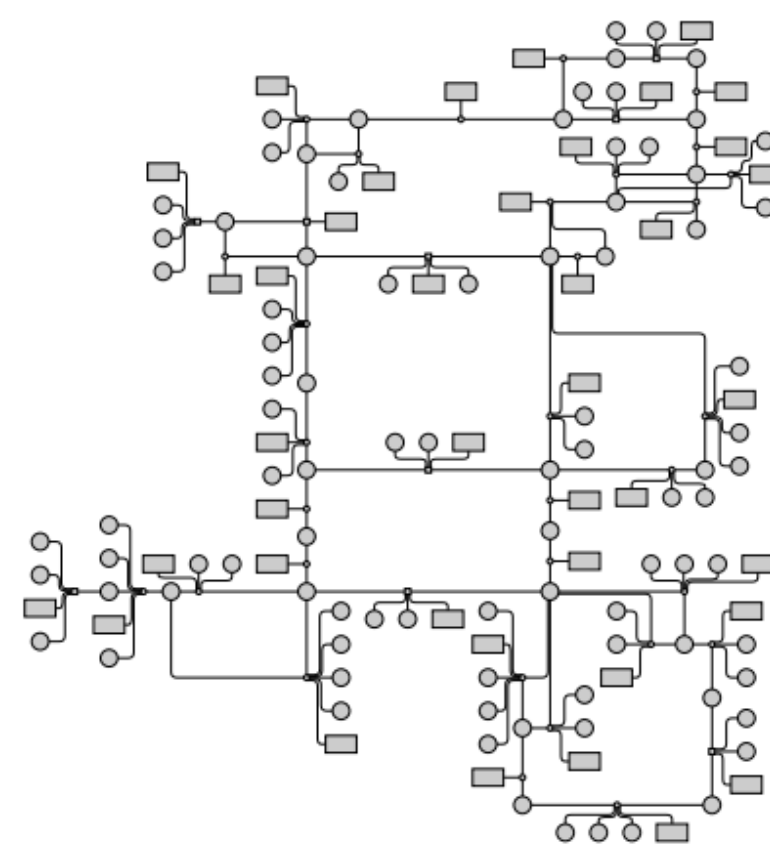
Human-centered layout



Human



algo-yFiles



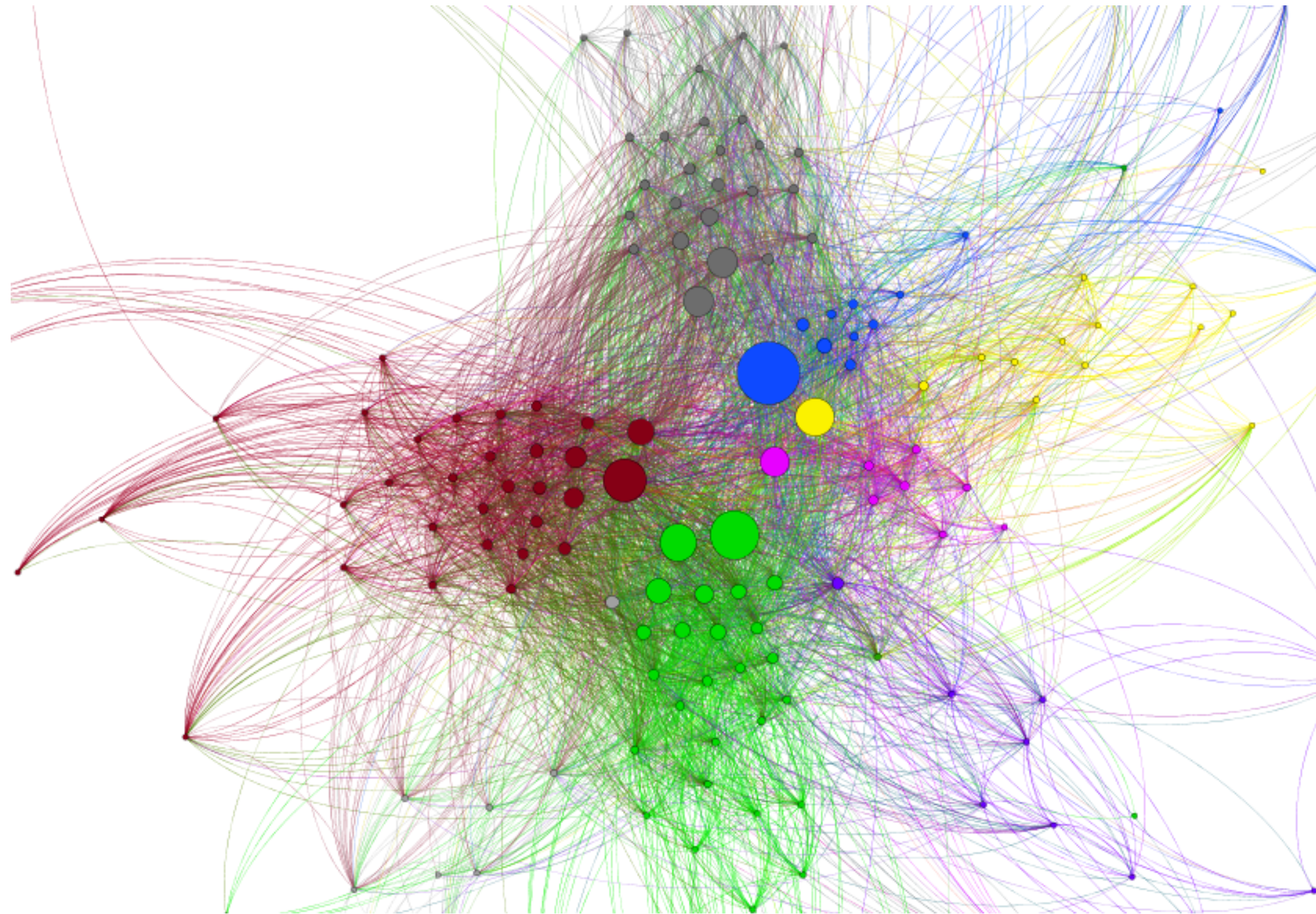
algo-HALO
(new)

1. User study
2. Develop algorithm
3. Evaluate algo-created layouts against human-created layouts

Kiefer et al. (InfoVis 2015).
HOLA: Human-like Orthogonal Network Layout

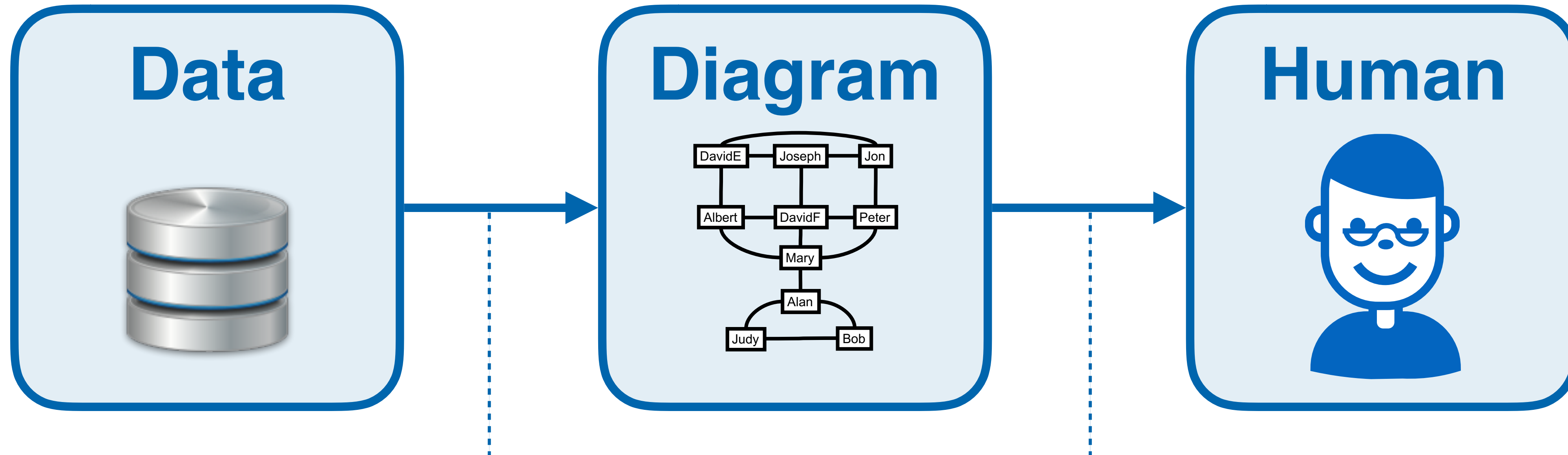
Scalability — Too many
nodes and/or edges

Showing all the data?



<https://twitter.com/axelmaireder/media>

Measures: Faithfulness VS. Readability



Faithfulness measures
how well the diagram
represents the data.

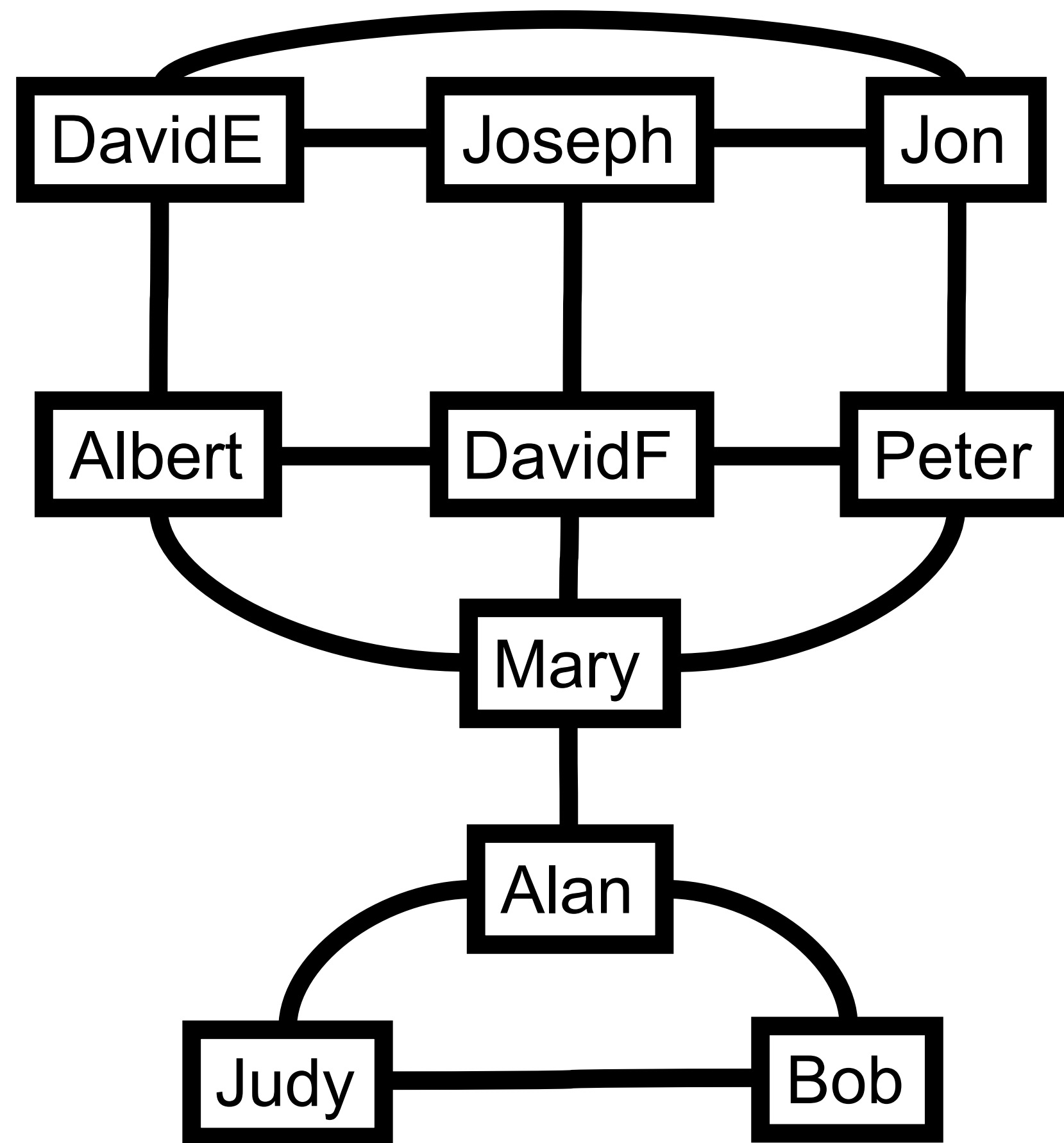
(a mathematical concept)

Readability measures
how well the human
understands the diagram.

(a psychological concept)

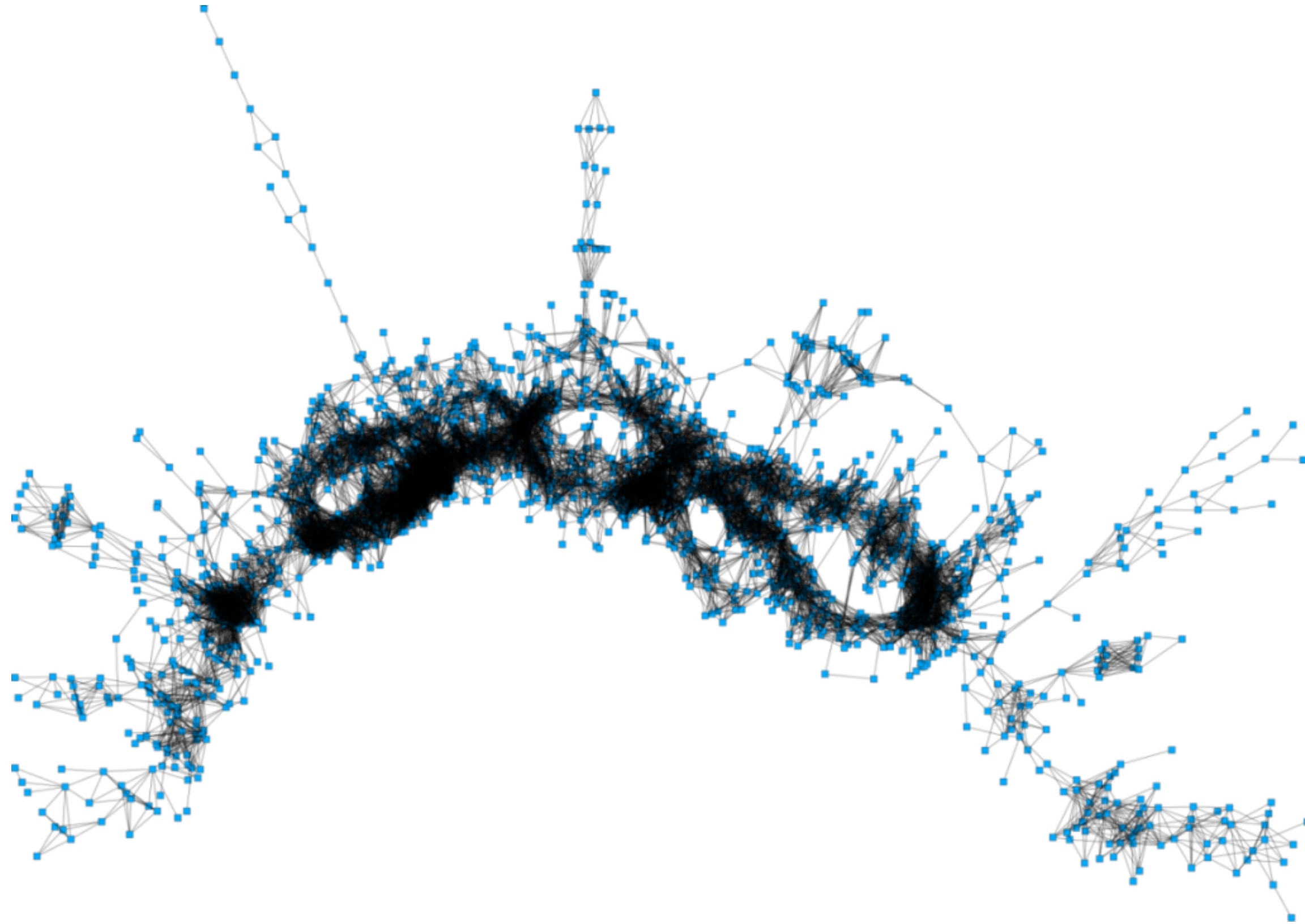
*Quan Nguyen et al.
(PacificVis 2013).
On the faithfulness
of graph visualizations*

In small graphs: faithfulness usually given



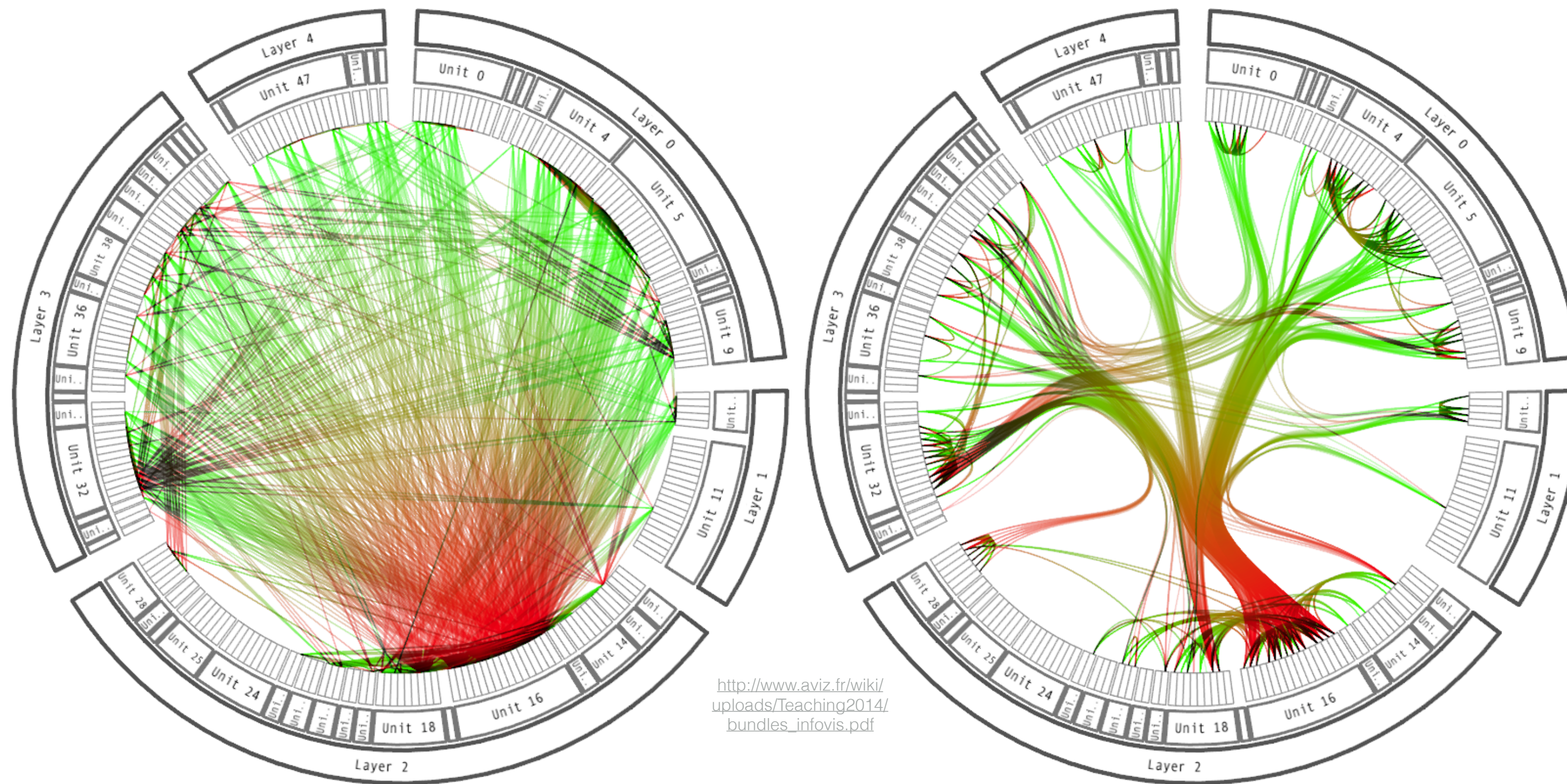
—> optimize readability

In large graphs: faithfulness usually not given



—> tradeoff between
faithfulness & readability

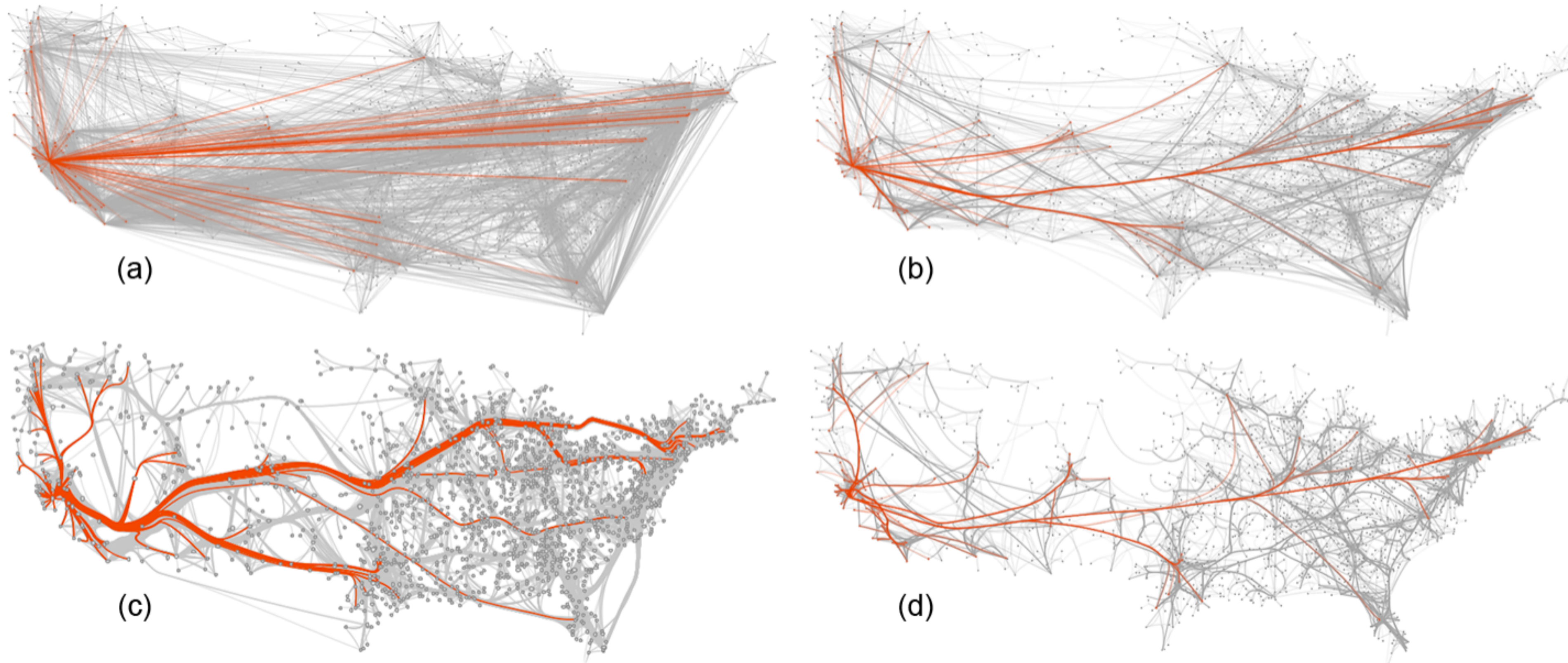
Edge bundling



Sacrifice faithfulness,
gain readability

Holten (InfoVis 2006).
Hierarchical Edge Bundles:
Visualization of Adjacency Relations in Hierarchical Data

Edge bundling

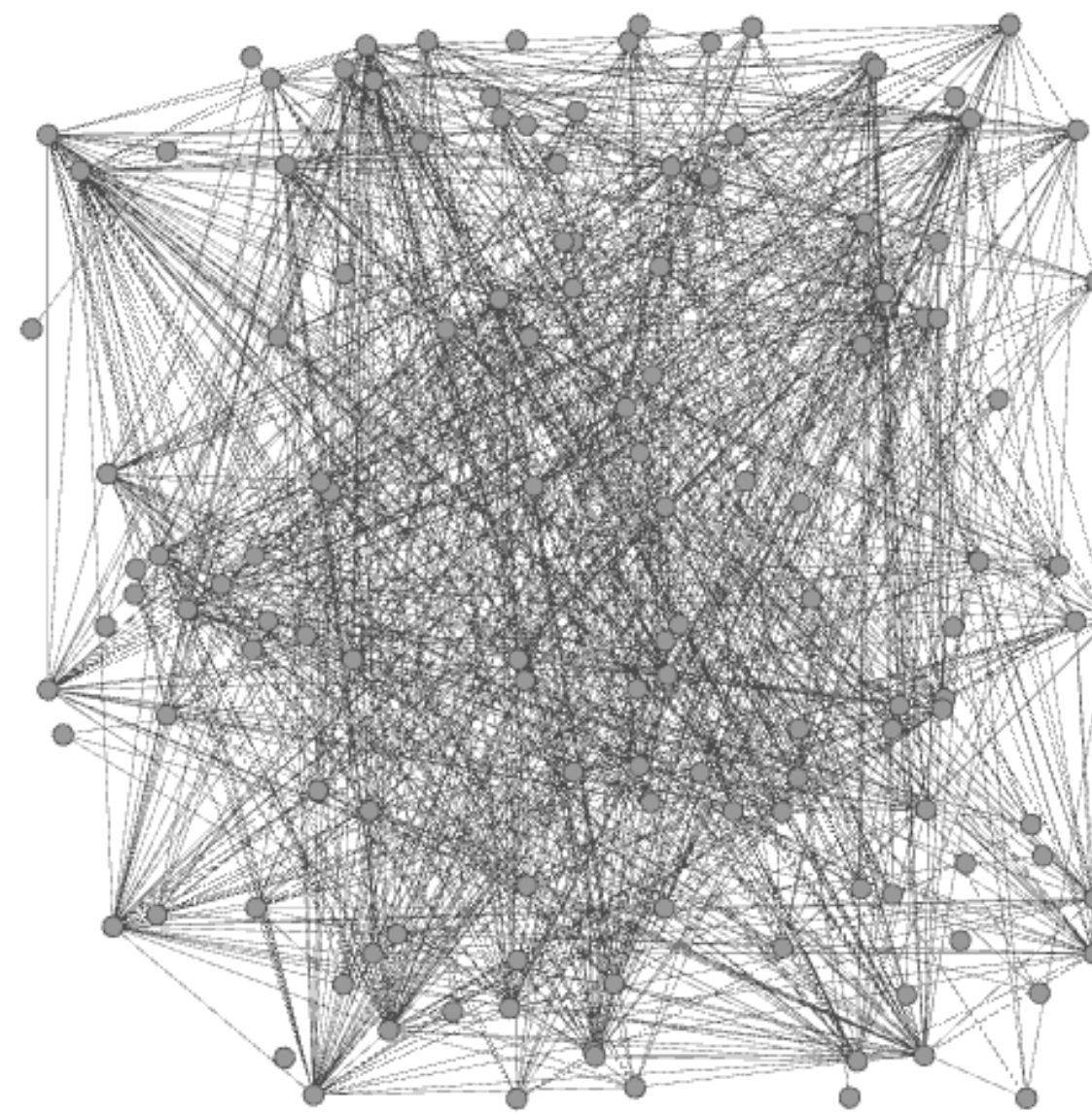
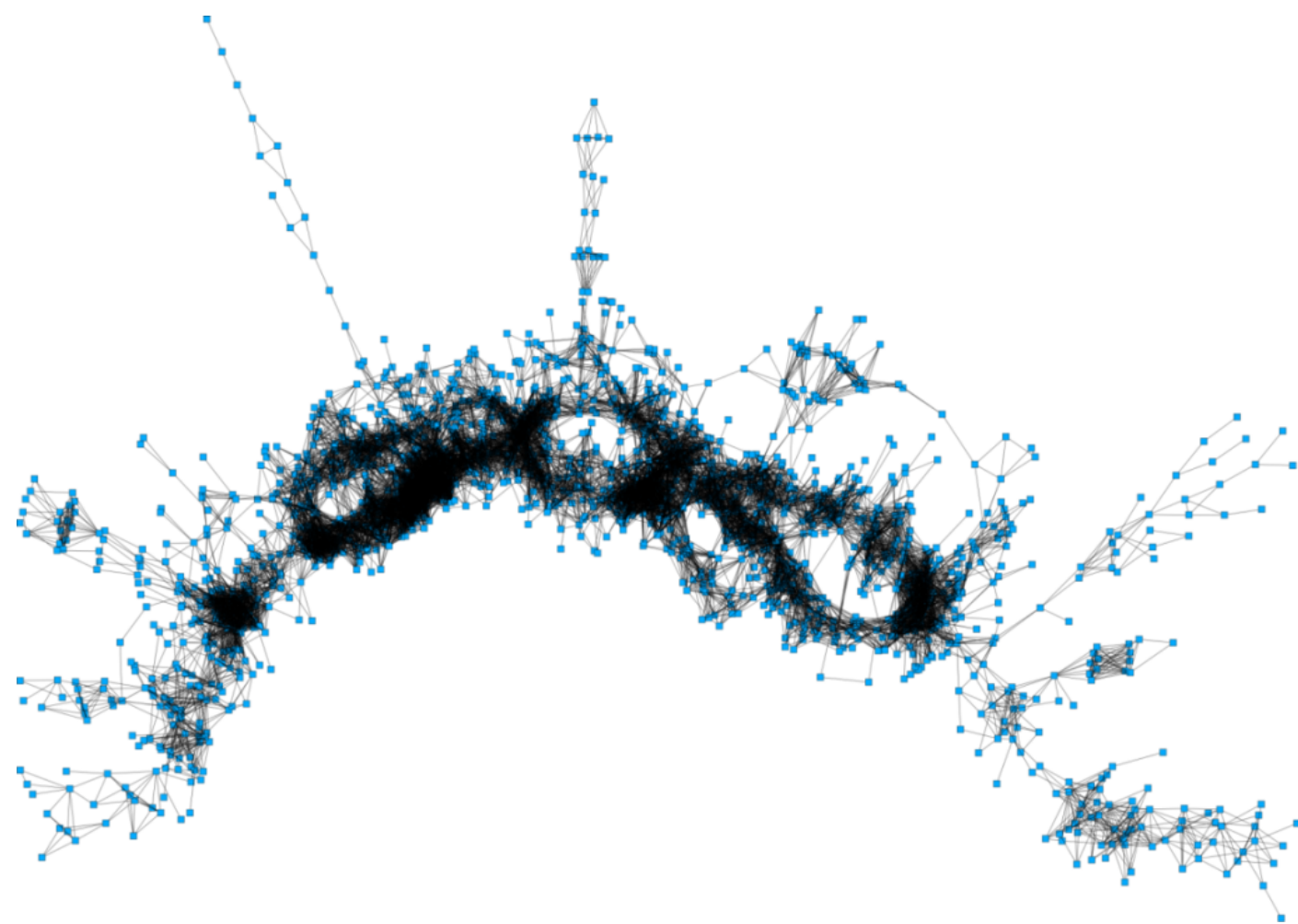


US migration graph

*Holten & van Wijk
(EuroVis 2009).*
Force-Directed Edge
Bundling for Graph
Visualization.

What about edge crossing?

- Some quality measures that work well for small graphs (such as edge crossing) seem to lose their importance the larger a graph gets

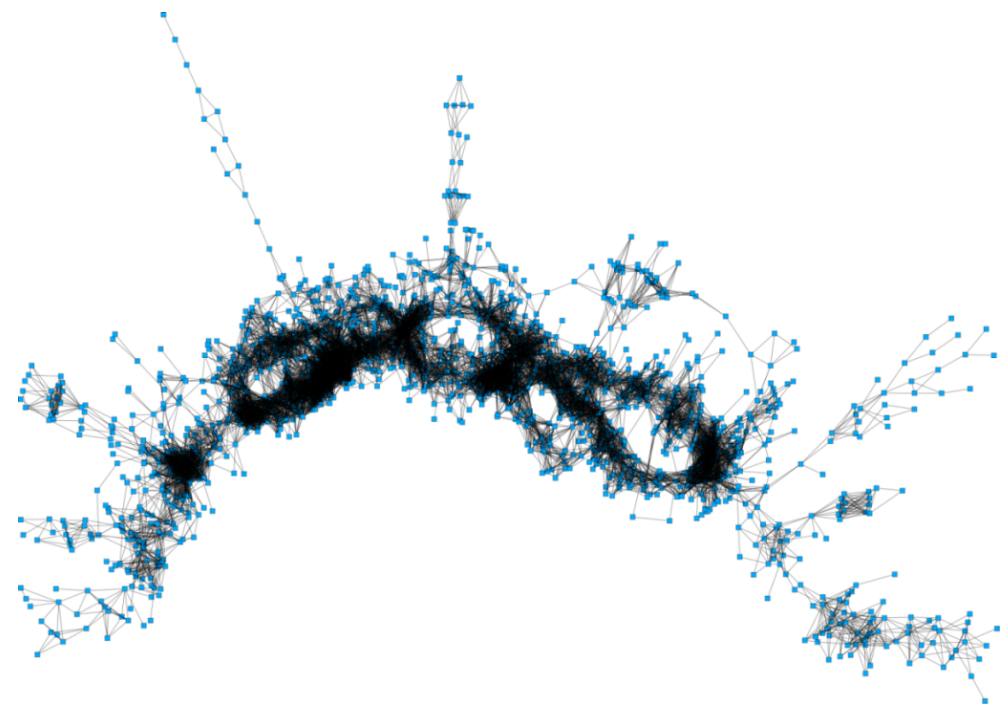


<http://eppsnet.com/images/facebook-hairball.png>

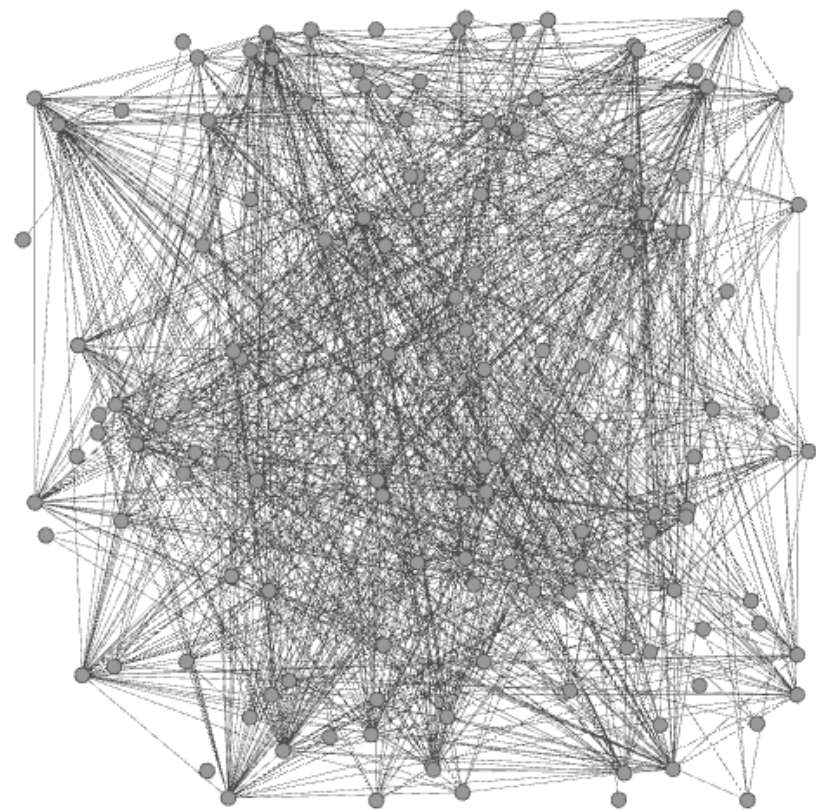
© Eades

How many edge crossing do you see?

Instead: “Show me the structure”



A



B



“Diagram A is better than diagram B because diagram A shows the structure of the graph, and diagram B does not show the structure.”

1.11 2.23 3.34 4.45 5.56 6.67 7.78 8.89 9.10 11.12 12.13 13.14 14.15 15.16 16.17 17.18 19.19 20.20 21.21 22.22 23.23 24.24 25.25 26.26 27.28 29.29 30.30 31.31
32.33 34.34 35.35 36.36 37.37 38.38 39.39 40.40 41.41 42.42 43.43 44.44 45.45 46.46 47.47 48.48 49.49 50.50 51.51 52.52 53.53 54.54 55.55 56.56 57.57
58.58 59.59 60.60 61.61 62.62 63.63 64.64 65.65 66.66 67.67 68.68 69.69 70.70 71.71 72.72 73.73 74.74 75.75 76.76 77.77 78.78 79.79 80.80 81.81 82.82 83.83 84.84
85.85 86.86 87.87 88.88 89.89 90.90 91.91 92.92 93.93 94.94 95.95 96.96 97.97 98.98 99.99 100.100 101.101 102.102 103.103 104.104 105.105 106.106 107.107 108.108 109.109 110.110 111.111 112.112 113.113 114.114 115.115 116.116 117.117 118.118 119.119 120.120 121.121 122.122 123.123 124.124 125.125 126.126 127.127 128.128 129.129 130.130 131.131 132.132 133.133 134.134 135.135 136.136 137.137 138.138 139.139 140.140 141.141 142.142 143.143 144.144 145.145 146.146 147.147 148.148 149.149 150.150 151.151 152.152 153.153 154.154 155.155 156.156 157.157 158.158 159.159 160.160 161.161 162.162 163.163 164.164 165.165 166.166 167.167 168.168 169.169 170.170 171.171 172.172 173.173 174.174 175.175 176.176 177.177 178.178 179.179 180.180 181.181 182.182 183.183 184.184 185.185 186.186 187.187 188.188 189.189 190.190 191.191 192.192 193.193 194.194 195.195 196.196 197.197 198.198 199.199 200.200 201.201 202.202 203.203 204.204 205.205 206.206 207.207 208.208 209.209 210.210 211.211 212.212 213.213 214.214 215.215 216.216 217.217 218.218 219.219 220.220 221.221 222.222 223.223 224.224 225.225 226.226 227.227 228.228 229.229 230.230 231.231 232.232 233.233 234.234 235.235 236.236 237.237 238.238 239.239 240.240 241.241 242.242 243.243 244.244 245.245 246.246 247.247 248.248 249.249 250.250 251.251 252.252 253.253 254.254 255.255 256.256 257.257 258.258 259.259 260.260 261.261 262.262 263.263 264.264 265.265 266.266 267.267 268.268 269.269 270.270 271.271 272.272 273.273 274.274 275.275 276.276 277.277 278.278 279.279 280.280 281.281 282.282 283.283 284.284 285.285 286.286 287.287 288.288 289.289 290.290 291.291 292.292 293.293 294.294 295.295 296.296 297.297 298.298 299.299 300.300 301.301 302.302 303.303 304.304 305.305 306.306 307.307 308.308 309.309 310.310 311.311 312.312 313.313 314.314 315.315 316.316 317.317 318.318 319.319 320.320 321.321 322.322 323.323 324.324 325.325 326.326 327.327 328.328 329.329 330.330 331.331 332.332 333.333 334.334 335.335 336.336 337.337 338.338 339.339 340.340 341.341 342.342 343.343 344.344 345.345 346.346 347.347 348.348 349.349 350.350 351.351 352.352 353.353 354.354 355.355 356.356 357.357 358.358 359.359 360.360 361.361 362.362 363.363 364.364 365.365 366.366 367.367 368.368 369.369 370.370 371.371 372.372 373.373 374.374 375.375 376.376 377.377 378.378 379.379 380.380 381.381 382.382 383.383 384.384 385.385 386.386 387.387 388.388 389.389 390.390 391.391 392.392 393.393 394.394 395.395 396.396 397.397 398.398 399.399 400.400 401.401 402.402 403.403 404.404 405.405 406.406 407.407 408.408 409.409 410.410 411.411 412.412 413.413 414.414 415.415 416.416 417.417 418.418 419.419 420.420 421.421 422.422 423.423 424.424 425.425 426.426 427.427 428.428 429.429 430.430 431.431 432.432 433.433 434.434 435.435 436.436 437.437 438.438 439.439 440.440 441.441 442.442 443.443 444.444 445.445 446.446 447.447 448.448 449.449 450.450 451.451 452.452 453.453 454.454 455.455 456.456 457.457 458.458 459.459 460.460 461.461 462.462 463.463 464.464 465.465 466.466 467.467 468.468 469.469 470.470 471.471 472.472 473.473 474.474 475.475 476.476 477.477 478.478 479.479 480.480 481.481 482.482 483.483 484.484 485.485 486.486 487.487 488.488 489.489 490.490 491.491 492.492 493.493 494.494 495.495 496.496 497.497 498.498 499.499 500.500 501.501 502.502 503.503 504.504 505.505 506.506 507.507 508.508 509.509 510.510 511.511 512.512 513.513 514.514 515.515 516.516 517.517 518.518 519.519 520.520 521.521 522.522 523.523 524.524 525.525 526.526 527.527 528.528 529.529 530.530 531.531 532.532 533.533 534.534 535.535 536.536 537.537 538.538 539.539 540.540 54



Peter Eades et al.
(Graph Drawing 2015).
Shape-Based Quality Metrics for
Large Graph Visualization.

Outline

1. Technique-driven research

- Trends in graph drawing
- Trends in visualization — Related to graph drawing

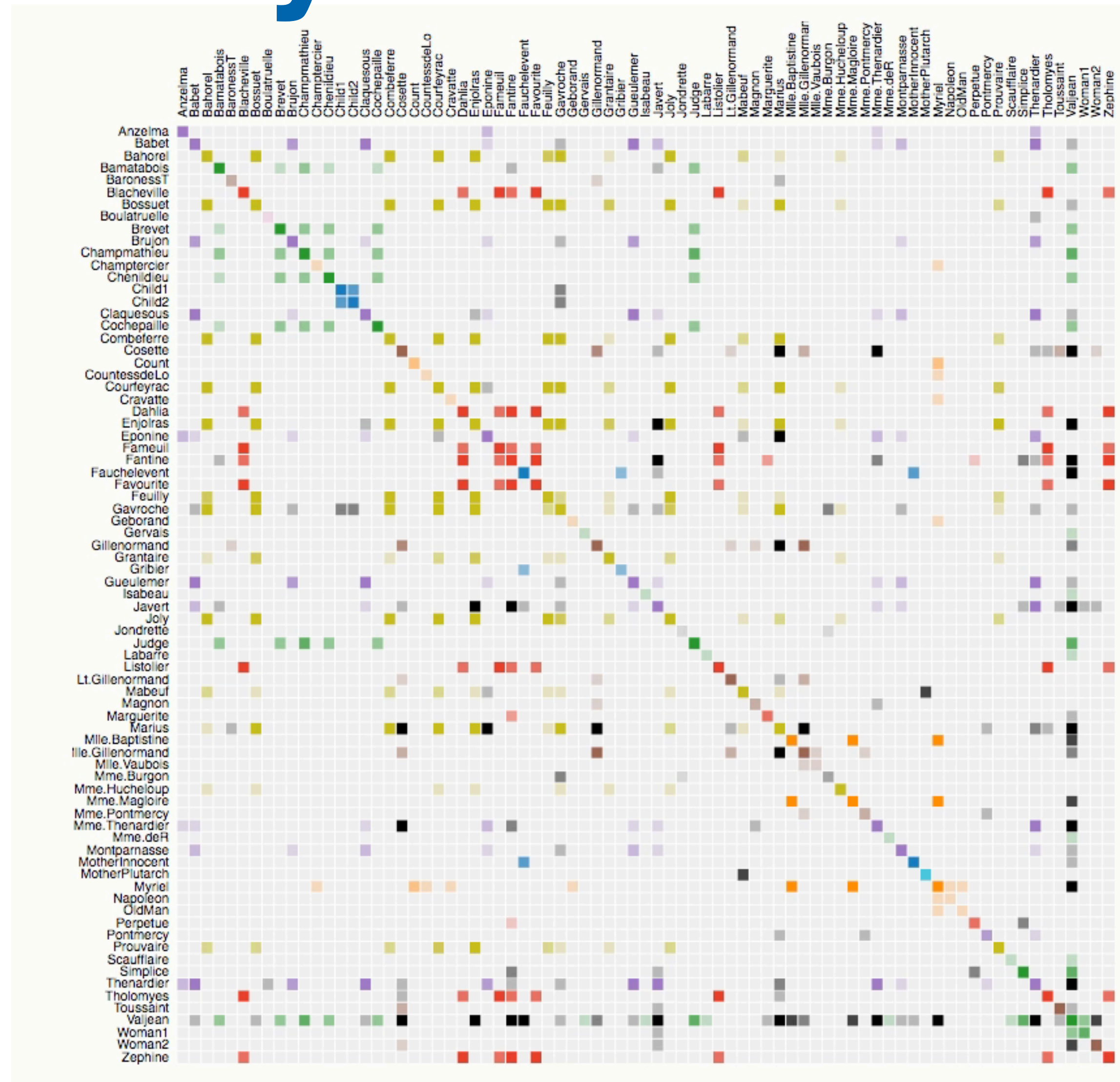
2. Problem-driven research

- Design Study Example — RelEx
- Design Study Methodology

3. Summary

Alternative representations

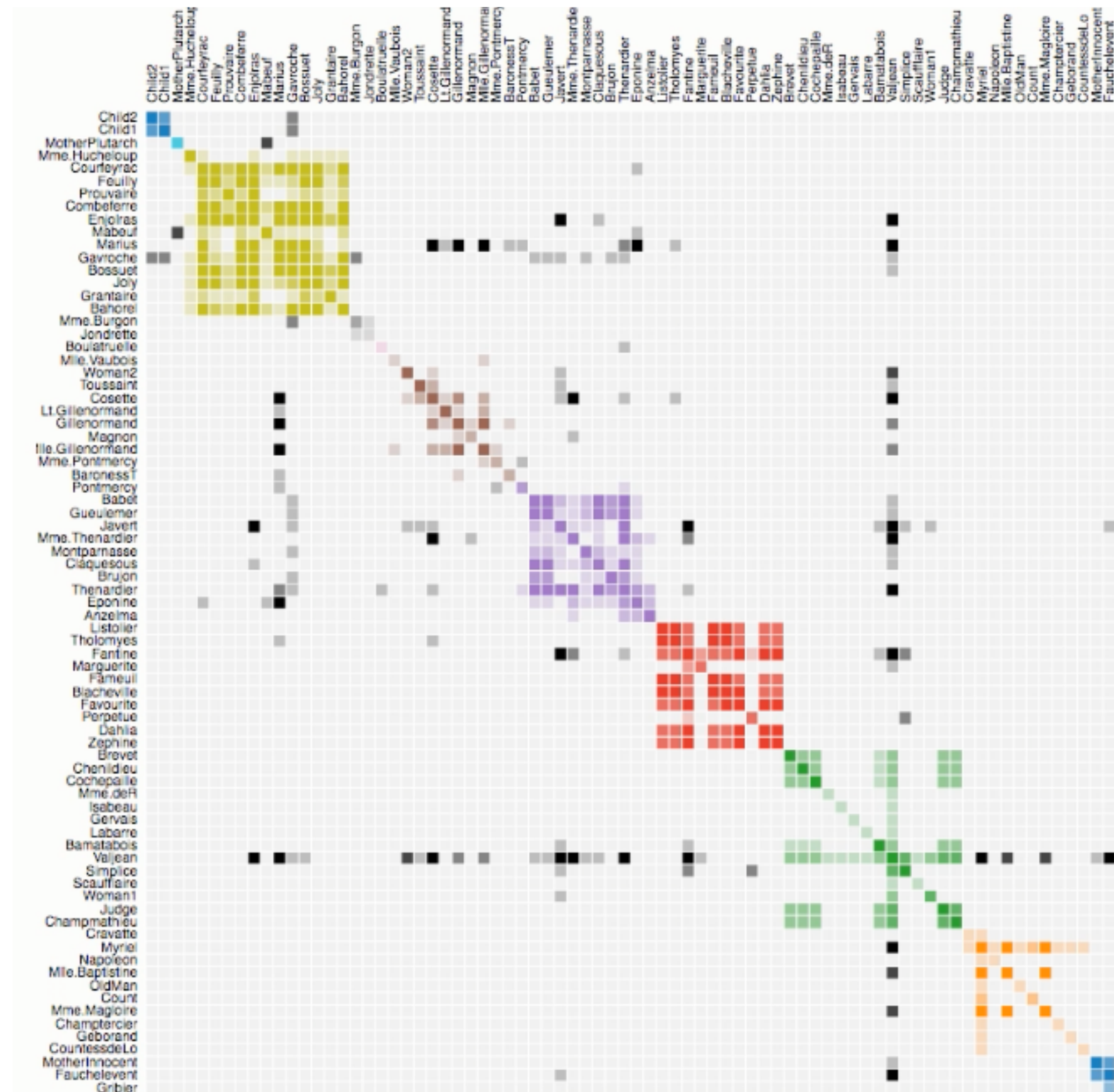
Adjacency Matrix



Michael Behrisch, et al.
(EuroVis STARs 2016).
Matrix Reordering Methods
for Table and Network
Visualization.

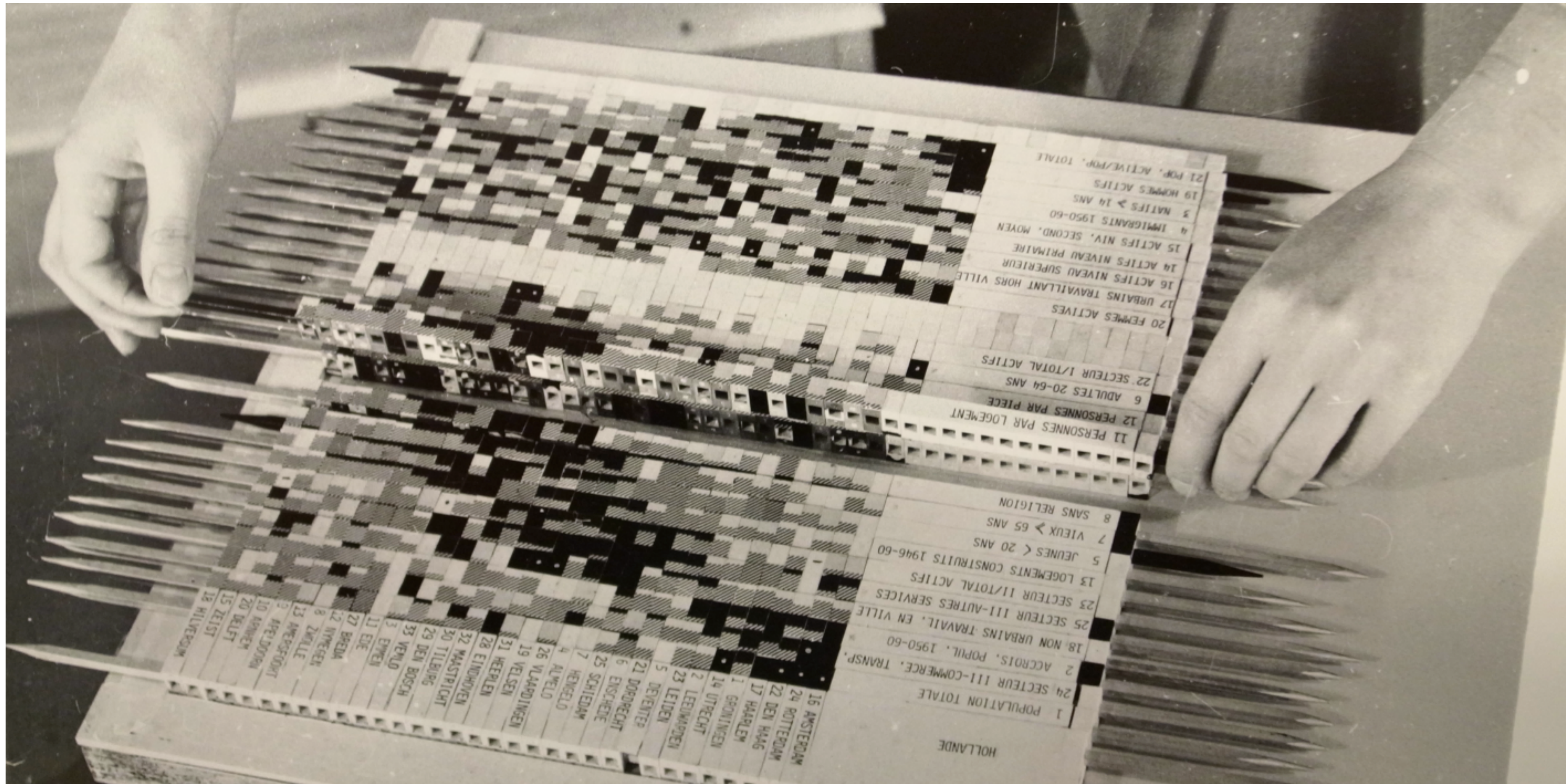
<https://bost.ocks.org/mike/miserables/>

Adjacency Matrix



Michael Behrisch, et al.
(EuroVis STARs 2016).
Matrix Reordering Methods
for Table and Network
Visualization.

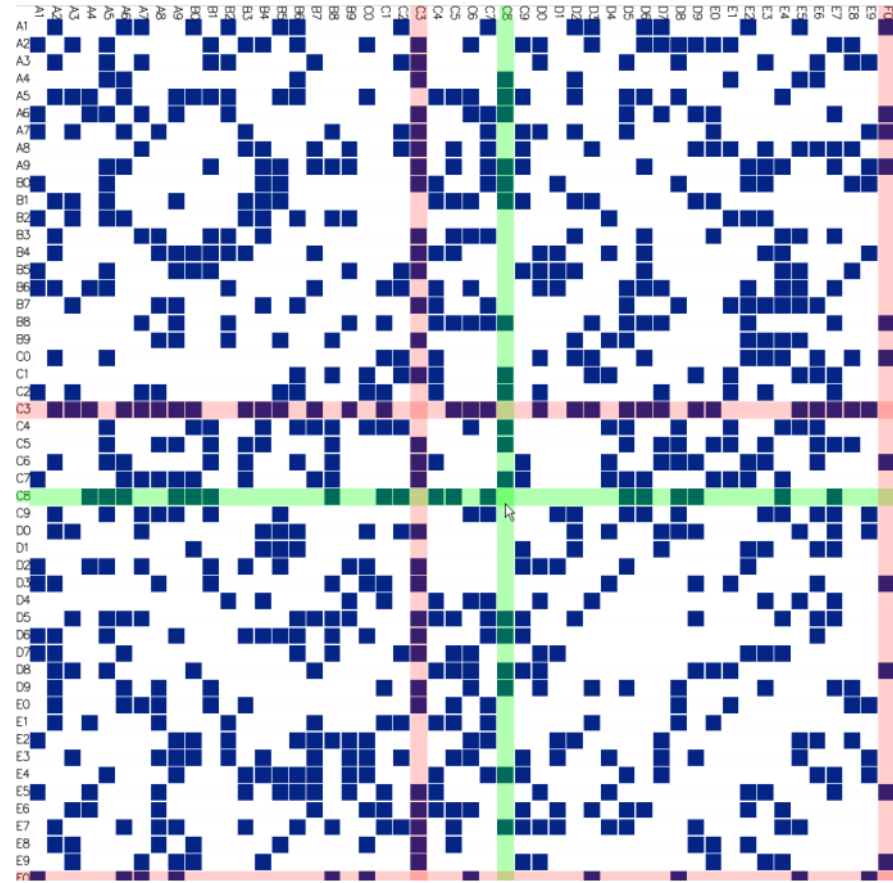
Adjacency Matrix (physical)



Jacques
Bertin,
1968

<http://www.aviz.fr/wiki/uploads/Bertifier/bertifier-authorversion.pdf>

Matrix or Node-link?

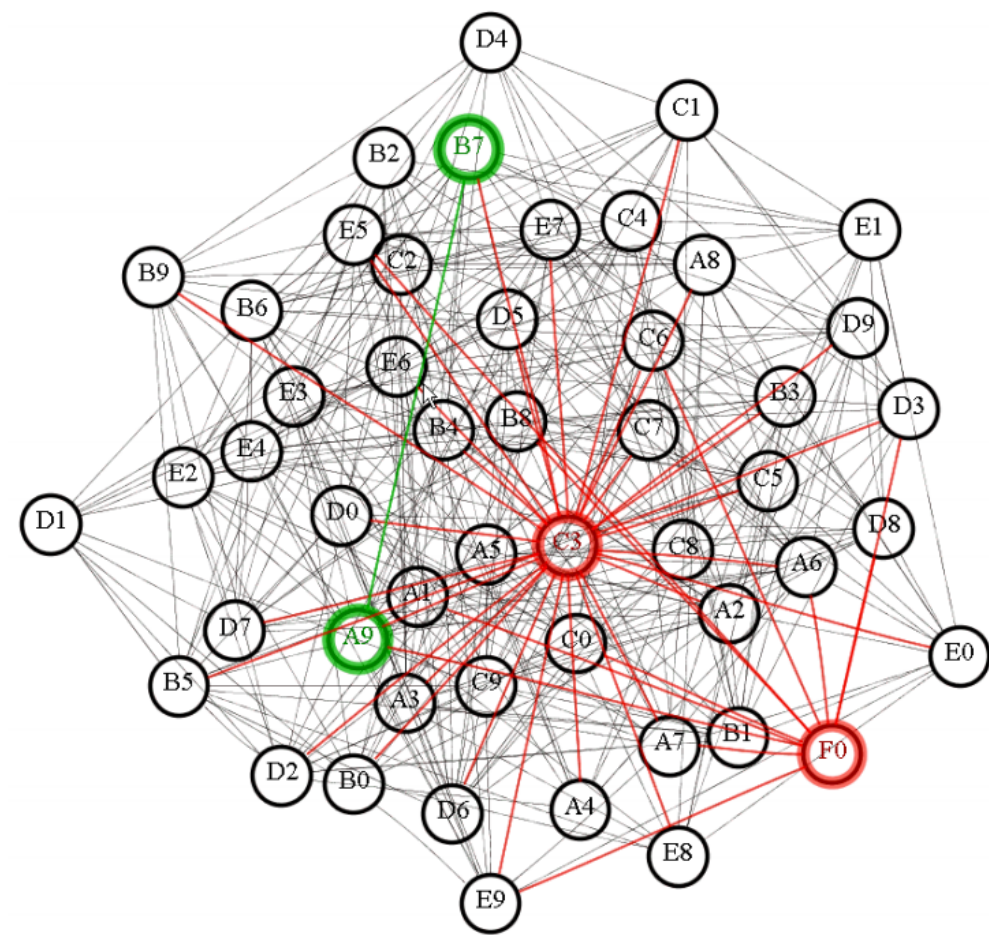


- Study
 - 36 users
 - 9 networks
 - 7 tasks —> measure time & errors

- Results

- **Node-link** only for:
 - small graphs (~20 nodes)
 - path finding tasks
- Else **Matrix**

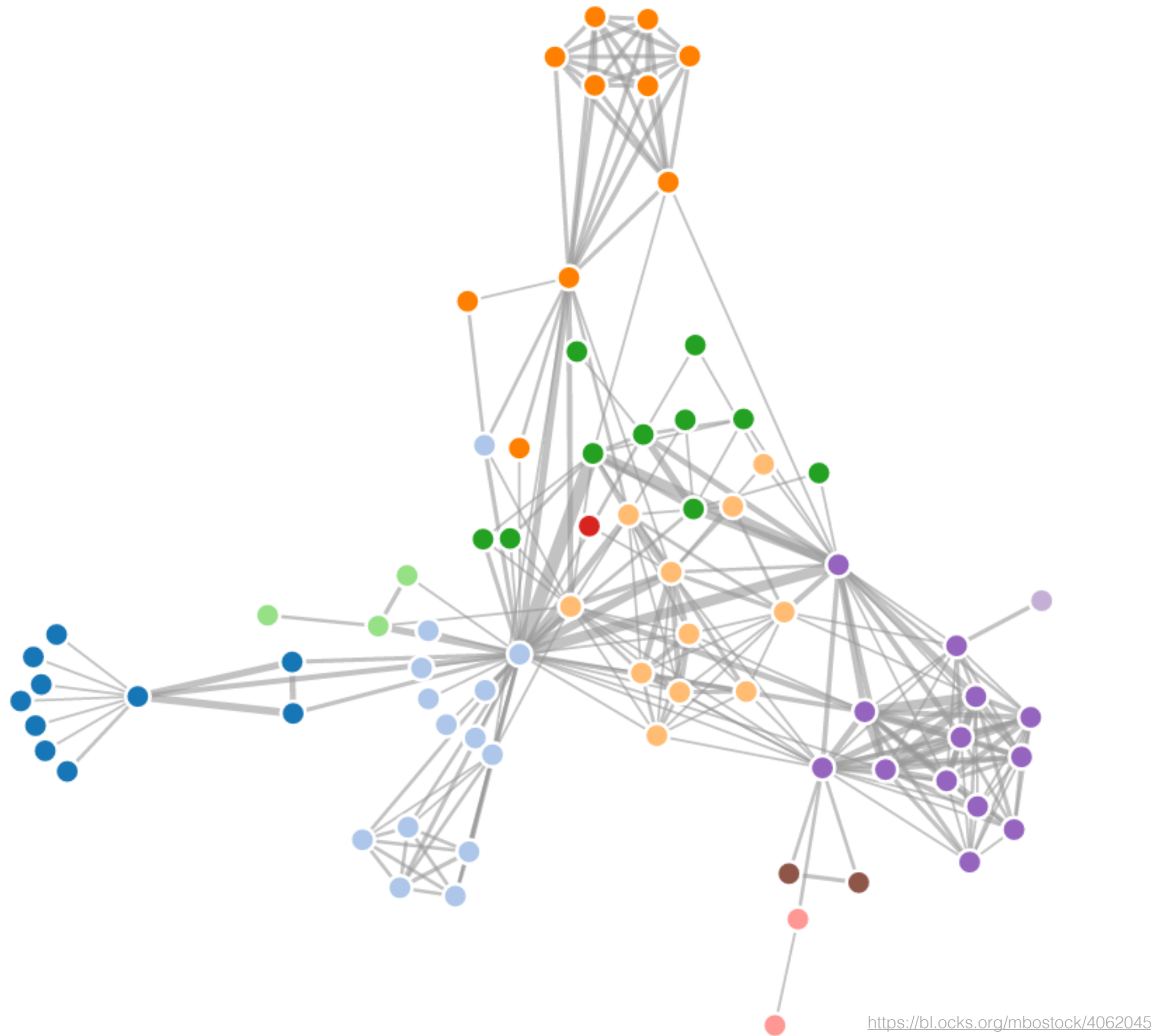
- Limitations



Ghoniem et al. (InfoVis 2004).
A Comparison of the Readability of
Graphs Using Node-Link and
Matrix-Based Representations.

Additional encodings

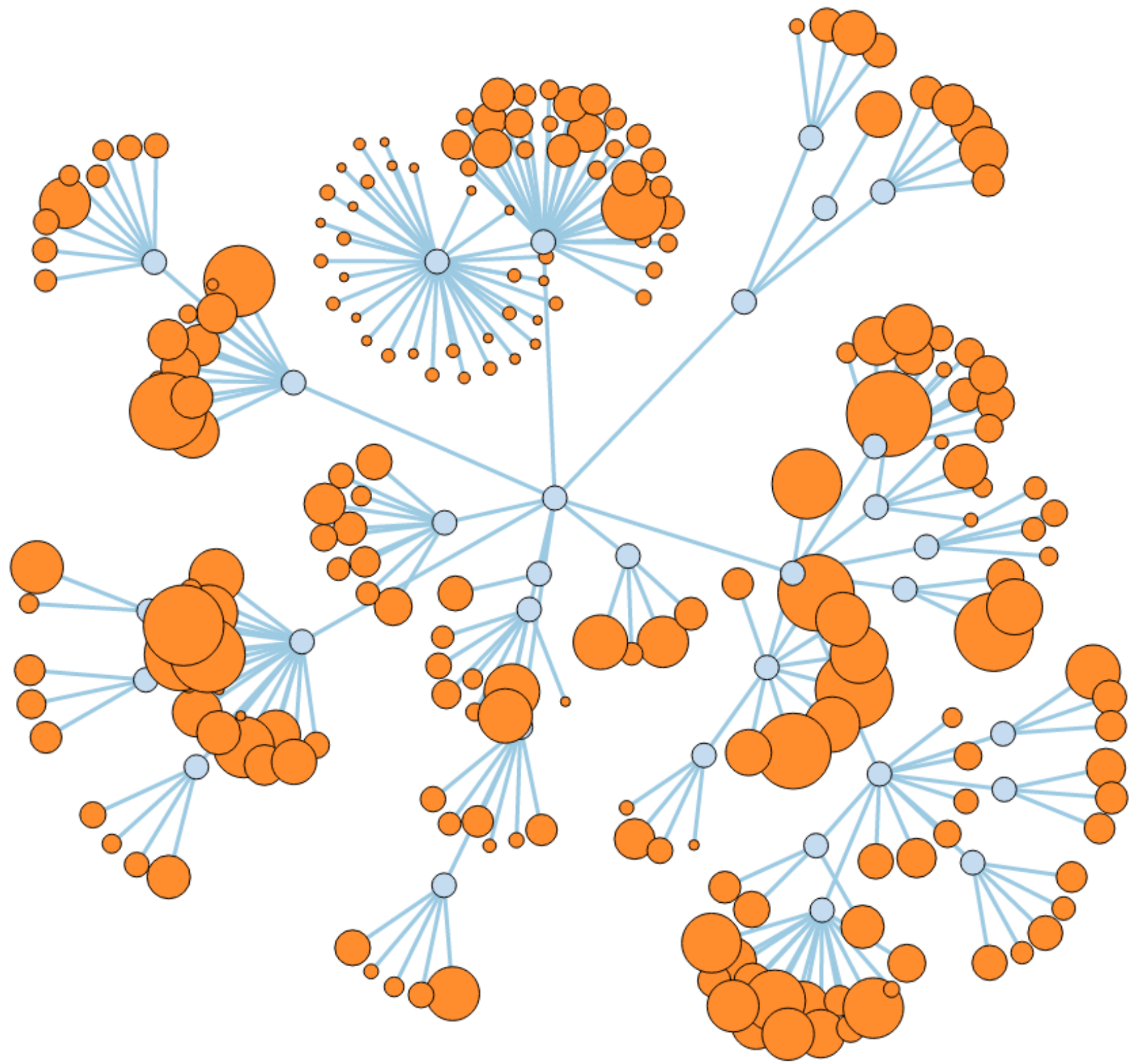
Color and width



Additional encodings

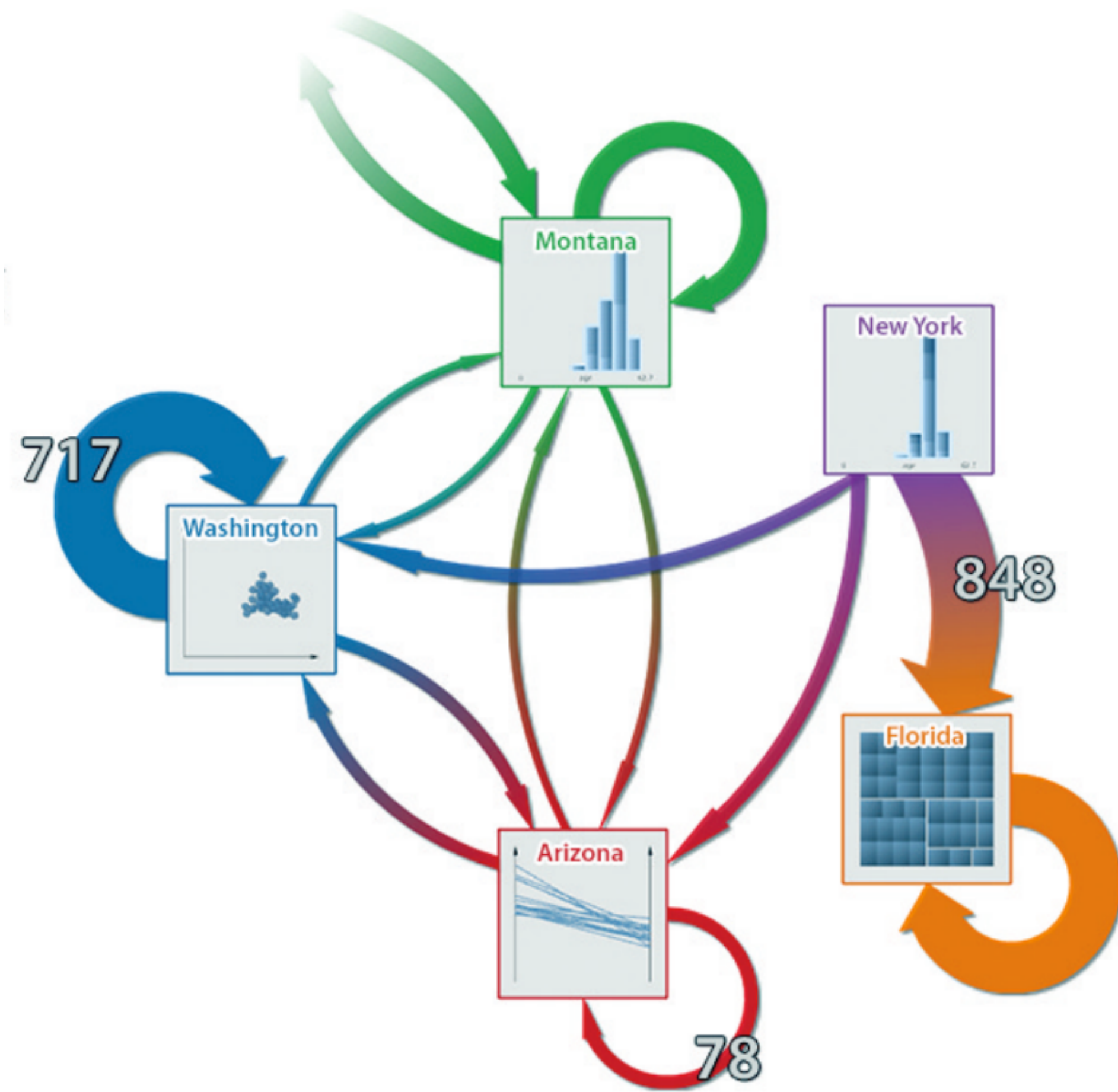
- Nodes, e.g. through color
- Edges, e.g. stroke-width

Size



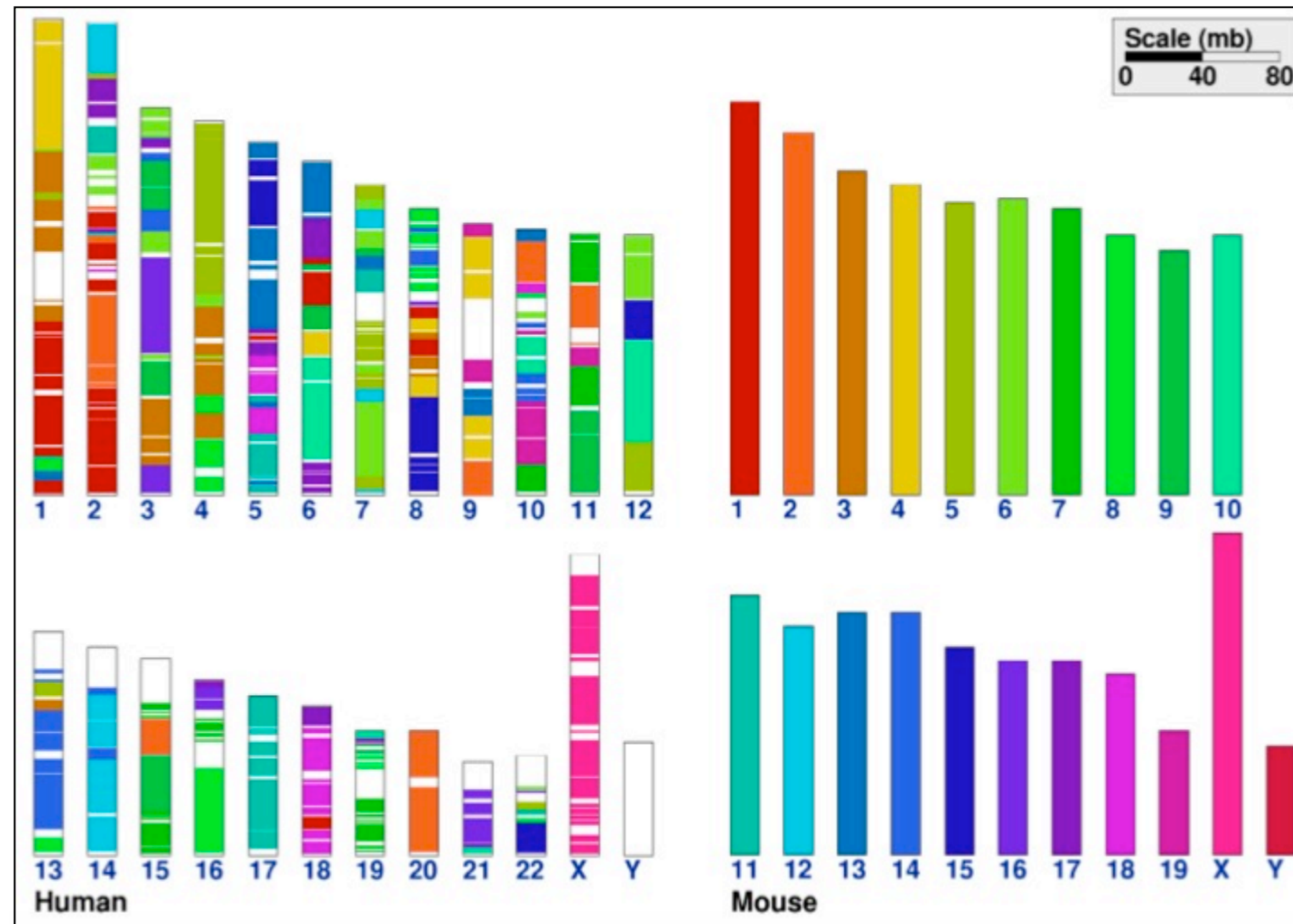
<http://mbostock.github.io/d3/talk/20111116/force-collapsible.html>

More complex data



Stef van den Elzen and Jarke J. van Wijk (InfoVis 2014)
Multivariate Network Exploration and Presentation:
From Detail to Overview via Selections and Aggregations

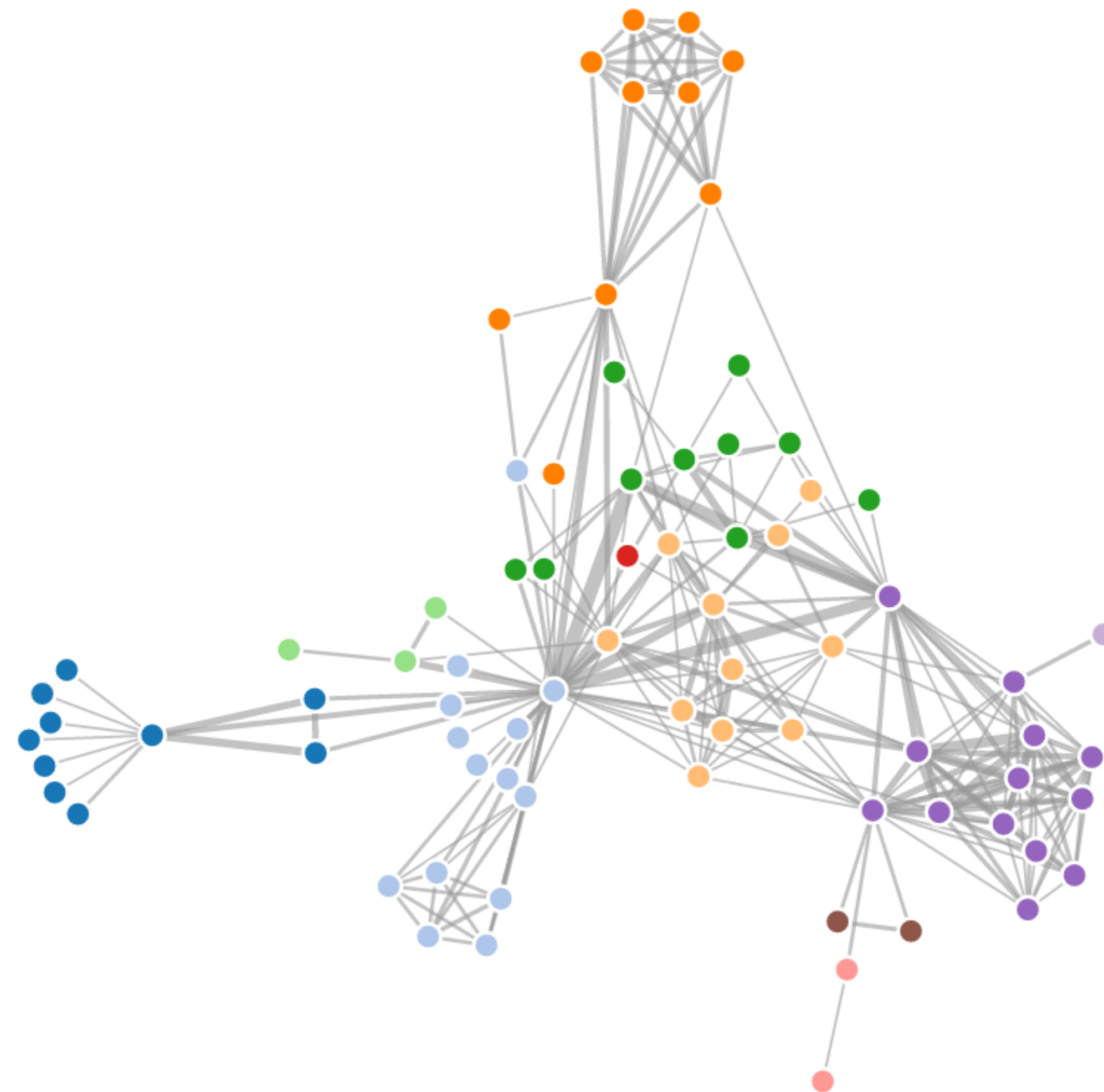
Visual Encoding: Color?



noncontiguous small
regions of color:
only 6-12 bins

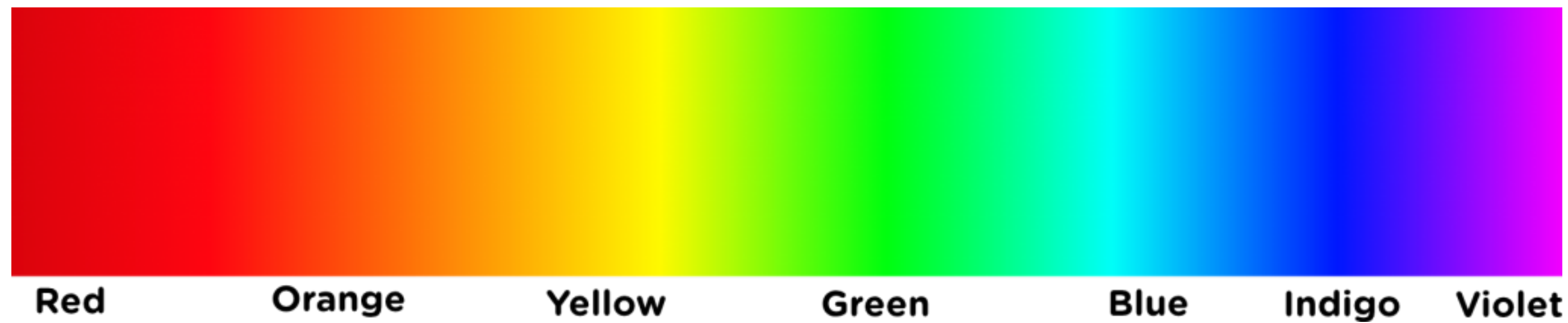
Sinha and Meller. Cinteny: flexible analysis and visualization of synteny and genome rearrangements in multiple organisms. Bioinformatics 2007.

Visual Encoding: Color?

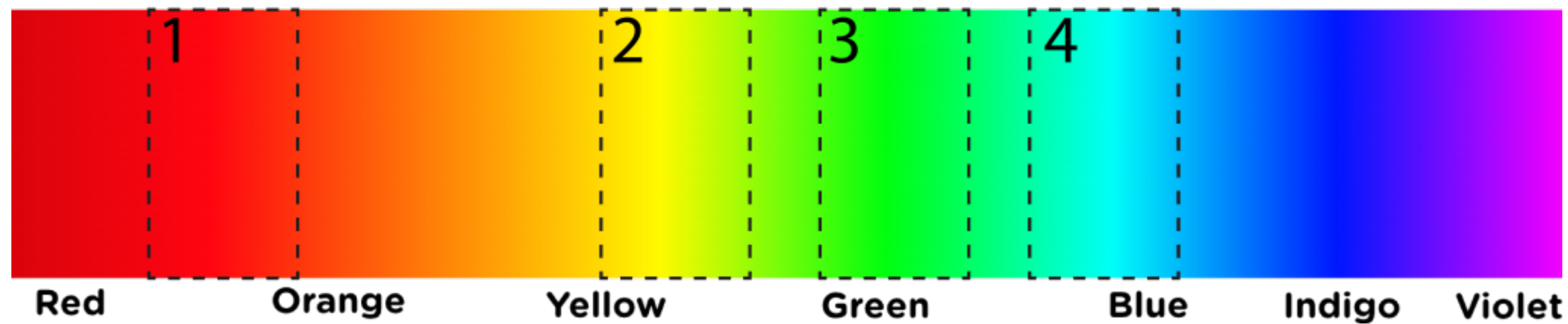


noncontiguous small
regions of color:
only 6-12 bins

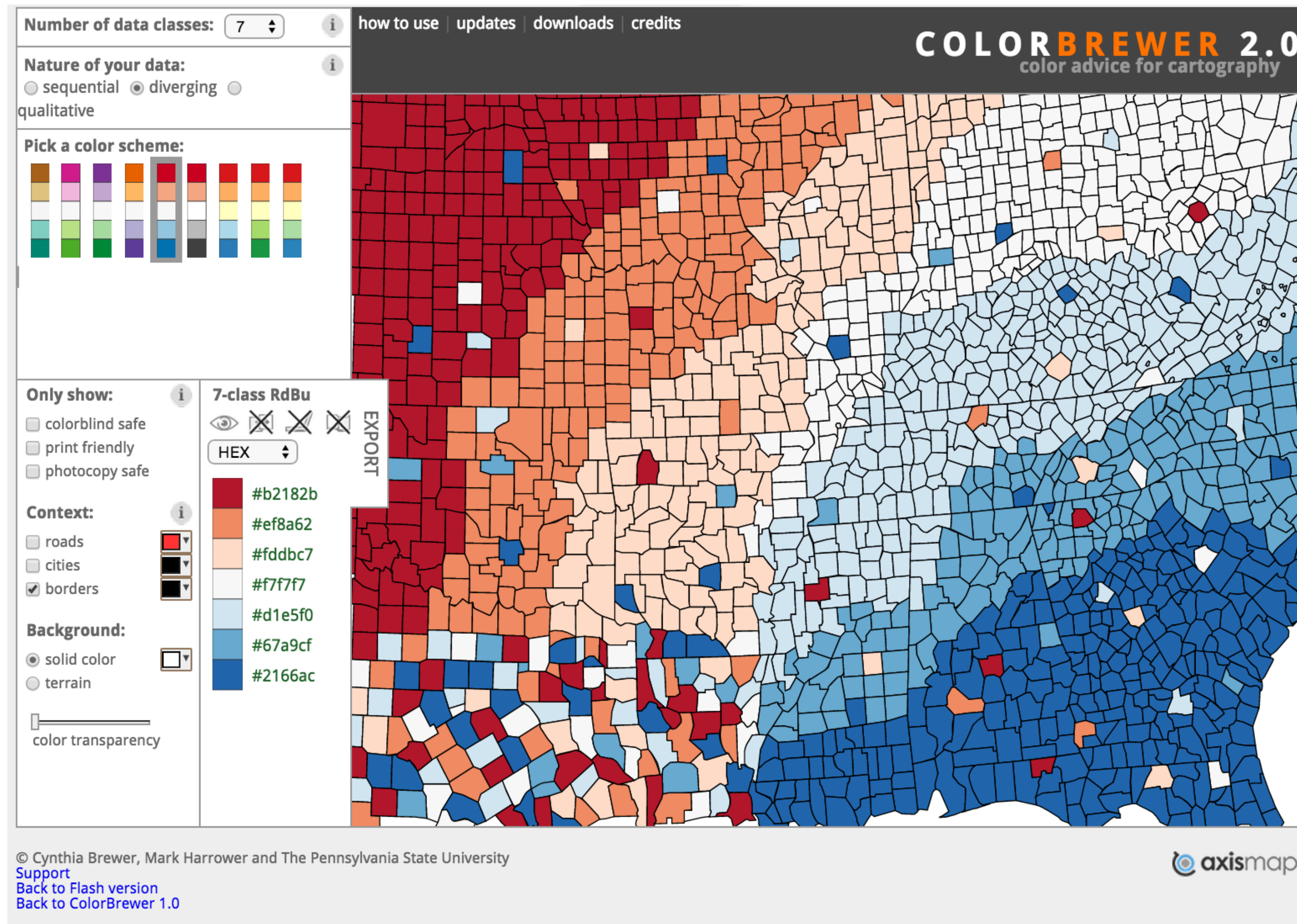
Rainbow color maps?



<https://courses.washington.edu/engageuw/why-you-should-dump-the-rainbow/>

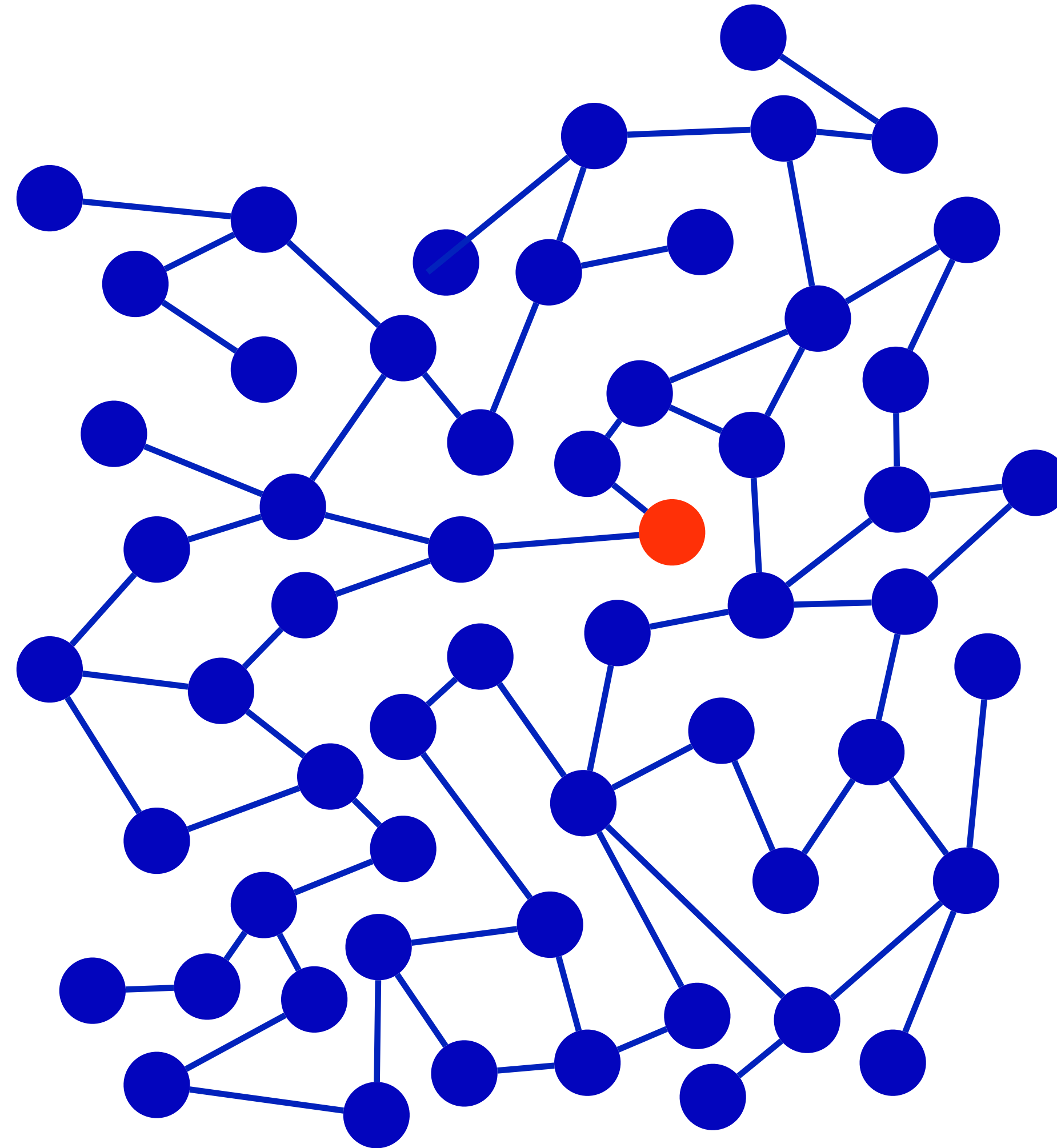


Solutions, e.g. ColorBrewer

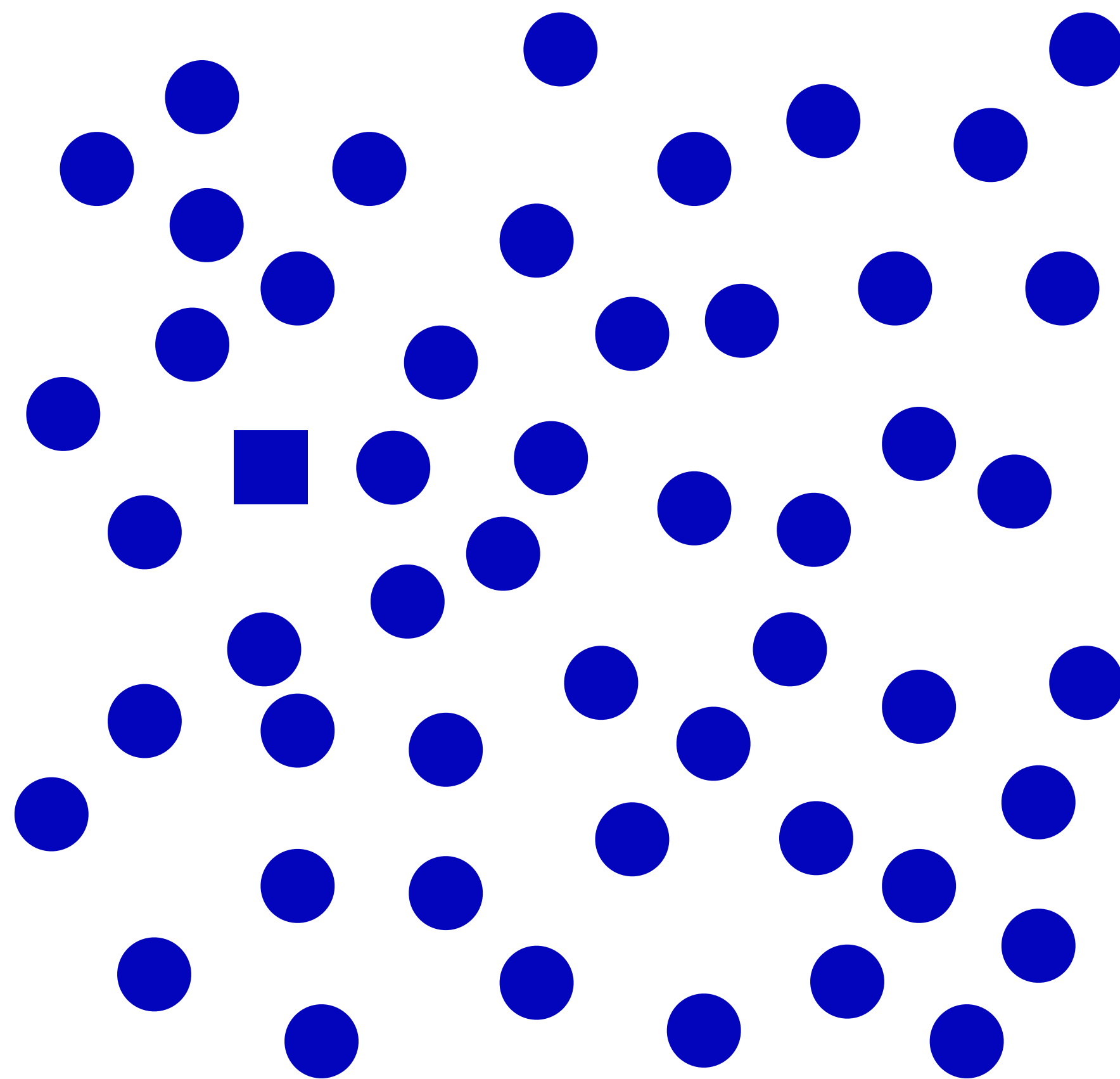


<http://colorbrewer2.org/#type=sequential&scheme=BuGn&n=3>

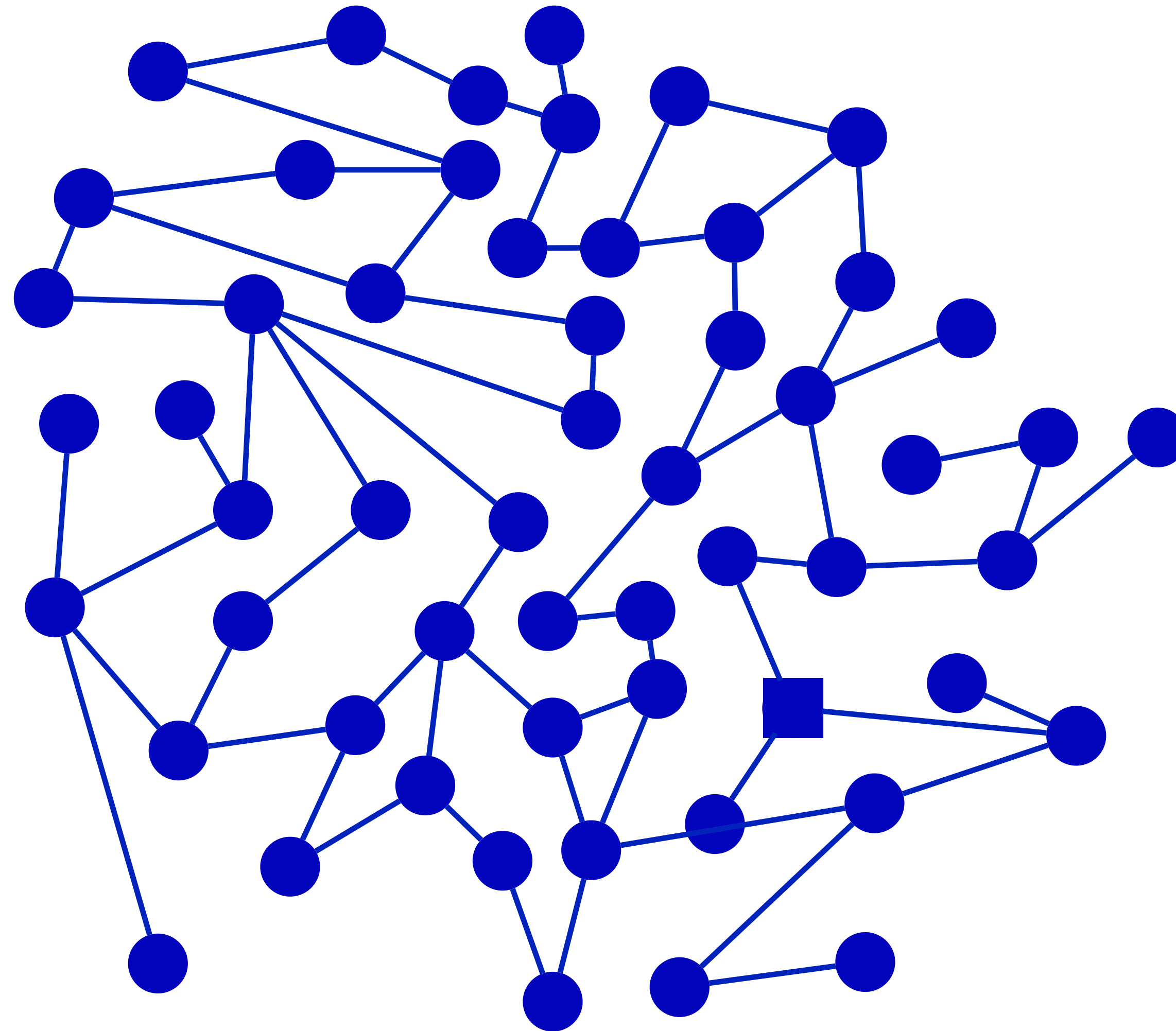
Popout



Popout

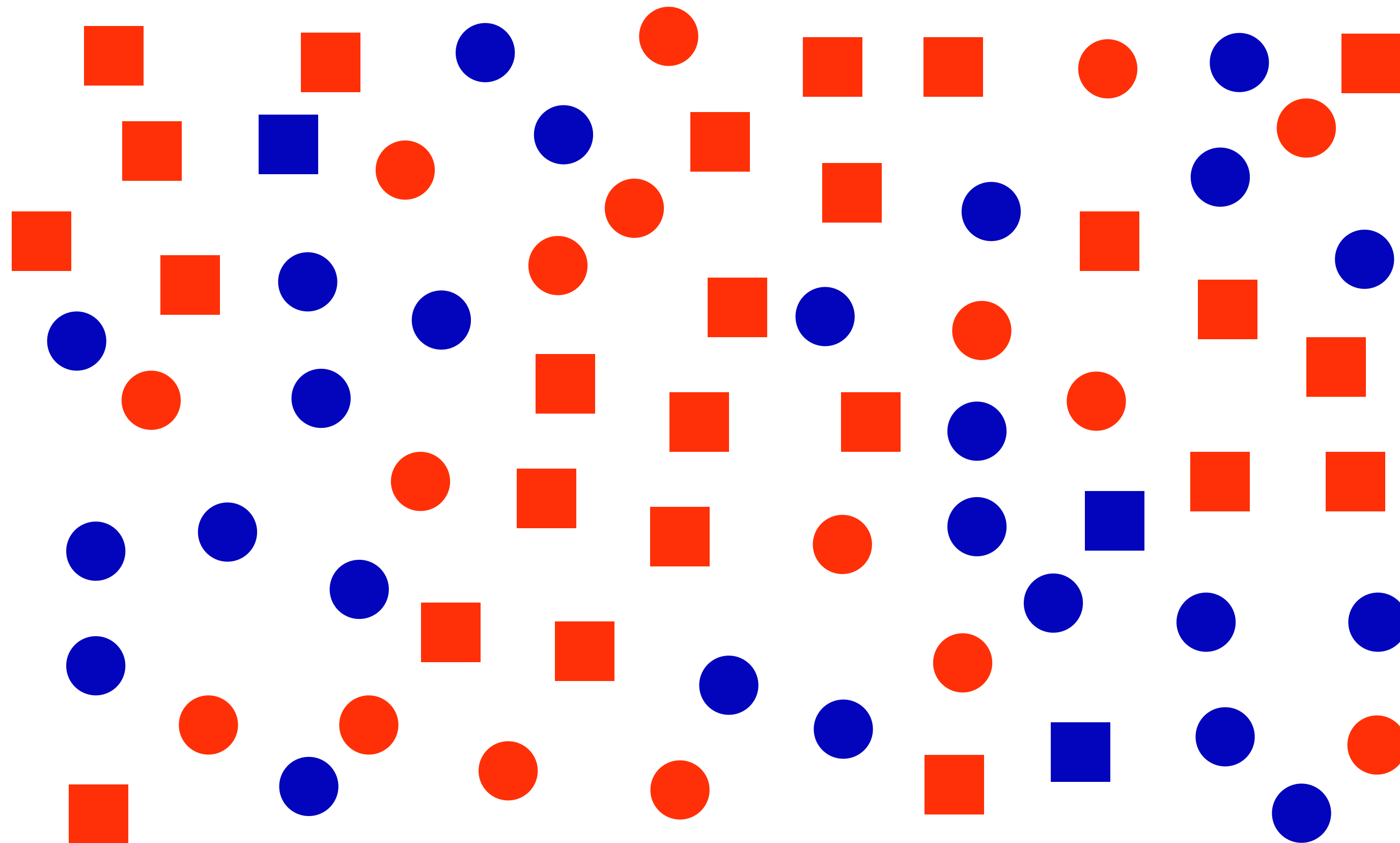


Popout



Popout: combining channels?

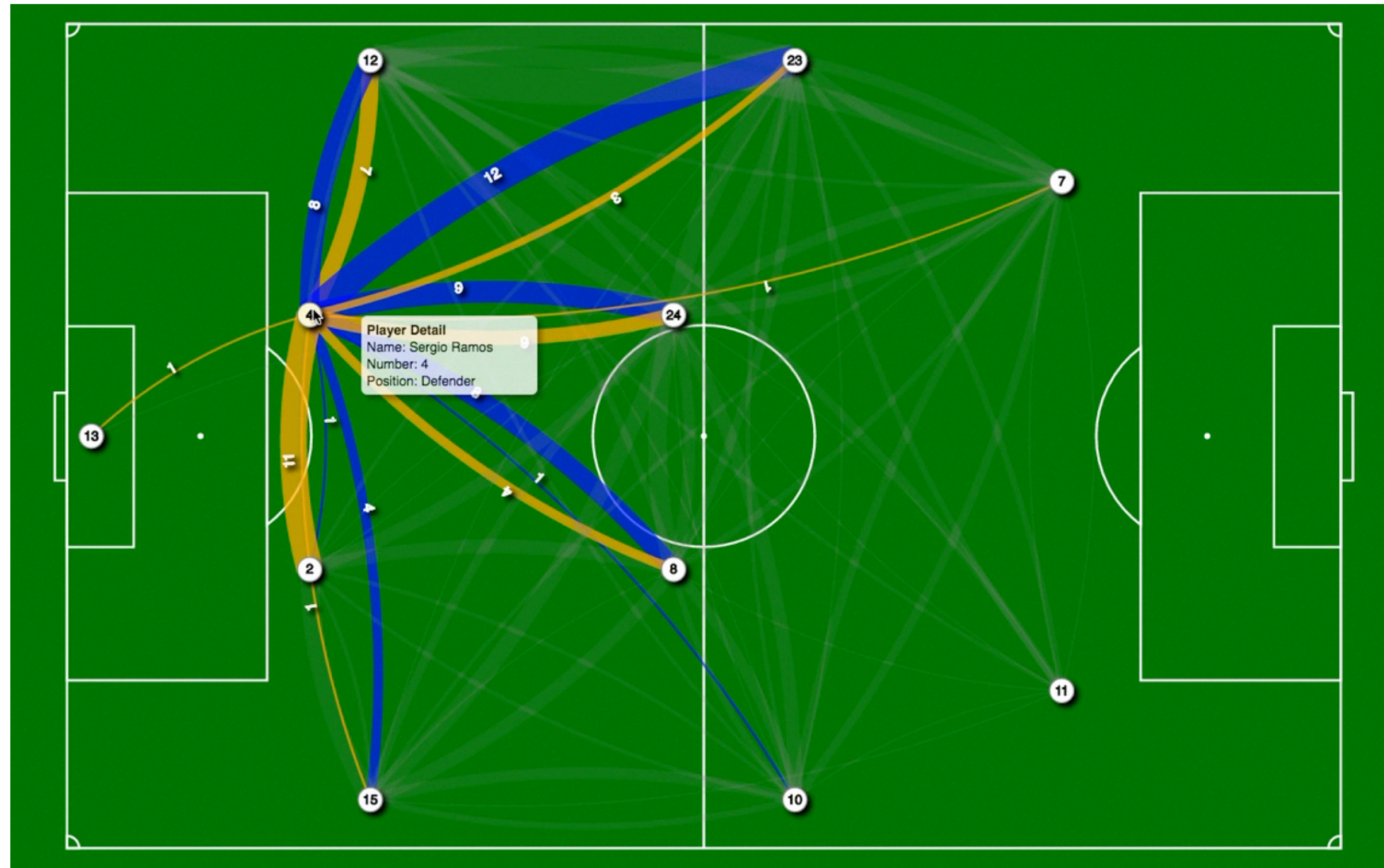
How many blue rectangles?



Interaction

(as a way of dealing with scalability)

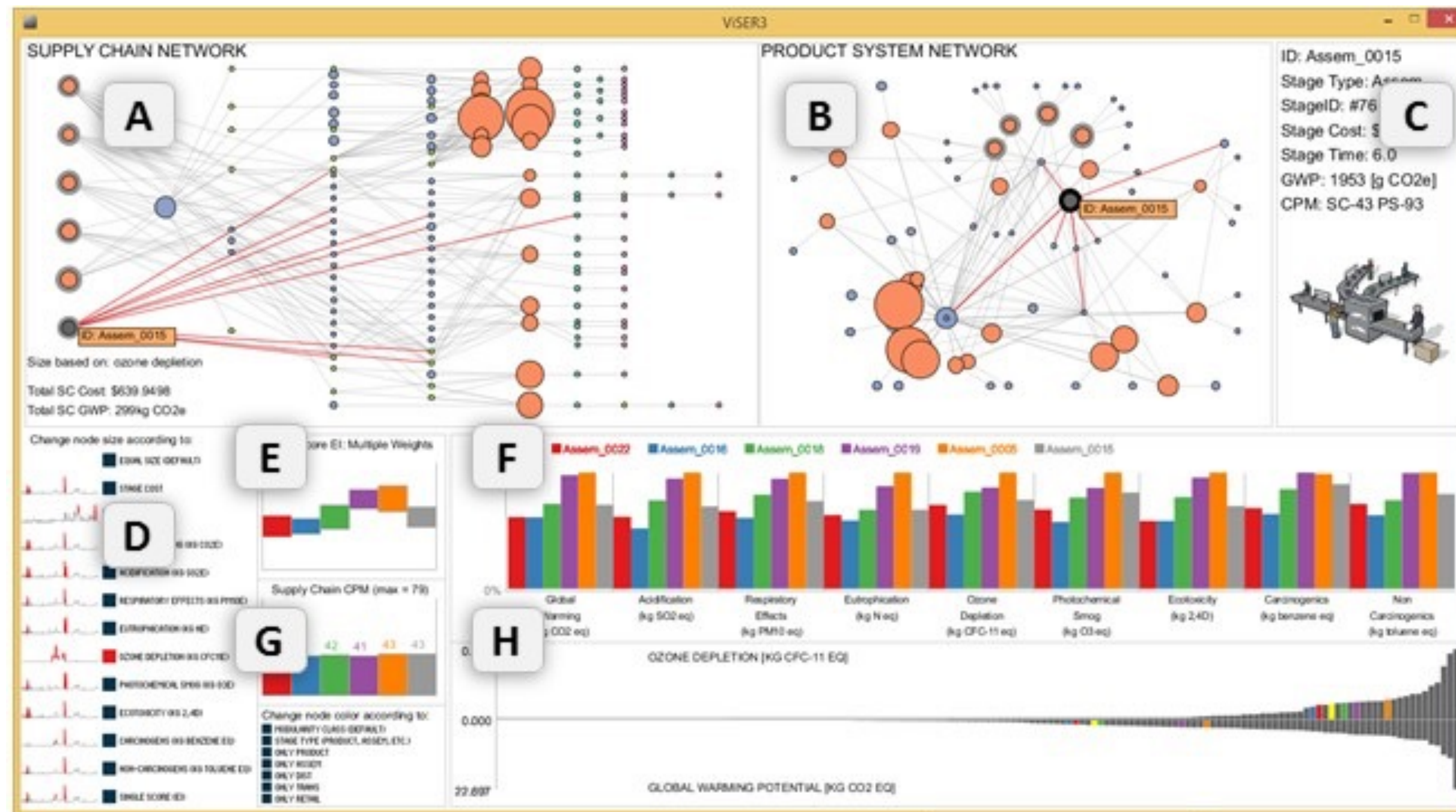
Interactive highlighting



<http://bl.ocks.org/fernand/9a9f93f2a6b0e83a9294>

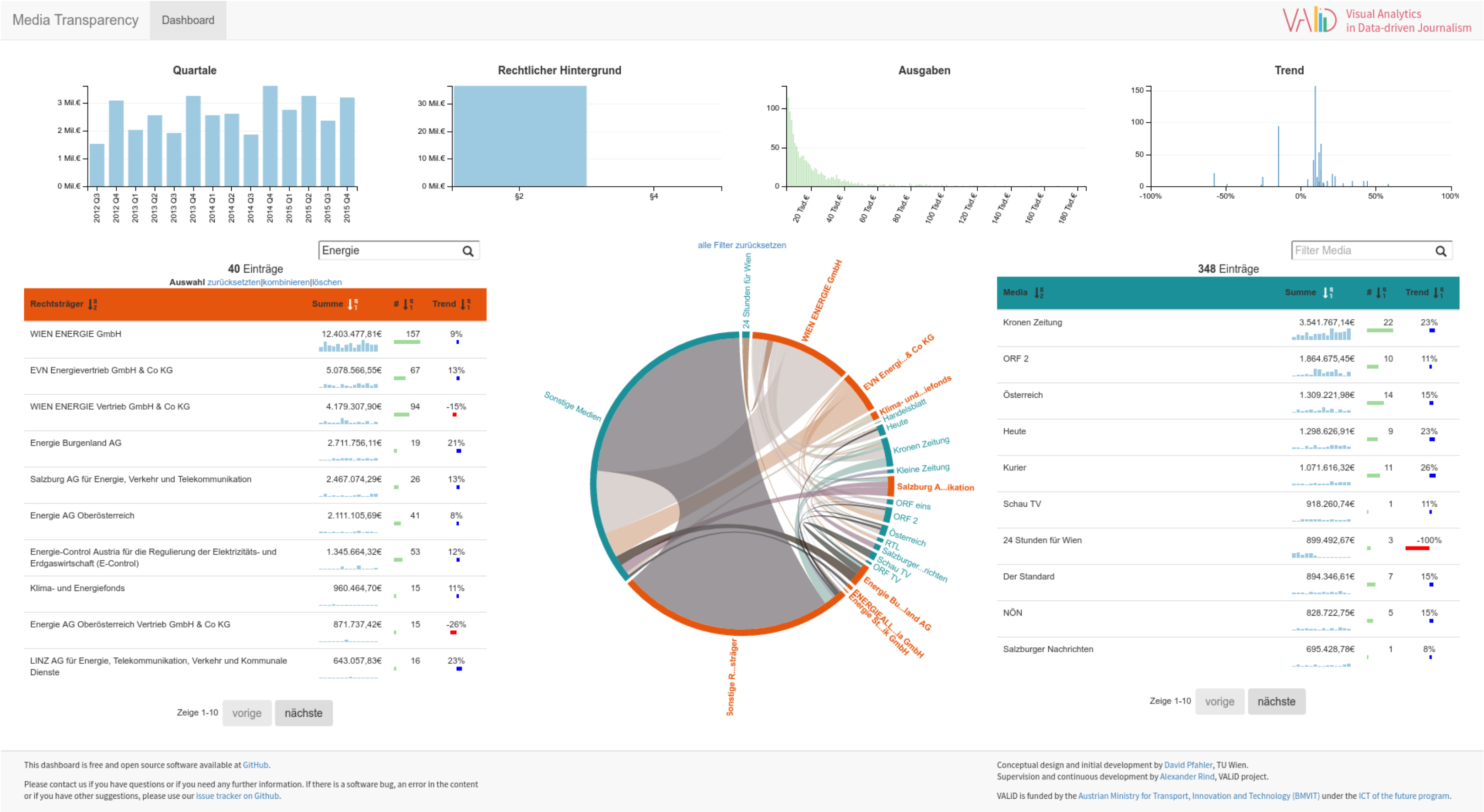
- Inherent design tradeoff:
- Amount of data shown
 - Time (Interaction/Animation)

Multiple Views + Linking and brushing



William Z. Bernstein, et al.
Mutually coordinated visualization of product and supply chain metadata for sustainable design.
Journal of Mechanical Design. 2015 Dec 1;137(12):121101.

Multiple Views + Linking and brushing



This dashboard is free and open source software available at [GitHub](#).

Please contact us if you have questions or if you need any further information. If there is a software bug, an error in the content or if you have other suggestions, please use our [issue tracker](#) on [Github](#).

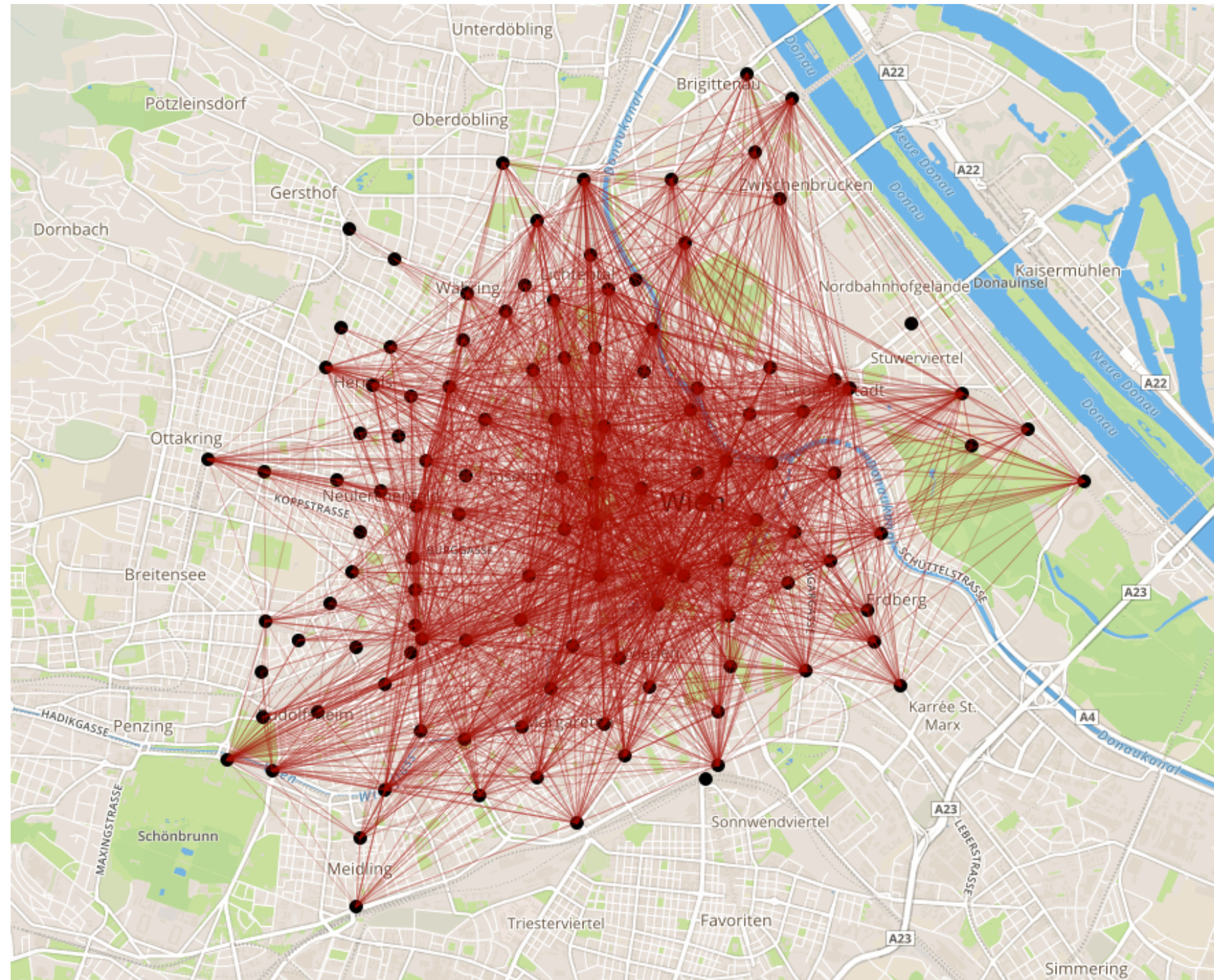
Conceptual design and initial development by [David Pfahler](#), TU Wien.
Supervision and continuous development by [Alexander Rind](#), VALID project.

VALID is funded by the [Austrian Ministry for Transport, Innovation and Technology \(BMVIT\)](#) under the ICT of the future program.



<http://medientransparenz.validproject.at/>

Demo: Bike Sharing Atlas



<http://oppermann.at/citybike/routes.php>

- Goal
 - visualize open data of 380 bike sharing networks
- Nodes: Stations
 - current status (full/empty)
 - filling levels record over 10 month (each 15 minutes)
 - ...
- Edges: trips
 - (only for very few networks really available)

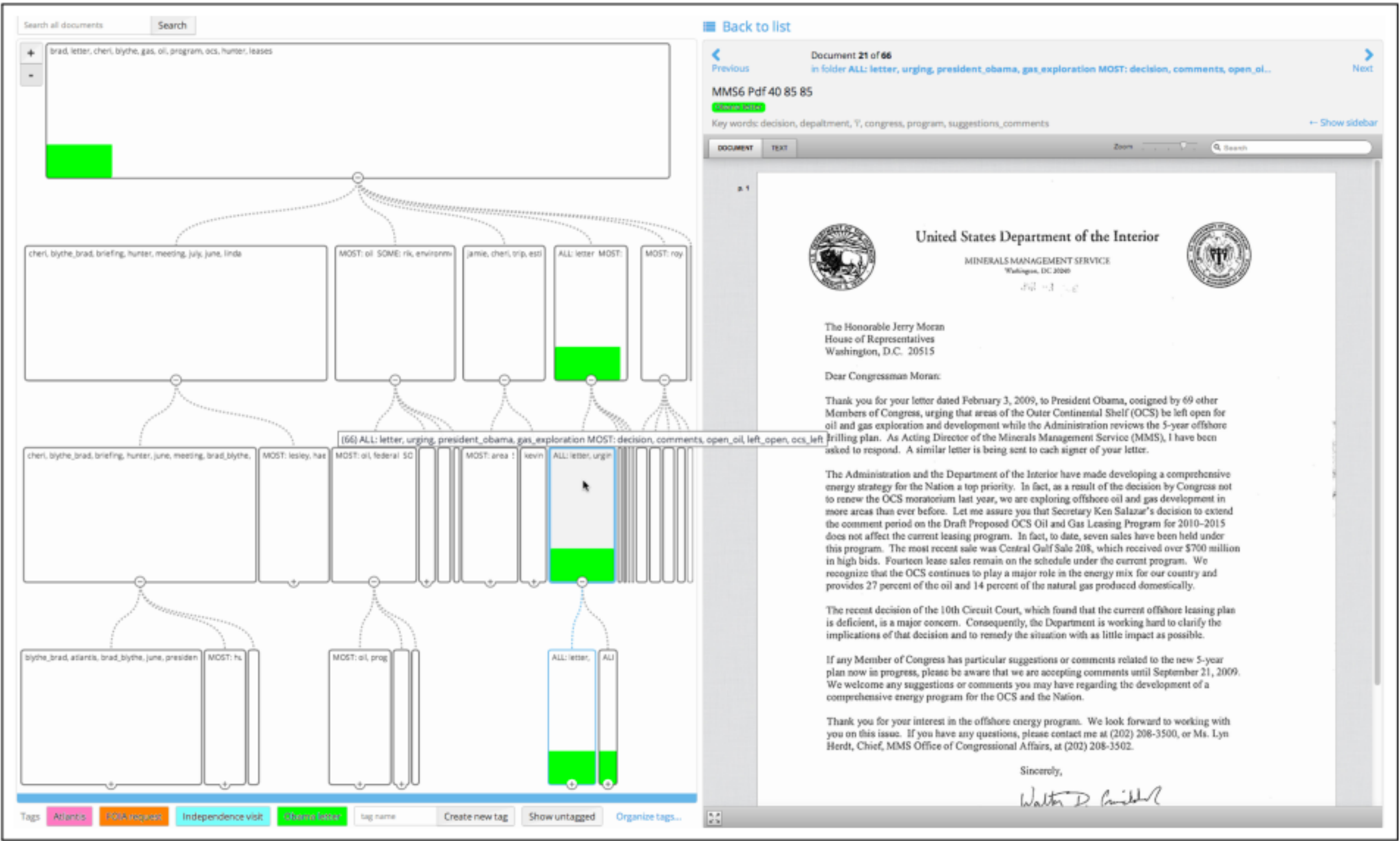
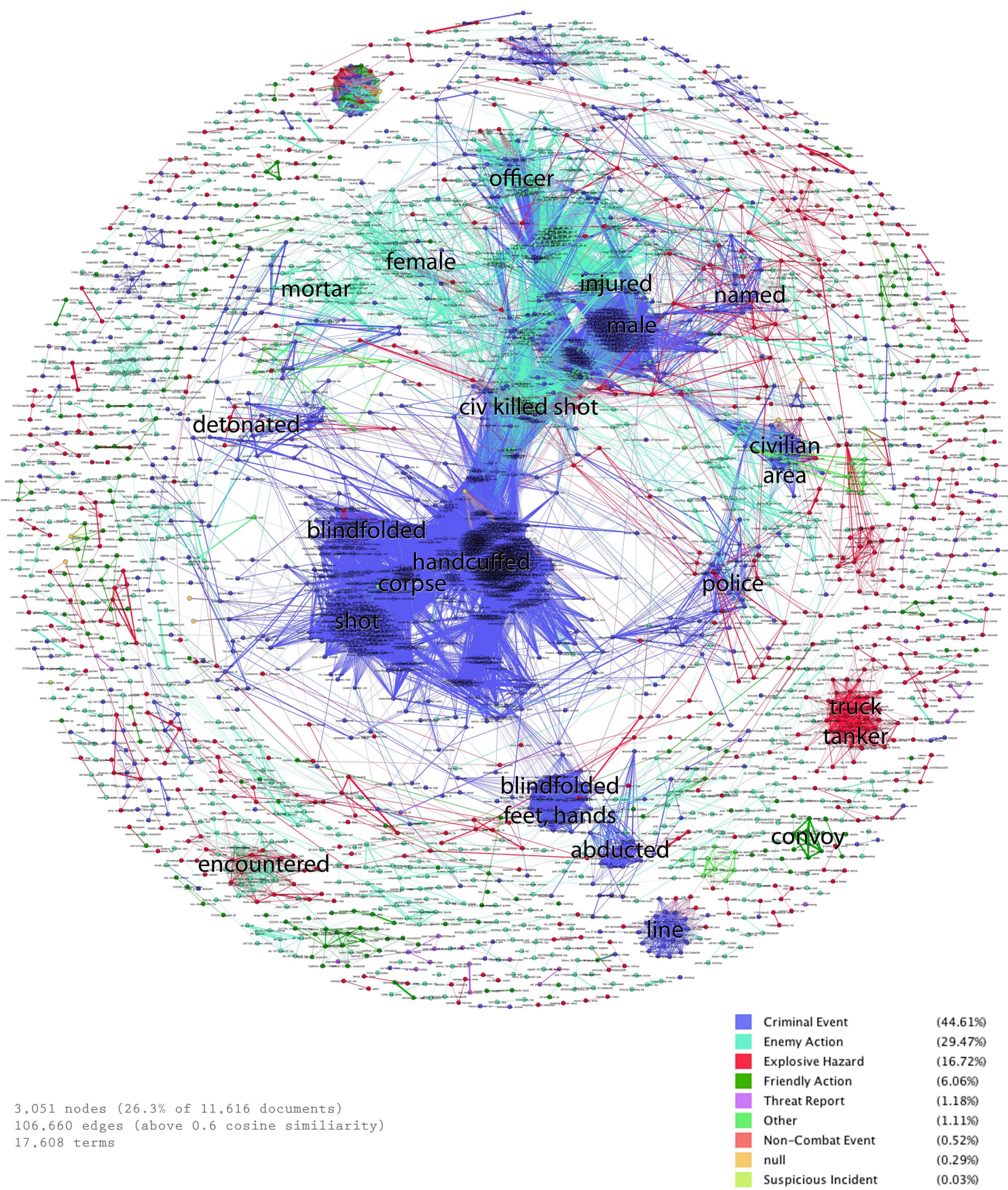
Demo

Michael Oppermann, Torsten Möller, Michael Sedlmair.
A Global Perspective on Bike-Sharing Networks and Urban Commuting Patterns.
In submission for ACM Conf. on Human Factors in Computing Systems (CHI), 2017.

Role of network vis in network problems?



WikiLeaks Iraq SIGACTS (redacted) - Dec 2006



Outline

1. Technique-driven research

- Trends in graph drawing
- Trends in visualization — Related to graph drawing

2. Problem-driven research

- Design Study Example — RelEx
- Design Study Methodology

3. Summary

The ominous “user”

- Classical HCI pitfall: **The Elastic User**
- Are our techniques really helping users?
- What exactly are their tasks, problems, and challenges?
- How to effectively combine existing and new techniques to help solving these problems?

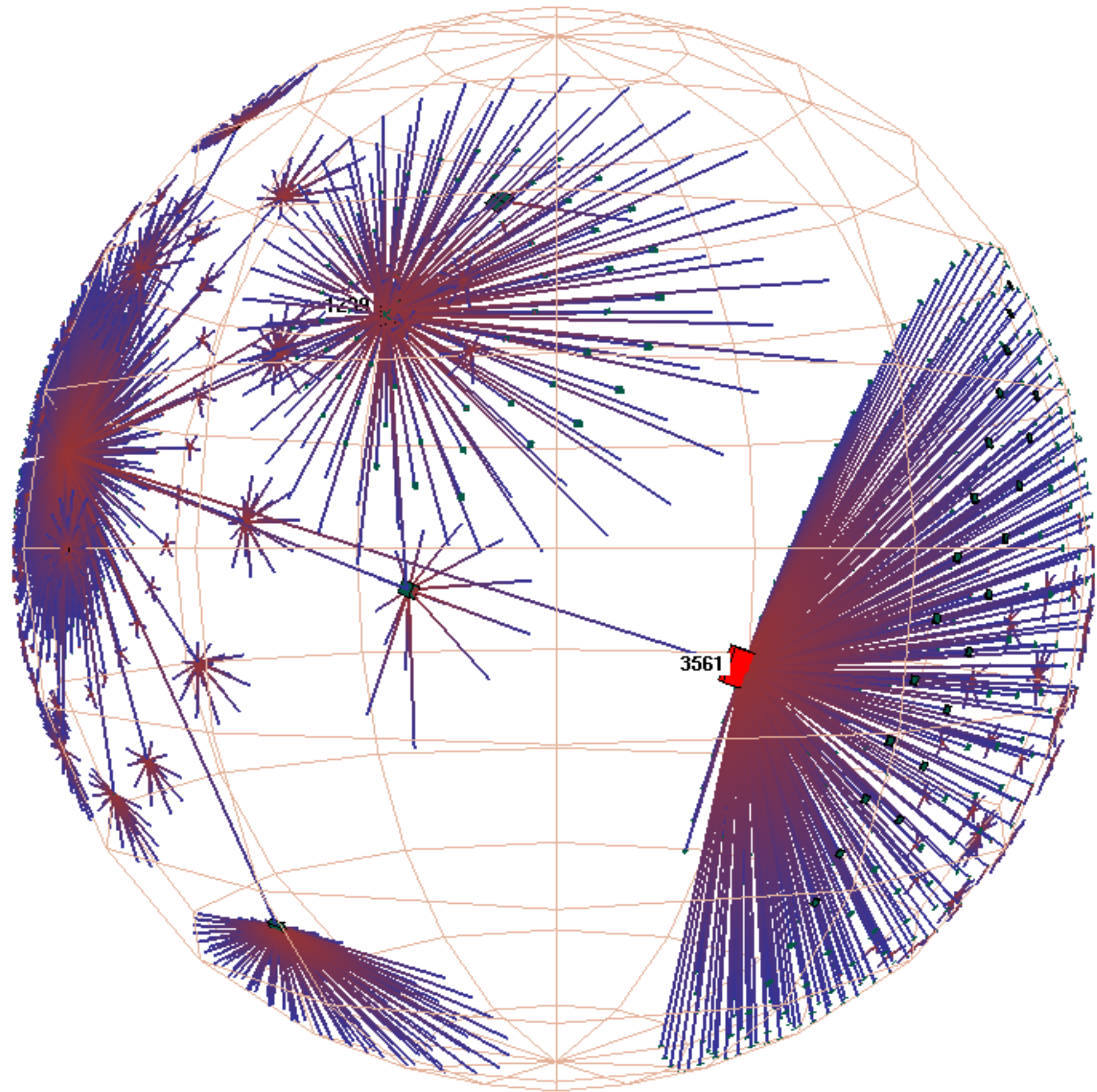


<http://flylib.com/books/en/2.151.1.84/1/>



<http://businessmajors.about.com/od/jobprofiles/p/ProFinAnalysts.htm>

Visualizing the internet?



<https://graphics.stanford.edu/papers/h3cga/html/>



http://www.huffingtonpost.com/dr-travis-bradberry/8-small-things-people-use_b_10169120.html

Tamara Munzner (IEEE CG&A 1998)
Exploring Large Graphs in 3D Hyperbolic Space

goal: help **people** with their
ill-defined (network) problems



**How to involve humans into our
design and research processes?**

Design Studies

*“A design study is a project in which visualization researchers analyze a specific **real-world problem** faced by domain experts, **design** a visualization system that supports solving this problem, **validate** the design, and **reflect** about lessons learned in order to refine visualization design guidelines.”*

*Michael Sedlmair, Miriah Meyer, Tamara Munzner.
Design Study Methodology: Reflections from the Trenches and the Stacks .
IEEE TVCG (Proc. InfoVis), 2012.*

Outline

1. Technique-driven research

- Trends in graph drawing
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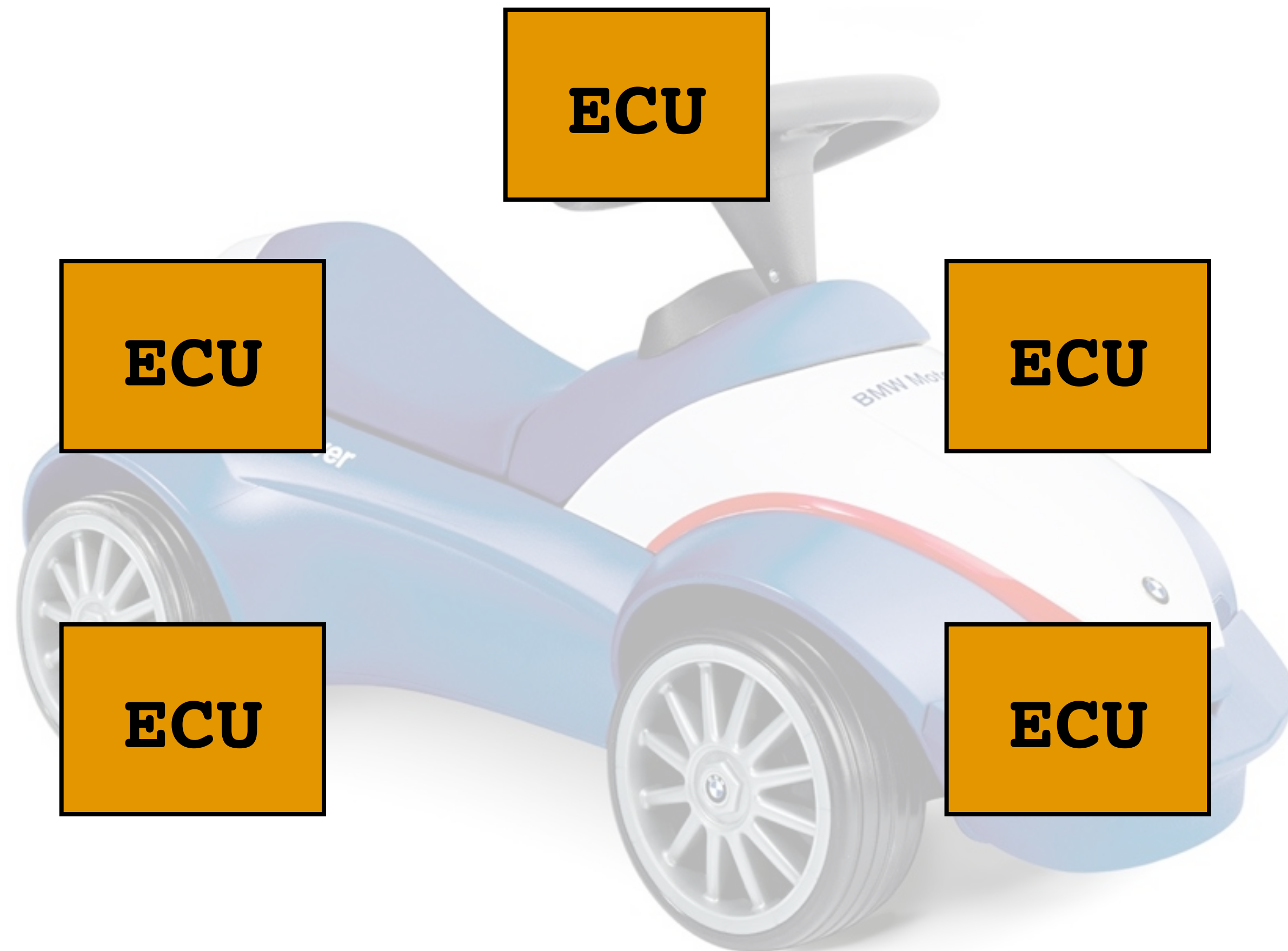
3. Summary

Michael Sedlmair, Annika Frank, Tamara Munzner, Andreas Butz.
RelEx: Visualization for Actively Changing Overlay Network Specifications.
IEEE TVCG (Proc. InfoVis), 2012.

Domain: In-car Electronics

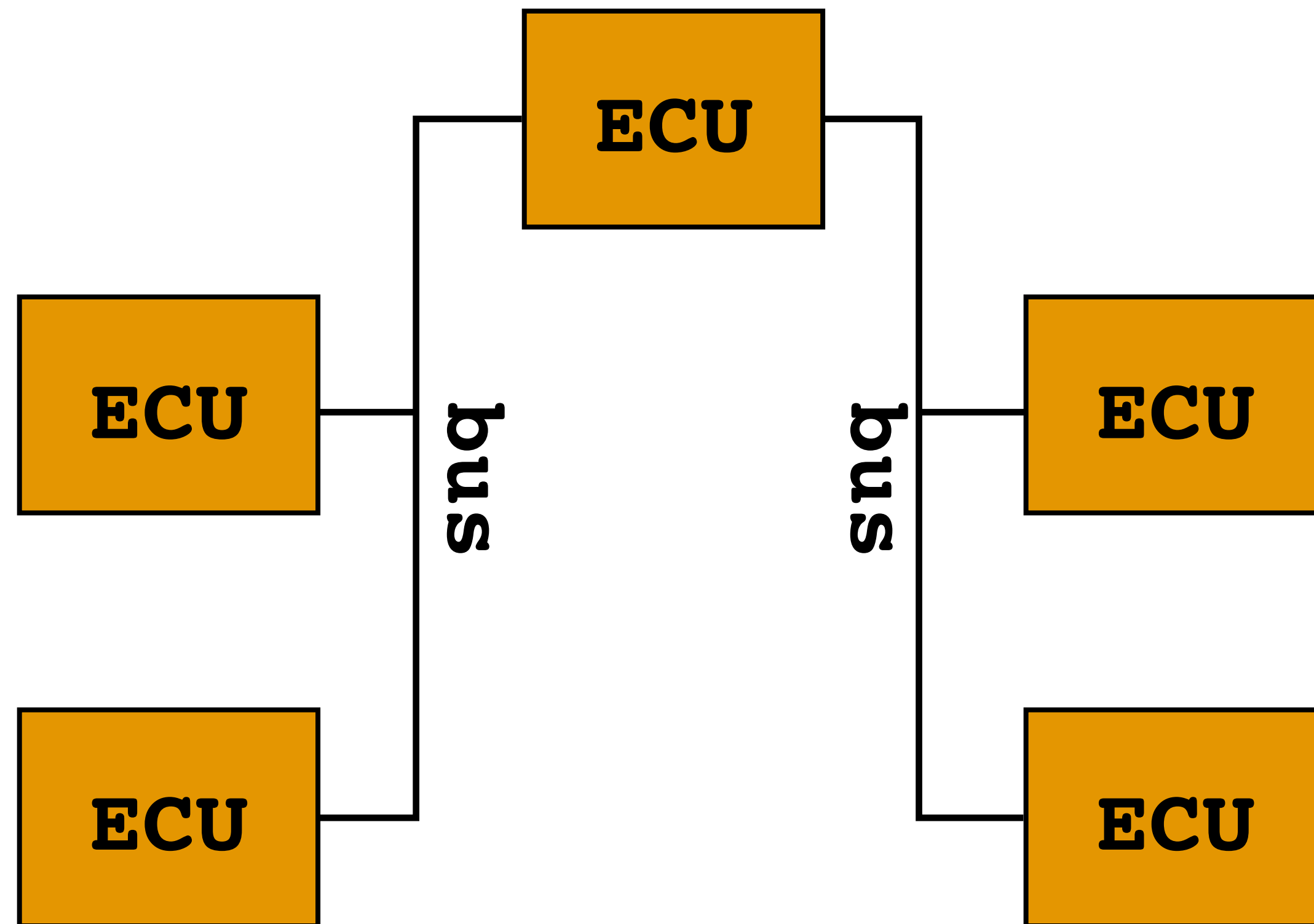


Physical network (Hardware)



~100 ECU (nodes)

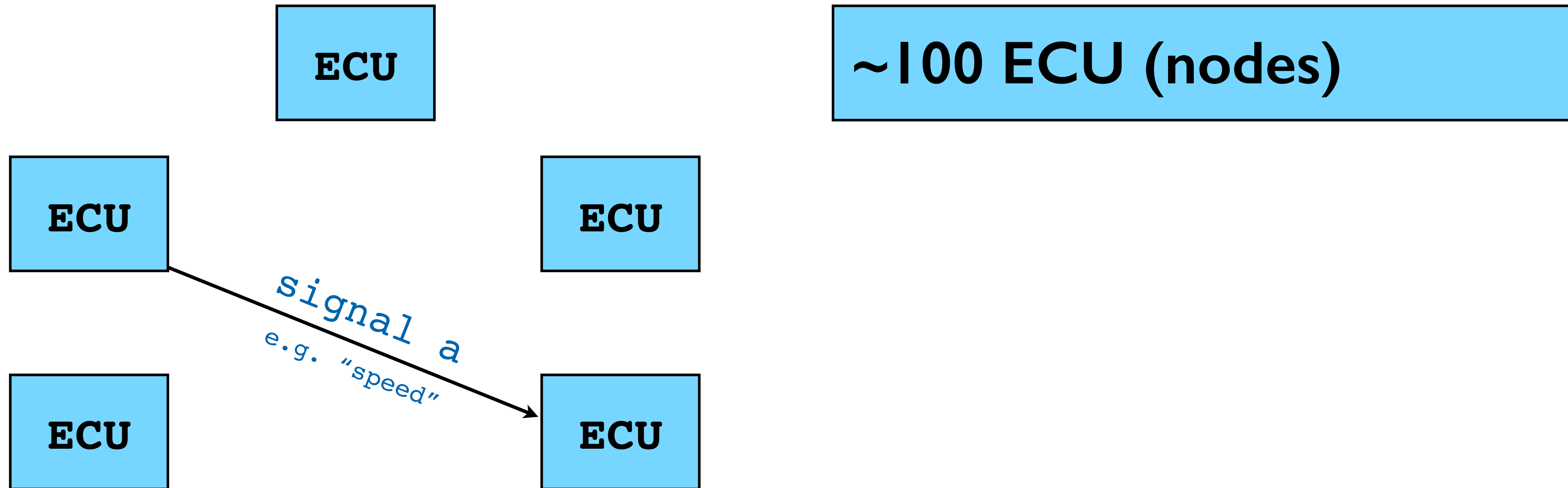
Physical network (Hardware)



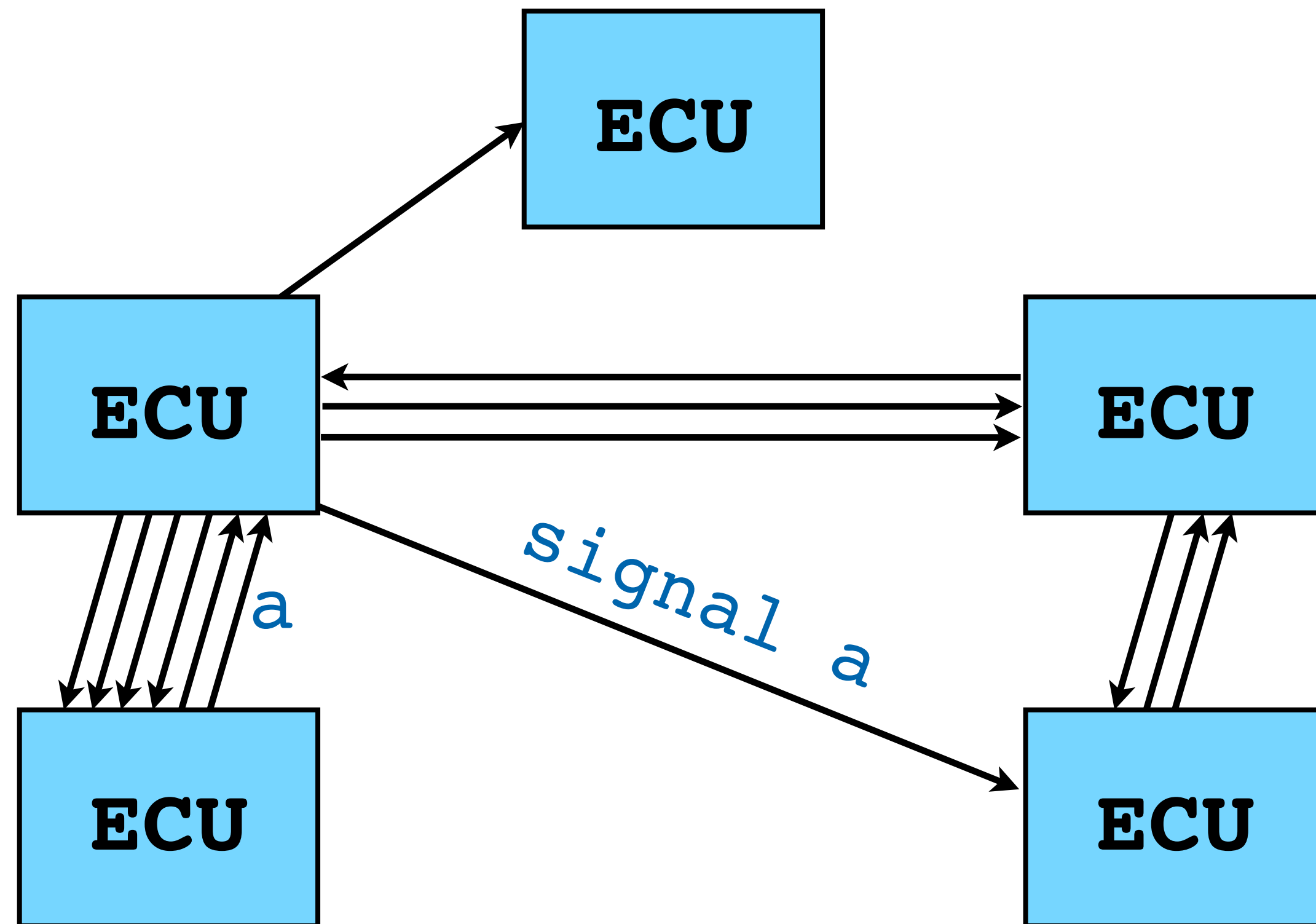
~100 ECU (nodes)

10-15 Bus systems (edges)

Logical Network (Software)



Logical Network (Software)

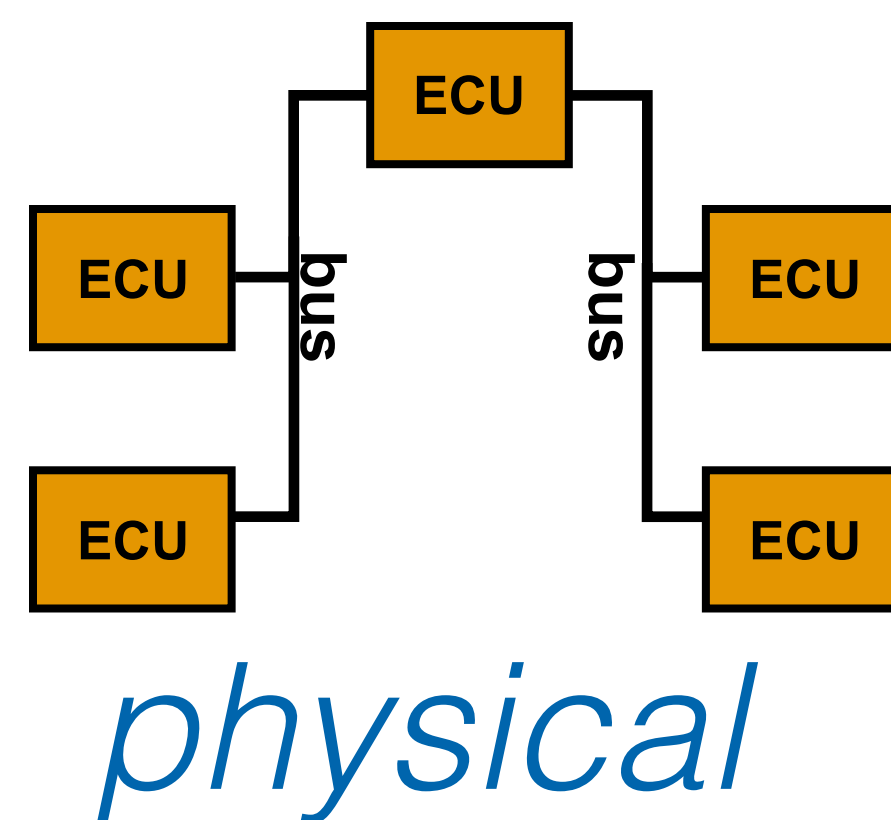
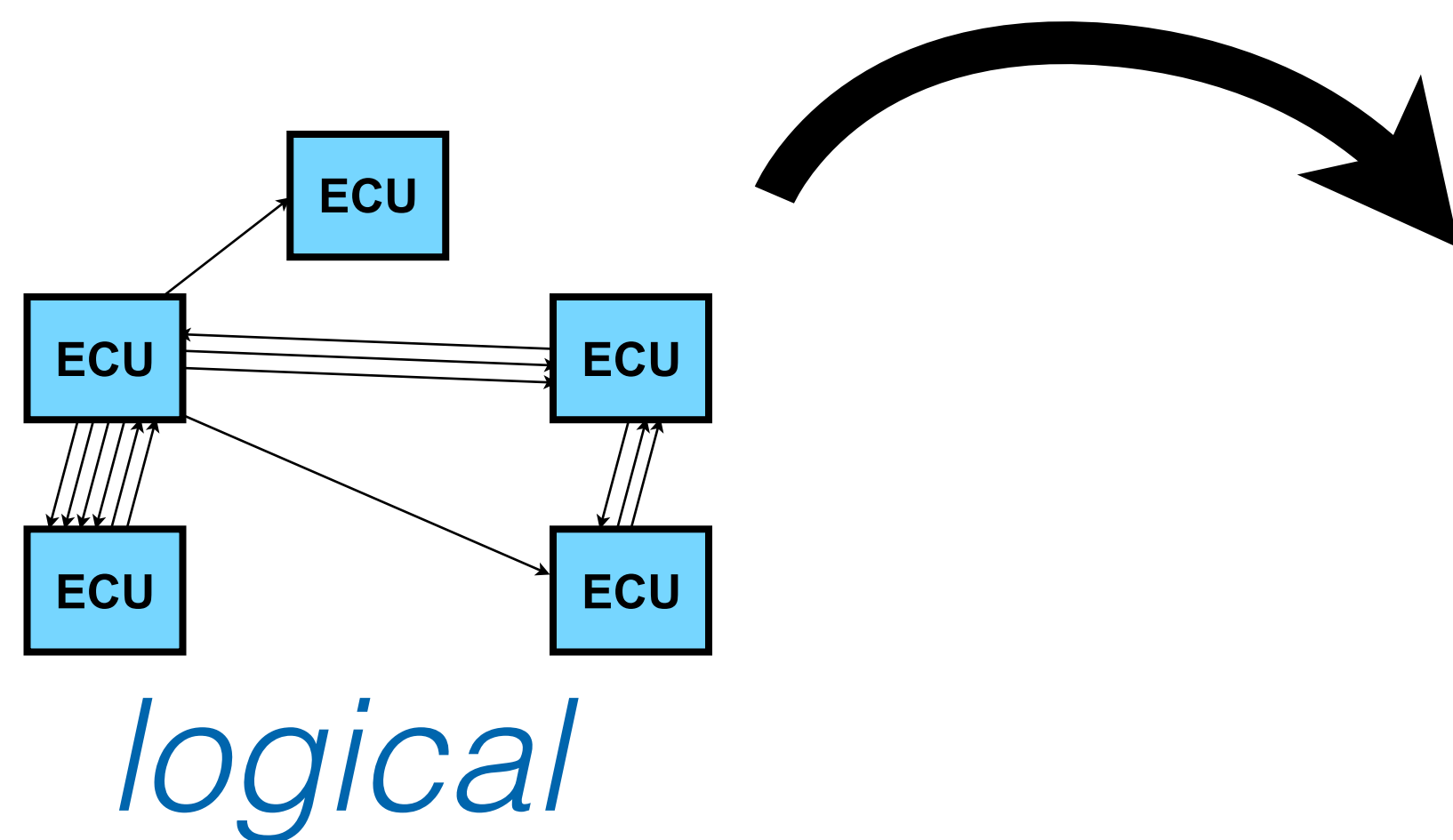


~100 ECU (nodes)

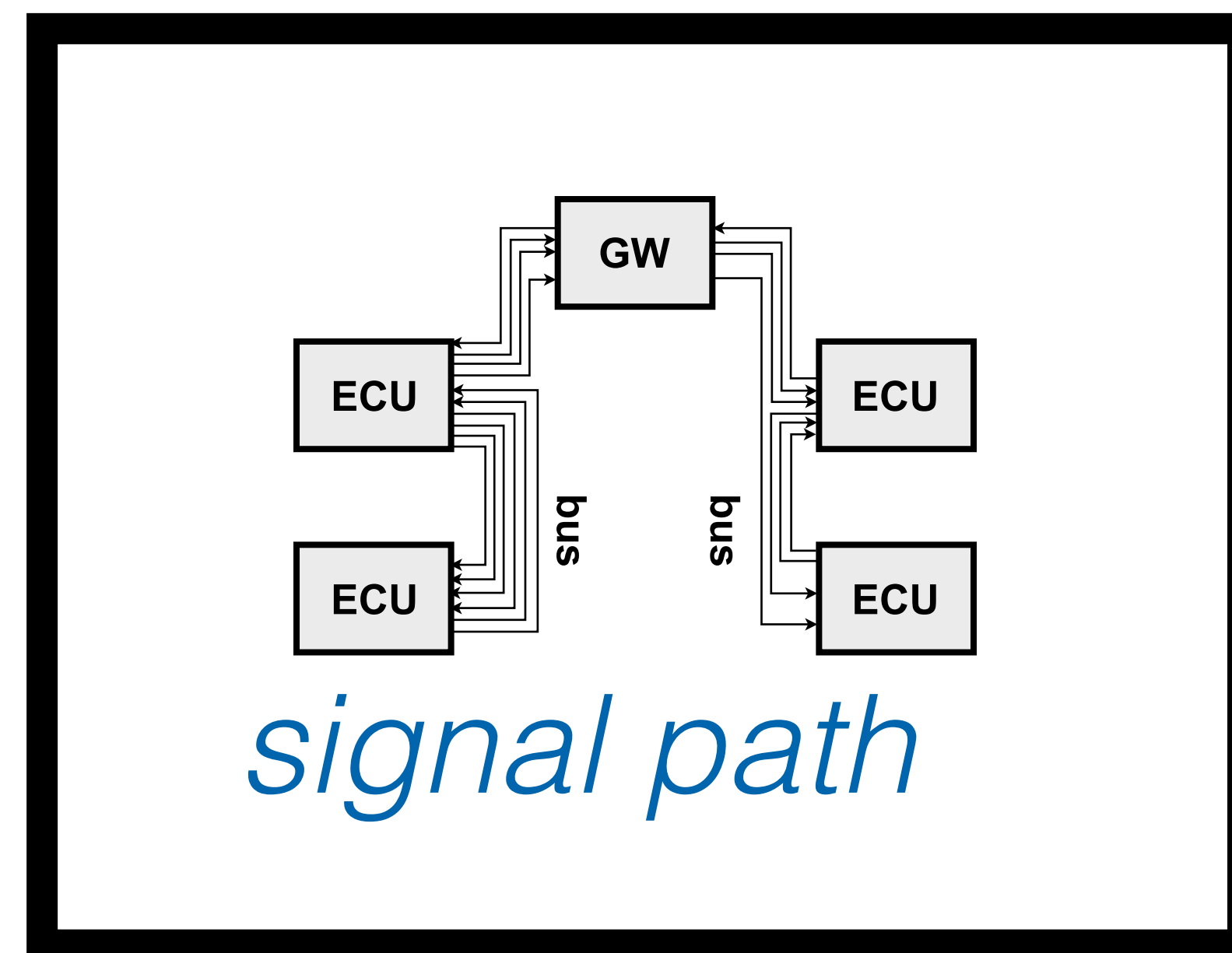
~10k signals (edges)



Tasks: Mapping



=



ReEx: Problem characterization



Problem characterization & abstraction

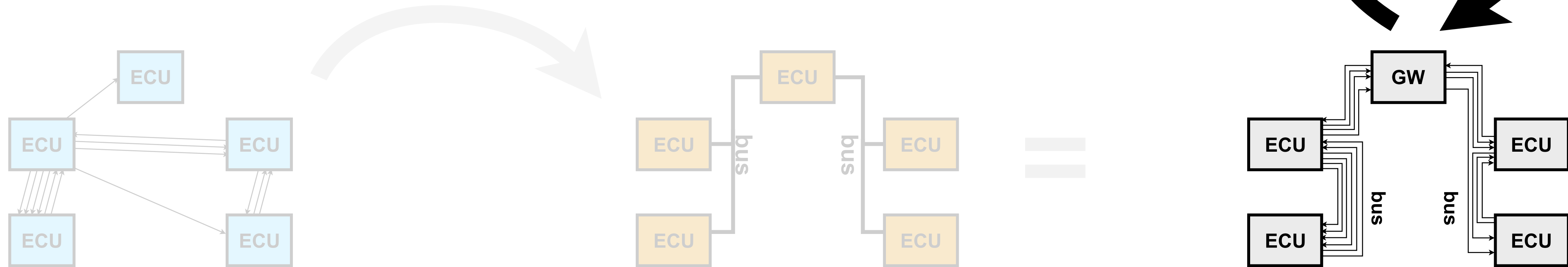
(3 month)

- Understanding
 - Talking/Observing
 - Focus groups
 - Analyzing previous tools
 - Reading
- Abstracting & requirements



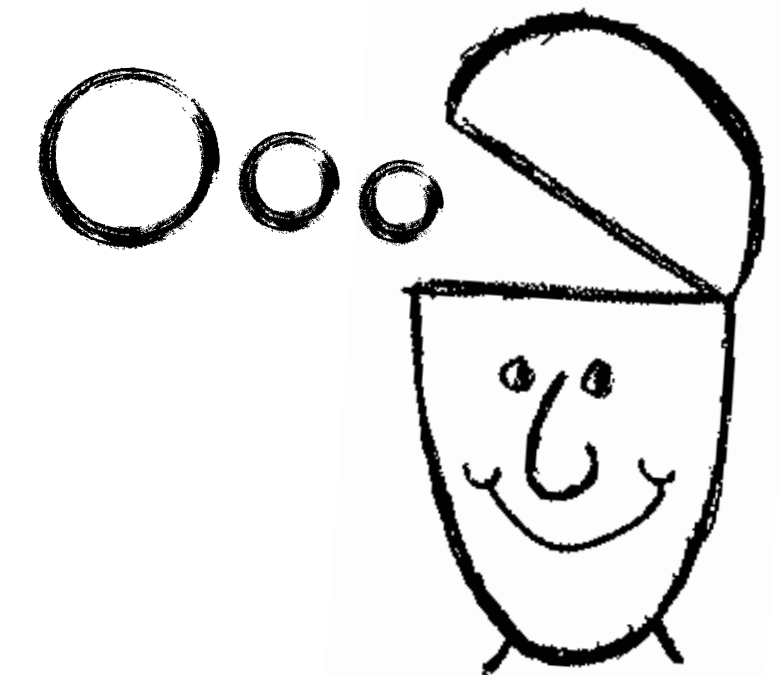


Tasks: Multi-objective optimization



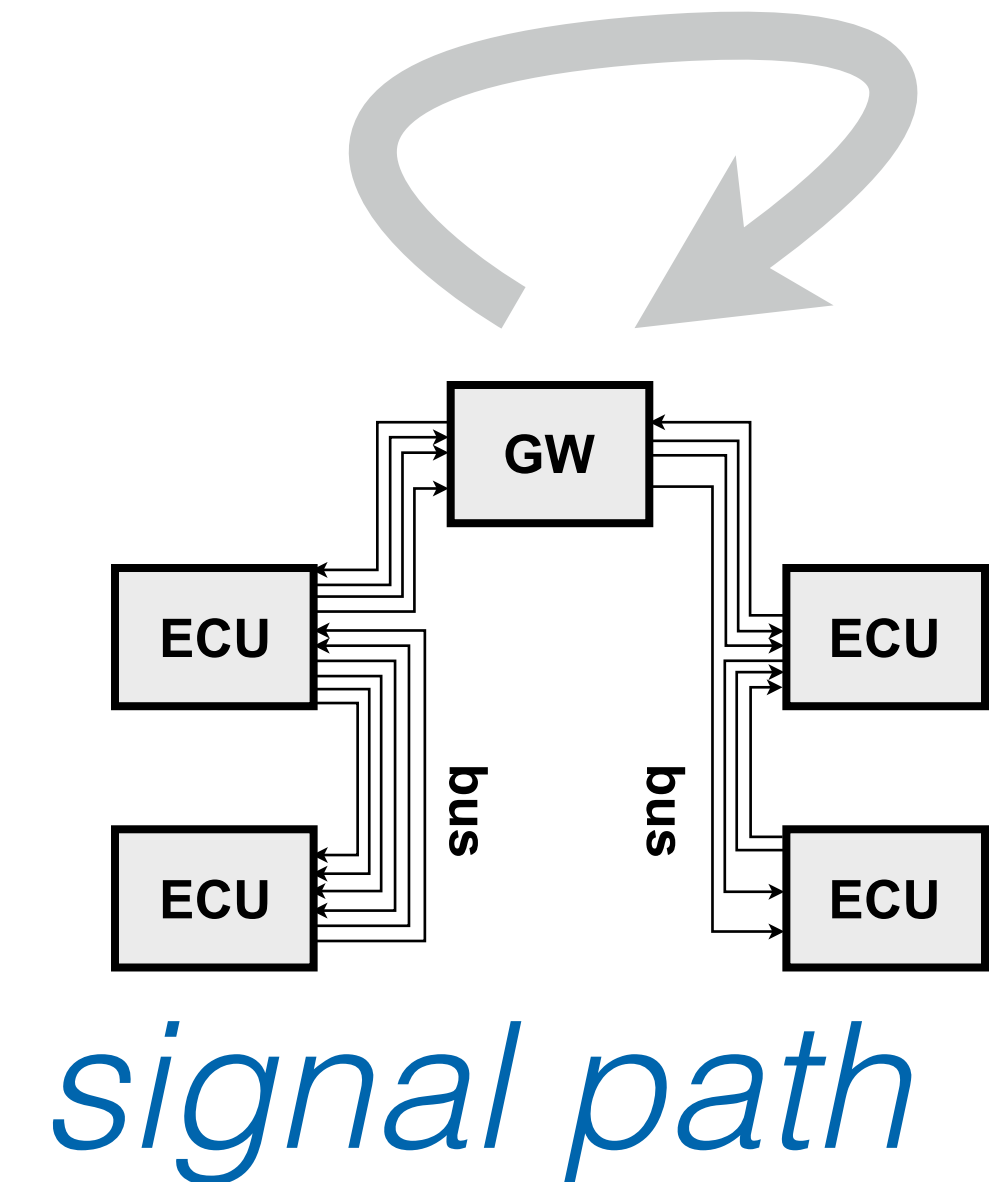
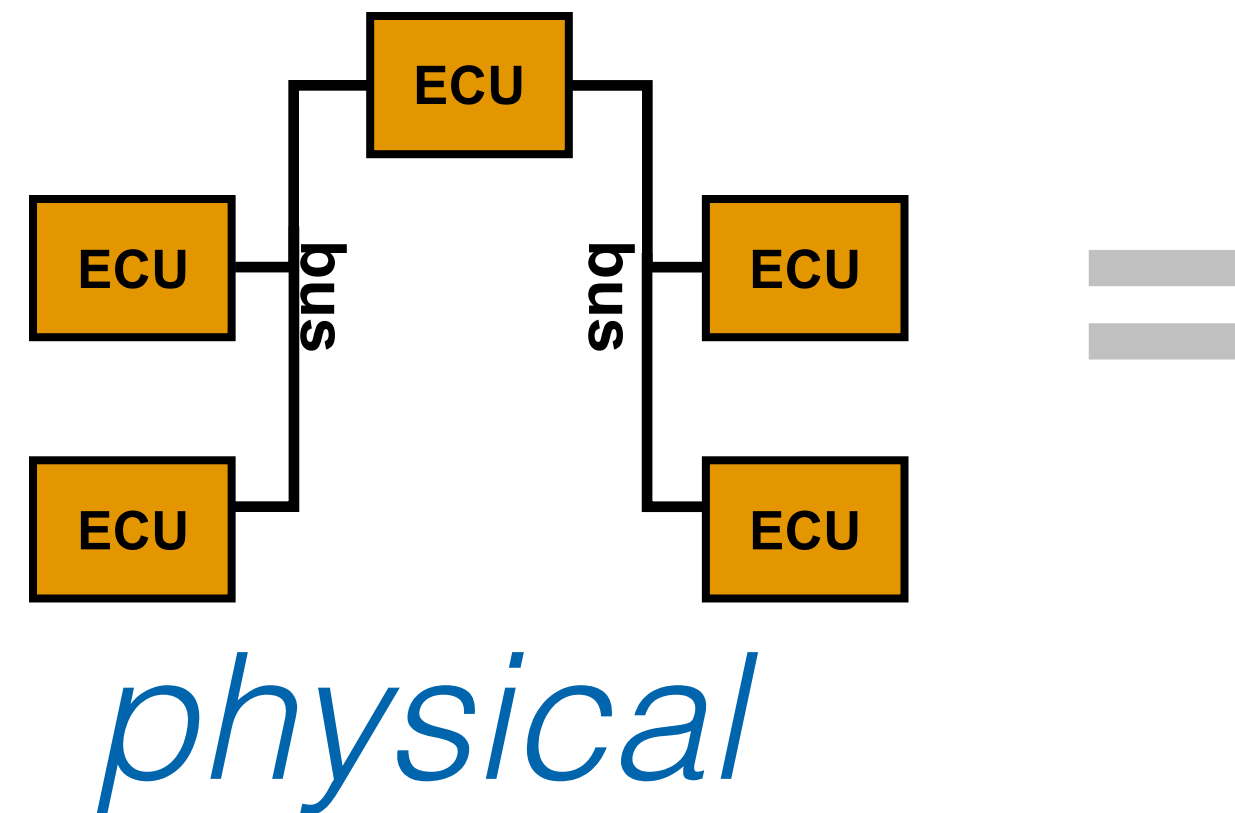
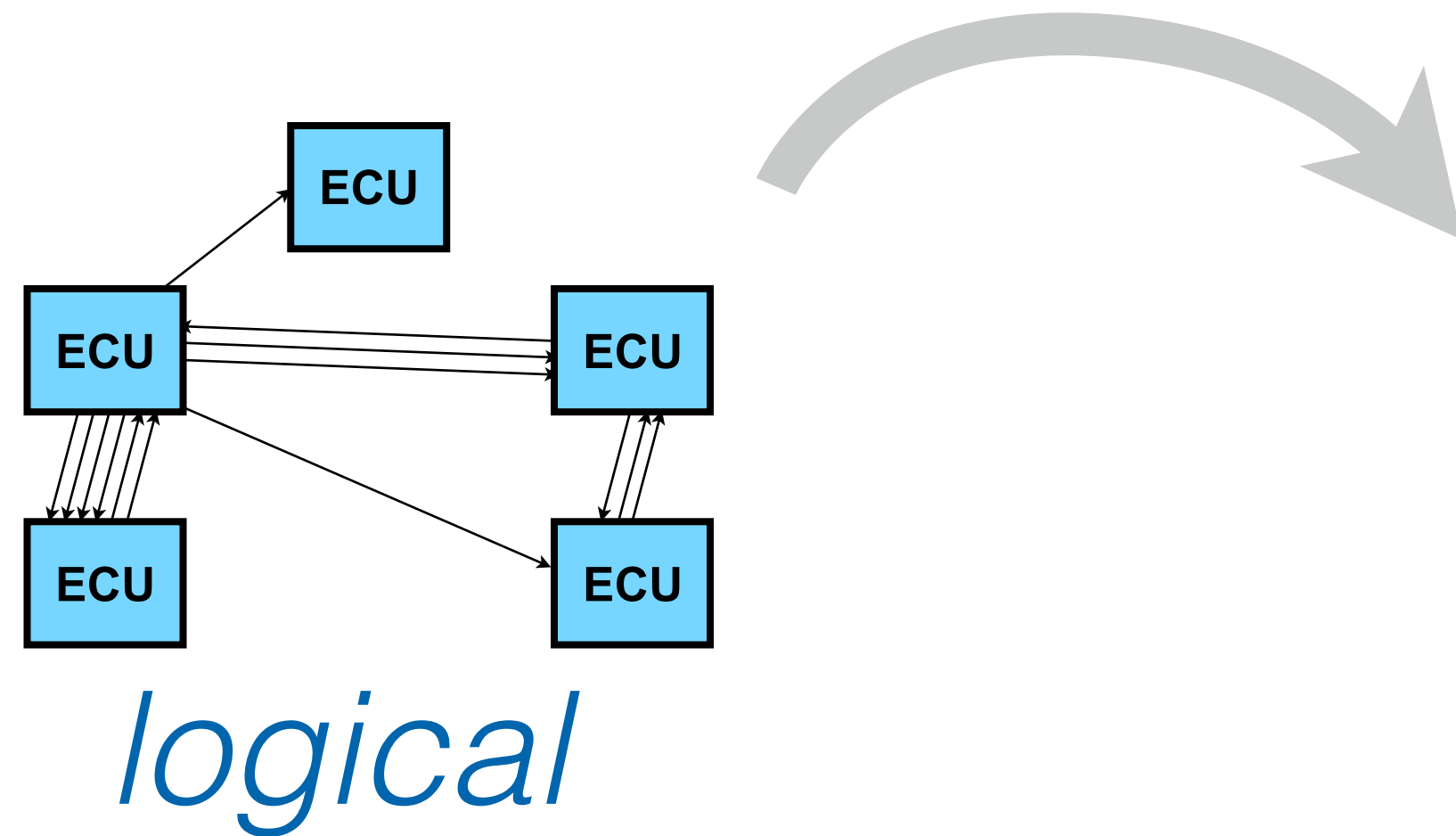
Ill-defined constraints

bandwidth ... delay/real time ...
path length ... load balance ...
reliability ... money ...





Tasks: External Change Requests

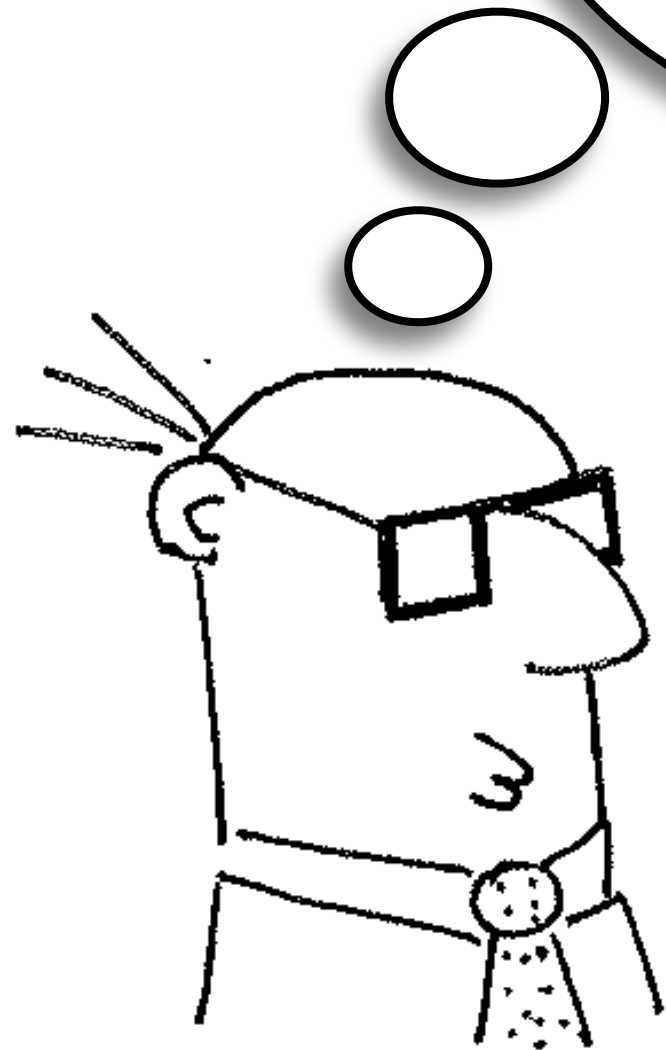


Change
(trivial requests might lead to complex changes)

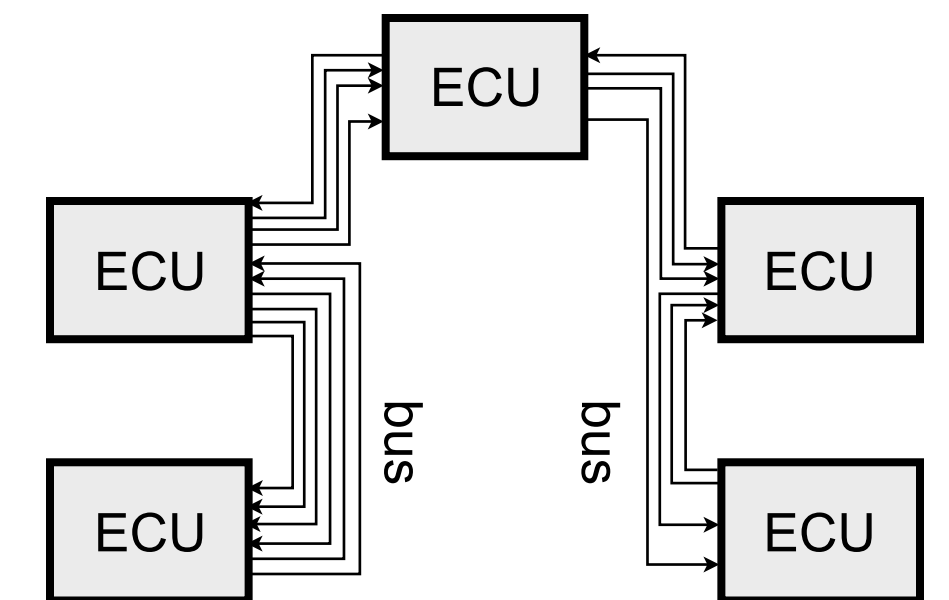
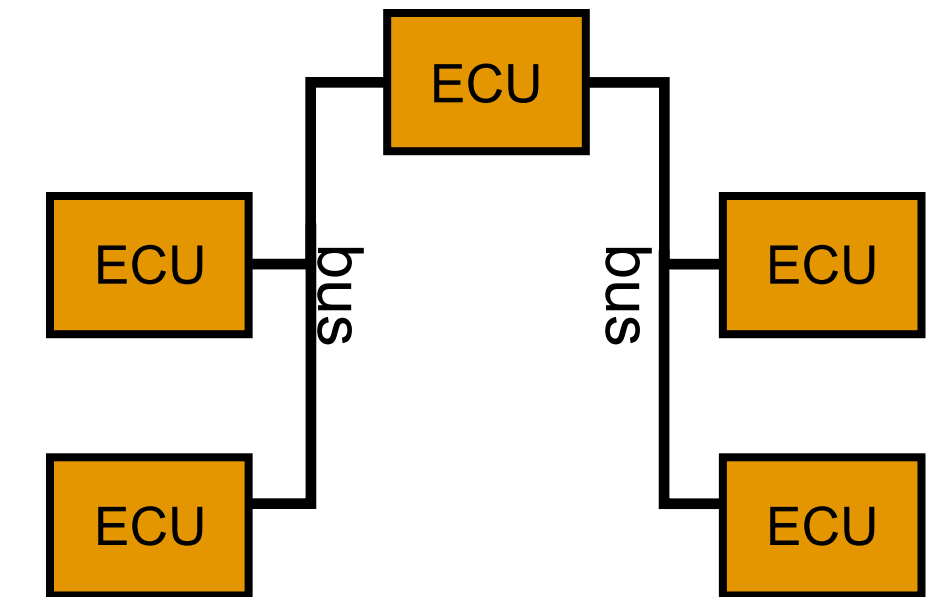
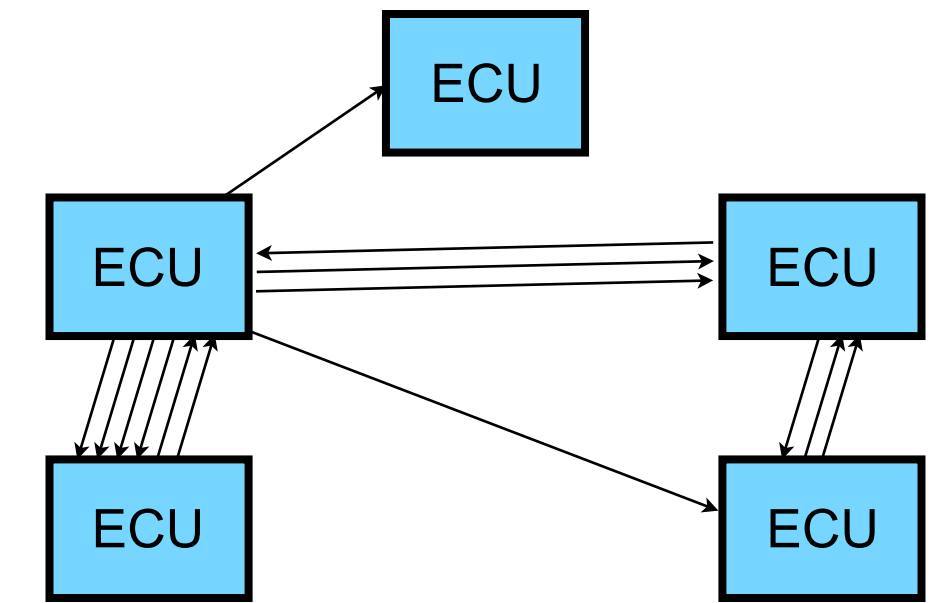
Low Level Tasks

Queries about relations

Which ECU is communicating with which ECU?
Which signals do they exchange?
What is the path the signals take? ...

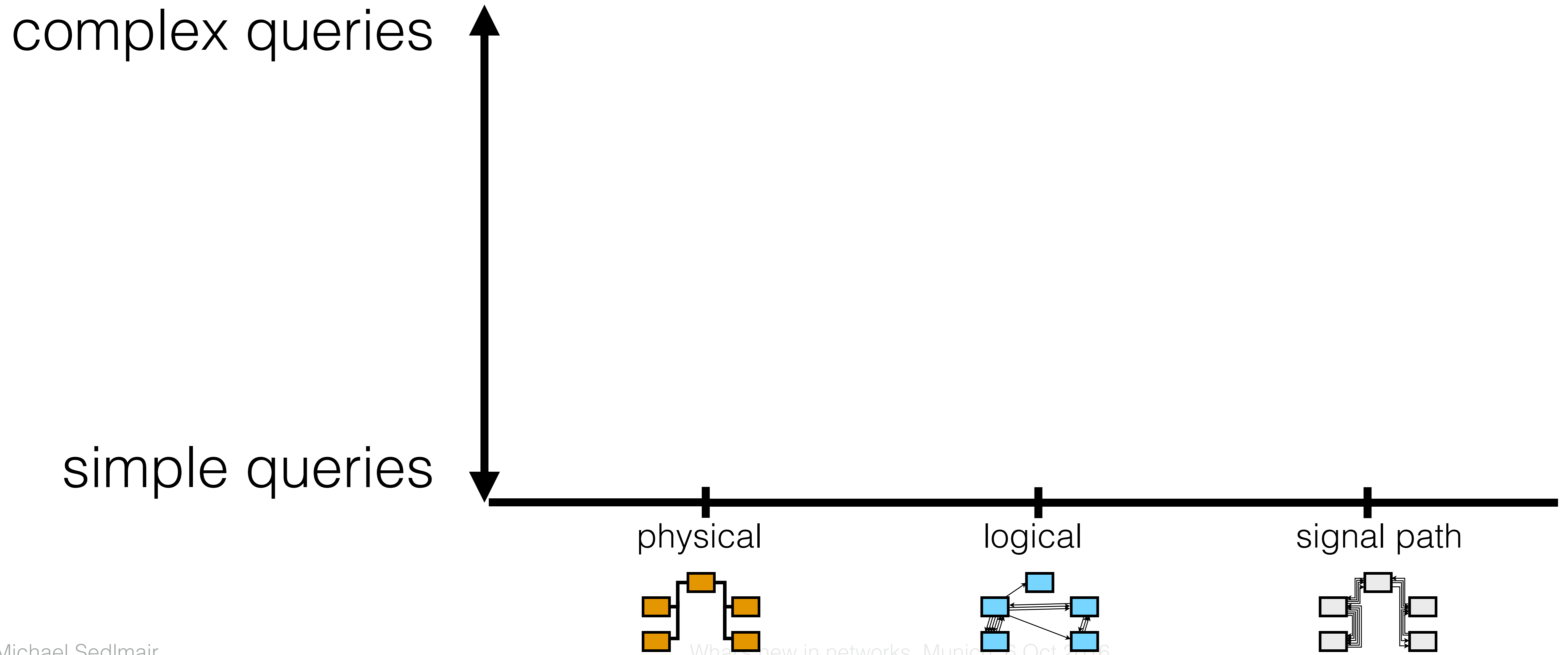


-- engineer, BMW --



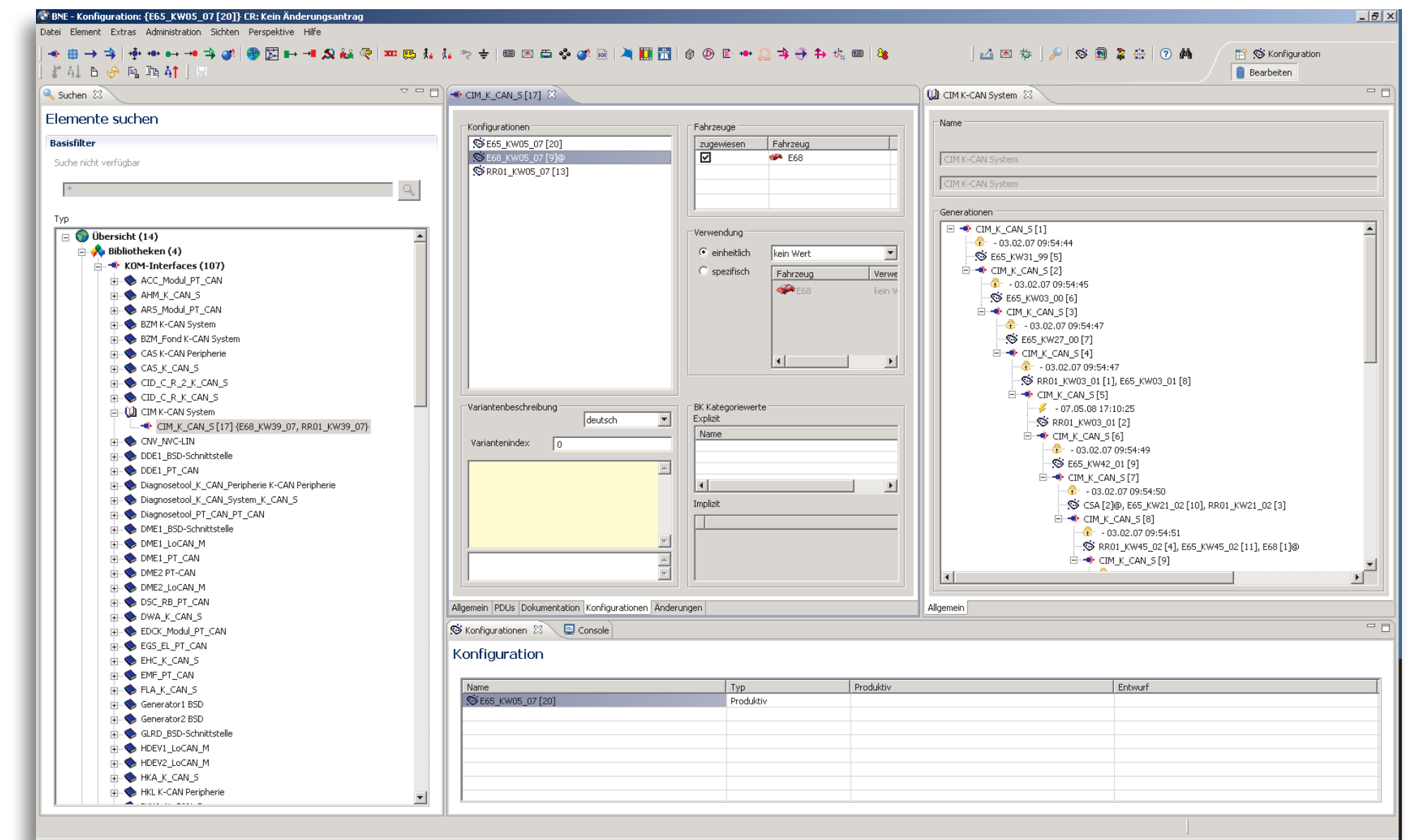
Low Level Tasks

Query complexity



Low Level Tasks

Query complexity

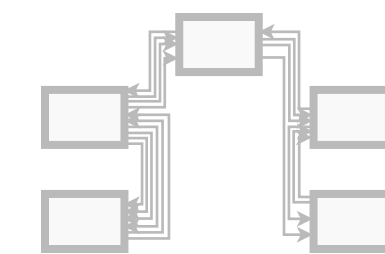
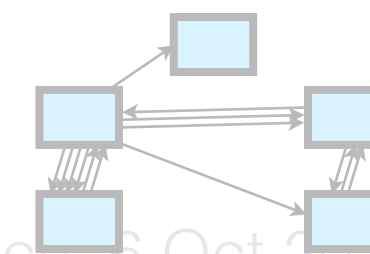
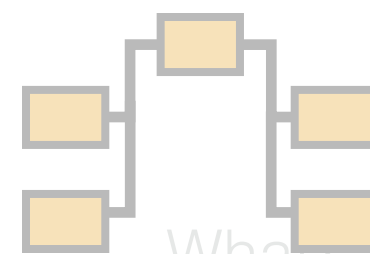


simple queries
2-way relations

physical

logical

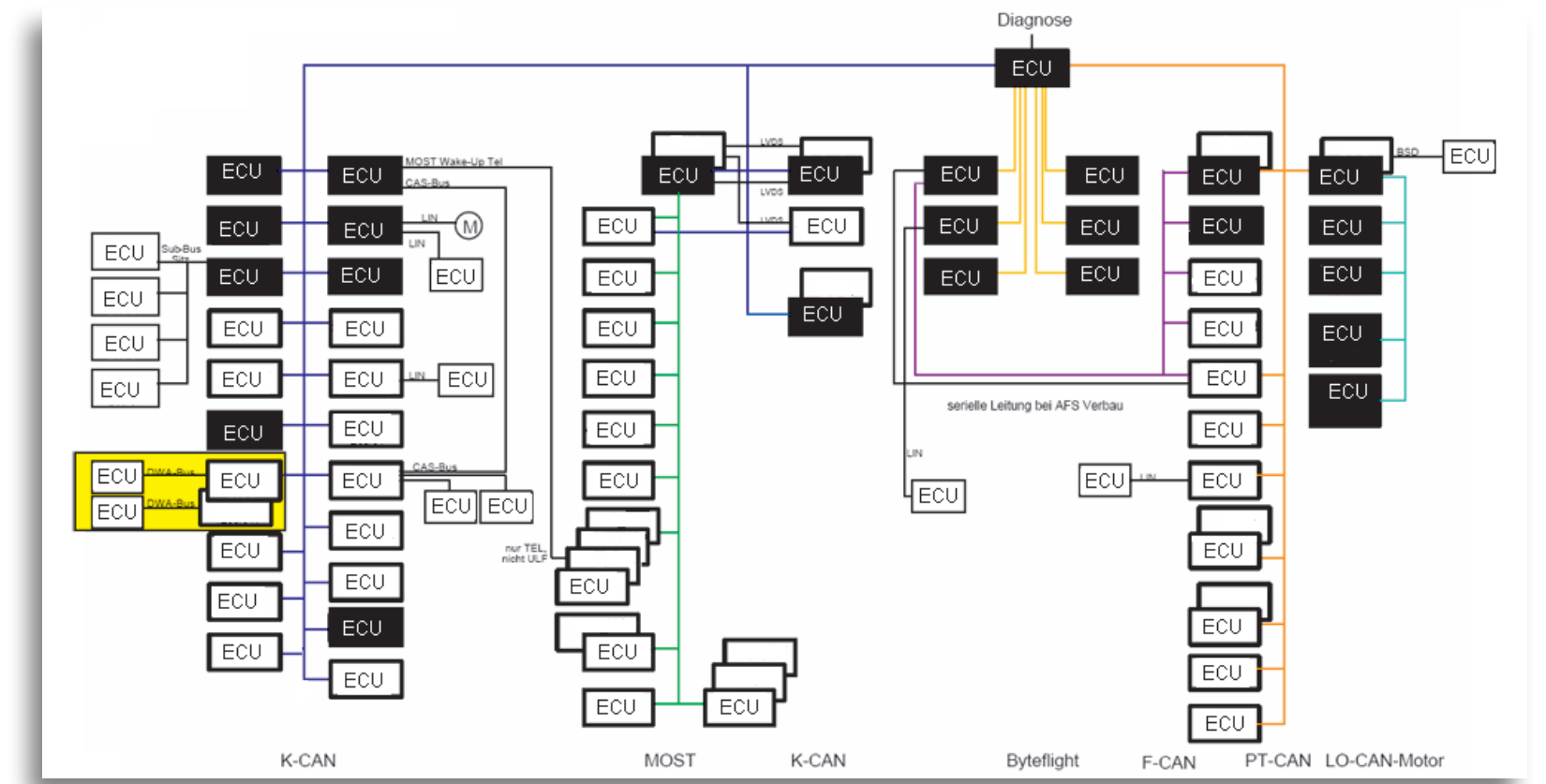
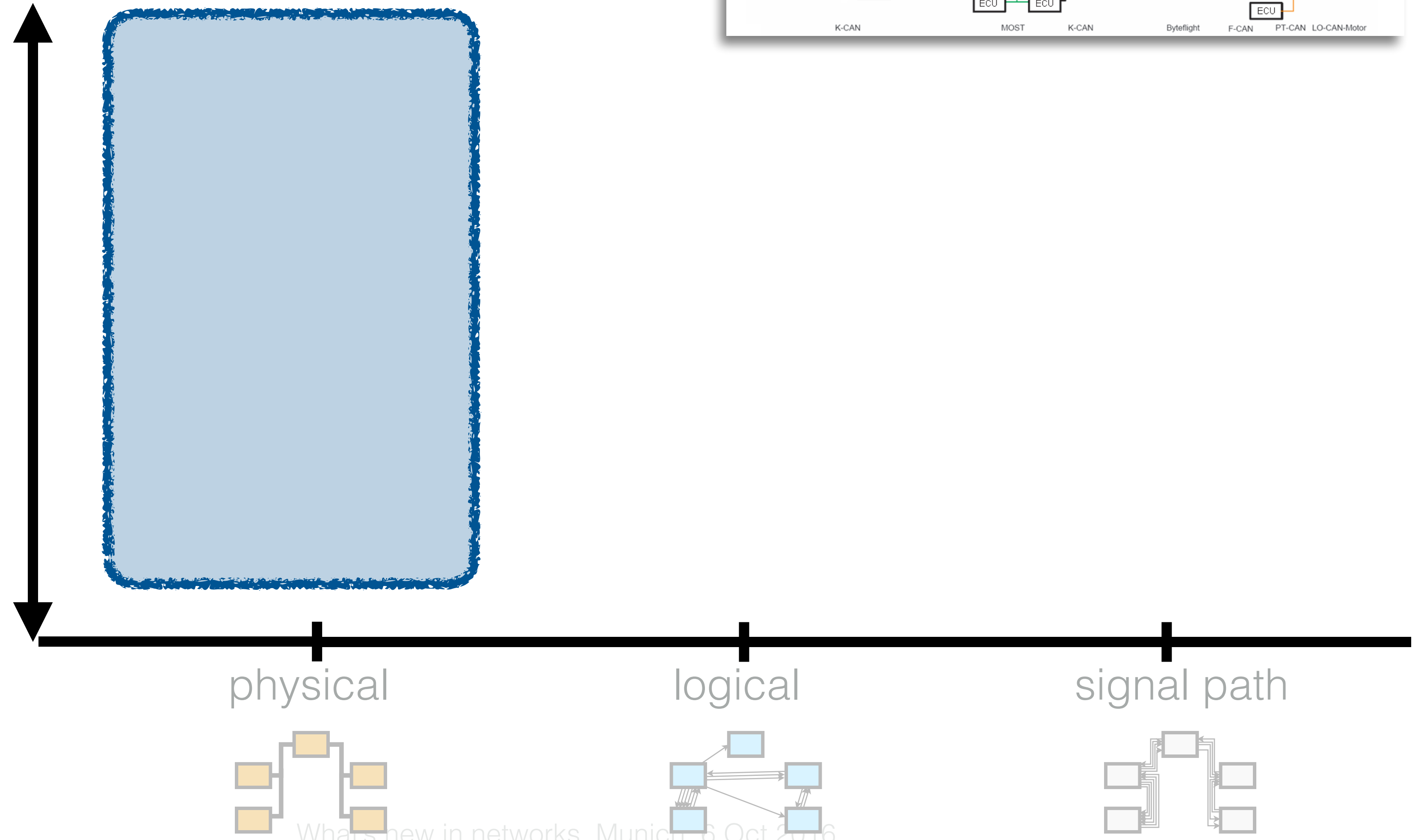
signal path



Low Level Tasks

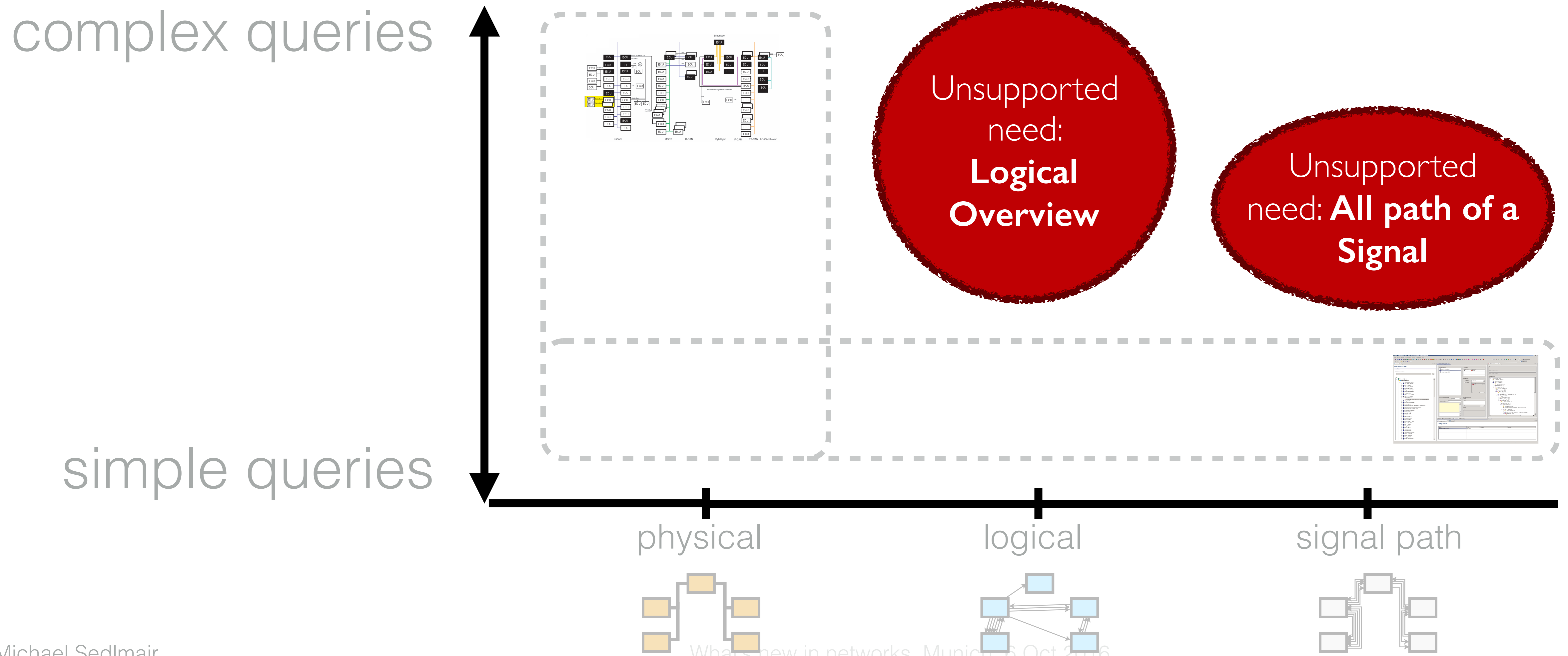
Query complexity

complex queries
Overview

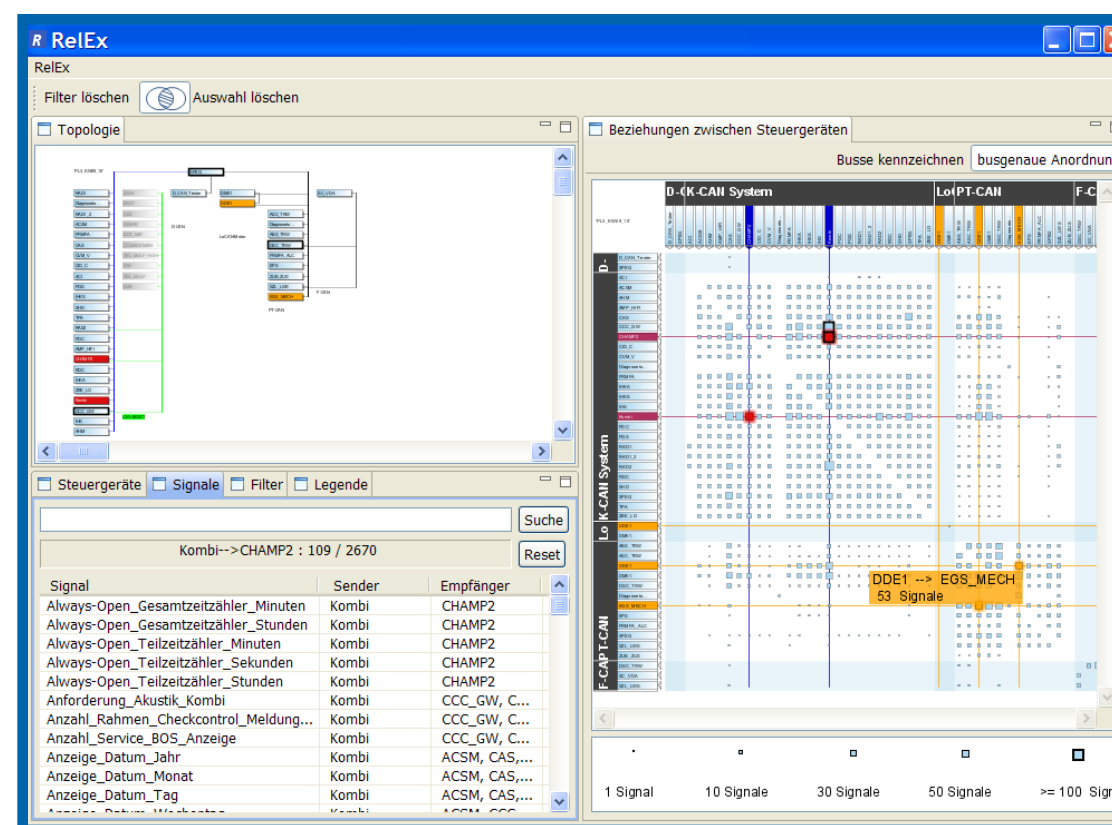


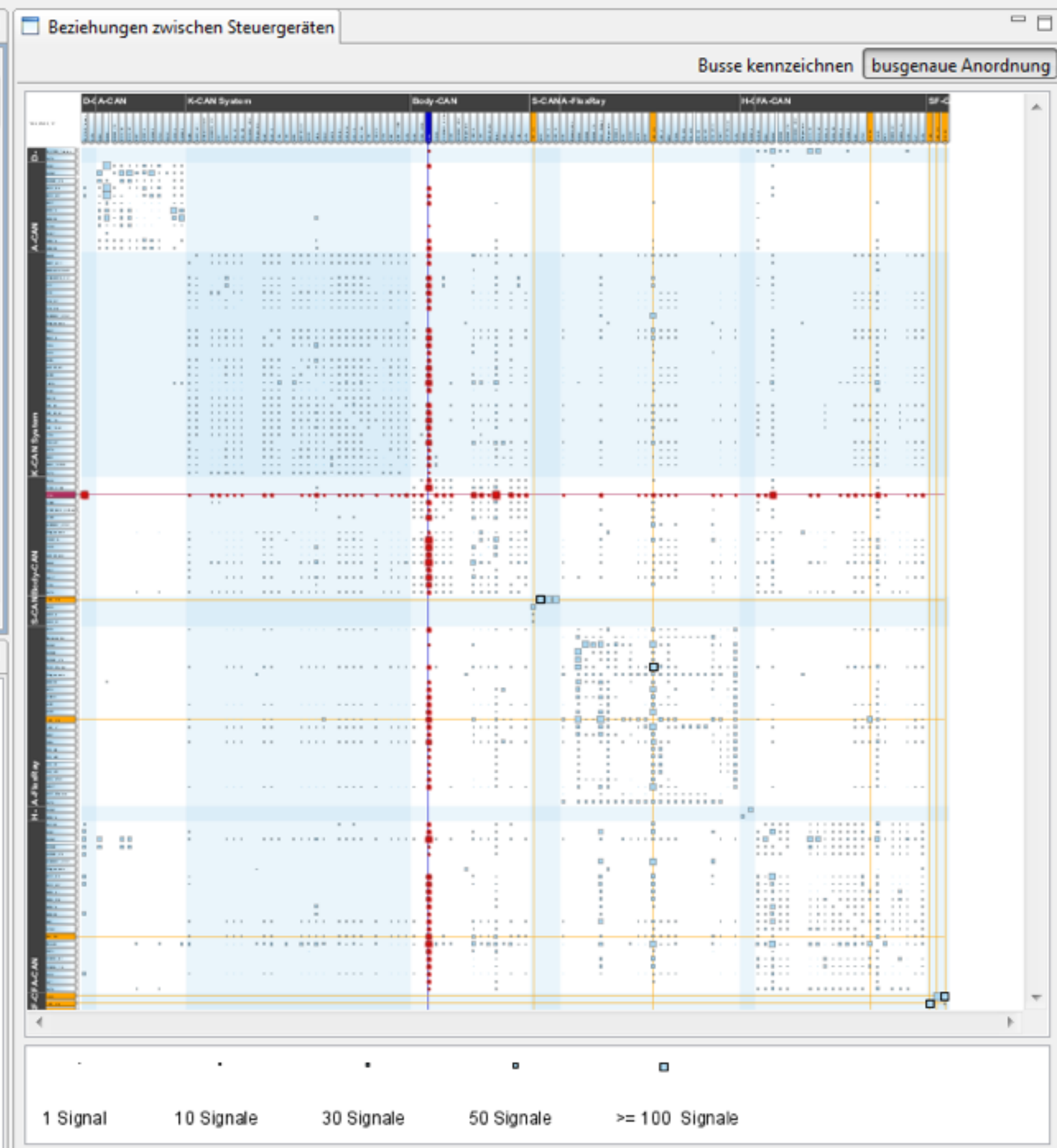
Low Level Tasks

Query complexity



RelEx: Design

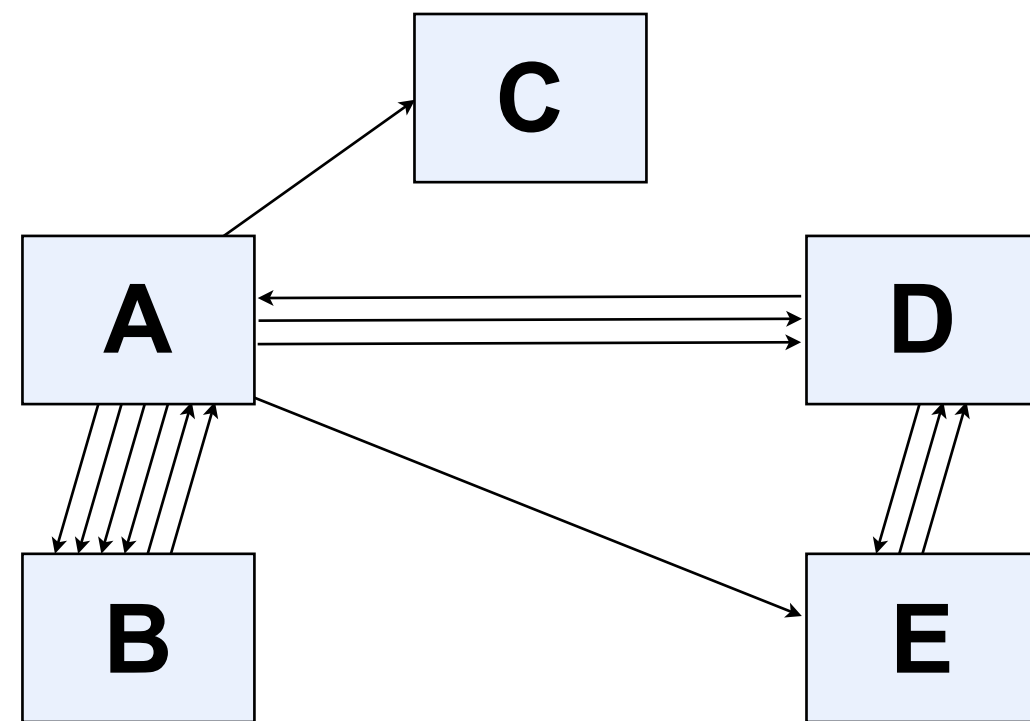




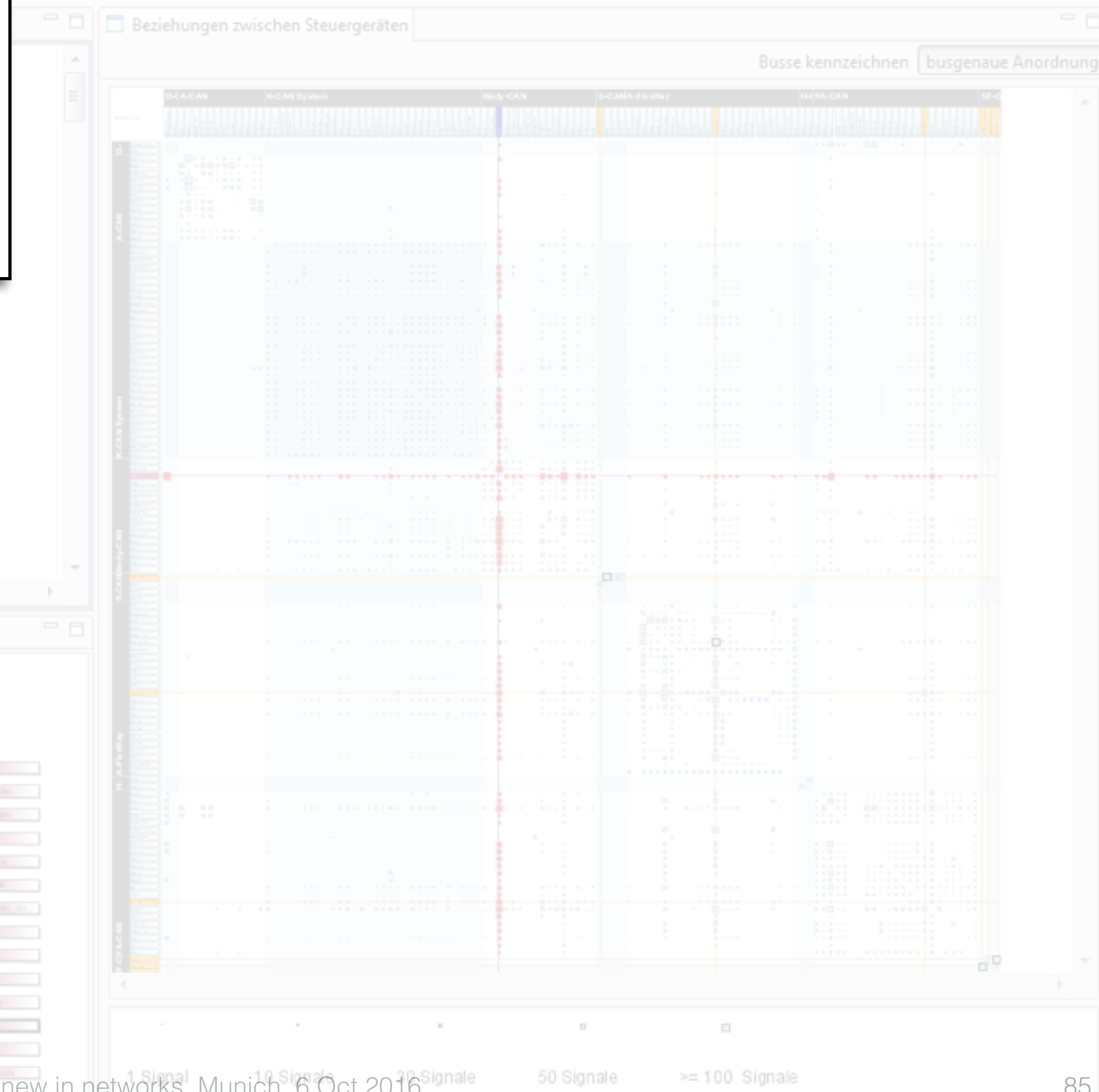
RELEX:

Logical Overview

LOGICAL NETWORK



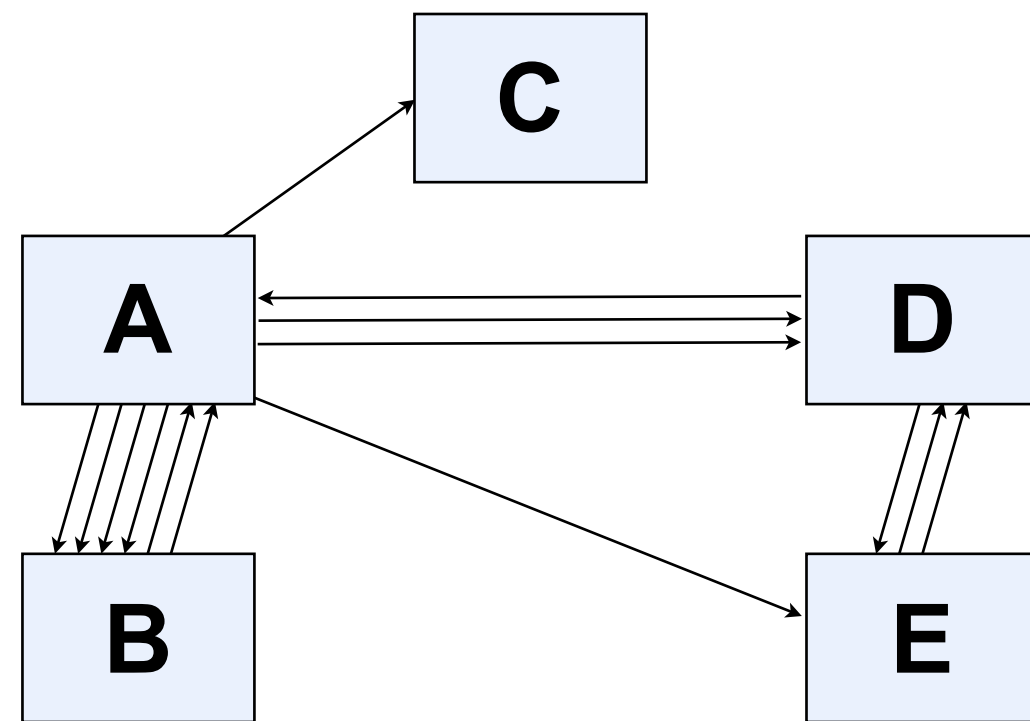
- multigraph
- 100 nodes/10k edges



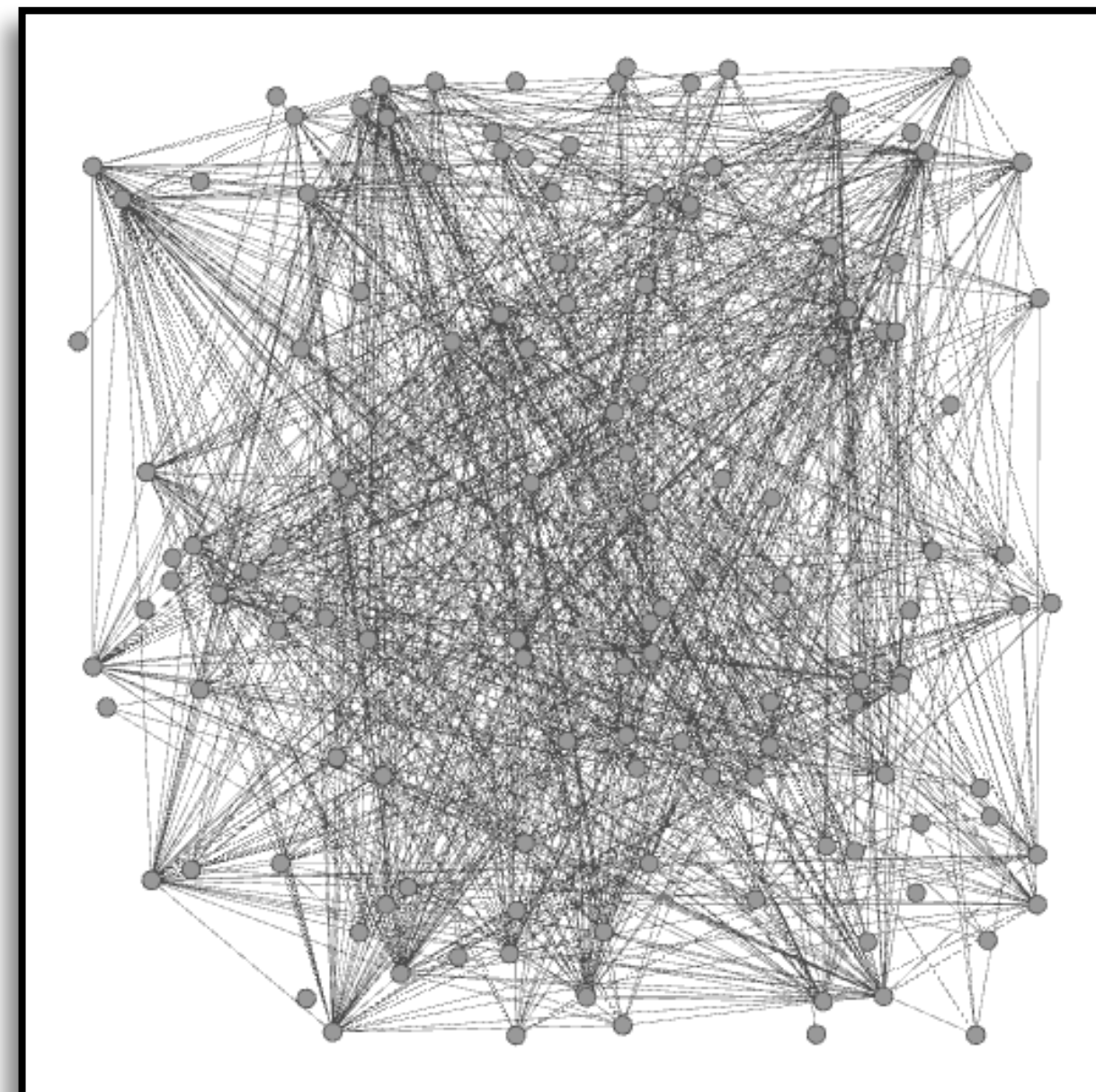
RELEX:

Logical Overview

LOGICAL NETWORK



- multigraph
- 100 nodes/10k edges

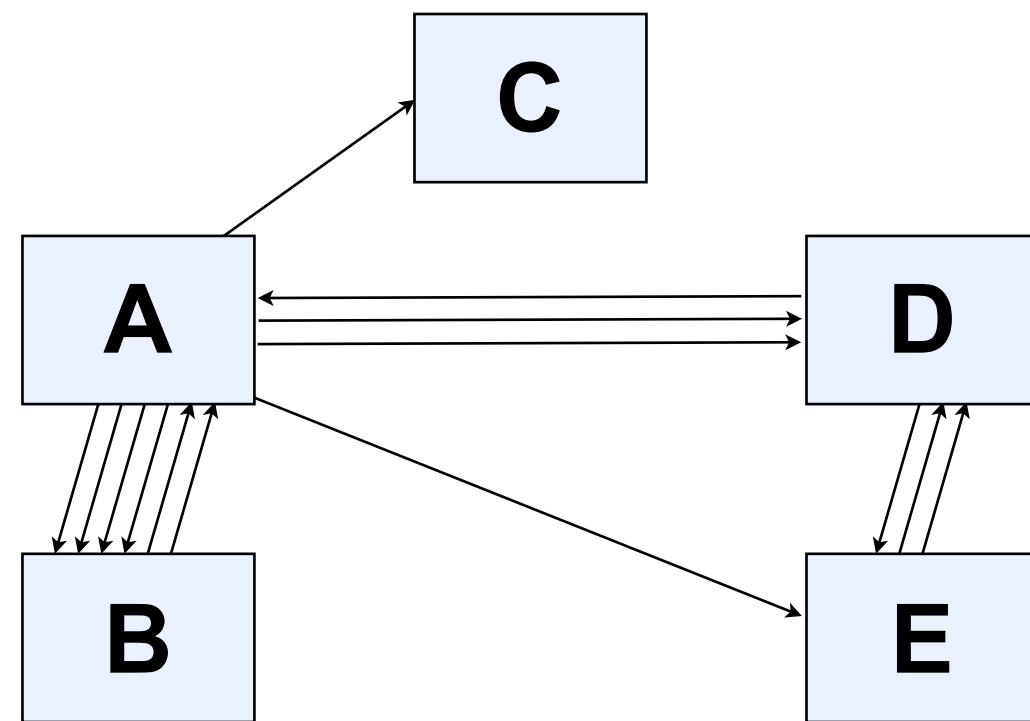


???

RELEX: Logical Overview

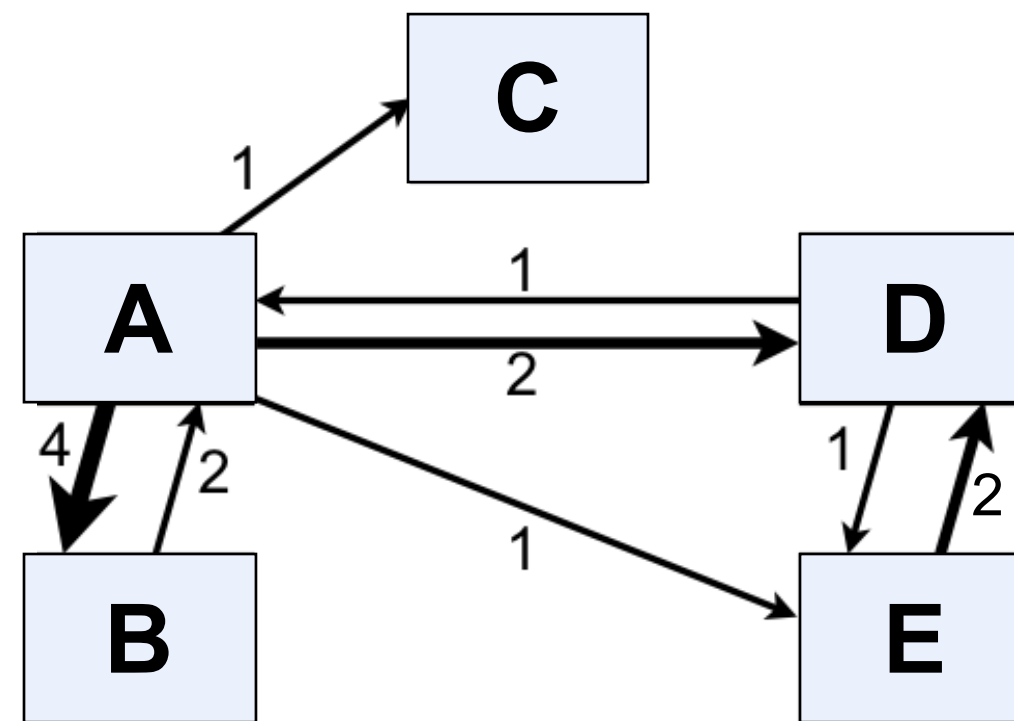
Guideline [Ghoniem 2004]
Matrix for dense graphs

LOGICAL NETWORK



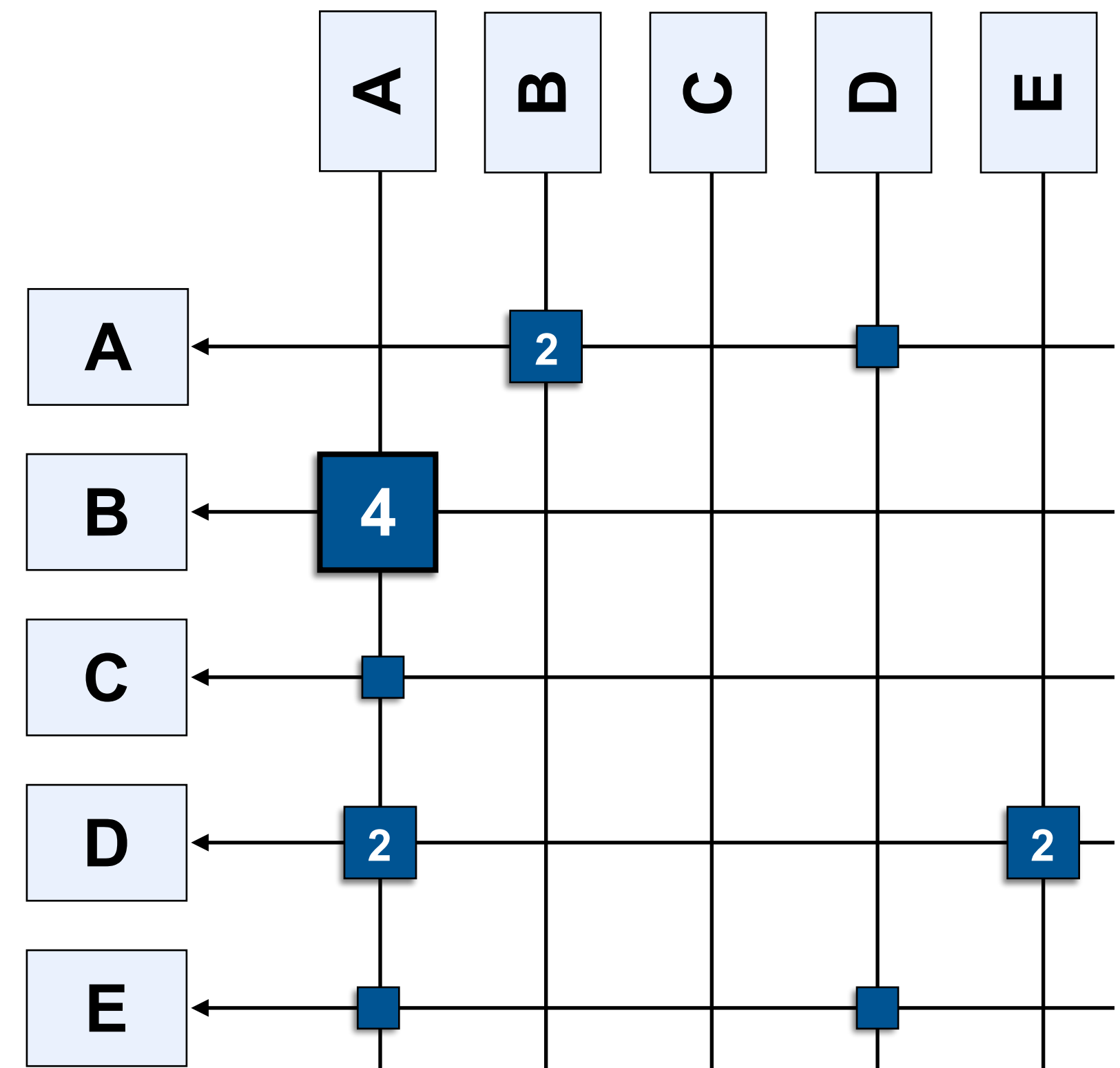
- multigraph
- 100 nodes /10k edges

SIGNAL COUNT NETWORK

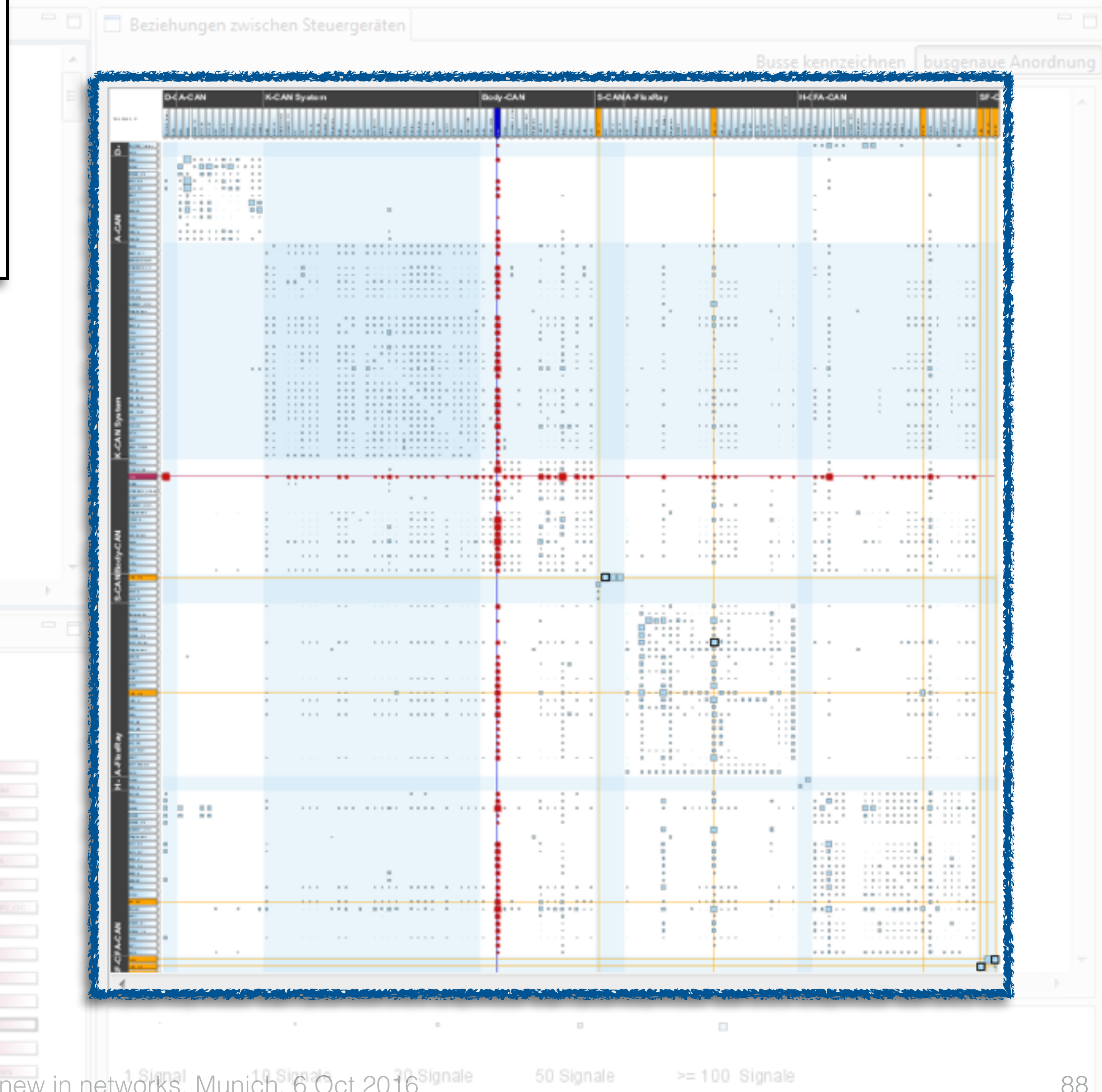
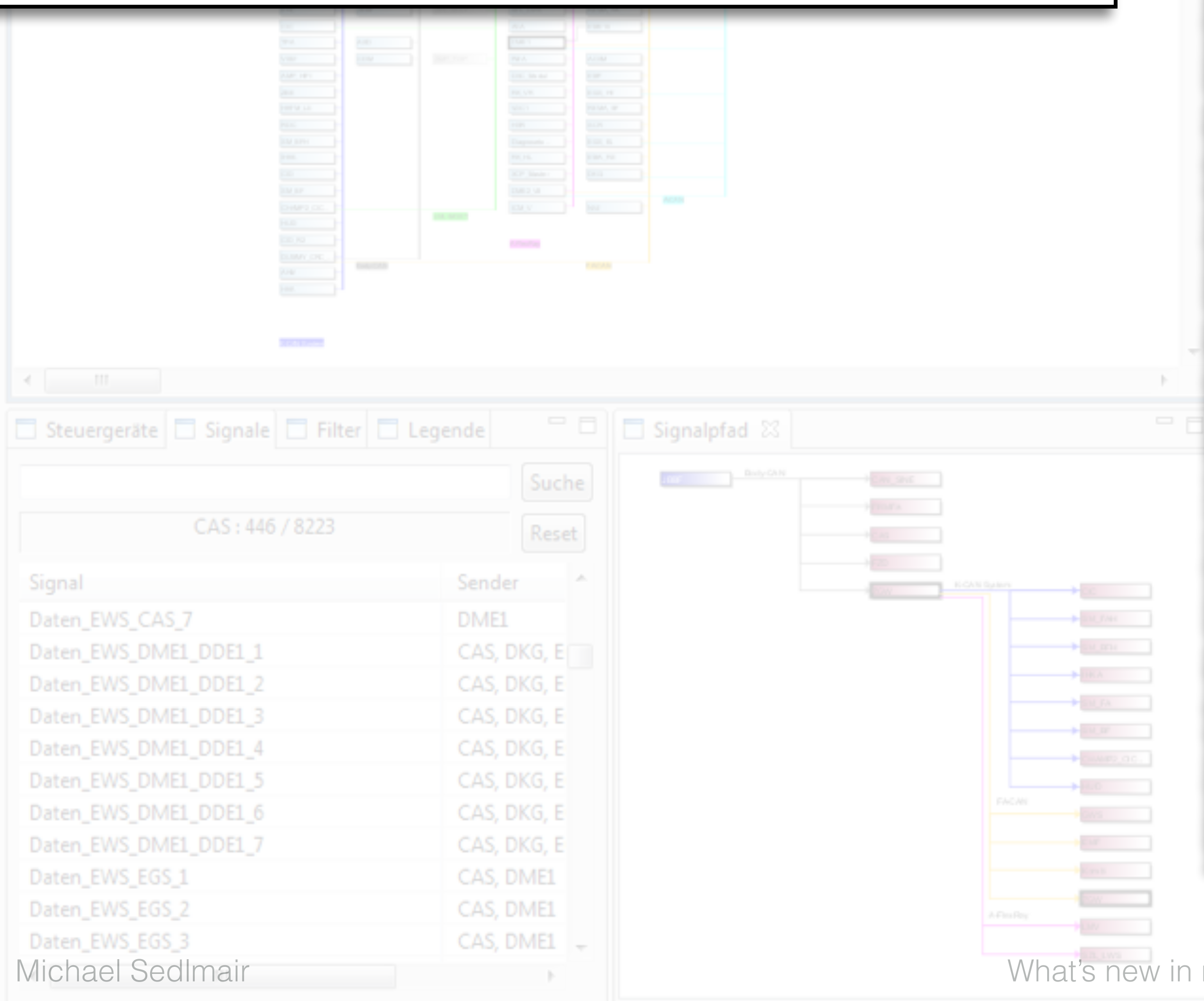


- directed graph
- 1k weighted edges

VISUAL ENCODING: SIZE-CODED MATRIX



RELEx: Logical Overview

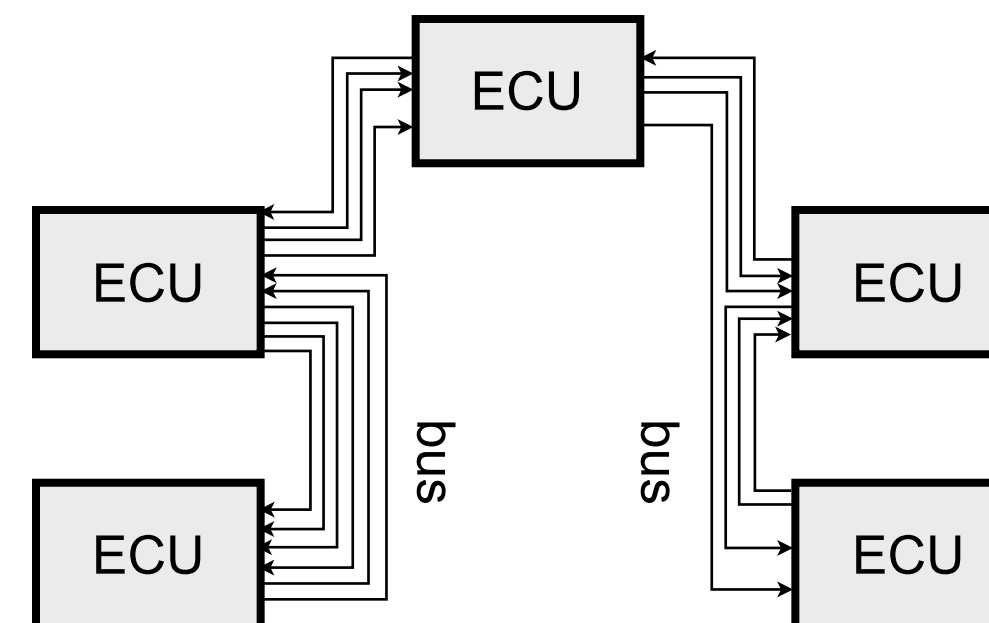


RELEX:

All Paths of a Signal

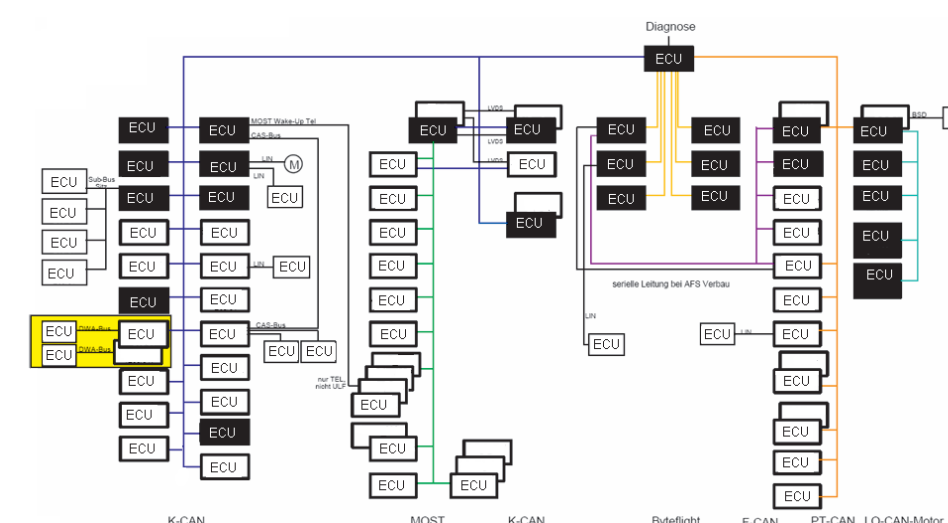
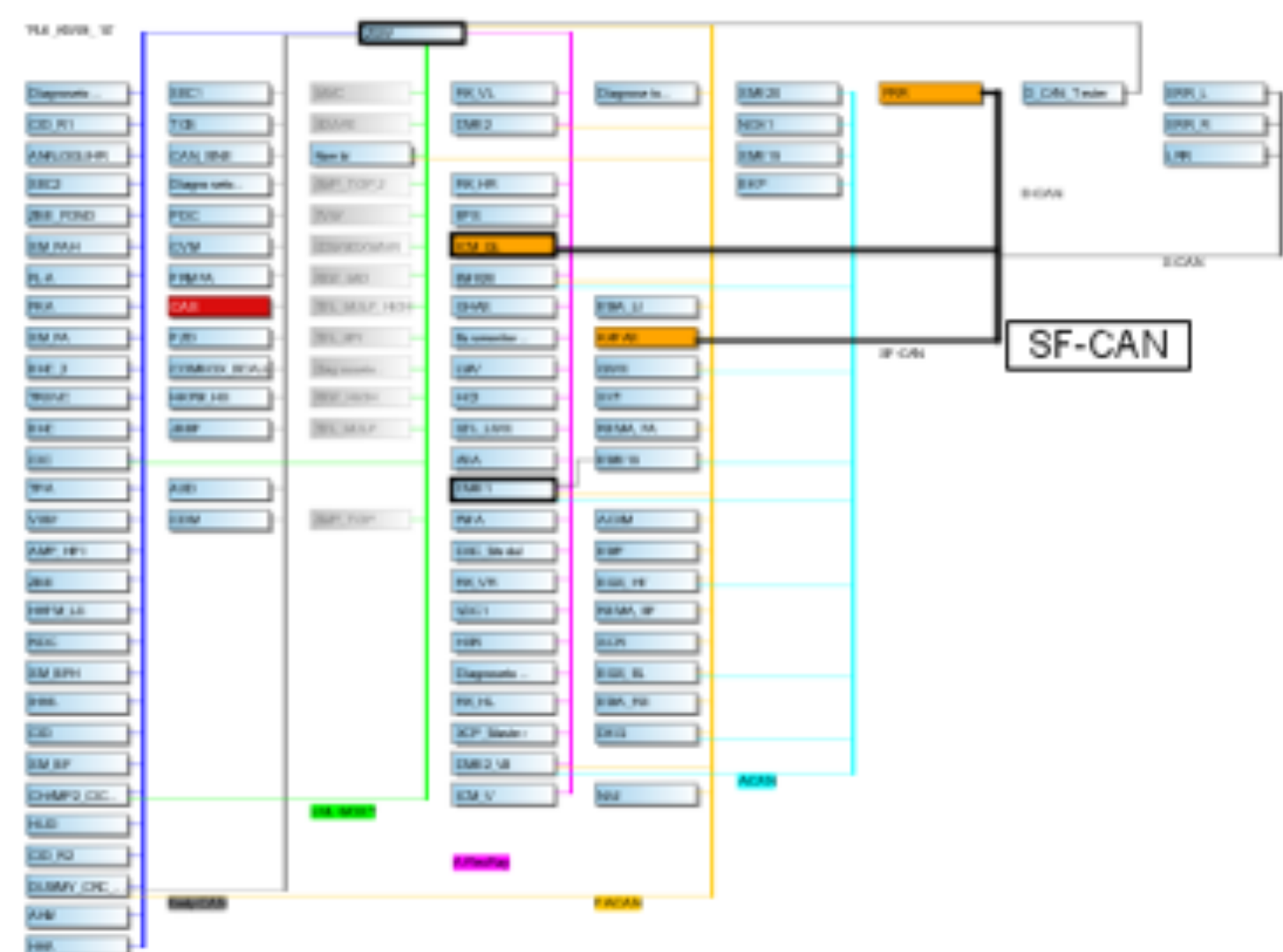
Guideline [Ghoniem 2004]
**Node-link for path
following tasks**

**SIGNAL PATH
NETWORK**



filtered by signal

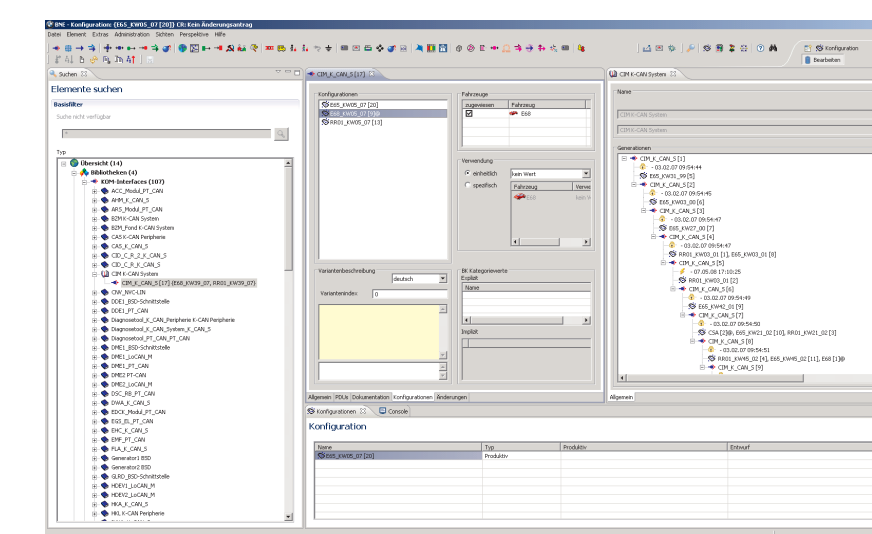
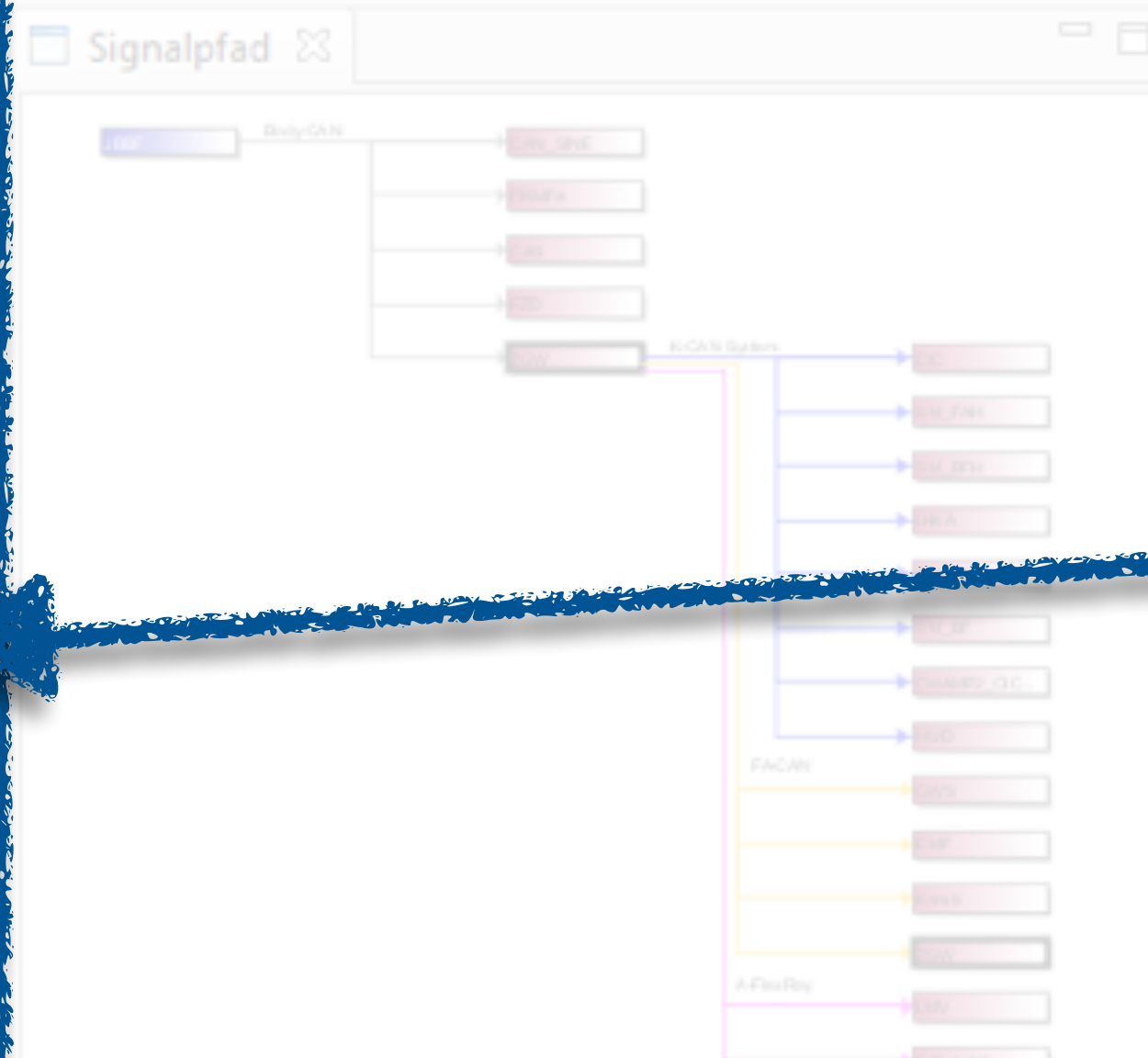
MORE STUFF: Support of Current Practices



☐ Steuergeräte
☐ Signale
☐ Filter
☐ Legende

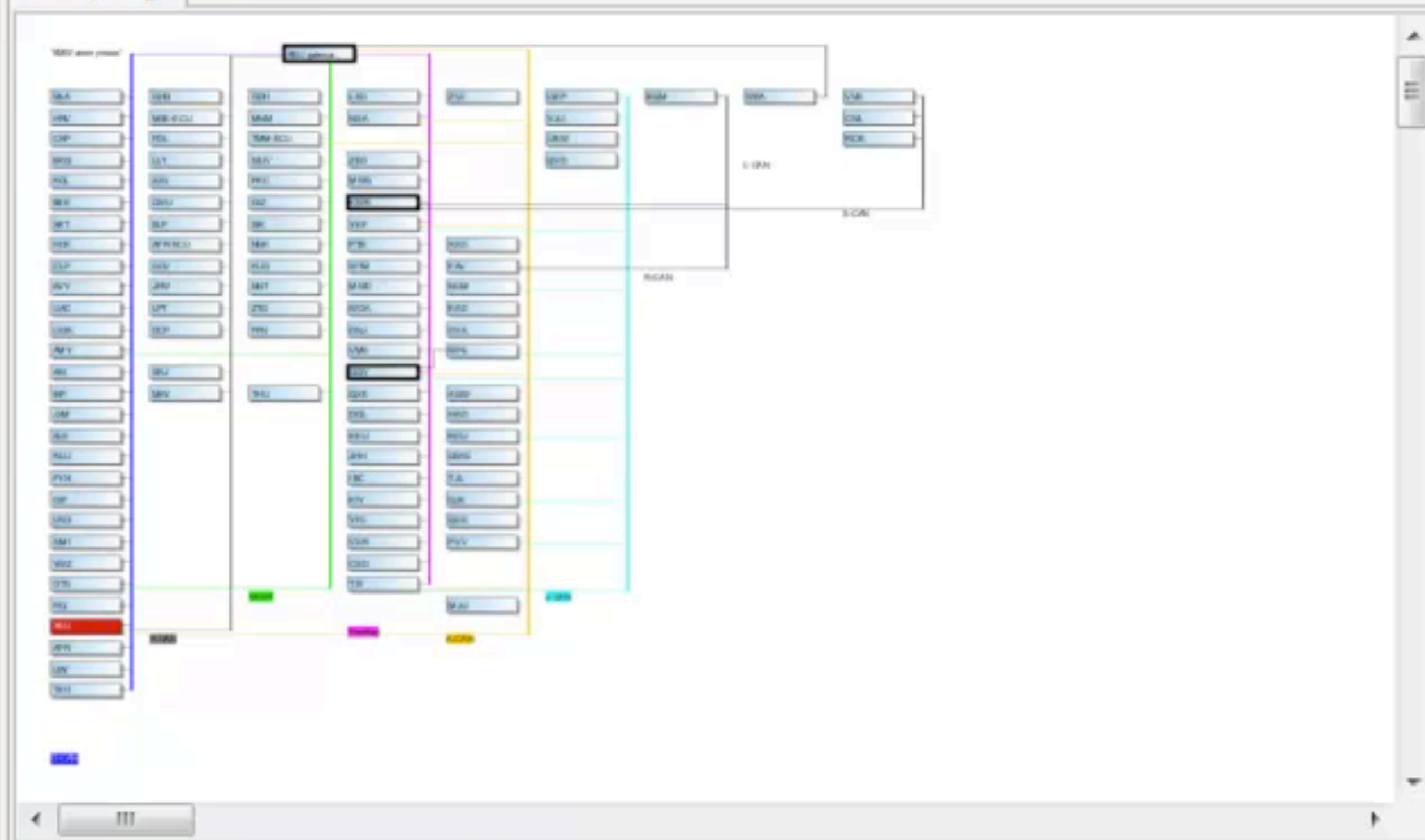
CAS : 446 / 8223

Signal	Sender
Daten_EWS_CAS_7	DME1
Daten_EWS_DME1_DDE1_1	CAS, DKG, E
Daten_EWS_DME1_DDE1_2	CAS, DKG, E
Daten_EWS_DME1_DDE1_3	CAS, DKG, E
Daten_EWS_DME1_DDE1_4	CAS, DKG, E
Daten_EWS_DME1_DDE1_5	CAS, DKG, E
Daten_EWS_DME1_DDE1_6	CAS, DKG, E
Daten_EWS_DME1_DDE1_7	CAS, DKG, E
Daten_EWS_EGS_1	CAS, DME1
Daten_EWS_EGS_2	CAS, DME1
Daten_EWS_EGS_3	CAS, DME1



Filter löschen  Auswahl löschen

☐ Topologie



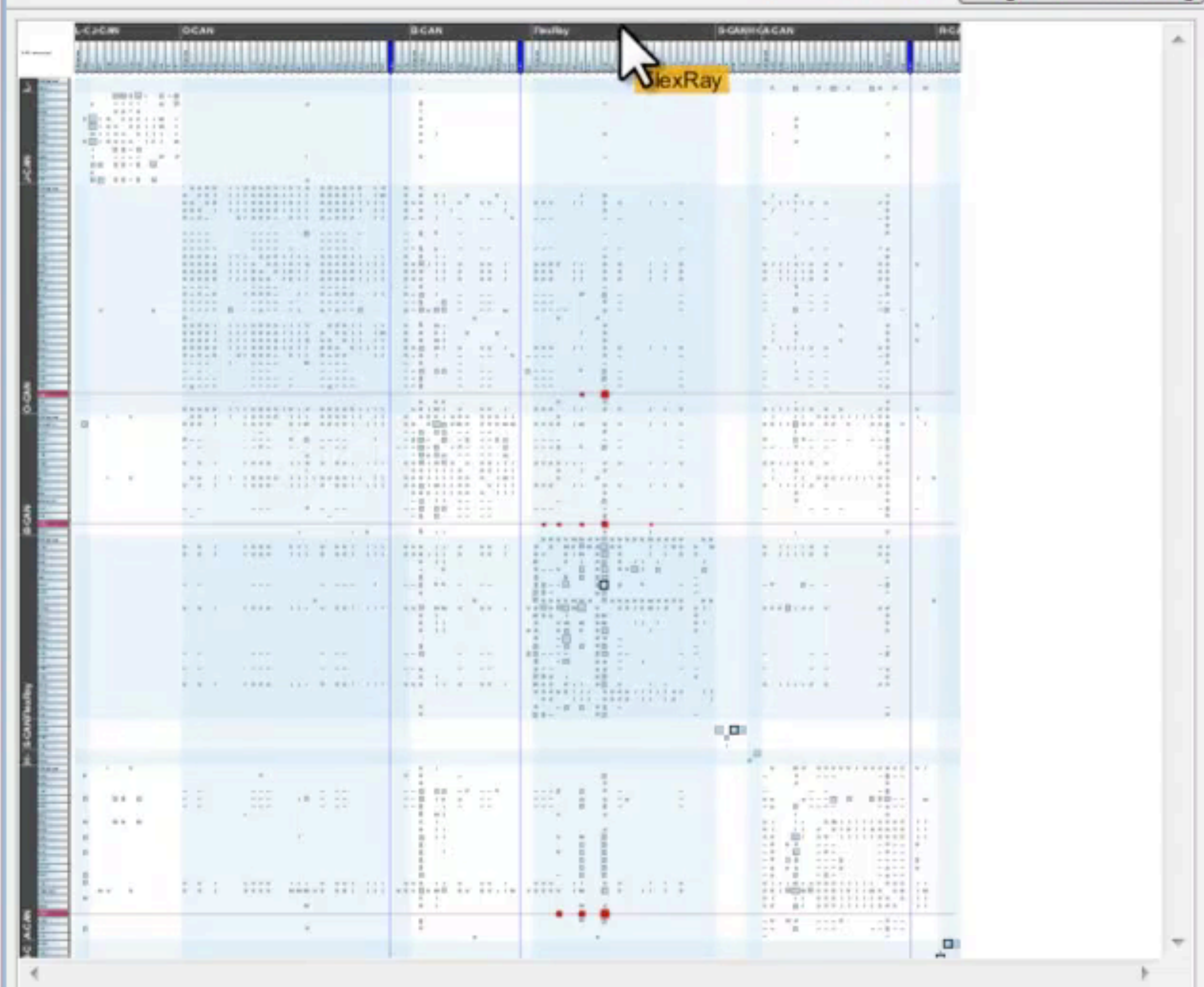
☐ Steuergeräte ☐ Signale ☐ Filter ☐ Legende

XBU : 158 / 8222

Signal	Sender	Empfänger
ABHN-Signal	KWR	TMM-ECU, XBU
AONQ-Signal	DNJ	KWR, XBU
APWC-Signal	KWR	XBU
ARNL-Signal	KWR	AGW, CSD, ELP, MSE-ECU, MWD,...
AWKZ-Signal	DNJ	ELP, FAV, KWR, MWQ, PVV, QXE, ...
AXYQ-Signal	KWR	BQM, CSD, IBC, JHH, MSE-ECU, X...

☐ Beziehungen zwischen Steuergeräten

Busse kennzeichnen busgenaue Anordnung



1 Signal 10 Signale 30 Signale 50 Signale >= 100 Signale

RelEx: Evaluation



Evaluation

————— *during design (formative)* —————

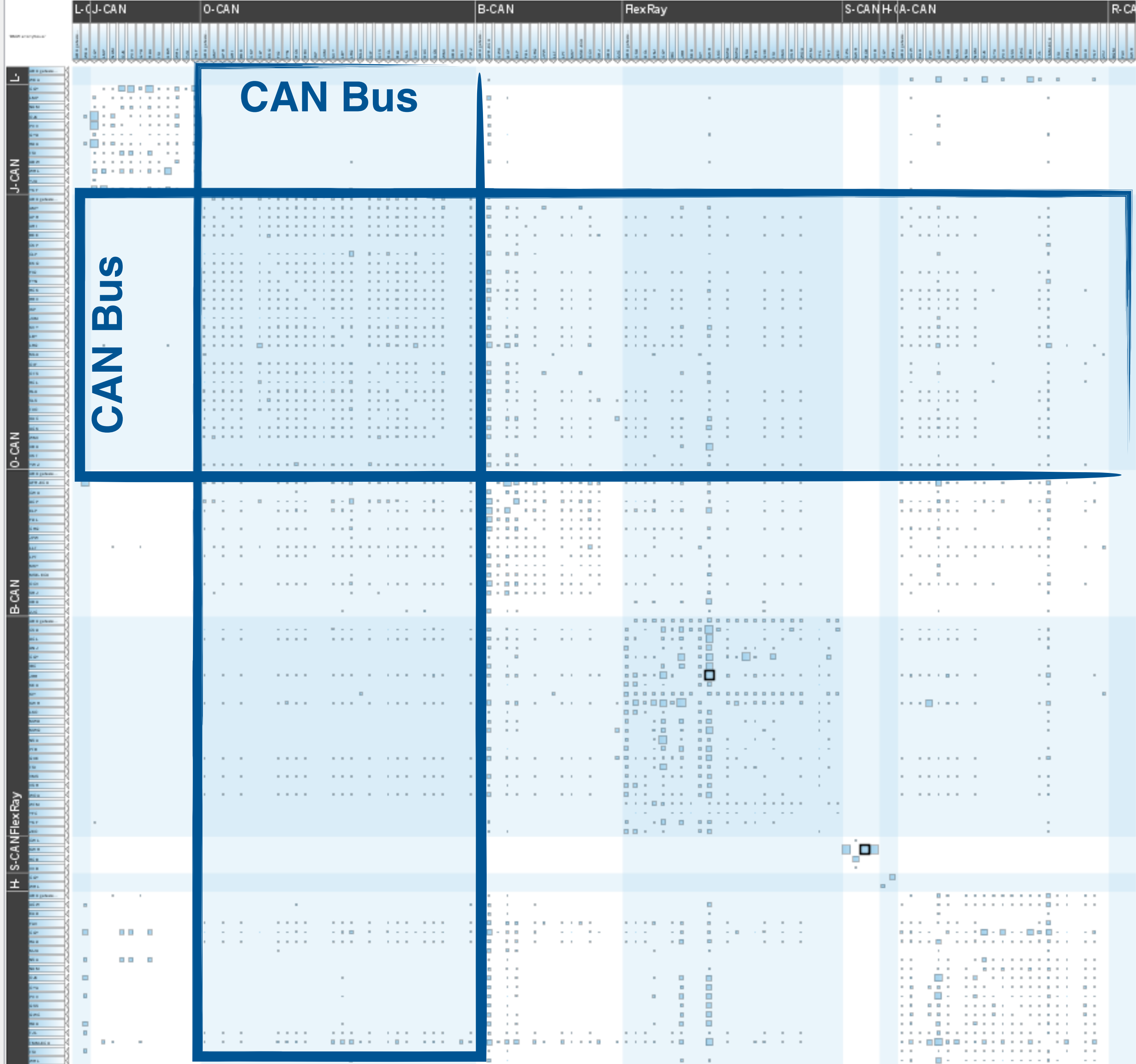
- iterative paper prototyping
- agile design: 6 deployed releases
 - 3 lead users (domain experts)
- usability studies with
 - 4 users: domain experts & HCI students

————— *after design (summative)* —————

- field study with final release
 - 7 engineers / 5 weeks
- think aloud study
 - 10 engineers / 1h sessions
- 3-month post study - adoption?



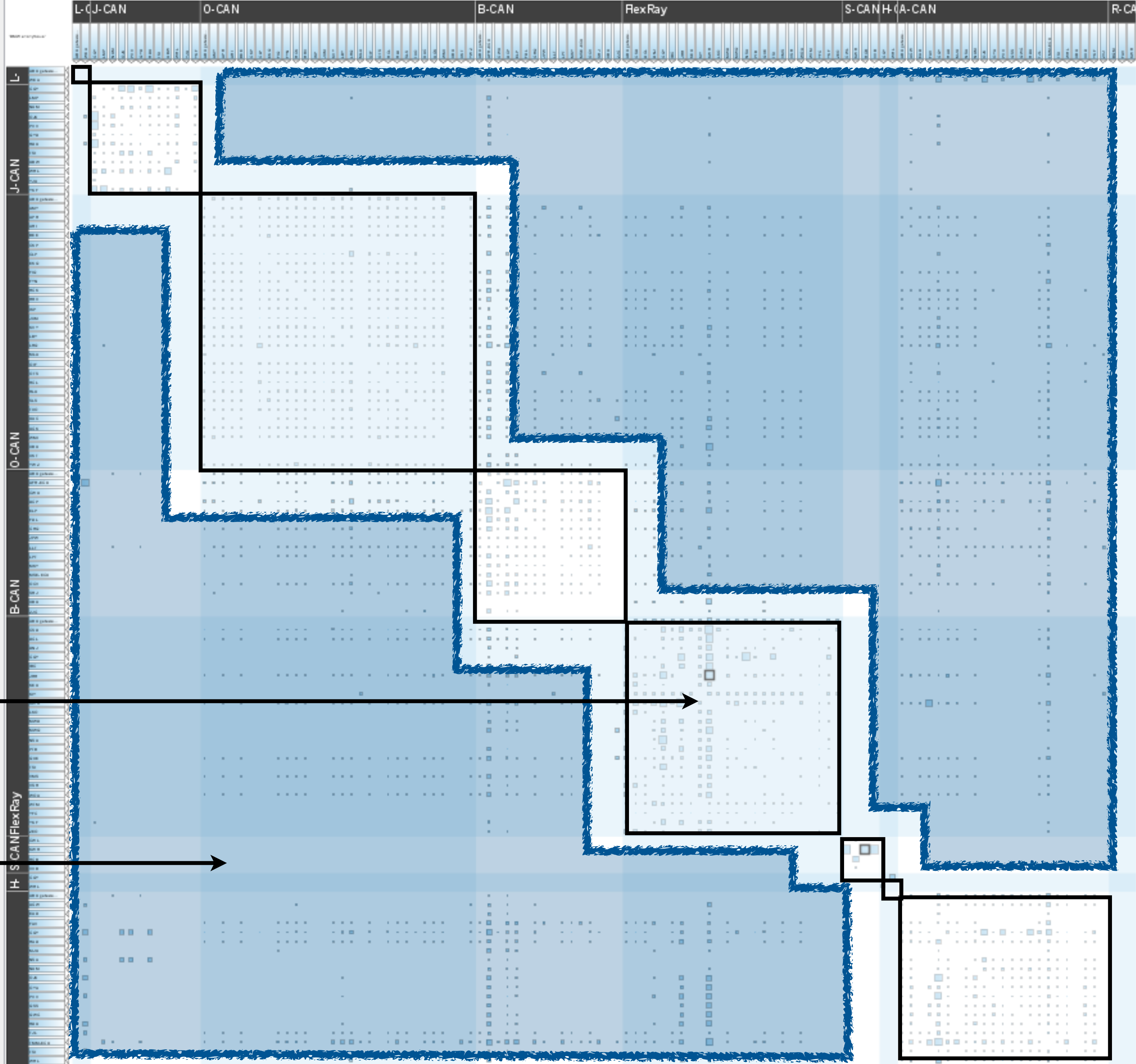
Novel insights: Bus communication patterns



Novel insights: Bus communication patterns

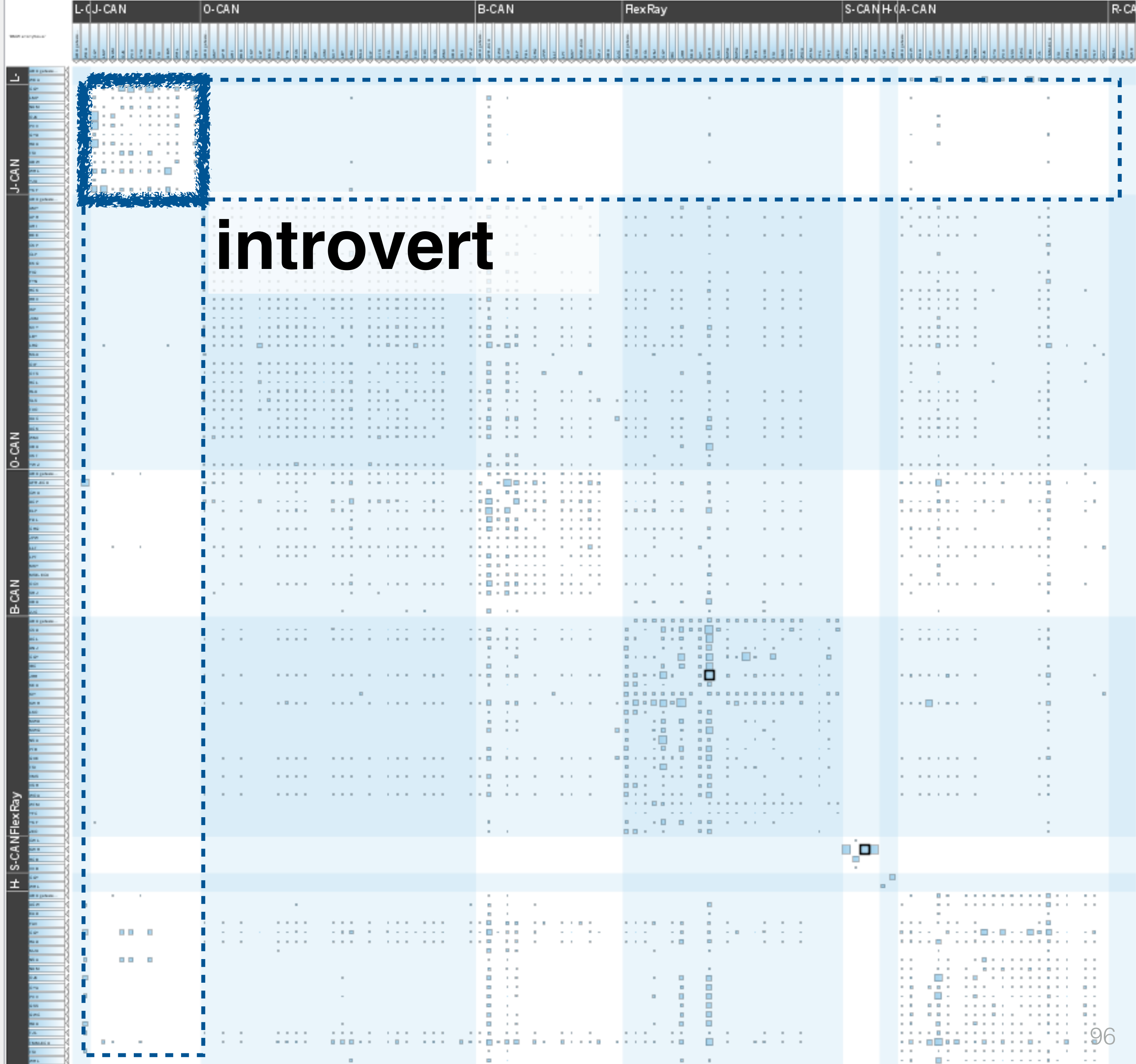
Within-bus

Between-bus



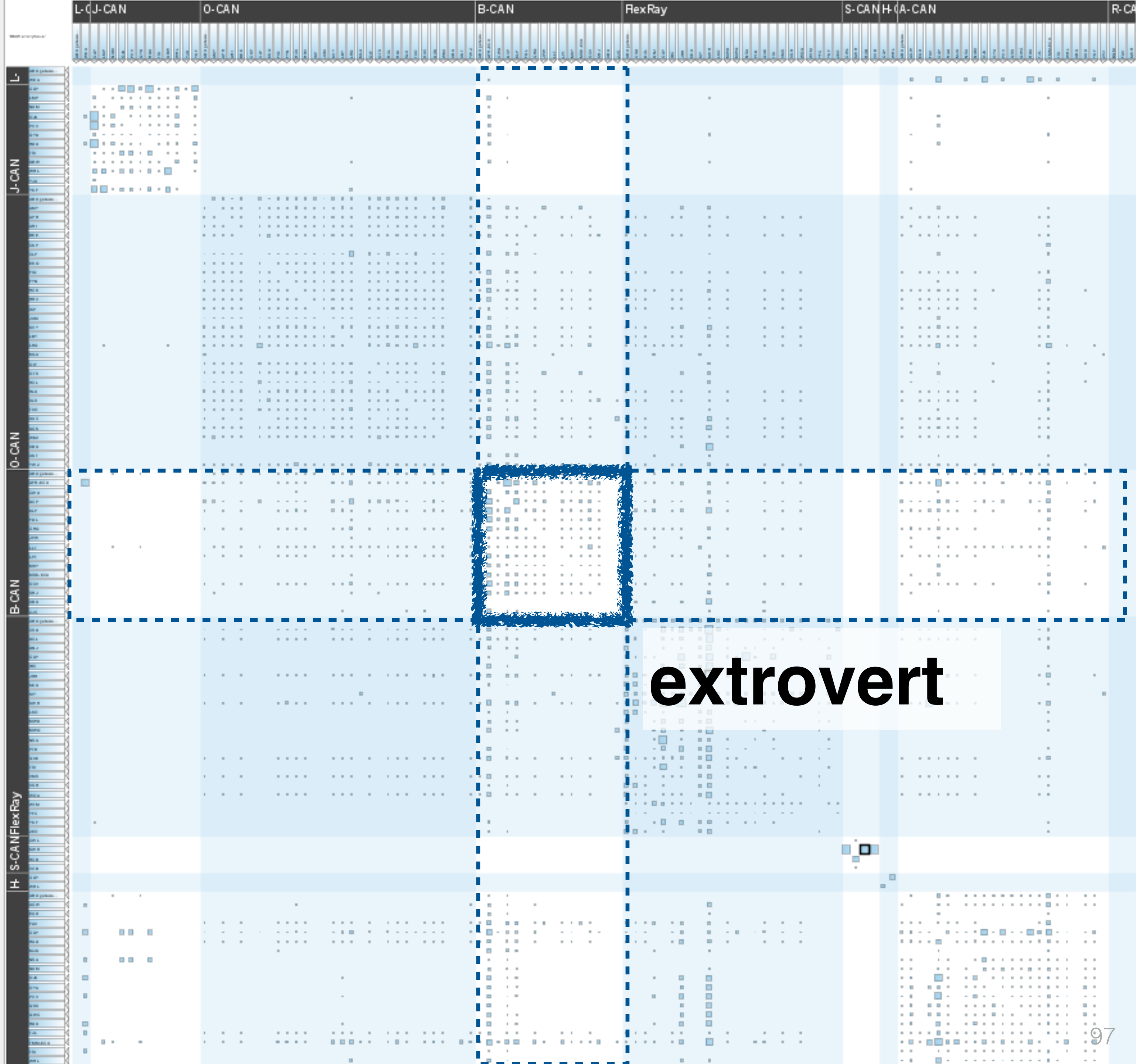
Novel insights: Bus communication patterns

introvert
vs.
extrovert



Novel insights: Bus communication patterns

introvert
vs.
extrovert



extrovert

Speedup

“RelEx gives me a more compact, way faster access to the information I need”

BMW engineer
(translated from German).

Adoption

- 3-month post study
- 15+ engineers

Outline

1. Technique-driven research

- Trends in graph drawing
- Trends in visualization — Related to graph drawing

2. Problem-driven research

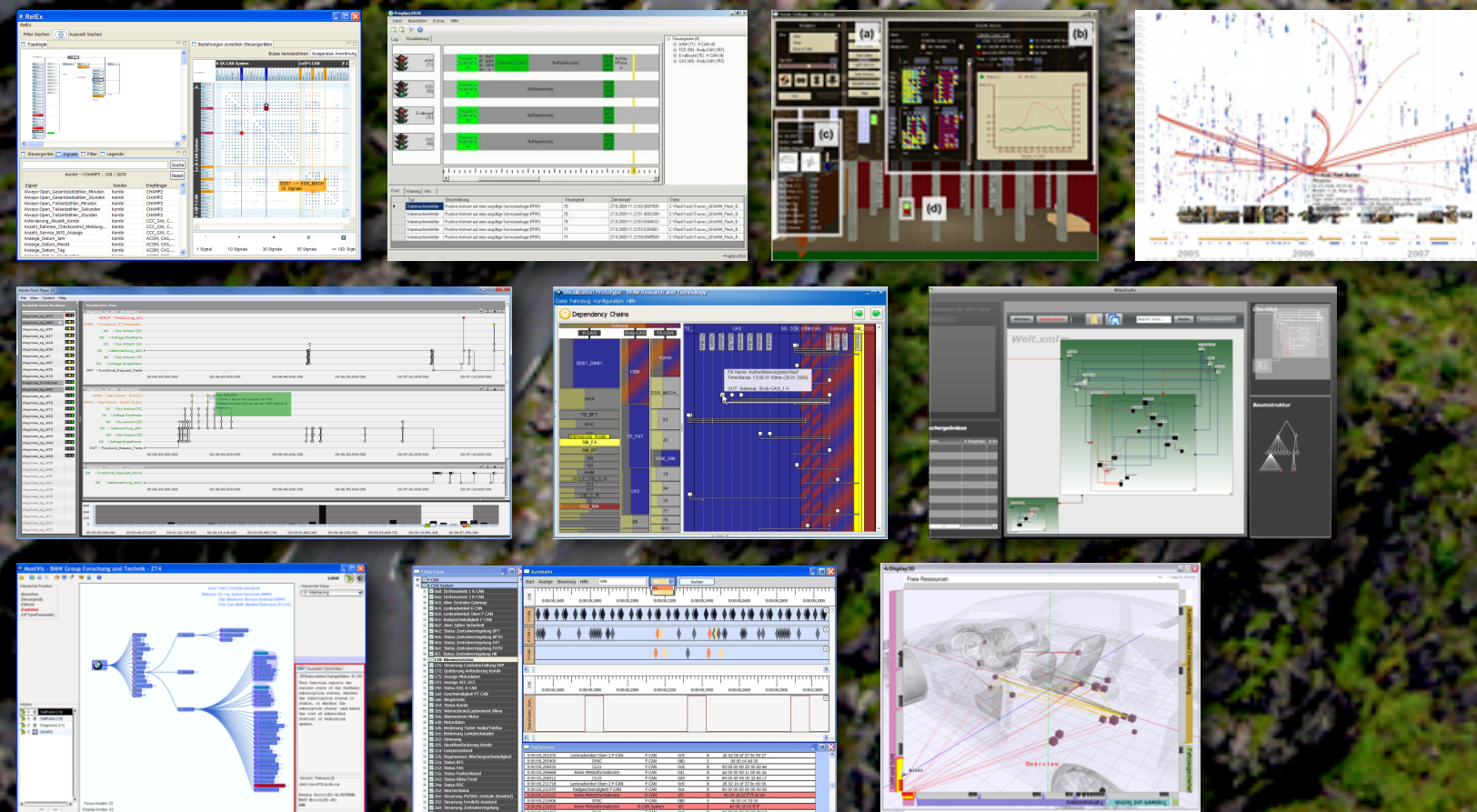
- Design Study Example — RelEx
- Design Study Methodology

3. Summary

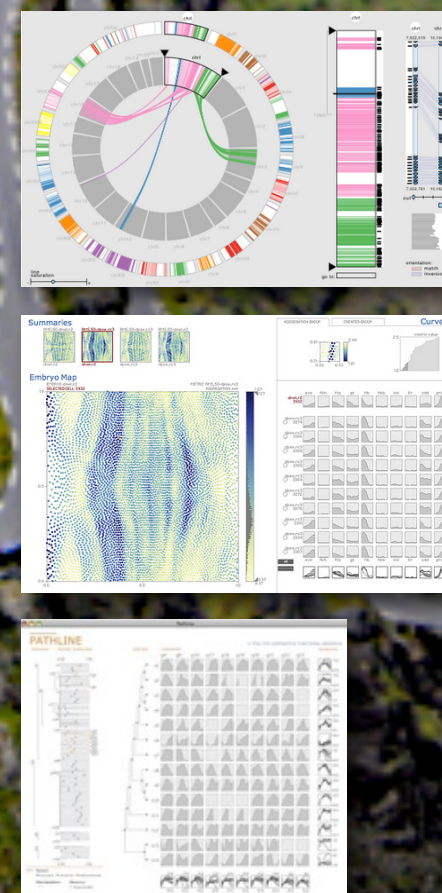
design studies: long and winding road with many pitfalls!



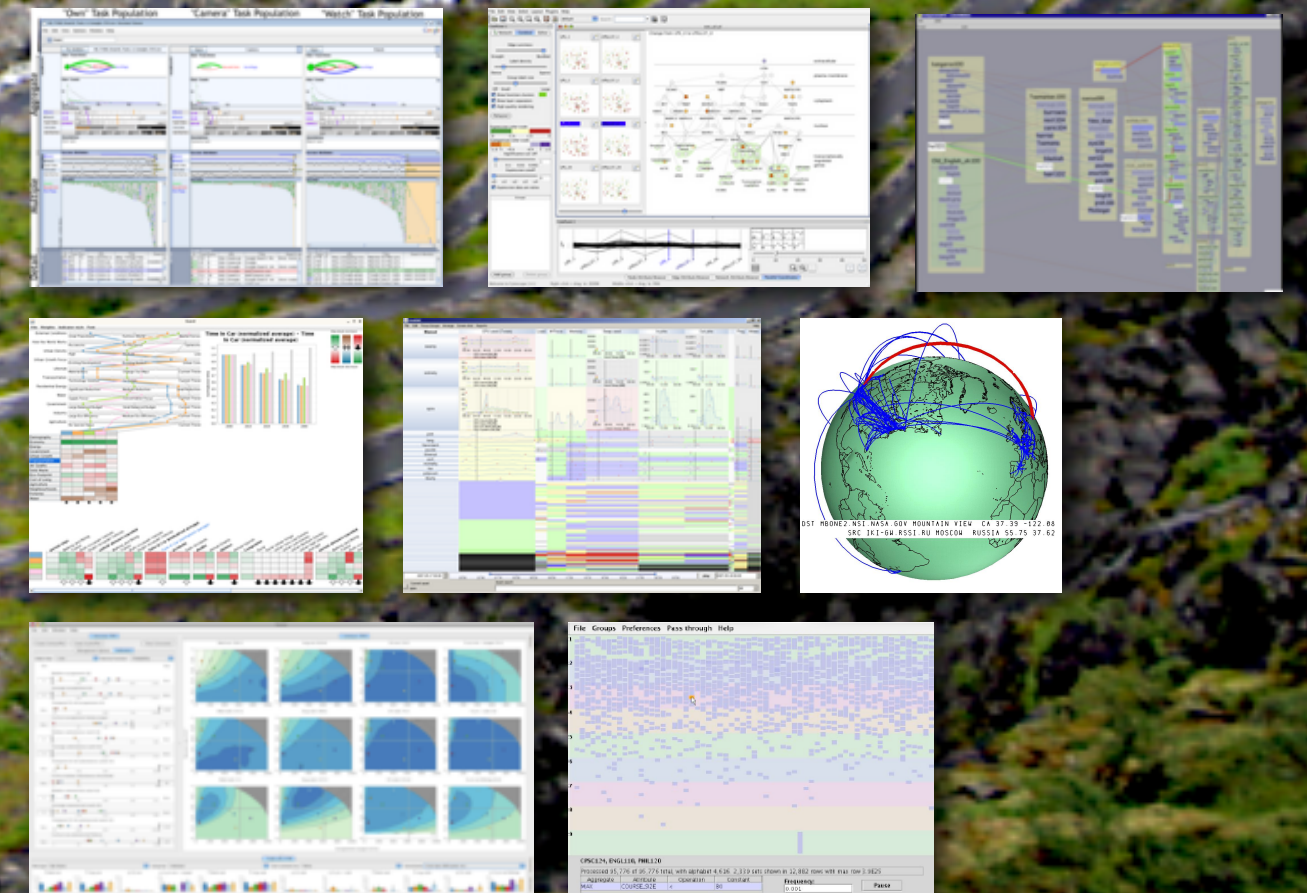
et al.



et al.

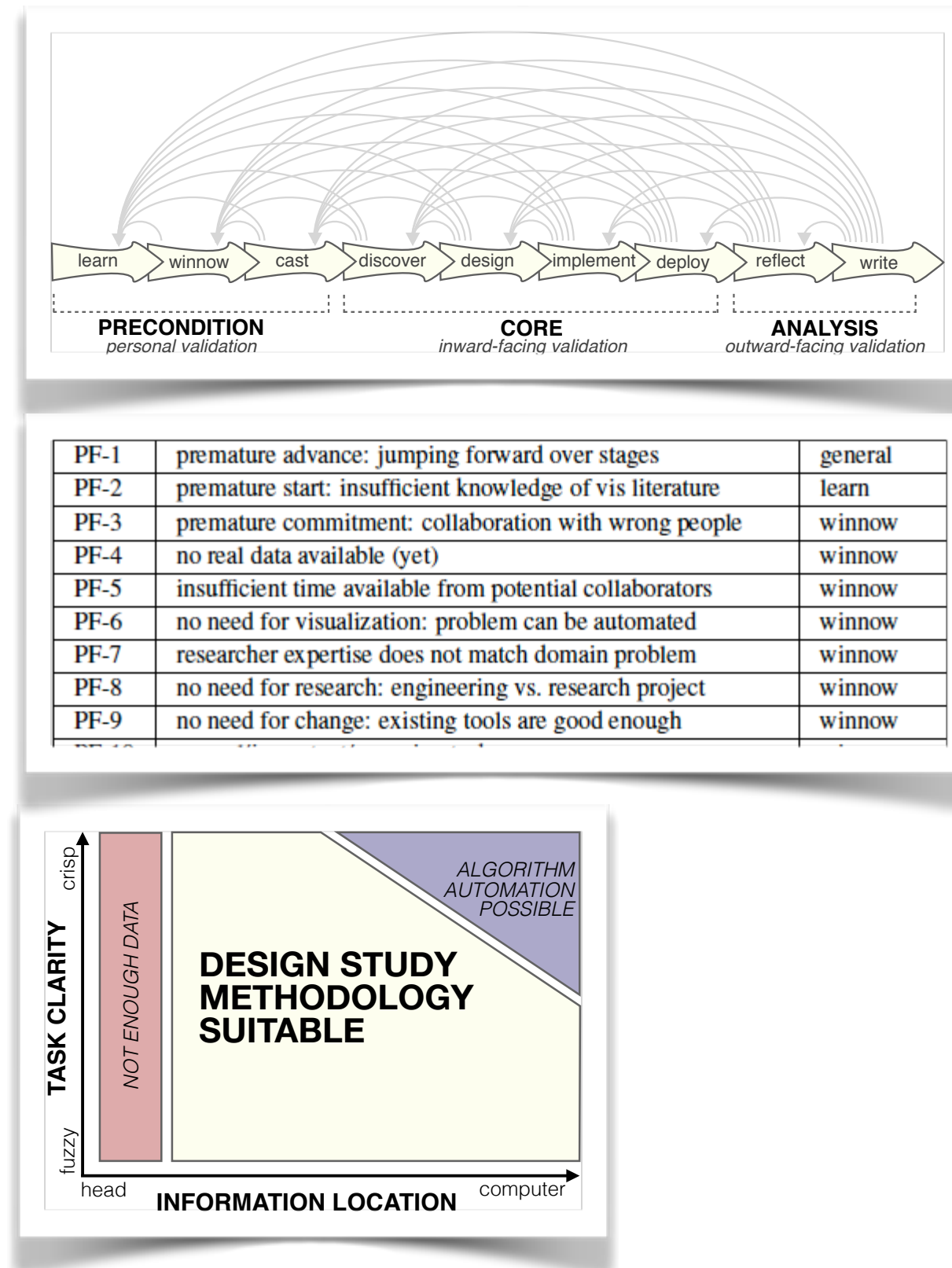


et al.



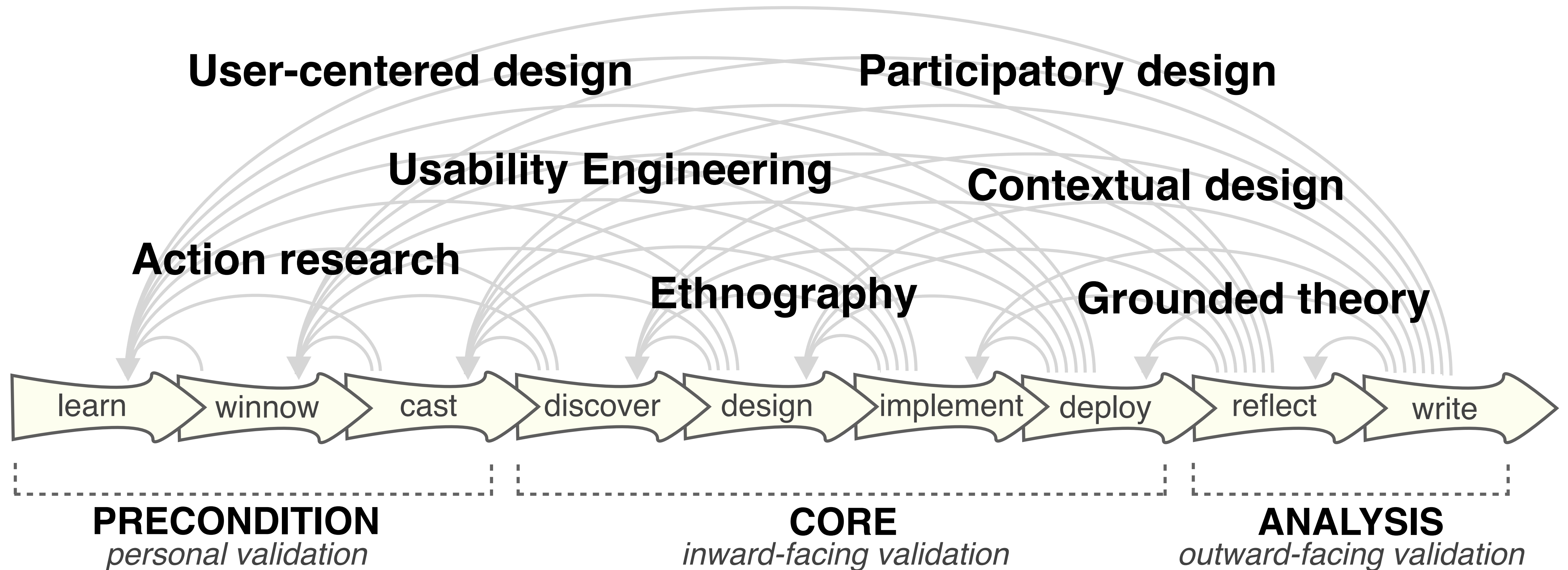
How to do design studies?

- 9-stage framework
- 32 pitfalls
- Why design studies



Michael Sedlmair, Miriah Meyer, Tamara Munzner.
Design Study Methodology: Reflections from the Trenches and the Stacks .
IEEE TVCG (Proc. InfoVis), 2012.

9-stage framework



32 pitfalls:

Example — premature publishing

Must be first!



http://www.alaineknipes.com/interests/violin_concert.jpg

technique-driven

Am I ready?



<http://www.prlog.org/10480334-wolverhampton-horse-racing-live-streaming-wolverhampton-mandicap-8-jan-2010.html>

problem-driven

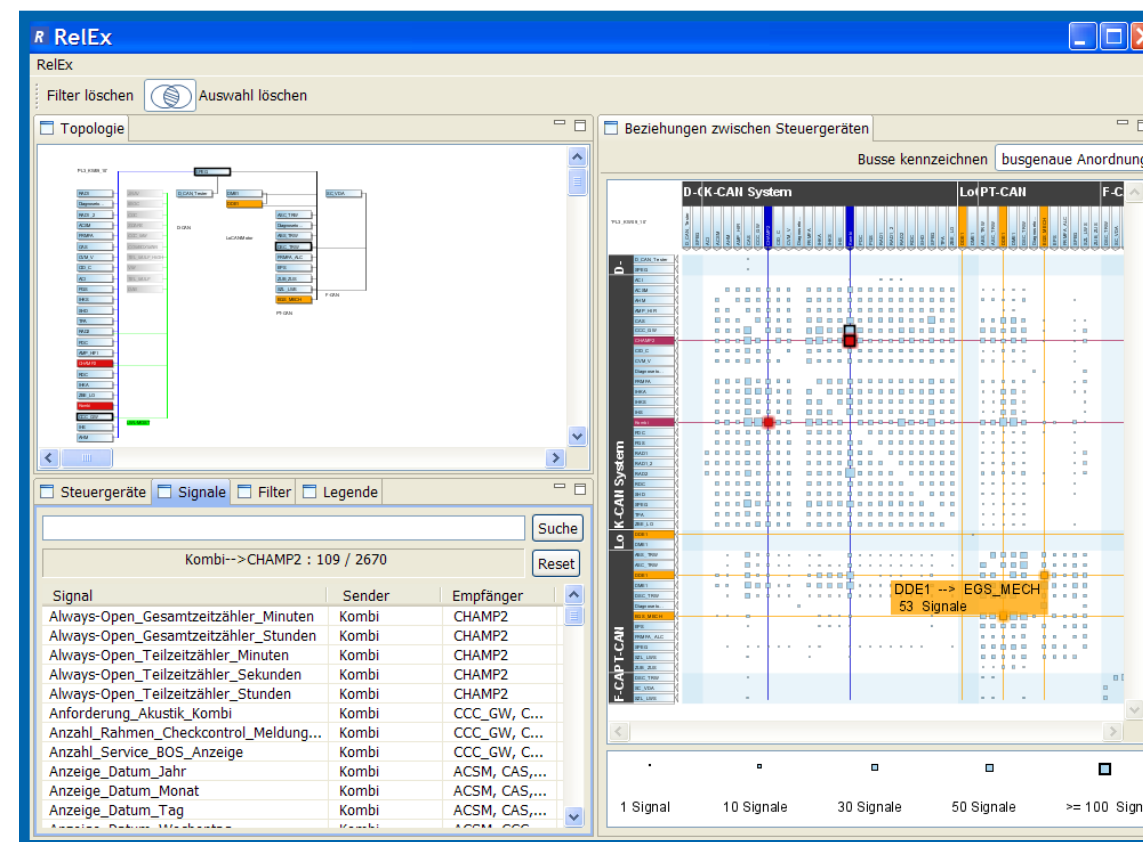
32 pitfalls:

Example — no reflection

Reflection is where research emerges from engineering

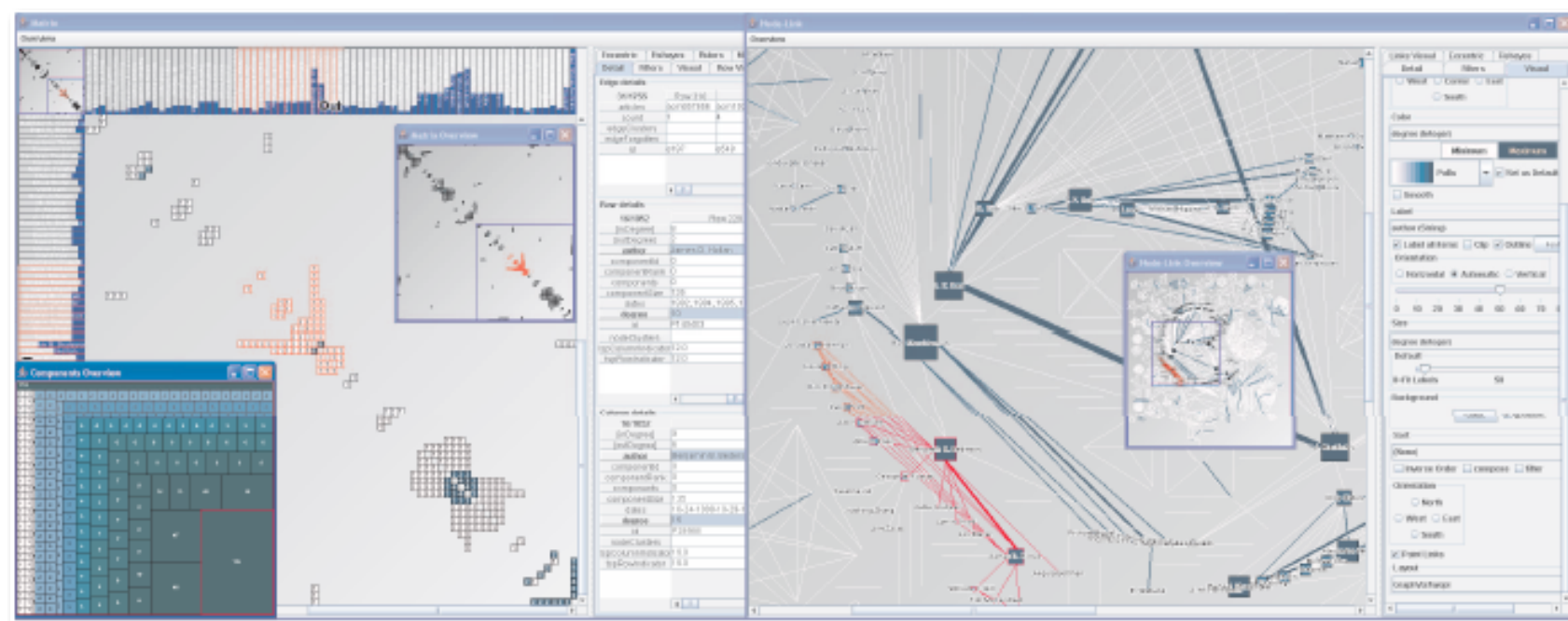
Transferability: relate to other design studies

RelEx: Reflection

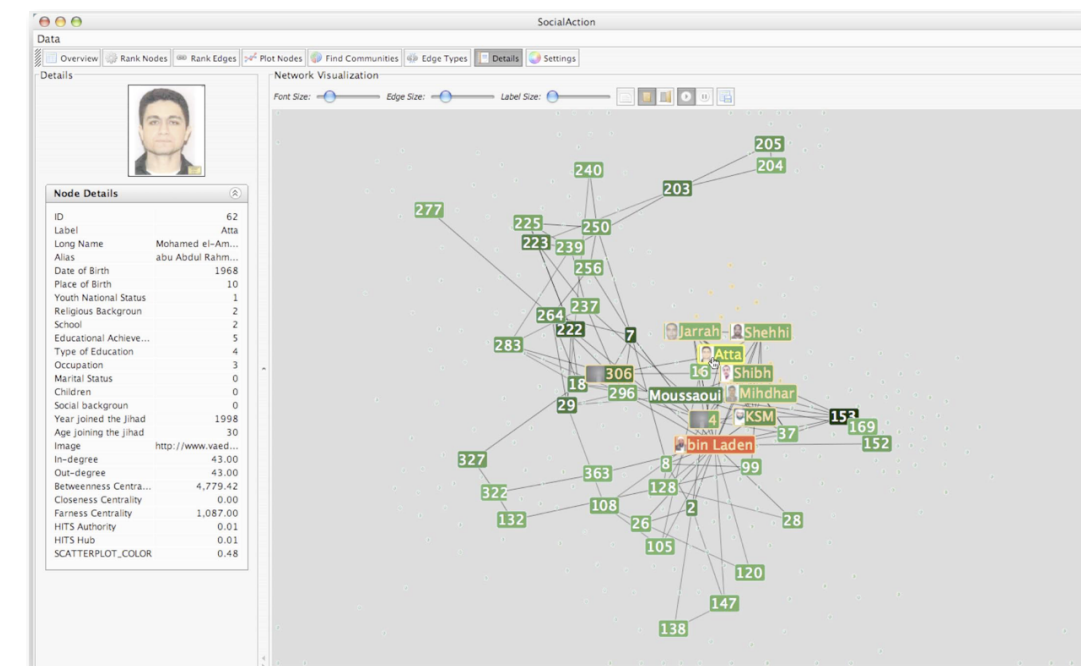


Previous work: Focus on social network analysis

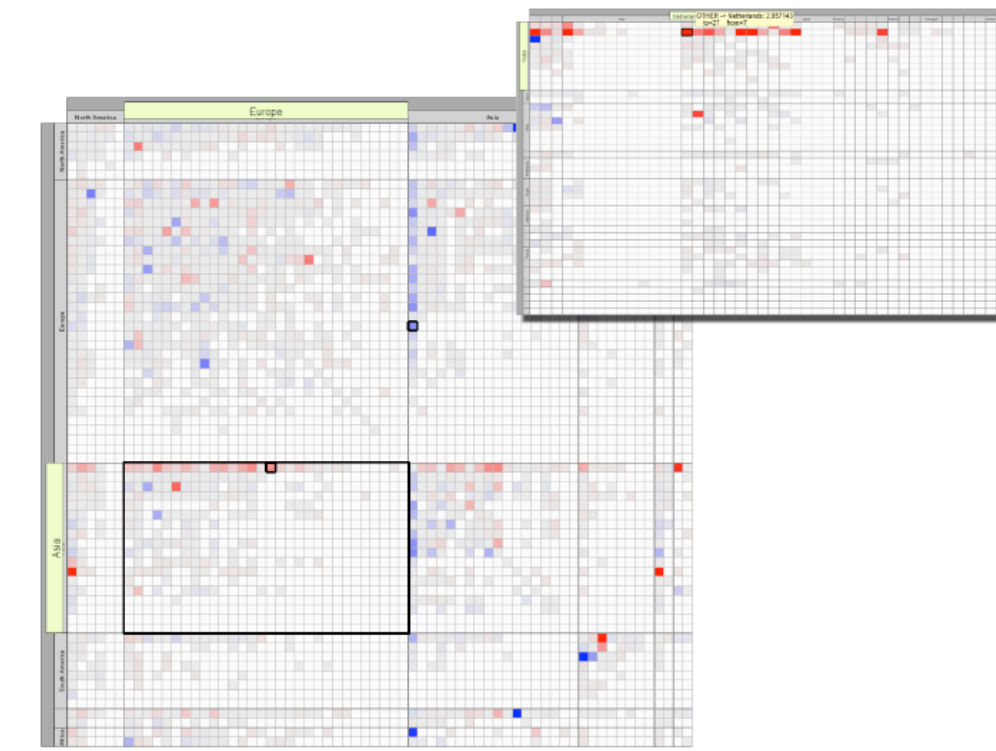
- radically different task and data abstractions



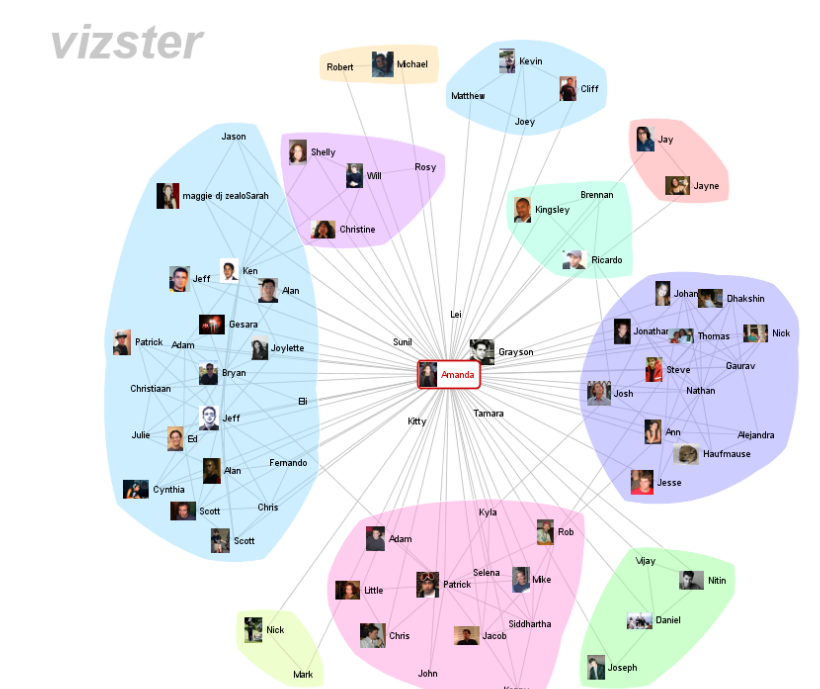
MatrixExplorer



SocialAction



Honeycomb

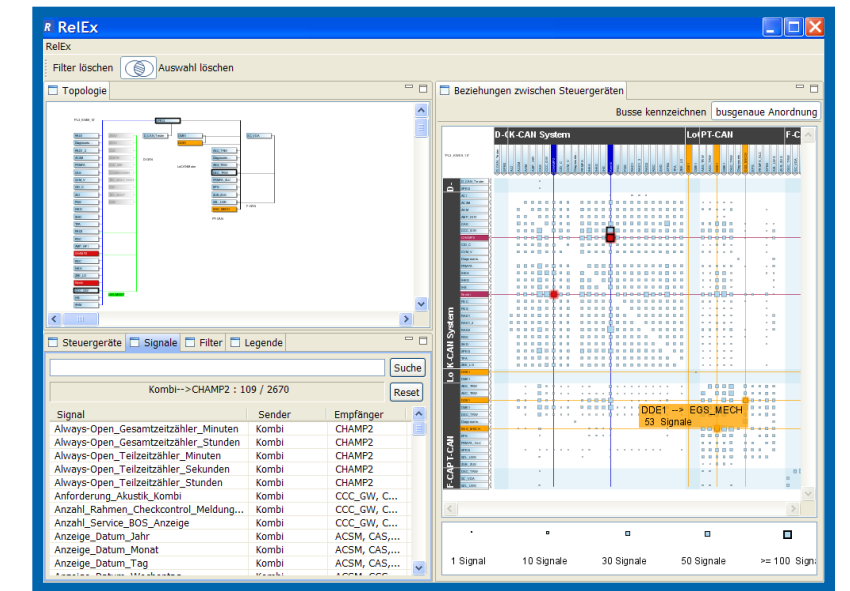


vizster

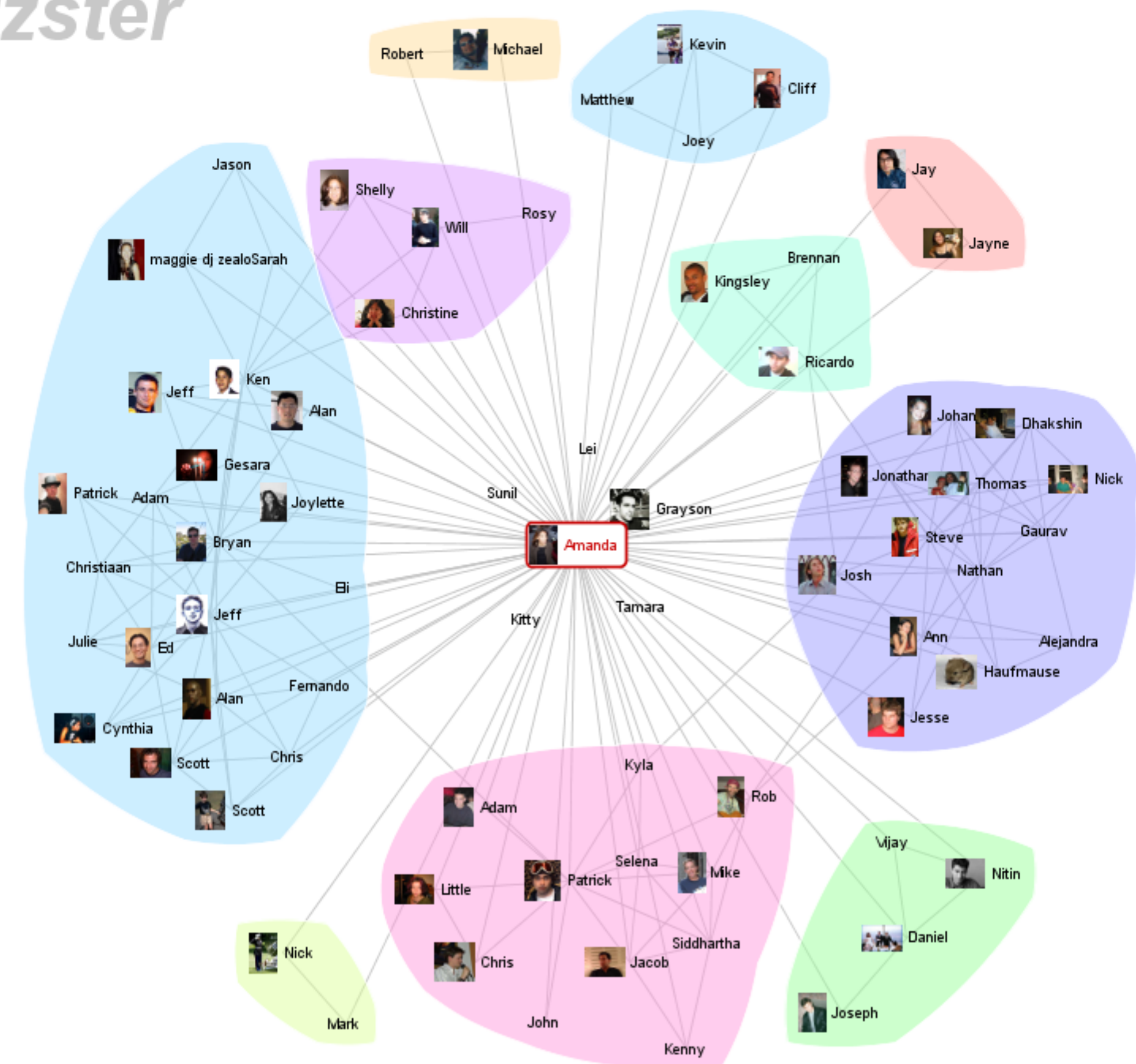
Previous work: Social network analysis

Task abstraction:

- find clusters



vizster

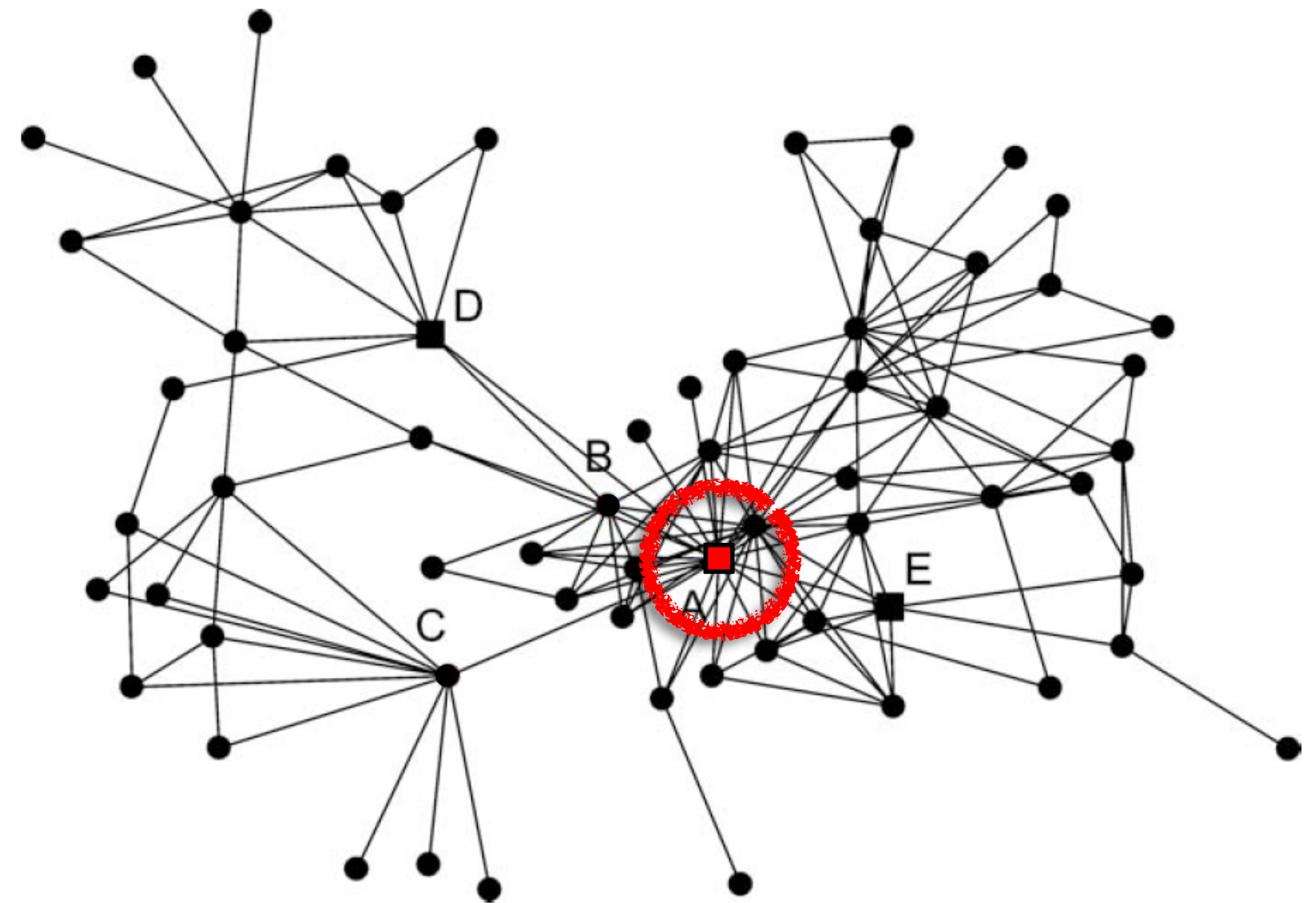


Previous work:

Social network analysis

Task abstraction:

- find clusters
- find high-degree nodes

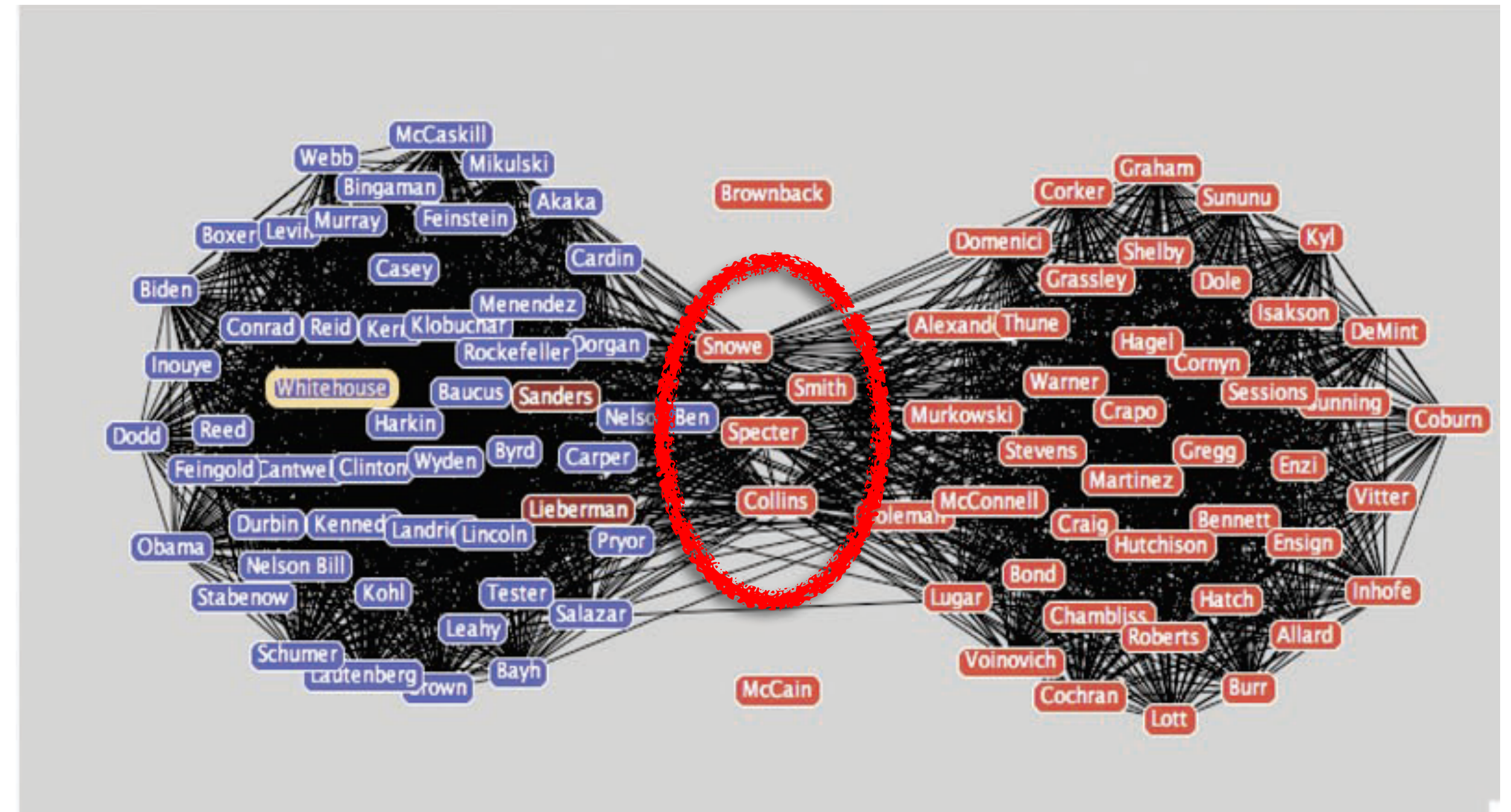


Previous work:

Social network analysis

Task abstraction:

- find clusters
- find high-degree nodes
- find bridging nodes

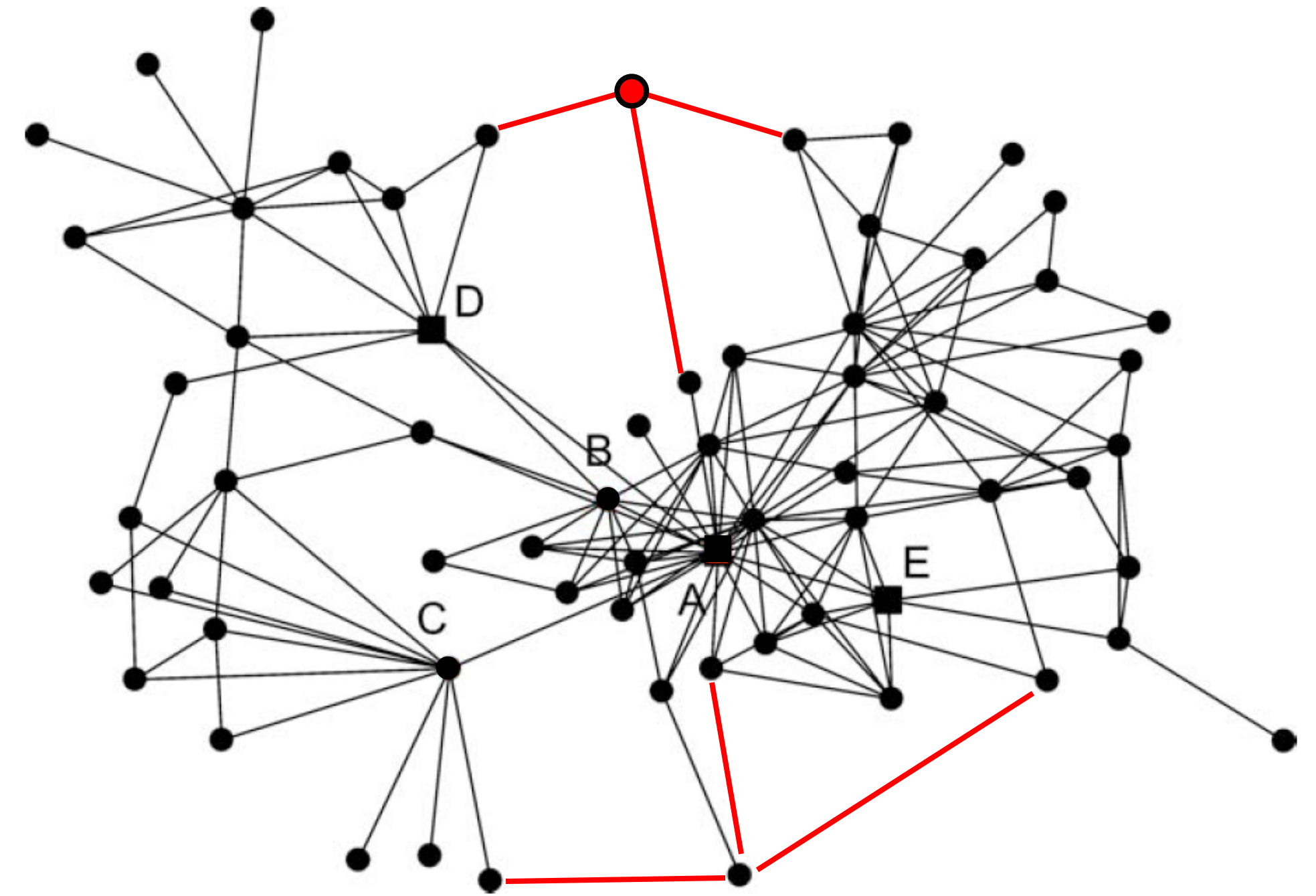


Previous work:

Social network analysis

Task abstraction:

- find clusters
- find high-degree nodes
- find bridging nodes
- understand temporal dynamics
 - passively notice changes



Abstraction Innovation



Social network analysis

Tasks

- find clusters, high-degree/bridge nodes
- passive changes



Data

- single network
- node scalability
 - sparse edges



Overlay network optimization

Tasks

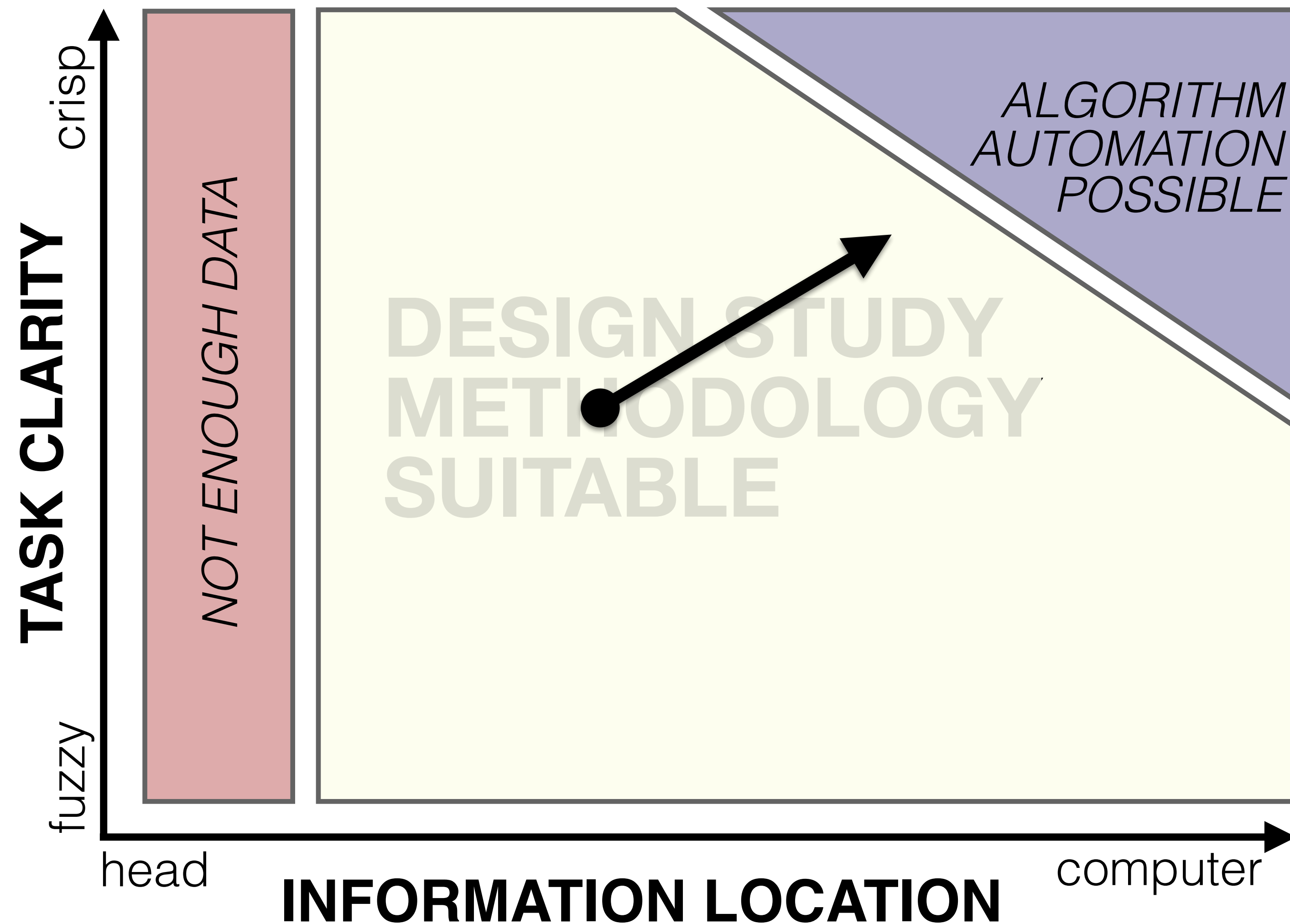
- traffic optimization
- active changes



Data

- three related networks
 - physical, logical, overlay
- path scalability
 - dense edges, few nodes

Why do design studies?

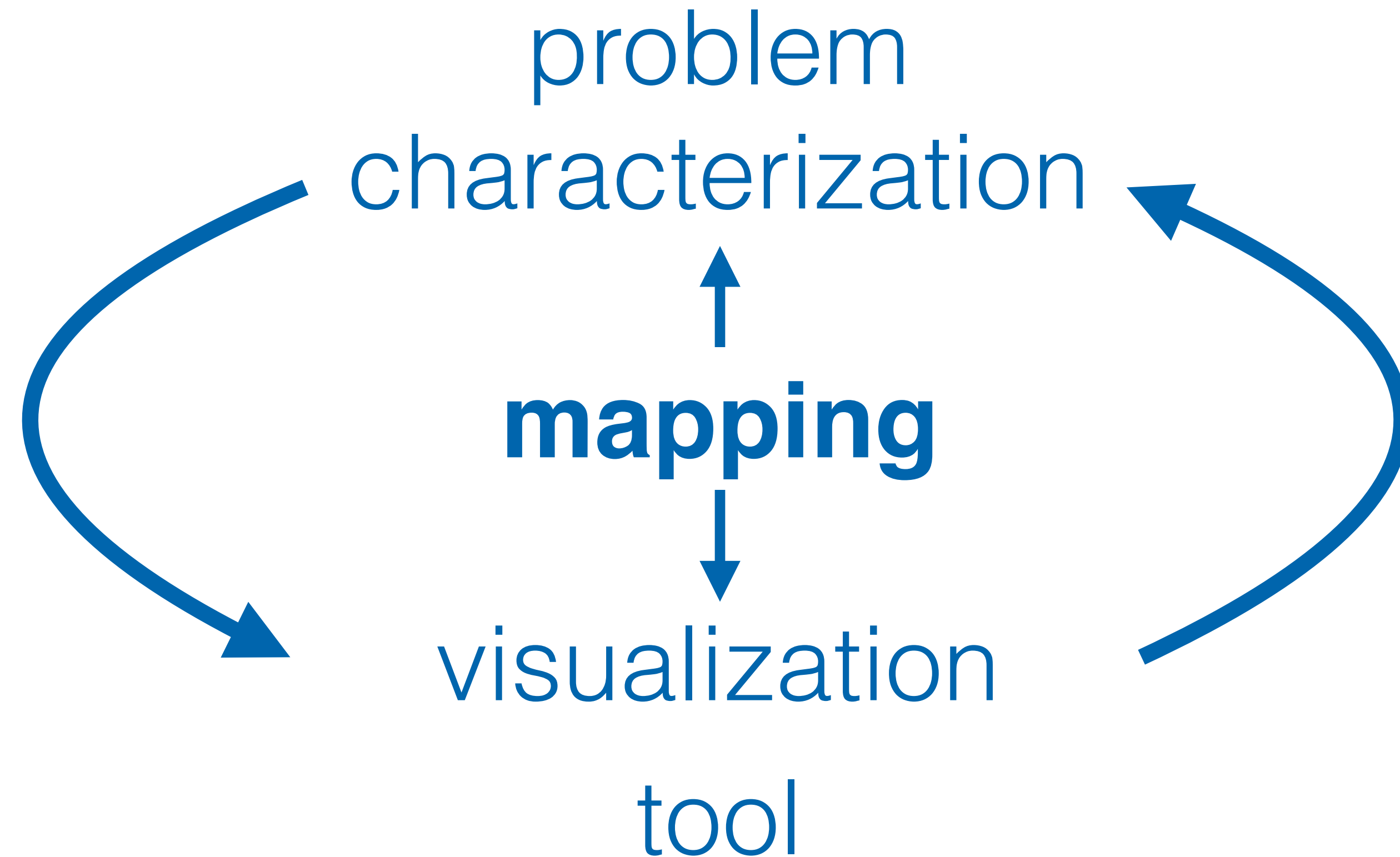


problem
characterization

&

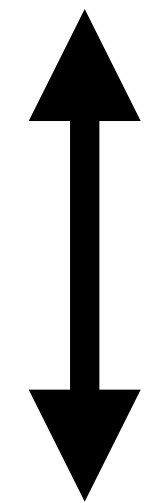
visualization
tool

Why not just ask a social scientist?



Challenge: “Visualization Cookbook”

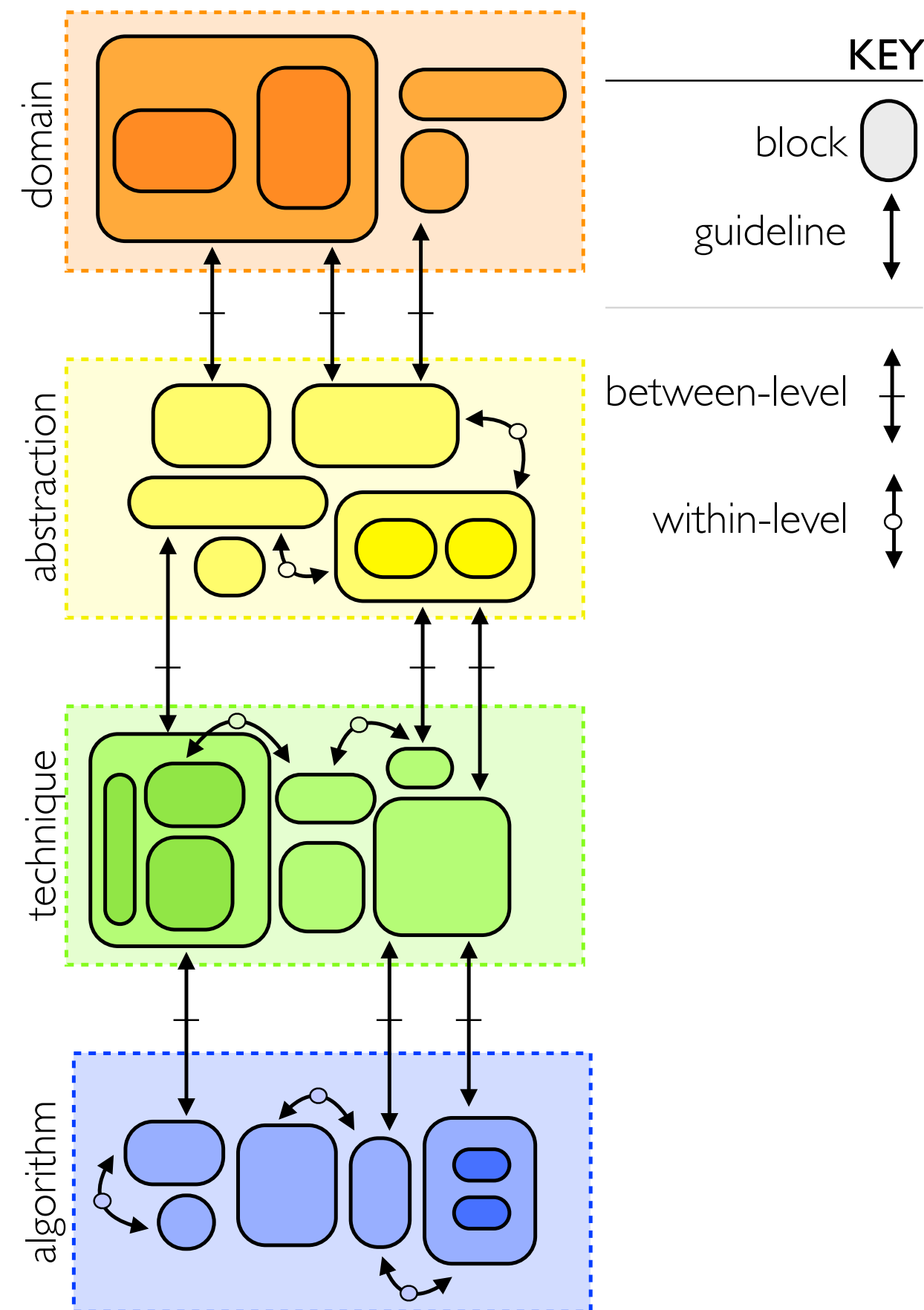
abstract data & task



data analysis technique



Challenge: “Visualization Cookbook”



- Understand problems (user/task/data)
 - abstraction
 - taxonomies & theories
- Mapping
 - problems to techniques
 - combine visual & computational

Meyer, Sedlmair, Quinan, Munzner.
The Nested Blocks and Guidelines Model.
Information Visualization, 14(3): 234-249, 2015.

Challenge: “Visualization Cookbook”

vast amounts of research on
human-centered data science
necessary, e.g. design studies.



Sir Francis Bacon 1561-1626

Outline

1. Technique-driven research

- Trends in graph drawing
- Trends in visualization — Related to graph drawing

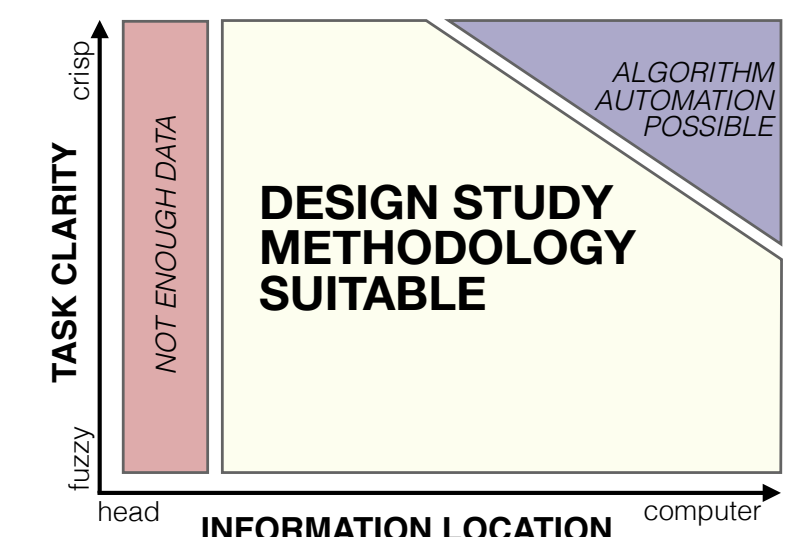
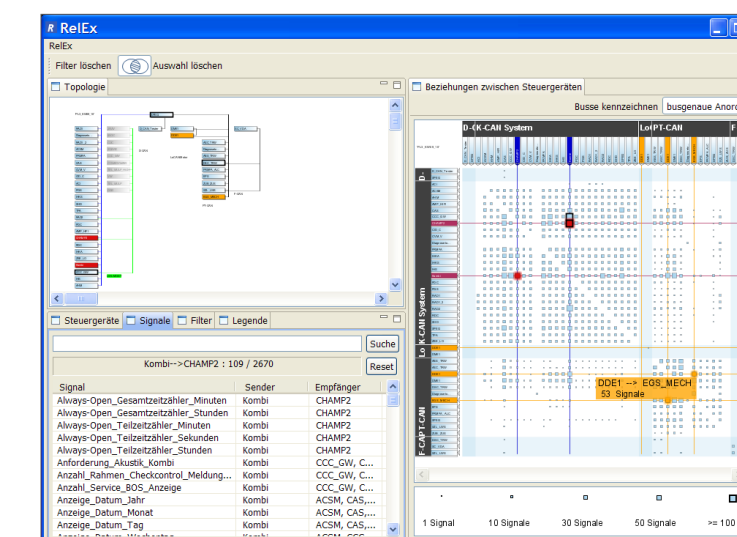
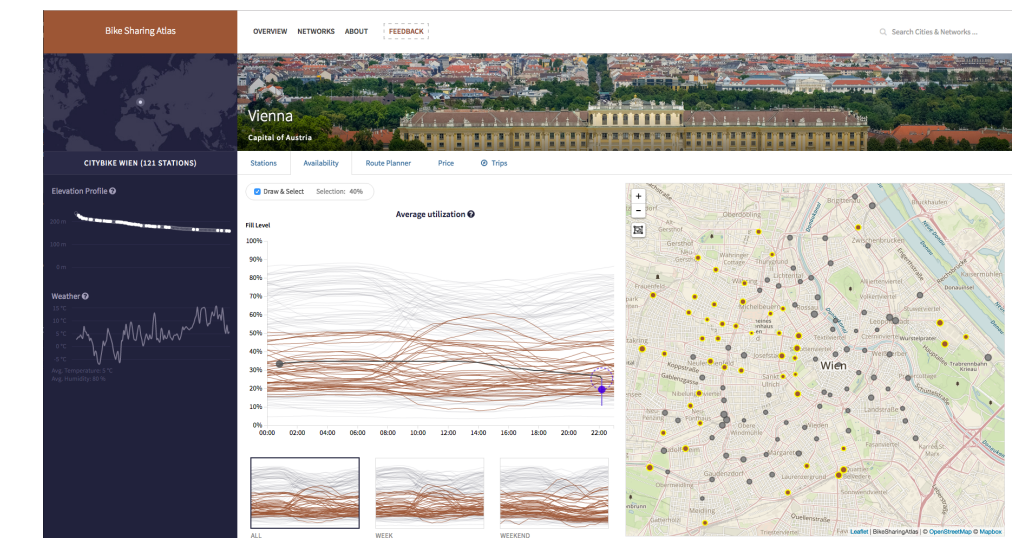
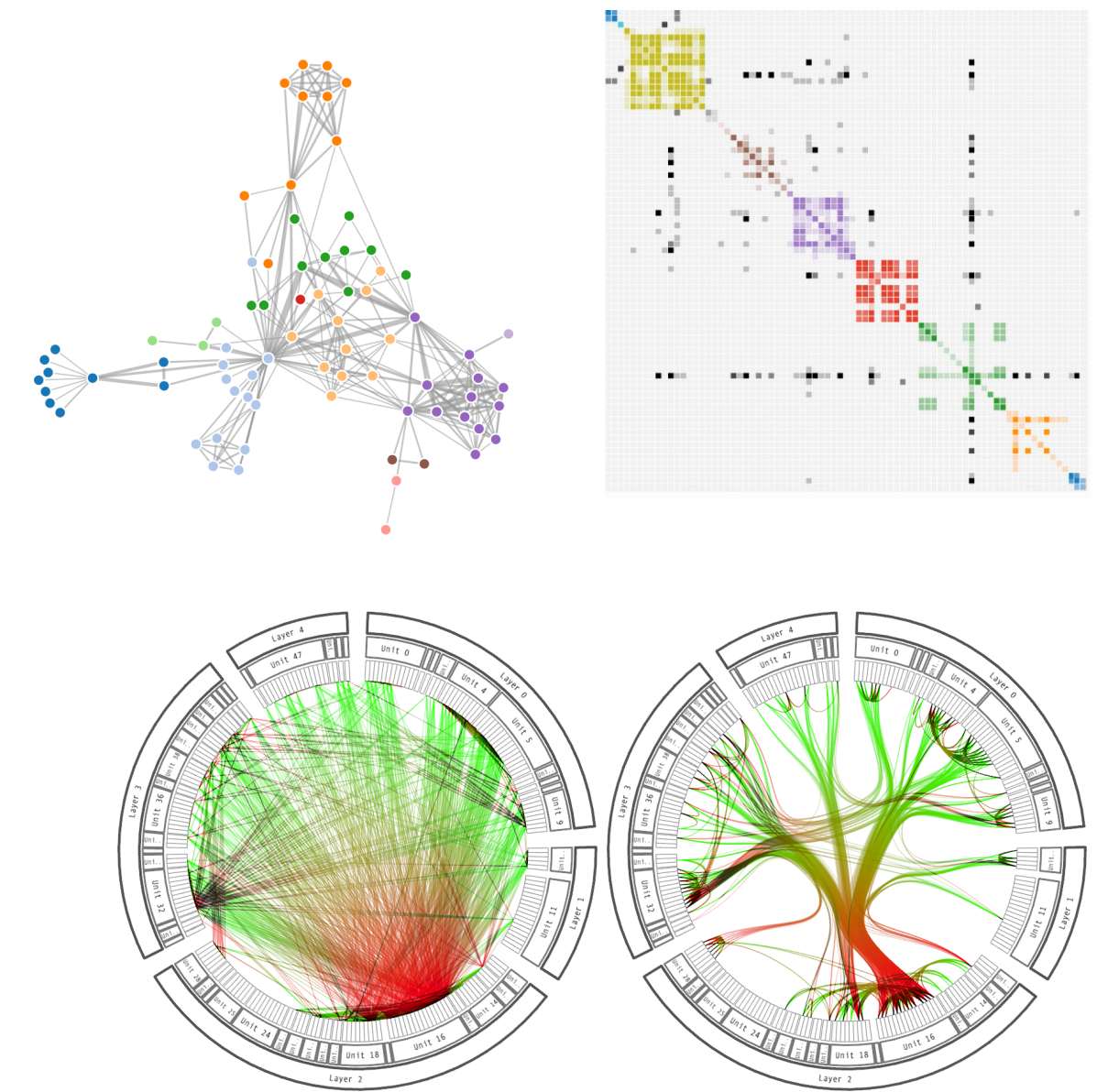
2. Problem-driven research

- Design Study Example — RelEx
- Design Study Methodology

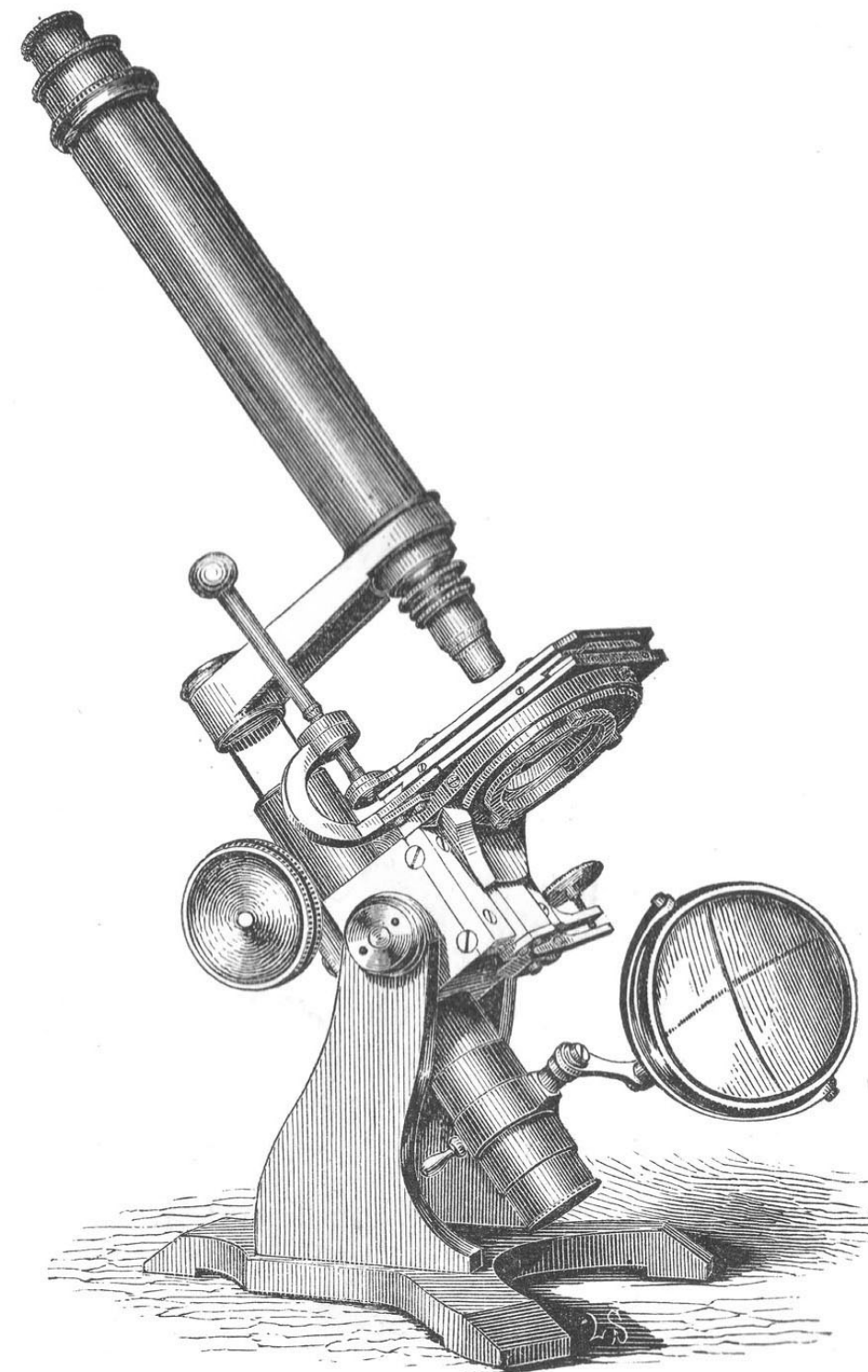
3. Summary

Summary

- Drawing networks
 - Challenge: Scaling up
 - Challenge: Graphs in Context
- Problems, Tasks, Users
 - Challenge: Understand problems
 - Challenge: Mapping to solutions



Visualization: The Human Lens to Networks/Data

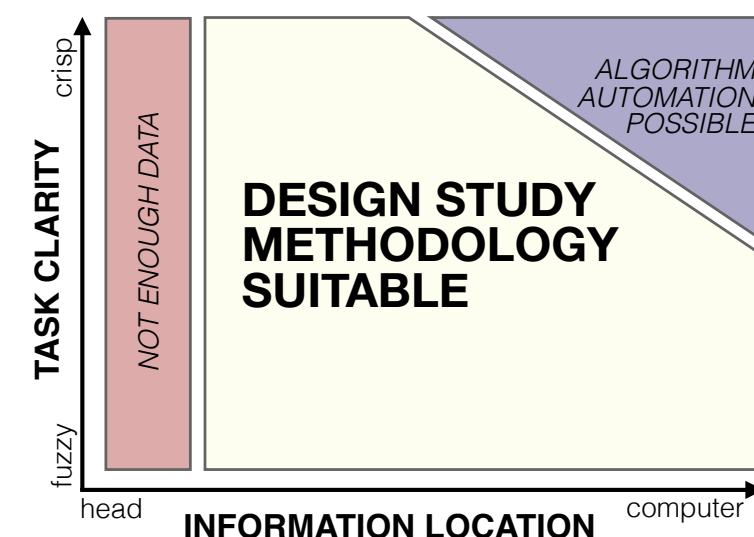
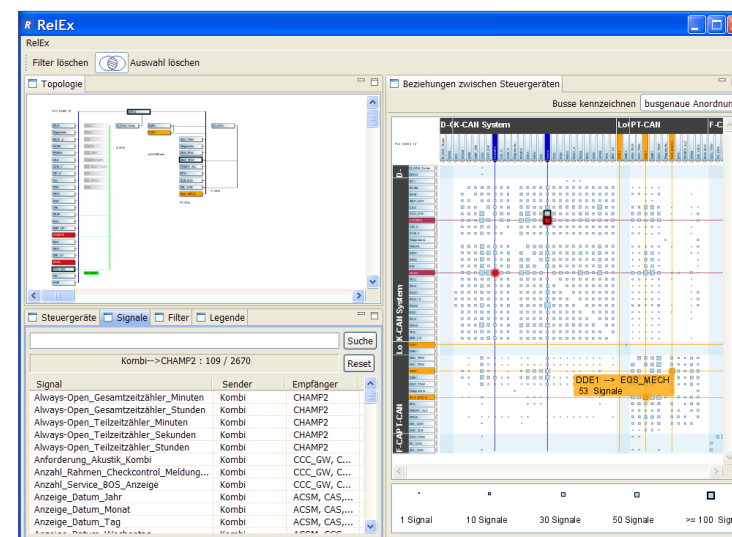
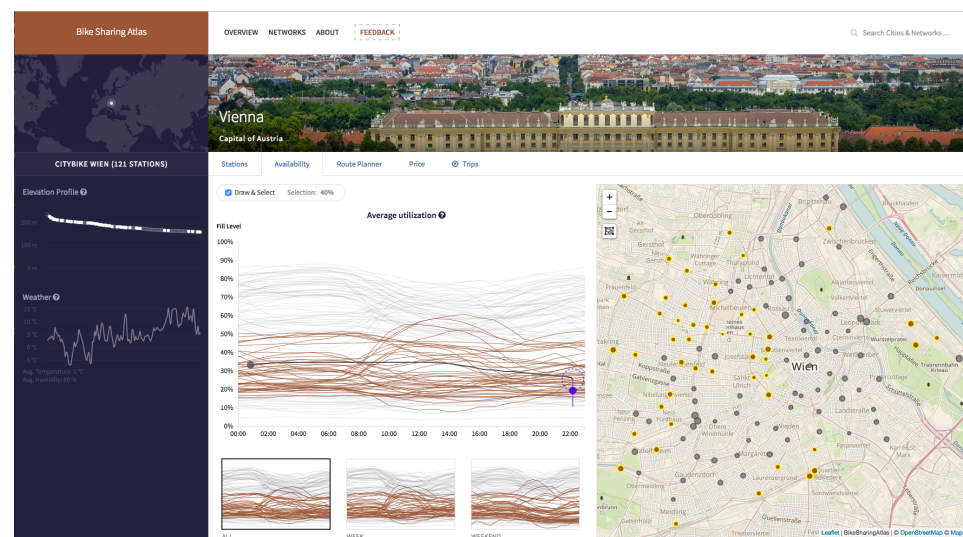
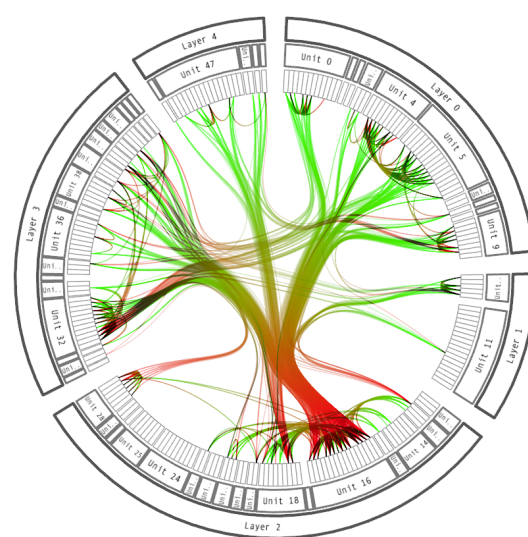
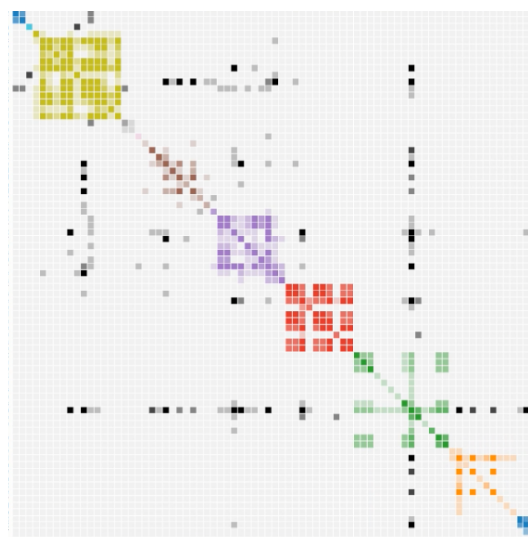
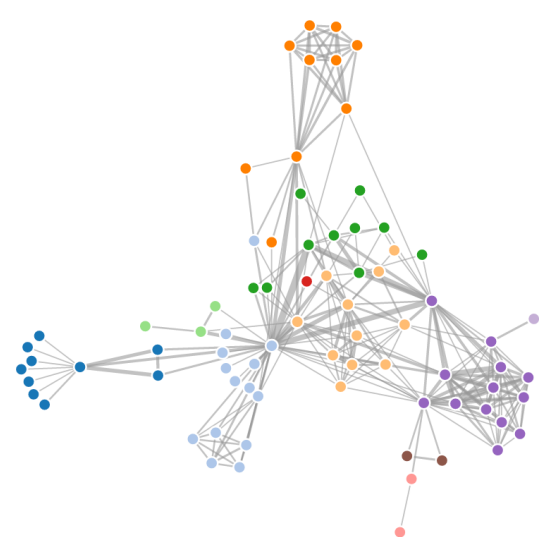


<http://www.microscope-antiques.com/grunow.html>



<http://galileo.rice.edu/sci/instruments/telescope.html>

Thank you!



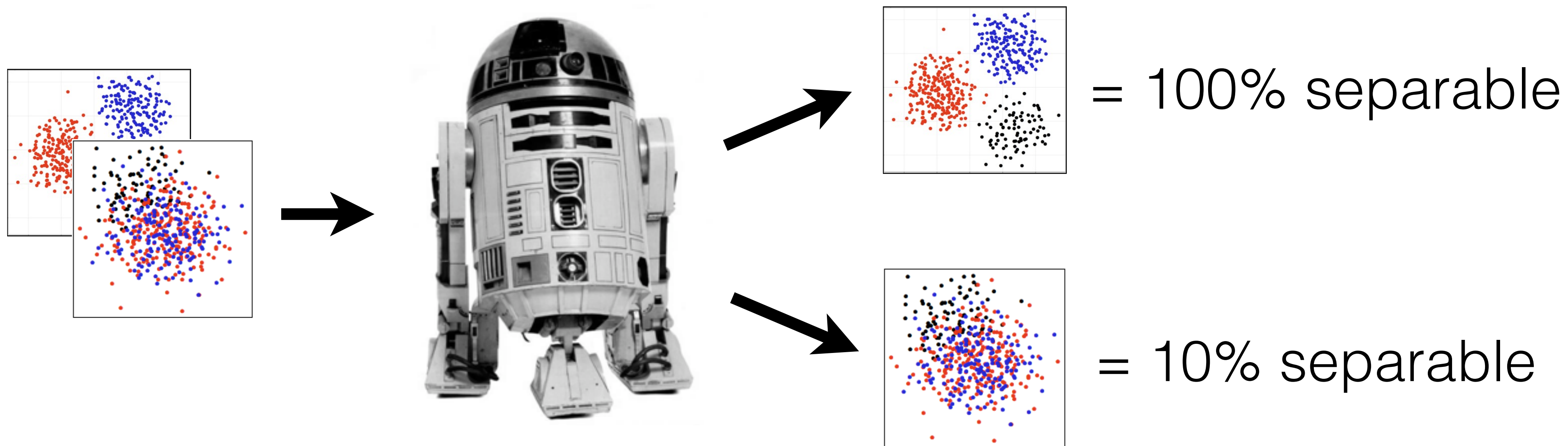
michael.sedlmair@univie.ac.at
Visualization & Data Analysis Group



Appendix

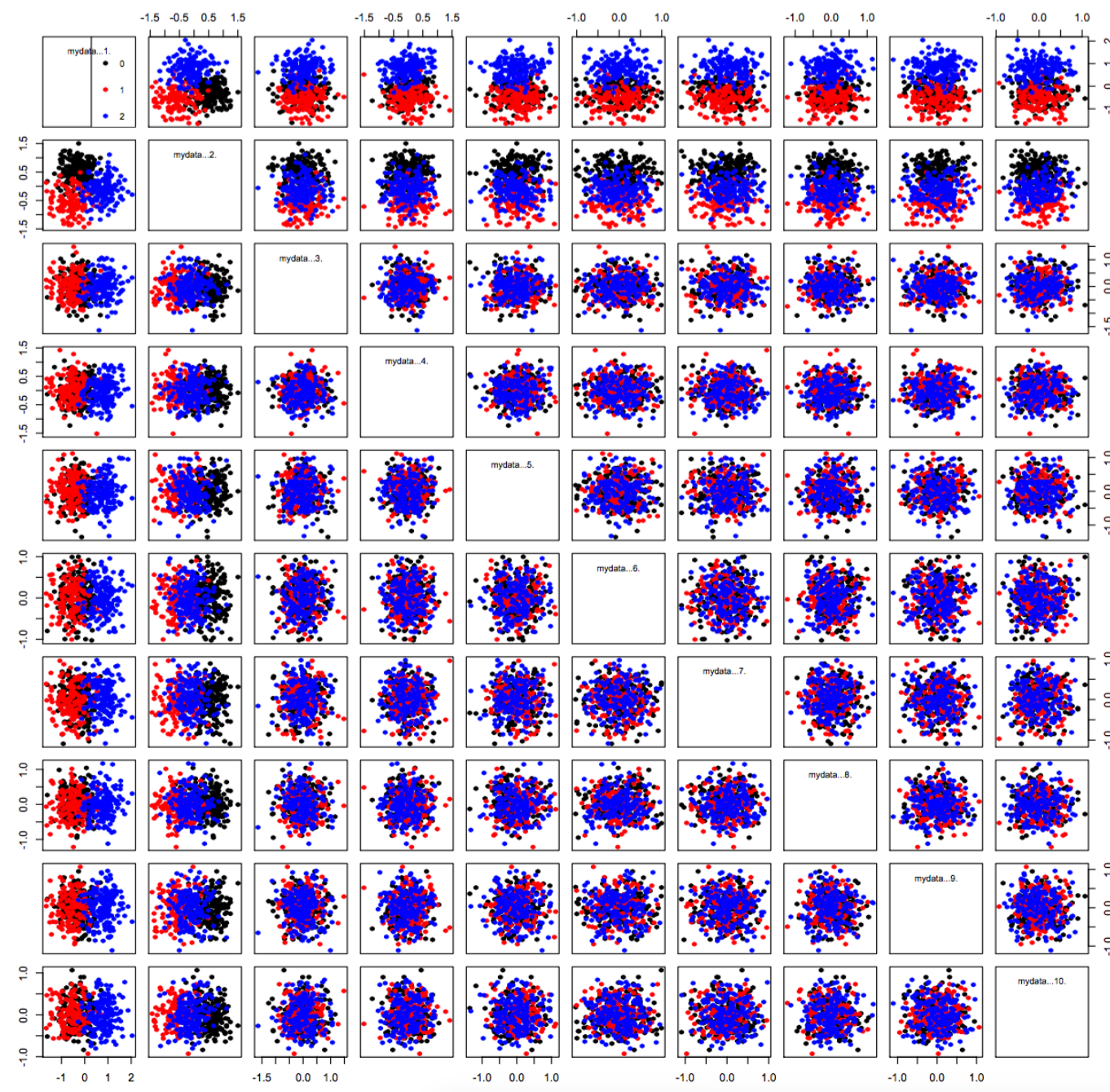
Guiding with measures

Visual quality measure,
e.g. class separation measures



Guiding with measures

example: finding interesting
projections in high-dim data?

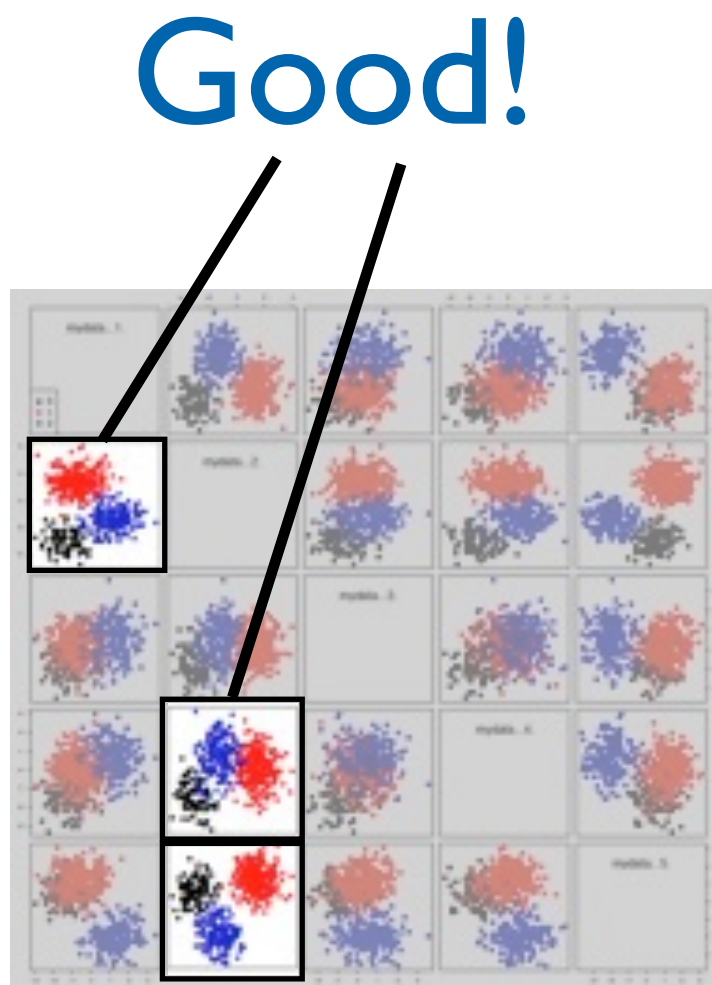
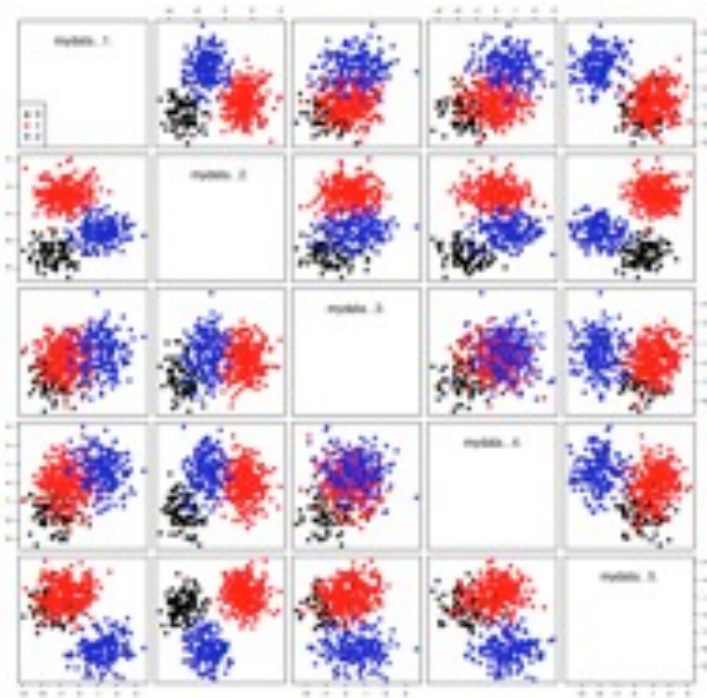


10D $\rightarrow$ 45 Views

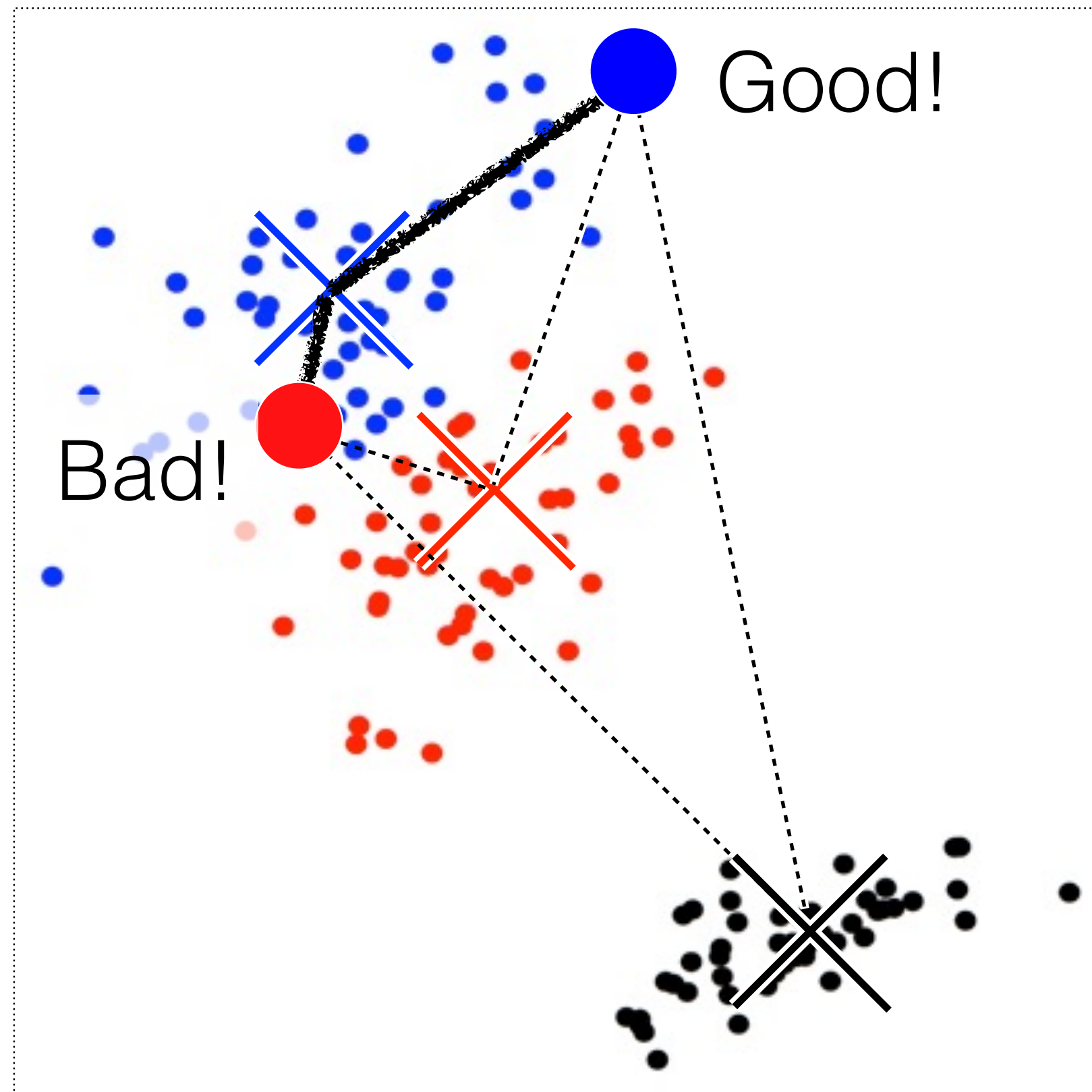
200D $\rightarrow$ ~20k Views

Guiding with measures

Visual quality measure,
e.g. class separation measures



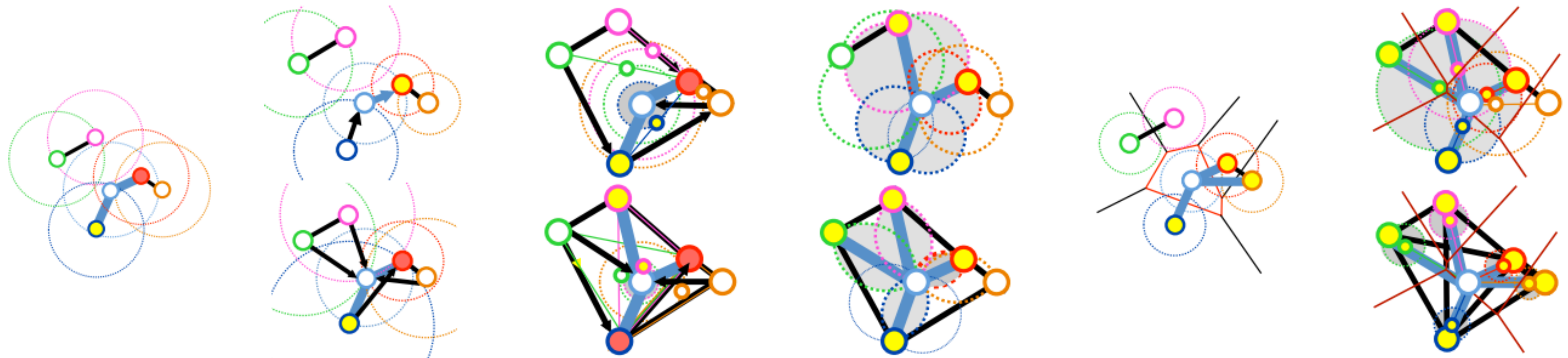
Centroid measure (DSC: Distance Consistency)



DSC: 93

Sips et al. (EuroVis 2009).
Selecting good views of high-dimensional
data using class consistency.

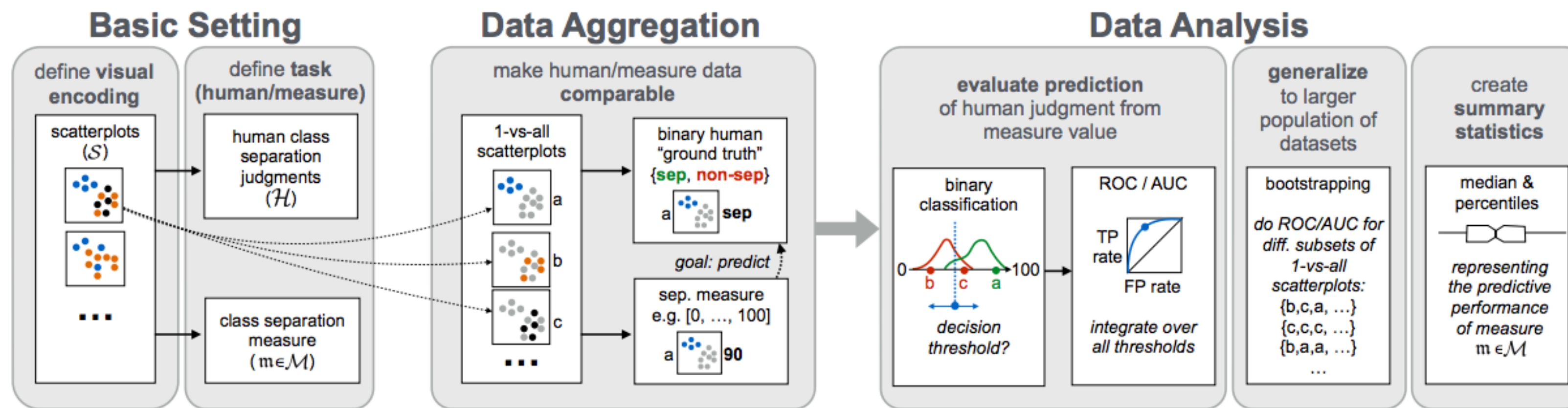
How: Modeling point clouds with graphs



2002 measures

Michaël Aupetit, Michael Sedlmair.
SepMe: 2002 New Visual Separation Measures.
In Proceedings of IEEE Pacific Visualization Symposium (PacificVis), 2016.

How: Modeling point clouds with graphs



- Human labeled data (~800 scatterplots)
- Evaluation: ROC/AUC
- Best stat-of-the-art DSC: 82%
- Best of ours: 92%

Michael Sedlmair, Michaël Aupetit.
Data-driven Evaluation of Visual Quality Measures.
In Computer Graphics Forum (Proc. EuroVis 2015), 2015.