

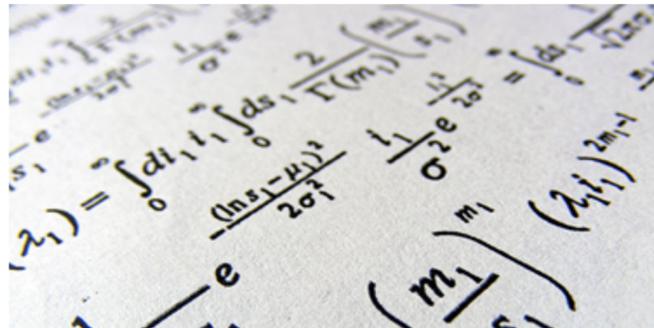
Human-centered Network Visualization

Michael Sedlmair

Visualization & Data Analysis Group



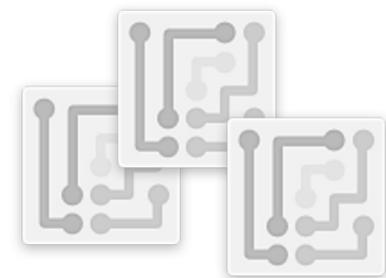
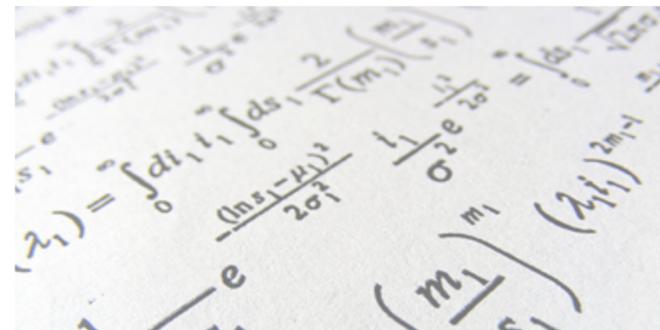
Data



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



Visualization



Look at / Interact



Definition: Visualization (Vis)

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

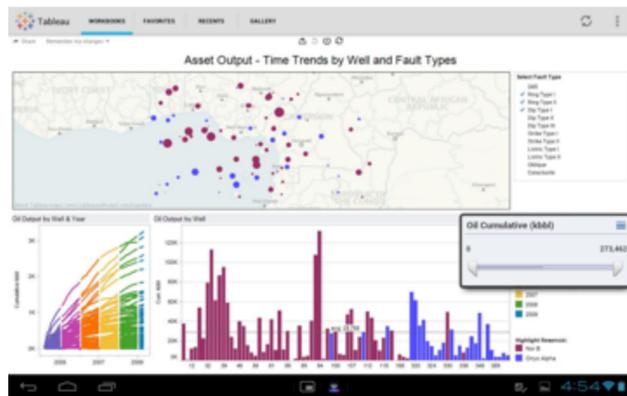
Tamara Munzner.

Visualization Analysis and Design.

A K Peters Visualization Series, CRC Press, 2014.

Interactive visual analysis

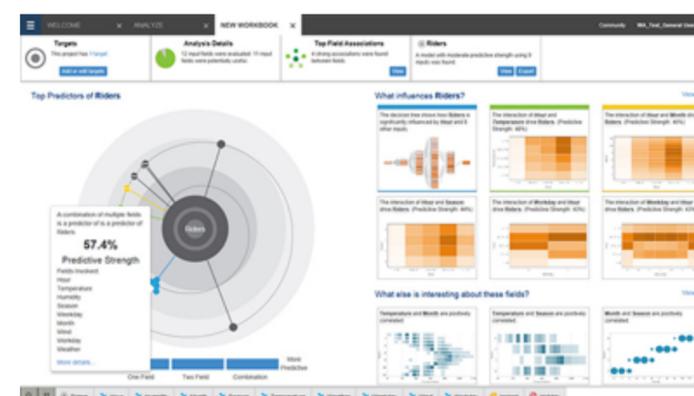
“Computer-based visualization systems provide visual representations of datasets intended to help people carry out some task more effectively.”



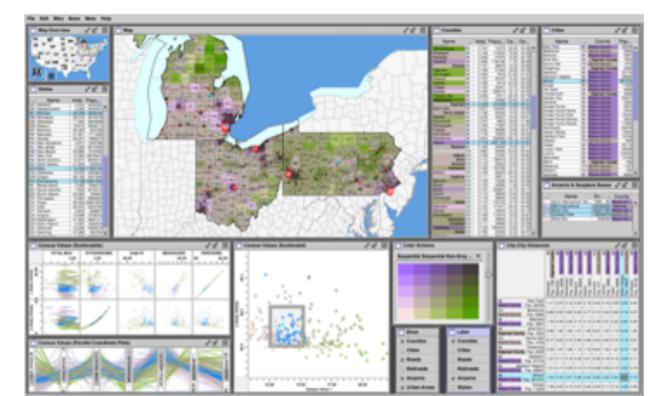
Tableau



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
- Keplerplatz
- 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

start

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

end

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

Why visual representations?

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



**Perception
beats
Cognition!**

Visualization research



→
technique-driven

New algorithms

New visualization techniques



←
problem-driven

Understand users & tasks

Design studies

Visualization research



technique-driven

**My
research
focus**



problem-driven

Graph Drawing

Network Visualization

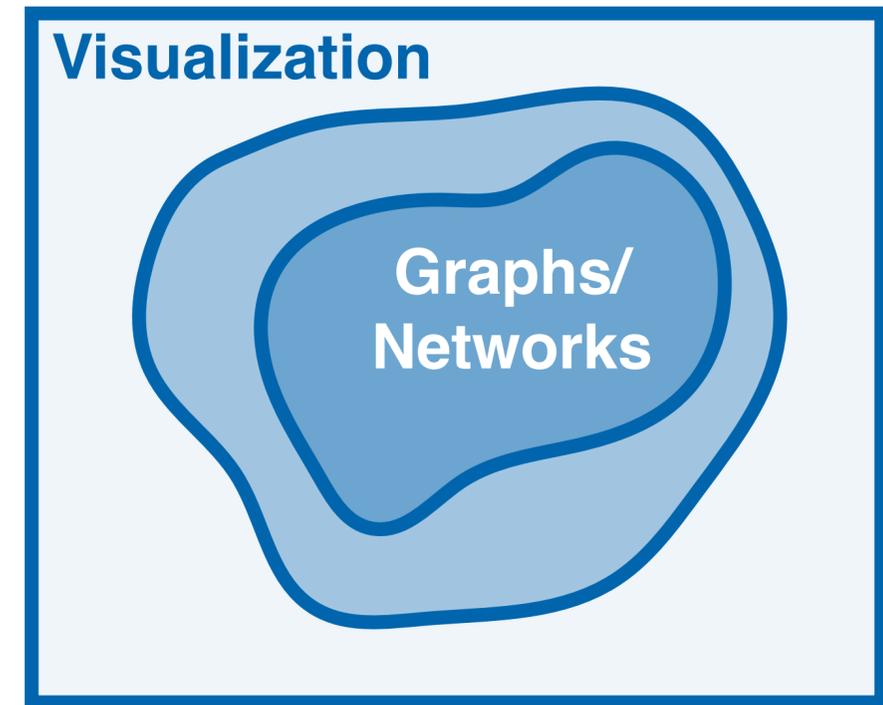
Today's goal: Graph/network visualization and around

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?



Outline

1. Technique-driven research

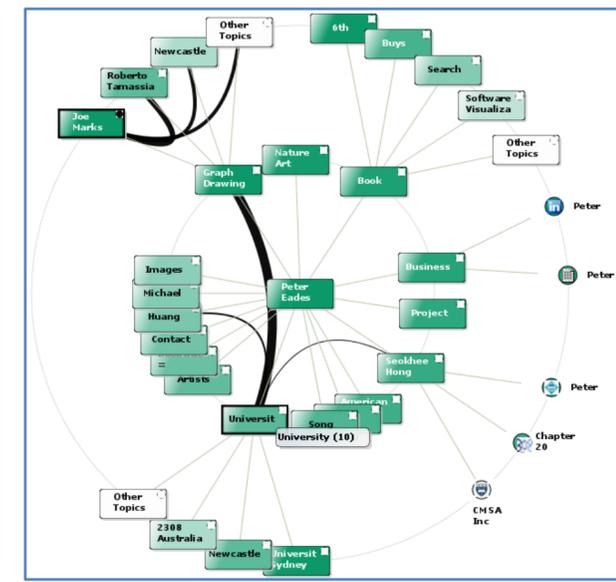
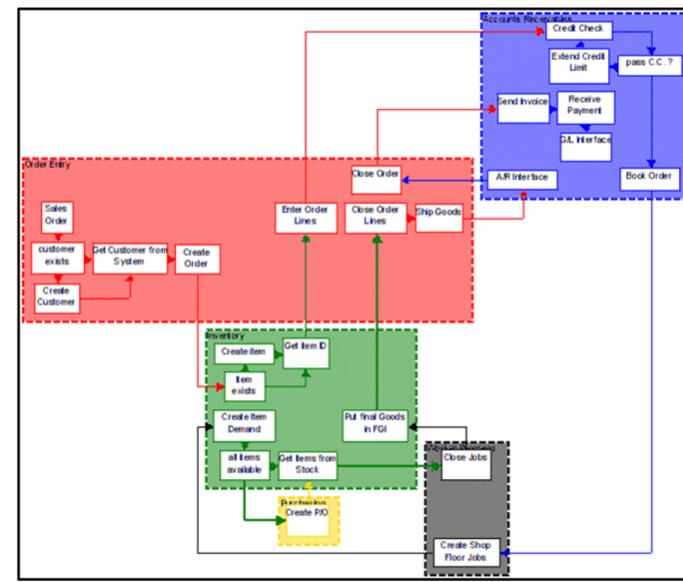
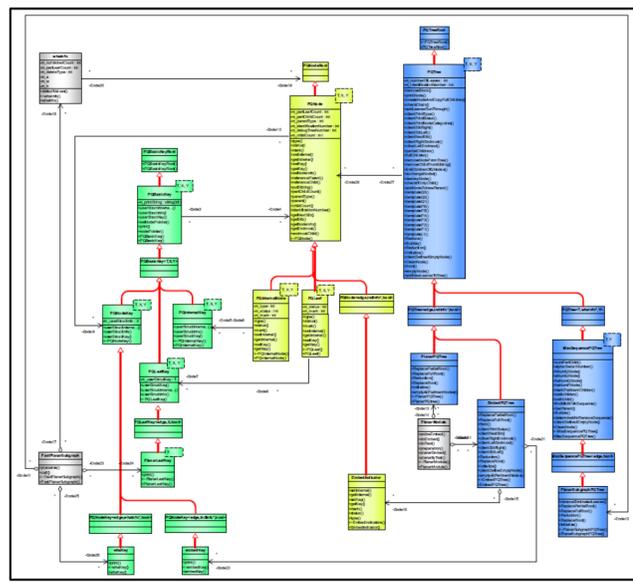
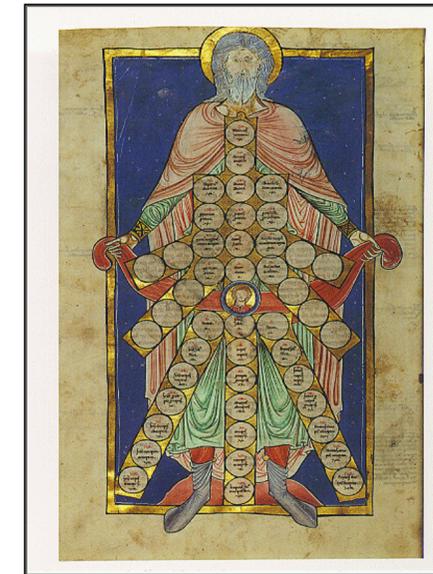
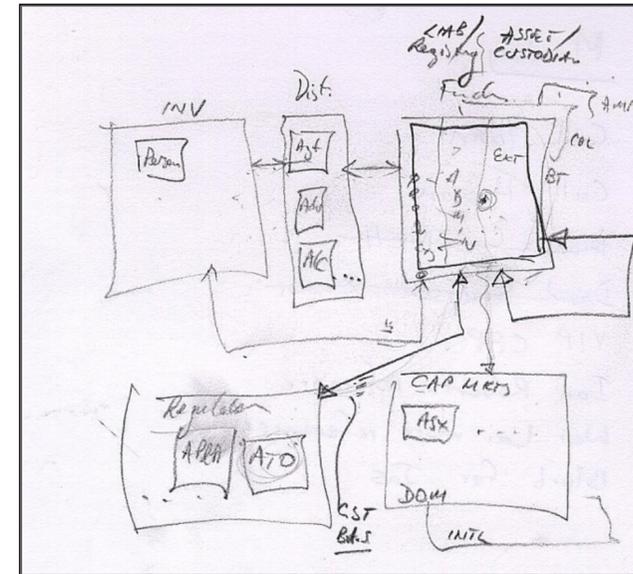
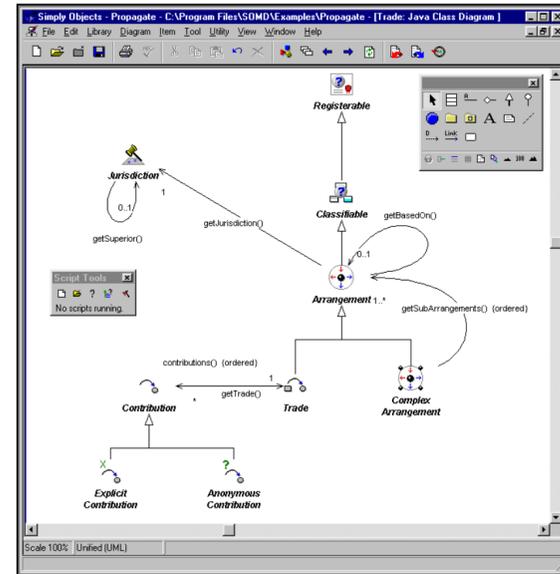
- Trends in graph drawing
- Trends in visualization — Related to graph drawing

2. Problem-driven research

- Design Study Example — RelEx
- Design Study Methodology

3. Summary

Networks & Graphs



etc.

© Eades

Graph Drawing

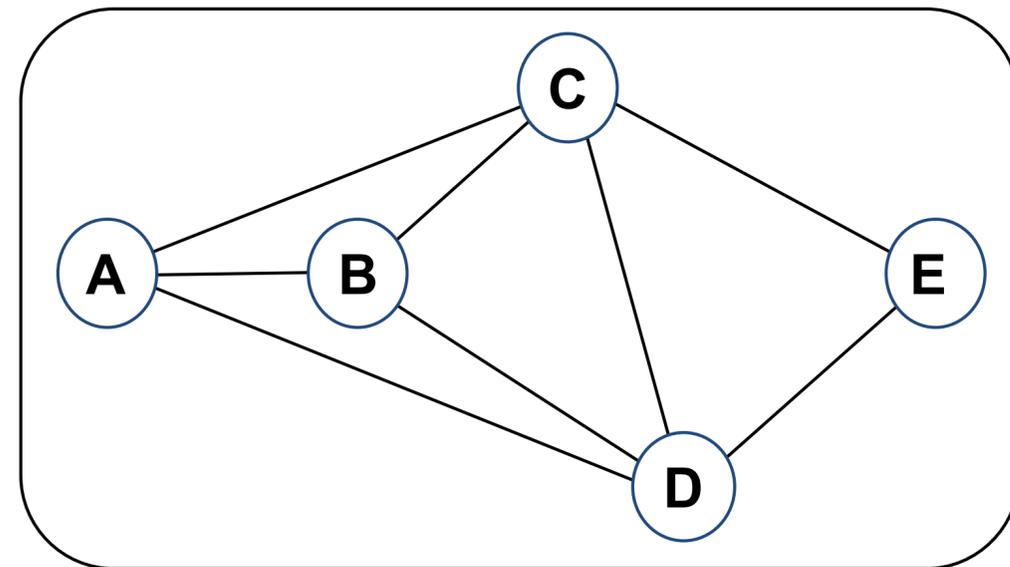
- The classical graph drawing problem is to develop **algorithms to draw graphs nicely.**

graph

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



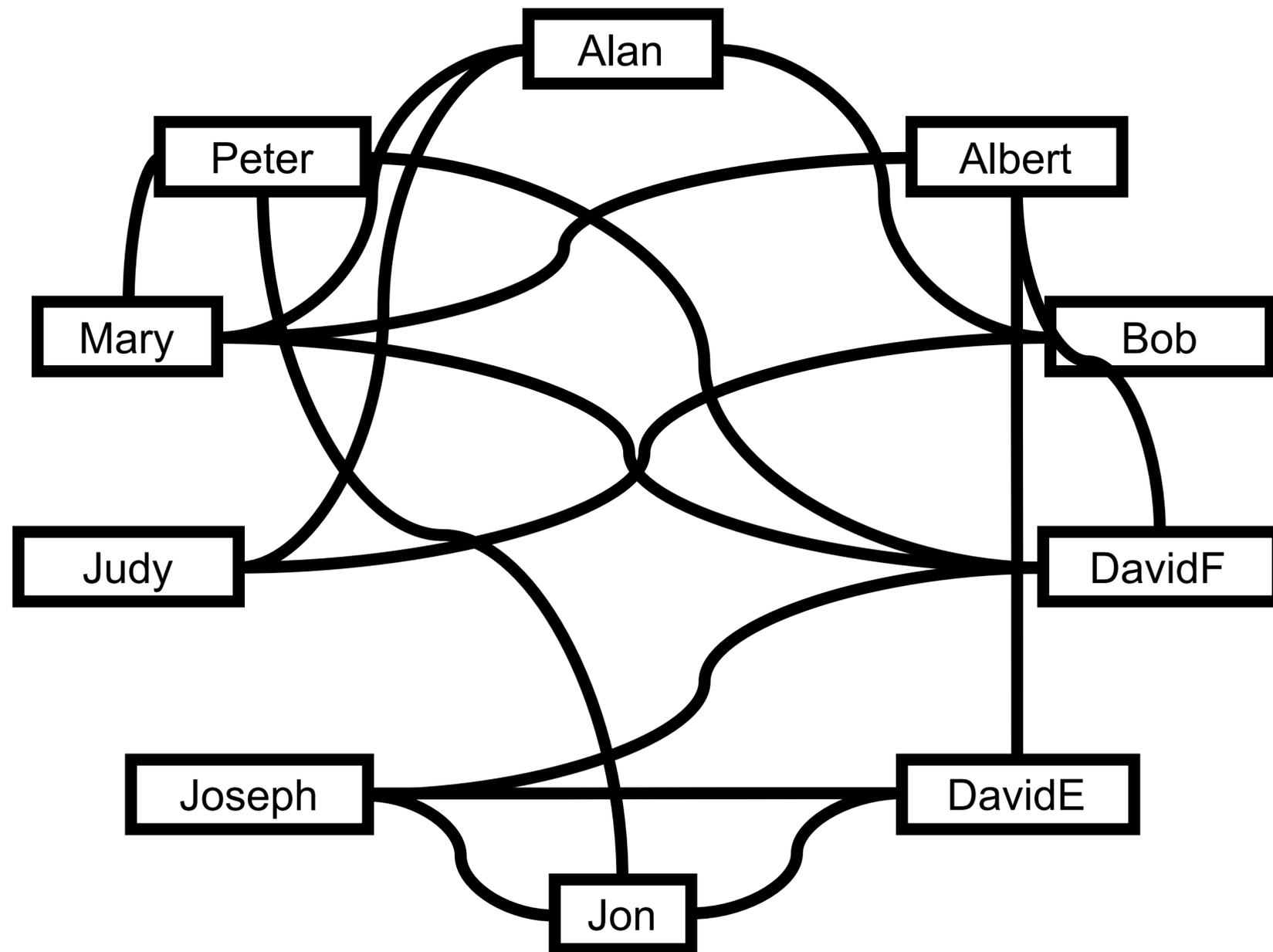
nice graph drawing



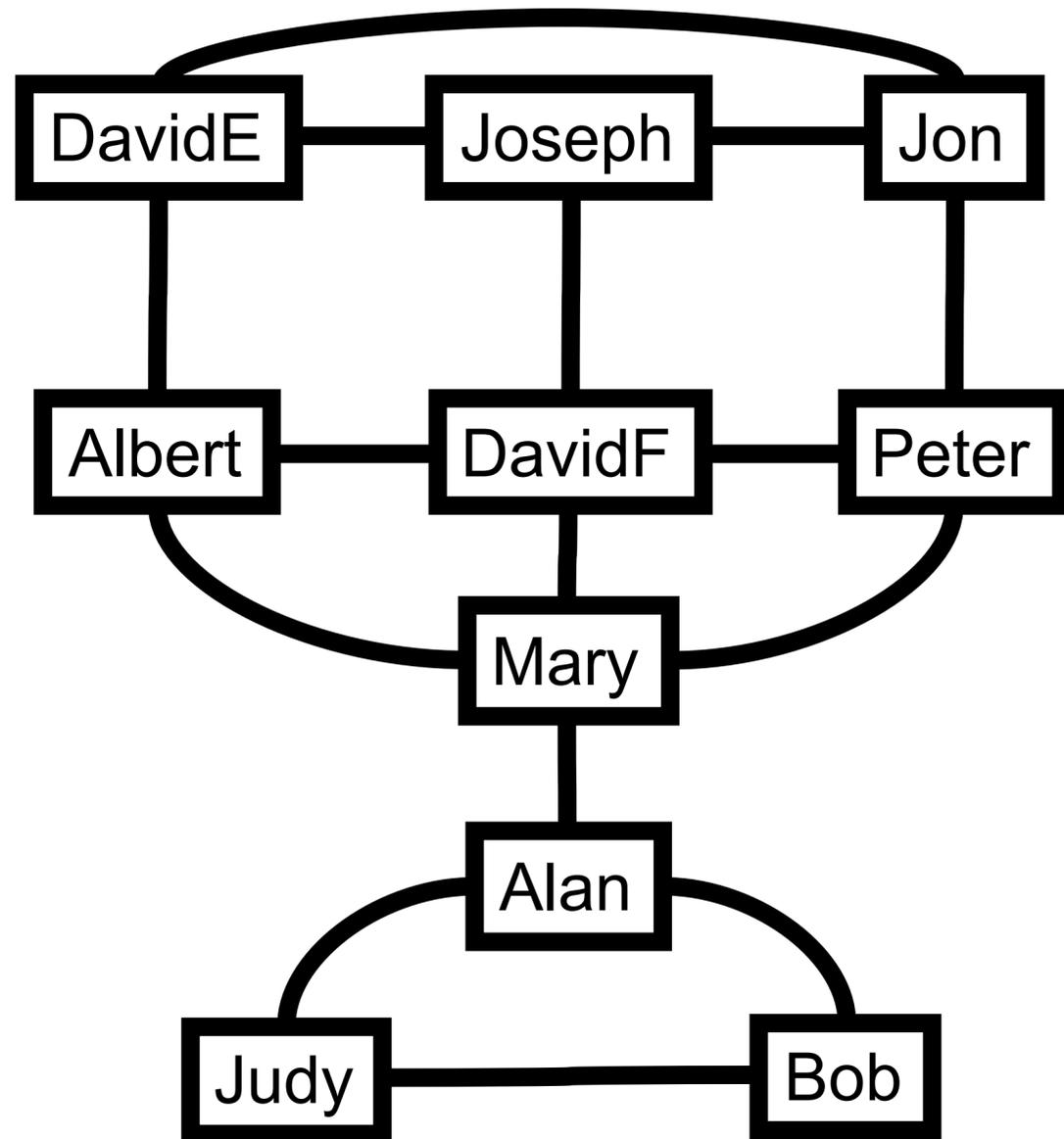
Example

X	<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

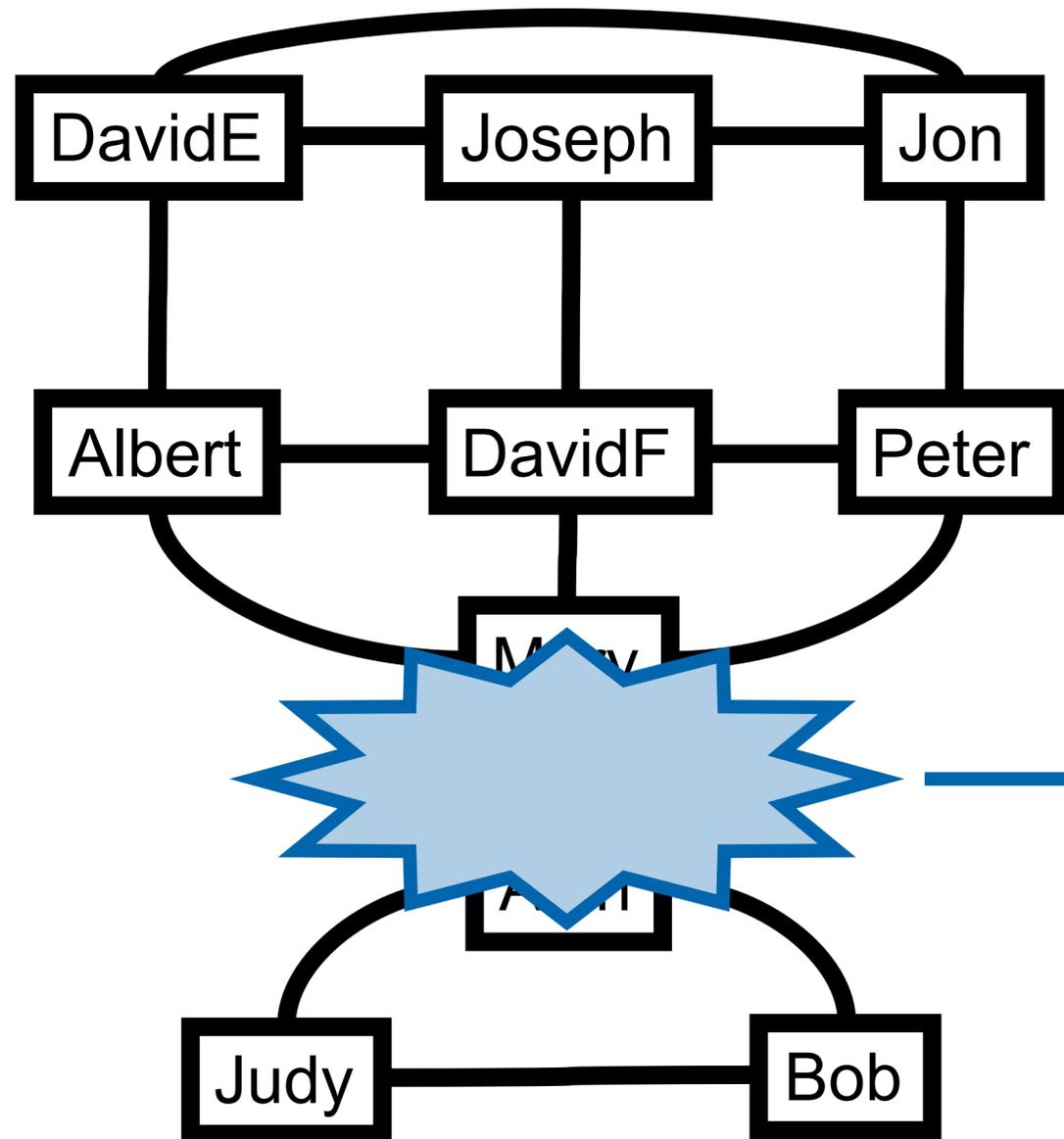
Example



Example



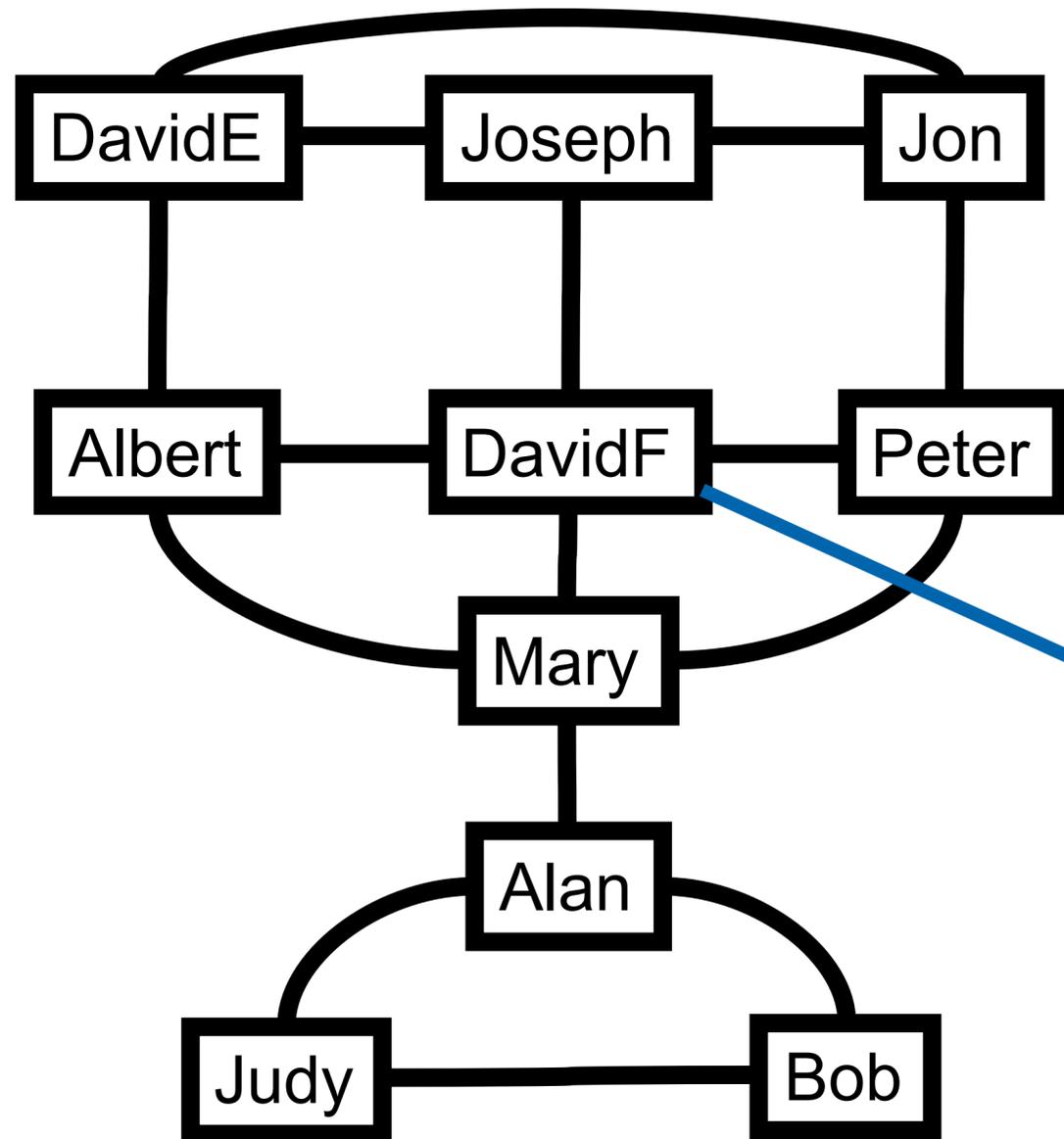
Example



Terrorist network

Eliminate

Example



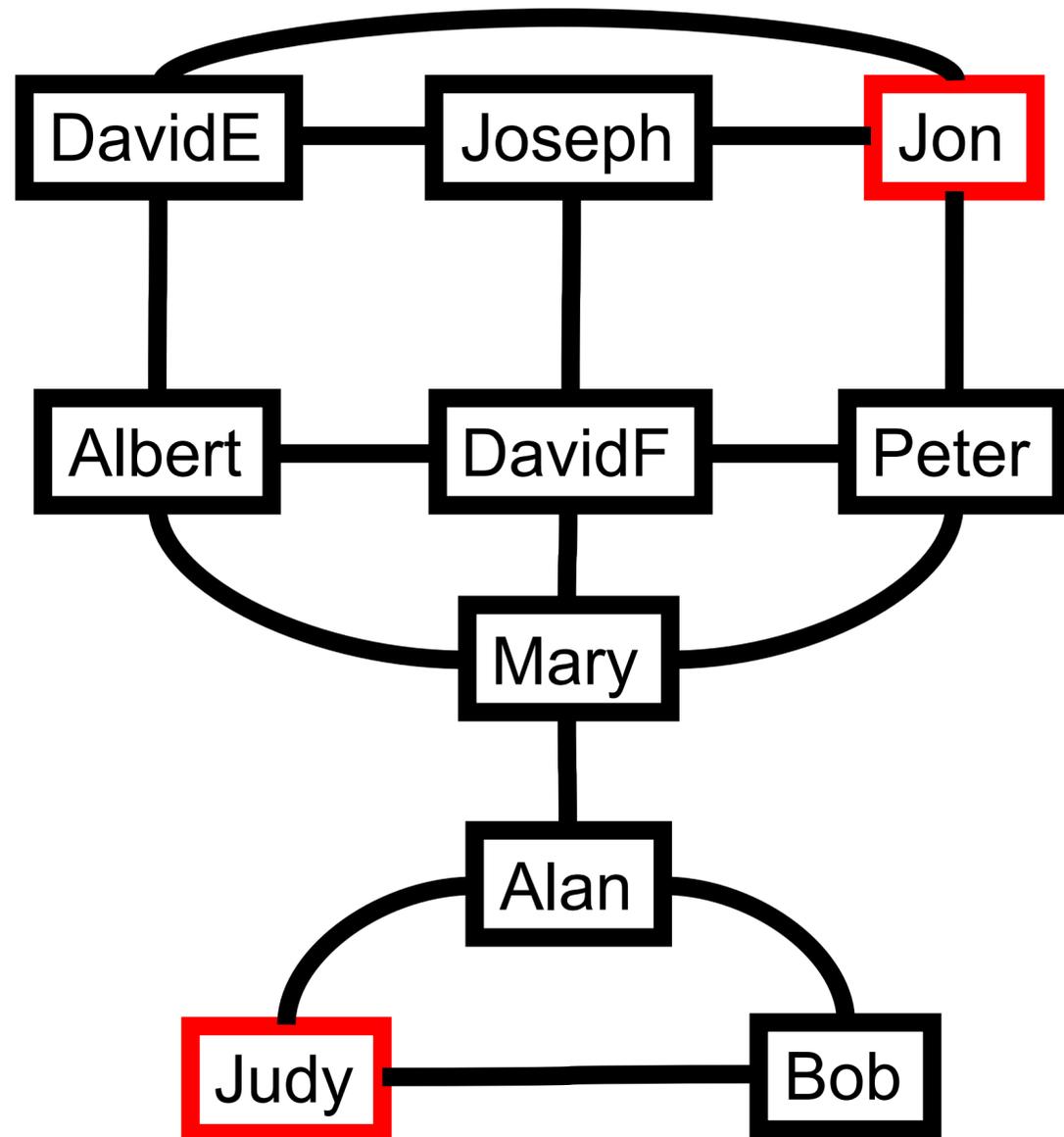
Mobile phone network:

* **nodes: people**

* **edges: phone calls**

Good deal \$\$\$\$

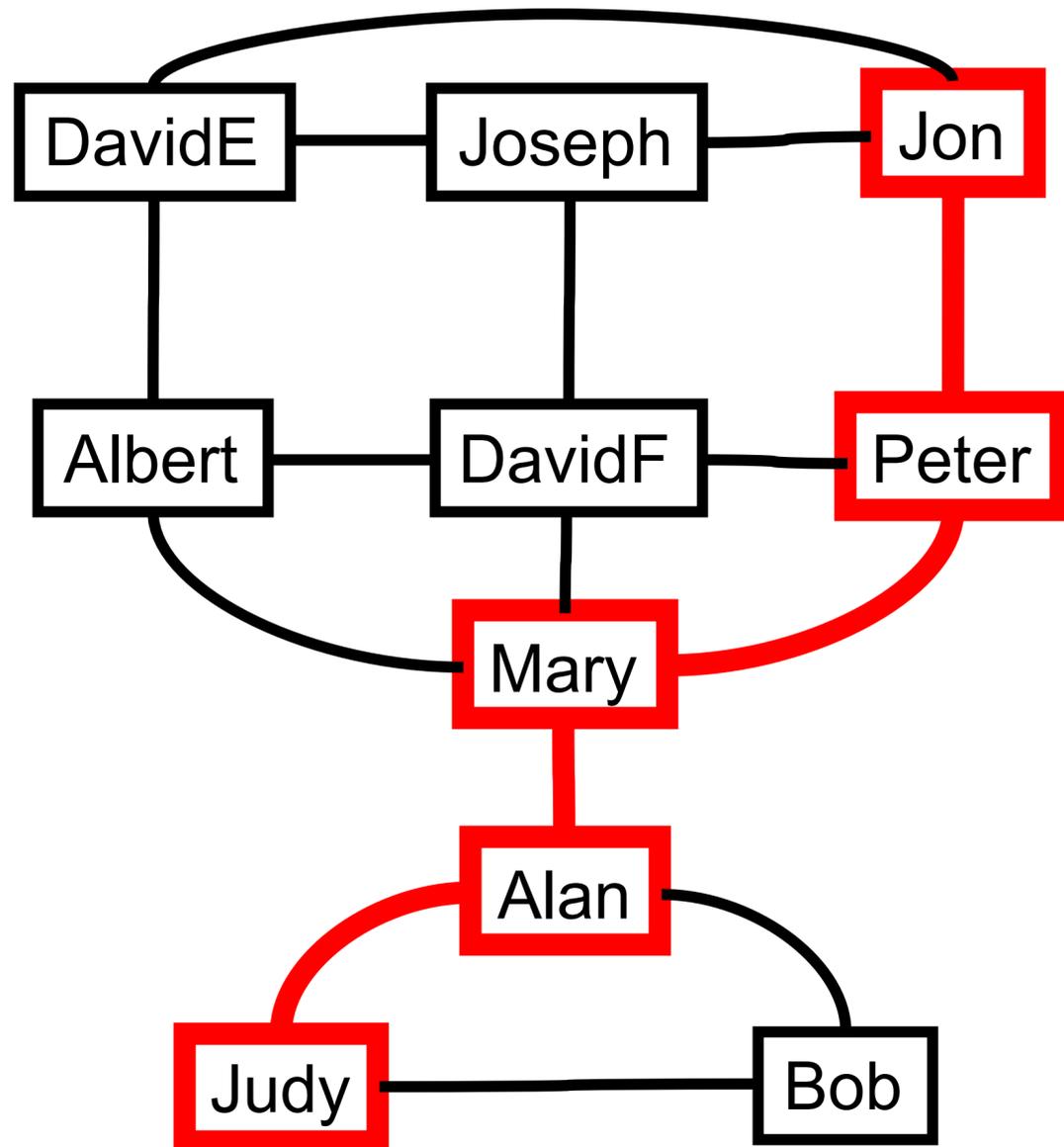
Example



Transport network:

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

Example

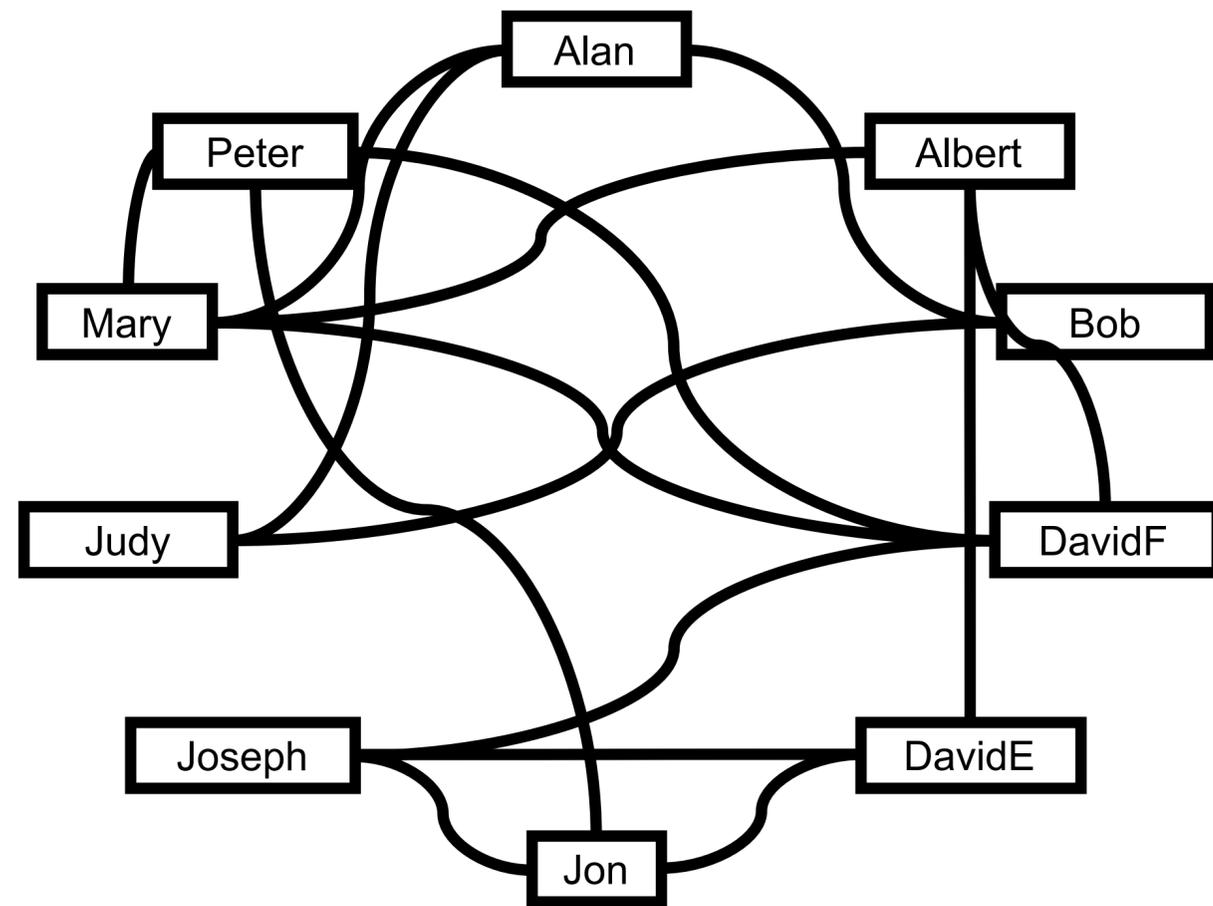


Transport network:

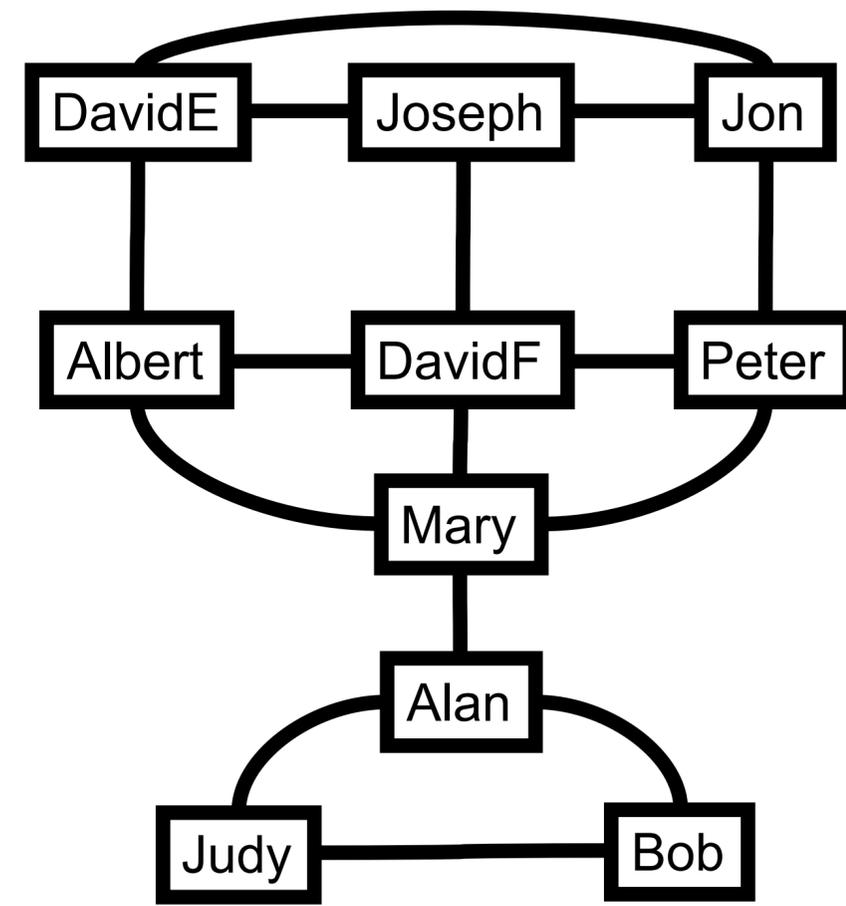
- * **nodes: places**
- * **edges: train lines**

Shortest path?

What algorithm give good drawings of graphs?

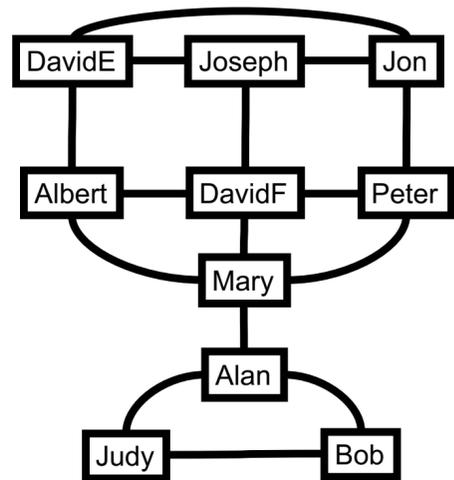
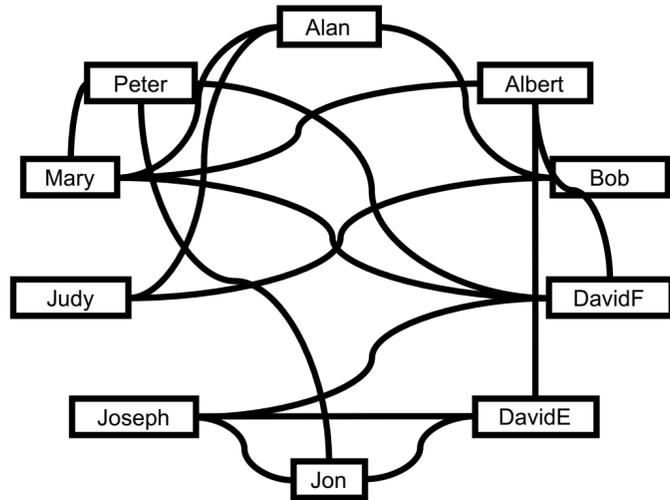


Bad



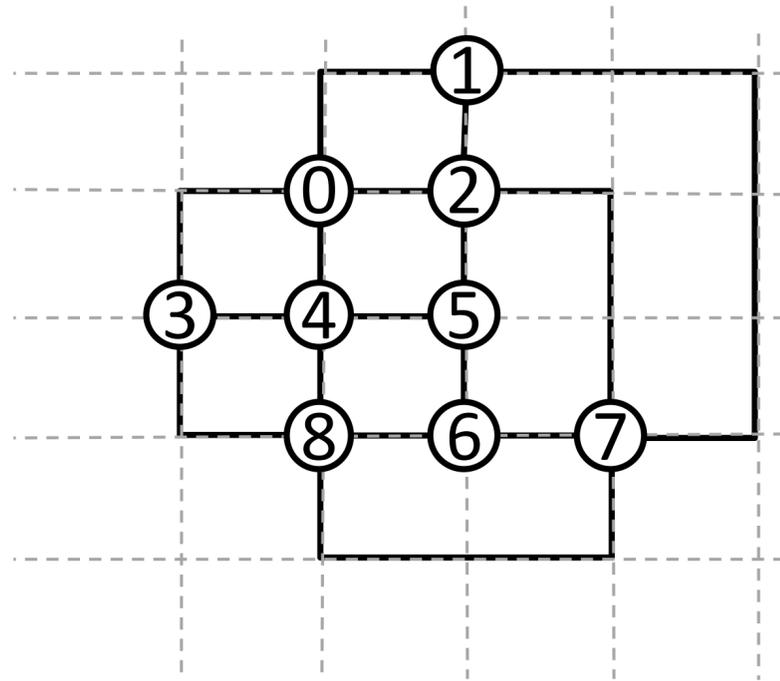
Good

Quality measures for networks

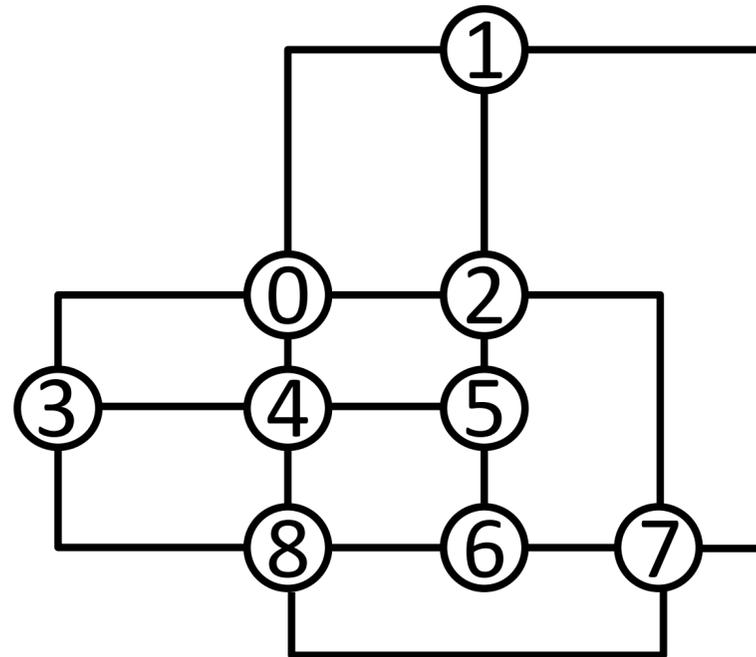


- Classical quality measures
 - minimize edge crossings
 - minimize bends
 - ...
- Human subject experiments found crossings & bends to be most important *wrt* readability
 - Purchase et al., 1997
 - Ware et al 2002
 - Huang et al 2004

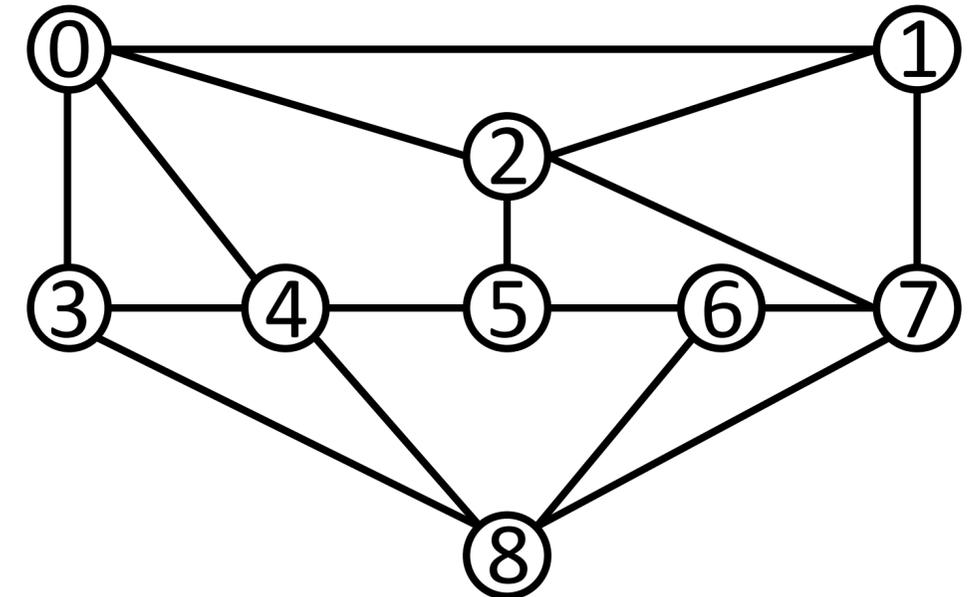
Different kinds of layouts



grid-based



orthogonal

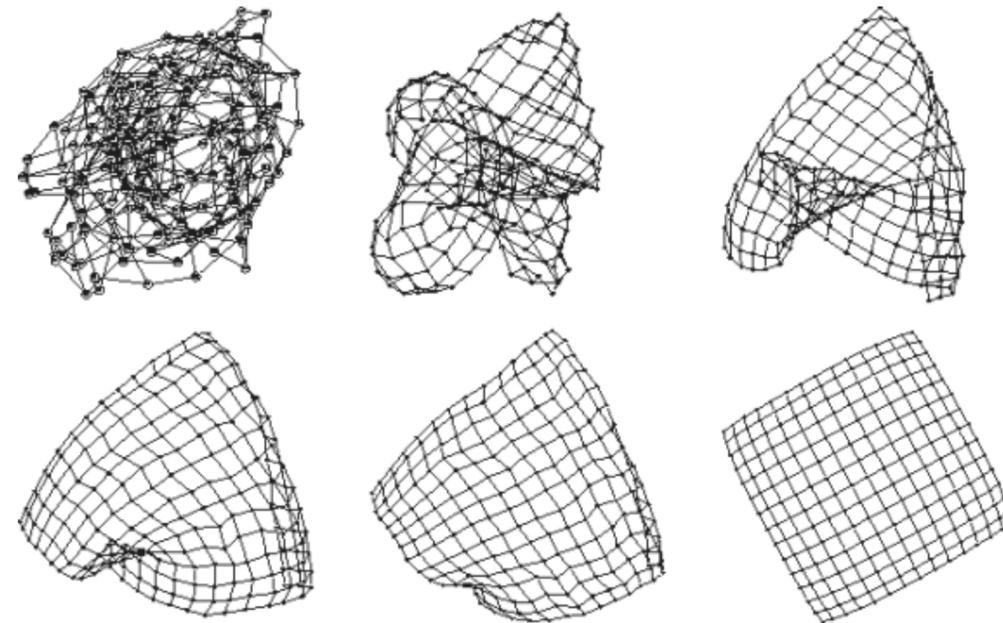


straight-line

Force-directed layouts

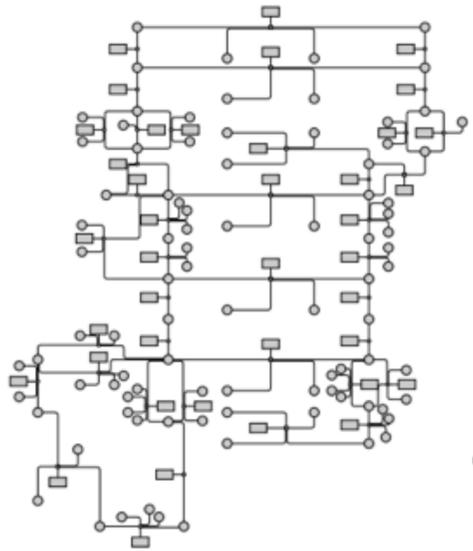


<https://bl.ocks.org/mbostock/4062045>

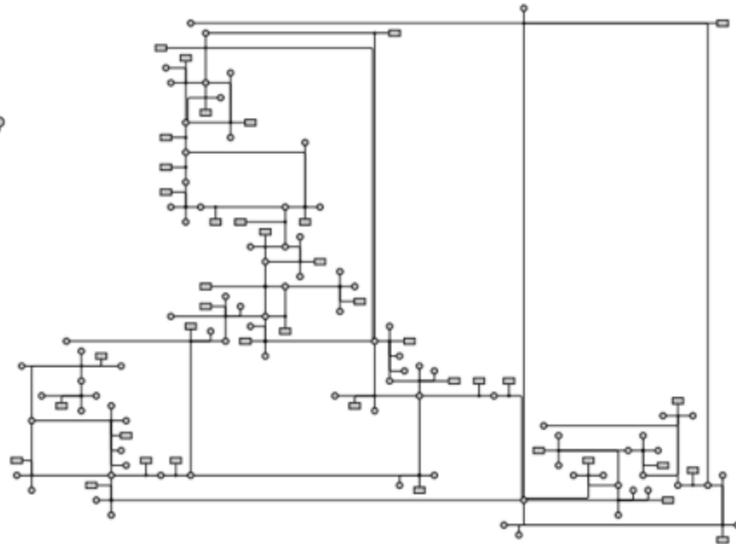


© Sander

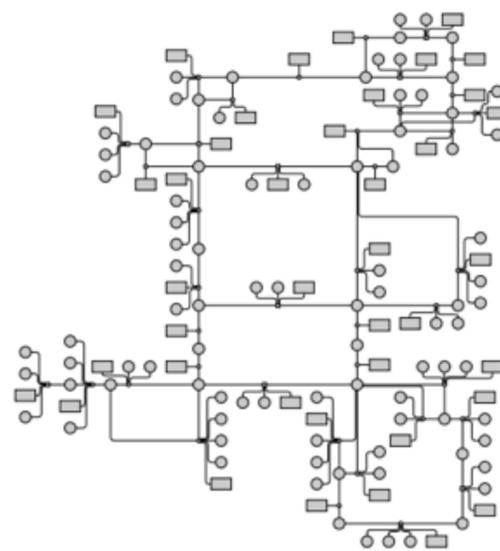
Human-centered layout



Human



algo-yFiles



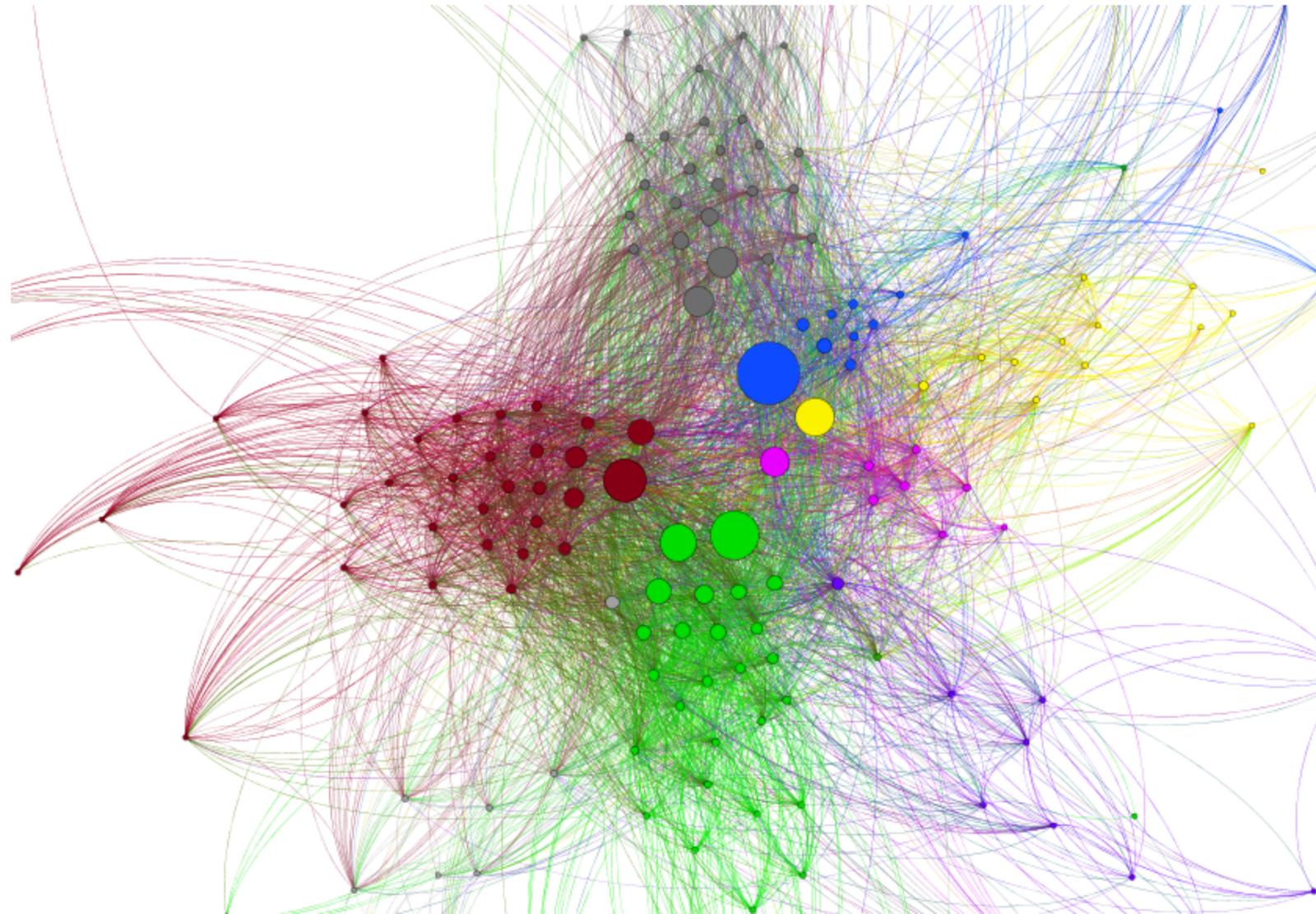
algo-HALO
(new)

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?

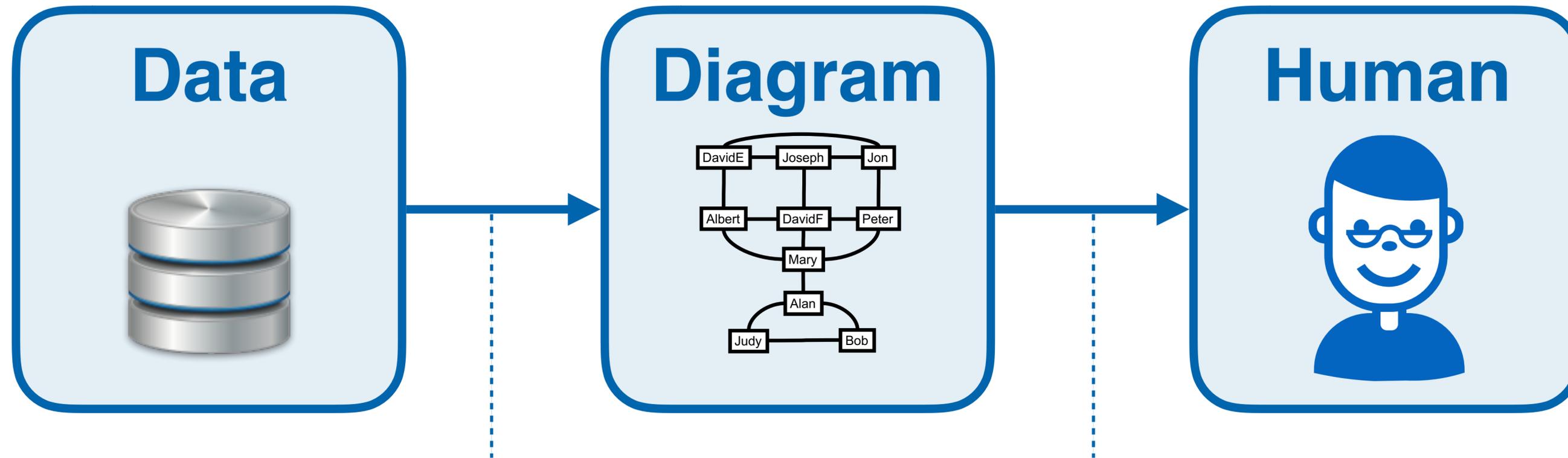


<https://twitter.com/axelmaireder/media>



Hairball

Measures: Faithfulness VS. Readability



Faithfulness measures how well the diagram represents the data.

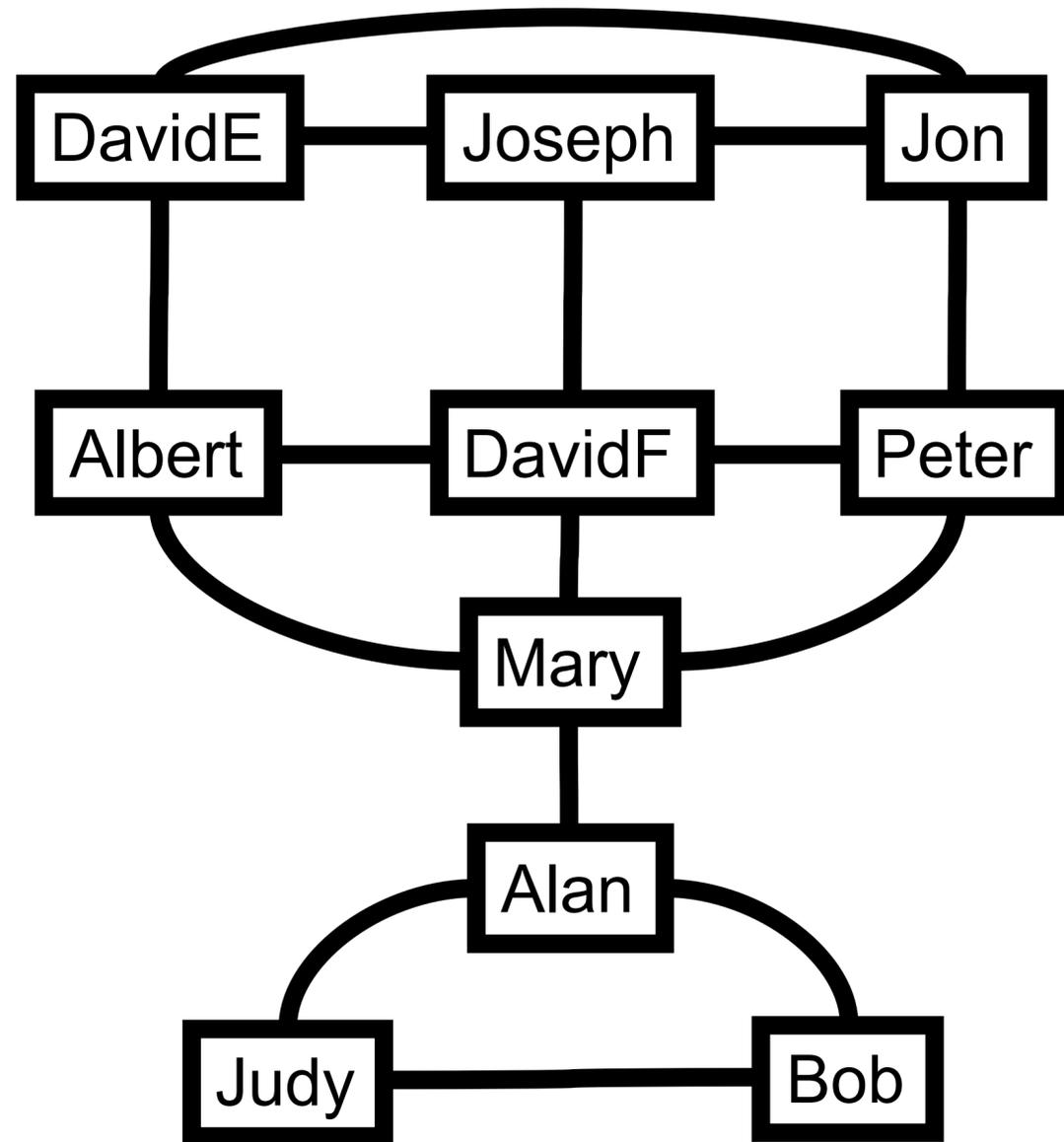
(a mathematical concept)

Readability measures how well the human understands the diagram.

(a psychological concept)

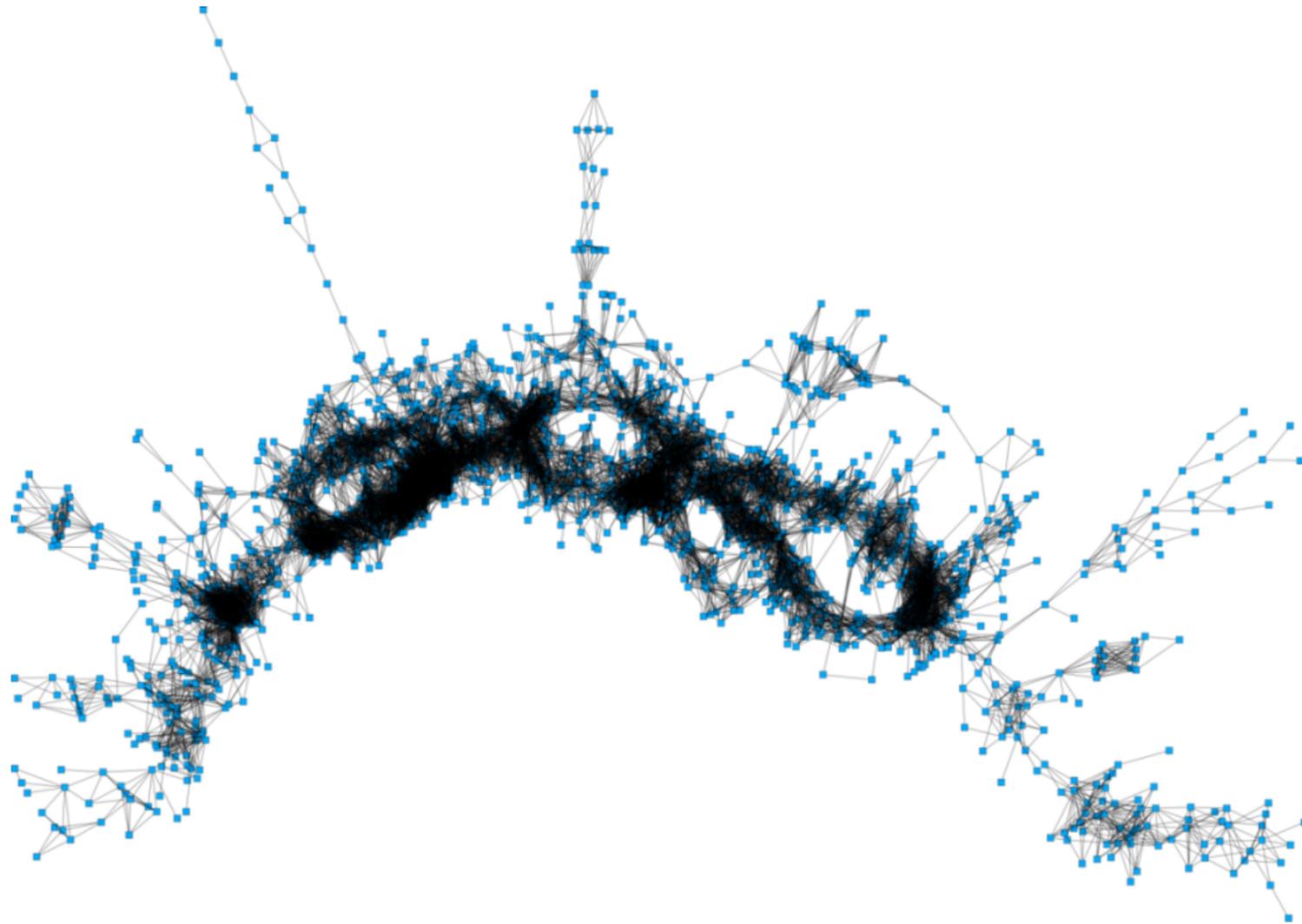
*Quan Nguyen et al.
(PacificVis 2013).
On the faithfulness
of graph visualizations*

In small graphs: faithfulness usually given



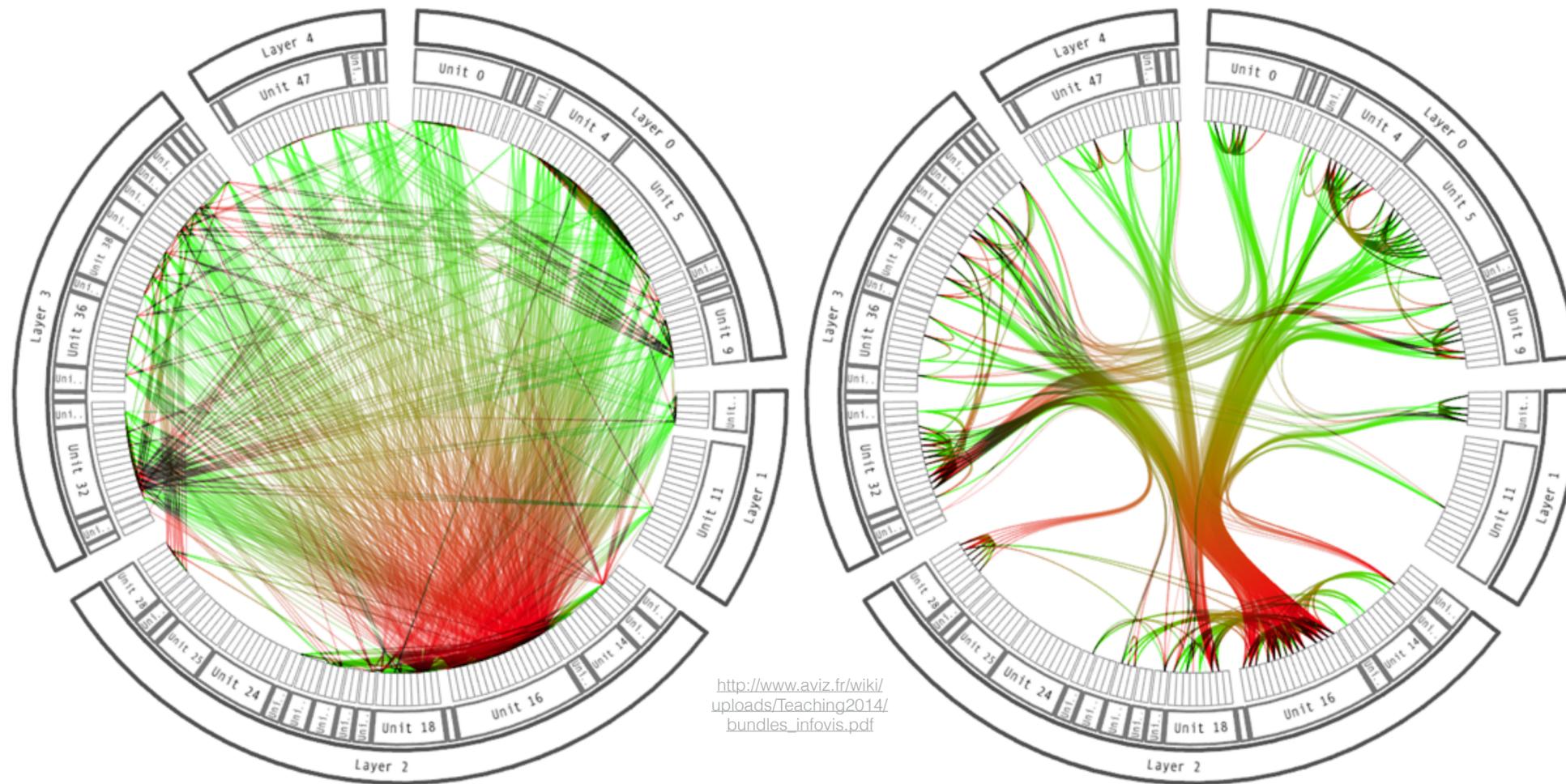
—> optimize readability

In large graphs: faithfulness usually not given



—> tradeoff between
faithfulness & readability

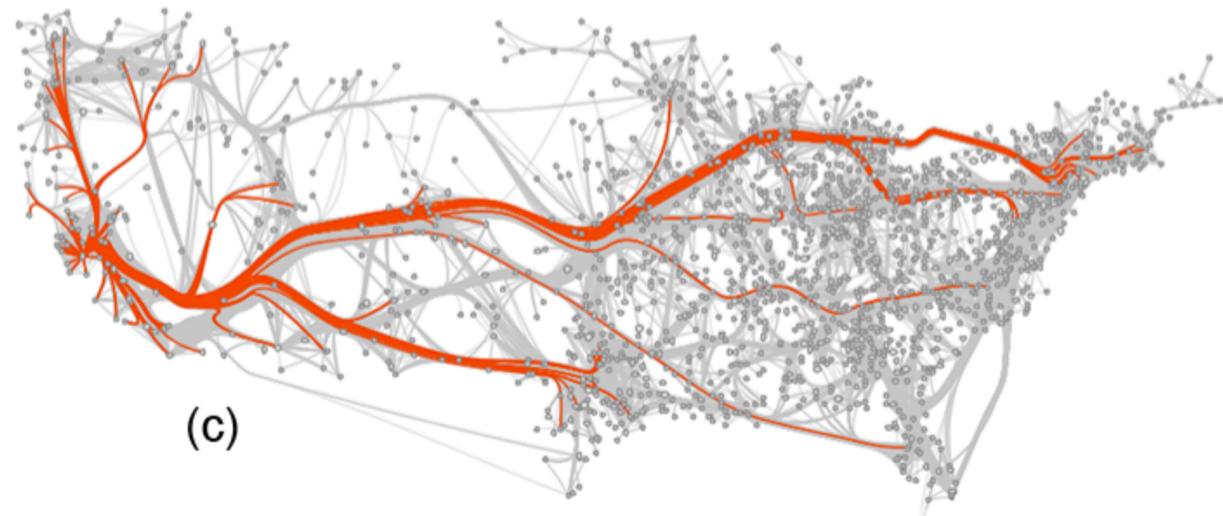
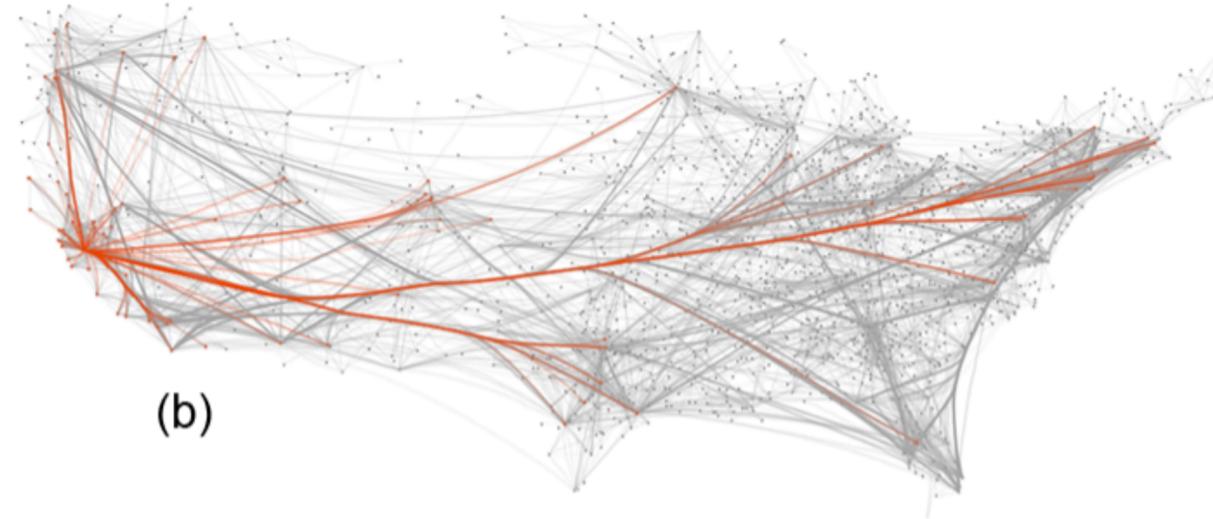
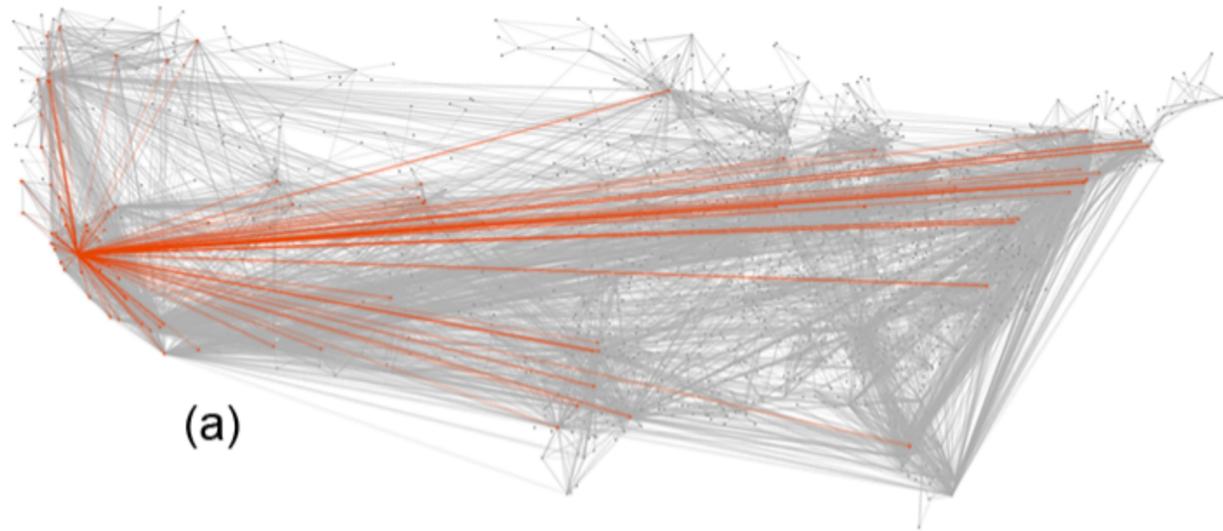
Edge bundling



Sacrifice faithfulness,
gain readability

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

Edge bundling

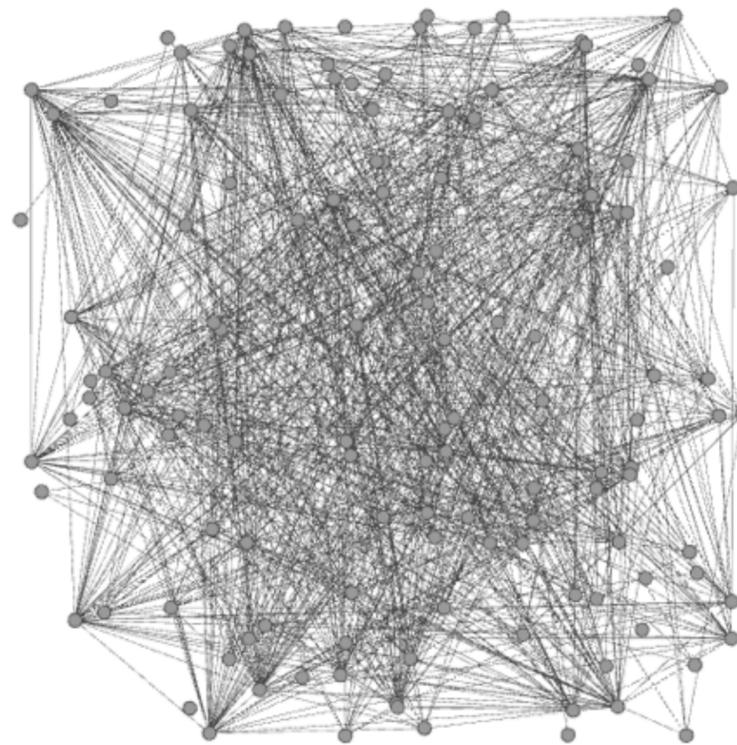
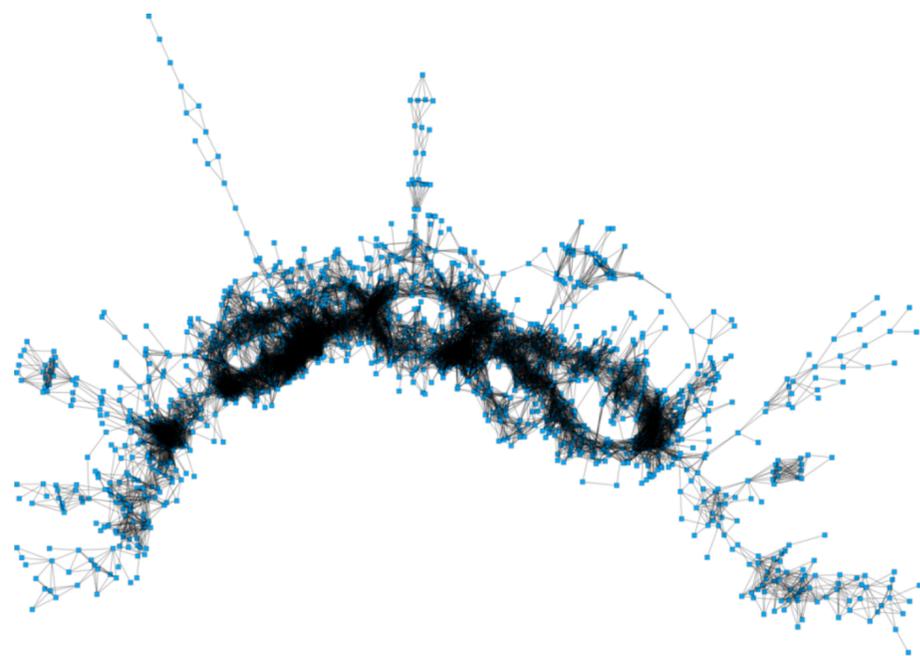


US migration graph

*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

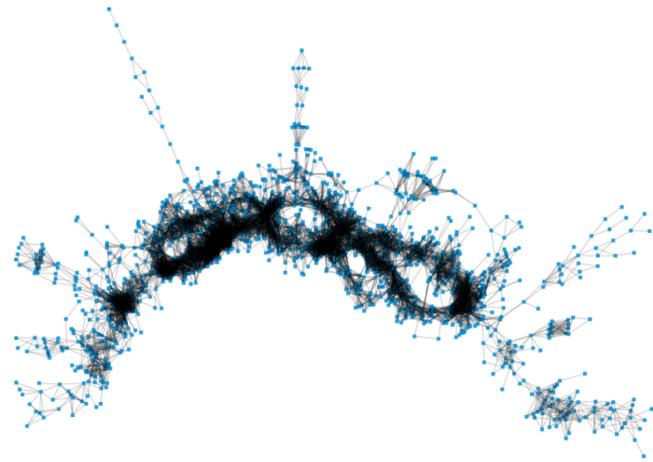


<http://eppsnet.com/images/facebook-hairball.png>

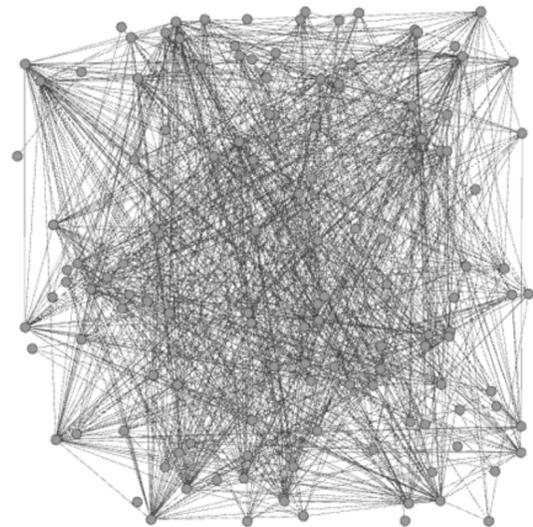
© Eades

How many edge crossing do you see?

Instead: “Show me the structure”



A



B

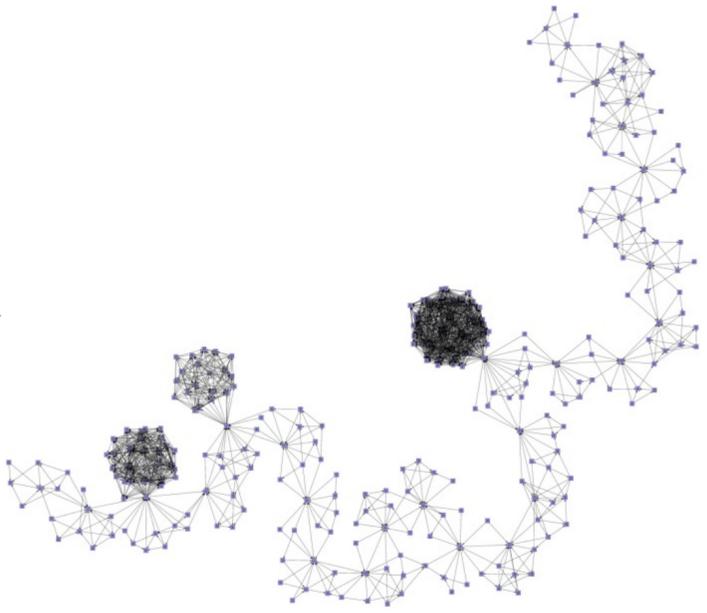


“Diagram A is better than diagram B because diagram A shows the structure of the graph, and diagram B does not show the structure.”

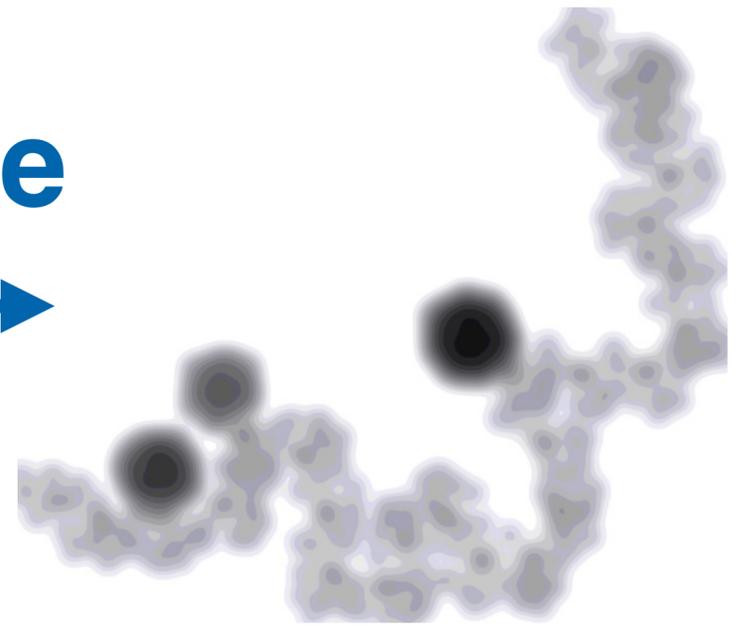
Shape

```
0,1,1,2,2,3,3,4,4,5,5,6,6,7,7,8,8,9,10,10,11,11,12,12,13,13,14,14,15,15,16,16,17,17,18,18,19,19,20,20,21,21,22,22,23,23,24,25,0,26,1,27,2,28,3,29,4,30,5,3
1,32,7,33,8,34,9,35,10,36,11,37,12,38,13,39,14,40,15,41,16,42,17,43,18,44,19,45,20,46,21,47,22,48,23,49,24,47,48,50,0,50,1,51,0,51,1,52,0,52,1,53,1,53,
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```

draw



shape



For a good quality drawing: the shape of the drawing should be faithful to the input graph.

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

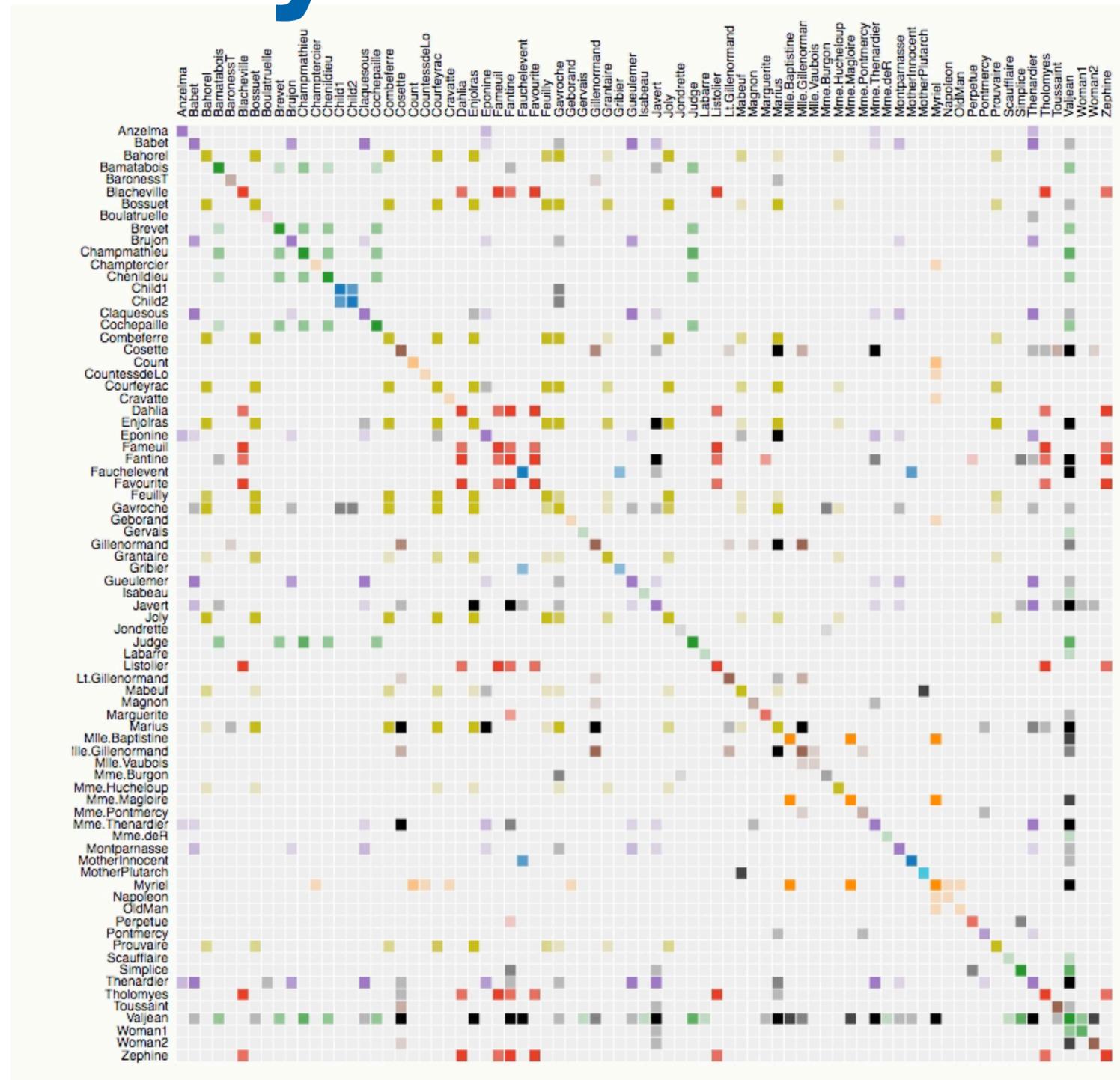
2. Problem-driven research

- Design Study Example — RelEx
- Design Study Methodology

3. Summary

Alternative representations

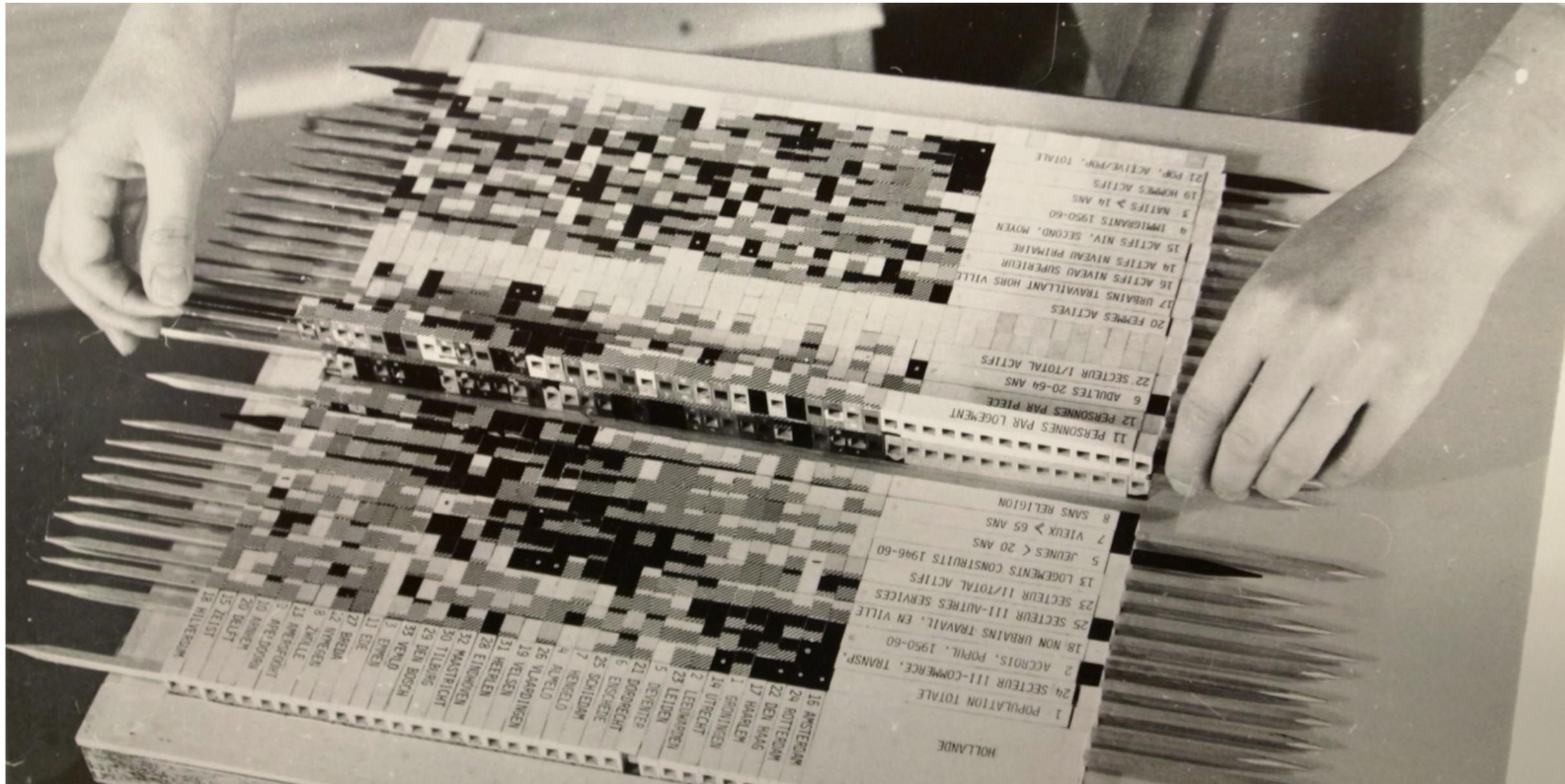
Adjacency Matrix



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

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

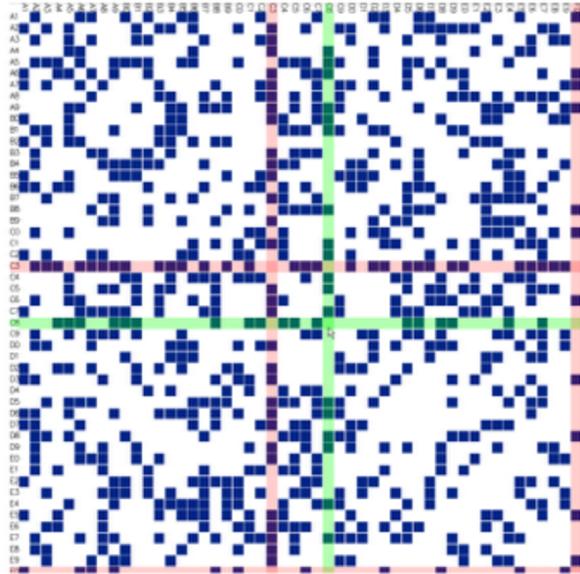
Adjacency Matrix (physical)



Jacques Bertin,
1968

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

Matrix or Node-link?



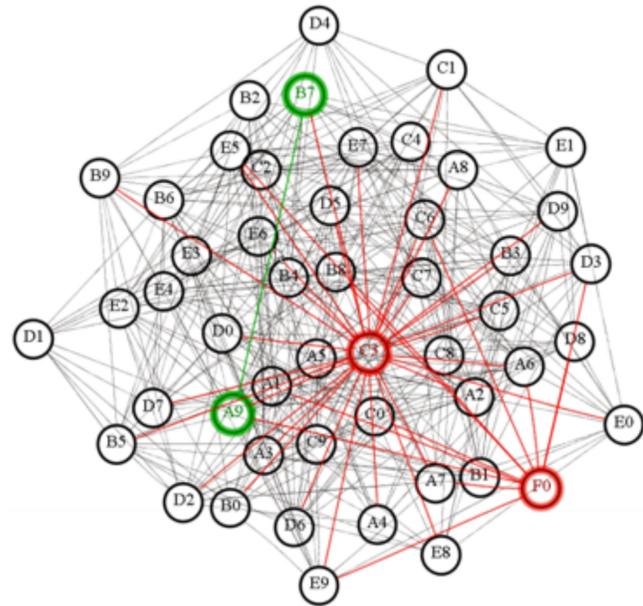
- Study
 - 36 users
 - 9 networks
 - 7 tasks → measure time & errors

- Results

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

- Else **Matrix**

- Limitations



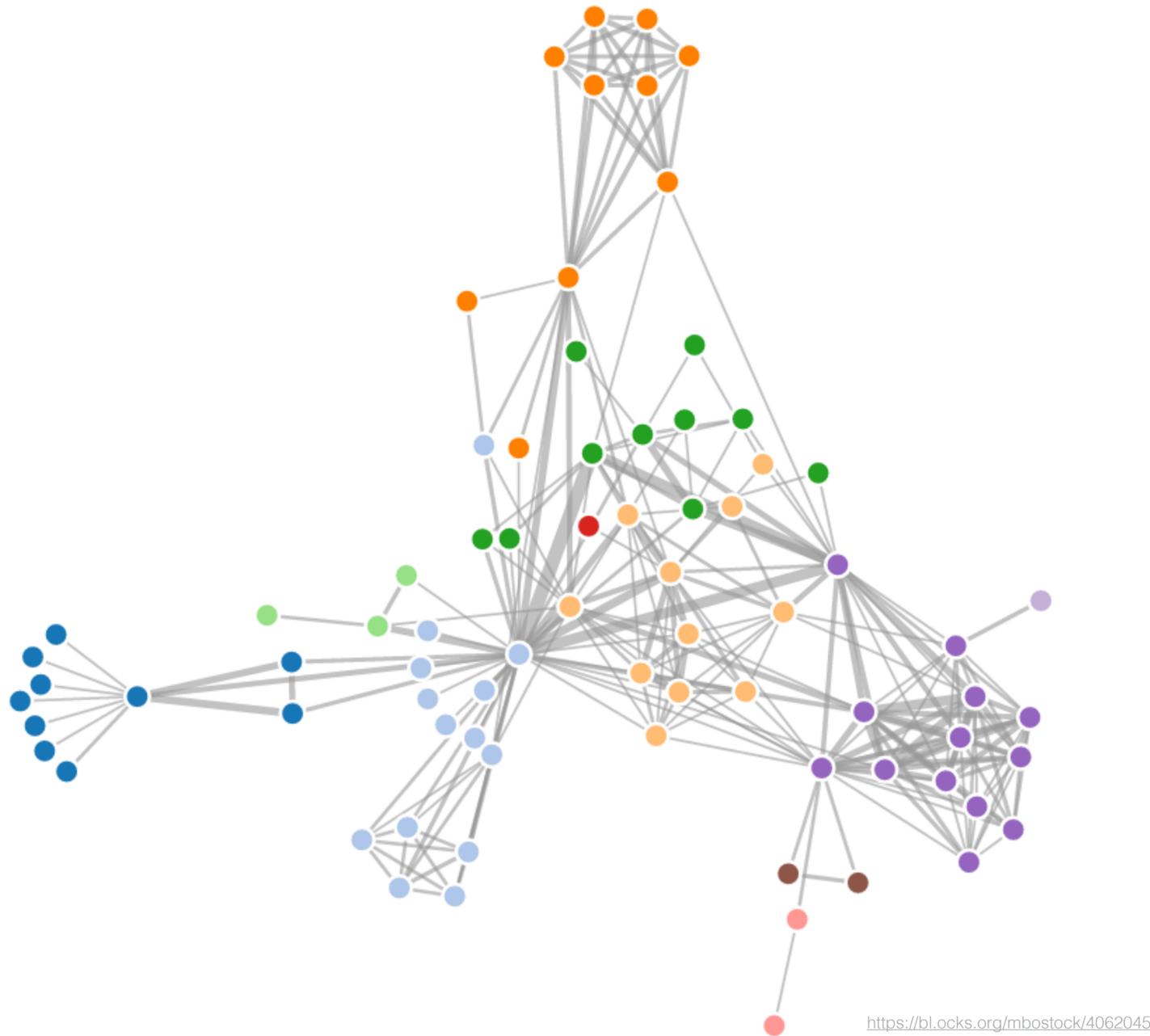
*Ghoniem et al. (InfoVis 2004).
A Comparison of the Readability of
Graphs Using Node-Link and
Matrix-Based Representations.*

Additional encodings

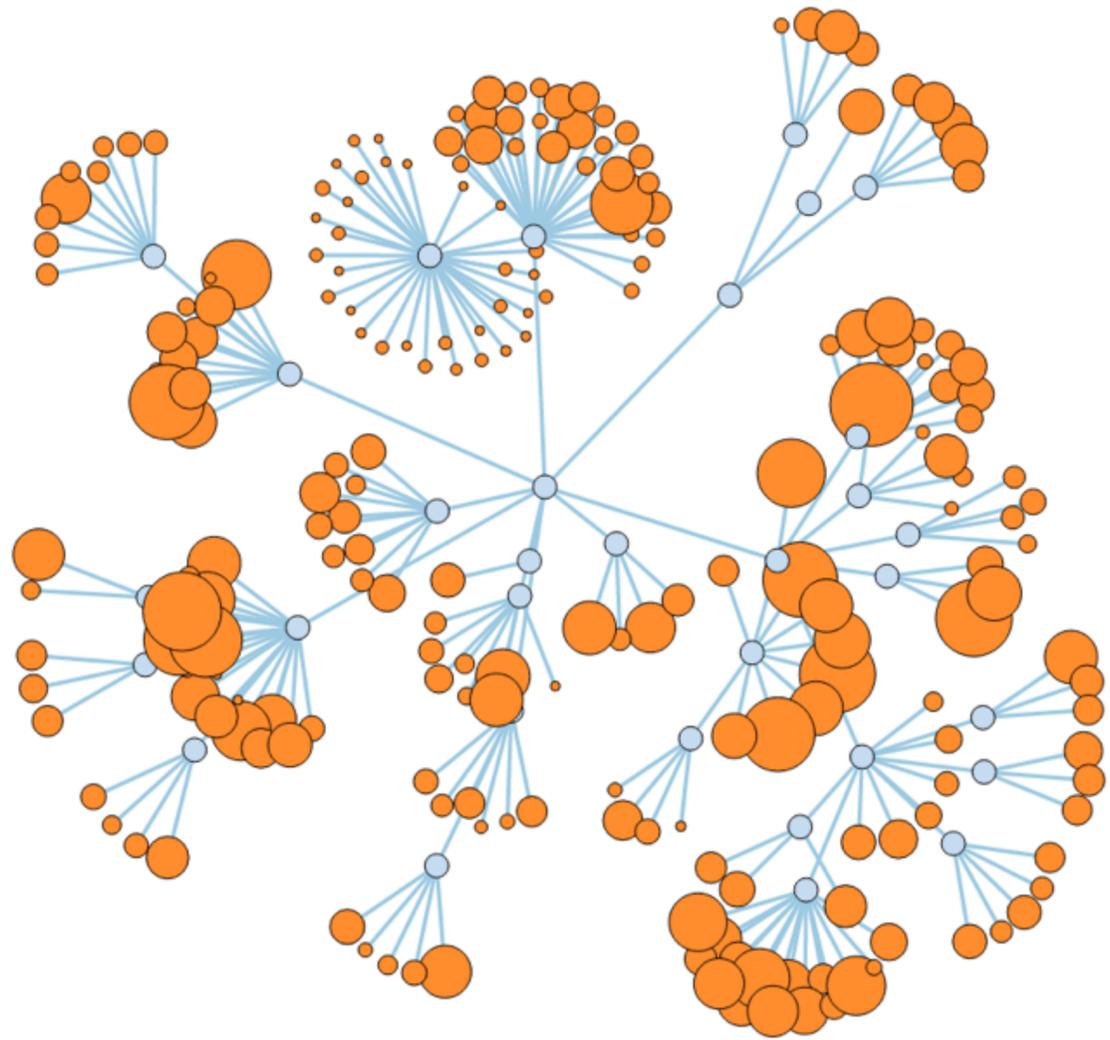
Color and width

Additional encodings

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

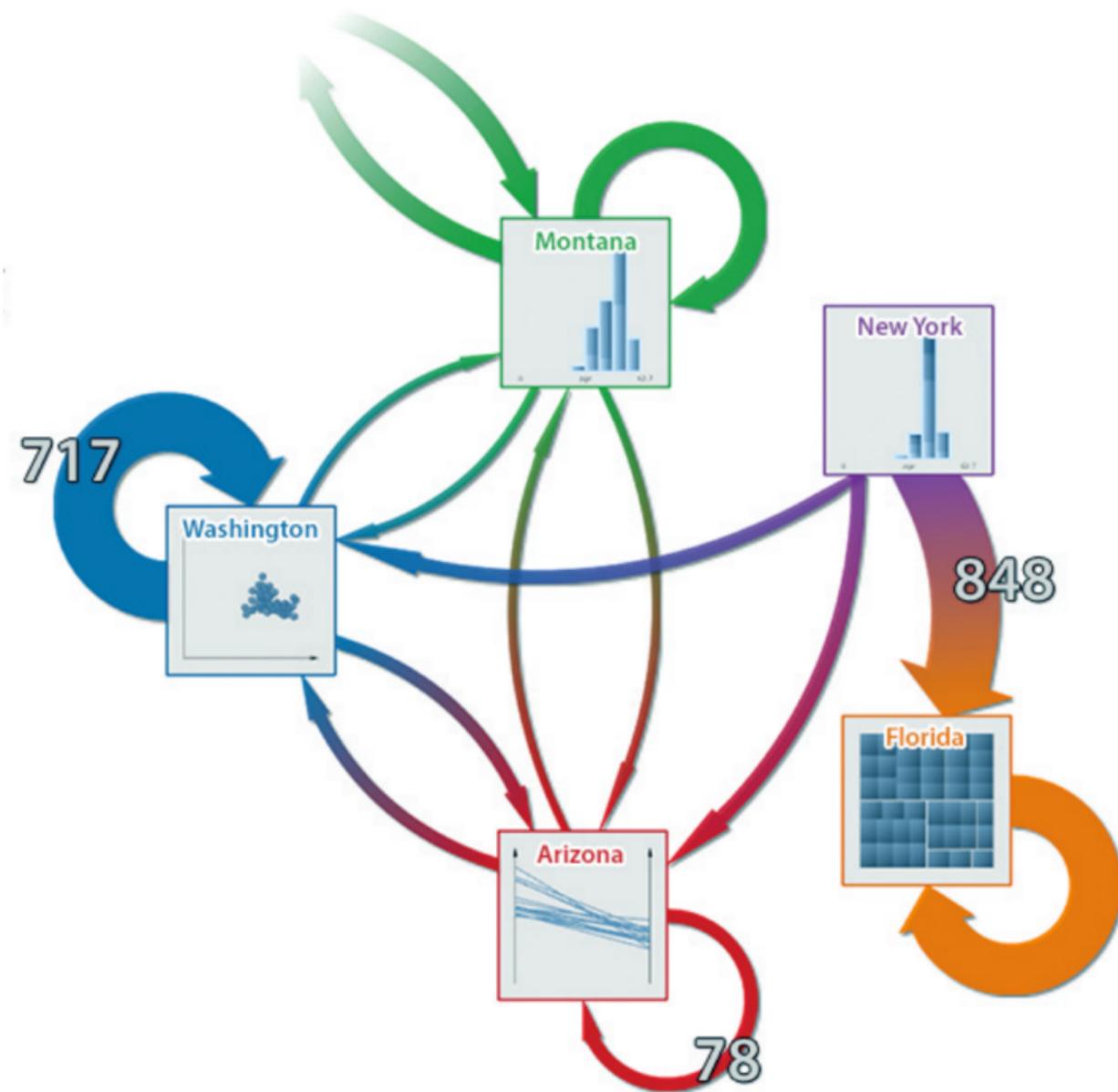


Size



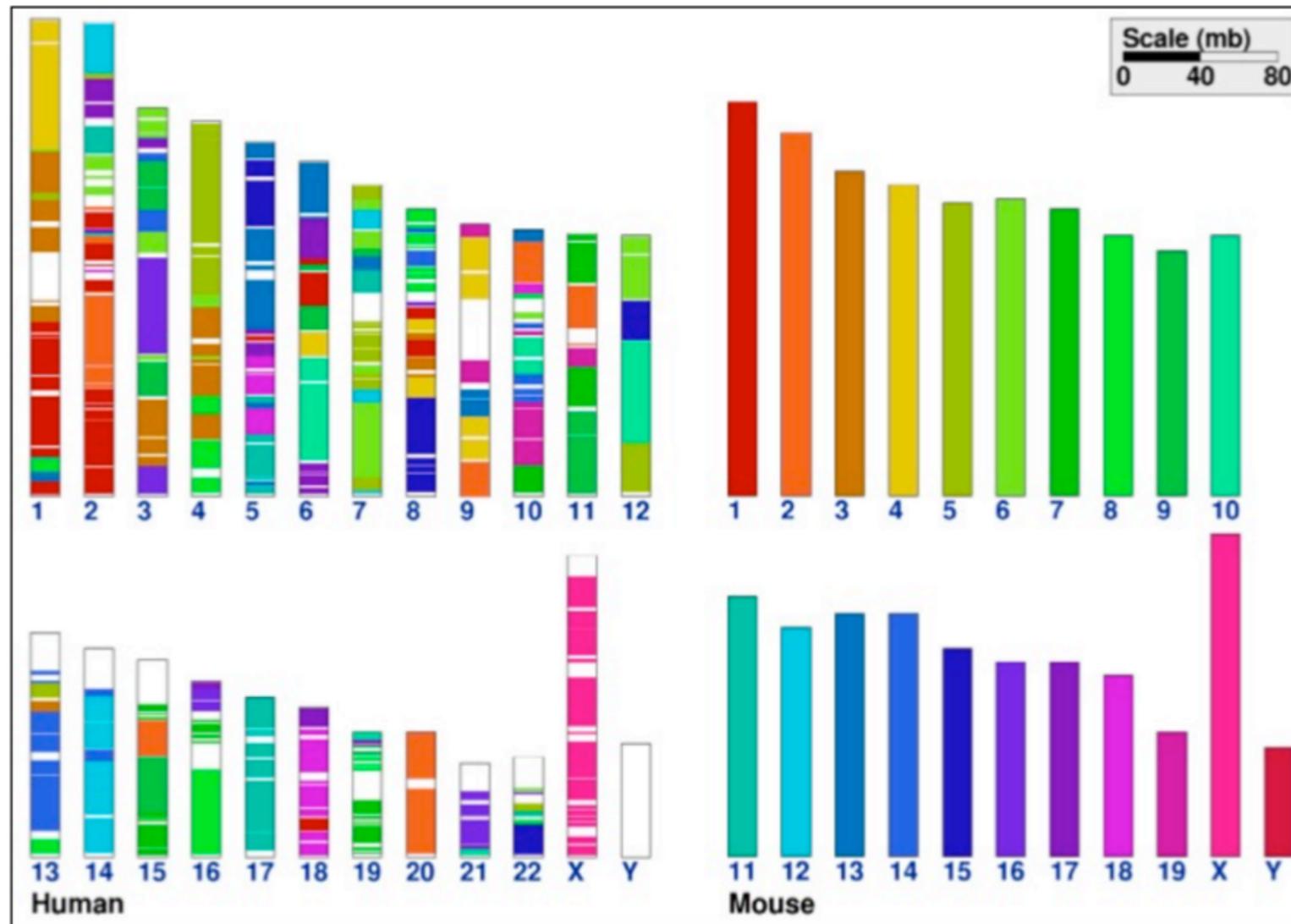
<http://mbostock.github.io/d3/talk/20111116/force-collapsible.html>

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?

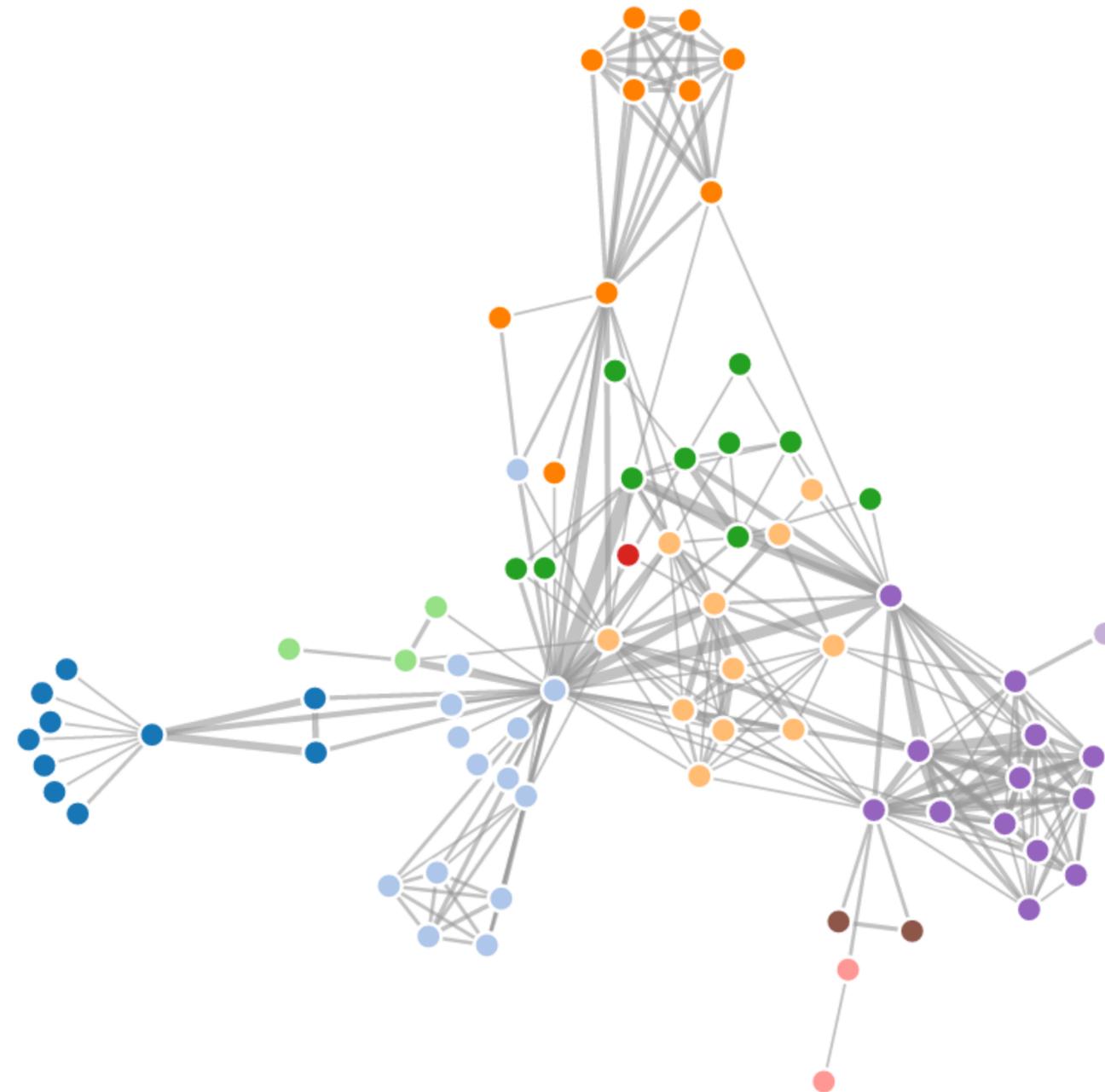


—> Achim!

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.

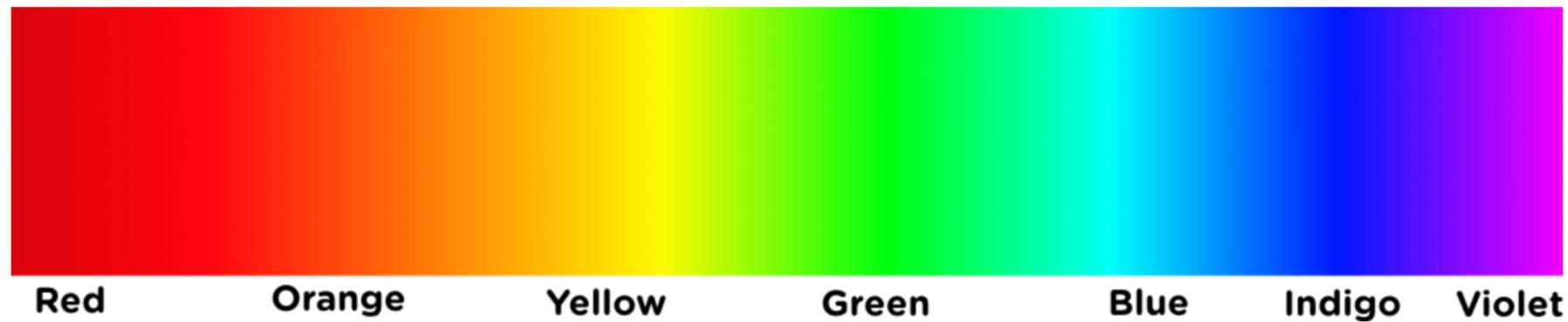
Visual Encoding: Color?



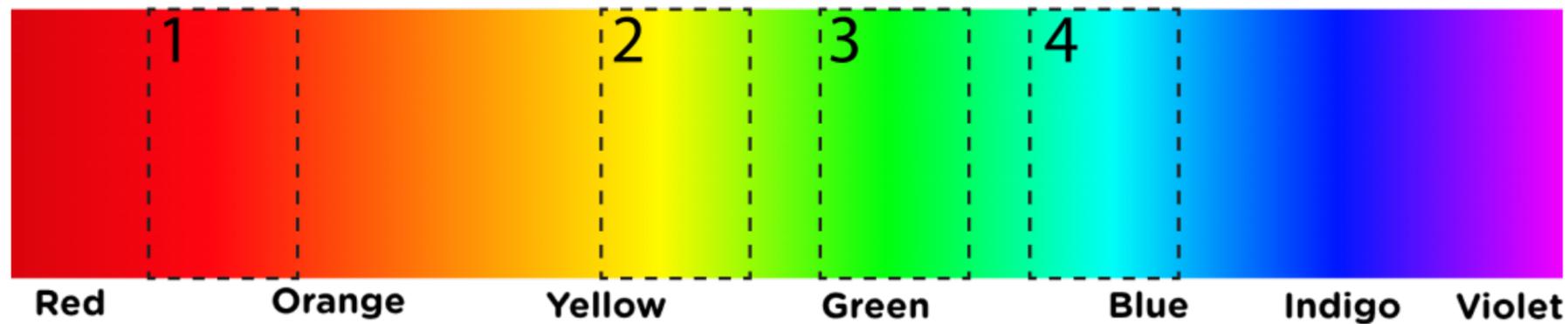
—> Achim!

noncontiguous small
regions of color:
only 6-12 bins

Rainbow color maps?



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



—> Achim!

Maureen Stone



Solutions, e.g. ColorBrewer

The screenshot displays the ColorBrewer 2.0 web application interface. At the top, it says "COLORBREWER 2.0 color advice for cartography". The interface is divided into several sections:

- Number of data classes:** Set to 7.
- Nature of your data:** Radio buttons for "sequential" (selected), "diverging", and "qualitative".
- Pick a color scheme:** A grid of various color schemes, with the "7-class RdBu" scheme selected.
- Only show:** Checkboxes for "colorblind safe", "print friendly", and "photocopy safe".
- Context:** Checkboxes for "roads", "cities", and "borders" (checked).
- Background:** Radio buttons for "solid color" (selected) and "terrain".
- Color transparency:** A slider control.
- 7-class RdBu color legend:** A vertical list of seven color swatches with their corresponding HEX codes: #b2182b, #ef8a62, #fdbbc7, #f7f7f7, #d1e5f0, #67a9cf, and #2166ac.
- EXPORT:** A button with a dropdown menu set to "HEX".

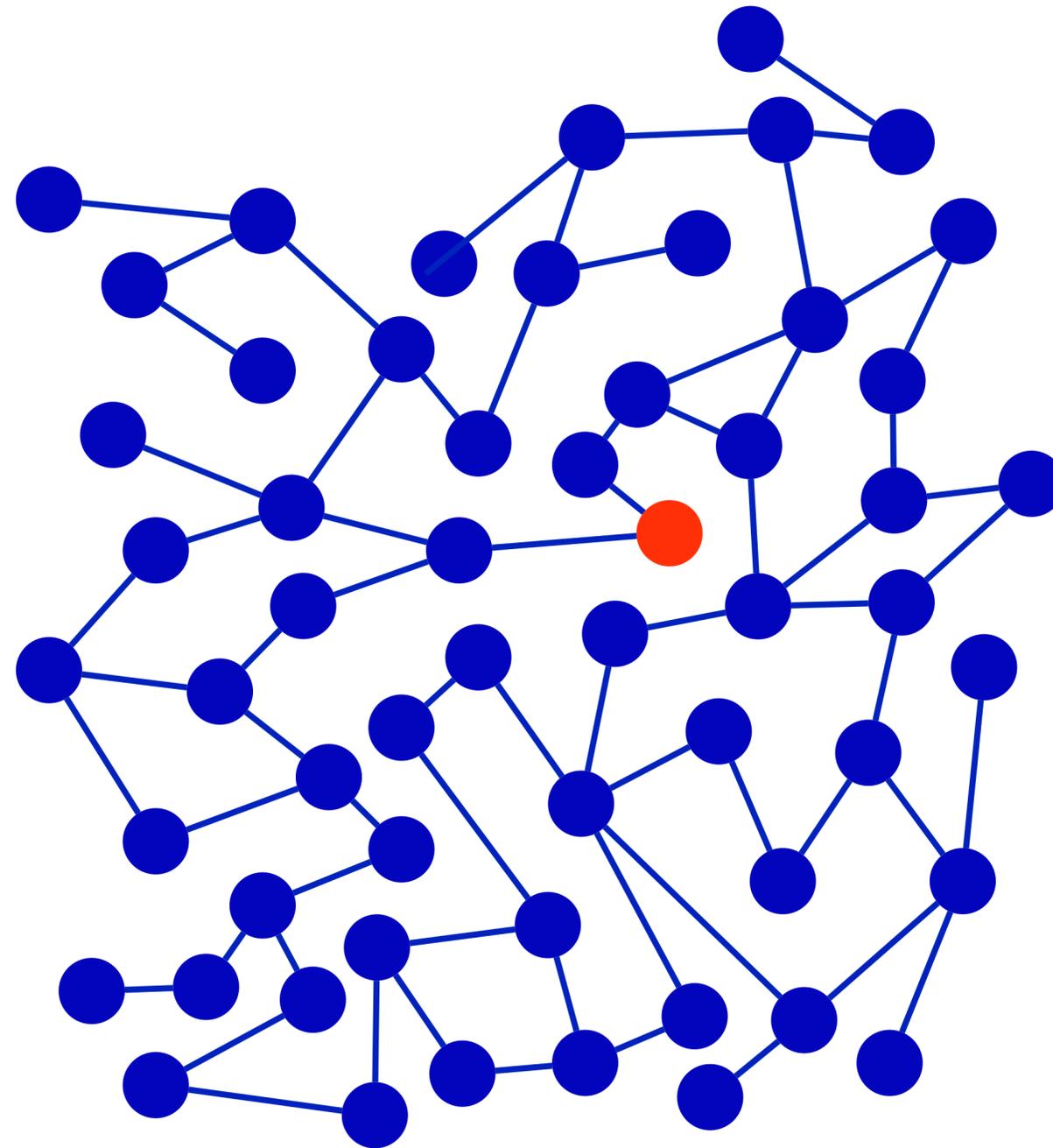
The main map area shows a map of the United States with a 7-class sequential color scheme applied to the data. The colors range from dark red on the left to dark blue on the right, with intermediate colors of orange, light orange, white, light blue, and medium blue. The map is overlaid with a grid of small squares, likely representing a network visualization.

© Cynthia Brewer, Mark Harrower and The Pennsylvania State University
Support
[Back to Flash version](#)
[Back to ColorBrewer 1.0](#)

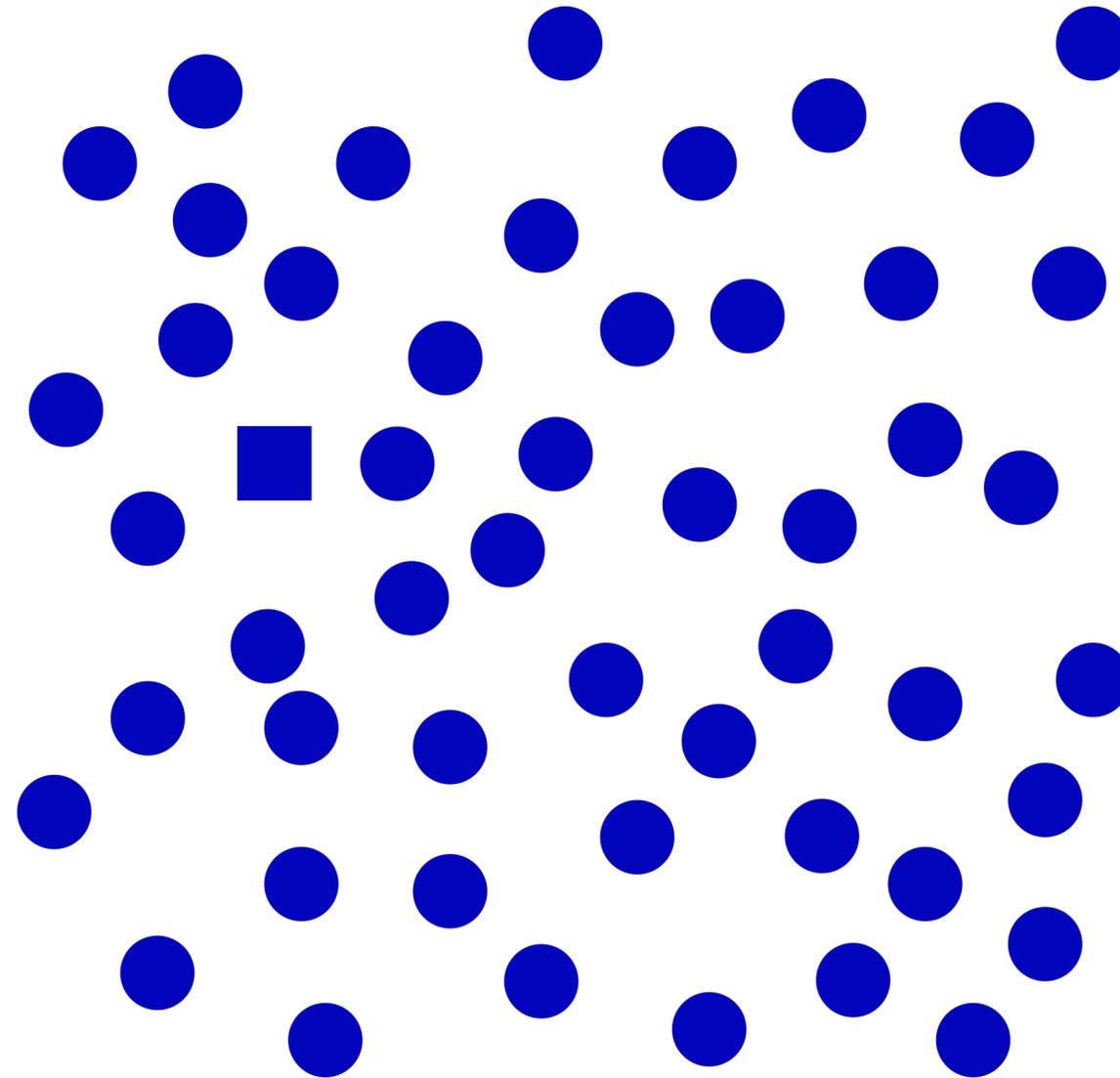
axismaps

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

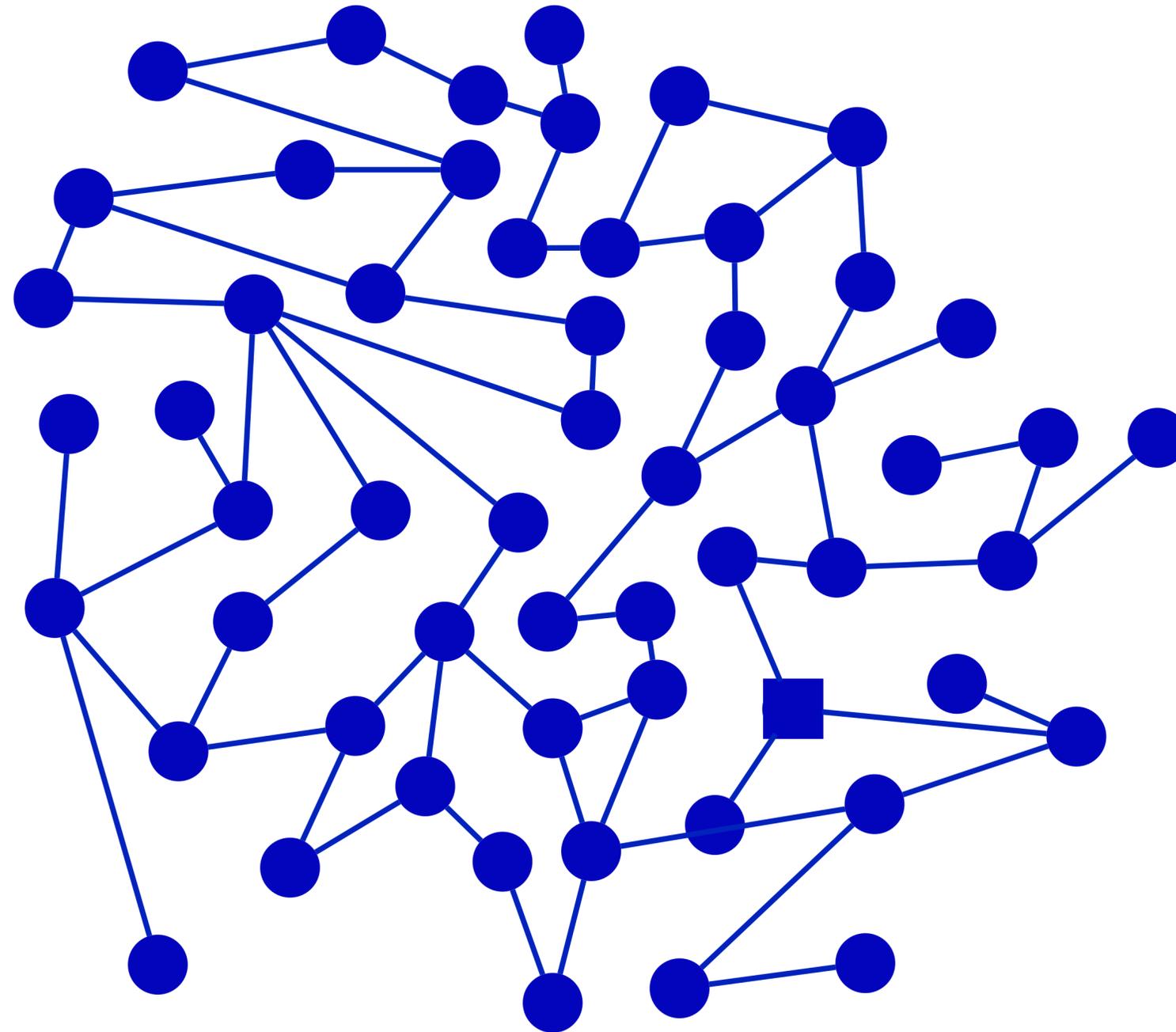
Popout



Popout

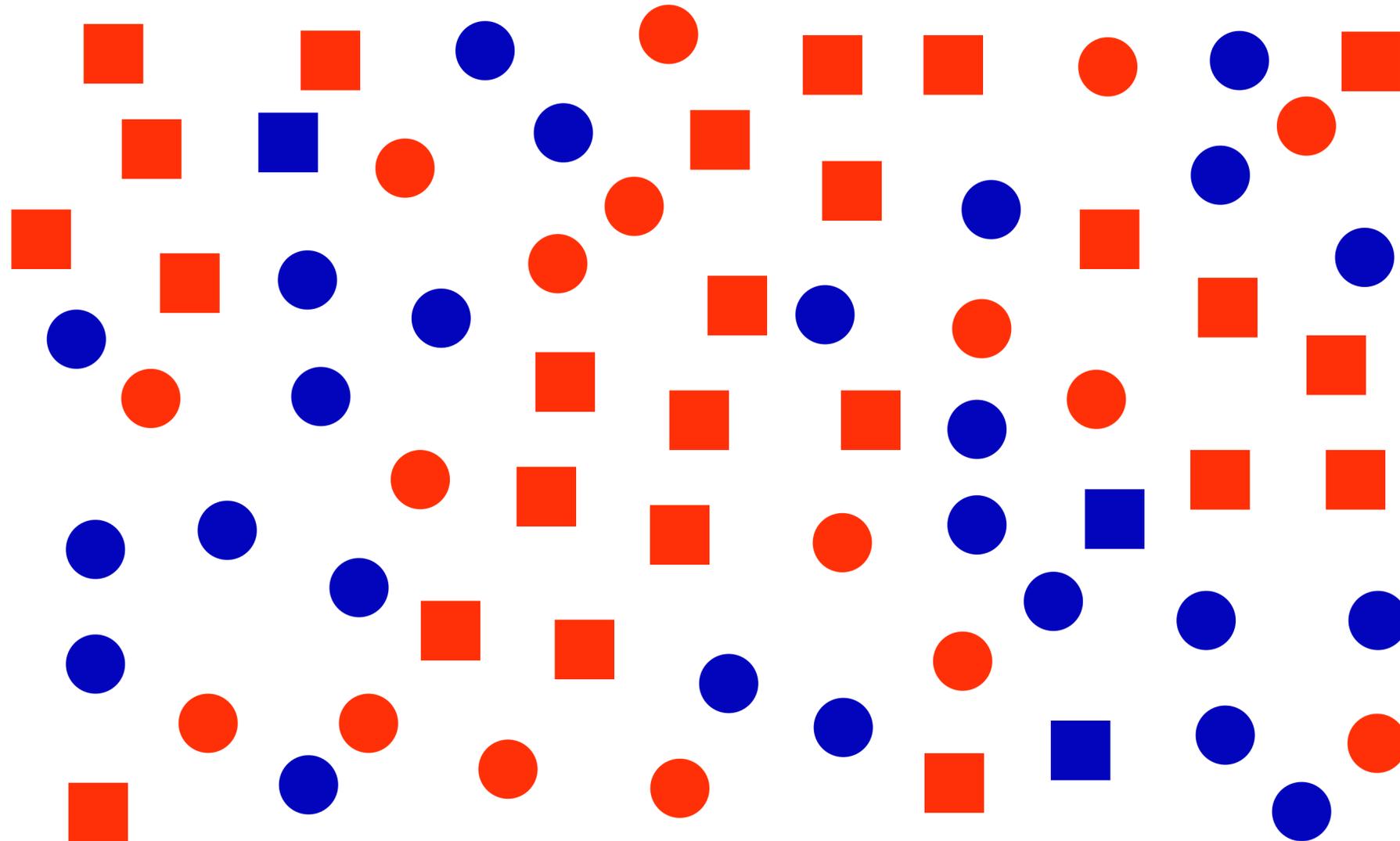


Popout



Popout: combining channels?

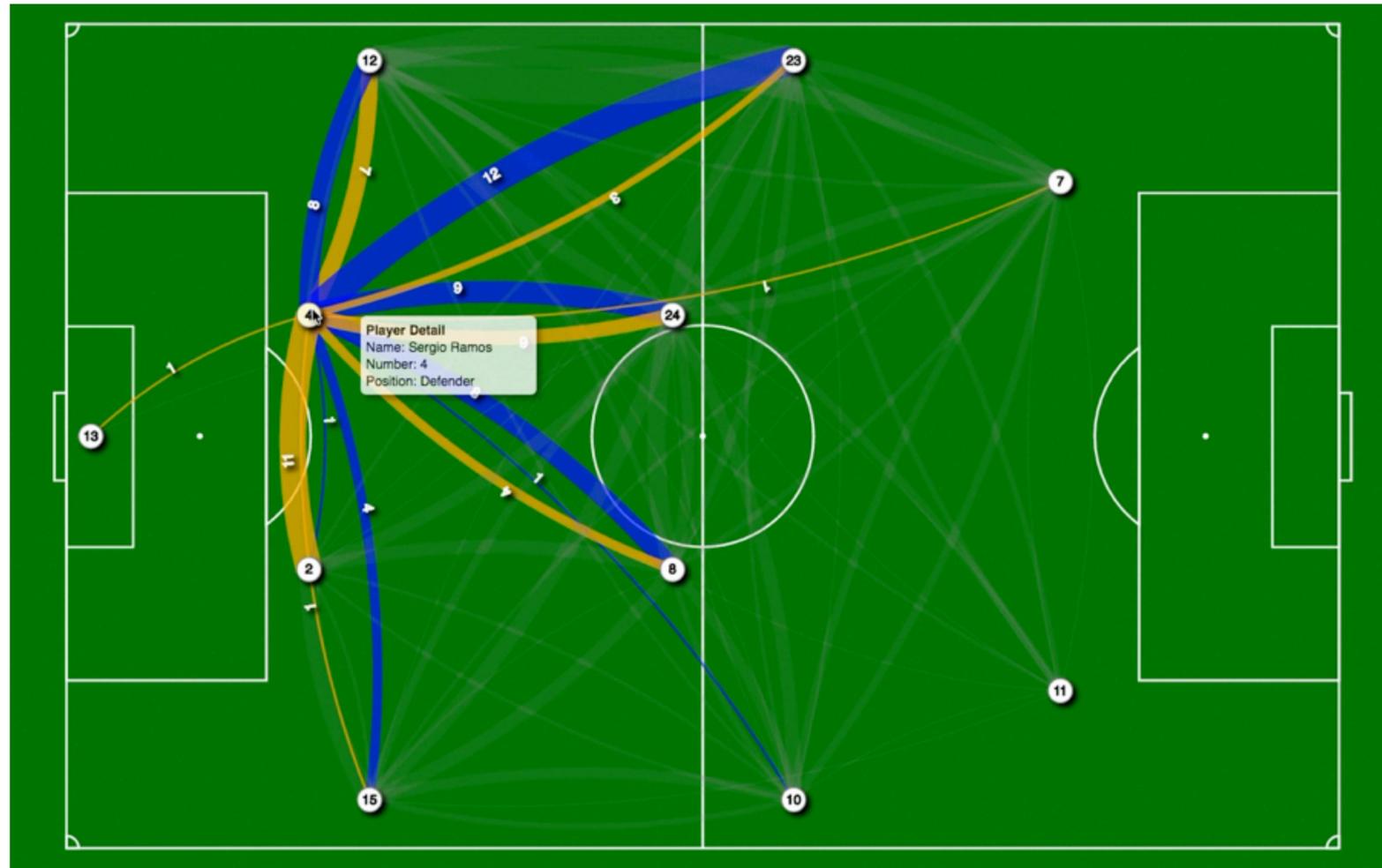
How many blue rectangles?



Interaction

(as a way of dealing with scalability)

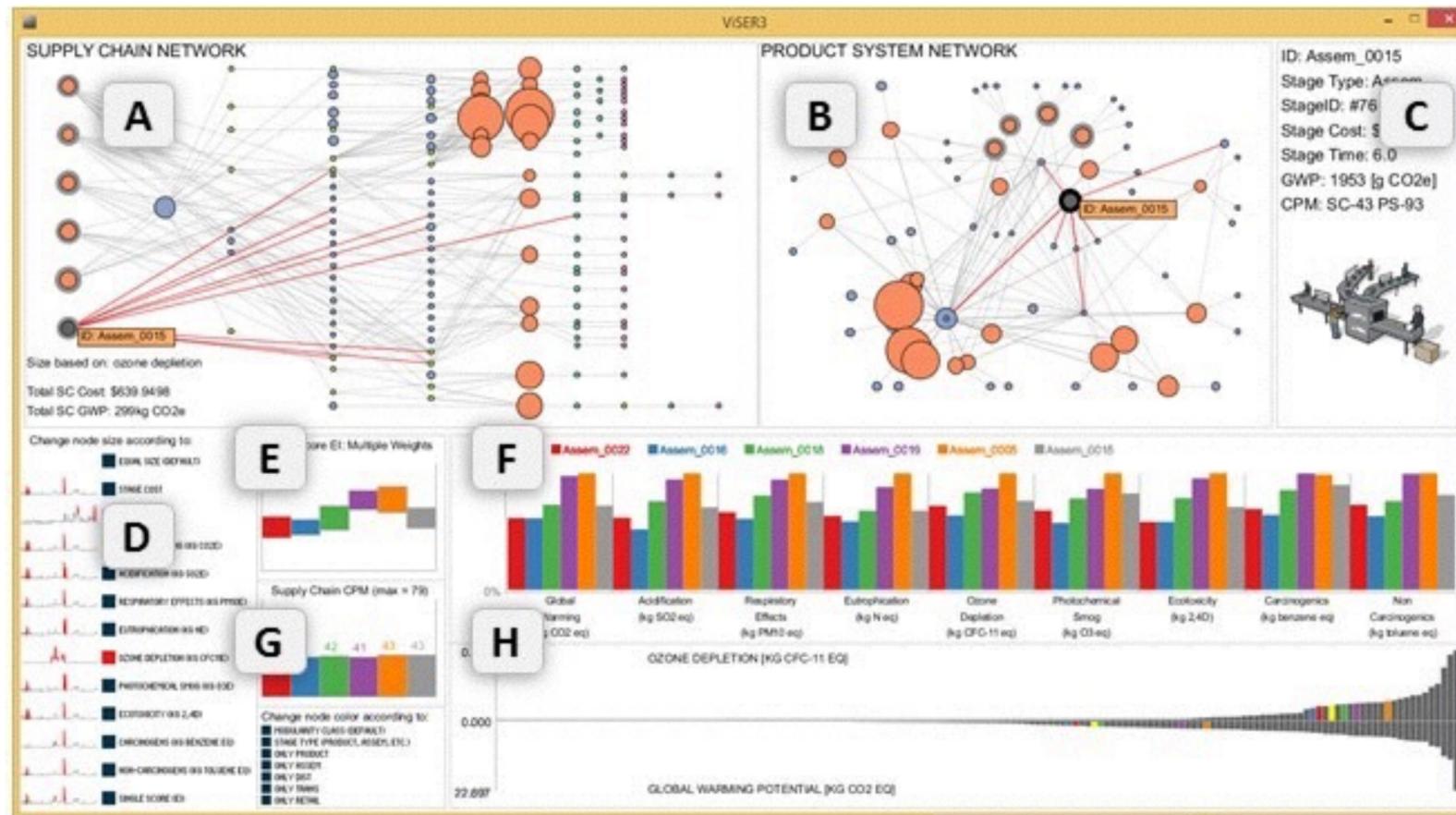
Interactive highlighting



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

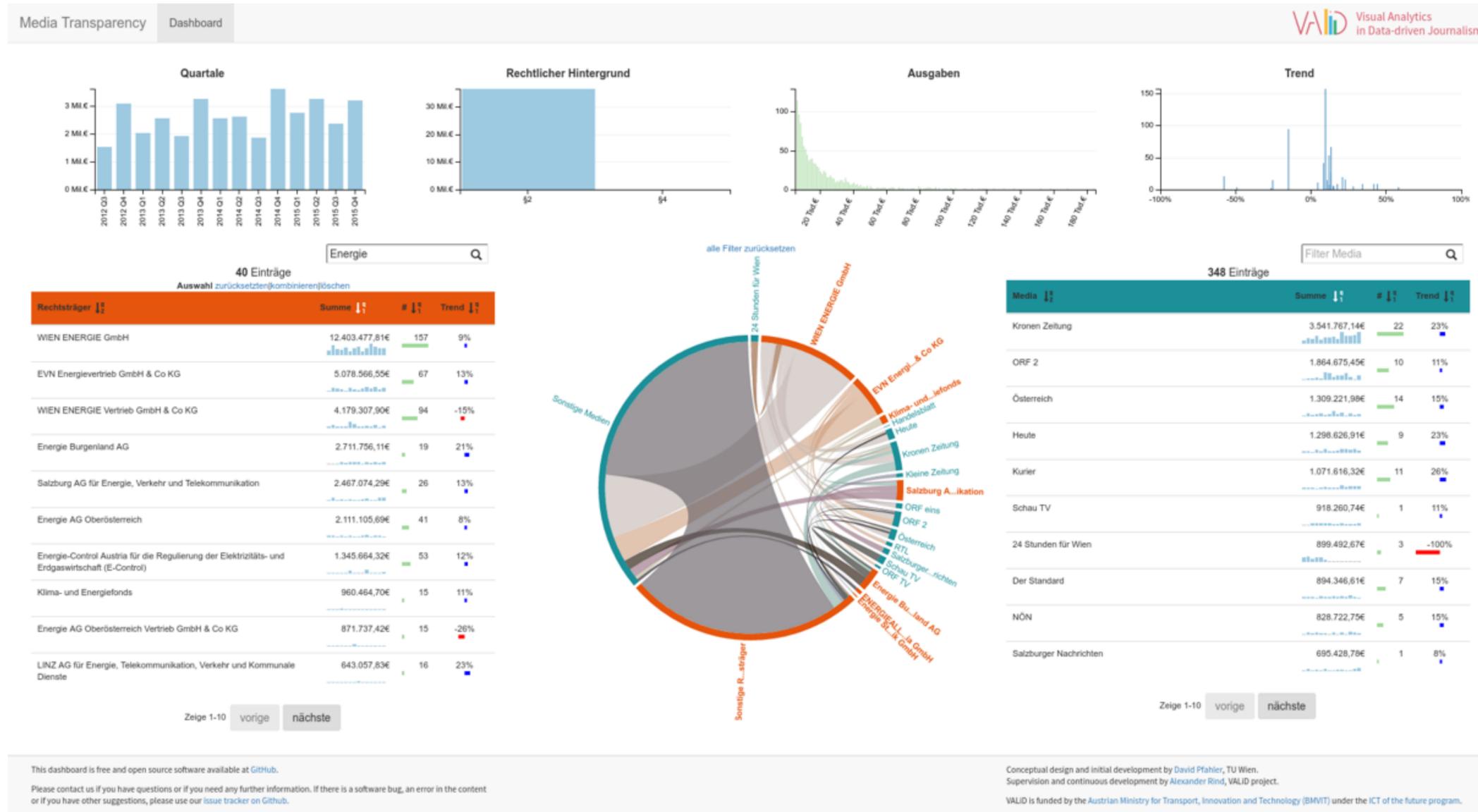
- Inherent design tradeoff:
- Amount of data shown
 - Time (Interaction/Animation)

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.

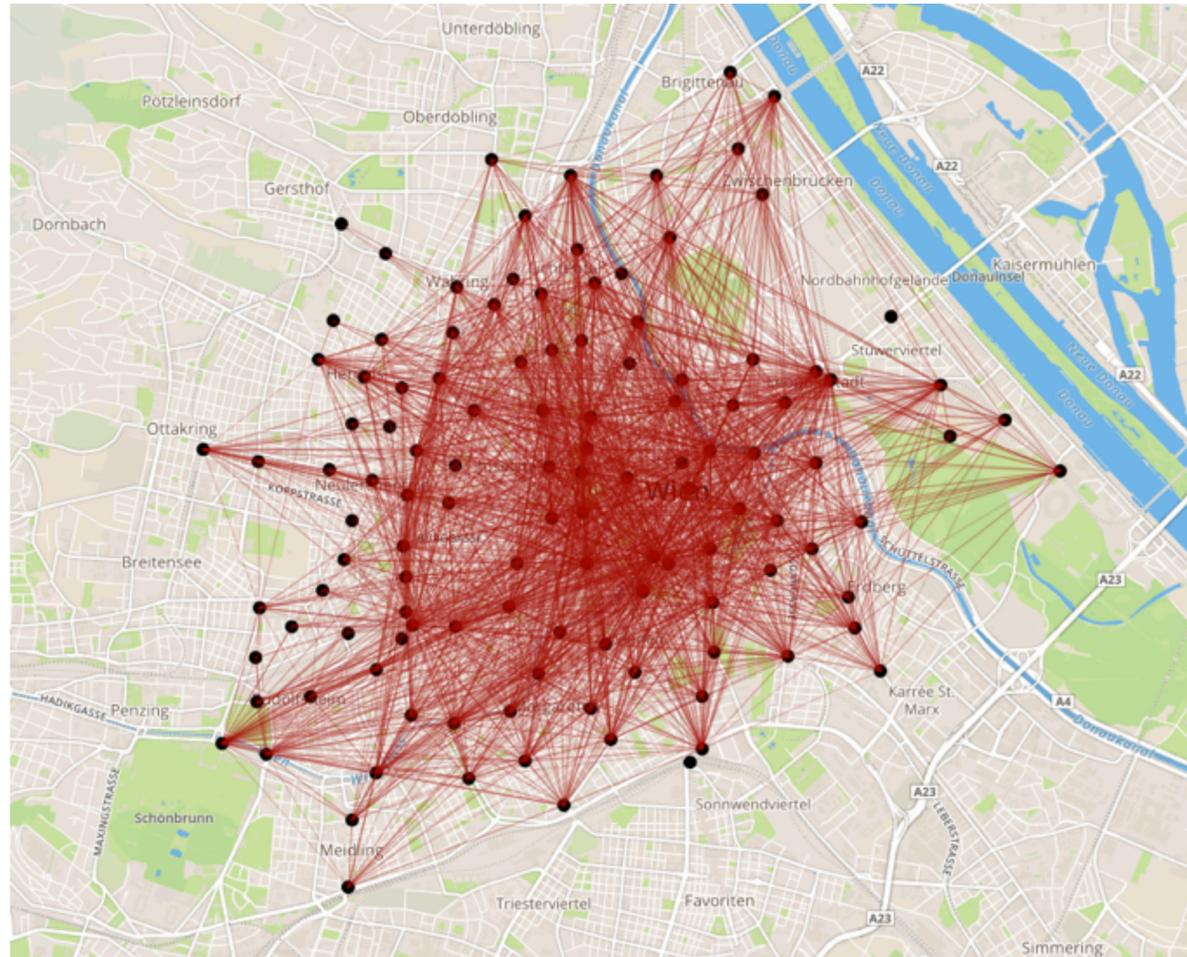
Multiple Views + Linking and brushing



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

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.

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)

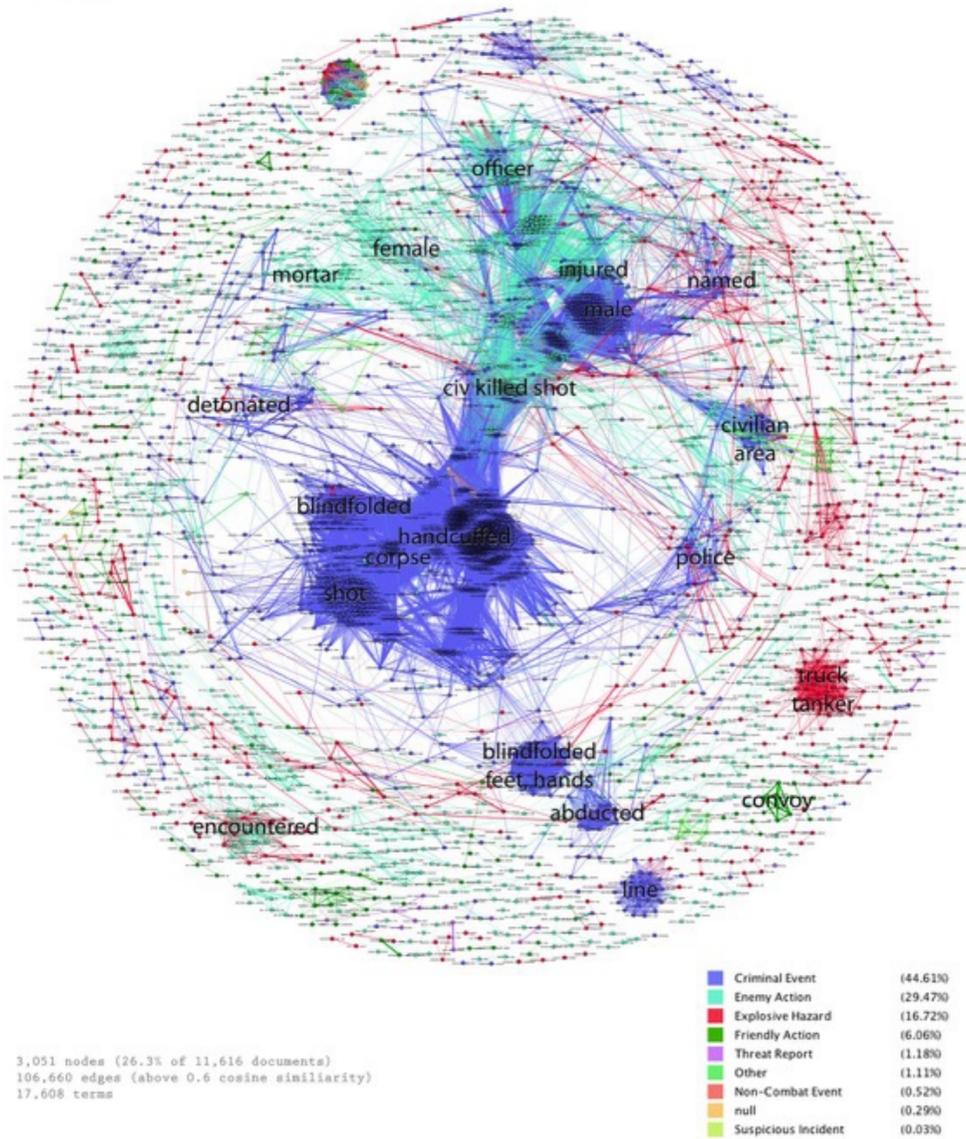
Demo

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



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Back to list

Document 21 of 66
in folder ALL: letter, urging, president_obama, gas_exploration MOST: decision, comments, open_oil...

MMS6 Pdf 40 85 85

Key words: decision, department, congress, program, suggestions, comments

United States Department of the Interior
MINERALS MANAGEMENT SERVICE
Washington, D.C. 20515

The Honorable Jerry Moran
House of Representatives
Washington, D.C. 20515

Dear Congressman Moran:

Thank you for your letter dated February 3, 2009, to President Obama, co-signed by 69 other Members of Congress, urging that areas of the Outer Continental Shelf (OCS) be left open for oil and gas exploration and development while the Administration reviews the 5-year offshore drilling plan. As Acting Director of the Minerals Management Service (MMS), I have been asked to respond. A similar letter is being sent to each signer of your letter.

The Administration and the Department of the Interior have made developing a comprehensive energy strategy for the Nation a top priority. In fact, as a result of the decision by Congress not to renew the OCS moratorium last year, we are exploring offshore oil and gas development in more areas than ever before. Let me assure you that Secretary Ken Salazar's decision to extend the comment period on the Draft Proposed OCS Oil and Gas Leasing Program for 2010-2015 does not affect the current leasing program. In fact, to date, seven sales have been held under this program. The most recent sale was Central Gulf Sale 208, which received over \$700 million in high bids. Fourteen lease sales remain on the schedule under the current program. We recognize that the OCS continues to play a major role in the energy mix for our country and provides 27 percent of the oil and 14 percent of the natural gas produced domestically.

The recent decision of the 10th Circuit Court, which found that the current offshore leasing plan is deficient, is a major concern. Consequently, the Department is working hard to clarify the implications of that decision and to remedy the situation with as little impact as possible.

If any Member of Congress has particular suggestions or comments related to the new 5-year plan now in progress, please be aware that we are accepting comments until September 21, 2009. We welcome any suggestions or comments you may have regarding the development of a comprehensive energy program for the OCS and the Nation.

Thank you for your interest in the offshore energy program. We look forward to working with you on this issue. If you have any questions, please contact me at (202) 208-3500, or Ms. Lyn Herdt, Chief, MMS Office of Congressional Affairs, at (202) 208-3502.

Sincerely,
Walter D. Anderson

Tags: Atlanta, Independence visit, log name, Create new tag, Show untagged, Organize tags...

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?

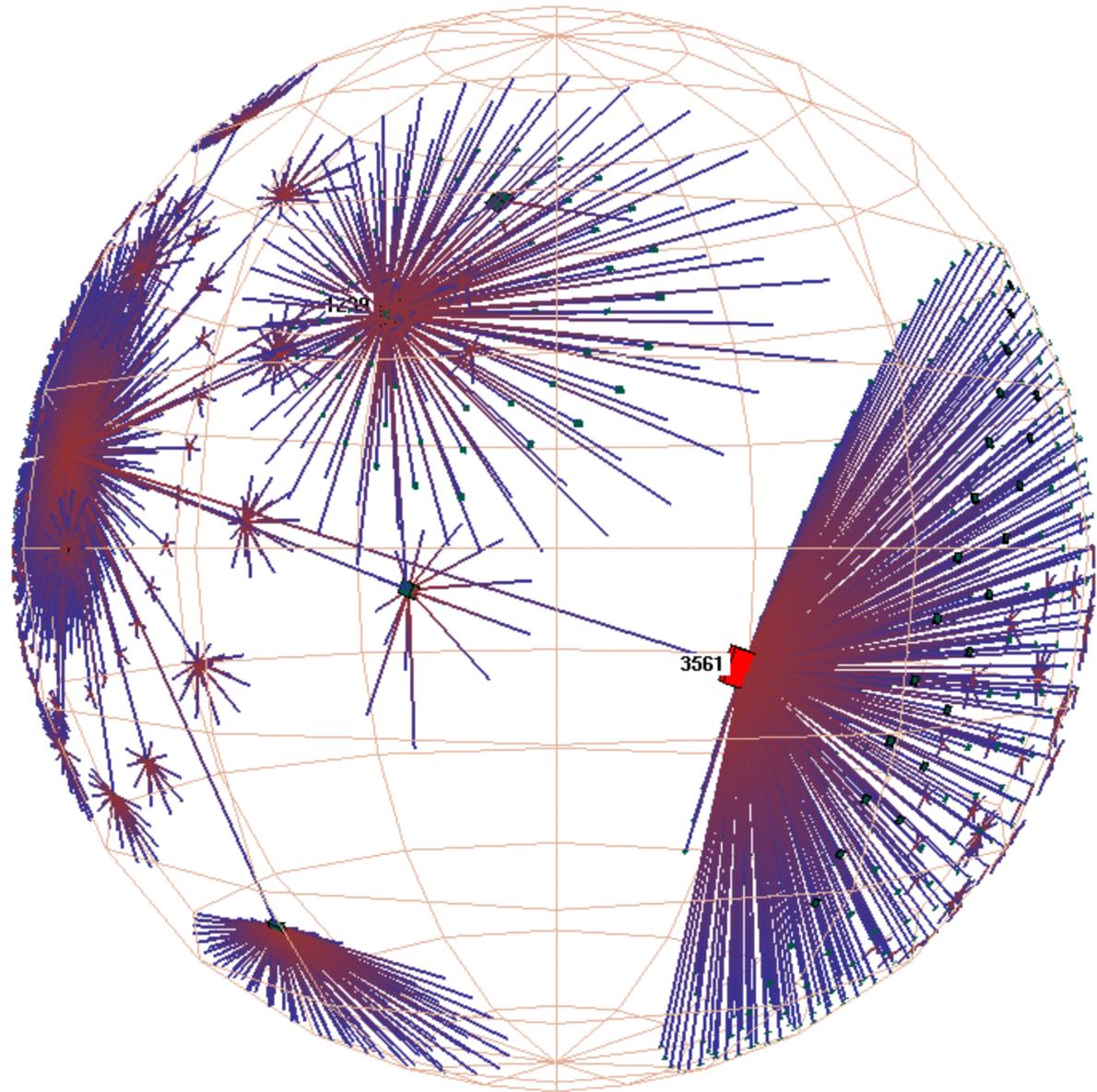


<http://flylib.com/books/en/2.151.1.84/1/>



<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

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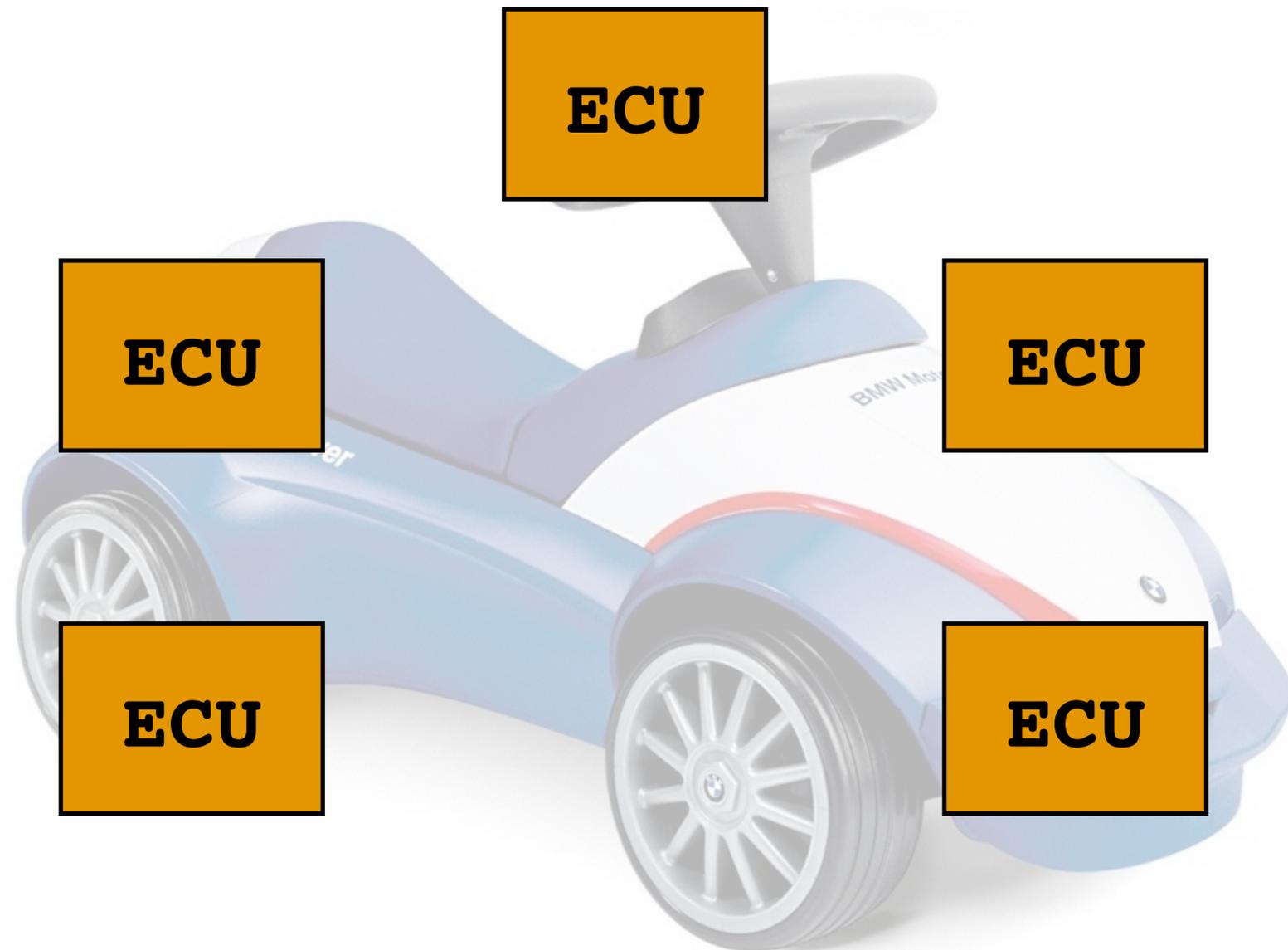
3. Summary

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

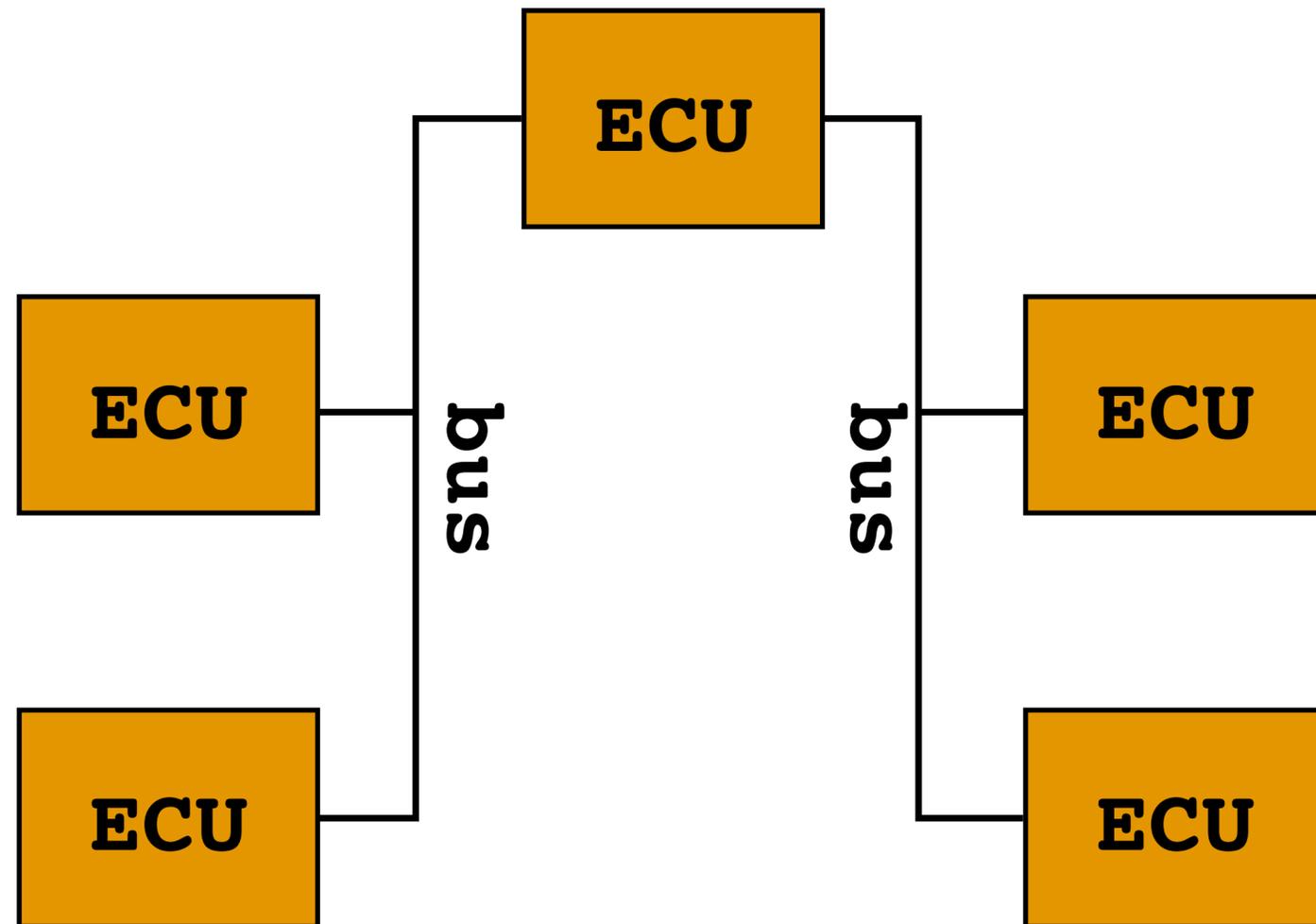


Physical network (Hardware)



~100 ECU (nodes)

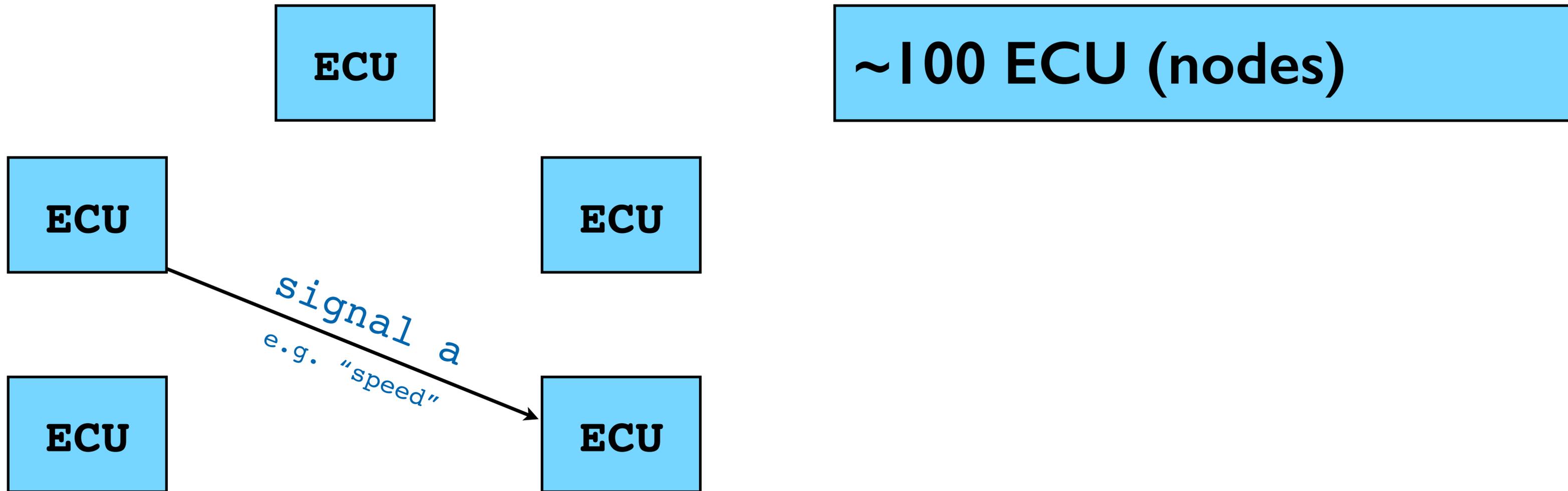
Physical network (Hardware)



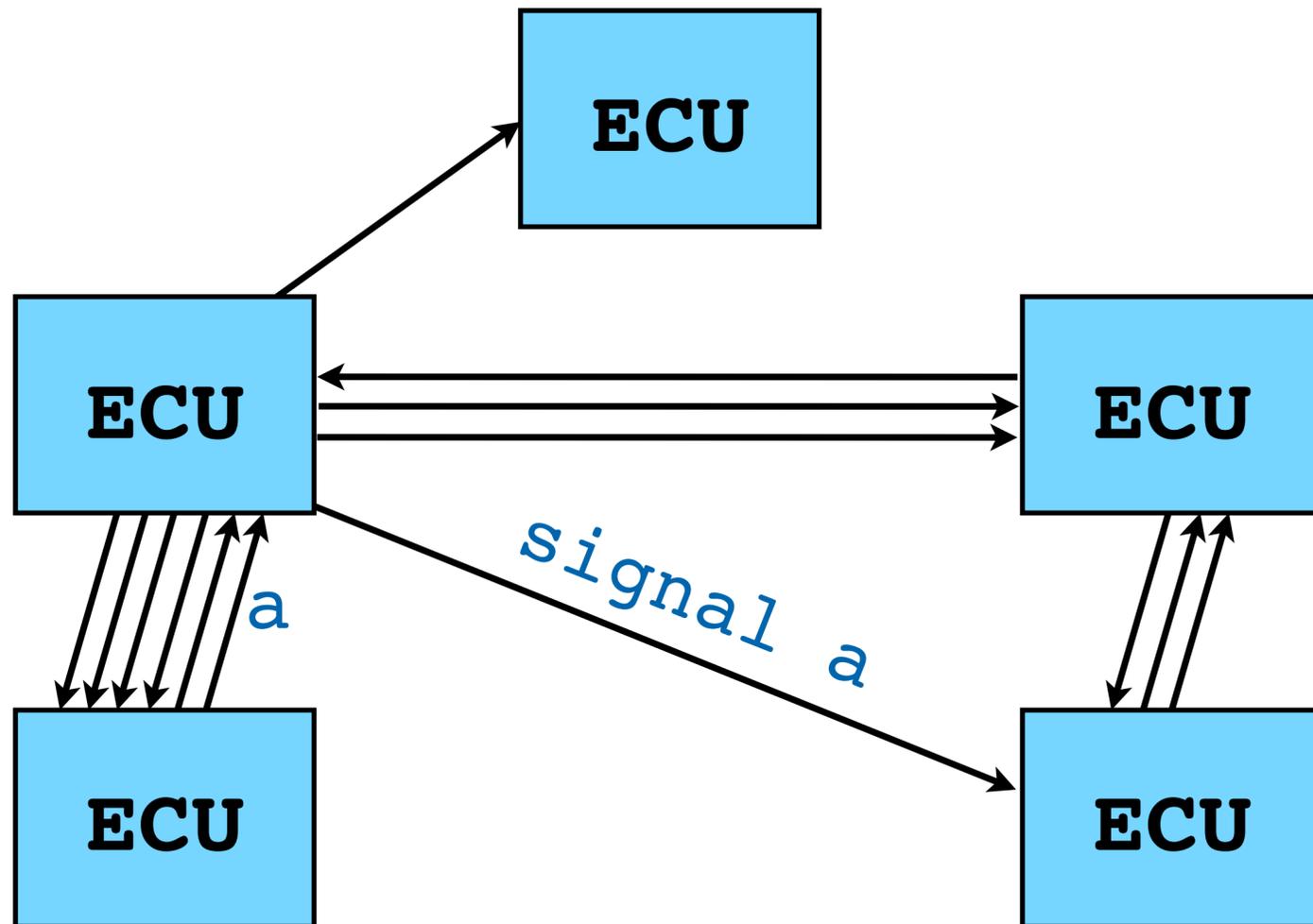
~100 ECU (nodes)

10-15 Bus systems (edges)

Logical Network (Software)



Logical Network (Software)

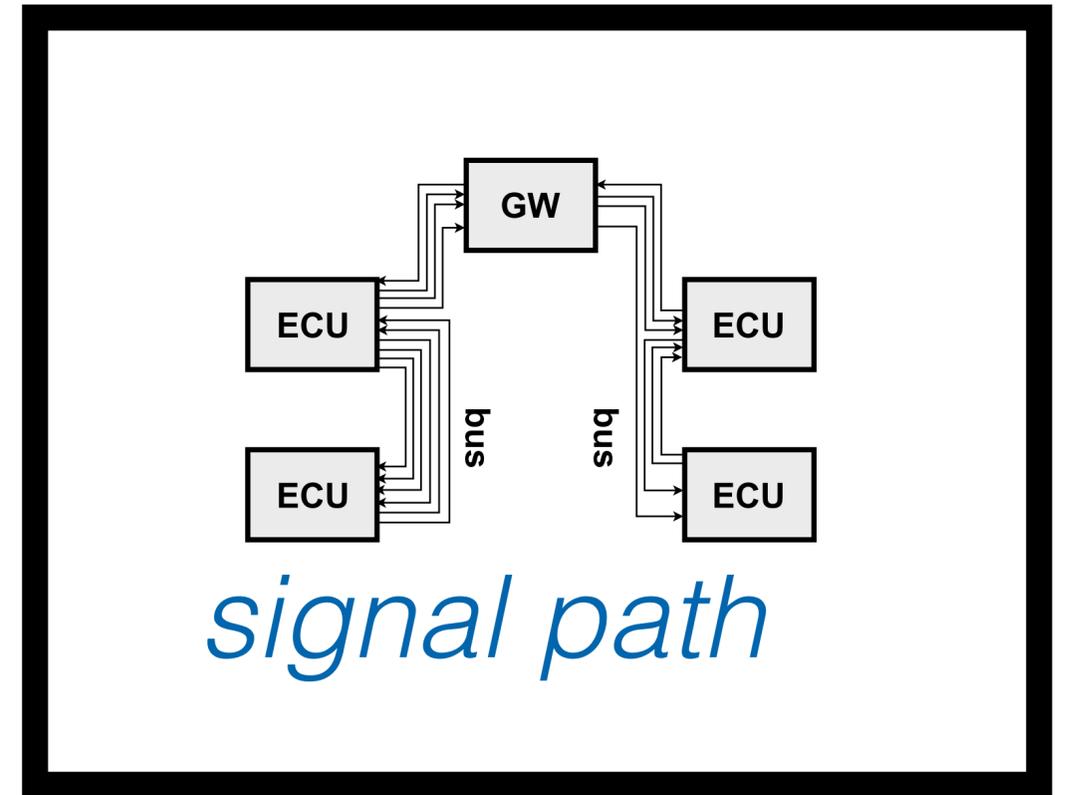
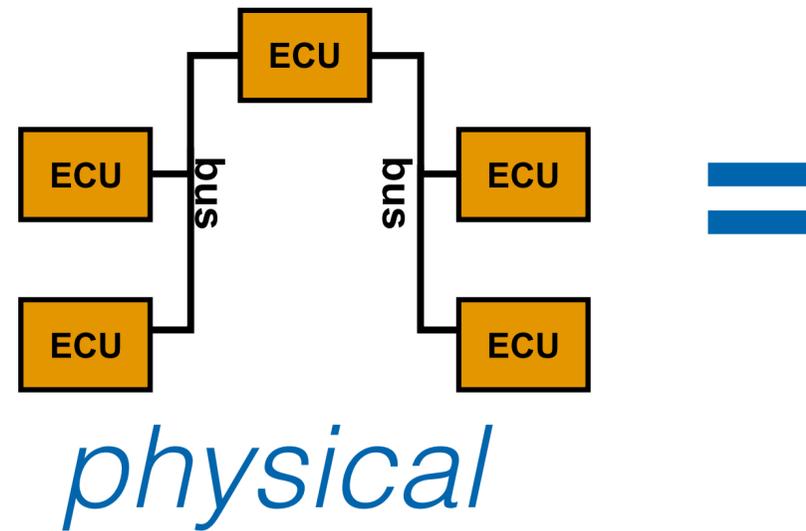
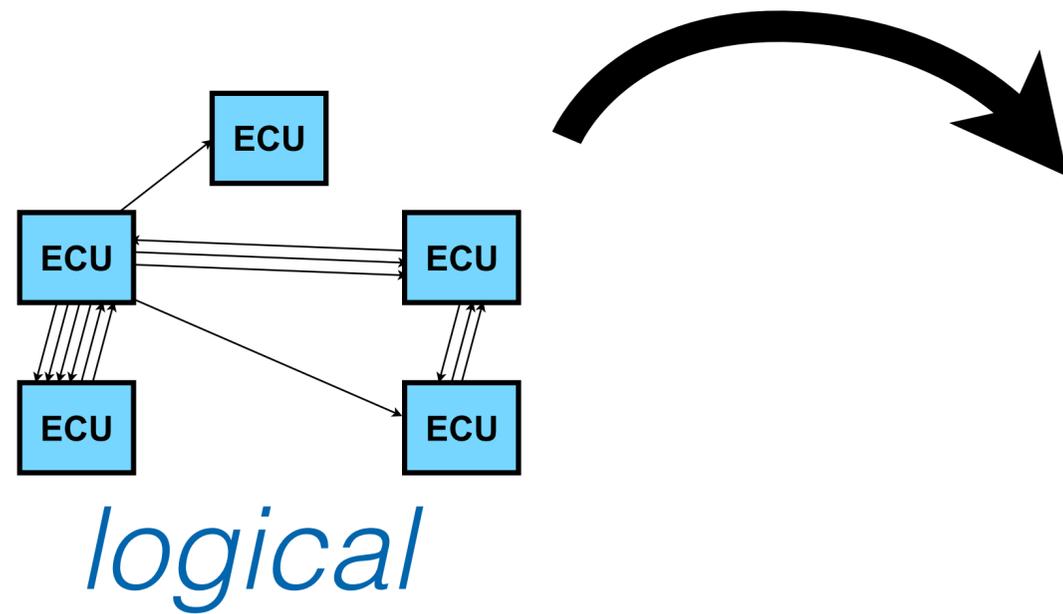


~100 ECU (nodes)

~10k signals (edges)



Tasks: Mapping



RelEx: Problem characterization



Problem characterization & abstraction

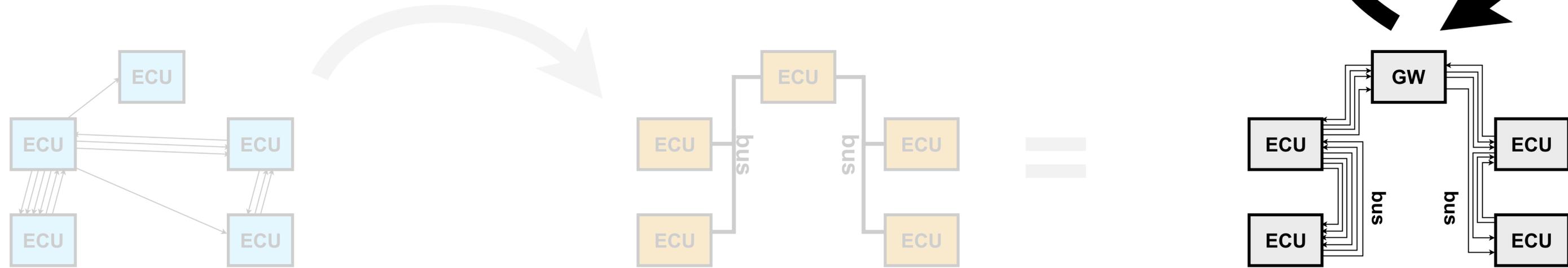
(3 month)

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



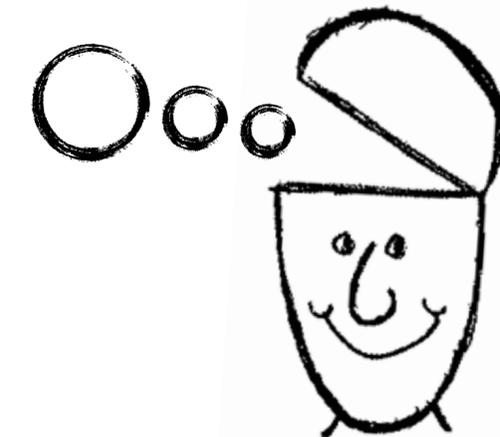


Tasks: Multi-objective optimization



Ill-defined constraints

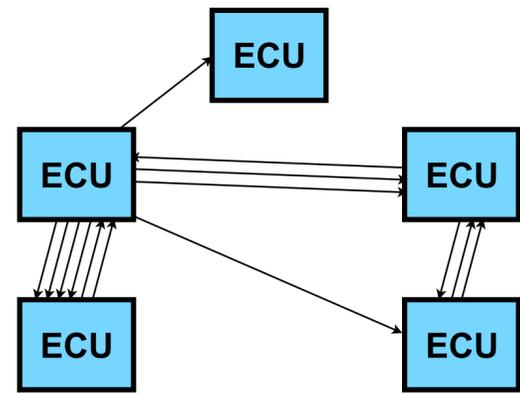
bandwidth ... delay/real time ...
path length ... load balance ...
reliability ... money ...



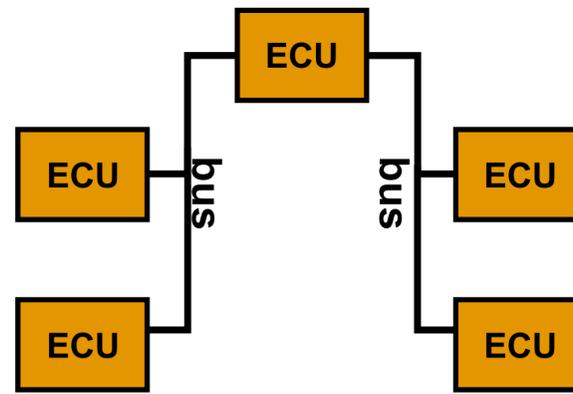
-- engineer, BMW --



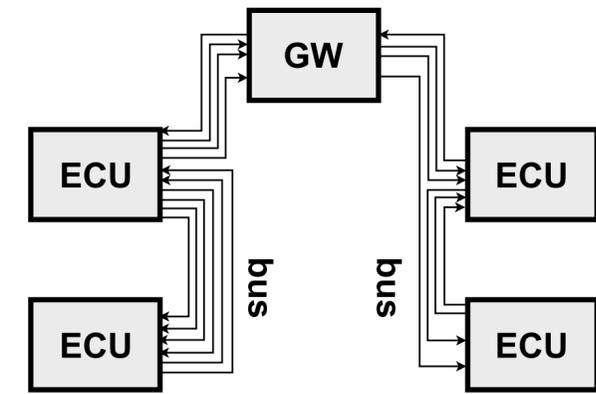
Tasks: External Change Requests



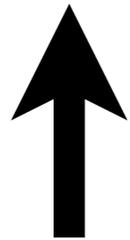
logical



physical



signal path

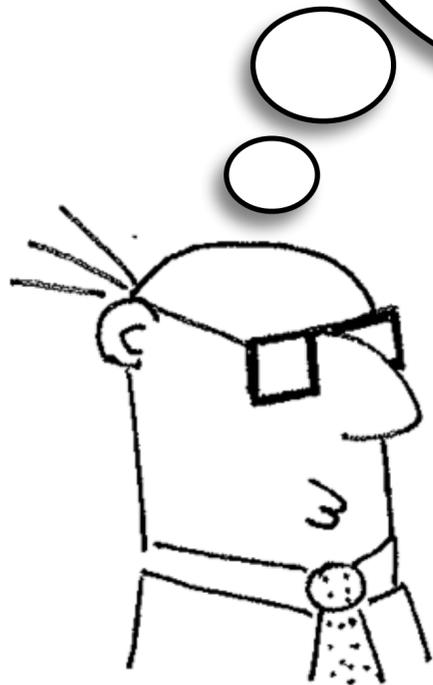


Change
(trivial requests might lead to complex changes)

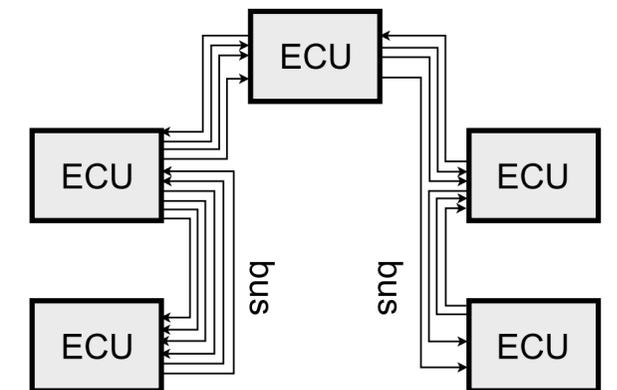
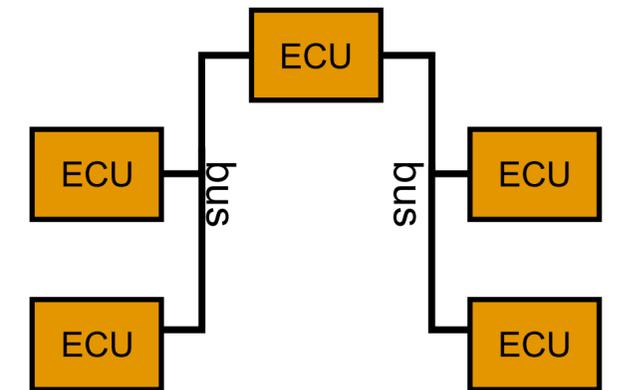
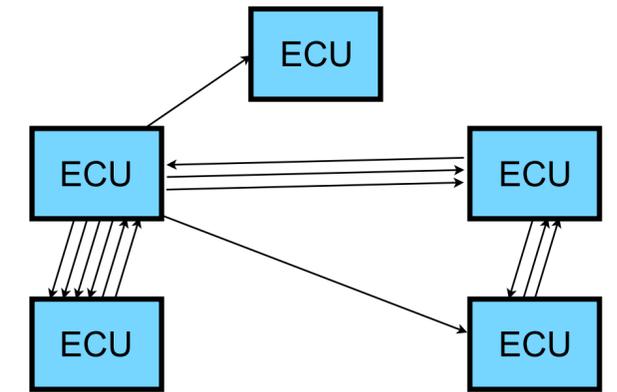
Low Level Tasks

Queries about relations

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



-- engineer, BMW --



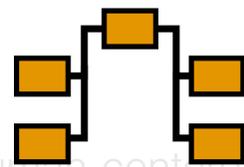
Low Level Tasks

Query complexity

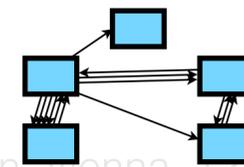
complex queries

simple queries

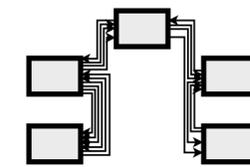
physical



logical

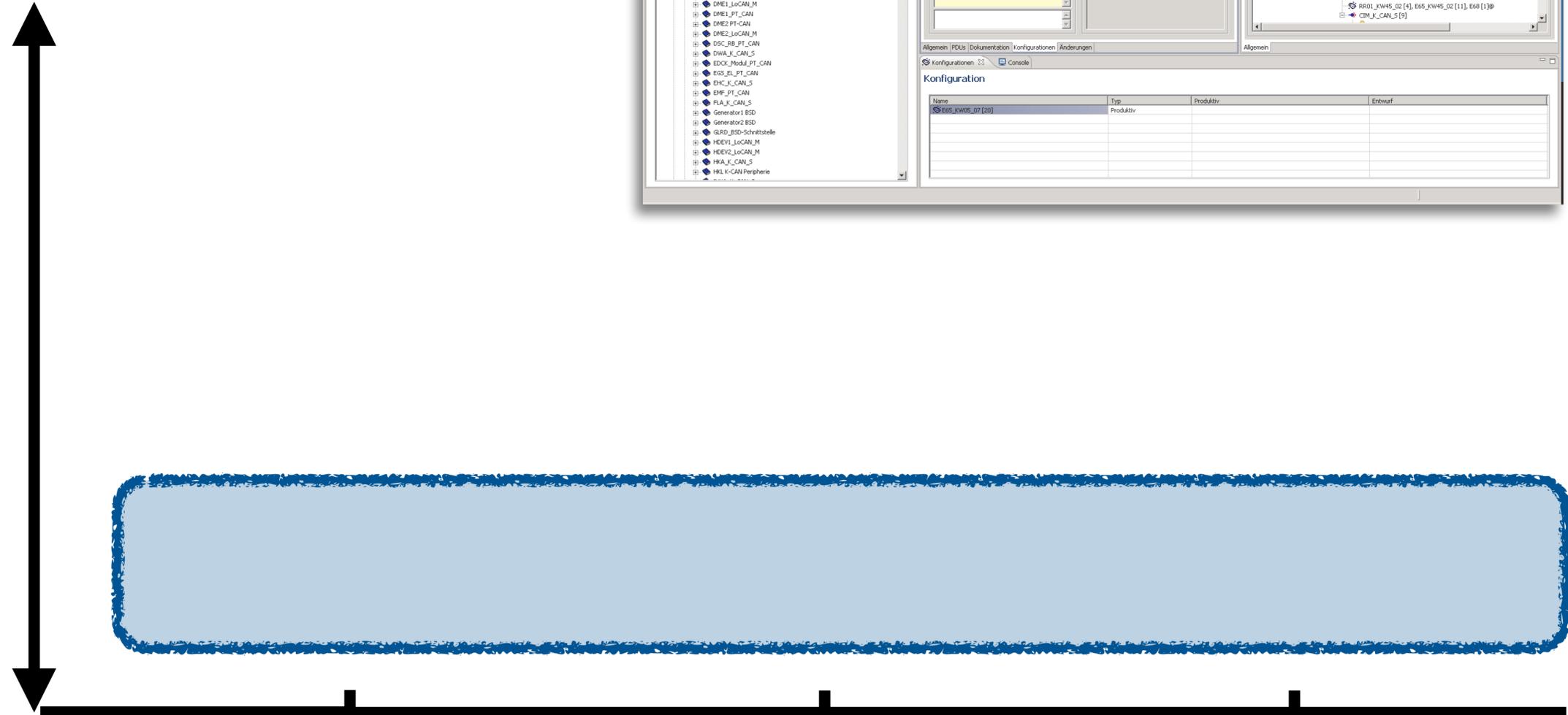
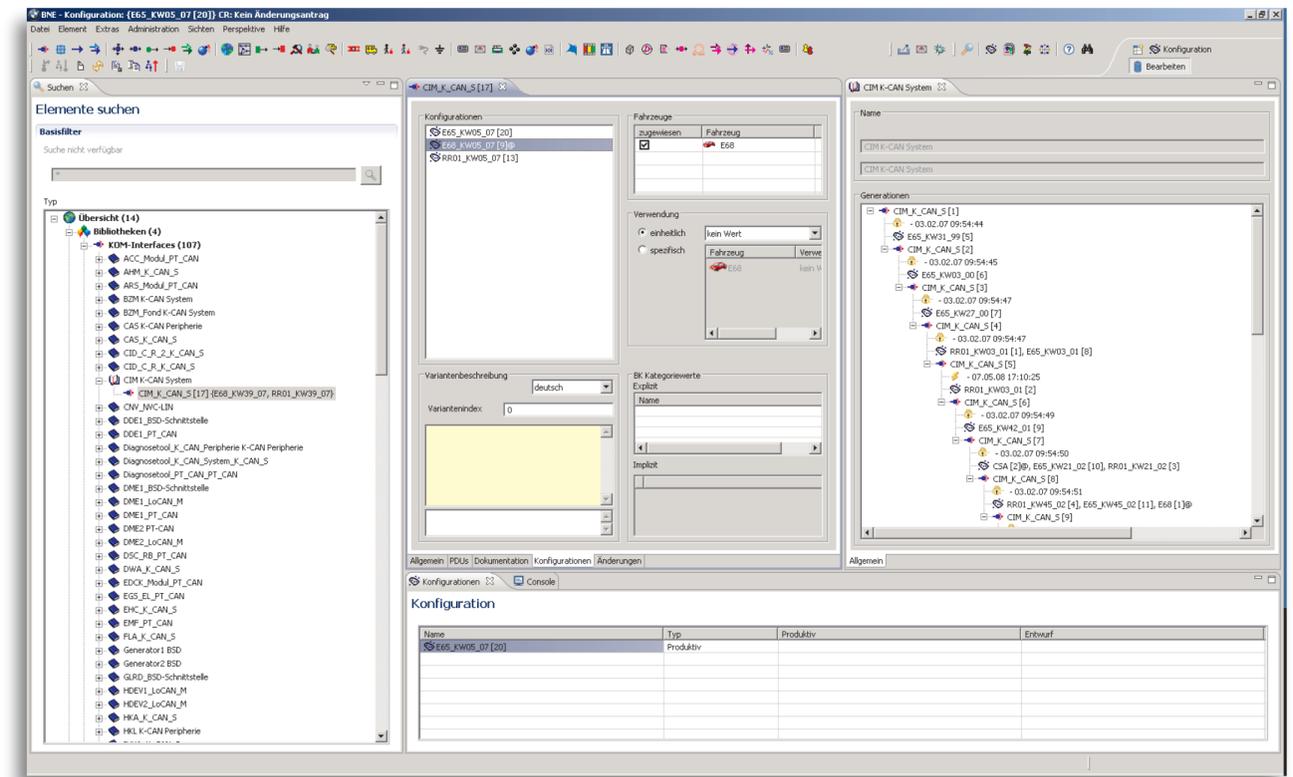


signal path



Low Level Tasks

Query complexity

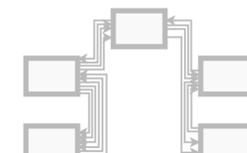
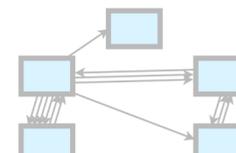
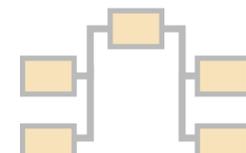


simple queries
2-way relations

physical

logical

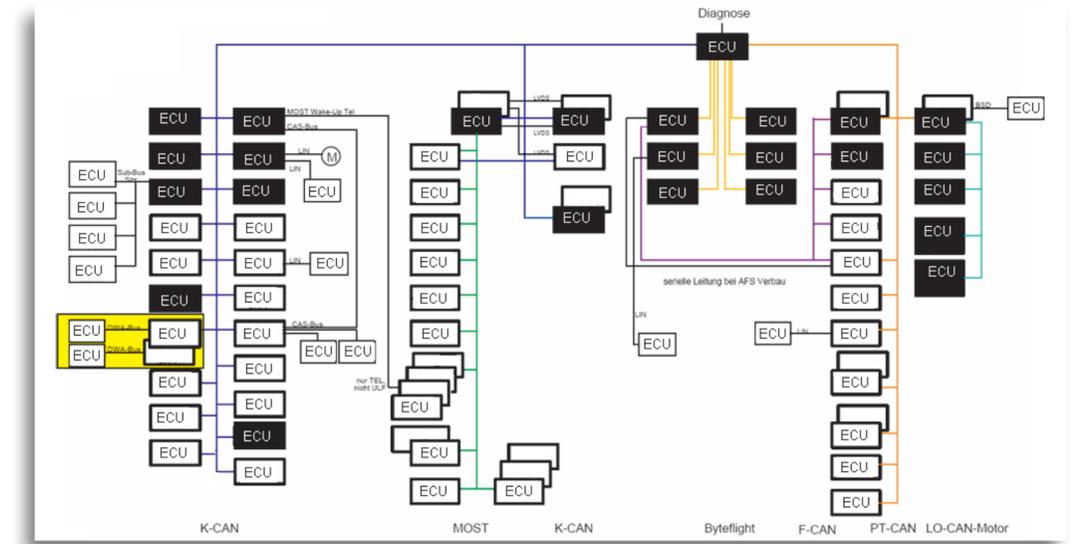
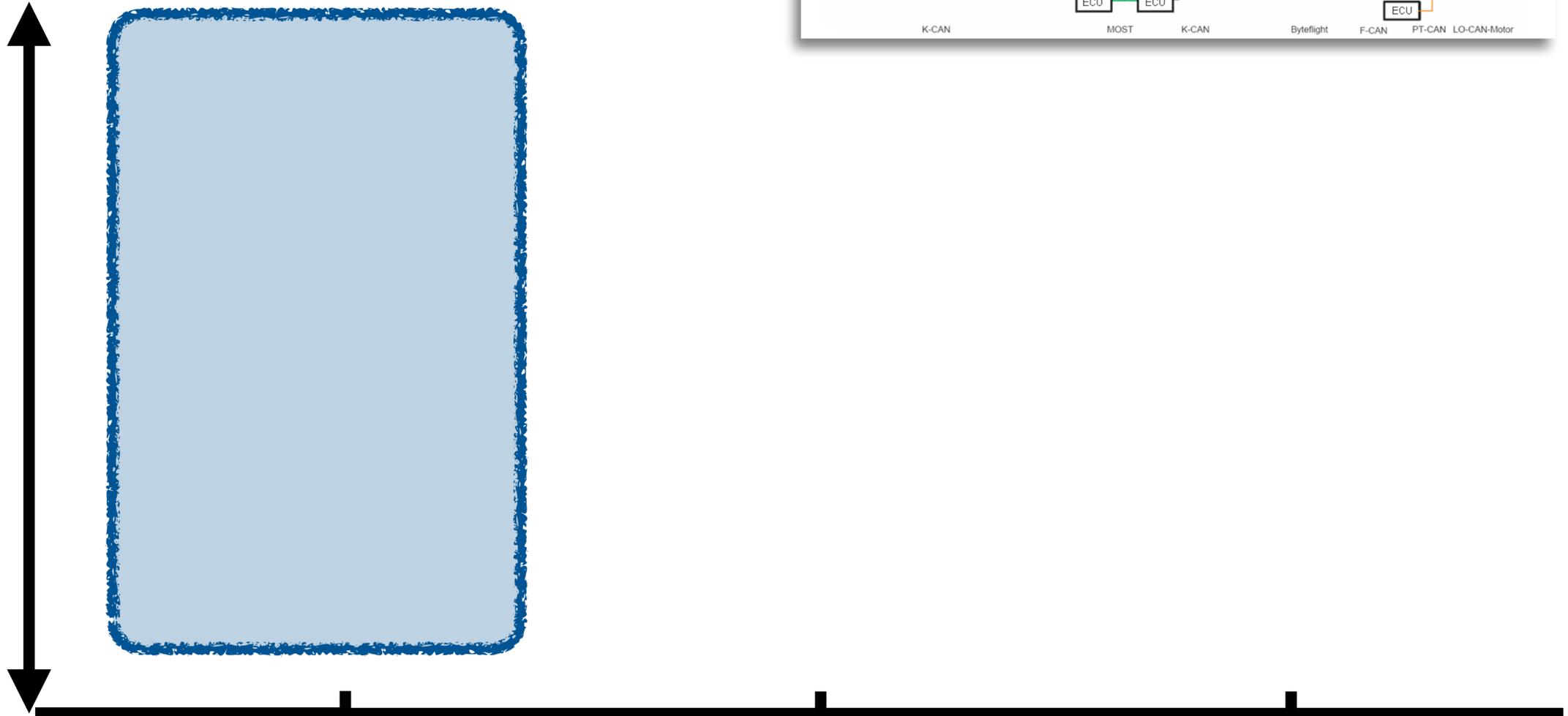
signal path



Low Level Tasks

Query complexity

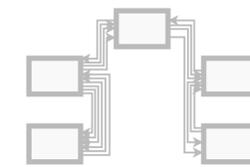
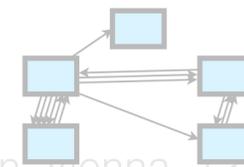
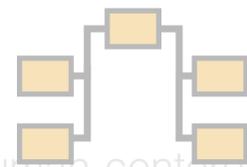
complex queries
Overview



physical

logical

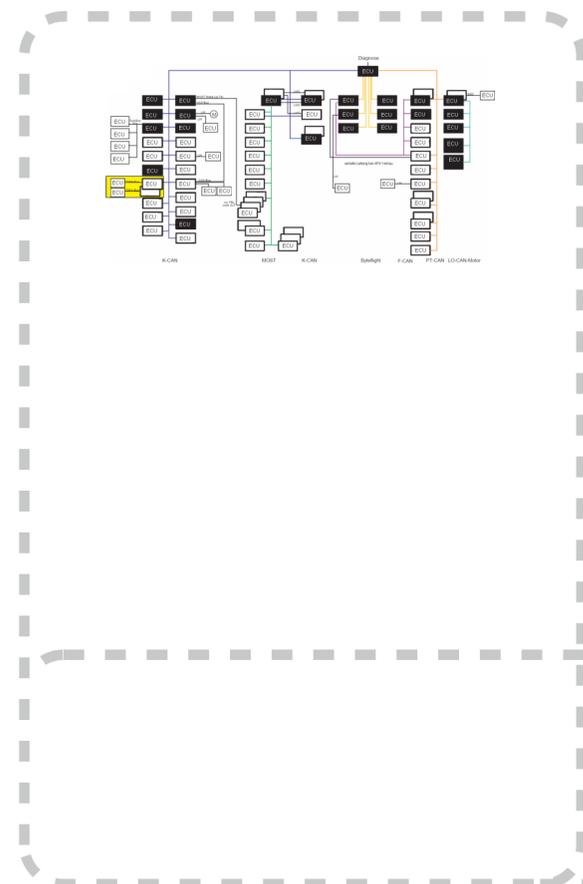
signal path



Low Level Tasks

Query complexity

complex queries



Unsupported need:
Logical Overview

Unsupported need: **All path of a Signal**

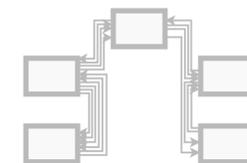
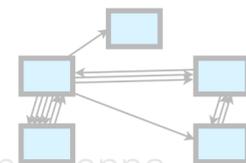
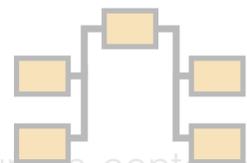
simple queries



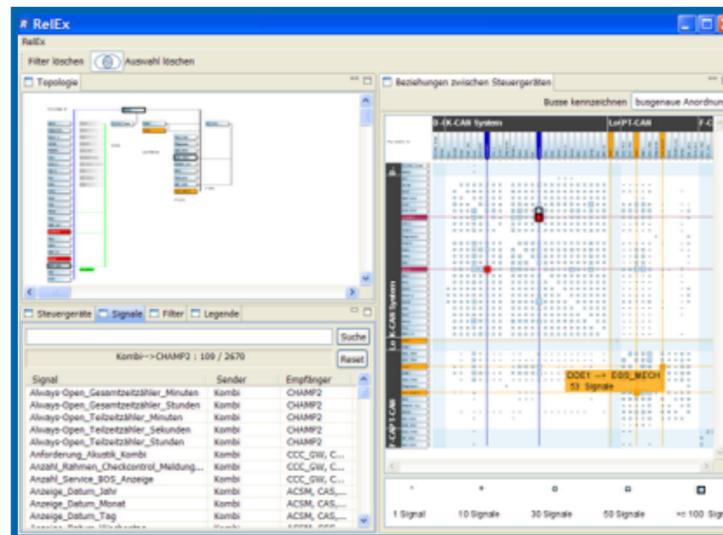
physical

logical

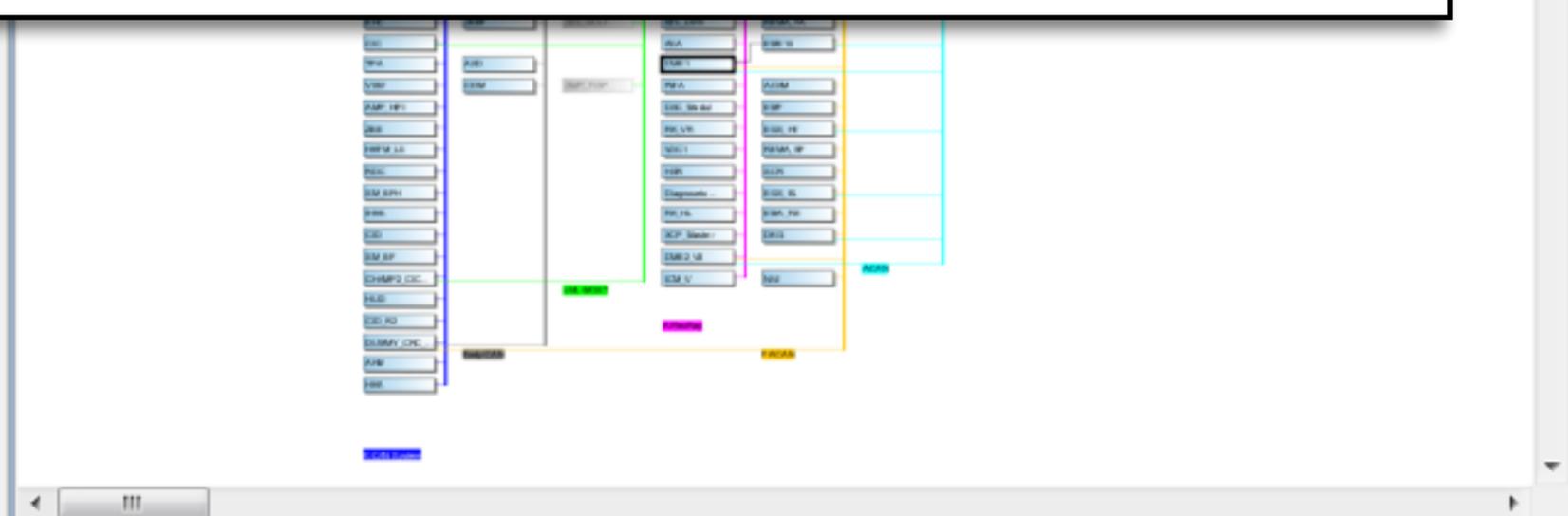
signal path



RelEx: Design



RELEX: Relation Explorer



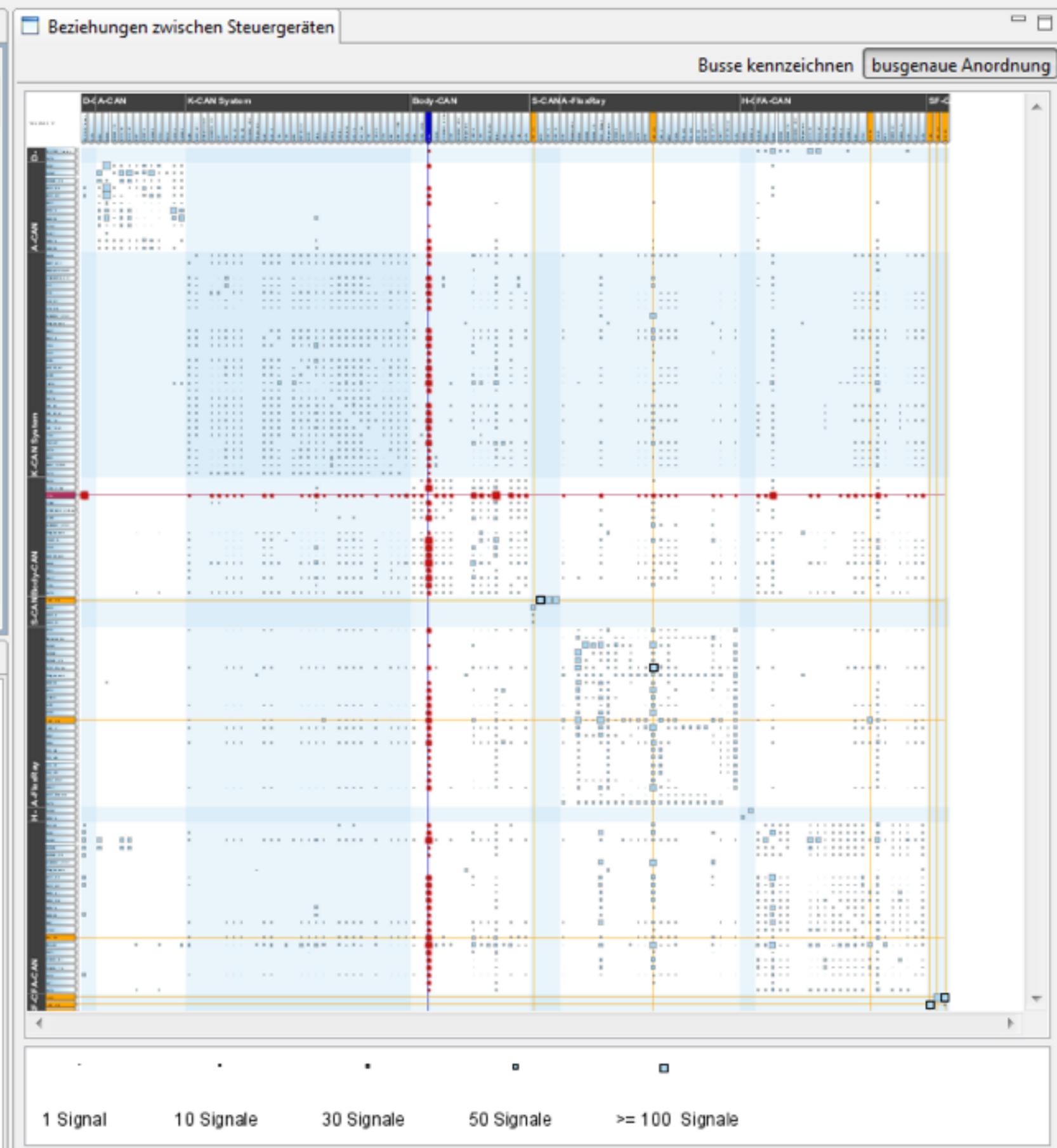
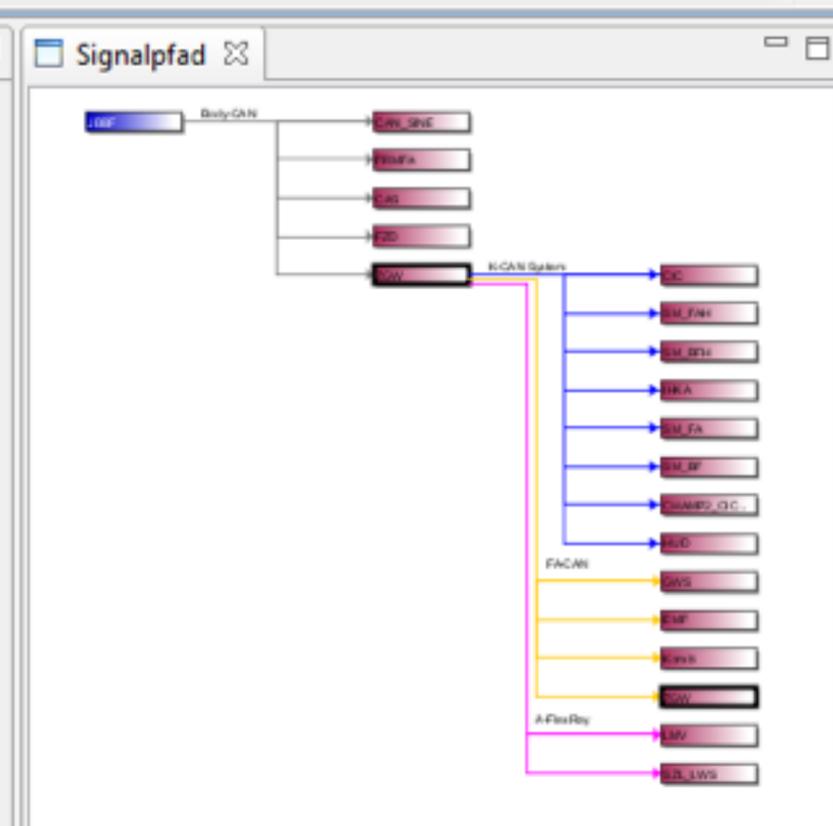
Steuergeräte Signale Filter Legende

Suche

CAS: 446 / 8223

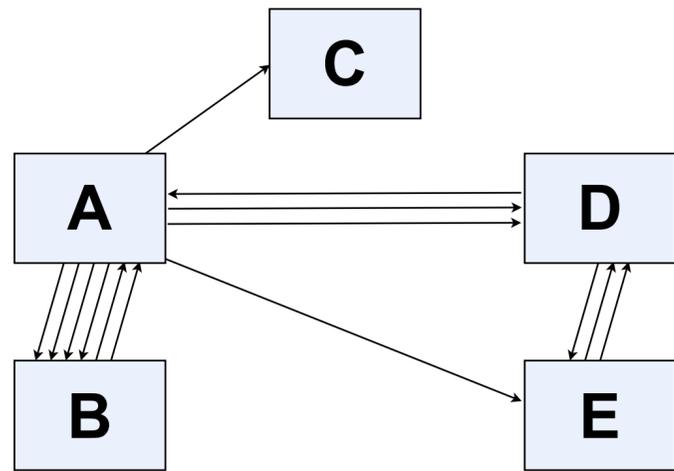
Reset

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

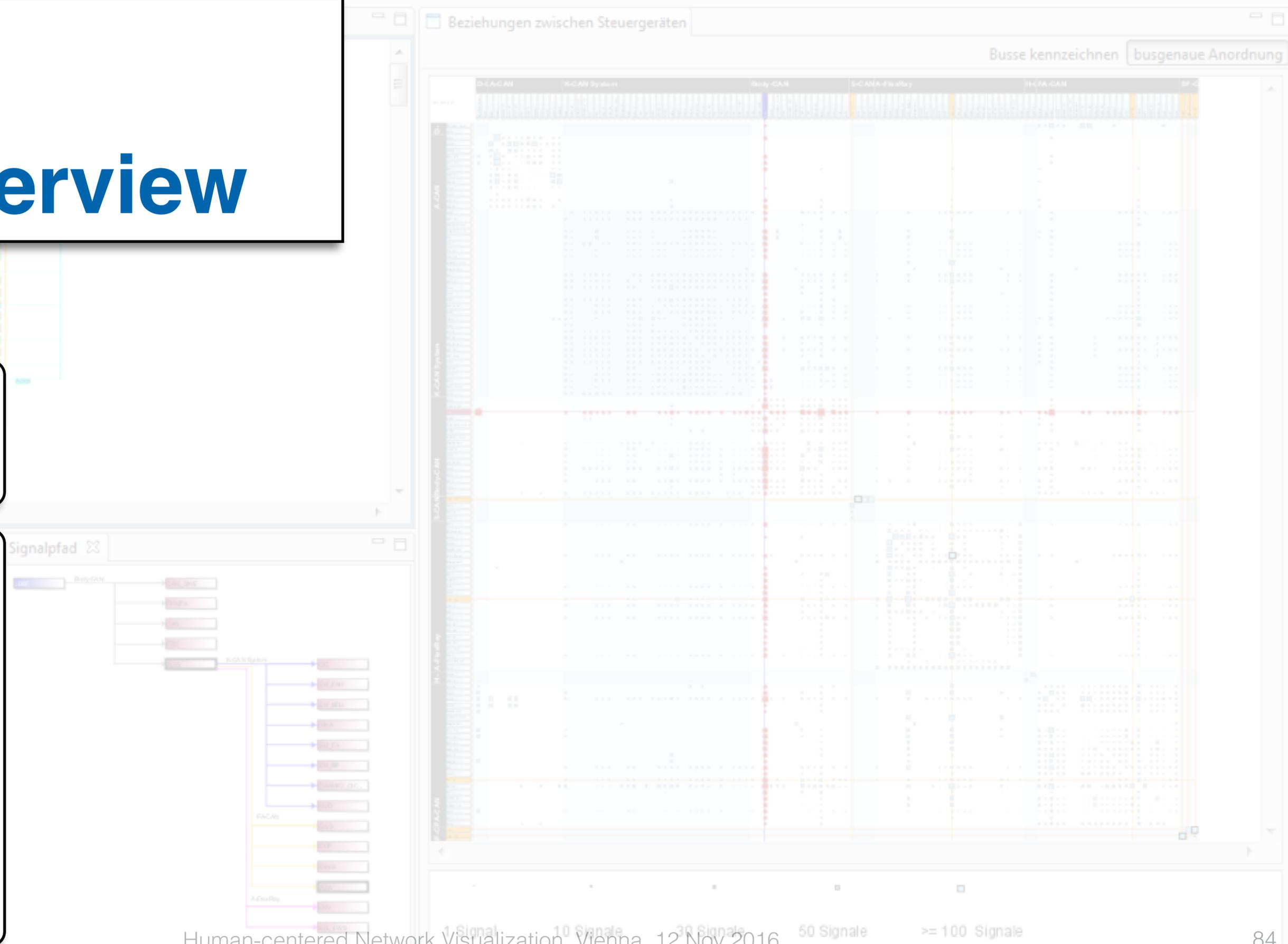


RELEX: Logical Overview

LOGICAL NETWORK

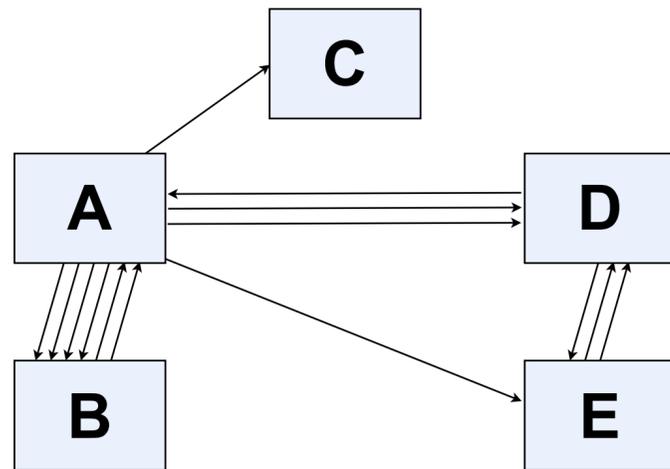


- multigraph
- 100 nodes/10k edges

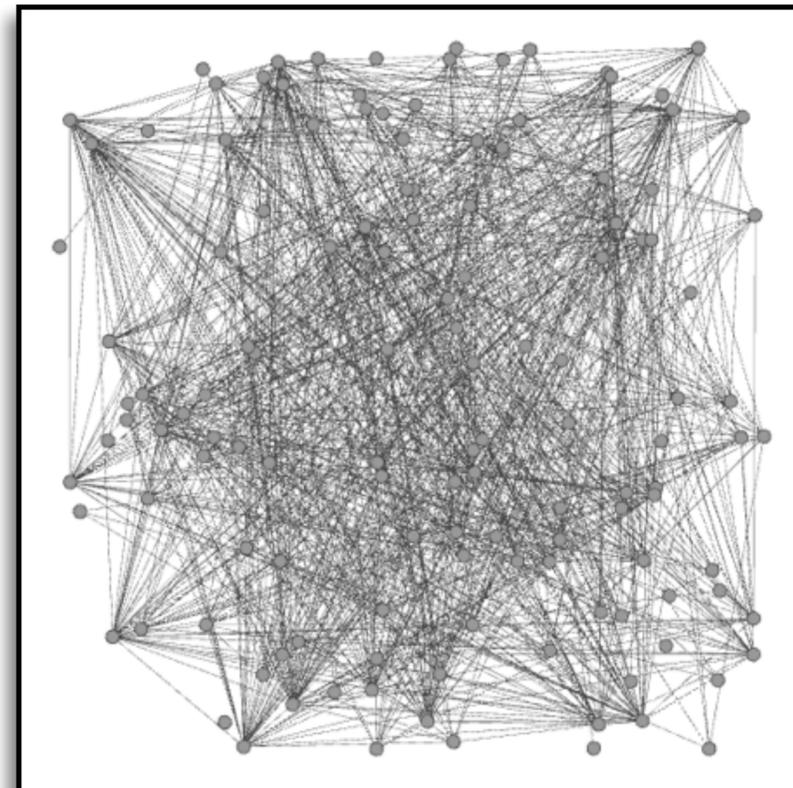


RELEX: Logical Overview

LOGICAL NETWORK



- multigraph
- 100 nodes/10k edges

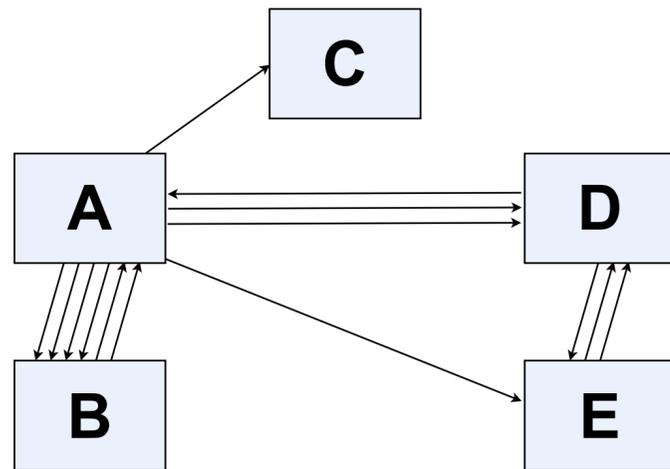


???

RELEX: Logical Overview

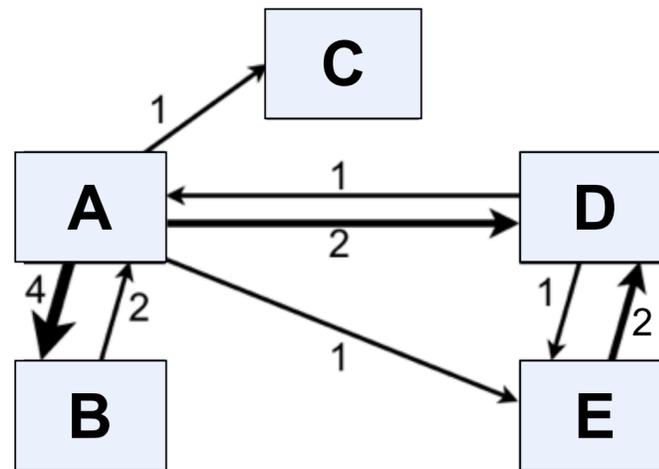
Guideline [Ghoniem 2004]
Matrix for dense graphs

LOGICAL NETWORK



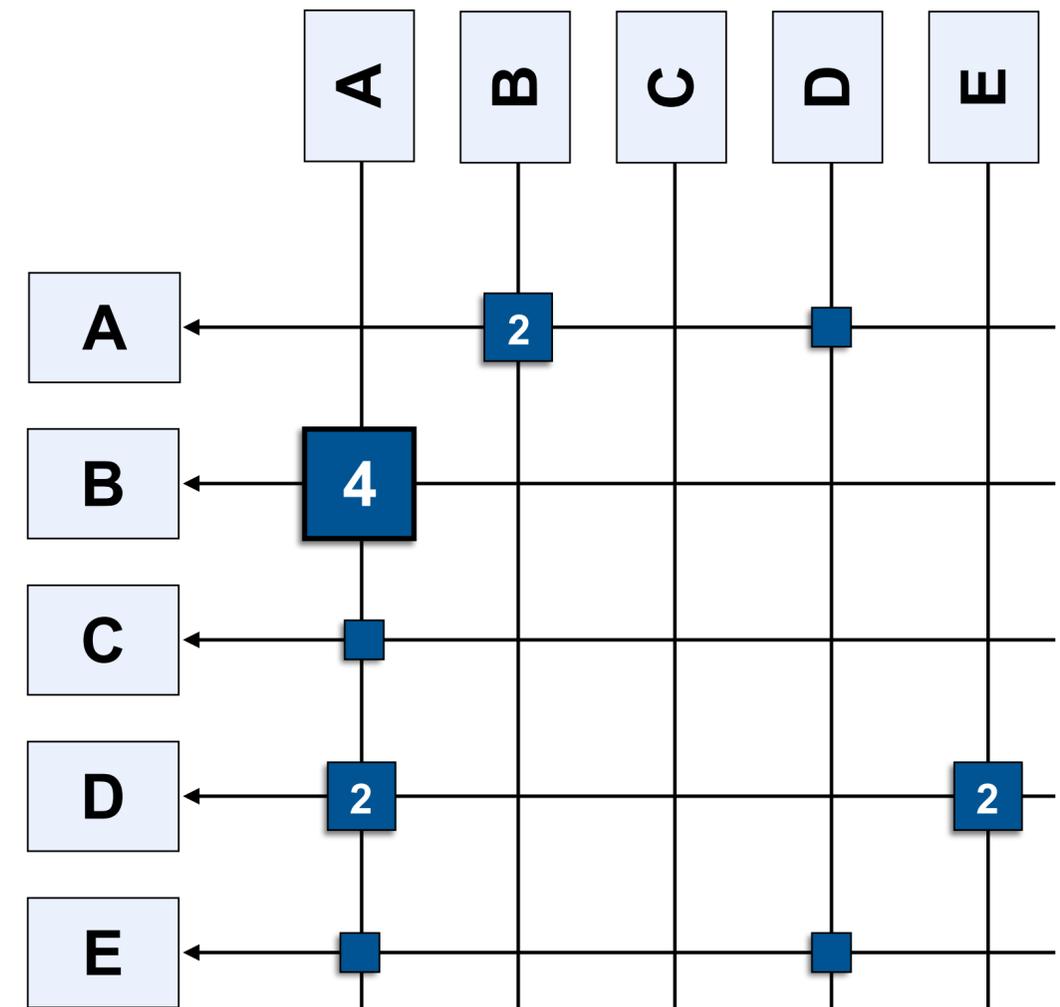
- multigraph
- 100 nodes / 10k edges

SIGNAL COUNT NETWORK



- directed graph
- 1k weighted edges

VISUAL ENCODING: SIZE-CODED MATRIX

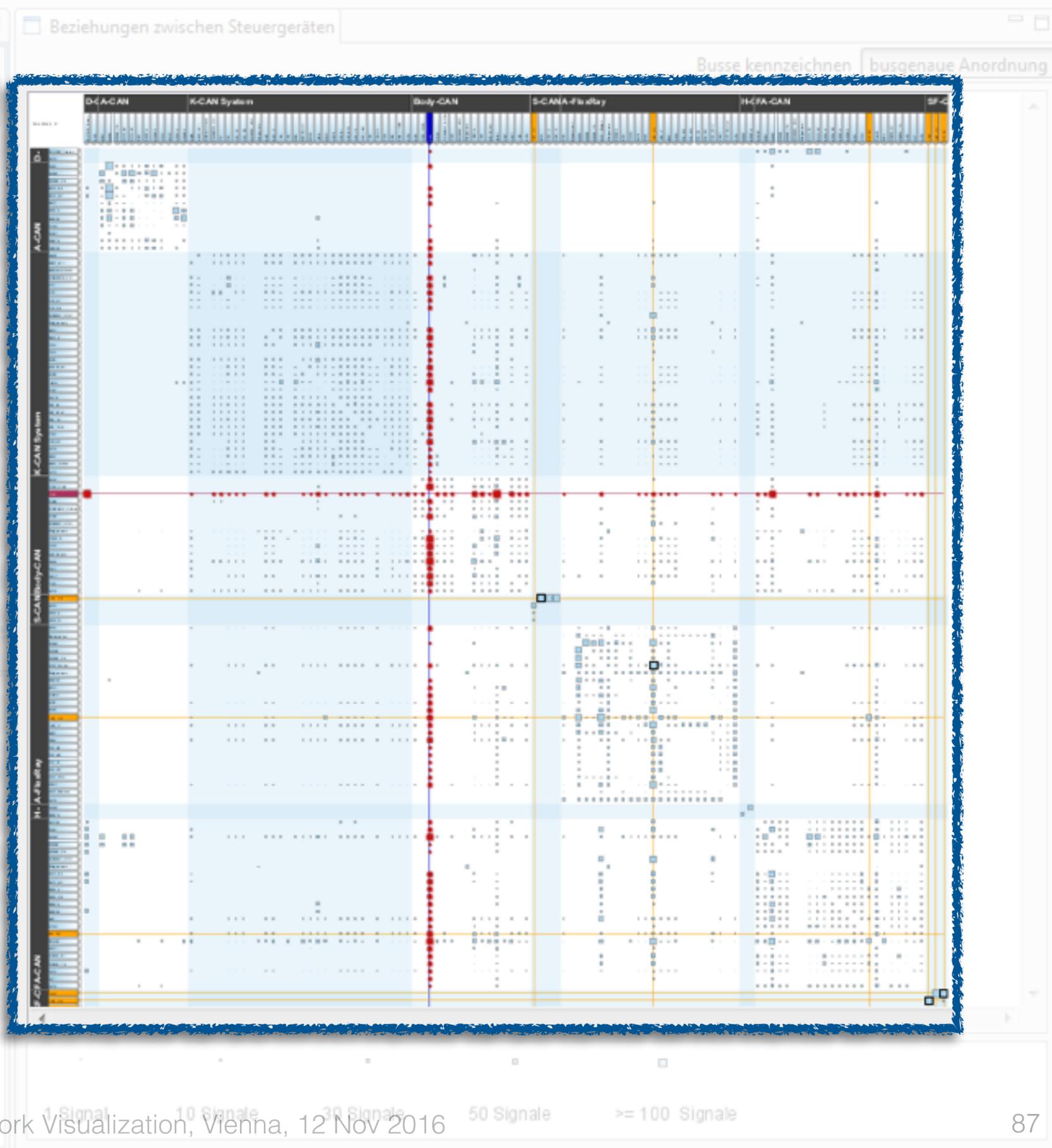


RELEX: Logical Overview

The screenshot shows the RELEX software interface. At the top, there are buttons for "Filter löschen" and "Auswahl löschen". Below is a network diagram with various nodes and connections. At the bottom left, there is a search bar with "CAS : 446 / 8223" and a "Suche" button. Below the search bar is a table with the following data:

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

At the bottom right, there is a "Signalpfad" diagram showing a path from "BodyCAN" to "K-CAN System" and then to various components like "EWS", "DME1", "DME2", "DME3", "DME4", "DME5", "DME6", "DME7", "DME8", "DME9", "DME10", "DME11", "DME12", "DME13", "DME14", "DME15", "DME16", "DME17", "DME18", "DME19", "DME20", "DME21", "DME22", "DME23", "DME24", "DME25", "DME26", "DME27", "DME28", "DME29", "DME30", "DME31", "DME32", "DME33", "DME34", "DME35", "DME36", "DME37", "DME38", "DME39", "DME40", "DME41", "DME42", "DME43", "DME44", "DME45", "DME46", "DME47", "DME48", "DME49", "DME50", "DME51", "DME52", "DME53", "DME54", "DME55", "DME56", "DME57", "DME58", "DME59", "DME60", "DME61", "DME62", "DME63", "DME64", "DME65", "DME66", "DME67", "DME68", "DME69", "DME70", "DME71", "DME72", "DME73", "DME74", "DME75", "DME76", "DME77", "DME78", "DME79", "DME80", "DME81", "DME82", "DME83", "DME84", "DME85", "DME86", "DME87", "DME88", "DME89", "DME90", "DME91", "DME92", "DME93", "DME94", "DME95", "DME96", "DME97", "DME98", "DME99", "DME100".



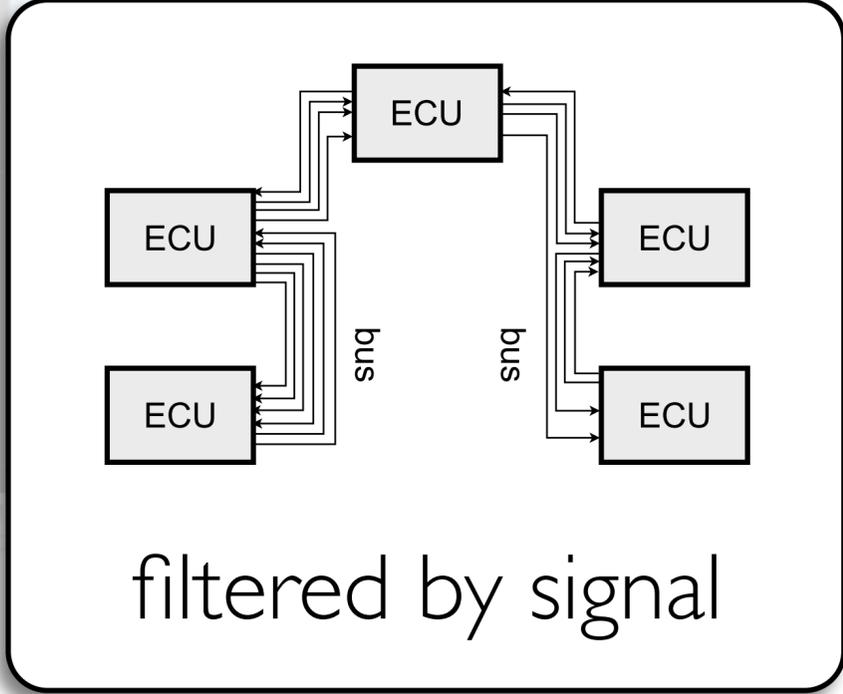
RELEX: All Paths of a Signal

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

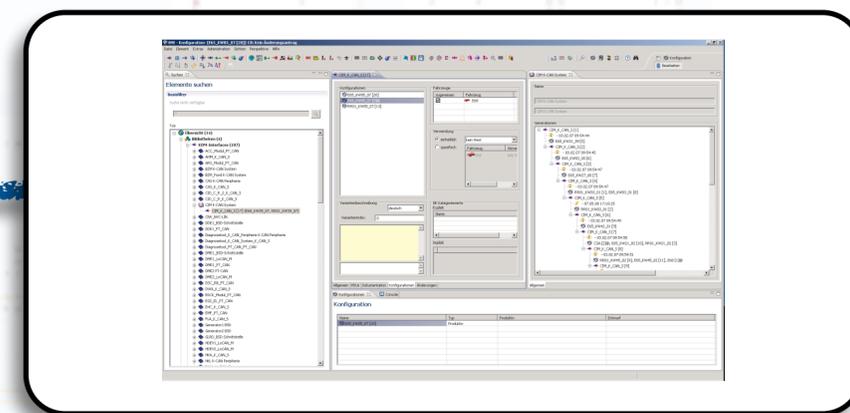
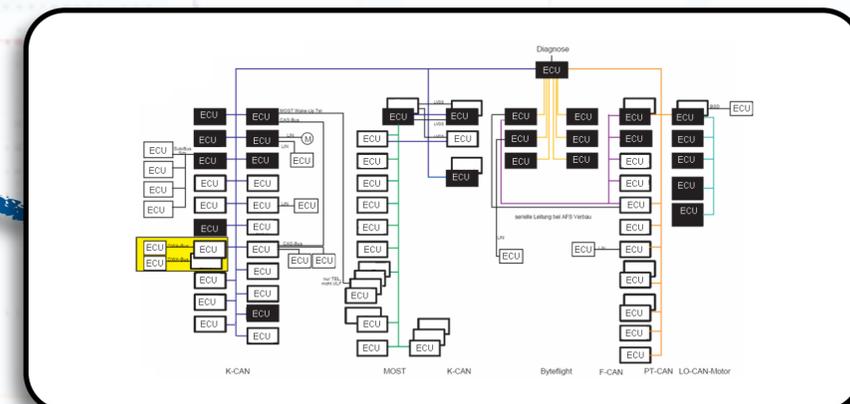
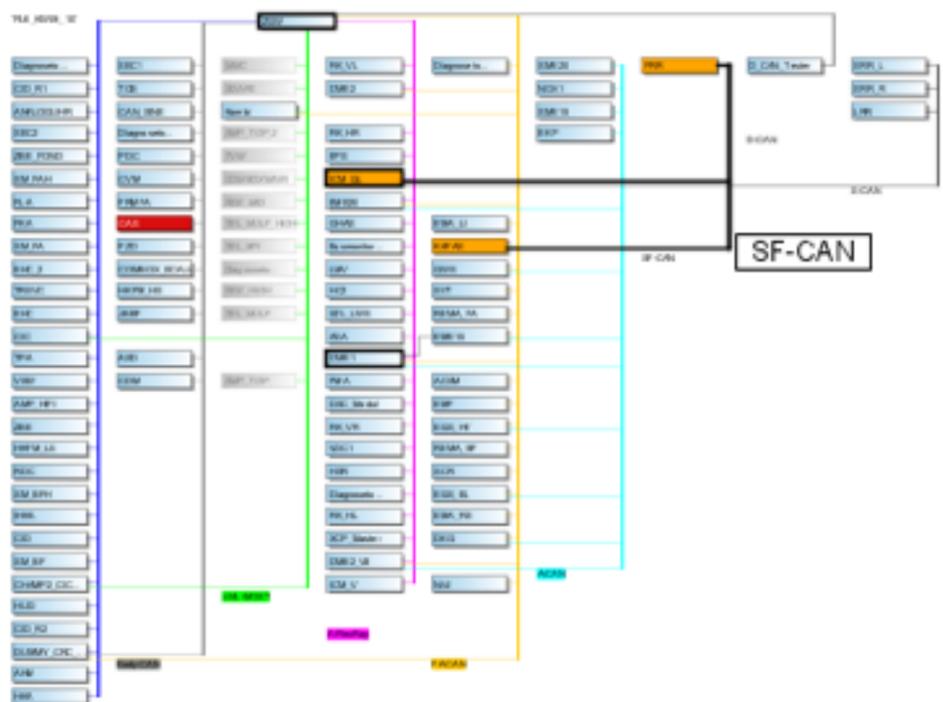
The screenshot shows the RELEX software interface. At the top, there are buttons for 'Filter löschen' and 'Auswahl löschen'. Below, a complex network diagram is visible. In the foreground, a window titled 'Signalpfad' displays a detailed signal path network. A table below the diagram lists signals and their senders.

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

**SIGNAL PATH
NETWORK**



MORE STUFF: Support of Current Practices

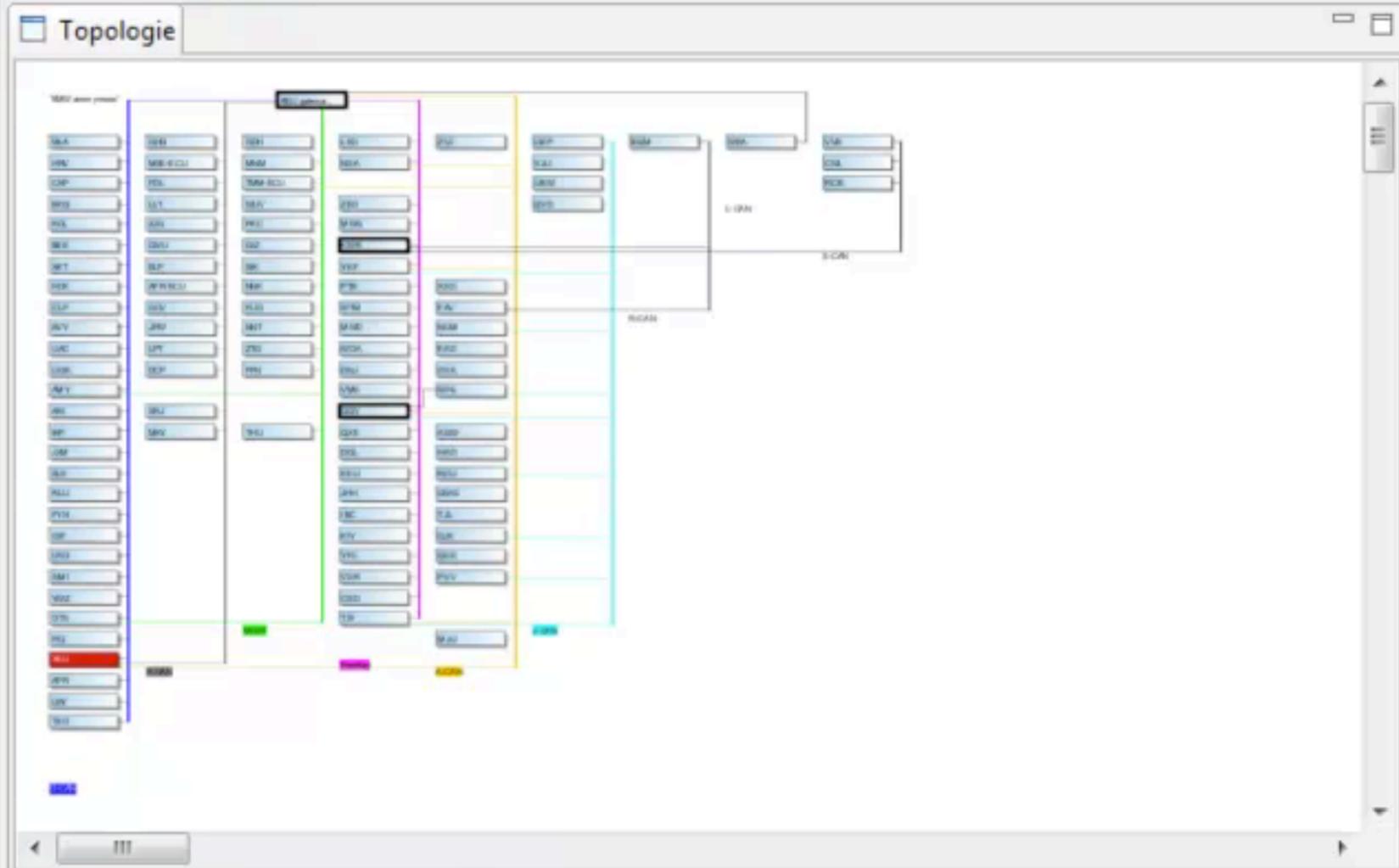


Steuergeräte | Signale | Filter | Legende

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



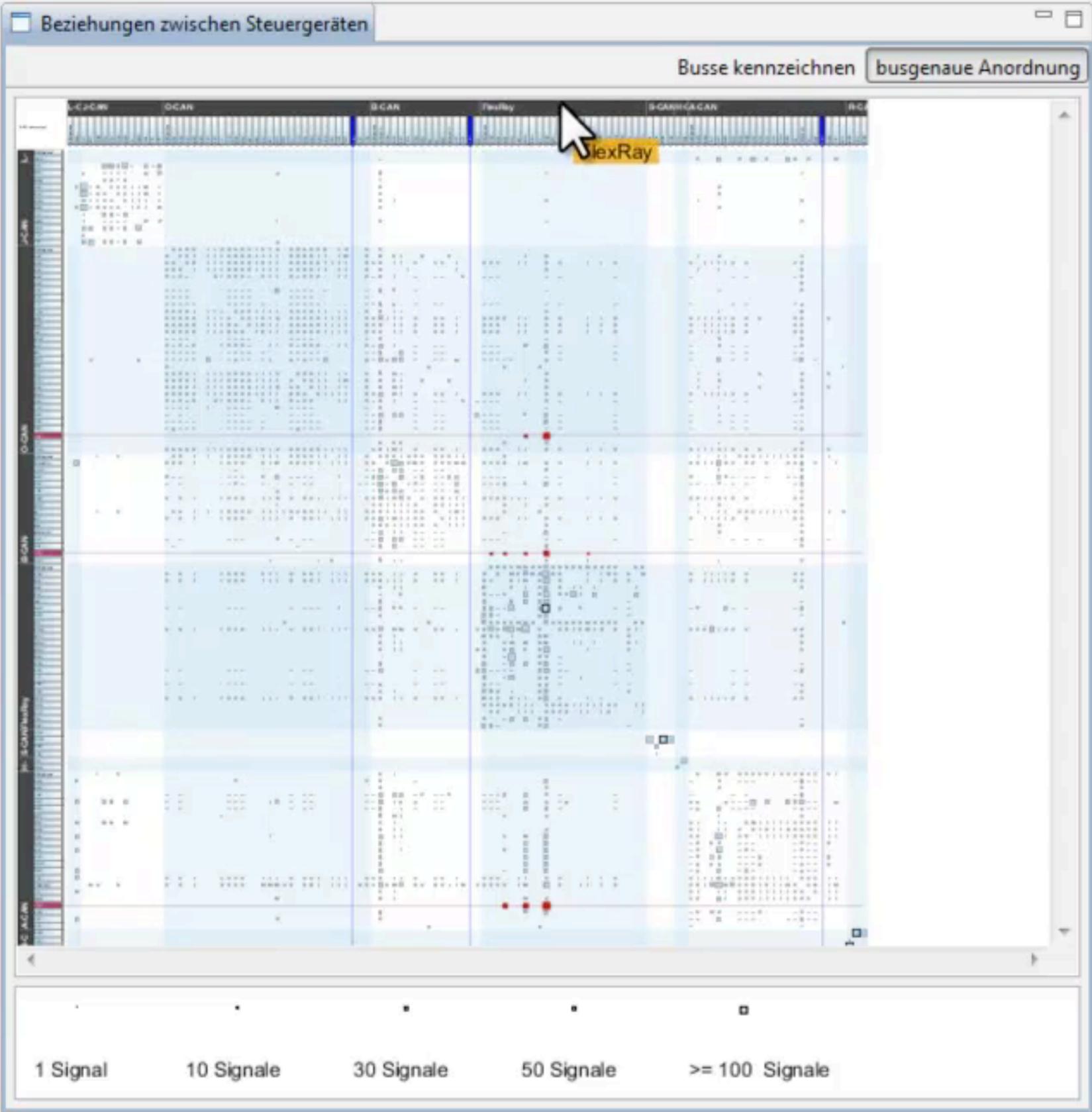
Steuergeräte Signale Filter Legende

Suche

Reset

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...



ReEx: Evaluation



Evaluation

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

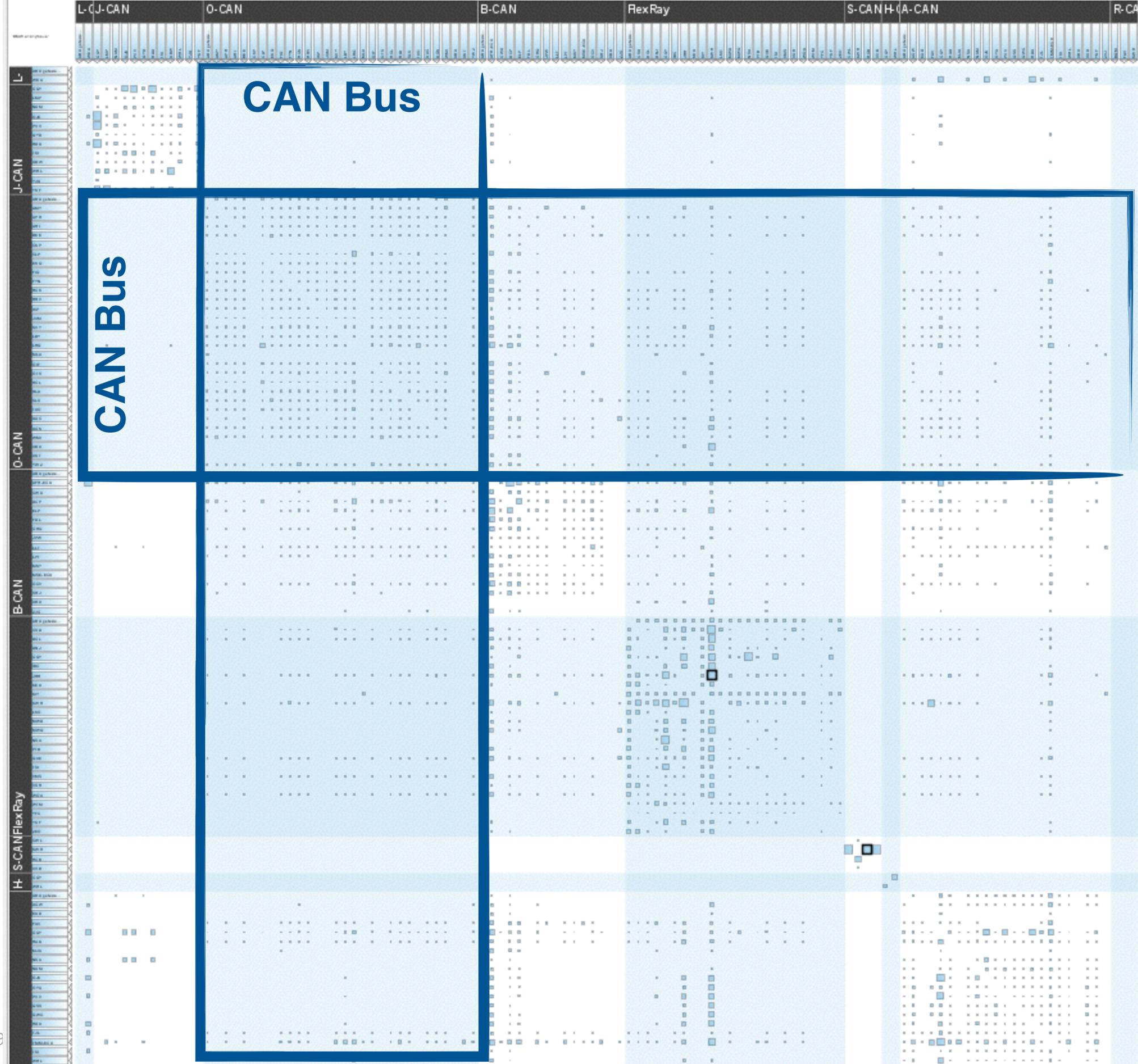
- iterative paper prototyping
- agile design: 6 deployed releases
 - 3 lead users (domain experts)
- usability studies with
 - 4 users: domain experts & HCI students

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

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



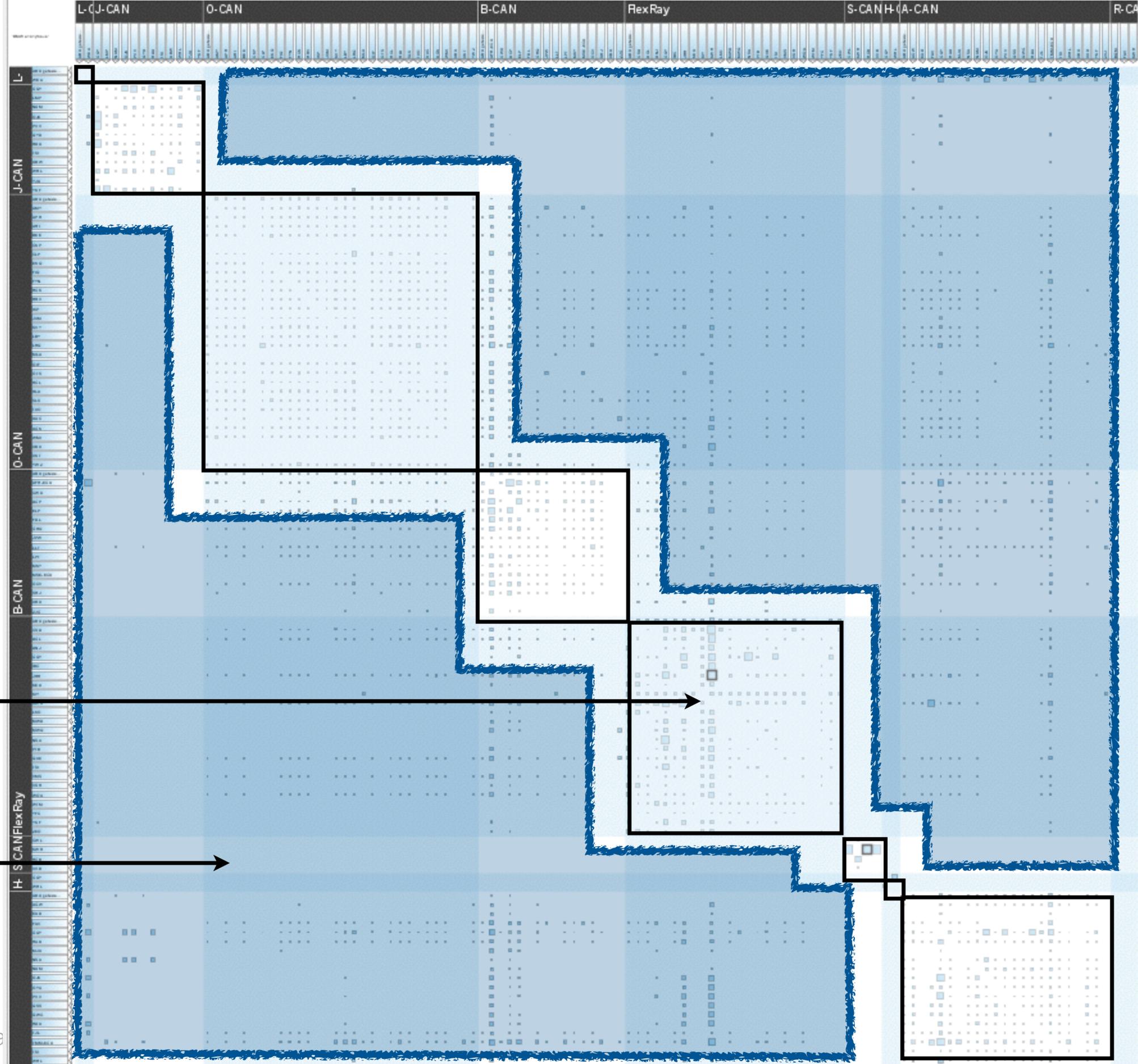
Novel insights: Bus communication patterns



Novel insights: Bus communication patterns

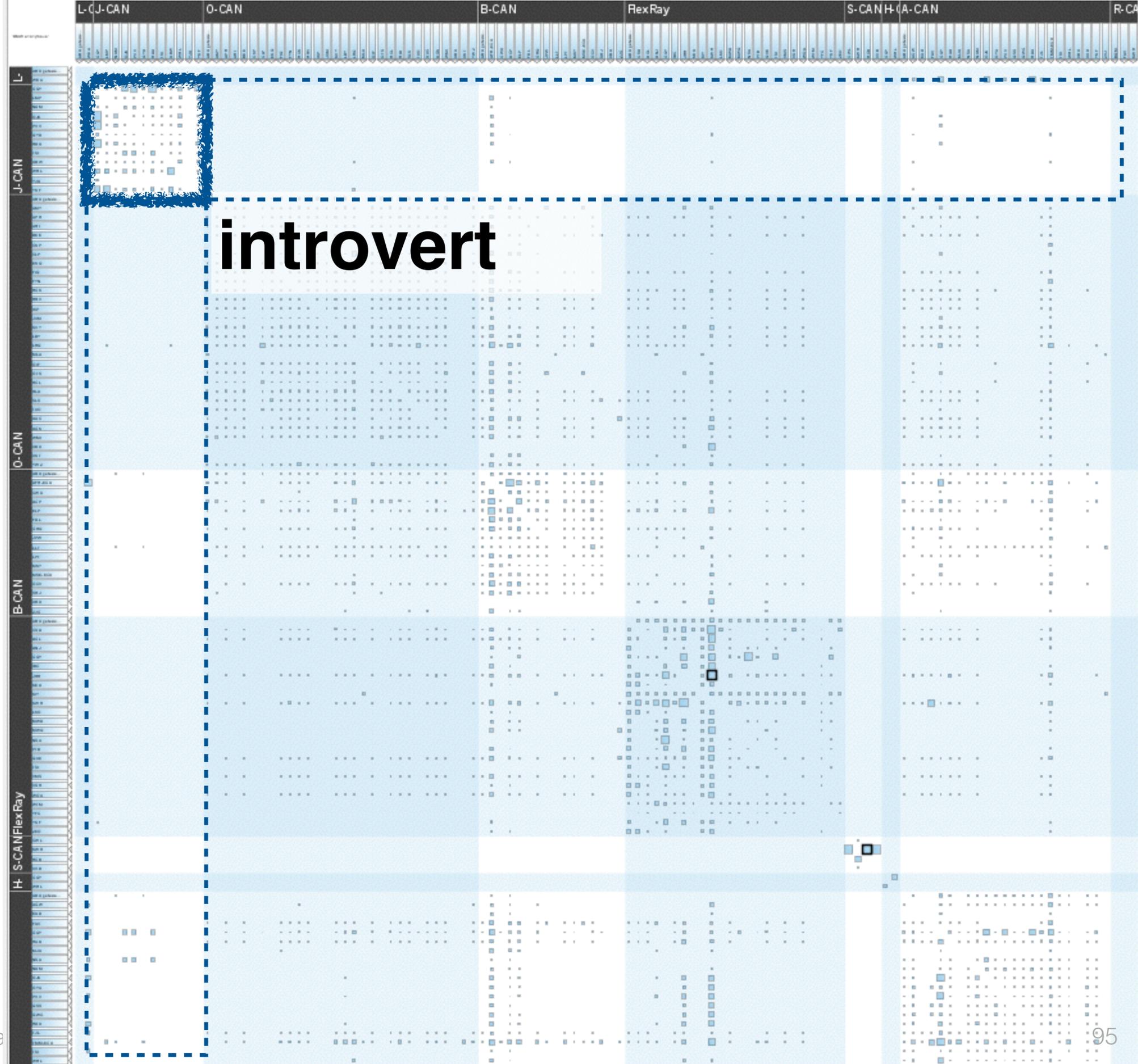
Within-bus

Between-bus



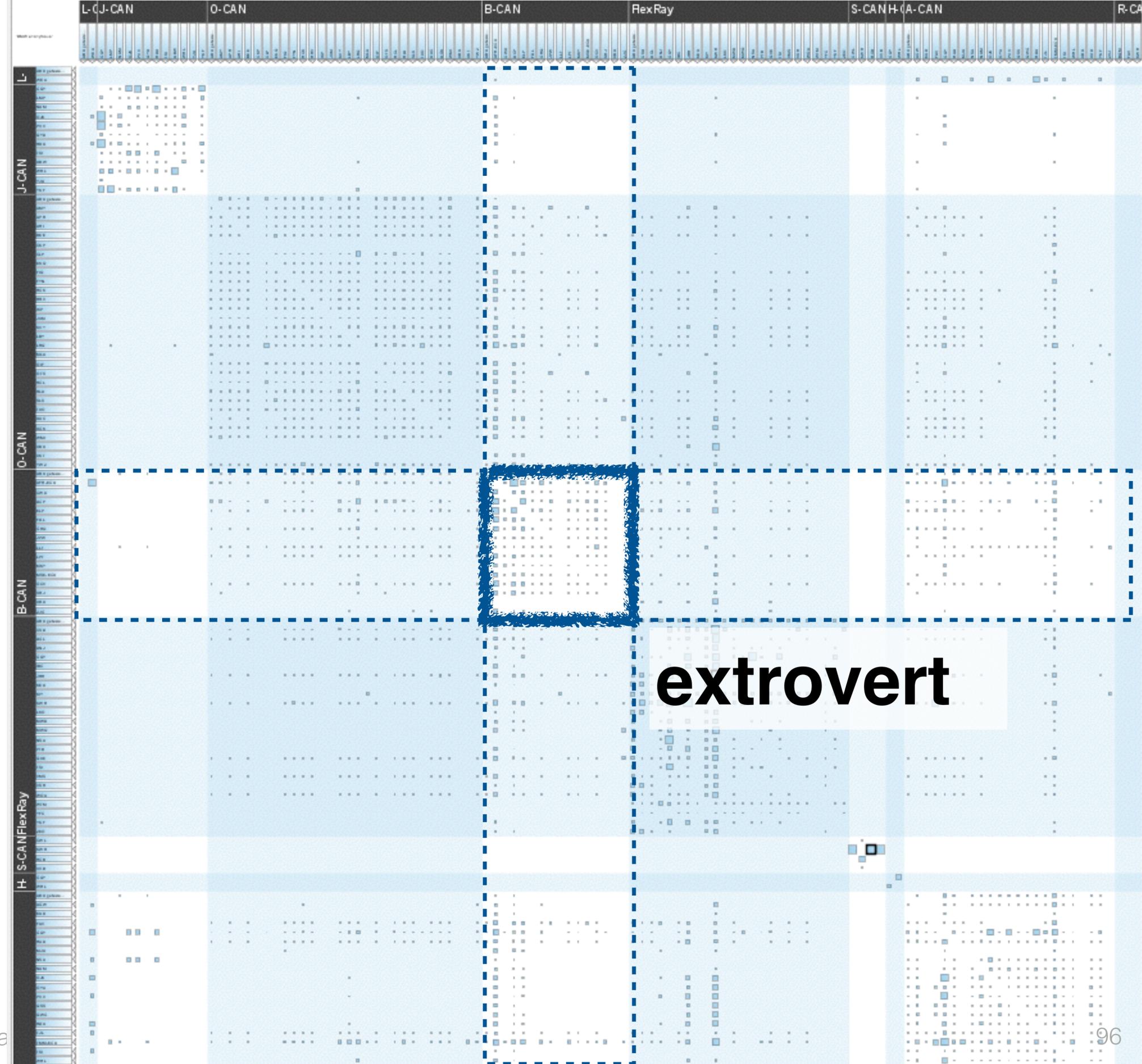
Novel insights: Bus communication patterns

introvert
vs.
extrovert



Novel insights: Bus communication patterns

introvert
vs.
extrovert



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 — ReEx
- Design Study Methodology

3. Summary

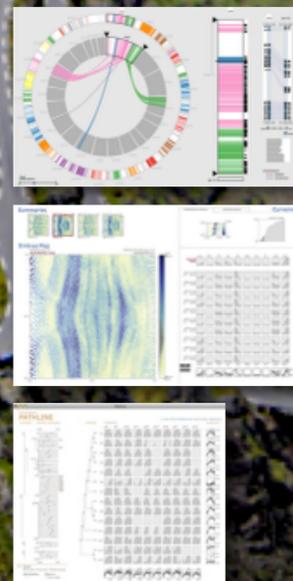
design studies: long and winding road with many pitfalls!



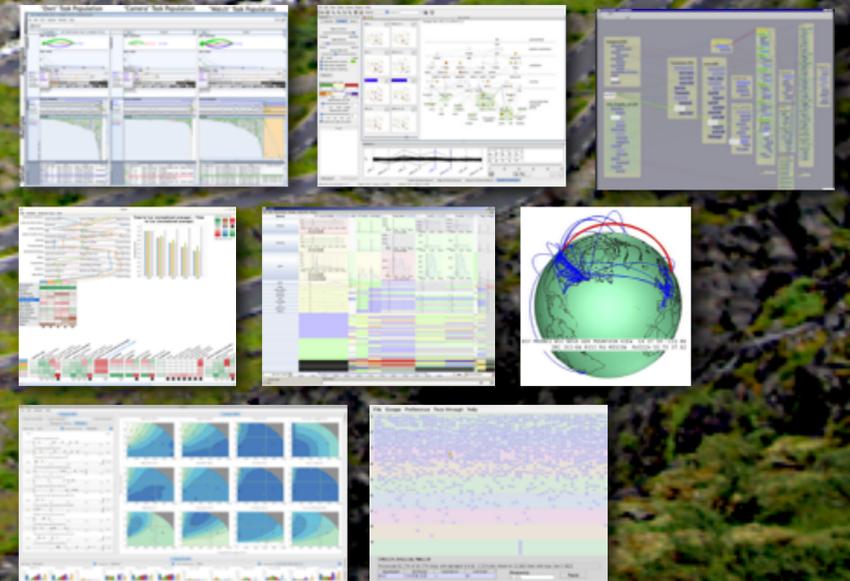
et al.



et al.

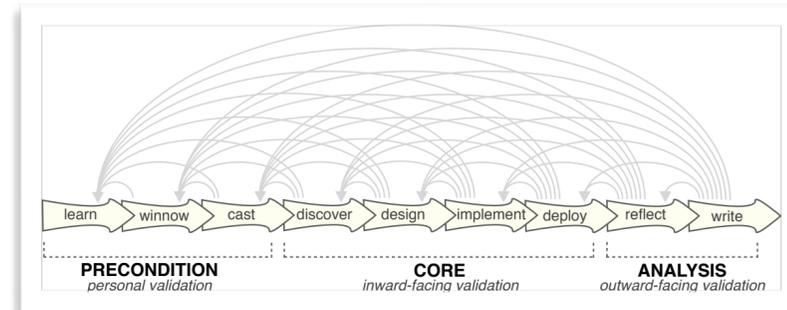


et al.

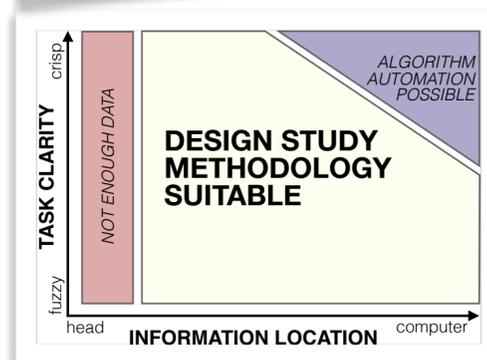


How to do design studies?

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

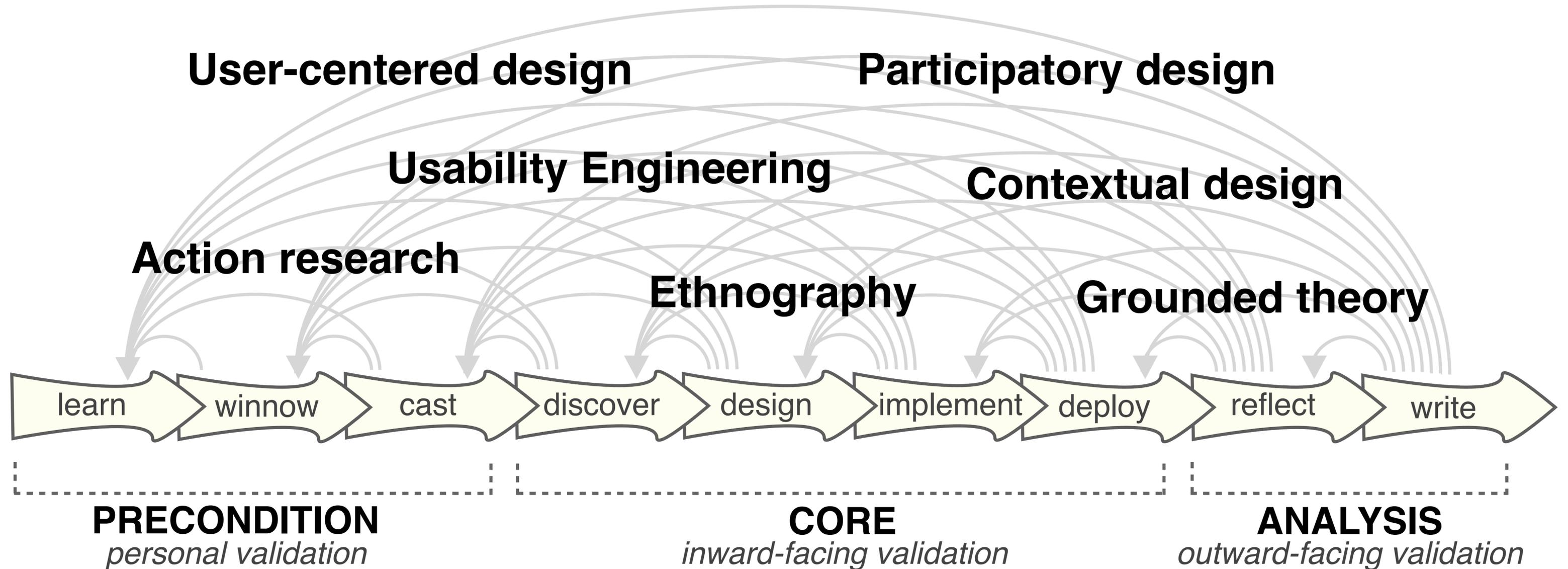


PF-1	premature advance: jumping forward over stages	general
PF-2	premature start: insufficient knowledge of vis literature	learn
PF-3	premature commitment: collaboration with wrong people	winnow
PF-4	no real data available (yet)	winnow
PF-5	insufficient time available from potential collaborators	winnow
PF-6	no need for visualization: problem can be automated	winnow
PF-7	researcher expertise does not match domain problem	winnow
PF-8	no need for research: engineering vs. research project	winnow
PF-9	no need for change: existing tools are good enough	winnow



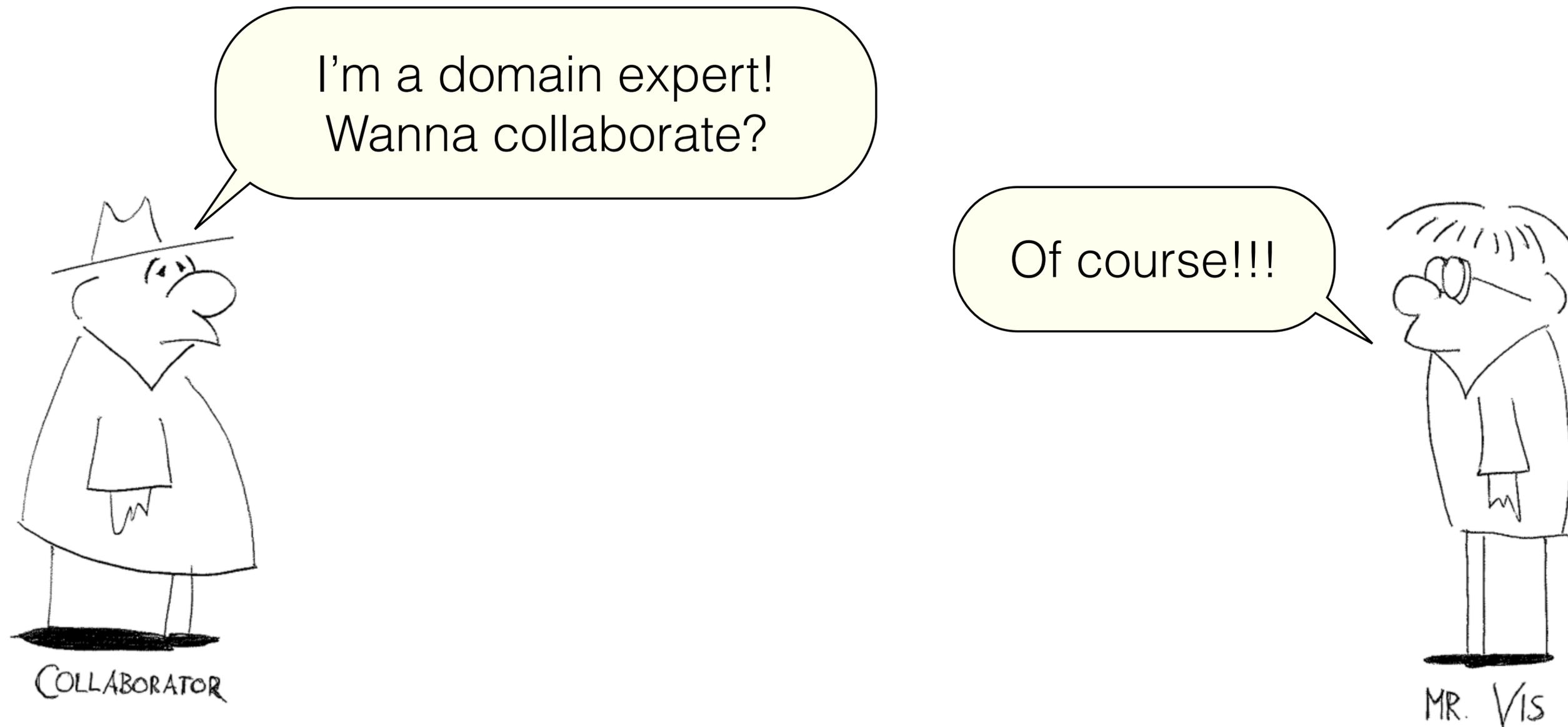
Michael Sedlmair, Miriah Meyer, Tamara Munzner.
 Design Study Methodology: Reflections from the Trenches and the Stacks .
 IEEE TVCG (Proc. InfoVis), 2012.

9-stage framework



32 pitfalls:

Example pitfall — premature collaboration



Considerations!



Have **data**?
Have **time**?
Have **need**?
...



Roles!



Are you a **user**???

... or maybe a **fellow tool builder**?



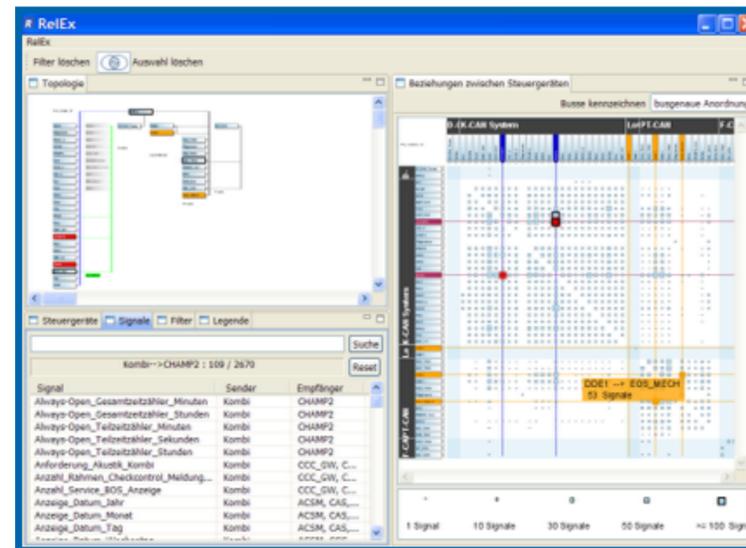
32 pitfalls:

Example pitfall — no reflection

Reflection is where research emerges from engineering

Transferability: relate to other design studies

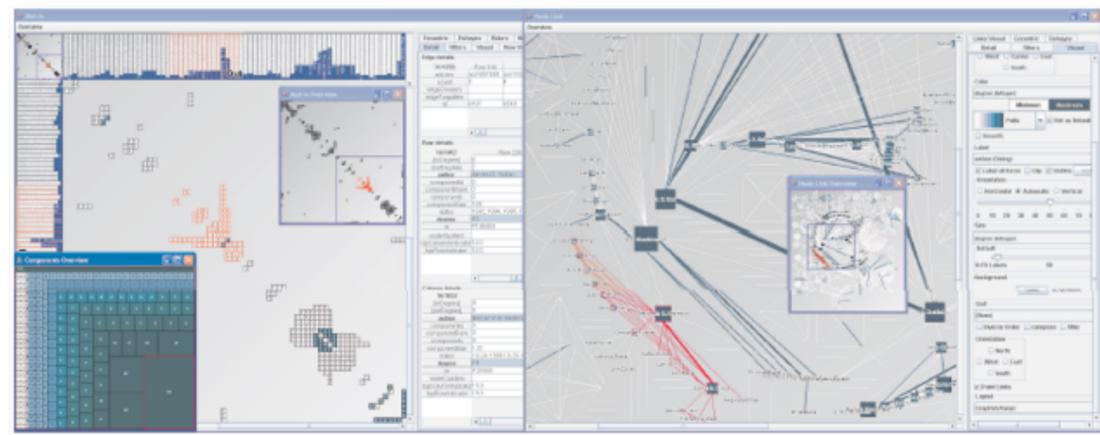
RelEx: Reflection



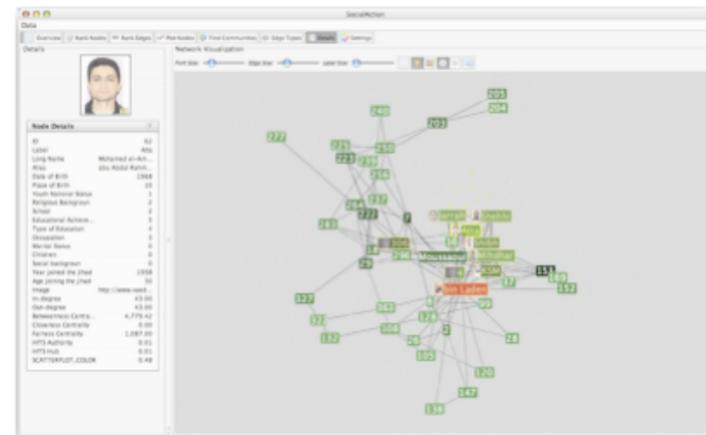
Previous work: Focus on social network analysis



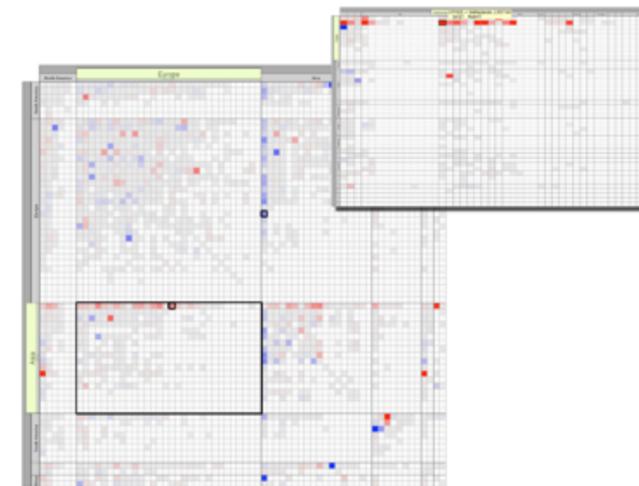
- radically different task and data abstractions



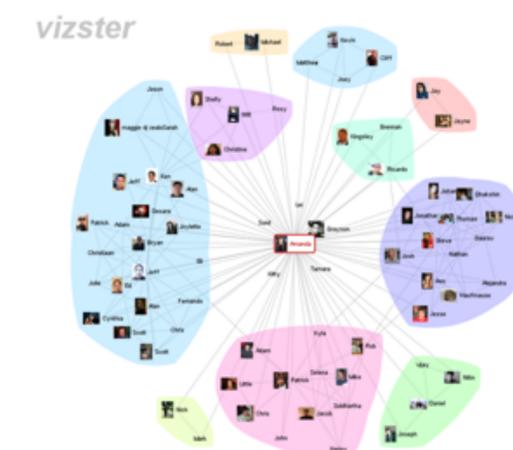
MatrixExplorer



SocialAction

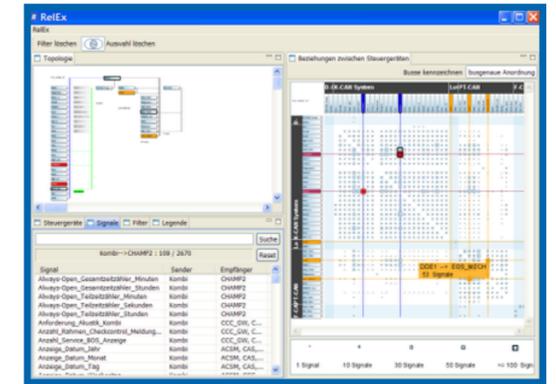


Honeycomb



vizster

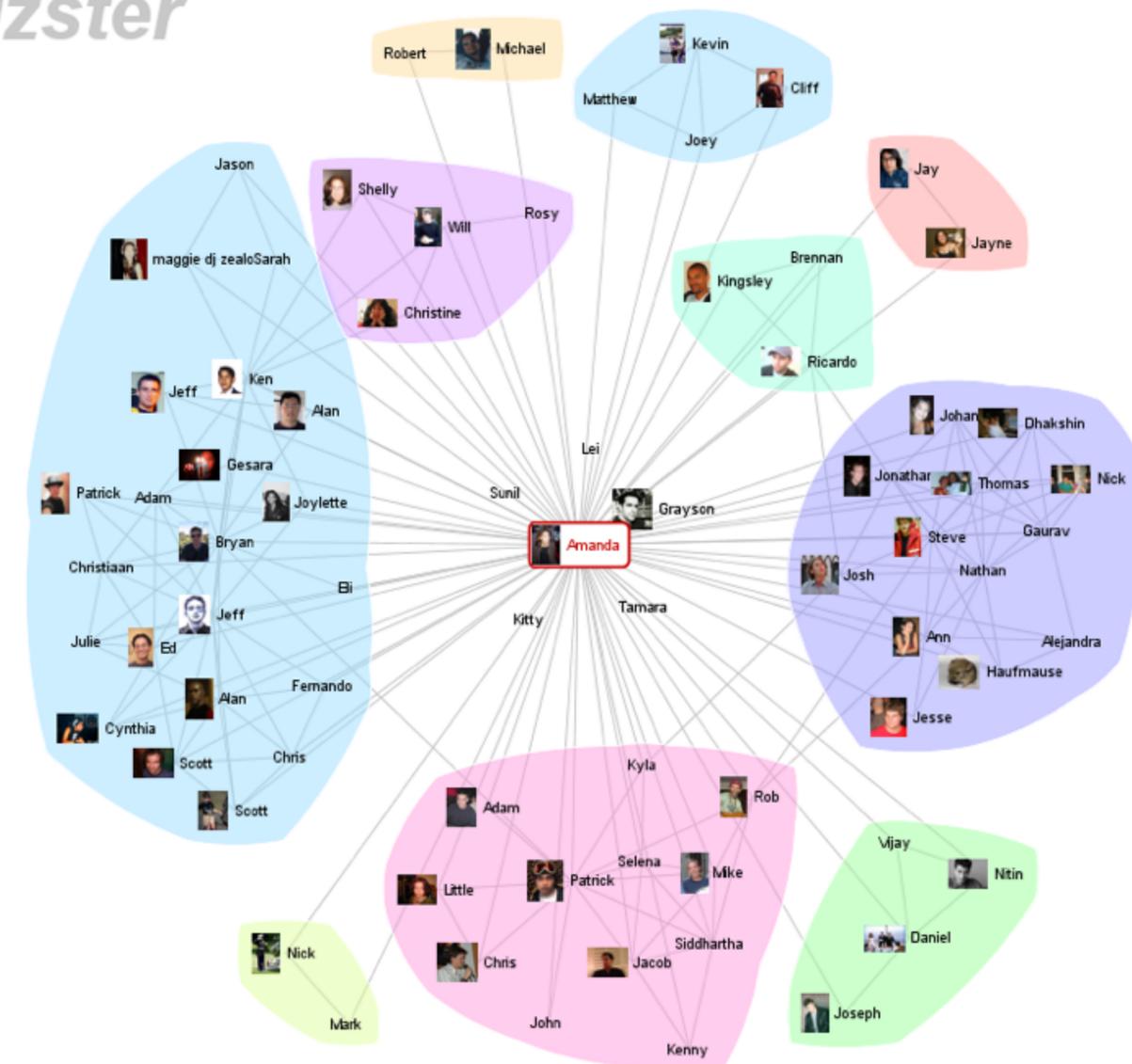
Previous work: Social network analysis



Task abstraction:

- find clusters

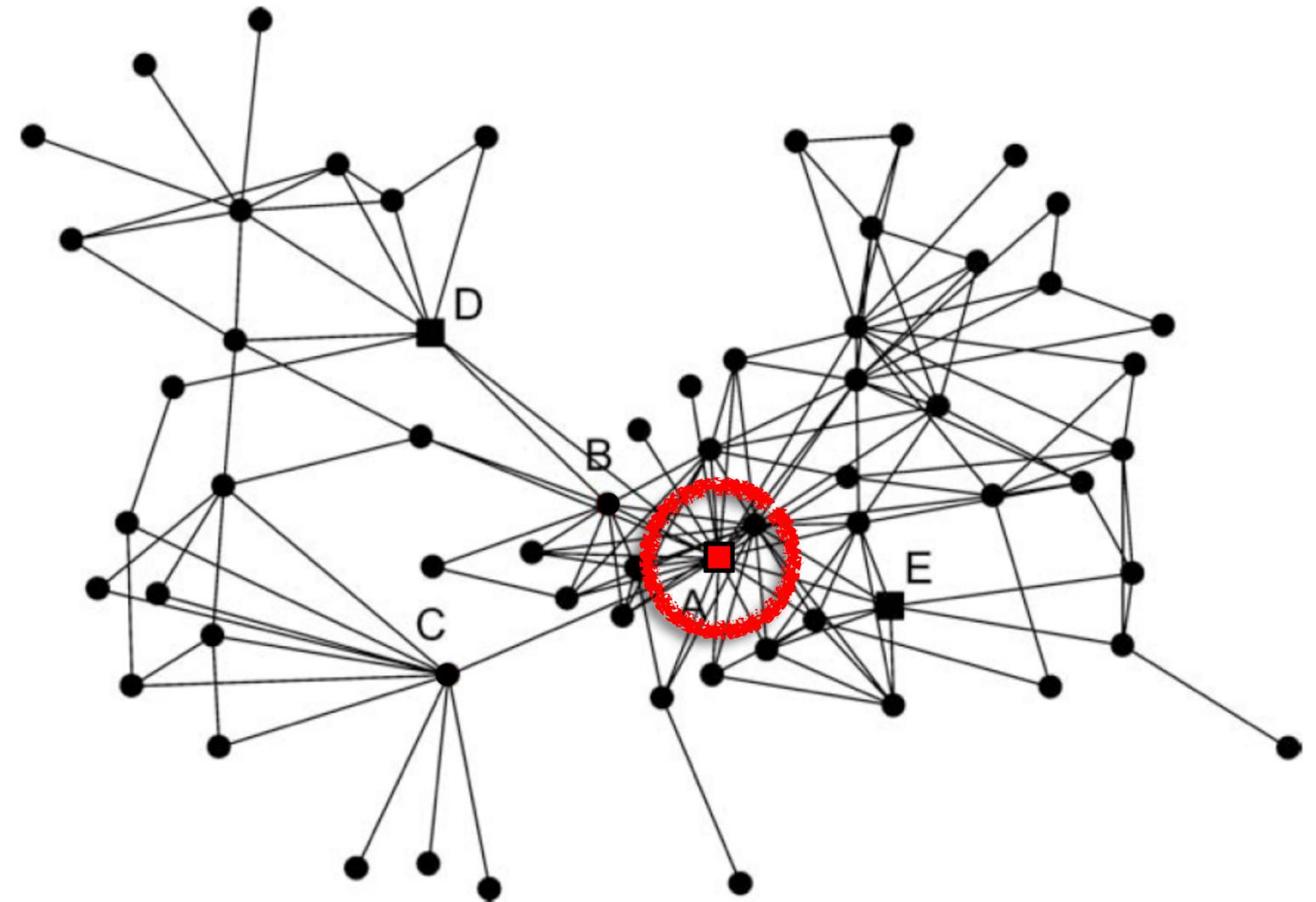
vizster



Previous work: Social network analysis

Task abstraction:

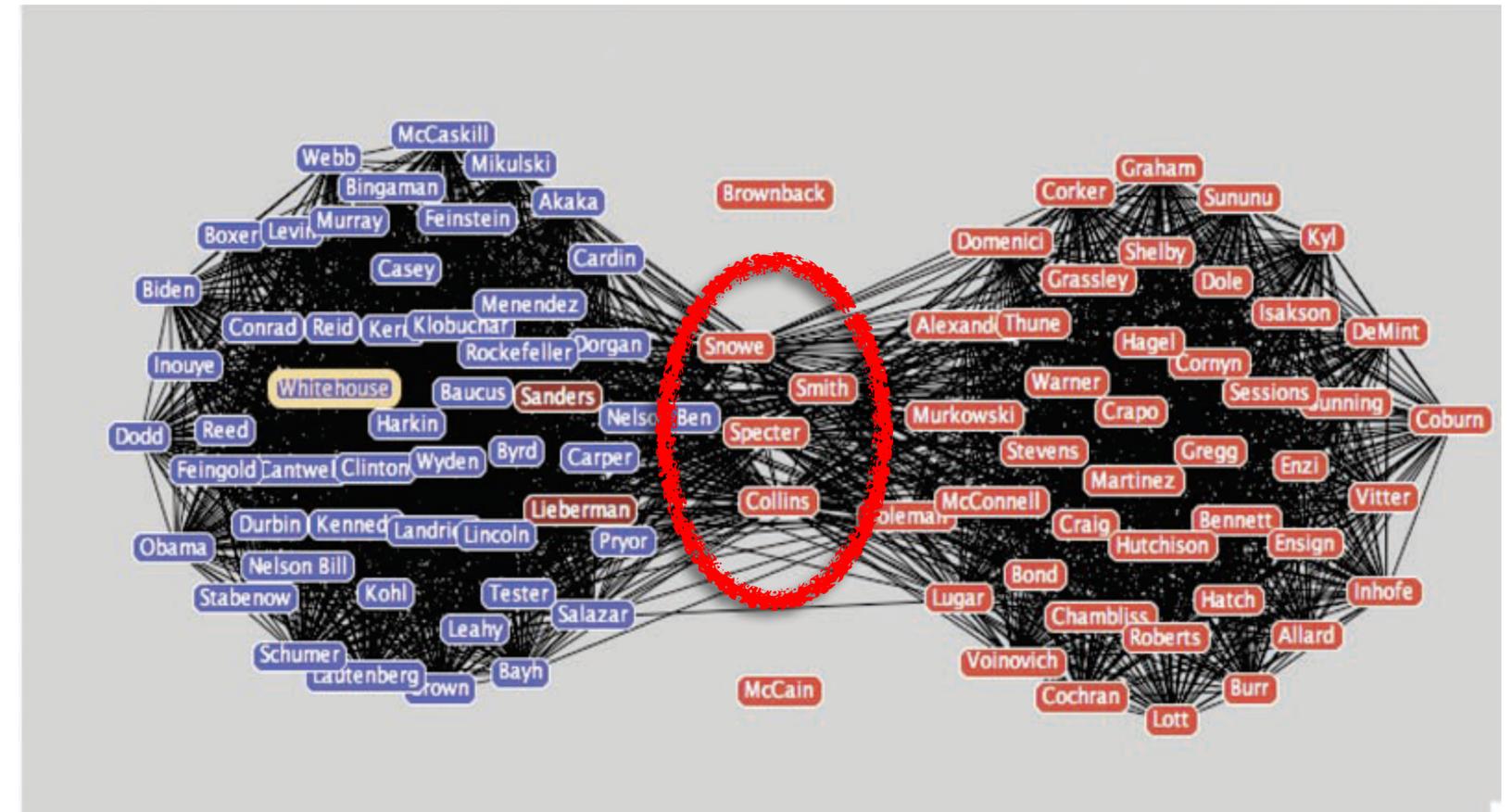
- find clusters
- find high-degree nodes



Previous work: Social network analysis

Task abstraction:

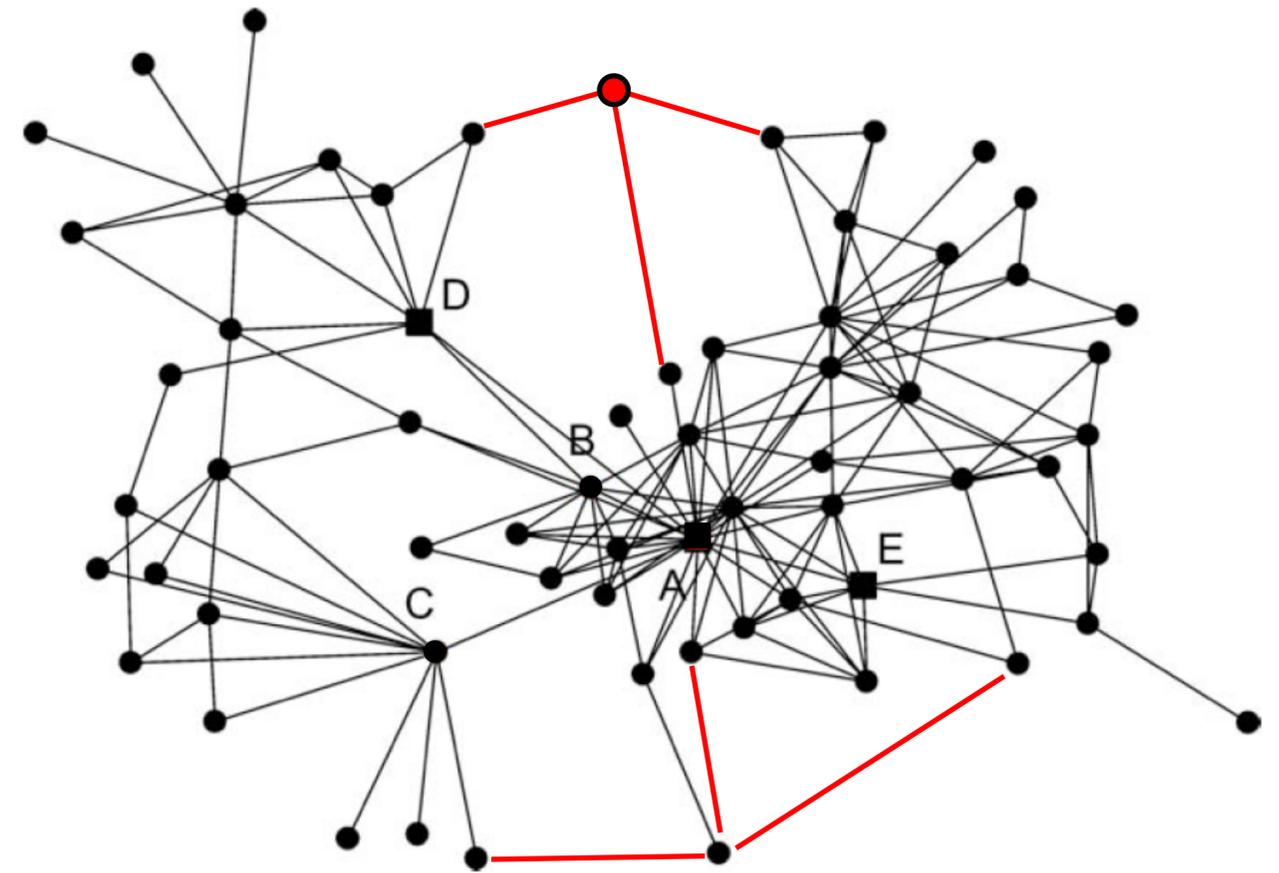
- find clusters
- find high-degree nodes
- find bridging nodes



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

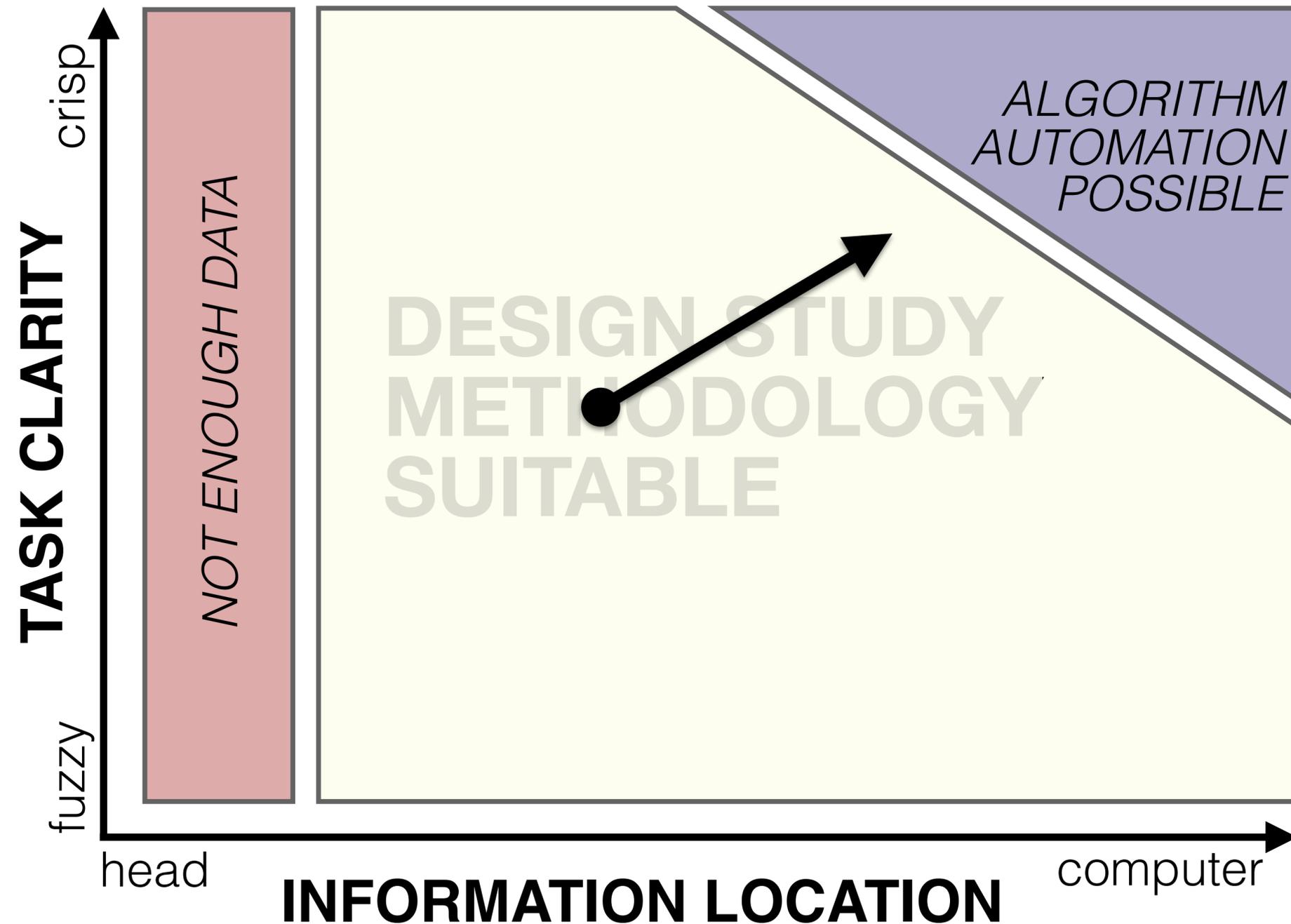
- traffic optimization
- active changes



Data

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

Why do design studies?

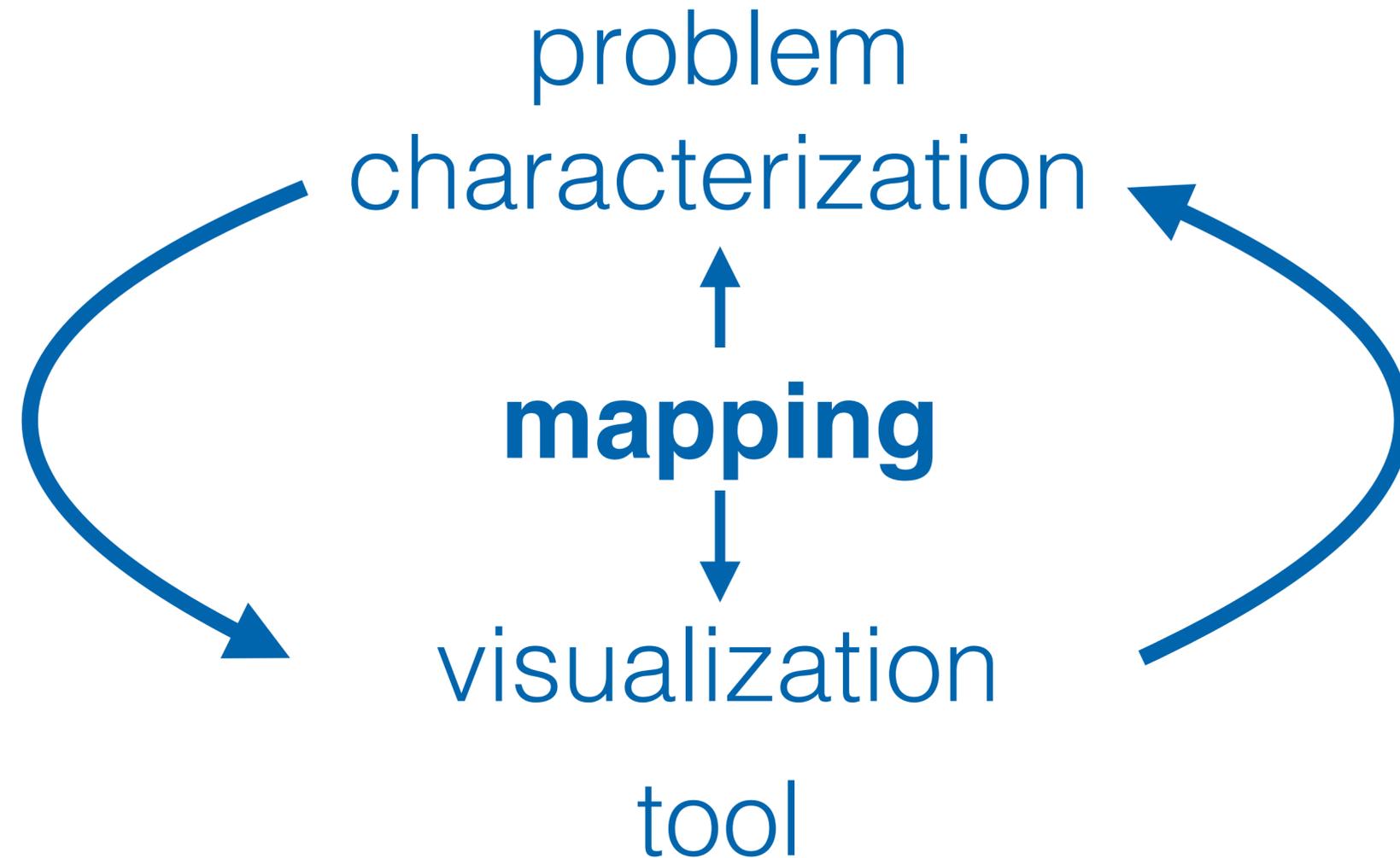


problem
characterization

&

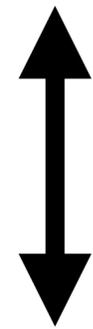
visualization
tool

Why not just ask a social scientist?



Challenge: “Visualization Cookbook”

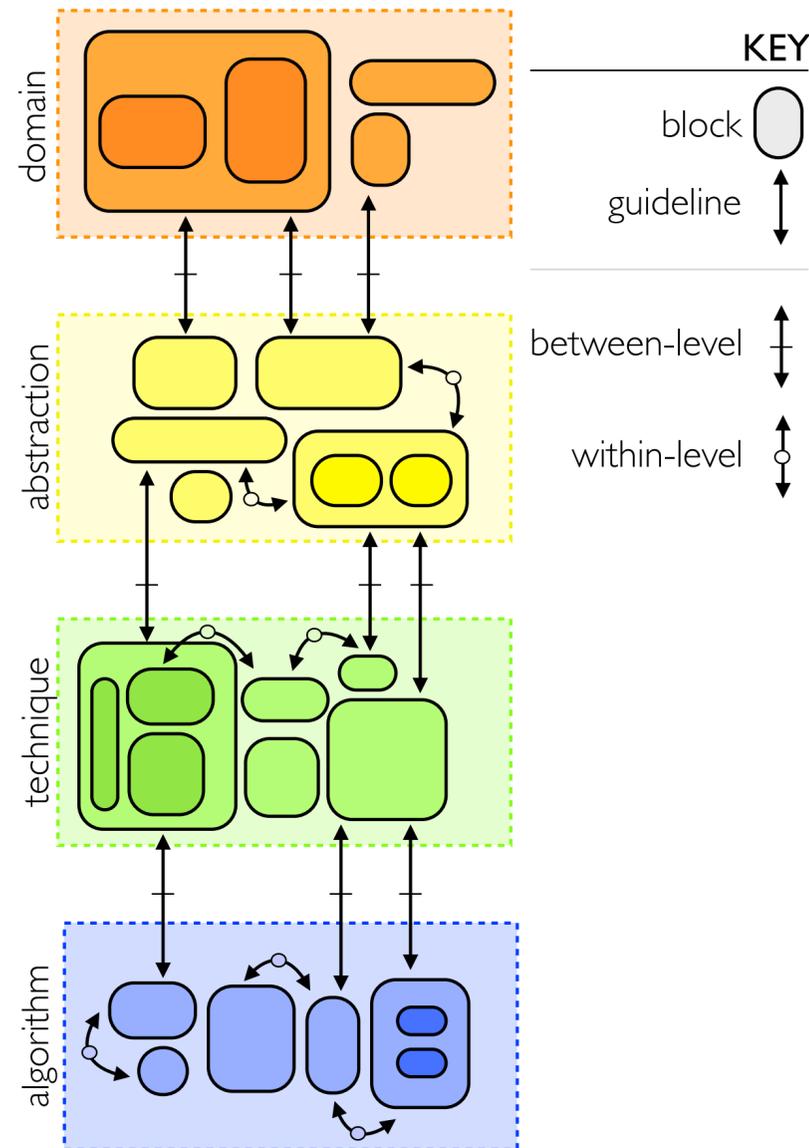
abstract data & task



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

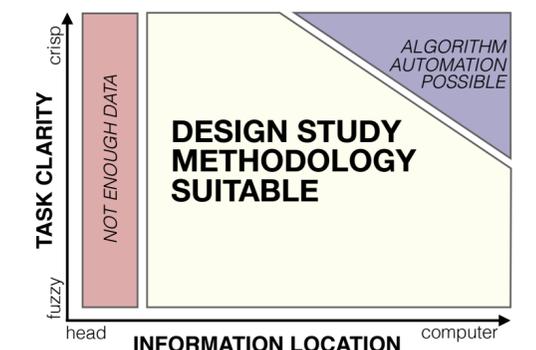
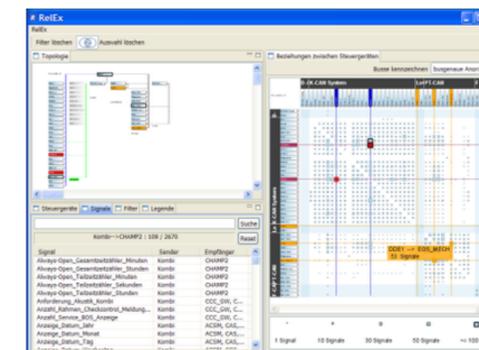
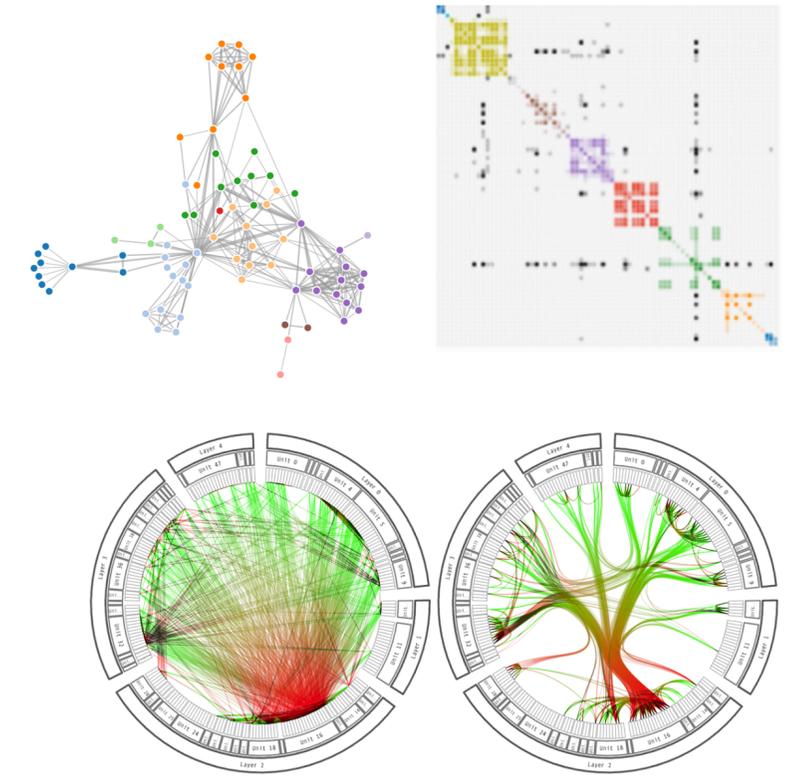
2. Problem-driven research

- Design Study Example — RelEx
- Design Study Methodology

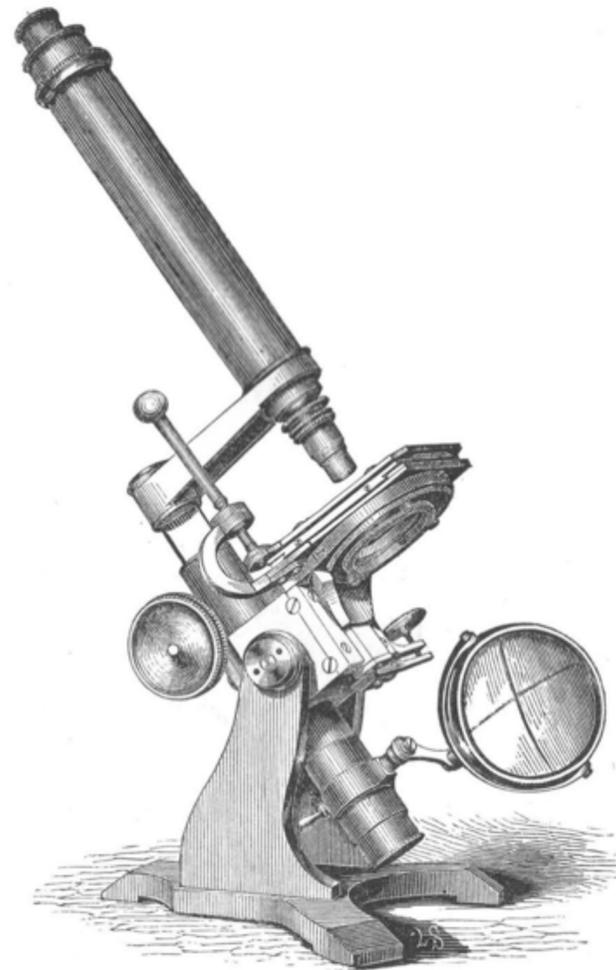
3. Summary

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

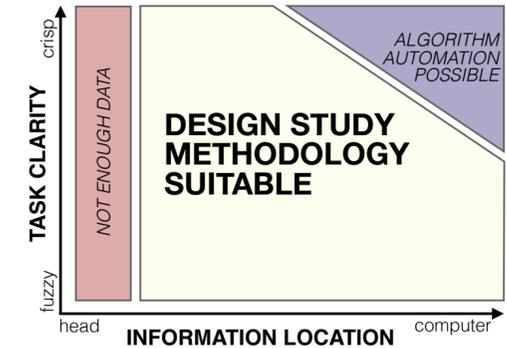
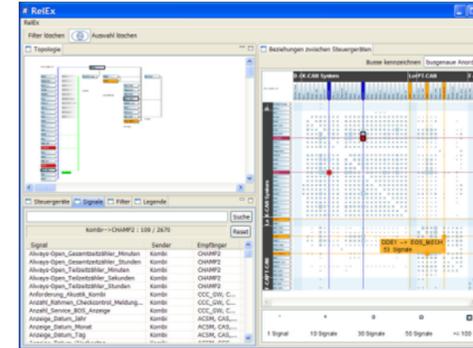
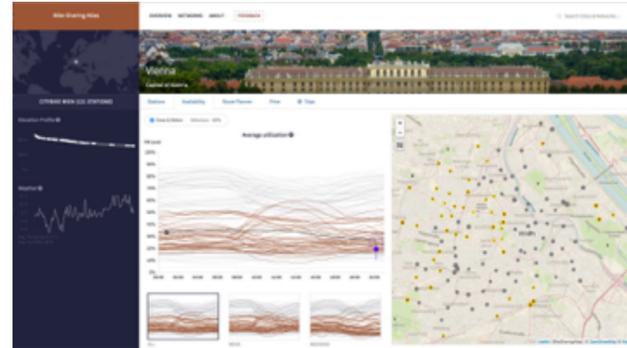
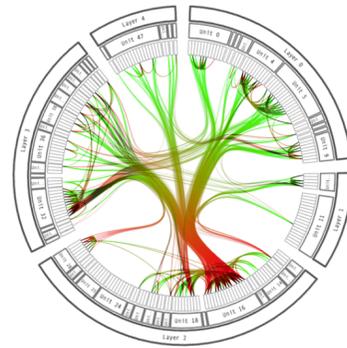
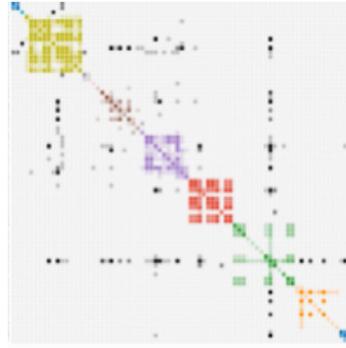
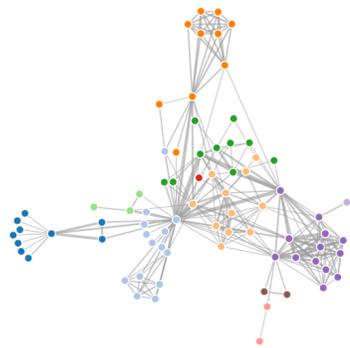


<http://www.microscope-antiques.com/grunow.html>



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

Thank you!



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Visualization & Data Analysis Group

