RelEx

Visualization for Actively Changing Overlay Network Specifications

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[1] University of British Columbia
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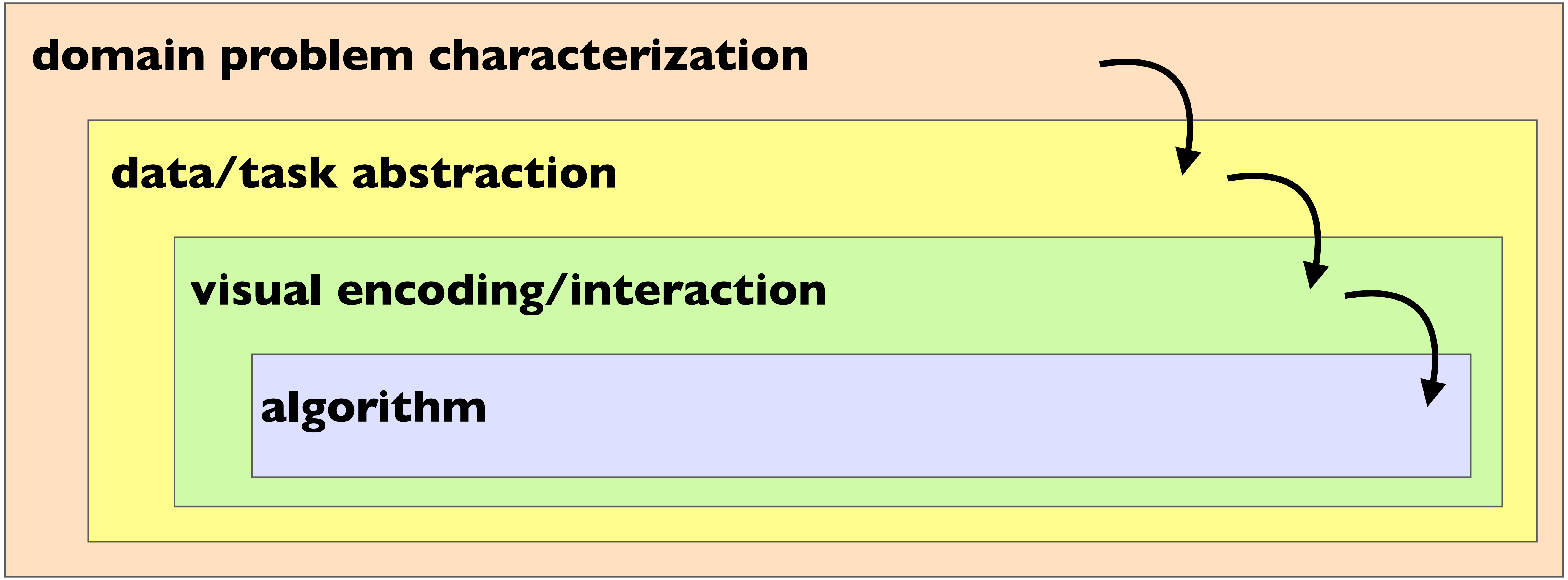
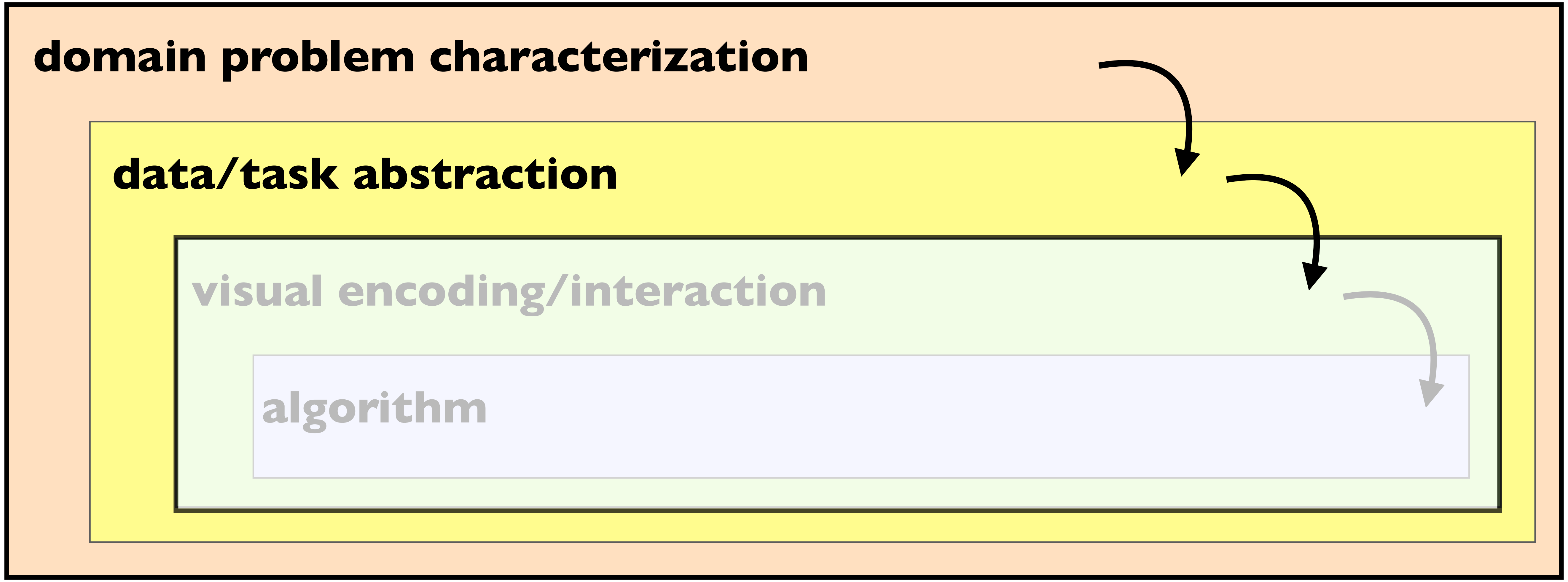
[3] University of Munich
[4] (formerly) BMW Group

Focus
Nested Model



Munzner, InfoVis 2009

Focus
Nested Model

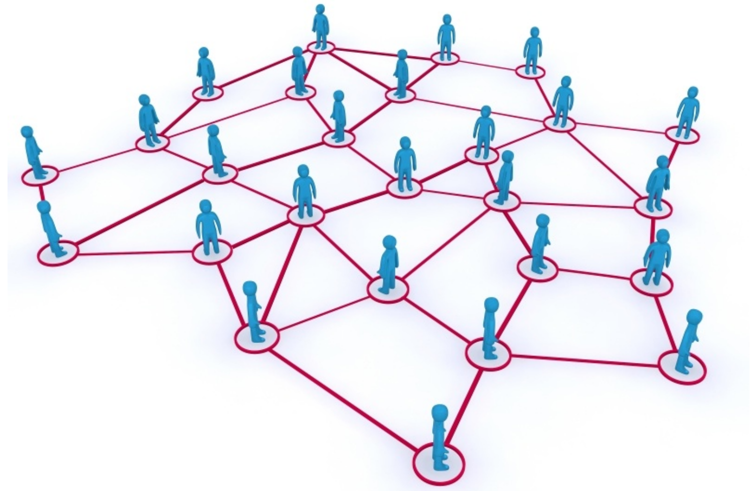


Munzner, InfoVis 2009

NETWORK VIS
Data and Tasks?

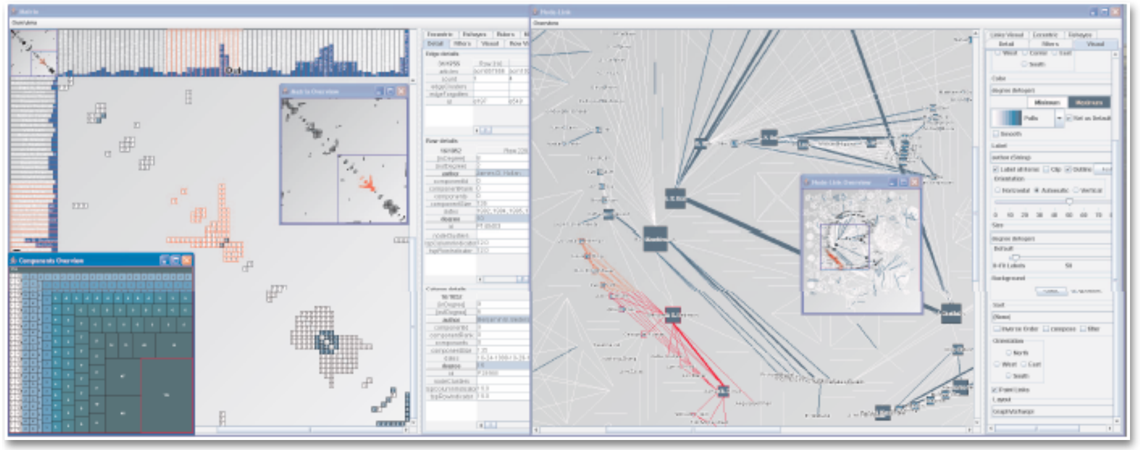
What are network analysts doing?

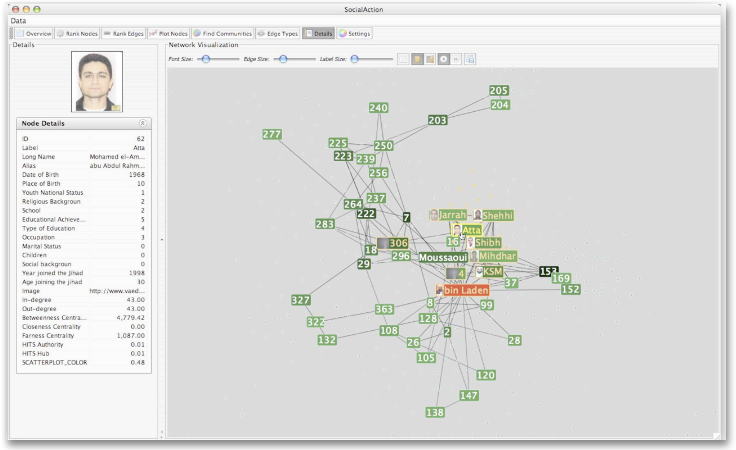
Network Vis
Data and Tasks?

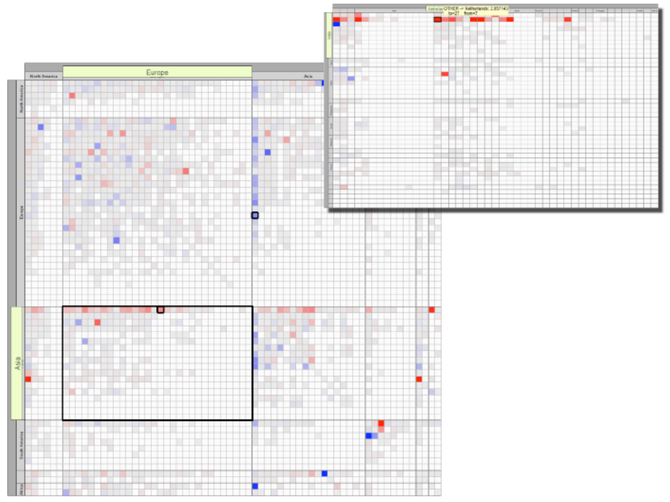


What are network analysts doing?

Social Network Analysis!







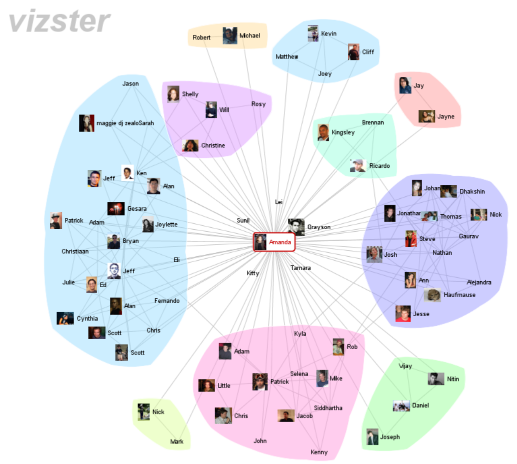
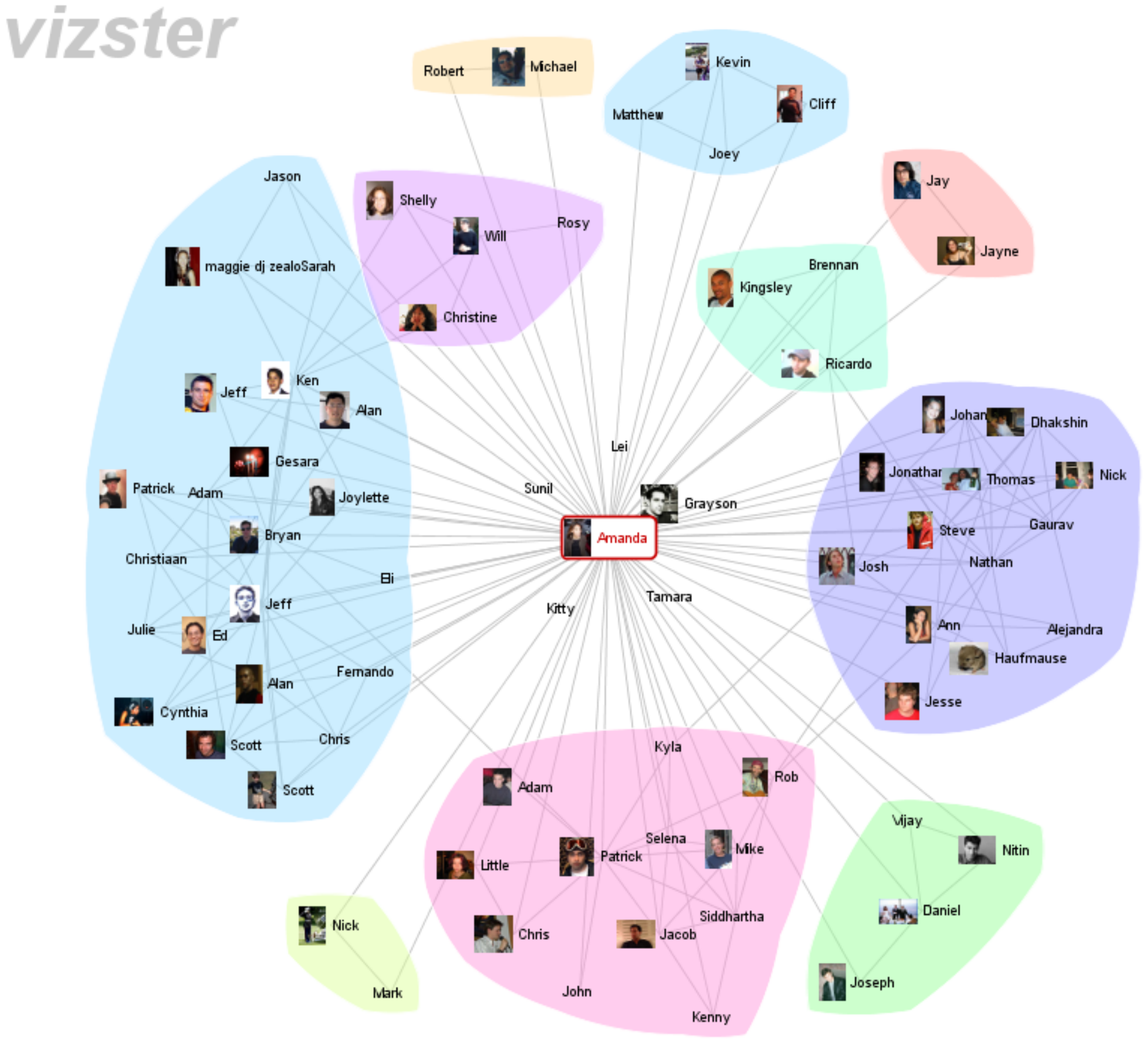


Image: http://www.orbitalrpm.com/wp-content/uploads/2007/10/sna-graphic-7.jpg

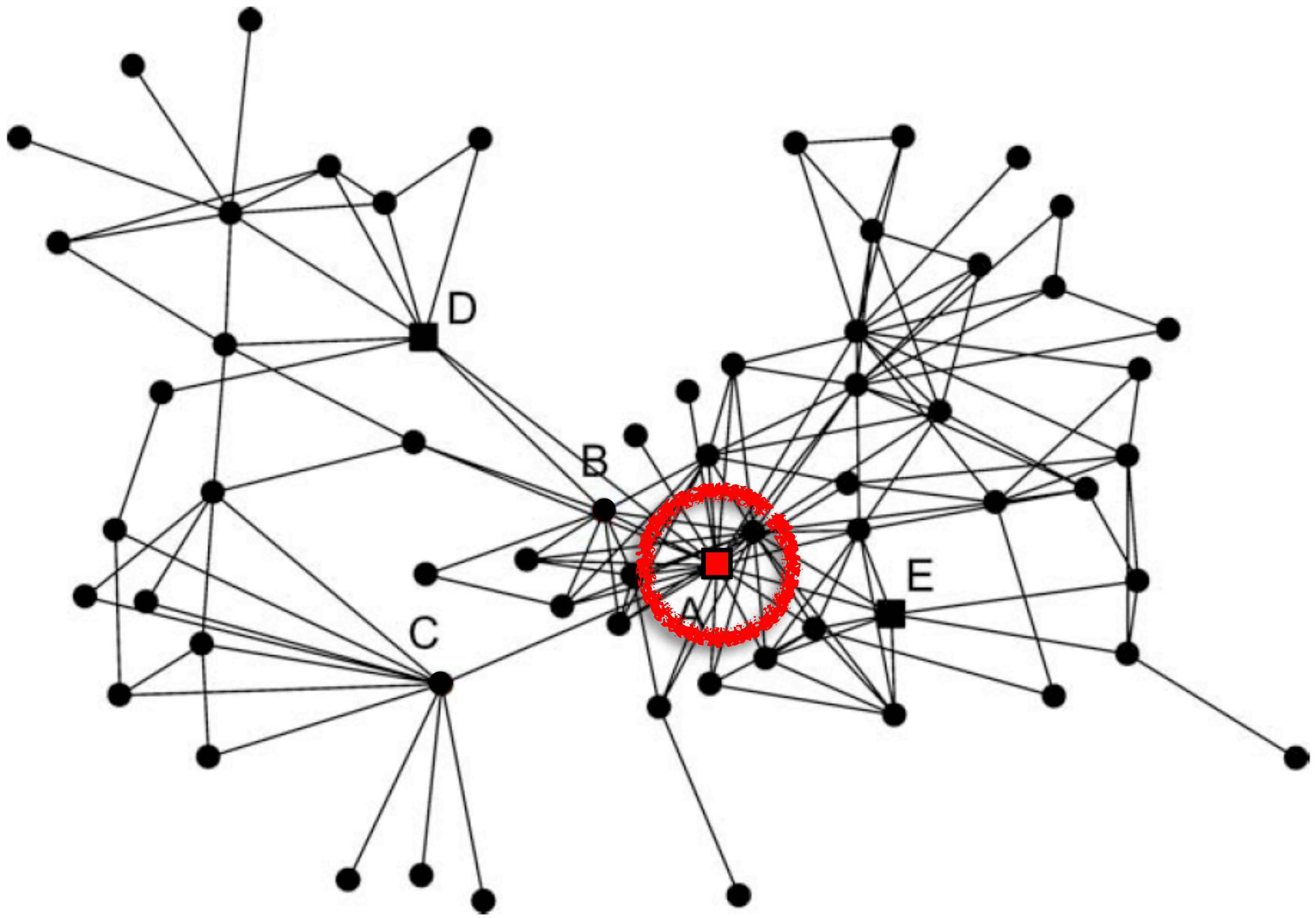
Social Networks
Abstract Tasks

1. Find clusters



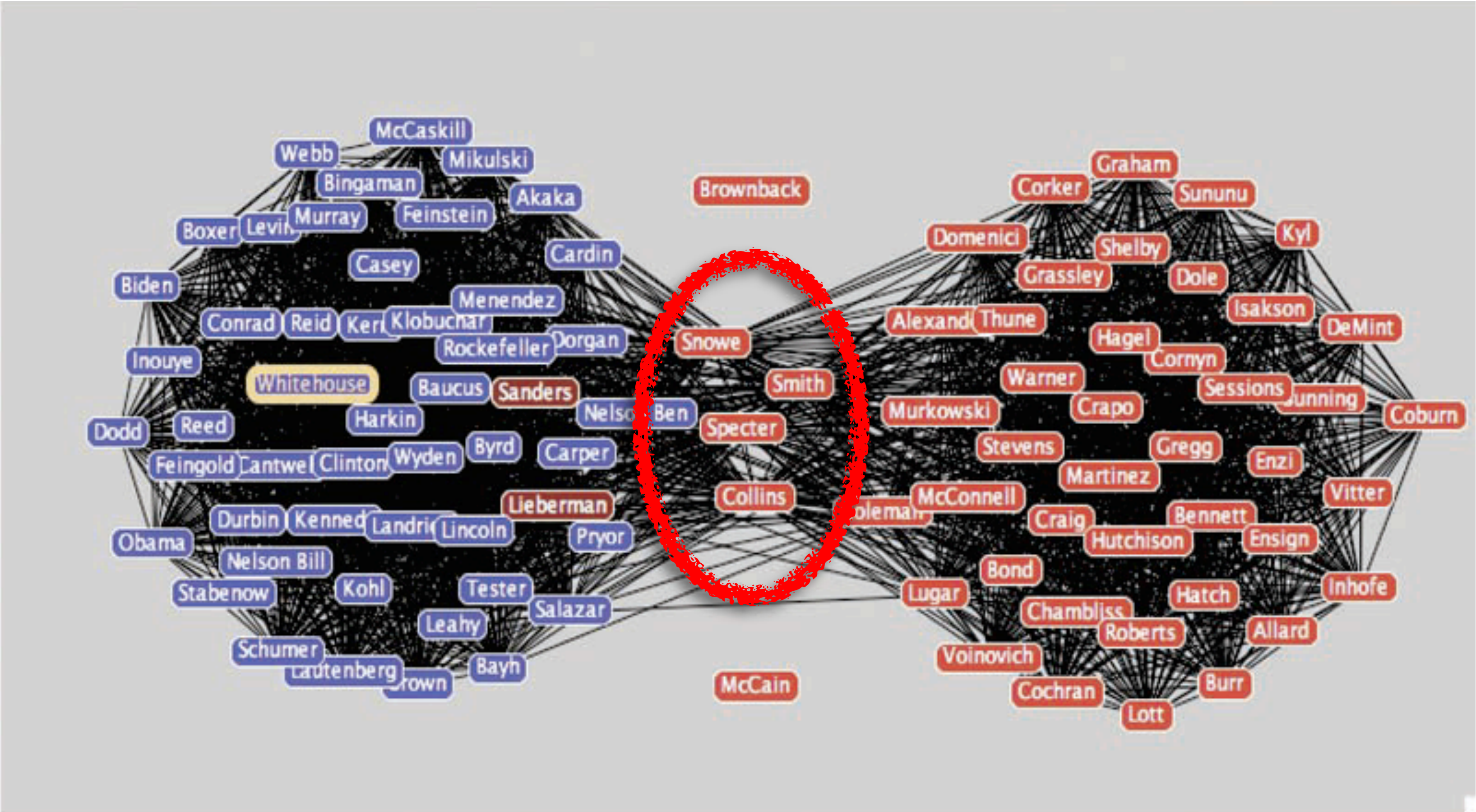
SOCIAL NETWORKS
Abstract Tasks

1. Find clusters
2. Find high-degree nodes



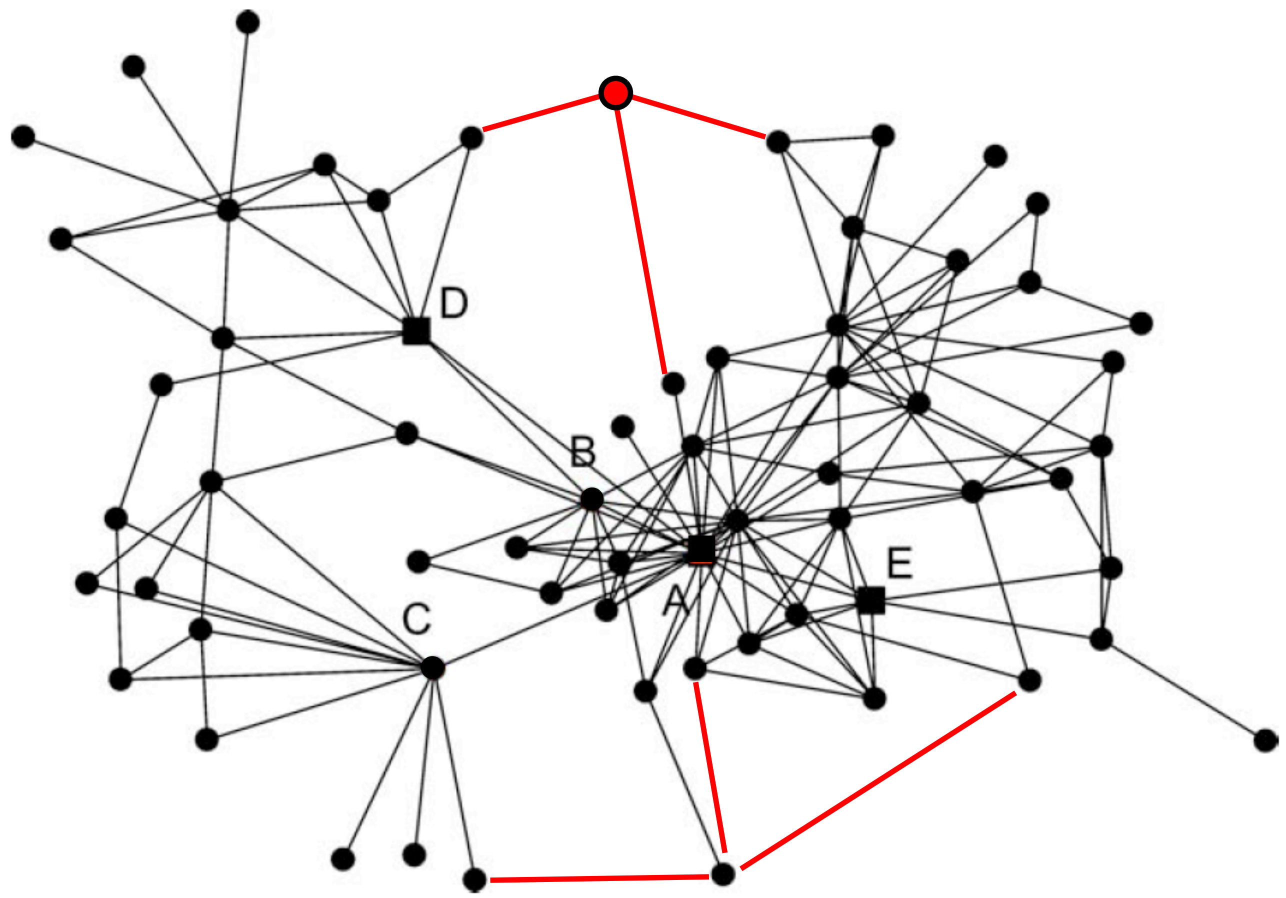
SOCIAL NETWORKS
Abstract Tasks

1. Find clusters
2. Find high-degree nodes
3. Find bridge nodes



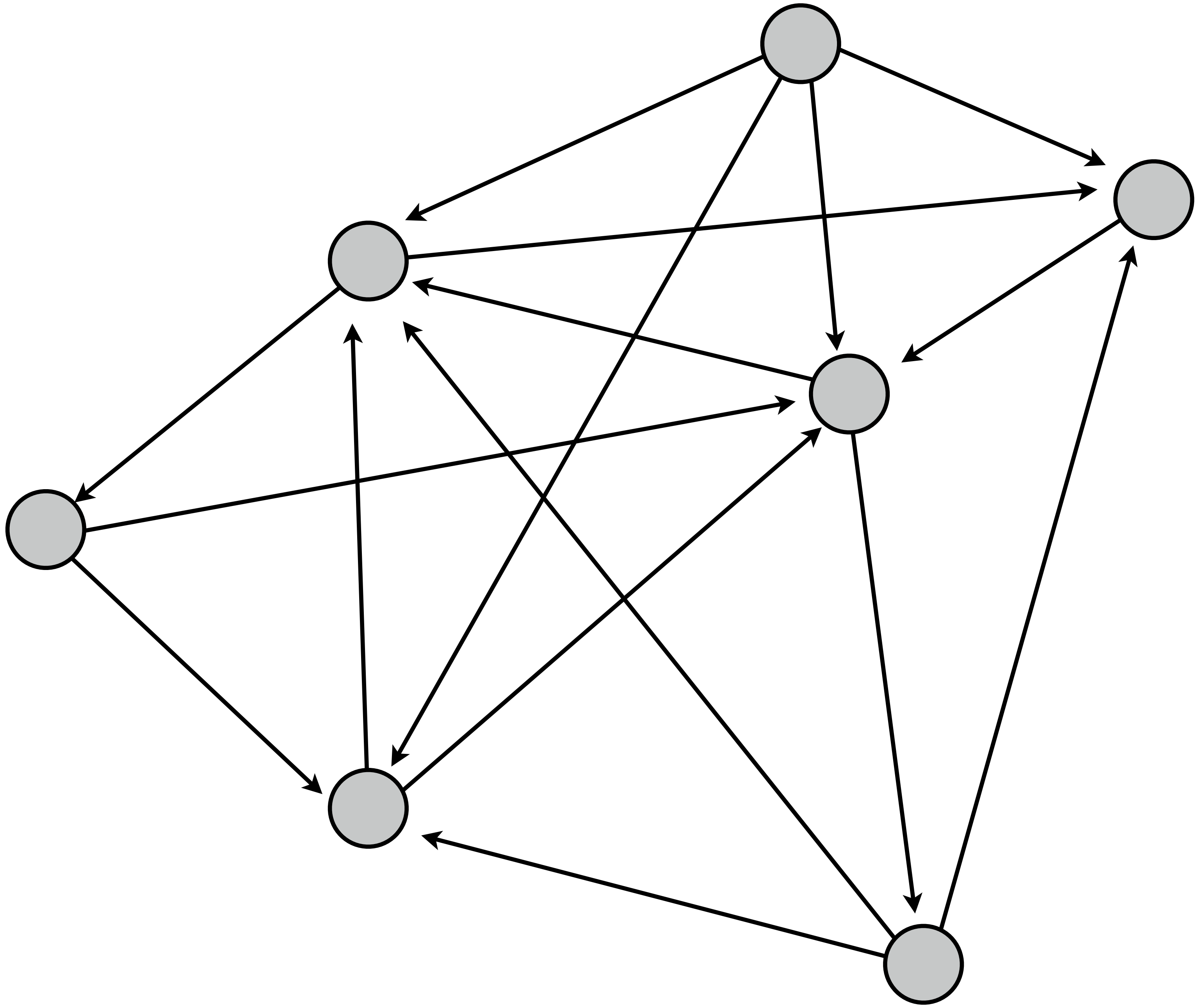
SOCIAL NETWORKS
Abstract Tasks

1. Find clusters
2. Find high-degree nodes
3. Find bridge nodes
4. Understand temporal dynamics



Social Networks
Abstract Data

Single (directed) graph



Social Networks
Abstract Data

Single (directed) graph

Node scalability challenge

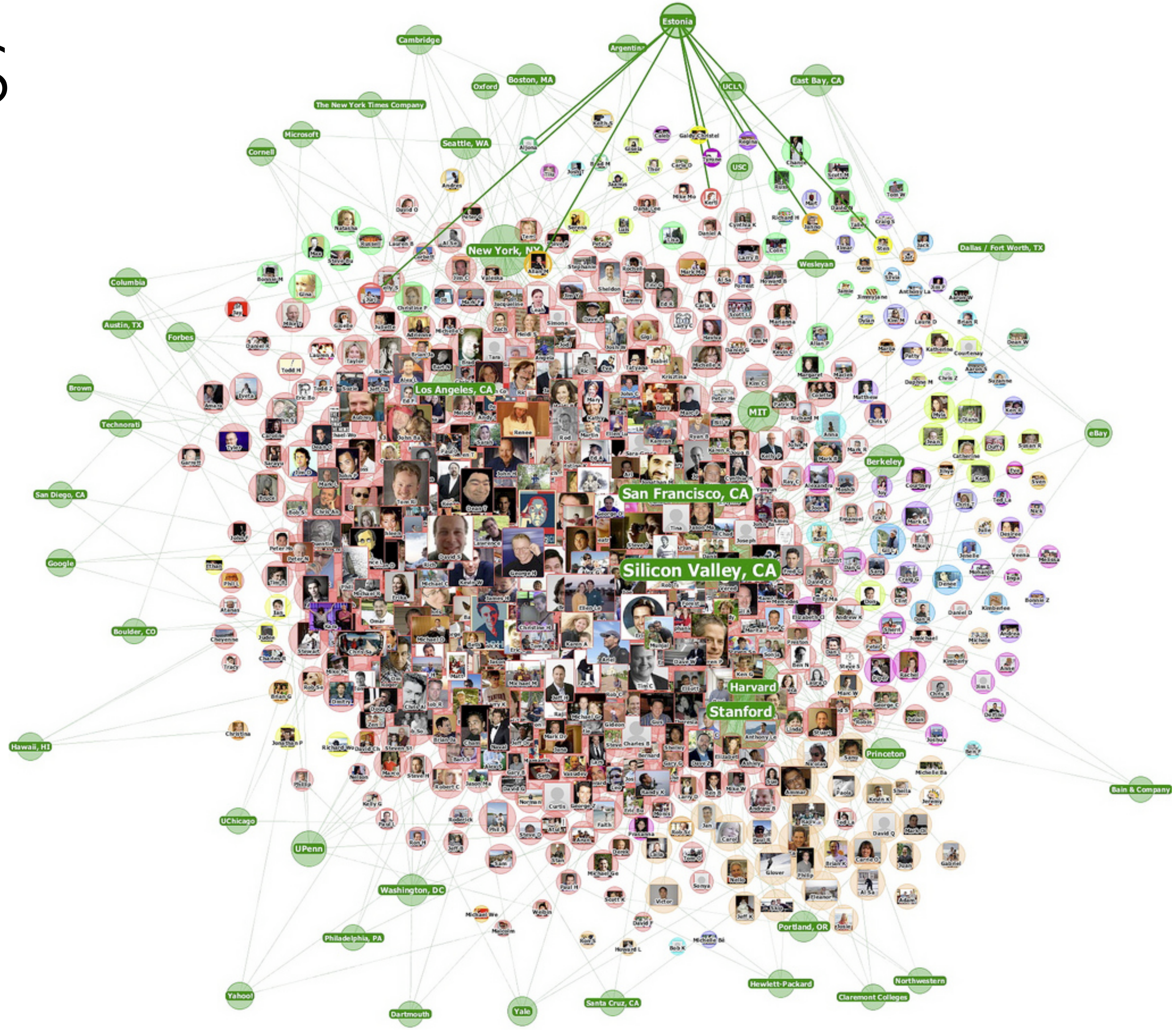


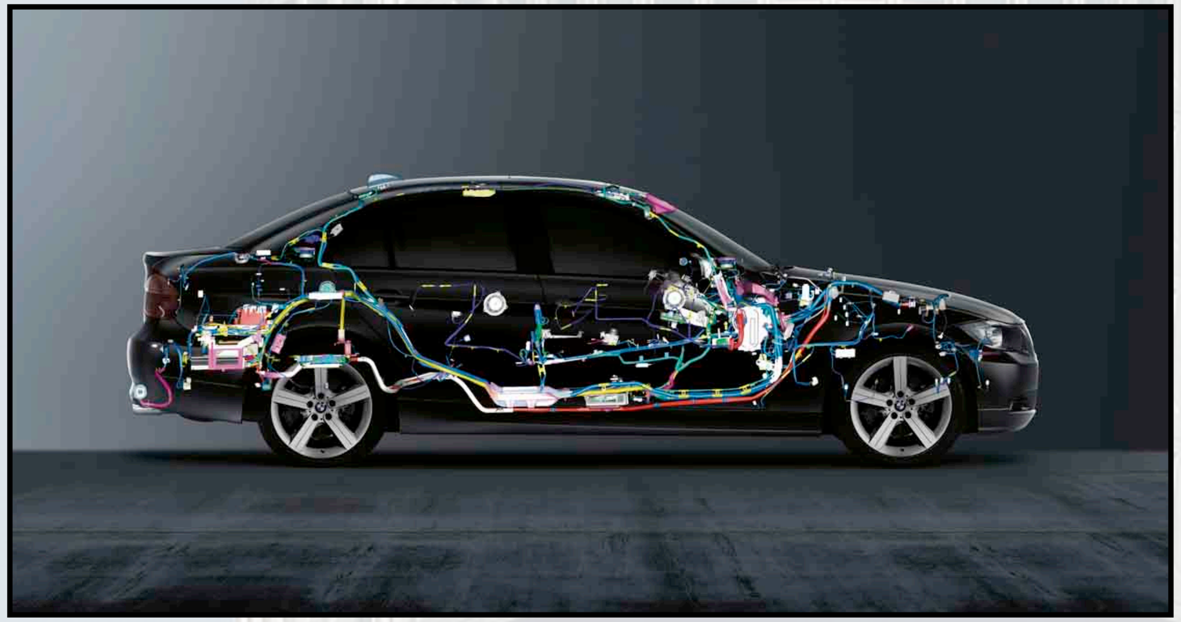
Image: http://fpra-capital.org/articles/lets-talk-about-facebook/

Network Vis beyond Social Networks ???

email, academic papers?

NETWORK VIS
What we did

Design Study: **In-car network engineering**



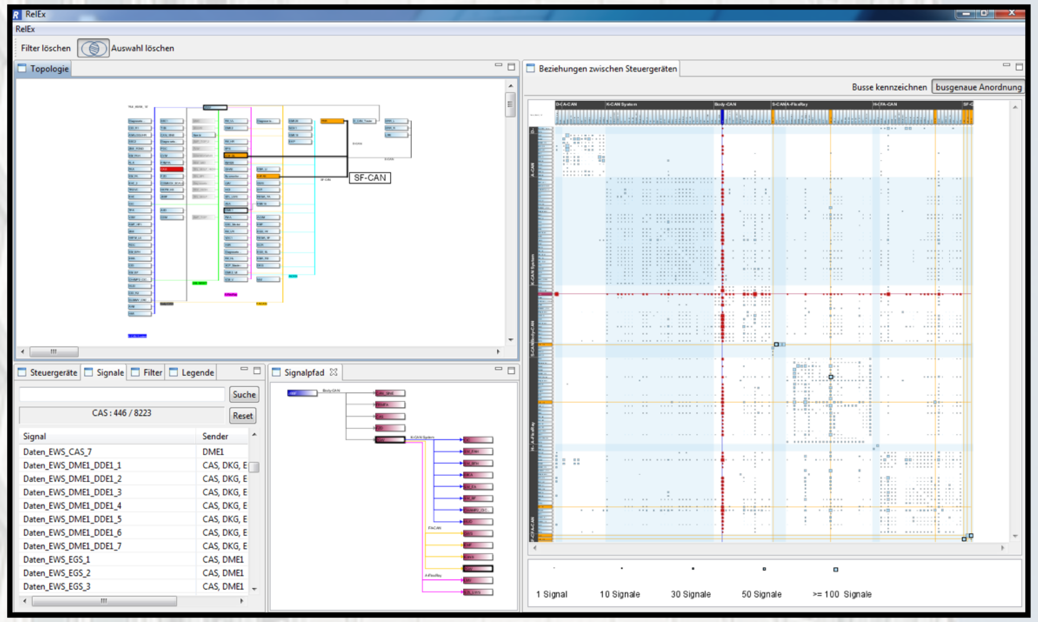
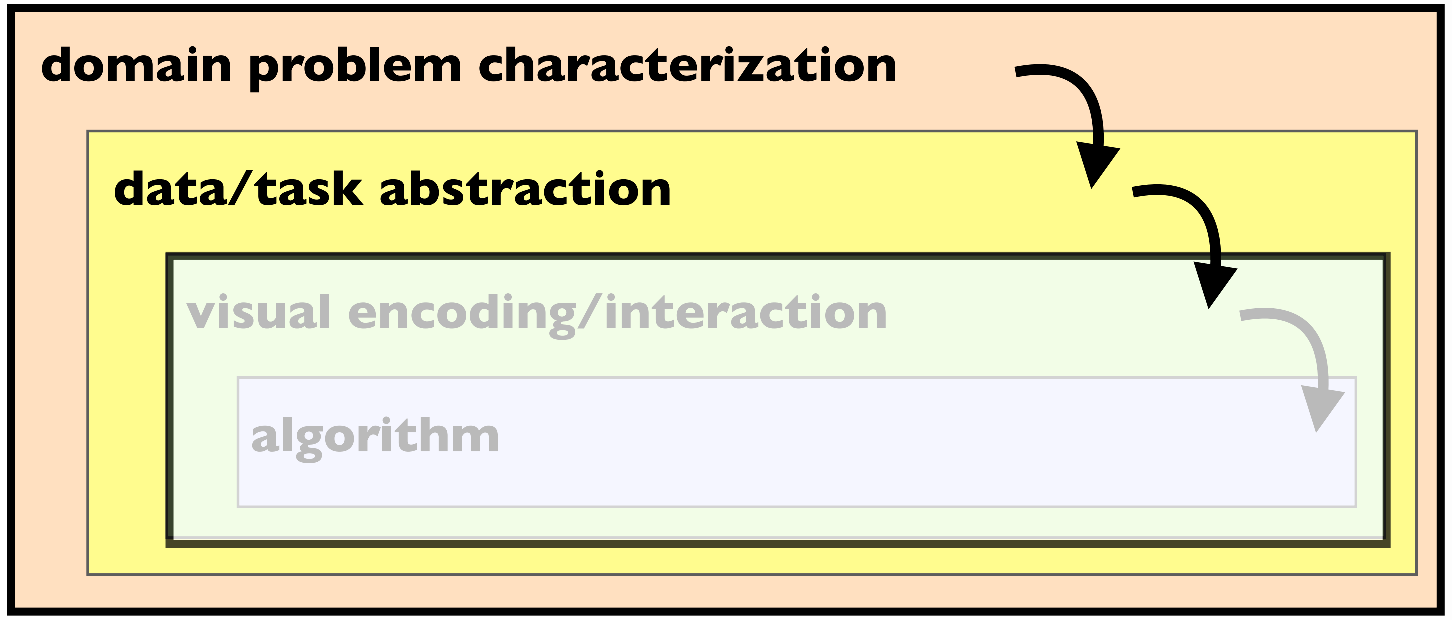


Image: http://www.bmwblog.com/wp-content/uploads/bmw-hq-munich-4.jpg

Radically different task and data abstractions



Understanding diversity is crucial to ensure applicable research[1,2]

[1] Borgatti (2005): Centrality and network flow.
[2] Willinger (2009): Mathematics and the internet: A source of enormous confusion and great potential.

Image: http://www.bmwblog.com/wp-content/uploads/bmw-hq-munich-4.jpg

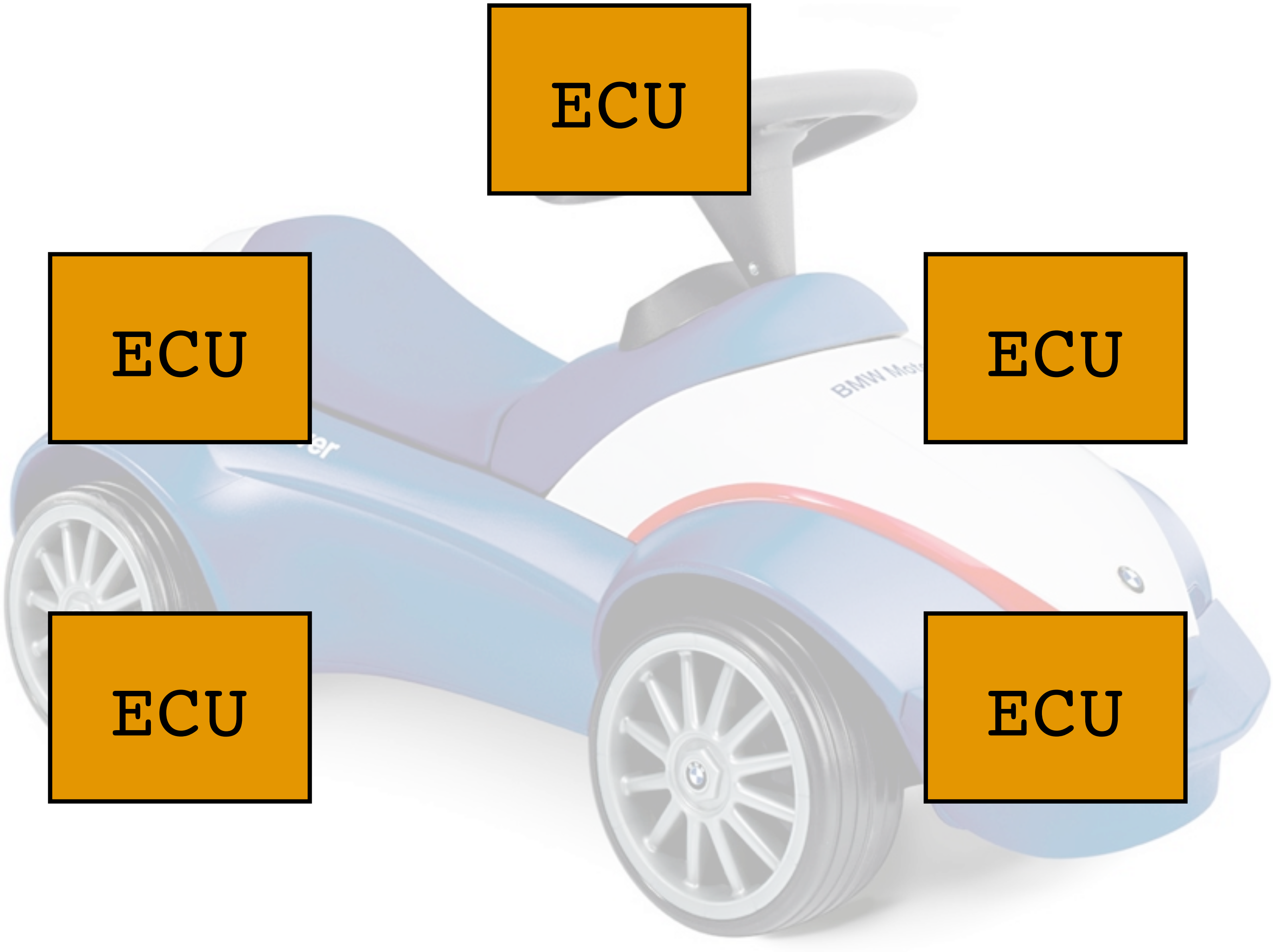
Problem characterization and abstraction:

Data

Data
In-car Electronics

DATA ABSTRACTION

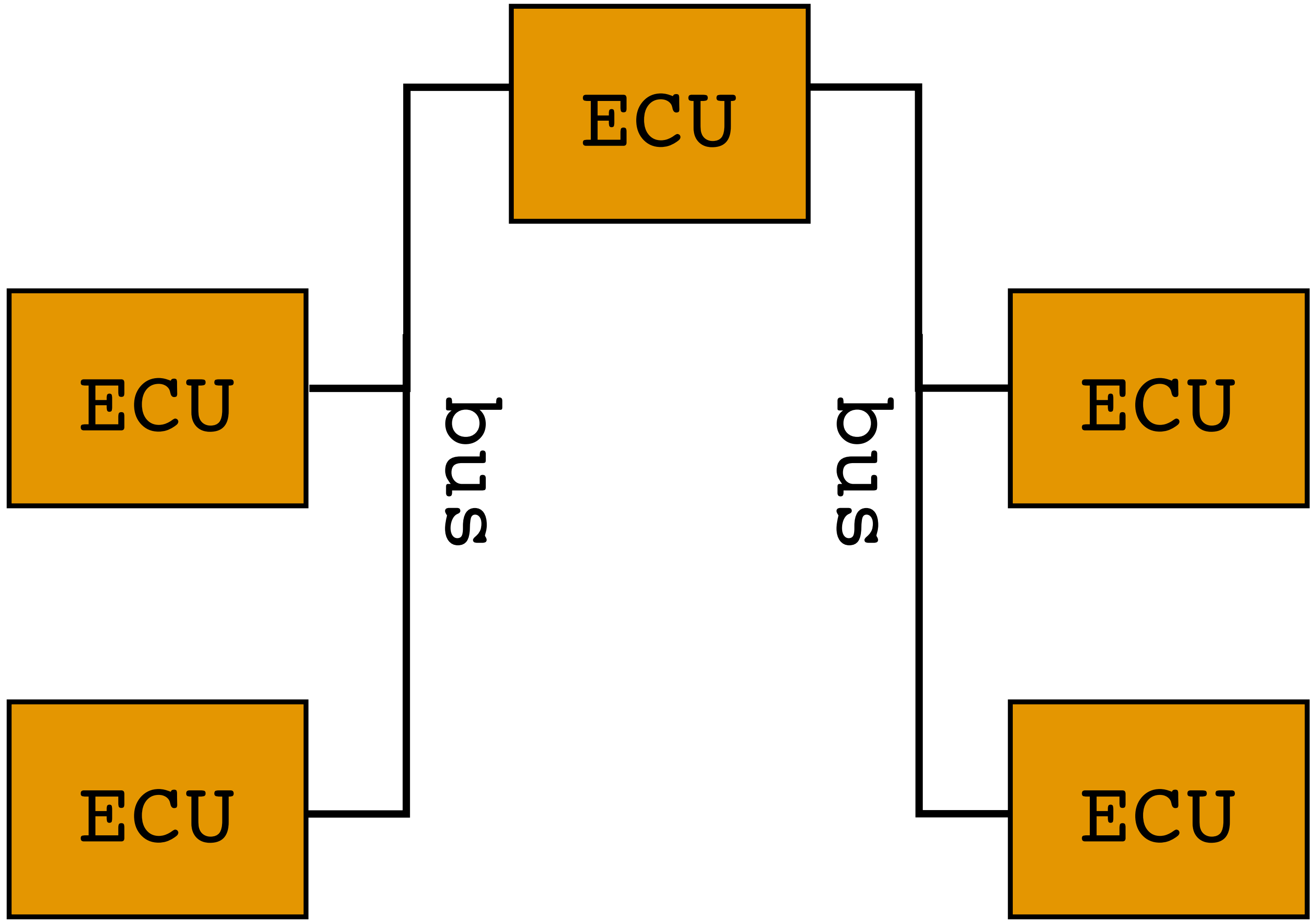
Base: Physical Network



~100 ECU (nodes)

Data Abstraction

Base: Physical Network

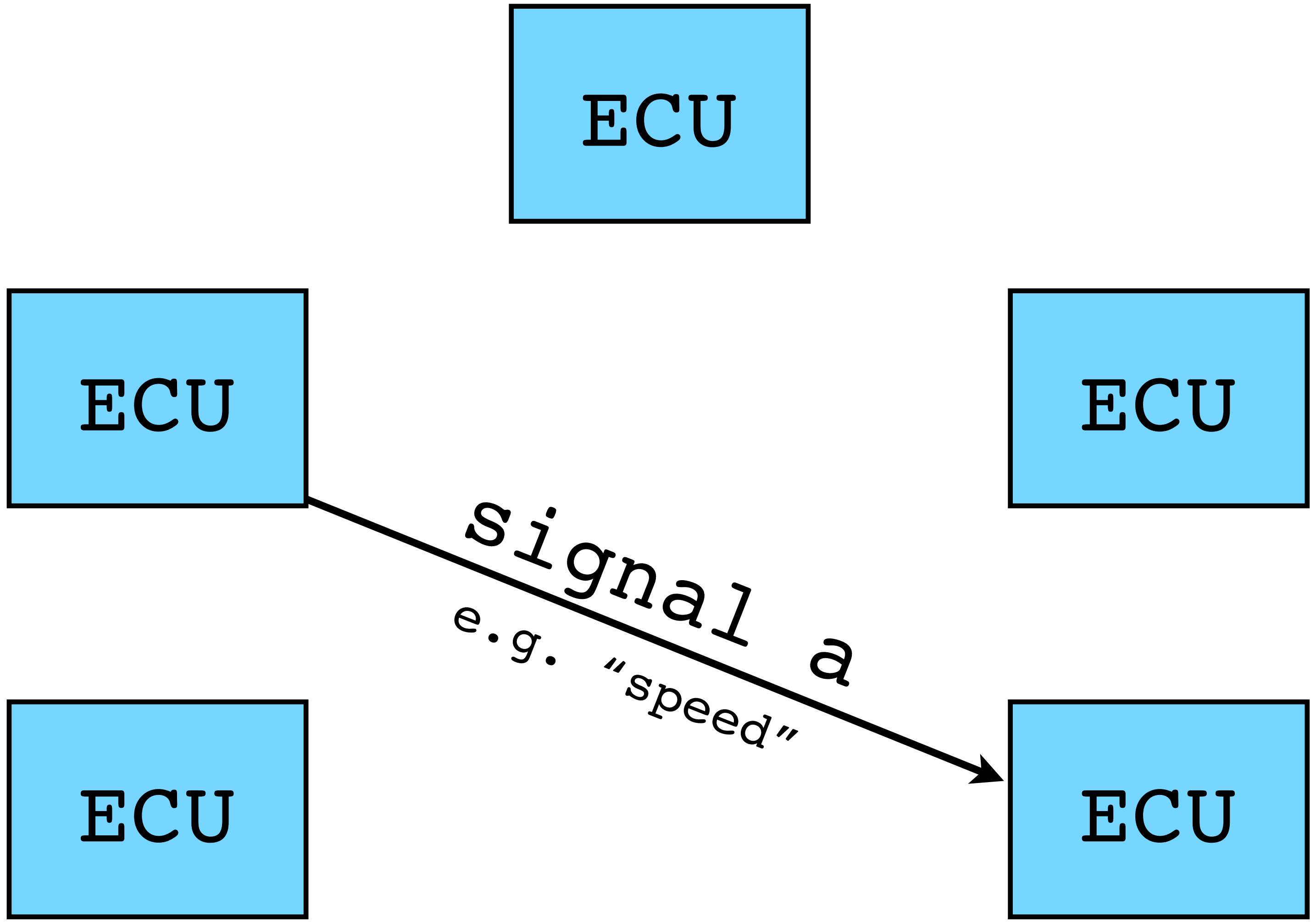


~100 ECU (nodes)

10-15 Bus systems (edges)

DATA ABSTRACTION

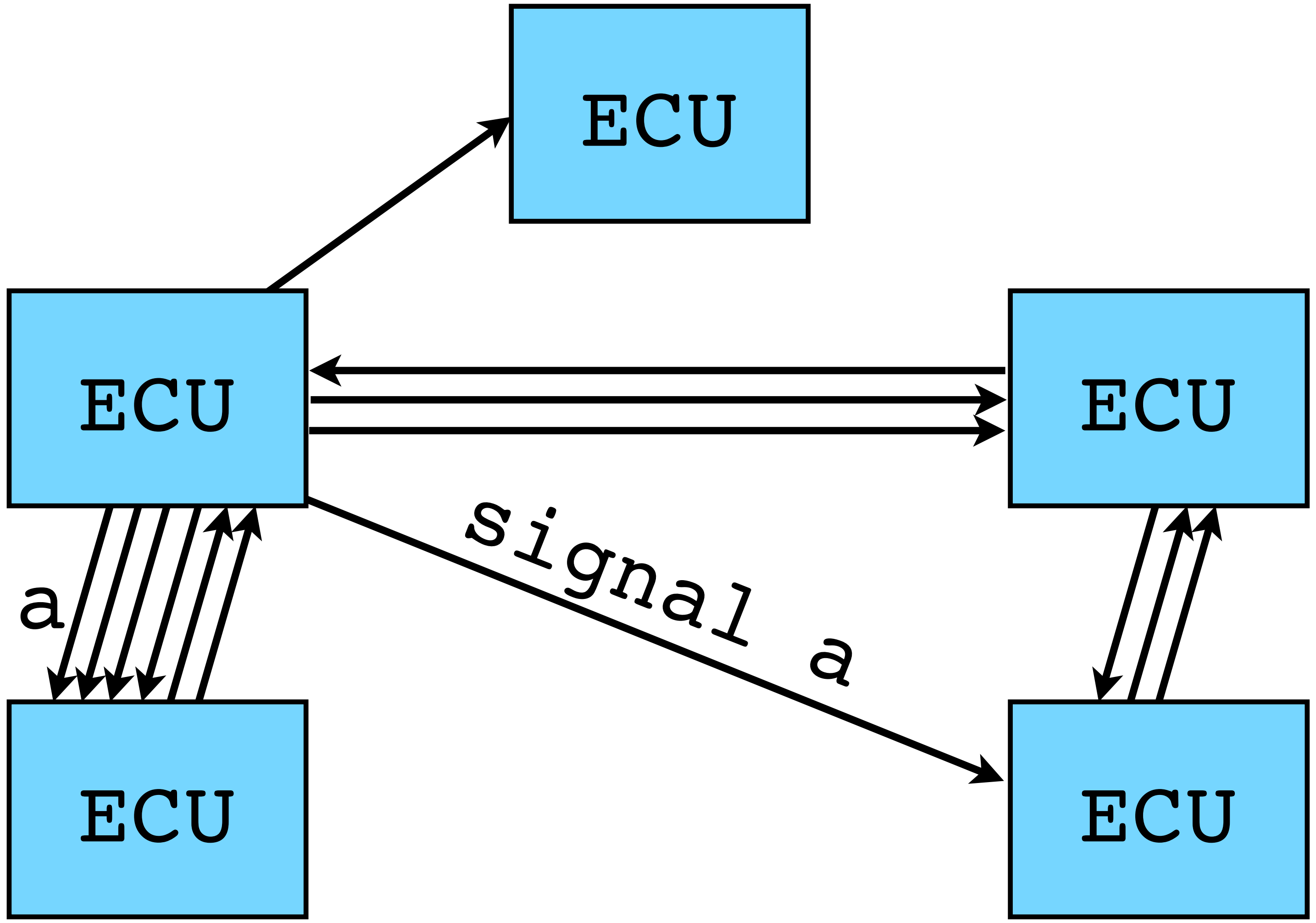
Overlay: Logical Network



~100 ECU (nodes)

Data Abstraction

Overlay: Logical Network

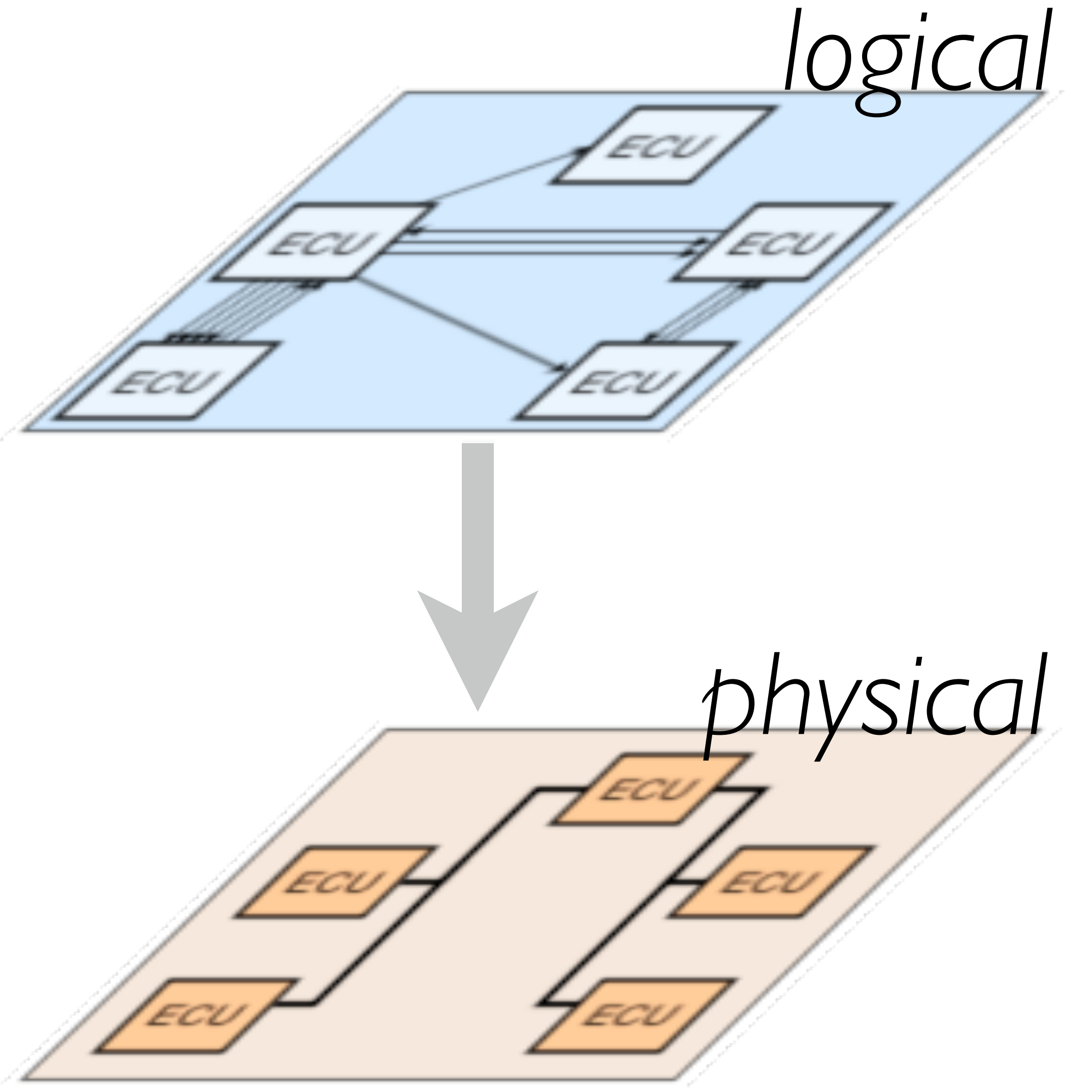


~100 ECU (nodes)

~10k signals (edges)

Data Abstraction

Mapping: Signal Path Network



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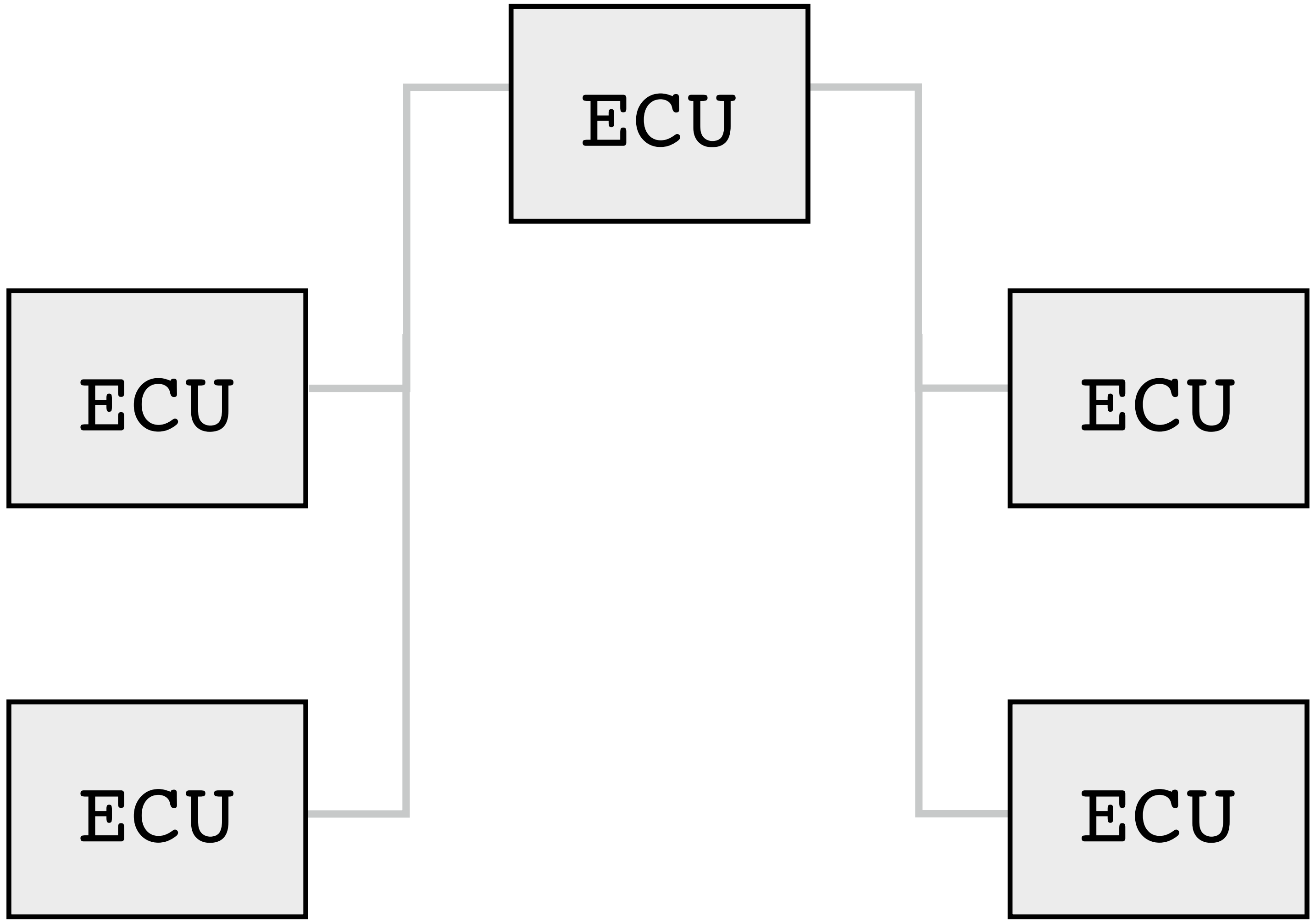
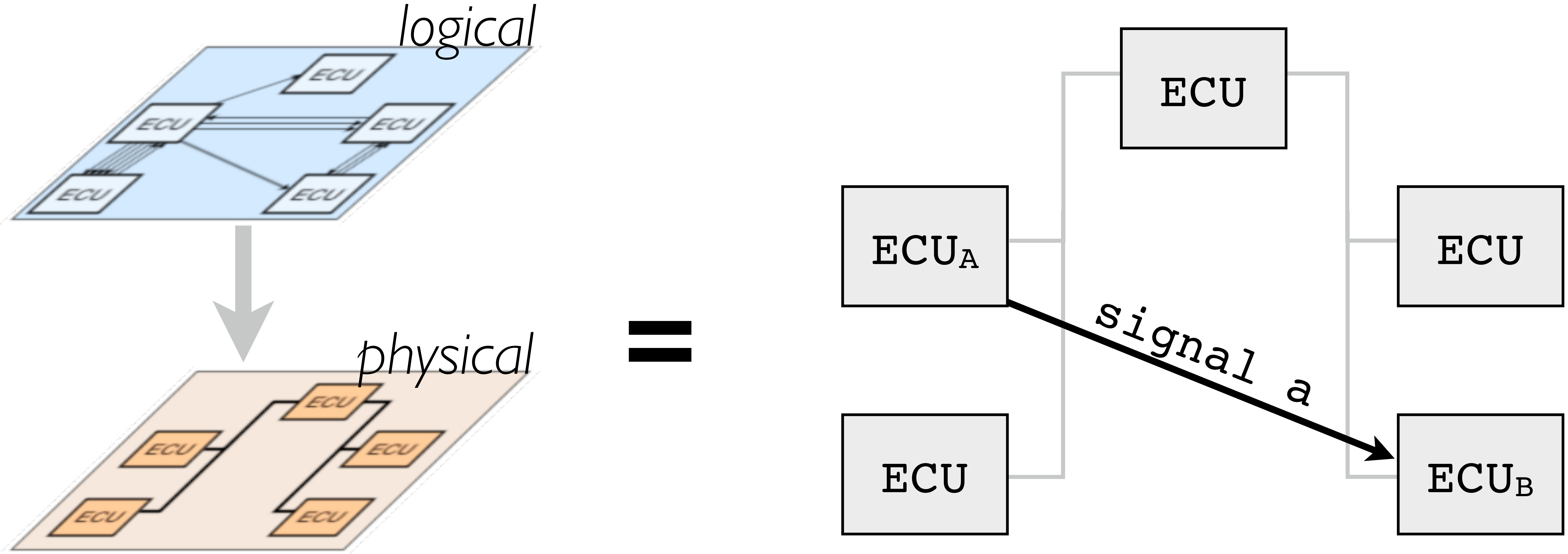
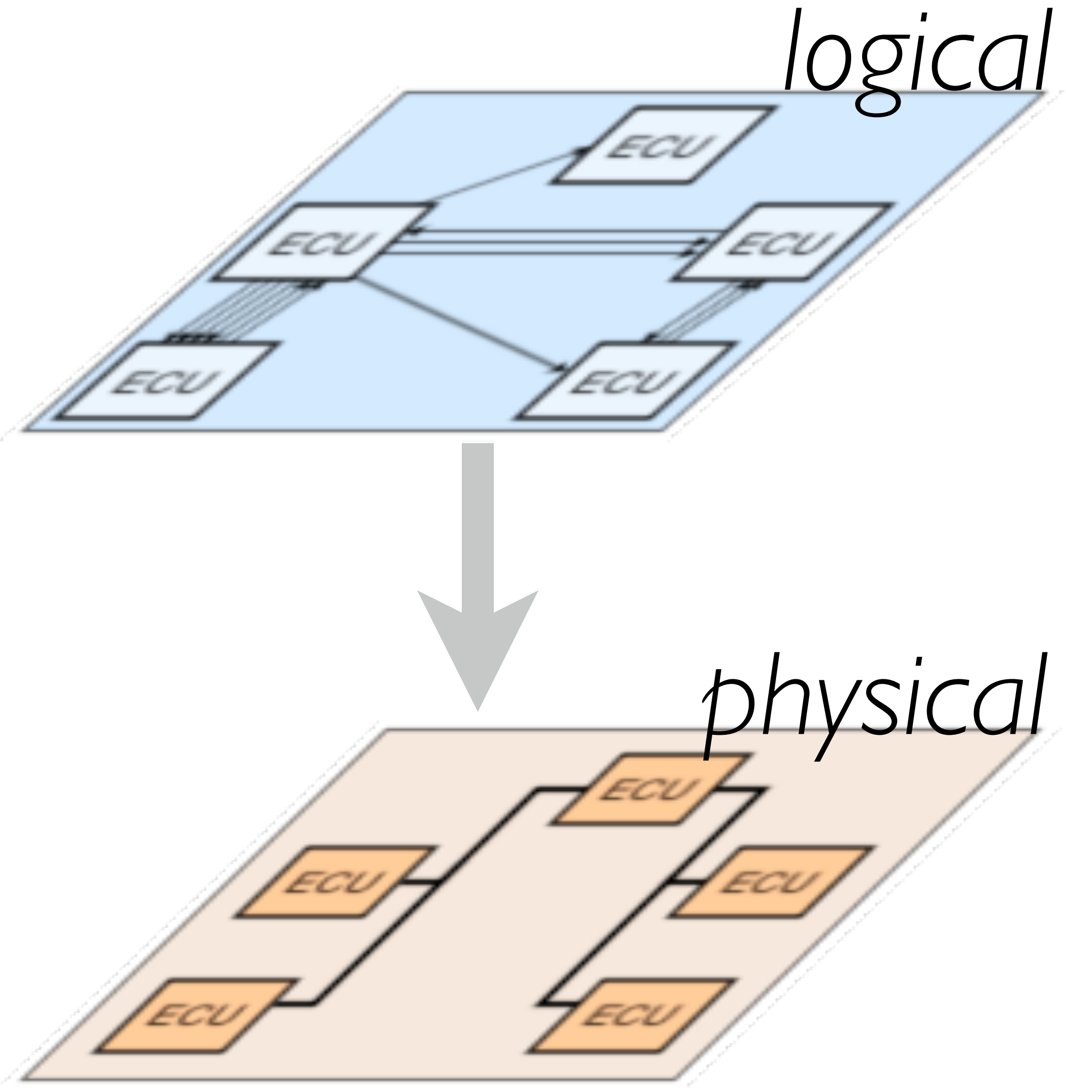


DATA ABSTRACTION
Mapping: Signal Path Network



Data Abstraction

Mapping: Signal Path Network



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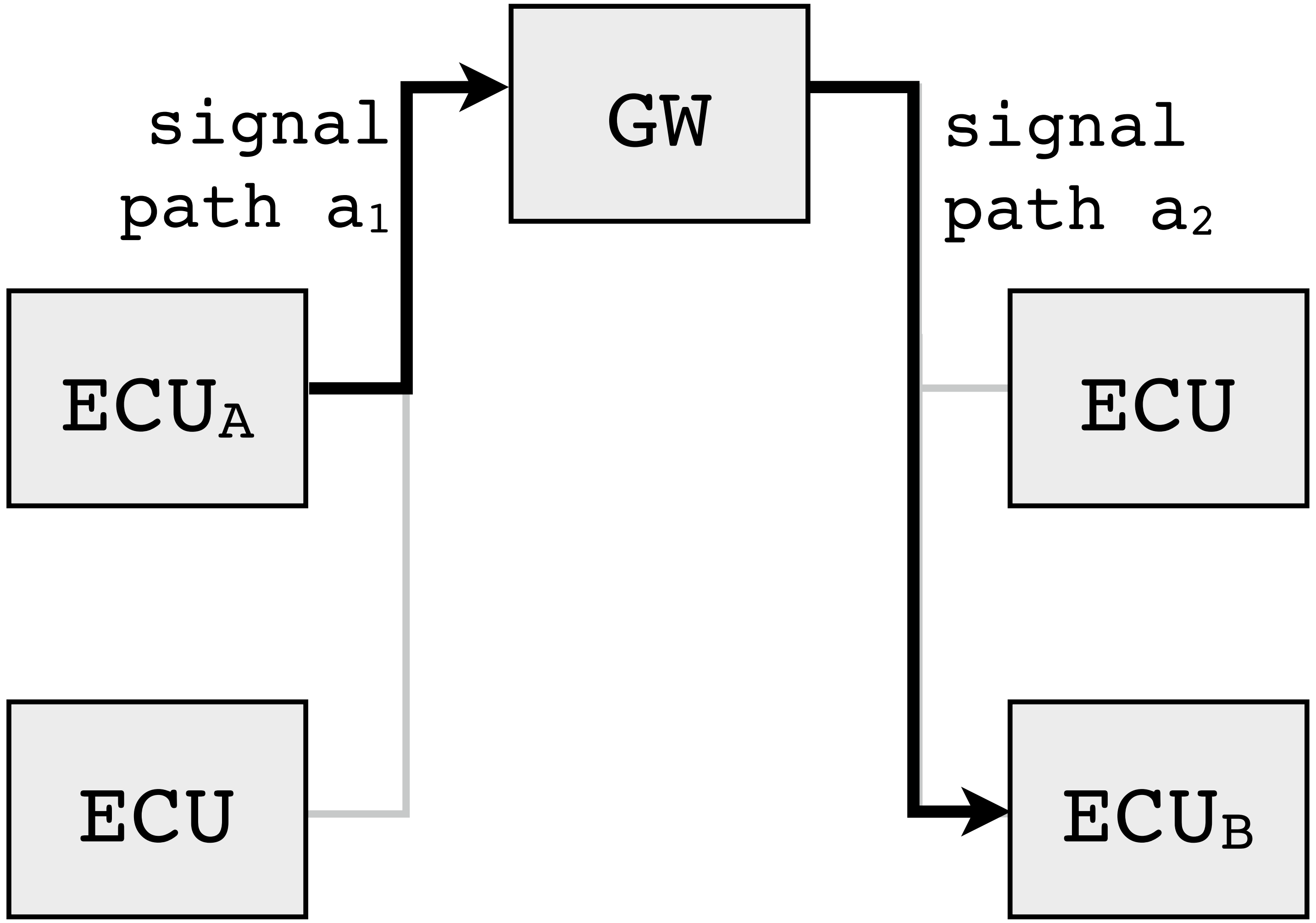
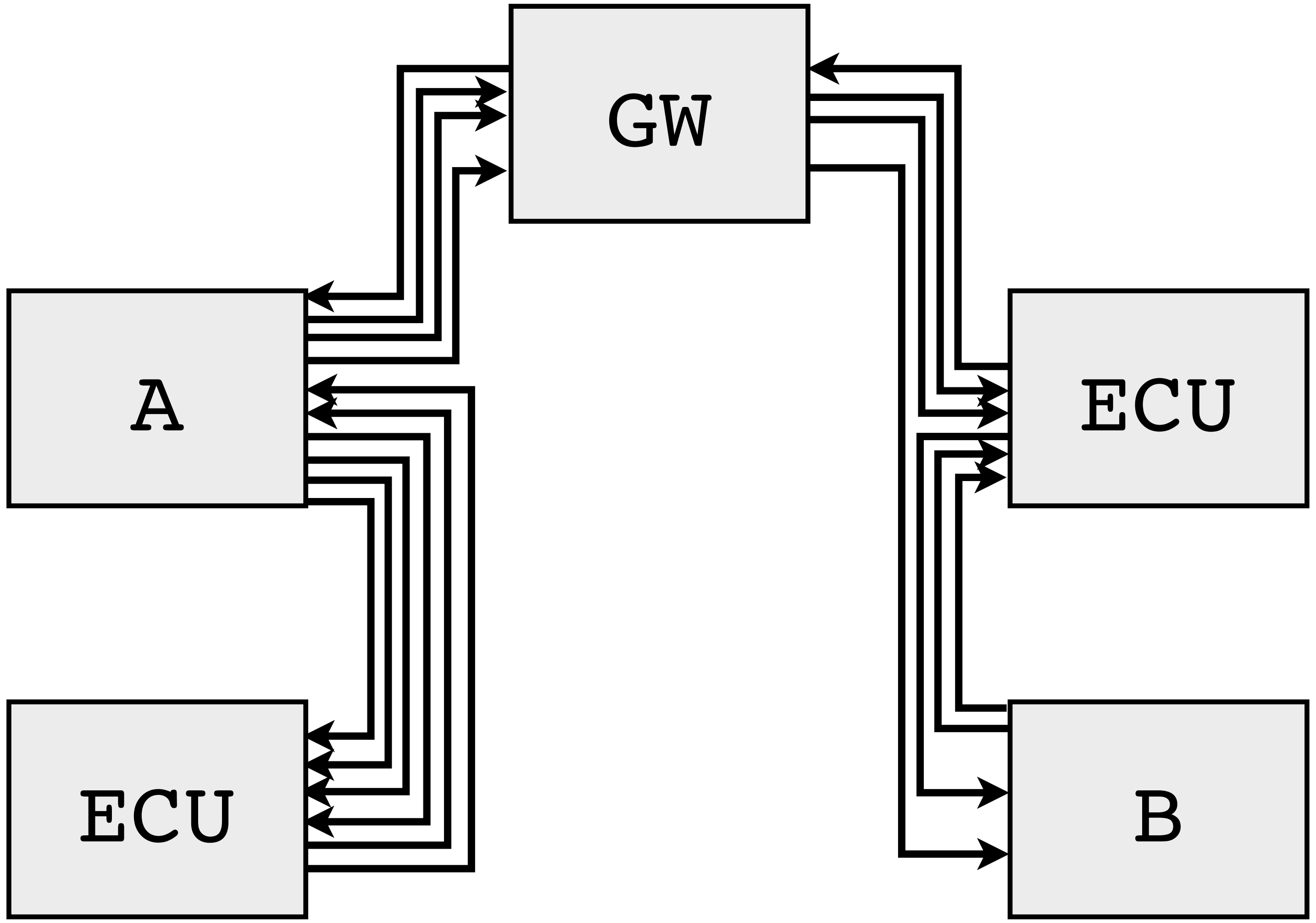


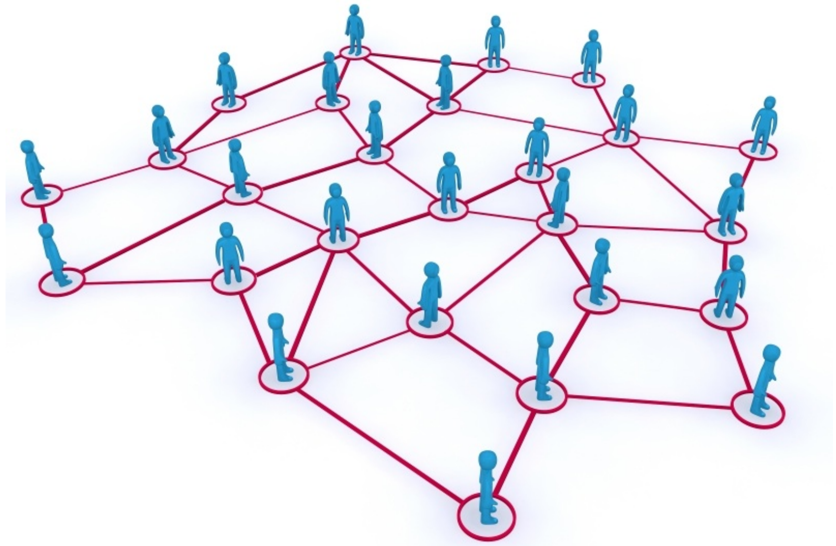
Data Abstraction

Mapping: Signal Path Network

~30k signal paths
(edges)



DATA ABSTRACTION
Differences



- Overlay network
- Path scalability
  (few nodes / dense edges)

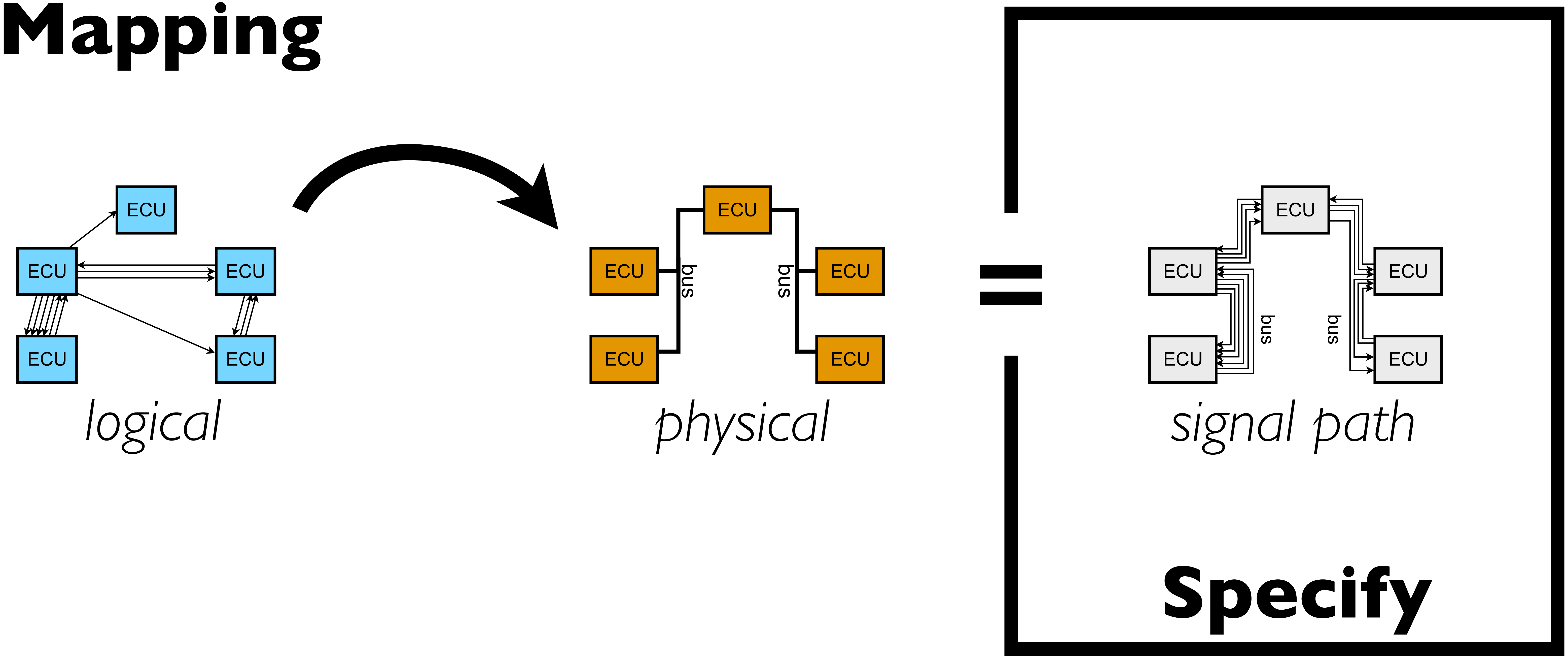
- Simple (directed) graph
- Node scalability

Problem characterization and abstraction:

Task

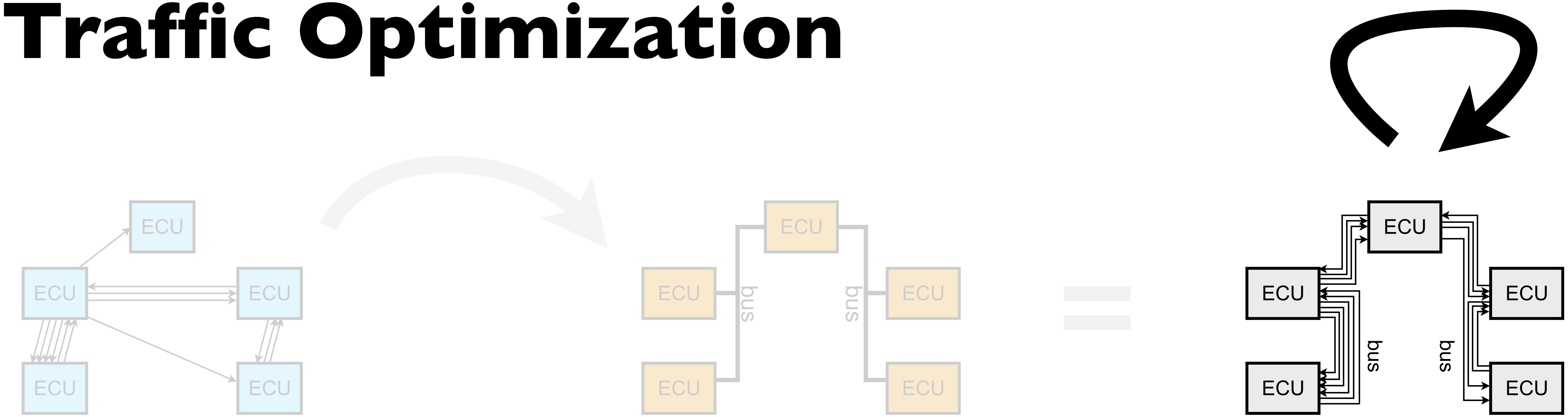
Task Abstraction

Mapping



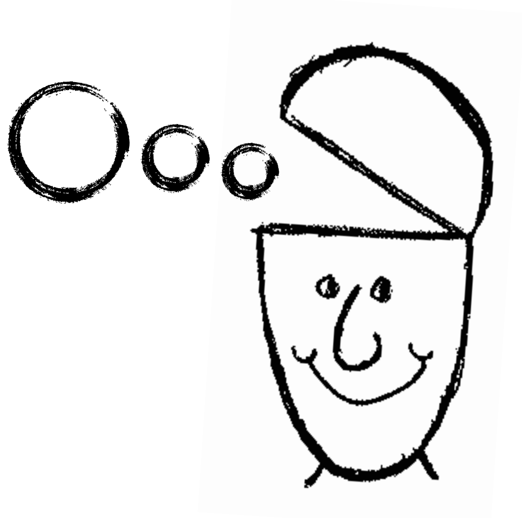
TASK ABSTRACTION

Traffic Optimization



Many constraints

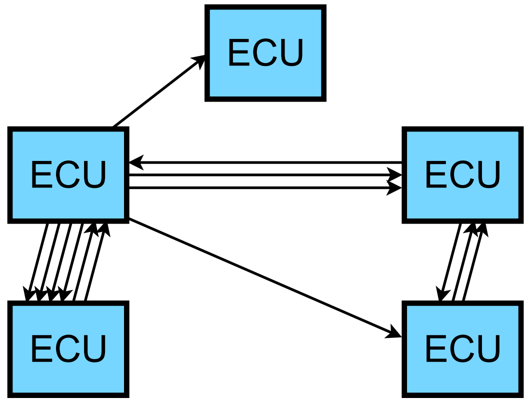
bandwidth ... delay/real time ...
path length ... load balance ...
reliability ... money ...



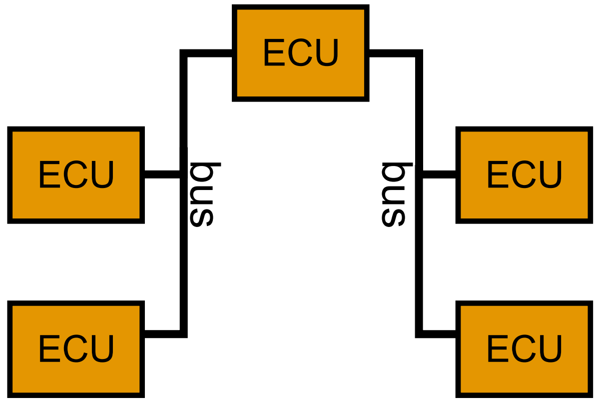
-- engineer, BMW --

Task Abstraction

External Change Requests

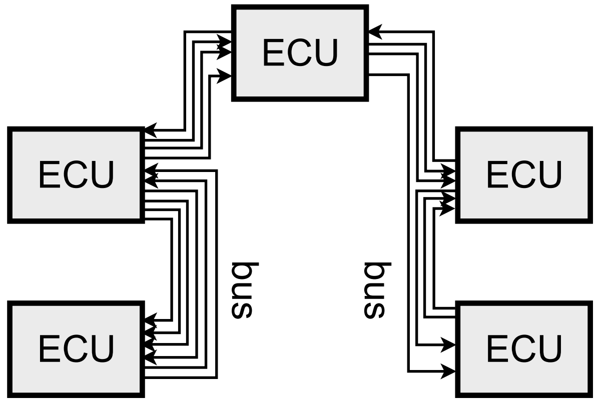


logical



physical

=



signal path

Change

(trivial requests might lead to complex changes)

Task Abstraction

Differences

Implement **active** changes

Understand **passive** changes

Low-level

Tasks

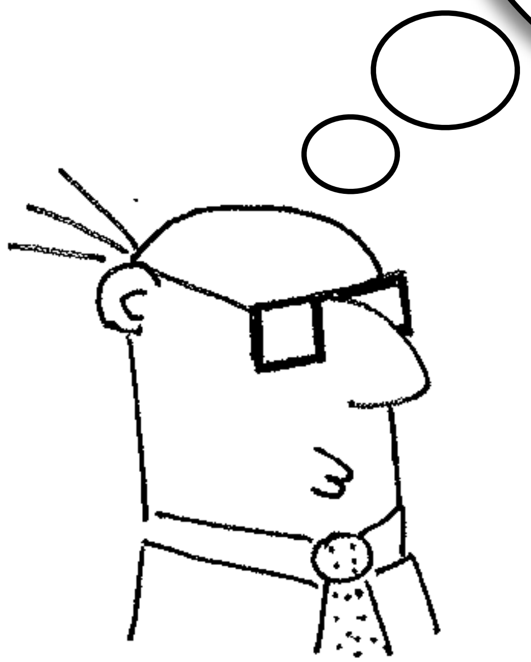
Low Level Tasks

Queries about relations

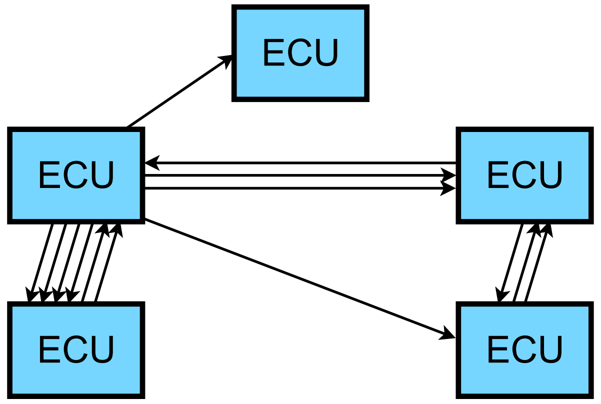
Which ECU is communicating with which ECU?

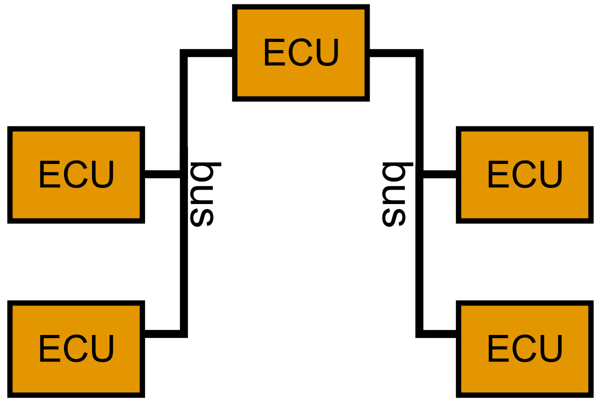
Which signals do they exchange?

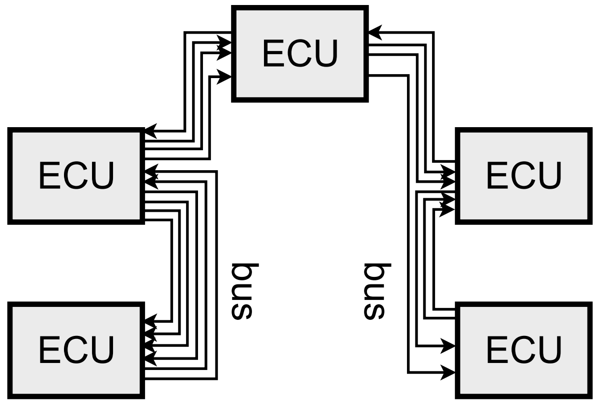
What is the path the signals take? ...



-- *engineer, BMW* --

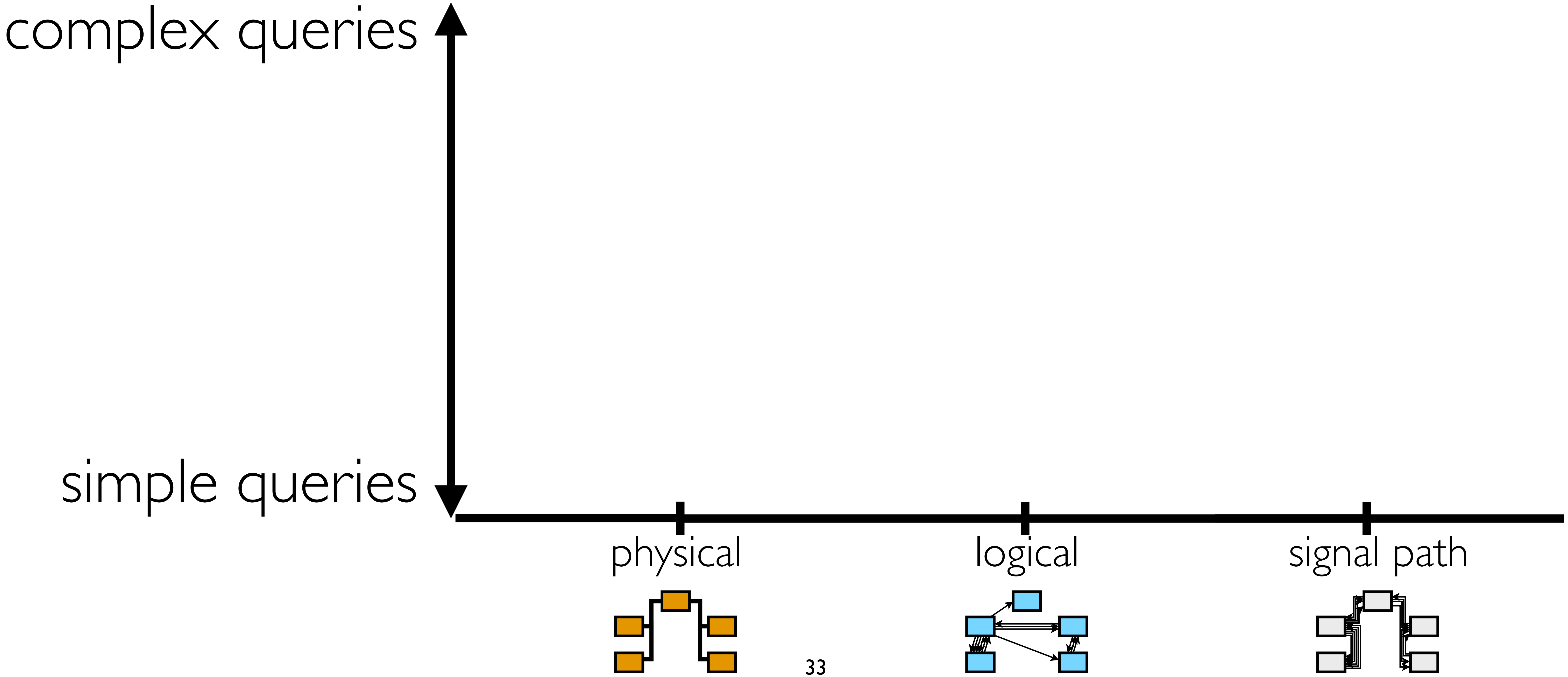




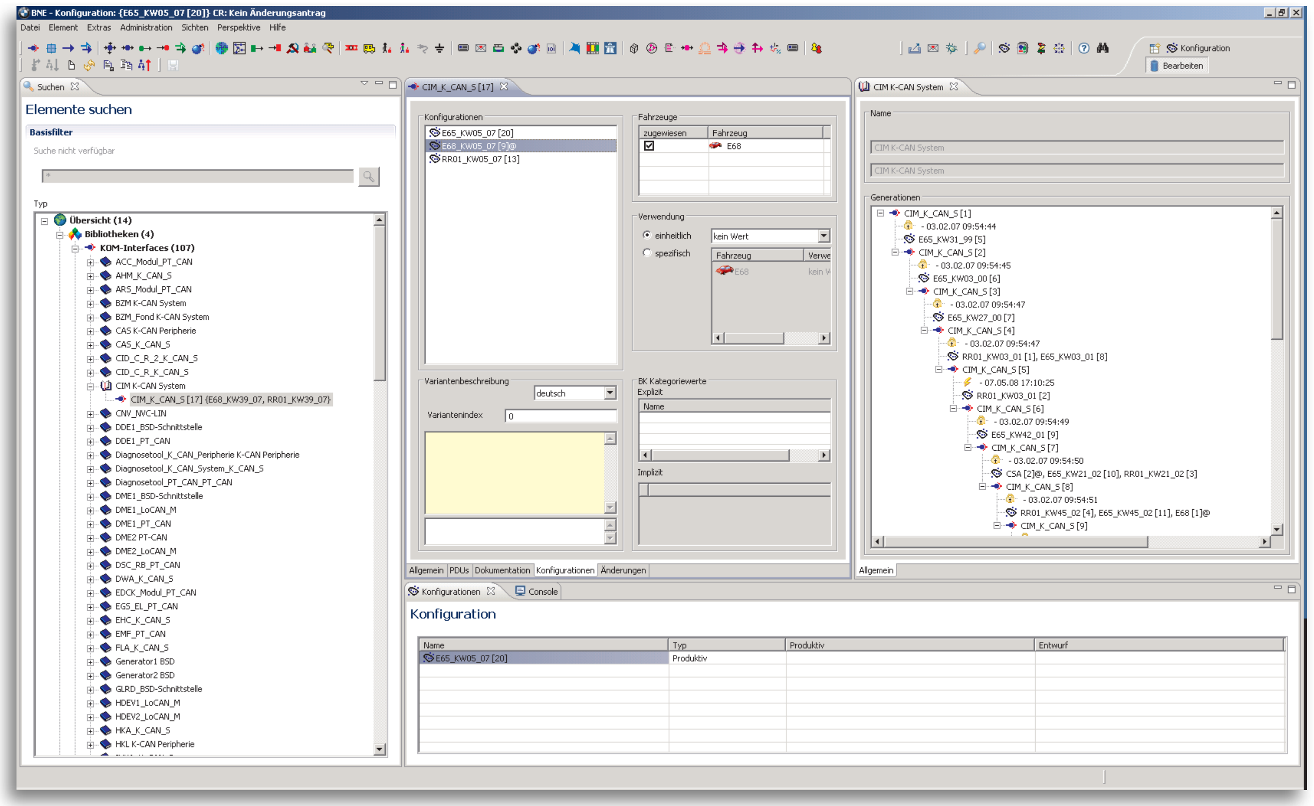


Low Level Tasks

Query complexity



Low Level Tasks
Query complexity

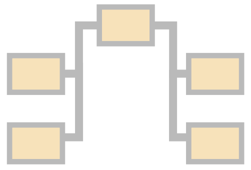


complex queries

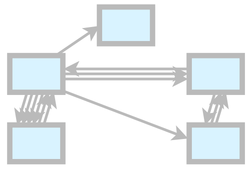
simple queries

2-way relations

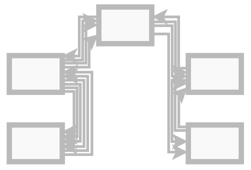
physical



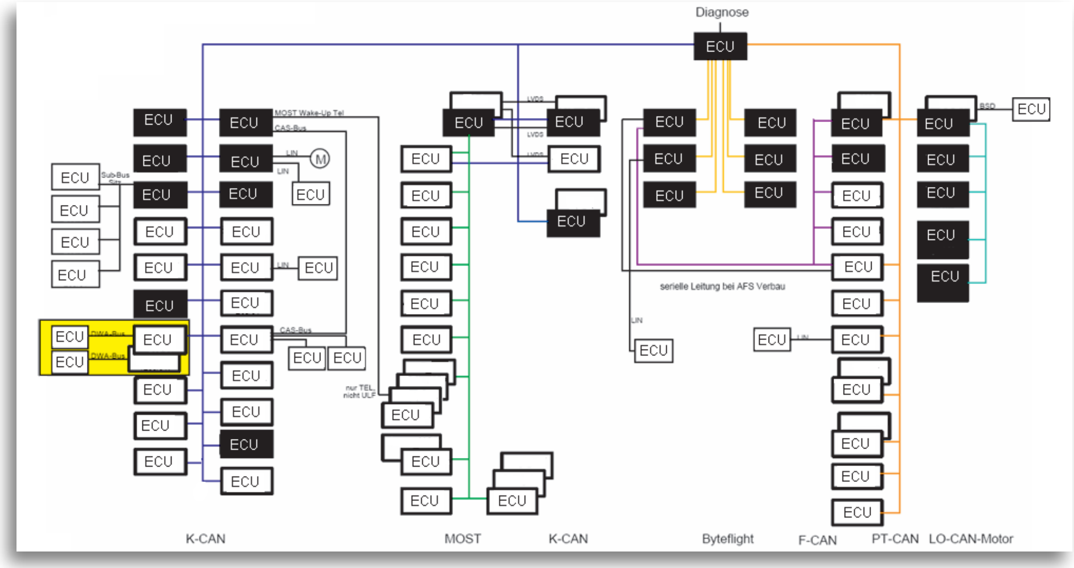
logical

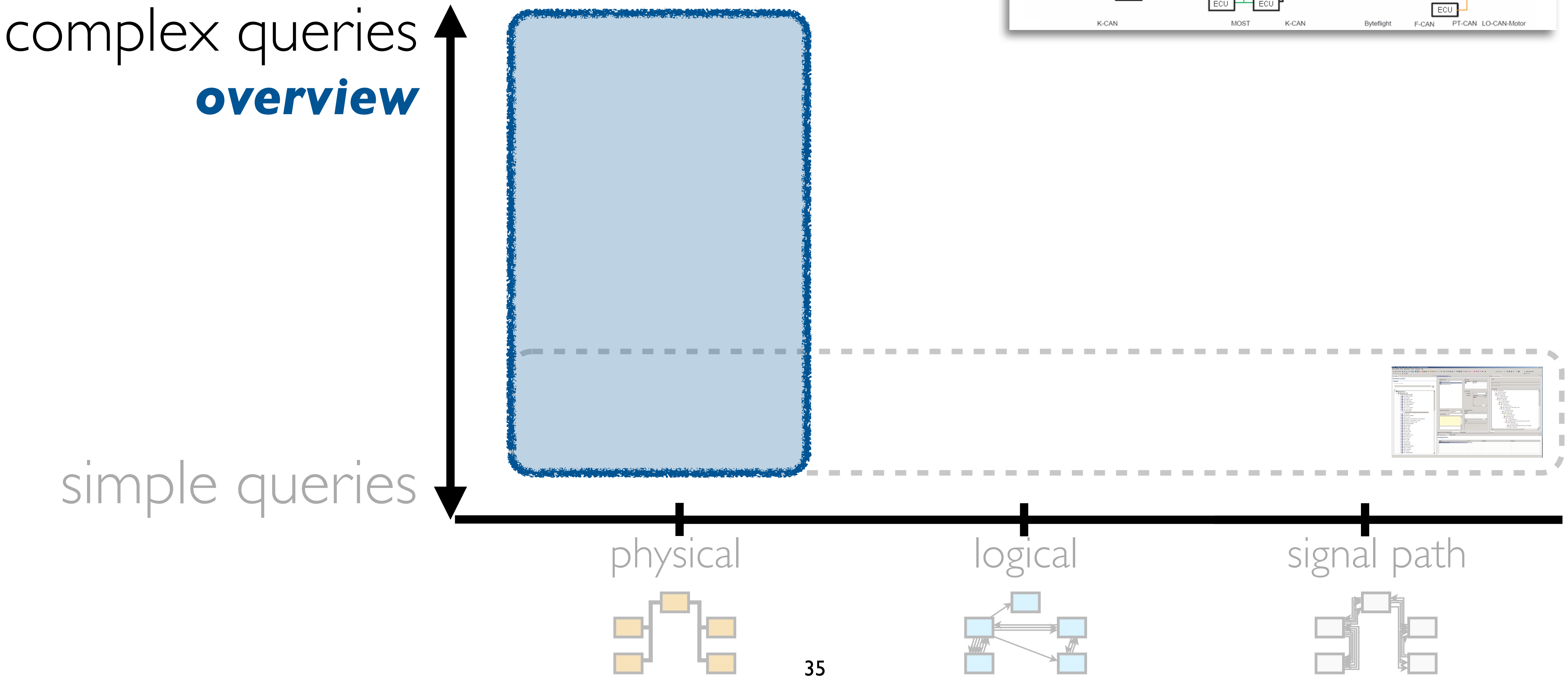


signal path

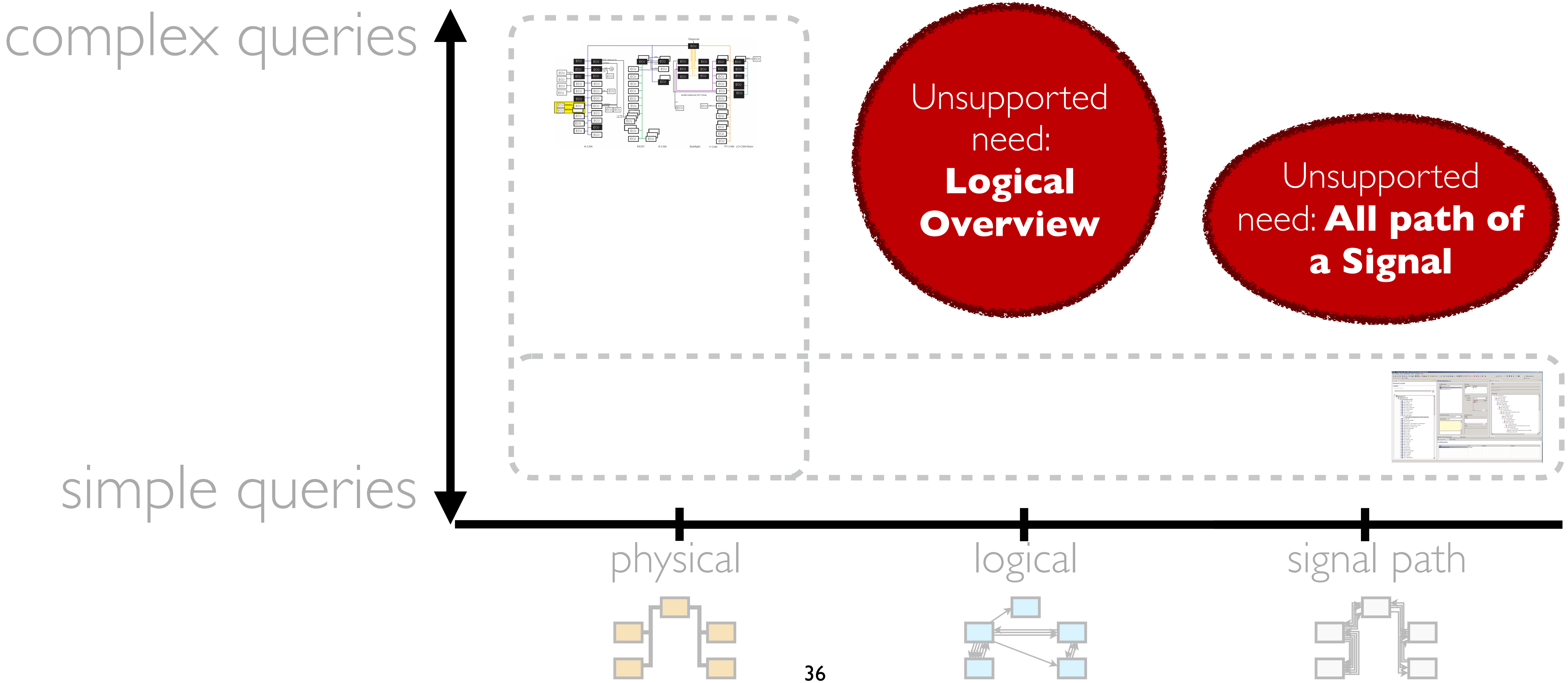


Low Level Tasks
Query complexity

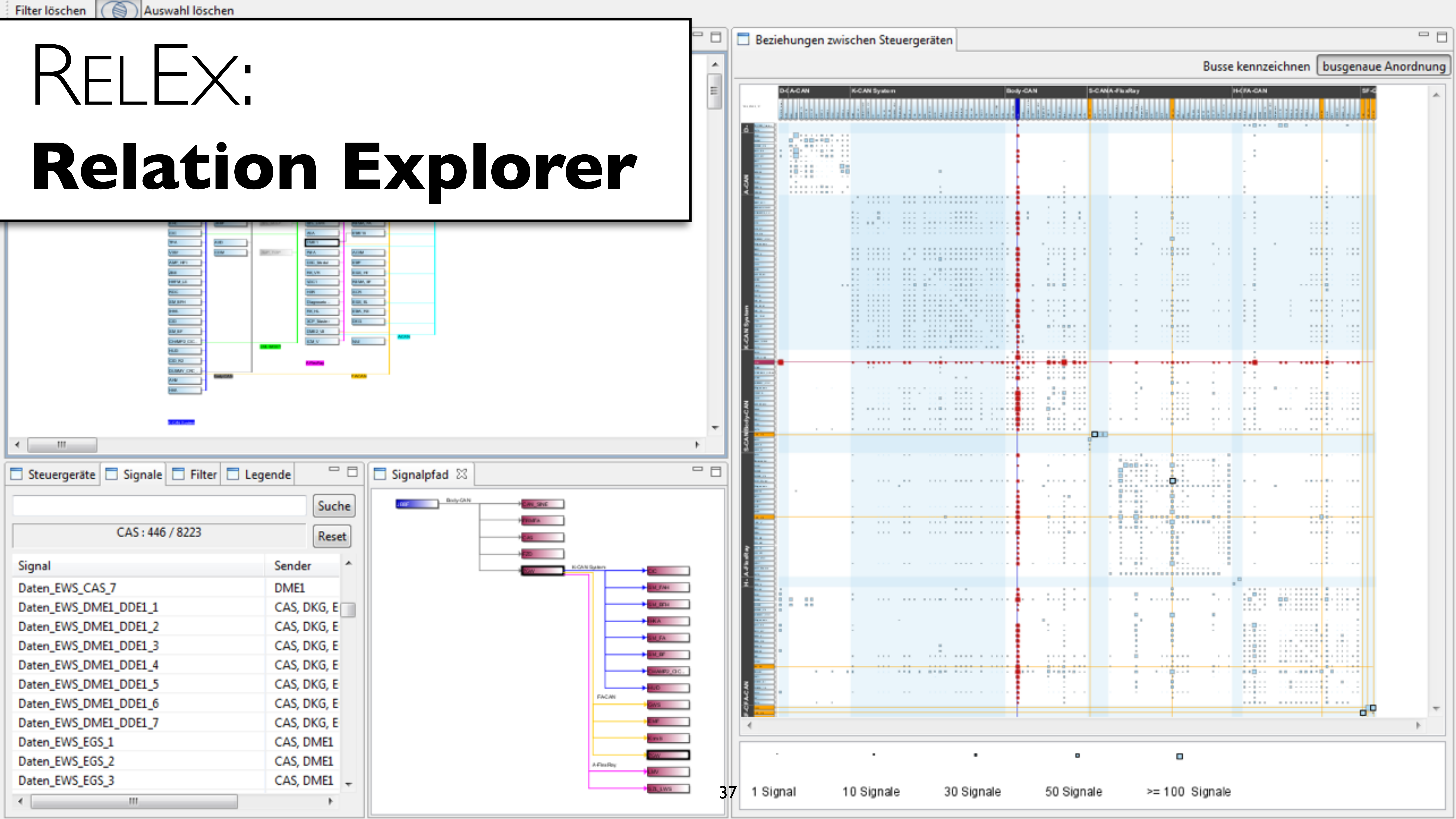




Low Level Tasks
Query complexity

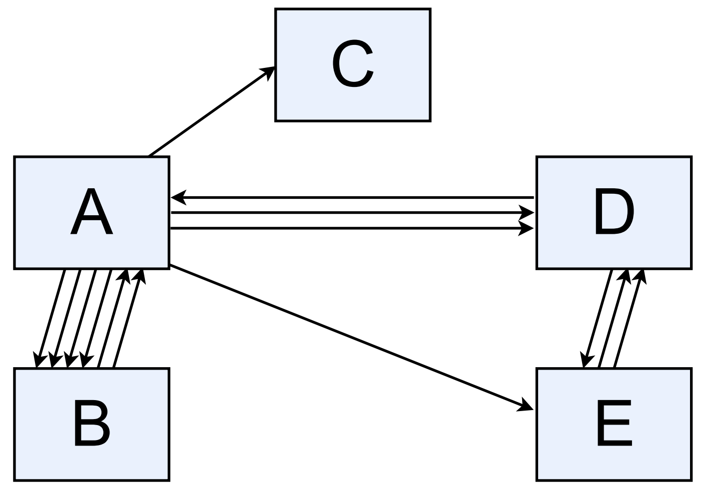


RelEx: **Relation Explorer**



RELEX:
Logical Overview

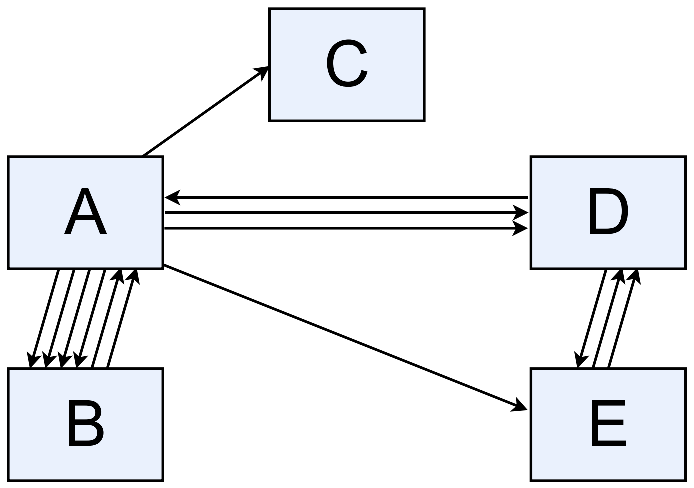
LOGICAL NETWORK



- multigraph
- 100 nodes /10k edges

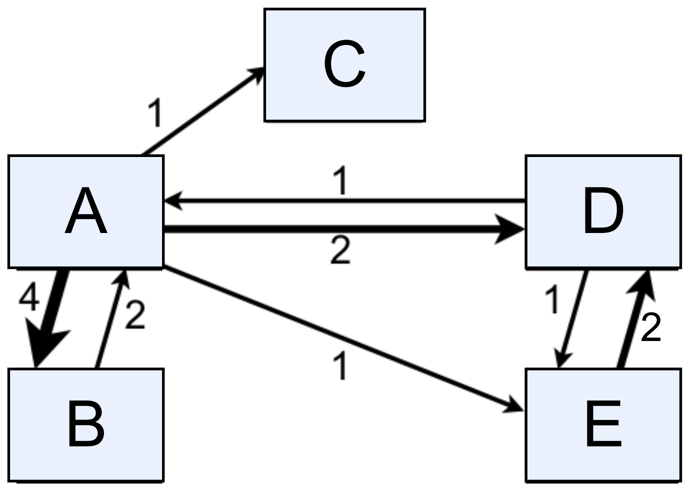
RELEX: **Logical Overview**

LOGICAL NETWORK



- multigraph
- 100 nodes /10k edges

SIGNAL COUNT NETWORK

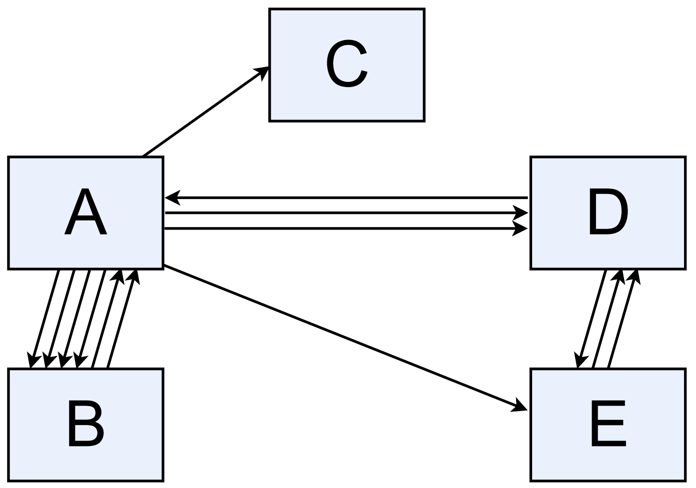


- directed graph
- 1k weighted edges

RelEx: **Logical Overview**

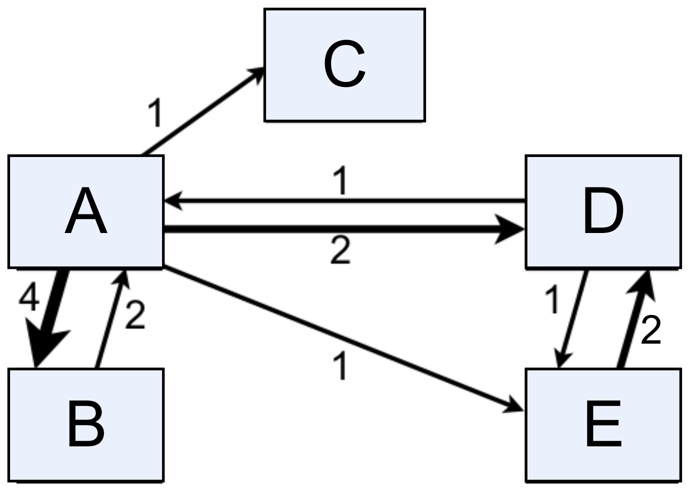
Vis Guideline [Ghoniem 2005]
Matrix for dense graphs

Logical Network



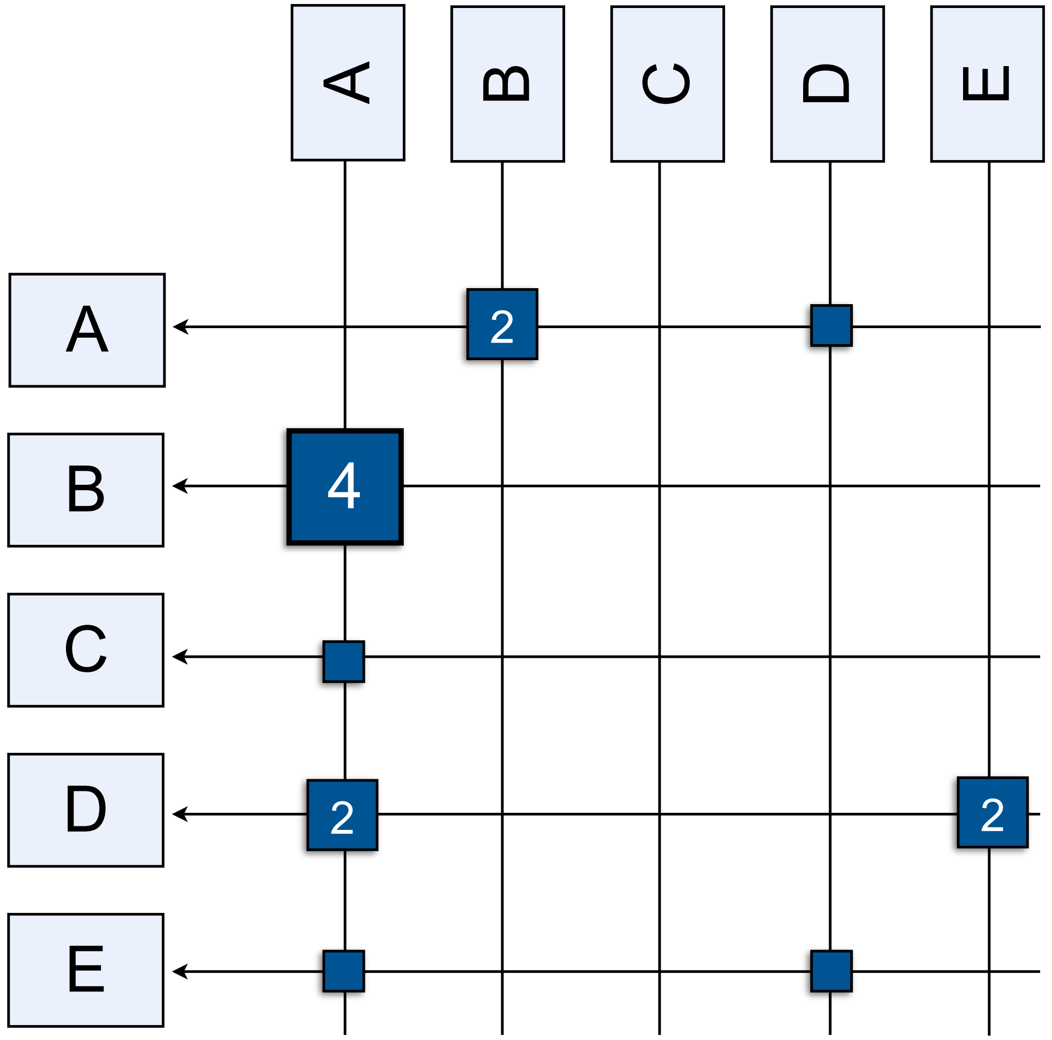
- multigraph
- 100 nodes / 10k edges

Signal Count Network

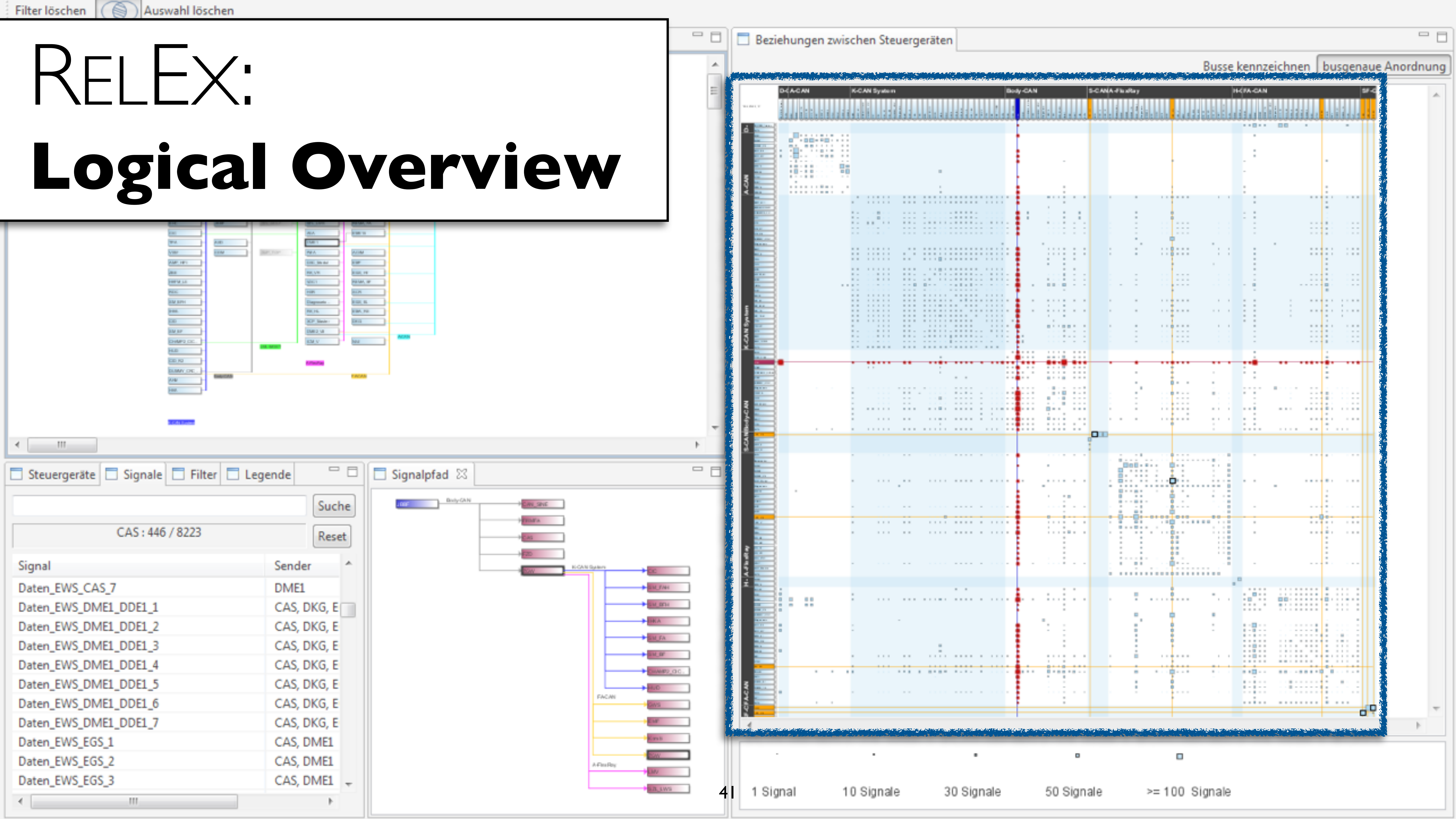


- directed graph
- 1k weighted edges

Visual Encoding: Size-Coded Matrix



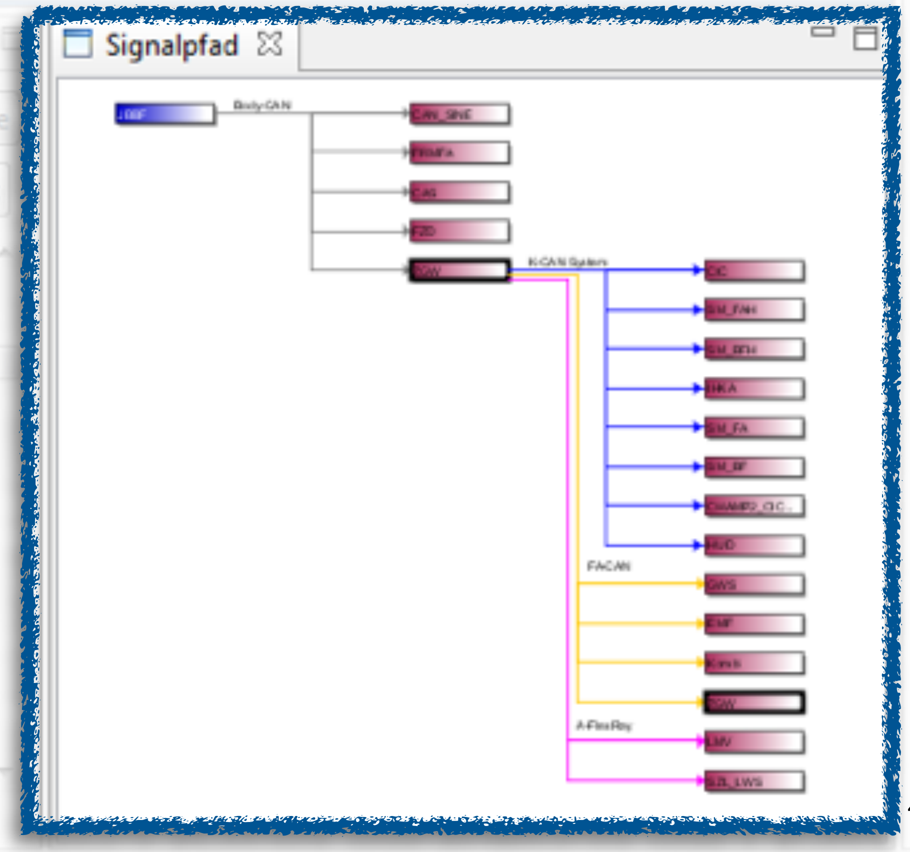
RelEx: **Logical Overview**



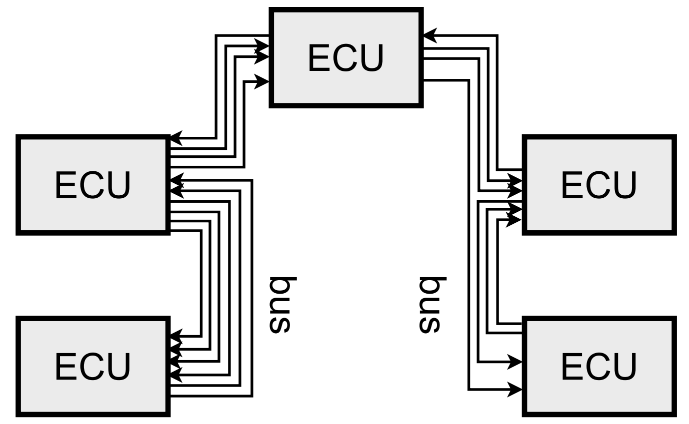
ReLEx: **All Path of a Signal**

Vis Guideline [Ghoniem 2005]

Node-link for path following tasks

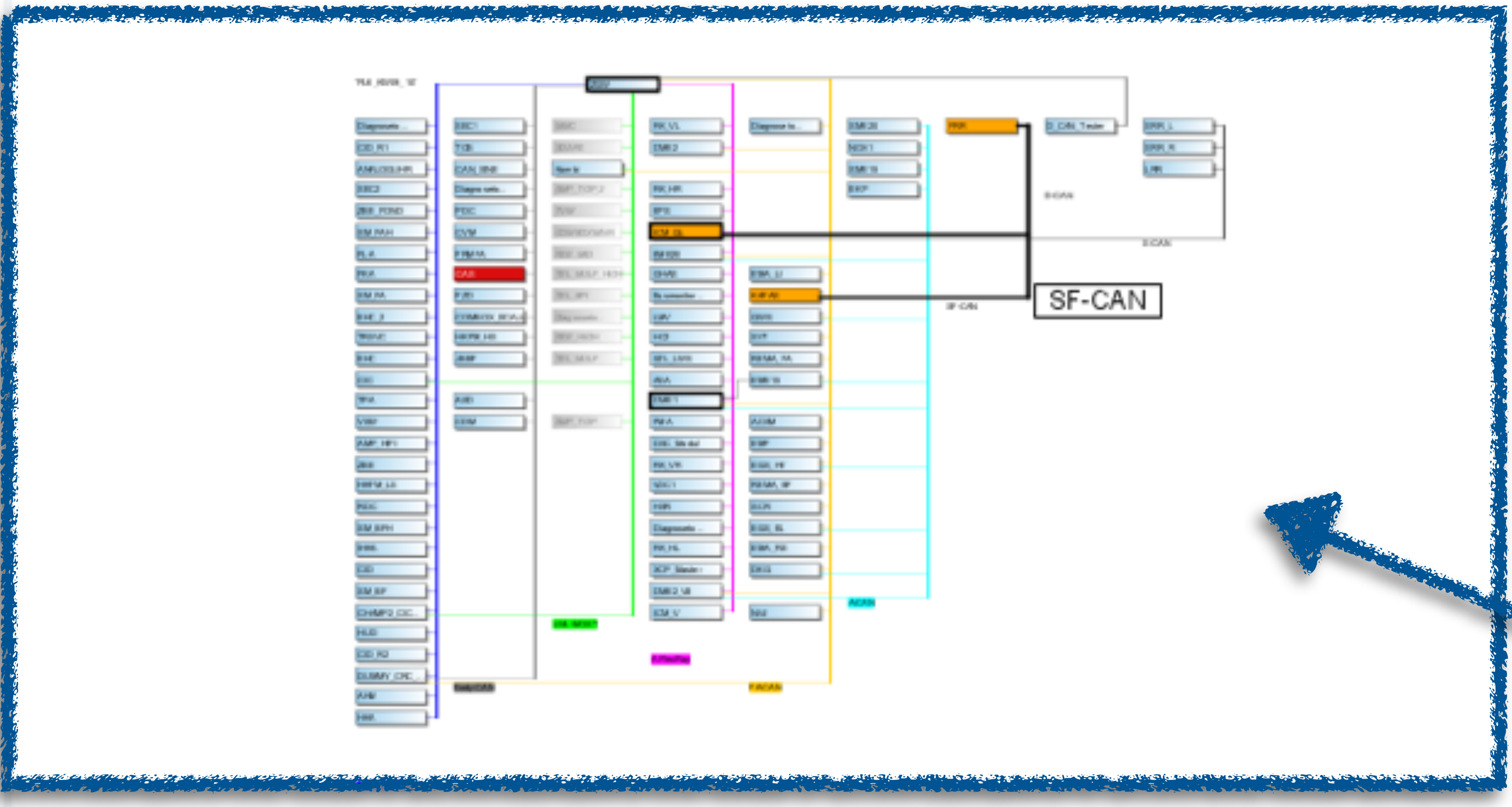


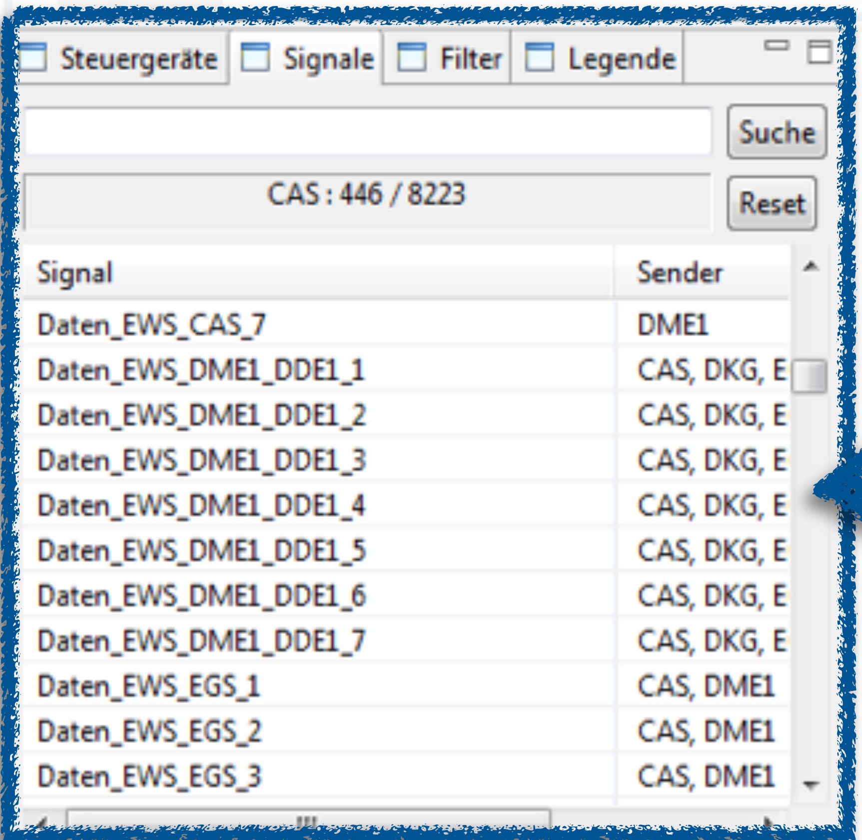
Signal Path Network

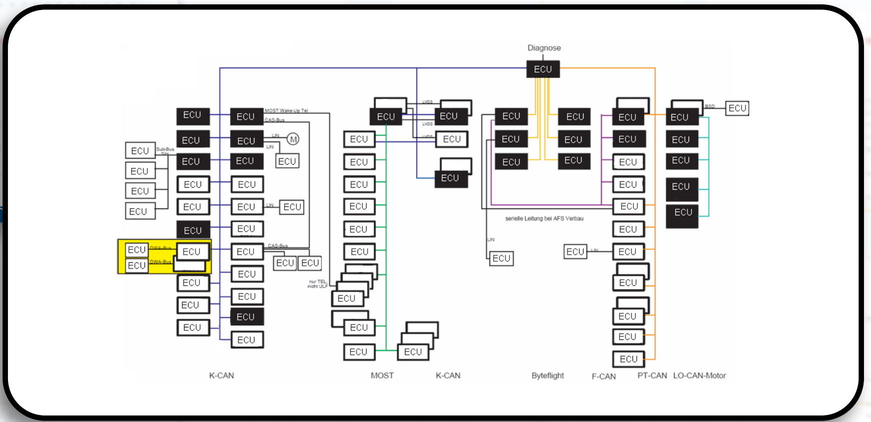


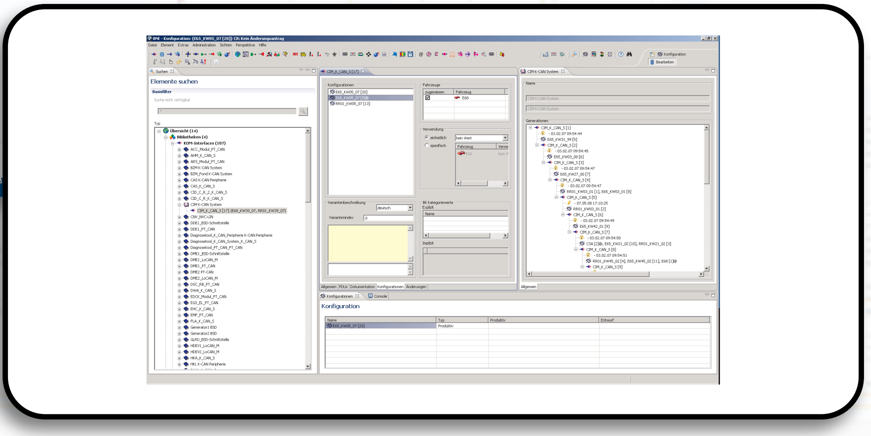
filtered by signal

MORE STUFF:
Support of Current Practices

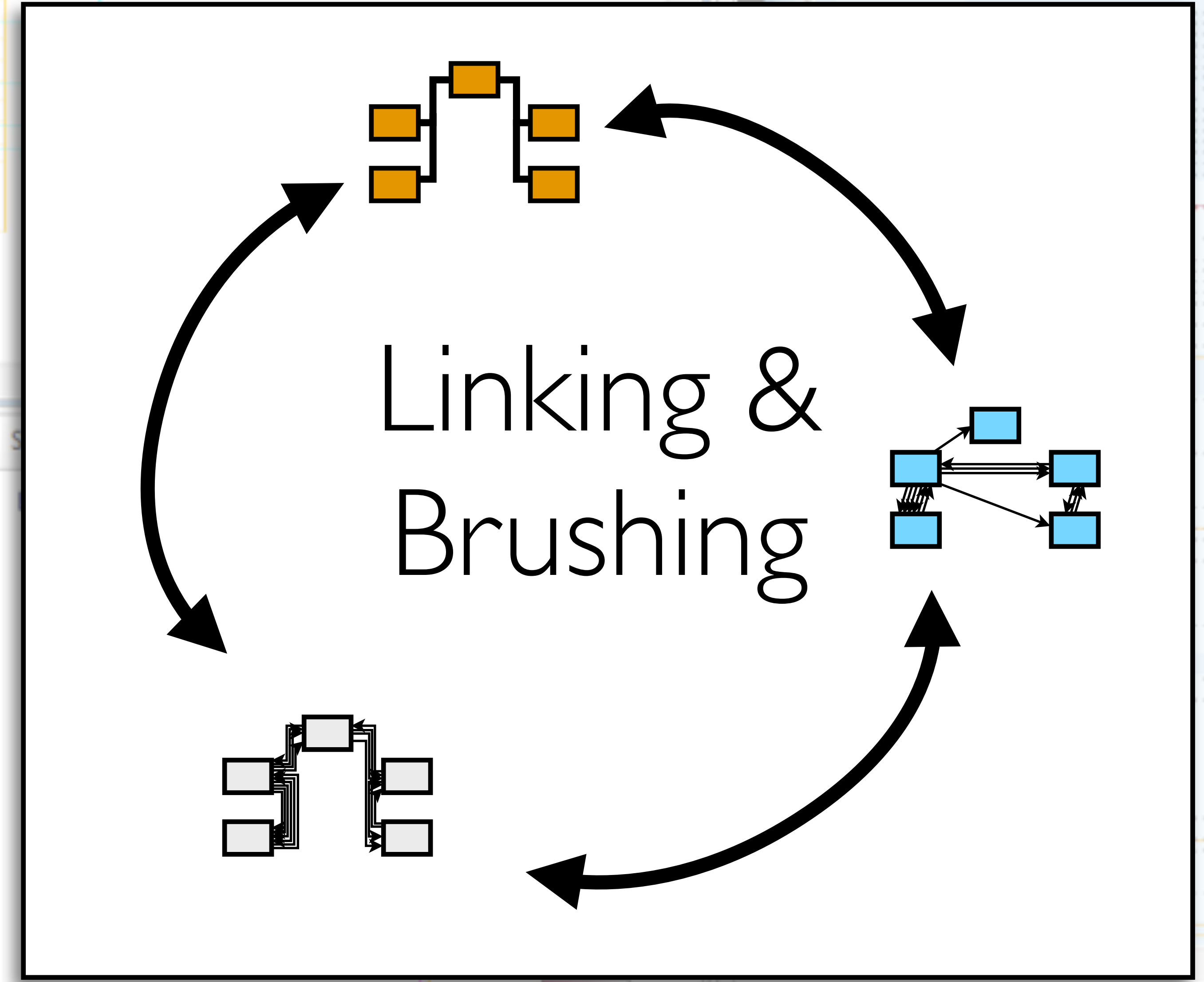








MORE STUFF:
Cross-Network Relations

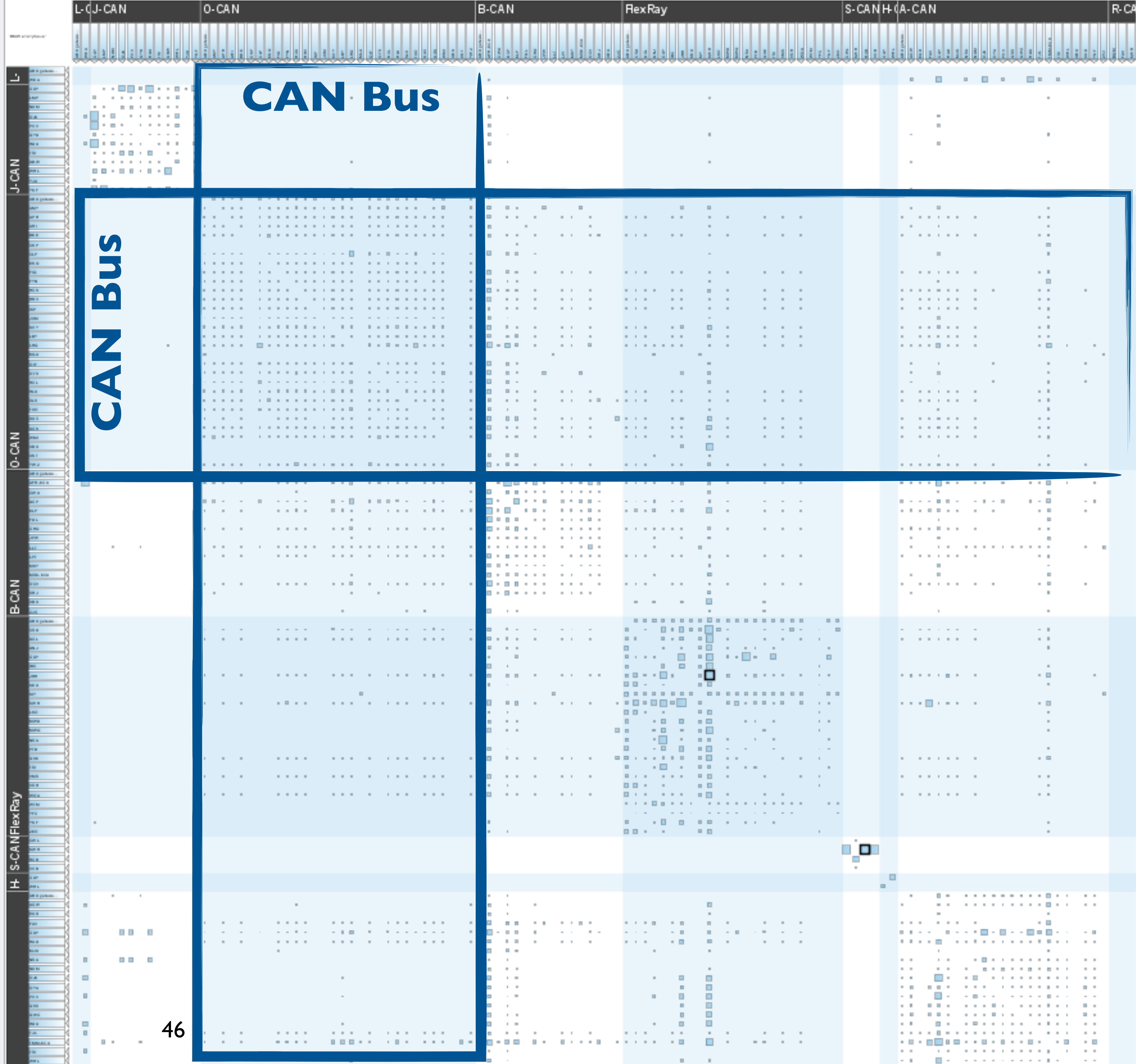


Mid-level

Interests

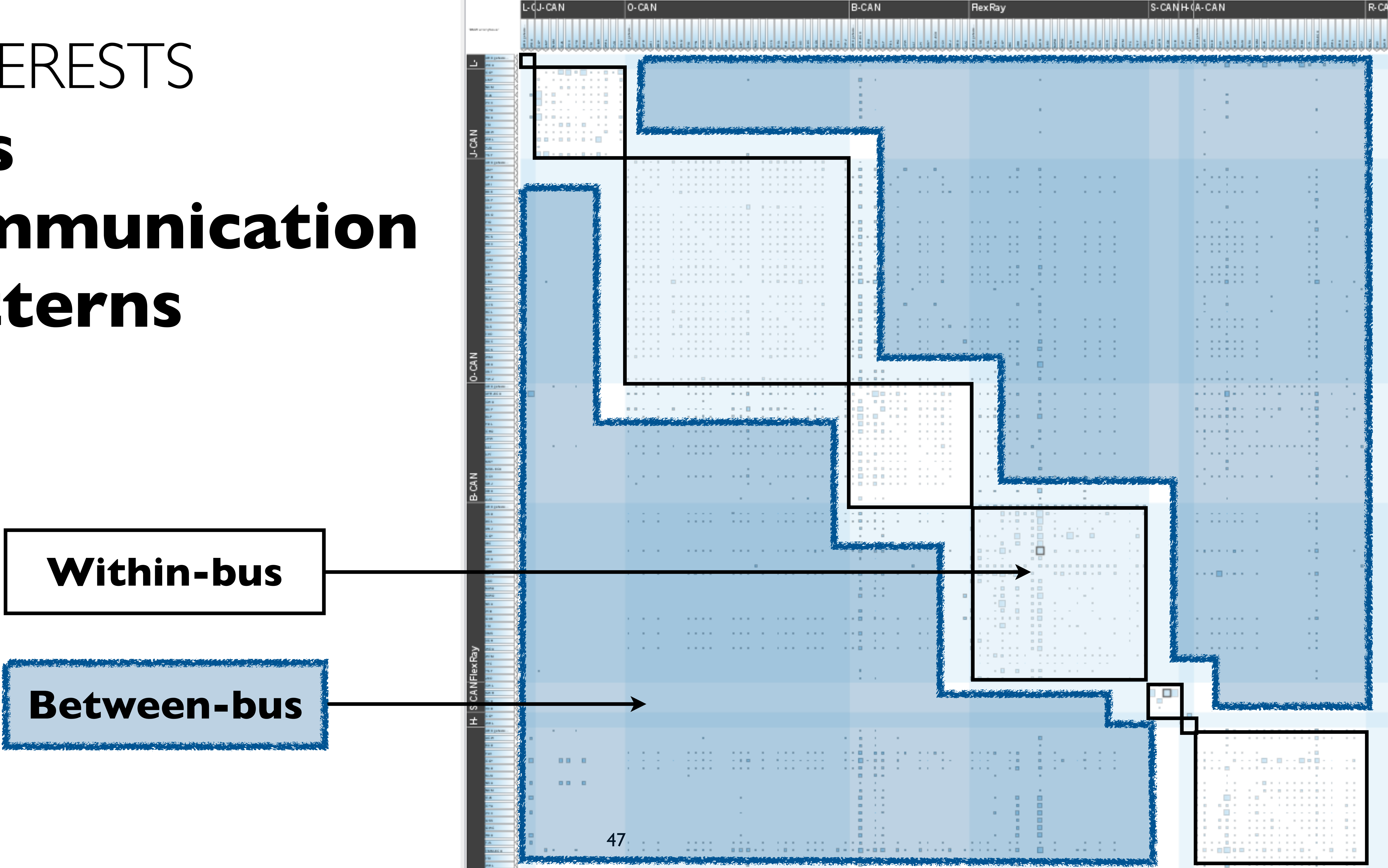
INTERESTS

Bus communication patterns



INTERESTS

Bus communication patterns



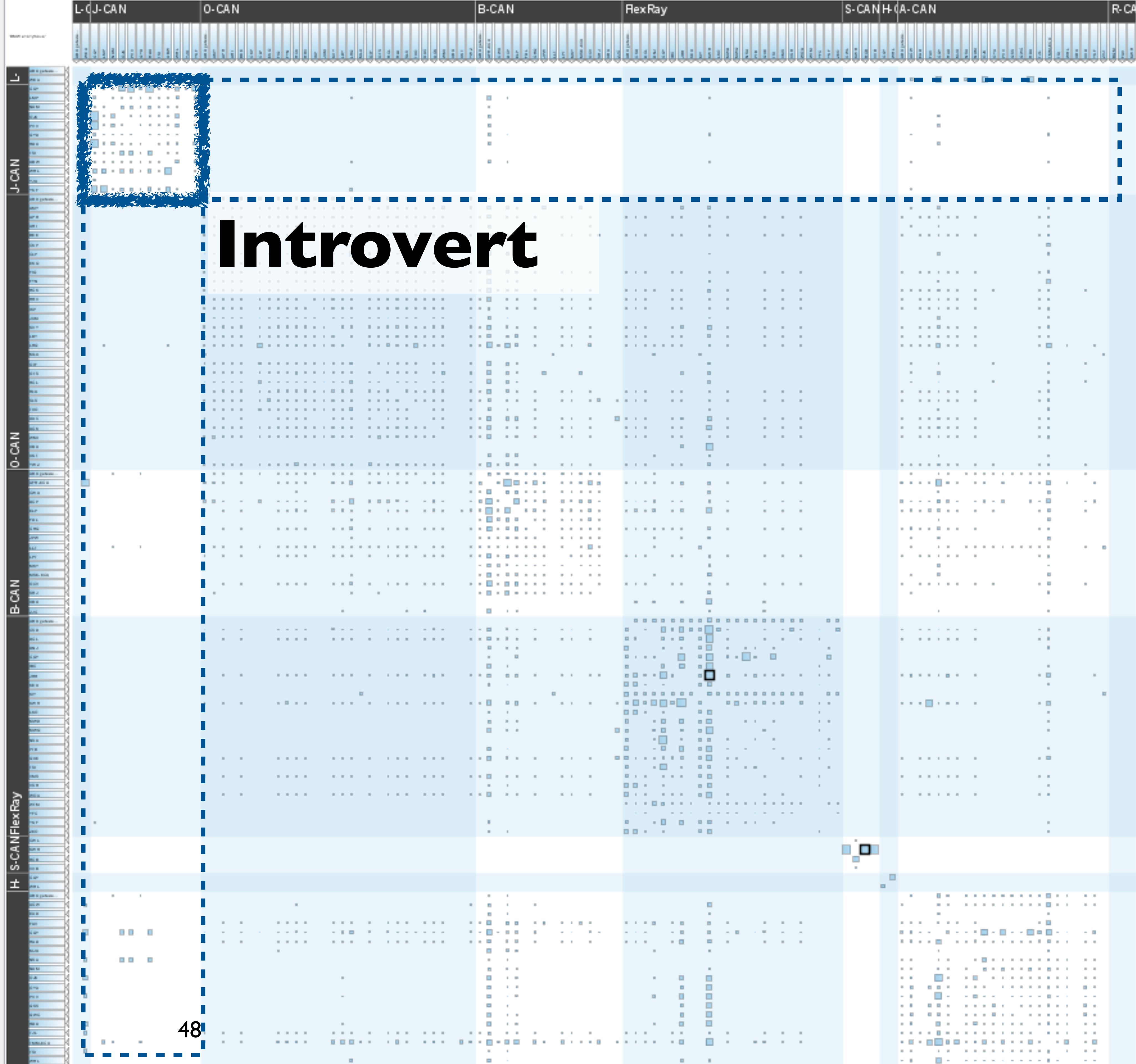
Interests

Bus communication patterns

introvert

vs.

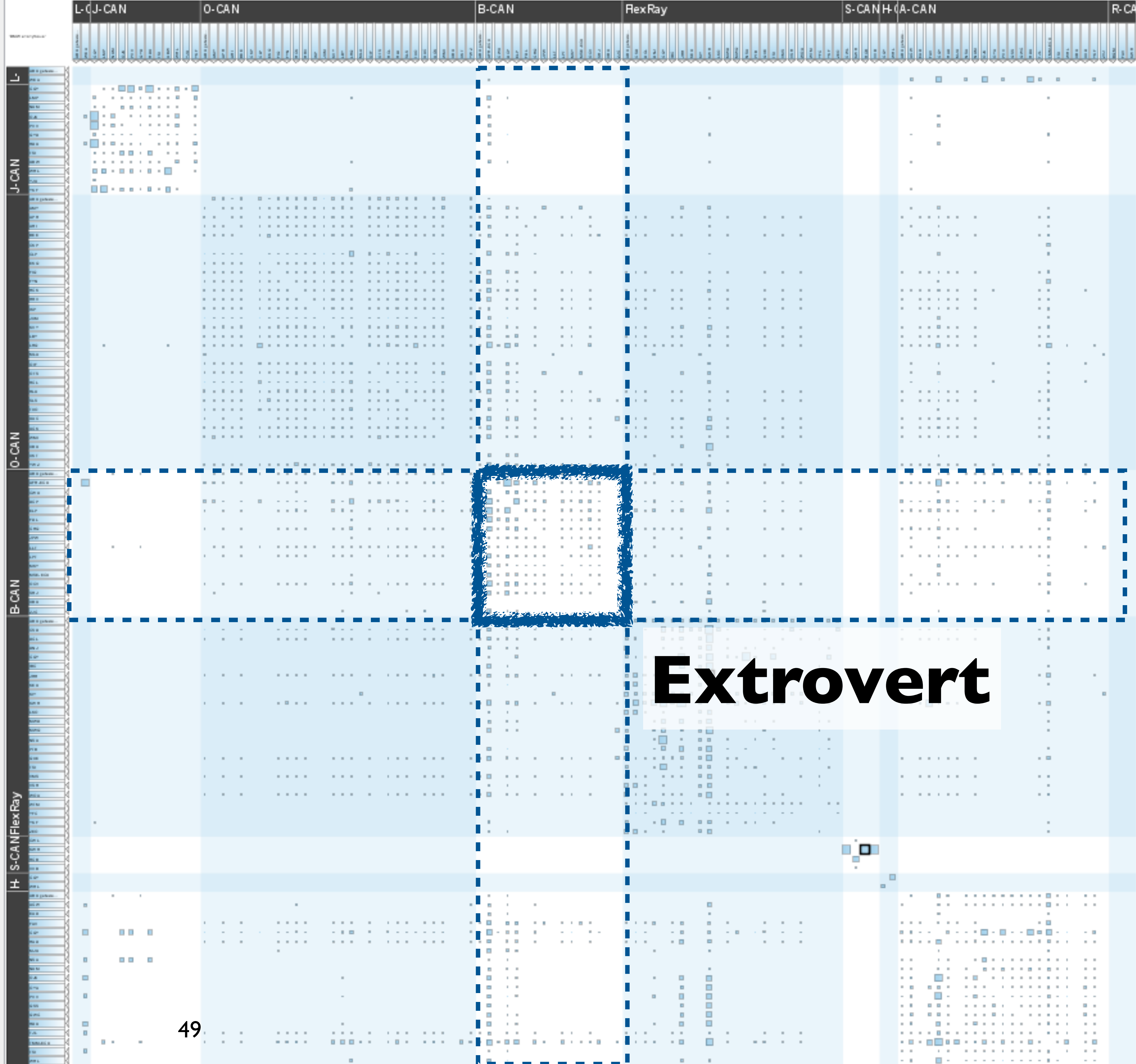
extrovert



INTERESTS

Bus communication patterns

introvert
vs.
extrovert



Methods

How we did it?

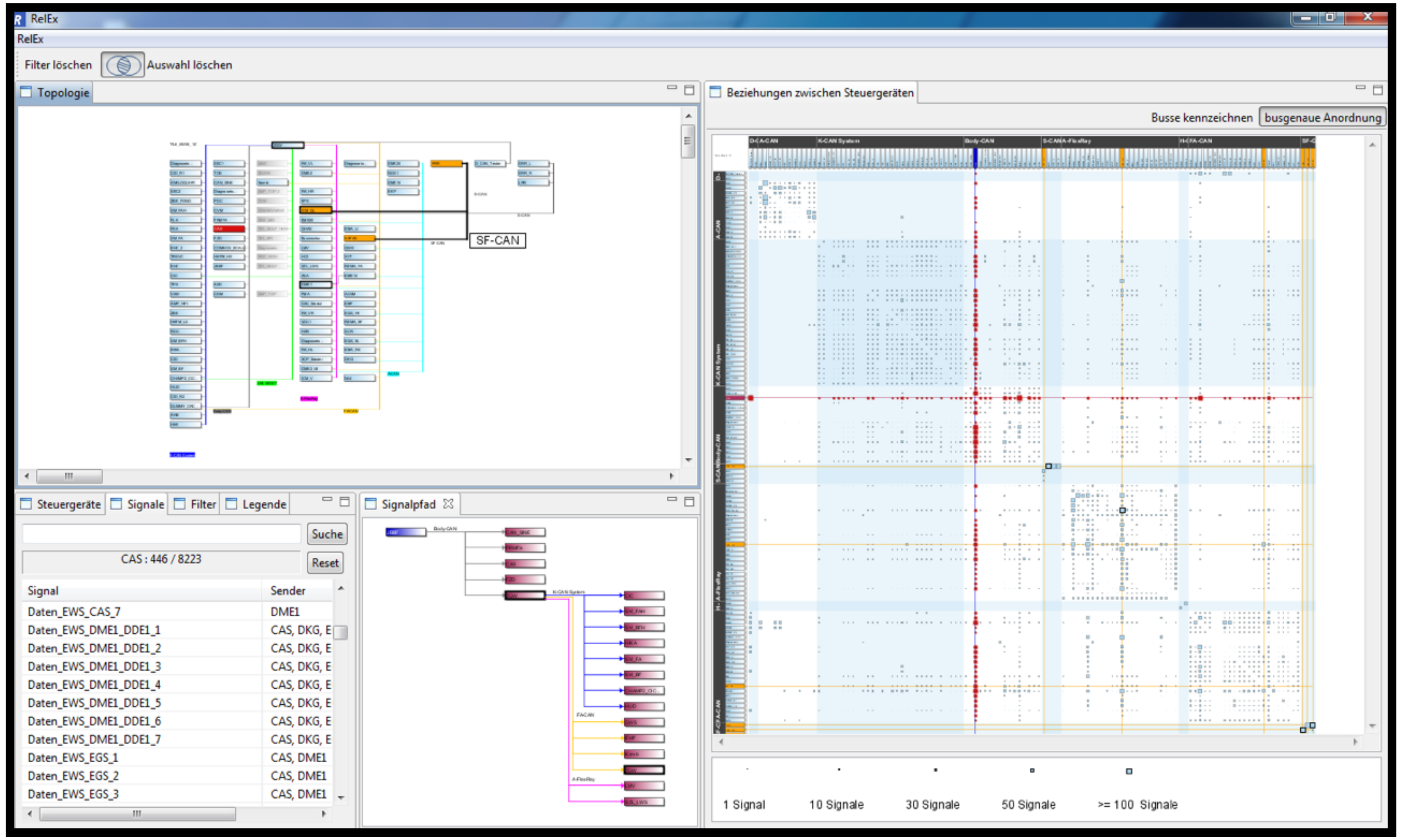
1. Problem characterization & abstraction
3 month

- Embedded within BMW
- Understanding
  - Talking/Observing
  - Focus groups
  - Analyzing previous tools
  - Reading
- Abstracting
- Deriving design requirements

2. Design, implement, deploy

4 month

- iterative paper prototyping
- agile software development
  - 3 lead users (engineers)
  - 6 deployed releases
- usability engineering
  - domain experts
  - HCI students

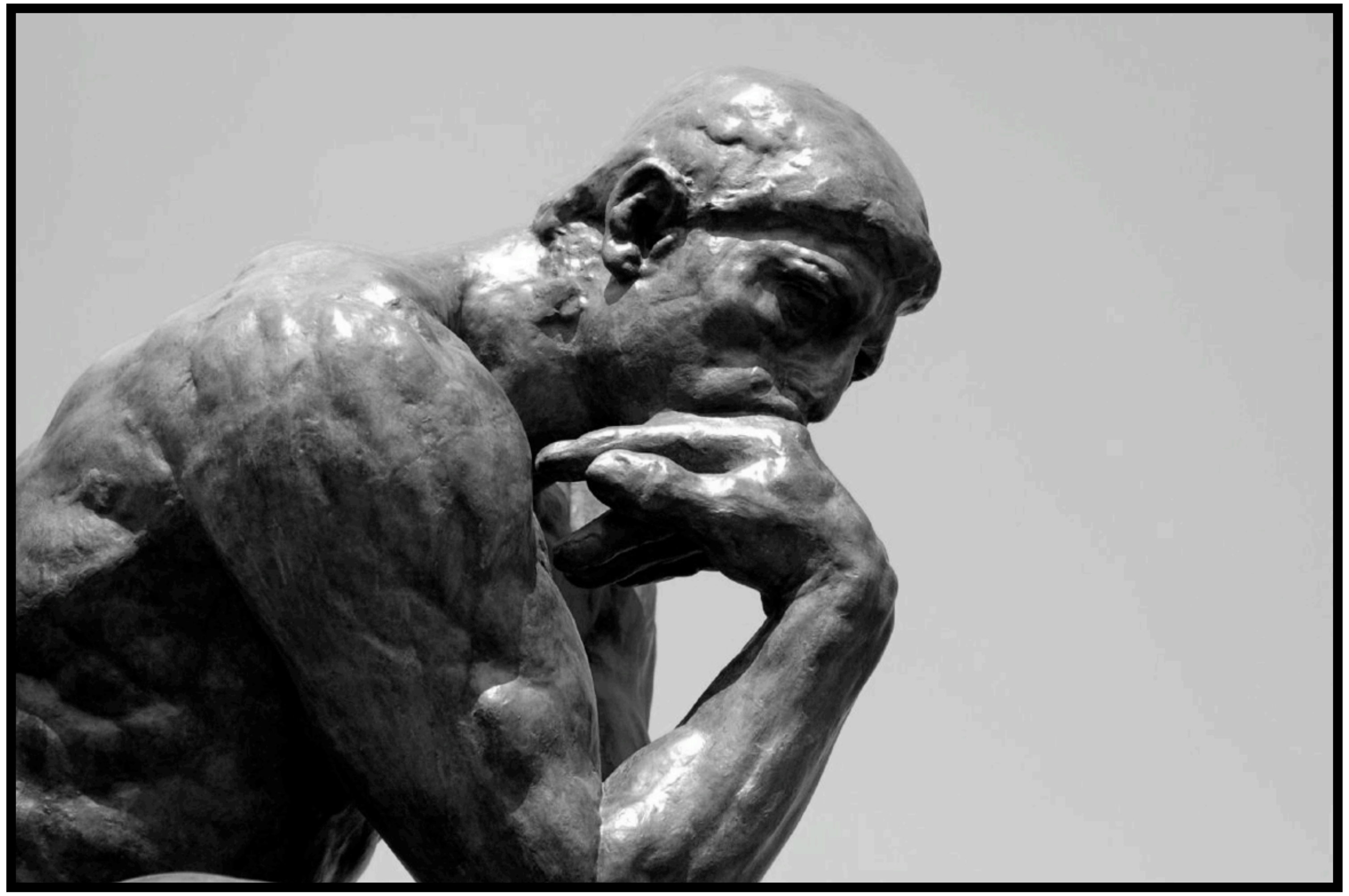


3. Summative Evaluation
2 month

- field study
  - 7 engineers
  - 5 weeks
- think aloud study
  - 10 engineers
  - ~1 hour each session
- adoption
  - 15+ users, 3 month post-study

4. Reflection
3 month

- revisit abstractions
- relate to other design studies
- write up



Summary

SUMMARY

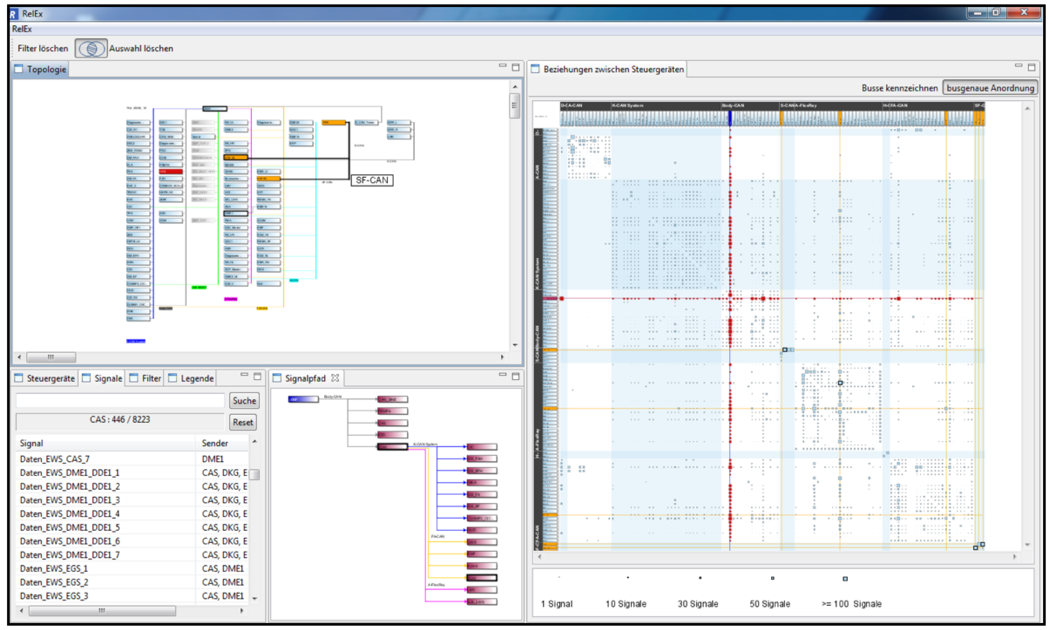
Contributions

1. New network task and data abstractions

- radically different from previous work (Social Networks)

SUMMARY
Contributions

1. New network task and data abstractions
2. **Fully validated design of RelEx**
   - validated along the entire design cycle
   - first post-deployment study of a matrix view
   - supported target user needs (better/faster, entirely new possibilities)
   - adoption



THANK YOU!

RELEX

Visualization for Actively Changing Overlay Network Specifications

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