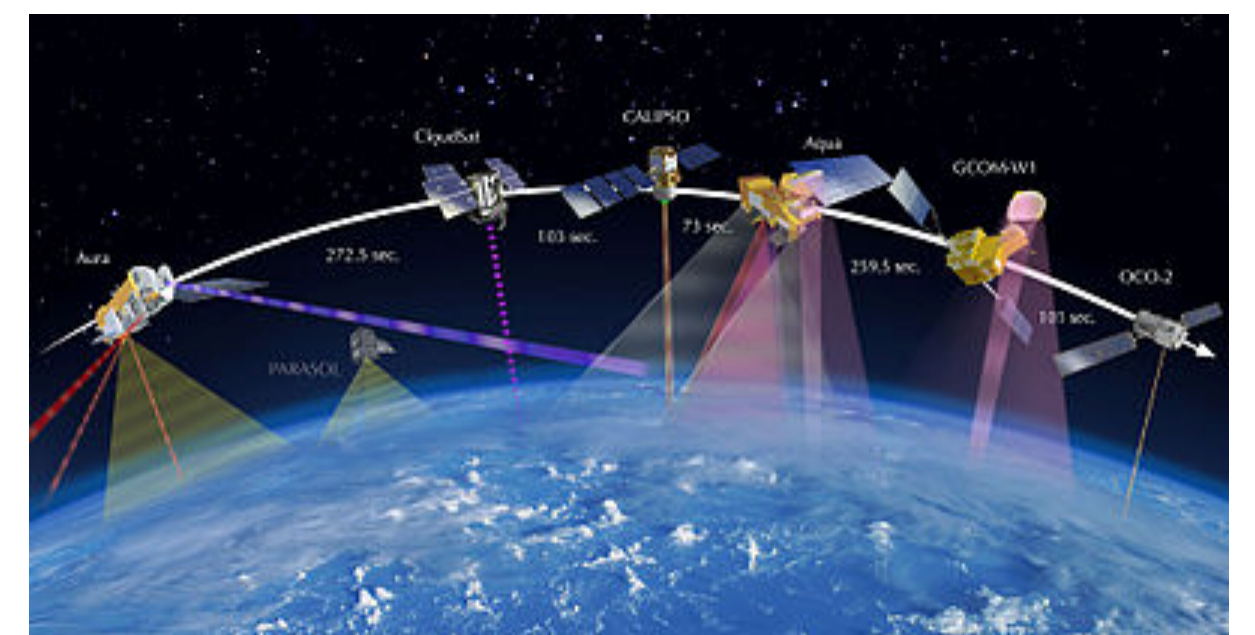
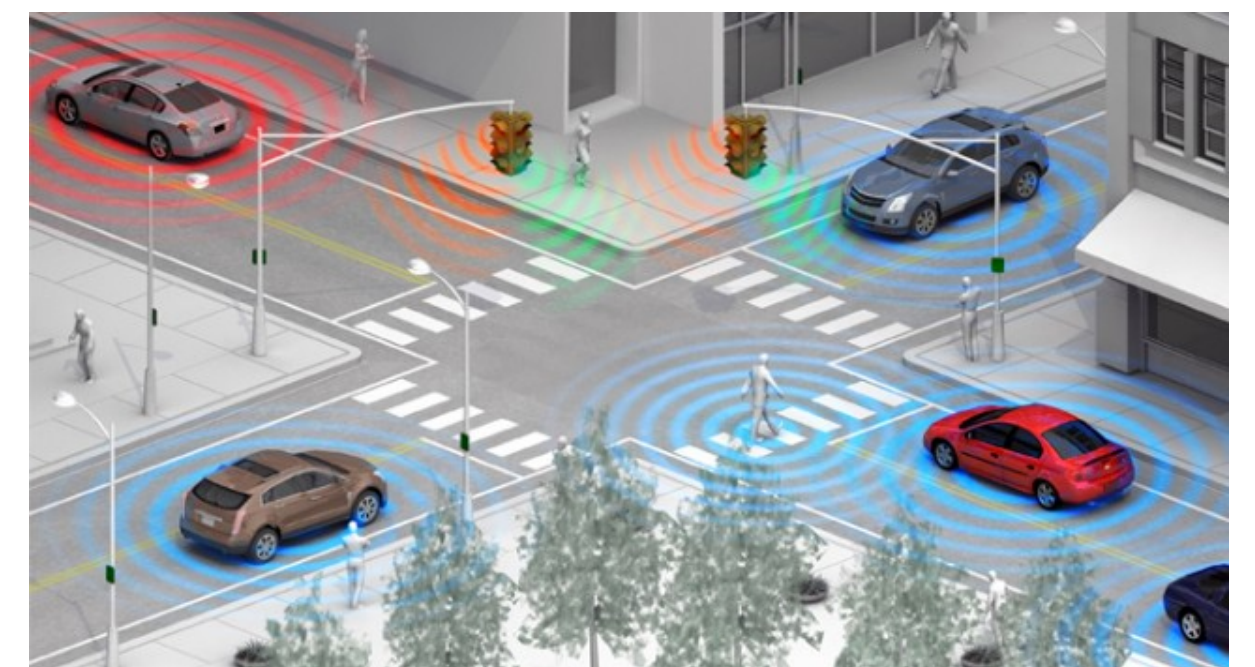


Visualization: The Human Lens to Data

Dr. Michael Sedlmair
Visualization & Data Analysis Group



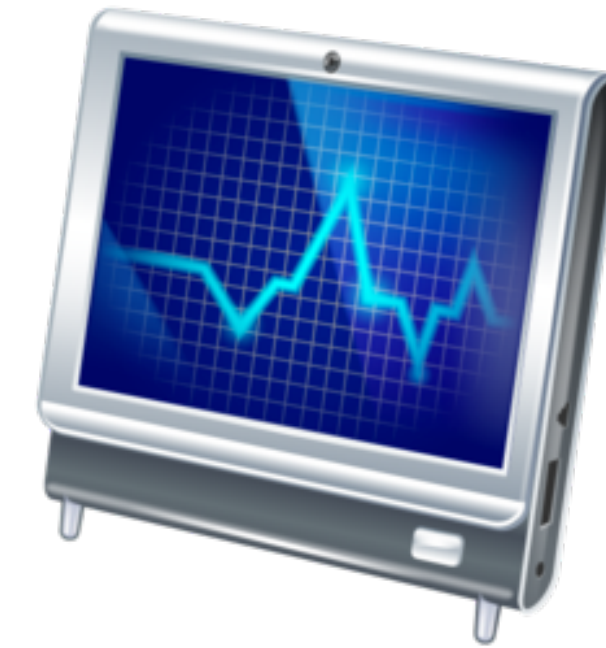
Data



[illegible]

Visualization

Scientists
Engineers
Journalists
Policy Makers



Understand patterns

Gain insights

Make decisions

Communicate

Visualization — Why?

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

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

Visualization — Why?



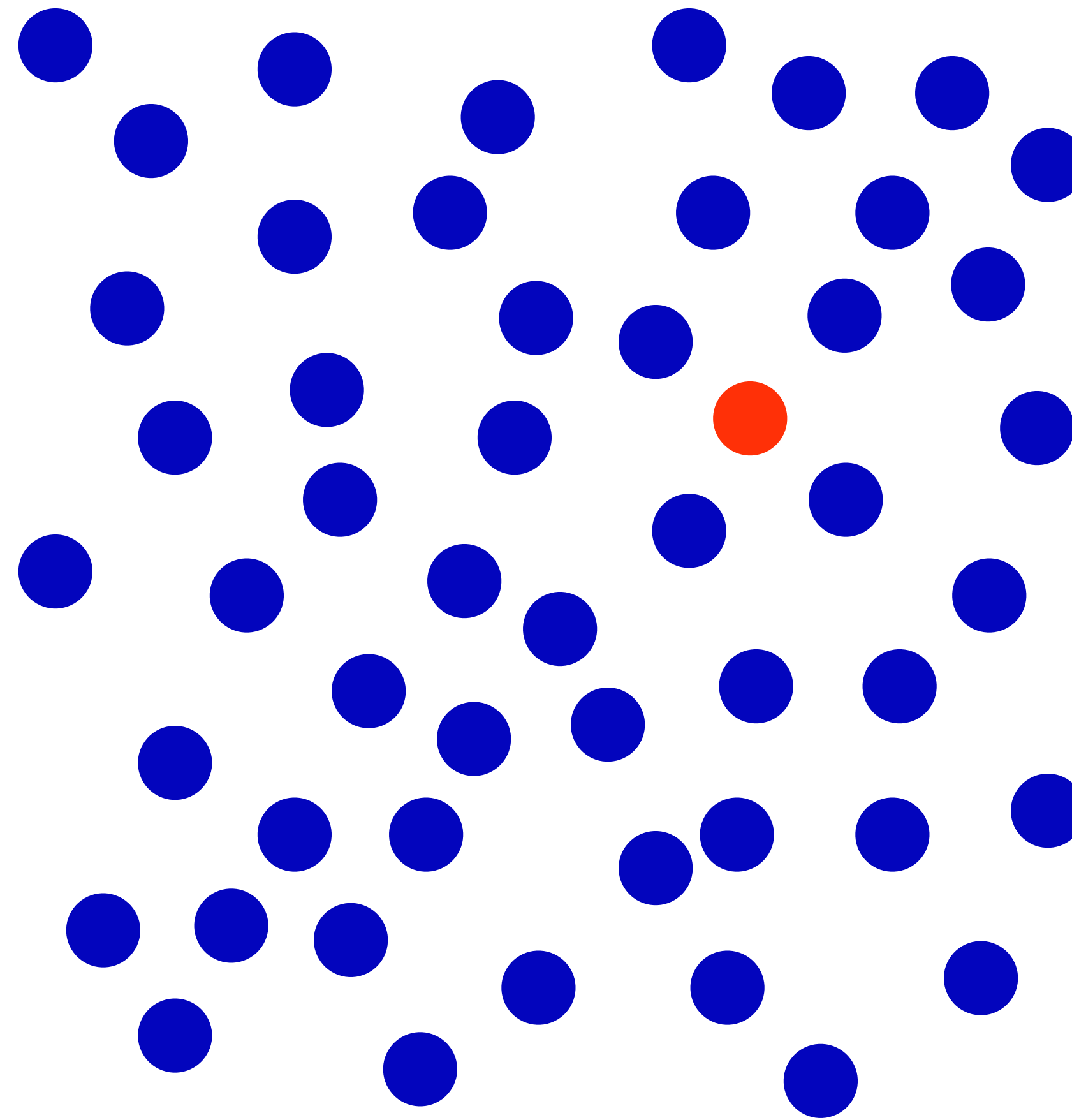
Perception
beats
Cognition!

Outline: How to visualize data?

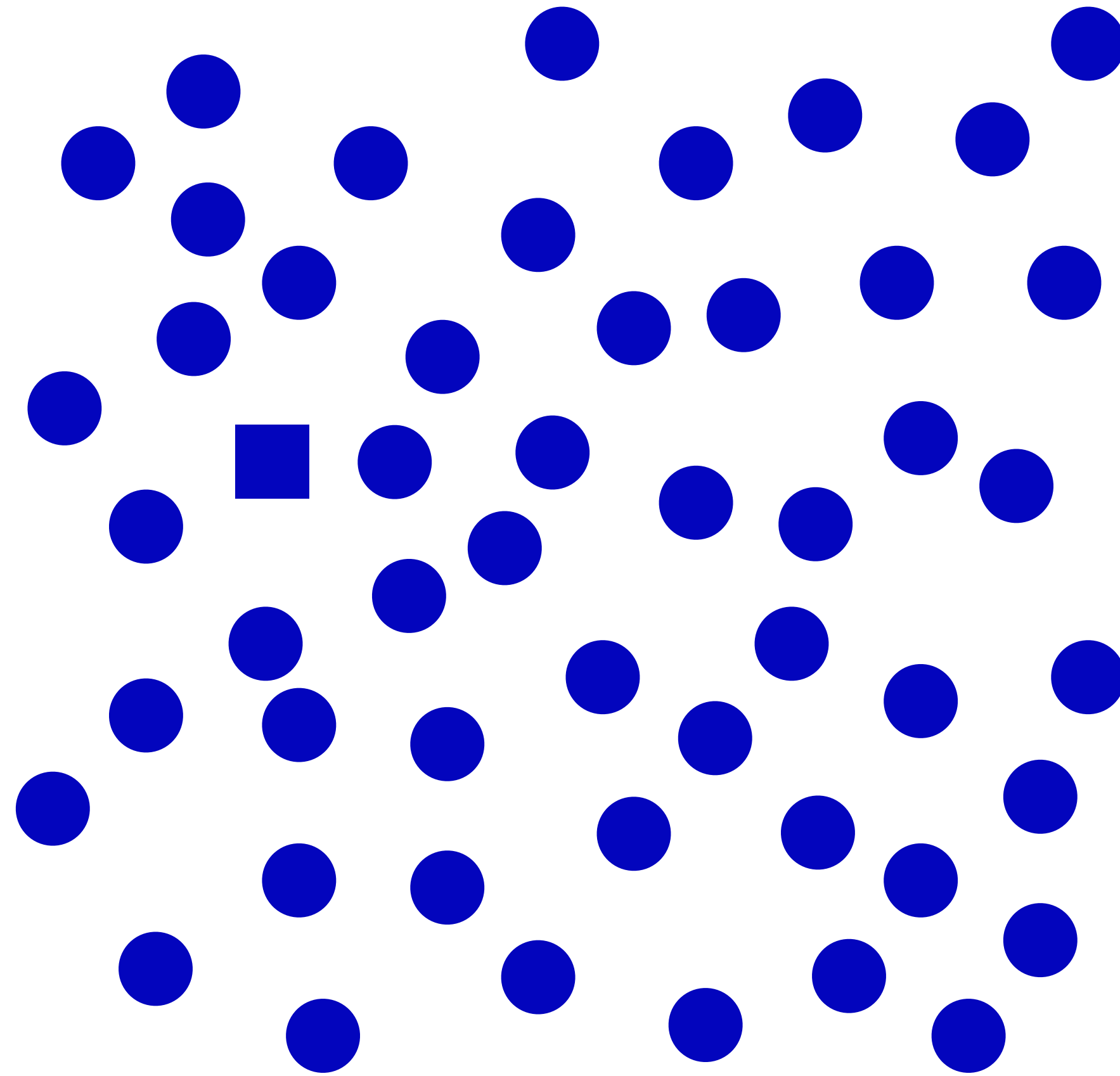
- Leverage perception
- Make it interactive
- Combine computation and visualization

Use perception ...

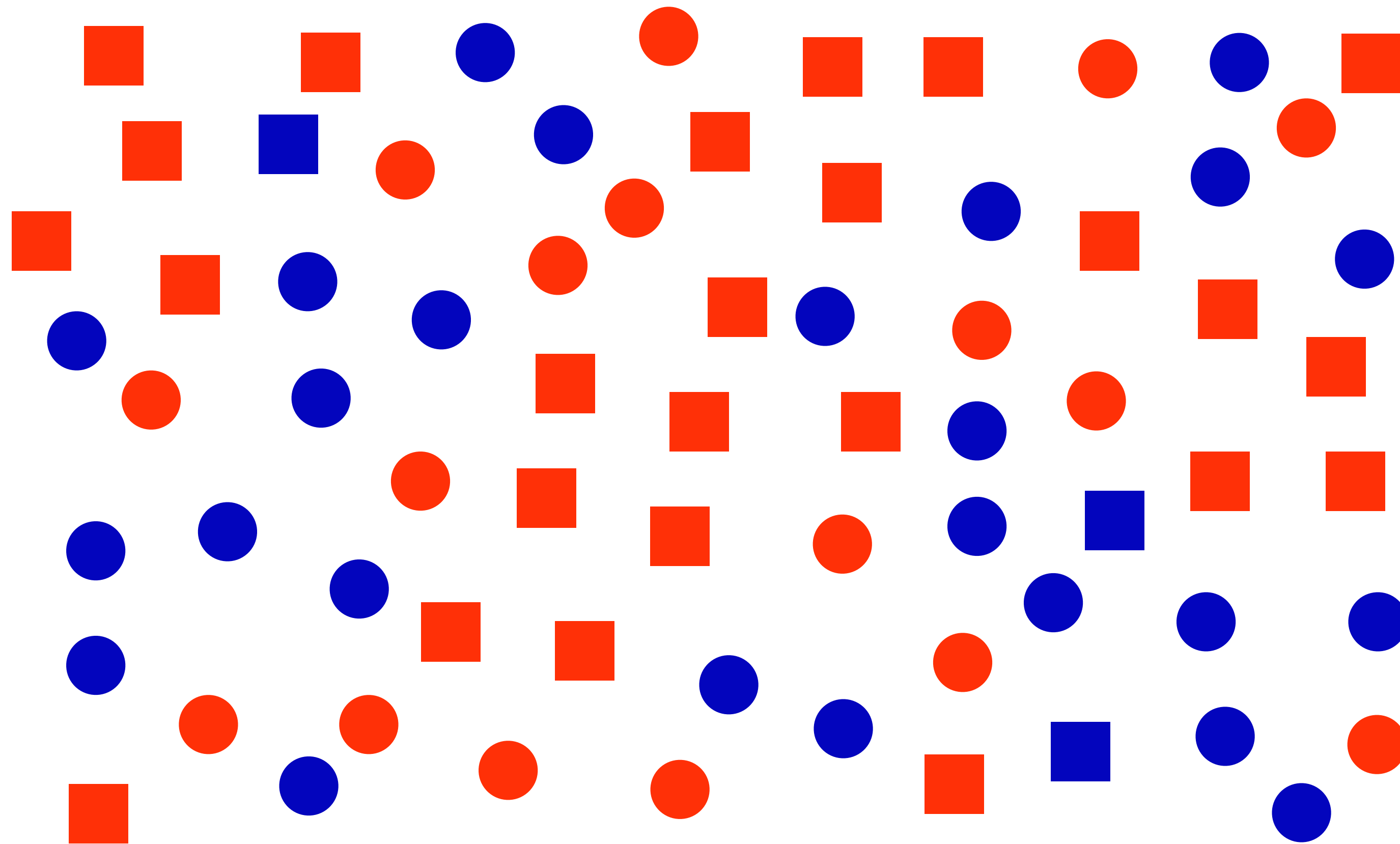
Human perception: Popout



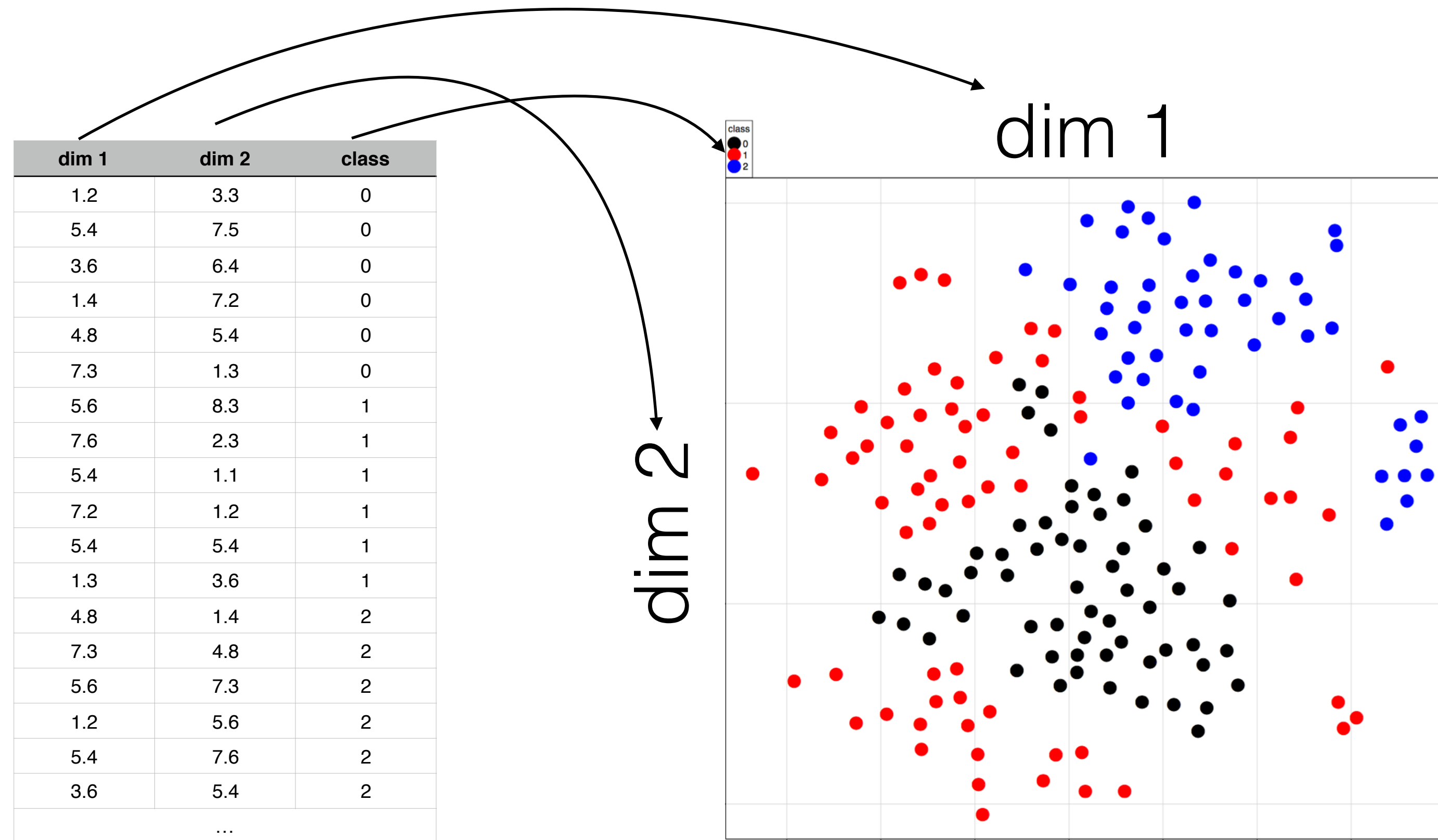
Human perception: Popout



Popout: Combining channels?



2D Scatterplot

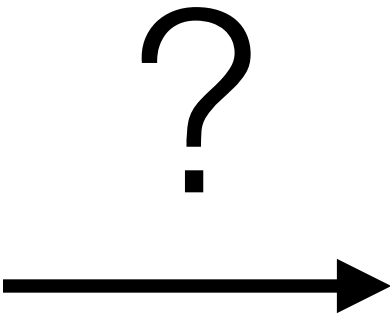


data

visualization

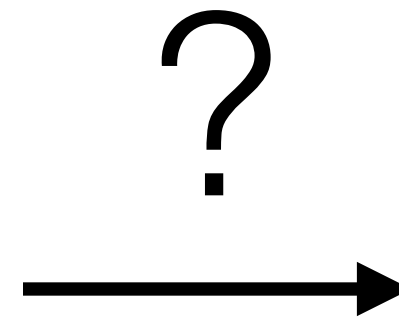
3D Scatterplot?

dim 1	dim 2	dim 3	class
1.2	3.3	5.4	0
5.4	7.5	1.3	0
3.6	6.4	4.8	0
1.4	7.2	7.3	0
4.8	5.4	5.6	0
7.3	1.3	1.2	0
5.6	8.3	5.4	1
7.6	2.3	3.6	1
5.4	1.1	3.3	1
7.2	1.2	7.5	1
5.4	5.4	6.4	1
1.3	3.6	7.2	1
4.8	1.4	5.4	2
7.3	4.8	1.3	2
5.6	7.3	8.3	2
1.2	5.6	3.3	2
5.4	7.6	7.5	2
3.6	5.4	1.2	2
...			

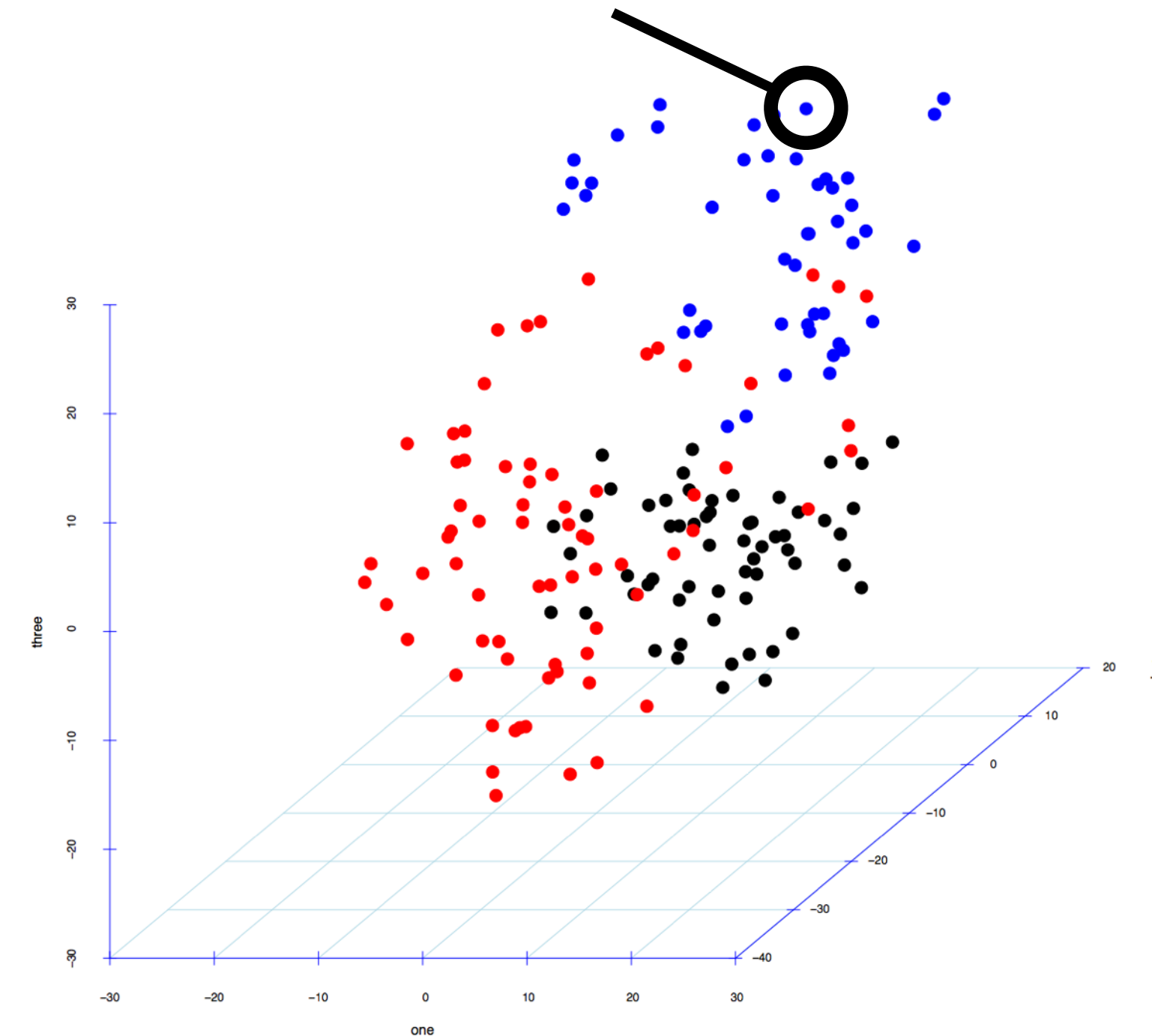


3D Scatterplot?

dim 1	dim 2	dim 3	class
1.2	3.3	5.4	0
5.4	7.5	1.3	0
3.6	6.4	4.8	0
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7.3	1.3	1.2	0
5.6	8.3	5.4	1
7.6	2.3	3.6	1
5.4	1.1	3.3	1
7.2	1.2	7.5	1
5.4	5.4	6.4	1
1.3	3.6	7.2	1
4.8	1.4	5.4	2
7.3	4.8	1.3	2
5.6	7.3	8.3	2
1.2	5.6	3.3	2
5.4	7.6	7.5	2
3.6	5.4	1.2	2
...			



what's the value of this point?

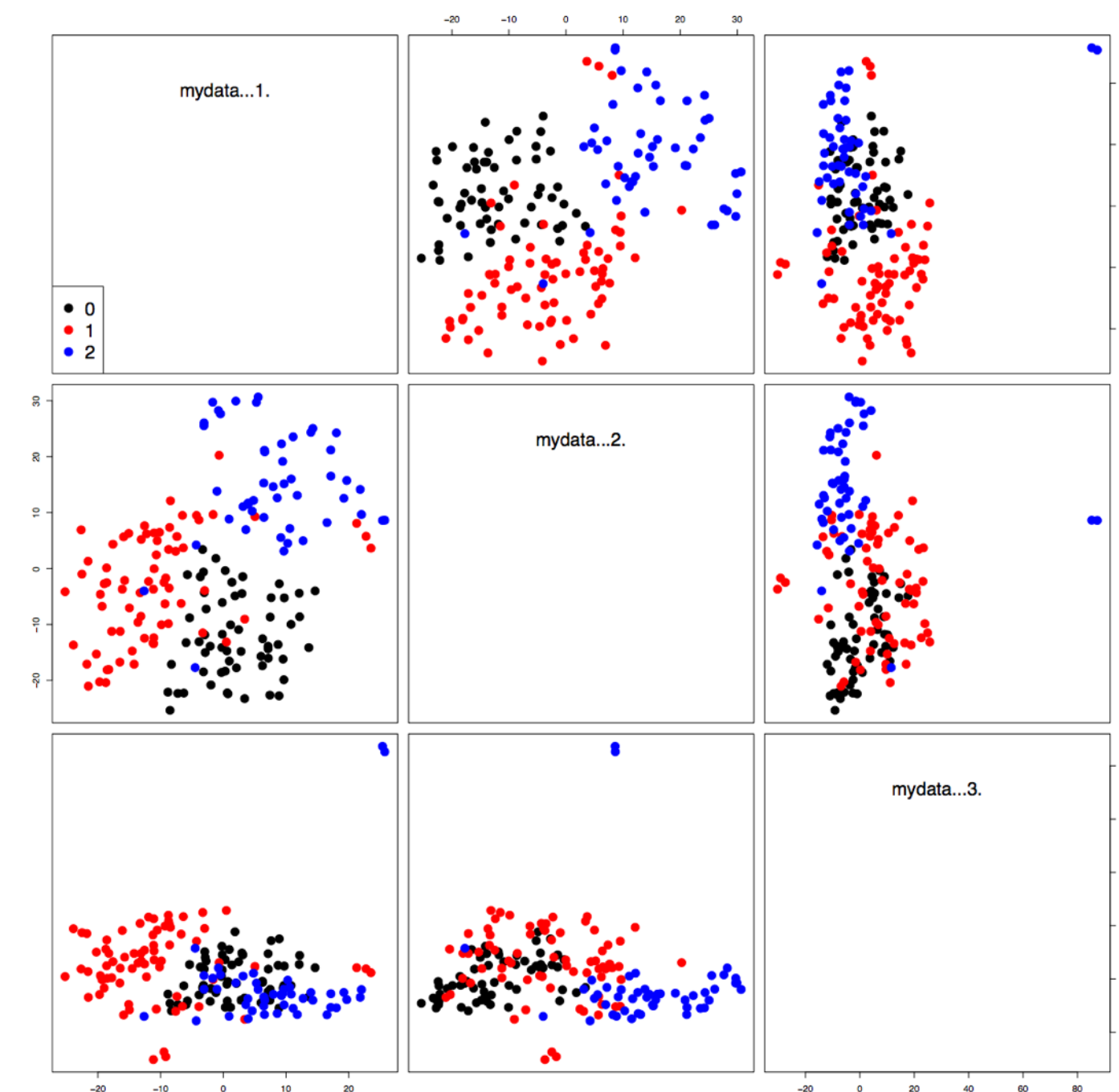


No 3D for abstract data!

dim 1	dim 2	dim 3	class
1.2	3.3	5.4	0
5.4	7.5	1.3	0
3.6	6.4	4.8	0
1.4	7.2	7.3	0
4.8	5.4	5.6	0
7.3	1.3	1.2	0
5.6	8.3	5.4	1
7.6	2.3	3.6	1
5.4	1.1	3.3	1
7.2	1.2	7.5	1
5.4	5.4	6.4	1
1.3	3.6	7.2	1
4.8	1.4	5.4	2
7.3	4.8	1.3	2
5.6	7.3	8.3	2
1.2	5.6	3.3	2
5.4	7.6	7.5	2
3.6	5.4	1.2	2
...			

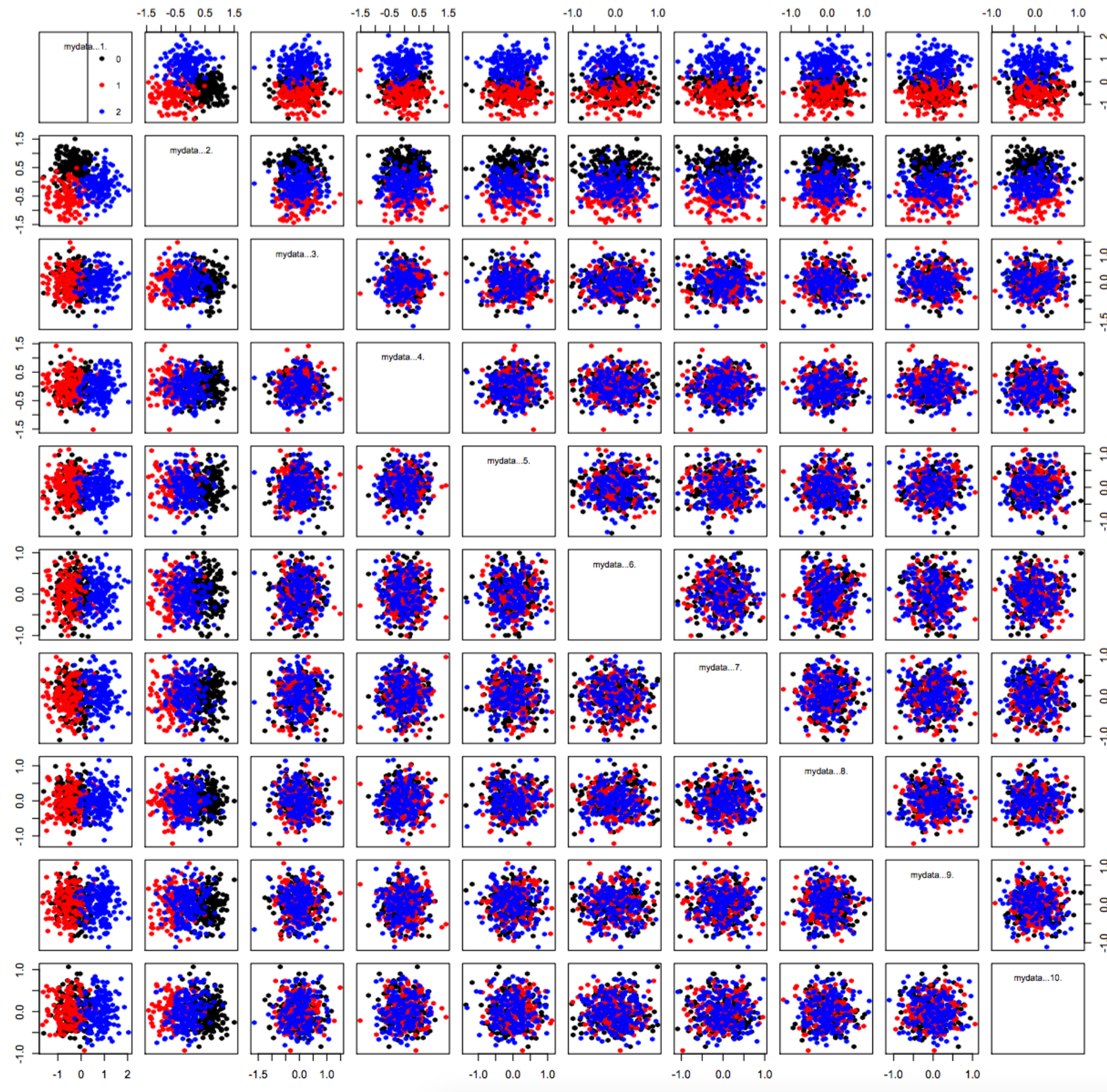


Scatterplot Matrix



Sedlmair, Munzner, Tory: Empirical Guidance on Scatterplot and Dimension Reduction Technique Choices (InfoVis 2013).

Scatterplot Matrix with more dimensions?

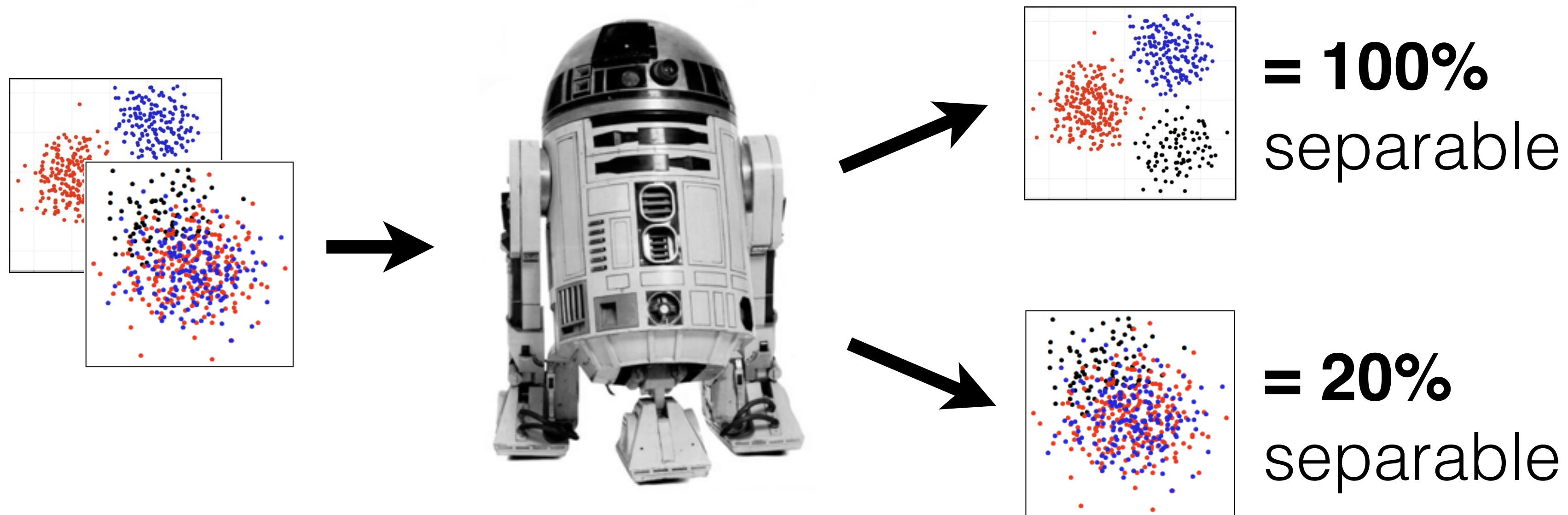


10D —> 45 Views

200D —> ~20k Views

Modeling human perception

e.g. class separation measures

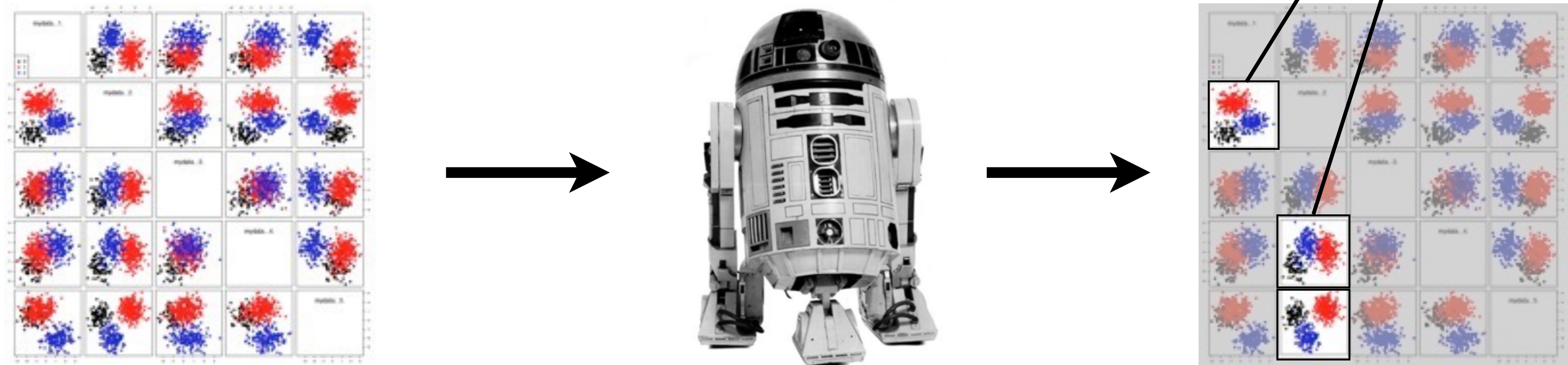


Aupetit, **Sedlmair**: SepMe: 2002 New Visual Separation Measures (PacificVis 2016).

Sedlmair, Aupetit: Data-driven Evaluation of Visual Quality Measures (EuroVis 2015).

Sedlmair, Tatu, Munzner, Tory: A Taxonomy of Visual Cluster Separation Factors (EuroVis 2012).

Measures help humans finding the good views

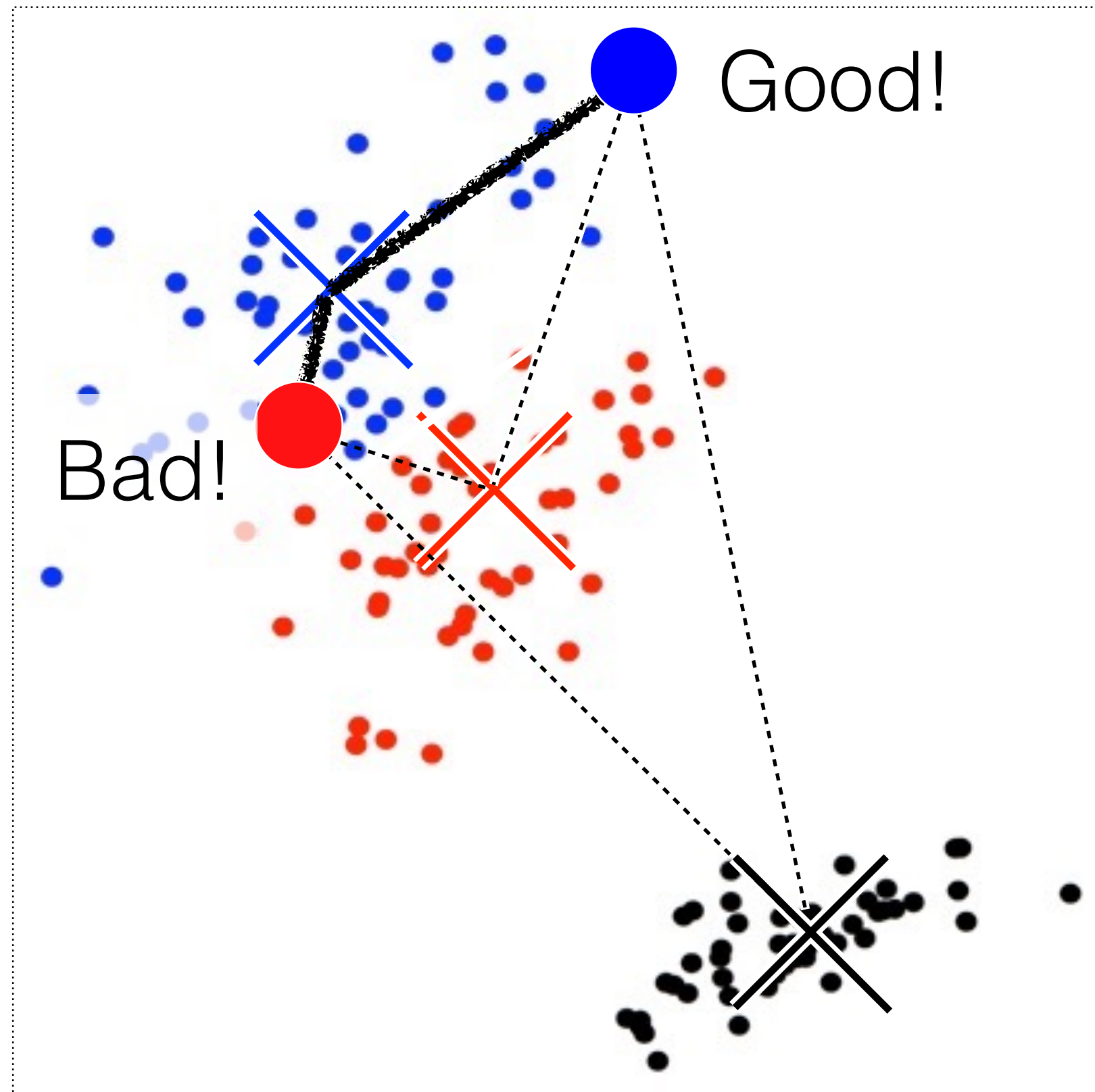


Aupetit, **Sedlmair**: SepMe: 2002 New Visual Separation Measures (PacificVis 2016).

Sedlmair, Aupetit: Data-driven Evaluation of Visual Quality Measures (EuroVis 2015).

Sedlmair, Tatu, Munzner, Tory: A Taxonomy of Visual Cluster Separation Factors (EuroVis 2012).

Example: Centroid measure

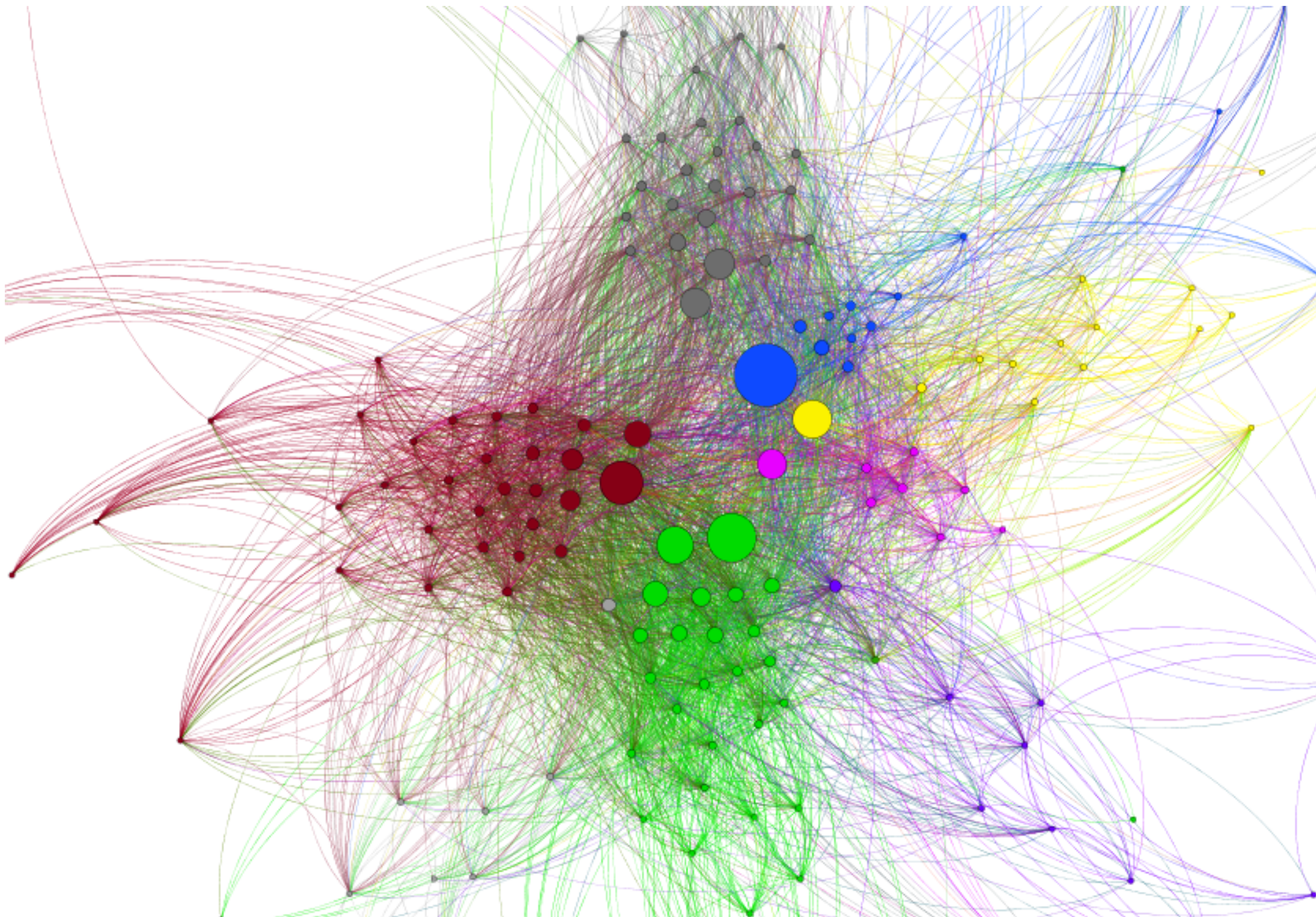


Centroid measure
= **93%** separable

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

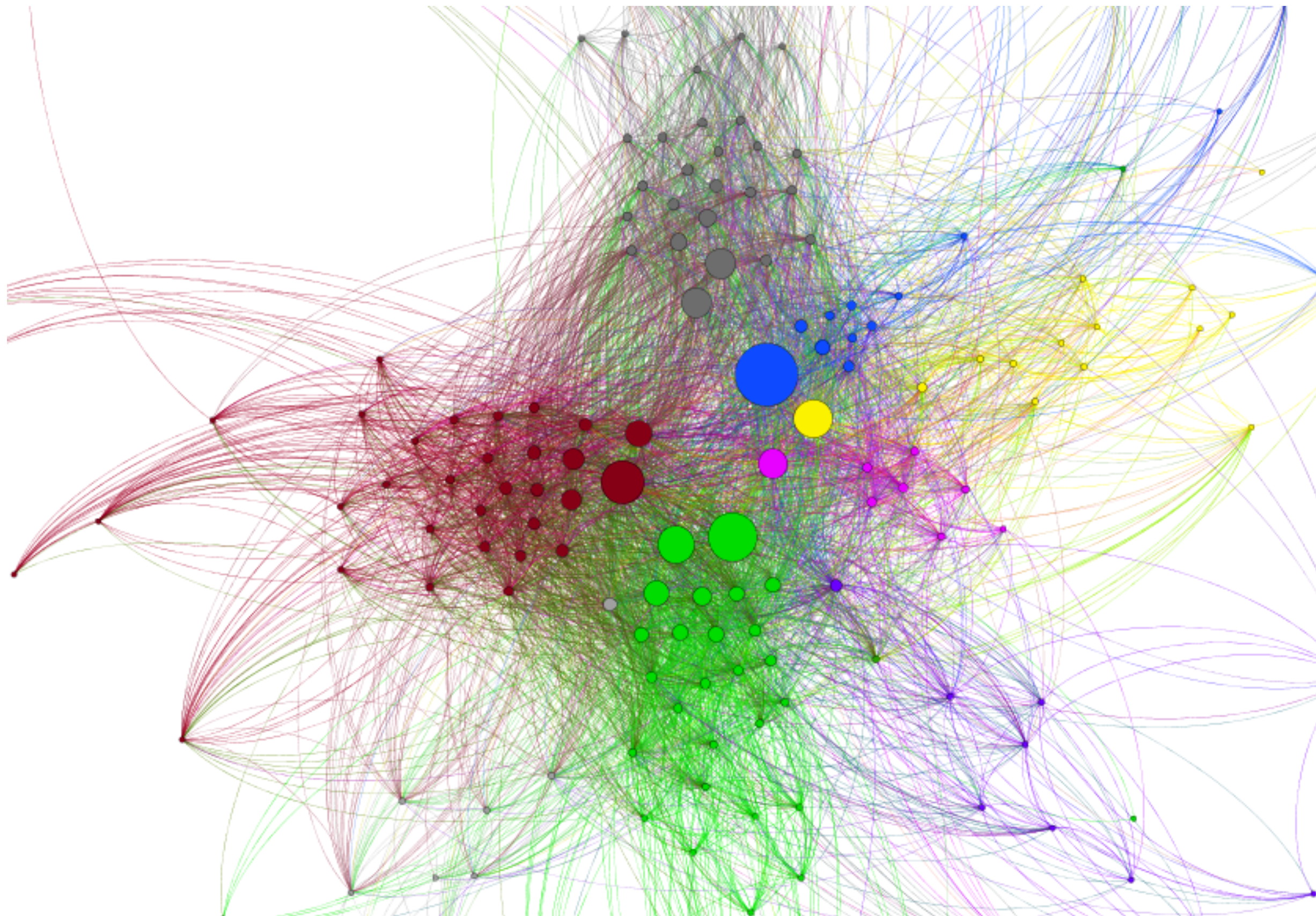
Make it interactive ...

Showing all the data?



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

Showing all the data?



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



Hairball

Make it interactive

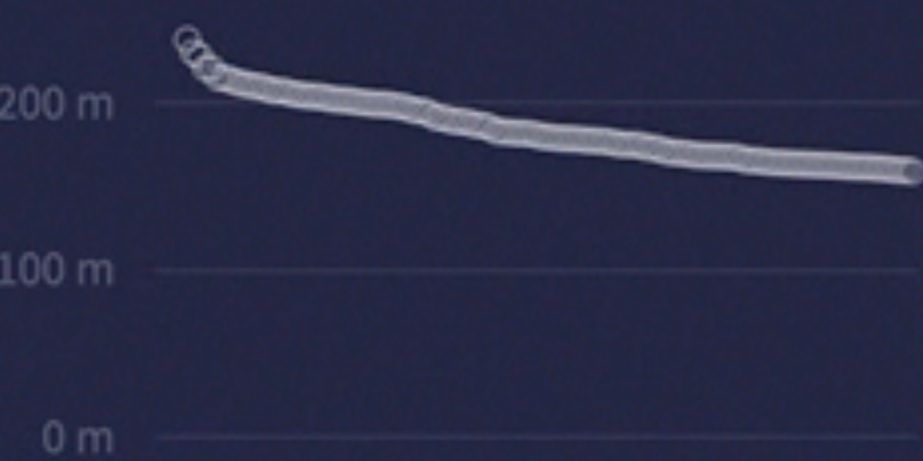


Oppermann, Möller, **Sedlmair**.
ongoing work.

example:
bikesharingatlas.org

- 468 networks
- 21.500 stations
- Fill levels every 15 min, for 1.5 years
(i.e. > 1 billion fill level values)

Elevation Profile ?



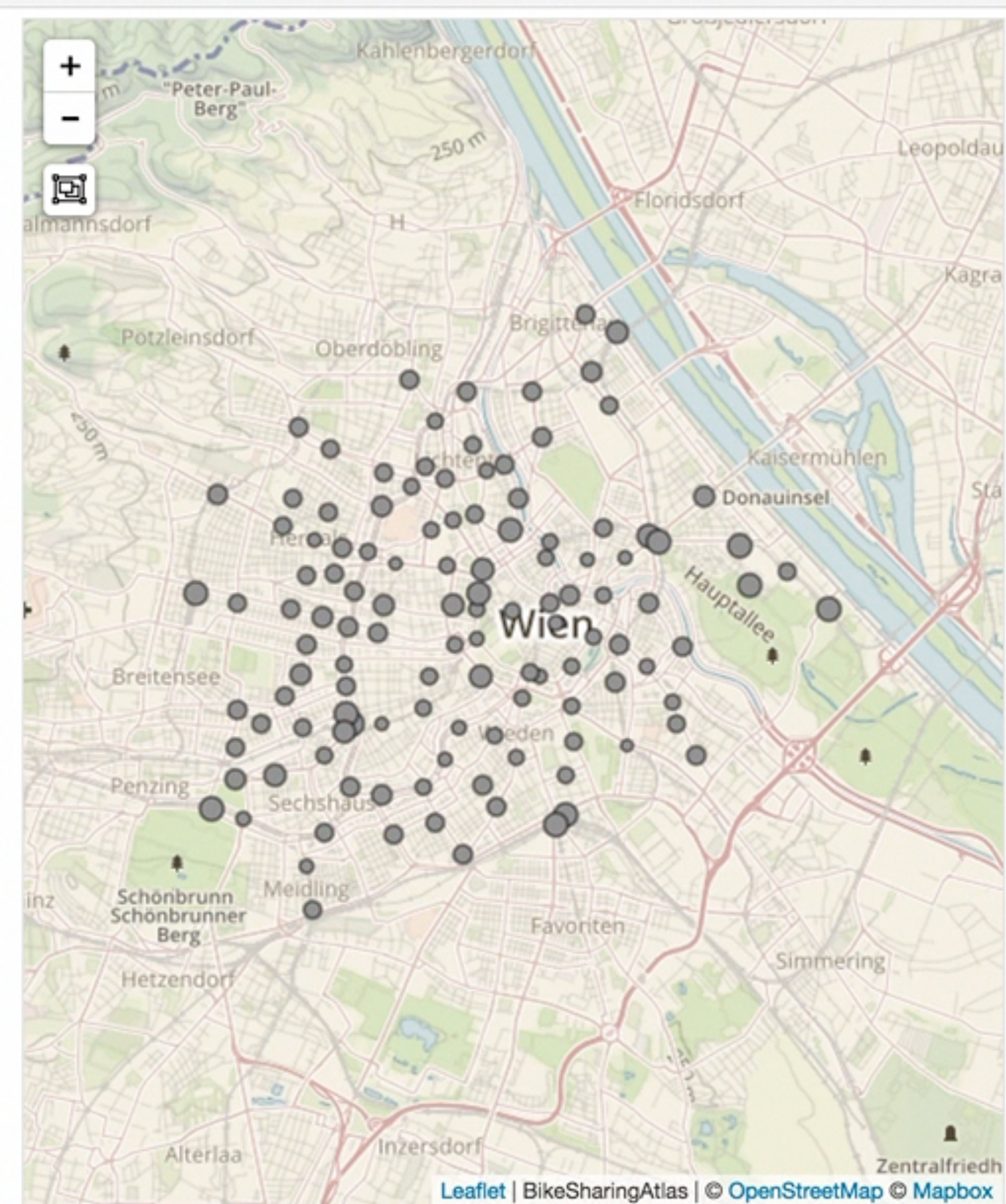
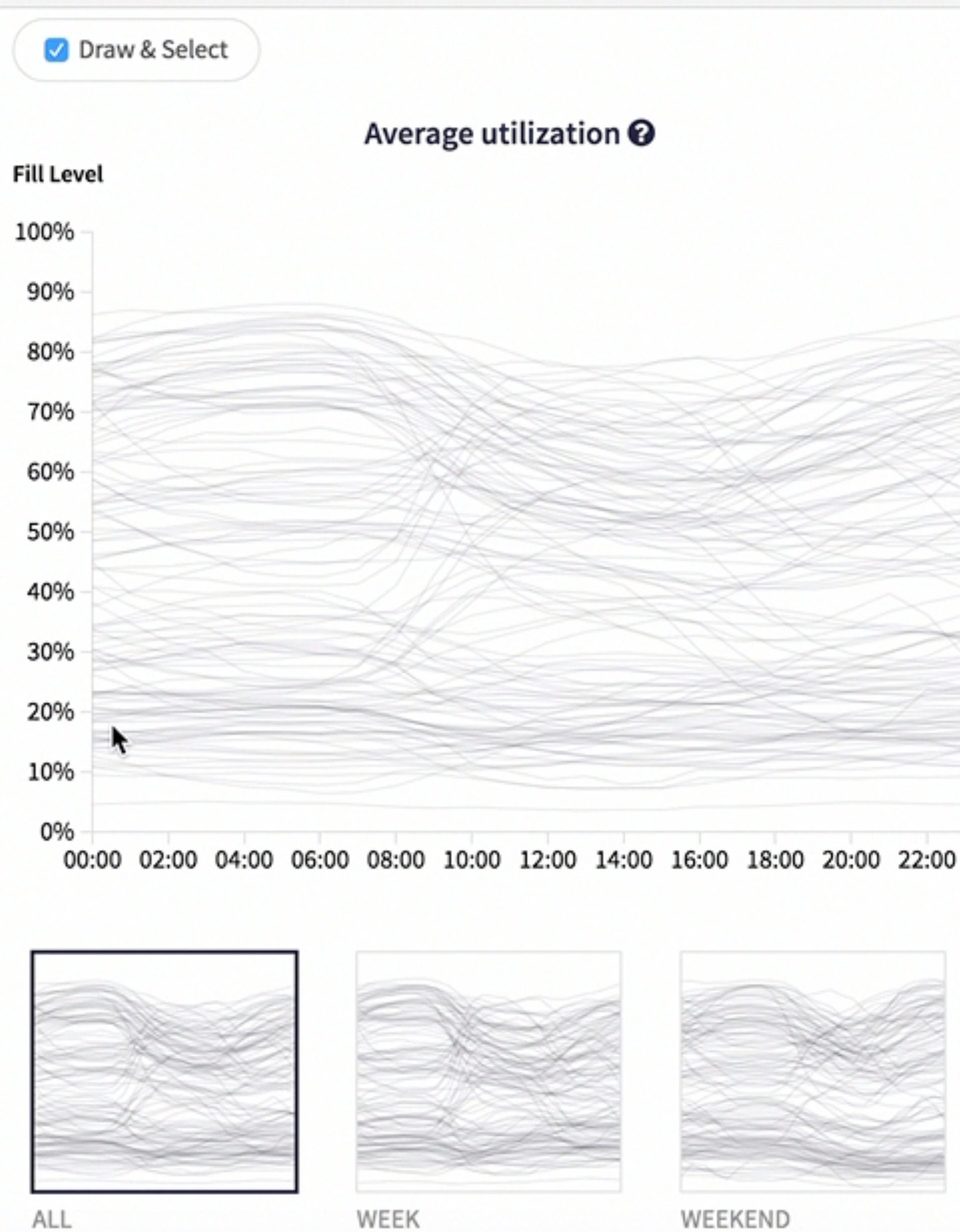
Weather ?



Avg. Temperature: 5 °C
Avg. Humidity: 80 %

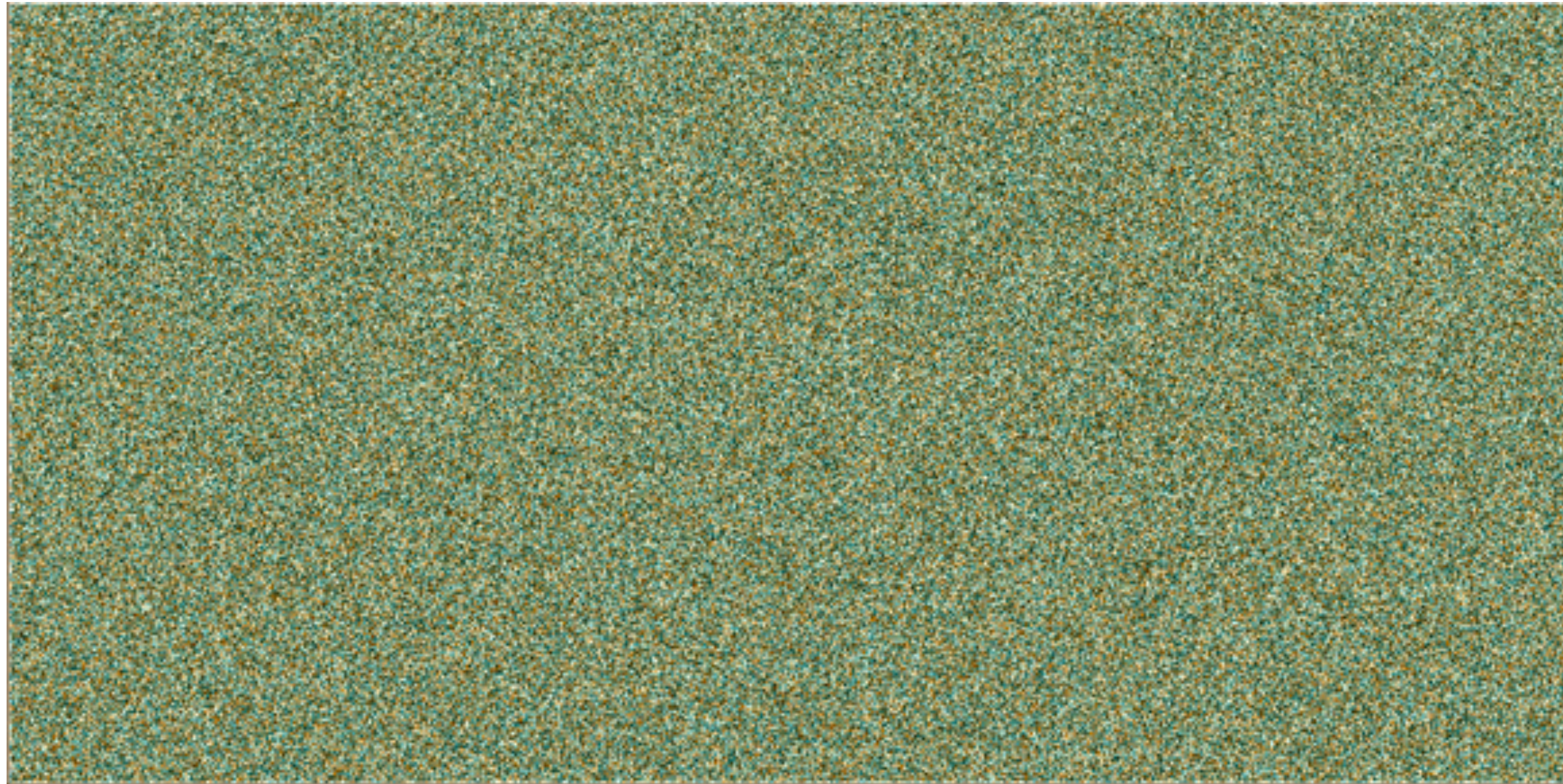
Similar Networks

- 📍 Marseille, FR
- 📍 Dresden, DE
- 📍 Usedom, DE



Combine
Computation & Visualization

Even too much data for interaction



<https://www.geek.com/geek-cetera/pi-visualized-to-4-million-decimal-places-in-one-image-1486849/>

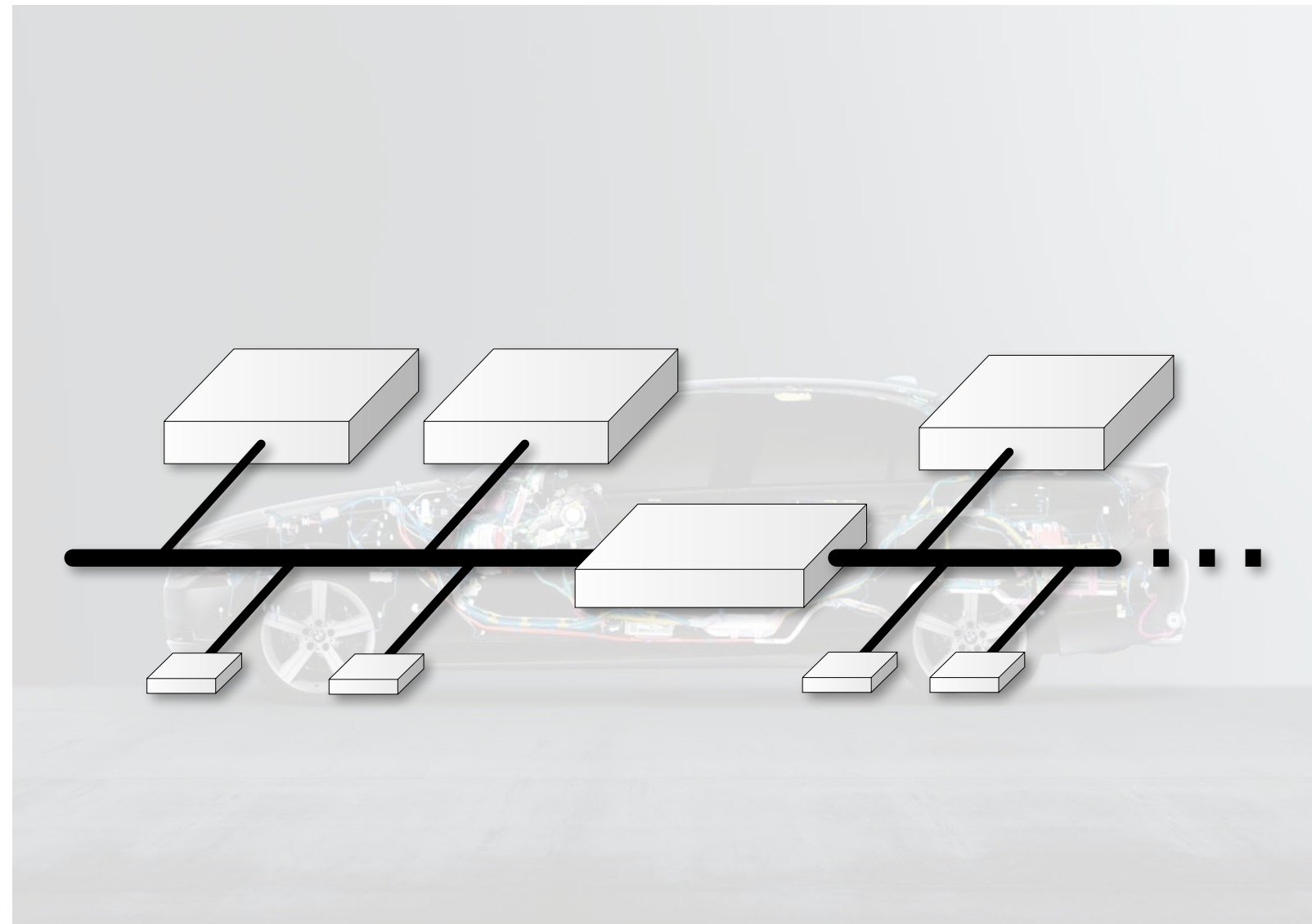
Combine visual and computational

example: Cardiogram @BMW



Sedlmair, Isenberg, Baur, Mauerer,
Pigorsch, Butz: Cardiogram: Visual Analytics
for Automotive Engineers (CHI 2011).

Combine visual and computational

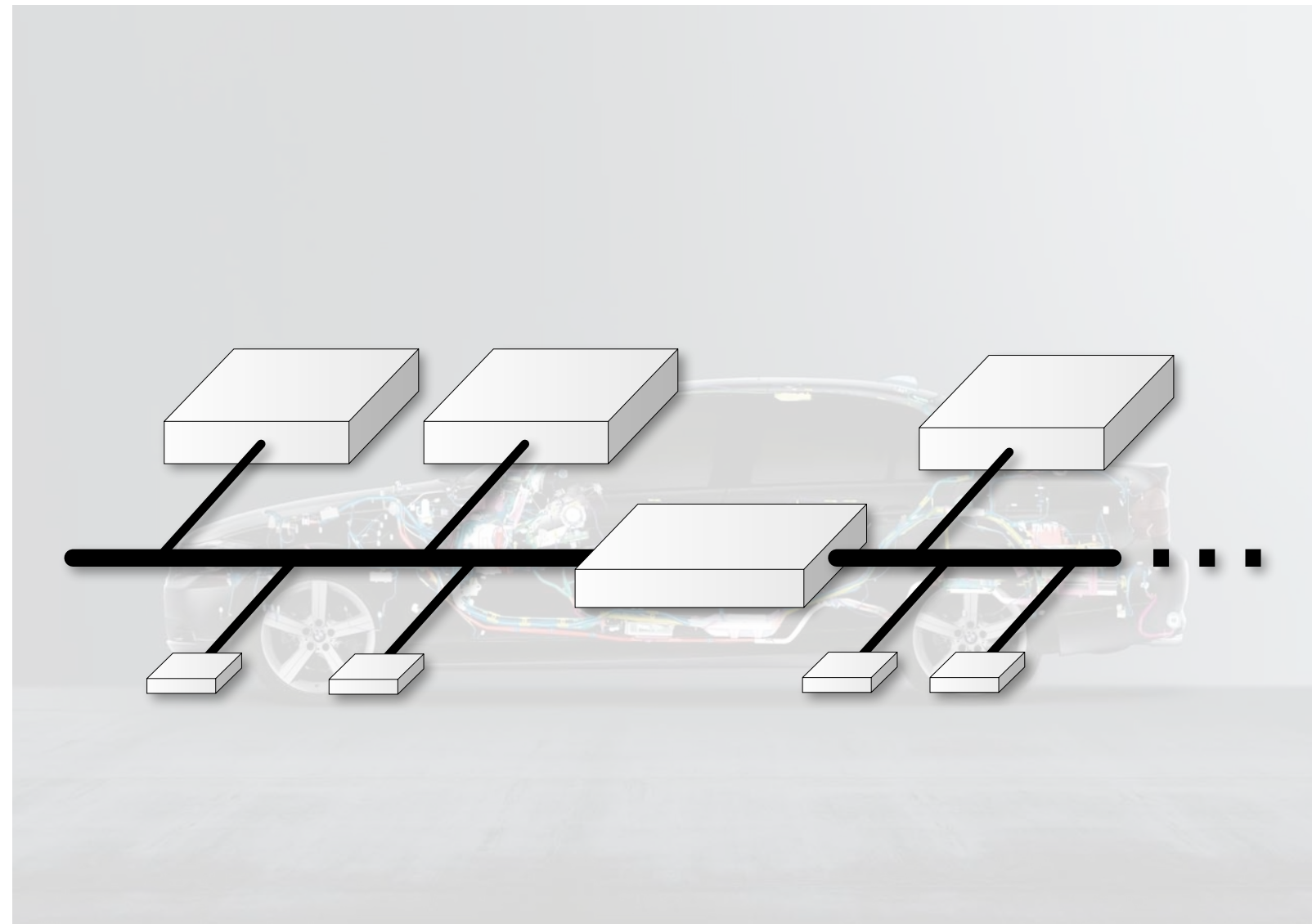


example: Cardiogram @BMW

- 70 interconnected ECUs

Sedlmair, Isenberg, Baur, Mauerer,
Pigorsch, Butz: Cardiogram: Visual Analytics
for Automotive Engineers (CHI 2011).

Combine visual and computational

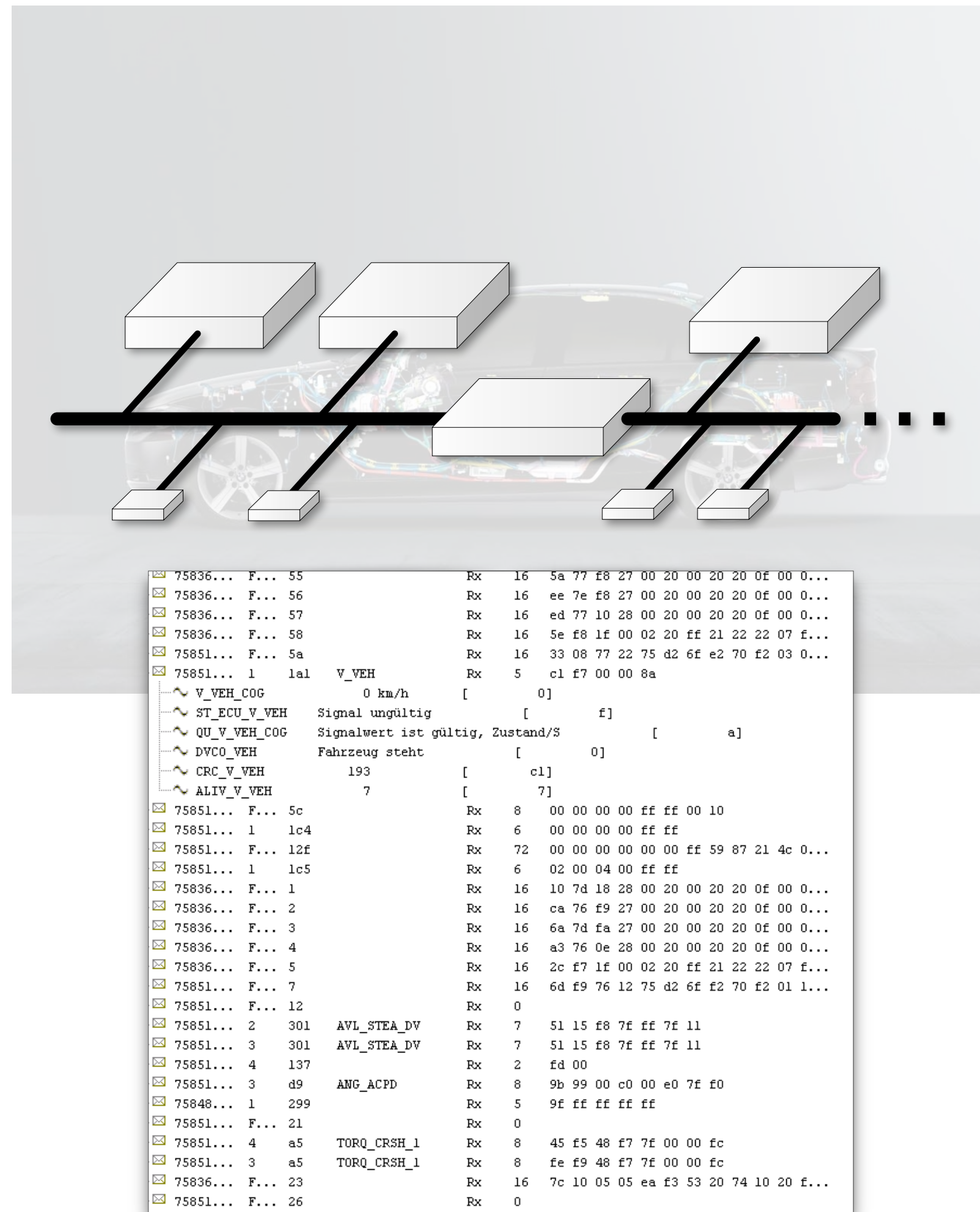


Sedlmair, Isenberg, Baur, Mauerer,
Pigorsch, Butz: Cardiogram: Visual Analytics
for Automotive Engineers (CHI 2011).

example: Cardiogram @BMW

- 70 interconnected ECUs
- **task:** finding errors
- **process:** analyse test drives
- **data:** recorded traces
(15k messages/sec)

Combine visual and computational



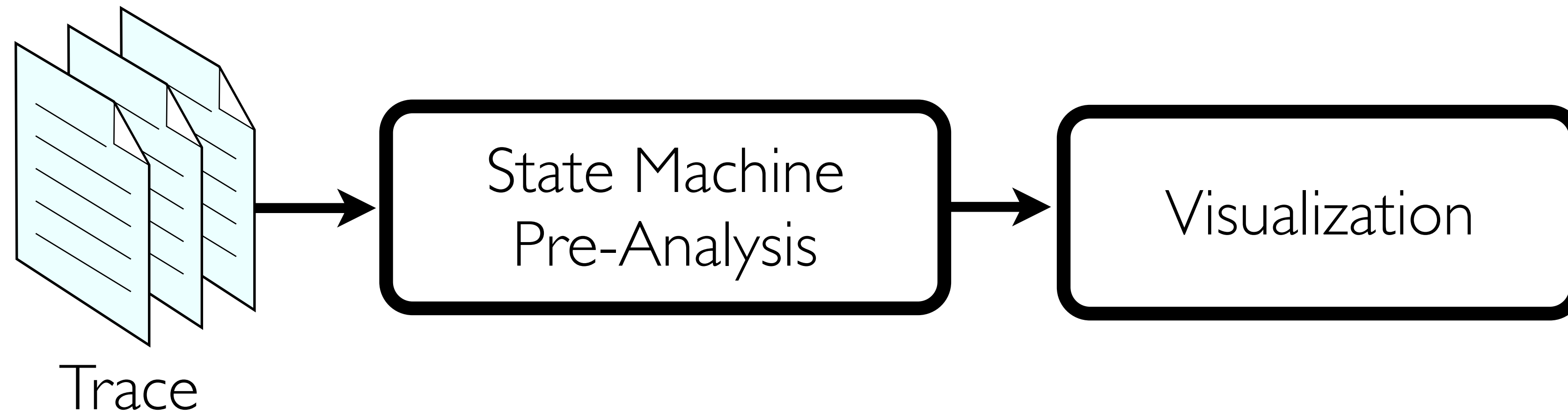
example: Cardiogram @BMW

- 70 interconnected ECUs
- **task:** finding errors
- **process:** analyse test drives
- **data:** recorded traces (15k messages/sec)
- **current practices:** mainly textual lists

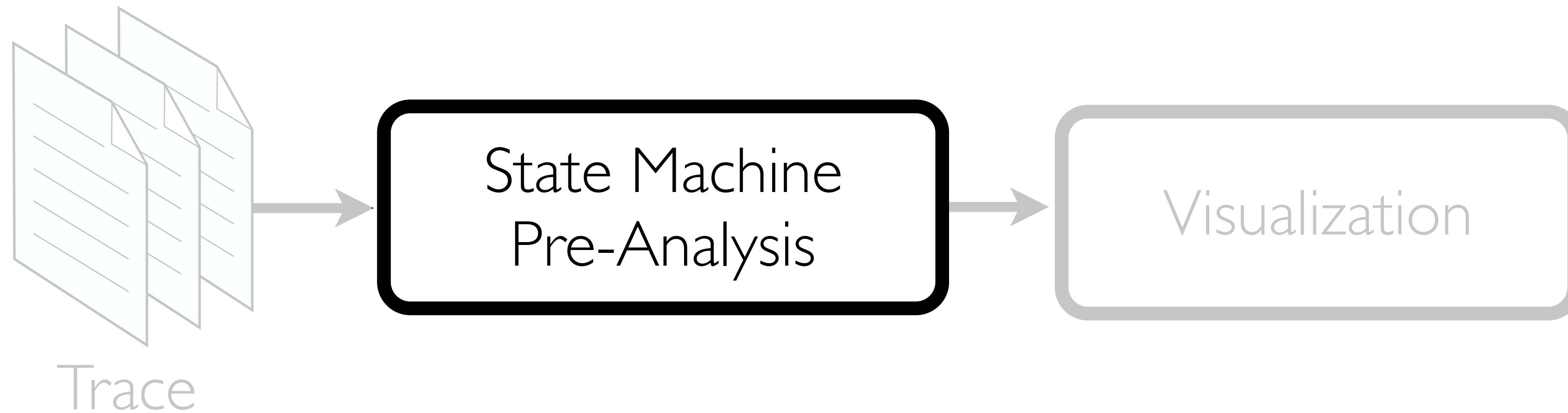
Main challenges

- handling masses of test traces (large and many)
- understanding correlation between trace and car behavior
- ... *(and others)*

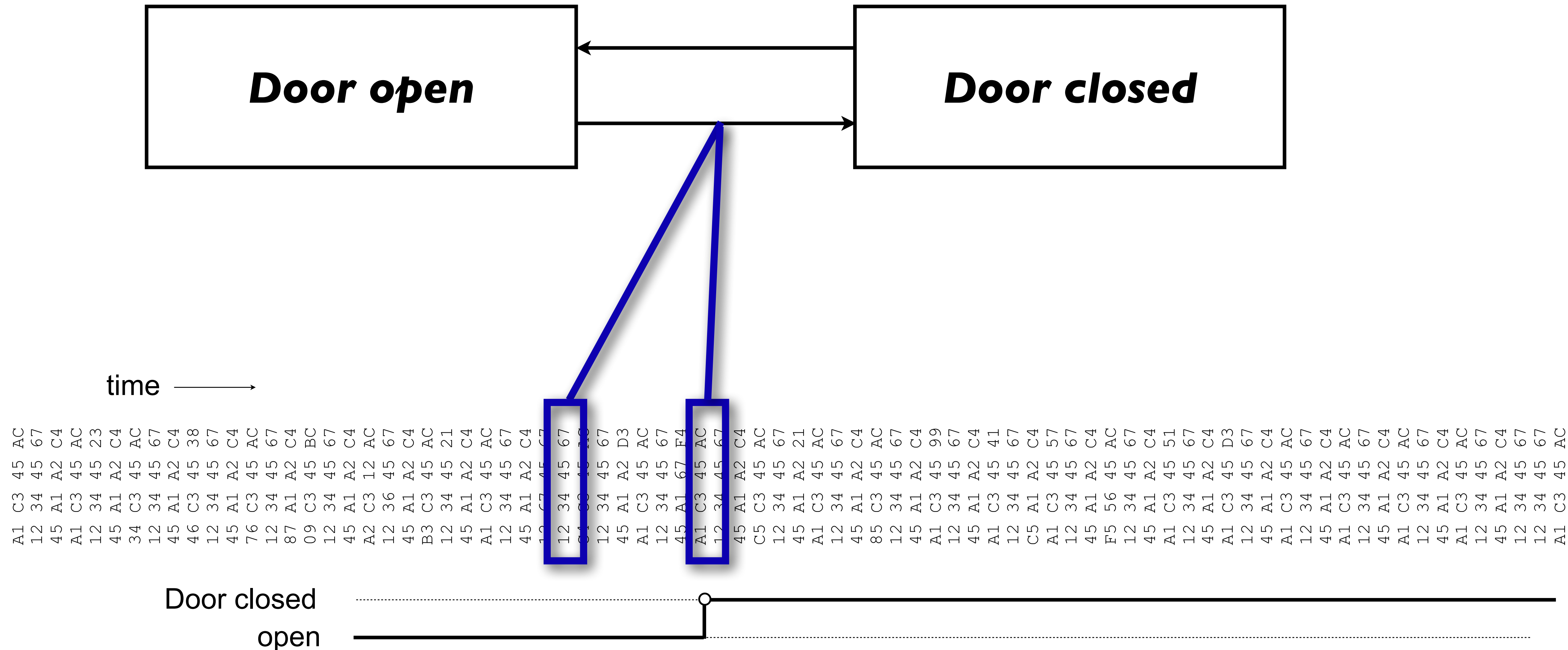
Our solution: **Cardiogram**



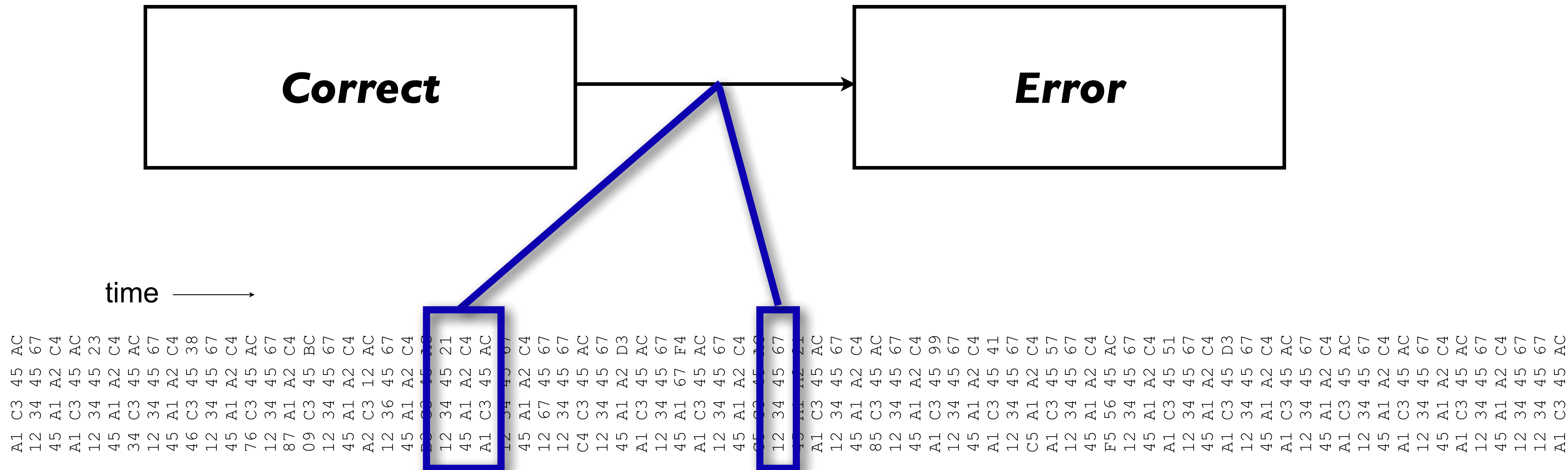
State machine pre-analysis



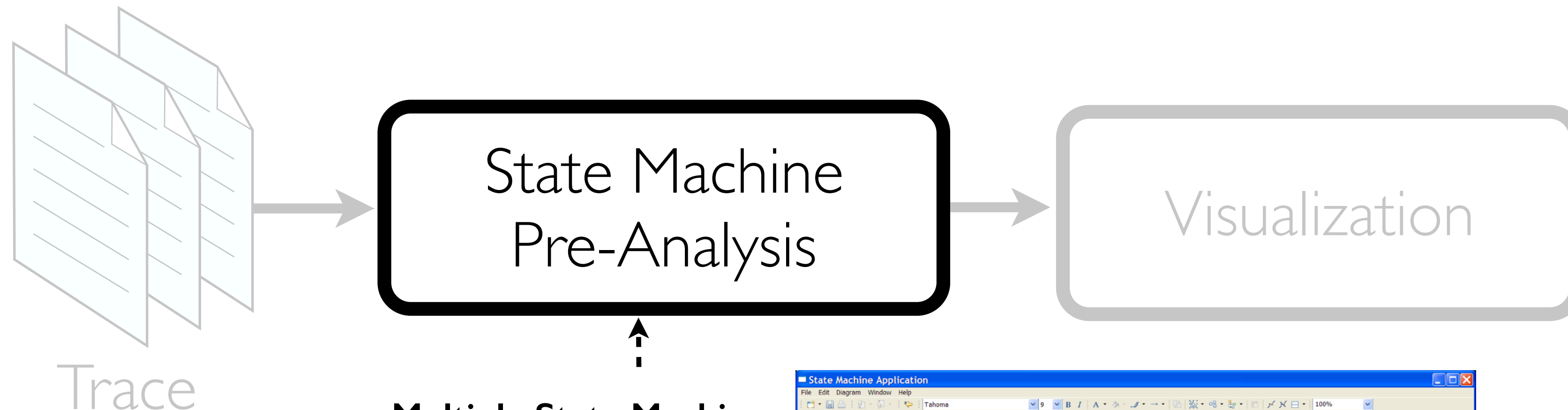
State machines: Behavior



State machines: **Error detection**

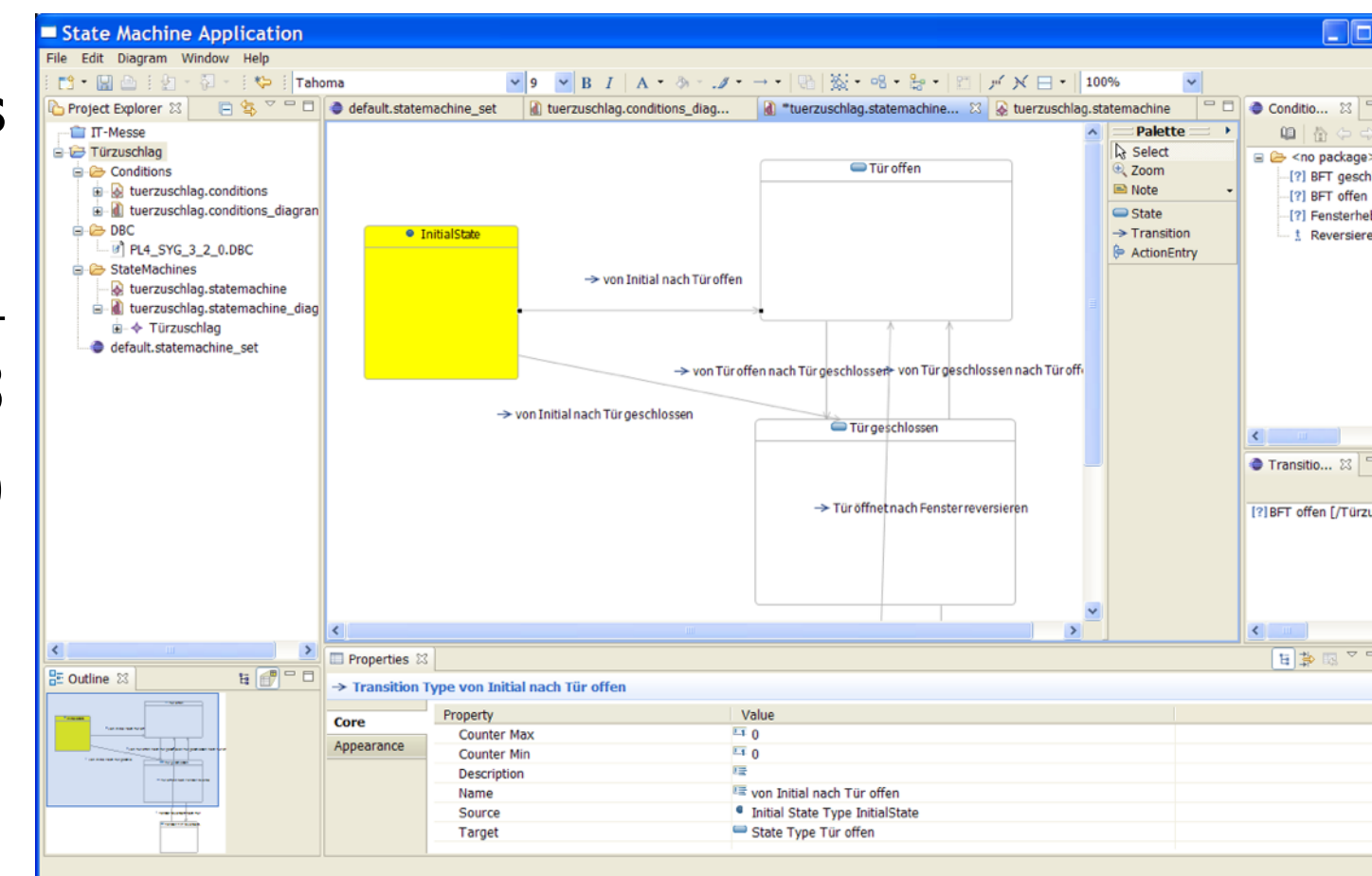


Create/select state machines

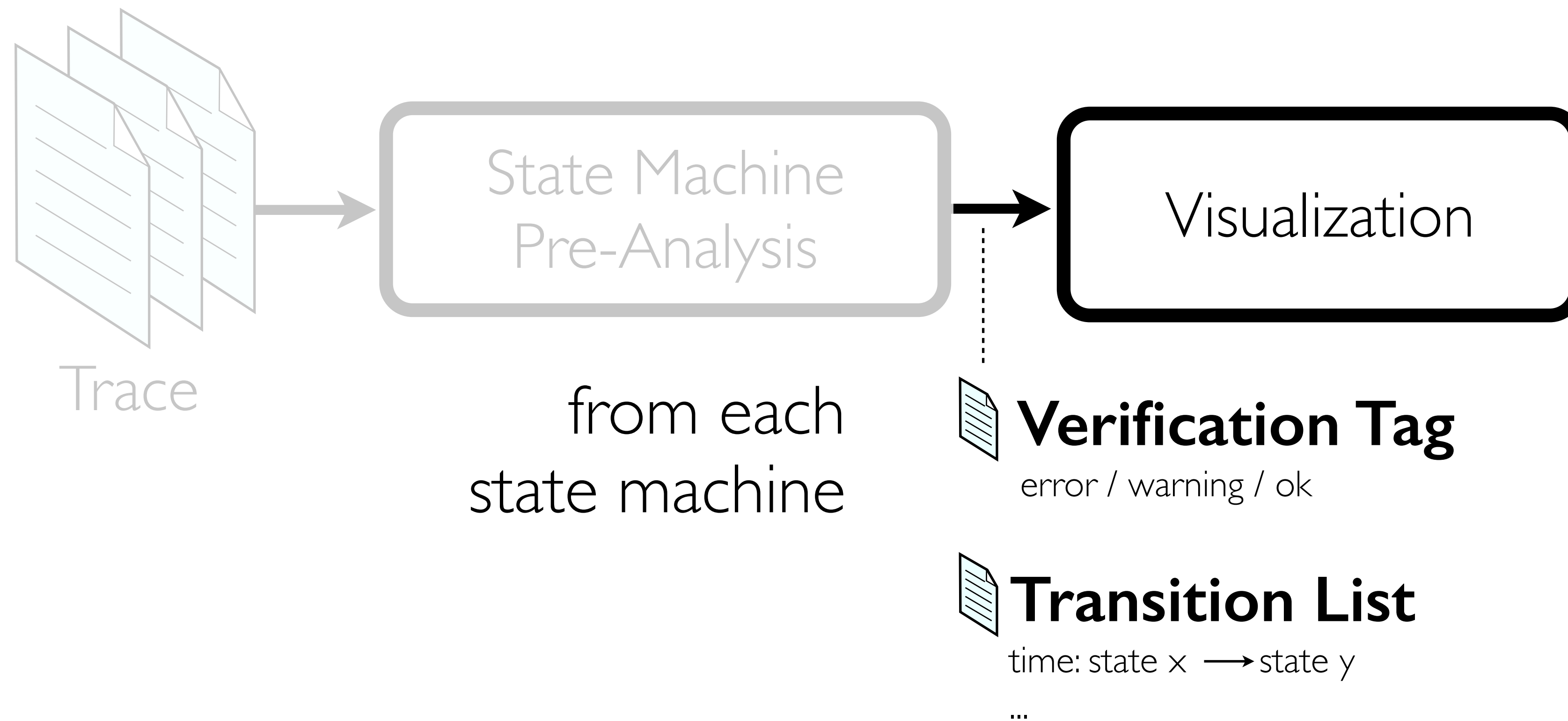


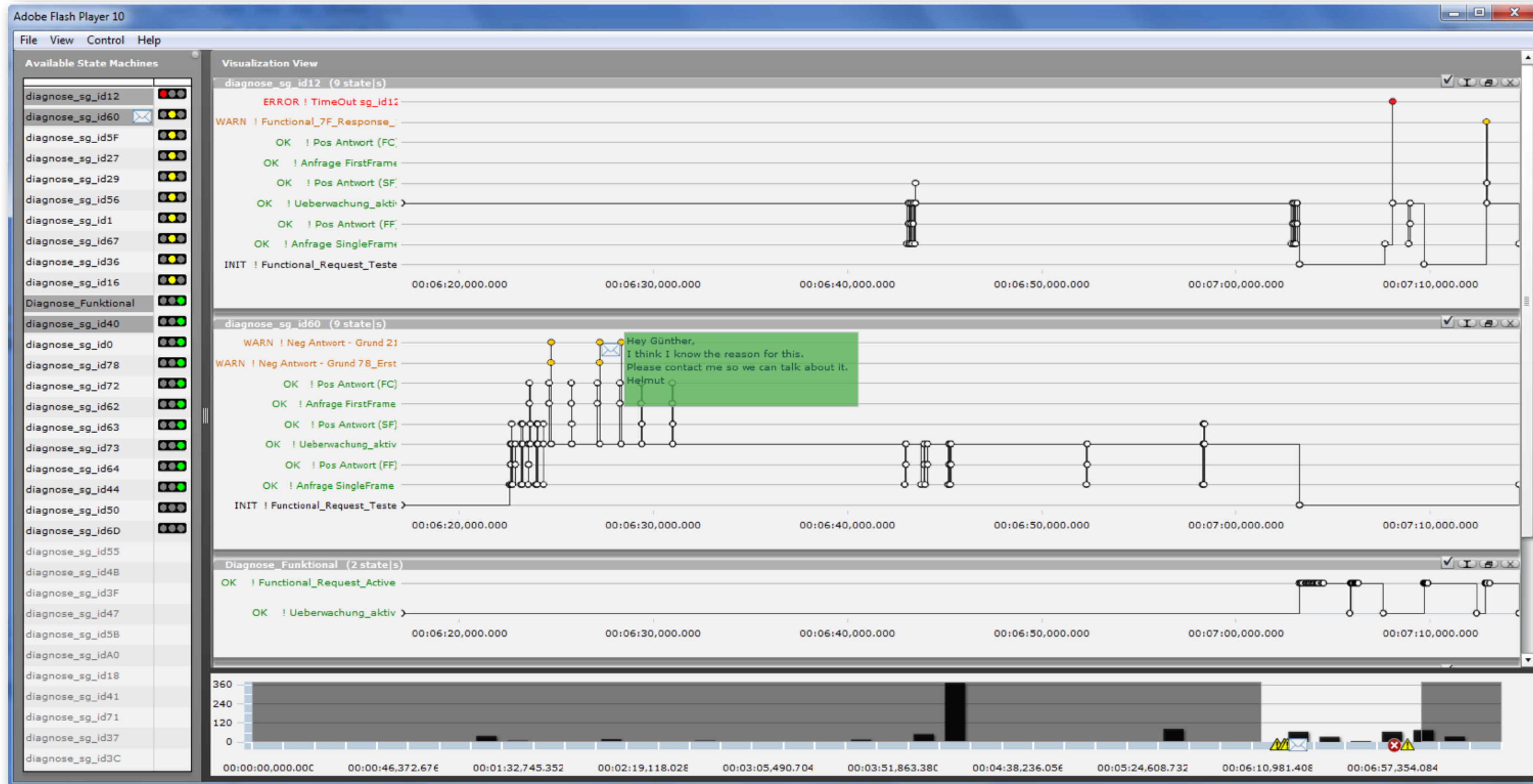
Multiple State Machines

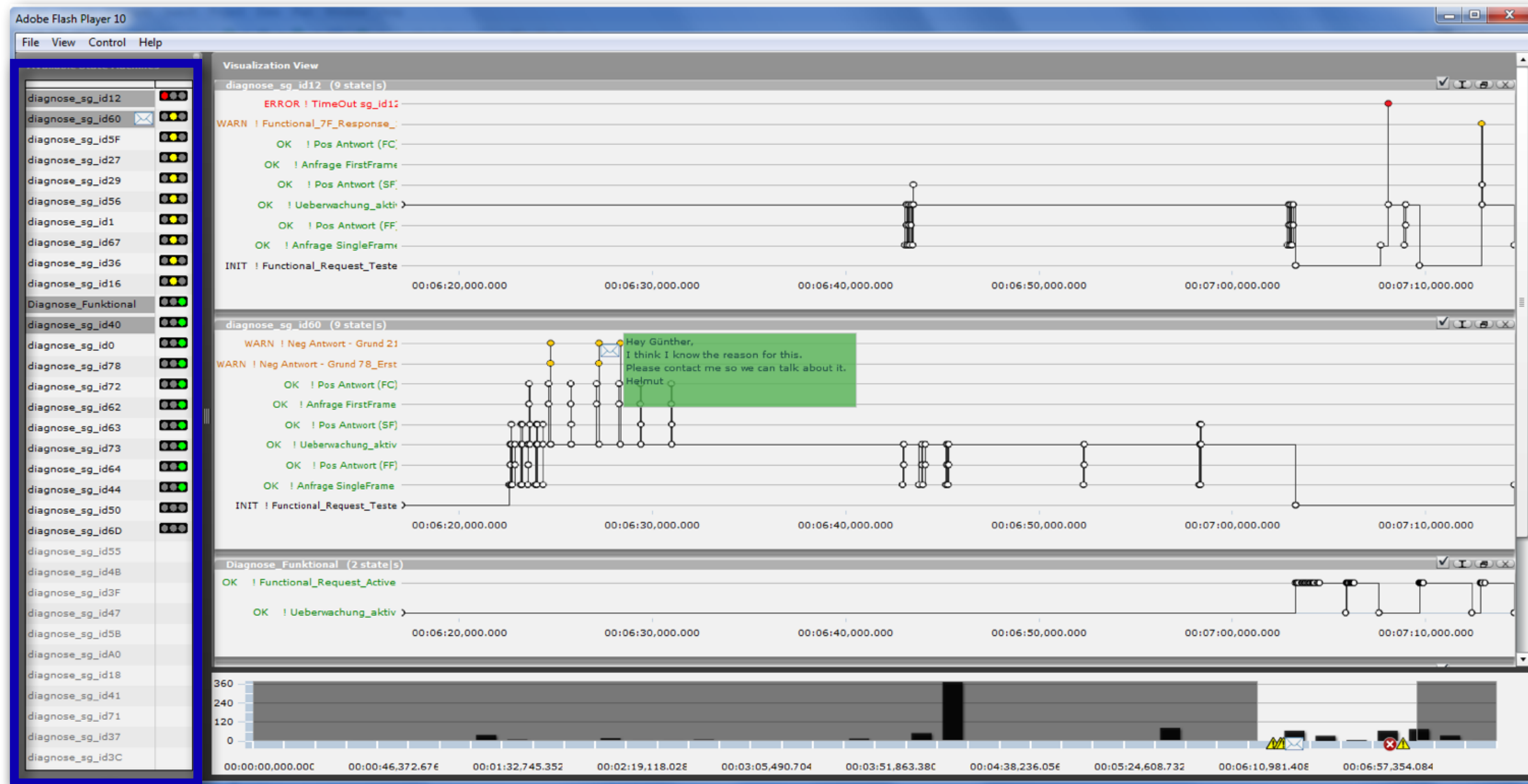
- State Machine 1
- State Machine 2
- State Machine 3
- ... (dozens)

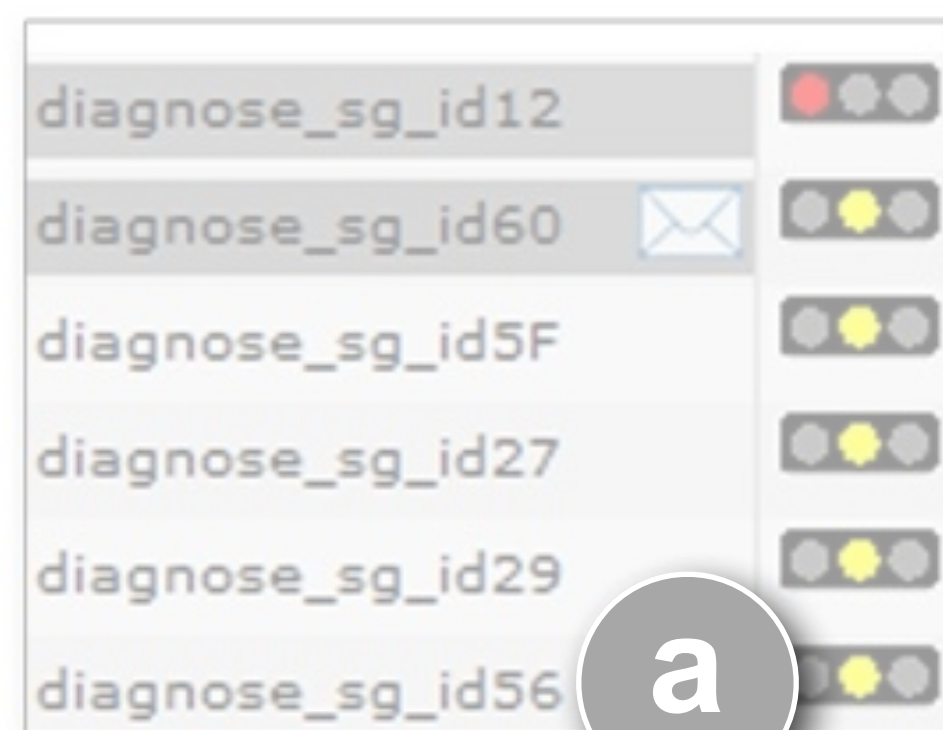
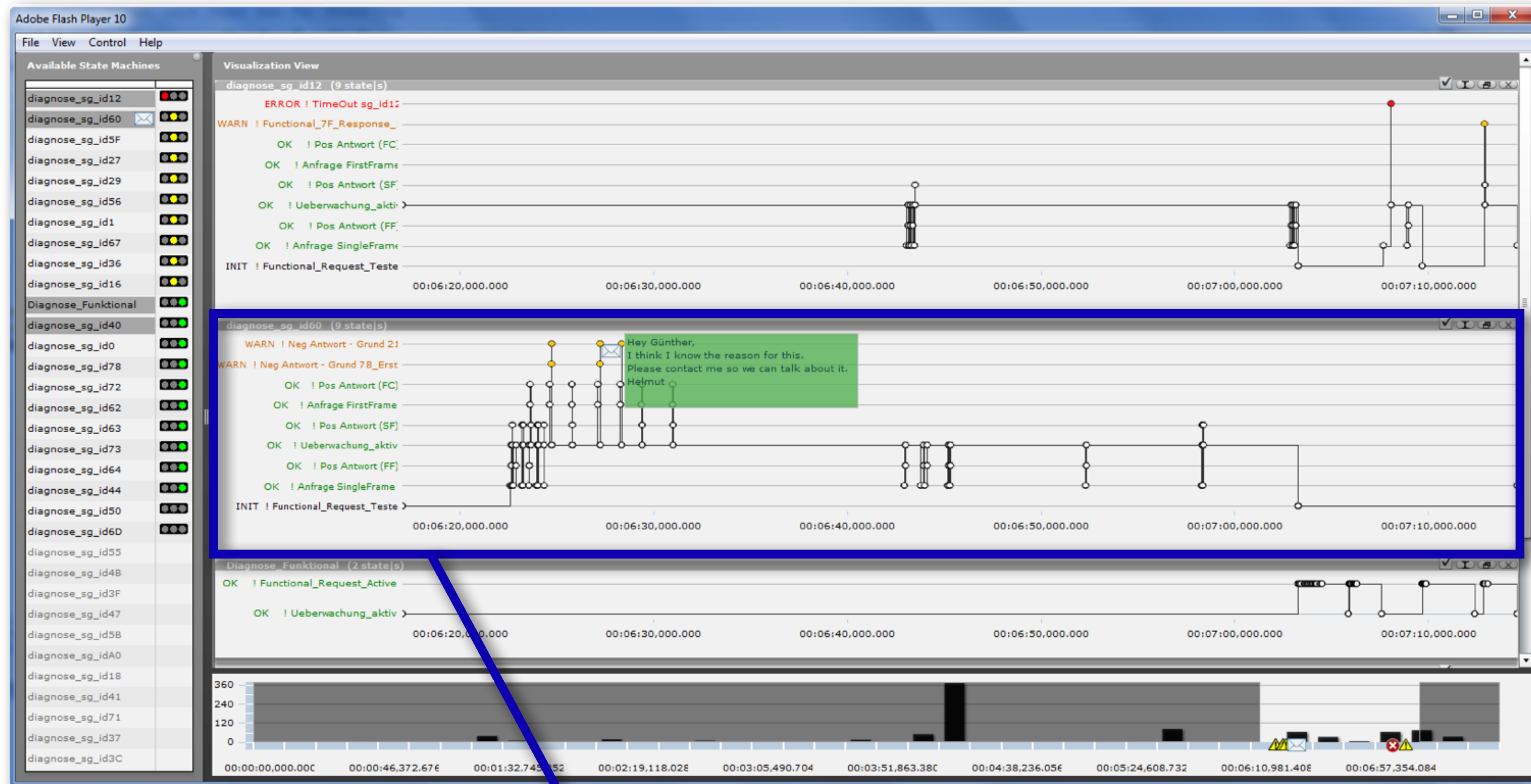


Data abstraction/reduction

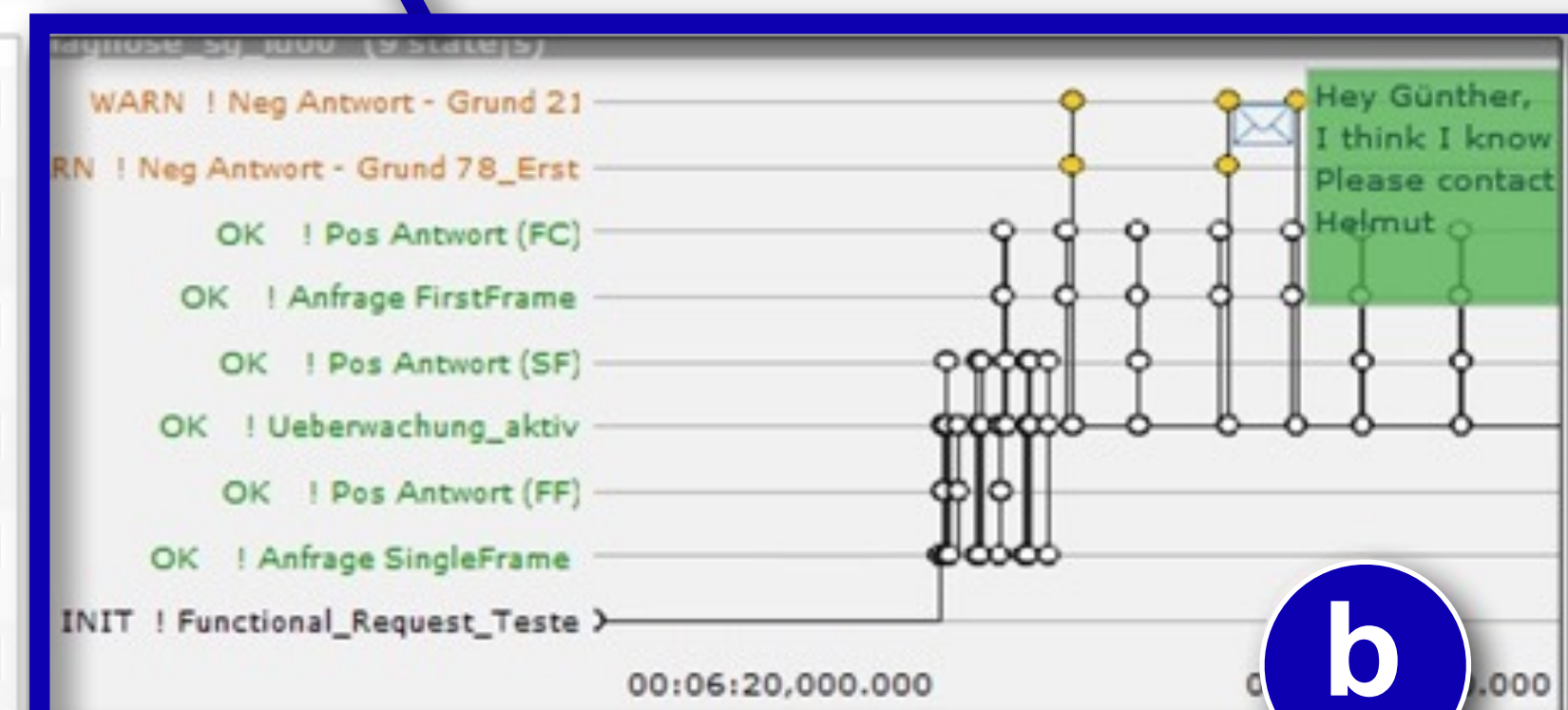




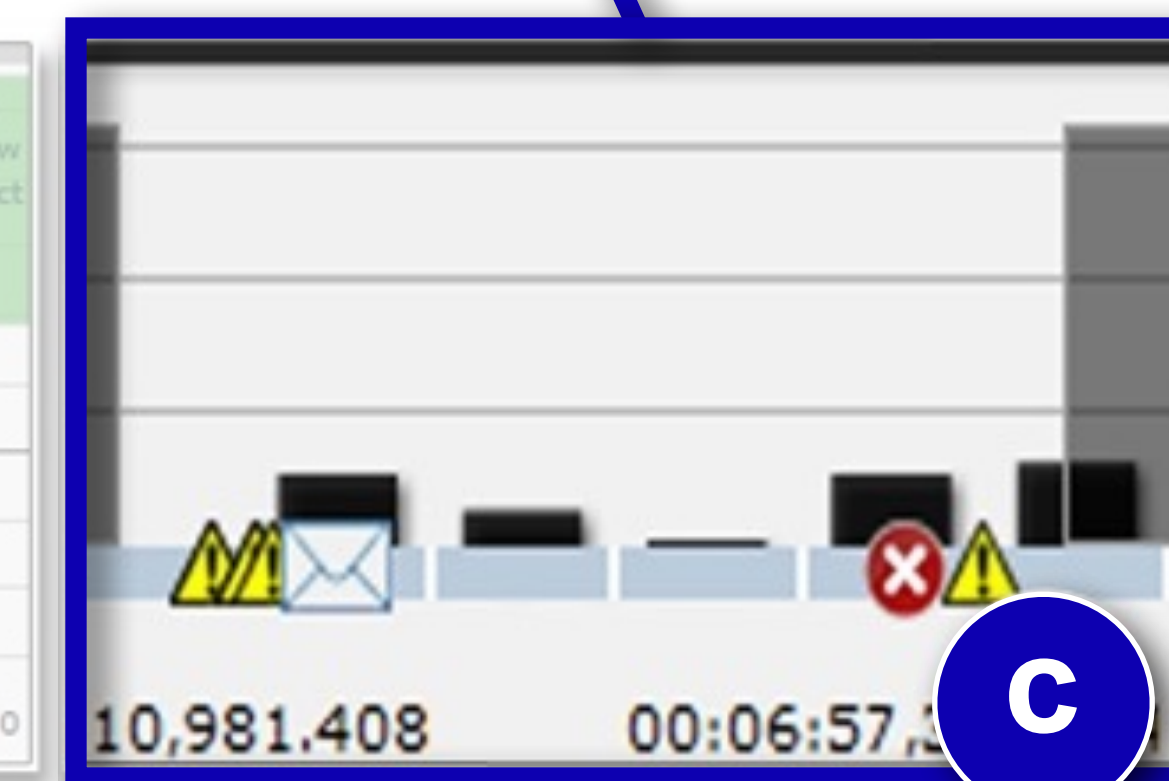
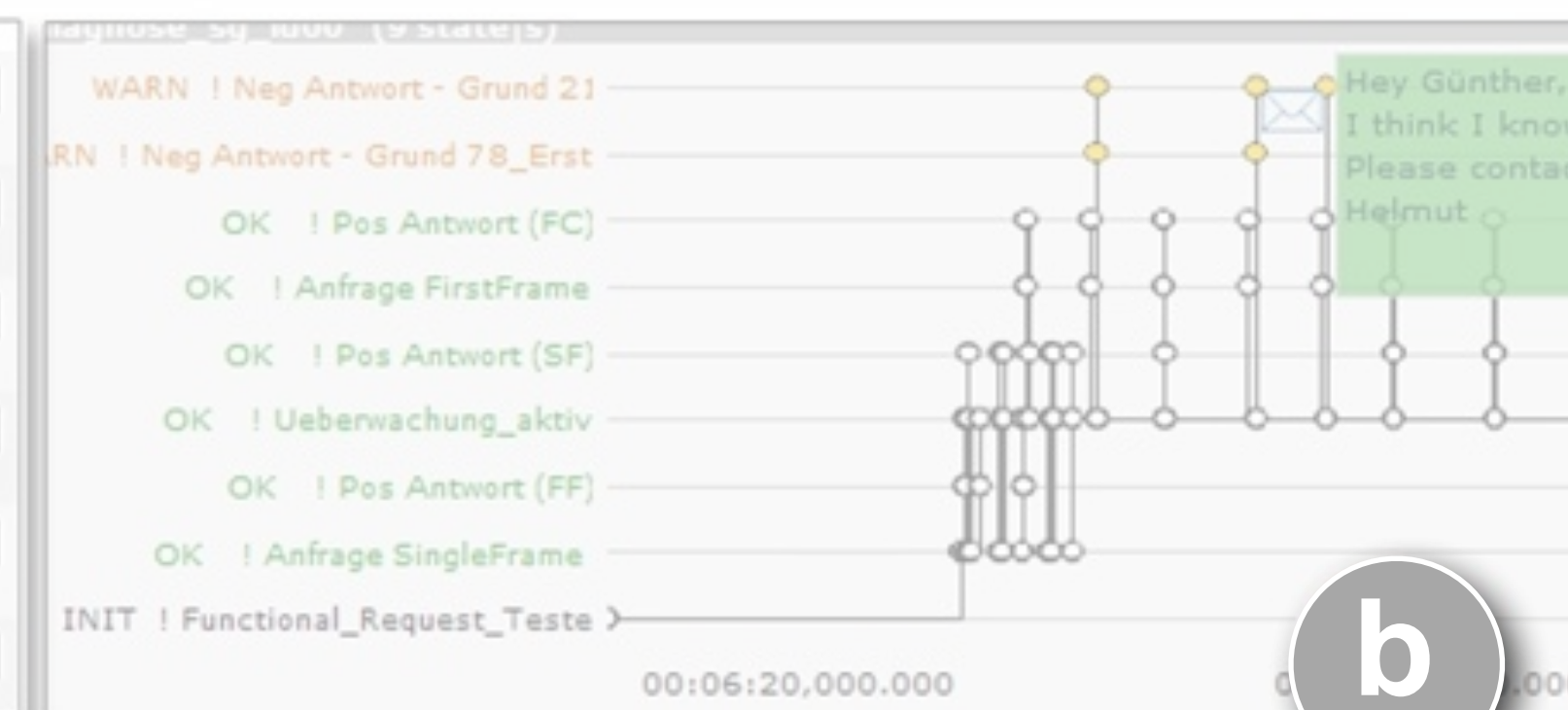
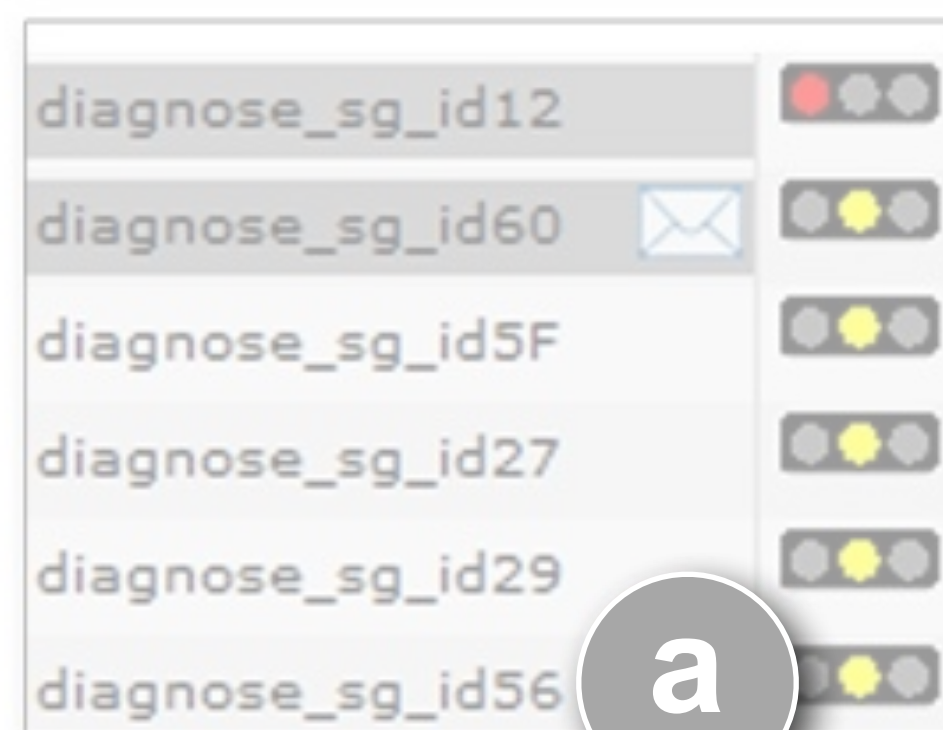
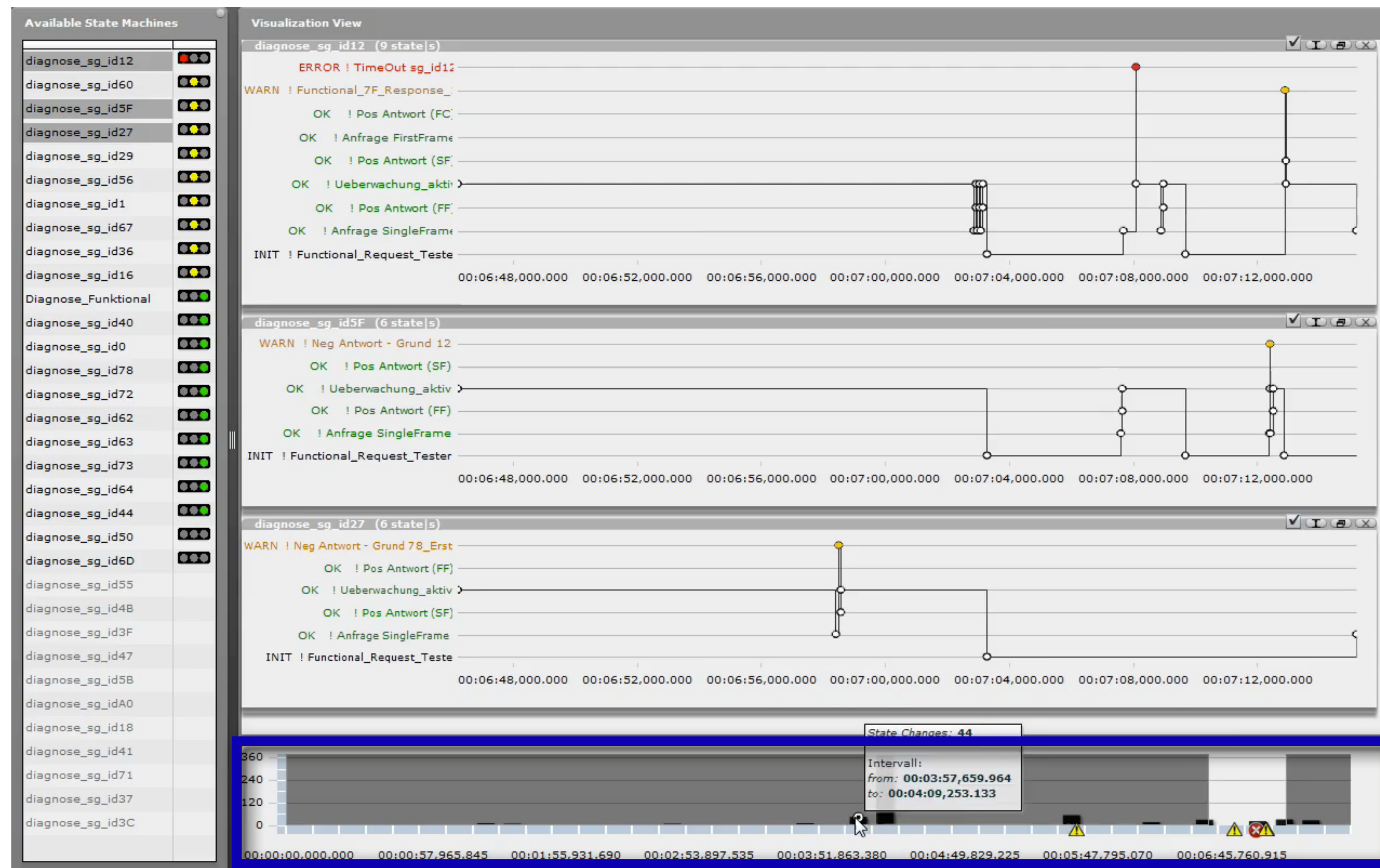




a



b

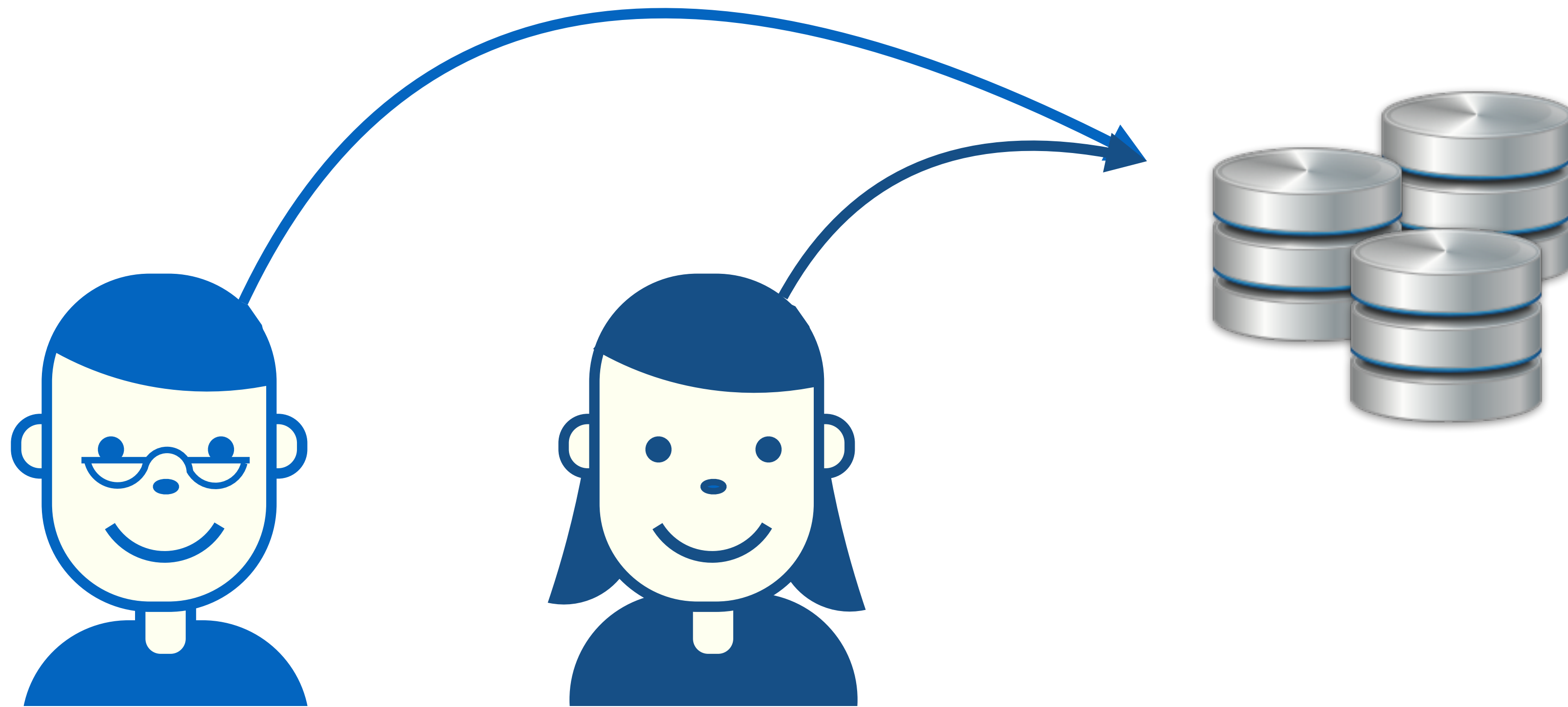


Longitudinal field study

- 1 year, 15 engineers

Results

- externalization and sharing of expert knowledge



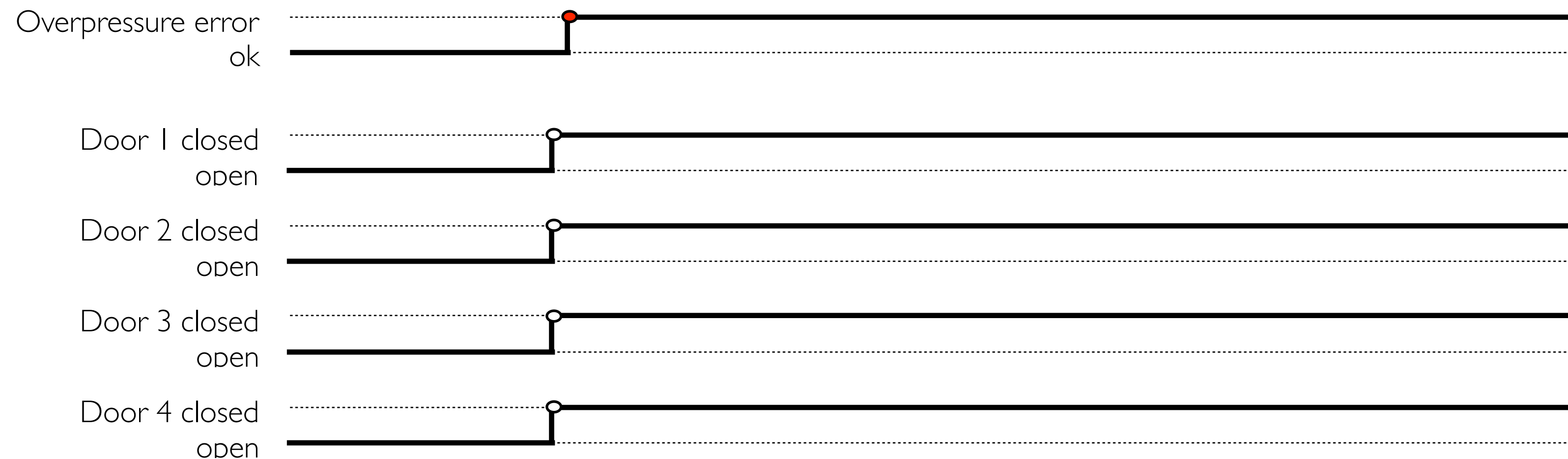
Results

- externalization and sharing of expert knowledge
- complete coverage of traces vs. sparse sampling

[illegible][illegible][illegible][illegible][illegible][illegible][illegible]

Results

- externalization and sharing of expert knowledge
- complete coverage of traces vs. sparse sampling
- understand behavioral correlations

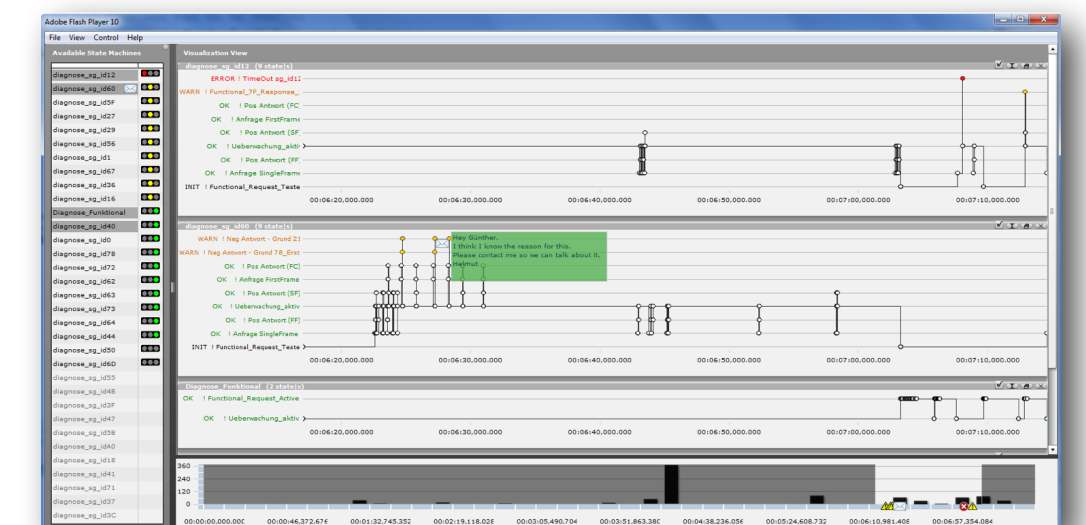
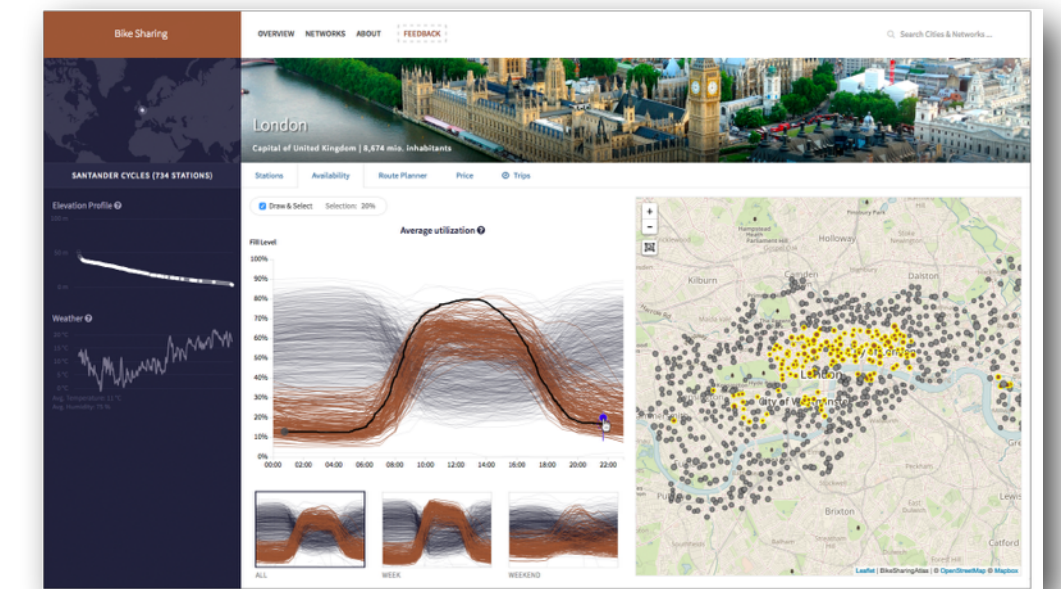
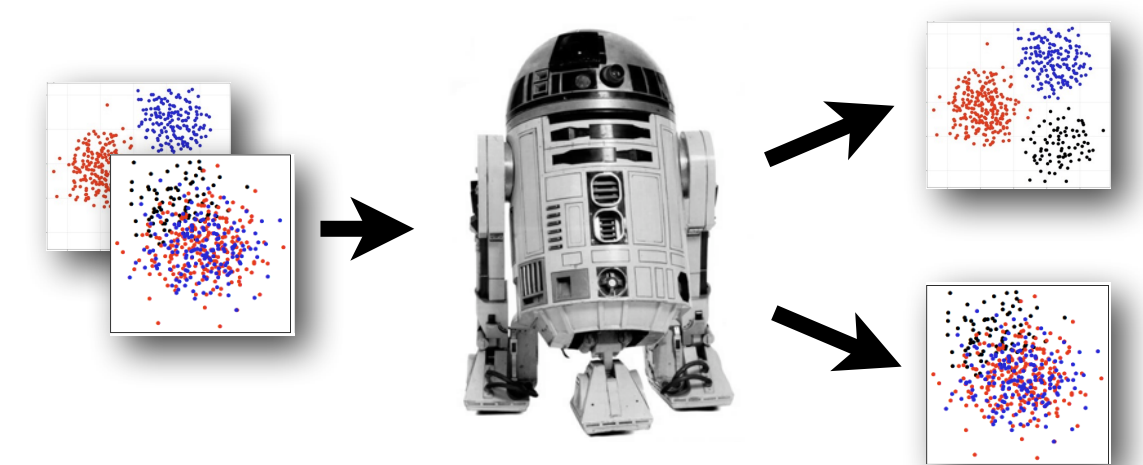


<http://www.automotiveaddicts.com/5276/bmw-x1-officially-released-images-first-drive-videos/bmw-x1-top-doors-open>

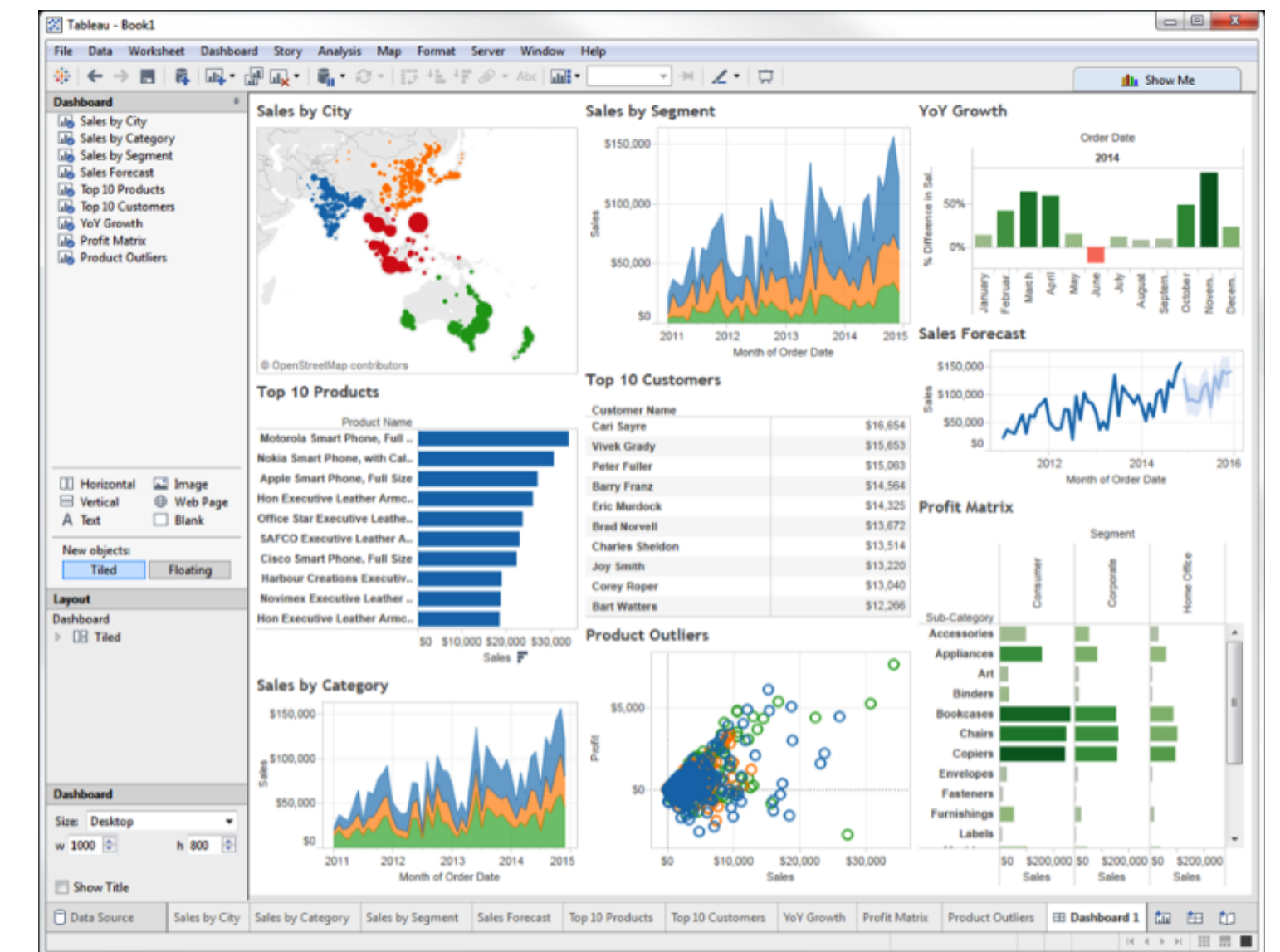
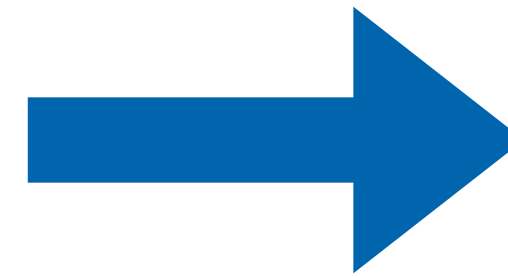
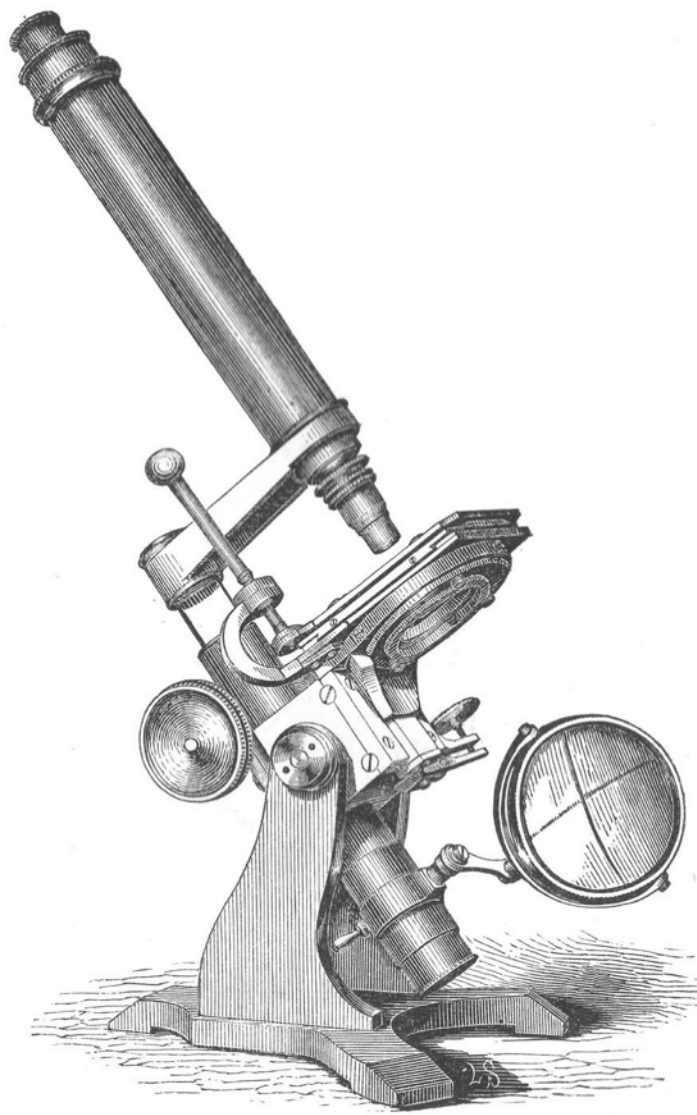
Summary

Summary: How to visualize data?

- Leverage perception
- Make it interactive
- Combine computation and visualization

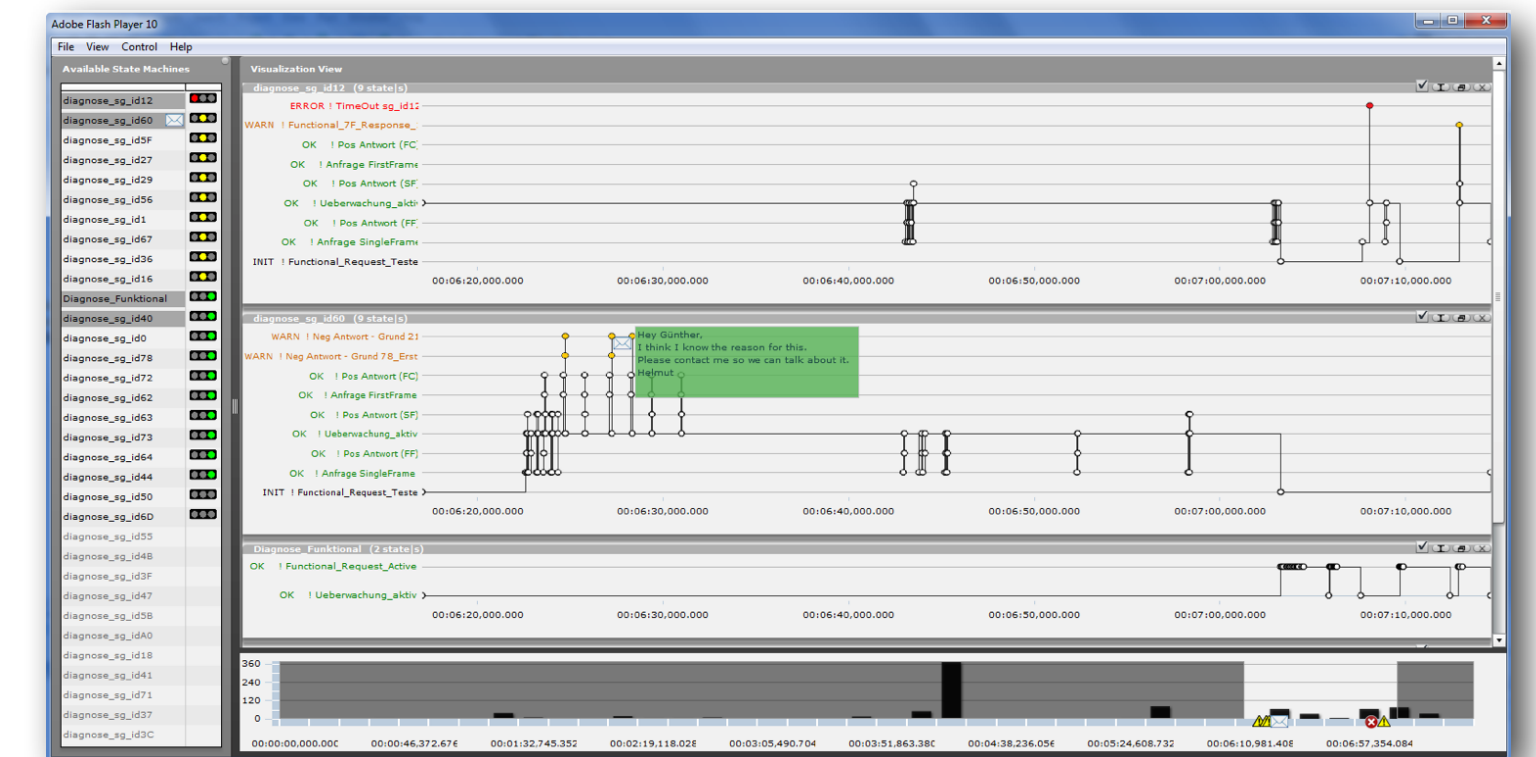
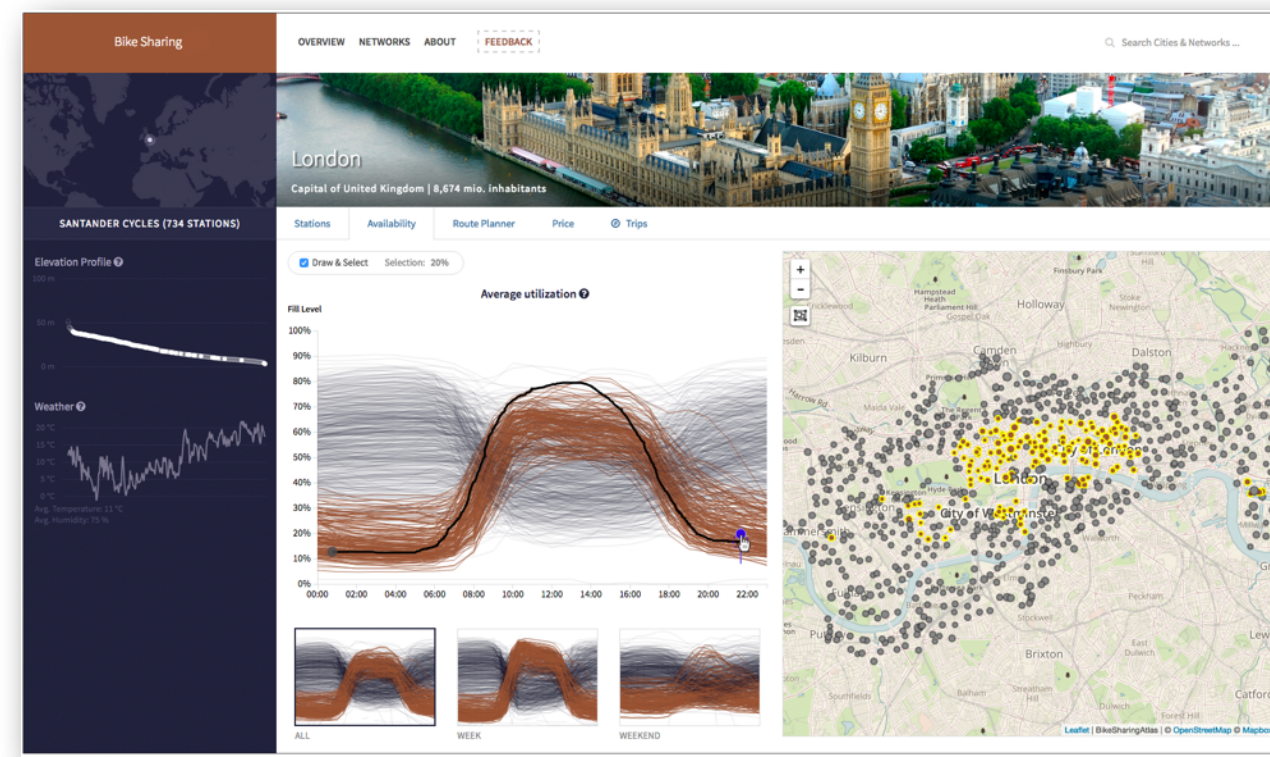
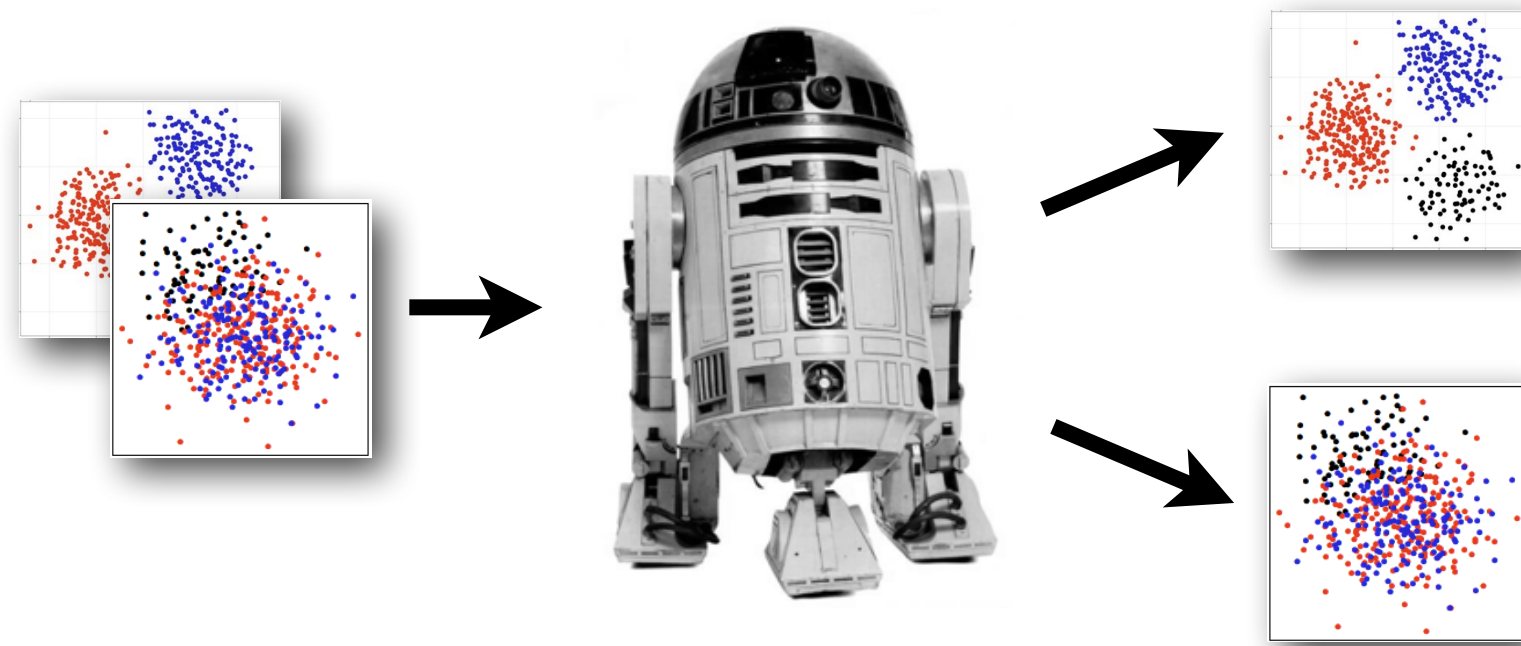


Visualization: The Human Lens to Data



Tableau

Thank you!



Dr. Michael Sedlmair
michael.sedlmair@univie.ac.at
slides: goo.gl/TS26EZ



universität
wien