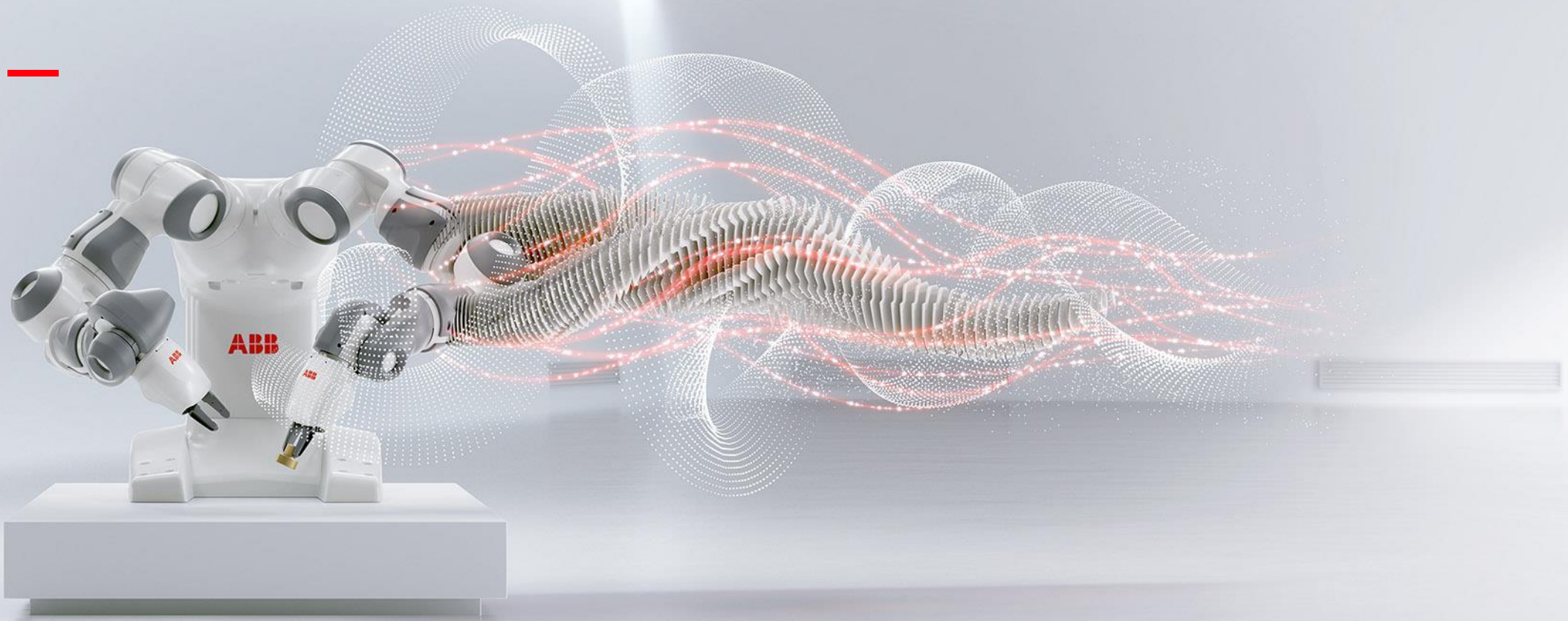

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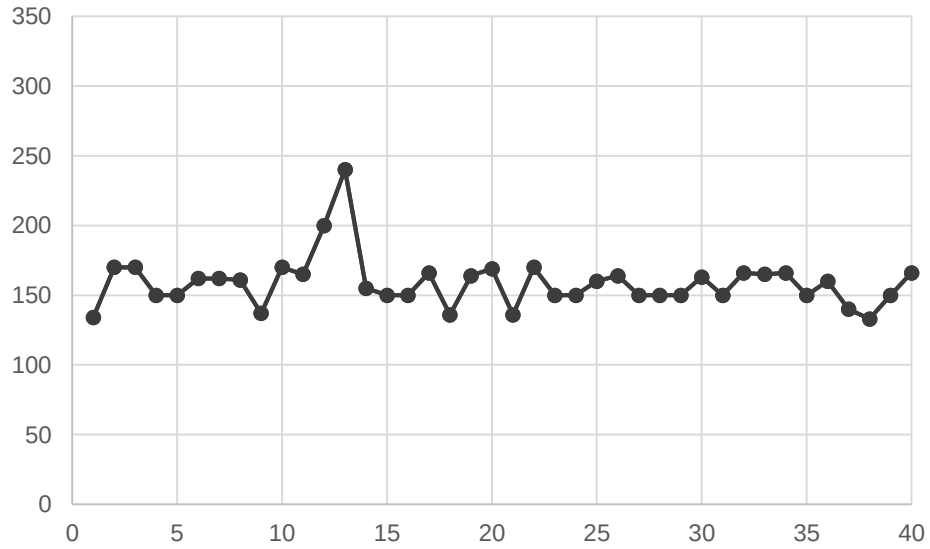
Holistic Development of Industrial Big-Data Applications and Services

Marcel Dix, Dr. Benjamin Klöpper, ABB Corporate Research

Data Analytics Exercise

Spot the anomaly



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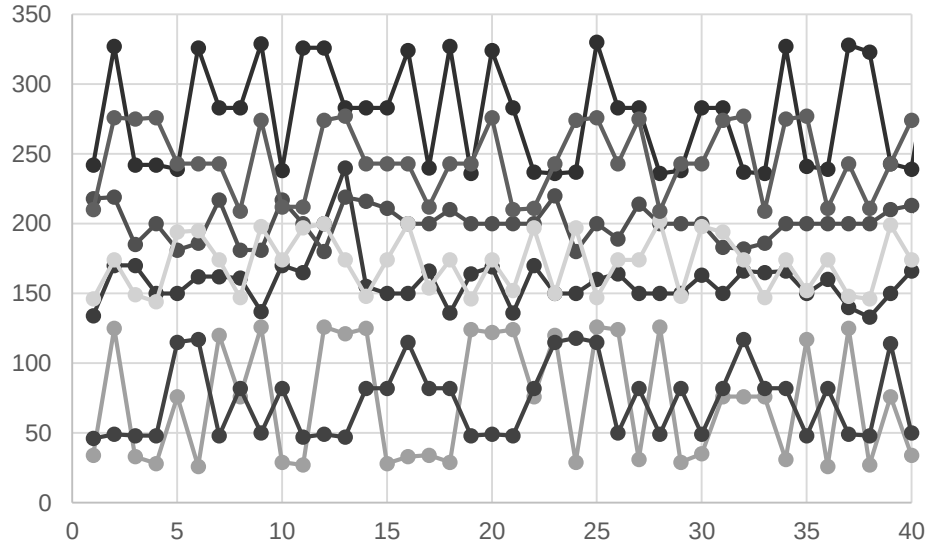
Data Analytics Exercise

Spot the anomaly now



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Large Scale Monitoring Applications

A problem we share with our customers

... hundreds of robots per factory!

... hundreds of pumps per site!

... hundreds of inverter DC/DC stages per field!

... thousands of signals per plant!

Analytics and machine learning make large scale industrial monitoring affordable!

Potential for Industrial Big Data Analytics

Example Figures

High Volume, e.g.:

– > 300 GB measurements Data p.a. in a single refinery
– 400 GB alarm data p.a. in a petro-chemical plant

High Velocity, e.g.:

– 66.000 sensors with sampling rates between 1s and 60s in a single refinery

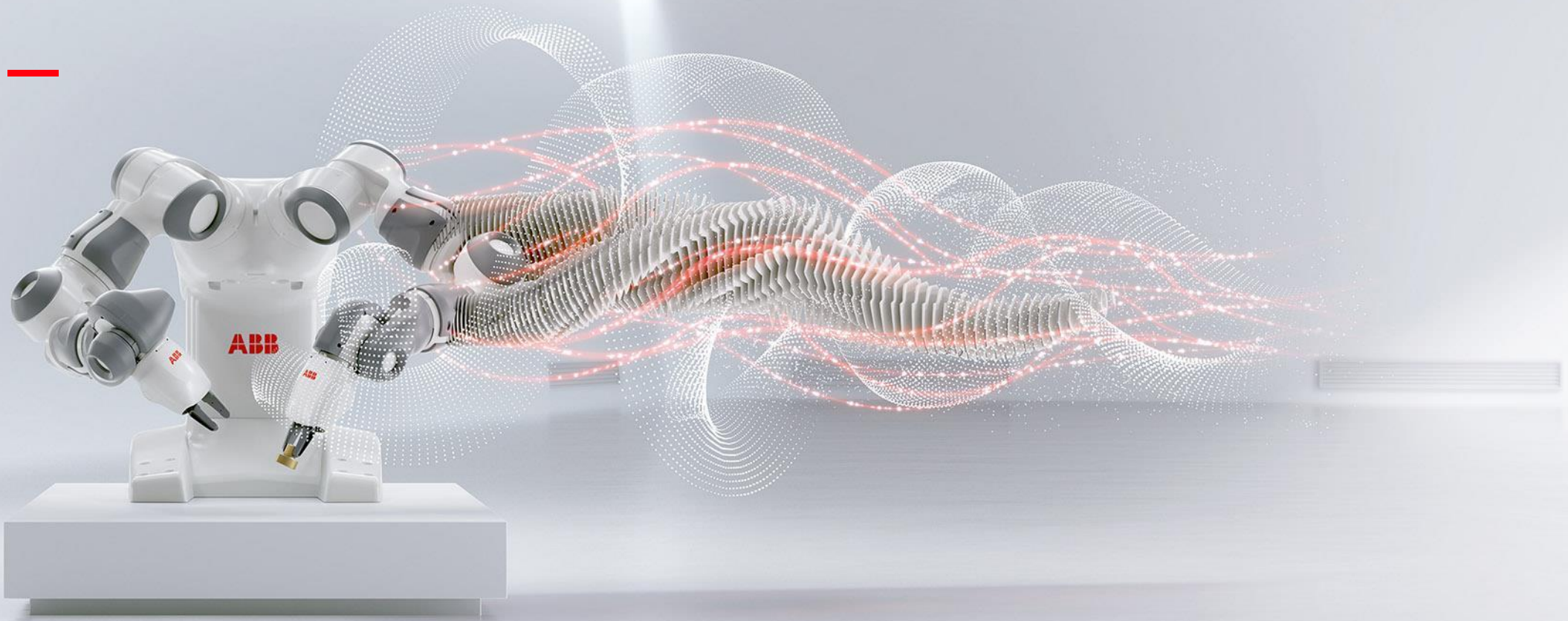
High Variety, e.g.:

– Time-series, log-data, unstructured data, video-data

Low Veracity , e.g.:

– time-synchronizing, faulty readings, missing data

FEE Development Partners: rapidminer TECHNISCHE UNIVERSITÄT DRESDEN UNIKASSEL VERSITÄT mrt ABB



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Introducing ABB

The pioneering technology leader

Shaping the world through innovation

Pioneering technology since 1883

1900	1920	1940	1960	1980	2000	2020
Founding fathers	Steam turbine	Turbochargers	Electrical drive system for locomotives	Gearless motor drives	Variable speed drives	Extended control systems
		Gas turbine		GIS		Ultrahigh voltage
			HVDC	Industrial robot	Electric propulsion systems	Collaborative robot

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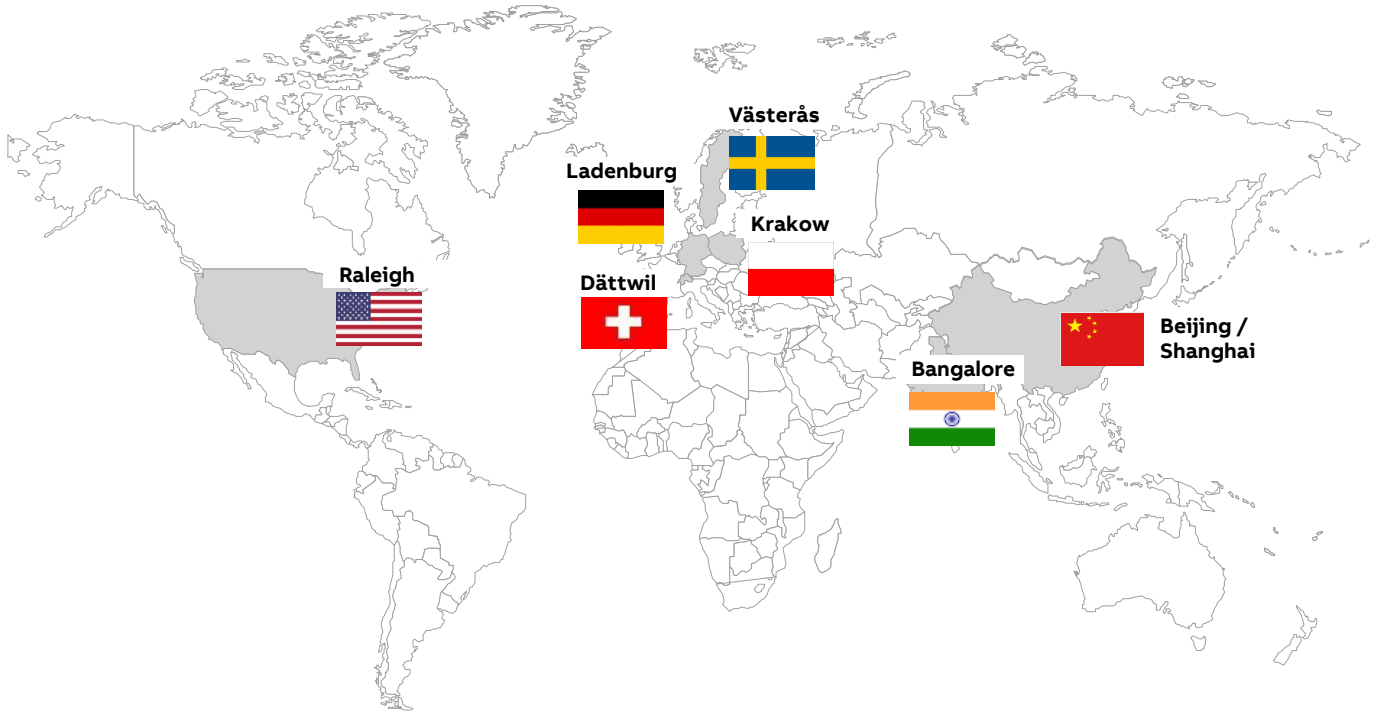
Corporate Research

Providing technology for tomorrow‘s innovations

ABB Corporate Research

Key figures

- ~ 130 mn US$ project volume
- in 8 global research areas aligned to ABB core technologies
- ~ 700 highly qualified scientists and engineers
- in 7 corporate research centers around the world



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Corporate Research Center Ladenburg

Key figures

70
Inventions/ year

30
Cooperations with universities

8
Significant innovations /year

~100
Employees

120
Scientific publications/ year

~80
Students/year

20 Mio. USD
Project volume/year

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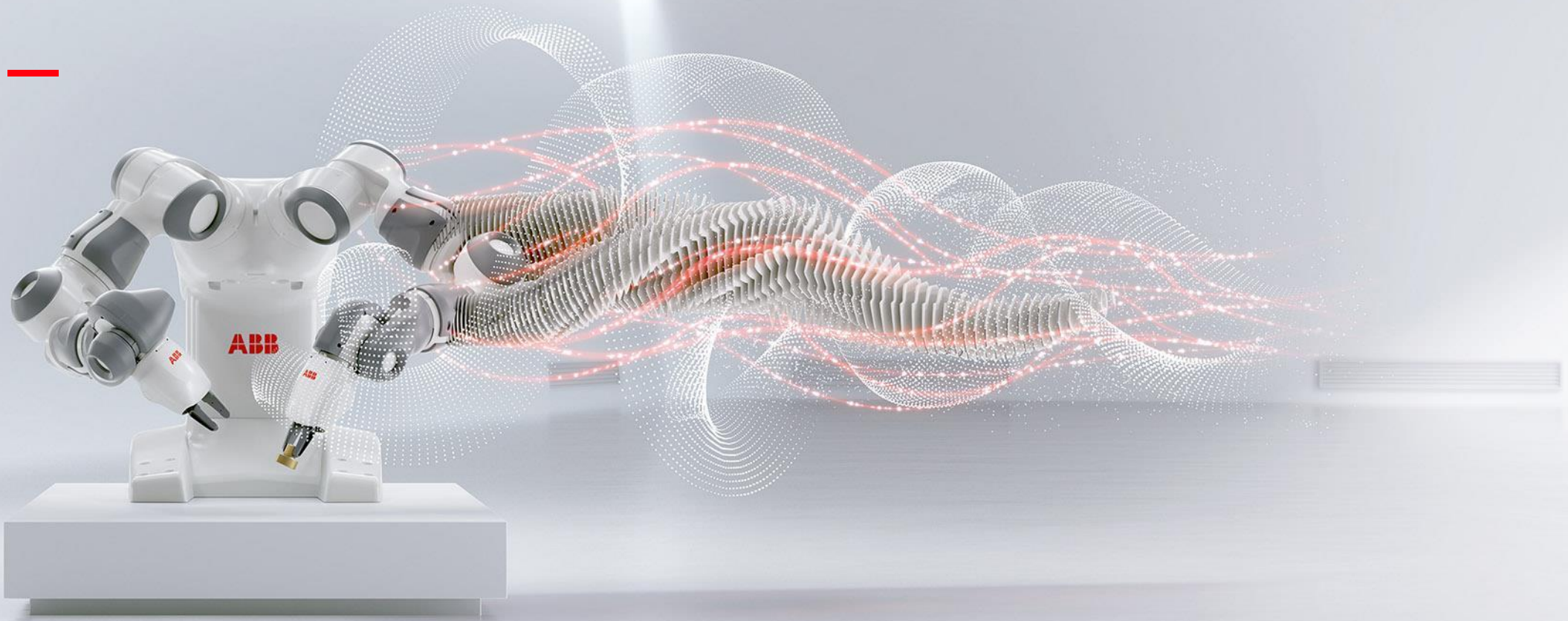

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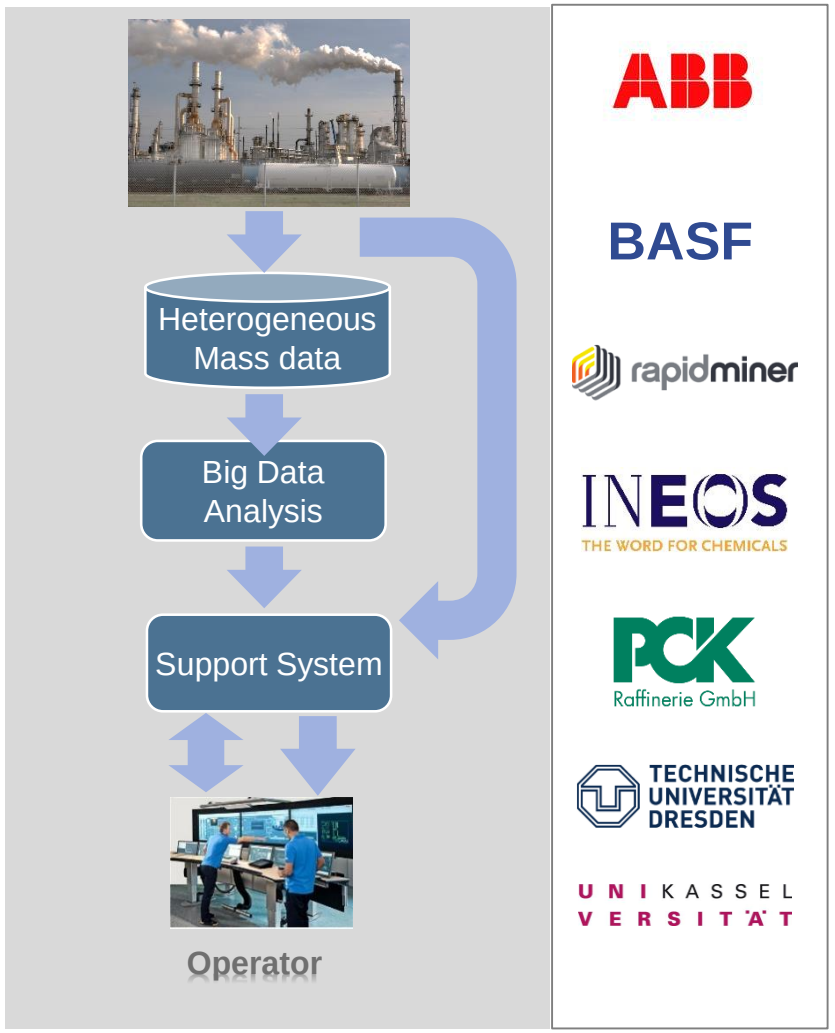
Example Analytics Research Project

The FEE Project

https://www.fee-projekt.de/

Project Overview



Objective: Operator Support functions

- Early Warnings
- Ad-hoc Analysis
- Decision Support

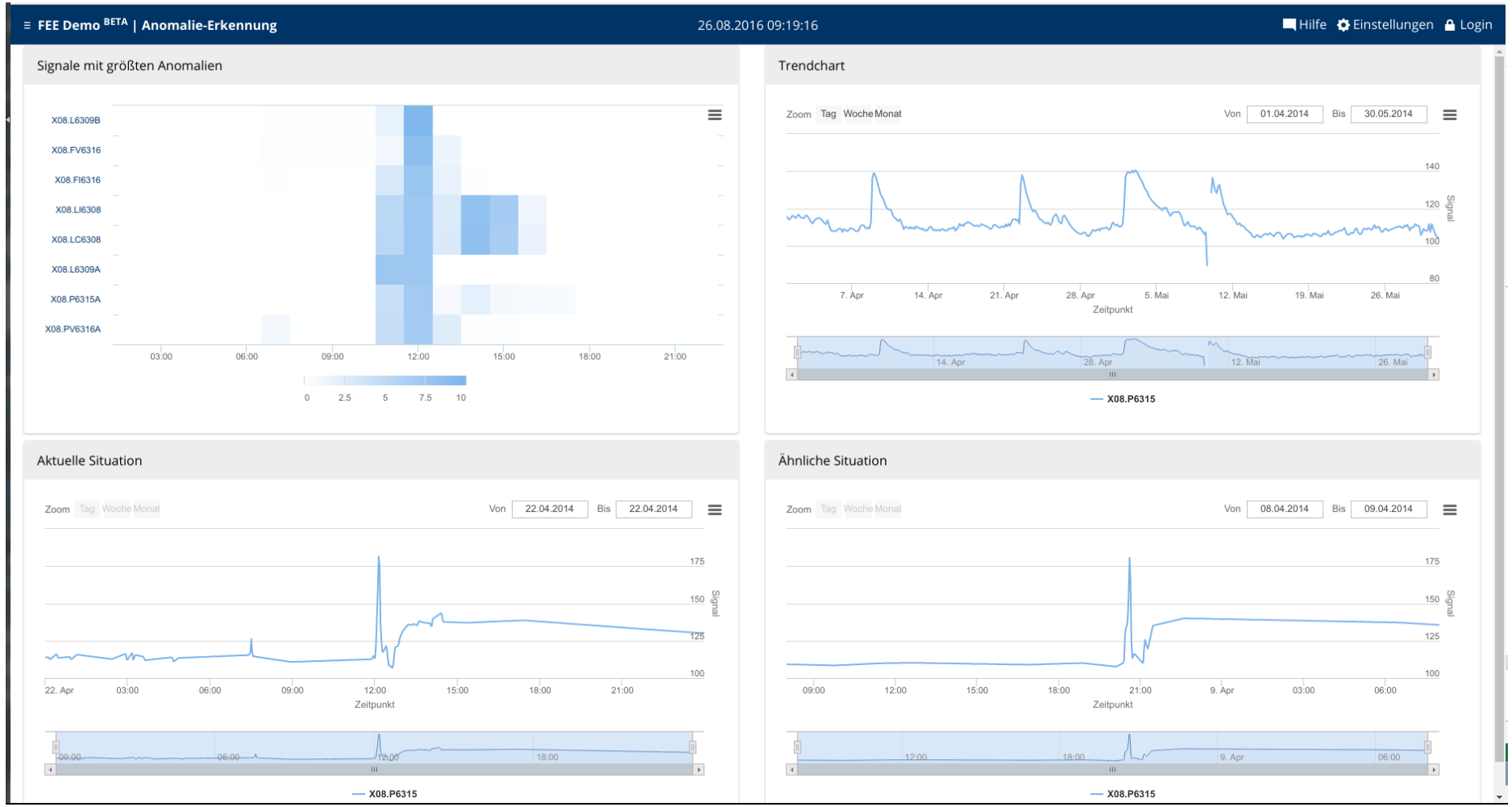
Approach: Integrated Analysis of all plant data

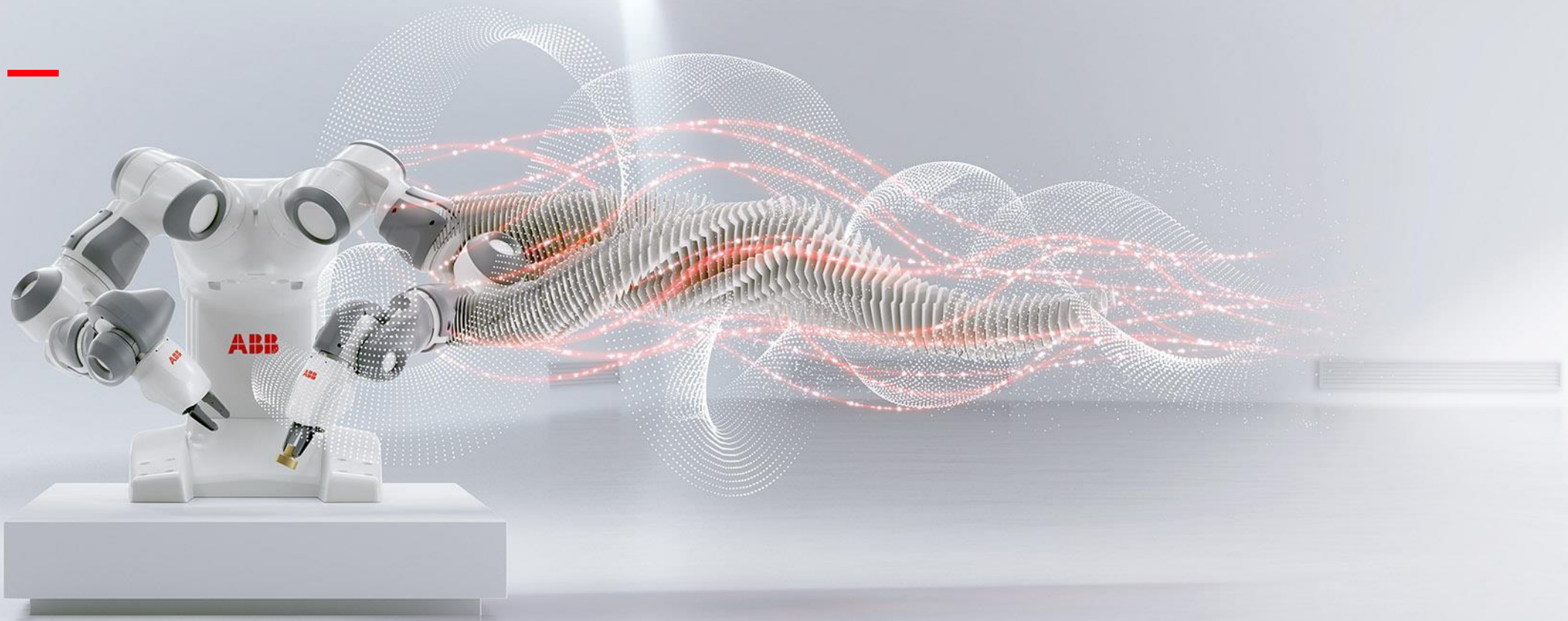
- Measurements, engineering data, electronic shift books,…

Research Topics

- Algorithm development
- Indexing of and search in process data
- Integration into real-time plant operation
- Big data technologies and architecture
- User Centered interaction concepts

Operator Interface for Anomaly Detection





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Analytics Research

How is it done?

The Analytics process at ABB

From Value Proposition to Continuous Value Delivery

Work with Customer to Identify **Value Proposition**

1

What are **Customer's pains and gains**?

Can analyzing data help?

Leverage domain knowledge

From Value Proposition to specific analytics questions

Develop the right thing

Analysts **Investigate Available Data**

2

Explore available data

Plan data collection

Collect sample data

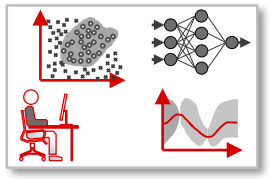
Explore data and formulate hypothesis

Clean & prepare the data

Use the right data

Analysts Implement **Data Analytics Techniques**

3



Develop analytics models

Design based on analytics question and available data

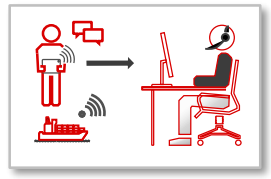
Variety of approaches available

No cookbook for selecting the best approach

Understand the methods

Deploy results for continuous application

4



Validate results on actual fleet

Develop best visualization with end user (service staff, customer)

Deploy approach on the ABB analytics architecture

Make it repeatable

Value Proposition in Analytics Projects

Common Value Proposition

Maintenance

1. Values: **Prevent or minimize** unexpected **downtimes** and minimize **maintenance costs**
   Examples: Root-Cause Analysis, predictive/preventive maintenance, spare-part optimization

Asset Optimization

2. Values**: Improve efficiency of assets** or small subsystems (e.g. drive-train, PV installation)
   Examples: Pump efficiency, PV output optimization

Operation Support

3. Values: **Improve Operator efficiency**, effective operation of systems
   Examples: Recommender systems, anomaly detection, event prediction, process troubleshooting

Operation Optimization

4. Values**: Improve efficiency of production processes**
   Examples: KPI systems/dashboards

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Project Example FEE – Big Data for Operator Support

Description of Application scenarios

Current State:

Who:
- Operator in the control room (and process engineers)

What:
- Monitoring of the plant in ‚calm' situations

How:
- Browsing operator screens and trend display for suspicious signals
- Is only done in ‚calm' situation without stress

Problems:
(1) **Risk to simply overlook** a suspicious signal
(2) Monitoring without broad coverage **in stressful situations**
(3) Difficult for unexperienced operators to judge the ‚suspiciousness' of signals

Desired State:

FEE Support:
Identify suspicious signals and providing relevant data for diagnosis

Desire:
(1) **Fast visual impression on abnormalities** in the process
(2) Put into context to historical ‚normal' and ‚abnormal' signal paths
(3) Providing extended context (relevant alarms, operator notes, documents)

Paper Prototypes

Project Example FEE – Big Data for Operator Support

Scenario Canvas for Application Partner Workshops

1

Title:
Plant:
Operation Mode (e.g. Start-up, Shut-down, Product Transition):

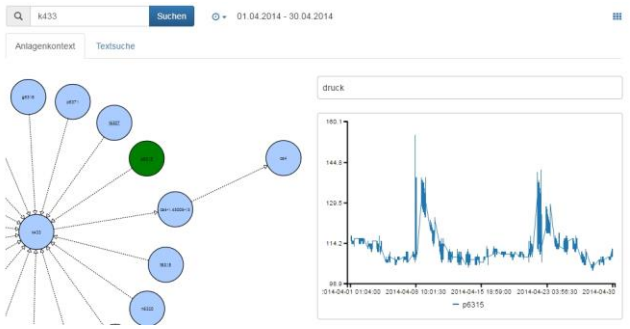
Situation

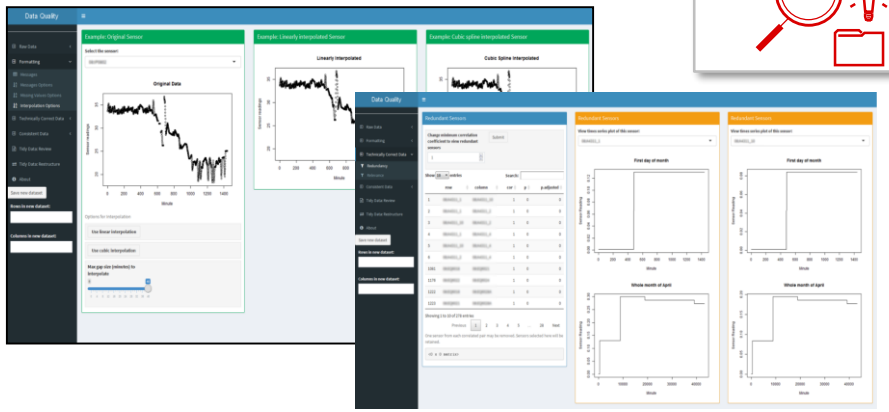
Role/ Actor:
Frequency:

Online-Data	*Actions*	*Info. Sources*
Predictors Can it be predicted?	**Avoid Situation** Does a prediction help? How early is it needed?	**Means of support** Access to domain knowledge
Indicators Can it be detected? How to find in historic data?	**Handle Situation** Does detection help?	**Historical data** Is there sufficient data Where is it recorded?
Consequ What happens, if the situation is not dealt? What happens, if the situation is wrongly handled?	Is a project worthwhile?	

Project Example FEE – Big Data for Operator Support

Domain Specific Data Exploration and Preperation Tools





Full-Text Search across all data

One access point to alarms, operator notes, manuals…

Quickly find relevant events

Understand context of events

Graphical Search on Plant Topology

Link assets found in notes and alarms to process signals

Explore process signals directly in the tool

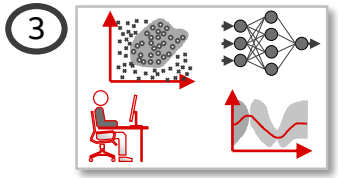
Tool for typical data quality tasks

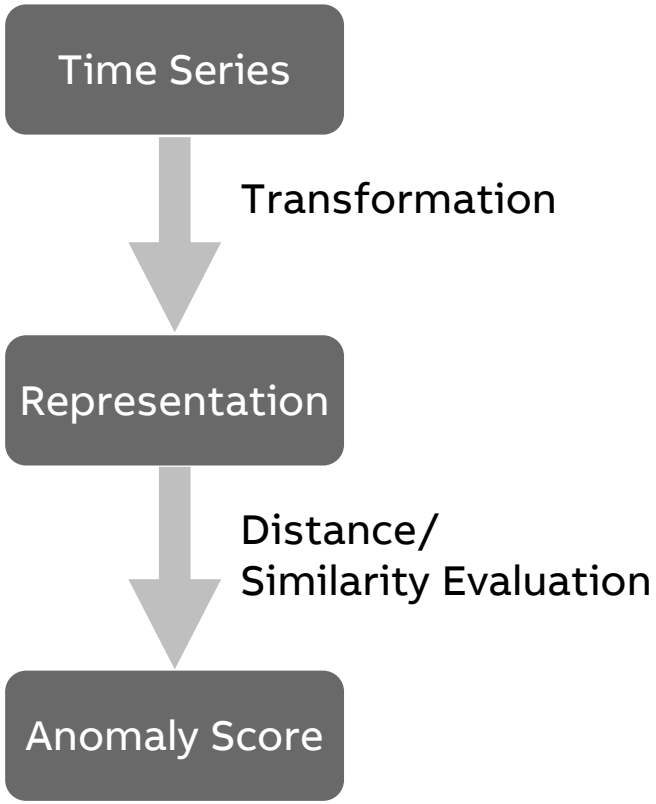
Guided process to cleansed data set

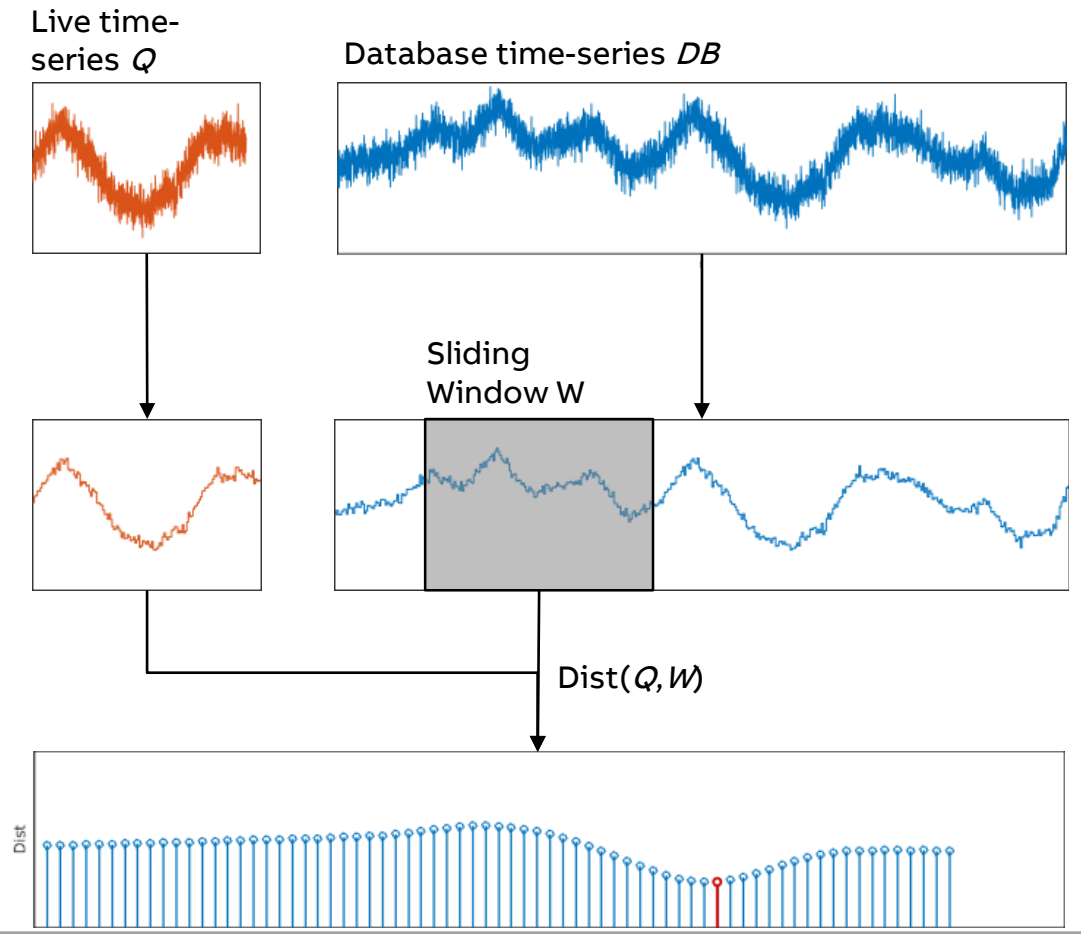
Identifies low quality and redundant signals

Smoothing and handling missing values

Project Example FEE – Big Data for Operator Support







The distance between a live data time-series and the most similar subsequence from historical database is used to calculate the anomaly score.

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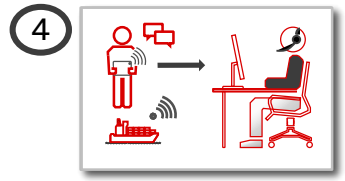
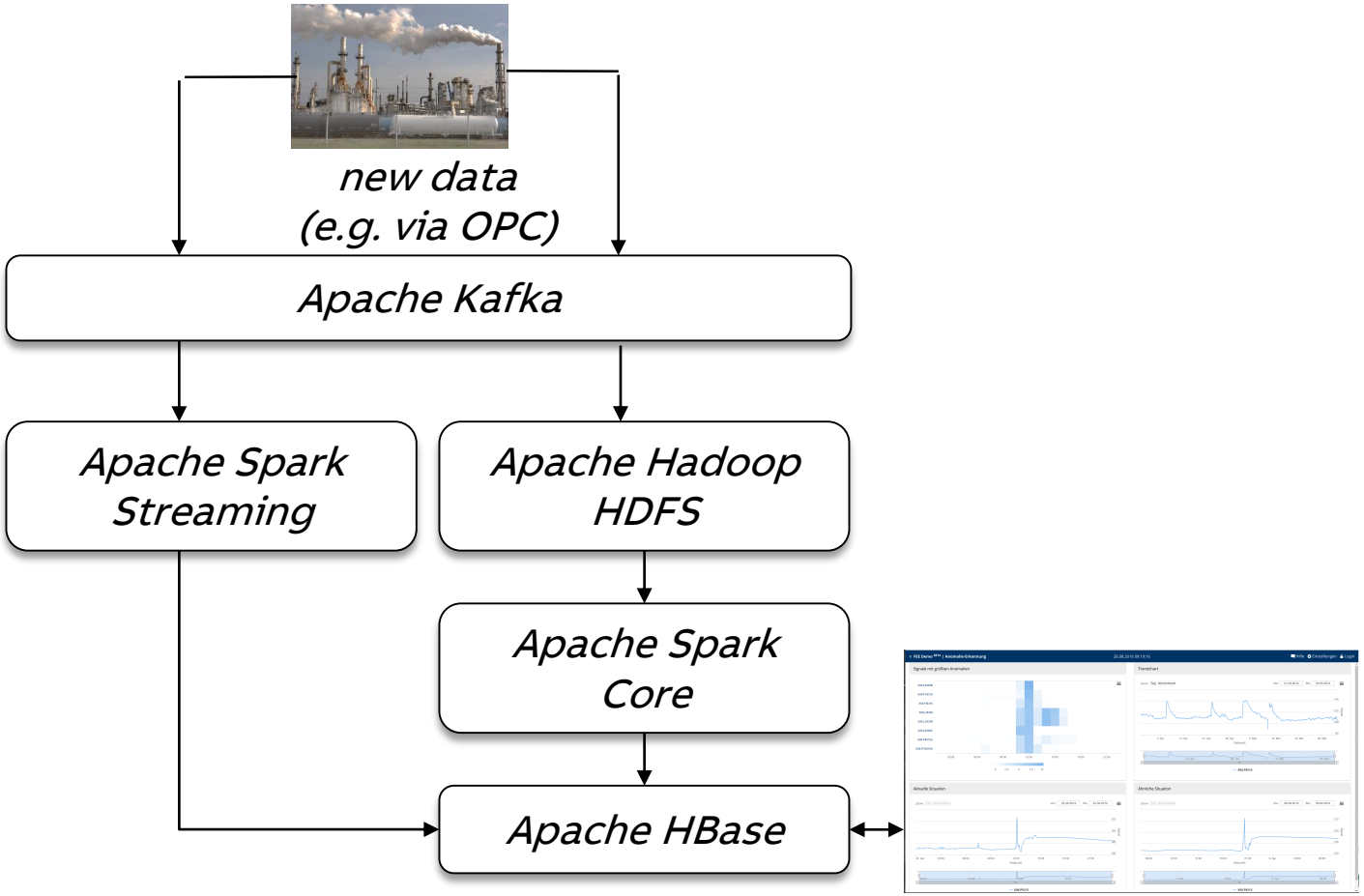
Project Example FEE – Big Data for Operator Support

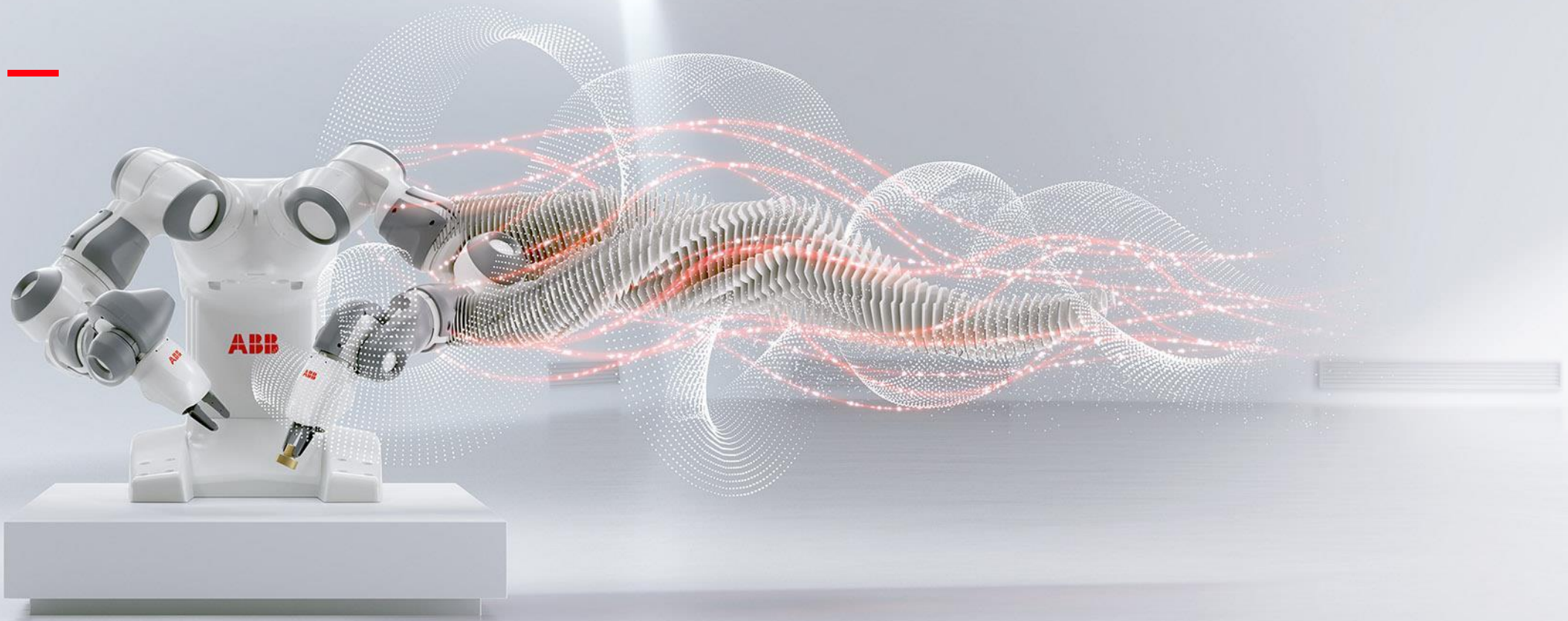
Big Data Architecture for Anomaly detection in chemical plants





Analysierter Zeitraum: 14 Monate
Analysierte Signale: 982
Virtueller Cluster: 4 Physikalische Rechner
12 virtuelle Knoten,
8 cores per node,
8GB RAM per node

Batch Calcuation Time	Nodes
12 min 39 sec	12
14 min 43 sec	9
31 min 35 sec	3
>16 h	Ohne Parallelisierung
Streaming Time	**Nodes**
15 Sekunden	3



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Holistic Development of Industrial Big-Data Applications and Services

Summary

Conclusion

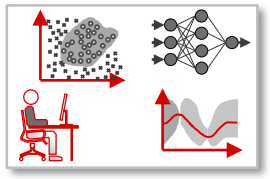
1

Develop the right thing

2

Use the right data

3



Understand the methods

4

Make it repeatable

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