



# **Industrie 4.0 in Germany - selected aspects -**

**Prof. Dr.-Ing. Birgit Vogel-Heuser  
Institute of Automation and Information Systems (AIS)  
Department of Mechanical Engineering  
Technische Universität München  
Vogel-heuser@tum.de**



## Data processing for humans

Assistance systems for Engineering

Data processing and integration for humans



**Architecture models (reference architecture)** for a category of aggregation/modules related to properties, capabilities, interfaces...

## Intelligent products and production units

Production units with **inherent capabilities**

**Data analysis** of process and alarm data and connection with engineering data

**Flexible production units, adaptable** to modified product requirements, allow also structural changes

**Description of product and operating resources**, e.g. ontology, for independent analysis, presentation, organisation and execution of a production process

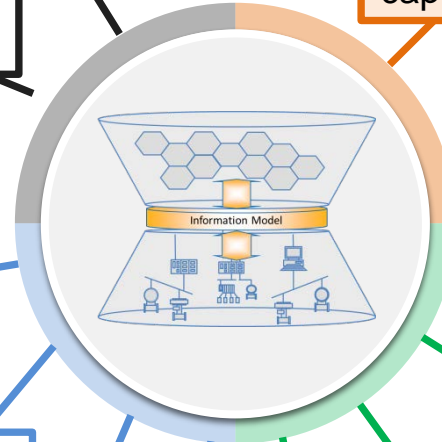
## Communication and data consistency

**Appropriation of necessary data** for configuration, production, negotiation

**World wide distribution of data, high availability, access protection**

**Data consistency** about different „stakeholders“ in different engineering phases and crafts

**Digital networks** and interfaces for communication (between machine, human and plant, plant and plant)



Source: B. Vogel-Heuser, G. Bayrak, U. Frank: Forschungsfragen in "Produktautomatisierung der Zukunft". acatech Materialien. 2012.

## **Identifiability**

- Unique identifier in network
- Physical objects are referenced by an ID
- Security
- Timely Behavior
- Different address types for I4.0 components and (application) objects

## **Virtual Description**

Virtual representation (including dynamic behavior) and manifesto

## **Security and Safety**

- Protection for functionality and data (Security)
- Machine safety (Safety)
- Mindset-infrastructure security by Design (SbD)

## **I4.0-conform Semantics**

Support of the semantics standardized for I4.0

## **State**

State can be obtained at any time

## **Combinability**

I4.0 components can be composed to form a bigger component

## **Quality of Service**

Satisfaction of required characteristics as e.g. real-time properties, dependability etc.

## **I4.0-konforme Dienste und Zustände**

- Distinction between shop floor/office floor
- Protocols and application functions can be updated/ extended
- Application layers with different protocols

## **I4.0-conform communication**

Self-identification (SOA-Service model)

**Quelle:** VDI/VDE-Gesellschaft Mess- und Automatisierungstechnik: Statusbericht; Industrie 4.0; Wertschöpfungsketten. Düsseldorf: VDI e.V., April 2014.



**MsAC:** Minimum structural Adaptivity Cost

**QoRAI:** Quality of Response Adaptivity Index

**FHAI:** Fault Handling Adaptivity Index

**FDIAI:** Fault Detection Isolation Adaptivity Index

**Adaptivity  
Coverage  
Metrics**

**Quality of  
Service  
Metrics**

**Adaptivity Metrics  
for automated  
Production  
Systems**

**Real-time  
Capabilities  
Metrics**

**Interaction  
Metrics**

**pLatency:** performance Latency

**plcDFAI:** PLC-Cycles to Detect Faults Adaptivity Index

**plcIFAI:** PLC-Cycles to Isolate Faults Adaptivity Index

**plcSTSAI:** PLC-Cycles to Switch to Soft Sensor Adaptivity Index

**TA:** Time for Adaption (plcDFAI + plcIFAI + plcSTSAI)

**RUiAI:** Removed User  
Interaction Adaptivity  
Index



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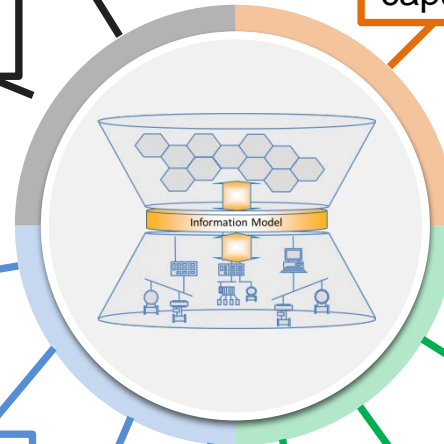
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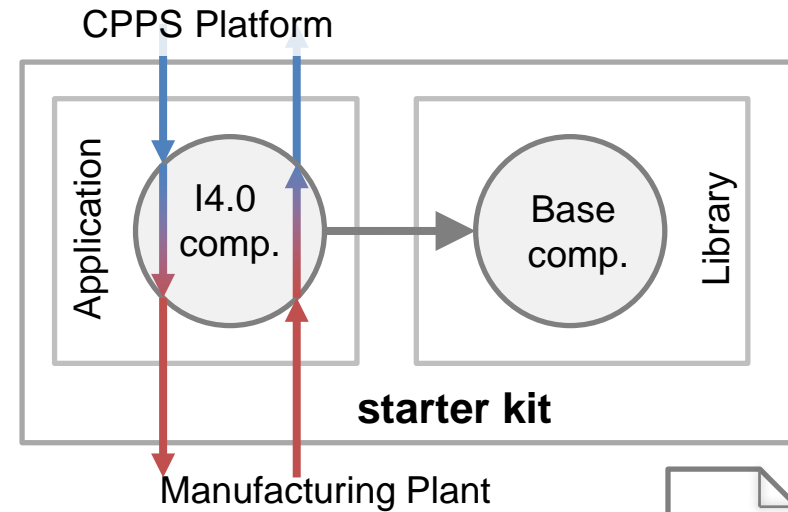
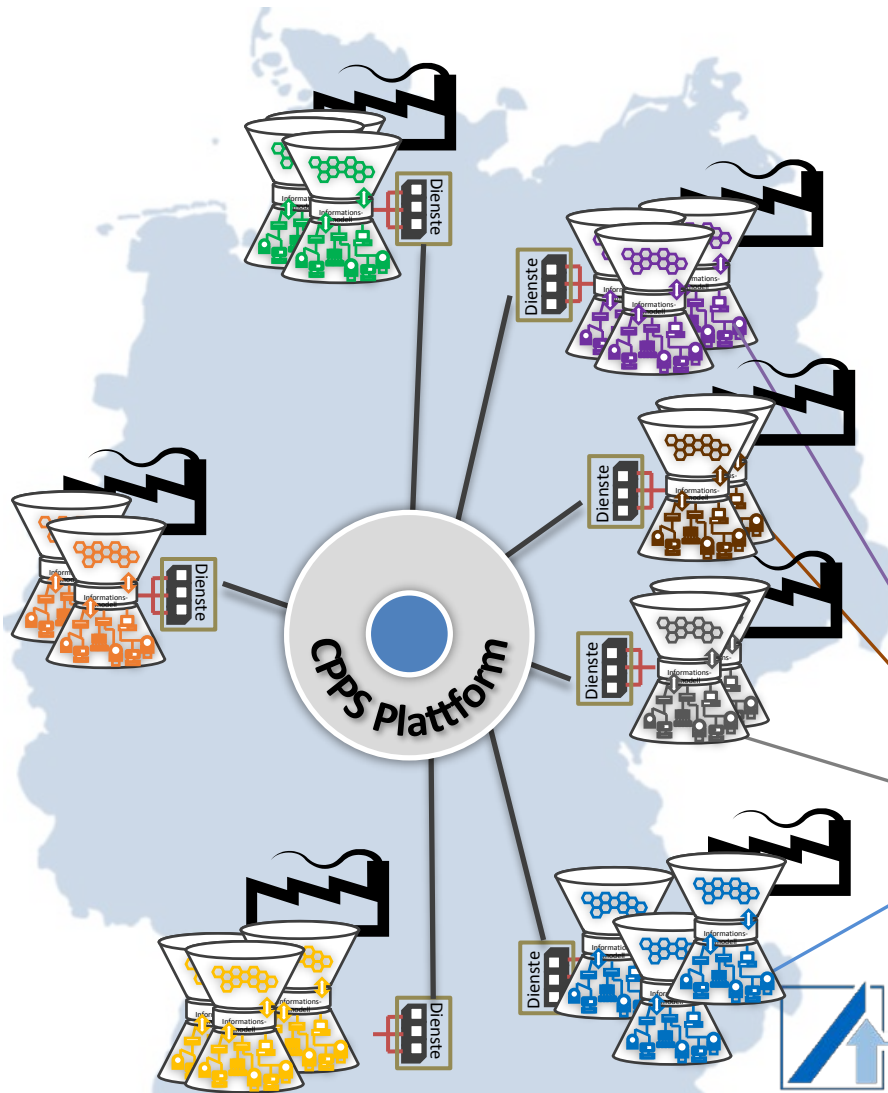
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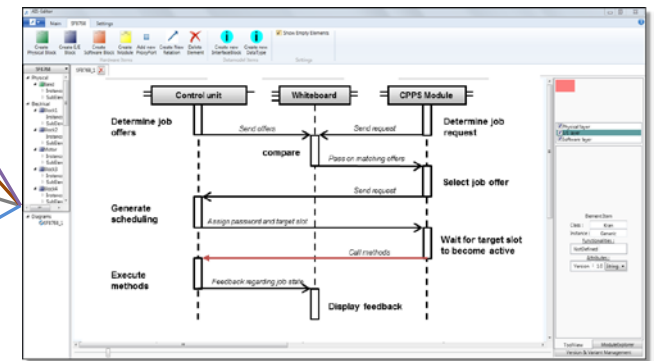
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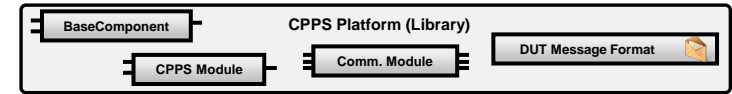
# Aim of the Project: extension of the starter kit with standardized building blocks for IEC 61131-3 → CPPSOpen



<http://i40d.ais.mw.tum.de/>



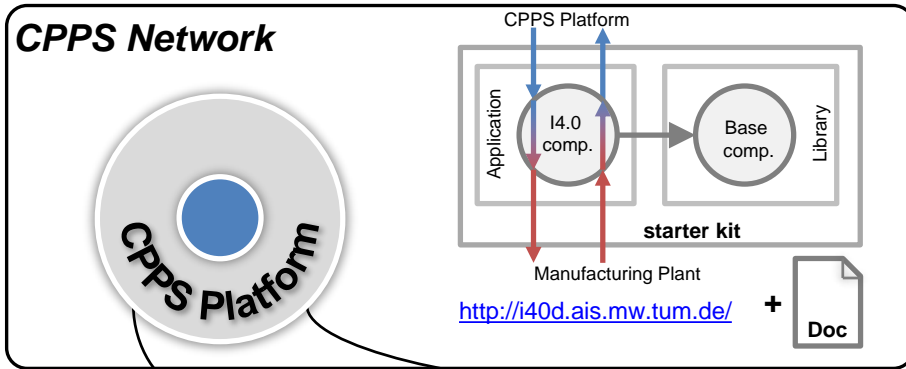
## Tool for Application Development



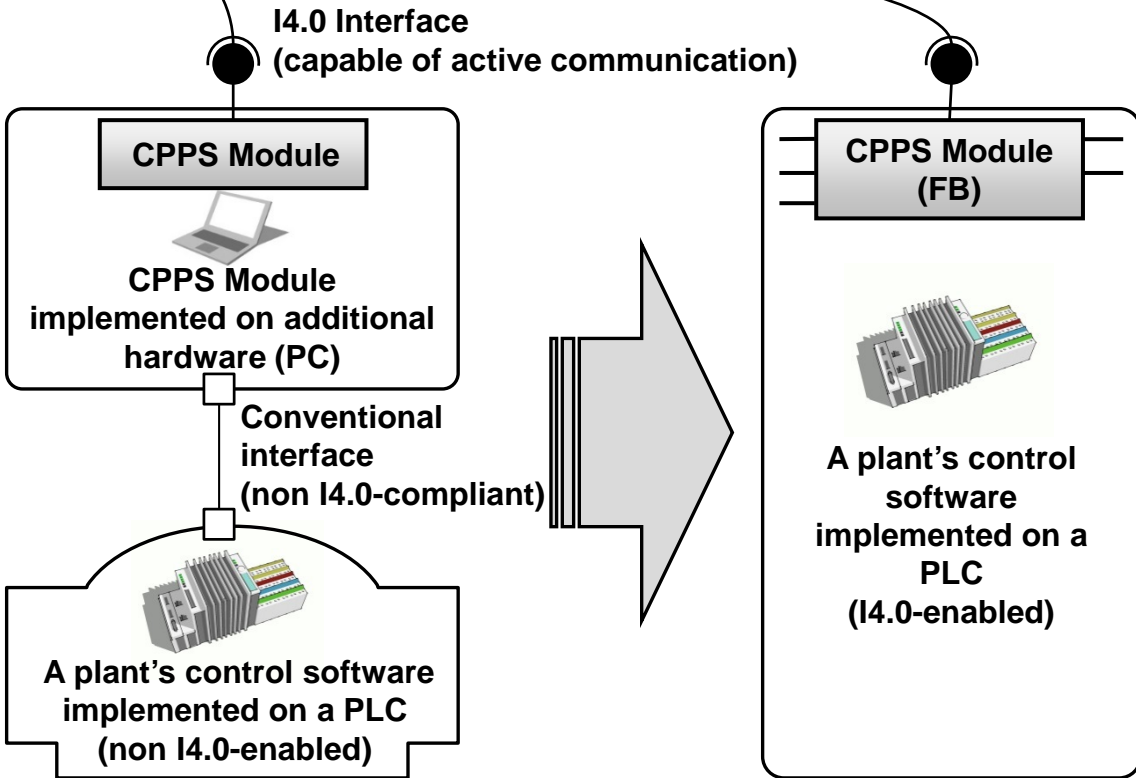
## CPPS@PLC Library

Cp.: D. Pantförder, F. Mayer, C. Diedrich, P. Göhner, M. Weyrich, B. Vogel-Heuser:  
 Agentenbasierte dynamische Rekonfiguration von vernetzten intelligenten Produktionsanlagen –  
 Evolution statt Revolution. In: Industrie 4.0 in Produktion, Automatisierung und Logistik, Springer, 2014.

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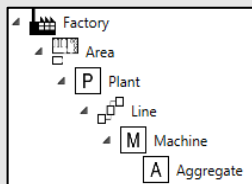
- Starter kit as a reference platform
- Coupling of plants already possible (using additional hardware)
- Approaches for direct coupling of IEC 61131-3 controls (via Ethernet based interfaces) promising



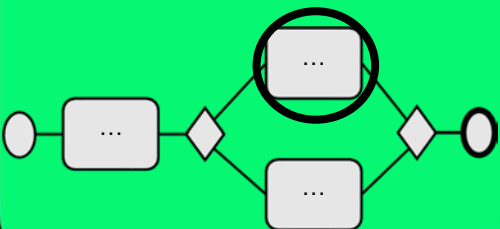
### Next steps:

- Immediate, continuous field level connection
- Implementation using special I4.0 function blocks
- Development of a library of I4.0 FBs → CPPS@PLC
- Model based approach for application development using CPPS@PLC

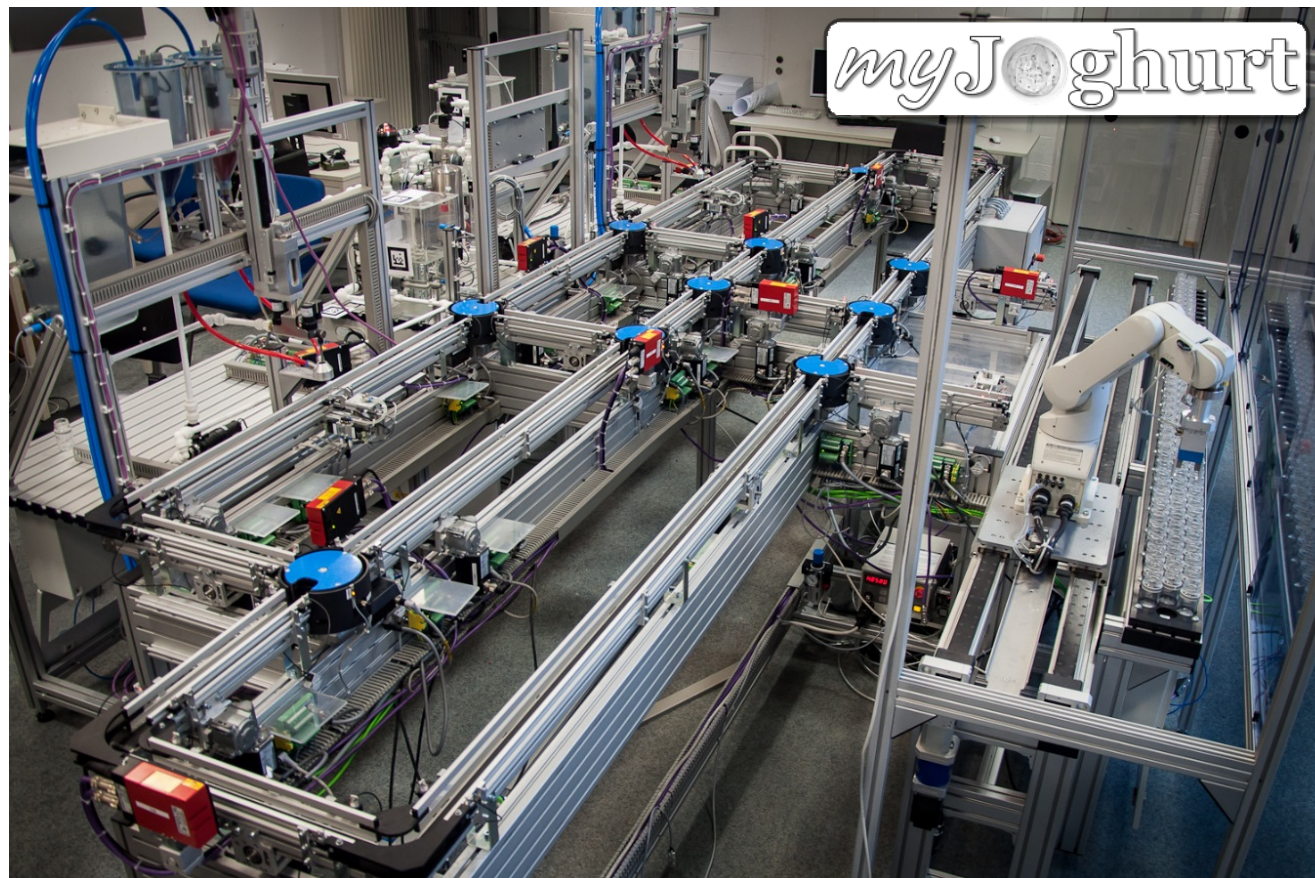
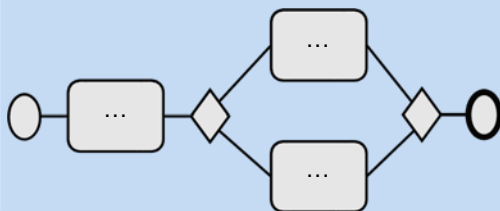
## Structural model (Resource model)



## Process model



## MES model





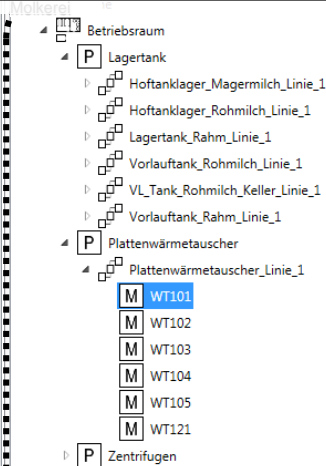


# Model based Parameterization of a CPPS Module: Description of the **Technical System** using MES-ML



## I4.0 Interface (TCP/IP)

**CPPS Module**  
Plant's representation within the CPPS network



Hierarchic  
plant structure

**Properties**

Name	Wert
Name	WT101
Type	Machine

Klassifizierung	Datenpunkt	Datenpunkt-Klasse	Beschreibung
WS	00062 - WS_Cur_Batch_ID	WS_Tracing	Chargenbezeichnung Istwert
WS	00064 - WS_Cur_Order_ID	WS_Tracing	Auftragsnummer Istwert
AutoMES	09801 - AM_Cur_Process	AM_Process	This data point gives the information of the current process on the machine.
AutoMES	09802 - AM_Cur_Sub_Process	AM_Process	This data point gives the information of the current process on the machine.
AutoMES	09803 - AM_Cur_Prc_Operatio	AM_Process	This data point gives the information of the current process on the machine.
AutoMES	09901 - AM_Machine_ID	AM_Mach_ID	This data point gives the information of the current process on the machine.
AutoMES	48001 - AM_Cur_Vol_Flow	AM_Measure_Value	This data point gives the information of the current process on the machine.
AutoMES	48002 - AM_Cur_Temperature	AM_Measure_Value	This data point gives the information of the current process on the machine.
AutoMES	48010 - AM_Cur_Temperature	AM_Measure_Value	This data point gives the information of the current process on the machine.
AutoMES	48011 - AM_Cur_Temperature	AM_Measure_Value	This data point gives the information of the current process on the machine.
WS	50101 - WS_Cons_Clean_Wate	WS_Cons	Wasserverbrauch
WS	50102 - WS_Cons_Hot_Water	WS_Cons	Heißwasserverbrauch
WS	50110 - WS_Cons_Electricity	WS_Cons	Stromverbrauch
AutoMES	58001 - AM_Cur_HeatFlow_He	AM_Count_Value	This data point gives the current heat flow during heating up

Adding of new  
data points

**Datenpunkt bearbeiten**

Klassifizierung: WS

Datenpunkt: 00062 - WS\_Cur\_Batch\_ID

Datenpunkt-Klasse: WS\_Tracing

Zugriffsmodus: ReadWrite

Ist virtuell?:

Beschreibung: Chargenbezeichnung Istwert

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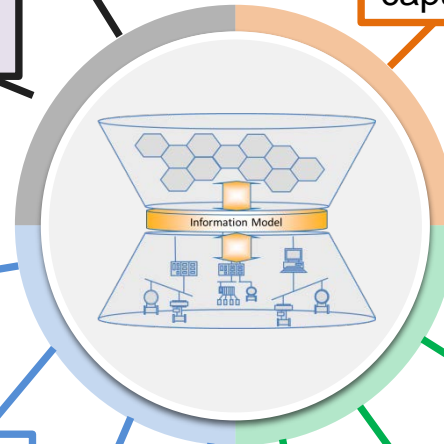
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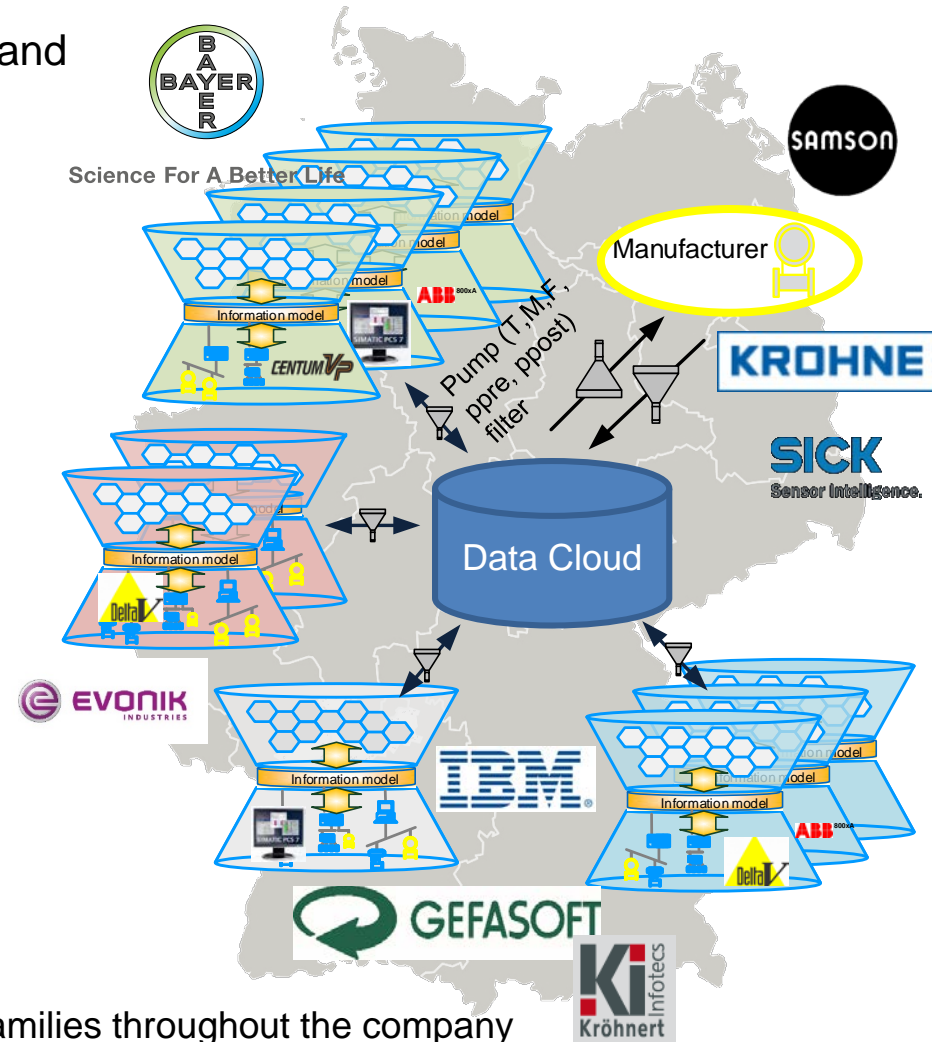
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- Bundle detailed knowledge of processes and plants and include in analysis
- Data logistics
  - Secure provision and transport
  - Secure storage
- Aggregation and analysis of data
  - Aggregation of data specific to processes and plants with historical data → Activation of existing know-how in order to gain information
  - Identification of unknown correlations in data → make implicit knowledge explicit
  - Integration of field device manufacturers (metrology and fittings) for augmenting the data base and for improving field devices
- Data use
  - Application of the analytical findings to plant families throughout the company
  - Provide company
  - Supporting the operating personnel in engineering, process management, servicing and maintenance





- Industrie 4.0 and smart data are merging from the application point of view
- Existing Demonstrators at different location (mostly academic locations)
  - smart factory at Kaiserslautern (Prof. Zühlke)
  - Fraunhofer IPA (Stuttgart), IML (Dortmund) Fraunhofer IOSB /InIT, TU Munich (myJoghurt, RIAN, Prof. Vogel-Heuser) and others
- All larger companies working on Industrie 4.0 and smart data
  - Automation companies
  - MES companies
  - In machine and plant manufacturing situation differs
  - Increasing interest in food & beverage
- First benefit as ROI often seen in energy consumption and faster more automatic change of products
  - Metrics are required to separate real solutions from marketing announcements and support evaluation beforehand
- challenge: proof of benefit