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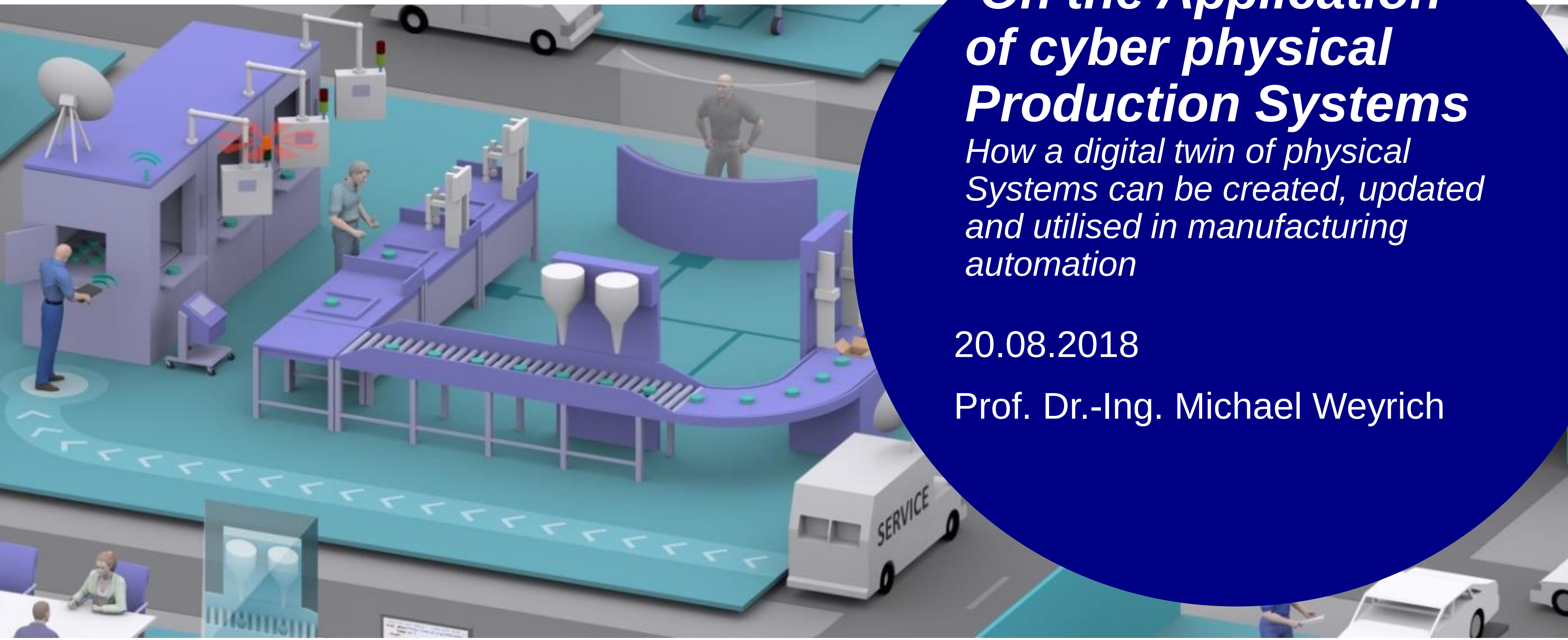

On the Application of cyber physical Production Systems

How a digital twin of physical Systems can be created, updated and utilised in manufacturing automation

20.08.2018

Prof. Dr.-Ing. Michael Weyrich

Agenda

Concept of Cyber-physical Production Systems

Digital Twin

Example of Projects

Research Approach and next steps

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New Approaches are available for Application

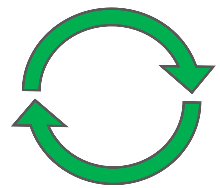
Commercial Providers promote methods and procedures which promise an automation of the value chain

… however … what about research?

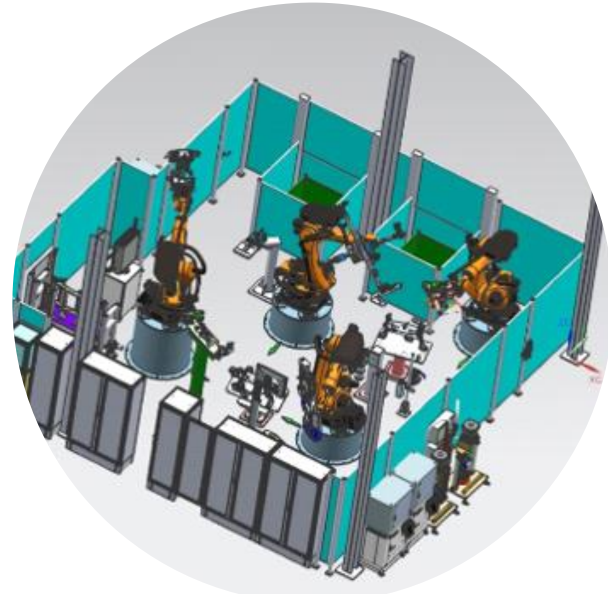
Cyber physical Systems - Composition of Software, Data, IT and physical devices

Physical

(Source: http://media.daimler.com)



Cyber

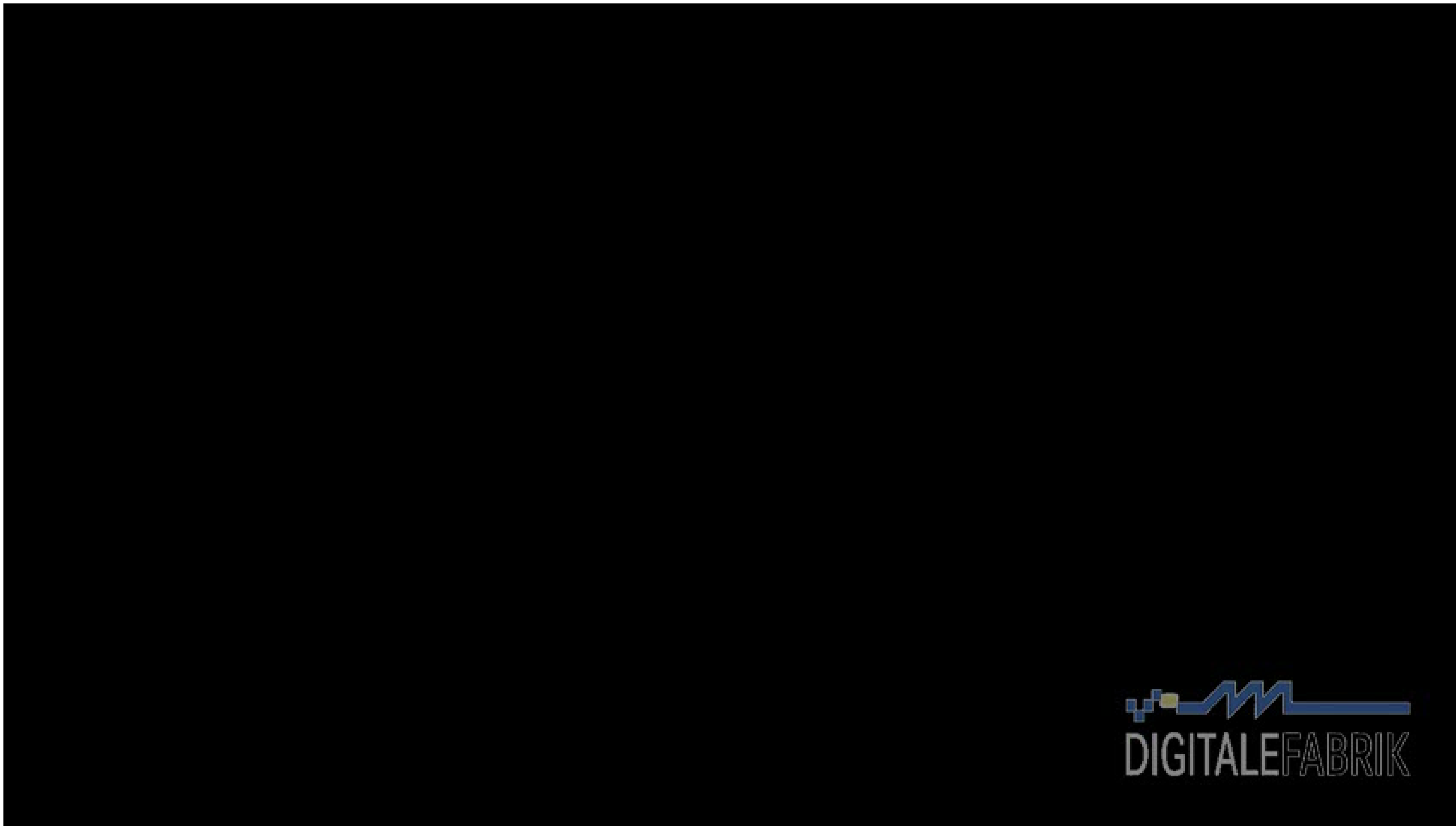


The very large Diversity, e.g. hundreds of sub-systems demand for a standard information model for functional groups, classification of components etc.

Complexity is created in practical application due to the linkage of components and interdependencies between the sub- domains / disciplines.

Body-in-White in Assembly Solutions

Video showing the State-of-the-Art in Industrial Application (Source Daimler 2018)



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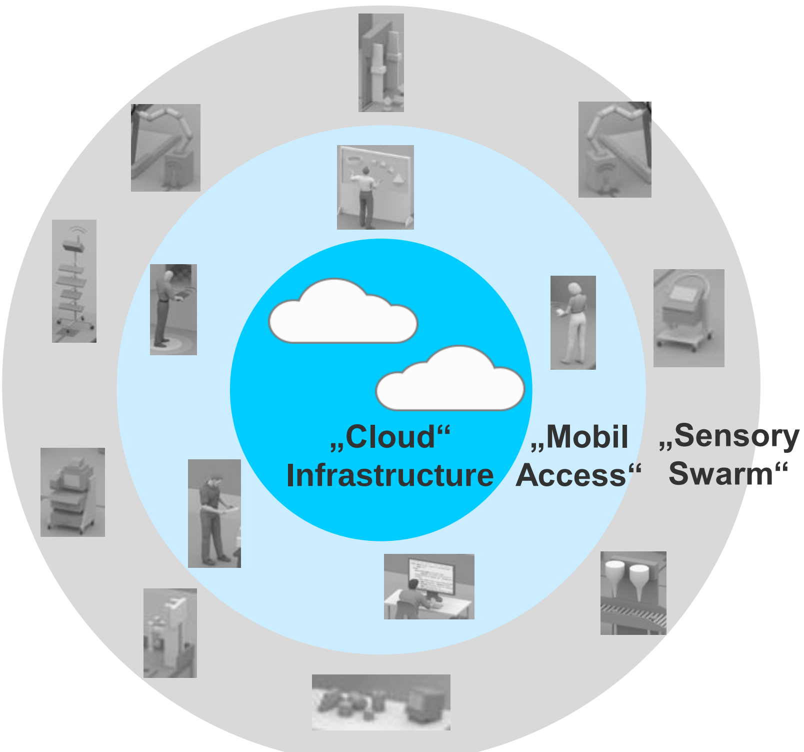
Networking of physical Assets results in a diversity of Data

New technologies for the acquisition and analysis



[based on: Rabaey, Pederson 2008]

- **M2M Communication:** 4G / 5G, TSN, …
- **Cloud:** Amazon Cloud, Microsoft Azure, …
- **IoT Operating systems:** Siemens MindSphere, PTC Thingworx, Bosch IoT Suite, …

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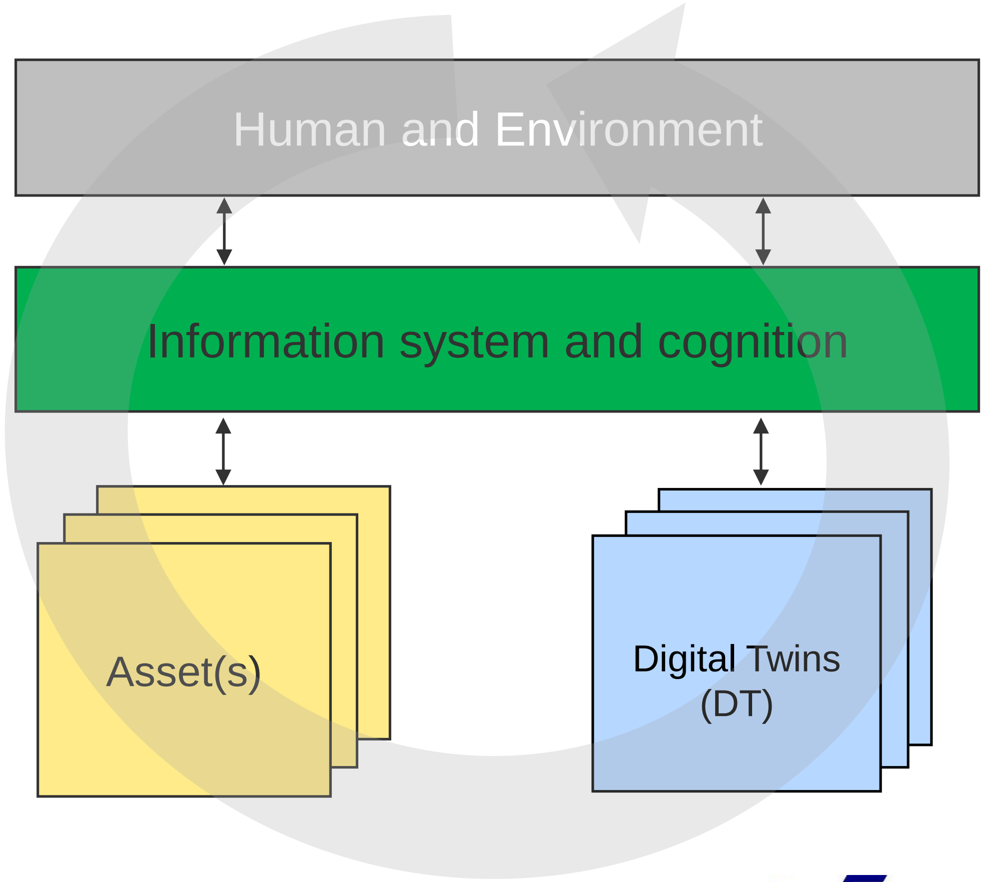
- **Engineering PLM Backbone:** Teamcenter, Enovia

How to master the tremendous complexity of software systems and their data?

Steps towards cyber physical Manufacturing (2)

A digital twin means in unison with physical systems, a cyber reproduction is being created.

- The characteristics and functionalities of physical assets are pictured by a Digital Twin along the lifecycle



Frontiers of the automation technology of today

In Industry, there are numerous frontiers for the usage of automation systems

- **Effort for Engineering** requires more interoperability
- **Missing Standards**, e.g. for a semantic processing of information
- **Problem of Complexity for very large automation systems**
- **Limitation in „Self-X functionalities** (Analytics, Machine Learning, Artificial Intelligence)

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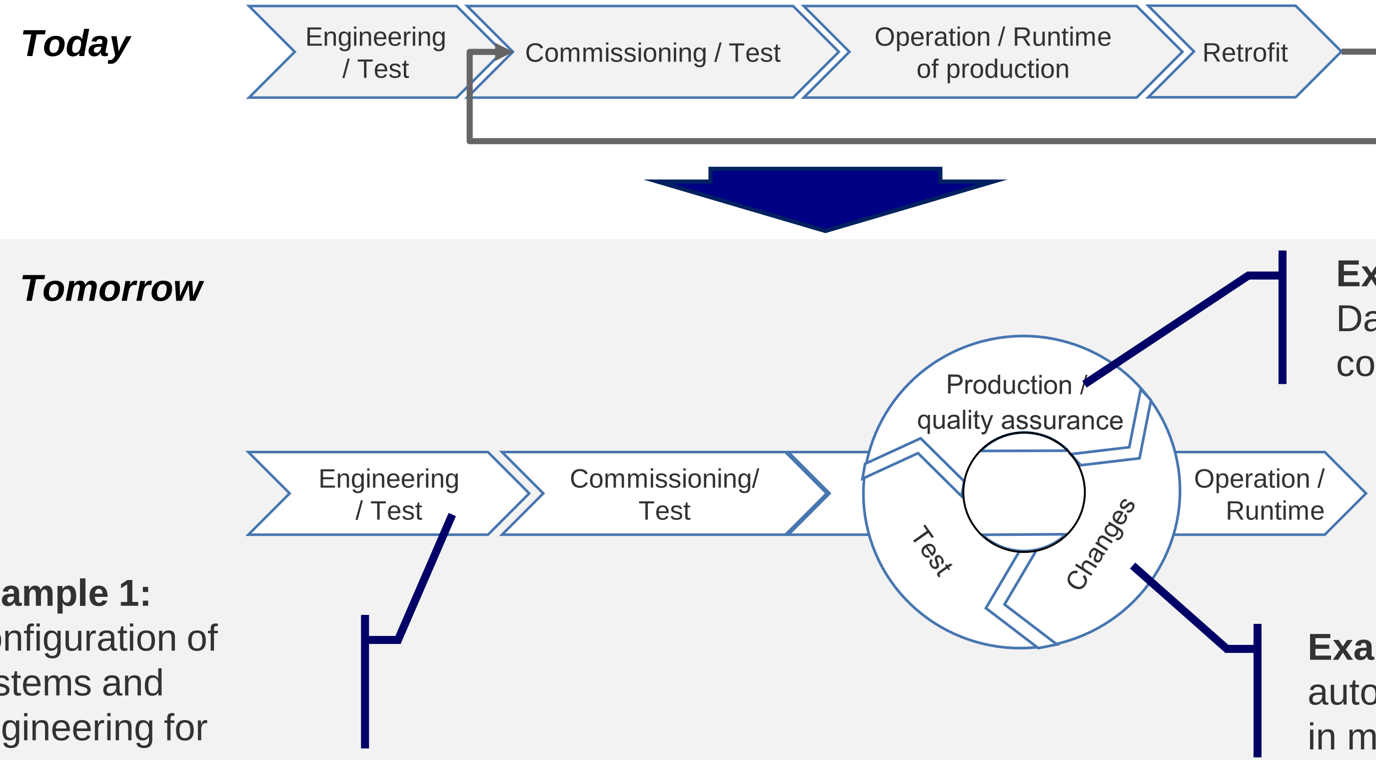
Digital Twin – Design moves to Runtime

How could the interchange be used between the cyber and physical world?



Example 3:
Data driven quality control in Operation

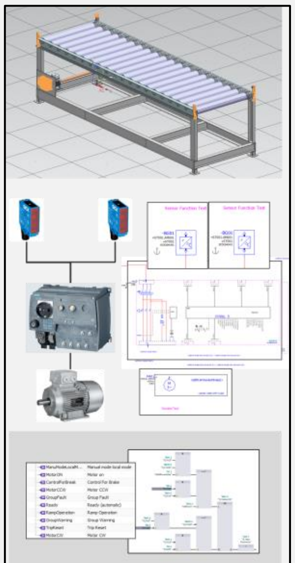
Example 1:
Configuration of systems and Engineering for Change

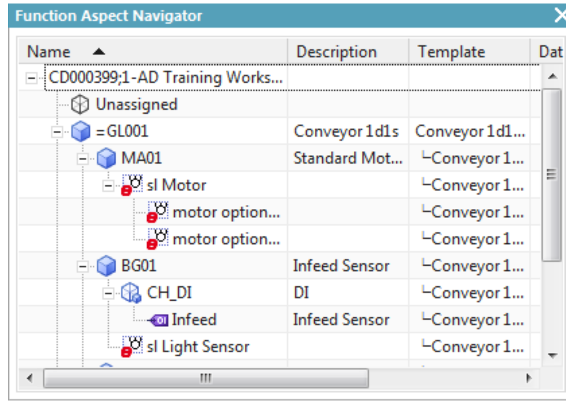
Example 2:
automatic changes in manufacturing

Example 1: Multiple Sub-domains / Disciplines

Manufacturing systems are designed using IT-based Engineering systems which support different views of the various mechatronic elements

Components





Station

Whole Line

- Discipline mechanical Design
- Discipline Layout of plant
- Discipline Electronics electric
- Discipline Software for control

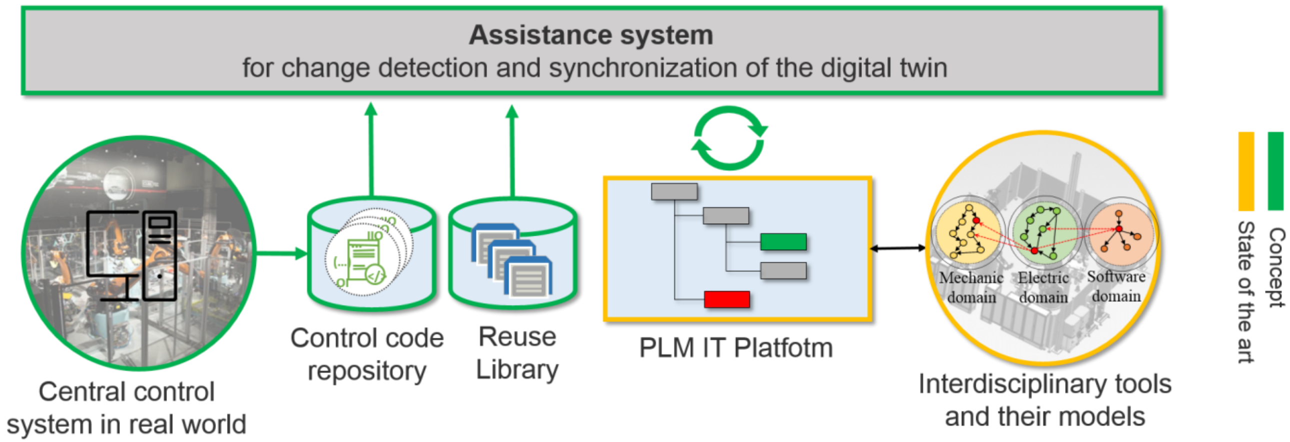
…

➢ **Challenge:**
How to synchronize the multiple legacies of the Engineering systems?

(Source: Siemens AG-Automation Designer)

Example 1: Synchronization of a Digital Twin

Anchor point method for synchronization of the Digital Twin in the PLM Platform



GSaME Project - see: [Ashtari et al 2018]

SIEMENS ARENA2036

➢ Challenge:

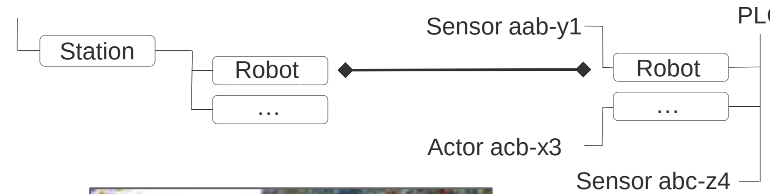
PLM IT platforms entail data of mechatronic components from multiple domains (Software, Mechanical and Electronics) which need to be synchronized in the event of change.

Example 1: Variety of Information in Automotive Body-in-White

A large variety of divers data and information is available and needs to be systematically assigned.

Type of Data:

- Manufacturing planning based on Standards and De-factor Standards
- IT Network Scan of all fieldbus systems
- 3D Scans of the shopfloor
- High-resolution pictures of all installed systems



Manufacturing Service Bus

Special standards of the domain

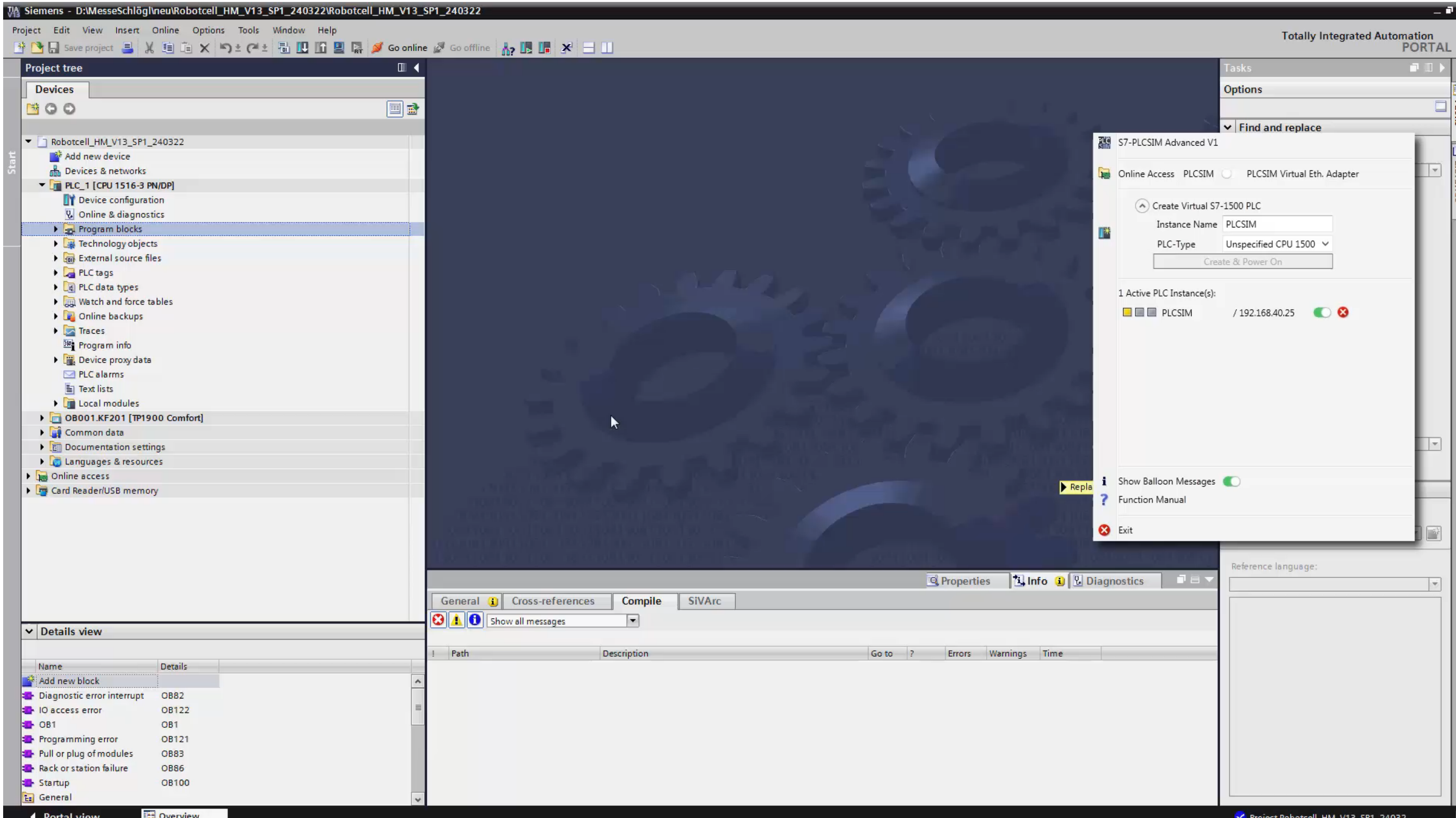
Integra

Automation-ML

…

Challenge: how to create transparency, e.g. by automatic interconnecting fragmented information which can be utilized in planning of retrofits.

Virtual Commissioning (Source Siemens, 2018 / Arena 2036)



Example 1: Update of a Digital Twin in Operation

Automatic Updates of planning objects in the digital factory based on the data of real Automation IT and 3D-Scans

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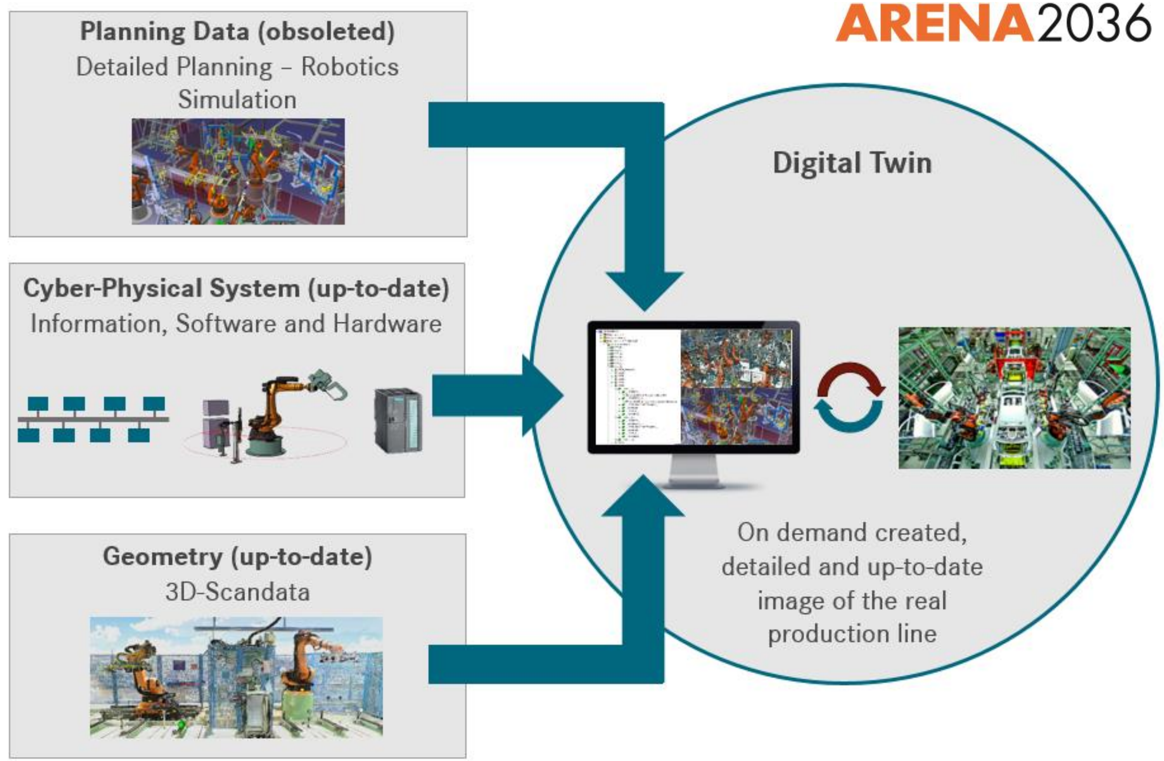
There is a necessity to adjust existing manufacturing systems to fit the need of new vehicle models

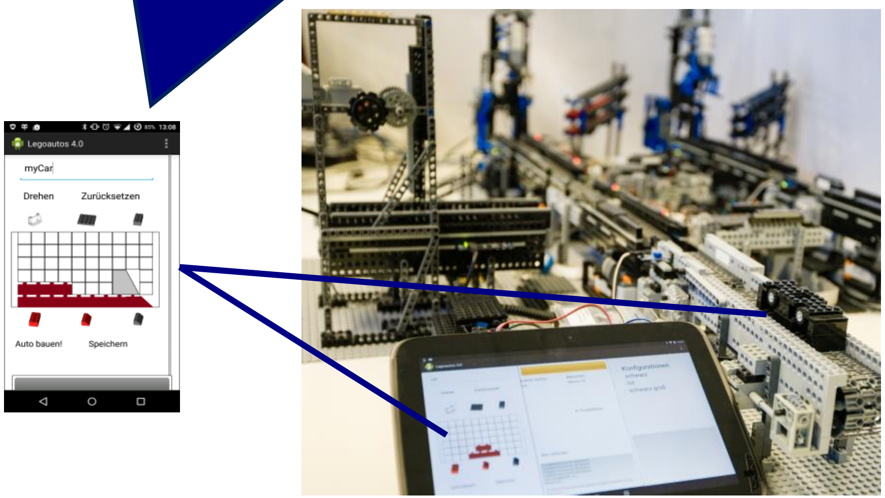


GSaME Project - see: [Bieisnger et al 2018]

Example 2: Decentral Control of automated manufacturing systems based on agent technology

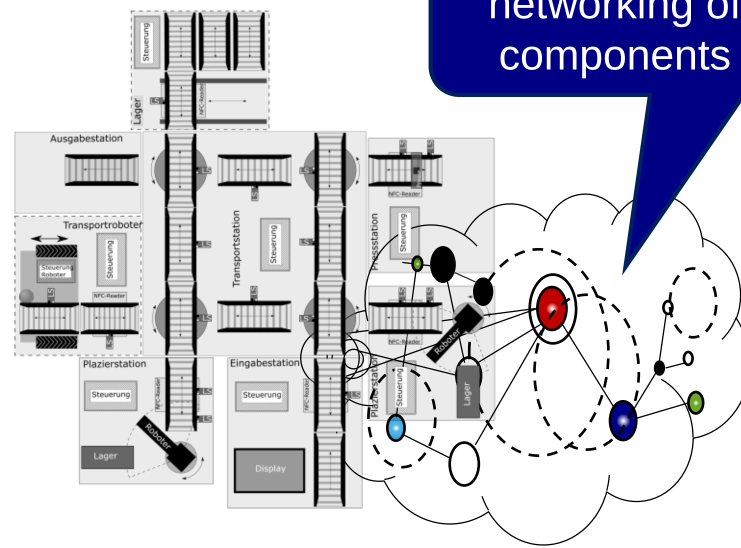
How could we reduce the effort for configuring and programming in the event of changes?

Interpretation / recognition
„ The product steers through production“



Decentral control by agents

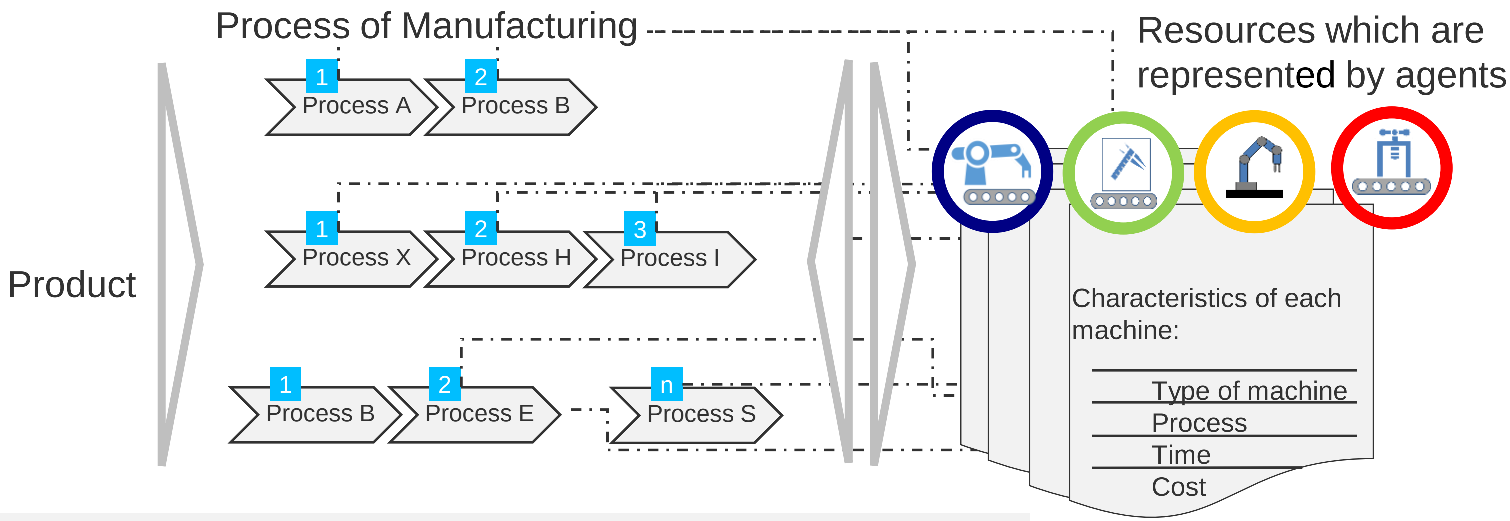
Automatic networking of components



Reference project on the Roadmap Industrie 4.0 of the Platform Industrie 4.0, see [Klein, Weyrich 2016]; [Faul et al 2018]

Example 2: Automatic Allocation of suitable Resources to the Process steps

The product chooses its resources depending on the process requirements



Challenges

- Resource communicate the status automatically using a semantic
- Agents control the allocation of process and recourses using the market place approach

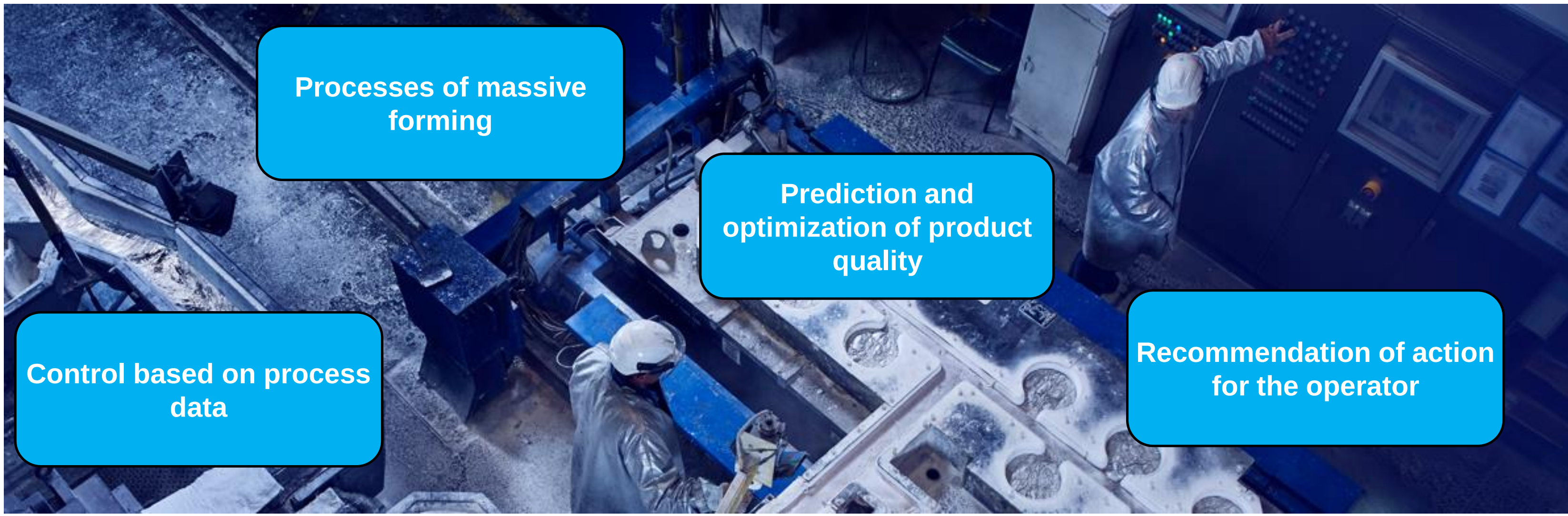
[Klein et al 2018]

Smart Lego Plant

(Source IAS Univ. Stuttgart, 2018)

Example 3: Data driven quality control in Operation

Sensor data entail information about the plant and process and can be analyzed to improve process quality



see: http://www.massivumformung.de/forschung/emudig-40/; Source: Otto Fuchs KG

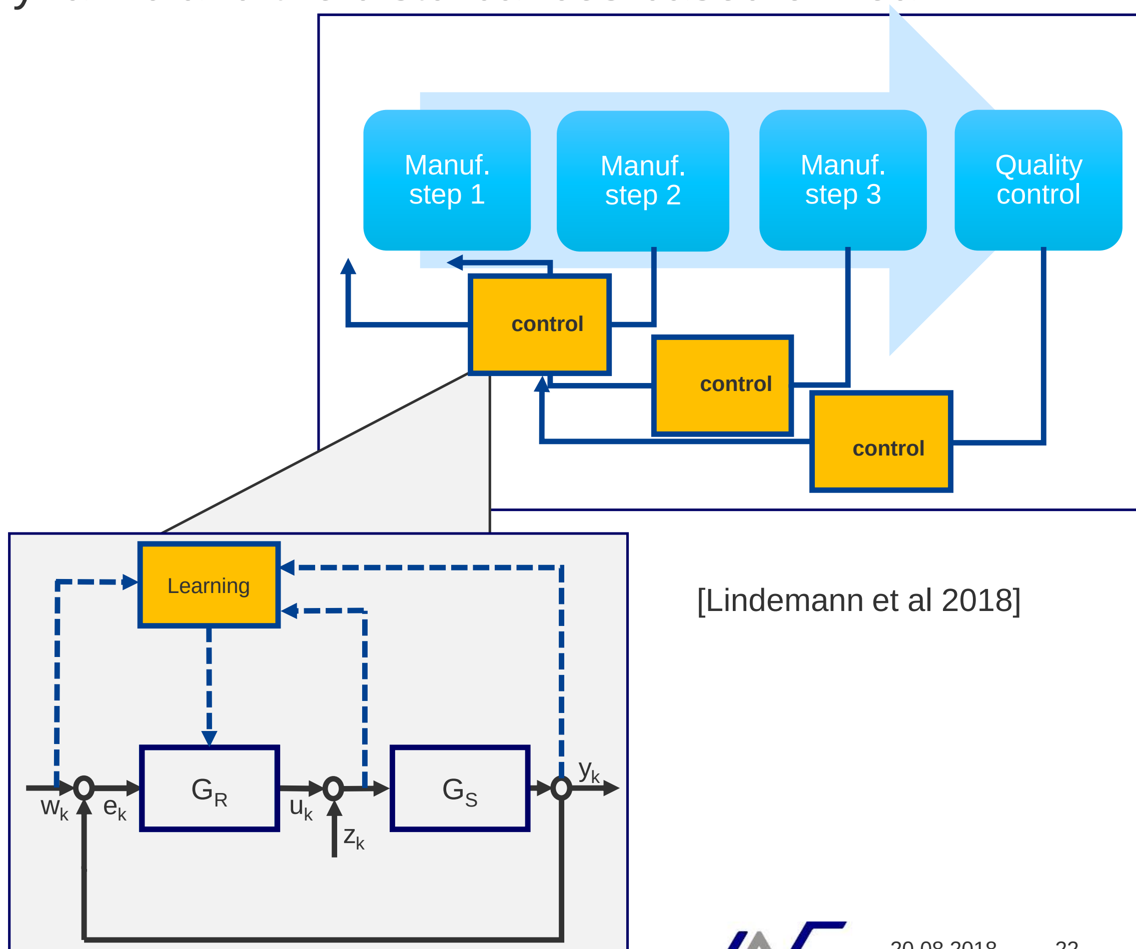
Challenges:

- Capture of data and extraction of unknown patterns
- Generation of action proposals

Example 3: Self-learning of System Components

The System learns about the dynamic and the disturbances based on real process data.

A special learning approach is utilized in order to optimize the cascaded quality controller.



[Lindemann et al 2018]

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Arena 2036: On Campus of the University of Stuttgart

ARENA2036 - “Active Research Environment for the Next Generation of Automobiles”
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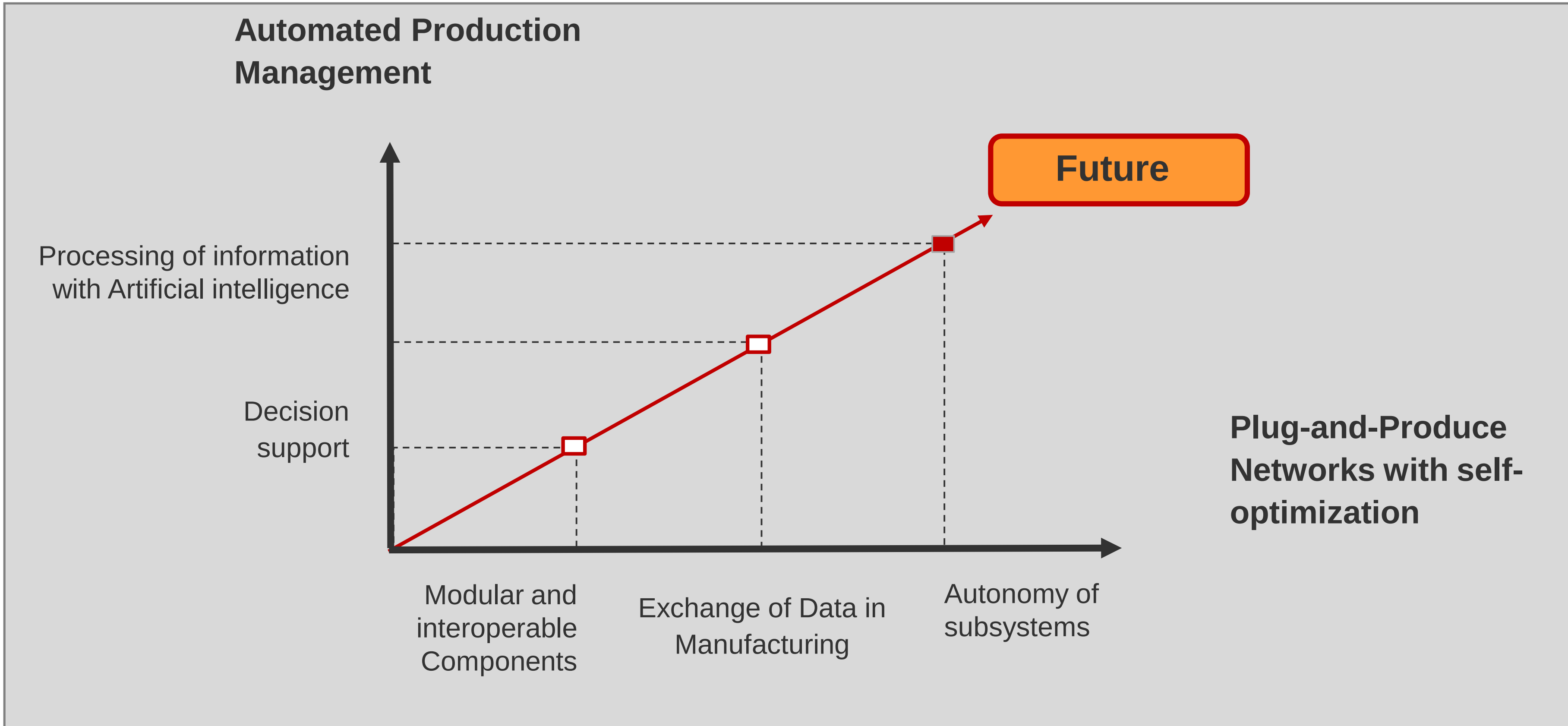
DSM · DXC.technology · EWS Tool Technologies · FARO · SIEMENS · TRUMPF · Universität Stuttgart

In ARENA 2036 IAS is involved in the research project "Flexible Production System" as a project leader in cooperation with industrial partners: SIEMENS, KUKA and TRUMPF

Towards the automation of the future …

Characteristics: cyber physical, intelligent, flexible and efficient



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Summary

- Models for explanation
- Examples from research projects
- Next steps and frontiers

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