Industrie 4.0 in Germany
- selected aspects -

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Data processing and integration 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)

### Characteristics of Industrie 4.0 based on RAMI 4.0

#### Identifiability
- Unique identifier in network
- Physical objects are referenced by an ID
- Security
- Timely Behavior
- Different address types for Industrie 4.0 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 Industrie 4.0

#### State
State can be obtained at any time

#### Combinability
Industrie 4.0 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)

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

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

Real-time Capabilities Metrics

Interaction Metrics

Adaptivity Metrics for automated Production Systems

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 Adaptation (plcDFAI + plcIFAI + plcSTSAI)

RUiAI: Removed User Interaction Adaptivity Index

Characteristics of Cyber-Physical Production Systems (CPPS) – Industrie 4.0

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Univ.-Prof. Dr.-Ing. Birgit Vogel-Heuser
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
Motivation: Standardized Interfaces for continuous field level connection (IEC 61131-3)

- 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

CPPS Network

CPPS Platform

I4.0 Interface (capable of active communication)

CPPS Module

CPPS Module implemented on additional hardware (PC)

Conventional interface (non I4.0-compliant)

A plant’s control software implemented on a PLC (non I4.0-enabled)

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

Doc

A plant’s control software implemented on a PLC (I4.0-enabled)

CPPS Module (FB)

CPPS Module

Manufacturing Plant

Application

I4.0 comp.

Base comp.

Library

starter kit

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Consistent data integration / aggregation for OEE enhancement in MES

**Source:** Institute of Automation and Information Systems, TU München
Model based Parameterization of a CPPS Module: Description of the Technical System using MES-ML

I4.0 Interface (TCP/IP)

Hierarchic plant structure

Adding of new data points

CPPS Module
Plant’s representation within the CPPS network

Properties

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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

Source: Institute of Automation and Information Systems, TU München

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• 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

Conclusion and outlook