Interoperability of Heterogeneous Systems – Standardization Roadmap vs. Adaptive Integration

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Standards provide interoperability!?

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Outline

I. Motivation: Heterogeneous Systems

II. Interoperability

III. Standardization, Plug, Bus, Communication

IV. Adaptive Integration; what’s needed right now

V. Summary and Outlook
Heterogeneous Systems Hardware

Shop floor

• Different machine generations
• Manual, semi and full automated processes
Machines used in manufacturing got a lifespan from 5 to 25 years and more

- Historic plugs and interfaces
- State-of-the-art technology
- Individual cabling
- Slow changing hardware (power plug)
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Flow of Information within a Manufacturing Company

**Challenges**
- Data Interchange between considered levels.
- Integrative view on production and manufacturing processes.

ERP, Enterprise Resource Planning; MES Manufacturing Execution System
Interchange of data

Complex structure of data and tool specific information

- Mostly poor data quality.
- Heterogeneity of data (syntactical, structural and semantical).

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<th>Kind of Heterogeneity</th>
<th>Description/Examples</th>
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<td>Syntactical</td>
<td>Presentation of data; e.g. format of numbers, encoding.</td>
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<tr>
<td>Structural</td>
<td>Order, in which data attributes are exported.</td>
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<tr>
<td>Semantical</td>
<td>Meaning of attribute denominations; t = time or temperature?</td>
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→ no interoperability according ISO/IEC 2382-01 - 2382:2015
Information technology — Vocabulary

Terms and definitions

- Organization of Data
- Distributed data processing
- Databases
- Artificial Intelligence – Machine Learning
- Information theory
- ....

since 1976
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“A special difficulty arises here for terminology and standardization. Basically, it would be sufficient only to define the additional level of integration and its emergent behaviour. But to do that, the existing system landscape would first have to be coherently and completely defined in a globally standardized manner. This is not always the case. Against this background, the relevant models of the classical architecture require integration and rounding off in addition to Industry 4.0 itself.”
What's granted by using standards:

- interoperability in applications
- protection of environment, plants, equipment and consumers by means of uniform safety rules
- provide a future-proof foundation for product development
- assist in communication between all those involved
Plugs and Buses

There's no I 4.0 plug:

- Main objective is the connection between all kinds of machines
- There is no standard plug/interface for I 4.0 machines
- There is no standard bus for data/information exchange
- Every interface for data/information exchange should be usable
- DKE Working Group 651.03, Plug connectors with additional functions
Communication

Information exchange between nearly everything:

- Established bus communication ala PROFI Bus etc. is more shop-floor-oriented
- More and more sensors and actors send and receive information via the network topology
- Office floor should be integrated for information exchange
- More and more radio-based communication

DIN SPEC 91345 “Reference Architecture Model for Industry 4.0 (RAMI4.0)”
Communication

Sensor

Actor

Programmable Logic Controller (PLC)

Sensor fct.

Communication fct.

Actor fct.

Communication fct.

MES fct.

Communication fct.

PLC fct.

Manufacturing Execution System (MES)
Major categories of Failure:

1. The standard fails to get started.
2. The standards group fails to achieve consensus and deadlocks.
3. The standard suffers from “feature creep” and misses the market opportunity.
4. The standard is finished and the market ignores it.
5. The standard is finished and implementations are incompatible.
6. The standard is accepted and is used to manage the market.

Possible Solution: ESKAPE

Evolving Semantic Knowledge and Aggregation Processing Engine

Source: Why Standardization Efforts Fail, Carl F. Cargill, Volume 14, Issue 1: Standards, Summer 2011

http://quod.lib.umich.edu/j/jep/3336451.0014.103?view=text;rgn=main
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1. Schema analysis and creation of the semantic model
2. Data integration
3. Information search as well as data enrichment, transformation and extraction

Schema analysis and creation of the semantic model

ESKAPE
Analyze the schema of an unknown data source to prepare it for information modeling

Add data source

Recognized scheme + conceptual proposals

Analysis & Matching

Analyzed scheme

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The user creates a semantic model for his data on the basis of the knowledge graph of the platform and his own mental model.
Data integration

The data is put into an uniform data format, which allows the linking of data and information.
Data integration

Knowledge graph

Semantic model

DS: Data Source

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Annotated data sources can be found using the concepts of the semantic model.

Query

Search

Semantic Model

Identified data source
Data enrichment, transformation and extraction

Integrated data sources can be enriched, analyzed and combined in an information-based manner

- Convert units to the desired format
- Extraction of words from flow text
- Combinates data sources

Selection of integrated data sources and definition of the processes

Semantic Data Lake

Status Updates

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Summary and Outlook

• What is already done?
  • Data integration of heterogeneous sources
  • Semantic annotation of data
  • Automatic generation of information

• What do we need?
  • The complete coverage of the basic requirements mentioned by BOSCH
    • Sufficient Internet connection
    • Digitally-controlled machines
    • Machine-to-Machine Communication
    • Connection to the company IT
    • Future-proof investments
    • Qualification programs for associates
    • Consideration of the entire value chain

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[https://www.youtube.com/watch?v=sXECUiqBtvI](https://www.youtube.com/watch?v=sXECUiqBtvI)
Thank you for your attention,
do you have any questions?

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References


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OPC Unified Architecture Wegbereiter der 4. industriellen (R)Evolution

Referenzarchitekturmodell Industrie 4.0 (RAMI 4.0)

I 4.0 Basic Requirements © Bosch Rexroth AG 2016

GERMAN STANDARDIZATION ROADMAP Industry 4.0 Version 2 January 2016
© DIN DKE VDE

Network-based Communication for Industrie 4.0: Proposal for an Administration Shell

Safe Autonomous Robot Interaction Systems

- Interoperability
- Interfaces
- Standards
- Adaptive System Integration

- Information Modeling
- Information Retrieval
- Theory of Planned Behavior
- Intention-Based Human-Robot Interaction

- Kinematics
- Sensors
- Actors
- Annotated Robot Movements