Interoperability of Heterogeneous Systems – Standardization Roadmap vs. Adaptive Integration

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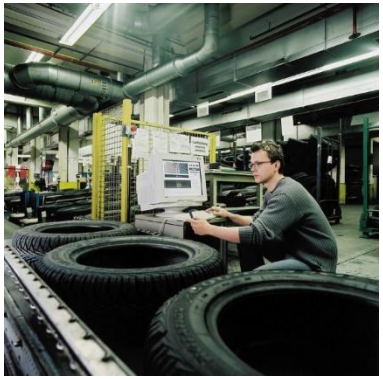
Standards provide interoparbility!?

Youtube[https://www.youtube.com/watch?v=Uk_vV-JRZ6E]

Outline

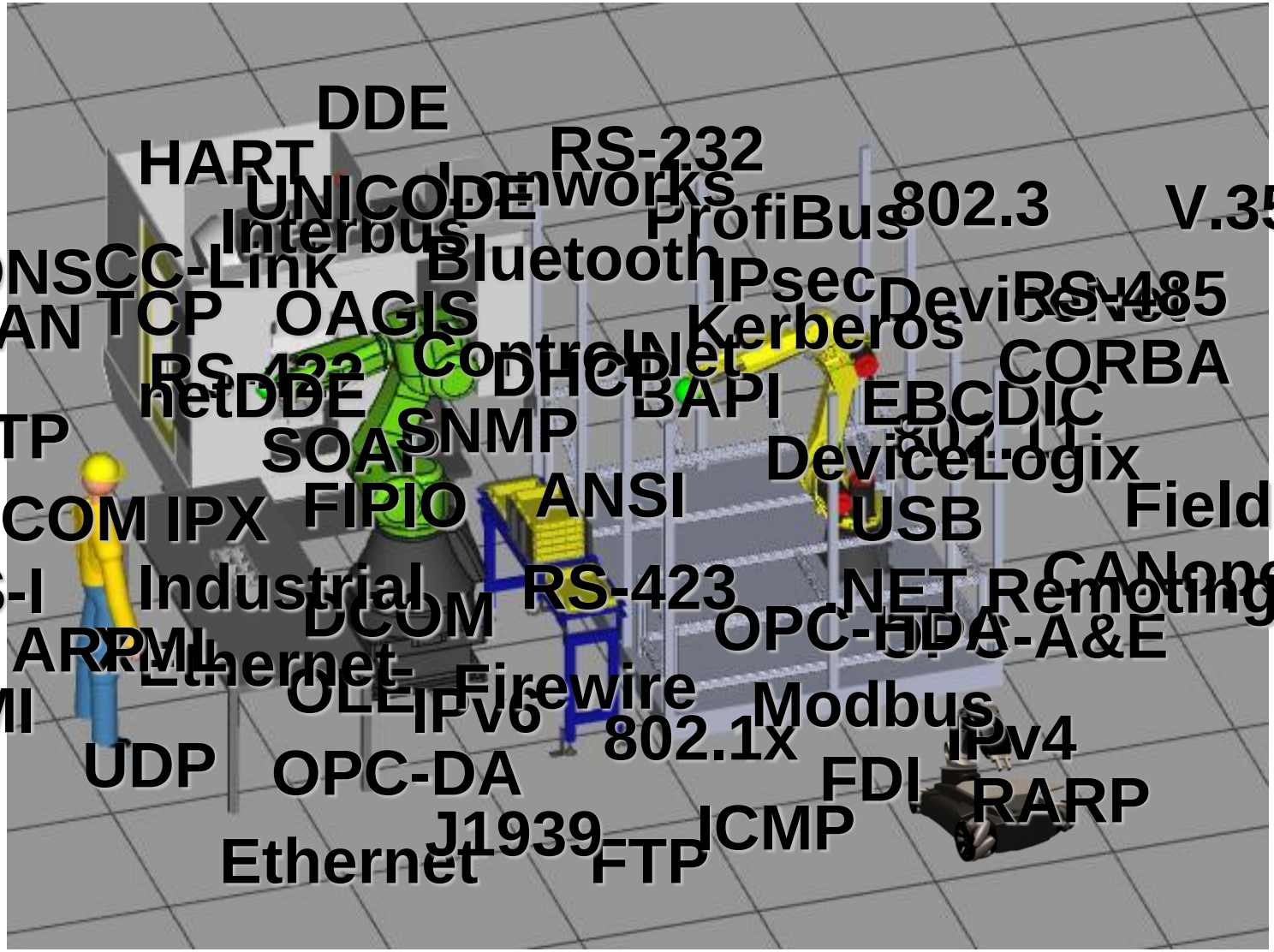
Heterogeneous Systems Hardware



Shop floor

- **Different machine generations**
- **Manual, semi and full automated processes**

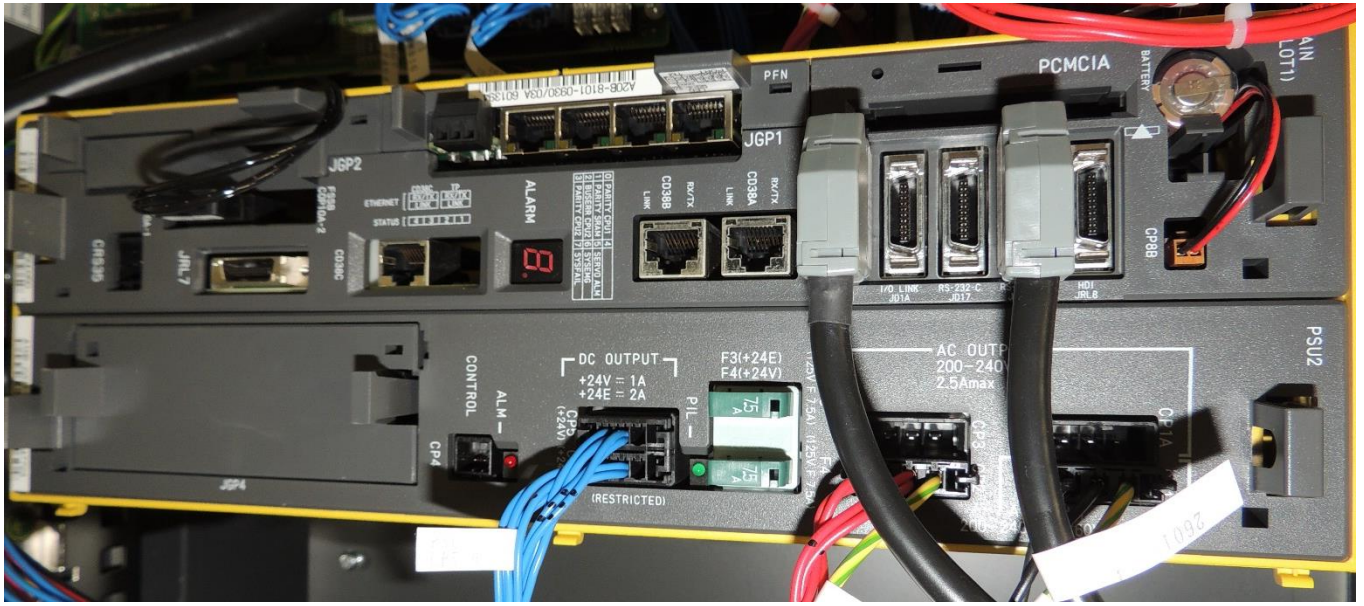
Heterogeneous Systems Software



Heterogeneous Systems Interface?

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)**



Outline

I. Motivation: Heterogeneous Systems

II. Interoperability

III. Standardization, Plug, Bus, Communication

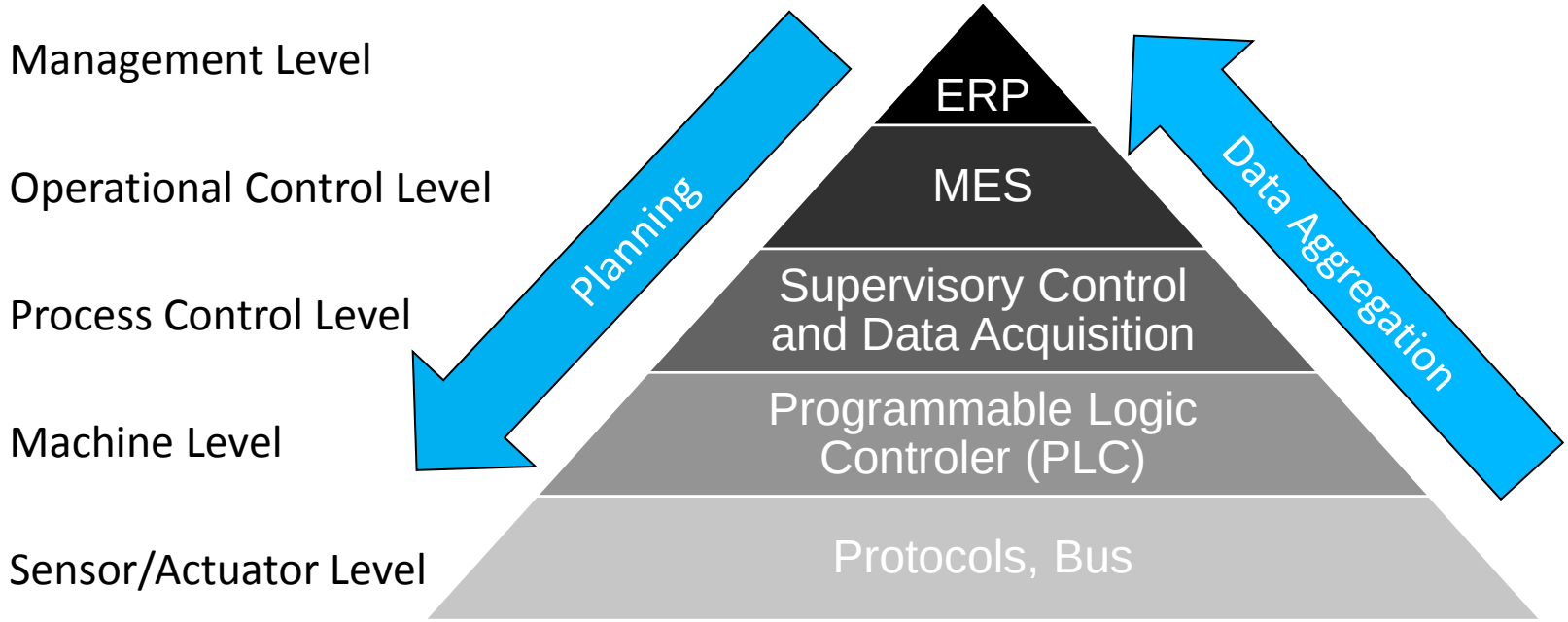
IV. Adaptive Integration; what`s needed right now

V. What do the system look like?

VI. Summary and Outlook

Automation Pyramid

Flow of Information within a Manufacturing Company



According to Wagner 2003

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).

Kind of Heterogeneity	Description/Examples
Syntactical	Presentation of data; e.g. format of numbers, encoding.
Structural	Order, in which data attributes are exported.
Semantical	Meaning of attribute denominations; t = time or temperature ?

⇨ no interoperability according ISO/IEC 2382-01 - 2382:2015

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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GERMAN STANDARDIZATION
ROADMAP Industry 4.0 Version 2
January 2016
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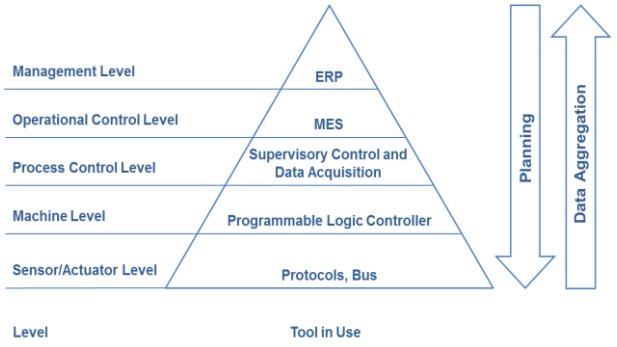
"A special difficulty arises here for terminology and standardization. Basically, it would be sufficient only to define the additional level of integration and its emergent behaviour. But to do that, the existing system landscape would first have to be coherently and completely defined in a globally 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."

DIN: Deutsches Institut für Normung (German Institute for Standardization);
DKE: Deutschen Kommission Elektrotechnik Elektronik Informationstechnik (German Commission for Electrical, Electronic & Information Technologies);
VDE: VDE Verband der Elektrotechnik Elektronik Informationstechnik e.V.

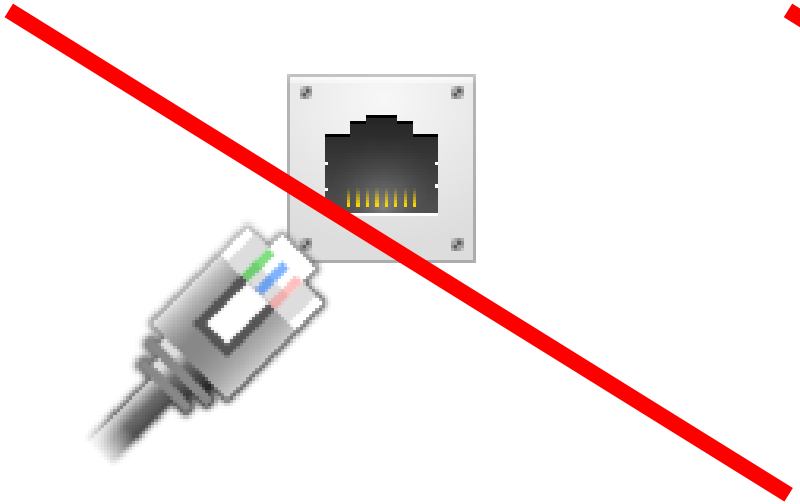
What`s granted by using standards:

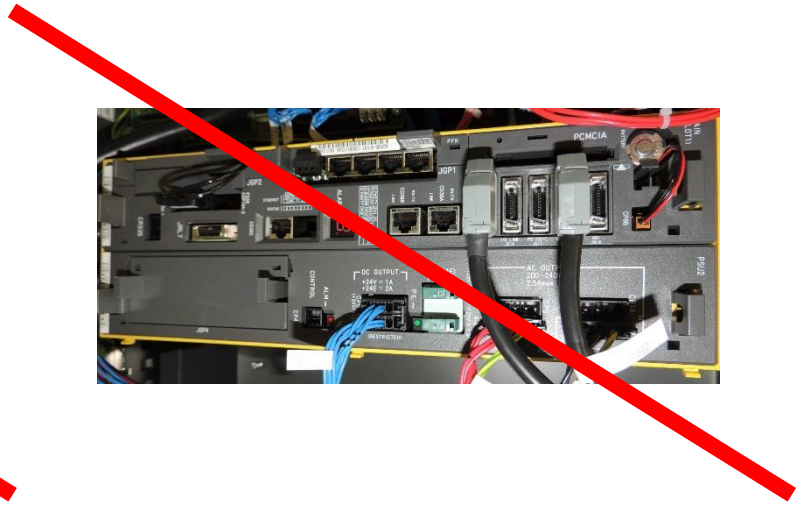
- interoperability in applications
- protection of environment, plants, equipment and consumers by means of uniform safety rules
- provide a future-proof foundation for product development
- assist in communication between all those involved

Integration
Vertical and horizontal



Plugs and Buses

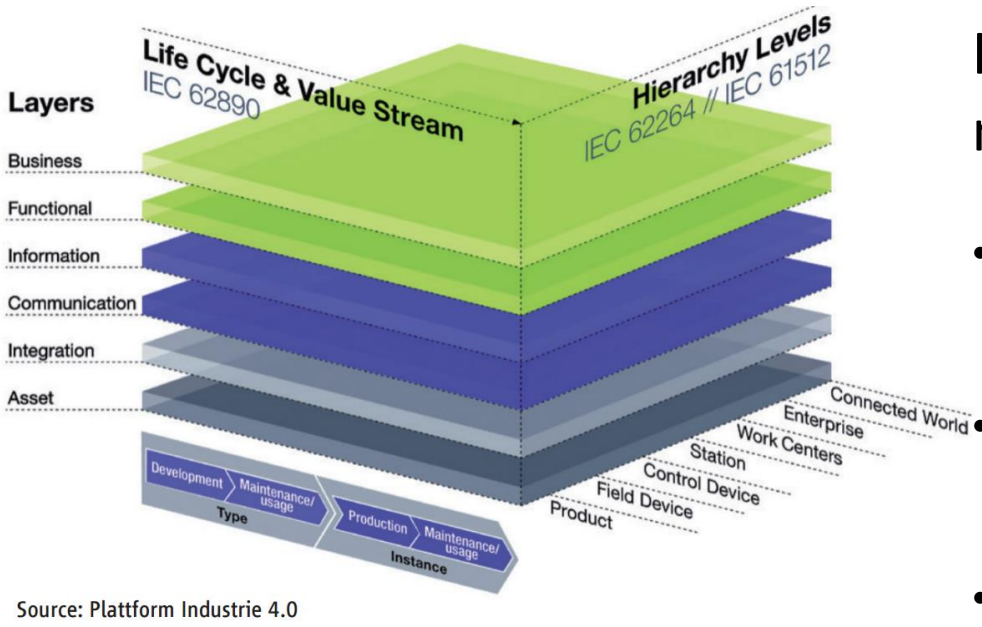




There`s no I 4.0 plug:

- 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



Source: Plattform Industrie 4.0

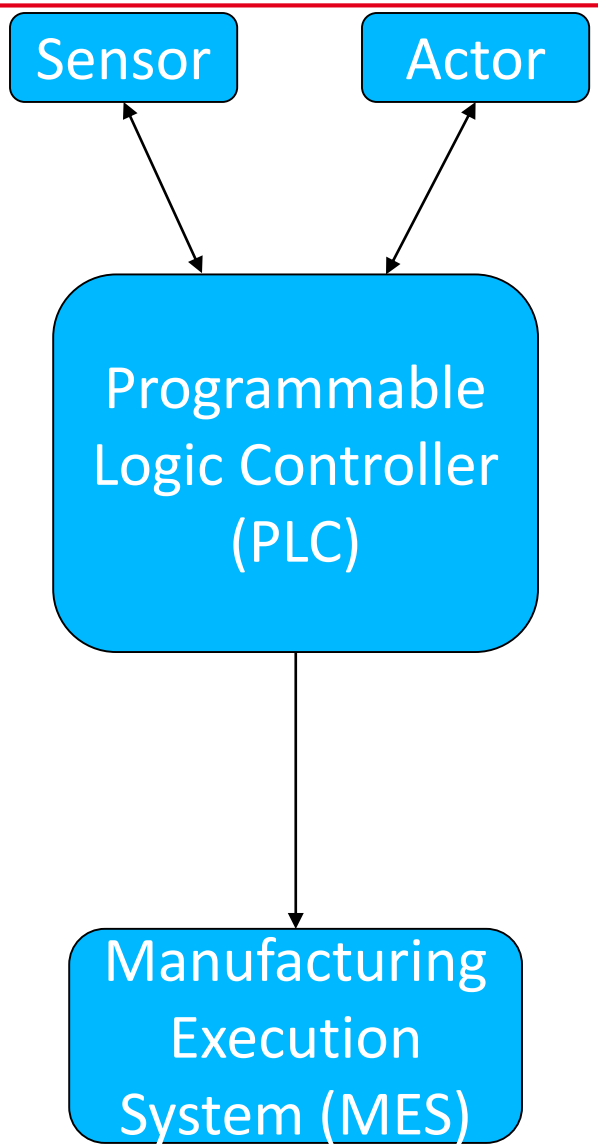
DIN SPEC 91345 “Reference Architecture Model for Industry 4.0 (RAMI4.0)”

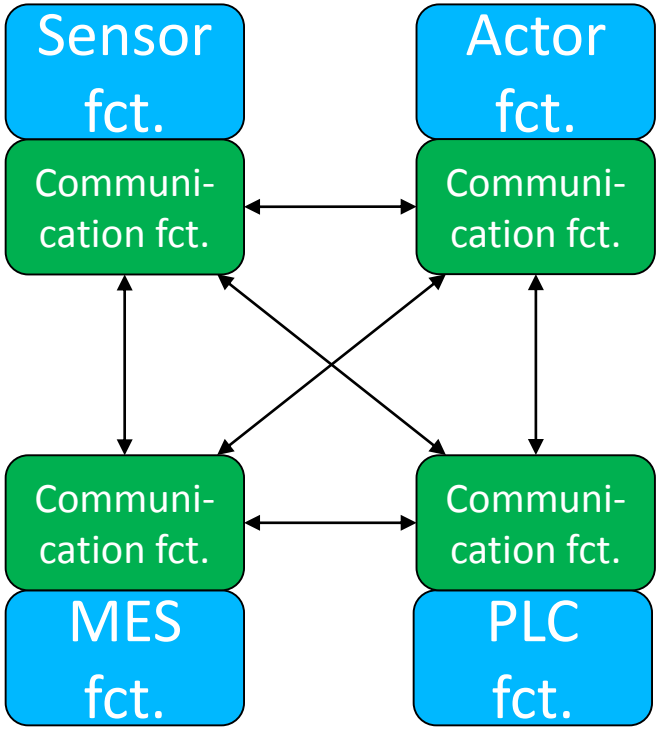
Information exchange between nearly everything:

- 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

http://www.zvei.org/Downloads/Automation/ZVEI-Industrie-40-RAMI-40-English.pdf

Communication





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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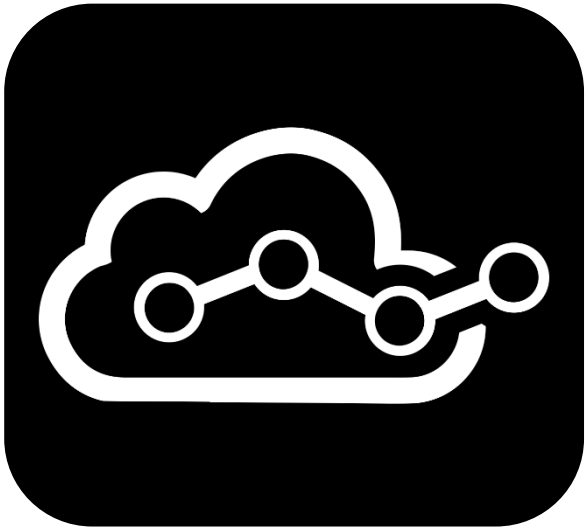
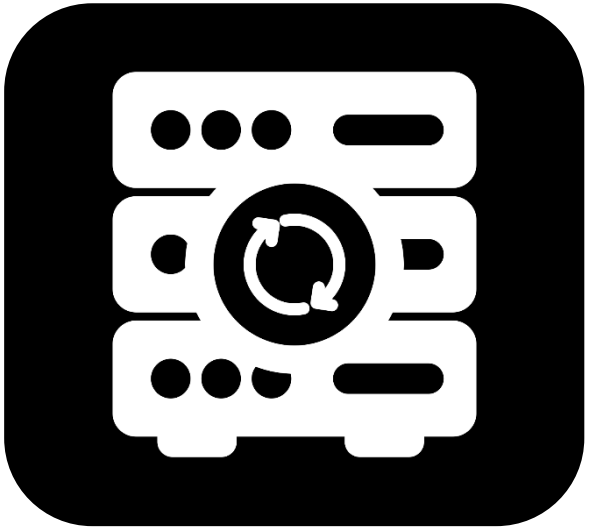
Adaptive Integration vie ESKAPE



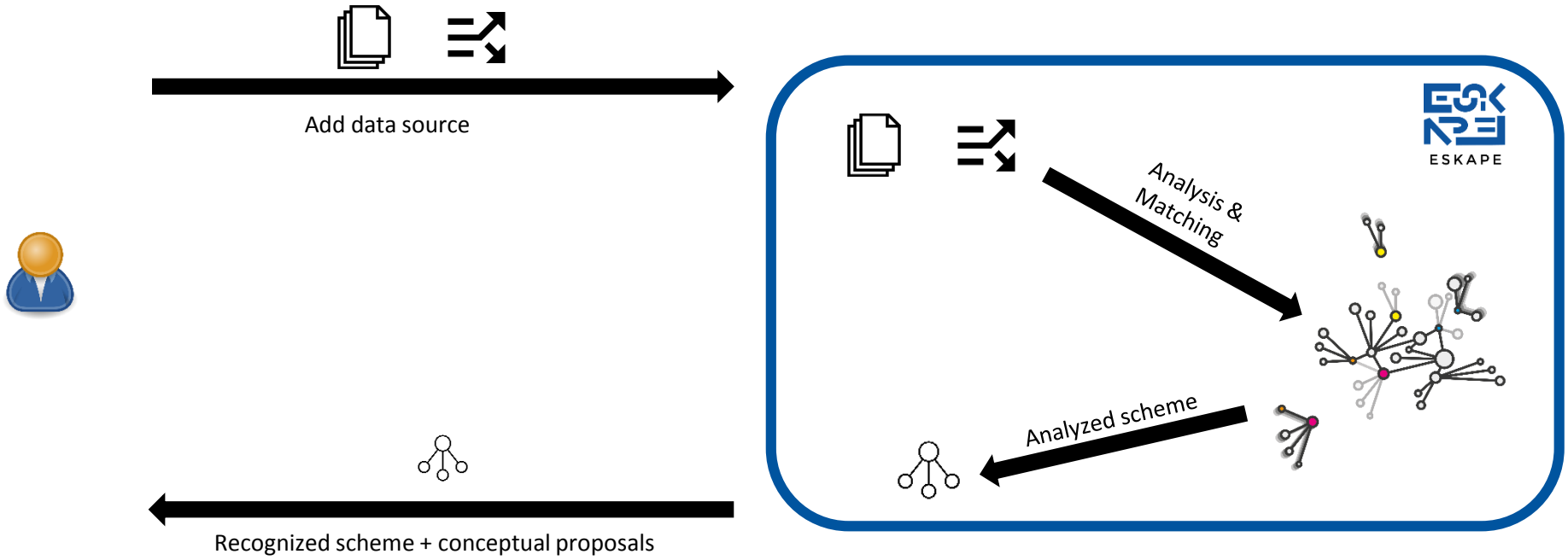


1. Schema analysis and creation of the semantic model
2. Data integration
3. Information search as well as data enrichment, transformation and extraction

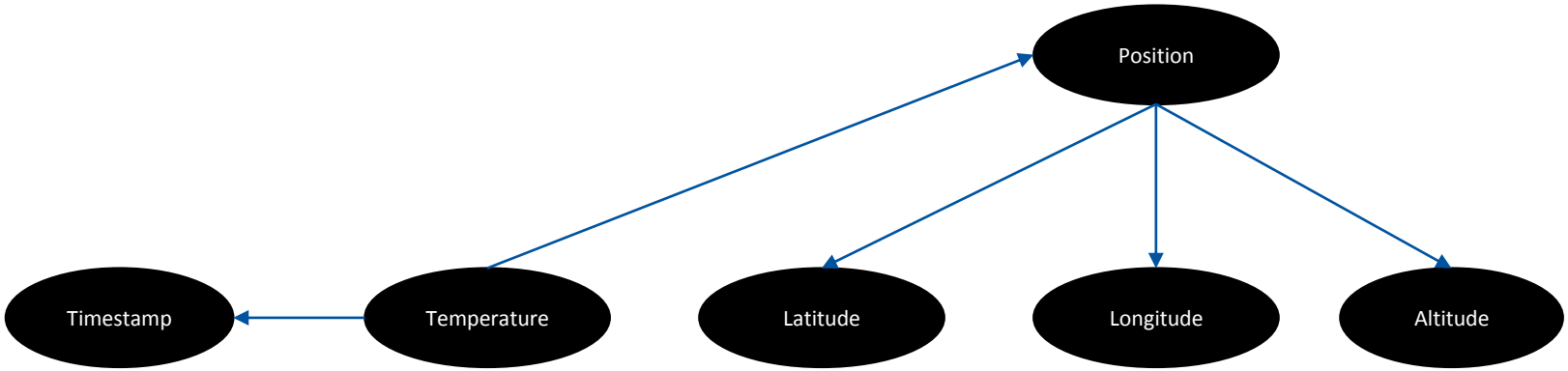
Schema analysis and creation of the semantic model

ESKAPE

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



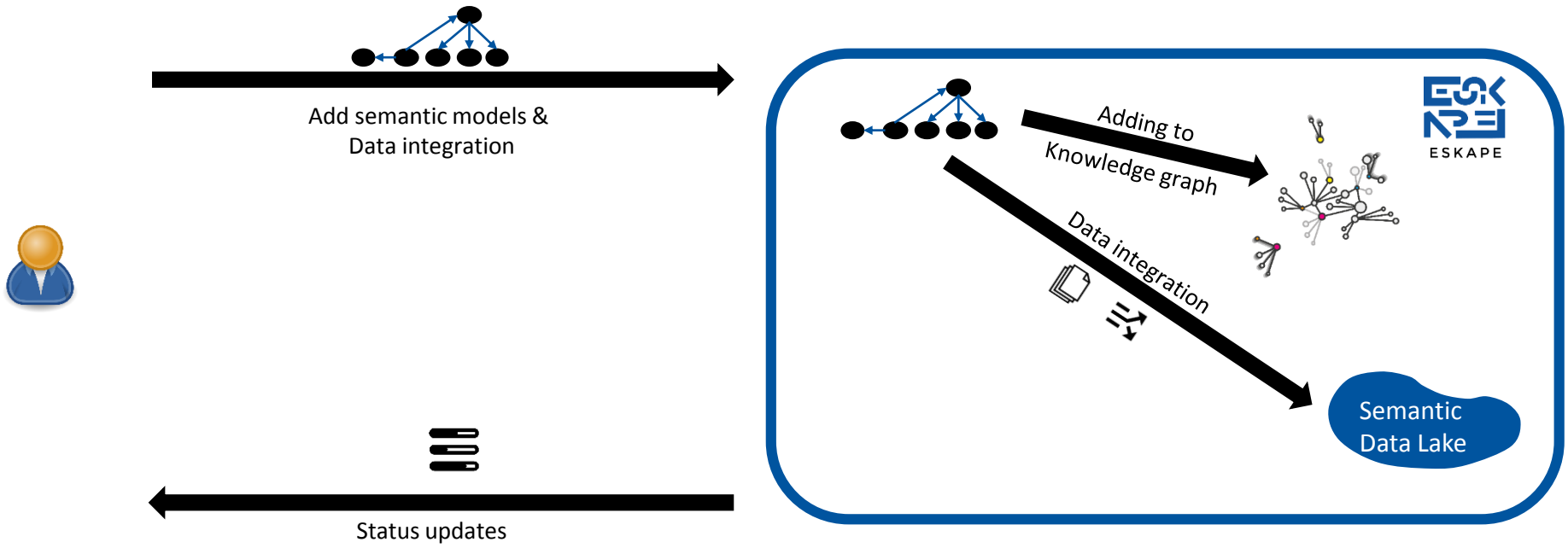
The user creates a semantic model for his data on the basis of the knowledge graph of the platform and his own mental model



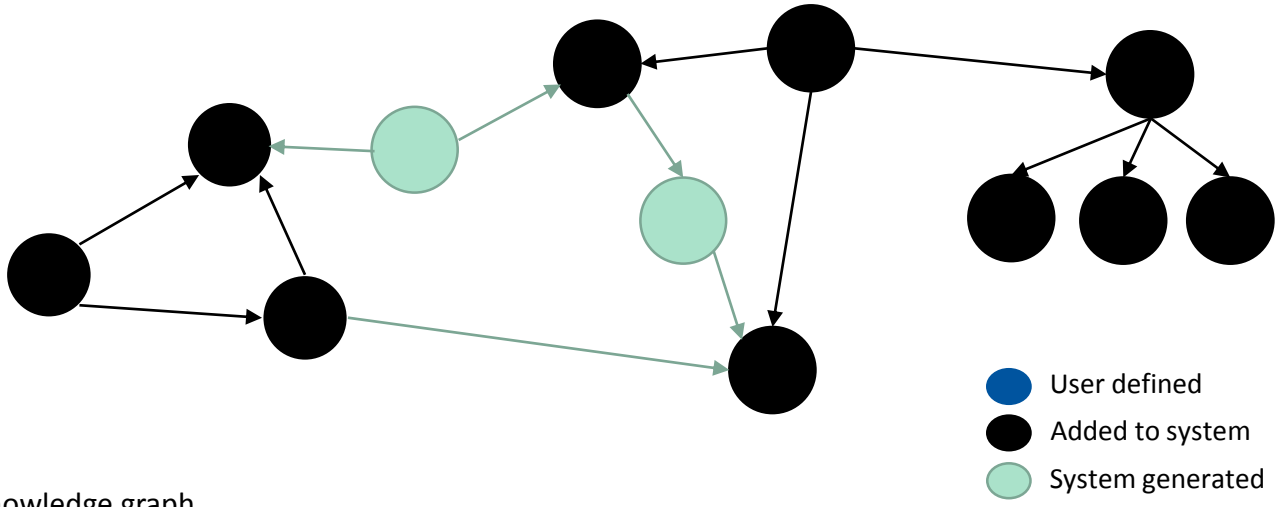
TS	TEMP	POS_Y	POS_X	ALT
1476835200	3	50.780296	6.104511	12
1476835200	4	50.774423	6.085856	4
1476835200	10	50.776057	6.043272	11

Data integration

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

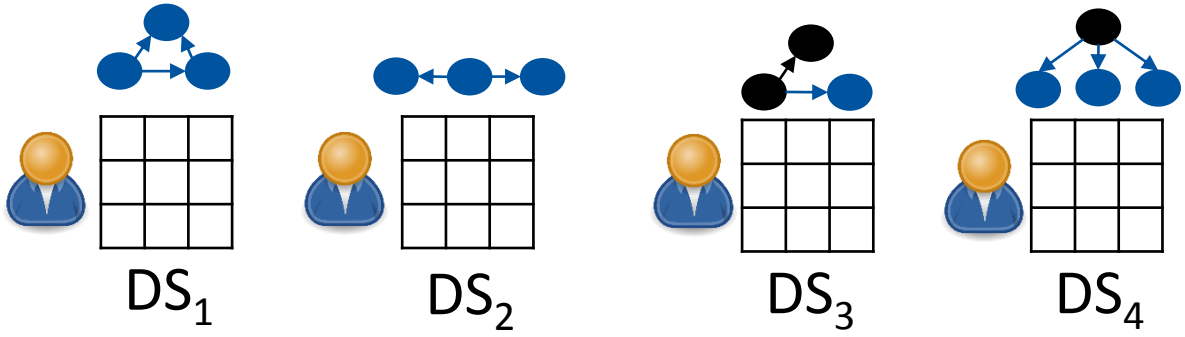


Data integration



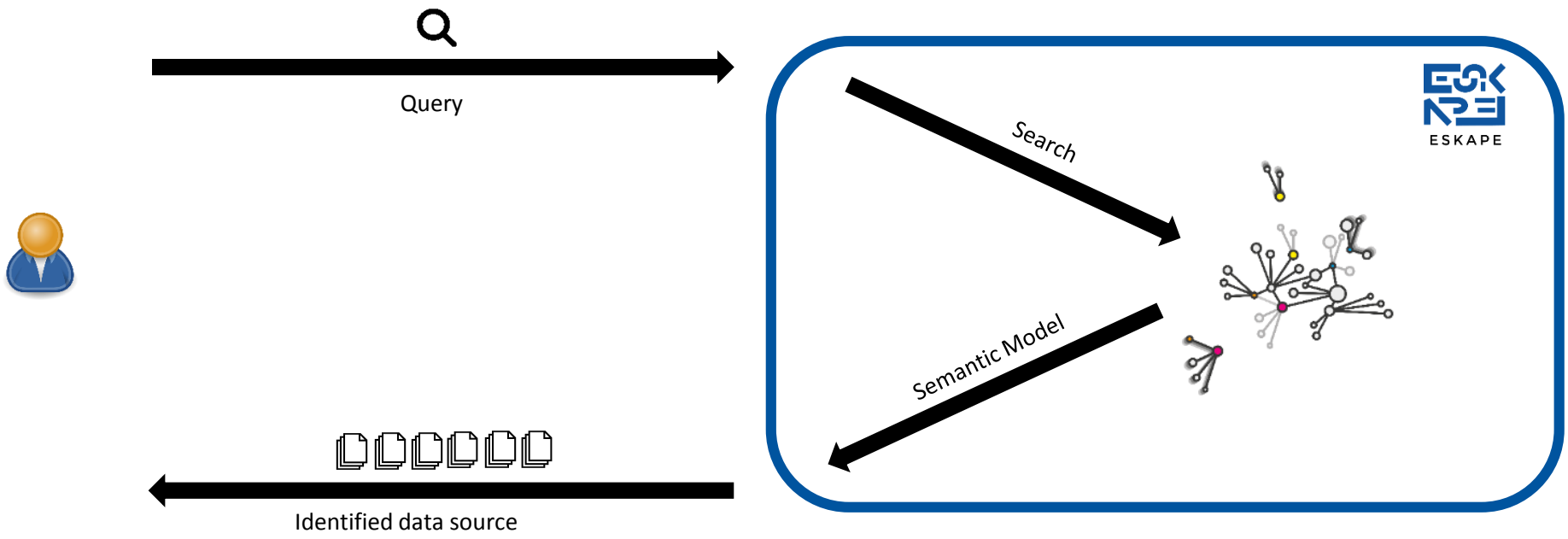
Knowledge graph

Semantic model



DS: Data Source

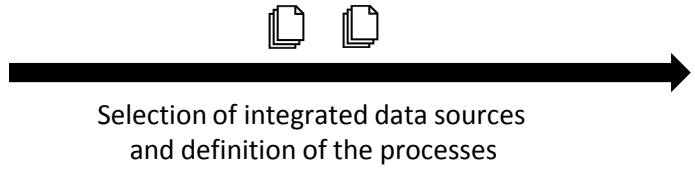
Annotated data sources can be found using the concepts of the semantic model

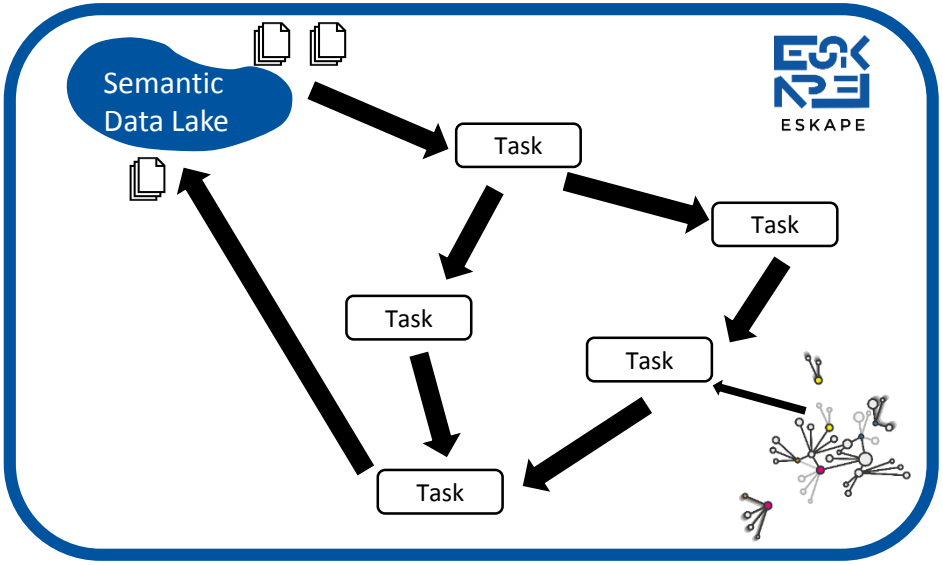


Data enrichment, transformation and extraction

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





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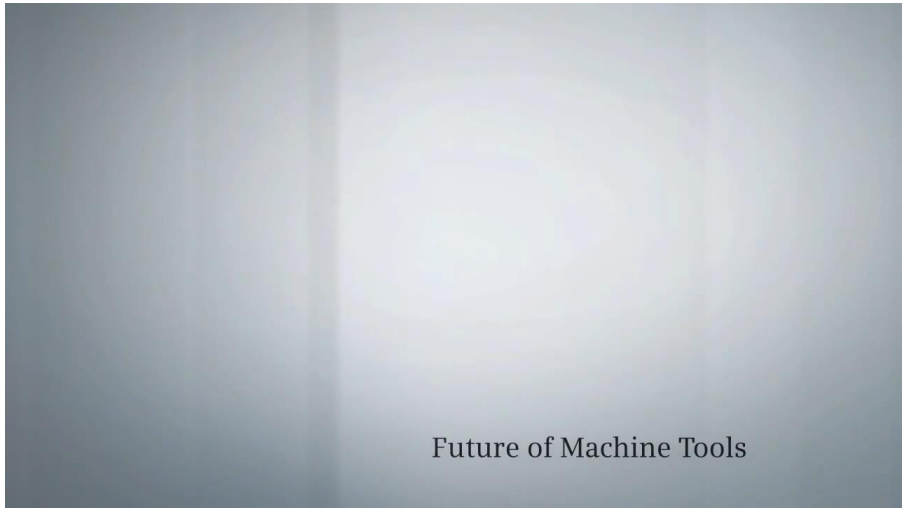
Summary and Outlook

- 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**

http://apps.boschrexroth.com/microsites/connected-automation/en/Bosch_Rexroth_Industry4.0_Checklist_English.pdf

Thank you for your attention,

do you have any questions?

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GERMAN STANDARDIZATION ROADMAP Industry 4.0 Version 2 January 2016
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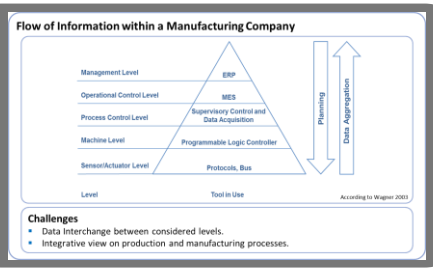
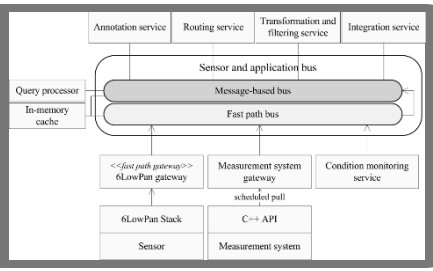
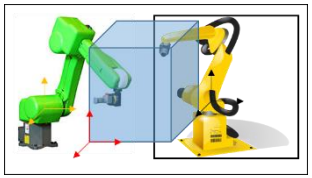
Safe Autonomous Robot Interaction Systems

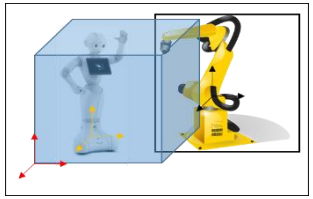


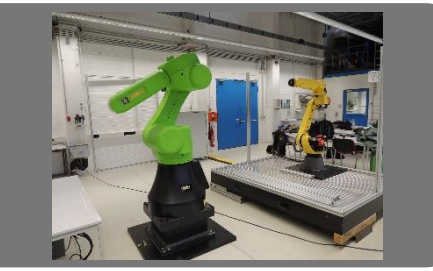
- Interoperability
- Interfaces
- Standards
- Adaptive System Integration



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







- Kinematics
- Sensors
- Actors
- Annotated Robot Movements