



German
Research Center
for Artificial
Intelligence

IFS Innovative
Factory Systems

Towards a Factory-of-Things

Technologies for the factory of the future

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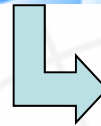
My background



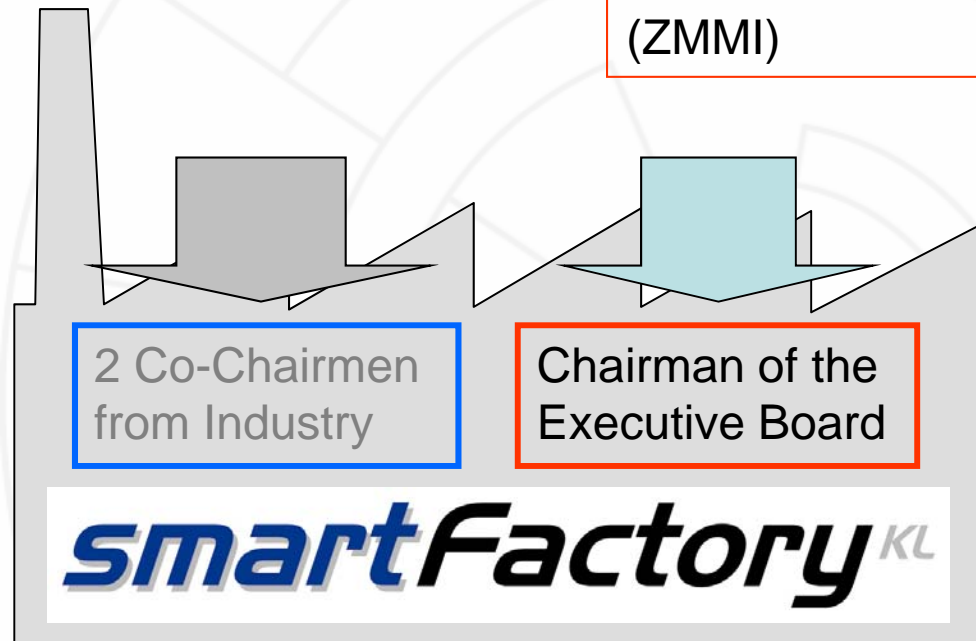
Professor
Production Automation



German Research
Center for Artificial
Intelligence GmbH



Director
Innovative Factory Systems (IFS) and
Center for Human-Machine-Interaction
(ZMMI)



- **Introduction**
- **The *SmartFactory*^{KL}-Initiative**
- **R&D Projects**
- **Lessons learned**

Our future world

Our life is deeply affected by many new technologies which have reached a sufficient level of maturity!

WLAN, Bluetooth, UMTS...

SmartPhones, PDA's, SubNotebooks...

Speech interaction, gesture control...

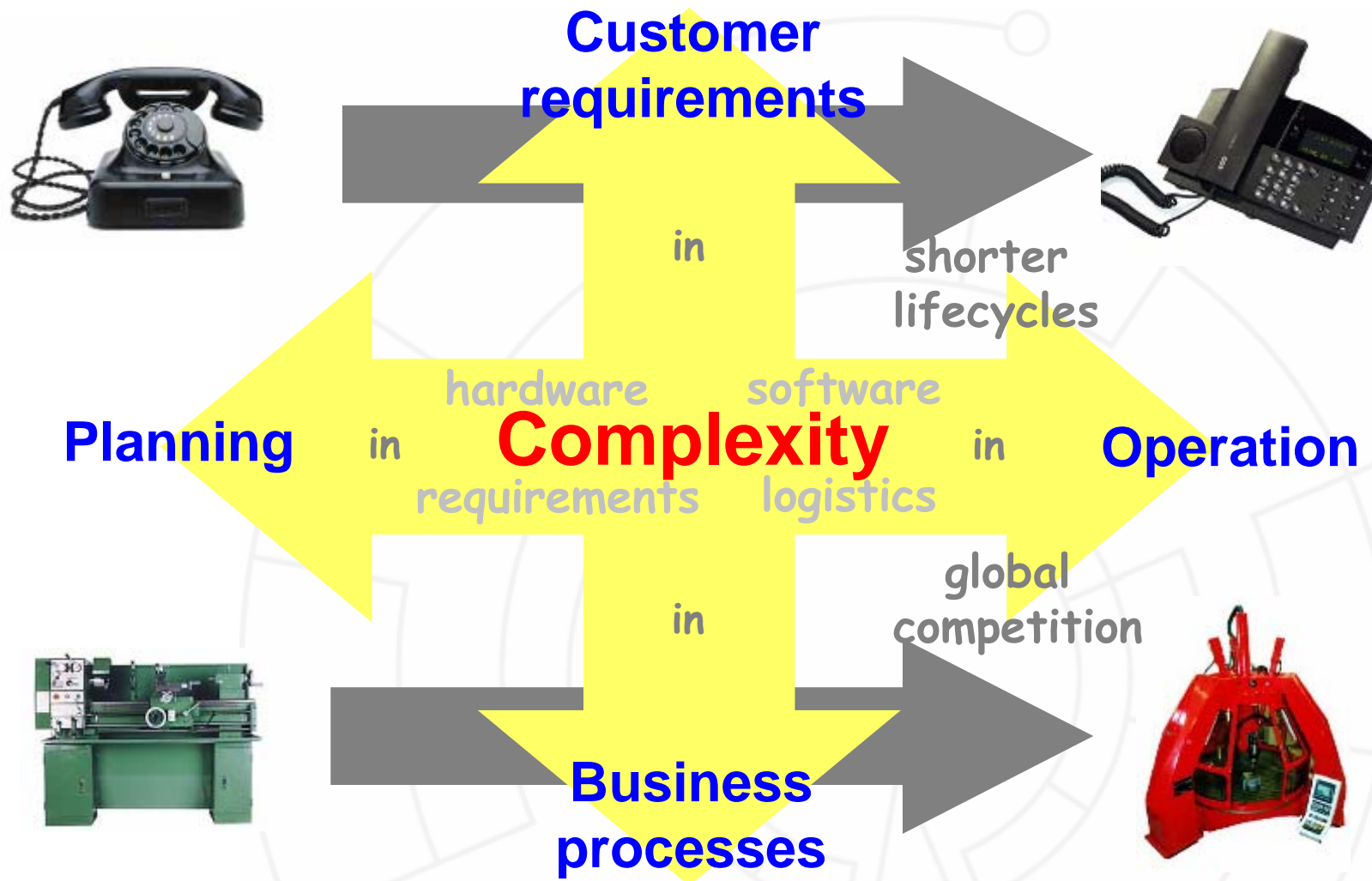
From telephone to VoIP...

The internet of things...

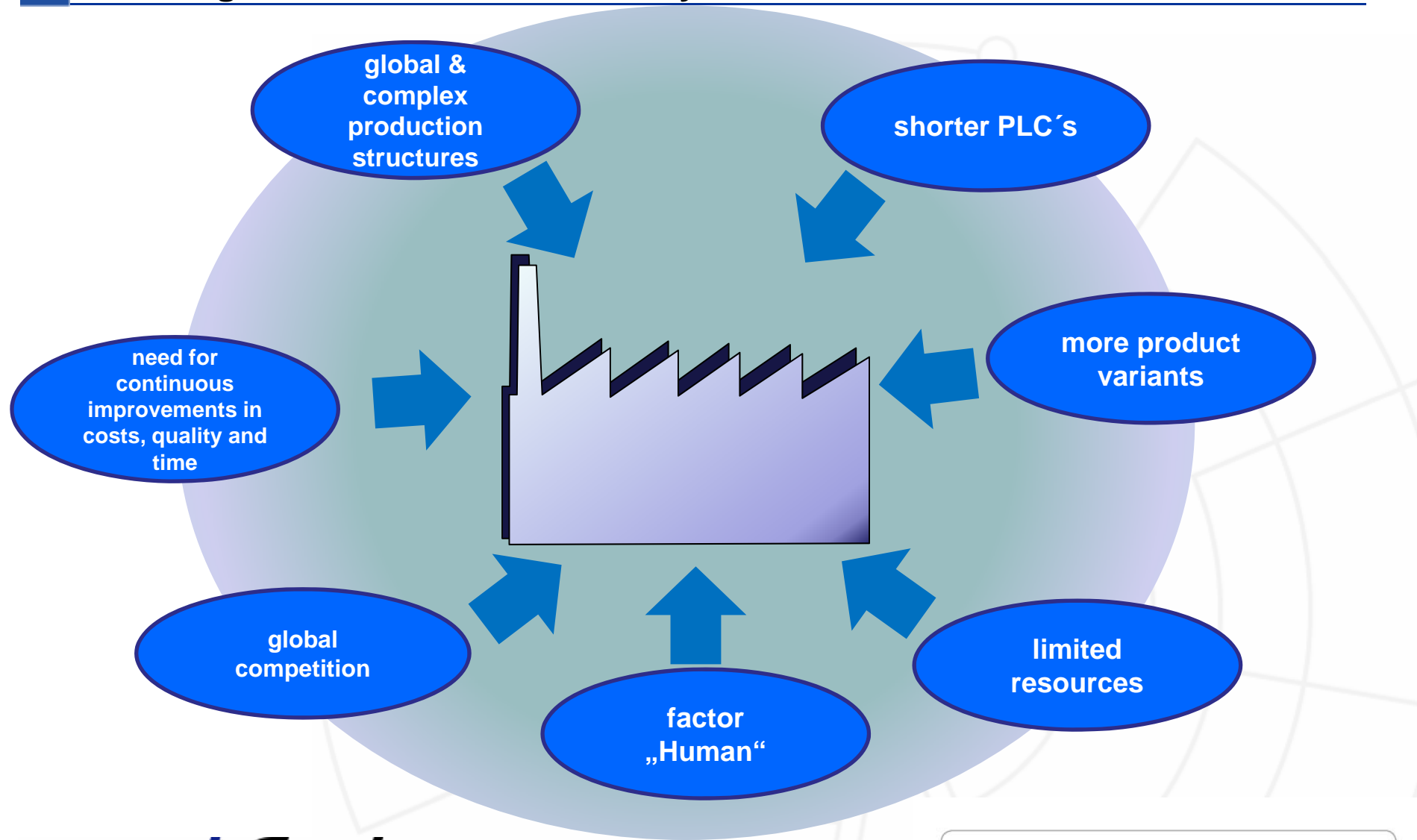
Information will be available
**anywhere, anytime, with any content, for any user
using any device and any access**



Complexity problem



Challenges for future Production Systems



- Introduction
- **The *SmartFactory*^{KL}-Initiative**
- R&D Projects
- Lessons learned

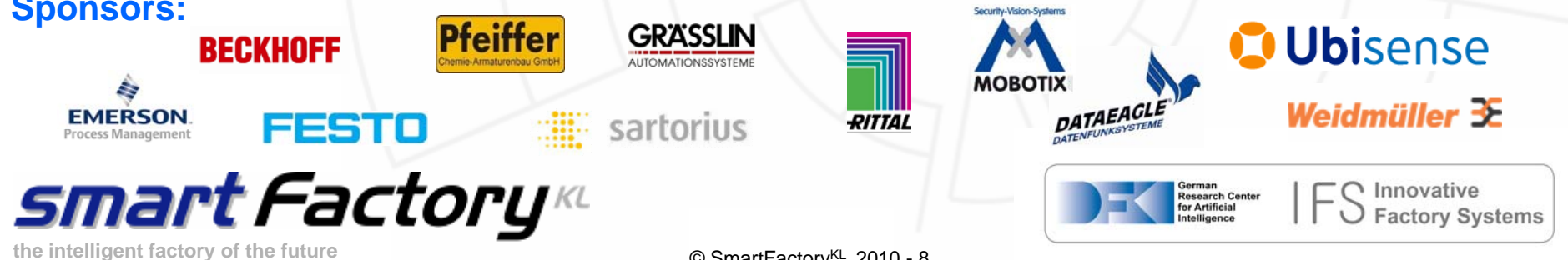
Membership / Sponsorship SmartFactory^{KL}

- ✓ First multi vendor research, development and demonstration center for industrial ICT
- ✓ Goal: The integration of mature ICT into factory automation

Members:



Sponsors:



Picture of the Shop Floor

continuous flow process
colored soap production



discrete handling process
bottling, handling, labeling, QC, packaging...



Live-Webcam: <http://www.smartfactory.de/webcam.de.htm>

smartFactory^{KL}

smartFactory^{KL}
the intelligent factory of the future

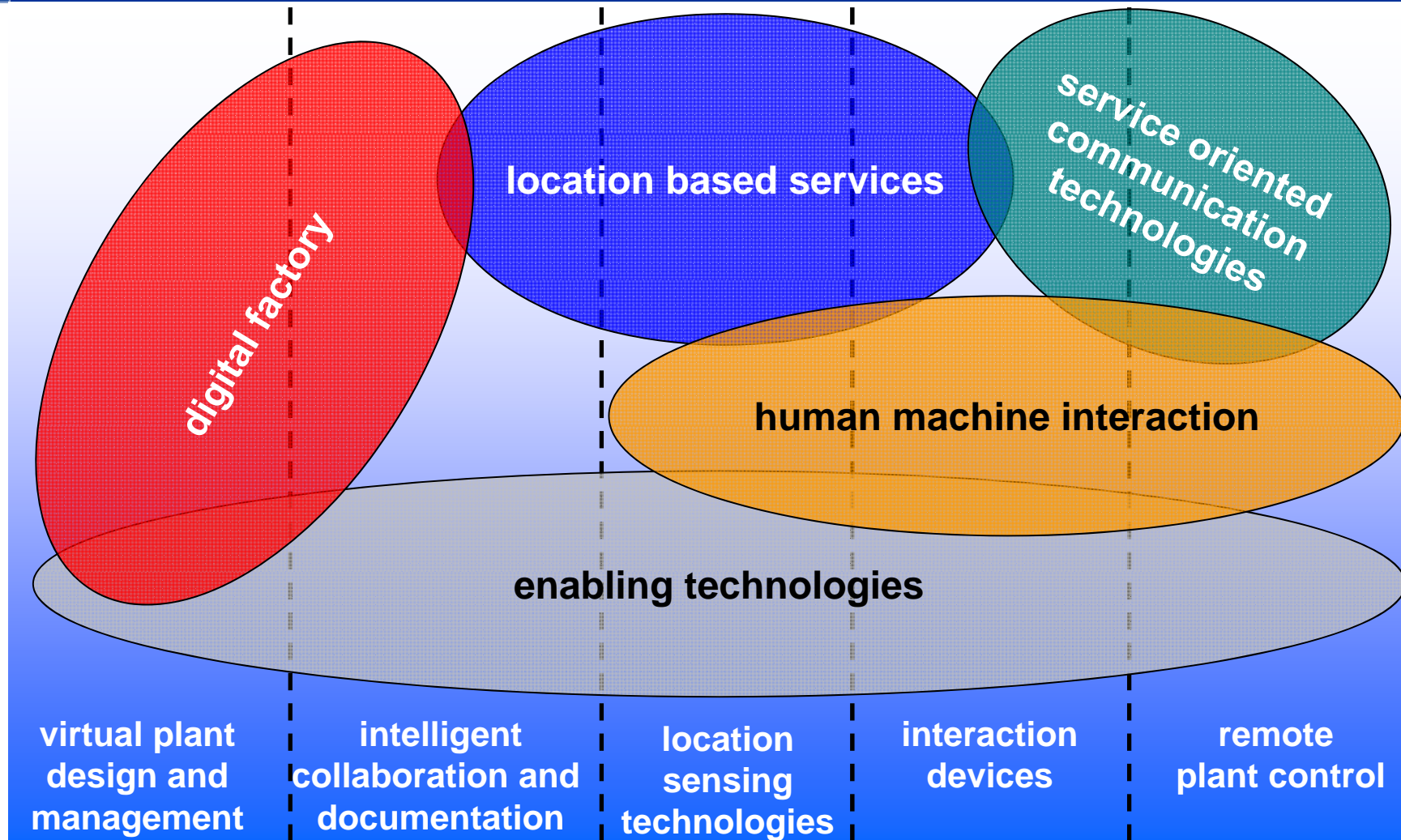
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Outline

- Introduction
- The *SmartFactory*^{KL} -Initiative
- **R&D Projects**
- **Lessons learned**

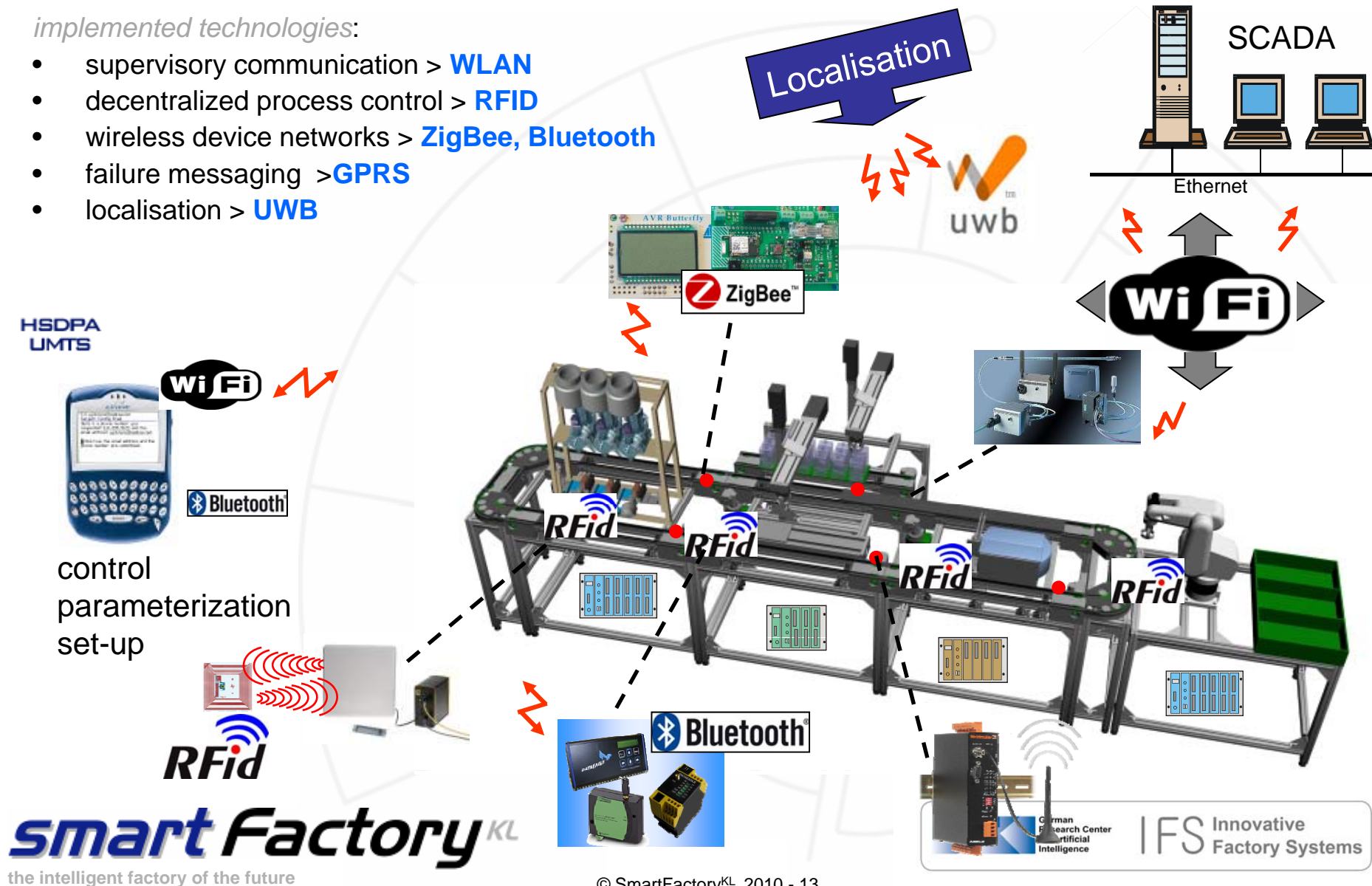
Cluster Analysis – Fields of Research



The wireless SmartFactory^{KL}

implemented technologies:

- supervisory communication > **WLAN**
- decentralized process control > **RFID**
- wireless device networks > **ZigBee, Bluetooth**
- failure messaging > **GPRS**
- localisation > **UWB**



Wireless systems

GPRS/UMTS	high quality of service very stable	expensive slow response
DECT	good quality of service stable	few devices low data rates
UWB	??? quality of service ??? stable	few devices low data rates
WLAN	high data rates cheap	„everyone´s darling“ fair QoS, unstable
Bluetooth	high quality of service very stable, cheap	high power consumption low data rates, no roaming
Zigbee	high quality of service very stable, low energy	to be developed low data rates

Band coexistence !

Wireless application fields



Class A	Safety critical operation Emergency stop, hazardous tasks
Class B	Time critical operation Network control systems, predictable response time
Class C	Non critical operation Nomadic information retrieval, „nice to have“ operation

*But...
Things will improve !*

Lessons learned

Wireless

Pro's

- enabler for mobility
- brings flexibility
- may save installation cost

But it...

- should be complemented by wireless power supply
- needs intensive radio planning
- needs more frequency resources (on the long run)
- is vulnerable by environmental changes
- can not offer real-time transmission
- can be jammed easily and unnoticed

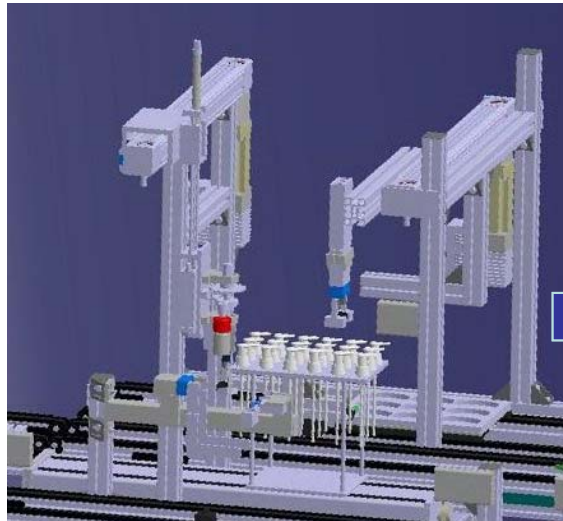
Con's

in a nutshell

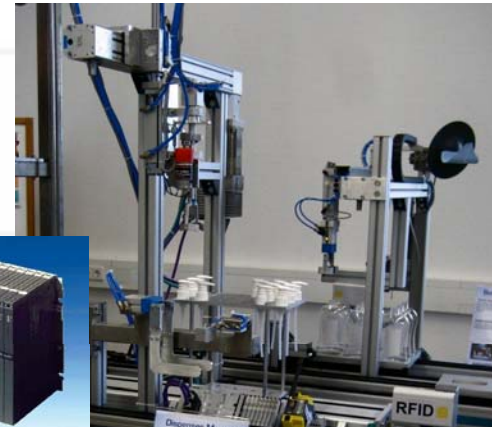
Wireless systems do not yet meet basic industrial requirements !
They offer advantages in non-critical applications only !

Project Group: „Digital Factory“

digital
world



real
world



Institut
Informations- und
Datenverarbeitung



SIEMENS
PLM Software

SAP RESEARCH



Lucian
Blaga
University
Sibiu/RO



Federal Ministry
of Education
and Research

Objective

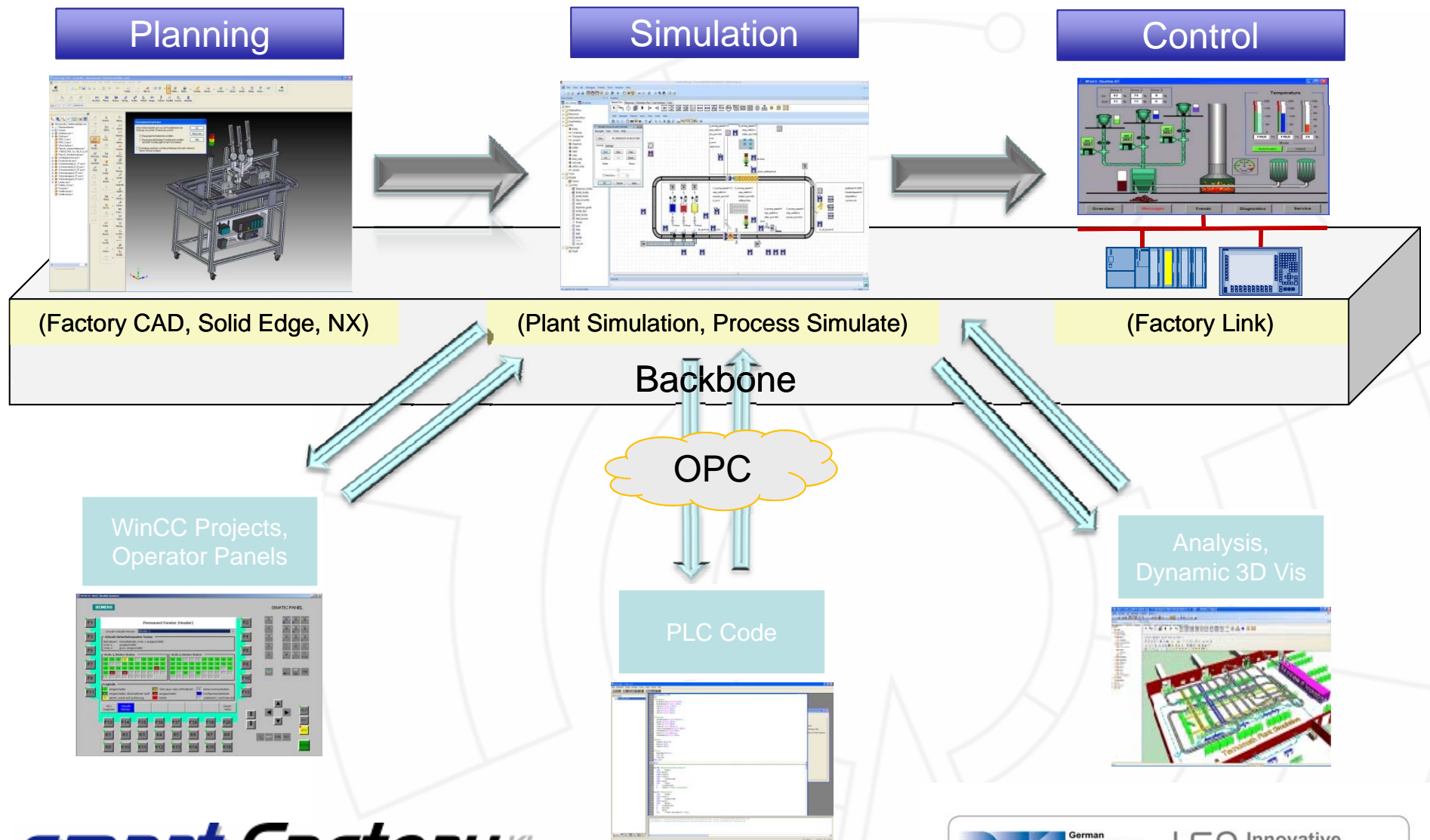
- Demonstration of a „Digital Factory“

Milestones

- Setup of a digital model of the existing factory
- Simulation of the factory
- Automated control system generation
- Simulation support during operation
- Linking the ERP and MES Systems
- Creation of a research-, development- and demonstration platform

smart Factory^{KL}
the intelligent factory of the future

Project Group: „Digital Factory“



Lessons learned

Digital factory

Pro's

- will reduce planning effort
- will reduce time to market
- allows for component re-use
- may save cost (on the long run)

But it...

Con's

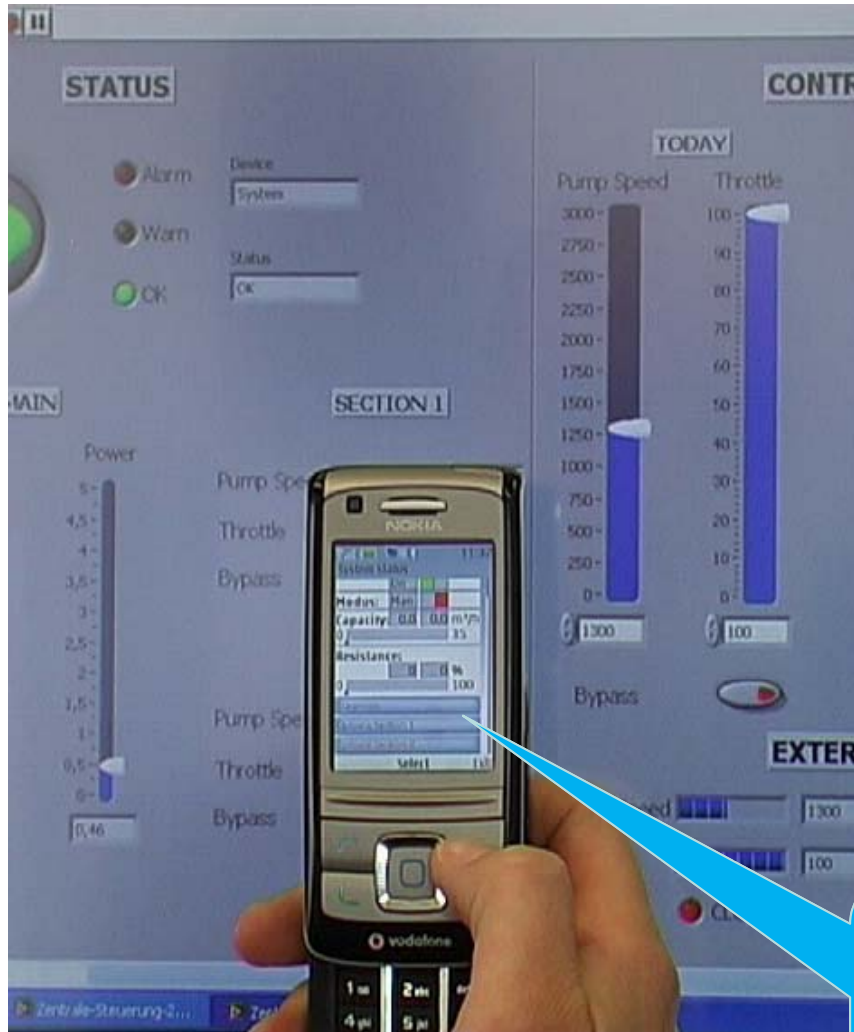
- needs a collaborative platform
- needs intensive expertise by the users
- must be linked to the control level
- is for big players only

in a nutshell

A digital factory tool world will make planning and operation more effective!

But it needs years to develop and new standards to ease integration!

Smartphones as universal interaction devices



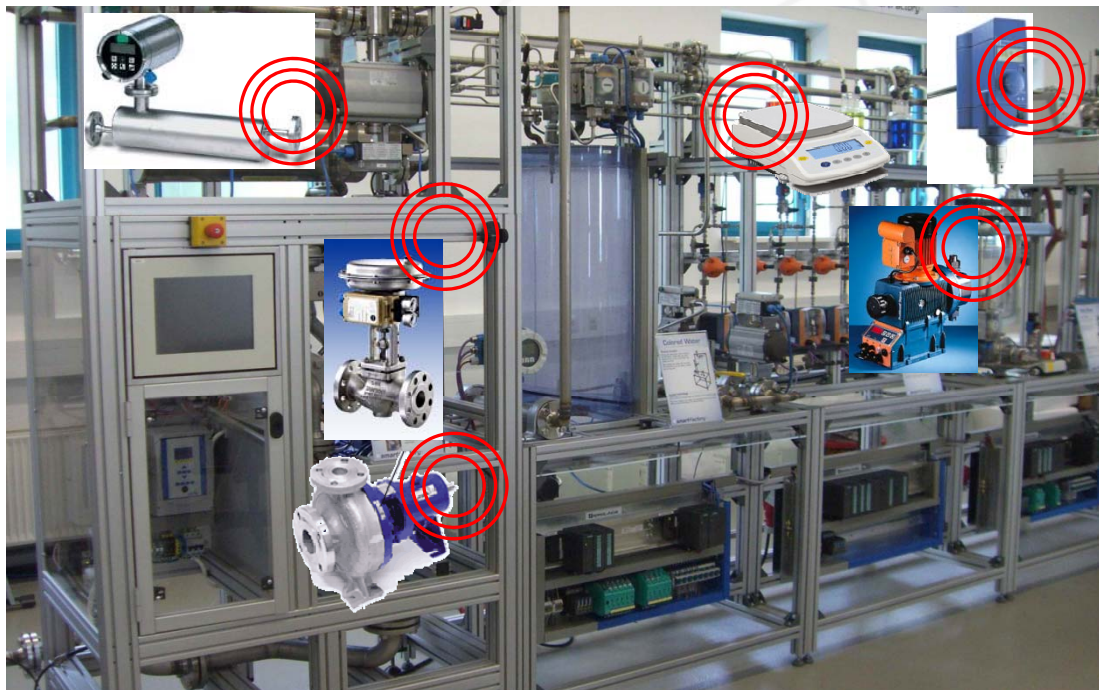
- Development of a platform-independent software for mobile phones of different manufacturers
- Data link via Bluetooth
- Automatic detection of available field devices
- Communication via heterogeneous infrastructure with different access paths and gateways

Result:

- > 20 smartphones Java2ME
- > 4 were o.k.
- > 6 had minor problems
- > 10 failed completely

Future interaction with smart production items

- **SmartFactory^{KL}** as a testbed:
 - 20 field devices can be controlled wirelessly via Bluetooth
 - users can access them according to their tasks, education and preferences
 - dedicated remote operation device is under development



Dosing pumps

Mass-flow meters

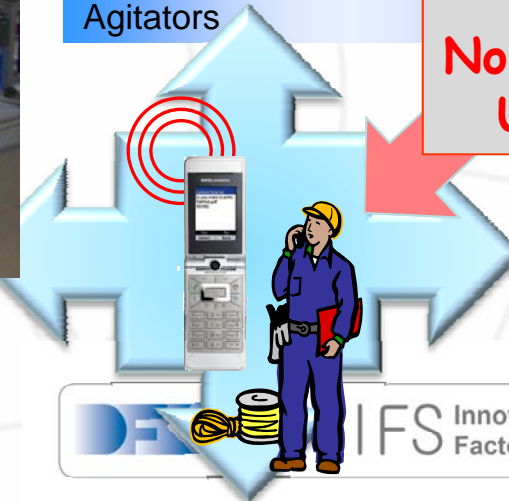
Valves

Weighing machines

FlowUnit components

Agitators

**The
Nomadic
User**

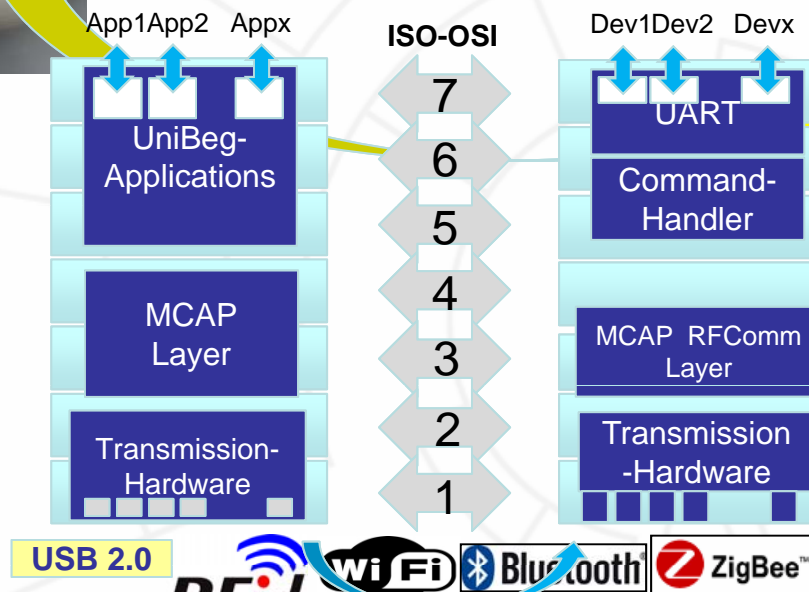
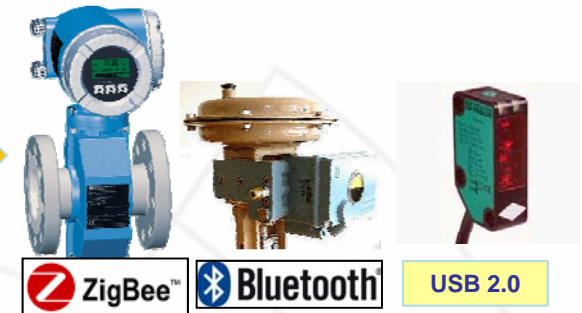


Universal Interaction Device by UniPO GmbH

The first industrial product...



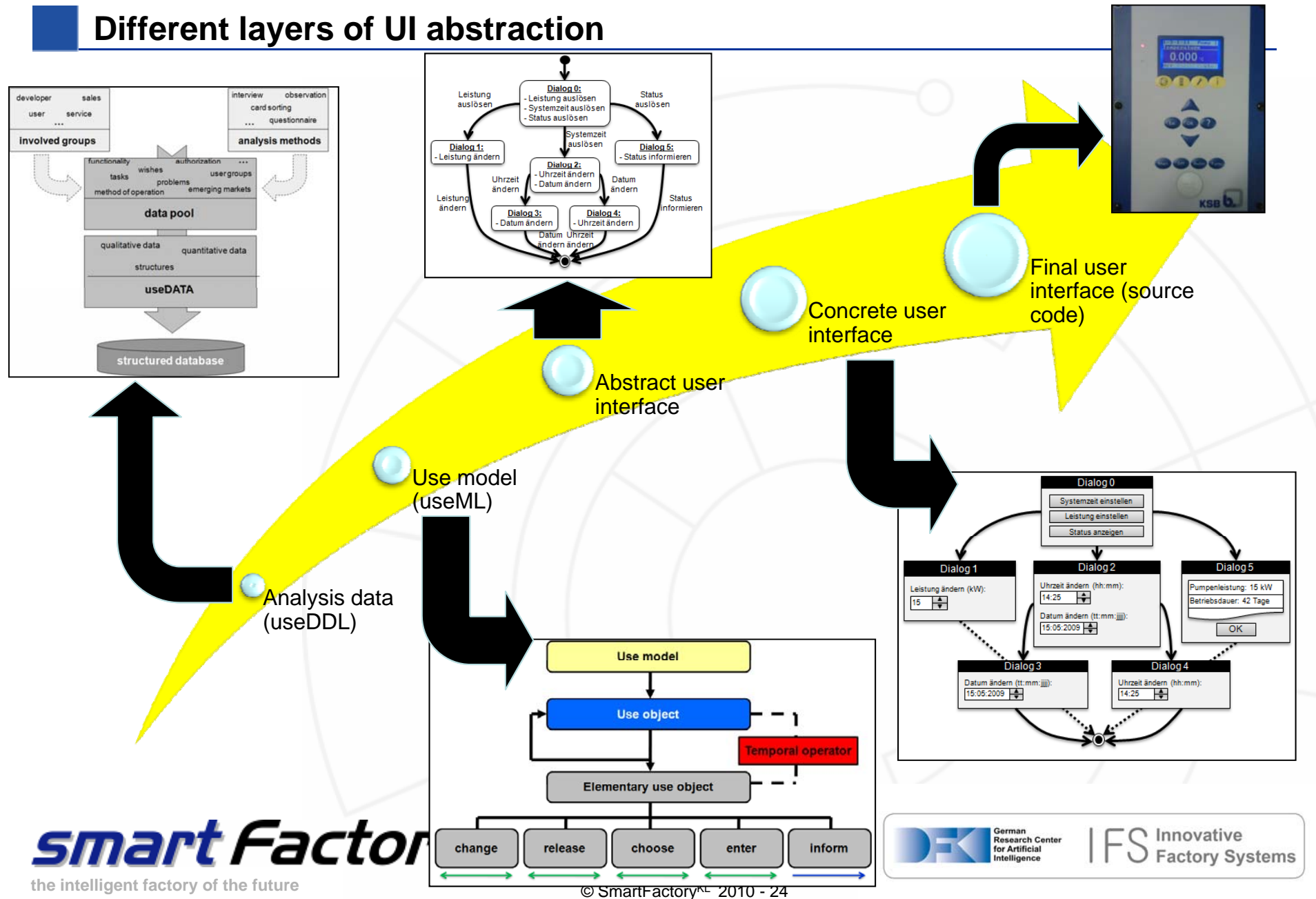
Universal Gateway



The future challenge of designing user interfaces



Different layers of UI abstraction



Lessons learned

User-friendly operation

Pro's

- supports the user to do it right
- brings more flexibility
- is important for customer satisfaction

But it...

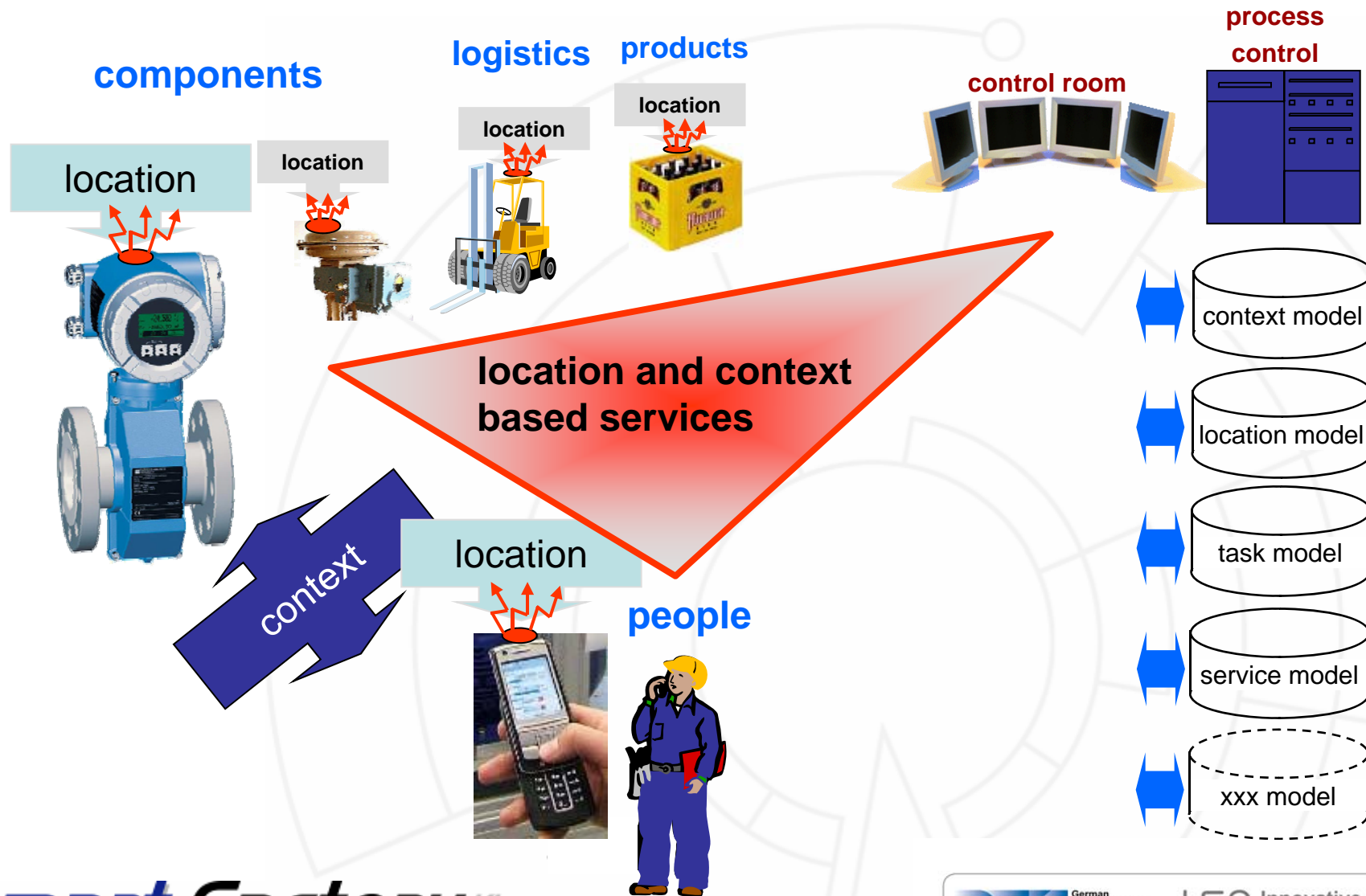
Con's

- must be developed with methodology
- must focus on the users tasks
- should be hardware independant
- should care for cultural differences
- should be treated as important as hard- and software

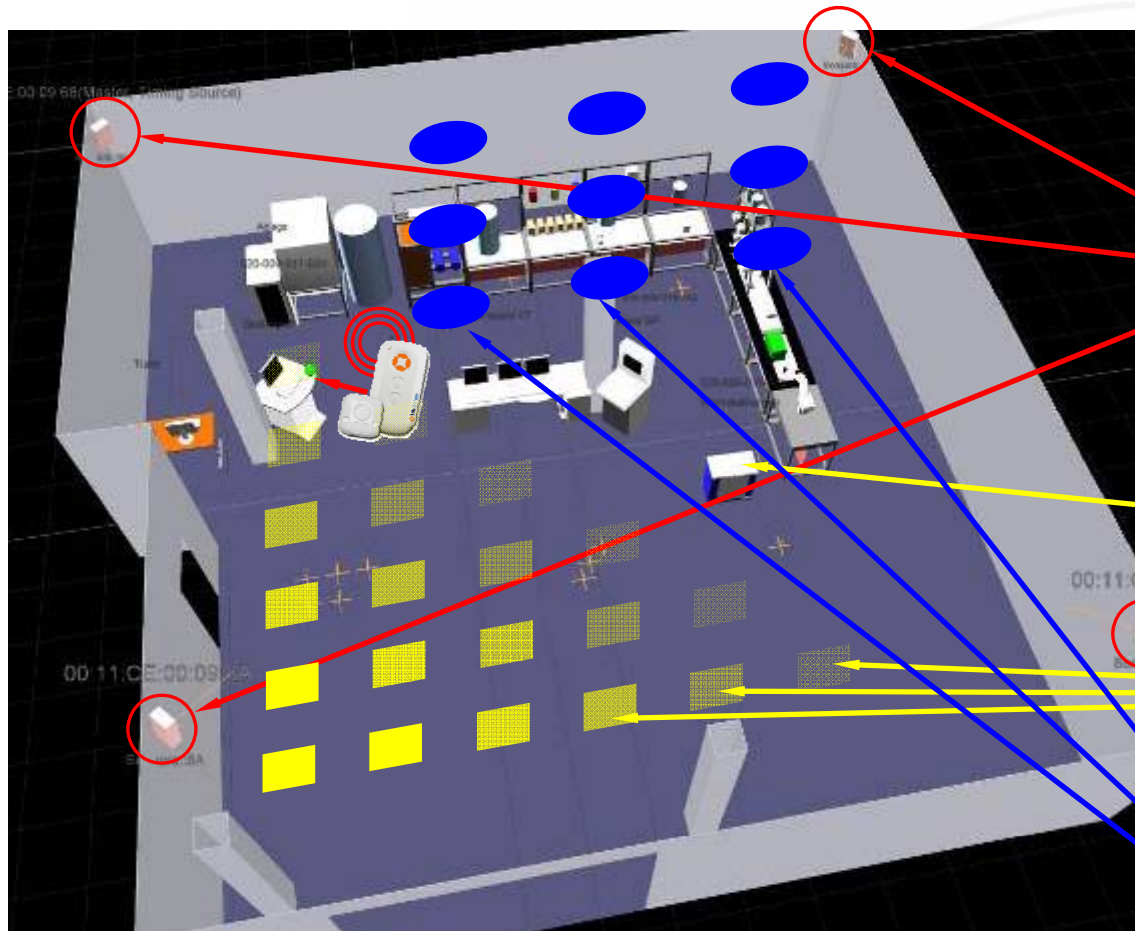
in a
nutshell

Help the users to perform the tasks by a good usability!
Be prepared for rapid hardware changes and nomadic access!

Location Based Services in Industrial Applications



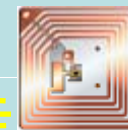
Indoor Positioning Systems installed in the *SmartFactory*^{KL}



- Ubisense UWB-Realtime Positioning System







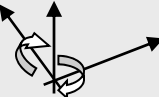



- RFID Grid for Mobile Workshop Navigation



- Cricket Ultrasonic Indoor Location System



Location Based Services in Industrial Applications

	World level Accuracy: 5-15m 3 axes	 <div> Systems: GPS (US) GLONASS (russ.) GALILEO (europ. from '12) cell phone localization </div>
Accuracy: 0.5 – 1.5m / 3 - 5° 4 axes	 Building level 	<div> Systems: UbiSense DOLPHIN Cricket WLAN localization </div>
Systems: iGPS-Laser UbiSense UWB localization		 Room level Accuracy: 1 – 10cm / 1.0° 4 - 5 axes
Systems: ???		 Device level

Lessons learned

Location-based services

Pro's

- will be essential in wireless applications
- enable context and position dependancy
- enable a more efficient use of resources

But it...

Con's

- we need indoor location sensing systems
- we need location standards
- needs a careful handling of sensitive information (privacy)

in a
nutshell

We still need a convincing „Indoor-GPS“!
We should seriously discuss the very sensitive privacy issues!

The biggest challenge

The biggest challenge....

design, setup and maintenance of highly complex systems must be improved in terms of

- Time
- Quality
- Cost and
- Complexity

Advances on the device level

analog
(4-20mA)



digital
(Profibus)



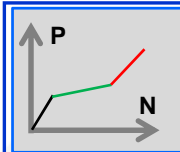
smart + wireless
(WLAN)



Device Modelling

Physical Device

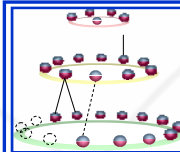
Device Model



Energy-Model

- energy consumption
- power per mode

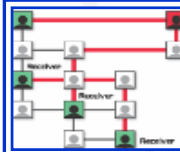
???



Service-Model

- elementary services
- working logic

BPEL
XPDL



Communication-Model

- layer
- protocol

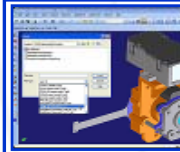
GSD
EDDL

Model No.	SPS No.	Model No.	SPS No.	Model No.	SPS No.
T-517000-001	305	Q15	85	100	
T-517000-002	305	Q15	85	100	
T-517000-003	305	Q15	85	100	
T-517000-004	305	Q15	85	100	
T-517000-005	305	Q15	85	100	
T-517000-006	305	Q15	85	100	
T-517000-007	305	Q15	85	100	
T-517000-008	305	Q15	85	100	
T-517000-009	305	Q15	85	100	
T-517000-010	305	Q15	85	100	

Product-Data

- part number
- part description

STEP
PDB



CAD-Data

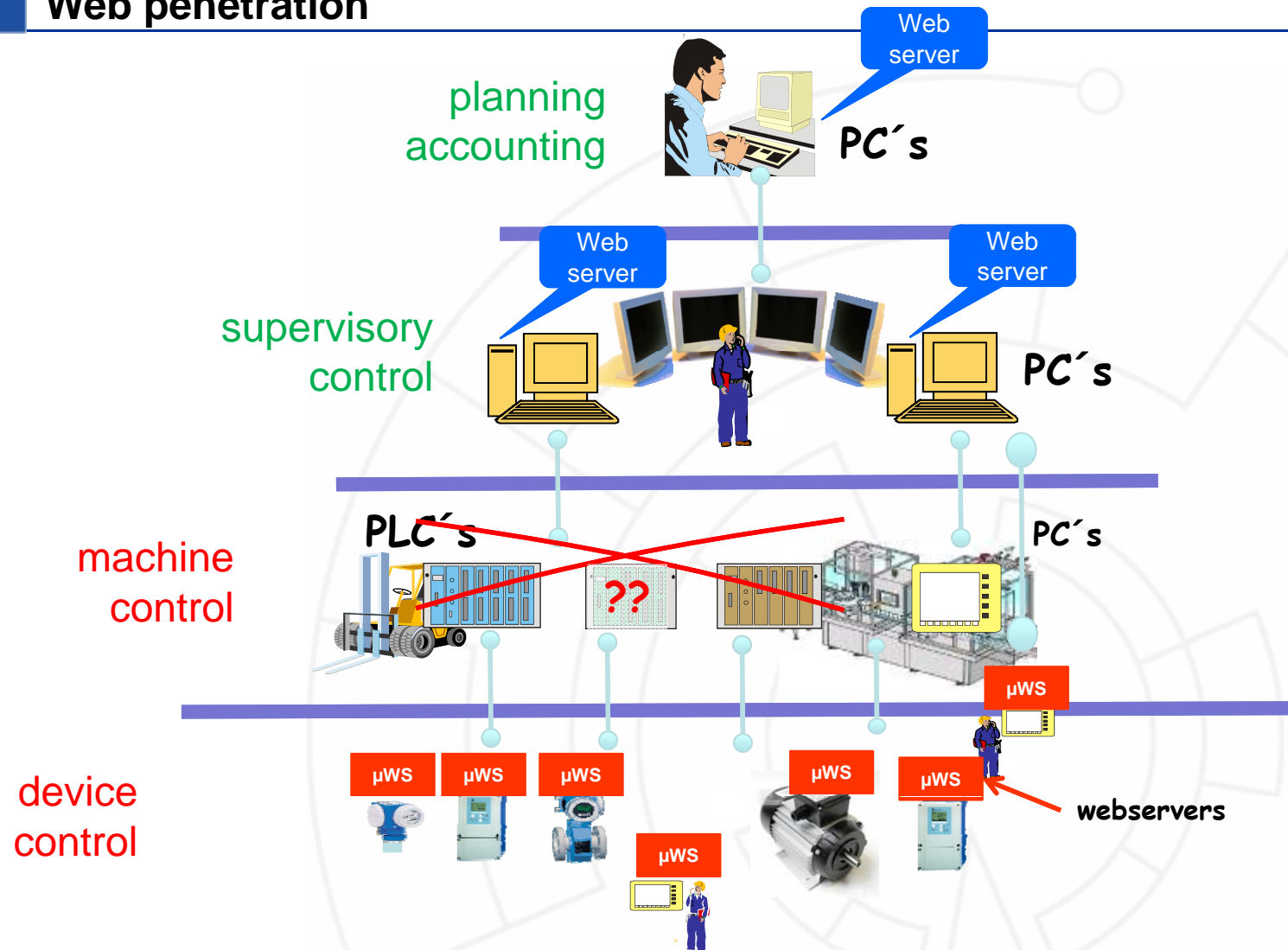
- mech. data
- electr. data

STEP
IGES

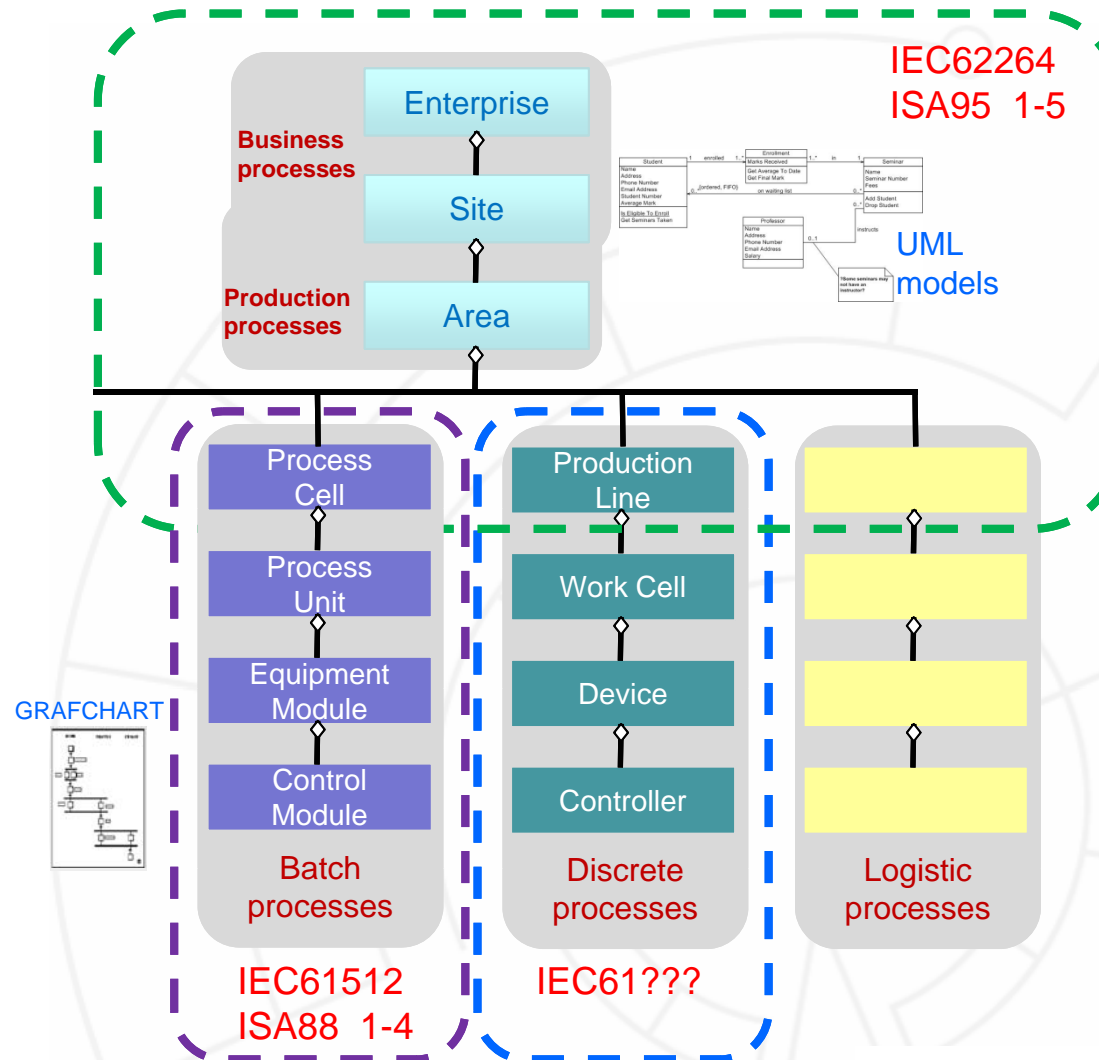
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the intelligent factory of the future

Web penetration



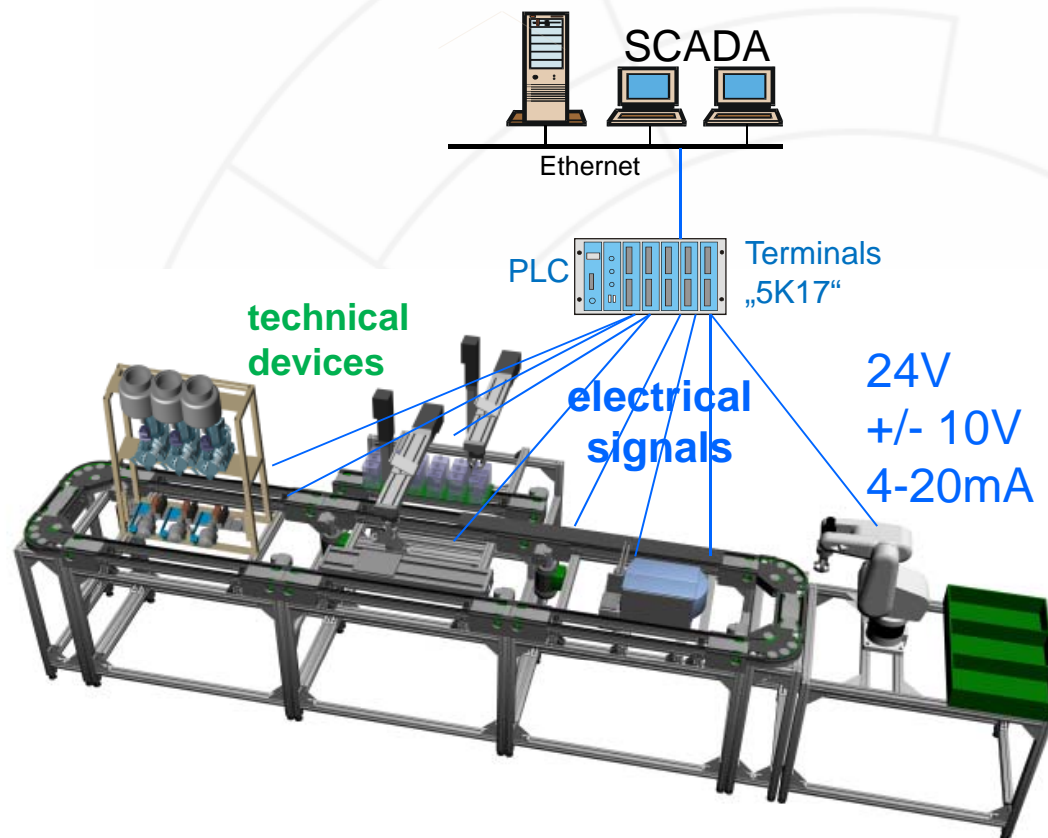
Advances in Factory/Process Modelling



Production in the 80th: *Electrical Signals*

Initial situation:

- Automation via electrical signals



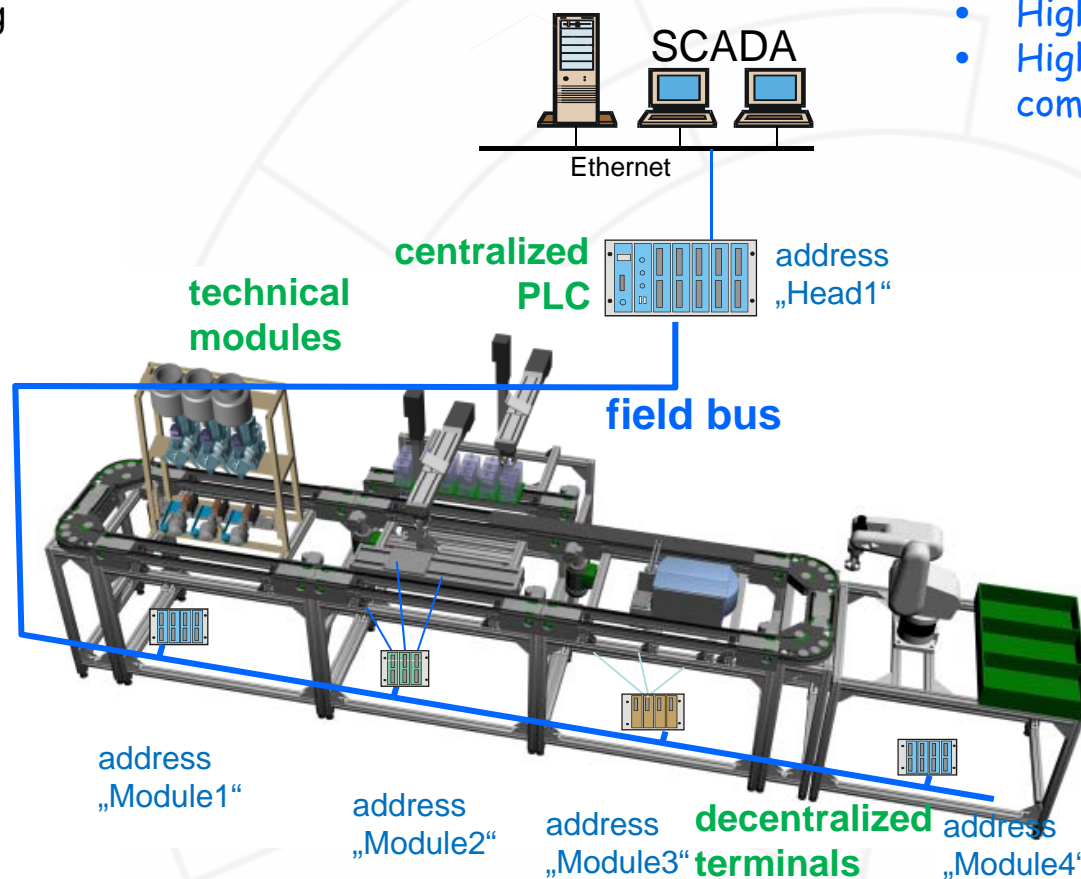
Production in the 90th: *Bits and Bytes*

Main changes:

- Microprocessor technology
- Advances in digital signal processing

Driven by:

- Increasing functionality of the field devices
- High wiring effort
- High error rate during wiring of complex systems



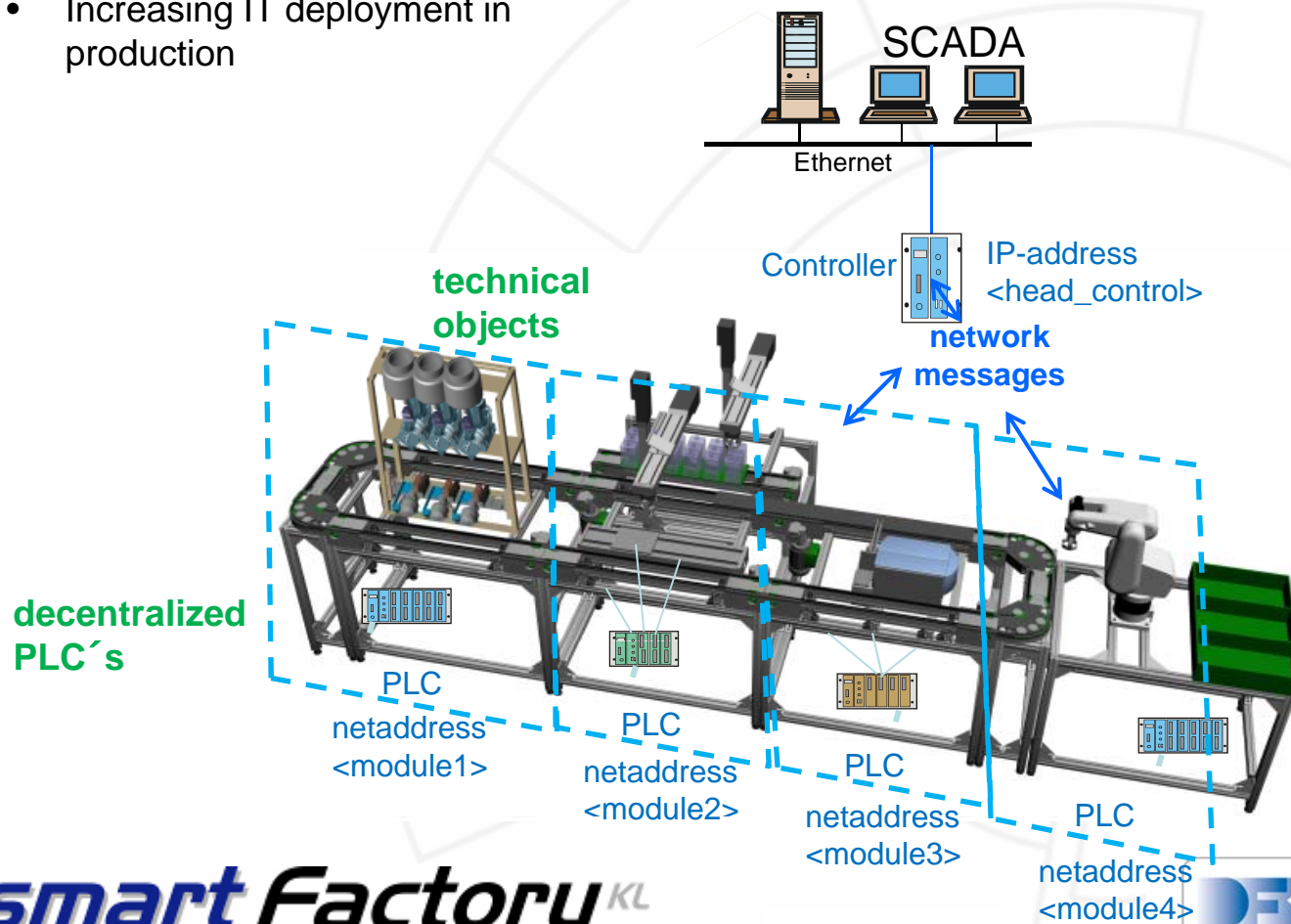
Production in the 00th: *Functions*

Main changes:

- Mechanical and control modularity
- Increasing IT deployment in production

Driven by:

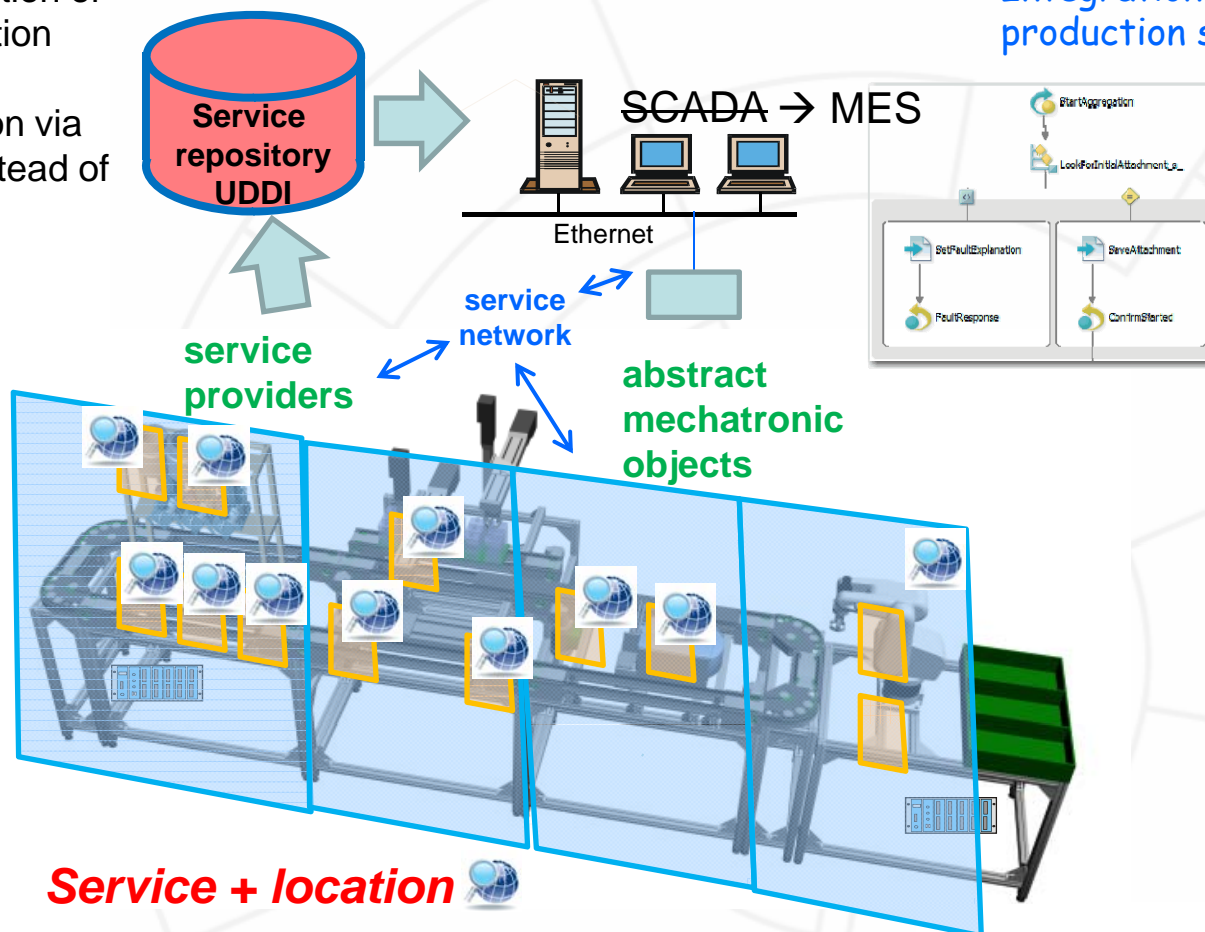
- Demand for faster design and faster setup of the equipment



Production in the 10th: *Services*

Main changes:

- Standardization of communication interfaces
- Orchestration via services instead of functions



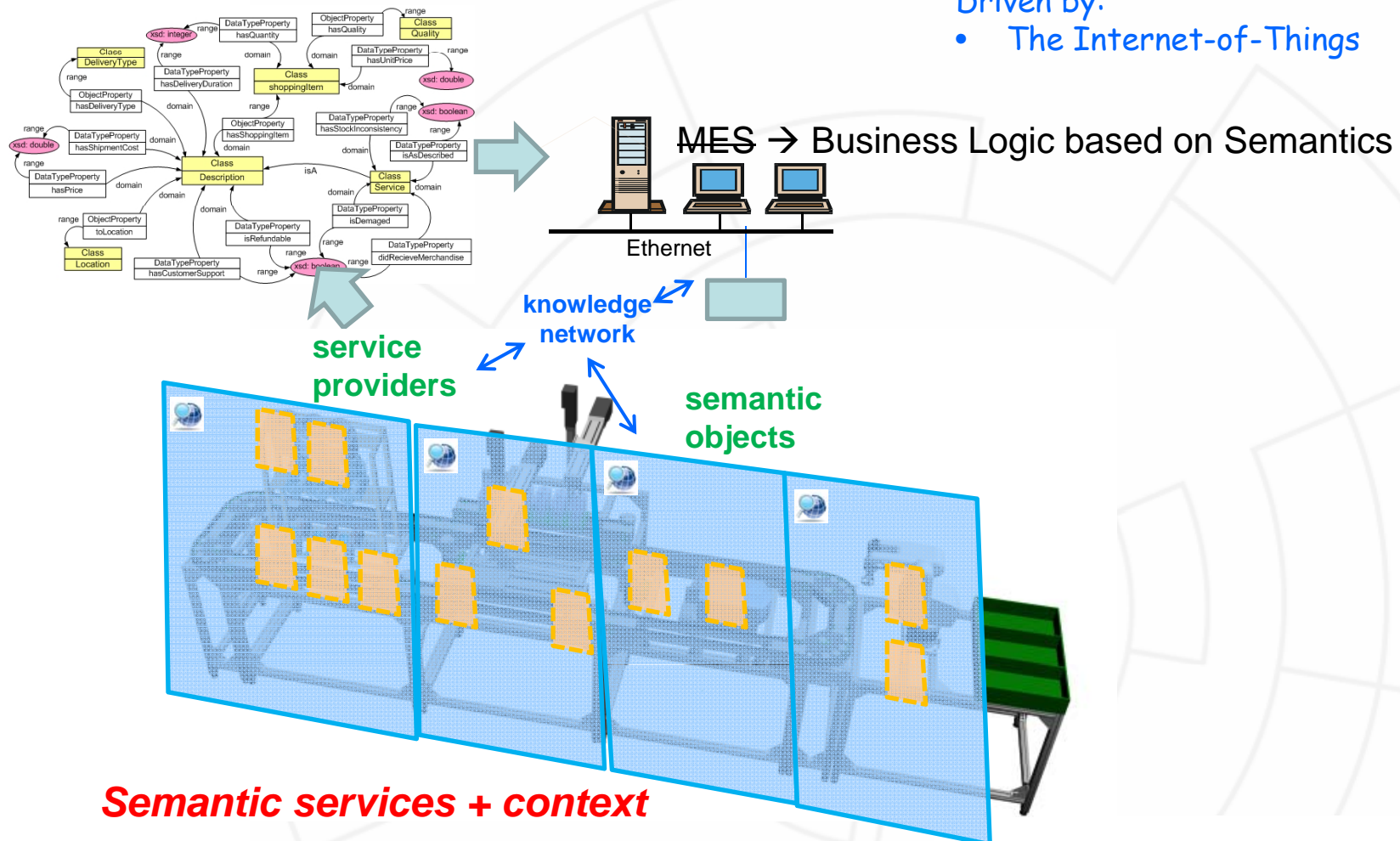
Driven by:

- Integration of business and production systems

Production in the 20th: **Semantics**

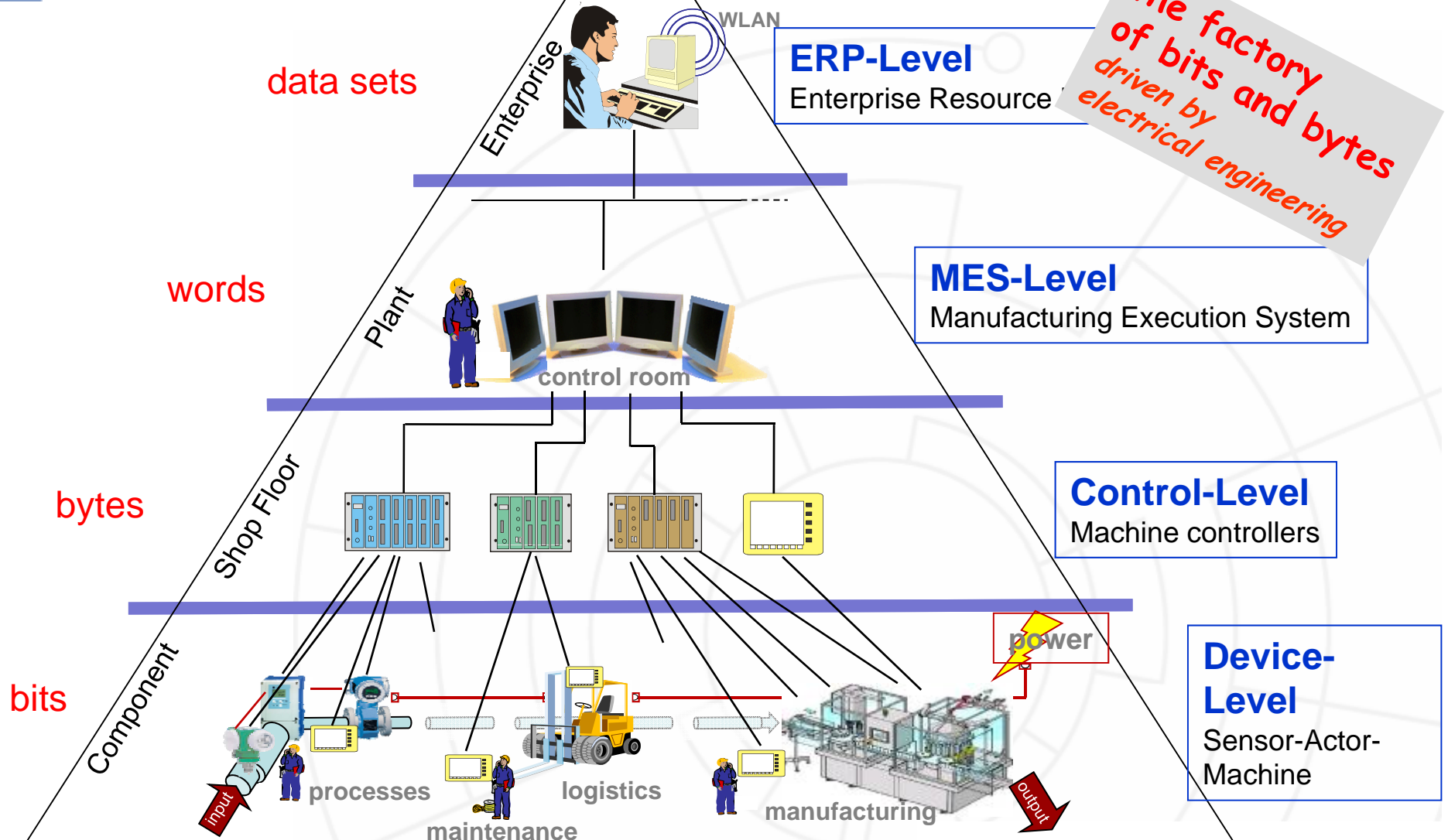
Driven by:

- The Internet-of-Things



The Pyramid of Automation

yesterday



The Pyramid of Automation

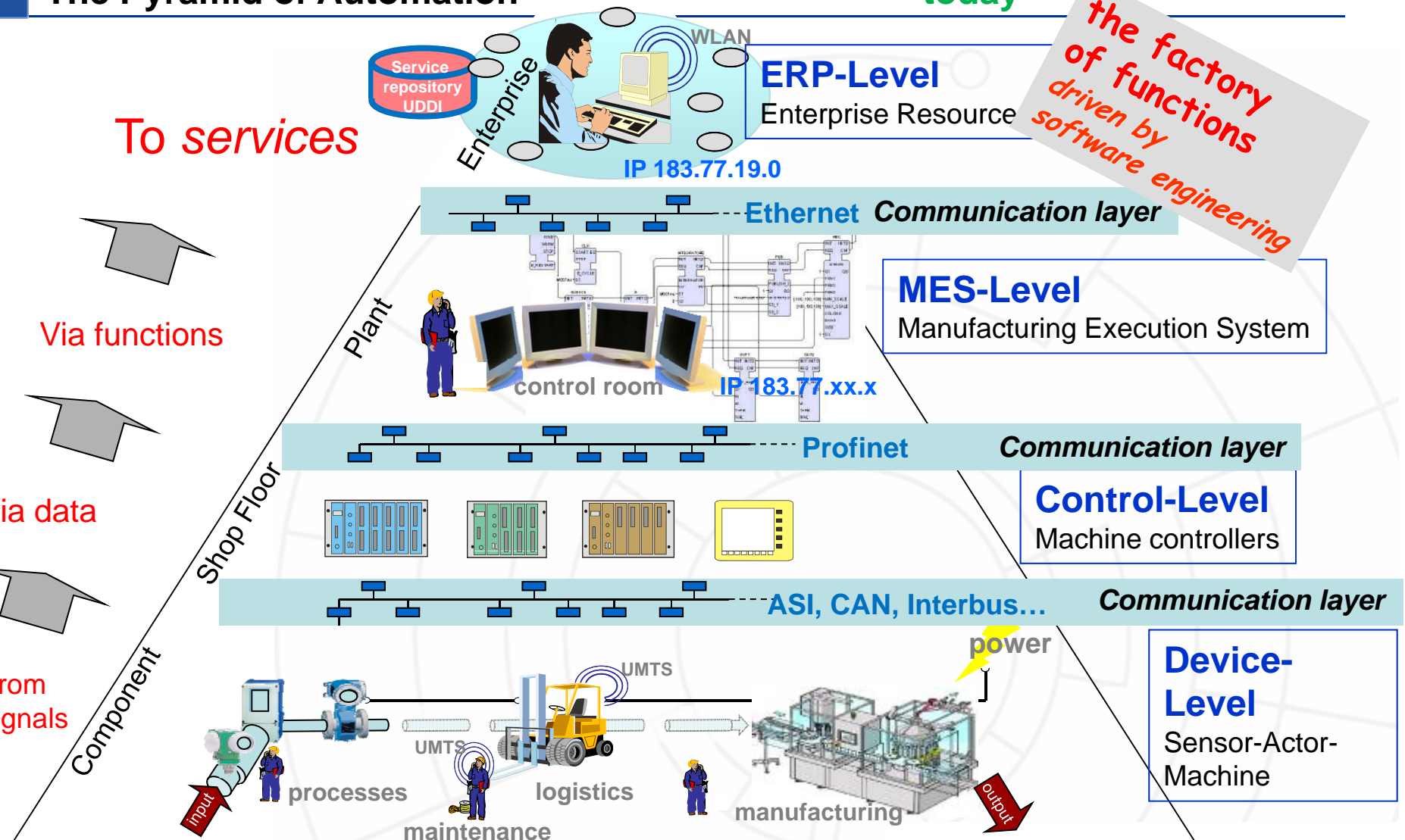
today

To services

Via functions

Via data

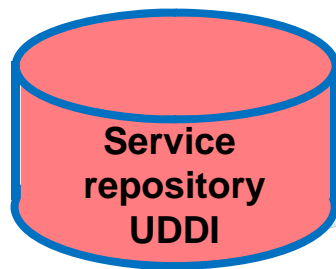
From signals



The Pyramid Network of Automation Services

tomorrow

from services



to services

???

the factory of things driven by artificial intelligence

bluetooth

WLAN



control room

IP 183.77.....

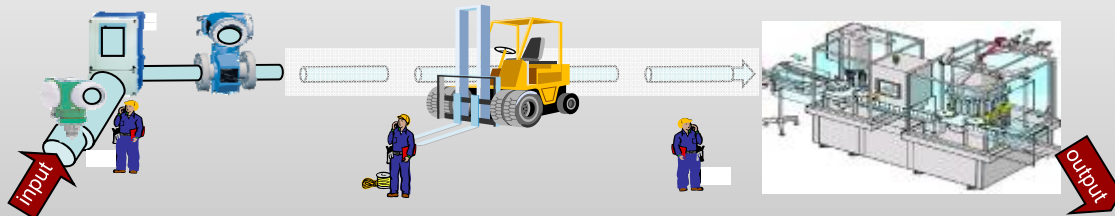
services

global services

domain services

services

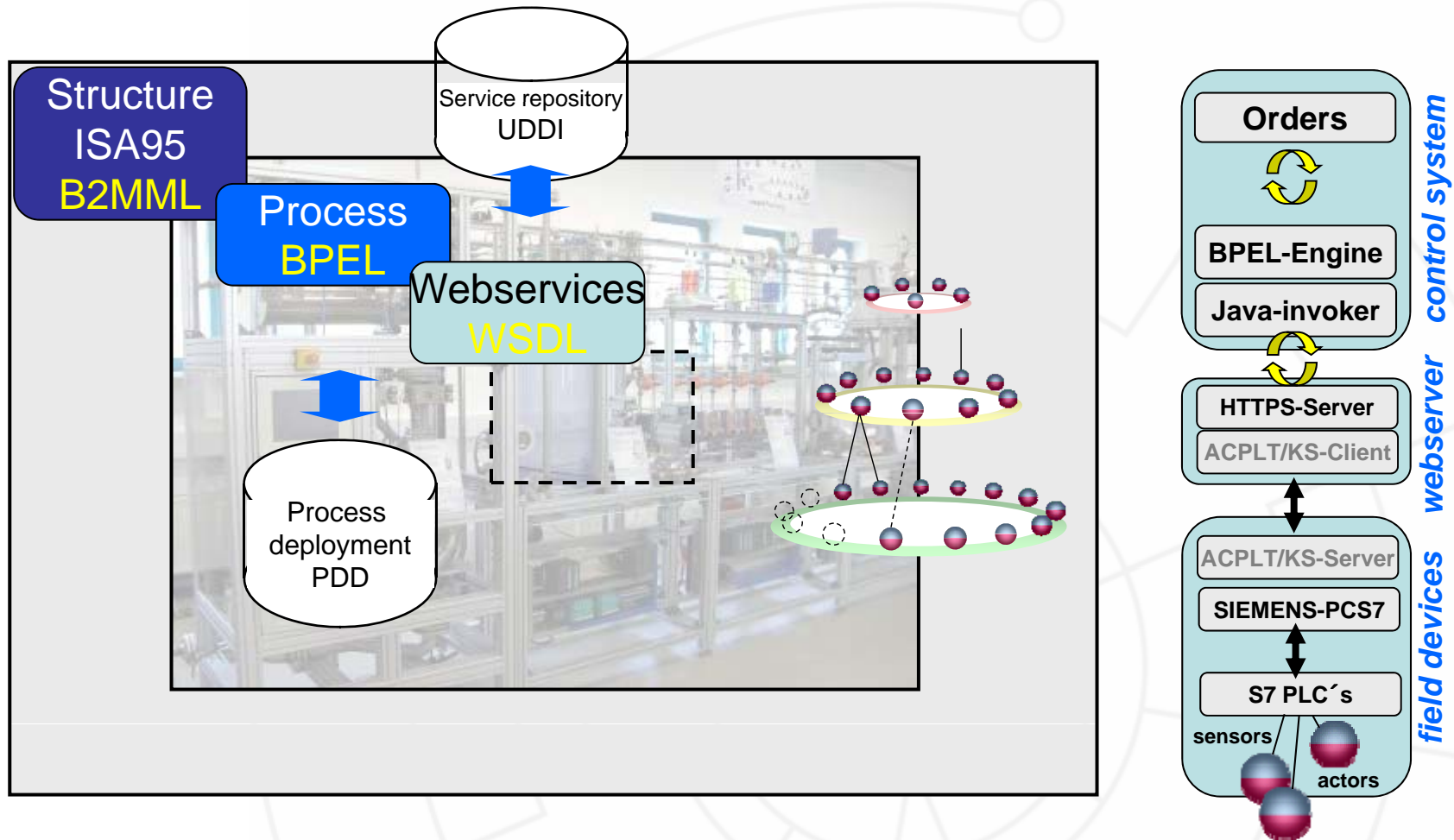
Res



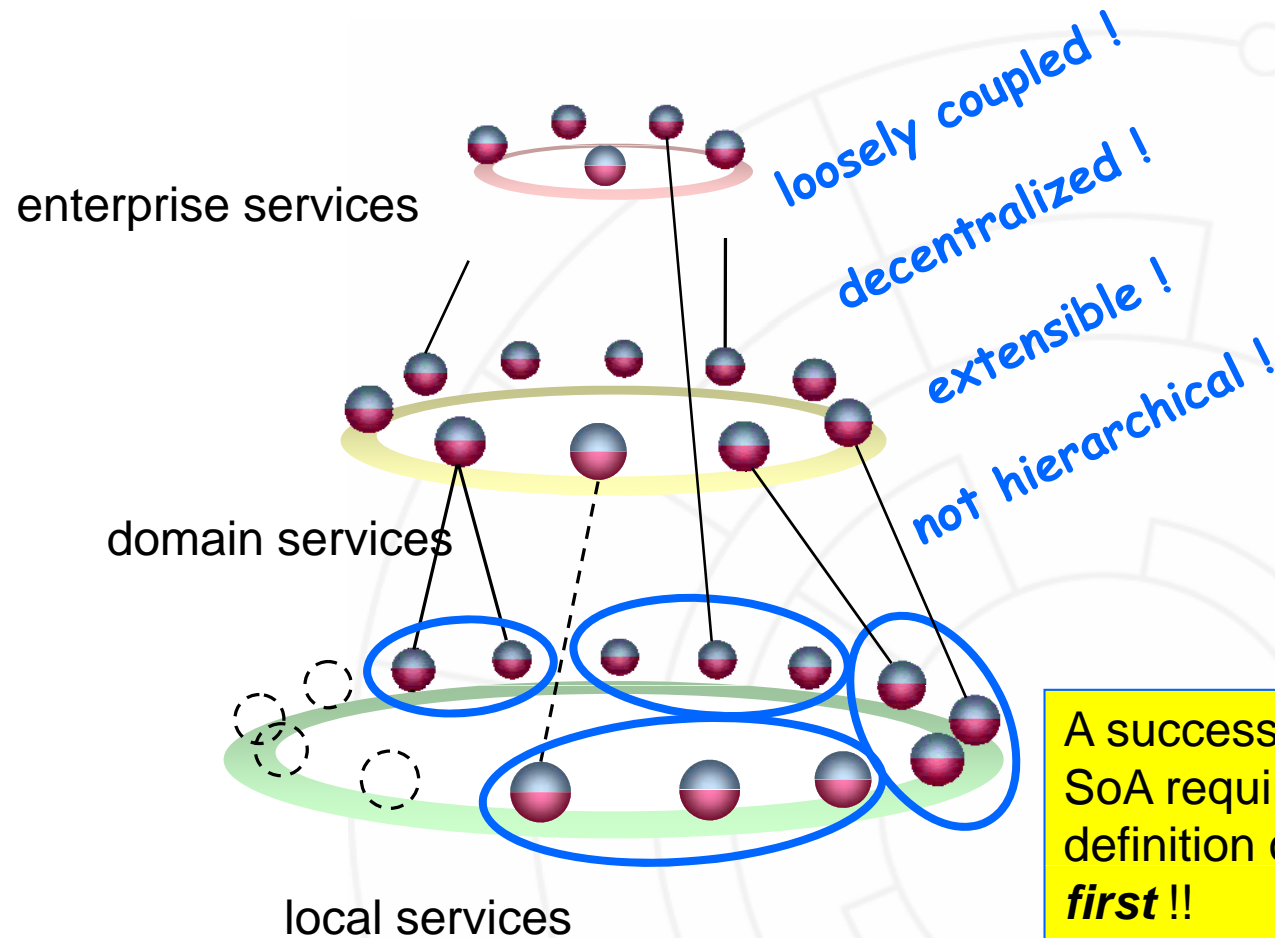
smart Factory^{KL}

the intelligent factory of the future

Project: SoA-Architecture for the SmartFactory^{KL}



SoA structure and problems



Problems:

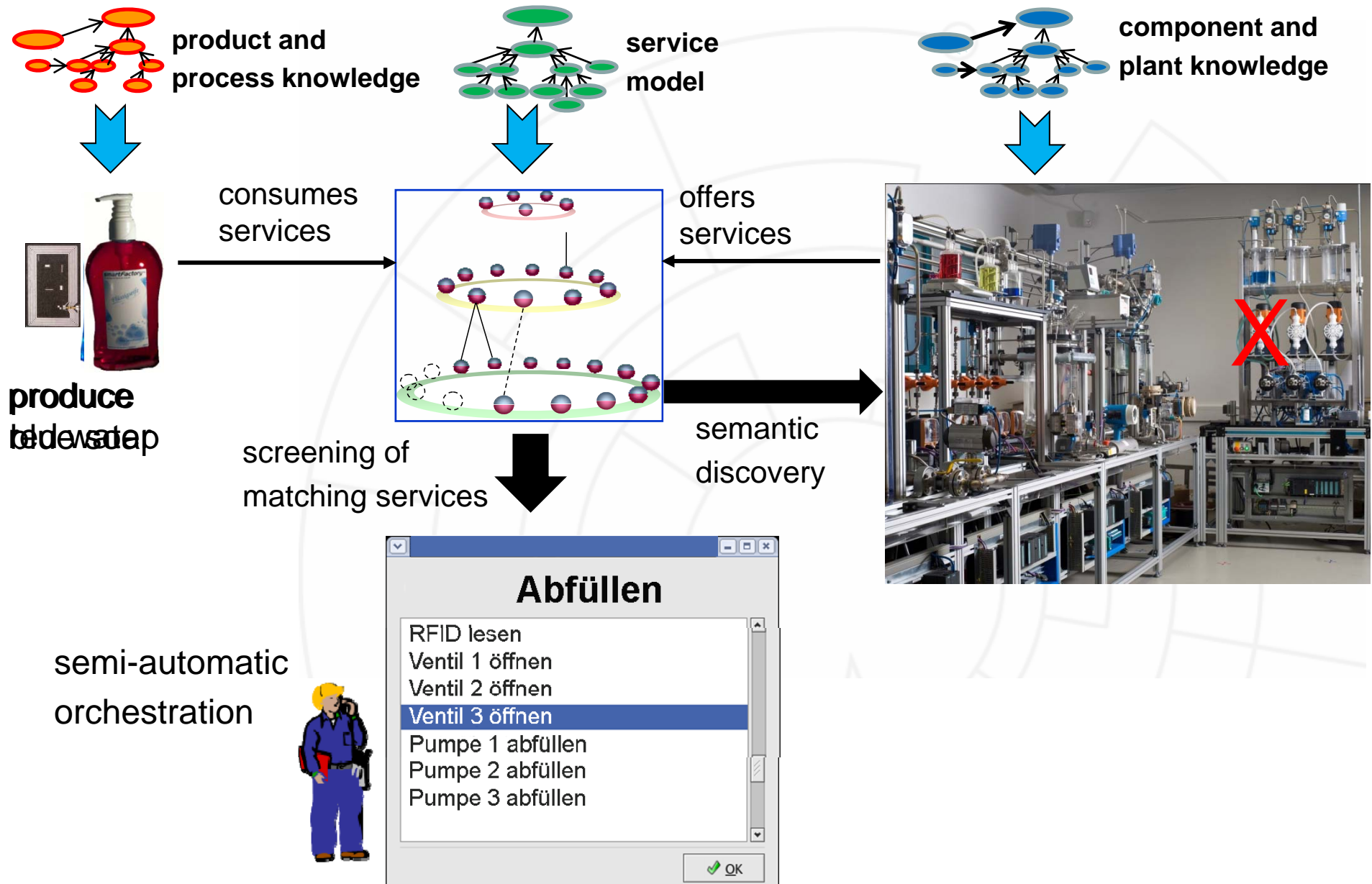
- no experience
- no trust
- no experts

A successful implementation of SoA requires the company-wide definition of tasks and services

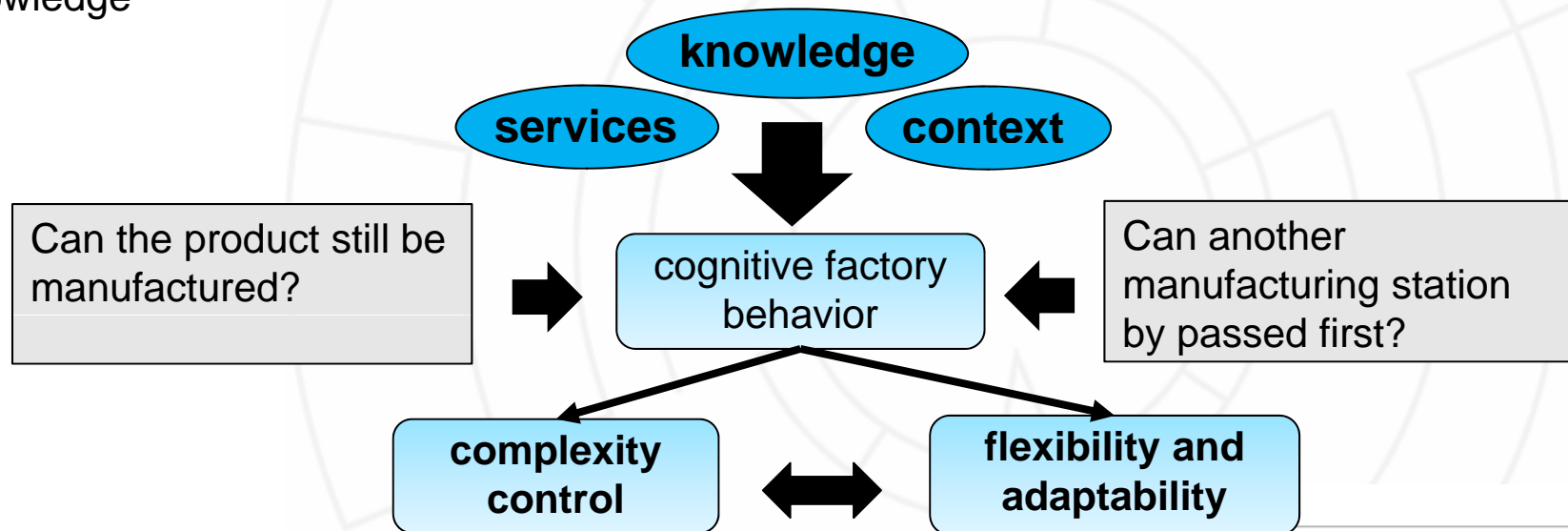
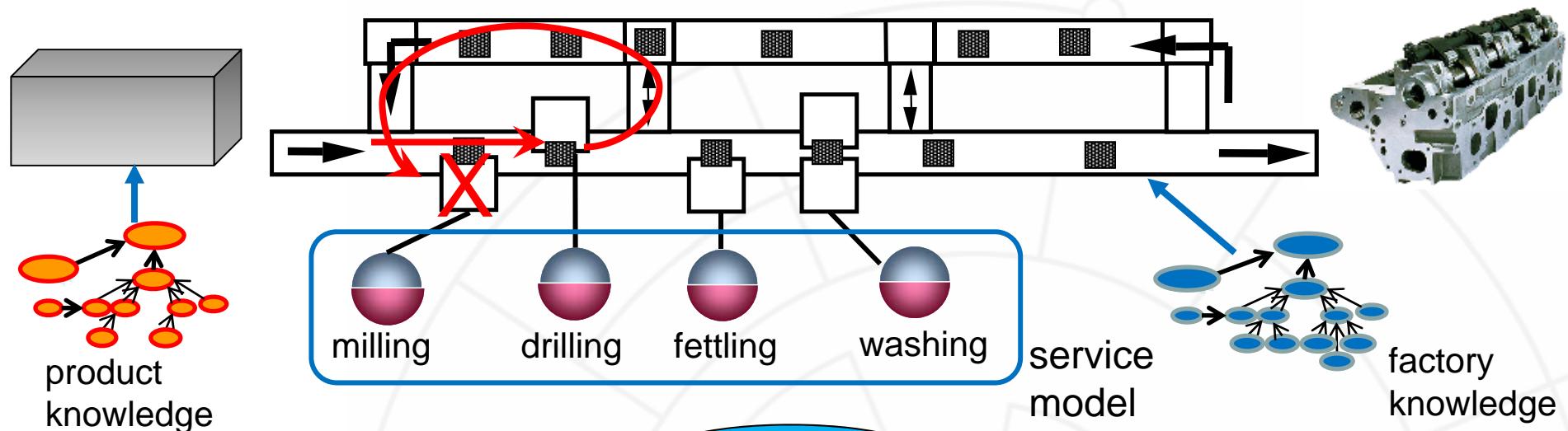
first !!

Tools and software come **second !**

The next step: Semantic Services in the SmartFactory^{KL}



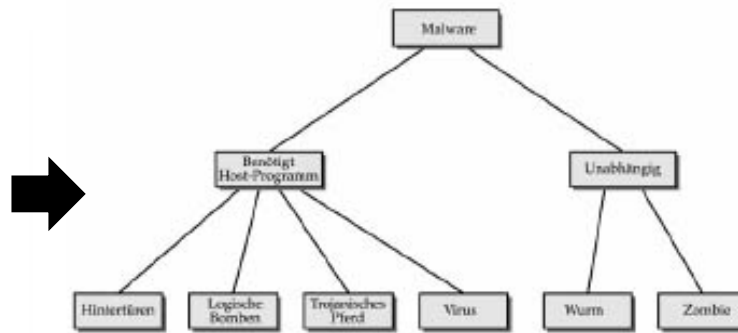
Why semantics in industrial production?



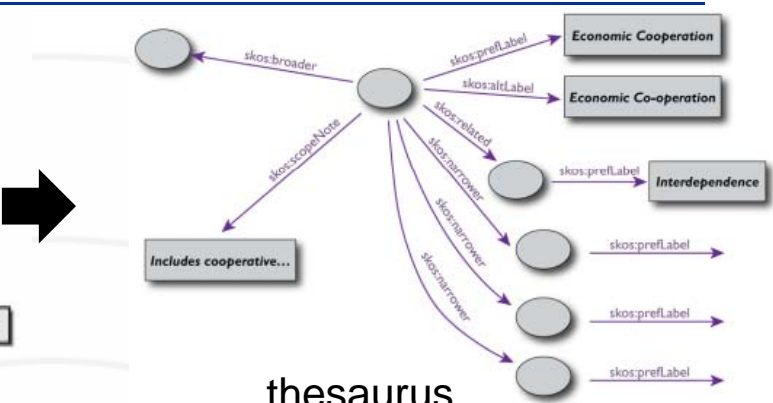
Different Forms of Knowledge Representation



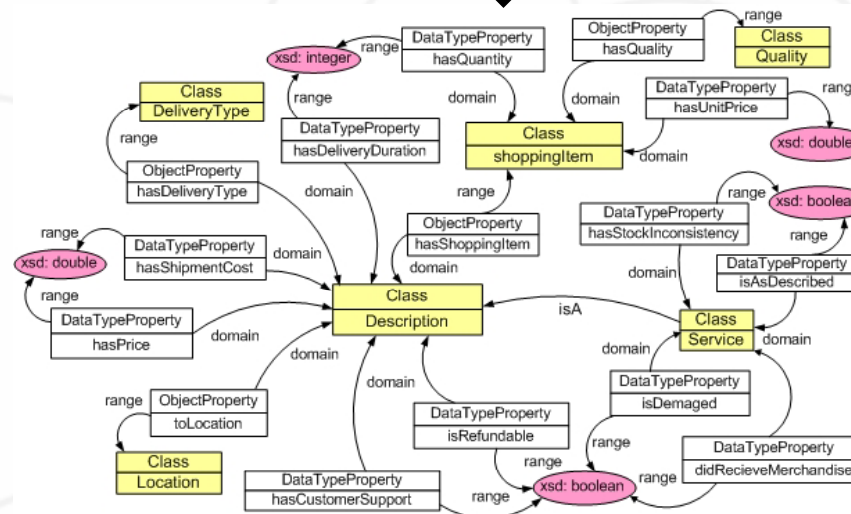
glossary



taxonomy

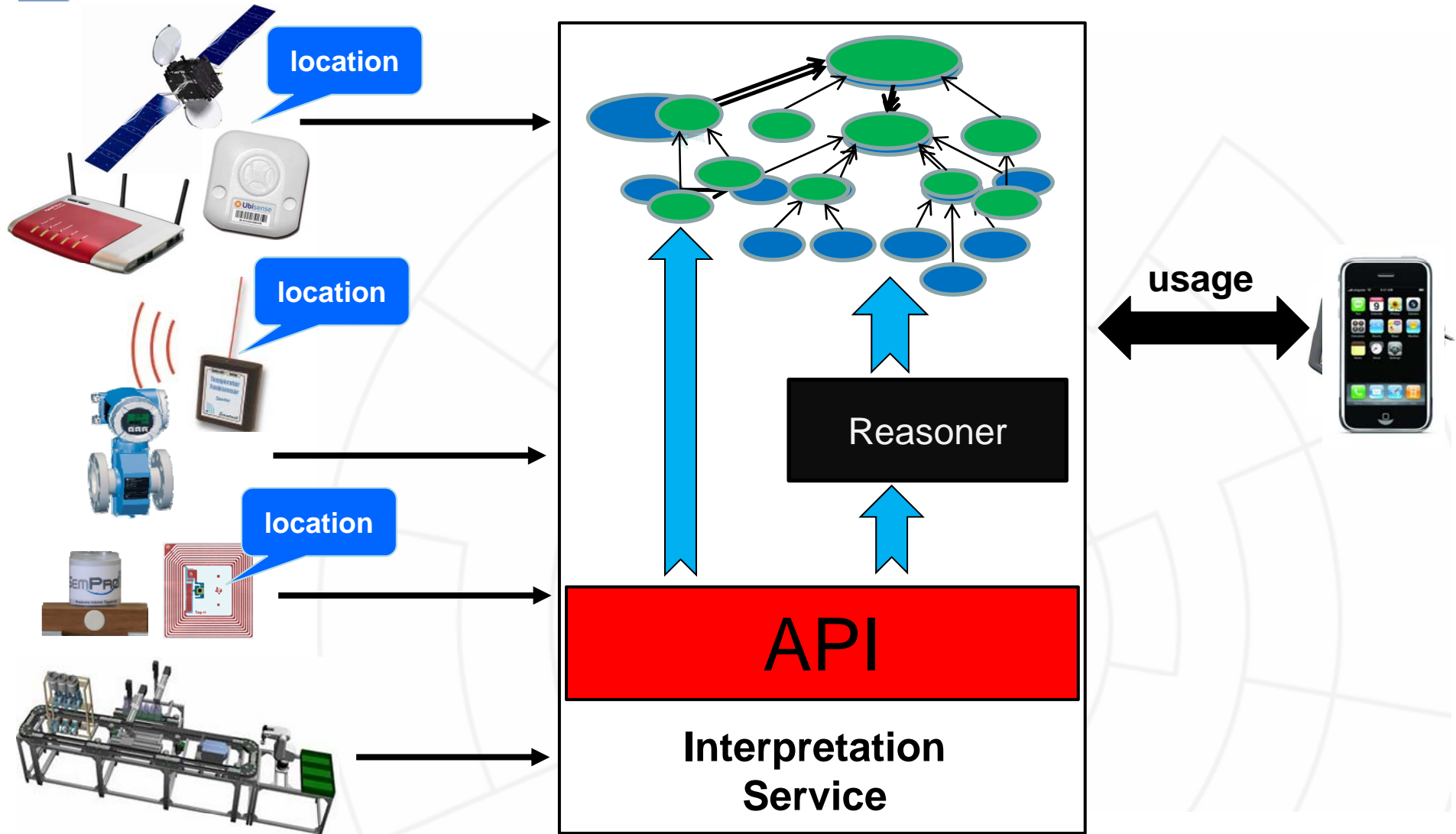


thesaurus



ontology

Interpretation of Context Data



Usage Scenarios and Prototypes in the SmartFactory^{KL}

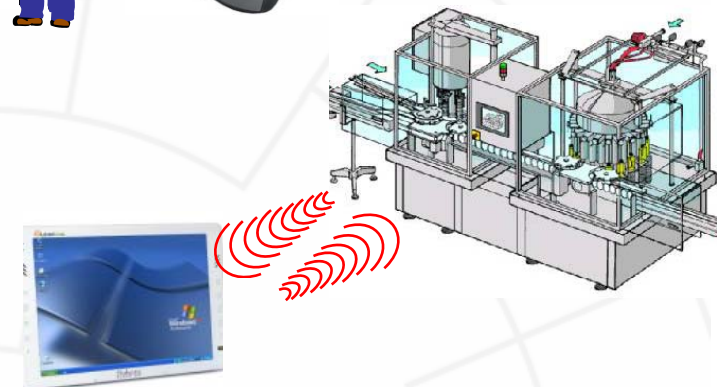
- **Mobile Maintenance**

Derivation of the current situation of a maintenance worker using a mobile navigation device based on location information



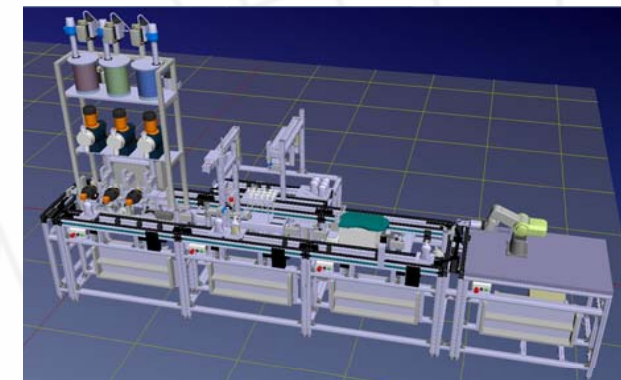
- **Universal Interaction (Touch And Connect)**

Which communication interface is suited for a special field device and guarantees a certain response time?

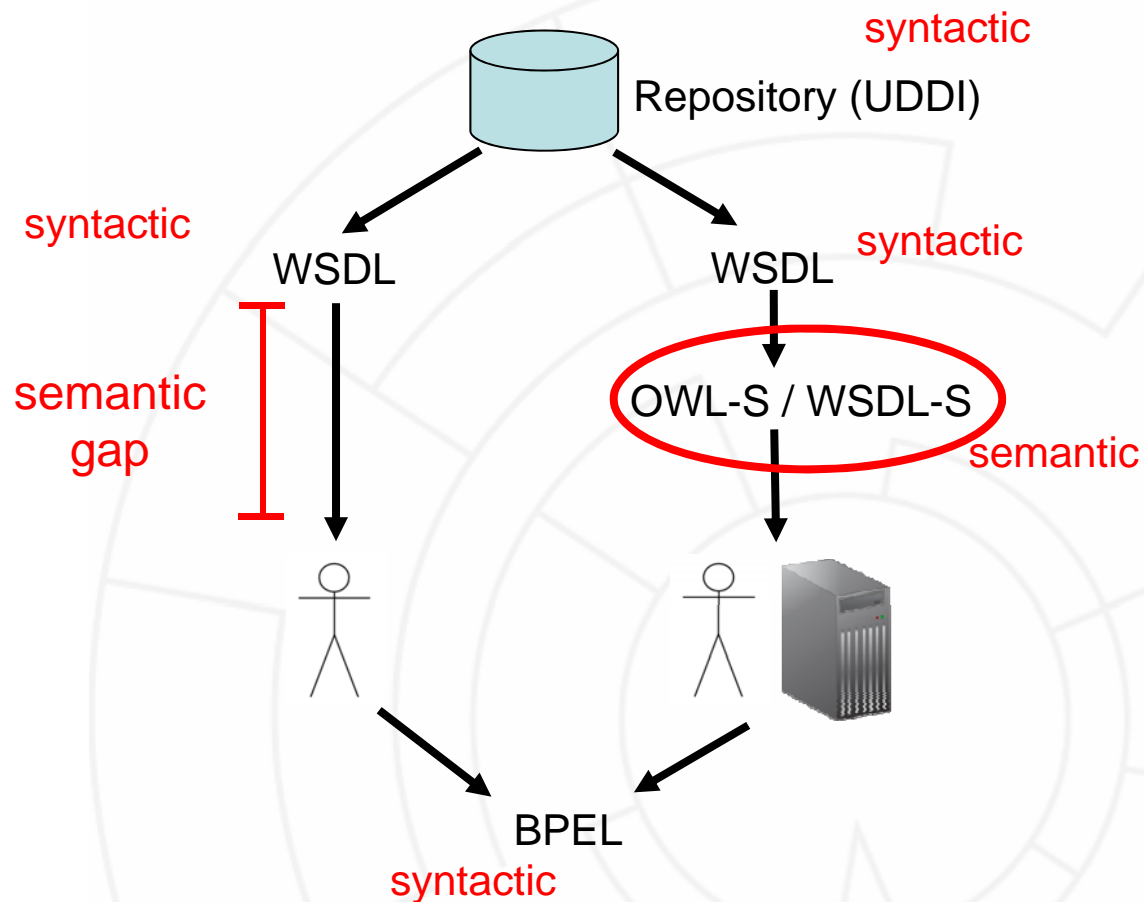


- **Reconfiguration of plants (digital factory)**

Is this plant suited to manufacture a certain product?



Why Semantic Service Description?



Lessons learned

SoA architectures

Pro's

- will decouple hardware from control engineering
- will bring more agility
- will focus on a semantic control level

But it...

Con's

- may have an unpredictable behaviour
- needs new expertise of users
- needs smart webservers in each device
- needs well defined service standards
- revolutionizes control engineering

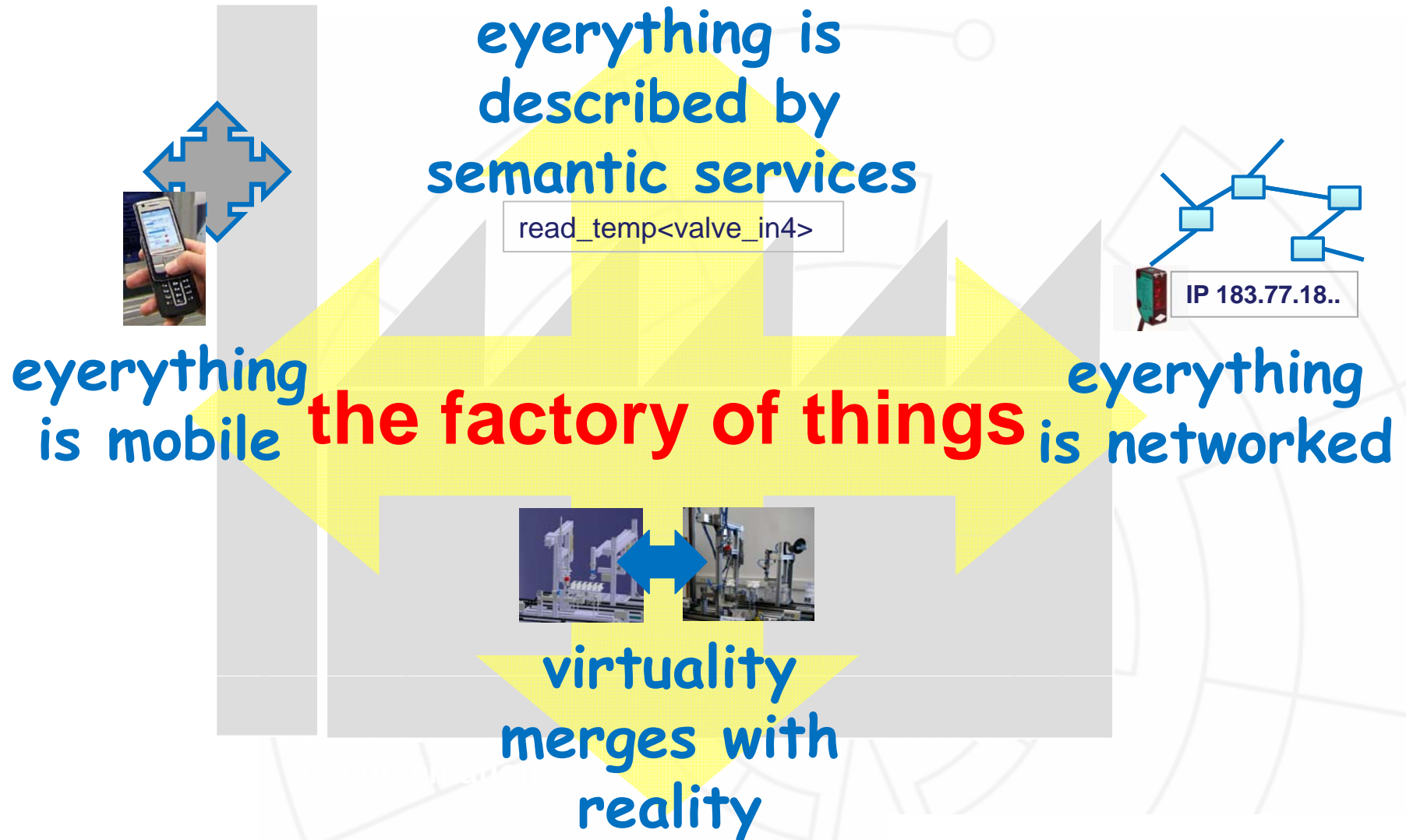
in a
nutshell

SoA is an enabler for the Factory-of-Things!
SoA is a new engineering paradigm and needs a different way of thinking!

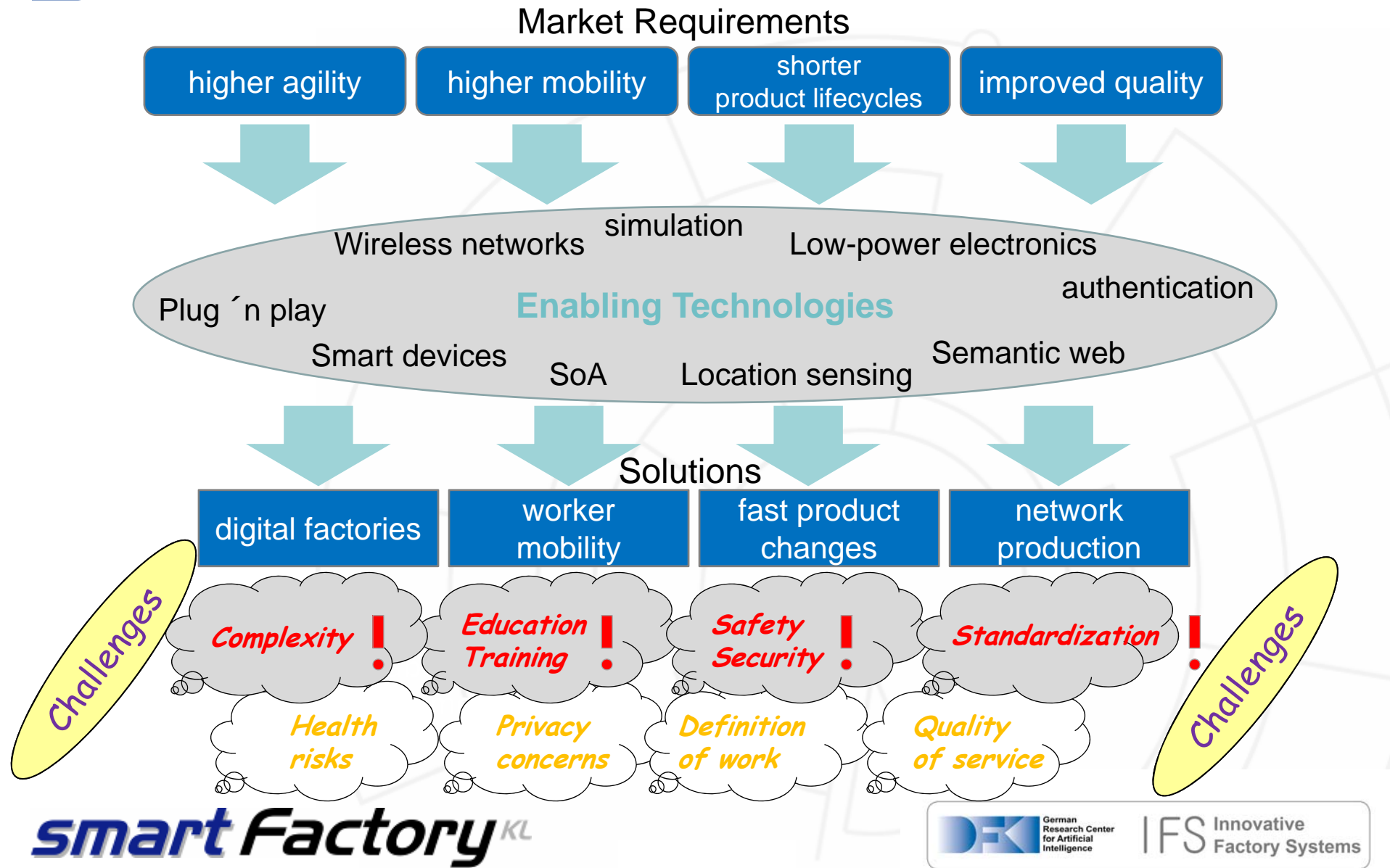
Outline

- Introduction
- The *SmartFactory*^{KL} -Initiative
- R&D Projects
- Lessons learned

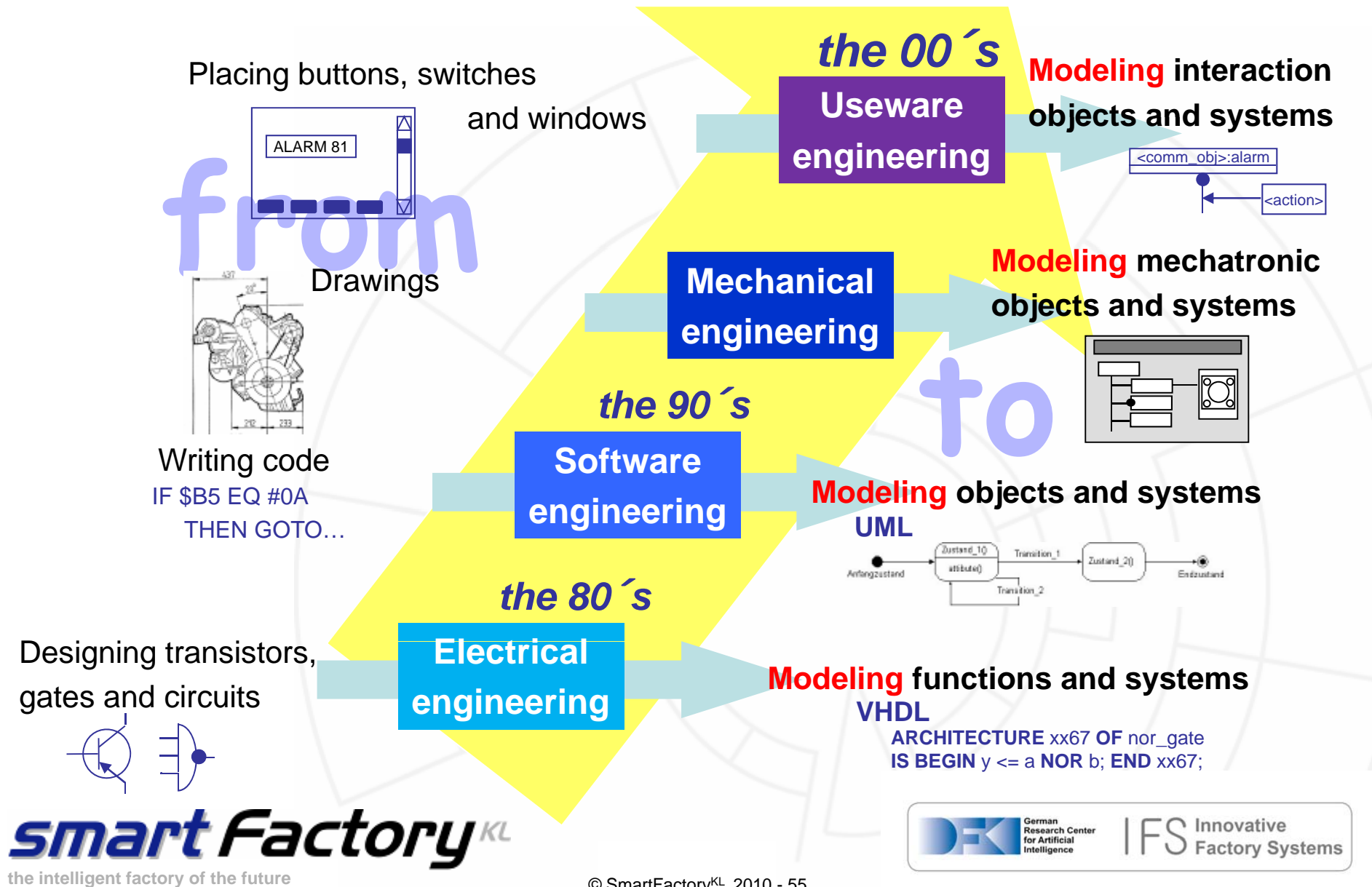
Key changes in the factory of the future



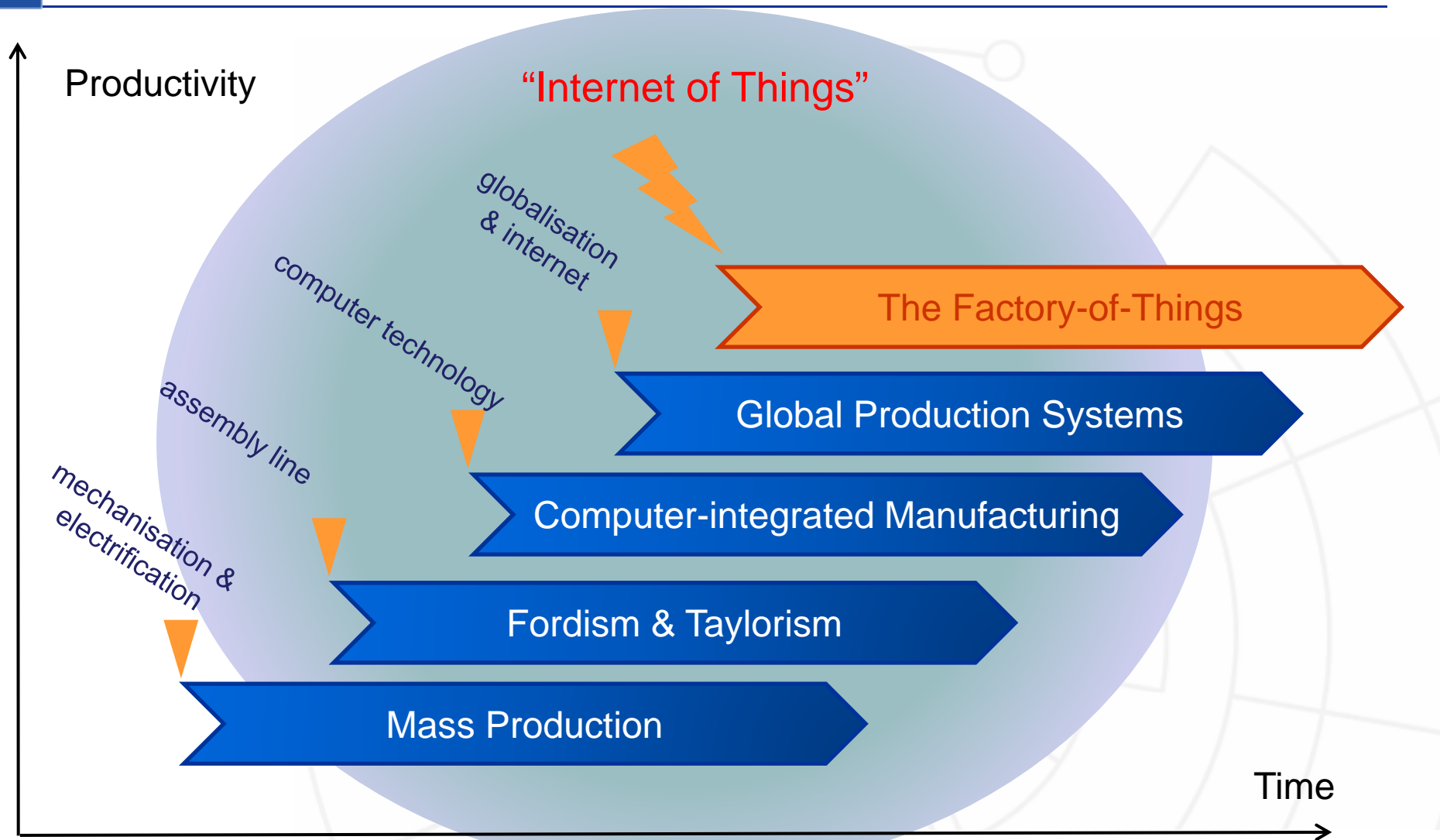
Requirements and challenges



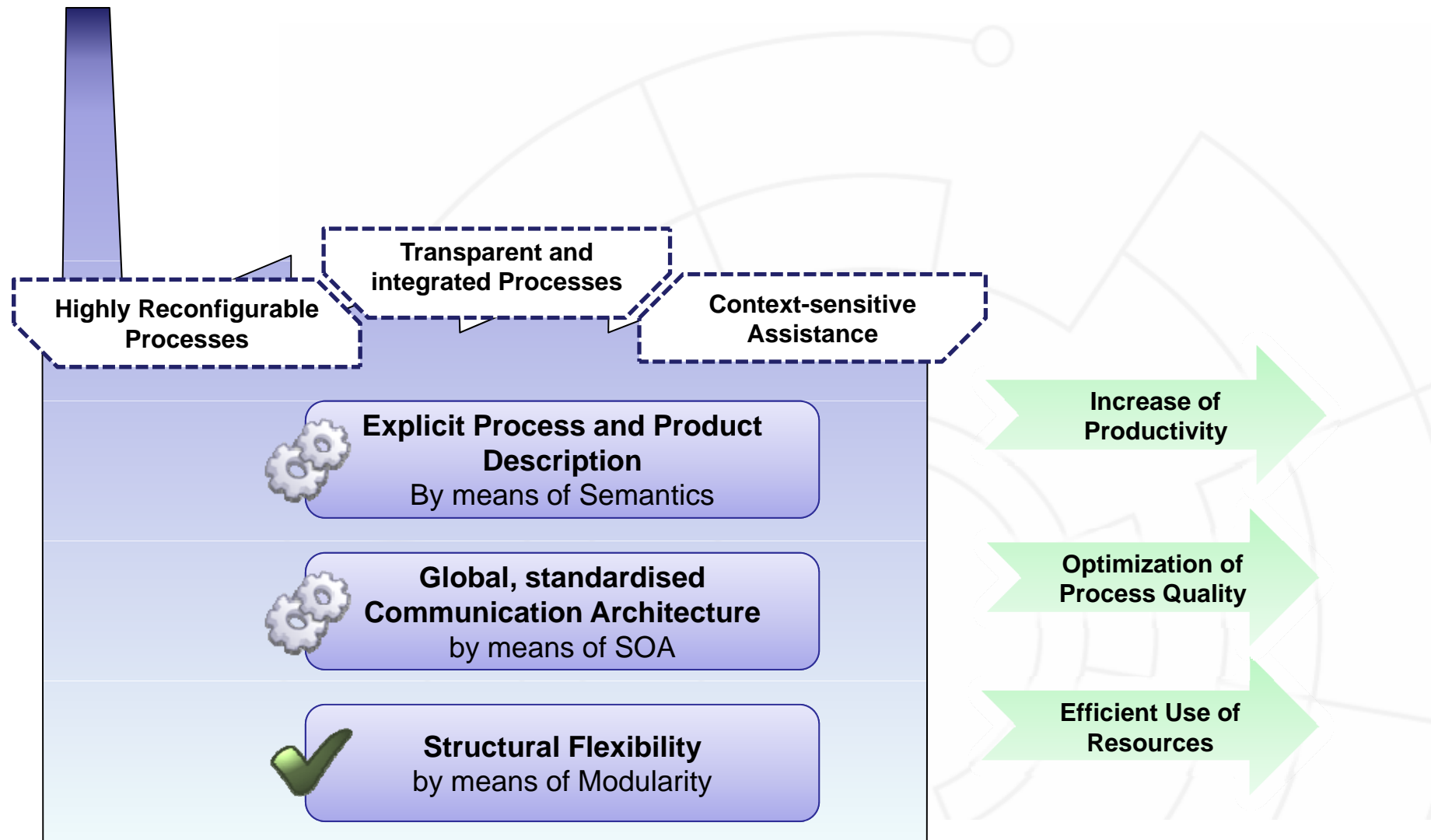
We need new engineering paradigms



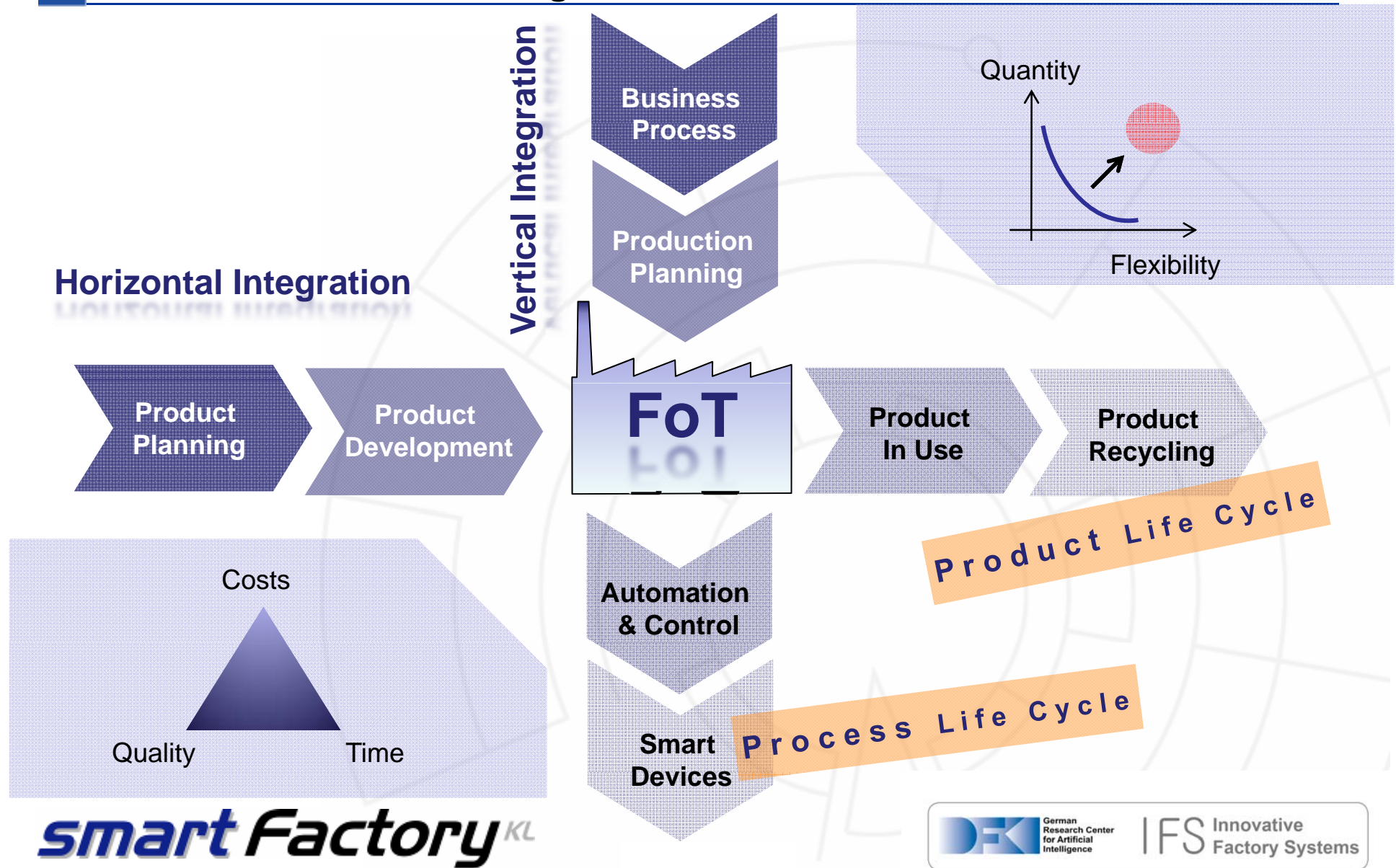
Towards Future Production



Paradigms of the Factory of Things



Horizontal and Vertical Integration



Thank you !

smartFactory^{KL}

shaping the future
of manufacturing ICT

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the intelligent factory of the future

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