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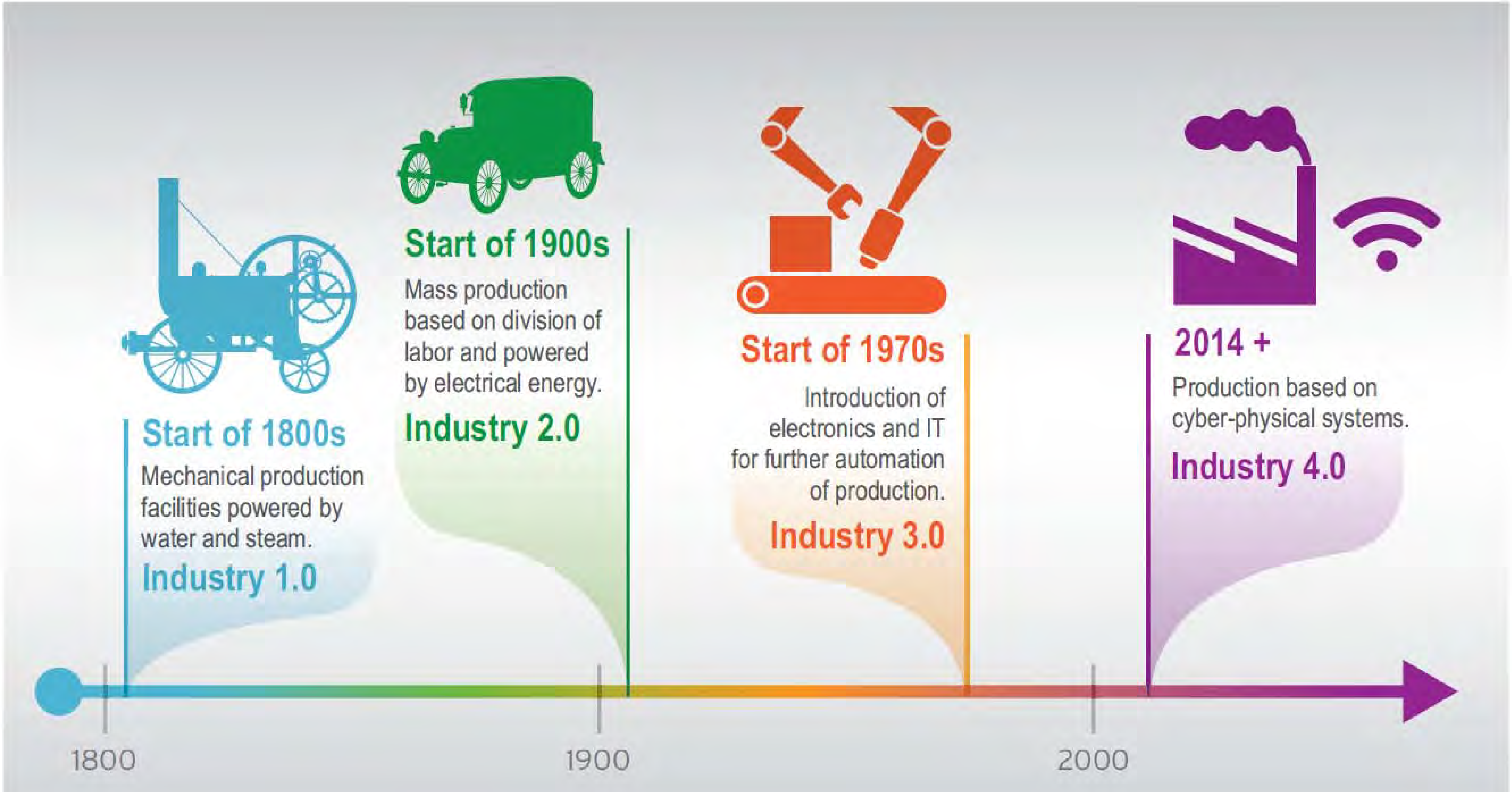
Applying Industry 4.0 in Production and Logistic Systems

BIBA - BREMER INSTITUT FÜR PRODUKTION UND LOGISTIK GMBH AT THE UNIVERSITY OF BREMEN

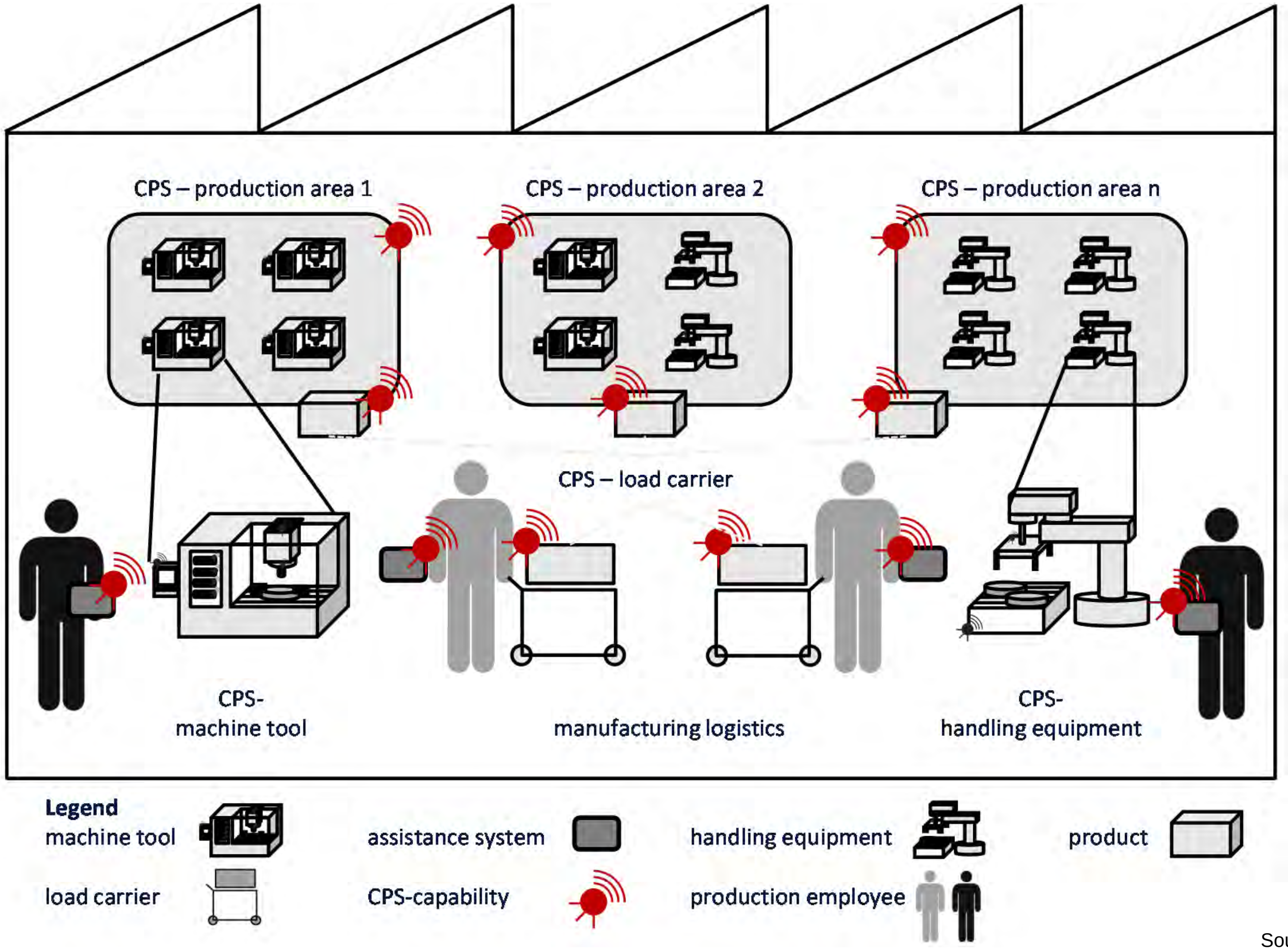
Professor Dr.-Ing. Klaus-Dieter Thoben

Towards Industry 4.0



Source: Cognizant, Informed Manufacturing: The Next Industrial Revolution

VISION:
CYBER-PHYSICAL PRODUCTION AND LOGISTICS SYSTEM



Source: Reinhart et al. 2013

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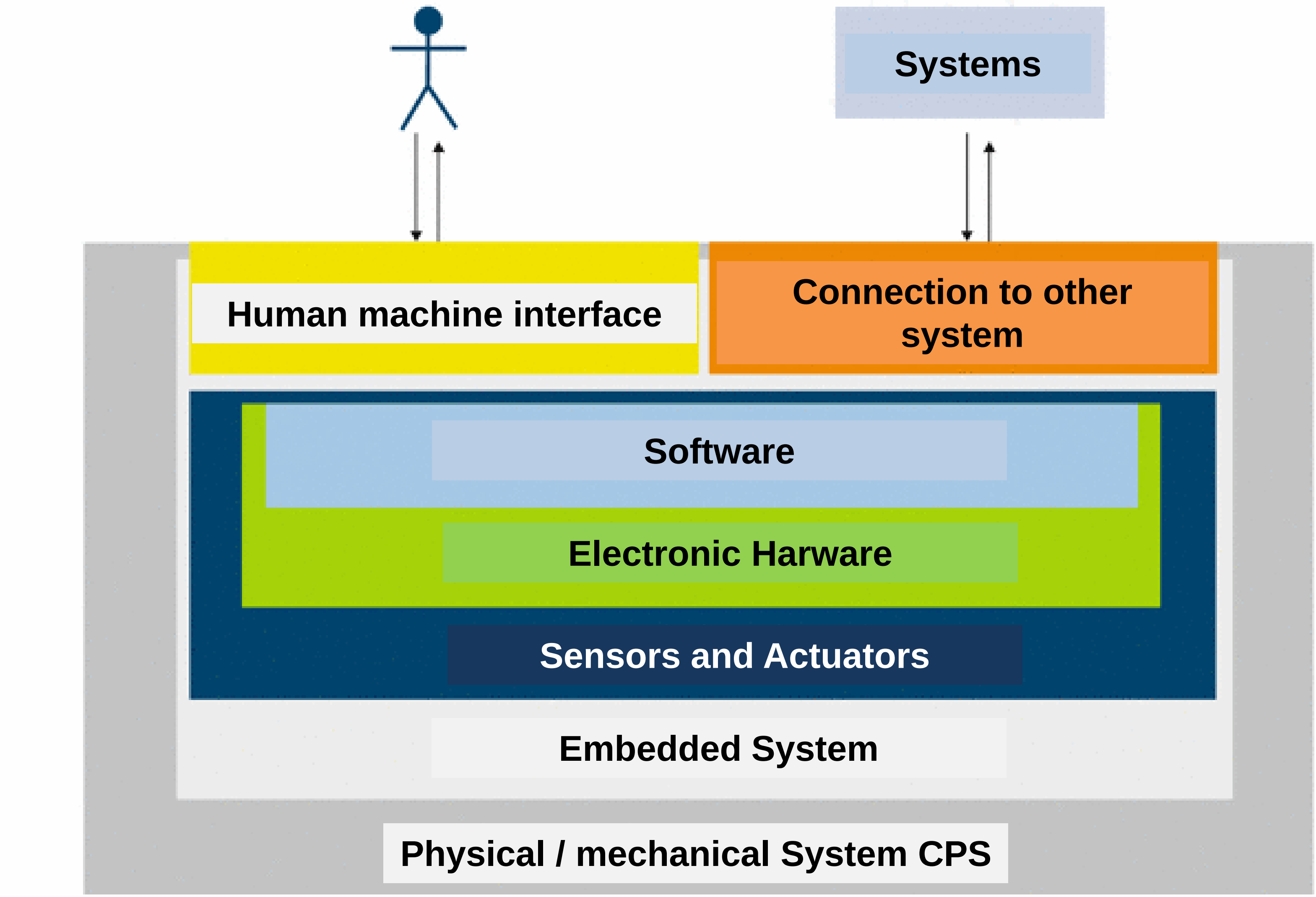
Structure of a Cyber-Physical Systems (CPS)



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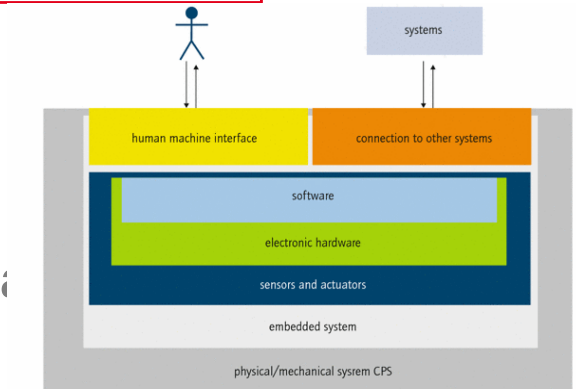
Benefits of Cyber-Physical Systems (CPS)



- A cyber-physical system summarizes ...
  - the benefits of embedded systems
  - the support of a broad range of communica technologies
- The technical background of CPS enables…
  - the acquiring of data of its environment autonomously
  - the decision-making processes over acquired data
  - the autonomous interaction with the environment
  - the autonomous collaboration between CPS in a continuously changing environment
  - the autonomous support of production and logistic processes

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Communication as a Pre-Condition for Collaboration

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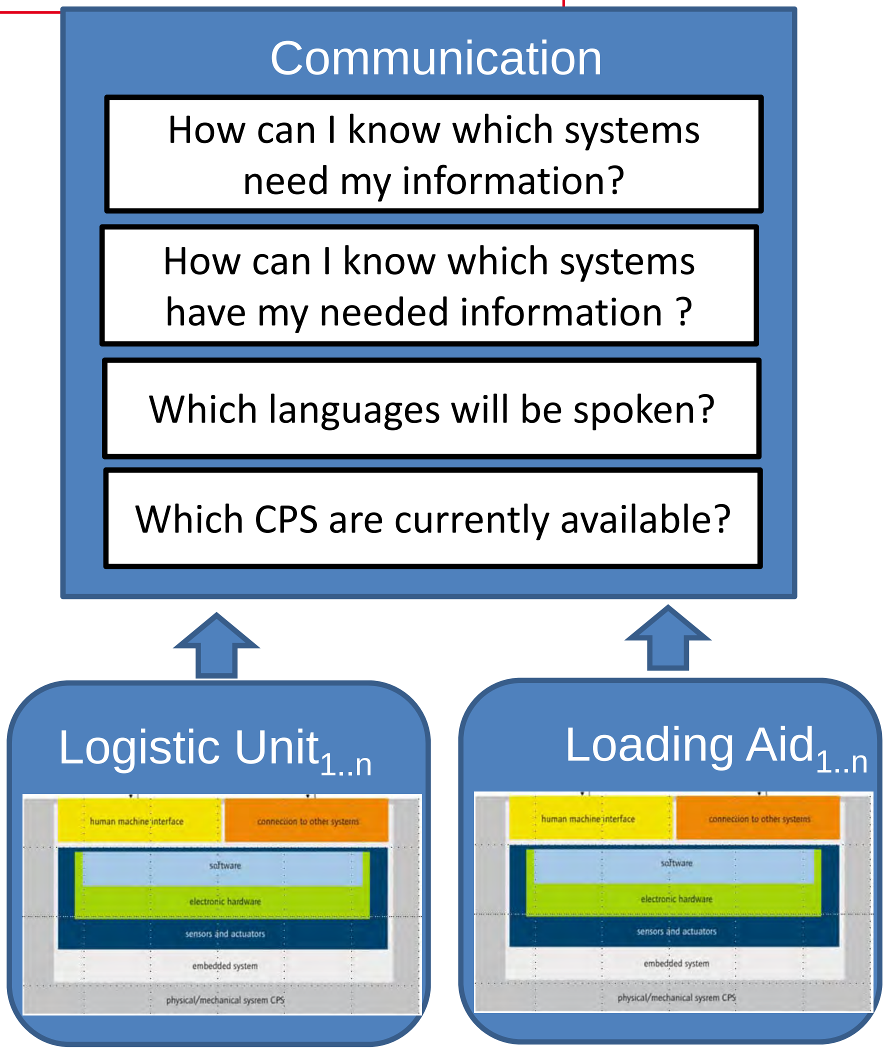
- **The collaboration between CPS includes e.g.**
  - Continuous monitoring of the environment
  - Continuous decision-making processes and corresponding conflict management
- **One pre-condition of collaboration is the communication between CPS**
  - CPS must communicate among each other to achieve a complete view over the environment
  - CPS must communicate among each other to react both goal-oriented and collective while a disturbance is occurred
- **To ensure the flexibility and adaptability in the collaboration a corresponding communication approach must satisfy that e.g.**
  - Different kinds of CPS can communicate among each others
  - CPS can both connect or disconnect without endanger the stability of the communication medium



Challenges of a Flexible Communication

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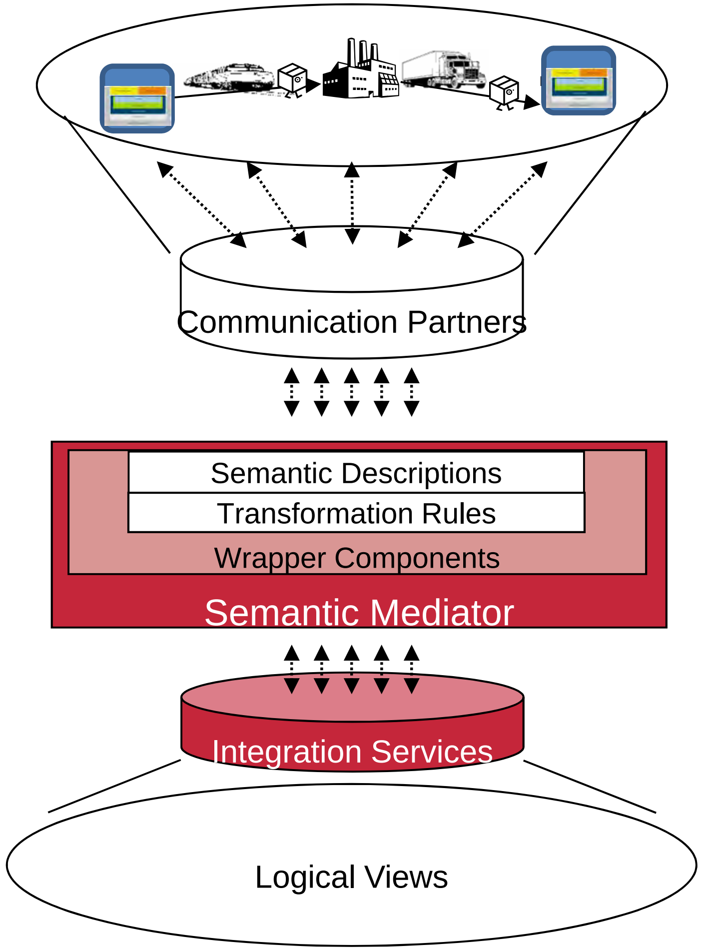
Data Integration Approach for CPS-Based Environments

Problem situation

- The number of systems (including CPS) is increasing in a production environment
- The communication systems are heterogeneous according to its technical implementation, especially for the data representation
- The CPS can be used flexible with regard to the role and place of use, which challenges a rigid and hard wired communication medium

Objective

- Researching and implementing of a service-oriented and semantic data integration approach for communication in a cyber-physical environment



Semantic Mediator

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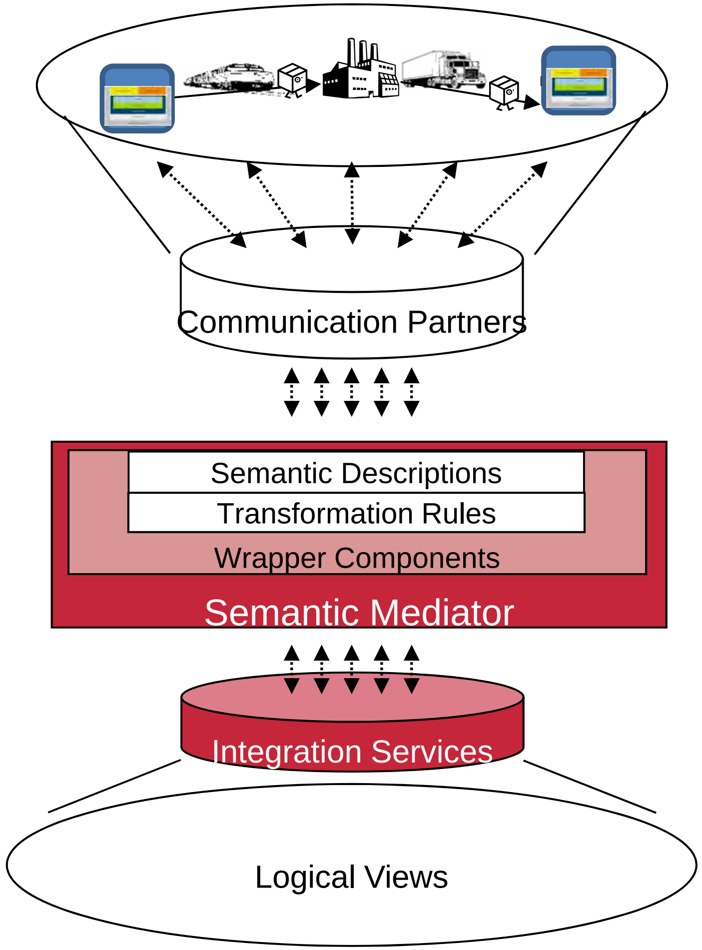
Data Integration Approach for CPS-Based Environments

Results

- Demonstrator: Semantic Mediator
- Development of semantic descriptions of relevant data formats for production and logistics environment
- Development of transformation mechanisms
- Process model for the generation of logical views
- Implementation of a service-oriented approach for semantic data integration



Semantic Mediator

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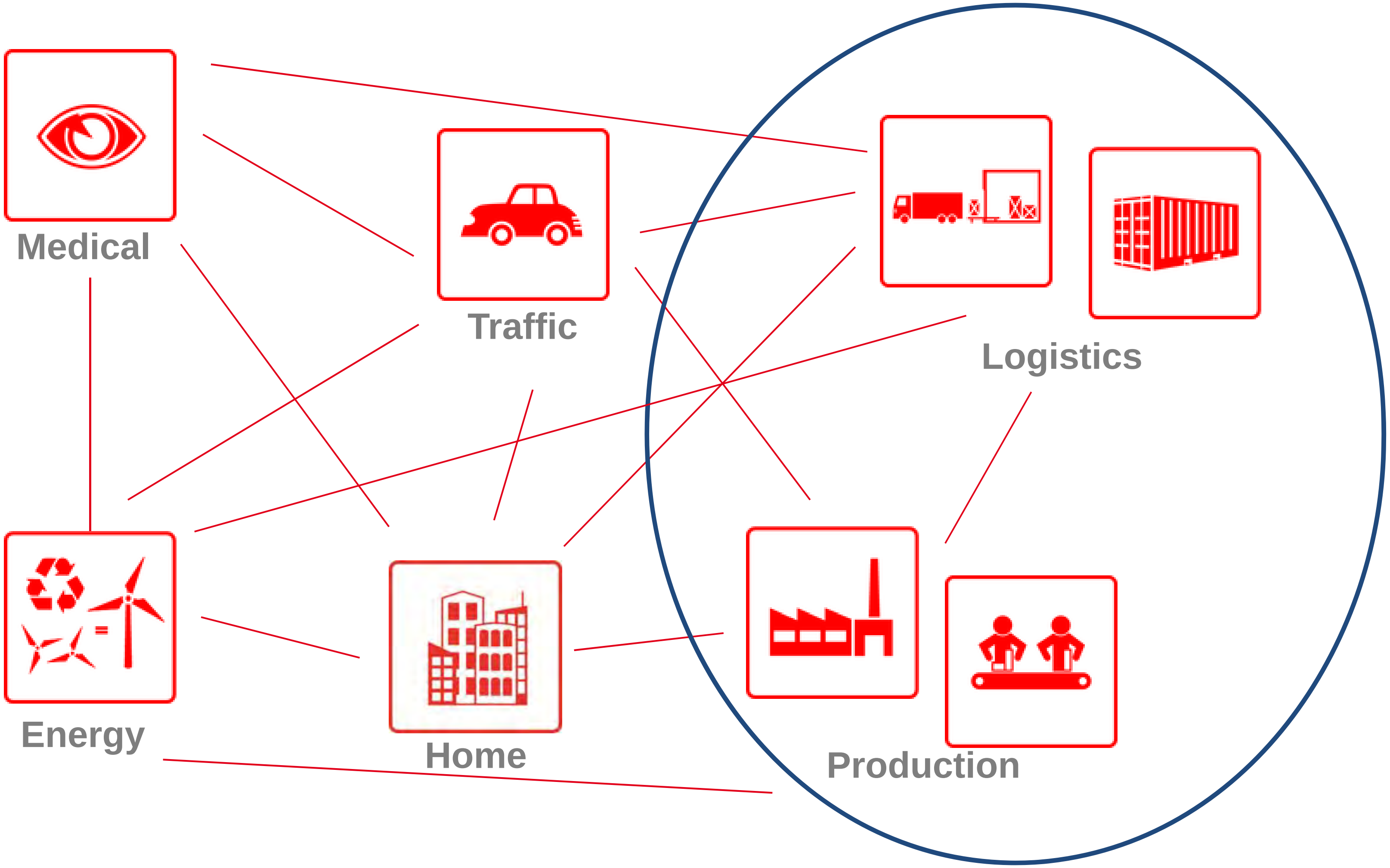
Domains of Industry 4.0



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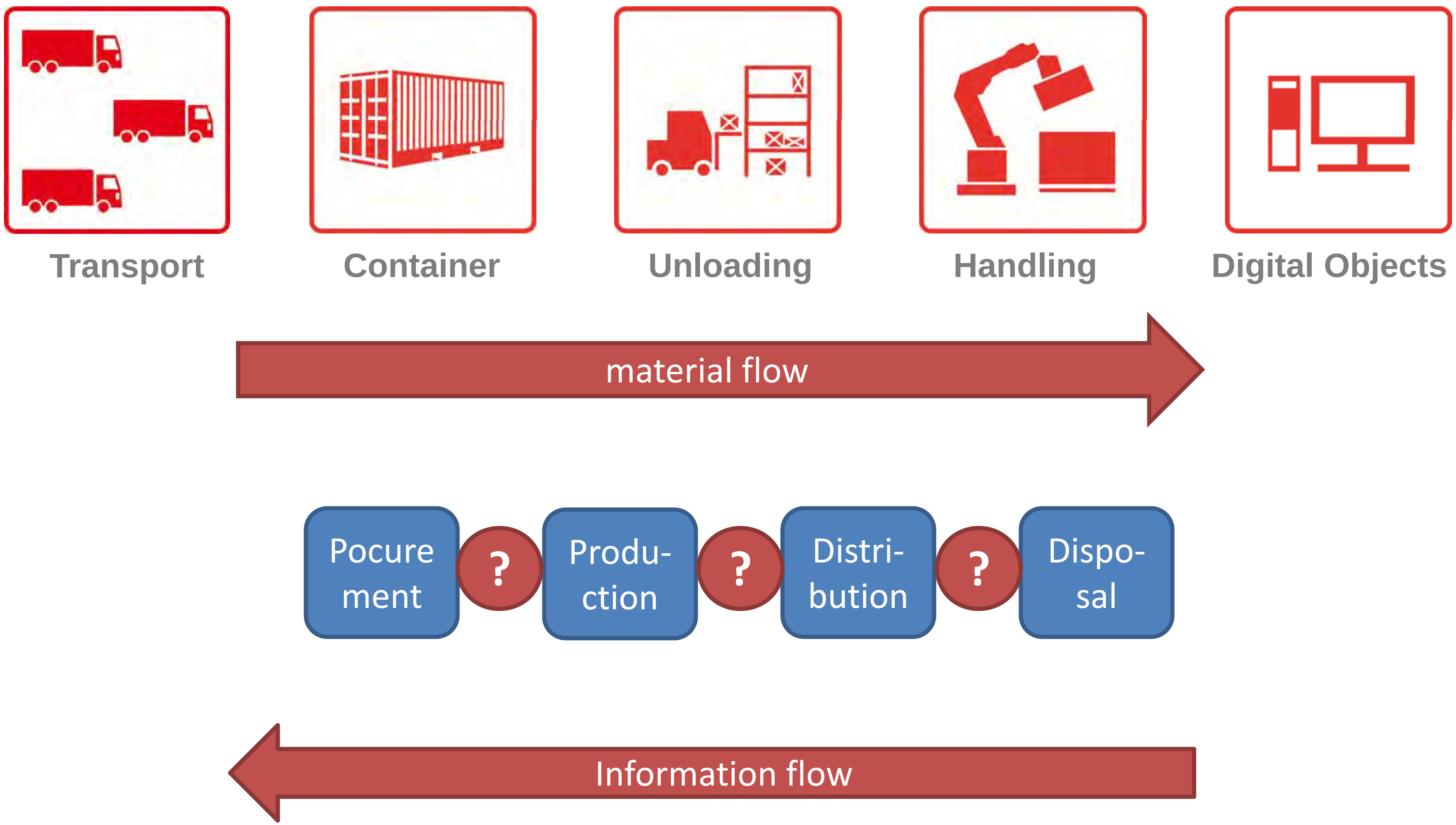
Entities of logistics & shared resources



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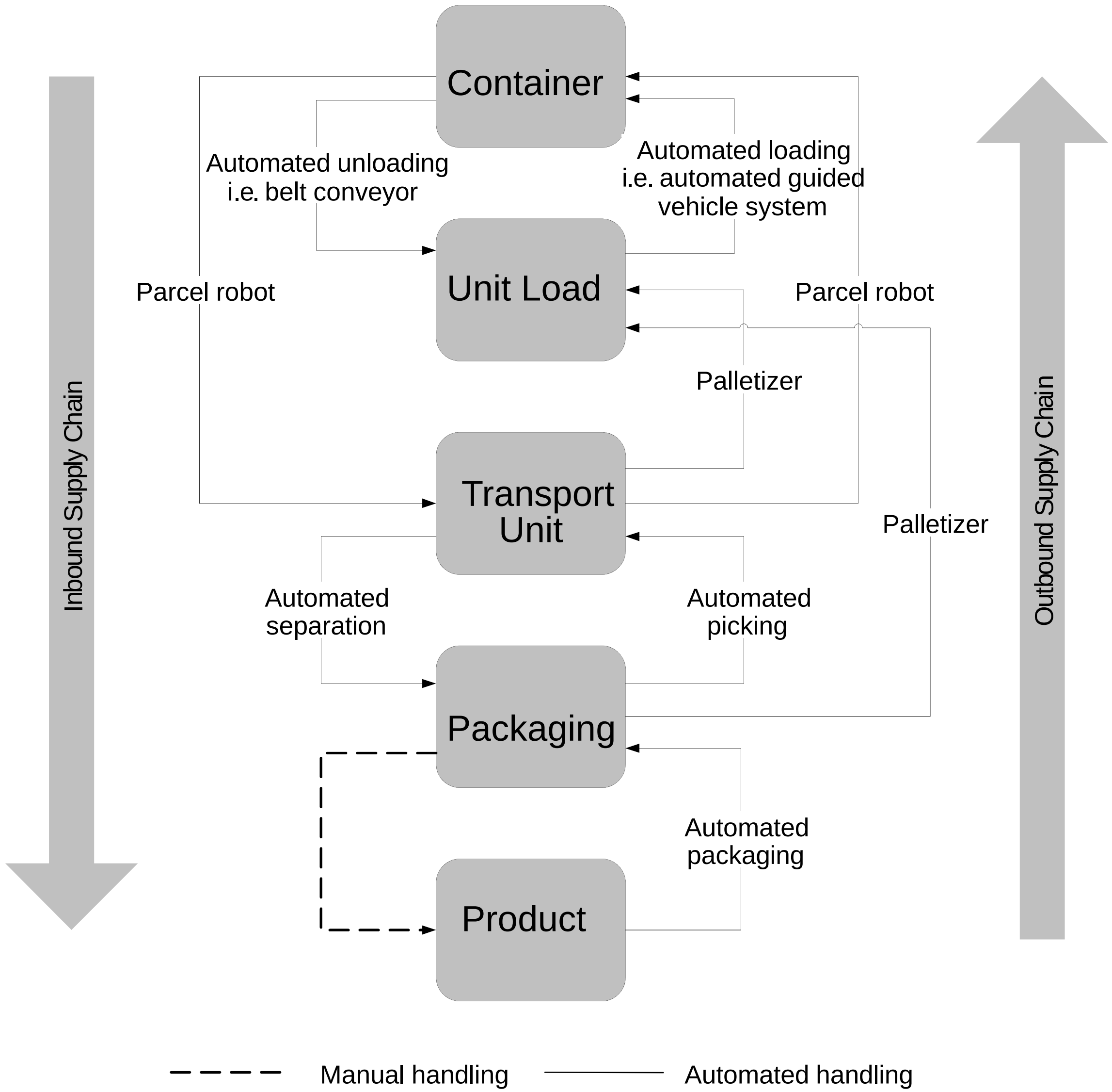
Intelligent Objects in Inbound and Outbound Logistics



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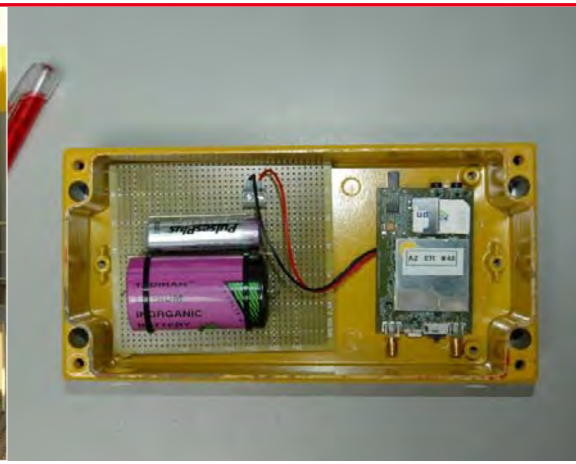
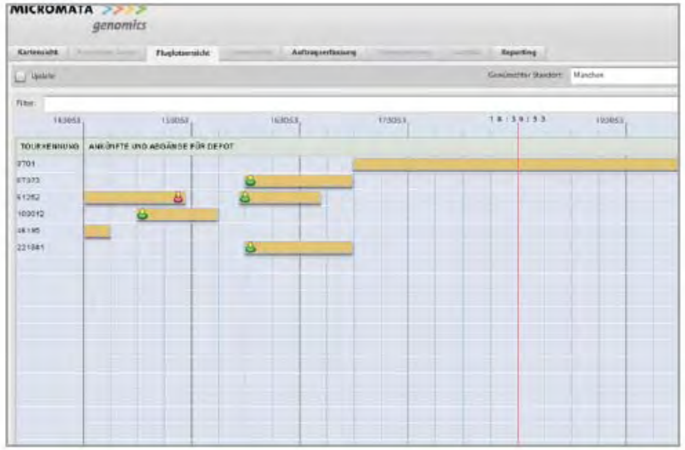
Linked Resources in Transport Logistics





- Increase of road transport volume
- Hardware and software systems to support transport processes for logistics
- Using of a telematics unit for gathering relevant information of expensive transport units (swap trilors / containers)
- Reduction of traffic in a global logistics network of approximately 10%

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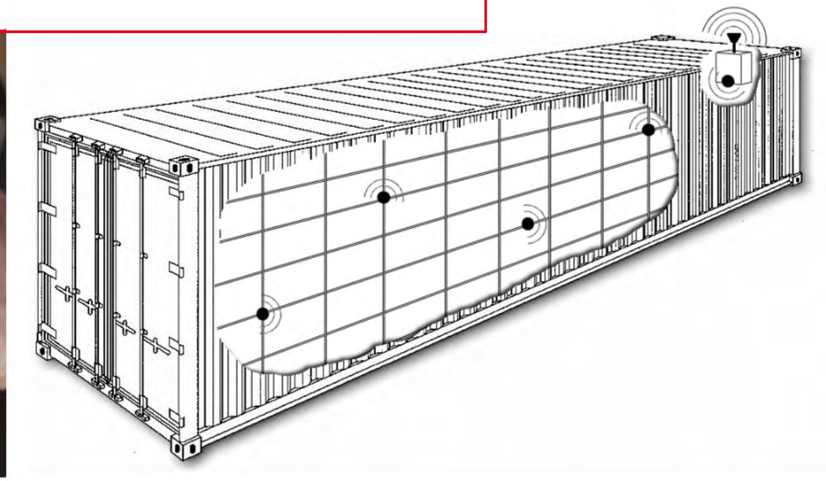
Containers as Cyber Physical Systems



- Food quality is sensitive to changes in logistics conditions, e.g. temperature
- Information gap during transport
- Changes in the quality are not captured
- …

Der Intelligente Container

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Containers as Cyber Physical Systems

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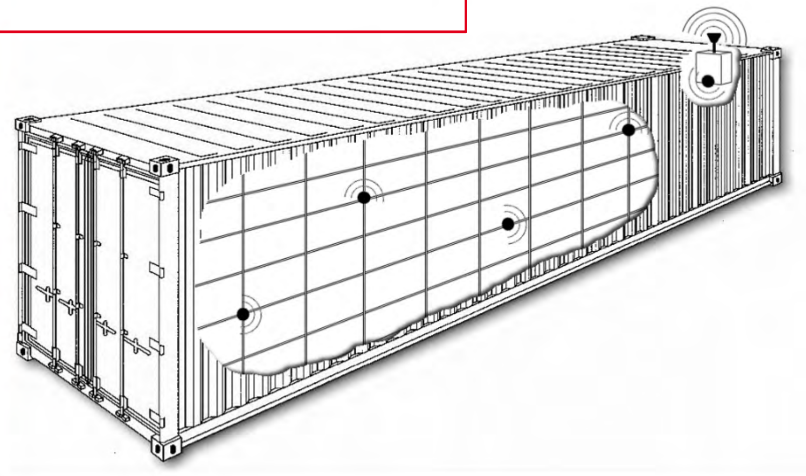

The Intelligent Container

http://www.intelligentcontainer.com

- **Improvement of the traceability of food by autonomous monitoring of food quality etc.**
- **Reduction of food losses by dynamic FEFO in practical applications**
- **Development of shelf life models to predict quality changes as function of temperature**
- **Prototype implementation and field tests of the ‘intelligent container’**

Der Intelligente Container

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Containers, Packages and Robots build a complex Cyber Physical Logistic System

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- **Reaching a new level of automation in the logistics chain**
- **Autonomous unloading of containers**
- **A cognitive and autonomous robot**
- **Capability of 3D perception in a challenging scenario (high variability of objects inc. deformable, dynamic scenes)**
- **…**

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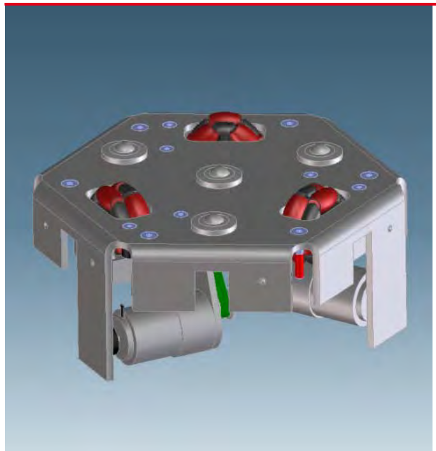
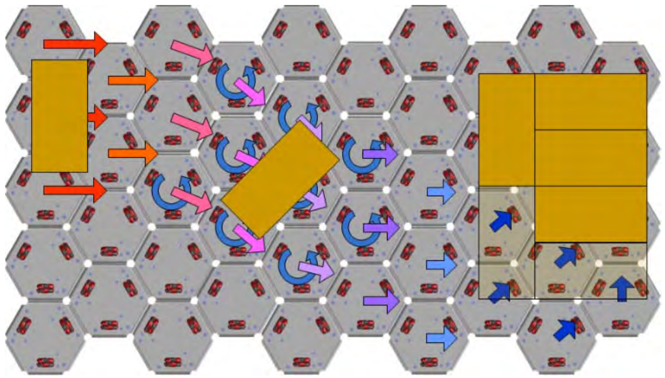
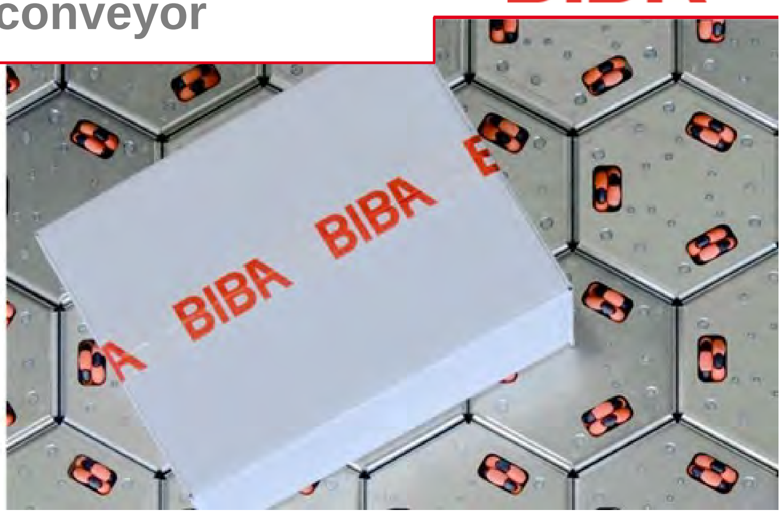
Plug and Play of CPS modules in Intra Logistics

Communication between packages and conveyor







- Increase of shipment and returns
- Next day delivery
- Increase of the complexity and dynamics of logistics systems
- Cellular conveyor system
- Flexibility and Adaptability
- Cost efficiency

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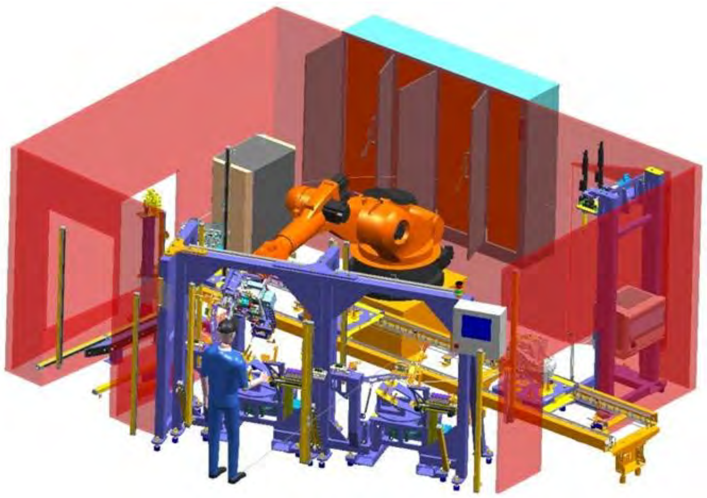
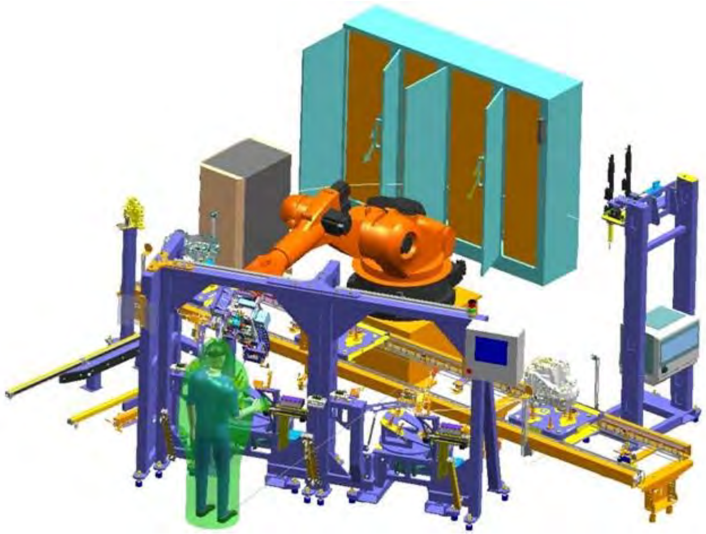


traditional protection solution



new protection solution

- Integrated protection and security concepts in cyber physical environments are necessary
- Save cooperation between human and robots

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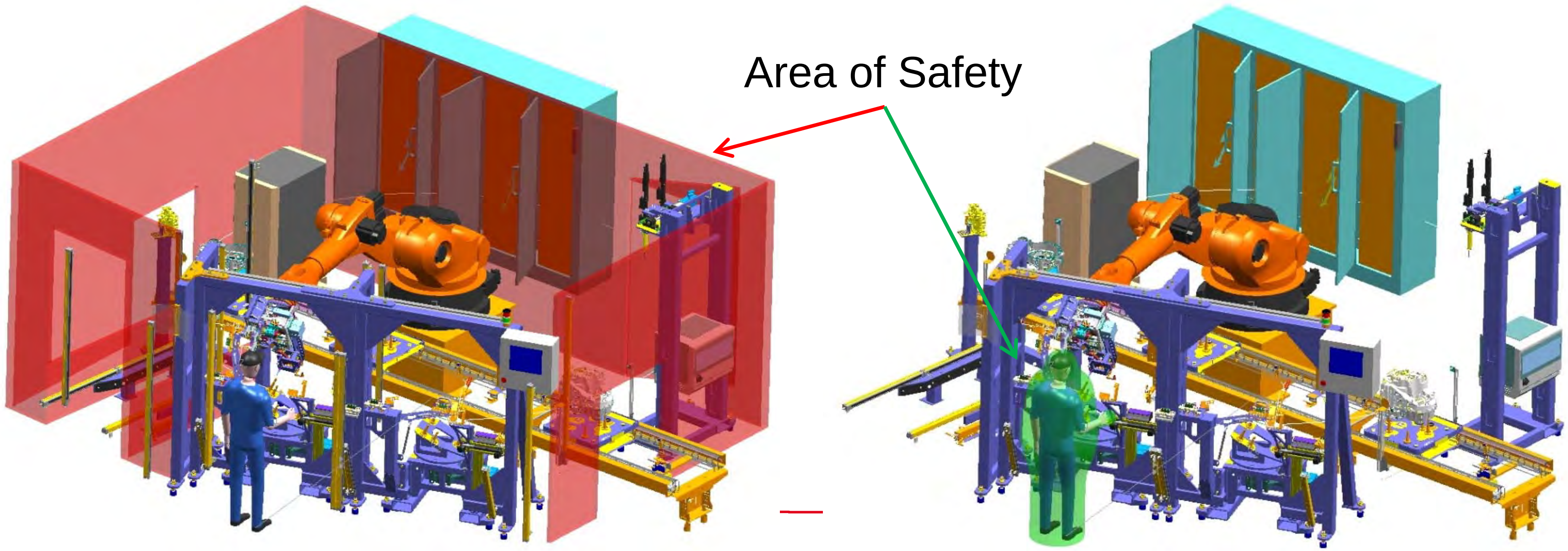
Activation of the most appropriate safety function according to the condition/context of the individual actors (humans, machines, processes)

Without InSA:

- Safety area in the working area (60m3)
- 5 light curtains
- 18 m safety fence
- 2 safety switches at the doors
- vmax = 250mm/s

With InSA:

- Safety area around the human
- 1 sensor-based safety suit
- Multisensor framework
- vmax = 1.500mm/s



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OVERCOMING LIMITATIONS OF LEAN PRODUCTION BY ENHANCED INFORMATION FLOWS

- Lean Production enables efficient material flow but does not focus on efficient information exchange

- Industry 4.0 as an overall concept promotes the informatization (computerization) of traditional industries (production / logistics) and **focus on an efficient information exchange**

- Approach within the CyProS project:
- Cyber-Physical Productionsystems
- Enhancement of productivity and flexibility through networking of intelligent systems in the factory
- E.g. to assist the application of lean production in complex production environments using Cyber Physical Production Systems

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INDUSTRIAL CASE STUDY
INTRA-LOGISTICS PROCESSES OF WITTENSTEIN BASTIAN

Factory (shop floor)

Electric train for material supply

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ANALYZING THE AS-IS SITUATION: FACTS AND FINDINGS

- High variation of number of transported floor rollers in one cycle (from 1 up to 15)
- Fixed cycle times (every full hour) lead to cycles where the electric train is operated with low capacity.
- Missing information about the actual status of orders, lead to unnecessary loops for the electric train.
- Missing information creates “waste” (conflict with lean principles).
- …
- Moving from a fixed cycle material supply to a demand driven material supply: The start of a cycle has to be initiated by a demand.

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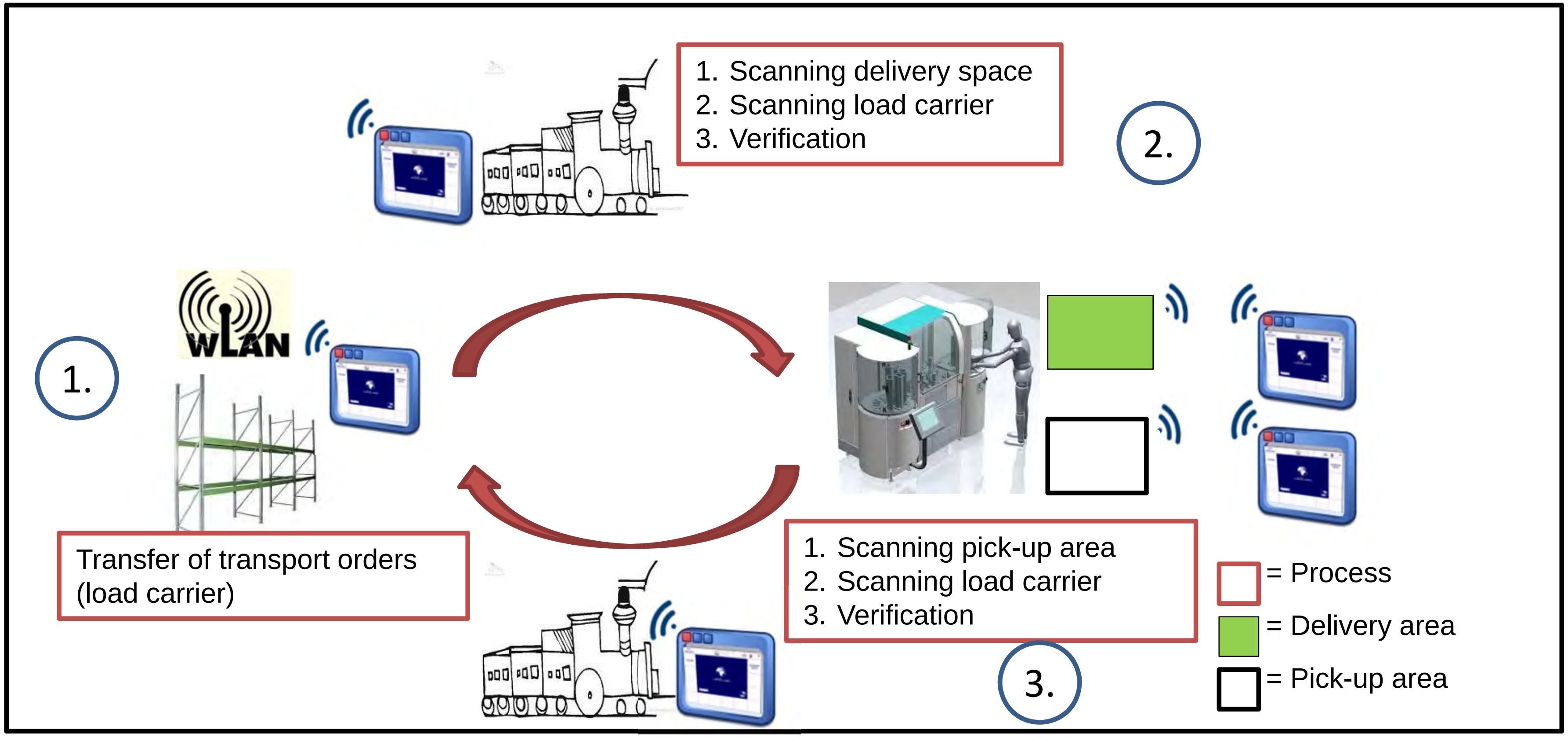
SCENARIO OF A CPPS ENABLED DEMAND-DRIVEN MATERIAL-SUPPLY (FIRST STEP)



→ Extension towards an automatically identification within the milk run process by intelligent load carriers will follow in upcoming steps.

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INDUSTRIAL CASE STUDY
FIRST STEPS

Source: Wittenstein

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INDUSTRIAL CASE STUDY
FIRST STEPS

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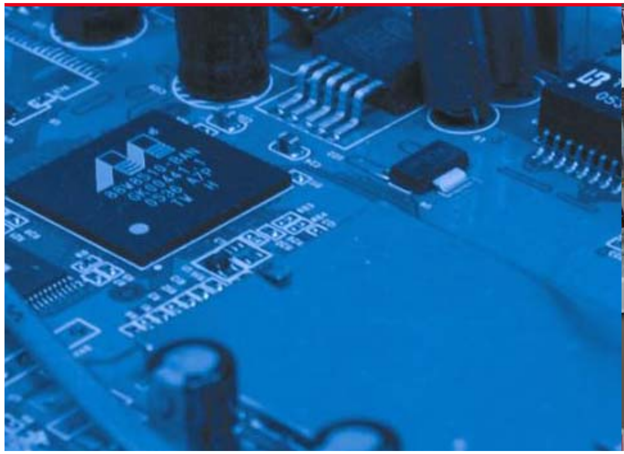
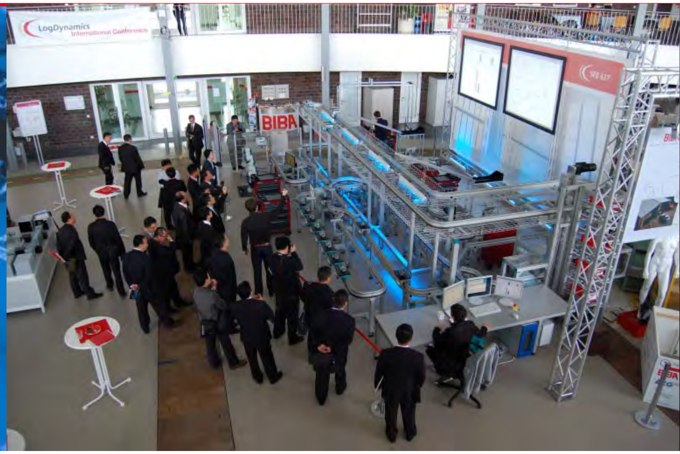
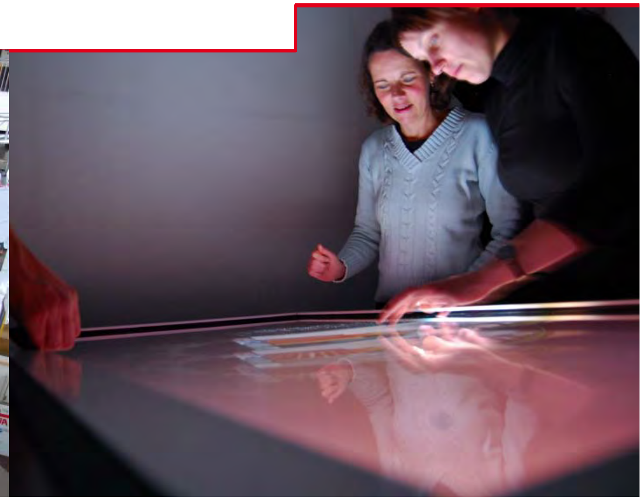
Dialogue of Science and Industry







Competence and transfer center for CPS in logistics

- Development a representative spectrum of Cyber-Physical System modules for production and logistics systems
- Creation of the technical and methodological basis for the economic operation of Cyber-Physical Systems in real production environments.
- Deployment and transfer strategies
- New business models

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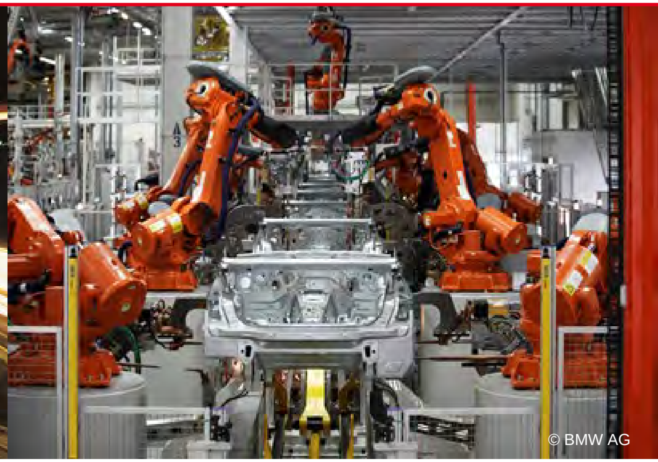
Conclusion



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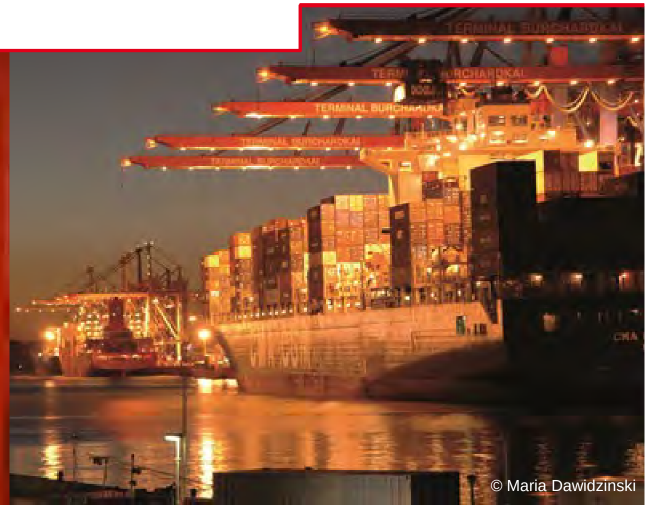

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- **Focus on understanding of processes and technologies**
- **Control of complexity to integrate new technologies and services**
- **Stronger focus on interfaces competencies**
- **Strengthening dialogue of science and industry**

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