Applying Industry 4.0 in Production and Logistic Systems
Towards Industry 4.0

Start of 1800s
Mechanical production facilities powered by water and steam.
Industry 1.0

Start of 1900s
Mass production based on division of labor and powered by electrical energy.
Industry 2.0

Start of 1970s
Introduction of electronics and IT for further automation of production.
Industry 3.0

2014 +
Production based on cyber-physical systems.
Industry 4.0

Source: Cognizant, Informed Manufacturing: The Next Industrial Revolution
VISION:
CYBER-PHYSICAL PRODUCTION AND LOGISTICS SYSTEM

Source: Reinhart et al. 2013
Structure of a Cyber-Physical Systems (CPS)

- **Embedded System**
  - Electronic Hardware
  - Sensors and Actuators
  - Software
  - Connection to other system
  - Human machine interface

Physical / mechanical System CPS

Broy, 2010
Benefits of Cyber-Physical Systems (CPS)

- A cyber-physical system summarizes ...
  - the benefits of embedded systems
  - the support of a broad range of communication 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
Communication as a Pre-Condition for Collaboration

- 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
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.
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**
Domains of Industry 4.0

- Medical
- Traffic
- Logistics
- Energy
- Home
- Production
Entities of logistics & shared resources

Transport  Container  Unloading  Handling  Digital Objects

material flow

Pocurement  Production  Distribution  Disposal

Information flow
Intelligent Objects in Inbound and Outbound Logistics

- **Inbound Supply Chain**
  - Container
    - Automated unloading i.e. belt conveyor
  - Unit Load
    - Parcel robot
  - Transport Unit
    - Automated separation
    - Automated picking
  - Packaging
    - Automated packaging
  - Product

- **Outbound Supply Chain**
  - Container
    - Automated loading i.e. automated guided vehicle system
  - Unit Load
    - Parcel robot
  - Transport Unit
    - Palletizer
  - Packaging
    - Palletizer

- Manual handling
- Automated handling
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%
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
- ...
The Intelligent Container

- 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’
- 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)
- …
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
Safe Human-Machine-Interaction in Complex Logistic Systems

- Integrated protection and security concepts in cyber physical environments are necessary
- Save cooperation between human and robots
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
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
INDUSTRIAL CASE STUDY
INTRA-LOGISTICS PROCESSES OF WITTENSTEIN BASTIAN

Factory (shop floor)  Electric train for material supply

Source: Wittenstein
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.
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.
INDUSTRIAL CASE STUDY
FIRST STEPS
INDUSTRIAL CASE STUDY
FIRST STEPS

Source: Wittenstein
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
Conclusion

- 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
Thank you for your attention!