INDUSTRY 4.0 TESTBED

Ing. Václav Kaczmarczyk, Ph.D.

Content

- Introduction
- Motivation
- Testbed
  - Industry 4.0 features
  - Impacts

Introduction

- Brno University of Technology
- Faculty of Electrical Engineering and Communication
- Department of Control and Instrumentation
  - Control group, measurement group, robotic and AI group, Computer vision group **and**
  - Industrial automation group
    - 2 Associate professors
    - 3 Assistant professors
    - ~6 Ph.D. Students

Motivation – educational problems

Department of Control and Instrumentation:

- Control group, measurement group, robotic and AI group, Computer vision group and **Industrial automation group**

We focus on making ideal graduate, with knowledge of

- **HW designer** – to design multiple HW platforms
- **SW designer** – to prepare programs for PLCs, embedded, robots, everything…
- **Technologist** – to understand technology processes, to know standards and to implement them
- **Designer** – to design modifications or completely new mechanical components wrt manufacturing technology
- **Mechanical engineer** – to prepare and understand technical documentation, to design specific-purpose machines
- **IT specialist** – to work with advanced tools, system integration (SOA)

Motivation – risks

Time limitation - students

- Limited student's time – cannot just add new lectures

Time limitation – staff => Labour shortage

- Dynamic progress in state-of-the-art
- Time consuming to follow it, limited time – cannot just add new lectures

What should we teach?

- A lot of theory is already there.
- Department covered many I4 topics even before I4 came.
- Difficult to select appropriate scale – not too much „implementation details", but not too wide.

Remaining problems

- Difficult to check new knowledge, missing motivation risk etc.

Motivation – solution

Topics for education:

- Industrial automation
  - Hierarchical physical model
  - From process level to enterprise systems (ISA-95)
  - PLCs
  - Manufacturing Execution Systems
  - ERP systems, PLM systems
  - Batch control (ISA-88)
- Communication
- Relational databases
- Cloud platforms
- Basic I4.0 concepts →

Necessary skills for I4.0:

- CPS
- Decentralization
- Modularity
- Autonomous manufacturing driven by product
- Interoperability
- Cloud services
- Internet of things

Motivation - Consequence

Decision to build a TESTBED - physical „thing“, teaching aid

- Shows a lot of already known
  - from process level to ERP.
  - Batch processes (local level) / Discrete manufacturing (global level)
  - Standardized communication
- Attractive way - soft drinks production (food-grade materials necessary)
- Shows many I4.0 principles.
- Students can try and understand these principles.
- Students can implement many new (updated) features…

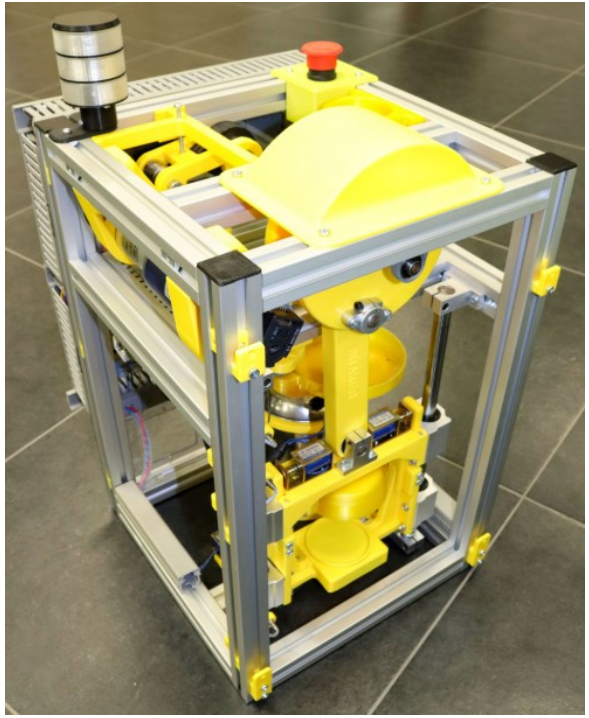
A group of several autonomous units

- **Manufacturing cells** – implement physical/chemical transformation of material
- **Warehouse cells** – implement intermediate product storage
- **Transport units** – move everything everywhere…

Testbed - decentralization

Decentralization & Interoperability

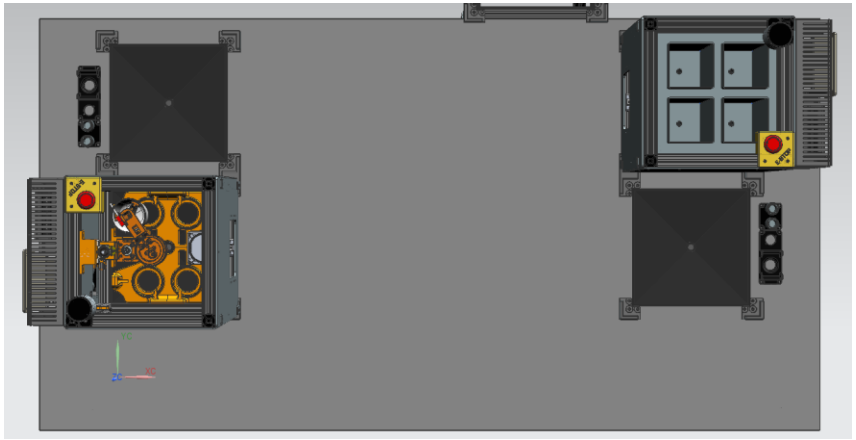
- Each process cell controlled by its own PLC (S7-1200) with basic touch panel.
- OPC-UA Gateway (AAS) for interoperability
  - Custom HW+SW solution (IEC 62541)
  - Common data model
- Possibility to work autonomously
  - Just after the product container is placed inside.
  - Recipe + **manufacturing state** stored inside the product container.
  - Safety stop, light beacon



Testbed - modularity

Modularity

- Cells can be removed
  - Reorganization
  - Replace with another
  - Add duplicate
- The factory responds on the fly
- Autonomous manufacturing reorganization
  - The possibility of producing new products increases.
  - Other products manufacturing may become unavailable.



Testbed – Autonomous manufacturing

Each product has his own software agent

- During production, the agent negotiates services (manufacturing + transport)
- Then agent selected the best production cell
  - Agent asks for a reservation.
  - The production cell confirms it.

Every production cell keeps the dynamic list of its reservations.

→ A challenge due to

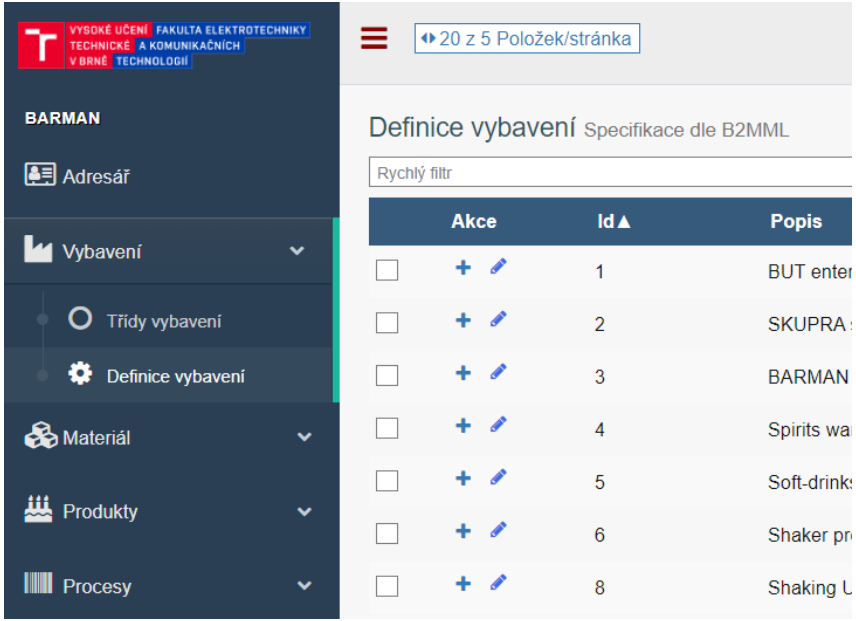
- the dimensions of the device and the complexity of the HW equipment.
- the need to maintain food quality
- advanced algorithms

Work in progress

Testbed – classic manufacturing

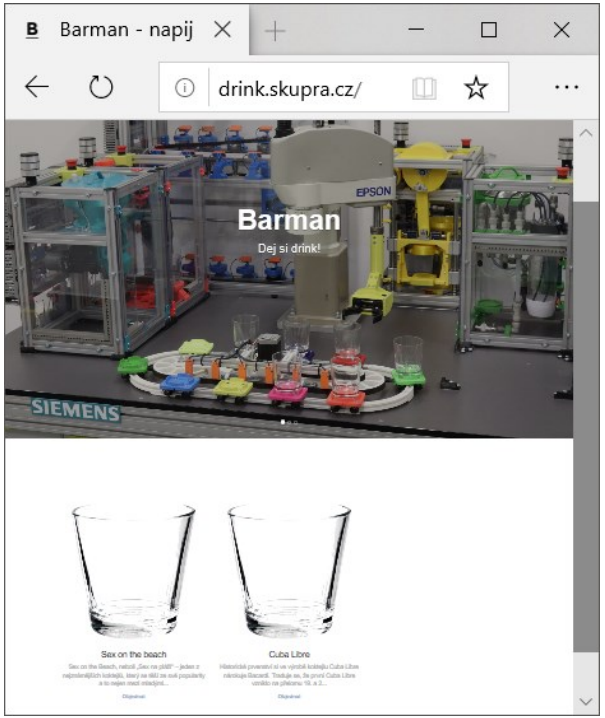
Standard I3.0 manufacturing

- Centralized solution controlled by MES system
- Custom MES core implementation (according to ISA-95).
- .NET + DOTVVM architecture
- Opened modular architecture – challenge for students.
  - **Future implementation of more MES modules**
  - Data collection, dashboards, products tracing, optimization…



Testbed – cloud services

- Web applications/databases hosted on-premise now.
  - ASP.NET platform
  - MySQL databases
- Can be migrated to the cloud
  - Data collection from edge devices to the cloud
  - Web applications (E-shop, production planning)
- Thinkink about Siemens Mindsphere



Testbed – Rapid prototyping

- Using Siemens NX for design
  - MCD for validation of mechanial parameters, PLC programs
- FDM plastic printing.
  - Cheaper than traditional manufacturing.
  - 99 % pieces OK, remaining made from aluminium (strength), stainless steel (food grade)
- 3D printers farm with possibility of sharing between staff and students.
  - Development of machine current/vibration/temperature sensoric systém together with industrial partner

Testbed - conclusion

- Testbed is a physical thing – teaching aid
- Shows how everything important from process level to ERP level works and how it is connected together.
- Batch processes (local level) / Discrete manufacturing (global level).
- The result of the work of employees and dozens of final theses of students.
- Every year we have 5-10 final theses bound with testbed.
- Built in the spare time of the research group .
- Built without the use of subsidy funds.

Thank you for your attention

Ing. Václav Kaczmarczyk, Ph.D.
Department of Control and Instrumentation
Faculty of Electrical Engineering and Communication
kaczmarczyk@vut.cz