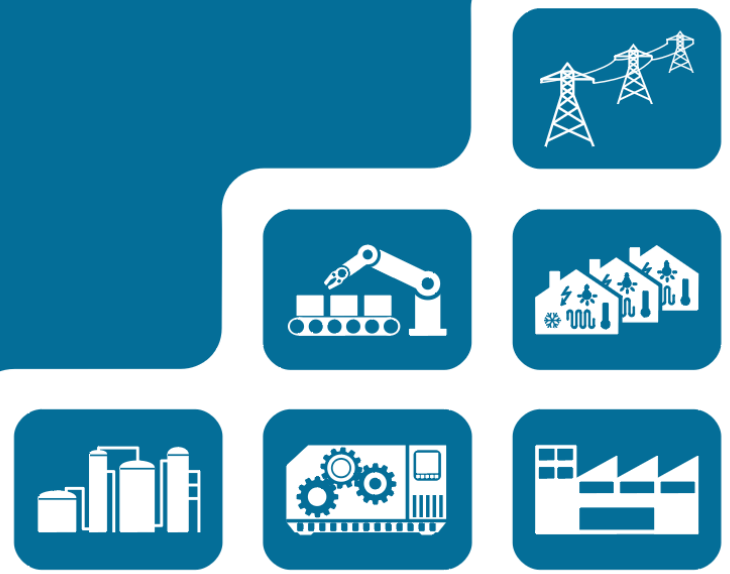
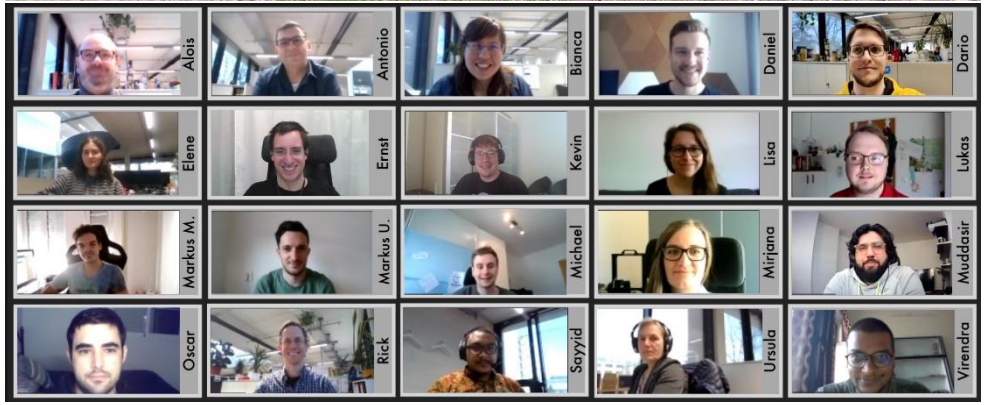
Theses Topics (and PR) at the LIT CPS Lab (and the CD Lab VaSiCS)

Univ. Prof. Dr. Rick Rabiser and Univ.-Prof. Dr. Alois Zoitl
Christian Doppler Lab VaSiCS
LIT | Cyber-Physical Systems Lab
Johannes Kepler University Linz



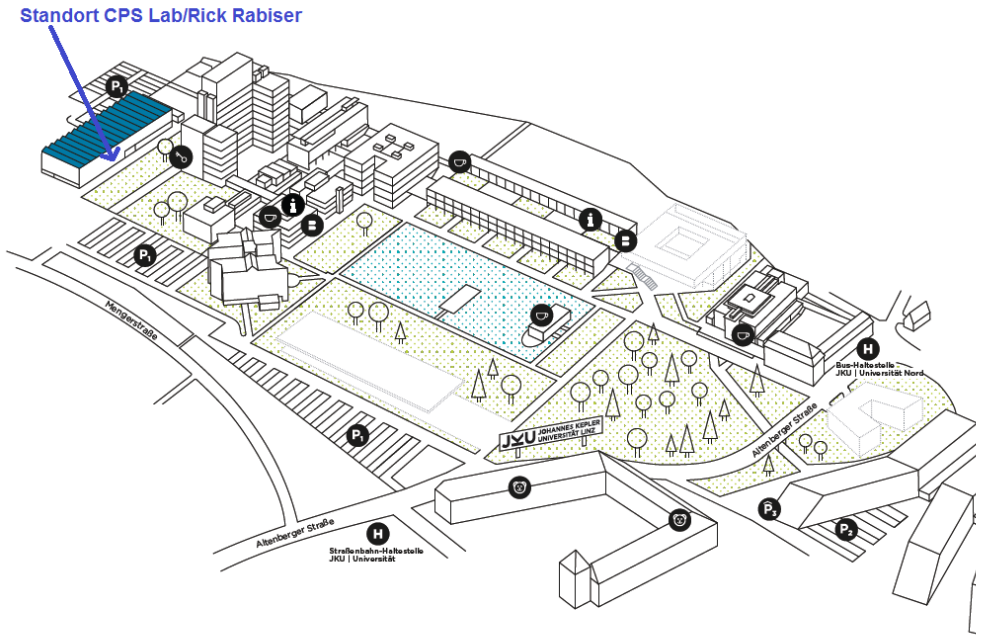
LIT Cyber-Physical Systems Lab

https://www.jku.at/lit/cps-lab

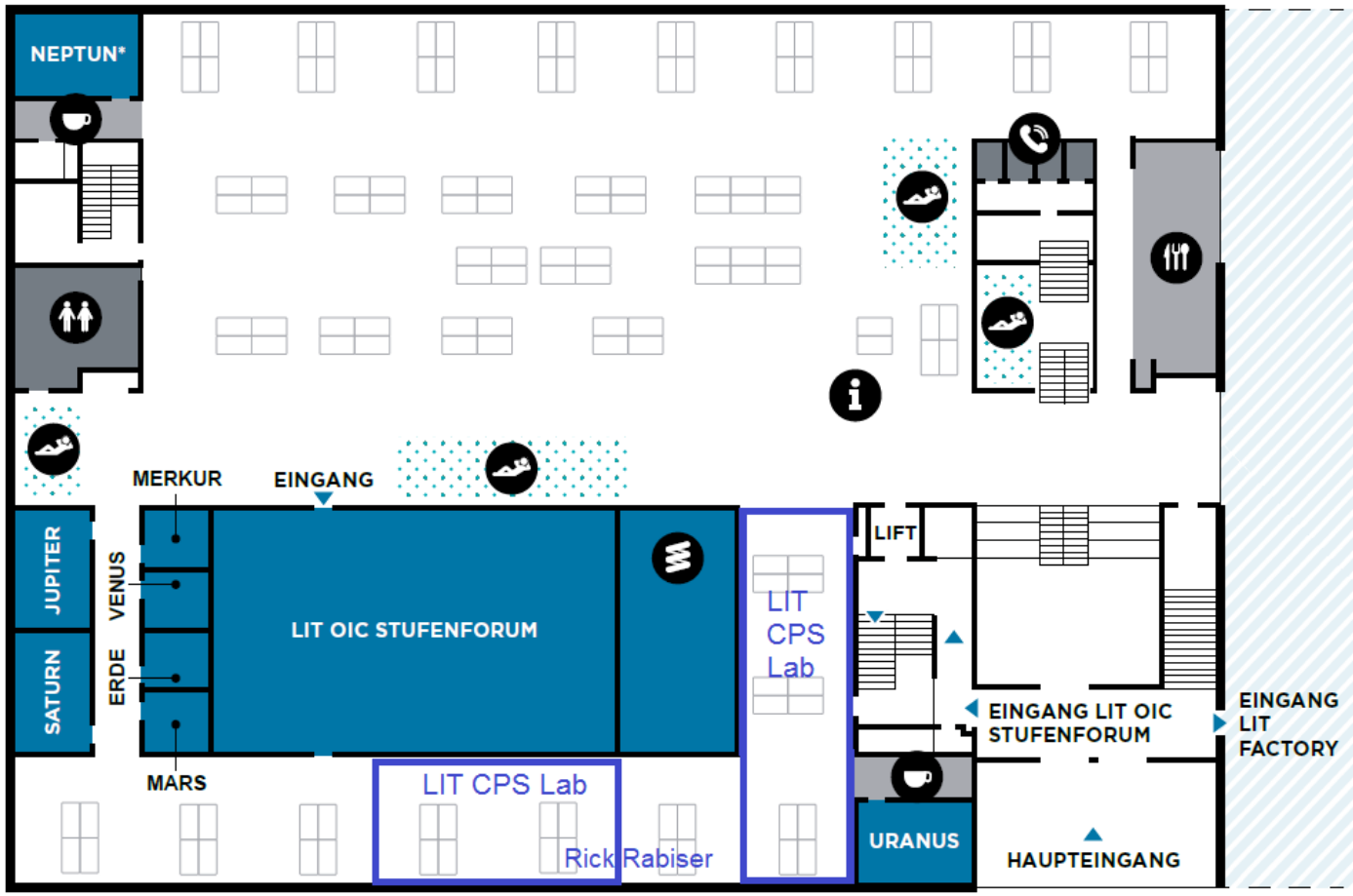


Where to find us

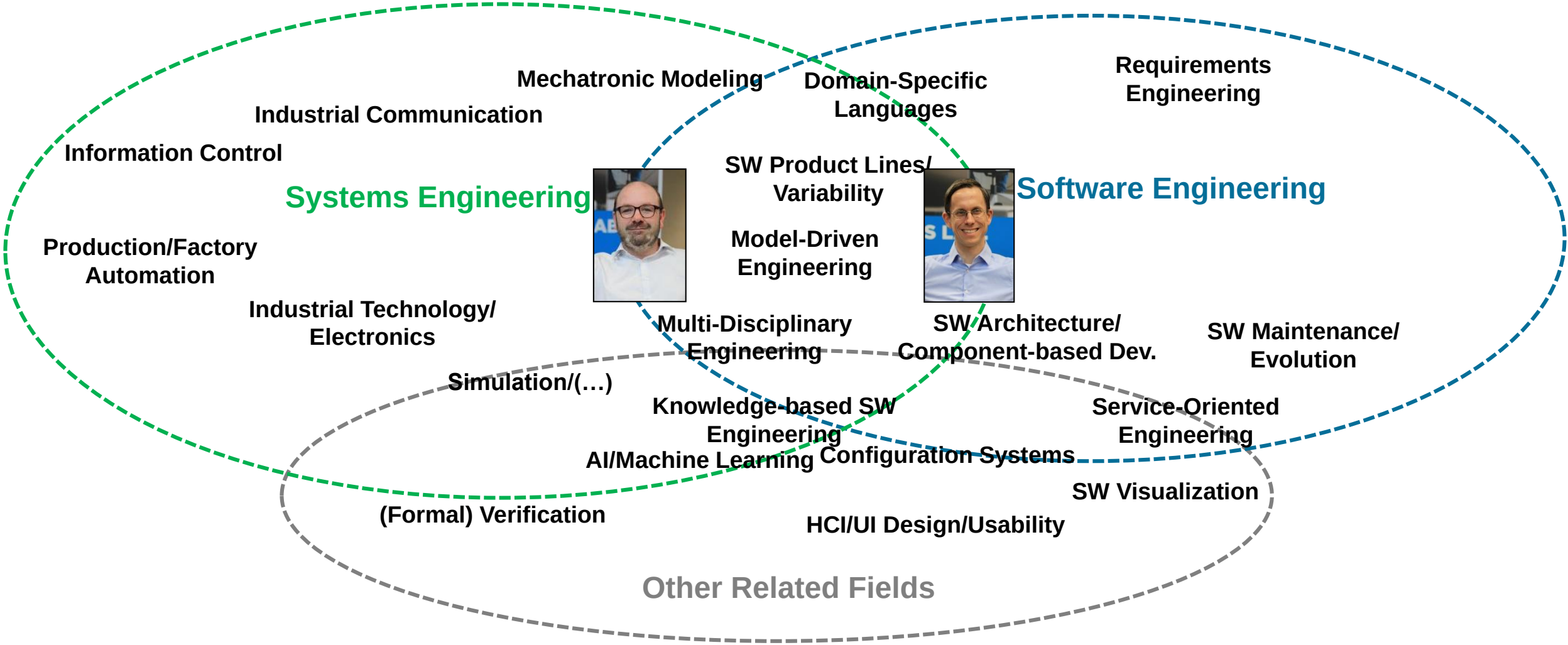
DER JKU CAMPUS.
OPEN INNOVATION CENTER



LIT OPEN INNOVATION CENTER.
ERDGESCHOSS



Scientific Landscape and LIT CPS Lab Profs.

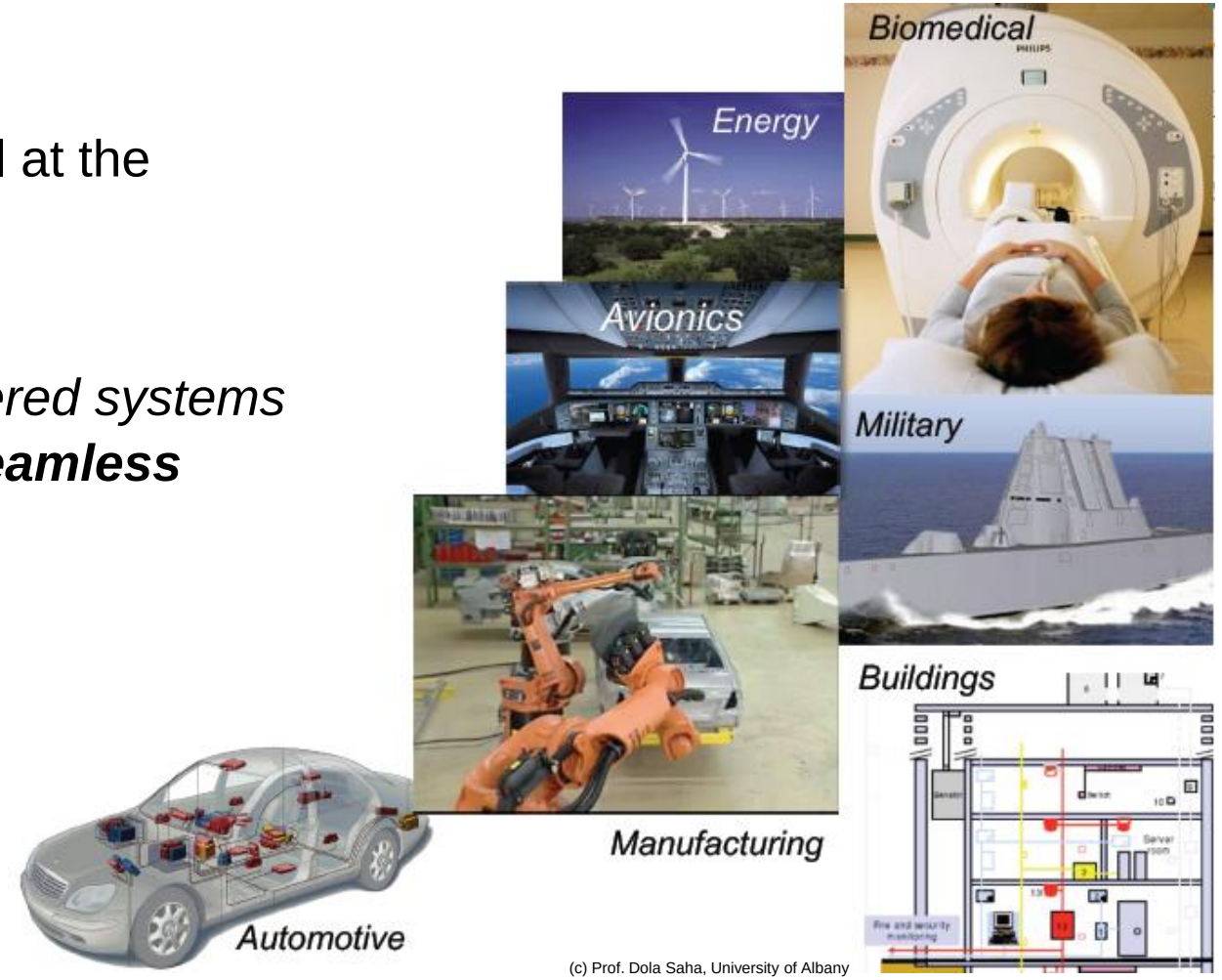


Cyber-Physical Systems

- Term emerged in 2006, coined by Helen Gill at the National Science Foundation in the USA

- "*Cyber-physical systems (CPS) are engineered systems that are built from, and depend upon, the* ***seamless integration of computation and physical components***."

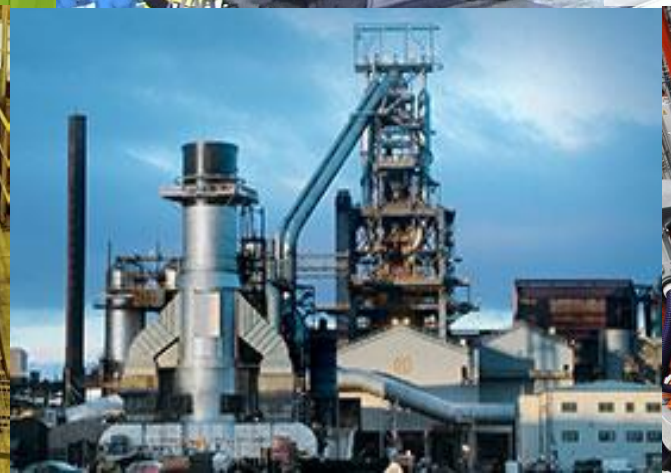
- "*Cyber-physical systems are everywhere —and are operated by everyone*" (M. Broy)

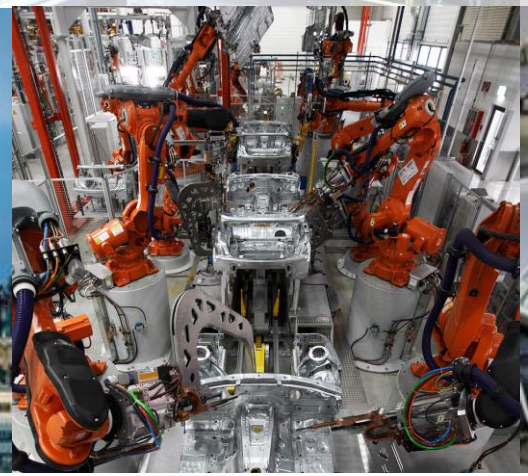


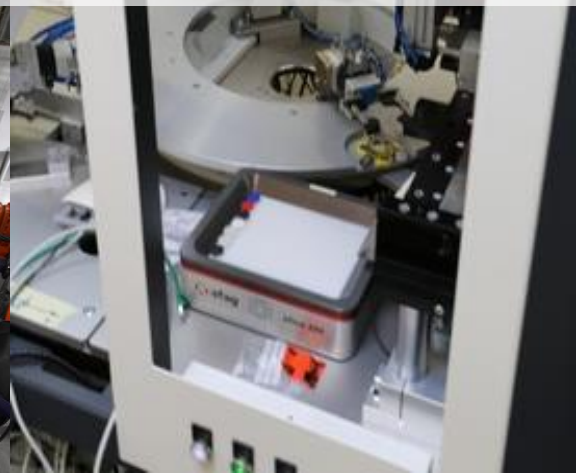
(c) Prof. Dola Saha, University of Albany

Cyber-Physical Production Systems (CPPS)

- CPPS reflect the characteristics of CPS to the production domain [Biffl et al. 2017]
- Increasing availability and use of distributed industrial CPS devices and systems (Industry 4.0) [Harrison et al. 2016]







Hot Topics

- **“Digitalization”**
- **Industry 4.0**
- Artificial Intelligence (Machine learning/Deep Learning)
- (Big) Data (analytics/science)
- Cloud-based computing
- Internet of Things (IoT)
- …

While […] machine learning, big data, or IoT are often seen as the key elements of digitalization, ***software and software engineering play the key role in research, teaching and practice***
(Broy et al. in Informatik_Spektrum_39_6_2016)

→ Cross-cutting issue, particularly relevant for CPPS: **Systematically dealing with variability and complexity!**

Software Engineering
1968 vs. 2018

We have to deal with complexity by ***hierarchically ordering function and variability***
(E.W. Dijkstra: Complexity Controlled by Hierarchical Ordering of Function and Variability. NATO Software Engineering Conference, **1968**.)

We have to understand how to design and implement reliable software such that maintenance, changeability, and variability are easier to handle. […]

(M. Broy, "Yesterday, Today, and Tomorrow: 50 Years of Software Engineering", IEEE Software, 35(5):38-43, **2018**.)

Teaching (Winter Semester)

- **Networked Embedded Systems** (VO/UE, Englisch) (Alois Zoitl, diverse)
  - Pflichtfach für ELIT, Mechatronik
- **Production Automation Systems** (VO, Englisch) (Alois Zoitl)
  - Wahlpflichtfach für Artificial Intelligence, Wahlfach für diverse Studienrichtungen
- **Practical Work in AI (Master)** (PR) (Alois Zoitl)
  - Pflichtfach für Master AI
- **Seminar in AI (Master)** (SE) (Alois Zoitl)
  - Pflichtfach für Master AI
- **Special Topics: Cloud Computing** Architectures, Processes and Operations (Rick Rabiser, Andreas Grimmer, Johannes Bräuer)
  - Wahlfach
- Project in **Computational Engineering** (PR) (Alois Zoitl, Rick Rabiser)
  - Wahlpflichtfach für Computer Science
- Project in **Software Engineering** (PR) (Alois Zoitl, Rick Rabiser)
  - Wahlpflichtfach für Computer Science
- **Projektpraktikum** (PR) (Bakk-Arbeit) (Rick Rabiser, Alois Zoitl)
  - Pflichtfach für Informatik
- **Master's Thesis Seminar** SS (SE) (Alois Zoitl, Rick Rabiser)
  - Begleitend zur Masterarbeit
- **Dissertantenseminar** Informatik (SE) (Alois Zoitl, Rick Rabiser)
  - Pflichtfach für Doktoratsstudium, Fach Informatik

Teaching (Summer Semester)

- **Algorithmen und Datenstrukturen** (VO/UE) (Rick Rabiser, div.)
  - Pflichtfach für ELIT, Mechatronik, Maschinenbau
- **Präsentations- und Arbeitstechnik** (KV) (Grünbacher, Kotsis, Rabiser, div.)
  - Pflichtfach für Informatik Rick Rabiser
- **Programmieren II: Software Engineering für Jurist*innen** (KS) (Rick Rabiser)
  - Wahlpflichtfach für Bachelor Rechtswissenschaften
- **Product Line Engineering** (KV) (Rick Rabiser, div.)

- **Production Automation Systems** (UE) (Alois Zoitl)
  - Wahlpflichtfach für Artificial Intelligence, Wahlfach für diverse Studienrichtungen
- **Network Embedded Systems** (PR) (Alois Zoitl)
  - Pflichtfach für ELIT, Mechatronik

- **Parallel Computing** (KV) (Wolfgang Schreiner, Alois Zoitl)
  - Wahlpflichtfach für Computer Science
- Project in **Computational Engineering** (PR) (Alois Zoitl, Rick Rabiser)
  - Wahlpflichtfach für Computer Science
- Project in **Software Engineering** (PR) (Alois Zoitl, Rick Rabiser)
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Further Information

- https://www.jku.at/lit/cps-lab

(Selected) Current Projects

Please note: for all these projects, practica and theses are possible (Bachelor, Masters, PhD)

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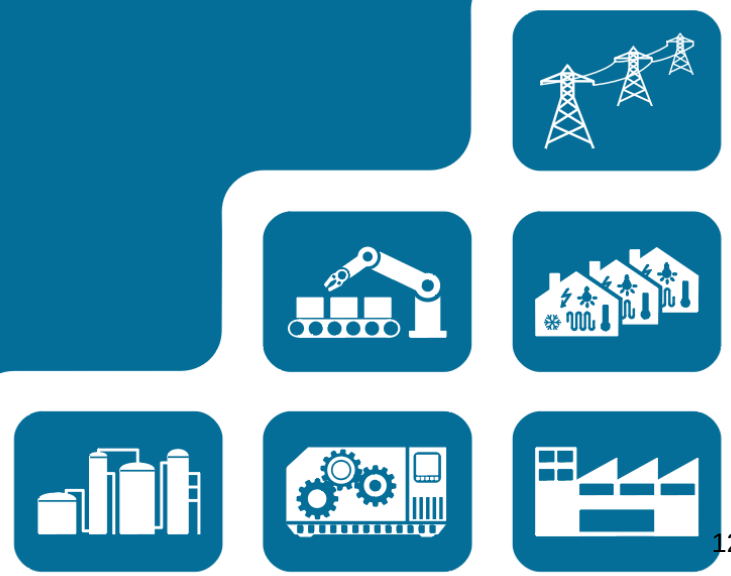
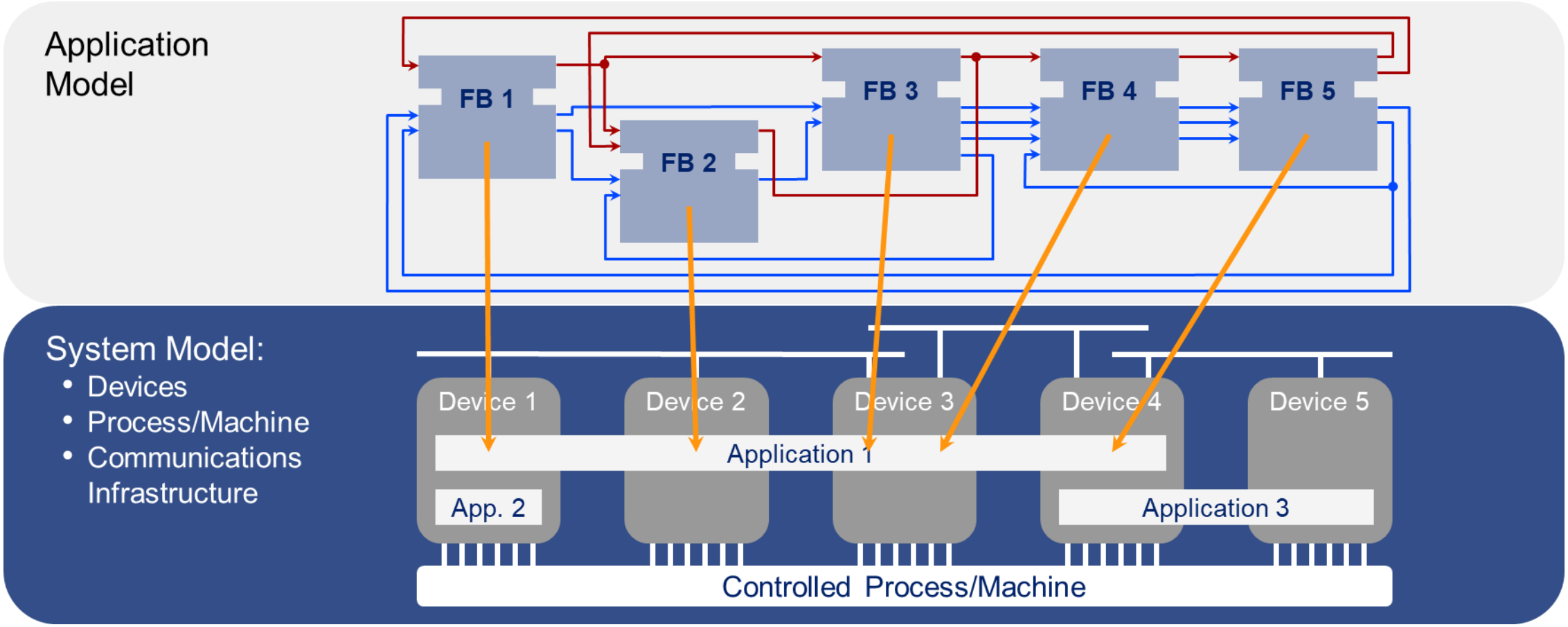
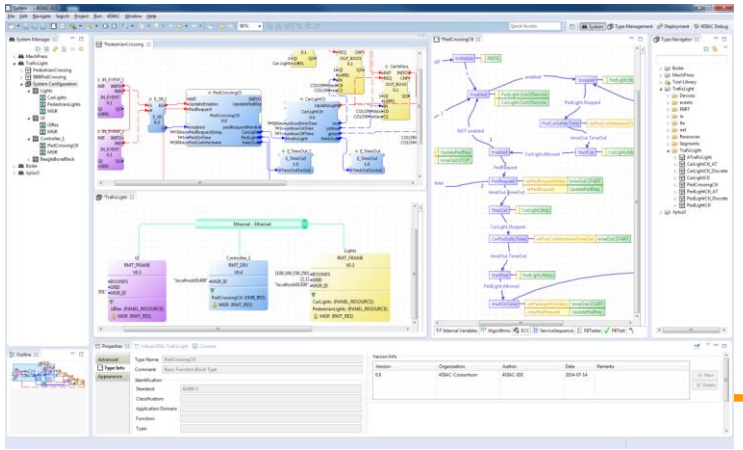


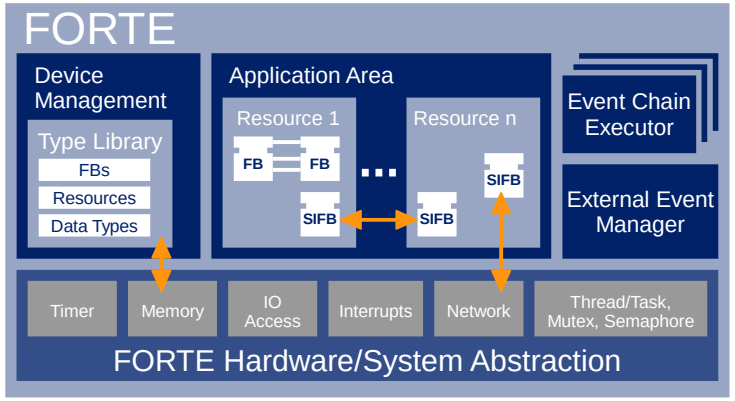
IEC 61499

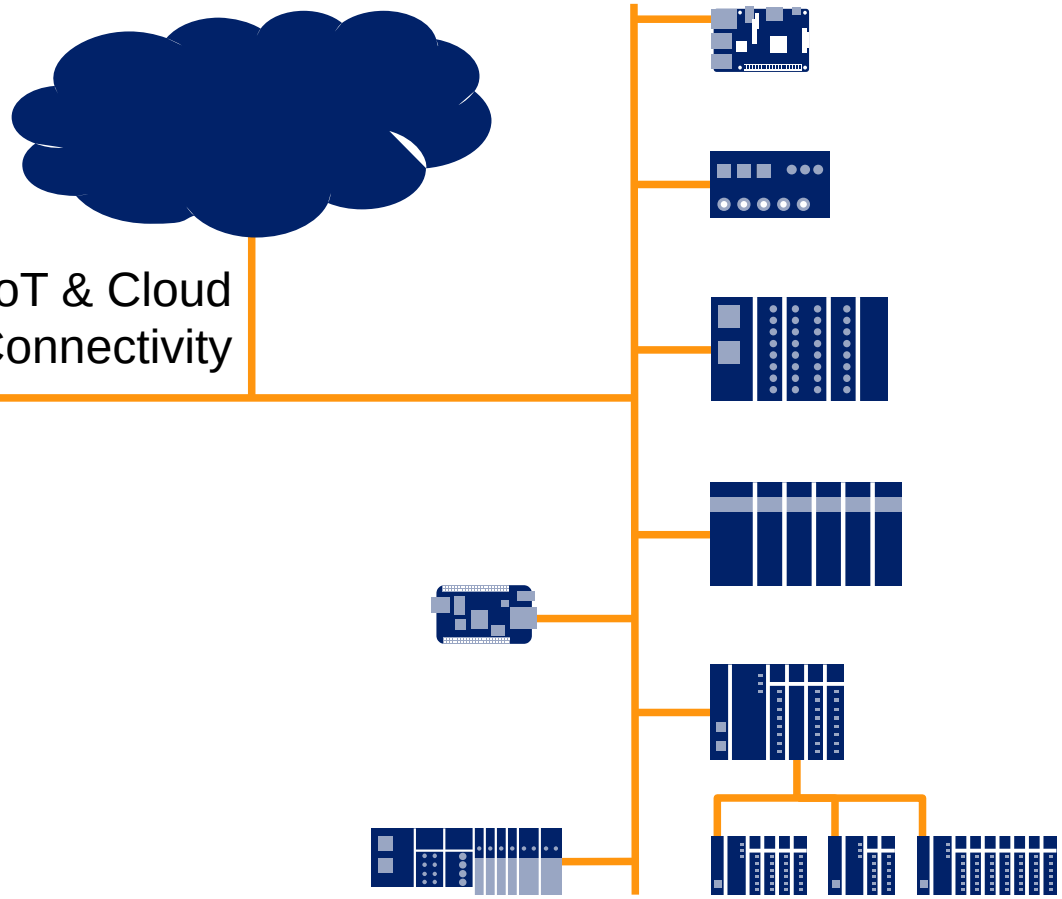
Domain-specific Modeling Language for Distributed Industrial Process Measurement and Control Systems



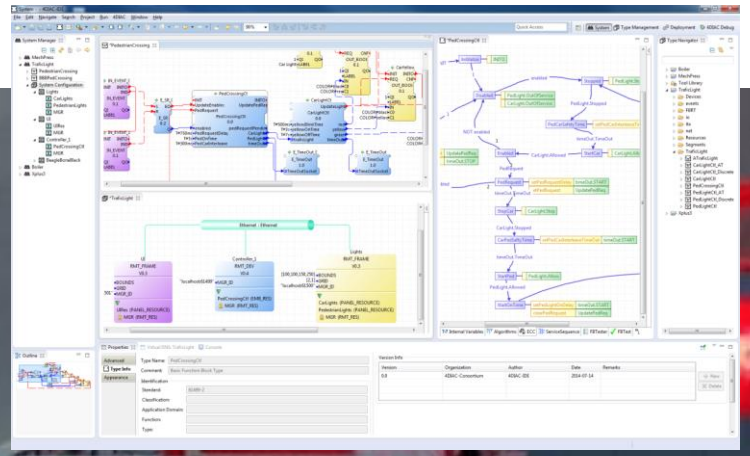
Open Source Implementation
Eclipse 4diac







Contact: Alois Zoitl



Tool Development:

- Sequence Diagrams
- Model-Checking
- Version Management
- Doc Generation
- Tools in the Cloud
- Other Inputs
- UX
- ...

Web-based HMI:

- Connect Machines and Web Servers
- Web-Server <-> Browser

Control Applications:

- Automating Example Machines
- Library Development
- Design Patterns

IEC 61499

Improved Device Support:

- Porting
- I/O Support

Communication:

- Evaluating DDS from OMG
- Integrating the Production Performance Management Protocol
- TSN (deterministic Ethernet)

et Hacks

Contact: Alois Zoitl

16,000+ STUDENTS, 111 COUNTRIES
16 YEARS, 715 OPEN SOURCE ORGANIZATIONS

38,000,000+

LINES OF CODE

Google Summer of Code is a global program focused on bringing more student developers into open source software development. Students work with an open source organization on a 10 week programming project during their break from school.

GET STARTED

2021 Program Announced

View the whole timeline to learn when and how you can get involved.

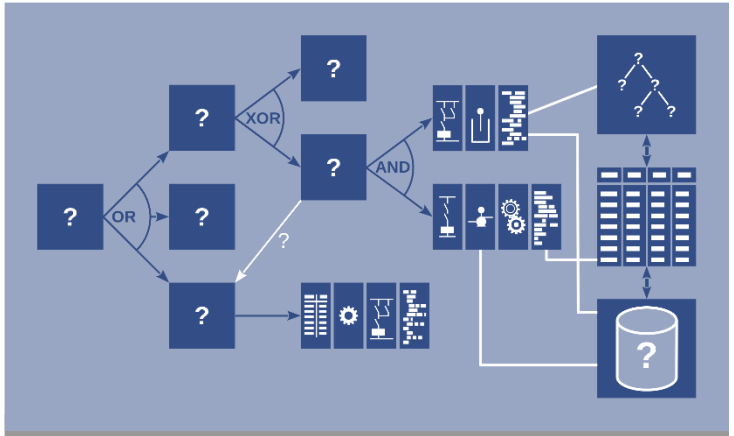
Contact: Alois Zoitl

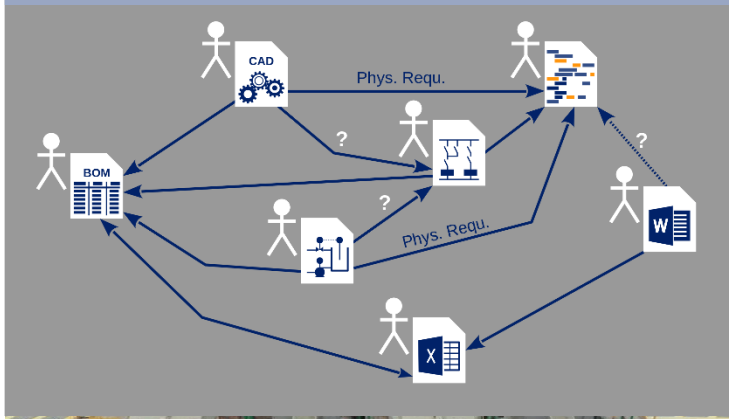
Christian Doppler Lab VaSiCS (2/2021-1/2028)

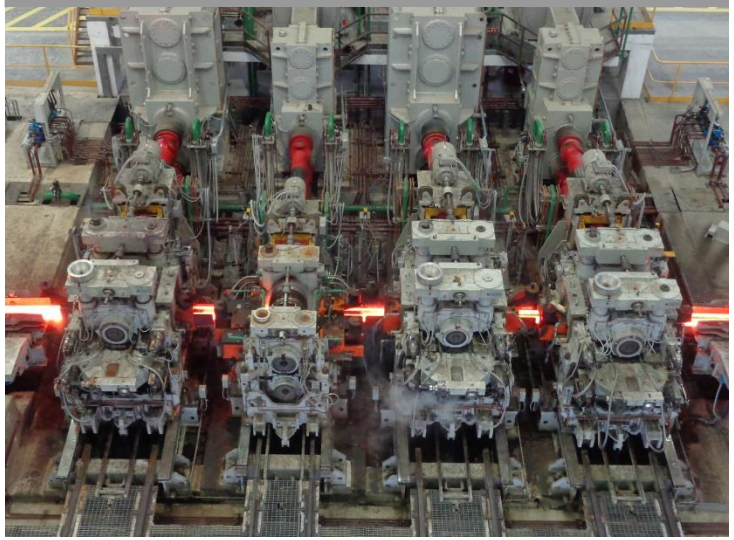
- **VaSiCS: Mastering Variability in Software-intensive Cyber-Physical Production Systems**
  - CPPS variability modeling approach
  - analyze existing CPPS artifacts to automatically mine and model variability
  - support configuring and generating CPPS target artifacts
  - support CPPS roundtrip/evolution

PRIMETALS TECHNOLOGIES

https://www.jku.at/cdl-vasics/

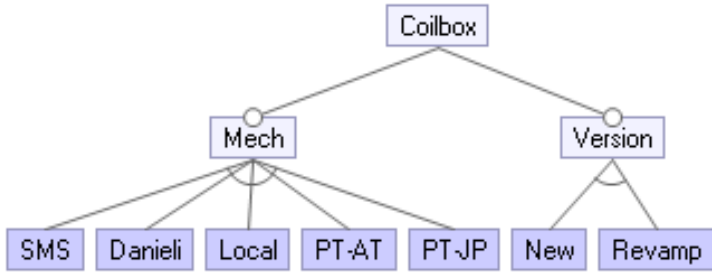


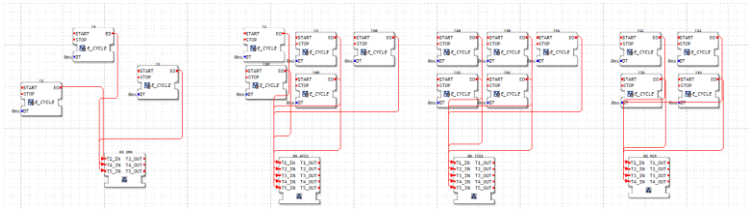


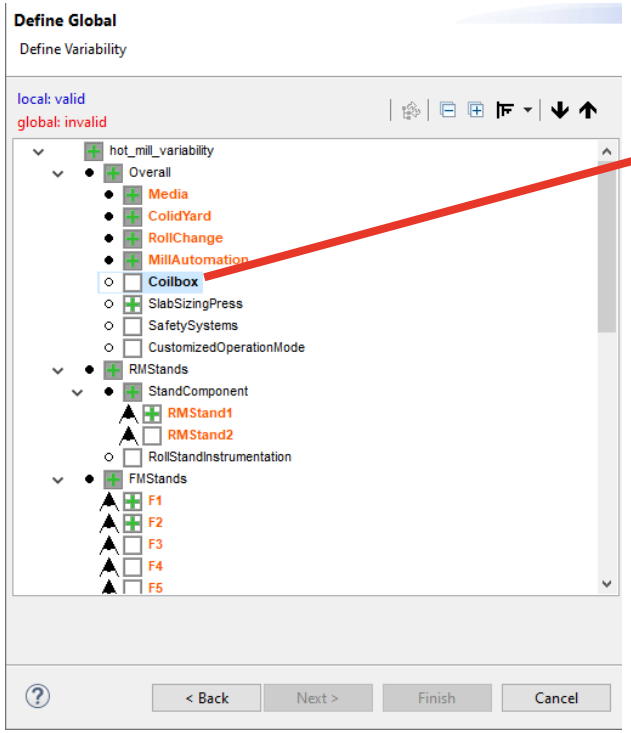


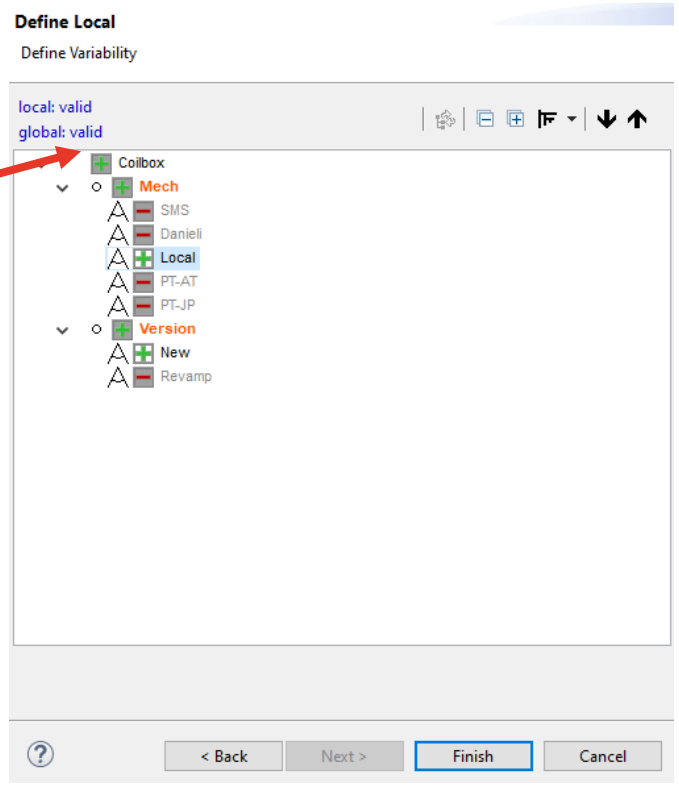
Heterogeneous Multi-Dimensional Variability Modeling in Cyber-Physical Production Systems (Dissertation Sayyid Fadhlillah)

- Main Focus of CDL VaSiCS (https://www.jku.at/en/cdl-vasics/)
- Configure/Generate Target Artifacts such as Control Software Code, XML files









Contact: Rick Rabiser

Better Control Software Design (Dissertation Lisa Sonnleithner)

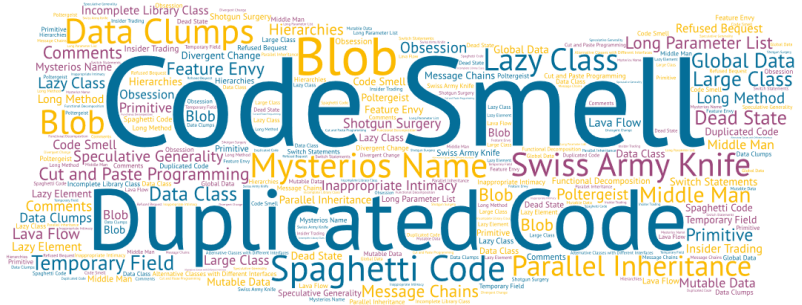
- Work of CDL VaSiCS (https://www.jku.at/en/cdl-vasics/) and EU Project 1-SWARM (https://www.jku.at/en/lit-cyber-physical-systems-lab/research/research-projects/1-swarm)

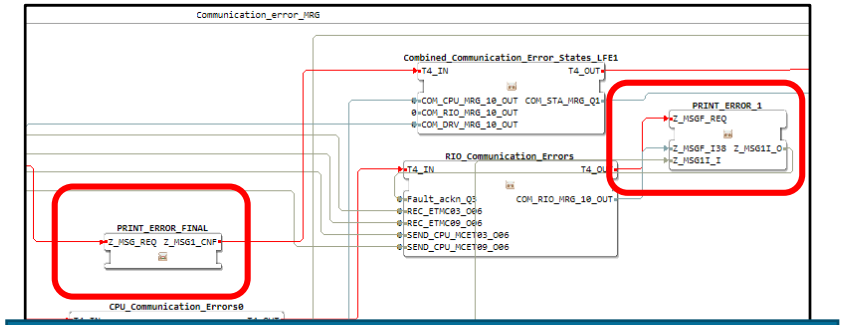
- Cooperation (among others) with Primetals Technologies (CDL) and multiple partners in the EU-Project (see https://cordis.europa.eu/project/id/871743)

- Bad Smells, Metrics, Design Patterns, etc. for CPPS

IEC 61499 Bad Smells Catalog

Name	Level	Description	Impl.
Duplicated Code	ALL	The same or similar code appearing more than once.	N
Long Algorithm	FB	An algorithm that is too long and complex.	N
Large Type	FB	An FB type that is too large and complex.	N
Large Interface	FB	Too many interface elements.	N
Divergent Change	FB	One change leading to many changes within the same FB type.	N
Shotgun Surgery	FB	One change leading to changes in many different FB types.	N
Feature Envy	ALL	An IEC 61499 component having high cohesion to another that should not be coupled tightly.	N
Data Clumps	FBN	A group of interface elements that always appear together.	N
Lazy Element	ALL	An IEC 61499 component without purpose (e.g., CFB only containing one FB).	N
Dead State	ECC	State (except start state) which does not have any input transitions or to which a path cannot be found from the EC initial state by following the directed links.	Y
Dead Transition	ECC	Transition with lower priority than the 1 transition condition	Y
Dead FB	FB	FB (except start FB) which does not have any input event connections.	Y
Terminal State	ECC	State that is reachable, but which does not have any outgoing EC transitions.	Y
Unused Event	FB	Event input/output of the FB type containing the ECC that is not used in any EC transitions.	Y
Unused Data	FB	When the particular input event is connected, the associated data input is unconnected or not configured.	Y
Mutable Data	ALG	The algorithm writes on a data input.	N
Dead Event	FB	An event that is not used in the transition condition of any stable ECC state and is thus always ignored.	N





Improve SW Quality

Improve Understandability

Reduce Maintenance Effort

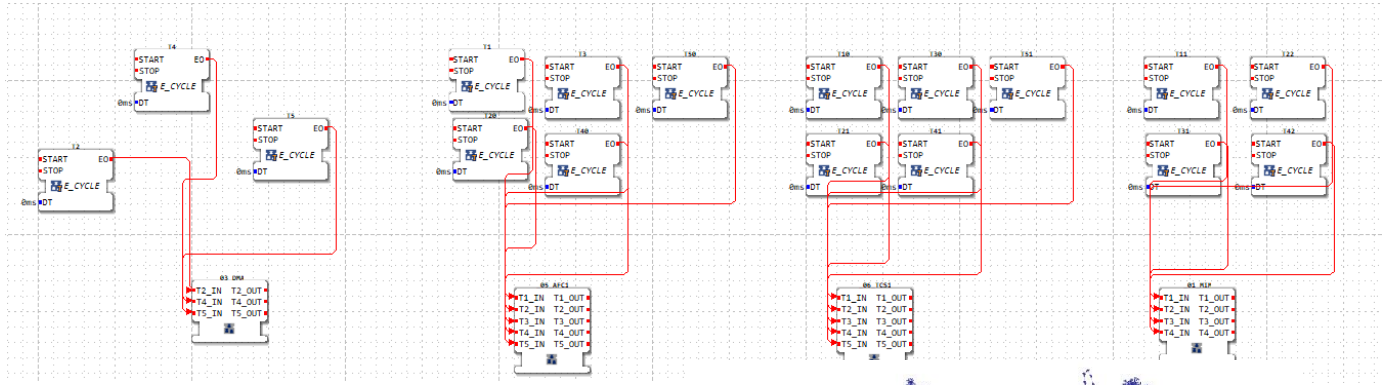
Contact: Alois Zoitl

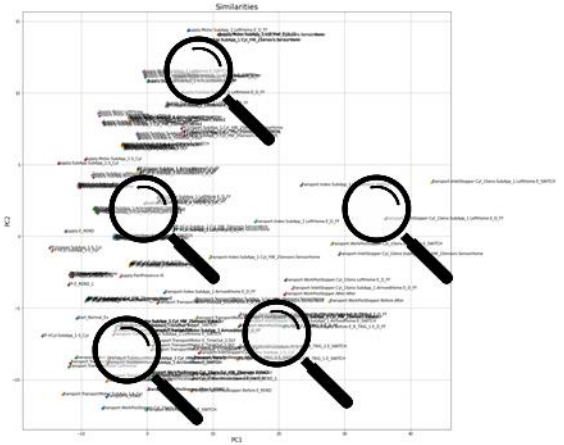
JKU LINZ INSTITUTE OF TECHNOLOGY

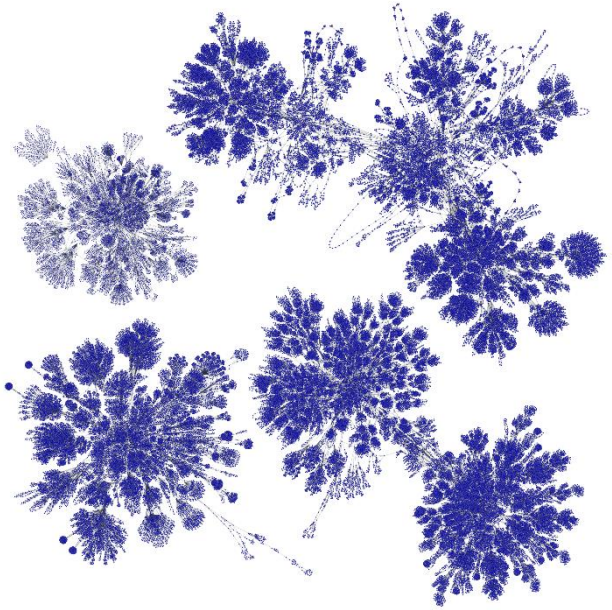
Christian Doppler Lab VaSiCS

Graph Mining from (4diac/IEC 61499) function block networks (MT Markus Unterdechler)

- Work of CDL VaSiCS (https://www.jku.at/en/cdl-vasics/)
- Clone detection/Similarity analysis
- Modularity analysis
- Variability mining

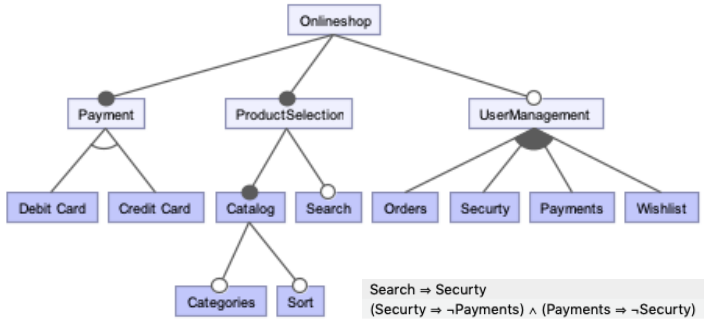






TRAVART: An Approach for Transforming Variability Models (Dissertation Kevin Feichtinger)

- https://github.com/SECPS/TraVarT
- Coop. with TU Vienna



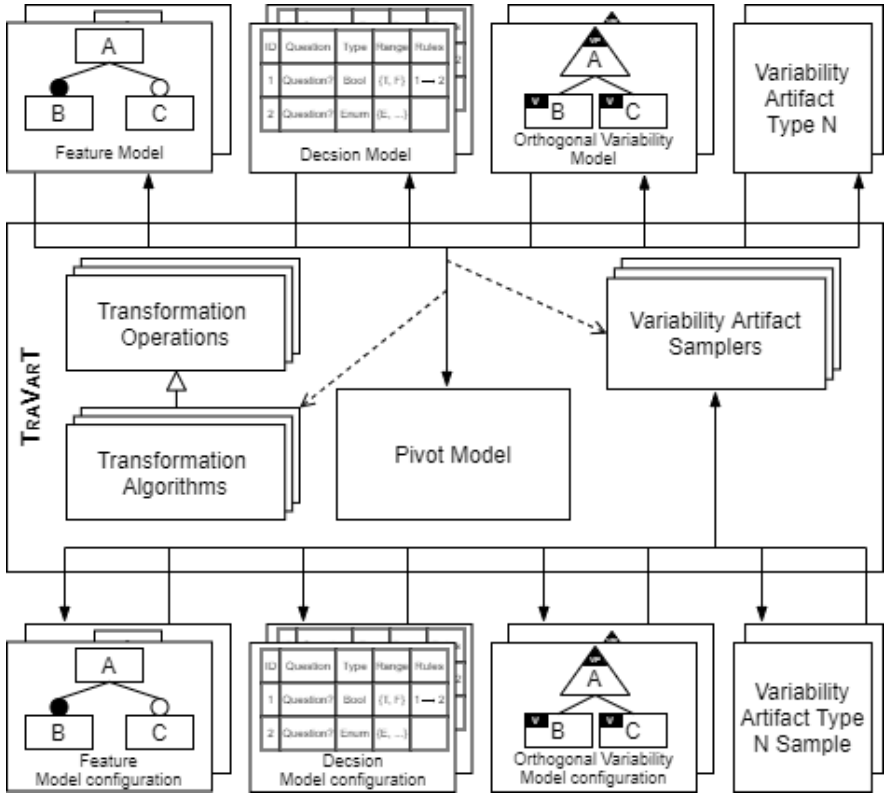

```
menu "Power management and ACPI options"
  depends on !X86_VOYAGER

  config PM
    bool "Power Management support"
    depends on !IA64_HP_SIM
    ---help---
        "Power Management" means that ...

  config PM_DEBUG
    bool "Power Management Debug Support"
    depends on PM

  config CPU_IDLE
    bool "CPU idle PM support"
    default ACPI

  config PM_SLEEP
    bool
    depends on SUSPEND || HIBERNATION ||
               XEN_SAVE_RESTORE
    default y
...
endmenu
```



Thank you!

https://www.jku.at/lit/cps-lab

Prof. Rabiser / Prof. Zoitl
Christian Doppler Lab VaSiCS
LIT | Cyber-Physical Systems Lab
Johannes Kepler University Linz

PRIMETALS TECHNOLOGIES
ober österreich
Federal Ministry
Republic of Austria
Digital and
Economic Affairs