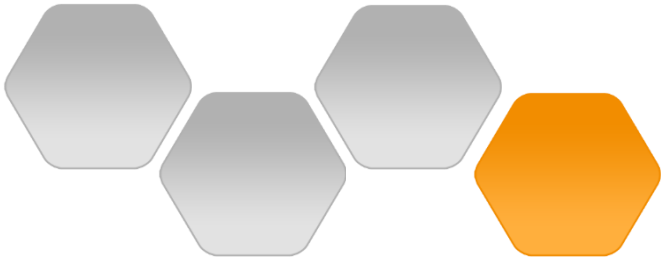


Unterstützung flexibler Lehr- und Lernmethoden in der Ingenieursausbildung durch das Online-Lab Netzwerk „goldi-labs.net“

K. Henke, H.-D. Wuttke, T. Vietzke, R. Hutschenreuter, S. Fincke

Grundfragen Multimedialen Lehrens und Lernens – GML² 2016
Center für Digitale Systeme (CeDiS)
Berlin, Deutschland, 10.-11.03. 2016

Integrated Communication Systems Group
Ilmenau University of Technology

Ilmenau University of Technology

Ilmenau
Thuringia
Germany

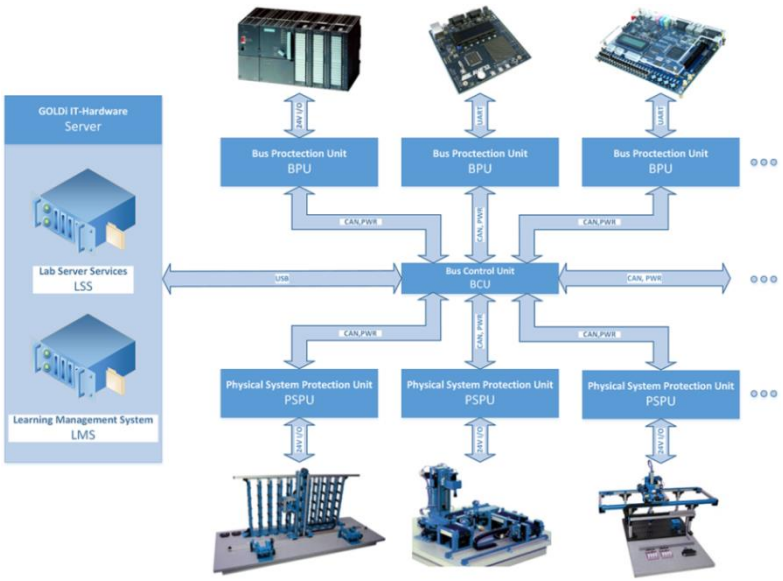
Ilmenau University of Technology

TECHNISCHE UNIVERSITÄT ILMENAU

- **Campus University**
- **7.000 students**

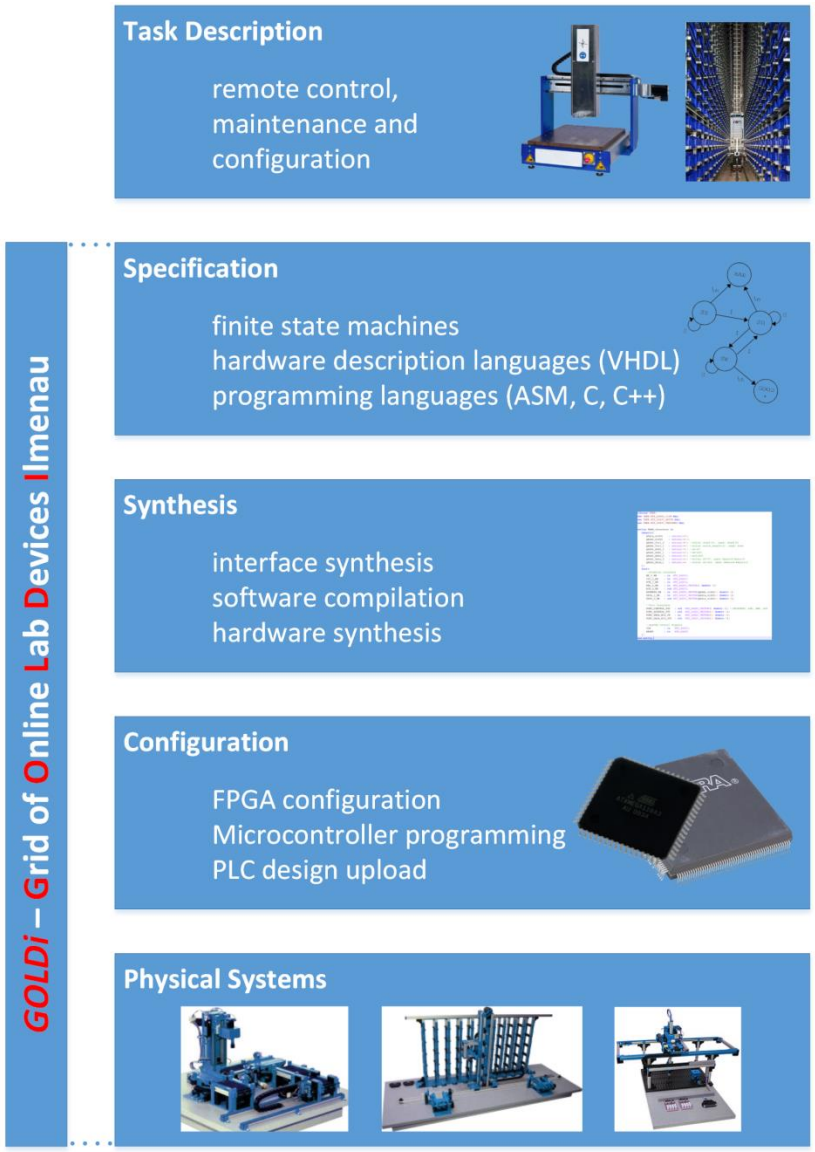
Outline

- Motivation
- Architecture of the IUT Hybrid Online Lab *GOLDi*
  - Server side infrastructure
  - Client side infrastructure
  - GIFT – Graphical Interactive Finite State Machine Toolset
- *GOLDi* experiment configuration
- *GOLDi* labs cloud
- *GOLDi* booking system
- Conclusions / Future work
- Questions



www.goldi-labs.net

GOLDi - Designflow



GOLDi

Grid of
Online
Lab
Devices
Ilmenau

www.goldi-labs.net

GOLDi - Designflow

Task Description

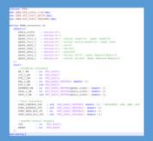
remote control,
maintenance and
configuration

Specification

finite state machines
hardware description languages (VHDL)
programming languages (ASM, C, C++)

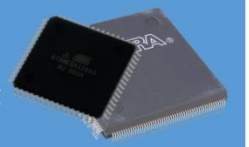
Synthesis

interface synthesis
software compilation
hardware synthesis



Configuration

FPGA configuration
Microcontroller programming
PLC design upload



Physical Systems

GOLDi – Grid of Online Lab Devices Ilmenau

Different specification techniques

GOLDi - Designflow

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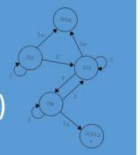

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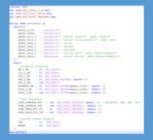

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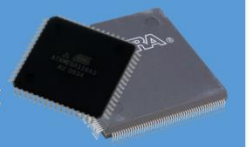

Physical Systems

GOLDi – Grid of Online Lab Devices Ilmenau

Tool support

GOLDi - Designflow

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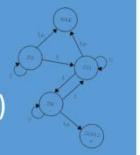

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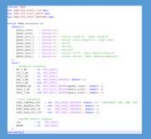

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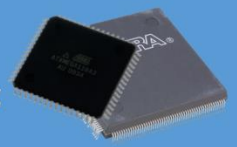

Physical Systems

GOLDi – Grid of Online Lab Devices Ilmenau

Different HW platforms

GOLDi - Designflow

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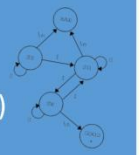

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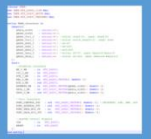

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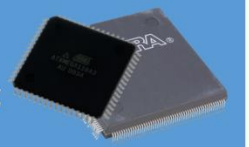
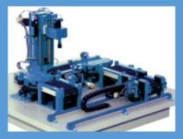
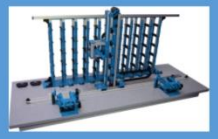


Physical Systems





GOLDi – Grid of Online Lab Devices Ilmenau

Physical systems in the remote lab

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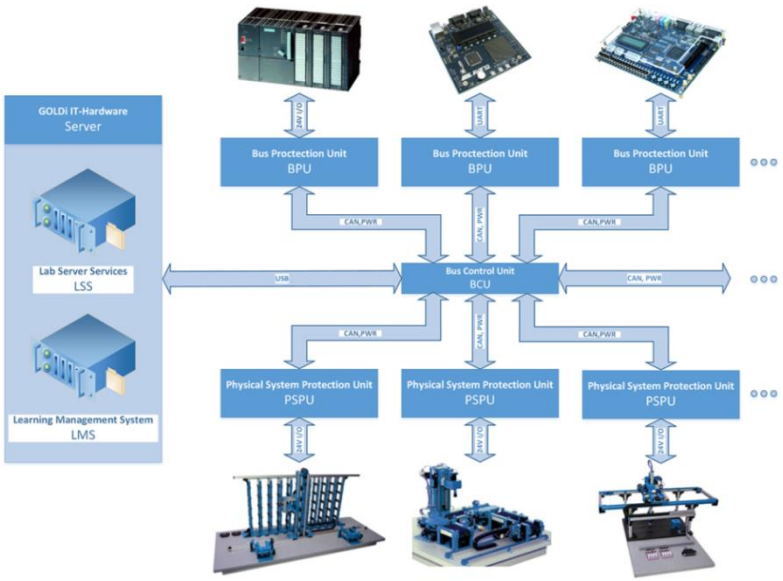
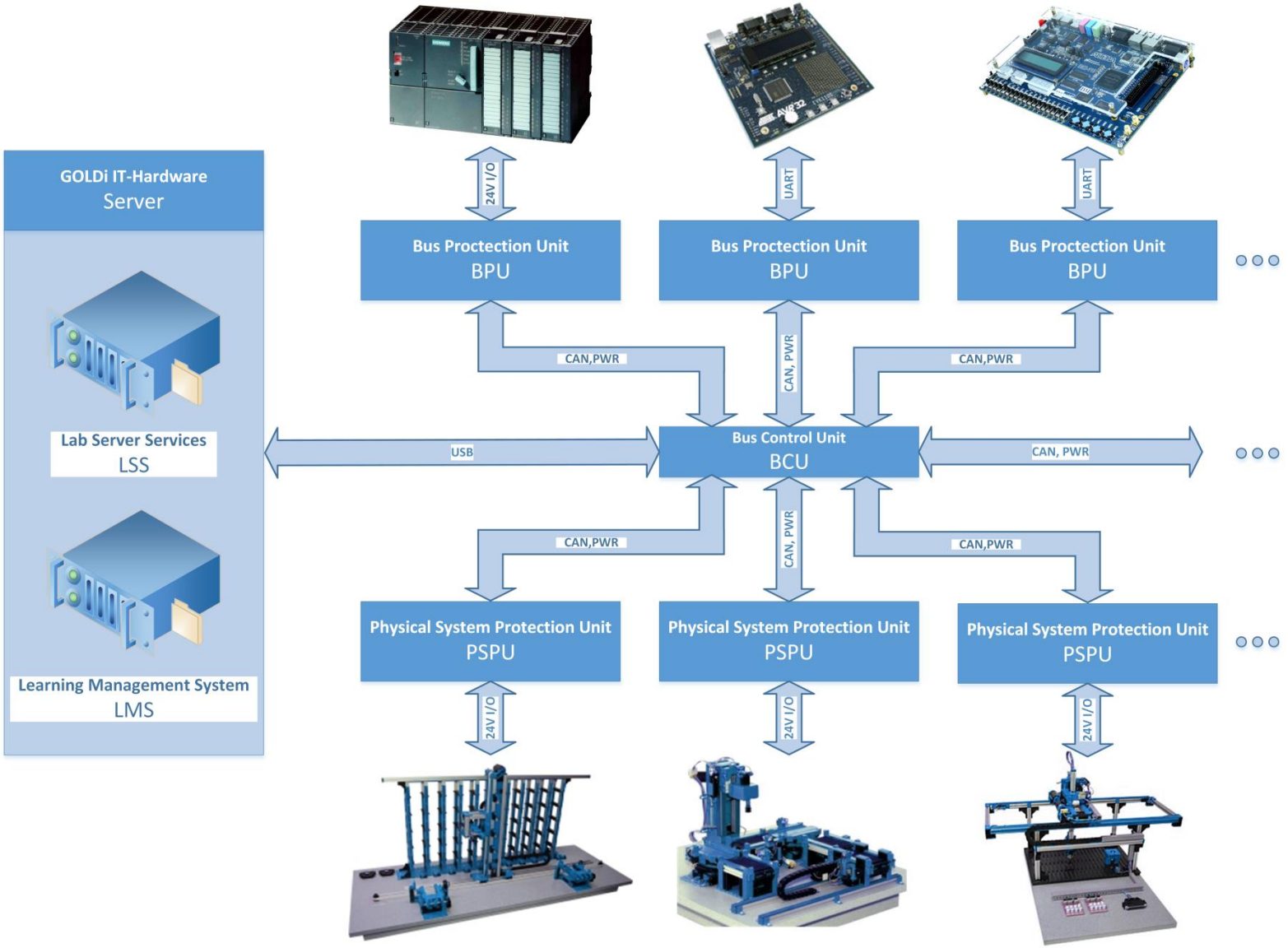


GOLDi – Remote Lab Infrastructure



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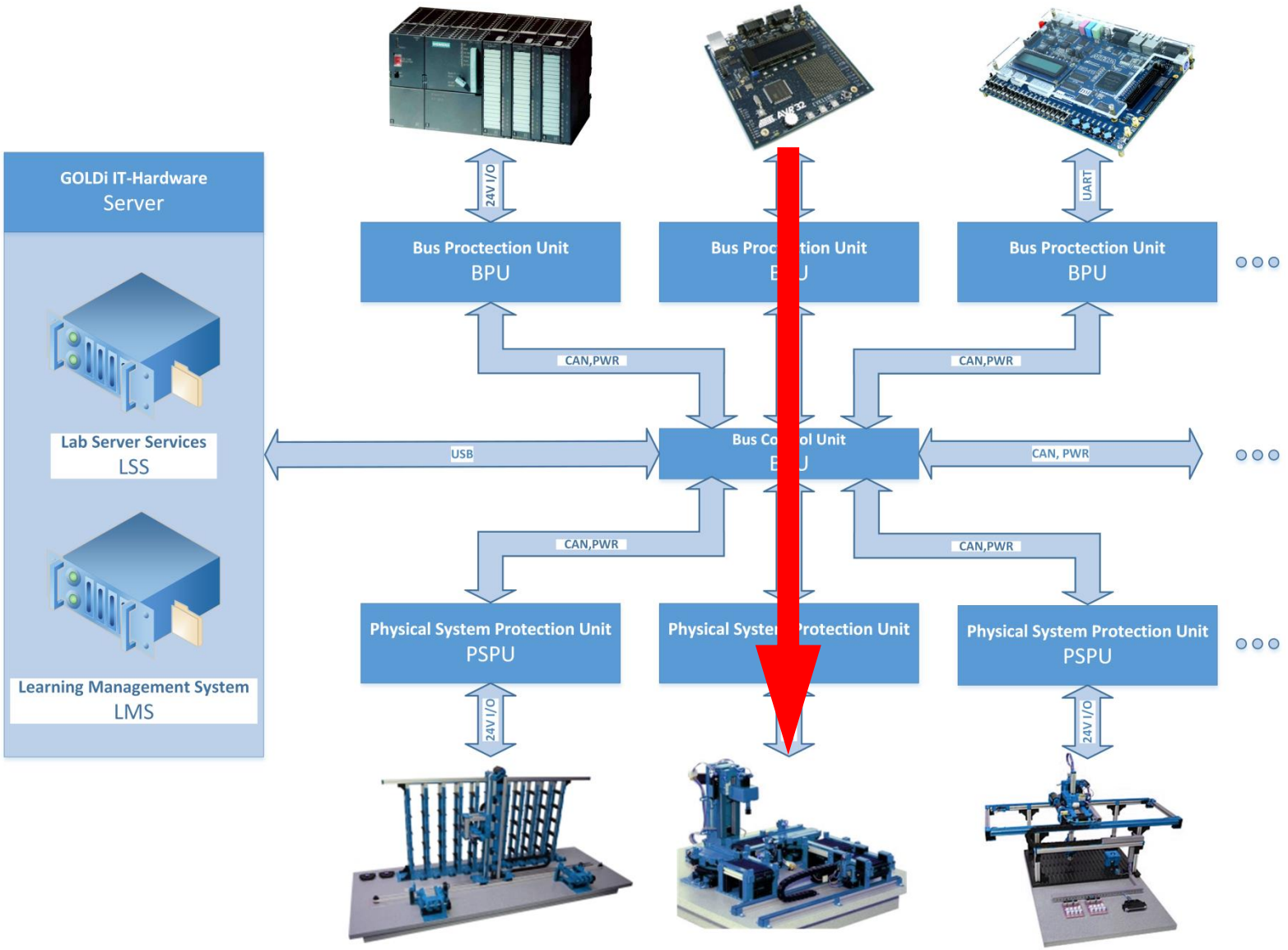

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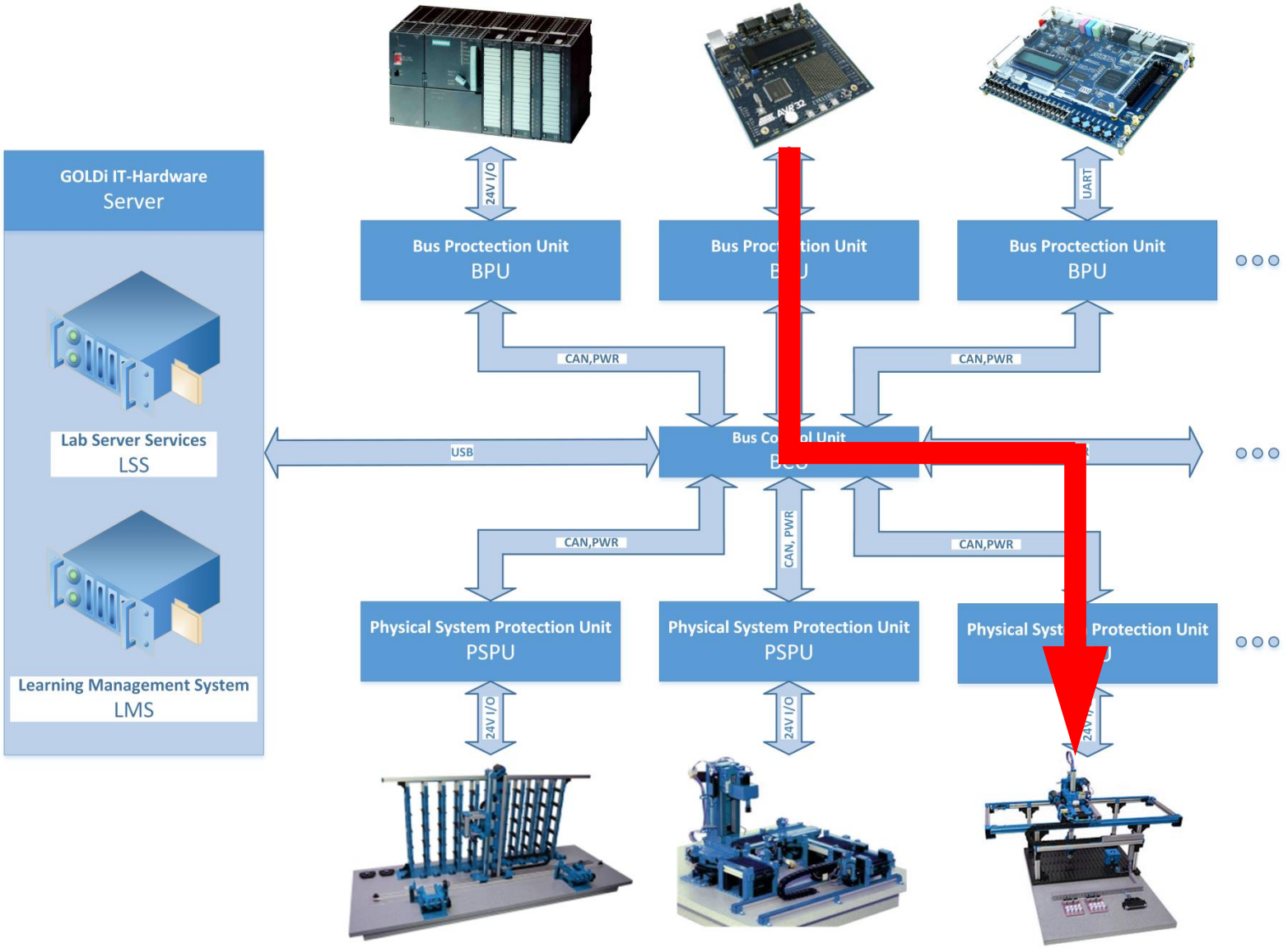

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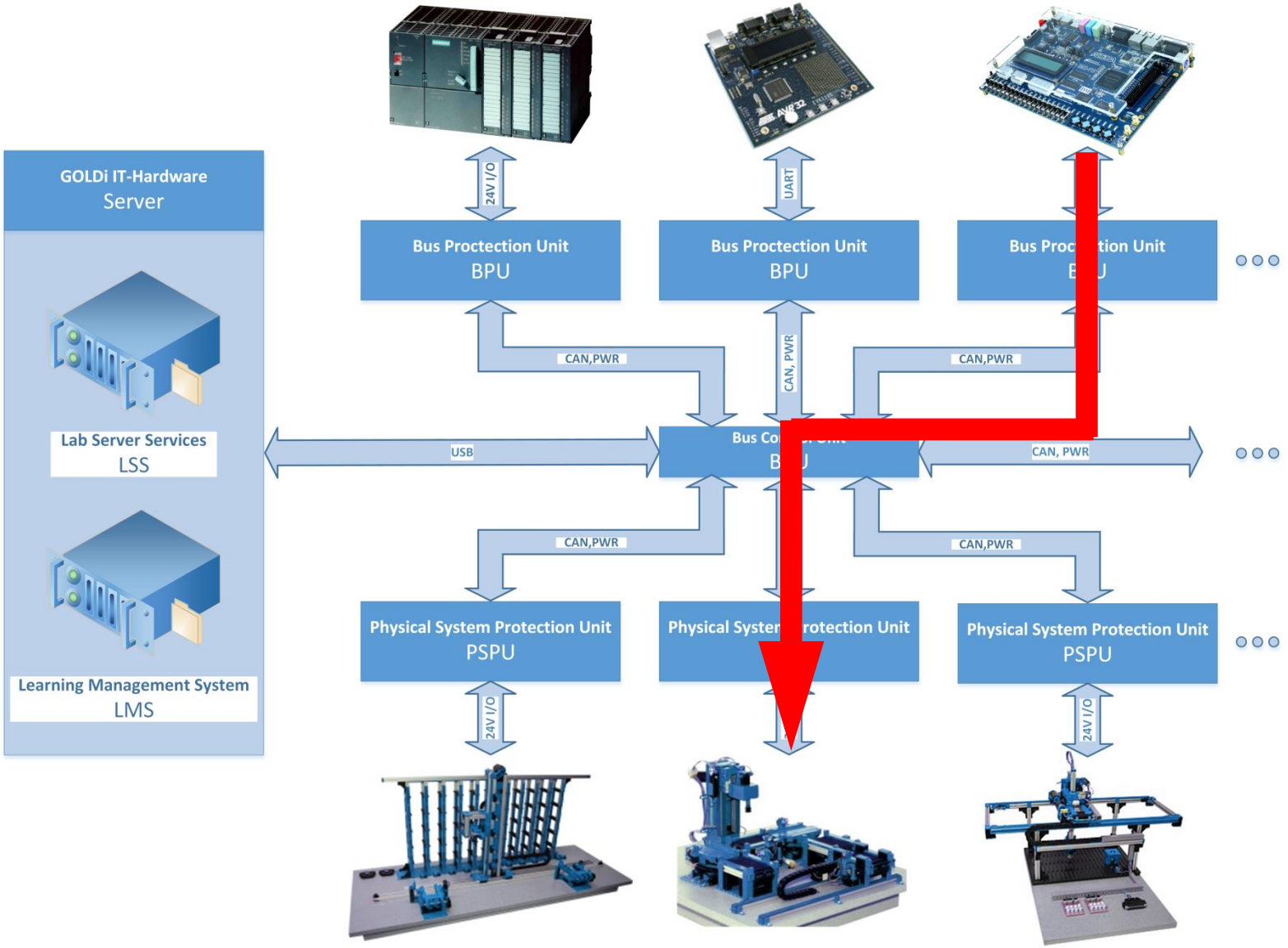
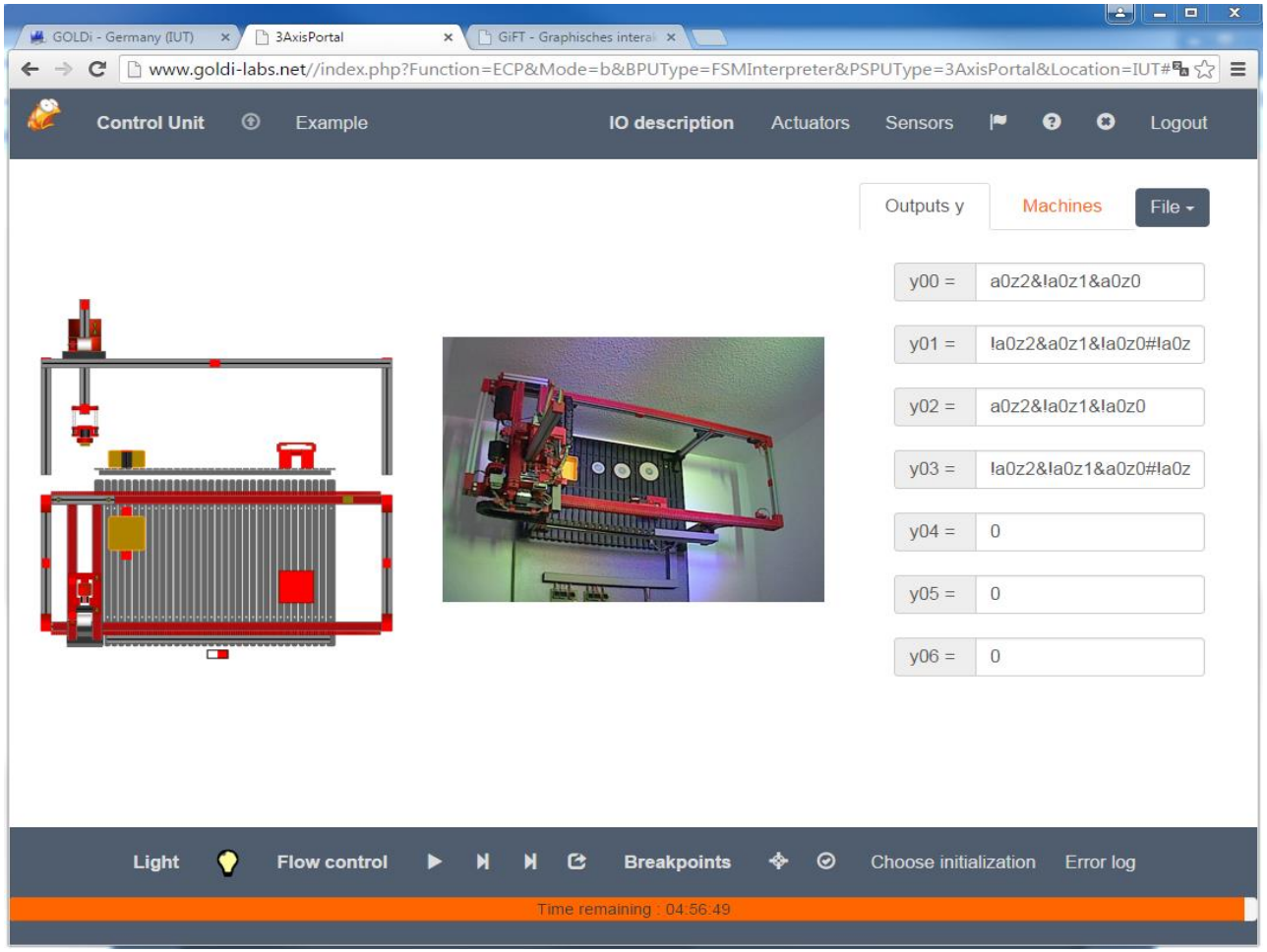


ECP – the Experiment Control Panel

- Realized as HTML5, JavaScript, Web socket application



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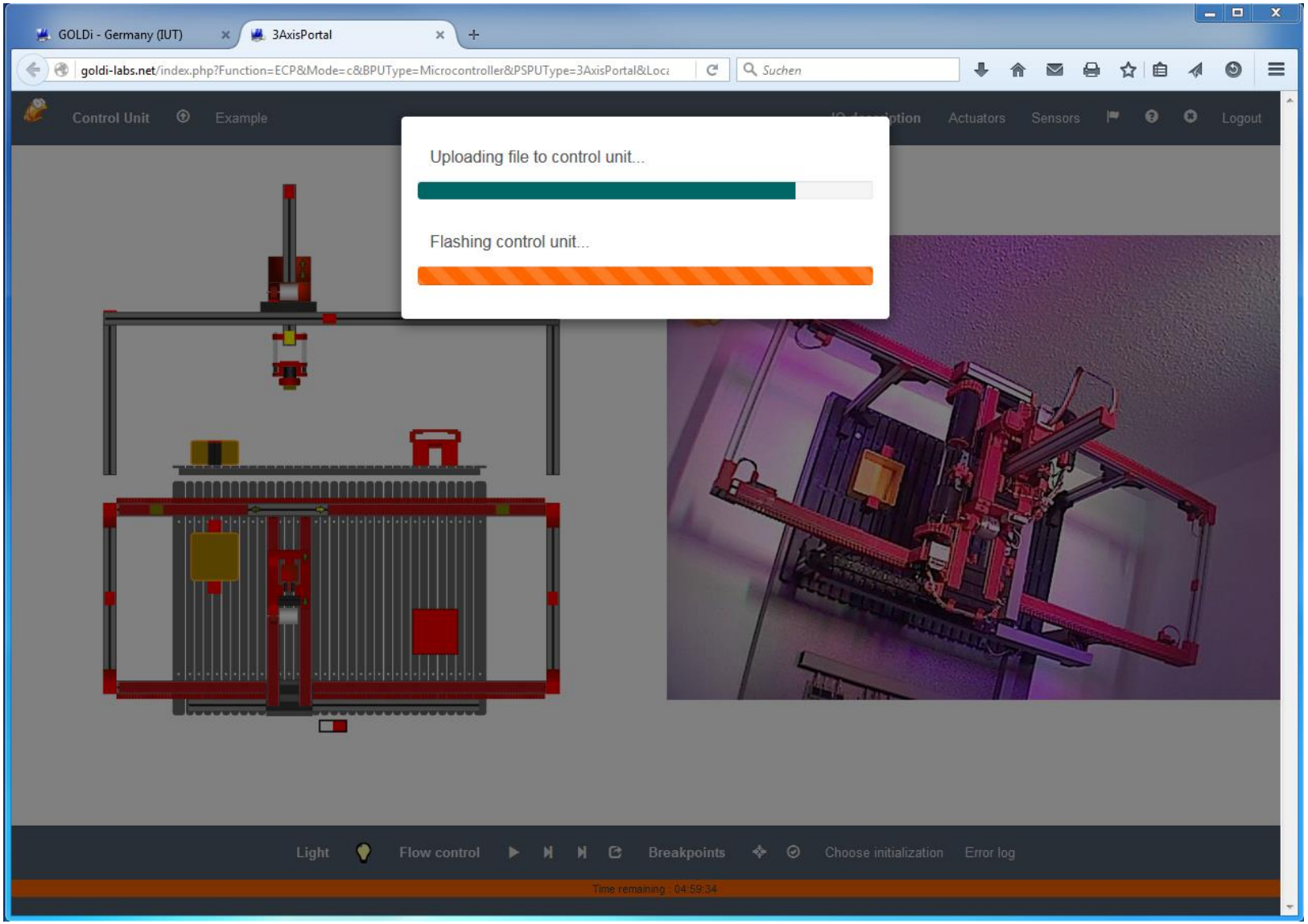

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  - upload the synthesized/compiled designs in the lab room,
  - handle the experiment (e.g., start, stop, reset),
  - use the interactive debugging features (break on sensor/actuator changes or special conditions),
  - single step processing, by pausing the execution on every sensor/actor change,
  - change environmental variables if necessary and
  - watch the experiment by manipulating variables inside an I/O monitor

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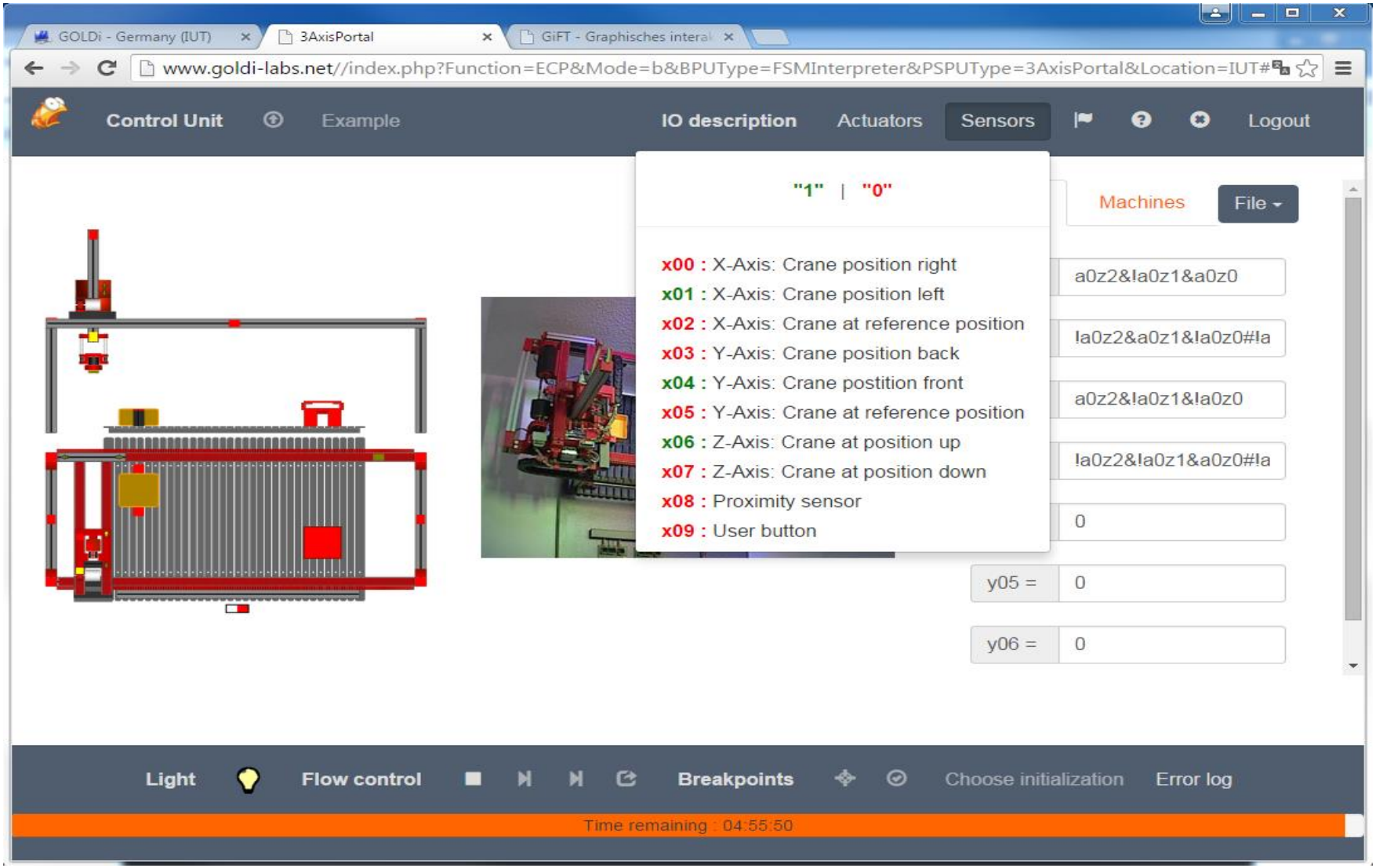

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  - observe the control of the physical system directly via a webcam.

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  - single step processing, by pausing the execution on every sensor/actor change,
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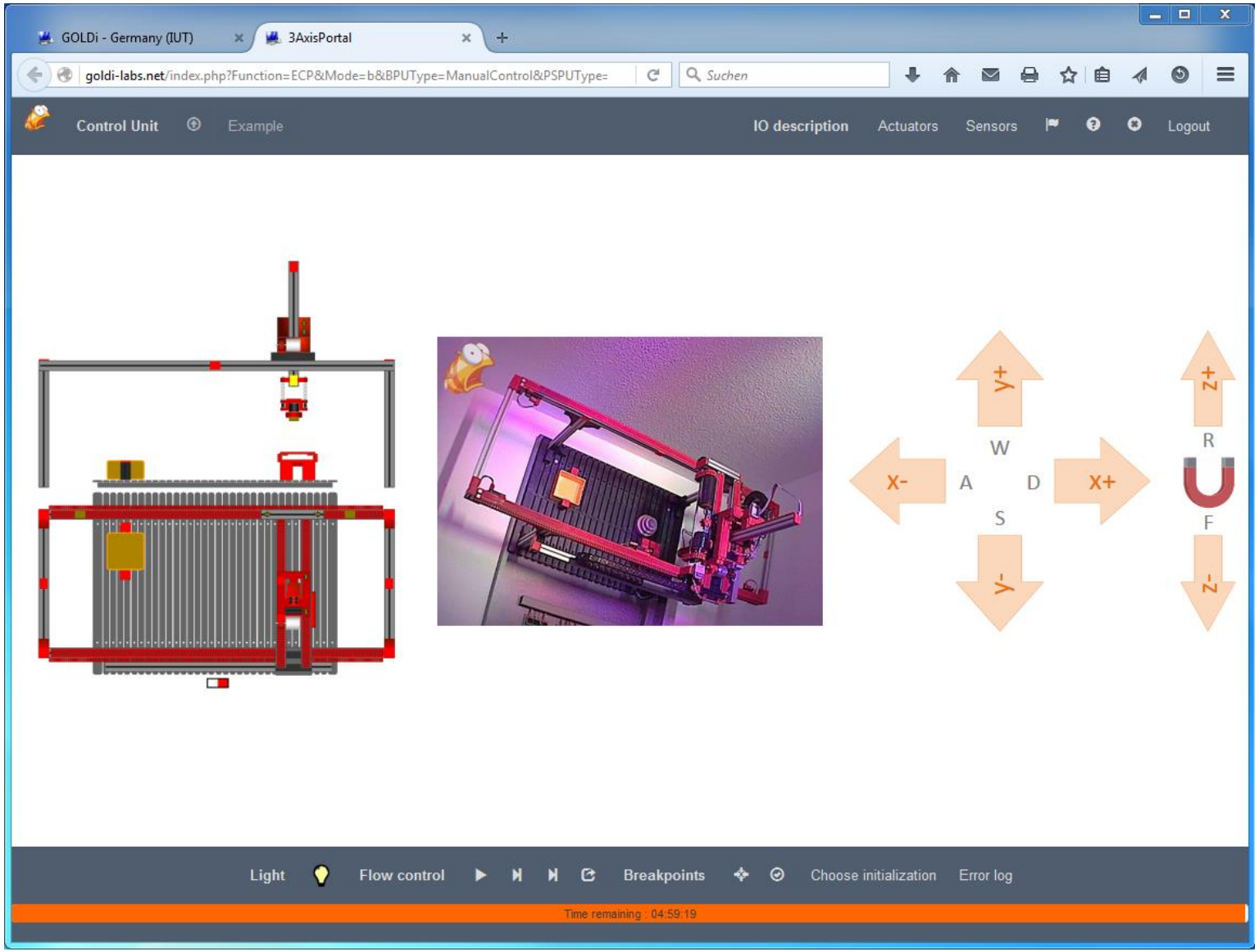
  - observe the control of the physical system directly via a webcam
  - choose an individual initial situation for the experiment.

ECP – the Experiment Control Panel



Outline

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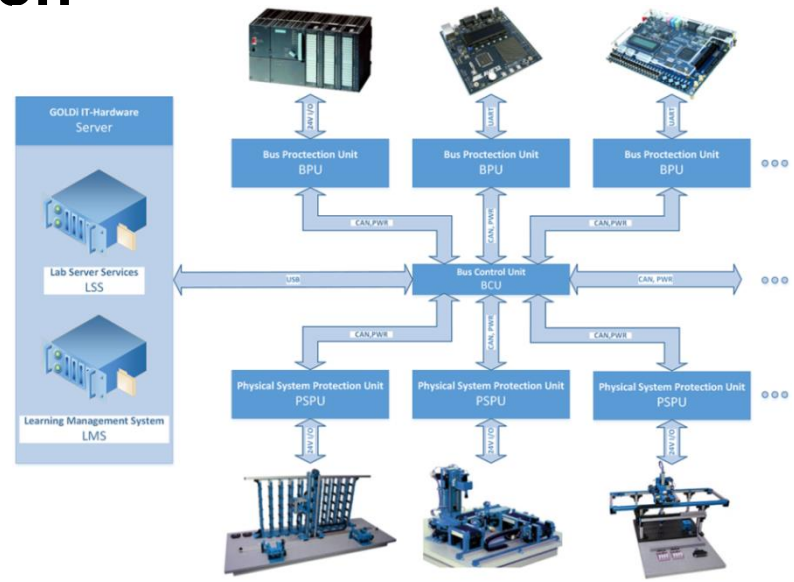


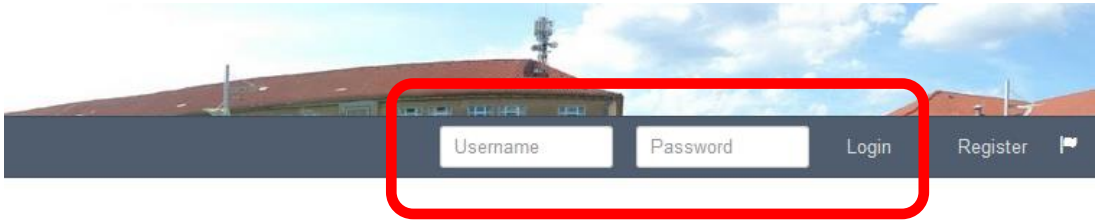
GOLDi Experiment Configuration

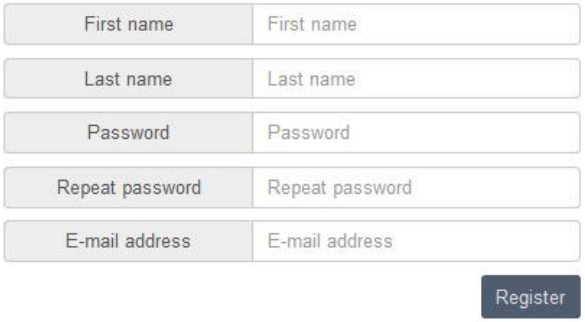
(1) Authentication mechanisms:

a) login via the university LDAP user account,

b) login after an individual registration,

c) login via the eduroam login mechanism (coming soon)





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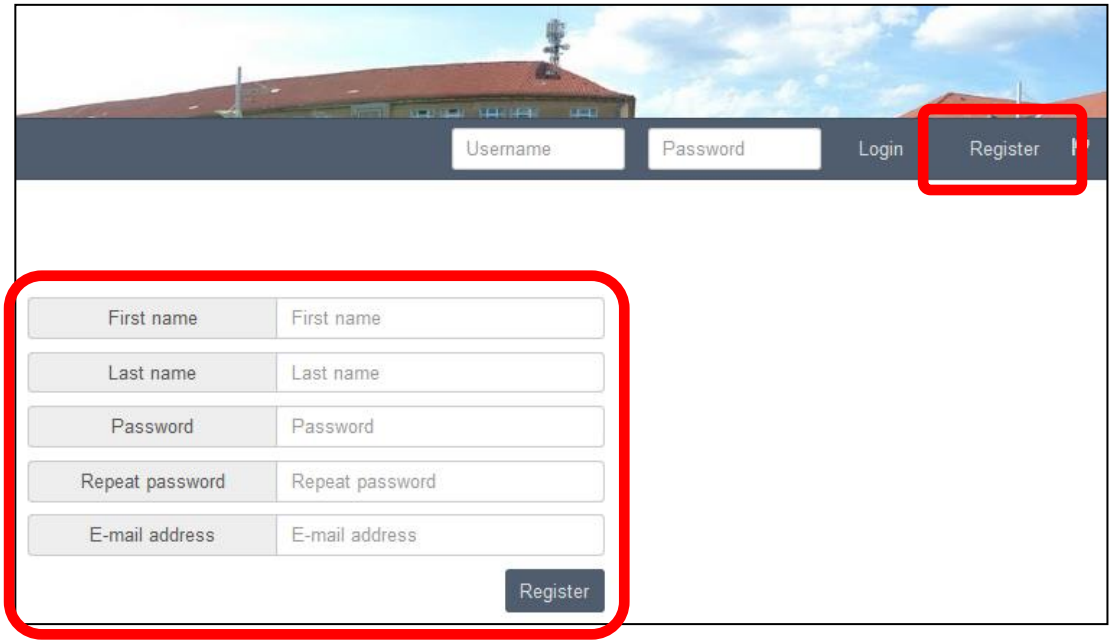

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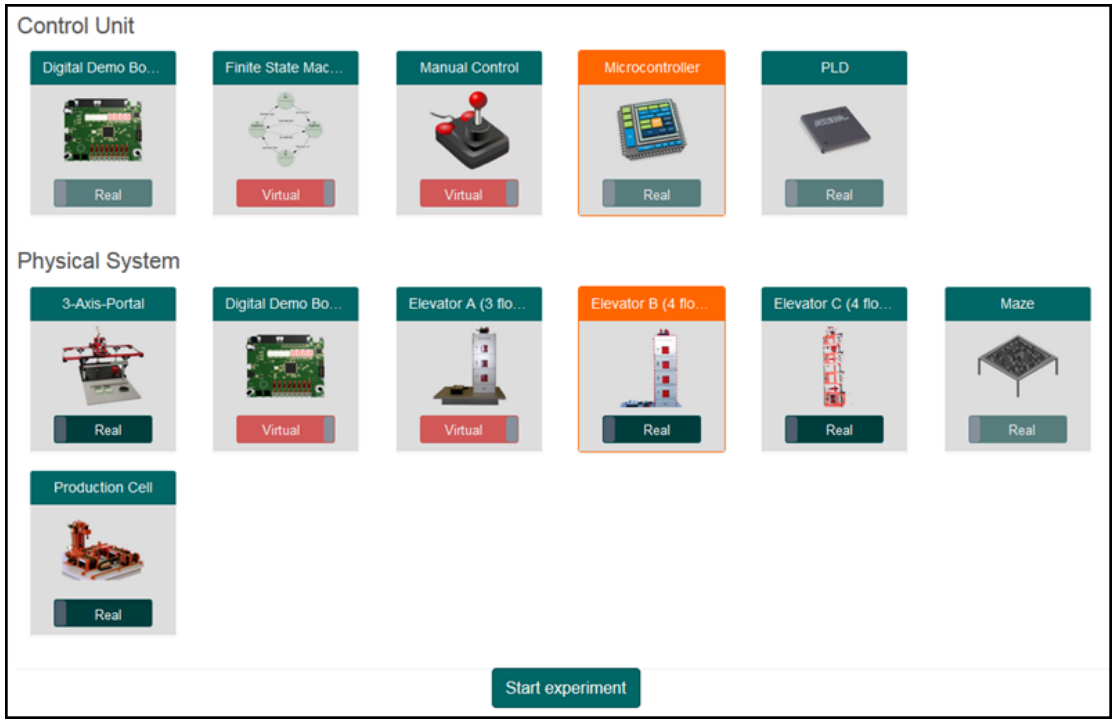
GOLDi Experiment Configuration

(2) Each experiment consist of two components:

- **control units**
- electromechanical **physical systems**, which can be used
  - as **real** physical system

  - as **virtual** model



GOLDi Experiment Configuration

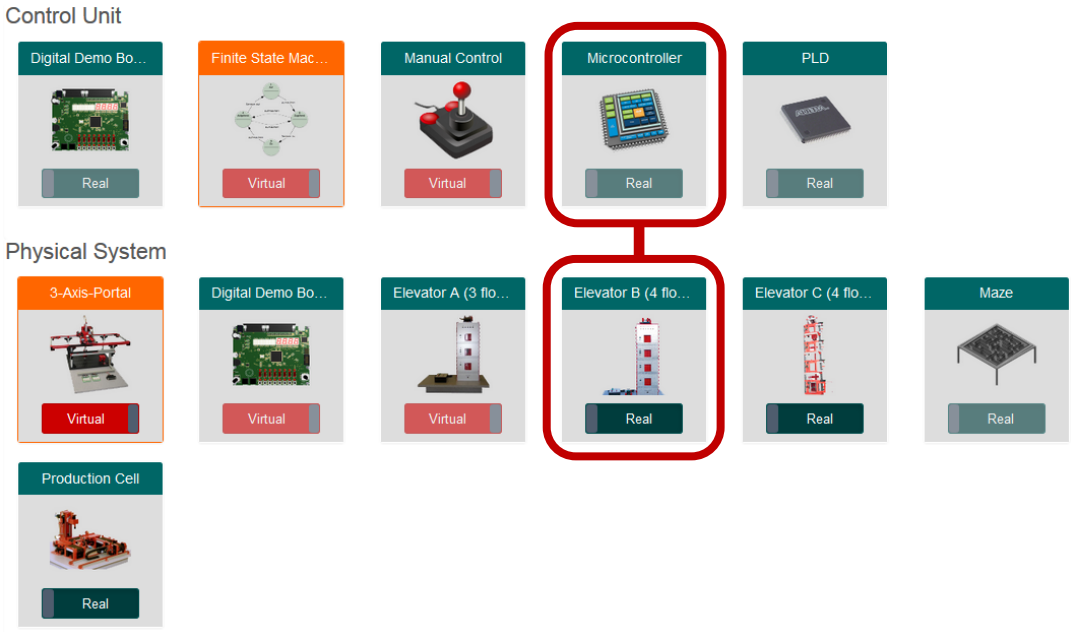
a) FSM based experiment configuration

- Finite State Machines (FSM) as specification
- in case of a virtual model
  - no Internet is necessary
  - especially for face-to-face lectures in classrooms
  - each student can work with the same physical system simultaneously

GOLDi Experiment Configuration

b) Microcontroller based experiment configuration

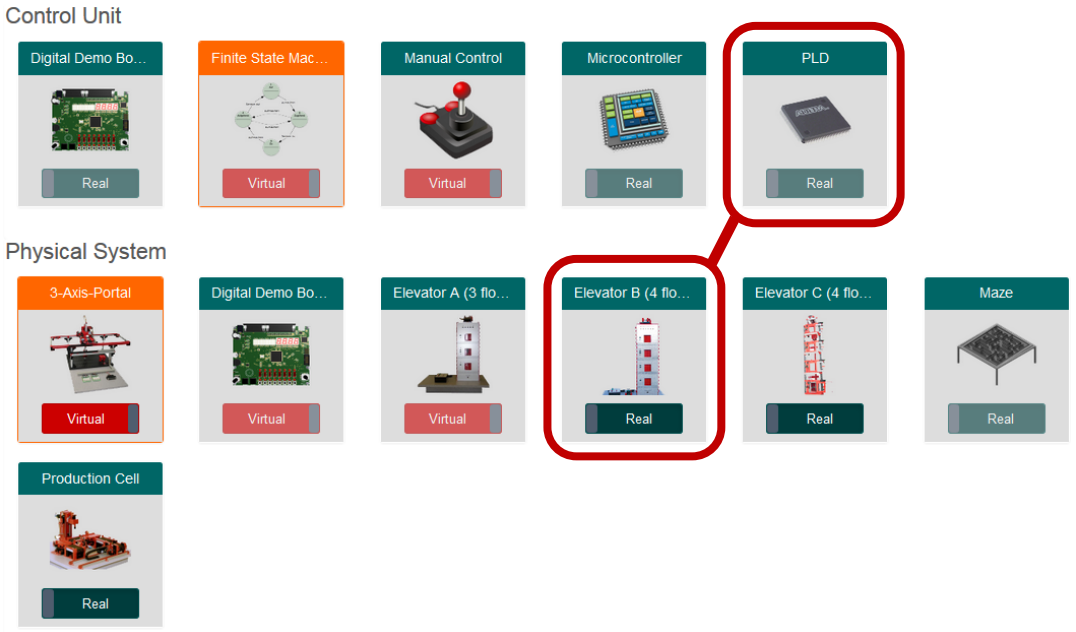
- for a software-oriented implementation
- by using common development tools (e.g. Atmel Studio)
- after compilation the hex code will be transferred into the remote lab
- programming in the background



GOLDi Experiment Configuration

c) PLD based experiment configuration

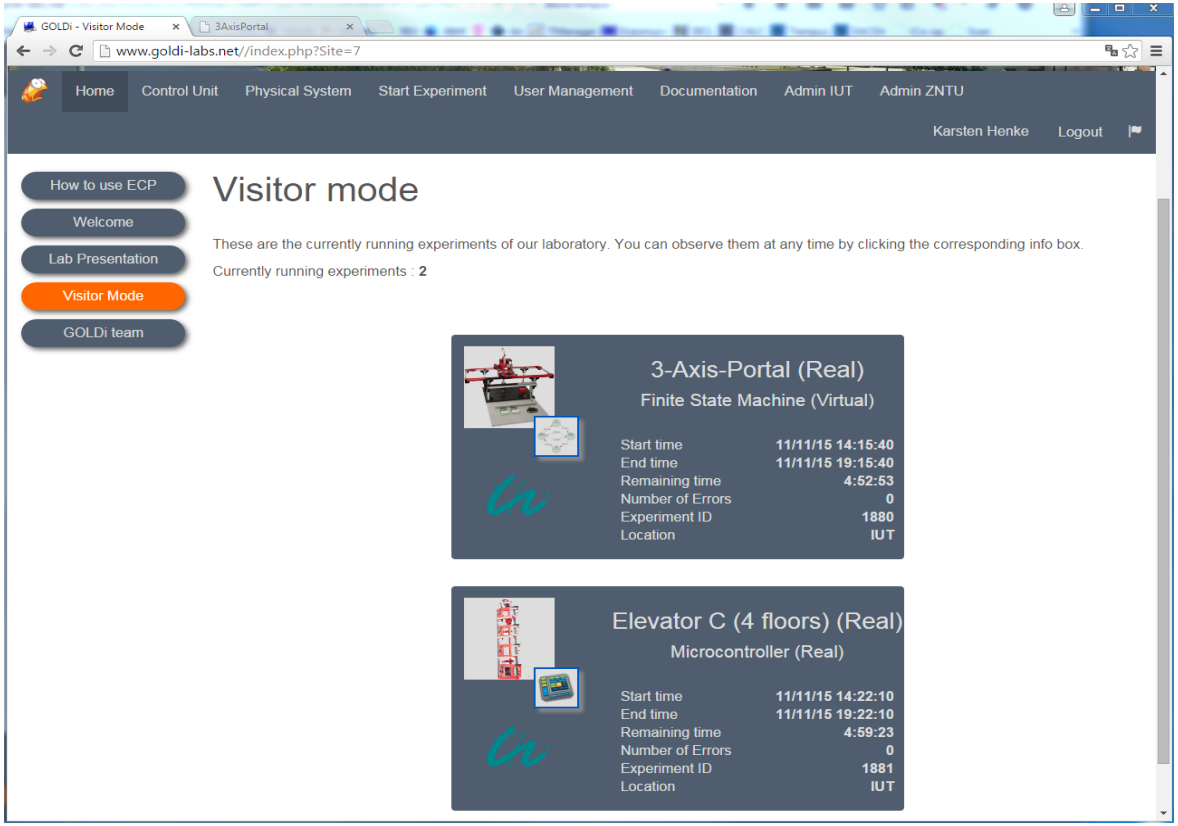
- for a hardware-oriented design using a FPGA
- hardware description languages (e.g. VHDL) as specification
- by using common development tools (e.g. Quartus)
- generated bit file is uploaded to the remote lab
- programming in the background



GOLDi Experiment Configuration

d) Watching an experiment as guest

- to observe running experiments
- without direct manipulation



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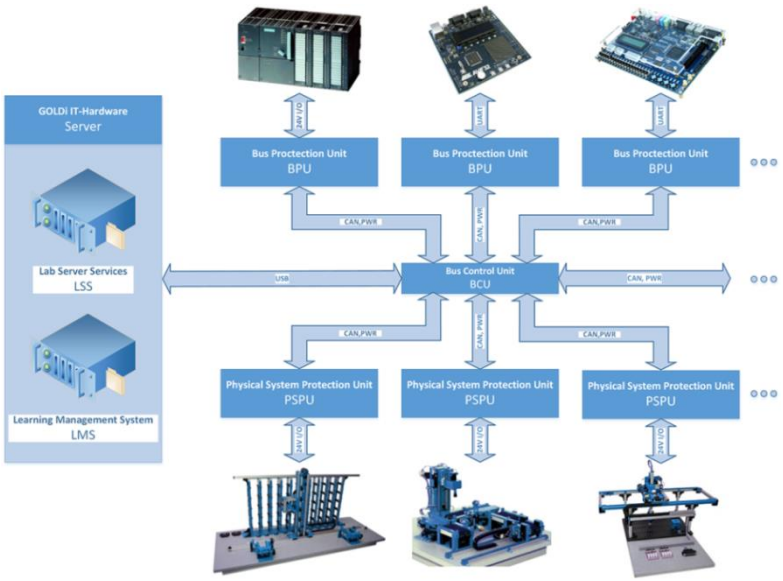


GOLDi Labs Cloud

- ***GOLDi*** infrastructure is used within two running TEMPUS projects (ICo-op and DesIRE)
- 10 *GOLDi* labs are running at universities in AM, GE and UA

➡ **huge problems in maintenance:**

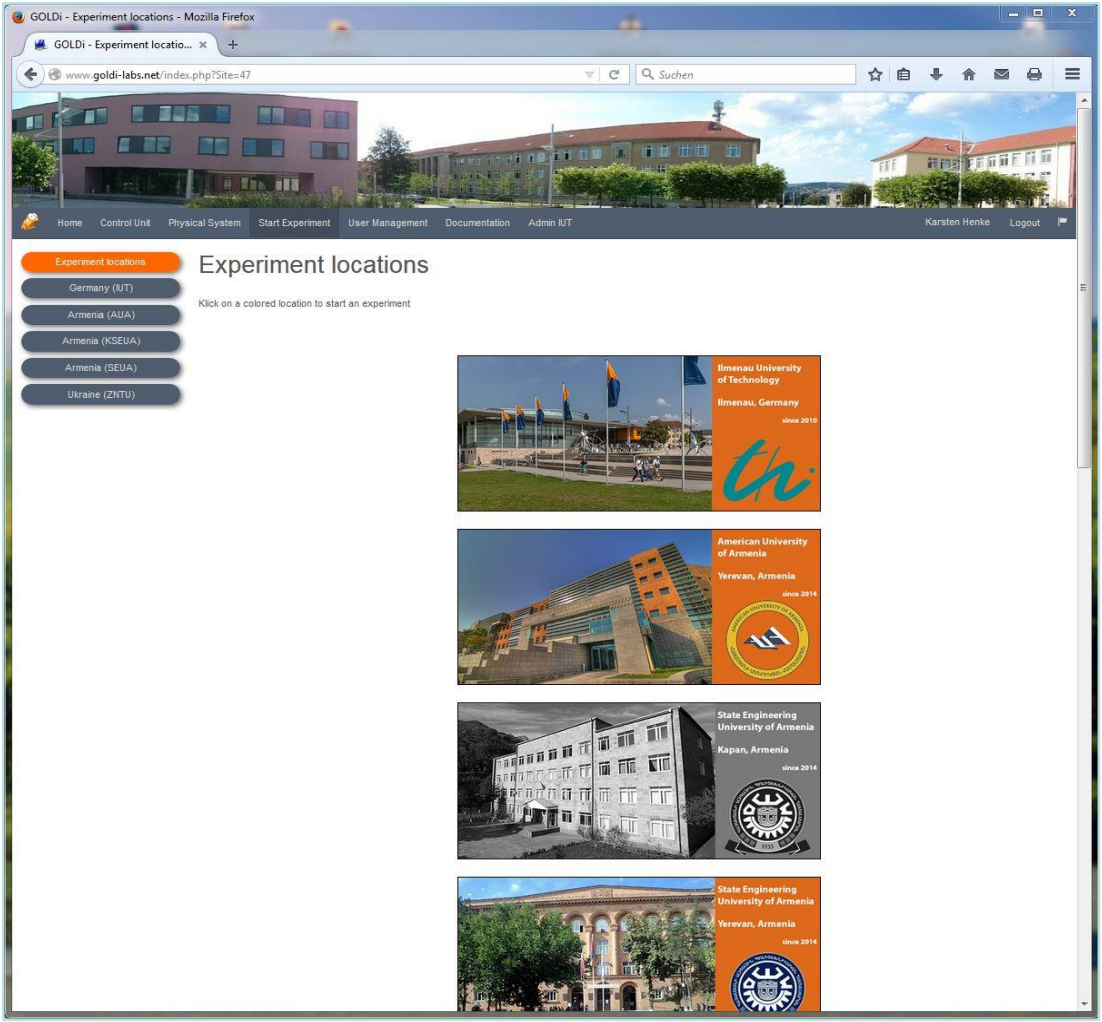
  - any new functionality or new firmware must be implemented manually on each partner website,
  - each institution has specific modifications according their own requirements,
  - each university has different network architectures,
  - each university has different remote lab configurations,
  - to have access to an experiment of the partner labs, a separate user account on the corresponding partner website is necessary.

➡ Each *GOLDi* partner has to handle the maintenance itself!

GOLDi Labs Cloud

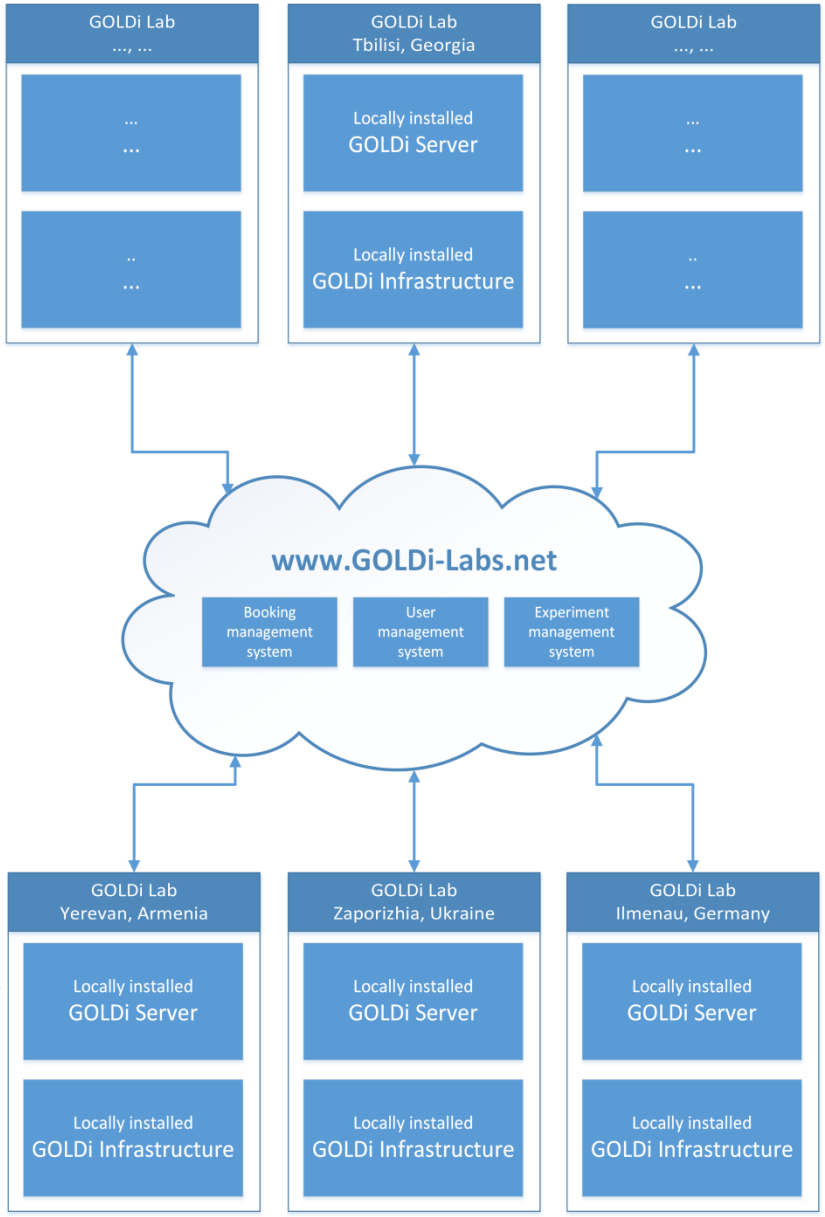
- necessary to reengineer the existing *GOLDi* network

- *GOLDi* cloud system
  - available *GOLDi* cloud servers are registered in the *GOLDi* cloud
  - “ready to use” servers are highlighted on the central *GOLDi* website **www.goldi-labs.net**



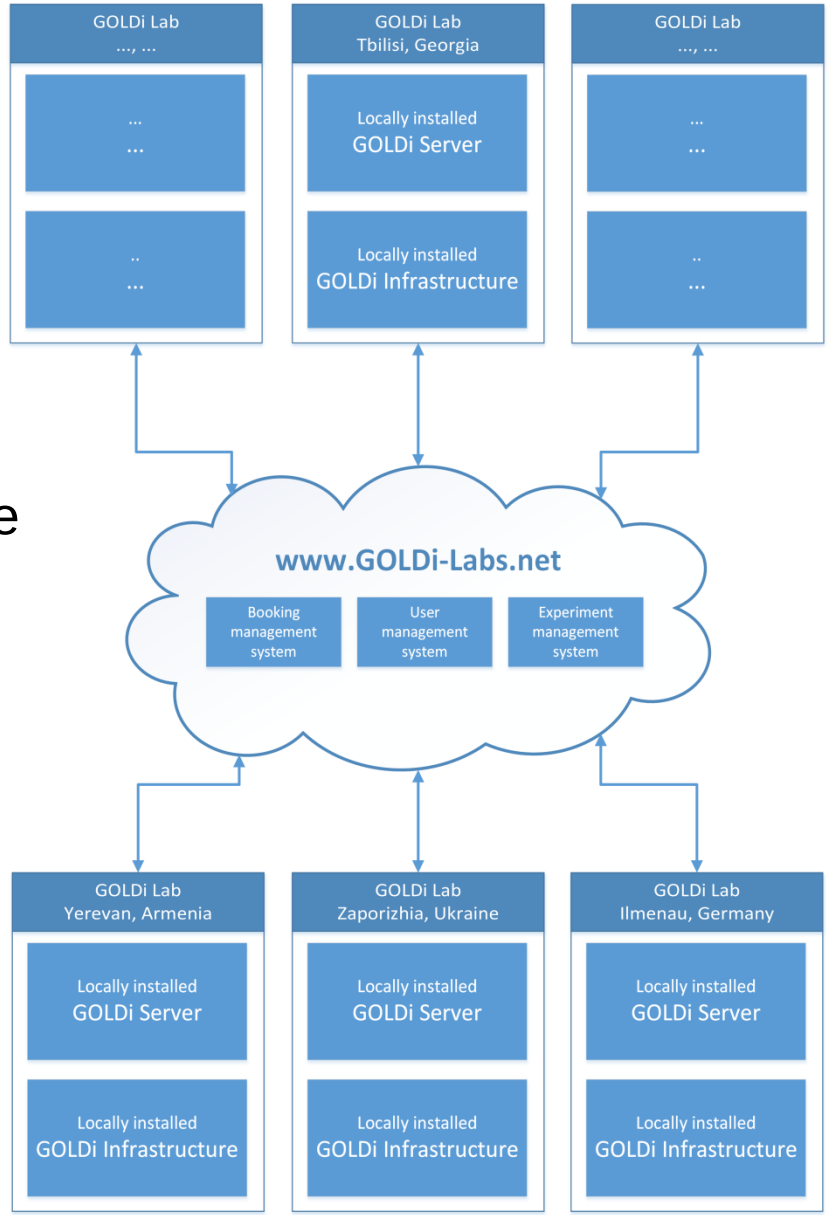
GOLDi Labs Cloud

- Maintenance of the whole system on one central location: goldi-labs.net,
- All partner universities have the same *GOLDi* version,
- New functionalities are immediately available for all partners,
- Usage of all partner labs with one central goldi-labs.net user account,
- The user can determine which lab has the lowest delay (best reaction time) regarding his current geographic position and internet connection,
- Overview about all running experiments in all partner labs worldwide with the possibility to observe these experiments



GOLDi Labs Cloud

- Each *GOLDi* client communicates with the *GOLDi* cloud for the
  - central user management
  - experiment management and the
  - booking management
- All privacy-relevant data of the cloud are located in the computing department of the Ilmenau University of Technology
- Each client application exchanges only the sensor/actuator signals directly with the local *GOLDi* infrastructure



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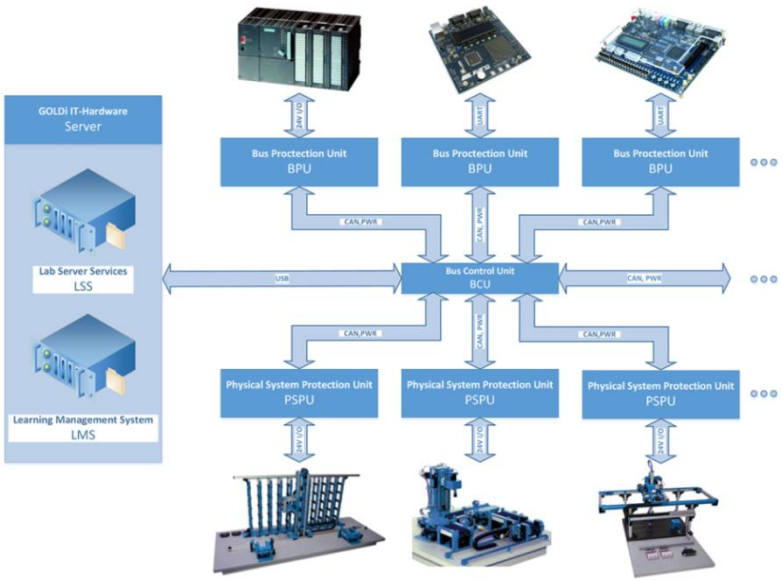
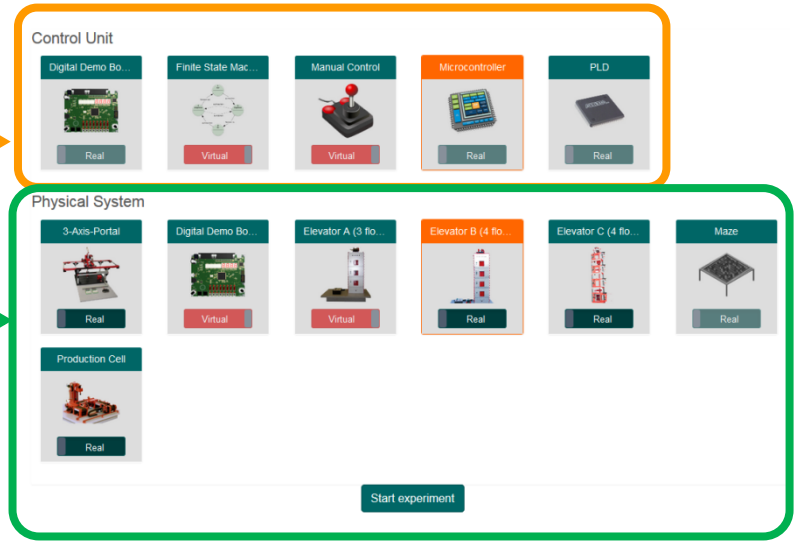


GOLDi Booking System

- Complex grid structure
  - various control units
  - electromechanical physical systems
    - as real hardware model
    - as simulated virtual model

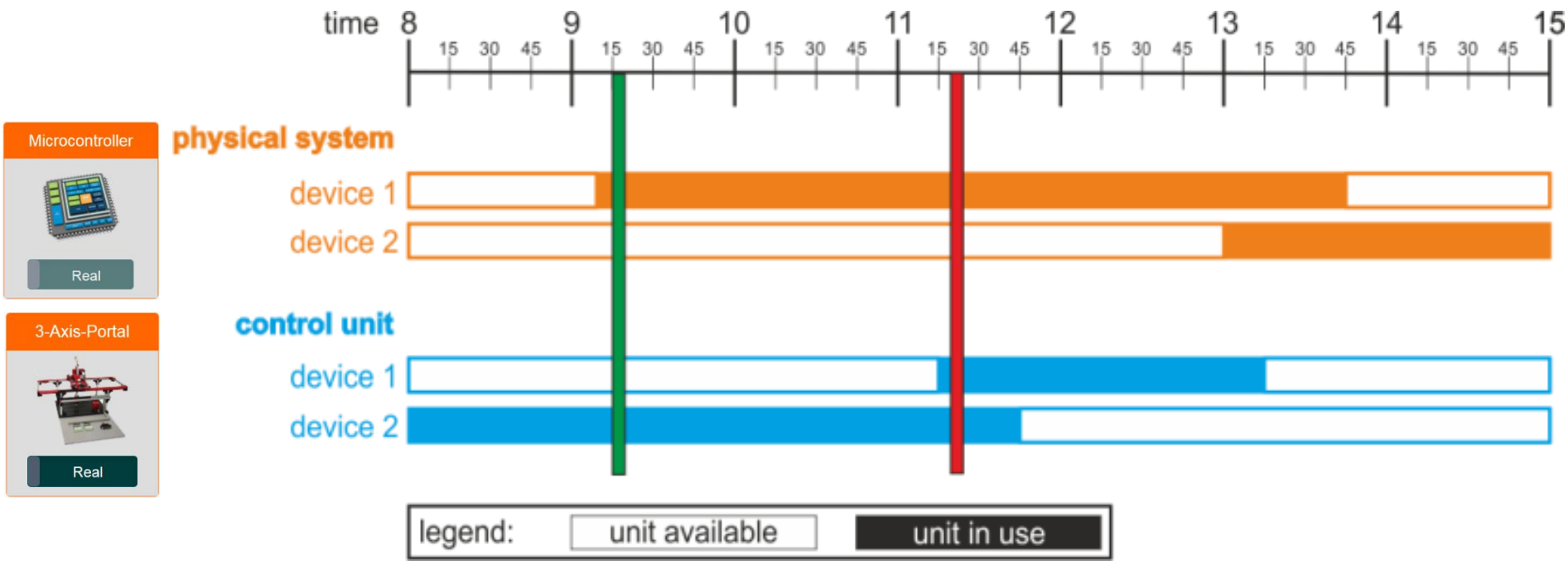


- Max. different experiments = control units x phys. systems

GOLDi Booking System

(1) Direct start mechanism:

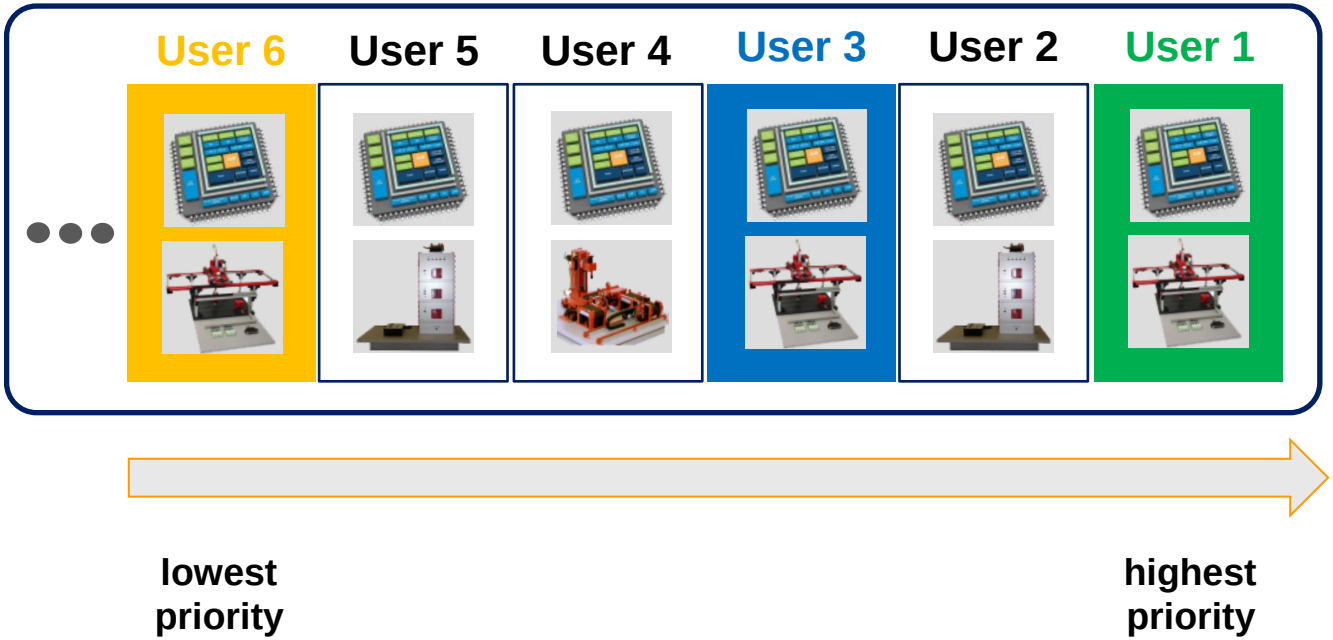
- user can start just in time
- time limit: 30 minutes
- will be increased, if no other user will use the used hardware (control unit or physical system)



GOLDi Booking System

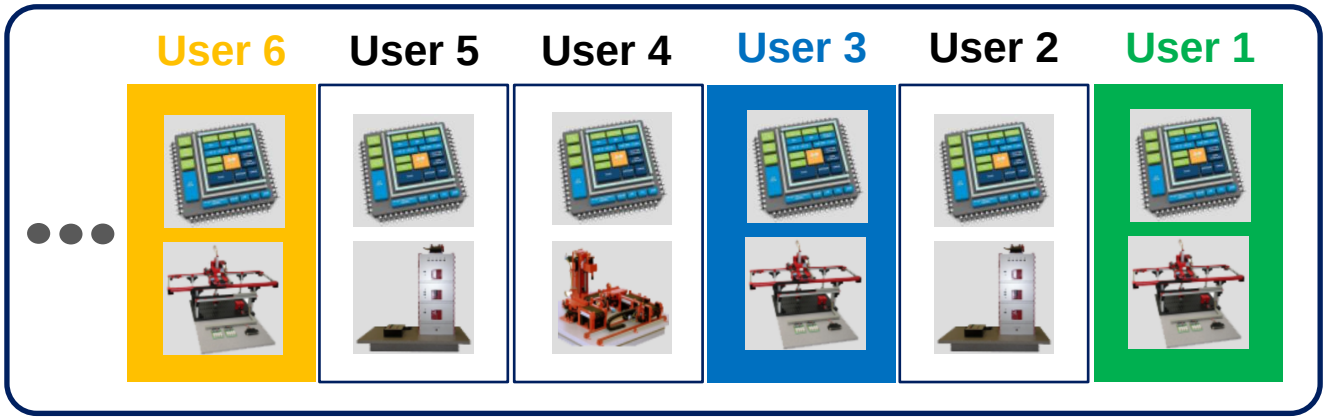
(2) Queue-based start mechanism:

- after combining the experiment
- the user will be appended to a queueing system
- changes the user priorities dynamically regarding the load of the lab
- to get the highest possible load

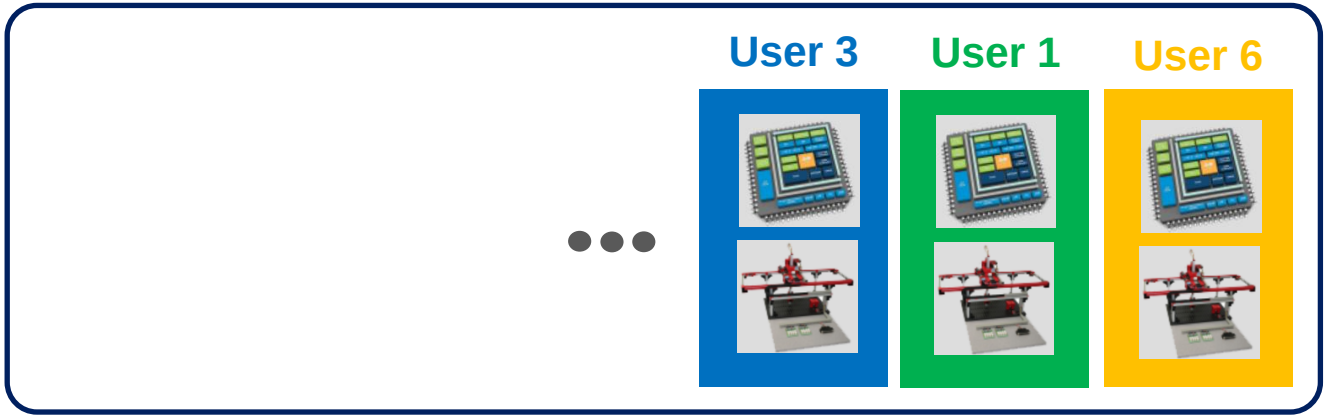


GOLDi Booking System

queue 1
control unit

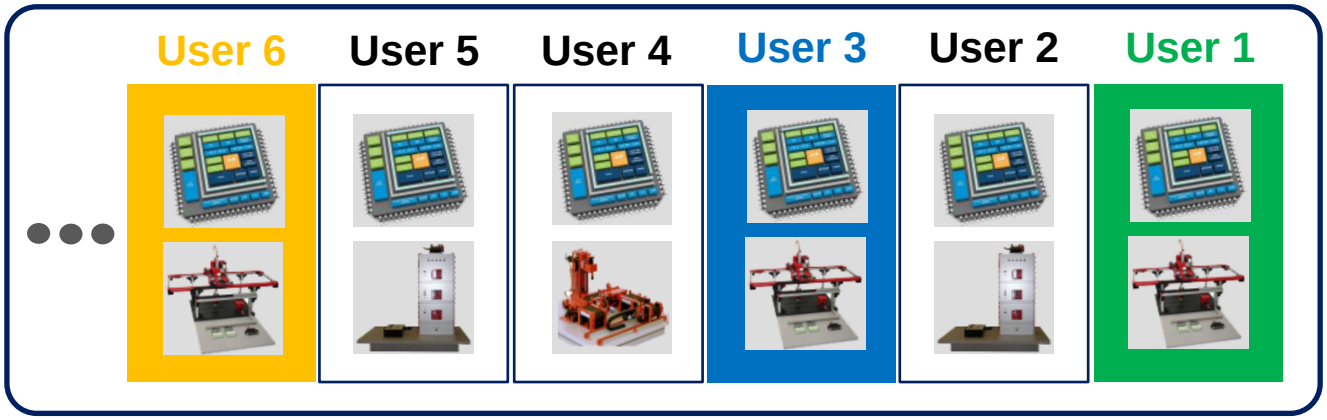


queue 2
physical system



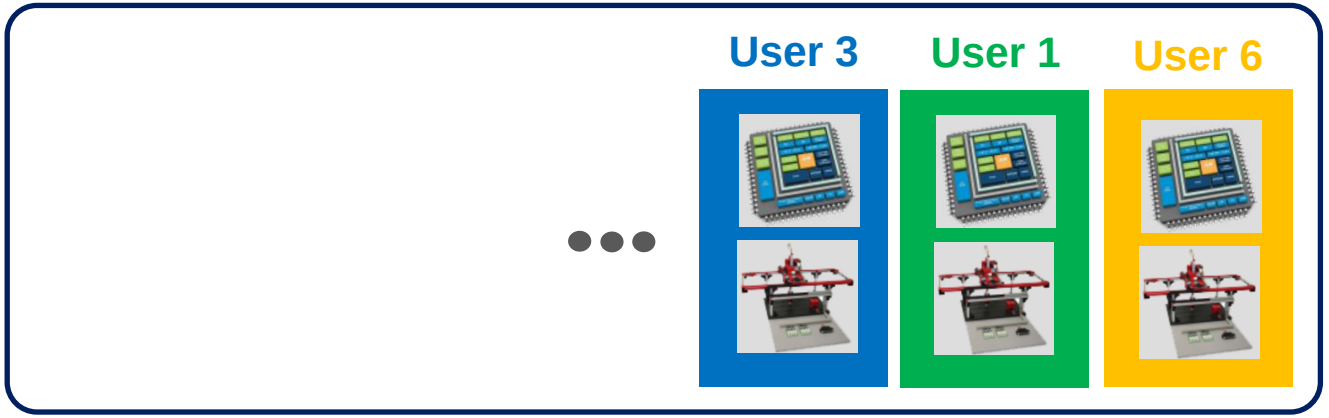
GOLDi Booking System

queue 1
control unit



µController available

queue 2
physical system

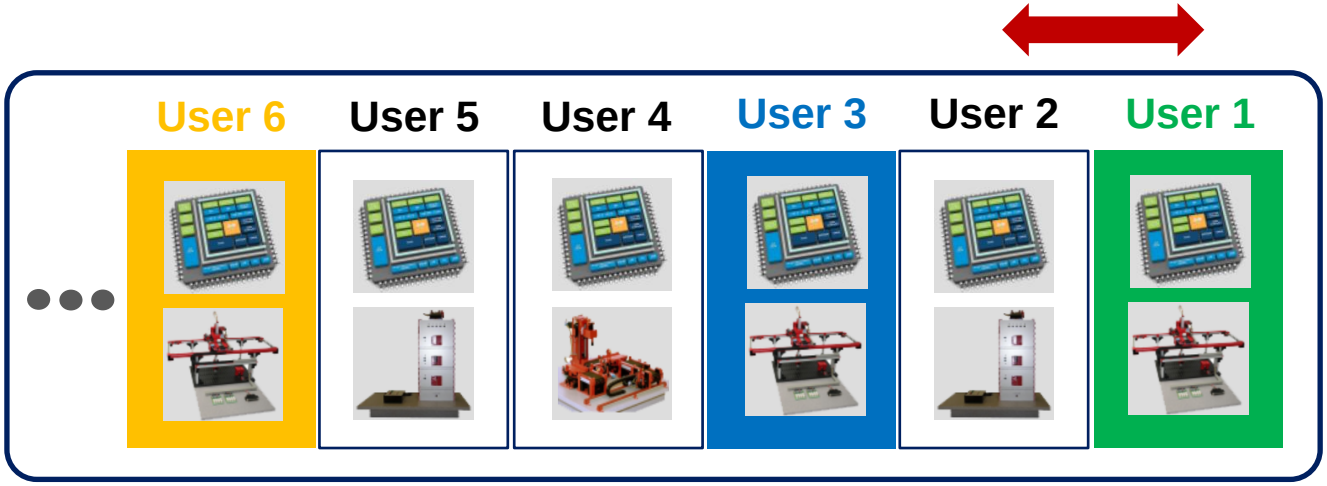


GOLDi Booking System

queue 1
control unit

Microcontroller

Real

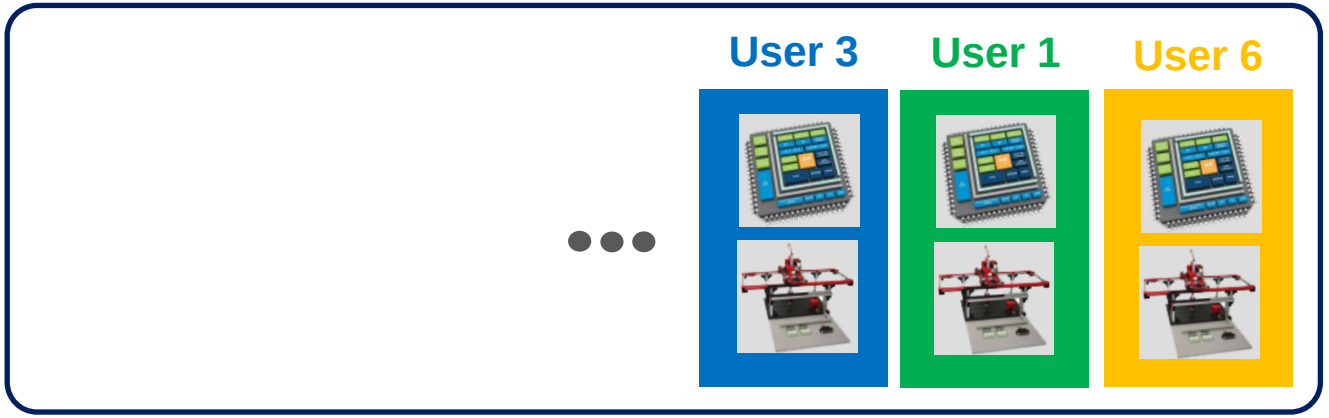


µController available

queue 2
physical system

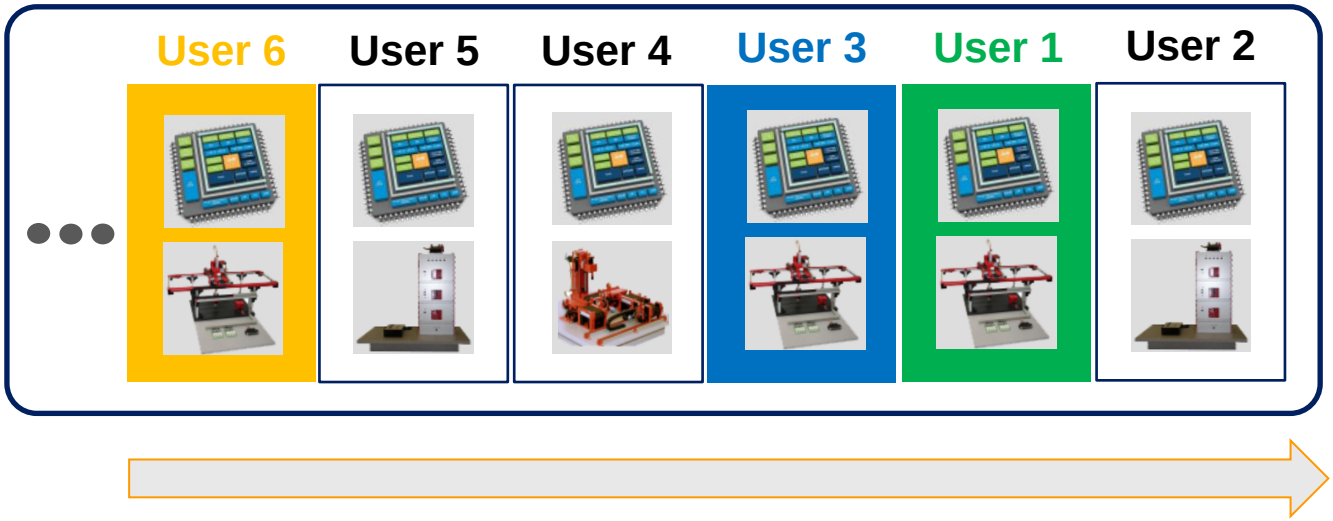
3-Axis-Portal

Real

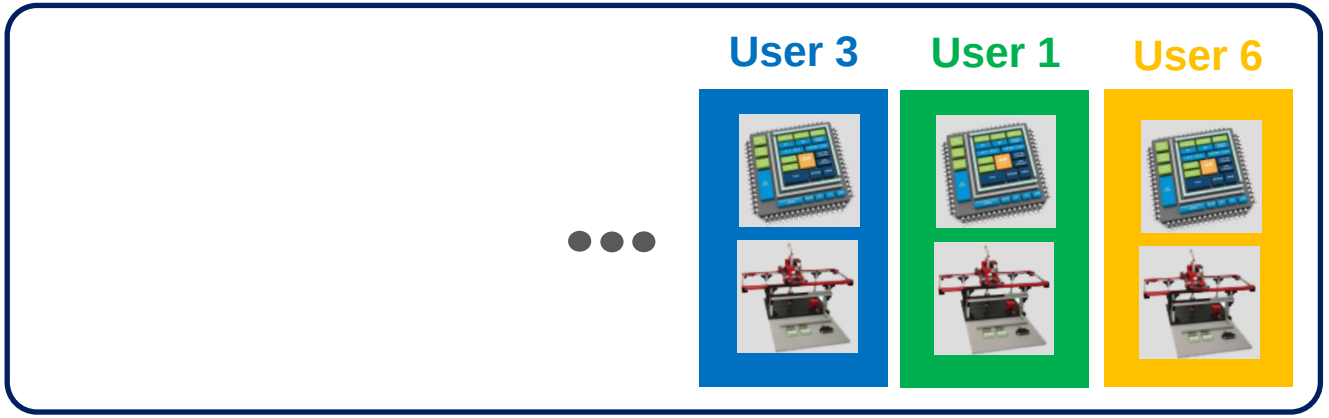


GOLDi Booking System

queue 1
control unit

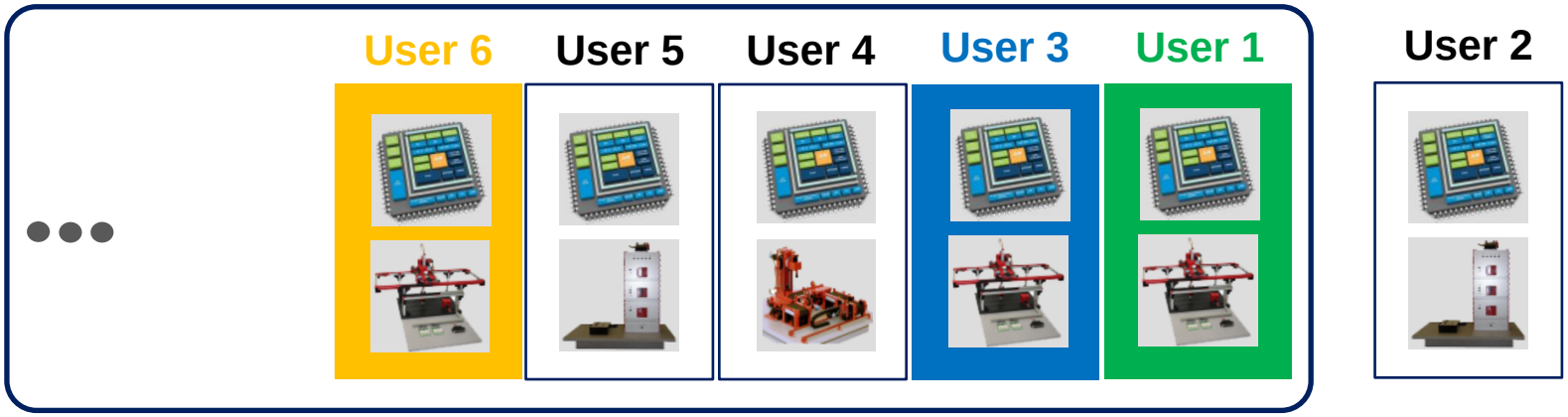


queue 2
physical system

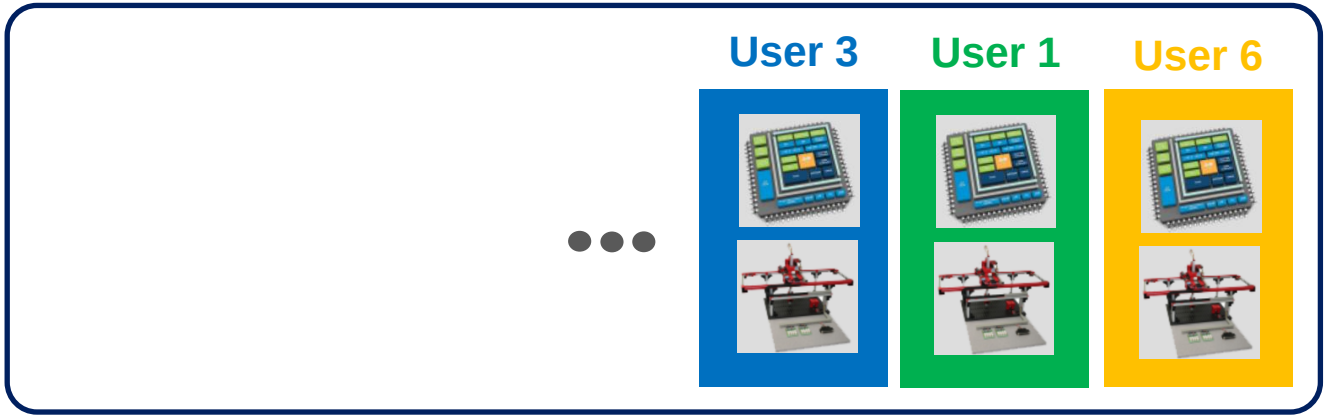


GOLDi Booking System

queue 1
control unit

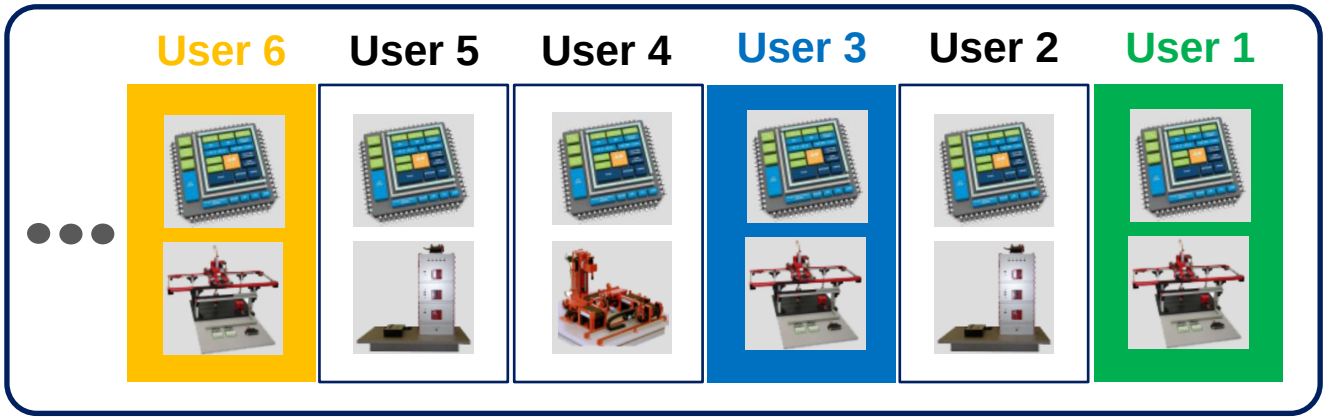


queue 2
physical system

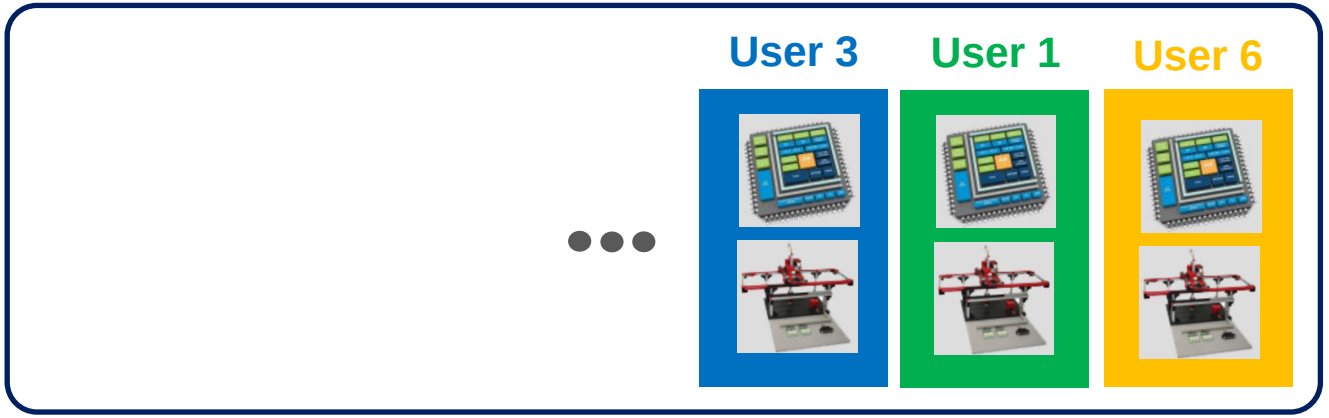


GOLDi Booking System

queue 1
control unit



queue 2
physical system

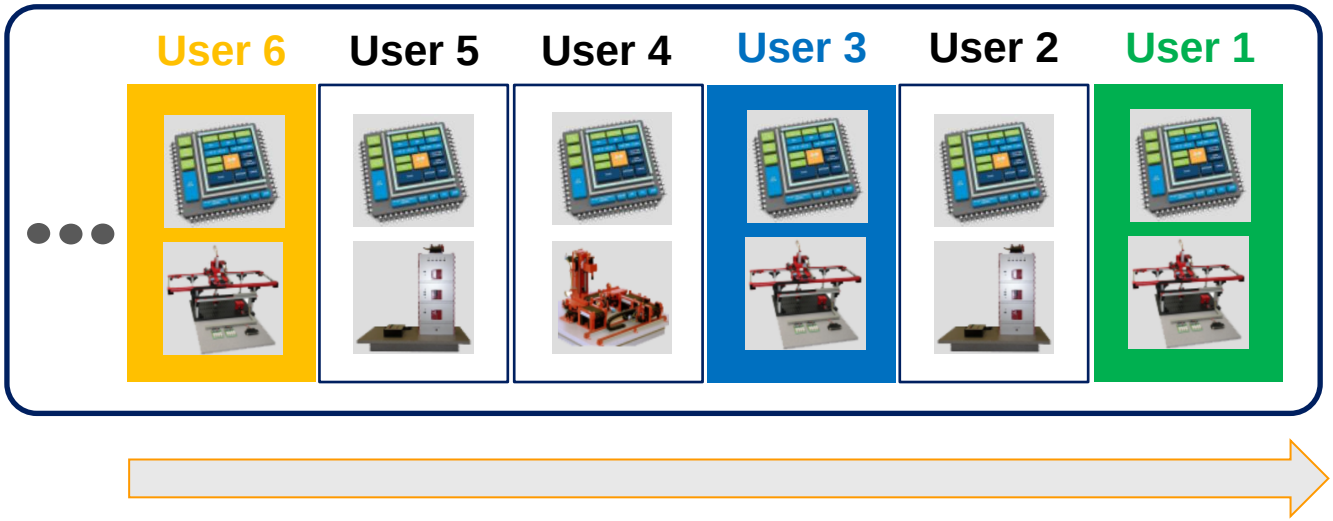


physical system available

GOLDi Booking System

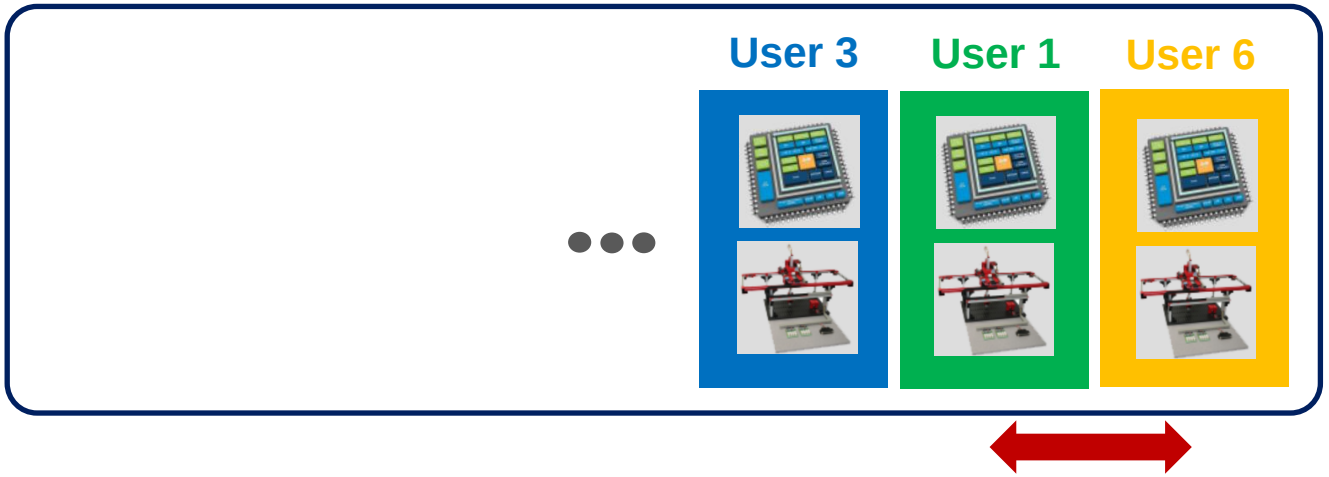
queue 1
control unit

Microcontroller



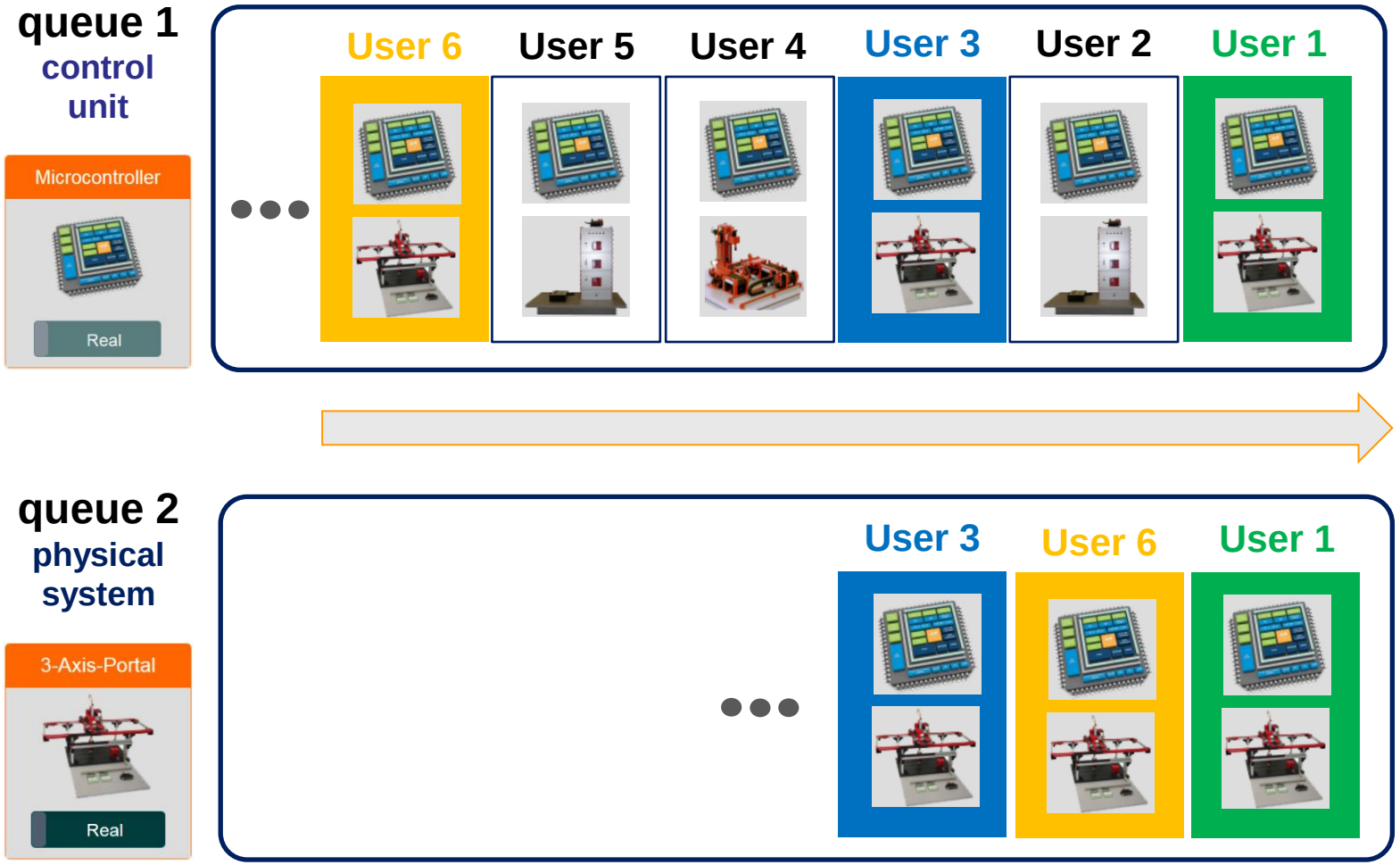
queue 2
physical system

3-Axis-Portal



physical system available

GOLDi Booking System

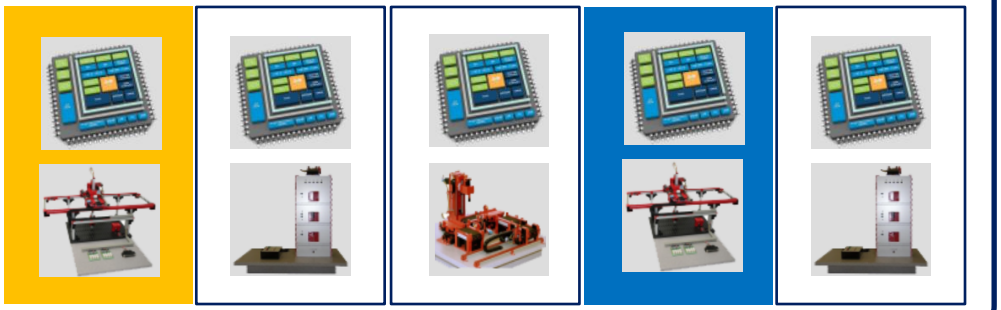


GOLDi Booking System

queue 1
control unit

Microcontroller

Real

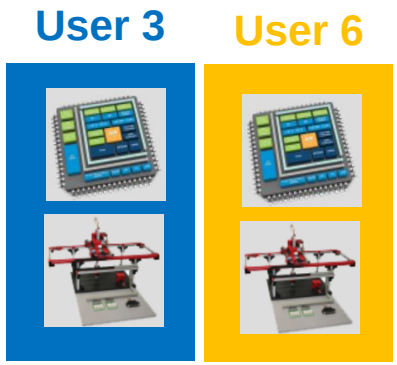


start experiment

queue 2
physical system

3-Axis-Portal

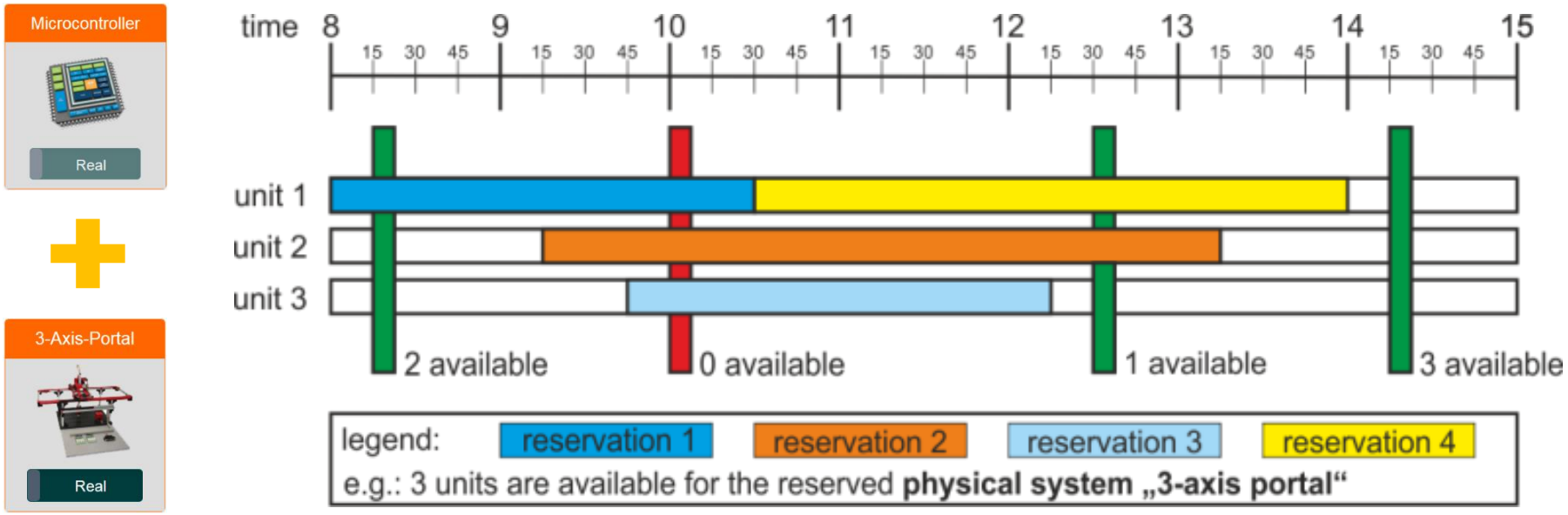
Real



GOLDi Booking System

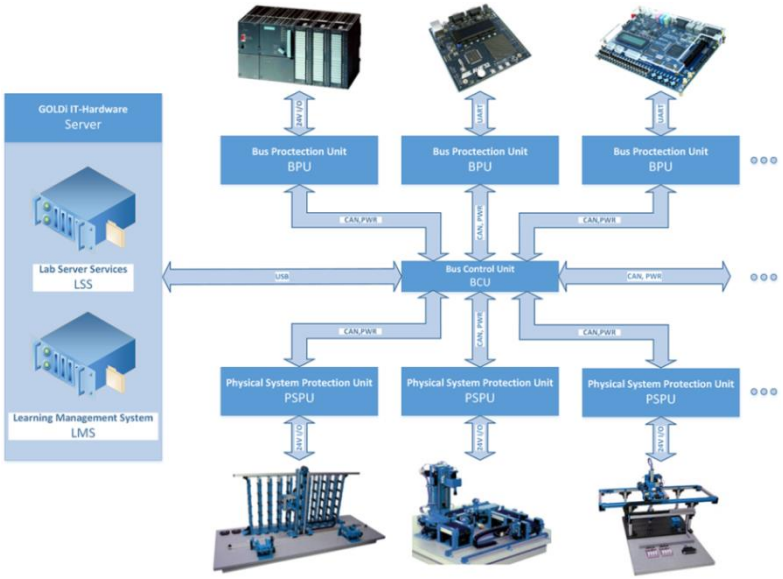
(3) Pre-reserved start mechanism:

- user can reserve an experiment in advance
- selected hardware will be blocked during reserved time
- e.g. for an exclusive reservation for teachers for a group of students to work together on a pre-defined experiment



Outline

- Motivation
- Architecture of the IUT Hybrid Online Lab *GOLDi*
  - Server side infrastructure
  - Client side infrastructure
  - GIFT – Graphical Interactive Finite State Machine Toolset
- *GOLDi* experiment configuration
- *GOLDi* labs cloud
- *GOLDi* booking system
- **Conclusions / Future work**
- Questions

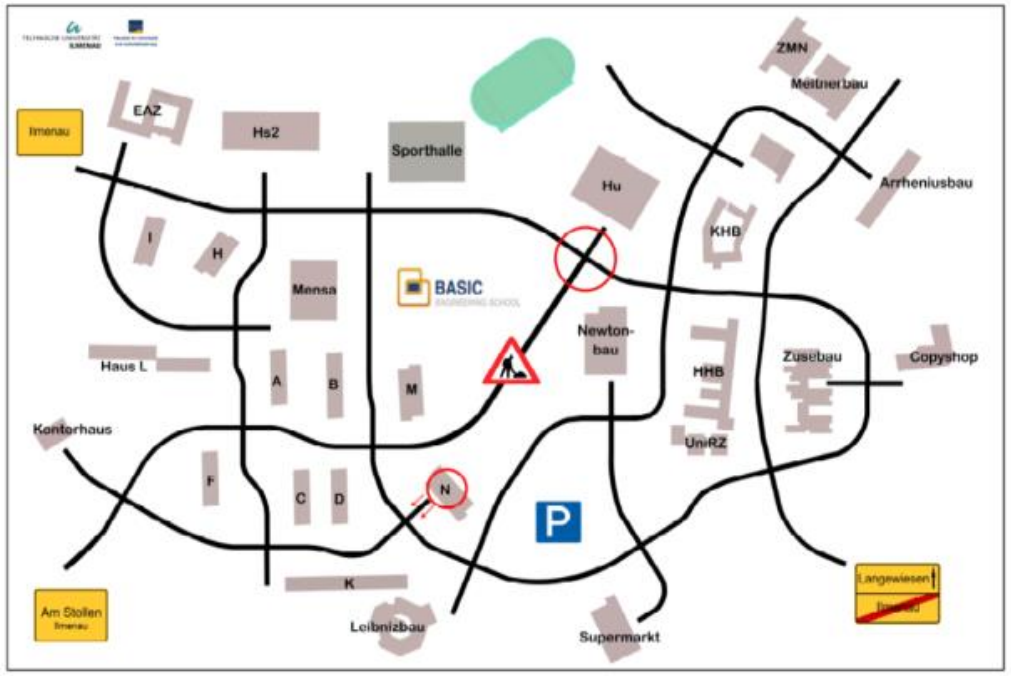


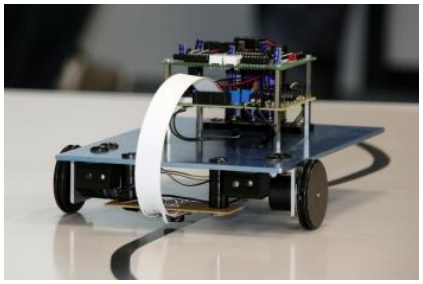
Future Work – FMS (Fernsteuerbarer & Modularer Systemroboter)

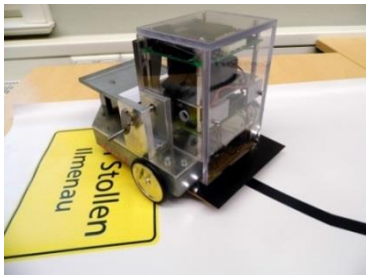
Previous work: AMT (Autonomer Miniatur Transporter)

- Built an AMT that is able to follow a black line on a white board with a defined, but programmable route:
  - During the movements the number of left and right turns has to be counted
  - All parts should be designed and produced in the laboratories of the University

Start: Haus N in Pfeilrichtung
Ziel: Humboldt-Kreuzung







Future Work – FMS (Fernsteuerbarer & Modularer Systemroboter)

Very good experiences

- increased study motivation, support for one‘s own initiative
- better results in exam / written tests im most courses (in average)
- increased study skills, increased competences in the fields of systematical analysis, analytic thinking, managing complexity…

final presentation of project works, 2014

But: how to use this concept for a large number of students?

Source of pictures: IUT Ilmenau / BASIC

Future Work – FMS (Fernsteuerbarer & Modularer Systemroboter)

Idea: Integration of the FMS (AMT compatible) into the GOLDi remote lab

Future Work – FMS (Fernsteuerbarer & Modularer Systemroboter)

Idea: Integration of the FMS (AMT compatible) into the GOLDi remote lab

Now it's your turn …

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