Raspberry Pi Controller for Remote Laboratory Hardware Access

University of Applied Sciences Mittweida

Adrian Sieber, Nicolas Hentschel, Isabel Heinze, Theo Kaminsky, Michelle Marasas,

Rico Beier-Grunwald, Alexander Lampe, Marc Ritter, Christian Roschke, Matthias Vodel
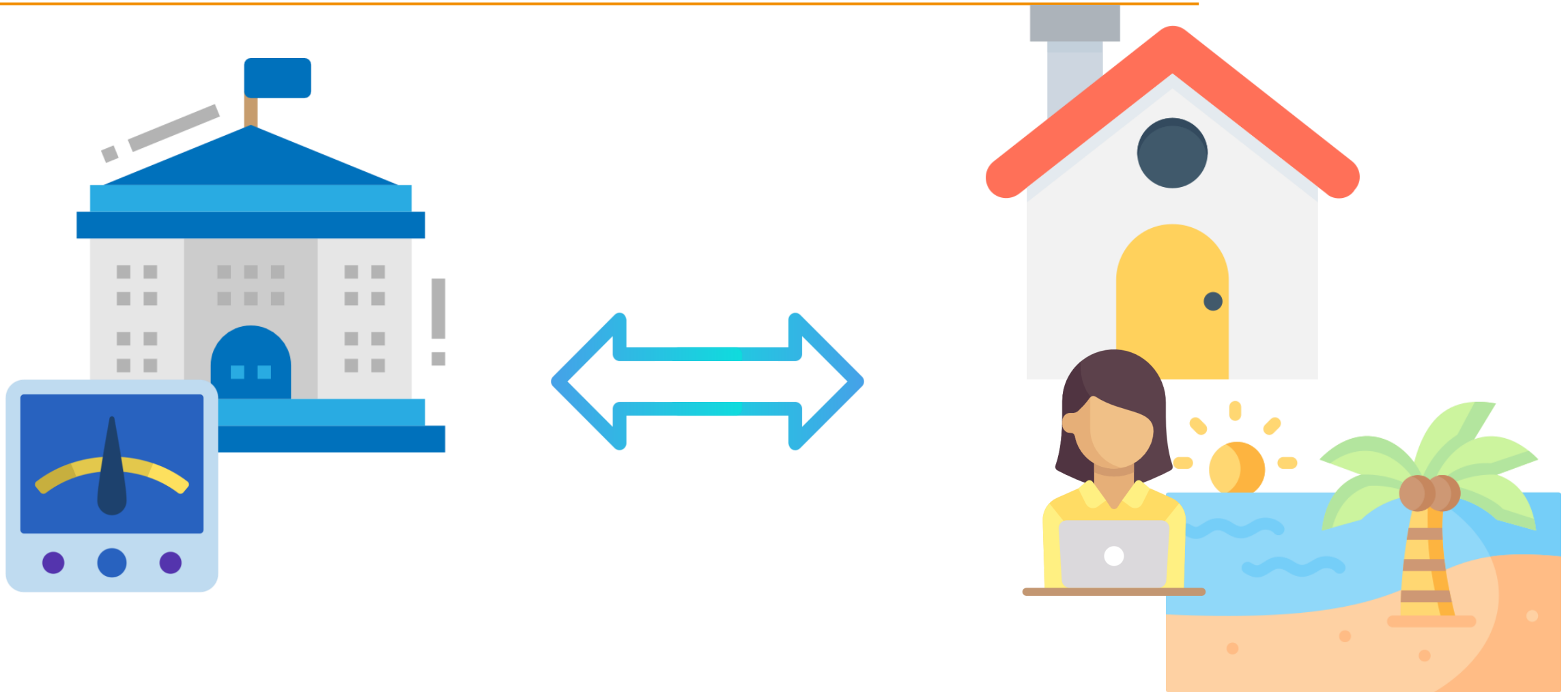
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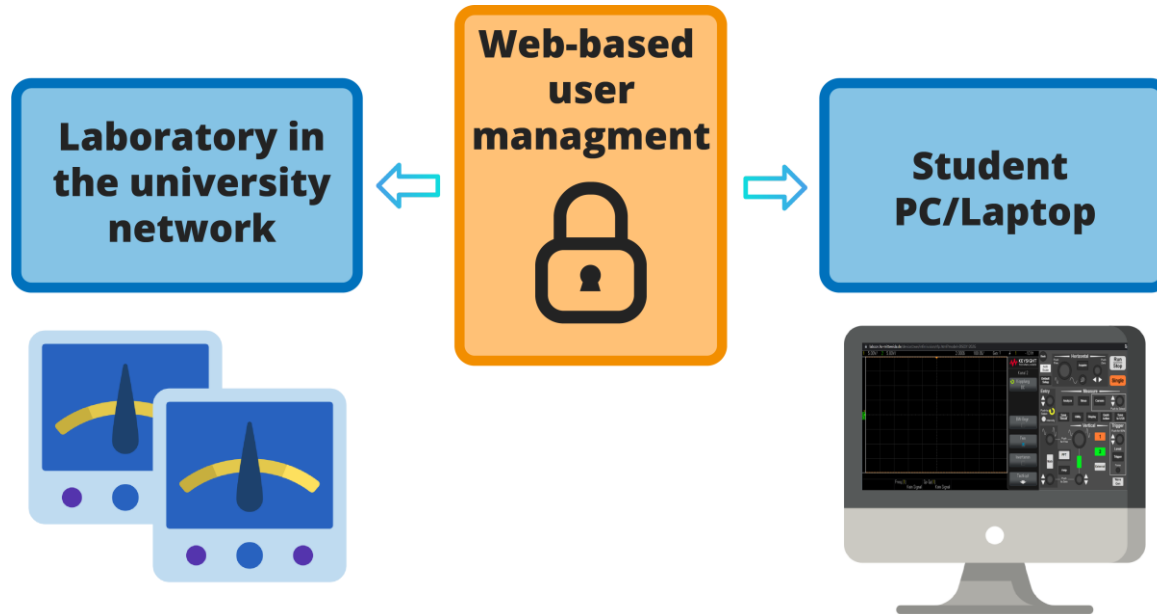
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Agenda

1. Remote Learning Systems

2. LabCon limitations

3. RaspCon solution
   - Requirements
   - Hardware
   - Software
   - WebUI
   - Integration

4. Quality Assessment

**Alexander Lampe**
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Remote Learning Systems

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Remote Learning Systems

Laboratory in the university network → Web-based user managment → Student PC/Laptop

- ✓ Using open-source SW
- ✓ Web-based
- ✓ LMS Functions
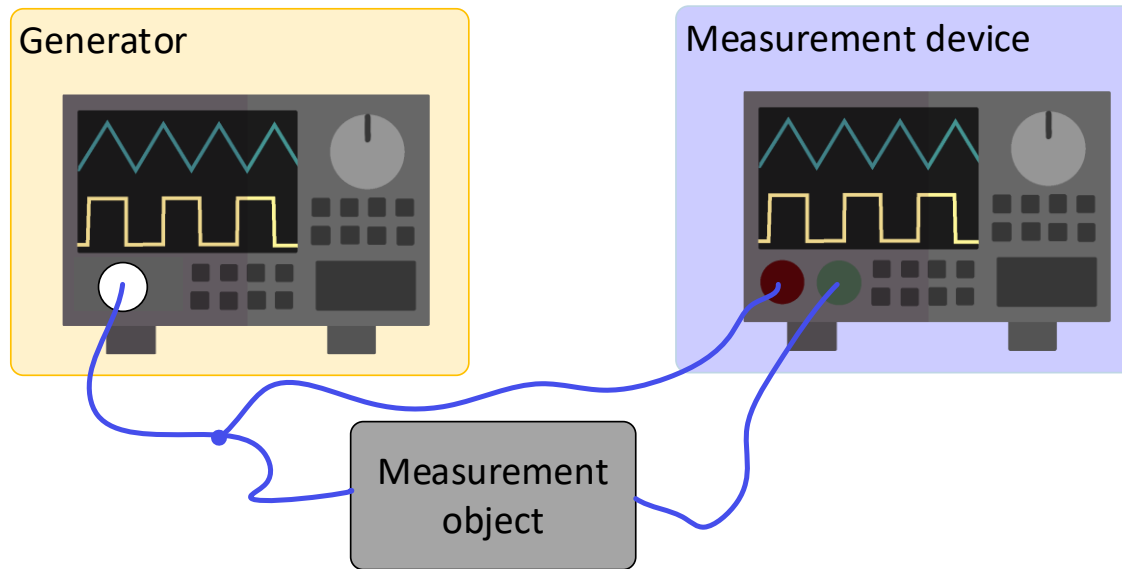- ✓ Expandable
- ✓ Easy to integrate
- ✓ ...
- ✓ Inexpensive

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Our current solution - LabCon
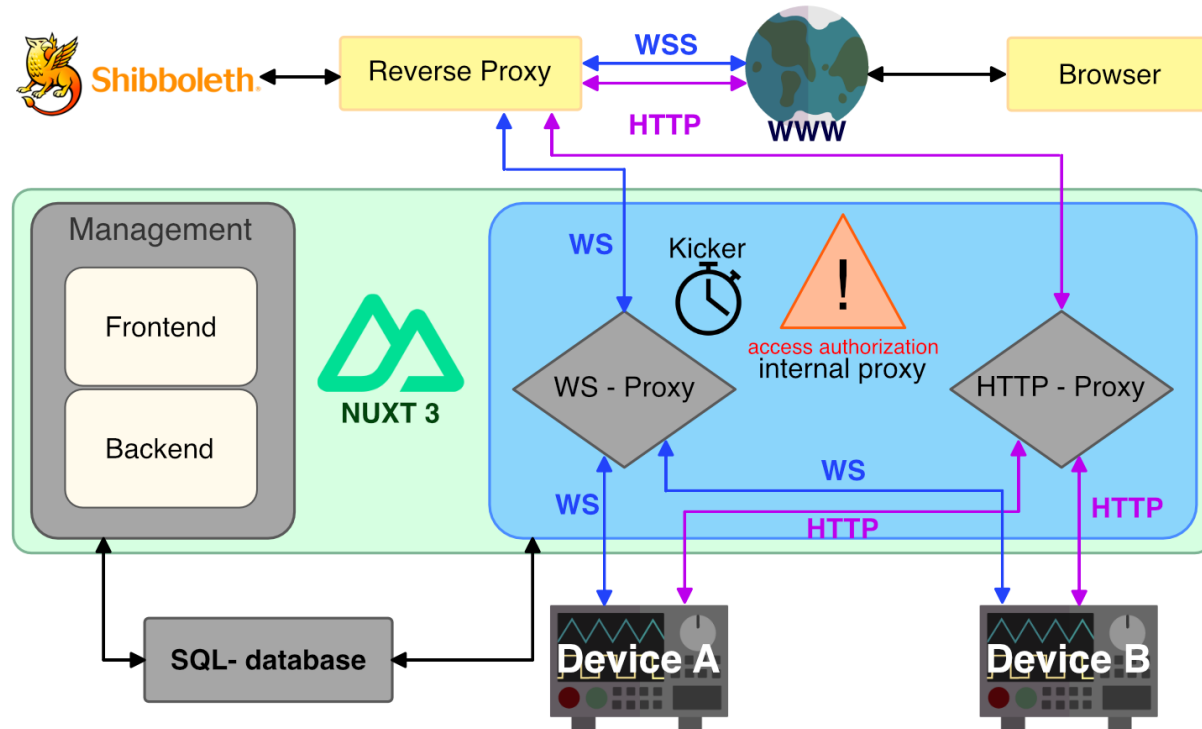
LabCon

- Web-based RLS

- Control of parallel access
  to assigned laboratory hardware

- Integrated user management

Current limitations

Generator

Measurement device

Measurement object

Only one Measurement Object (MO)

can be connected to one GENerator (GEN)

and Measurement Device (MD)

Current limitations
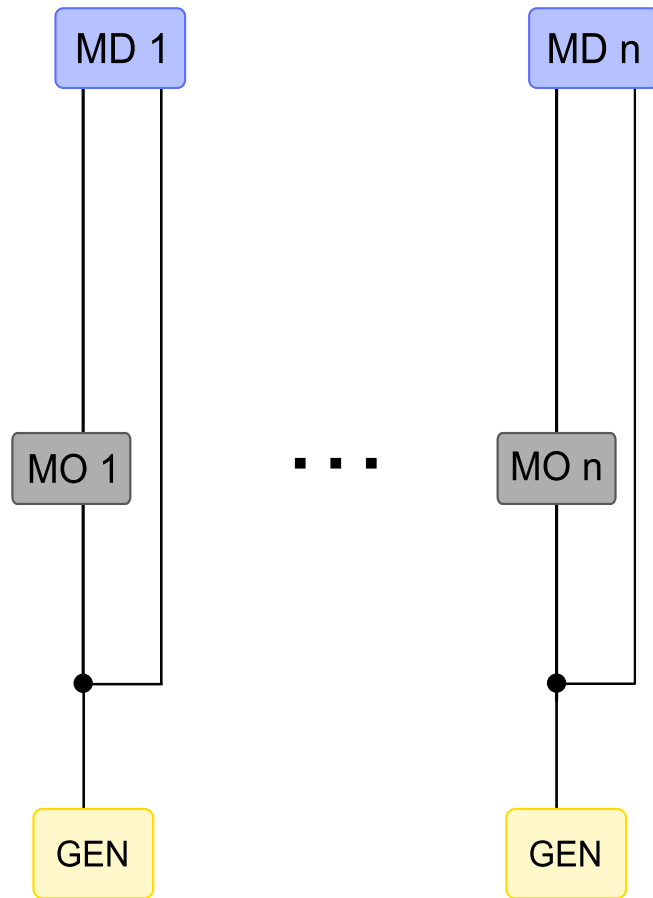
Only one Measurement Object (MO)
can be connected to one GENerator (GEN)
and Measurement Device (MD)

➔ Students have to switch between setups to conduct experiments

➔ Limited number of parallel experiments due to restricted HW availability

➔ Manual reconfiguration of setups needed

Solution
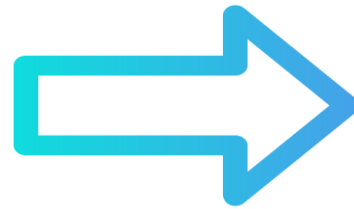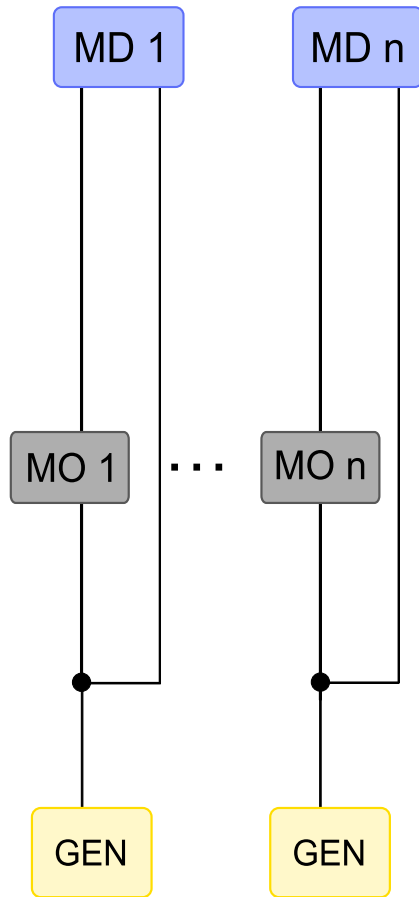
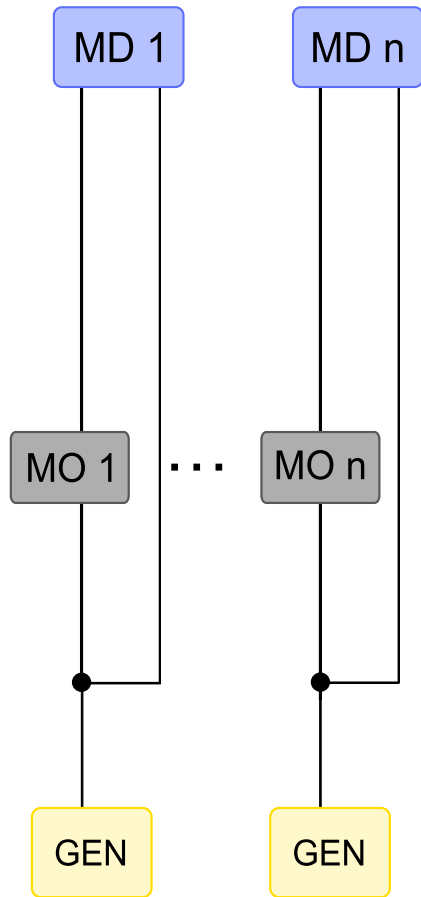Dynamically configurable measurement setup with electronic switch matrix
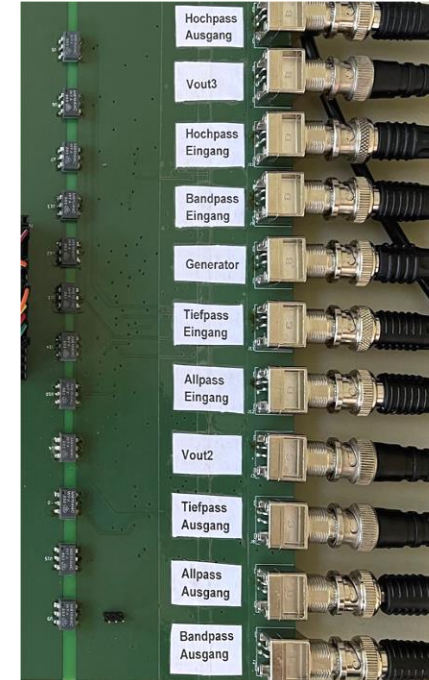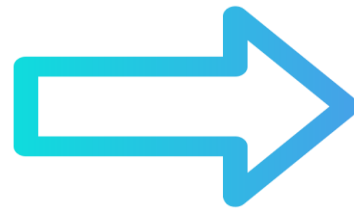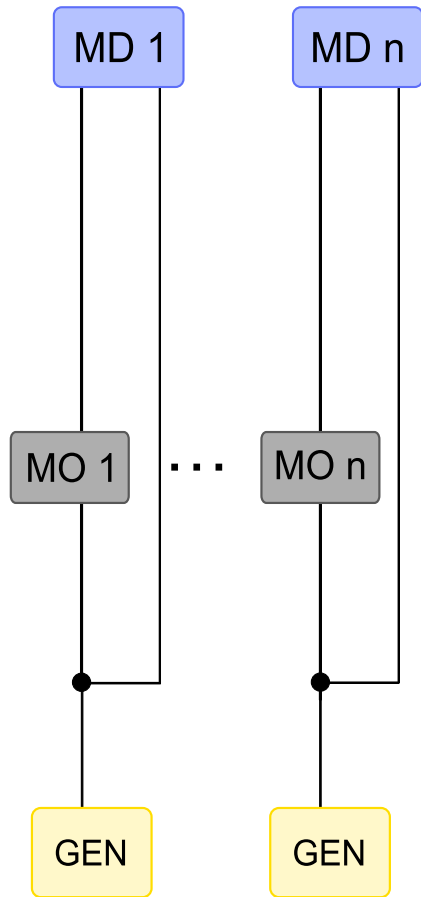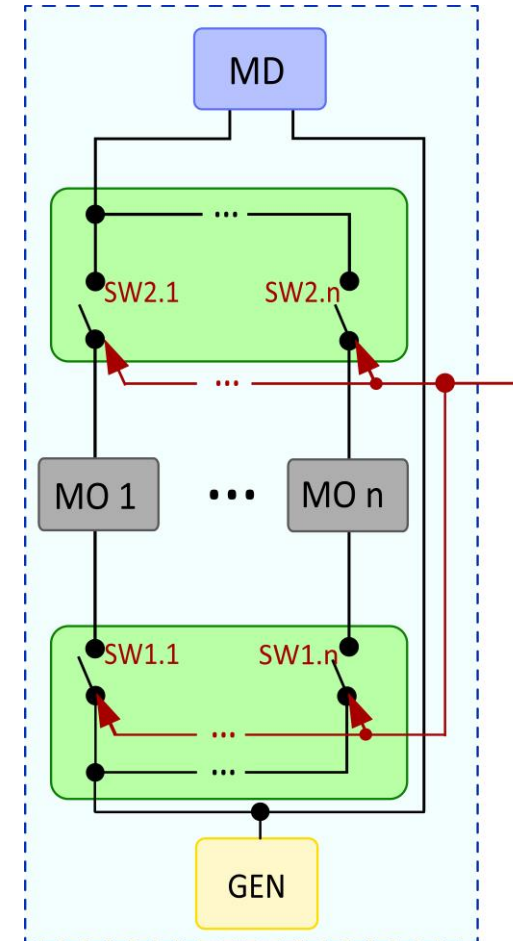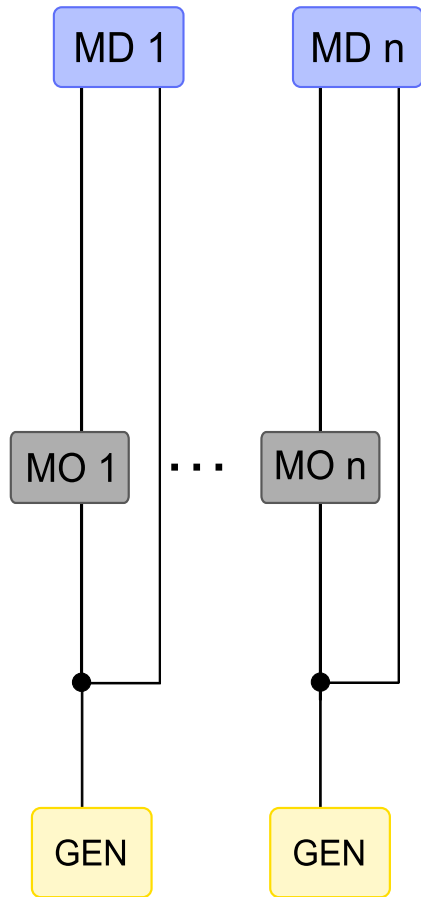
Solution

Dynamically configurable measurement setup with electronic switch matrix
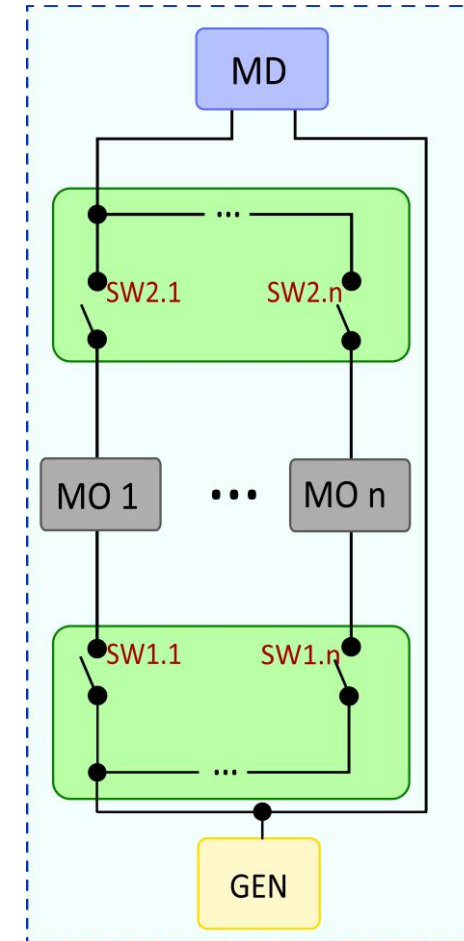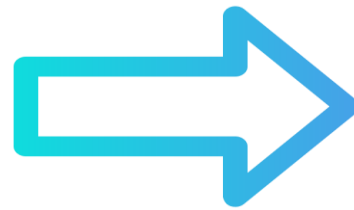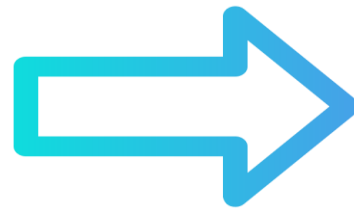
Solution

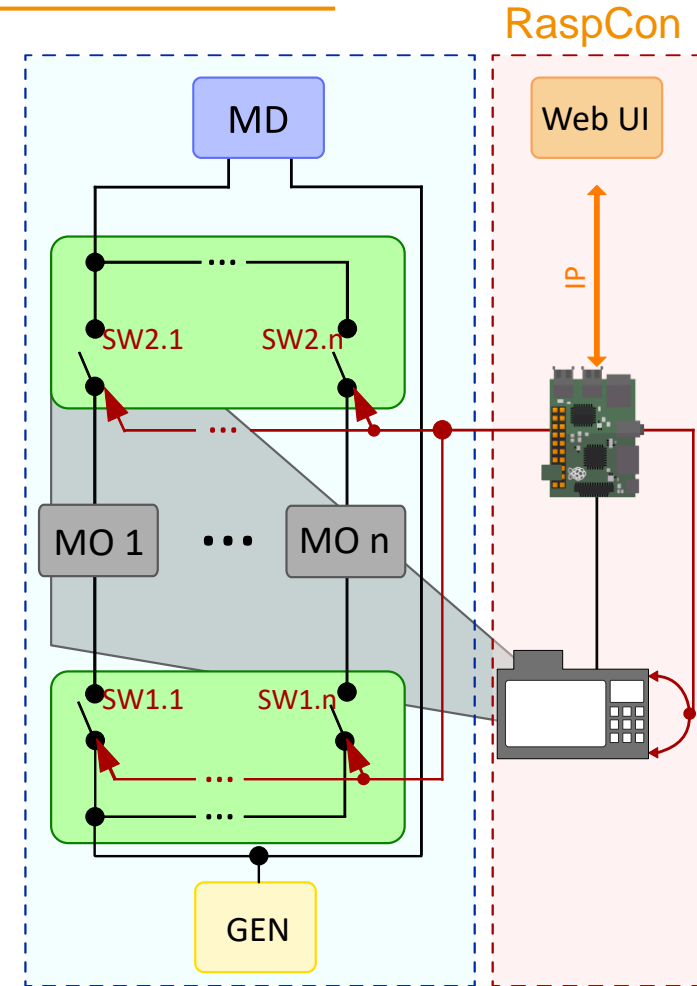Dynamically configurable measurement setup with electronic switch matrix

Solution

RaspCon

Dynamically configurable measurement setup with RaspCon controlled electronic switch matrix

RaspCon requirements

- Controller Hardware:
  - IP-accessible web application
  - sufficient number of programmable GPIOs
  - high-bandwidth camera connector
  - scalable and cost-efficient
- Controller Software:
  - generation of control signals for hardware switches
  - robust web server and video live streaming
  - seamless integration into existing LabCon
  - open-source software components
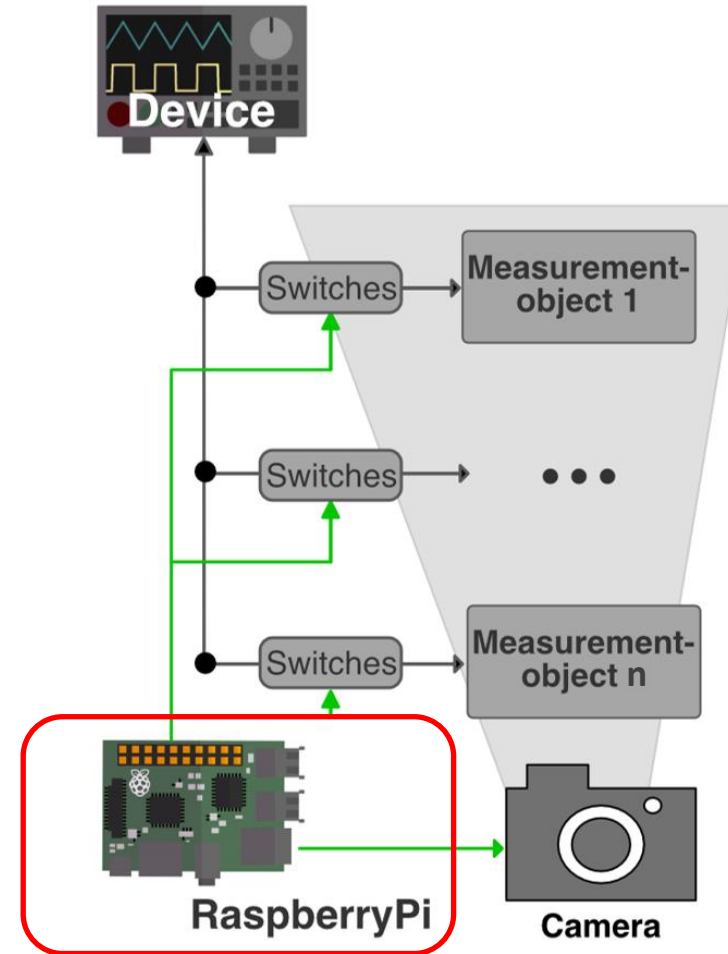- Web UI:
  - intuitive usage and resilient to abuse
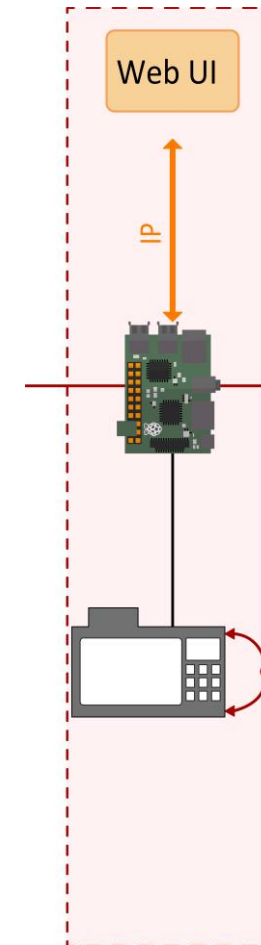
RaspCon hardware
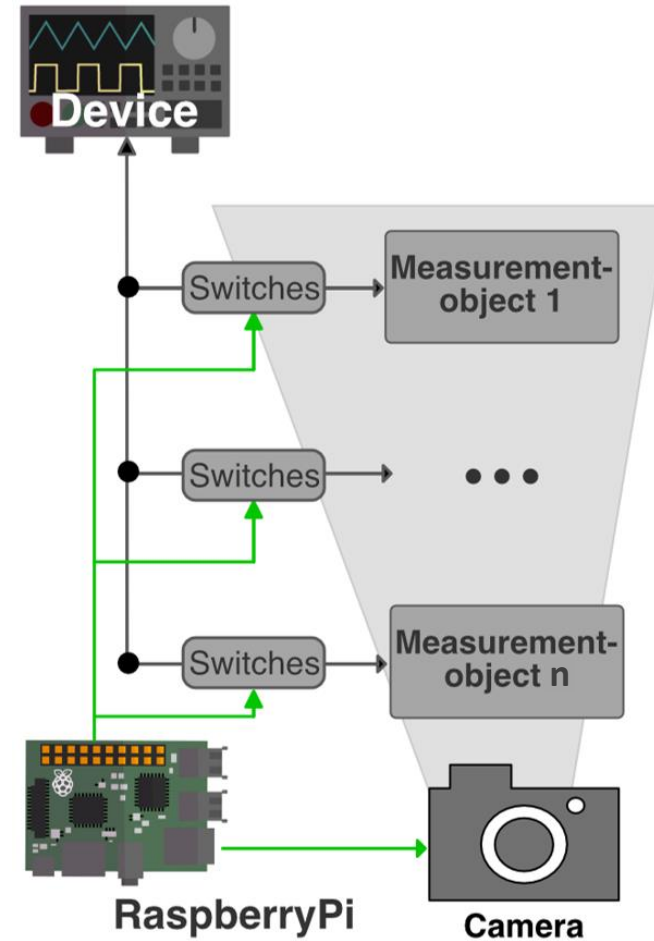
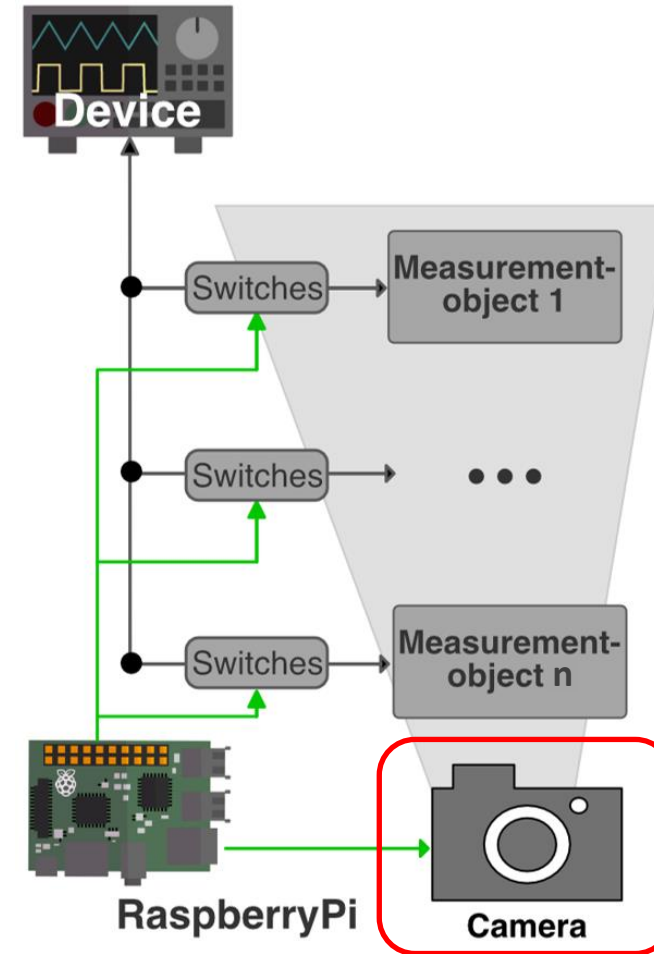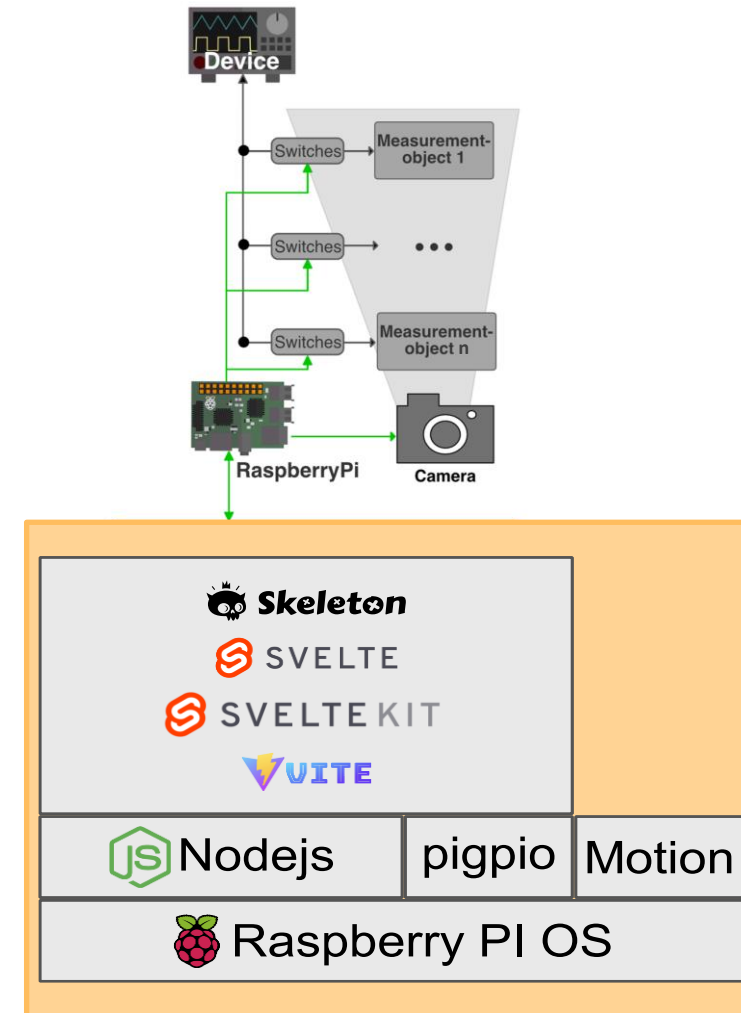- Arduino, Raspberry Pi, … evaluated as controller platform

RaspCon hardware

- Arduino, Raspberry Pi, … evaluated as controller platform
- Raspberry Pi selected
  - full Linux operating system
  - wide range of available interfaces and extension boards

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- Raspberry 2 camera module
- Raspberry 2 DOF Pan-tilt HAT module to enable horizontal and vertical camera rotation
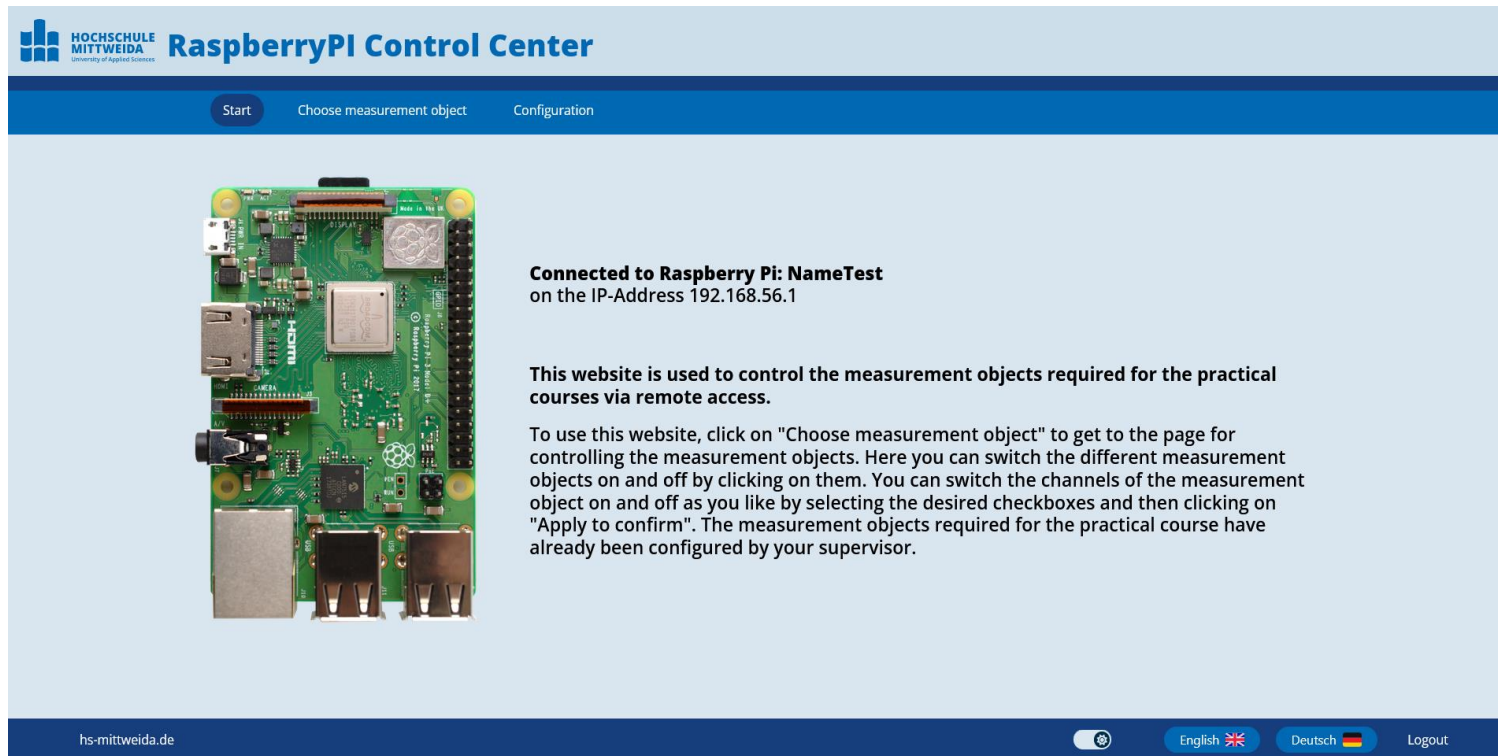
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RaspCon software

- SvelteKit as basis of application
  - Running on top of Javascript runtime environment Node.js
  - Developer friendly component-based architecture
  - Good scalability and maintainability
  - Built-in support for server-side rendering
- Pigpio C library used for GPIO control
- Motion used for video stream serving as MJPEG over HTTP
- Skeleton applied for WebUI development

RaspCon WebUI

- Start page: Introduction to RaspCon System

RaspCon WebUI

- Configuration Page:
  - Suite of tools for setting up and managing experimental configurations
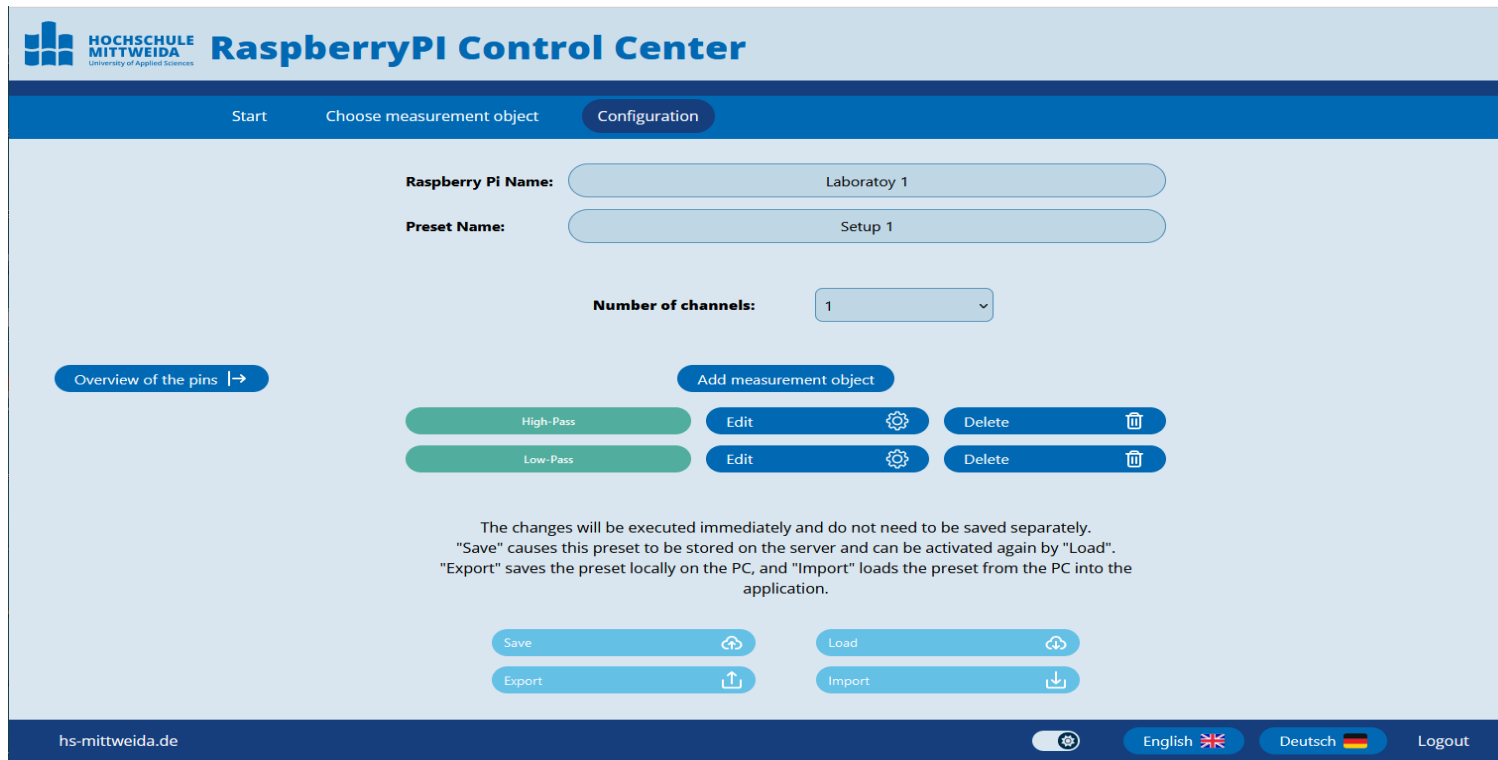
RaspCon WebUI

- Configuration Page:
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  - Opportunity for GPIO configuration to support variety of hardware switches

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RaspCon WebUI

- Configuration Page:
  - Suite of tools for setting up and managing experimental configurations
  - Opportunity for GPIO configuration to support variety of hardware switches

RaspCon WebUI

- Measurement Object Page:
  - Selection of connections between MOs and MDs via switch matrix table
  - Visual control of laboratory environment
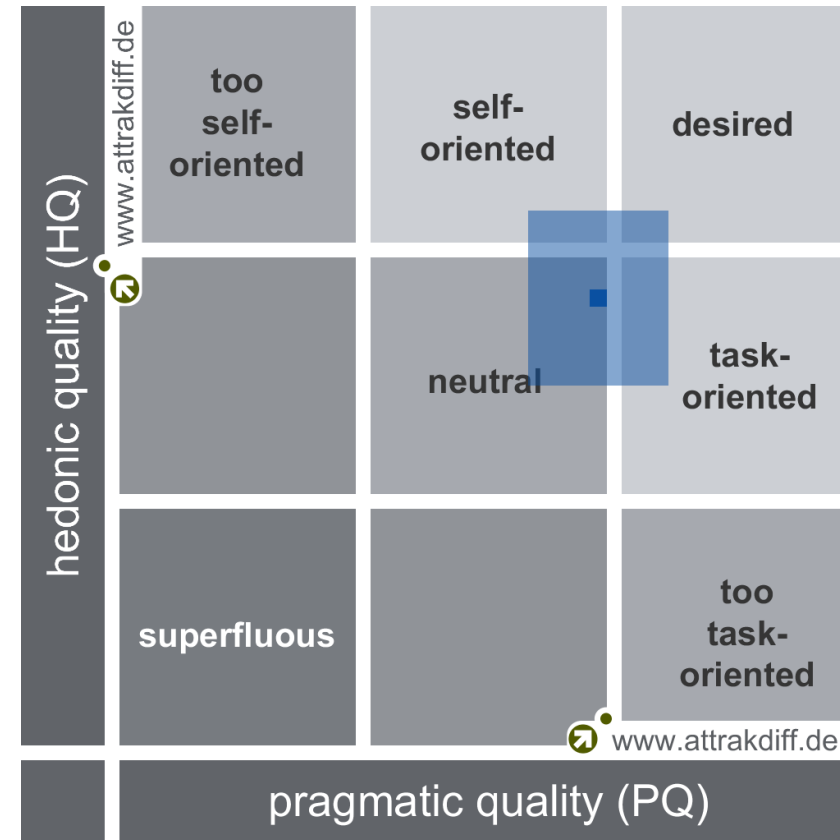
RaspCon integration

- RaspCon is integrated as subsystem into LabCon

  ➔ reuse of LabCon hardware management and access control functions
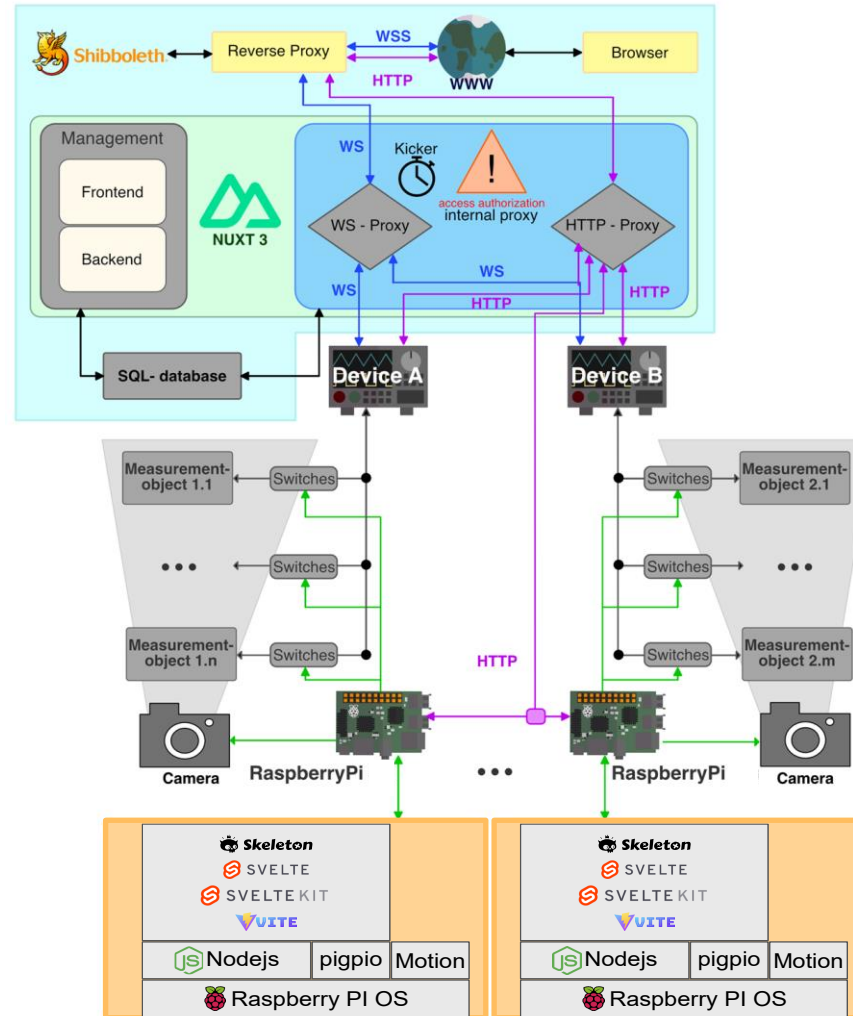
Quality Assessment

- Two quality assessment rounds conducted for users and administrators with AttrakDiff

- Pragmatic quality (PQ) and hedonic quality (HQ) verified

- Application based on received feedback refined

Thank You !

Adrian Sieber, Nicolas Hentschel, Isabel Heinze, Theo Kaminsky, Michelle Marasas, Rico Beier-Grunwald, Alexander Lampe, Marc Ritter, Christian Roschke, Matthias Vodel

Hochschule Mittweida | University of Applied Sciences
Technikumplatz 17 | 09648 Mittweida | Germany