



**HOCHSCHULE
MITTWEIDA**
University of Applied Sciences

Raspberry Pi Controller for Remote Laboratory Hardware Access

University of Applied Sciences Mittweida

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

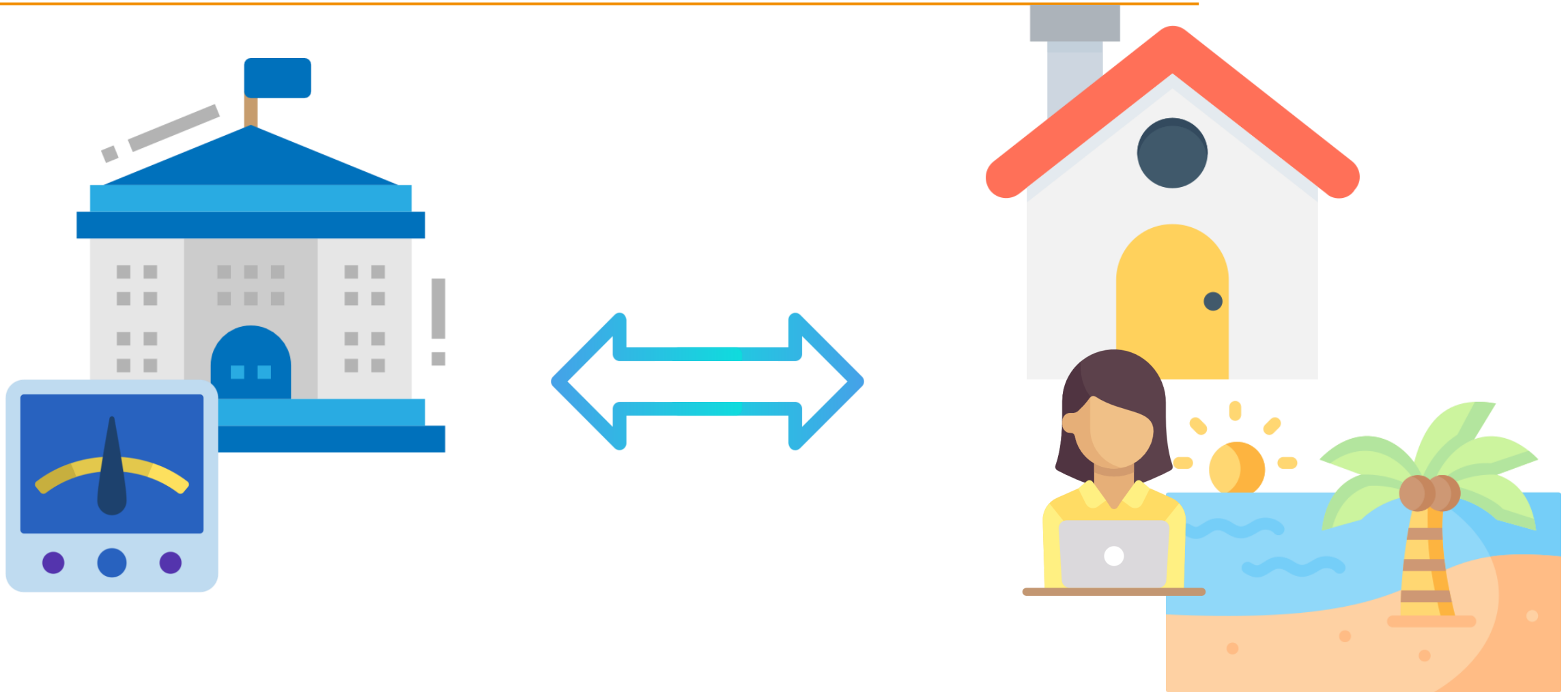
[hs-mittweida.de](https://www.hs-mittweida.de)

Agenda

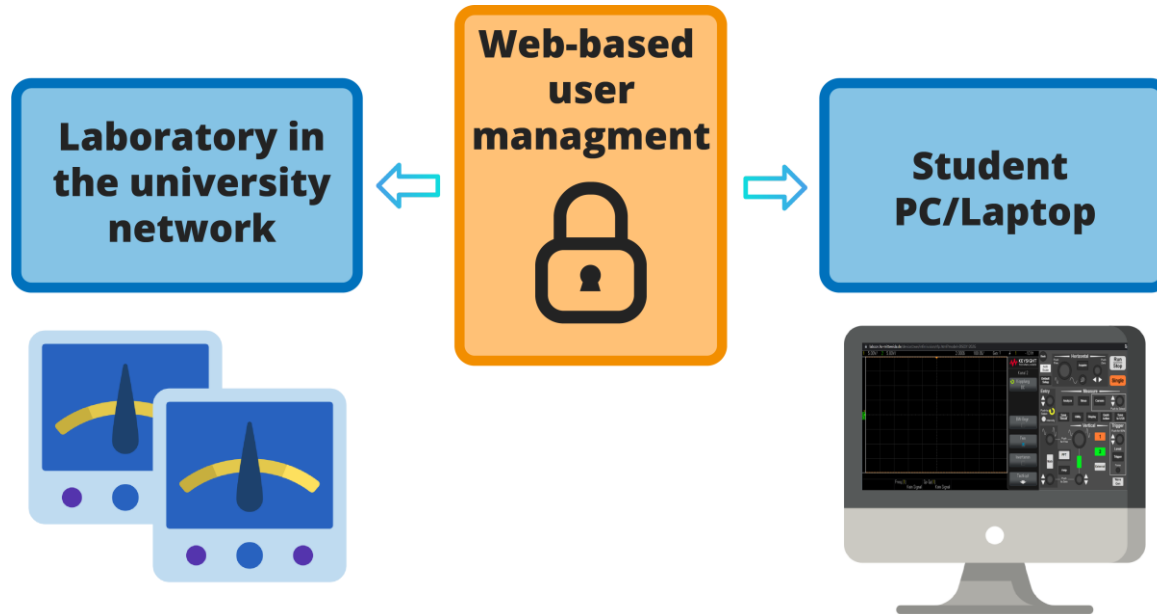
1. Remote Learning Systems
2. LabCon limitations
3. RaspCon solution
 - Requirements
 - Hardware
 - Software
 - WebUI
 - Integration
4. Quality Assessment



Remote Learning Systems

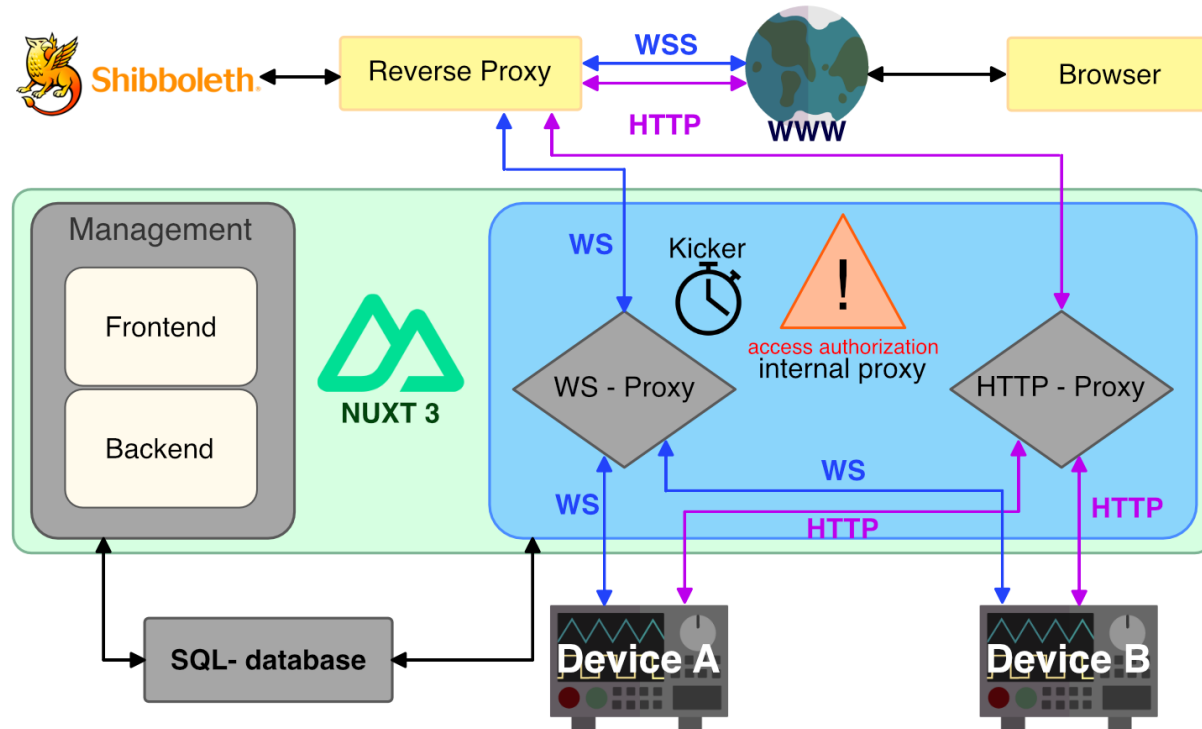


Remote Learning Systems



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

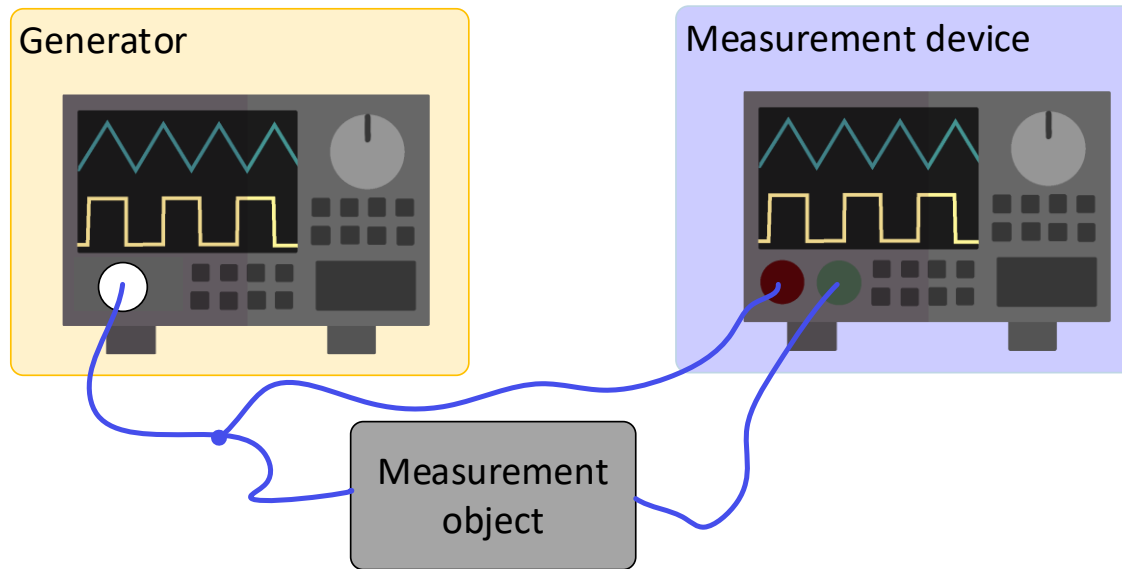
Our current solution - LabCon



LabCon

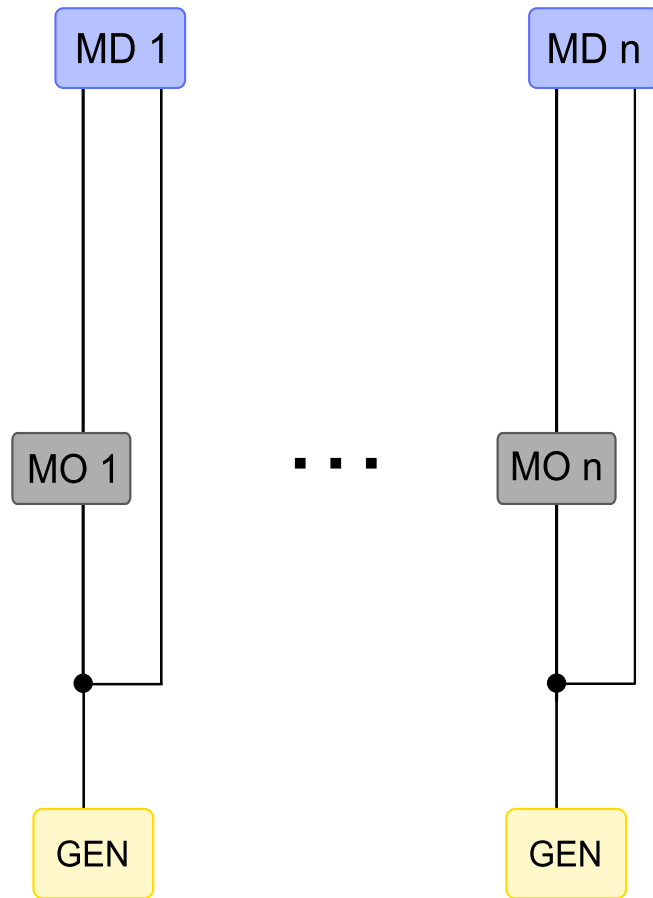
- Web-based RLS
- Control of parallel access to assigned laboratory hardware
- Integrated user management

Current limitations



Only one Measurement Object (MO)
can be connected to one GENERator (GEN)
and Measurement Device (MD)

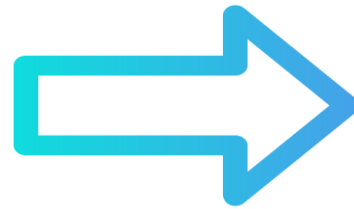
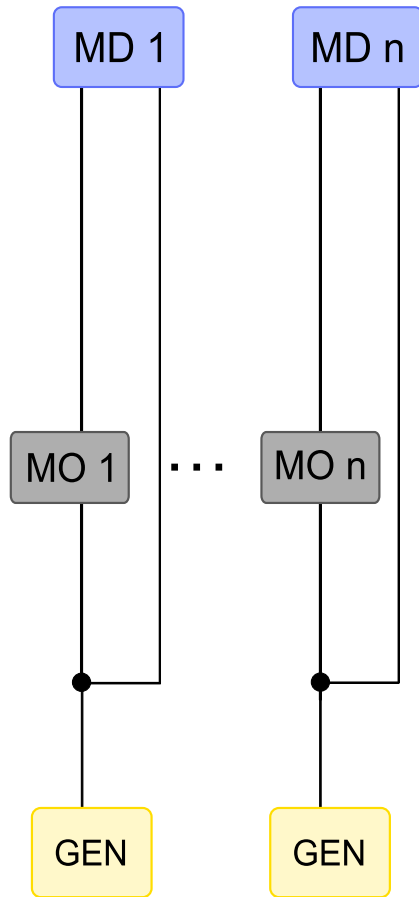
Current limitations



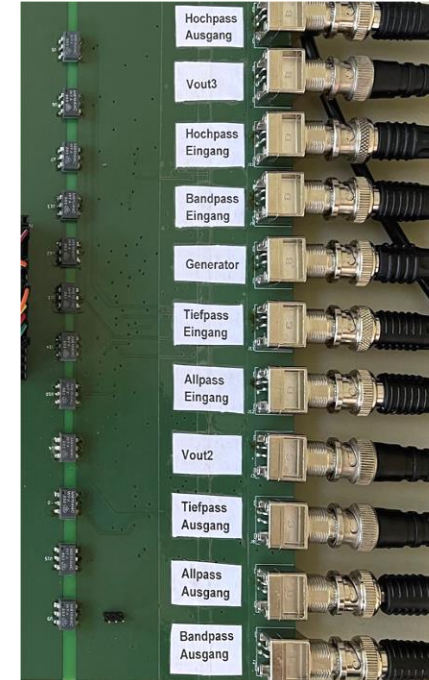
Only one Measurement Object (MO) can be connected to one GENERator (GEN) and Measurement Device (MD)

- ➔ Students have to switch between setups to conduct experiments
- ➔ Limited number of parallel experiments due to restricted HW availability
- ➔ Manual reconfiguration of setups needed

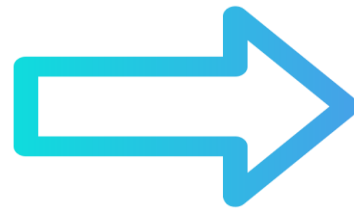
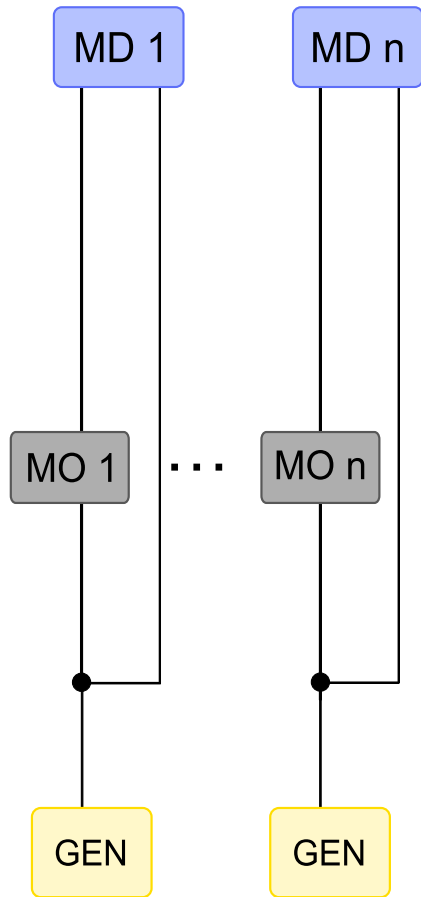
Solution



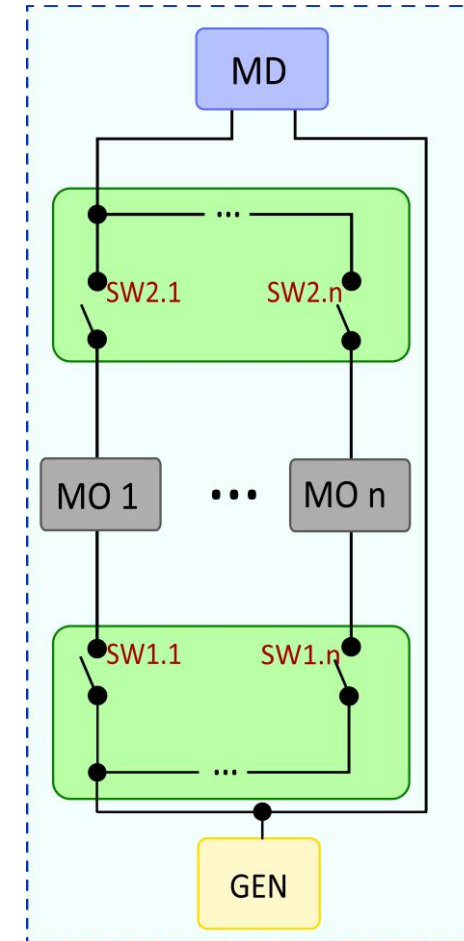
Dynamically configurable measurement setup with electronic switch matrix



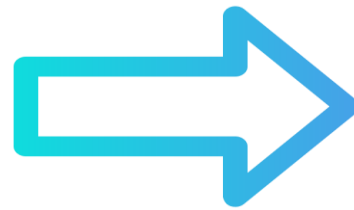
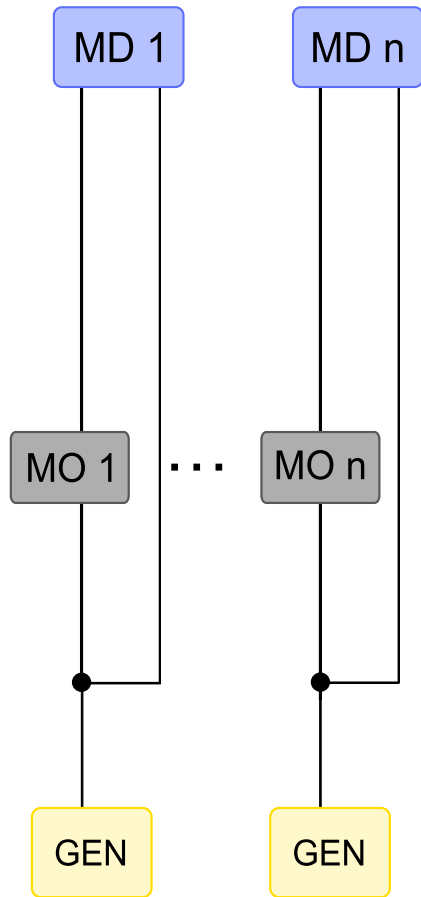
Solution



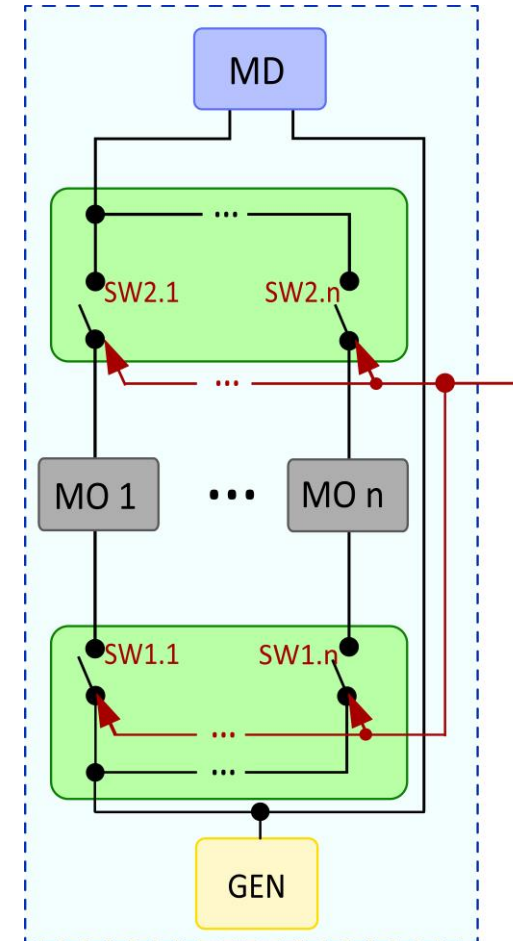
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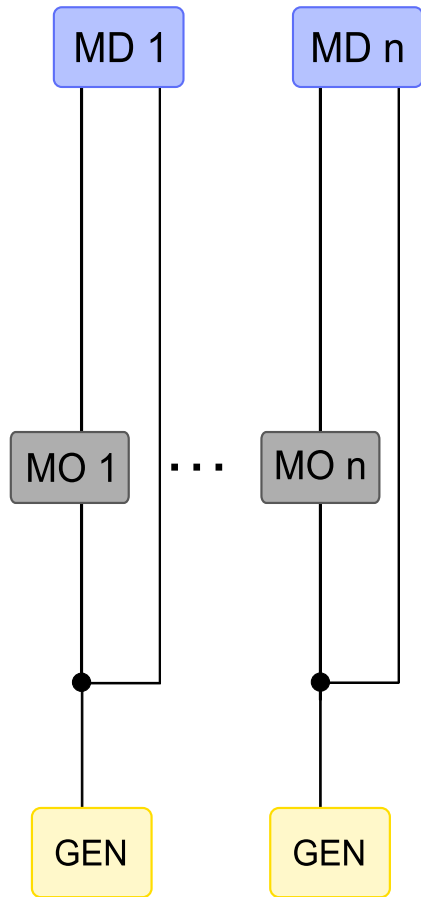
Solution



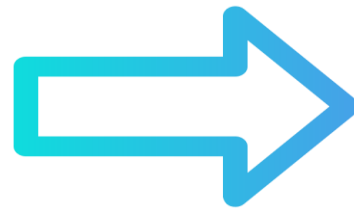
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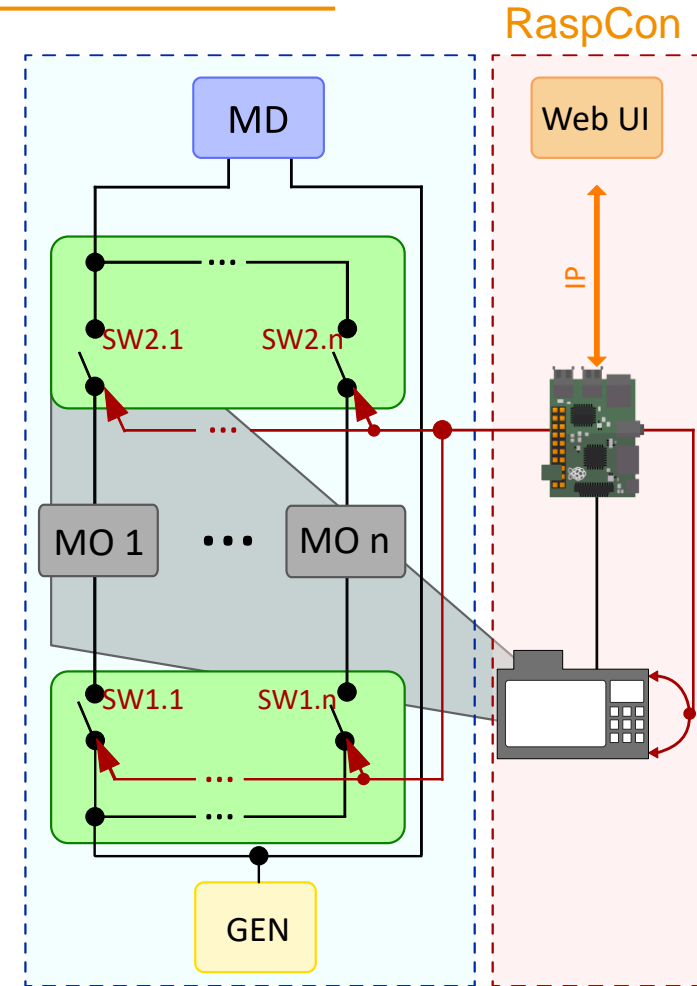
Solution



RaspCon

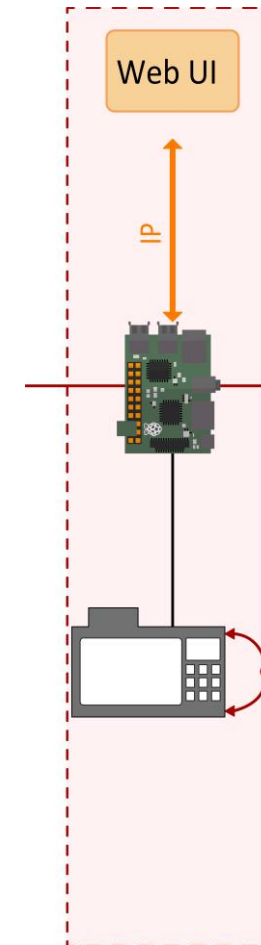


Dynamically configurable measurement setup with RaspCon controlled electronic switch matrix



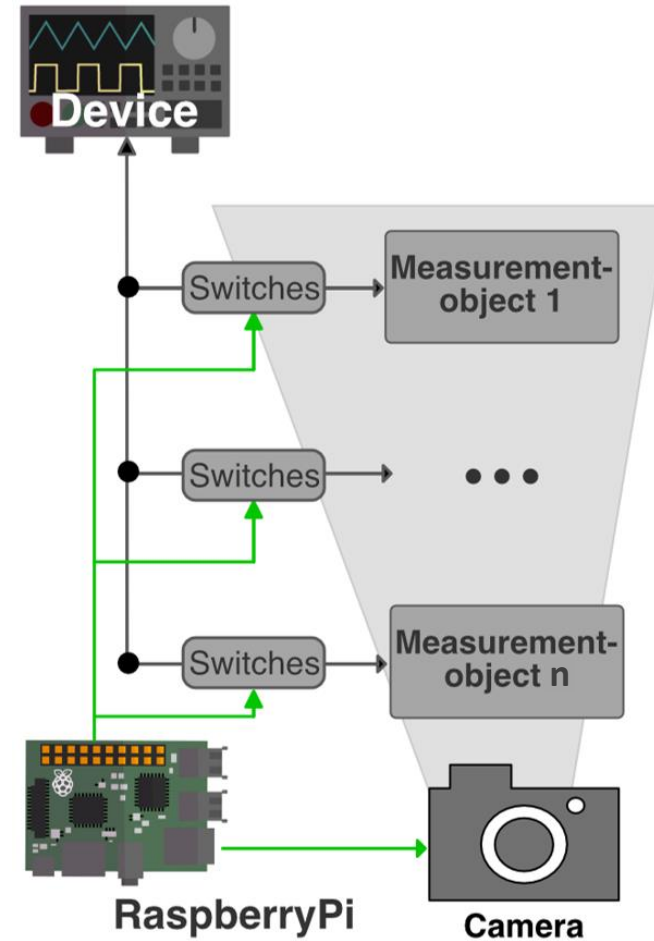
RaspCon requirements

- 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



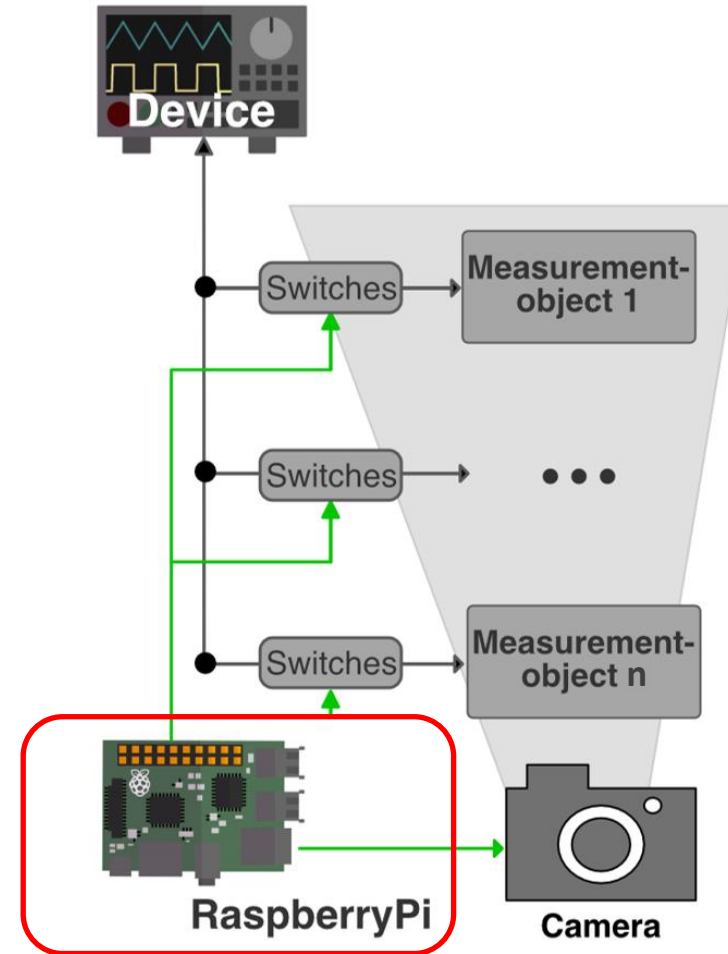
RaspCon hardware

- Arduino, Raspberry Pi, ... evaluated as controller platform



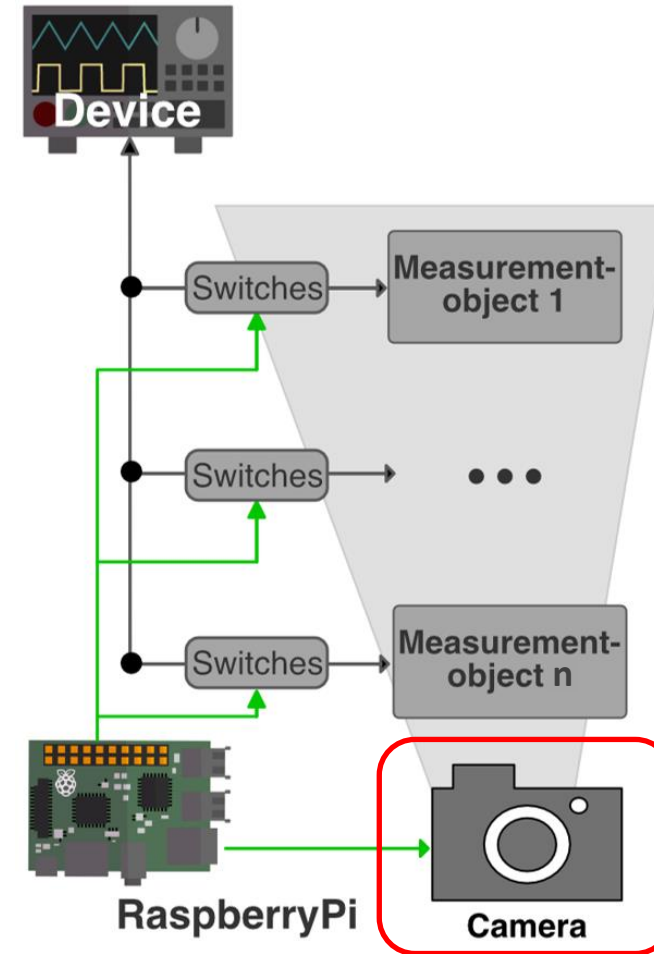
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- Arduino, Raspberry Pi, ... evaluated as controller platform
- Raspberry Pi selected
 - full Linux operating system
 - wide range of available interfaces and extension boards



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



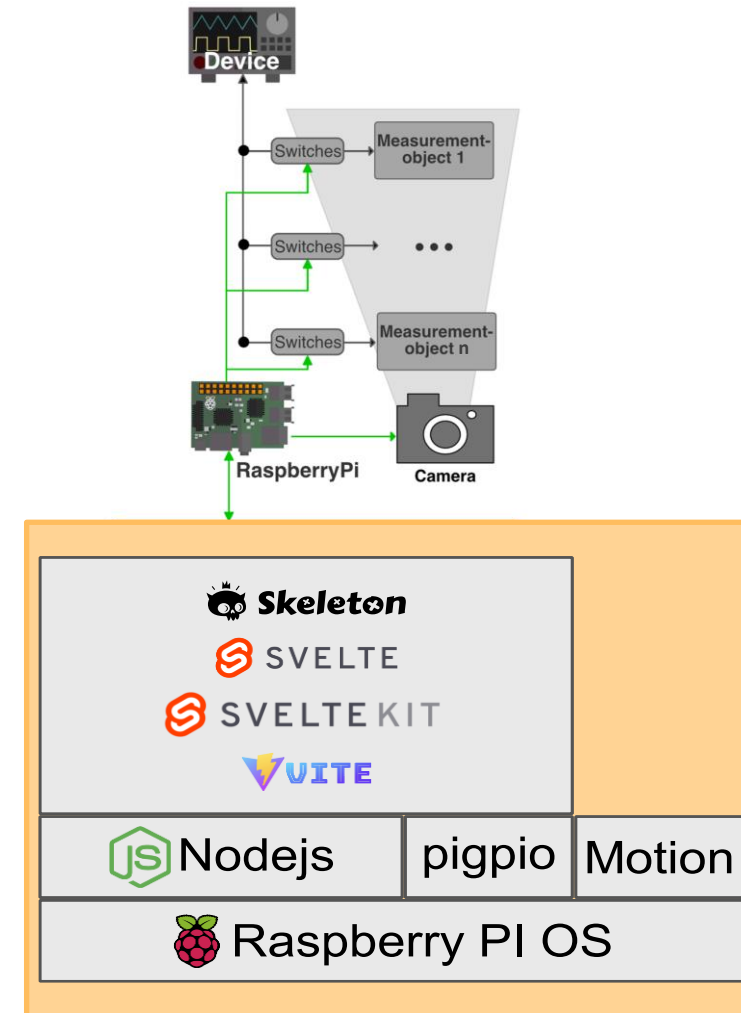
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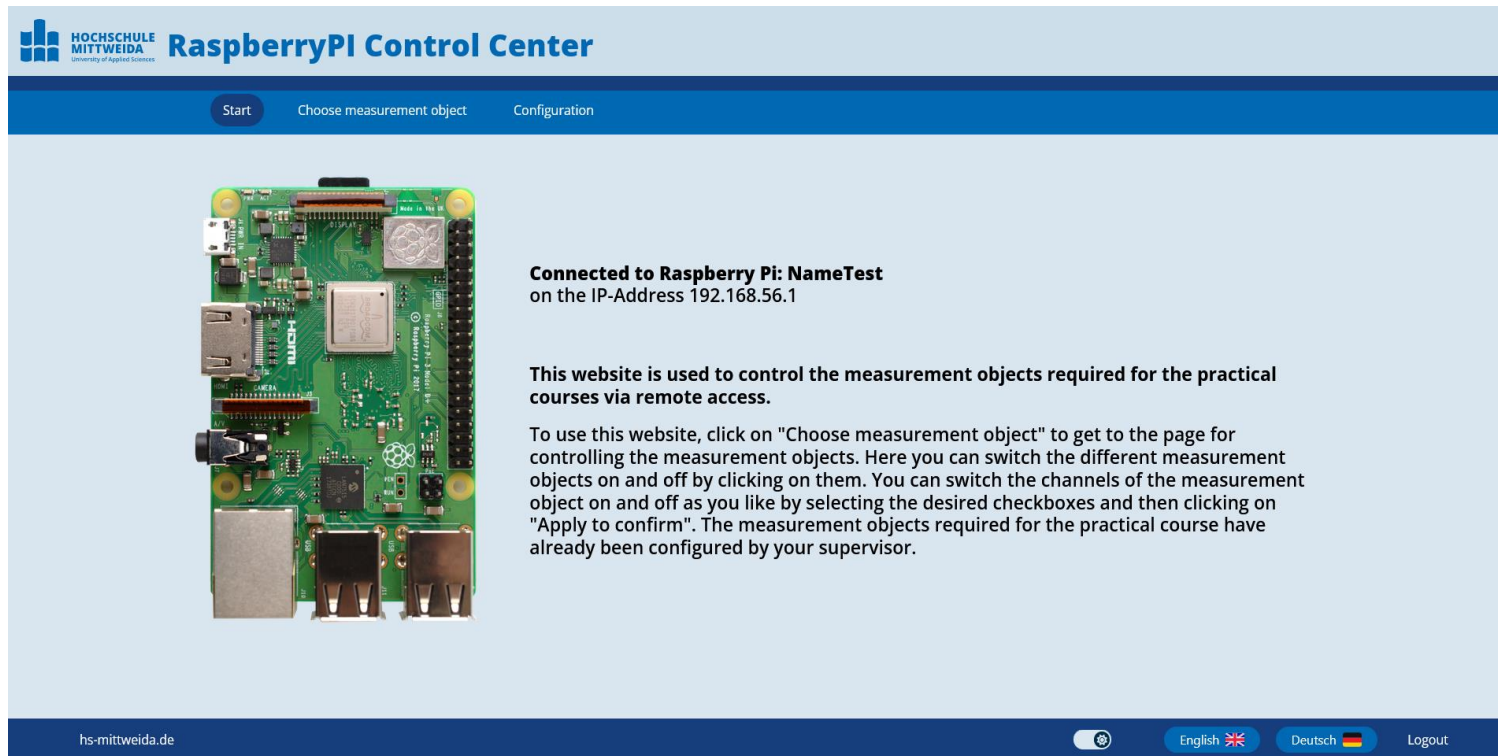
RaspCon software

- 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



The screenshot displays the RaspCon WebUI interface. At the top left is the logo for Hochschule Mittweida, University of Applied Sciences. The main header reads "RaspberryPI Control Center". Below this is a navigation bar with three tabs: "Start" (which is active), "Choose measurement object", and "Configuration". The main content area features a photograph of a Raspberry Pi 4 on the left. To the right of the photo, the text reads: "Connected to Raspberry Pi: NameTest on the IP-Address 192.168.56.1". Below this, a paragraph explains the website's purpose: "This website is used to control the measurement objects required for the practical courses via remote access." A second paragraph provides instructions: "To use this website, click on 'Choose measurement object' to get to the page for controlling the measurement objects. Here you can switch the different measurement objects on and off by clicking on them. You can switch the channels of the measurement object on and off as you like by selecting the desired checkboxes and then clicking on 'Apply to confirm'. The measurement objects required for the practical course have already been configured by your supervisor." At the bottom of the interface, there is a footer with the URL "hs-mittweida.de", a language selector showing "English" and "Deutsch", and a "Logout" button.

RaspCon WebUI

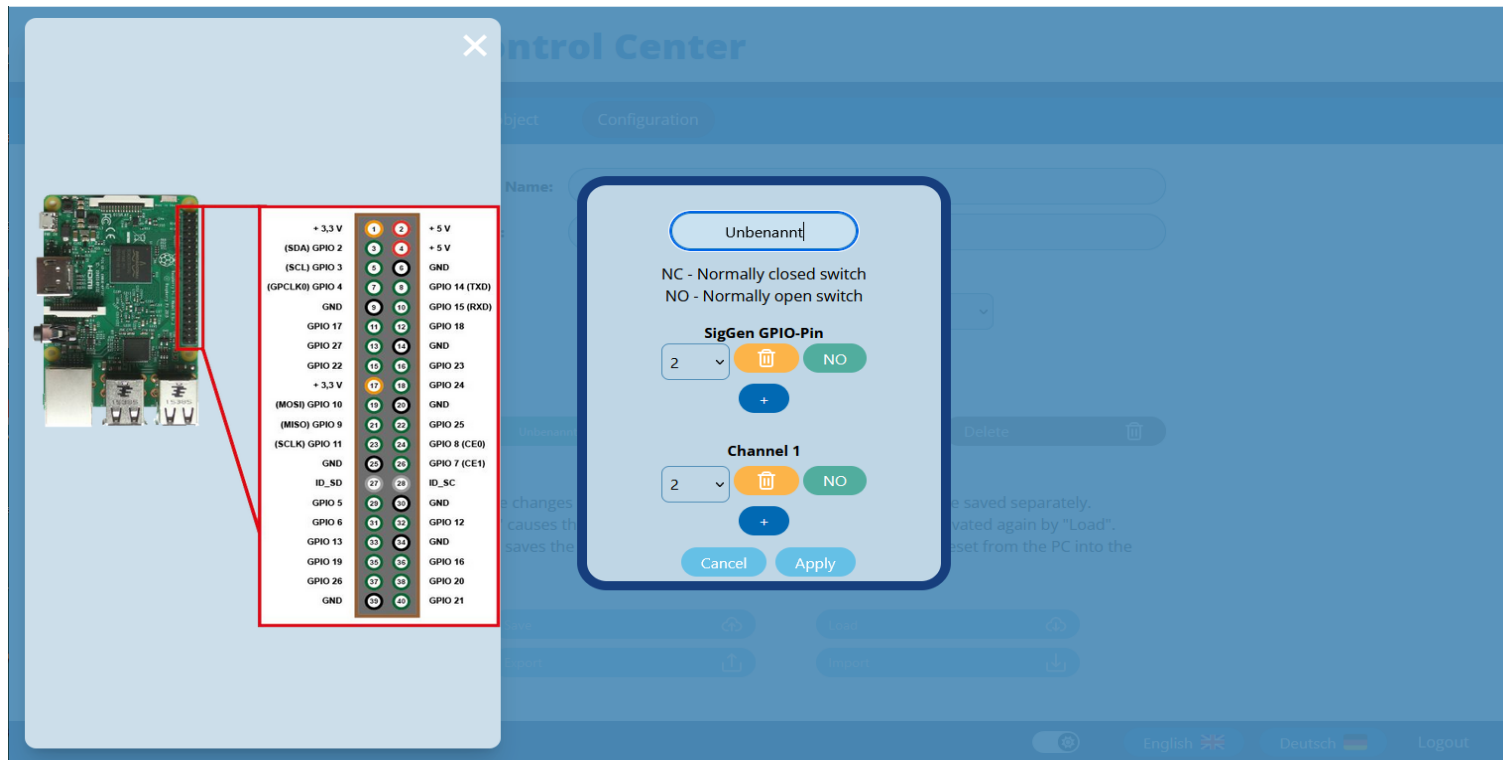
- Configuration Page:
 - Suite of tools for setting up and managing experimental configurations



The screenshot displays the 'RaspberryPI Control Center' web interface. The header includes the logo for Hochschule Mittweida and the title 'RaspberryPI Control Center'. A navigation bar at the top contains three tabs: 'Start', 'Choose measurement object', and 'Configuration', with 'Configuration' being the active tab. The main content area features several input fields: 'Raspberry Pi Name' with the value 'Laboratoy 1', 'Preset Name' with the value 'Name of the preset', and 'Number of channels' with a dropdown menu set to '2'. Below these fields is a blue button labeled 'Add measurement object'. A row of three buttons is visible: 'Unbenannt' (green), 'Edit' (blue with a gear icon), and 'Delete' (grey with a trash icon). A text block explains that changes are executed immediately and do not need to be saved separately, and defines the functions of 'Save', 'Load', 'Export', and 'Import' buttons. At the bottom, there are four buttons: 'Save' (blue with a save icon), 'Load' (blue with a save icon), 'Export' (blue with an upload icon), and 'Import' (blue with a download icon). The footer contains the website 'hs-mittweida.de', a settings icon, and language selection buttons for 'English' and 'Deutsch', along with a 'Logout' link.

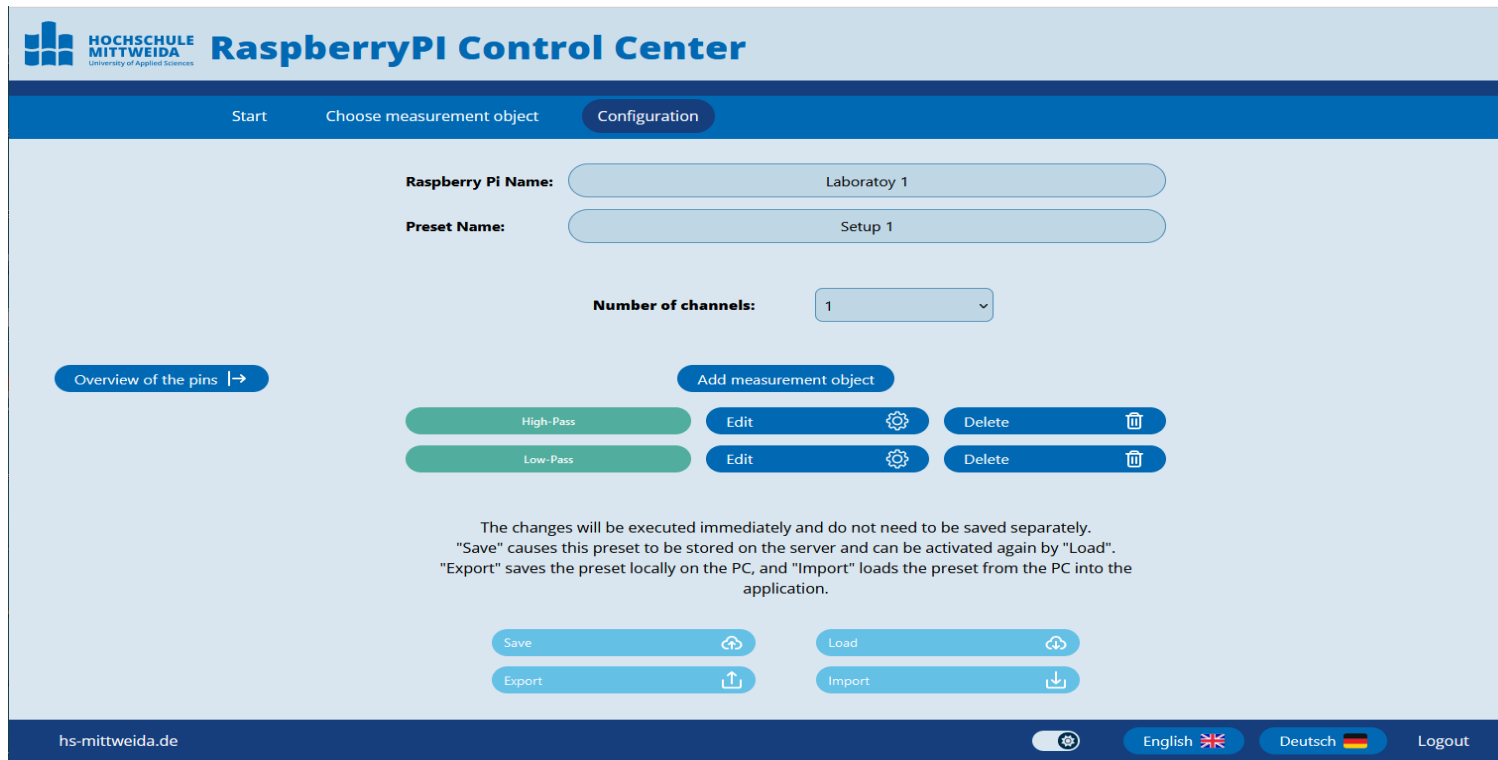
RaspCon WebUI

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



RaspCon WebUI

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



The screenshot displays the 'RaspberryPI Control Center' web interface. At the top, the logo for Hochschule Mittweida is visible. The main navigation bar includes 'Start', 'Choose measurement object', and 'Configuration'. The configuration page features input fields for 'Raspberry Pi Name' (set to 'Laboratoy 1') and 'Preset Name' (set to 'Setup 1'). A dropdown menu for 'Number of channels' is set to '1'. Below these fields, there is a section for 'Add measurement object' with two entries: 'High-Pass' and 'Low-Pass'. Each entry has 'Edit' and 'Delete' buttons. A text block explains that changes are executed immediately and provides instructions for 'Save', 'Load', 'Export', and 'Import' functions. At the bottom, there are buttons for 'Save', 'Load', 'Export', and 'Import', along with a footer containing the website 'hs-mittweida.de', a language selector for 'English' and 'Deutsch', and a 'Logout' button.

RaspCon WebUI

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

RaspberryPI Control Center

Start Choose measurement object Configuration

Livecam

Activate the channels of the measurement object by clicking on the checkboxes.

In your practical course it is noted which ones you need.

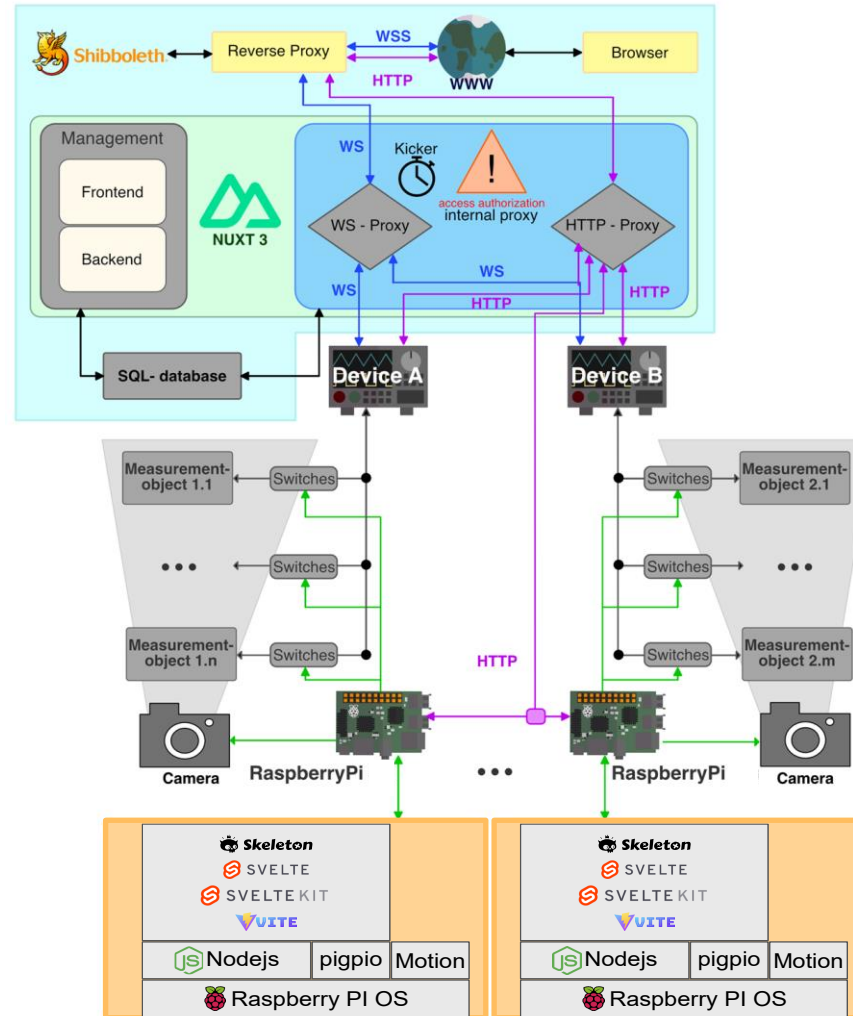
Measurement objects:	1	2	3	4
Hochpass	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Tiefpass	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Bandpass	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Bandpass 2	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>

Apply

hs-mittweida.de English Deutsch Logout

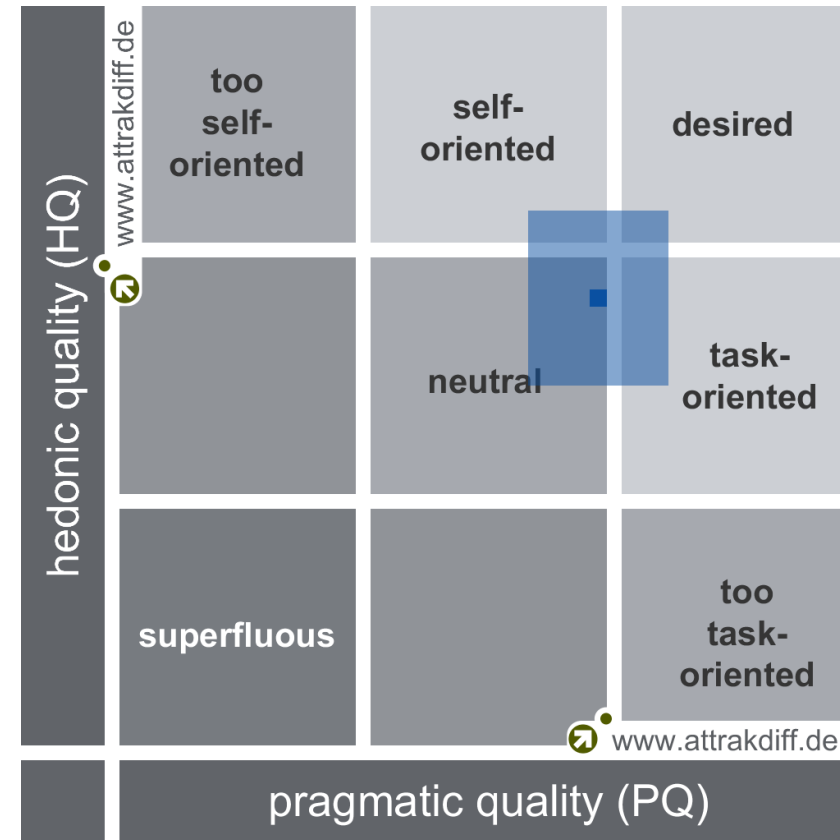
RaspCon integration

- 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





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Thank You!

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