Master Practical Course: Edge Computing and the Internet of Things

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Why are we here?

Learn by doing:

You can pass exams without ever learning anything…

you cannot ***design and build*** *a system without learning…*

Why are we here?

Idea: *Build a prototype*

From an idea to a documented prototype.

Use state of the art practices and tools.

Using a variety of devices and technologies.

Includes both embedded hardware and edge computing!

Why are we here?

Key elements:

Team

People to work and learn with.

Equipment

Real devices to build with.

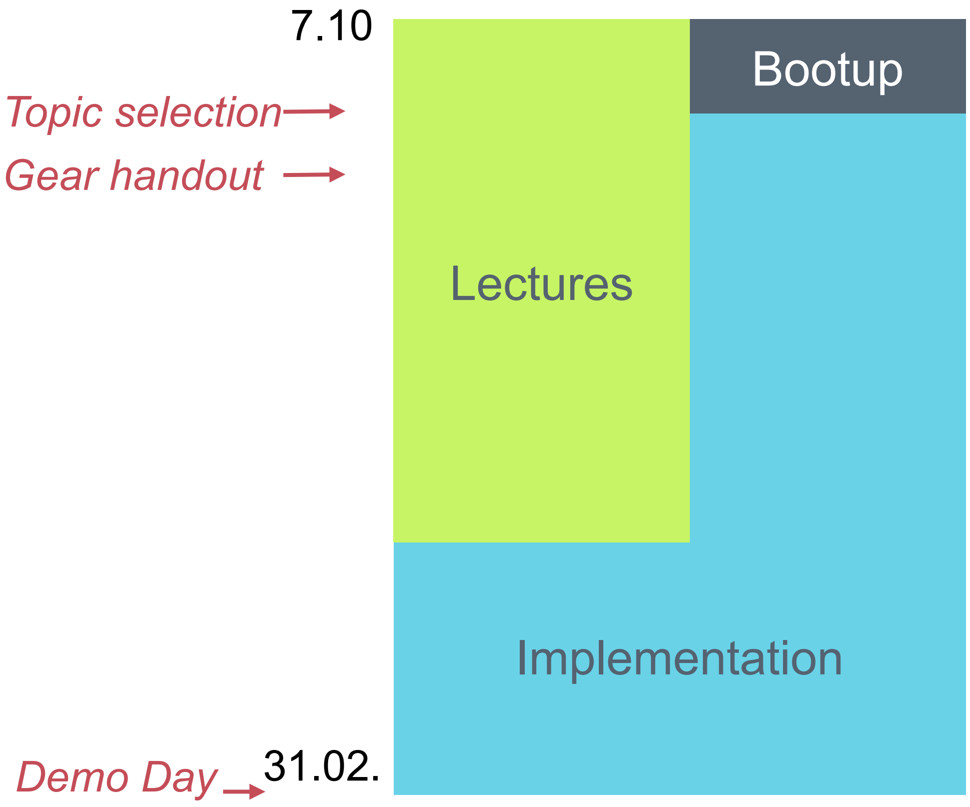
Goal

Clear goal and a structured path towards it.

Time

Full semester, lots of credits.

Course Structure



7.10

Bootup

Topic selection

Gear handout

Lectures

Implementation

Demo Day

31.02.

Developing a project idea.

Implementation **sprints**.

Progress meetings:

Every other Friday

Rough Overview

*10 ECTS / 60 days = 10 ECTS * 25 h/ECTS / 60 days*

= ~*4* h/working day

Lectures

Monday 16:00–18:00, Room 02.07.014 (Probably)

Covers technologies and approaches needed for successful projects.

Strong **SHOULD** attend (email us if you will miss a lecture).

Practical Sessions

Every other Friday 13:00–17:00, Room 02.07.014 (Probably)

Progress update for all teams + discussion.

Implementation

Continuously updating repository

Lecture Contents

- Introduction to Internet of Things + Edge
- IoT OS Overview (Linux, Riot, …)
- IoT Sensor Programming
- IoT & Edge service architectures
- Physical Layer overview
- IP v4 and v6 + 6LowPAN
- REST Protocols, REST for constrained devices (CoAP)
- MQTT Protocol, Mashups (node red) + Web of Things
- Big Data & Cloud for IoT & Edge

Project Management

Intensive development effort will fail without *structure*,
but we’re not here to run a *bureaucracy*.

Scrum-ish project management:

Backlog:

Tasks go into the backlog (issue tracker).

Work is done from the backlog.

The backlog is changed, ranked and tracked.

Visible to the course staff.

Bi-weekly presentations:

What was done, what will be done, any problems, feedback

Equipment

We provide a list of equipment available.

Range of consumer devices available today.

Each team will choose their needed equipment.

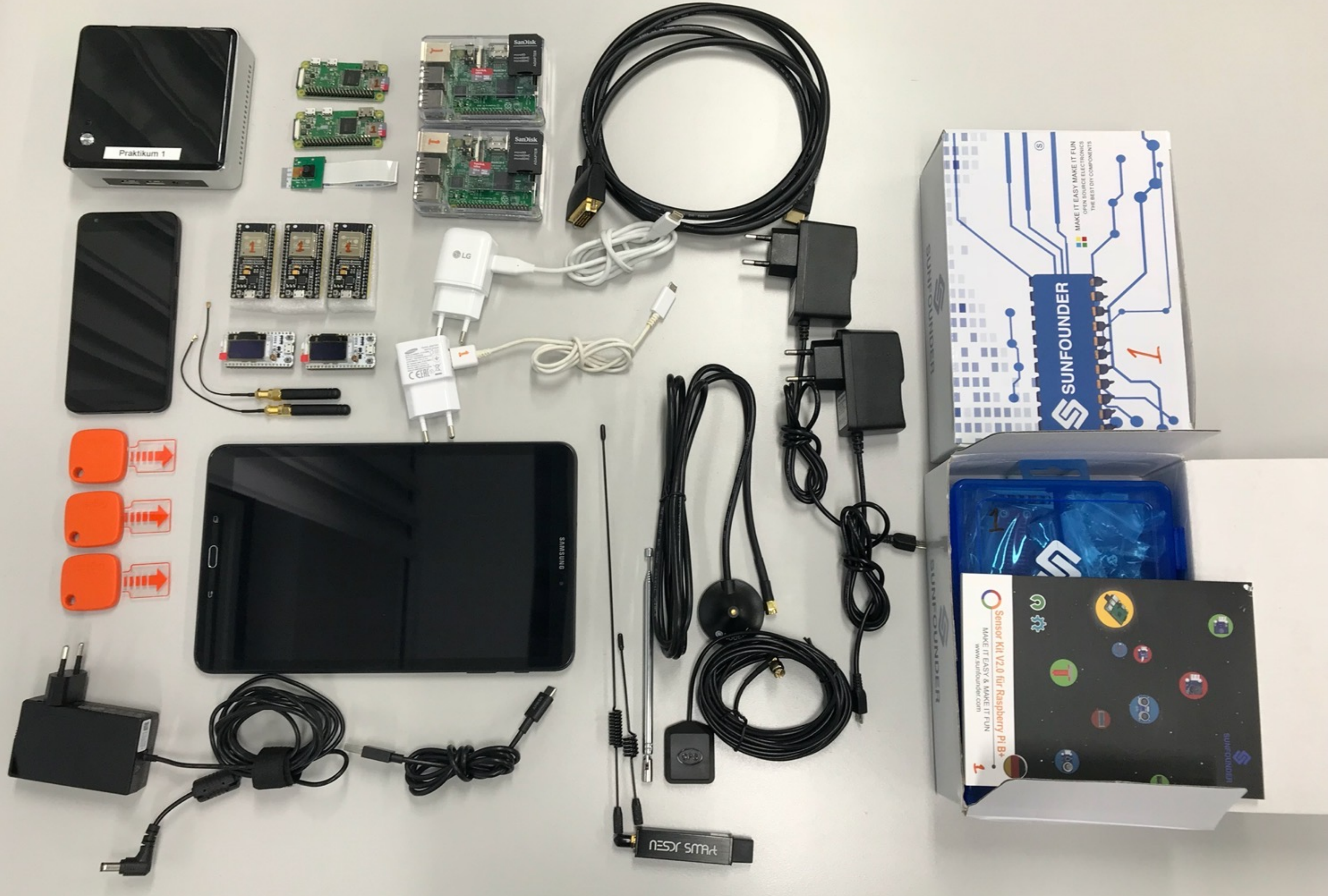
Based on the project.

We will provide sets of equipment to the teams.

Within reason and availability.

Teams are responsible for the equipment.

You sign for it and return it after the course.


Praktikum 1
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Sensor Kit V2.0 für Raspberry Pi B+
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Equipment (selection)

Computing

Raspberry Pi 3/4
Raspberry Pi Zero W
ESP32 Microcontrollers
ESP32 + LoRa
Android Phones
Mini-PCs
NVIDIA Jetson

Communication etc.

RFID reader + beacon/card
GPS receiver
Software defined radio receiver
433 MHz simple link kit

Components

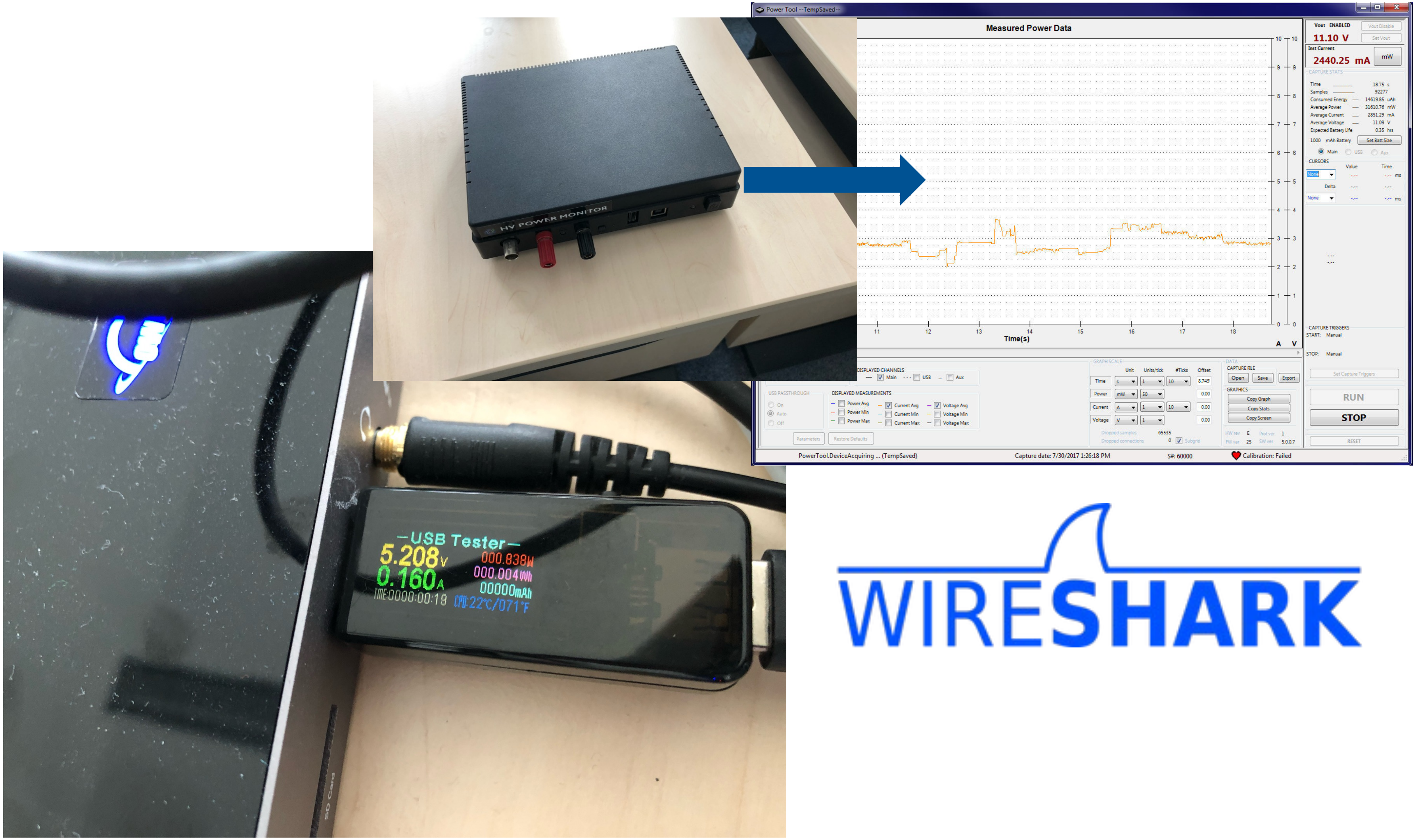
Breadboards
Connectors
Passive electronics
Active electronics
Solar panels
Batteries + Wireless charging
Powerbanks

Sensors + Actuators

PIR motion sensor
Ultrasonic distance sensor
Temperature sensor
Temperature + humidity sensor
Volatile gas sensor
Sound sensor
Buzzer (active/passive) module
Capacitive touch sensor
LCD character display
Relay switch
Force sensing resistor
Infrared line tracker
Triple axis accelerometer + gyro
Capacitive touch switch
Raspberry Pi camera
Servo motor
Stepper motor
RGB LED module
RG LED module
Auto flash LED module
I2S microphone

Laser module
Button module
Tilt-switch module
Mercury switch module
IR receiver module
Reed switch module
Photo interrupter module
Rain detector module
Joystick module
Potentiometer module
Hall switch module
Analog temperature module
Thermistor module
Sound sensor module
Photoresistor module
Flame sensor module
IR remote controller
Rotary encoder module
IR distance module
Pressure sensor module
Real-time clock module
Speakers
Shelly Plug
Power-Sensor

Measurement Equipment



Power Tool --TempSaved--

Measured Power Data

Vout ENABLED

11.10 V

Inst Current

2440.25 mA

CAPTURE STATS

```
Time                  ———   18.75 s
Samples               ———   92277
Consumed Energy       —     14619.85 uAh
Average Power         —     31610.76 mW
Average Current       —     2851.29 mA
Average Voltage       —     11.09 V
Expected Battery Life       0.35 hrs
1000 mAh Battery
```

● Main ○ USB ○ Aux

CURSORS

```
          Value   Time
None      -.--    -.-- ms
   Delta  -.--    -.--
None      -.--    -.-- ms
```

CAPTURE TRIGGERS

START: Manual

STOP: Manual

DISPLAYED CHANNELS

☑ Main ☐ USB ☐ Aux

USB PASSTHROUGH

○ On ● Auto ○ Off

DISPLAYED MEASUREMENTS

☐ Power Avg ☐ Power Min ☐ Power Max ☑ Current Avg ☐ Current Min ☐ Current Max ☑ Voltage Avg ☐ Voltage Min ☐ Voltage Max

GRAPH SCALE

	Unit	Units/tick	#Ticks	Offset
Time	s	1	10	8.749
Power	mW	50		0.00
Current	A	1	10	0.00
Voltage	V	1		0.00

Dropped samples 65535

Dropped connections 0 ☑ Subgrid

DATA

CAPTURE FILE

GRAPHICS

HW rev E Prot ver 1

FW ver 25 SW ver 5.0.0.7

PowerTool.DeviceAcquiring ... (TempSaved) Capture date: 7/30/2017 1:26:18 PM S#: 60000 ♥ Calibration: Failed

WIRESHARK

Image Sources:
https://www.wireshark.org/
https://www.msoon.com/online-store/High-Voltage-Power-Monitor-p90002590

Additional Resources

Basic electronics workstation

Soldering, lab power supply, oscilloscope, etc.

Basic 3D printing

Bambu Lab X1C (Multi-Material)

Prusa i3 MK3s+

Basic filaments

Limited resources

If you need them, email us for an appointment

What to do with the equipment?

Each individual piece has limited usefulness,

but the pieces become valuable as a *networked system*.

Big providers build *centralized systems* to which every device connects,

but we want to build the system ourselves by having the *devices communicate directly*.

This is an *advanced* course; we expect you have learned a lot already. This is a chance to put it into action and fill the gaps.

Challenge yourself, try something new and challenging.

(i.e., don’t just run PHP+MySQL on a PC and connect to it with a phone’s web browser, don’t just connect everything to a cloud service, etc.)

Grading

Combination of a **team** and an **individual** grade.

The **process** is evaluated (25%).

Idea creation, implementation, presentations.

The **end result** is evaluated (50%).

Prototype (demo), documentation, final report (8 pages).

quantitative evaluation.

Individual contributions are evaluated (25%).

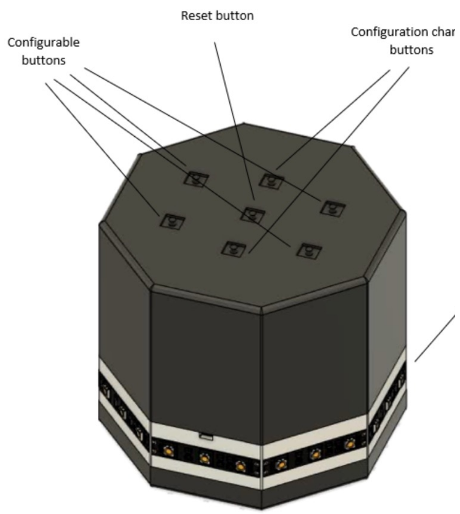
Peer evaluation, practical meetings, repository activity,

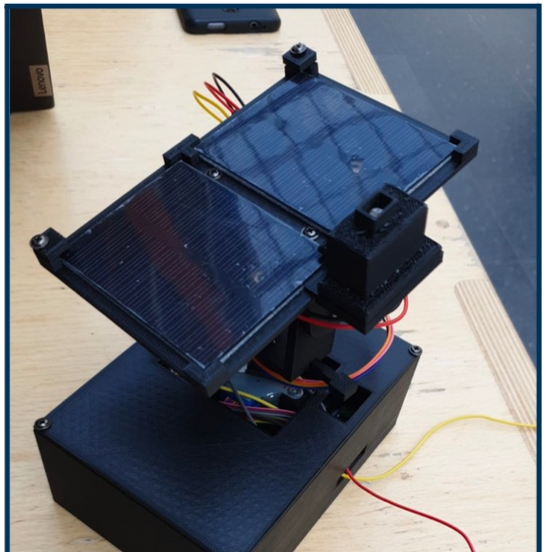
lecture attendance and contributions.

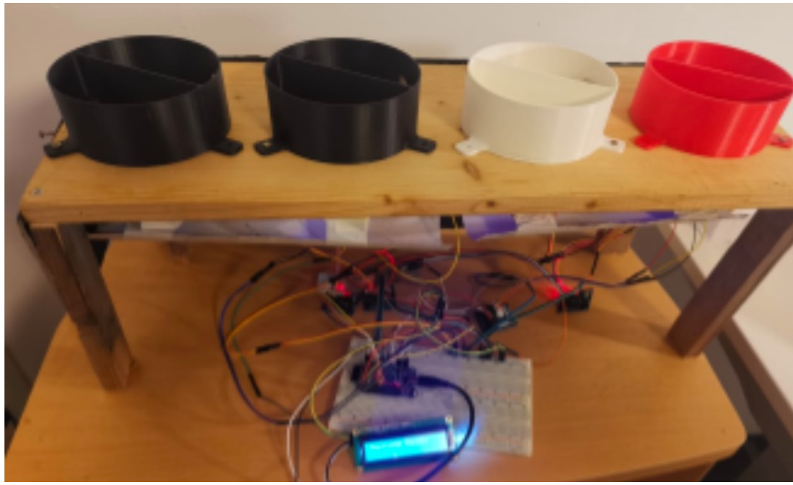
Deep Dive: Requirements

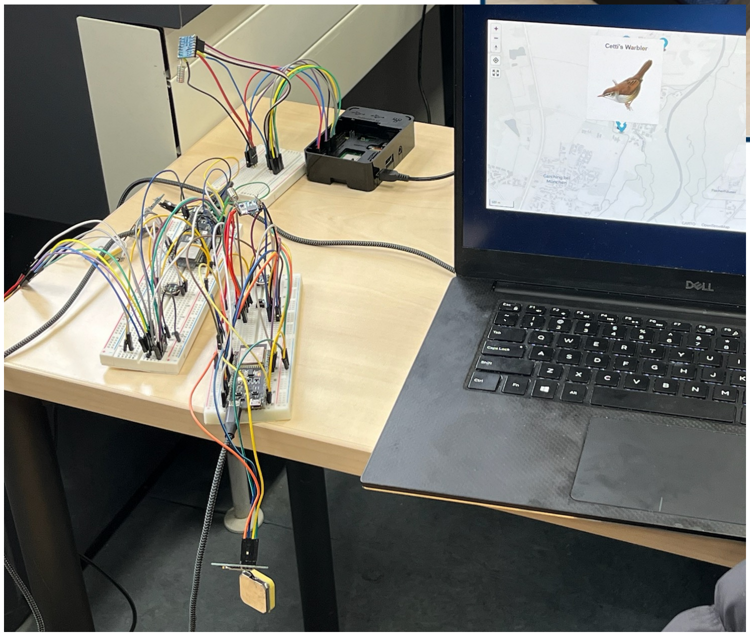
- Focus on **embedded and lower-level development**
  - Not a course on web-development!
  - Don’t just use Node-Red to glue together scripts
  - You will need to use some sensor / actuator
- Focus on **technical challenges**
  - You must be able to do a demo, but you should build more than a flashy demo
- Follow good software engineering practices
  - You must use **Git** (Proper commit messages, Pull requests)
  - You must set up **CI** (at least test your algorithms)
- You should use **edge computing**
  - Find something that benefits from local compute and **highlight** the benefits
- Your system should be **optimized** for the edge
  - Small messages (can you use sth. that has less bandwidth than Wi-Fi?)
  - Use low-power devices

IoT Examples (From This Course)









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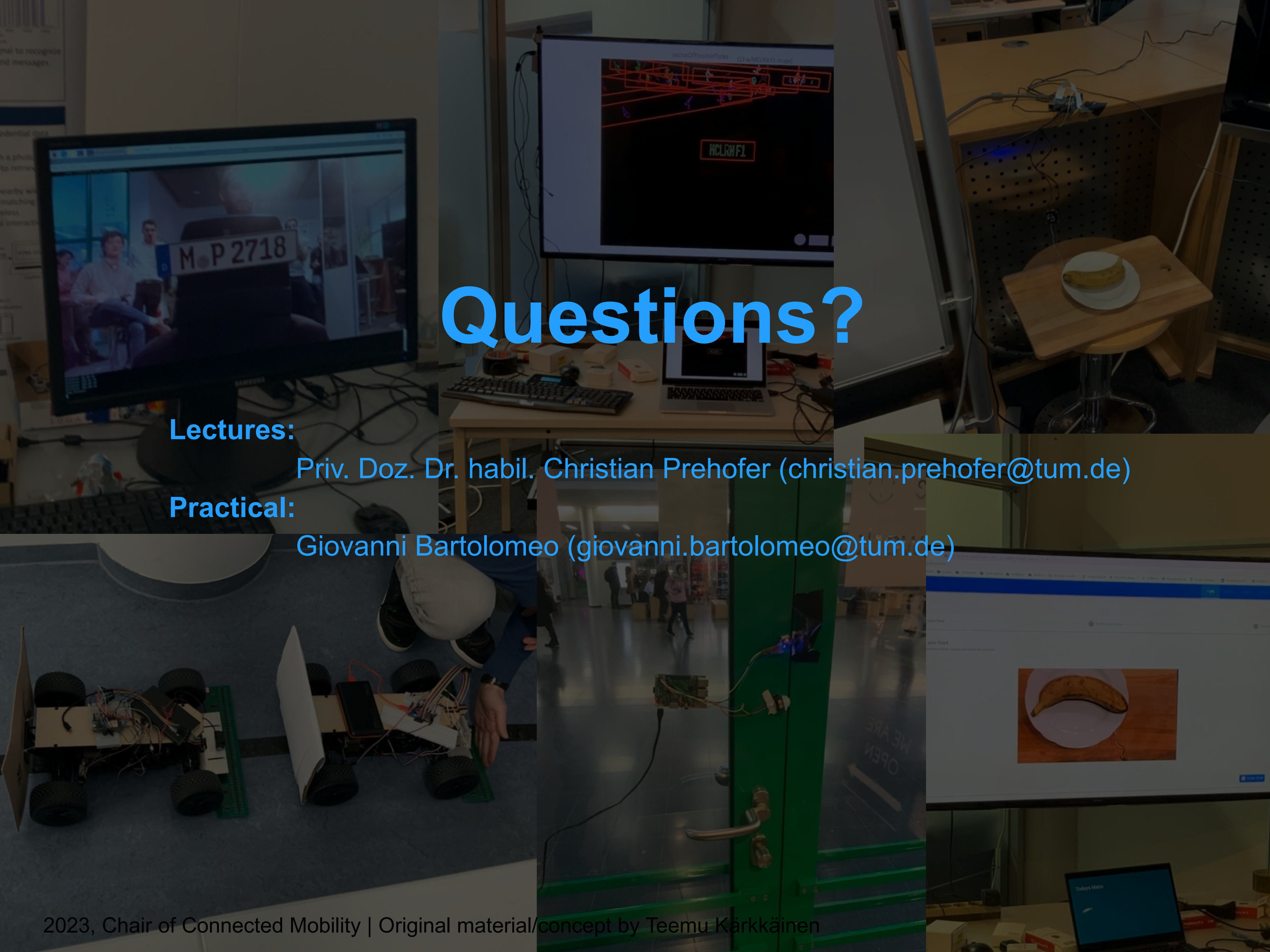
Ahmed Kaddah



Questions?

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