# Bachelor Lab Course

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#### Goals

- Familiarization with IoT Cloud concepts
- Deepen your computer architecture and system level programming skills
- Understand Hardware/Software interaction

#### **Use Case: Seminar Room Monitoring**





#### **Microcontroller vs Microprocessor**

- Microprocessor
  - Processor with external memory
- Microcontroller
  - Processor with integrated memory
  - Flash + SRAM
  - A lot of I/O interfaces

### **Espressif ESP32**



https://www.espressif.com/en/products/socs/esp32

## ESP32 Block Diagram

embedded flash	Bluetooth link controller	Bluetooth baseband	rec	RF receive				
SPI		C	Clock generator					
I2C		WiFi	8-11	DE	S	8		
125	WIFI-MAC	baseband	tra	nsmit				
SDIO	core and m	core and memory			Cryptographic hardware			
UART					ion			
CAN	2 (or 1) x Xter bit LX6 Microp	2 (or 1) x Xtensa@ 32 bit LX6 Microprocessor			RSA			
ETH	ROM	SRAM	AES	AES RNG				
IR								
PWM	RTC							
Touch Sensor								
DAC	MMU	ULP co-proce	ssor	Recovery memory				
ADC					,			

### LILYGO Wrover-B Board

![](_page_7_Picture_1.jpeg)

![](_page_7_Picture_2.jpeg)

![](_page_7_Picture_3.jpeg)

### FreeRTOS

- ESP IDF is based on the Free Real Time Operating System (FreeRTOS)
  - <u>freertos.org</u>
  - Maintenance taken over by Amazon from Real Time Engineers Itd.
    - Integration of sensors with the Greengrass edge runtime
  - It is free: No need to publish your code if developed with FreeRTOS, no fees
- Basically a runtime system linked to the application
- Managing resources: CPU, memory, timers, IO
- Supports soft and hard realtime requirements

#### Sensors

![](_page_9_Picture_1.jpeg)

Sound Sensor

![](_page_9_Picture_3.jpeg)

Soil Moisture Sensor

![](_page_9_Picture_5.jpeg)

Light Sensor

![](_page_9_Picture_7.jpeg)

Ultrasonic sensor

![](_page_9_Picture_9.jpeg)

Relay

![](_page_9_Picture_11.jpeg)

Water Sensor

![](_page_9_Picture_13.jpeg)

Temperature and Humidity Sensor

# Organization

- Part 1 (6 weeks): Basics of ESP32 and freeRTOS
  - Mode 1 (no corona): Intensive training at Frauenchiemsee
    - 3 day (13.-15.10.)
    - Full board, costs 150 €
  - Mode 2 (corona): Weekly online meetings
- Part 2 (6 weeks): Select and implement an IoT use case
  - We offer the chairs IoT platform providing sensor value storage and analysis.
  - We help finding use cases.
- You will work in groups
- Language: English

## Requirements

- Lecture and lab Introduction into Computer Architecture
- C/C++ programming skills
- Experience with Arduino would be helpful but is not required
- Basic knowledge about voltage, current, resistors, ...

# Learning Outcomes

- You will
  - understand features and programming of microcontrollers.
  - be able to manage and profit from multicore architectures.
  - know the concepts of real time operating systems.
  - have the required skills to design energy efficient IoT solutions.