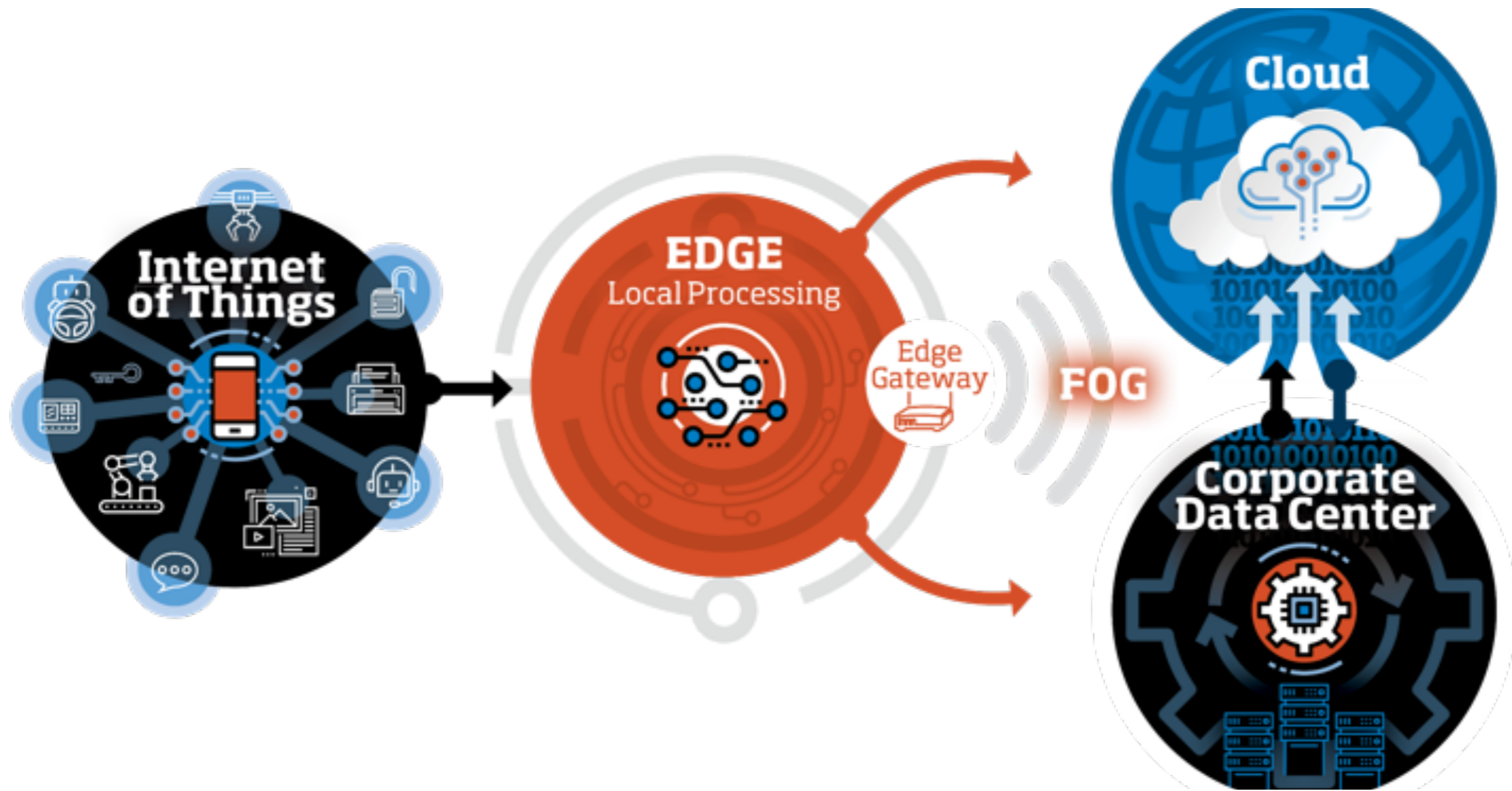# Bachelor Lab Course
# IoT Sensor Nodes

Michael Gerndt, Isaac Nunez

Technische Universität München
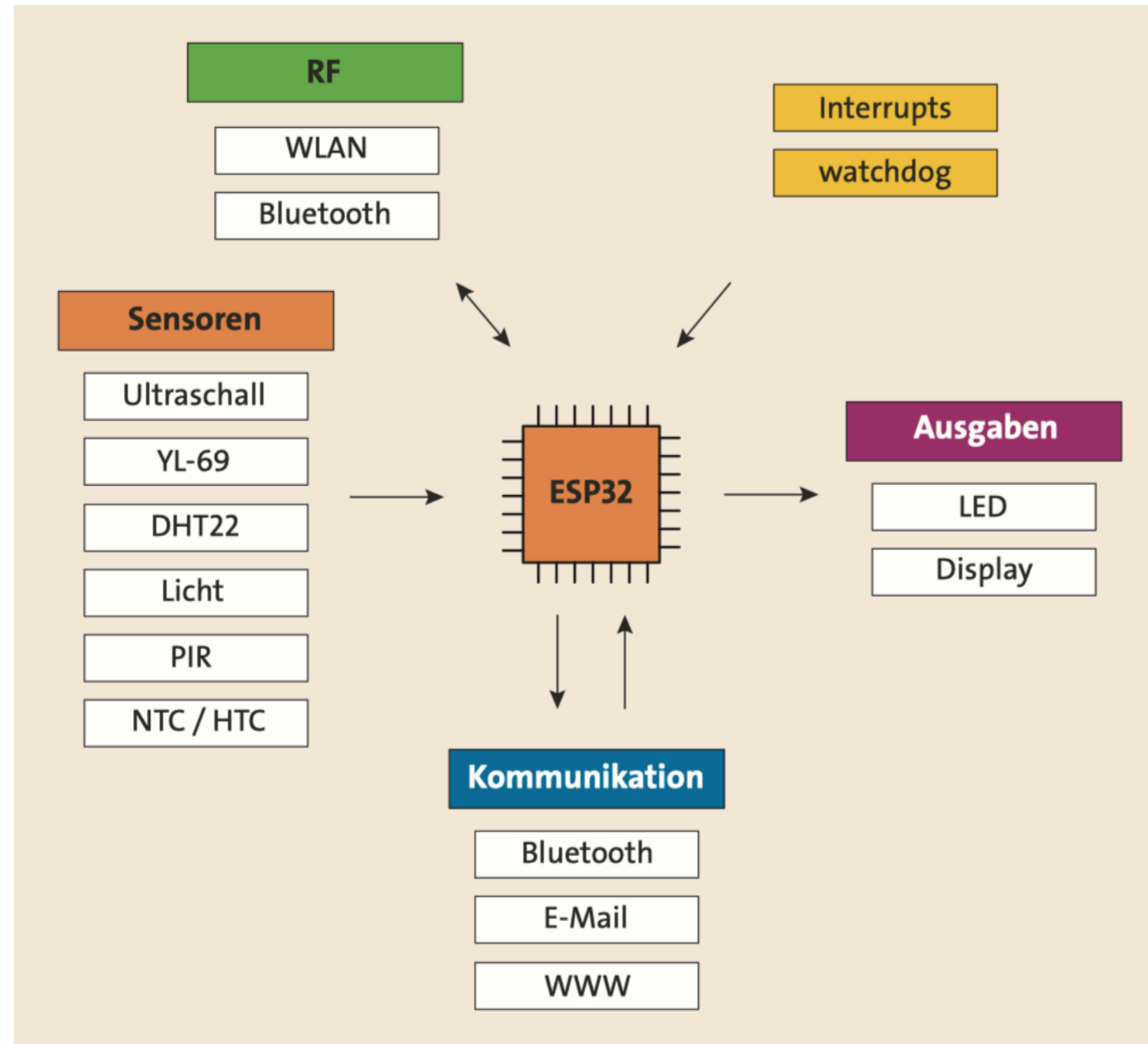
# IoT Components

# What to expect?

- You have the opportunity to develop the skills for embedded programming!

- The lab provides you with the environment to experiment around sensors and the challenges of resource constraints!

- We also explore the other side of sensing: the requirements to store, process, visualize, and act on incoming data!

- You will also develop the necessary skills to work in teams across a diverse set of skills!

# First steps…

- µProcessor vs µController?

- µProcessor
  - Has external memory
  - Only arithmetic and logic functionality
  - It scales to more applications. Multiple µProcessors in a IC.

- µController
  - Memory is integrated
    - It has Flash and SRAM
    - More registers
  - I/O interfaces are also available
  - It is contained in a single IC.
  - Usually found in embedded applications

- Then SoC? SoP?

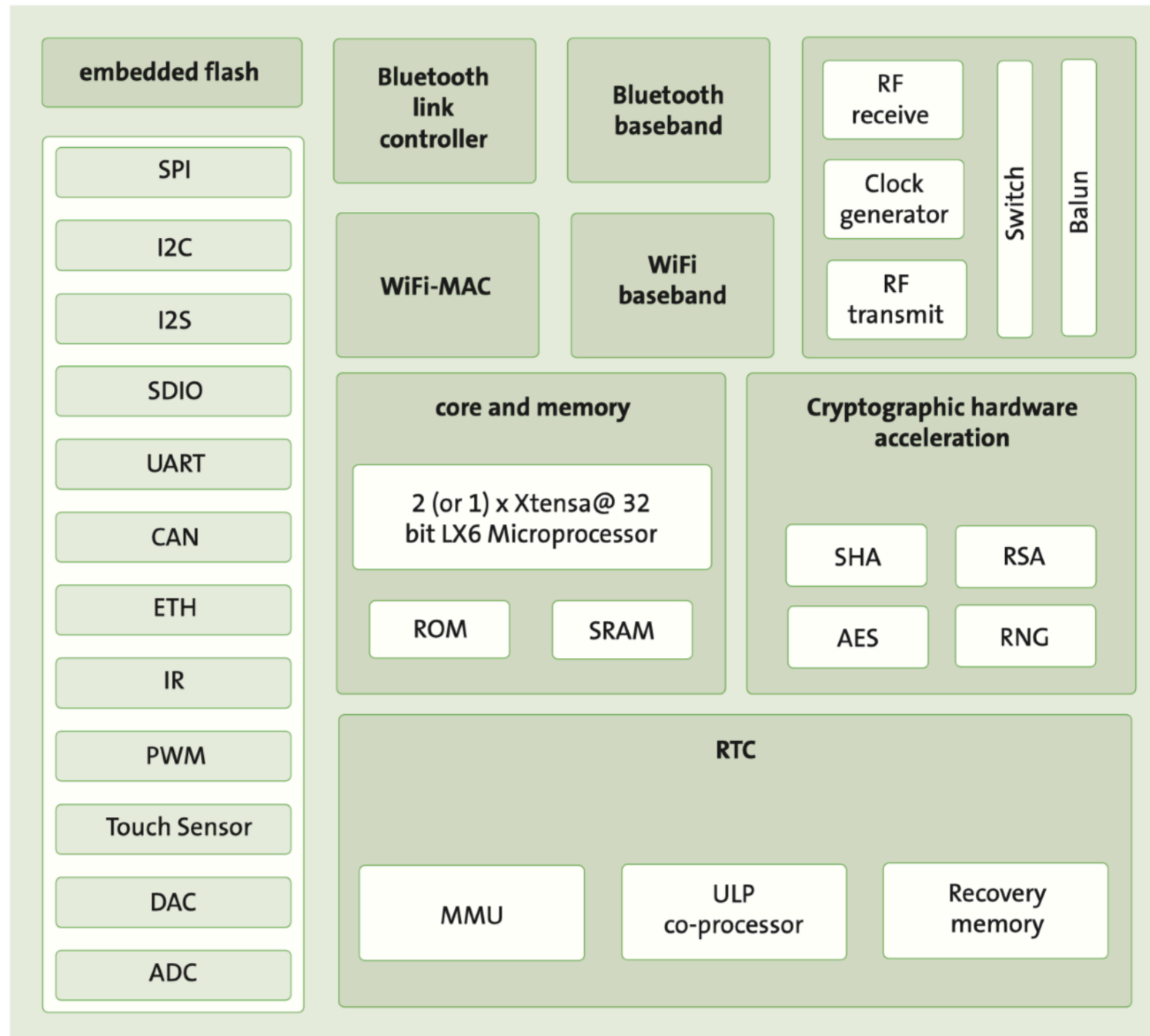- Nowadays, terms are more continuous than clear separations…

# What we will be using?
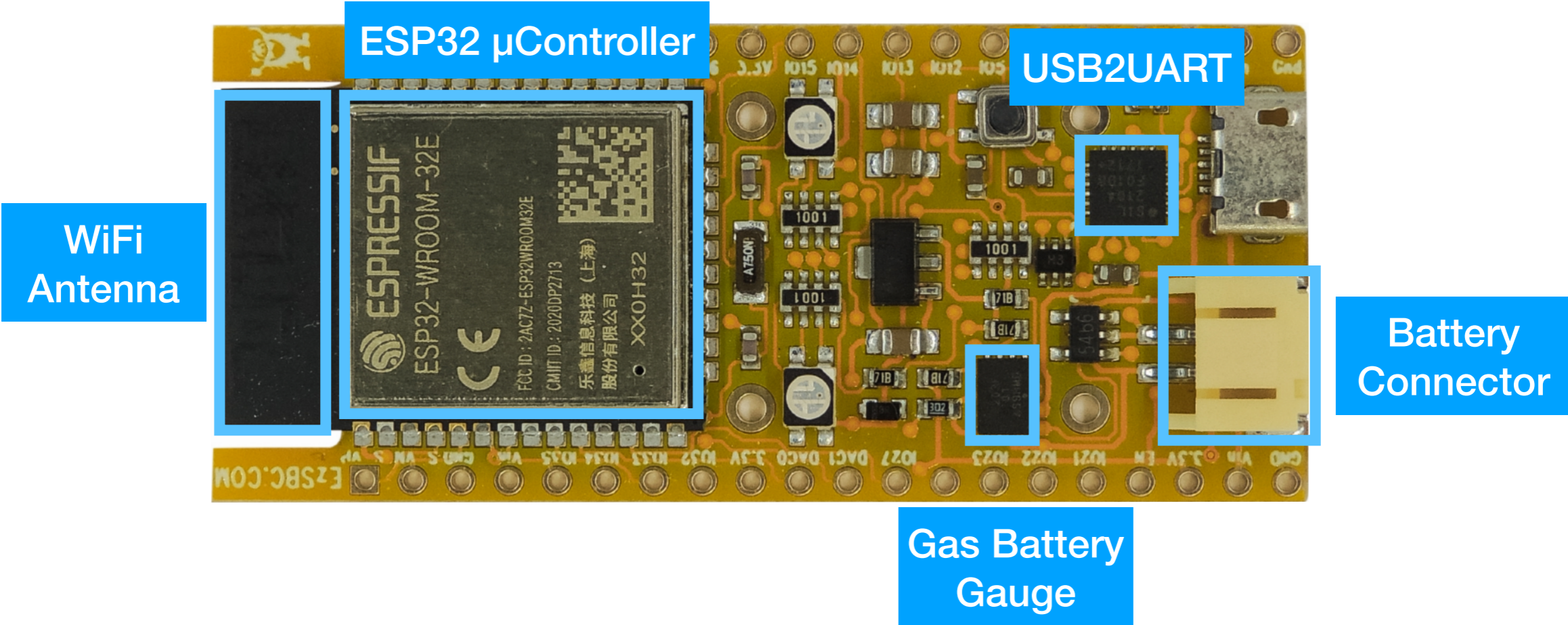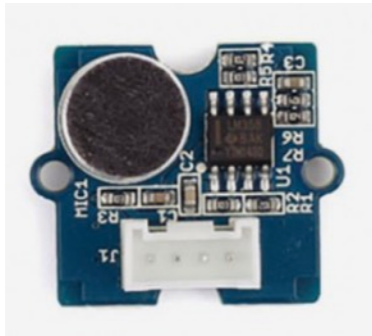
# Espressif ESP32



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

# ESP32 Block Diagram

# EZSBC ESP32 WROOM



ESP32 µController

USB2UART

WiFi Antenna

Battery Connector

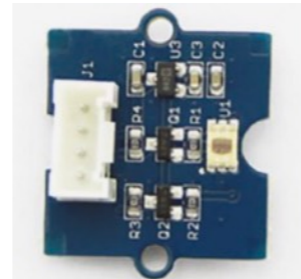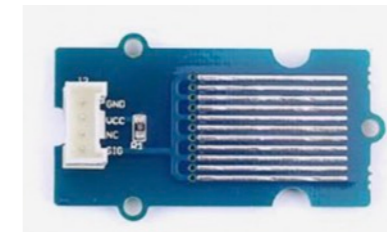Gas Battery Gauge

8

# Sensors


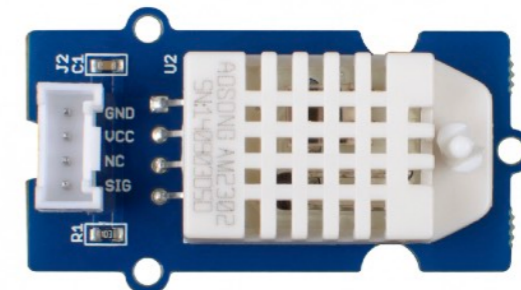Sound Sensor


Light Sensor


Water Sensor


Soil Moisture Sensor


Ultrasonic sensor


Temperature and Humidity Sensor


Relay

# FreeRTOS

- ESP IDF is based on the Free Real Time Operating System (FreeRTOS)
    - freertos.org
    - Maintenance taken over by Amazon from Real Time Engineers ltd.
        - 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

# Your final project!

- Sense data around Fraueninsel for max. two days.

- You must showcase your data and its meaning using our IoT Platform!

- We want:
  - Count people
  - Collect environment data

# Organization

- Part 1 (~6 weeks): Basics of ESP32 and freeRTOS
  - Weekly meetings
  - Mondays between 10:00 and 11:30
  - By solving weekly assignments, you will develop the skills to work with the ESP32, FreeRTOS, and sensors!
- Part 2 (~6 weeks):
  - Teamwork to develop one functionality. More details during the semester!
  - The end of this phase is marked by going to Fraueninsel
    - Your functionality will be part of one (or many) sensor node(s)
    - Your sensor will have to collect data for a few hours
    - **Participating in the trip to Fraueninsel is required to pass the Praktikum!**
- Language:
  - Default: English.
  - TAs and I can also assist in German, although it is not required to participate.

# Suggested Pre-requisites

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

- **You don't need to know all of them!** We can also teach you the fundamentals!

ПШ

# 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.