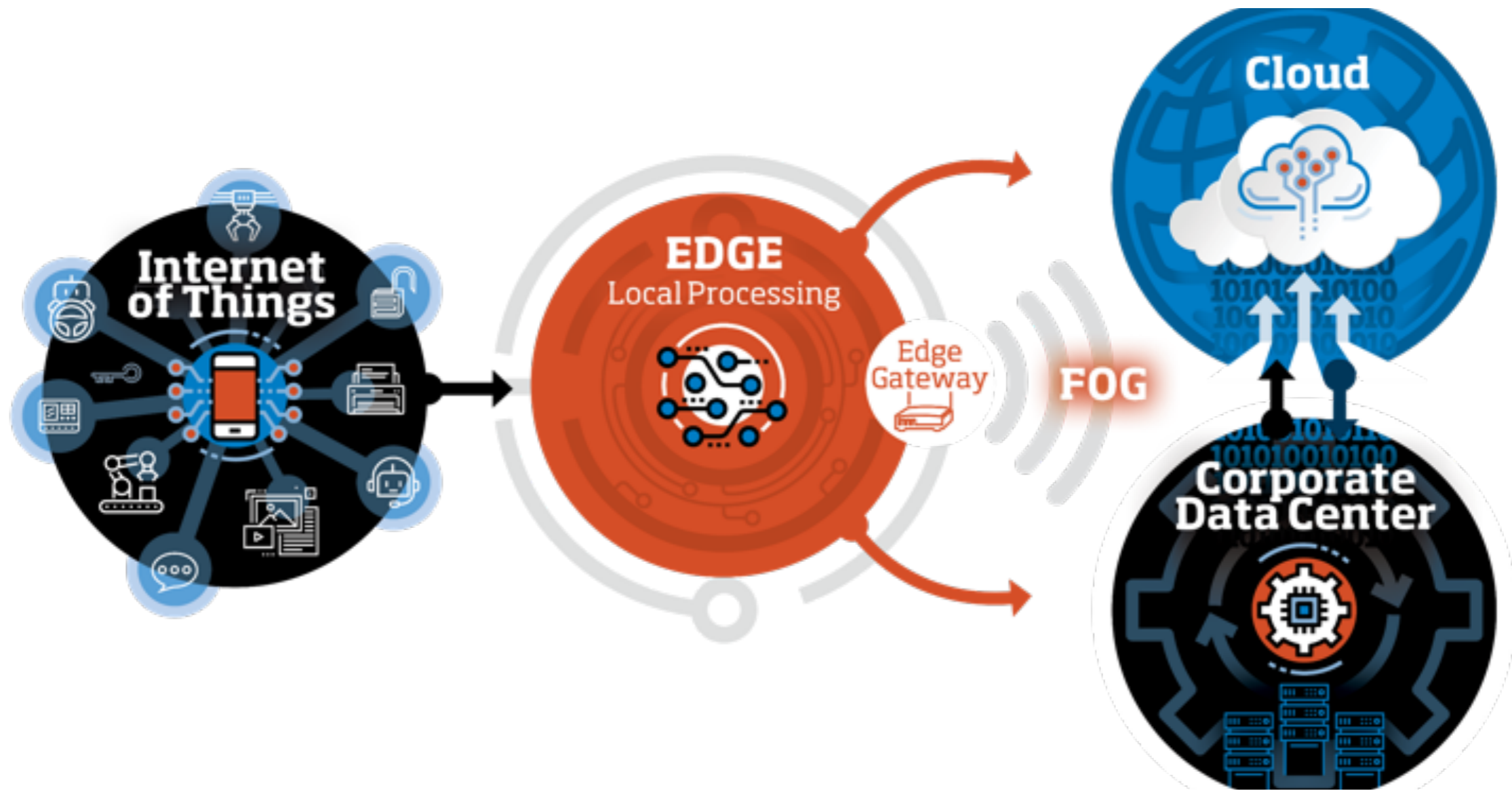# Bachelor Lab Course
IoT Sensor Nodes

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!

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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?
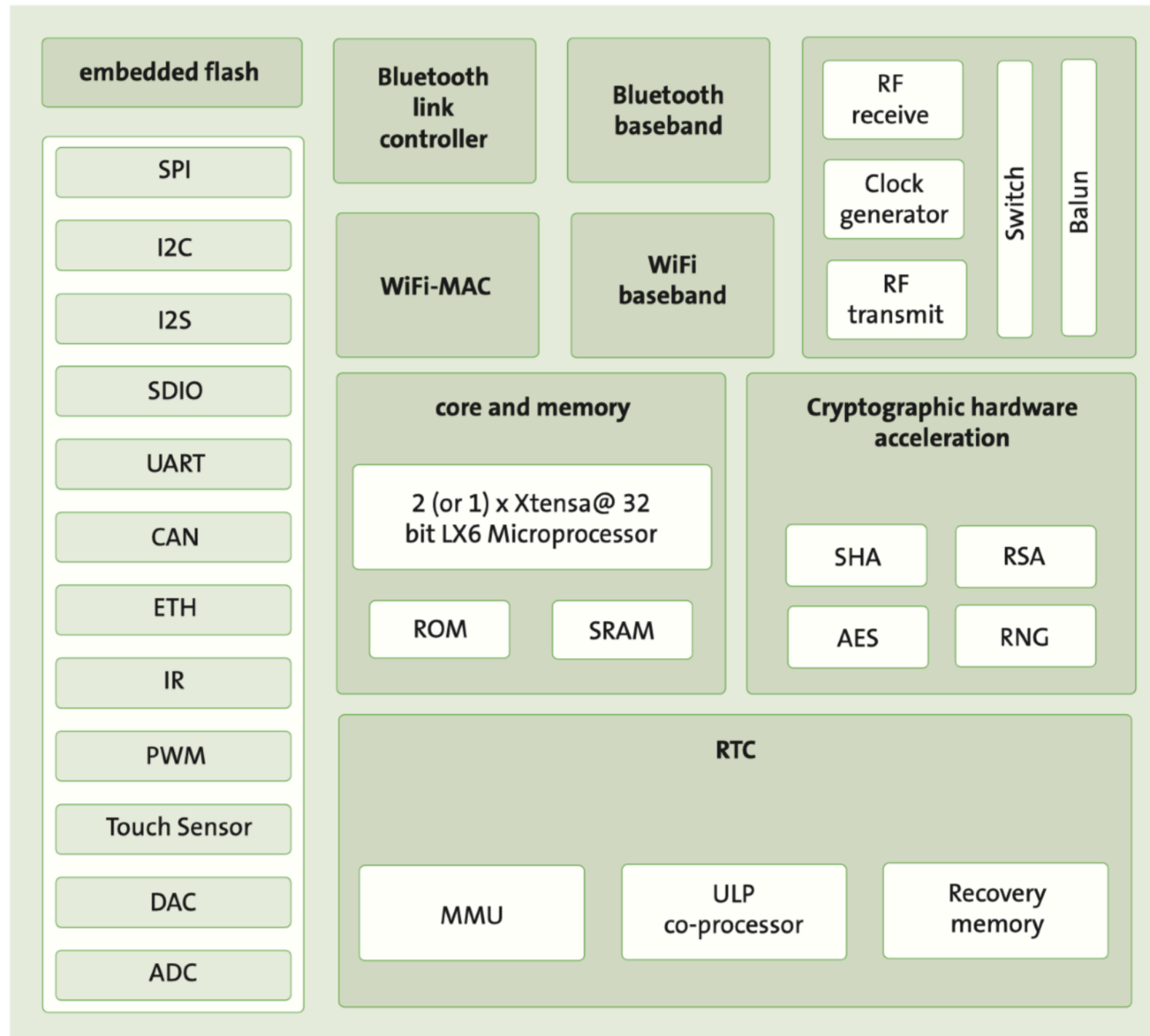- Nowadays, terms are more continuous than clear separations…
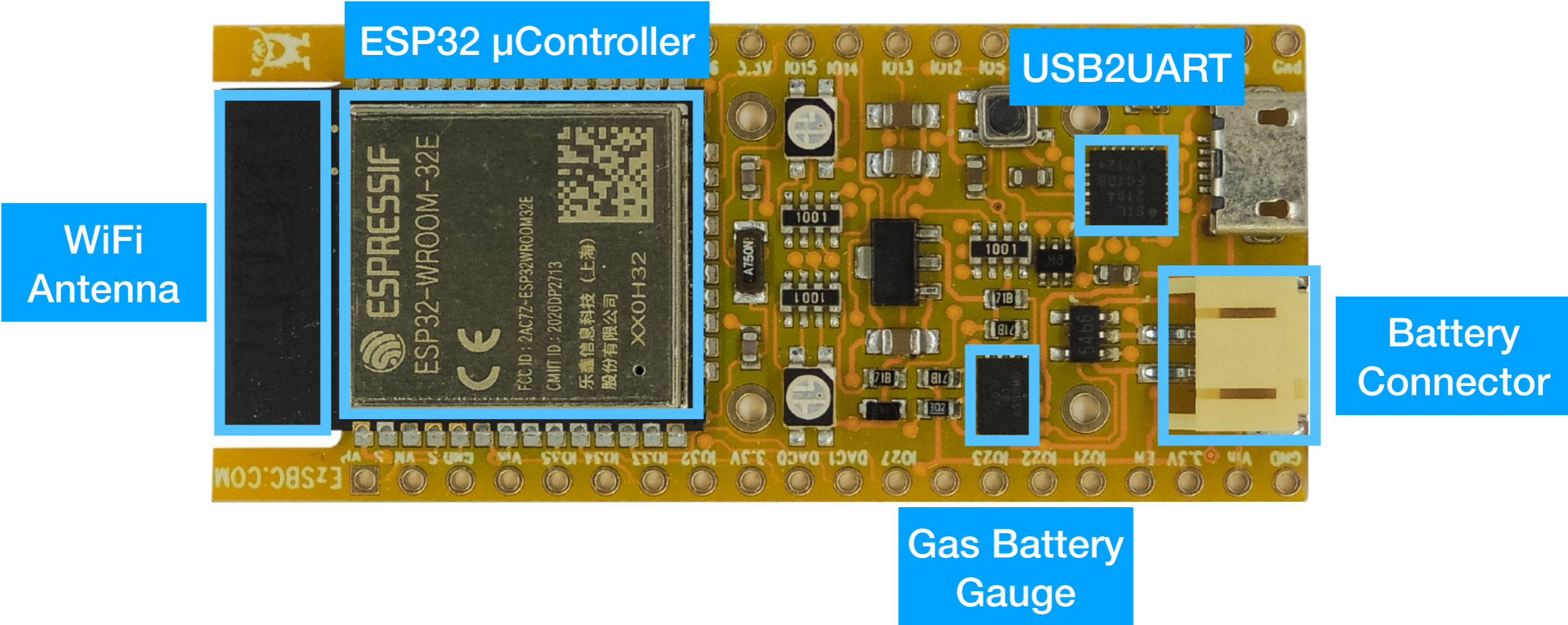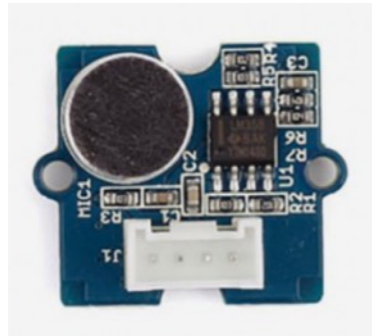
What we will be using?

Espressif ESP32

https://www.espressif.com/en/products/socs/esp32
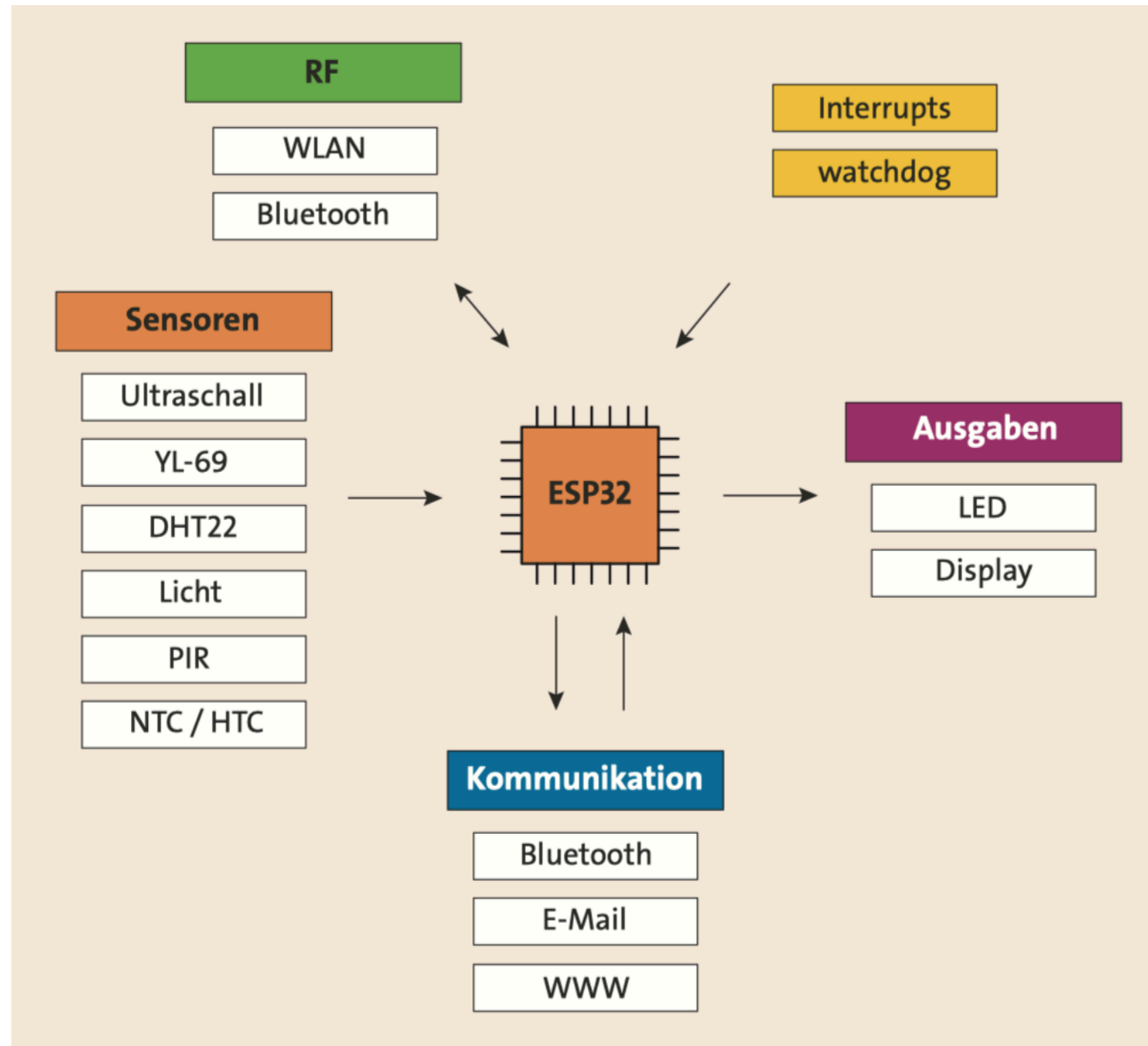
ESP32 Block Diagram

EZSBC ESP32 WROOM

ESP32 µController

USB2UART

WiFi Antenna

Battery Connector

Gas Battery Gauge
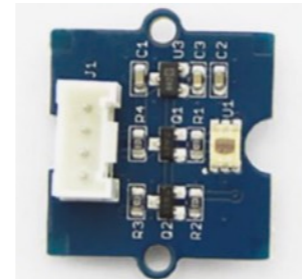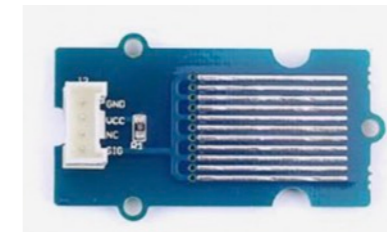
Sensors

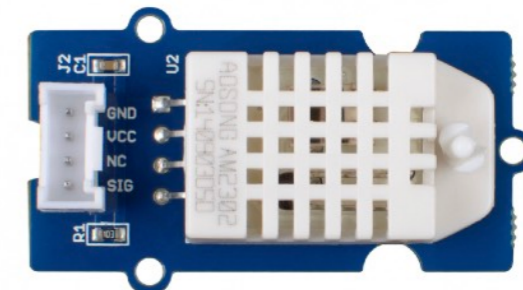Sound Sensor

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 12:00 and 14:00
  - 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!

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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.