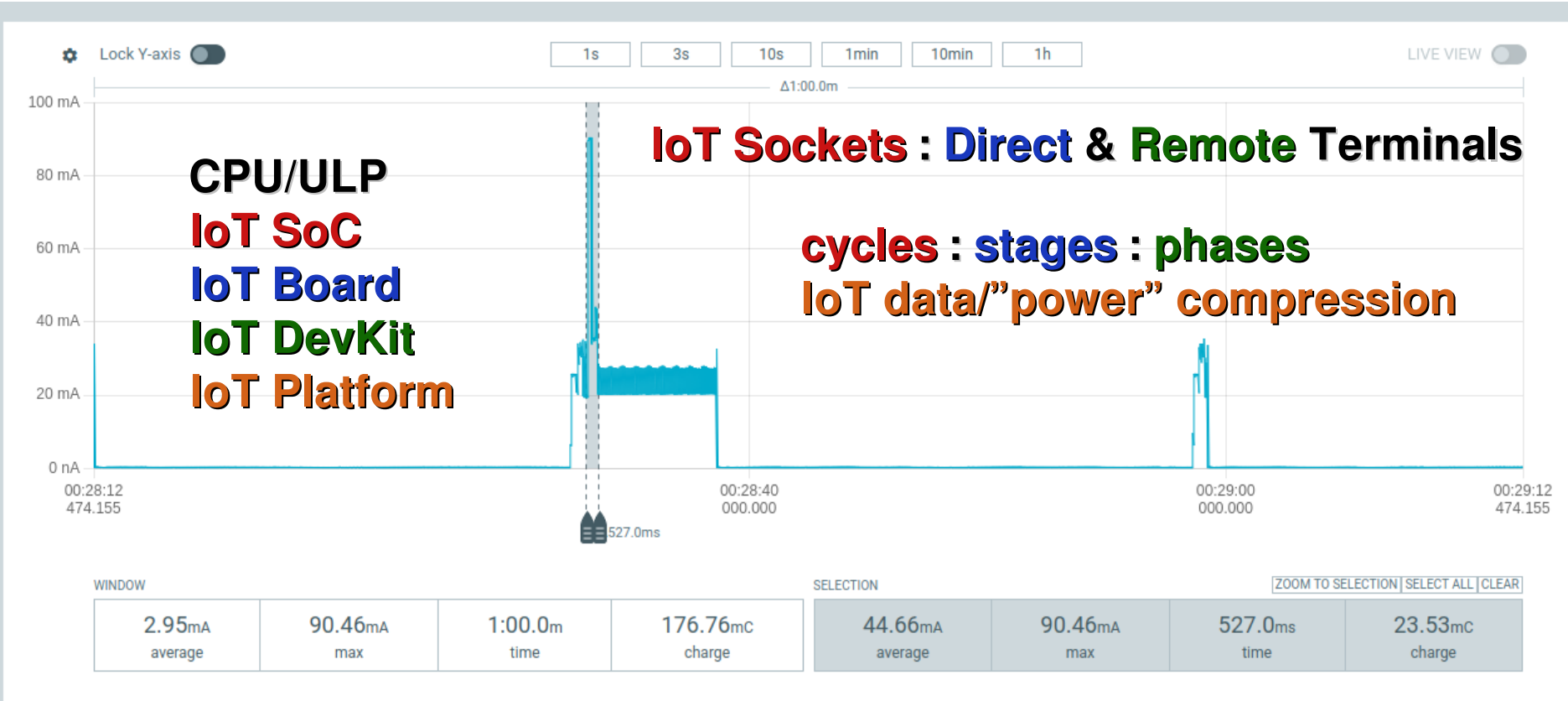
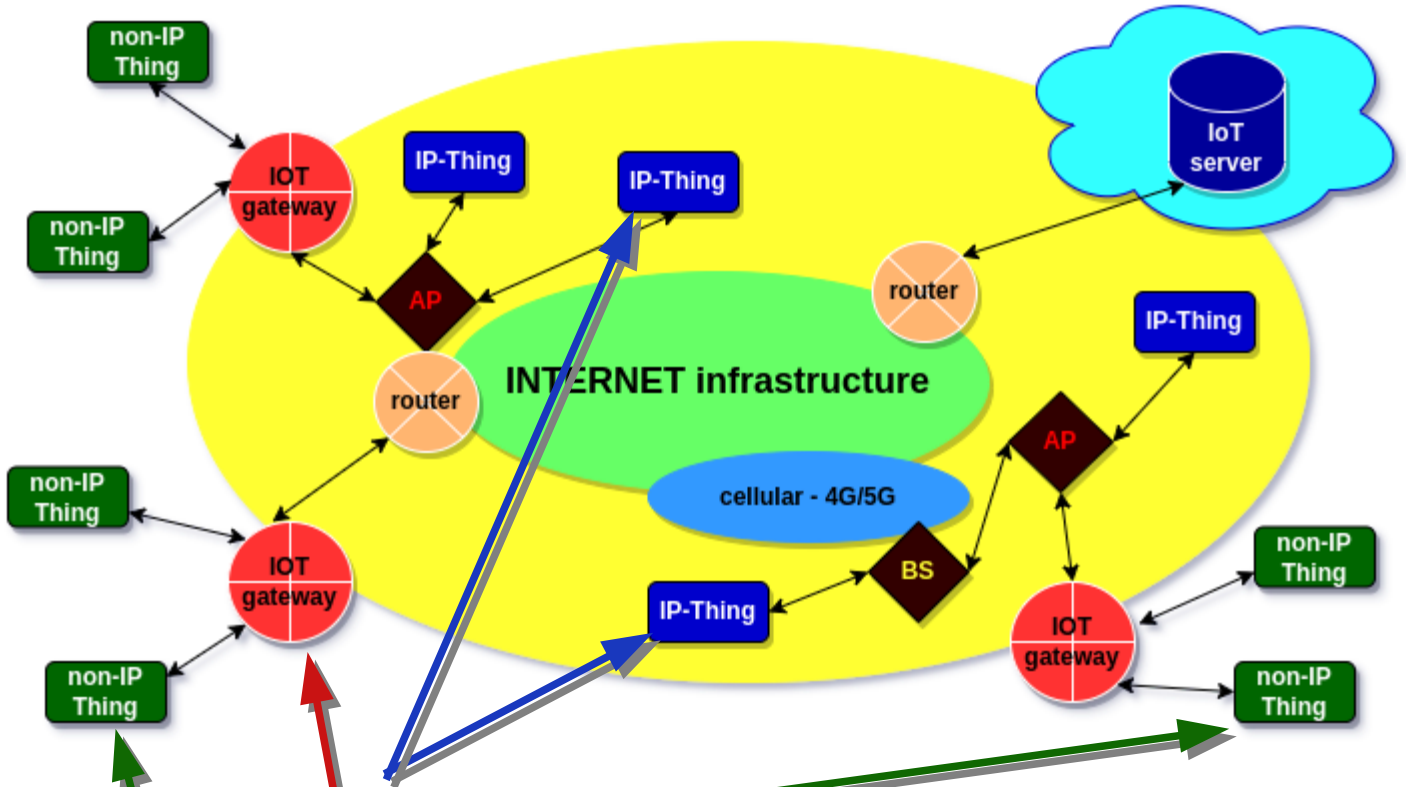
Low Power IoT Architectures

Principles and Practices



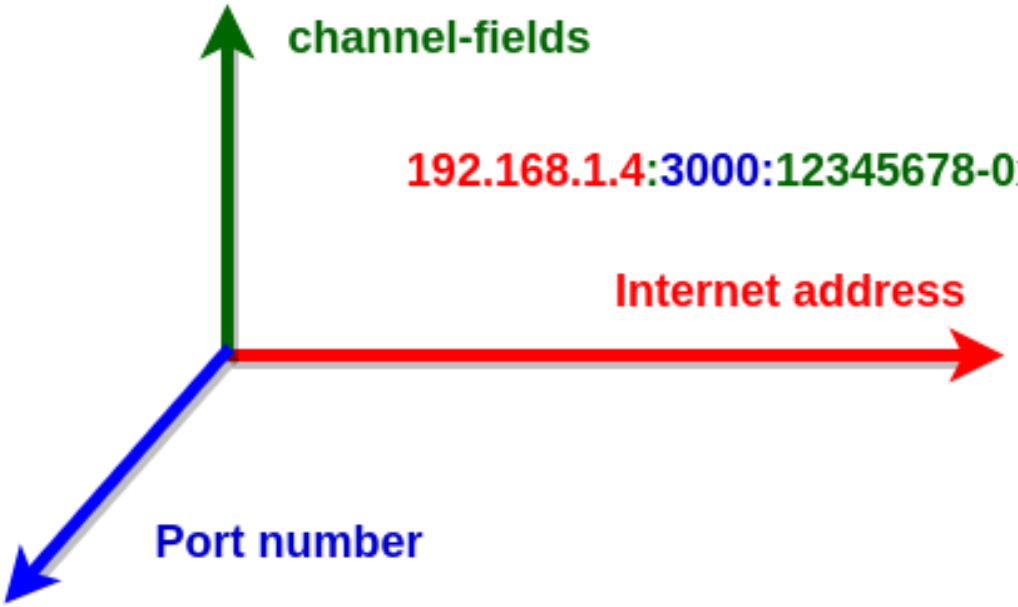
IoT : Direct & Remote Terminals



IP-Thing : **Direct Terminal** connected to INET via **WiFi**/4G/5G link

non-IP-Thing : **Remote Terminal** connected to INET via **LoRa** link and **IoT gateway**

IoT Sockets : @IP:port:channel



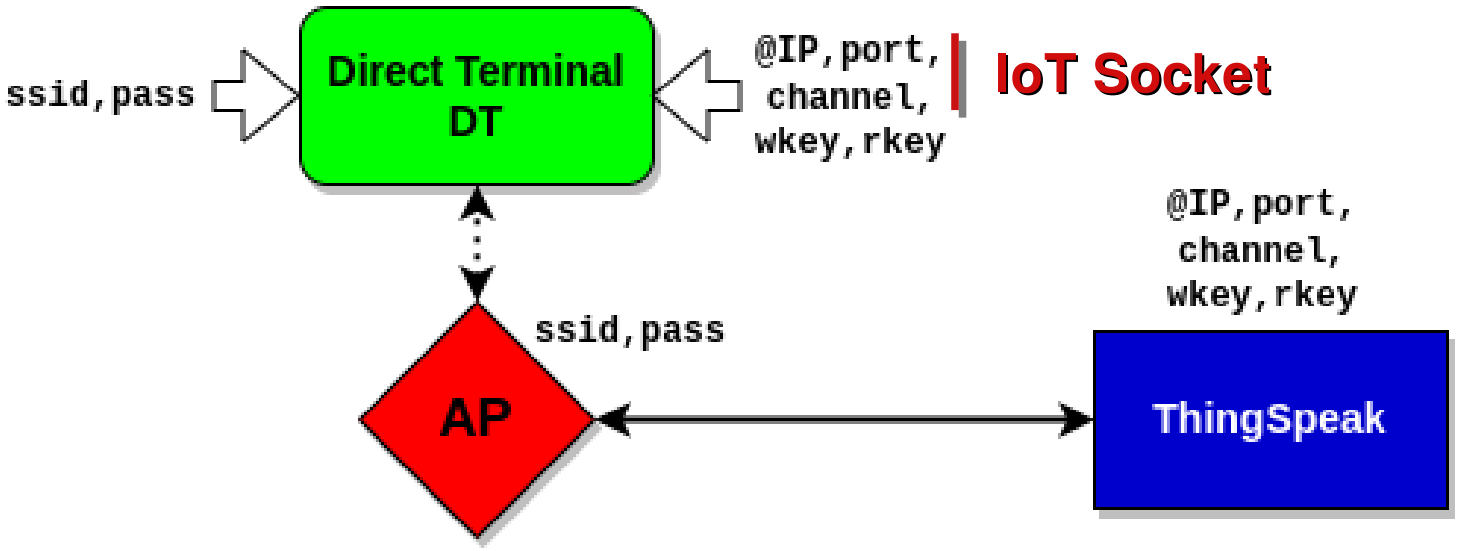
IoT socket => IP address: Service port:Channel number-fields

Direct Terminals know: IP address:Service port:Channel number

Gateways know: IP address:Service port

Remote Terminals know only: Channel number (identifier)

Direct Terminals and IoT Sockets

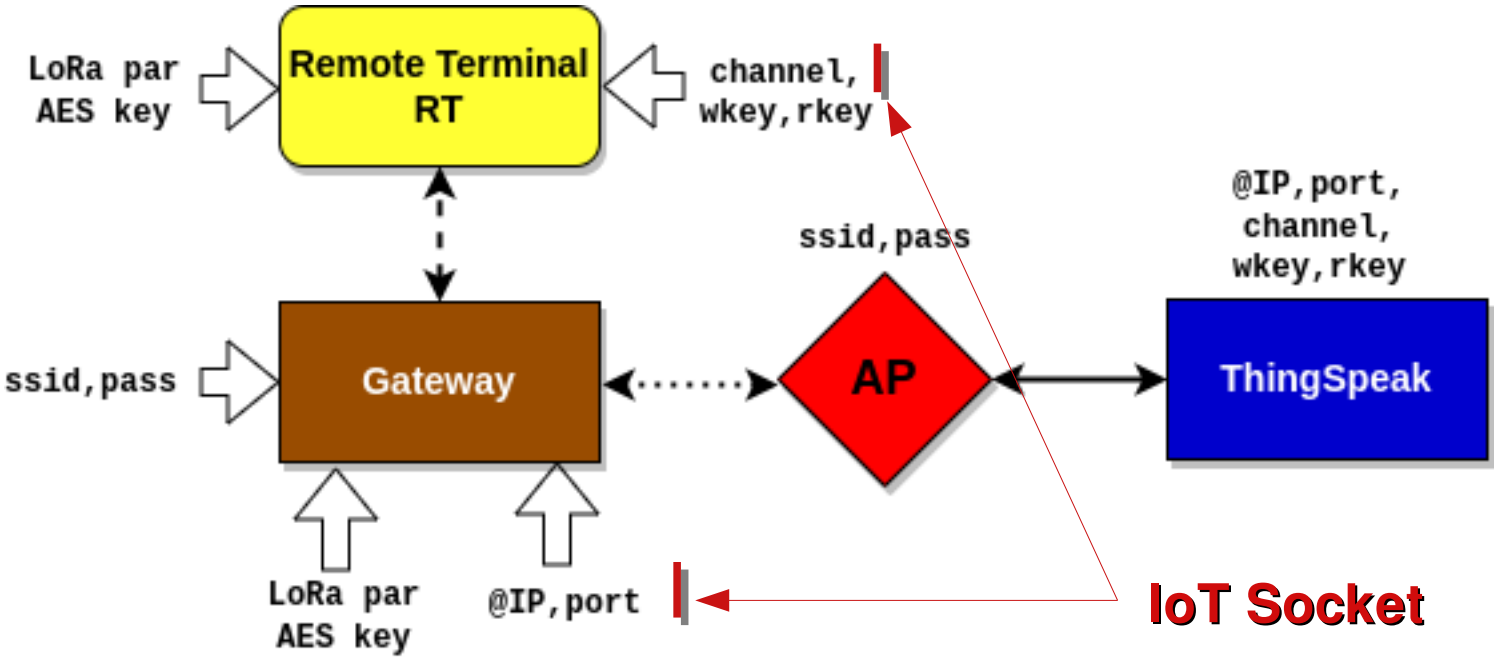


Direct Terminals know: IP address:Service port:Channel number

plus: write and optionally read key

A channel contains fields (max.8) that may be interpreted as IoT data streams to be "compressed".

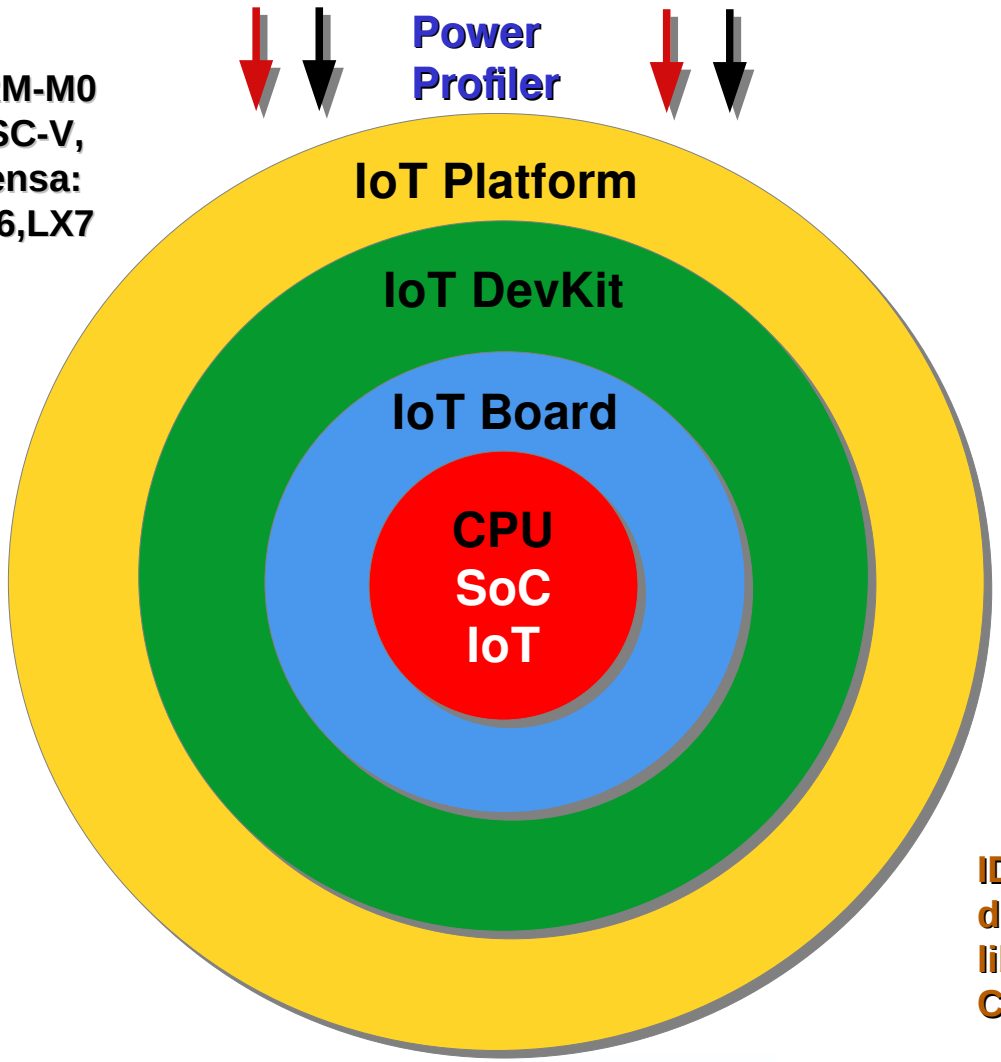
Remote Terminals and IoT Sockets



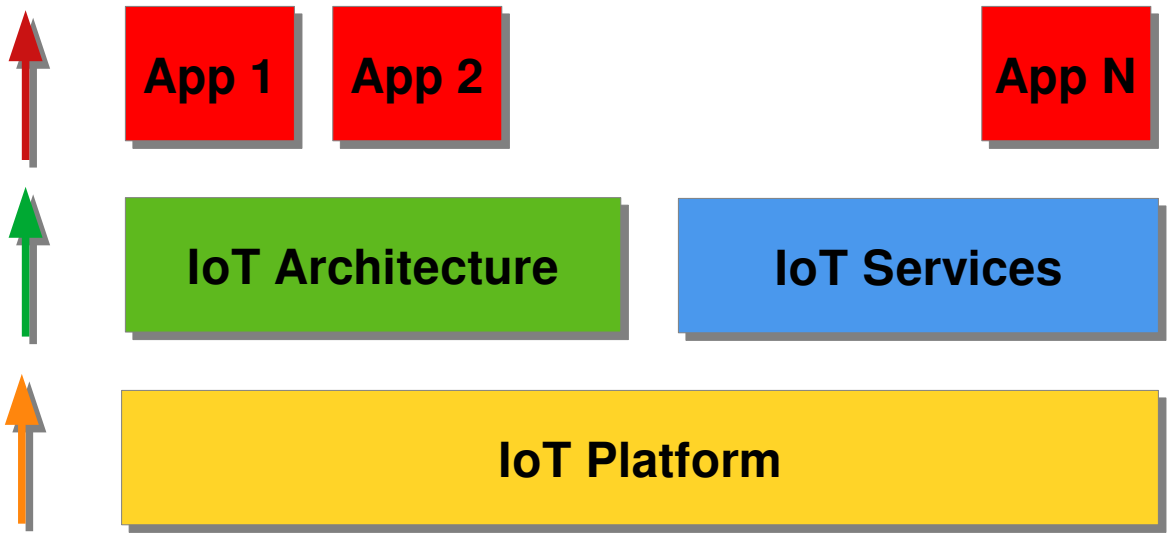
Gateways know IP address : Service port

Remote Terminals know only Channel number (identifier)

From IoT SoC to IoT Platform



From Platform to Application



AI assisted - Generation/Development process

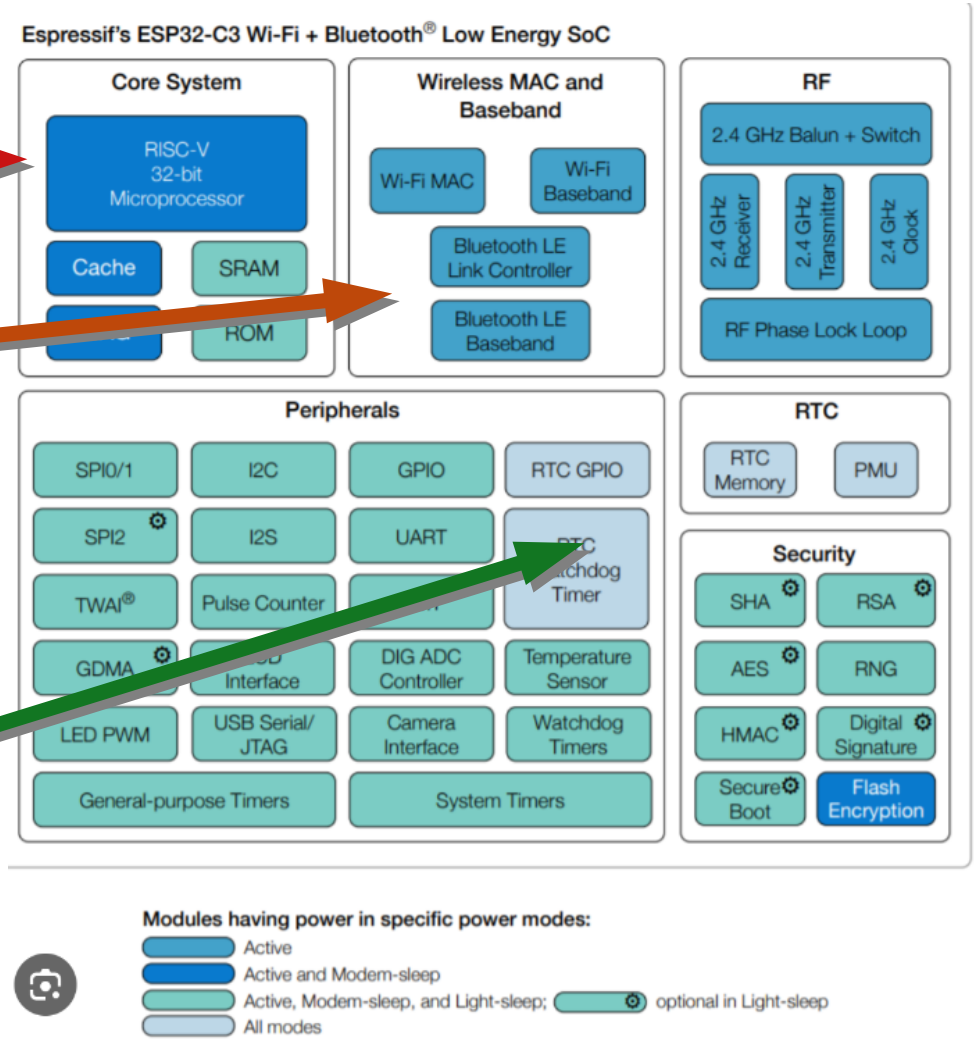
ESP32C3 IoT SoC

RISC-V : 5-stages pipeline

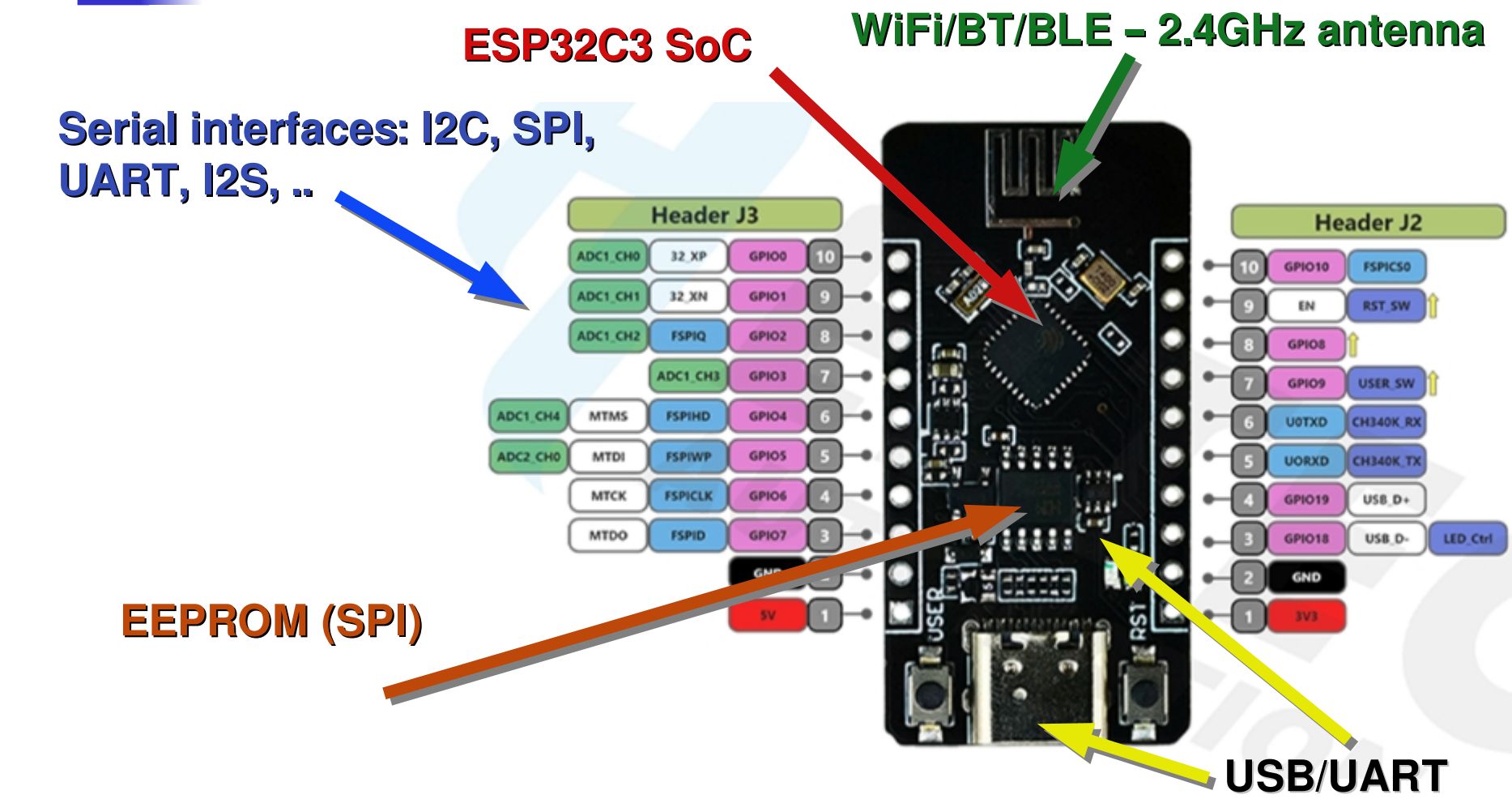
Radio: WiFi, BT/BLE

Serial interfaces: I2C, SPI, UART, I2S, ..

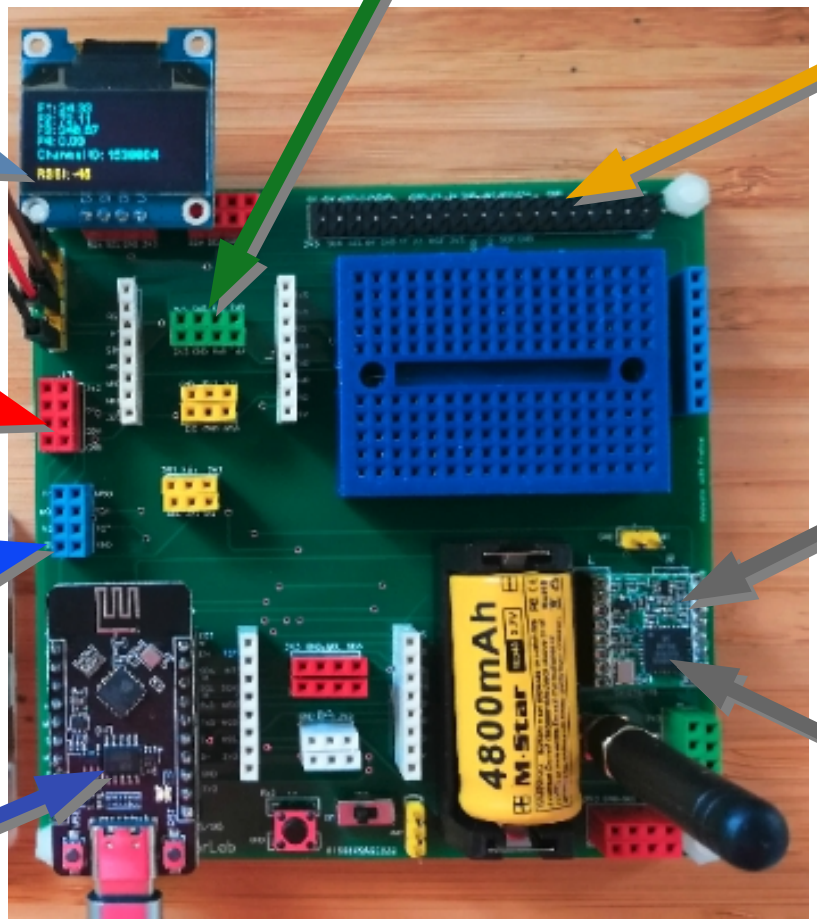
low power : deepsleep
RTC clock, memory, ..



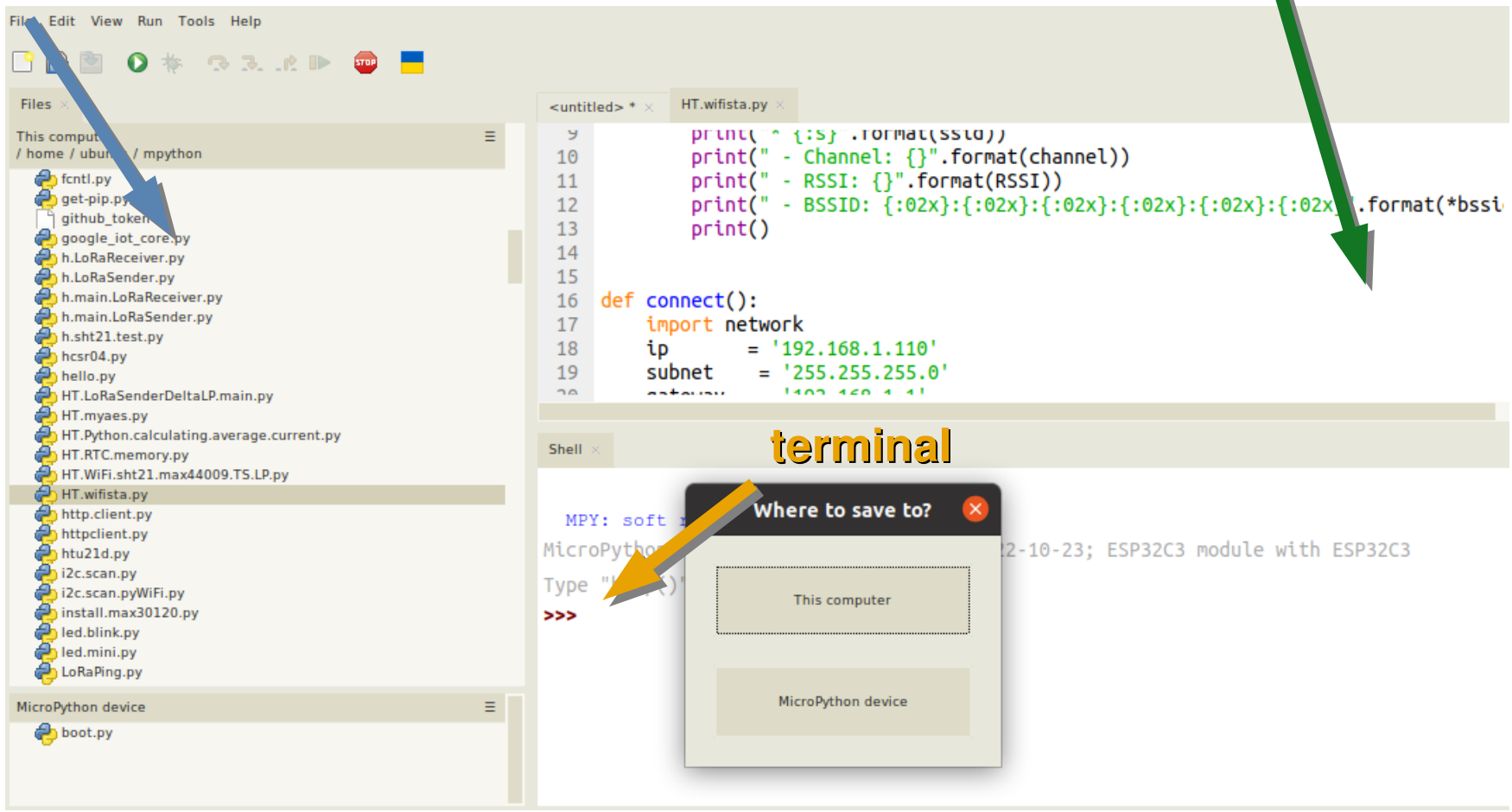
Heltec – ESP32C3 board



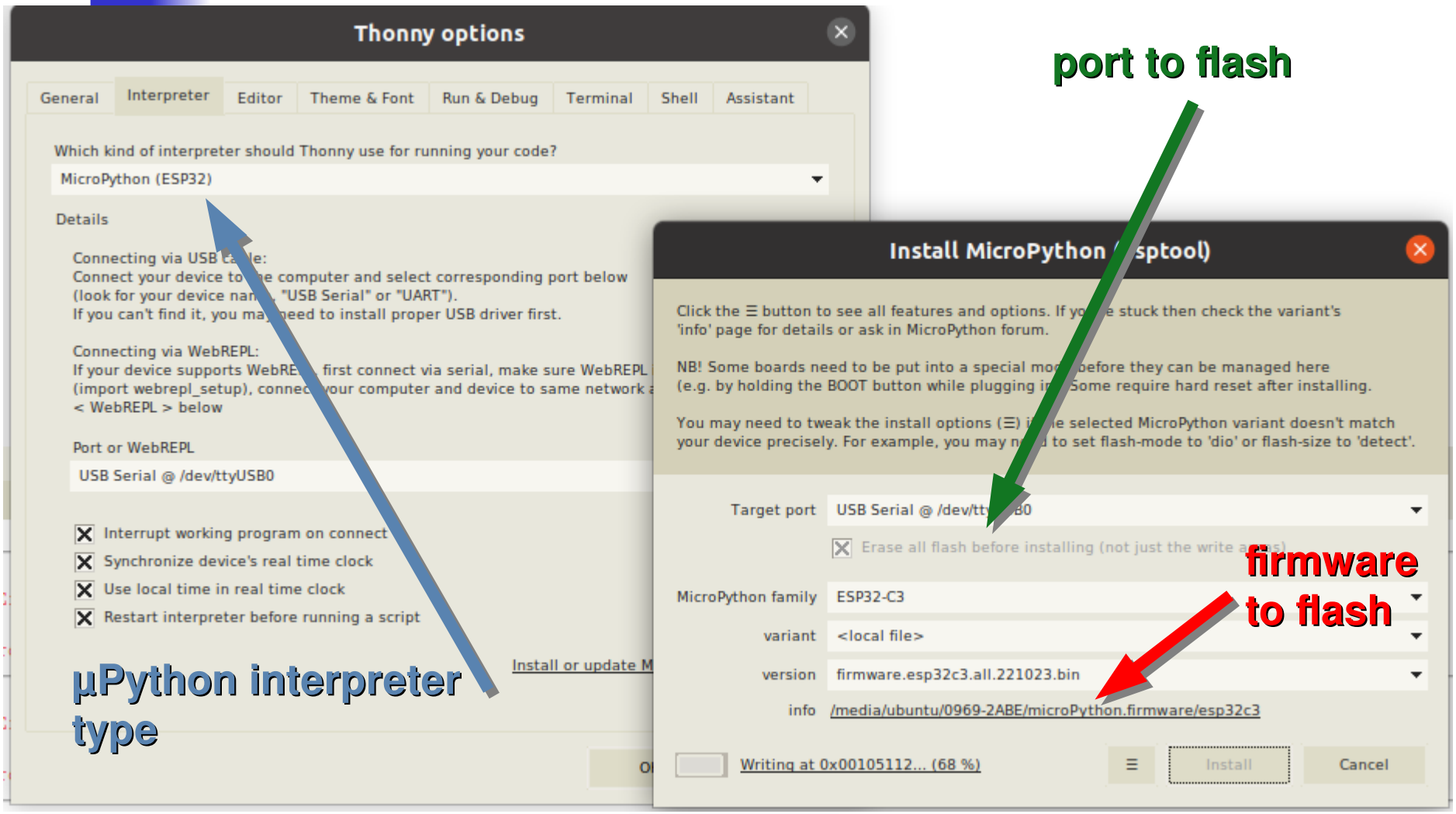
IoT DevKit – HT ESP32C3



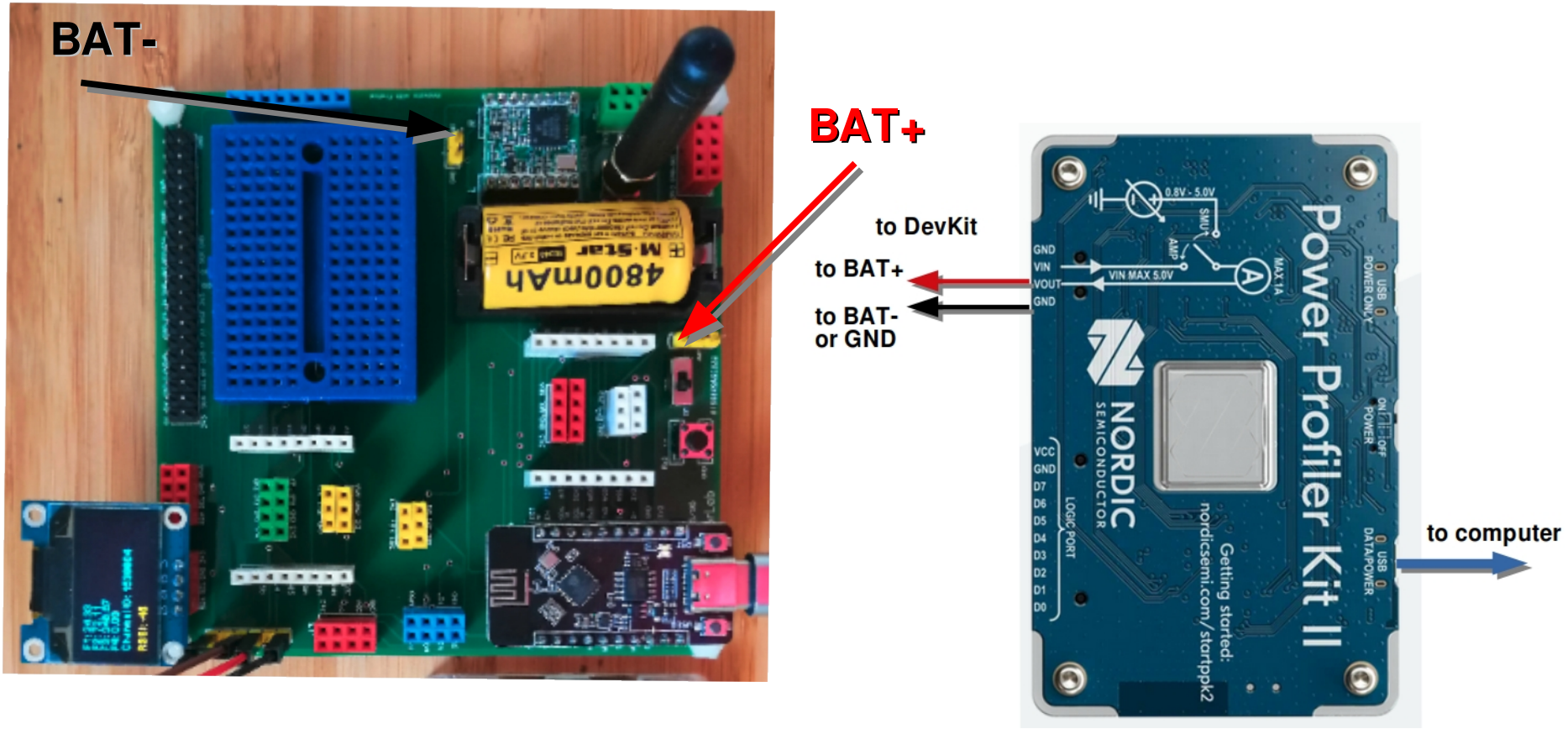
Platform – Thonny IDE



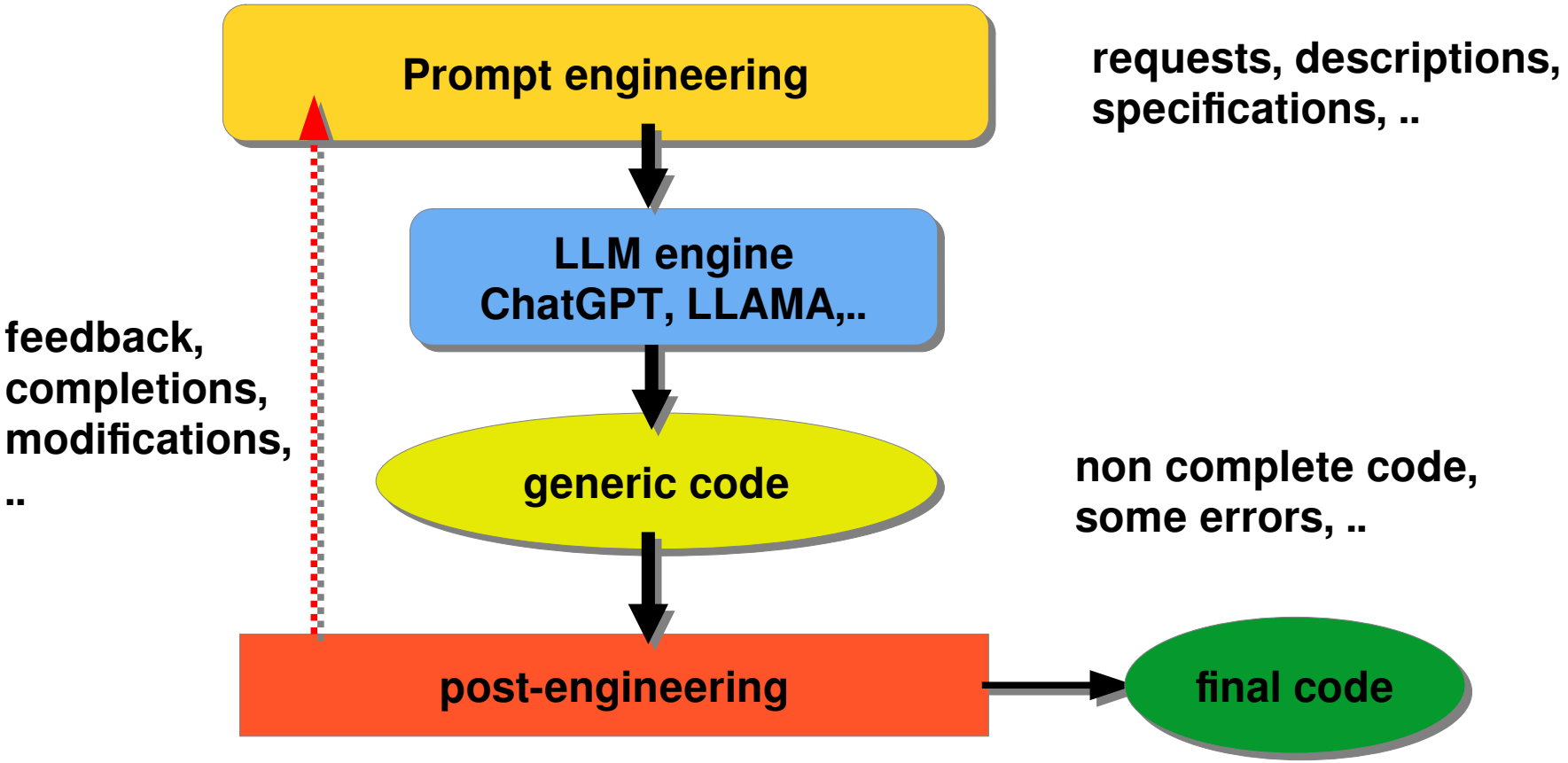
Platform – Thonny IDE



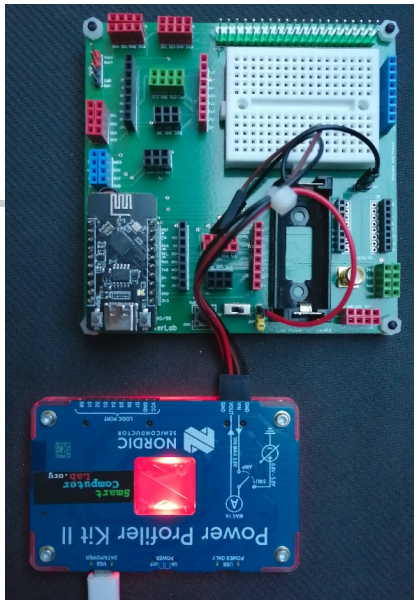
Power Profiler Kit 2 (PPK2)



Chat GPT development assistance



Simple example

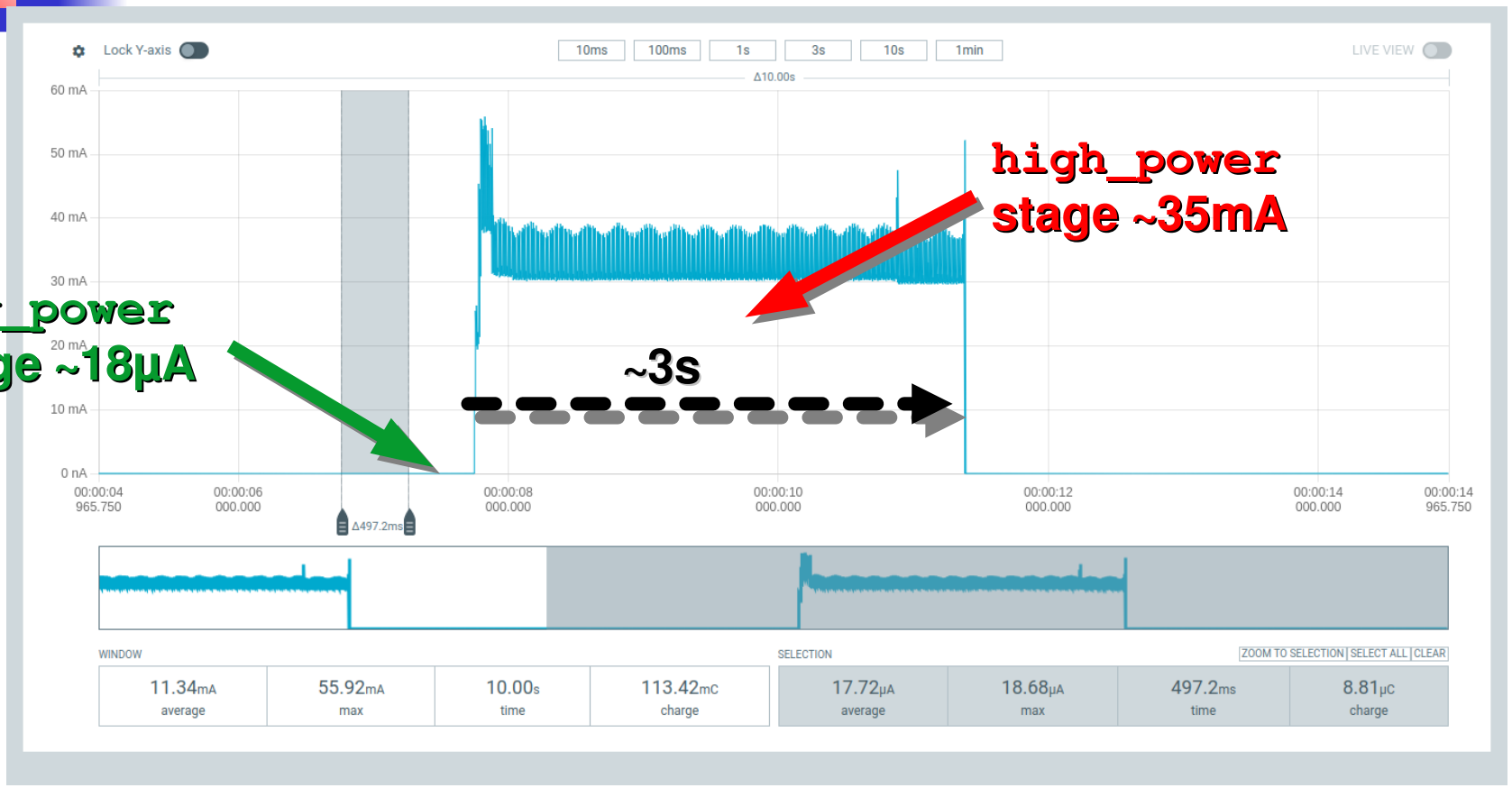


Prompt:
Write MicroPython code for ESP32 to switch on the signal (buzzer) on Pin 3 for 3 seconds. Then switch off the signal and go to deepsleep for 6 seconds.

```
from machine import Pin, deepsleep
import time
# Initialize the SIG pin
led = Pin(3, Pin.OUT)
# Turn on the SIG
led.value(1)
print("SIG is ON")
time.sleep(3)
# Turn off the LED
led.value(0)
print("SIG is OFF")
# Go to deep sleep for 6 seconds
print("Going to sleep for 10 seconds...")
time.sleep(0.2)     # added to see the print
deepsleep(6000)  # 6 seconds in milliseconds
```

Remark:
The code is correct, no post-engineering and/or feedback

Simple example – PPK2 diagram



Calculate the average current for a cycle with 600s `low_power` stage ?

(18*600+35000*3)/(600+3) = 192µA

IoT Labs – Session 1

Lab 1: Working with sensors and displays (I2C bus)

Example Prompts

Prompt:
With ESP32 that is programmed with MicroPython we use frequently I2C bus to connect the sensors. Explain the operations of I2C bus.

```
from machine import Pin, I2C
# Configure I2C
i2c = I2C(0, scl=Pin(9), sda=Pin(8))  # I2C bus 0 with custom pins
# Scan for I2C devices
devices = i2c.scan()
print("I2C devices found:", devices)
# Assuming a device is found at address 0x3C
device_address = 0x3C
# Write to the device
data_to_write = bytearray([0x00, 0xFF])  # Example data
i2c.writeto(device_address, data_to_write)
# Read from the device
num_bytes = 2
data_read = i2c.readfrom(device_address, num_bytes)
print("Data read:", data_read)
```

IoT Labs – Session 1

Lab 1: Working with sensors and displays (I2C bus)

Example Prompts

Prompt:
Write for ESP32 in MicroPython the function and module sensors.py with drivers for max44009 (luminosity) and sht21 (temperature, humidity) sensors operating over I2C bus. The function takes two arguments : sda, scl to specify the pins of I2C bus. It returns 3 values: luminosity,temperature,humidity=sensors(sda,scl).

IoT Labs – Session 1

Lab 2: Communicating with WiFi and IoT servers

Example Prompts

Prompt:
Write in Micropython for ESP32 a module (`wifi_tools.py`) with 3 functions related to WiFi: `connect_WiFi(ssid,pass)`, `disconnect_WiFi()` and `scan_WiFi()`.

Prompt:
Write MicroPython code - function for ESP32 to get WiFi configuration: IP, port, .. after a successful connection to access point.

IoT Labs – Session 1 – Lab 2

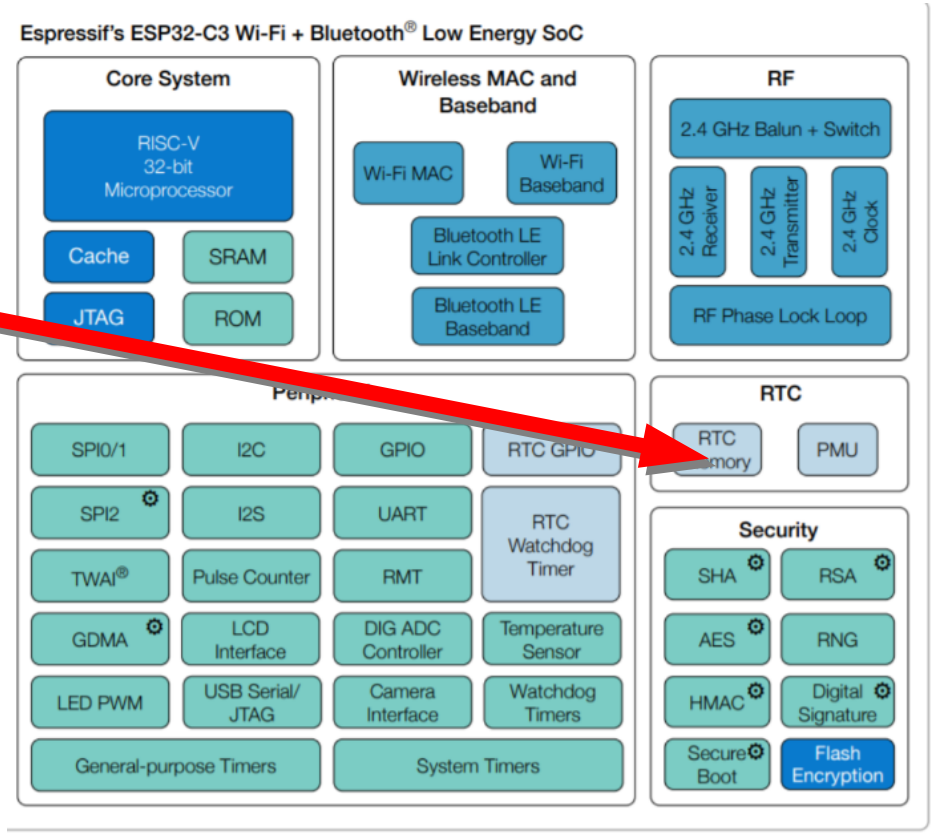
Prompt:
Write MicroPython programs for ESP32 to send and receive simple UDP datagrams with socket() functions

Prompt:
Explain the function and the use of NTP protocol and server.

Prompt:
Write micropython code for ESP32 using the generated wifi_tools.py module to read time from an external NTP server. Read the time in a 10 second infinite cycle. Note that the time must be synchronized only in the first cycle. Print the values of hour, minute, and second.

IoT Labs – Session 1 – Lab 2

Prompt:
Give simple example in micropython for ESP32 of the usage of RTC memory. The example provides a counter of the cycles built with deepsleep mode for 6 seconds. Print the value of the counter in each cycle.

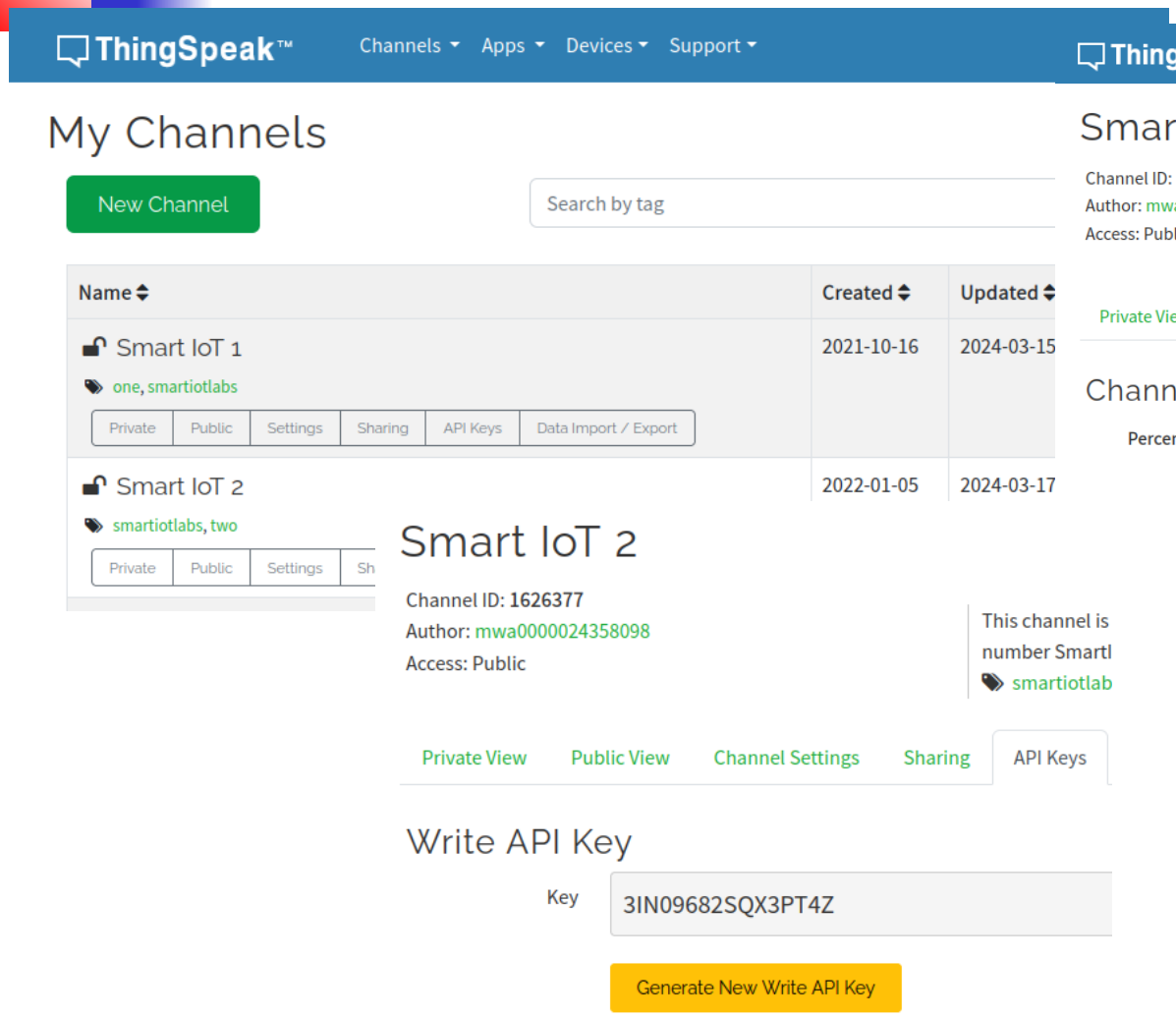


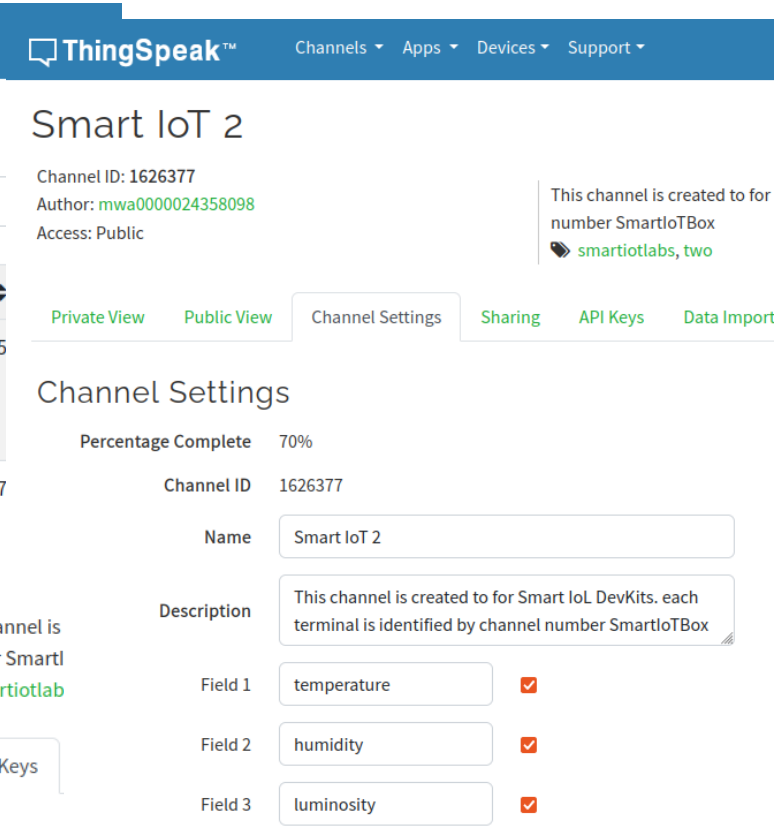
IoT Labs – Session 1 – Lab 3

Prompt:
Write MicroPython code for ESP32 to connect to WiFi Access Point and to send (publish) MQTT message. The message contains readings from MAX44009 and SHT21 with `sensors.py` module. Use previously created `wifi_tools.py` module to connect to WiFi access point.

Prompt:
Write MicroPython code for ESP32 to send several sensor data values to ThingSpeak server. Use MAX44009 and SHT21 sensors – `sensors.py` . Use `wifi_tools.py` module predefined previously to connect to the WiFi and ThingSpeak.com server.

IoT Labs – Session 1 – Lab 2

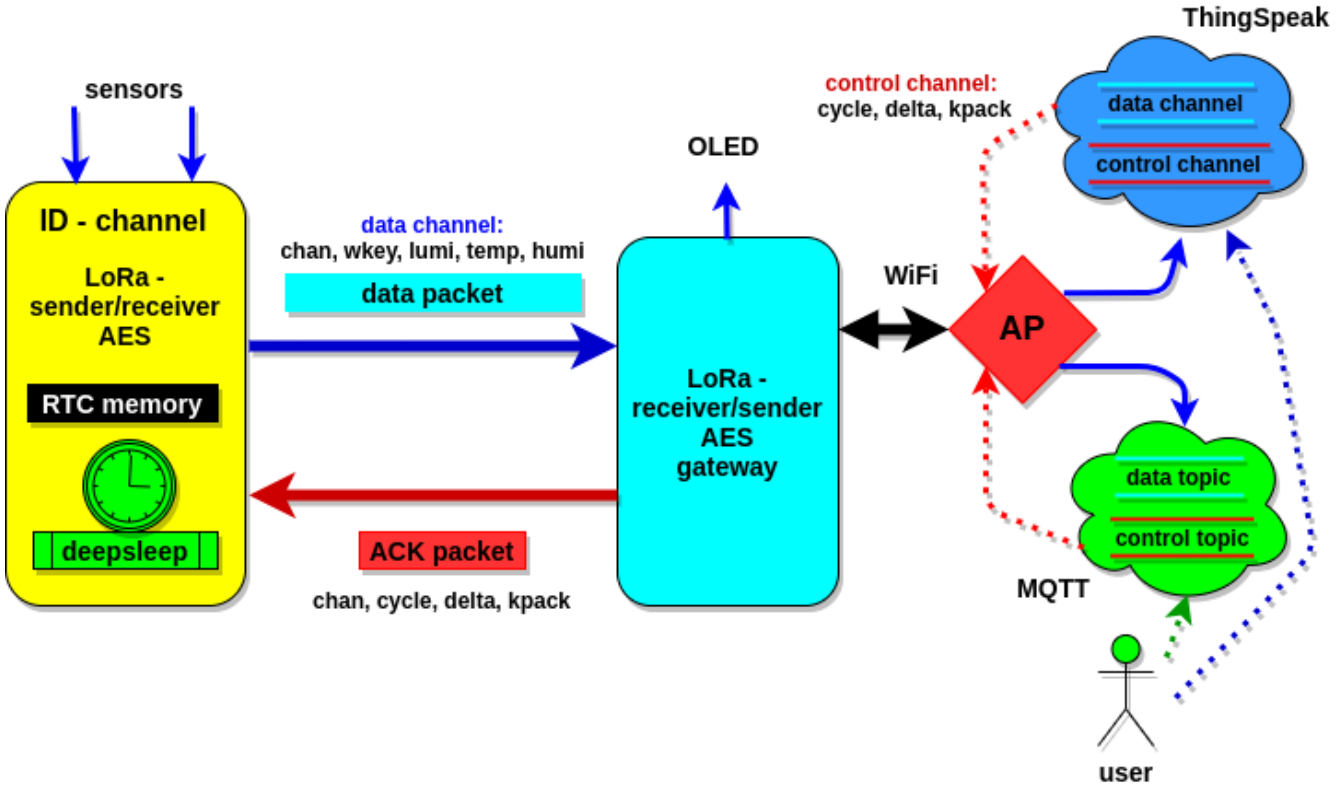




IoT Labs – Session 1 – Lab 3 & Lab 4

Lab 3: Building Close Terminals and Gateways with MAC-WiFi

Lab 4: Long distance communication with Remote Terminals over LoRa radio links



IoT Labs – Session 2 - Lab 5 + Project

Lab 5 : AIoT - EDGE

Projects and Applications with advanced IoT boards