

BLUETOOTH-LOW-ENERGY GATEWAY USING ESP32 CHIPSET

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INTRODUCTION

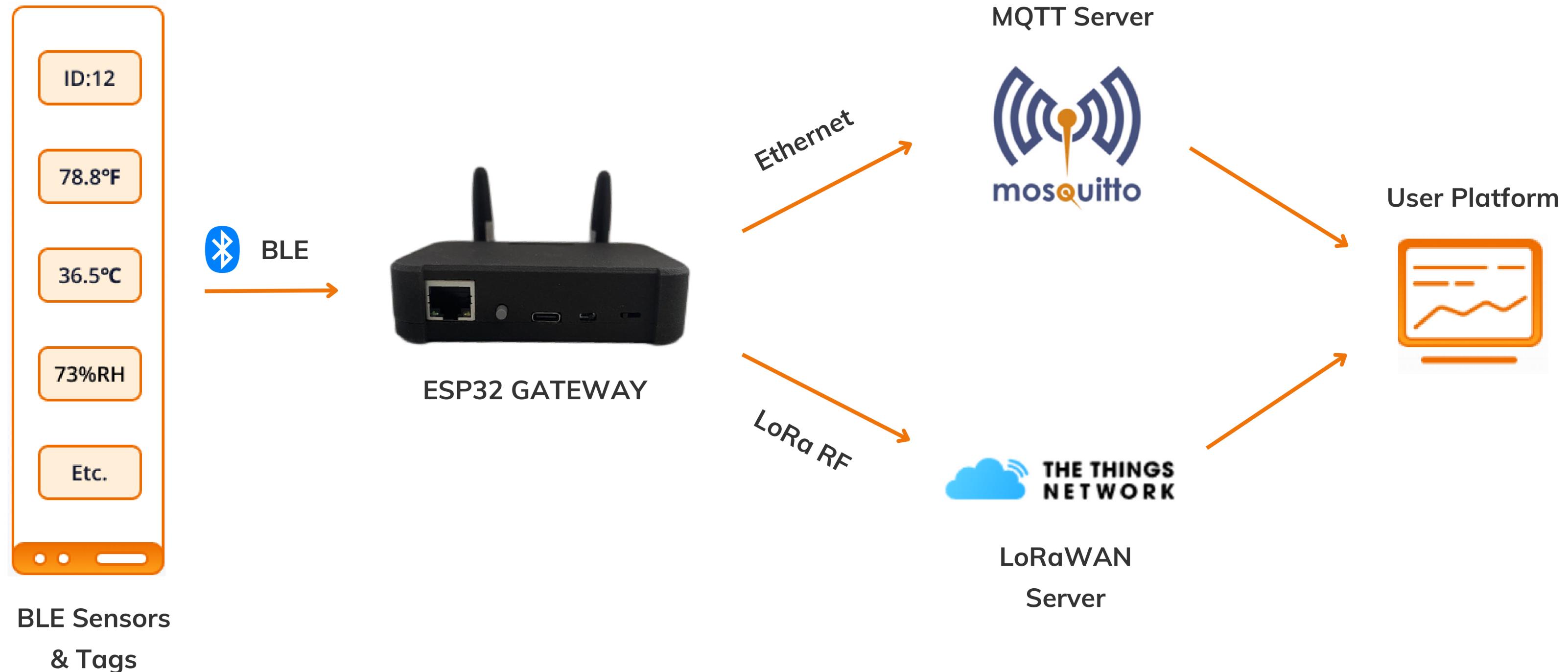
What is a BLE Gateway?

- Bridge between BLE end devices and cloud platform.
- Receiving information from BLE end devices and forward information to the network server via Wi-Fi/Ethernet/LTE/LoRa.
- Help to exchange the data with BLE devices remotely.

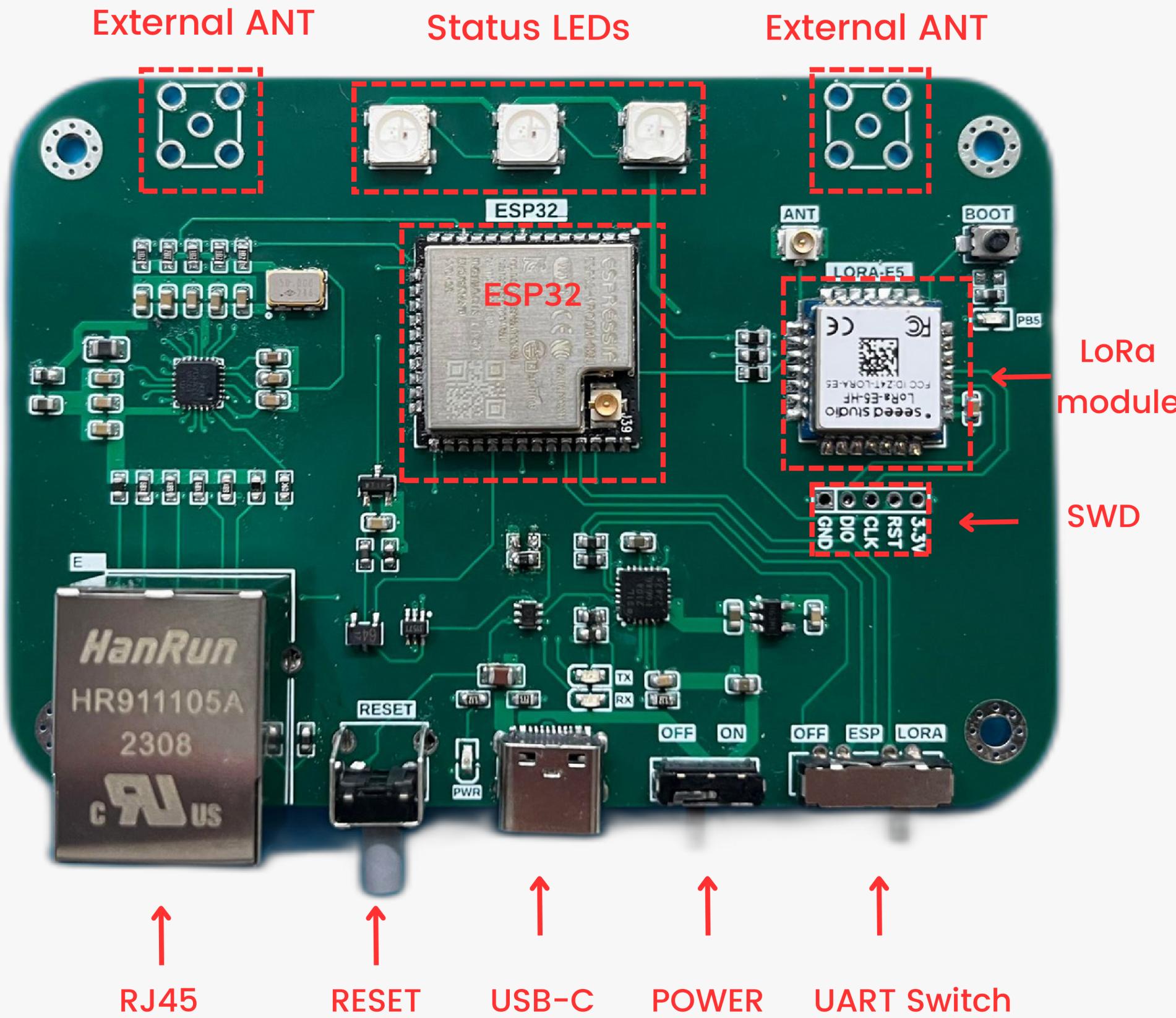
Why the ESP32 chipset?

- Low cost for chipset module and development board.
- Support BLE, WiFi protocol.
- Easy to find resources and support.

DESIGN TOPOLOGY



GATEWAY OVERVIEW



- ESP32-WROOM-32U with 16MB Flash: BLE 4.2, WiFi, Ethernet.
- LoRa E5 Module: with embedded STM32WLE5JC, support EU868/US915 frequency.
- 3x Status LEDs.
- USB-C 5V Power supply.
- CP2104 Serial-To-USB Chip.
- Ethernet LAN8720 Chip.
- 2x External Antennas.

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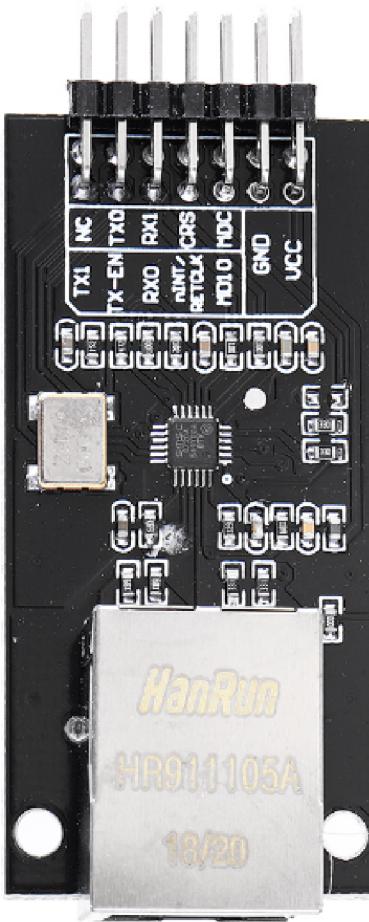
III Firmware Development

BLE Beacon Gateway

Data and Visualization

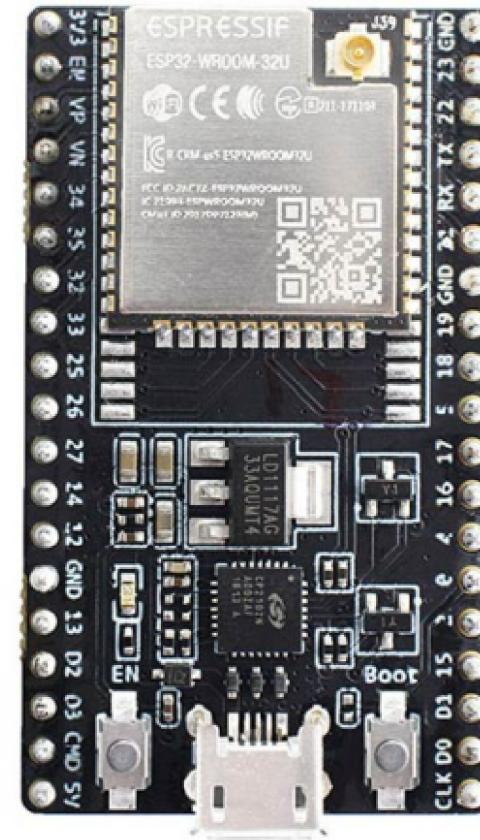
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PROOF-OF-CONCEPT PROTOTYPE



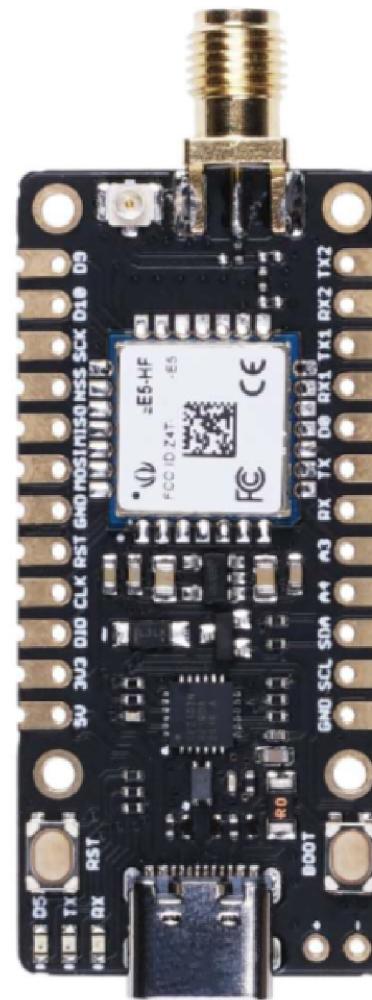
Ethernet
LAN8720A
module

↔
RMII



ESP32
Development
Board

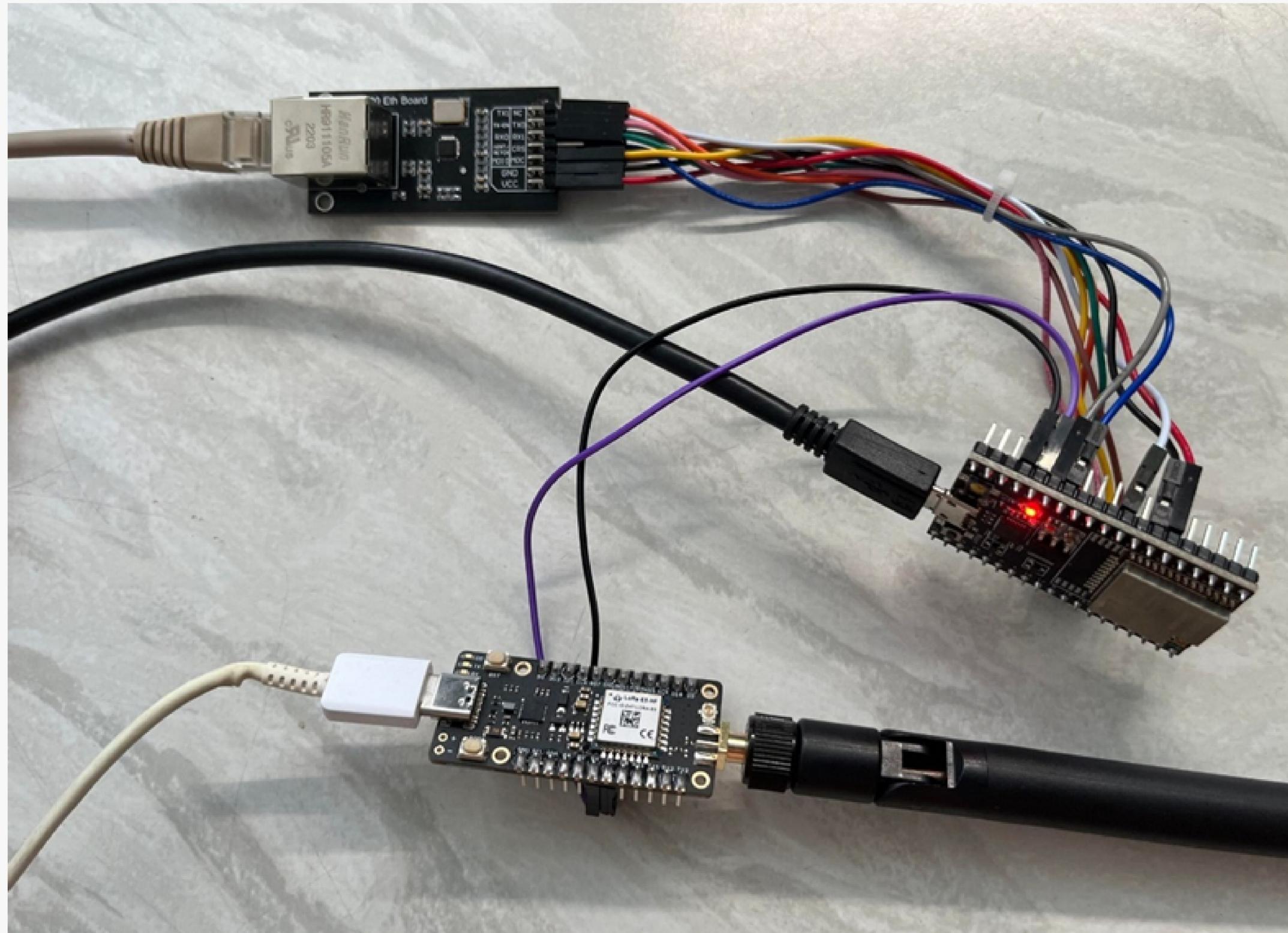
↔
UART
AT
Command



LoRa E5
Development
Board

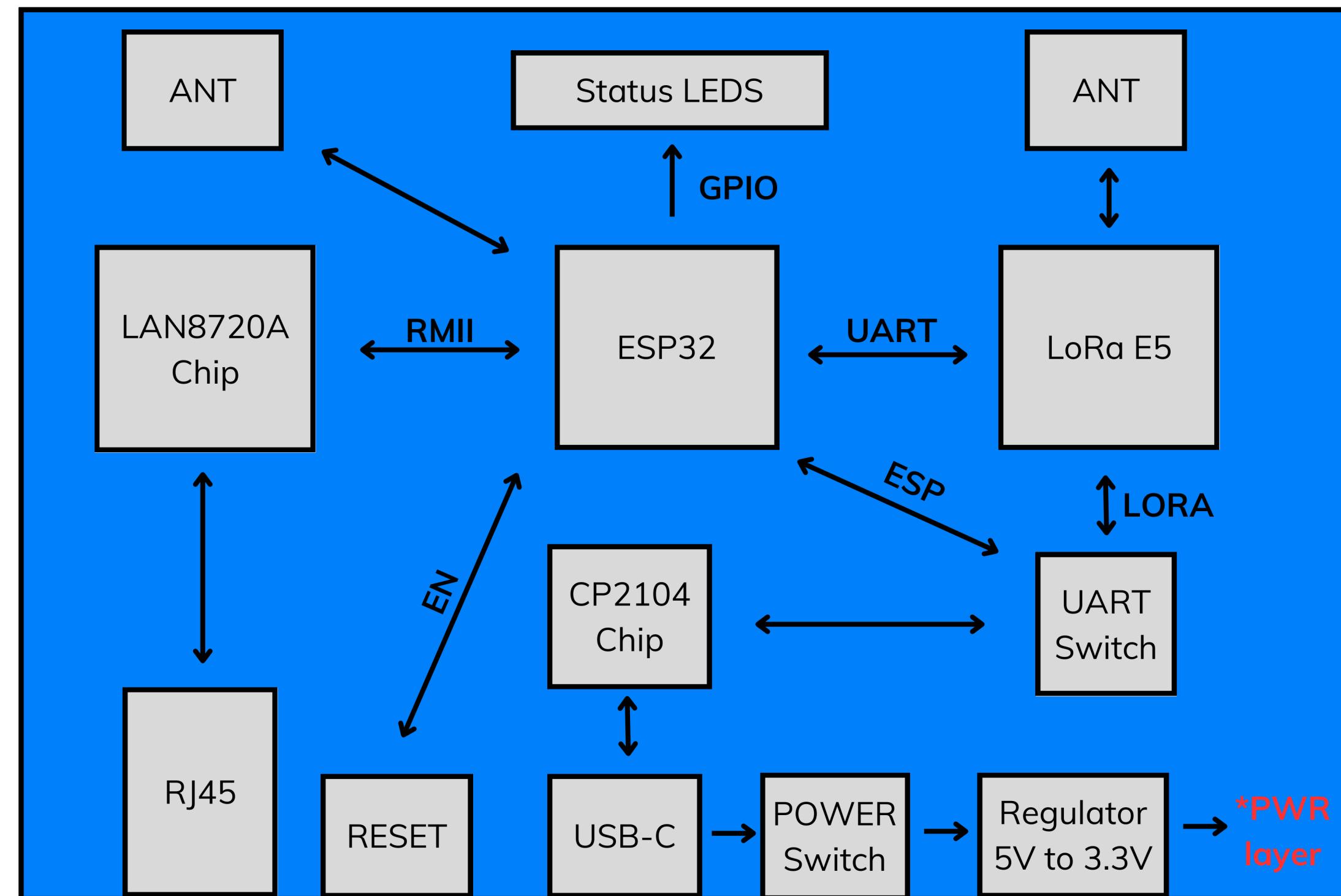
PROOF-OF-CONCEPT PROTOTYPE

POC SETUP:



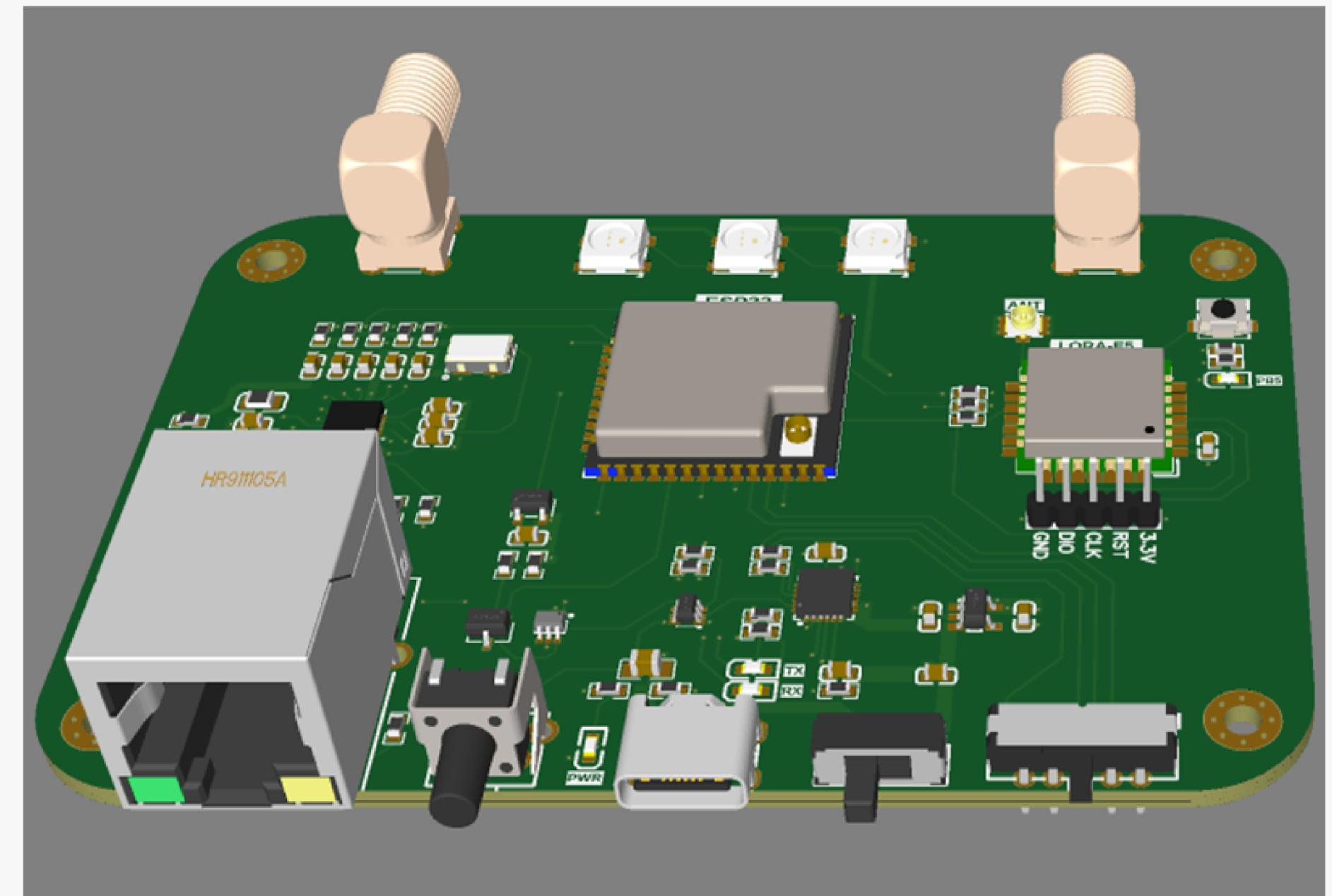
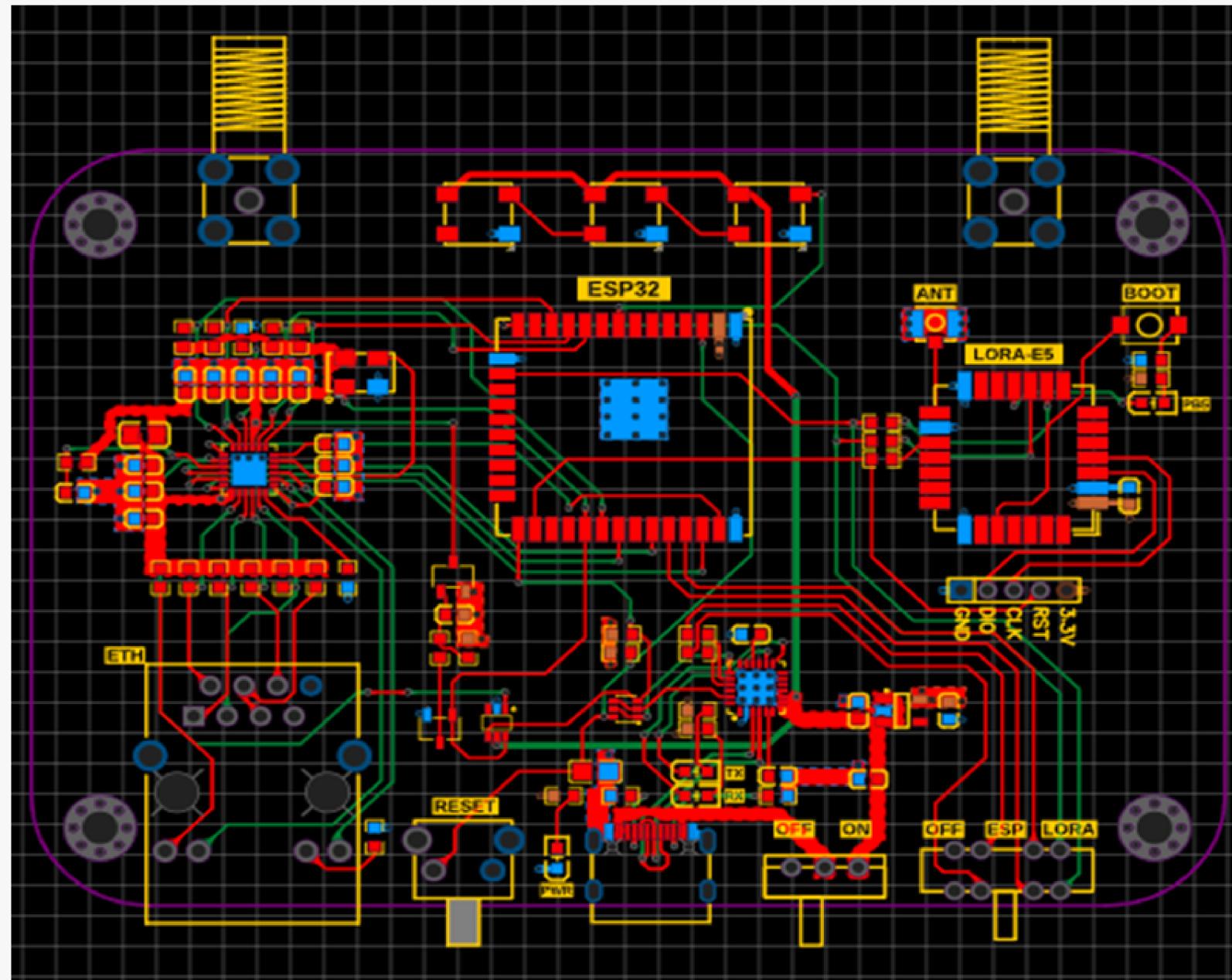
PCB DESIGN

PCB BLOCK DIAGRAM



PCB DESIGN

PCB LAYOUT

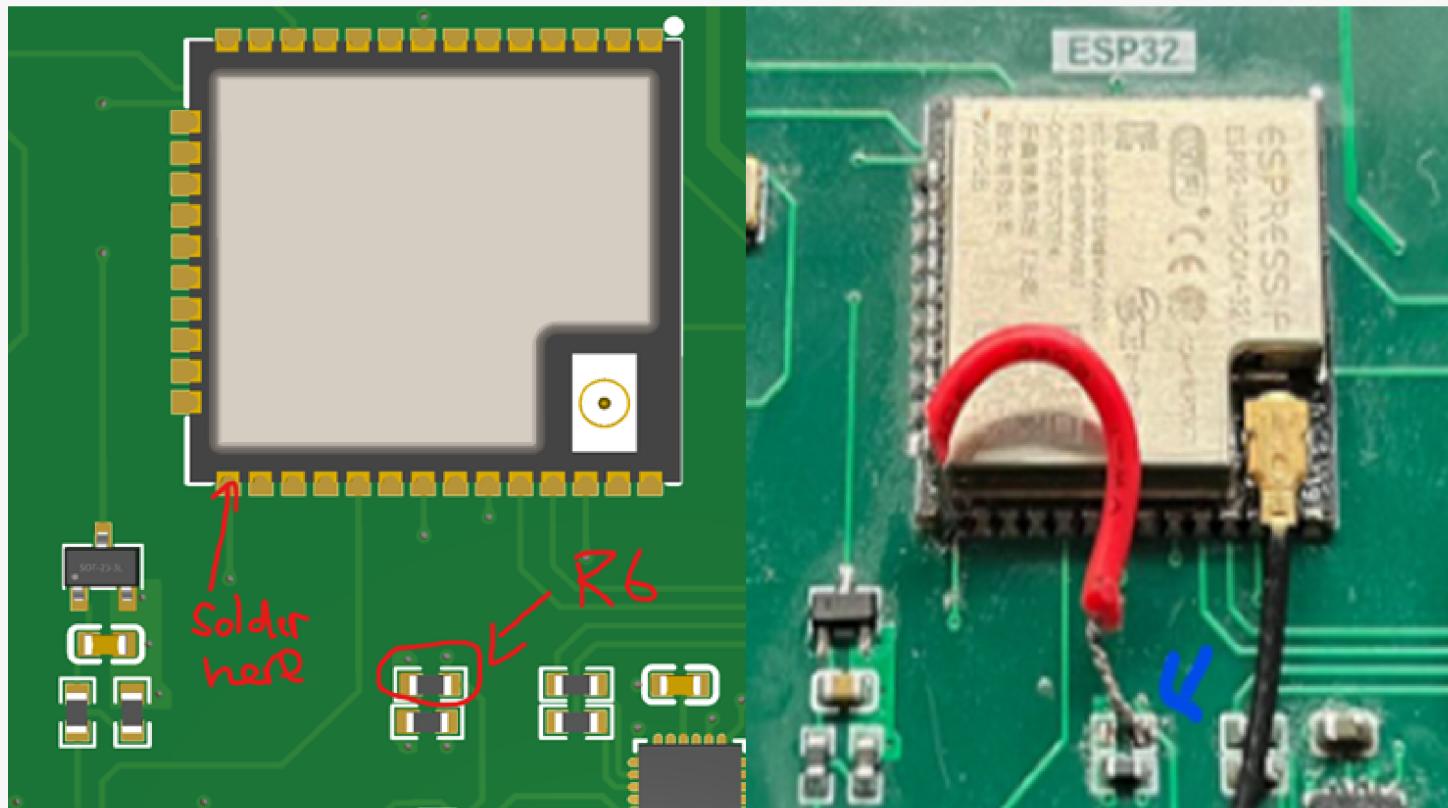


4 LAYERS:

- L1 SIGNAL, L2 GND, L3 PWR, L4 SIGNAL

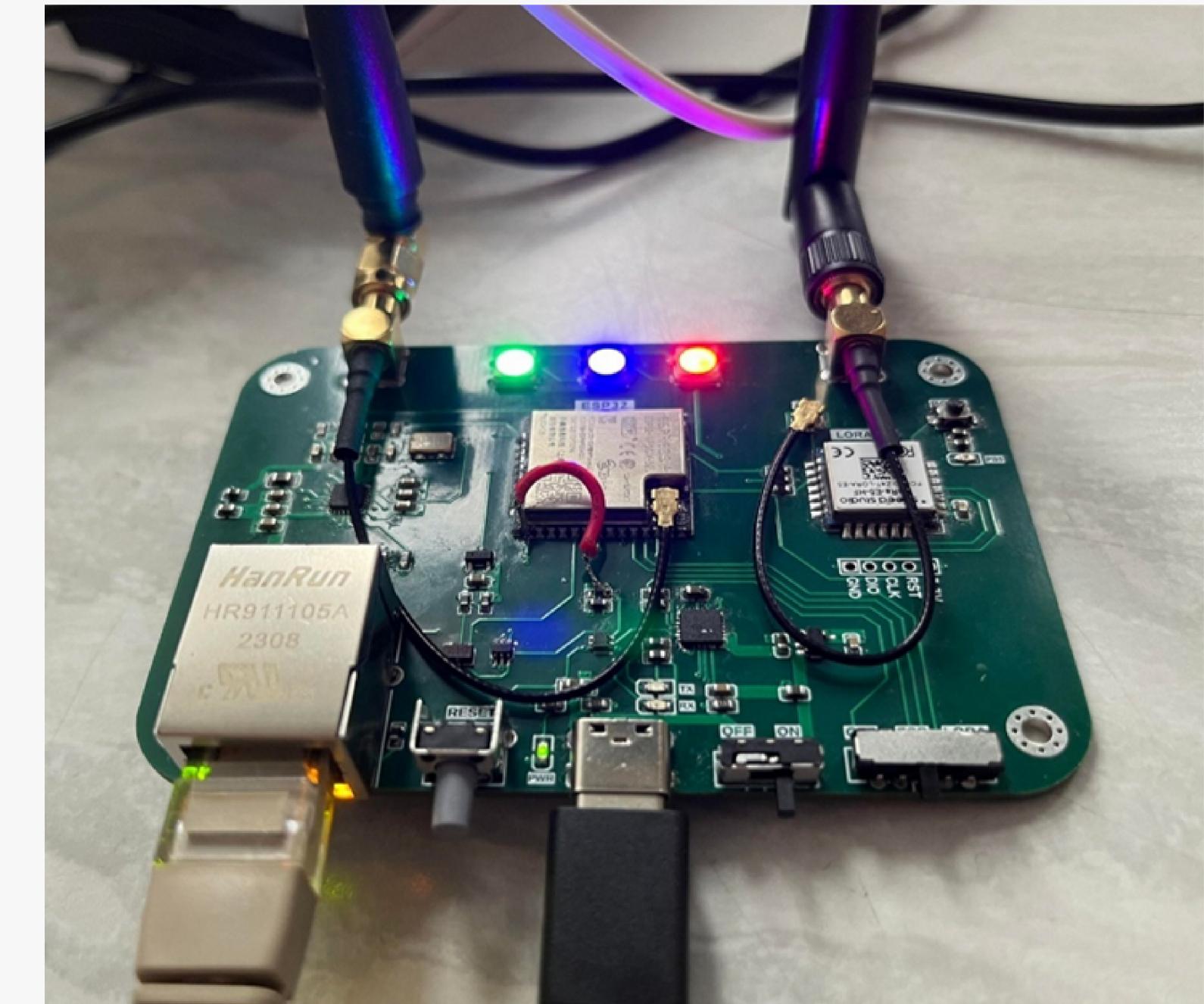
PCB DESIGN

FIXING ERROR



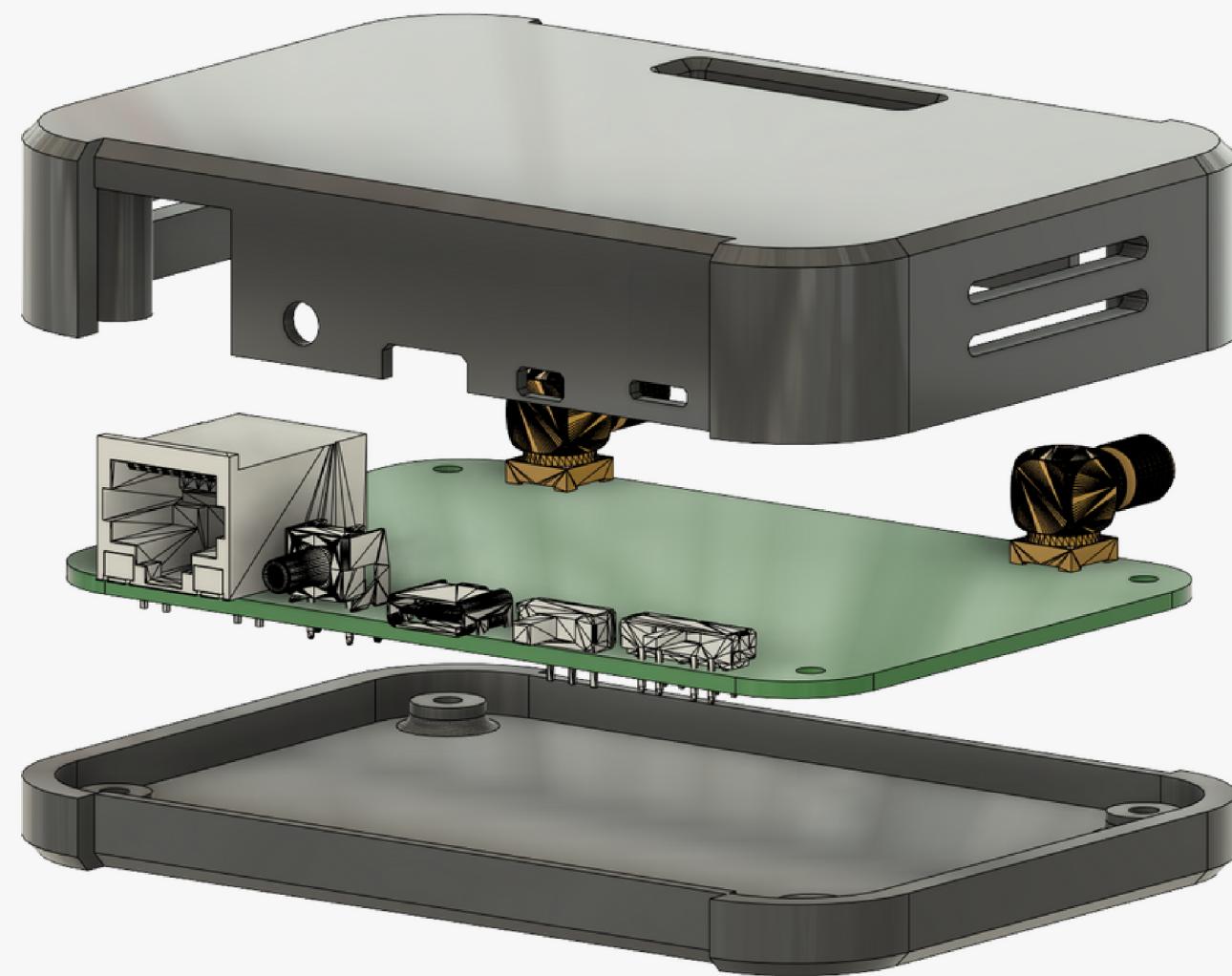
Problem: Cannot upload firmware to ESP32.

Solution: Remove the pull-up resistor and solder an external wire.



Fully functional PCB

ENCLOSURE DESIGN



- Software: Fusion 360.
- Material: 3201PA-F Nylon from JLCPCB.

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BLE BEACON GATEWAY

Firmware development

BLE Beacon:

- Broadcaster type.
- Sending the advertise packets with data (ID, temperature...) at a regular intervals.

BLE Beacon Gateway firmware:

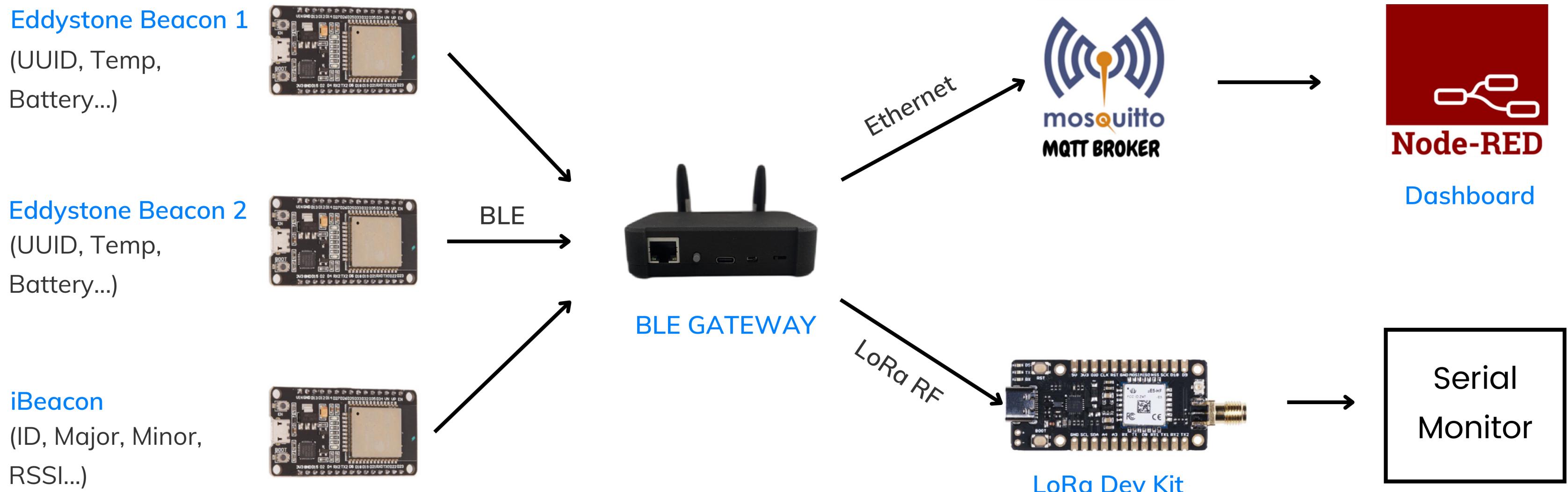
- Scan for advertise packets of BLE Beacons nearby and fetch the desire data from them.
- The firmware focuses on iBeacon and Eddystone beacon frametype.
- Sending the data to MQTT Server and LoRa Server when the MAC address matches.

Software:

- PlatformIO IDE on VS code.
- Arduino Framework (or IDF framework from Espressif).

BLE BEACON GATEWAY

Demonstration Setup:



BLE BEACON GATEWAY

Demonstration Setup:



Node-RED: 192.168.0.103

Not secure | 192.168.0.103:1880/#flow/504d4ae3d690e048

Node-RED

debug

MQTT Server(NODE-Red)

```
03/05/2023, 19:41:08 node: d55af2e2cf5ffca  
BLEtoMQTT/Eddystone2 : msg.payload : Object  
↳ { MAC: "30:ae:a4:1e:98:62", UUID: "0000feaa-0000-1000-8000-00805f..", BatteryVoltage: 3300, Temperature: 10.31000042, AdvertiseCount: 1531 ... }
```

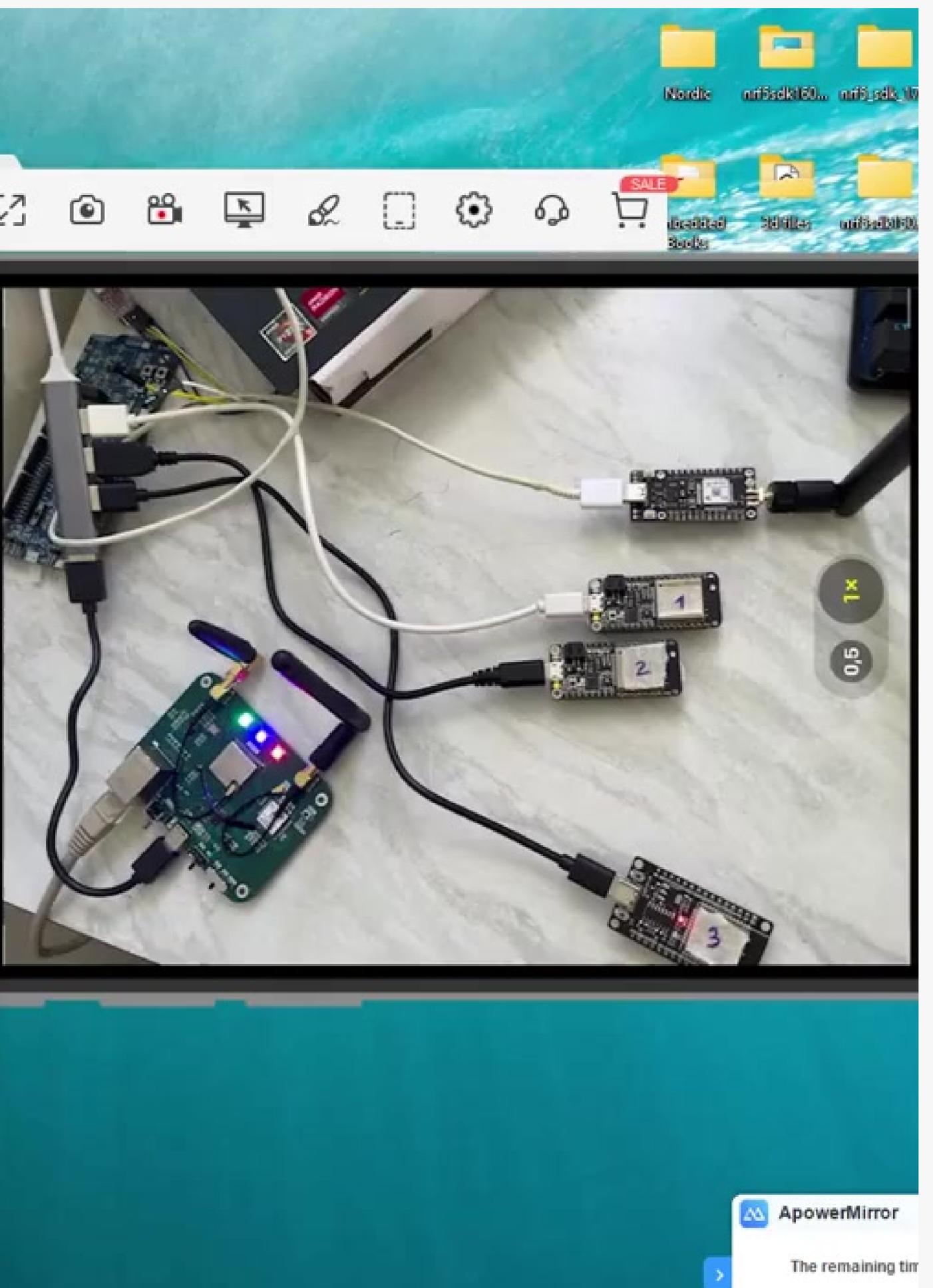
File Edit View Navigate Code Refactor Run Tools VCS Window Help LoraDecode - main.py

LoraDecode > main.py

LoRa Server (Serial monitor)

```
Project Run: main ×  
Run: main ×  
Structure  
Bookmarks  
"AdvertiseCount": 1527,  
"TimeSinceReboot": 22406  
}  
{  
"MAC": "30:ae:a4:19:78:56",  
"UUID": "0000feaa-0000-1000-8000-00805f9b34fb",  
"BatteryVoltage": 2900,  
"Temperature": 20.65999985,  
"AdvertiseCount": 1227,  
"TimeSinceReboot": 16779  
}  
{
```

Compare with Clipboard
Pause Output
Clear All



DATA AND VIZUALIZATION

```
03/05/2023, 16.44.27 node: d94f4e90630ad7ec
BLEtoMQTT/Eddystone1 : msg.payload : Object
  ▼ object
    MAC: "30:ae:a4:19:78:56"
    UUID: "0000feaaa-0000-1000-8000-00805f9b34fb"
    BatteryVoltage: 2900
    Temperature: 16
    AdvertiseCount: 3
    TimeSinceReboot: 27

03/05/2023, 16.44.27 node: db31e2cdf4beacad
BLEtoMQTT/iBeacon : msg.payload : Object
  ▼ object
    MAC: "b8:d6:1a:5c:1e:c6"
    ID: 76
    Major: 5
    Minor: 88
    UUID: "2d7a9f0c-e0e8-4cc9-a71b-a21db2d034a1"
    SignalPower: -59
    RSSI: -41

03/05/2023, 16.44.27 node: d55af2e2cf5ffca
BLEtoMQTT/Eddystone2 : msg.payload : Object
  ▼ object
    MAC: "30:ae:a4:1e:98:62"
    UUID: "0000feaaa-0000-1000-8000-00805f9b34fb"
    BatteryVoltage: 3300
    Temperature: 12.82999992
    AdvertiseCount: 386
    TimeSinceReboot: 5653
```

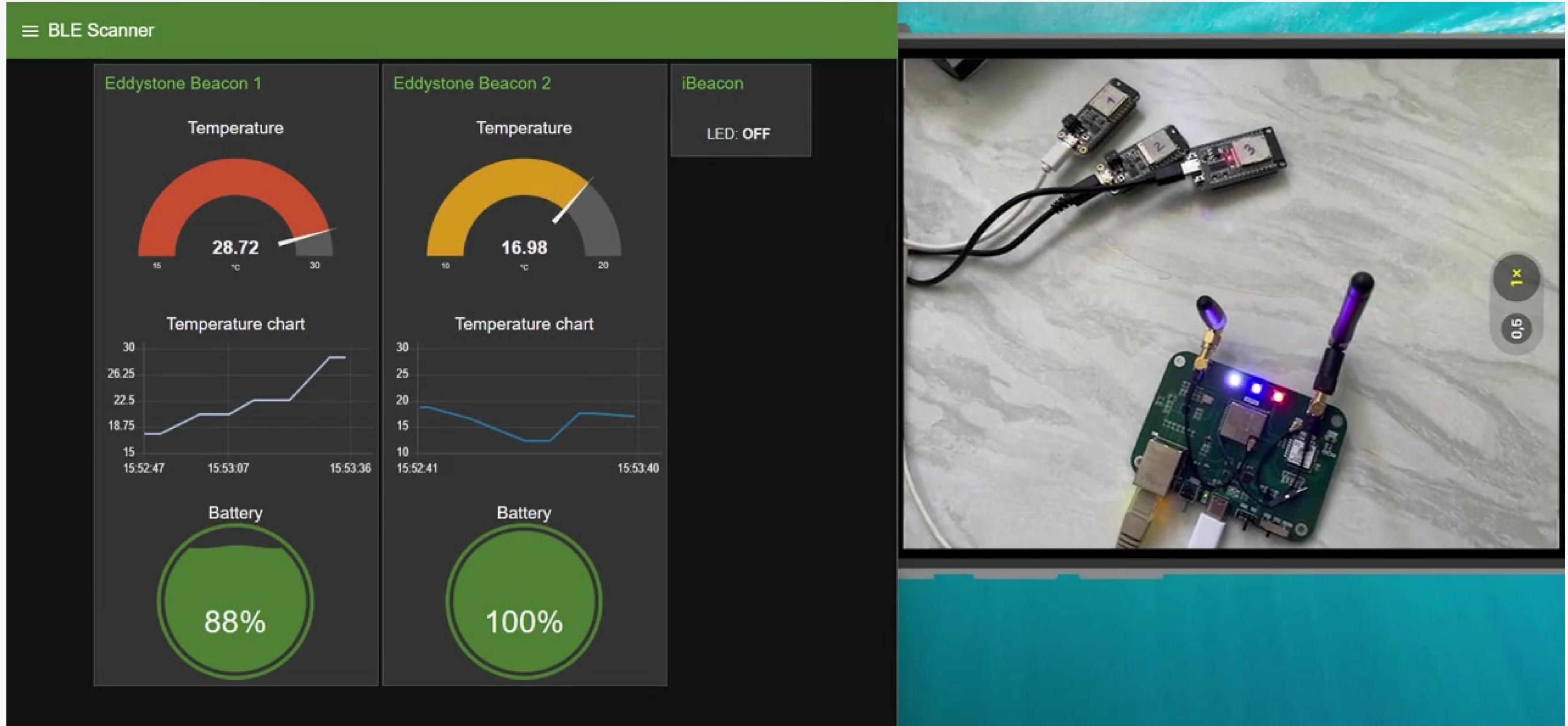
MQTT Server

```
main ×
  "TimeSinceReboot": 1130
  "MAC": "30:ae:a4:1e:98:62",
  "UUID": "0000feaaa-0000-1000-8000-00805f9b34fb",
  "BatteryVoltage": 3300,
  "Temperature": 19.01000023,
  "AdvertiseCount": 78,
  "TimeSinceReboot": 1130
  "MAC": "b8:d6:1a:5c:1e:c6",
  "ID": 76,
  "Major": 5,
  "Minor": 88,
  "UUID": "2d7a9f0c-e0e8-4cc9-a71b-a21db2d034a1",
  "SignalPower": -59,
  "RSSI": -46
  "MAC": "30:ae:a4:19:78:56",
  "UUID": "0000feaaa-0000-1000-8000-00805f9b34fb",
  "BatteryVoltage": 2900,
  "Temperature": 16.29999924,
  "AdvertiseCount": 111,
  "TimeSinceReboot": 1505
```

LoRa Server

DATA AND VIZUALIZATION

NODE-Red Dashboard



CONCLUSION

- Successful created a simple, compact and effective BLE gateway using the ESP32 chipset.
- There are errors on the PCB design but overall still fully functional device.
- Demonstration firmware have shown the gateway meet the intended criteria.
- Future work might include: firmware developed using the IDF Espressif for more efficiency and stress test for the gateway or antenna range...

BOM COST

Not included:

- Custom duties, tax, shipping cost
 - Enclosure.

**Thank you
for listening!**