

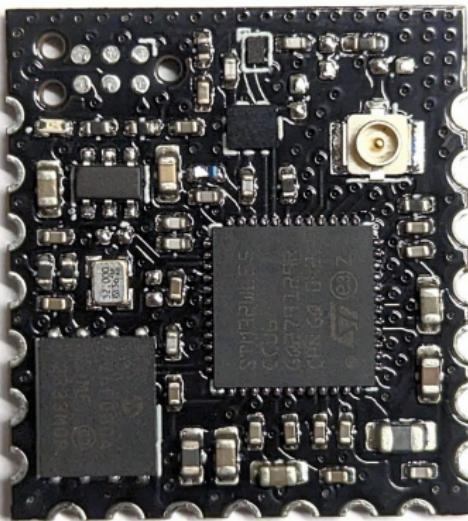
Sensor Network for Smart Agriculture

Jiří Maňák

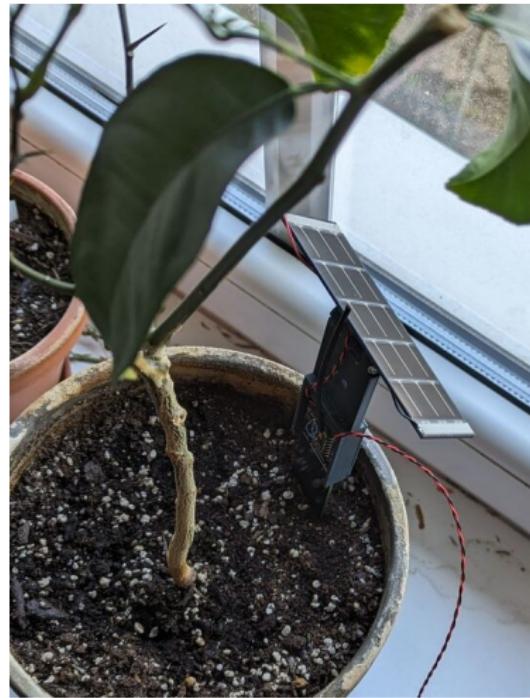
June 7, 2024

Goals

1. Create a universal platform:
LoRa Module and Firmware



2. Demonstrate its capabilities:
Wireless soil moisture sensor

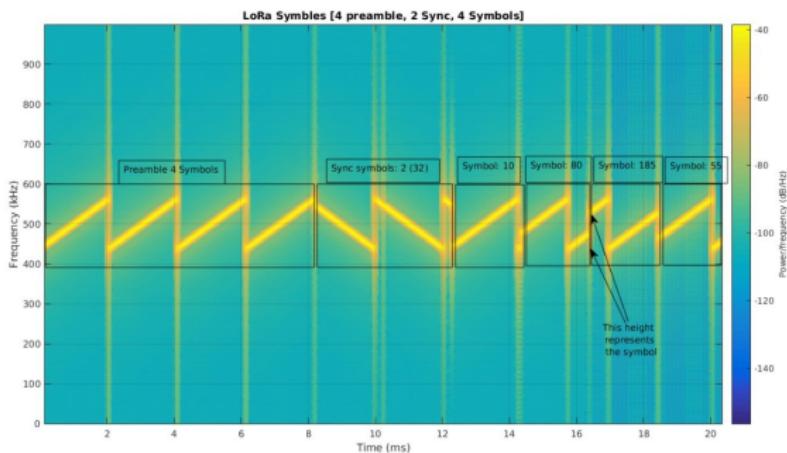


Goals

1. Low-power LoRa Module
 - ▶ A platform for rapid application development
2. Custom soil moisture sensor network
 - ▶ Able to cover large-enough area (kilometers)
 - ▶ Zero-maintenance
 - ▶ No external dependency on commercial networks
 - ▶ Potentially extensible with more sensor types

Cover large-enough area with no external dependency

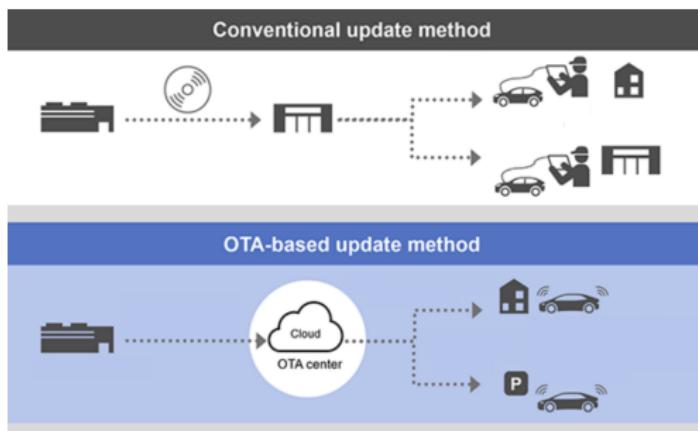
- ▶ LoRa
 - ▶ Long range (kilometers)
 - ▶ Low power (5 mA receive)
- ▶ Custom protocol
 - ▶ Low duty-cycle
 - ▶ Not reliant on LoRaWAN
 - ▶ Efficient



LoRa signal - Frequency/Time, [1]

Zero-maintenance and extensible

- ▶ Solar power
 - ▶ No infrastructure required
 - ▶ Self-sufficient
- ▶ Over-the-Air updates
 - ▶ New features and improvements
 - ▶ Long-term support
 - ▶ Unusual for LoRa nodes



Conventional × OTA update, [2]

Soil Moisture Sensor

Absolute soil water content measurement is impractical

- ▶ High power draw
- ▶ Bulky
- ▶ Expensive

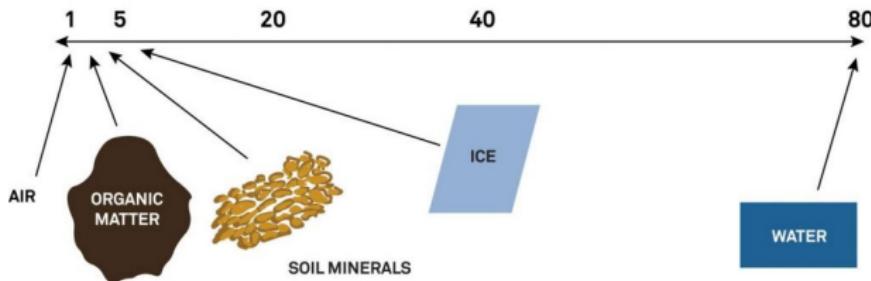
Properly calibrated relative measurement is sufficient for monitoring purposes

→ Capacitive soil moisture sensor

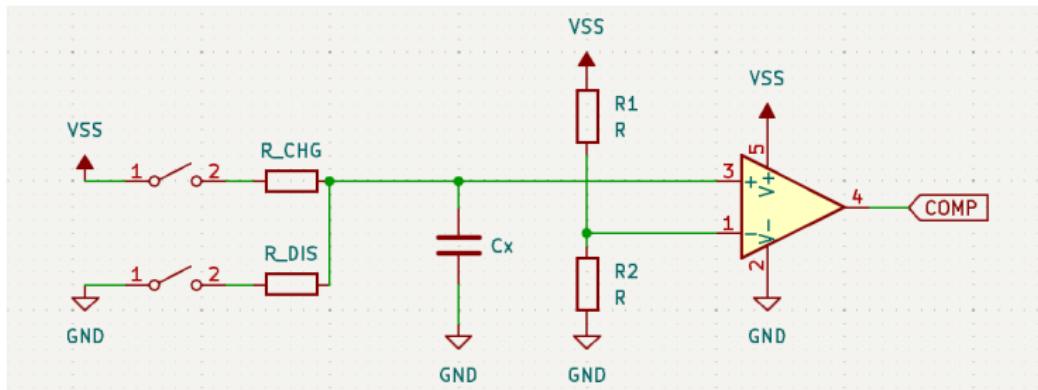
Soil Moisture Sensor

$$C = \frac{\epsilon_r \epsilon_0 S}{d} \quad [\text{F}]$$

$$\tau = RC \quad [\text{s}]$$

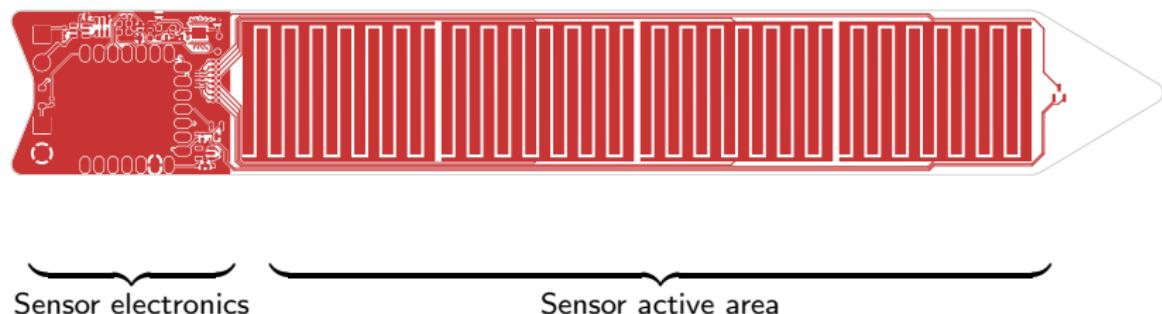


Dielectric constant ϵ_r of materials found in soil, [3]

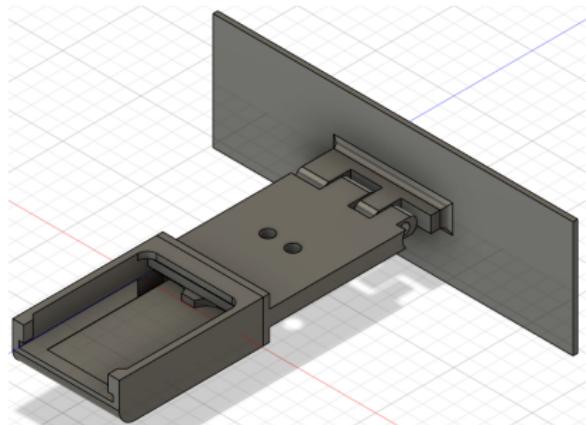


Soil Moisture Sensor

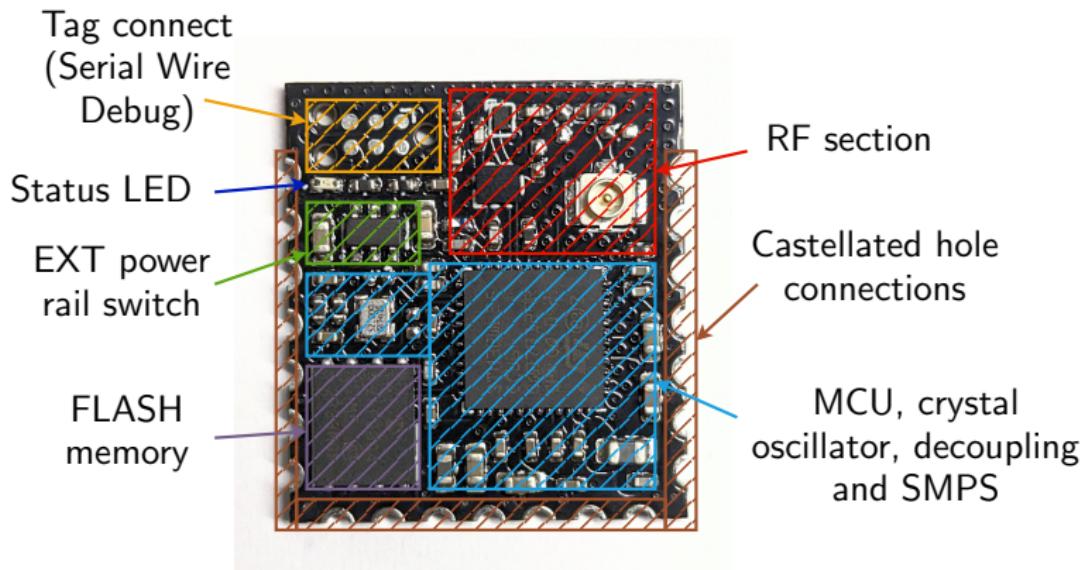
- ▶ PCB construction
- ▶ 4 capacitive zones (15 cm total depth)
- ▶ 330 mAh lithium cell, 150 mWp solar panel



Soil Moisture Sensor

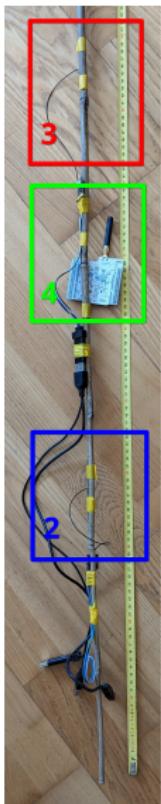


LoRa Module



- ▶ **STM32WLE5CC**
- ▶ 868 MHz, 15 dBm
- ▶ **20.32×22.48 mm**
- ▶ 1 MB FLASH
- ▶ 2.3–3.5 V
- ▶ 16 IO pins

LoRa Module Range Test

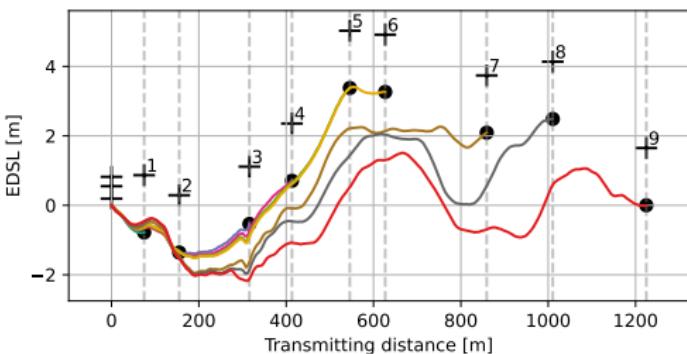
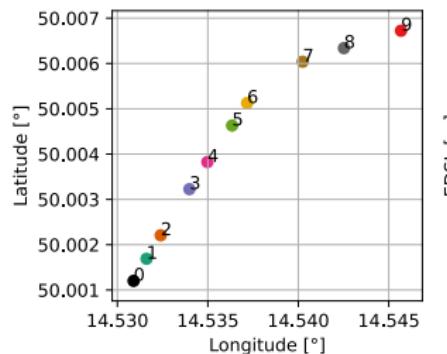
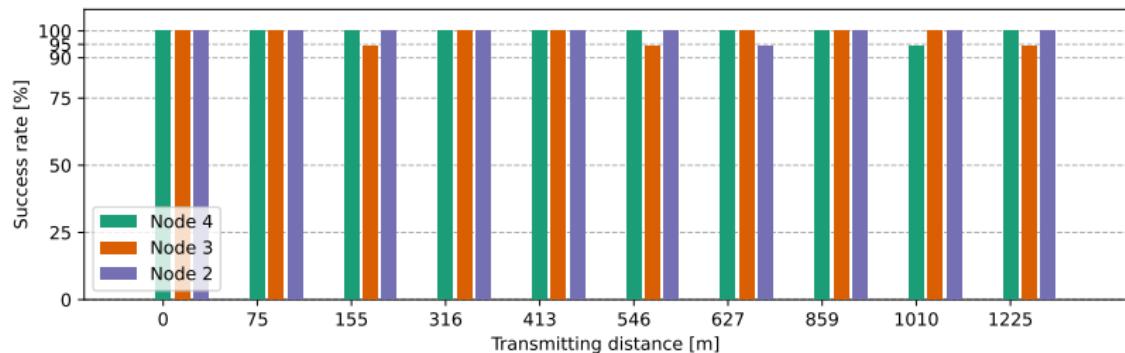


Node 2



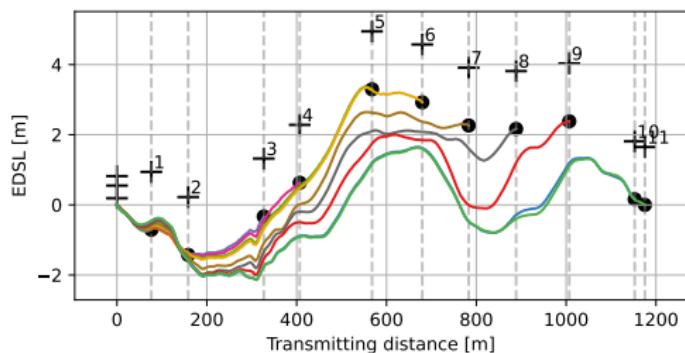
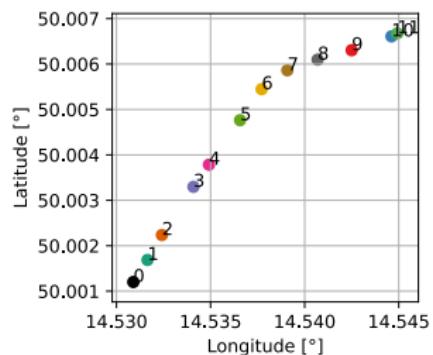
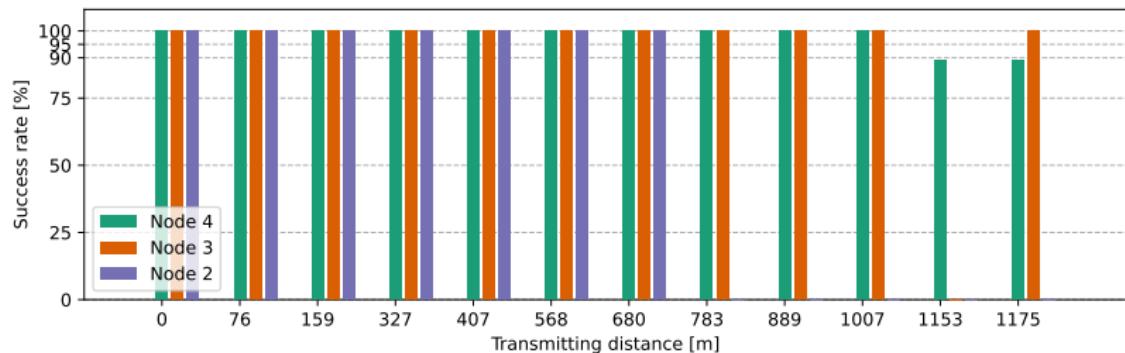
Node 3

LoRa Module Range Test - SF11



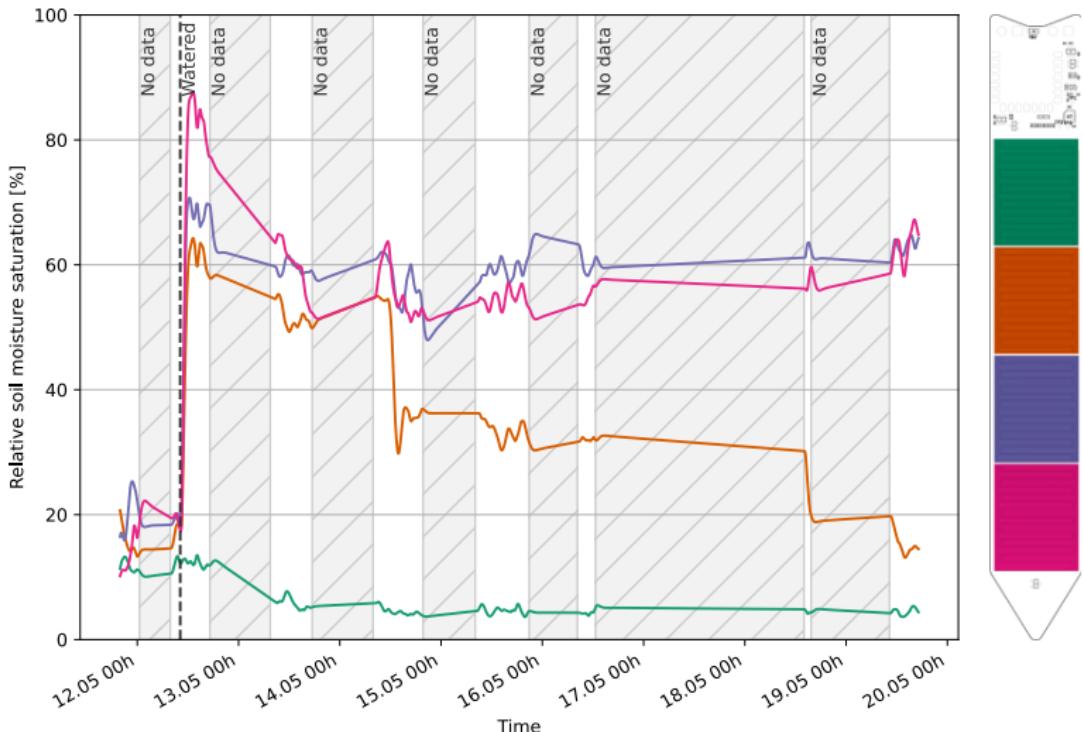
Node 2 - 20 cm, Node 3 - 80 cm, Node 4 (Nucleo) - 50 cm, 1.125 s round-trip, 300 bps, Page 41, Section 4.4.4

LoRa Module Range Test - SF5



Node 2 - 20 cm, Node 3 - 80 cm, Node 4 (Nucleo) - 50 cm, 0.125 s round-trip, 3 kbps, Page 41, Section 4.4.4

Soil Moisture Sensor Validation



Live Demo



(or visit the link)

Conclusion

This thesis brought

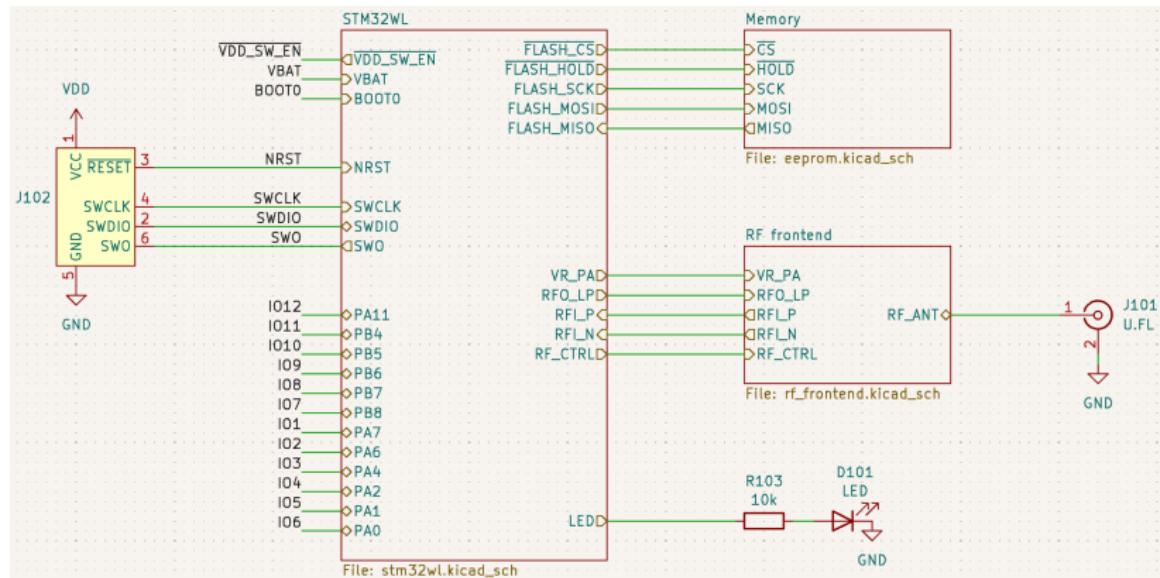
- ▶ **STM32 LoRa Module - a low-power platform for connected sensors**
 - ▶ module-runtime Rust package - HAL, protocol, async executor; enabling rapid application development with emphasis on reliability
 - ▶ Optimized for low duty-cycle operation
 - ▶ Over-the-Air update capability with rollback
- ▶ **Soil moisture sensor - an application of the module**
- ▶ Backend service combining soil moisture sensor data with weather forecast to optimize watering schedule

All publicly available at <https://github.com/manakjiri>

References |

-  Giuseppe Panza, "What LoRaWAN and "Chirp Spread Spectrum" (CSS) technology have in common? Part III | LinkedIn." [Online]. Available: <https://www.linkedin.com/pulse/what-lorawan-chirp-spread-spectrum-css-technology-have-giuseppe-panza-hz5dc/>
-  Mobility Connected, "What are OTA Updates?" Jan. 2024. [Online]. Available: https://www.hitachi.com/products/it/lumada/global/en/spcon/uc_00866s/
-  METER Group, "Soil moisture sensors—How they work. Why some are not research grade - METER Group," May 2023, section: Measurement Insights. [Online]. Available: <https://metergroup.com/measurement-insights/soil-moisture-sensors-how-they-work-why-some-are-not-research-grade/>

LoRa Module



LoRa Module



STDES-WL5U4ILH



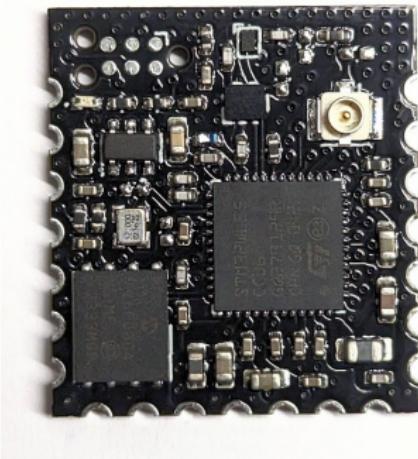
Nucleo-WL55JC

Existing solution?



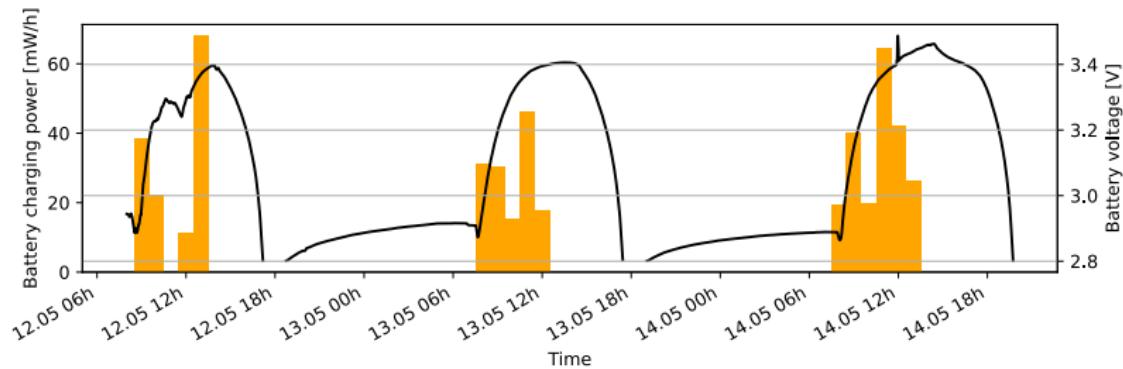
Seeed Studio Wio-E5

>
?
<

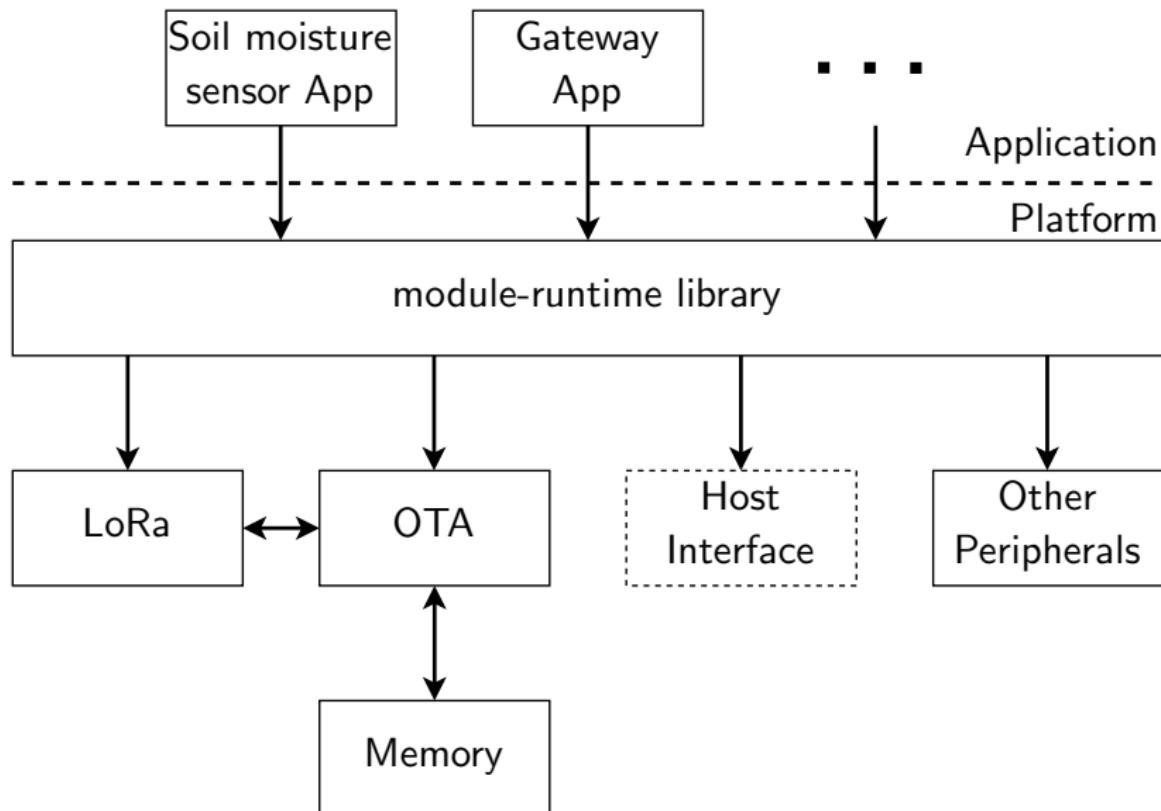


My LoRa Module

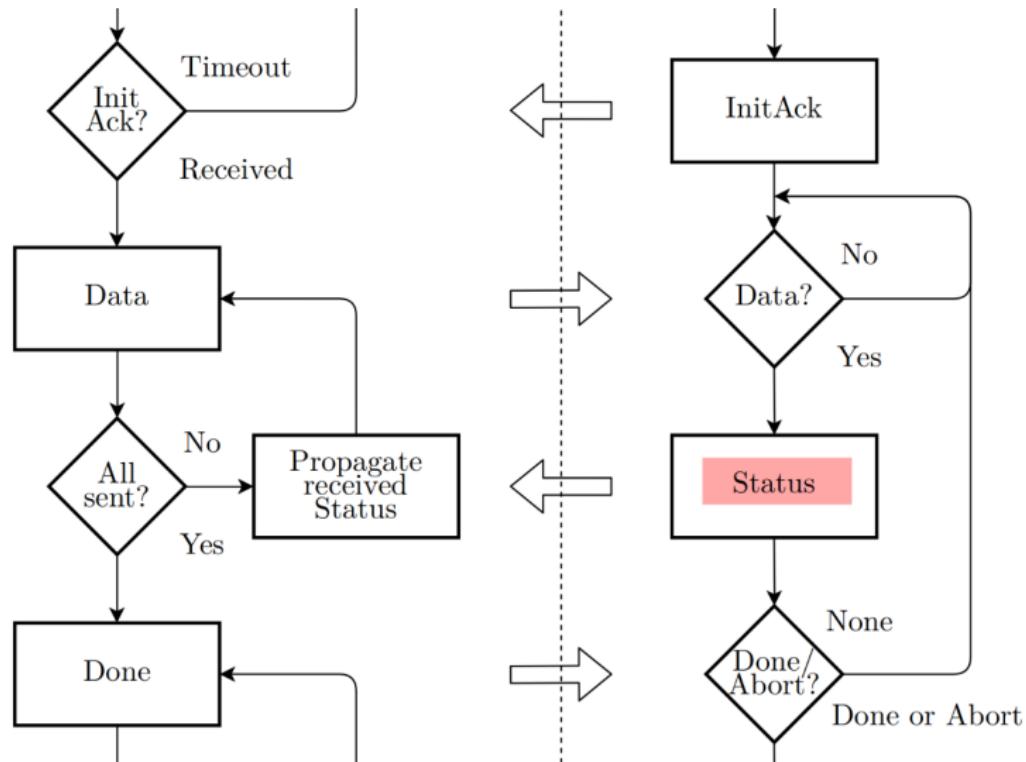
Solar Power



Firmware



Over The Air Update



Page 36, Figure 4.9

LoRa Module

- ▶ 2.8–3.3 V nominal voltage range,
- ▶ low power design - support for switchable power rails,
- ▶ target the EU868,
- ▶ wide temperature range
- ▶ minimize the amount of specialized hardware,
- ▶ support for OTA updates,
- ▶ integrated RF,
- ▶ host communication interface,
- ▶ minimal footprint,
- ▶ low cost.

Page 15, Section 3.2.3