IoT Environmental Monitoring System Using LoRaWAN, MQTT and Node-RED

Project 8

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Problem Statement

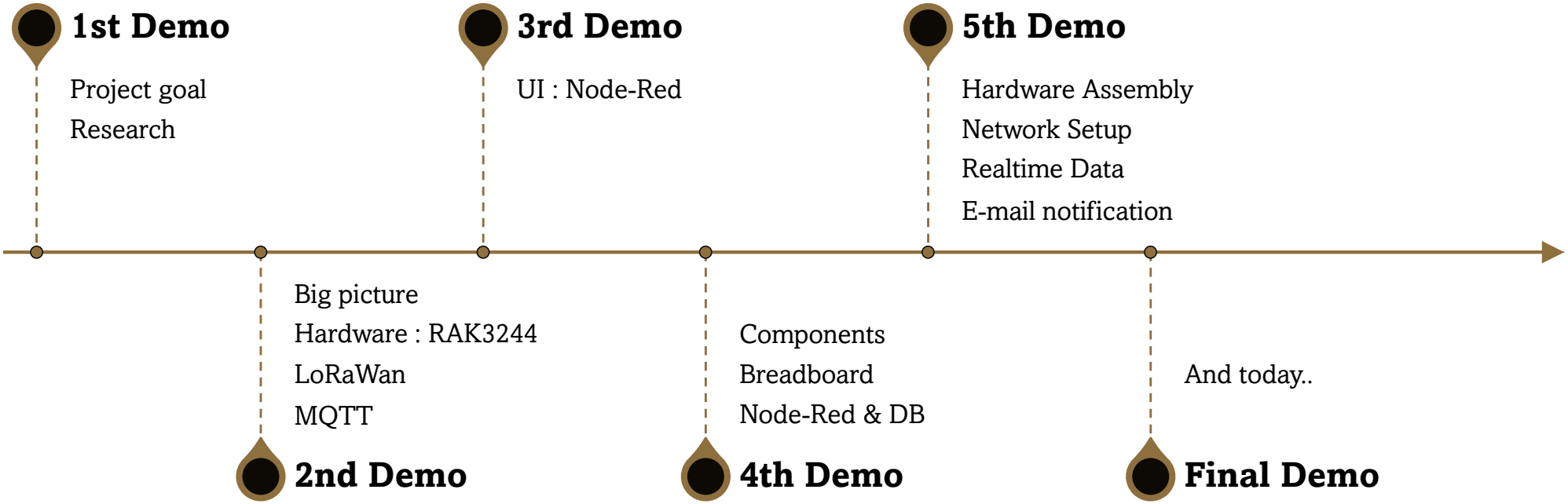
- Unpredictable weather is causing problems for agriculture [1].
- Many prior studies have developed a smart farm system with IoT technology, but it has the limitation that it can be used only in a confined space like greenhouses or urban farming [2].
- **construct IoT weather monitoring system for vast land (American farms)**

[1]K. Sivanraju, "IoT in Agriculture : Smart Farming," *IJSRCSEIT*, vol.3, no.8, pp.181-184, 2018.
[2] N. V. Dharwadkar and R. K. M. Math, "IoT Based Low-cost Weather Station and Monitoring System for Precision Agriculture in India," *International Conference on I-SMAC (IoT in Social, Mobile, Analytics and Cloud)*, 2018, pp. 81-86

Project Goal

- monitor & maintain various sensor data by using Node-Red platform
- manage the long-distance data transmission by using LoRa and MQTT protocol
- use Solar Power so farmers don't need to replace batteries and run cables for all station

Our footprints



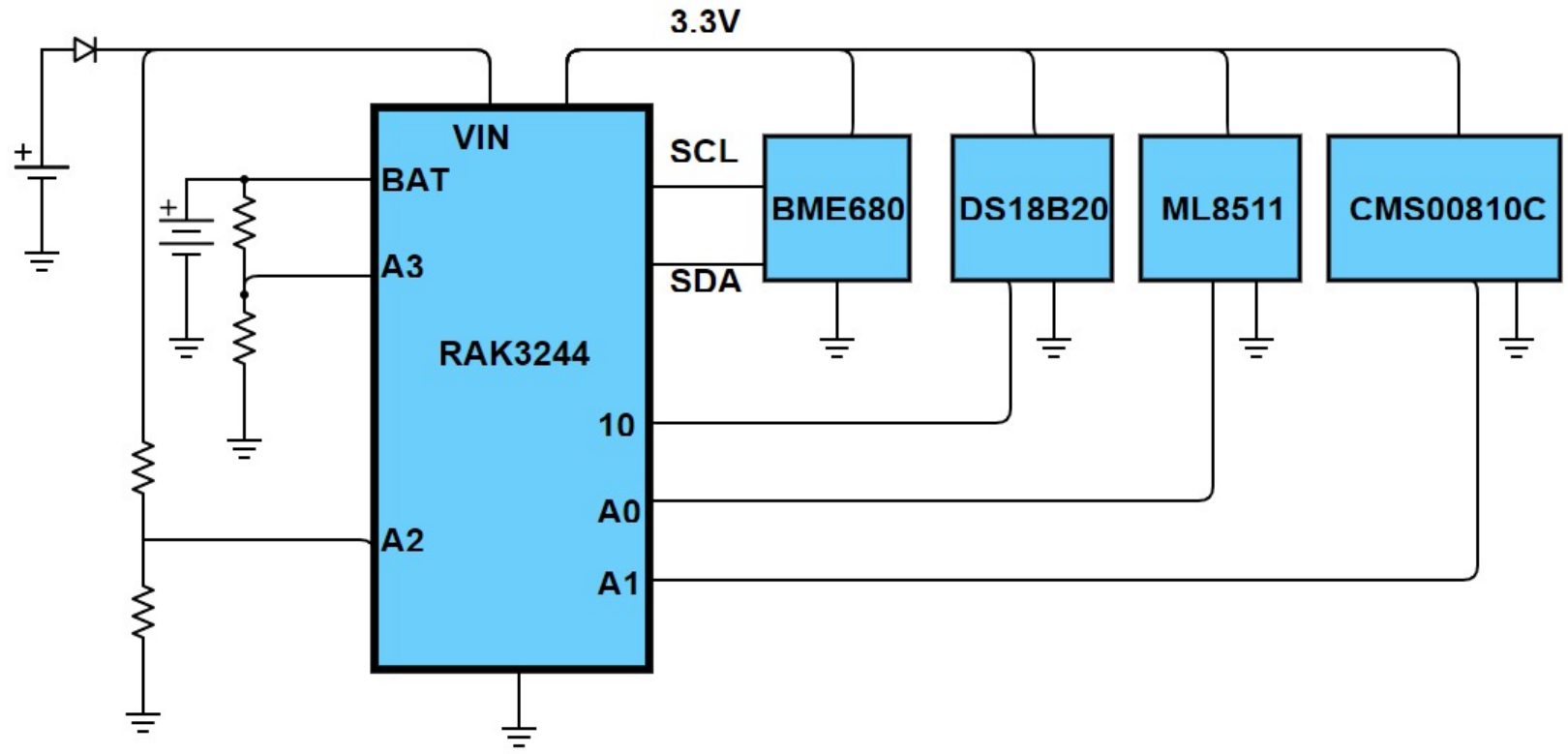
Hardware - components

1. LoRa Gateway
2. Soil Moisture Sensor
3. Temperature Humidity Barometric Pressure IAQ Sensor Module
4. Solar Panel
5. Breadboard
6. Waterproof Temperature Sensor
7. Lithium Polymer Battery
8. Wire
9. UV Sensor Module

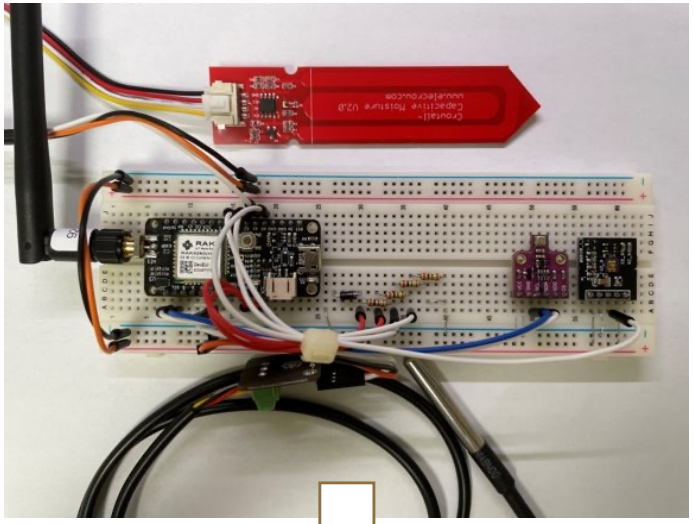
\+ Enclosure Box

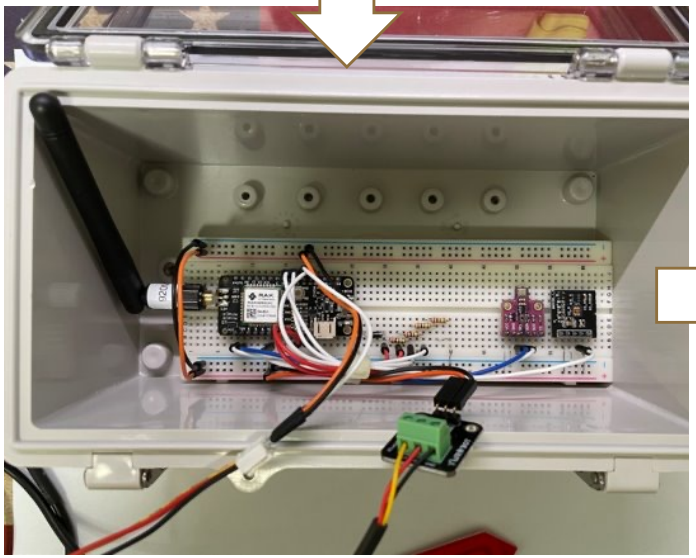
Hardware

schematic diagram



Hardware



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프로젝트 데이터 수집용 장비입니다.
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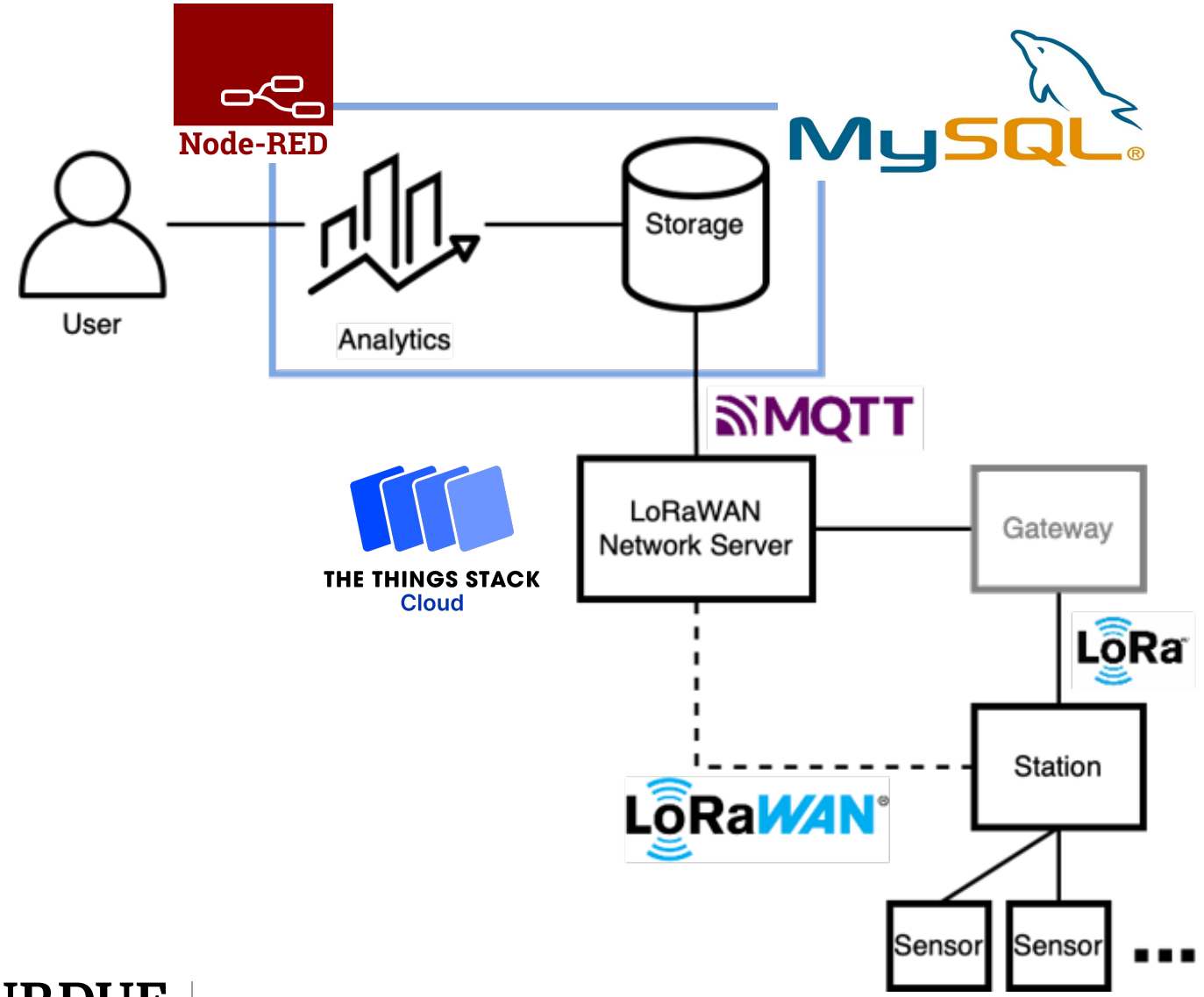
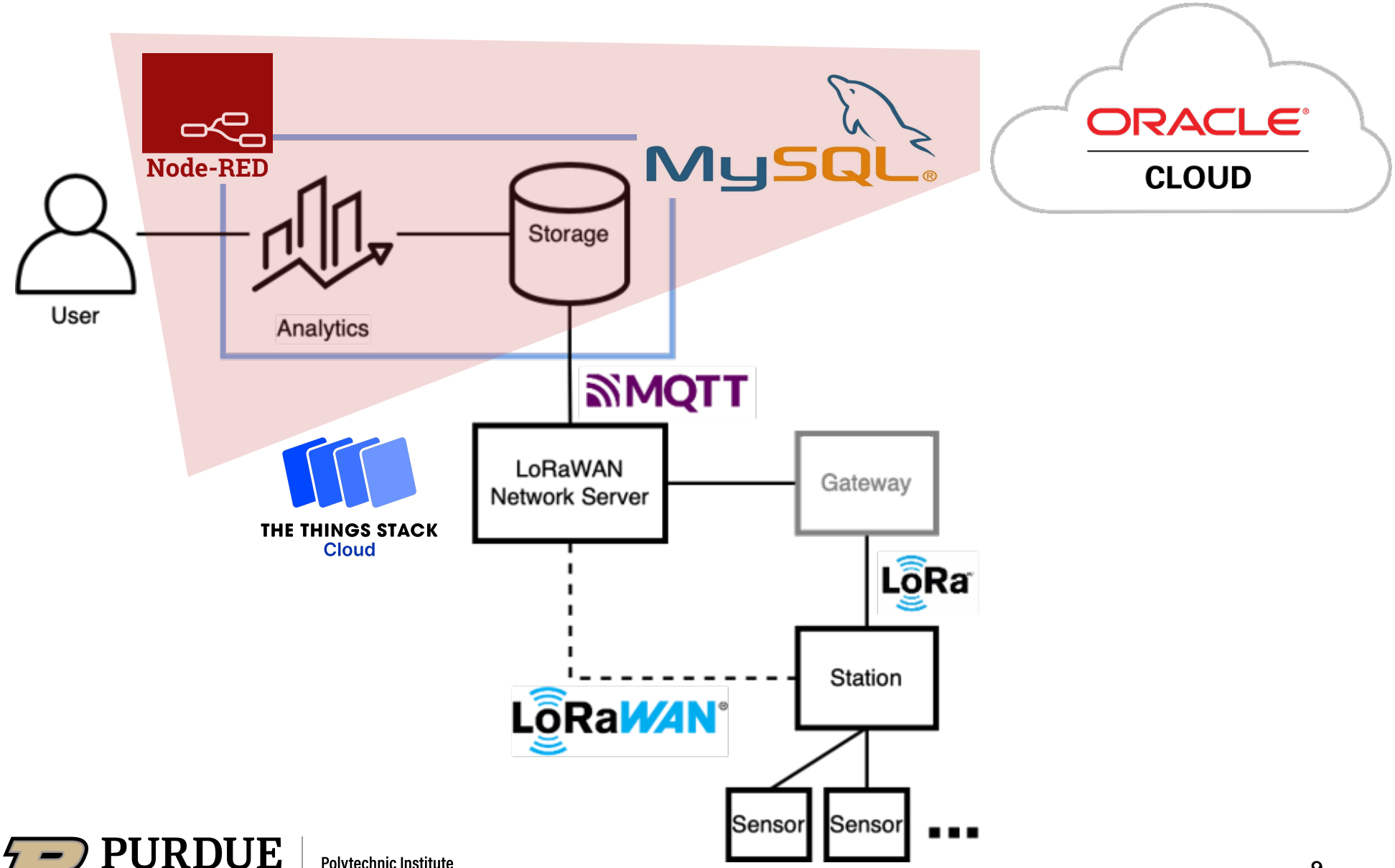
연락처: 010-7446-3526

Software


Node-RED
MySQL
User
Analytics
Storage
MQTT
THE THINGS STACK
Cloud
LoRaWAN
Network Server
Gateway
LoRa
Station
LoRaWAN
Sensor
Sensor

Software


Node-RED
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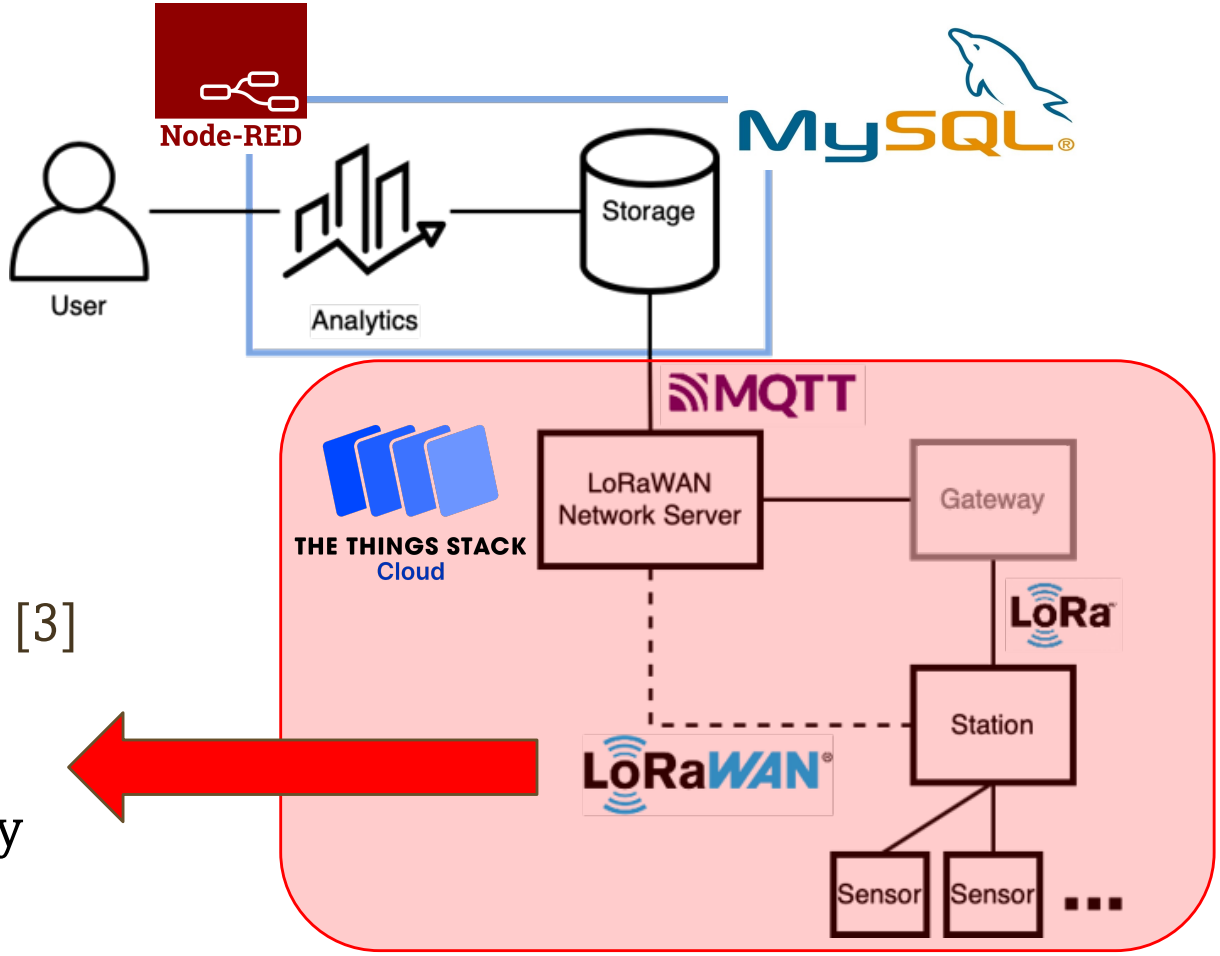
Software

Network



Modified library [3]

to support

KR920 frequency

[3] Beelan-LoRaWAN. (ver. 2.0.0). Beelan. Accessed: Aug. 19, 2021. [Online]. Available: https://github.com/BeelanMX/Beelan-LoRaWAN

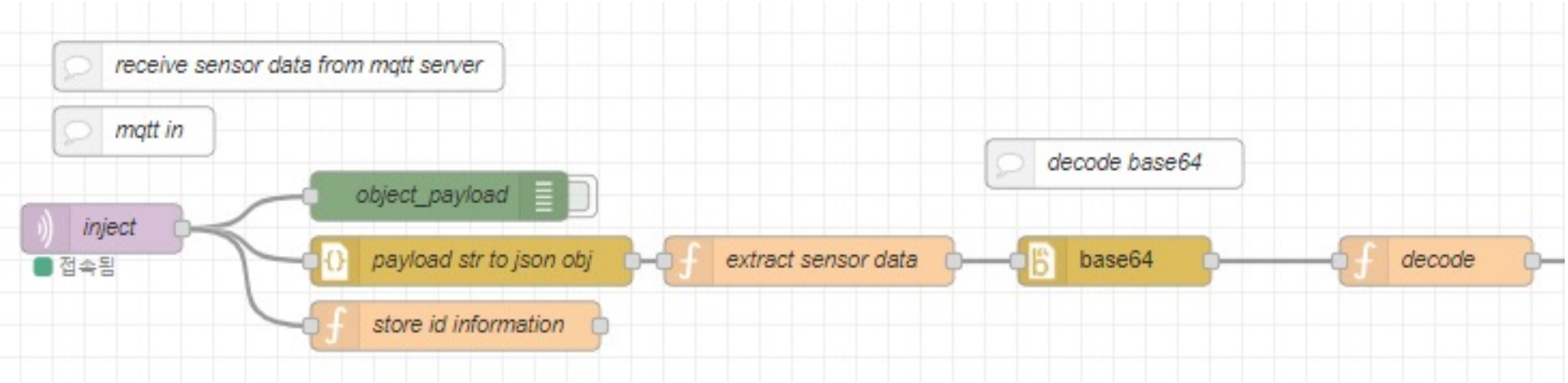
Data packet encoding

Voltages : 8-bit unsigned integer
Temperature Sensors : 16-bit signed integer
Other Sensors : 16-bit unsigned integer

Data	Encoded with	Decode with	Unit
Battery Voltage*	(value * 100) - 320	(data + 320) / 100	V
VIN Voltage*	value * 10	data / 10	V
Ambient Temperature	value * 100	data / 100	℃
Ambient Humidity	value * 100	data / 100	%
Barometric Pressure	value * 10	data / 10	hPa
Gas Resistance	value * 100	data / 100	kΩ
Soil Temperature	value * 100	data / 100	℃
Soil Moisture*	value	data	- (Raw 10-bit ACD value)
UV Intensity	value * 100	data / 100	mW/cm²

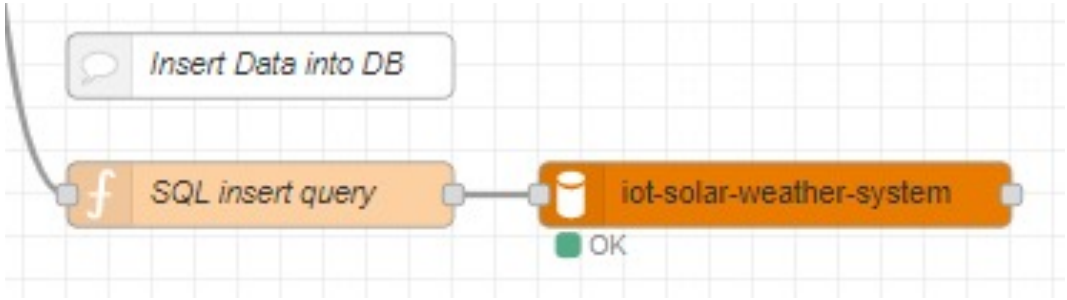
Software

Decode base64



Software

Data Storage

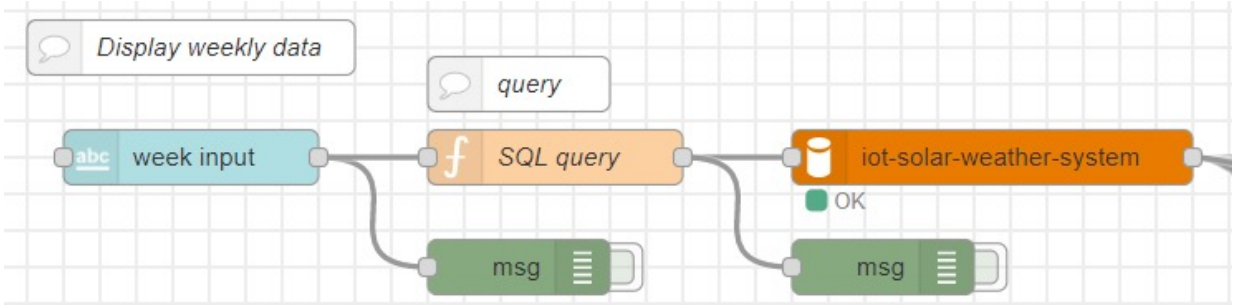


Store data to DB

msgID	time	Battery_voltage	VIN_voltage	Ambient_temperature	Ambient_humidity	Barometric_pressure	Gas_resistance	Soil_temperature	Soil_moisture	UV_intensity
7dc24b4482020712	2021-08-16 19:22:47	3.43	0.60	20.35	72.40	1008.40	7.65	22.50	840	9.15
377e1234f2b89acb	2021-08-16 19:17:43	3.43	0.60	20.38	72.80	1008.40	7.63	22.50	840	9.15
b05bd764d2ebddbe	2021-08-16 19:12:39	3.43	0.60	20.41	72.29	1008.40	7.61	22.50	840	9.15
10eaf228cd556e13	2021-08-16 19:07:36	3.43	0.60	20.43	72.38	1008.40	7.60	22.50	841	9.18
245fc3a4bea9b703	2021-08-16 19:02:32	3.43	0.60	20.46	73.32	1008.30	7.58	22.50	841	9.18
942b411d2faab2ad	2021-08-16 18:57:29	3.43	0.60	20.47	71.29	1008.30	7.58	22.50	841	9.18
b70e2a5ef5587d89	2021-08-16 18:52:25	3.44	0.60	1.29	70.99	1008.20	7.60	22.50	841	9.18
d2428621f53c0f11	2021-08-16 18:47:21	3.44	0.60	1.29	72.59	1008.20	7.58	22.50	841	9.18
e5e5cdfafc39a38a	2021-08-16 18:42:18	3.45	0.60	1.30	71.51	1008.20	7.60	22.50	841	9.18
8e375633e3d2ba83	2021-08-16 18:37:14	3.45	0.60	1.32	72.90	1008.20	7.60	22.50	841	9.20
bbd35eb8b3fc4b9b	2021-08-16 18:32:10	3.45	0.60	1.33	72.35	1008.20	7.59	22.50	841	9.20
448becd877fdea37	2021-08-16 18:27:07	3.45	0.60	1.35	74.02	1008.20	7.58	22.50	841	9.20
9c8dac5df250019f	2021-08-16 18:22:03	3.45	0.60	1.38	72.47	1008.30	7.52	22.50	841	9.23
764c324f10a867f2	2021-08-16 18:16:59	3.45	0.60	1.43	72.75	1008.30	7.48	22.50	841	9.23

Software

Data Storage

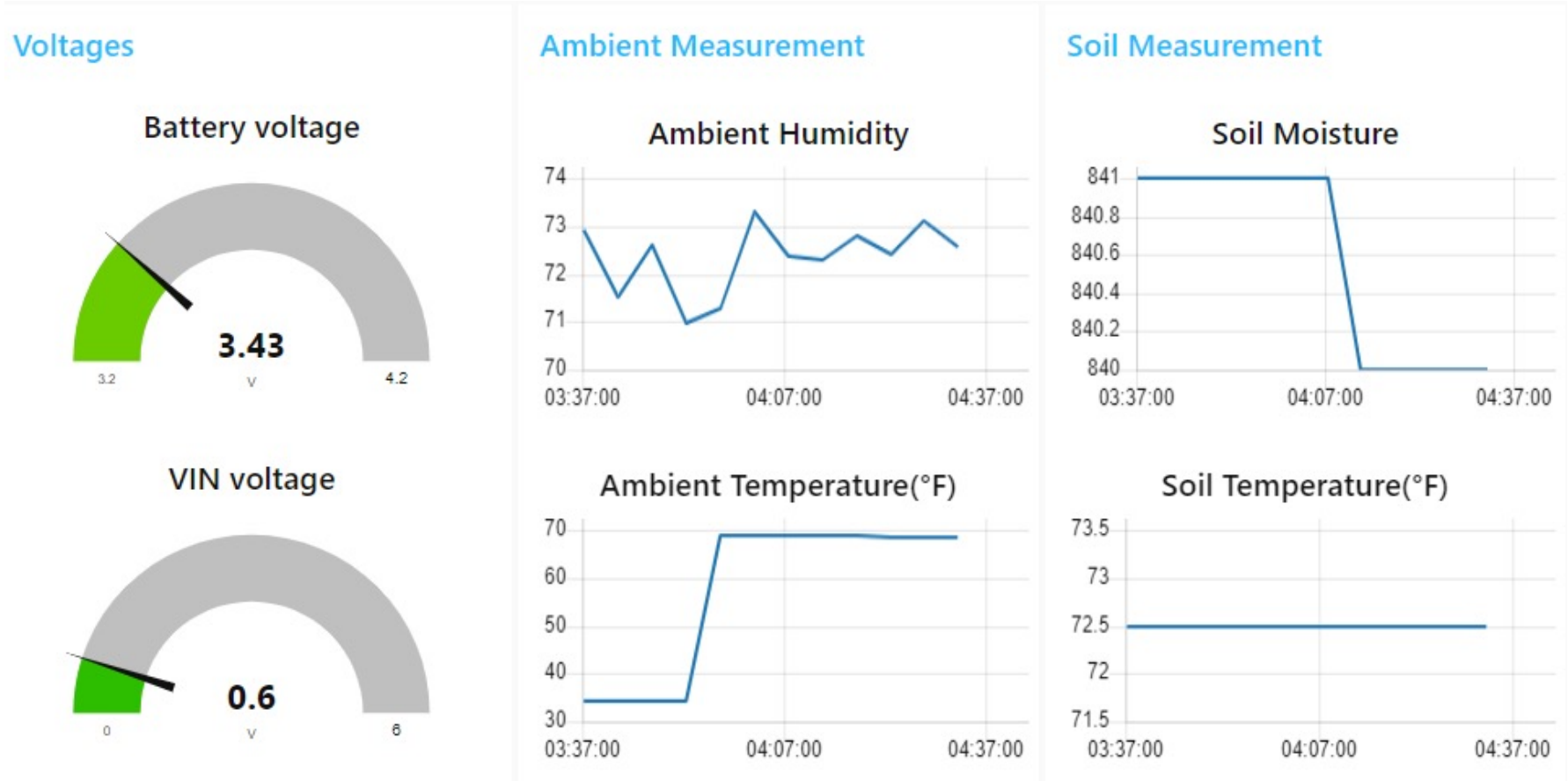


Get data from DB

```
msg.topic = "select date_format(time, '%Y-%m-%d') as day, \
avg(Battery_voltage) as Battery_voltage, avg(VIN_voltage) as VIN_voltag
, avg(Ambient_temperature) as Ambient_temperature, avg(Ambient_humidity
, avg(Barometric_pressure) as Barometric_pressure, avg(Gas_resistance)
, avg(Soil_temperature) as Soil_temperature, avg(Soil_moisture) as Soil
, avg(UV_intensity) as UV_intensity \
from `iot-weather`.SensorData \
where "+"\""+msg.payload+"\"" +" between \
        DATE_FORMAT( \
          DATE_ADD(time, INTERVAL (WEEKDAY(time)) * -1 DAY), \
          '%Y-%m-%d' \
        ) \
        and \
        DATE_FORMAT( \
          DATE_ADD(time, INTERVAL (6 - WEEKDAY(time)) * +1 DAY), \
          '%Y-%m-%d' \
        ) \
group by day \
order by day asc";
return msg;
```

Software

UI


Voltages
Battery voltage
3.43
3.2
V
4.2
VIN voltage
0.6
0
V
6
Ambient Measurement
Ambient Humidity
74
73
72
71
70
03:37:00
04:07:00
04:37:00
Ambient Temperature(°F)
70
60
50
40
30
03:37:00
04:07:00
04:37:00
Soil Measurement
Soil Moisture
841
840.8
840.6
840.4
840.2
840
03:37:00
04:07:00
04:37:00
Soil Temperature(°F)
73.5
73
72.5
72
71.5
03:37:00
04:07:00
04:37:00

Demo

Recorded video

Limitations

Struggling

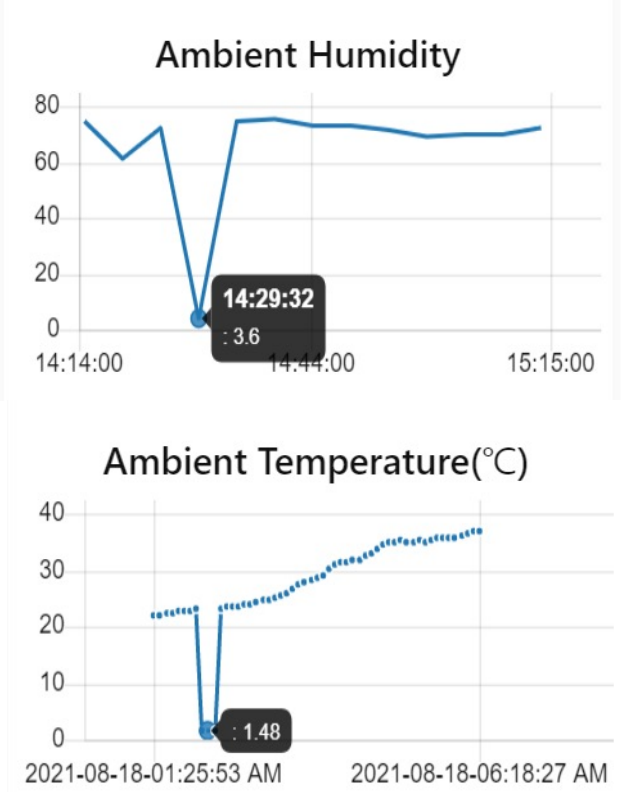
- Support KR920 frequency
- Unstable NodeRED
- Making query

Limitations

- User input is not flexible.
- Limited UI implementation
- Only have one station
- Fixed time zone
- Battery life
- Inaccurate data

Limitations

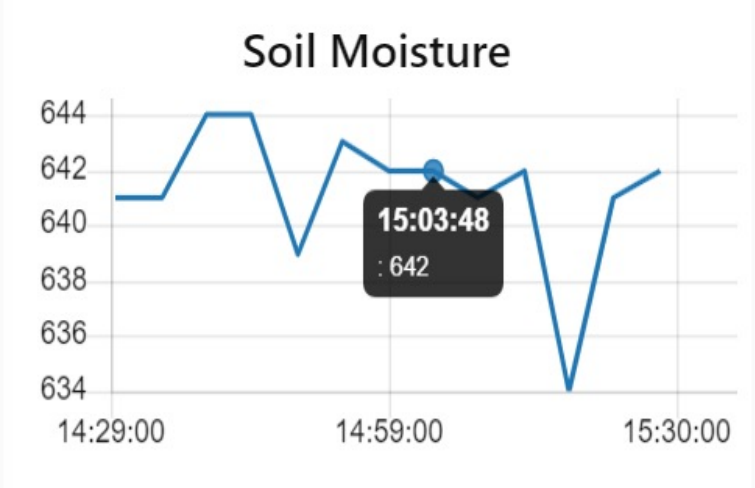
Limitations



- Sometimes the station sends data values that are way out of normal range

-> Compare it to the most recently added data value
-> If the difference between them goes over certain degrees, don't display or store it to the database

Limitations



- Soil moisture sensor measures the moisture level by the electric capacitance. If the soil is dry, output will be higher. [4]
- So if the value is high, it means that the soil is dry. This is not intuitive to the user.

-> We can set up a calibration system using principles of the tensiometer to get more accurate values. [5]

[4] Electropeak, "Complete Guide to Use Soil Moisture Sensor w/ Examples", Arduino Project Hub, 2019. [Online].
Available : https://create.arduino.cc/projecthub/electropeak/complete-guide-to-use-soil-moisture-sensor-w-examples-756b1f. [Accessed: Aug. 18, 2021]
[5] ltrium, "Soil Moisture Sensor Calibration", Instructabales, 2020. [Online]. Available: https://www.instructables.com/Soil-Moisture-Sensor-Calibration/.
[Accessed: Aug. 18, 2021]

Future Plans

- improve previous limitations
- simple & easy UI

Thank You

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