

checkBin

2nd delivery

Brief recap

The screenshot shows a web browser window displaying the [checkBin](https://dev7723.d2wnn0xh1kb5op.amplifyapp.com) application. The main feature is a map of Rome, Italy, with various recycling bins marked by icons. A legend on the right side defines three fill levels:

- Fill level between 8 and 10 (Red icon)
- Fill level between 5 and 7 (Orange icon)
- Fill level between 0 and 4 (Green icon)

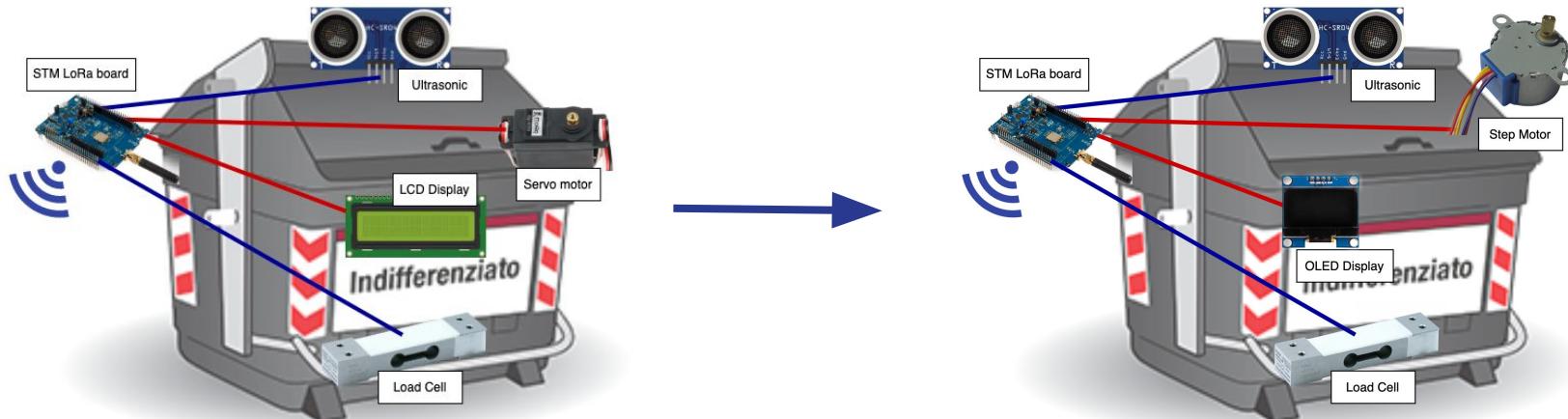
A message on the map indicates a 90% fill level at coordinates 23.4202, 12.4675 on April 23, 2022, at 17:24:27. Below the map, there is a form for adding new bins:

To add a new bin, fill the form with the coordinates and click on "Add Bin".

Latitude: _____
Longitude: _____

GitHub Repository: [checkBin](#)

Changes in the actuators

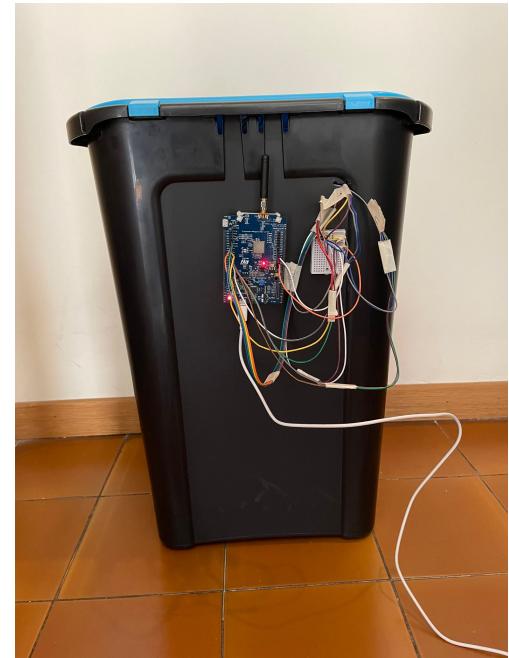


Servo Motor → Step Motor

LCD Monitor → OLED Display

Technical work

Prototype build



Prototype build

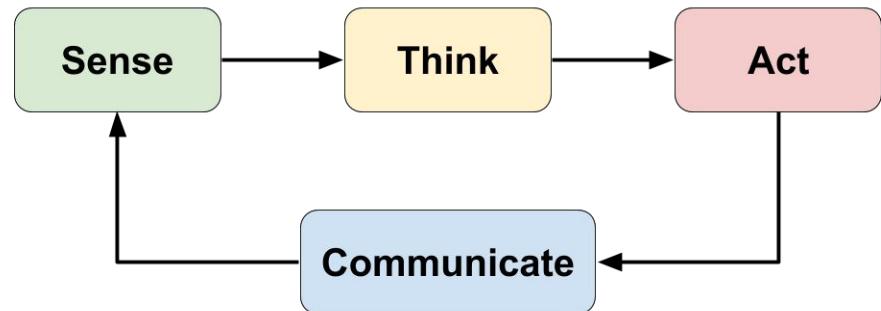


Code on the Board

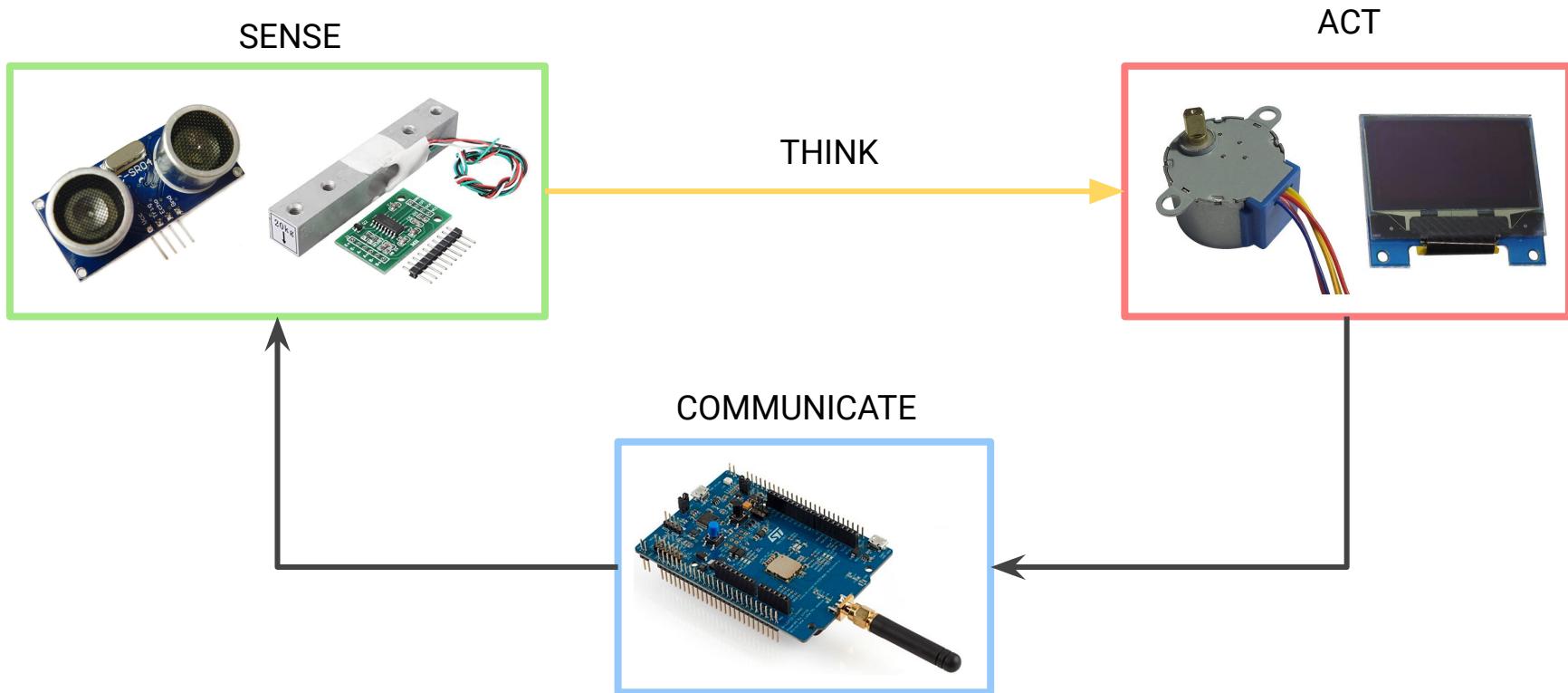
Functions necessary to:

- read values from the sensors
- act using the actuators
- send data using LoRa

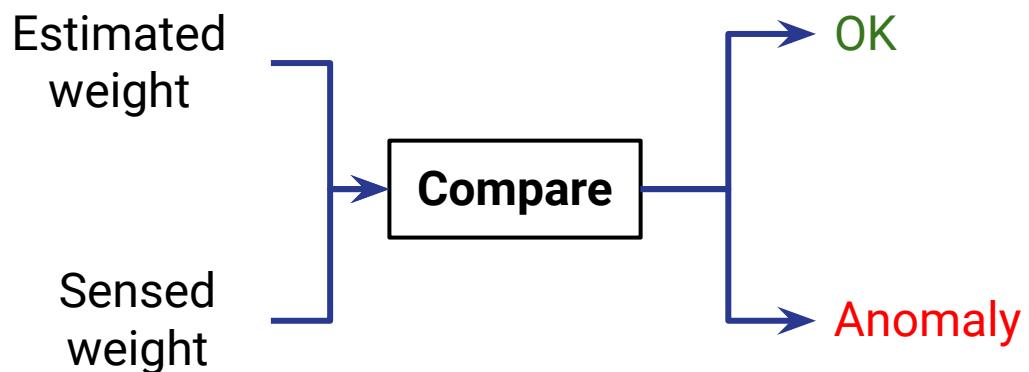
Moreover we wrote all the logic that governs the system using the above functions.



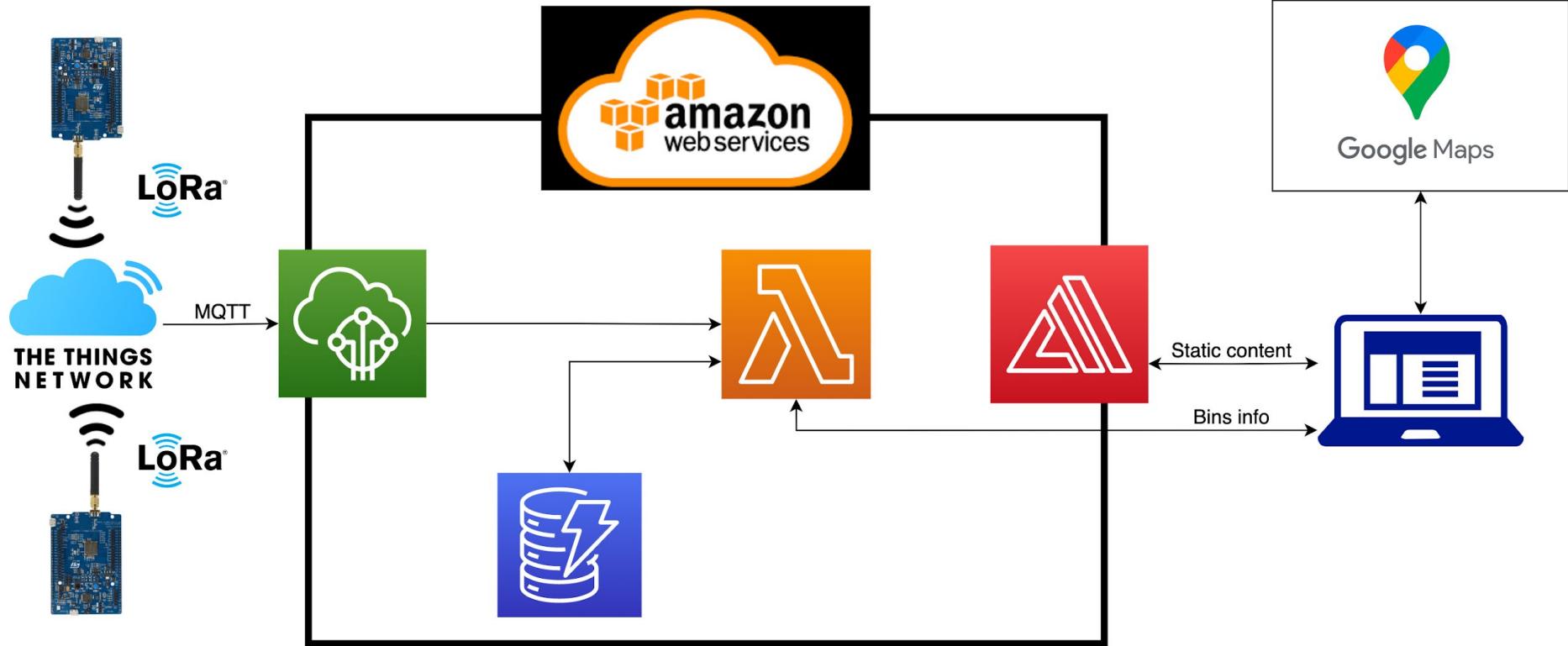
Logic



Anomalies



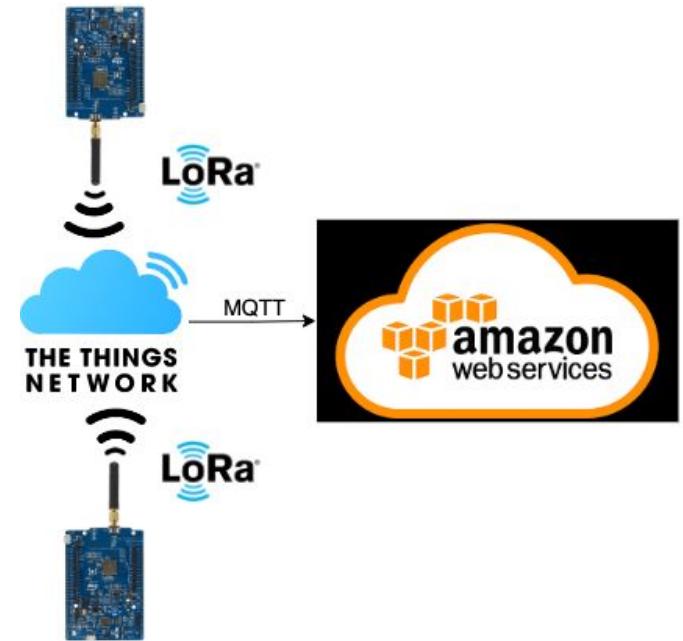
Cloud: Overview



The Things Network

We used Lora Gateways provided by The Things Network.

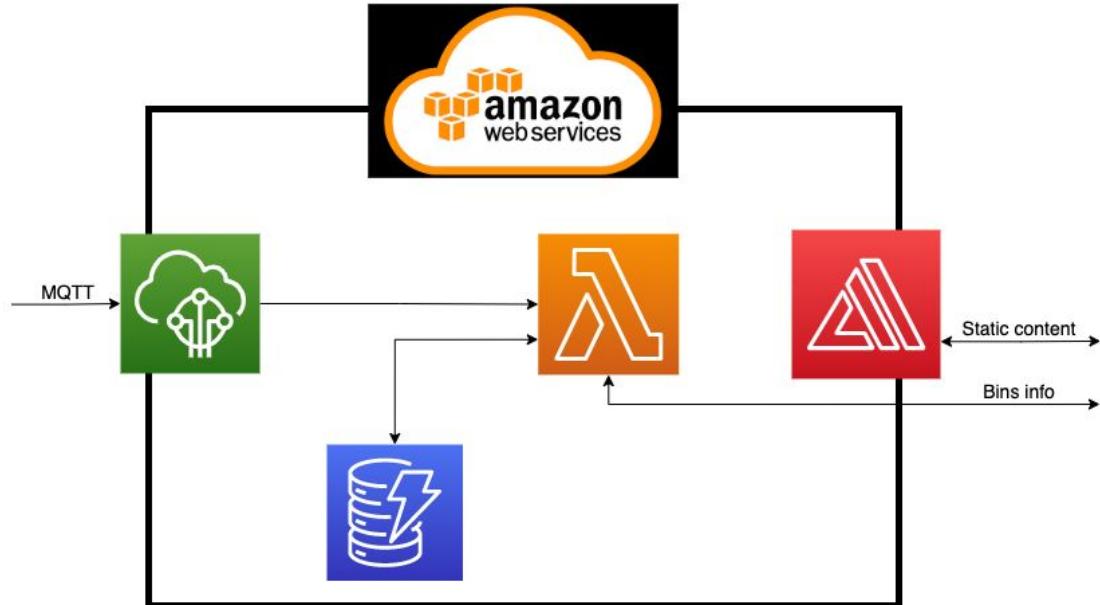
These gateways allow us to easily receive packets from the boards and immediately relay them to AWS IoTCore.



Amazon Web Services

The used AWS services are:

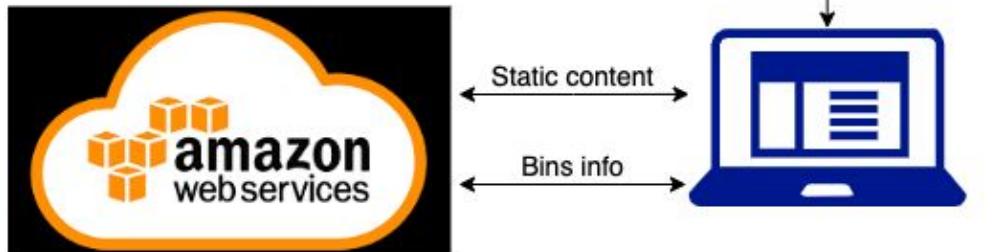
- IoT Core
- Lambda
- DynamoDB
- AWS Amplify



Web Interface

To develop the web interface we used:

- services and functions hosted on AWS
- Google Maps APIs



Web interface

The screenshot shows a web browser window displaying the checkBin application. The main content is a map of Rome, Italy, with various locations marked by icons. A legend on the right side defines three fill levels for the bins:

- Fill level between 8 and 10 (Red pin)
- Fill level between 5 and 7 (Orange pin)
- Fill level between 0 and 4 (Green pin)

Below the map, there is a form with fields for "Latitude" and "Longitude", and a button labeled "Add Bin". To the right of the form, instructions say: "To add a new bin, fill the form with the coordinates and click on 'Add Bin'." At the bottom right, a link points to the GitHub Repository: [checkBin](#).

Map details include labels for neighborhoods like LABARO, GROTTAROSSA, Tufello, and Setteville, as well as landmarks such as the Colosseum, Palazzo della Civiltà Italiana, and Villa Borghese. Numerous red, orange, and green pins are scattered across the map, indicating the locations of the bins.



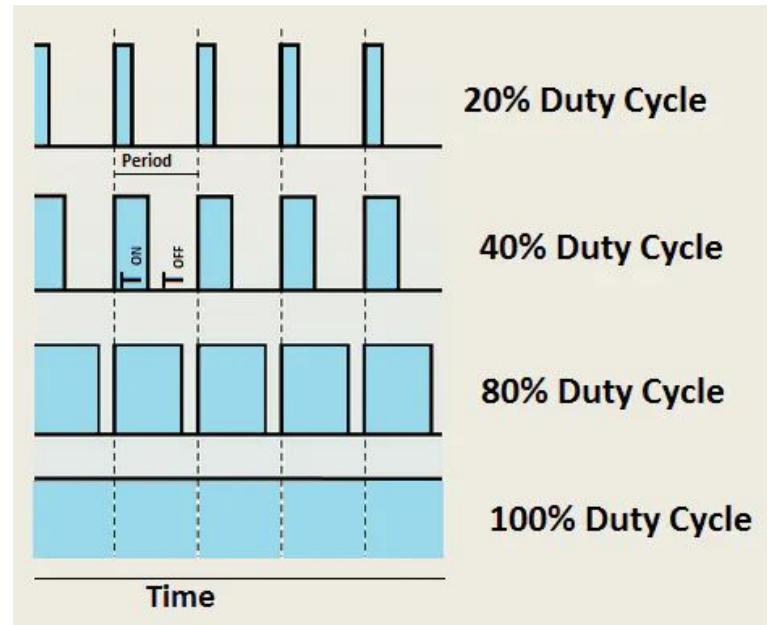
Conducted evaluation

Energy consumption

- Sensors: ultrasonic and load cell
 - Actuators: OLED display and stepper motor
 - Board
 - Radio
-

Analysis on sampling frequency

- Continuous sampling of all the sensors
- Continuous sampling of one sensor and sensing of the other only when an event is detected
- **Periodic sensing**



Analysis on radio usage

- Transmit the fill level every time a new one is computed
- **Transmit the fill level every time it changes with respect to the last measured one**





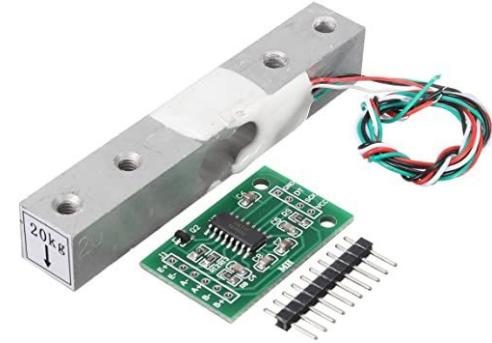
Sensors precision

Ultrasonic sensor

Fill level → value between 0 and 9

Fill level step represents a range of size $\text{bin_height}/10$

Error percentage of the fill level: max 10% of the total height



Load cell

Conversion formula:

$$(\text{base_value} - \text{measured_value})/0.104$$

Error: ~2%

Accuracy of the system

Fill level from ultrasonic sensor	Total measurements	Detected anomalies	Undetected anomalies
0	2	0	0
1	3	0	0
2	5	0	0
3	4	0	0
4	7	0	0
5	6	1	0
6	3	0	0
7	3	1	0
8	4	0	1
9	3	0	0
-----	-----	-----	-----
Total	40	2	1

Network

- Bandwidth: size of the payload is less than 10 bytes
- Latency: from the sending of the message to the update in the dashboard is less than 2 seconds
- Gateway infrastructure: must cover all the bins

```
↓ 15:04:34 Schedule data downlink for... Rx1 Delay: 5
↑ 15:04:34 Forward uplink data message MAC payload: 31 34 7C 30 <> [ ] FPort: 2 Data rate: SF7BW125 SNR: 9 RSSI: -87
↑ 15:04:34 Successfully processed dat... DevAddr: 26 0B A4 76 <> [ ] FCnt: 16 FPort: 2 Confirmed uplink Data rate: SF7BW125 SNR: 9 RSSI: -87
↓ 15:04:09 Schedule data downlink for... Rx1 Delay: 5
↑ 15:04:09 Forward uplink data message MAC payload: 31 34 7C 39 <> [ ] FPort: 2 Data rate: SF7BW125 SNR: 7 RSSI: -84
↑ 15:04:09 Successfully processed dat... DevAddr: 26 0B A4 76 <> [ ] FCnt: 15 FPort: 2 Confirmed uplink Data rate: SF7BW125 SNR: 7 RSSI: -84
```

checkBin - Future plans

Technical updates for 3rd delivery



System optimisation

- Consider the possibility of using as bin identifier the DEV_EUI assigned to the board for the LoRa communication
- Study the power management API of RIOTOS to understand if it can be useful for our purposes.

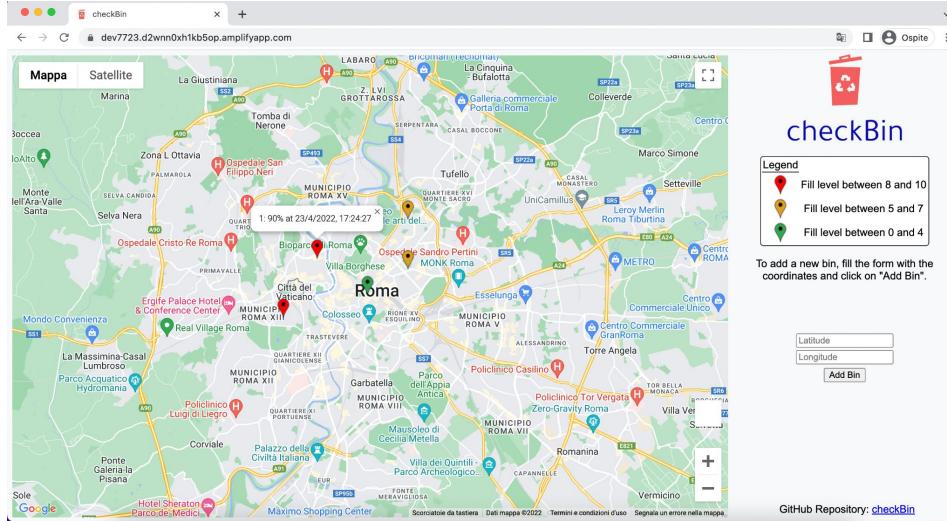
Technical updates for 3rd delivery



Changes in the prototype

- Try different charging methods.
- Show the fill level as a progress bar on the oled display.
- Add a button or an NFC reader to open the bin.

Technical updates for 3rd delivery



Changes in the web dashboard

- Websocket implementation to update the fill levels on the dashboard in real time.
- New button to delete a bin, given its identifier.

Evaluation plans for 3rd delivery: Energy



- Energy consumption during wake-up time
- Energy consumption to activate the sensors and compute the fill level
- Energy consumption to transmit data using LoRa
- Energy consumption during sleep mode
- Energy consumption of the OLED display

Evaluation plans for 3rd delivery: Network

- Total size of LoRa packets
- Total size of the payloads
- Total latency from the beginning of the measuring phase to the update of the web dashboard



DEMO

LINK: <https://youtu.be/C8MtbwdandU?t=208>