Smart Jugs

IoT - Project

Authors

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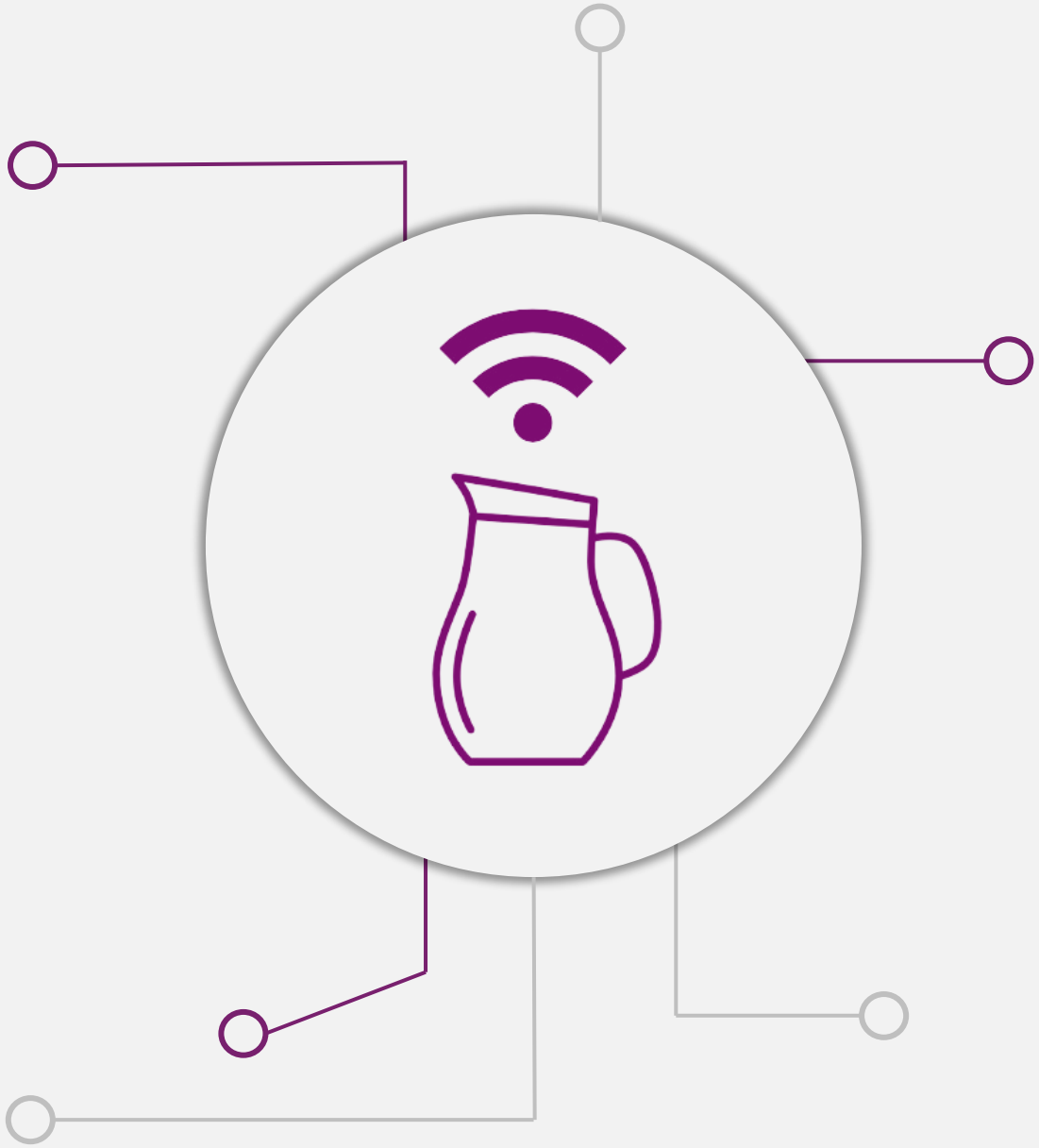
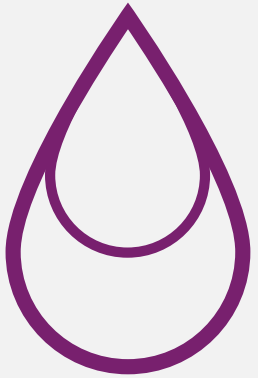


Overview

- Our project involves the connectivity of “Smart (Water) Jugs” and the tracking of the **fluid filtered** each second.

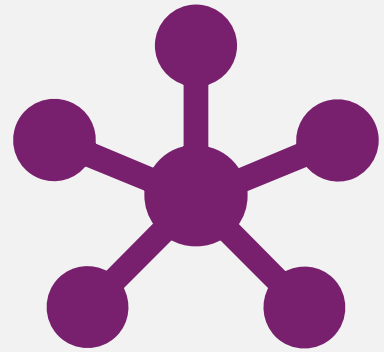
- We track:
  - The total number of liters filtered
  - The amount of water consumed each day
  - The filter usage
  - The kilograms of plastic saved
  - The location



- Coupled with an application developed in parallel with the **Mobile Development** course. The application part represent the user / client dashboard.

Technologies

- The technologies we adopted are the following ones:
  - **Arduino** – as hardware for emulating a sensor
  - **TypeScript** – to have a scalable simulated number of sensors
  - **Godot** – to have a gamificated version of the simulated sensor
  - **Node-RED** – representing the middleware between ThingWorx and the mobile devices, also used for dashboards. Authentications done via JWT Tokens.
  - **ThingWorx** – used mainly as remote database to save things data persistently
  - **Redis** – cache service used to limit the traffic of requests to ThingWorx



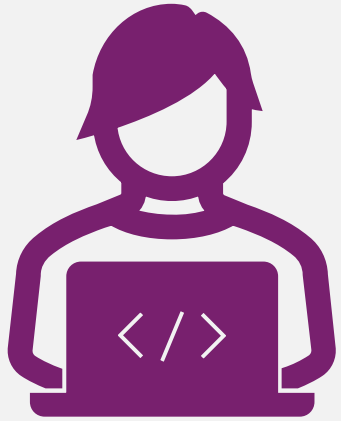
- We will discuss each one in the following sections.

TypeScript

- We implemented our simulator in TypeScript, that allowed us to write some functions with which both the sensor and mobile device could interface

- The peculiarity of the code is the fact that allowed us to test our implementations on a **scalable number of sensors** (since, for example, owning 10 Arduino cards would be infeasible)

- We developed using **Bun** instead of NodeJS, a popular JavaScript runtime that provides faster performance, simpler APIs, and better development experience

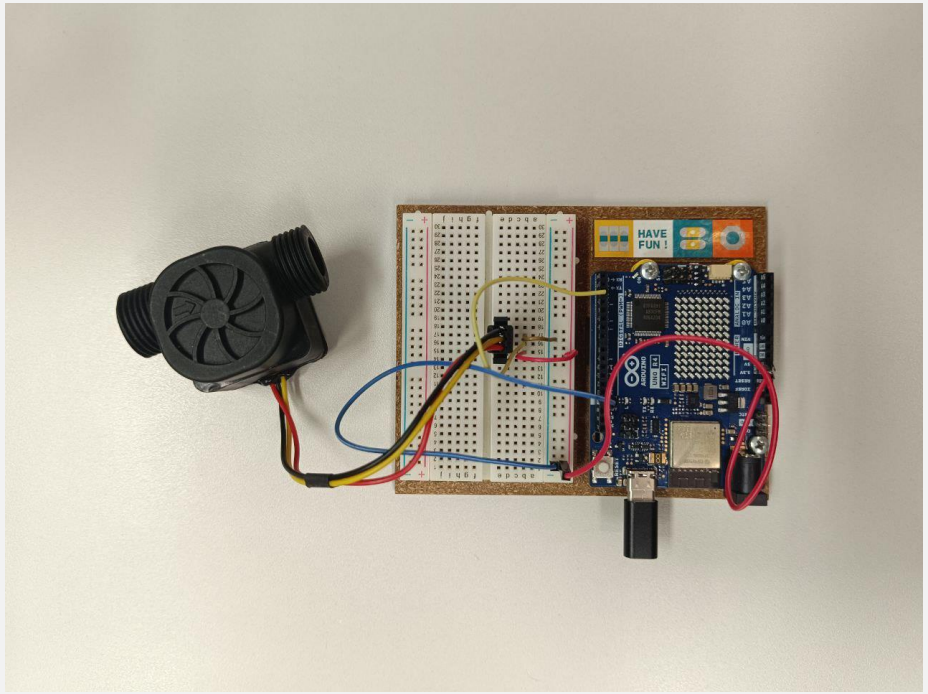


Arduino

- Arduino represents the **hardware** version of the sensor and represents the **physical jug** itself or an “**adapter**” that can be put on the pouring part of the jug (with a smaller version of course).

- The script that executes does the following:
  - Open a **Wi-Fi hotspot** self-hosted by the Arduino
  - Pair the sensor with the mobile device and link itself to a user
  - After the first step, to send data via **MQTT** directly to ThingWorx

- The pairing is done via a self-hosted Wi-Fi from the Arduino itself, on which the client Wi-Fi (home) credentials can be transmitted: in this way the Arduino connects to Internet and start publishing via MQTT

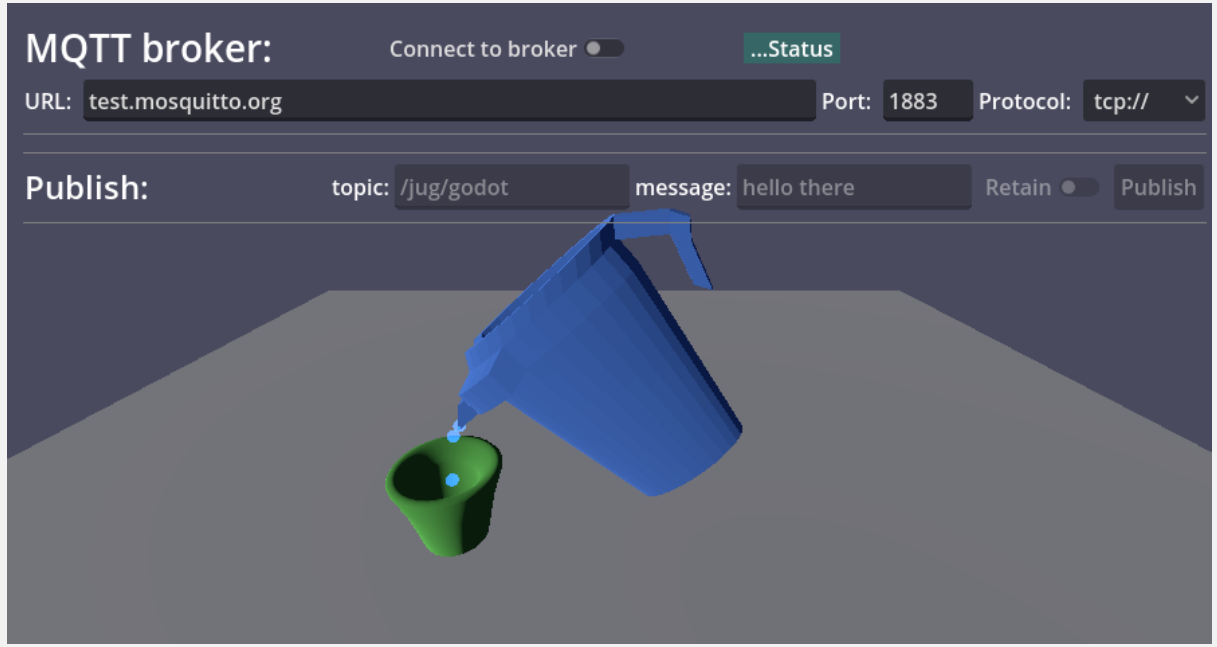


Godot

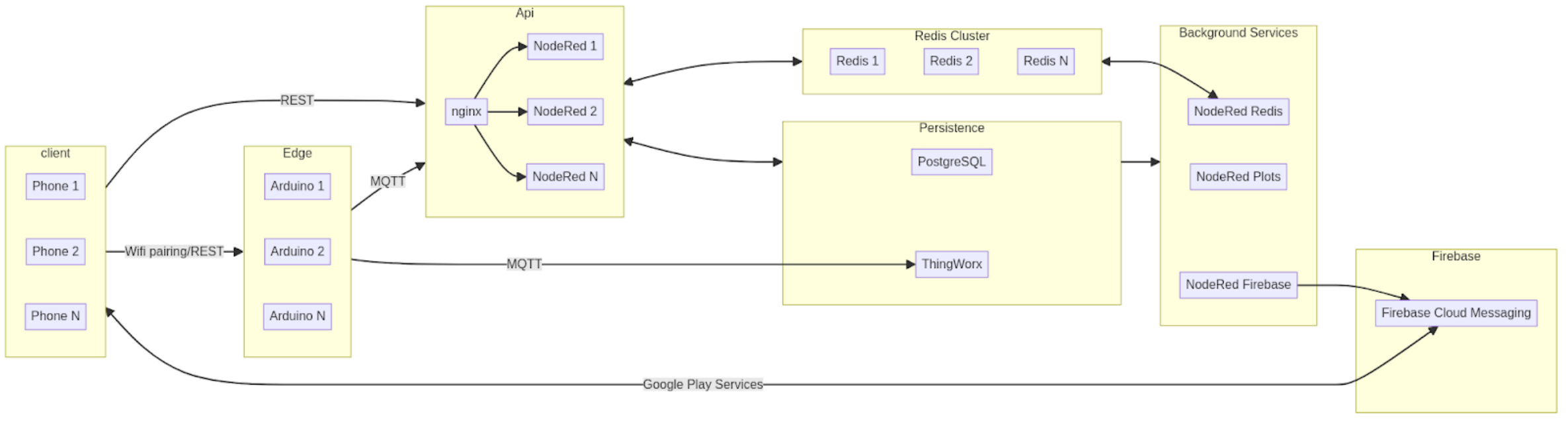
- We want also to spice the project up with something extra, like the interiorization of the **gamification** process in these topics

- We delve into a **3D implementation** of a jug and tried to simulate the behavior of the pouring of a jug

- Please note that while the entire scene has been made by us, the MQTT implementation of this part has been taken externally from GitHub, and adapted to our objectives, since knowing how Godot works with MQTT was not our primary focus. Thanks to: https://github.com/goatchurchprime/godot-mqtt?tab=readme-ov-file

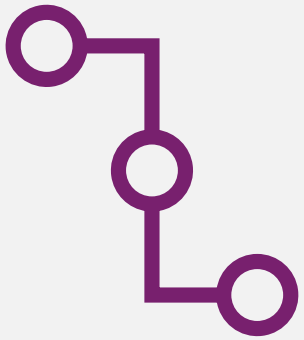


Architecture

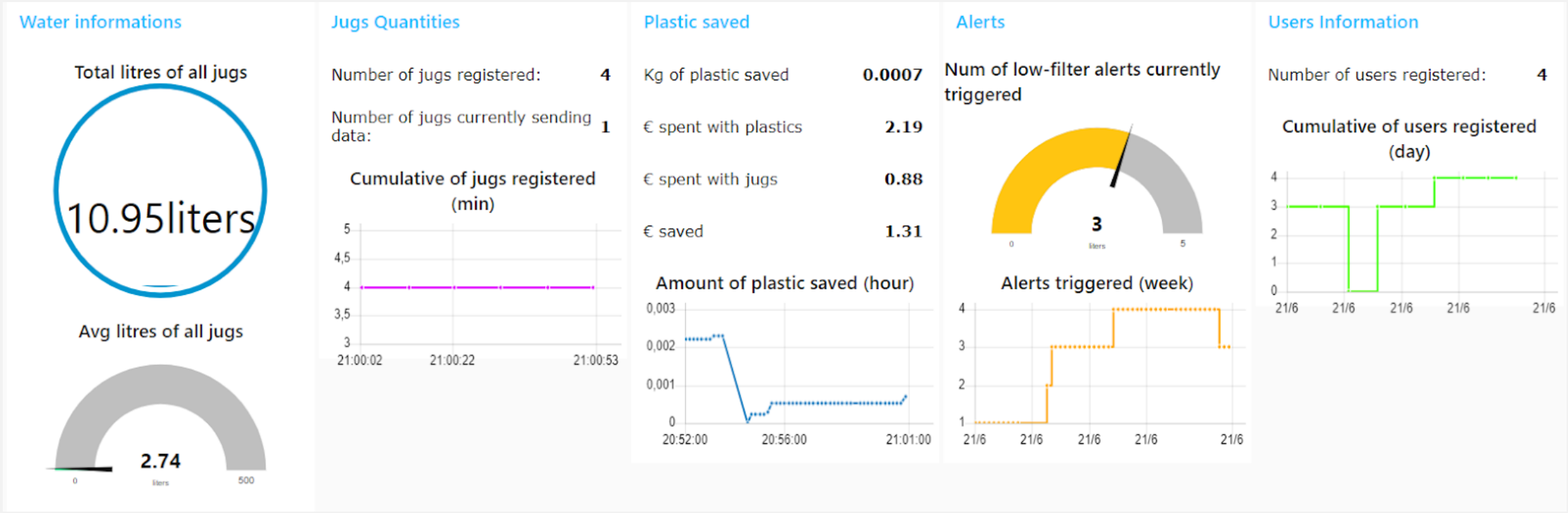


Node-RED

- Represents the **middleware** (“fog”) that implements all the APIs needed to make the mobile application works with the IoT system.
- Contains also the APIs needed to the jug sensor to make the pairing work.
- We also implemented the enterprise **dashboard** with it and split it in different categories.
- Any operation involving the authentication to perform operations on jugs and so to verify the effective owning of a jug from a user has been made by verifying a **JWT Token** assigned univocal upon login to the user.



Dashboard #1 - Overview



This is the main dashboard that the **employee** of SmartJugs can see and have an overview about the current registered jugs and the liters filtered **in real-time.**

Dashboard #1 - Details

In this dashboard the following data are displayed:

- **Water information**: real-time information about the total and the avg liters poured until now from the jugs
- **Jug Quantities**: how many jugs have been paired by the users of SmartJugs
- **Plastic saved**: a metric to observe how much kilograms we saved instead of use plastic water bottles (see also next slide)
- **Alerts**: those alerts are implemented application-side and marks the number of mobile notification sent because the filter of a certain jug is about to expire
- **User information:** we track how many users registered and the curve in the current day

Plastic saving

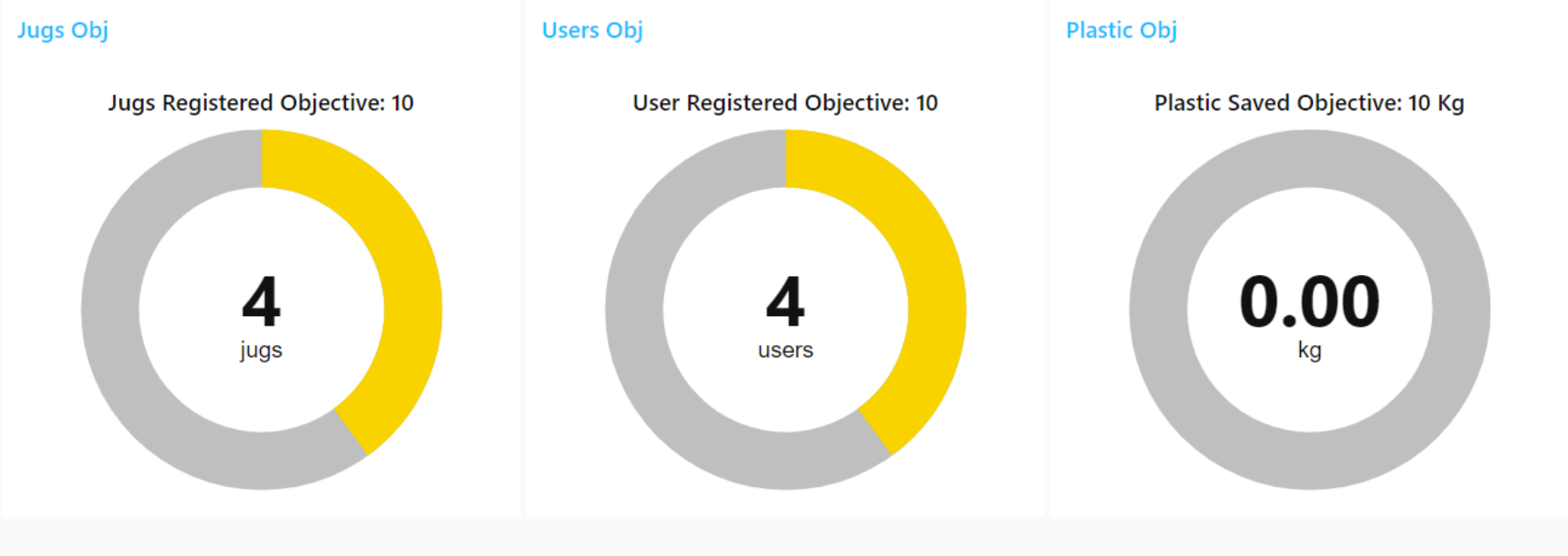
An ecological and financial parenthesis

Since we are talking of water and we know the **problem of plastic** in the modern days, we also felt the necessity to talk about plastic.

In our dashboard we provide two main categories of metrics for plastics, the first that weight the **environment** and the latter that weight the **money** topic:

- **Kg of plastic saved**: with this metric, we computed the equivalent of plastic water bottles weight in terms of water consumed
- **€ saved by using jugs**: with this metric, we observe the difference into use jugs compared with buying the equivalent in plastic water bottles

Dashboard #2 - Objectives



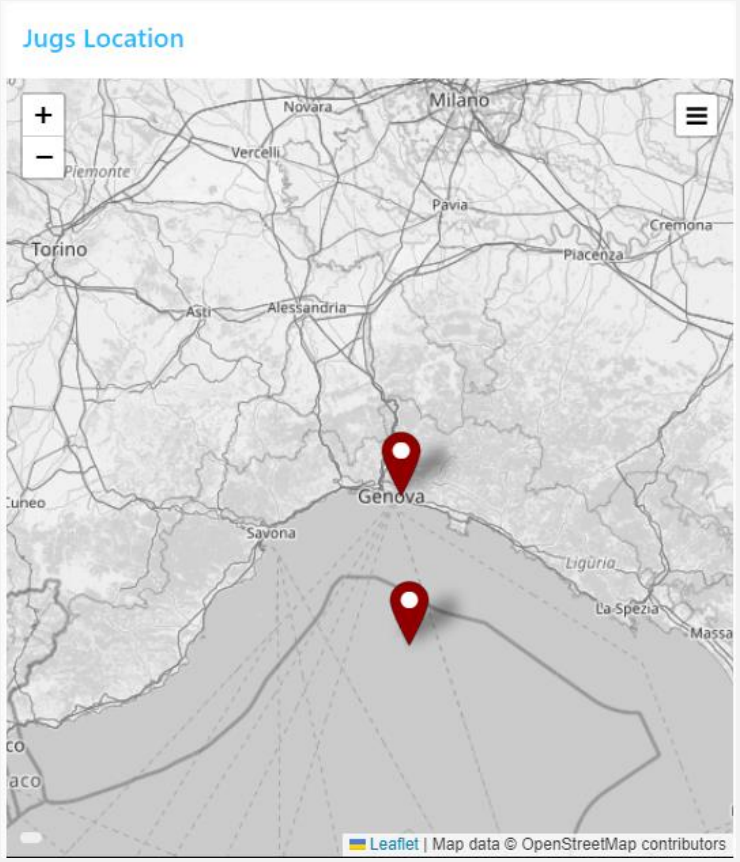
We also thought about the possibility to fix some **objectives** in the company and see how far we have got.

Dashboard #3 - Location

- We decided to **track the jug position** on pairing process, by taking the position from the mobile device and to show it on a map. We do not track the user movement. The user can choose if share the approximate position or no position at all.

- On the map provided as example, the jug was located at DIBRIS (University of Genova), we can see:
  - The **approximate** position, on the bottom
  - The **precise** position, on the Genova label, set just for presentation purposes (not included in implementation)

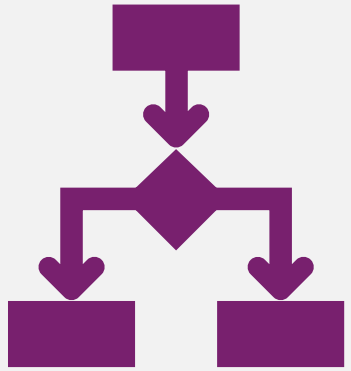
- Each mark holds the coordinates and the jug name.



ThingWorx

- We use the ThingWorx platform to create the things and **save persistently** the data.

- In particular of ThingWorx we used:
  - **Properties**: to save things details (e.g. liters per second, total liters)
  - **Shape**: to represent the jug filter details
  - **Template**: to represent in a scalable and efficient way each thing, implements the interface above
  - **Value Stream**: to log the total liters filtered and retrieve it to achieve aggregation per day, per week etc. on Node-RED



Redis

- We implement a Redis **cache service** (as a separated server) to achieve for efficiency in our implementation

- The main objective was to **limit the HTTP traffic** to ThingWorx when getting the data stream, since we observed a certain **fragility** when we scale to a very big number of things

Thanks for your attention