



Simple home air quality monitoring platform

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The need for air quality monitoring

- According to the *Global Burden of Disease* study 1.6 million people died prematurely in 2017 as a result of indoor air pollution
- Humidity is connected to thermal comfort, sleep quality, transmission of viruses and condensation in households
- Household ventilation influences temperature, humidity and air quality



leaf features

LEAF is a low-cost IoT system developed for monitoring indoor air quality and conditions

The system provides real-time monitoring of air pollution levels, tracking the indoor **Air Quality Index (AQI)**, while also measuring **temperature** and **humidity**.

Users can explore the data through a **Telegram bot** that provides internal and external information, warnings, tips, rewards and statistics over different periods of time.

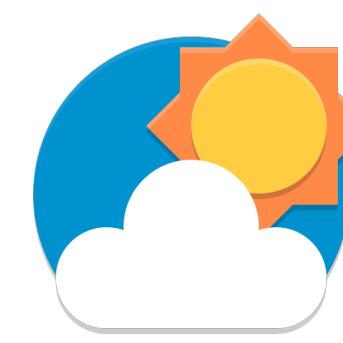
The software architecture provides **modularity** and **scalability**, allowing users to register multiple platforms for different rooms of the house.



Monitoring of AQI, Humidity and Temperature



Warnings, tips, statistics and rewards



Internal and external conditions



Modular system, scalability to multiple platforms

Software characteristics



Configuration

Services are based on JSON configuration files allowing runtime changes



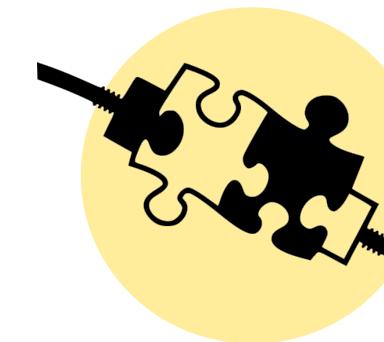
Modularity and Scalability

The system handles registration of multiple users and functionalities



Adaptability

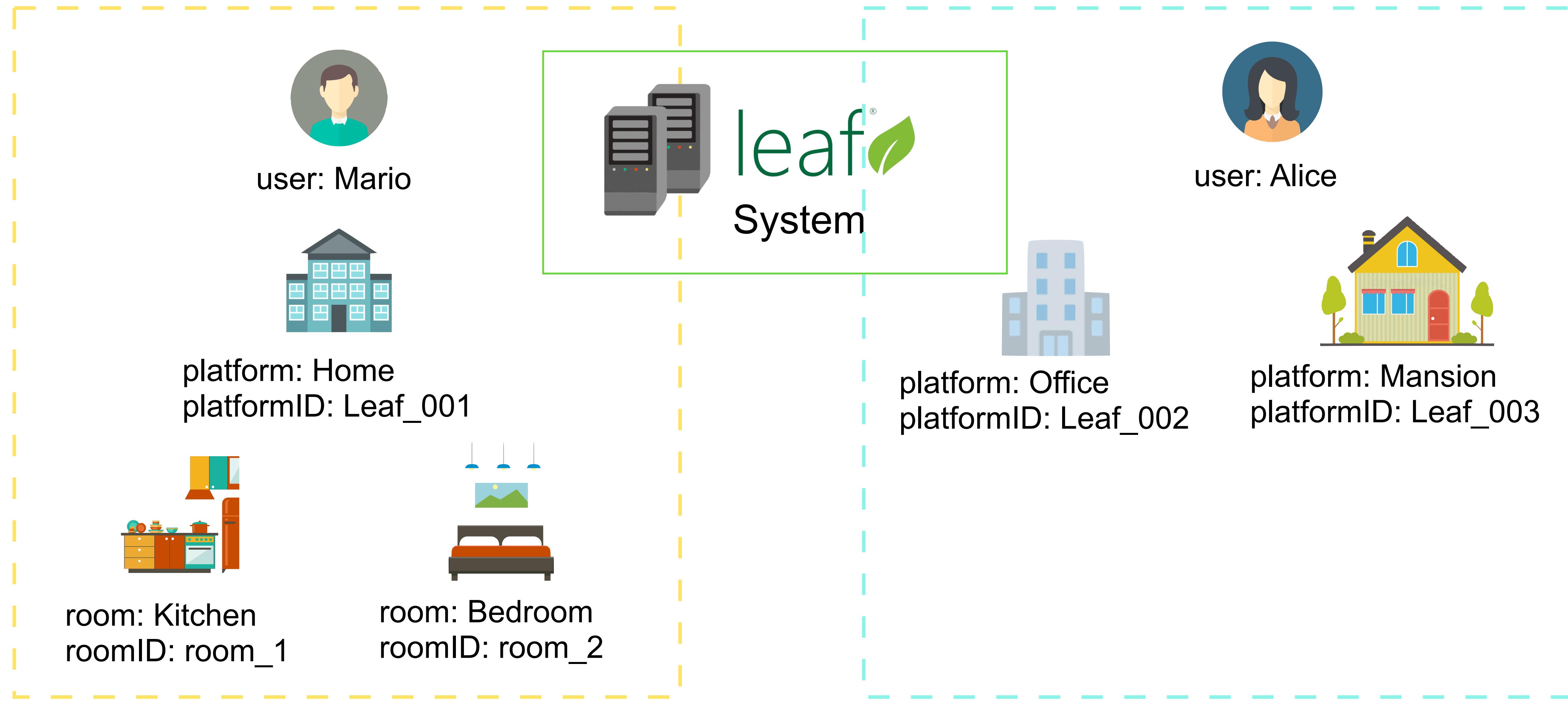
Services can run independently on different nodes thanks to web-based communications



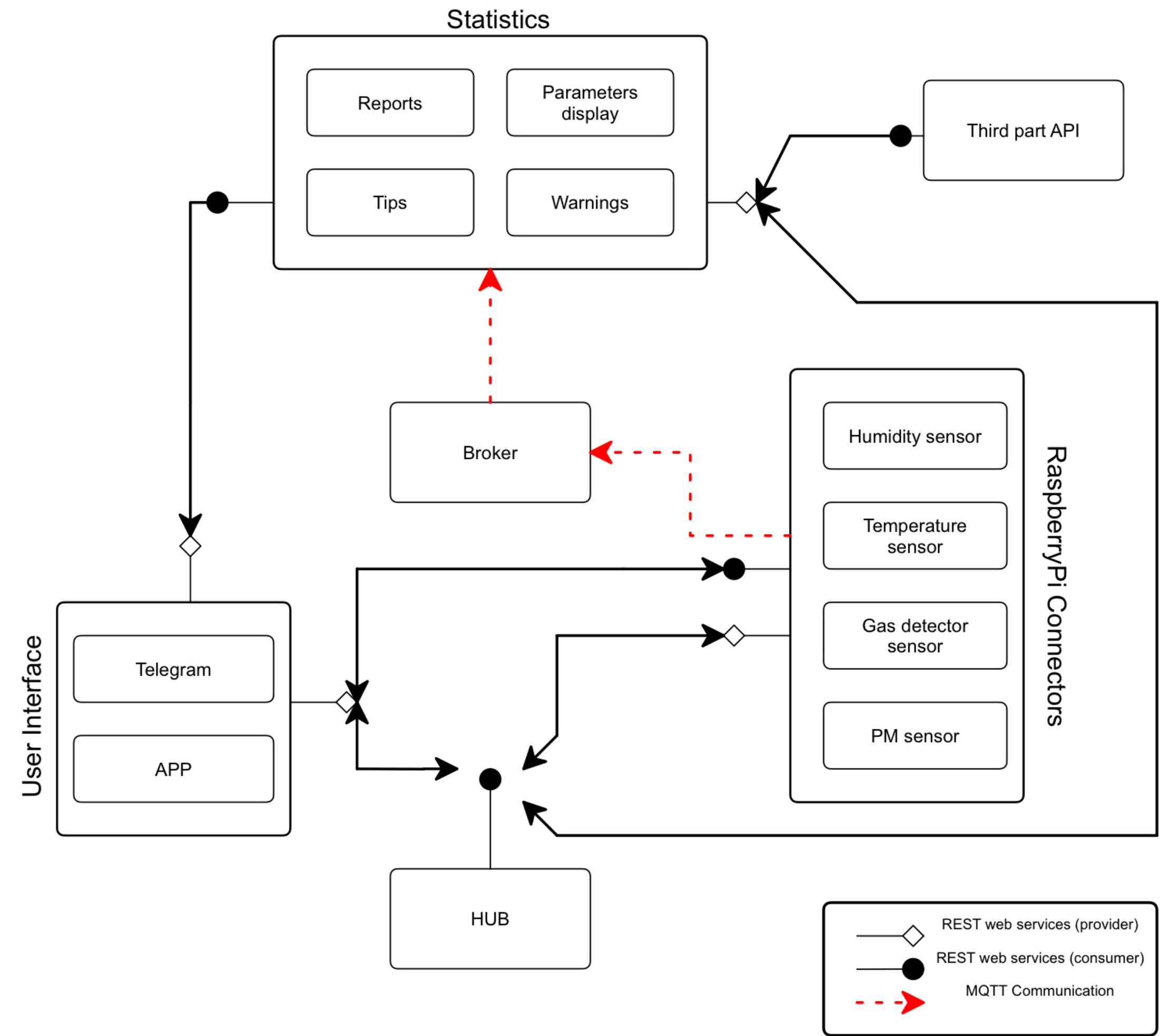
Integration

External services can be integrated into the system via public APIs

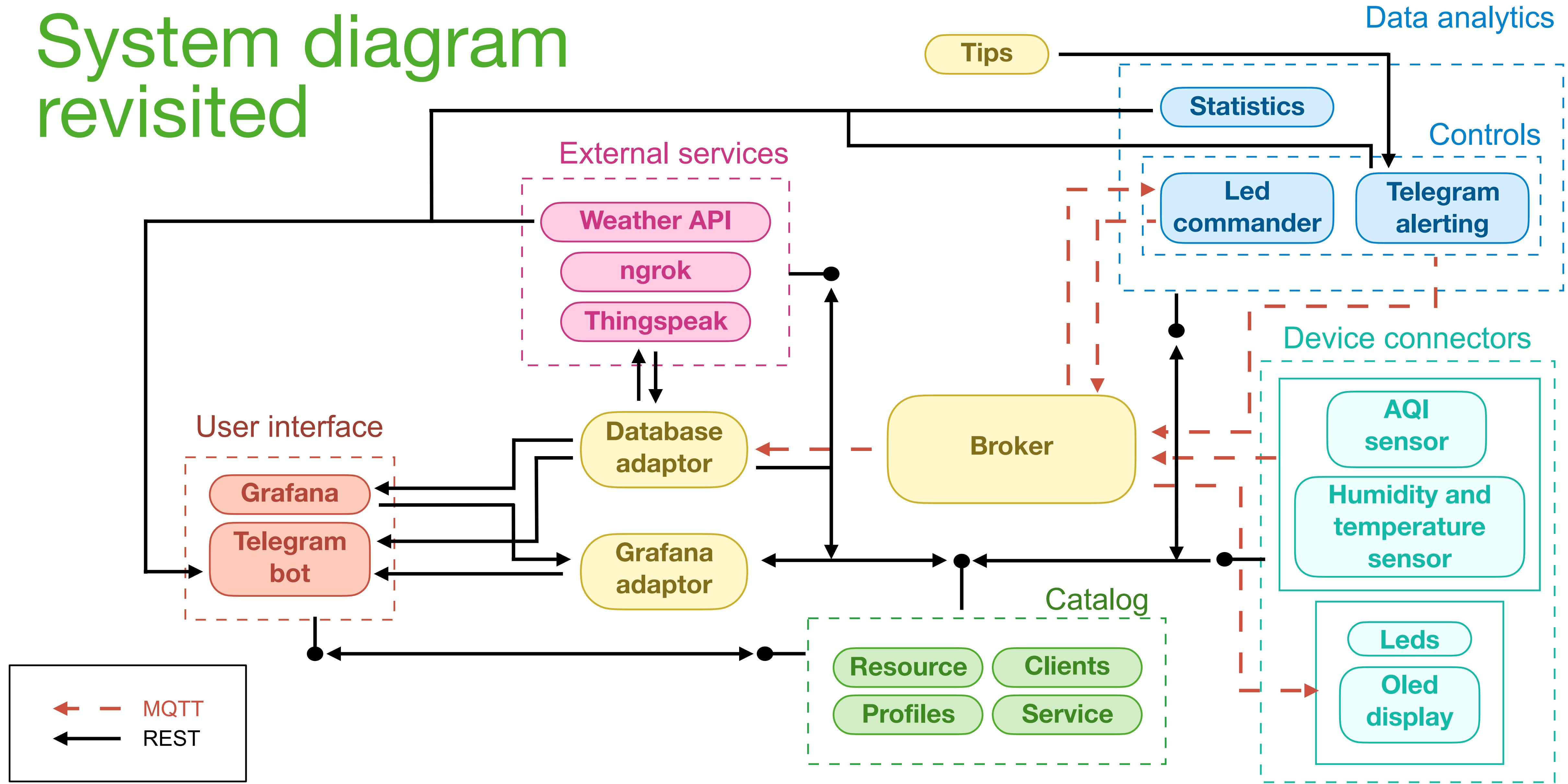
Structure overview



Proposed system diagram



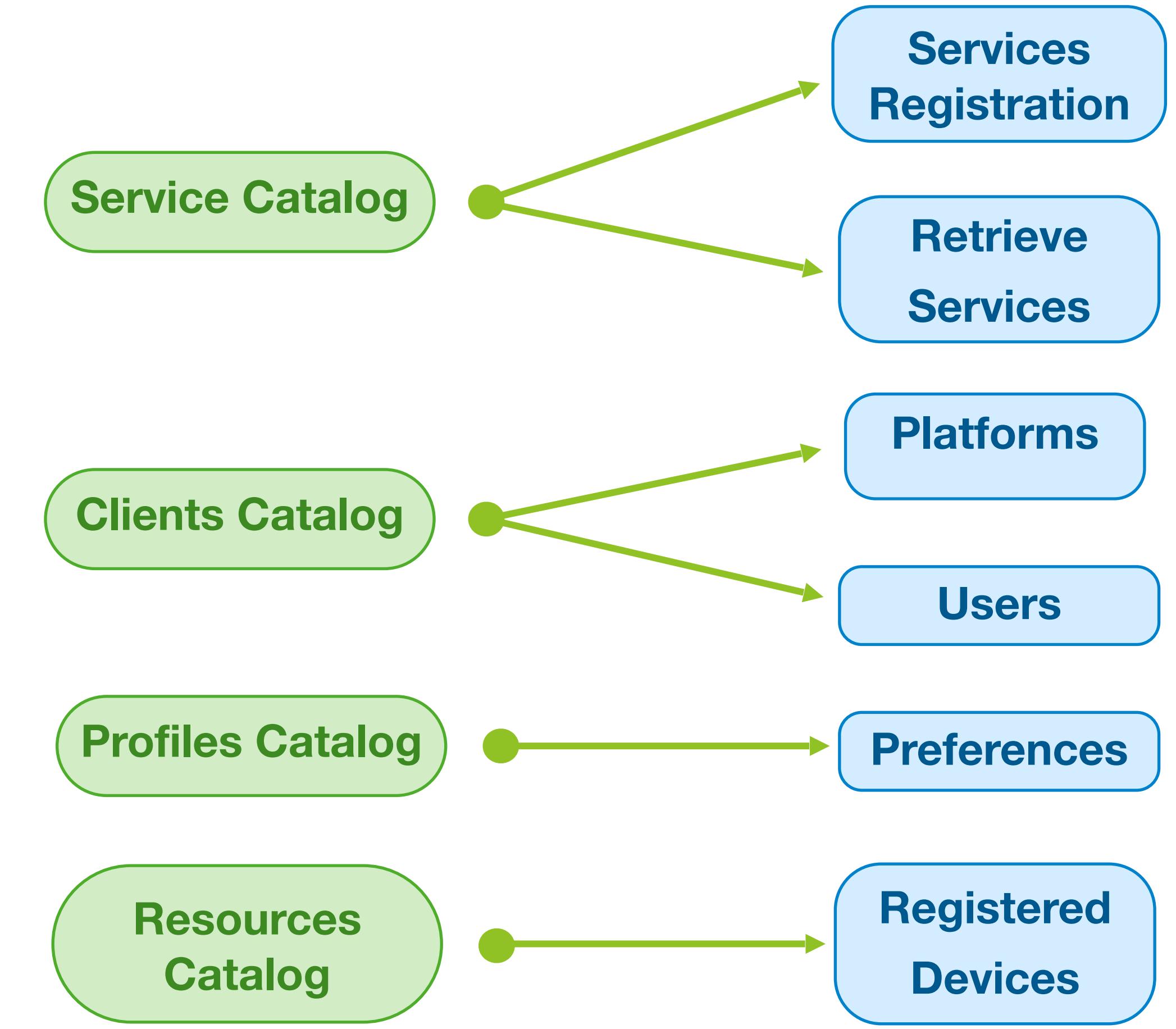
System diagram revisited



Catalog

Microservices-based approach allows for modular registration of services, clients, profiles and resources

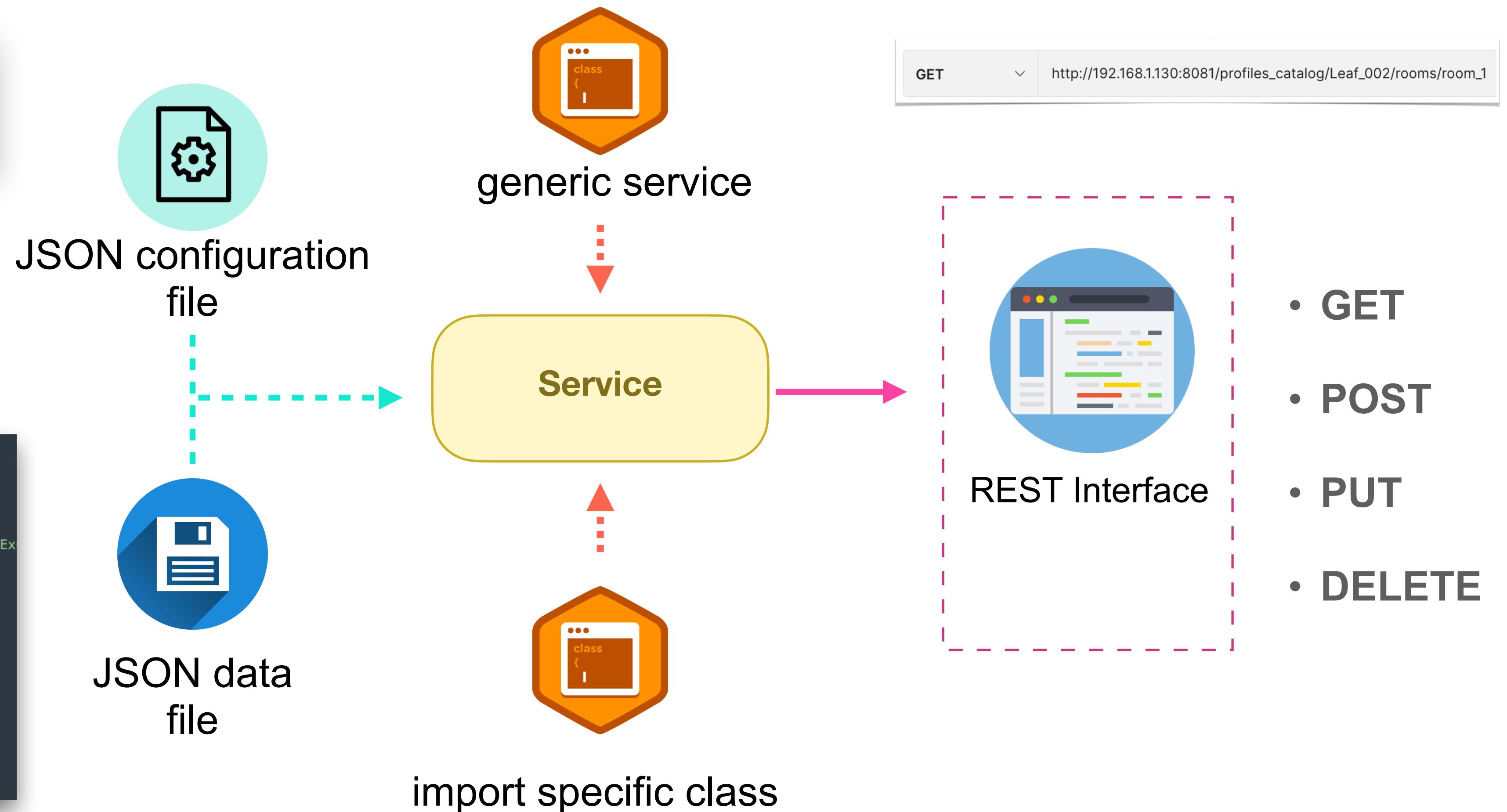
- **Service Catalog**, for registering and retrieving services information
- **Clients Catalog**, storing information concerning the formally deployed platforms and registered users
- **Profiles Catalog**, where preferences set by the user referred to platforms are collected
- **Resources Catalog**, tracking all the present and available devices (i.e. sensors, LED, display) following a hierarchical structure according to platforms and rooms



Service implementation

```
{  
    "description": "Welcome to the users registration service",  
    "service_catalog": "http://192.168.1.89:8080/service_catalog",  
    "service_name": "clients_catalog",  
    "IP_address": "192.168.1.89",  
    "IP_port": 9090  
}
```

```
{  
    "platform_ID": "Leaf_002",  
    "associated": true,  
    "specs": {  
        "grafana": {  
            "org_ID": "59",  
            "org_key": "eyJrIjoiWEY5TDZLUHFDY0pCSTNGZURGamt2Snh4TjhNbEx"  
        },  
        "thingspeak": [  
            {  
                "room": "room_1",  
                "channelID": "1021300",  
                "write_key": "58EQ7229TU905RXP",  
                "read_key": "D270Y6P75NOTG7UA",  
                "put_key": "B6PLW4MR0Z7AEJ2C",  
                "fields": {  
                    "field5": "humidity",  
                    "field1": "AQI",  
                    "field3": "temperature"  
                }  
            },  
            {  
                "room": "room_2",  
                "channelID": "1021301",  
                "write_key": "58EQ7229TU905RXP",  
                "read_key": "D270Y6P75NOTG7UA",  
                "put_key": "B6PLW4MR0Z7AEJ2C",  
                "fields": {  
                    "field5": "humidity",  
                    "field1": "AQI",  
                    "field3": "temperature"  
                }  
            }  
        ]  
    }  
}
```

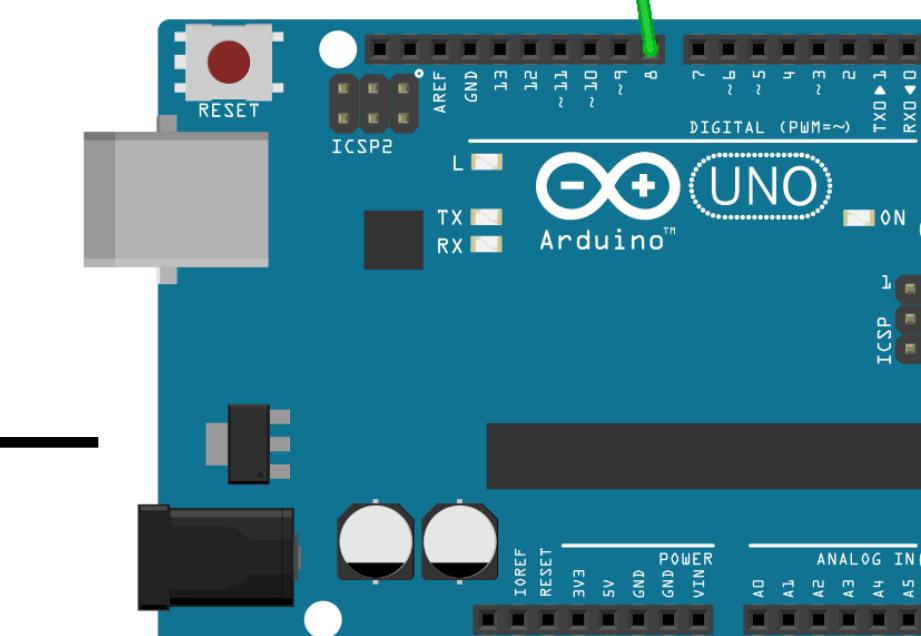


Hardware Platform

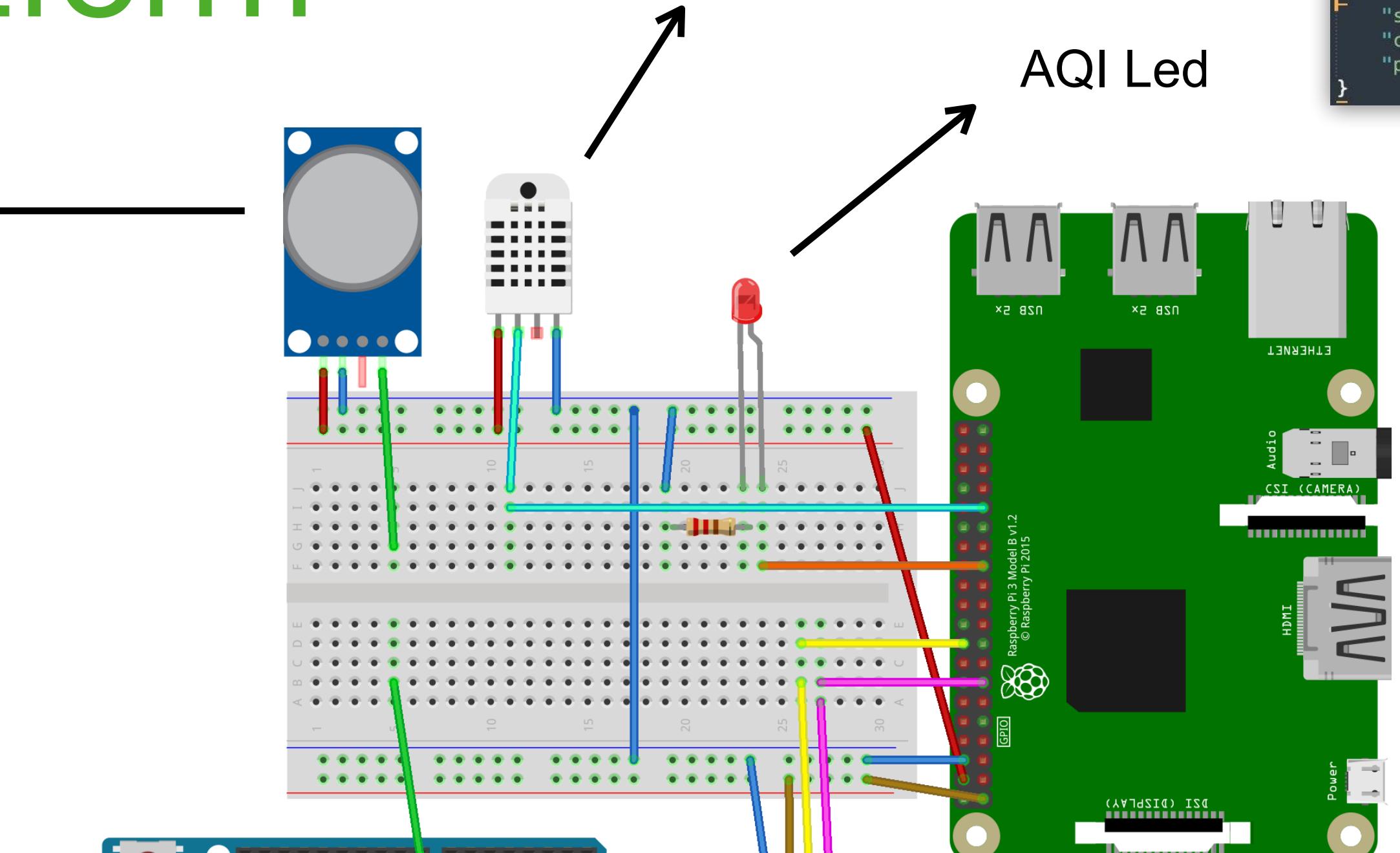
```
"service_catalog": "http://192.168.1.89:8080/service_catalog",
"sensorID": "dht11",
"end_points": "MQTT",
"time_sleep": 3,
"parameters": [
  {
    "parameter": "temperature",
    "value": null,
    "unit": "C",
    "timestamp": null
  },
  {
    "parameter": "humidity",
    "value": null,
    "unit": "%",
    "timestamp": null
  }
]
```



Arduino



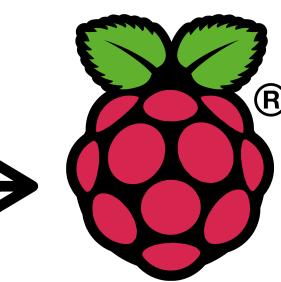
MQ135
gas sensor



DHT11 Temperature
and humidity sensor

AQI Led

```
"service_catalog": "http://192.168.1.89:8080/service_catalog",
"clientID": "LED_1",
"parameter": "AQI"
```

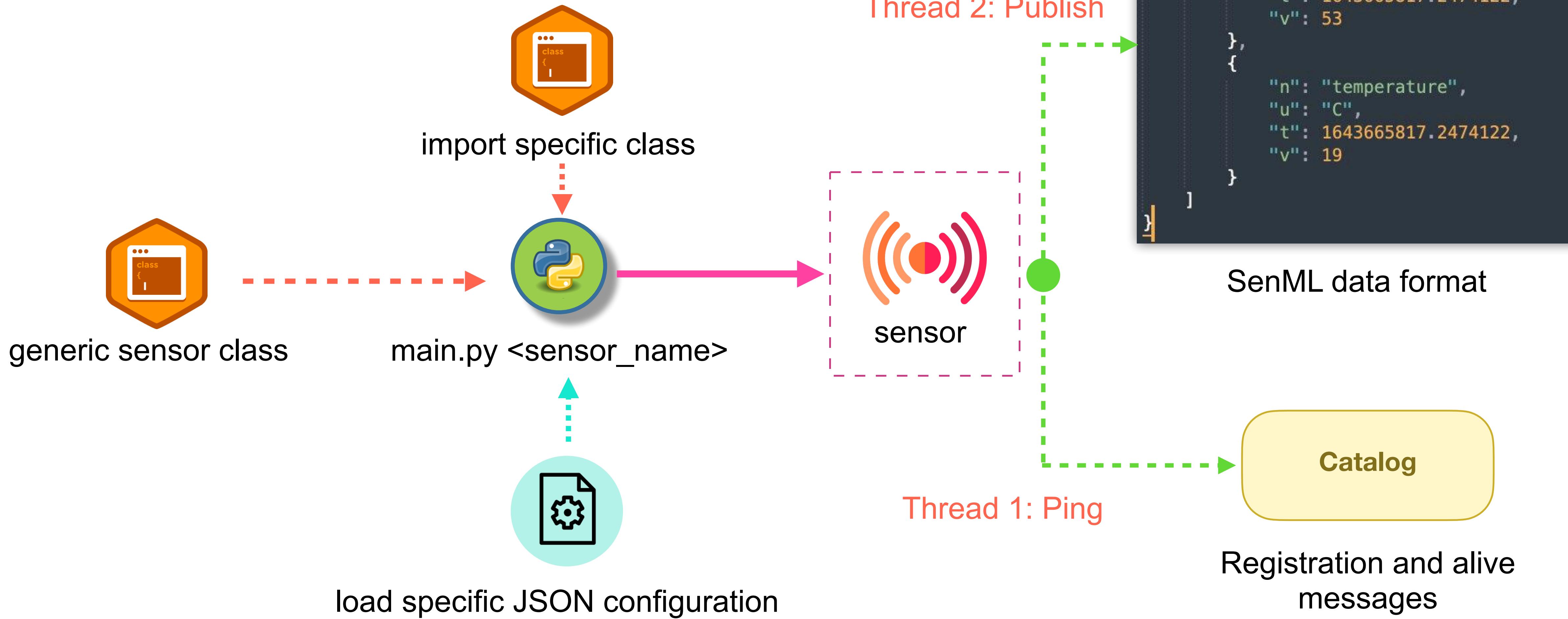


RaspberryPi 4

Oled
display

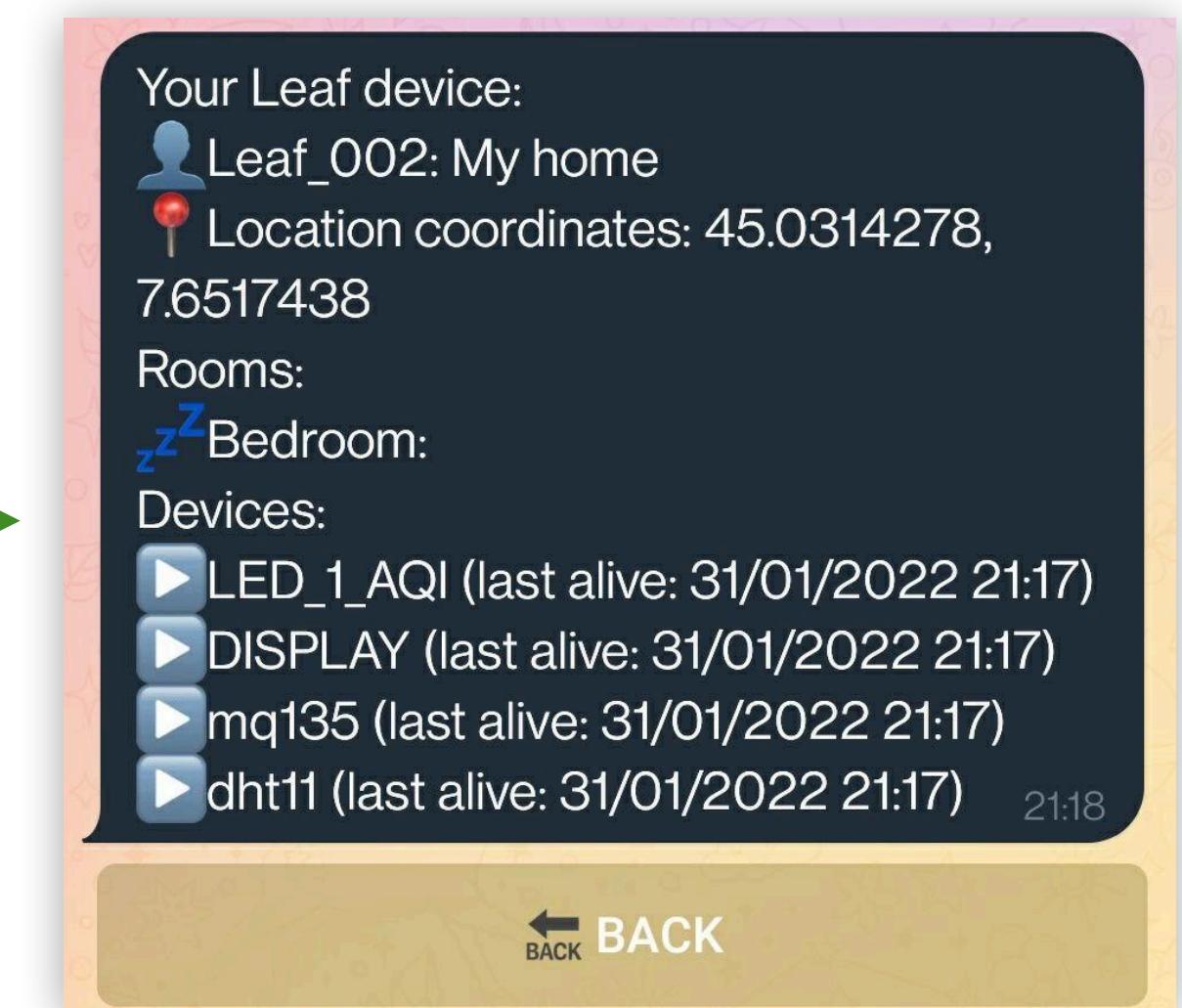
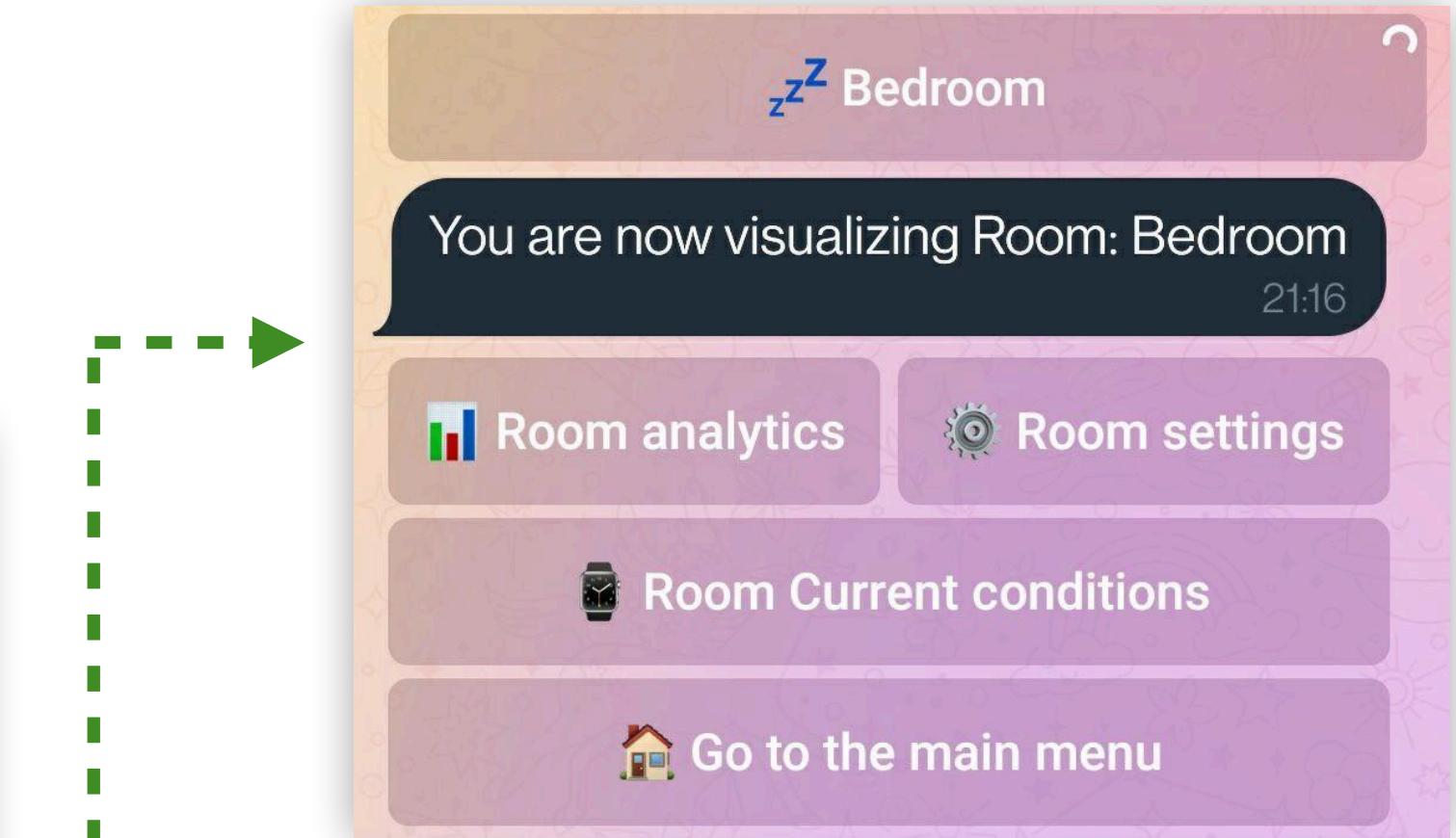
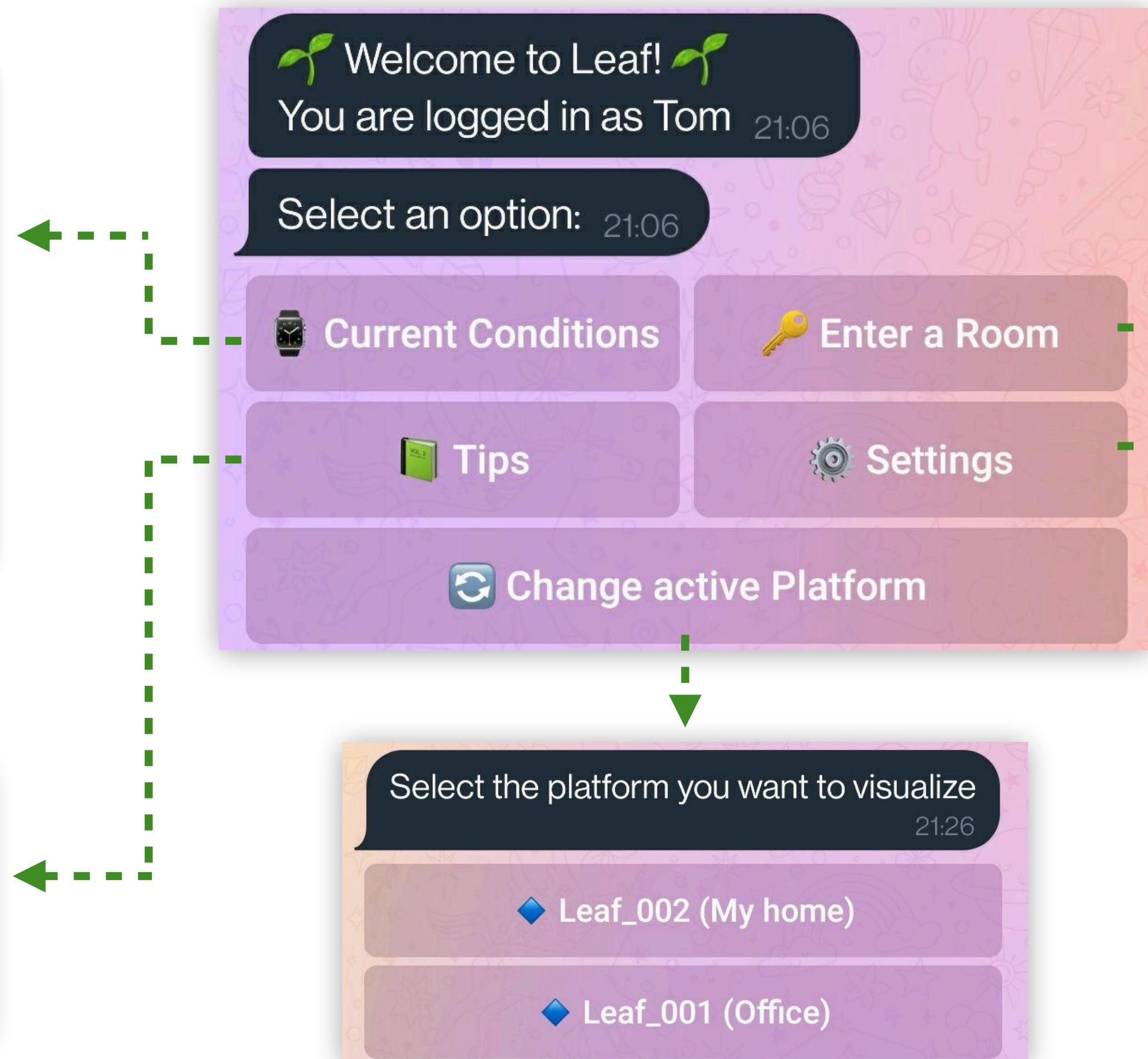
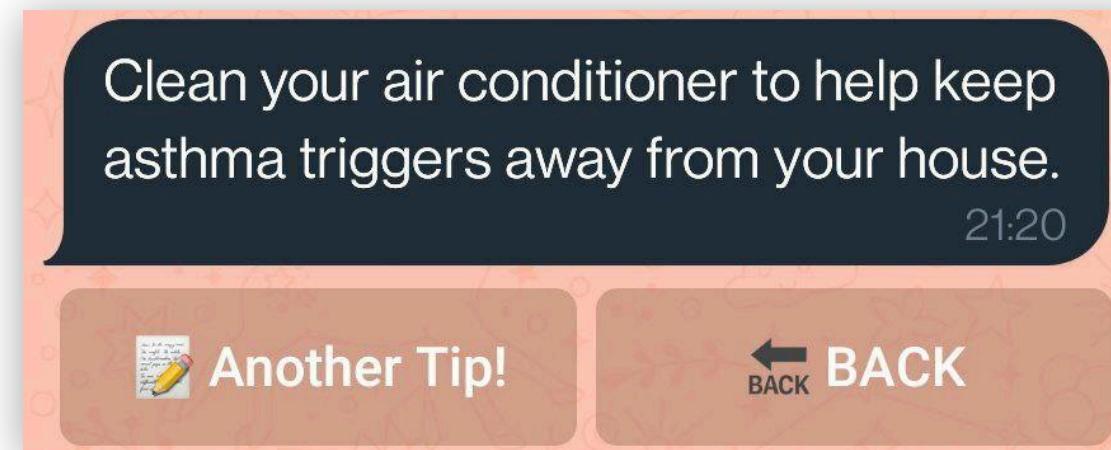
Hardware Platform

Software implementation



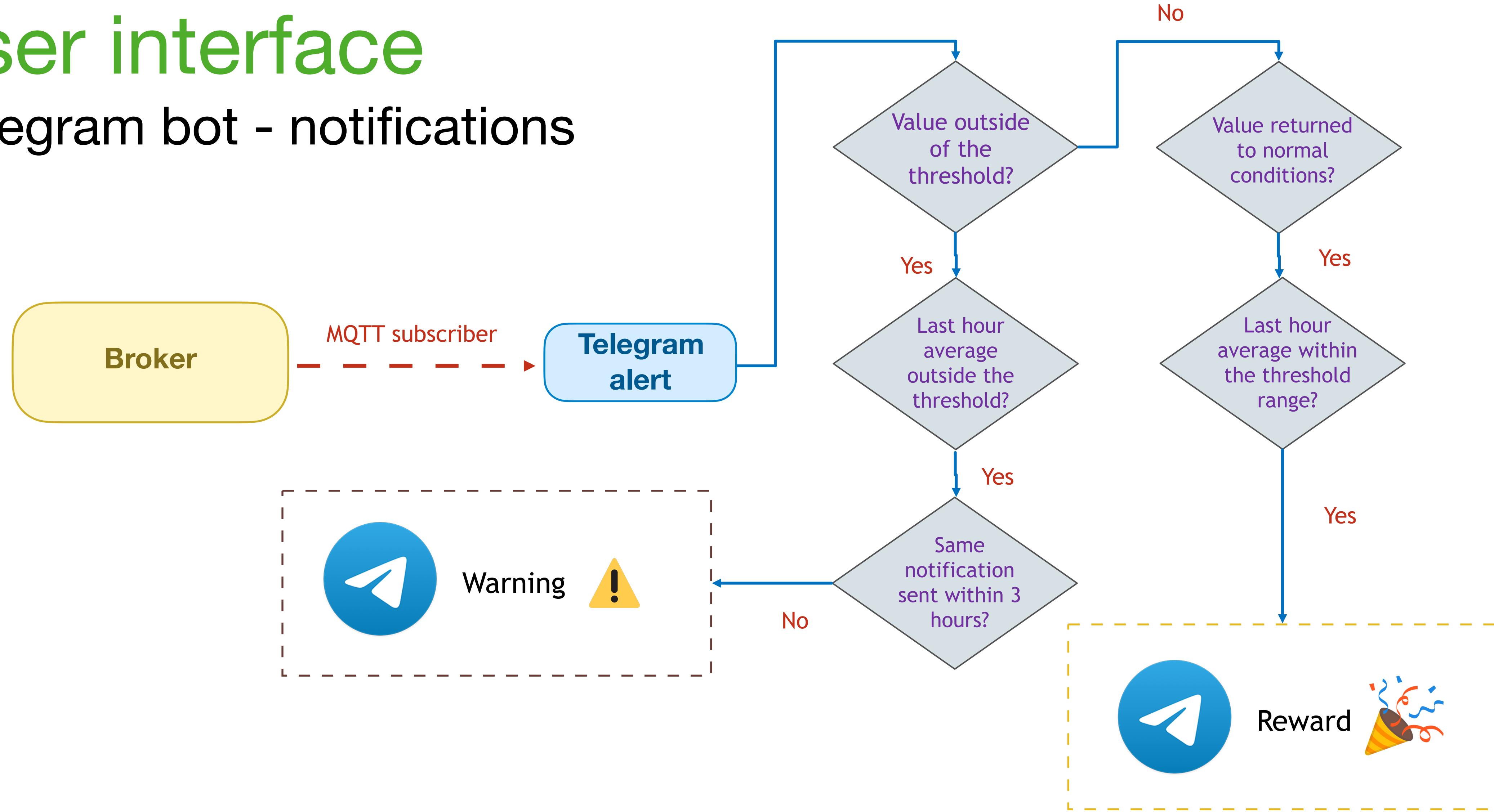
User interface

Telegram bot - functions



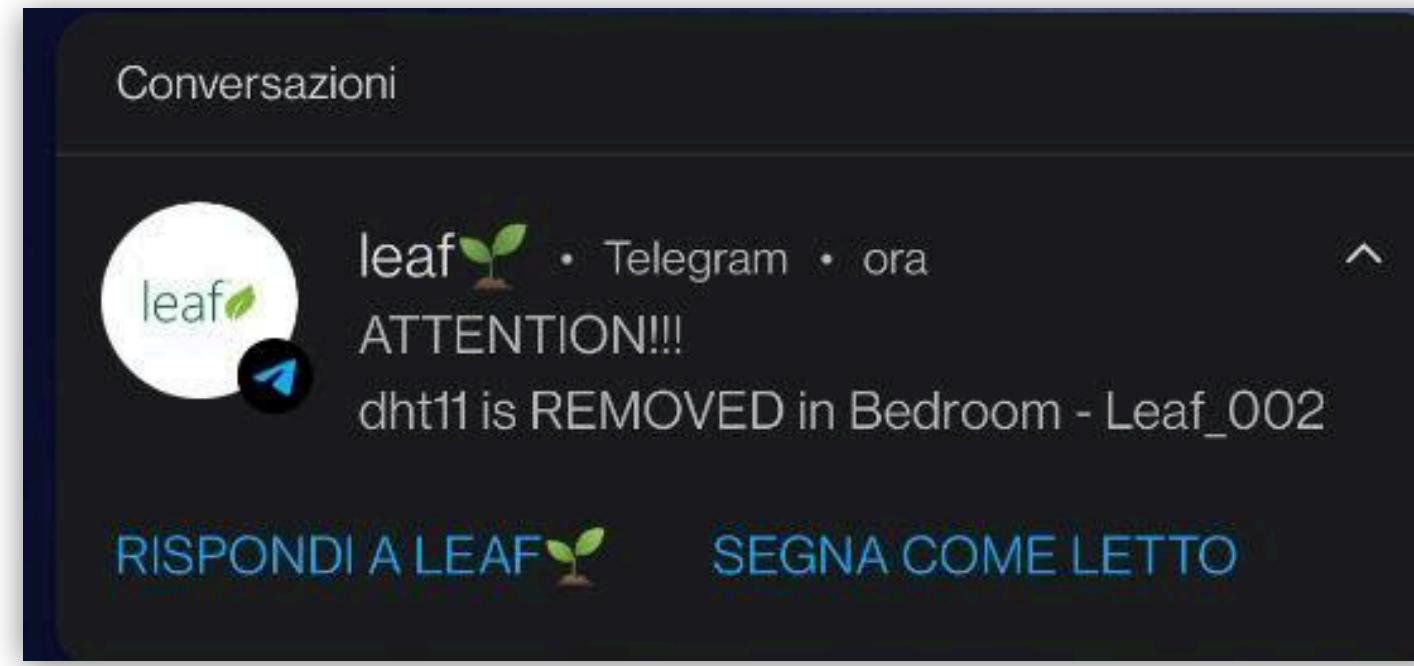
User interface

Telegram bot - notifications



User interface

Telegram bot - notifications



Notification for sensor removed (inactivity)



Notification for high humidity conditions and tip for reducing it



Positive notification for humidity levels coming back to normal after user action

User interface

Grafana



**Dehumidifier effect
on temperature and
humidity**

Gauge indicators for current internal conditions

Visualization of time series over selected time interval

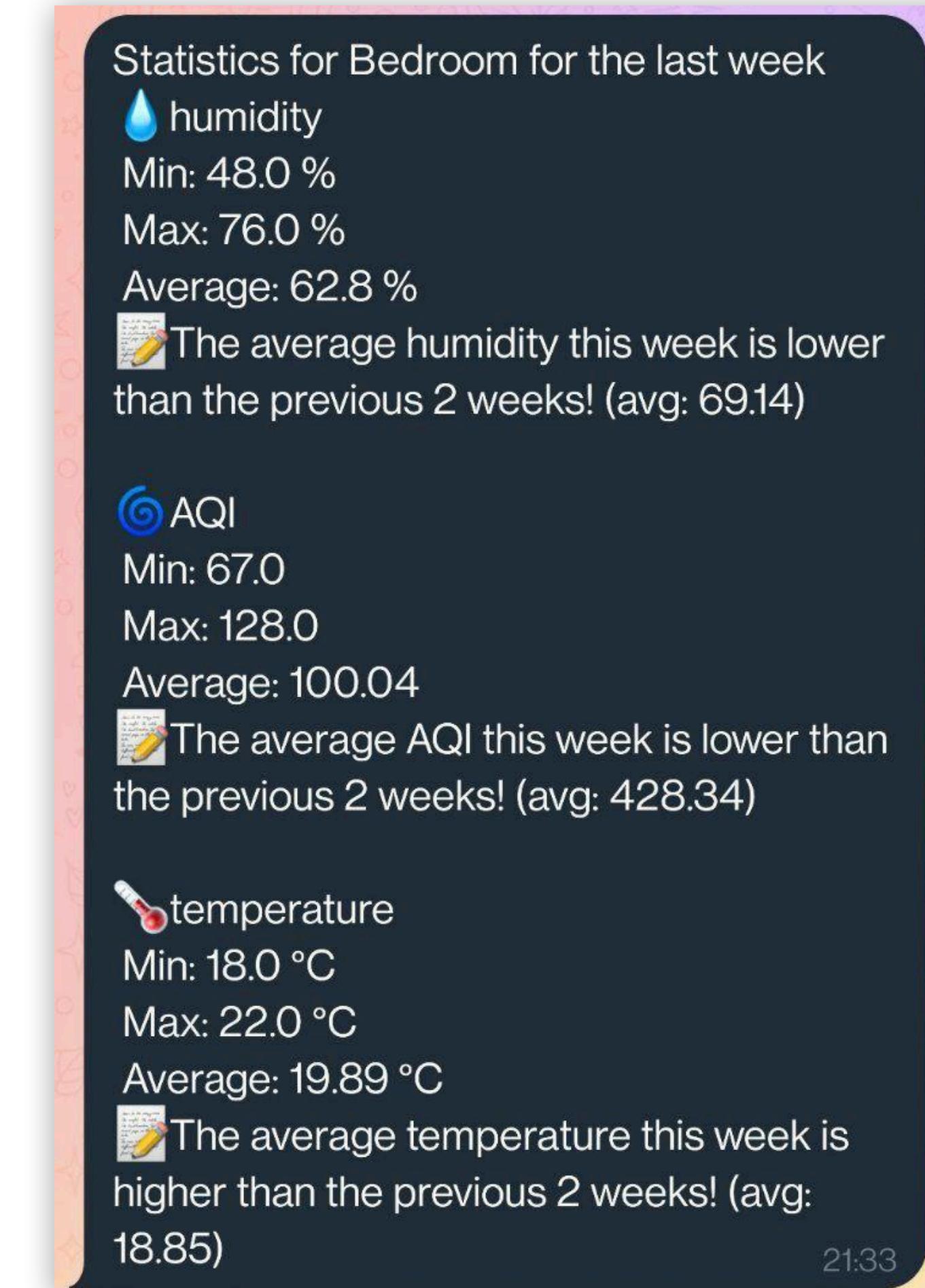
Averages over selected time interval

Map and location information for the external Weather API

Data analytics

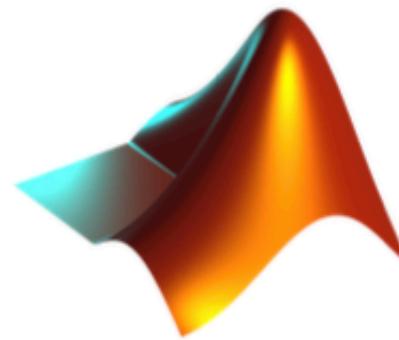
Data are collected and processed to provide useful insights:

- **Statistics**, elaborating a short report by comparing current conditions to daily, weekly and monthly averages.
- **Telegram alerting**, generating warnings and messages for non-ideal conditions, supported by tips on how to improve the situation.
- **Led commander**, for real-time non intrusive feedback



External services

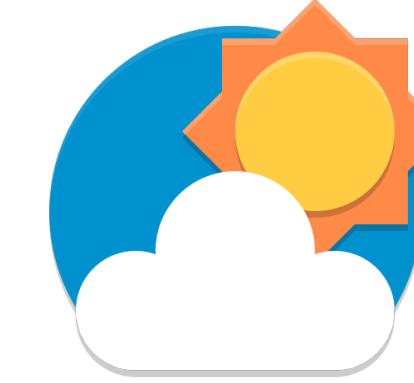
Multiple external services are integrated in the functions of the system exploiting REST communication



Thingspeak acts as cloud database storing historical data from physical platforms



ngrok for exposing specific services using public tunnelling

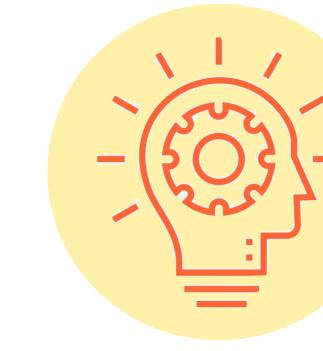


Weather API provides real-time external condition information based on user-set location

Conclusions



- 69% in a home
- 2% in a bar/restaurant
- 5% in a vehicle
- 11% in others location
- 5% in an office/factory
- 8% outdoors



Awareness about indoor air quality conditions



Optimization of HVAC systems in the household



Management of devices from a unique interface using hierarchical structure



Rewards towards positive behaviours to encourage users



Thank you!

The code for LEAF is available at:

https://github.com/tommasocarluccio/IOT_Leaf

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