Fire Fighting

Autonomous and Intelligent Sensors in the Fight against Forest Fires

A system of sensors to detect, prevent and monitoring fires in forests

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PROJECT DESCRIPTION

INTRODUCTION (MAIN GOAL AND CONTEXT)

The main goal of this project it's a **system capable of detect, prevent and monitor fires occurring in forests**. The concept of this system will be to provide some kind of **support to people and autonomous devices in fight against forest fires**.

This system will be composed of **components (sensors and devices) capable of**:

- ➔ **Detection of the possible occurrence of fires in some places, by evaluating some aspects of the global environment, that can, possibly, trigger the start of a new fire**;
- ➔ **Detection of a start a new fire**;
- ➔ **Keep some information data about all the extinguished fires;**
- ➔ **Keep the information about the users and autonomous devices currently using this system;**
- ➔ **Measure some important metrics about the fires, as also, all the people and autonomous devices involved in the fight against them;**

This **components (sensors and devices)** will be, **specifically or randomly, scattered in some physical coordinate points, where it's pretended to implement the system**.

This **components will sense, collect and analyse data informations about involved environment and fires. This components will be responsible to interact (as also, notify and alert) mobile and autonomous devices, using the system**.

The most of **sensed, collected, analysed data informations about involved environment and fires**, will be kept in a kind of remote server, provided by a **cloud service**.

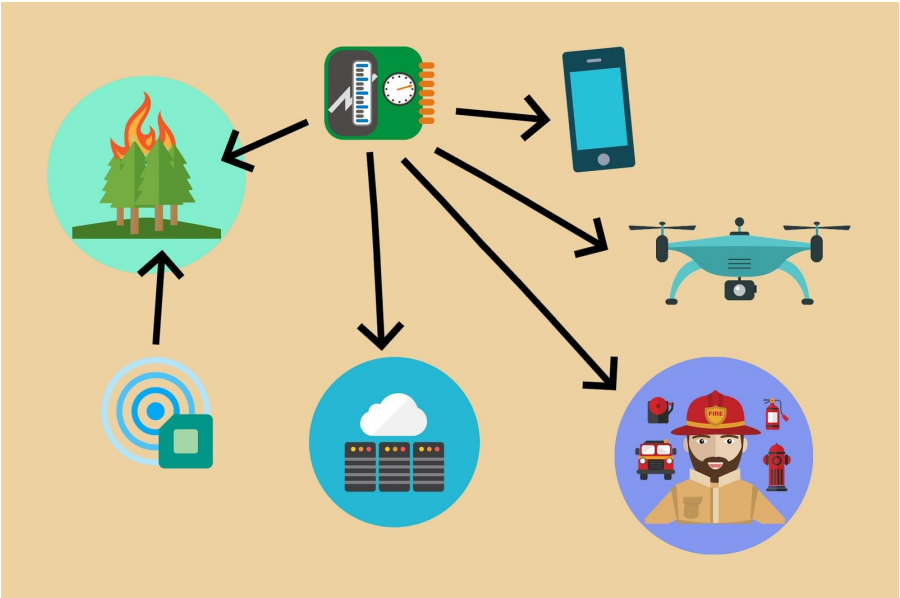


Image 1: Scheme of global view of the system, its components, autonomous and mobile devices, as also, the respectively interactions and communications

BRIEF DESCRIPTION OF THE BEHAVIOUR OF THE MOBILE APPLICATION

- ➔ The mobile application will support a kind of management of accounts of two distinctly types:
  - ***Administrator***;
  - ***User***;

- ➔ Initially, will be provided a menu with the options of ***register*** or ***login***, in the case of, be the first time that an user will use the mobile application:
  - The ***register*** option, will be only directed for the ***Users***. The ***Users*** will be asked to fill a provided form with the personal data information that will be kept in a database in the previously mentioned remote server;
  - The ***login*** option, will be directed for both, ***Administrators*** and ***Users***. The application will provide a form to be filled with the username and password;

After performed the ***login*** operation, will be provided the following described options and features in the next section.

FUNCTIONALITIES OF THE MOBILE APPLICATION OF THE SYSTEM FROM THE USER'S PERSPECTIVE

The system will provide a mobile application/interface to all users, where they can:

- ➔ See a **representative map of the neighborhood**, where the users can **see the points of coordinates where**:
  - It's **more possible to occur a start of a new fire**, displaying also, some concept of probability for this occurrences related with some colors that represents the idea of alerts;
  - It's **occurring the currently active fires**;
  - Was **occurred the extinguished fires;**

- ➔ See **more detailed information of this previously mentioned fires**, by **clicking on the point of coordinate of the map that represents the fire, that it's pretended to know more about**. The information provided will be:

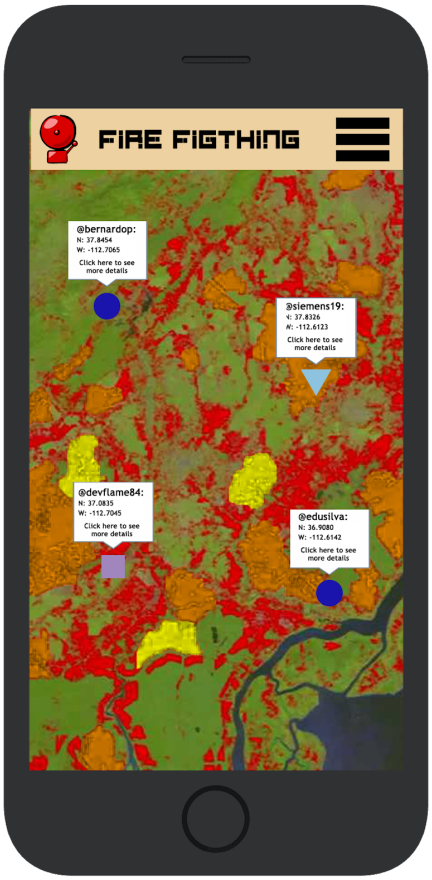
  - In the case of, a **possible occurrence of a new fire's triggering**, the information provided will be, among others:
    - **Current temperature of the area**;
    - **Current velocity of the wind**;
    - **Humidity of the air presented on the area**;

  - In the case of, a **currently active fire**, the information provided will be, among others:
    - **Current temperature of the area**;
    - **Current velocity of the wind**;
    - **Humidity of the air presented on the area**;
    - **Date and time of the start of the fire;**
    - **Number of people or autonomous devices currently attending the fire**;
    - **Estimated minimum number of necessary people or autonomous devices to extinguish the fire**;
    - **Area of the fire's spread**;
    - **Estimated velocity of the fire's spread**;

- In the case of, a **extinguished fire**, the information provided will be, among others:
    - **Current temperature of the area**;
    - **Current velocity of the wind**;
    - **Humidity of the air presented on the area**;
    - **Date and time of the start of the fire;**
    - **Date and time of extinguish of the fire**;
    - **Probability of a possible reignition**;

➔ See **where the other users or autonomous devices, which are using the system, are currently**, as also, see some informations about them, by **clicking on the point of coordinate of the map that represents that user or autonomous device**. The information provided will be:

- **Its characterisation (i.e., if it's a user or autonomous device)**;
- **Its state (i.e., if it's idle or currently attending a fire)**;
- **Some metrics (i.e., the total number of attended fires, the total distance covered, among others)**;



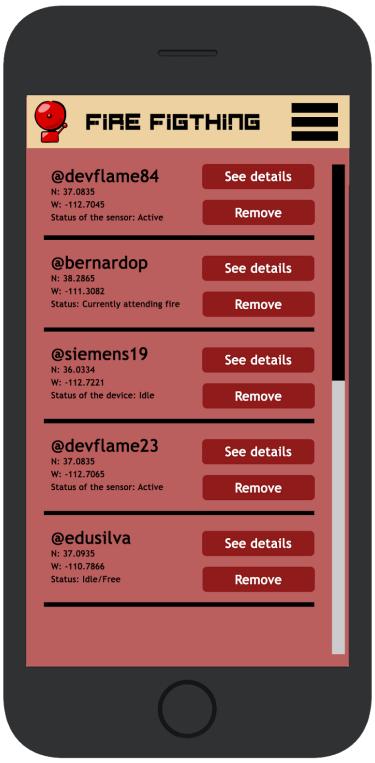
NOTE:

- Too **see detailed information** about the **devices** and **components**, the user will need to click in the popup window in the provided map in the mobile application;

The following table illustrate the previously mentioned concept of possible prediction and the related alerts:

COLOR AND NAME OF THE STATUS/ALERT		PROBABILITY OF A FIRE OCCURRENCE	BRIEF DESCRIPTION OF THE ALERT AND RELATED NOTIFICATIONS
	Connecting to WiFi	**N/A**	***Connecting to WiFi Network:*** • The sensor it's connecting to a WiFi network and blinking a blue color and emitting a constant low sound alert
	Idle alert	**[0% - 29%]**	***No occurrence of a fire:*** • The sensor read and send the data to the server for every each 6 seconds. And the mobile app can request the information about the current status of this sensor by the logs registered in the server, where it will be marked with green color in the map on the mobile application
	Yellow alert	**[30% - 59%]**	***Possible occurrence of a fire:*** • If the current readings and measurements of the sensor device detect the parameters established for the yellow alert, the marker on the map it will be changed to a yellow marker in the mobile application
	Orange alert	**[60% - 89%]**	***Very possible occurrence of a fire:*** • If the current readings and measurements of the sensor device detect the parameters established for the yellow alert, the marker on the map it will be changed to a orange marker in the mobile application
	Fire alert	**[90% - 100%]**	***Imminent occurrence of a fire:*** • If the sensor detects a fire, it will send the data to the server once and the marker on the map it will be changed to a red marker in the mobile application

Table 1: The available provided alerts/status and their respectively related information and markers in the map of the mobile application



In addition, the ***Administrators*** can **manage the information related to the sensors and autonomous devices installed in the system**, like, per example, reset the sensors' data and also, register or remove an autonomous device.

NOTE:

- Only an ***Administrator*** can **register**, **edit** and **remove devices, sensors, actuators, and other, kind of components**;

BRIEF DESCRIPTION OF THE BEHAVIOUR OF THE SENSORS AND ACTUATORS

The system will be composed by some of the following components (sensors and actuators), filtered by the previously described capabilities of system:

- ➔ **Prediction of a possible occurrence of a new fire's triggering:**
  - ◆ ***Temperature sensor;***
  - ◆ ***Air humidity sensor;***
- ➔ **Detection of a currently active fire:**
  - ◆ ***Flame detectors;***
  - ◆ ***Light sensors;***
  - ◆ ***Temperature sensor;***
  - ◆ ***Air humidity sensor;***
- ➔ **Measurement of some metrics, after an extinguished fire:**
  - ◆ ***Temperature sensor;***
  - ◆ ***Air humidity sensor;***

- ➔ **Other physical behaviours on a detection of a currently active fire and related alerts:**
  - ◆ ***LEDs actuators (Yellow, Orange and Red Colors);***
  - ◆ ***Buzzer actuators;***

These **components** will be **connected to an Arduino system**, which **processes sensor readings** and, depending on those readings, **activates the built in actuators and sends relevant data to the remote server, notifying the users**.

The idea, as a product, would be to **extend this prototype, having multiple of these Arduino units in the field, in order to create a cheap, replaceable and reliable network capable of tracking active fires (direction and affected area) and also, its prediction**. **As a prototype and single unit**, it will only be able to **determine if an area is affected or determining if that area poses a threat**.

These **components** will **interact with the mobile application of the users**, by the following **situation mechanisms and behaviours**:

- ➔ In a situation of ***prediction of a possible occurrence of a new fire's triggering***, the ***temperature and humidity sensors*** will **measure some metrics, and accordingly with the data information collect, can generate different alerts** and **notify the users** based on the type of the generated alert;
  - ◆ This situation will **trigger some physical behaviours** on the ***LEDs actuators*** **placed close to the *flame detectors (blinking Yellow, Orange and Red Colors, accordingly with the color associated to the generated alert)***;
- ➔ In a situation of ***detection of a currently active fire***, the ***flame detector***, as also, the ***light, temperature and humidity sensors*** will **auxiliate in this process,** accordingly to some previously defined parameters and **notify the users** about this situation;
  - ◆ This situation will **trigger some physical behaviours** on the ***Buzzer actuators*** **placed close to the *flame detectors*, like sound alerts**;
- ➔ In a situation of ***measurement of some metrics, after an extinguished fire***, the ***temperature and humidity sensors*** will **measure some environment's data information** and **send it to the remote server**, where will be kept, to the users can see it;

ARCHITECTURE OF THE COMMUNICATION BETWEEN COMPONENTS

Our server consists in a ***cloud-based REST server (most specifically, a server based in Google App Engine)***, where will be taken advantage of the implemented storage system. Our ***mobile application will make REST calls (HTTP REST requests and responses) to our server for registration, login*** *and* ***current informations about sensor's node***. Only in case of ***fire detection***, the server will ***send a push notification to the mobile application***. A s***ensor's node will make REST calls (HTTP REST requests and responses) to the server, sending the current readings of the sensor's node***. When a ***sensor's node is connected, it will make a one time REST call (HTTP REST request) registering itself on the network. For the sake of simplification, only a single sensor node will be connected to the server, although, the server will be ready to connect to several nodes***.

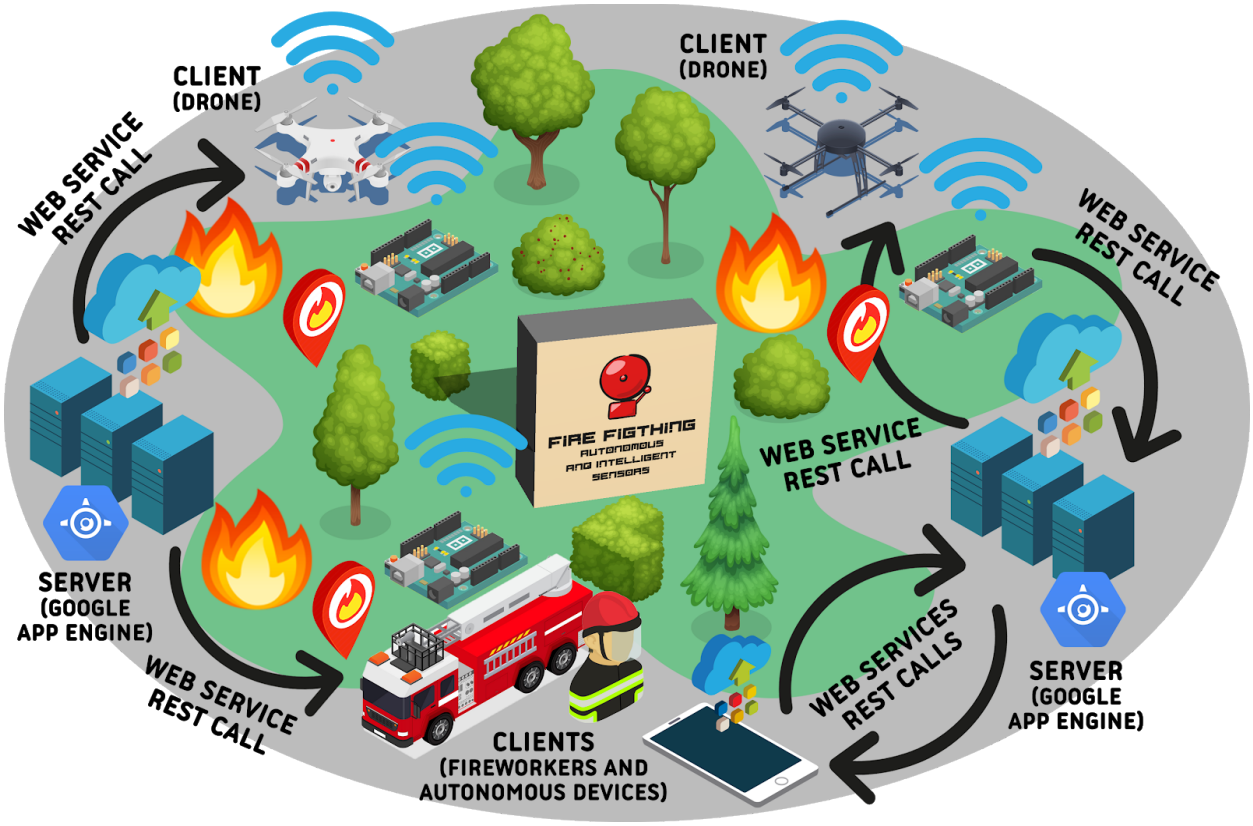


Image 2: Simple and high-level descriptive scheme of the several components presented in the System and the respectively interactions and communications between all the components

The following schemes represents, respectively a **low-level architecture and a high-level descriptive scheme of the several components presented in the System and the respectively interactions and communications between all the components:**

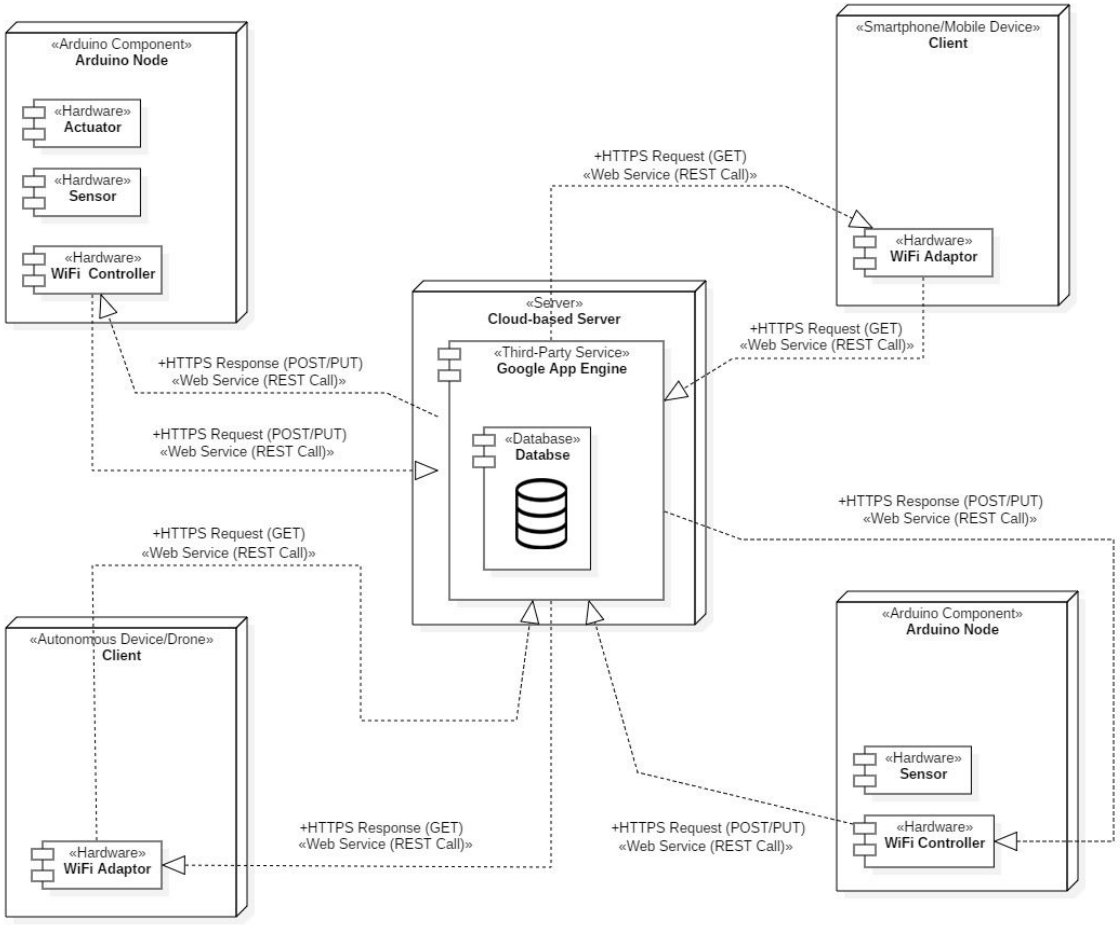


Image 3: Simple and low-level architecture scheme of the several components presented in the System and the respectively interactions and communications between all the components

ARDUINO COMPONENT - SCHEMATIC

The following figure shows the project's sensor schematic:

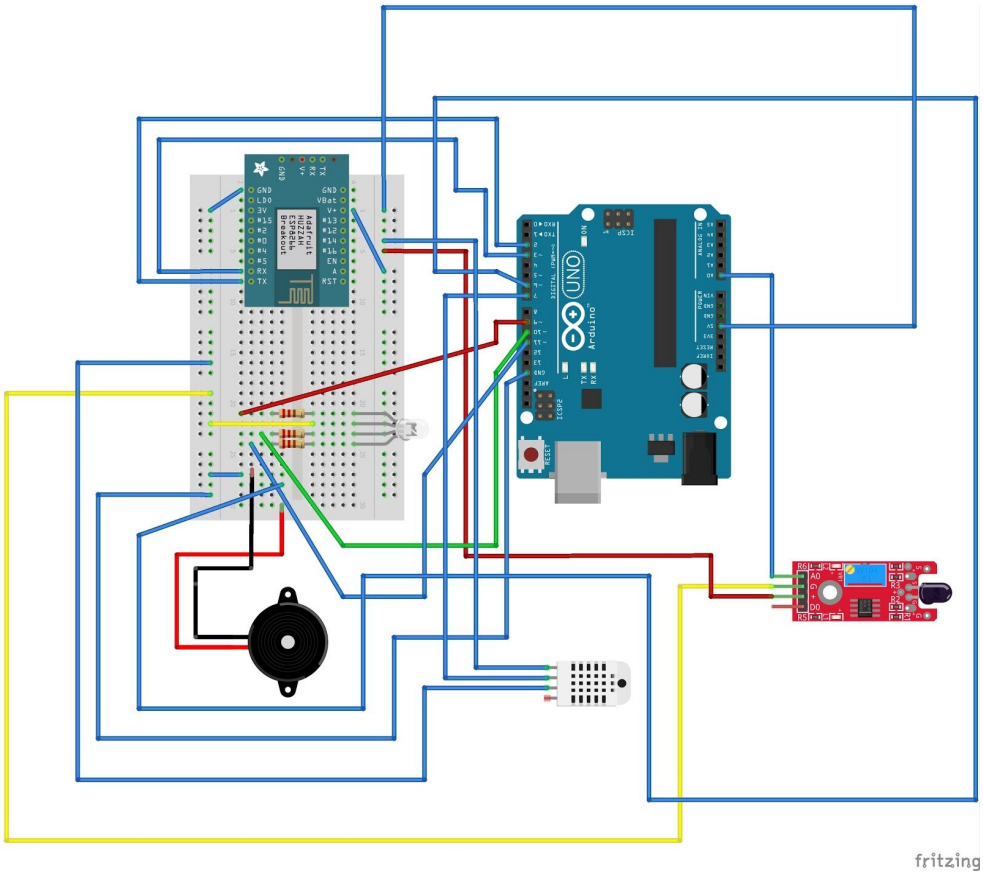


Image 4: Schematic of the Arduino and links between all the sensors' components links

ARDUINO COMPONENT - BRIEF EXPLANATION

The ***Fire*** and ***DHT*** (***Humidity*** and ***Temperature***) are constantly reading and measuring the related to the current conditions and sending it to the server. If some parameters was detected it will trigger some alerts (***yellow*** and ***orange*** for the ***DHT Sensor*** and ***red*** for the ***Fire Sensor***).

SOME EXPERIMENTAL TESTS

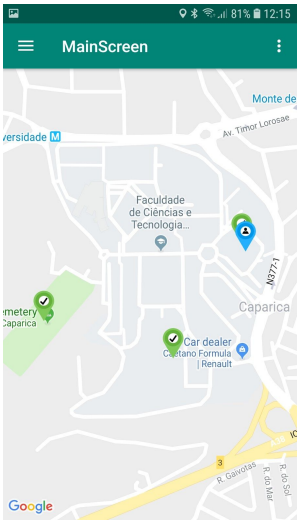
It was realized some experimental tests on our prototype, where was tested the functionalities of the ***idle status***, where are currently sending data to the server, the detection of the ***yellow alerts***, ***orange alerts*** and the ***fire alerts***, where all the inf. It will be tested the ***registration of the sensors and of the users*** (spatial entities), as also, the ***login*** of this last one. Finally, it was recorded some live videos of demonstration of the prototype.

MOBILE APPLICATION

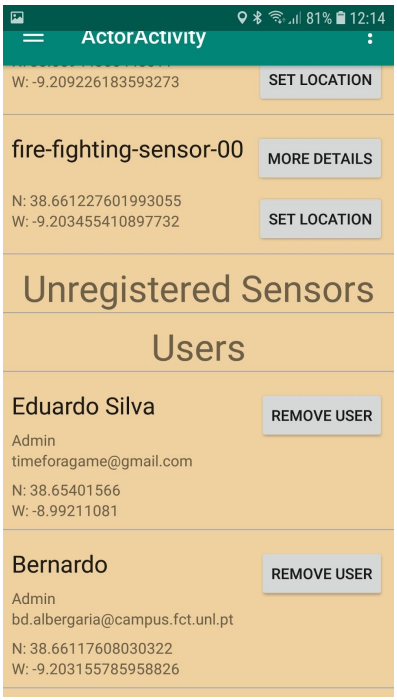
The mobile application was developed using the ***Android Studio***, connected to a server based on ***Google App Engine***, using ***HTTP REST*** calls (receiving and sending), as also, constantly, receiving ***HTTP requests*** from the ***Arduino HUZZAH WiFi ESP8266*** module.

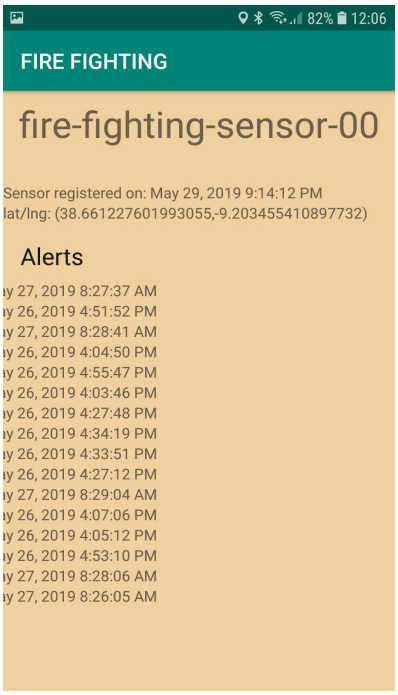
SOME SCREENSHOTS OF THE MOBILE APPLICATION

Here, it will be shown some print screens of the execution of the mobile application:

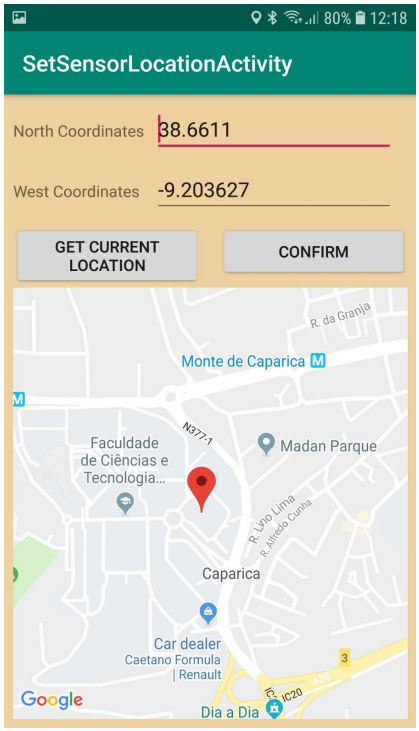


Here it's shown some markers on the map in the mobile application, where it's distributed some sensor's nodes and mobile devices (***administrators*** or ***users***) and shown a popup containing a **sensor's node information**.

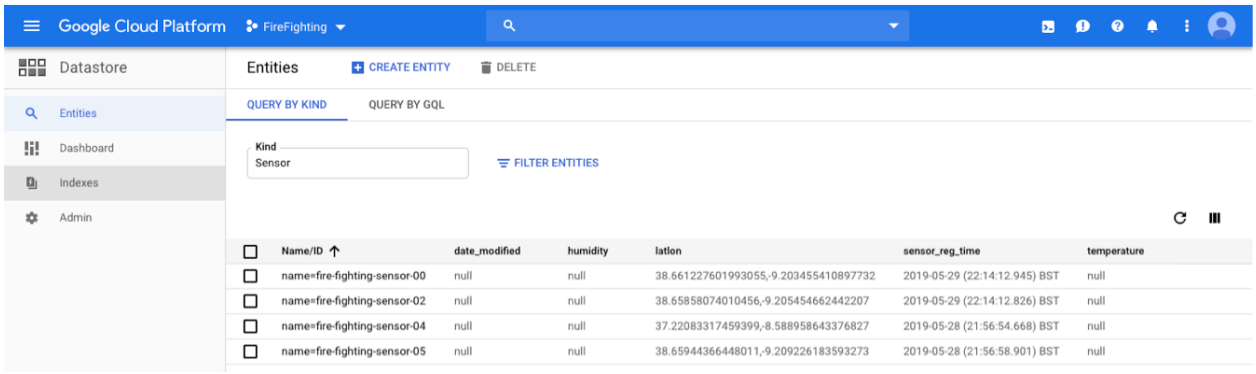


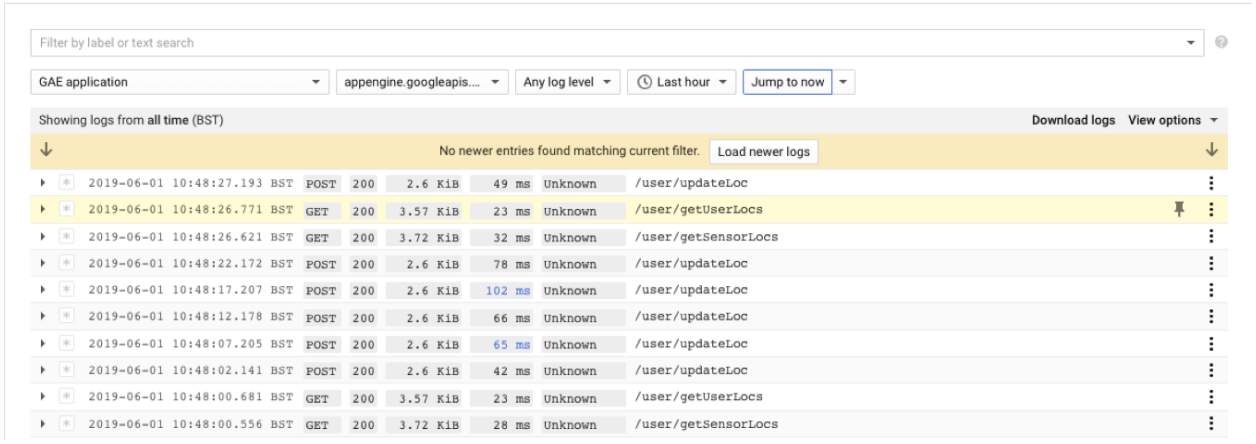


Here it's shown a menu with some ***sensors' nodes*** and ***users*** registered with the options of remove and edit their information, as also, some ***logs about alerts***.



Here it's shown the functionality of ***registering a sensor's node with the respectively information***, with the ***marker in the map, related to its coordinates***.





Here it's shown some ***logs about the sensors' nodes information***, as also, some ***HTTP REST Requests***, in the server based on ***Google App Engine***.

CONCLUSIONS

For conclusion, this kind of systems are hard to test if we aren't inserted in the correct environment with most precise conditions to test.

Some aspects could be improved, like fire's sensor threshold to trigger the fire alert, per example, considering that the sensor detects Infrared Rays and not precisely the Flame itself.