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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Integrated Master of Computer Science and Engineering
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2018/2019
(2nd Semester)

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**.

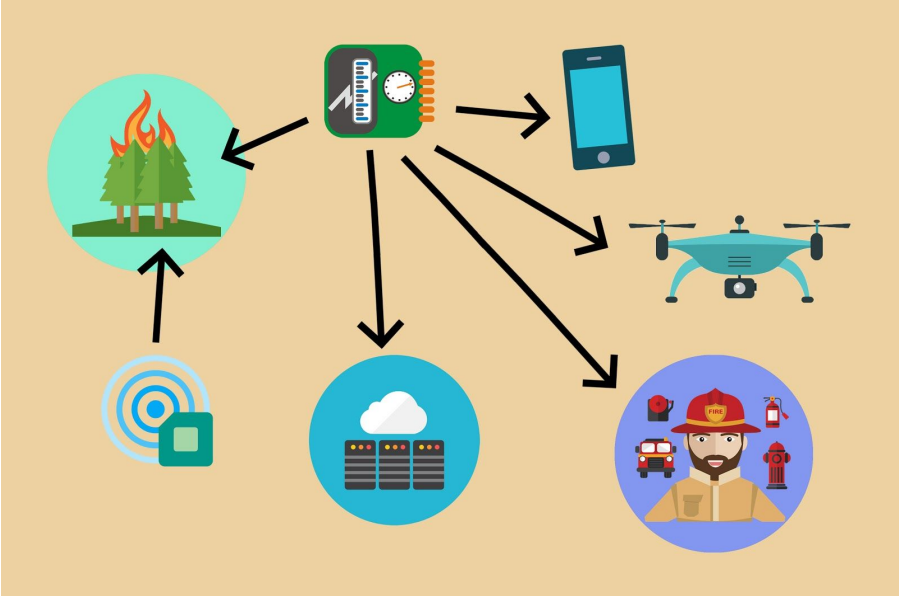


Image 1: Scheme of global view of the system, its components, autonomous and mobile devices, as also, the respectively interactions and communications

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:

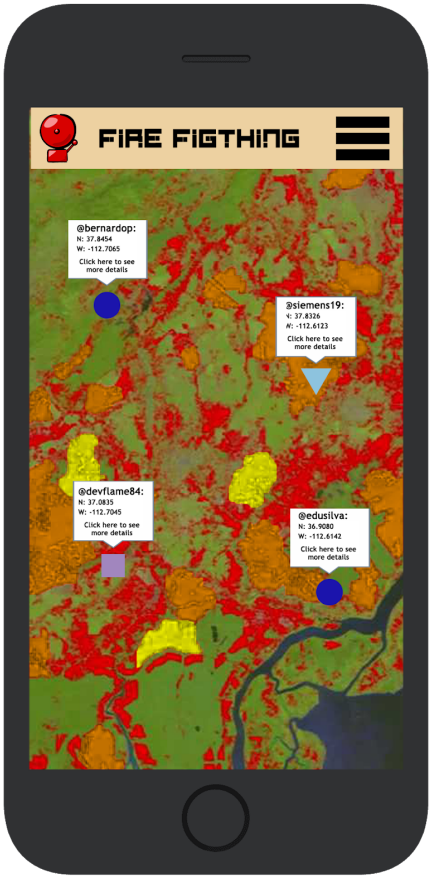
  - In the case of, a **possible occurrence of a new fire's triggering**, the information provided will be, among others:
    - **Current temperature of the area**;
    - **Current velocity of the wind**;
    - **Humidity of the soil presented on the area**;
    - **Amount of CO2 presented on the area**;

  - 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 soil presented on the area**;
    - **Amount of CO2 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 soil presented on the area**;
    - **Amount of CO2 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)**;



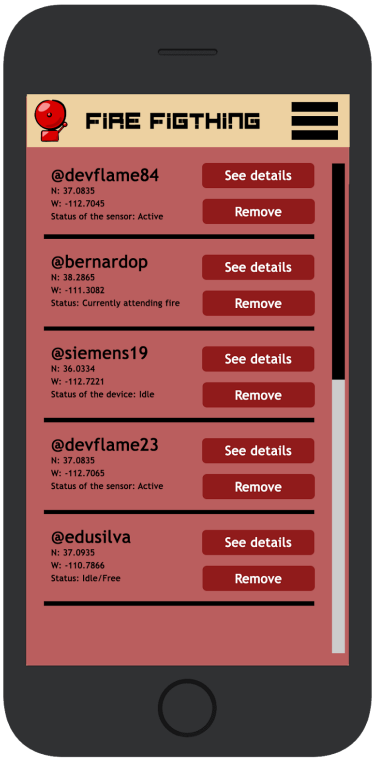
NOTE:

- 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 ALERT		PROBABILITY OF A FIRE OCCURRENCE	BRIEF DESCRIPTION OF THE ALERT AND RELATED NOTIFICATIONS
	Yellow alert	[30% - 59%]	***Possible occurrence of a fire:*** • The users and autonomous devices will be notified about the possible occurrence of the fire for each 2 hours
	Orange alert	[60% - 79%]	***Very possible occurrence of a fire:*** • The users and autonomous devices will be notified about the possible occurrence of the fire for each 1 hour
	Red alert	[80% - 100%]	***Imminent occurrence of a fire:*** • The users and autonomous devices will be notified about the possible occurrence of the fire for each 30 minutes

Table 1: The available provided alerts and their respectively related information and



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;***
  - ◆ ***Soil humidity sensor;***
  - ◆ ***CO2's level sensor;***
- ➔ **Detection of a currently active fire:**
  - ◆ ***Flame detectors;***
  - ◆ ***Light sensors;***
  - ◆ ***Temperature sensor;***
  - ◆ ***Soil humidity sensor;***
  - ◆ ***CO2's level sensor;***
- ➔ **Measurement of some metrics, after an extinguished fire:**
  - ◆ ***Temperature sensor;***
  - ◆ ***Soil humidity sensor;***
  - ◆ ***CO2's level 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, soil humidity*** **and** ***CO2's level 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, soil humidity*** **and** ***CO2's level 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, soil humidity*** **and** ***CO2's level 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***.

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:**

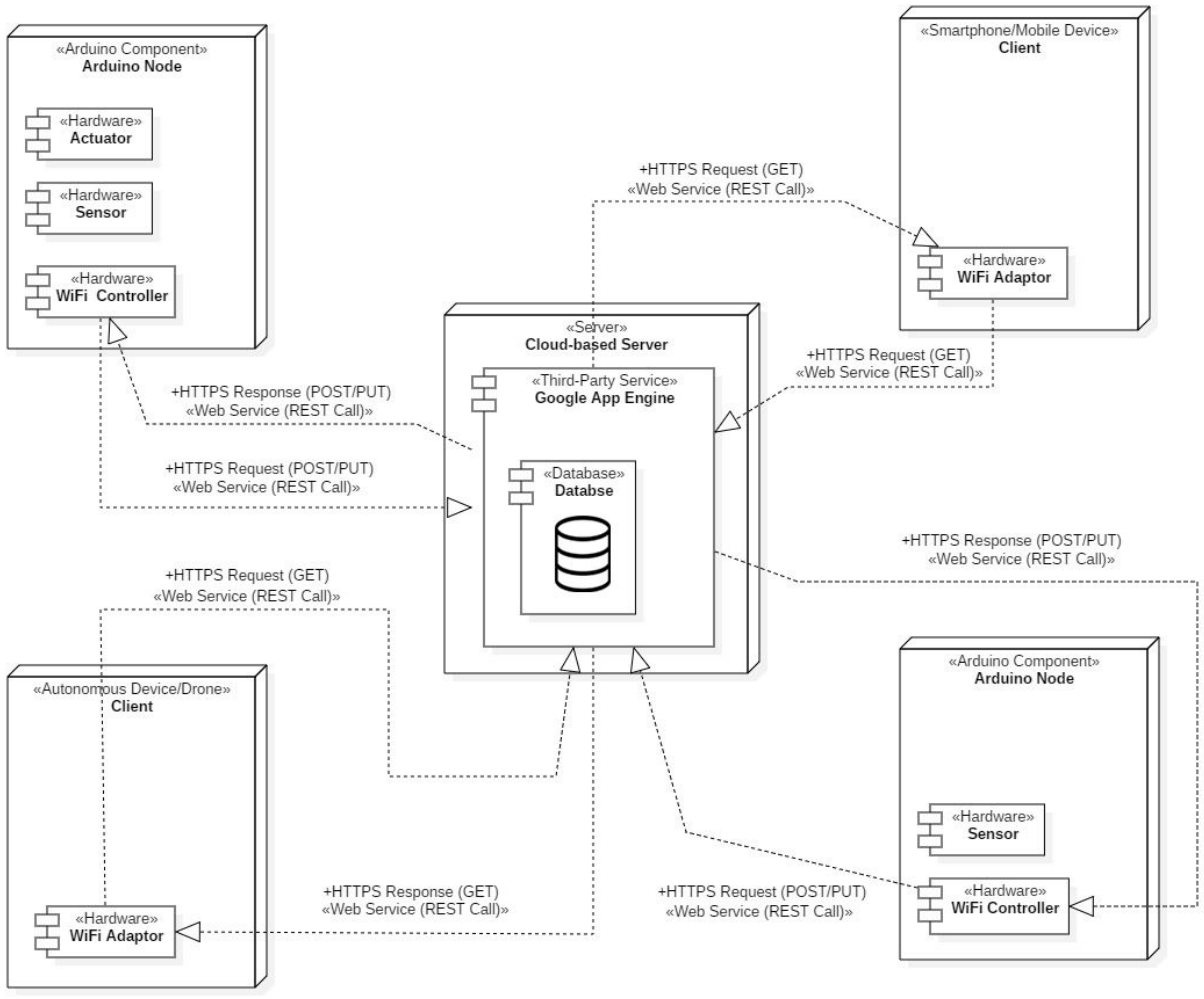


Image 2: Simple and low-level architecture scheme of the several components presented in the System and the respectively interactions and communications between all the components

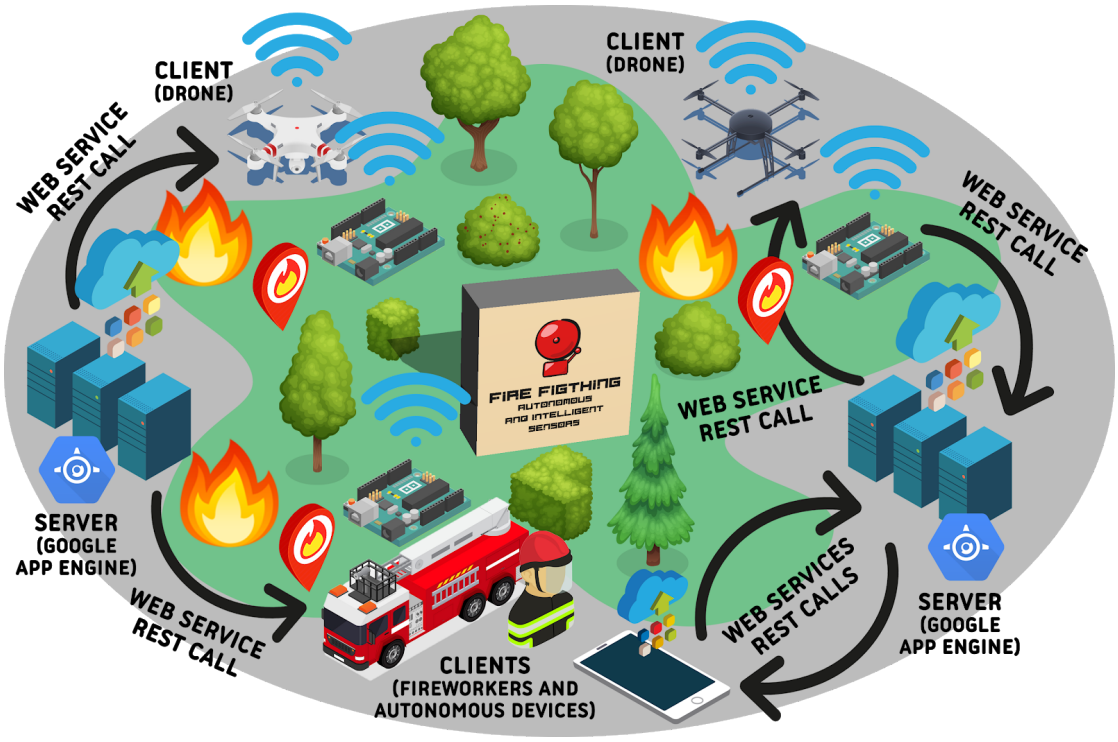


Image 3: Simple and high-level descriptive scheme of the several components presented in the System and the respectively interactions and communications between all the components

This project will be kept on the following GitHub repository:

- https://github.com/rubenandrebarreiro/fire-fighting-autonomous-intelligent-sensors