

Platform for Collaborative Waste Management in an Academic Campus

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Abstract. The creation and development of collaborative systems for encouraging environmentally conscious behavior can play a key role in aligning communities with sustainable waste management practices. This article presents the development of a system that aims to support the waste management initiative “Técnico Faz a Diferença” at Instituto Superior Técnico for introducing waste separation in campus. This system allows the population of different buildings to notify building managers of problems in the different eco-islands present in the buildings. The system is composed of two web apps: one for enabling the building’s population to make reports, and one for allowing building managers to analyze the submitted reports. The goal of the system is to promote interaction of the campus population with the “Técnico Faz a Diferença” initiative, while producing useful data regarding the different eco-islands.

Keywords: Recycling · Web App · Frontend · Backend.

1 Introduction

One of the greatest challenges humanity faces is how to deal with the enormous amounts of waste being generated everyday. From the amount produced to the management of it afterwards, waste is a problem that doesn’t seem to have an end in sight. Using Portugal as an example: each Portuguese citizen produces on average half a ton of waste every year [apa], of which around 40% is sent for reuse or recycling. This figure has been increasing for the past decade, but it is not enough.

In order to address this issue, initiatives that promote recycling and waste-reducing behaviours are essential. One such project is the “Técnico Faz a Diferença” (TFaD), a project that comes as a follow-up on the pilot project “Mecânica I Faz a Diferença” [main] which in turn was based upon a similar undertaking by the University of Milano-Bicocca [main].

The main purpose of “Técnico faz a Diferença” is to implement a Solid Waste Management System in the various buildings present on campus, expanding the work done in “Mecânica I faz a Diferença”. This efforts aim to increase

the separation of waste, while also allowing for the monitoring of the waste being produced and separated. The main actions being taken are focused on the different waste bins. By removing most of the undifferentiated bins from inside rooms and offices and replacing them with paper bins, as well as introducing eco-islands, waste separation islands made up of several bins, one for each type of waste (plastic, glass, paper, undifferentiated), strategically position in various locations.

The system presented in this article aims to complement the TFaD initiative by enabling direct interaction between the building users and the project, while collecting useful data.

2 System

The project consists of 3 major sections: The **Alerts Web App**, the **Management Web App** and the **Backend**. The “Alerts Web App”, allows users to alert about possible problems within the different eco-islands. These alerts are then available to the building managers through the “Management Web App”. This app shows the different alerts on each island. All data is handled by the backend, which contains a database.

2.1 Architecture

The architecture for the system is illustrated in Figure ??.

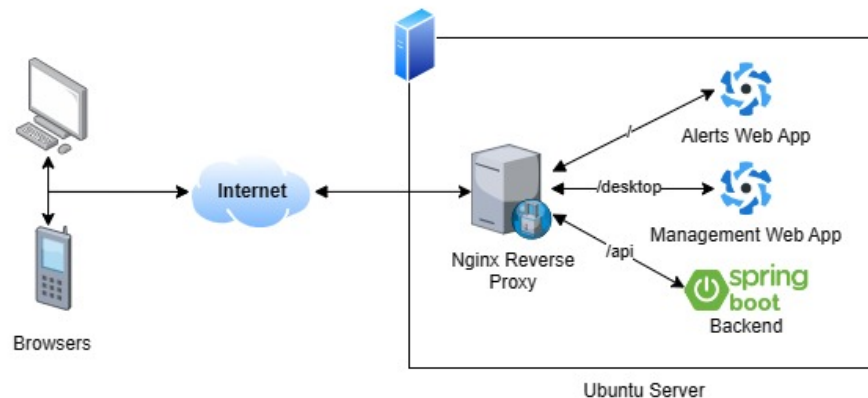


Fig. 1: System Architecture

To develop both the “Alerts Web App” and “Management Web App”, the Quasar Framework [quasar] was employed. Quasar Framework is a cross-platform

Vue.js [vue] based framework that allow for a quick and easy development of apps for several systems. They were developed as web apps to try to improve the engagement of users by providing a system of easier access.

The backend deals with storing and handling of all the data required by the two web apps. It was developed using Spring Boot [spring'boot], a java framework. It also contains a MySQL [MySQL] database to store the data. The Nginx [nginx] reverse proxy directs the several request to the server to the correct app. All these components are deployed using Docker [Docker'2022], for an easier and faster deployment.

2.2 Functionalities

Alerts Web App The alerts app is meant to be used primarily on mobile. Its main purpose is to allow the building population to make alerts regarding the different eco-islands. The app can be accessed by using the camera on the smartphone and reading the QR code present on the eco-island, which opens the device's browser on the required page to make the alert which can be seen in Figure ???. The web app also contains a internal qr code reader that can be used to the same purpose as the device's camera. This page can be seen in Figure ???. Finally the app also has a main page ???. This page contains a brief explanation of the app, as well as a way to open the scan page.

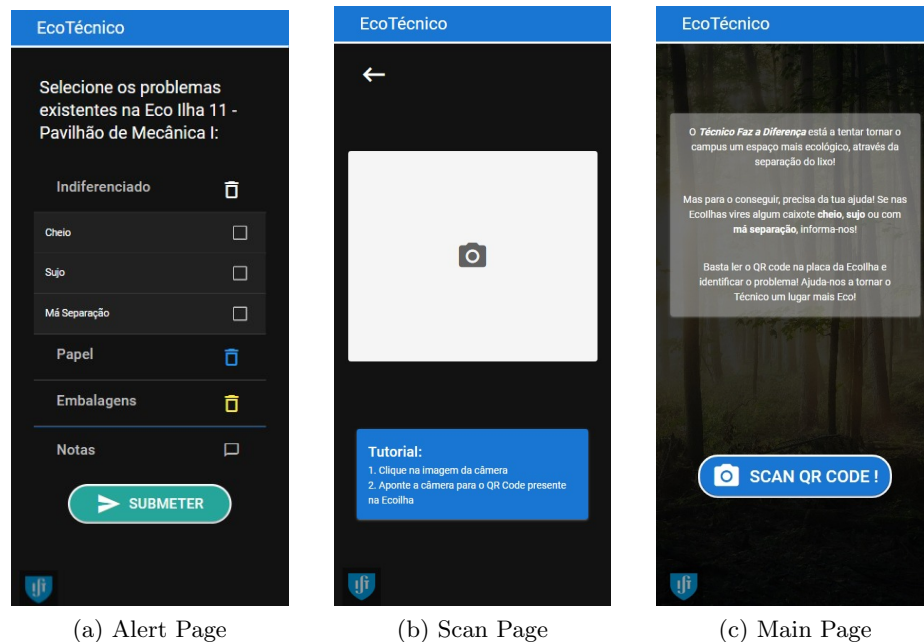


Fig. 2: Alerts Web App Pages

The alerts can be used to identify if each of the bins present on the eco-island is dirty, full, or has bad separation of waste. It can also be used to make a more detailed alert using text.

Management Web App This web app is meant to be used primarily on a computer. The target users are the building managers.

Eco-islands. The app allows users to manage the eco-islands: creating, deleting or modifying them.

Reports. The app allows users to inspect the reports created on the “Alerts Web App”, identifying when and where they were made, as well as, what the problems are. The users can also chose to be associated to buildings, which allows them to receive emails whenever a new report is made.

Users. There are three types of users that have different types of permissions. The **viewers** can only see the information. The **editors**, besides being able to see the information, can also modify it. At last the **admins** have permissions to modify the other users permissions.

The authentication in the app is done using the accounts for Instituto Superior Técnico.

3 Testing

Currently, only one phase of tests was been conducted, focusing on the usability of the mobile part of the system. The test consisted of two simple tasks, which the testers needed to complete. Each task was followed by an “Single Ease Question” to ascertain the difficulty of the assignment. At the end, the users were asked to answer a “System Usability Scale” [Brooke’1995] questionnaire in order to evaluate the usability of the web app.

3.1 Testers

The test was performed by 8 individuals which had some familiarity with the TFaD project, but no previous experience with this system.

3.2 Tasks

- The first task consisted of making an alert, informing that the paper bin was full and the yellow bin was dirty.
- The second task consisted in also an alert, informing that there was bad recycling in undifferentiated waste bin, and adding a note asking to add a new bin for the glass in the eco-island

3.3 Results

Single Ease Question The single ease question, consists of a question that evaluates a tasks regarding its difficulty. The grade varies between 1, for very difficult, and 7 for very easy. The First Task had an average score of 6.75. The Second Task had an average score of 6.625

This results indicate that both tasks were very easy to execute.

System Usability Scale The System Usability Scale consists of a 10 item questionnaire, where the answer score varies between 1 and 5. It is used as a fast and easy way to evaluate the usability of systems.

The score is calculated by: subtracting one from each odd numbered question. For each of the even numbered questions, subtracting their value from 5. These new values are then added and multiplied by 2.5, giving a score out of 100.

The average calculated score was 96.175, which means that the users felt that the web app presented great usability.

4 Current State

A real world phase of testing started on the 10th of July 2023. In this testing phase a qr code was added to all the eco-islands in the building “Pavilhão de Mecânica I”, with the objective of determining if the app would actually be used by its intended users. This test phase is very limited due to the reduced amount of people using the building during the month of July and the fact that the building is currently under construction. At the moment, after a week of testing, only one alert has been submitted to the app, which wasn’t even made as intended. This user used the note section of the alert to submit a question. Even though this was not the intended use, it lead to the consideration of adding this as a new functionality.

5 Conclusion and Future Work

We have presented the development of a collaborative platform for supporting a waste management system that was recently introduced in a university campus, and its early stages of deployment. While tests showed that the “Alerts Web App” usability was highly rated by the users, due to the short time that the system has become operational, coupled with the lack of potential users at this time, it is not possible to draw conclusions regarding the actual positive influence of the system at this stage.

For the next developing cycle, the focus will be on how to have more people using the “Alerts Web App”. The current proposed measures involve the use of gamification mechanics [**gamification’Deterding’Dixon’Khaled’Nacke’2011**] to improve the engagement. This would mean adapting the system to include features such as points, leaderboards and even missions, that the users would need to complete.

Nevertheless, this system can have a positive impact if successful, having the potential to foster a healthy ecosystem in the buildings, stimulating positive relationships between the population of the buildings, the eco-islands, and the building managers.