Teenpower: an integrated architecture for an mHealth platform designed for e-Empowering teenagers to prevent obesity

A showcase of the TeenPower platform

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***Abstract* — Adolescents, reportedly, easily adopt a sedentary lifestyle and unhealthy behaviors. Furthermore, the use of smartphones, especially in this age group, is made on a daily basis. In this context, the TeenPower Project includes an mHealth platform integrated in an intervention programme to engage teenagers to embrace more healthier lifestyle behaviors. This paper describes the technical aspects of the development and implementation of the software applications that compose the TeenPower Platform. The platform consists of two applications: a mobile app (Android) to be used by adolescents, mainly for self-monitoring and educational purposes; and the backoffice (web) application to be used by teachers and health professionals. Both applications are integrated and work through a web service (REST-based) API, which allows them to exchange data seamlessly, keep all related contents updated and enhance communication between adolescents and health professionals.**

Keywords: Adolescents; e-Health; e-Therapy; mHealth; Mobile Computing; Mobile Applications; Web Applications; Obesity;

I. INTRODUCTION

The World Health Organization (WHO) has been pointing out the existence of epidemic percentages of overweight/obesity in adolescents [1]. Adolescence is considered a nutritional risk age group due essentially to the adoption of a sedentary lifestyle and unhealthy behaviors [2]. According to the Childhood Obesity Surveillance Initiative - COSI Portugal 2016 Portugal is one of the European countries with the highest prevalence's of overweigh/obesity [3]. These results reinforce the need to continue investing in the knowledge of the nutritional status of the school population, in the training of families' food education, in the inspection of food supply in schools and in the promotion of adolescent's physical activity.

According to Luis, L. et al, "Nutrition interventions are a cost-effective way to promote healthy behaviors, reducing obesity and chronic diseases among teens." [4] In 2015, the Pew Research Center reported that 92% of the American adolescents between 13 and 17 years old, indicated going online at least once a day [5]. About 88% of teens have mentioned access to a smartphone or laptop/computer on a daily basis. This has motivated the development of an mHealth platform called "TeenPower: e-Empowering teenagers to prevent obesity". We believe that using Information and Communication Technologies (ICT) integrated with a health intervention programme will optimize resources and maximize the impact and outcomes of this programme [4].

Figure 1. The TeenPower project concept [6]

The project required the contribution of several scientific areas such as Multimedia and Arts Design, Healthcare and Technology and focuses on the analysis of effective responses to a serious public health problem (the high prevalence of overweight in adolescents) based on e-Therapy as shown in Figure 1.

II. Platform Components

The TeenPower mHealth platform is composed by two main software applications: an Android mobile application which is to be used by teenagers and provides health related content and self-monitoring tools to e-empower teenagers to prevent obesity; and a web based backoffice to support health professionals to access and update contents available on the teens' mobile app, and to analyze their usage and self-monitoring data. The modules and functionalities that compose these applications are briefly described below.

A. Backoffice Application

The backoffice application is a web application created for the teachers and health professionals of the project. It's main objectives are to support the mobile application and the decision making process of the health professionals regarding the customization of the mHealth intervention, monitoring clinical data such as physical condition, eating habits, hydration, physical activity, sleep monitoring, among others [7]. As such, the TeenPower Backoffice Application contains the following modules:

- Users management module:
  - Bulk user creation through Comma Separated Values (CSV) files;
  - Users Basic Management Operations - Create-Read-Update-Delete (CRUD).
- Content management system:
  - Management of multimedia contents and documents to be made available to teenagers.
- Social interaction module:
  - Private chat (backoffice users chat with each other or with teenagers);
  - Discussion forums.
- Data analysis module:
  - Interactive dashboards showcasing the information gathered through the teenager's usage of the app;

The TeenPower platform includes features for the following user roles: teenager, teacher, health professional and administrator. Only teenagers cannot access the backoffice application. Teachers can use both the social interaction and data analysis modules. Health professionals have the same permissions as teachers, with the addition of the user management module. Administrators have full access to the platform.

B. Android Mobile Application

The TeenPower mobile application is an Android application that includes several pre-defined scenarios (kitchen, bedroom, gym, library and park) and is composed by three main modules:

- Self-monitoring, which allows the teen to register data regarding:
  - Sleeping hours;
  - Meal intake;
  - Physical activity (step count, abs and push-up counts);
  - Biometrics (height, weight - body mass index - and waist circumference);

  Historical registered data can also be seen through interactive charts.
- Educational resources:
  - Showcase contents like videos, leaflets, histories, manuals, diets, links, suggestions, interactive contents, quizzes, and challenges.
- Social interaction:
  - Private chat with colleagues and health professionals;
  - Discussion forums.

The app is structured as a game that enrolls the user in a journey while inciting obesity prevention behaviors. The user is represented by customized avatar that can explore the different scenarios through the TeenPower map (Figure 2).

Within each scenario, the user can interact with placed objects to register data or access media content (videos, leaflets, links, etc). Figure 2 shows the app's kitchen scenario screen with a female avatar, where nutritional info on food can be accessed by clicking the fridge, and meal intake can be registered by clicking the avatar.

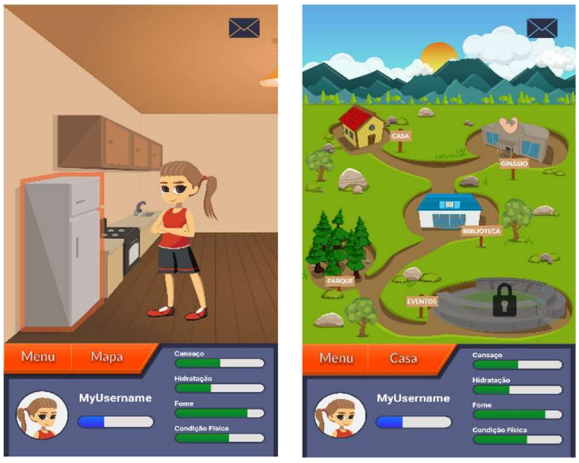

Figure 2. TeenPower Map and Kitchen Section (TeenPower Mobile App)

As mentioned, the avatar follows the user along other scenarios such as the "park", the "gym" and the "library". The park presents the recorded steps and expended calories for the week as well as exercise related videos. The gym not only allows the user to watch exercise related content but also supports a section for registering weight, waist and body mass index. Finally, the library presents multimedia and encouraging health related leaflets to pass information to the

user. The user also receives daily challenges that promote the inclusion of exercise and healthy eating during her/his day.

III. System Architecture & Implementation

The following section describes in moderate detail the architecture of the applications that compose the TeenPower platform.

A. Backoffice Application Architecture

The TeenPower Backoffice web application has been developed using the Hypertext Preprocessor (PHP) Laravel Framework (see Figure 3). It can be divided in two parts: the website that holds the features for teachers and health professionals; and the Representational State Transfer (REST) application programming interface (API) that is consumed by the mobile application.

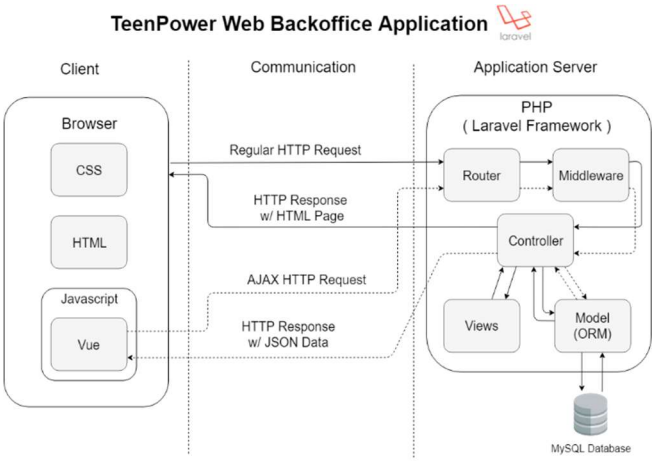

Figure 3. TeenPower Backoffice Application Architecture

The website is presented as pages of Hypertext Markup Language (HTML) and Cascading Style Sheets (CSS), that may contain data dynamically loaded from the TeenPower databases. Occasionally, the Vue.js JavaScript framework was used to introduce reactivity to the page, improving the usability of some features.

B. Mobile Application Architecture

The TeenPower Mobile Application has been developed according to Android development guidelines, using Android Architecture Components and implementing the *Model-View-ViewModel* (MVVM) design pattern [8] (which separates business logic from user interface logic). Java was the selected coding language.

1) Model-View-ViewModel

Some features described in section II, namely the monitorization of the user's diet, sleeping habits, biometric data and exercise routines generate considerable amounts of data, since the user can define values for every day. For this reason, it proved necessary to implement an in-app database, to store records of such data without having to reach out to an external data repository (example: a web server).

Android foresees the creation of in-app databases and recommends the usage of the Room Persistence Library (RPL) [9], which provides an abstraction layer over SQLite [10] database operations.

RPL guidelines suggest the creation of a database object (a *Singleton*) containing references to data access objects (DAO), which are interfaces that have the @DAO annotation. Each DAO contains the operations allowed over a database entity. An Entity is a model class that has been annotated with @Entity. Each propriety of an Entity will be mapped to a column on the entity's table.

Live Data and Observers were then chosen to bridge the gap between activities and view models, which means that the user interface will react to changes in data.

After the inclusion of all these Architecture Components, the resulting architecture can be seen in Figure 4, which also presents a data retrieval cycle.

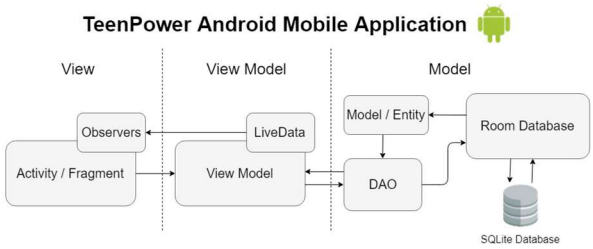

Figure 4. TeenPower Android Application Design Pattern

2) Firebase Cloud Messaging

The Firebase Cloud Messaging Service [11] is a cross-platform messaging service that was selected to carry the notifications sent from the backoffice web application to the mobile application. These notifications are sent every time someone makes use of the Social Interaction Module (for instance, by sending instant/direct messages or posting in forums).

3) Google Fit

The Google Fit Platform [12] allows the monitorization of a user's daily activities based on the context retrieved from the user's smartphone. Although Google Fit has a dedicated mobile app, it allows the integration with third party applications through the usage of the provided APIs. For Android, the API comes in the form of services that can be included in an app. The association with a Google account is also required, meaning that the teenager will need to select an account on the application's first run. The fitness data later recorded will be associated with the selected account.

Currently, these services are used to count the teenager's daily steps and expended calories displayed in the "park".

C. TeenPower Application Programming Interface (API)

To persist self-monitoring data generated by the user, consume and persist contents in the Social Interaction Module, consume the interactive health contents, and handle operations regarding the user's profile, the backoffice

application also provides a REST API, which is composed by a set of routes which accept and return JSON data.

1) API Authentication Process

Before consuming the API, an OAuth2 [14] Access Token needs to be generated. This token is used to verify the identity of an API consumer and needs to be present in the Authorization header of each request made to the API.

As Figure 5 shows, a token can be generated by sending valid user credentials to a certain API route. After checking them against the users' database records, the request is forwarded to the OAuth2 Server created using the Laravel Passport package. This server uses the Password Grant Method to generate a pair of OAuth2 access and refresh token, which are only valid for a certain duration, meaning that a user must renew its credentials after some time. The tokens are then promptly sent in the response, along with the freshest data regarding the user.

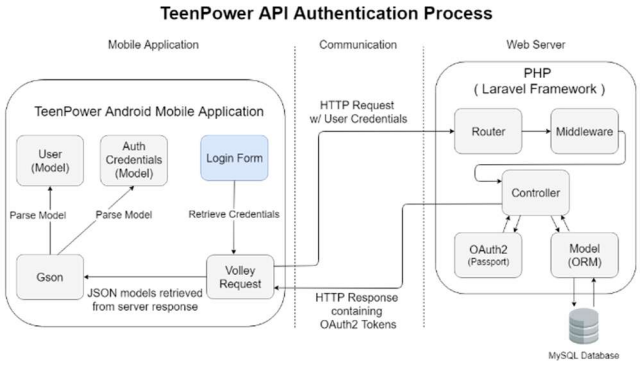

Figure 5. API authentication process

2) Data Retrieval

Figure 6 shows how the mobile app retrieves entities stored in the Teenpower database. By making an HTTP Request to an API route, the server responds with JSON encoded entities, that are parsed usign the GSON Library [13]. To make such requests the Volley HTTP Library [14] is used, as it was created with the objective of exchanging small amounts of data in an optimized way.

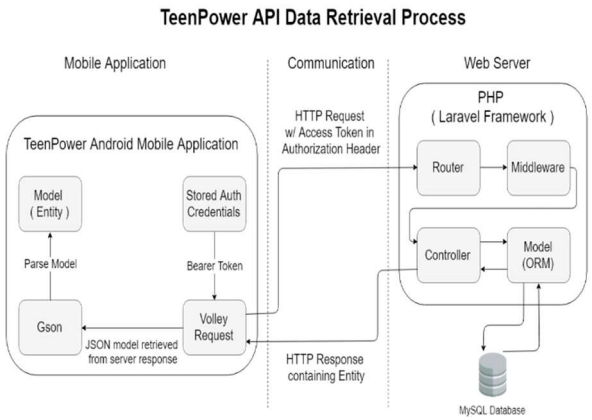

Figure 6. Data retrieval process for transfering data from the backoffice to the mobile application

IV. Conclusions and Future Work

The mHealth TeenPower platform (backoffice and mobile applications) is currently being developed with the direct support of an interdisciplinary team (developers, designers, nurses, nutritionists, exercise physiologists, psychologists, among other professionals). The backoffice application will be managed by health professionals and school teachers to allow the monitoring, interaction with adolescents and educational content management. The mobile application requirements and resources are based on the results of several prototype evaluations with usability tests, focused on the needs of the involved regional healthcare stakeholders and adolescents, included at the beginning of the development process.

Both applications are ready to be deployed and used by the real end users. The project goals include the definition of a gamification strategy defined in the backoffice and applied to the mobile application that will, in the future, improve the adherence to our platform considering what adolescents prefer and providing a fluid and fast platform.

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