Abstract—Obesity is a serious public health concern in the current society, mainly, in developed countries. Common and key treatments for obesity include dieting and frequent physical activity. But more important, it requires a strong individual discipline, motivation, and constant monitoring of the food intake. This paper presents SapoFitness, a mobile health application for a dietetic monitoring and assessment. SapoFitness is customized to its user keeping a daily personal health record (PHR) of his/her food intake and daily exercise. This PHR contains vital health information that will evaluate the nutritional state of the patient (user). The application supports continuous user monitoring and sends alerts/messages concerning his/her diet program taking into account his/her physical activity. SapoFitness is a challenged mobile application that delivers the action to the user, anytime and anywhere, motivating him for a healthier life style. The proposed system was evaluated in several Android-based mobile devices and it is ready for use.

Keywords: Mobile Computing; Mobile Health; m-Health; Ubiquitous Application

I. INTRODUCTION

Health telematics is offering less expensive solutions in healthcare services. Patients that live in remote rural areas, that travel constantly, in case of accident scenes, and among other scenarios, are often physically inaccessible to receive any kind of health monitoring or treatment [1]. E-Health brings a new hopefulness for such patients with more accessible and affordable healthcare solutions [2]. In the last decade, with the advent of mobile communications supported on smart mobile devices, mobile computing has been increasing lots of attention and organizational barriers [4, 5]. Physicians could download medical records, lab results, images, and drug information to handheld devices like personal digital assistants (PDAs) and smartphones. Patients could be aware of their diagnostic, disease control, and monitoring with comfortable mobile devices that accompany them everywhere. M-Health systems, and its inherent mobility functionalities, have a strong impact on typical healthcare monitoring and alerting systems, clinical and administrative data collection, record maintenance, healthcare delivery programs, medical information awareness, detection and prevention systems, drug-counterfeiting, and theft [6].

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I. INTRODUCTION

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Usually, healthcare providers keep and maintain patient health records. However, it is becoming more common that patients also request access to these data. Medical records (or health records) allow medical doctors to easily access patient information without needing to ask them in person. E-Health systems are typically sustained on electronic health records (EHR) [6]. An EHR-System is basically a repository of information regarding the health records of patient/consumer in a computer form [7]. A mobile EHR-System (mEHR-System) complements a typical EHR-System enabling access to health information regardless of the patient time and place. M-Health systems use the Internet and Web services to provide an authentic pervasive interaction among doctors and patients. A physician or a patient can easily access the same medical record any time, any where through his personal computer or his smartphone.

Overweight and obesity are defined as abnormal or excessive fat accumulation that presents a serious risk to health. In 1997, the World Health Organization (WHO) formally recognized obesity as a global epidemic [8]. The centers for disease control and prevention (CDC) and the U.S. National Health and Nutrition Examination Survey (NHANES), indicate that an estimated 17 percent of children and adolescents between ages 2-19 years are obese [9]. The main treatment for obesity includes dieting and frequent physical activity. Diet programs keeps and cause weight loss over short, medium or long term. However, it is necessary frequent physical exercise to maintain balanced body energy. Nevertheless, to maintain such treatments it is crucial having a strong individual discipline, motivation, and constant monitoring of its food intake [8].

This paper presents SapoFitness, a mobile health application for obesity prevention. This application is based on the user Personal Health Records (PHR) of its daily food intake and physical activity. This PHR contain vital information to evaluate the user nutritional state. SapoFitness uses Web services to communicate securely anytime and anywhere with server database for continuous monitoring of its user weight and nutritional state regardless of time and place. This mobile application delivers the action to its user, motivating him to a healthier life style.

The rest of the paper is organized as follows. Section II presents the related work focusing on available mobile health applications for obesity prevention. Section III addresses the application development including its system architecture, used technologies, and key aspects. The application demonstration,
including its user interface and experimental evaluation and validation is addressed on Section IV with a users survey about the application. Finally, Section V concludes the paper and pinpoints possible future works.

II. RELATED WORK

This section elaborates on related work about mobile applications focused on dietary intake and physical activity.

F. Zhu et al. propose a prototype system that uses a mobile device with a built-in camera, network connectivity, and an integrated image analysis that will provide an accurate account of daily food and nutrient intake [10]. Its goal is to use visualization tools with a nutrient database, allowing user to record his eaten food. Acquired images are used to estimate the amount of food and nutrients consumed.

A mobile application/game Time to eat for Iphone is present in [11]. Time to eat is a mobile-phone-based health game created to promote and motivate children to practice healthy eating habits. This game gives to children the control of a pet that reacts to photos showing the food they consume. The pet interacts with the user by sending healthy-eating reminders via email. These messages change depending on the day of the week. Each player must take a photo of his or her meal and submit it. The user will then receive a score given by the pet, based on the healthiness of the food and the amount of food eaten.

A Mobile phone application for real time monitoring caloric balance, called Patient-Centered Assessment and Counseling Mobile Energy Balance (PmEB), is presented in [12]. This application allows users to self-monitor caloric balance in real time. The PmEB is a mobile client application and uses a Web interface that allows users to register and personalize the mobile client. The client application allows the user interaction with the PmEB system. The server application sends updated caloric reminders to the client, stores food, and activity information, keeping data updated about the users daily caloric consumed.

A. Khalil et al. presents the StepUp application, a step counter application [13]. This application uses sensor-enabled mobile phones to automatically count the number of steps walked by the user. Its primary goal is returning to the user the measured quantity of his/her daily activities and create a healthy competition which serves has a source of positive feedback. The StepUp application also aims to increase the users awareness and understanding the importance of physical activities and facilitate the integration of regular exercise into their daily life.

A mobile phone short message service messaging for behavior modification in a community-based weight control program in Korea is presented in [14]. Mobile phones were used to deliver weekly short message service (SMS) messaging about weight loss. It delivers information about diet, exercise, and behavior modification once a week. A total of 927 participants that visited a public healthcare center tested this service. Post-results showed that the majority of participants were satisfied and attested that this service may be an effective method of behavior modification in weight control.

K. Patrick et al. also presents a text message-based intervention for weight loss [15]. This study describes the development and evaluation of a text message-based intervention intended to help a person to lose or maintain weight in a 4 months period. This service includes personalized SMS and multimedia message service (MMS) sent two to five times daily, printed materials, and brief monthly phone calls from a health counselor. Post-results showed that 92% of participants would recommend this intervention for weight control to friends and family. Proving that text-based services might be a productive channel of communication to support weight loss.

SapoFitness gathered contributions from the above-described works and also from the most popular applications on online markets, CardioTrainer [16], MyFitnessPal [17] and CalorieCounter [18]. These applications complement each other with different functionalities. CardioTrainer uses the GPS to track the meters walked by the user and measure the calories burned. MyFitnessPal and CalorieCounter are similar applications, both keep track of the user food intake, and Calorie Counter even allows the input of physical activities. However both applications do not have a suggestion of a diet or exercise plan. SapoFitness complements all the above approaches and intents to be a more complete solution for obesity prevention and treatment. The main contribution of SapoFitness is the advantage of all the inherent pervasive characteristics of the proposed web services and the concept of mobile Internet that allows the system to be used anytime and anywhere. Furthermore, SapoFitness is not a typical fitness application that assents on the individual. As a motivation tool for loosing weight, the application has a social network function that allows the user to share achievements with other SapoFitness users or with friends in various social networks, such as, Twitter or Facebook. These contributions and the application will be presented and described in detail, in next sections.

III. APPLICATION CONSTRUCTION

This section discusses the system architecture and the required technologies to create it. The focus will be on available and emerging architectures that foster its practical deployment.

A. SapoFitness System Architecture

SapoFitness is a mobile application that requires several daily inputs from users, mainly, food and exercise, and others like weight, age, and height. These data is updated on the user PHR through a Web service for easily and immediate access. The user profile makes use of the PHR for determining the user nutritional status. This status includes his/her Body Mass Index (BMI), user daily caloric and energetic needs.

SapoFitness must keep its user well motivated not only to use the application but also to loose weight. Thus, it allows its user to share his/her performance and achievements through well-known social networks (such as Facebook, Twitter, Hi5, Myspace, etc.). Figure 1 presents the SapoFitness system architecture with main actions defined for communication. All data is get and save on a remote database through HTTP on a SOAP and REST Web service that furnishes all the required information. The database contains the user personal data,
PHRs and all the user intake food and physical activities. This information will customize the alert system and its messages to the user. This alert system maintains a frequent application-user interaction and motivates the user to follow the respective diet program and physical activities. The user food habits monitoring is essential to update the user profile.

Figure 1. Illustration of the SapoFitness system architecture.

B. Used Technologies

SapoFitness targets mobile devices running Android platform, which is a software stack for mobile devices that includes an operating system, middleware, and key applications. By the way, the system can easily be reproduced to other mobile operating systems, such as iPhone, Windows mobile, Symbian, BlackBerry, Maemo, etc. The major solution for application development was Java programming language, using the Android SDK (Software Development Kit).

The created Web service communicates through Simple Object Access protocol (SOAP) messages over Hypertext Transfer Protocol (HTTP) with the PHR and the SapoFitness services. The information is returned to the mobile application in JavaScript Object Notation (JSON) or Extensible Markup Language (XML).

C. Strong Aspects

SapoFitness presents several strong aspects and novelties. The ability to share milestones with social networks, a user-machine interaction, easy handling, and a good ratio between fun/motivation and control weight, applied not only to control obesity but also to encourage on problems related with malnutrition. The application monitors its user continuously. The application keeps track of all food intakes and sends several customized alerts regarding his/her diet progress. SapoFitness also allow adding a list of food allergies.

Using Web Services in SapoFitness system, allow the use of different platforms to communicate with the database. Web Services are well known by its general model for building applications and can be implemented for any operation system that supports communication over the Internet [19]. Using WCF, it is possible to send data as asynchronous messages from one service endpoint to another. A service endpoint is part of a continuously available service hosted by Internet Information Services (IIS). At the other endpoint it is the SapoFitness client who communicates with the created services that requests data from a service endpoint. Finally, the application includes a certain dose of fun, allowing a user to interact and have fun with the application, but at the same time controlling his/her weight and promoting several physical activities.

The main decision algorithm for application-user interaction is shown in Figure 2. This diagram presents the system main functions and how they interact with the user. This interaction is based on text alerts sent to the user depending on its nutritional evolution. This procedure begins with the evaluation of calories intake and energy needs. By comparing the balance between both and also the amount of daily exercise the system will suggest and alert the user to its next step on food intake and physical activities.

IV. SYSTEM DEMONSTRATION AND VALIDATION

This section presents an overview of the mobile application and demonstrates its use in a real deployment. It includes the main application windows and the application validation.

A. SapoFitness Demonstration

As above-mentioned, the SapoFitness user’s interface is simple, uses large buttons and includes appropriate size for fingers use. The application monitors the user’s diet, even running in the background, and alerting the user whenever is necessary to take another meal, all in accordance with the customization specified for the user. After logging in, the application communicates with the SapoFitness Web services in order to obtain the respective credentials and load all the need data from the user, such as height, weight, age, sex and daily physical activities. These will determine the Body Mass Index (BMI) and the maximum daily calories to consume. Thus, automatically sets a user profile and the system basically informs the user about his/her obesity condition including more information surrounding, such as weight target, date for the
purpose, and calories to consume. After load all the data, the application goes directly to the Main Menu window. It considers the following eight button options: Diary, My Profile, Food, Diet, History, Physical Activities, Alerts and History of Sharing. Again, Diary and My Profile options are described in detail, since they are the main features of the application.

The user Diary is the main window of SapoFitness (Figure 3a). In this window, the user records eating habits and observes its diet progress. The diary presents the current date and time, how many calories users have eaten until the current time of the day and how many calories he/she should consume on average per day. In background is portrayed a motivation image of the user. Meals and physical activity are information to be recorded daily. Based on this information, it is possible to calculate the daily calories consumed and also a weekly weight loss that can be validated or corrected by the user.

The window of physical activity allows the user to choose different kind of exercises, its intensity, and frequency. Multiple activities are saved in the database as an historic of physical activities. In the button Meals (Figure 5b), the user can search the food database. When a user writes the name of a meal, the application displays all the meals that begin with the typed characters (allowing a faster choice). The food database is composed by food that makes up a meal. For instance, a lunch should include baked potato + salad + fish. Therefore, it is useful that the user can see all available foods already included in the database. It is also important to put a window to enter quantities (i.e. 100gr), or 2 tablespoons or a medium apple, since the calories for food will depend on the quantities.

The window User Profile, shown in Figure 3b, presents the user nutritional status. Through the SapoFitness Web service and user data collected from the PHR, it calculates the BMI and reports back if the user is over weighted or not. It also indicates his/her ideal weight and how many calories should be eaten per day. By pressing “Learn more about your nutritional status”, user will have access to medical information about dangers of obesity/malnutrition and nutritional status. In this window, the user also has access to food plans suggested according to their nutritional status (2 or 3 at maximum). The user can also modify his/her profile data. For example, if after three months he/she lost 3 pounds of weight, the field “weight” should be updated on his/her Plan. This window also includes a motivation picture that changes depending on user status. For example, if the user is leaner, a red icon is presented, if he/she is in a good shape, it shows a green icon, or a red icon appears if he/she is overweight.

B. Application Validation

The performance evaluation and real deployment of SapoFitness is presented on this section. The application validation was performed through exhaustive running experiments. Real devices were used in all the performed experiments, instead of the bundled Android emulator, as may be seen in Figure 4. SapoFitness was deployed in three different devices with three different screen sizes, and the behaviour of the application user interface performed very well, as expected.

Extensive surveys where made in SurveyMonkey which provides free online questionnaire and survey software. A total of 106 users have answer the questionnaires. They have used the application for some time. After the experience, they completed a SapoFitness survey. The questions are shown in Table I.

Table I. SapoFitness Survey Questions.

<table>
<thead>
<tr>
<th>Question</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Question 1</td>
<td>Is the application an attractive design?</td>
</tr>
<tr>
<td>Question 2</td>
<td>Is the application easy to use?</td>
</tr>
<tr>
<td>Question 3</td>
<td>Is the application environment user friendly and intuitive?</td>
</tr>
<tr>
<td>Question 4</td>
<td>Are the Navigation options clear and consistent?</td>
</tr>
<tr>
<td>Question 5</td>
<td>Are Fonts (style, color, saturation) easy to read in screen?</td>
</tr>
<tr>
<td>Question 6</td>
<td>Is the Feedback and response time of the application fast enough?</td>
</tr>
<tr>
<td>Question 7</td>
<td>Is the application helpful for meal control?</td>
</tr>
<tr>
<td>Question 8</td>
<td>Does the application help to understand the problem of obesity?</td>
</tr>
</tbody>
</table>

In Figure 5 and Table II it can be perceived that the majority...
of users strongly agree that platform has an attractive design, the environment is user friendly and intuitive, navigation options are clear, consistent and text blocks are written in minimalist style, Fonts are easy to read in screen and the application help to understand the problem of obesity. Other big percentage of users thinks that the platform is very easy and the application is helpful for meal control. In almost questions the remaining percentage the users seem to agree with the questions. The only question that contains lower ratings is the 7, it is due to the connection to the server is still a test version.

**Table II. Table of SapoFitness Survey.**

<table>
<thead>
<tr>
<th>Questions</th>
<th>Q1</th>
<th>Q2</th>
<th>Q3</th>
<th>Q4</th>
<th>Q5</th>
<th>Q6</th>
<th>Q7</th>
<th>Q8</th>
<th>Q9</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agree</td>
<td>20</td>
<td>10</td>
<td>10</td>
<td>10</td>
<td>10</td>
<td>10</td>
<td>10</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>Tend to agree</td>
<td>8</td>
<td>7</td>
<td>7</td>
<td>7</td>
<td>7</td>
<td>7</td>
<td>7</td>
<td>7</td>
<td>7</td>
</tr>
<tr>
<td>Undecided</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Tend to disagree</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Disagree</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Strongly disagree</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

**Figure 5. Results of SapoFitness Survey.**

### V. CONCLUSIONS AND FUTURE WORK

This paper presented SapoFitness, a m-Health system for obesity prevention. It includes an application very intuitive and easy to use. Its main goal is the user motivation for loosing weight, increasing physical activity, and having a good and balanced nutritional state. SapoFitness accesses PHRs through Web services to the user food intake and physical activities data to determine his/her nutritional state. This feature allows a continuous user monitoring regardless of time and space. SapoFitness is a challenged mobile health application that promotes a healthier live style. It was demonstrated and validated, and it is ready for use.

Future improvements include the use of geo-referential technologies and algorithms to provide context and location-aware services. These services could enable collaboration and cooperation among users, socializing and helping each other to reach pre-defined thresholds.

### ACKNOWLEDGMENTS

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