POLITECNICO DI TORINO

Master's degree
in Computer Engineering

Master's Degree Thesis

A CROSS-PLATFORM MOBILE APPLICATION SUPPORTING A HEALTHIER LIFESTYLE

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Contents

Introduction

The work that is being presented in the next pages is based on two main arguments: the importance of following a healthy lifestyle and how technology can help in achieving this goal. Infact, our project work along with my colleagues concerned the implementation of an application suited for achieving a good lifestyle. The application, composed both by a frontend part and a backend one, allow the users to track their data regarding nutrition, as well as physical activity, sleep and emotional state. These data can be either inserted manually or collected through a wearable device. The application still requires the user to insert his basics information, such as username, weight and height. They are then all available in the application, where the user can eventually change them. The application also integrates a gamification approach through a specific section of the app, that allow the users to learn and deepen their knowledge about the topic, granting a form of reward when users complete a specific task. Finally, the application also involves the usage of recommendation as a way to provide suggestion about health and lifestyle to the user and improve his healthy journey. The thesys is then structured in 5 chapters: the first one deepen the health and well being topic, considering the guidelines that literature has found over the years of studying the topic. It then focuses on how technology can help us in achieving a better lifestyle, by considering which are the main software and hardware tools that can be used, such as smartphone application and wearable devices that allow to collect data and share them with application to create a more complete picture of the user's health. The second chapter moves into more tecnical aspects, by considering the technology stack that has been used to develop the application, starting from the used programming languages and automation tools, moving then to the IDE (Integrated Development Environment) and to the backend related aspect. The third chapter then talks about the overall implementation of the application, by focusing on my particular contribution. The fourth chapter talks about the performance analisys of the application, by considering the different testing devices that have been used to test the application performances. Finally, the fifth chapter concludes the work by considering the results that have been achieved and the future work that can be done to improve the application.

1 Health and Well Being

Health is one of the most important, if not the most important aspect of a person's life. For this reason, over the years, different organisations have established guidelines on how to stay healthy, thus increasing people's life expectancy and quality of life. Among these, the most widely worldwide recognized is the World Health Organization (WHO) [1] that provides several guidelines not only in term of physical activity, covering also other health aspects.
As far as concerns the physical activity, the WHO estimates that 1 in 3 adults and 4 in 5 adolescents do not do enough physical activity, with adolescents girls less active than adolescents boys and with inactivity levels that increases after 60 years of age. This level is expected to rise due to country economic development (more use of technology, change of cultural values and more sedentary behaviour). This trend sadly keep going in the wrong direction, despite the fact that physical activity has countless benefits, like reducing the risk of heart disease, cancer, diabetes, hypertension and depression.

- Children and Adolescents:
  - **Regular physical activity** enhances fitness, cardiometabolic health, bone strength, cognitive and mental health while reducing body fat.
  - **Sedentary behavior** leads to increased adiposity, poorer cardiometabolic health, behavioral issues, and reduced sleep duration.

- Adults and Older Adults:
  - **Active adults** experience lower body fat, risks of all-cause mortality, cardiovascular diseases, hypertension, specific cancers, and type-2 diabetes. They also enjoy improved mental health, cognitive function, and sleep quality.
  - **Sedentary lifestyles** are associated with higher mortality rates and increased incidences of chronic diseases like cardiovascular issues and cancer.

- Pregnant and Post-Partum Women:
  - **Engaging in physical activity** decreases the risks of pre-eclampsia, gestational hypertension, gestational diabetes, excessive weight gain, newborn complications, and postpartum depression, while having no negative effects on birth weight or stillbirth risk.

Active vs Sedentary lifestyle[2].

Food is also crucial in order to be healtier. Having a healthy diet helps to prevent several diseases (like heart disease, diabetes and cancer) and also malnutrition in all its forms. However, care has to be taken in choosing the right food sources that have good quality and avoid processed foods. Eating noble foods like fruits, vegetables, legumes, nuts, and whole grains, while limiting the intake of salt, sugar, and fats, is the key to a healthy diet. For all these reasons, both physical activity and diet are strongly promoted by the WHO through his global action plan, by calling international partners, private sector and also civil society to take action in order to support them.

1.1 Guidelines

1.1.1 Physical Activity Guidelines

As far as concerns the physical activity, the WHO gives some recommendation based on the age group [3]:

- 5-17 years:
  - Should do at least 60 minutes of physical activity with moderate/vigorous-intensity daily (of course more than 60 minutes provides additional benefits), as well as bone-strengthening and muscle-strengthening activities.
- 18-64 years:
  - Should do at least 150 minutes of physical activity with moderate-intensity in a week or at least 75 minutes of physical activity with vigorous-intensity in a week or an equivalent combination of both (increasing moderate-intensity will provide additional benefits), but also muscle-strengthening activities by involving major muscle groups.
- 65 years and above:
  - Should do at least 150 minutes of physical activity with moderate-intensity in a week or at least 75 minutes of physical activity with vigorous-intensity in a week or an equivalent combination of both (increasing moderate-intensity will provide additional benefits), recruiting major muscle groups with muscle-strengthening activities but also including exercises to enhance balance and prevent falls in case of poor mobility.

1.1.2 Healthy Diet Guidelines

Regarding having an healthy diet, also here the WHO gives some guidelines, emphasizing that a good diet includes legumes, fruit, vegetables, animal sources foods (like meat, fish, eggs, and milk), cereals (like wheat and barley) and also tubers (like potato and yam). It also gives some further recommendations[4]:

- Babies and young children breastfeeding:
  - Breastfeeding promotes healthy growth, as well as having long-term benefit, like reducing the risk of developing nonncommunicable diseases, overweight, obesity. From birth until 6 month of life is important to feed the baby only with breastmilk, while from 6 month to 2 years of age is important to introduce also additional complementary foods, while still breastfeeding.

- Eat lots of vegetables and fruit:
  - These foods are rich in vitamins, minerals, dietary fiber, antioxidants and plant protein, which help to prevent heart disease, stroke, diabetes, obesity and some cancers.

- Eat less fat:
  - Fats and oils are concentrated source of energy, so it is important to limit them, especially saturated and industrially-produced trans-fat that can increase the risk of stroke and heart disease. To avoid gaining weight in an unhealthy way because of them, care has to be taken in using unsaturated vegetable oils (like olive oil) instead of animal fats or oils high in saturated fats (like butter or palm) and in any case fat consumption should not exceed 30% of total energy intake.

- Limit sugars:
  - Sugar consumption should be the 10% of total energy intake. This should be achieved by limiting soft drinks, soda and other drinks high in sugars (fruit juices or yogurt drinks) and also by avoiding the consumption of processed foods high in sugars (like cookies, cakes, chocolate). Better to choose fresh fruits instead of them.

1.2 Technology Role in Health

Having clear in mind the importance of an healthy lifestyle and a good dieting, it is also important the role that technology can have in this. Even though it is still possible to achieve a good lifestyle without technology, it has to be said that using technology sure makes it easier across several aspects. Several researches in this aspect have been performed by the National Institutes of Health (NIH) [5], an american health organization driven by the U.S. Department of Health and Human Services. The NIH found notable improvement in diet and activity habits with usage of mobile technology.
They took 204 adult people that met these constraints:

- Being obese or at least overweight.
- Having a diet high in saturated fat and low in fruits and vegetables.
- Perform a small amount if daily physical activity.
- Having lots of sedentary time.

then they divided these people into four groups, where each one had a specific diet. Furthermore, a mobile device was given to them and they had to enter their diet and activity data into the device for a 20-week follow-up period. Coaches would then receive the data during this period to monitor these people, as well as contacting them in order to provide encouragement and support towards an healthy change. The results found overall improvements in all four groups, emphasizing how technology can improve a fitness journey, also as a means to provide support and motivation [6].
Another aspect in which technology surely can help is about measurements: during physical activity and dieting, several aspects require measurements: the amount of calories burned, the heart rate during physical activity, the amount of calories taken, as well as the types of food consumed, their macronutrients (carbohydrates, proteins and fats) and so on. In this aspect, technology can provide several tools to help, like smartphone applications or wearable devices.
In the first place, technology helps in easing the process of performing measurements and gather these data (both for physical activity and dieting) that can be boring to do repetitively for us humans. In the second place, technology can provide a more accurate measurement of these data, more difficult to achieve manually. Related to this aspect, a study of the NIH showed how physical activity measurements taken by devices proved to be more punctual compared to the one taken manually with a diary [7].

1.2.1 Smartphone Applications

Moving to the technological tools that can be employed, smartphones surely are one of the most used devices and they allow to exploit several aspects related both to dieting and physical activity. Also here a study of the NIH [8] showed that users were more stimulated into following a healthy diet, particularly liking applications that were quick and easy to administer, and those that increase awareness of food intake and weight management. Even though work has to be made to increase food awareness, the study recognizes the importance of smartphone applications in this aspect. Dually another study has been done also on physical activity [9], showing that smartphone apps can be efficacious in promoting physical activity. Also in this case users tend to prefer applications that are user-friendly, thanks to their capability of automatically track physical activity (e.g., steps taken), track progress toward physical activity goals, as well as be flexible enough to be used with different types of physical activity. Countless of these smartphone applications are available to support an healthy lifestyle. They are cross-platform, so they can be used on both Android and iOS devices, in order to reach the largest audience possible. Here are some of the most popular applications, where for each the main features and the feature that distinguishes the application from other on the market are listed:

App Name	**Features (Distinguishing Features In Bold)**
MyFitnessPal	Food logging with a large database, barcode scanning, calorie and macro tracking, personalized insights, exercise logging, and integration with other apps. **Share and View Your Diary with Others.**
Fitbit	Step tracking, heart rate monitoring, sleep analysis, GPS tracking, food logging, and activity reminders. **Comprehensive health metrics tracking, including stress levels and Active Zone Minutes.**

Google Fit	Step counting, activity tracking, heart points, integration with health apps, and customizable fitness goals. **Collaborates with the American Heart Association and WHO for heart health insights.**
Nike Training Club	Guided workout programs, personalized fitness plans, workout tracking. **Free access to a variety of workouts, from yoga to high-intensity interval training.**
Strava	GPS tracking for running, cycling, performance metrics, social sharing, and route planning. **Community-focused with support for sharing routes and competing with others.**
Noom	Weight loss coaching, food logging, biometric tracking, and habit-building tools. **Focus on the psychological aspects of diet and health for long-term results.**
JEFIT	Exercise logging, workout planning, personalized workout, and performance tracking. **Training optimization with advanced analytics.**
Cronometer	Nutrition tracking, biometrics tracking, diary and diary groups, and micronutrient breakdown. **Advanced nutrient tracking suitable for specific diets.**
Lifesum	Food tracking, calorie counting, diet plans, water tracking, and nutrient breakdown. **Visual and user-friendly meal planning tailored to dietary preferences.**
Yazio	Calorie counting, meal planning, recipes, nutrition tracking, and progress reports. **Extensive recipe database and meal planning features.**

Table 1: Overview of popular diet and fitness apps with distinguishing features highlighted

1.2.2 Wearable Devices

Considering the Wearable Devices, even though they are less used compared to smartphones, their usage is growing more and more. Furthermore they are a good tool in order to track physical activity and dieting. Their main advantage is that they can be worn on the body, like a watch or a bracelet, but they are equipped with sensors allowing to collect data about the body, like the heart rate, the number of steps taken, the calories burned, the quality of sleep, and so on. They can also be connected to a smartphone in order to share these data with it, so that the user can have a more detailed view of his health status. Given their diffusion, applications have been introducing a way to connect to these devices, in order to exploit their data. This has been done by carefully considering their diffusion [10].

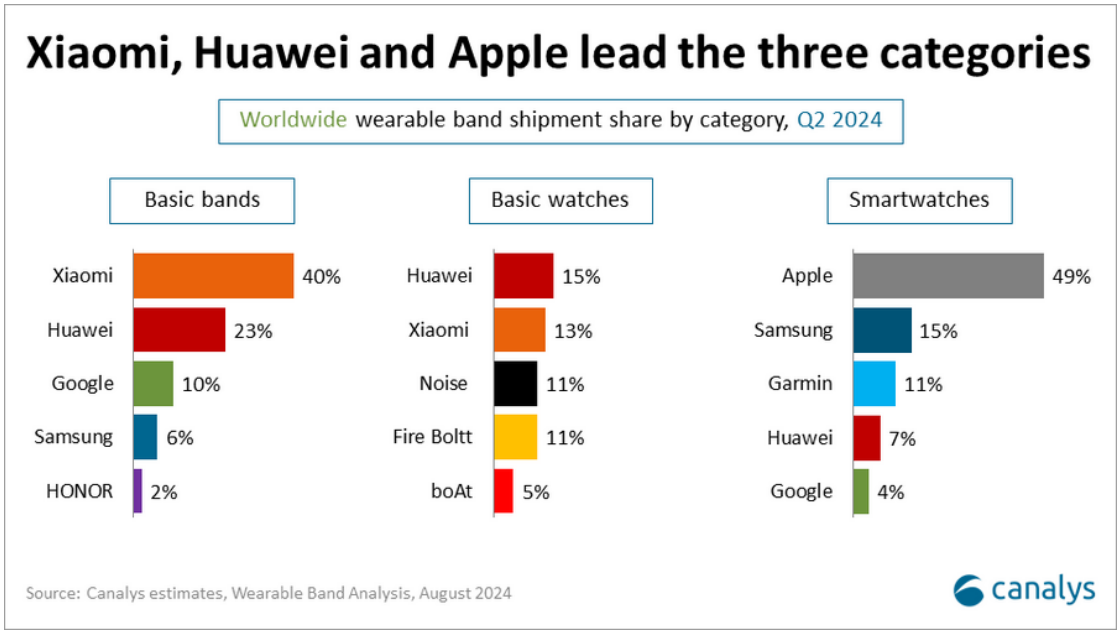

Figure 1: Wearable diffusion by major brands [10].

2 System Specifications and Technological Stack

This section of the elaborate will involve the discussion of the system requirements, as well as how the system have been designed. Finally, the technological stack and the major tools adopted for the project will be covered, such as the programming languages, IDE, libraries, automation dependency tools.

2.1 System Requirements

Given the fact that this project was already existing, it had some implemented features (and consequently some basic requirements related to them), our work was based on extending the app capabilities by implementing new features or refactor existing ones.
Considering this aspect, I will classify the functional requirements that regards our work as follows:

FR1	**User Management**	
FR 1.1	Home Page	Allow a user to enter and also visualize data regarding his emotional state.
FR 1.2	Home Page	Allow a user to visualize data on the charts that exceeds the related goals differently (they visually differ from the other ones).
FR 1.3	Health Measures Page	Allow a user to view his vital metrics by using charts organized in different tabs instead of raw values, for a better understanding.
FR 1.4	Personal Information Page	Allow a user to provide his personal measures as well as his activity goals, used as upper bound into the charts of the Home Page.
FR 1.5	Notification System	Allow a user to receive notification with different frequencies to prompt him into inserting data regarding food, emotional aspect, balance capability, strenght capability.
FR 1.6	Assessment	Allow a user to visualize a periodic assessment produced thanks to the data that were previously inserted.
FR 1.7	User Registration	Allow a user to enter his demographics (age,sex,...) and body (height,weight,...) data when the registration is in progress.

Table 2: Overview of Functional Requirements related to the User Management.

FR2	**Data Management**	
FR 2.1	Data Source Migration	Migrating the main app data source from FitBit Server to Health Connect and Apple Health (Health data management and integration platforms, developed by Google and Apple respectively), while still keeping Google Firebase as additional data source.
FR 2.2	User Goal Data Integration	Allow a user to retrieve, visualize, insert and edit his goals.
FR 2.3	User Emotional Data Integration	Allow a user to retrieve, visualize and insert his emotional data, based on the selected time period.
FR 2.4	Health Data Backup	Added the necessary logic to perform a backup of the users's health data.
FR 2.5	Food Data Integration	Allow a user to insert his food data once received the notification.
FR 2.6	Emotional Data Integration	Allow a user to insert his emotional data once received the notification.
FR 2.7	Balance Capability Data Integration	Allow a user to insert his balance capability data once received the notification.
FR 2.8	Strenght Capability Data Integration	Allow a user to insert his strength capability data once received the notification.

Table 3: Overview of Functional Requirements related to the Data Management.

As far as concerns the non-functional requirements, we can classify them as follows:

NFR	**Type**	**Description**
NFR1	Reliability	The system should ensure at least 80% accuracy and functionality over the course of a year.
NFR2	Portability	The application must be capable of running on Android and IOS devices.
NFR3	Security	Robust login mechanisms should be implemented to protect user data and limit access only to authorized individuals.
NFR4	Usability	The application should be intuitive enough for users of all ages and skill levels, requiring minimal training.
NFR5	Data Privacy	User data must adhere to OAUTH for secure data handling.
NFR6	Performance	The app should smoothly load and handle user interactions within two seconds under typical conditions in order to achieve an optimal user experience.
NFR7	Interoperability	The application should seamlessly connect with third-party platforms like Health Connect and Apple Health, maintaining data accuracy and improving functionality.
NFR8	Localization	The app should support at least English and Italian languages, adapting content and formats (e.g., date, currency) accordingly.
NFR9	Modularity	The app's architecture should support modular development to facilitate future updates without impacting the entire codebase.

Table 4: Overview of Non-Functional Requirements related to the system.

2.2 System Architecture And Design

Focusing on the system architecture and his design, it can be summarized as follows:

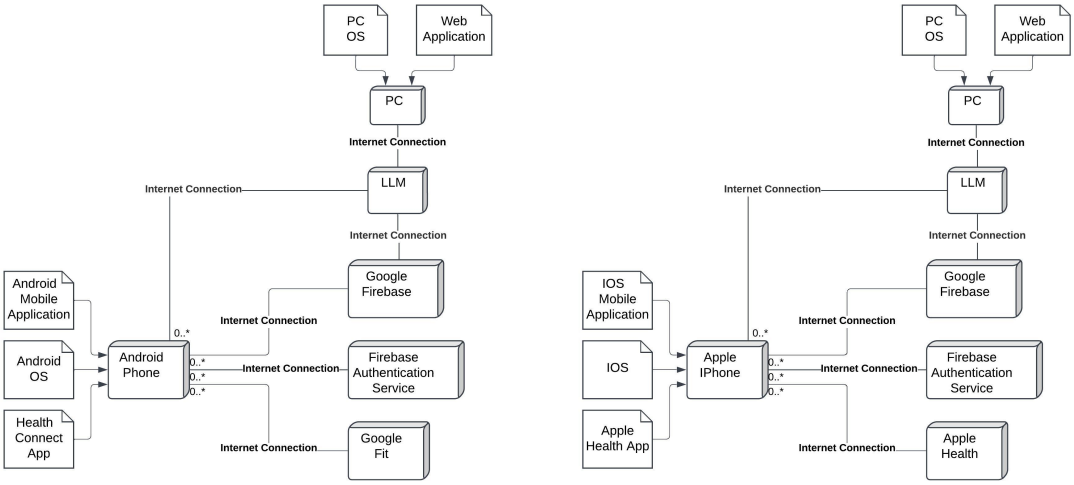

Figure 2: Overview of the System Architecture.

We can clearly distinguish the two main use cases (Android and IOS) with their distinguishing components and the common ones:

- Android Architecture:
  - **Android Phone** that represent the physical smartphone, along with his operating system, our application installed and health connect installed, used to manage the health data on Android, that further interacts with google fit server whenever is needed.
  - **Google Fit** server, used among the health connect app data sources.

- IOS Architecture:
  - **Apple IPhone** that represent the physical smartphone, along with his operating system, our application installed and apple health installed, used to manage the health data on IOS, that interacts with apple health server whenever is needed.
  - **Apple Health** server, used as data source for the apple health application.

- Common Components:
  - **Firebase Authentication Service** server, employed in order to perform and enforce authentication.
  - **Google Firebase** employed as a data source for the application logic, containing other needed data, such as profile information, in addition to the backup of the health data for each user (see table 3 FR 2.1) stored in Firebase Storage, Google Firebase service focused on storing user-generated content such as photos, videos, and other types of files.
  - A **Large Language Model** pre-trained and then fine tuned on the health data of the users employed to generate recommendation for the user.
  - A **Personal Computer** along with his operating system and a web application that allows to interact with the llm on administrator side to adjust recommendation as well as editing sentences that prompt the user into inserting data.

In addition to this architecture, the system can be further enriched by integrating a wearable device, that can be a very useful tool to gather data, as previously explained in section 1.2.2. In this scenario the wearable device will be connected to the smartphone:

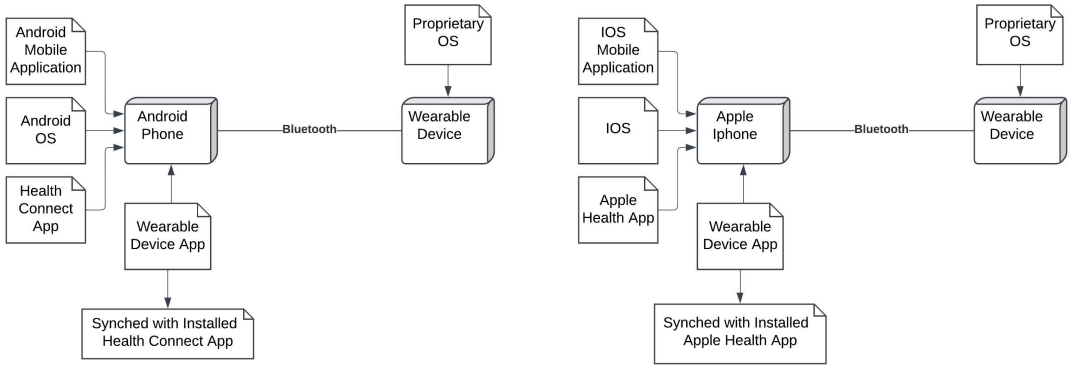

Figure 3: Overview of the Mobile System Architecture with Wearables.

In this case the architecture has been extended with the wearable devices, along with his operating system, that throuugh bluetooth connection can communicate with the smartphone (Android or IOS). On the smartphone side, the wearable application will be able to retrieve the data from the wearable device to then sync with the respective data management service (respectively Health Connect or Apple Health).

2.3 Technological Stack

3 Results

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List of Figures