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FIT4WORK

SELF-MANAGEMENT OF PHYSICAL AND MENTAL FITNESS OF OLDER WORKERS

CO-FUNDED BY

AAL PROGRAMME

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Prototype of the Fit4Work system

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Lead author: Maciej Bogdański, Poznań Supercomputing and Networking Center

Co-author: Cosmin Carjan, Teamnet

Jure Sorn, Jožef Stefan Institute

Aleksander Stroiński, Poznań Supercomputing and Networking Center

Cristian Neagu, Teamnet

Filip Manisor, Teamnet

Mitja Luštrek, Jožef Stefan Institute

Božidara Cvetković, Jožef Stefan Institute

Martin Gjoreski, Jožef Stefan Institute

Michał Kosiedowski, Poznań Supercomputing and Networking Center

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1 Introduction

The Fit4Work project aims at delivering an innovative system capable of detecting, monitoring and countering physical and psychological stress related to professional occupation of older adults. To this end the project has developed a system based on combination of state-of-the-art ICT, including such advanced technologies as wearable wellness sensors, ambient sensors, mobile devices, AAL middleware and cloud services. These off-the-shelf technologies are extended with specialized components able to collect, store and analyze physical and mental fitness related information in order to provide personalized recommendations and exercises through intuitive user applications. From the point of view of end users, the resulting product is a light-weight coupling of non-distracting devices with a smartphone and a watch-like wellness sensor forming the core of the personal wellness network.

The service provided this way makes it possible to continuously monitor oneself at work and manage one's own fitness thanks to highly motivating training participation scheme. As a result, Fit4Work supports increase in quality of life for end users and their health-related fitness, thus making them more eager to actively participate in their work. High quality of the proposed service model is ensured through collective expertise of the project consortium and through the fact that Fit4Work developments have been driven by end user participation at all stages of project implementation. In Fit4Work end users defined initial requirements, have continuously supported technological teams with their expert knowledge on ICT usability for older adults, have validated the system prototypes in two pilot trials and provided input for the market analysis leading to elaboration of a detailed business model. These users acted as representatives of the target group of Fit4Work solution users, which includes most persons aged 55 and more, actively occupied in paid and voluntary settings.

During the course of the project, two Fit4Work system prototypes have been developed and tested with representatives of target end users. User feedback gathered within those tests and evaluations has been thoroughly analyzed and resulted in changes, both on the early prototype testing stage on the way to the final version, as well as through updates from the date of publishing what was regarded as then final prototype. Those further updates were incorporated into the software and where necessary, also into this report.

In this document we present the details of implementation of both prototypes – the initial, early one (in Section 2) and the final one (in Section 3 – as available at the end of the project).

2 Early prototype

The early prototype focused on testing the initial overall system design related to usability and physical activity monitoring. In this paragraph we describe general functionality, system architecture processes and components involved in this version of the prototype.

2.1 General functionality

The following list includes high level user-facing system features of the early prototype:

- Monitoring user physical activity - based on two activity sensors – mobile phone and wearable wrist band
- Viewing current, daily, weekly and monthly results for physical activity based on pre-set daily and weekly physical activity goals
- Receiving instant recommendations - based on physical activity level compared to pre-set goals
- Receiving long term recommendations - based on physical activity level compared to pre-set goals
- Signing in into Fit4Work - using an existing user Google account
- Creating a Fit4Work profile

2.2 System architecture implementation

Below, we present the implementation architecture of the Fit4Work system (see Figure 2.1), which is based on the architecture described in (Carjan, C. et al, 2016). Only elements necessary for monitoring user's physical activity have been implemented in this early prototype version of the system.

The system consists of the following components:

- Mobile Gateway Application (or Mobile Application for short) – Fit4Work mobile application implemented on the Android platform (acting as the Mobile Gateway) (Google, 2017a)
- Activity Sensor – using Microsoft Band 2 fitness band (Microsoft, 2017)
- Cloud Integration Layer – Fit4Work cloud services gateway implemented in the Java language (Oracle, 2017) using the Spring Framework (Pivotal, 2017a)
- Data Storage – long term Fit4Work data storage using the Personal Wellness Record, implemented using Spring Framework (Pivotal, 2017a) and Spring Boot (Pivotal, 2017b)
- Google Firebase service (Google, 2017c) – service provided by Google and used for mobile application monitoring and analytics
- Google Identity Platform (Google, 2017e) – service provided by Google where Google Sign In is used for authenticating users within the Fit4Work system

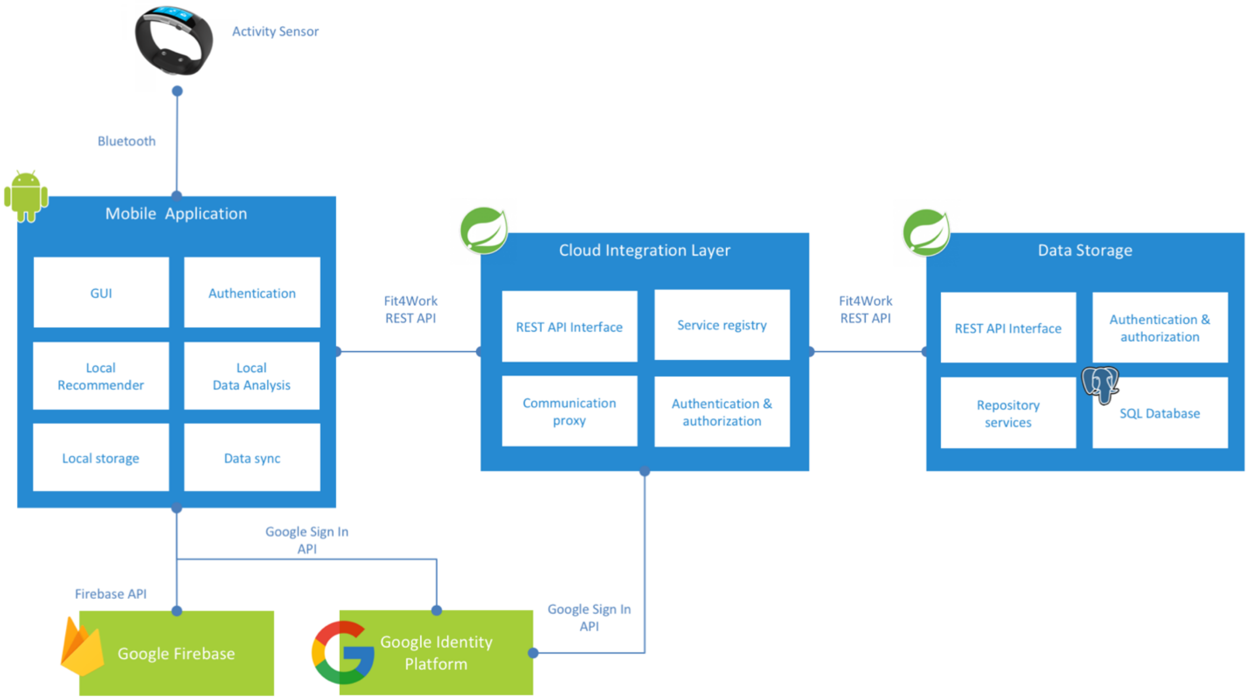

Figure 2.1 Early Fit4Work system prototype architecture implementation

2.3 Component communication

Fit4Work is a complex and distributed system whose individual components communicate with each other over the public Internet network. In order to ensure high level of security Fit4Work uses established industry standards.

System communication is conducted over encrypted secure connections, using the HTTPS protocol (Internet Engineering Task Force, 1999). Fit4Work's components (Mobile Application, Cloud Integration Layer and Data Storage) use Fit4Work-specific REST API, exchanging data in JSON format (Internet Engineering Task Force (IETF), 2014). This communication utilizes JSON Web Tokens (Internet Engineering Task Force (IETF), 2015) or HTTP Basic Authentication (Internet Engineering Task Force, 1999) for exchanging security information.

Communication with third party services is conducted over safe, encrypted connections as well, and is implemented using software libraries provided by those third parties.

2.4 Main processes

This paragraph presents main system processes involved in early prototype functionality in the context of components used and flow of information.

2.4.1 Monitoring user physical activity

User's physical activity is monitored with 2 sensors: Activity Sensor (Microsoft Band 2 wearable fitness band) and user's phone's accelerometer. Data from these two sensors is combined and analyzed by Local Data Analysis to recognized user's activity type (walking, running, standing etc.) and intensity level (low, moderate, high – expressed in METs). Those sensors can also be used independently (e.g. the user can only have their phone in the pocket and not wear the Activity Sensor and the system will still recognize their activity).

Local Analysis' output data, containing recognized user activities, is scored against pre-set physical activity goals (200 kcal of active burned calories + 10 minute walking streak for the daily goal, and 75 minutes of vigorous physical activity for the weekly goal). This data is shared both with the Mobile Application's GUI, to present it to the user, and stored in Local Storage, as well as Data Storage where it is sent by the Data Sync component through Cloud Integration Layer.

2.4.2 Viewing current, daily, weekly and monthly physical activity results

Mobile Application's GUI receives data related to user's physical activity levels and scores from the Local Data Analysis component through a set of standard local Android SDK component interfaces. This data is divided into period-based categories:

- Current and daily – today's user physical activity level (measured against the daily goal)
- Weekly – user's activity level based on the weekly goal
- Monthly – showing physical activity levels for each day of a specific month (each day measured against the daily goal)

2.4.3 Receiving instant recommendations

The outcome of the raw sensor data processing by Local Data Analysis (recognized user activities) is used by Local Recommender to generate appropriate, real-time user recommendations. Those recommendations are presented on the main screen of the Mobile Application. Mobile Application's GUI uses local Android SDK integration mechanisms to receive the recommendations from Local Recommender.

2.4.4 Receiving long-term recommendations

The outcome of data processing by Local Data Analysis component is also used by Local Recommender to generate appropriate long-term user recommendations (related to the whole day or week of user's activity). Those recommendations are presented on the day and week views of the Mobile Application, respectively. Mobile Application's GUI uses local Android SDK integration mechanism to receive the recommendations from Local Recommender.

2.4.5 Signing into Fit4Work

In order to improve user's experience with signing into Fit4Work, existing Google account of the user is used. When the Mobile Application is first started up, the user needs to sign in into the Fit4Work system using their Google account.

Mobile Application's Authentication component uses Android's existing software infrastructure during this process for dealing with creating a Google account, if necessary, and handling the sign in process (verifying user's identity by Google's services). The JWT security access token (Internet Engineering Task Force (IETF), 2015) obtained in this procedure is then used to make a sign-in request to Cloud Integration Layer (CIL) by the Authentication component. After authenticating the Google access token, CIL generates another, Fit4Work-specific JWT access token, which is securely stored on user's phone and subsequently used by Mobile Application whenever it needs to communicate with Fit4Work's cloud services through CIL.

2.4.6 Creating user profile

During the initial Mobile Application setup process, after the user has successfully signed into Fit4Work, the user is prompted to create a simple profile to improve recommendations generated by the system. This profile information includes user age, height, weight, gender and work type (active, sedentary) and is stored in Local Storage, and in Data Storage in the cloud, and used by Data Analysis.

2.4.7 Analytics and crash reporting

In order to improve user experience with the Mobile Application in future releases, and allow developers to gather useful information about how the application is used in real life, Firebase Analytics and Crash Reporting services are used (Google, 2017c).

Firebase Analytics provides anonymous statistical data pertaining to the app's usage (e.g. what options are often used by the users and which are used only rarely; what is the application's version distribution among users).

Firebase Crash Reporting collects information related to errors occurring within the application and allows developers to efficiently find and fix software bugs that could not be discovered during regular pre-release testing.

2.5 Component implementation

This section describes each of the implementation components high level functions and, where significant, technologies used.

2.5.1 Mobile Application

The Fit4Work Mobile Gateway Application, or Mobile Application for short, plays a central role in the system, in that it provides the user with access to the system and also feeds Fit4Work analytical components with data coming from sensors connected to the phone running the Mobile Application – the phone's and Activity Monitor's accelerometers.

The Mobile Application has been implemented on the Android Platform, using native Android SDK (supporting version 6 and 7 of the Android operating system) (Google, 2017a).

2.5.1.1 GUI

The graphical user interface layer of the Mobile Application provides the user with means of interacting with and navigating features of the Fit4Work system exposed to the end user. Certain user interface elements have been grayed out to indicated to the user they are not available in this version (see Figure 2.2).

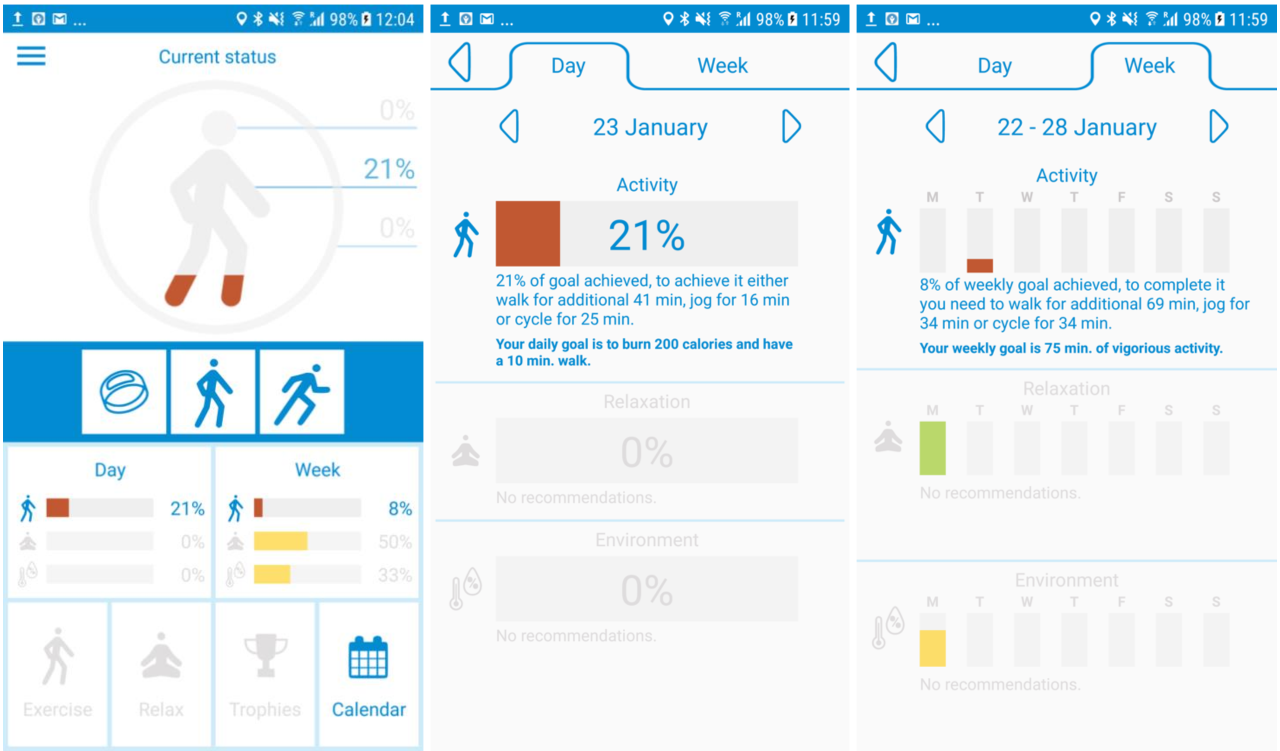

Figure 2.2. Early prototype Mobile Application – example screens

2.5.1.2 Authentication

This component is responsible for authenticating the user with the Fit4Work system – both, Google Sign In service and Cloud Integration Layer's authentication service are used to accomplish this. The Google account defined in the Android operating system of the phone is used to make it faster and easier for the user to sign in into Fit4Work.

2.5.1.3 Local Data Analysis

Local Data Analysis is composed of two major modules - the Preprocessing Module and Machine-Learning Module. The Preprocessing Module is responsible for detecting the presence of the sensor devices (checking if the user is wearing the Activity Monitor and if the smartphone is somewhere on the user's body, e.g. in their pocket), receiving and fusing the raw data from those devices and performing data transformation and feature extraction.

The Machine-Learning Module is responsible for utilizing the data as preprocessed by the Preprocessing Module to recognize activities, estimate energy expenditure and estimate mental stress (not enabled in the initial system prototype). For detailed description please refer to Deliverable 3.2.1/3.2.2 Data Analysis (Luštrek, M. et al, 2016).

2.5.1.4 Local Recommender

Local Recommender uses the results of the Data Analysis component to generate recommendations. In physical activity monitoring, the Local Recommender generates two types of recommendations, the daily recommendations and weekly recommendations. Daily recommendation is generated by utilizing daily results of the person's expended energy to calculate which activity should be performed by the user and the duration of the activity to reach the daily goal. Similar calculation is done for the weekly goal. For details, please see Deliverable 3.3.1/3.3.2 Recommendation System (Cvetković, B. et al, 2016)

2.5.1.5 Local Data Storage

This component is responsible for storing analyzed data on the mobile phone for faster access using Android's built-in database based on SQLite (Google, 2017g).

2.5.1.6 Data Sync

Component responsible for synchronizing analyzed data with Fit4Work's Data Storage. It communicates with Data Storage over the Cloud Integration Layer and user's Android's Sync Adapter mechanism (Google, 2017h).

2.5.2 Activity Sensor

Microsoft Band 2 (Microsoft, 2017) has been used as the Activity Sensor. The band collects user's physical activity sensor data and sends it over Bluetooth to the Mobile Application for analysis. The band is equipped with sensors such as and accelerometer, heart rate and heart rate variability as well as galvanic skin response. Signals from those sensors are used by Local Data Analysis in determining user's physical activity and mental stress (analysis has been limited to physical activity in the early prototype).

2.5.3 Cloud services

Fit4Work uses a number of cloud services performing backend operations necessary for the functioning of the whole system.

2.5.3.1 Cloud Integration Layer

Cloud Integration Layer (CIL) acts as a gateway to all Fit4Work cloud services (i.e. cloud service components implemented within the project). All communication between Fit4Work's components occurs through CIL which takes care of appropriate routing and communication security.

This component has been implemented using the Spring Framework (Pivotal, 2017a). It exposes a series of REST endpoints used by the Mobile Application and Fit4Work cloud services.

2.5.3.2 Data Storage

Data Storage is used for long-term data storage of user profiles, as well as wellness information analyzed by other Fit4Work components.

This component has been implemented using the Spring Framework (Pivotal, 2017a), and more precisely Spring Boot (Pivotal, 2017b), with an underlying PostgreSQL database (The PostgresQL Global Development Group, 2017).

More details about its implementation have been presented in Deliverable D5.5 (Stroiński, Bogdański & Kosiedowski, 2017).

2.5.3.3 Google Identity Platform

Google Identity Platform (Google, 2017e) is a third-party service provided by Google and allowing easy implementation of user authentication within the system.

2.5.3.4 Firebase

Firebase (Google, 2017c) is a third-party service provided by Google allowing Fit4Work to gather mobile application anonymous analytics and crash reporting data.

3 Final prototype

The final prototype implements all three main aspects of the Fit4Work system - physical activity monitoring, stress monitoring and ambient monitoring. General functionality, system architecture, main processes and components involved in this version of the prototype are presented below.

It is important to note that aside from planned functionality, this version of the prototype also includes changes based on user feedback collected during the test of the early prototype in Pilot 1. The final prototype description below focuses on changes and additions made compared to the early prototype.

3.1 General functionality

The following list presents high level user-facing system features of the final prototype:

- Monitoring user physical activity based on two activity sensors – mobile phone and wearable wrist band
- Monitoring user mental stress - based on sensors in the wearable wrist band
- Monitoring user ambient conditions - based on a standalone ambient sensor located at the user's workplace
- Setting custom physical activity goals
- Viewing current, daily, weekly and monthly results for:
    - users' physical activity,
    - mental stress,
    - and ambient conditions
- Receiving instant recommendations related to:
    - user's physical activity,
    - mental stress levels
    - and ambient conditions
- Instant recommendations made smarter and presented to the user at more appropriate times to minimize distractions
- Receiving long term recommendations based on:
    - user's physical activity levels,
    - mental stress levels
    - and ambient conditions
- Performing guided stress relief exercises
- Manually logging physical activities that were not monitored by Fit4Work
- Signing in into Fit4Work
- Creating a Fit4Work profile
- Receiving contextual help within the Mobile Application

3.2 System architecture implementation

Below, we present the implementation architecture of the Fit4Work system (see Figure 3.1) which is based on the architecture described in (Carjan, C., et al, 2016).

The system consists of the following components:

- Mobile Application – Fit4Work mobile application implemented on the Android platform (acting as a Mobile Gateway) (Google, 2017a)
- Activity Sensor – using Microsoft Band 2 fitness band (Microsoft, 2017)
- Ambient Sensor – using Netatmo personal weather station (Netatmo, 2017b)
- Desktop Application – desktop web application, providing optional and complimentary statistical Fit4Work information to the user, implemented in the JHipster framework (JHipster, 2017)
- Cloud Integration Layer – Fit4Work cloud services gateway implemented in the Java language using the Spring Framework (Pivotal, 2017a)
- Cloud Ambient Recommender – component processing Ambient Sensor data and generating ambient recommendations for the user
- Data Storage – long term Fit4Work data storage using the Personal Wellness Record
- Netatmo Connect – Netatmo developer service allowing to retrieve ambient sensor data (Netatmo, 2017a)
- Google Cloud Messaging (Google, 2017d) – used for sending push notifications to the Mobile Application
- Google Firebase (Google, 2017c) – service used for mobile application monitoring and analytics
- Google Identity Platform (Google, 2017e) – where Google Sign In service is used for authenticating users within the Fit4Work system

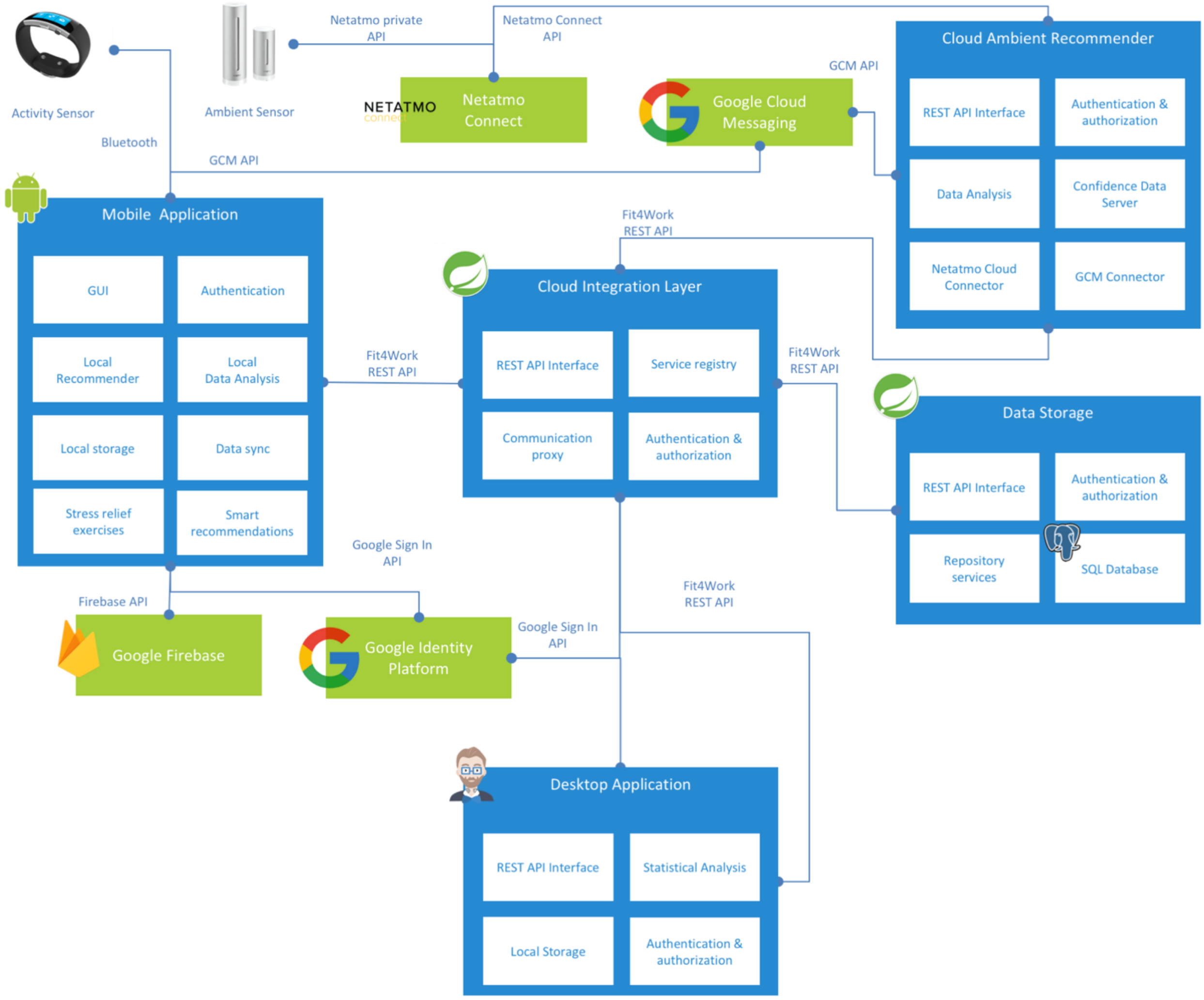

Figure 3.1. Final Fit4Work system prototype implementation architecture.

3.3 Component communication

Component communication has remained unchanged from the early prototype, as far as technologies and security measures used (see 2.3). The communication interfaces have been augmented with new endpoints added to accommodate new features.

3.4 Main processes

Main system processes are described below with the focus on changes and improvements made in the final version of the prototype.

3.4.1 Monitoring user physical activity

This process has remained largely unchanged from the early prototype version (see 2.4.1) except for minor changes allowing the user to set their own physical activity goals and manually log activities unmonitored by Fit4Work. Updated local Android interfaces between GUI and Local Data Analysis accommodate this system behavior.

3.4.2 Monitoring user mental stress

This process is mainly implemented by Local Data Analysis and Activity Sensor. Physiological signals, such as heart rate, heart rate variability and galvanic skin response, as well as context of current user's physical activity, are used to determine user's mental stress level.

Mental stress levels are saved in Local Data Storage and synchronized with cloud Data Storage (via CIL) using Data Sync.

For more details about mental stress monitoring please refer to deliverable D3.2.1/D3.2.2 (Luštrek, M. et al, 2016).

3.4.3 Monitoring user ambient conditions

Netatmo weather station is placed in user's office and sends data from its environment sensors to Netatmo Connect. This data is later periodically retrieved by Cloud Ambient Recommender, with the help of Netatmo Connector, and analyzed in order to calculate user's environmental well-being and predict the best course of action for the user increasing their environmental well-being. These actions are send as recommendations to Mobile Application as Android push notifications (through Google Cloud Messaging).

Data processed by Cloud Ambient Recommender is sent to Data Storage (through CIL) and synchronized with Mobile Application (through Data Sync).

For more details about mental stress monitoring please refer to deliverable D3.2.1/D3.2.2 (Luštrek, M. et al, 2016).

3.4.4 Viewing current, daily, weekly and monthly results for user activity

In addition to viewing current, daily, weekly and monthly physical activity scores (see 2.4.2), user mental stress and ambient comfort scores can now also be viewed for the same periods of time. This information is combined from Local Data Analysis and Cloud Ambient Recommender processing, presented in the Mobile Application and saved in Data Storage.

3.4.5 Receiving instant recommendations

The mechanism behind instant recommendations has remained largely unchanged from the early prototype (see 2.4.3). New recommendations related to mental stress and ambient comfort are now also generated and Cloud Ambient Recommender is involved in the process (see 3.4.3).

Mental stress recommendations are generated by Local Recommender (and sent to Mobile Application's GUI through local Android interfaces), whereas ambient comfort recommendations are generated by Cloud Ambient Recommender and sent to the Mobile Application through push notifications using the Google Cloud Messaging service.

3.4.6 Receiving long term recommendations

The mechanism behind long-term recommendations has also remained largely unchanged from the early prototype (see 2.4.4). Long-term recommendations now include mental stress and ambient recommendations and Cloud Ambient Recommender is involved in the process (see 3.4.3). The mechanism for their generation is similar to the one described above, in 3.4.5.

3.4.7 Performing guided stress relief exercises

A set of 8 guided stress relief exercises has been added in the Mobile Application to help the user with stress management. The GUI component of the Mobile Application communicates with Local Data Analysis to inform it that the user has started performing an exercise (the user can start the exercise on their own or be prompted to perform such exercise by the Mobile Application through an instant recommendation).

While the user is performing the exercise their heart rate and relaxation score are being monitored and presented at the end of the exercise. Each exercise is saved by the system in Local Storage and Data Storage (similarly to other user activities recognized by the system).

3.4.8 Manually log physical activities that were not monitored by Fit4Work

Sometimes the user may perform an activity, such as walking, running or swimming, without taking their phone or Activity Sensor with them. In order for the user to still be able to receive credit for such unmonitored activities, an option to manually log physical activities has been added to the Mobile Application.

The user can choose from 23 common activities (e.g. walking, running, aerobics, cycling, gardening etc). After logging one of such activities, its number of calories burned and active minutes is calculated by Local Data Analysis and added towards user's physical activity goals (daily and weekly). Those activities are saved in Local Storage and cloud Data Storage with a special flag marking them as added manually by the user.

3.4.9 Signing in into Fit4Work

This process has remained largely unchanged from the early prototype (see 2.4.5). The same process (of using an existing Google Account) is now also used by the Desktop Application.

3.4.10 Creating a Fit4Work profile

This process has remained unchanged from the early prototype (see 2.4.6). The user profile can now be updated by both the Mobile and Desktop Application.

3.4.11 Receiving contextual help within Mobile Application.

The user is now presented with certain help screen overlays explaining main elements on some Mobile Application screens. This can happen automatically during the first time user sees a particular screen, but can also be triggered manually by the user, and is fully implemented by the Mobile Application GUI component.

3.4.12 Analytics and crash reporting

This process has remained unchanged from the early prototype (see 2.4.7).

3.4.13 Viewing statistical information in Desktop Application.

The final prototype of the Desktop Application has added a Statistical Analysis module. The module receives the user's data from Data Storage and builds four types of visualizations based on it:

- Activity – the number of minutes spent by the user per activity type. The activity breakdowns can be done per day, week, and month or for total activities.

- Calories – the total number burned by the user. The number of burned calories can be viewed per day, week or month.
- Intensity – the intensity of the user's activities. The activity intensity is shown for a certain day.
- Wellbeing – the evolution of the user's physical wellbeing score.

3.5 Component implementation

This section describes each of the implementation components high level functions and, where significant, technologies used. It focuses on changes made compared to the early prototype version of the system.

3.5.1 Mobile Application

The Mobile Application has been extended with new features provided by Fit4Work:

- Mental stress monitoring
- Ambient conditions monitoring
- Guided stress relief exercises
- Smart recommendations
- Ability to set custom physical activity goals
- Contextual help
- Manually logging unmonitored physical activities

The same technologies have been used to implement the Mobile Application (see 2.5.1)

3.5.1.1 GUI

The user interface style has remained unchanged. New added features required changes in existing views and additions of new ones. Figure 3.2 presents selected example screens of the Mobile Application.

3.5.1.2 Authentication

The authentication component is the same as in the early prototype (see 2.5.1.2).

3.5.1.3 Local Recommender

Local recommender was changed according to the feedback from users. The physical activity monitoring recommendations use user's weight to calculate the daily goal and the walking streak goal has been removed.

Mental stress instant and long-term recommendations have been added.

Detailed description is in deliverable D3.3.1/3.3.2 (Cvetković, B., et al, 2016)

3.5.1.4 Local Data Analysis

This component has not been changed in the final prototype, except for enabling stress monitoring. Please refer paragraph 2.5.1.3 and deliverable D3.2.1/D3.2.2 (Luštrek, M., et al, 2016) for more details.

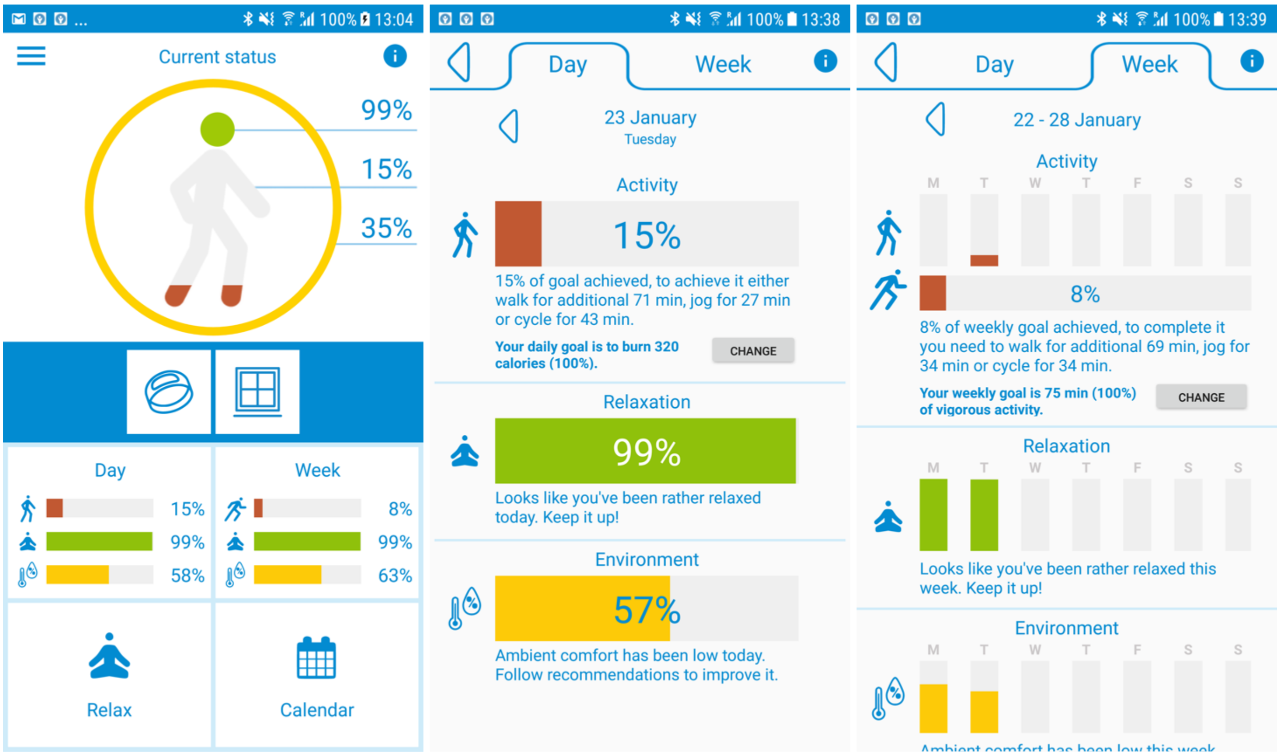

Figure 3.2. Final Mobile Application prototype - example screens.

3.5.1.5 Local Storage

This component has largely the same features as in the early prototype (see 0). New data related to mental stress and ambient monitoring is now being stored by it as well.

3.5.1.6 Data Sync

This component is technologically the same as the one in the early prototype (see 2.5.1.6). It has been extended to include mental stress and ambient monitoring data (within a pre-established data model).

3.5.1.7 Stress Relief Exercises

This component includes locally stored definitions of guided breathing and muscle relaxation exercises. Each exercise has a name, short description and consists of a series of steps, each with its own voice instruction, pre-set duration and an image (see Figure 3.3).

A series of local Android interfaces between this component and Local Data Analysis have been defined in order to let Local Analysis know the user is performing a stress relief exercise, and also to retrieve the recommended stress relief exercise, as well as exercise summary details from Local Data Analysis.

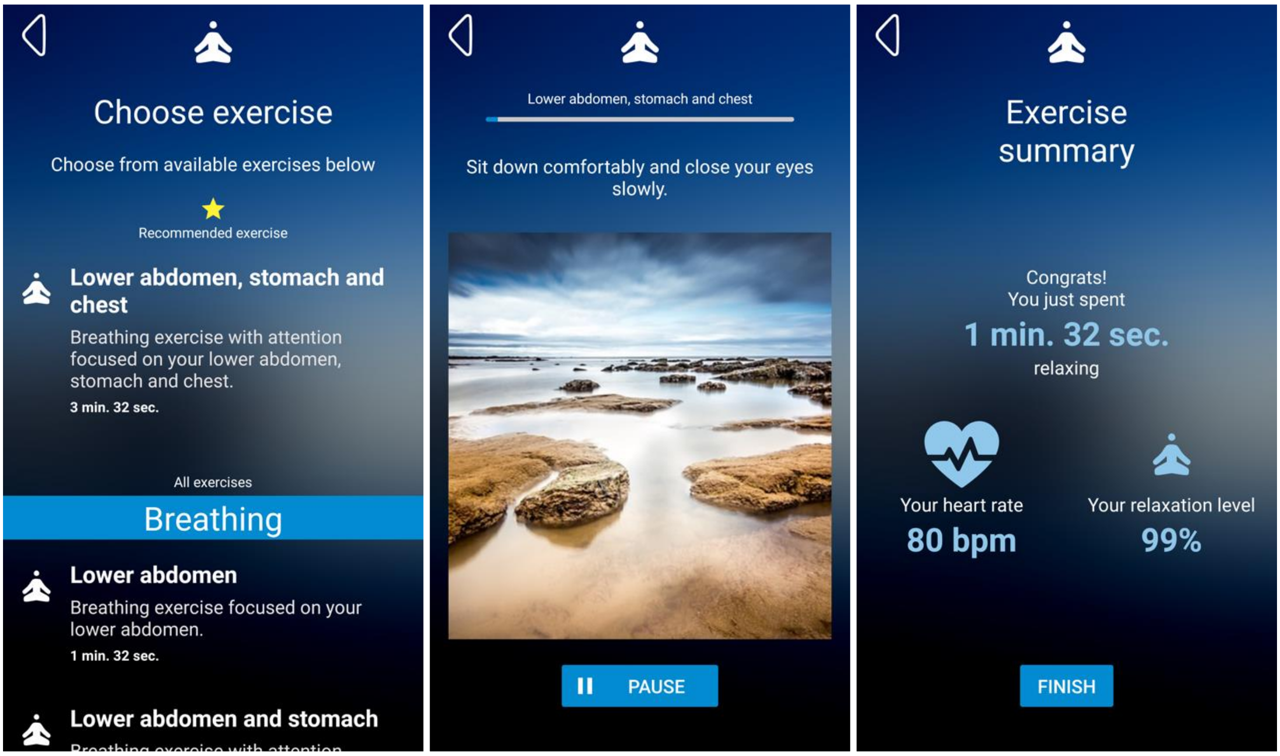

Figure 3.3. Guided stress relief exercises - example screens.

3.5.1.8 Smart Recommendations

In order to improve user experience with recommendations generated by the Fit4Work system, a Smart Recommendations component has been introduced. As an input, it takes recommendations generated by Local Recommender or Cloud Ambient Recommender and decides whether to show them to the user at a particular time or not, based on pre-defined set of conditions. The conditions take into account the time of day, day of the week (weekday or weekend), user location and whether or not particular recommendation had been shown to the user recently. Figure 3.4 shows the Smart Recommendations component from the user perspective.

This component also utilizes Android system notifications to communicate new recommendations to the user when they are not using the Mobile Application (Google, 2017f).

3.5.2 Desktop Application

The Desktop Gateway Application, or Desktop Application for short, serves as an additional source of knowledge about overall well-being for the Fit4Work user. It focuses on providing information related to physical activities and wellbeing to the user, by performing statistical analysis on the data from the Data Storage and including the results in easily understandable visualizations (see Figure 3.5).

The Desktop Application has four main parts:

- Authentication & Authorization module
- REST API interface
- Statistical analysis module

- Local storage

The Desktop Application is developed using technologies from the JHipster technology stack (JHipster, 2017): AngularJS (Google, 2017b), Bootstrap (Bootstrap, 2017), Spring Boot (Pivotal, 2017b) and Spring (Pivotal, 2017a).

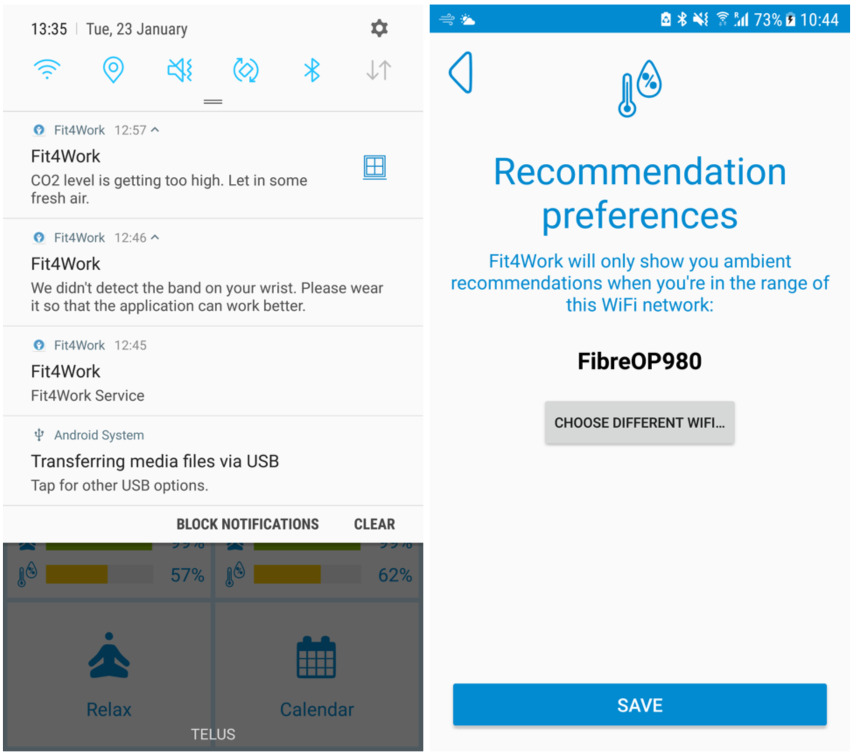

Figure 3.4. Recommendation experience improvements - example screens.

3.5.2.1 Authentication & Authorization

The Authentication & Authorization component checks the identity of the user within the Fit4Work system, in order to grant access and match the corresponding data from the Data Storage. The Desktop Application uses Google accounts for its users and the Google Sign in service for authentication. The process is similar to the one used by the Mobile Application, which has been described previously.

The features of the Desktop Application can only be accessed by an authenticated user. After the user is done navigating, the application offers him the option to sign out of his Fit4Work account.

3.5.2.2 REST API interface

The REST API interface is responsible for communication between the Desktop Application and the Data Storage. After the user is authenticated in the Fit4Work system, the REST API connects to the database and queries it for the user’s corresponding data. It then handles the transfer of the data to the Desktop Application, so that it can be used in statistical analysis.

Figure 3.5. Desktop Application – example screens showing calories burned

There are two types of data passed through the REST API. The first type is related to the user's profile, such as name, weight or height. The user's profile information can also be edited in the Desktop Application, in which case the REST API handles the modifications. The second type of data is regarding the user's activity and wellbeing, which is used for statistical analysis.

3.5.2.3 Statistical Analysis

The Statistical Analysis module transforms the user's raw data into easily understandable statistics and visualizations. The raw data contains information regarding user's activity and wellbeing. After data analysis, the module produces four types of visualizations for each user:

- Activity – the types of activities the user is engaged in
- Burned calories – the number of calories burned per time interval
- Activity intensity – the intensity of the user's activities
- Wellbeing – the evolution of physical wellbeing of the user

Some of the visualizations are produced for several types of time intervals: daily, weekly, monthly or all time. The user can navigate through time interval and view the corresponding statistics.

3.5.3 Activity Sensor

Data related to user's physical and mental stress activity is streamed by Microsoft Band 2 (Microsoft, 2017) over Bluetooth to the Mobile Application where it is analyzed in real-time by the Local Data Analysis component.

3.5.4 Ambient Sensor

The Netatmo weather station has been used for monitoring user's ambient conditions at their workplace (Netatmo, 2017b). The sensor is placed in the room the user spends most of their time at work and connected to local Wi-Fi network in order to able to send sensor data to Netatmo's services over proprietary protocol. This data can later be accessed by the Cloud Ambient Recommender periodically querying Netatmo's services using a REST based API defined by Netatmo (Netatmo, 2017a).

3.5.5 Cloud services

Fit4Work's set of used cloud services has been extended in the final prototype to accommodate new functionalities relating to mental stress and ambient monitoring.

Below, we describe each cloud component, again, focusing on changes introduced in the final prototype.

3.5.5.1 Cloud Integration Layer

The Cloud Integration Layer's functions and implementation have remained the same in the final prototype (see 2.5.3.1).

3.5.5.2 Data Storage

New endpoints for fetching data by the Cloud Ambient Recommender and Desktop Application have been added. Otherwise, this component has remained unchanged from the early prototype (see 2.5.3.2).

3.5.5.3 Cloud Ambient Recommender

This component has been introduced to allow for long-term, resource-intensive processing of ambient data collected by the Ambient Sensors and for generating appropriate recommendations for the users.

3.5.5.3.1 REST API Interface

This API component is used for communicating with GCM (Google, 2017d), Netatmo Connect (Netatmo, 2017a) and with Data Storage.

3.5.5.3.2 Data Analysis

Data Analysis uses all collected ambient sensor data for processing current state of user's office environment. With help of machine learning models and user experience, it decides what is the best recommended action for this current state.

3.5.5.3.3 Authentication and authorization

The REST API Interface is secured by Basic Authentication (Internet Engineering Task Force, 1999) for communicating with Data Storage. Netatmo Connect API (Netatmo, 2017a) uses the OAuth 2.0 protocol, which is an (Internet Engineering Task Force, 2012) industry-standard protocol for authorization.

3.5.5.3.4 Confidence Data Server

Confidence Data Server represents a storage collecting all processed data from Data Analysis, storing all data from Netatmo sensors and containing authorization data for accessing Netatmo Connect API (Netatmo, 2017a).

3.5.5.3.5 Netatmo Cloud Connector

Netatmo Cloud Connector implements the logic of communicating with Netatmo Connect (Netatmo, 2017a) and converting ambient sensor data received from Netatmo for processing by Data Analysis.

3.5.5.3.6 GCM (Google Cloud Messaging) Connector

This component implements the logic of communicating with GCM (Google, 2017d) in order to send appropriate ambient conditions related recommendations to Mobile Application(s) in form of push notifications.

3.5.5.4 Netatmo Connect

This component is a cloud service offered by Netatmo (Netatmo, 2017a) to allow registered developers and applications to access data from specific Netatmo weather stations (Ambient Sensors). Netatmo Connect Connector is communicating with this component to periodically download new data collected by Fit4Work Ambient Sensors. The communication protocol is defined by Netatmo and based on a REST API using data in the JSON format.

3.5.5.5 Google Cloud Messaging

Google Cloud Messaging service provided by Google (Google, 2017d) is used to send push notifications to Mobile Applications. In the final prototype this component is used by the Cloud Ambient Recommender to send ambient monitoring related recommendations to users' Mobile Applications.

3.5.5.6 Google Identity Platform

This component's (Google, 2017e) use is the same as in the early prototype (see 2.5.3.3), the only difference being that it is now used by the Desktop Application as well during a user sign-in process.

3.5.5.7 Firebase

This component (Google, 2017c) is used for the same purposes as in the early prototype (see 2.5.3.4). Events related to new Fit4Works system features in the Mobile Applications have been added to user analytics (accessing new screens, generating new recommendations etc.).

4 Summary

This document describes two versions of the Fit4Work system prototype as developed in the scope of the project. Both versions have been tested with end users. The user feedback and analytics data has been used to extend and improve the system between the early and final prototypes. Those changes have been highlighted above.

We also presented high level details of implementation, communication and processes related to various components and functionalities developed for Fit4Work prototypes.

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