ELF@Home

Elderly sELF-care based on sELF-check of health conditions and sELF-fitness at home

D2.3 General Architecture Design

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Abstract

This document contains the results of task 2.5 of the ELF@Home project and describes the planned general architecture of the system. The general architecture is divided into seven functional blocks: health sensors, activity sensor, fitness box, evaluation unit and planning engine, web interface, database and integration services. Each block is described detailing use cases, communication interfaces and sub-modules. The design presented in this report is an initial version of the final architecture design that will be improved during the technological development in work packages WP3, WP4 and WP5.

Executive Summary

This document describes the general architecture design of the ELF@Home system. Seven functional blocks were identified during the execution of the task 2.5:

- Health sensors: sensors to acquire medical variables of the user.
- Activity sensor: sensor to acquire the activity level of the user.
- Fitness box: device connected to the TV to provide the user interface.
- Evaluation unit and planning engine: implementation of all the intelligence needed in the solution.
- Web interface: interface for caregivers.
- Database: storage of users' information.
- Integration services: services to guarantee the integration of all the functional blocks.

Each functional block is detailed in this document describing its sub-modules, use cases and the communication interfaces needed to guarantee the solution functionality.

Document Information

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Abstract (for dissemination)	This document contains the results of task 2.5 of the ELF@Home project and describes the planned general architecture of the system. The general architecture is divided into seven functional blocks: health sensors, activity sensor, fitness box, evaluation unit and planning engine, web interface, database and integration services. Each block is described detailing use cases, communication interfaces and sub-modules. The design presented in this report is an initial version of the final architecture diagram that will be improved during the technological development in work packages WP3, WP4 and WP5.
Keywords	general architecture design, technological components

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Abbreviations

AS: Activity level sensor

BT: Bluetooth

DB: Database

EDR: Enhanced data rate

EU&PE: Evaluation unit and planning engine

FB: Fitness box

GUI: Graphical user interface

HS: Health status sensors

IS: Integration services

ISP: Intelligent service platform

REST: Representational state transfer

RFID: Radio frequency identification

WS: Web service

1 Introduction

Figure 1 shows the general architecture design proposed for the ELF@Home system. This system could be divided into seven functional blocks:

- **Activity sensor**. The activity sensor (AS) must measure the user activity and send it to the intelligent service platform (ISP). The main objective of this sensor is to monitor the outdoor fitness sessions evaluating the user performance and health conditions.

  2DD will be in charge of the activity sensor design and its integration in the ELF@Home system studying and developing the required data gateway services.

- **Health sensors**. The health sensors (HS) must measure the user health status and send it to the intelligent service platform (ISP). Using the health sensors, the health status of the user must be analysed to provide personalized fitness programs.

  EXP will be in charge of the health sensors selection and their integration in the ELF@Home system studying and developing the required data gateway services.

- **Fitness box**. The fitness box (FB) must provide the user interface to access to the ELF@Home system. The fitness box will be connected to a TV and a computer vision system to provide the interface to the user guiding the sensors use, providing the fitness programs and evaluating the right execution of the exercises. Fitness box must also integrate data gateways to collect sensor information (health status and activity level) and send it to the ISP.

  CTIC will be in charge of the fitness box designing the user interface and the computer vision system.

- **Evaluation unit and planning engine**. Using the information provided by the activity sensor, the health sensors, the user performance and relevant information from the user profile, the evaluation unit and planning engine (EU&PE) must plan personalized exercises to the users.

  IIS will be in charge of the design and implementation of this module.

- **Web interface**. Formal and informal caregiver access to the ELF@Home system by a web interface to manage and supervise user performance and health conditions.

  IZER will be in charge of the web interface design.

- **ELF@Home database**. The ELF@Home database must describe all the collected information, the exercises catalogue and the exercises plan for each user.

  IZER will be in charge of the database design and it will be deploy in Sweden in a server managed by EXP.

- **Integrations services**. To integrate all the functional blocks, integrations services must be designed. These services must guarantee the communication between all the functional blocks of the ELF@Home system.

  IZER will be in charge of the integration services development according to the guidelines given by each technological partner (2DD, EXP, CTIC and 2DD).

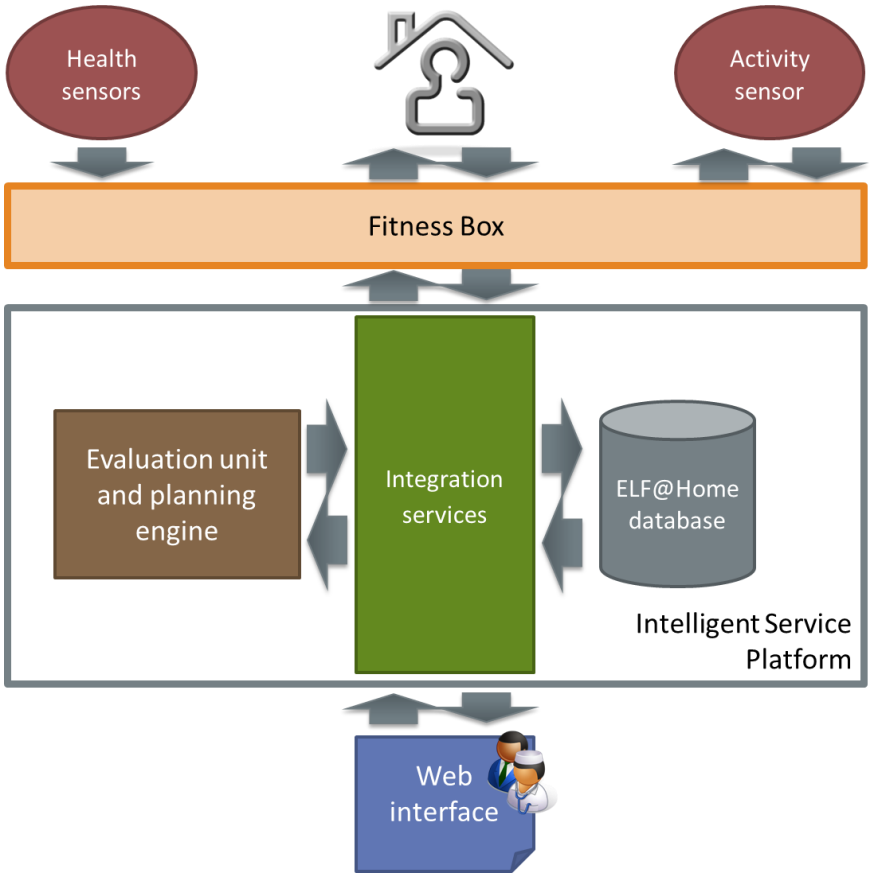


Figure 1: Functional blocks of the ELF@Home system

2 Activity sensor

2.1 Description

2.1.1 Design

The purpose of the activity sensor is to record health exercise data in outdoor exercise scenarios. Figure 2 shows the design of the activity sensor. The activity sensor is an autonomous unit with a power supply, sensor elements, memory for storing recorded data, a possibility for providing visual and haptic feedback to the user and a wireless communication interface for connecting to external sensors and for transferring recorded data to the fitness box. Because charging and data transfer will be via wireless interfaces, the activity sensor could have a watertight housing with no openings which makes it especially suited for outdoor exercises.

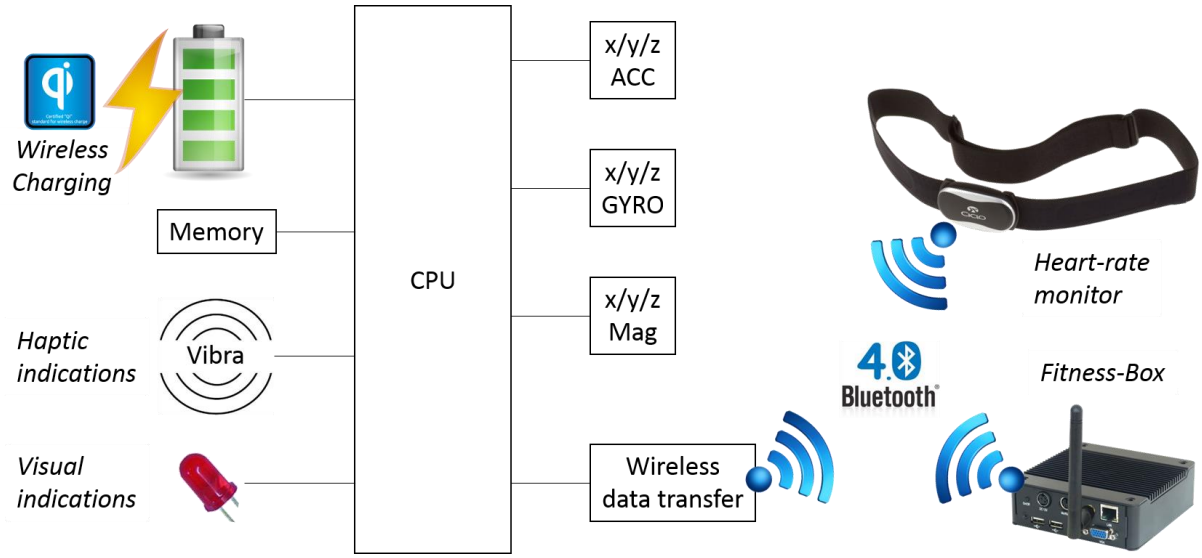


Figure 2: Activity sensor design

The internal sensor elements are:

- Three-dimensional acceleration sensor
- Three-dimensional gyroscope
- Three-dimensional magnetometer

The only external sensor currently considered is a heart-rate sensor which will connect via Bluetooth.

2.1.2 Functionalities

This section describes the functionalities of the activity sensor in three situations: starting an outdoor exercises session, during an outdoor exercises session and after an outdoor exercises session.

2.1.2.1 Starting a training session

1. Activity-Sensor (AS) is lying on the wireless charging station. Battery will be loading/is loaded. AS is connected to the Fitness Box (FB) via Bluetooth (BT).
2. The user starts an outdoor activity. FB programs AS with needed settings (limits for heart rate, measurement rate for sensor).
3. AS vibrates to indicate that it is now ready for recording.
4. The user picks up the AS. When the AS detects movement it starts looking for the heart rate monitor. If found it starts a BT 4.0 (low energy) connection to it.
5. Then the AS starts recording automatically.

2.1.2.2 During a training session

1. The AS constantly records the activity.
2. If a limit value, e.g. maximum recommended heart rate is reached the user is informed by this by vibrating alarm.
3. If the recommended time limit is reached the user is informed by vibrating alarm.

2.1.2.3 Finishing a training session

1. The user puts the AS onto the wireless charging station.
2. When charging has started the AS will end its connection with the heart rate monitor.
3. After that, it opens a BT 2.1 EDR (high speed) connection to the FB.
4. Once the connection is established the AS will download all recorded data to the FB.
5. After the download has finished the AS will clear its internal memory.

2.2 Use case and interaction diagram

Figure 3 shows the use case of the activity sensor. The activity sensor must *"evaluate outdoor exercises"* taking into account the outdoor exercises program (*"ask for outdoor exercises"*) and checking the user health measures (*"check health measures"*). Each outdoor exercises program has health thresholds that must be evaluated during the exercises execution to guarantee a healthy performance. The activity sensor must also *"send activity data"* to the ELF@Home system that will be used in the evaluation unit and planning engine (EU&PE) for the evaluation of the outdoor exercises performance.

An overview of the required web services (WS) for the activity sensor is shown in Figure 4.

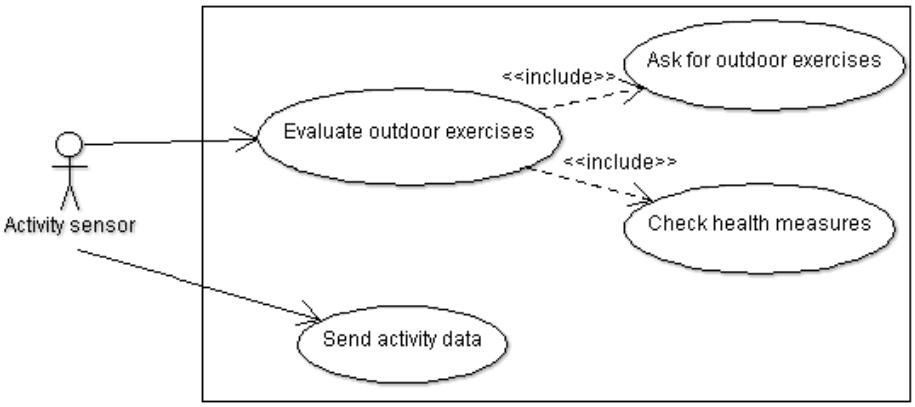


Figure 3: Activity sensor use case

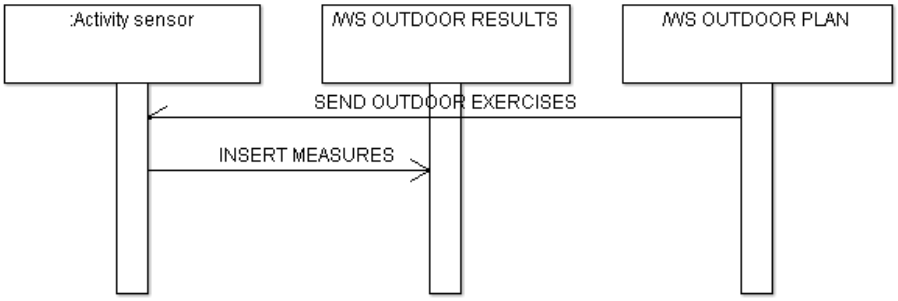


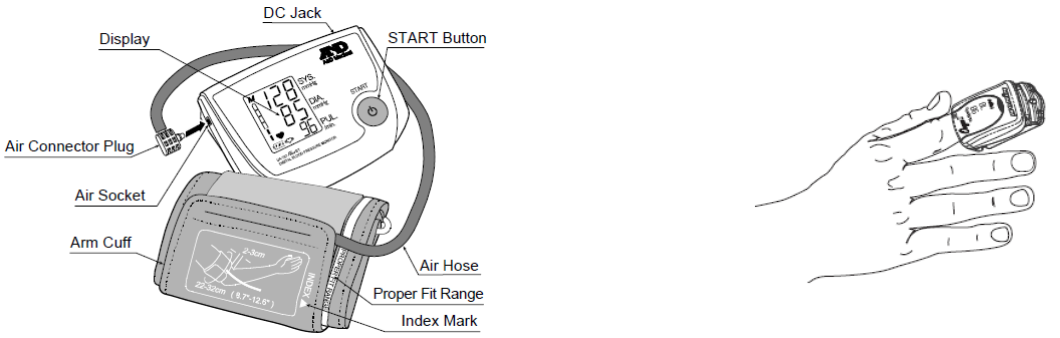
Figure 4: Activity sensor interaction diagram

3 Health sensors

3.1 Description

Health status will be defined using two health sensors (HS): a blood pressure monitor (Figure 5.a) and a pulse oximeter (Figure 5.b). These sensors will be connected via Bluetooth with the fitness box. The fitness box will integrate a health sensors data gateway to receive health sensors data and send it to intelligent service platform (ISP).

Figure 6 shows the diagram of the health sensors data gateway and a way of handling the measurement data from the health sensors. The main program of the fitness box (GUI) will display instructions for the user about how to take a measurement. In a background thread, the main program will create a new object (depending on health sensor) and call the *"Connect"* method. When a connection has been established between the sensor and the fitness box the background thread will call the *"GetPackage"* method to obtain the values from the health sensor. The GUI will display the measure (or tell the user the measurement was ok) and send the values to the ISP. All these services will be integrated in the fitness box by a health sensors data gateway.



(a) **(b)**

Figure 5: Health sensors

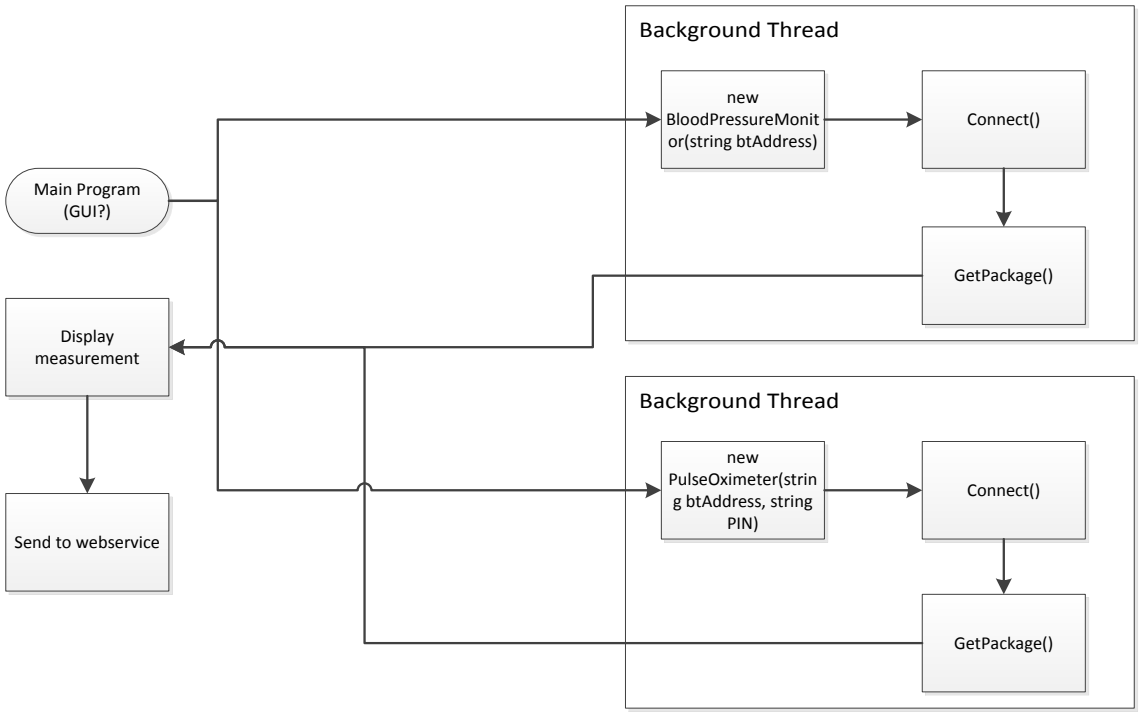


Figure 6: Health sensor data gateway architecture diagram

3.2 Use case and interaction design

Figure 7 shows the use case diagram of the health sensors. They only must *"send data"* to a web service as it is shown in Figure 8.

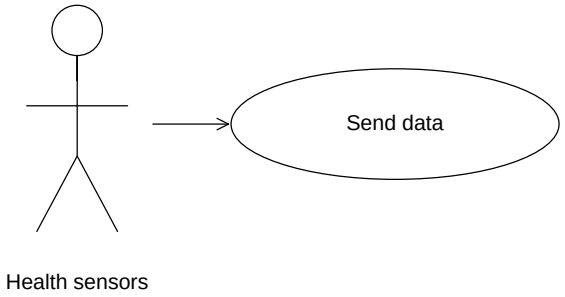


Figure 7: Health sensors use case diagram

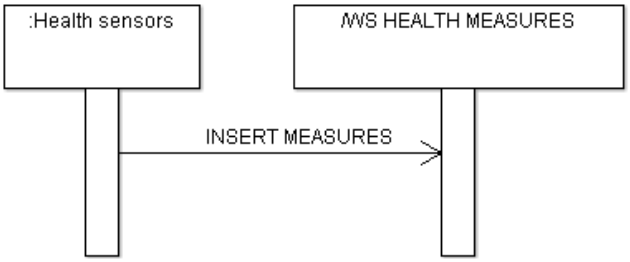


Figure 8: Health sensors interaction diagram

4 Fitness box

4.1 Description

The fitness box (FB) is the device connected to the user TV to access to the ELF@Home system. The fitness box must provide the user interface (GUI logic) guiding the user to use the health sensors and evaluating the right execution of the exercises. The fitness box must also integrate the health sensors and the activity sensor data gateway. Figure 9 shows the general architecture of the fitness box.

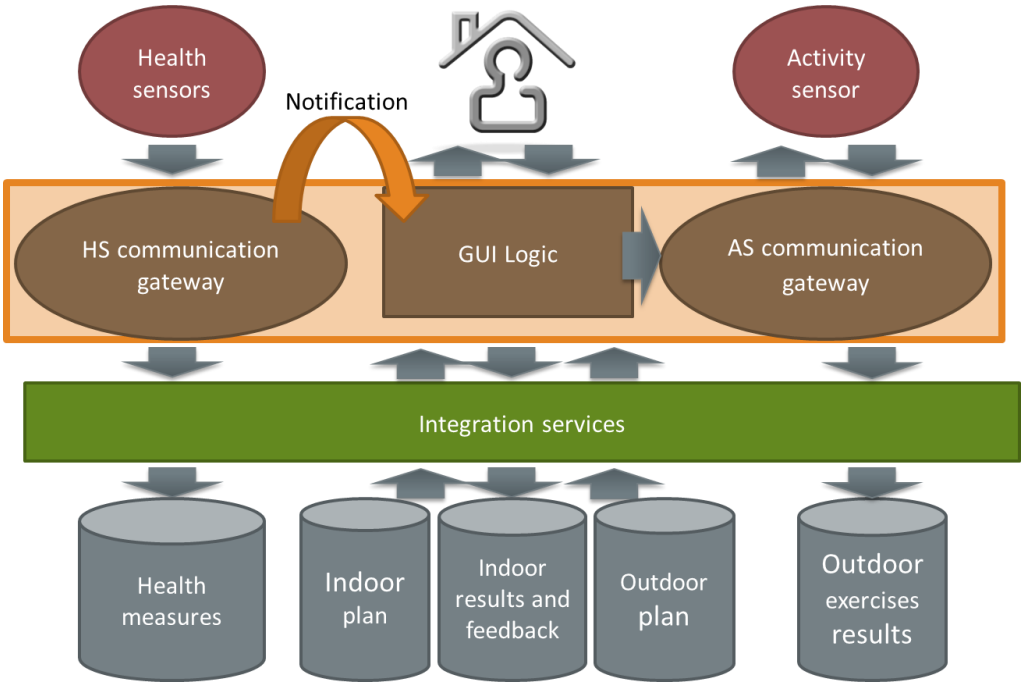


Figure 9: Fitness box architecture diagram

4.2 Use case and interaction diagram

Figure 10 describes the use case of the fitness box and Figure 11 its interaction diagram. Fitness box must:

- *"login"* users using a RFID card and allows them to access to the ELF@Home system.
- *"display health variables measurement instructions"* asking for the health variables that it is necessary to measure and giving instructions to use the health status sensors
- *"display indoor exercises"* using the TV if the user has the right start conditions. Fitness box must also guide users to do the exercises and evaluate its performance.
- *"display feedback questions"* after each exercise, asking users feedback questions about the exercises.
- *"display planned outdoor exercises"* sending the outdoor fitness plan to the activity sensor.
- *"display health status"* and "*display exercise performance*". Users using the fitness box must have access to its health status and to its exercise performance.

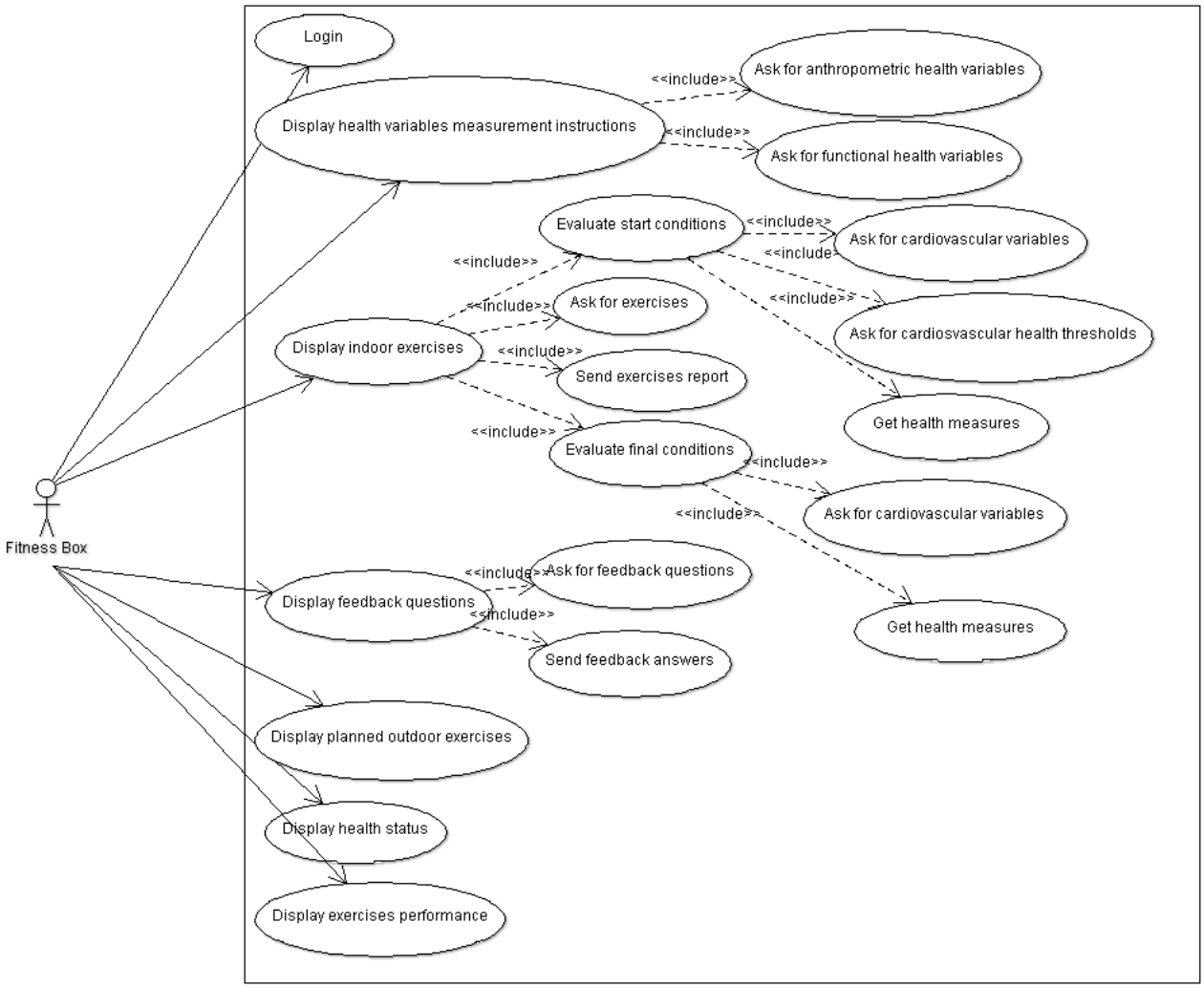


Figure 10: Fitness box use case diagram

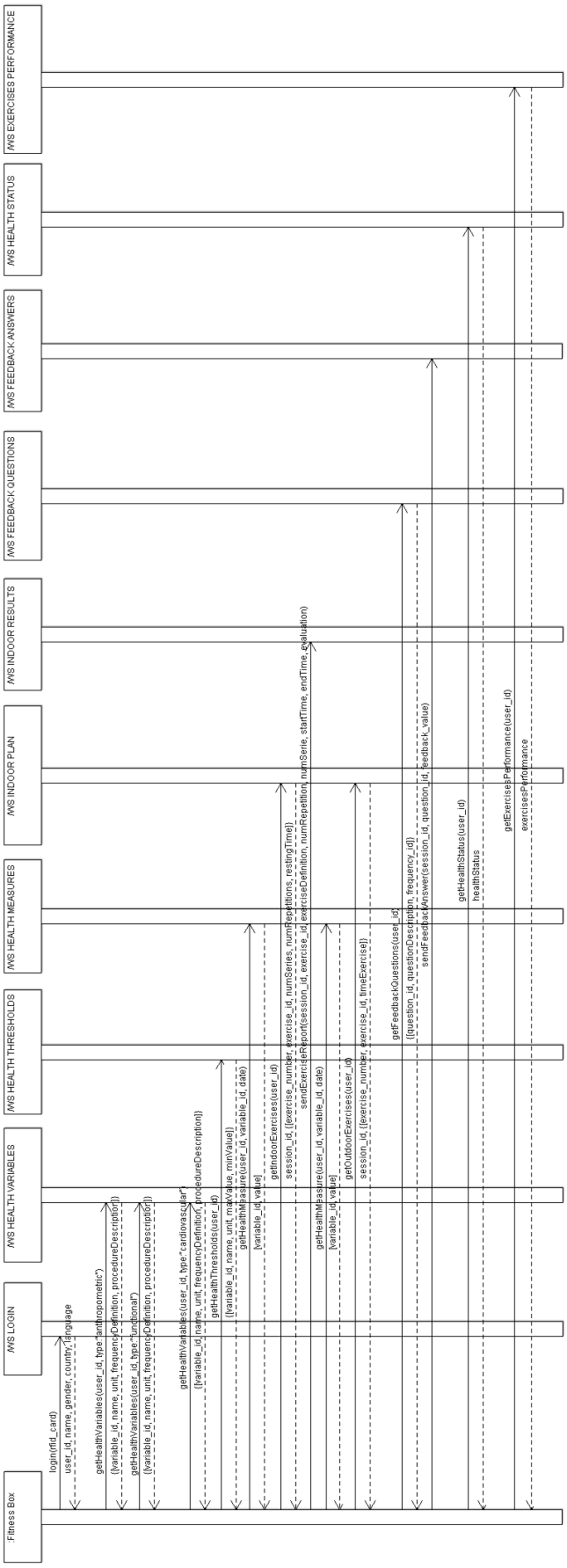


Figure 11: Fitness box interaction diagram

5 Evaluation unit and planning engine

5.1 Description

The evaluation unit and planning engine (EU&PE) is the module inside the intelligent service platform (ISP) in charge of calculate the health thresholds to decide if a user can or not do exercises and to set the indoor and outdoor exercises plan.

5.2 Use case and interaction diagram

Figure 12 shows the use case of the evaluation unit and planning engine. This functional block must calculate the health thresholds (*"set health thresholds"*) according to the user characteristics. Also, it must associate an outdoor and an indoor exercises plan to a user according to his health status and its exercises reports (*"set exercises plan"*). The idea is to give a personalized exercise plan according to the user characteristics: health status and exercises execution. The logic to decide the association will be further studied during the following work packages.

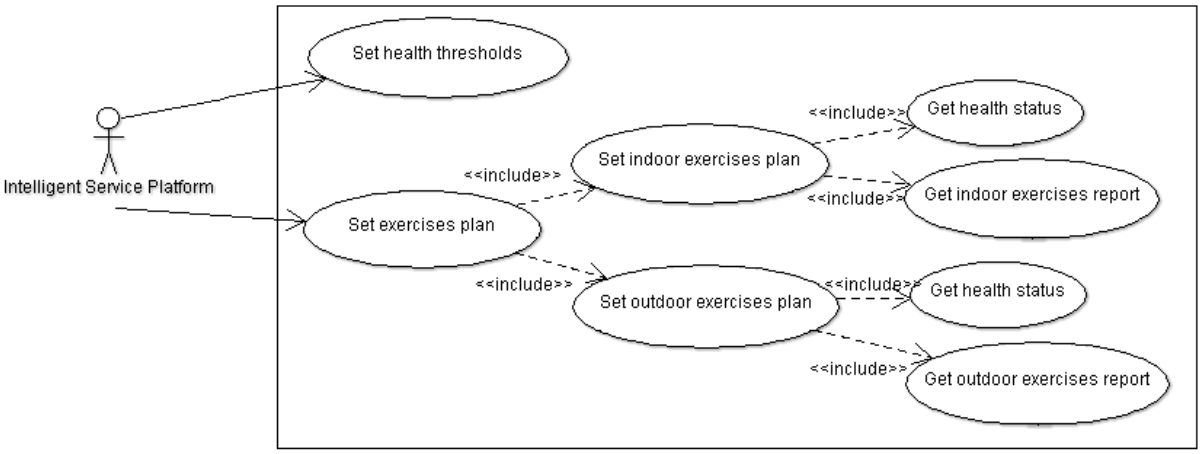


Figure 12: Evaluation unit and planning engine use case

Figure 13 shows the interaction diagram for setting the health status (Figure 13.1) and refreshing the thresholds of the users' health variables (on a monthly basis, Figure 13.2a) and/or triggered by the users' birthday (Figure 13.2b).

Figure 14 describes the interaction diagram for setting the new indoor plan (Figure 14.3) and calculation of the users' indoor exercise performance (Figure 14.4). The calculation of a new indoor plan could be triggered optionally by a request or automatically done on a weekly basis. This decision will be taken during the work package WP5 execution.

Figure 15 shows the interaction diagram for setting the new outdoor plan (Figure 15.3) and calculation of the users' outdoor exercise performance based on the raw data (at least for the development phase and before the transfer of the algorithms to the activity sensor, Figure 15.4). Step one in Figure 15.3 can be triggered optional by a request or automatically done on a weekly basis.

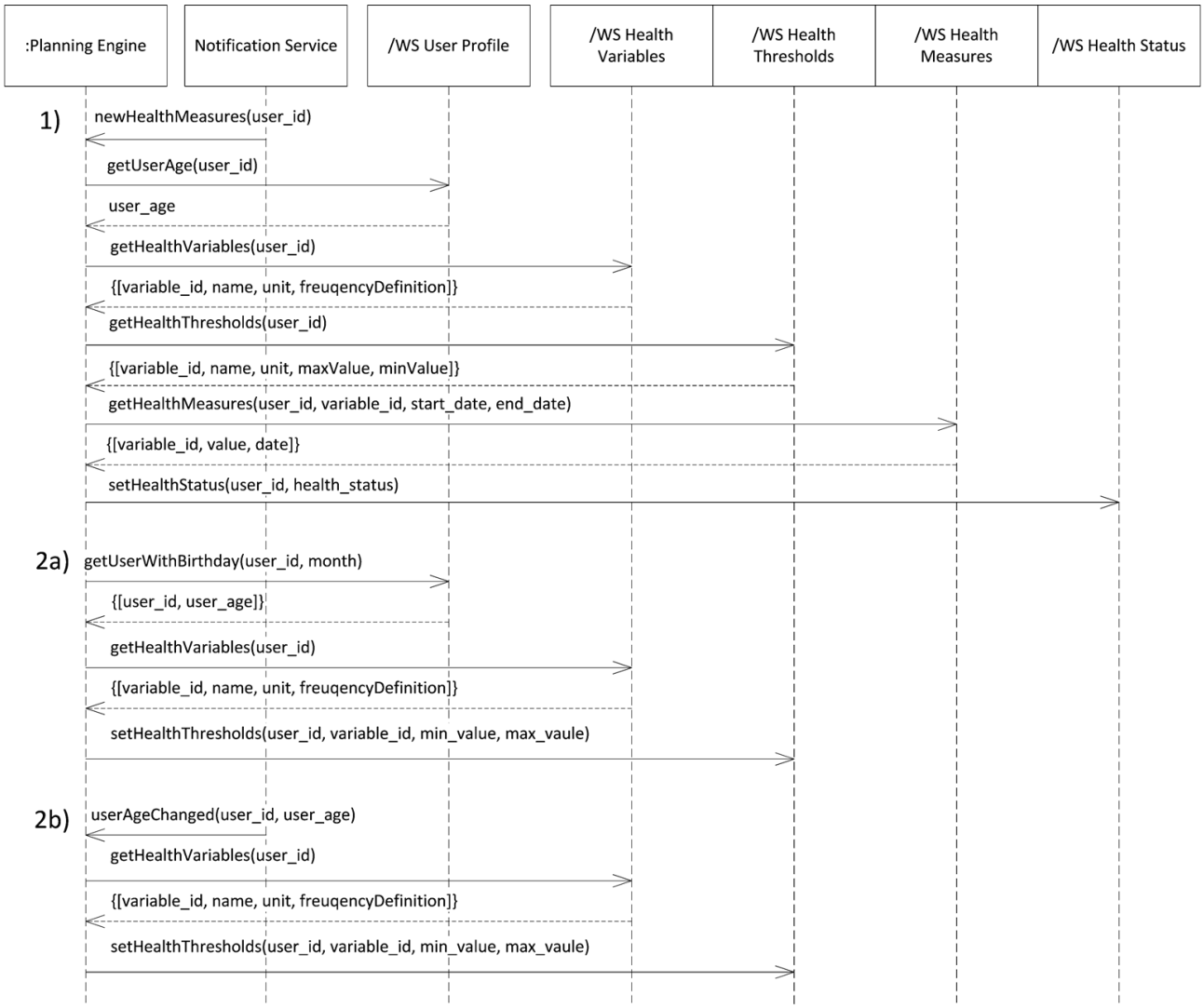


Figure 13: Evaluation unit and planning engine interaction diagram – set health thresholds

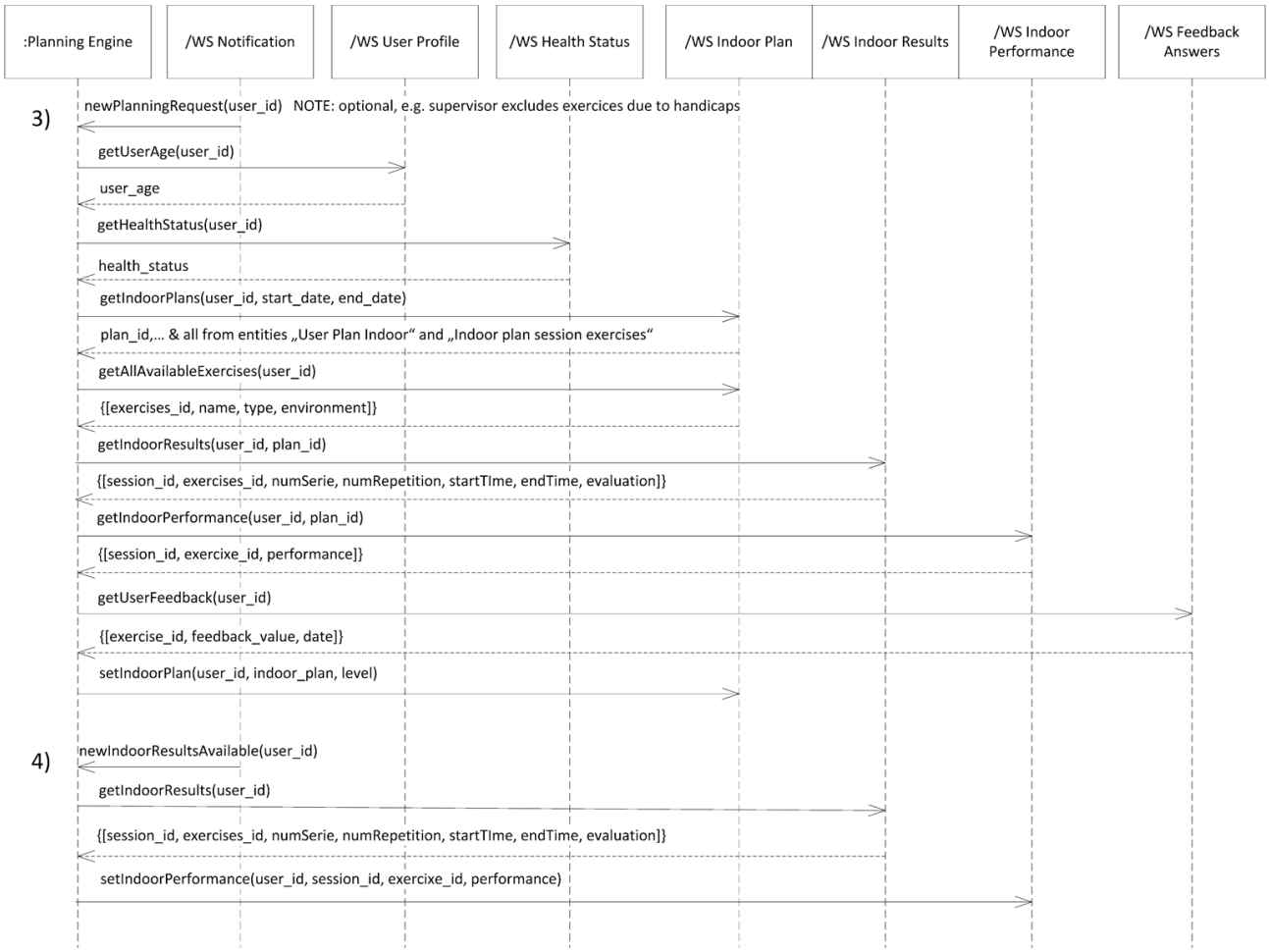


Figure 14: Evaluation unit and planning engine interaction diagram – set indoor exercises plan

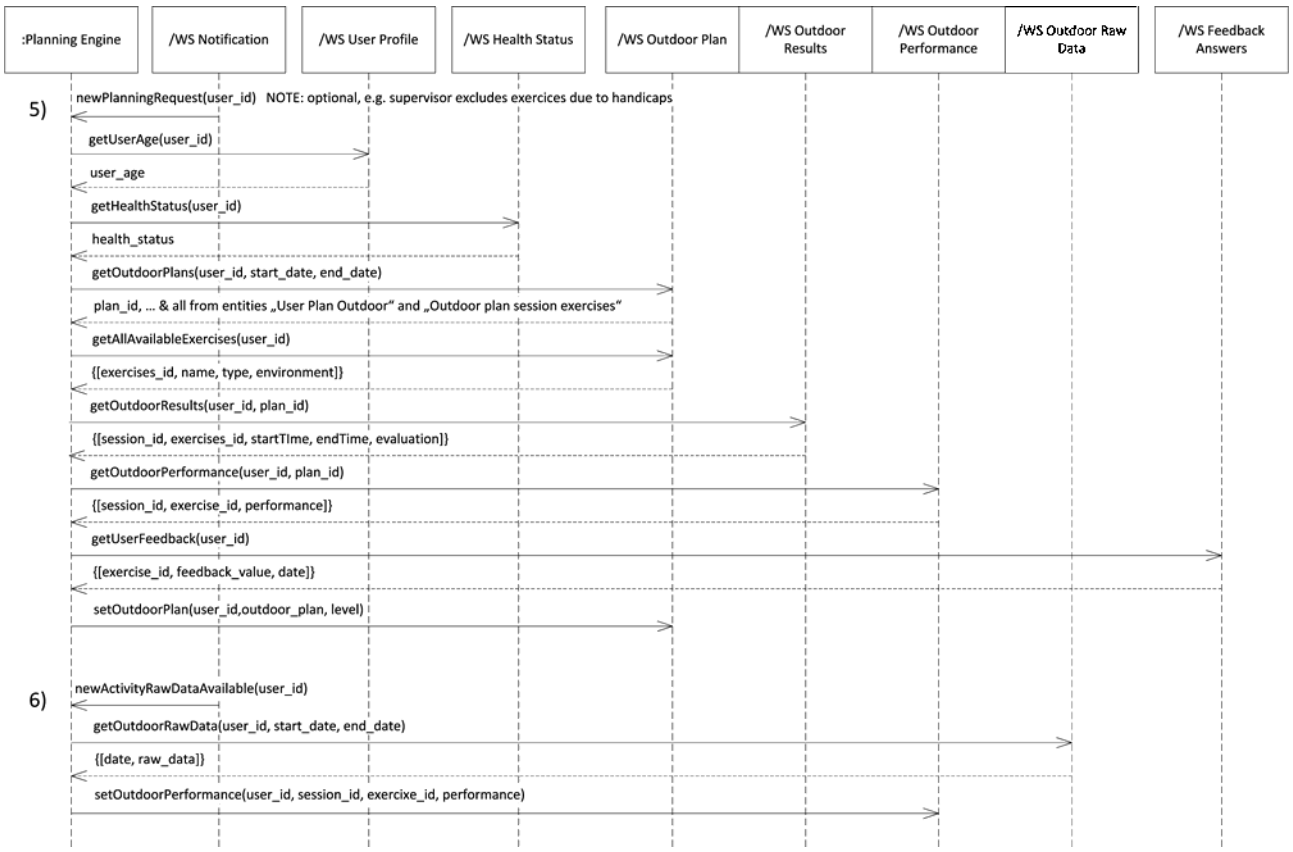


Figure 15: Evaluation unit and planning engine interaction diagram – set outdoor exercises plan

6 Web interface

6.1 Description

The web interface is the interface between caregivers (formal and informal) and the ELF@Home system. The web interface will be used for the supervision of users. Formal and informal caregivers must have access to the user health status and exercises performance.

6.2 Use cases and interaction diagram

A web interface must allow formal and informal caregivers to access to the ELF@Home system to supervise elderly users. Using the web interface, as shown in Figure 16 and Figure 17, caregivers must *"login"* to the ELF@Home web interface to:

- *"set/get/modify user health variables"* to change the health variables that a user must measure.
- *"set/get/modify user health thresholds"* to change the health thresholds that a user must reach to do exercises.
- *"set/get/modify user exercises"* to change the exercises associated to a user.
- *"view user health status"*
- *"view user exercises performance"*

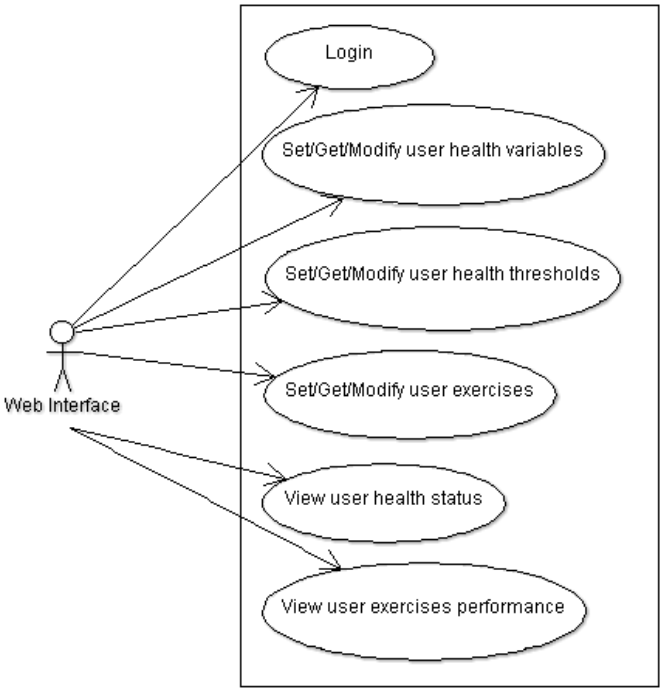


Figure 16. Web interface use case diagram

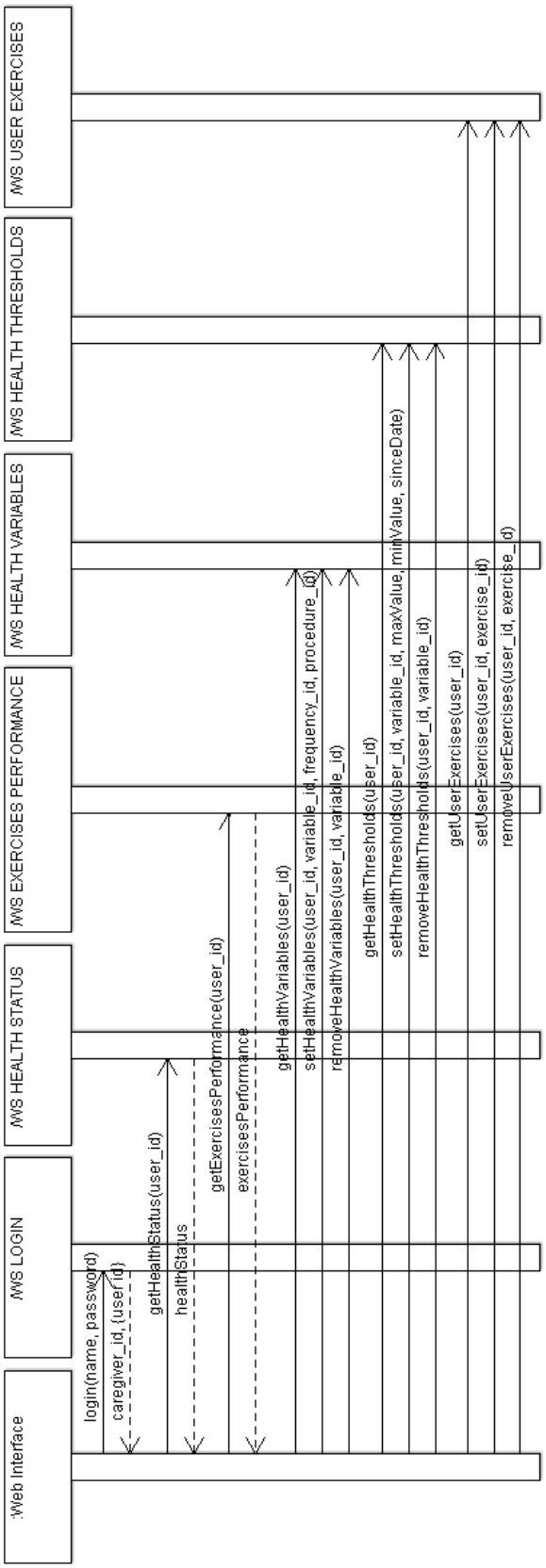


Figure 17. Web interface interaction diagram

7 Database

Figure 18 shows the initial version of the ELF@Home database. This database will be further developed during the next work packages. The database could be divided into:

- Users and caregivers information: information about users, caregivers and its relations.
    - Tables: *"Users"*, *"Caregivers"*, *"User – caregiver"*.
- Health variables information: definition of health variables, the procedure to be acquired and the acquired values for each user.
    - Tables: *"User – variable"*, *"Frequency definition"*, *"Measuring procedure definition"*, *"Health thresholds"*, *"Health variables definition"*, *"Health measures"*.
- Exercises information: definition of exercises and association to the users.
    - Tables: *"Exercises definition"*, *"User – exercises"*.
- Plan definition: definition of the indoor and outdoor exercises plan.
    - Tables: *"Plan definition"*, *"Levels definition"*, *"Exercises levels definition"*.
- Plan association information: associated plan of indoor and outdoor exercises for each user.
    - Tables: *"User plan"*, *"Plan session exercises"*, *"Session results"*.
- User feedback information: definition and values of user feedback.
    - Tables: *"Questions definition"*, *"User – question"*, *"User feedback"*.

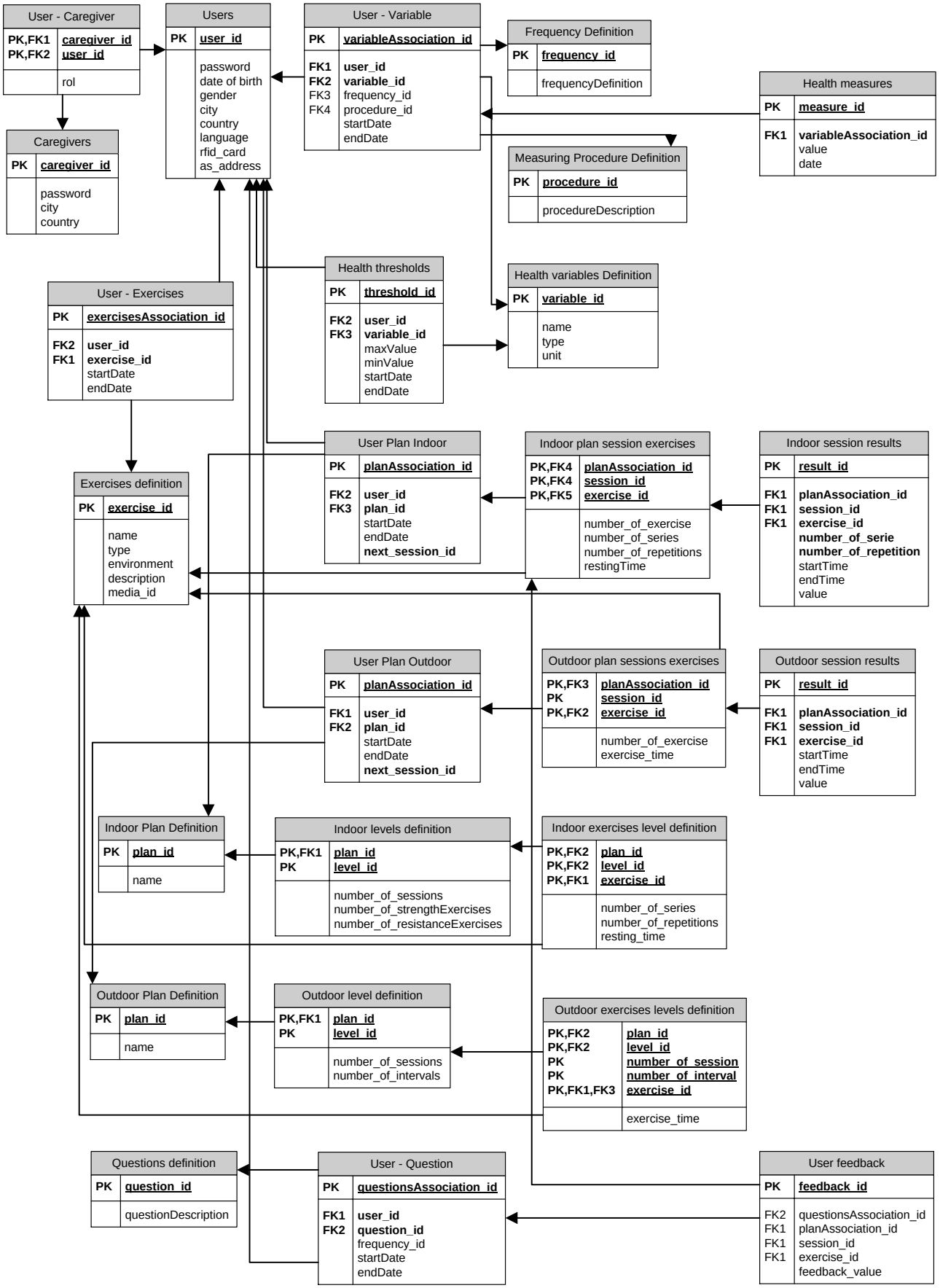


Figure 18: ELF@Home initial database design

8 Integration services

The integration services (IS) platform will consist in a RESTful based catalogue of services that will be published. The intelligent services platform and the fitness boxes will be able to obtain the necessary data to perform their business logic adequately.

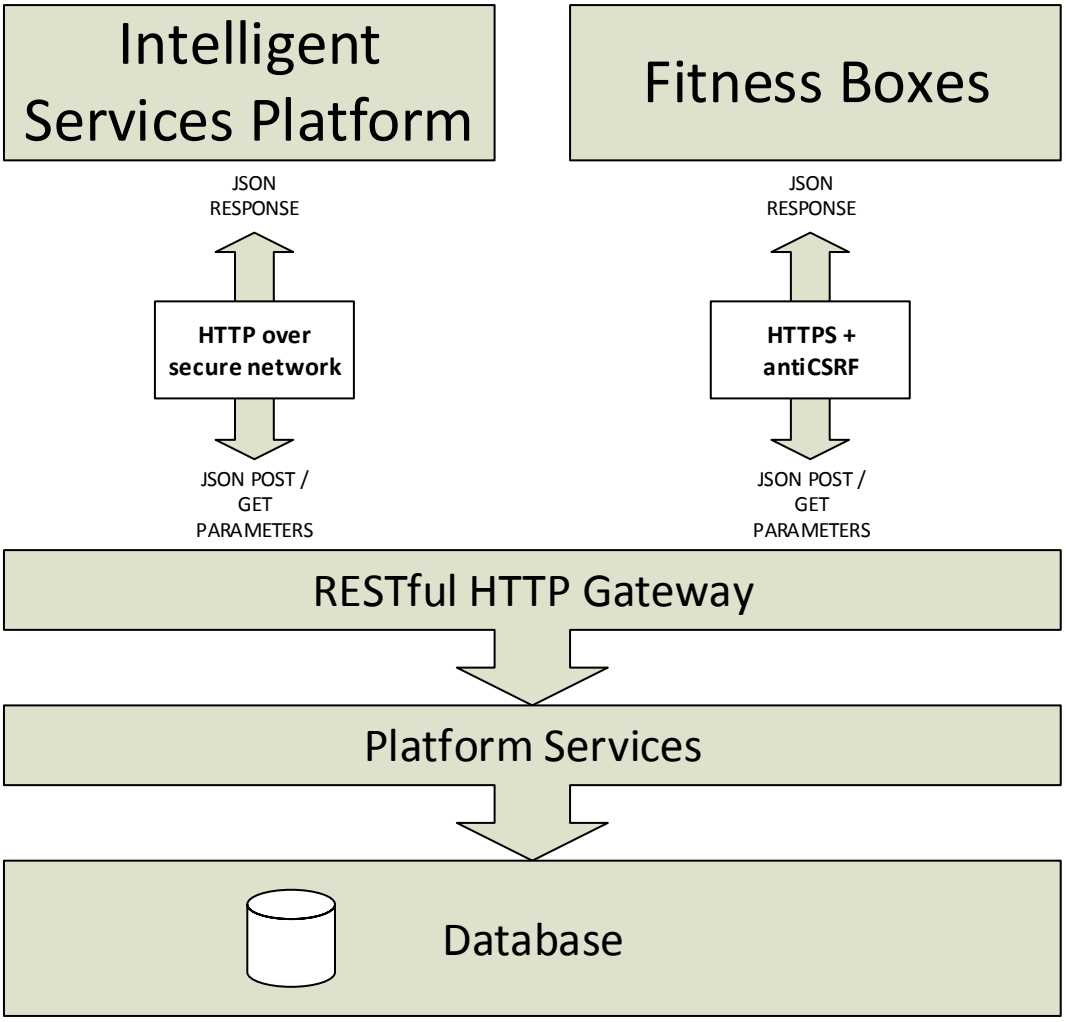


Figure 19: Integration services diagram

As seen in the diagram above, the clients will be able to access the service catalogue in two different ways:

- The fitness boxes browse the catalogue over the internet, so they will have a higher security level by using a secure HTTPS communication and anti CSRF[1] mechanisms to avoid phishing. A subset of the fitness box services will require an authentication token to work.
- In the case of the intelligent services platform, there will not be any special security considerations regarding security, as they will communicate over a trusted medium like a private network or tunnel. These services will not require any kind of authentication for the same reason.

Delving under the hood, the services gateway will be responsible of receiving requests and handling responses to the clients that require them by fulfilling each of the established contracts for each service. Once the server reaches its maximum capacity, this layer will also be in charge of queuing petitions to avoid system overwhelming.

[1] Cross-site request forgery, also known as a one-click attack or session riding and abbreviated as CSRF (sometimes pronounced sea-surf) or XSRF, is a type of malicious exploit of a website whereby unauthorized commands are transmitted from a user that the website trusts. Unlike cross-site scripting (XSS), which exploits the trust a user, has for a particular site, CSRF exploits the trust that a site has in a user's browser.

Deep in the platform services layer runs the business logic necessary to perform each of the implemented use cases for each client. This is the only layer allowed to access directly to the database.

According to the interaction diagram described in the previous sections, Table 1 shows the initial list of the web services required to the ELF@Home system.

Web service name	Description
Login	Web service to log a user in the system
User profile	Web service to get data about a user
Health variables	Web service to get the health variables associated to a user
Health thresholds	Web service to get the health thresholds associated to a user
Health measures	Web service to introduce in the database the health measures of a user
Indoor plan	Web service to get the personalized indoor exercises of a user
Indoor results	Web service to introduce the results about the indoor exercises execution
Outdoor exercises	Web service to get the personalized outdoor exercises of a user
Activity measures	Web service to introduce in the database the activity measures of a user
Outdoor results	Web service to introduce the results about the outdoor exercises execution
Feedback questions	Web service to get the feedback questions that a user must answer
Feedback answers	Web service to introduce the feedback that a user give to a feedback question
Health status	Web service to get a summing health status of a user
Exercises performance	Web service to get a summing exercises performance of a user

Table 1: List of web services

9 Conclusions

This document reports and describes the initial general architecture design of the ELF@Home system based on seven functional blocks:

1. Activity sensor
2. Health sensor
3. Fitness box
4. Evaluation unit and planning engine
5. Web interface
6. Database
7. Integration services

Each identified functional block must be developed and further specified during the technological work packages:

- WP3 planned from March 1st 2014 to May 31st 2015 is leaded by EXP and focused on the design and development of the activity sensor and the health sensors.
- WP4 planned from March 1st 2014 to May 31st 2015 is leaded by CTIC and focused on the design and development of the fitness box and web interface.
- WP5 planned from March 1st 2014 to May 31st 2015 is leaded by IIS and focused on the intelligent services platform (evaluation unit and planning engine, database and integration services).