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MILANO 1863

TrackMe project - Argiro' Anna Sofia,
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Design Document

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1. Introduction

1.1 Purpose

This document means to provide developers and stakeholders with detailed information regarding the architecture of the software. A particular effort has been devoted to testing plan and integration testing plan, since the Integration Test Plan Document is not required.

1.2 Scope

The Data4Help System means to provide services to authenticated users only. Those services are addressed to both:

- Individual Users
- Third parties Users

To dispatch specific functionalities to the user they are reserved, the Data4Help System avails itself of:

- a Mobile Application, reserved to individual users
- a Web Page, reserved to third party users

The Mobile Application, using the GPS location provided by the smartphone, allows the individual user to:

- check his own health parameters (measured by a smartwatch)
- enable and disable additional services (AutomatedSOS and Track4Run)
- give or deny authorization to every third party to access health data about himself

The Data4Help System handles both data of the past and real time ones. The Web Page allows the Third-party user to:

- make requests for statistical data of the past or real time
- make requests for individual data of the past or real time (the requests are forwarded to the individual user)
- organize and watch run competitions

This factorization allows the system to be accurate in providing every user with all and only resources he has the right to access: authentication and authorization processes rely on the access control.

The necessity to use a mobile app could prevent third parties from choosing Data4Help over other services of data collection: the Data4Help Web Page can be easily accessed from a browser hosted on a computer or a mobile.

1.3 Definitions

- *Data4Help System*: the whole system, offering Data4Help, AutomateSOS and Track4Run services.
- *User*: a person or an entity, that has registered;
- *Individual User*: every registered person from whom the system collects data;
- *Third-Party User*: every entity registered with the purpose to request data for external use;
- *non-human Third-Party User*: a software that access to the offered D4H services through the exposed APIs
- *Live Data*: the data about a IU produced in real time.
- *Stored Data*: the data about a IU collected so far.
- *Data Request*: a request for data made from a TPU.
- *Stored Data Request*: a data request for stored data.
- *Subscription Request*: a request for subscribing to newly generated data.

1.4 Acronyms

- API: Application Programming Interface
- IU: Individual User
- TPU: Third-party User
- D4H: Data4Help
- ASOS: AutomatedSOS
- T4R: Track4Run
- UX: User experience
- REST: REpresentational State Transfer
- EENA: European Emergency Number Association
- PSAPs: Public Safety Answering Points
- NG112: Next Generation 112
- DRT: Database Response Time

1.5 Abbreviations

- Gn: n-goal
- Dn: n-Domain assumption
- Rn: n-Requirement

1.6 Revision history

- **v0.1 - 27/11/18** Document created
- **v0.2 - 30/11/18** Component view
- **v0.3 - 2/12/18** Model diagrams, User interface and High level overview
- **v0.4 - 8/12/18** Architectural patterns, interfaces, deployment, high level architecture review
- **v0.5 - 10/12/18** Implementation, integration and testing
- **v1.0 - 10/12/18** Requirement traceability, references, introduction, general revision
- **v1.1 - 14/12/18** Nomenclature corrections, grammar corrections

1.7 Document Structure

Introduction

This section means to present briefly the software and the world it's going to live in. The terminology that is going to be used through the document is specified.

Architectural Design

This section illustrates:

- high level components and their interaction
- main components the system is divided into and their interaction
- diagrams reporting entities relationship
- different representation of the model that highlights the interaction with server, its formalization in the deployment view
- sequence diagram showing the runtime behavior
- component interfaces
- patterns.

User Interface Design

In this section each user interface (presented in RASD) is reported and accurately explained. The interaction among interfaces clarifies the path to reach every interface starting from any other.

Requirements Traceability

This section means to map all the requirements with the corresponding design components.

Implementation, Integration and Test plan

This section reports how the implementation of components has been designated, including: the implementation order, the integration order, components testing, components integration testing. Details about implementation and testing are provided.

Effort Spent

This section reports, with a tabular representation, the effort spent by each member of the group.

References

This section is a list of documents and web sites consulted in order to realize the Design Document.

2. Architectural Design

2.1 Overview

The architecture style used is a client/server structure with multiple tiers while an event-backbone will handle the dispatch of live data through the whole system. The presentation layer will be hosted on both client (IUs and TPUs clients) while the application server will host the logic layer and the database server the data layer. The IU client is going to be a thick client, hosting a branch of the application logic to handle better and faster some system functionalities.

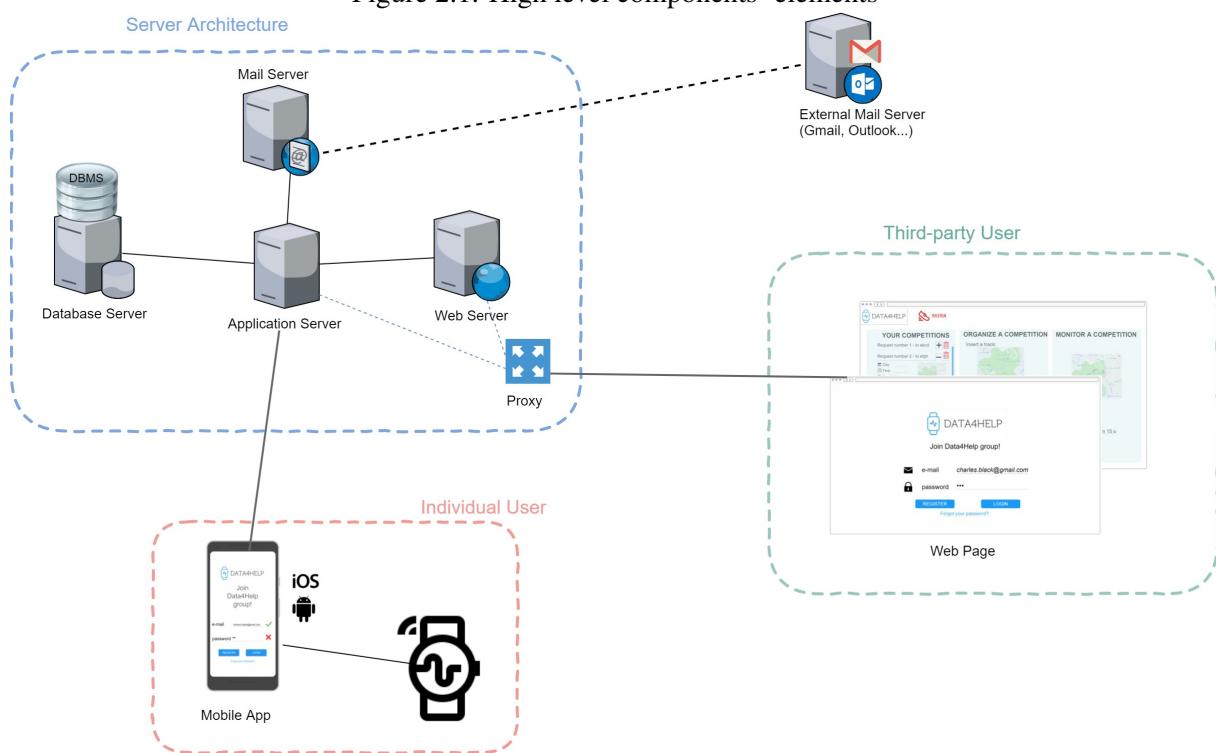
A server structure can either be hosted locally on a dedicated physical server or on a cloud server furnished by a cloud-server-hosting provider. Cloud server solutions, over local servers, are the ideal fit for system having variable demands and workload and meet the following needs:

- to avoid hardware faults: the Data4Help System availability percentage needs to be equal or superior to 99.995. Since this percentage does not take into account hardware faults and a local server cannot guarantee an hundred percent availability, the Data4Help System availability cannot be affected by the one of a local server
- to enhance security
- to only pay for the exact amount of server space used
- minimization of data losses and recovery time: the availability of a system is affected by recovery (restart and repair) time. The Data4Help System, to guarantee an availability of 99.995 percent, needs to avail itself with a recovery-time minimize solution

Many cloud-server-hosting providers exist, solutions furnished are quite similar and valid. Google Cloud Platform might be chosen over other cloud-server-hosting providers because of the possibility to use both SQL and NoSQL databases. It's up to developers to evaluate the provider to use, according to the budget assigned and a future possible differentiation of services that nowadays seems to offer similar solution at the same price. The Data4Help System can avail itself of a CDBMS which is a Database Manager as a cloud service: this solution is designated to be scalable and flexible and to run on a cloud server architecture. Google Could Platform offers [Cloud SQL](#) which is a database services fully integrated with MySQL and PostgreSQL(beta).

2.1.1 High level components and basic interactions

Figure 2.1: High level components' elements

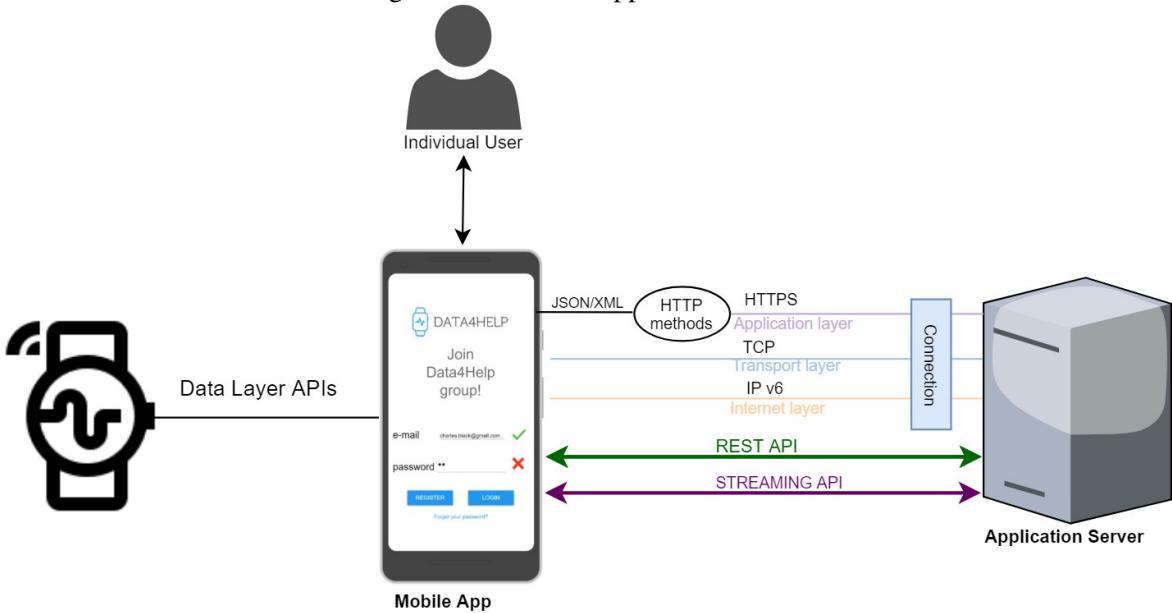


The overall structure, at high level, is made of three main components and their interaction.

The component on the bottom shows the Data4Help Mobile Application and a smartwatch which are the tools that allows the Individual User to interface with the Data4Help System. The Mobile Application communicates with the Application Server which is part of the component that represents the Server Architecture. This last is composed by a Database Server that includes the DBMS, a Mail Server which means to exchange SMTP messages with other Mail Servers (external to the system), an Application Server communicating with any other element in the Server Architecture, a Web Server and a Proxy (meant to dispatch requests to Application and Web Servers). The proxy links the Server Architecture with the component charged with the interaction with the third party user that takes place through the Data4Help Web Page.

2.1.2 Interaction between Server Architecture and Individual User

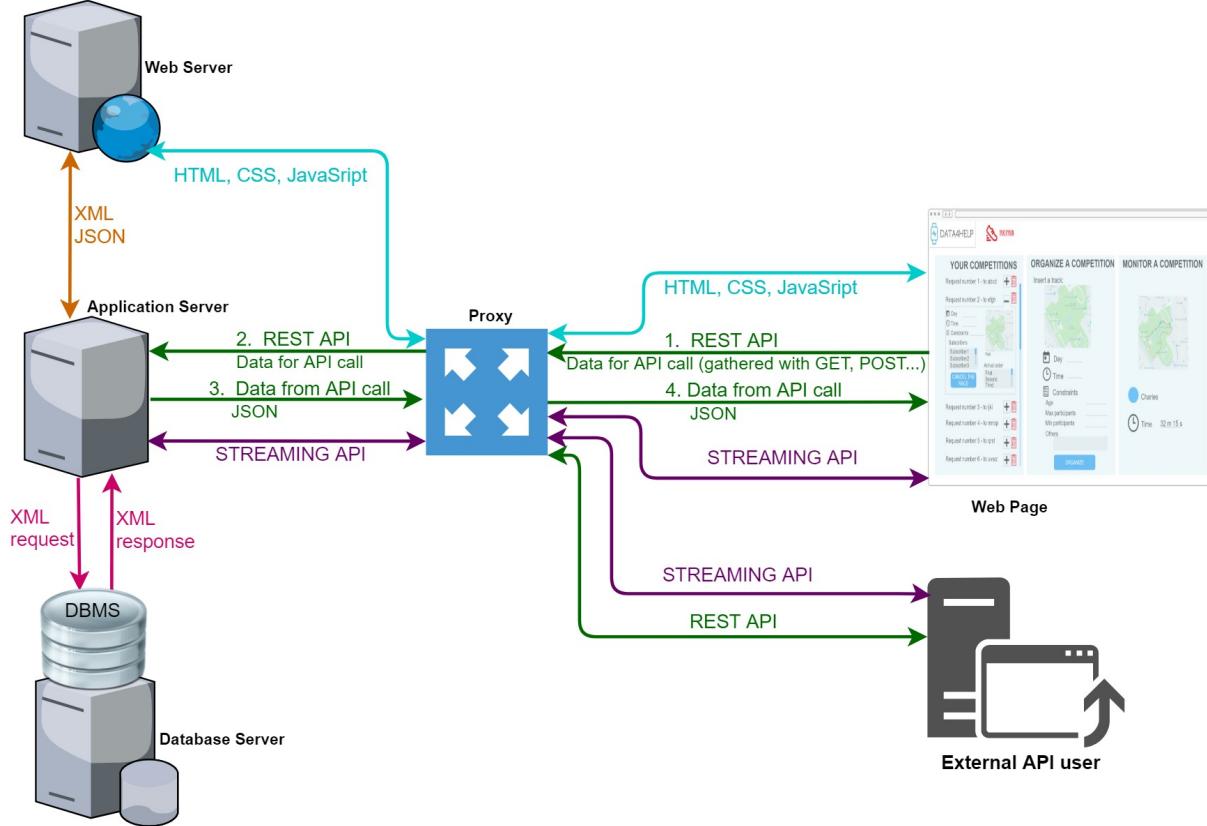
Figure 2.2: Mobile App connections



The Data4Help Mobile Application receives data from the smartwatch and exchanges information (using different modalities) with the Individual User and the Application Server. At 3 different levels are specified protocols that are supposed to generate the connection with the Application Server; a STREAMING API communication needs to be established to exchange real time data, all other information to be exchanged use REST API communication.

2.1.3 Interaction between Server Architecture and Third-Party User

Figure 2.3: Connection between Web Page and Servers



The browser hosting the Web Page needs to communicate both with the Web Server and the Application Server. The Web Server can easily handle and exchange HTML, CSS and JavaScript files with the client; the Application Server manages methods like GET, POST receiving a REST API call (used to exchange every information but real-time data) and forwarding data in JSON format. Real time data are exchanged using STREAMING APIs: both the Data4Help Web Page and a non-human TPU, request and receive real time data. Data to forward are provided by the Database Server which includes the DBMS: a request in XML is sent by the Application Server, the DBMS processes the request and extracts data from the database that are sent back to the Application Server in a XML file. To establish a communication channel between the Application Server and the Web Server is not a necessity, however it provides an alternative to REST API: developers are up to decide to implement them both or to keep the REST and STREAMING APIs alone.

2.2 Component view

The Data4Help System is divided in four subsystems:

- **Backbone**
- **Data4Help**
- **AutomatedSOS**
- **Track4Run**

The subsystems realizing the main services, namely the D4H services, are the backbone and Data4Help. The Backbone is the core of the system: all other subsystems interact with it and don't interact with each other. The backbone provides interfaces for authentication and to receive live data published from the Backbone with a event-based paradigm.

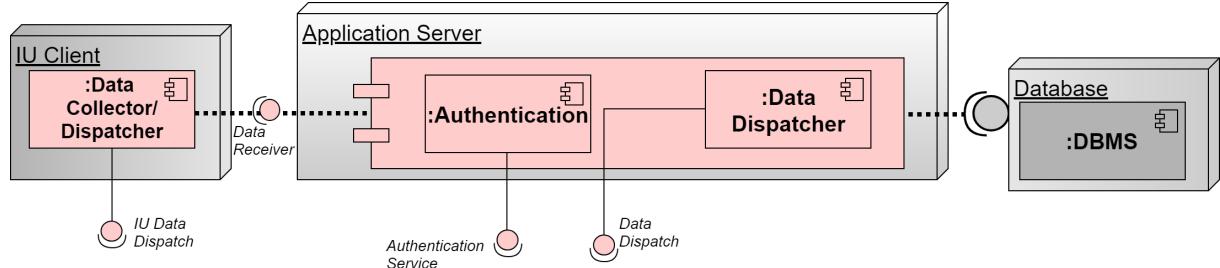
The last three are divided, on the Application server, in a router that provides an interface gathering all the subsystems functionalities, and a module, containing all other components of the subsystem, which uses the exposed method of the DBMS to be able to work independently.

On the IU and TPU clients the view component represents the presentation layer of the system, which Users can access directly.

The relation between the components and the model is further defined in figure 2.10.

2.2.1 Backbone

Figure 2.4: Backbone Component View



This is the backbone of the system: collects the data of the device, keeps it synchronize through the system, stores it into the database and provides the functionalities to receive live data; furthermore provides functionalities concerning authentication.

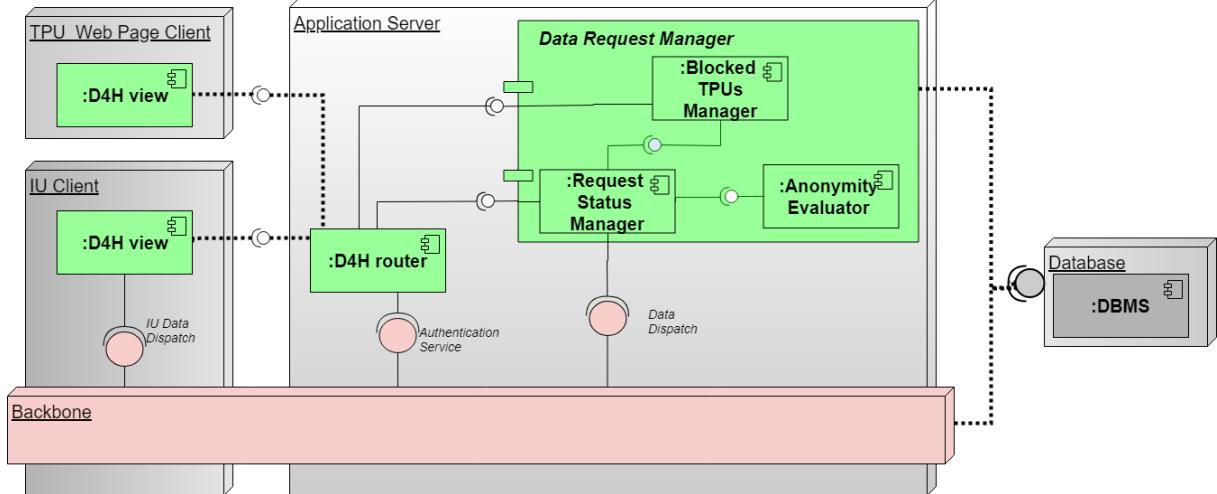
Data collector/dispatcher Allows subscription from other components on the IU client and publishes/dispatches the collected live data of the Individual User logged in from the device.

Autentication Offers services related to User authentication and the functionalities to handle their info.

Data Dispatcher Allows subscription from other components on the application server and publishes/dispatches the collected live data of all Users and stores it into the database.

2.2.2 Data4Help

Figure 2.5: Data4Help Component View

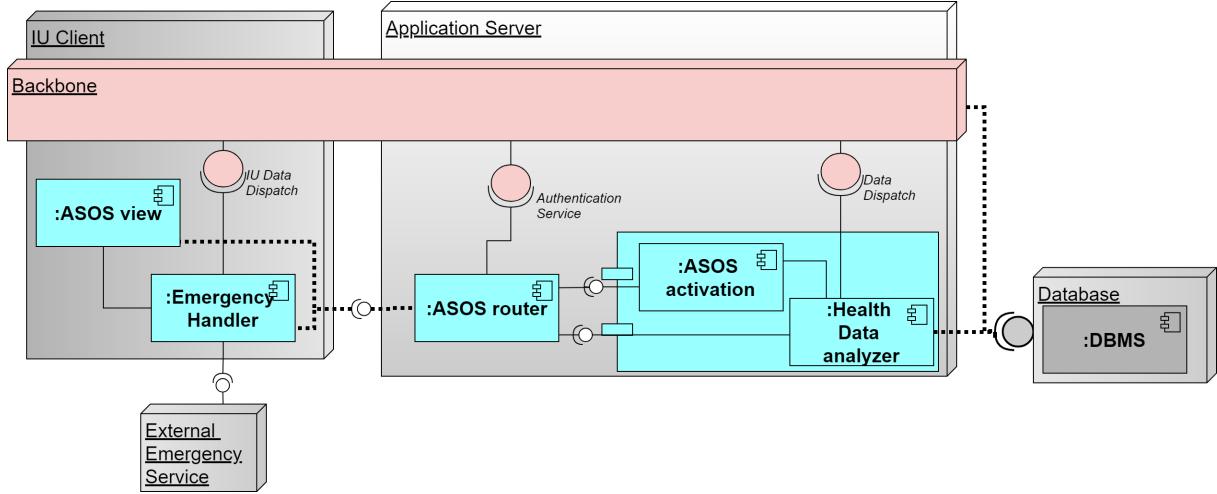


D4H router Validates the requests received from the client and dispatches them to the corresponding module or component.

Data Request Manager Provides functionality to create, approve, deny requests, block users and provide the relative data; Anonymity Evaluator is responsible to check anonymity constraints.

2.2.3 AutomatedSOS

Figure 2.6: AutomatedSOS Component View



ASOS router Validates the requests received from the client and dispatches them to the corresponding module or component.

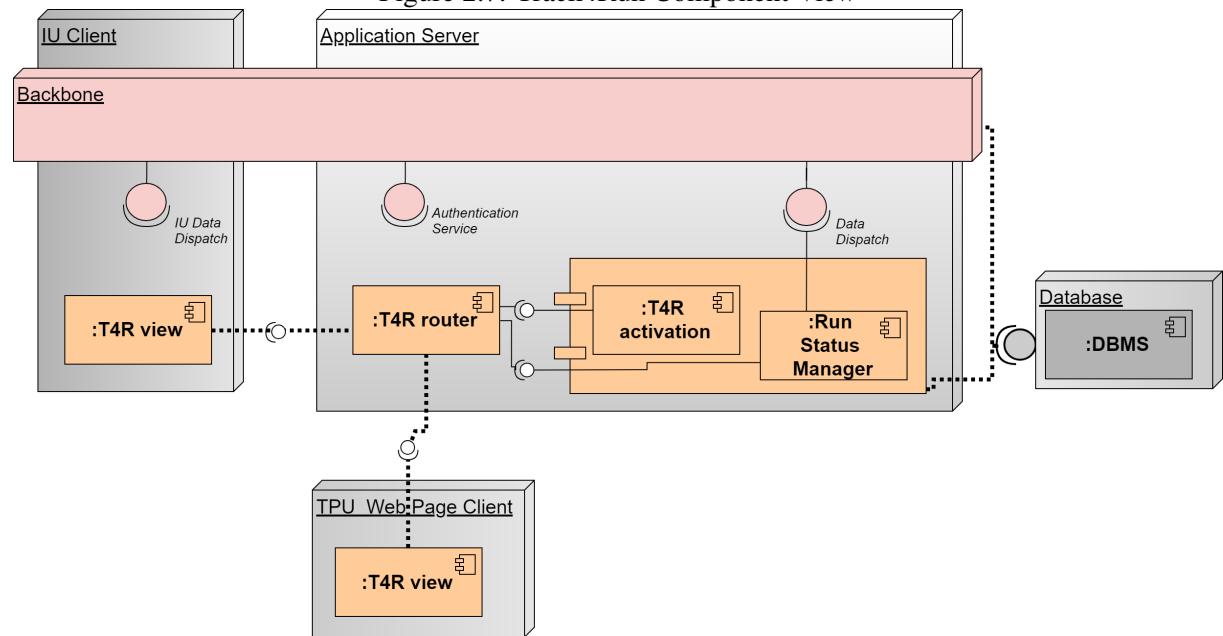
ASOS Activation Offers the functionality for the activation and deactivation of the ASOS service.

Health Data analyzer Offers functionality to extrapolate the critical health parameters for every Individual User;

Emergency Handler Responsible to handle critical health conditions based on the data published by the *Data collector/dispatcher*; the method for contacting the emergency service is further explained in section 2.7.1.

2.2.4 Track4Run

Figure 2.7: Track4Run Component View



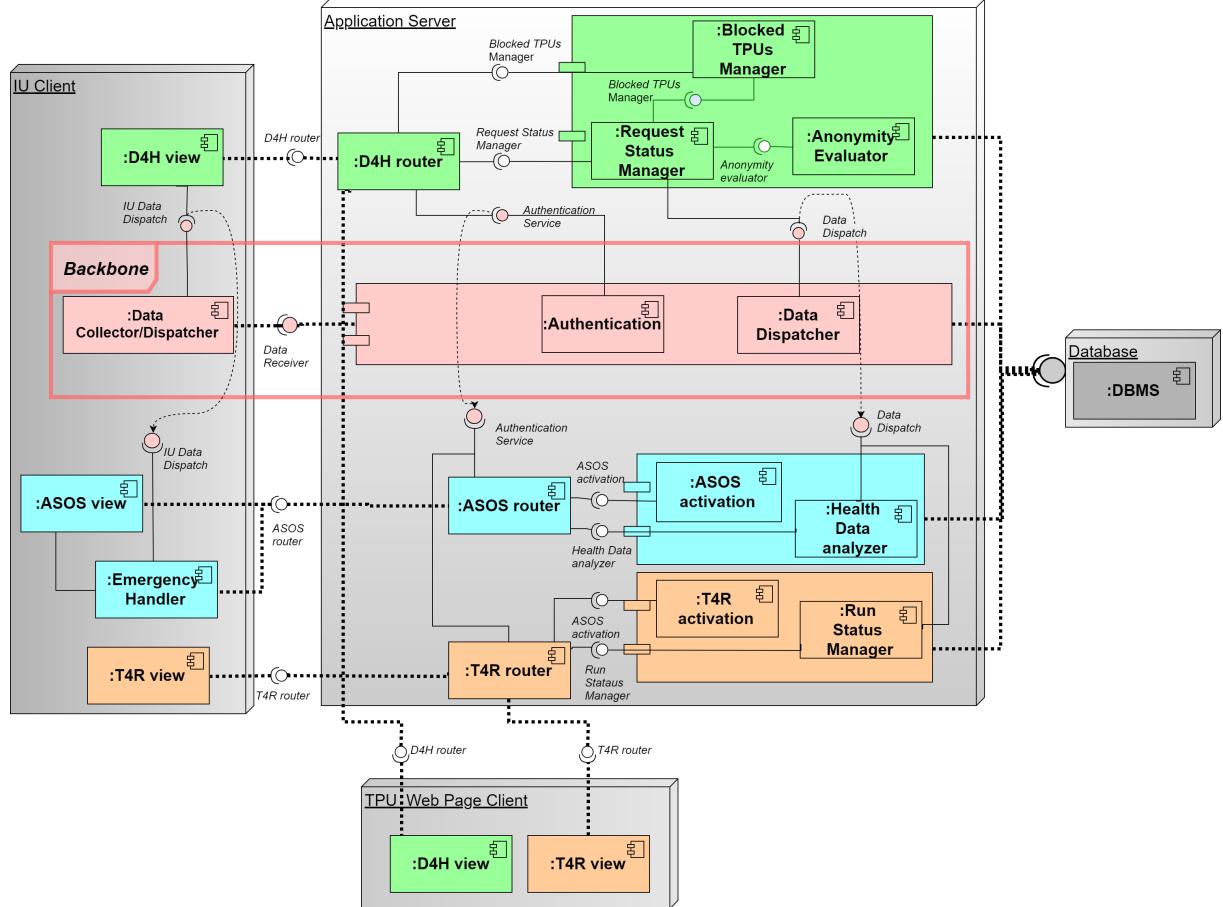
T4R router Validates the requests received from the client and dispatches them to the corresponding module or component.

T4R Activation Offers the functionality for the activation and deactivation of the T4R service.

Run Manager Provides functionality to create, cancel and enrol in runs.

2.2.5 Data4Help System

Figure 2.8: Complete Component View



Data Managing From a more high level point of view, the backbone provides services to retrieve the Individual Users live data.

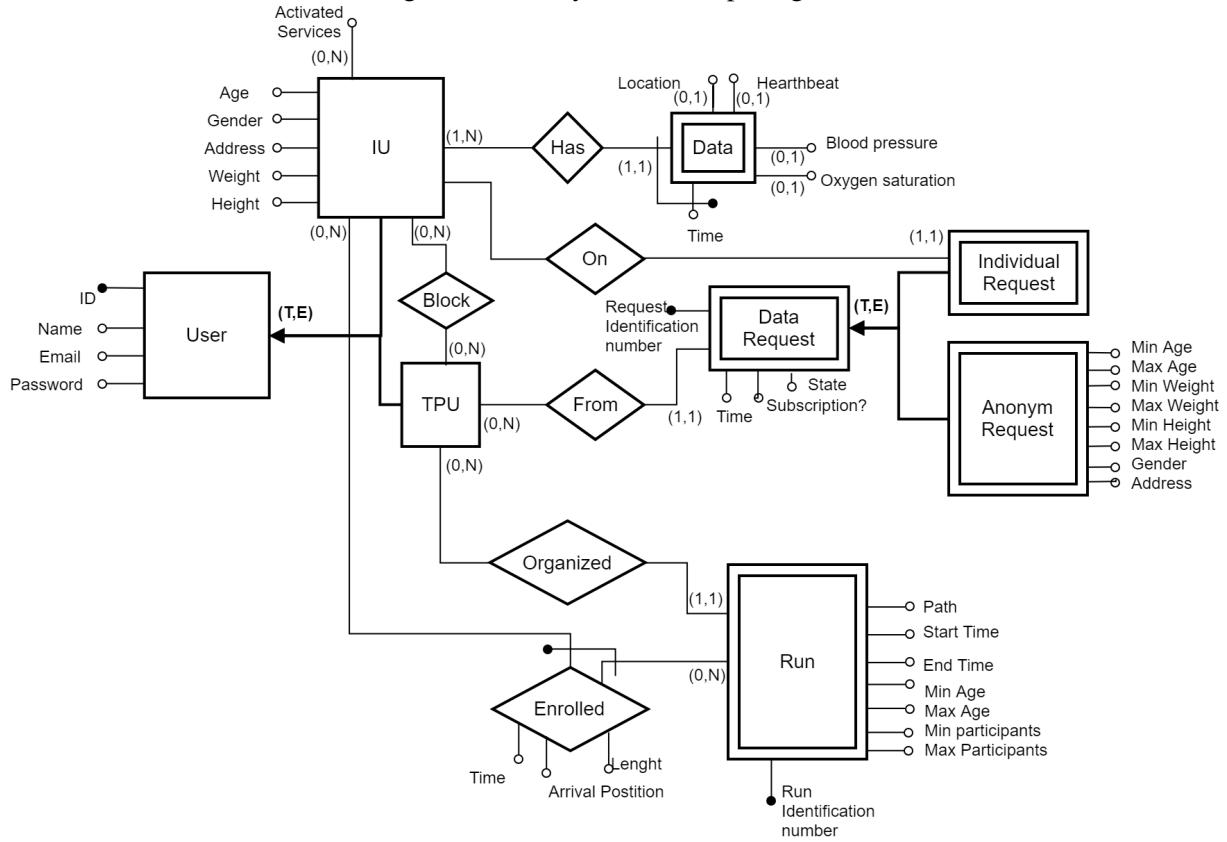
This makes the red components and modules of the architecture the backbone, collecting and dispatching data, while the other subsystems can handle their unique authorization condition: D4H authorizing data dispatching based on approved requests, ASOS on the activation of the service and T4R on the enrollement in competitions.

This way all subsystem can work independently from each other.

2.2.6 Entity Relationship Diagram

The following section provides a conceptual representation of the model.

Figure 2.9: Entity Relationship Diagram



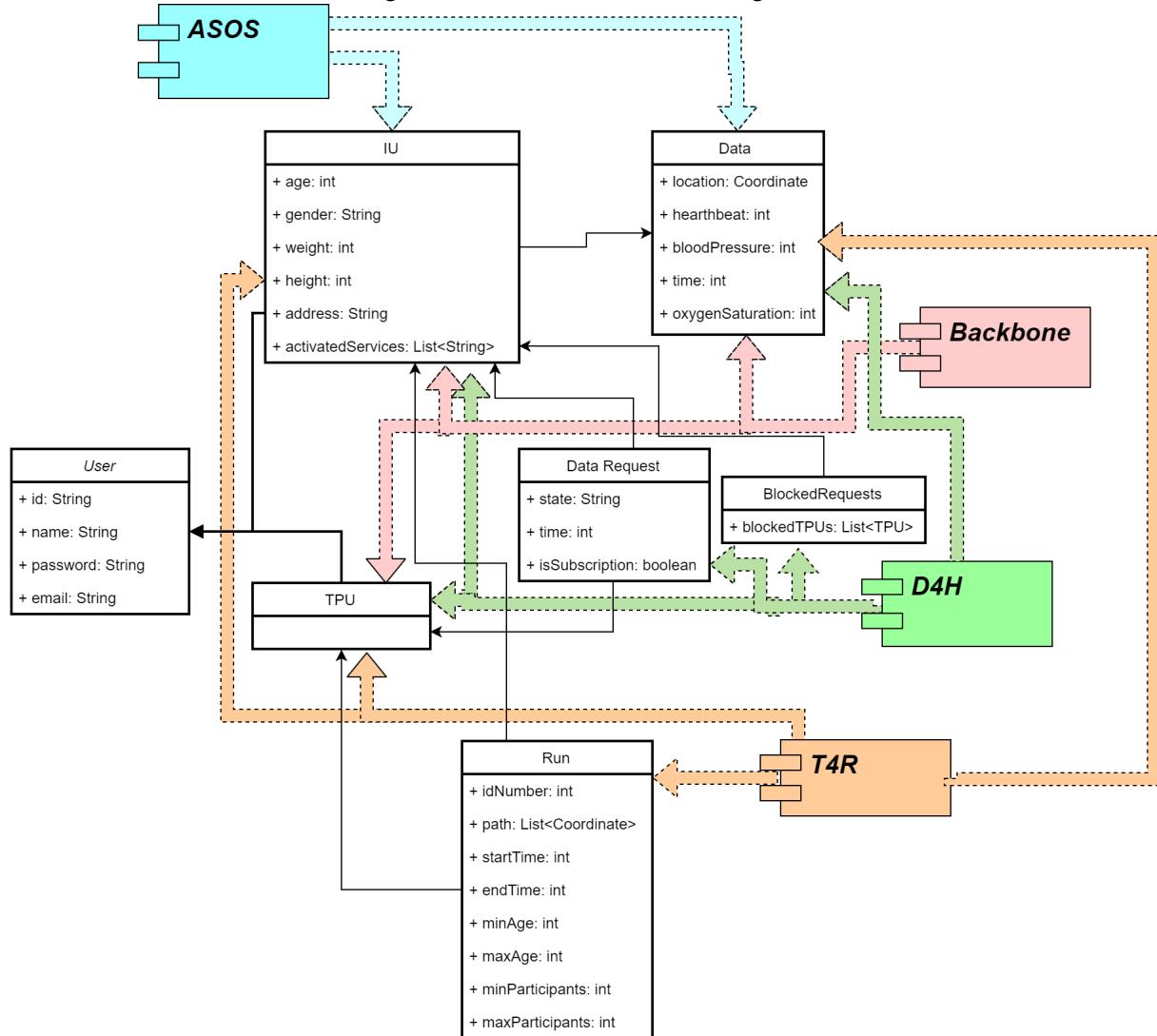
Tables

- **User**(ID, Name, Email, Password)
- **TPU**(ID, Name, Email, Password)
- **IU**(ID, Name, Email, Password, Age, Gender, Address, Weight, Height)
- **Data**(IU, Time, Location, Heartbeat, Blood pressure, Oxygen saturation)
- **Individual Request**(Request Identification Number, IU, TPU, Time, State, Subscription?)
- **Anonym Request**(Request Identification Number, TPU, Time, State, Subscription?, Min Age, Max Age, Min Weight, Max Weight, Min Height, Max Height, Gender, Address)
- **Run**(Run Identification number, TPU, IU, Path, Start Time, End Time, Min Age, Max Age, Min participants, Max Participants)
- **Run Result**(Run Identification number, IU, Length, Time, Arrival Position)

2.2.7 Model Interaction Diagram

The following diagram shows a different representation of the model to better highlight its interaction with the application server. For each subsystem module that was connected to the DBMS in 2.2.5 is shown its relationship with the module.

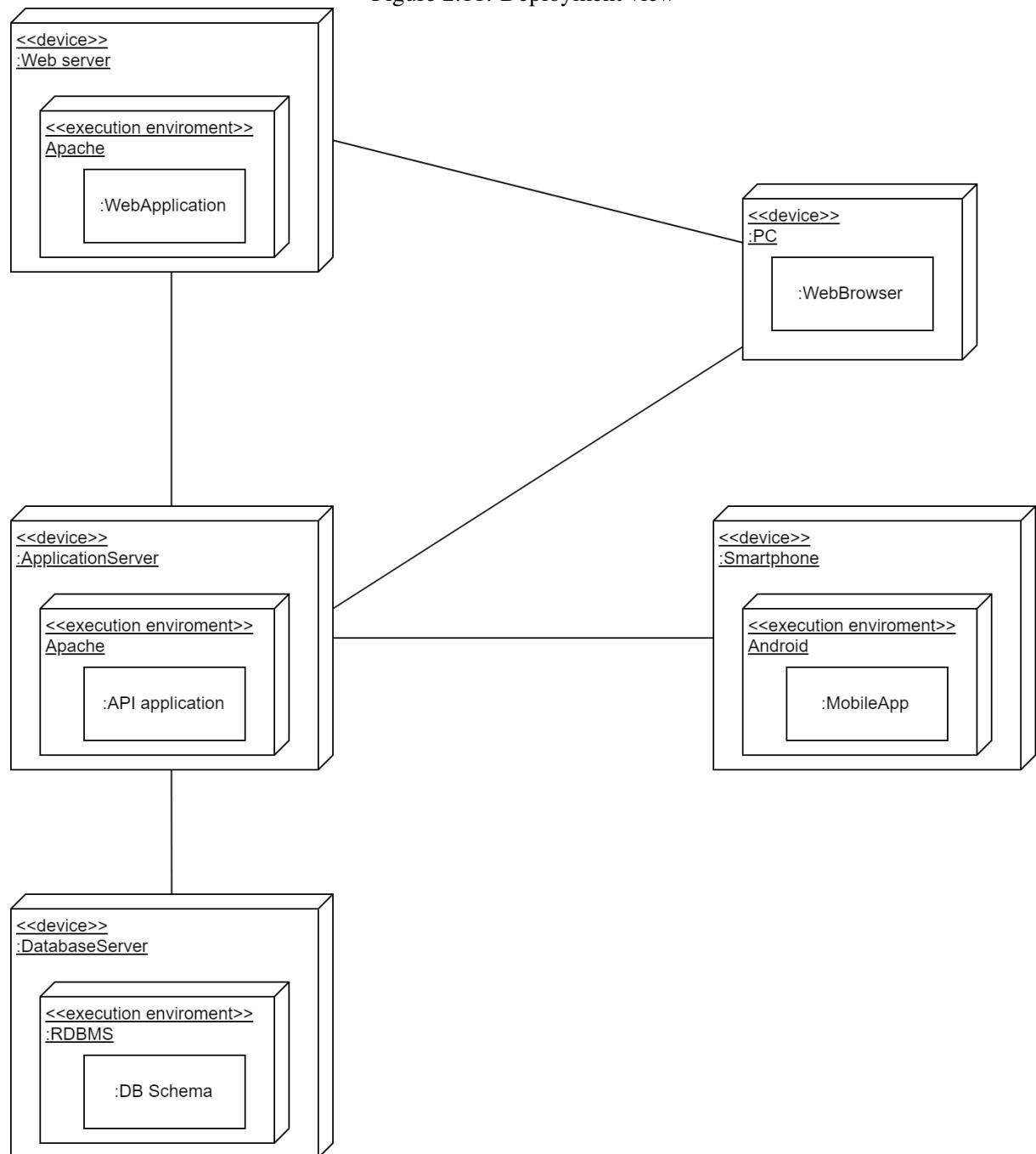
Figure 2.10: Model Interaction Diagram



2.3 Deployment view

As stated in the previous sections the system has two different client interfaces, one hosted on a web browser and the other on mobile application. They both rely on the application server while the former also interacts with the web server which hosts the web application. The application server provides the logic of the system and interacts with the database server which hosts the data layer of the system.

Figure 2.11: Deployment view



2.4 Runtime view

Figure 2.12: IU Registration

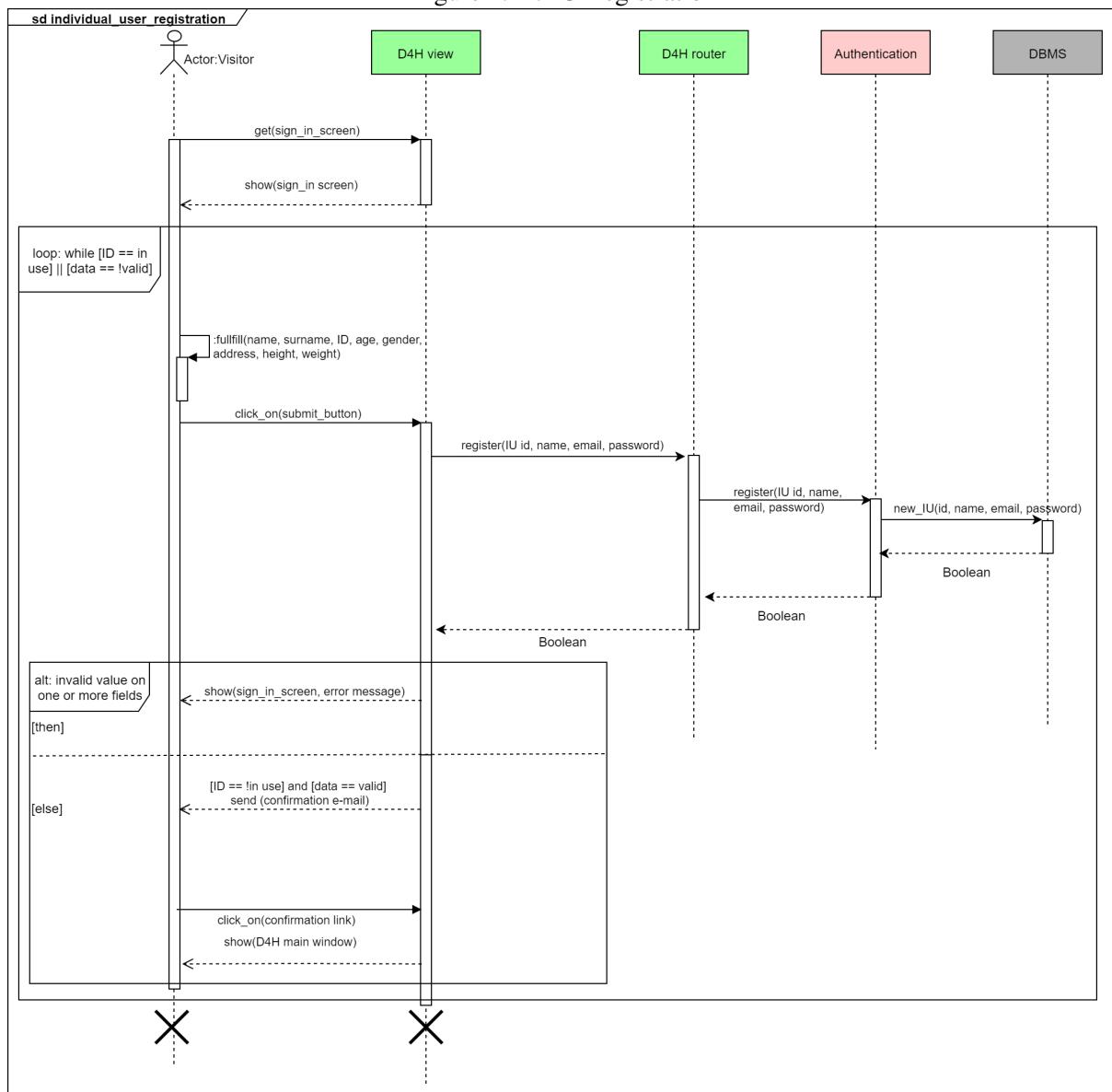


Figure 2.13: Data Requests

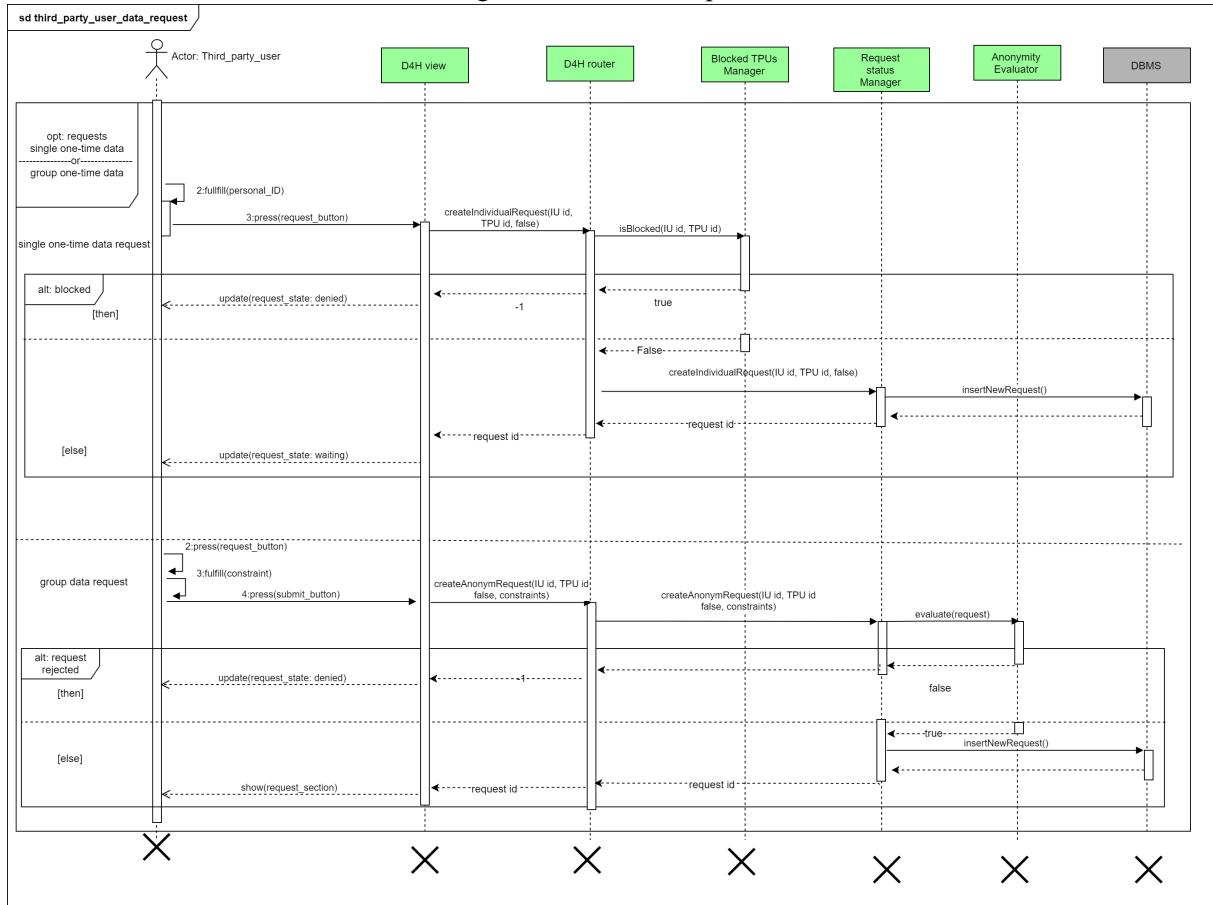


Figure 2.14: Emergency call

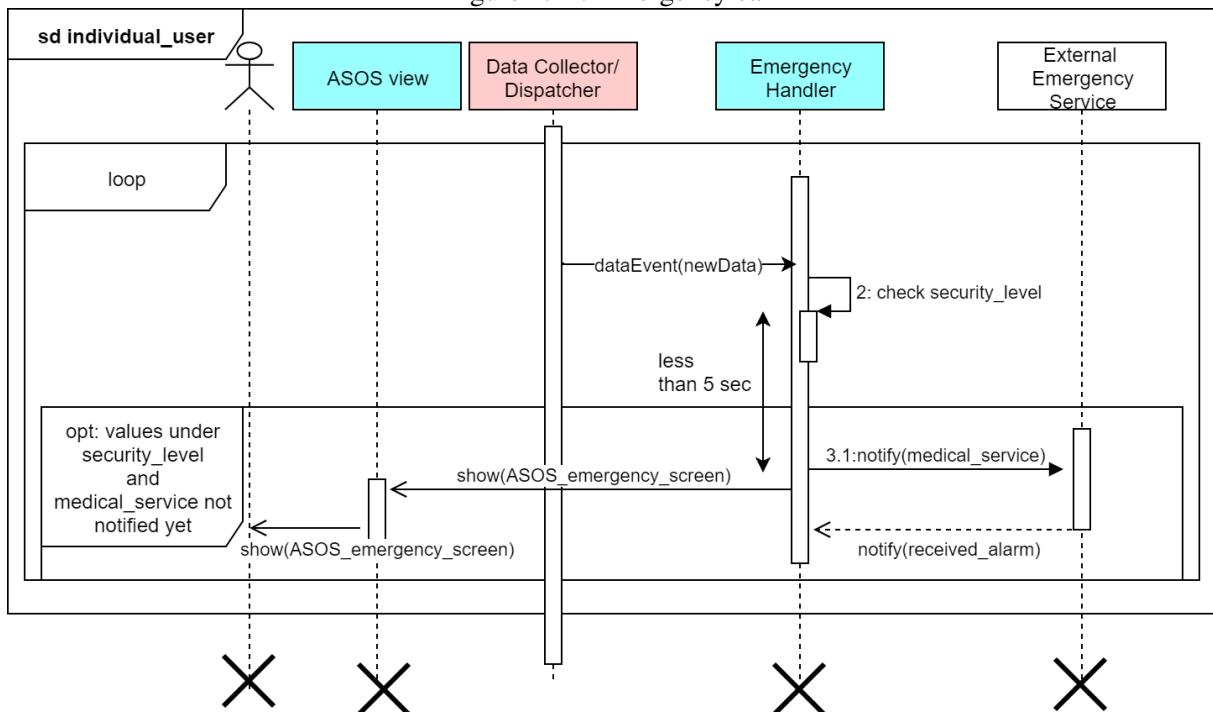
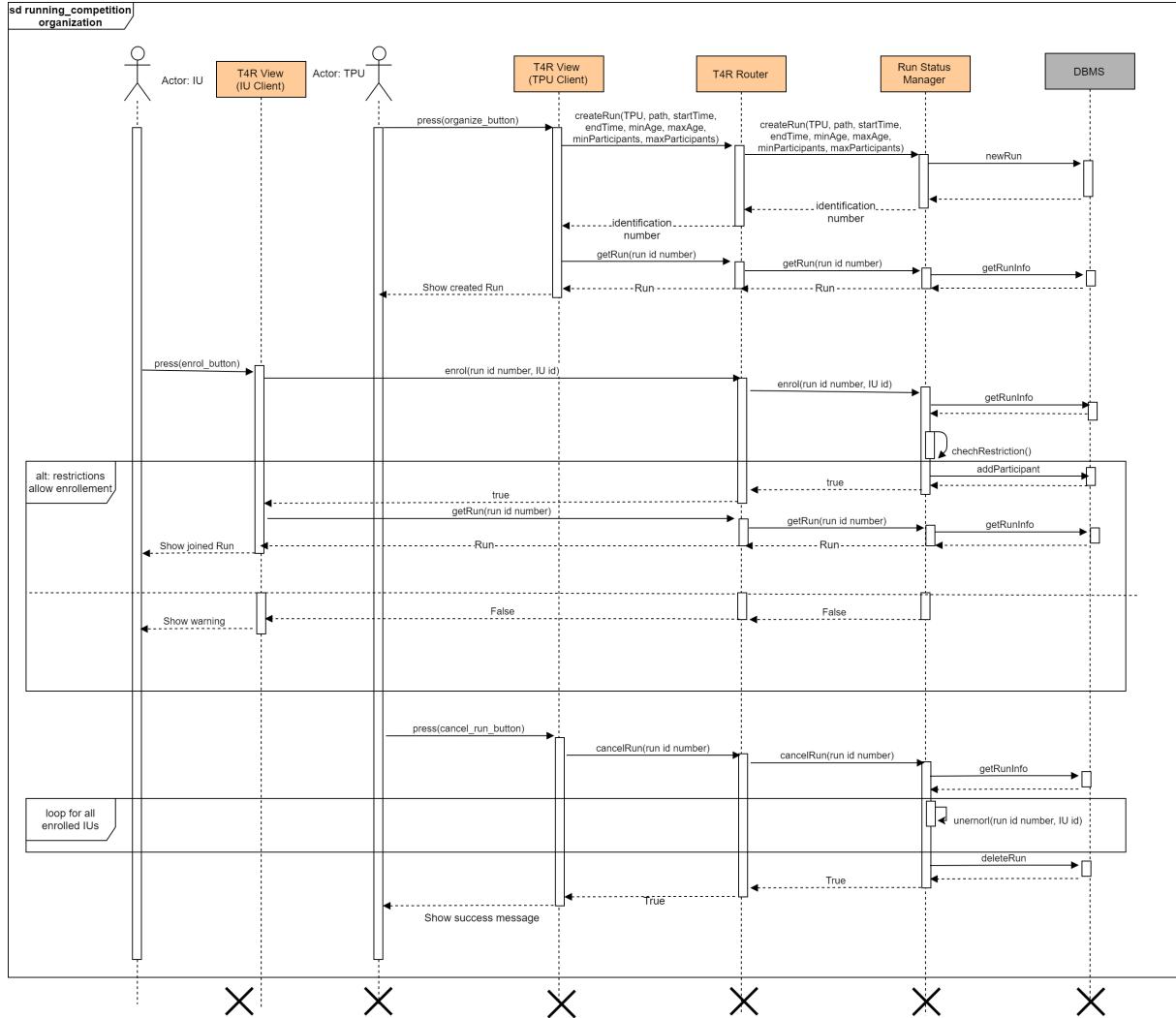


Figure 2.15: Run Status Management

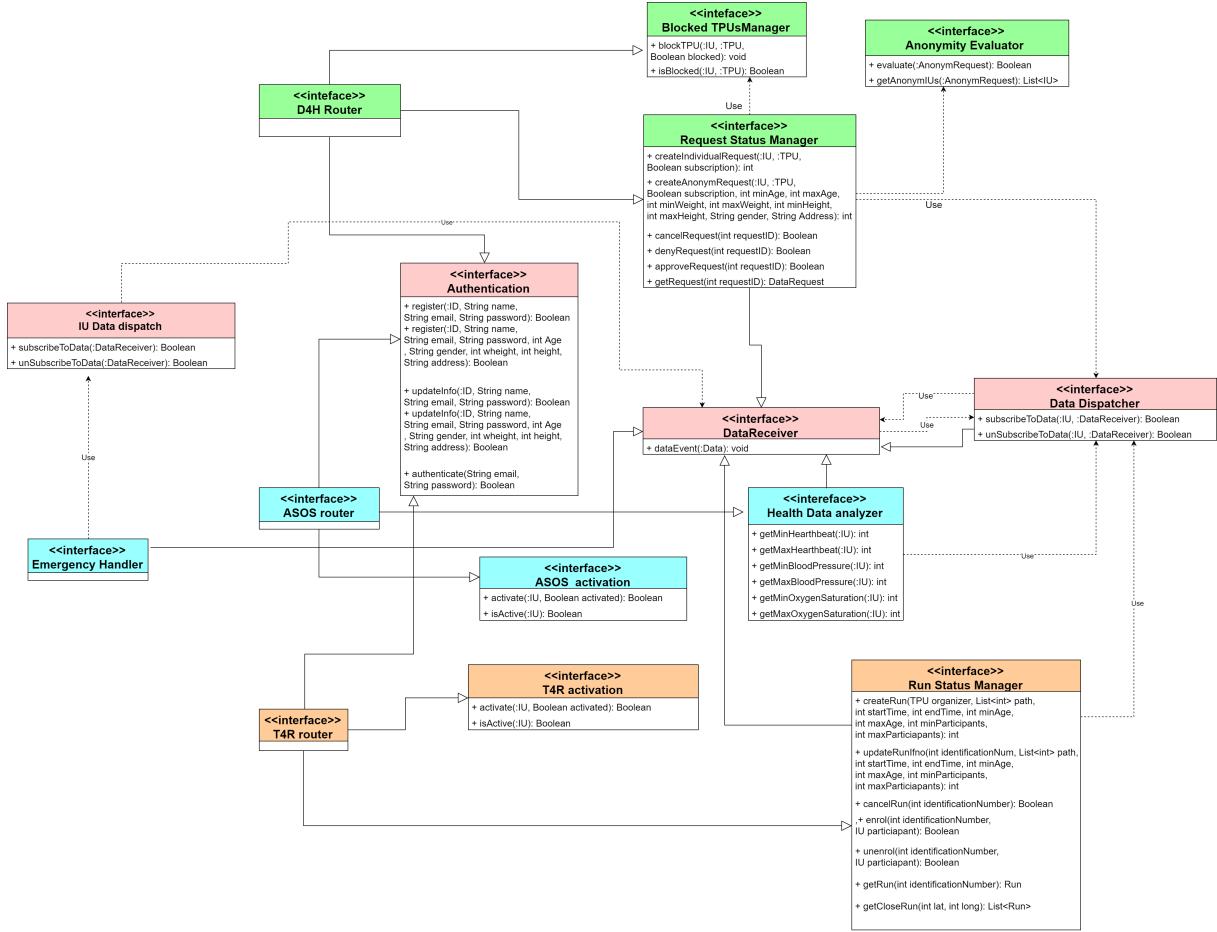


2.5 Component interfaces

The next diagram shows the most important methods of the components interfaces which, for clarity, are named in figure 2.2.5 tracing the components names.

The routers gather all the methods required to provide the client with the corresponding subsystems services and expose the relative APIs for the clients (for the D4H router also non-human TPUs) to use. A generic interface *Data Receiver* is extended by all the interfaces that use the *Data Dispatcher* service, to receive the updates.

Figure 2.16: Component Interfaces



2.6 Selected architectural styles and patterns

2.6.1 Client/server multi-tier

The architecture style chosen is a client/server structure with multiple tiers. The presentation layer is divided between the two clients (IUs and TPUs clients) which are thick clients since they host a branch of the application logic to handle better and faster some system functionalities. In particular, in order to provide the fastest possible emergency response time, the client directly handles critical conditions contacting the emergency service and the backbone handles the dispatching of the IU live data to other components on the client.

The application server hosts the logic layer, exposing API to the clients, in order to access the subsystem functionalities and, for the D4H router, also to non-human TPUs which might access directly through the APIs; the application server is divided in four subsystems, each handling a piece of logic: a backbone, handling the core logic, storing data and user authorization, and providing interfaces to other subsystem to use its functionality, while the other subsystem independently handles the functionalities of the three services offered: D4H, ASOS and T4R.

The database server hosts the data layer and all the subsystems on the application server and independently interacts with it.

This will make for a modular software, enabling a fairly independent implementation and testing of each subsystem; moreover, alongside the tiered structure, will improve scalability and maintainability.

2.6.2 Event based paradigm

The backbone, namely the Data Dispatcher components, is an event-based subsystem that handles the dispatch of live data through the system. Live data, collected by the Data Collector/Dispatcher, serves as the event, broadcasted to all registered components. While introducing potential scalability problems, it simplifies the addition of the other subsystem.

2.6.3 REST and Real-Time API

By creating a RESTful system, that uses REST API and using a stateless protocol which relieve the server from storing client context between requests, we increase performance, reliability, and scalability. That said, using this software architectural style only could be too restrictive since it doesn't cope well with Real-Time transmission of data: for example within the Backbone, meaning between the component that collects the data on the client and the component on the server that receives, stores and forwards it. To publish data as fast as possible a Real-Time oriented API is used as support to handle the automated, synchronous and bi-directional communication between the server and both the clients and eventual non-human TPUs, while the REST API will be used for all other needs.

In particular a Streaming API is named in the [2.1.1](#) section, which implements a real time approach through a live connection. Other more event-based or push based methods are available.

2.6.4 Model View Controller

The pattern dictates the separation the user interface components (the view components in figure [2.2.5](#)), the data, which resides on the DBMS, and the response to user input and logic, located mostly on the application server and partly on the client.

2.7 Other design decisions

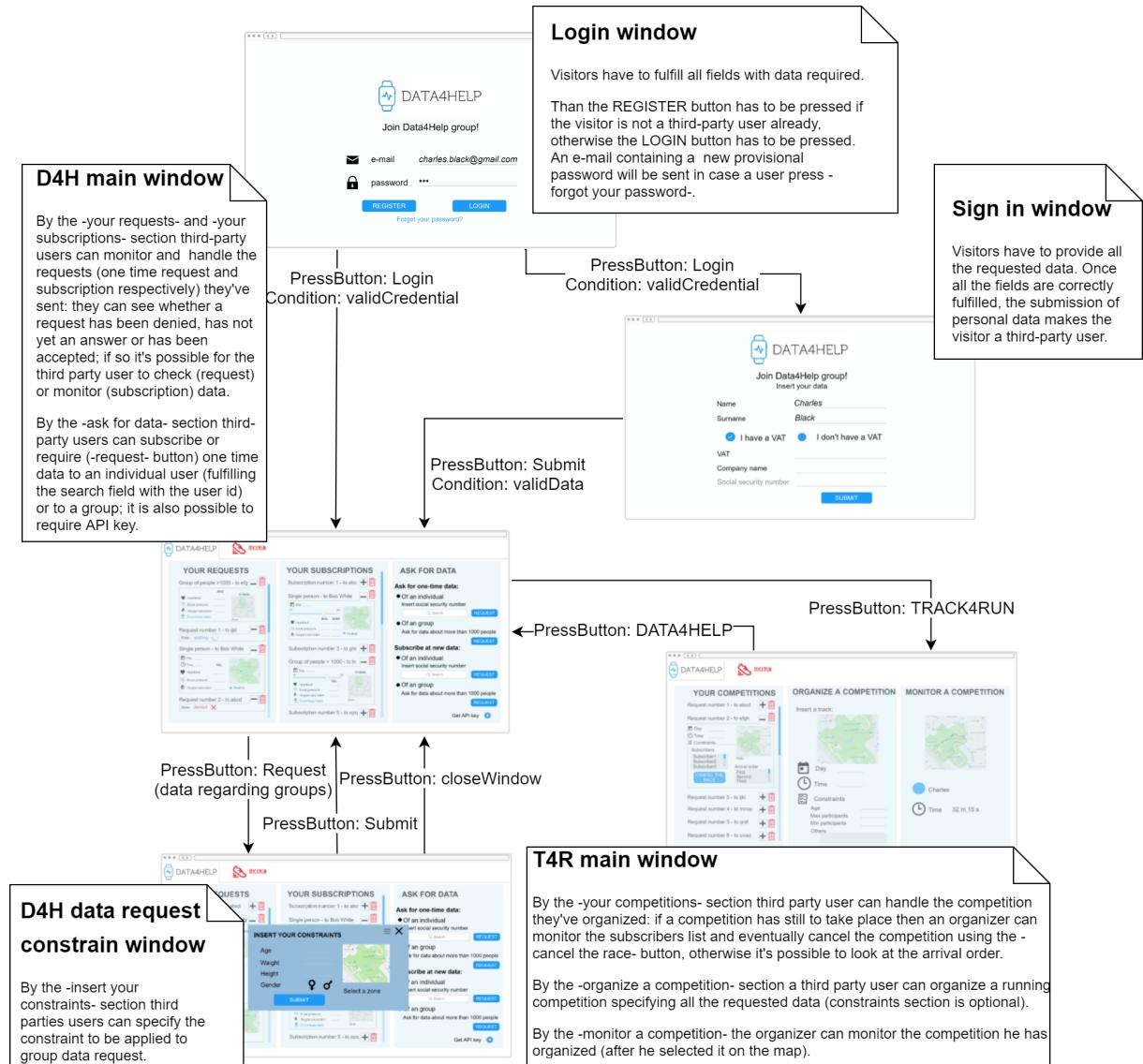
2.7.1 Emergency service

As method of contacting an ambulance there are some options: in Europe a single emergency number exists (112) and the European Emergency Number Association (EENA) handles a network of Public Safety Answering Points (PSAPs) and provides documentation, standards and regulations for automated access to 112 services. Access is possible, in its simplest form, with an automated call which relies on the IU communicating their info, or in better and more automated forms, using the Next Generation 112 (NG112) methods that are being implemented by PSAPs all over Europe.

3. User Interface Design

The user interfaces mock-ups are represented in sections 3.1.1, 3.1.2 of RASD. The following UX schemes represent a complete description of the user experience. The screen -T4R unsubscribe screen has been added and a better description of each mock-up has been provided.

Figure 3.1: Third-party user - UX graphical representation



Third-party user The scheme above represents the main desktop screens and how -condition and action needed- the third-party user can move through them.

Figure 3.2: Individual user - UX graphical representation (left part)

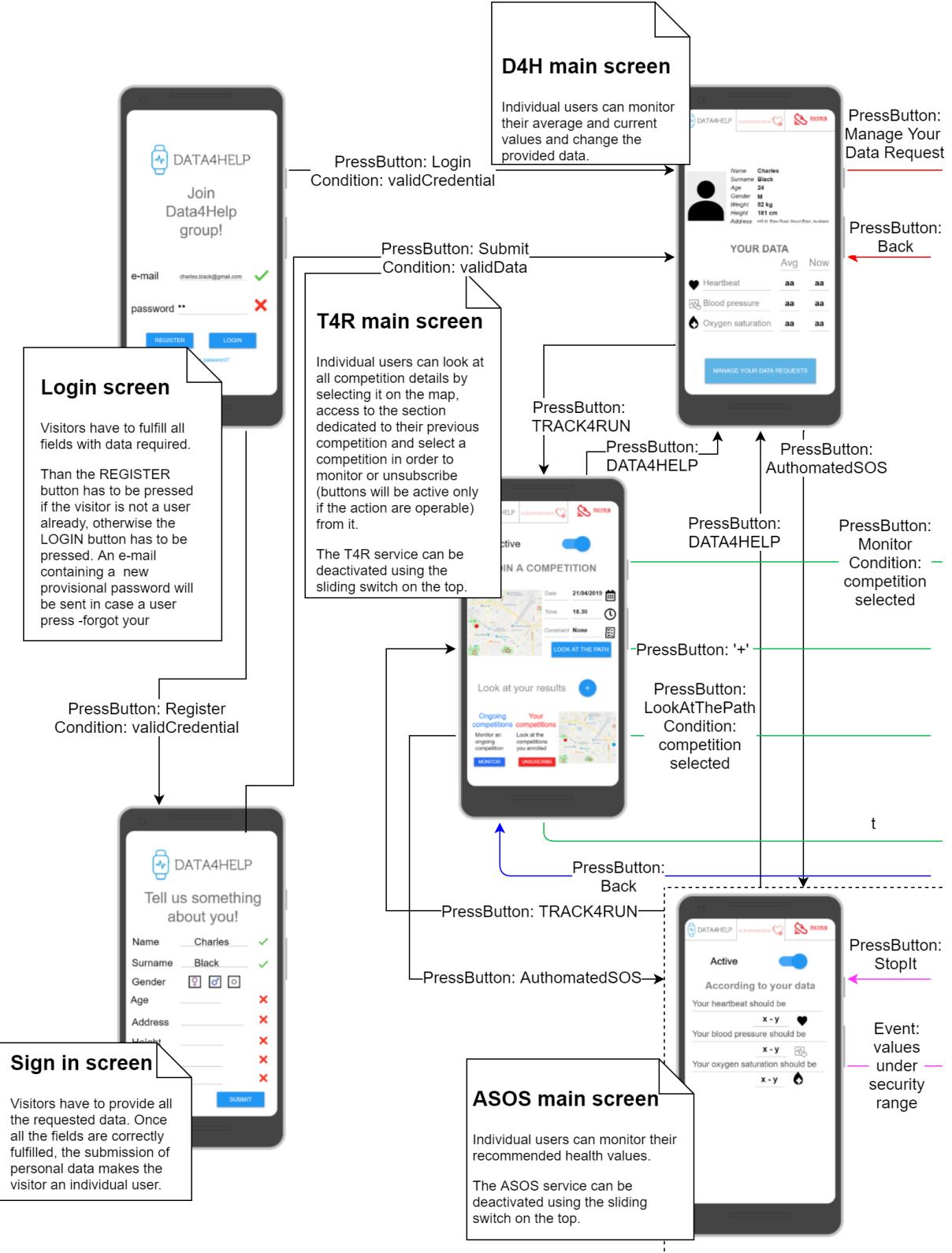
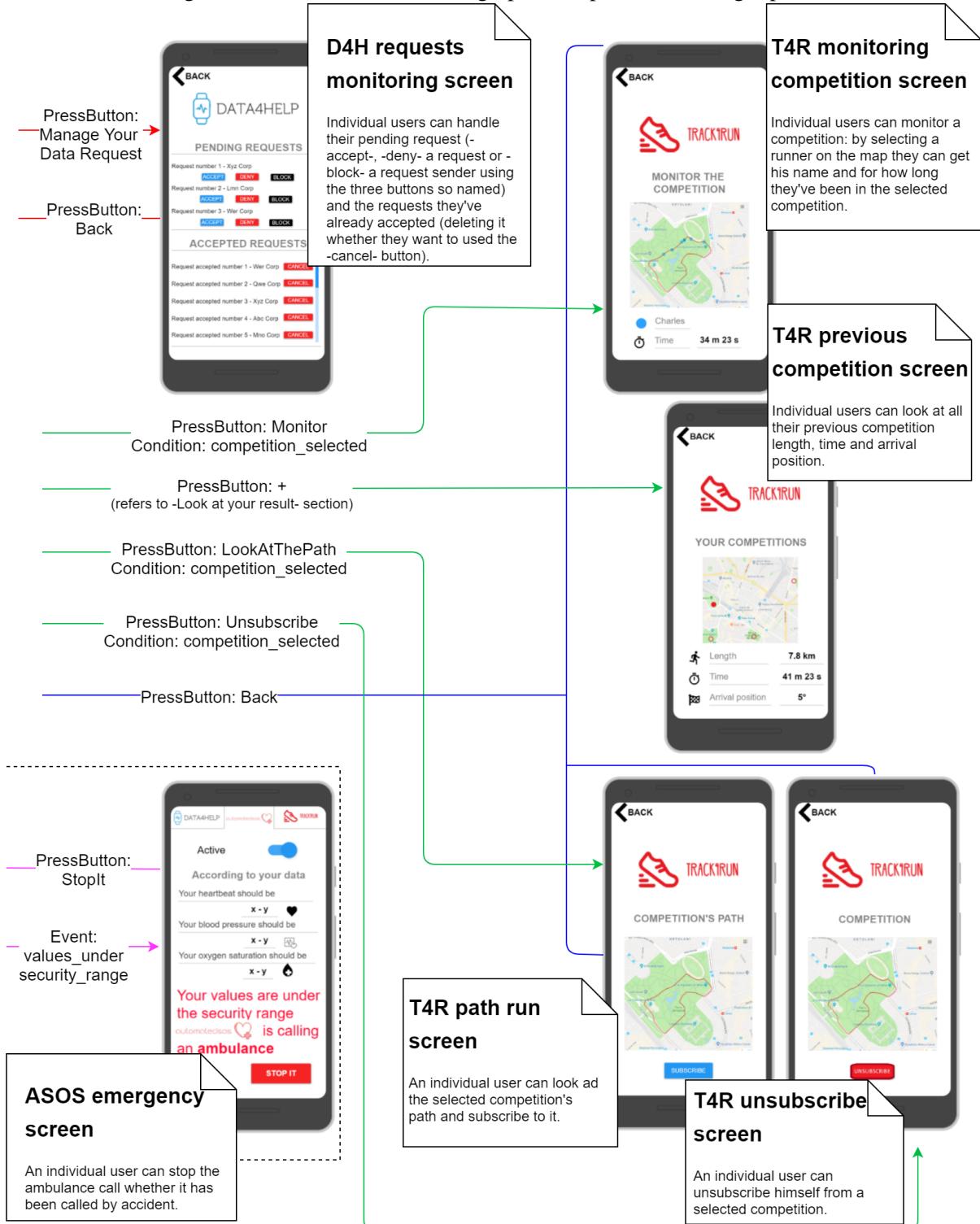


Figure 3.3: Individual user - UX graphical representation (right part)



Individual user The two schemes above represent the main mobile screens and how -condition and action needed- an individual user can move through them. The scheme has been divided in two parts in order to provide a better readability.

4. Requirements Traceability

In the following pages requirements are mapped with their respective components, goals -requirements refers themselves to- are also reported. For every requirement are specified major and secondary (auxiliary) components according to their relevance for the specific requirement. When multiple requirements (associated to the same goal) need to be mapped to the same set of components, those requirements are reported in sequence and followed by the set of components.

G1 Allow users to properly use the services they wish to employ

R1 The Users must be able to log in

Major:

- Authentication

Secondary:

- Data Dispatcher
- DBMS
- IU Data Dispatcher
- D4H Components on Application Server

R2 An IU must be able to opt in and out of any additional service besides D4H

Major:

- T4R Activation
- ASOS Activation

Secondary:

- Data Dispatcher
- Authentication
- DBMS
- IU Data Dispatcher

G2 Allow visitor to register as individual or third-party user

R4 A visitor must be able to register to the Data4Help System

R4.1 A visitor must insert name, age, gender, height, weight, ID, address, email and password

R4.2 A third party must insert name, ID, email and password

Major:

- Authentication

Secondary:

- Data Dispatcher
- DBMS
- IU Data Dispatcher
- D4H Application Server

G3 Allow individual users to monitor their location and health parameters

R5 The system must provide to logged IU their current location and health parameters

Major:

- IU Data Dispatcher

Secondary:

- Data Dispatcher
- D4H view
- Authentication

R6 The system must collect and keep track of the location and health data

Major:

- Data Dispatcher
- IU Data Dispatcher

Secondary:

- Authentication
- DBMS

G4 Allow third-party users to request the data on specific users

R7 A logged in TPU must be able to request the stored data or subscribe to newly produced data, after providing an ID of the user

R7.1 A TPU must be warned whether the data they requested is available

Major:

- Data Request Manager

Secondary:

- Data Dispatcher
- Authentication
- DBMS

R8 A TPU must be able to obtain the data it has access to

Major:

- Data Request Manager

Secondary:

- Data Dispatcher
- IU Data Dispatcher
- Authentication
- DBMS

G5 Allow individual users to approve or deny the specific request for their data

R9 The IU must be notified when a TPU requests their data

Major:

- Data Request Manager

Secondary:

- Data Dispatcher
- IU Data Dispatcher
- Authentication
- DBMS

R10 An IU must be able to accept the request on their data

R11.1 An IU must be able to deny access to their data

R11.2 An IU must be able to block a TPU to automatically deny their future requests for data

R12 User must be able to cancel the TPU subscriptions to their data that they previously accepted

Major:

- Data Request Manager

Secondary:

- Data Dispatcher
- IU Data Dispatcher
- Authentication
- DBMS

G6 Allow third-party users to request data on anonymized groups of individual users

R13.1 A logged in TPU must be able to request the stored data or subscribe to newly produced data, after providing the specifics of the group it is interested in

R13.2 A TPU must be warned whether it is possible to properly anonymize the data requested

Major:

- Data Request Manager

Secondary:

- Authentication
- Data Dispatcher

G7 Call an ambulance if the system detects a critical health condition

R14 When a critical condition is registered, the system should contact the ES and provide it with the location and health status of the IU

Major:

- Health Data analyzer
- Emergency Handler

Secondary:

- ASOS view
- ASOS router

R15 The IU must be able to cancel the call

Major:

- ASOS view
- ASOS router

Secondary:

- Emergency Handler

G8 Allow third-party users to organize running competitions

R16.1 A TPU must be able to create a new run, specifying time, duration, path, restriction for enrolment

R16.2 A run organizer must be able to cancel a run

Major:

- Run Status Manager

Secondary:

- T4R router
- Autentication

R17 Run organizers, participants and spectators must be able to see the status of the ongoing run

Major:

- T4R view

Secondary:

- Run Status Manager

- T4R router
- Autentication

G9 Allow Individual users to enrol in existing running competitions as participants

R18.1 An IU must be able to enrol in a future run

R18.2 A participant must be able to cancel their inscription to the run

Major:

- Run Status Manager

Secondary:

- T4R router
- Autentication

G10 Allow Individual users to subscribe in existing running competition as spectators to monitor underway competitions

R17 Run organizers, participants and spectators must be able to see the status of the ongoing run

Major:

- T4R view

Secondary:

- Run Status Manager
- T4R router
- Autentication

5. Implementation, Integration and Test plan

5.1 Implementation strategy

The implementation of D4H, T4R and ASOS will follow a critical-module-first approach. According to this strategy implementation should start with the most complex, critical and connected components. Both a bottom-up approach or a top-down one, considered as sole strategy, would be only partially effective. As a matter of fact the great advantage given to the design structure of the project, that is to say the possibility of parallelize the implementation of the three applications, wouldn't be fully exploited. The critical-module-first approach choice is due to the structure of the the Data4Help System as it has been designed. The backbone of the three application is, indeed, the same for D4H, T4R and ASOS; so it is for sure the most critical and connected module. The implementation of the three application, once all the shared components will be tested and the integration tests will be performed, could also be done in parallel.

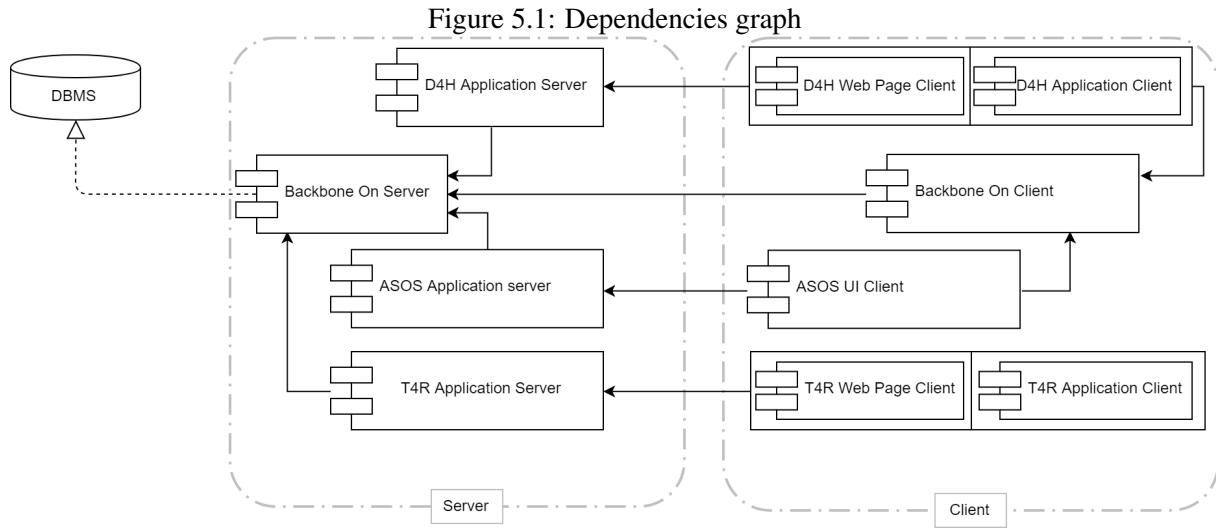
Of course this implementation strategy requires a sort of bottom-up approach. In fact, once the backbone of the application will be completed, the actual implementation will consists in the piecing together of systems to generate more complex systems.

About the programming language to be used, HTML5 + Java/Javascript are feasible options, but other options as Python or Android Studio are perfectly equally valid possibilities. Considering the design of the project there's no particular recommendation about programming language choice needed.

In order to provide a more exhaustive description of the implementation strategy an analysis of the dependences is provided.

In this section the modules of the four subsystems on the Application Server are divided logically in Backbone Application Server, D4H Application Server, ASOS Application Server and T4R Application Server although they are a single software on a single server.

5.1.1 Dependencies



The represented modules refer to the 2.2 section. Arrows stand for -depends on-.

The following order is not mandatory for developers. It is to be considered an advice given in order to optimize the implementation time.

1- Backbone On Server is for sure the very first module to be implemented, since many modules depend on it and it is crucial in the communication with the DBMS.

This module is composed by the following components:

- Authentication
- Data Dispatcher

2- Backbone On Client is the second module to be implemented in order to complete as soon as possible the applications' backbone.

This module is composed by the following components:

- Data Collector/Dispatcher

Once applications' backbone is completed the implementation of D4H, T4R and ASOS can run independently.

Whether a parallelized implementation is not possible a coherent with the assignment order is suggested. Here it is a possible implementation order:

3- D4H Application Server module is composed by the following components:

- D4H Router
- Request Status Manager
- Blocked TPUs Manager
- Anonymity Evaluator

4- ASOS Application Server module is composed by the following components:

- ASOS Router
- ASOS activation

- Health Data Analyzer

5- T4R Application Server module is composed by the following components:

- T4R Router
- T4R activation
- Run Status Manager

6- D4H Web Page Client/D4H Application Client module is composed by the following components:

- D4H view

7- ASOS UI Client module is composed by the following components:

- ASOS view
- Emergency Handler

8- T4R Web Page Client/T4R Application Client module is composed by the following components:

- T4R view

5.2 Testing on components strategy

Testing on single components should be done as soon as the components themselves are produced. The testing order of the single components must be coherent with the implementation order indicated at 5.1. In testing process might be useful the support of a multiplicity of software verification tools which allow to run large number of tests during the development and verification of the whole system. Of course the choice of verification tools depends on the programming language chosen, anyway some useful tools could be:

- **JUnit** - JUnit is one of the commonest testing software. It can be used both in unit and integration testing; the first usage is by the way the most recommended one for the three subsystems development; JUnit can be useful in verifying assertions on return values after method invocations. The aim of testing tool usage is of course helping the developers to verify the logic of a piece of the program. That's why, in order to avoid having to perform lots of manual tests, the use of JUnit and the resulting possibility of running automatically tests helps to identify software regressions introduced by changes in the source code meantime the implementation phase and leads to high test coverage of the code.
- **Mockito** - It is an indicated testing tool since it is a mock framework which can be used in conjunction with JUnit. Mockito also allows developers to create and configure mock objects, which according to the testing planning will probably be largely used. In particular, a use of the following test replacements (test doubles) for the real dependencies is recommended:
 - Dummy object; to fill the parameters of methods.
 - Fake objects;
 - Stub class; during the early integration tests some partial implementations for interfaces or classes with the purpose of using an instance of this stub might be useful.
 - Mock object; dummy implementation for an interface or a class in which the output of certain method calls is already defined by the developers.

So using Mockito it will be possible to mock away external dependencies and run the integration tests sooner and validate whether the code is executed correctly.

- **Apache JMeter** - is a Java application designed to load test functional behavior and measure performance. It can be useful to simulate a heavy load on servers, but can be used also in order to analyze overall performance under different load types.

The following table is reported in order to indicate some values that it's worth to submit. Those values are indicated to stress software and obtain a good testing coverage.

The `-!(type)-` stands for `-submit` types different from the indicated one-. The `✓` stands for `-submit this kind of value-`.

Data	sub. model	Null	Neg.	!(int)	!(String)	!(Coord)	!(List)	!(0_1 value)	!(legal value)
age	IU	✓	✓	✓					
gender	IU	✓			✓				✓
weight	IU	✓	✓	✓					
height	IU	✓	✓	✓					
address	IU	✓			✓				✓
activatedServices	IU	✓					✓		✓
location	Data	✓				✓			✓
heartbeat	Data	✓	✓	✓					
bloodPressure	Data	✓	✓	✓					
time	Data	✓	✓	✓					✓
oxigenSaturation	Data	✓	✓	✓					
state	DataRequest	✓			✓				✓
time	DataRequest	✓	✓	✓					✓
isSubscripted	DataRequest							✓	
id	User	✓			✓				✓
name	User	✓			✓				✓
password	User	✓			✓				✓
email	User	✓			✓				✓
blockedTPUs	Blocked Requests	✓					✓		✓
idNumber	Run	✓	✓	✓					
path	Run	✓				✓	✓		✓
startTime	Run	✓	✓	✓					✓
endTime	Run	✓	✓	✓					✓
minAge	Run	✓	✓	✓					
maxAge	Run	✓	✓	✓					
minParticipants	Run	✓	✓	✓					
maxParticipants	Run	✓	✓	✓					

5.3 Integration strategy

5.3.1 Completion of components before starting testing

The integration and integration testing should start as soon as possible. Of course before starting with integration is necessary to be sure that the external services and APIs that will be used in the applications

should be available and ready. In order to speed up the integration process, only a certain percentage of completion is actually needed. In particular the completion of components before the starting the integration should be at least:

- Backbone On Server - 90-100%
- Backbone On Client - 80-90%
- D4H Application Server - 75-85%
- ASOS Application Server - 70-80%
- T4R Application Server - 70-80%
- D4H Web Page Client/D4H Application Client - 65-75%
- ASOS UI Client - 60-70%
- T4R Web Page Client/T4R Application Client - 60-70%

According to the critical-module-first approach and the testing approach expressed at point 5.2 also component integration should happen firstly in applications backbone and just then in the three applications core. Since a parallel implementation is possible, as soon as components completion meets the required percentages integration should be performed. Whether parallel implementation is not possible, the following graphical representation shows a possible integration order (obviously coherent with the implementation plan).

Figure 5.2: 0 and 1 integration phase

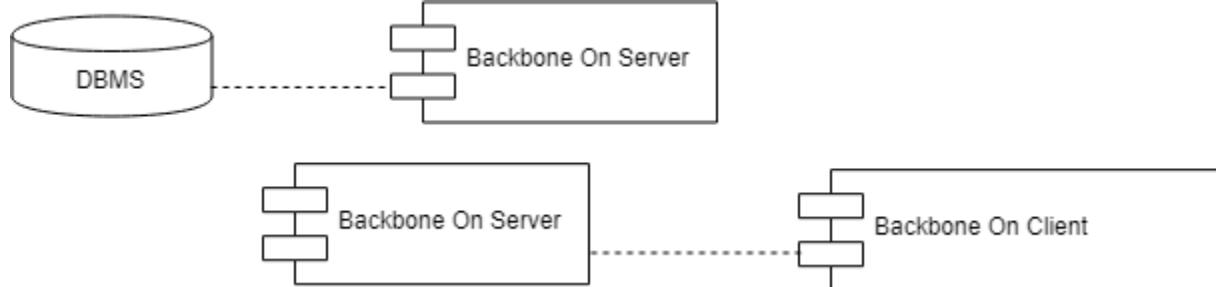
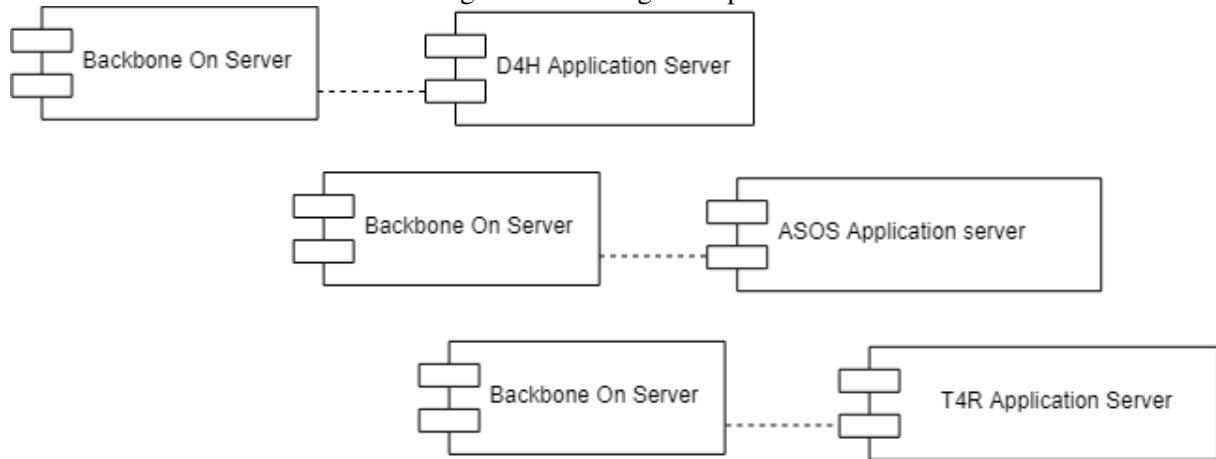


Figure 5.3: 2 integration phase



The integration order of the following modules has to depends on the implementation order. The following order is just a suggestion which doesn't consider the parallel implementation possibility.

Figure 5.4: 3 integration phase

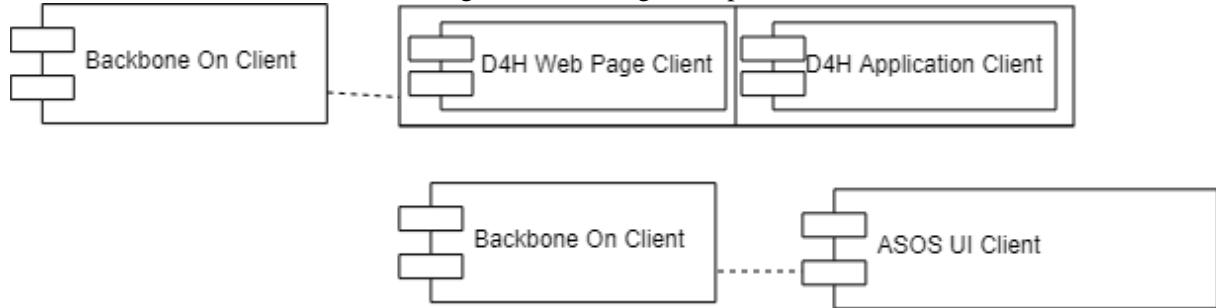
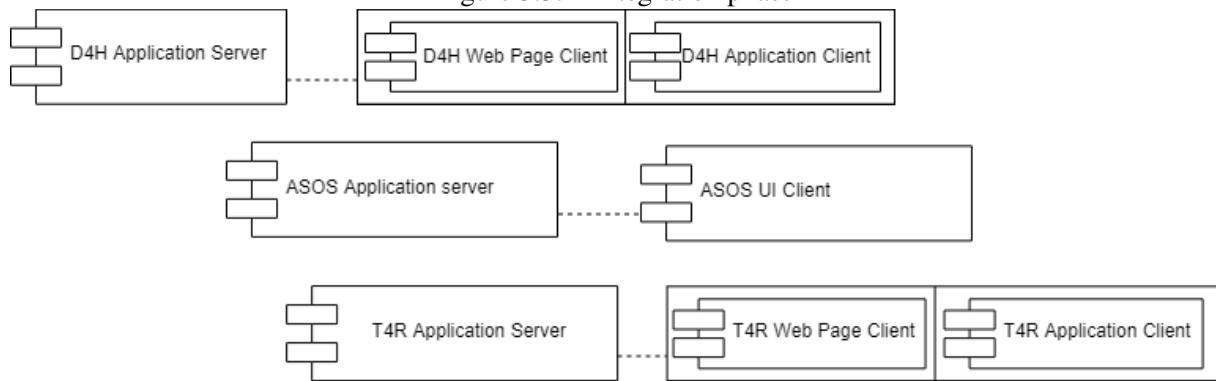


Figure 5.5: 4 integration phase



5.4 Integration test plan

The following section should represents a testing guide line: some of the most important tests that is necessary to perform in the various integration phases are listed.

Tests IDs are structured as follows: the first two characters stand for the integration test number (tNumber), while the last two characters stand for the integration phase (iNumber).

5.4.1 0 integration phase

All the following tests will be generic: it is not really important the kind of data request, all that matters is submitting both valid and not valid input in order to test the server-DBMS communication. To provide a better coverage the greater possible number of different request kinds should be performed. Stub objects and oracles should be used instead of the not yet implemented components.

Test ID: t1i0	
Components involved	Data Dispatcher, Authentication, DBMS
Input specification	Data x that belonging to y stored in DBMS request
Output specification	Data x
Requirements-goals involved	R7, R8 - G4, G6
Description	To test the communication between DBMS and the Backbone On Server in download some data requests have to be performed. The communication should be effective and fast enough: Database Response Time should not be more than 30ms (real time data) or 200ms (historical data). The authentication procedure has to be tested as well in this section.

Test ID: t2i0	
Components involved	Data Dispatcher, Authentication, DBMS
Input specification	Data x belonging to y, storing request
Output specification	Boolean: true
Requirements-goals involved	R6-G3
Description	To test the communication between DBMS and the Backbone On Server in upload some data requests have to be performed. The communication should be effective and fast enough: Database Response Time should not be more than 30ms. Whether the storage is performed correctly, the return value expected is true.

Test ID: t3i0	
Components involved	Data Dispatcher, Authentication, DBMS
Input specification	Data x that belonging to y not stored in DBMS request
Output specification	Warning
Requirements-goals involved	R8-G3, G4, G6
Description	The system has to warn the user that the requested data are not present in DBMS. The communication should be effective and fast enough: Database Response Time should not be more than 30ms (real time data) or 200ms (historical data).

Test ID: t4i0	
Components involved	Data Dispatcher, Authentication, DBMS
Input specification	Several requests of data x, stored or not in DBMS, have to be performed
Output specification	Data requested
Requirements-goals involved	R8, R13.1,R13.2,R7-G4, G6
Description	A great number of requests (more than 1000) should be performed to test the system availability. This is necessary in order to be sure to have a proper backbone subsystem for the application. For each request Database Response Time should not be more than 30ms (real time data) or 200ms (historical data). According to requirements system availability must be at least 99.995%.

5.4.2 1st integration phase

The following test should be performed in order to test the behaviour of the Backbone On Client. Stub objects and oracles should be used instead of the not yet implemented components.

Test ID: t1i1	
Components involved	Data Dispatcher, Authentication, DBMS, IU Data Dispatcher
Input specification	Several storing requests x belonging to y
Output specification	boolean
Requirements-goals involved	R6-G3
Description	Synchronization of client data test: if the storing request is successful a true value is returned, otherwise (false value must be returned) is necessary to check whether data are still memorized (client side).

5.4.3 2nd integration phase

All the following test will be performed in order to test the integration between modules of the Backbone and the application servers. AuthenticationService, DataReceiver and DataDispatcher are the interfaces involved in this integration phase. Each of the following test should be performed using different mocks (one per application). Stub objects and oracles should be used instead of the not yet implemented components.

Test ID: t1i2	
Components involved	Data Dispatcher, Authentication, DBMS, IU Data Dispatcher, D4H Application Server
Input specification	Individual user or third-party user registration data
Output specification	boolean
Requirements-goals involved	R4, R4.1, R4.2-G2
Description	By the submission of all the required data a client should be able to register successfully. In this case a true boolean value should be returned. Some attempts with incomplete or wrong data submissions should be operated in order to test the system. In this case a false boolean value should be returned.

Test ID: t2i2	
Components involved	Data Dispatcher, Authentication, DBMS, IU Data Dispatcher, D4H Application Server
Input specification	Individual user or third-party user update info
Output specification	boolean
Requirements-goals involved	R4-G2
Description	Individual or third-party users should be able to update of one or more personal data. In case the process ends successfully a true boolean value should be returned. Some attempts with incomplete or wrong updates should be operated in order to test the system. In this case a false boolean value should be returned.

Test ID: t3i2	
Components involved	Data Dispatcher, Authentication, DBMS, IU Data Dispatcher, D4H Application Server
Input specification	Individual user or third-party user login data
Output specification	boolean
Requirements-goals involved	R1-G1
Description	By the submission of all the required data a client should be able to register successfully. In this case a true boolean value should be returned. Some attempts with incomplete or wrong login data submissions should be operated in order to test the login process. In this case a false boolean value should be returned.

Test ID: t4i2	
Components involved	Data Dispatcher, Authentication, DBMS, IU Data Dispatcher, D4H Application Server, T4R Application Server, ASOS Application Server
Input specification	Data event
Output specification	
Requirements-goals involved	R2-G1
Description	By this test is possible to check the update of all the involved application server when a data event occurs

Test ID: t5i2	
Components involved	Data Dispatcher, Authentication, DBMS, IU Data Dispatcher, D4H Application Server
Input specification	IU, DataReciver
Output specification	boolean
Requirements-goals involved	R7, R13.1-G4,G6
Description	This test should verify whether third party users are able to subscribe or unsubscribe to data. Also not well formulated requests should be performed in order to test the subscription process. In this case a false boolean value should be returned.

The following tests should be performed firstly in the integration of the modules' components. This first stage doesn't depend on integration phases and can be performed as soon as the components are created according to section 5.3.1, exploiting stub objects and oracles where needed.

5.4.4 3rd and 4th integration phase

During those integration processes stub objects and oracles should be gradually substituted by implemented components. In particular the integration should regard client modules with the Backbone on client and client modules with the respective server modules.

Test ID: t1i3/4	
Components involved	Data Dispatcher, Authentication, DBMS, IU Data Dispatcher, BlockedTPUsManager, D4H Router
Input specification	IU, TPU
Output specification	
Requirements-goals involved	R11.2-G5
Description	This test should verify whether Individual users can block correctly a data requests sender.

Test ID: t2i3/4	
Components involved	Data Dispatcher, Authentication, DBMS, IU Data Dispatcher, D4H Router, Request Status Manager
Input specification	IU, TPU, subscription
Output specification	int (requestID)
Requirements-goals involved	R7, R7.1,R8-G4
Description	This test should verify whether third-party users are able to formulate properly individual data requests. If the request is correctly formulated, a univocal request ID is generated.

Test ID: t3i3/4	
Components involved	Data Dispatcher, Authentication, DBMS, IU Data Dispatcher, D4H Router, Request Status Manager
Input specification	createAnonymRequest input parameters
Output specification	int (requestID)
Requirements-goals involved	R13.1, R13.2 ,R8-G6
Description	This test should verify whether third-party users are able to formulate properly group data requests. If the request is correctly formulated, a univocal request ID is generated.

Test ID: t4i3/4	
Components involved	Data Dispatcher, Authentication, DBMS, IU Data Dispatcher, D4H Router, Request Status Manager, Anonymity Evaluator
Input specification	requestID
Output specification	boolean
Requirements-goals involved	R10, R11.1, R11.2, R12-G5
Description	This test should verify whether users are able to cancel requests and individual users can deny or approve a single data request. Whether the action is performed correctly a true value should be returned.

Test ID: t5i3/4	
Components involved	Data Dispatcher, Authentication, DBMS, IU Data Dispatcher, ASOS view, ASOS router, T4R view, T4R router, ASOS activation, T4R activation
Input specification	IU, activated (boolean)
Output specification	boolean
Requirements-goals involved	G7, G8,G9,G10
Description	This test should verify whether individual users are able activated or deactivated the ASOS and T4R services. Whether the action is performed correctly a true value should be returned.

Test ID: t6i3/4	
Components involved	Data Dispatcher, Authentication, DBMS, IU Data Dispatcher, ASOS view, ASOS router, Health Data Analyzer
Input specification	IU
Output specification	int
Requirements-goals involved	G7
Description	This test should verify whether individual users can get their data parameters correctly.

Test ID: t7i3/4	
Components involved	Data Dispatcher, Authentication, DBMS, IU Data Dispatcher, T4R view, T4R router, Run Status Manager
Input specification	createRun/updateRun input parameters
Output specification	int (run identificationNumber)/boolean
Requirements-goals involved	R16.1, R16.2, R17-G8
Description	This test should verify whether third-party users are able to create or update their own running competitions.

Test ID: t9i3/4	
Components involved	Data Dispatcher, Authentication, DBMS, IU Data Dispatcher, T4R view, T4R router, Run Status Manager
Input specification	getCloseRun/cancelRun/getRun input parameters
Output specification	Run, boolean
Requirements-goals involved	R16.2, R17-G10, G8
Description	This test should verify whether third-party users are able to cancel a running competition they've previously organized. It should also verify whether individual users are able to select a particular set of running competition from the map.

Test ID: t10i3/4	
Components involved	Data Dispatcher, Authentication, DBMS, IU Data Dispatcher, T4R view, T4R router, Run Status Manager
Input specification	runIdentificationNumber, IU participant
Output specification	boolean
Requirements-goals involved	R18.1, R18.2-G9
Description	This test should verify whether individual users can enroll or unenroll to an organized competition.

6. Effort Spent

6.1 ARGIRO' ANNA SOFIA

DATE	DESCRIPTION OF THE TASK	HOURS SPENT
27/11/18	group work	3
2/12/18	high level overview	4
2/12/18	group work	4
8/12/18	Architecture revision, Introduction	4
8/12/18	group work	4
10/12/18	group work	4
10/12/18	Requirement traceability	4
Total		27

6.2 BATTAGLIA GABRIELE

DATE	DESCRIPTION OF THE TASK	HOURS SPENT
27/11/18	group work	3
30/11/18	component view	4
2/12/18	model diagrams	4
2/12/18	group work	4
6/12/18	Components interfaces	8
8/12/18	Deployment, sequence diagram	4
8/12/18	group work	4
10/12/18	Sequence diagram, architecture design	4
10/12/18	group work	4
Total		39

6.3 CASASOLE BERNARDO

DATE	DESCRIPTION OF THE TASK	HOURS SPENT
27/11/18	group work	3
2/12/18	User interface design	4
2/12/18	group work	4
5/12/18	Implementation and testing	5
8/12/18	Implementation and testing	4
8/12/18	group work	4
10/12/18	References, testing revision	4
10/12/18	group work	4
Total		32

7. References

7.1 Reference Documents

Past courses material

- DD samples from A.Y. 2015-2016
- DD samples from A.Y. 2016-2017
- TrackMe RASD - <https://github.com/BernardoCasasole/ArgiroBattagliaCasasole.git>
- ITPD sample from A.Y. 2016-2017

Slides from lesson

- Design
- Design Descriptions and Principles
- Design Process
- Design - quantitative analysis of designs
- Architecture and Design in Practice
- IntroToVerificationAndValidation
- VerificationAndValidation Analysis
- VerificationAndValidation TestingIntroAndActivities
- VerificationAndValidation TestingTechniques

Emergency service call

- <https://eena.org/>

Software development and testing

- https://en.wikipedia.org/wiki/Top-down_and_bottom-up_design#Software_development
- <https://aaltodoc.aalto.fi/handle/123456789/21410>

From Data Base 1 course

- Esercizi di progettazione di Basi di Dati Relazionali

Testing tools

- <http://www.vogella.com/tutorials/Mockito/article.html>
- <http://home.deib.polimi.it/dubois/provafinale/junitjavadoc.pdf>
- <https://www.qasymphony.com/blog/100-plus-best-software-testing-tools/>
- <https://jmeter.apache.org/>
- <https://junit.org/junit5/>

Cloud computing architecture

- <https://sysgen.ca/cloud-vs-in-house-servers/>
- <https://www.rackspace.com/library/cloud-vs-dedicated>
- <https://www.newgenapps.com/blog/top-5-cloud-platforms-and-solutions-to-choose-from>
- <https://kinsta.com/blog/google-cloud-vs-aws/>
- <https://medium.com/@robaboukhalil/a-tale-of-two-clouds-amazon-vs-google-4f2520516a38>
- <https://www.hostingadvice.com/how-to/best-cloud-server-hosting/>
- <https://www.probrand.co.uk/it-services/cloud-server>
- https://en.wikipedia.org/wiki/Cloud_computing_architecture
- <https://www.chargebee.com/blog/understanding-types-cloud-computing/>
- https://en.wikipedia.org/wiki/Amazon_Web_Services
- <https://aws.amazon.com/it/>
- <https://www.newgenapps.com/blog/top-10-cloud-computing-examples-and-uses>
- <https://cloud.google.com/sql/>

API

- https://en.wikipedia.org/wiki/Representational_state_transfer
- <https://realtimeapi.io/hub/realtime-api-design-guide/>

7.2 Software

- <http://www.tug.org/texworks/TeXWorks v0.6.2>
- <https://about.draw.io/Draw.io v9.4.1>
- <https://proto.io/proto.io v6.3.2.3>