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Data4Help DD

Design Document
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1 Introduction

1.1 Purpose

The purpose of this document is to further analyze the design and architectural choices for the system to be. Whereas the RASD presented a general view of the system and its features, this document will detail those concepts by showing components of the system, its run-time behavior, deployment plan and algorithm design.

The document will therefore contain a presentation of:

- Overview of the high-level architecture
- Main components and their interfaces provided one for another
- Runtime behavior
- Design patterns
- Implementation plan
- Integration plan
- Testing plan

1.2 Scope

(An SDD shall identify the design stakeholders for the design subject.

An SDD shall identify the design concerns of each identified design stakeholder.

An SDD shall address each identified design concern.

Stakeholders are those people, groups, or individuals who either have the power to affect, or are affected by the endeavor you're engaged with.

)

1.3 Definitions, Acronyms, Abbreviation

1.3.1 Definitions

- User: individual who allows *Data4Help* to monitor his location and health status.

- Third party: individual or organization registered to *Data4Help* which can request users' data.
- Data collection: gathering of users' data through a wearable device.
- Anonymized data: data about more than 1000 users whose personal information has been previously removed so that they are not directly relatable to the system's users.
- Elderly: user who is subscribed to *AutomatedSOS* and is older than 60 years old.
- Risk threshold: Set of boundary health parameters defined for each elderly. If monitored values of the user's health parameters get below these boundaries, an SOS request is placed to an external ambulance provider.
- Athlete: user who participates in a run.
- Run organizer: third party who can manage runs for athletes.
- Spectator: non-registered individual who follows a run through a map with runners' positions.
- Wearable: a personal device provided with biometric sensors and GPS given to each user for free after the registration process.

1.3.2 Acronyms

- API: Application Programming Interface
- DB: Database
- DBMS: Database Management System
- DD: Design Document
- GUI: Graphical User Interface
- RASD: Requirements Analysis and Specifications Document
- GPS: Global Positioning System

1.3.3 Abbreviations

- Gn: nth goal.
- Dn: nth domain assumption.
- Rn: nth functional requirement.
- Rn-NF: nth nonfunctional requirement.

1.4 Reference Documents

- IEEE Standard on Software Design Descriptions (*IEEE Std 1016-2009*)
- <https://www.uml-diagrams.org/>

1.5 Document Structure

To be completed

2 Architectural Design

2.1 Overview

This system is based upon a three-tier architecture, consisting of three logical computing “layers”. The first one is *Presentation* tier which is the front-end and consists of the web-app’s user interface and client logic. The second layer is represented by the *Application* tier, which contains the functional business logic. The last layer, the *Data* tier, is responsible for the database storage system and data access.

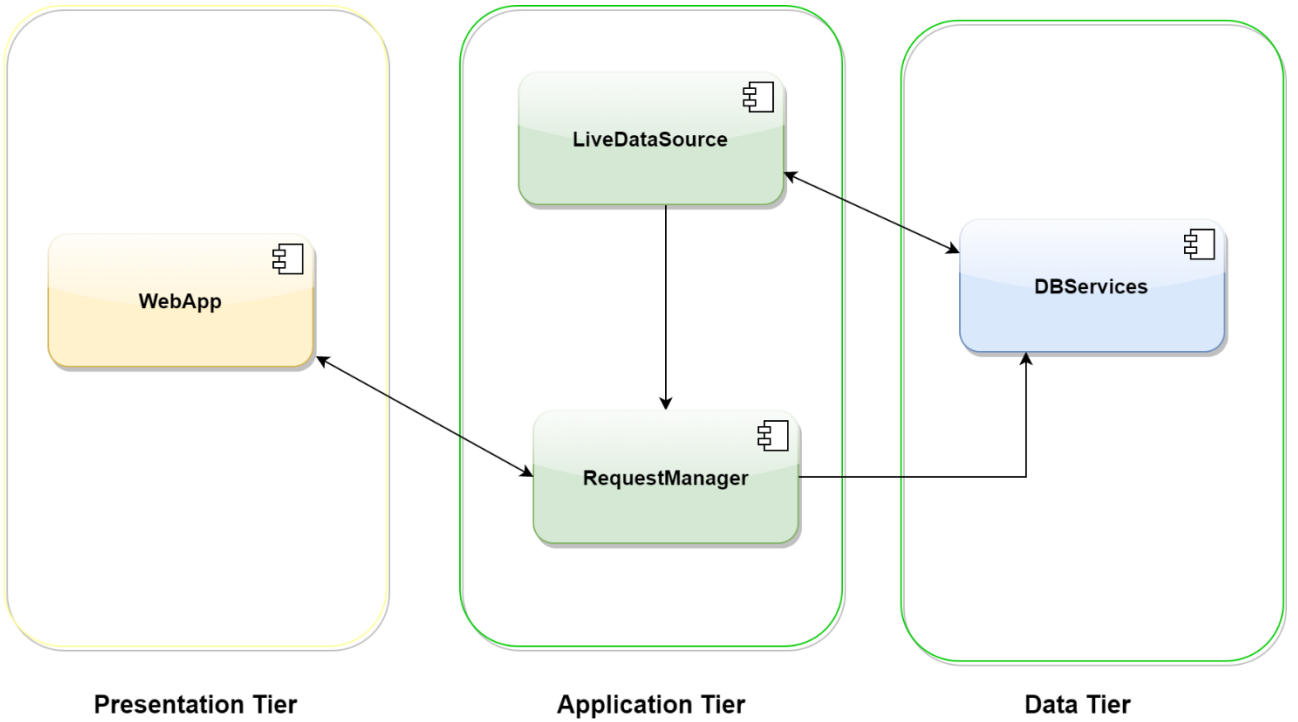


Figure 1: Data4Help High-level Architecture

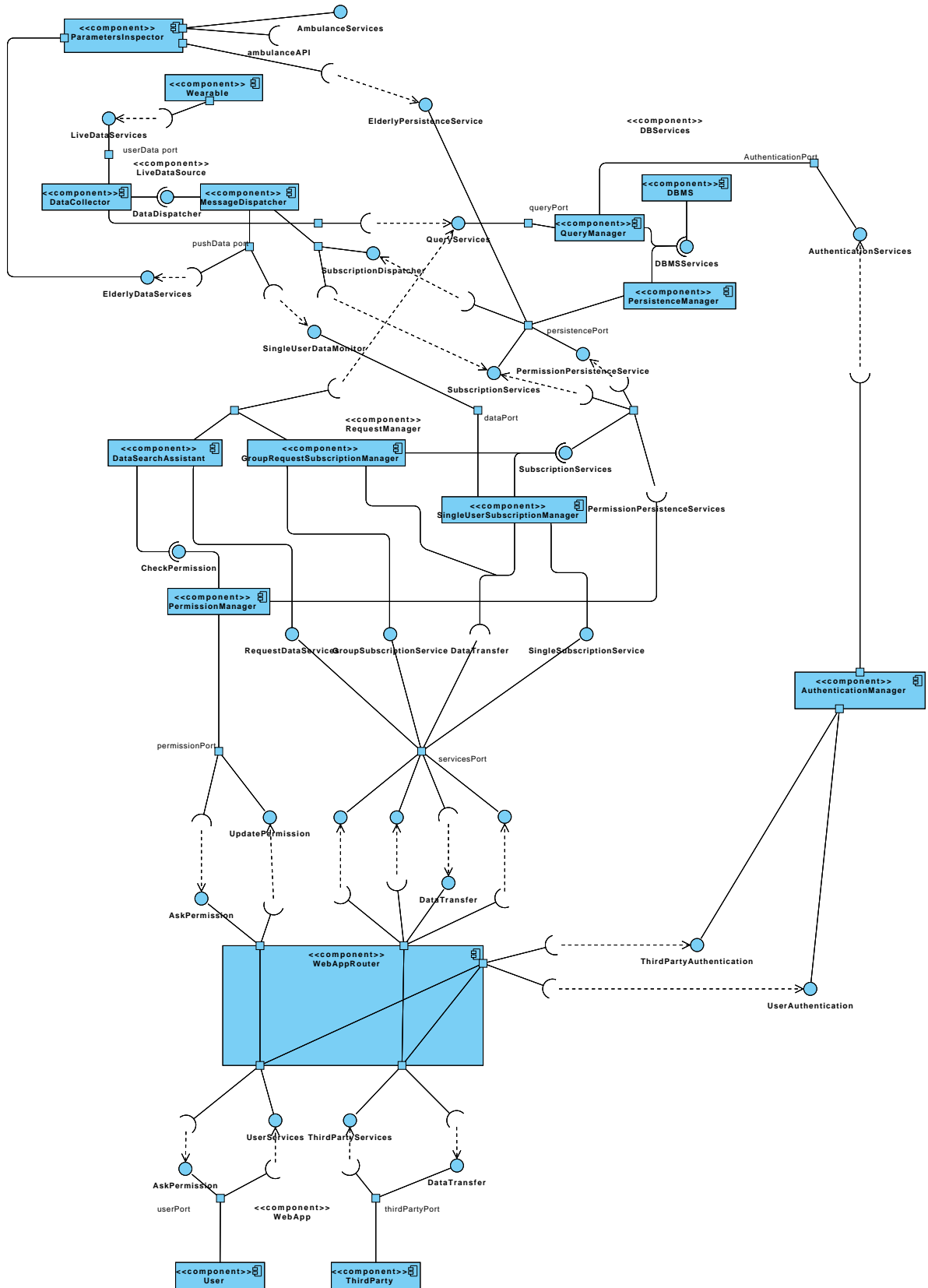
WebApp is the high-level component related to the *Presentation* layer. Its task is to present the user interface and react to user input.

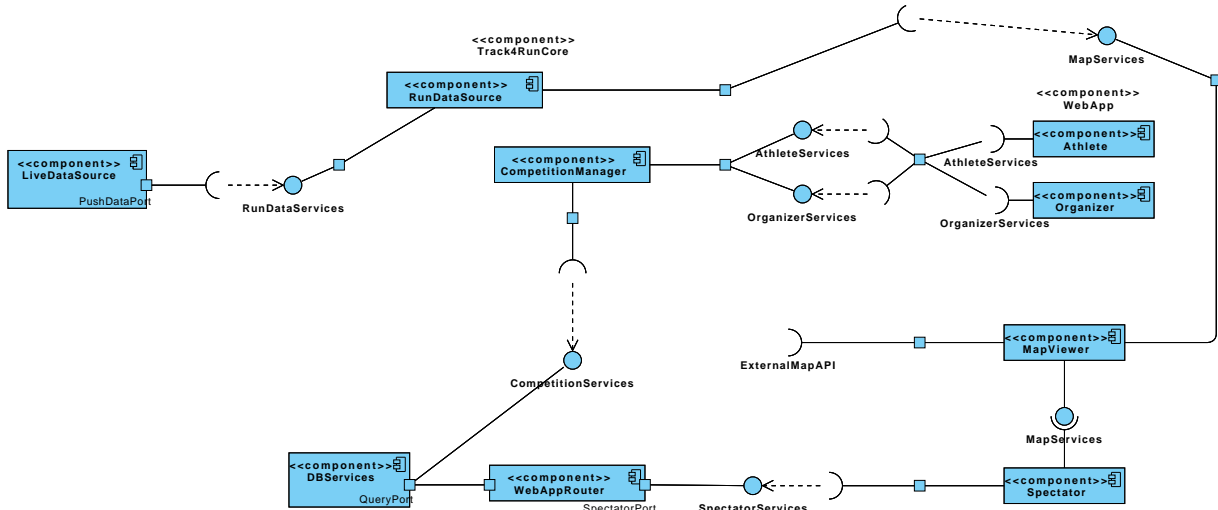
Data tier corresponds to the *DBServices* component, which stores data in the database and makes queries.

Application tier is composed by two main components: *LiveDataSource*, which is responsible for collecting users’ data and then redistributing them immediately to third parties or submit them to the *DBServices*, and *RequestManager*, which contains all the logic related to third parties’ requests and subscriptions.

Track4Run and *AutomatedSOS* services are built on top of this architecture, extending *Data4Help* core functionalities.

2.2 Component View





(to be completed)

2.2.1 DataCollector

This component receives fresh biometric and GPS data from wearable devices and holds responsibility of saving them to the database and simultaneously relaying them to the *MessageDispatcher* component.

2.2.2 ParametersInspector

Is responsible of monitoring elderly subscribers' health status and, if necessary, to request the dispatch of an ambulance. To accomplish the latter:

- It is able to contact the ambulance provider and send it data through the *AmbulanceAPI* interface, provided by the external provider's API.
- It is able to be informed on user being picked up by the ambulance through the *AmbulanceServices* interface, in order to stop sending data to the ambulance provider.

2.2.3 MessageDispatcher

This component is in charge of relaying live data through the system, thus needing to be informed of message recipients. In order to do this:

- It is able to load data in case of cold restart or component failure through the *SubscriptionServices* interface.
- Is informed of every new subscription, be it an elderly subscribing to *AutomatedSOS* or a single user's data subscription from a Third Party, through the *SubscriptionDispatcher* interface.

- It is able to send (push paradigm) messages to *ParametersInspector* and *SingleSubscriptionManager* through their respective interfaces, *ElderlyDataServices* and *SingleUserDataMonitor*

2.2.4 *PersistenceManager*

The component is responsible of allowing persistence of the system's data, translating them to the query language offered by the DBMS.

In order to do this, the component exposes two interfaces:

- *PermissionPersistenceServices*, which allows to save new user permissions on the database.
- *SubscriptionServices*, which similarly allows to save new data subscriptions and to restore them from the database in case of failure or restart.

2.3 Deployment View

The deployment diagram shows the physical topology of the system.

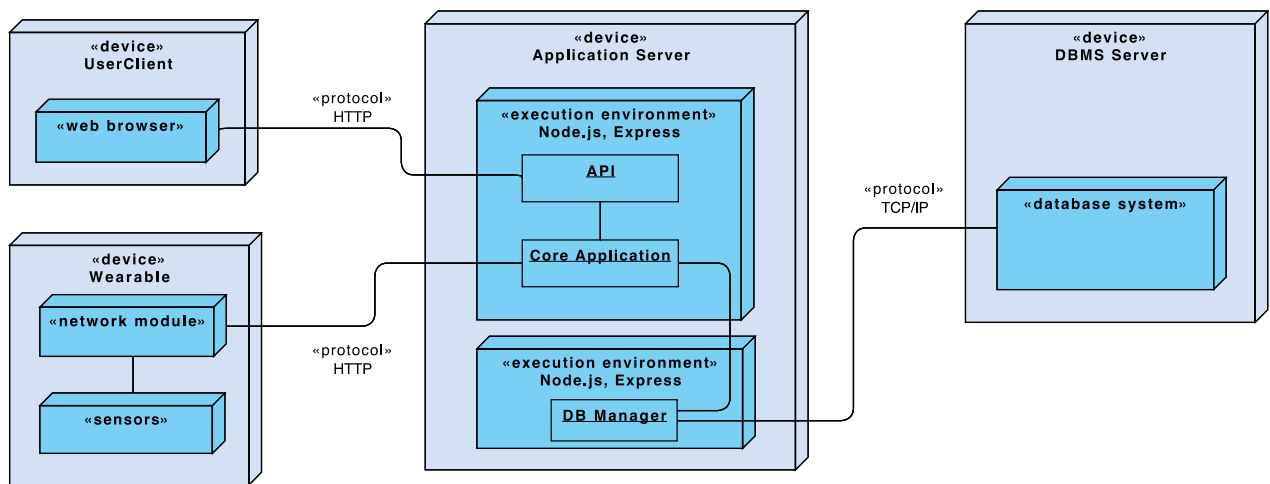
We can see the three-tier architecture explicitly.

All users can benefit from *Data4Help* services by accessing its web application with their own devices. The web application sends requests to the Application Server API. The Application Server handles all the business logic and the communication with the DB and sends the requested data to the client.

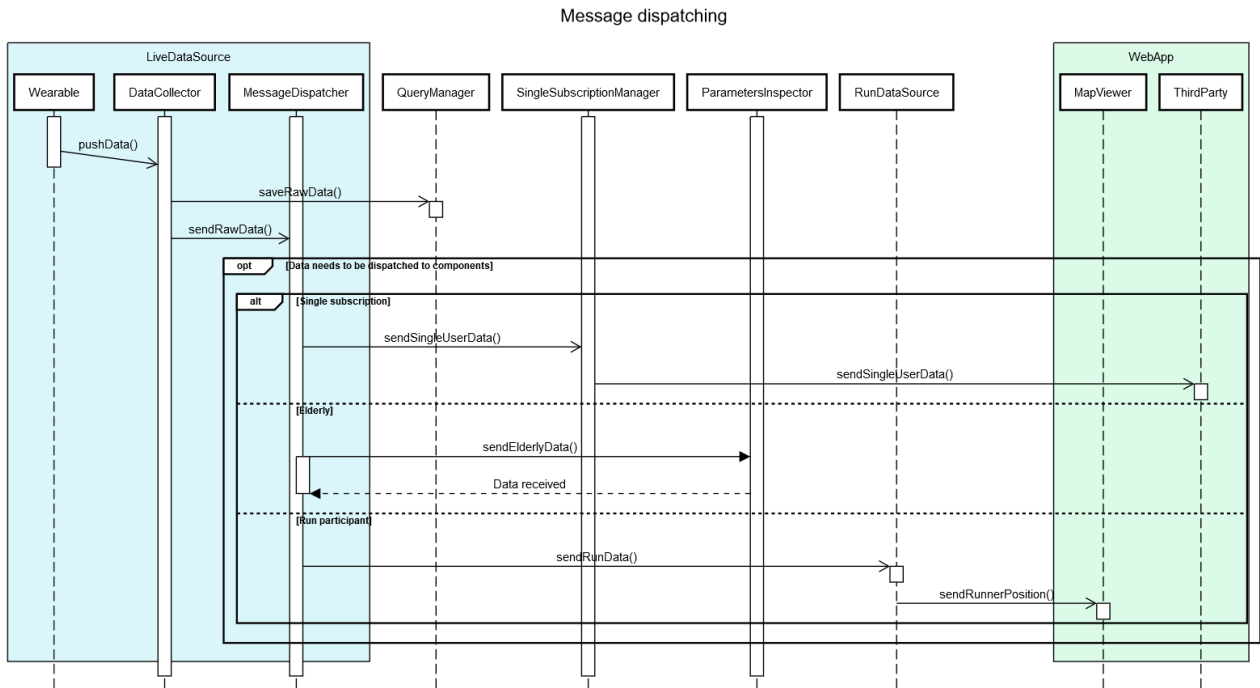
In the Application Server, there is a dedicated node to deploy the DB Manager. This way there is less coupling with the Application Server, and it is possible to maintain and update the two modules independently.

The DBMS Server is in charge to store all the data of the application. Deploying it in a dedicated server increases decoupling between system components.

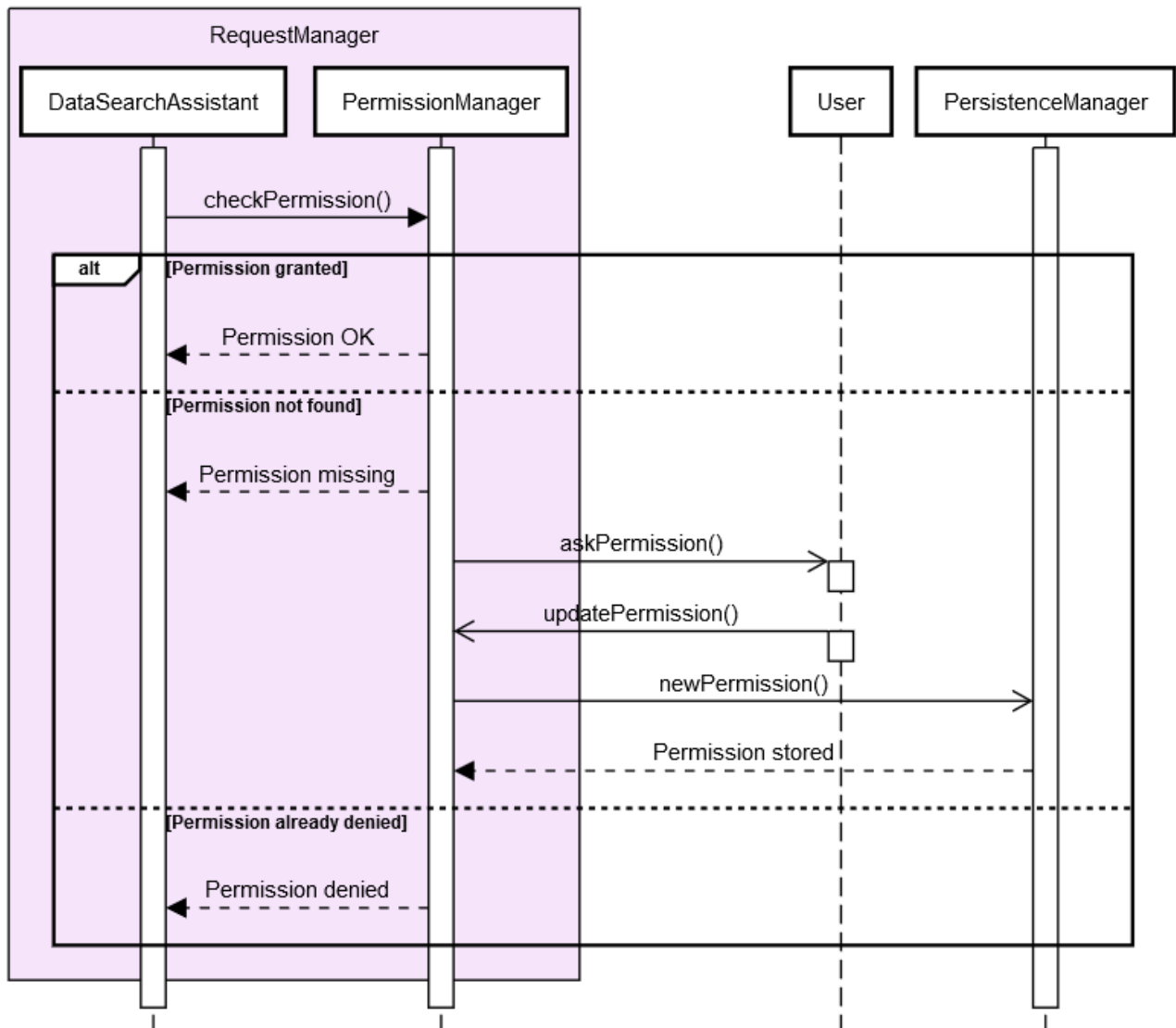
The wearable device runs simple code that reads data from sensors and sends them to the Application Server through the wearable's network module.



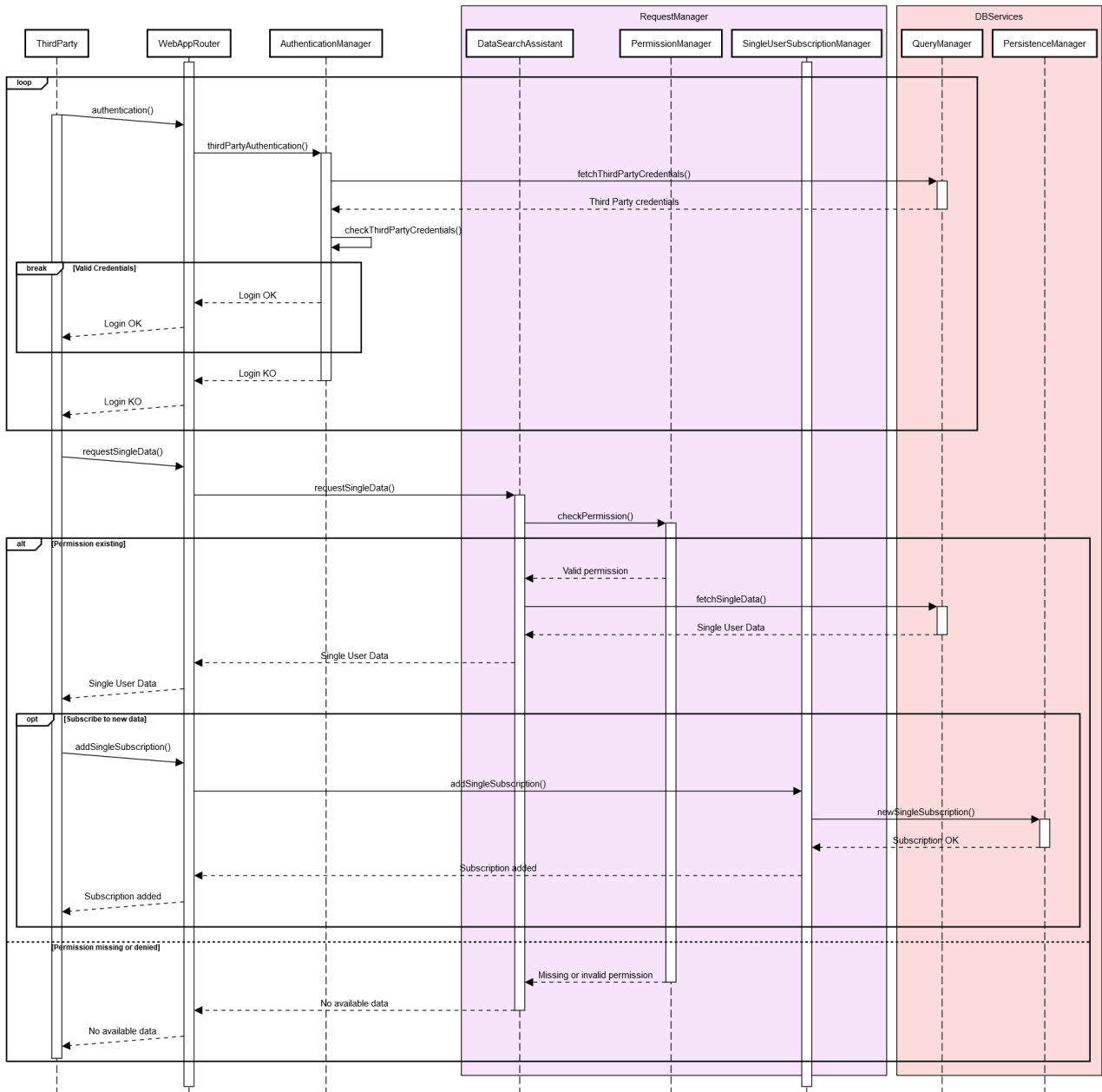
2.4 Runtime View



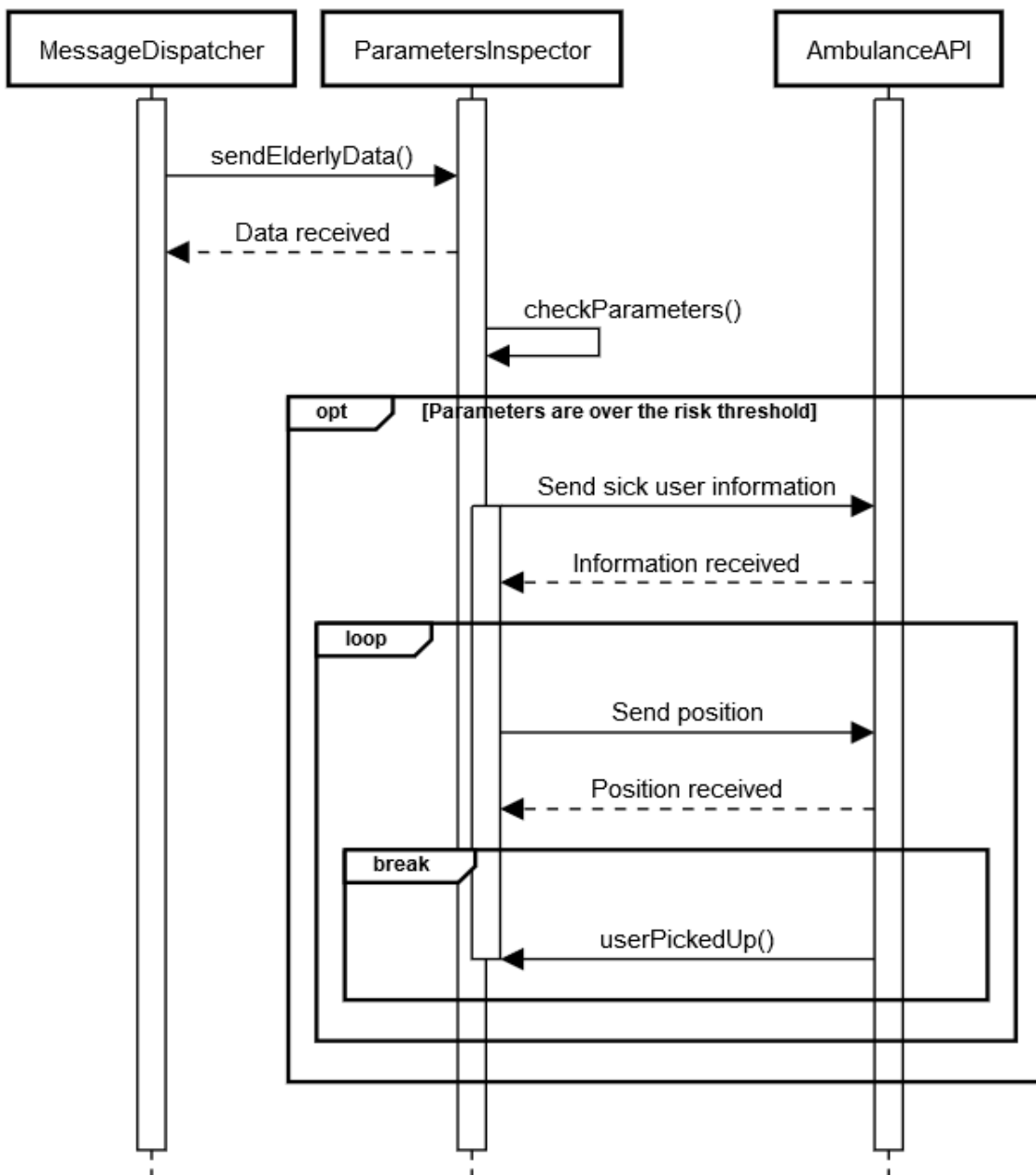
Permission request



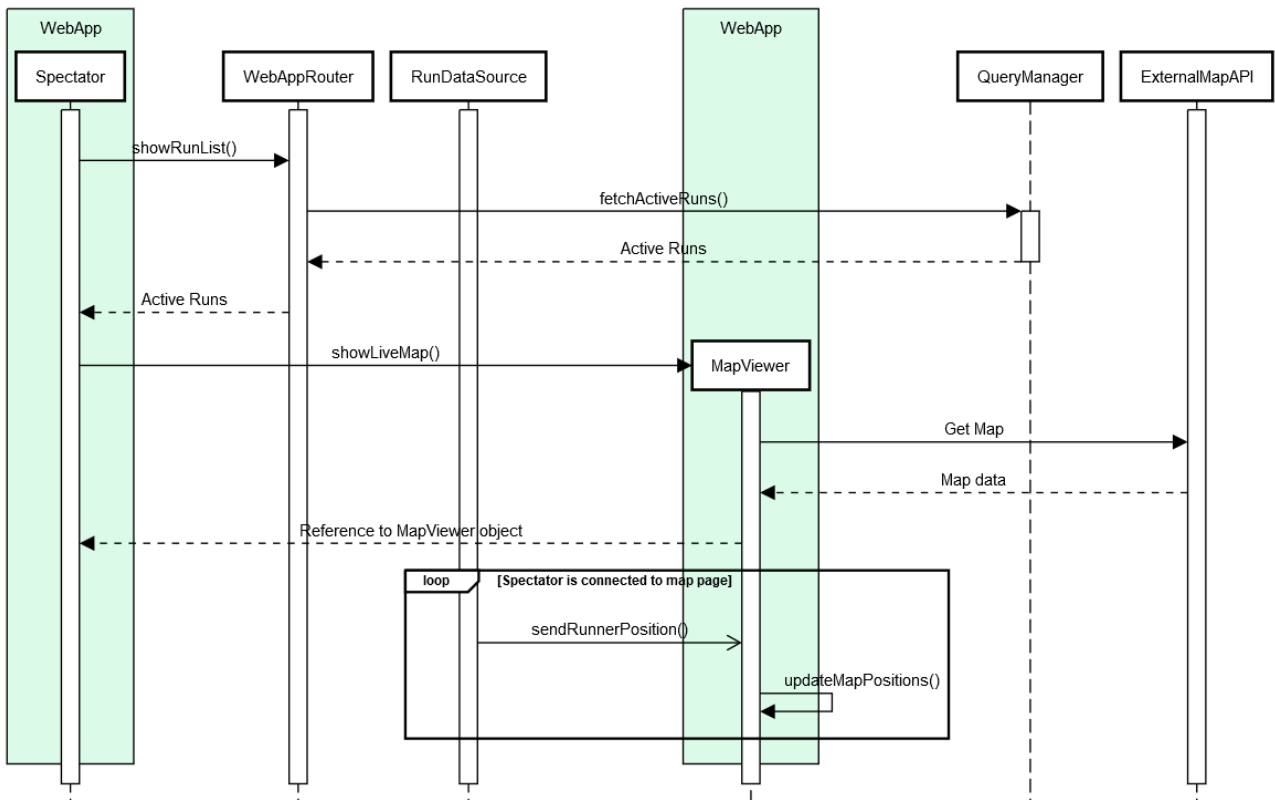
Single User query and subscription



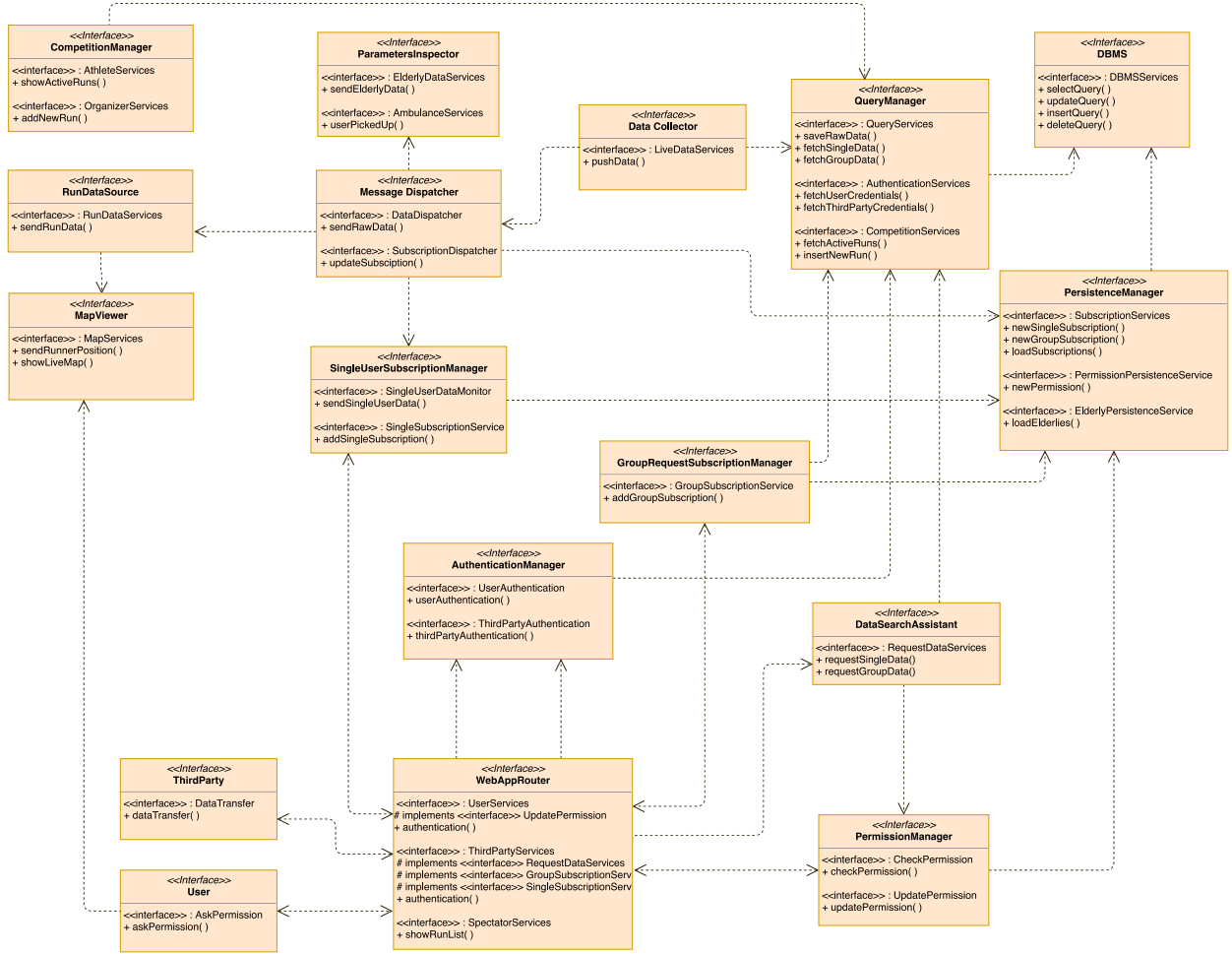
Ambulance dispatch



Spectate run



2.5 Component Interfaces



2.6 Selected Architectural Styles And Patterns

2.6.1 General architecture

To allow an easy logical distinction of subsystems' responsibilities, for this system we propose an architecture consisting of three tiers.

This kind of architecture well suits a client-server approach mixed with a thin client design, leaving to the client the sole responsibility of presenting the data to the user and acting as an interface to the server functionalities (*Presentation* tier).

Furthermore, the system to be relies heavily on data storage and later retrieval of this data, making a distinct database entity necessary. Encapsulating the DBMS and its related services into a logical persistence tier allows us to decouple the persistence structure from the rest of the system and to perform easier maintenance and changes, like modifying the DB infrastructure or services, without having the application tier to be informed of the real implementation of the persistence tier but just of its interfaces.

The business logic is handled by the Application tier, which manages every interaction between the system and the external world (users' clients, wearable, external services), and communicates with the Data Persistence tier, which stores all the application data. Considering the topological deployment of the system, the Application Server exposes an API for the client, and the DB manager inside the application server makes requests to the DBMS.

2.6.2 Subsystems architecture

- Data Collector

The *Data Collector* can be implemented following the event-based paradigm. The *Data Collector* itself acts as the event dispatcher: it receives data from users' wearables, and then broadcasts this data to the DBMS (in order to save the data) and to the *Message Dispatcher*.

This paradigm allows a high modularity between different components of the systems, significantly increasing decoupling and enhancing flexibility.

Since all the data has its own timestamp, it's not relevant if the data collector dispatches not sorted data.

The weakness of this paradigm is that *Data Collector* can become a bottleneck of the system. In order to address this problem, it is possible to set a policy for which, once a defined amount of wearable is subscribed to the data collector, a new instance of *Data Collector* is spawned, and all new wearables will subscribe to this new one.

- Message Dispatcher

The *Message Dispatcher* uses the same architecture of the *Data Collector*.

Its role is to send real-time data to the components that need them, specifically *Parameters Inspector*, *SingleUserSubscriptionManager* and *RunDataSource*.

Considering this, we could describe the message dispatcher as an event handler, receiving data from *Data Collector* and broadcasting it to the components mentioned above.

The *Message Dispatcher* stores internally a list of all *AutomatedSOS* users, single user subscriptions and the list of runners currently engaged in a competition. When some modifications of these data structures occur on the DB, the *Message Dispatcher* memory is updated accordingly. The *Message Dispatcher* can also load such data from the DB in case of reboot or failure of the component.

The *Message Dispatcher* shall be very reliable, since the *Parameters Inspector* depends on it. For this reason, it is necessary to have multiple parallel instances of this component in order to increase robustness to failures.

Regarding scalability, it is possible to use a load balancer which receives data from the *Data Collector* and distributes it to multiple instances of *Message Dispatcher*, accordingly to their requests load. These multiple instances shall use shared memory, ensuring that they all know to which component to redirect data.

- Parameters inspector

The *Parameters Inspector* is an event listener too. It waits for users' data from *Message Dispatcher*, and then checks if the contained health parameters exceed the owner's risk thresholds.

The *Parameters Inspector* stores internally a list of every *AutomatedSOS* user's risk thresholds, which needs to be consistent with the data on the DB. To ensure consistency with new subscriptions, whenever the component receives data about a user missing from the maintained list, it loads from the database the corresponding risk thresholds. In case of component failure or reboot, the *Parameters Inspector* is able to load from the database the complete list of elderlies and their threshold.

If some user's health parameters exceed risk thresholds, the *Parameters Inspector* begins a rescue procedure, where it contacts the ambulance provider and provides the health and position data of the ill user.

Due to the criticality of this component, it is necessary to have multiple instances in parallel, in order to increase fault tolerance.

Also, since R1-NF requires the system-to-be to place a SOS request to the external provider within 5 seconds after detecting data exceeding risk thresholds, it is possible to use an elastic load balancer controlling the provisioning of *Parameters Inspector* instances, based upon the amount of data received, allowing the satisfaction of R1-NF.

- Single and Group Subscription Manager

These components are event listeners that wait for requests for new data subscriptions. When they receive these requests, they call `addSubscription` in order to add the new information to the DB.

These components are also in charge of sending new data coming from (user or group) subscriptions to third parties.

In order to do this, *SingleUserSubscriptionManager* receives new single users' data from *Message Dispatcher*.

GroupRequestSubscriptionManager instead, maintains an internal list of group requests, each one associated with an update interval. Whenever one of the update timeouts expires, the component repeats the group data request to the DB and sends the result to the Third Party.

- WebApp Router

The *WebApp Router* is the API exposed by the application server to the client. It handles the client-server interface and relays calls to the methods of the external interface to the single components implementing them.

This kind of behaviour can be implemented through a façade pattern, allowing for a lightweight implementation and reducing the number of distinct ports and interfaces exposed to the client.

Due to its “single access point” nature, this component could easily become a bottleneck to the system, so it shall be replicated and run in parallel. The amount of replication and the provisioning of new instances responsibilities could be assigned to a load balancer to adjust to the user client load and avoid severe failures.

3 User Interface Design

(Provide an overview on how the user interface(s) of your system will look like; if you have included this part in the RASD, you can simply refer to what you have already done, possibly, providing here some extensions if applicable.)

Login to Data4Help services

Personal Area

Login ID

ipsum@lorem.com

Password

●●●●●●●●●●

Login as user

Login as Third Party

Sign up as third party user

Company Name

Enter company's full name

VAT ID

Enter company's Value Added Tax ID number

Address

Enter company's legal address

Select the company's country

Select



SUBMIT

Sign up as data4help user

First Name

Enter your first name

Last Name

Enter your last (family) name

ID Number

Enter your ID Number

email

Enter your email

Select your birth date

12 May 1990



Select your gender

Select

☐ I agree to subscribe to Track4Run service. [? More information](#)

☐ I agree to subscribe to AutomatedSOS service. [? i](#) You will be required to complete your health profile later

☒ I agree to allow TrackMe to collect my location and health data in order to subscribe. [? Privacy policy](#)

SUBMIT

Personal information recap

First name: Armando

Last name: Ferri

Date of birth: 22/04/1943

Gender: Male

email contact: armando.ferri@domain.com

AutomatedSOS subscriber: No

SUBSCRIBE

Track4Run subscriber: Yes

UNSUBSCRIBE

EDIT INFO

DELETE ACCOUNT

Manage third party data access permissions

Company name 1 ☒

Company name 2 ☒

Company name 3 ☐

Company name 4 ☐

Company name 5 ☒

Company name 6 ☐

SAVE CHANGES



Search single user

ID Number



0123456789AB

SEARCH

Search user groups

Define only those fields you want to use as search parameters

None

Gender

18-25

Age range

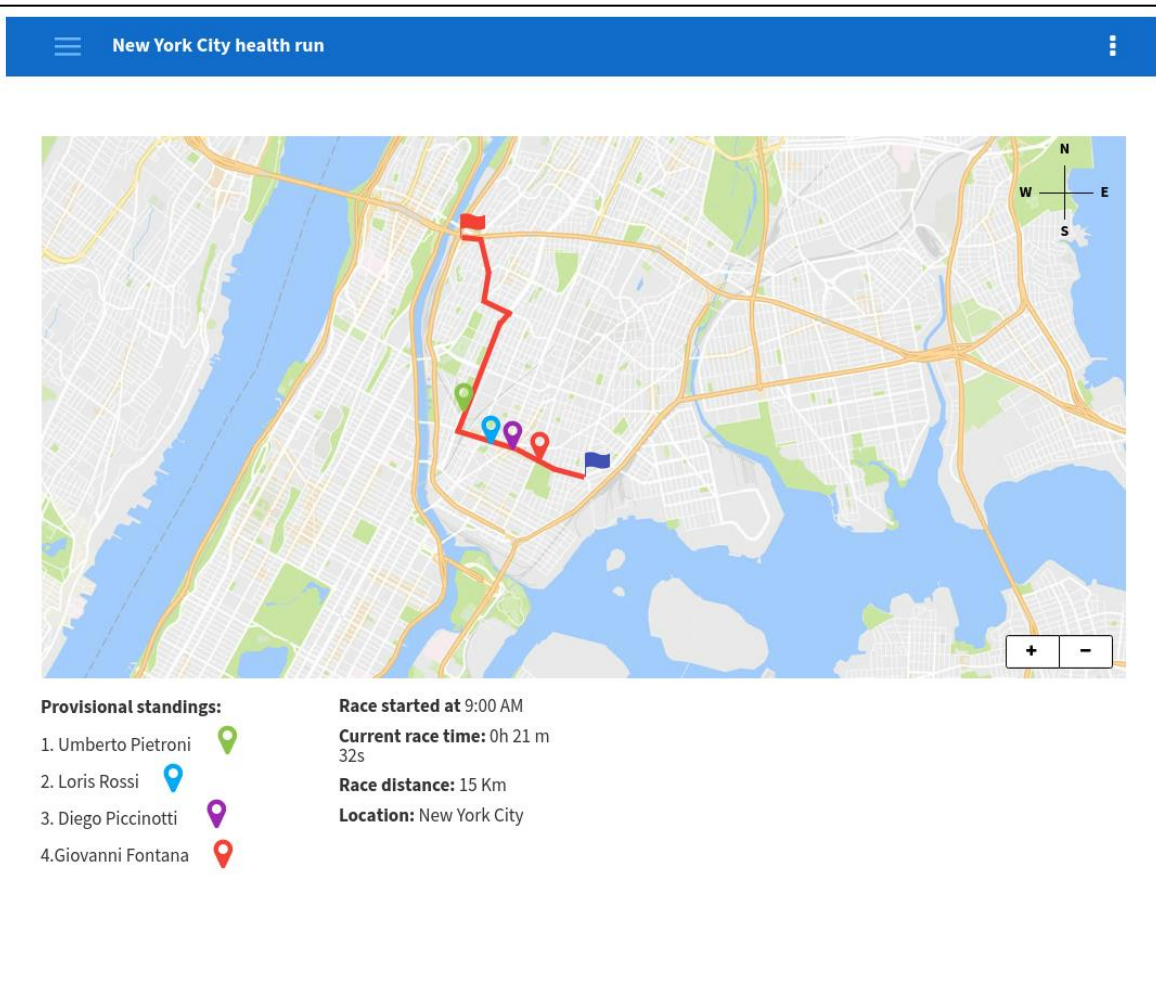
Piazza Leonardo

Location



Active in the last 24 hours

SEARCH GROUP



Add description below images. Look at 5.2 integration process for title format

4 Requirements Traceability

(Explain how the requirements you have defined in the RASD map to the design elements that you have defined in this document.)

G1: The user can be recognized by providing a form of identification.

- *User* [R1, R3, R4]
- *AuthenticationManager* [R1, R2]
- *QueryManager* [R2]

[R1]: The system shall allow registration of individuals through an email and a password.

[R2]: The system shall guarantee the unicity of email addresses.

[R3]: The system shall ask users to provide their personal data (birthdate, gender, residency address, ID number).

[R4]: The system shall ask the user to agree to a policy that specifies that, by registering, users agree that TrackMe acquires their data.

G2: Allow third parties to monitor data about location and health status of individuals.

- *DataCollector* [R5]
- *MessageDispatcher* [R5, R7]
- *QueryManager* [R5, R6, R30]
- *Wearable* [R5]
- *ThirdParty* [R6, R30]
- *AuthenticationManager* [R6, R30]
- *GroupRequestSubscriptionManager* [R7]
- *SingleUserSubscriptionManager* [R7]
- *PersistenceManager* [R7]

[R5]: The system shall store past position and health data of every single user.

[R6]: The system shall support the registration of third parties and provide them with a unique identifier (ID).

[R30]: The system shall support the login of third parties with their ID and password.

[R7]: Third parties shall be allowed to subscribe to new data and the system shall send data as soon as they are produced.

G3: Allow third parties to access data relative to specific users.

- *ThirdParty* [R8]
- *DataSearchAssistant* [R8, R9]
- *QueryManager* [R8, R9]
- *PermissionManager* [R9]
- *User* [R9]

[R30]

[R7]

[R8]: Third parties shall be able to request and receive a specific user's data by providing user's ID number.

[R9]: Upon every data collection request, the system shall check if the permission to access that data has already been granted by the user, otherwise it shall ask them

G4: Allow third parties to access anonymized data of groups of users.

- *ThirdParty* [R10]
- *DataSearchAssistant* [R10]
- *QueryManager* [R10, R11]
- *GroupRequestSubscriptionManager* [R12]
- *PersistenceManager* [R12]
- *MessageDispatcher* [R12]

[R30]

[R7]

[R10]: The system shall allow third parties to search for the desired group of individuals.

[R11]: The system shall accept a group data request only if the data can be properly anonymized. Anonymization is considered proper if the number of people involved in the request is greater than 1000.

[R12]: The system shall allow third parties to subscribe to periodic updates relative to a certain group of individuals provided that the data contained in each update can be properly anonymized.

G5: Allow third parties to offer a personalized and non-intrusive SOS service to elderly people so that an ambulance arrives to the location of the customer in case of emergency.

- *User* [R31, R13]
- *AuthenticationManager* [R31, R13]
- *ParametersInspector* [R14, R15, R16, R17]
- *MessageDispatcher* [R14]

[R31] The system shall support the login of user with their email and password.

[R13]: The system, in order to allow Data4Help users to subscribe to AutomatedSOS, shall ask them to input their risk thresholds.

[R14]: Frequently enough, health parameters of each user are monitored by the system and compared against their threshold to detect risk situations.

[R15]: If a user's parameters get below risk thresholds the system shall contact the ambulance provider and require the dispatch of an ambulance.

[R16]: After an emergency request has been placed the system shall send data about the user and keep sending them regularly to the ambulance provider.

[R17]: The system shall allow the ambulance provider to notify when the user has been picked up, in order to stop data transmission.

G6: Allow athletes to enroll in a run.

- *User* [R18]
- *AuthenticationManager* [R18]
- *Athlete* [R19, R20]
- *CompetitionManager* [R19, R20, R21]
- *QueryManager* [R19, R21]

[R18]: The system shall allow athletes to register to the system.

[R31]

[R19]: The system shall allow athletes to check a list of available runs.

[R20]: The system shall provide the ability to enroll to the desired run only to registered athletes.

[R21]: The system shall allow enrolling only if the user has already agreed to share publicly his location for the duration of the run.

G7: Allow organizers to manage runs.

- *Organizer* [R22, R23, R24, R25, R26]
- *AuthenticationManager* [R22]
- *CompetitionManager* [R23, R24, R25, R26]
- *QueryManager* [R22, R23, R24, R25, R26]

[R30]

[R22] The system shall allow organizers to register to Track4Run platform.

[R23] The system shall allow organizers to create and delete races.

[R24] The system shall allow organizers to add a path for the run.

[R25] The system shall allow organizers to check a participants list.

[R26] The system shall allow organizers to add or remove participants before the start of the race.

G8: Allow spectators to see on a map the position of all runners during the run.

- *Spectator* [R27, R28]
- *QueryManager* [R27]
- *MapView* [R28, R29]
- *RunDataSource* [R28, R29]

[R27] The system shall provide a public list of live runs and allow the spectator to select one of them.

[R28] The system shall allow the spectator to see a map of the desired run, with live participants' position.

[R29] The system shall update the positions of the runners on the map as soon as new data is received.

5 Implementation, Integration and Test Plan

5.1 Implementation Plan

The implementation of this system shall be conducted in a bottom-up way by first implementing the low-level components which are used by other components and then going upwards in the system levels. Using this approach stubs won't be needed while testing and several subsystems will be already working and eventually, they will be integrated into a single system.

However, the low-level components inside a higher-level component, for instance *DataCollector* and *MessageDispatcher* inside *LiveDataSource*, will be implemented in parallel and will be tested concurrently following incremental integration and testing approach (this will be better explained in the following paragraphs).

Following this approach, the components order of implementation shall be:

1. *DBServices* (*DBMS*, *QueryManager*, *PersistenceManager*)
2. *LiveDataSource* (*DataCollector*, *MessageDispatcher*), *Wearable*
3. *RequestManager* (*DataSearchAssistant*, *GroupRequestSubscriptionManager*, *SingleUserSubscriptionManager*, *PermissionManager*)
4. *WebApp* (*User and ThirdParty*), *WebAppRouter*, *AuthenticationManager*
5. *ParametersInspector*
6. *Track4RunCore*
7. *Track4Run WebApp* (*MapView*, *Athlete*, *Organizer*, *Spectator*)

The first component to be implemented will be *DBServices* because all the other components interact with it and it is a vital part of the system which must store and retrieve data from the database. Its sub-components (*DBMS*, *QueryManager*, *PersistenceManager*) are implemented concurrently in order to be integrated and tested as soon as a new version is available.

Another crucial component of the system is the *LiveDataSource* which has the responsibility to collect each user's data and distribute it to *DBServices* and the third parties subscribed to them. For these reasons *LiveDataSource* is the second component that will be implemented together with *Wearable*.

When *DBServices* and *LiveDataSource* will be implemented then the flow of data from the wearable of each user to the database will be active, therefore it will remain to implement the link with third parties. *RequestManager* is the component that realizes this connection and it exploits the interfaces made available from the previously implemented components. In particular it uses *DBServices* interfaces in order to fetch data for the third parties' request or subscription and it takes advantage of *LiveDataSource* to provide data in real time. Since

RequestManager sub-components don't interact with each other, it's not necessary to implement them in parallel. For instance, one choice could be to implement first *SingleUserSubscriptionManager* and then test and integrate it with *DBServices* and *LiveDataSource* before starting implementing other components. Only *DataSearchAssistant* requires some functionalities of another component of *RequestManager*, *PermissionManager* and for this reason it would be better to integrate them incrementally.

The last component needed to complete *Data4Help* functionalities is the *WebApp*. This component offers to the third parties and the users a way to communicate with others module with a GUI. During this implementation phase, other component such that *WebAppRouter* and *AuthenticationManager* will be implemented because their functionalities are exploited by *WebApp* sub-components.

After these steps the major functionalities of *Data4Help* will be available and on top of them *AutomatedSOS* and *Track4Run* services will be built separately. For the first one it is enough to implement *ParametersInspector* which uses an external API, exploits an interface of *DBServices* and provides an interface for the *MessageDispatcher*.

Regarding *Track4Run*, firstly *Track4RunCore* component will be implemented and then the *Track4Run WebApp* (*MapView*, *Athlete*, *Organizer*, *Spectator*), which is a high-level component.

5.2 Integration and Test Plan

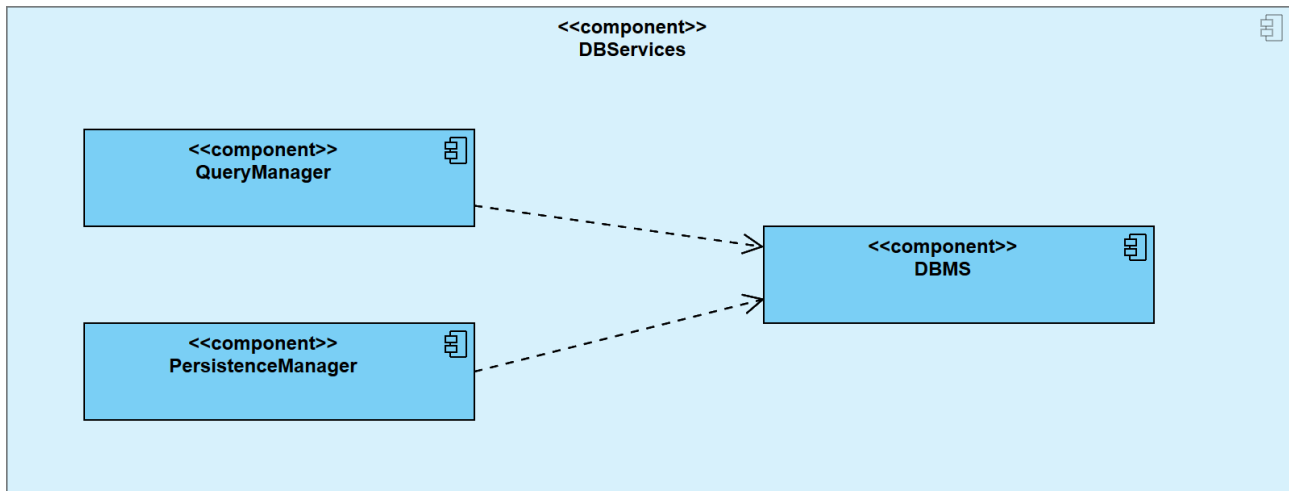
5.2.1 Integration and Testing Strategy

As it is stated in the previous section the testing of this system follows a bottom-up strategy: it starts at the leaves of the “uses” hierarchy and goes upwards until several working subsystems are obtained and then integrated. To start testing at the bottom level of hierarchy means testing of critical modules or functionality at an early stage. This helps in early discovery of errors. With this approach there is rarely need for stubs when unit-testing each component since the modules that provide functions used by the component are already implemented. However, unit-testing requires the creation of drivers which shall call the component methods.

While high-level components like *DBServices*, *LiveDataSource*, *RequestManager*, *WebApp* are tested following a bottom-up strategy, the subcomponents inside each of them will be integrated by means of Incremental Integration Testing approach to check interfaces and flow of information between modules. As soon as a new version of components is available they are integrated and tested, in this way it is possible to obtain higher observability, diagnosability and less cost of repair.

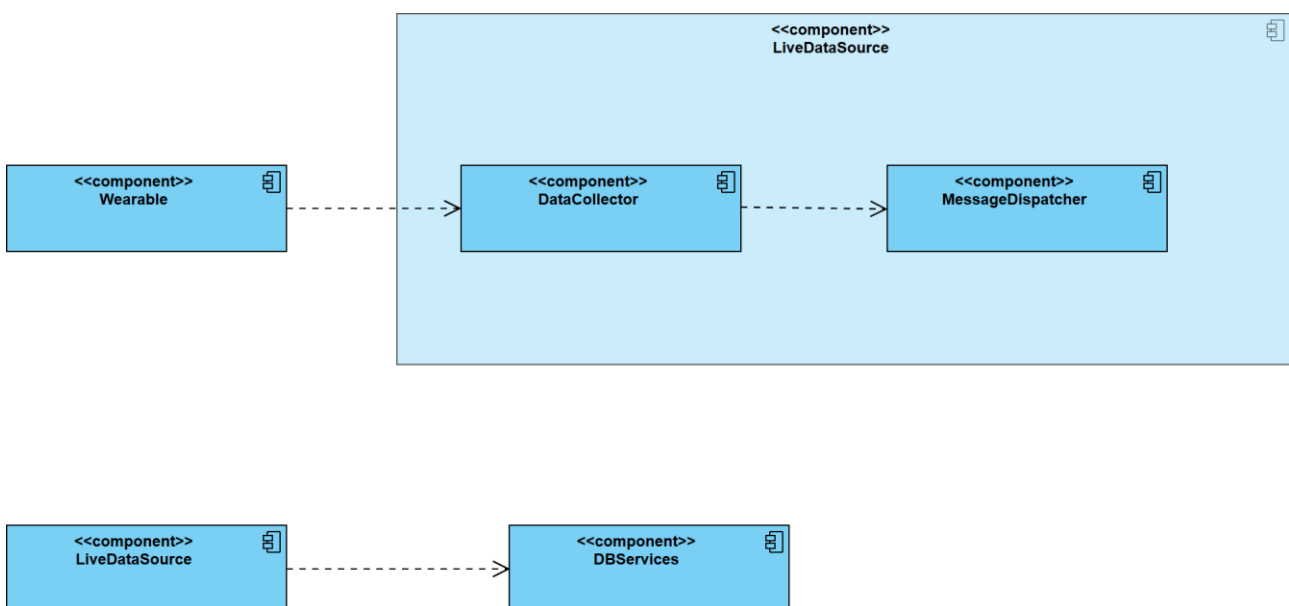
5.2.2 Integration Process

Integration of components inside DBServices



The first high-level component to be implemented and tested, as stated before, is the *DBServices*. Inside *DBServices*, however, there are three subcomponents which interact with one another. The dashed arrow stands for the dependency relation that there is between two components. In this case, for instance, both *QueryManager* and *PersistenceManager* use some methods of the interface provided by *DBMS*. These components are integrated and tested following Incremental Integration Testing. As soon as a first version of them is ready they are integrated allowing an early identification of faults.

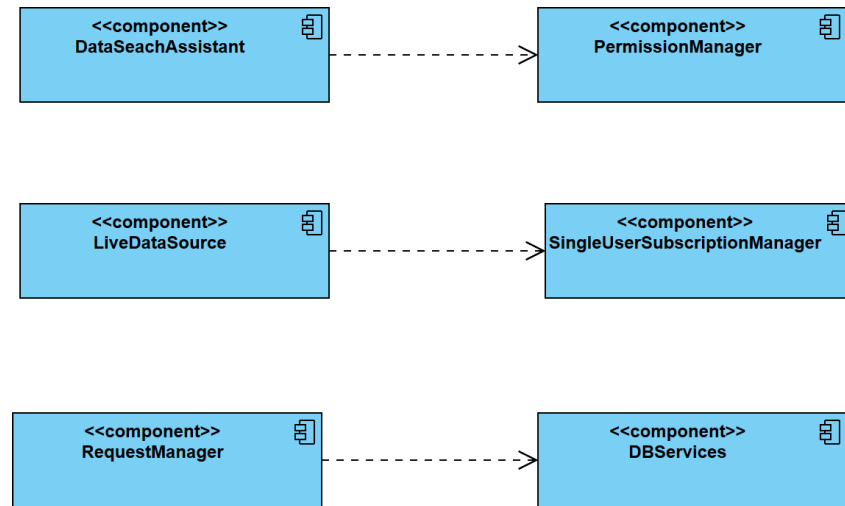
Integration of LiveDataSource components



Similarly to the components inside *DBServices* also those contained in *LiveDataSource* are integrated incrementally until all their functionalities are correctly implemented and tested.

Since *DBServices* is already implemented, *LiveDataSource* components are integrated and tested also with it during this phase.

Integration of RequestManager components

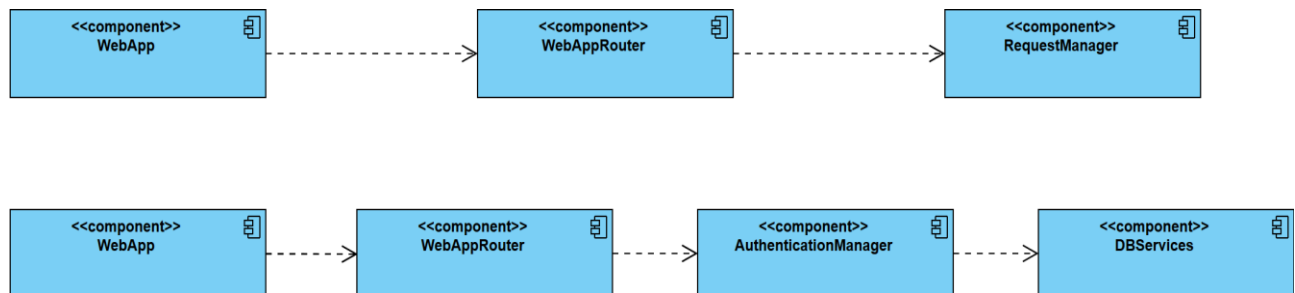


Components inside *RequestManager* don't interact with one another so they don't need to be integrated and tested. The only exception is *DataSearchAssistant* which uses *PermissionManager* interface in order to check if some third party is allowed to search some data and for this reason they are integrated incrementally.

Another interaction which should be tested is between *LiveDataSource*'s component, *MessageDispatcher*, and *SingleUserSubscriptionManager*.

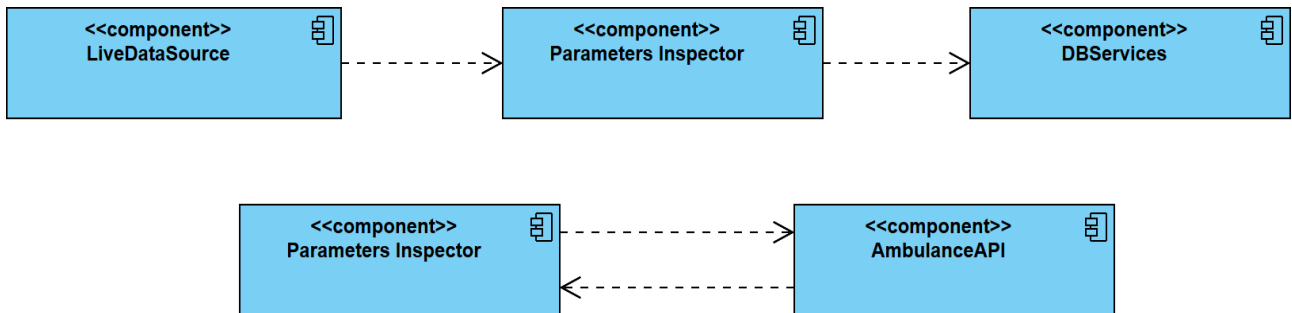
During the implementation of each *RequestManager* component, it is possible to integrate it with *DBServices* which is already implemented.

Integration of WebApp components



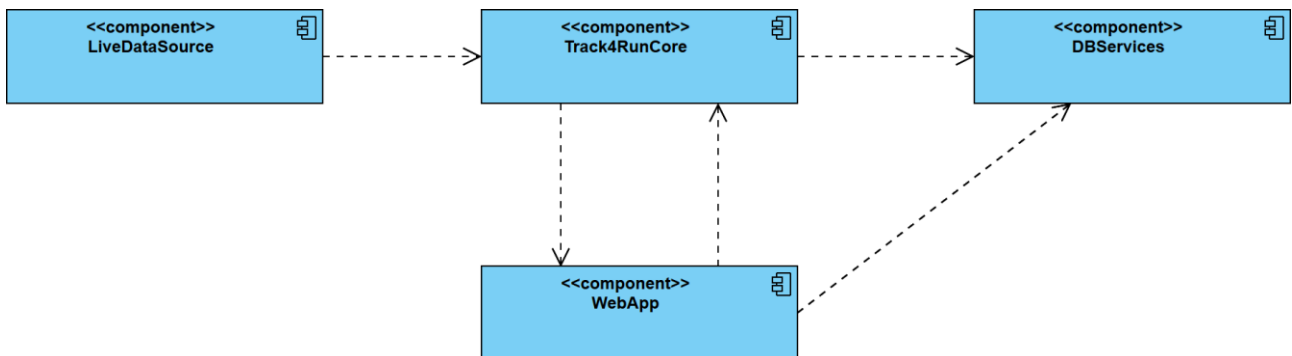
Last high-level component of *Data4Help* to be integrated is *WebApp*. Its subcomponents, *ThirdParty* and *User*, don't need to be tested together, however it will be integrated with *RequestManager* by means of *WebAppRouter*'s interface and with *DBServices*, exploiting the functionalities offered by *AuthenticationManager*.

Integration of AutomatedSOS services



In order to realize *AutomatedSOS* services, the related component *ParametersInspector* must be integrated and tested with *LiveDataSource* and *DBServices* components. Furthermore, it is vital to test it with the external ambulance provider API to send and manage emergency requests.

Integration of Track4Run services



The two *Track4Run* components, *Track4RunCore* and *WebApp*, exploits each other interfaces and for this reason it's better to incrementally integrate and test them. Concurrently, to carry out their functionalities they will be integrated with *LiveDataSource* and *DBServices*.

6 Effort Spent

6.1 Piccinotti Diego

Description of the task	Hours
Purpose, Scope, Definition	2
High-level Components and their Interaction	3
Component View	11.5
Deployment View	
Runtime View - Sequence Diagrams	4.5
Selected Architectural Styles and Patterns	1
Component Interfaces	0.5
User Interface Design	3.5
Requirements Traceability	
Implementation, Integration and Test Plan	

6.2 Pietroni Umberto

Description of the task	Hours
Purpose, Scope, Definition	2
High-level Components and their Interaction	4
Component View	5
Deployment View	
Runtime View - Sequence Diagrams	
Selected Architectural Styles and Patterns	
Component Interfaces	2
User Interface Design	
Requirements Traceability	2

Implementation, Integration and Test Plan	7
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6.3 Rossi Loris

Description of the task	Hours
Purpose, Scope, Definition	2
High-level Components and their Interaction	3
Component View	4.5
Deployment View	2
Runtime View - Sequence Diagrams	4
Selected Architectural Styles and Patterns	3
Component Interfaces	4.5
User Interface Design	
Requirements Traceability	
Implementation, Integration and Test Plan	

7 References