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eMall
E-MOBILITY FOR ALL

RASD

Requirement Analysis and Specification Document
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1 Introduction

This *Requirements Analysis and Specification Document (RASD)* aims to provide an overview of the eMall project. The following document will help the reader to understand the purpose of the project i.e. in which environment the application operates and which services offers to its users. In particular way it will illustrate goals and how these may be reached, guaranteeing the meeting of certain functional and nonfunctional requirements.

1.1 Purpose

Billions of tons of CO2 are released into the atmosphere every year as a result of coal, oil, and gas production. Human activity is producing greenhouse gas emissions at a record high, with no signs of slowing down. While science tells us that climate change is irrefutable, it also tells us that it is not too late to stem the tide. This will require fundamental transformations in all aspects of society; one of the most debated ones undoubtedly regards the mobility and the increasingly widespread usage of electric vehicles. When it comes to climate change and air quality, electric vehicles are clearly preferable to petrol or diesel ones and the benefits will further increase going forward, as world will adopt more renewable energy sources in the future.

The **e-Mobility for All (eMall)** is a software application designed to support the growing use of electric vehicles. The application eMall requires the user to create an account to access its services, the functionalities unlocked after registration depend on the type of account selected. The purposes of eMall are different. The first one is to allow drivers to charge their electric vehicle easily, quickly and effectively through out the dedicate software functionalities. These want to be a way to limit the carbon footprint caused by the urban and sub-urban mobility needs, providing useful information to electric vehicle drivers (e.g. where to charge their vehicle) and allowing to drivers to carefully plan the charging process of their electric vehicle in such a way that it introduces minimal interference and constraints on their daily schedule.

Secondly, eMall is focused on supporting the Charging Point Operators (CPOs) that own and manage the charging stations. In particular, support is given to human operators working for CPOs, allowing them to manage certain dedicated functionalities connected to the Charge Point Management System (CPMS), IT infrastructure used by the CPOs. This offer a more simple and quick way to manage the charging stations and the relations between the Charging Point Operators and the Distribution System Operators (DSOs), entities from which they buy the electric energy.

Finally, eMall guarantees an effective and reliable interaction between eMSP and CPMSs in order to provide full support to users on both sides.

1.1.1 Goals

In this section, we will go to extract the main goals of eMall.

- [$G.1$] - The system allows Users to register and to log in the application.
- [$G.2$] - The system allows Users to visualize the charging stations in a selected area.
- [$G.3$] - The system allows Users to visualize data of the charging points in a selected charging station.
- [$G.4$] - The system allows to differentiate the functionalities dedicated to the Drivers and the functionalities dedicated to human operators.
- [$G.5$] - The system allows Drivers to reserve a socket of a charging point in a selected charging station for a certain time slot.
- [$G.6$] - The system allows Drivers to control (start and stop) the charging process.
- [$G.7$] - The system allows Drivers to visualize the data of the charging process.
- [$G.8$] - The system allows Drivers to pay for the charging service.
- [$G.9$] - The system allows human operators to visualize data about the internal status of a selected charging station.
- [$G.10$] - The system allows human operators to visualize data about DSOs.
- [$G.11$] - The system allows human operators to select from which DSOs buy electric energy.
- [$G.12$] - The system allows human operators to set the price of a charging and set special offers of a selected charging station.
- [$G.13$] - The system allows human operators to decide whether to use batteries, energy from DSOs or a mix of them for charging electric vehicle connected in a selected charging station.

1.2 Scope

In this section we want to give a brief analysis of the world and of the shared phenomena. The Machine is the application software that we want to develop.
The World is the external environment, namely the part of the real world that is affected by our system.
These two parts communicate and influence each other.World phenomena are events that take place in the real world and taken by themselves do not have a direct impact on the System.Shared phenomena can be of two types: controlled by the Machine and observed by the World, or viceversa controlled by the World and observed by the Machine. Below, we will show a table on shared phenomena related to Drivers point of view and a table on shared phenomena related to Operators point of view.

1.2.1 World and Machine Table : Drivers

Phenomenon	**Controlled by**	**Shared**
A Driver wants to charge an electric vehicle	W	No
A Driver does not show up to the charging station or arrives after the reservation deadline	W	No
The machine shows data about the status of a selected charging station	M	Yes
The machine reserves a socket of a charging point of a certain charging station for a time slot	M	Yes
The machine sends a ticket QR-Code to scan at the charging point	M	Yes
The machine shows data about the charging process of the electric vehicle (e.g. battery percentage, price, kWatts, spent & remaining time)	M	Yes
The machine shows if the payment has been successfully completed or eventually any problem occurred during the payment process	M	Yes
The machine notifies that the charging process is started or finished	M	Yes
A User opens the eMSP application	M	Yes
A User signs up to the eMSP application	M	Yes
A Driver logs in the eMSP application	M	Yes
A User selects a charging station for view its data	M	Yes
A Driver books a socket of a charging point in a selected charging station for a time frame	M	Yes
A Driver scans the QR-Code to confirm the presence at the socket	M	Yes
A Driver connects or disconnects the electric vehicle to the reserved socket	M	Yes
A Driver starts or stops charging the electric vehicle	M	Yes
A Driver inserts data of payment	M	Yes

Table 1: World and Machine table: Drivers

1.2.2 World and Machine Table: Operators

Phenomenon	**Controlled by**	**Shared**
A DSO changes the price of the energy sold	W	No
The battery in a certain charging point is empty	W	No
The machine shows data about the "external" status of a selected charging station	M	Yes
The machine shows data about the "internal" status of a selected charging station	M	Yes
The machine shows data about the DSOs	M	Yes
A Operator selects price and offers of sockets of a charging point	M	Yes
A Operator visualizes the list of DSOs	M	Yes
A Operator selects the DSOs from which buy energy	M	Yes
A Operator selects where to get energy for charging	M	Yes

Table 2: World and Machine table: Operators

1.3 Definitions and abbreviations

1.3.1 Acronyms

- **RASD**: Requirement Analysis and Specification Document.
- **eMSP**: e-Mobility Service Provider.
- **eCPMS**: e-Charge Point Management System.
- **CPO**: Charging Point Operator.
- **CPMS**: Charge Point Management System.
- **DSO**: Distribution System Operator.
- **UML**: Unified Model Language.
- **API**: Application Programming Interface.
- **QR-code**: Quick Response code.
- **EV**: Electric Vehicle.
- **CS**: Charging Station.
- **CP**: Charging Point.
- **FC**: Fiscal Code.

1.3.2 Definitions

- **User**: person or entity who use the application and is not registered to it.
- **Driver**: User who owns an electric vehicle, can use the charging stations for charging purposes and is registered to the application.
- **Charging Point Operator (CPO)**: entity or organization that technically manages all the EV infrastructure assets.
- **e-Mobility Service Providers(eMSP)**: software functionalities used by Drivers for manage their charging purposes.
- **e-Charge Point Management System(eCPMS)**: software services used by human operators for manage some functionalities of the CPMS.
- **Charge Point Management System (CPMS)**: software system that manages the charge point infrastructure,it can manage either the technical and economic aspects of the charging infrastructure.
- **Operator**: human operator who works into the staff of a CPO.
- **Distribution System Operator (DSO)**: entity responsible for the operation and management of distribution networks,from which the CPOs can buy energy.

- **Charging Station**: station in which Drivers can charge their electric vehicles.
- **Charging Point**: structure of a charging station with sockets where the Drivers can connect their electric vehicle.
- **Fiscal code**: a 16 characters code used in Italy to uniquely identify a person.

1.3.3 Abbreviations

- $[G.n]$ = n-th goal.
- $[R.n]$ = n-th functional requirements.
- $[D.n]$ = n-th domain assumption.
- $[UC.n]$ = n-th use case.

1.4 Revision history

Version	Date	Details
1.0	23/12/22	RASD first deadline draft

Table 3: revision history

1.5 Reference Documents

Title	Authors	Links
The World and the Machine	Michael Jackson	Online PDF
Alloy Official Documentation	MIT Software Design Group	Alloy documentation

Table 4: table of references

1.6 Document Structure

The rest of the document is organized as follow:

Overall Description (Section 2) gives an overall description of on eMSP and eCPMS functionalities that application eMall offers, underlining the principle goals of them. Here we also given an introduction about the world in which the system will be collocated, highlighting the boundaries between the machine and the world.

Specific Requirements (Section 3) contains an in-depth description and explanation of the system that we want to develop. In particular we will provide a class diagram in order to give a general view of the application, some state diagrams to explain the evolution of some parts of the domain and finally an explanation about different users and domain

assumptions.

Formal analysis using Alloy(Section 4) uses Alloy to generate a formal model of some critical parts of the domain. Some images of significant instances satisfying this model are provided.

2 Overall description

2.1 Product perspective

To better understand the peculiarities of the product, it is important to detail the domain for which it is intended. In this chapter a detailed analysis of the shared phenomena and a visual representation of the domain model will help to achieve the scope.

2.1.1 Scenarios

Scenario 1: Charles Leklerk needs to charge his EV which has a low percentage of battery.

Scenario 2: It will be not a good day for Max Van Der Stappen.

Scenario 3:

Scenario 4:

2.1.2 Class Diagrams

Below is presented a high-level class diagram of the application.

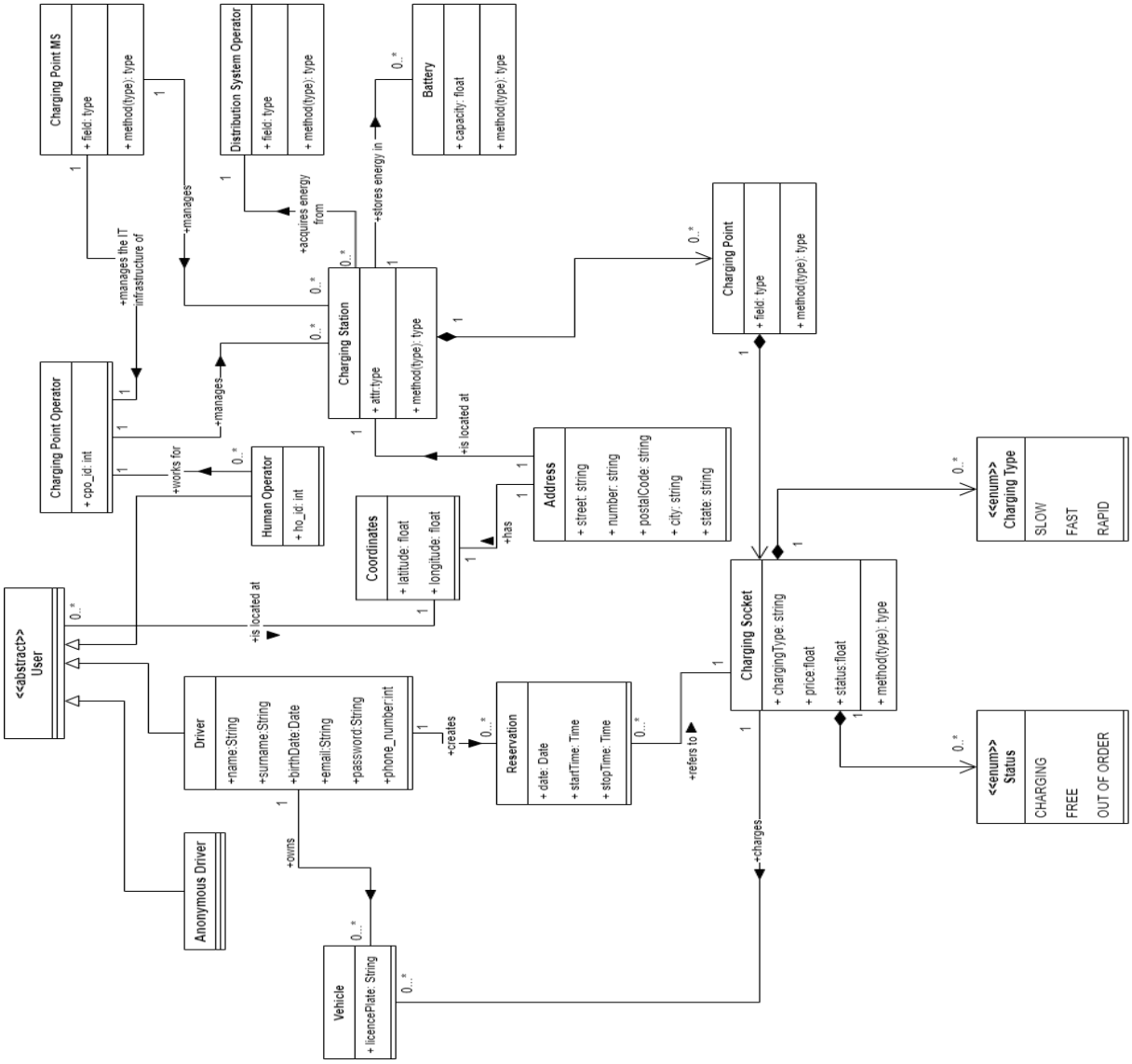

Figure 1: Class Diagram

2.1.3 Statecharts

Next,the state chart diagrams below are used to describe the main sequences of events the system handles in its common scenarios.

2.2 Product functions

In this section we will present in a descriptive form the main functionalities of the eMall application. Starting from the involved scenarios, the most important requirements will be extrapolated with the purpose of conducting a more precise and formal analysis of them in the next chapter.

2.2.1 Generic functionalities

There are some functionalities of eMall that can be performed by all the Users.

- **Registration and Login**
  To use the eMSP functionalities dedicated to the Drivers, a User must register in the application. In particular way, Users have to provide: name, surname, email address, FC and a valid password to register. In addition, Users have to agree on Terms and Conditions of Use, that includes for them an agreement on privacy and data collection.
  Drivers, who are already registered, have to provide only: email address, FC and the valid password to logs in the application and use eMSP functionalities.
  Operators have to provide: business email address,a valid password and an identification number to logs in a dedicated section of the application and use the eCPMS dedicated functionalities. Operators will not have to register to the system because they are already registered into their CPO organization and they will be recognized directly by the CPMS.

- **Visualization of the charging stations on the map**
  Each kind of User is traced by GPS. In this way they can visualize in a map the presence of CSs, close to their position or in a selected area.

- **Visualization of "external" status of a Charging Point**
  Each kind of User can select a certain CS on the map and visualize its "external" data, such as: location, number of CPs, number of charging sockets available for each CP, type of each socket (slow/fast/rapid), cost of each socket, if the sockets of a certain type are occupied and, in this last case, the estimated amount of time until the socket of that type is freed.

2.2.2 eMSP functionalities

We will now explain the eMSP functionalities that Drivers can use.

- **Book a socket**
  The Driver can book in advance a socket of a CP. Time slots consist of 30 minutes slots and the Driver can book a minimum of 30 minutes to a maximum of time depending on the type of socket(4 hours for the slow, 2 for the fast and 1 for the rapid type). For book a socket the Driver have to select one or more time slots, if the time slots selected are free the Driver will receive a unique QR-code ticket as a confirm of the reservation. The Driver also has the possibility, through a special button, to cancel the booking. By booking a certain time slot, to the Driver will be guaranteed prices and offers in force at the time of reservation, even if later there will be changes.

- **Start of the charging process**
  To start the charging process, the Driver must firstly connect the EV to the socket, with the appropriate cable; must secondly scan the QR-Code to the socket and finally must insert valid data of payment. All these passages must be done by the Driver within 10 minutes after the arrival time declared in the booking, otherwise the Driver will loose all time slots booked before.

- **Stop of the charging process**
  The Driver has the possibility to stop in advance the charging process via a button on the app.

- **Visualization of data during the charging process**
  During the charging process, the Driver can see the data about it, such as: kWatts used for charge the EV, price per kWatts used, time spent since the start of the charging process, remaining time to reach 100 % charge.

2.2.3 eCPMS functionalities

We will now explain the eCPMS functionalities that Operators can use.

- **Visualize the internal status of a charging station**
  The Operators can visualize the "internal" status of a selected charging station, such as: the amount of energy available in its batteries (if batteries are presents), the number of vehicles being charged and, for each charging vehicle, amount of power absorbed and time left to the end of the charge.

- **Setting of DSOs**
  The Operators can visualize: the list of available DSOs, from which they can select a new DSOs from which buy energy; the list of DSOs from which they already buy energy and deselect them.

- **Setting of price and offers**
  The Operators can modify the prices of a selected CP and they can set special offers according to the market needs.

- **Decide where to get energy for charging**
  If batteries are present in a CS, the Operators can decide how to get energy for charging the EV, such as: get energy from station batteries, get energy from DSOs, or a mix of these two modalities.

2.3 User characteristics

- **User**: person who: can download the eMall application, is not registered to it and can only benefit from the Generic functionalities.

- **Driver**: User who owns an electric vehicle, can use the charging stations for charging purposes and is registered to the application. Drivers can benefit from Generic functionalities and also from the so-called eMSP functionalities.

- **Operator**: person who works for a CPO and can make some business choices through dedicated functionalities. Operators can benefit from Generic functionalities and also from the so-called eCPMS functionalities.

2.4 Assumption, dependencies and constraints

2.4.1 Domain assumption

Domain assumptions are descriptive assertions assumed to hold in the world.

- $[D.1]$ = Each Driver will create only one account.
- $[D.2]$ = The data (FC, email, etc...) provided during registration are valid and belong to the person who creating the account.
- $[D.3]$ = User's device must be connected to the Internet to guarantee the proper functioning of the application.
- $[D.4]$ = User's device must be equipped with a GPS system enabled in order to select a CS from the interactive map.
- $[D.5]$ = The Driver remains in the reserved seat for a time less or equal to that declared into the time slot table.
- $[D.6]$ = When a QR-Code ticket is generated, the system doesn't allow to generate another ticket with the same QR-Code.
- $[D.7]$ = When a Driver arrives at the reserved socket, the Driver finds the socket free, not occupied by another Driver.
- $[D.8]$ = Two or more Operators can not control and modify the same CSs: each Operator has its own CS to manage.

2.4.2 Dependencies

-

2.4.3 Constraints

-

3 Specific Requirements

3.1 External interface requirements

3.1.1 User interfaces

In this section, we are going to show the user interfaces of eMall application. The eMall application is available for mobile and tablet,so as to be suitable everywhere without excessive limits. Graphical interfaces shall have a simple structure and shall be easy to use by all type of users. The interfaces between the system and Users are presented using mockups. Since some functionalities are common to all the Users, others are just for one of the two categories: Drivers and Operators. For simplicity, we will show only mockups for mobile application.

- **eMall Logo**

Figure 2: eMall Logo

The eMall Logo is composed by: the name of the application "eMall", the slogan "e-mobility for all" and finally a green and light blue car with simple shapes with a lightning bolt inside.
This simple image fully captures the purpose of the service: offer a simple, fast and effective service for the charging of electric vehicles.

- **Visualization of CSs on the map**

Figure 3: Visualization of CSs on a map

The interface for visualize the map of the CSs is composed by: a white background; the eMall logo on the top-center; the login icon on the top-right;the settings menu on the top-left; the map at the center, which shows the actual position of the User and the CSs closer to him; the search bar at the bottom-center, which gives the possibility to the User to search for a different zone.

- **Visualization of the external status of the CSs selected**
  The User can select a CS on the previous map for visualize its "external" status in

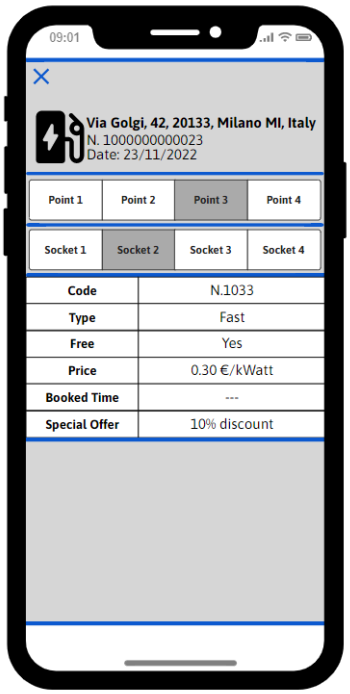

Figure 4: External status of CSs

that moment. From top to bottom the User can see: a grey background; a exit icon at the top-left, used for return to the map; the icon of a CS with its address position, serial number and the date of today; the bar of the number of the CPs present in the CS from which the User can select a particular CP; the bar of number of sockets present in the CP selects before, from which the User can select a particular socket; the data about the socket selected before, such as the code, the type, if it is free or not, the current price, the booked-time if it was not free and the special offers if presents.

- **Registration and Login**

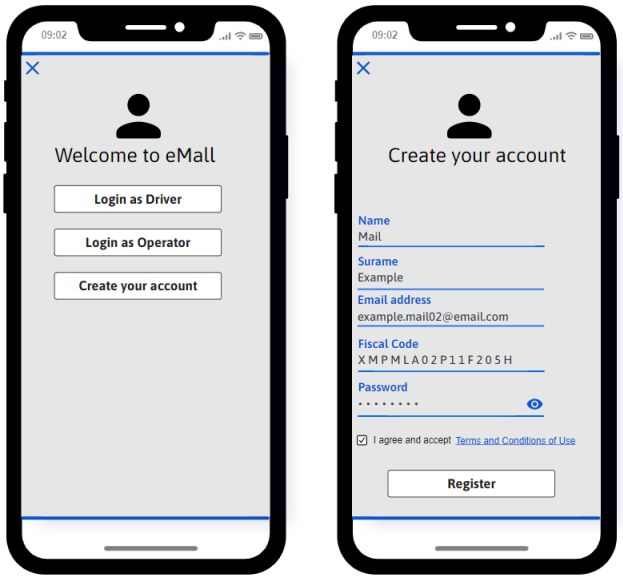

Figure 5: eMall Registration: a) Selection interface, b) Create an account

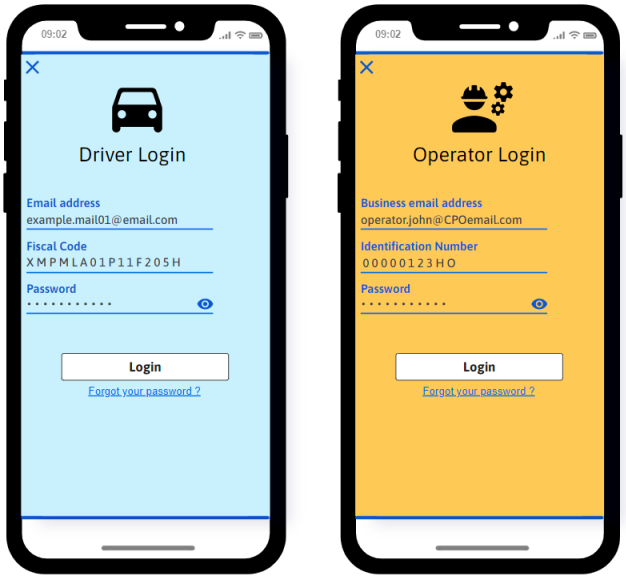

Figure 6: eMall Login: a) Driver, b) Operator

By clicking on the login icon, the User will see (Figure 5.a): an icon representing a man; an inscription "Welcome to eMall"; three buttons to enter the application as Driver or Operator, and finally a button to register. Buttons have the following functionalities:

- Create your account (Figure 5.b): for sign in the application a User has to provide: name, surname, email address, FC and a valid password for sign in the eMall application and become a Driver. the User has also to accept the "Terms and Condition of Use".
- Login as Driver (Figure 6.a): the Driver, User already registered, has to insert email address, FC, password and press "Login" button to log in the application. A Driver has also the possibility to recover the password if he forgot it.
- Login as Operator (Figure 6.b): a Operator has to insert: business email address, his identification code, password and press "Login" button to log in the application and use the eCPMS functionalities.
  A operator has also the possibility to recover the password if he forgot it.

- **Driver initial page**
  When a Driver logs in the application, he can see an interface (Figure 7.a) similar

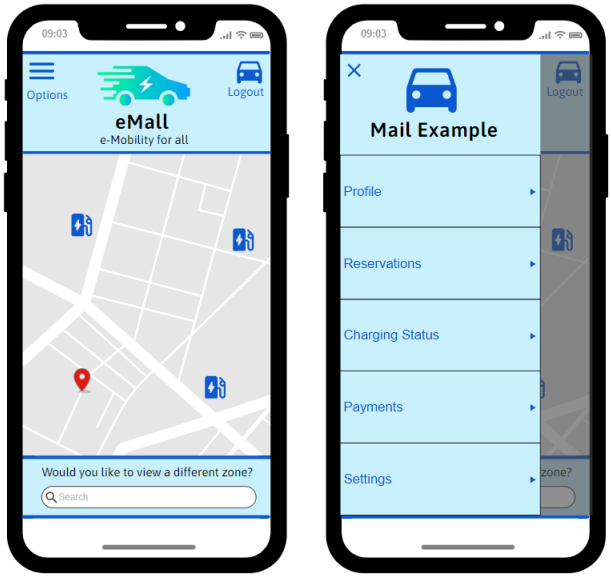

Figure 7: a) Driver principal page, b) Driver options menu

to the main interface (Figure 3) but with: a light blue background; a car icon as logout at the top-right; the CSs on the map colored by blue and a options menu at the top-left. By clicking on the options menu the Driver can see some functionalities (Figure 7.b).
We describe now, in a qualitative way, these options:

- Profile: the Driver can visualize details about his profile, such as: name, surname, email address etc.
- Reservations: the Driver can visualize the booking done before, or in progress, and their details.
- Charging status: the Driver can visualize, if are in progress, data about the charging process.
- Payments: the Driver can visualize the payments done before, with their details, and the credit cards memorized on the application.
- Settings: the Driver can visualize and modify some settings of the application, such as: language,unit of measurement (km, miles), change password etc.

- **Operator principal page**
  When a Operator logs in the application, he can see an interface (Figure 8.a)

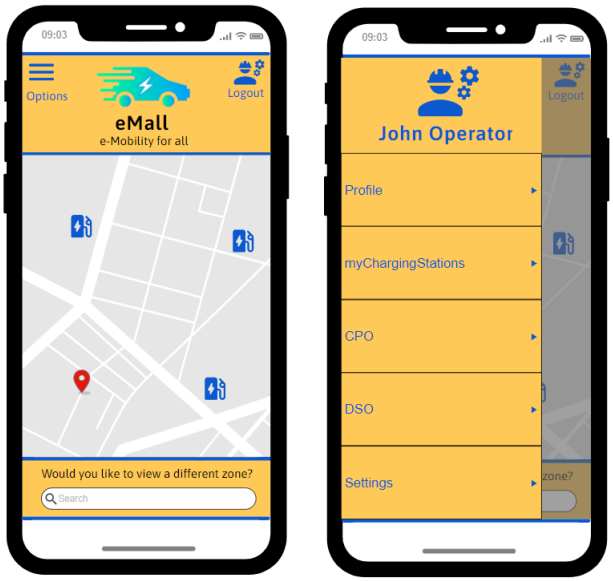

Figure 8: a) Operator principal page, b) Operator options menu

similar to the main interface (Figure 3) but with: an orange background; a worker icon as logout at the top-right; the CSs on the map colored by blue and a options menu at the top-left. By clicking on the options menu the Operator can see some functionalities (Figure 8.b).
We describe now, in a qualitative way, these options:

- Profile: the Operator can visualize details about his profile, such as: name, surname, business email address etc.
- myChargingStations: the Operator can: visualize the internal status of the CSs managed; can choose the price and the offers; can decide how to charging the EV (if there are present batteries).

- CPO: the Operator can visualize data about his CPO.
- DSO: the operator: can display the DSO in a list and select, or deselect, those from which to buy energy.
- Settings: the Operator can visualize and modify some settings of the application, such as: language,currency (€,$,£), change password etc.

- **Booking a time slot**
  We qualitatively describe here the passages of a booking in eMall application:

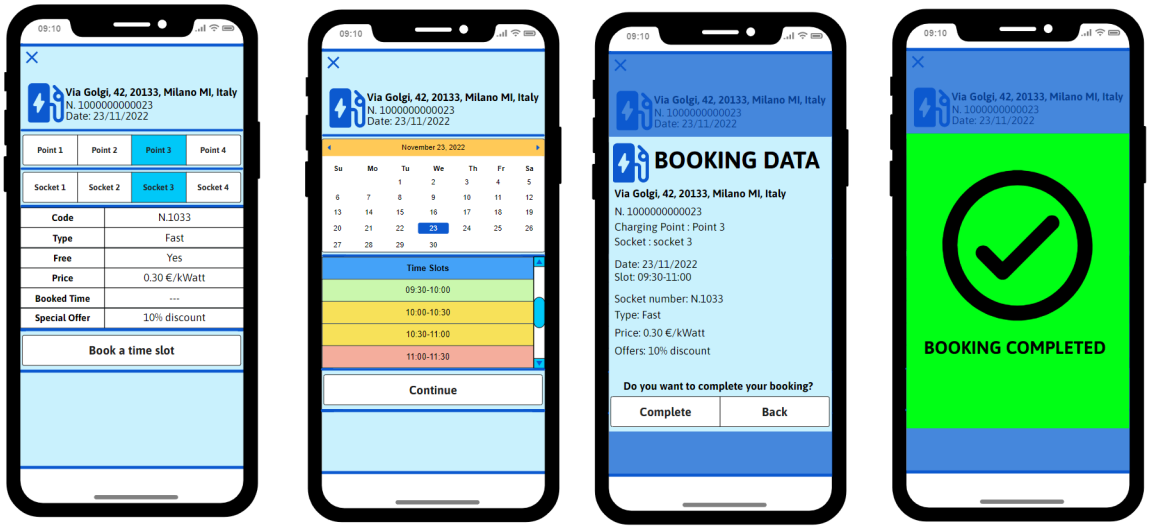

Figure 9: a) External status, b) Select a date, c) Booking data, d) Booking completed

- Figure 9.a : clicking on a CS, the Driver can view its "external" status and can, if socket is free, through the button "Book a time slot" start the booking phase of the selected socket.
- Figure 9.b : then, the Driver will display a calendar from which he can select a day for booking. After selecting the day, the Driver will later visualize a list of time slots: if the time slot is green then it can be selected, otherwise if it is already busy the time slot is red. When the Driver selects time slots, they will turn yellow.To proceed to the final stage of the booking, just click on the "Continue" button.
- Figure 9.c : at this stage, the Driver will be shown all the details of his booking, he can then complete or return to the time slot selection through the appropriate buttons below.
- Figure 9.d : after clicking on "Complete", the Driver will display a pop up as a booking confirmation.

- **Confirm of arrival via QR-code**

Figure 10: a) Reservations, b) Reservation details

After arriving in time to the reserved socket (maximum 10 minutes after declared start time) and after connecting the EV to the socket through the appropriate cable, the Driver must confirm via QR-code that it has arrived at the reserved socket. To do so, the Driver must go to "options" and click on "Reservations" to view the reservations made. As shown in Figure 10.a, if the booking ticket is green then the booking successfully completed; if the ticket is red, it means that the Driver did not show up on time to the booked socket; while the yellow tickets are "waiting tickets", those to be made. By clicking on the tickets, the booking details about it are shown. For the "waiting tickets" Figure 10.b, the QR-code will also be shown to be scanned by the tower to confirm the reservation.

- **Payment data**

Figure 11: a) Payment, b) Driver's cards

After scanning the QR code correctly, the Driver will be shown a screen (Figure 11.a) in which to enter the payment data and then start, through the appropriate button at the bottom, the charging process. Clicking on "My cards" the Driver can select, through a special menu, the data of a card previously used and saved (Figure 11.b).

- **Visualization of charging process**

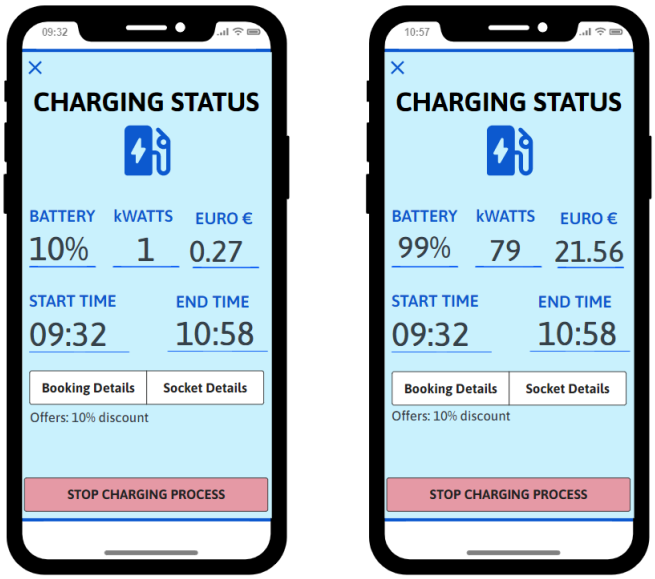

Figure 12: a) Beginning of the charging process, b) End of the charging process

If the payment data are correct, the charging process of the EV begins. At any time, the Driver can view the progress of the charging process. The Driver can visualize at run-time: the battery level of the vehicle, the kwatts entered, the cost, the time in which the charge has started and the estimated charge and charge time. The end of charge time indicates when the vehicle will reach 100 % charge. In addition, the Driver can view: booking details, details of the socket booked through the appropriate buttons and special offers present at the time of booking. Finally, the Driver can stop the charging process in advance if needed.
Figure 12.a shows the data of the charging status at the beginning of the charging process.
Figure 12.b shows the data of the charging status towards the end of the charging process.

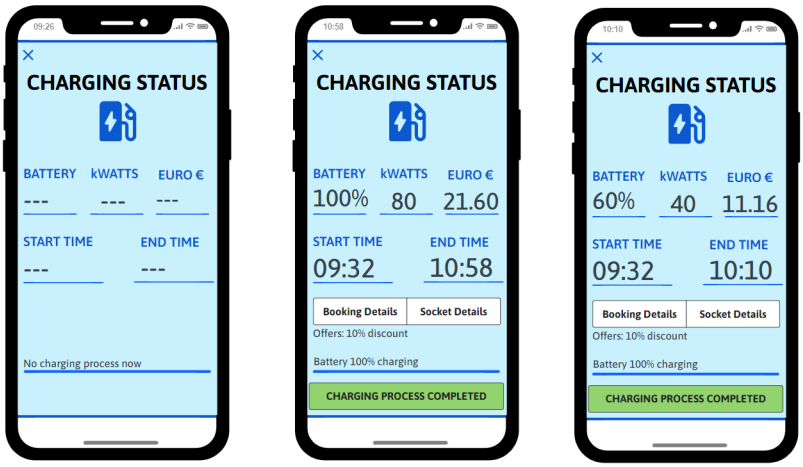

Figure 13: a) Before the start of the process, b) 100 % of battery reached, c) Process stopped in advance

As shown in Figure 13, we can display: Figure 13.a the charging process data when the vehicle is not yet connected to the socket; Figure 13.b the charging process data when the vehicle battery has reached 100%; Figure 13.c the data of the process of charge when the process is stopped in advance.

3.1.2 Hardware interfaces

The System does not offer any Hardware Interfaces.

3.1.3 Software interfaces

3.1.4 Communication interfaces

3.2 Functional requirements

3.2.1 Use Case Diagrams

3.2.2 Use Case Analysis

3.2.3 Sequence Diagrams

3.2.4 Requirements, Domain Assumptions, Goals Matrix

Requirements

- $[R.1] =$
- $[R.2] =$
- $[R.3] =$
- $[R.4] =$
- $[R.5] =$
- $[R.6] =$
- $[R.7] =$
- $[R.8] =$
- $[R.9] =$
- $[R.10] =$
- $[R.11] =$
- $[R.12] =$
- $[R.13] =$
- $[R.14] =$
- $[R.15] =$
- $[R.16] =$
- $[R.17] =$

- $[R.18] =$
- $[R.19] =$
- $[R.20] =$

Goals Matrix

GOALS	**DOMAIN ASSUMPTIONS**	**REQUIREMENTS**
G.1	D...	R...
G.1	D...	R...
G.2	D...	R...
G.3	D...	R...
G.4	D...	R...
G.5	D...	R...
G.6	D...	R...
G.7	D...	R...
G.8	D...	R...
G.9	D...	R...
G.10	D...	R...

Table 5: Goal Matrix table

3.3 Performance requirements

3.4 Design constraints

3.4.1 Standards compliance

3.4.2 Hardware compliance

3.4.3 Software system attributes

3.4.4 Reliability

3.4.5 Availability

3.4.6 Security

3.4.7 Maintainability

3.4.8 Portability

4 Formal analysis using Alloy

5 Efforts

Individual Work		
	Eutizi Claudio	***Perego Gabriele***
Tasks	**Hours**	**Hours**
Introduction (chapter 1)	3	5
Overall description (chapter 2)	3	3
Specific requirements (chapter 3)	0	0
Formal analysis using Alloy (chapter 4)	0	0
Final Revision	0	0
Total	**0**	**0**

Table 6: Time spent by each team member

6 References

- R&DD Assignment AY 2022-2023
- Alloy references: https://www.csail.mit.edu/research/alloy