POLITECNICO DI MILANO

SOFTWARE ENGINEERING II

eMall- e-Mobility for All
Requirements Analysis and Specification Document

Version 2.0

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1. Introduction

1.1 Purpose

The purpose of this project is to deliver the Requirement Analysis and Specification Document (RASD) for the “e-Mobility for All” (eMall) system-to-be. The RASD describes to the fullest extent the mentioned system in terms of both functional and nonfunctional requirements, and furthermore specifies the constraints that it needs to respect as well as its boundaries. On one hand this document is addressed to the developers who will implement the requirements. On the other hand, it is intended as a contractual basis for the users. Therefore it does not contain any specific terminology if not properly defined.

1.1.2 Goal

The following are the goals that we want to achieve by implementing our software:
[G1] User finds the charging stations nearby, their cost, any special offer they have.
[G2] User can book a charge.
[G3] CPO manages the internal and external status of a charging station.
[G4] CPO manages the charging process of the station.
[G5] User can charge his vehicle
[G6] User receive proactively suggestions to smartly recharge the electric vehicle

1.2 Scope

During the last few years,electric mobility (e-Mobility) has increased due to the fact that it is a way to limit the carbon footprint caused by our urban and suburban mobility needs.
eMall is a system that allows,thanks to an intuitive interface, end users the possibility to know about the charging stations nearby, their cost, any special offer they have; book a charge in a specific charging station for a certain timeframe; start the charging process at a certain station or notify the user when the charging process is finished.
In order to do that, the application offers to the users the possibility either to make a reservation i.e. a planned booking with a given date and range time or to get the status of a charging i.e. they can know precisely how much is left until the end of the recharge, the amount spent until that moment, to check the status of the station i.e. if it works properly
and an estimation of cost/time to complete the process.
On the other hand eMall offers to the CPOs ,a different interface w.r.t. users, the possibility to managing the station i.e.it decides if and from which DSO acquire energy based on acquired data and also allow CPOs to get the status of the owned station i.e. get the information about the external and internal status of the charge station

In particular, in order to avoid wasting time either to reach the station and start charging or to pick up the car at the end of the time frame , Users will be alerted by notifications.
After a booking event is created an alphanumeric string will be provided to Users in such a way they can use the booked station. This string is converted into a two-dimensional bar code using the standard QRCode. This must be shown to the QRCode reader attached to the station.
Acquiring and combining such data, eMall will support the work of two types of actors:

- Users,
- CPMs.

According to the World and Machine paradigm, introduced by M. Jackson and P. Zave. We can identify the Machine as the System to be developed and the environment in which e-Mall will be used as the World. The separation between these two concepts allows us to classify the entire phenomena in three different types.

1.2.1 World phenomena

Phenomena events that take place in the real world and that the machine cannot observe.

[W1] User wants to charge his car
[W2] User goes to the charging station
[W3] User downloads the e-Mall application on one of his devices
[W4] User prints the QR-code to have a paper copy

1.2.2 Shared phenomena

Phenomena controlled by the world and observed by the machine.
[SP1] User inserts credit card information
[SP2] User books a reservation
[SP3] User cancels a reservation
[SP4] The QR-code of a user is scanned at the charging station
[SP5] User plugs the cable to start the charging
[SP6] DSO provides information about own charging price to CPMS
[SP7] CPO sets a new price for a specific station
[SP8] CPO creates new special offers

Phenomena controlled by the machine and observed by the World.
[SP9]App sends end charging notification to the user
[SP10]App shows stations which are near the user
[SP11]App shows free temporal slots for a given station
[SP12]App shows information about charging status to the user
[SP13]App shows costs and offers about the station
[SP14]App shows to CPO information about available DSOs

1.3 Definitions, Acronyms, Abbreviations

1.3.1 Definitions

- **Booking**: The action of booking a recharge station for a timeframe performed by a user.
- **TimeFrame**: A time interval during which the recharge station is booked to a specific User.
- **Smart User/User**: User who has got a smartphone with the e-mall app. She/He's able to manage bookings by herself/himself.
- **QR-code**: A machine-readable code consisting of a sequence of black and white squares.

- **QR-reader**: electronic device which scans QR-codes. It also has a small screen.
- **Internal status of a charging station**: it includes the amount of energy available in its batteries, if any, the number of vehicles being charged and, for each charging vehicle, the amount of power absorbed and the time left to the end of the charge
- **External status of a charging station**: it includes the number of charging sockets available, their type such as slow/fast/rapid, their cost, and, if all sockets of a certain type are occupied, the estimated amount of time until the first socket of that type is freed

1.3.2 Acronyms

- **e-Mall** : e-Mobility for All.
- **RASD** : Requirement Analysis and Specification Document.
- **CPMS** : Charge Point Management System.
- **CPOs** : Charging Point Operators.
- **DSOs** : Distribution System Operators.
- **UI** : User interface.
- **UML**: Unified Modelling Language

1.3.3 Abbreviations

- [Gn] - the n-th goal of the system
- [WPn] - the n-th world phenomena
- [SPn] - the n-th shared phenomena
- [UCn] - the n-th use case
- [Rn] - the n-th functional requirement
- [EV] - electric vehicle

1.4 Revision history

- Version 1.0 (23 December 2022);
- Version 2.0
    - remove requirement 23 not needed
    - added 2 requirement related to the charging process
    - correct use case diagram: remove connection between SoftwareSocket and Charging Suggestion

    - correct sequence diagram: add Socket Software actor to the UC4; correct some messages on UC12, UC16, UC9, UC3, UC6, UC7, UC2, UC1.
    - correct use case description: add point 2 to the event flow of UC4; correct UC6 description on exceptions; updated event flow of UC3; updated entry condition and event flow of UC2; remove Google Maps actor from UC13; update event flow of UC12; remove exceptions from UC7.
    - adding a signature about the offer and facts related to the offer.
    - adding a predicate related to the CPO word

1.5 Reference Documents

This document is strictly based on:

- The specification of the RASD and DD assignment of the Software Engineering II course, held by professor Matteo Rossi, Elisabetta Di Nitto and Matteo Camilli at the Politecnico di Milano, A.Y 2022/2023;
- Slides of Software Engineering 2 course on WeBeep;
- Official link of Enel: https://www.enelx.com/uk/en.html, to get information on recharge time

1.6 Document Structure

Mainly the current document is divided in 4 chapters, which are:

1. **Introduction**: it aims to describe the environment and the demands taken into account for this project. In particular it's focused on the reasons and the goals that are going to be achieved with its development;
2. **Overall Description**: it's a high-level description of the system by focusing on the shared phenomena and the domain model (with its assumption);
3. **Specific Requirements**: it describes in very detail the requirements needed to reach the goals. In addition it contains more details useful for developers (i.e information about HW and SW interfaces);
4. **Formal Analysis**: this section contains a formal description of the main aspect of the World phenomena by using Alloy;
5. **Effort Spent**: it shows the time spent to realize this document, divided for each section;
6. **References**: it contains the references to any documents and to the Software used in this document.

2. Overall Description

2.1 Product Perspective

2.1.1 Scenarios

1. **User books a charge station**
   Daniele wants to charge his electric vehicle near his current position , but due to shortage of charge stations available the access to them is guaranteed only by a previous booking process.
   Daniele knows that there is an e-Mall app that allows people to book a station for a given timeframe, so he opens the e-Mall application and selects the nearest station in the map of the city, apply some further filter such as:
   - the type of charge(rapid/fast/normal);
   - time frame of the booking;

   Finally, the system shows a page with a set of timeFrame and stations available according to those filters.
   Daniele chooses the station,the timeframe and the duration. At this point if everything is ok he can click on “Book a station”.Once the user has booked a station, the system shows a page with the recap of the reservation and, after Daniele confirms the reservation, displays the QR-code of the booking.
   Fifteen minutes before the appointment the system sends to Daniele a notification that acts as a reminder for the booking.
   If he arrives in time everything will go as expected.
   Eventually, Daniele will print the QR-code, in order to use the booked station at the selected time frame.
2. **User misses a booking**
   Tommaso, because of his tight schedule, cannot afford to waste too much time therefore in order to plan the next day he decides to book a charging socket of a station the day before. When the reservation is completed he receives the QR-code which will grant the access to the station. The day of the booking Tommaso has a meeting that lasts longer than expected while the timeFrame of the charge is approaching. Tommaso does not see the notification for confirmation and he does not reply to it. As soon as the meeting ends Tommaso rushes to the station but he is extremely late and when the QR-Reader attached to the station scans his QR-code, it gets rejected and Tommaso cannot charge his vehicle. His charge booking is considered missed by the system. In fact eMall considers a booking as missed if the user does not arrive on time. In this case the system will automatically set that socket available and it will be able to be booked again.

Fortunately, if no one books that socket in the meantime, Tommaso will be able to still reserve the same socket and he will not lose the opportunity to charge his vehicle.

3. **User cancels a booking**
   Davide received a call from his manager that told him that he should go to make some commitment for him. After the call he remembers that he has to reschedule his day. While checking the calendar, Davide finds out that he booked a charging station and now, according to his commitment, Davide cannot go there to charge the vehicle. So he decides to cancel the booking in order to allow other users to use that station.
   Furthermore, if Davide does not cancel the booking, he will receive, fifthteen minutes before, the confirmation notification as a reminder so that he can cancel the booked socket.
4. **User who booked can charge the car**
   Sara booked a charge station a few days ago and it's finally time for her to go to charge her vehicle. She needs to be at the station with the plug and the QR-code , because she absolutely needs to charge the vehicle so she gets there perfectly on time indeed. Virginia's turn has come but the station doesn't admit her because the battery of the charging station is empty or the intended socket is not working properly. However as soon as the system found a solution, i.e recharge the internal battery or find another working socket that is free in that time Frame, Virginia is allowed to attach the wire to the station so that it can start the charging process. Hence she hands her QR-code to the QR-reader who scans it again. Virginia now can leave the vehicle and go to do her commitment without thinking about her vehicle. When the recharge process is done the system will notify her and ask to pay at the check-out and so then she can take back her car.
5. **User get notification of the charge process**
   Michele knows that during the recharge process he will have some commitment and he doesn't have neither time nor want to stay near the vehicle so that he can check when the charge will terminate. So, during the booking phase , he chooses from the options to be notified at the end of the charge and also chooses to be notified N minutes ,where N is an amount of time decided by the user, before in order to organize himself to arrive in time for the end of the recharge.
   On the day of the recharge, Michele plugged the vehicle into the socket of the station and started the recharge; meanwhile he went about his business without worrying about the charging process.As chosen during the booking phase, Michele is notified 20 minutes before the complete recharge in order to arrive at the station in time.
   In this way he doesn't waste time and he doesn't get any sanction due to the fact he doesn't move the vehicle in due time.

6. **Application suggests the user to go and charge the vehicle**
   Luca is a salesperson with a very busy schedule. Since he always moves around the city he decided to buy an electric vehicle in order to save money but the long duration of a recharging session puts him in trouble with his commitments and he rarely has the time to plan a recharging session efficiently. So, Luca decides to register to eMall, and allows it to interface with his calendar. Luca is used to arrange his visits daily, in a dynamic way, based on the client schedule. Consequently, he enters his commitments into Google Calendar. Based on Luca's calendar eMall sends him a notification to book a charge with a suggestion based on the scheduled events, their location and their duration.He then decides to book the suggested recharge socket located near the client where he has to go.
   Then, Luca confirms the reservation for that day in a time slot that perfectly fits the duration of the meeting.

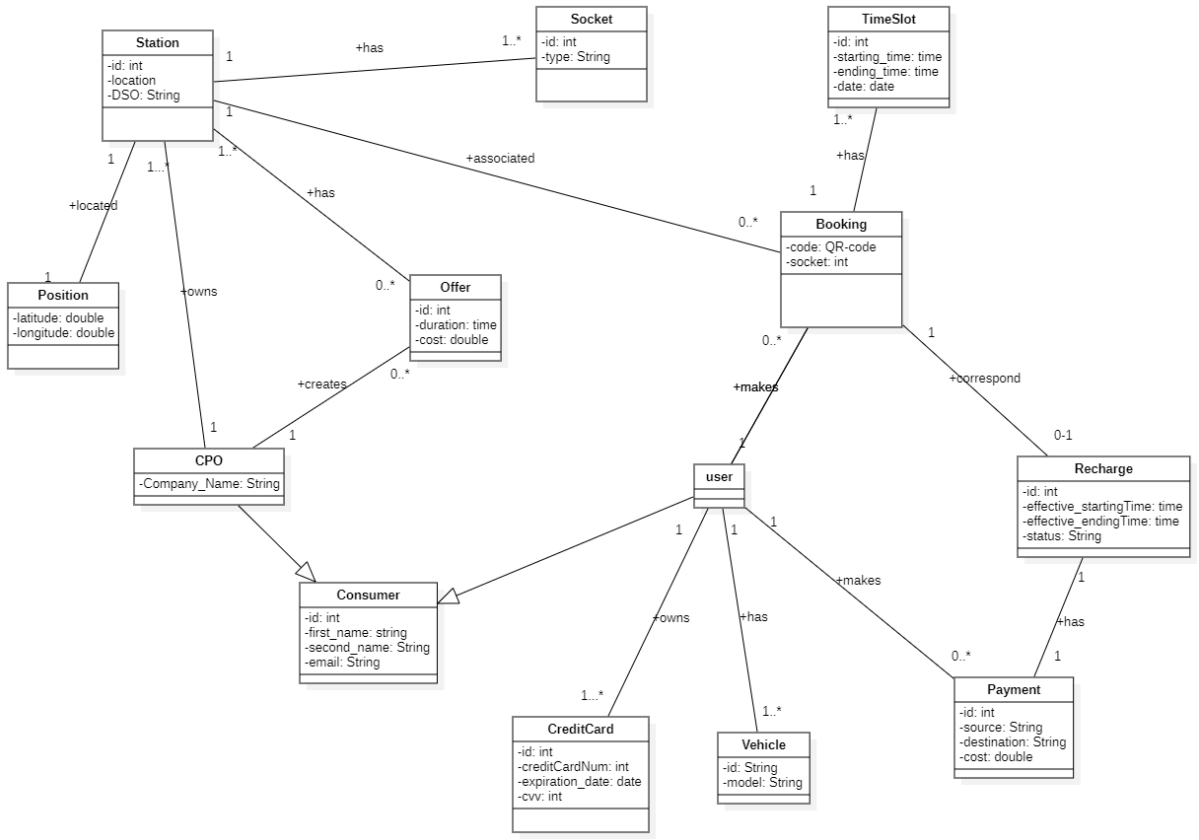
7. **Operator sees the internal and the external state of his station**
   Luigi, a Repower operator, has to periodically check the stations in order to acquire details about the internal and external status so that he can either make decisions or get statistics from them. Luigi enters into the eMall system as a registered user. In the CPO's homepage he selects a station and presses the bottom "See internal status" and the system shows the internal status of the selected station in order to see if it works properly. Then he presses the bottom "See external status" and the system shows the external status about the selected station. Then he also decides to print the statistics for each station in order to show them later to the business sector of the company to find out if they have to change the position of some stations since they aren't used so much by users.

8. **Operator decides where to get energy for charging**
   Giovanni, an Enel X operator, has to deal daily ,based on the market prices, with from where to recharge the stations owned by his company in order to be competitive w.r.t. other competitors . After logging into eMall, Giovanni clicks on the button "Get DSOs prices". Then ,Giovanni, based on the prices, decides from which DSO acquires the energy. After clicking on "Select DSO" all the stations located in that city start to acquire energy from that DSO. Furthermore, Giovanni decides to allow the system to make automated decisions and presses the button "set the system as automatic".

2.1.2 Domain class diagram

In Figure(2.1) is represented the Domain class diagram related to eMall. It contains all the elements of the domain in which the system operates and the interaction between such elements. In the following are described the most relevant parts of the diagram in order to ease the understanding of the domain.

- There are two types of Consumer: user(User), operator (CPO). They have in common the fact that they use the system and, indeed, all of them have a first_name and a second name second_name. A CPO can also be a user.
- The only users considered in the domain are those who make at least one Booking. The user's Position is necessary because the system needs to have access to the location of all the users in order to provide the nearby stations.
- Booking is associated with at most one Recharge because it might happen that the recharge never takes place. The Booking is made over both non-empty sets of TimeFrame and Socket related to the same Station. At most one Socket is involved in the association with Booking. Booking have an unique identifier for the system (id) to distinguish between two different booking that may coincide and each one of them generates one and only one QR_code

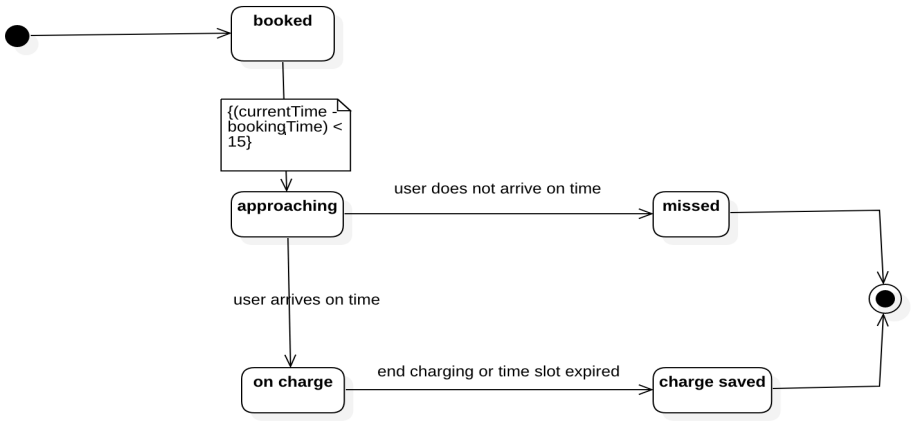


(Figure 2.1) Domain class diagram

2.1.3 Statecharts

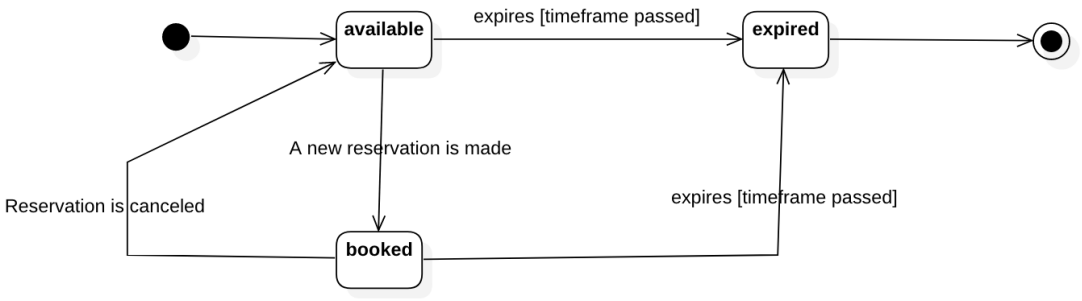
The statecharts discussed in this section are the ones of the charging process and of the time slot.
The first one is necessary to have a better understanding of the charging process starting from the booking for a charge, while the latter describes the possible states of a timeslot and the conditions for it to transit from one state to another.

Charging process



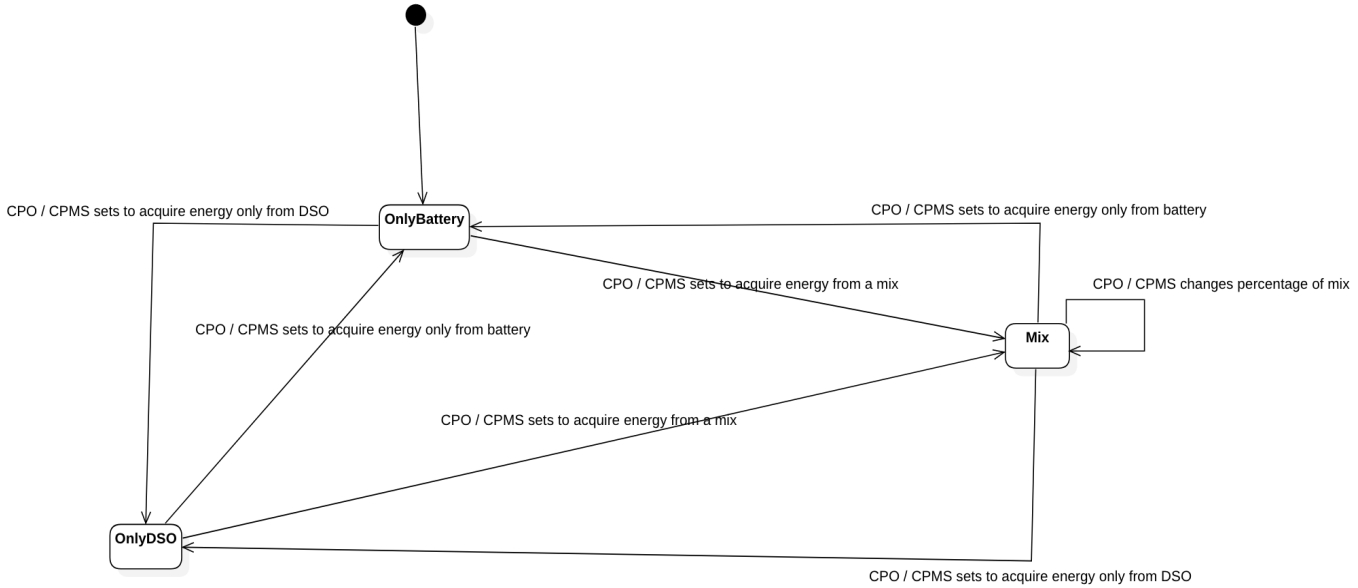
The state *booked* represents the very initial state in which a charging process is when a reservation is made by a user. The process goes into the *approaching* state when it is at maximum quarter to the time on which the charging should start. This time is calculated as the difference between the currentTime, that is the effective time, and the bookingTime, that is the time in which the reservation should start. If the user does not arrive on time for the charging, then the process goes into the *missed* state and the user misses his booking and the possibility to charge his car on the booked time slot. So if the user wants to charge his car he will have to book another slot.
Instead, if the user arrives on time, the process goes into the *on charge* state. This is the state in which the user is charging his car (after having scanned the QR code) and as soon as the charging ends or the time slot expires, the process goes into the *charge saved* state, that is the state in which the system saves information about the charging that just occurred.
Both *charges saved* and *missed* are final states.

Time slot



This statechart represents the states of a time slot of a single socket in a station. Time slots are time frames of thirty minutes each that can be booked by a user to charge his car. The first state of the slot is *available* that indicates that the time slot has been booked by no user. Then if a user books the time slot the slot goes into the *booked* state that indicates that it is no more available. But if the user decides to cancel the reservation then the slot goes back into the *available* state and it can be booked again. Instead, if the user does not cancel the reservation and the time slot expires, it goes to the *expired* state, that is the final state. If no one makes a reservation for the time slot, so the time slot expires without being booked, it goes from the *available* state into the *expired* state.

Energy acquisition



This statechart represents the states of energy acquisition changing for at least one of the stations managed by a CPO. The state changing can be handled either manually by human operators or automatically by CPMSs.

The types of energy acquisition are three: onlyBattery, onlyDSO and a mix of the two. The initial state is *OnlyBattery* because the acquisition of the energy is by default totally from the battery of the station.

From any state we can go to all the other states. From the *mix* state we can also go to itself again when the percentage of mix is changed by CPO or CPMS.

2.2 Product Functions

2.2.1 Sign Up and Login

These functions will be available to all the users.
The sign up functionality allows users to register themselves to the system.
In particular, each user will be asked to provide an email (the email will be the username of the user) and a password. Then a verification email is sent to the user.
Once the user has confirmed the email, the system will ask the user to insert his personal information and if he is a user also the vehicles owned. Instead if he is an operator he has to insert also the stations owned.

2.2.2 Manage reservations

The main function of eMall is to manage reservations so that a user can reserve a socket without worrying about the recharging problem and finding a working station nearby. The criteria for allowing reservations, hence, takes into account both of these aspects that need to be met. In order to guarantee the right functionality of each station, only a limited number of bookings can be made upon the same time slot based on the number of sockets that each station has.
When booking a visit, the user must select the slots for a station he wants to book (every slot has a duration of thirty minutes) based also on the type of socket that he needs (e.g. rapid charge). Once the procedure has been completed the system returns a QR-code that will be used by the users to start the charging process of the vehicle.

2.2.3 Manage the station

This function will be available to the CPOs.
This functionality will allow operators to manage the stations. From the eMall dashboard the operator can see the stations he manages and, after having selected one, he can see the internal or external status of it by pressing the specific button to get the necessary information needed for the operator to make decisions.
The internal and external status of the station is composed for example by the number of charging sockets available, their type, their cost, amount of energy available in its batteries, number of vehicles being charged, amount of power absorbed and time left to the end of the charge.
On the other hand, the system allows the CPO to set some configuration, based on what he reads from the data, in order to have full control of the stations, for example to decide from which DSO to acquire energy or set how to acquire energy for a station (from the DSO or from its batteries or a mix of the two). Furthermore, the CPO can decide to make the system semi-automatic by setting thresholds on the different parameters of the station so that the station can also work on its own.

2.2.4 Smart suggestion

This function will be available to the user.
This functionality will allow a user to receive smart suggestions from the eMSP.
The user will have the opportunity to take advantage of suggestions ,created ad hoc by the application, on where and when to recharge the vehicle. In order to use this functionality, a user will be required to provide access to the calendar and to authorize bluetooth connection that allows the system ,thanks to the device where eMall is installed, to see the status of the battery of the vehicle. Then, constantly the application in a smart way, based on the information retrieved, will provide the user with suggestions including the time slot, the type of the recharging socket and the station. Suggestions will be based on: vehicle battery charge status, prices, available offers.
The suggestion aims to book reservations in correspondence to user’s commitments, at the closest station to the appointment’s location and with a duration of the recharge suitable for the duration of the commitment.

2.3 User characteristics

There are mainly two kinds of users that interact with the system: users and CPOs.

2.3.1 User

A user is a person who owns a device able to connect to the internet and download the eMall app, i.e. a smartphone or a tablet. They need to register to the app to use the eMall functionalities.

2.3.2 CPO

CPO (Charging Point Operator) is a registered user that manages the admin functionalities of the application: decide from which DSO to acquire energy, decide the cost of a charging, set special offers and decide whether to store or not energy and whether to use the energy available in the batteries instead of acquiring it from DSOs.

2.4 Assumptions, dependencies and constraints

2.4.1 Regulatory policies

The eMall application will ask for user personal information like name, surname and email address. Email addresses won't be used for commercial purposes. Personal information will be processed in compliance with the GDPR.

Moreover, the system will have to ask for users' permission to retrieve and use their position. GPS positions will be stored for as long it's needed to find the stations nearby. The same is for the user's calendar.

2.4.2 Domain Assumptions

The following are the assumptions made for the domain. Such assumptions are properties and/or conditions that the system takes for granted, mostly because they are out of the control of the system itself, and hence need to be verified to assure the correct behavior of e-MAll.

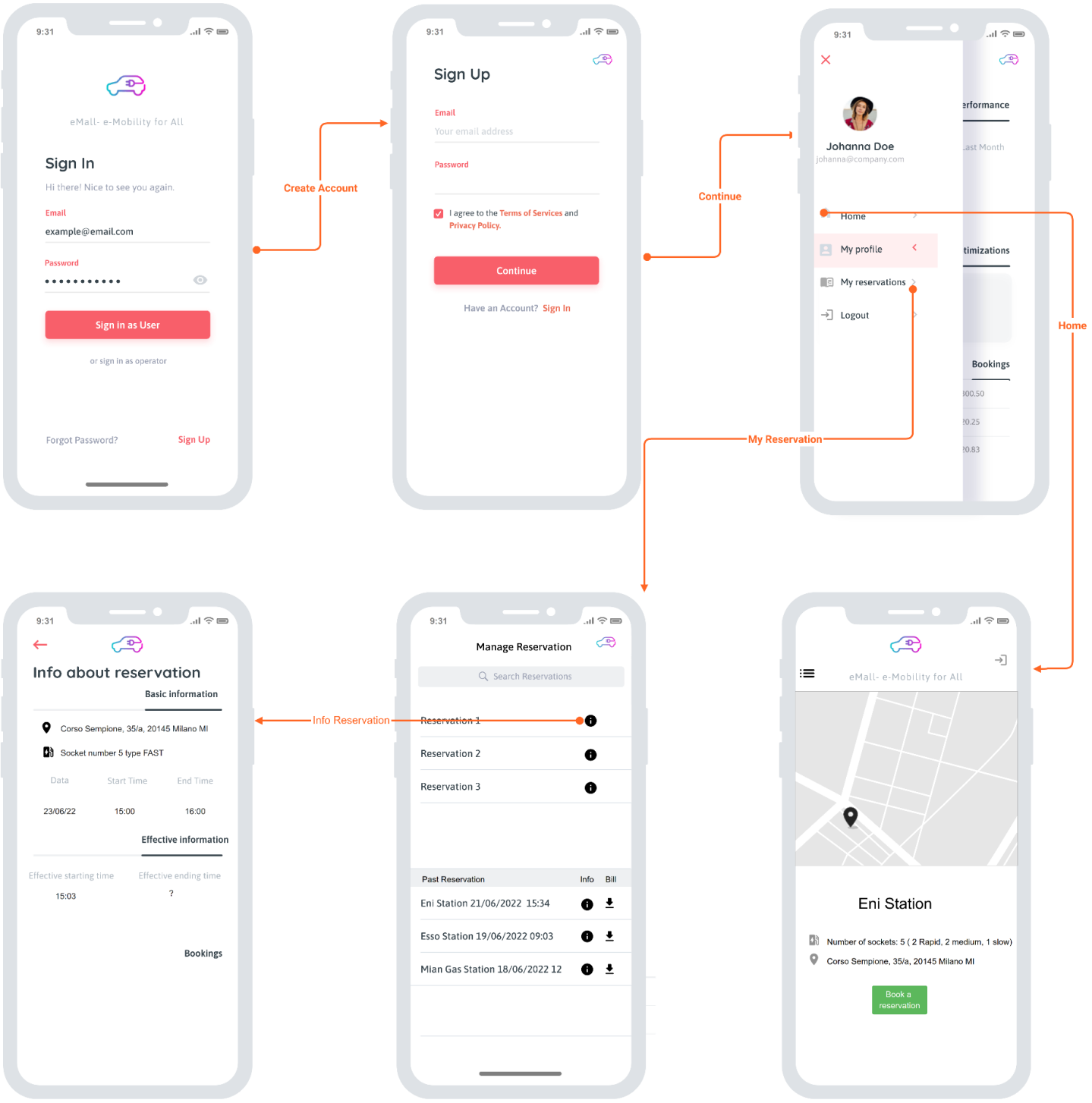
[D1]: User must have an internet connection
[D2]: When the timeframe has ended, client must have left the station
[D3]: Stations have a QR reader
[D4]: User allows GPS connection
[D5]: User allows access to the calendar and to the navigation system
[D6]: Information about station must be correct(e.g.a socket marked as free it is really free)
[D7]: Connections between systems must be reliable
[D8]: User must have the cable to charge his vehicle
[D9]: Notifications must arrive in 10 seconds
[D10]: Information about the distance from the station must be correct
[D11]: Time left and price for charging must be consistent with what application shows
[D12]: Operator inserts in the system all the stations for which he is responsible
[D13]: CPOs are provided with at least one device able to connect to internet
[D14]: User allows bluetooth connections between the vehicle and telephone

3. Specific requirements

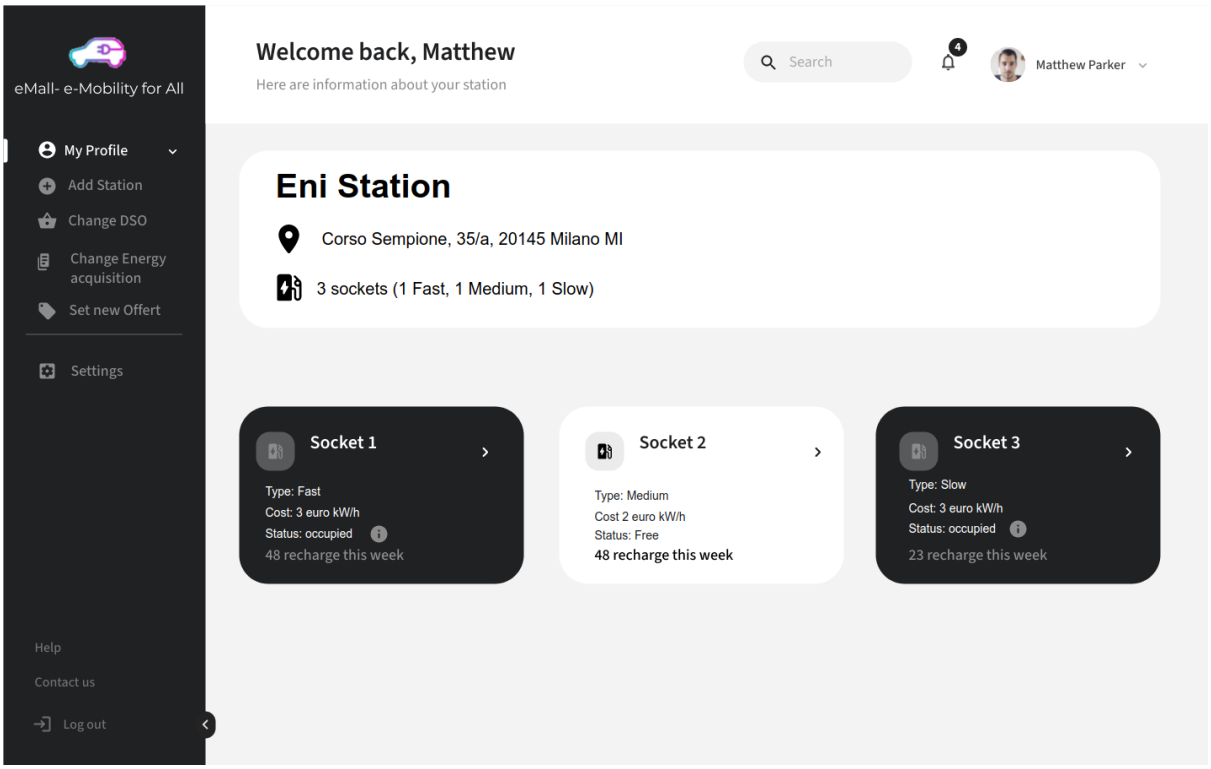
3.1 External Interfaces

3.1.1 User Interface

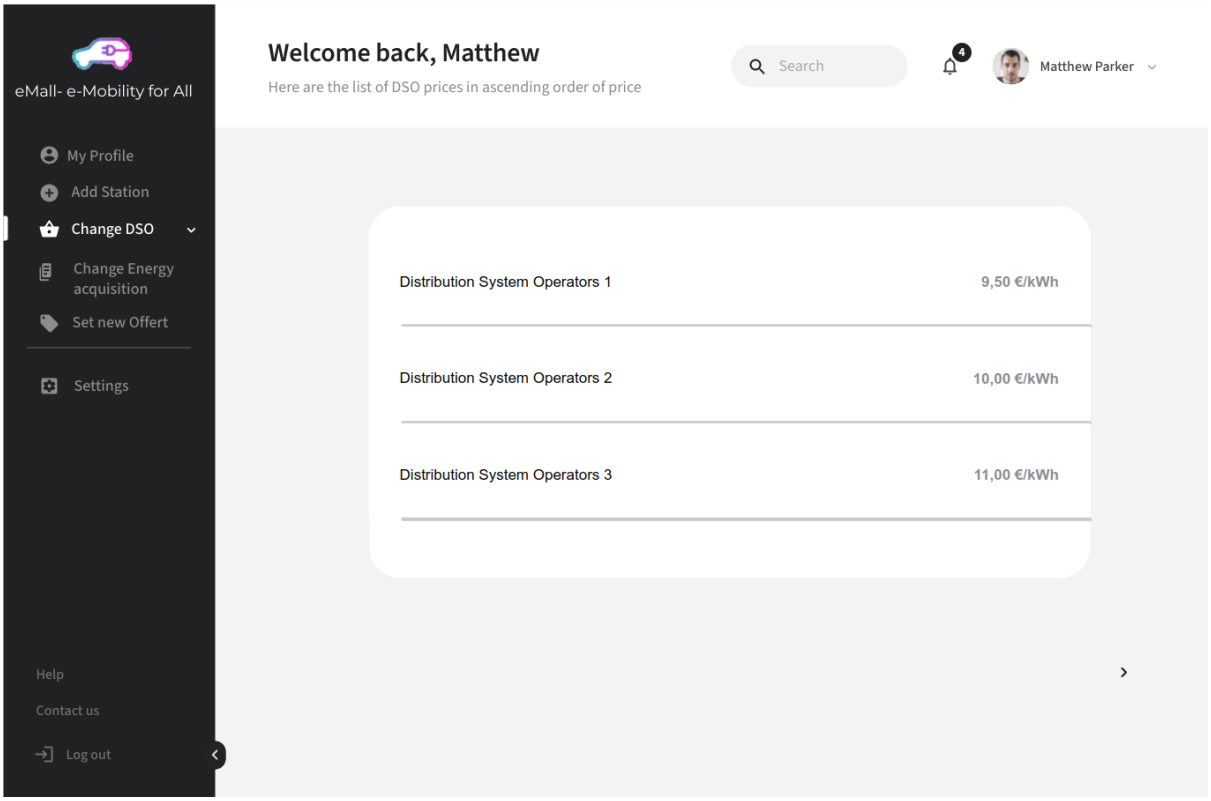
In this section of the document is presented the mobile application UI: the views both the user and the operator are going to see when using the mobile application. A user needs to book a visit while the operator of a station needs to access information about the stations and to control them remotely , therefore two different sets of views are needed.Some of them will only be visited by the operator while the others will only be visited by the users. CPOs are allowed to be also simple users by signing up by private credential.



User interfaces



Operator interface to get information about a station



Operator interface to retrieve the list of DSO prices

Since the service has to be accessed by an heterogeneous set of customers, along with the mobile application a web application is developed. In this way a user(an operator can be also ,after registration, a simple user) via the mobile can manage all the operations related to the charging process such as login, book a recharge, see old recharge details and so on.
On the other hand, the web application is used only by a CPO(it is more suitable to the operator operation) to manage all the operations related to the owned stations such as start a recharge, change DSO ,etc…

3.1.2 Hardware interfaces

The system offers services to the users described in the section 2.3 via different hardware interfaces.

- Users that access eMall via smartphone application are required to have a smartphone with internet connection available and the possibility to use the GPS to retrieve their location.
  Furthermore, users are required to allow the connections via bluetooth between the vehicle and the smartphone in order to send data about the battery status to the system via the application installed on the user's phone.
  Those who access eMall via the web application are required to have a device able to connect to the internet and, if the device is not mobile, they are required to own a printer to print their QR-code in order to take that with them when they reach the store.
- CPOs have access to the management service of eMall which is provided via a web page, hence they are required to have just a device with a working internet connection. In alternative they can also use the same smartphone application as the users, which adds the requirement for operators to also own a smartphone.

Furthermore,two devices will be attached to the stations: an optical sensor, i.e. a camera, able to read QR-codes and a display for reading the eventual notifications such as a success message only after a valid QR-code has been scanned, while it shows a rejection message if the QR is invalid.

3.1.3 Software interfaces

The system requires some software interfaces in order to provide its services. Below are reported the most significant :

- Google Maps API: the system communicates with external APIs to provide services related to the position and to offer users a map of their surroundings that they can navigate.
- Calendar API: it is needed to develop the application's intelligent subsystem, which is needed to implement the intelligent suggestion mechanism.
- Socket software: it is the software that manage the sockets of a station
- Payment authority: the system communicates with external APIs to provide services related to the payment of a recharge.

3.1.4 Communication interfaces

The system exploits the internet connection for the communication to and from all devices, while it uses the GPS connection to retrieve the location of the customers. The eMSP should exhibit an uniform interface so that the communication with multiple CPMSs is reliable. Furthermore, the software must be OCPI-compliant in order to support connections between eMobility Service Providers who have electric vehicle drivers as customers, and Charge Point Operators who manage charge stations.

3.2 Functional requirements

In the following are specified all the requirements that the system has to fulfill. In order to work properly, the system should:

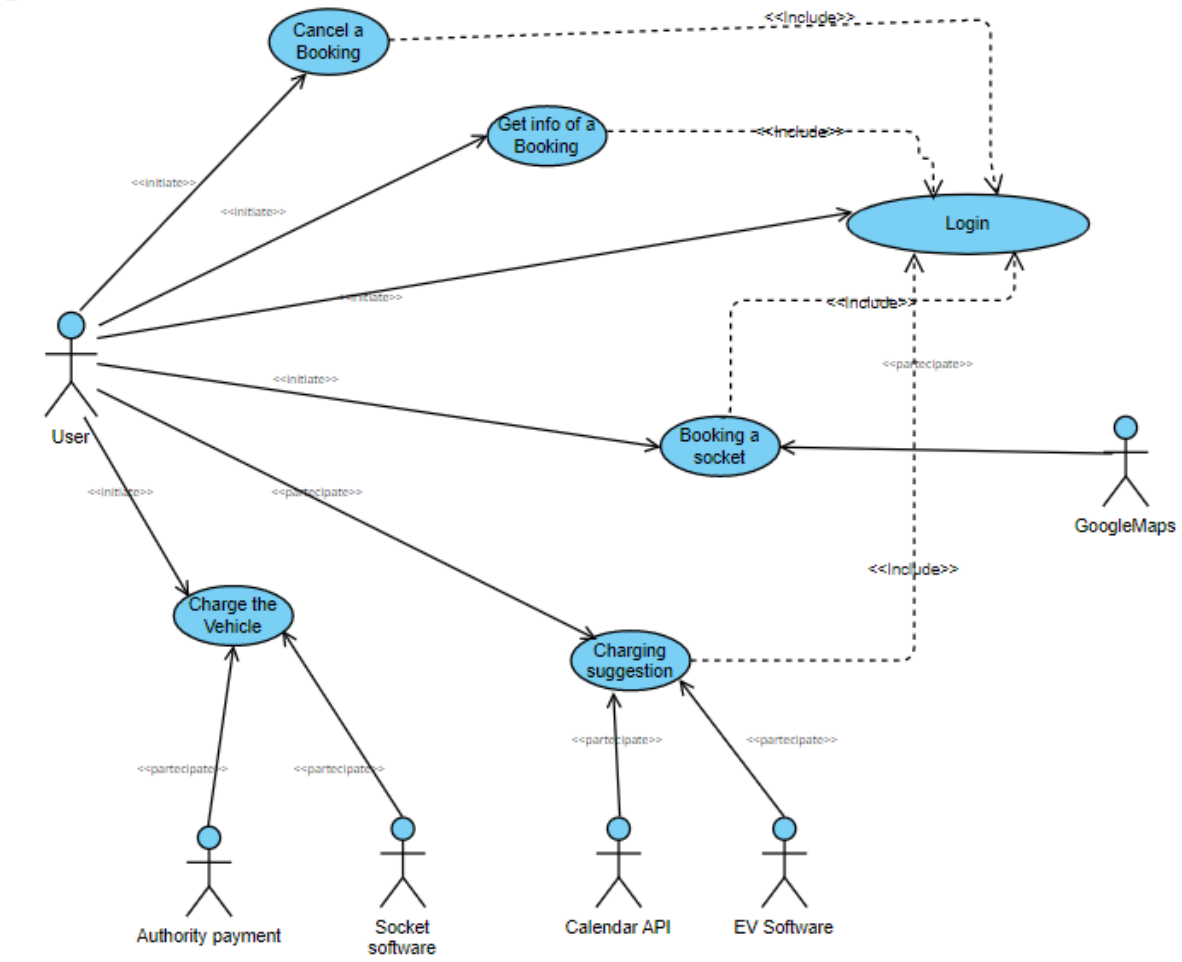
[R1] The system allows users to sign up
[R2] The system allows CPOs to sign up
[R3] The system allows registered CPOs to login
[R4] The system allows registered users to login
[R5] The system allows CPOs to insert information about station for which they are responsible
[R6] The system allows CPOs to see the list of stations that they manage
[R7] The system allows CPOs to see the exact number of vehicle attached to a station that they manage
[R8] The system allows CPOs to get the information about the recharged vehicle
[R9] The system allows CPOs to see the details of a booking
[R10] The system allows CPOs to see all the details of booking during a specific timeFrame
[R11] The system allows CPOs to modify the way in which socket batteries are charged
[R12] The system allows CPOs to decide from which DSO acquire energy
[R13] The system allows users to select a charging station(and so a socket) from a map
[R14] The system allows users to search for a specific station
[R15] The system allows users to select the exact date and time of the slot they are booking from a list of available timeFrame
[R16] The systems allows users to cancel a booking
[R17] The system allows users to see all the previous charging process occurred
[R18] The system allows users to select the number of timeslot(15 min each one)of a charging process
[R19] The system allows users to insert their personal information (i.e. first name, second name,telephone number, email, and credit cards details)
[R20] The system allows users to download a PDF of the ticket

[R21] Notify users that use the application when the time of their booking is approaching
[R22] Notify users when the charging process ended or when time slot expired
[R23] The system allows users to pay for a charging
[R24] The system notifies users about special offers
[R25] The system notifies users about prices changing on the stations in which they have a reservation
[R26] The system disallows user to take two different socket in the same time slot
[R27] The system suggests users to go and charge the vehicle
[R28] The system allows user to start a recharge
[R29] The system allows users to attach the electric vehicle

3.2.1 Use cases diagrams

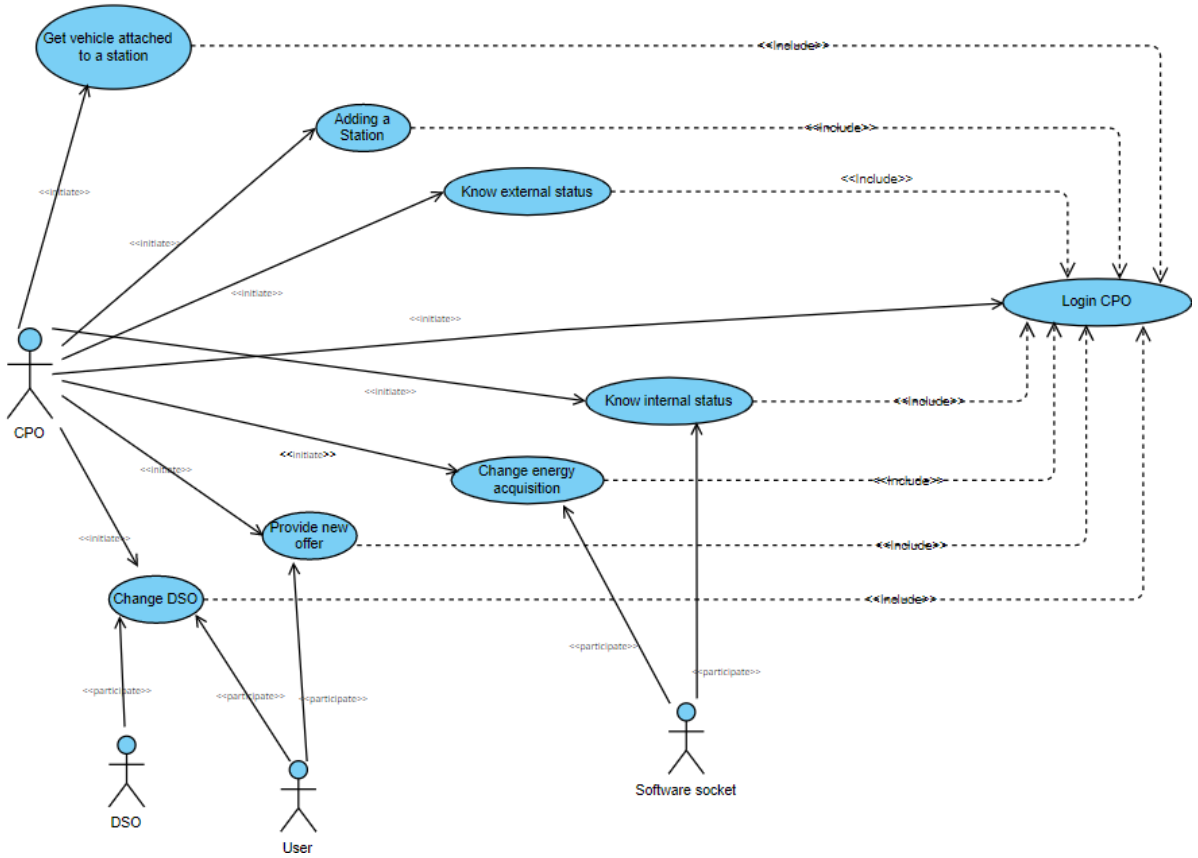
In the following are provided the use case diagrams deduced from the scenarios reported in paragraph 2.1.1. They help identify the actors interacting with the system and their role within each use case.

User Use Case Diagram



(Figure 3.2) User use case diagram

CPO Use Case Diagram



(Figure 3.3) CPO use case diagram

3.2.2 Use Cases

[UC1] - Login User

Name	Login User
Actors	User
Entry Condition	The user has opened the eMall application
Event flow	**1** - The user inserts his username and password in the form **2** - The user clicks on the “Login” button **3** - The system checks the credentials **4** - The application shows the proper dashboard
Exit condition	The user has access to the services for the right interface provided by eMall
Exception	**3** - The data inserted are not valid. The system returns to the entry condition.

[UC2] - Login CPO

Name	Login CPO
Actors	CPO
Entry Condition	The CPO has opened the eMall web application and as clicked on “Enter as an operator” button
Event flow	**1** - The inserts his username and password in the form **2** - The clicks on the “Login” button **3** - The system checks the credentials **4** - The application shows the proper dashboard
Exit condition	The CPO has access to the services for the right interface provided by eMall
Exception	**3** - The data inserted are not valid. The system returns to the entry condition.

[UC3] - Get vehicle attached to a station

Name	CPO gets vehicle attached to station
Actors	CPO
Entry Condition	The CPO op is logged in the eMall application
Event flow	1 - The system shows the stations managed by the CPO 2 - op selects the station s from the list of stations he manages 3 - The system shows a view with: ● the number of users currently attached to s ● the most recent charging process occurred in s 4 - op selects a vehicle v to see its details 5 - The system shows a view with information about selected vehicle
Exit condition	The op returns to the home page of his dashboard
Alternative	1.a - The op searches the station s by typing the name of s in the search bar.

[UC4] - Know internal status

Name	CPO knows internal status
Actors	CPO, Socket Software
Entry Condition	The CPO op is logged in the eMall application and has selected a station s
Event flow	1 - op presses the button to see information about internal status of s 2 - The system contacts the Socket Software of the selected station to get the status battery of the station 3 - The system shows information about internal status of s: ● energy available in its batteries ● number of vehicles being charged ● amount of power absorbed and time left to the end of the charge
Exit condition	The op returns to the home page of his dashboard

[UC5] - Know external status

Name	CPO knows external status
Actors	CPO
Entry Condition	The CPO op is logged in the eMall application
Event flow	1 - op presses the button to see information about external status of s 2 - The system shows information about external status of s: ● number of charging sockets available ● their type such as slow/fast/rapid ● their cost ● number of vehicles occupied ● estimated amount of time until the first socket of that type is freed
Exit condition	The op returns to the home page of his dashboard
Alternative	1.a - The op searches the station s by typing the name of s in the search bar.

[UC6] - Registration of the CPO

Name	Registration of the CPO
Actors	CPO, Email provider
Entry Condition	The CPO is not already registered in the system
Event flow	1 - The CPO opens the application 2 - The CPO clicks on the button ”Sign Up as a CPO” 3 - The system shows the registration form 4 - The CPO inserts his email and a password 5 - The system sends a confirmation email to the CPO through an email provider 6 - The CPO confirms his email by clicking in the link received by email 7 - The system shows a form asking for the personal information, used in order to identify the CPO 8 - The CPO inserts the requested data 9 - The system shows a form asking for the information regarding all the stations owned by the CPO such as position, number of sockets 10 - The CPO inserts the requested data

	11 - The system redirects to the login page
Exit condition	Registration has been successful. The CPO’s data is stored into the system’s database. The CPO then will be able to login in the system by using their credentials.

[UC7] - Registration of a User

Name	Registration of the User
Actors	User
Entry Condition	The User is not already registered in the system
Event flow	1 - The User opens the application 2 - The Userclicks on the button ”Sign Up” 3 - The system shows the registration form 4 - The User inserts their email and a password 5 - The system sends a confirmation email to the User 6 - The User confirms their email by clicking in the link received by email 7 - The system shows a form asking for the personal information, used in order to identify the User 8 - The User inserts the requested data 9 - The system shows a form asking for the information regarding the vehicles owned by the User 10 - The User inserts the requested data 11 - The system redirects to the login page
Exit condition	Registration has been successful. The User’s data is stored into the system’s database. The User then will be able to login in the system by using their credentials.

[UC8] - Get info of a booking

Name	Get info of a booking
Actors	User

Entry Condition	● The user has logged in the system
Event flow	1 - The user clicks on the button ”My reservations” 2 - The system shows the reservations view 3 - The user selects the reservations he is interested in 4 - The system displays the required reservation
Exit condition	Data are properly displayed

[UC9] - Booking a socket

Name	Booking a socket
Actors	User, GoogleMaps
Entry Condition	● The user u has logged in the system ● The user u has given location permissions to the application
Event flow	1 - The system contacts GoogleMapsServer to retrieve a map with nearby stations (also those not affiliated to eMall) 2 - The system filters the stations by selecting only those affiliated 3 - The system shows the filtered map 4 - u selects a station and clicks the button “Book a reservation” and selects a date 5 - The system shows all the available slots and their type (e.g. rapid charge) for the selected station 6 - u selects at least one slot 7 - The system shows a confirm button 8 - u presses the confirm button 9 - The system checks that u has not already done other reservations on the same timeframe 9 - The system saves the reservation 10 - The system delivers a downloadable file containing the QR-code that will be used to use the socket’s station
Exit condition	The visitor successfully booked a charging socket of a station
Exceptions	● u has already done other reservations on the same timeframe. The system will send an error message ● u aborts the use case: the user has changed his mind and does not confirm the reservation

[UC10] - Cancel a booking

Name	Cancel a booking
Actors	User
Entry Condition	The user u has logged in the system and he is on “My reservations” page and has selected a reservation (see UC8)
Event flow	1 - u clicks on the button ”Cancel reservation” 2 - The system shows a confirm button 3 - u presses the confirm button 4 - The system registers the cancellation and shows a confirm message
Exit condition	The visitor successfully cancel the reservation of that specific socket of a station
Exceptions	• u aborts the use case: the user has changed his mind and does not confirm the cancellation

[UC11] - Change DSO

Name	CPO changes DSO
Actors	CPO, DSO, User
Entry Condition	The CPO has logged in the system and changing system is setted as ‘manually’
Event flow	1 - The CPO opens the application 2 - The CPO clicks on the button ”Get DSOs prices” 3 - The system sends to the DSOs the request 4 - DSOs return prices information 5 - The system shows all the DSOs prices that are available 6 - The CPO checks the prices 7 - The CPO selects a DSO that he is interested in 8 - The system communicates the choice to the selected DSO 9 - The system shows a confirm message to the CPO 10 - The system sends a notification about prices changing to the User who have a reservation on the stations involved by the changing
Exit condition	The CPO successfully changes the DSO of the stations he manages

[UC12] - Charge the vehicle

Name	User charges the car
Actors	User , Payment authority, Socket software
Entry Condition	The User u is at the station and has the QR-code for the reservation which is approaching
Event flow	1 - u shows the QR-code at the QR-reader of the socket 2 - The QR-reader scans the ticket 3 - The socket software sends the QR-code to the system 4 - The system verifies that the QR corresponds to a legitimate booking 5 - The socket software shows a message to u that the QR is valid 6 - u attaches the vehicle to the station's socket 7 - The system sends to the Authority payment User's credit card in order to check if the payment can be made 8 - The system tells the socket software to start the charging 9 - The socket software starts the charging and informs u and the system that the charging has started 10 - The system registers the starting time of the charge and sets the socket as busy 11 - The socket software informs the system that the charging is ended 12 - The system notifies the user about the ending of the charge 13 - The system registers the ending time of the charge and sets the socket as free 14 - The system processes the payment by contacting the Payment authority 15 - The system saves charge information 16 - The system sends to u a recap of the charge
Exit condition	u makes successfully the charging process
Exceptions	• The QR is considered not valid, the socket software shows an error message • u's credit card is not accepted, the system shows an error message

[UC13] - Adding a station

Name	Adding a station
Actors	CPO
Entry Condition	The CPO has logged in the system
Event flow	• The CPO opens the application • The CPO clicks on the button ”Add station” • The system shows a form • The CPO inserts information of the station to add • The system saves the new station • The system shows a confirm message
Exit condition	The CPO successfully add a station

[UC14] - Change energy acquisition

Name	Change energy acquisition
Actors	CPO, Socket software
Entry Condition	The CPO has logged in the system
Event flow	1 - The CPO opens the application 2 - The CPO clicks on the button ”Change energy acquisition” 3 - The system shows a form 4 - The CPO selects the stations for which he wants to do the changing and selects “Set totally from DSO” 5 - The system informs the socket software of the selected stations about the changing 6 - The system shows a confirm message
Exit condition	The CPO successfully changes the way to acquire energy
Alternative	4 - CPO selects the stations, selects “Set partially from DSO” and inserts the percentage of energy to acquire from DSO

[UC15] - Provide new offer

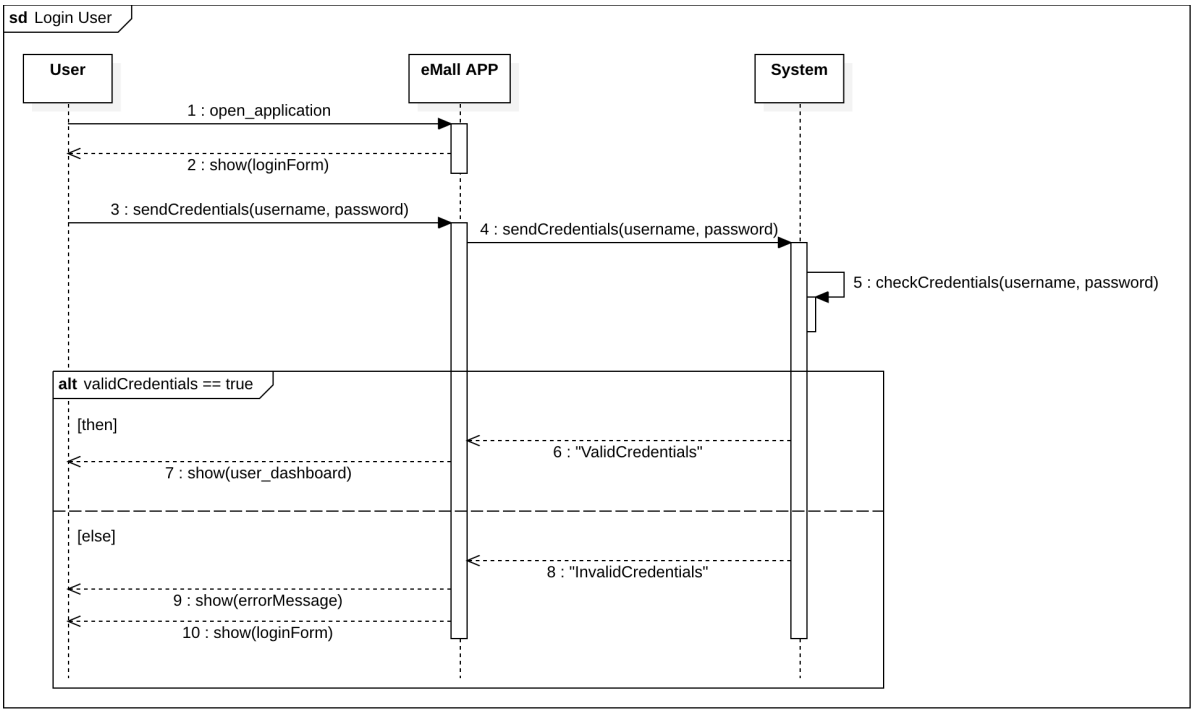
Name	Provide new offer
Actors	CPO, User
Entry Condition	The CPO has logged in the system
Event flow	1 - The CPO opens the application 2 - The CPO clicks on the button ”Set new offer” 3 - The system shows a form 4 - CPO inserts the stations involved, price and duration of the offer 5 - The system shows a confirm message 6 - The system sends a notification about new offer to the Users who have a reservation on the stations involved by the changing
Exit condition	The CPO successfully changes the way to acquire energy

[UC16] - Charging suggestion

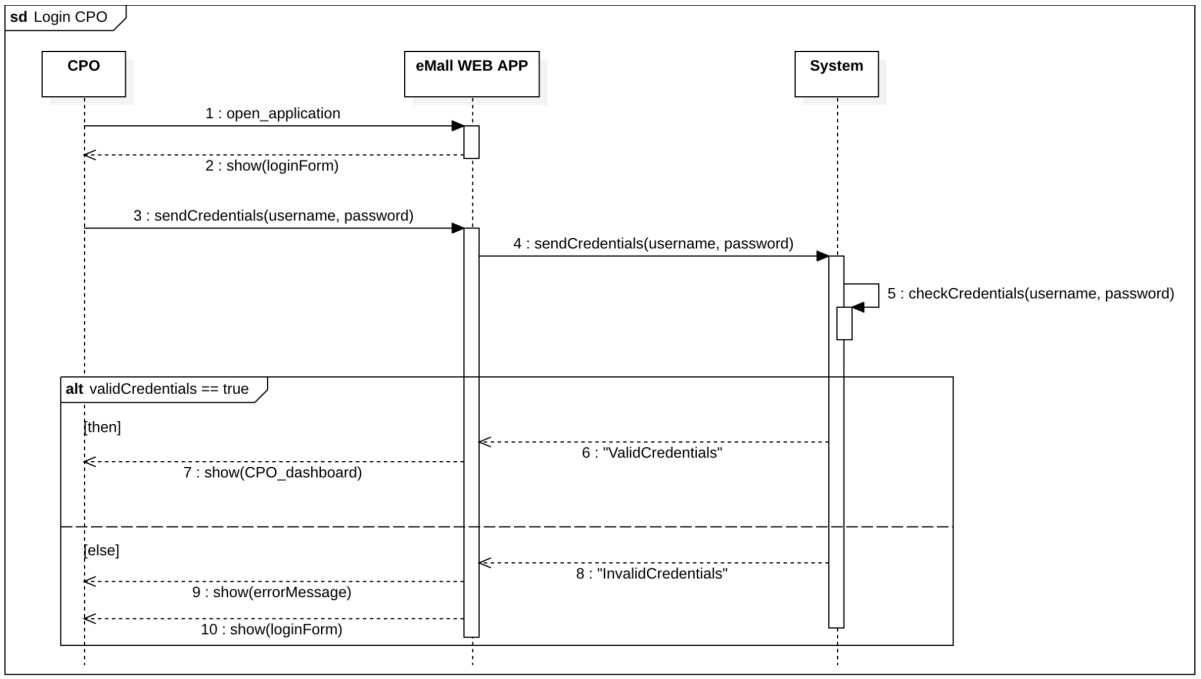
Name	Charging suggestion
Actors	User, EV Software, Calendar API
Entry Condition	● The User u has logged in the system ● The User u has given calendar permissions to the application ● The User u has allowed bluetooth connections between his car and his mobile device
Event flow	1 - The system gets the battery status from the EV software 2 - The system gets the u’s schedule from the Calendar API 3 - The system checks if special offers exist 4 - The system checks the availability of the slots of the selected stations 5 - The system sends a suggestion notification to u
Exit condition	The User u successfully receives a suggestion notification

3.2.3 Sequence diagrams

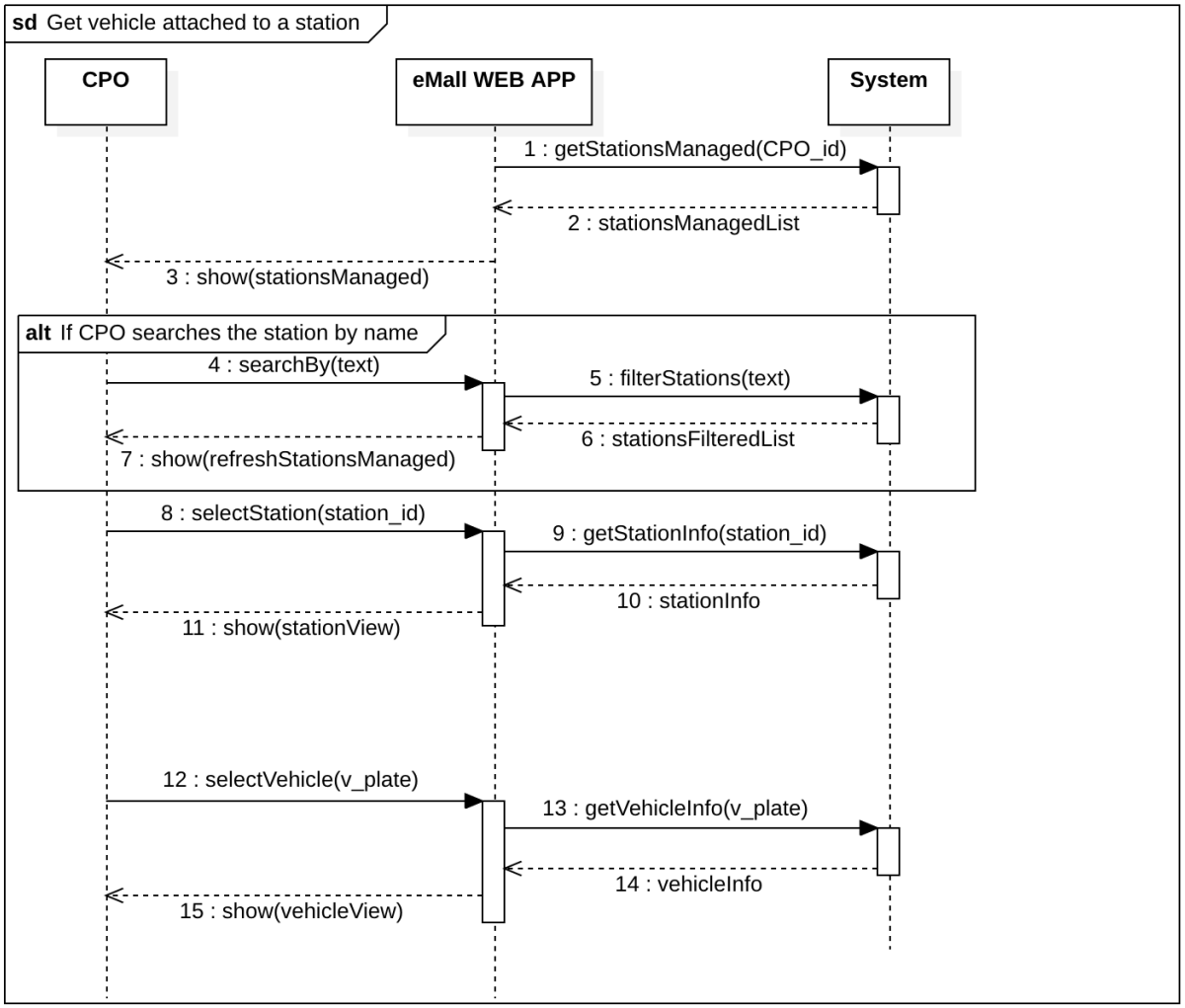
[UC1] - Login User



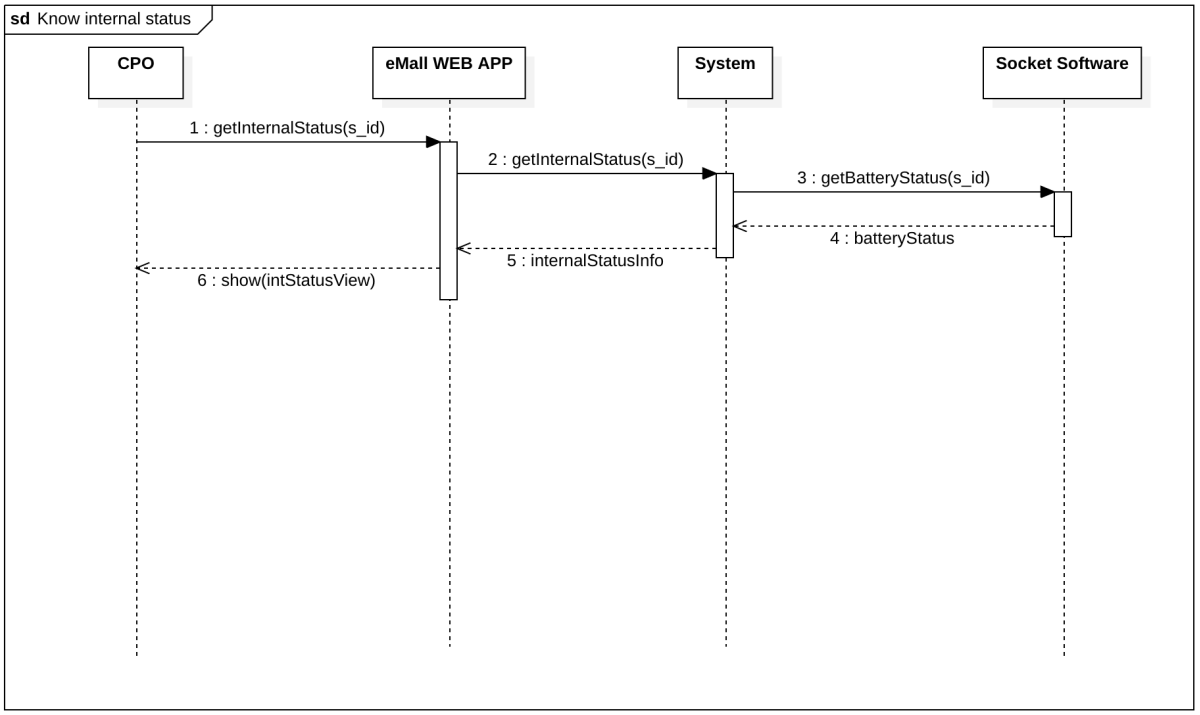
[UC2] - Login CPO



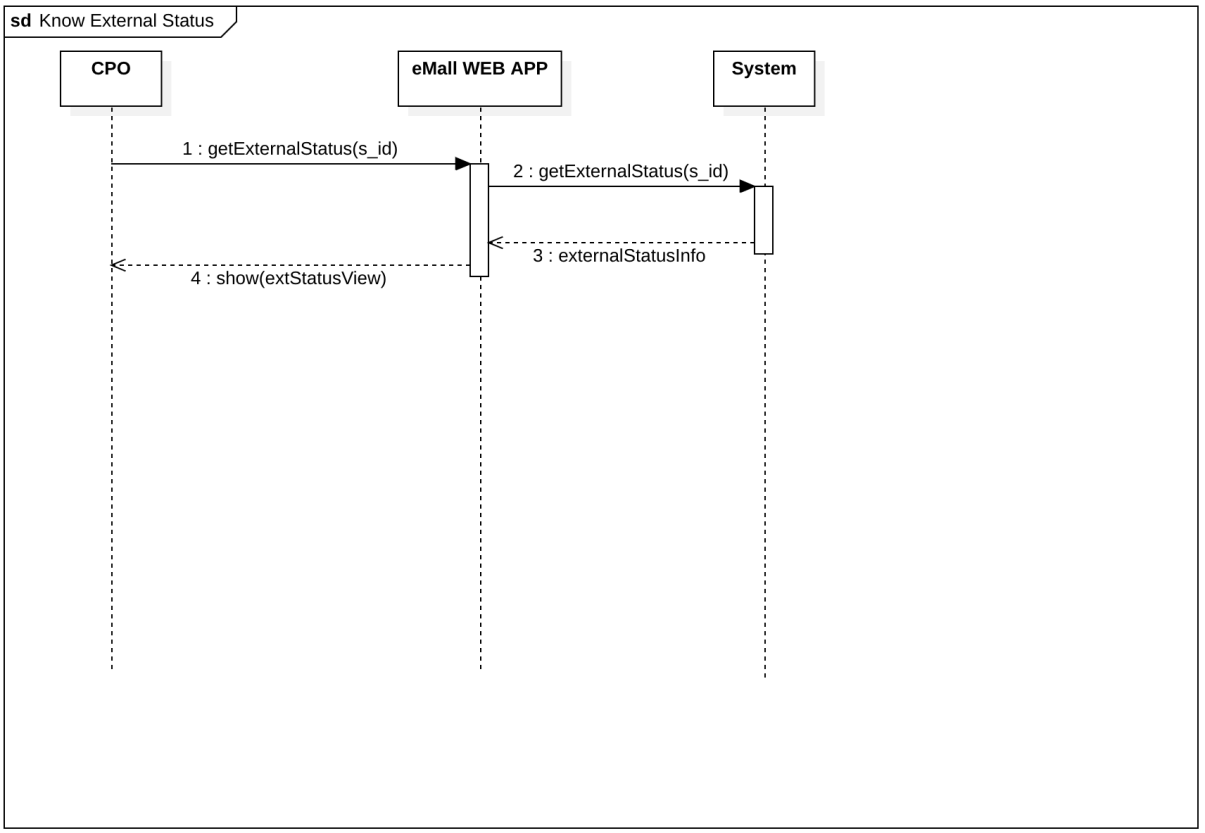
[UC3] - Get vehicle attached to a station



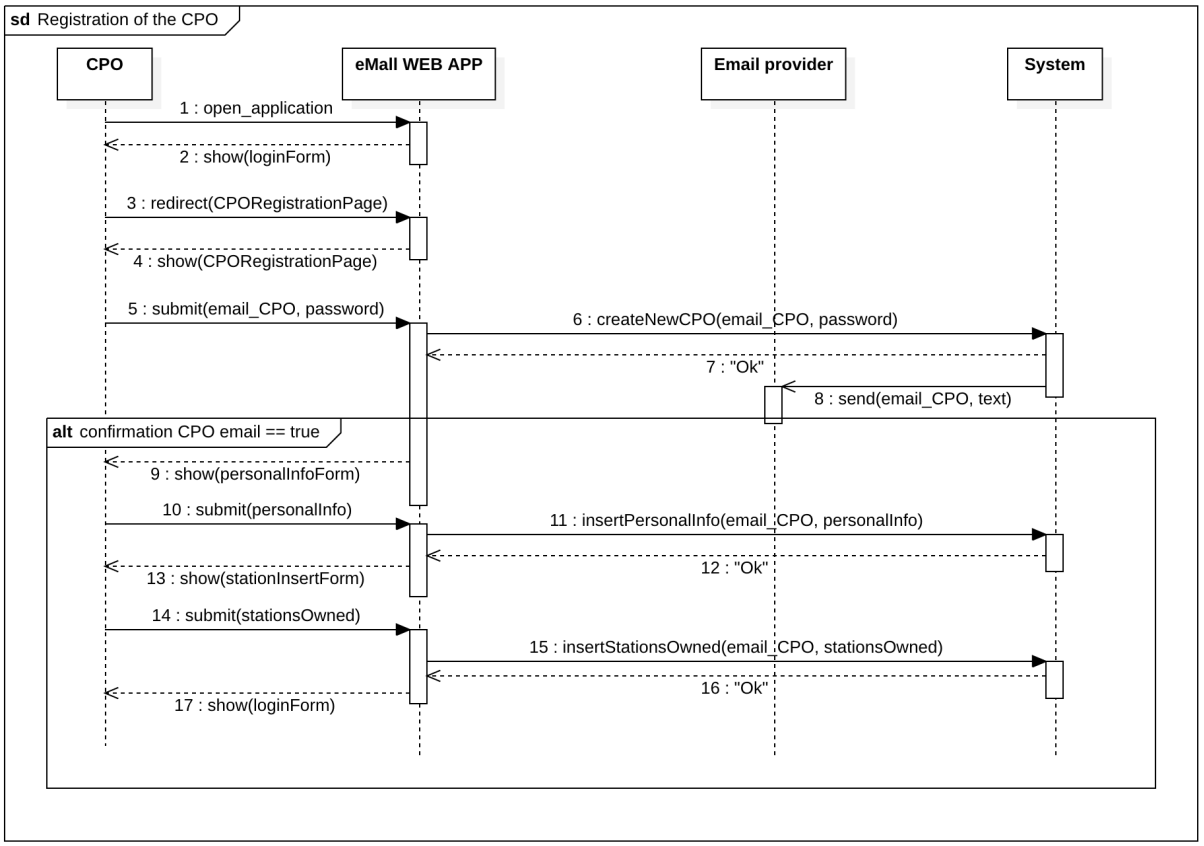
[UC4] - Know internal status



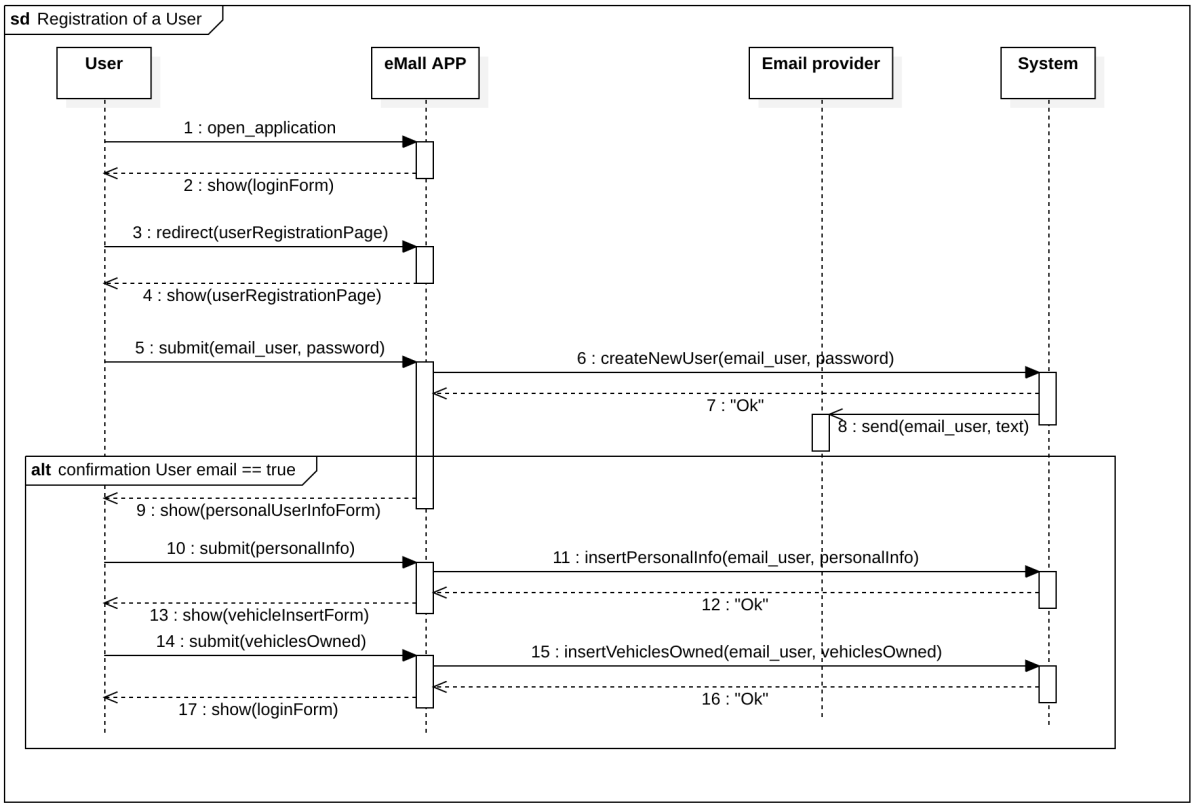
[UC5] - Know external status



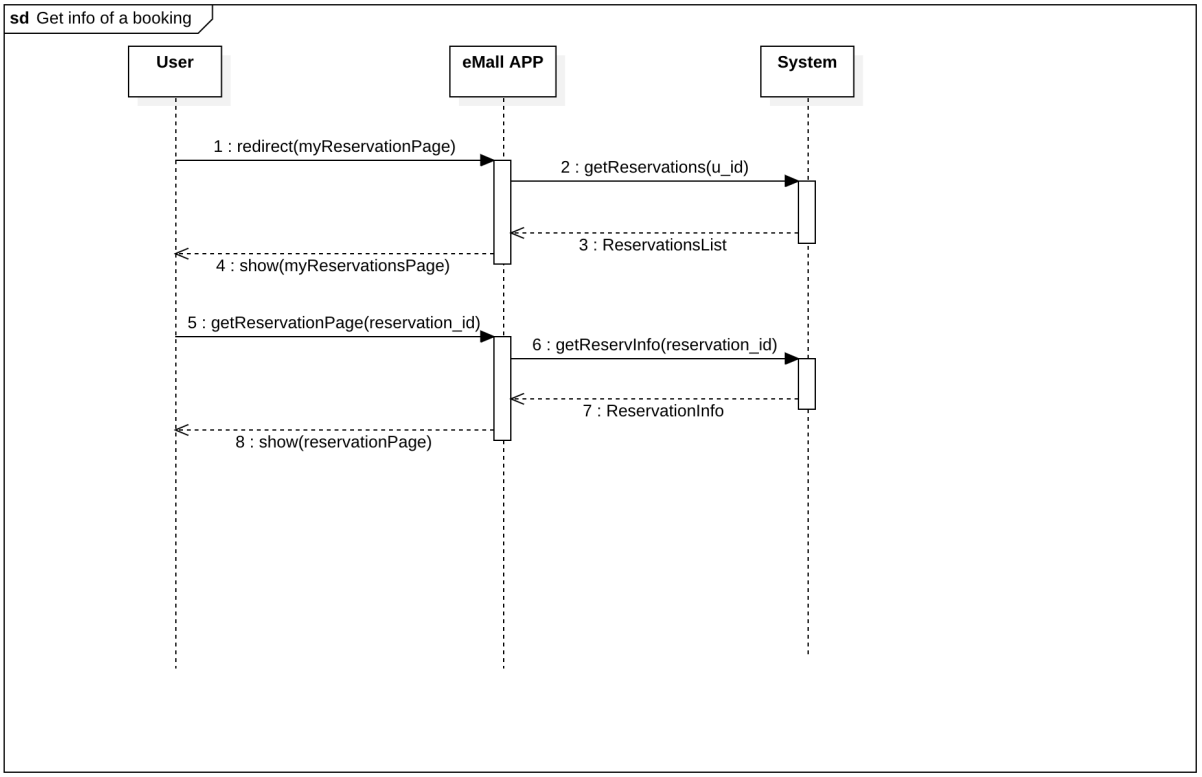
[UC6] - Registration of the CPO



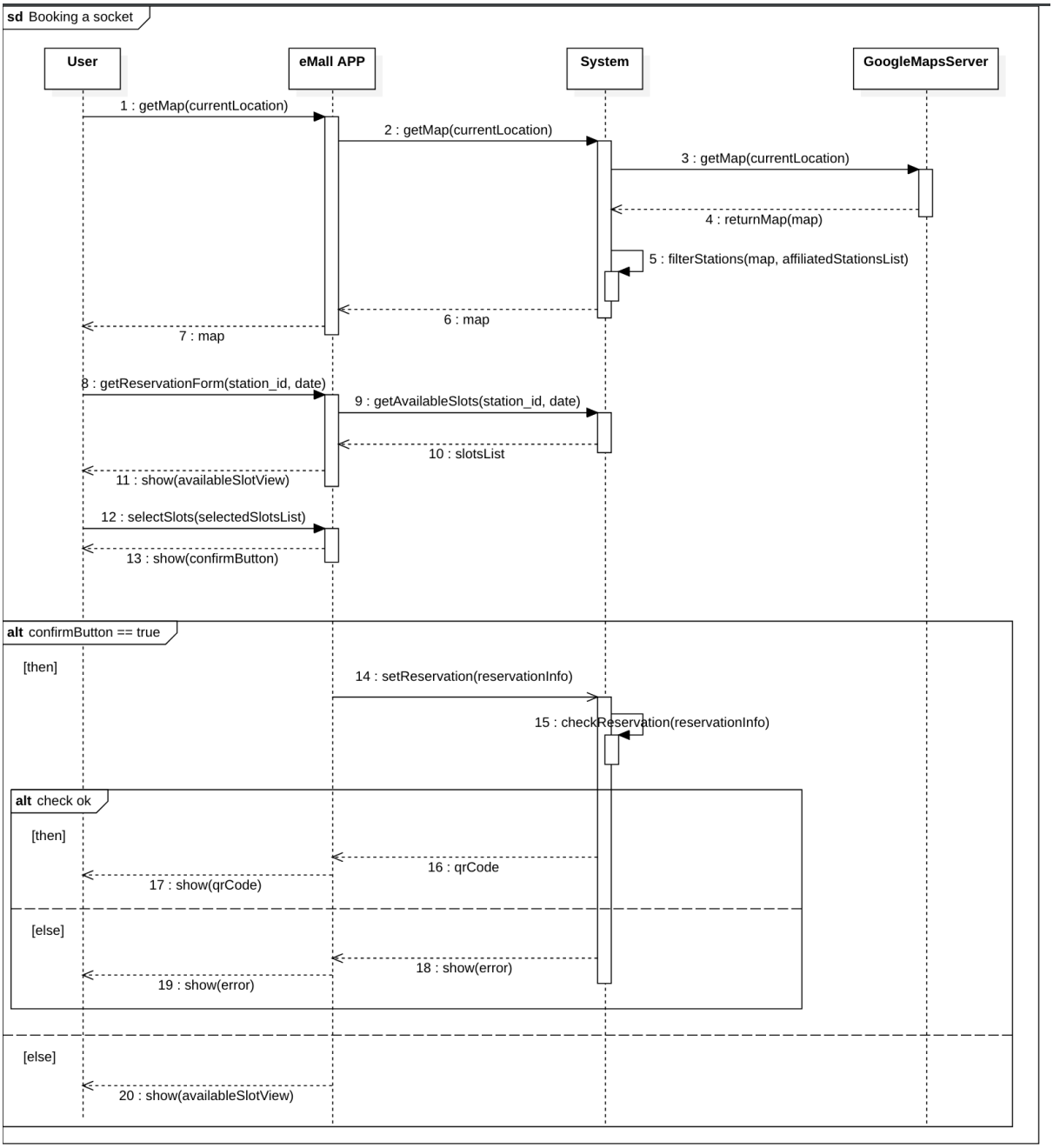
[UC7] - Registration of a User



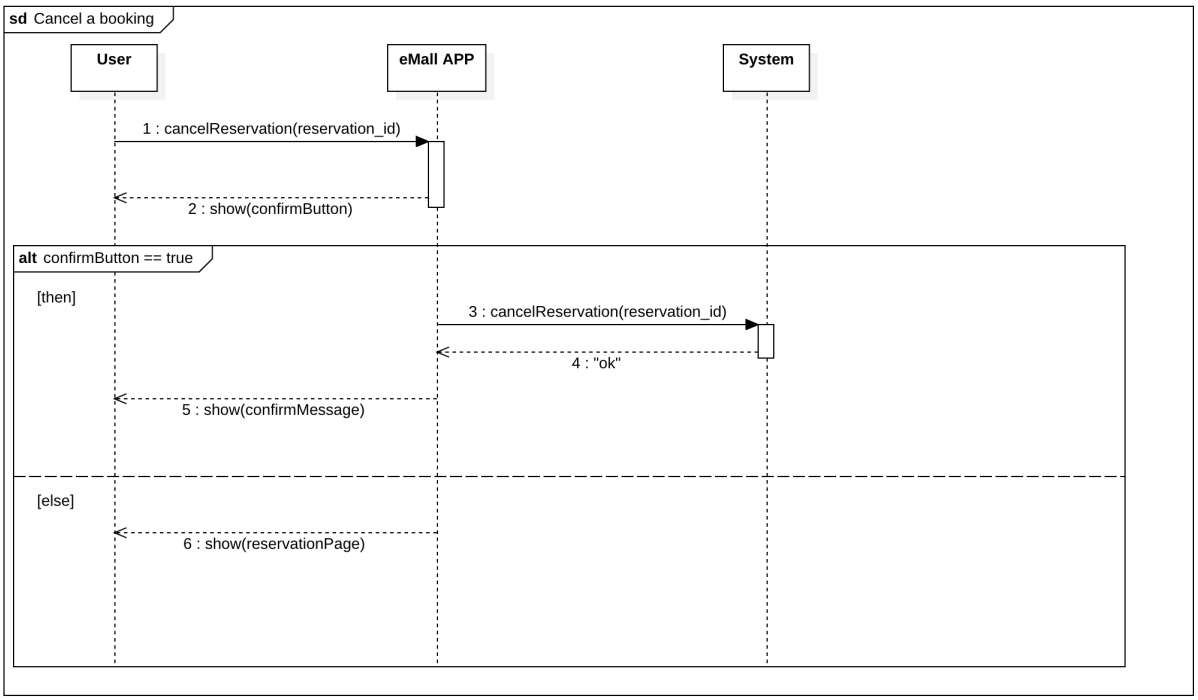
[UC8] - Get info of a booking



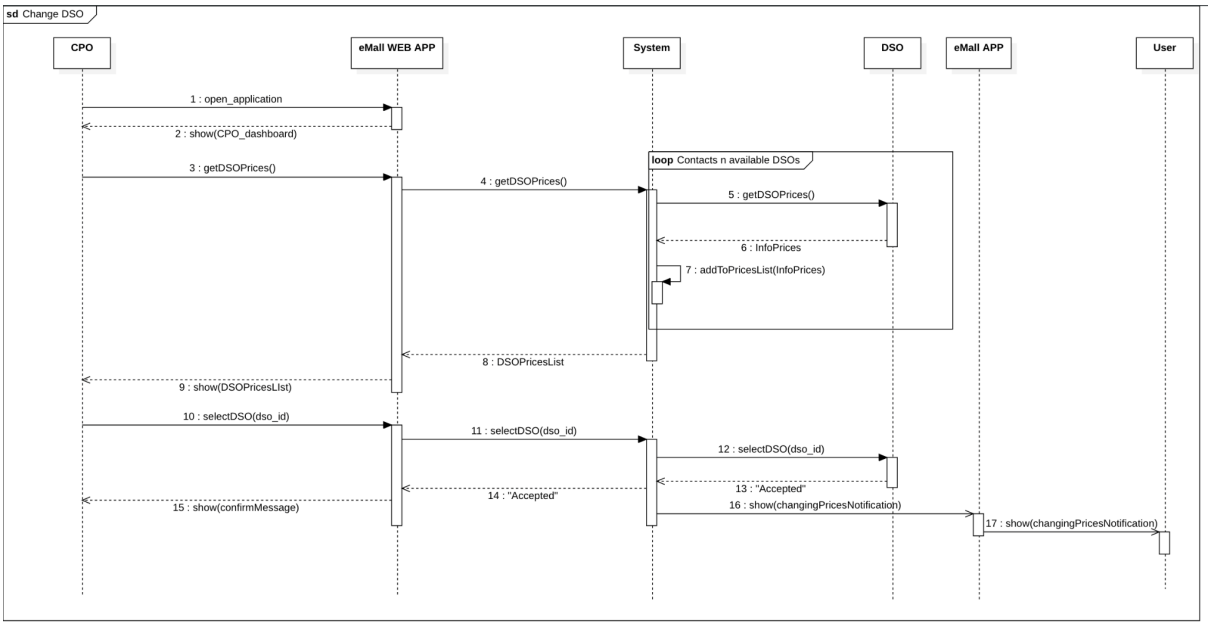
[UC9] - Booking a socket



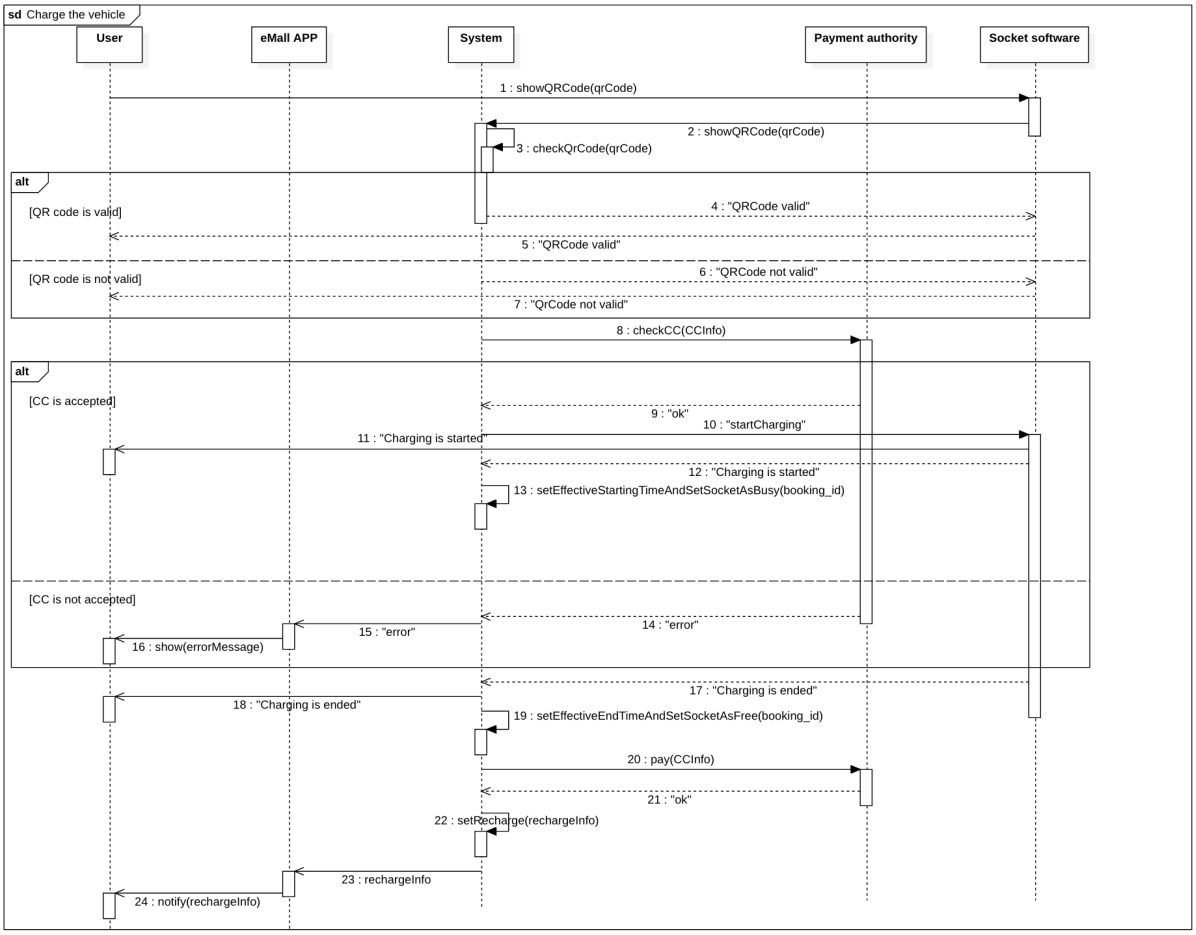
[UC10] - Cancel a booking



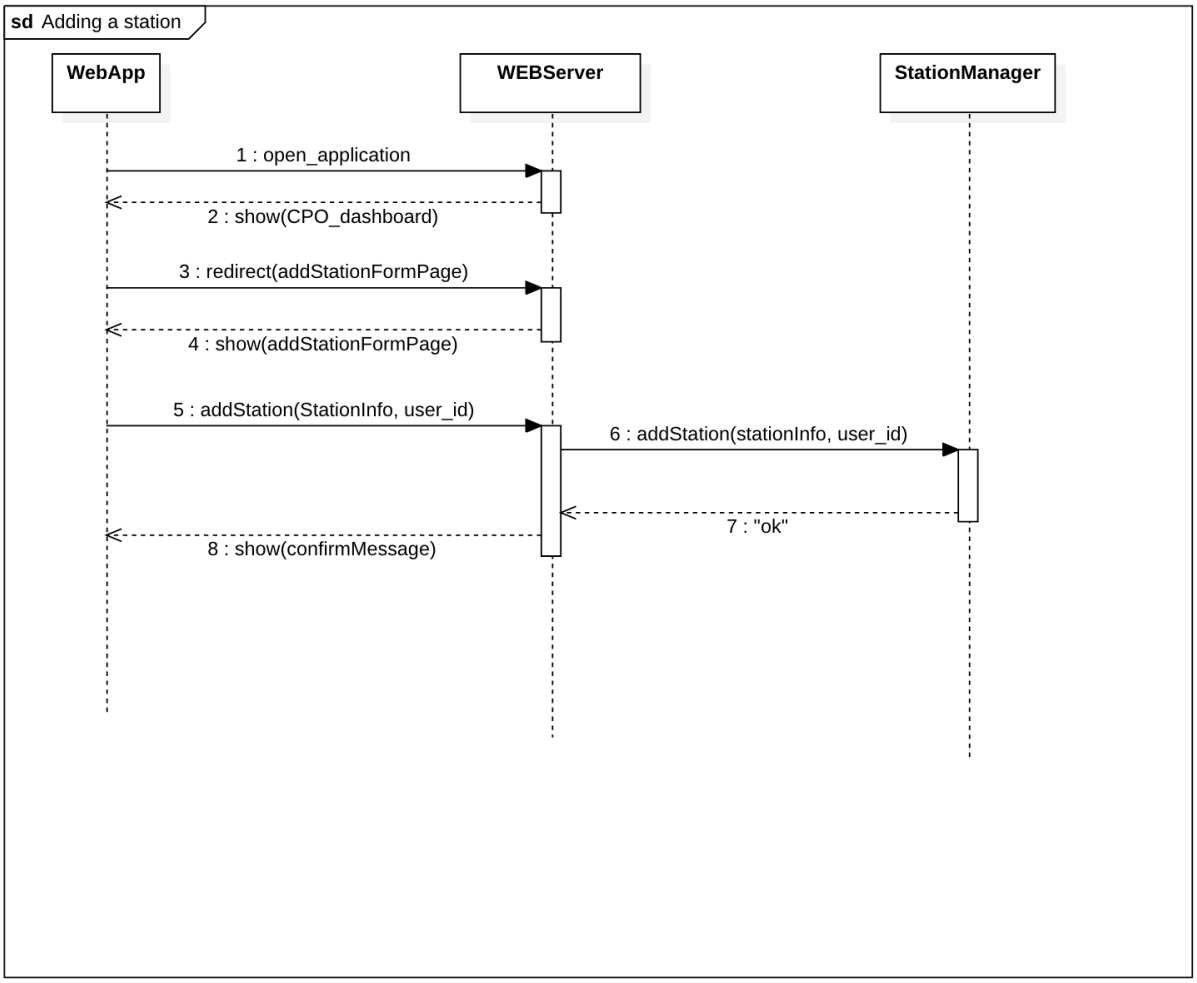
[UC11] - Change DSO



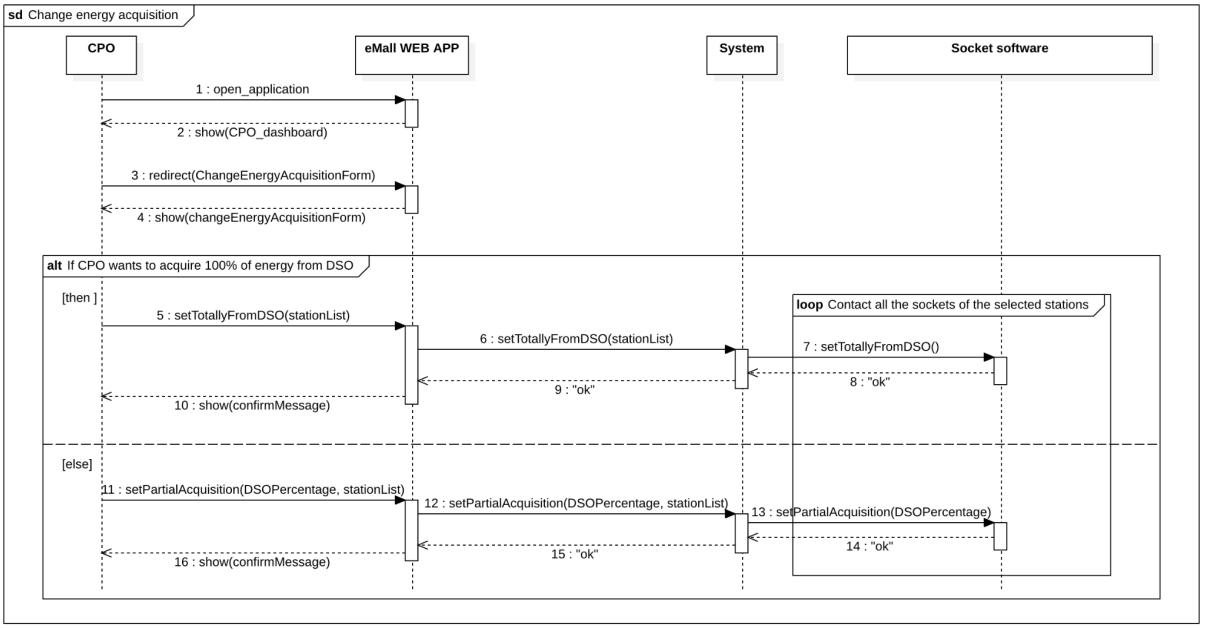
[UC12] - Charge the vehicle



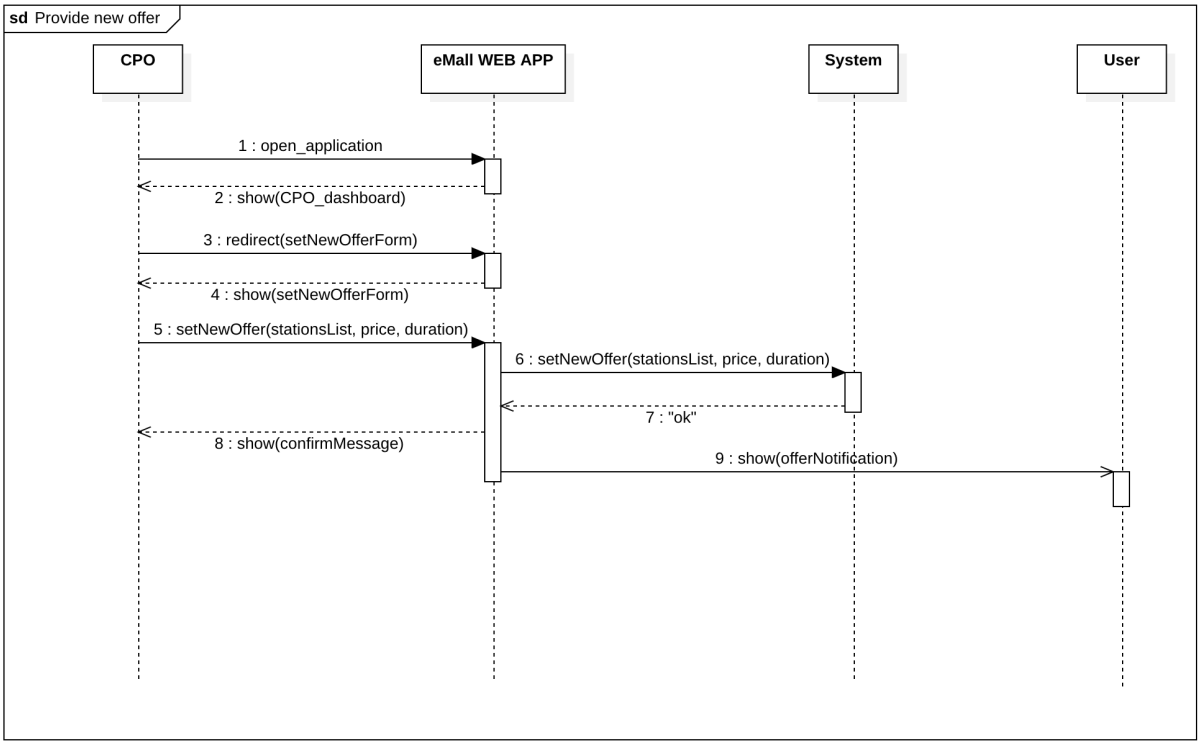
[UC13] - Adding a station



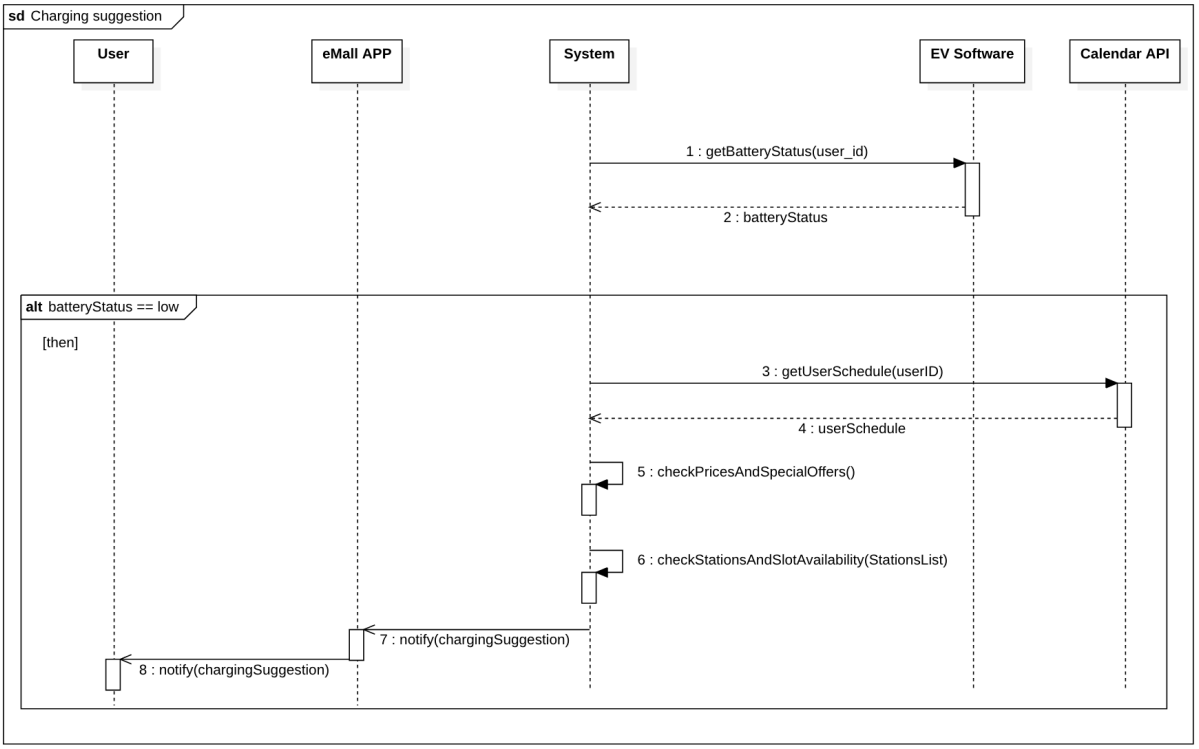
[UC14] - Change energy acquisition



[UC15] - Provide new offer



[UC16] - Charging suggestion



3.2.4 Requirements mapping

[G1] User finds the charging stations nearby, their cost, any special offer they have	
[R1] The system allows users to sign up [R4] The system allows registered users to login [R13] The system allows users to select a charging station (and so a socket) from a map [R14] The system allows users to search for a specific station [R25] The system notifies users about special offers	[D1] : Client must have an internet connection [D4]: User allows GPS connection

[G2] User can book a charge	
[R1] The system allows users to sign up [R4] The system allows registered users to login [R13] The system allows users to select a charging station(and so a socket) from a map [R14] The system allows users to search for a specific station [R15] The system allows users to select the exact date and time of the slot they are booking from a list of available timeFrame [R16] The systems allows users to cancel a booking [R17] The system allows users to see all the previous charging process occurred [R18] The system allows users to select the number of timeslot(15 min each one)of a charging process [R19] The system allows users to insert their personal information (i.e. first name, second name,telephone number, email, and credit cards details)	[D1]: Client must have an internet connection [D4]: User allows GPS connection [D6]: Information about station must be correct(e.g.a socket marked as free it is really free) [D10]: Information about the distance from the station must be correct

[R20] The system allows users to download a PDF of the ticket [R26] The system notifies users about prices changing on the stations in which they have a reservation [R27] The system disallows user to take two different socket in the same time slot	

[G3] CPO manages the internal and external status of a charging station	
[R2] The system allows CPOs to sign up [R3] The system allows registered CPOs to login [R5] The system allows CPOs to insert information about station for which they are responsible [R6] The system allows CPOs to see the list of stations that they manage [R7] The system allows CPOs to see the exact number of vehicle attached to a station that they manage [R8] The system allows CPOs to get the information about the recharged vehicle [R12] The system allows CPOs to decide from which DSO acquire energy	[D13]:CPOs are provided with at least one device able to connect to internet [D7]: Connections between systems must be reliable [D12]: Operator inserts in the system all the stations for which he is responsible

[G4] CPO manages the charging process of the station	
[R2] The system allows CPOs to sign up [R3] The system allows registered CPOs to login [R7] The system allows CPOs to see the exact number of vehicle attached to a station that they manage [R8] The system allows CPOs to get the information about the recharged vehicle [R9] The system allows CPOs to see the details of a booking [R10] The system allows CPOs to see all the details of booking during a specific timeFrame [R11] The system allows CPOs to modify the way in which vehicles attached to a socket are charged [R12] The system allows CPOs to decide from which DSO acquire energy	[D12]: Operator inserts in the system all the stations for which he is responsible [D13]: CPOs are provided with at least one device able to connect to internet [D7]: Connections between systems must be reliable

[G5] User can charge his vehicle	
[R21] Notify users that use the application when the time of their booking is approaching [R22] Notify users when the charging process ended or when time slot expired [R24] The system allows users to pay for a charging [R28] The system allows user to start a recharge [R29] The system allows users to attach the electric vehicle	[D1] : Client must have an internet connection [D2]: When the timeframe has ended, client must left the station [D8]: User must have the cable to charge his vehicle [D11]: Time left and price for charging must be consistent with what application shows [D3]: Stations have a QR reader

[G6] User receives proactively suggestions to smartly recharge the electric vehicle	
[R25] The system notifies users about special offers [R26] The system notifies users about prices changing on the stations in which they have a reservation [R28] The system suggests users to go and charge the vehicle	[D1]: User must have an internet connection [D4]: User allows GPS connection [D5]: User allows access to the calendar and to the navigation system [D7]: Connections between systems must be reliable [D14]: User allows bluetooth connections between the vehicle and telephone

3.3 Performance Requirements

The system has to guarantee good performance in order to be able to serve a great number of users and CPOs simultaneously. This means that the delay between an interaction with the system and its response should be no more than a couple of seconds, given that the internet connection works properly. If a user has a slow internet connection, the response time can increase because it depends on factors out of the control of the system, which must be correctly detected and handled.

3.4 Design Constraints

3.4.1 Standards compliance

About the privacy of data, the eMall project is subject to the General Data Protection Regulation (GDPR), a regulation in EU law on data protection and privacy for all individuals within the European Union (EU) and the European Economic Area (EEA).
The system has to adopt international standards about date and time use and representation.
The system adopts as a unit of measure for energy the kWh.

3.4.2 Hardware limitations

In the following is reported a summary of all the hardware requirements:

- Regarding the user: Internet connection (2G/3G/4G/5G/Wi-Fi), iOS/Android smartphone, a GPS sensor and bluetooth connection
- Regarding the CPO: Internet connection (2G/3G/4G/Wi-Fi), modern web browser

3.4.3 Any other constraint

Since everyone needs to charge his car, i.e. any kind of person can charge his car, also without being an expert app user, the application should be easy to use and provide intuitive ways to interact with it.

3.5 Software System Attributes

3.5.1 Reliability

The system has to be able to run continuously without any interruptions for long periods. To be fault-tolerant the system backend deployment must take advantage of some sort of replication and redundancy. The system has to have offline backups of the data storage to exploit in disaster recovery after a data loss.

3.5.2 Availability

Given the fact that eMall is not an emergency service or anything related to critical situations, the system must provide availability of 99.9%. This means that the average time between the occurrence of a fault and service recovery (MTTR) has to be contained at around 0.365 days per year.

3.5.3 Security

The system stores some sensitive personal information about users, so the security aspect cannot be under- estimated. The central database must be protected with all the available measures to avoid any external or internal attack. The passwords inside the data store have to be encrypted and in case of password recovery, this must never be sent in clear. To communicate over the internet eMall must use some sort of encryption to avoid traffic sniffing and spoofing, thus avoiding cheating attacks and guaranteeing privacy and consistency.

3.5.4 Maintainability

The system must guarantee a high level of maintainability. Appropriate design patterns should be used, together with good standards. The code must be well documented and hard-coding must be avoided. A testing routine has to be provided and it has to cover at least 75% of the entire codebase, excluding interface code.

3.5.5 Portability

The application must be developed for two different platforms: iOS and Android devices (e.g. smartphones or tablets). The web application must run on any OS (like Windows, Mac OS, Linux, etc) that supports a web browser.

4 Alloy

4.1 Signatures

In the following are stated all the signatures defined for the Alloy modelization. They are ordered in alphanumeric order and some of them are grouped if they extend the same concept. For instance the *statuses* of the recharge are found under the ***Recharge*** signature, the same happens for ***TimeSlot*** and ***Customer*** which have both some sort of sub-signatures

```
// DateTime is used to represent a couple <date,time>
sig DateTime {}

// Position is used to represent the coordinates of a determined user or station
sig Position{}

// A Booking may happen for some time slots and socket,
// is made by a user and is associated with an unique QR_code
sig Booking{
        timeSlots: some TimeSlot,
        reservedSocket: one Socket,
        user: one User,
        ticket : one Ticket
}

//definition of a DSO
sig DSO{
        source : one String,
}


//Offer made by a  CPO
sig Offer{
        startingDate: one DateTime,
        endingDate: one DateTime,
        discountPercentage: one Int,
        operator: one CPO,
        stations: some Station
} {
        stations in operator.stations
        discountPercentage > 0 and discountPercentage =< 50
}
```

```
// Type of sockets (Fast, Rapid, Slow)
abstract sig TypeSocket {}
one sig Rapid extends TypeSocket {}
one sig Fast extends TypeSocket {}
one sig Slow extends TypeSocket {}

// Socket of a single station
sig Socket{
        type: one TypeSocket,
        station: one Station
}

// A Station is composed by a positive number of socket,
// has exactly one CPO and exactly one position
sig Station {
        sockets: some Socket,
        operator: one CPO,
        position: one Position,
}

// A ticket is generated at the end of the booking process
sig Ticket {}


// A time slot is related to exactly one socket and can be in only
// one status (timeSlotStatus)
sig TimeSlot {
        timeSlotStatus: one TimeSlotStatus,
        socket: one Socket,
        startTime: one DateTime,
        endTime: one DateTime
}{
        startTime != endTime
}

abstract sig TimeSlotStatus{}
one sig Available extends TimeSlotStatus{}
one sig Full extends TimeSlotStatus{}
one sig Expired extends TimeSlotStatus{}


// An customer is an abstract signature that includes User and CPO
abstract sig Customer{}
```

```
// A user has at most one position
sig User extends Customer {
	bookings: set Booking,
	position: lone Position
}

//  A CPO is a kind of customer, no further informations are necessary
// for this alloy modelization
sig CPO extends Customer{
	stations: some Station
}



// --- Recharge --- //
// A recharge is related to exactly one booking
// it has one of the states described above (RechargeStatus signature)
// and has start and end time
sig Recharge {
	booking: one Booking,
	rechargeStatus: one RechargeStatus,
	startTime: lone DateTime,
	endTime: lone DateTime
} {
// End time must be different by start time because we assume that the duration of a
recharge is greater than zero except for the case in which the recharge it is not started yet
	startTime != endTime or ( startTime = none and endTime=none )
 }

// Cost of a recharging
sig Cost {
	euros: Int,
	cents: Int
}{
	euros >= 0
	cents >= 0
}

// Payment of a single recharge
sig Payment {
	recharge: one Recharge,
	cost: one Cost
}
```

```
// Visit statuses: see chapter 2.1.3
abstract sig RechargeStatus{}
one sig Booked extends RechargeStatus{}
one sig Approaching extends RechargeStatus{}
one sig Missed extends RechargeStatus{}
one sig OnCharge extends RechargeStatus{}
one sig Saved extends RechargeStatus{}
```

4.2 Facts

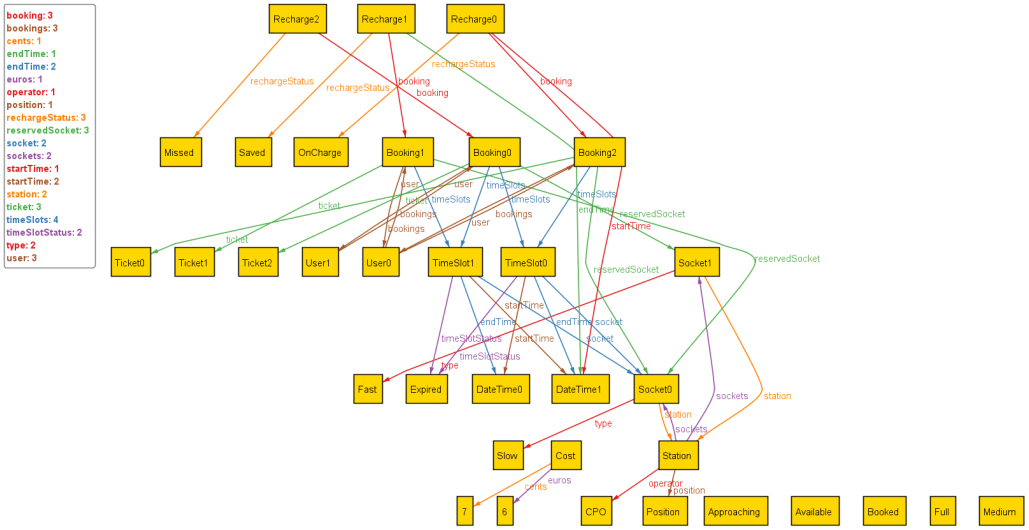
In the following are stated in Alloy the facts that must hold for the domain modeled in order to maintain consistency with the real world

```
//A socket cannot have two booking in the same Time slot
fact noOverlappingBooking {
        no disj b1, b2: Booking, t1, t2: TimeSlot | b1.reservedSocket = b2.reservedSocket
        and (t1 in b1.timeSlots) and (t2 in b2.timeSlots) and t1.startTime = t2.startTime

}

// If two booking are different, they generate two different tickets
fact disjointTickets {
        all disj b1, b2: Booking | b1.ticket != b2.ticket
}

// If two recharge are different, they have been generated by two different Booking
fact disjointRecharges {
        all disj r1, r2: Recharge | r1.booking != r2.booking
}

// If a user made two or more booking, the entry and exit time of those booking can not be
//the same
fact disjointBookingsForCustomers {
        all disj b1, b2: Booking | b1.user = b2.user implies
        no t1, t2: TimeSlot | t1 in b1.timeSlots and  t2 in b2.timeSlots and
        t1.startTime = t2.startTime

}
```

```
// A booking can belong only to one user list
fact disjointUserBooking {
  all b: Booking |
  no disj u1, u2:User |b in u1.bookings and b in u2.bookings
}



// If a customer made two or more recharges, the entry and exit time of those recharges can
//not be the same. Furthermore, a customer can have only one visit in the state InProgress
fact onlyOneRechargeOnChargeForCostumer {
        no disj r1, r2: Recharge | r1.booking.user = r2.booking.user and
        r1.rechargeStatus = OnCharge and r2.rechargeStatus = OnCharge
}

// Every socket stored in the system belongs to one store
fact everySocketIsOfOneStation {
        all s: Socket | one st: Station | s in st.sockets and s.station = st
}

// Every CPO manages at least one station
fact everyCPOManageAtLeastOneStation {
        all cpo: CPO | one s: Station| cpo in s.operator
}


// if a recharge is messed by the user this means that the booked timeslot is expired
fact missedRechargeImpliesTimeSlotExpired {
        all r: Recharge | r.rechargeStatus = Missed
        implies (all t: TimeSlot | t in r.booking.timeSlots and t.timeSlotStatus = Expired )
}

// if a recharge is messed by the user this means that the booked timeslot is expired
fact missedRechargeHasNoEffectiveInformation {
        all r: Recharge | r.rechargeStatus = Missed implies
        r.startTime = none and r.endTime = none
}

// A recharge is in progress if the system stored the entry time but not yet the exit time,
// hence the car is still attached to the socket
fact onChargeImpliesNoEndTime {
        all r: Recharge | r.rechargeStatus = OnCharge implies
        r.endTime = none and r.startTime != none
}
```

```
// if a recharge is booked or in Approaching status by the user this means that the recharge
information are not available
fact bookedAndApproachingImpliesNoEffectiveInformation {
        all r: Recharge | r.rechargeStatus = Booked or r.rechargeStatus = Approaching
        implies r.startTime = none and r.endTime = none
}


// All the tickets are associated with one reservation
fact oneBookingForEachTicket {
        all t: Ticket | one b: Booking | b.ticket = t
}

// if a recharge is Saved status this means that all the recharge information are available
fact savedRechargeImpliesFullEffectiveInformation{
        all r: Recharge | r.rechargeStatus = Saved implies
        r.endTime != none
}

// All the payments correspond to only one recharge and the recharge has to be ended
(Saved status)
fact oneRechargeForEachPayment {
        all p: Payment | one r: Recharge | p.recharge = r and r.rechargeStatus = Saved

}

// Booking that belongs to a user must belong also to his list of bookings
fact consistencyForBookingAndCustomer{
        all b: Booking | one u: User | b in u.bookings and b.user = u
}


pred show [] {
        #Station = 1
        #Booking = 3
        #{r1: Recharge | r1.rechargeStatus = Missed} = 1
        #{r2: Recharge | r2.rechargeStatus = OnCharge} = 1
        #{r3: Recharge | r3.rechargeStatus = Saved} = 1
}
 run show for 3
```

```
Executing "Run show for 3"
  Solver=sat4j Bitwidth=4 MaxSeq=3 SkolemDepth=1 Symmetry=20 Mode=batch
  6120 vars. 426 primary vars. 11296 clauses. 182ms.
  Instance found. Predicate is consistent. 48ms.
```



Metamodel showing the states of the recharge. It is also possible to see other constraints of the system. For example the missed recharge is connected to some time slots that are all expired.

5 Time Spent

The time tables written below represent just an approximation of the time spent for the writing and discussions the team had for each specific chapter of this document. These times have not been measured while producing this document and are just based on the personal perception the team members have of the time spent.

Tommaso Giorgeschi

Chapter	**Effort(in hours)**
1	7
2	12
3	30
4	6

Daniele Manfredonia

Chapter	**Effort(in hours)**
1	7
2	10
3	22
4	17

Amor Madhkour

Chapter	**Effort(in hours)**
1	7
2	16
3	21
4	16

6 References

- Diagrams made with: StarUML, Visual Paradigm
- Mockups made with: moqups.com
- Alloy models made with: Visual Studio Code (Alloy, Alloy VSCode)
- Alloy models runned and checked with: alloytools