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eMall - e-Mobility for All

RASD
Requirement Analysis and Specification Document

Delivery Date here

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POLITECNICO
MILANO 1863

Contents

1 Introduction

1.1 Purpose

With the higher focus on the impact of our urban and suburban travel on the environment and the higher accessibility of electric mobility, an increase of circulating electric vehicles can be observed. [1] [2] [3] This increase concerns both private vehicles and goods transporting ones. As a result of restrictions on fuel vehicle production and sell that will concern a large part of the world's population[4], the number of electric vehicle is still set to increase. For these reasons, the main vehicle manufacturers have started making huge investments in electric mobility[5], which will lead to greater accessibility to the market by drivers.
A main problem of electric vehicles is that a full charge requires much more time than a fuel vehicle refuel. [6] Thus, a single charge can have a huge impact on our daily schedule, and it is necessary to plan wisely when and where to charge. To solve this problem is one of the main objective of the eMall - e-Mobility for All system. This system aims to develop an efficient planning of the charging process of electric vehicles that limits the carbon footprint caused by people mobility needs.

The following document is the RASD for the eMall - e-Mobility for All system. It provides a description of the system focusing on the requirements and specifications, providing scenarios and use cases to specify what the system must do, how it will interact with the stakeholders and the constraints it is subject to.

Goal

G1	Allows electric vehicle (EV) driver to plan efficiently their charging process
G2	Avoids that EV driver must physically line up at the charging station
G3	Provides smart managing of charging stations

1.2 Scope

The software should represent an automated solution to solve these actual problematics.
On the first hand, the huge interference and constraints on the EV's owner daily schedule.
On the other hand, the CPOs problems due to the physical management of their EVCP.
The digital system eMall should provide three main features:
• Booking: allows EV's owners to book a charge. The remote booking avoids interference in the daily schedule of the owners, and the sistem should include a notification system by means of which alerts owners when their reservation is going to start.
• Charging: allows EV's owners to charge an EV, remotely monitor their charging process and to notify the end of the charge. Thanks to these features, owners have not anymore the need to physically go to the CP when they want to retrieve details of their charge.
• Managing a EVCP: allows CPOs to make statistics on live and historical details on the EVCP, to acquire information on the current price of energy offer by DSOs and to decide in an automated way where to get energy for charging.

[1] https://www.eea.europa.eu/ims/new-registrations-of-electric-vehicles
[2] https://www.statista.com/statistics/1101415/number-of-electric-vehicles-by-type/
[3] European Investment Bank Climate Survey
[4] Places with planned fossil-fuel vehicle restrictions
[5] EV plans from major manufacturers
[6] Why consumers don't buy electric vehicles

World phenomena

WP1	An EV driver arrives at a charging station
WP2	Someone owns an electric vehicle
WP3	A charging station is connected to the electrical grid
WP4	Some charging station has solar panels
WP5	Some charging station has a storage battery
WP6	A battery discharges

Shared phenomena

ID		Controlled by
SP1	An EV driver books a charge at a certain charging station	world
SP2	An EV driver search for a specific charging station	world
SP3	The system suggest to charge based on daily schedule, special offers and availability	machine
SP4	An EV driver starts the charging process	world
SP5	An EV driver receives a notification when the charging process is completed	machine
SP6	An EV driver pays for the charge	world
SP7	The system shows to CPO the status of its charging station as amount of energy in batteries, number of vehicle being charged and for each the time left of the charge	machine
SP8	The system shows to CPO information about the DSOs	machine
SP9	A CPO decide to acquire energy from a certain DSO	world
SP10	The system notifies a EV driver that the charging shift will begin shortly	machine
SP11	An EV driver monitors the charging status	machine
SP12	An EV driver delete a reservation	world
SP13	A CPO decide to retrieve the historical reservations on its EVSEs	world
SP14	An EV driver retrieves the historical reservations	world

1.3 Definitions, Acronyms, Abbreviations

Definitions

Here we define what is a EVCP (electric vehicle charging pool), that CP and EVSE are synonyms and we define them and so on

- EVCP - Electric Vehicle Charging Pool

Acronyms

RASD	Requirement Analysis and Specification Document
eMall	e-Mobility for All
eMSP	electric mobility service provider
EV	electric vehicle
CPO	charging point operator
DSO	distribution system operator
CPMS	charging point management system
EVSE	electric vehicle supply equipment
CP	charging point
EVCP	electric vehicle charging pool

Abbreviation

WPx	x-World Phenomena
SPx	x-Shared Phenomena
Gx	x-Goal
Dx	x-Domain Assumption
Rx	x-Functional Requirement
Ux	x-Use Case

1.4 Revision history

Nothing here

1.5 Reference Documents

Requirement Engineering and Design Project: goal, schedule and rules

1.6 Document Structure

Nothing here

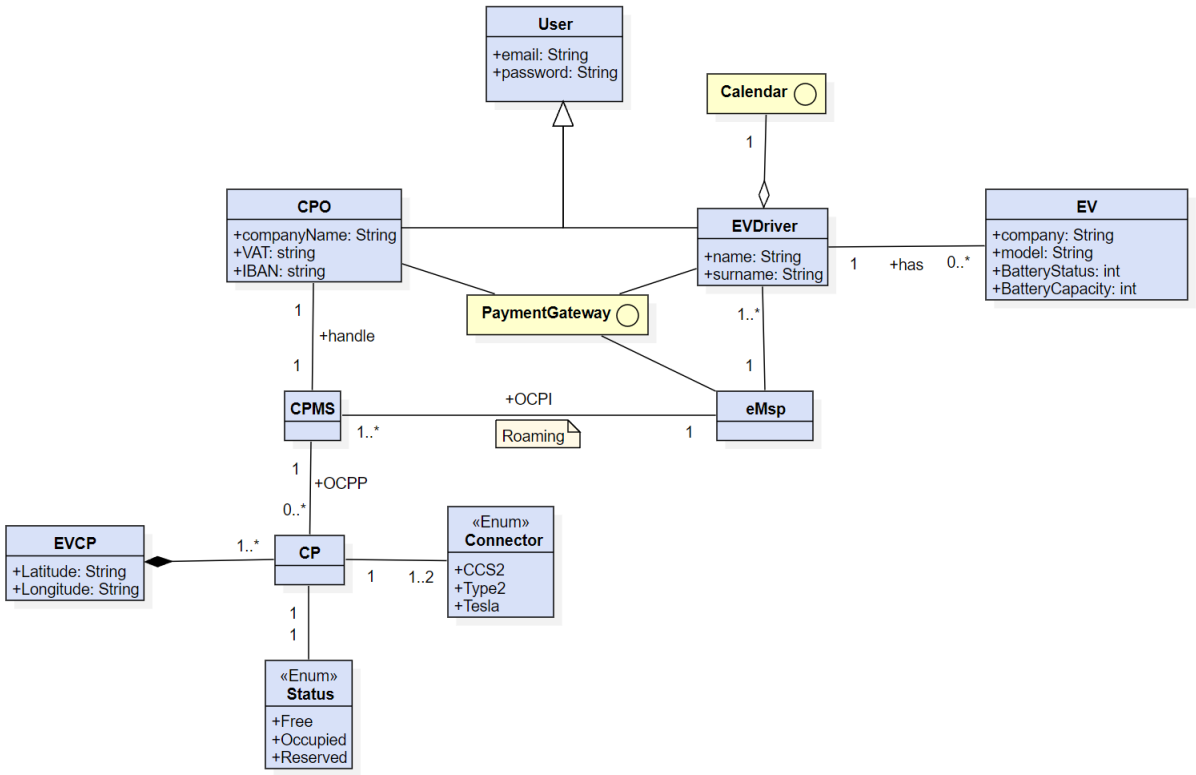
2 Overall Description

2.1 Product perspective

eMall helps on the first hand to manage to limit the carbon footprint caused by our urban and sub-urban mobility needs, providing a way to introduce minimal interference and constraints on the owner EV daily schedule; on the other hand the eMall helps the CPOs to manage remotely their EVCP.

2.1.1 Entity diagram

The UML entity diagram below represents a conceptual, high-level model of the software to be. Given its nature, it may model objects that will not be represented in the actual system that will be developed. At this level, it not include any references to methods and other low-level details, those will be detailed during the design phase.



2.1.2 State diagrams

In the paragraphs below, a representation of the behavior of the main conceptual components of the system. The focus is on how these components respond to external influences and modify accordingly their states. For this purpose, some UML State Charts are proposed:

2.1.3 Scenarios

A. Registration

Einar is a driver of an electric vehicle that uses every day to go to his office. He decided to download the eMall app because he heard by a friend of him that he can discover all the charging points in the entire world, booking one, starting a charge and pay for the charge, entirely through the app. After having downloaded it, launches the app for the first time and select sign in button to register

into the system. He provides all the personal data required to access in the system and accept to personalize his experience by selecting his car from a provided list of all the EVs. He submits his data and the system asks him to verify his account through email or phone number.

B. Book a charge
Edvar has the necessity to go shopping in the next days at the blue and yellow furniture retailer of the city. Knowing that shopping will take some time he wants to find and book a EVCP nearby the shopping centre to charge his EV that uses every day. In the home of the app he filters the results on the location of the mall and the day he wants to go. After submitting the form, the home page change according to his information and displays a map of the selected zone with the available charging stations to book. He discovers that there is one available really close from the shopping centre. He selects the marker of the EVCP and are displyed the information about the CPO, the types of CP, the availability at the actual moment of the research, the availability of them for the filtered date, the charging power at which the connector operates and the cost for recharging 1 kWh. To book the charge he selects one connector that is available and indicate when he wants to start the charge and when to finish. The app, because Edvar accepted to insert his EV model, knows how much time is needed to charge his car so suggested the optimal time to book for a complete charge from 10% to 100%. He can accept the suggested book range or override the suggestion and modify the range at his willing inside the availability of the connector. He then confirms the booking of the charge and see the reservation on the reservations' tab.

C. Manage a charge
Anne plans a long trip from Oslo to Stockholm to do with her brand new EV. Considering the suggested time by the app to do a full charge on her EV, she books a three hour charge through the eMall app at her trusted charging station with high power connectors. When she arrives at the CP station she parks in a free slot with the booked connector. Through the app she selects the reservation in the reservations' tab and starts the charge inside the app. The connector socket is unlocked and the charge can start by plugging the connector on the EV. Meanwhile waiting for the complete charge, Anne goes for a walk because she feels relaxed to control at any time the status and the remaining time of the charge with the app. When the charge is completed, as expected before the three hours, Anne is already back from the walk and a notification about the end of the charge appears on Anne's phone, she disconnects the connector and gets back home to prepare the luggages for the trip. She doesn't worry about the payment because is executed in background with the payment method that she indicates before the booking operation.

D. Charging point status
Erling is the owner of a restaurant and installed two charging columns in the parking slot in front of the restaurant because he wants to acquire good clients that can stop for charging the EV and have a meal at the restaurant. To make the CP accessible to the largest possible public he subscribes to the eMall-business for CPOs because he is interested in a service that permits to add and manage CPs and make the CPs visible by EV drivers in the eMall app. After submitting the registration by providing essential information about the the company, including VAT number of the restaurant and IBAN bank account to get payments from the driver he waits for the approval to be inserted into the app. When the approval arrives Erling inserts the charging point of the restaurant by specifying the number of sockets by type, the amount of power supplied by each socket and the API to connect the charging columns to the dashboard. With the dashboard he can visualize how many vechicles are charging in real time and for each charging vehicle the amount of power absorbed and the time left to the end of the charge. He can visualize the import that gets from each charge, decide the price for a charge and add special promotions to the charge to win the loyalty of the existing clients or acquire new clients.

E. Charging point management
Grethe, admin of a CPO using the CPMS function of eMall from the early days, receives an mail from the CPMS about a malfunction involving one of her CPs. She enters the CPMS and directly from the dashboard she modifies the CP status to "in maintenance". She is sure that the CP under mantainance now results as unvailable for every user trying to book it until she modifies back the status to "available". Then verifies the status of the others CP controlling that they work as intended.

2.2 Product functions

As described above in this document, the major functions offered by our system to main actors are:

- **EV driver's functions. The system allows to:**
  - search in map
  - view your current position
  - indicate time interval of charging
  - have suggestion on when to charge based on daily schedule and special offers
  - specify the charging point in which you want charge
  - book a charge
- **CPO's functions. The system allows to:**
  - monitor status of charging points
  - add, modify and delete CP
  - retrieve price of energy
  - change status of a charging point
  - view reservations
  - managing charging point

2.3 User characteristics

It is possible to distinguish two different types of actors who use the system:

1. EV's driver: someone who wants to book a charge. EV's driver wants to book remotely avoids interference in his daily schedule, be notified when his/her reservation is going to start and end, monitor charging process.
2. CPO: someone who wants to manage efficiently his/her EVCP, make statistics on live and historical details on the EVCP, to acquire information on the current price of energy offer by DSOs and to decide in an automated way where to get energy for charging.

2.4 Assumptions, dependencies and constraints

Domain Assumptions

D1	An EV driver arrives at the charging station at a time close to its reservation starting time
D2	An EV driver leaves the charging station when the charge is finished
D3	An EV driver doesn't occupy an already booked charging spot
D4	The accurate location of an EV driver is known by GPS
D5	An EV driver provides correct information when registering
D6	A CPO provides correct data of its EVSEs when registering
D7	At least one DSO can always provide energy to the CPOs
D8	An user that books a charge has an electric vehicle to charge
D9	An user that books a charge is always reliable
D10	The system must allow booking of an EVSE for a certain time interval

Dependencies

A list of API, OS, browser the app/webapp depends on

Constraints

?

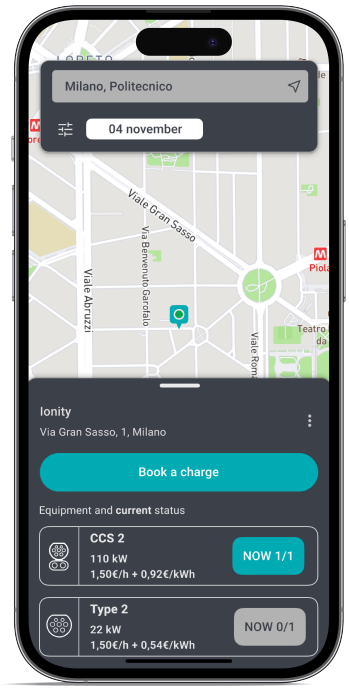
3 Specific requirements

3.1 External Interface Requirements

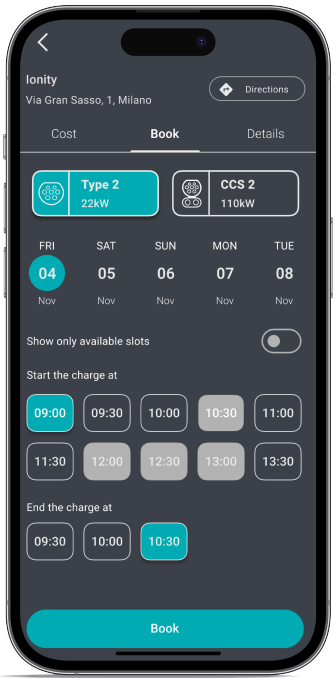
In this section are described details about user interfaces, hardware and application programming interfaces.

3.1.1 User Interfaces

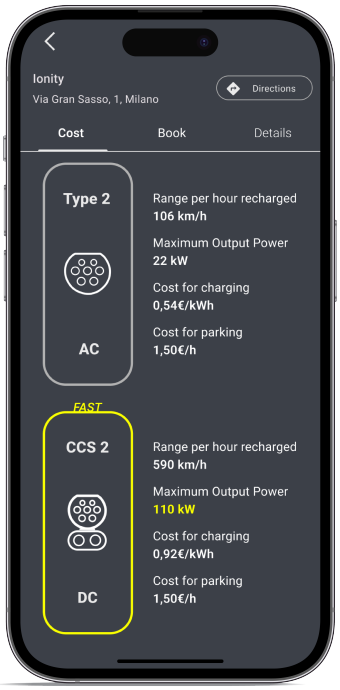
(a) Details



(b) Booking



(c) Cost detail



3.1.2 Hardware Interfaces

To use the system, both EV drivers and CPOs must use a mobile device or a personal computer. Due to the outdoor expected use of the system, a smartphone will be more suitable device for a EV driver, instead for a CPO is suggested to use the system from a personal computer.

3.1.3 Software Interfaces

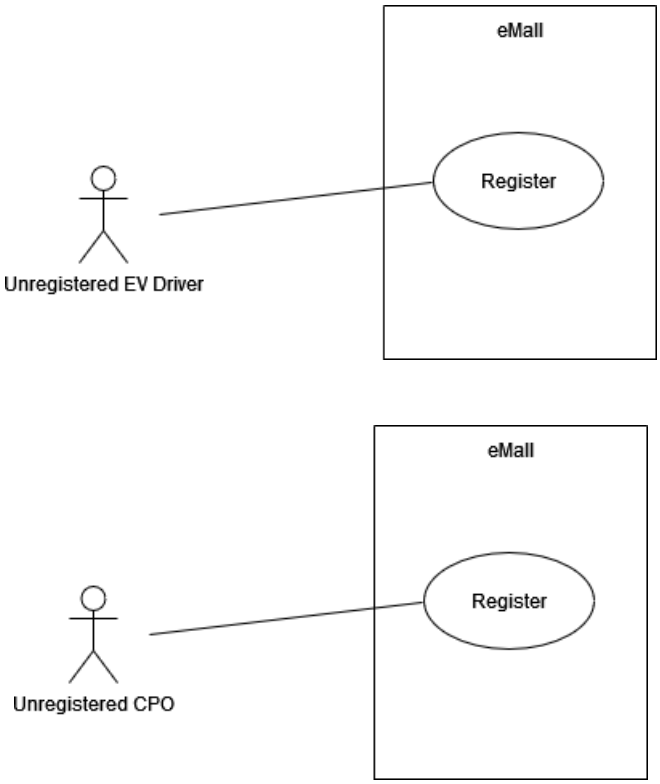
The system should integrate:

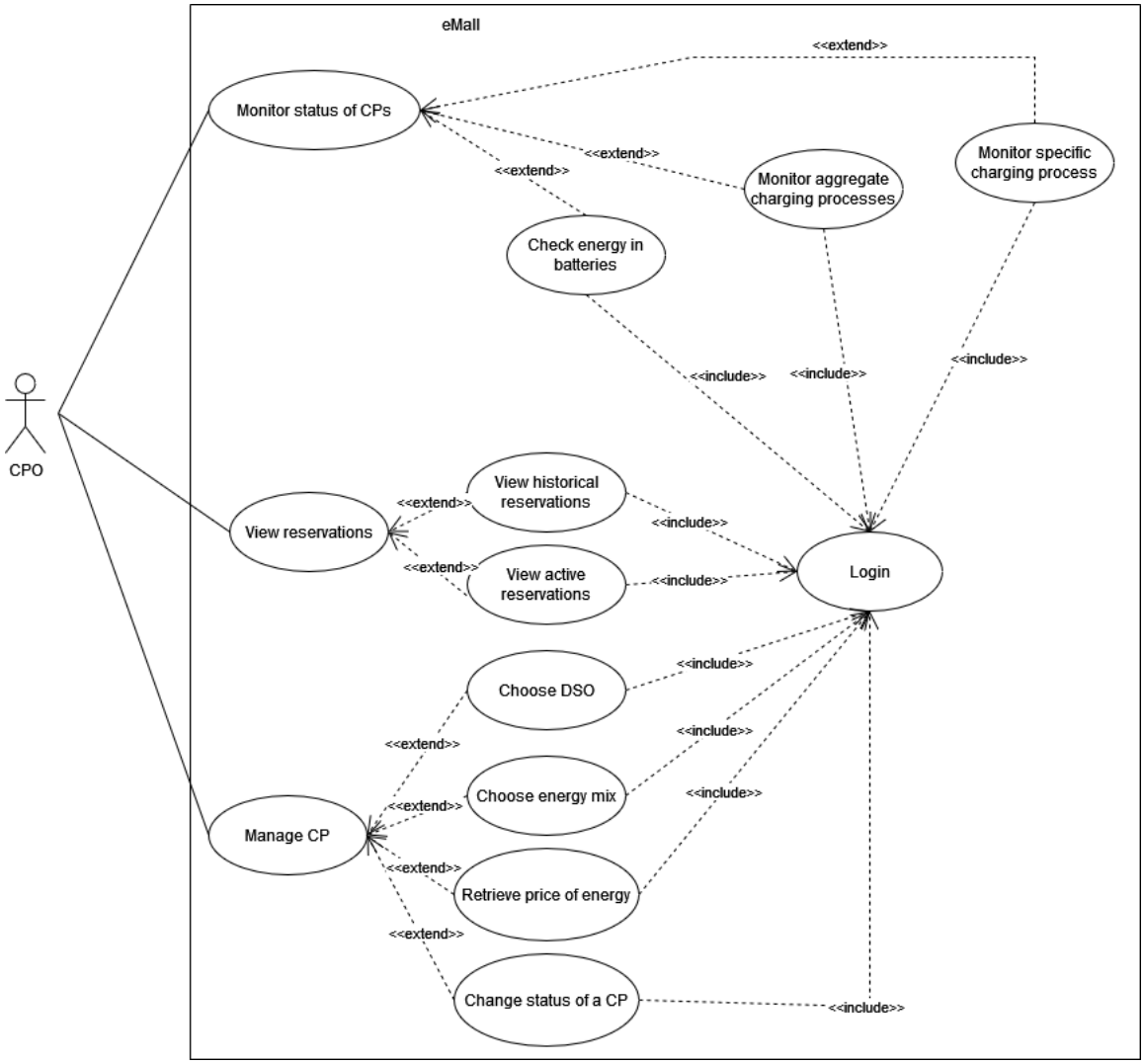
- a map service that provide driving direction and an estimation of the time required to arrive to the selected charging point given a starting position (including the current EV driver position).
- geolocalization through GPS will be used to show the current EV driver position.
- notifications will be sent to update in real time the EV driver that the charging shift will begin shortly
- an SMS with a secret code will be sent both to CPO and EV driver upon login in order to verify their identity through a third party service.

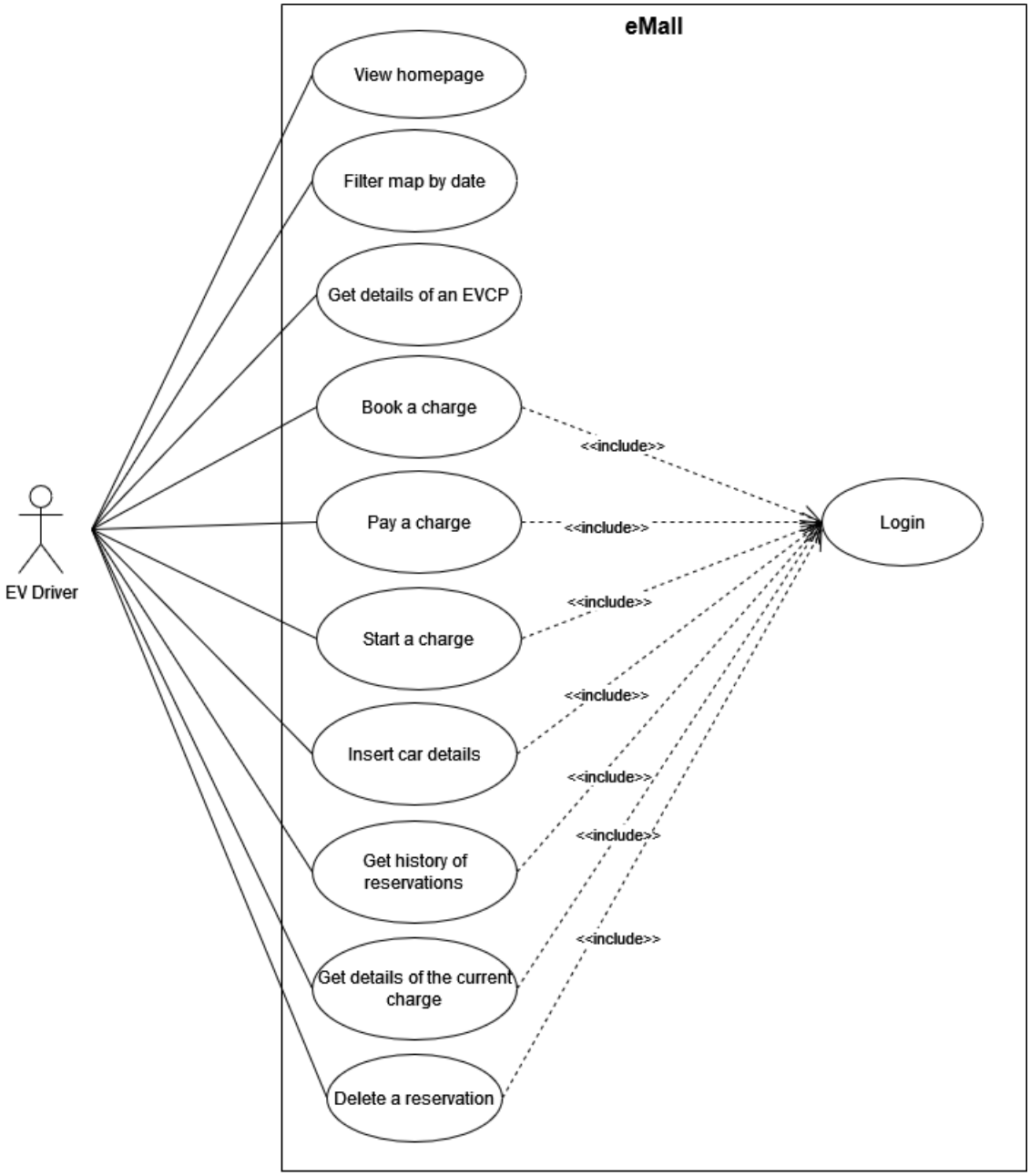
3.1.4 Communication Interfaces

The system requires a stable internet connection to work properly. The backend of the system will expose a unified REST compliant API to communicate with all clients (both CPOs and EV drivers) using HTTPS and TCP/IP.

3.2 Use cases


eMall
Register
Unregistered EV Driver
eMall
Register
Unregistered CPO


eMall
CPO
Monitor status of CPs
Monitor aggregate charging processes
Monitor specific charging process
Check energy in batteries
View reservations
View historical reservations
View active reservations
Login
Manage CP
Choose DSO
Choose energy mix
Retrieve price of energy
Change status of a CP
<<extend>>
<<include>>


eMall
View homepage
Filter map by date
Get details of an EVCP
Book a charge
Pay a charge
Start a charge
Insert car details
Get history of reservations
Get details of the current charge
Delete a reservation
Login
EV Driver
<<include>>
<<include>>
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<<include>>

3.2.1 Use Case: EV driver registration

Name	EV driver registration
Actors	EV driver
Entry Condition	EV driver clicks 'Sign Up' in the application homepage
Event Flow	1. The system sends user the registration form 2. Driver enters name, surname, birth date, telephone number and password. Then submits the data upon reading and accepting the Privacy Policy and the Terms of Service 3. The system sends a SMS to driver through an API containing a secret code 4. The driver submits the received verification code 5. The system verifies the code and displays a success message
Exit Condition	A new EV driver account is created
Exceptions	• A required registration field is missing when the form is submitted • A wrong verification code is submitted • The timeout of verification expires
Notes	All the exception are treated the same: the system will notify user with a human-readable message and the user is redirected to the homepage

3.2.2 Use Case: CPO registration

Name	CPO registration
Actors	CPO
Entry Condition	CPO clicks 'Sign Up' in the business dedicated application homepage
Event Flow	1. The system sends operator the registration form 2. Operator enters company name, VAT, IBAN, and password. Then submits the data upon reading and accepting the Privacy Policy and the Terms of Service 3. The system processes the provided information and display a success message
Exit Condition	A new operator account is created
Exceptions	• A required registration field is missing when the form is submitted • The operator is not associated to the given VAT • Loss of internet connection • The actor cancels the operation
Notes	All the exception are treated the same: the system will notify operator with a human-readable message and the operator is redirected to the homepage

3.2.3 Use Case: Check energy in batteries

Name	Check energy in batteries
Actors	CPO
Entry Condition	Authenticated CPO is in "Monitor status of EVCP" tab
Event Flow	1. The operator choose a specific EVCP and clicks 'check energy in batteries' 2. The system shows the battery status of the selected EVCP, if any
Exit Condition	The 'Check energy in batteries' chart is shown
Exceptions	• Loss of internet connection • The actor cancels the operation
Notes	...

3.2.4 Use Case: Monitor specific charging process

Name	Monitor specific charging process
Actors	CPO
Entry Condition	Authenticated CPO is in "Monitor status of CP" tab
Event Flow	1. The operator choose a specific EVCP and clicks "monitor specific charging process" 2. The system shows a list of active charging process and ask operator to choose one 3. The operator choose a specific active charging process from the list 4. The system shows the details of the chosen charging process
Exit Condition	The details of the specific charging process are displayed
Exceptions	• Loss of internet connection • The actor cancels the operation
Notes	...

3.2.5 Use Case: Monitor aggregate charging process

Name	Monitor aggregate charging process
Actors	CPO
Entry Condition	Authenticated CPO is in "Monitor status of CP" tab
Event Flow	1. The operator choose a specific EVCP and clicks "monitor aggregate charging process" 2. The system shows a chart with a detailed view of aggregate charging processes
Exit Condition	The aggregate charging process details charts are displayed
Exceptions	• Loss of internet connection • The actor cancels the operation
Notes	...

3.2.6 Use Case: View historical reservations

Name	View historical reservations
Actors	CPO
Entry Condition	Authenticated CPO is in "View reservations" tab
Event Flow	1. The operator choose a specific EVCP, choose "historical reservation" tab, and sets a specific time frame 2. The system shows the reservation details of the chosen EVCP during the chosen time frame
Exit Condition	The details of the historical reservations are displayed
Exceptions	• Loss of internet connection • The actor cancels the operation
Notes	...

3.2.7 Use Case: View active reservations

Name	View active reservations
Actors	CPO
Entry Condition	Authenticated CPO is in "View reservations" tab
Event Flow	1. The operator choose a specific EVCP, choose "active reservation" tab 2. The system shows a list of active reservation for the chosen EVCP
Exit Condition	The details of the active reservations are displayed
Exceptions	• Loss of internet connection • The actor cancels the operation
Notes	...

3.2.8 Use Case: Choose DSO

Name	Choose DSO
Actors	CPO
Entry Condition	Authenticated CPO is in "Manage CPs" tab
Event Flow	1. The operator choose a specific EVCP, choose "Choose DSO" tab 2. The system provides a list of available DSOs 3. The operator select one DSO among the available ones and submit their choice to the system 4. The system processes the provided information and display a success message
Exit Condition	The choice of DSO is completed
Exceptions	• Loss of internet connection • The actor cancels the operation
Notes	...

3.2.9 Use Case: Choose energy mix

Name	Choose energy mix
Actors	CPO
Entry Condition	Authenticated CPO is in "Manage CPs" tab
Event Flow	1. The operator choose a specific EVCP, choose "Choose energy mix" tab 2. The system provides a list of available sources of energy (station battery, DSO, or a mix) 3. The operator select one source of energy among the available ones and submit their choice to the system 4. The system shows a list of active reservation for the chosen EVCP
Exit Condition	The choice of a CP energy mix is completed
Exceptions	• Loss of internet connection • The actor cancels the operation
Notes	...

3.2.10 Use Case: Retrieve price of energy

Name	Retrieve price of energy
Actors	CPO
Entry Condition	Authenticated CPO is in "Manage CPs" tab
Event Flow	1. The operator choose a specific EVCP, choose "Retrieve price of energy" tab 2. The system provides a list of prices of sources of energy from different DSOs
Exit Condition	The details of price energy are displayed
Exceptions	• Loss of internet connection • The actor cancels the operation
Notes	...

3.2.11 Use Case: Change Status of a CP

Name	Change Status of a CP
Actors	CPO
Entry Condition	Authenticated CPO is in "Manage CPs" tab
Event Flow	1. The operator choose a specific EVCP, choose "Change Status of a CP" tab 2. The system provides a page on which the operator can set a specific time frame in which the operator wants to change the status of CP 3. The operator set a specific time frame 4. The system processes the provided information and display a success message
Exit Condition	The status of a CP is displayed
Exceptions	• Loss of internet connection • The actor cancels the operation
Notes	...

3.3 Functional Requirements

3.3.1 CPO Functional Requirements

R1	The system must allow unregistered operator to register an account and its EVSEs
R2	The system must allow making a special offer
R3	The system must allow monitoring the charging process to infer when the battery is full
R4	The system must allow retrieving details on the amount of energy available in its EVSEs batteries
R5	The system must allow retrieving details on the number of vehicle being charged and for each vehicle the amount of absorbed power
R6	The system must allow retrieving details on the charge time left for each connected vehicle
R7	The system must allow retrieving details on active and historical reservations on its EVSEs
R8	The system must allow acquiring information from the DSOs about the current price of energy
R9	The system must allow deciding from which DSO to acquire energy from
R10	The system must dynamically decide where to get energy for charging (electrical grid, battery or a mixture)
R11	The system must allow add, modify and delete a CP

3.3.2 eMSP Functional Requirements

R11	The system must allow unregistered users to register an account
R12	The system must allow registered users to login
R13	The system must allow authenticated users to personalize their experience by providing information of their EV
R14	The system must allow users to search for EVSEs in the map
R15	The system must show to the users EVSEs nearby their current position
R16	The system must allow retrieving details on a given EVSE regarding connector types supported and cost of the charge
R17	The system must allow booking of an EVSE for a certain time interval
R18	The system must allow booking of an EVSE if and only if it is free for the specified time interval
R19	The system must notify users when the charging shift is about to start
R20	The system must allow authenticated users to start the charge
R21	The system must suggest users when to charge based on daily schedule, special offers and availability
R22	The system must allow authenticated users to monitor the charging status
R23	The system must notify authenticated users when the charging process is completed
R24	The system must allow authenticated users to pay for the charge
R25	The system must allow authenticated users to delete a reservation
R26	The system must allow authenticated users to view historical reservations

3.3.3 Mapping on requirement

Goal	Requirements	Assumptions
G1	R1,R2,R3	D1,D2,D3
G2	esempio	esempio
G3	esempio	esempio

3.4 Performance Requirements

The requirements of the system are not critical, so these performance requirements are focus on guarantee the best of possible experience to both EV drivers and CPOs. To do that, the system should provide: • a scalable, reactive and load-balancing backend • the visualization of the map in 5 seconds, or less; • the list of active and historical reservations in less than 5 seconds; • the booking confirmation in 7 seconds, or less; • the loading of the available time slots for a specific charging point in less than 5 seconds; • push app notification with a delay that is imperceptible to the user. • Notice that a good internet connection is assumed in the previous estimations.

3.5 Design Constraints

3.5.1 Standards compliance

Specifications described in this document must be respected by the system. Source code of the application must be commented on and documented adequately. The system should respect the line guides described by the European GDPR.

3.5.2 Hardware limitations

The system requires any device and a stable internet connection.

3.6 Software System Attributes

3.6.1 Availability and Reliability

The system should offer its functionalities with an availability equal to 99.5, or more. In other words, the system must be inaccessible for less than two days every year. To achieve this goal, the system should provide a high redundancy for the most critical components. Furthermore, in order to guarantee better reliability performances, all the scheduled maintenance intervents on the system should be done during the night.

3.6.2 Security

The connection between the application and the server must be safe. System use the TLS (Transport Layer Security) protocol. To do that for this purpose, it is needed an SSL/TSL certificate. Moreover, all passwords must be encrypted

3.6.3 Maintainability

Source code and correlated documentation must be commented and kept updated. Modularity, low coupling and high cohesion between components must be a focus during the designing and developing phases.

3.6.4 Portability

The system is a web application so it will be supported by any device with a modern browser.

4 Formal Analysis Using Alloy

Nothing here

5 Effort Spent

Giovanni

Introduction	0.5h
Overall description	0.5h
Specific requirements	0.5h
Formal analysis: Alloy	0.5h
Total	1000h

To Do: Use Cases

Matteo

Introduction	0.5h
Overall description	0.5h
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Formal analysis: Alloy	0.5h
Total	1000h

To Do: Product functions, User characteristics, Scope
In progress: Product functions

Lorenzo

Introduction	0.5h
Overall description	0.5h
Specific requirements	0.5h
Formal analysis: Alloy	0.5h
Total	1000h

To Do: Scenarios, State Diagrams
In progress: Scenarios

6 References

Nothing here