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SCUOLA DI INGEGNERIA INDUSTRIALE  
E DELL'INFORMAZIONE

# Software Engineering 2

## Requirements Analysis and Specification Document

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# 1 | Introduction

The EVs are eco-friendly vehicles that will be on our roads in the next future. In order to keep global warming below 1.5°C, Europe have decided to reduce greenhouse gas emissions of CO<sub>2</sub> per person per year by 2030, and, by the same year, the IEA predicts that electric vehicles will have a market share of roughly 30 percent, with a total number of 23 million e-cars on the roads. EVs consumption is measured in kilowatt-hours per 100 kilometers, and most of the current electric cars can travel between 150 and 350 kilometers on a single charge, but premium-brand models can currently cover more than 500 kilometers.

In this context, when people use an electric vehicle, knowing where to charge it and carefully planning the charging process in such a way that it introduces minimal interference and constraints on our daily schedule is of great importance.

That's were **eMALL** operates: it can find charging stations owned by several Charging Point Operators - CPO - and, considering the activities in user's schedule, it can propose the best possible path of charging process in order to minimize the cost and the wasted time at the station.

## 1.1. Purpose

ID	Description
G1	The EVD can see charging stations nearby a specific location on the map
G2	The EVD can get the detailed information of charging stations
G3	The EVD can search for special offer provided by charging stations
G4	The EVD can book a charge for his EV at a charging station for a specified time frame
G5	The EVD can pay for the recharging service
G6	Given the destination inserted in an activity in his calendar application, the EVD receives suggestions to charge his EV

Table 1.1: The goals.

## 1.2. Scope

ID	Description
WP1	The DSO provides energy to charging stations
WP2	The EVD wants to charge his EV's battery
WP3	The EVD wants to know the prices of a specific charging station
WP4	The EVD wants to know if there are any special offer he can redeem
WP5	The EVD wants to know the position of a specific charging station
WP6	An eMSP activates a new offer for his customers
WP7	The CPO have deals with eMSP and offer them their charging station
WP8	The EVD pays for the service
WP9	The EVD inserts a new activity in his calendar
WP10	Charging Points are distributed in the territory
WP11	CPO buys energy from a DSO at the price defined by the latter
WP12	CPO defines the selling price of electricity
WP13	CPO defines special offers for its customers
WP14	The EVD connects the plug of the charging point to the EV
WP15	The EV reaches the desired level of battery charge

Table 1.2: World Phenomenas.

ID	Description	Controller	Observer
SP1	The EVD creates an account in the eMALL system	EVD	eMALL
SP2	The EVD logs in eMALL	EVD	eMALL
SP3	eMALL gets EVD's current position	eMALL	EVD
SP4	The EVD asks for the list of charging stations nearby to his/her position to eMALL	EVD	eMALL
SP5	eMALL returns the list of all the charging stations nearby his/her position to the EVD	eMALL	EVD
SP6	The EVD asks for detailed information about a specific charging station to eMALL	EVD	eMALL
SP7	eMALL returns the charging cost per kWh of the charging station specified by the EVD	eMALL	EVD

SP8	eMALL returns the charging cost per minute of the charging station specified by the EVD	eMALL	EVD
SP9	eMALL returns the cost per minute of the additional fare for late unplugging of the charging station specified by the EVD	eMALL	EVD
SP10	eMALL returns the charging power of the charging station specified by the EVD	eMALL	EVD
SP11	eMALL returns the types of connectors accepted by the charging points of the charging station specified by the EVD	eMALL	EVD
SP12	eMALL returns the number of charging points of the charging station specified by the EVD	eMALL	EVD
SP13	eMALL returns the current status (available, occupied, maintenance) of the charging station specified by the EVD	eMALL	EVD
SP14	The EVD asks for special offers that he/she can redeem to eMALL	EVD	eMALL
SP15	eMALL returns all the active special offers to the EVD	eMALL	EVD
SP16	The EVD asks for the schedule of a specific charging station to eMALL	EVD	eMALL
SP17	eMALL returns the schedule of the charging station specified by the EVD	eMALL	EVD
SP18	The EVD specifies the timeframe he/she wants to be reserved for his booking	EVD	eMALL
SP19	The EVD books a charging point for a specific plug through eMALL	EVD	eMALL
SP20	The EVD pays for a caution before booking a charging session through eMALL	EVD	eMALL
SP21	The EVD inserts a new payment method and the required information into eMALL	EVD	eMALL
SP22	eMALL returns the outcome of the validity of the payment method inserted by the EVD	eMALL	EVD

SP23	The EVD asks to unlock the charging point he/she has booked to eMALL	EVD	eMALL
SP24	The EVD connect the EV to the charging point and starts the charging process	EVD	eMALL
SP25	eMALL notifies the EVD of the current state of the charging process (battery's level, current cost, estimated time, ...)	eMALL	EVD
SP26	The EVD pauses the charging session	EVD	eMALL
SP27	The EVD ends the charging session	EVD	eMALL
SP28	eMALL notifies the EVD that the battery of his/her EV is charged	eMALL	EVD
SP29	eMALL suggests the EVD to end the charging session after a defined level of the EV's battery is reached	eMALL	EVD
SP30	The EVD pays for the charging session using the module offered by eMALL	EVD	eMALL
SP31	eMALL returns the outcome of the payment done by the EVD	eMALL	EVD
SP32	eMALL notifies the EVD about the need of charging the EV	eMALL	EVD
SP33	The CPO creates a Charging Point Operator account on eMALL	CPO	eMALL
SP34	The CPO adds a new charging station in its profile specifying all the needed information	CPO	eMALL
SP35	The CPO updates information of an existing charging station	CPO	eMALL
SP36	The CPO activates a new special offer for its charging stations	CPO	eMALL
SP37	The CPO manually updates the DSO which provides it energy	CPO	eMALL
SP38	The CPO updates the selling price of its electricity	CPO	eMALL
SP39	The CPO sets the battery capacity of a charging station	CPO	eMALL



SP40	The CPO asks for information about the DSOs to eMALL	CPO	eMALL
SP41	eMALL returns the information about the DSOs to the CPO	eMALL	CPO
SP42	eMALL gets EVD's current schedule from his/her calendar	eMALL	EVD

Table 1.3: Shared Phenomenas.

### 1.3. Definition, Acronyms, Abbreviations

Acronyms	Definition
eMSP	e-Mobility Service Provider
CPO	Charging Point Operator
CPMS	Charge Point Management System
DSO	Distribution System Operator
RASD	Requirements Analysis and Specification Document
WP	World Phenomena
SP	Shared Phenomena
GX	Goal Number X
EVD	Electric Vehicle Driver

Table 1.4: Acronyms used in the document.

### 1.4. Revision history

### 1.5. Reference Documents

The specification document `Assignment RDD AY 2022-2023.pdf`.

### 1.6. Document Structure

The document is structured in six sections, as described below.

First section introduce the goals of the project, purposes, and a brief analysis on world and shared phenomena; abbreviations and definitions useful to understand the problem are listed as well.

The following section, the second one, provides an overall description of the problem: here scenarios and further details on domain, and scenarios are included, aside from more product and user characteristics, assumptions, dependencies and constraints.

Later on, the third section focuses on the specific requirements and provides a more detailed analysis of external interface requirements, functional requirements and performance requirements.

Lastly, the fourth section provides a formal analysis, using alloy. This chapter is crucial to prove the correctness of the model described in the previous sections, and should focus on reporting results of the checks performed and meaningful assertions.

Section five reports the effort spent by each group member in the redaction of this document, meanwhile the last section simply lists bibliography references and other resources used to redact this document.

## 2 | Overall Description

### 2.1. Product perspective

#### 2.1.1. Scenarios

#### 2.1.2. Class Diagrams

The figure below list and describes the classes involved in the system, and their basic functionalities, their basic attributes and relationships between them. Some suggestions for a further expansion and deepening of the diagram below, could be to evaluate the use of a decorator pattern to implement the "Fee" class; also, to evaluate the use a status pattern to assign the state of a charging point (free, booked, occupied, broken). Furthermore, another suggestion could be to adopt the factory pattern to implement the "plug" interface.

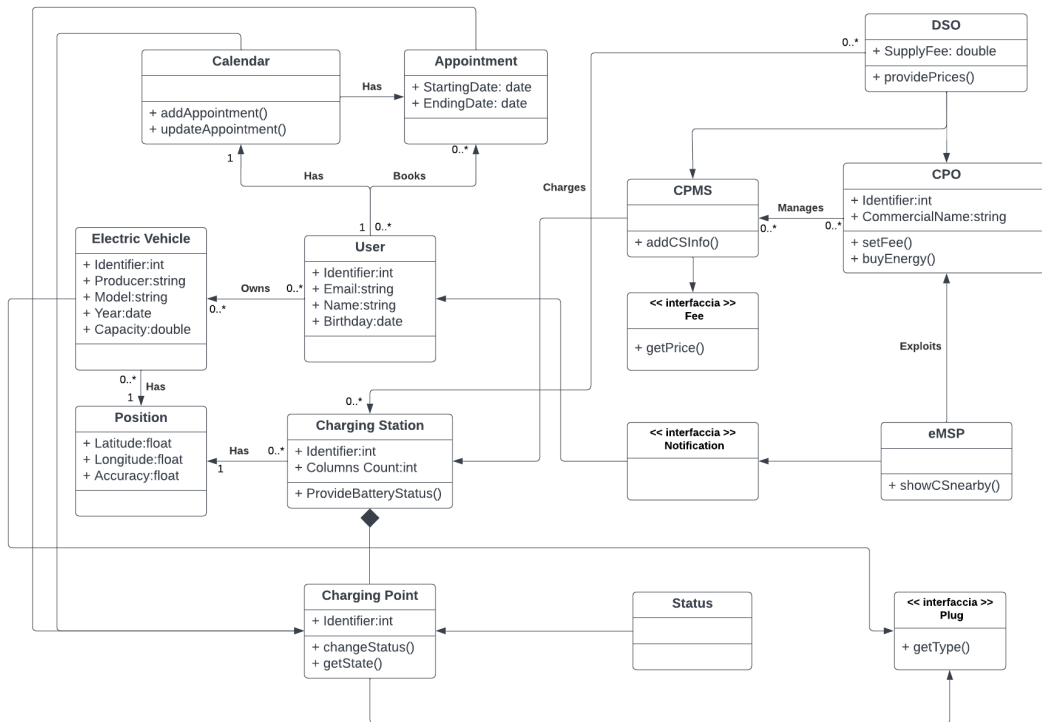


Figure 2.1: A simplified Class Diagram

### 2.1.3. State Diagrams

**EVD wants to know position and characteristics of charging stations at a certain location.**

EVD Andrew is going to use his car to go to the university for the Software Engineering 2 exam, but his EV is out of battery. So, he needs to decide where to charge his vehicle. To do that, he decides to open the eMALL application and enters the map section. At first, he sees if there is any charging station around him. The problem is that at his current position there is only one charging station, that is shown as broken at the moment. So, he decides to see where to charge his EV nearby the university, inserting Milan in the location bar. From the huge amount of charging station, he decides to decide the one that costs less then the other ones. So, he selects a charging station and gets its additional information. He repeats the process until the decision of the charging station is made. At this point, the navigation process ends.

It is shown a state diagram that summaries the flow of activities done in the charging stations navigation process:

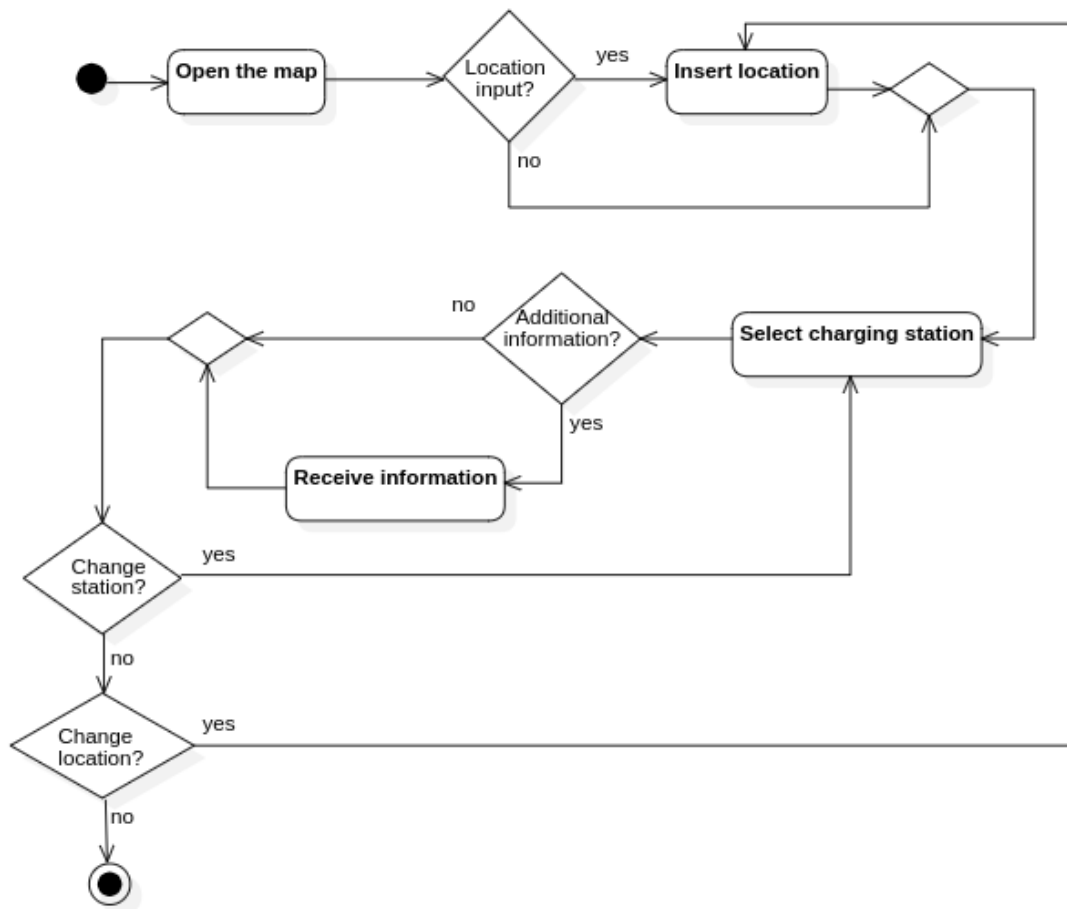


Figure 2.2: Get locations of charging stations state diagram

**EVD wants to book a charge at a specified charging station at a certain time-frame**

Now, Andrew needs to book a charge for his EV. Once the choice of the charging station is done, he selects it on the map and enters the booking section. If the charging station cannot offer reservation to EVD because of not availability status, the EVD is notified. Mario has to decide in which timeframe wants the charging point to be reserved. So, he gets availability schedule of the charging station and selects when he thinks to go to charge. If it is no more available, the EVD is returned at the previous section. Otherwise, if there is a caution to pay it is shown to the EVD. Finally, the EVD receives an e-mail that confirms the reservation, with all the useful information.

It is shown a state diagram that summaries the activities in the booking process:

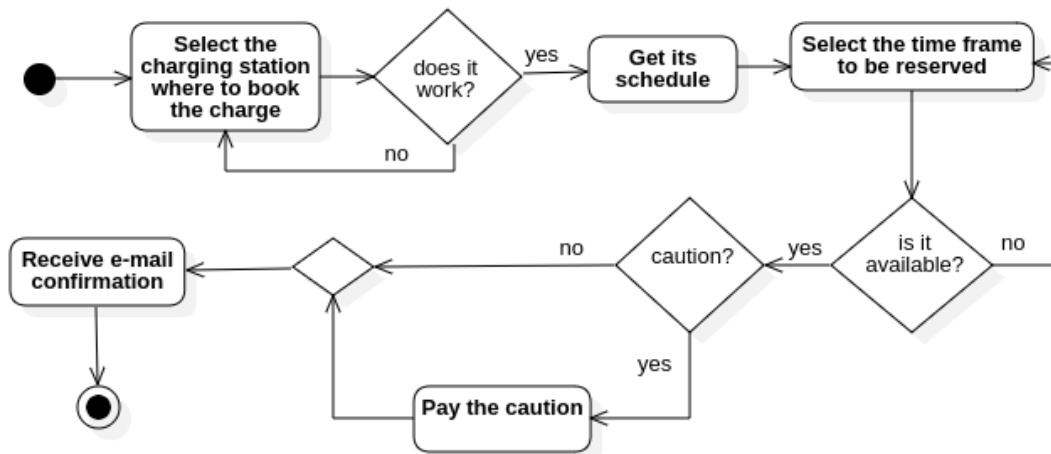


Figure 2.3: Book a charge state diagram

### CPO wants to add charging points in its CPMS

LIGHT is the new company of the successful businessman Nole Mask. They decided to trust the eMALL project, entrusting them the responsibility of managing their IT infrastructure. After logging in, they start inserting new charging points owned by them distributed in the territory. If it belongs to a new charging station, it has to be created too. So, they insert all the information they are requested (location, costs, connectors, power, etc.). After they confirm and submit what they inserted, they can add a new charging point. Otherwise, they easily end the process.

It is shown a state diagram to summaries the activities in the charging points insertion process:

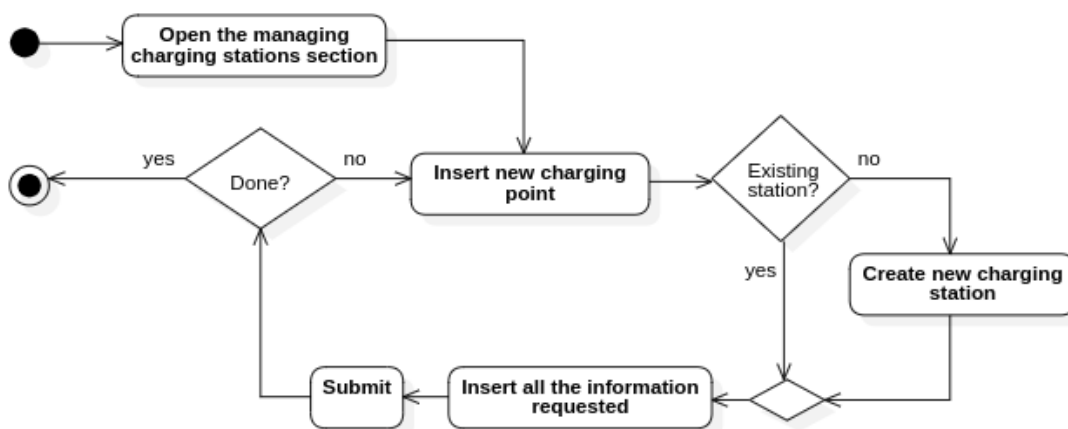


Figure 2.4: Insert charging points state diagram

## 2.2. Product functions

## 2.3. User characteristics

The actors listed below are considered in the eMALL system

- **CPO:** owns one or more charging stations, and manages bookings and promotions about its charging points. He buys energy from DSOs, based on prices and needs. CPOs has their own IT system.
- **Unregistered EV Driver:** anybody who owns an electric vehicle, but isn't registered in the eMALL system. Before accessing its benefits, it needs to get an account.
- **Registered EV Driver:** an electric vehicle owner who already joined the eMALL system, and access its benefits. He's identified with a unique ID, and can own one or more vehicles with different specifics. They can check prices and position of charging points, in addition to receiving notifications about promotions reserved to them.

## 2.4. Assumptions, dependencies and constraints





## 3 | Specific Requirements

### 3.1. External Interface Requirements

#### 3.1.1. User Interfaces

#### 3.1.2. Hardware Interfaces

#### 3.1.3. Software Interfaces

#### 3.1.4. Communication Interfaces

### 3.2. Functional Requirements

### 3.3. Performance Requirements

### 3.4. Design Constraints

#### 3.4.1. Standards compliance

#### 3.4.2. Hardware limitations

#### 3.4.3. Any other constraint

### 3.5. Software System Attributes

#### 3.5.1. Reliability

#### 3.5.2. Availability

#### 3.5.3. Security

#### 3.5.4. Maintainability

#### 3.5.5. Portability

## 4 | Formal Analysis Using Alloy



## 5 | Effort Spent



## 6 | References





# A | Appendix A

If you need to include an appendix to support the research in your thesis, you can place it at the end of the manuscript. An appendix contains supplementary material (figures, tables, data, codes, mathematical proofs, surveys, . . . ) which supplement the main results contained in the previous chapters.



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