Software Engineering 2 - RASD

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1 Introduction

1.1 Purpose

In the last years, the high carbon footprint has been a global challenge for its negative environmental impact, since it plays a relevant role in climate change and air pollution. In particular, the transportation sector is one of the primary sources of greenhouse gas emissions due to the combustion of fossil fuels.

Electric mobility represents a solution to alleviate the problem: electric cars require less energy and produce less polluting gas as well. However, people should take into account the charging-related issues when using electric vehicles. To facilitate the procedure, the eMall (e-Mobility for All) system proposes to keep together and to coordinate all the activities that the charging process would require.

The eMall system connects the various providers involved in the activity: e-Mobility Service Providers (eMSPs) aim to help drivers in planning and completing the charging process of their electric vehicles introducing minimal interference and constraints with respect to their daily schedule, while Charging Point Operators (CPOs) manage the changing stations, offer functionalities through their own Charge Point Management System (CPMS), and eventually acquire energy from Distribution System Operators (DSOs).

1.1.1 Goals

Goal	Description
G1	The system shall allow the drivers to acquire information about charging stations
G2	The system shall allow the drivers to book a charge in a charging station
G3	The system shall allow the drivers to charge the vehicle at a certain station
G4	The system shall allow the End-users to be notified when the charging process is finished
G5	The system shall allow the End-users to pay for the obtained service
G6	The system shall allow the End-users to receive suggestions on where to go to charge the vehicle based on circumstances
G7	The system shall allow to know the location and the status of a charging station
G8	The system shall allow to start charging a vehicle and monitor the charging process
G9	The system shall allow to acquire by the DSOs information on energy
G10	Allow to decide from which DSO to acquire energy
G11	Allow to decide dynamically where to get energy for charging
G12	The system shall allow the CPOs to change the charging cost and the special offers

1.2 Scope

This document will focus on the analysis of the subsystems eMSP and CPMS, and their interaction approach. In our application domain, each CPMS is owned by a different CPO, and an eMSP can interact with multiple CPMSs.

1.2.1 World Phenomena

Identifier	Description
WP1	People use electric vehicles
WP2	Drivers need to charge their vehicle
WP3	There are available charging stations
WP4	Charging stations have enough energy supply
WP5	Users' vehicle has a rechargeable/working battery

1.2.2 Shared Phenomena

World Controlled Phenomena

Identifier	Description
SP1	User registers an account
SP2	User logs into his account
SP3	User consults information about the charging stations
SP4	User books a charge in a charging station and chooses a time slot
SP5	User starts the charging process in a booked charging station
SP6	User pays for the obtained service

Machine Controlled Phenomena

Identifier	Description
SP7	System notifies the user when the charging process is finished
SP8	System suggests the user which charging station to choose and to charge the vehicle
SP9	System gives information on the status of a charging station

1.3 Definitions, acronyms, abbreviations

TODO! ...

1.3.1 Abbreviations

Abbreviation	Description
RASD	Requirements Analysis and Specification Document
WP	World Phenomena
SP	Shared Phenomena
GX	Goal number X
DX	Domain assumption number X
RX	Requirement number X
eMall	e-Mobility for All

1.4 Revision history

1.5 Reference Documents

1.6 Document Structure

This document is composed of six sections that describe our system in detail:

The first section consists of an introduction of our project. It starts with a description of the main problem that our system will deal with, a list of goals to achieve and the specification of its scope with various phenomena occurring. In the last part, there are several definitions and abbreviations, necessary for better understand the document.

Section two contains an overall description of our system. It includes several realistic scenarios on the interaction between Users and the System, clarified by statecharts which describe the behavior of system and by a class diagram which offers an overview of the main entities of our system and their relationships. Moreover, there is a list of main functionalities that our system will offer under some domain assumptions, assumed to hold in the world.

TODO! (need further modification, not sure about the content) In section three, the requirements on the system is specified. they include functional, non-functional requirements and requirements on external interfaces. Furthermore use cases are described, clarified by use case diagrams and sequence diagrams. Section three also contains details on the relationships between functional requirements, the goals of the system and the use cases. Lastly, it specifies the design constraints.

TODO !! Section four contains a formal analysis making use of Alloy. Together with the Alloy code, the analysis objective is described.

In section five there is a presentation of the project members total effort spent on writing RASD.

Section six contains the references used in this Document.

2 Overall Description

2.1 Product perspective

2.1.1 Scenarios

1. Driver wants to start to use the system

The Driver owns an electric vehicle but he always has troubles on choosing which charging stations to go to charge his car. He decides to start to use the e-Mall platform. First, he downloads the application and then registers himself with the requested data. After the completion, he logs into his account and finally, he can take advantage of all the services offered by the application.

2. Driver wants to get information about the charging station

The Driver D arrives in a new city for business and he wants to compare the price of charging stations with those in his city. For this reason he decides to use the e-Mall application. After he does the login with his account, he clicks on the "map" button. The map shows where the driver D is and the nearby charging stations available with their prices.

3. Driver wants to book a charge

The Driver E realises that his electric vehicle is running out of battery and he decides to user the e-Mall platform to find the nearest charging station. He does the login and successfully enters into his account and then clicks on the "book" bottom. It appears a list of charging stations sorted by the distance. He chooses the nearest charging station and books it selecting the earliest time frame available.

4. Driver starts the charging process at the station

The Driver Z has already booked a charge on the e-Mall platform. He arrives at the chosen charging station by time, and he successfully authenticates at the charging column through the code shown on his mobile application. Then he plugs the vehicle in, and the display of the charging column shows him the remaining charging time. Then the car is locked there and the driver Z is free to go to deal with personal

issues while leaving the car at the charging station.

5. Driver receives suggestions about going to charge the vehicle

The e-Mall system checks the status of the battery and the schedule of the driver Y when he begins his journey. The sensor detects the low battery state of the vehicle, and the system is notified about this fact. After checking the calendar and the navigation system of the driver, the system notices that the driver will pass nearby a certain charging station with available charging slots. At this point the Driver Y receives a notification from his smartphone with the suggestion to go at that charging station and charge the vehicle. The charging station's location will be displayed too.

6. Operator wants to check the status of the charging station

The Operator X wants to check the status of the charging station managed by him. He logs into his operator account by filling the username and the password in the login page of the e-Mall application, and then he is redirected to his personal page. There he visualizes the status page of the charging station: the information shown includes its location, its external status (number of charging sockets available, their type, their cost, and the estimated time until finishing the charge), and its internal status (the amount of energy available in its batteries, number of vehicles being charged, the time left and the amount of power absorbed).

7. Operator wants define a special offer

The Operator W wants to change the charging price in his charging station in order to promote a special offer. He logs into his operator account, and access to the page managing the charging offers. He chooses the charging option for which he wants to modify the cost, and input a new cost. Then he clicks on the confirm button, and the page is refreshed. Now the most recent costs are displayed.

8. Operator wants to acquire energy

The Operator V wants to check the status of the charging station managed by him. He logs into his operator account, and he clicks on the "energy supply" button to check the list of the current prices of energy published by the Distribution System Operators. After thinking on the options, the operator V decides from which DSO he would like to acquire energy, and select it from the list. He is asked to input the quantity of energy he wants to acquire, and after clicking the confirm button, the request will be sent to the DSO.

9. Operator wants to decide where to get energy for charging

The Operator U wants to decide where to get energy for the charges. He logs into his operator account, and he visualizes the current schedule in the main page of the charging station managed by him. Clicking on "Change source", he can see a list of available alternatives. He can select one of them from the list and apply it by clicking the confirm button.

2.1.2 Class diagram

2.1.3 Statecharts

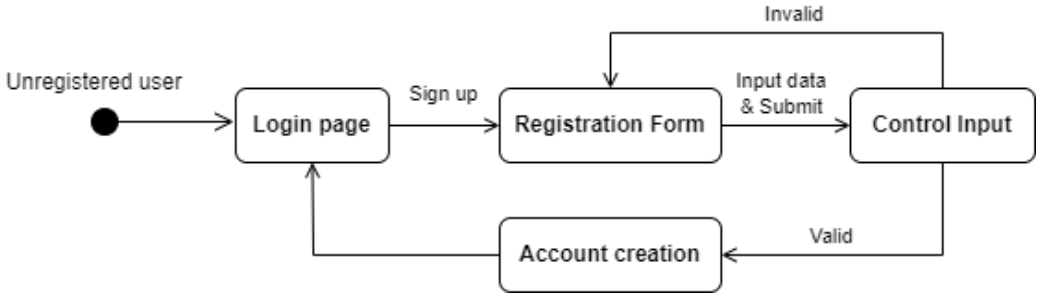

Figure 1: State diagram of the Registration process

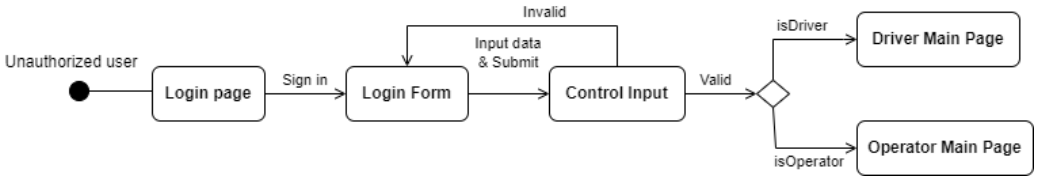

Figure 2: State diagram of the Login process

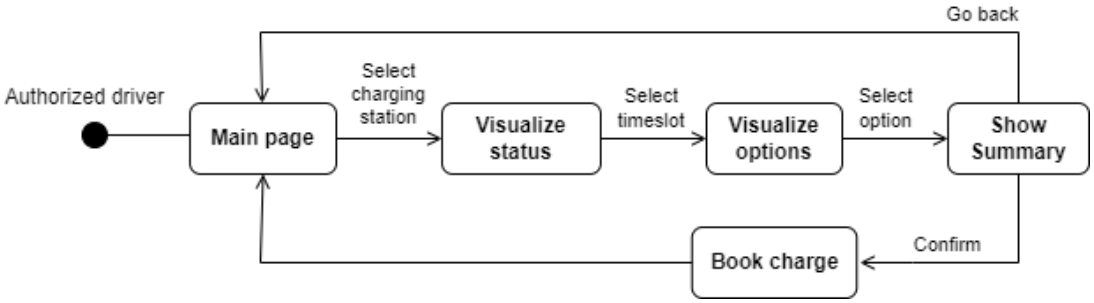

Figure 3: State diagram of the booking charge process

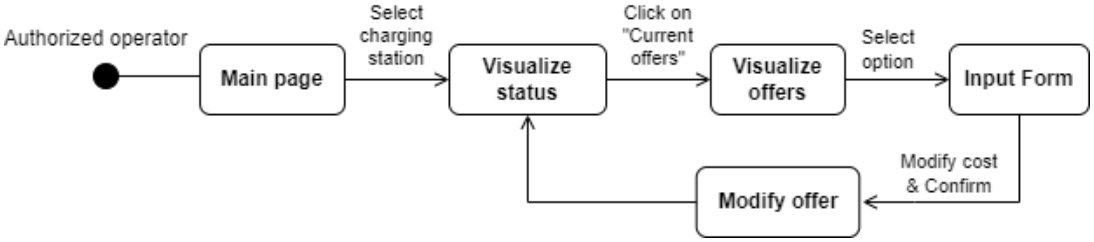

Figure 4: State diagram about modifying the current offers at the charging points

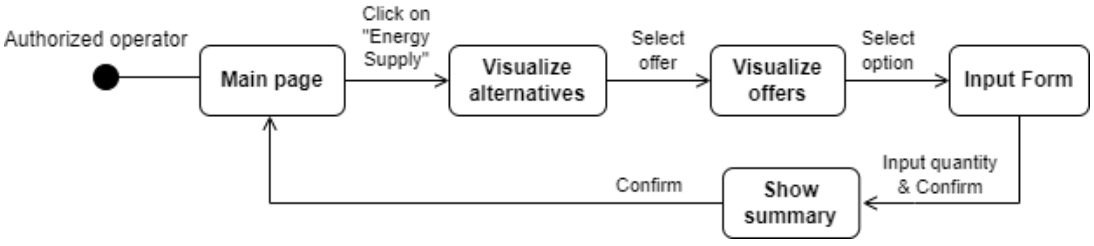

Figure 5: State diagram of the energy acquisition process

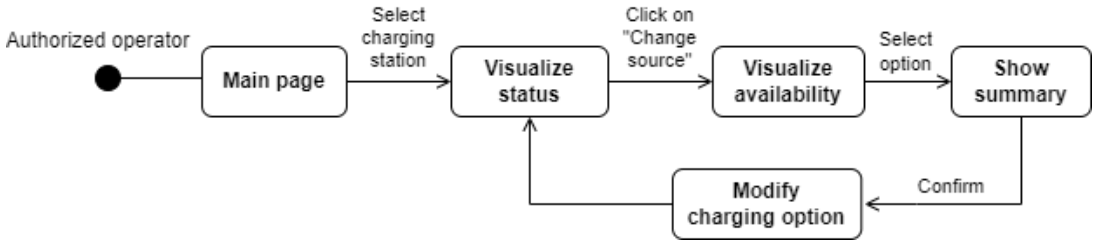

Figure 6: State diagram about changing the charge option of the station

2.2 Product functions

In this section the main functionalities of eMall are presented and described in more detail.

2.2.1 Give information about the charging stations to users

Giving information about the charging stations is at the basis of the system, which will give different information to different type of user. The system will show to the drivers the location of nearby charging stations, their cost and their eventual special offer. The drivers will know the number and type of available charging sockets in the chosen station, if all sockets of the chosen type are occupied, the system will also show the estimated amount of time to have it be freed. The system will show to the operators the status of their charging station, such as the amount of energy available in its batteries, the number of vehicles being charged, the amount of power absorbed by these vehicles and the time left to finish the charge.

2.2.2 Book a charge

The system will offer to the drivers the possibility to book a charge at a chosen charging station. This functionality will help them to avoid long queue of people waiting for a charging socket. The system will present to the drivers the charging stations and their sockets' available timeframe. If the driver confirms a book, the system will reserve that socket in that timeframe.

2.2.3 Charge a vehicle

The ability to charge a vehicle is one of the most important functionalities of the system. The system will start a charging process at a certain station according to the amount of power supplied by the socket. The process will also be monitored by

the system to infer when the battery is full. When the process is finished, the system will notify the driver.

2.2.4 Suggest the users to charge the vehicle

The system will be able to make suggestions to the driver depending on different aspects. The system will check the status of the vehicle's battery and suggest the driver to charge when the battery is low. The system will also recommend some special offers of charging stations after checking the availability of the charging slots at these stations. The system will provide the possibility to have all the previous suggestions made refer to the driver's schedule, by getting access to his/her calendar and navigation system, if the driver gives consent.

2.2.5 Manage the charging station

An important aspect of the system is to manage the charging station. A charging station needs to acquire energy from external DSOs. So, it's important to decide when, how much and from which DSO to acquire energy. The system will be able to make these decisions automatically by checking the availability of the DSOs and the current energy information acquired by them. The system will also provide a functionality to dynamically decide the cost of a charging and set special offers based on the previous information. When a vehicle starts charging, the system will monitor the process and decide dynamically where to get energy for the charge, such as from station battery, DSO or a mix thereof according to availability and cost. All this kind of decisions will be made by the system automatically, but it will also provide the possibility to handle this decision by human operators.

2.3 User characteristics

There are considered three actors in the eMall system:

1. **Unregistered user**
   An electric vehicle's owner that can't use eMall's functionalities without registering to the eMall platform.

2. **Driver**
   An electric vehicle's owner, registered to the platform, who can use the system to find charging stations and charge his/her electric vehicles, to book charges and to receive suggestions.

3. **Operator**
   A registered user, who works for a specific CPO. The Operator can use the system to manage the charge stations of the belonged CPO and to receive current energy information from DSOs.

2.4 Assumption, dependencies and constraints

2.4.1 Domain assumptions

Identifier	Description
D1	There exists APIs that retrieve correct information about Drivers's daily schedule and his navigations system
D2	Each (electric) vehicle has a number plate
D3	Driver will charge in a booked charging station and finish his charging process within his booked time slot
D4	Driver makes a significant use of his calendar
D5	Driver cannot book a time slot before the current time
D6	Driver actually pays for the obtained service
D7	The information offered by CPMSs is reliable
D8	The information offered by DSOs is reliable
D9	The charging stations function correctly

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

3.2.1 Use cases

1. Driver registration

Actor	Driver
Entry conditions	The driver have not registered an account yet, and he is on the Login page of the system
Event flow	1. 2. 3.
Exit condition	
Exceptions	

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

3.6 Other Requirements

4 Formal Analysis using Alloy

5 Alloy code

```
sig Email{}
sig Name{}
sig Surname{}
sig Password{}
sig LicenceId{}
sig PlateNumber{}
sig Identification{}
sig Price{}
sig Date{}
sig Time{}
sig Address{}
sig City{}

abstract sig Bool {}
one sig TRUE extends Bool {}
one sig FALSE extends Bool {}

abstract sig User {
  email: one Email,
  name: one Name,
  surname: one Surname,
  password: one Password
}

sig DRIVER extends User {
  licence_id: one LicenceId
}
sig OPERATOR extends User {}


sig VEHICLE {
  plate_number: one PlateNumber,
  battery_status: int
}

sig CHARGING_STATION {
  identification: one Identification, ?
  name: one Name,
  address: one Address,
```

```
  city: one City,
  number_socket: int,
  energy_price: one Price
}

sig SOCKET {
  identification: one Identification, ?
  available: one Bool,
  type: ?
  amount_power: float
}

sig OFFER {
  from_date: one Date,
  to_date: one Date,
  price: one Price
}

sig CHARGING_PROCESS{
  date: one Date,
  estimated_time: int,
  price: one Price
}

sig RESERVATION{
  date: one Date,
  from: one Time,
  to: one Time
}

sig ENERGY{
  identification: one Identification ?,
  name: one Name,
  price: one Price
}

fact allDriverHasVehicle {}

fact uniqueEmails{}

fact uniqueIdentification{}

fact uniqueLicenceId{}

fact uniquePlateNumber{}
```

```
pred addVehicle {}

pred createAccount{}

pred addReservation{}

pred delReservation{}

pred addOffer{}

pred delOffer{}

pred updatePrice{}

pred updateChangingSource{}

assert delUndoesAddRes {
}

assert delUndoesAddOffer {
}
```

6 Effort Spent

7 References