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eMall (e-Mobility for All)

RASD

Requirement Analysis and Specification Document
a.a. 2022/2023

Version: 1.0
Date: 23/12/22

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- underlined text: doubts;
- **underlined and bold text**: Our assumptions.

1 Introduction

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

1.1 Purpose

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

The purpose of the **eMall (e-Mobility for All)** software application is to allow drivers to charge their electric vehicle easily, quickly and effectively. This application wants to be a way to limit the carbon footprint caused by the urban and sub-urban mobility needs, providing useful information to electric vehicle drivers (e.g. where to charge their vehicle). This allow to carefully plan the charging process both for drivers and providers in such a way that it introduces minimal interference and constraints on their daily schedule.

The eMall software application also offers to the *Charging Point Operators (CPOs)* the possibility to manage each charging station in the best way.

1.1.1 Goals

We may extract the following goals for the application:

- [G.1] - The system allows Users (Drivers or CPOs) to be registered in the application (with two different forms of identification).
- [G.2] - The system allows Drivers to visualize the charging stations in a selected area.
- [G.3] - The system allows Drivers to reserve a socket of a charging point in a selected charging station.
- [G.4] - The system allows Drivers to charge their electric vehicle.

- [G.5] - The system allows Drivers to pay for the charging service.
- [G.6] - The system allows CPOs to visualize data about any of the charging stations managed.
- [G.7] - The system allows CPOs to decide how to provide electric energy to a charging vehicle at a selected charging station.
- [G.8] - The system allows CPOs to decide from which Distribution System Operators (DSOs) to buy electric energy.
- [G.9] - The system allows CPOs to decide the price of the energy and any special offers of a selected charging station.
- [G.10] - The system allows Charge Point Management Systems (CPMSs) to access data about a charging station e.g location and status.
- [G.11] - The system allows CPMSs to start charging a vehicle and to monitor the charging process.
- [G.12] - The system allows CPMSs to dynamically and automatically decide where to get energy for charging (i.e from batteries or DSOs).
- [G.13] - The system allows CPMSs to view relevant data from DSOs (e.g. energy price) and to decide from which DSOs to buy electric energy.

1.2 Scope

In this section we want to give a brief analysis of the world and of the shared phenomena.

- The Machine is the application software that we want to develop.
- The World is the external environment, namely the part of the real world that is affected by our system.

These two parts communicate and influence each other.

1.2.1 World phenomena

World phenomena are events that take place in the real world and taken by themselves do not have a direct impact on the System.
We identify the following world phenomena:

- A Driver wants to charge his electric vehicle.
- A DSO changes the price of the energy sold.
- The battery in a certain charging point is empty.
- The electricity network is out of order.
- A Driver does not show up to the charging station or arrives after the reservation deadline.

1.2.2 Machine phenomena

Machine phenomena are events that entirely take place inside the System and cannot be observed in the real world.
We identified:

- Retrieving result data for a request.
- Storing collected data.

1.2.3 Shared Phenomena: controlled by the Machine and observed by the World

- The machine shows to the Driver data about a selected charging station.
- The machine reserves a charging point socket in the charging station for the Driver who booked it.
- The machine shows to the Driver data about the charging process of the electric vehicle (e.g. price, kWatts, spent & remaining time).
- The machine shows to the Driver if the payment has been successfully completed or eventually any problem occurred during the payment process.
- The machine shows to the CPOs or the CPMSs data about DSOs.
- The machine shows to the CPOs or the CPMSs data about the status of a charging station.

1.2.4 Shared Phenomena: controlled by the World and observed by the Machine

- A User signs up to the application.
- A User signs in the application.
- A Driver selects a charging station.
- A Driver books a socket in a selected charging station.
- A Driver inserts the code into the socket to unlock the reserved socket.
- A Driver connects the electric vehicle to a socket of a charging station.
- A driver inserts data of payment.
- A driver stops charging the electric vehicle.
- A CPO selects a charging station between the ones it manages.
- A CPO modifies the prices of one of the charging stations it manages.
- A CPO adds a price offer to one of the charging stations it manages.

- A CPO or a CPMS selects the DSOs from which to buy energy.
- A CPO or a CPMS modifies the energy source of one of the charging stations it manages.

1.2.5 World and Machine Table

Phenomenon	Controlled by	Shared
A driver wants to charge his electric vehicle	W	No
A DSO changes the price of the energy sold	W	No
The battery in a certain charging station is empty	W	No

1.3 Definitions and abbreviations

1.3.1 Acronyms

- RASD : Requirement Analysis and Specification Document.
- eMSPs : e-Mobility Service Providers.
- CPOs : Charging Point Operators.
- CPMS : Charge Point Management System.
- DSOs : Distribution System Operators.
- UML: Unified Model Language.
- API: Application Programming Interface.
- EV : Electric Vehicle.
- CS : Charging station.
- CP: Charging point.

1.3.2 Definitions

- User: a generic person that is registered into system. Can be referred to a Driver or a CPO.
- Anonymous User: a generic person who is not registered to the application.
- Driver: person who drive an EV.
- Charging Point Operator (CPO): person who manages charging stations.
- e-Mobility Service Providers (eMSP): the software application that provides access to the eMall functionalities.

- Distribution System Operators (DSO): entities from which the CPOs can buy energy.
- Charging station: station in which drivers can charge their electric vehicles.
- Charge Point Management System (CPMS): IT infrastructure used by CPOs to administer charging stations.
- Charging Point : structure of a charging station with sockets.

1.3.3 Abbreviations

- $[G.n]$ = n-th Goal
- $[R.n]$ = n-th Requirement
- $[D.n]$ = n-th Domain assumption

1.4 Revision history

Version	Date	Details
...	...	...
...	...	...

Table 1.4.1: revision history

1.5 Reference Documents

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

Table 1.5.1: table of references

1.6 Document Structure

The rest of the document is organized as follows:

Overall Description (Section 2) gives an overall description of the eMall application and services that it is going to offers, underlining its principle goals. Here we also given an introduction about the world in which the system will be collocated, highlighting the boundaries between the machine and the world.

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

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

2 Overall description

2.1 Product perspective

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

2.2 Product functions

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

2.3 User characteristics

2.4 Assumption,dependencies and constraints

2.4.1 Domain applications

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 Scenarios

Scenario 1: Charles Leklerk needs to charge his EV which has a low percentage of battery. Knowing that in the area there are several charging stations, he has just downloaded the eMall application on his smartphone and wants to try its features. He opens the app and, from the homepage, selects the Sign-up option. For signing-up he is required to insert name and surname, a valid email address and a password. Charles proceeds by inserting the data. The password is not matching the security constraints so the application displays an alert with the required characteristics. Charles changes the password with a compatible one and confirms the agreement of eMall terms and conditions. A pop-up message asks for the authorization of push notifications and for the use of location tracking, Charles accepts both of them. Then, the application redirects him to a page that shows on a map the position of the nearest CS in the area. Charles selects the closest CS from his position; after that he proceeds to reserve a free socket in a charging point of the CS. The application then: shows that the socket reserved by Charles is locked; sends the digital ticket (i.e. QR Code) that he must scan at his arrival and shows a countdown timer of 15 minutes, period of time in which Charles must scan the QR code at the CP QR reader in order not to loose his reservation. Fortunately, he arrives in time to the socket and he scans the ticket's QR code. The application then shows a new timer countdown of 5 minutes, in this period of time Charles must connect his EV to the socket and he must insert a valid credit card for the payment. In 4 minutes Charles connects the EV to the socket and inserts a valid credit card for the payment. At this moment, the charge of the EV starts. Charles goes to drink coffee in a bar near him and is able to view from the application the progress of the vehicle charge, such as: the vehicle battery charge in percentage, the number of kwatt used for charging, the elapsed charging time, the remaining time to get to 100% of the battery, the total cost per kwatt and a "Stop And Pay" button to anticipate the end of the charging process. An hour later, the EV has reached 100% of battery: the socket stops charging the EV and the application notifies Charles, with a pop-up that the charging process is finished, showing the final data about it. Then, Charles goes back to his EV, disconnects it from the socket and goes away.

Scenario 2: It will be not a good day for Max Van Der Stappen. Before coming back home, after an hard day of work, he needs to charge his EV. He opens the eMall app and, having already an account, he inserts his personal credentials and reserves a socket of a CS close to his position. Due to the traffic, the 15 minutes passed and the app sends to Max that he lost the reservation at the previously booked CS. Max decides to check to another CS closer to his position and reserves a socket of it. After 10 minutes he arrives at the socket reserved and scan the new ticket QRCode. Now he has 5 minutes to connects the EV to the socket and inserts valid credit card for the payment. However, Max does not insert a valid credit card at time and unfortunately he looses again the reserved position at the CS. Max decides to select the same CS, where he is now and to reserve the free socket beside. In less than 20 minutes he is able to park the EV, to scan the third new QRCode ticket, to connect the EV to the socket and to insert valid credit card for the payment. Subsequently, the charging process starts and Max goes to the sport shop near the CS. After 30 minutes, Max suddenly realizes that he has an anniversary dinner with his girlfriend that night and he is being late. So, he runs out of the shop and stops in advance the charging process of the EV by clicking on the "Stop And Pay" button of the app. After that, the socket stops the charging process of the EV, which has the 80% of battery, and Max comes back home for prepare himself for the dinner.

Scenario 3:

Scenario 3:

3.2.2 Use Case Diagrams

3.2.3 Use Case Analysis

3.2.4 Sequence Diagrams

3.2.5 Requirements, Domain Assumptions, Goals Matrix

3.3 Performance requirements

3.4 Design constraints

3.4.1 Standards compliance

3.4.2 Hardware compliance

3.4.3 Software system attributes

3.4.4 Reliability

3.4.5 Availability

3.4.6 Security

3.4.7 Maintainability

3.4.8 Portability

4 Formal analysis using Alloy

5 Efforts

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

6 References

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