RASD&DD

1 Introduction

1.1 Purpose

Electric mobility (e-Mobility) is a way to limit the carbon footprint caused by our urban and sub-urban mobility needs. When using an electric vehicle, knowing where to charge

the vehicle and carefully planning the charging process in such a way that it introduces minimal interference and constraints on our daily schedule is of paramount importance.

There are four main entities that need to interact in order to provide the mentioned service:

1. eMSP (e-Mobility Service Providers): an application that links together the final users (owners of electric vehicles) and the charging stations
2. CPOs (Charging Point Operators): they own and manage the charging station
3. DSOs (Distribution System Operators): energy providers

The purpose of this project is to develop e-Mall (e-Mobility For All), a set of applications that:

- will grant the user the possibility to book charges for its vehicles and pay for it, monitoring costs and special offers;
- allows CPOs to handle their own charging areas through CPMS (Charge Point Management System) that manages the charging columns and the energy acquisition for the single charging stations, automatically or manually by employees.

This document later will further expand on the goals and requirements put on the system to be with the purpose of guiding the development.

1.1.1 Goals

Goals	Description
G1	Allow user to pay for a charge
G2	Allow user to book a charge
G3	Allow user to register to the eMSP system
G4	Allow user to know about charging station prices and special offers
G5	Allow user to perform a charging process
G6	Allow CPMS to notify eMPS when a charging process is finished
G7	Allow CPMS to manage reservations
G8	Allow CPMS to manage the power input/output of the charging station

Scope

Our system focuses on the eMSP and CPMS subsystems with all the features listed in the specification document whithout making the eMSP smarter than it needs to for the end user.

World phenomena

Identifier	Description
	Energy cost shifts
	Car is low on battery
	User gets to the charging station

Shared phenomena

Identifier	Word controlled
	User makes a reservation
	User plugs the car to the carging station
	User registers an account
	User validates it’s reservation through nfc on the charging column
	User unplugs the car from the charging station
	User searches for a specific charging station
	User is late to the reservation [MAYBE WORLD PHENOMENA]
	Chargin Station operator decides on which energy provider to use
	Chargin Station operator decides on the price/offer for the energy
	Chargin Station operator decides whether to store energy in batteries or to use stored energy

Identifier	Machine controlled
	A payment is charged to the user
	CPMS allows charging column to charge vehicle
	System shows informations about charging stations

	System shown reservation list
	System sends “Charging done” notification
	System shows charging stations map
	CPMS asks for energy prices to the DSOs
	CPMS decides which energy source to use

Definitions, Acronyms, Abbreviations

Definition	Description
Charging column	A device with one ore more standard charging sockets equipped with a NFC reader
Charging station	A group of charging colums displaced in a nearby area owned by a CPO and managed through the CPMS
User	Person interested in using the system
Operator	Instructed personnel that manages a charging station

Acronyms	Description
eMSP	e-Mobility Service Providers application that links together the final users and the charging stations
CPOs	Charging Point Operators owners and managers of the charging station
DSOs	Distribution System Operators energy providers
CPMS	Charge Point Management System manages reservations and energy for charging stations
eMall	Electric Mobility for All
IoT	
NFC	

Abbrevations	Descrpition
RASD	Requirements Analysis and Specification Document

Revision history

Reference Documents

The specification document “Assignment
RDD AY 2022-2023_v3.pdf”

Document structure

Overall description

Product perspective

Scenarios

S1. User sign up

Elon want’s to sign up to the eMSP system because he just bought a Tesla Model S. He opens the previously downloaded app and selects the option to sign up. He inserts his data and the payment methods which will first need to be verified to be effectively registered to the service.

S2. Making a new reservation for the next week

Jeff will be on travel next week so he wants to make a reservation so that he will be able to have lunch while the car is charging. He opens the app and through the search bar he searches for the location he will be having lunch in. The map moves and shows the nearby charging station marked with different colors accordingly to their max charging rate. Jeff selects the nearest CS with ultra fast charging speed, views it’s cost and selects “Book a charge”. He now inputs the date and, from the available time-frames list with relative charging rates, he selects the most suitable for his time of arrival and expected permanence. A small booking fee is charged on Jeff’s payment method.

S3. Making a reservation for the immediate future

Bill’s car is signaling that is low on charge so he pulls over and opens the app. He selects “Charge NOW” and the map moves to his current location. Different SC with available slots for the current time are shown marked with colors accordingly to their max charging rate and with an exclamation mark in case there’s a ongoing offer. Bill

notices that a nearby charging station is promoting a good offer so he clicks on it and the current price is shown. He selects the required duration and then “Go NOW” to confirm his booking and arrival. A small booking fee is charged on Bill’s payment method.

S4. Charging process

Mark arrived at the charging station right on time for his quick charge reservation. He identifies the right charging column for the requested charging speed and parks near it. After getting out of the car and opening the app he places his NFC enabled phone on the reader marked on the charging column. The CPMS validates the reservation and unlocks the charging socket to which Mark plugs the car to before leaving for the bar. When the booked time-frame is up the eMSP app notifies Mark that his reservation ended and to go retrieve his car to which he goes. He unplugs it and get’s in to drive home; on his way the payment is processed and receives a notification with the total charging cost.

S5. Missed reservation

Warren had a reservation for a charge at 11:00 am but he forgot about it. After 15 minutes of delay he receives a notification on his eMSP app that his reservation time is up and that his reservation fee is not refoundable.

S6. CPO employee manual override

Silvio, the charging station operator, has received directives to start buying greener energy. He overrides the automatic decision of the CMPS from his terminal, he chooses from a list of DSOs the most convenient one that utilizes green energy and, since the batteries of the chargin station are almost empty, to also fully charge them.

ALTRO

Product functions

Here we include the most important features of both eMSPs and CPMSs.

Booking of a timeframe

A booking can be performed either for the immediate future or later. The first one is based upon the fact that a user might need to charge his vehicle immediately and thus is searching for a place nearby to book a timeframe. The software shows a map centered in his current position with each charging station signaled by a different color with respect to the maximum charging rate available at the current time and a special mark for those who are providing a limited time special offer. The user is able to look for and select the one that most suits his needs and book a charge by selecting the arrival, residence time and charging speed. In the case that he wants to book a charge for the future, the map also has the possibility to search for specific locations or charging stations. When the research string is submitted the map moves to the new location and shows the charging stations nearby with the same iconography as stated before. The user is now able to select arrival date and time, charging duration and charging rate.

In both cases after the choosen timeframe is submitted and confirmed by the CPMS a small fee for the bookin is required. When the payment is finalized the reservation is effectively confirmed.

Charging a vehicle

After the user has reached the charging station and identified a suitable charging column for his booked charging speed, he approaches it and through the app confirms his arrival through a NFC reader or by inserting a one time key displayed on the column directly on his phone. After confirmation, based on the timeframe duration and chargin rate the CPMS calculates the maximum energy that the charge should consume and processes the payment through eMSP. If the payment succedes the socket is freed and the user has 1 minute to plug the car in. He then can leave and the CPMS takes control of the chargin process by monitoring power consumption and vehicle’s battery level. After the timeframe is up or the vehicle is fully charged the system notifies the user to unplug the car and leave the charging column free. The chaging bill of the actual consumed enrgy is then processed by the eMSP and the difference, if any, is refounded to the user which then gets notified of the final cost. The user is also able to leave early by simply unplugging the vehicle. When the car is unplugged the user must leave in five

minutes and the remaining time of the booked timeframe is rendered available for other users to reserve.

Power management

One of the most critical requirements of the CMPS is to manage the power input and output. For this it is capable to monitor the battery packs level and decide smartly from where to acquire power or whether to use the stored energy to provide competitive costs despite an increase in general DSO costs. In order to to this the CPMS periodically (hourly) checks the DSO prices and if a better than the current provider is found a new contract is stipulated. The batteries level are also checked and if the battery level is low and it’s currently daytime, only if the current DSO price is lower or equal than the energy cost inside the battery, than they are charged. Otherwhise if it’s night, so, the price of energy is lower than the daytime one, batteries should be charged to full.

Eventually some discounts are promoted to the public. When a new vehicle is plugged the system checks battery levels If battery are not low and the price of energy stored in battery is lower than the actual DSO price the vehicle will be charged using battery energy otherwhise it is charged through the DSO.

User characteristics

The following three actors are considered in the eMSP and CPMS systems:

- Unregistered customer
  A user that owns an electric vehicle and wants to start using the eMSP system services
- CPO employee
  An employee with given credentials to access the CPMS system which is able to take decisions about the charging stations
- Customer
  A registered user which necessitates to use the app to charge his vehicle

Assumptions dependencies and constraints

Domain assumptions

Assumption	Description
D1	During the night hours energy is less expensive
D2	Inside charging areas there is free WiFi (in order to avoid low signal problems)
D3	After a vehicle reserved timeframe finishes the charging socket is immediately freed
D4	The device used by the CPO employee has already the software installed and ready for use
D5	There exists an API that the CPMS can use to comunicate with DSOs
D6	An API that allows to manage battery pack and retrieve information about its status exists
D7	An API that allows to manage charging columns and retrieve information about its status exists
D8	An API that allows to manage power switcher and retrieve information about its status exists
D9	An API that allows eMPS to obtain a list of CS owned by a CPO exists.
D10	There exist an API that manages payments on behalf of the eMSP
D11	

Specific requirements

External interface requirements

User interfaces

The user interface of eMSP is a phone app available on both Android and iOS which uses a simple and intuitive graphical interface. It should be as easy to use as possible, regardless of the technical background of the user.

The user interface for CPO employees should be available only for laptops and desktops since it would be used only by trained personnel in the work enviroment. It should be made professional but intuitive so that training would be easy to perform.

Hardware interfaces

For the eMSP the only hardware necessary should be a phone with either an Android or iOS operating system and, for added functionality, the presence of NFC and GPS.

The CPMS system has:

- on the charging columns a display for the one time keys, and the different sockets with respective power output sensors
- on the battery packs, sensors used to comunicate power levels and manage charging
- inside an employee reserved area a space with a computer capable of running the CPMS software for CPO employees

Communication interfaces

Many of the functionalities offered by the system relies on communication with other services. The communication is either of the type where the CPMS or eMSP communicates with external services, or where CPMS and eMSP exchange informations/request between each other. Specifically, there are seven different interfaces that CPMS and eMSP utilize, possibly through Web APIs. Below we list the required function offered by each interface. Note that the description of each interface are assumptions made in this project.

- Retrival of data from battery pack
  Each battery pack inside the charging area is equipped with an IoT device that is capable to provide informations about the battery level and input/output power delivery
- Retrival of data from charging column
  Each charging column in the charging area is able to provide information about the number of unplugged sockets and the power consumption of each one, the charging percentage of the vehicle attached to the socket. It is also able to read the NFC and provide the CPMS with the token read and display the one-time-use code supplied by the CPMS
- Information exchange with power switcher
  The power switcher of the charging area is able to receive directives on how to deliver power to the different sockets and provide information about which kind of energy source each one is utilizing

- Booking information exchange between CPMS and eMSP
  For the eMSP app to be able to provide a booking service it’s necessary that the CPMS communicates which timeframes of a specific dates are free and the eMSP communicates which timeframes must be reserved for a user.
- Positional information of charging stations
  The CPO exposes and API that is able to answer with the geolocation of all it’s charging stations to the eMSP so that it can display to the user the correct map with all neighboring charging areas of the different CPOs
- Retrival of data from DSO
  The CPMS makes use of the DSOs interface to retrieve data about price and availability so that it can decide on which one to use
- Exchange of information with payment service
  Both eMSP and CPMS must check and ask for payments to be performed with the different payment services so that users get correctly billed for the obtained service

Functional requirements

Requirements	Description
R1	eMSP shall allow users to sign up to the eMPS service
R2	eMSP shall allow registered users to sign in
R3	eMSP shall allow users to link a payment method to his account
R4	eMSP must verify users payment methods
R5	eMSP must verify users email upon registration
R6	eMSP shall allow registered users to make a reservation to a specific CS at a specific date
R7	eMSP must show registered users correct positional data and nearby charging stations
R8	eMSP shall allow registered users to select an area in which to search for charging stations
R9	eMSP must be able to order payments from given payment methods
R10	eMSP must notify registered users of missed reservations
R11	eMSP must notify registered users of the final billing for the received service

Requirements	Description
R12	eMSP must notify registered users when the booked timeframe is up
R13	eMSP must notify the user when the CPMS sends a charge complete response
R14	eMSP must notify CPMS of code to accept through NFC
R15	eMSP must notify CPMS of the one-time-token inserted through the app
R16	CPMS must be able to allow CPO employees to manually decide how to manage battery and net power
R17	CPMS must be able to allow CPO employees to manually decide which DSO buy energy from
R18	CPMS must be able to automatically decide how to manage its own battery and net power
R19	CPMS must be able to automatically decide which DSO buy energy from
R20	CPMS must be able to answer eMSP requests for free timeframes and relative prices
R21	CPMS must allow a user to charge it’s vehicle if and only if a timeframe has been reserved
R22	CPMS must be able to manage reservations through a DBMS
R23	CPMS must be able to authorize users with reserved timeframes
R24	CPMS must be able to interact with all APIs that manage charging stations components
R25	CPMS must notify eMSP when the vehicle of a user is fully charged
R26	CPMS must be able to notify user of exceptions
R27	CPMS must be able to notify user of successful actions
R28	eMSP must be able to notify user of exceptions
R29	eMSP must be able to notify user of successful actions
R30	CPMS bust be able to notify eMSP of exceptions
R31	CPMS bust be able to notify eMSP of successful actions
R32	eMSP must be able to retrieve charging stations locations and prices from a CPO list
R33	CPMS must notify eMSP of final power bill

Mapping on Goals

Goal	Domain assumption	Requirement
G1 pay for charge	D10, D2	R2, R3, R4, R9, R11, R28, R29, R30, R31, R33
G2 book charge	D2, D3, D9	R2, R3, R4, R6, R7, R8, R9, R20, R22, R28, R29, R30, R31, R32
G3 register	-	R1, R3, R4, R5, R28, R29
G4 price and offers	-	R2, R7, R8, R16, R17, R18, R19, R20, R24, R28, R29, R32
G5 charging proc	D2, D3, D6, D7,D8	R2, R3, R4, R6, R12, R13, R14, R15, R16, R18, R21, R23, R24, R25, R28, R29
G6		
G7		
G8		