RASD e-Mall Hints

1.1 Purpose

e-Mall wants to expand the electric charging infrastructure with the means of realizing a world-wide network which fullly connects all the actors taking place in the charging processes. This is achieved by making all the back-end operations transparent to the everyday user which is supported in the charging process. Incentivize the electric mobility.

- limit the carbon footprint of our urban and sub-urban mobility needs by:
  - having a platform/app/system (eMSP) that allows monitoring electric mobility with the use of CPMS in order to optimize its services such as:
    - knowing where to charge the e-vehicle (locate charging stations owned and managed by CPOs)
    - planning charging processes in a way to limit constraints on our daily schedule
    - choose from various charging possibilities based on special offers set by various external energy providers (DSO)

1.1.1 Goals (WP <==> G)

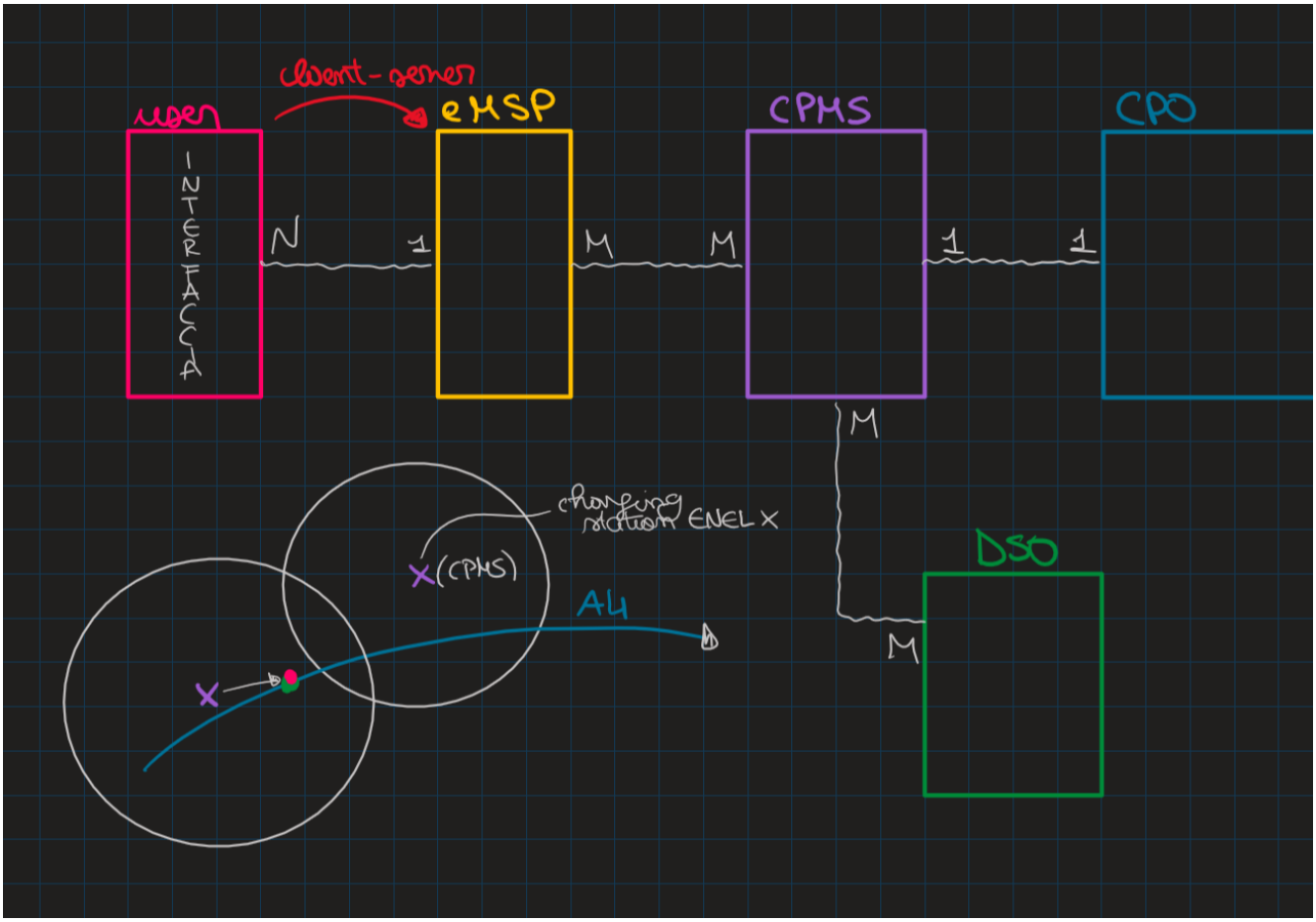
Sub-system = eMSP (e-Mobility Service Provider)
Sub-system = CPMS (Charge Point Management System)

- G1: The eMSP should allow the user to obtain information about the charging stations.
- G2: The eMSP should allow the user to book a charge in a certain charging station before the vehicle runs out of energy.
- G3: The eMSP should allow the user to manage the charging process (from its start to the payment) once he/she reaches the charging point.
- G4: The eMSP should give the possibility to the user to receive updates on the charging process.
- G5: The eMSP should show the user the optimized path to the destination based on the residual energy of the vehicle.
- G6: The CPMS should be able to handle the acquisition of energy from external third party providers (DSO).
- G7: The CPMS should be able to gather information about the DSOs' current price of energy.
- G8: The CPMS should store informations about the location, external and internal status of a charing stations. ("external/internal").
- G9: The CPMS should provide energy according to the type of socket chosen by the user.
- G10: The CPMS should decide where to get energy from (station batteries, DOS, mix).

1.2 Scope

ACTORS:

- **Registered USER**
- **e-MSP** (e-Mobility Service Provider) is the remote sub-system (passive server) called by the user which gathers informations by contacting CMPSs through uniform APIs.
  -which uses the exposed interfaces by CMPSs and used by users on their own local app instances.
- **CPO** (e.g. ENEL X/IONIX) (Charging Point Operator) administrated through CPMS and deployed through:
  - Charging stations
- **CPMS** (Charge Point Management System) administrates CPO's IT infrastructure by managing the relationship between the energy acquired by a DSO and the charging vehicle connected to the charging station's sockets.
- **DSO** (Distribution System Operators): external third party energy providers.



1.2.1 World Phenomena

- WP1: User's e-vehicle is running out of energy.
- WP2: User physically looks for an available charging station.
- WP3: Charging station's socket doesn't work properly.
- WP4: Catastrofic environmental disasters (earthquakes, avalanches, hurricanes, floods, heavy storms).
- WP5: Accidental damages occured on the infrastructures.
- WP6: User prepares the vehicle (parks, open the charging socket) for the charing process.
- WP7: There is a fully geographical network coverage and connectivity to the system is ensured.

1.2.2 Shared Phenomena

#todo TODO: system = sub-system + sub-system or not
#todo Insert new Controller/Observer columns
SP1: The charging station doesn't provide the guaranteed services presented by the eMSP. (Discrepancies between the real-world situations and the services CPO intends to guarantee)
SP2: The user looks up for a nearby charging station.
SP3: The user chooses the best charging station from the available ones based on its preferences.
SP4: The system shows the user informations about the charging process.
SP5: The system shows the user several payment methods.
SP6: The system automatically decides from which DSO energy should be acquired.

1.3 Definitions, acronyms, abbreviations

1.3.1 Definitions

#todo

1.3.2 Acronyms and abbreviations

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
e-MSP - e-Mobility Service Provider
CPO - Charging Point Operator
CPMS - Charge Point Management System
DSO - Distribution System Operator
API - Application Programming Interface
VIN - Vehicle Identification Number

1.4 Reference Documents

The specification document: "Assignment RDD AY 2022-2023_v3.pdf"

1.5 Document Structure

#todo ..

2 Overall Description

2.1 Product perspective

2.1.1 Scenarios

1. Unregistered user wants to use e-Mall
    1. Registering by adding:
    1. Personal information
    2. Associating Vehicle : e-Mall System with VIN (assumption:

integration with the Department of Motor Vehicle databases for person:vehicle association AND integration with Car Manufacturer's database for vehicle's real time data and details)
3. Access its profile and consult next charges

Description:

The user Alice has just bought an electric car and wants to use e-Mall. She can only do so if she is registered, so through the index page of the corresponding site she fills the registration module by entering her personal information and vehicle details. e-Mall is integrated with the DMV's database to confirm the association between vehicle and owner, and with vehicle manufacturers' database to associate the vehicle owner with the vehicle details. After registering, Alice can finally use all the services offered by e-Mall: searching for charging stations, booking charging stations, scheduling trips and managing the charging process. Every time she uses the app data will be updated so that she is in control of any information, directly from the app. Now Alice can get in her car and make her first recharge thanks to e-Mall.

2. **User looking up for charging stations (+filters)**

    1. User wants to know the position of charging stations so selects SEARCH section of APP
        1. based on current location
        2. at a certain position

2. Filtering and Sorting (ASC, DESC)
    1. range of distance from current or remote position
    2. range of price
    3. preferred CPOs
    4. preferred payment methods
    5. availability of sockets
    6. type of sockets
    7. special offers (range of sales percentage)

    Description:

    The user Cassandra is at home which is 10km away from the main town. She wants to charge her electric vehicle so she accesses e-Mall app from her smartphone by using her fingerprint. From the Home Page she selects the Searching Page to which she's being redirected. She can now choose to either let the system find the most convenient charging station based on the information about the vehicle's status (park location, battery level) acquired by e-Mall or to insert preferences (range of distance from current or remote position, range of price, preferred CPOs, preferred payment methods, availability of sockets, type of sockets, special offers) about the searching operation on her own. Cassandra wants to go get some groceries from the town centre so she inserts the destination of the grocery shop and wants to retrieve the most economic (range of price) nearby charging stations within 200m from it (distance range filter). The system provides a list of three charging stations and Cassandra decides to consult them from the map point

of view. Two of them are availble but characterized by a slightly high cost, meanwhile the last one is occupied but the system estimates that the charging process is about to end within the next 15 minutes, exactly the time Cassandra needs to reach the location. Furthermore, this last charging station is managed by a CPO providing a special offer lasting for other few hours. Cassandra reasons about the next step.

3. User booking a charge

1. Selecting a certain charging station from the list provided
2. Reads infos about the charging station
2. Selects a timestamp for the booking and make a reservation
3. Requires booking
4. Receiving ack for the booking or notifying a failure (overlapping of the timestamp with other events in the calendar) and requiring other timestamps.

Description:

The user Mario notices that the car battery is not fully charged, so he decides to charge it. After searching for the charging stations nearest to him based on the search criteria (filters) entered, he chooses one, thus obtaining more information regarding the charging station (available sockets, price, special offer,...). If the information convinces him, then either he selects a charging timestamp and makes the reservation, or he selects the battery level he wants to achieve with that charging and makes the reservation. He clicks on the

BOOK button, and if he receives a notification of successful booking, this means that he can reach the charging station and the book is added to the user's calendar, otherwise, he will receive a notification with the error that occurred (eg. at that time on his calendar he has an appointment so you have an overlap), in which case Mario will have to choose a different timestamp.

4. **User scheduling a travel**

1. Select TRAVEL section of the APP
2. Inserts destination and time of travelling.
3. System calculates the best path using certain algos (e.g.Dijkstra, Bellman-Ford) and possibly based on battery level if requested by the user and shows it to the user
4. User confirms or declines the proposal.

Description:

The user Vittorino has to travel from Milan to Budapest for a business trip the next Monday. He is registered to the e-Mall app which has updated information about Europe's most recent electric mobility infrastructures. From Home Page he clicks on the Travel Button which immediately redirects him to the Travel Page. Vittorino inserts the destination he wants to reach, the day and time by which he needs to arrive and suggests the app to assume the vehicle will be fully charged by the time he leaves. The app calculates two convienent routes (using algorithms like Dijkstra or Bellman-Ford) Vittorino could choose from based on the time he wants do

start the trip but also detects an overlap between the trip time and a certain event inserted onto the user's calendar. A notification is showed to Vittorino which clearly forgot to reschedule the event on the calendar and decides to continue to choose from the routes proposed anyway, ignoring the notification. Later on he will reschedule his event.

5. **User's vehicle is running out of battery**

   1. System detects that battery is running out of ernergy
   2. System notifies the user in order to go an charge the vehicle suggesting the most convenient one.

   Description:

   Mrs. Braz is on her way to Portugal to visit her family. After a few hours of driving, Mrs. Braz is focused on the road and does not notice that her car's battery is getting low, so having arrived at the remaining 10% the system recognizes that the battery is getting low and approaching zero, so it searches for the most convenient charging stations close to the car's current location, and sends a notification to Mrs. Braz advising her to recharge the vehicle at the recommended charging station as soon as possible.

6. **Charging process executing (failure managements)**

   1. User reaches the charging station
   2. User takes the proper socket and connects it to the vehicle
   3. User selects the percentage to achieve
   4. User selects Start on APP to start the charging process and

selects target battery level or duration of the charge.
5. Different sources (battery, direct (DSO deciding), mix (deciding), deciding DSO)

Description:

The user Nicola has booked a charge at a charging station through e-Mall. He reaches the charging stations, parks his car, and connects the socket. Once he connects the socket he receives a notification with the details of his reservation and with the option to start the process. He chooses to start the process and in real time, both from the app and on the display of the charging point, he receives details about the status of the charging that is taking place according to the strategy defined by the CPMS (take advantage of the battery inside the charging point, or use an external DSO). As soon as it reaches 100%, charging is complete and Nicola can disconnect the socket and leave the area, after having payed for the service. However, if some unforeseen event happens during the charging process (the socket is accidentally disconnected, the vehicle's motor is turned on, or the charging point has problems), the charging is suspended and details of the problem appear on his own device with options to fix or report what happened to the CPO, or even stop the process and pay only for how much energy was dispensed. Nicola is very pleased with such a smart process and is looking forward to charging his vehicle again by using e-Mall application.

7. **Payment**
    1. Several methods (+ Apple/Google/Samsung payments)
    2. 3DS secured methods

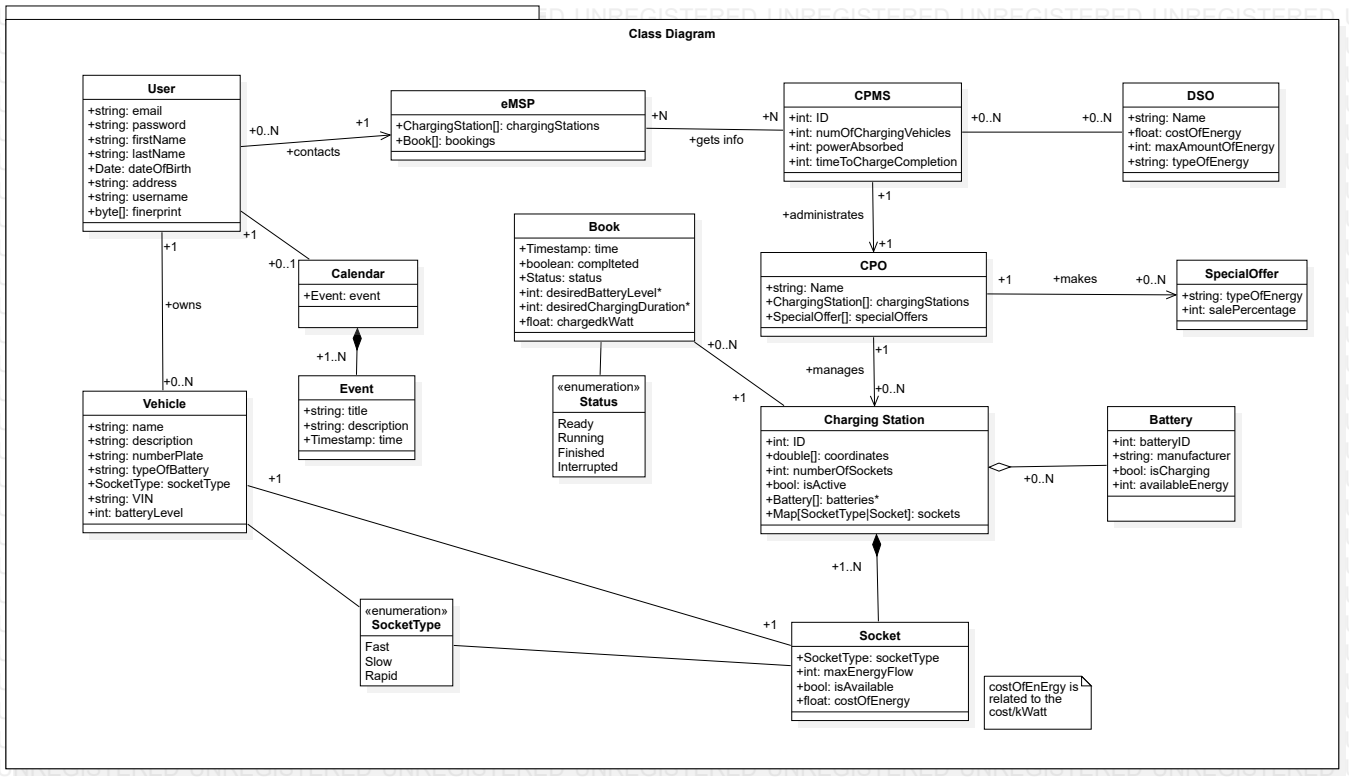
    Description:

    The user Stefan is taking a walk while he is waiting for his vehicle to be fully charged at the charging station. Suddenly his phone rings and he notices a notification from e-Mall app has been received. Stefan accesses the app by using his fingerprint. He then realizes his vehicle is up about to reach the desired battery level decided at the booking phase and decides to reach the charging station. Finally continues using the app and selects one from the payment methods provided, all supported by 3DS secure methods. He waits for the transaction to be completed but a failure occurs and the app suggests to choose another payment method. He then realized his card just expired two days ago and decides to use Paypal in order to complete the payment. Once the transaction has finally completed the app suggests Stefan to disconnect the socket and leave as soon as possible as another charging process is about to get started within the next 10 minutes at that location.

2.1.2 Class Diagram

The below class diagram shows the system's main objects class diagram.
Note: The attributes of the objects are set as public even if some of them should be assigned as private. Setters and Getters

implementation must be provided in order to set attributes' values and retrieve them as pleased.



2.1.3 State Diagrams

#todo Scenario - state diagram to be scheduled

2.2 Product functions

In this section we present the main functionalities introduced by e-Mall.

2.2.1 Identification of the nearby charging points

2.2.2 Efficient and optimized charging station's booking system

2.2.3 Interoperability and connectivity ensured for all the Infotainment systems (cars manufacturers)

2.2.4 Fault tollerance towards operations.

2.2.5 Sharing knowledge through the network among participants

2.2.6 Collect and share information for Data Analytics purposes

2.3 User characteristics

1. Unregistered user
   A certain user needs to register to the system in order to use the functionalities provided.
2. Registered user
   A registered user who is able to improve its electric mobility routine by using the functionalities provided by the system such as looking for a charging station from anywhere and at any time.

2.4 Assumptions, dependencies, constraints

2.4.1 Domain assumptions

- D1: There exist uniform APIs allowing the user to interact through the eMSP with one or multiple CPOs.
- D2: There exist uniform APIs allowing the CPOs to interact with one or multiple DSOs through the CPMS.
- D3: The user inserts valid data when performing the registering phase.
- D4: The user approaches the charging station once he/she has book a charge within a certain time.
- D5: The user interacts with the charging station by following the instructions attached to the charging station.
- D6: The user interacts with eMSP by following the guideline provided by the eMSP.
- D7: Absence of inconsistencies between the a-priori defined energy flow offered by the DSO and the actual one used to charge the vehicle.
- D8: The user pays the booked service after the charging process has finished.
- D9: The user schedules a travel to a timestamp greater than the current one.
- D10: The system works properly in absence of inconvenient and unexpected events during travel.
- D11: The user frees the charging station once the charging process has finished.

  #todo

3 Specific Requirements

3.1 External Interface Requirements

3.2 Functional Requirements

3.2.1 Use case diagrams

1. User registration
2. User login
3. Charging station look up
4. Charging station book
5. Charging process
6. Payment

3.2.2 Use case descriptions

1. User registration
    1. Actor: Unregistered user
    2. Entry condition:
        1. The user does not have an account and is on the index page of the application.
    3. Event flow:
        1. The user clicks on "Create Account"
        2. The user inserts his/her personal data: first and last name, date of birth, place of residence, eMail address, username, password and telephone number (`#todo` update the class diagram).

3. The user can also enter biometric data such as fingerprint.
4. The user enters an identification document to confirm his/her identity (ID card or driver's license) or uses a digital identity provider such as SPID or CIE.
5. The user enters the VIN of the vehicle(s) he wants to associate with his profile. By querying the DMV (Deparment of Motor Vehicle) dataset the system will confirm whether that vehicle is owned by the user or not.
6. If confirmation occurs, the vehicle manufacturer's dataset is also queried to associate the vehicle's details with the user, which will be updated in real time (or at least periodically).
7. e-Mall processes the information, verifies it, and returns a successful transaction message to the user and redirects it to the Home Page.
8. The user can remember the credentials for future access.

4. Exit condition:
    1. The account is created.
5. Exceptions:
    1. The user did not enter all the required data.
    2. The user provided invalid data.
    3. The query of the database of the civil DMV and/or the vehicle manufacturer was unsuccessful.

In all cases the user receives a notification.

2. User login

1. Actor: Registered User
2. Entry condition: User is registered, not logged in and on the e-Mall's index page.
3. Event flow:
    1. User presses login button.
    2. User insert either email address and password or uses fingerprint to access the application.
    3. User submits.
    4. e-Mall processes the information and displays a success message after having checked .
4. Exit condition:
    1. User is logged in to e-Mall.
5. Exceptions:
    1. User does not enter password or email before submitting.
    2. User insert invalid email/password combination.
    3. User does not have fingerprint saved.
    4. User uses invalid fingerprint.

3. Charging station look up

1. Actor: Registered user

2. Entry conditions: The user is registered, logged in to the e-Mall app and on the Home Page.
3. Event flow:
    1. The user presses the Search button which redirects the user to the Searching Page.
    2. The user can either directly look up for the nearest charing stations using default preferences imposed by the system itself based on the information acquired by the calendar and the vehicle's Infotainment system by selecting Fast Search (e.g: battery status) or insert his own current preferences to filter the search. (further detailed infos in the corrisponding scenario).
    3. The system looks up for the charging stations based on the searching preferences and returns a list of them. The list shows an overview station by station and can contain available charging stations which are waiting to be booked or even occupied charging station characterized by imminent ending charing process. Both of the types can be booked. Charging stations can also be visualized from a map view.
    4. Based on the user's choice, he/she can select a certain charging station from the provided list in order to view futher detailed information about it.
4. Exit condition:

    1. The user selects Exit/Home Page from the Searching Page.

2. Search operation succedes and an the page is updated with requested data.
Any of the above operations leads to the exit condition.

5. Exceptions:
1. The user doesn't insert all mandatory data for the searching filters.
2. The user selects an invalid data for certain mandatory fields.
If any of the above occurs, e-Mall shows the user a notification error message and reccomends to retry.

4. Charging station book

1. Actor: Registered User
2. Entry condition: A registered user, logged on to e-Mall, and about to look for a charging station.
3. Event Flow:
    1. The user selects a certain charging station from the list provided or chooses it from the map view.
    2. Reads informations about the charging station selected.
    3. Selects either a timestamp or the target level of battery and make a reservation for the charging station.
    4. Press button BOOK.
    5. Receives ack for the booking or nack in case of failure (eg. overlapping of the timestamp with other

events in the calendar) and the system requires other timestamp to be inserted.

4. Exit condition:
    1. An ack is received and a book is scheduled.
5. Exceptions:
    1. User unauthorized to book.
    2. Overlapping with other events from the user's calendar.
    3. Concurrent book operations between several different users on the same charging station within the same range of time.

5. **Charging process**

    1. Actor: Registered user
    2. Entry condition:
        1. The user has arrived at the charging station, inserts the socket, and receives a notification on the e-Mall app in order to consent the start of the charging process.
    3. Event flow:
        1. The user receives the notification with a reminder to their reservation details.
        2. The user starts charging by clicking on the "Start Charging" button on the app.
        3. Energy is delivered according to the strategy dynamically defined by the CPMS (the energy source

can be a DSO, or the internal battery if present, or both) which will impact on the duration of the recharge.

4. Charging stops when the time or threshold limits (desired battery level) set by the user are reached.
5. The user can monitor the charging status in real time either from the app, the vehicle's Infotainment system or the display located at the charging station.
6. The user receives a notification that the recharge is completed.

4. Exit condition:
    1. The car battery has been recharged as requested by the user.
5. Exceptions:
    1. The socket is suddenly plugged out from the vehicle.
    2. The user turns on the vehicle's motor.
    3. User suddenly stops the charging process before reaching the desired battery level/time from the app.

       In all cases, charging is suspended and the user is notified with options to fix the problem (if within his or her scope), send a report to the CPO, or stop charging definitely.

6. **Payment**

1. Actor: Registered user
2. Entry conditions:
    1. The user is registered, logged on to e-Mall, the charging process has finished and the system sent him/her a notification.
3. Event flow:
    1. The user receives a notification about the completion of the charging process of the vehicle and is invited to:
        - reach the vehicle
        - pay for the service
          The above activities can be executed on the prefered sequence.
        - disconnect the socket from the vehicle and reconnect it to the charging station
    2. The user confirms that the notification has been received and the system provides the user with different payment methods:
        1. Paypal
        2. Credit/debit card
        3. Bank transfer
        4. Several payment apps: e.g Google Pay, Samsung Pay, etc
    3. The user provides payment based on the chosen payment method.
4. Exit condition:

1. Payment transaction committment is received by the system and notified to the user.

5. Exceptions:
    1. The user reached the card's daily limit.
    2. Fake fraudulent purchase detection.
    3. Card/Paypal account/Bank coordinates are invalid.
    4. Payment transaction rolled back.
       If any of the above operations occurs the payment operation starts from scratch again.

3.2.3 Requirements

- R1: The eMSP should allow an unregistered user to register an account.
- R2: The eMSP should allow a registered user to look for a charging station.
- R3: The eMSP should be able to access the registered user's details (vehicle's Infotainment's system, user's calendar).
- R4: The eMSP should be able to retrieve a list of the nearby charging stations based on the current position of the user's vehicle.
- R5: The eMSP should be able to show the registered user the list of the nearby charging stations.
- R6.0: The eMSP should allow the registered user to select a charging station from the list of nearby charging stations.
- R6.1: The eMSP should be able to detect if the battery status is going below a fixed threshold.

- R6.2: The eMSP should automatically show the user a list of nearby charging stations when the battery threshold is overpassed.
- R7: The eMSP should allow the registered user to book a charge at the selected charging station.
- R8: The eMSP should have access to the registered user's infotainment system.
- R9: The eMSP should allow the user to insert filters on the looking up operation of the charging stations.
- R10: The eMSP should allow the user to get information about the charging station selected (sockets available, type of sockets, costs, special prices).
- R11: The CPMS should allow the CPO to choose the DSOs from which to acquire energy.
- R12: The CPMS should allow the CPO to choose either to directly distribute the energy acquired or to store it into batteries collocated at charging stations.
- R13: The CPMS should allow the user to monitor the information about the charging process (price, energy flux rate, estimated remaining time, battery's charging status).
- R14: The CPMS should manage payment processes with different payment methods, responsible for the transactions.
- R15: The eMSP should allow the user to decide the desired battery level at the end of the charging process or the duration of the charging process.
- R16: The CPMS should be able to dynamically calculate the residual time for the charging process.

HINTS:

- User can insert preferencies on the range of the charging stations's look up but the system can scale it based to the vehicle's remaining battery level.
- User decide where to go by inserting a destination and the system proactively calculates the most convenient path by individualizing the possible charging stations on it.

3.2.4 Mapping on Goals

G1 - D1, D3, D6 - R1, R2, R4, R5, R9, R10, R16
G2 - D1, D3, D4, D6, D9 - R1, R2, R3, R4, R6.0, R7, R9, R10, R15, R16
G3 - D1, D2, D5, D7, D8, D10, D11 - R11, R12, R13, R14
G4 - D1, D3, D5, D6, D7, D10 - R1, R13, R14, R16
G5 - D1, D3, D10 - R1, R2, R4, R5, R6.0, R6.1, R6.2, R7, R8, R9, R10
G6 - D2, D7, D10 - R11, R12
G7 - D2 - R10, R11
G8 - D1, D4 - R10, R13
G9 - D2, D7 - R11
G10 - D2, D7 - R11, R12