



Requirement Analysis and Specification Document

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Contents

1	Introduction	3
1.1	Description of the given problem	3
1.2	Actual system	3
1.3	Scope	3
1.4	Actors	3
1.5	Goals	3
1.6	Domain properties	8
1.7	Glossary	8
1.8	Assumptions	10
1.9	Constrains	10
1.9.1	Regulatory policies	10
1.9.2	Hardware limitations	10
1.9.3	Interfaces to other applications	11
1.10	Proposed system	11
1.11	Identifying Stakeholders	11
1.12	Reference documents	11
2	Actors Identifying	12
3	Requirements	13
3.1	Functional requirements	13
3.2	Non-functional requirements	16
3.2.1	User interface	16
4	Scenario identifying	20
4.1	Scenario 1: Registration from the website	20
4.2	Scenario 1: Registration from the mobile application	20
4.3	Scenario 2: Login in the app	20
4.4	Scenario 3: Reserving and using a car	20
4.5	Scenario 4: Parking and regular fees	21
4.6	Scenario 5: Power grid and discounted fees	21
4.7	Scenario 6: Parking and sanctioned fees	21
4.8	Scenario 7: Lost reservation	21
4.9	Scenario 8: Two passengers + special parking area	21
4.10	Scenario 9: Money saving option	22
4.11	Scenario #: Left the city	22
4.12	Scenario #: Recover a car with user input	22
4.13	Scenario #: Recover a car without user input	22
4.14	Scenario #: User breaking the law	22
5	UML models	23
5.1	Use case diagram	23
5.1.1	Use case 1: Reserve a car	23
5.1.2	Use case 2: Park in known safe area	24

5.1.3	Use case 3: Park with money saving option	25
5.1.4	Use case 4: Park in a recharging area	26
5.1.5	Use case 5: Retrieve a car with user input	26
5.1.6	Use case 6: Manually assist a parked car	28
5.1.7	Use case 7: Manage infractions	29
5.1.8	Use case 8: Assist user after an accident	29
5.1.9	Use case 9: Assist a user on-site after a car breakdown . .	30
5.1.10	Use case 10: Assist a user with a not on-site reparation .	32
6	Alloy modeling	33
7	Appendix	34
7.1	Used tools	34
7.2	Hours of work	34

1 Introduction

1.1 Description of the given problem

The system we are going to develop is a car-sharing service called *PowerEnJoy*, based on mobile application and which has a website. The system allows users to locate and reserve a car to drive in their geographical region using mobile application. Geographical region is identified using GPS on user's smartphone, he can also insert it manually. User can drive a car only inside one chosen geographical region. People in the system are not considered as registered until they fill an online form on the website or on the main page of the mobile application and until their driving license are not checked by the system as valid ones.

The main purpose of the system is to be efficient, reliable and easy to use to fulfill the will of users and the customer.

1.2 Actual system

There is nothing created until now, and we suppose that we have to create the entire application, depending only on the problem given by the customer.

1.3 Scope

1.4 Actors

- Guest: all guests can only see the login page of the application or of the website, where they can complete the registration form to be able to login from mobile application as registered users.
- Registered User: after logging in to the system users can "use" (change this word) the application, where they can see map with available cars, reserve one and get notifications from the system and also can see their profile and make some changes in it.

1.5 Goals

1. The system allows guests to register; to complete the registration procedure the system sends a password to the guest as an access key.
2. The system should enable a registered user to find the location of an available car near a given location, reserve it and use it for a predefined amount of money per minute.
3. The system should encourage good user behaviour and discourage bad behaviour through the application of discounts and sanctions to the fee per minute.

4. The system should aid the people working at PowerEnJoy in the execution of their jobs by keeping a channel of communication open between them and the users for emergencies and by keeping track of all activities of its cars.
1. The system allows guests to register; to complete the registration procedure the system sends a password to the guest as an access key.
2. The system should enable a registered user to find the location of an available car near a given location, reserve it and use it for a predefined amount of money per minute.
3. The system should be able to locate the users once they have given their permission.
4. The system should keep track of every activity within the cars of PowerEnJoy, by means of sensors and tracking devices, i.e. location, battery charge, health status, number of passengers.
5. The system should be able to command remotely and automatically some of the features of the cars, for example locking and unlocking the doors.
6. The system should encourage good user behaviour and discourage bad behaviour through the application of discounts and sanctions to the fee per minute.
7. The system keeps a channel of communication open between the users and the administrators of the system in case of emergencies.
1. The system allows guests to register; to complete the registration procedure the system sends a password to the guest as an access key.
2. The system should be able to locate the users once they have given their permission.
3. The system should enable a registered user to find the location of an available car within a certain distance from the user's location or from a specified address.
4. The system enables user to reserve a single available car in a certain geographical region for one hour before the user picks it up. If the car is not picked up by that time, the reservation expires, the system tags this car as available again and it charges the user a fine of 1 EUR.
5. The system should keep track of every activity within the cars of PowerEnJoy, by means of sensors and tracking devices, i.e. location, battery charge, accident detection, number of passengers.
6. The system should be able to command remotely and automatically some of the features of the cars, for example locking and unlocking the doors.

7. The system charges the user for a predefined amount of money per minute. A screen on the car notifies the user of the current charges.
 8. The system starts charging the user as soon as the car ignites. It stops charging them when the car is parked in a safe area and the user exits the car. The user must confirm the operation, otherwise the system keeps charging them.
 9. The system should encourage good user behaviour and discourage bad behaviour through the application of discounts and sanctions to the fee per minute.
 10. The system keeps a channel of communication open between the users and the administrators of the system in case of emergencies.
1. The system allows guests to register; to complete the registration procedure the system sends a password to the guest as an access key.
 2. The system should enable a registered user to find the location of an available car within a certain distance from the user's location or from a specified address.
 3. The system enables user to reserve a single available car in a certain geographical region for one hour before the user picks it up. If the car is not picked up by that time, the reservation expires and the system tags this car as available again. The system charges the user a fine of 1 EUR.
 4. When the user tells the system that he's near the reserved car, the system unlocks the car to let the user enter.
 5. The system locks the car automatically when the user exits the car inside a safe area.
 6. The system charges the user for a predefined amount of money per minute. A screen on the car notifies the user of the current charges.
 7. The system starts charging the user as soon as the car ignites. It stops charging them when the car is parked in a safe area and the user exits the car. The user must confirm the operation, otherwise the system keeps charging them.
 8. If the user has chosen to keep being charged, the system allows them to exit and close and re-open the car through a bluetooth system.
 9. The set of safe parking areas is pre-defined by the management system.
 10. The system allows the user to earn a discount to the charge of the current ride if:
 - There are at least two other passengers in the car.

- The car is returned by the user with more than 50% of power charge.
 - The user returns their car to a recharging safe area and plugs it into the power grid.
11. The system applies a sanction to the charge of the current ride if:
 - The car is returned in a safe area at more than 3 km from the nearest recharging safe area.
 - The car is returned with less than 20% of power charge.
 12. The system provides an option (*money saving*) to get information about the best safe area where the user can leave the car. The best safe area ensures a uniform distribution of cars among the city and takes into account the destination and the nature of the safe areas (recharging or not).
 13. In *money saving option*, the system applies a certain discount for the current ride if the car is returned in the suggested safe area.
 14. Cars returned with less than 20% of power charge are recharged within 1 day.
- **G1** Guest are able to register to the System. Each guest must fill a profile to become a user.
 - **G2** To complete the procedure of registration the system sends a password to the guest as an access key.
 - **G3** The system should enable a registered user to find the location of an available car within a certain distance from the user's location or from a specified address.
 - **G4** The system enables user to reserve a single available car in a certain geographical region for one hour before the user picks it up.
 - **G5** If the reserved car is not picked up within one hour from the reservation time, the reservation expires and the system tag this car as available. The system charges user a fee of 1 EUR.
 - **G6** When the user tells the system that he's near the reserved car, the system unlocks the car to let the user enter.
 - **G7** The system charges the user for a predefined amount of money per minute.
 - **G8** The system starts charging the user as soon as the car ignites.
 - **G9** The system stops charging the user when the car is parked in a safe area and the user exits the car. The user must confirm the operation, otherwise the system keeps charging them.

- **G10** A screen on the car notifies the user of the current charges.
- **G11** The system locks the car automatically when the user exits the car inside a safe area.
- **G12** If the user has chosen to keep being charged, the system allows them to exit and close and re-open the car through a bluetooth system.
- **G13** If the user has chosen to stop being charged, the system keeps a 10–minutes window of time when they are allowed to re-open the car if it has not already been reserved by someone else.
- **G14** The set of safe parking areas is pre–defined by the management system.
- **G15** The system allows the user to earn a 10% discount for the current ride if there are at least two other passengers in the car.
- **G16** The system applies a 20% discount on the current ride if the car is returned by the user with more than 50% of power charge.
- **G17** If a user returns a car to a recharging safe area and plugs it into the power grid, the system applies a 30% discount on his current ride.
- **G18** The system applies a 30% sanction on the current ride if the car is returned in a safe area at more than 3 km from the nearest recharging safe area.
- **G19** The system applies a 30% sanction on the current ride if the car is returned with less than 20% of power charge.
- **G20** The system provides an option (*money saving*) to get information about the best safe area where the user can leave the car. The best safe area ensures a uniform distribution of cars among the city and takes into account the destination and the nature of the safe areas (recharging or not).
- **G21** In *money saving option*, the system applies a certain discount for the current ride if the car is returned in the suggested safe area.
- **G22** Cars returned with less then 20% of power charge are recharged within 1 day.
- **G1** The system notifies the user of the final charges on their smartphone as soon as 10 minutes passes or another user reserves a car.

1.6 Domain properties

We assume that the following properties hold in the analyzed world:

- A tablet is permanently installed in every car.
- The tablet is alimented through the car and cannot be switched off.
- All cars are equipped and located with a GPS system provided by the tablet.
- All GPS systems always give the right position.
- GPS tracking is always on.
- All cars has sensors to detect the presence of passengers in each seat.
- The system is always able to tell how many people occupy a car.
- All cars are equipped with a Bluetooth system provided by the tablet.
- The Bluetooth system is always on.
-
- A user can always provide his location, either by GPS or by giving their position themselves.
- The safe areas are predefined and within the municipality of Milan.
- The payments of all services are managed by an external company, which guarantees fulfillment.
- The cars always ignite when they have more than 3% of power charge.

1.7 Glossary

User We will refer to all people who are registered to the system as 'users'. All users have personal profiles which contain the following information:

- First name;
- Family name;
- Email;
- Username;
- Password;
- Payment information; this in particular includes:
 - Credit card number;
 - Credit card expiration date;
 - CVV number.

- Driving license information; this in particular includes:
 - License number;
 - Issued date;
 - Expiration date;
 - Status.

And, optionally:

- Personal photo;
- Telephone number.

Users should be able to locate, reserve and drive the cars offered by the service.

Guest We shall call 'guests' all people who are using the interface of the system without being registered or logged in. Guests can't access any functionality of *PowerEnJoy* except for the registration process or the log in.

Parking areas Also called *Safe areas*, parking areas are predefined parking slots within the municipality that are reserved for the car-sharing system *PowerEnJoy*.

Special parking areas , or *recharging areas* are *Parking areas* that provides a plug to recharge the car. Recharging parking areas are a subset of Parking areas (parking areas *may* be recharging areas, while the contrary doesn't apply).

Reserved car We will call 'reserved car' a specific car that is booked by current user, not taken by other users, and is located in the same geographical region as him.

Available car is the car that is not reserved by other users.

Power grid

Standard price We shall call 'standard price' the price per minute charged to the user, without any discount or sanction applied.

Discount A discount is a deduction of a given percentage from the standard price. It is applied every time a user has a virtuous behavior.

Sanction A sanction is an increase of a given percentage to the standard price. It is applied every time a user has a wasteful or incorrect behavior.

Money saving option An option offered to the users by the system. The user inputs their final destination and the system indicates them the best close station where to leave the car.

1.8 Assumptions

The assignment document was unclear and ambiguous on some points of the specifications. Hence, we will make the following assumptions:

- Parking areas and special parking areas are two different things; however, common sense suggests that it isn't logical to charge users if they plug the car to the power grid in a recharging area but are not parked in a safe area. Neither it makes sense to sanction them if they park it in a safe area that is 3 km far from the power grid. Having the two areas separate would lead to the consequences above, so we decided that while a safe area may not be a recharging area, recharging areas are always safe areas. Furthermore, assuming that a city has many safe areas, so that users can enjoy the service all around the city, it is reasonable to think that just a few of them have been equipped with a power grid connection, for economic and infrastructural reasons.
- The users are able to reserve an available car only from their geographical region.
- There is a "manual" way to close and open the car, i.e. that the user is allowed to temporarily park the car – while still being charged –, get out, close the car, and then get back and open it again. This means that the system can be used not only for one-way travels, but also when more stops or a round trip is needed.
- Parking areas and special parking areas are allotted and private parking spaces owned by *PowerEnJoy* and distributed throughout the urban area.
- We assume that all cars are the same model and have the same features; specifically, they are all 5-door Citroën C-Zero Micro Car with four seats, customized for the purposes of *PowerEnJoy*.

1.9 Constrains

1.9.1 Regulatory policies

According to privacy law the system must require to User the permission to get his position and to acquire, store and process his personal data.

1.9.2 Hardware limitations

- Mobile application
 - Space for app package (30MB)
 - 3G connection
 - GPS
- Website

- Modern browser The Website of the service must work with all versions of Google Chrome, Opera, Firefox and Internet Explorer released after 2010.

1.9.3 Interfaces to other applications

PowerEnJoy has

1.10 Proposed system

1.11 Identifying Stakeholders

Main stakeholders are the inhabitants of Milan willing to use an ecologic and comfortable mean of transport, without the need to buy and maintain a personal car. The system can be adopted in any other city, so the inhabitants of other cities too can become stakeholders. In Milan, the project is promoted and participated by the city council as minor investor.

1.12 Reference documents

2 Actors Identifying

The system involves as main external actors:

User The final target of the system. Once registered, they can reserve a car and use it in respect of the agreements established with *PowerEnJoy*. They are charged for the usage of the car. It is expected

Guest A potential user not registered in the system yet.

The following actors have also been identified inside *PowerEnJoy* as needed by the system:

Admin Back-office administrators, they have access to a control panel.

Operator Maintenance operators who provide field-based assistance and ensures cars are always ready to be used.

Car The car provided to users. It interacts with the system to be develop to provide information about usage and status and to receive commands.

The system has moreover to interact with the following external service provider:

Payment service Provider of every service related to users payment management.

Local police Local law enforcement agencies such as *Polizia locale* or *Cara-binieri* that interacts with the system for legal issues.

3 Requirements

3.1 Functional requirements

We assume that all domain properties stipulated in paragraph 1.6 hold. We decided to use a *goal-driven* method to structure our requirements, meaning that we decomposed the high-level goals of paragraph 1.5 into low-level requirements. Some of these requirements stem directly from the requests of our clients, while others are born from the necessity to have a sound system.

For each goal, we derive the following requirements:

G1 Registration procedure

- The system has to allow any person to sign up.
- The system has to send a newly generated password to the user via email when prompted by the admin.
- The system must be able to check whether a password is correct or not.
- The system must let the user log in only if the password is correct.

G2 Localization

- The system must be able to locate the user through their smart-phone's GPS with sufficient precision.
- The system must locate the user if and only if they have given their permission.

G3 Finding cars

- The system must be able to find any specific address on the city map.
- The system must be able to find parking areas in a given area of the map.
- The system must be able to identify available cars inside parking areas.
- The system must let users see whether there are available cars in a specified radius.

G4 Services provided

- The system must allow users to reserve an available car.
- The cars cannot be reserved by more than one user at any given time.
- The system must keep the current reservation standing until the user has opened the car or an hour has passed.
- The system must be able to autonomously cancel reservations.

G5 Knowledge of the cars

- The system must be able to locate any car at any given time with sufficient precision.
- The system must be able to detect whether there are passengers inside a car, and how many.
- The system must be able to collect data about the power charge of any of its cars.
- The system must be able to detect when a severe accident has occurred to a car.
- The system must be able to detect when a user is near a car through the car's (and the user's mobile phone's) bluetooth system.
- The system must be able to tell when a car is parked in a safe area.
- The system must be able to detect when a car is plugged to the power grid.
- The system must be able to detect whether the driver is still in the car.

G6 Control of the cars

- The system must be able to automatically unlock a car when the user that has reserved it is nearby.
- The system must be able to automatically lock a car when the user has exited it inside a safe area.

G7 Charges

- The system must be able to calculate the fee to charge the user.
- The system should notify the user of the fee per minute he's being charged through a screen inside the car.

G8 Boundaries of charges

- The system must be able to tell when the car has ignited.
- The system should start counting the charges from the ignition onward.
- The system must ask the user whether they wish to end the ride or not as soon as they are parked in a safe area and have exited the car; if they decide so, the system should stop charging them, otherwise it should keep doing so.

G9 Discounts and sanctions

- The system must apply a discount every time a user brings two or more passengers in the car with them.
- The system must apply a discount every time the car has more than 50% of power charge by the end of the ride.

- The system must be able to apply a discount every time the user plugs the car in the power grid as soon as they're finished using the car.
- The system must apply a sanction every time a car is returned in a safe area at more than 3 km from the nearest recharging safe area.
- The system must apply a sanction every time a car is returned with less than 20% of power charge.
- The system must provide an option (*money saving*) to get information about the best safe area where the user can leave the car so that an uniform distribution of cars among the city is distributed.
- The system must be able to compute which is the best safe area for a user with *money saving* activated according to their destination and the nature of the safe areas (recharging or not).
- The system must apply a discount every time the car is returned in the suggested safe area with the *money saving* option.

G10 Emergency management

- The system must always allow a user to notify the back-end administrators if they have a problem with the car.
- The system must be able to locate *PowerEnJoy* operators in order to facilitate their quick dispatch.

G1 Registration of a guest to the system.

- The system has to allow any person to sign up.

G2 Access to the system

- The system has to send a newly generated password to the user via email when prompted by the admin.
- The system must be able to check whether a password is correct or not.
- The system must let the user log in only if the password is correct.

G3 Finding cars

- The system must be able to locate the user through their smartphone's GPS.
- The system must be able to find a specific address in its map.
- The system must be able to find parking areas in a given area of the map.
- The system must be able to identify available cars inside parking areas.

- The system must let users see whether there are available cars in a specified radius.

G4 Reservation of a car

- The system must allow users to reserve an available car.
- The cars cannot be reserved by more than one user at any given time.
- The system must keep the current reservation standing until the user has opened the car or an hour has passed.

G5 Fine for not picking up a reserved car.

- The system must be able to cancel reservations.

G6 Opening a car

- The system should be able to detect when a user is near a reserved car through the car's Bluetooth system.
- The system should be able to unlock a specific car.

G7 Charging fees to the user

- The system must be able to calculate the fee to charge the user.
- The system should notify the user of the fee per minute he's being charged.

G8 Starting charging

- The system must be able to tell when the car has ignited.
- The system should start counting the charges from the ignition onward.

G9 Ending charging

- The system must be able to tell when the car is parked in a safe area.
- The system must be able to detect whether the driver is still in the car.
- The system must ask the user whether they wish to end the ride or not as soon as they are parked in a safe area and have exited the car; if they decide so, the system should stop charging them, otherwise it should keep doing so.

G10 Notification of the current charges

- The system must calculate the charges in real time.
- The system should show the current charges onscreen.

G11 Locking a car

- The system should be able to lock a specific car without user input.

G12

G13 Time window

- The system must allow the last user who has driven a car to unlock and open it within a 10-minutes window and if and only if the car has not already been reserved by someone else.
- The system must not allow more than one user at a time to open a car.

G14 Parking areas

- The system must know the location of all parking areas at any given time.

G15 Passenger's discount

- The system must be able to detect how many passengers are in the car through specific sensors.
- The system must be able to apply a discount to every ride where there are two or more passengers in the car.

G16 Discount for power charge

- The system must be able to apply a discount on every ride when the car has more than 50% of power charge by the end of the ride.
- The system must be able to collect data about the power charge of any car.

G17 Discount for plugging the car to the power grid

- The system must be able to discern whether a car is currently plugged in to the power grid and is being recharged.
- The system must be able to apply a discount on every ride if the user plugs the car in the power grid as soon as they're finished.

G18 Sanction for distance

3.2 Non-functional requirements

3.2.1 User interface

The interface of our application is thought to be used mainly via mobile app, with some content also displayed in a web page. The team reasoned that the main functionalities of the system (such as reserving and managing a car) make sense only in a *movable* context (meaning, such that the user can do them anywhere they have an internet connection). Those functionalities are available

on the mobile app. On the other hand, operations such as signing up are more easily managed in front of a computer, so the web page allows users to register, login and manage their profiles (which they can do also via mobile app anyway).

We pondered on the possibility of adding the possibility of reserving a car via web browser. However, upon consideration, we decided it is not a good mechanism: with that functionality, a user could very well be registered without having downloaded the app and reserving a car without being able to access it in any way. Hence, the reservation of *PowerEnJoy* cars can be made only via mobile app.

Mobile app

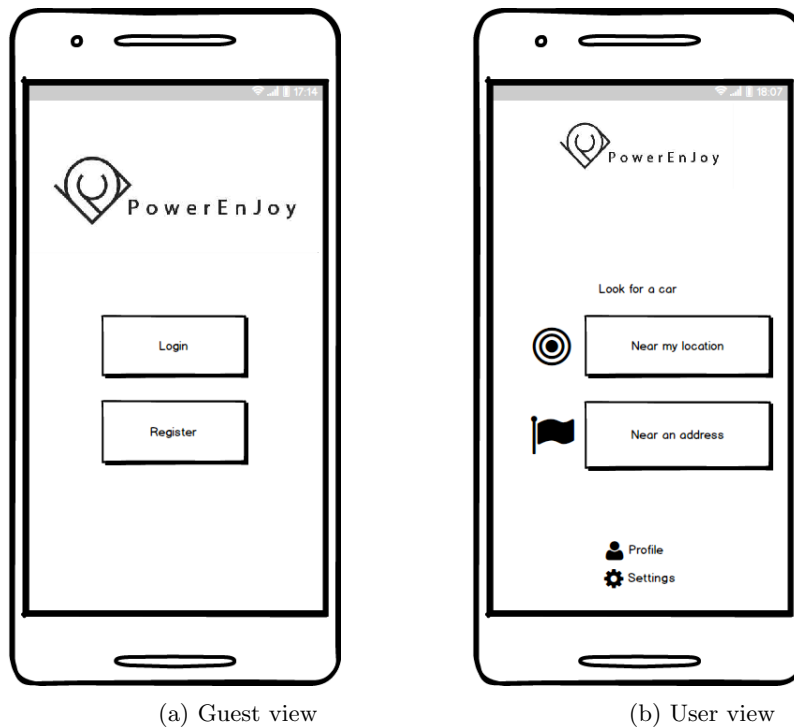
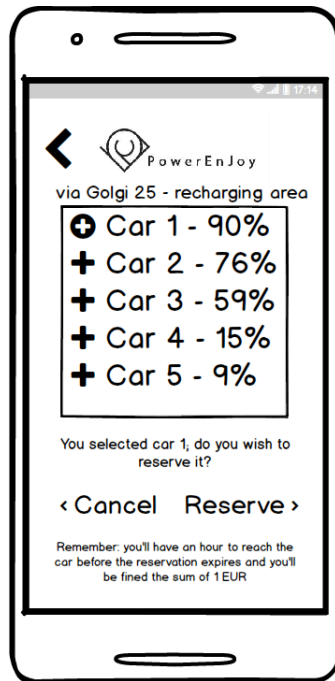


Figure 1: Mobile app: home page view

Figure 1 shows the first page that is shown when entering the app. Picture 1.a is the guest view, who has only the possibility of either logging in or registering in the system. Picture 1.b shows the user view. The user has more functionalities: they can look for cars in their vicinity or near an address, see and edit their profile, and changing settings (notification and sound settings).

Figure 2 shows the main functionalities of the *PowerEnJoy*'s app: reserving a car (2.a and 2.b) and what you can do while using a car (2.c).

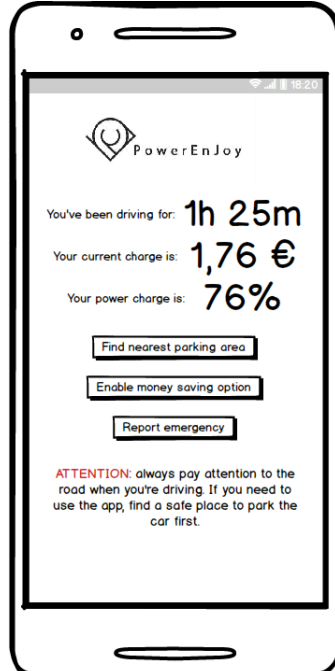
Figure 3.a and 3.b shows, respectively, the website homepage from the standpoint of a guest and the sign up page. We haven't drawn the website mockup from the standpoint of a registered user since there are no more functionalities than those already present in the mobile app, as said above.



(a) View for the reservation



(b) View after having selected a parking area



(c) Display of the app while using a car

Figure 2: Mobile app: main functionalities



(a) Website homepage

PowerEnJoy · Sign up

http://powerenjoy.com/signup

Home About PowerEnJoy Fees Parking areas Login

Sign up now

Personal information

First name

Last name

Email

Birthdate 1 Jan 1997

Nationality Italy

Place of residence

Address

City

Zip code

Payment information

Credit card

CVV

Expiration date Jan 2017

I hereby confirm that I have received, reviewed and understand the

☐ PowerEnJoy Terms and Conditions, and that I accept and agree to the Terms and Conditions contained within those documents.

I hereby confirm that I have received, reviewed and understand the

☐ PowerEnJoy Privacy Policy. I acknowledge and accept PowerEnJoy's policy as it relates to any information I provide as part of my

Sign me up

(b) Sign up on website

Figure 3: Website

Documentation

In order to keep track of all phases of the development process and the overall structure of the system, the team will release the following documents:

RASD , Requirement Analysis and Specification Document, which provides a thorough description of the system, the requirements and the specification thanks to the use of UML models.

DD , Design Document, which contains a more in-depth description of the functionalities of the system.

ITPD , Integration Test Plan Document, which describes integration tests and the team's intended plan to accomplish them.

PP , Project Plan, which defines a planning for the development project.

4 Scenario identifying

4.1 Scenario 1: Registration from the website

Anakin has just moved to Milan and has rented a flat; however, he couldn't afford a place close to the city centre, where he works; he also doesn't have a car, so he's been going back and forth with public transport. Because of that, he needs to wake up half an hour earlier and usually gets home very late, and he's getting tired. He then decides to look for a solution on Google, and he finds the car-sharing service of *PowerEnJoy*, which has a parking place close to his home. The *PowerEnJoy* web page has all the information readily available, pricing, features, an approximated map of the parking areas included and a link to download the application from suitable store, so Anakin decides to sign up. He completes a form, where he writes his complete name, personal information, information about his driving license, credentials and payment; the system checks Anakin's driving license and only then sends him the password, so he can login from the phone application and access the private area of the system.

4.2 Scenario 1: Registration from the mobile application

Chewbacca was advised the *PowerEnJoy*, so he finds the application on the mobile appstore and downloads it directly to his phone. Opening the application he sees the main page where he can register just as his friend Anakin.

4.3 Scenario 2: Login in the app

Padmé has registered on the *PowerEnJoy* website and now has downloaded the application on her smartphone. Opening the application, she finds a screen asking her to log in. Padmé registered with *Naboo-princess* username, and the password she received in her email is *7aKmm93s*, so she fills the login form with this information. The first time she writes the password wrong, so the login is rejected and the application asks her to try again. The second time she typed the password right, so the system accepts the login and shows the main page of the application.

4.4 Scenario 3: Reserving and using a car

Luke must reach his aunt and uncle for the usual sunday roast. He doesn't have a car, and usually he just takes the subway. However today the public transport workers are on strike, and the metro is out of order. Luke is a distracted kid, always with his head in the clouds, so he forgot about the strike and has walked for the fifteen minutes needed to reach the metro. He is nevertheless smart and resourceful, and so he remembers that he's signed in the *PowerEnJoy* system. He opens the app and presses the "find car" button. He has the GPS activated, so the system locates him and tells him that there's a parking area with an

available car next to the metro station. The application gives him the choice of reserving the car or cancel the operation, and Luke reserves the car.

4.5 Scenario 4: Parking and regular fees

Leia needs to get to the american consulate ASAP. She's a frequent user of the car-sharing service, so she already knows all the safe areas where she can park around the diplomatic block in the city centre, since she often needs to go there. While she drives, the smart display in her car tells her how much the system is currently charging: the fee per minute is 0,50 EUR, and she's been driving for half an hour, so her fee currently is 15 EUR. She reaches the diplomatic area after two more minutes, and she knows that the parking area is around the corner from the consulate, so she reaches there. This particular safe area is not a recharging area, and Leia left the car with a 60% battery full, so the system charges her 16 EUR. The display notifies her that she's parked in a safe area and that no sanction applies to her fee. The system also asks her if she wants to keep the car reserved and keep being charged, and she declines. She exits the car and the system locks it automatically.

4.6 Scenario 5: Power grid and discounted fees

4.7 Scenario 6: Parking and sanctioned fees

Han, Leia's husband, is also a regular user of the system. He's however less abiding to rules and is a bit of a free spirit, so he generally never gains any discount and is often sanctioned for wasteful behaviour. For example, last monday he needed to reach his bank in Porta Genova for a meeting with his broker. He was very late, so he parked right outside the bank, outside any safe area. It took him twenty minutes to get there, so the system had charged him 10 EUR. As soon as he stops the car, the display notifies him that he is in an unsafe area, so he'll keep being charged even if he isn't using the car. Han confirms and exits. The car doesn't lock automatically, so he needs to turn his bluetooth on and close it with the *PowerEnJoy* application.

4.8 Scenario 7: Lost reservation

Han and Leia want to go a restaurant. Han thinks that they are about to leave the house, so he decides to reserve a car while still at home to make sure they will have a car after leaving home, but it takes Leia more than an hour to get prepared. In one hour they are not near the car to open it, so the system cancels Han's reservation, notifies him about the 1 EUR sanction charged for uselessly reserving it and asks if he wants to reserve another available car.

4.9 Scenario 8: Two passengers + special parking area

Chewbacca met Han and Leia on his way, so he invited them to take one car. When they sit in the car, Chewbacca receives a notification on the display

that two other passengers are detected. When they arrive to their destination, Chewbacca sees on the application's map that there is a special parking area near them, therefore he decides to put the car there and doesn't forget to plug in the car to the power grid. At the end of the ride Chewbacca gets a discount of 40% (10% for the 2 passengers + 30% for leaving the car on the special parking area and plugging it to the power grid).

4.10 Scenario 9: Money saving option

4.11 Scenario #: Left the city

4.12 Scenario #: Recover a car with user input

Obi-Wan is driving peacefully to reach his yoga instructor, Qui-Gon Jinn, when the car breaks down; he tries to restart it or check what is wrong, but the system doesn't detect any anomaly and he isn't a mechanic, so he decides to notify the company: he opens the app on his phone and enters the *Emergency help* section. The app asks him to broadly describe the problem by filling a form. He then selects the option "car doesn't work" and the system tells him that an operator is on his way. In the meantime the system, having located the car, notifies the operator of its whereabouts. The operator – which is also a mechanic – goes there with a truck. He checks the car on site and then, since the car needs more serious repairs, he loads it on the truck. The operator informs the system that the breakdown was not Obi-Wan's fault, so Obi-Wan's charges are dropped for faulty service. The system then offers him to reserve another car in a safe area nearby.

4.13 Scenario #: Recover a car without user input

An unnamed user has left a car with 0% battery in an area far from the power grid. As soon as the emergency battery kicks in, the system locates the car and alerts an operator of the situation. In this case, two operators are dispatched on the same truck: when they reach the car, they try to charge it on site. If they manage to do so, one operator drives the car to the nearest recharging area while the other follows with the truck. If they don't, they load the car on the truck and transport it to the nearest recharging area.

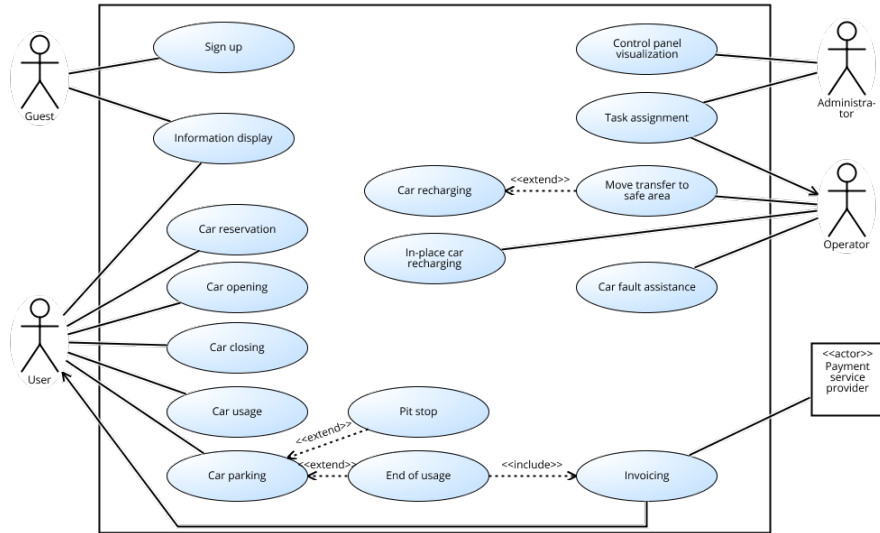
4.14 Scenario #: User breaking the law

Darth Maul has broken the law while driving a *PowerEnJoy* car: he was driving too fast in a residential area. Since the police has identified the car plate, the notification of the fine is sent to the company. The company pays the fine in advance. The system administrator then checks who was driving that specific car at that time and discovers it was him: he then charges the amount of the fine to Darth Maul through his preferred method of payment.

5 UML models

5.1 Use case diagram

A global picture of the system interaction with actors is provided here by means of use case diagrams. Following, an analysis of the most interesting use case situations derived from scenarios is presented.



5.1.1 Use case 1: Reserve a car

Name Reserve a car

Actors

User The user who wants to reserve a car.

Entry condition The user decides to reserve a car to take within the next hour.

Flow of events

1. The user logs in into the mobile app and goes to the reservation section.
2. The system automatically retrieves and displays the location of the user, but the user can specify a different location if needed.
3. The system displays the position of the available cars close to the selected location.
4. The user selects a car and confirms the reservation.

Exit condition The system reserves the car for the user.

Exceptions

- **The system is not able to locate the user automatically.** The user is required to insert a position manually.
- **The system is not able to find a position inserted manually.** The user is informed and the operation is aborted.
- **There are no available cars.** The user is informed and the operation is aborted.
- **The user cancels the operation before confirming.** The reservation process is not completed and the car remains available to other users.

Special Requirements None.

5.1.2 Use case 2: Park in known safe area

Name Park in known safe area

Actors

User The user of the car.

Car The car in use.

Entry condition The user is driving and has reached their destination. They know a safe area close to the destination.

Flow of events

1. The safe area is free and the user parks in it.
2. As the car is turned off, the system detects it is in a safe area.
3. The system asks the user if he wants to keep the car or to end the ride.
4. The user selects to end the ride.
5. The user exits the car.
6. The system closes the car.
7. The system charges the user for the ride.

Exit condition The user leaves the car and the car becomes available to other users.

Exceptions

- **The safe area is taken.** The user can't end their ride and this operation is aborted.
- **The car is badly parked.** ???
- **The user selects to keep the car when prompted.** The user keeps being charged and the car is not made available for other users.

Special Requirements None.

5.1.3 Use case 3: Park with money saving option

Name Park with money saving option

Actors

User The user of the car.

Car The car in use.

Entry condition The user selects the *money saving option* at some point of their ride and insert their destination.

Flow of events

1. The system indicates the user the suggested safe area for their destination.
2. The user parks in the suggested safe area.
3. As the car is turned off, the system detects it is in a safe area.
4. The system asks the user if he wants to keep the car or to end the ride.
5. The user selects to end the ride.
6. The user exits the car.
7. The system closes the car.
8. The system charges the user for the ride. A discount is applied for using the *money saving option*.

Exit condition The user leaves the car and the car becomes available to other users.

Exceptions

- **The suggested safe area becomes taken while the user is driving.** The system selects another safe area and notifies the user of the new suggestion.
- **The user parks in another safe area.** The system notifies the user that they will not receive a discount. If the user decides to end the ride anyway, the system charges them without applying the *money saving option* discount.
- **The destination of the user changes.** The user selects a new destination and the system indicates another suggestion.
- **The user disables the *money saving option* while driving.** The suggested safe area stops being displayed and the ride continues as normal.

Special Requirements The *money saving option* must be selected before stopping the car in a parking area.

5.1.4 Use case 4: Park in a recharging area

Name Park in a recharging area

Actors

User The user of the car.

Car The car in use.

Entry condition The user is about to park in a recharging area.

Flow of events

1. The user parks the car in the recharging area.
2. As the car is turned off, the system detects it is in a safe area.
3. The system asks the user if he wants to keep the car or to end the ride.
4. The user selects to end the ride.
5. The user exits the car.
6. The system closes the car.
7. The system charges the user for the ride.
8. The user plugs the car into the power grid through the supply point installed in the parking space.
9. The system detects the car is recharging.
10. The system modifies the charge applied to the user for the ride. A 30% discount is applied to promote virtuous behaviors.

Exit condition The user leaves the car and the car becomes available to other users.

Exceptions

- **The user does not plug the car into the power grid.** The user is charged as if they parked in a safe area.

Special Requirements The user plugs in the car within 10 minutes from the moment they exits the car. Otherwise the discount is not applied.

5.1.5 Use case 5: Retrieve a car with user input

Name Retrieve a car

Actors

User The user of the car.

Operator The field operator.

Entry condition The car doesn't work and the user has parked it safely somewhere on the road.

Flow of events

1. The user checks whether the system has already notified the breakdown.
2. The user enters the app from their smartphone and manually notifies the malfunction.
3. The system asks the user to fill a form with the information needed.
4. The system locates the car.
5. The system analyses the user's form and decides how many operators are needed
6. The system notifies the operators of the car's location and asks them to retrieve the car.
7. The operators drive the truck to the car's location.
8. The operators check the car on site.
9. The operators loads the car on the truck and drives it away to be repaired.
10. The system notifies the user of the annulment of all charges.
11. The system asks the user if he wants to reserve another car.

Exit condition The operator brings the car in to be repaired; the user doesn't pay anything and is offered another car.

Exceptions

- **The user fills the form with wrong information** The field operators report this as soon as they arrive at the location and alert the system. The operators decide whether to have the user pay the fare anyway (if they inconvenienced the operators for naught) or not and notify the system. The system charges the user accordingly.
- **There are no cars available nearby** The system alerts the user that there are no available cars in a 1km radius. The system then asks the user if they want to increase the radius of the search or to cancel it.
- **The system knows of the malfunction** The system already knows of the malfunction
- **The car isn't safely parked** The user ticks a box in the form to inform the system of the unsafe parking. The system looks for a safe place to park nearby and notifies the operators. The operators park there and reach the car on foot to check on it. If the car needs to be transported, the operators alert the local police.

- **The car is impossible to reach** The operators cannot reach the car in its location. The operators notify the system. The system alerts the local police.

Special Requirements The operators must reach the car in 30 minutes time at most.

5.1.6 Use case 6: Manually assist a parked car

Name Manually assist a car

Actors

Admin The administrator who sends the operator.

Operator The operator sent to recover the car.

Car The car in use.

Entry condition The administrator is notified by the system that a parked car needs manual assistance.

Flow of events

1. The admin checks the issue the system is displaying. It can be one of the following:
 - the car is in a safe area without enough power charge to be used;
 - the car is in a recharging area without the plug inserted.
2. The admin assigns the maintenance work to an operator.
3. The operator accepts the assignment and the admin is notified of it.
4. When available, the operator performs the *maintenance operation* (see below).
5. The operator checks the assignment as completed.

Exit condition The maintenance activity has been performed and the admin is notified of the completion.

Exceptions

- **The operator is not able to perform the maintenance.** The assignment is marked as *not completed*, the cause is inserted into the system. The admin will be notified of it and will either assign the problem to another operator or manage it without the help of the system. The assignment will be anyway closed at the end of this process.

Special Requirements The operator cannot refuse an assignment if he is online and always accept it within a working day. An operator is always online when at work. The operator always marks the assignment as either *completed* or *not completed* before the end of the workday.

In the previous use case we refer to *maintenance operation* as to one of the following:

- **Issue:** the car is in a safe area without enough power charge to be used. **Maintenance operation:** the car is towed to a recharging area and plugged into the power grid once there.
- **Issue:** the car is in a recharging area without the plug inserted. **Maintenance operation:** the car is plugged into the power grid.

5.1.7 Use case 7: Manage infractions

Name Manage infractions

Actors

Admin The system administrator.

User The user responsible for the infraction.

Entry conditions The company receives by mail the notification of the infraction.

Flow of events

1. The company pays the fine for the infraction to the police.
2. The admin logs into the system and inserts the license plate and the time of the infraction to find the responsible user.
3. The system shows the name of the user.
4. The system charges the user with the fine.
5. The system notifies the user of the payment.

Exit conditions The legal procedure has been closed and the user has paid the fine.

Exceptions

- **The infraction causes the user to lose their license**

5.1.8 Use case 8: Assist user after an accident

Name Assist user after an accident

Actors

User The user driving the car.

Admin The administrator who receives the notification from the system.

Operator The operator sent to assist the user.

Entry condition The user is driving and is involved in an accident.

Flow of events

1. The User notifies the Admin that an accident has happened. In case of serious accidents, it is the Accident Detection System of the car, instead of the User, that notifies the Admin. After the notification, the User waits for an Operator to arrive.
2. The Admin dispatches an Operator with a tow-truck.
3. The Operator arrives on site.
4. The Operator manages the jointly-agreed statement for insurance purposes with other drivers involved and takes care of contacting the insurance company.
5. When everything is done on site, the Operator takes the car to the company garage, to be analyzed by the insurance company if needed.
6. The user leaves the site when the Operator takes the car away.

Exit condition Eventually, the car is repaired and the insurance company emits a result on the accident report and refunds the company for the reparation costs of the car. The car is put back in use (the car is taken to a parking area; it can be reserved again).

Exceptions

- **The User leaves the site before the removal of the car.** The Operator can report it to the system, and the user will be charged of an extra. If the User is penally implied in the accident, the Operator provides their personal details to the law enforcement.
- **The insurance asserts that the accident is fault of the User and doesn't take responsibility for it.** The User is fully charged of the reparation costs.

Special Requirements The Operator cannot refuse to be assigned to an accident if he is online and always accept it within 10 minutes. An Operator is always online when at work. The Accident Detection System always detects an accident when the User is unconscious. In this cases, it also notifies the emergency services.

5.1.9 Use case 9: Assist a user on-site after a car breakdown

Name Assist user after a car breakdown

Actors

User The user driving the car.

Admin The administrator who receives the notification from the system.

Operator The operator sent to assist the user.

Entry condition The user is driving and notices a car breakdown. An empty battery while driving is considered as a car breakdown.

Flow of events

1. The User notifies the Admin that a breakdown has happened. After the notification, the User waits for an Operator to arrive. The charges for the User are suspended.
2. The Admin dispatches an Operator for an *on-site reparation*.
3. The Operator arrives on site.
4. The Operator repairs the car.
5. Once the reparation has ended, the User is assigned again to the car and the charges start again.

Exit condition The Operator marks the assignment as *completed* and leaves. The User is back on their car.

Exceptions

- **The Operator decides that the reparation can't be done on-site.** The use case *Assist a user with a not on-site reparation* is invoked.
- **The User leaves the site before the reparation ends.** The Operator report it to the system. At the end of the reparation, the User is not assigned to the car anymore and is invoiced for the ride (until the breakdown occurred). The Operator notifies the Admin that the car must be taken to a parking area and leaves the site. The Admin dispatches an Operator with a tow truck. The Operator takes the car to the closest available parking area.
- **The Operator asserts that there is no need for intervention and the User is still on site.** The User is fined (parameter). The car is assigned to the User again and the charges start again.
- **The Operator asserts that there is no need for intervention and the User has gone from the site.** The User is fined (parameter, higher than in previous exception). The Operator notifies the Admin that the car must be taken to a parking area and leaves the site. The Admin dispatches an Operator with a tow truck. The Operator takes the car to the closest available parking area.

Special Requirements The Operator cannot refuse an assignment if he is online and always accept it within 10 minutes. An Operator is always online when at work.

5.1.10 Use case 10: Assist a user with a not on-site reparation

Name Assist a user with a not on-site reparation

Actors

User The user driving the car.

Admin The administrator who receives the notification from the system.

Operator The operator sent to assist the user.

Entry condition The operator sent to fix a breakdown asserts that the reparation can't be done on-site and notifies the Admin of the change. The notification contains a brief description of the reason.

Flow of events

1. The User is not assigned to the car anymore and is invoiced for the ride (until the breakdown occurred). The car cannot be reserved anymore.
2. The Admin dispatches a new Operator with a tow truck.
3. The new Operator contacts the insurance company and notifies the breakdown.
4. The new Operator takes the car to the company garage.

Exit condition Eventually, the car is repaired and the insurance company emits a result on the accident report and refunds the company for the reparation costs of the car. The car is put back in use (the car is taken to a parking area; it can be reserved again).

Exceptions

- **The insurance asserts that the accident is fault of the User and doesn't take responsibility for it.** The User is fully charged of the reparation costs.

Special Requirements The new Operator cannot refuse the assignment if he is online and always accept it within 10 minutes. An Operator is always online when at work.

6 Alloy modeling

7 Appendix

List of Figures

1	Mobile app: home page view	17
2	Mobile app: main functionalities	18
3	Website	19

List of Tables

7.1 Used tools

For this assignment, we used the following tools:

Alloy

LaTeX The group used LaTeX to structure the final document and to help with versioning.

Github We leaned on Github for versioning and coordinating synchronized work.

Toggl We used toggl to keep track of work hours.

Slack

7.2 Hours of work