Design Document - v1.0

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POLITECNICO
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Contents

Introduction

Purpose

The purpose of this document is to provide technical informations about the service we are going to deploy described in the RASD.

Scope

Our service is about electric car sharing to provide a valid option to public transportation for low length trips. It is provided via mobile application for the final users and via web application for the operators of the company. Users can download the app with the Android play store or with the Apple store. Operators can enter the system directly from a browser in the boundaries of the companies network after logging in.

Definitions, Acronyms, Abbreviations

- PWE: PoWer Enjoy.
- API: application programming interface, in this document we are mainly referring to web APIs that are defined interfaces through which the client-server interaction happens.
- QR code: a matrix barcode.
- JEE : Java Enterprise Edition, a set of APIs and a runtime environment for developing and running enterprise software.
- RESTful: REpresentational State Transfer web services provide interoperability between computer systems on the net allowing the client-server interaction through a set of pre-defined stateless operations.
- JAX-RS: Java API for RESTful Services, the Java APIs for developing RESTful compliant applications, JAX-RS is part of the JEE framework.
- JDBC: Java DataBase Connection, a set of Java APIs which defines the interaction between a Java program and a DBMS JDBC compatible.
- DBMS: DataBase Management System, a software system to handle the creation, the manipulation and the retrieval of data in a database.
- JSON: JavaScript Object Notation, it's a lightweight format for data-interchange.
- RASD: Requirements Analysis and Specification Document.
- DD: Design Document.
- Controller
- Legacy system
- Ride

Reference documents

- RASD
- Specification document

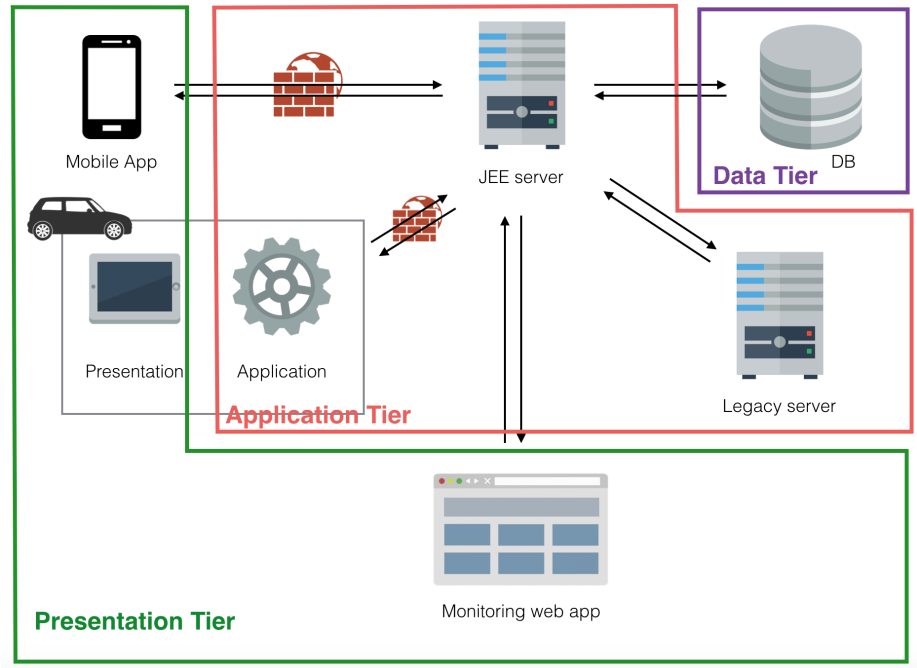
Architectural Design

Overview

We are going to build our system following these guidelines (appropriate reasons for each choice will be given in the next sections):

1. Our application will be implemented using a three-tier architecture as it is the most suitable(this point will be clear in the next steps) and maintainable one for our system.
2. For the mobile application the client side will be light-weighted, with only the presentation layer as there's no need to perform any kind of data manipulation on the user's mobile phone.
3. The car will be equipped with a machine with our application running on it. On the contrary of the mobile app case, the on-board application will need to exploit some logic to perform its functionalities.
4. The operators will access the system through a web application.
5. Integration with the legacy server will happen trough its APIs for the purpose of providing maintenance to the cars and clients care.
6. Firewalls will keep secure the communications with the mobile clients and the cars.

Refer to the Architectural and technological choices for a more in depth analysis of this points.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JEE server
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Presentation
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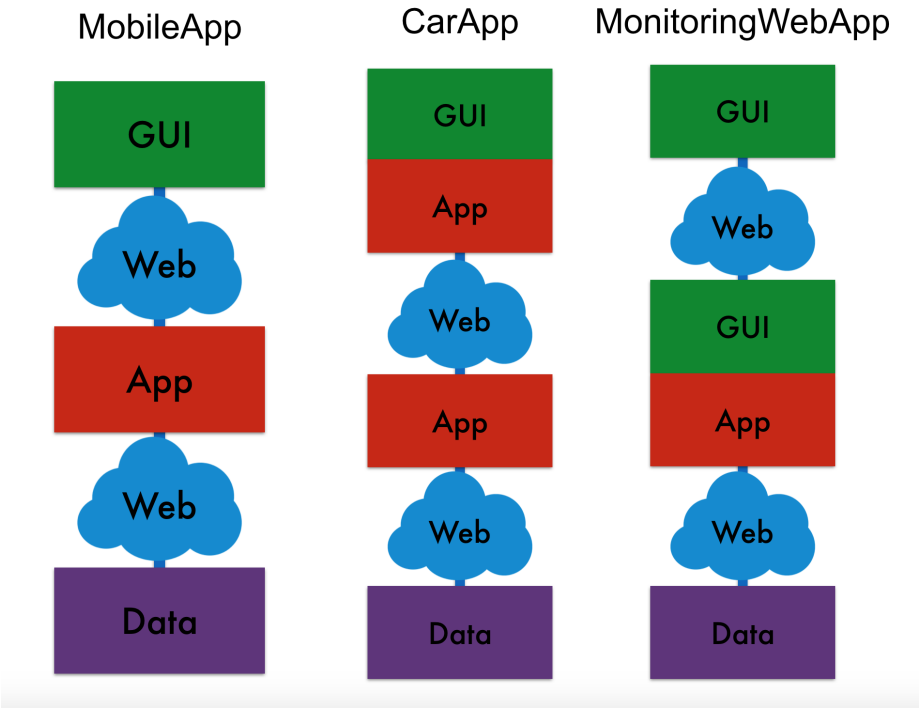
Legacy server
Monitoring web app
Presentation Tier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CarApp
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MonitoringWebApp
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High level component view

In this section we are going to give a look at the architectural structure of our system at the level of the components that we are going to develop and the main ones that we are going to interact with.

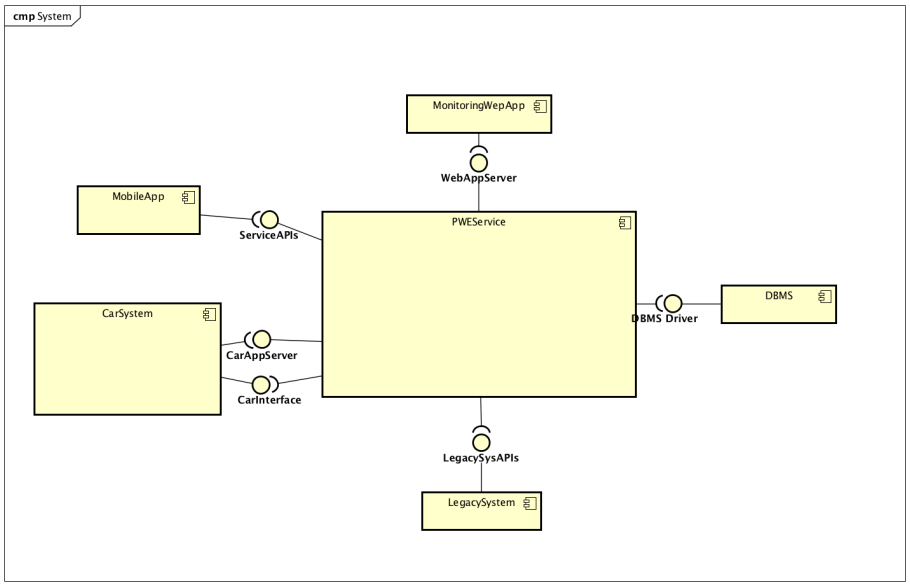


Figure 1:

Components to be developed:

- **PWEService**: It is the core of the system, it has a role of services provider and tasks coordinator. The core of the logic aimed to fulfill our business goals is implemented here.
- **CarSystem**: The component representing the on-board application of the car, its main functionalities are the ones related to the handling of a ride and the monitoring of the car status. It also offers presentation functionalities to give(receive) feedback to(from) the client. It expose its own interface to grant the central component control over its functionalities and uses a dedicated PWEInterface to ask for the server services and to send updates.
- **MobileApp**: The component providing the client the access to the system. It fulfills only presentation functions. It behaves like a synchronous client and interacts with the central component through the ServiceAPIs in a call/response, classic client-server fashion.
- **MonitoringWebApp**: The component providing operators of the company access to monitoring and configuration functionalities. It has only

presentation functionalities(web pages) and communicates with the central component through the provided interface.

Components to be integrated in the system:

- **LegacySystem**: the already existing system of the company, our system will exploit its functionalities through the provided APIs.
- **DBMS**: the system that will take care of the management of our data, integrated in our system using a specific driver.
- **GoogleMaps and PayPal**: respectively the provider of the maps and the payment service(they are not in the diagram, their integration in the system will be discussed later on).

Component view

Car System

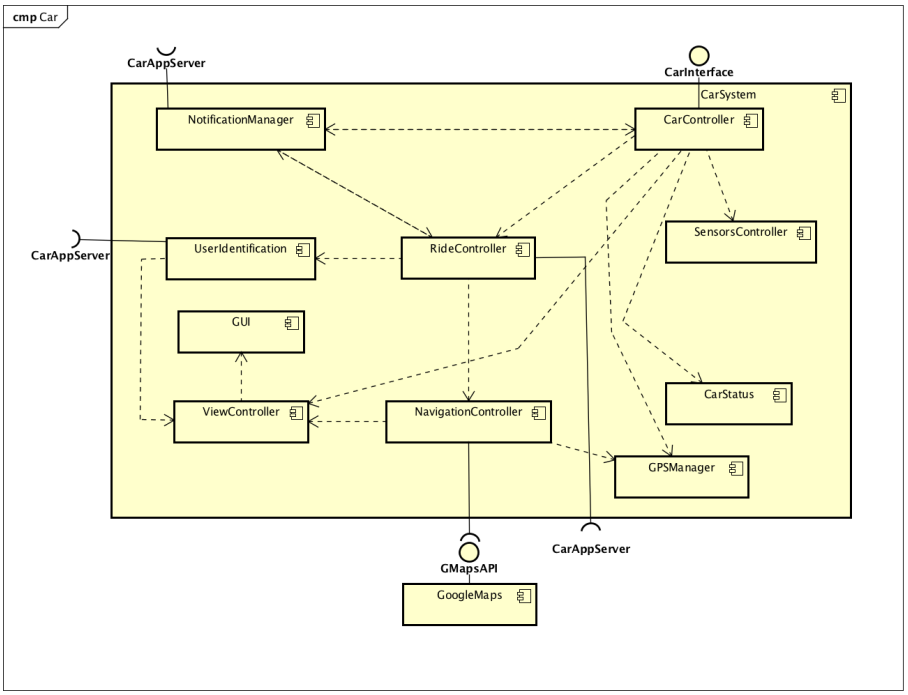


Figure 2:

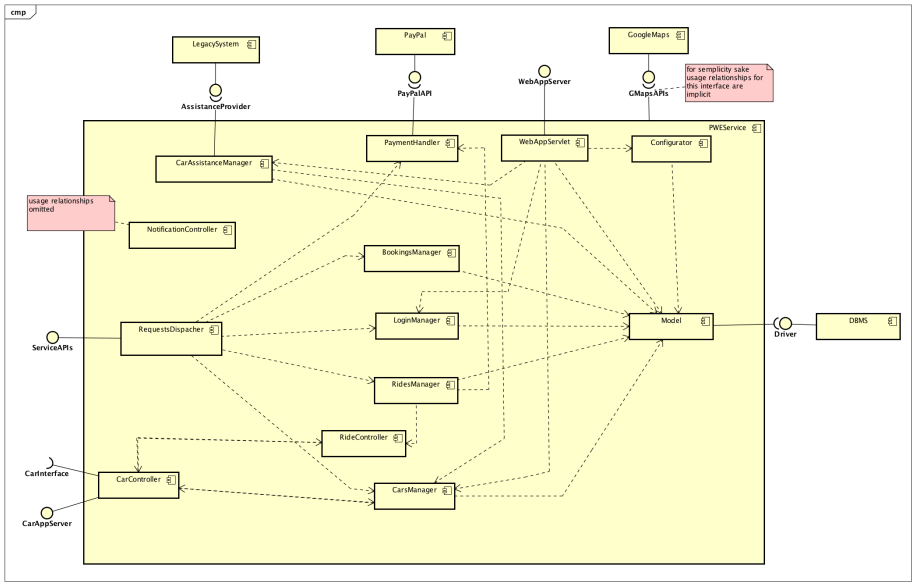
Components description:

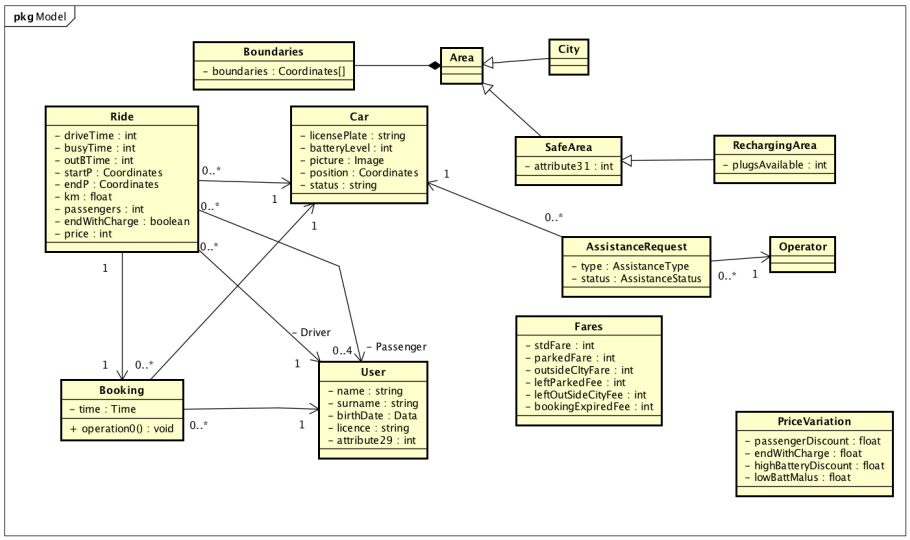
- **CarController** : The main controller of the car. It retrieves informations from the other components, executes the requests of the server and updates

the car status.

- **RideController** : The handler of the operations concerning the execution of a ride. It communicates with the central component which has its own control functionalities over the ride: after the users have been identified the ride controller creates the ride instance, communicates the initial details on the ride to the central system (e.g. the number of passengers) and then goes on sending updates periodically or when the ride status change (e.g. the car exits the city boundaries), further details will be given in the runtime view.
- **UserIdentification** : The component that will handle the identification of the users that check-in at the start of the ride.
- **Navigation Controller** : The component that will provide navigation utilities using the GoogleMaps APIs and the GPS.
- **GPSManager** : The component that will handle GPS localization of the car.
- **CarStatus** : An internal representation of the status of the car.
- **SensorsController**: The component that handles the retrieval of information from the sensors thought the OBD interface.
- **NotificationManager**: The component that handles notifications coming from the central component and that perform the sending of the outgoing ones.
- **ViewControlLer**: The component that handles the update of the GUI and the retrieval of the user input through the interface.
- **GUI**: Implementation of the presentation layer of the car application.

PWEService and Model





Components description:

- **RequestDispatcher**: The component handles the requests from the mobile application clients using the functionalities of the specific components and sends back the responses.
- **BookingManager**: The component that handles the operations concern-

ing the usage of a car.

- **RideController**: It interacts with the RideController component in the car as already mentioned in the section above the way the two components interact with each other will be clarified in the Runtime View section.
- **RidesManager**: The component that handles the set of rides that are ongoing in the system, it interacts with the other components to give the single RideController access to the functionalities that it needs.
- **CarController**: It interacts with the CarController component in the single car to offer services and perform supervising functionalities over a single vehicle.
- **CarsManager**: The component the supervises the set of all the car available in the system interacting with the single CarController and providing operators with informations about the cars status and a way to change the status itself.
- **LoginManager**: The component that handles the log-in of operators and users.
- **PaymentHandler**: The component that handles the payment operations and makes sure that users unable to pay are correctly banned until they pay. It uses the PayPal APIs to process the payments.
- **PayPal**: The payment handler of choice for our system.
- **LegacySystem**: The old system of the company, our system uses its APIs to send assistance where needed.
- **CarAssistanceManager**: The component that offers the functionalities needed to provide assistance to the vehicle when they need to moved, recharged or repaired. It exploits the functionalities of the legacy system to send road-operators to the car location.
- **WebAppServlet**: The component the makes the system functionalities accessible from the WebApplication.
- **Configurator**: The component that offers the configuration functionalities to customize a set of parameters of the system (set of SafeAreas, fares, fees and so on).
- **NotificationController**: a component that offers notification functionalities towards the various components of the system.
- **Model**: the structure of the data in our system (specified in a distinct diagram).
- **GoogleMaps**: Provider of the maps services.

Requirements Traceability

In this section we will show how the components of our system are meant to satisfy the requirement and goals specified in the RASD. For ultility we report the goals and requirements here too.

Goals

The system must:

- [G0] Make the user able to access to the system.
- [G1] Allow the clients to find an available car within a selected radius around his or a specified location.
- [G2] Allow the clients to book a car and pick it up.
- [G3] Monitor the usage of the car and charge the client with the right fare.
- [G4] Incentivize a correct usage of the service to allow as many as possible users to use the same car without the need of the service of an operator.
- [G5] Ensure a correct distribution of cars in the recharging stations according to the available plugs.
- [G6] Allow operators to manage and monitor the state of all the cars and notify them when maintenance is needed on a specific vehicle.
- [G7] Allow management system to set up and modify parameters of the system.
- [G8] Provide a real time, interactive, pleasant and transparent user experience.

Functional Requirements

In the following section we are going to identify the requirements that our system will have to fulfill to reach the goals.

- [G0] Make the user able to access to the system.
  - [R0.1] A user must sign up with valid credential.
  - [R0.2] The system must generate a password for the user and send it to him through e-mail.
  - [R0.3] A user must be able to visualize and modify all his personal informations.
- [G1] Allow the clients to find an available car within a selected radius around his or a specified location.
  - [R1.1] The system must be able to retrieve the location of the user.
  - [R1.2] The user must be able to scroll the map of the city to find a car or specify the radius (in km) around a selected location for the car research.
  - [R1.3] Upon the selection of a car the system must show an informative screen with current car details.
- [G2] Allow the clients to book a car and pick it up.
  - [R2.1] A client must be able to choose one of the available cars and book it.

  - [R2.2] Once a car has been booked no others reservation can be performed by the same client until the first one is pending.
  - [R2.3] After the reservation has been confirmed to the client, he has a maximum of 1 hour to reach the car, unlock it and start the engine. If the timeout expires the reservation is cancelled and a fee is applied.
  - [R2.4] The user is able to unlock a booked car trough the app at any time after the reservation, however he has a maximum of 15 minutes to turn it on after the unlocking. If this timeout expires, the reservation is cancelled the fee is applied.
  - [R2.5] The user in order and start the car has to check-in scanning a QR code in the car display and then press the physical start button.

- [G3] Monitor the usage of the car and charge the client with the right fare.
  - [R3.1] As soon as the engine starts the system must start charging the user with a fixed amount for minute and show the current price of the ride in the display of the car.
  - [R3.2] When a car is parked in a safe area and the engine is turned off, the system will ask the user through the car display if he wants to keep the car busy for at maximum 2h, if the user selects 'NO' or does nothing and leaves the car, the ride is considered as ended. If the user selects 'YES' the car is marked as busy.
  - [R3.3] An user can leave the car he's using and keep it busy with a time limit of 2 hours. During this time, since the battery is not being used, the management may configure a different fare. When the timeout expires if the car hasn't been picked up yet the client will be charged with the price of the ride up to that point.
  - [R3.4] A car parked in a place not marked as safe will be considered as busy, but if the client breaks the 2 hours timeout he will get a fine for improper use of the service (plus the regular price for the ride). The situation will be notified to the operators that will be able to choose if the car needs to be moved or not.
  - [R3.5] If the user drives outside the boundaries of the area of the service, the system must detect it, notify it to the user a and apply an additional time fare as a penalty. After 30 minutes an operator will be notified of the situation.
  - [R3.6] If the signal of a car is lost for more than 10 minutes, an operator will be notified with the last known position.
  - [R3.7] 5 minutes after the end of the ride the user is charged with the right amount and a push notification will be delivered on the user's mobile phone. The five minutes delay is necessary to give the client the possibility to eventually plug the car and get the corresponding discount.
  - [R3.8] If a user is unable to pay for a ride he will be banned from the system until the pending payment will be satisfied.

- [G4] Incentivize a correct usage of the service to allow as many as possible

users to use the same car without the need of the service of an operator.(Note that discounts and penalties will not be applied to short rides, further details in Text Assumption n.1)

  - [R4.1] The system will show in the car display a QR code that must be scanned by the user, using the application, to check in. If 2 or more users check in, in addition to the driver, a discount will be applied to the ride.
  - [R4.2] The system will apply a discount in the case that a car is left with more the 50% of the battery capacity available.
  - [R4.3] The system will detect when a car is left plugged in a recharging station at the end of a ride (using the GPS sensor and the informations sent to the system by the station) and will apply a discount . If the car is left in the recharging station but not plugged within 5 minutes the discount will not be applied.
  - [R4.4] The system will detect when a car is about to be left more than 3km away from the nearest recharging station and with 20% or less battery available, will warn the client and if the client proceeds to leave the car will apply a penalty to the price of the ride.
  - [R4.5] The client will be able to select a money saving option so that the system will provide him, trough the GPS navigator of the car, informations to reach the available recharging station which is more suitable according to the client destination and the need of the system to distribute car uniformly among the recharging stations.
  - [R4.6] The user will get only the higher discount between the ones of which at [R4.2] and [R4.3], eventually cumulated with the one stated at [R4.1], however the system will keep track of all the discounts applicable of a certain ride, then a procedure will calculate the final price according to this policy.

- [G5] Ensure a correct distribution of cars in the recharging stations according to the available plugs.

  - [R5.1] The system will help operators and the users with the money saving option on to choose the station in which cars should be recharged and left so that cars are reasonably distributed among the different stations in the city.
  - [R5.2] The amount of plugs available in a certain station must be monitored and the presence of non working ones detected.

- [G6] Allow operators to manage and monitor the state of all the cars and notify them when maintenance is needed on a specific vehicle.

  - [R6.1] The system will provide operators of the company with an interface to check the state of the cars.
  - [R6.2] Push notifications will notify when a car is need for assistance.
  - [R6.3] Cars with low battery level which are not likely to be used anymore will be flagged.

  - [R6.4] The system must interact with the old system to effectively ensure maintenance to the cars.

- [G7] Allow management system to set up and modify parameters of the system.
  - [R7.1] The system will provide an interface to select areas to mark as safe for parking. The selection of the locations will be possible specifying the boundaries of the areas using a map or a radius around an address.
  - [R7.2] The system will provide an interface to select the price for minute of the rides and during the busy state.
  - [R7.3] The system will provide and interface to customize fees and the percentage of discount and penalty for the cases highlighted in the [G.4] scope.

- [G8] Provide a real time, interactive, pleasant and transparent user experience.
  - [R8.1] After the end of each ride the system must notify the user with all the informations concerning the last usage, among which the total amount of money charged and details about eventual discounts or penalties.
  - [R8.2] If at the beginning of a ride the client is suitable for the discount of which at [R4.1], the system will notify it with an on screen notification.
  - [R8.3] At the end of a ride, if the user results parked inside a charging station, the system reminds him to insert the plug in the specific socket to get the discount of which at [R4.4] using an on screen notification.
  - [R8.4] The system eventually notifies the user with every update regarding the service, including changes in the terms and conditions document which will always have to be accepted again.

Non-functional Requirements

- [NFR1]The mobile application must work on all the android devices with version 4.3 or higher and iOS 7 or higher.
- [NFR2]The system must optimize bandwidth usage to guarantee a responsive service and to detect the position of a car real time.
- [NFR3]For communication, secure protocols must be used.

Traceability

The following pictures show which components are involved in the fulfilment of each requirements group (each group corresponding to a goal). Note that

to keep the diagram simple some component is not linked to any group of requirement, but it's obvious that they fulfil the same requirements of the components the makes of of them (e.g. a CarController is used to fulfil almost the same requirements of the CarsManager).

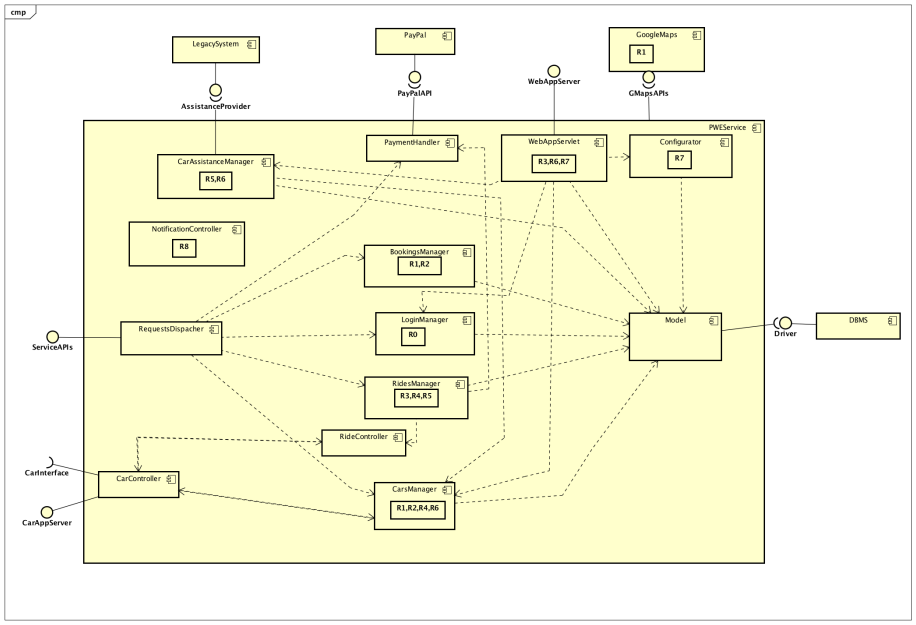


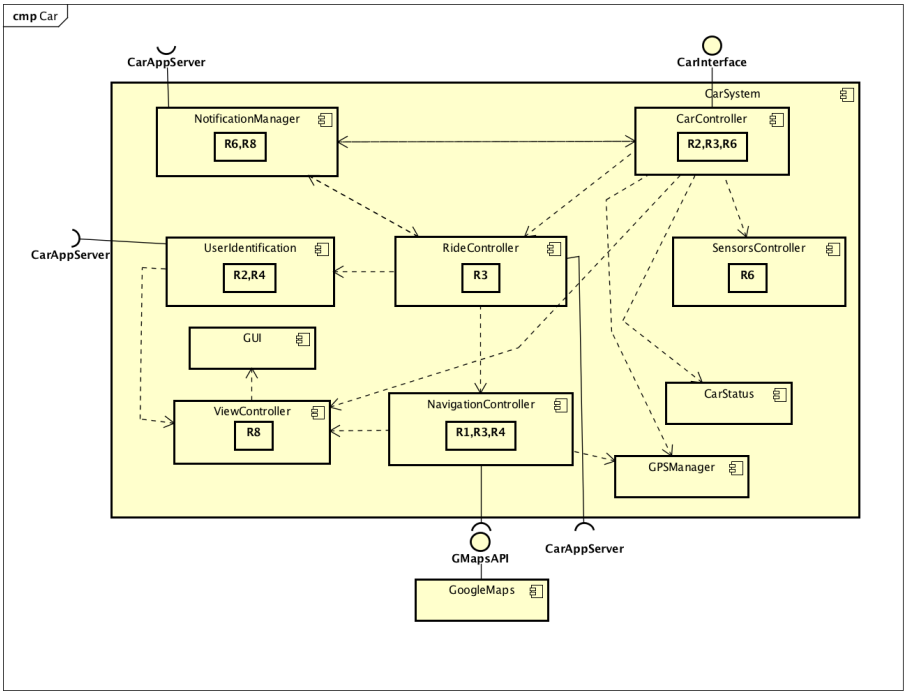
Figure 3:

How we are going to meet the non-functional requirements will be clarified in the architectural choices.

Architectural and technological choices

Server-side (Web , Business Logic and Data tiers)

- We will develop our application and web server using the Java EnterpriseEdition framework (formally, using JEE, we should refer to our application as multi-tier, but for simplicity sake and because our system is distributed over client machines, JEE server machine and a database we will consider it three-tier) .
  - JEE will allow us to shorten the development time and to achieve high performances while keeping our application complexity manageable.
  - JEE makes our project use architectural structure that follows well-known best practices.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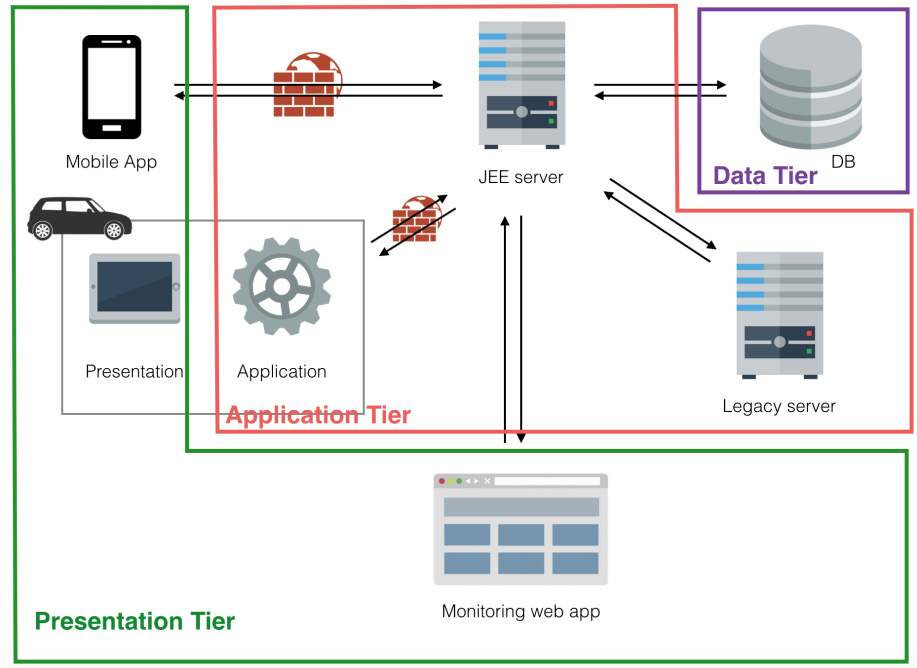
CarAppServer
CarInterface
CarSystem
NotificationManager
R6,R8
CarController
R2,R3,R6
CarAppServer
UserIdentification
R2,R4
RideController
R3
SensorsController
R6
GUI
CarStatus
ViewController
R8
NavigationController
R1,R3,R4
GPSManager
GMapsAPI
CarAppServer
GoogleMaps

Figure 4:


Mobile App
JEE server
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Data Tier
Presentation
Application
Application Tier
Legacy server
Monitoring web app
Presentation Tier

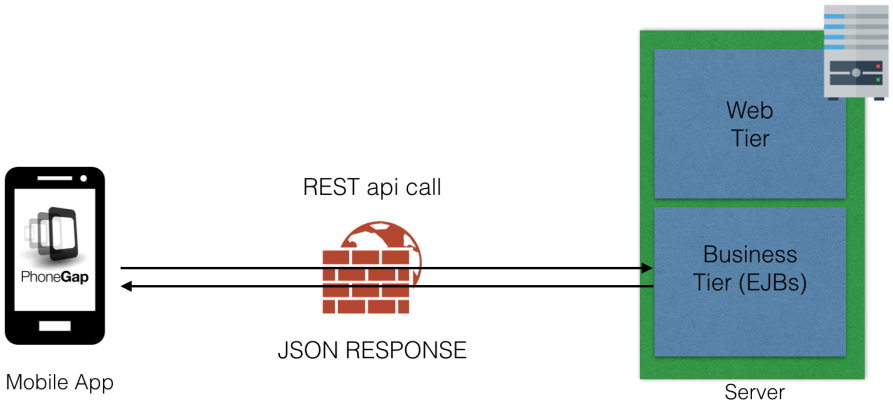
Figure 5:

- We will use Oracle GlassFish Server (the commercial edition) as application server.
  - GlassFish gives very good performance guarantees and is well supported.
- We will use the JAX-RS APIs to expose RESTful APIs with JSON that will be used client-side to interface with the web server.
  - The usage of the RESTful standard will give our system robustness and flexibility.
  - This will allow us to use Adobe PhoneGap to develop an hybrid multi-platform application for the client side.
- We will use the MySQL to manage our Database.
  - We don't need advanced feature for data management that other DBMSs offer.
  - MySQL is fast and easy to use.
  - Free.
  - Compatible with JDBC.

Client-side

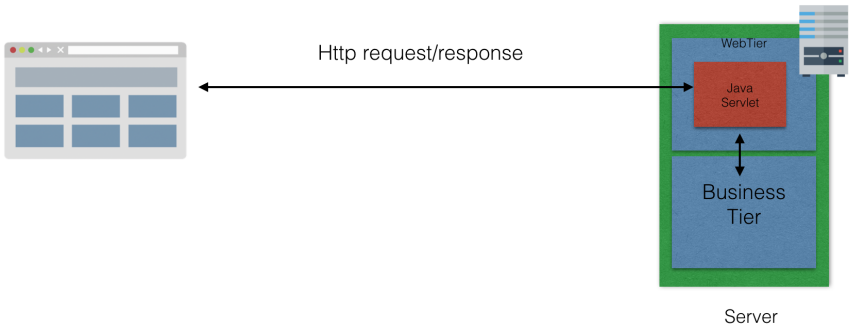
Mobile application

- We will develop our application using the standard web technologies (AngularJS, HTML, css) and use Adobe PhoneGap (built on Apache Cordova) to create a multi-platform mobile app. This approach will allow us to:
- Benefit from the experience of our engineers in web development.
- Reduce development time and cost.



Monitoring WebApp

- We will develop the monitoring Web using a JavaServlet.
- Easy to deploy.
- Integrated in the JEE framework.



Car on-board application

- We will develop a Java application to run in the system of the car.
- We need a tool to have control over the car status.
- The application needs to contain not only presentation features, but also logic to elaborate the data coming from the sensors and manage the

execution of a ride without a continuos interaction with the server and deal with real time issues.

- The application will be able to retrieve informations from the car sensors (such as the battery level or the presence of mechanical problems)through OBD connector(Java libraries to read information from an OBD adapter already exist).
- For the communication with the server the Remote Procedure Call pattern will be used.
  - Java offers a solid implementation of it: RMI.
  - The existence of multiple cars fits well with a remote object representation of them.

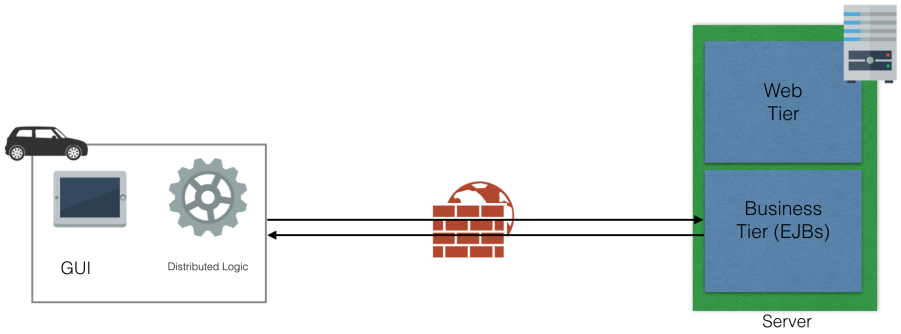


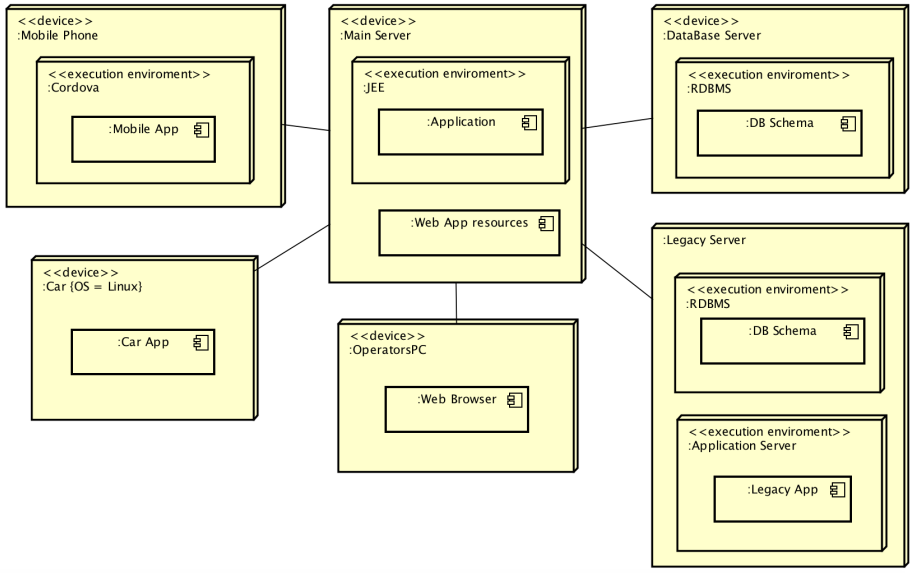
Figure 6:

Patterns

These are the main design patterns that we are following in the design process:

- Model-Control-View : used pretty much everywhere, it's a really good choice of design that allow to keep very clear the role of every component of the system and that makes the system easy to deploy and maintain.
- Client-server : the staple good practice of a web based system.

Deployment view



Runtime view

Component Interfaces

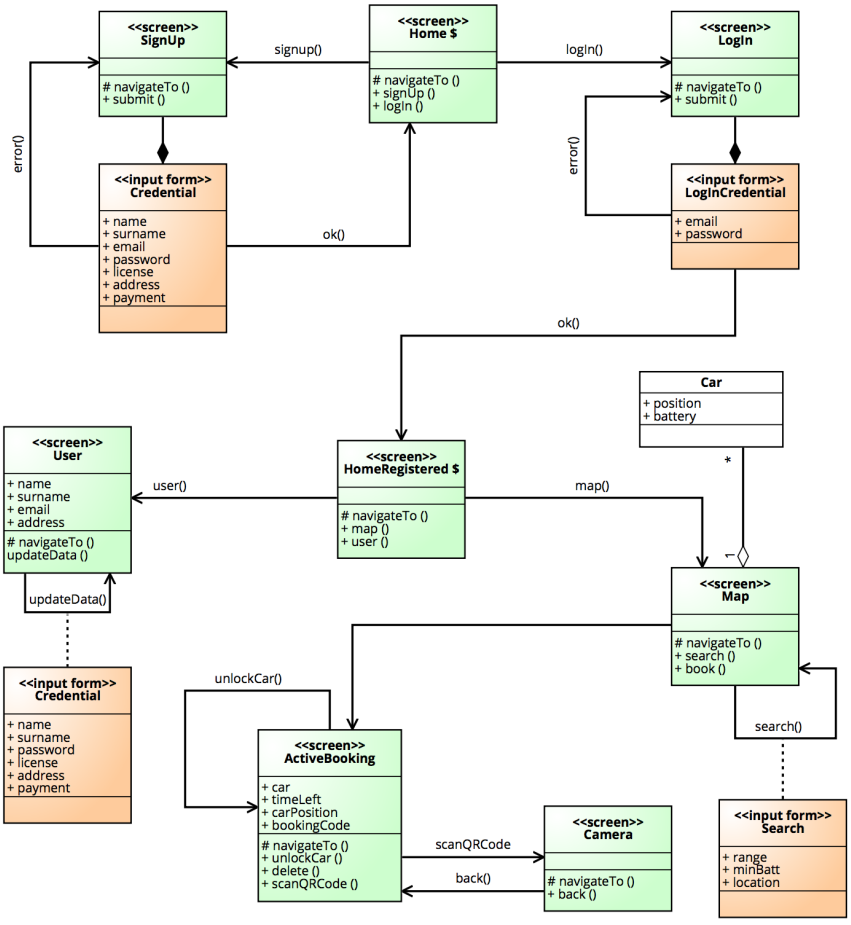
Other design decisions

Algorithm design

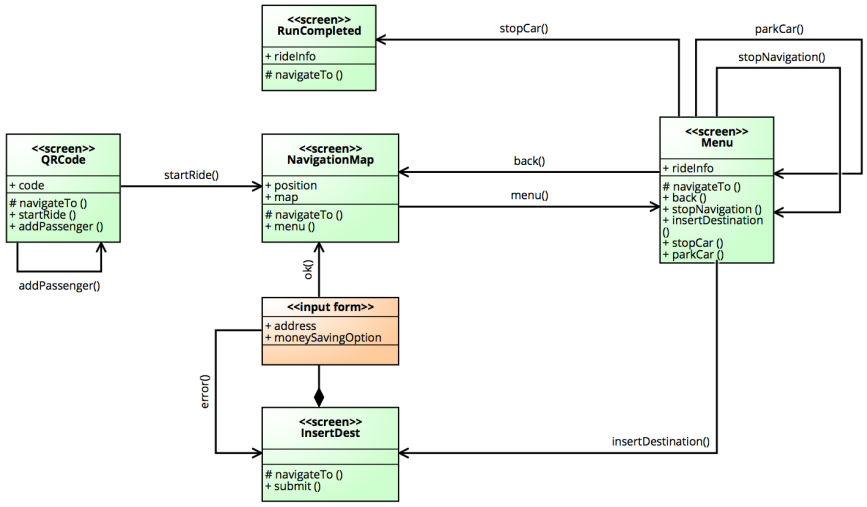
User Interface design

User Experience diagrams

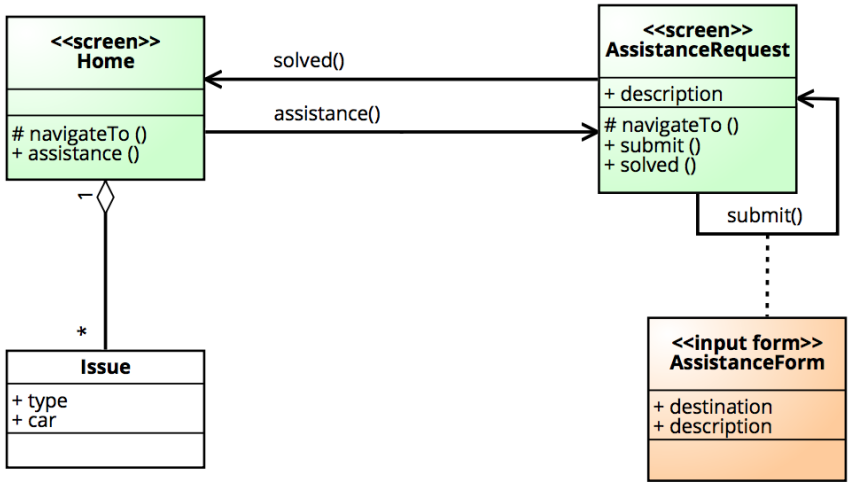
Mobile application



Car application

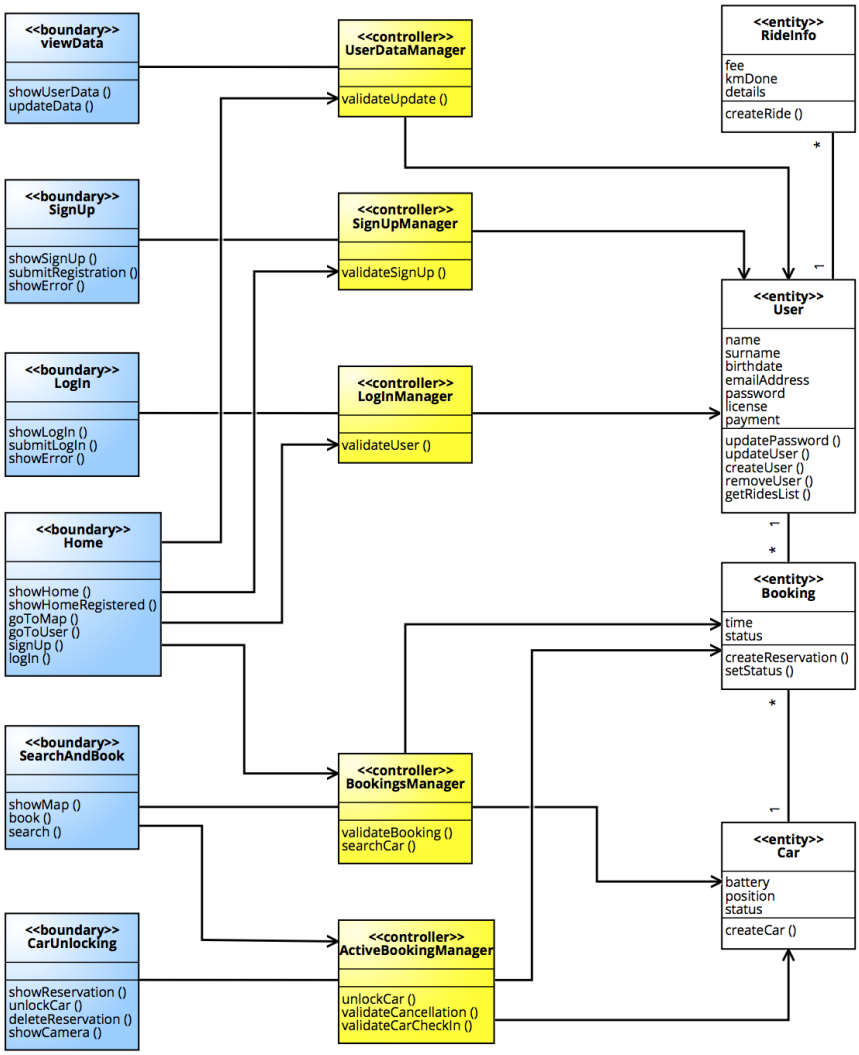


Operators application

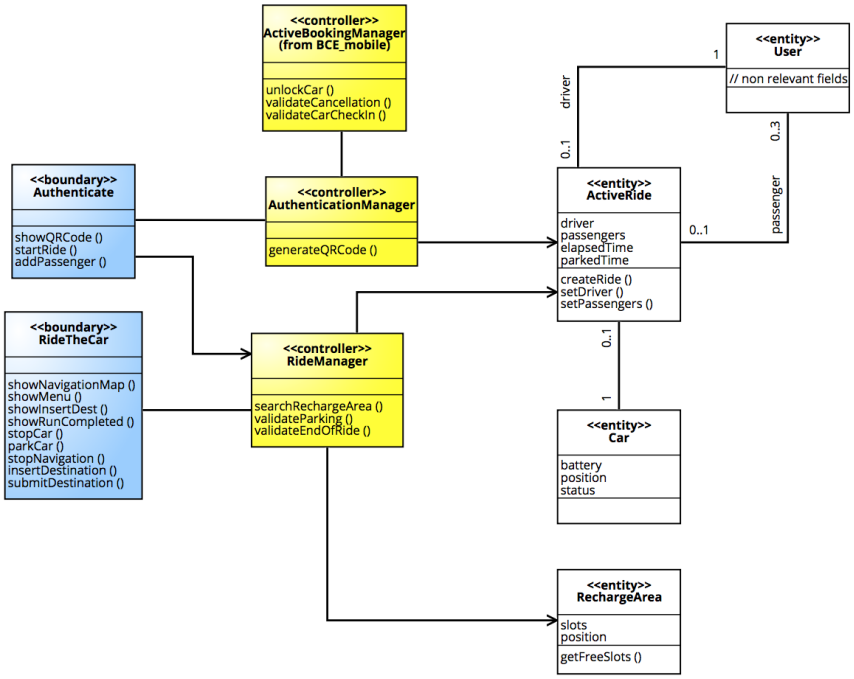


Boundary entity control diagrams

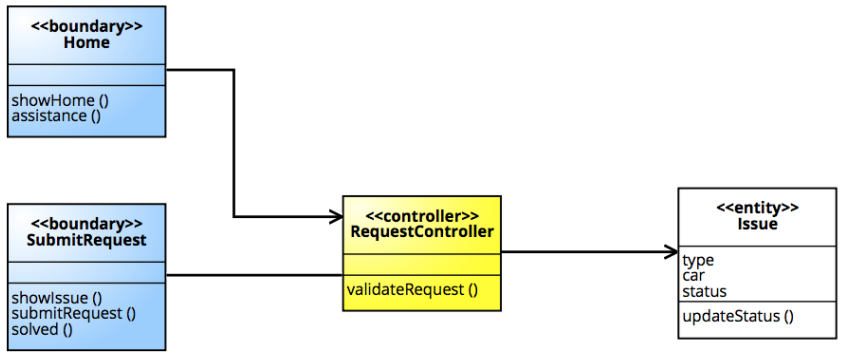
Mobile application



Car application



Operators application



Effort spent