



POLITECNICO DI MILANO 1863

SOFTWARE ENGINEERING 2 PROJECT

Design Document (DD)

SafeStreets

Version 1.0

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1 Introduction

1.1 Purpose

This is the Requirement Analysis and Specification Document (RASD) of SafeStreet application. Goals of this document are to completely describe the system in terms of functional and non-functional requirements, analyze the real needs of the customer in order to model the system, show the constraints and the limit of the software and indicate the typical use cases that will occur after the release. This document is addressed to the developers who have to implement the requirements and could be used as a contractual basis.

1.1.1 Description of the given problem

SafeStreets is a crowd-sourced application that intends to provide users with the possibility to notify authorities when traffic violations occur, and in particular parking violations. The application allows users to send to authorities pictures of violations, including their date, time and position. Examples of violations are: vehicles parked in the middle of bike lanes, in places reserved for people with disabilities, on footpaths, double parking etc.

SafeStreets stores the information provided by users, completing it with suitable meta-data every time it receives a picture. In particular it is able to read automatically the license plate of a vehicle and store it without asking the user to type it. Also it stores the type of the violation which is input by the user from a provided list. Lastly it stores the name of the street where the violation occurred, retrieving it automatically from the geographical position where the user took the picture. Then the application allows both end users and authorities to mine the information crowd-sourced. Two visualizations are offered: the first is an interactive map where are highlighted with a gradient color the streets with the highest frequency of violations. The second is a list of the vehicles that committed the most violations (available only to authority users).

In addition the app offers a service that creates automatically traffic tickets which can be approved and sent to citizens by the local police. This is done using the data crowd-sourced by the users. The application guarantees that every picture used to generate a ticket hasn't been altered. In addition, the information about issued tickets is used to build statistics. Two kind of statistics are offered: a list of people who received the highest number of tickets and some trends of the issued tickets over time and the ratio of approved tickets over the violations reported.

1.2 Scope

1.3 Definitions, acronyms, abbreviations

1.3.1 Definitions

- Heatmap : A heatmap is a graphical representation of data that uses a system of color-coding to represent different values
- Enduser : a regular citizen which will use the app
- Authority user : someone who's working for an authority like police, municipality etc.
- Geocoding : the process of converting addresses (like a street address) into geographic coordinates (latitude and longitude)
- Reverse geocoding: the process of converting geographic coordinates into a human-readable address

1.3.2 Acronyms

- ALPR : Automated Licence Plate Recognition
- GUI : Graphical User Interface
- GDPR : EU General Data Protection Regulation
- API : Application Programming Interface

1.3.3 Abbreviations

- APP : The SafeStreet mobile application to be developed

1.4 Revision history

This is the first released version 10/11/2019.

1.5 Reference Documents

References

- [1] Robert C. Martin, Clean Architecture: A Craftsman's Guide to Software Structure and Design, Prentice Hall, Year: 2017 ISBN: 0134494164,9780134494166
- [2] OpenALPR Technology Inc. , OpenALPR documentation <http://doc.openalpr.com>
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1.6 Document Structure

This document is divided in five parts.

1. **Introduction**
2. **Architectural Design**
3. **User Interface Design**
4. **Requirements Traceability**
5. **Implementation, Integration and Test Plan**
6. **Effort spent** contains the tables where we reported for each group member the hour spent working on the project

2 Architectural Design

2.1 Overview

The system to be developed has a three tier structure and it follows the structure service oriented.

1. Mobile application (client)
2. Application Server
3. Database

The first tier consists in a mobile app running on mobile devices, smartphones or tablets with iOS or Android. This is the application the users will interact with.

The second tier consists in an Application Server which provides the service as a RESTful API to the clients which are the running applications, and it's connected to the third tier, the Database Server where all data is stored.

There are some advantages of our system architecture: the first one is the modularity of this approach of having different subsystems. The second is scalability, which is the ability of the system to manage changes in the scale of demand. Since we have separated the client, the server and the database, it's easy to manage for example an increase of the data stored, just updating the database with a bigger one, without touching the application server.

Moreover the software that runs on clients and on the server will be developed with a layered Clean architecture, as described in detail in Section 2.6 which is organized through abstraction levels, starting from Entities to Use Cases and finally to Controllers and Presenters. One big advantage of this architecture is that we have a separated component for each use case.

2.2 Component view

Here are proposed the component views for both part of the system, the mobile application and the application server.

2.2.1 Mobile Application

Figure 1

Entities Entities are the domain of the system, they represent the business objects of the application. In our case entities are plain objects that don't have any dependency on other part of the system (eg. frameworks). Since the core of our system is based on **Users**, **Violations** and **Tickets** we have included those entities.

Use Cases Use cases are components that represent our system actions, they are pure business logic which describe what is possible to do with the application. We have one component for every possible use case.

We encapsulate all use case in a **Use Case interactor** which manages all possible use cases, it depends on the entities and has communication ports with the Controller and Presenter. In fact the use case interactor has two ports: an input, which interfaces with the Controller and an output port connected with the Presenter. As an example: if there is data coming from the camera, this is acquired by an adapter of the controller and is passed to the Use case interactor which coordinates the Use Cases and the data just acquired. After data is processed, it goes to the Presenter and visualized by the widgets of the UI.

Here follows the list of every Component of the Use case group. We have to add a note here: when it's written for example that a component interacts with the Application server, it doesn't

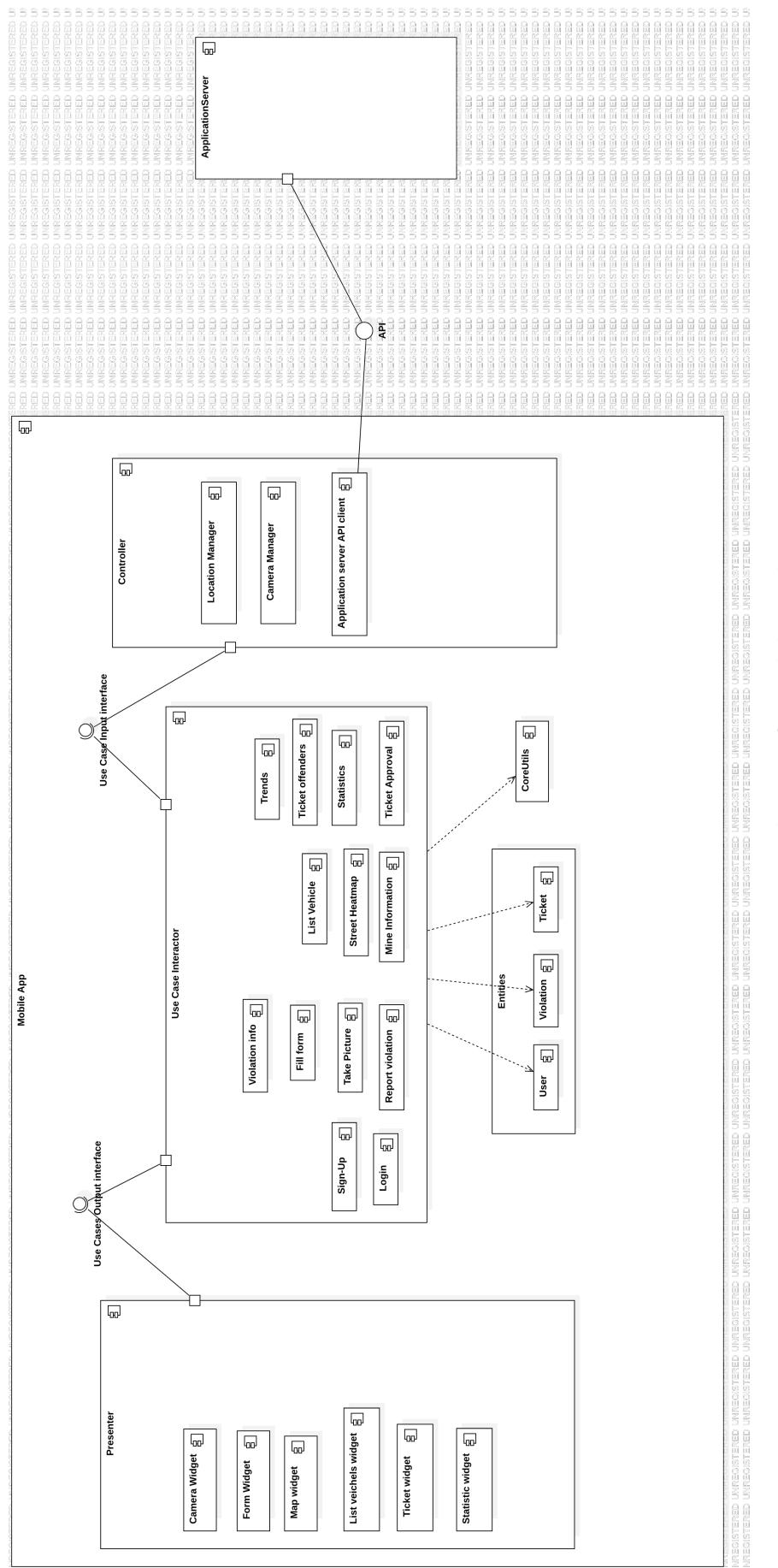


Figure 1: Component diagram for Mobile Application

mean that this component interacts directly with the Application API. As we have written before, every use case has to interact firstly directly with the controller which handles then the connections with the external interfaces. The same goes for communicating with the UI, every data transfer happens via the Use-Case/Presenter interface. In order to keep the following descriptions short, we just say what the component does in a higher level.

- **Sign-Up:** This component allows to add new users to the system. It has to get the input strings (username, password, user data etc.) from the sign-up widget, validate them before sending the request to the Application Server. After, it has to get the answer from the Server and communicate to the user if the sign-up was successful or not.
- **Login:** This component allows the login to the App. It has to get the input from the Login widget, communicate the strings to the Application Server and interpret the response if the user is authorized to login or not.
- **Take Picture:** This component makes possible to take picture of violations. After the picture has been taken, it has to send it to the Application Server and wait for an answer. If the answer is that a plate is found, than it calls the next use case "Send form". If no plates are found it asks the user to take a picture again discarding the previous one. If more than one plate is found, it activates a "brush tool mode" (in the Camera Widget) to ask the user to cover the other plates present in the picture. Then it has to manipulate directly the picture changing the color of the pixels selected by the user. Lastly it can send the picture to the Server.
- **Send form:** This component presents the user the form in which he can choose the type of violation. After the form has been submitted by the user, it is sent to the Application Server in order to be stored.
- **List Vehicles:** This component asks the Application Server in order to get the list of vehicles that committed the most violations. Then it opens the widget to show a scrolling list view of plates with the count of violations.
- **Street Heatmap:** This component asks the Application Server to provide the heatmap visualization of the areas where the violations happened.
- **Ticket Approval:** This component is responsible of showing the tickets available for approval. Every time the Authority user opens this or refreshes the list, the component has to call the Application Server in order to get the data about the pending ticket. Moreover this component offers the feature of approving or not a pending ticket using two buttons.
- **Ticket Offenders:** This component is responsible of showing the list of the most egregious offenders by querying the Application Server
- **Trends:** This component has to show the desired statistics about the issued tickets, querying the Application Server.

CoreUtils This component encapsulates all the libraries and classes with methods that can be needed by any use case. Here we list some of these functions:

- Input validation
- Error handling and reporting
- Exceptions
- Data conversion

Controller The controller component encapsulates all the specific adapters which are devoted to retrieve and store data from different sources such as the local filesystem, the device sensors, the camera and lastly our application service API which is described in section 2.2.2. Each component of the controller in fact implements the interfaces required by the use cases. Here is the description of each sub-component:

- **Location Manager**: this component is responsible of getting the location of the user accessing the libraries of the OS of the device
- **Camera Manager**: this component is responsible of getting access to the camera of the device
- **Application server API client**: this component handles all the HTTP requests to and from our Application server

Presenter The presenter is a macro component that includes all the components of the UI. Here follows the list of every component with the description:

- **Page Manager**: this components coordinates every page shown in the mobile application, and provides the navigation bar
- **Login Widget** : this is the login page and sig-up page, with the required input fields
- **Camera Widget** : this shows what is recorded by the camera, has a button for taking pictures, activate zoom and other camera functionalities. It also shows the picture once taken and implements the "brush tool mode"
- **Form Widget**: this shows a list of possible description of violations the user can select
- **Map Widget** : this is responsible for showing the street heatmap
- **List Vehicles Widget** : this widget shows the list of vehicles that committed the most violations
- **Ticket Widget**: this shows the list of tickets the authority user can approve or not. It also shows information about each one
- **Statistics widget**: this can show some data visualization about the tickets issued

2.2.2 Application Server

The architecture of the Application server looks the same as the Mobile Application, but has completely different components in the Presenter and Controller.

Entities Since the core of our system is based on **Users**, **Violations** and **Tickets** are the main Entities of the Systemm, those are the same as the Mobile Application.

Use Cases The use cases components for the server-side have almost the same names as the ones as the application, but they have a completely different logic. As an example: on the application side we have the use case "Take picture" which has to interact with the device physical camera in order to take the picture and then send it as POST HTTP request to the server, whereas on server side we have the "Get picture" use case, which fetches the HTTP requests, parses the content, sends the picture to the OpenALPR service to get the decoded plate and then stores the picture.

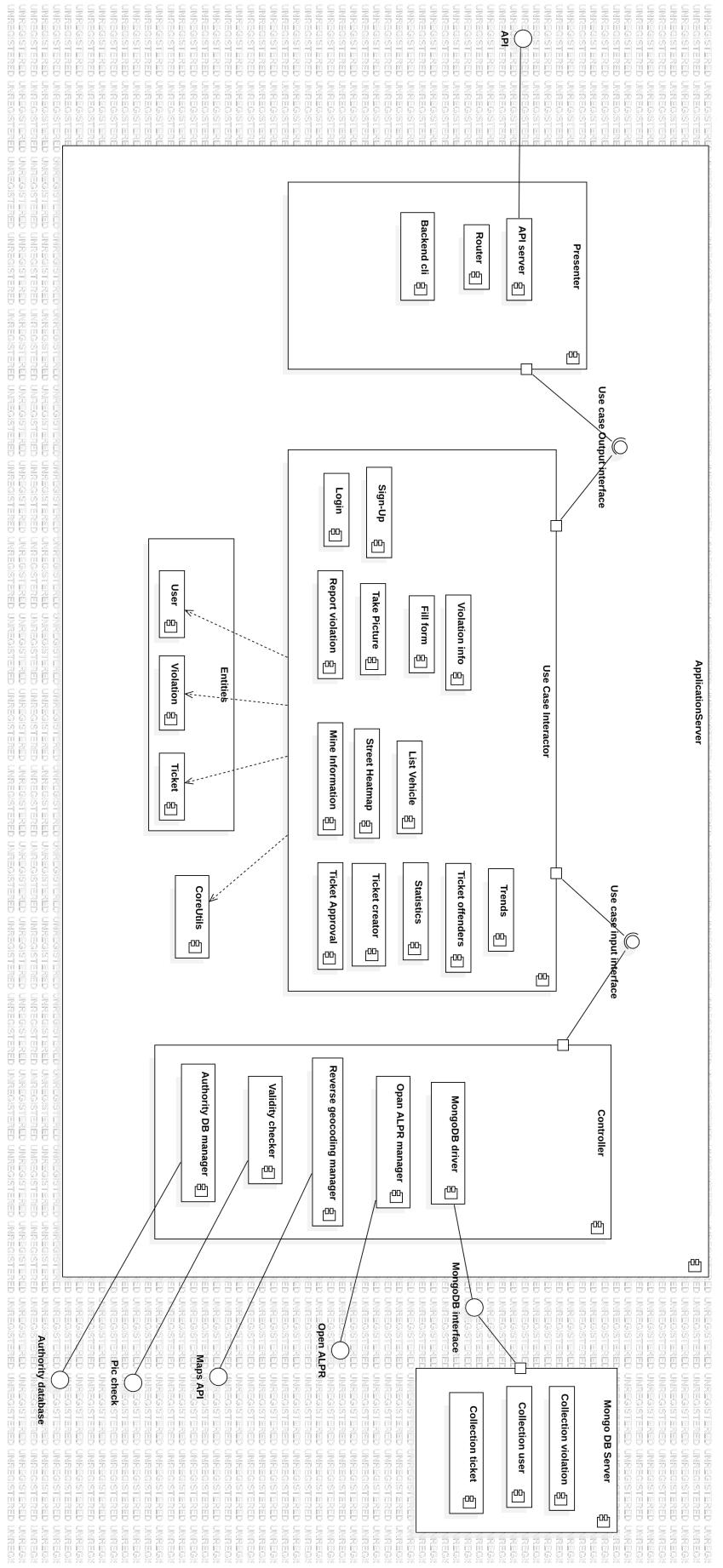


Figure 2: Component diagram for Application Server

- **Sign-Up:** This component receives from the APP the username, password and personal information of a new user who is registering to the service. It must be able to check if the username is already in use or not. Then it must encrypt the password. Lastly it stores the new user in the database.
- **Login:** This component receives from the APP the request of a user trying to login to the service. It has to send back a successful login answer if the user exists and the password is correct. It has also to communicate an API key to the mobile app that will be used for every successive API call. This API key is needed to ensure identification of each user and to provide a restricted access to users to some functionalities.
- **Get Picture:** This component receives the POST request from the APP containing the picture of the violation and the coordinates of the location of the user. The picture is stored temporarily in the filesystem and then is sent to the external OpenALPR API which has to decode the plate. If no plates are returned by the OpenALPR service, it has to send to the APP a message of error asking to take a picture again. If more than one plates are detected it has to send to the APP a message of error so the app can ask the user to use the "brush tool" to cover the other plates. If one plate is correctly found, it sends to the APP the plate just decoded with a success message. This component has also to send the coordinates to the reverse geocoding service of the Maps API in order to get the street name and number. Then it moves the picture in a specific directory and saves in the database a new record containing the path where the picture is stored, the received decoded plate as string, the raw coordinates, the string containing the name of the road and the number.
- **Get form:** This component receives the PUT request from the APP containing the content of the form associated to the picture of the violation. This request is PUT type because it must update the existing violation document in database adding the kind of violation.
- **List Vehicles:** This component is used to query the database of violations in order to get the list of vehicles with the associated count of violations occurred.
- **Street Heatmap:** This component is responsible of getting the map from
- **Ticket Approval:** This component is used to provide the mobile APP the list of ticket available for approval and then set the
- **Ticket Creator:** This component is used to automatically create a new ticket, based on the data present in the violation database.
- **Ticket Offenders:** This component does the query of the ticket database in order to return to the mobile APP the list of people who received the highest number of tickets.
- **Trends:** This component contains the logic in order to provide some aggregated data about the emitted tickets.

CoreUtils This component encapsulates all the libraries, classes with methods and middleware that can be needed by any use case.

- Input validation
- Error handling and reporting
- Exceptions
- Data conversion
- Body parser for HTTP requests

Controller

Presenter The presenter is the macro components that encapsulates all the frameworks needed to provide an API interface.

2.3 Deployment view

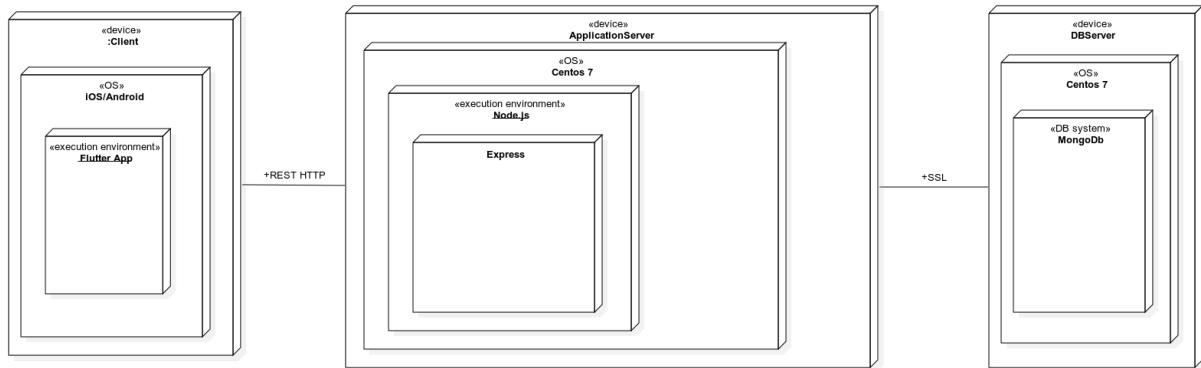


Figure 3: Deployment diagram

In Figure 3 is shown the Deployment diagram of all the system.

The deployment consist of three main devices. The first tier consist is **Mobile device** the user will use, which can be a smartphone or a tablet using as operating system either iOS or Android. The exection enviornment is the built Flutter app.

The second tier is the **Application Server**. It is supposed to be a dedicated server running a linux distribution specific for server use. As an example of OS we choose CentOS 7. Other distros can be used like Red Hat Enterprise Linux, Debian, OpenSUSE. As execution enviornment we install Node.js which is an open-source JavaScript runtime environment that executes JavaScript code outside of a browser. Inside Node.js we use the web application framework Express.js which is designed for building web applications and APIs.

The third tier is the **DB Server**. It consists in another server where we run the DB system MongoDB. We choose to run the database in a separate server and not in the same as the ApplicationServer in order to increase scalability. MongoDB is a cross-platform document-oriented database program. Classified as a NoSQL database program, MongoDB uses JSON-like documents with schema.

2.4 Runtime view

A note for the sequence diagrams, to keep the diarams more readable, we omit that every call to and from a specific use case must pass from the use case interactor which manae the component interfaces.

2.4.1 Reporting Violation

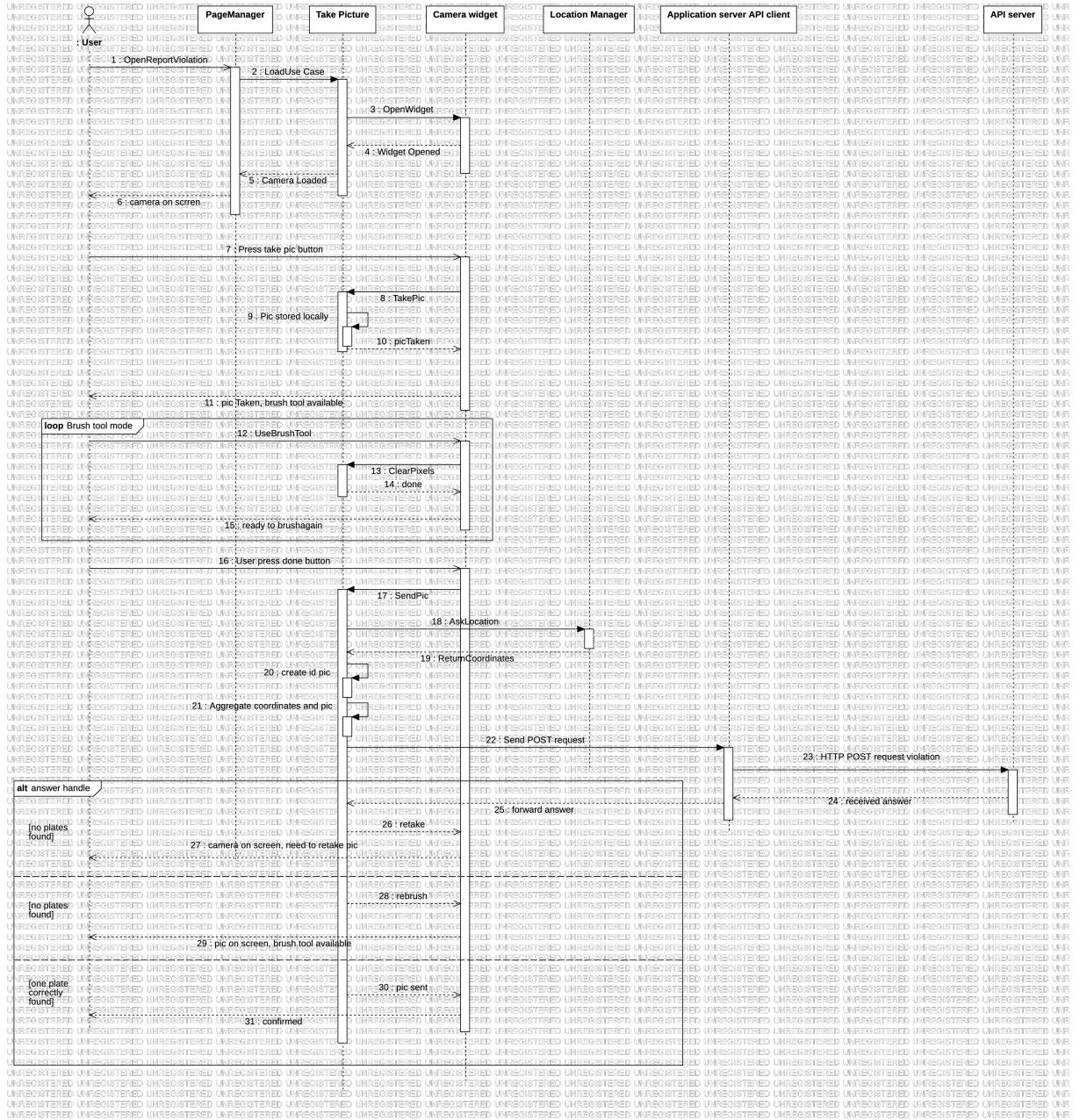


Figure 4: Sequence diagram for picture upload via the Mobile Application

In figure 4 is shown the sequence diagram for the use case of taking a picture using the mobile application. The user interacts with the **PageManager** pressing the button to open the "Report Violation section", so the **TakePicture** use case is loaded because it's the first step needed to start the reporting of a violation. This opens the **CameraWidget** that is the component of the Presenter responsible of showing on screen the camera recording. When the widget is correctly started the user can take the picture pressing the main button. The widget has to tell the **TakePicture** use case that the button has been pressed so the picture can actually be taken and stored locally. The camera widget can now show the picture just taken and show the brush tool mode. If there is need the user can cover whith is finger some areas of the picture. The widget communicates to the use case the location of those areas so the image can be manipulated

by the **TakePicture** use case and stored. This can happen until the user presses the "done button". Now the the **TakePicture** use case asks the the **LocationManager** to return the GPS coordinates of the device. An Unique identifier is generated which is passed with the picture to the **Application Server API client** which has to actually make the POST HTTP request to the Application Server. What happens in the application server is described later in the following Sequence diagram in Figure 5. When an answer is received there are three options possible: if no plates have been found, the use case has to start again, so it tells the widget to show a message for the user, asking to retake the picture including the plate. If more than one plates are found, the use case has to ask the widget to show a message asking the user to use again the brush tool mode to cover the plates not required. If one plate is correctly identified the use case can tell the widget to show a success messae and terminates.

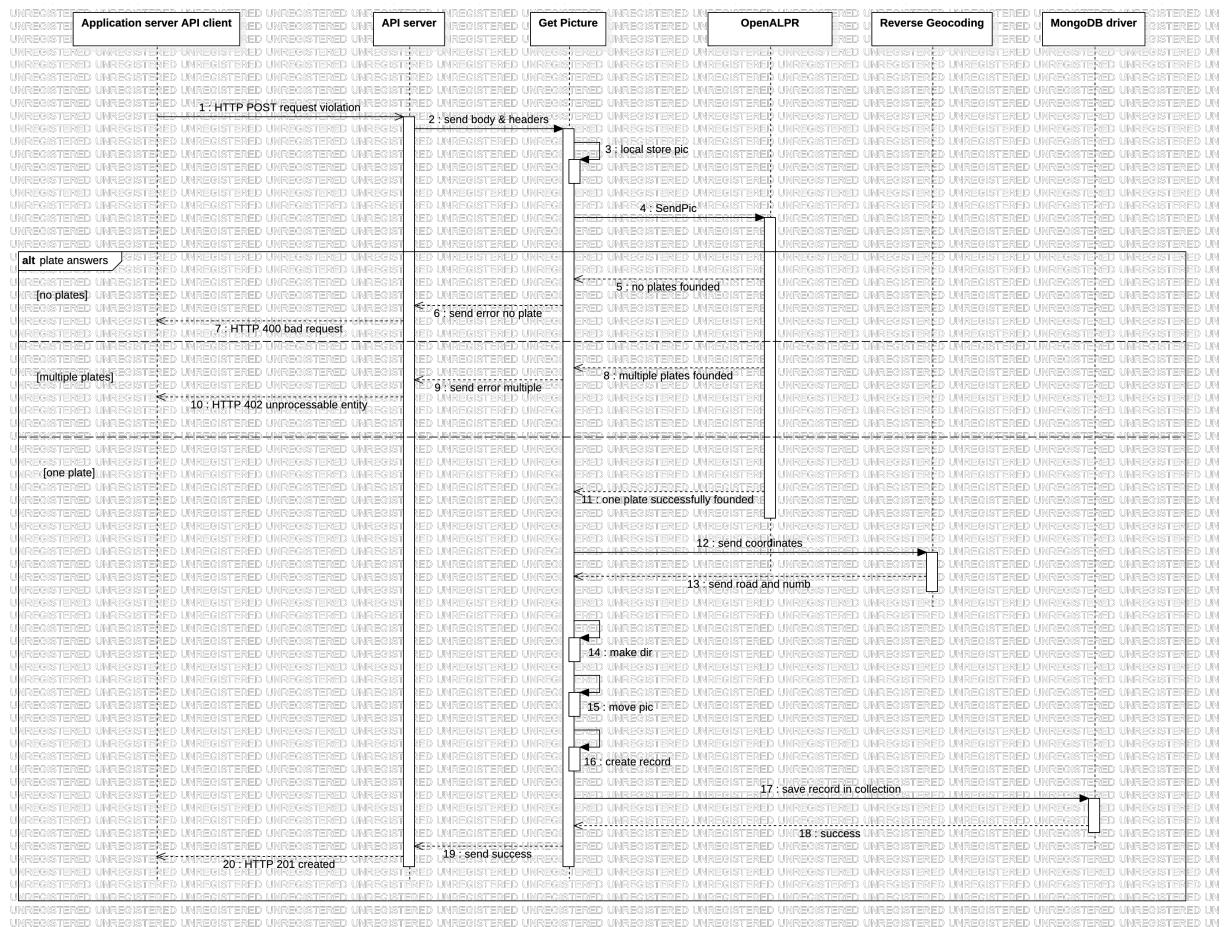


Figure 5: Sequence diagram for picture storage by Application Server

In figure 5 is shown the sequence diagram for the Application Server when it receives a POST request of a new picture.

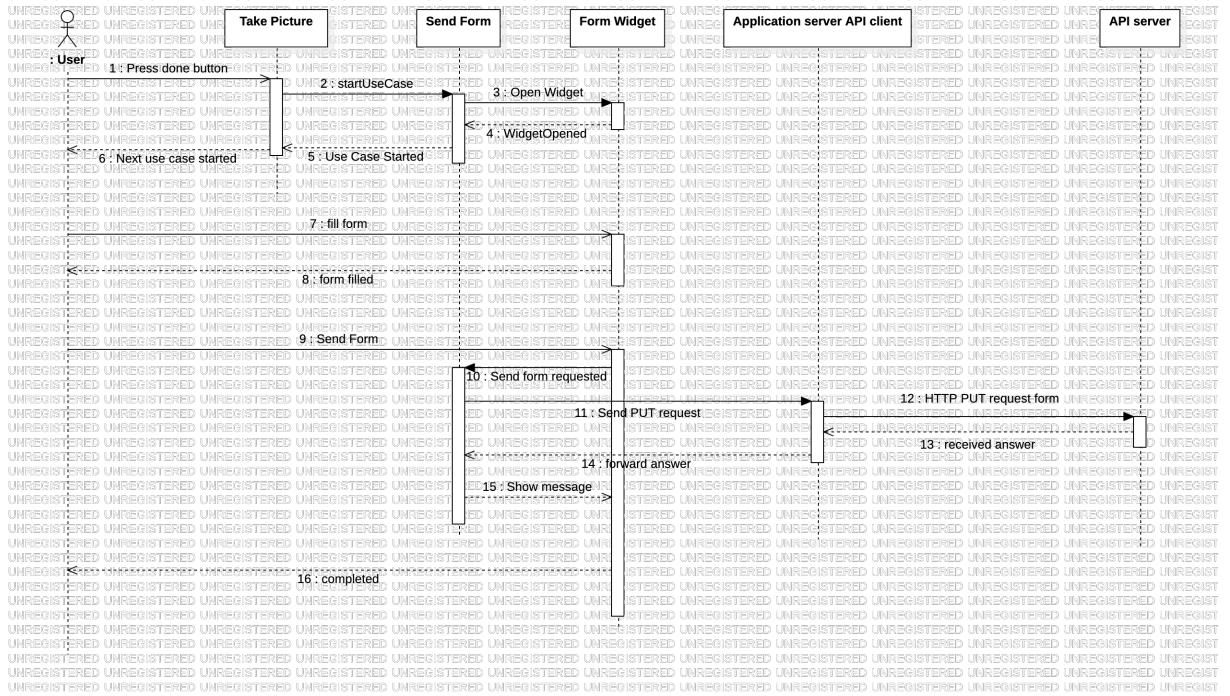


Figure 6: Sequence diagram for filling form on Mobile App

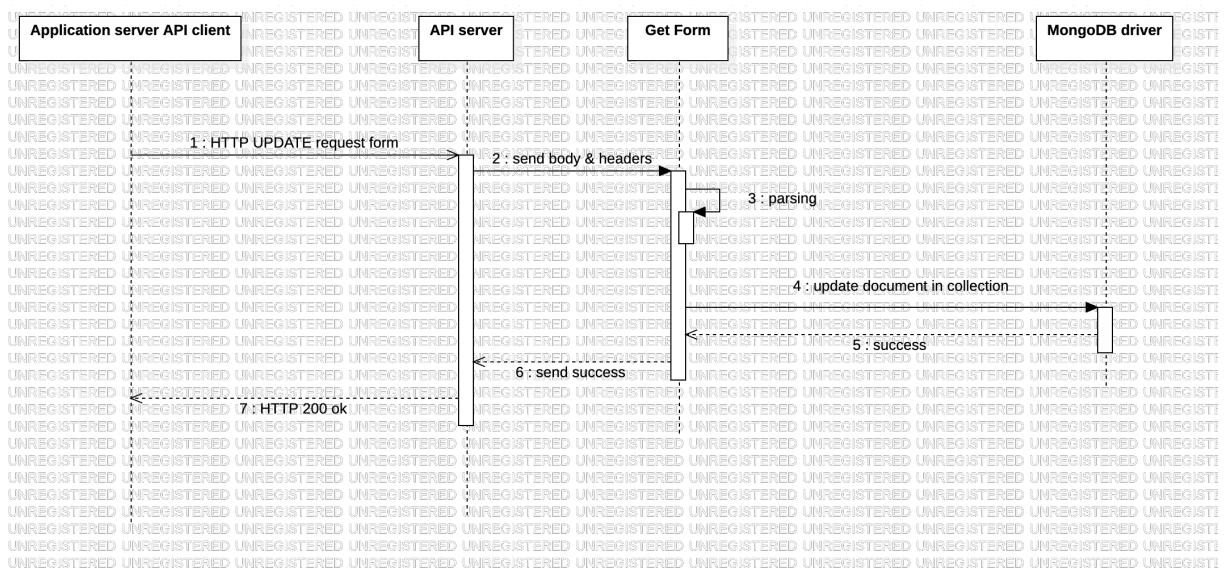


Figure 7: Sequence diagram for getting the form by Application Server

2.4.2 Streets Heatmap

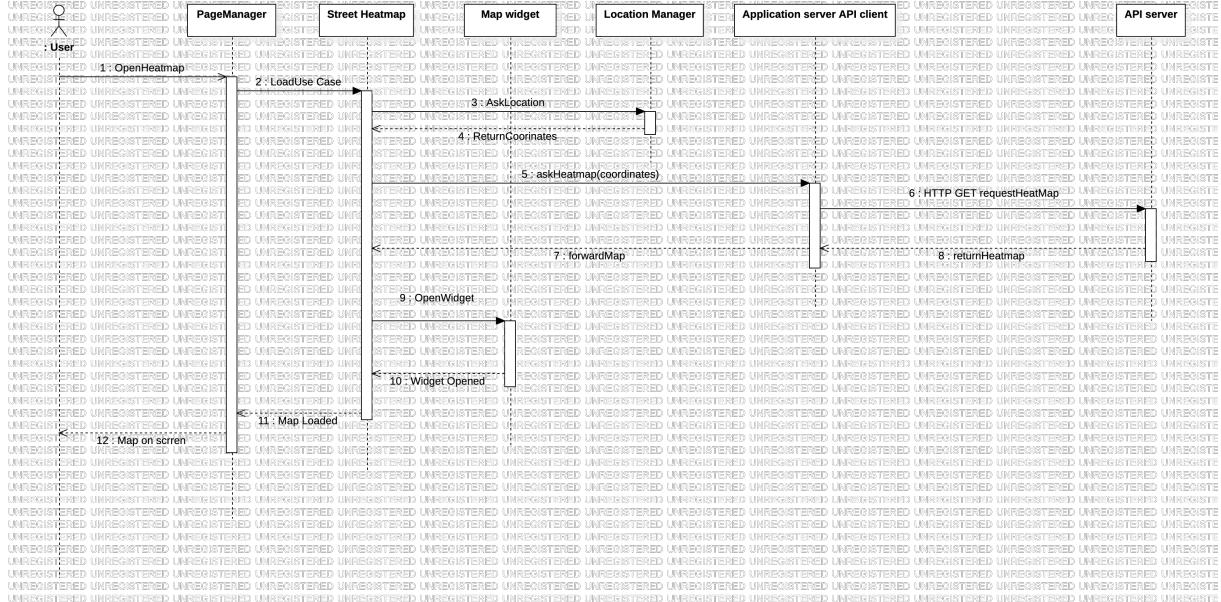


Figure 8: Sequence diagram for

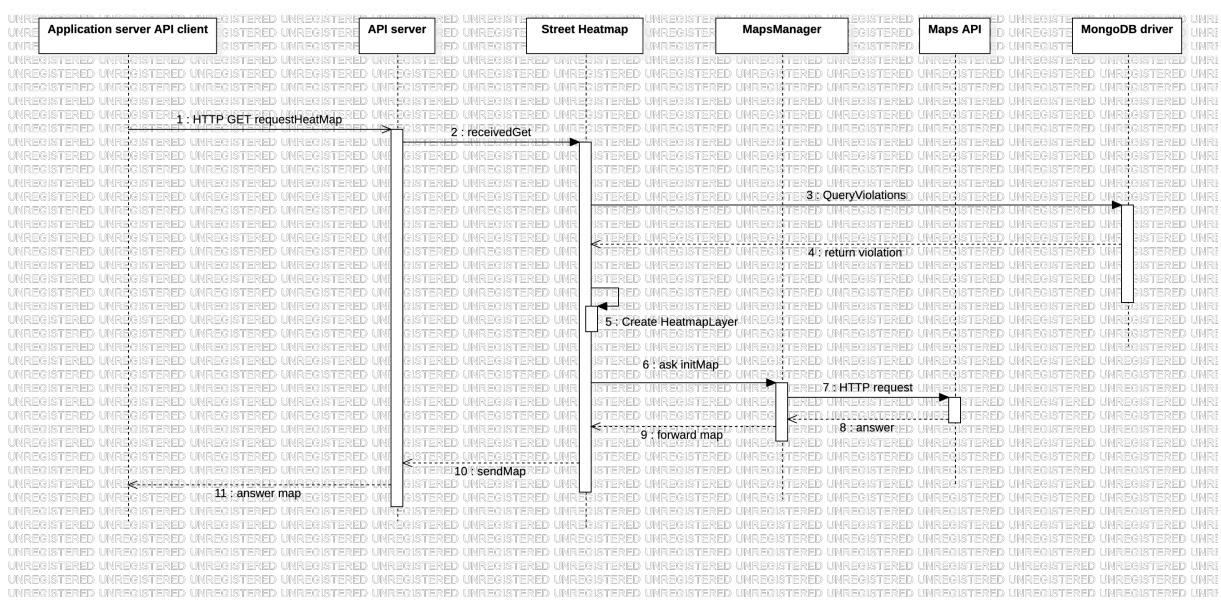


Figure 9: Sequence diagram for

2.4.3 Vehicle list by violations

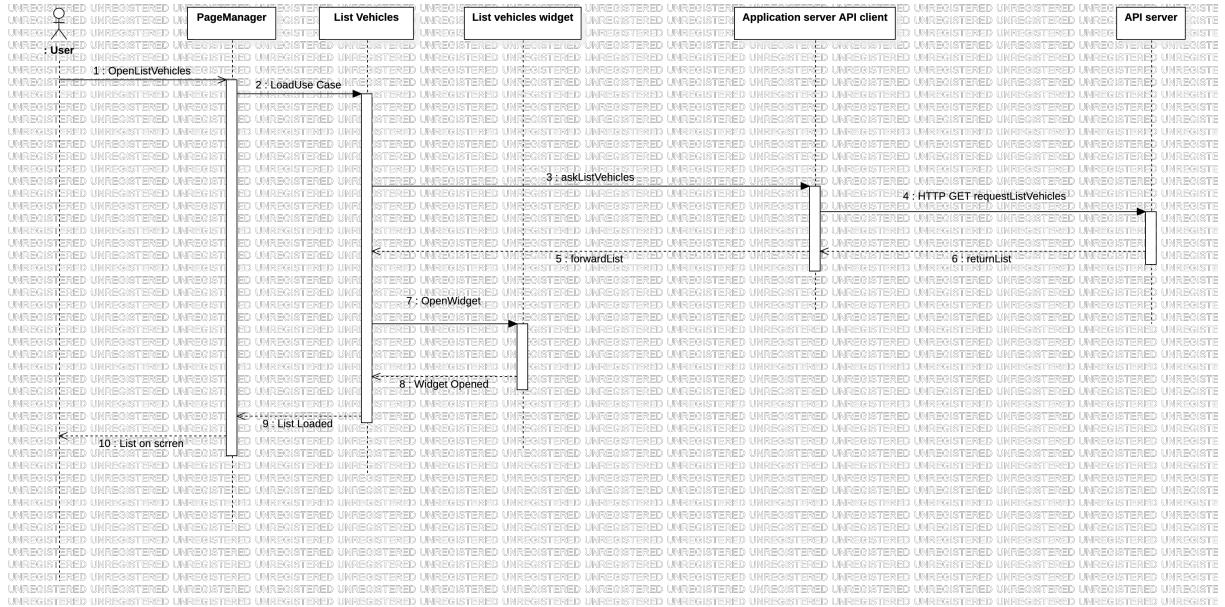


Figure 10: Sequence diagram for

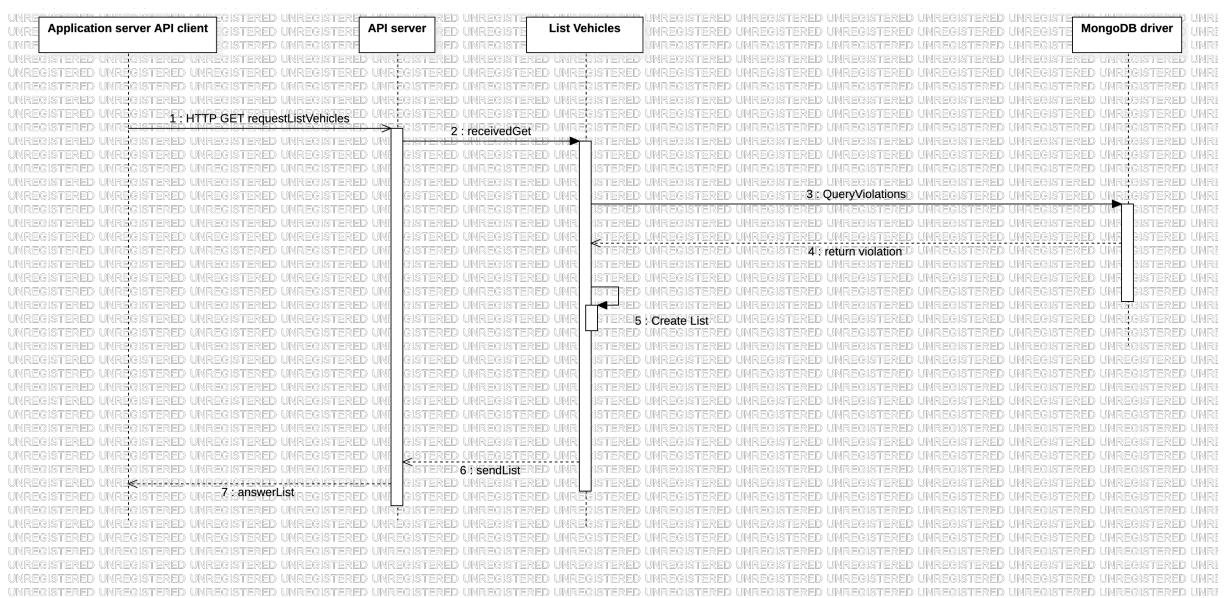


Figure 11: Sequence diagram for

2.5 Component interfaces

2.6 API interfaces

2.7 Selected Architectural styles and patterns

As already introduced, each part of our system will use the Clean Architecture, proposed by Robert C. Martin. We apply this architecture both on the mobile application and in the Application Server.

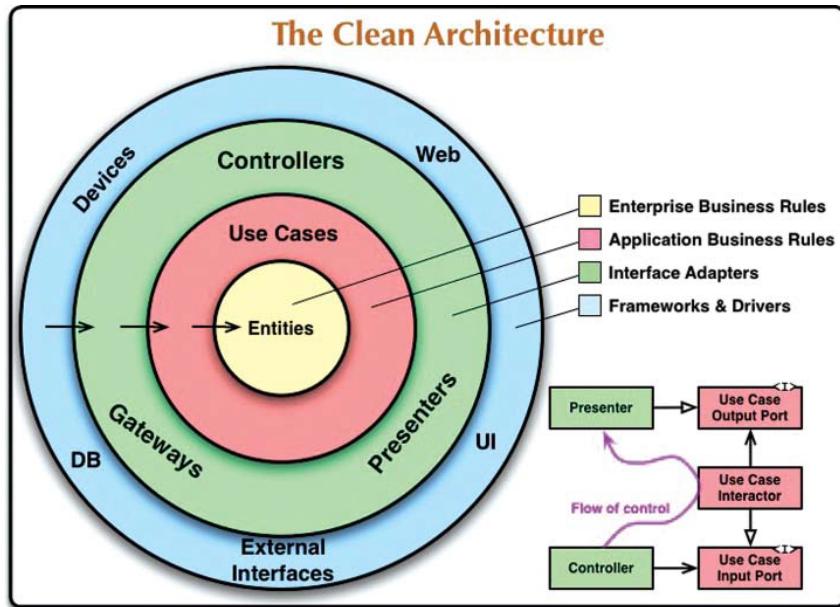


Figure 12: Clean Architecture [1] p. 203

2.7.1 Dependency Rule

"The concentric circles in Figure 8 represent different areas of software. In general, the further in you go, the higher level the software becomes. The outer circles are mechanisms. The inner circles are policies. The overriding rule that makes this architecture work is the Dependency Rule: Source code dependencies must point only inward, toward higher-level policies. Nothing in an inner circle can know anything at all about something in an outer circle. In particular, the name of something declared in an outer circle must not be mentioned by the code in an inner circle. That includes functions, classes, variables, or any other named software entity." [1]

2.7.2 Entities

"Entities encapsulate enterprise-wide Critical Business Rules. An entity can be an object with methods, or it can be a set of data structures and functions. It doesn't matter so long as the entities are the business objects of the application. They are the least likely to change when something external changes. For example, you would not expect these objects to be affected by a change to page navigation or security. No operational change to any particular application should affect the entity layer." [1]

2.7.3 Use Cases

"The software in the use cases layer contains application-specific business rules. It encapsulates and implements all of the use cases of the system. These use cases orchestrate the flow of data to and from the entities, and direct those entities to use their Critical Business Rules to achieve the goals of the use case. We do not expect changes in this layer to affect the entities. We also do not expect this layer to be affected by changes to externalities such as the database, the UI, or any of the common frameworks. The use cases layer is isolated from such concerns. We do, however, expect that changes to the operation of the application will affect the use cases and, therefore, the software in this layer. If the details of a use case change, then some code in this layer will certainly be affected." [1]

2.7.4 Interface Adapters

"The software in the interface adapters layer is a set of adapters that convert data from the format most convenient for the use cases and entities, to the format most convenient for some external agency such as the database or the web. The presenters, views, and controllers all belong in the interface adapters layer. The models are likely just data structures that are passed from the controllers to the use cases, and then back from the use cases to the presenters and views." [1]

2.7.5 Advantages of Clean architecture

Following are some reasons why a good architectural pattern for our system:

- All business logic is in a use case, so it's easy to find and not duplicated anywhere else
- Good monolith with clear use cases that you can split in microservices later on

2.7.6 REST

The communication between the mobile application and the microservice will be done via HTTP requests following REST principles. REST (Representation State Transfer) is an architectural style for communication based on strict use of HTTP request types. One of the most important REST principles is that the interaction between the client and server is stateless between requests. Each request from the client to the server must contain all of the information necessary to understand the request. The client wouldn't notice if the server were to be restarted at any point between the requests.

2.8 Other design decisions

Here we describe the frameworks and languages that should be used to produce a state-of-art application.

Flutter

Node.js To build a

MongoDB MongoDB is a noSQL database. It represents the data as a collection of documents rather than tables related by foreign keys. Those documents are collected in collections and can have different schemas. We choose to use MongoDB because it's so well integrated with Node.js, because there are very useful libraries such as Mongoose which make easier to communicate with the DB. Document-based data storage is the main aim of using a non-structured database like NoSQL. MongoDB is a distributed database which allows ad-hoc queries, real-time integration, and indexing efficient.

3 User Interface Design

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4 Requirements Traceability

The advantage of using clean architecture is that we have a component for each use case so it's very easy to keep track of the requirement traceability.

	Requirement	Component
[R1]	User must be able to choose the kind of violation from a list	Fill form
[R2]	User must be able to read detailed information about each kind of violation he can report	Violation info
[R3]	Date, time and position should be automatically added to the violation reported	Report violation
[R4]	We should require the user to send again a picture in case the plate is not visible	Take picture
[R5]	The user must be able to select the vehicle to report in case there are other vehicles in picture	Take picture
[R6]	Application must automatically determine the street name where User is	CoreUtils
[R7]	Application must be able to count occurrence of violations	Street Heatmap
[R8]	Application must be able to count violation for each vehicle	List vehicles
[R9]	Application should show all the vehicles ordered with the number of violations	List Veichle
[R10]	Application should visualize the areas where violation occurred	Street Heatmap
[R11]	Application must use a gradient of color to show the occurrences of violations as an overlay of a interactive map	Street Heatmap
[R12]	Regular users cannot mine data about plates of the offenders	Mine Information
[R13]	Authority users can know the exact licence plate when mining data about offenders	Mine Information
[R14]	Only authority users can access the ticket approval section	Ticket approval
[R15]	Application must be able to read every violation stored and automatically generate a ticket	Ticket Creator
[R16]	Application should offer to authorities the possibility to approve tickets or not	Ticket approval
[R17]	Application must store all the tickets created	Ticket creator
[R18]	Application must read all the history of tickets created	Trends
[R19]	The application must be able to know if a picture has been altered	Ticket Creator
[R20]	If a picture has been altered the application must automatically flag as not valid the corresponding ticket	Ticket Creator

Table 1: Requirements Traceability matrix

5 Implementation, Integration and Test Plan

This section will discuss the implementation, integration and testing of the SafeStreet application. The section aims to prevent any setbacks entailing changes on the project once started its development and do multiple tasks twice. First of all, it is important to divide the project into smaller components in order to have more concrete goals that help keep the developers' motivation high and make a straightforward development of the project. Therefore, we will divide the project in different components, starting from the ones that are responsible of the basic features and going on until the end, where we will develop the most specific ones. It is not a new method, because it has been studied during this course and it is referred to as 'bottom-up' strategy. This method will help providing a better integration of the project tier-by-tier and make different tests of the behaviour of the application before it ends. The System can be divided into three main parts as following:

- **Frontend components:** contains the Mobile App.
- **Backend components:** contains the application server with all its components and the DBMS.
- **External components:** contains all the external components, such as the ALPR, to extract the license plate from a photo, and so on.

It should be noted that the external systems' components need not to be implemented and tested just because they are external and they can be considered reliable. Going back to our project, we will divide the Mobile App component to three main entities, corresponding to User, Violation and Ticket. The services that have to be created for each entity are:

- User: Sign-UP, Login
- Violation: Report Violation, Take Picture, Fill Form, Violation Info, List Vehicles, Street Heatmap, Mine information.
- Ticket: Ticket Approval, Statistics, Ticket offenders, Trends.

In figure 9, the overall process structure of the implementation has been shown. First, the blue part, will be implemented and tested. After the blue part works efficiently, the orange part, services related to report a violation, will be implemented and tested. Finally, if the blue and orange part will work efficiently, the final green part, Ticket, will be implemented and tested. During the implementation and testing process, we will make the component integration once we have finished each tier and tested each isolated component, meaning we will mix the different phases and try to detect possible defaults in our design.

As mentioned in 9, we will start with developing the User component. The Sign-Up and Login components are clearly an entry condition for the right functioning of the system, but they are not the main features and they are not very complicated. These two components can be implemented and tested at any order. After Implementing and testing User component, we will continue with the next part of the implementation of the software which is Violation component. We will integrate all the services and test whether the whole Violation component will work as it is expected. If the result is positive, we will continue with the next last of the implementation of the software. If the result is negative, we should study if something is wrong in our code or if we should make any changes in the project development.

5.1 Sequence of component integration

The diagrams below describe the sequence of the component implementation, integration and testing of the system. The arrows starts from the component which uses the other one.

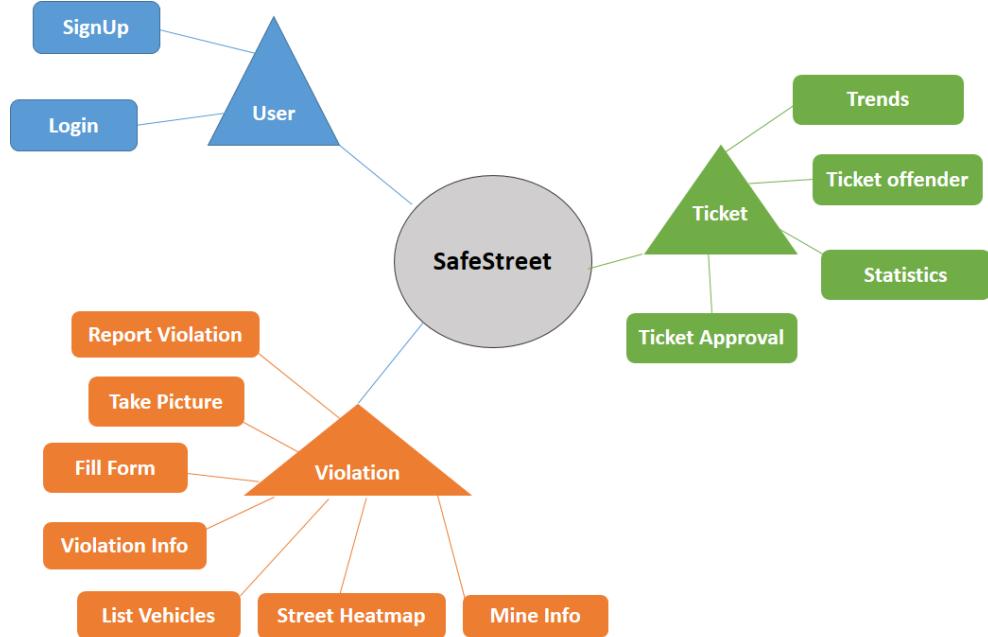


Figure 13: A general overview of the service implementation

Integration of the all internal components of the application server Firstly all the components will be implemented and tested with unit tests. Then the integration process will proceed in the following order and the integration is tested as well.

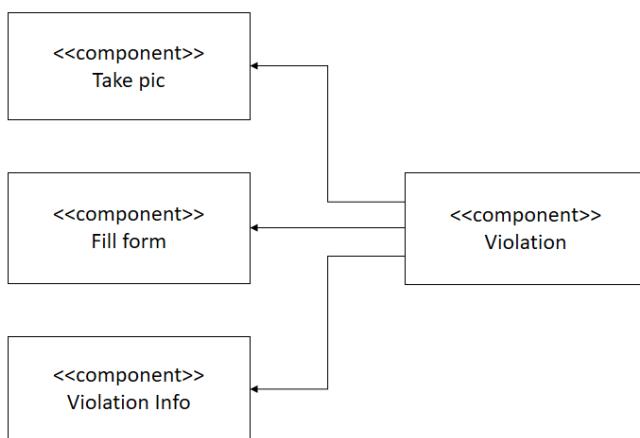


Figure 14: report violation integration

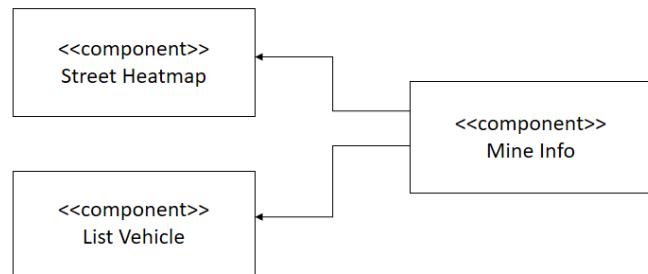


Figure 15: Mine Information integration

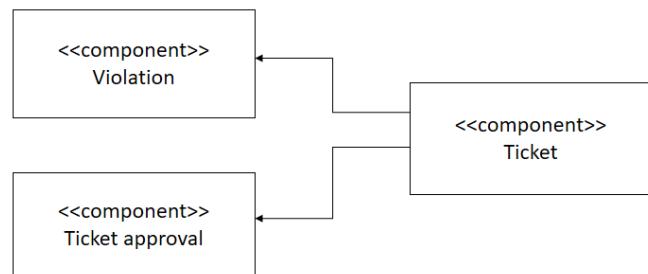


Figure 16: Issuing Ticket integration



Figure 17: Show Statistics integration

Integration of the frontend with backend Once all the components are implemented and tested among each others, the frontend will be integrated and tested within the backend. The subsystems to be integrated are 1:

- The Mobile app Client, that interacts with the Use Case Interactor



Figure 18: Mobile App integration

Integration of all subsystems Once the front-end has been integrated with the Back-end, the system will be fully tested, with the respect of all the components shown in the Component Diagram.

6 Effort Spent

Tiberio	
Task	Time
Structure of document	1h
Component diagrams and study of REST	2h
Component diag	1h 30 min
Meeting design	1h 30 min
Study clean architecture and DeploymentDiagram1	3h
Study clean architecture	1h
New Component diagrams	3h
Design patterns and frameworks	2h
Requirements traceability	2h
meeting	1h 30 min
Work on sequence diagrams	2h
User case components	3h
Sequence diagrams and explanation	2h
Sequence diagrams new	3h
meeting	1h
Total	17 h

Saeid	
Task	Time
Meeting design	1h 30 min
Study previous projects	2h
Study Architectural patterns	2h
Architectural styles and patterns	2h
Architectural styles and patterns	1h 30min
meeting	1h 30 min
Test Plan	1h 30 min
Integration and Test Plan	2h 30 min
Component diag analysis	1h 30 min
Integration diagram and explanation	2h
meeting	1h
Total	36 h 30 min