1. **INTRODUCTION**
   A. *Purpose*
   B. *Scope*
   C. *Definitions, Acronyms, Abbreviations*
   D. *Revision history*
   E. *Reference Documents*
   F. *Document Structure*
2. **ARCHITECTURAL DESIGN**
   A. *Overview*: High-level components and their interaction
   C. *Component view*
   D. *Deployment view*
   E. *Runtime view*: You can use sequence diagrams to describe the way components interact to accomplish specific tasks typically related to your use cases
   F. *Component interfaces*
   G. *Selected architectural styles and patterns*: Please explain which styles/patterns you used, why, and how
   H. *Other design decisions*
3. **USER INTERFACE DESIGN**: Provide an overview on how the user interface(s) of your system will look like; if you have included this part in the RASD, you can simply refer to what you have already done, possibly, providing here some extensions if applicable.
4. **REQUIREMENTS TRACEABILITY**: Explain how the requirements you have defined in the RASD map to the design elements that you have defined in this document.
5. **IMPLEMENTATION, INTEGRATION AND TEST PLAN**: Identify here the order in which you plan to implement the subcomponents of your system and the order in which you plan to integrate such subcomponents and test the integration.
6. **EFFORT SPENT:** In this section you will include information about the number of hours each group member has worked for this document.
7. **REFERENCES**

http://www.cloudcomputingpatterns.org/

Notes

Display and clustering

When a new violation is added it checks whether the same violation already exists, by checking on the same license plate, location, time. If it already exists it is added on the same report.
When the map is displayed, reports of the same violation type are clustered together.

Suggestions

Suggestions interact with clustering, suggestion are hardcoded.

Location

Each picture is linked with a location. The report however has only one location. The location in the report can be the average between the locations of the pictures.

Database

Each user has the list of each report sent.

Folders

Violation Reports
Clusters
Users
Municipalities
~~Groups~~
Accidents
Issued tickets

Groups

Unifies the reports that represents the same violation. It is a list of indexes of the reports that represents the same violation. The tuple also has the state of the reports (since it is the same for all reports that represents the same violation)

Groups merged with municipalities

Municipalities

Structure

Municipalities

- Municipality 1 [attribute = <ip api issued tickets & accidents>]
    - Approved
        - Group 1
            - Report1 ID
            - Report2 ID
        - Group 2
    - Rejected
        - Group 4
            - Report1 ID
            - Report2 ID
        - Group 73
    - Confirmed
        - ....
    - Issued Ticket
        - ticket1
            - plate
            - location
            - type
            - timestamp
            - (done by)
        - ticket2
    - Accidents
        - accident1
            - description
            - plate
            - location

        - timestamp
    - accident2
- Municip 2
- Municip 3

Clusters

It is divided by violation type. Each violation type has the list of all clusters
Clusters

- Typeofviolation
    - Cluster1
        - Location
        - UserSuggestions (if implemented)
        - Reports
            - Report1
            - Report2
    - Cluster2

Microservices (triggers)

- GroupingMS
    - Same violation
    - Verify if the violation has already been reported (location, time, licence plate)
    - Triggered by DB insert
    - Uses DB and Maps API
- ClusteringMS
    - Same location/type.
    - Triggered by DB insert
    - Uses DB

- ApprovingMS
    - Approves the report also using cloud vision.
    - Triggered by DB insert
    - Uses DB and Vision API
- MunicipalityDataRetrieverMS.
    - Accidents retriever
    - Tickets retriever
    - Triggered by a time event (like every day updates)
    - Uses DB and Storage
- OnReportConfirmedMS / OnReportRejectedMS.
    - Update the state of the reports from the municipality.
    - This is a trigger that when the state of a group of reports is updated, then we update all the corresponding reports in the DB.
    - Triggered by municipality
    - Uses DB
- Statistics ms
    - ????

Reports

Using Google vision the pictures wil be checked if they have at least one veichle in one of their photos. The report has the state, because a user must be able to retrieve his reports and the state, without accessing "Clusters" which contains sensitive information.

Interface

My reports
Settings

Web interface

The interface takes each group that is approved and not yet reviewed.
When the employee clicks on a report, it is opened and the photos are downloaded.

Statistics

List of statistics:

- number of issued tickets filtered by:
  - type of violation
  - interval of time
  - plate
-

1. Introduction

1.1. Purpose

TODO

1.2. Scope

As seen in the RASD, the idea behind this product is to give to the citizen the possibility to report traffic violations he sees during the day, to the authorities. Normally, the citizen would stop, call the non emergency police number, give information about current location, type of violation, brand of the car, license plate number, ecc., spending a lot of time on the phone just to report a violation. Our purpose is to make all of this quicker and easier. With our application, all that the user must do is snap a few pictures of the car in violation including the license plate and send the report to our system. In turn, the system will send the report to the municipality that operates in the corresponding city. We believe that reducing the effort will lead to an increase in the number of reports and ticket issued, reducing overall traffic violations.

Furthermore, the product will have an additional function: we want to give the citizens and municipalities the opportunity to mine the information regarding our data and that of the municipalities. Both the citizens and the municipalities will be able to see and filter violations occurred on the map of the city.

Finally the system will be able to give the municipality some suggestions on how to improve the condition of the roads. These suggestions will be based on the number of similar violations reported in the proximity of a specific area. For example, if in a certain area a lot of cars park on the street because there are not enough parking lots the system would suggest to increase their number or redesign them in a more space efficient way.

1.3. Definitions, Acronyms, Abbreviations

1.3.1. Definitions

- Entity: a “natural person”, or a “juridical person” in the case of the municipality.
- User: a citizen registered to the SafeStreets service.
- Municipality: a city or town that has corporate status and local government.
- Timestamp: a representation of date and time.
- Anonymized data: data that don't give any personal information, such as license plate, pictures and names.

- Valid violation report: a violation report composed by at least one picture, exactly one location, exactly one timestamp, exactly one type of violation and the license plate of the vehicle.
- Approved violation report: a valid violation report that may represent a correct violation report.
- Correct violation report: an approved violation report that the municipality evaluated as a traffic violation.
- Area: a district or a neighborhood of a country or city, especially one characterized by a particular feature or activity.
- GPS fix: a position derived from measuring in relation to GPS satellites.

1.3.2. Acronyms

- API: Application Programming Interface.
- GPS: Global Positioning System.
- UI: User Interface.
- S2B: Software To Be.
- GDPR: General Data Protection Regulation.
- OS: Operating System.
- RASD: Requirement Analysis and Specification Document
- HTTPS: Hypertext Transfer Protocol Secure
- HTML: Hypertext Markup Language

1.3.3. Abbreviations

- Gn: nth goal.
- Dn: nth domain assumption.
- Rn: nth requirement.

1.4. Revision history

- Version 1.0: Initial release.

1.5. Reference Documents

TODO

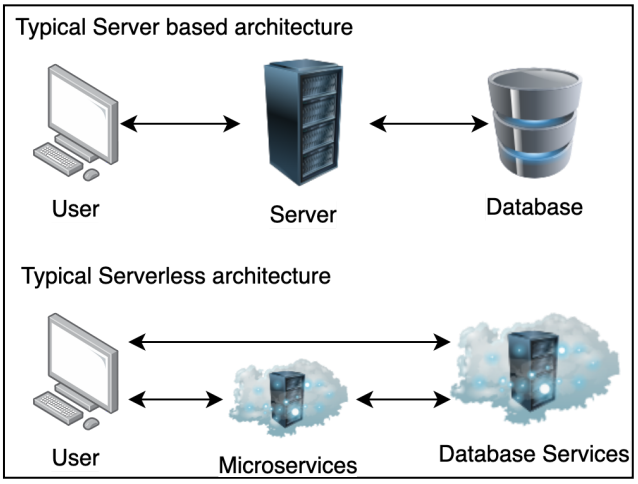
1.6. Document Structure

TODO

2. Architectural design

2.1. Overview

The paradigm that has been followed for designing the SafeStreets system is the Serverless paradigm[1].

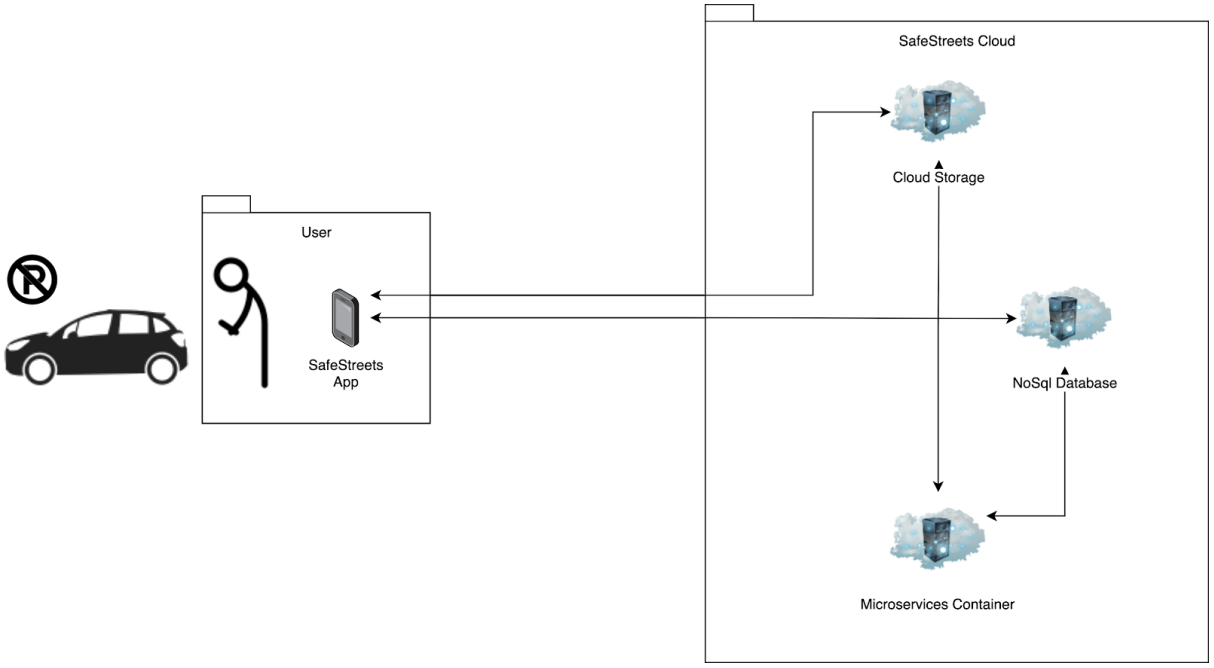


This modern approach has been chosen since the functionalities offered by SafeStreets are easy enough to be built on a 2-tier system, where the client interacts “directly” with the databases and the services. So the middle tier is removed and its logic is split on the remaining tiers. The system relies solely on a combination of third-party services, client-side logic and cloud-hosted procedure calls (microservices). This allows it to be extremely scalable and performant with little to no server-management.

The architecture structure of SafeStreets can be seen from two different points of view: the one of the user and the one of the municipality.
In the next sections these point of views are represented using a high level view of the architecture using informal diagrams. It is important to note, however, that some simplifications have been made for allowing a better understanding of the architecture:

- Only nodes that belong to one of the three main actors in the system (user, municipality, SafeStreets) are displayed.
- The *Authentication Server* node is not represented since it will make the diagram a lot harder to read. This node provides functionalities for authenticating users and municipalities to the other nodes, so it’s heavily used when performing login and sign up of users, login of municipalities and, to make sure that documents in the databases are managed according to the security rules.

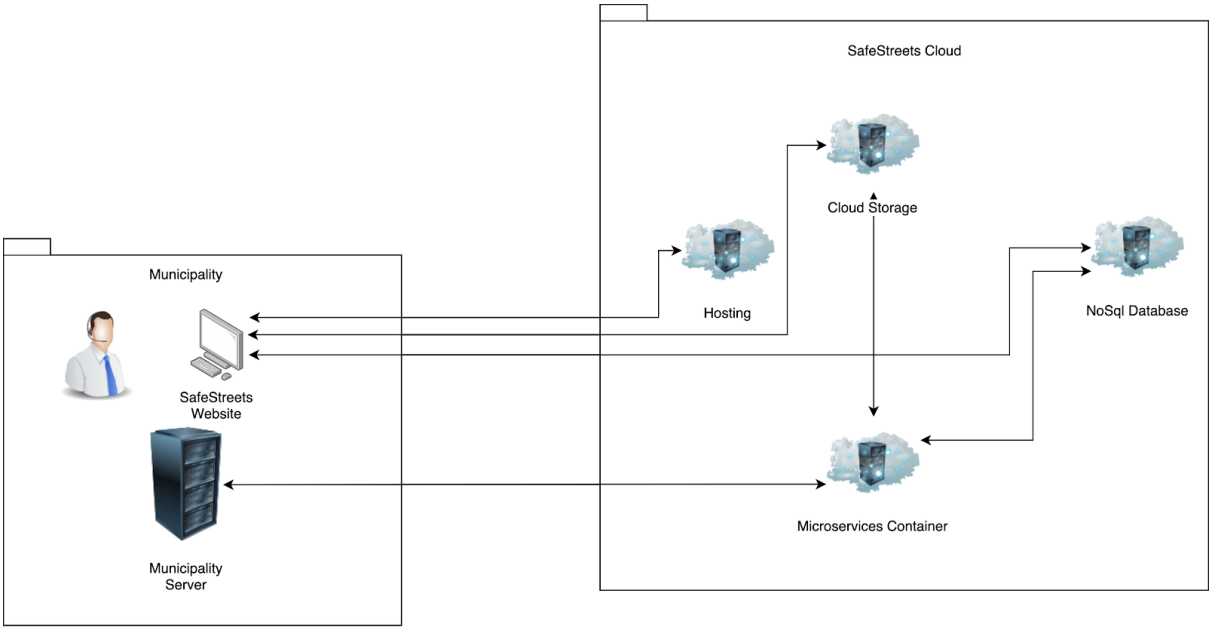
2.1.1. User’s point of view



The user mainly interacts with 3 nodes:

- *Cloud Storage:* using this node the application of the user can easily upload large files, like images, on the cloud.
- *NoSql Database:* by interacting with this node the user’s application can read and write data on the database. Note that the access to the database is limited to what the security rules allow; for instance, the user cannot see the photos posted by other users or the licence plates.
- *Microservices Container:* this node contain stateless functions that are run in their own isolated secure execution context, are scaled automatically and have a lifecycle independent from other functions. They can modify both the database and the storage while also interacting with the user.

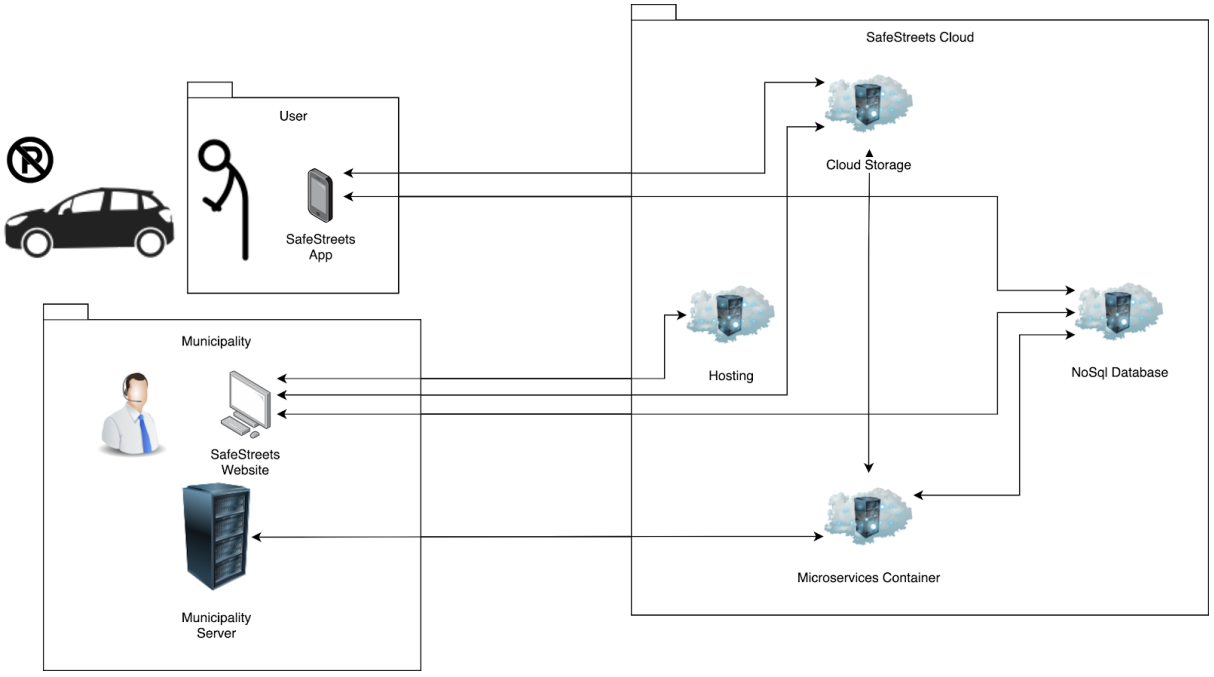
2.1.2. Municipality's point of view



The municipality, similarly to the user, utilizes the *Cloud Storage*, the *NoSql Database* and the *Microservice Container* nodes, but now their behaviour depends on the actions of the municipality.
In order to interact with the cloud the municipality will also use another node:

- *Hosting Provider:* this node is a simple server that listens for connections on port 443 (HTTPS) and serves static HTML pages to the municipality.

2.1.3. Overall high level view of the architecture



2.2. Component view

The following diagrams show the main components of the system and the interfaces through which they interact.
We divided the architecture intro three subsystems:

- The cloud architecture is simple and has only a few components:
  - The *hosting service*, which hosts the web interface.
  - The *authentication system*, used both by the SafeStreets App and the web interface.
  - The *MicroservicesContainer*. This is a collection of Microservices that are used to manage the subsystem and to provide useful APIs to both users and municipality. It is the most important and complex component of this subsystem and will be analyzed in detail later in the document.
  - The *DBMS*, which manages the database.
  - The *data storage*, in which we mainly store pictures of violations.

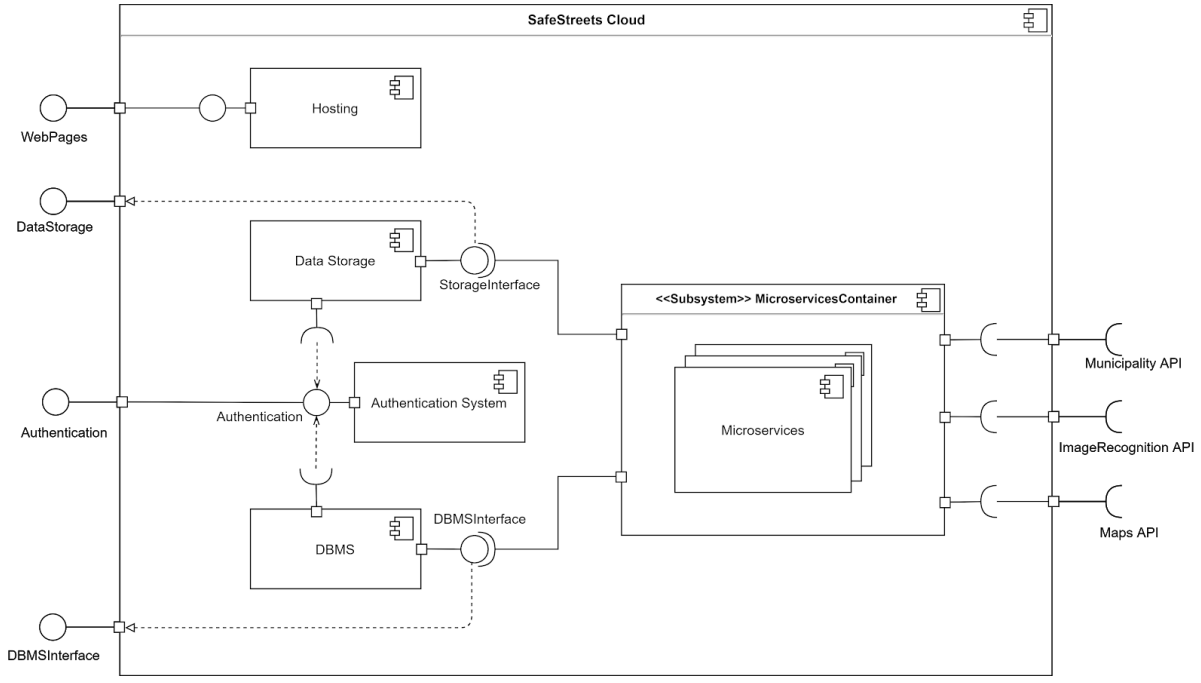
- The SafeStreets mobile application is built using the Model - View - Controller design pattern. In this diagram, however, we wanted to highlight the role of the Controller and how it interacts with the various components of the cloud architecture; the Model and the View will be analyzed later.
  The Controller has the following components:
  - *ReportViolationManager*: the main function of the application. It includes the logic that allows the user to submit violation reports.
  - *AuthenticationManager*: it interfaces with the Authentication System to provide the authentication service to the user.
  - *DatabaseConnection*: connects to the DBMS.
  - *StorageConnection*: connects to the data storage.
  - *MapManager*: uses the StatisticsManager and the Maps API to display violations and other data on the map.
  - *RetrieveViolationsManager*: *non si è ancora capito sinceramente TODO: Write this* component that handles all the queries.

- The web interface offered to the municipality. This has the same structure of the application with the obvious difference that the view will be an HTML web page. It has, however, an extra component.
  - *StatisticsManager:* it uses the statistics microservice to provide useful statistics to the municipality, such as the effectiveness of the SafeStreets initiative, the increase in tickets, the eventual decrease of traffic violations, weekly number of reports, ecc

Furthermore, the system will use some external services to grant and enhance the service. They are the following:

- *Maps API:* we use a geolocation service to display data about violations and accidents in the map.
- *Image Recognition service:* this is a powerful tool that will be used in order to automatically validate the report; in particular, we will automatically discard the reports that don't have at least one vehicle in the photos. This is in order to avoid storing unwanted data, to prevent flooding attacks to the system and to increase efficiency.
- *Municipality API*: if the municipality offers a service where we can retrieve data about violations, ticket issued and accidents on its area of operation, we are able to cross this data with ours to provide more accurate statistics, both to the user and to the municipality.

2.2.1. Component Diagram of the Cloud



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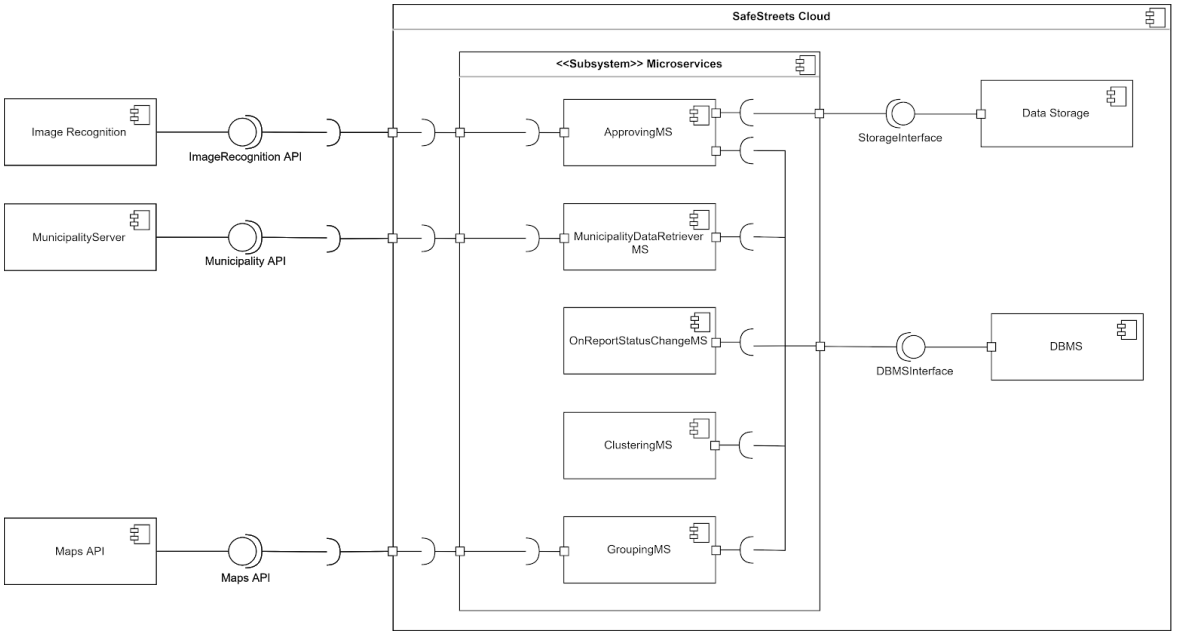
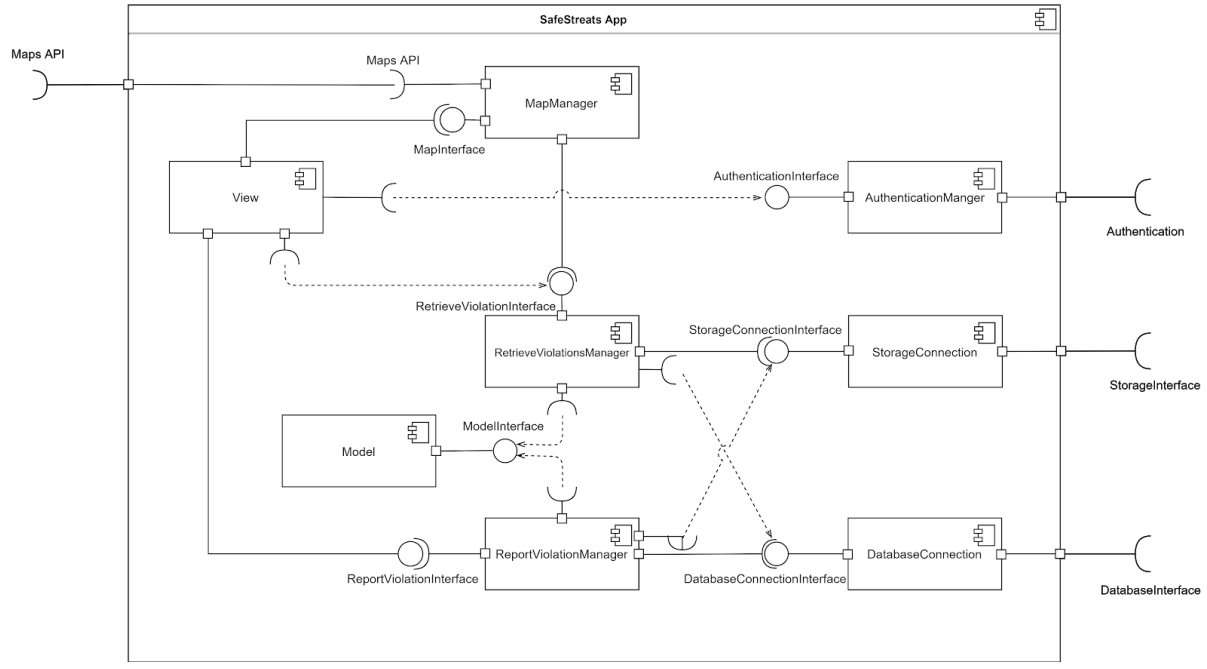
2.2.2. Component Diagram of the Microservices



2.2.3. Component Diagram of the Application



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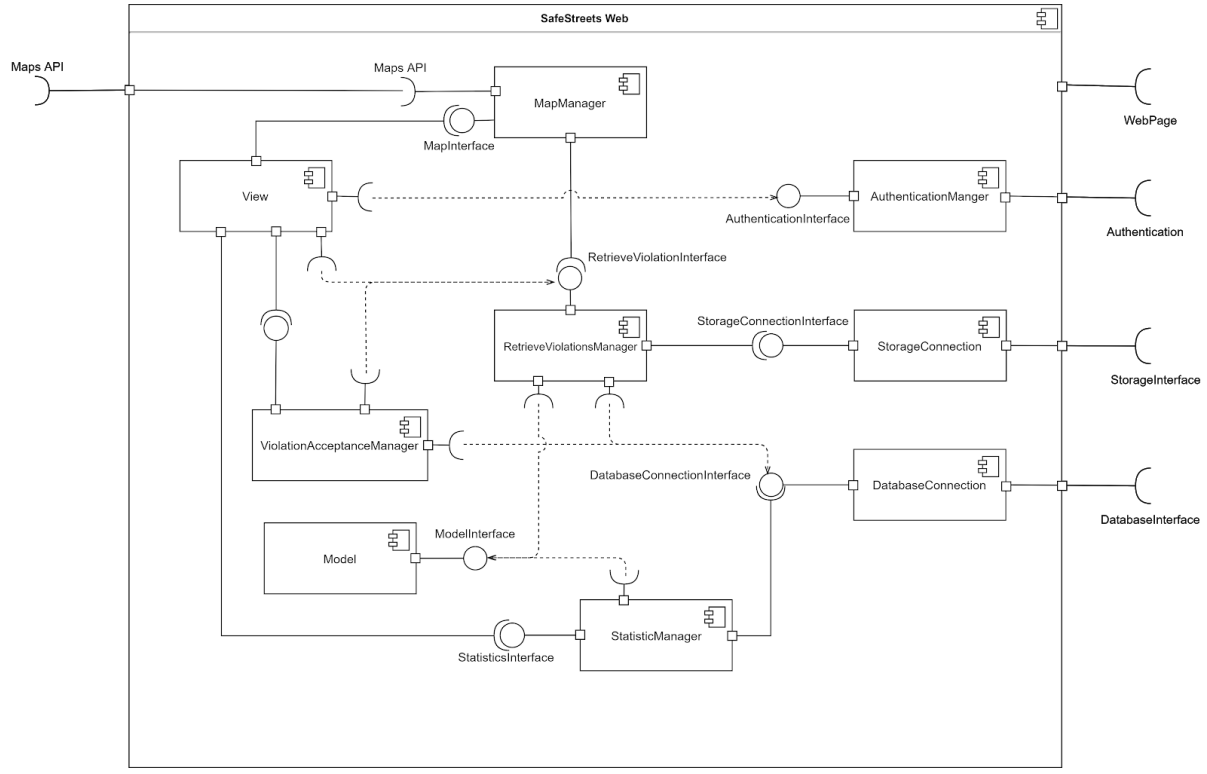
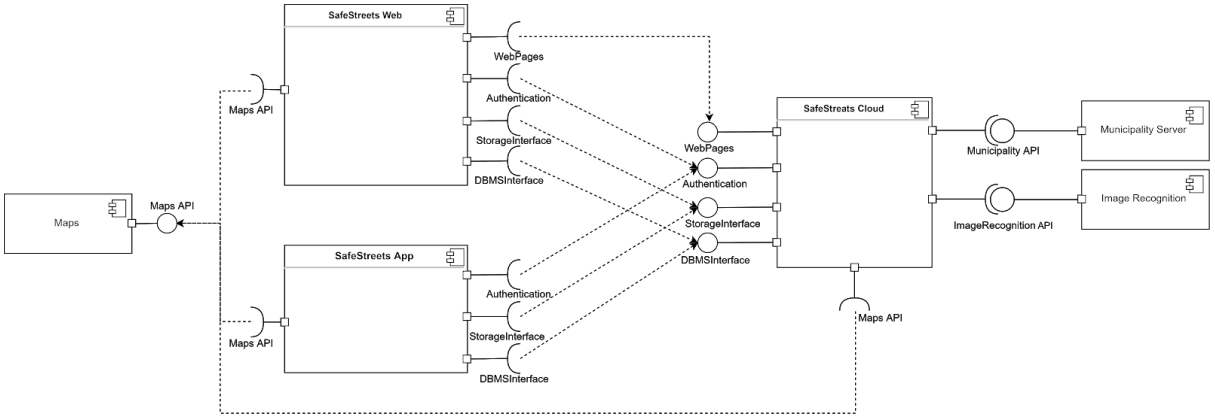
2.2.4. Component Diagram of the Municipality



The web interface offered to the municipality. This has the same structure of the application with the obvious difference that the view will be an HTML web page. It has, however, an extra component.

- *StatisticsManager:* it uses the statistics microservice to provide useful statistics to the municipality, such as the effectiveness of the SafeStreets initiative, the increase in tickets, the eventual decrease of traffic violations, weekly number of reports, ecc

2.2.5. Overall Component Diagram



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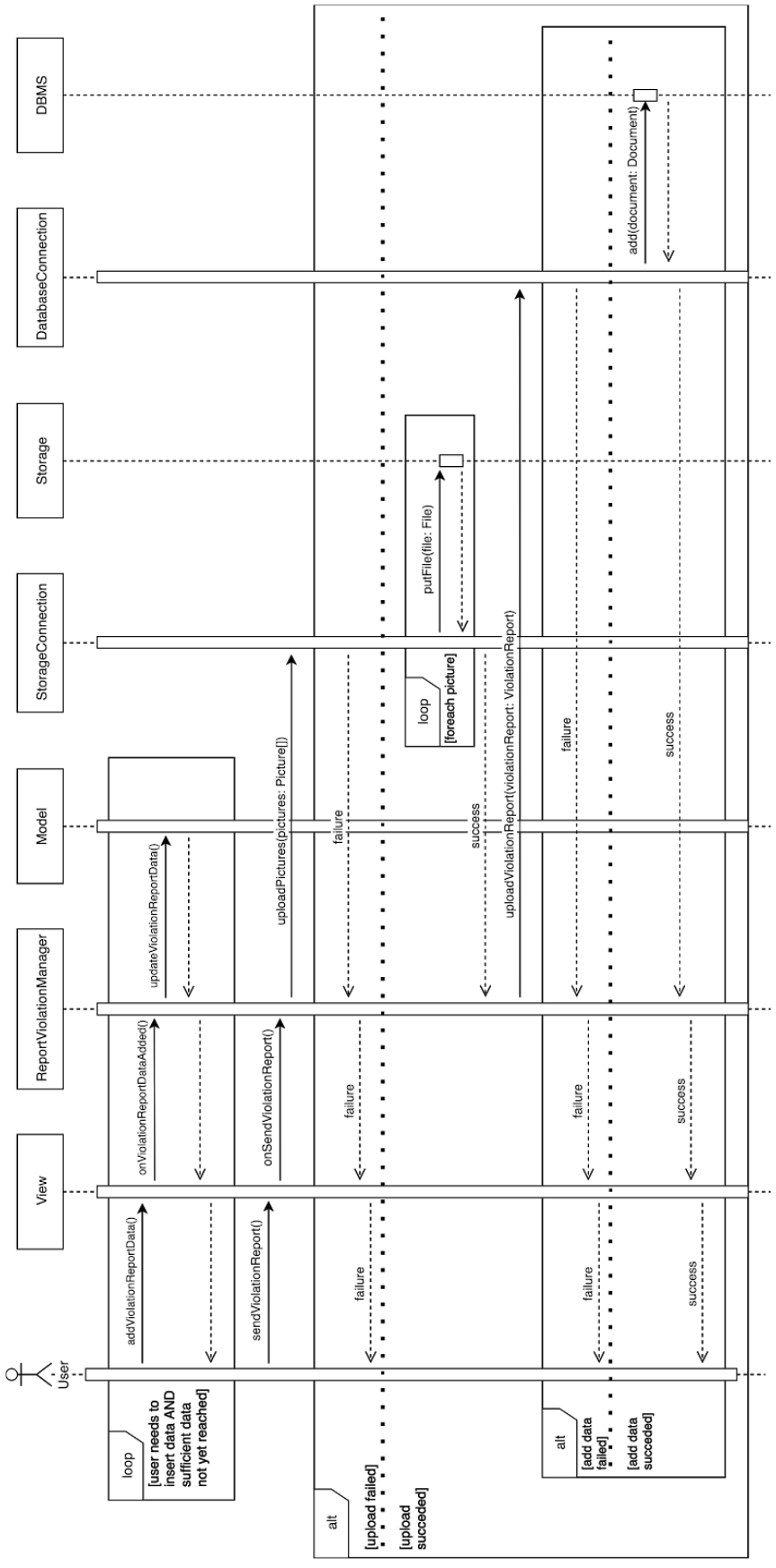
- *Municipality API*: if the municipality offers a service where we can retrieve data about violations, ticket issued and accidents on its area of operation, we are able to cross this data with ours to provide more accurate statistics, both to the user and to the municipality.

2.3. Deployment view

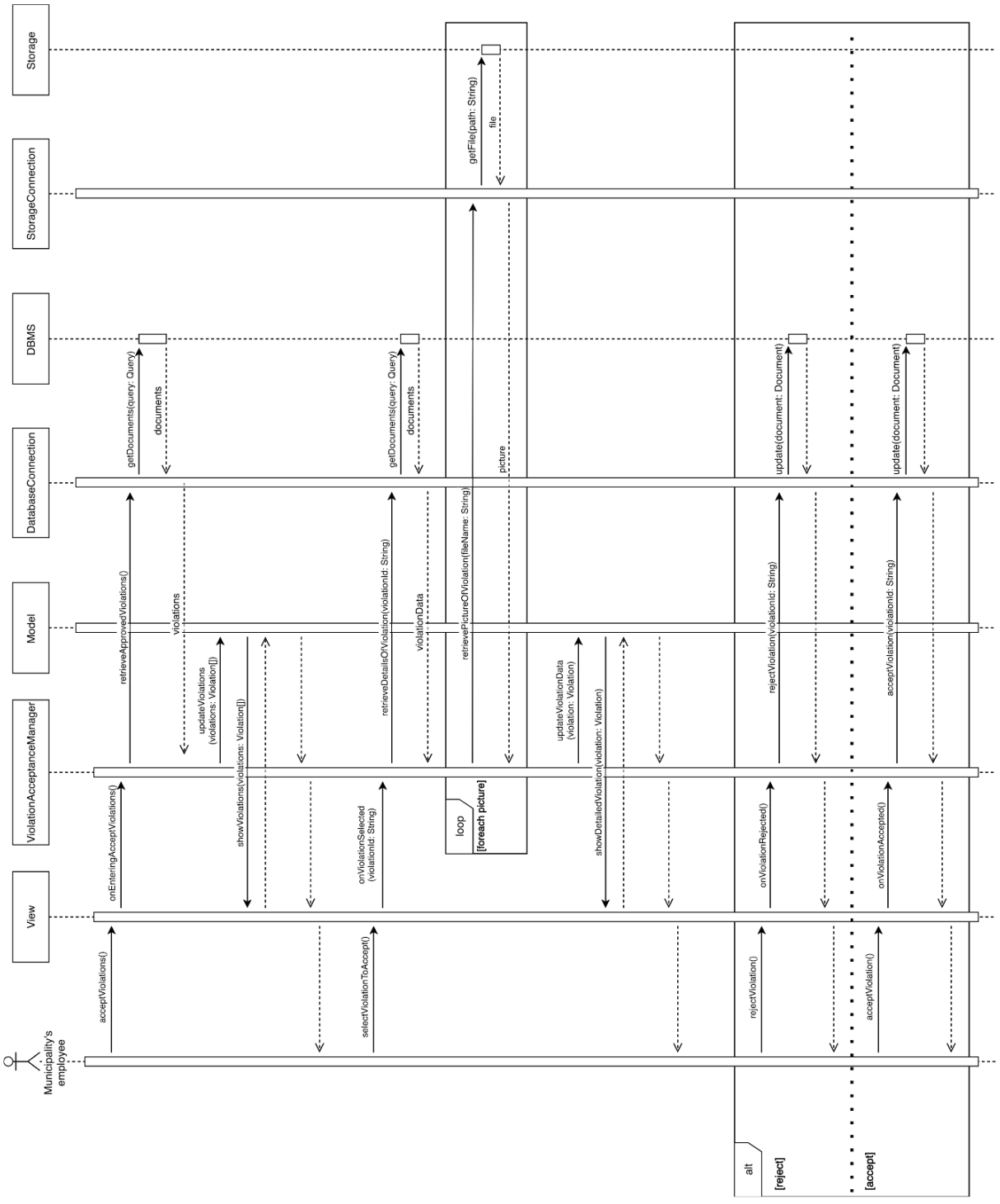
TODO

2.4. Runtime view

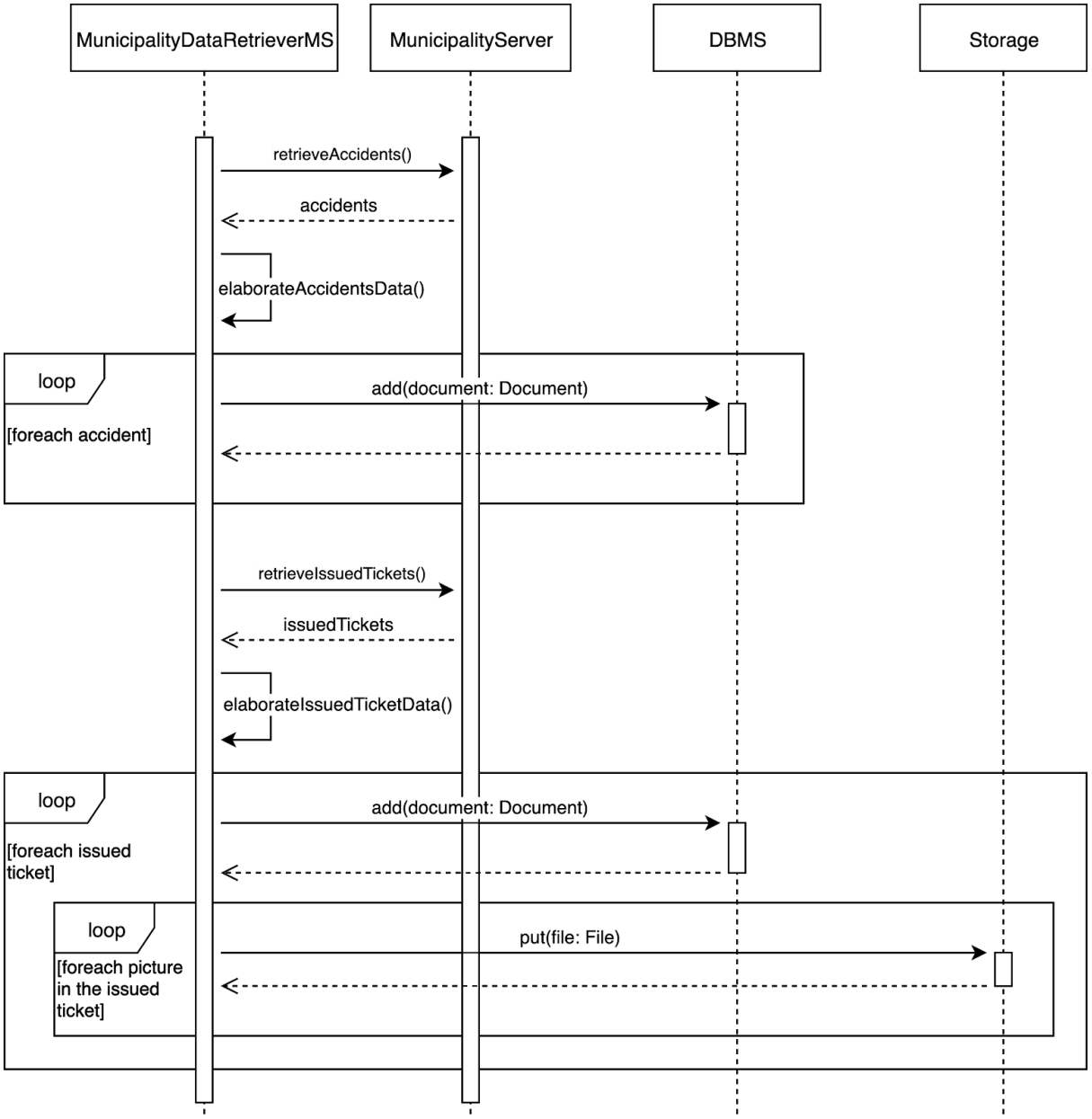
2.4.1. User violation reporting



2.4.2. Municipality violation accepting



2.4.3. Retrieving of municipality's data



2.5. Component interfaces

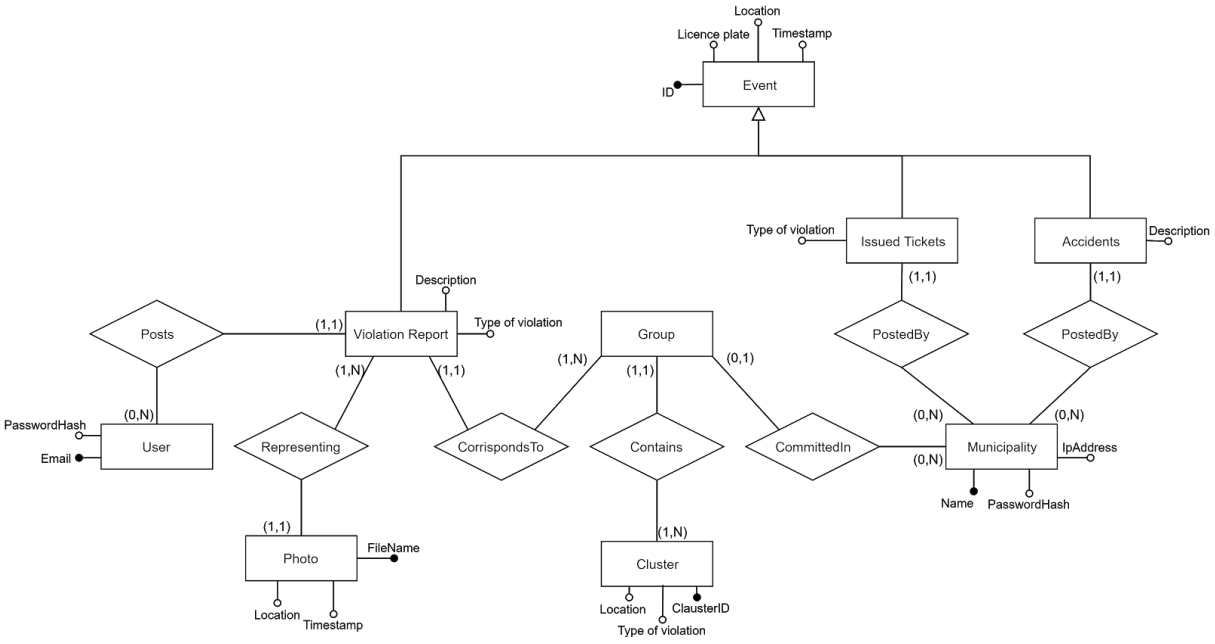
2.6. Selected architectural styles and patterns

Model–View–Controller: it is a software design pattern commonly used for developing user interfaces which divides the related program logic into three interconnected elements. This is done to separate internal representations of information from the ways information is presented to the user. Following the MVC architectural pattern decouples these major components, which is one of the most common and effective ways to avoid a dangerous level of coupling between the various parts of the whole system.

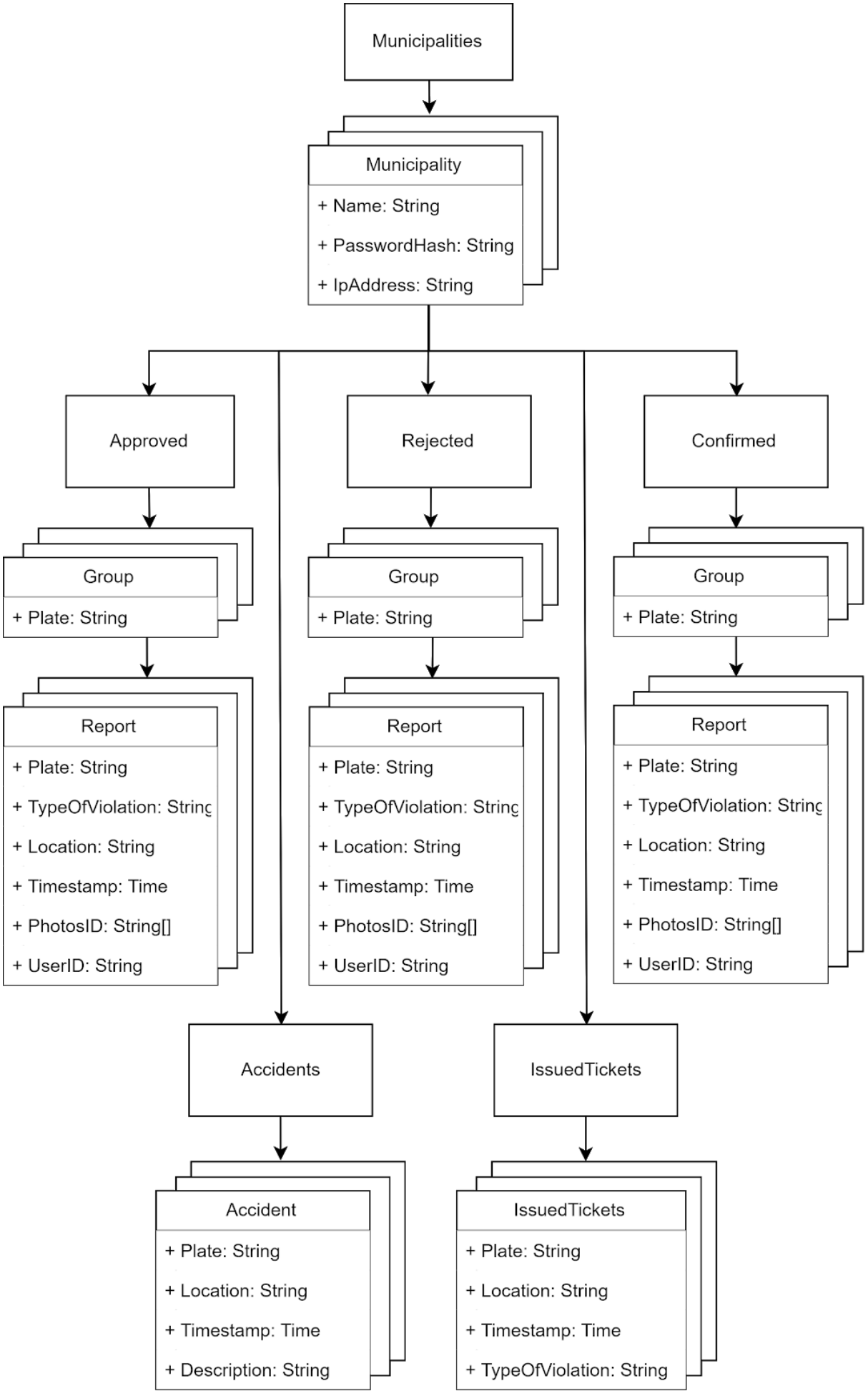
2.7. Other design decisions

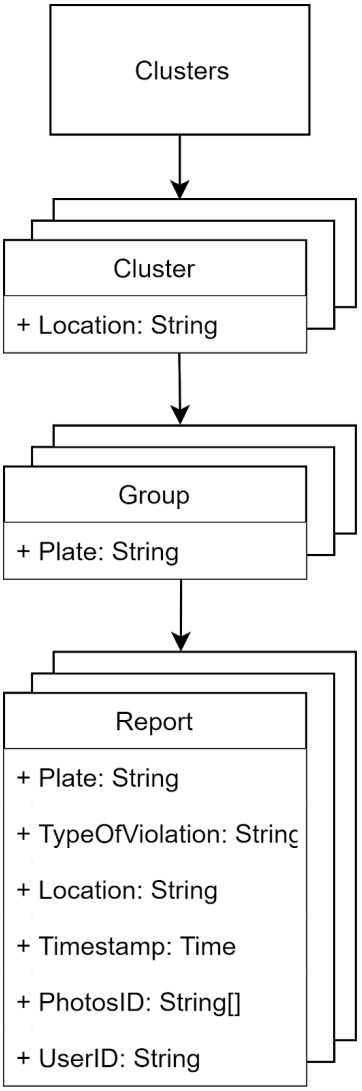
2.7.1. Data Structure

Data will be stored in a NoSql Database, so its structure is very important in order to have fast and easy-To-write queries. This can be achieved by duplicating information among the files of the DB.
To understand the overall structure is useful to introduce the entity-relationship diagram that will help identify the entities and their relationships and attributes even though it will not represent the actual DB structure.



Every Violation Report is associated with a user, at least one photo and a Group. A Group is the set of all the Violation Reports that represent the same real violation, i.e. the set of violations with the same licence plate, the same type of violation, relatively close locations and timestamps. In order to propose suggestions and optimize the visualization of the marks on the map, close Groups that have the same type of violation are grouped together creating a cluster.
Every group can be associated with a specific municipality. The Municipality can post to the server its Issued tickets and its accidents.
Two tree structures that capture all these aspects are reported next.


Municipalities
Municipality
+ Name: String
+ PasswordHash: String
+ IpAddress: String
Approved
Rejected
Confirmed
Group
+ Plate: String
Group
+ Plate: String
Group
+ Plate: String
Report
+ Plate: String
+ TypeOfViolation: String
+ Location: String
+ Timestamp: Time
+ PhotosID: String[]
+ UserID: String
Report
+ Plate: String
+ TypeOfViolation: String
+ Location: String
+ Timestamp: Time
+ PhotosID: String[]
+ UserID: String
Report
+ Plate: String
+ TypeOfViolation: String
+ Location: String
+ Timestamp: Time
+ PhotosID: String[]
+ UserID: String
Accidents
IssuedTickets
Accident
+ Plate: String
+ Location: String
+ Timestamp: Time
+ Description: String
IssuedTickets
+ Plate: String
+ Location: String
+ Timestamp: Time
+ TypeOfViolation: String



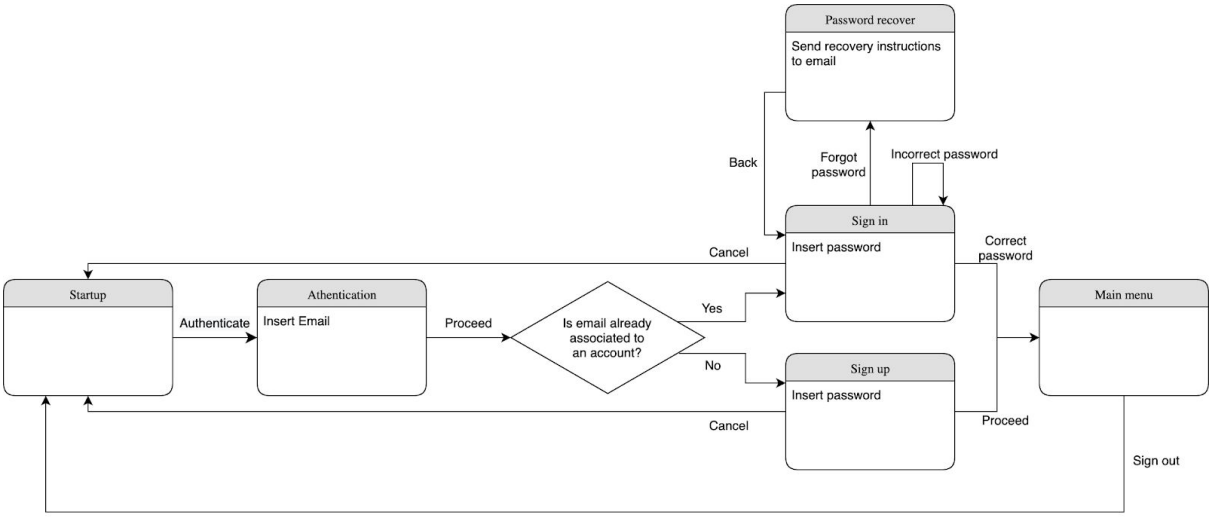
Maps API and image recognition by google?

3. User interface design

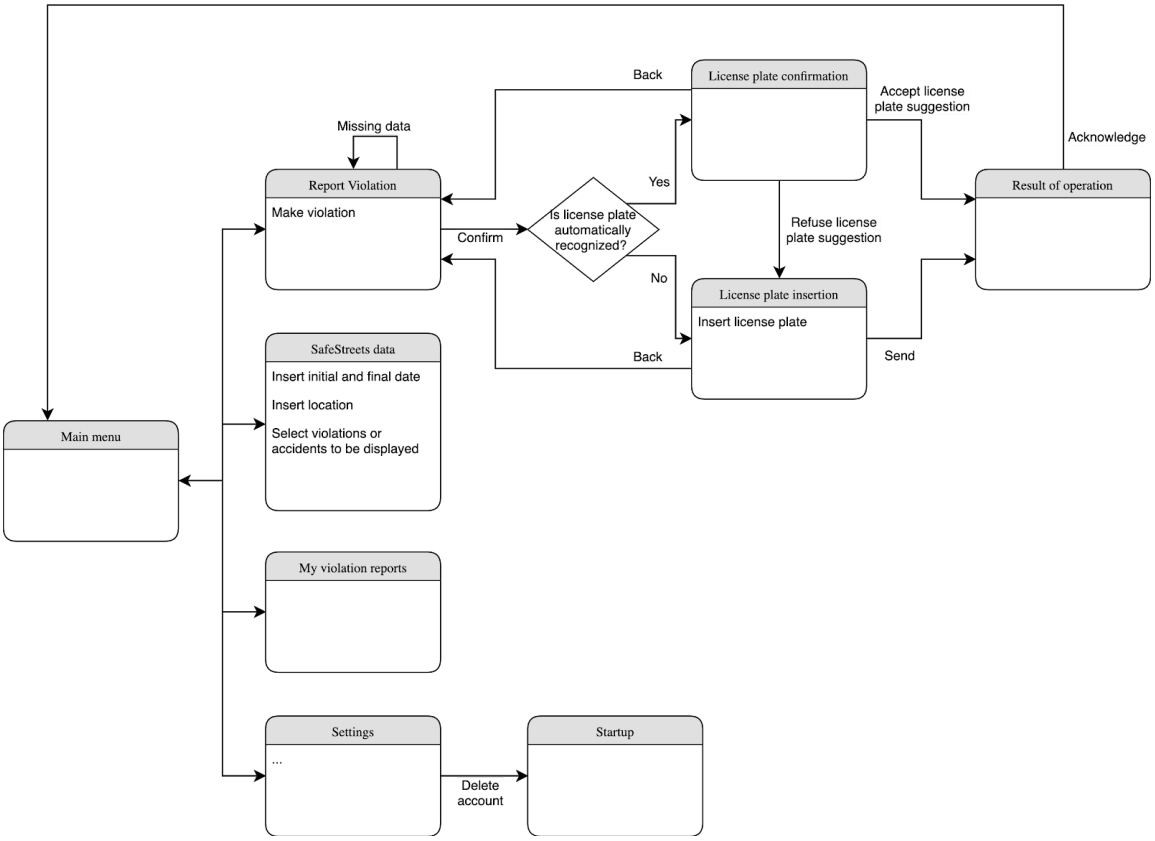
3.1. SafeStreets App

In this section it is shown the user interface design applied to the SafeStreets application.
First are presented the UX diagrams were it is shown the flow followed by the users to utilize the app. There are two UX diagrams to better represent different parts of the application: one for the authentication process of the user and the other for the main features of the app that are available only after the authentication process.
Then mockups are presented. The mockups presented here were already developed for the RASD document, but are copied for readability purposes and to associate them with their corresponding page in the UX diagram.

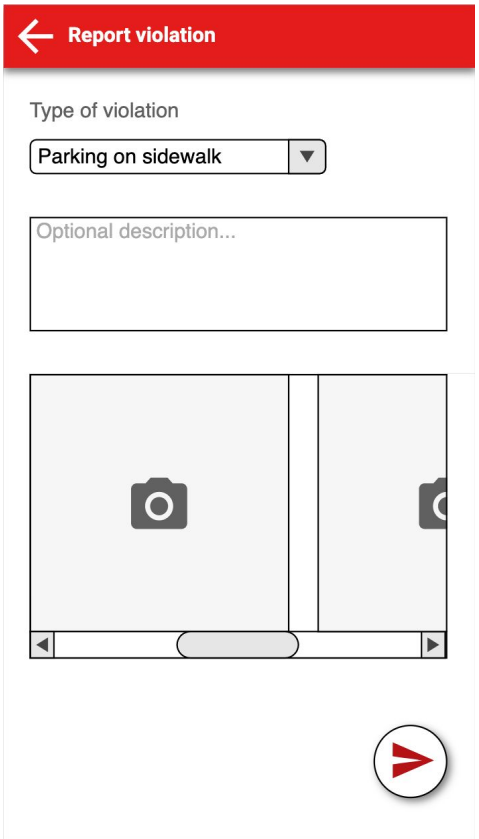
3.1.1. User authentication - UX diagram



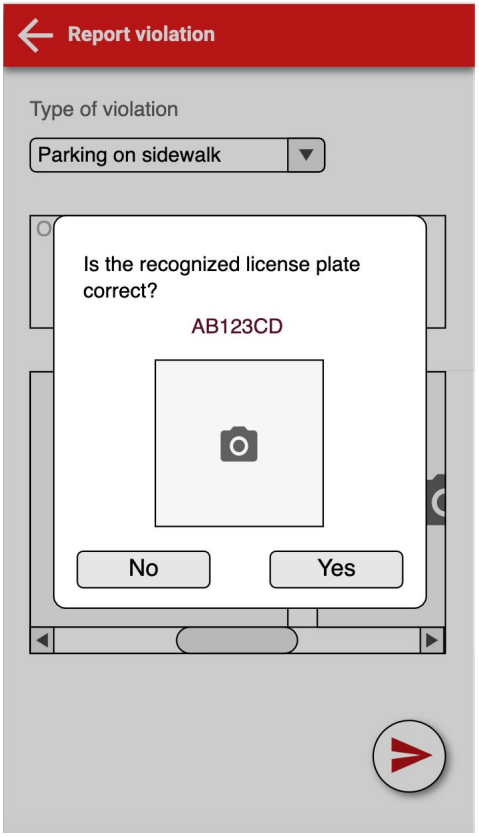
3.1.2. App features - UX diagram



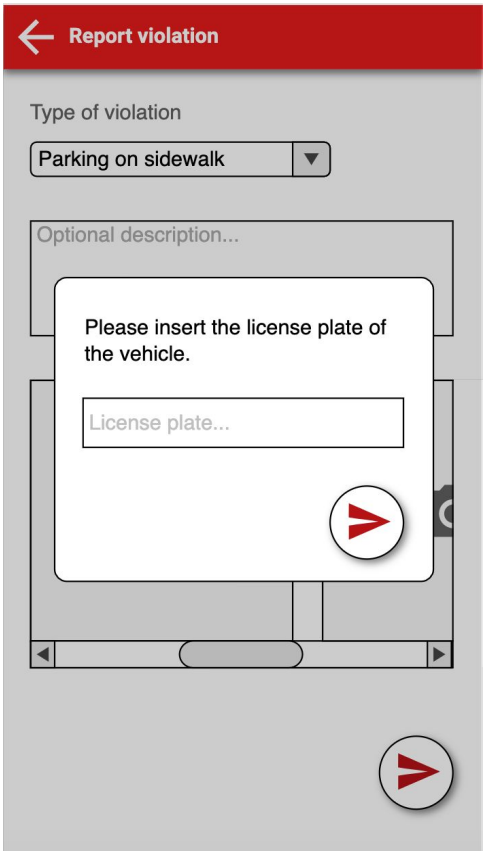
3.1.3. Mockup of the “Report Violation” page



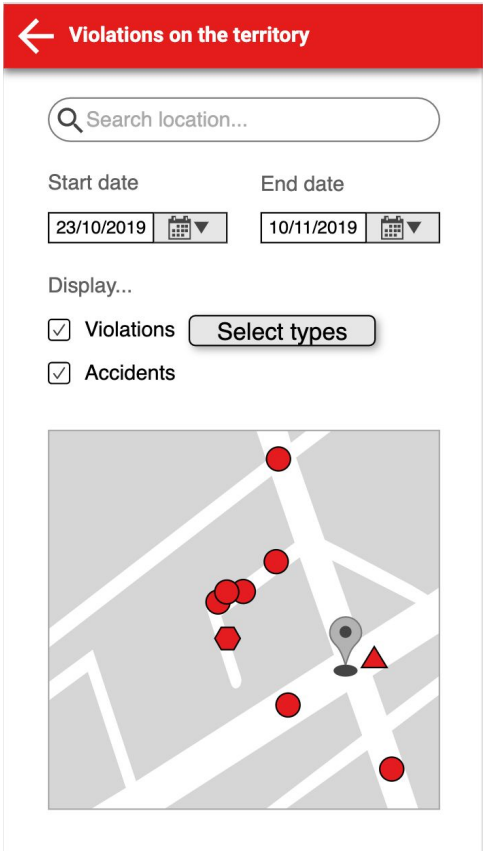
3.1.4. Mockup of the “License plate confirmation” page



3.1.5. Mockup of the “License plate insertion” page



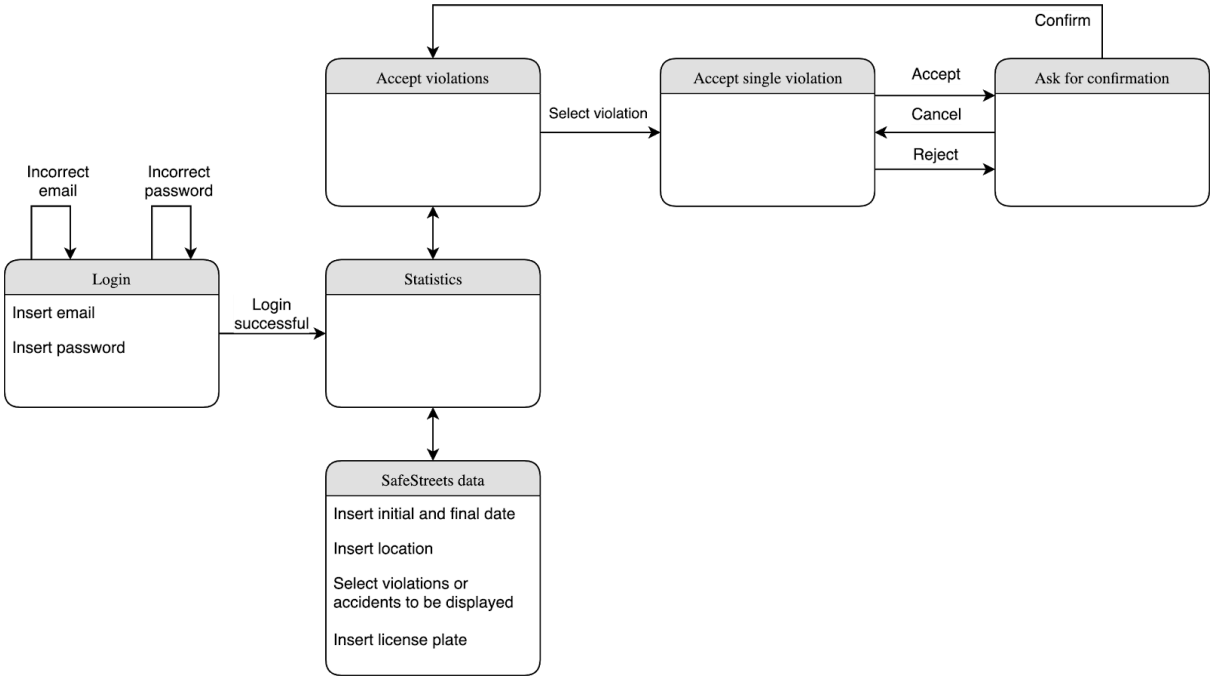
3.1.6. Mockup of the “SafeStreets data” page



3.2. Municipality web interface

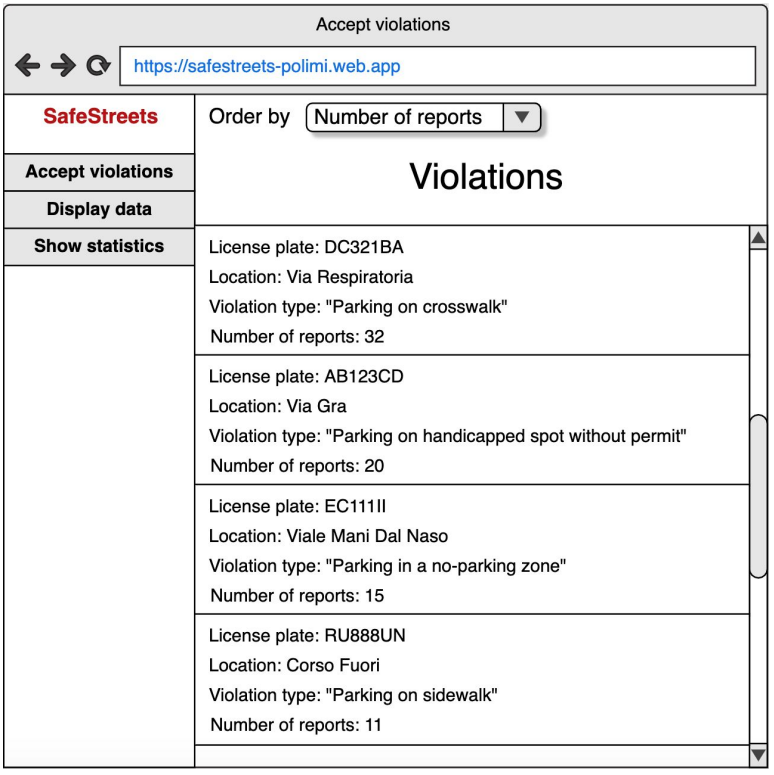
In this section it is shown the user interface design applied to the SafeStreets web interface for municipalities.
First is presented the UX diagram were it is shown the flow followed by the employees of the municipalities, then the mockups are presented.

3.2.1. UX diagram

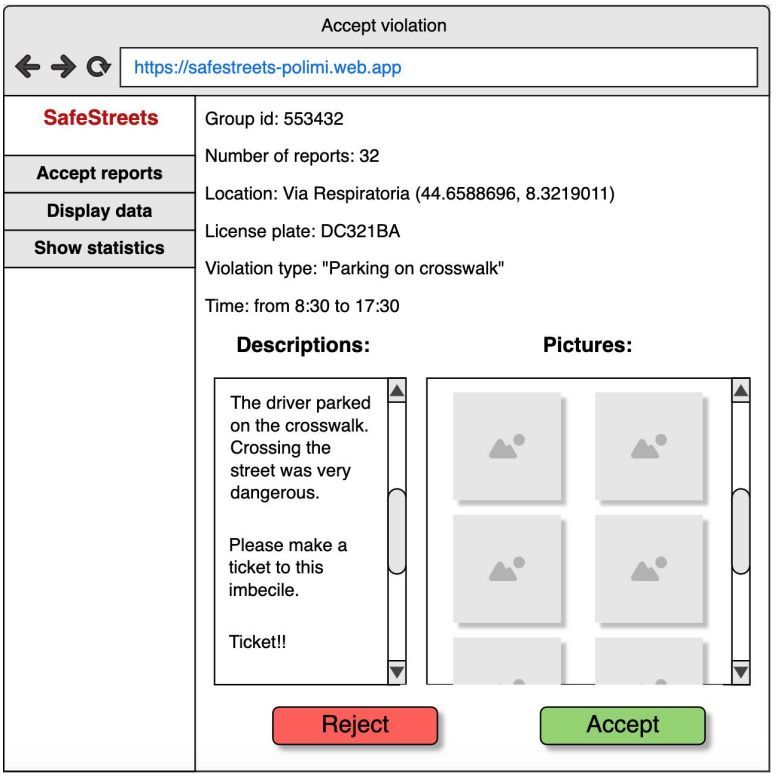


3.2.2. Mockup of the “Login” page

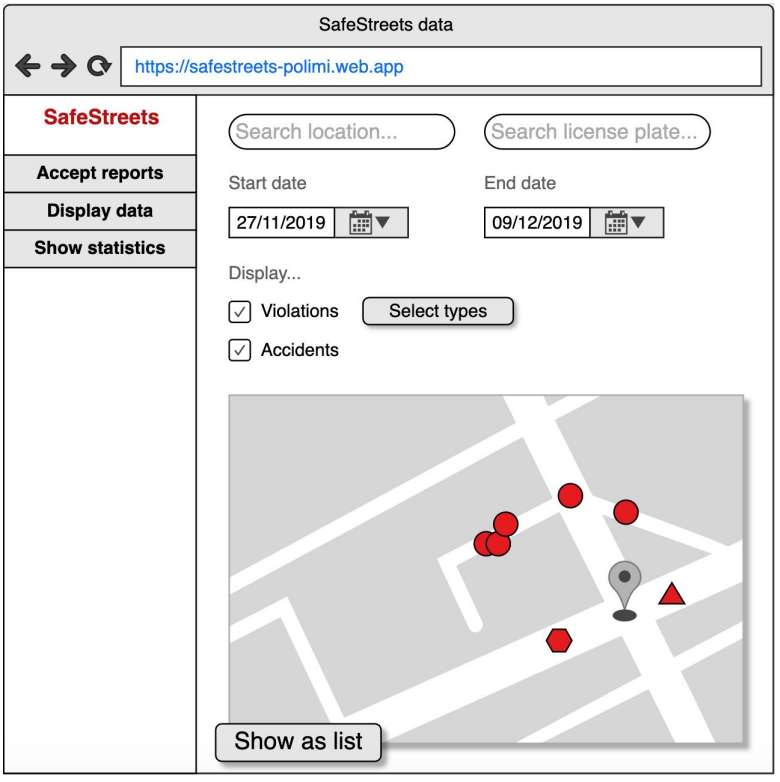
3.2.3. Mockup of the “Accept violations” page



3.2.4. Mockup of the “Accept single violation” page



3.2.5. Mockup of the “SafeStreets data” page



4. Requirements traceability

3.2.4.1. Satisfying goal 1

[G1] A citizen can report a violation.

- [D1] A citizen who wishes to report a violation has a mobile phone with the SafeStreets app installed.
- [R1] A citizen not yet registered must be able to sign up and become a user.
- [R2] The application must allow users to authenticate through log in.
- [R3] The application must allow users to report a violation.

3.2.4.2. Satisfying goal 2

[G2] A violation report received by the system must have enough information to be valid, i.e. has at least one picture of the violation, exactly one GPS position, exactly one timestamp, exactly one type of violation and the license plate of the vehicle.

- [R4] The application must allow reporting of violations only from devices equipped with a GPS receiver which are in the conditions to obtain a GPS fix.
- [R5] The application must allow reporting of violations only from devices equipped with a camera.
- [R6] The application must allow reporting of violations only from devices with an active internet connection.
- [R7] A user has the possibility to specify the type of the reported violation choosing from a list.
- [R8] The application creates a violation report with at least one picture, exactly one timestamp, exactly one location, exactly one type of violation and the license plate of the vehicle.

3.2.4.3. Satisfying goal 3

[G3] Users and municipality can retrieve information about violations, accidents and issued tickets in a certain area, with different levels of visibility.

- [D2] Municipality offers a service to retrieve information about accidents.
- [D3] Municipality offers a service to retrieve information about tickets.
- [R9] The system saves all the information regarding the violations reported by users.
- [R10] The system must be able to retrieve data regarding issued tickets and accidents from the municipality.
- [R11] The system must offer an interface to retrieve information about violations, accidents and issued tickets.
- [R12] The system must show to users only anonymized data.
- [R13] The system must analyze valid violations report and approve which of them may represent a correct violation.

3.2.4.4. Satisfying goal 4

[G4] Municipality will be able to retrieve suggestions for possible interventions in order to increase safety.

- [D2] Municipality offers a service to retrieve information about accidents.
- [D3] Municipality offers a service to retrieve information about tickets.
- [R9] The system saves all the information regarding the violations reported by users.
- [R10] The system must be able to retrieve data regarding issued tickets and accidents from the municipality.
- [R14] The system must be able to elaborate data about violations, accidents, issued tickets and generate useful suggestions about possible interventions.
- [R15] The system must offer an interface to the municipality for retrieving useful suggestions about possible interventions.

3.2.4.5. Satisfying goal 5

[G5] Municipality receives enough information about the violation in order to issue a ticket.

- [D4] When a device is able to obtain a GPS fix, the location provided has an accuracy of at least 20 meters.
- [D5] The municipality checks if approved violation reports can actually represent a traffic violation (for example they could check if the license plate actually corresponds to the car model in the picture).
- [R8] The application creates a violation report with at least one picture, exactly one timestamp, exactly one location, exactly one type of violation and the license plate of the vehicle.
- [R13] The system must analyze valid violations report and approve which of them may represent a correct violation.
- [R16] The system must offer a service to the municipality for retrieving correct violations report.

3.2.4.6. Satisfying goal 6

[G6] The integrity of the violation report is guaranteed.

- [D6] Data transferred through connections that use modern encryption protocols can not be manipulated.
- [R17] The application will allow using pictures in a violation report only if the picture was taken by the application itself, preventing it to be manipulated on the device.
- [R18] All connections used by the system use modern encryption protocols.
- [R19] Data saved in the server can not be manipulated.

5. Implementation, integration and testing

5.1 Feature identification

The following is a table of the main features of our system, complete with their importance and their difficulty of implementation. (why is it used)

Feature	Relevance	Difficulty of implementation
Report violations	High	Medium
Visualize data	High	High
(User) See own violation	Medium	Low
(Municipality) Retrieve and review violations	High	High
(Municipality) Visualize statistics	Medium	Medium

Feature 1: Report violations
This feature is indeed the foundation on which the app is built. Only when a large pool of data is collected, the users will be able to use the application to retrieve and visualize data.
The difficulty of implementing this is Medium because, as already said, the system will interface with an image recognition service to filter unwanted reports. *The difficulty comes from writing efficient algorithms to maximize the probability of rejecting an unwanted report without generating too many false rejections.* (come si può scrivere meglio?)

Feature 2: Visualize data
This feature brings to the user the possibility to localize violations (and possibly data from the municipality) by seeing them on a map.
The system will interface with a mapping API, necessary to visualize violations. Furthermore, the system will be entrusted with drawing inferences from the big amount of data collected, both from the users and the municipality.

Feature 3: See own violation
This function will give the user the possibility to see their own violation and their statuses.

Feature 4: Retrieve and review violations
This is another key point in the system. Using a web interface, the municipality can connect to it and, after authenticating, it will be able to review violations report

submitted from the users. We will then update the status of the reports based on the decision of the municipality.
The difficulty of building this feature is “high” because it will require a whole subsystem to be built.

Feature 5: Visualize statistics
Using this function, the municipality will be able to visualize useful statistics such as the effectiveness of the SafeStreets initiative, the increase in tickets, the eventual decrease of traffic violations, weekly number of reports, ecc.

It’s important to notice that Feature 1 and 3 are exclusive to the SafeStreets mobile app, whether Feature 4 and 5 are exclusive to the SafeStreets web interface. Feature 2 is common to the three subsystems.

5.2 Implementation, integration and testing plan

The implementation plan will follow a bottom-up approach. (breve descrizione, vantaggi, le feature sono milestones, piccole parti / sottosistemi di un sistema ← spiegarlo)

The plan is to implement the reporting of violation first. Then the features will be built in order of relevance; if they have the same level of relevance, no particular order is followed.

Feature 1: Report violations
As said above, this feature is the core of the system and without this, nothing can function, because Feature 2, 3 and 4 rely on reports to work. So it is only natural that it will be the first feature to be implemented and tested.

For this function to work, the core features of the mobile application should be built. As a base, the “Model” and the “View” have to be implemented and tested, as well as the “AuthenticationManager”, the “DatabaseConnection” and the “StorageConnection”.
Then, the “ReportViolationManager” will be implemented, integrated with the previously stated components, and then tested.

On the Cloud side, the microservices “ApprovingMS”, “GroupingMS” and “ClusteringMS” have to be implemented and tested.
In particular, the “ApprovingMS” has to be integrated with the Image Recognition API.

Feature 2: Visualize data

6. Effort spent

Andrea Marcer		
Date	Task(s)	Time
22/11	Discussion	3 hr 0 min
24/11	Architecture diagram	1 hr 15 min
25/11	Component view	1 hr 0 min
28/11	Component view	1 hr 0 min
30/11	Relationships	2 hr
30/11	General overview	30 min
2/12	Component diagram	4h 30 min
2/12	Entity-Relationship diagram	1hr 30 min
3/12	Component diagram	1hr 45 min
3/12	Component diagram, Entity-Relationship diagram	1hr 45 min
3/12	Entity-Relationship diagram description	1hr
Total:		

Matteo Marchisciana		
Date	Task(s)	Time
22/11	Discussion	3 hr 0 min
24/11	Architecture diagram	1 hr 15 min
25/11	Component view	1 hr 0 min
28/11	Component view	1 hr 0 min
29/11	Component view	1 hr 20 min

30/11	Component view	4 hr 0 min
Total:		

Dennis Motta		
Date	Task(s)	Time
22/11	Discussion	3 hr 0 min
23/11	User interface design	2 hr 0 min
24/11	Architecture diagram	1 hr 15 min
24/11	User interface design	1 hr 0 min
25/11	Component view	1 hr 0 min
26/11	Architectural design overview	2 hr 0 min
27/11	Fixes after DD review; Architectural design overview	1 hr 45 min
28/11	Component view	1 hr 0 min
30/11	User interface design	2 hr 15 min
1/12	User interface design	1 hr 0 min
2/12	Component view; sequence diagram	2 hr 0 min
3/12	Sequence diagrams	3 hr 30 min
Total:		

7. References

1. “Serverless paradigm”. https://en.wikipedia.org/wiki/Serverless_computing
2.