

**CLup project Roberto Buratti, Hrvoje  
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# **Requirement Analysis and Specification Document**

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# 1 Introduction

## 1.1 Purpose

### 1.1.1 Description of the Proposed System

The project "CLup - Customer Line up" is a line spot reservation system planned to be used by managers, clerks, and customers of many local vendors and chains. The system aims to come up with a handy solution for the ongoing issue of proper social distancing management, particularly in grocery shopping, by providing assistance to cope with the customer load for managers and helping customers access products in a safe and controlled manner.

In particular, users will be able to see the locations, get a line number, and book in advance for the grocery stores they would like to visit. Once assigned a line number, the customer will track the estimated time of arrival of the line and wait for the notification that informs about his or her line's forthcoming arrival; hence waiting time in the line in the crowd is minimum. Also, "CLup" provides uniquely generated QR codes per the line number, which can be utilized by the store managers as a proper monitoring tool in the entrances and exits of the locations. The product's general purpose is to keep the congestion levels in line with the locations at a minimum via providing useful features for all the users.

### 1.1.2 Goals

- $G_1$  Customers can issue a line number for a location.
- $G_2$  Customers can issue line numbers for their future visits.
- $G_3$  Customers can detail their visits by category or product.
- $G_4$  Customers can plan their visit to the store.
- $G_5$  Customers may prefer to use alternative time slots or partner stores for their visit.
- $G_6$  Managers can prevent customers from issuing line numbers.
- $G_7$  Managers can customize the system to allow optimizations for increased granularity, flow control, and time slot forecasting.
- $G_8$  Clerks and Managers can monitor the customers through their entrance and exits.
- $G_9$  Customers can obtain printed line number tickets.

## 1.2 Scope

The system is expected to implement the following features, which are detailed in the future sections of this document:

- **Generate Line Number:** The customers of the store can generate a line number for themselves as soon as possible to visit a store.
- **Schedule Line Number:** The customers can generate a line number for a future planned visit. Using the CLup app the customers can further define the products and product categories that they plan to visit to allow finer granularity and better time estimation for a visit. The system thus will allocate them a line number according to the time slot the customer has selected and it will send an email to the customer if the line number is canceled for a reason. From the system, the customers can view the store's location and plan their route accordingly. While scheduling their line numbers,

the customers can see an occupancy forecast for the store during time slots so that they can further decide on visiting the store. If added by the manager, the customers can instead prefer to visit a partner store.

- **Print Line Number:** The clerks in the store can generate line number tickets for those customers who have not used the CLup app to generate a line number.
- **Manage Store:** The managers in the store can update the information regarding the store, which are the name and the location of the store. Furthermore, the managers can use this feature to activate or deactivate additional features provided by the system to manage customers more effectively. They can update the timeout interval for a ticket to expire, to manage the queue in front of the store. They can add products or product categories that their store provides, for the customers to select before booking their visit as mentioned before. They can assign more managers and clerks if necessary to use the system to its full extent. They can administer the time slots for their customers by setting the opening and closing hours, with possible breaks in between. They can administer the partner stores of their stores if they exist, for their customers to select instead. They can enable the reservation limit to prevent any customer from abusing the system by setting the limit for how many tickets a customer can generate per a given time interval of a month, a week, or a day.

The system is expected to be delivered in two parts, a client application, and a server. Given its functionality is depending on the current ongoing pandemic, the app is expected to be implemented before the COVID-19 crisis ends. For this, the client application is expected to be implemented as an app running on a browser, increasing the range of devices being able to run the app, without increasing the development costs, which can then be ported to a mobile application if needed. The server is expected to serve the client application to its users and handle any transaction incoming. To implement the location-specific features of the system, due to the complexity of those, namely location finding, addressing, and route planning tasks, an external Maps API is used.

### 1.2.1 Targeted Users

"CLup" aims to resolve the problem of Customers queueing up in front of a location, without control of availability of place in the location and future contact tracing by managers.

#### **Customer:**

Customers will be able to obtain specific line numbers for various locations using CLup, which they can track the estimated time available with and also view the location on a map application to plan their visit. Customers can further obtain line numbers for future visits, based on the system's info about the availability of free spots on the specific time intervals. They may prefer to visit a different branch of the same chain. Furthermore, they can provide specific products they intend to purchase or set an estimated time for their visit to allow finer granularity. Some customers may also prefer to obtain a line number upon visiting the store physically. To plan their visit in a time slot where the location will be less crowded, the users can see the location's occupancy based on already taken line numbers and forecasts provided by the system.

#### **Clerk:**

The clerk (which can be a shopping assistant or a security detail) can monitor customers' flow and manually intervene in case of missing line numbers via performing manual checkout for a specific customer or by printing line numbers physically for some customers.

#### **Manager:**



The location manager (which could be an actual manager or someone responsible for handling customer management) can provide details regarding the availability of products and the location in general, by setting the opening hours, maximum allowed customers in the shop, in-shop location of different products and categories, the maximum amount of reservations that can be made per customer, line number timeout and the location. Also, for chains and relevant stores, the manager can add chain members for the location.

### 1.2.2 Relevant Phenomena

To define the limits for the scope of the system, the following Relevant Phenomena table is provided. In this table, the specific entities related to the proposed system is given as various phenomena. If an entity provided in this table is bound to the physical world, it is marked as a world phenomenon, while an entity exists in the proposed system's implementation and does not directly exist on the world, it is marked as a machine phenomena. Furthermore, if an entity has a relevance to both the physical world and the system, it is labeled as shared.

Phenomenon	World / Machine	Shared
Line Number	Machine	Yes
Line Number Ticket	World	No
Product	World	Yes
Product Category	World	Yes
In-store Location	World	Yes
Occupancy Forecast	Machine	No
Store	World	Yes
Time Slot	Machine	Yes
Ticket Printer	World	No
Line Number Timer	Machine	No
Customer Scheduling Algorithm	Machine	No

Table 1: Relevant Phenomena of CLup

Since the entities that solely exist in the world and solely in the system won't be related to how the system adds value to its users, the requirements and related aspects are given in this document will be described considering solely the shared phenomena mentioned on **Relevant Phenomena of CLup** table.

## 1.3 Definitions, Acronyms, Abbreviations

### 1.3.1 Definitions

- *Location*: the physical location of the business that operates the line reservation system
- *Manager*: the user in charge of executive action within the location
- *Customer*: the user to visit the location
- *Clerk*: the user in charge of handling the entrance and exit of customers
- *Visit Time*: the time interval in which a customer performs a visit to the location
- *Line Number*: A number that indicates the ordering of a specific customer in the line
- *Line Number Ticket*: A physical ticket printed that features the line number and the QR code.

- *Time Slot*: Specific intervals of time determined by the opening hours and average visit time per customer.
- *Partner Store*: A different location included in the same beneficiary chain of command (such as another member of the franchise or store chain) or a mutual agreement with the specific location
- *Product*: Any item, items, service or services demanded by the customer, and provided by the store to the customer.
- *In-store Location*: A location of a specific product or a product category inside the store.
- *Working hours*: The time intervals that the store is open during each day.
- *Maps API*: A third-party mapping service implementation used for location tracking

### 1.3.2 Acronyms

- **RASD**: Requirement Analysis and Specification Document
- **QR Code**: Quick Response Code
- **API**: Application Programming Interface
- **ETA**: Estimated Time of Arrival

### 1.3.3 Abbreviations

- $G_n$ :  $n^{th}$  goal
- $D_n$ :  $n^{th}$  domain assumption
- $R_n$ :  $n^{th}$  functional requirement

## 1.4 Revision history

Version	Changes	Commit Hash
1.0.0	First release of the document	d7a9e39b1f 59e7d186f7 67e690996d 4b0bd02bf5
1.0.1	<ul style="list-style-type: none"> <li>• Remove TODO items</li> <li>• Fix document grammar</li> <li>• Remove distinction between PartnerStore and Store in Alloy</li> <li>• Add ETA abbreviation</li> <li>• Add Alloy code description</li> <li>• Fix an error in Effort Table</li> </ul>	a91b7b3195 b125740180 4be2b0e152 4bde5f7ff4
1.1.0	Implement changes according to advices of industry advisor: <ul style="list-style-type: none"> <li>• Export references to BibTeX to the references section</li> <li>• Rewrite goals to reflect actual goals of the system</li> <li>• Add user and action details to scenarios</li> <li>• Write Scope section to reflect some core architectural decisions and functions</li> <li>• Remove unnecessary and limiting domain assumptions</li> <li>• Improve Portability section</li> </ul>	

Table 2: Revision History

## 1.5 Reference Documents

- **Specification Document: R&DD Assignment AY 2020-2021**

## 1.6 Document Structure

This document is composed of six sections, each with the purpose described below:

- **Introduction:** This section provides an introduction of the problem, the scope of the project with details regarding the goals, target users, and phenomena. The project's goals are formulated per the description of actions and actors in the Specification Document. Within the project's scope, the properties and duties of different users and user groups are described in the Target Users section. Furthermore, under the project's scope, the relevant phenomena of the project are presented through their relevance to the world and the machine.
- **Overall Description:** This section builds upon the introduction section by providing an expansion of the system's scope and relevant functionalities. The fundamental perspective is provided considering the shared phenomena between the world and the system and the system's integrations with other parties and products. The overall actions that can be conducted over the system are described using a detailed class diagram, portraying all required components of the system, their inner state, and provided functionalities for other components to facilitate their purpose. All core features of the system are listed and explained using user scenarios to understand better the real-world condition on which the use case should apply, a state chart for demonstrating the relationship between various states the system can be in during the execution of the provided core feature scenario. Next, the system's requirements to archive the goals mentioned above and allow the provided scenarios' execution are given. Based on their roles in the system, the user characteristics are further evaluated in this section through the means of the needs that they have, how the

system archives those needs via its requirements and goals. No system can be designed without a broad idea of what domain it exists and how much the environment limits its ability to perform its features. Ergo, we provide the standard assumptions of the domain, the system's dependencies to external components, and the world's limits on the system.

- **Specific Requirements:** This section is the main section of the document. The external interfaces that the system requires to function correctly are presented with details and additional mockups if needed. The interfaces section is mainly concentrated on different views of the user interfaces as the user-facing part is the main way to integrate with the system. In this section, the system's functional requirements are presented in detail, a common use case diagram is provided, and each use-case of the system is analyzed with details on a use case description table and a sequence diagram. The performance requirements of the system, with a focus on development speed and scalability, are provided. The system's design constraints, with a focus on different standard compliances, hardware limitations of the system to function, and other constraints, like GDPR, are also elaborated in this section. The vertical aspects that need consideration are evaluated under the Software System Attributes subsection of this document, with an emphasis on Reliability, Availability, Security, Maintainability, and Portability.
- **Formal Analysis Using Alloy:** This section features various models built, and hypothesis verified using Alloy. This section demonstrates that some aspects of the requirements document can be formally proven correct and provide additional information about the proposed system to the engineers.
- **Effort Spent:** This section features the effort table, in which all team members provide a rough estimation of the time spent on the creation of the various sections of the document.
- **References:** This section features different reference materials referred to in this document.

## 2 Overall Description

### 2.1 Product Perspective

The CLup system is expected to be developed ground-up, without any core components being shared with other services, and is expected to integrate with few external services. The system will be using a maps API to allow its various requirements regarding navigation. The system will be used to control, verify, and schedule customer visits to different stores.

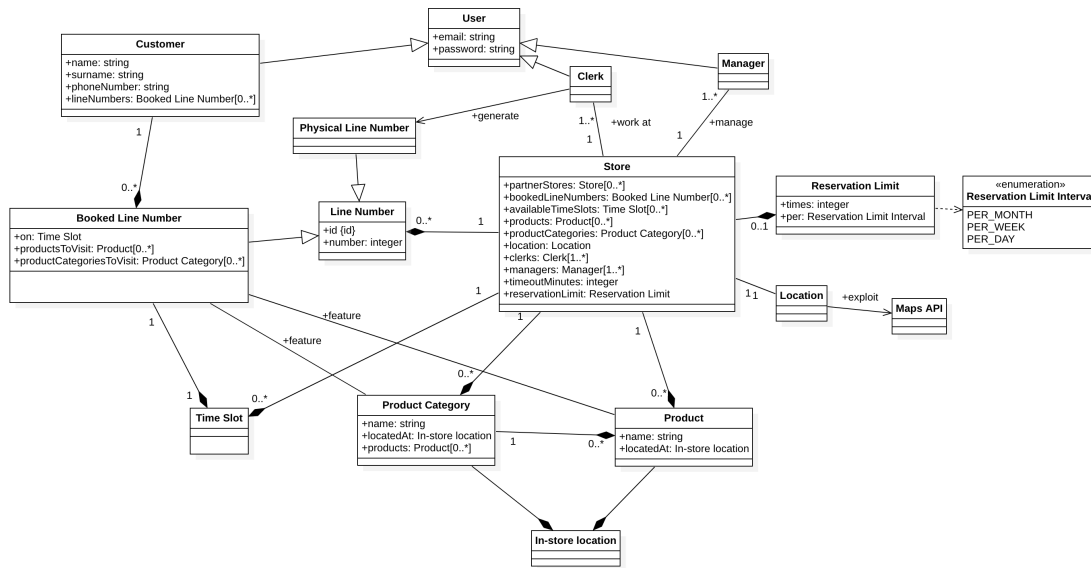


Figure 1: Class Diagram

The **Class Diagram** provided above illustrates the system's core high-level components and their interactions.

The system is designed to be used by different types of users, the **Customers** whom visit or plan to visit the **Store**, the **Managers** who are responsible for handling management related tasks like providing store details, handling system stops, and the **Clerks** who are on active duty for monitoring the entrance and exit of customers. All users on the system are identified with their *e-mails* and require their *passwords* to authenticate. The **Customers** need to register to the system with their *name*, *surname* and *phoneNumber*, in addition to the information required for authentication. All **Line Numbers** feature a unique *id* and an actual *number* that indicate their order in line. Customers can have many **Booked Line Numbers**, limited by the *reservationLimit*, from various stores, which provide many **Time Slots** that the customers can select from under *availableTimeSlots*, which then becomes the time slot the booking is *on*. The line number is to be invalidated after *timeoutMinutes* from its target time interval. The **Store's Location** is set by the **Manager** and observed by customers through a **Maps API**. The **Reservation Limit** imposes a customer can book a line number at most for some *times* per a specific **Reservation Limit Interval** (one of *PER\_MONTH*, *PER\_WEEK* or *PER\_DAY*). Customers' visits can also feature different **Products** or **Product Categories** that they might want to visit under their line number's *productsToVisit* and *productCategoriesToVisit*, each having a *name* and *locatedAt* their own **In-store Location**. **Clerks** can generate **Physical Line Numbers** for customers that do not have the app available for them.

Below some scenarios, statecharts and their brief description are enumerated for the system's core and critical functionalities. It is important to note that the app is targeted at users of all age ranges; thus, the scenarios feature different users of different ages. The statecharts apply to many other scenarios that might occur out of interaction with various types of users.

### 2.1.1 Book Line Number

#### Scenario

Ozan wants to visit the new hamburger place that has recently opened just around the corner of his house. However, Ozan does not want to wait in a long line to purchase a burger and some fries. The fast-food joint has incorporated the CLup system in its customer service portfolio, making it possible for Ozan to reserve his ticket beforehand without visiting the location. Ozan downloads the CLup application and books his line number from his house. Using the app, he can plan his route and schedule to the location beforehand and place his order directly upon his arrival.

#### State Diagram

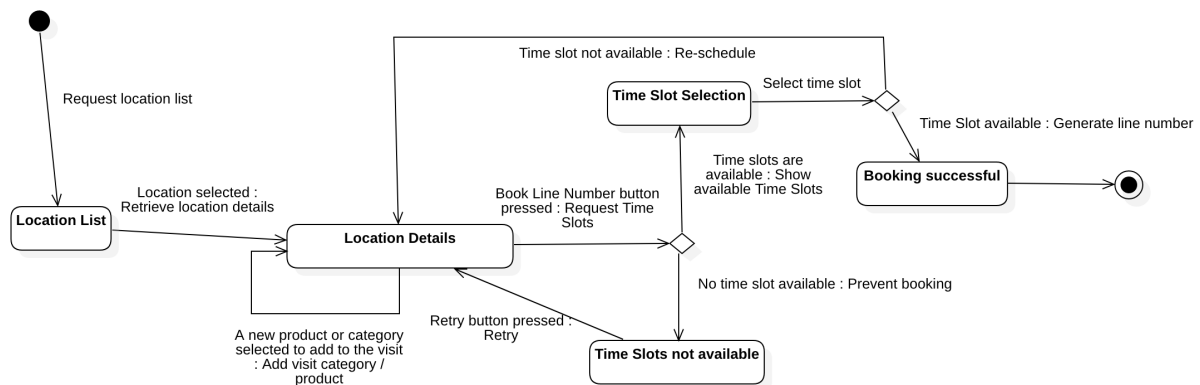


Figure 2: State Diagram for feature Book Line Number

The **State Diagram for feature Book Line Number** represents the execution flow of one of the core use cases, namely booking a line number for the future. The customer books the line number by first listing what locations are available for them to book. Then, when a customer selects a location, they view the location's details, where they can add products or product categories to their target visit. The customer can then view the time slots that the system will generate specifically filtered for their visit based on the location's provided data and availability. When the customer selects a specific time slot, the system tries to book that specific location. If the system successfully allocates the desired time slot, it displays the success message and the customer's ticket. Else the user is notified of the failure and brought back to the scheduling screen to select another slot.

### 2.1.2 Get Line Number

#### Scenario

Roberto lives in Milan during the COVID lockdown and wants to visit a grocery store near his house. He wants to obtain a line number for his visit through his phone not to waste time while waiting in line for other customers to be done with their affairs. He hears that the store he plans to visit has been on CLup, so he downloads the application and opens it. Using the app, Roberto can now see when he should take off to reach the shop without waiting in front of the store.

#### State Diagram

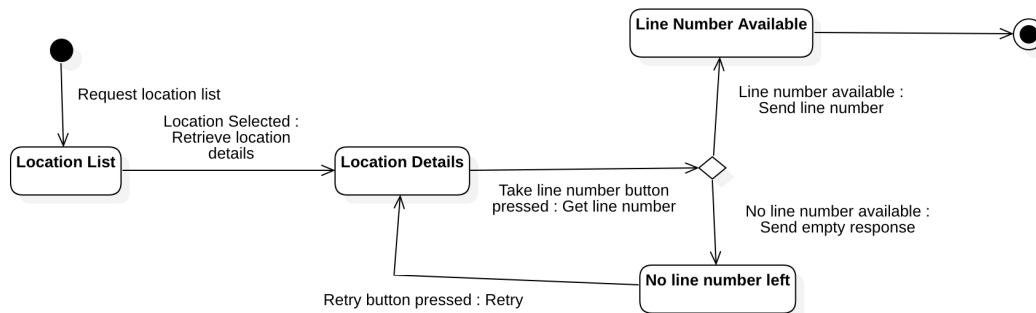


Figure 3: State Diagram for feature Get Line Number

The **State Diagram for feature Get Line Number** represents another core use case's execution flow, booking a line number for a recent visit. The customer generates a line number by going over the list of available locations, similar to the Book Line Number feature; however, they press the "Take Line Number" button directly this time. Then, the system tries to generate a line number for them, and if it is successful, the user retrieves the resulting line number. If the system can not fulfill the user's request, it communicates the problem to the user and allows a retry.

### 2.1.3 Print Line Number

#### Scenario

Hrvoje, a Croatian who recently arrived in Italy, is not aware of the popularity of the CLup app; however, he wants to visit an electronics store to purchase a new phone because his current phone has died out of battery failure. Upon arrival, since he does not have a phone, he can not register to the CLup system; however, the security, that is also in charge of validating line numbers, prints him a ticket that he should keep during his whole visit. Therefore, Hrvoje is allowed in the store, even if he does not have the application, and the shop manager can monitor his entrance and exit.

#### State Diagram

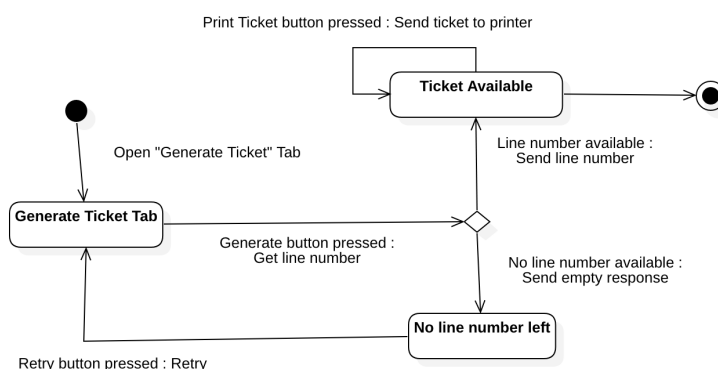


Figure 4: State Diagram for feature Print Line Number

The **State Diagram for feature Print Line Number** represents the execution flow of a similar use case,

printing an actual ticket for on foot visitors. Upon the arrival of a new customer that does not have a line number, the clerk opens the generate ticket tab and presses the "Generate" button to create a new line number. If all the constraints are satisfied, the system allocates a new ticket number for the customer. The clerk can then print the ticket out using a printer. In case there are no line numbers left, the system notifies the clerk as such, with an option to retry the operation.

## 2.1.4 System Stop

### Scenario

Gianfranco is a team lead in a shoe factory. The shoe factory also has an outlet store, where the local brand sells its shoes directly to customers at a discounted price. One day, a fire erupts due to a malfunction in the automated sewing machine, and it starts to spread all over the building. Gianfranco coordinates the evacuation of the factory and the store. He also uses the CLup application to issue a system stop to prevent further customers from flooding in. All the store customers receive notification regarding this unfortunate event and do not arrive at the location.

### State Diagram

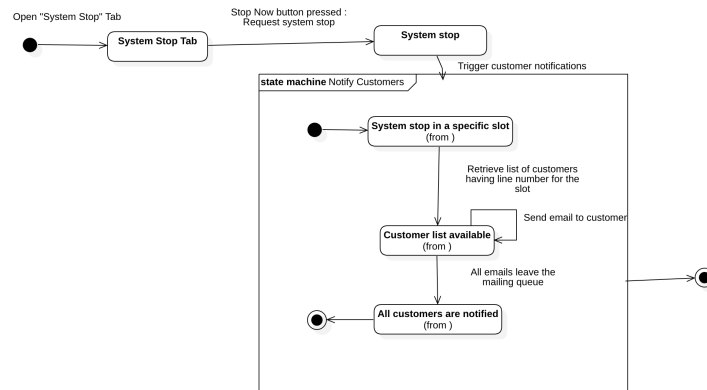


Figure 5: State Diagram for feature System Stop

The **State Diagram for feature System Stop** represents the execution flow for a critical use case, the manager's ability to halt the system so that all line numbers get canceled, all users are notified, and no other line numbers are issued. The manager first opens the System Stop tab on their phone and afterward requests a system stop. This action stops the system from issuing more tickets and triggers the distribution of notifications for the time zones the system is stopped in. In the notification part of the state diagram, the system starts with a request for a stop for a specific time slot and retrieves all the customers that have already scheduled for that slot. The system then starts sending emails to all customers that are in the list provided. When all emails leave the mailing queue, the system has successfully notified all the customers regarding the stop. The state machine of Notifying Customers is re-used to describe the notification mechanism in the **State Diagram for feature Schedule System Stop**.

## 2.1.5 Schedule System Stop

### Scenario

Giuseppe is the owner of a famous local pizza place. He is using the CLup system in his store to manage the customer lines. He is also preparing a new radio advertisement for his store, with an advertisement agency. They have a meeting next week during work hours, and he does not have anyone to give the authority to manage the store. Therefore, he has to shut the store down for half the day. He



schedules a system stop from the CLup system to prevent ticket numbers from being issued on that day for his store.

### State Diagram

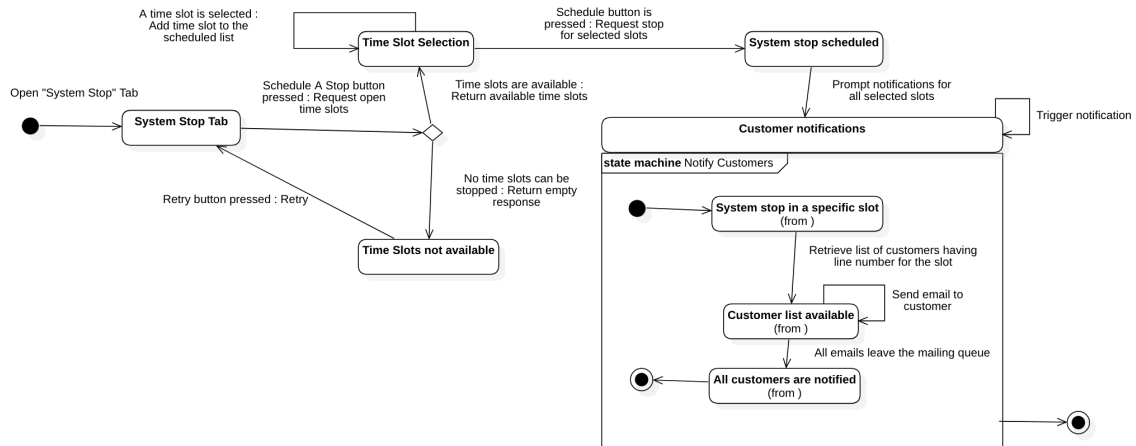


Figure 6: State Diagram for feature Schedule System Stop

The **State Diagram for feature Schedule System Stop** represents the final core use case of the system that is considered significant, scheduling the system to stop in the future. To start this flow, the manager first opens the System Stop tab and presses the schedule a stop button. The system then pools all the available slots that the manager can issue a stop on and returns the list to the time slot selection screen. If no such slot is available, a screen indicating such a case is visible, with an opportunity to retry the action. The manager selects specific time slots from the time slot selection list that the system shall stop for and press the Schedule button to schedule a system stop. A scheduled system stop also sends a notification to all customers that have booked a time slot for that shop before the system stop. The mechanism of customer notification is detailed in the description of the **State Diagram for feature System Stop**, so it will not be repeated here.

## 2.2 Product functions

This section describes some essential functions of the software that are the most important ones and sums up the whole idea of the CLup application.

### 2.2.1 Schedule store visit

Since the start of the COVID-19 pandemic, keeping a physical distance from unknown people has never been more critical. A lot of new restrictions were introduced, which were mainly oriented towards keeping people separated. Stores now have a restriction on the number of people they could let in. The CLup application helps people and the community prevent its users from waiting in long lines on the streets during pandemic conditions. It allows customers to schedule a visit to the store in their desired time slot if available. Each customer can register through the CLup application and then reserve his visit to the store. Furthermore, a customer can choose which products or products section he will buy and how long his shopping will approximately last. After a customer has successfully scheduled his visit time, he will receive a line number, which he is obligated to show to enter the store.

### 2.2.2 Line number ticket entry

Before entering the store, a customer must show his line number ticket to a clerk who will then scan his ticket. If the customer has arrived in the scheduled time slot, he will enter the store. If the customer does

not have a line number ticket, the clerk will provide him with one, but he will not be able to enter the store immediately unless the time slot for that moment is not occupied with other customers. To sum up, a customer with a scheduled store visit can visit the store at a scheduled time without waiting in line in front of a store, while a customer without the line number ticket depends on the free available time slots.

### **2.2.3 Store management**

Through the CLup application, the manager can edit all the store information such as location-specific information, the maximum number of customers in the store at any given time, opening and closing hours of the store per each day, line number timeout, and much more. Customers can see working hours and in-store occupancy, and therefore, they can visit the store at the desired time if available. The manager can also select which product categories or products are available at the store. By doing so, customers can know precisely in which store to go based on the products available.

## **2.3 User characteristics**

### **2.3.1 Customer**

A person who is registered on the CLup application can use its functionalities to successfully schedule a visit to the store in the desired visit time if available. The amount of product training needed for a customer is none since the level of technical expertise and educational background is unknown as the range of customers includes all demographics. The only skill needed by a user is the ability to use the application.

### **2.3.2 Clerk**

An employee of the store with basic knowledge about the application. The clerk must be able to use its functionalities so he could handle all physical visits of customers.

### **2.3.3 Manager**

A particular employee of the store with basic knowledge about the application. The manager is in charge of managing a particular store through the CLup application; they don't need to be a real store manager.

## **2.4 Assumptions,dependencies and constraints**

### **2.4.1 Domain Assumptions**

- $D_1$  %80 of the customers and all clerks and managers have basic ICT skills, has an e-mail address that they are willing to use to authenticate to the system, and has a smartphone or equivalent device that can connect to the Internet, have a browser that supports UTF-8, display QR codes and has a mapping application.
- $D_2$  Locations will be visited by no more than 1000 people in any time slot.
- $D_3$  %98 of the customers will arrive at the given location either without a ticket or with a ticket that has not timed out.
- $D_4$  E-mail addresses are not shared by multiple users of the system.
- $D_5$  Clerks' mobile devices are equipped with at least one camera that the system can use.
- $D_6$  All users have a basic understanding of how the line numbering system works and respects the system's ordering.

- $D_7$  Managers have an estimate for the number of reservations that their location can at most have.
- $D_8$  Managers' device has location services with a location acquisition error for no more than 20 meters.
- $D_9$  Clerks are continually monitoring the locations entrances and exits.
- $D_{10}$  Locations have printing equipment in 5 meters range of all the entrances that can print QR codes and line numbers.
- $D_{11}$  At least one manager is available in the location during the working hours.
- $D_{12}$  The customer's entry and exit to the store are determined by whether the clerks have checked them in and out.
- $D_{13}$  The customer has their line number or line number ticket available with them through their visit, including their exit from the store.

#### **2.4.2 Dependencies**

The application will be running on a server provided by the hosting provider. The application will be dependant on Maps API, of which the details will be determined later in the Design Document.

#### **2.4.3 Constraints**

Application interface should be user friendly and intuitive enough for all demographics to use. It should also be mobile friendly as well as desktop friendly. The application should work on smartphones, tablets, and desktop devices to be available to as many devices as possible. The application should be developed and fully functional before the end of the COVID-19 crisis.

### 3 Specific Requirements

#### 3.1 External Interface Requirements

##### 3.1.1 User Interfaces

Below are some sample screenshots from the project's user interfaces with Samsung Galaxy S9 viewport:

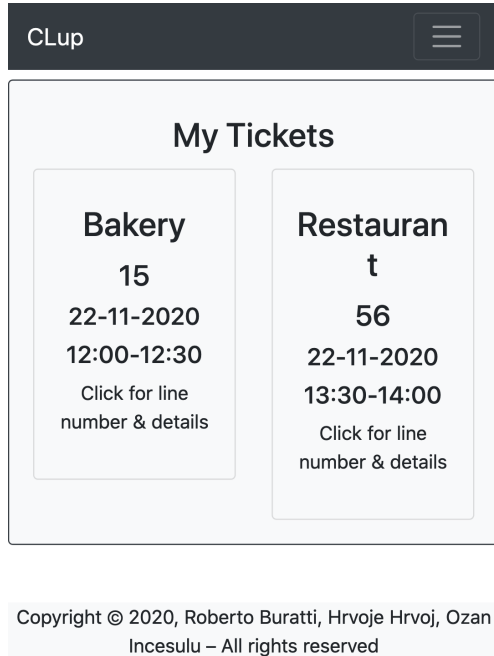


Figure 7: Screenshot: List tickets

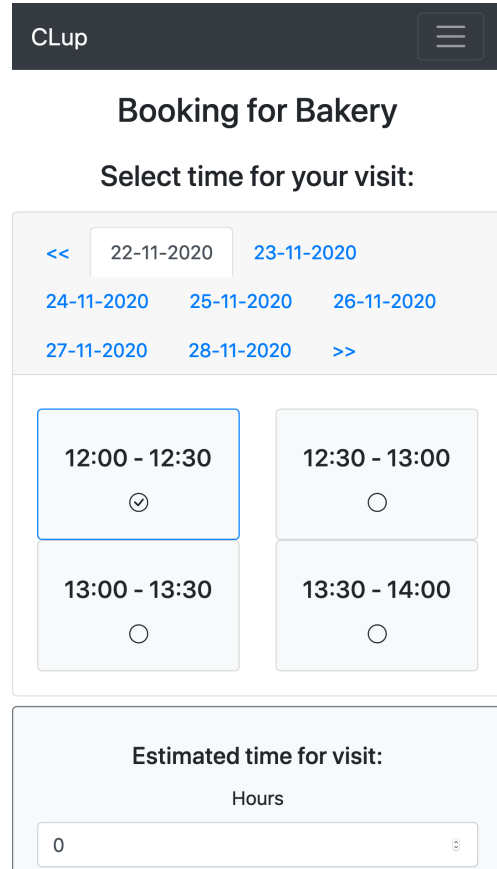


Figure 8: Screenshot: Booking a new ticket

CLup

## Edit Location

Name

Bakery

Customer Ticket Timeout (minutes)

30

### Products

Bread	Update	x
Sweets	Update	x
Sandwiches	Update	x
Coffee & Tea	Update	x

### New Product

Name:

Add

Figure 9: Screenshot: Edit location screen of manager

CLup

## Generated ticket:

15

Print Ticket

Create New Ticket

Copyright © 2020, Roberto Buratti, Hrvoje Hrvoj, Ozan Incesulu – All rights reserved

Figure 10: Screenshot: Ticket generate screen of clerk

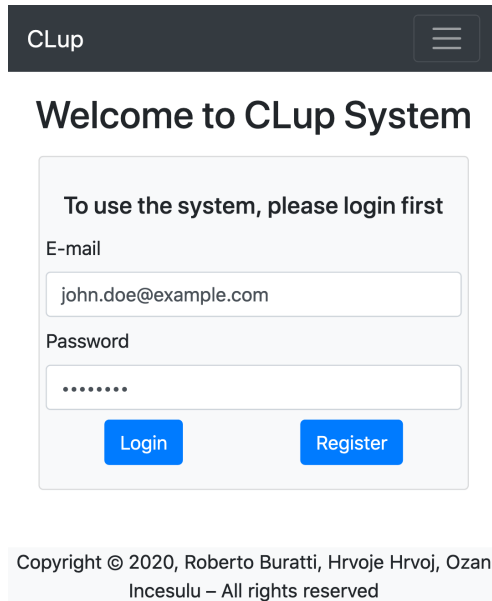


Figure 11: Screenshot: Login screen

Privacy Policy and [Terms of Use](#)'." data-bbox="547 101 859 488"/>

Figure 12: Screenshot: Register screen

### 3.1.2 Hardware Interfaces

The application will be able to run on a desktop as well as tablet and smartphone. The operating system or actual performance of the device used are not critical since the vast majority of devices will be supported. Usage of a smartphone or a tablet could be beneficial to the user since they can bring them to the store. As mentioned in the domain assumptions, the clerk should have a smartphone with a working camera module. The manager should mainly use a desktop computer to manage store information quickly. He should be able to do all his tasks from a smartphone or a tablet, but a desktop computer should be the primary target device for the functionality.

### 3.1.3 Software Interfaces

The application should run on every operating system such as Windows, Linux, or macOS for desktop devices, and Android or iOS. The application will use a QR code generator to produce QR codes that will be scanned when entering the store and contain all the information related to the customer's visit time.

### 3.1.4 Communication Interfaces

The device should have an active internet connection, and the application should communicate through TCP/IP.

## 3.2 Functional Requirements

### 3.2.1 Customer

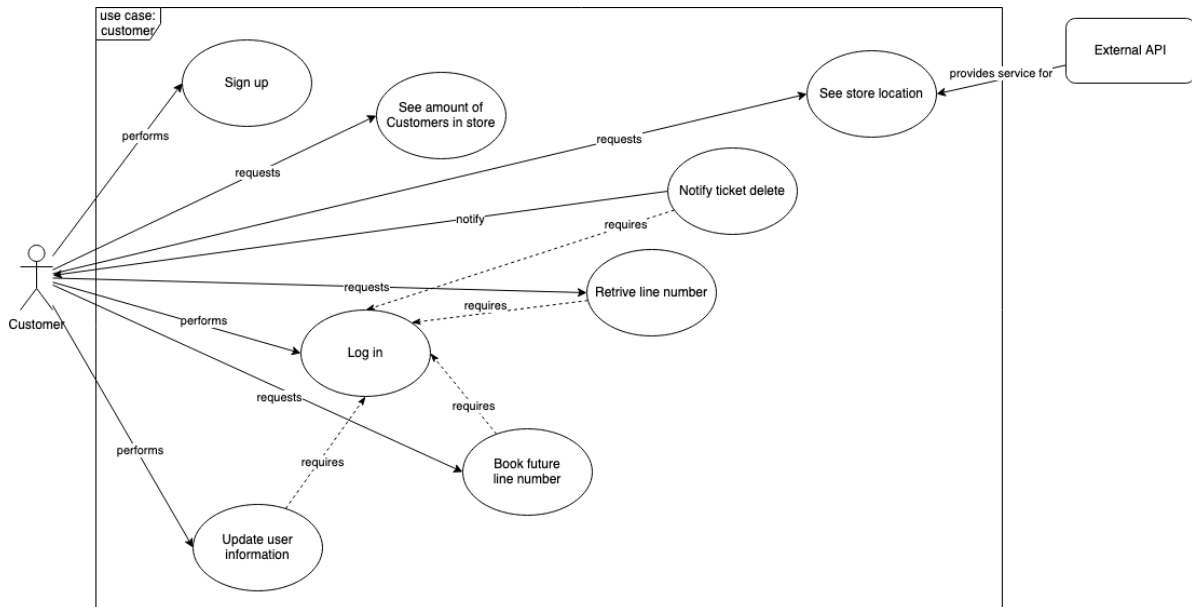


Figure 13: Use Case Diagram for Customer

### Use cases

<i>Name</i>	<b>Book future line number</b>
<i>Actors</i>	Customer
<i>Entry conditions</i>	The customer is logged in the application and wants to book a visit to the store.
<i>Event flows</i>	<ul style="list-style-type: none"> <li>• The customer clicks on the "Book a Visit" button in the application.</li> <li>• The application asks the time slot and the estimated time of the visit presenting as a default value the average of the previous visit of the same user.</li> <li>• The customer sets the time slot and the estimated time of their visit.</li> <li>• The application asks what category of products the customer wants to buy.</li> <li>• The customer sets the product categories.</li> <li>• The application requests the line number from the server.</li> <li>• The application generates the QR code on the response from the server.</li> </ul>
<i>Exit conditions</i>	The customer has booked a visit for the store.
<i>Exceptions</i>	<ul style="list-style-type: none"> <li>• The server cannot retrieve the line number since the time slot is full.</li> </ul>

Table 3: Use Case: Book future line number

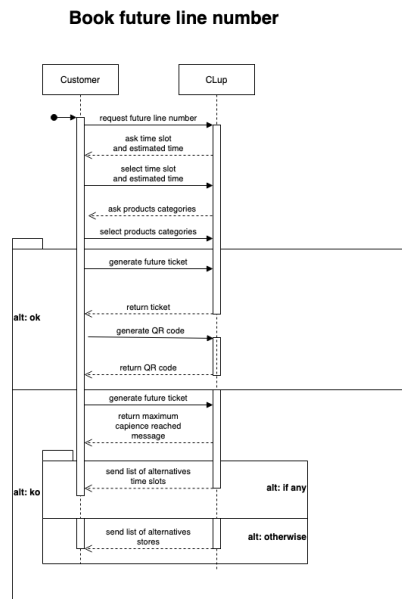


Figure 14: Sequence Diagram for Use Case: Book future line number

<i>Name</i>	<b>See amount of customers in the store</b>
<i>Actors</i>	Customer
<i>Entry conditions</i>	The customer is logged in to the application and wants to know how many customers are in the store to decide whether to book a visit or retrieve a line number.
<i>Event flows</i>	<ul style="list-style-type: none"> <li>• The customer clicks on the "Live Store Info" button.</li> <li>• The application sends a count request to the server.</li> <li>• The server returns the live data for the number of customers in the store for each time slot.</li> </ul>
<i>Exit conditions</i>	The customer knows the number of customers in the store and can plan their visit.
<i>Exceptions</i>	

Table 4: Use Case: See amount of customers in the store



## See amount of customers in store

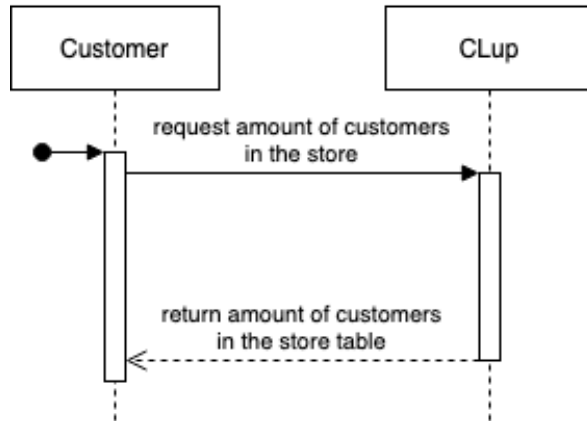


Figure 15: Sequence Diagram for Use Case: See amount of customers in the store

<i>Name</i>	<b>See store location</b>
<i>Actors</i>	Customer, Maps API
<i>Entry conditions</i>	The customer needs to know where the store is located and the travel time
<i>Event flows</i>	<ul style="list-style-type: none"> <li>• The customer clicks on the "Store Location" button.</li> <li>• The application contacts the Maps API with the store location.</li> <li>• The Maps API returns a map from the customer position to the store with the time estimation.</li> </ul>
<i>Exit conditions</i>	The customer knows how to go to the store and the travel time needed.
<i>Exceptions</i>	<ul style="list-style-type: none"> <li>• The customer's smartphone doesn't provide or allow access to location services.</li> </ul>

Table 5: Use Case: See store location

## See store location

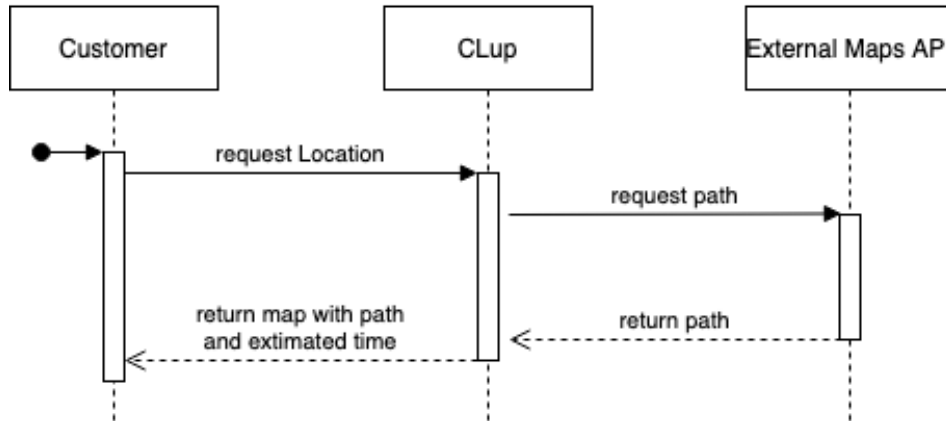


Figure 16: Sequence Diagram for Use Case: See store location

<i>Name</i>	<b>Sign up</b>
<i>Actors</i>	Customer
<i>Entry conditions</i>	The customer opened the application, and they are not registered yet, and they want to register.
<i>Event flows</i>	<ul style="list-style-type: none"> <li>• The customer clicks on the "Sign Up" button.</li> <li>• The customer inserts their credentials.</li> <li>• The application sends the information to the server.</li> <li>• The server stores the data related to the user.</li> <li>• The server returns an acknowledgment to the app.</li> </ul>
<i>Exit conditions</i>	The customer is now registered and can use all the functionalities of the app.
<i>Exceptions</i>	<ul style="list-style-type: none"> <li>• The e-mail provided in the registration form is already used by another user.</li> <li>• The credentials provided in the registration form are ill-formatted.</li> </ul>

Table 6: Use Case: Sign up

## Sign Up

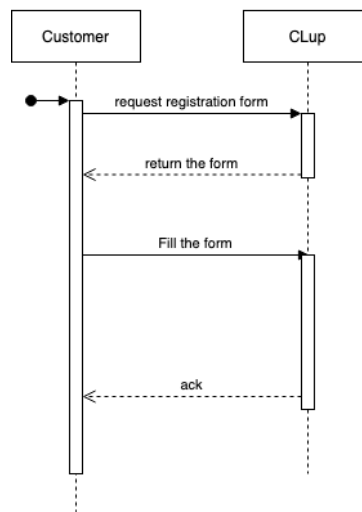


Figure 17: Sequence Diagram for Use Case: Sign up

<i>Name</i>	<b>Login</b>
<i>Actors</i>	User
<i>Entry conditions</i>	The user has already signed up and wants to login to use CLup functionalities
<i>Event flows</i>	<ul style="list-style-type: none"> <li>• The customer clicks on the "Login" button</li> <li>• The user provides their login credentials.</li> <li>• The system authenticates the user</li> </ul>
<i>Exit conditions</i>	The user is logged in and can now use all the CLup functionalities
<i>Exceptions</i>	<ul style="list-style-type: none"> <li>• The credentials are wrong</li> </ul>

Table 7: Use Case: Login

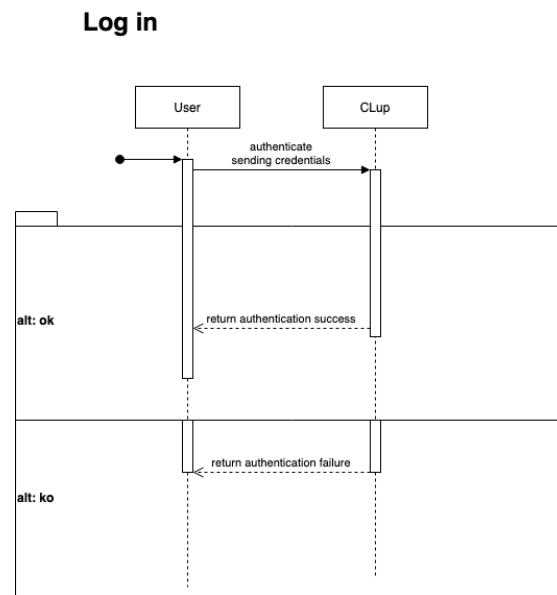


Figure 18: Sequence Diagram for Use Case: Login

<i>Name</i>	<b>Notify ticket delete</b>
<i>Actors</i>	Customer
<i>Entry conditions</i>	A ticket of the customer was deleted from the server.
<i>Event flows</i>	<ul style="list-style-type: none"> <li>The system sends an email to the customer to notify the deletion of their ticket</li> </ul>
<i>Exit conditions</i>	The customer is informed about the deletion of their ticket.
<i>Exceptions</i>	<ul style="list-style-type: none"> <li></li> </ul>

Table 8: Use Case: Notify ticket delete

## Notify ticket delete

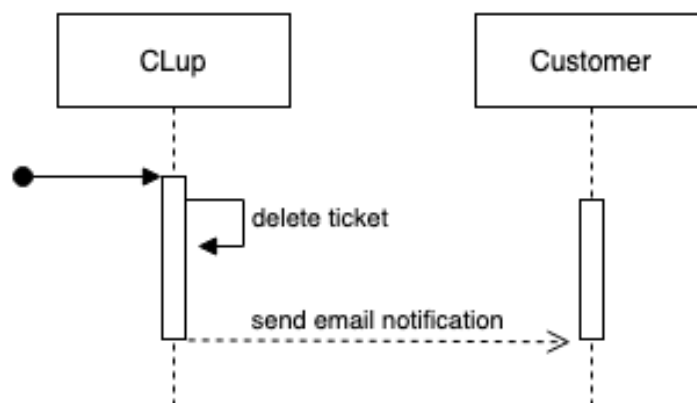


Figure 19: Sequence Diagram for Use Case: Notify ticket delete

<i>Name</i>	<b>Update user information</b>
<i>Actors</i>	User
<i>Entry conditions</i>	The user wants to change the information about themselves.
<i>Event flows</i>	<ul style="list-style-type: none"> <li>• The user clicks on the "Update User Information" button.</li> <li>• The application shows a precompiled form with user's previous information.</li> <li>• The user changes the information on the respective fields and presses the "Submit" button.</li> <li>• The system saves the changes.</li> </ul>
<i>Exit conditions</i>	The user successfully updated their information.
<i>Exceptions</i>	<ul style="list-style-type: none"> <li>• The new information provided is ill-formatted.</li> </ul>

Table 9: Use Case: Update user information

### Update user information

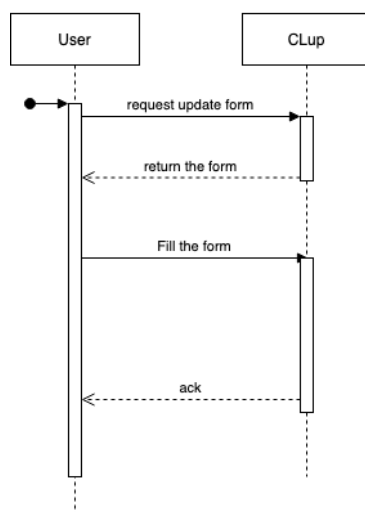


Figure 20: Sequence Diagram for Use Case: Update user information

<i>Name</i>	<b>Retrieve line number</b>
<i>Actors</i>	Customer
<i>Entry conditions</i>	The customer is logged in the application and wants to retrieve a line number.
<i>Event flows</i>	<ul style="list-style-type: none"> <li>• The customer clicks on the "retrieve line number" button in the application</li> <li>• The application returns an ETA and asks for confirmation from the customer.</li> <li>• The customer confirms.</li> <li>• The customer asks the application to generate the QR code.</li> <li>• The application returns the QR code.</li> </ul>
<i>Exit conditions</i>	The customer have retrieved a line number.
<i>Exceptions</i>	<ul style="list-style-type: none"> <li>• The server cannot retrieve the line number since the time slot is full.</li> </ul>

Table 10: Use Case: Retrieve line number

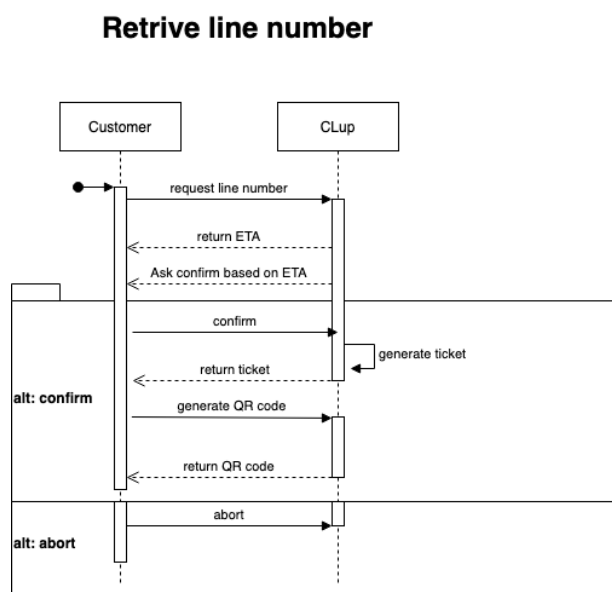


Figure 21: Sequence Diagram for Use Case: Retrieve line number

### 3.2.2 Clerk

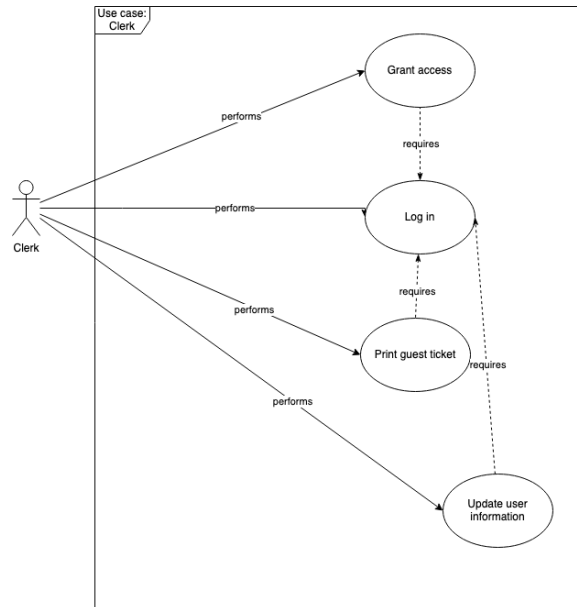


Figure 22: Use Case Diagram for Clerk

### Use cases

<i>Name</i>	<b>Grant access</b>
<i>Actors</i>	Clerk, Customer
<i>Entry conditions</i>	The customer has already obtained the QR code, and they plan on entering the store.
<i>Event flows</i>	<ul style="list-style-type: none"> <li>• The clerk scans the QR code from the customer's smartphone or printed ticket using the application</li> <li>• The application analyzes the QR code and contacts the server</li> <li>• The server decides if the customer can enter based on the information received in the QR code</li> <li>• The server responds to the clerk application with the result</li> <li>• The application displays authorized message for the clerk to let the customer enter the store</li> </ul>
<i>Exit conditions</i>	The customer enters the store
<i>Exceptions</i>	<ul style="list-style-type: none"> <li>• The server communicates to the clerk that the customer cannot enter because their line number is not available.</li> </ul>

Table 11: Use Case: Grant access

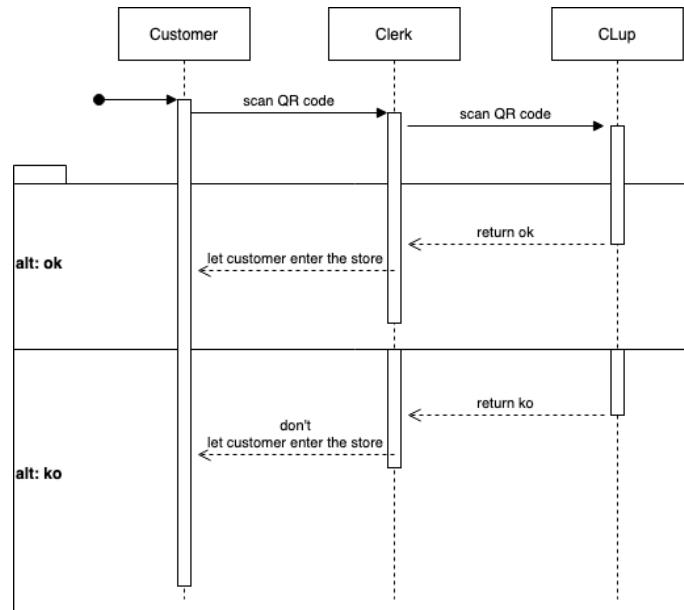


Figure 23: Sequence Diagram for Use Case: Grant Access

<i>Name</i>	<b>Print guest ticket</b>
<i>Actors</i>	Clerk, Customer
<i>Entry conditions</i>	The customer has arrived at the location, doesn't have a ticket on their smartphone, and needs a physical ticket to enter.
<i>Event flows</i>	<ul style="list-style-type: none"> <li>• The customer asks the clerk for a ticket.</li> <li>• The clerk generates a ticket using the app.</li> <li>• The application sends a request to the server to generate a ticket.</li> <li>• The server generates a line number and a ticket.</li> <li>• The server sends the ticket back to the app.</li> <li>• The application generates the printable ticket so that the clerk can provide the customer a ticket.</li> </ul>
<i>Exit conditions</i>	The customer has a ticket.
<i>Exceptions</i>	<ul style="list-style-type: none"> <li>• The server cannot generate a line number due to capacity constraints.</li> </ul>

Table 12: Use Case: Print guest ticket



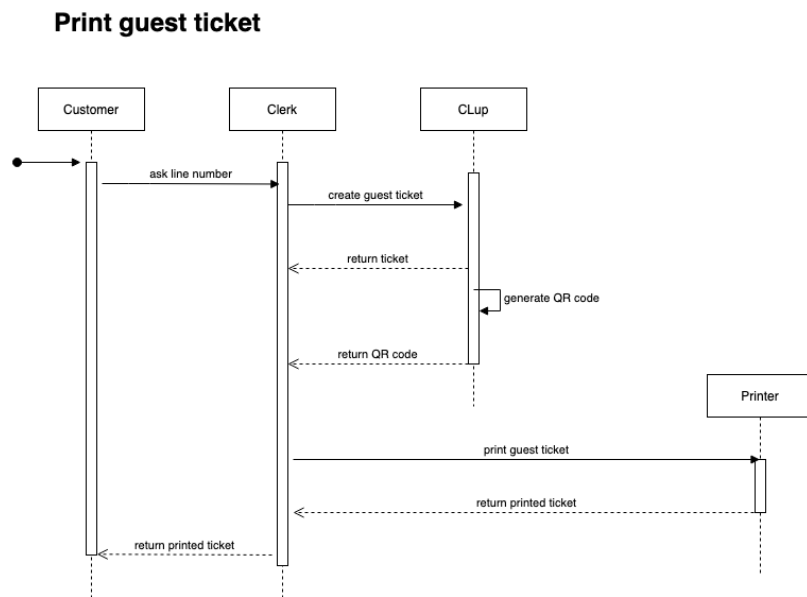


Figure 24: Sequence Diagram for Use Case: Print guest ticket

### 3.2.3 Manager

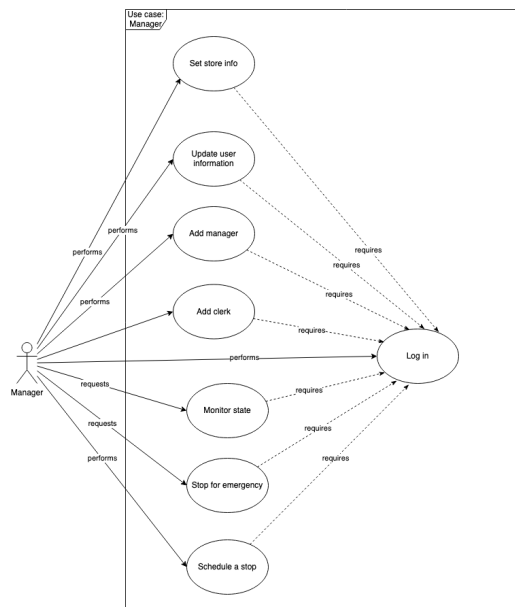


Figure 25: Use Case Diagram for Manager

### Use cases

<i>Name</i>	<b>Initialize</b>
<i>Actors</i>	Manager
<i>Entry conditions</i>	The manager of the store needs to set the necessary information of the store to start the service
<i>Event flows</i>	<ul style="list-style-type: none"> <li>• The manager clicks on the initialize button</li> <li>• The application shows the location form to the manager</li> <li>• The manager fills the form and sends it to the server via the app</li> <li>• The server registers the information and acknowledges</li> </ul>
<i>Exit conditions</i>	The system is initialized and can offer all its functions
<i>Exceptions</i>	<ul style="list-style-type: none"> <li>• Some mandatory parts of the form are not filled.</li> </ul>

Table 13: Use Case: Initialize

### Set store info

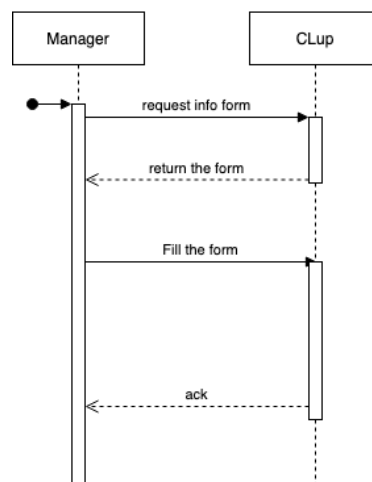


Figure 26: Sequence Diagram for Use Case: Initialize

<i>Name</i>	<b>Monitor state</b>
<i>Actors</i>	Manager
<i>Entry conditions</i>	The manager wants to monitor the number of customers in the store in real-time.
<i>Event flows</i>	<ul style="list-style-type: none"> <li>• The manager clicks on the "Monitoring" button.</li> <li>• The application sends the number request to the server.</li> <li>• The server returns the number of customers in the store.</li> <li>• The application repeats the process periodically as long as the monitoring page is open.</li> </ul>
<i>Exit conditions</i>	The manager is informed of the number of customers in the store in real-time.
<i>Exceptions</i>	•

Table 14: Use Case: Monitor state

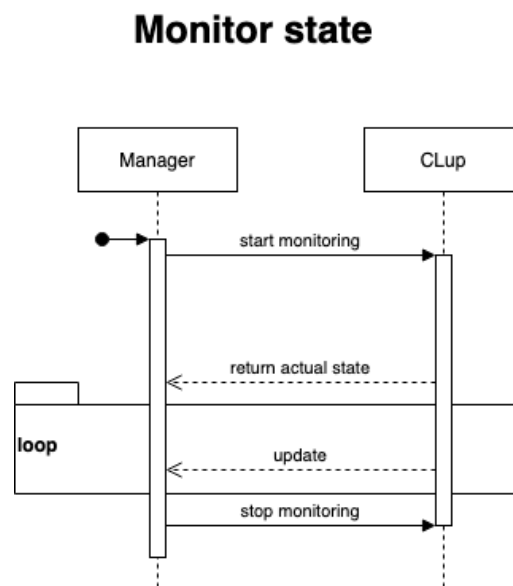


Figure 27: Sequence Diagram for Use Case: Monitor state

<i>Name</i>	<b>Schedule a stop</b>
<i>Actors</i>	Manager
<i>Entry conditions</i>	The manager wants to schedule a period in which the store will be closed so the users can not book a visit.
<i>Event flows</i>	<ul style="list-style-type: none"> <li>• The manager clicks on the "Schedule a Stop" button.</li> <li>• The application shows a form for the time of the stop.</li> <li>• The manager fills the form and submits it to the server through the app.</li> <li>• The server stores the information in the database and returns an acknowledgment.</li> </ul>
<i>Exit conditions</i>	The system has a scheduled stop stored in its database and will use it to prevent customers from booking a visit in that period.
<i>Exceptions</i>	<ul style="list-style-type: none"> <li>• There is already a planned stop in that period.</li> </ul>

Table 15: Use Case: Schedule a stop

## Schedule a stop

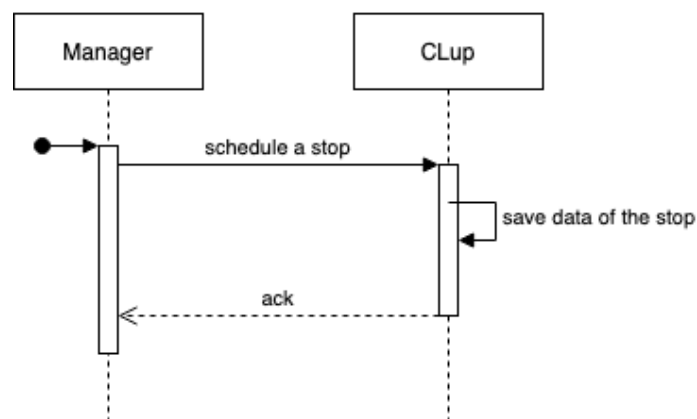


Figure 28: Sequence Diagram for Use Case: Schedule a stop

<i>Name</i>	<b>Stop for emergency</b>
<i>Actors</i>	Manager
<i>Entry conditions</i>	An emergency occurred, and the manager wants to stop the system from distributing line numbers immediately.
<i>Event flows</i>	<ul style="list-style-type: none"> <li>The manager click on the "Emergency Stop" button</li> <li>The application asks for confirmation from the manager.</li> <li>The manager confirms the stop of the system.</li> <li>The application sends the system stop request to the server.</li> <li>The server stops the service and return an acknowledgement.</li> </ul>
<i>Exit conditions</i>	The system has interrupted the service.
<i>Exceptions</i>	<ul style="list-style-type: none"> <li>The manager aborts the operation.</li> </ul>

Table 16: Use Case: Stop for emergency

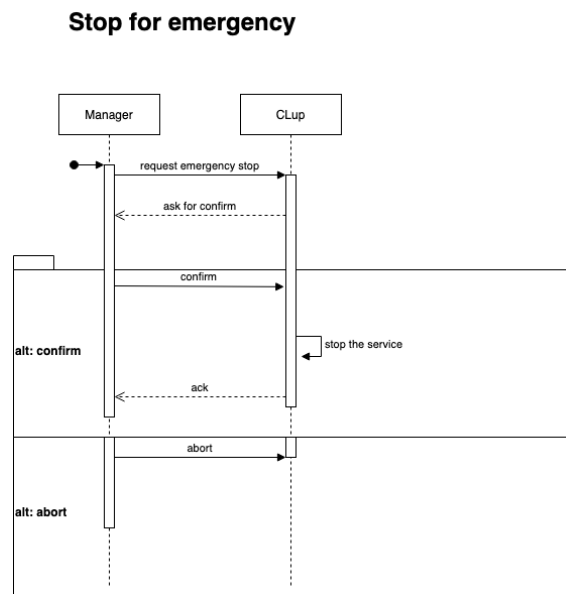


Figure 29: Sequence Diagram for Use Case: Stop for emergency

<i>Name</i>	<b>Add Clerk</b>
<i>Actors</i>	Manager
<i>Entry conditions</i>	The manager wants to add a new clerk to the system
<i>Event flows</i>	<ul style="list-style-type: none"> <li>The manager clicks on the "Add Clerk" button</li> <li>The system asks the data of the new clerk (e.g., the credentials)</li> <li>The manager inserts the data and press "Submit"</li> </ul>
<i>Exit conditions</i>	The new clerk is added to the system
<i>Exceptions</i>	<ul style="list-style-type: none"> <li>The data of the clerk are incomplete or incorrect</li> </ul>

Table 17: Use Case: Add Clerk

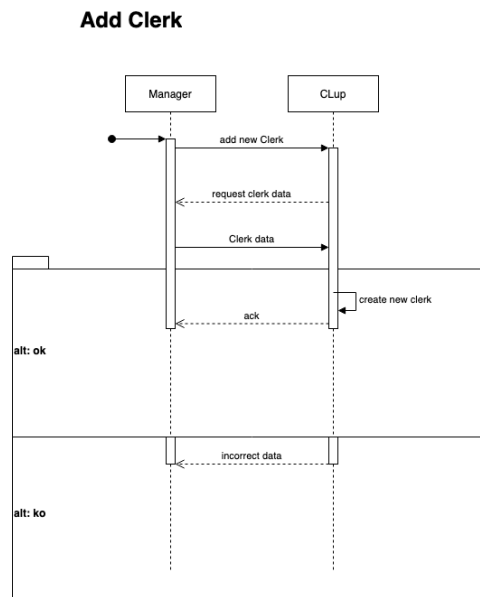


Figure 30: Sequence Diagram for Use Case: Add Clerk

<i>Name</i>	<b>Add Manager</b>
<i>Actors</i>	Manager
<i>Entry conditions</i>	The manager wants to add a new manager to the system
<i>Event flows</i>	<ul style="list-style-type: none"> <li>• The manager clicks on the "Add Manager" button</li> <li>• The system asks the data of the new manager (e.g., the credentials)</li> <li>• The manager inserts the data and press "Submit"</li> </ul>
<i>Exit conditions</i>	The new manager is added to the system
<i>Exceptions</i>	<ul style="list-style-type: none"> <li>• The data of the manager are incomplete or incorrect</li> </ul>

Table 18: Use Case: Add Manager

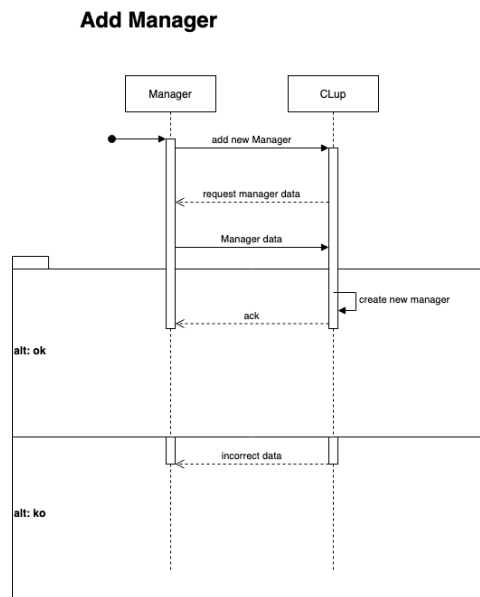


Figure 31: Sequence Diagram for Use Case: Add Manager

### 3.2.4 Requirements

- $R_1$  The system must allow users to authenticate using their e-mail address and password.
- $R_2$  The system must allow customers to register using their e-mail address, their name, surname, phone number, and a new password.
- $R_3$  Managers must be able to add additional managers and clerks as users.
- $R_4$  Managers must be able to set and update location-specific information, that is, the maximum number of customers in the location at any given time, opening and closing hours of the store per each day, line number timeout, the limit of reservation per customer on a predetermined time interval that is one of the month, week or day, and location of the place
- $R_5$  Managers can add any other location as a partner store.
- $R_6$  Managers can stop the system from issuing any more tickets for a given day
- $R_7$  Managers can schedule the system stop for a future time.
- $R_8$  Managers can set in-shop locations for different categories and product items.
- $R_9$  In case of a system stop, no other line numbers can be issued for the given time slots.
- $R_{10}$  In case of a system stop, all line numbers in the stop time slots have to be canceled.
- $R_{11}$  The system must cancel those line numbers that the customer did not arrive at the store for more than the set timeout interval.
- $R_{12}$  In case of ticket cancellation, the customer must be notified with an e-mail notification.
- $R_{13}$  Clerks must register the customers' entrance and exit via scanning the QR code for their line number.
- $R_{14}$  Clerks must be able to generate line number tickets in a compatible printer format.

- $R_{15}$  Customers must be able to obtain a line number, except when the system is stopped or the store is full.
- $R_{16}$  Customers must be able to obtain line numbers for different time slots in the future.
- $R_{17}$  Customers can not obtain line numbers that exceed the quantity per time interval limits.
- $R_{18}$  Customers can not obtain line numbers for time intervals that the system is stopped by a manager.
- $R_{19}$  Customers must be able to see the estimated time available for their line number.
- $R_{20}$  Customers must be able to set or update their phone number, password, name, and surname.
- $R_{21}$  Customers can select a specific product or product categories they plan to visit in the location while obtaining a line number.
- $R_{22}$  Customers can set an estimated time for their visit while obtaining a line number.
- $R_{23}$  Customers must be able to view the shop location
- $R_{24}$  Customers can view the occupation forecasts for the location at different time slots.
- $R_{25}$  Customers can see the alternative suggestions for time slots while obtaining a line number for the future.
- $R_{26}$  Customers can view the partner stores occupancies' if the preferred time slot is not available while obtaining a line number.
- $R_{27}$  The system must be able to provide a forecast for each location's occupancy for any given time based on past visits.

### 3.2.5 Summary Table

Goal	Requirements	Domain Assumptions
$G_1$	$R_1, R_2, R_{11}, R_{15}, R_{17}, R_{18}$	$D_1, D_{13}$
$G_2$	$R_1, R_2, R_{11}, R_{16}, R_{17}, R_{18}, R_{26}$	$D_1$
$G_3$	$R_1, R_2, R_8, R_{21}, R_{22}$	$D_1$
$G_4$	$R_1, R_2, R_{12}, R_{19}, R_{23}, R_{24}, R_{27}$	$D_1, D_3, D_6, D_8$
$G_5$	$R_1, R_2, R_5, R_{24}, R_{25}, R_{26}$	$D_1$
$G_6$	$R_1, R_3, R_6, R_7, R_9, R_{10}, R_{12}, R_{18}$	$D_1, D_{11}$
$G_7$	$R_1, R_3, R_4, R_{11}, R_{17}, R_{27}$	$D_1, D_7$
$G_8$	$R_1, R_3, R_{13}, R_{20}$	$D_1, D_3, D_4, D_5, D_6, D_9, D_{11}, D_{12}, D_{13}$
$G_9$	$R_3, R_{14}$	$D_2, D_6, D_{10}, D_{13}$

Table 19: Summary Table



### 3.2.6 Tracability Matrix

Requirement	Use case
$R_1$	Login
$R_2$	Sign Up
$R_3$	Add Clerk Add Manager
$R_4$	Initialize
$R_5$	Initialize
$R_6$	Stop for Emergency
$R_7$	Schedule a Stop
$R_8$	Initialize
$R_9$	Schedule a Stop Stop for Emergency
$R_{10}$	Schedule a Stop Stop for Emergency
$R_{11}$	Retrieve Line Number
$R_{12}$	Notify Ticket Delete
$R_{13}$	Grant Access
$R_{14}$	Print Guest Ticket
$R_{15}$	Retrieve Line Number
$R_{16}$	Book Future Line Number
$R_{17}$	Book Future Line Number Initialize
$R_{18}$	Book Future Line Number Schedule a Stop Stop for Emergency
$R_{19}$	Retrieve Line Number
$R_{20}$	Update User Information
$R_{21}$	Book Future Line Number
$R_{22}$	Book Future Line Number
$R_{23}$	See Store Location
$R_{24}$	See Amount of Customers in the Store
$R_{25}$	Book Future Line Number
$R_{26}$	Book Future Line Number
$R_{27}$	See Number of Customers in the Store

Table 20: Tracability Matrix

## 3.3 Performance Requirements

## 3.4 Design Constraints

### 3.4.1 Standards compliance

The code produced should follow the requirements contained in this document. Furthermore, its comments should be clear and focused. The application shall use QR codes generated accordingly with the ISO/IEC 18004:2015 standard[1]. All dates and times shown shall comply with the ISO 8601 UTC timing standard[2].

### **3.4.2 Hardware limitations**

To use the application, the customers should have a smartphone, tablet, or desktop computer with a working display, an input device such as a keyboard, a physical or touch screen keyboard, and an active internet connection. The clerks should have a smartphone with a working display, an input device, a working camera module, and an active internet connection. The managers should have a desktop computer with a working display, input device, and an active internet connection.

### **3.4.3 Any other constraint**

The application shall use and store user data according to GDPR.

## **3.5 Software System Attributes**

### **3.5.1 Reliability**

The application should produce the same results independent of the system it is used on. For example, a customer should schedule a time visit for a store using their smartphone, tablet, or desktop computer. The application should give consistently correct results.

### **3.5.2 Availability**

The system should have 99,5% available time per month with a maximum monthly 33m 49.7s downtime. In case of upgrade or maintenance, the maintenance window will be out of business hours.

### **3.5.3 Security**

System integrity or security should be sufficient to prevent unauthorized access to application functions, preventing information loss, ensure that the application is protected from virus infection, and protecting the privacy of data entered into the system. All user data must be encrypted before being stored. Furthermore, all passwords must be hashed.

### **3.5.4 Maintainability**

The application should be developed before the COVID-19 crisis is over. Its maintainability isn't a concern since the application will be developed for this pandemic only.

### **3.5.5 Portability**

The application should be available to the vast majority of people.

## 4 Formal Analysis Using Alloy

### 4.1 Alloy Introduction

In this section is presented the Alloy representation of some critical aspects the system must present. It is worth highlighting that below only stable states are considered, in which the system may be found. As a consequence, no edge cases are treated.

In particular, the following features are modeled:

- There can't be more customers in a section than the maximum capacity of that section at any given moment.
- A booking is possible only by a registered customer.
- Every visit to the store is granted by an access title.

### 4.2 Alloy code

```
//Signatures-----

sig Store {
    sections : some Section
}

sig Section {
    maxCapacity: one Int
}{
    maxCapacity > 0
}

sig Email {}

sig Password {}

abstract sig User {
    email : one Email,
    password : one Password
}

sig Customer extends User {}

some sig Manager extends User {
    store : one Store
}

some sig Clerk extends User {
    manager : one Manager,
    store : one Store
}{
    manager.store = store
}
```

```

abstract sig AccessTitle{
    customer : lone Customer,
    sections: some Section,
    estimatedEnterTime : one Time,
    estimatedExitTime: one Time,
}{
    estimatedEnterTime.timestamp < estimatedExitTime.timestamp
}

sig Ticket extends AccessTitle{
    lineNumber : one ActualLineNumber
}

sig Booking extends AccessTitle{
    lineNumber : one BookedLineNumber
}{
    estimatedEnterTime.timestamp > lineNumber.timeSlot.start.timestamp
    estimatedEnterTime.timestamp < lineNumber.timeSlot.end.timestamp
    #customer = 1
}

sig Visit{
    accessTitle : one AccessTitle,
    enterTime : one Time,
    exitTime : lone Time
}{
    enterTime.timestamp < exitTime.timestamp
}

//UTC standard format: number of seconds from 1970/01/01 00:00:00
sig Time {
    timestamp : one Int
}{
    timestamp>=0
}

sig TimeSlot {
    start : one Time,
    end : one Time
}{
    start.timestamp < end.timestamp
}

abstract sig LineNumber {
    timeSlot : one TimeSlot,
    number : one Int
}{
    number >= 0
}

```

```

sig ActualLineNumber extends LineNumber{}

sig BookedLineNumber extends LineNumber{}

//Facts-----

fact credentialInUsers {
  all mail : Email | mail in User.email
  all pw : Password | pw in User.password
  no mail : Email, disj user1, user2 : User | mail in user1.email && mail
    ↪ in user2.email
  no pw : Password, disj user1, user2 : User | pw in user1.password && pw
    ↪ in user2.password
}

fact everySectionInAStore {
  all section : Section | section in Store.sections
  no section : Section, disj store1, store2 : Store | section in store1.
    ↪ sections && section in store2.sections
}

fact everyLineNumberInAnAccessTitle {
  all ln : LineNumber | ln in (Ticket.lineNumber + Booking.lineNumber)
  no ln: LineNumber, disj t1, t2 : Ticket | ln in t1.lineNumber && ln in
    ↪ t2.lineNumber
  no ln: LineNumber, disj t1, t2 : Booking | ln in t1.lineNumber && ln in
    ↪ t2.lineNumber
  all disj ln1, ln2 : LineNumber | ln1.number = ln2.number => ln1.timeSlot
    ↪ != ln2.timeSlot
}

fact AVisitForEachAccessTitle {
  no at: AccessTitle, disj visit1, visit2 : Visit | at in visit1.
    ↪ accessTitle && at in visit2.accessTitle
}

fact bookOnlyAStore {
  all accessTitle : AccessTitle | one store : Store | accessTitle.
    ↪ sections in store.sections
}

fact consistentQueue {
  all disj at1, at2 : AccessTitle |
    ((at1<:Ticket).lineNumber.number < (at2<:Ticket).lineNumber.number
    ↪ && (at1<:Ticket).lineNumber.timeSlot = (at2<:Ticket).
    ↪ lineNumber.timeSlot) =>
    at1.estimatedEnterTime.timestamp =< at2.estimatedEnterTime.
    ↪ timestamp

  all disj at1, at2 : AccessTitle |

```

```

        ((at1<:Booking).lineNumber.number < (at2<:Booking).lineNumber.number
        ↪ && (at1<:Booking).lineNumber.timeSlot = (at2<:Booking).
        ↪ lineNumber.timeSlot) =>
        at1.estimatedEnterTime.timestamp =< at2.estimatedEnterTime.
        ↪ timestamp
    }

fact noOverBooking {
    all time : Time, section : Section |
        #{at : AccessTitle | at in
            {visit : Visit |
                ((visit.enterTime.timestamp =< time.timestamp && visit.
                ↪ exitTime.timestamp>= time.timestamp) ||
                (visit.enterTime.timestamp =< time.timestamp && visit.
                ↪ accessTitle.estimatedExitTime.timestamp>= time.
                ↪ timestamp) ||
                (visit.accessTitle.estimatedEnterTime.timestamp =< time.
                ↪ timestamp && visit.accessTitle.estimatedExitTime.
                ↪ timestamp>= time.timestamp) )&&
                section in visit.accessTitle.sections
            }.accessTitle
        } =< section.maxCapacity
    }

fact equallyLongTimeSlots{
    all ts1, ts2 : TimeSlot | ts1.end-ts1.start = ts2.end-ts2.start
}

//Assertions-----

assert noMoreVisitsThanAccessTitle {
    #Visit =< #AccessTitle
}
check noMoreVisitsThanAccessTitle

assert atLeastACustomerForHavingABooking {
    #Customer = 0 => #Booking=0
}
check atLeastACustomerForHavingABooking

assert neverMoreCustomerThanMaxCapacity {
    all time : Time, section : Section |
        #{c : Customer | c in
            {visit : Visit |
                ((visit.enterTime.timestamp =< time.timestamp && visit.
                ↪ exitTime.timestamp>= time.timestamp) ||
                (visit.enterTime.timestamp =< time.timestamp && visit.
                ↪ accessTitle.estimatedExitTime.timestamp>= time.
                ↪ timestamp) ||

```

```

        (visit.accessTitle.estimatedEnterTime.timestamp =< time.
          ↳ timestamp && visit.accessTitle.estimatedExitTime.
          ↳ timestamp>= time.timestamp) )&&
        section in visit.accessTitle.sections
      }.accessTitle.customer
    } =< section.maxCapacity
  }
check neverMoreCustomerThanMaxCapacity

//Worlds-----

//Normal Condition
pred world1{
  #Store=2
  #Section=3
  #User=5
  #Customer=3
  #AccessTitle=5
  #Visit=3
  #TimeSlot=5
}

//No Customers
pred world2{
  #Customer=0
  #Ticket=1
  #TimeSlot=1
}

//Saturated Store
pred world3{
  #Store=1
  #Section=1
  Section.maxCapacity=3
  #Visit=3
  no cus : Customer | cus not in AccessTitle.customer
  #TimeSlot=1
  #Time = 2
}

run world1 for 10
run world2 for 10
run world3 for 10

```

### 4.3 World generation

In the following paragraph are displayed examples of worlds generated from the predicates featured in the Alloy implementation.



World 1 describes the model in normal conditions, its only purpose is to show an instance of the model without checking any particular property.

World 2 describes the model when there are no registered customers, so that there can not be bookings and all the tickets are made as guest going to the clerk in the store.



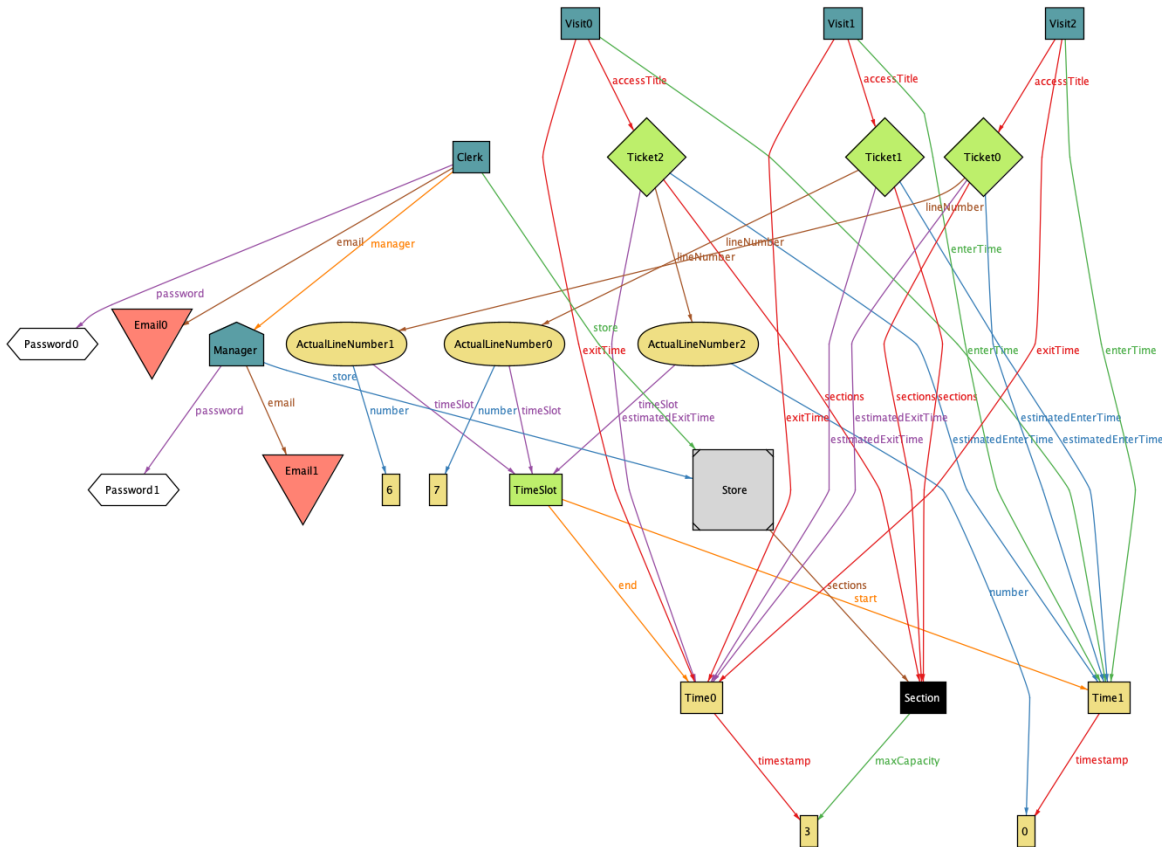


Figure 34: World 3

World 3 describes the model when there is only one section and it has the same number of customers as the maximum capacity.

#### 4.4 Alloy Analyzer results

6 commands were executed.

The results are:

- #1: No counterexample found. noMoreVisitsThanAccessTitle may be valid.
- #2: No counterexample found. atLeastACustomerForHavingABooking may be valid.
- #3: No counterexample found. neverMoreCustomerThanMaxCapacity may be valid.
- #4: Instance found.world1 is consistent.
- #5: Instance found.world2 is consistent.
- #6: Instance found.world3 is consistent.

## 5 Effort Spent

Date:	Person:	Part:	Time (in hours):	Description:
10/10/2020	Roberto Buratti	Alloy implementation	1	First attempt to implementing alloy model
11/10/2020	Roberto Buratti	Alloy implementation	1	First attempt to implementing alloy model
17/10/2020	Roberto Buratti	Alloy implementation	0.75	First attempt to implementing alloy model
18/10/2020	Ozan Incesulu	General Structure	0.75	Imported and built the general document structure, switched LF -> CRLF for Windows, replaced template parts with names, year and project title
18/10/2020	Ozan Incesulu	Introduction	1.5	Start writing introduction by adding comments for draft goals, adding further subsections, writing basic definition of the system, some abbreviations, definitions, acronyms and references
18/10/2020	Roberto Buratti	Use-case	2	Sequence diagrams
24/10/2020	Ozan Incesulu	Document Structure	1.5	Write the document structure of the introduction, provide some comments and assumptions regarding how other parts of the document shall be structured.
24/10/2020	Roberto Buratti	Use-case	2	Sequence diagrams
25/10/2020	Roberto Buratti	Use-case	2	Sequence diagrams
26/10/2020	Ozan Incesulu	Scope	1.25	Write the Scope section, by defining different users of the system and define different phenomena with the categories they belong. Also add additional definitions.
26/10/2020	Aydin Javadov	Scope	1	Extend the goal test to provide details about system function
29/10/2020	Ozan Incesulu	Introduction	0.25	Add the clerk role to the system instead of using door automation
30/10/2020	Roberto Buratti	Use-case	2	Sequence diagrams
31/10/2020	Ozan Incesulu	Domain Assumptions	1	Write domain assumptions for the system, considering different users and phenomena
31/10/2020	Ozan Incesulu	Requirements	1.5	Write system requirements for the system based on agreed goals of the system.
01/11/2020	Roberto Buratti	Use-case	1	Use case tables
03/11/2020	Hrvoje Hrvoj	Overview	2	Write product functions
06/11/2020	Ozan Incesulu	Goals	1	Write system goals, merge changes from previous team member, some extra housekeeping tasks.
06/11/2020	Roberto Buratti	Use-case	1	Use case tables
08/11/2020	Roberto Buratti	Use-case	0.75	Use case tables
09/11/2020	Roberto Buratti	Use-case	1.25	Use case diagrams
12/11/2020	Hrvoje Hrvoj	Overview	2	Write user characteristics

14/11/2020	Ozan Incesulu	Use-case	1.5	Export diagrams to images, try to align everything, fix grammar and text
14/11/2020	Hrvoje Hrvoj	Overview	2.5	Write assumptions,dependencies and constraints
14/11/2020	Roberto Buratti	Alloy implementation	1.25	Fixing the previous alloy model
15/11/2020	Roberto Buratti	Alloy implementation	1.5	Fixing the previous alloy model
15/11/2020	Ozan Incesulu	Product Perspective	3	Create state diagrams, write scenarios and explanation
17/11/2020	Hrvoje Hrvoj	Requirements	4	Write design constraints
21/11/2020	Roberto Buratti	Alloy implementation	1.5	Completing alloy model
22/11/2020	Hrvoje Hrvoj	Requirements	4	Write software system attributes
22/11/2020	Ozan Incesulu	Product Perspective	2	Create class diagram for the system.
22/11/2020	Roberto Buratti	Alloy implementation	1.5	Completing alloy model
22/11/2020	Roberto Buratti	Alloy implementation	1.5	Adding world generation
23/11/2020	Ozan Incesulu	Product Perspective	1.5	Add description section, add line number difference to class diagram
23/11/2020	Hrvoje Hrvoj	Requirements	4	Write external interface requirements
28/11/2020	Ozan Incesulu	Functional Requirements	1.5	Add traceability matrix and summary table
05/12/2020	Roberto Buratti	Alloy implementation	1	Exported alloy model into latex, and added description
20/12/2020	Ozan Incesulu	Whole Document	1.5	Implement version history, write scope sections, fix references

## References

- [1] Qr code bar code symbology specification. Standard ISO/IEC 18004:2015, International Organization for Standardization, 2015.
- [2] Date and time — representations for information interchange. Standard ISO 8601-1:2019, International Organization for Standardization, 2019.