



POLITECNICO

MILANO 1863

RASD

Requirements Analysis and Specification Document

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1 INTRODUCTION

1.1 Purpose

The purpose of the project CLup (Customer Line-up) is to develop a digital system of lining up that saves people from having to stand outside of stores for hours, avoids crowds inside the store, and, more in general, allows to regulate the influx of people in the stores.

The idea is to create a digital version of the traditional mechanism of lining up that is easy to use by everyone. In this way, the system would help to deal with the strict rules imposed by the government due to the global pandemic.

The system should give customers the possibility to line up from their home and approach to store only when their number is close to being called. This mechanism should avoid the situation in which the customers wait for their shift in the proximity of the store that is not an acceptable scenario in a lockdown situation.

G.1	Allows to regulate the influx of people that enter the building.
G.2	Avoids that customers must line up and wait outside of stores for hours.
G.3	Guarantees that everyone can shop, even people who do not have access to the required technology.
G.4	Provides smart managing of lining up and booking with a digital system.

1.2 Scope

The software should represent a digital alternative to the situation in which people retrieve a physical number that gives their position in the queue when they want to enter a store.

CLup should provide three main features:

- **Lining up:** allows customers to line up from their homes and avoids crowds outside the stores. It should include a notification system that alerts people when their number is close to being called. These alerts should consider the time customers need to get to the shop from the place they currently are and should be based on precise estimation of the waiting time. Moreover, CLup must provide effective fallback options for people who do not have access to the required technology.
- **Booking:** allows customers to book a visit to the supermarket. Since the time that it takes to visit a supermarket is not uniform, the system should give to user the possibility to specify an estimation of the duration of the visit. Alternatively, it might infer this information analysing the previous visits, if any.
- **Suggestion:** suggests different time slots for visiting the store (also on different days) to deal better with the restriction in the number of people inside the store. Alternatively, the system

should propose other available supermarkets to the customers and alerts them in case a new time slot becomes available (e.g. after the deleting of a booking by another customer).

The customer that wants to use the service must be registered. Thanks to this, the system would be able to track the lining up, the booking, and the duration of the previous visits and use this information to manage better the influx of people and estimates with acceptable accuracy the waiting time.

1.2.1 World Phenomena

W.1	Limitation on the number of entrances into buildings.
W.2	Distance of at least one meter between people.
W.3	Prohibition of gathering and long lines near the shops.
W.4	The required technology is not accessible to everyone.
W.5	Variable visit time inside the shops.

1.2.2 Shared Phenomena

S.1	Regulation of the influx of people in the shop.
S.2	Management of the lines outside of stores.
S.3	Line up at the store from a smartphone.
S.4	Monitoring of the entrances by store managers.
S.5	Estimation of the waiting time.
S.6	Notification that alerts customers when their shift will begin shortly.
S.7	Line up for people that do not have access to the required technology.
S.8	Book a visit to the supermarket.
S.9	Estimation of visit time inside the shops.
S.10	Suggestion of different stores (also of different chains).
S.11	Suggestion of different time slots to visit the store.
S.12	Periodic notification of available time slots in a day/time range.

1.3 Definitions, Acronyms, Abbreviations

1.3.1 Definitions

Time slot	Period or day that can be chosen for a booking by the customers.
Store data	Data about the store like the number of people allowed, opening and closing times, address, name, and photo.
Reservation	A word that might indicate either a booking or a lining up in a specific store.
Active reservation	Lining up or booking that is not yet expired. It means that the reservation has been taken but customers still have to wait for their shift.
Store manager	Manager, cashier, or generic employee of a store.
Available shop	A shop that is registered into the system.

1.3.2 Acronyms

CLup	Customer Line-up
RASD	Requirements Analysis and Specification Document
SSL	Secure Sockets Layer
TLS	Transport Layer Security
UI	User interface

1.3.3 Abbreviations

W.n	World phenomena n-th
S.n	Shared phenomena n-th
G.n	Goal n-th
R.n	Requirement n-th
U.n	Use cases n-th

1.4 Revision history

DATE	DESCRIPTION
31/10/2020	First version and goals definition.
07/11/2020	World and shared phenomena definition.
25/11/2020	Mock-ups, textual descriptions, definitions, acronyms, and abbreviations.
29/11/2020	Mapping between goals, requirements, and domain assumptions. General improvements.
02/12/2020	Adding Product Functions and Product Perspective descriptions.
07/12/2020	Adding sequence diagrams and their descriptions.
13/12/2020	Performance Requirements, Design Constraints, and Software System Attributes.
16/12/2020	Use cases mapping.
18/12/2020	Alloy integration.
22/12/2020	Scenarios and use cases improvements. Integration of the last versions of diagrams.
23/12/2020	Final corrections and improvements.
09/01/2021	Small changes on requirements and mockups.
07/02/2021	Small changes on requirements definition and on Sign Up use case.

1.5 Reference Documents

- *Requirement Engineering and Design Project: goal, schedule, and rules*
- *I&T assignment goal, schedule, and rules*
- Slides of the course *Software Engineering 2*

1.6 Document Structure

The document is composed of six chapters. They are the following:

- **Chapter 1:** provides an introduction to the purposes and the whole scenario of the software. First, it includes the general description of the system and the goals. Then, there is a sufficiently detailed specification of the main features that the system should provide and the analysis of the world and shared phenomena. Lastly, it includes the list of abbreviations,

acronyms, and definitions used in the document, the revision history, and the reference documents.

- **Chapter 2:** specifies the most relevant functions of the system to be and provides its representation with a Class Diagram and some Statecharts. Lastly, in this chapter, there is the clarification of the different users of the system, the list of the domain assumptions, and some examples of possible scenarios.
- **Chapter 3:** shows a high-level description of the interfaces of the system and specifies the functional requirements. Here are present also the Use Cases Diagrams, the Sequence Diagrams, and the mapping between requirements, domain assumptions, and use cases.
- **Chapter 4:** includes the metamodel generated with Alloy and the code used for this scope. Also, it is present a description of the main objectives of this analysis.
- **Chapter 5:** shows the amount of time that each member has spent to produce the document.
- **Chapter 6:** specifies the reference documents and online resources used during the production of this document.

2 OVERALL DESCRIPTION

2.1 Product perspective

CLup helps to manage the influx of people both inside and outside the stores avoiding crowds. It represents the digital counterpart of the traditional mechanism of lining up that is not suitable in a lockdown situation.

In the following, a summary of the problem is presented.

- The customers who want to avoid standing outside of stores for hours require a digital lining up using the CLup platform. They specify the store that they want to visit and select the option for lining up. Furthermore, they indicate the expected duration of the visit, if it is not automatically inferred from the previous visits by the system. Then, the system provides an estimation of the waiting time and shows this last one and the other active reservations in a specific section of the software. According to the time that the customers need to get to the shop from the place they currently are and with the waiting estimation, the system sends a notification when the customers' number is close to being called. Lastly, the customers can delete a lining up at any time and they can have only one active lining up at a time for each store.
- The customers can also book a visit to the supermarket. As seen for the lining up, even for the booking they specify the store that they want to visit and the expected duration of the visit, if it is not automatically inferred. Moreover, in this case, they need to indicate the time slots when they want to visit the store. The system shows this and the other active reservations in a specific section of the software. Lastly, the customers can delete a booking at any time, and they can have only one active booking at a time for each store.
- If the desired shop is not available in the selected time slot for any reason, the system gives the customers some suggestions about different time slots or different stores. Moreover, the system can alert customers when a new time slot becomes available.
- For each reservation, CLup generates a QR code that the customers must scan at the entrance and exit of the shop. The system gives the possibility to print the QR code too.
- People who do not have access to the required technology are also allowed to line up at the store. The store managers help them and give them a printout of the QR code and the estimated waiting time.
- The store managers own a special version of CLup that has no limits on the number of reservations. This allows to manage the lining up also for people who do not have access to the required technology. They can also scan a QR code to allow customers to enter and exit the store.
- CLup requires registration to access its functions. This allows to track the duration of the previous visits and use this information to better manage the influx of people and estimates with acceptable accuracy the waiting time.

2.1.1 Scenarios

Scenario 1: Valentina is a very busy career woman. While she is working, she remembers that she must buy some basic needs. She decides to book a visit to her favourite shop choosing a time slot that is suitable concerning her working hours.

Scenario 2: Vanessa is an old woman that wants to visit her favourite supermarket near her home. However, she does not own a smartphone, so she asks her daughter Victoria for help. Victoria gets a reservation for her mother and provides her with a printout of the QR code that also includes an indication of the estimated time of the visit.

Scenario 3: Enrico is an old man that wants to buy something to dine with his children. He is not able to use a smartphone, so he asks the store manager for help. He gets a reservation for Enrico and gives him a printout of the QR code that also includes an indication of the estimated time of the visit.

Scenario 4: Paolo is an off-site student in the middle of his exam period. Like all students like him, he is very busy and considers the traditional lining up outside the stores a waste of time. Thanks to CLup he can get a reservation for the shop while he is studying, and, according to his position, receive a notification that alerts him when it is time to approach the store. In this way, he reduces the time needed to do the shopping.

Scenario 5: Gabriele is a store manager that wants to avoid crowds inside and outside his store and, at the same time, manage the lining up system in a very clever and modern way. He decides to use a digital system of booking and lining up like CLup.

Scenario 6: Martina books a visit to the shop. While she is waiting for her shift, an unexpected event changes her plans. So, she deletes her reservation with minimal effort.

Scenario 7: Veronica needs to buy a great number of things for the birthday of her sister. To avoid long waits outside the shop, she chooses to download for the first time CLup. She completes the registration process at the platform and logs in from her smartphone. She expects to spend a long time, so she tries to provide an adequate estimation when the application requires it.

Scenario 8: Gianfranco has got a reservation for the shop in the city center. According to his position, he receives a notification when his number is close to being called. When it is his shift, she shows the QR code to the store manager that scans it. The QR code is valid, so Gianfranco can enter the store. When he finishes the shopping, he pays as usual and, then, he scans again his QR code to exit the store. In this way, entrance and exit are registered by the system.

2.1.2 Class Diagram

The UML class diagram below represents a conceptual, high-level model of the software to be. Given its nature, it may model objects that will not be represented in the actual system that will be developed. Moreover, at this level, it should not include any references to methods and other low-level details that will be detailed during the design phase.

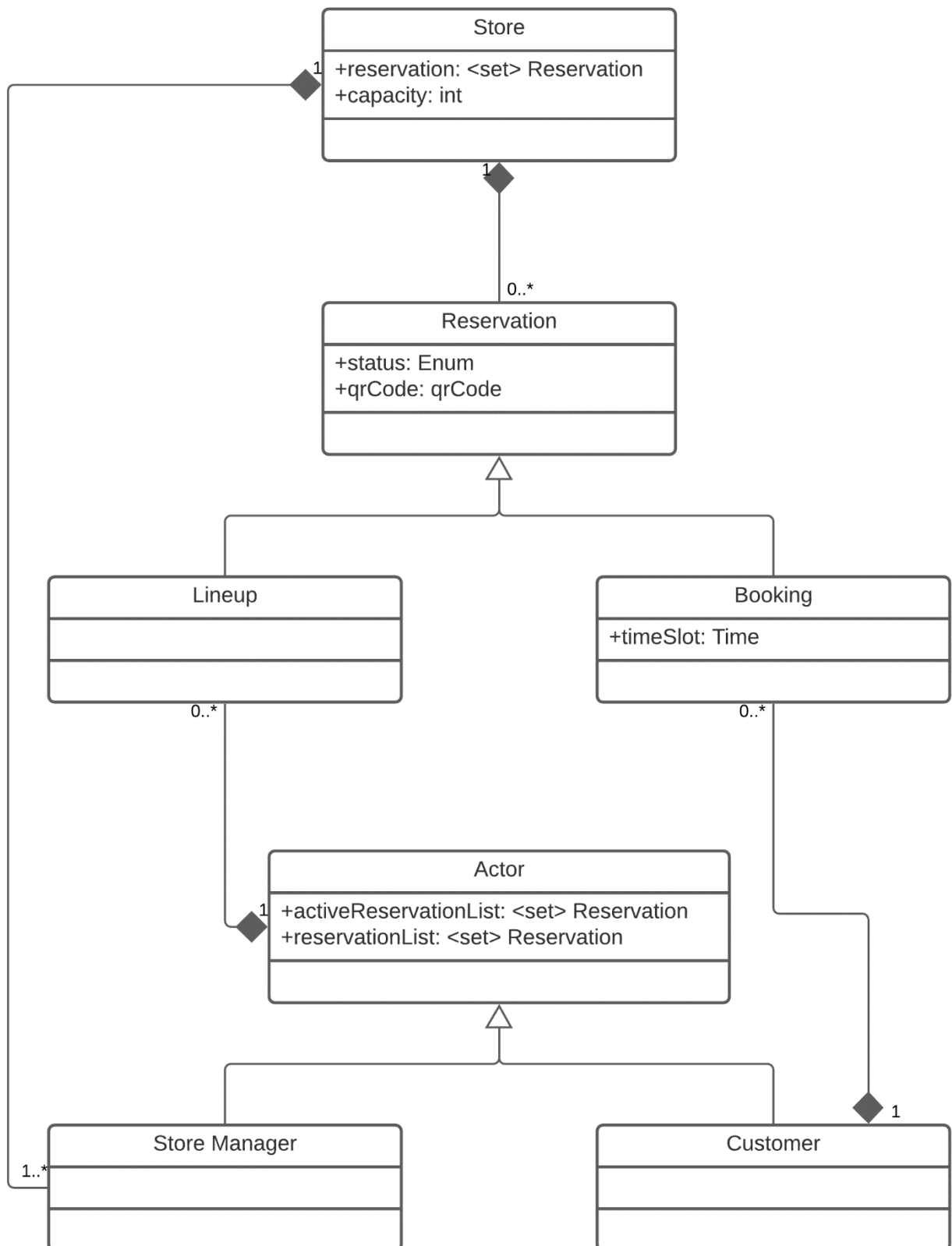


Figure 1: Class Diagram

2.1.3 State Charts

In the paragraphs below, a representation of the behavior of the main conceptual components of the system. The focus is on how these components respond to external influences and modify accordingly their states. For this purpose, some UML State Charts are proposed.

1. Reservation

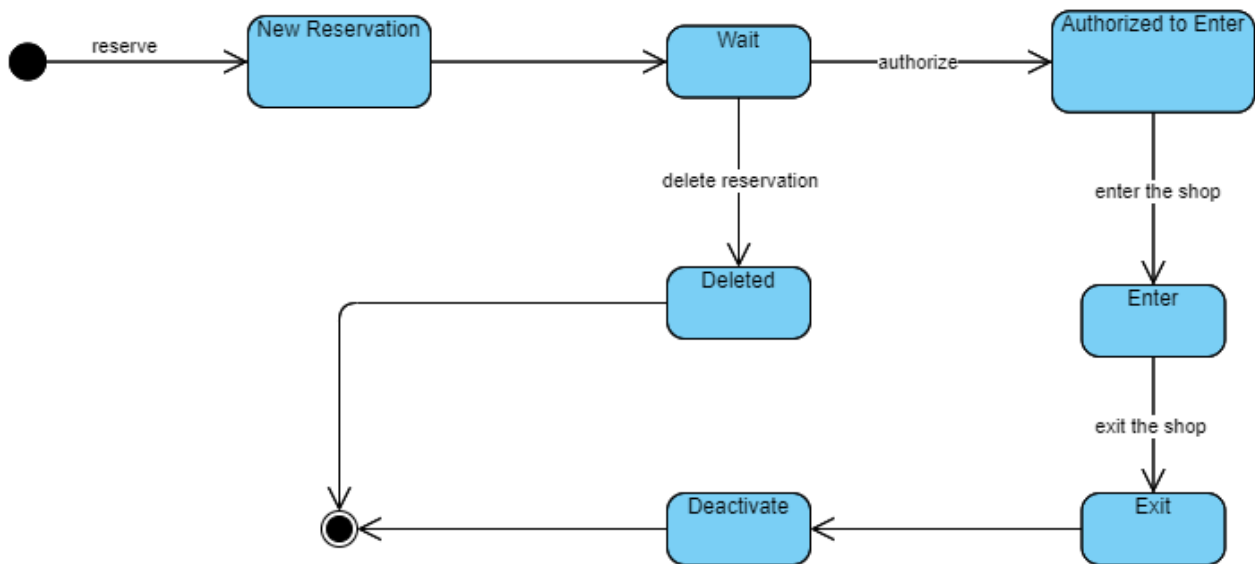
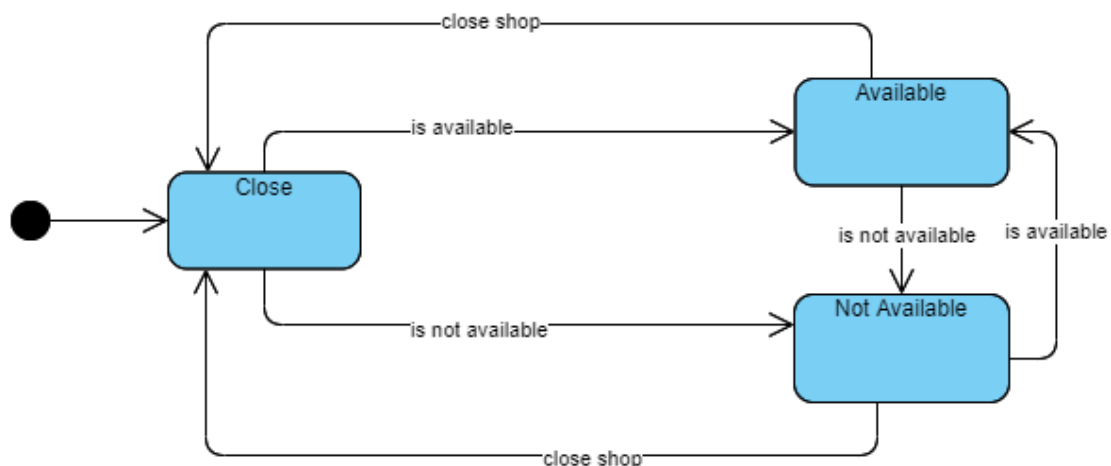


Figure 2: State Chart – Reservation

The State Chart above describes the changes over time of the entity reservation. The states are:

- New Reservation: the reservation has been successfully created;
- Wait: the reservation is active, and the customers are waiting for their turn;
- Authorized to Enter: it is the customer's turn and s/he can approach to the entrance;
- Enter: the customer is into the store;
- Exit: the customer exits the store;
- Deactivated: the reservation is expired and no longer active.

2. Shop States



The chart above describes the different shop's states. The states are:

- **Close:** the shop is closed, hence no customer can line up but can book a visit;
- **Available:** the shop is available, hence any customer can get a reservation (booking or lining up);
- **Not Available:** the shop is not available, hence no customer can get a reservation (neither booking nor lining up).

2.2 Product functions

As described above in this document, CLup offers several functions that help to manage the influx of people both inside and outside the stores. In the following, a list of the basic and advanced functions is presented.

- **Line up.** The system allows to:
 - specify the store that customers want to visit;
 - indicate the expected duration of the visit;
 - delete a lining up at any time;
 - see the list of the active lining ups;
 - see the history of the lining ups;
 - send a notification according to the time that the customers need to get to the shop from the place they currently are and with the waiting estimation.
- **Booking.** The system allows to:
 - specify the store that customers want to visit;
 - indicate the expected duration of the visit;
 - delete a booking at any time;
 - see the list of the active bookings;
 - see the history of the bookings;
 - get suggestions about different time slots or different stores if the desired shop is not available in the selected time slot for any reason. The system can also alert customers when a new time slot becomes available;
 - indicate the time slots when they want to visit the store.
- **Fallback option.** People who do not have access to the required technology can line up at the store too.

Moreover, for each reservation, the system generates a QR code that can be scanned by the store manager at the entrance and exit of the shop. This code can be also printed.

CLup requires a sign up to access its functions. This allows to track the reservations from a specific customer and the duration of the previous visits.

R.1	The system generates a single QR code to enter and exit the store for each booking or lining up.
R.2	The system allows to get a reservation for the supermarket.
R.3	The system provides customers a precise estimation of the waiting time.
R.4	The system allows customers only one booking at a time for each shop.
R.5	The system alerts the customers before their shift according to the geolocation information.
R.6	The system allows people (who do not have access to the required technology) to digitally line up directly when they are at the store.
R.7	The system suggests alternative time slots for visiting the store when the desired one is not available.
R.8	The system suggests alternative stores when the desired one is not available.
R.9	The system allows customers to insert the approximated expected duration of the visit.
R.10	The system infers customers' expected duration of the visit based on an analysis of the previous visits.
R.11	The system allows store managers to get a lining up only for their own store.
R.12	The system provides periodic notifications of available time slots in a day/time range.
R.13	The system shows the list of shops.
R.14	The system shows the available time slots for each grocery.
R.15	The system provides a QR code printing service.
R.16	The system requires a sign up/login.
R.17	The system shows active reservations.
R.18	The system shows the history of reservation of each customer.
R.19	The system allows users to delete a reservation.
R.20	The system allows customers only one lining up at a time for each shop.
R.21	The system uses information about the customer that exit the store to infer better the waiting time.
R.22	The system allows the store manager to scan the QR codes.

2.3 User characteristics

It is possible to distinguish two different types of actors who use the system:

1. **Customer:** someone who wishes to access the supermarket. S/He wants to get smart reservations, manage them, see the active ones, and explore the shop visit history. S/He cannot have more than one active reservation for the same store at a time.
2. **Store Manager:** someone who helps people who do not have access to the required technologies to get a reservation. S/He might also help in the QR code scanning operation. S/He can have an unrestricted number of active lining up at a time but can only choose her/his own shop.

2.4 Assumptions, dependencies, and constraints

2.4.1 Domain Assumptions

D.1	The customers wait until their number is close to being called to approach the store.
D.2	The time that it takes to visit the supermarket is not uniform.
D.3	The approximated expected duration of the visit indicated by the customer is reliable.
D.4	One and only one customer can enter with one QR code.
D.5	Customers can get into the store if and only if they scan a valid QR code.
D.6	All customers that want to access the store use the digital system of lining up.
D.7	The system is applied to medium and large shops ¹ .
D.8	Customers exit from the store only after they had scanned a valid QR code.
D.9	Store data are provided by the store owner and are already present in the DB.
D.10	The store manager with the digital system helps people who do not have access to the required technology to line up directly when they are at the store.
D.11	The store manager prints the QR code for people who do not have access to the required technology.

¹ Shops that have a dimension greater than 400 square meters (warehouses, laboratories and offices are not included).

Notice on assumption D.9. Since is not planned any form of control mechanism to assure the existence of a store inserted into the system, the possibility to add a new shop is forbidden for the user (both customer or store manager) and allowed only for the system administrators. It is possible to assume that a store that wants to be added to the list of available stores must send an explicit request to the system support team. This request could be sent to a dedicated email address or through a form, for instance.

3 SPECIFIC REQUIREMENTS

3.1 External Interface Requirements

3.1.1 User interfaces

The system allows store managers and customers to manage the reservations and create new ones at any time. It also uses customers' location information to alert them when their number is close to being called. Lastly, the history of the reservations and a summary of the active ones are other functions that should be provided by the system.

Given these and the other purposes described above in this document, a smartphone is a suitable device to use all necessary functionalities. In general, it satisfies all the hardware requirements that will be described below. Hence, a mobile application might be adequate to allow customers and store managers to access the system.

Let us assume that the User Interface (UI) is divided into several sections dedicated to the different main functionalities. The following images show an idea of two of these sections.

The first one describes the Home Page of the application with the list of the active reservations. On the other hand, the second one shows the Booking Page with an example of possible choices and information that should be provided to the customers.

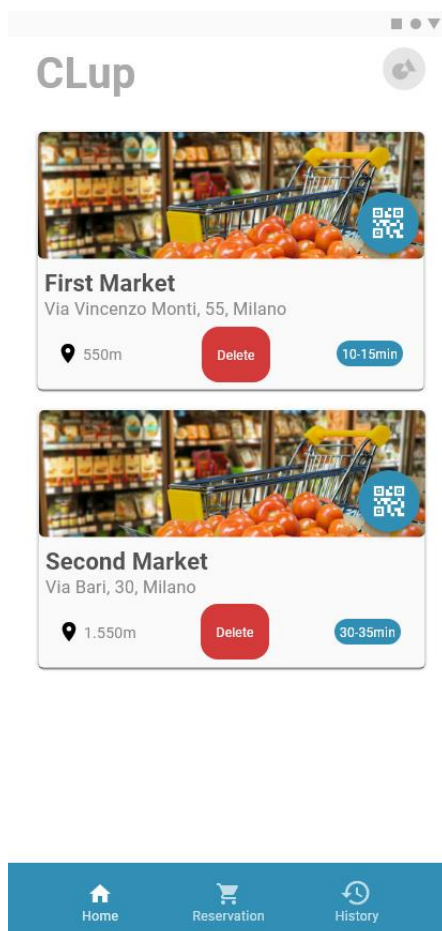


Figure 3 - Home Page mock-up

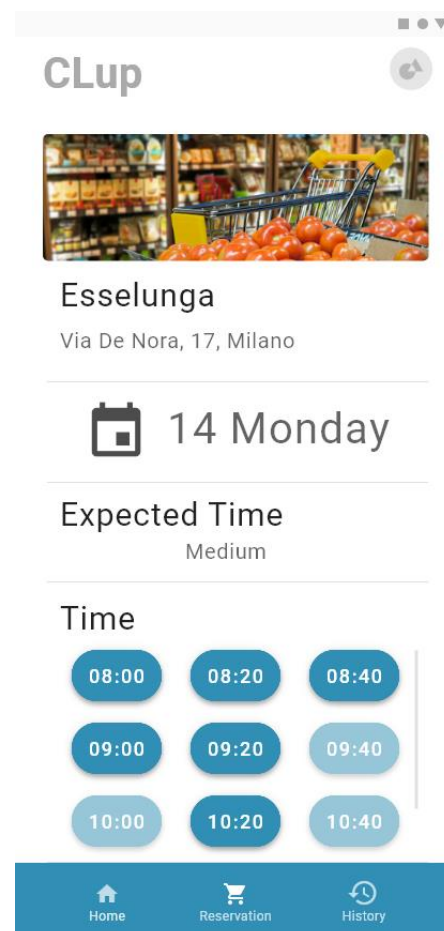


Figure 4 – Booking Page mock-up

3.1.2 Hardware interfaces

To use the system, both Customers and Store Managers must use a mobile device. Due to the communication capabilities needed, a smartphone might be a good example of a suitable device.

3.1.3 Software interfaces

The system should integrate a map service that helps to provide an estimation of the time required to arrive at the supermarket given the customer's current position. This estimation should be used to provide notifications to the customers when their shifts are close to being called.

3.1.4 Communication interfaces

The system requires a stable internet connection to work properly. This connection is used to exchange data between the mobile devices and a central database about the status of the reservations, the list of available stores, the available time slots, and other information useful for the software.

3.2 Functional Requirements

3.2.1 Use cases Diagram

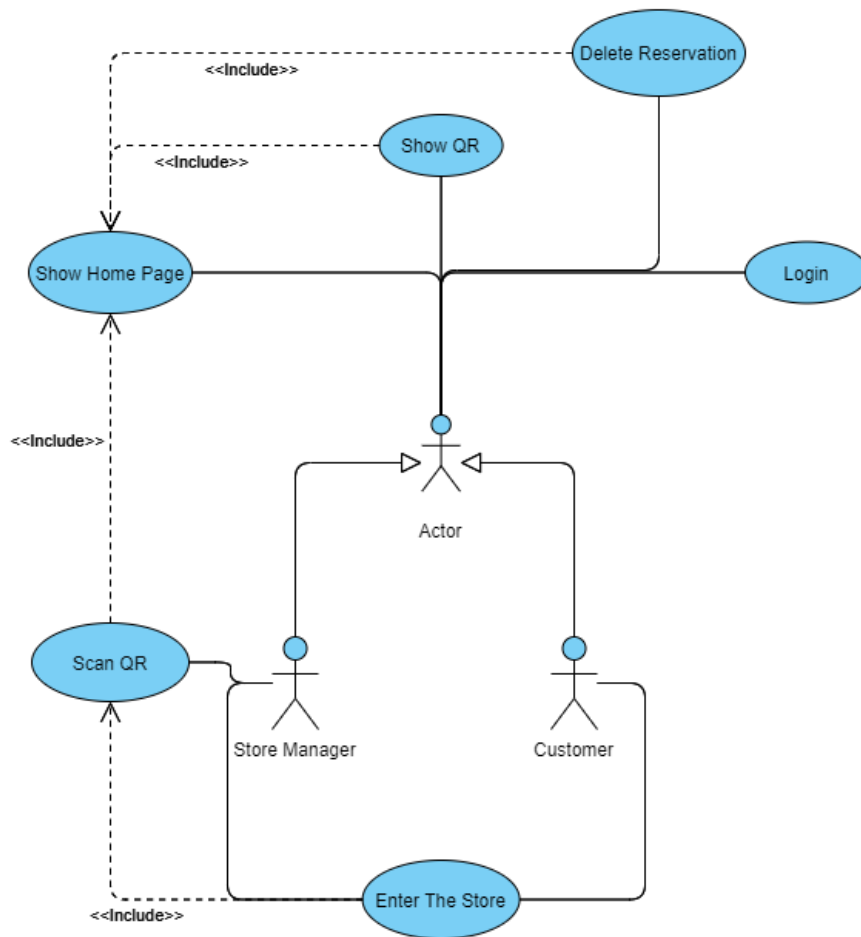


Figure 5: Use Cases Diagram (a)

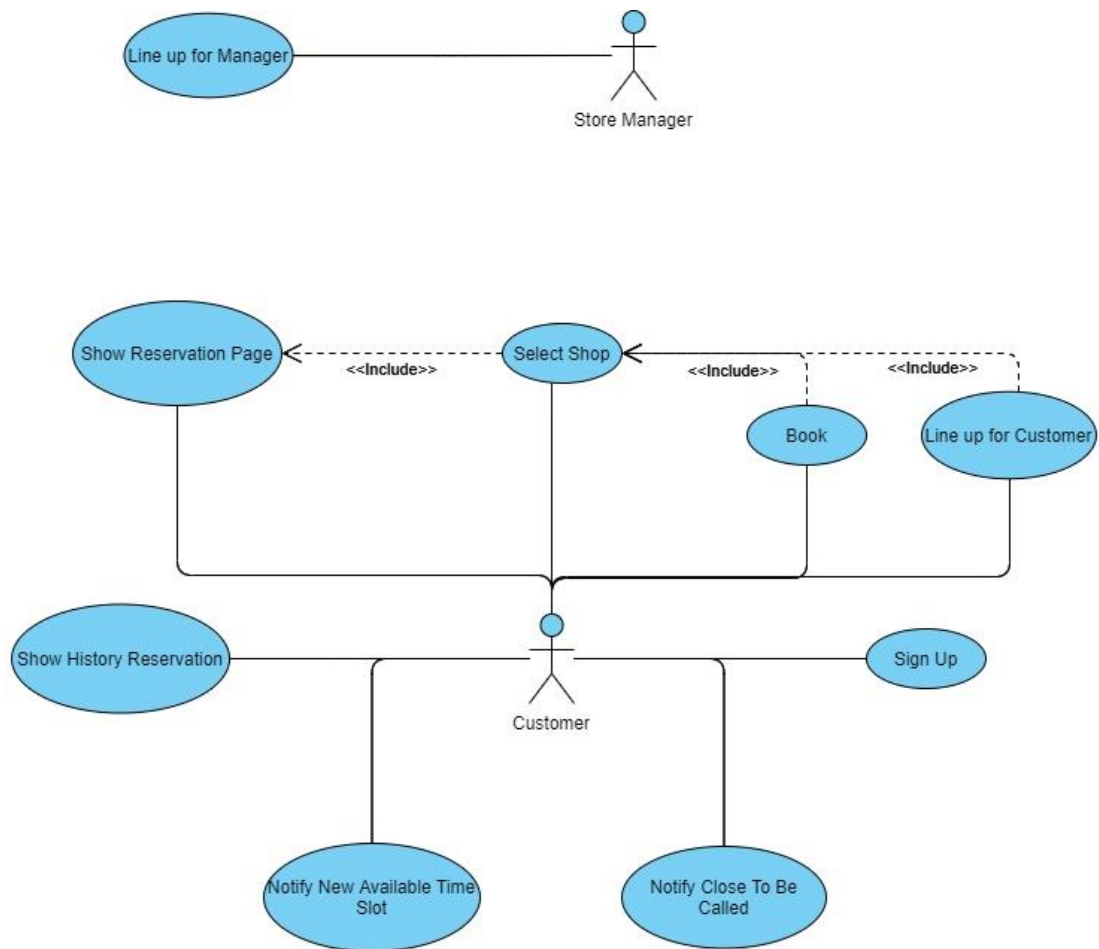
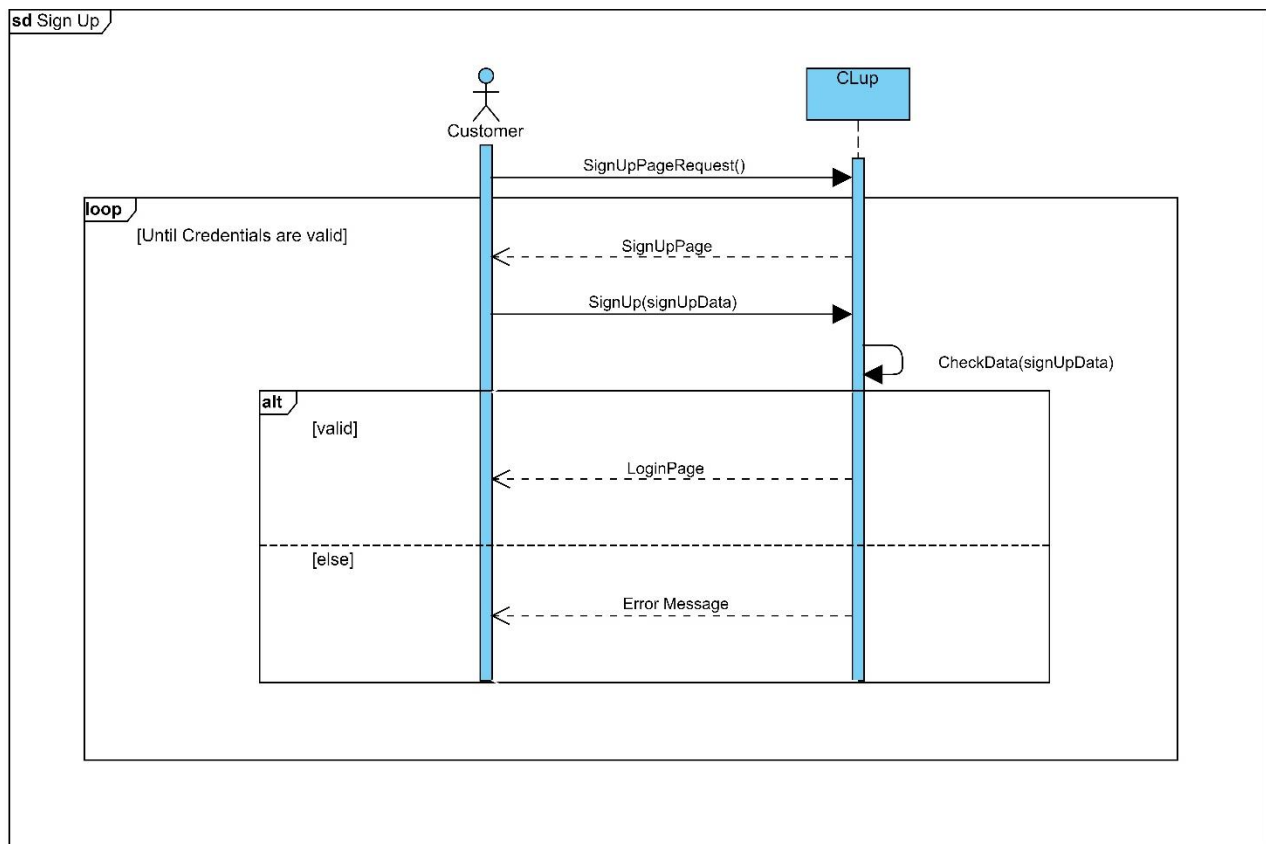


Figure 6: Use Cases Diagram (b)

3.2.2 Use cases

1. Sign Up

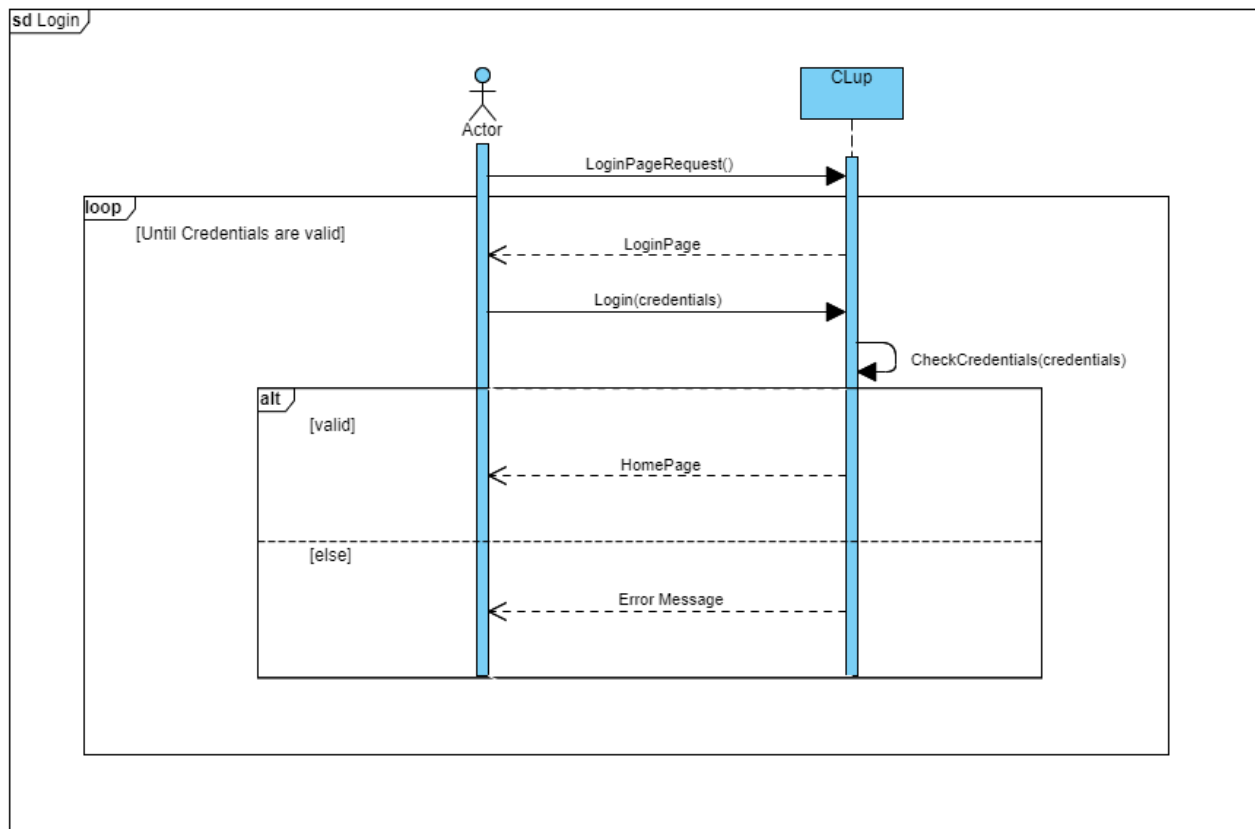


Name	Sign Up
Actors	Customer
Entry Condition	The actor is not already registered at the system
Event Flow	<ol style="list-style-type: none">1. The actor requires the Sign Up Page2. The system shows the Sign Up Page at the actor3. The actor fills all the mandatory fields4. The system checks the information5. The system saves the information6. The system shows the Login Page at the actor
Exit Condition	The actor is successfully registered to the system and the Login Page is shown
Exception	<ol style="list-style-type: none">1. Any mandatory fields are not filled2. Password and Confirm Password fields are different3. The actor is already present into the system4. Loss of internet connection

5. The actor cancels the operation before confirming

At this level, we assume that the Sign Up process requires some basic information such as name, email, and password. The password must be inserted twice in two different fields to prevent typing mistakes.

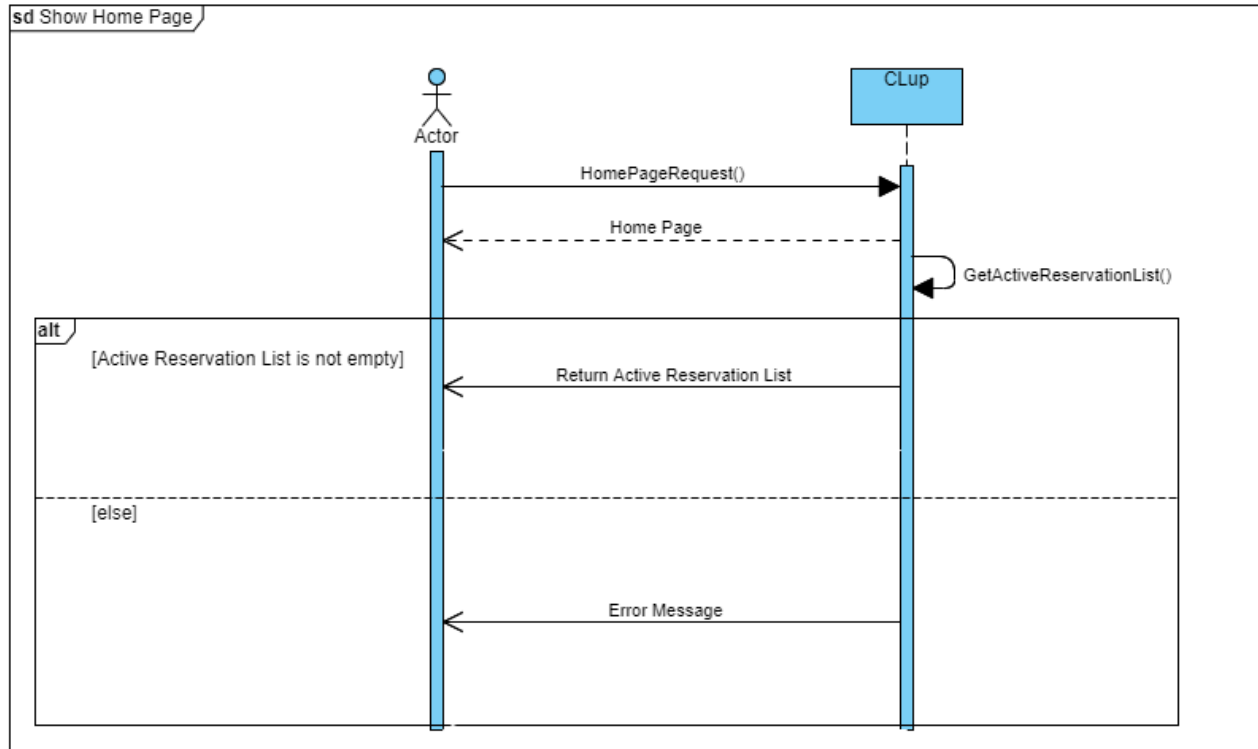
2. Login



Name	Login
Actors	Customer, Store Manager
Entry Condition	The actor is already registered at the system
Event Flow	<ol style="list-style-type: none">1. The actor requires the Login Page2. The system shows the Login Page at the actor3. The actor inserts and sends the credentials4. The system checks the information5. The system shows the Home Page at the actor
Exit Condition	The actor has successfully logged into the system and the Home Page is displayed
Exception	<ol style="list-style-type: none">1. The username is not valid2. The password is not valid

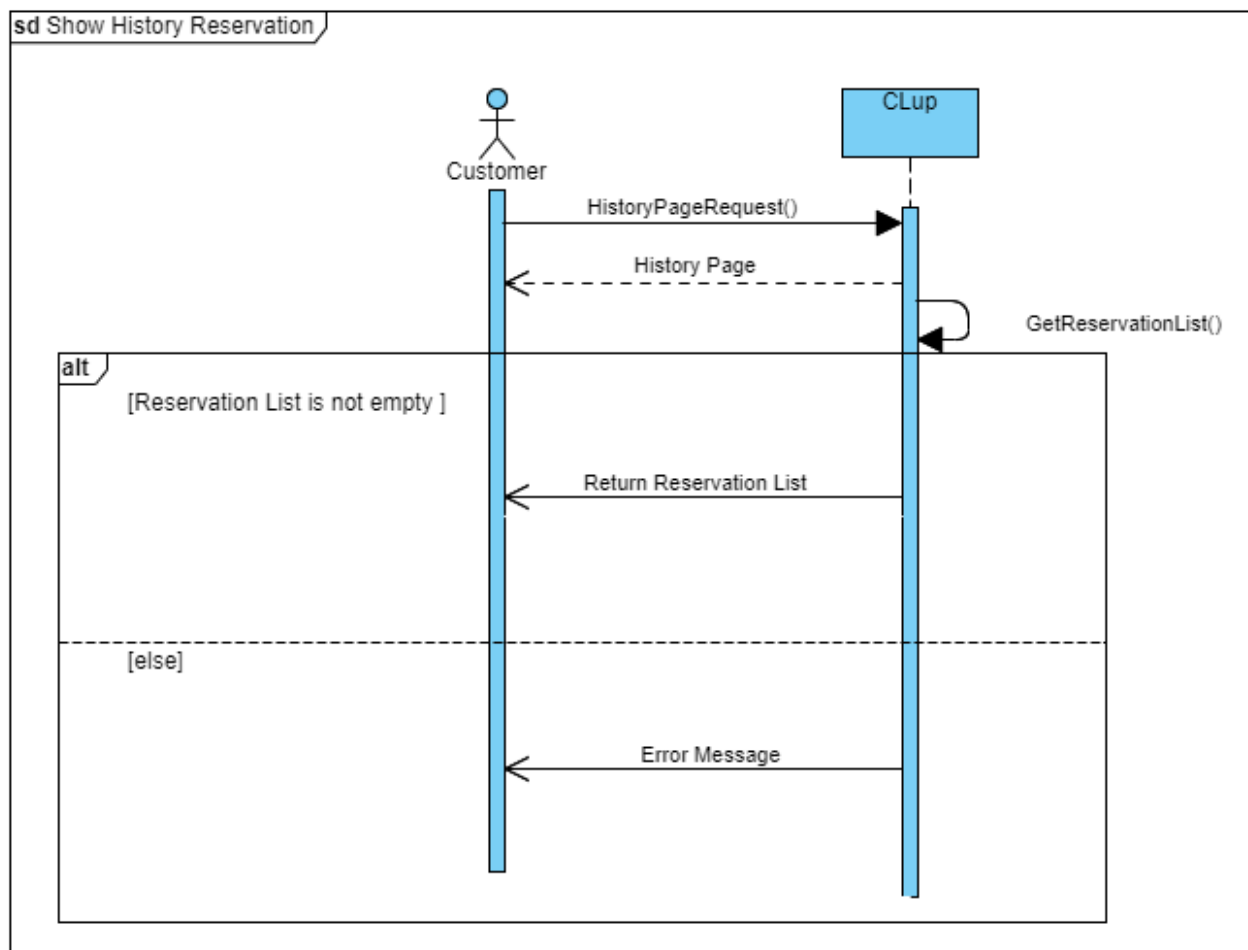
3. Loss of internet connection
4. The actor cancels the operation before confirming

3. Show Home Page



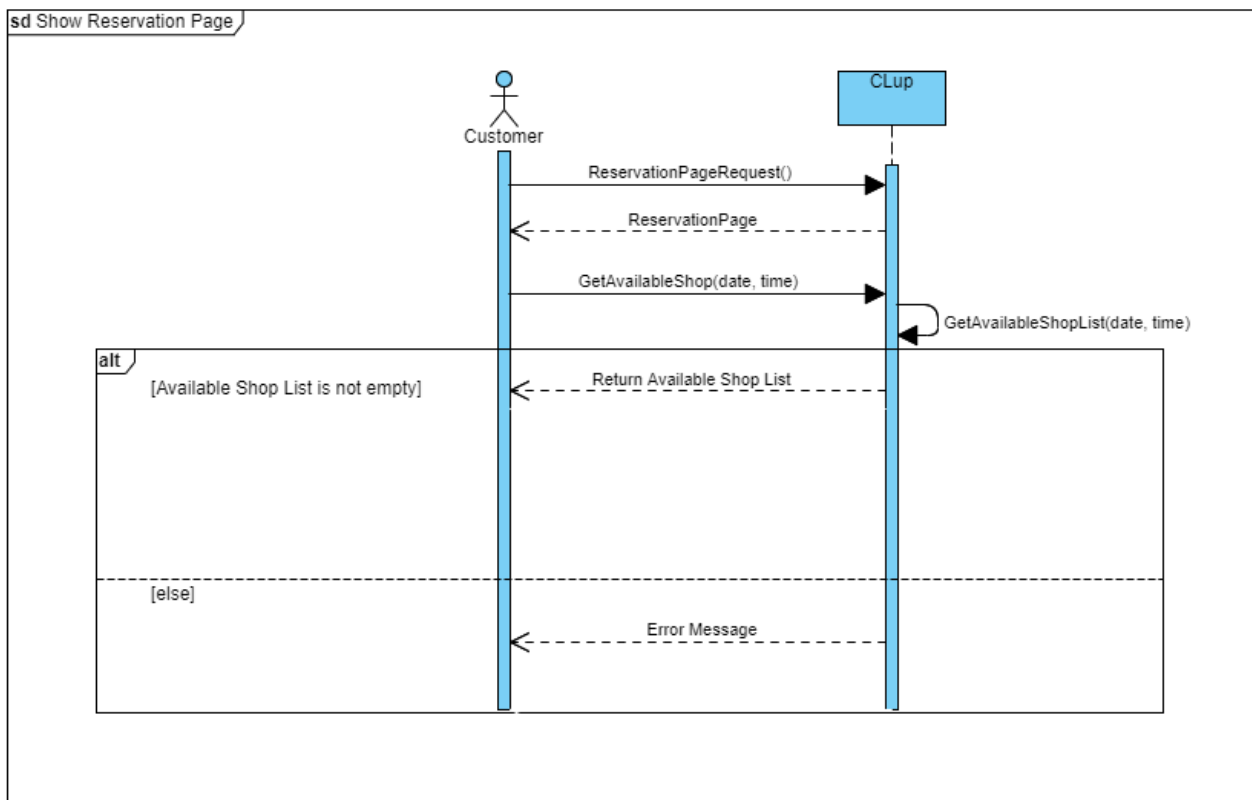
Name	Show Home Page
Actors	Customer, Store Manager
Entry Condition	The actor is already logged into the system
Event Flow	<ol style="list-style-type: none"> 1. The actor requires the Home Page 2. The system shows the Home Page at the actor 3. The system retrieves the list of active reservations 4. The system displays the list of active reservations in the Home Page
Exit Condition	The Home Page and the list of active reservations are displayed
Exception	<ol style="list-style-type: none"> 1. Loss of internet connection 2. The actor cancels the operation 3. The list of active reservations is empty

4. Show History Reservations



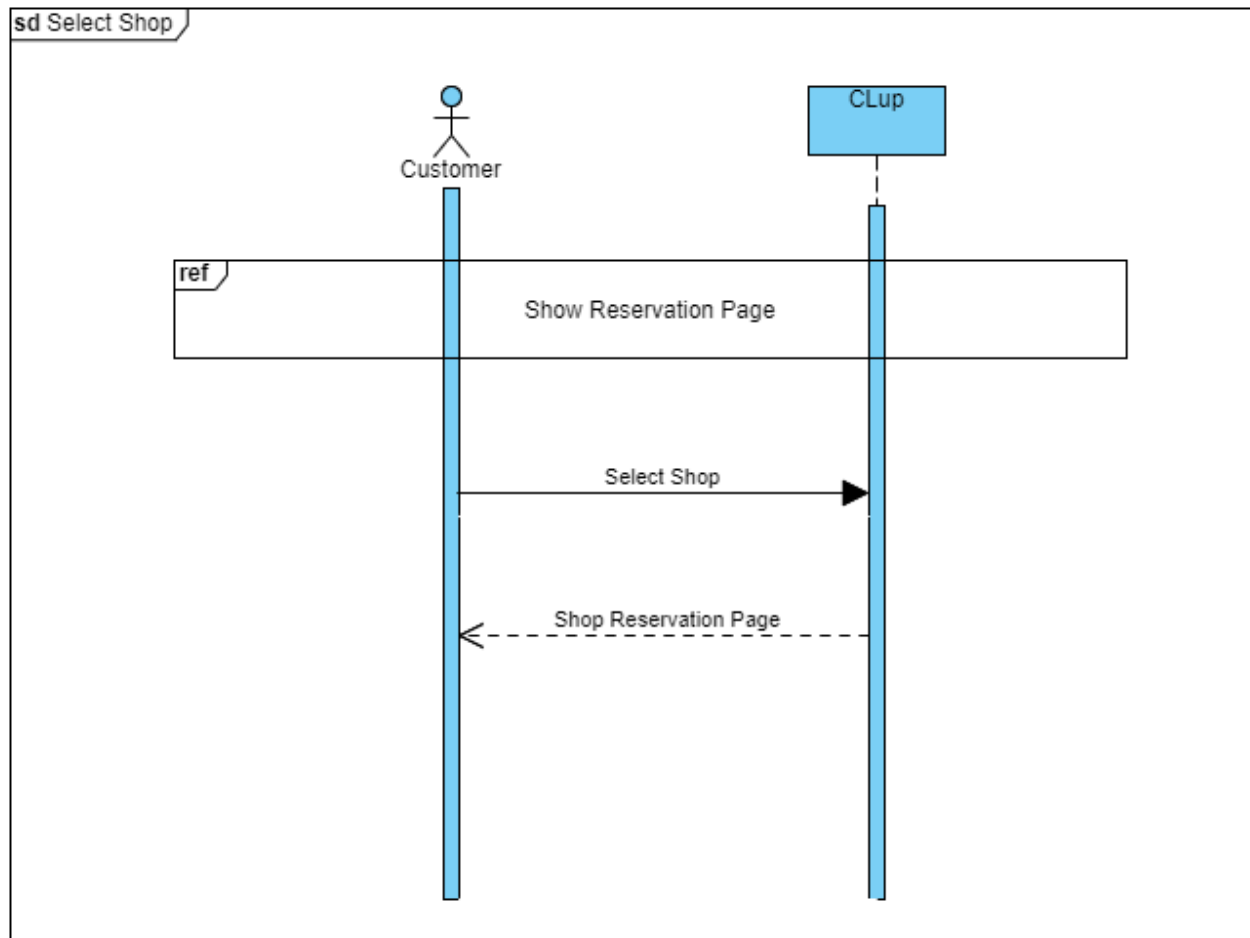
Name	Show History Reservation
Actors	Customer
Entry Condition	The actor is already logged into the system
Event Flow	<ol style="list-style-type: none"> 1. The actor requires the History Page 2. The system shows the History Page at the actor 3. The system retrieves the list of reservations 4. The system displays the list of reservations in the History Page
Exit Condition	The History Page and the list of reservations are displayed
Exception	<ol style="list-style-type: none"> 1. Loss of internet connection 2. The actor cancels the operation 3. The reservation list is empty

5. Show Reservation Page



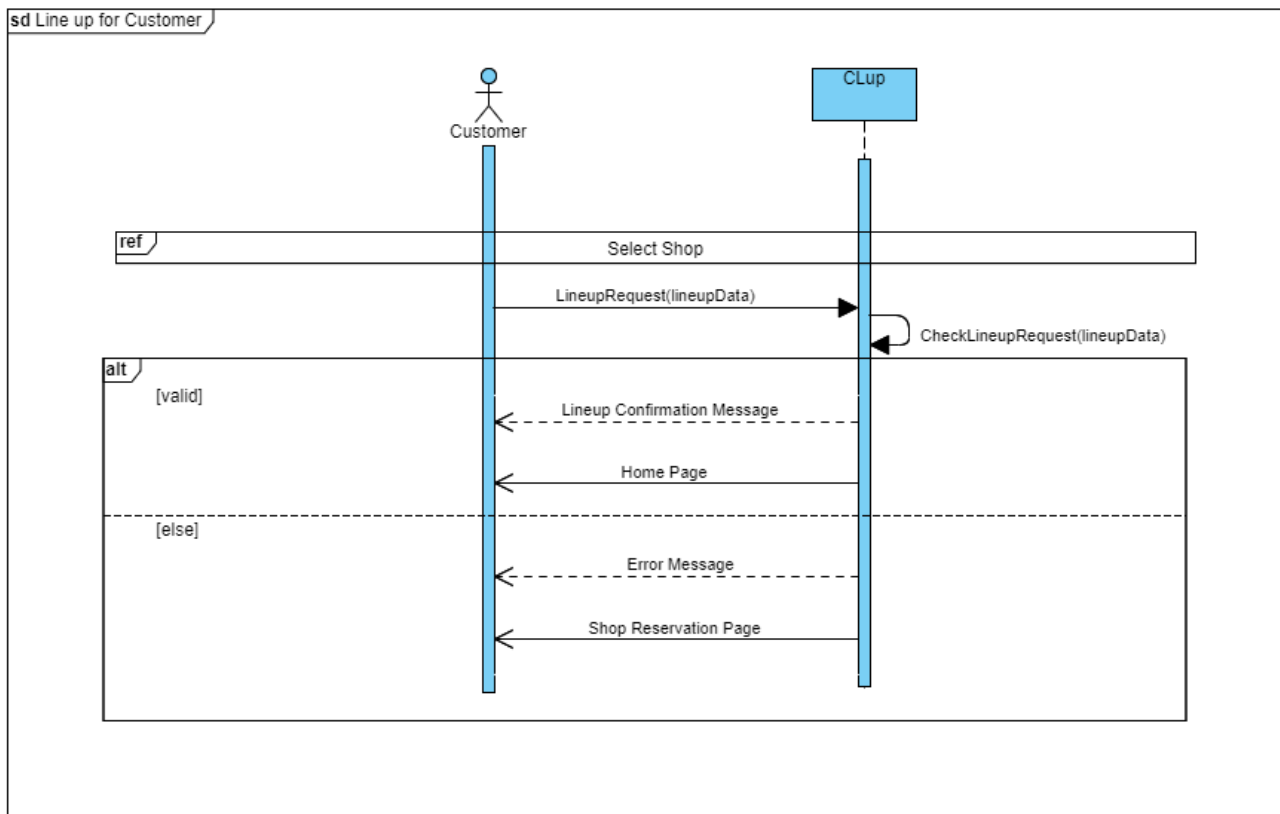
Name	Show Reservation Page
Actors	Customer
Entry Condition	The actor is already logged into the system
Event Flow	<ol style="list-style-type: none"> 1. The actor requires the Reservation Page 2. The system shows the Reservation Page at the actor 3. The actor requires the list of the current available shops 4. The system retrieves the list of available shops 5. The system displays the list of available shops in the Reservation Page
Exit Condition	The Reservation Page and the list of reservations are displayed
Exception	<ol style="list-style-type: none"> 1. Loss of internet connection 2. The actor cancels the operation 3. The list of available shops is empty

6. Select Shop



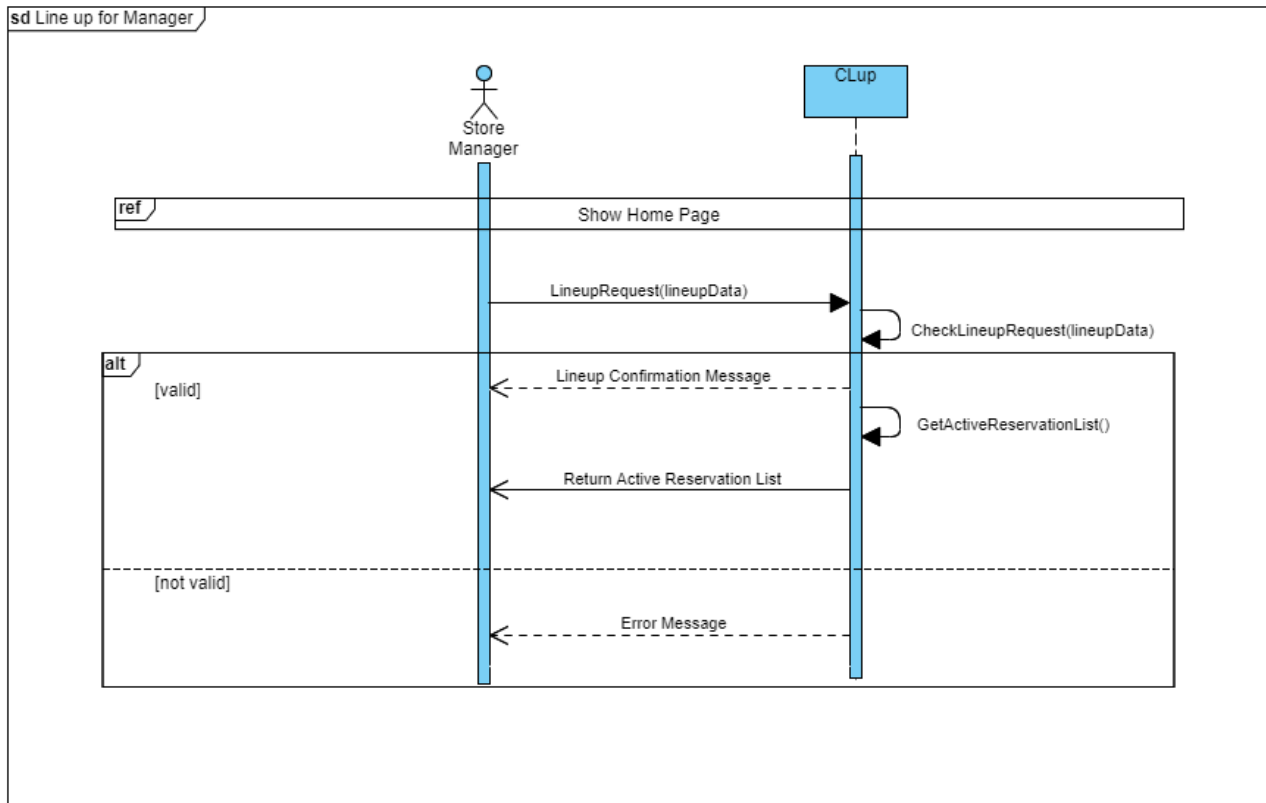
Name	Select Shop
Actors	Customer
Entry Condition	The actor is already logged into the system and the system already shows the Reservation Page
Event Flow	<ol style="list-style-type: none"> 1. The actor selects the desired shop 2. The system shows the Shop Reservation Page
Exit Condition	The Shop Reservation Page is shown
Exception	<ol style="list-style-type: none"> 1. Loss of internet connection 2. The actor cancels the operation

7. Line Up for Customer



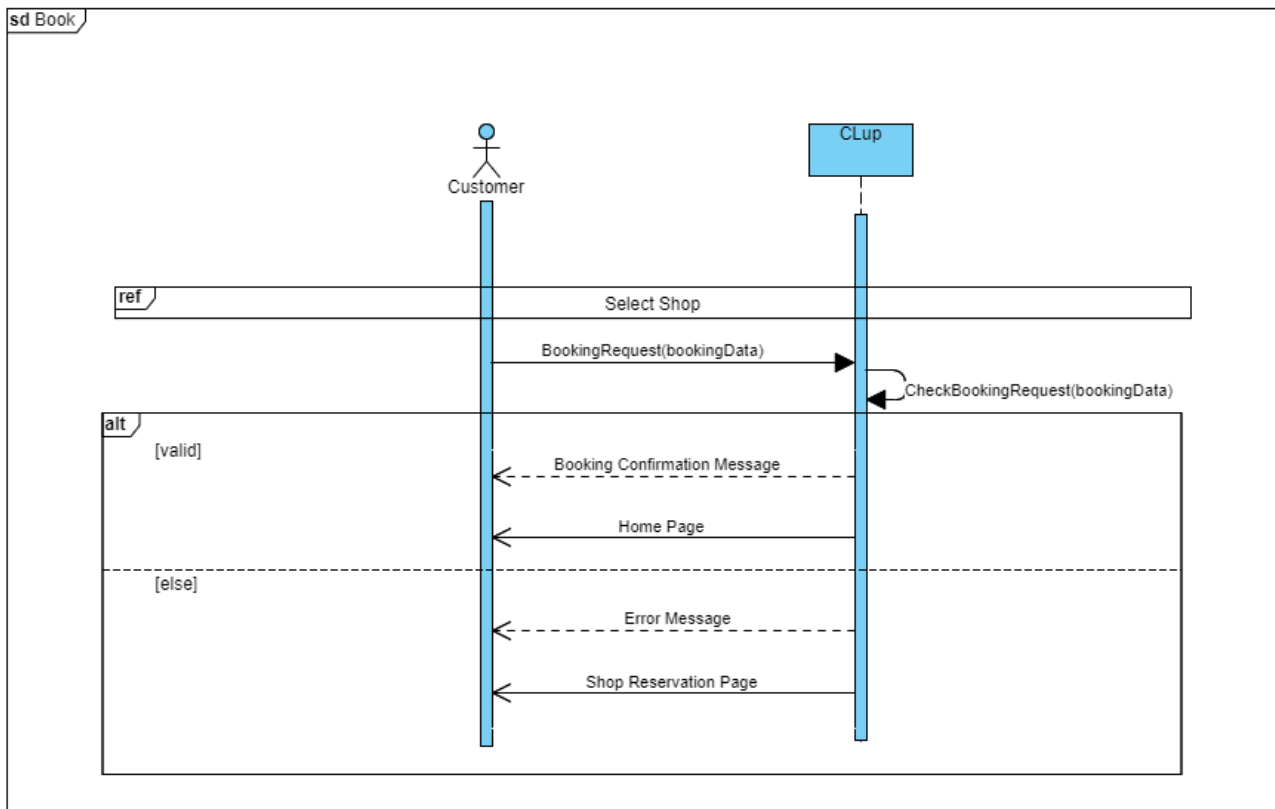
Name	Line Up for Customer
Actors	Customer
Entry Condition	The actor is already logged into the system and has already selected the shop
Event Flow	<ol style="list-style-type: none"> 1. The actor requires a Line Up 2. The system checks the request 3. The system shows a confirmation message 4. The system displays the Home Page
Exit Condition	The Home Page and the confirmation message are displayed
Exception	<ol style="list-style-type: none"> 1. Loss of internet connection 2. The actor cancels the operation 3. The store is no longer available in a specific time range 4. The actor has already another active lining up <p>If an error occurs, the system shows the Shop Reservation Page again to allow a new attempt.</p>

8. Line Up for Manager



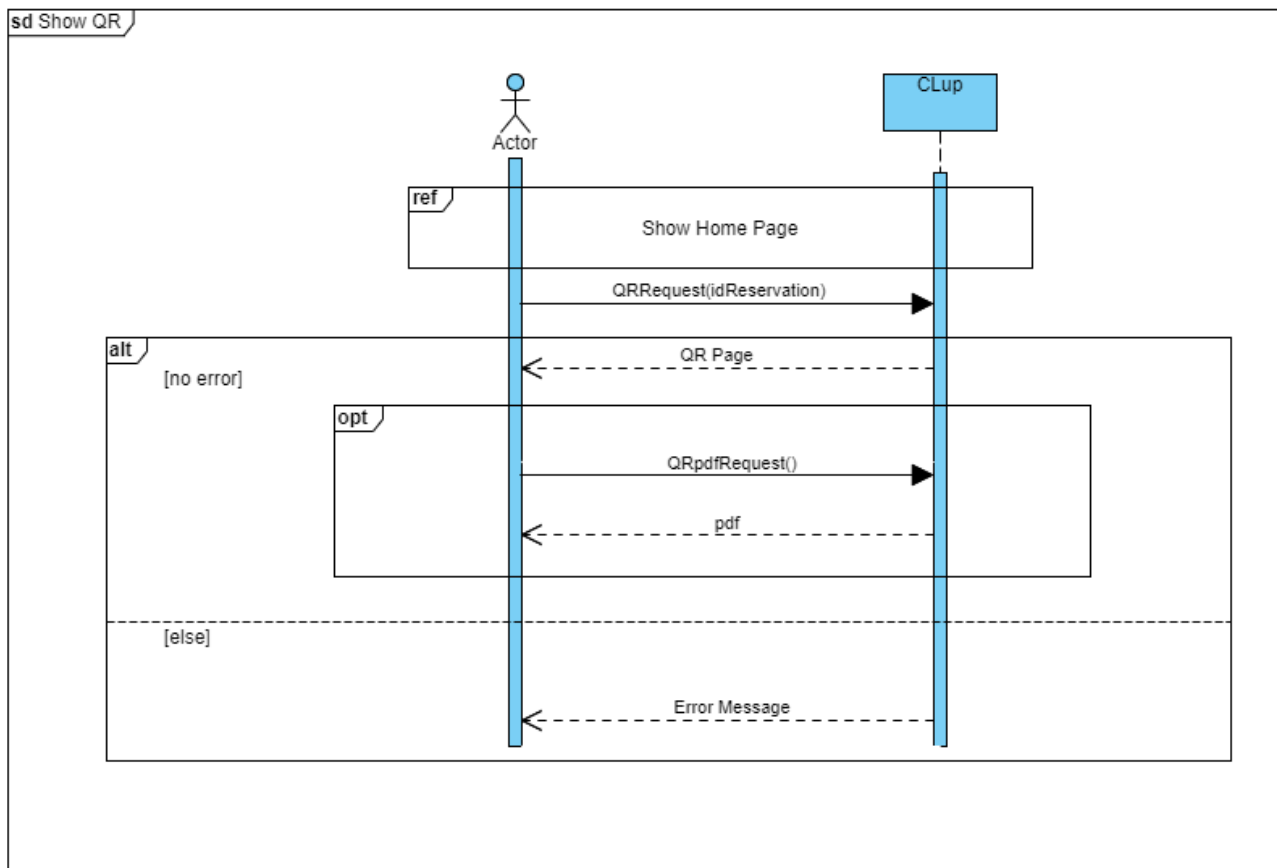
Name	Line Up for Manager
Actors	Store Manager
Entry Condition	The actor is already logged into the system and the system already shows the Home Page
Event Flow	<ol style="list-style-type: none"> 1. The actor requires a Line Up 2. The system checks the request 3. The system shows a confirmation message 4. The system retrieves the updated list of the active reservations 5. The system displays the list of active reservations in the Home Page
Exit Condition	The updated list of active reservations and the confirmation message are displayed
Exception	<ol style="list-style-type: none"> 1. Loss of internet connection 2. The actor cancels the operation 3. The store is no longer available in a specific time range

9. Book



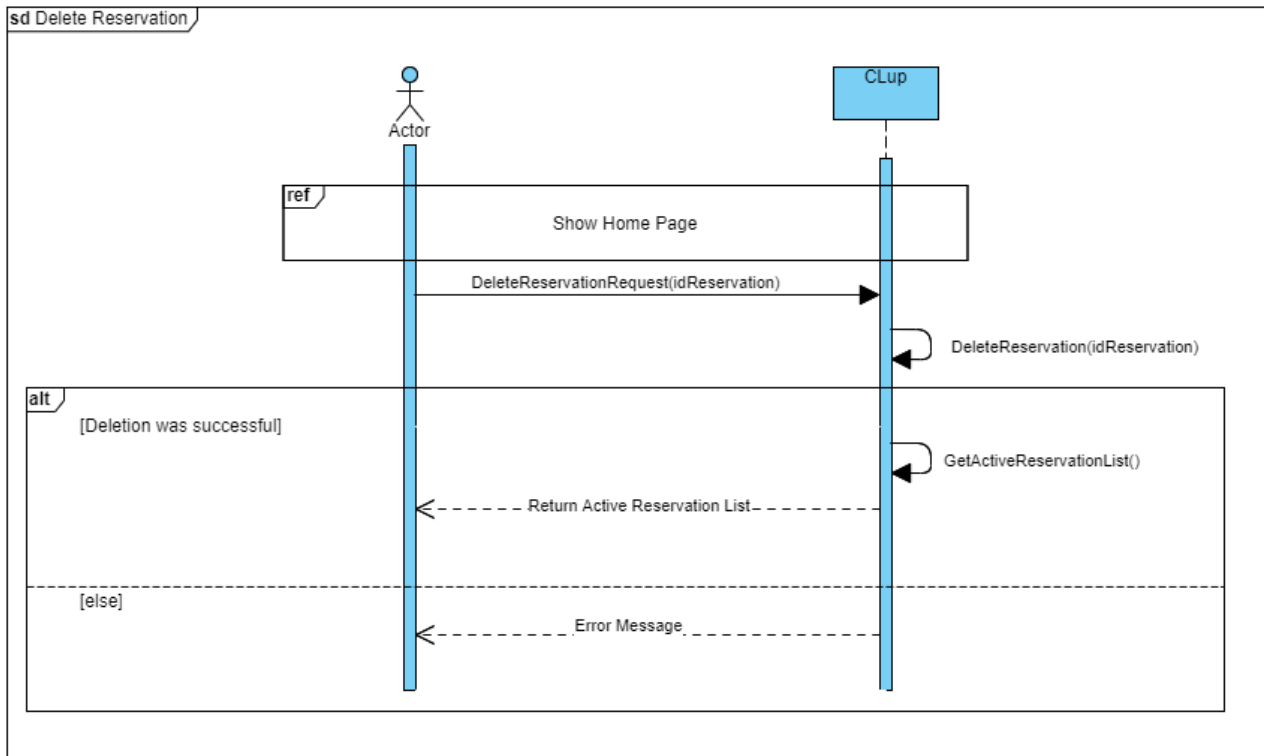
Name	Book
Actors	Customer
Entry Condition	The actor is already logged into the system and has already selected the shop
Event Flow	<ol style="list-style-type: none"> 1. The actor requires a Booking 2. The system checks the request 3. The system shows a confirmation message 4. The system displays the Home Page
Exit Condition	The Home Page and the confirmation message are displayed
Exception	<ol style="list-style-type: none"> 1. Loss of internet connection 2. The actor cancels the operation 3. The store is not available in a specific time range 4. The actor has already another active booking <p>If an error occurs, the system shows the Shop Reservation Page again to allow a new attempt.</p>

10. Show QR



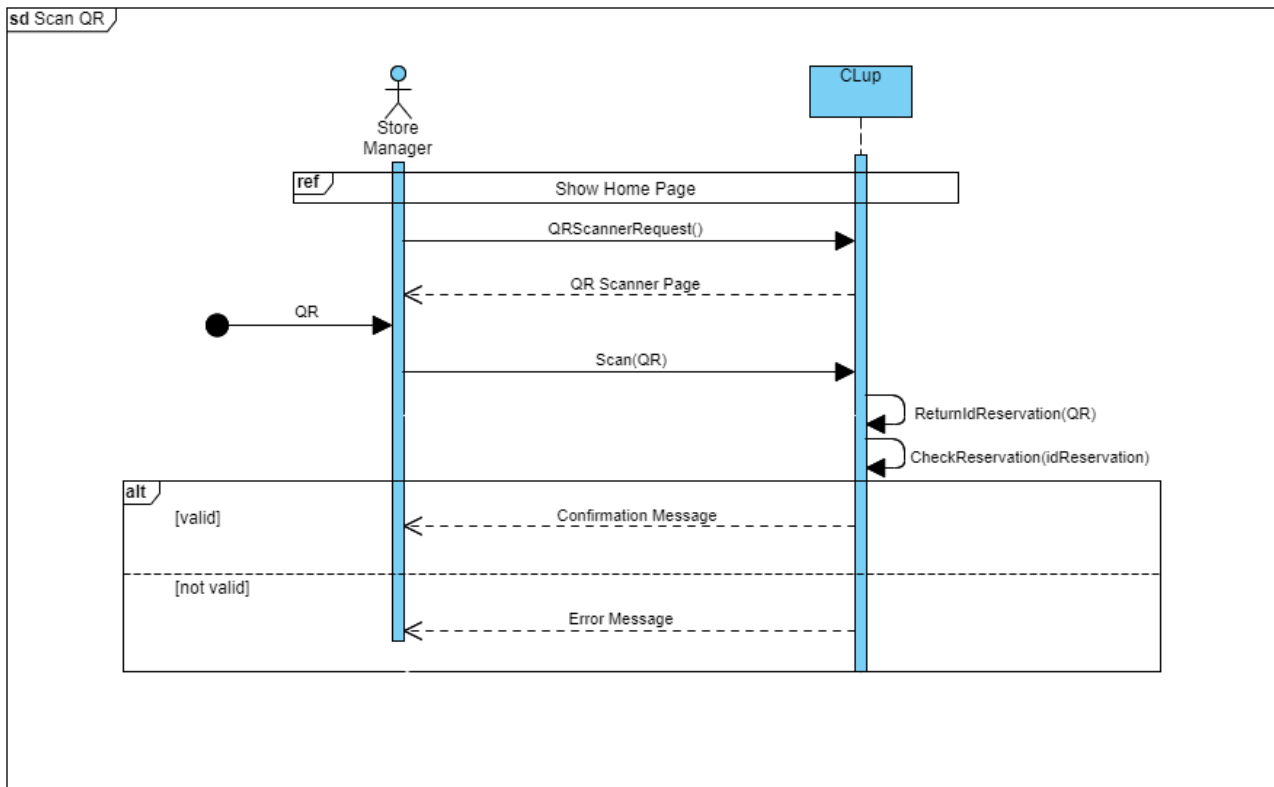
Name	Show QR
Actors	Customer, Store Manager
Entry Condition	The actor is already logged into the system and the system already shows the Home Page
Event Flow	<ol style="list-style-type: none"> 1. The actor requires the visualization of the QR code associated to a reservation 2. The system shows the QR Page 3. (Optional) The actor requires the PDF version of the QR code 4. (Optional) The system returns the PDF version of the QR code
Exit Condition	The QR Page or the PDF version of the code is returned
Exception	<ol style="list-style-type: none"> 1. Loss of internet connection 2. The actor cancels the operation

11. Delete Reservation



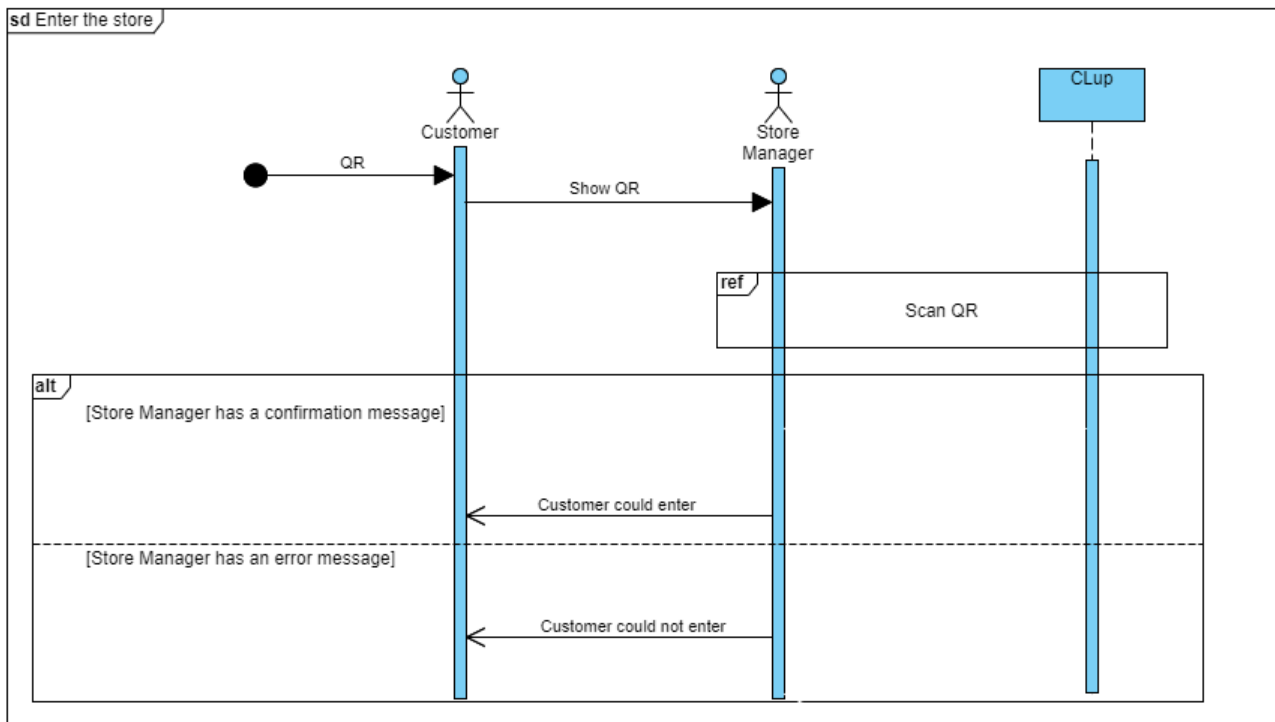
Name	Delete Reservation
Actors	Customer, Store Manager
Entry Condition	The actor is already logged into the system and the system already shows the Home Page
Event Flow	<ol style="list-style-type: none"> 1. The actor requires the elimination of a reservation 2. The system deletes the reservation 3. The system requires the list of the active reservations 4. The system shows the list of the active reservations in the Home Page
Exit Condition	The desired reservation is successfully deleted and the updated list of active reservations is displayed in the Home Page
Exception	<ol style="list-style-type: none"> 1. Loss of internet connection 2. The actor cancels the operation 3. The list of the active reservations is empty

12. Scan QR



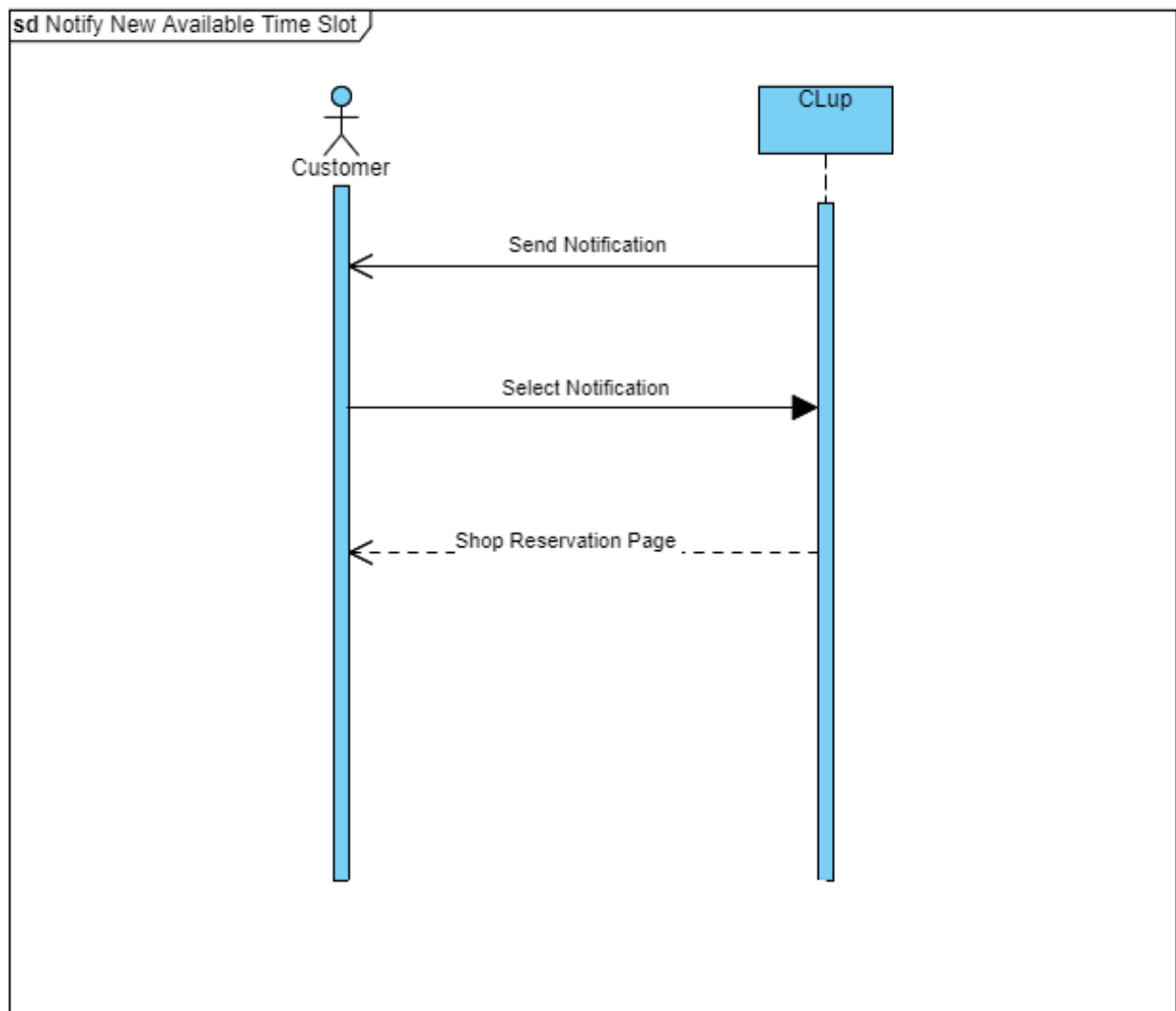
Name	Scan QR
Actors	Store Manager
Entry Condition	The actor is already logged into the system and the system already shows the Home Page
Event Flow	<ol style="list-style-type: none"> 1. The Store Manager requires the QR Scanner Page 2. The system shows the QR Scanner Page 3. A QR code to scan is given 4. The Store Manager scans the QR code using the tools provided by the QR Scanner Page 5. The system retrieves the id of the reservation associated to the QR code 6. The system checks the reservation associated to the QR code 7. The Store Manager receives a confirmation message
Exit Condition	A confirmation message is displayed
Exception	<ol style="list-style-type: none"> 1. Loss of internet connection 2. The actor cancels the operation 3. The QR code is not valid 4. The reservation associated to the QR code is not valid

13. Enter the Store



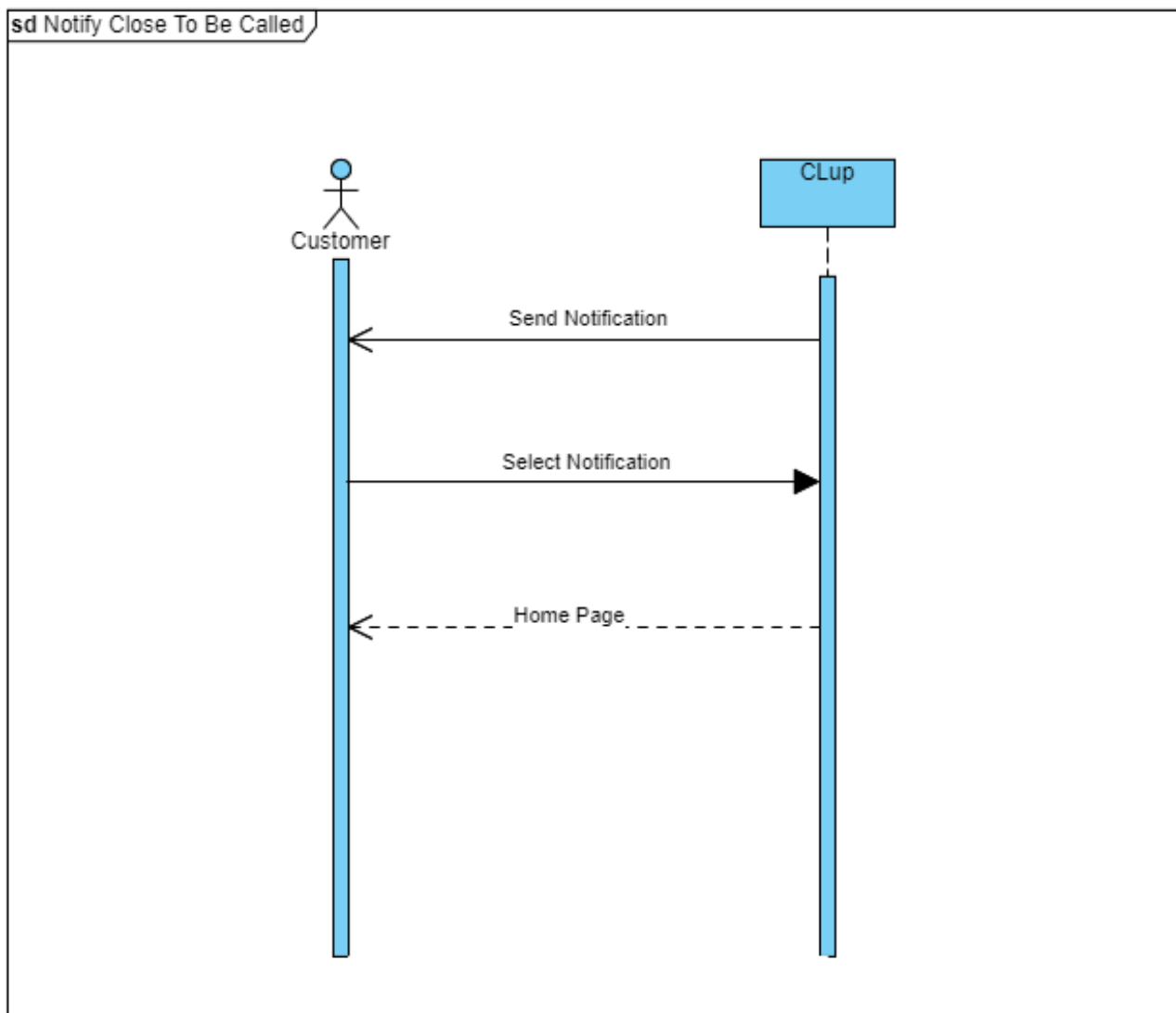
Name	Enter the Store
Actors	Customer, Store Manager
Entry Condition	The actors are already logged into the system, the Customer already owns the QR code, and the system already shows the QR Scanner to the Store Manager
Event Flow	<ol style="list-style-type: none"> 1. The actor shows the QR code to the Store Manager 2. The Store Manager scans the QR code 3. The Customer receives the authorization to enter the store
Exit Condition	The Customer can enter the store
Exception	<ol style="list-style-type: none"> 1. Loss of internet connection 2. The actor cancels the operation 3. The QR code is not valid

14. Notify New Available Time Slot



Name	Notify New Available Time Slot
Actors	Customer
Entry Condition	The actor is already logged into the system
Event Flow	<ol style="list-style-type: none"> 1. The system sends the actor a notification on the new available time slot 2. The actor selects the notification 3. The system shows the Reservation Page
Exit Condition	The system shows the Reservation Page in order to allow the actor to get a reservation
Exception	<ol style="list-style-type: none"> 1. Loss of internet connection 2. The actor cancels the operation

15. Notify Close To Be Called



Name	Notify Close To Be Called
Actors	Customer
Entry Condition	The actor is already logged into the system
Event Flow	<ol style="list-style-type: none"> 1. The system sends the actor a notification to alert that her/his shift is near to be called 2. The actor selects the notification 3. The system shows the Home Page
Exit Condition	The system correctly shows the Home Page
Exception	<ol style="list-style-type: none"> 1. Loss of internet connection 2. The actor cancels the operation

3.2.3 Mapping

Goals	Requirements	Domain Assumptions	Use Cases
G.1	R.1 R.2 R.6 R.17 R.19 R.20 R.22	D.4 D.5 D.6 D.7 D.9	U.3 U.5 U.6 U.7 U.8 U.9 U.10 U.11 U.12 U.13
G.2	R.1 R.2 R.3 R.5 R.6 R.9 R.10 R.16 R.21 R.22	D.1 D.2 D.3 D.6 D.7 D.8 D.9	U.1 U.2 U.3 U.5 U.6 U.7 U.8 U.9 U.10 U.12 U.15
G.3	R.4 R.6 R.7 R.8 R.14 R.15 R.16 R.22	D.5 D.6 D.8 D.10 D.11	U.3 U.8 U.10 U.12 U.13
G.4	R.1 R.2 R.6 R.7 R.8 R.9 R.10 R.11 R.12 R.13 R.15 R.18	/	U.1 U.2 U.3 U.4 U.5 U.6 U.7 U.8 U.9 U.10 U.12 U.14

G.1	Allows to regulate the influx of people that enter the building.
D.4	One and only one customer can enter with one QR code.
D.5	Customers can get into the store if and only if they scan a valid QR code.
D.6	All customers that want to access the store use the digital system of line up.
D.7	The system is applied to medium and large shops.
D.9	Store data are provided by the store owner and are already present in the DB.
R.1	The system generates a single QR code to enter and exit the store for each booking or lining up.
R.2	The system allows to get a reservation for the supermarket.
R.6	The system allows people (who do not have access to the required technology) to digitally line up directly when they are at the store.
R.17	The system shows active reservations.
R.19	The system allows users to delete a reservation.
R.20	The system allows customers only one lining up at a time for each shop.
R.22	The system allows the store manager to scan the QR codes.
U.3	Show Home Page

U.5	Show Reservation Page
U.6	Select Shop
U.7	Line Up for Customer
U.8	Line Up for Manager
U.9	Book
U.10	Show QR
U.11	Delete Reservation
U.12	Scan QR
U.13	Enter the Store

G.2	Avoids that customers must line up and wait outside of stores for hours.
D.1	The customers wait until their number is close to being called to approach the store.
D.2	The time that it takes to visit the supermarket is not uniform.
D.3	The approximated expected duration of the visit indicated by the customer is reliable.
D.6	All customers that want to access the store use the digital system of lining up.
D.7	The system is applied to medium and large shops.
D.8	Customers exit from the store only after they had scanned a valid QR code.
D.9	Store data are provided by the store owner and are already present in the DB.
R.1	The system generates a single QR code to enter and exit the store for each booking or lining up.
R.2	The system allows to get a reservation for the supermarket.
R.3	The system provides customers a precise estimation of the waiting time.
R.5	The system alerts the customers before their shift according to the geolocation information.
R.6	The system allows people (who do not have access to the required technology) to digitally line up directly when they are at the store.

R.9	The system allows customers to insert the approximated expected duration of the visit.
R.10	The system infers customers' expected duration of the visit based on an analysis of the previous visits.
R.16	The system requires a sign up/login.
R.21	The system uses information about the customer that exit the store to infer better the waiting time.
R.22	The system allows the store manager to scan the QR codes.
U.1	Sign Up
U.2	Lineup
U.3	Show Home Page
U.5	Show Reservation Page
U.6	Select Shop
U.7	Lineup for Customer
U.8	Lineup for Manager
U.9	Book
U.10	Show QR
U.12	Scan QR
U.15	Notify Close To Be Called

G.3	Guarantees that everyone can shop, even people who do not have access to the required technology.
D.5	Customers can get into the store if and only if they scan a valid QR code.
D.6	All customers that want to access the store use the digital system of lining up.
D.8	Customers exit from the store only after they had scanned a valid QR code.
D.10	The store manager with the digital system helps people who do not have access to the required technology to line up directly when they are at the store.

D.11	The store manager prints the QR code for people who do not have access to the required technology.
R.4	The system allows customers only one booking at a time for each shop.
R.6	The system allows people (who do not have access to the required technology) to digitally line up directly when they are at the store.
R.7	The system suggests alternative time slots for visiting the store when the desired one is not available.
R.8	The system suggests alternative stores when the desired one is not available.
R.14	The system shows the available time slots for each grocery.
R.15	The system provides a QR code printing service.
R.16	The system requires a sign up/login.
R.22	The system allows the store manager to scan the QR codes.
U.3	Show Home Page
U.8	Lineup for Manager
U.10	Show QR
U.12	Scan QR
U.13	Enter the Store

G.4	Provides smart managing of lining up and booking with a digital system.
R.1	The system generates a single QR code to enter and exit the store for each booking or lining up.
R.2	The system allows to get a reservation for the supermarket.
R.6	The system allows people (who do not have access to the required technology) to digitally line up directly when they are at the store.
R.7	The system suggests alternative time slots for visiting the store when the desired one is not available.
R.8	The system suggests alternative stores when the desired one is not available.
R.9	The system allows customers to insert the approximated expected duration of the visit.

R.10	The system infers customers' expected duration of the visit based on an analysis of the previous visits.
R.11	The system allows store managers to get a lining up only for own store.
R.12	The system provides periodic notifications of available time slots in a day/time range.
R.13	The system shows the list of shops.
R.15	The system provides with a QR code printing service.
R.18	The system shows the history of reservations.
U.1	Sign Up
U.2	Login
U.3	Show Home Page
U.4	Show History Reservation
U.5	Show Reservation Page
U.6	Select Shop
U.7	Line up for Customer
U.8	Line up for Manager
U.9	Book
U.10	Show QR
U.12	Scan QR
U.14	Notify New Available Time Slot

3.3 Performance Requirements

Due to the non-critical nature of the system, too strict performance requirements are not needed. However, in order to offer the best possible user experience, the system should provide:

- the list of available stores in 7 seconds, or less;
- the list of active reservations and their information in less than 5 seconds;
- the QR code generation in roughly 5 seconds;
- the history of reservations in at most 10 seconds;
- the validation of the QR code at the entrance of the shop in less than 12 seconds;
- the lining up and booking confirmation in 10 seconds, or less;

- the lining up and booking deleting in 10 seconds, or less;
- the loading of the available time slots for a specific store in less than 5 seconds;
- push app notification with a delay that is imperceptible to the user;
- login and sign up response in less than 5 seconds

Notice that a good internet connection is assumed in the previous estimations.

The system should also guarantee simultaneous access to 50 000 Customers and Store Managers.

3.4 Design Constraints

3.4.1 Standards Compliance

All the specifications that have been described in this document must be respected by the system. Also, the source code of the application must be commented on and documented adequately.

Moreover, the system should respect the line guides described by the European RGPD.

3.4.2 Hardware Limitations

The system requires a mobile device and a stable internet connection to work properly.

3.5 Software System Attributes

3.5.1 Reliability and Availability

The system should offer its functionalities with an availability equal to 99.5%, or more. In other words, the system must be inaccessible for less than two days every year. To achieve this goal, the system should provide a high redundancy for the most critical components.

Furthermore, in order to guarantee better reliability performances, all the scheduled maintenance interventions on the system should be done during the night.

3.5.2 Security

The connection between the application and the server must be safe. To keep a good level of security, the system should use the TLS (*Transport Layer Security*) protocol. For this purpose, it is needed an SSL/TSL certificate.

Moreover, all passwords must be encrypted.

3.5.3 Maintainability

The source code must be commented on as well as possible and the correlated documentation must be kept updated during the whole life cycle of the system.

Modularity and low coupling between components must be a focus during the designing and developing phases.

3.5.4 Portability

In the first phases of developing and launch of the system, the only supported platform will be Android. Further, future developments could take into account other platforms such as iOS and web applications.

4 FORMAL ANALYSIS USING ALLOY

4.1 Objectives of the analysis

In this section, a presentation of the formal modelling activity that has been done using the Alloy formal notation. The main goal of this activity is to formally describe the domain and properties of the system to be.

In particular, the main objective of this activity is to model and formally represent the following entities:

- actors of the system to be;
- reservations and their subtypes (lining up and booking);
- status of a reservation;
- shops and their elements;
- QR codes.

Moreover, the purpose is also to model:

- that each customer can have only one active reservation at a time;
- that each store manager is associated to only one store;
- the linking between QR codes and reservations;
- the possibilities for the store managers to get a reservation only for their own shops;
- the limits on the number of people into the shop.

Further constraints and details are directly provided as comments in the following code. There are present also the definition of several assertions and predicates.

4.2 Alloy Code

```
//+++++ DECLARATION +++++
```

```
// Definition of boolean type
```

```
abstract sig Bool {}
```

```
one sig True extends Bool {}
```

```
one sig False extends Bool {}
```

```
// Definition of the status of a reservation
```

```
abstract sig Status{} 
```

```
one sig Wait extends Status{} // the customer is waiting
```

```
one sig Enter extends Status{} // the customer has entered the shop but has not yet exit
```

```
one sig Exit extends Status{} // the customer has left the shop
```

// Definition of actors

abstract sig Person{

sig Customer extends Person{

lineup: set Lineup,

booking: set Booking,

}

sig StoreManager extends Person{

lineup: set Lineup,

shop: one Shop,

}

// Definition of reservations

abstract sig Reservation{

status: one Status,

qrcode: one QRCode,

}}

sig Lineup extends Reservation{

customer: lone Customer ,

storemanager: lone StoreManager,

shop: one Shop,

}{#customer = 1 <=> #storemanager =0}

sig Booking extends Reservation{

customer: one Customer,

shop: one Shop,

}

```
// Definition of shops  
// where an enterLineup (enterBooking) is a lining up (booking) associated to a customer that  
// has entered the shop but has not yet exit
```

```
sig Shop{  
  storemanager: one StoreManager,  
  enterLineup: set Lineup,  
  enterBooking: set Booking,  
  lineup: set Lineup,  
  booking: set Booking,  
  capacity: Int,  
  {capacity>0}
```

```
// Definition of QR code used to enter and exit the shop
```

```
sig QRCode{  
  reservation: one Reservation,  
  valid: Bool,  
  {(reservation.status = Exit implies valid = False) and (reservation.status != Exit implies valid =  
  True)}
```

```
//++++++ FACT ++++++
```

```
// Only one activeLineup for each customer at a time for each shop
```

```
fact OneLineUp{  
  all disj l1,l2: Lineup | (l1.status != Exit and l2.status != Exit) implies  
  (l1.customer != l2.customer or l1.shop != l2.shop)  
}
```

```
// Only one activeBooking for each customer at a time for each shop
```

```
fact OneBooking{  
  all disj b1,b2: Booking | (b1.status != Exit and b2.status != Exit) implies (  
  b1.customer != b2.customer or b1.shop != b2.shop) }
```

// Each store manager belongs to only one shop

fact ShopUnique {

all disj s1,s2: Shop | s1.storemanager != s2.storemanager }

// If a store manager belongs to a shop, then that shop has that store manager

fact StoreManagerCoherence {

all st: StoreManager, sh: Shop | st.shop = sh iff sh.storemanager = st }

// If a customer book a visit, then that booking is associated to that customer

fact BookingCustomerCoherence {

all b: Booking, c: Customer | b.customer = c iff c.booking = b }

// If a customer lines up, then that lining up is associated to that customer

fact LineupCustomerCoherence {

all l: Lineup, c: Customer | l.customer = c iff c.lineup = l }

// If a store manager lines up, then that lining up is associated to that store manager

fact LineupManagerCoherence {

all l: Lineup, s: StoreManager | l.storemanager = s iff s.lineup = l }

// If a reservation is associated to a QR code, then that QR code is associated to that reservation

fact QRReservationCoherence {

all r: Reservation, q: QRCode | r.qrcode = q iff q.reservation = r }

// If a lining up is associated to a shop, then that shop is associated to that lining up

fact ShopLineupCoherence {

all s: Shop, l: Lineup | s.lineup = l iff l.shop = s }

// If a booking is associated to a shop, then that shop is associated to that booking

fact ShopBookingCoherence {

all s: Shop, b: Booking | s.booking = b iff b.shop = s }

// A store manager can line up only on own shop

fact StoreManagerOnlyLineupOwnShop {

all sh: Shop, st: StoreManager | st.lineup.shop = sh implies st.shop = sh }

// An enterLineup is a lining up associated to a customer that has entered the shop

// but has not yet exit

fact EnterLineupDef{

all s:Shop | s.enterLineup.status= Enter

}

// If an enterLineup is associated to a shop, then that shop contains that enterLineup

fact EnterLineupOwner{

all s: Shop, l: Lineup | s.enterLineup = l iff l.shop = s

}

// An enterBooking is a booking associated to a customer that has entered the shop

// but has not yet exit

fact EnterBookingDef{

all s:Shop | s.enterBooking.status=Enter

}

// If an enterBooking is associated to a shop, then that shop contains that enterBooking

fact EnterLineupOwner{

all s: Shop, b:Booking | s.enterBooking = b iff b.shop = s

}

```
// The sum of people into the shop is less or equal than the capacity of the shop
```

```
fact CapacityConstraint{
```

```
all s:Shop | (#s.enterLineup+#s.enterBooking) <= s.capacity
```

```
}
```

```
//+++++ PREDICATE +++++
```

```
// The customer who lined up can enter the shop
```

```
pred itIsYourTurnLineup(l:Lineup){
```

```
l.status = Enter
```

```
}
```

```
run itIsYourTurnLineup
```

```
// The customer who booked a visit can enter the shop
```

```
pred itIsYourTurnBooking(b: Booking){
```

```
b.status = Enter
```

```
}
```

```
run itIsYourTurnBooking
```

```
//Predicate show
```

```
pred show {}
```

```
run show for 5
```

```
//+++++ ASSERTION +++++
```

```
// Checks if the number of activeLineup is less or equal than the total number of lining up
```

```
// for each shop
```

```
assert enterLineupCoherence {
```

```
all s:Shop | #(s.enterLineup) <= #(s.lineup)
```

```
}
```

```
check enterLineupCoherence
```



```
// Checks if the number of enterBooking is less or equal than the total number of booking
// for each shop
assert enterBookingCoherence {
all s:Shop | #(s.enterBooking) <= #(s.booking)
}
check enterBookingCoherence

// Checks if the sum of all customers into all shops is less or equal than the sum of
// all capacities
assert enterCapacityCoherence {
all s:Shop | sum(#(s.enterBooking)) + sum(#(s.enterLineup)) <= sum(s.capacity)
}
check enterCapacityCoherence
```

4.3 Predicates Results

Executing "Run itIsYourTurnLineup"

Solver=sat4j Bitwidth=4 MaxSeq=4 SkolemDepth=1 Symmetry=20
 3198 vars. 228 primary vars. 7353 clauses. 17ms.
Instance found. Predicate is consistent. 12ms.

Executing "Run itIsYourTurnBooking"

Solver=sat4j Bitwidth=4 MaxSeq=4 SkolemDepth=1 Symmetry=20
 3198 vars. 228 primary vars. 7353 clauses. 13ms.
Instance found. Predicate is consistent. 8ms.

4.4 Assertions Results

Executing "Check enterLineupCoherence"

Solver=sat4j Bitwidth=4 MaxSeq=4 SkolemDepth=1 Symmetry=20

3231 vars. 228 primary vars. 7475 clauses. 11ms.

No counterexample found. Assertion may be valid. 10ms.

Executing "Check enterBookingCoherence"

Solver=sat4j Bitwidth=4 MaxSeq=4 SkolemDepth=1 Symmetry=20

3231 vars. 228 primary vars. 7475 clauses. 15ms.

No counterexample found. Assertion may be valid. 13ms.

Executing "Check enterCapacityCoherence"

Solver=sat4j Bitwidth=4 MaxSeq=4 SkolemDepth=1 Symmetry=20

3508 vars. 228 primary vars. 8494 clauses. 22ms.

No counterexample found. Assertion may be valid. 16ms.

4.5 Models

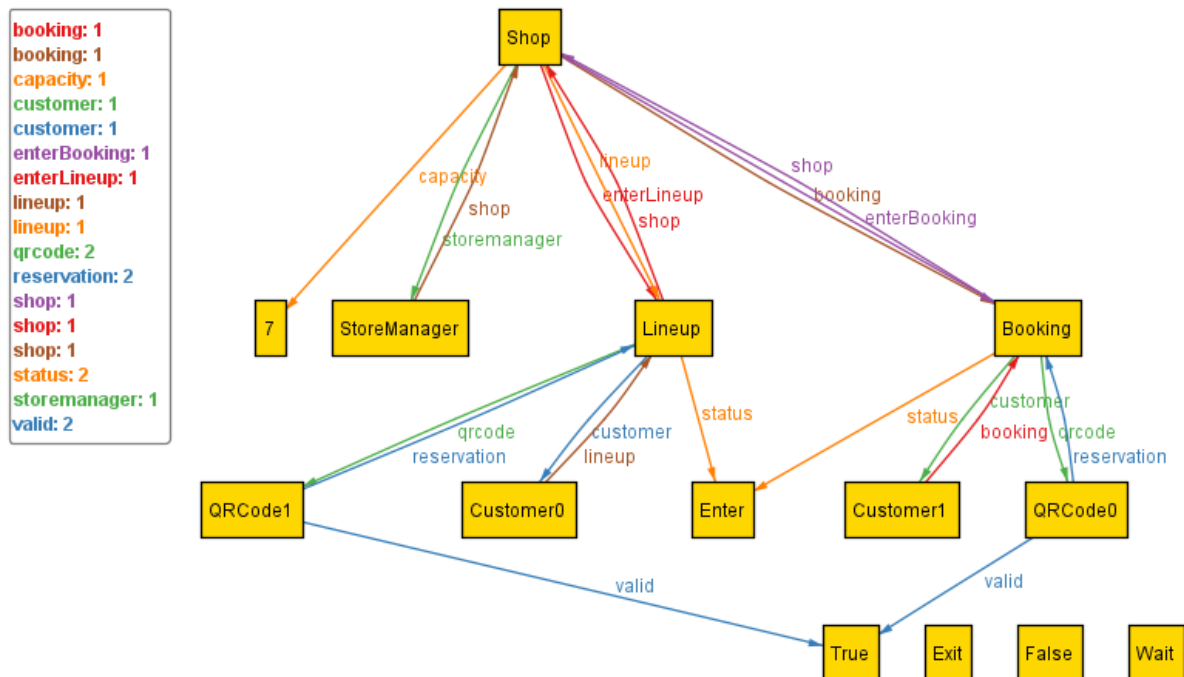


Figure 7: predicate show

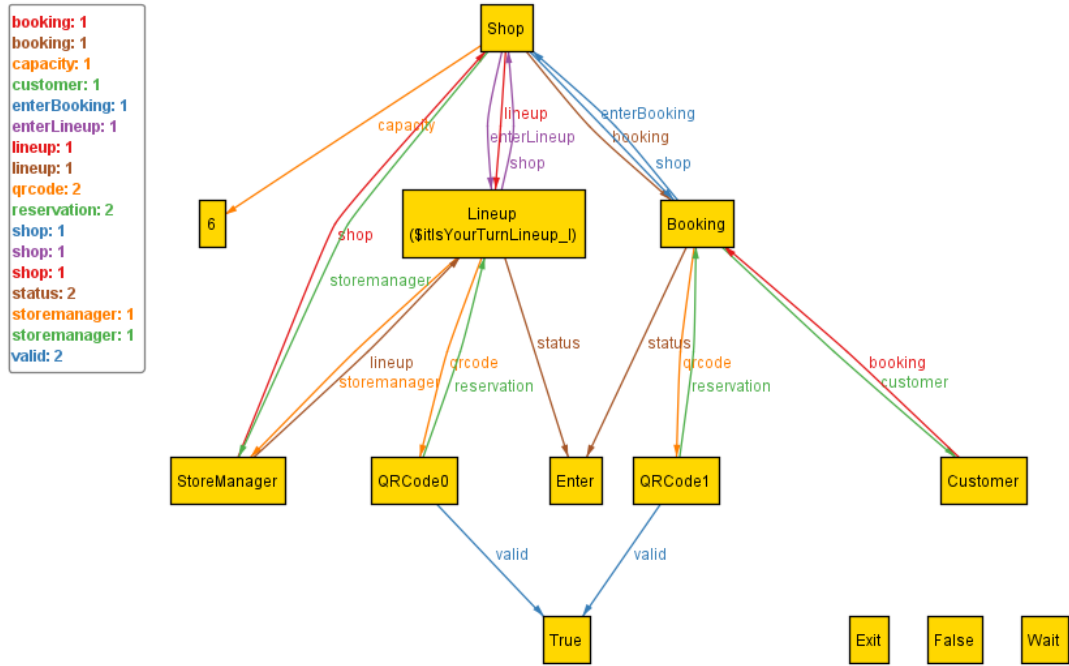


Figure 8: predicate *itIsYourTurnLineup*

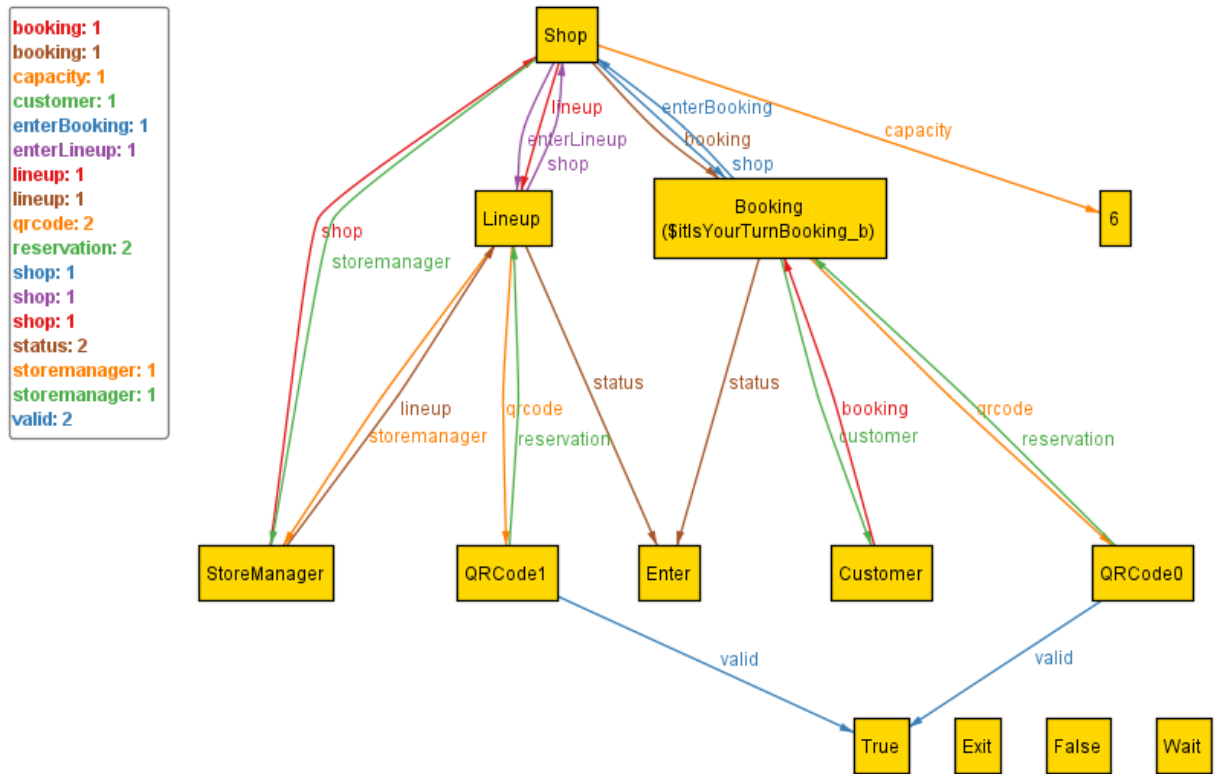


Figure 9: predicate *itIsYourTurnBooking*

5 EFFORT SPENT

This section shows the amount of time that each member has spent to produce the document. Please notice that each section, diagram, and specification is the result of coordinated work. The column *Member* specifies only the main contributor (or contributors, if more than one) for each topic but should not be interpreted as a lack of participation by other team members for that topic.

TOPIC	MEMBER	HOURS
General initial brainstorming and interpretation of the domain	Digregorio, Massaro, Tamma	5h
Creation of the document and identification of the goals	Digregorio, Massaro, Tamma	4h
World and shared phenomena	Digregorio, Massaro, Tamma	4h
Requirements	Digregorio, Massaro, Tamma	7h
Mock-up	Digregorio	3.5h
Mapping between goals, requirements, and domain assumptions	Digregorio, Massaro, Tamma	6h
Improvement on goals, requirements, and domain assumptions	Digregorio, Massaro, Tamma	3.5h
Product Perspectives, Product Functions and User Characteristics	Digregorio, Massaro	3h
Brainstorming and discussion of some key points	Digregorio, Massaro, Tamma	5h
Document formatting and other improvements	Digregorio, Massaro	2h
Examples of scenarios	Digregorio, Massaro, Tamma	1.5h
Sequence Diagrams	Tamma	15h
Sequence Diagrams descriptions and integration	Digregorio	8h
Class Diagram	Massaro	2h
New brainstorming and new discussion of some key points	Digregorio, Massaro, Tamma	3h

Use Cases diagrams	Tamma	3.5h
Alloy modelling	Digregorio, Massaro, Tamma	8h
Inserting of comments and explanations on Alloy	Massaro	1.5h
Definition of Performance Requirements and Design Constraints	Digregorio, Massaro, Tamma	1h
Performance Requirements and Design Constraints improvements	Digregorio	1h
Definition of Software System Attributes	Digregorio, Massaro, Tamma	1h
Drafting of Software System Attributes	Massaro	1h
State Charts	Digregorio, Massaro, Tamma	2h
Alloy improvements and corrections	Massaro	4h
Alloy description, integration into the document, and final adjustments	Digregorio	2h
Scenarios improvements	Digregorio	1.5h
Final improvements	Digregorio, Massaro, Tamma	3h

6 REFERENCES

- The diagrams have been made with: <https://www.visual-paradigm.com/> and <https://lucid.co/it>
- The mockups have been made with: Adobe XD
- Alloy Language Reference: <https://alloytools.org/download/alloy-language-reference.pdf>
- Alloy Tools: <https://alloytools.org/tutorials/day-course/>
- Sequence Diagram Reference: <https://www.uml-diagrams.org/sequence-diagrams-reference.html>
- *UML - Imparare a descrivere sistemi orientati agli oggetti graficamente e in modo standard*, APOGEO, Enrico Amedeo