



POLITECNICO
MILANO 1863

CLup

Requirement Analysis and Specification Document

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1 Introduction

1.1 Purpose

The coronavirus emergency has put a strain on society on many levels, in particular, grocery shopping can become a challenge in the presence of such strict rules: supermarkets need to restrict access to their stores to avoid having crowds inside and long lines outside. The goal of this project is to develop an easy-to-use application that, on the one side, allows store managers to regulate the influx of people in the building and, on the other side, saves people from having to line up and stand outside of stores for hours on end.

The application will allow customers to “line up” (i.e., retrieve a number) from their home, and then wait until their number is called (or is close to being called) to approach the store. In addition, the application could be used to generate QR codes that would be scanned upon entering the store, thus allowing store managers to monitor entrances.

The system must attain the following goals:

- G1 CLup should allow customers to queue up remotely and on premise in such a way that they don't need to form a physical line
- G2 CLup should allow store owners to regulate how many customers can be simultaneously in their stores
- G3 CLup should provide the customer with a reasonably precise estimate of waiting time
- G4 CLup should alert the customers when it is time to get to the shop taking into account travel time
- G5 CLup should allow customers to book future visits to stores
- G6 CLup should be able to infer an approximate duration of the visit from an analysis of the previous ones to plan visits and manage the queue in a finer way

1.2 Scope

The system to be allows to avoid creating queues in front of stores. This is accomplished by enabling the customers to queue up remotely. Moreover, the shop owners can oversee customers entering and exiting stores.

The system offers the following functionalities:

- F1 it allows customers to line up remotely or on premise
- F2 it allows customers whose position in queue allows it to enter and exit the store
- F3 it schedules customers in order to minimize overcrowding inside and outside of the store
- F4 it alerts customers when they should head to the store
- F5 it allows customers to book a visit and optionally specify duration and desired categories of products
- F6 it allows store owners to monitor flux of people inside the store and set how many customers can be simultaneously inside
- F7 it allows store owners to register stores

F8 it uses statistics build on entrance and exit data, and preferred categories to better evaluate duration of visits

User can access the system using a phone application provided that they own a smartphone with an internet connection. This application allows registered users to easily access the functionality of the system.

Moreover, for those who do not have access to the required technology or don't want to use the phone application, there is also a web app. Therefore, users will be able to log in and perform the same operations of the phone application using an internet browser.

Finally the customers of the store will also have the possibility to create reservations on premise: every shop will be equipped with a device to print tickets in order to give every client a very easy way to line up. Of course customers that wants to queue up "on the spot" must have a means of identification (e.g. document), in order to prevent fake reservations that would slow down the queue. For the same reason users that use the phone application or the web app must log in to identify themselves.

Only customer with a valid reservation (i.e it is their turn) will be allowed to enter the store; to achieve this, each store must have a device (e.g. a QR/NFC reader) to every entrance, and clients must validate their reservation before being admitted inside. They should also do the same to exit, in order to monitor the store's occupation.

1.2.1 World Phenomena

WP1 Customer reaches a store

WP2 Customer enters or exits a store

WP3 Store owner controls current number of customers in one of his stores

WP4 Customer buys products

1.2.2 Shared Phenomena

SP1 Customer queues up

SP2 Customer is identified

SP3 Turnstiles lock and unlock

SP4 Customer is alerted

SP5 Customer books a visit to a store

SP6 Printer prints a ticket

1.3 Definitions, Acronyms, Abbreviations

1.3.1 Definitions

Reservation	Virtual or physical artifact used to identify the position of a customer in a queue
Reservation	A place in the queue
Enqueued	A customer is enqueued when he has provided the system with a means of identification and requested a reservation
Authorized	A customer is authorized when he has been enqueued and is allowed temporary access to the store.
Occupation	Number of customers currently present in the store

1.3.2 Acronyms

RASD	Requirement Analysis and Specification Document
GPS	Global Positioning System
S2B	Software to be
UI	User Interface

1.3.3 Abbreviations

Gn	Goal number n
Rn	Requirement number n
Dn	Domain Assumption number n
WPn	World Phenomenon number n
SPn	Shared Phenomenon number n

1.4 Revision history

Not yet defined.

1.5 Reference Documents

1. IEEE Std 830-1998 Recommended Practice for Software Requirements Specifications
2. Specification Document: R&DD Assignment A.Y. 2020/2021

1.6 Document Structure

- Chapter 1: gives an introduction about the project, describing the purpose of the system informally and defining its scope, its main goals, world and shared phenomena. Moreover this section contains specifications such as the definitions, acronyms, abbreviation, revision history of the document and the references.
- Chapter 2: contains the overall description of the project, with a more in-depth look at its functionalities. Here are identified the main actors involved in the application's usage lifecycle, some scenarios that point out the major features of the S2B, and all the necessary domain assumptions, dependencies and constraints. This section also provides a class diagram, which aid to better understand the general structure of the project, and some state diagrams, to make the evolution of the crucial objects clear.
- Chapter 3: This section contains the core of the document: first it presents the interface requirement including user, hardware, software and communication interfaces. Then it offers the specification and the description of all the functional requirements necessary in order to reach the goals; is also provided a list of use cases, with their corresponding sequence diagrams and their mapping on the requirements, as long as some scenarios, useful to identify specific cases in which the application can be utilized. Finally non-functional requirements are defined, including performance, design and the software systems attributes.
- Chapter 4: includes the alloy code and the corresponding metamodels generated from it, in order to show how the project has been modeled and represented through the language.
- Chapter 5: shows the effort which each member of the group spent working on the project.
- Chapter 6: includes the reference documents.

2 Overall Description

2.1 Product perspective

The S2B will be used by two kinds of users: customers and store owners, and offers to each of them different functionalities:

2.1.1 Customer

The customer can create reservations for a desired store: such reservation is then inserted into a queue. This queue is managed in order to avoid overcrowding. To achieve this, statistics about visits' durations are exploited, taking also into account information that customers may provide (e.g. which department of the store they want to visit).

There are multiple types of reservations that can be requested:

1. Immediate reservation: the customer wants to queue up immediately to a store. He/she is also provided with an estimation of the time he has to wait before his/her turn.
2. Future reservation: the customer wants to book a future visit at a desired time and store. When creating the reservation the customer can specify how long he/she intends to stay and which departments of the market he/she plans to go to, in order to provide a better plan. If he/she does not specify the duration the system can infer it using some statistic built on his/her previous visits. Then the customer will be provided with the actual time he will be able to access the store (considering the bookings from other customers).
3. On premise reservation: the customer is allowed to enqueue directly at the store. Each of them will provide a system to print tickets so that those who do not have access to the required technology for the previous options can still line up. These tickets contain a reservation number and an estimation of the waiting time before being able to enter.

Customers who requested an immediate or a future reservation receive an alert when they need to depart to reach the store. This alert is based on the location of the customer, so that the time needed to reach the store is taken into account. Moreover immediate and future reservations can be deleted by who created them.

2.1.2 Store owner

The store owner can

1. register a store to the system so that it can be accessed by customers
2. set the maximum occupation threshold for each of his stores.
3. monitor the number of customers inside at any time
4. visualize statistics about the flow of clients and department occupation

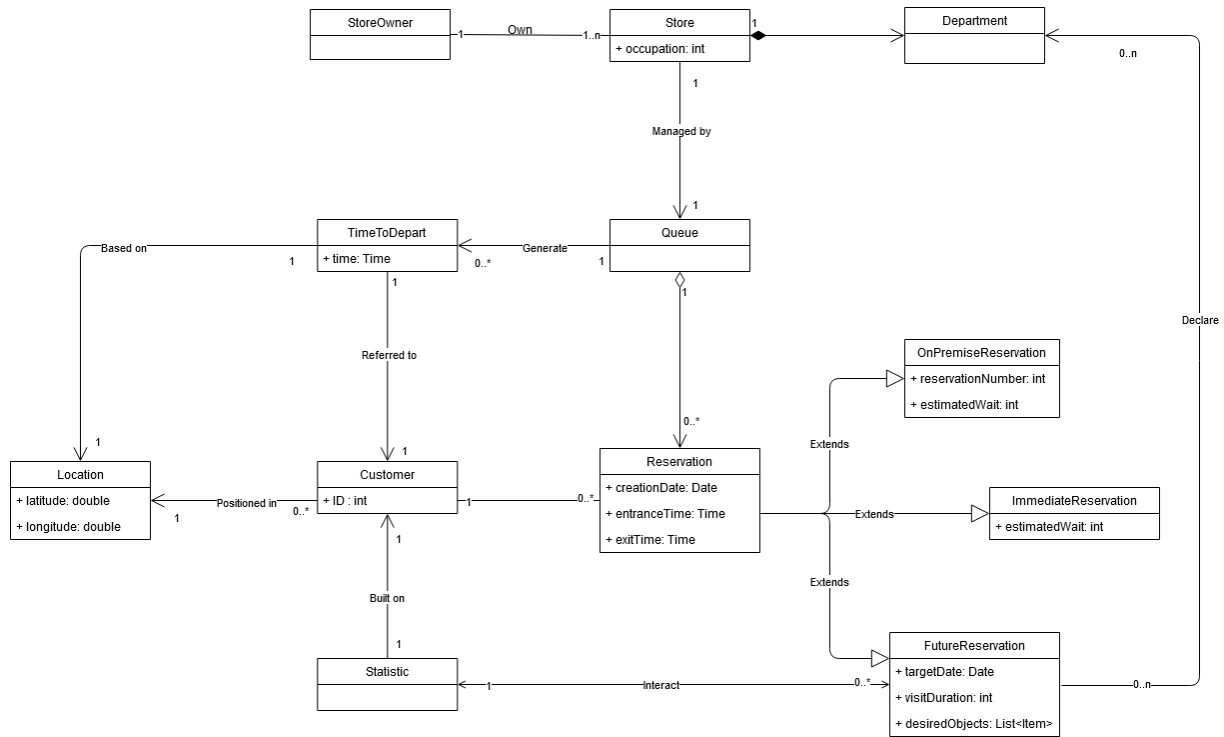


Figure 1: Class Diagram.

2.1.3 State charts

Here we show the main processes that the system will manage, and the states in which the system will find itself.

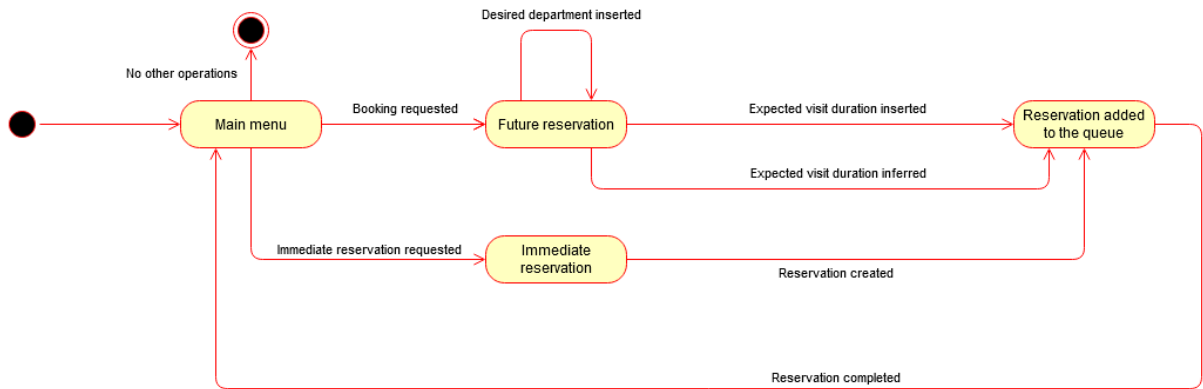


Figure 2: State Diagram 1: Creation of a reservation.

The figure above illustrates how the customer creates a reservation (virtual customer). The customer accesses the main menu. From there he/she can request an immediate reservation or a future reservation. If he/she requests an immediate reservation, it is created and the process terminates. If he/she requires a future reservation he can add the departments he/she intends to visit, and how much time he/she is going to spend at the store. Then the reservation is created and the process terminates.

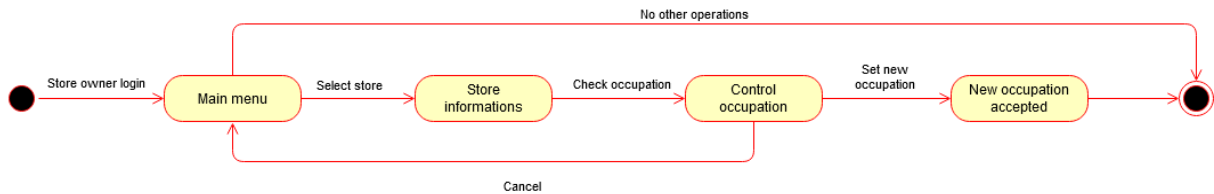


Figure 3: State Diagram 2: Store owner sets occupation.

The figure above illustrates how the store owner sets the maximum occupation of one of his stores. The store owner logs in and is provided a main menu. He/she selects one of his stores, and is presented with the current maximum occupation of his selected store. He can change it to a value to his liking, or go back to the main menu.

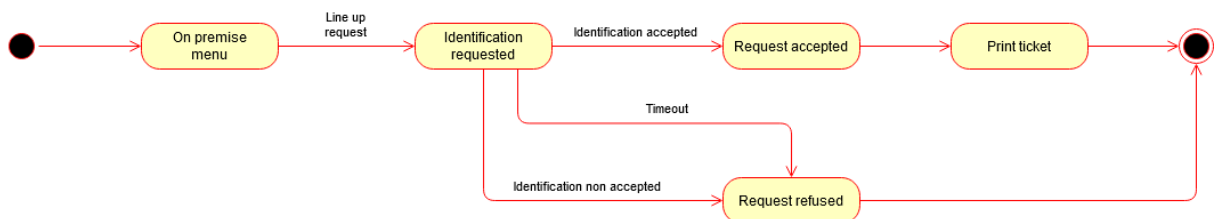


Figure 4: State Diagram 3: On premise creation of a reservation.

The figure above illustrates how a customer can queue up on premise (physical customer). The customer is presented with an on premise main menu. From there he/she can request to queue up (create a reservation) immediately. He will be prompted to identify himself (e.g. social security card). Once identified the customer will be provided a ticket with a number that represents his position in queue and an estimate of the waiting time.

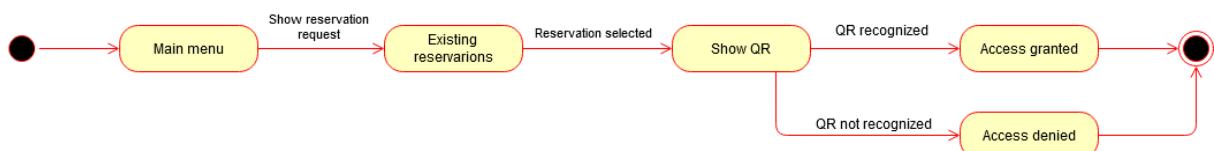


Figure 5: State Diagram 3: Customer enters a store.

The figure above illustrates how a customer who is authorized can access the store. At the entrance of his/her store of choice he is enabled to demonstrate his authorization. Once he/she does, he is allowed to enter the store.

2.2 Product functions

We describe here functions that the system will support.

1. Customers can queue up virtually or physically, immediately or in the future at one of the stores registered to the service.
2. Customers can access the desired store when its occupation reaches acceptable levels.
3. Customers that queued up virtually can be notified when it is time for them to depart to reach the store.
4. Store owners can monitor the occupation in each of their stores.
5. Store owners can define the maximum occupation of each of their stores.

6. Store owners can register stores to the system.

2.3 User characteristics

1. **Customers:** a physical person that needs to access any of the stores registered to the system. The customers belong to all demographics, thus the need for a user-friendly interface for both virtual and physical customers. The customer needs a reasonably precise estimate of waiting time and time to get to the store.
2. **Store owners:** a physical or legal person that owns any number of stores and needs to enable customer access through a queue system.

2.4 Assumptions, dependencies and constraints

2.4.1 Domain Assumptions

- D1 The stores have means to allow entrance or exit to customers that are authorized (e.g. with QR/NFC connected turnstiles).
- D2 Turnstiles only let one person in each time they unlock.
- D3 Outside stores a device can identify customers (e.g. with social security card) and print tickets.
- D4 Outside stores there is a monitor.
- D5 When provided, user location has maximum error of 5 meters.
- D6 There is no way for a customer to enter a store except from entrance and exit.
- D7 Each virtual and physical customer has means of identification unique to that user (e.g, telephone number, social security card).

3 Specific Requirements

3.1 External interface requirements

3.1.1 User interfaces

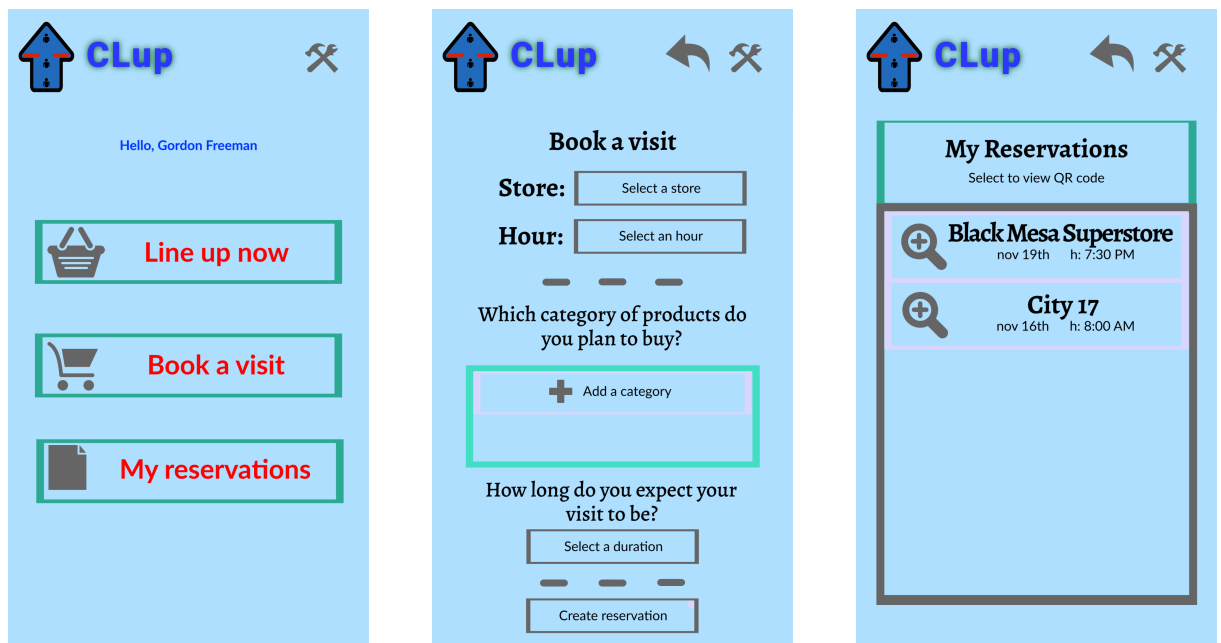
There are two categories of users that have different interface requirements:

- **Customers**

Customers belong to all demographics so a user friendly interface is needed. The customer is presented with a main menu which allows him/her to:

- line up immediately (immediate reservation) at a specific store
- book a visit (future reservation) at a specific store
- view and delete existing reservations

The customer will receive a notification when it is time for him/her to depart to reach the shop.



- **Store owners**

The store owner is presented with a main menu from which he/she can:

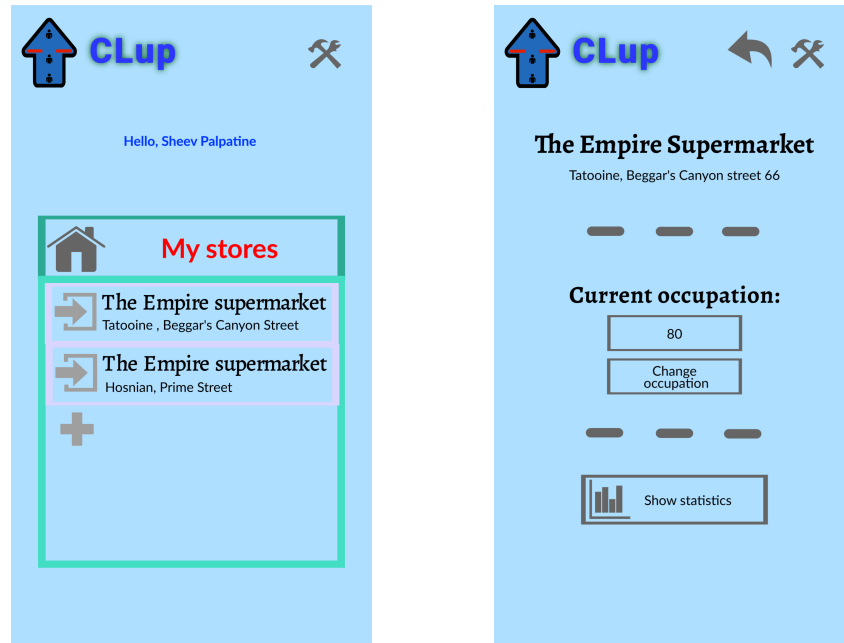
- register a store to the system
- delete a store from the system
- view and edit occupation for currently registered stores

3.1.2 Hardware interfaces

The S2B requires the following hardware interfaces:

1. **Computer or smartphone**

Users will need a computer or a smartphone to access the system's services which are provided via an application (only for smartphone owners) and a web application. Only users with an application will be able to receive notifications that alert them when it is time for them to depart and reach the store.



2. Turnstiles

Turnstiles allow authorized customers to enter or exit the store by providing a means of identification. (i.e. QR, NFC)

3. Ticket printer

The ticket printers located outside stores allows potential customers to queue up on premise provided that they identify themselves (e.g. social security card).

4. Monitor

A monitor located outside stores allows customers that queue up on premise to know when it is time for them to access the store.

3.1.3 Software interfaces

The system uses a public API to locate the customer and provide him/her with notifications about the time he will need to depart to reach the store.

3.1.4 Communication interfaces

Customers can access the system through a working internet connection.

3.2 Functional requirements

3.2.1 List of requirements

- R1 Turnstiles only unlock when activated by authorized customers.
- R2 The number of customers in the store never exceeds the occupation set by the owner.
- R3 The monitor outside the store shows the number of the last authorized customer.
- R4 The system allows customers and store owners to register and log in.
- R5 The system must be able to validate the authenticity of the identifying information provided in registration requests.

R6 The system allows customers to search for a store among those registered by their owners.

R7 Registered customers can send a reservation request to the system.

R8 Registered customers can specify information about their visit (e.g. estimated duration, desired category of products).

R9 The system must use gathered data to build statistics.

R10 The system provides customers with means to verify that they are authorized.

3.2.2 Mapping on requirements

3.2.3 Use case diagram

3.2.4 Use cases

3.2.4.1 Customer registration

Name	Customer registration
Actors	Customer
Entry condition	Customer has opened the smartphone application or the web app on his computer but has not logged in
Event flow	<ol style="list-style-type: none"> 1. a registration menu is provided to the customer 2. from such menu the customer selects the option to sign up as customer 3. the customer is then prompted to insert identifying information 4. the customer inserts requested information 5. the system validates provided information 6. the system confirms the registration of the customer and saves information provided
Exit conditions	Customer has registered to the system
Exceptions	<ol style="list-style-type: none"> 1. a customer with same identifying information already exists 2. validation of identifying information is not successful 3. the customer decides to cancel the registration <p>If one of the first two events described above occur, the application will alert the customer and provide him with the possibility to retry or go back to the initial menu.</p> <p>If event 3 occurs the customer is redirected to the main page.</p>

3.2.4.2 Store owner registration

Name	Store owner registration
Actors	Store owner
Entry condition	Store owner has opened the smartphone application or the web app on his computer but has not logged in
Event flow	<ol style="list-style-type: none"> 1. a registration menu is provided to the store owner 2. from such menu the store owner selects the option to sign up as store owner 3. the store owner is then prompted to insert identifying information 4. the store owner inserts requested information 5. the system validates provided information 6. the system confirms the registration of the store owner and saves information provided
Exit conditions	Store owner has registered to the system
Exceptions	<ol style="list-style-type: none"> 1. a store owner with same identifying information already exists 2. validation of identifying information is not successful 3. the store owner decides to cancel the registration <p>If one of the first two events described above occur, the application will alert the store owner and provide him with the possibility to retry or go back to the initial menu.</p> <p>If event 3 occurs the store owner is redirected to the main page.</p>

3.2.4.3 Customer queuing up remotely

Name	Customer queuing up remotely
Actors	Customer
Entry condition	Customer has logged in on the smartphone application or the web app on his computer
Event flow	<ol style="list-style-type: none"> customer selects the option to queue up from main menu customer selects a store from the list of stores registered to the system customer selects to queue up <ul style="list-style-type: none"> with an immediate reservation with a future reservation (and optionally inserts desired categories of item he/she intends to buy and how much time he/she intends to spend at the store) customer specify whether he is going to reach the store by car or on foot customer submits reservation request
Exit conditions	Customer reservation is confirmed
Exceptions	<ol style="list-style-type: none"> customer decides to cancel the reservation customer requests immediate reservaiton but store is closed at that time <p>If one of the events described above occur, the application will alert the customer and go back to the initial menu</p>

3.2.4.4 Customer queuing up on premise

Name	Customer queuing on premise
Actors	Customer
Entry condition	Customer has reached the store ticket printer
Event flow	<ol style="list-style-type: none"> 1. customer selects the option to queue up from main menu of the ticket printer 2. customer provides the ticket printer with a means of identification (e.g. social security card)
Exit conditions	<p>Customer reservation is confirmed and a ticket is printed containing the following information:</p> <ul style="list-style-type: none"> • how much time he needs to wait before being able to enter the store • a progressive number that will allow him to know when his/her turn is
Exceptions	<ol style="list-style-type: none"> 1. customer decides to cancel the reservation <p>If one of the events described above occur, the application will alert the customer and go back to the initial menu</p>

3.2.4.5 Customer entering store

Name	Customer entering store
Actors	Customer
Entry condition	Customer has logged in on the smartphone application and is at the entrance of a store or has printed authorization from the web app
Event flow	<p>If customer has a smartphone:</p> <ol style="list-style-type: none"> 1. customer selects the option to show existing reservations from main menu of the phone app 2. customer selects an existing reservation and if authorized (i.e. it is his turn to enter the store) he/she is given the means to identify him/herself (e.g. display QR or activate NFC) <p>Then the customer identifies him/herself at the turnstiles</p>
Exit conditions	Customer enters the store
Exceptions	<ol style="list-style-type: none"> 1. customer is not authorized to enter the store <p>If the event described above occurs, the turnstiles will not let the customer in</p>

3.2.4.6 Customer exiting store

Name	Customer exiting store
Actors	Customer
Entry condition	Customer has logged in on the smartphone application and is in a store
Event flow	<ol style="list-style-type: none"> 1. customer selects the option to show existing reservations from main menu 2. customer selects an existing reservation and if authorized (i.e. it is his turn to enter the store) he/she is given the means to identify him/herself (e.g. display QR or activate NFC) 3. customer identifies him/herself at the turnstiles
Exit conditions	Customer exits the store
Exceptions	

3.2.4.7 Store owner registering a store

Name	Store owner registering a store
Actors	Store owner
Entry condition	Store owner has logged in on the smartphone application or the web app on his computer
Event flow	<ol style="list-style-type: none"> 1. store owner selects the option register a store from main menu 2. store owner inserts necessary information and sets up equipment (i.e. connect printer, monitor and turnstiles to the system) 3. store owner submits store registration request
Exit conditions	Store registration is confirmed
Exceptions	<ol style="list-style-type: none"> 1. information is missing or incorrect 2. equipment is not working properly 3. store owner decides to cancel the store registration <p>If one of the events described above occur, the application will alert the store owner and provide him with the possibility to retry or go back to the initial menu</p>

3.2.4.8 Store owner setting maximum occupation of one of his stores

Name	Store owner setting maximum occupation of one of his stores
Actors	Store owner
Entry condition	Store owner has logged in on the smartphone application or the web app on his computer
Event flow	<ol style="list-style-type: none"> 1. store owner selects one of his stores from the list reachable from the main menu 2. store owner views current occupation of his store, and current occupation threshold 3. sets the new desired occupation threshold
Exit conditions	The new occupation threshold is set
Exceptions	<ol style="list-style-type: none"> 1. the threshold value is inadequate <p>If the event described above occurs, the application will alert the store owner and provide him with the possibility to retry or go back to the initial menu</p>

3.2.5 Sequence diagrams

3.2.6 Scenarios

3.2.6.1 Customer queues up remotely Gordon comes home from work at 5:30 PM. He would like to go to the store. He is a registered user of CLup. His smartphone has internet connection and GPS on. He opens the CLup mobile application and requests an immediate reservation to a store of his choice, selecting the car as means of transport. After some time he is alerted that he needs to depart to avoid being late at the store and losing the reservation. Pietro departs and arrives to the store. He opens the application and selects the reservation he created which now contains the number that represents his position in the queue. After some time the monitor outside the store shows his number, which means it is his turn to enter. He activates the turnstiles with the QR now shown in the reservation page of the mobile application and enters the store. He buys all the products he needs. He opens the application and selects the reservation he created which now contains a QR code. He activates the turnstiles and exits the store.

3.2.6.2 Customer queues up on premise Marco is an old man. He does not have a smartphone. He would like to go to the store next to his house on foot. He reaches the store, and retrieves a queue reservation ticket from the printer outside the store, by inserting his social security card. The ticket displays a QR code and a number that represents his position in queue. After some time the monitor outside the store shows his number, which means it is his turn to enter. He activates the turnstiles with the QR printed on his ticket and enters the store. He buys all the products he needs. He activates the turnstiles with his ticket and exits the store.

3.3 Performance Requirements

The system cannot guarantee that a customer can enter a store at a precise time unless it requires users to exit after a maximum time (which it doesn't). The system guarantees that if

- the customer never disconnects from the internet and GPS
- the customer specified the correct means of transport when creating the reservation

he/she will be alerted when he needs to depart to reach a store (in order not to be late) with a delay of at most 10 seconds.

3.4 Design Constraints

3.4.1 Standards compliance

The code should follow the requirements contained in this document, and be thoroughly commented.

3.4.2 Hardware limitations

The software the customer uses requires either:

- a smartphone to use the smart application
- a computer to use the web application and a home printer to print reservation

The software the store owner uses requires both:

- turnstiles activated by QR
- reservation printer activated by social security card

3.4.3 Any other constraint

Customers cannot have more than three active reservation requests for different stores and more than one for the same store.

3.5 Software System Attributes

3.5.1 Reliability

The system must have an appropriate infrastructure with a full backup system located in an separate office distant at least 100km (nuclear fallout radius). Adequate personnel will guarantee recovery time to substitute faulty hardware.

3.5.2 Availability

The system should be up for 99% of the time (3.65 MTTR) since its temporary downtime does not cause emergency situations. The system is fully automated. The users are alerted about system downtime with a delay of at most 10 minutes. The users are alerted that the system is up again with a delay of at most 10 minutes.

3.5.3 Security

The location of customers is sensitive information and therefore is never stored. Customers and store owners provide identifying information during registration: the databases containing such information must be protected against internal and external attacks. Communication between central system and users is encrypted.

3.5.4 Maintainability

The system is easy to maintain: its code is thoroughly commented and modular. Appropriate design patterns are exploited.

3.5.5 Portability

The smartphone application runs under Android and iOS. The web application runs under Android, iOS, Windows, MacOS.

4 Formal Analysis Using Alloy

```
sig Customer{
    opens: set Reservation
}

sig StoreOwner{
    owns: set Store
}

sig Store{}
{
    -- store has at most one owner
    no s: Store, disj o1, o2: StoreOwner | s in o1.owns and s in o2.owns
    --store has at least one owner
    all s: Store | some o: StoreOwner | s in o.owns
}

abstract sig Reservation{
    refersTo: one Store
}
{
    -- reservation is opened by at most one customer
    no r: Reservation, disj c1, c2: Customer | r in c1.opens and r in c2.opens
    -- reservation is opened by at least one customer
    all r: Reservation | some c: Customer | r in c.opens
}

sig ImmediateReservation extends Reservation{}
sig FutureReservation extends Reservation{}
sig OnPremiseReservation extends Reservation{}

pred show{
    #Customer >=3
}

run show for 5
```

5 Effort Spent

Provide here information about how much effort each group member spent in working at this document. We would appreciate details here.

5.1 Simone Abelli

Introduction	3.5
UML class diagram	4
Product perspective	3
State charts, External interface requirements	3
User interfaces	3
Requirements	3

5.2 Stefano Azzone

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Product functions, user characteristics, domain assumptions	2
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Use cases	2
Started alloy section	2
Requirements	3
Performance Requirements, Design constraints, Software system attributes, first two scenarios	1

References

- [1] S. Bernardi, J. Merseguer, and D. C. Petriu. A dependability profile within MARTE. *Software and Systems Modeling*, 10(3):313–336, 2011.