1. INTRODUCTION

1.1. Purpose

CLup aims to provide a reliable solution to the problem of people gathering inside and outside stores.

To face the problem, the application focuses on its principal causes, which are the management of people inside the store, that often leads to overcrowding, the effectiveness of standard queuing systems and the way people are allowed to visit the stores. Moreover, the system aims to provide a useful tool for store managers in order to help them in administering stores and monitoring their status.

In particular, the main goals that CLup aims to achieve, summarized in the table below, are the following:

- Prevent the store from being overcrowded, in order to avoid indoor gatherings while maximizing its occupancy, by means of a better access management system
- Reduce gatherings of people waiting to enter outside the store, providing a way to virtualize queues
- Provide a more efficient way to access stores, reducing the time customers waste while waiting to do it
- Help store managers in monitoring the status of the store and regulating the influx of people

1.1.1. Goals

G1	Prevent the store from being overcrowded while maximizing its occupancy
G2	Reduce gatherings of people waiting to enter outside the store
G3	Reduce the time customers waste while waiting to access the store
G4	Help store managers in monitoring the status of the store and regulating the influx of people

1.2. Scope

During the current situation of emergency, it is fundamental to prevent contacts among people. For this reason, governments impose strict rules concerning social distancing, both for indoor and outdoor contexts.

However, crowding management inside stores like supermarkets and grocery shops could be challenging. Currently, stores limit the maximum number of people allowed, and therefore long queues arise: entering a store for a few minutes might even require hours. Moreover,

customers who see a crowded store might avoid lining up to save time and prevent contact with others.

CLup fits into this context allowing customers to remotely line up in a queue and to be notified when they should head toward the store. Furthermore, it allows the customer to book a visit for a store on a specific day and time, which grants him priority over the queued customers.

CLup interacts with the outside world thanks to two distinct interfaces: one is an easy-to-use smartphone application designed for the customers, while the other is an administrative tool that allows store managers to add their shop to the system and modify some of its parameters.

Moreover, CLup also provides a physical proxy outside the stores as a fallback option for users who want to line up but do not have access to the application.

1.2.1. World phenomena

The following table illustrates the phenomena that happen in the real world and affect the system, which cannot control or detect them.

WP1	A person reaches the store
WP2	Some people gather in a specific area of the store
WP3	People wait in front of the store
WP4	The store opens
WP5	The store closes

1.2.2. Shared phenomena

The following table illustrates the phenomena that happen in the real world and can be observed or managed by the system. The following notation is used:

- MC for machine controlled phenomena (observed by the world)
- MO for machine observed phenomena (controlled by the world)

SP1	A customer requests to join the queue from the application	MO
SP2	A customer requests to join the queue using the physical proxy	MO
SP3	An alert is sent to the customer when he should reach the store	MC
SP4	A customer cannot reach the store in time anymore	MO

SP5	A customer is allowed to enter the store	MC
SP5.1	A customer enters the store	MO
SP6	A customer leaves the store	MO
SP7	A customer requests to book a visit to the store	MC
SP7.1	A customer specifies the estimated duration of the visit	MO
SP7.2	A customer specifies which kind of products wants to buy	MO
SP7.3	The system suggests booking alternatives to the customer	MC
SP7.4	The system accepts a booking request	MC
SP7.5	The system rejects a booking request	MC
SP8	The system notifies the customer when specific stores are becoming unavailable	MC
SP9	The store manager specifies the maximum occupancy of the store	MO
SP10	The store manager specifies the maximum occupancy of the product sections	MO
SP11	The manager monitors the status of the store	MO

1.3. Definitions, acronyms, abbreviations

WPx	World phenomena number x, according to the table of world phenomena
SPx	Shared phenomena number x, according to the table of shared phenomena
CLup	Also known as the system. It is the software to be developed
Customer application	Also known as application. It is used to access the functions provided by CLup
Administrative tool	The tool provided to store managers in order to administer stores
Proxy	The physical fallback option for customers that want to use CLup but cannot use the application

Turn Announcement System	A system which informs customers about who is allowed to enter the store
Access Management System	A system which regulates physical entrances and exits to the store it is associated with
App-customer	A customer who uses CLup functions through the application
Proxy-customer	A customer who uses CLup functions through the proxy
Current occupancy	Also known as occupancy. It can be referred to the store or one of its sections. It is the number of people inside it
Maximum occupancy	Refers to the store or one of its sections. It is the maximum number of people allowed to be in that area
Visit	With respect to a customer and a store, it is the representative event of entering, doing the shopping and exiting
Virtual queue	Also known as access queue or simply queue. It represents the set of customers who lined up through the app or the proxy
Line up	With respect to a customer and a store, it is the event of joining the queue
Visit request	A customer's request to visit a store. It can be either a line-up request or a booking request
Line-up request	A request made by the customer to line up for a store
Booking request	A request made by the customer to book a visit for a store
Visit token	A unique token bound to a visit request. It allows the Customer to enter and exit the store

1.4. Revision history

1.0 - First version of the document (DATA FINALE)

1.5. Reference documents

IEEE standard for Software Requirements Specifications, IEEE 29148-2018

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1.6. Document structure

The reference structure used for the document is the one suggested by professor Matteo Rossi of Politecnico of Milan. It is derived from the IEEE standard, which is used as a detailed reference source (IEEE standard for Software Requirements Specifications, IEEE 29148-2018).

Chapter 1 is an introduction to the software to be designed and developed and to the problem that it addresses. It presents the goals that should be achieved and an analysis of the context in which the system will be placed.

Chapter 2 is a more detailed description of the system to be realized, focused especially on a more detailed description of the context, e.g. presenting scenarios and the actors involved, on the product functions and on its requirements. Furthermore, it contains explicit constraints, dependencies and domain assumptions.

Chapter 3 includes specific requirements, with a level of detail sufficient to enable designers to design a system to satisfy those requirements, and testers to test that the system satisfies those requirements. It includes the description of all the functional and nonfunctional requirements, together with the description of the external interfaces, of the use cases and of eventual design constraints.

Chapter 4 is a formal analysis of the system using the Alloy model, showing also some worlds obtained running the model.

Chapter 5 contains a report on the effort spent by all the members of the group while writing the current document.

2. OVERALL DESCRIPTION

2.1. Product perspective

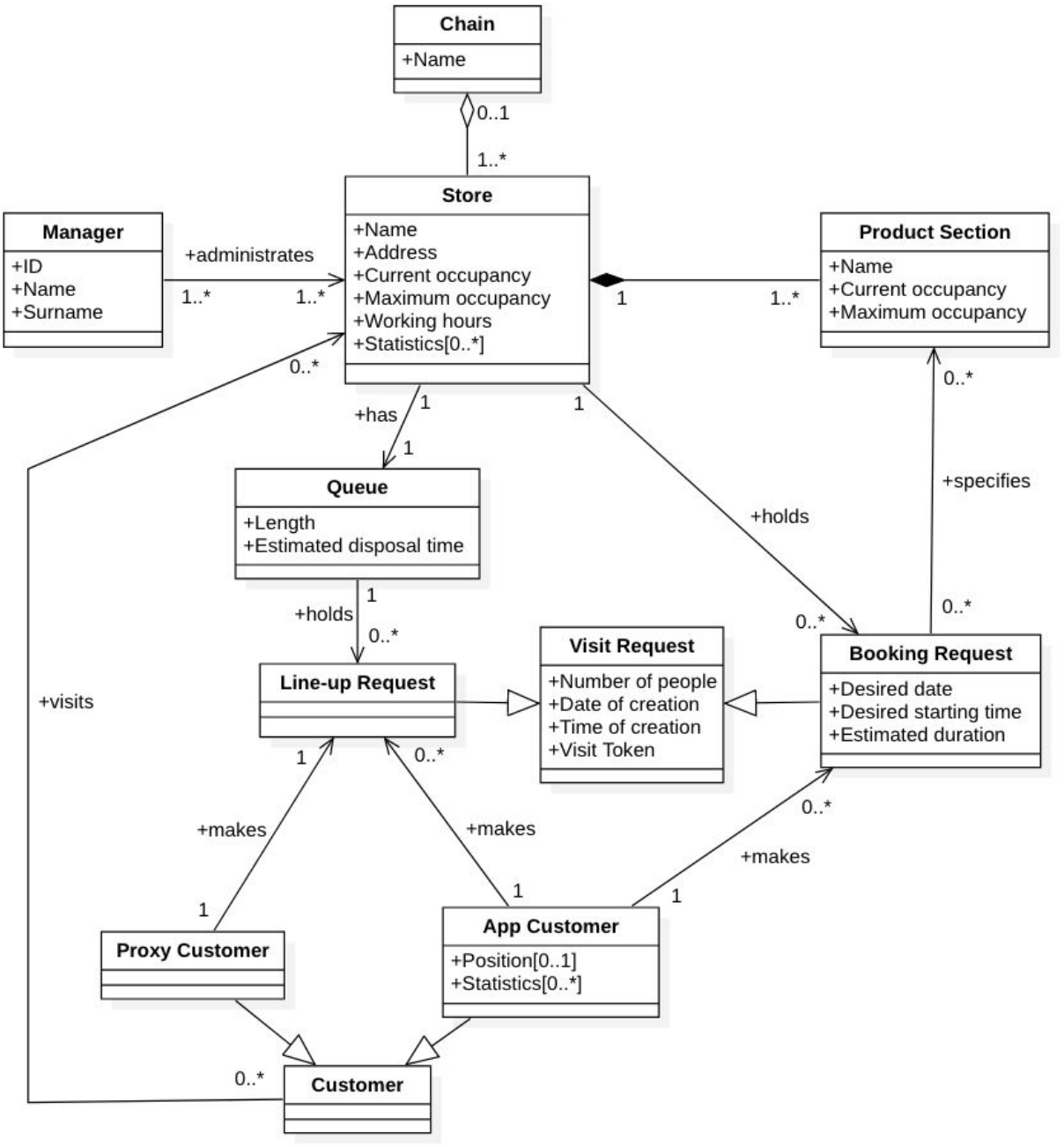
2.1.1. UML Class Diagram Description

CLup is intended to manage a chain of stores or, alternatively, a single store. Each chain is identified by a name and is associated with its stores.
Each store, which is composed of different product sections, is visited by customers and has at least one manager who administers it. Each manager is identified by a unique id. A store also maintains a queue of line-up requests made by customers and holds booking requests made by app-customers. Both the length and the estimated disposal time of the queue depends on the number of line-up requests which are held by the queue.

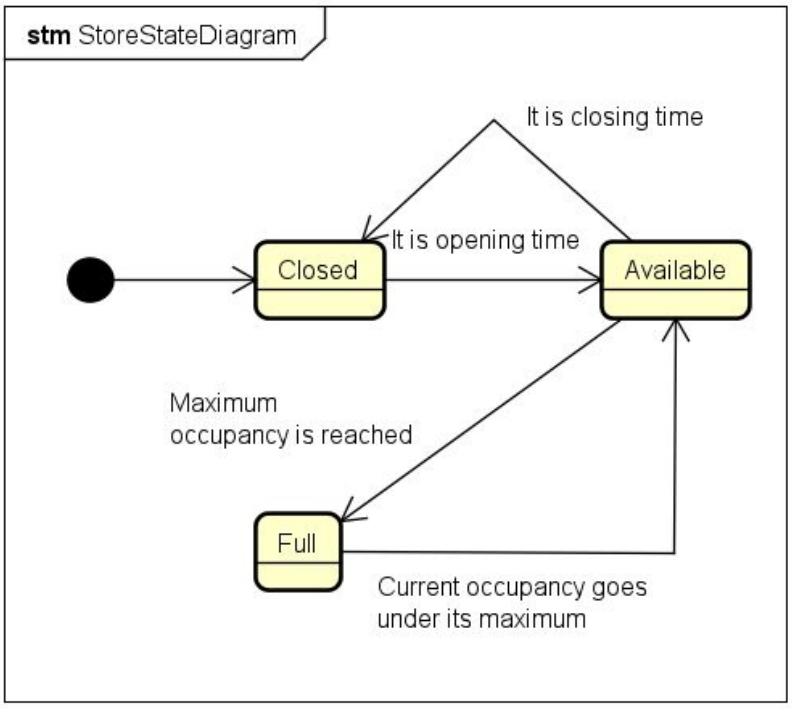
Customers make a line-up request every time they want to get in line for visiting a store.
Each booking request includes information about a scheduled visit. They can be associated with a set of store sections and are held by the store.
Line-up and booking requests are both types of visit requests, which are identified by a unique visit token and include the number of people who want to access the store.

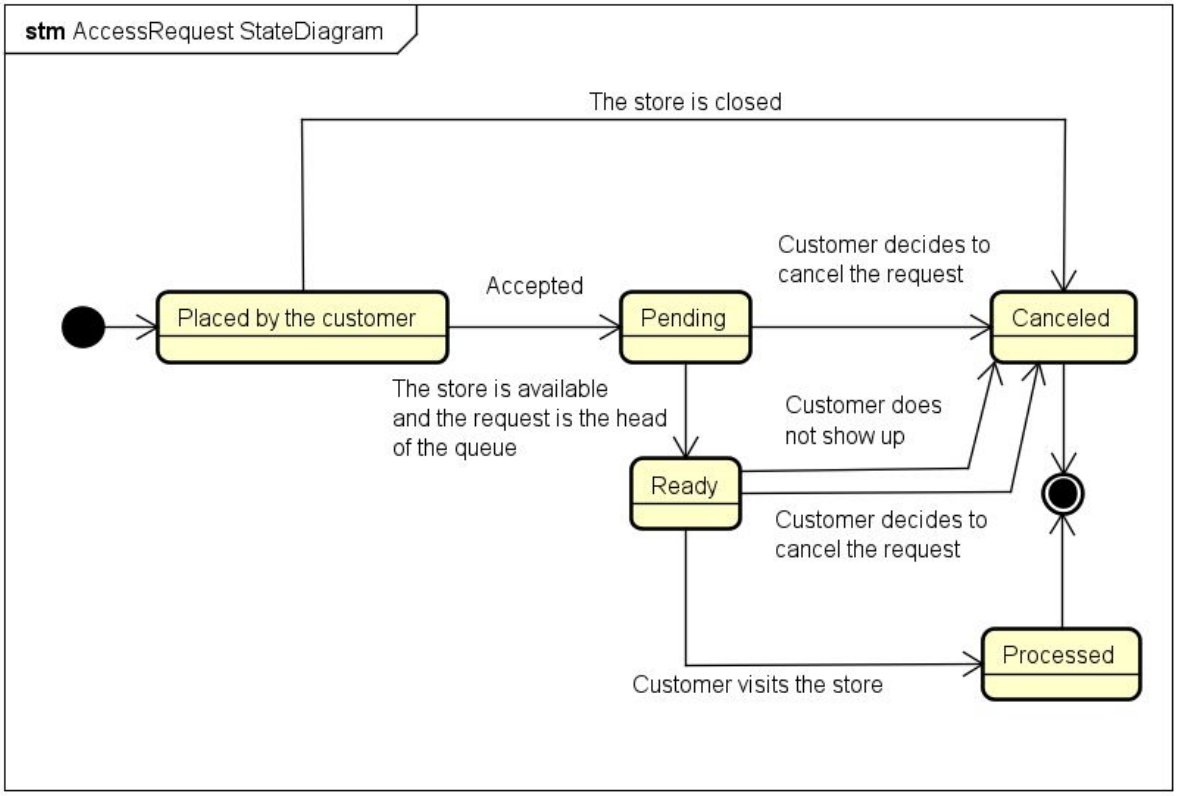
Both stores and app-customers can have statistics associated with.

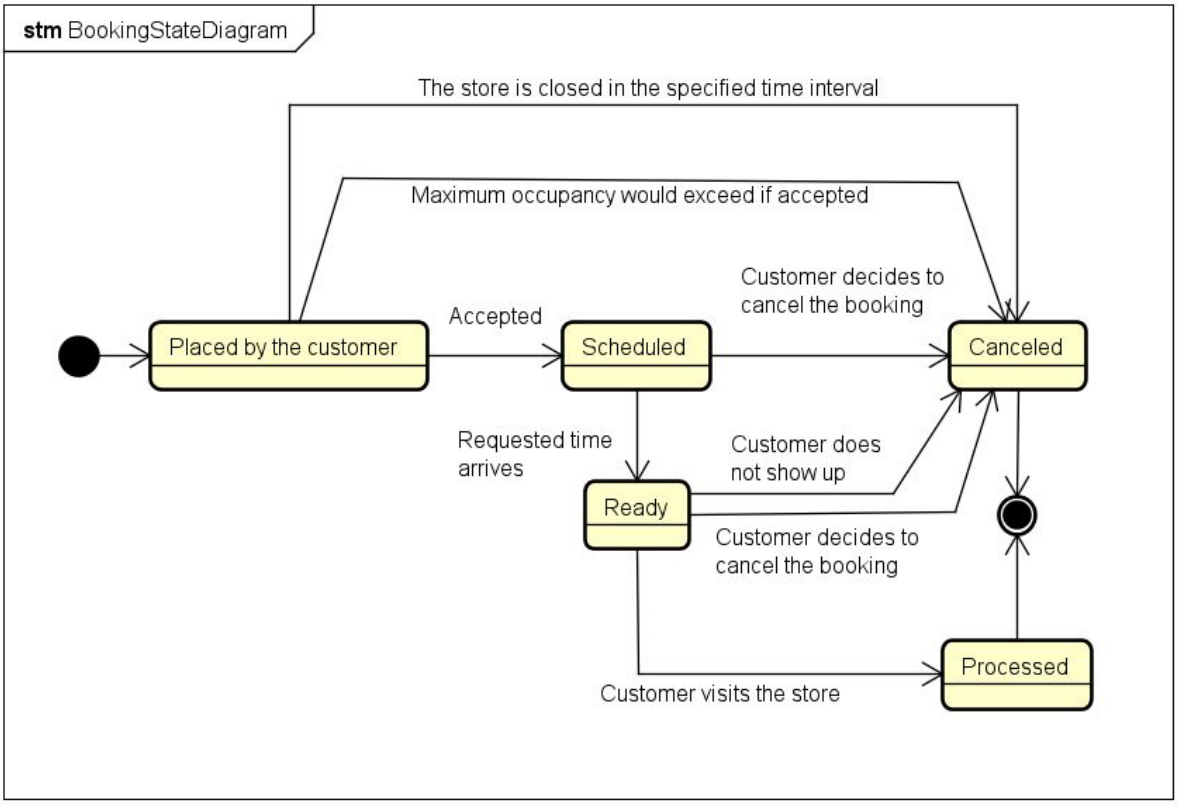
2.1.2. UML Class Diagram



2.1.3. Statecharts






stm BookingStateDiagram
The store is closed in the specified time interval
Maximum occupancy would exceed if accepted
Customer decides to cancel the booking
Accepted
Placed by the customer
Scheduled
Canceled
Requested time arrives
Customer does not show up
Ready
Customer decides to cancel the booking
Processed
Customer visits the store

2.1.4. Scenarios

Remotely line up for a store
Alice is at home and wants to do some grocery shopping at the store at the end of the street. She opens CLup and checks the store's current queue and the estimated time required to enter. She decides to get in line and starts doing something else. After some time, she receives a notification that suggests her to start heading the store. Thus, she reaches the store. Since it is her turn, she opens the app in order to get access to the store. When she is done with her shopping and payment, she opens the app in order to exit the store.

Line up for a store using the proxy
Bob is a 70-year-old man who is not so keen on using a smartphone, so he has not got any. He has to buy something at the minimarket near his house. He takes a visit token from the proxy located outside the store and waits along the street waiting his turn to come. When it is his turn, he is informed by the Turn Announcement System of the store and shows the visit token to be authorized to enter it. When he is done with his shopping and payment, he shows the visit token in order to exit the store.

Booking a visit for a store
Chuck is at work and he wants to do some shopping before coming back home. Since there are often many people in line to enter the store he wants to go to, he opens the CLup client and books a visit to the store for a specific time interval. Before reaching the store he must pick up his son from school, so he specifies that two people will visit the store. When the time arrives, they have priority over the people in the queue. Since it is their turn, Chuck opens the app in order to get access to the store. After the payment, he opens the app in order to exit the store.

Active suggestions for long-term customers
Isaac wants to book a visit for Saturday at noon. Since he is a long term customer, CLup provides him with an estimated duration of his visit, based on his previous statistics. However, the system also informs him that, for the selected time interval, the store is often crowded, and so suggests to him different alternatives. Sadly, George can only do shopping in the indicated one, so he places his booking anyway.

Booking alternatives are suggested
Emanuele lives near the store in "via Rubattino" and wants to do some grocery shopping next Saturday morning at 11 a.m. However, that store is already at its maximum occupancy in the selected time interval due to previous bookings by other users. So, the system provides two alternatives: the first one is to book a visit on the same day at 6 p.m., when the store, according to bookings and statistics, will be less crowded; the second one is to book a visit for the same time interval in another store of the same chain, which is less crowded than the Rubattino one. Emanuele chooses an option and fulfils his need.

There is always a way out
Giancarlo is a long term CLup user. After waiting from home, he reaches and correctly enters the store. After the payment, he notices that his phone ran out of battery so asks for help from

a store manager, who manually allows him to exit the shop. The occupancy of the shop is then automatically updated.

Overlapping bookings
Yesterday, Christian booked a visit to the local shop for Monday morning at 9 a.m., specifying the kind of products he intends to buy.
Davide is now trying to book a visit for the same time interval but is not sure about what he will buy, so he does not specify anything. However, since the system does not know where Davide will be inside the store, it assumes that Davide wants to visit the whole store. Thus, it rejects his booking request because, if accepted, the store would exceed its maximum occupancy.
Later, Lia tries to book a visit for that time interval too. She specifies what kind of products she intends to buy, which happen to be different from Christian's ones. The system then accepts her booking request, since the two will not meet inside the store and then its occupancy will still be under its maximum.

Forgetting about the visit
Vincenzo is a forgetful man. When his turn comes, he is not outside the store. CLup detects Vincenzo is not showing up and allows another customer to enter.

2.2. Product functions

CLup is intended to reach the goals introduced in Section 1.1.

It regulates the influx of people in a store to prevent it from being overcrowded. To do so, CLup provides a way to authorize the entrances to the shop with respect to the number of people inside it.

CLup uses unique visit tokens to authorize each customer to enter and exit the store. If the customer uses the application, the visit token will be available in the application itself. Instead, each time a customer uses the proxy of a given store, a visit token is physically provided by the proxy itself.

All the accesses are granted with respect to the store maximum occupancy. This parameter, the maximum occupancy of each product section and other details are specified by store managers in the administrative tool offered by CLup, from which they can also monitor the shop status and statistics, such as how many people are inside the store and the average time spent in the shop.

In order to reduce the possibility of queues forming outside the store, CLup provides the possibility to remotely line up in a queue. A customer can join the queue either using the application offered by CLup or by means of the proxy placed outside the store. To reduce the risk of people reaching the store too early or too late, the system allows customers to see the number of people ahead of them. It also provides a reasonably precise estimation of the waiting time both before and after joining the queue. Furthermore, CLup alerts app-customers when they need to reach the store, taking into account the time they need to get to the shop from their current position with respect to the time at which they will be authorized to enter it. Eventually, the system informs customers when they are allowed to enter the store through the Turn Announcement System and notifications for app-customers.

An app-customer can also use the application to book a visit to the shop. Doing so, he has to specify when he wants to reach the store, the expected duration of the visit and, if he wants, which kind of products he intends to buy. In case of long-term customers, the estimated duration of the visit can also be provided by CLup, based on statistics.
All these data are used by the system to manage who can enter the store in a specific time interval.

When a booking is placed, the system can also decide to reject it if, across the specified time interval, the bookings placed by other customers already maximize the store occupancy. The system also tries to balance the number of customers across all the working hours of the store. In both cases, it suggests alternative time intervals or alternative stores of the same chain when a customer is booking a visit.

CLup is able to manage the case in which, for any reason, a customer does not show up while he is allowed to enter the store and other people are waiting to enter it. Moreover, app-customers can always cancel their visit requests (both line-up and booking requests), if needed.

CLup monitors customer attitudes in order to build the previously mentioned statistics. App-customer attitudes are collected through the application itself. Data about customers who use the physical proxy are collected too, but they cannot be used to build individual statistics.

App-customers can choose to be notified about the availability of specified stores. Indeed, a customer can specify one or more recurrent time intervals in which he is interested in visiting the store. These intervals can also be inferred by the system based on the customer's statistics, if they are available. The system will notify him if, during one of those time intervals, the store is reaching its maximum occupancy. Doing so, the customer can take the opportunity to visit the store by booking or lining up.

2.3. User characteristics

Store manager: he adds his chain store to CLup and modifies its parameters, such as the working hours and the maximum occupancy. He also specifies the different product sections that compose the store and their relative maximum occupancies. He can also keep track of the real-time store occupancy, and might let people in and out of the store, if needed.

Customer: he uses CLup in order to visit a store of a given chain. To do so, he can either line up in the CLup queue, by means of the application or the proxy, or also book a visit through the application.

Access Management System: it is the system which regulates physical entrances and exits to the store it is associated with. It communicates with CLup in order to determine if a customer is allowed to enter it or not, and informs CLup whether the visit begins or ends.

Turn Announcement System: it receives information from CLup about customers allowed to enter the store it is associated with, in order to inform the ones waiting outside the store.

2.4. Assumptions, dependencies and constraints

2.4.1. Table of domain assumptions

A1	Opening and closing time of the store are respected
A2	If the number of people inside each product section is below their maximum occupancy specified by store managers, then safety is guaranteed inside the store
A3	Only customers authorized by CLup can enter and exit the store
A4	On average, the information provided by customers is correct
A4.1	The number of people associated with each line-up request and with each booking request is never exceeded when the visit takes place
A5	Customers who have access to the application prefer to use it rather than the proxy

2.4.2. Table of dependencies

CLup depends on an external system, the Turn Announcement System. Their interaction allows all the customers to be informed about who is allowed to enter the store. This system must be able to reach every type of customer and be able to provide other useful information.
CLup depends on an external system, the Access Management System. Their communication lets only customers authorized by CLup visit the store.

2.4.3. Constraints

The system must provide a fallback option that allows customers who cannot use the application to line up and visit the store.