



Politecnico di Milano
Department of Computer Science and
Engineering

Software Engineering 2

**CLup – Customers Line-up
Requirements Analysis
and
Specification Document**

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Chapter 1

Introduction

1.1 Purpose

1.1.1 Description of the Given Problem

1.1.2 Goals

We identified the following goals:

- [G1]: Keep customers in safe condition w.r.t the "*decreto del Presidente del Consiglio dei ministri*" (d.P.C.m) in force inside the store.
- [G2]: Limit the physical line situation in the proximity of the store.
- [G3]: Allow customers to line up from a remote device.
- [G4]: Allow store manager to monitor entrances.
- [G5]: Allow customers to line up from a physical spot.
- [G6]: Allow customers to book a visit from a remote device.

1.2 Scope

1.3 Definitions, Acronyms, Abbreviations

1.3.1 Definitions

Customer	a person who buys goods from the stores. We will use the term <i>customers</i> to refer to natural persons, instead the term <i>users</i> will be used to specify the virtual entity served by the application.
Store Manager	a person who is in charge of the store. In our context, we assume that the <i>store manager</i> controls the entrances to the store with the help of CLup service. In the real world scenario this activity can be delegated, without loss of generality.
Physical Spot	a digital device positioned outside the store that allows customers to obtain tickets to line up.
User	a virtual entity that interacts with the virtual service offered by CLup. The user can be a customers, a store manager and a physical spot (when it is acting as proxy). In case of ambiguous interpretations, we will specify the real entity name.
Proxy	an intermediary entity that exchanges information between two other entities. In our system, the physical spot can be seen as a proxy, since it allows customers to line up without the necessity to create an user account. From the point of view of the server, the physical spot is seen as an user.
Virtual Queue	a queue of users allocated in the memory of the server. When a user asks for a lining up operation, or a booking a visit operation, it is allocated in this queue.
Physical Queue	a queue of customers outside the store.
Ticket	a piece of paper or a virtual card given to customers to show that they have performed a lining up or a booking a visit operation.
QR code	a matrix composed by white and black squares encoding a string. It is reported on the ticket.
System	we use this term to represent the entire service, composed by smartphone application and servers.
Application	program executable on smartphones.

1.3.2 Acronyms and Abbreviations

API	Application Programming Interface
-----	-----------------------------------

CHAPTER 1. INTRODUCTION

CLup	Customers Line-up
d.P.C.m	<i>"decreto del Presidente del Consiglio dei ministri"</i>
FIFO	First In First Out
GPS	Global Positioning System

1.4 Revision History

1.5 Reference Documents

1.6 Documents Structure

Chapter 2

Overall Description

2.1 Product Perspective

2.2 Product Functions

In this section are described the main functionalities offered by the service.

2.2.1 Lining Up

In light of the motivations described in the previous sections, the main purpose of the application is to allow customers to line up from remote.

To achieve this result, the application provides the possibility to line up from the smartphone. The users have to log in the application, select the lining up operation, choose the store (in which they want to go) and confirm. Once the operation has been completed successfully, users are able to check the status of the queue and watch the QR code associated to the lining up. Moreover, users will receive live notifications about the status and the remaining time to be authorized to enter in the store. When the countdown is ending, customers have to approach to the store and wait outside for the call of their ticket number (showed with the QR code). At this time, they have to show the QR code to be scanned by the system and to be authorized to enter.

From the point of view of the server, when it receives the request, it has to check if the user can be allocated in the virtual queue and in which position. If it can, the user will be allocated, otherwise it will reply with an error message. The application sends to the server information about the global position of the customer. These information are used to estimate the time necessary by the customer to arrive to the store. All the collected information are used to schedule the entrances to the store. More precisely, the algorithm takes into account the position of the customer, to infer the cruise speed and the time needed to arrive, the number of customers already inside the store, the number of customers previously allocated to the virtual queue and the number of customers in the physical queue. The server can infer the residence time in the store looking at previous purchases of the same user or by computing the average residence time of the customers. Based on these data, the order in which customers ask for a lining up operation can be different by the allocation order

in the virtual queue. In case of huge delays (parameter that can be controlled by the store manager) by the customers, the virtual queue can be reorganized dynamically.

2.2.2 Booking a Visit

This functionality is an extension of the previous one, in particular it allows to specify the date and time to visit the store.

To book a visit, customers should select the corresponding button from the menu of the application, insert the requested data, such as the store in which they want to go, the date, the slot time, the category of grocery they want to buy (it is not mandatory), and confirm the operation. As for the lining up operation, customers can check the status and the obtained QR code.

From the point of view of the server, the behavior is similar to the lining up, but in this case it can infer more information from the category of grocery specified, such as the section in the store that will be visited by the customer. If not specified, the server can infer information from previous purchases. In any case, the server can allocate users in a finer way in the virtual queue exploiting these data: knowing the maximum capacity of the store and the section with higher density of customers, it can decide if an user has to be allocated in one or another slot of time.

2.2.3 Lining Up from Physical Spot

If a customer hasn't an user account, or if he doesn't want to use (or can't use) the smartphone application, he can line up from a physical spot installed outside the store. The physical spot is a digital device that runs the same smartphone application used by other users, but with less functionalities. From the physical spot, a customer can line up clicking on a button to confirm the operation and the spot will print the ticket showing the QR code and the ticket number.

The physical spot acts as proxy. The physical spot is logged in the application with a custom account. In this way customers haven't to insert the credentials when they perform a lining up operation. The server retrieves the missing information (destination store, position of the customer, etc.), about the lining up, by the association between the physical spot account and the associated store (It can be best appreciated in 3.11). In this way the physical spot can be treated as a common user.

2.2.4 Monitoring and Controlling the Queue

These are functionalities dedicated to the store manager. Since the system performs different estimations, it can occur that the real situation differs from the theorized sequence of events. To handle this possibility, the store manager can monitor the status of the queue and the number of customers inside and outside the store from his device and decide if the server has to schedule in a different way the users arrivals. To do that, the application provides a different home page, if you are logged in with a store manger account, that provides buttons and interfaces to get the status of the situation and to set scheduling parameters that the server will use. In extreme cases he can stop issuing tickets.

2.3 User Characteristics

2.4 Assumptions, Dependencies and Constraints

Below has been reported the list of our domain assumptions.

- [D1]: There is a d.P.C.m in force.
- [D2]: Customers follow the rules imposed by the d.P.C.m in force.
- [D3]: Customers enter in the store only if the system authorizes them.
- [D4]: Customers don't stay in the shop longer than necessary and they go away from the store after they have done their shopping.
- [D5]: Customers line up physically only if they have a valid (non expired) QR code.
- [D6]: Outside the store there is space to queue.
- [D7]: Customers have a smartphone.
- [D8]: Customers have installed the CLup application.
- [D9]: Customers allow the permissions requested by the application.
- [D10]: Customers keep Internet connection active.
- [D11]: There is a store manager present in the store.
- [D12]: Store managers allow the permissions requested by the application.
- [D13]: Store managers keep Internet connection active.
- [D14]: Physical spots are powered on every working day.
- [D15]: Physical spots are refilled when asked by the system.

Chapter 3

Specific Requirements

3.1 External Interface Requirements

3.1.1 User Interfaces

In this section we describe and present a possible mock-up for the application, following the order of events proposed in the sequence diagrams.

At the launch of the application the user has to insert the credentials in the Log In page 3.1(a). In case of new user, he can click on a button to open the Sign Up page 3.1(b), to create a new account.

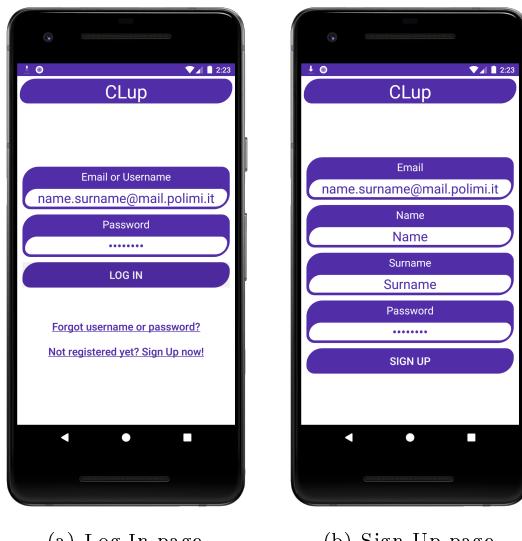


Figure 3.1: Example of Log In and Sign Up pages.

Once the login has been completed successfully, the user is redirected to the Home page 3.2. In particular, the reported figure shows the Home page for the customer account with all the functionalities. The application, knowing the type

CHAPTER 3. SPECIFIC REQUIREMENTS

of account, is able to show different buttons. For example, in case of physical spot account, the application will display only the Lining Up button, hiding the others. In case of store manager account, there will be displayed only buttons to control the queue and to analyze the statistics.

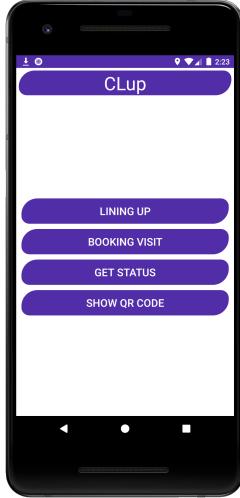
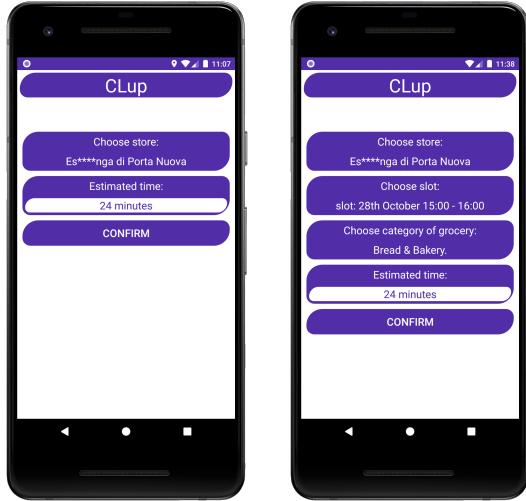


Figure 3.2: Home page.

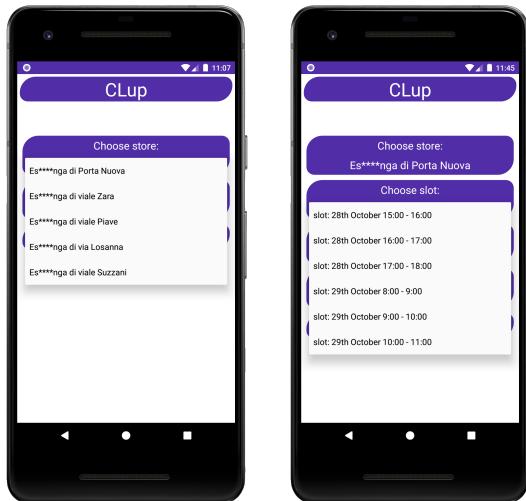
If a customer wants to line up, or book a visit, he can click on the corresponding button, in this way the application will show the form to insert the requested parameters 3.3. In the mock-up we show how the user can choose the store, the time slot and, in case of booking, the category of grocery, by expanding the drop down menu.

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(a) Lining Up page.

(b) Booking Visit page.



(c) Lining Up page with expanded spinner.
(d) Booking Visit page with expanded spinner.

Figure 3.3: Example of Lining Up and Booking Visit pages.

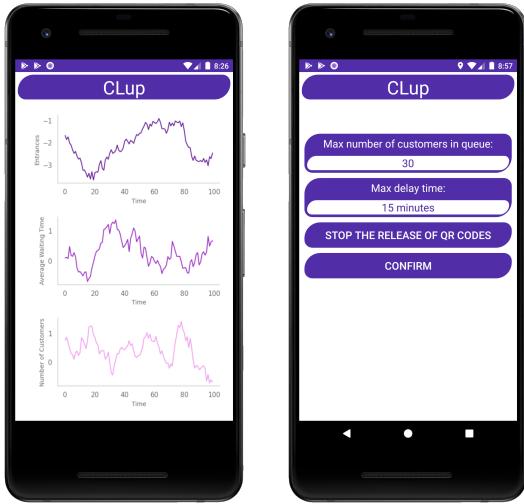
The application provides the possibility to check the queue status by clicking on the Get Status button and to watch the QR code by clicking on the relative button. These buttons aren't visible from the Home page until the user performs a lining up, or booking a visit, operation. If visible, the users will be able to see the interfaces: 3.4(a), 3.4(b).



(a) Get Status page. (b) Show QR code page.

Figure 3.4: Example of Get Status and Show QR code pages.

In figure 3.5(a) has been reported a mockup showing a possible interface for the store manager to control the statistics about the status of the queue, instead, in figure 3.5(b) a page to control the parameters of the algorithm that schedules users and releases QR codes.



(a) Show Stats page. (b) Control Queue page.

Figure 3.5: Example of Show Stats and Control Queue pages.

3.1.2 Hardware Interfaces

The system is distributed over three main hardware resources.

- **Smartphone:** used by the customers that wants to line up or book a visit from remote. The smartphone has to have a Global Positioning System (GPS) module to send the position and an Internet connection active to receive live updates by the server.
- **Physical spot:** is a totem composed by a tablet and a printer. The printer is a peripheral of the tablet. The tablet must have an Internet connection active.
- **Turnstile:** is used to control the entries. The tablet of the store manager, the QR code scanner and the display, that shows the next ticket numbers, are parts of the turnstile. More precisely, turnstile, scanner and display are peripherals of the tablet. We can imagine the turnstile as the metal detector in the airports, in which the guards are seated on the opposite side of the entrance. The store manager controls everything by the tablet and the tablet controls the peripherals under the constraints imposed by the store manager and the remote server. Indeed the tablet has to have an Internet connection active.

3.1.3 Software interfaces

The system, to work properly, needs external Application Programming Interface (API).

- **Store APIs:** are well-liked if they there are. Additional data provided by the store, such as the history of the purchases of the customers, can be used to improve the quality of the estimations of the residence time; the sections of the store that will be visited by customers and so on.
- **Maps APIs:** can be used to improve the estimation of the needed time to arrive to the store by the global position of the customer.

3.1.4 Communications Interfaces

In this service we aren't not scheduling to use external communications interfaces. Only the standard Internet protocols.

3.2 Functional Requirements

3.2.1 Requirements

Bla bla bla...

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Goal	G1: Keep customers in safe condition w.r.t the d.P.C.m in force inside the store.
Requirements	<ul style="list-style-type: none"> • [R1]: The system has to schedule entrances to the store. • [R2]: The system has to compute the maximum capacity of the store w.r.t. the social distances imposed by the d.P.C.m in force. • [R3]: The system has to monitor the customers residence time in the store. • [R4]: The system has to allow authorized customers to enter in the store. • [R5]: The system has to deny unauthorized customers to enter in the store. • [R6]: The system has to know when a customer enters in the store. • [R7]: The system has to know when a customer has left the store.
Domain Assumptions	<ul style="list-style-type: none"> • [D1]: There is a d.P.C.m in force. • [D2]: Customers follow the rules imposed by the d.P.C.m in force. • [D3]: Customers enter in the store only if the system authorizes them. • [D4]: Customers don't stay in the shop longer than necessary and they go away from the store after they have done their shopping.

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Goal	G2: Limit the physical line situation in the proximity of the store
Requirements	<ul style="list-style-type: none"> • [R8]: The system has to estimate the residence time, of a customer, in the store. • [R9]: The system has to infer the residence time of the customers based on past purchases. • [R10]: The system has to estimate the time needed to arrive, to the store, from the position of the customer. • [R11]: The system has to track the global position of the customers. • [R12]: The system has to release QR codes to the customers. • [R13]: The system has to limit the number of releasable QR codes if imposed by the store manager. • [R14]: The system has to allow the store manager to monitor the status of the queue. • [R15]: The system has to notify customers about the remaining time to be authorized to enter in the store. • [R16]: The system has to communicate which is the next served QR code number.
Domain Assumptions	<ul style="list-style-type: none"> • [D5]: Customers line up physically only if they have a valid (non expired) QR code. • [D4]: Customers don't stay in the shop longer than necessary and they go away from the store after they have done their shopping. • [D6]: Outside the store there is space to queue.

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Goal	G3: Allow customers to line up from a remote device.
Requirements	<ul style="list-style-type: none"> • [R17]: The system has to allow customers to register to the application. • [R18]: The system has to allow customers to login to the application. • [R19]: The system has to allow customers to get a QR code from the application. • [R20]: The system has to release QR codes to the customers through the application. • [R21]: The system has to alert customers if the queue is full. • [R22]: The system has to encode the lining up number in the QR code. • [R23]: The system has to allow customers to watch the QR code from the application. • [R24]: The system has to allow customers to watch the lining up number encoded in the QR code. • [R25]: The system has to allow customers to watch the remaining time to be authorized to enter in the store. • [R26]: The system has to update the remaining time showed to the customers. • [R27]: The system has to allow customers to delete a lining up operation. • [R28]: The system has to notify customers about the validation status of the QR code. • [R29]: The system has to check if customers have Internet connection active. • [R30]: The system has to check if customers have allowed the permissions requested by the application.
Domain Assumptions	<ul style="list-style-type: none"> • [D7]: Customers have a smartphone. • [D8]: Customers have installed the CLup application. • [D9]: Customers allow the permissions requested by the application. • [D10]: Customers keep Internet connection active.

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Goal	G4: Allow store manager to monitor entrances.
Requirements	<ul style="list-style-type: none"> • [R31]: The system has to register store managers in the application. • [R32]: The system has to allow store managers to login to the application. • [R33]: The system has to allow store managers to monitor the status of the queue. • [R34]: The system has to allow store managers to limit the number of QR codes released. • [R35]: The system has to allow store managers to monitor the number of customers inside the store. • [R36]: The system has to scan the QR codes of the customers. • [R37]: The system has to allow store managers to modify the timing parameters of the scheduler. • [R38]: The system has to check if store managers have Internet connection active. • [R39]: The system has to check if store managers have allowed the permissions requested by the application.
Domain Assumptions	<ul style="list-style-type: none"> • [D11]: There is a store manager present in the store. • [D12]: Store managers allow the permissions requested by the application. • [D13]: Store managers keep Internet connection active.

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Goal	G5: Allow customers to line up from a physical spot.
Requirements	<ul style="list-style-type: none"> • [R40]: The system has to allow unregistered customers to line up. • [R41]: The system has to allow customers to get a QR code from a physical spot. • [R42]: The system has to release QR codes to the customers through the physical spot. • [R43]: The system has to encode the lining up number in the QR code. • [R44]: The system has to print QR codes on a paper tickets. • [R45]: The system has to alert customers if the queue is full. • [R46]: The system has to alert when the paper and toner of the physical spot is going to finish.
Domain Assumptions	<ul style="list-style-type: none"> • [D14]: Physical spots are powered on every working day. • [D15]: Physical spots are refilled when asked by the system.

CHAPTER 3. SPECIFIC REQUIREMENTS

Goal	G6: Allow customers to book a visit from a remote device.
Requirements	<ul style="list-style-type: none"> • [R17]: The system has to allow customers to register to the application. • [R18]: The system has to allow customers to login to the application. • [R19]: The system has to allow customers to get a QR code from the application. • [R47]: The system has to allow customers to specify the date and time for a visit to the store. • [R48]: The system has to allow customers to specify the category of grocery they want to buy. • [R20]: The system has to release QR codes to the customers through the application. • [R21]: The system has to alert customers if the queue is full. • [R49]: The system has to encode the book-a-visit number in the QR code. • [R23]: The system has to allow customers to watch the QR code from the application. • [R50]: The system has to allow customers to watch the book-a-visit number encoded in the QR code. • [R25]: The system has to allow customers to watch the remaining time to be authorized to enter in the store. • [R51]: The system has to allow customers to delete a book-a-visit operation. • [R28]: The system has to notify customers about the validation status of the QR code. • [R29]: The system has to check if customers have Internet connection active. • [R30]: The system has to check if customers have allowed the permissions requested by the application.
Domain Assumptions	<ul style="list-style-type: none"> • [D7]: Customers have a smartphone. • [D8]: Customers have installed the CLup application. • [D9]: Customers allow the permissions requested by the application. • [D10]: Customers keep Internet connection active.

3.2.2 Definition of Use Case Diagrams

Bla bla bla...

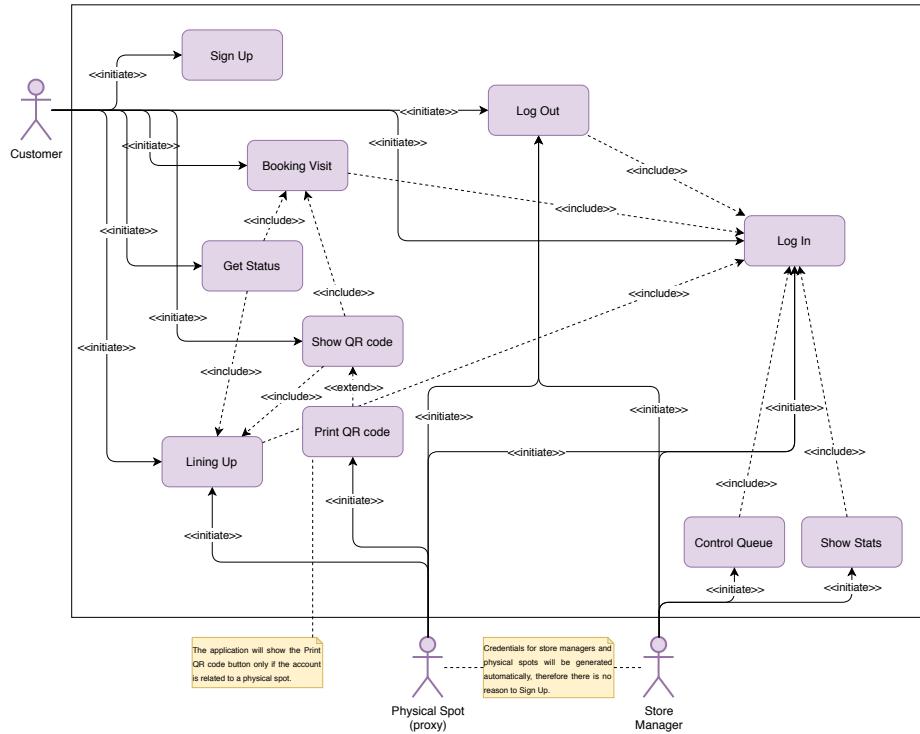


Figure 3.6: Use cases diagram.

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Name	Sign Up
Actor	Customer
Entry Conditions	Customer is on the Sign Up page.
Event Flows	<ul style="list-style-type: none"> • Customer inserts the requested information in the form. • Customer clicks on the Sign Up button.
Exit Conditions	Sign Up completed successfully and customer is logged in, then the application shows the Home page.
Exceptions	<ul style="list-style-type: none"> • Customer's username already in use. • Empty form field. • Policy agreement rejected. • Lost Internet connection.

Table 3.1: Use case: **Sign Up**.

Name	Log In
Actor	Customer - Physical Spot - Store Manager
Entry Conditions	Actor is on the Log In page.
Event Flows	<ul style="list-style-type: none"> • Actor inserts the requested information in the form. • Actor clicks on the Log In button.
Exit Conditions	Log In completed successfully and actor is redirected to the Home page.
Exceptions	<ul style="list-style-type: none"> • Actor's username or password incorrect. • Empty form field. • Lost Internet connection.

Table 3.2: Use case: **Log In**.

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Name	Log Out
Actor	Customer - Physical Spot - Store Manager
Entry Conditions	Actor is on the Log Out page.
Event Flows	<ul style="list-style-type: none"> Actor clicks on the Log Out button.
Exit Conditions	Log Out completed successfully and actor is redirected to the Log In page.
Exceptions	<ul style="list-style-type: none"> Actor already logged out. Lost Internet connection.

Table 3.3: Use case: **Log Out**.

Name	Lining Up
Actor	Customer - Physical Spot
Entry Conditions	Actor is on the Home page.
Event Flows	<ul style="list-style-type: none"> Actor clicks on the Lining Up button. Actor inserts the requested data in the form. Actor clicks on the confirmation button.
Exit Conditions	Lining Up completed successfully, the application returns the Status page.
Exceptions	<ul style="list-style-type: none"> Previous Lining Up action was not expired (only in case of remote customer). Previous Booking Visit action was not expired (only in case of remote customer). Actor wasn't logged. Lost Internet connection.

Table 3.4: Use case: **Lining Up**.

CHAPTER 3. SPECIFIC REQUIREMENTS

Name	Booking Visit
Actor	Customer
Entry Conditions	Customer is on the Home page.
Event Flows	<ul style="list-style-type: none"> • Customer clicks on the Booking Visit button. • Customer fills the form with the requested data. • Customer clicks on the Submit button.
Exit Conditions	Booking Visit completed successfully and the application returns, to the customer, the Status page.
Exceptions	<ul style="list-style-type: none"> • Previous Lining Up action was not expired. • Previous Booking Visit action was not expired. • Customer wasn't logged. • Lost Internet connection.

Table 3.5: Customer - use case: **Booking Visit**.

Name	Show QR code - Print QR code
Actor	Customer - Physical Spot
Entry Conditions	Actor is on the Home page.
Event Flows	<ul style="list-style-type: none"> • Actor clicks on the Show QR (Print QR) code button.
Exit Conditions	The application shows (print) the QR code.
Exceptions	<ul style="list-style-type: none"> • QR code wasn't saved on the application correctly (only in case of remote customer). • No Lining Up, or Booking Visit, action previously performed (only in case of remote customer). • Actor wasn't logged. • Spot finished the paper. • Spot finished the ink.

Table 3.6: Use case: **Show QR code - Print QR code**.

CHAPTER 3. SPECIFIC REQUIREMENTS

Name	Get Status
Actor	Customer
Entry Conditions	Customer is on the Home page.
Event Flows	<ul style="list-style-type: none"> • Customer clicks on the Get Status button.
Exit Conditions	The application returns the Get Status page showing information about the last Lining Up, or Booking Visit, operation.
Exceptions	<ul style="list-style-type: none"> • No operation previously performed, therefore there is no data to show. • Customer wasn't logged. • Lost Internet connection.

Table 3.7: Customer - use case: **Get Status**.

Name	Control Queue
Actor	Store Manager
Entry Conditions	Store Manager is on the Home page.
Event Flows	<ul style="list-style-type: none"> • Store Manager clicks on the Control Queue button.
Exit Conditions	The application returns the Control Queue page showing options to manage the queue.
Exceptions	<ul style="list-style-type: none"> • Store Manager wasn't logged. • Lost Internet connection.

Table 3.8: Store Manager - use case: **Control Queue**.

CHAPTER 3. SPECIFIC REQUIREMENTS

Name	Show Stats
Actor	Store Manager
Entry Conditions	Store Manager is on the Home page.
Event Flows	<ul style="list-style-type: none">• Store Manager clicks on the Show Stats button.
Exit Conditions	The application returns the Show Stats page showing information about the number of customers inside the store, the length of the queue and other information about the waiting time in queue.
Exceptions	<ul style="list-style-type: none">• Store Manager wasn't logged.• Lost Internet connection.

Table 3.9: Store Manager - use case: **Show Stats**.

3.2.3 Use Cases and Sequence/Activity Diagrams

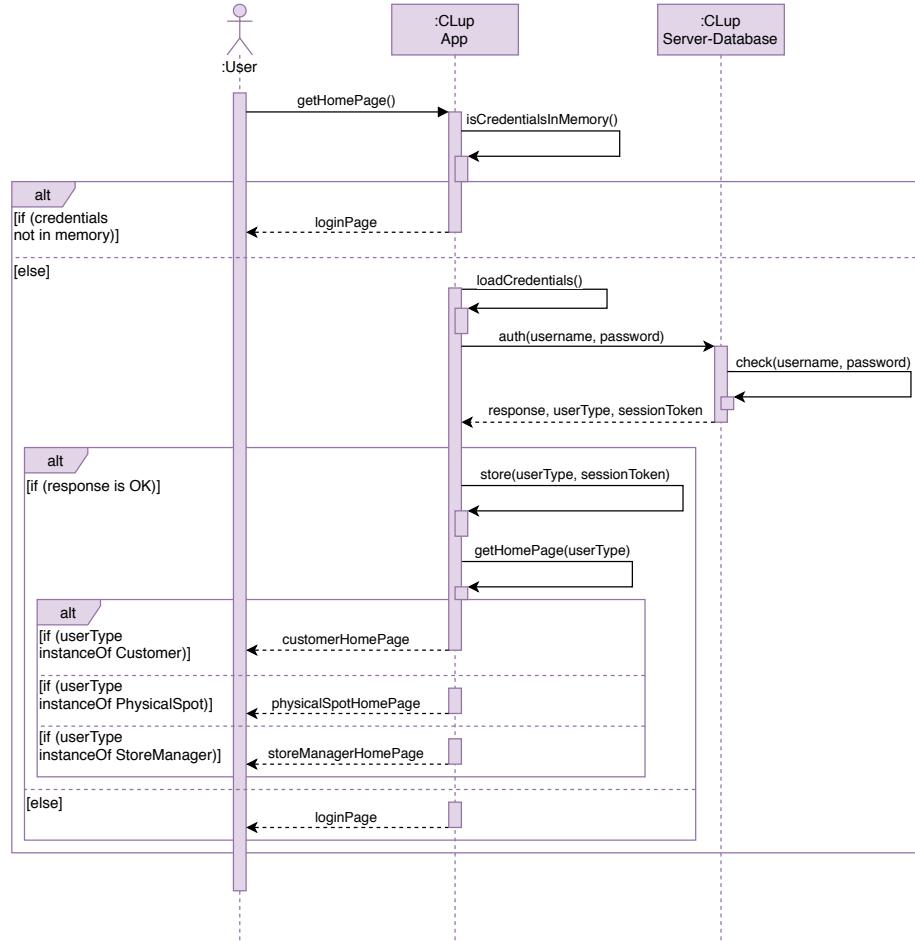


Figure 3.7: Home page sequence diagram.

CHAPTER 3. SPECIFIC REQUIREMENTS

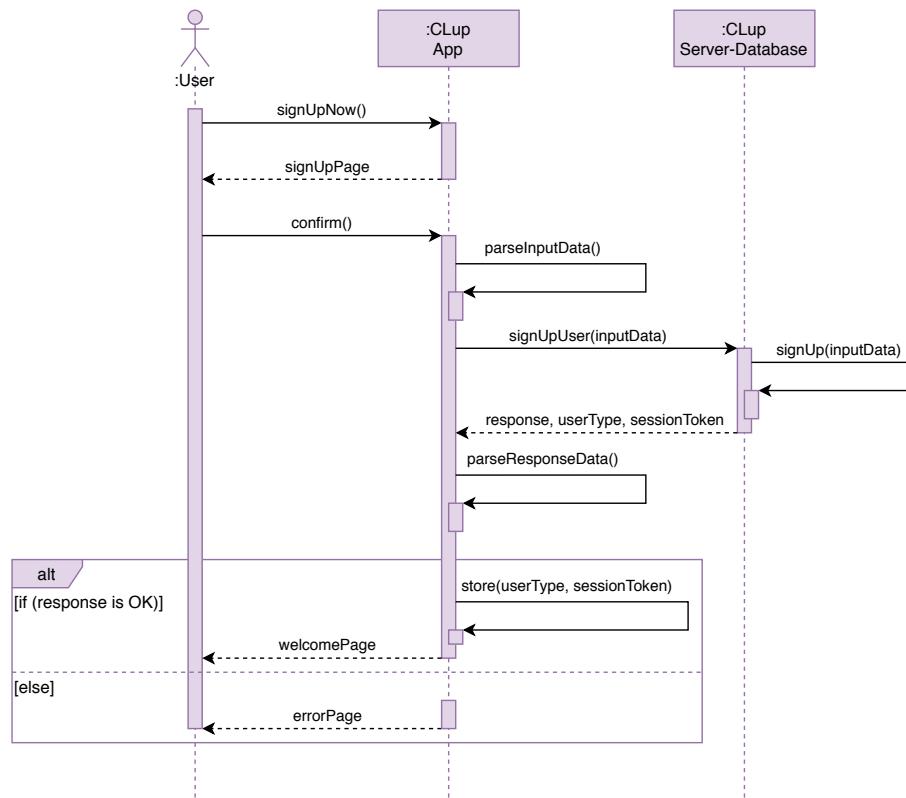


Figure 3.8: Sign Up sequence diagram.

CHAPTER 3. SPECIFIC REQUIREMENTS

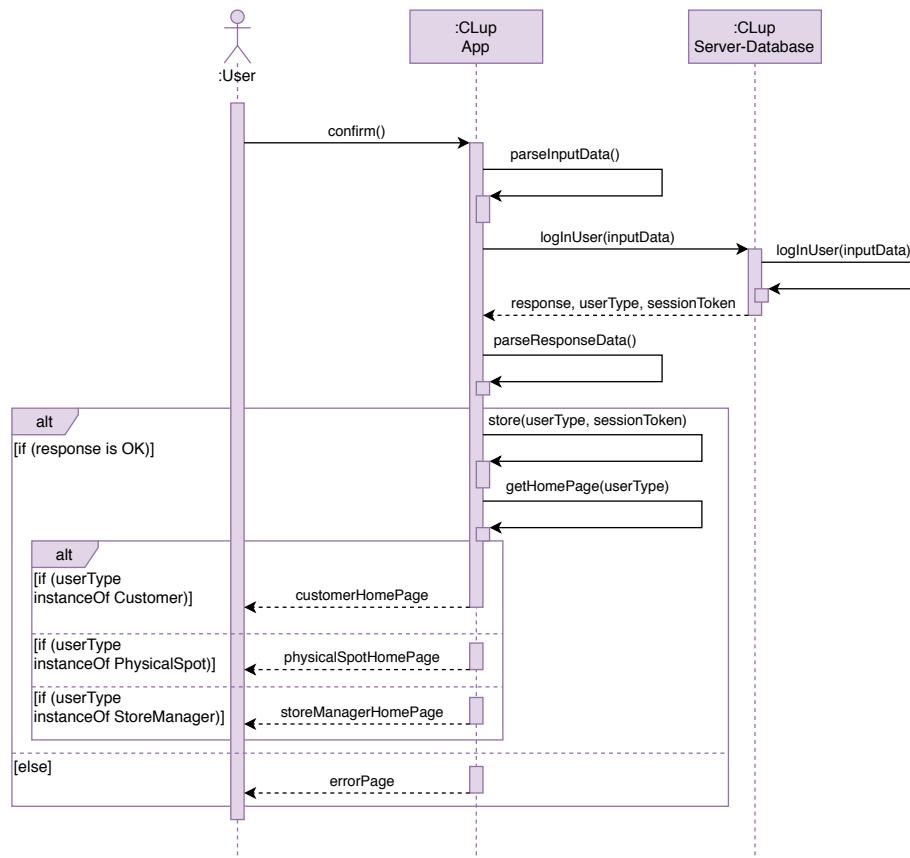


Figure 3.9: Log In sequence diagram.

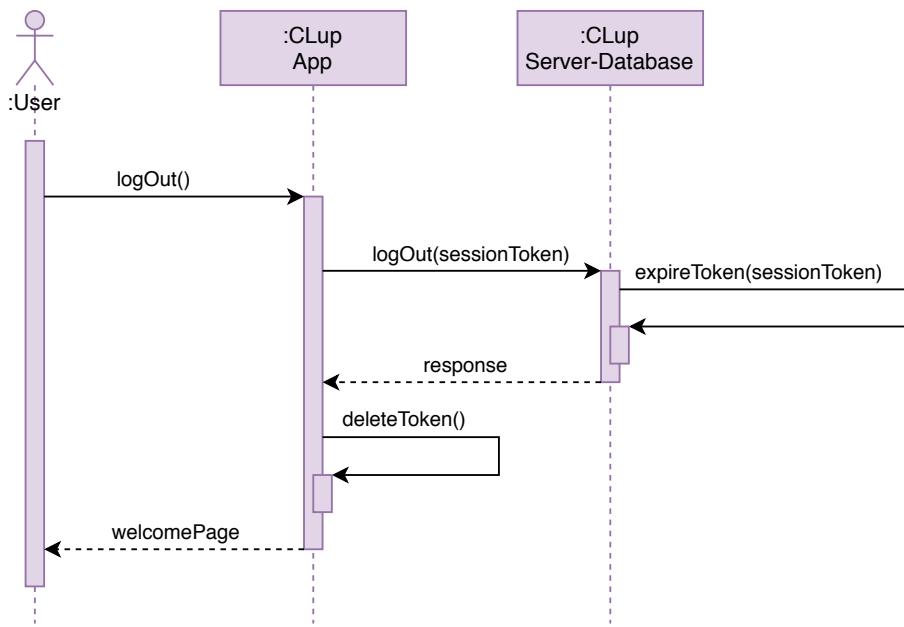


Figure 3.10: Log Out sequence diagram.

CHAPTER 3. SPECIFIC REQUIREMENTS

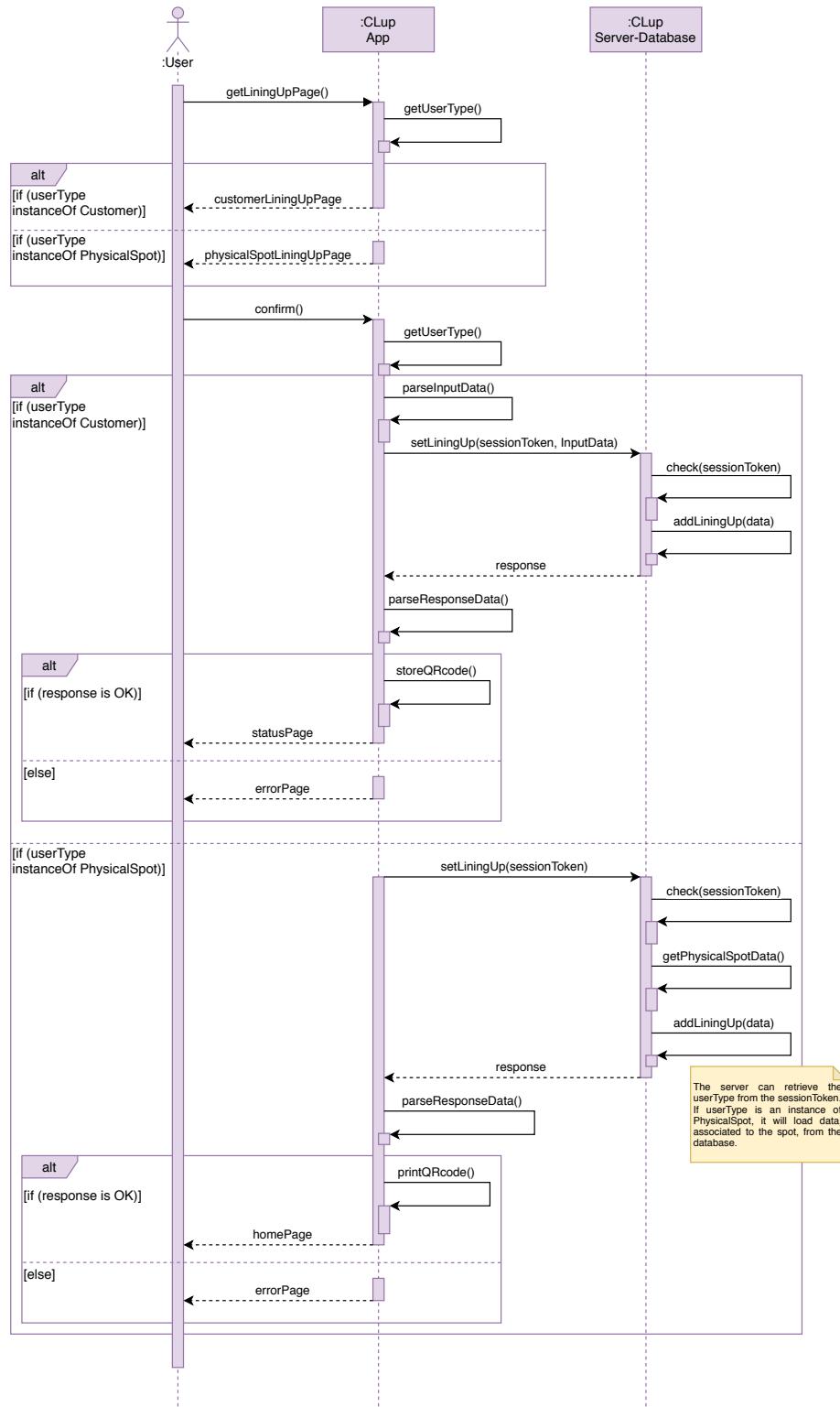


Figure 3.11: Lining Up sequence diagram.

CHAPTER 3. SPECIFIC REQUIREMENTS

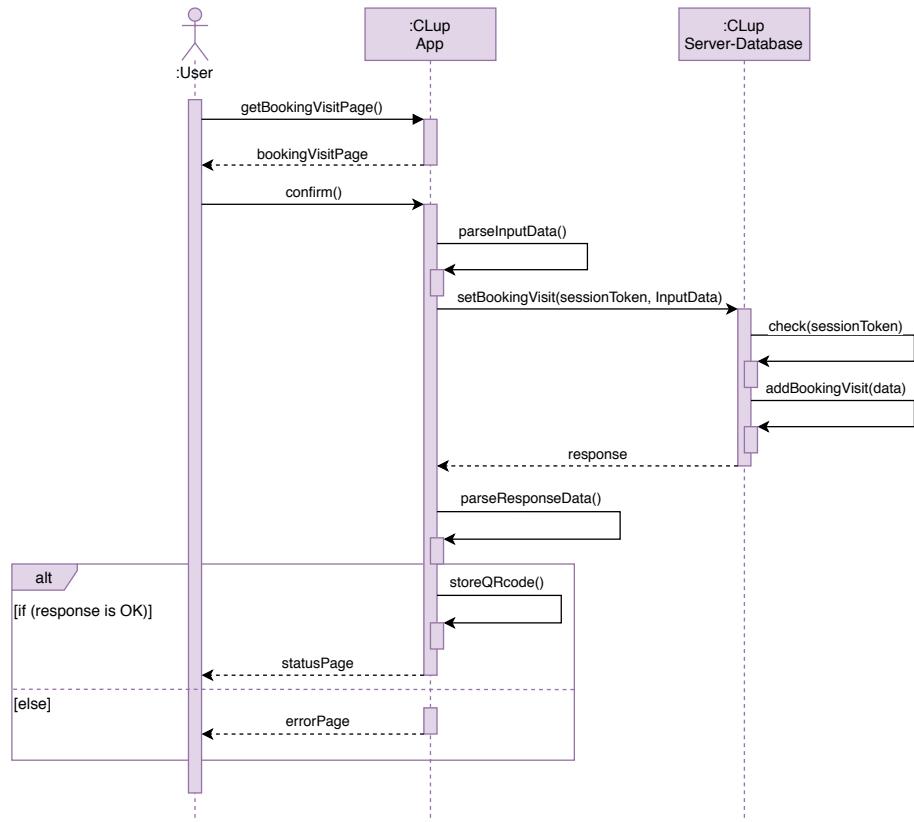


Figure 3.12: Booking a Visit sequence diagram.

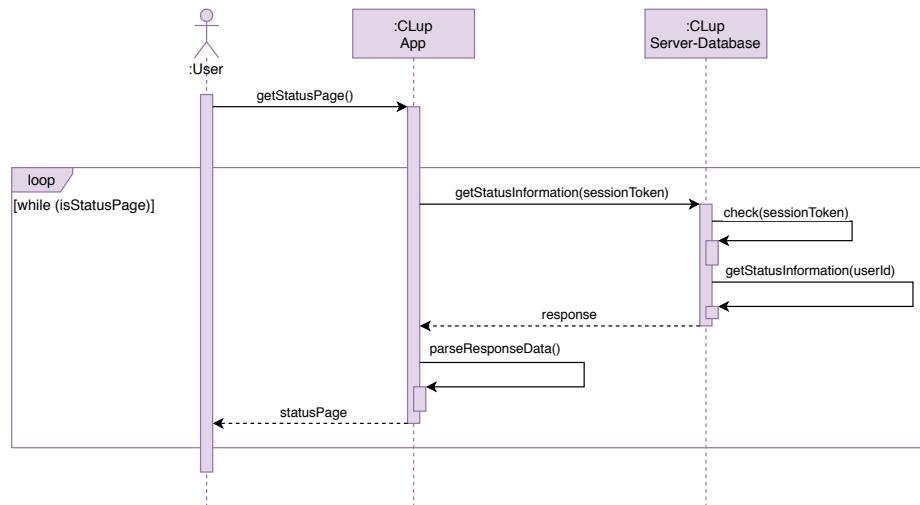


Figure 3.13: Get Status sequence diagram.

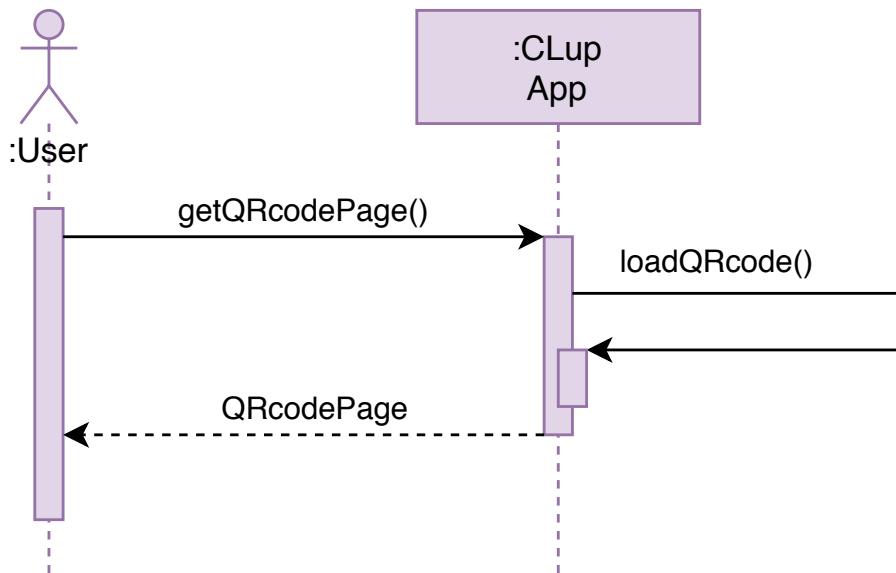


Figure 3.14: QR code page sequence diagram.

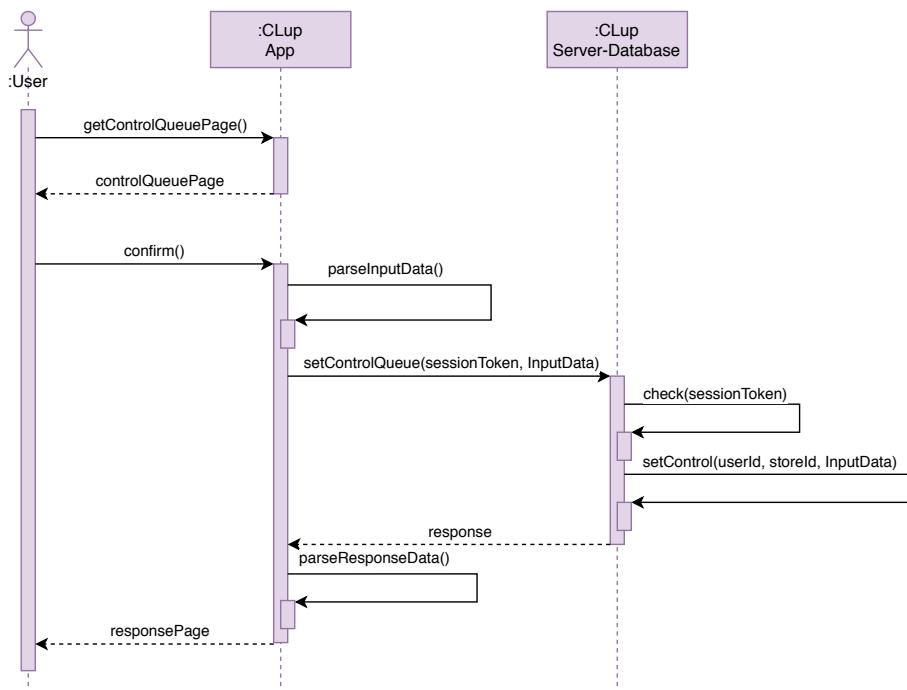


Figure 3.15: Control Queue sequence diagram.

CHAPTER 3. SPECIFIC REQUIREMENTS

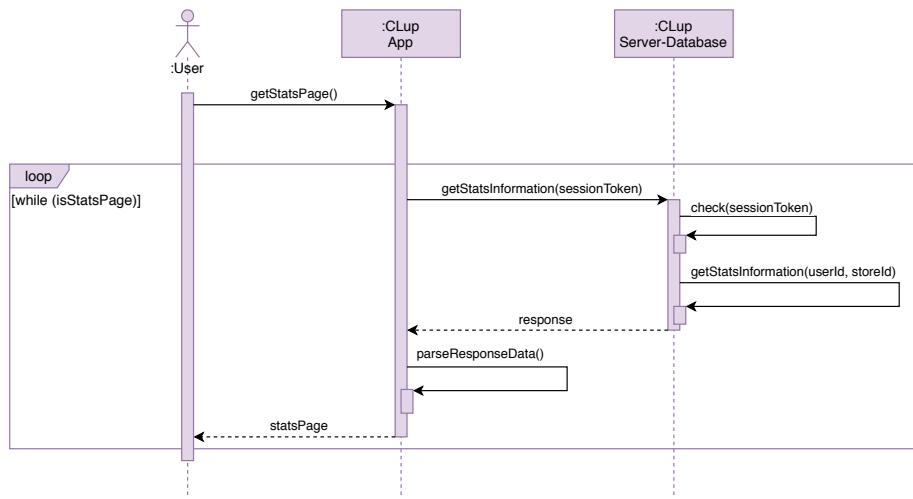


Figure 3.16: Show Stats sequence diagram.

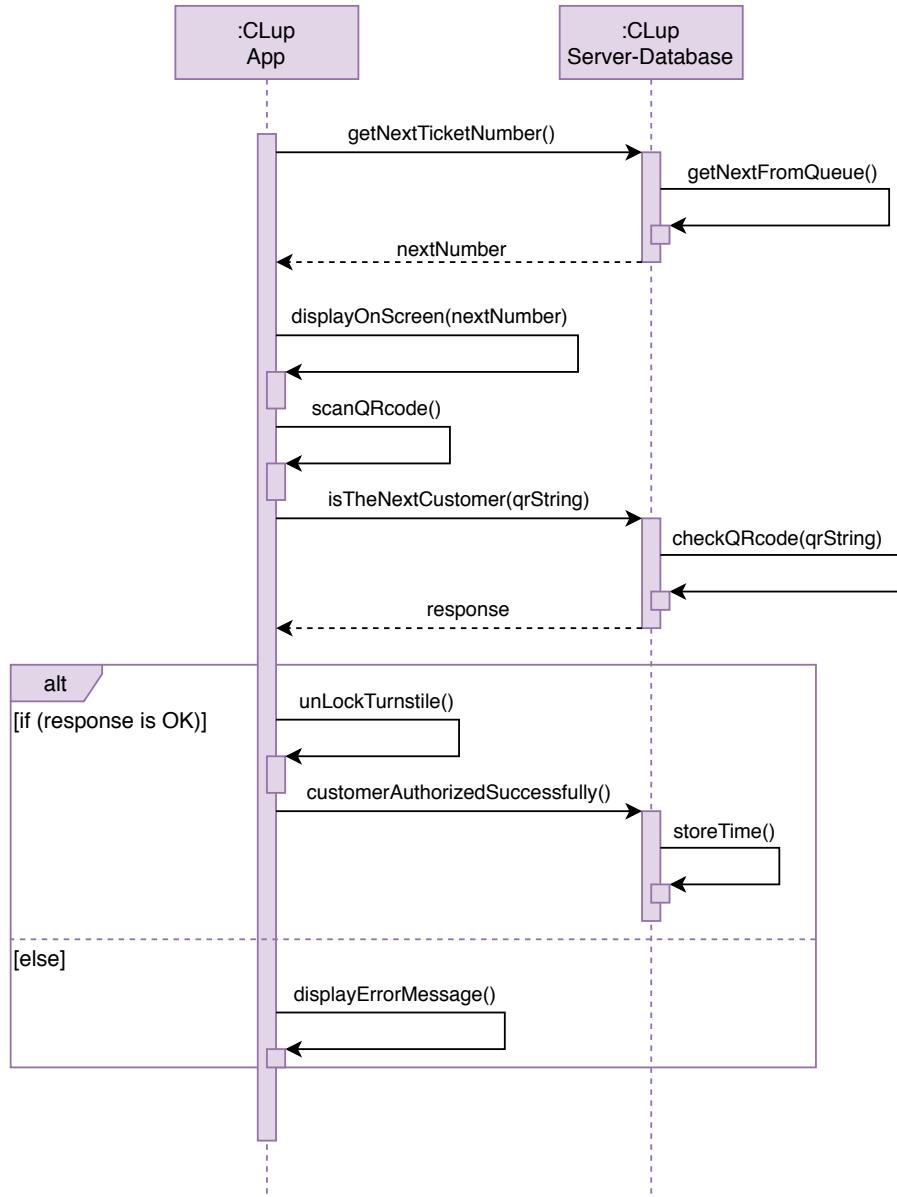


Figure 3.17: Sequence diagram reporting the activity periodically performed in background, by the application of the store manager, to authorize customers to enter in the store. For simplicity, the session authentication has been omitted.

3.2.4 Mapping on Requirements

3.3 Performance Requirements

3.4 Design Constraints

3.4.1 Standard Compliance

3.4.2 Hardware limitations

3.4.3 Any Other Constraint

3.5 Software System Attributes

3.5.1 Reliability

3.5.2 Availability

3.5.3 Security

3.5.4 Maintainability

3.5.5 Portability

Chapter 4

Formal Analysis Using Alloy

Chapter 5

Effort Spent

Chapter 6

References

API	Application Programming Interface
CLup	Customers Line-up
d.P.C.m	<i>"decreto del Presidente del Consiglio dei ministri"</i>
FIFO	First In First Out
GPS	Global Positioning System