1. **Introduction**
   1. **Purpose**

The purpose of this document is to serve as a Requirement Analysis and Specification Document (RASD) for the development of the CLup - Customer Line-up application. It will clearly introduce the problem at hand, propose an adequate solution and explain it in detail. It will do so using the appropriate language, with software engineers, system and requirement analysts, and product testers as the target audience.

The document fully details the scope and the basic functions of the system. Furthermore, it expands the core functionality with conceivable upgrades and improvements. It characterizes requirements, assumptions, and constraints of the system and outlines its goals.

CLup is a mobile application that helps grocery store chains manage the influx of customers and reduce crowding both inside and outside of the store. Moreover, it enables people to reserve a timeslot in a specific store through the "book a visit" feature.

* 1. **Scope**
     1. **Description of the problem**

Faced with a worldwide pandemic of the COVID-19 virus countries across the world imposed strict health measures in line with the recommendations of the World Health Organization. Most governments introduced decrees that limited the movement of the population to a certain degree. They did so in hope of reducing the spread of the virus. Only essential movement, such as: going to work, grocery shopping or outdoor exercise, was deemed acceptable.

Although successful in the mitigation of the disease, the act put a serious strain on society on many levels. For the time being, people are slowly becoming annoyed with the measures and uncertainty, occasionally leading to protests. To help reduce the stress and anxiety, many aspects of everyday life involving close contact can be considered and improved upon.

* + 1. **Proposed solution**

This project aims to help with, and resolve the issues surrounding grocery shopping. As we all know, grocery shopping is an essential activity which involves close contact inside the store. Since the COVID-19 virus spreads mainly through airborne particles, this activity plays a key role in its mitigation.

To reduce crowding inside the stores, supermarkets need to restrict access to their store and keep the number of people inside below the optimal maximum capacity. A solution to this seemingly easy task can be found by looking at the way banks and other community services handle the issue. In the most common situation, after retrieving a personal number at a printer, people wait in a line according to their ticket number.

This system can serve as a good base for the solution but does not come without flaws. Firstly, the interaction with the ticket printer normally includes the use of a touchscreen. To avoid constant wiping and sanitizing of the screen, the system should not use a printer's touchscreen as an interface.

Furthermore, while waiting outside for a number to be called dramatically reduces indoor crowding, if the current number is shown on a screen in the store, outdoor crowding is inevitable. To avoid larger gatherings, a person should be able to have an idea of how long until their number is called without nearing the store. In such a way, a person could enter a store without physically waiting in a line and avoid close contact.

To resolve the issues that arise with available solutions because of the pandemic, a software application can be used. The application could provide a virtual counterpart to a physical line up in front of a store. The main idea is to enable store customers to enter a queue from home (or wherever they find themselves) through simple interaction with the application. Upon the request, the person receives a number and a QR code. The person waits until that number is called to approach the store, and before entering, camera or store personnel, if available, scans the code to check its validity. Such a system allows store managers to monitor entrance in the store and control the influx of the customers.

Introducing such a system has its drawbacks and consequences, some more significant than others. The most obvious consequence is that upon implementing such a system, to attain the number of people inside the store under a certain threshold, all customers will be obligated to use it to enter the store. Creating a system that is usable, intuitive, and clear for all demographics of a society is hard, but necessary. The application should, therefore, be very simple to use. Moreover, to make sure every customer can access the grocery store, a solution should also be available for people who do not have access to the technology required by the system. The easiest solution is to have a traditional ticket printer in front of the store. A simple intervention of removing the touchscreen and printing a new ticket as soon as the last one is taken addresses the problems regarding the printer. Another important area to address is the effectiveness of the mechanism. Just like in real life physical lines, if a person arrives before/after their number is called the system should send the person back in line. To minimize the frequency of such events, the developed solution should be capable of calculating a reasonably precise estimation of the wait time for the customer. A basic approach is to simply provide the number of people in line that are ahead of you, but more precise estimations can and should be implemented. Furthermore, to avoid the loss of one’s place in line, the system should send occasional notifications to the user, to remind them of and update the estimated waiting time. **GOOGLE** **Maybe even include their distance from the store**. To je opcionalno, budemo lako nadodali ako se odlucimo to implementirat

After having resolved all conceived problems of the system, one more suggestion can be proposed to enhance its convenience and user experience. Besides managing crowding inside the store and real-time queueing, the application will give customers the option to "book a visit" to the grocery store. This feature will allow them to view available time slots for their grocery shop and book the most convenient one. Also, during the booking process, a person will have an option to indicate an approximated duration of their visit to further improve the accuracy of the wait time estimation of the system. **Long term customers and registration maybe too complicated for all demographics?**To cemo kasnije spominjat negdje ako bude bilo potrebe za registracijom

* + 1. **Domain**

The target audience for this application includes every person that shops for groceries in a store. Almost all demographics fall into this category, specifically people of age that use a smartphone (although a solution is given even for those who do not), have access to a store and live in fairly densely populated areas.

To use the application the person would have to have a smartphone and know how to use it, along with internet connection so the application can communicate with the database. This excludes some groups of the society, especially elderly ones, but still vast majority of young and working-class people should have easy access to it.

* + 1. **Goals; [Gn]:**
       1. Allow the user to "line up"/retrieve a number.
          1. Allow the user to retrieve a number through the application.
          2. Allow the user to retrieve a number physically from the printer.
       2. Allow the store manager to control the entrance of the user via QR code scanning.
       3. Allow the user to get precise calculations of the wait time.
       4. Allow the user to get updates/notifications on the estimated wait time.
       5. Allow the user to "book a visit" to the store.
          1. Allow the user to "book a visit" to the store without indicating the expected duration of the visit.
          2. Allow the user to "book a visit" to the store with indicating the expected duration of the visit.
       6. Allow the user to automatically indicate the expected visit duration while booking a visit.
  1. **Definitions, acronyms, and abbreviations**
     1. **Definitions**
        1. Application: a computer (mobile) program that is designed for a particular purpose.
        2. QR code: a machine-readable code consisting of an array of black and white squares, typically used for storing URLs or other information for reading by the camera or a scanner.
        3. Smartphone: a mobile phone that performs many of the functions of a computer, typically having a touchscreen interface, internet access, and an operating system capable of running downloaded apps.
     2. **Acronyms**
        1. RASD: Requirement Analysis and Specification Document.
        2. COVID-19: virus responsible for the spread of the coronavirus disease 2019.
        3. CLup: Customer Line-up.
        4. API: application programming interface, computing interface which defines interactions between multiple software intermediaries
     3. **Abbreviations**
        1. [Gn]: nth goal.
        2. [Dn]: nth domain assumption.
        3. [Rn}: nth functional requirement.
        4. App: application.
  2. **Revision history**
     1. Version 0.1; 7.11.2020.
     2. Version 0.2; First check and added some stuff; 9.11.2020.-.
     3. Version 1.0; Fist .tex document created and added all together ;15.11.2020.
  3. **Reference documents**
     1. Specification document "R&DD Assignment A.Y. 2020-2021.pdf".
     2. Alloy Dynamic Model example: “http://homepage.cs.uiowa.edu/~tinelli/classes/181/ Spring10/Notes/09-dynamic-models.pdf"
     3. Presentation, book, some other books, alloy tutorials/books, UML tutorials/books, some examples
  4. **Document overview**

The structure of this document is divided into six chapters.

The first chapter gives an elaborate introduction to the problem at hand and the proposed solution. In the first part of the chapter the purpose of the document and the goals of the project are presented. In the second part the project's scope is given, outlining the description of the problem, proposing a solution, and defining the domain of the problem. The third part includes the definitions, acronyms, and abbreviations necessary to understand the project. Fourth and fifth part of the chapter provide an oversight of the revision history of this document and a list of reference documents, and the last part presents the structure of the document.

The second chapter gives an overall description of the product. In the beginning introducing the product perspective, containing scenarios and further details on the shared phenomena and a domain model. It also introduces the product functions with the most important requirements and user characteristics. In the end, necessary assumptions are displayed together with the system's dependencies and constraints.

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The third part includes all the specific requirements of the system, explained in more detail where necessary, to help the development team. It includes external interface requirements, functional and performance requirements, design constraints and software system attributes.

The fourth part provides a formal analysis using Alloy, to prove the feasibility and soundness of the system. A formal model is presented and described and so are some worlds obtained by running it.

The fifth part provides information about the number of hours each group member has spent working on each part of this document.

The sixth part contains a list of references such as the tools used to create the content of the document.

1. **Overall description**
   1. **Product perspective .Product perspective: here we include scenarios and further details on the shared phenomena and a domain model (class diagrams and statecharts) - D**escribe external interfaces – system, user, hardware(printer for physical tickets), software, operations; - Site adaptation, hardware constraints(automatically prints a new ticket), potential issues

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* 1. **Scenarios**
  2. Scenario 1

During the COVID-19 pandemic the government has forbidden unnecessary trips outside of the living space, therefore only allowing people to go to the stores to buy groceries. Among the measures, the government has also allowed only up to 60 people in closed spaces. This has created a problem since the only place people can go is the store and there are often a lot of people waiting outside in line and by doing so, spreading the infection. The store owner decided to use CLup system to reduce the number of people outside of the store. He installed a small screen just inside the store so that the people can see the number displayed through the glass. He also put up a small printing device for the tickets as well as a store manager at the entrance so that the influx of people can be controlled. He also gives 5% discount to everybody who uses CLup app by scanning their QR code at the cash register. This way he encourages people to use the app and not come to the store prematurely, so that the infection would not spread. This can also increase the profit a store makes since a lot of people would decide to go to the other nearby store if the line is too big. The lines have now been reduced and people can also make reservations so that they know exactly when they are going to be able to enter the store without waiting.

* 1. Scenario 2

Esselunga, one of the biggest supermarket chains in Italy, has a problem in their stores. Every working day of the week they have so called "rush hours" between 11 and 13, which is lunch time, and between 16 and 18, right after people finish their work.

Because of the new restrictions, they are unable to allow everybody to go in which results in people going to the other stores and not waiting for their turn, since they do not have that much time. Every Esselunga store in Milano has therefore started using the CLup system. All Esselunga stores are put by the administrators in the system, along with their addresses and working hours. This way it will be easier for the users to find the exact Esselunga store they are looking for.    
Now customers can either reserve their spot in advance and plan their quick shopping accordingly, or just request a ticket when they are leaving their working space, so their waiting time is minimal. Both the stores and users have better shopping experience.

* 1. Scenario 3

A small store right next to the university and student housing area is having issues with too many students going to the store at once. Even though the store is only 50m away from the student housing, the students that are stuck in line decide to wait outside of the store and hang out with other students, therefore spreading the disease. The store owner has introduced the CLup system and completely disallowed people from entering the store without using the app. This way, students can easily make reservations and come to the store at a certain time, as well as just take a virtual ticket and come just a minute or two before it is their turn to enter. Since nearly every customer is a student and all of the students have access to the smartphones and Internet, the store owner hasn't lost any profit, and the students can now go to the store without waiting in line and risking getting the disease from one of their colleagues.

* 1. Scenario 4

Ludovico is an elderly citizen fighting diabetes. Although not as physically capable as he once was, he still goes for a long walk twice a week to and from a grocery store in the neighborhood. Such a physical activity helps him keep his blood sugar levels low, keeping a healthy body as well as the mind. Because of the new government recommendations, he would often have to wait in line in front of the grocery store. In fear of catching the virus, he slowly stopped his weekly routine, ordering his supplies online. As time passed, he started noticing that he tires more easily and that his blood sugar levels were rising. Luckily, his grandson introduced him to the CLup application which allows him to rebuild his old habit, while minimizing the health risks. As he knows exactly how much it takes him to get to the store, he uses the "book a visit" feature and indicates the time he wants to be able to enter the store.

* 1. Scenario 5

Umberto is a hard-working middle-aged man, with two children and a loving wife. Although content with his current life situation, he often finds himself balancing between order and chaos. Work from 9 to 5, late lunch, or early dinner, then watching over the children while his wife is away. As she does not drive a car, he also has to fit in grocery shopping in his schedule. While all was in order before the pandemic, the new restrictions brought long lines in front of stores and often pushed his schedule into chaos. His problem was solved by switching to a store using the CLup application. He can now "book a visit" days before his planned trip to the grocery store and be certain that he will not have to wait long lines to get in.

* 1. **Product functions -**here we include the most important requirements, summary of major functions, requirements as well

Functions of the final product should provide easy and accessible use for everyone, regardless of their experience and knowledge regarding technology and smartphones.

These functions are mentioned on several places in the document, but their most thorough explanation can be found here.

1. **Generating a scannable QR code**

The most important part of the system. It must be able to generate a QR code quickly and responsively on the screen that replaces a real-life ticket. By generating this code, it should also "insert" the virtual ticket into the current ticket queue that is interpolated together with the real-life tickets, which are handed out at the store entrance. This code should remain visible in the application until it expires, so even if the user exits the application it does not get lost. No additional data nor any permissions are needed from the user to get the code. Generation request of the QR code is done by pressing a single button that is presented on the main screen of the application, so that even the less experienced users have no trouble generating the QR code.

1. **Managing available shopping time slots**

To support "book a visit" function, the system must maintain a schedule that is specific for each store. This means reserving a specific timeslot up front so that the user can just come to the store without generating a ticket in advance. However, the ticket still needs to be generated and inserted into queue in real-time. This part is to be done by the system itself and without any help of the user. The QR code must remain active until the specific time slot has passed. The system will insert the virtual ticket in the queue at the right moment either by using the average buying time or by  temporarily reducing the maximum amount of people that are allowed to be at the store, so that a specific slot is reserved for the user.

1. **Calculating average waiting time**

The system needs to be able to calculate average waiting time if the user is to take the ticket at that specific moment. This can be done by calculating the average shopping time in a certain day or time of day and multiplying it with the number of customers that are currently waiting in the queue. While this will not provide a perfect estimation, since it is possible that every customer shops for a lot longer or a lot shorter time, the deviation should not be off by a lot. By doing this we would ensure that there are no crowds in front of the stores as the customers would be prompted to arrive only when there are a couple of minutes until their turn. This part of the system should also provide notifications for the virtual ticket holders and inform them of how many customers are currently in front of them, and therefore how many minutes until they will be able to enter the store.

1. **Calculating time needed to get to the store**

By providing their location, which has to be allowed by the user, the system can calculate the exact amount of time that user needs to get to the store. This is done by using one of the Google Maps APIs which allow the distance calculation of two specific locations as well as the time needed to get from one point to another. Together with the estimated shopping time provided by the user, this would allow the user to get the exact amount of time needed to make a shopping trip. While this function has no advantages to the effectiveness of the system itself, we believe that it is an important function for the user, and it would make the usage of the application much more enjoyable experience.

1. **User characteristics**

There are **4** different categories of users in this application:

1. *User:* a person using the CLup application, not necessarily registered. The person can request to be queued in line, get an approximation of the wait time, and get updates on the estimated time left until their number is called. Furthermore, the person can request to inspect and reserve available time slots for the "book a visit" feature during which they can also indicate the estimated visit duration.
2. *Store manager:*an employee of the grocery store that uses the CLup application in charge of monitoring and controlling the influx of customers of the store. The person scans the QR code of incoming customers to prevent irregularities and registers their exit time (specific information about which customer exactly is exiting is not necessary as this feature is used only for calculating wait time statistics). The person uses a different UI from an ordinary user and their credentials are added to the system directly through installation.
3. *System manager:* an employee of CLup in charge of maintaining and updating the application. The person has administrative authority in the application setup during the system's installation.
4. *Physical customer*(?) no phone: a person that for some reason is unable to line-up through the CLup application, and therefore must take a physical ticket from the printer. The person can take the ticket with minimal physical contact and wait until their number is called by the store manager.
5. **Assumptions, dependencies, and constraints**
   1. **Assumptions**
      1. **Domain assumptions**
         * [D1]: The user's username must be unique.
         * [D2]: The registered user's password secure.
         * [D3]: The user's device provides accurate GPS information.
         * [D4]: The system can use data about the registered user to calculate estimated wait time
         * [D5]:  The system can correctly save data about enter and exit times of anonymous customers, to calculate estimated wait time.
         * [D6]: The system can correctly save data to and pull data from available time slot schema in the database.
         * [D7]: The user always has internet connection for the device.
   2. **Dependencies and constraints**
      1. **Hardware limitations and dependencies**

The platform the CLup application is developed for is a device with uninterrupted internet connection(2G/3G/4G/5G) and GPS signal. For the store manager's installation, a functional camera is needed.

* + 1. **Software limitations and dependencies**

The CLup application will be developed for the Android operating system with possible versions for other operating systems, such as iOS, in the future.

* + 1. **User permissions and agreements**

The user will have to agree to the general terms and conditions agreement as part of the installation process to use the application. Moreover, if the user wants to register to the system, other permissions such as the access to the devices location for more precise wait time estimation will have to be accepted. Naturally, no user information will be used for commercial purposes.

1. **Specific Requirements**
2. **External interface requirements**
   1. **User interfaces**

CLup application interface will have to serve two types of users: customers and store managers. Opening screen of the application allows the user to pick a store or to login as a store manager. Depending on the choice, another screen is presented. For a customer, a screen with the options to retrieve a ticket, book a visit or change the store. For a store manager, a screen containing their camera view, and buttons to confirm the scanned ticket, notify the system about a customer exit and to log out of the application.

* 1. **Hardware Interfaces**

Depending on the current user the CLup application will require access to some hardware interfaces. If the current user is a customer, the application will require the device's camera and if the current user is the store manager the GPS location data will be needed. The application will require no further hardware interfaces.

* 1. **Software Interfaces**

CLup application will not require any specific software interfaces.

* 1. **Communication Interfaces**

The most important communication will occur between the device and the database. The decision on the specific communication interface which will be used depends on the database, and is, therefore, left to the developers.

1. **Functional requirements**
   1. [G1] Allow the user to "line up"/retrieve a number.
      1. [G1.1] Allow the user to retrieve a number through the application.
         1. [R1] The user must be able to select a specific store in which they want to do the shopping.
         2. [R2] The user must be able to request a number and a ticket.
         3. [R3] The user must be able to receive a number and a ticket.
      2. [G1.2] Allow the user to retrieve a number physically from the printer.
         1. [R4] The user must be able to physically retrieve a ticket from the printer containing a number and a QR code.

* + 1. [D8]: The user always has internet connection for the device.

* 1. [G2] Allow the store manager to control the entrance of the user via QR code scanning.
     1. [R5] The store manager must be able to scan a QR code.
     2. [R6] The store manager must be informed by the application if a user tries to enter the store out of order.
     3. [R7] The store manager must be informed when the capacity of the store is full.
     4. [R8] The store manager must be able to alert the system whenever a customer exits the store.

* 1. [D6]:  The system can correctly save data about enter and exit times of anonymous customers, in order to calculate estimated wait time.
  2. [D8]: The user always has internet connection for the device.

* 1. [G3] Allow the user to get precise calculations of the wait time.
     1. [R9] Allow the user to receive a precise estimation of wait time when retrieving a number.
     2. [R10] The system must provide the user with an estimation of wait time based on data.

* + [D4]: The system can use data about the registered user to calculate estimated wait time
  + [D6]:  The system can correctly save data about enter and exit times of anonymous customers, in order to calculate estimated wait time.
  + [D8]: The user always has internet connection for the device.

* 1. [G4] Allow the user to get updates/notifications on the estimated wait time.
     1. [R11] The system must be able to update its estimated wait time in real time.
     2. [R12] The system must be able to send an update to the user in specific intervals regarding estimated wait time until it is their turn.

* + [D4]: The system can use data about the registered user to calculate estimated wait time
  + [D6]:  The system can correctly save data about enter and exit times of anonymous customers, in order to calculate estimated wait time.
  + [D8]: The user always has internet connection for the device.

* 1. [G5] Allow the user to "book a visit" to the store.
     1. [G5.1] Allow the user to "book a visit" to the store without indicating the expected duration of the visit.
        1. [R13] The user must be able to request to see all the available timeslots in that specific store.
        2. [R14] The system must be able to provide the user with the list of all available timeslots upon the request.
        3. [R15] The user must be able to select a specific timeslot.
        4. [R16] The user must be able to receive a confirmation of his timeslot reservation, along with a number and a ticket.
        5. [R17] Allow the user to be at most five minutes late for his reservation before canceling his ticket.
     2. [G5.2] Allow the user to "book a visit" to the store with indicating the expected duration of the visit.
        1. [R18] The user must be able to specify expected duration of his visit to the store.

* + 1. [D3]: The user's device provides accurate GPS information.
    2. [D7]: The system can correctly save data to and pull data from available time slot schema in the database.
    3. [D8]: The user has internet connection for the device at all times.

* 1. [G6] Allow the store manager to login to his store manager account with credentials.
     1. [R19] The store manager must be provided with the login credentials upon request to the system administrator.

* + [D1]: The store manager's username must be unique.
  + [D2]: The store manager's password must be secure.

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| --- | --- | --- |
| **Requirement, [Rn]** | **Goals, [Gn]** | **Domains, [Dn]** |
| R1 | G1.1 | D8 |
| R2 | G1.1 | D8 |
| R3 | G1.1 | D8 |
| R4 | G1.2 | D8 |
| R5 | G2 | D6, D8 |
| R6 | G2 | D6, D8 |
| R7 | G2 | D6, D8 |
| R8 | G2 | D6, D8 |
| R9 | G3 | D4, D6, D8 |
| R10 | G3 | D4, D6, D8 |
| R11 | G4 | D4, D6, D8 |
| R12 | G4 | D4, D6, D8 |
| R13 | G5.1 | D3, D7, D8 |
| R14 | G5.1 | D3, D7, D8 |
| R15 | G5.1 | D3, D7, D8 |
| R16 | G5.1 | D3, D7, D8 |
| R17 | G5.1 | D3, D7, D8 |
| R18 | G5.2 | D3, D7, D8 |
| R19 | G6 | D1, D2 |

**3 use cases: lineup request, book a visit and manage influx**

**With sequence diagrams for lineup request and book a visit**

1. **Performance requirements**
2. **Design constraints**
3. **Software System Attributes**