LineUp: Virtual Queue Management

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DEZA, Aren
DY QUIANGCO JR., Christian Daniel
MOSONG, Jan Kristine

Francis DIMZON
Adviser

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Abstract

The average person experiences queueing as a regular everyday occurrence. Queues can be effective in bringing order to systems where one entity must serve multiple customers. However, queues that move too slowly impose economic and psychological costs on customers, and have potential to harm profits for businesses. For this reason, individuals and businesses are looking for technology-based solutions that can help mitigate problems associated with long wait times in physical queues. Although plenty of solutions exist currently in the form of virtual queueing and online ticketing, access to them is limited due to several reasons such as cost, availability, and other factors. This project examines virtual queues as a solution to physical queueing problems, analyzes how virtual queues are developed and implemented in different contexts, and creates a methodology and design for a virtual queue management system that is both effective and accessible to any user.

Keywords: queue management systems, virtual queues, digital tickets, waiting lines, mobile queues

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Chapter 1

Introduction

1.1 Overview of the Current State of Technology

Queueing systems are mathematical models of congestion that exist in any facility that produces a queue from customers requesting a service it cannot simultaneously handle (Armero & Bayarri, 2001; Srivastava, 2003). Instances of queue systems can be observed in daily life from the lines formed in amusement parks, reservations for restaurants, and ticket numbering in banks.

These systems are simple: the first persons to arrive are the first persons to be served. However, as the number of requests increases, so does congestion. To effectively manage this congestion, queue management systems are implemented. These have the dual effect of improving customer experience and maximizing profit (The Tamis Corporation, 2013).

Several different types of queue management systems exist to provide solutions to different problems in queueing. Among these are technology-based solutions that have become more necessary in recent years, and have become much easier to implement thanks to advancements in technology.

Virtual queue management systems are one such solution, which function similar to ticketing systems where customers receive a ticket to represent their position in a queue, and are then made to wait within a designated space until they are prompted for their turn.

Unlike these ticketing systems, virtual queues completely eliminate the need to wait within a designated space, and ensure that the only time a person needs to be physically present is when it is their turn to be served. Customers have the option of receiving a ticket online, and have the luxury of spending their waiting time wherever and however they like.

To avoid the problem of customers not knowing when it is their turn, virtual queue systems frequently have a means of prompting their customers when it is close to their turn, allowing them adequate time to travel to the facility.

In effect, this simultaneously removes congestion problems, reduces perceived wait time, improves customer time budgeting, and provides customers with better experiences overall.

While this technology could potentially be of significant help for people within the local setting, their access to it is somewhat limited. Other applications and services that provide this technology are either locked behind subscription services, are lacking in features, or are unavailable to users within the Philippines.

Therefore, the goal of this project is to create an application that provides access to virtual queueing technology that is free and readily available for all Filipinos to use.

1.2 Problem Statement

The Oxford Dictionary of English (2022) defines queues as “a line or sequence of people or vehicles awaiting their turn to be attended to or to proceed”. Although it is commonly understood that needing to wait in line is a regular occurrence in daily life, the act of physically lining up can grow to be cumbersome and inconvenient, imposing economic and psychological costs on all involved.

Standing in line for extended periods can “create severe difficulties for those seeking to combine work and family life” (Bittman & Wajcman, 2000), and can be especially challenging for the elderly, pregnant women, and disabled individuals. Furthermore, physically lining up can also pose medical risks due to the COVID-19 pandemic, as large numbers of people gathered in one location increase the risk of spreading communicable diseases.

With time being a crucial factor in everyone’s lives, Jacoby (1974) anticipated the growing intolerance of waiting and noticed that people look for alternative ways to reduce the time idly waiting to pursue engaging activities.

Such alternatives include various software and technology-based solutions that aim to remove the need to physically queue, or mitigate the negative effects associated with it.

The COVID-19 pandemic saw a rise in businesses transitioning to e-commerce platforms and other forms of online transactions that remove the need for physical contact (Alfonso, Boar, Frost, Gambacorta, & Liu, 2021). However, these online methods can be costly for both businesses and customers, and do not account for transactions that require customers to be physically present, such as medical consultations, automobile services, and bank account creation. As such, there is still a need to find a cost-effective solution to the difficulties imposed by physical queueing.

One technology-based solution is the implementation of virtual queueing, which addresses the concern of vulnerability to health risks and time budgeting by removing the need to enter a physical line until it is time to be served, allowing people more freedom in where and how they choose to wait.

1.3 Research Objectives

1.3.1 General Objective

The overall goal of this project is to reduce the amount of time in their daily lives that people spend waiting in line, which has potential to produce positive effects on their physical and mental wellbeing, and will allow them more time to spend on other activities.

In pursuit of this goal, the researchers intend to develop a cloud and mobile based queueing system that is accessible through a free and readily-available application. Businesses will be able to use this system to allow their customers to join queues without needing to be physically present until it's their turn to make a transaction, similar to an online ticketing system.

1.3.2 Specific Objectives

In line with the general objectives of this project, the specific objectives are:

1. To analyze existing virtual queue systems to understand how they are implemented and what they are lacking.

2. To design a virtual queue management system that will allow people to enter queues without needing to be physically present until their turn.

3. To develop a mobile and cloud based application that businesses and customers can use to access this virtual queue management system.

4. To formulate and implement an algorithm to estimate average wait times, throughput, and mean service time for each queue, along with expected wait times for each user based on the queue's history.

1.4 Scope and Limitations of the Research

The scope of this project includes planning, designing, and implementing a virtual queue management system that can be used by anyone with an internet connection. The system will allow businesses with registered accounts to create, manage, and update queues for their customers, and customers will be able to use a mobile application to track their positions on queues and receive notifications when it is close to their turn.

The application will also include an algorithm that predicts the expected wait time for a customer based on their current position based on historical data, and calculates the average wait time for a given queue.

This research project is additionally constrained by a number of limitations that could hopefully be addressed and avoided by future projects that aim to achieve similar goals.

The project is subject to time and budget constraints, as there is a limited timeframe allowed to complete the project, and the researchers have limited access to resources that are normally available to commercial developers.

Furthermore, the technology also requires an internet connection to function as intended. People who do not have access to the internet and people who are less technologically literate may find difficulty in using the system.

1.5 Significance of the Research

This research project has the potential to benefit the following groups:

Local businesses

As established, having the ability to mitigate the perceived waiting time for customers, local businesses will be able to significantly improve the experiences of their customers. Furthermore, reducing the need to reserve space for physical queues and designated waiting areas will allow businesses to maximize the space they are able to work with.

Clientele of local businesses

The customers of local businesses can benefit from this project in that they will have the luxury of deciding how they spend their time that would normally be dedicated to waiting in lines. Furthermore, they will also be able to avoid the inconveniences and negative effects associated with waiting in lines for extended periods.

Senior citizens, pregnant women, and disabled individuals

For individuals who are unable to stand in queues for extended periods of time due to health-related reasons, the technology proposed by this project has the potential to help them avoid placing themselves at further risk.

Health Workers

Due to how congestion in queues tends to increase the risk of spreading communicable diseases, the implementation of virtual queues in local businesses can potentially improve the efficiency with which social distancing can be enforced.

Future developers

Finally, this research project will be beneficial to researchers and developers who wish to develop their own digital queue management systems by laying groundwork that can be potentially expanded and improved upon.

Chapter 2

Review of Related Literature

2.1 The effects of waiting in lines

Spending time in physical queues imposes an economic and psychological cost on the individual (Chebat & Filiatrault, 1993). Not only does waiting in line elicit feelings of boredom, apathy, and frustration (Waitwhile, 2022), but it can seriously impose on the time a person would have used to do other things. For example, the average American spends roughly 37 hours each year (Stone, 2012).

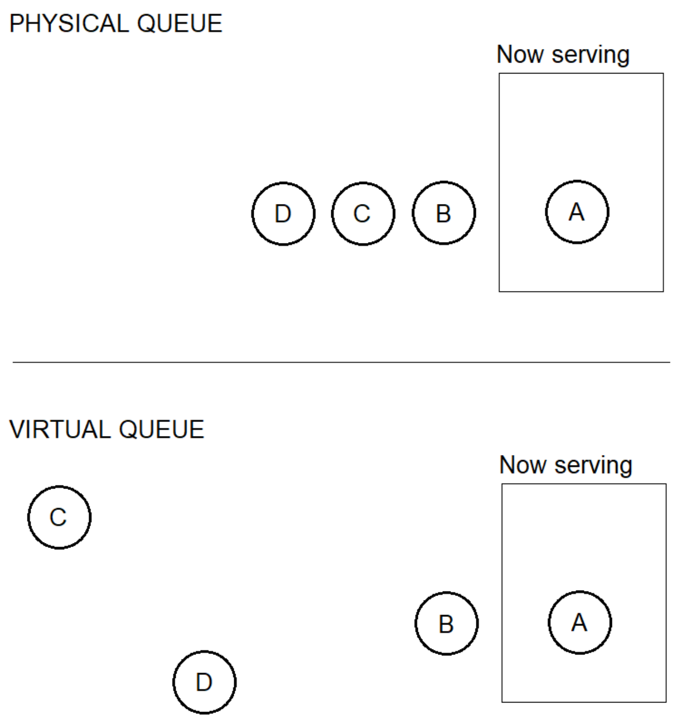
Long wait times can also be detrimental for businesses. Based on statistics cited by Brooke (2013), customers tend to react negatively to long wait times, becoming frustrated and abandoning lines if the wait goes for longer than expected, sometimes going so far as to actively avoid it in the future. Furthermore, as a customer's evaluation of a product or service can be heavily influenced by the time they spent waiting to receive it, businesses have the imperative to minimize their customers' perceived waiting time (Chebat & Filiatrault, 1993).

For these reasons, several different systems have been devised to make queueing more efficient and to mitigate the negative effects of waiting in line.

2.2 Queue Management Systems

Queue management techniques exist to either improve the efficacy and service rate of a given queue, or make the time spent waiting within a queue more pleasant for the customer (Norman, 2008).

Figure 2.1: Comparison of physical and virtual queues



In a virtual queue, customers only need to be physically present when they are prompted for their turn.

Among these techniques are virtual queue management systems (Mwangi, 2013). These are a specific form of queue management system that places customers in a virtual waiting line (Thamrin, 2020), removing the need to be physically present while waiting in a line (Waitwhile, 2022). As seen in figure 2.1, this offers a lot of convenience to customers, as they are not confined to a specific area and are free to use their waiting time as they see fit.

The benefits of virtual queueing apply to both customers and businesses (Thamrin, 2020), streamlining communication between both parties, reducing perceived waiting times, improving customer flow management and worker efficiency, and increasing customer satisfaction. Furthermore, the non-physical nature of virtual queues also make it much easier to help reduce the spread of communicable diseases, a problem which is worth consideration during a pandemic.

Compared to other queueing management systems, virtual queues are observed to have a stronger positive effect in reducing wait delays and improving customer experiences (Mwangi, 2013).

In a survey conducted by Waitwhile (Waitwhile, 2022) that compares customer perceptions towards virtual and physical queueing, almost 70% of respondents prefer virtual over physical queueing, and nearly 71% of respondents were more willing to wait for longer periods of time in a virtual queue.

2.3 Review of Similar Solutions

There exist several implementations of virtual queues and similar systems intended to offer virtual solutions to physical queues. Such solutions are frequently implemented by establishments such as banks, hospitals, and payment centers in the form of ticketing systems, where customers are instructed to take a number that represents their position in line. Once they have their number, they are to wait within a designated space until their number is reached and they are prompted for their turn.

In virtual queues like the Fastpass system that Disney theme parks implement for their own attractions (Cope, Cope, Bass, & Syrdal, 2011). This allows the parks to improve customer satisfaction and obtain additional revenue by allowing their guests to spend money on other attractions and services while they wait for their designated time.

Although ticketing systems are effective at reducing the problems associated with waiting in physical lines, customers are still confined to waiting areas.

There are also a number of software systems that fulfill a similar purpose as the intended research project.

Mwai (2018) developed a cloud and mobile based system for queue management. Using Android Studio to develop their mobile application, and Wampserver 2.1 to develop the web server with a MySQL database. Data exchange between the application and the web server was handled by Firebase Cloud Storage. The resulting system allows for customers to enter virtual queues through online tokens or physical kiosks and be notified through their mobile devices when it is their turn.

One mobile application available on the Google Store, *ApnaQ* (2021), provides a system for users to maintain and manage virtual queues, but is unavailable for users within the Philippines.

Queue: Virtual Queue Management (2022) is a free application that provides a cloud-based service for creating and implementing virtual queues created by users of the application. However, outside of the system used for implementing virtual queues, the application does not offer any additional features to its users.

Waitwhile (2022) is an advanced application that provides a virtual queue service that businesses can use to set up queues and waitlists for their customers. Their service allows customers to join a waitlist through various methods and will provide reminders through their medium of choice. It also uses machine learning technology to manage queue capacity and estimate waiting times. Although WaitWhile offers a free option for businesses, a paid subscription is necessary to provide more than two reminders and handle more than one location.

Qmatic (2022) is a company that offers customer management services and solutions to their partners. Virtual queues are among the solutions they provide, where customers are able to join queues through various methods such as links, QR codes, or self-service kiosks. Once they are in a queue, customers are able to monitor their progress within the queue in real time, and receive notifications when they are next in line. While this service provides a suitable amount of additional features to improve customers' experience of waiting in line, these services are only available to businesses that enter into a partnership with the company, which comes with additional fees.

Therefore, it is established that in order to create the best product for the intended user group discussed in Chapter 1, Section 1.5, the application project should be readily available for and affordable to the widest possible demographic, and should also provide an adequate number of features to improve the users' experience using the application.

Chapter 3

Research Methodology

3.1 Research Activities

The development of this project will be executed by following the waterfall model of design, which is a sequential approach to software development where the project is completed in various stages. As the development team is constrained by both time and budget, the waterfall model is deemed appropriate to use due to its simplicity, structure, and low time consumption. Furthermore, the sequential approach to development offered by the waterfall method is effective to use in the case of this particular project, where the requirements are not necessarily complex, and the project's scope is clearly defined by the developers' own specifications ahead of time.

In line with this approach, the project's development is structured into four distinct phases discussed below, although it needs to be remarked that the goal of the project is to merely create a functional system. Therefore, deployment and maintenance are not considered in our research activities.

Analysis and Requirements gathering
Identifying inconvenient physical queueing strategies as a problem that needed to be solved, the researchers conducted a review of related literature to identify the issues with most conventional queuing systems used in various businesses and contexts, and to investigate various technology-based solutions. The researchers then identified virtual queuing systems as a suitable technology-based solution that could be reasonably implemented given the available resources, and then worked to conceptualize how such a system could be implemented in a local context to help various businesses.

For this project, the researchers opted to use a cloud-based queueing system that users could access through their mobile devices, as it would be the method most accessible for people within a local context. With this in mind, the researchers opted to develop a mobile application that could fulfill this purpose.

The researchers then evaluated other virtual queueing applications and services, analyzing each system's strengths and weaknesses. It was identified that the majority of the systems that disclosed the methodology of their creation and design also opted for cloud-based systems that users could connect to through a mobile application. Furthermore, as most of the systems reviewed were hampered either by a lack of features or limited accessibility to most private users, the researchers opted to have the finished product be freely-available and easy to access, while still providing users with a host of useful features.

System and Product Design

Once the requirements have been established, the developers work on defining the features and functionalities of the system. Within the virtual queue system to be made for this project, the researchers first established its basic functionalities, which are discussed below:

Once users download the application, they must create an account to access the system's services. Once an account has been created, they can use the application to either create a new queue, or join a queue that was created by someone else. It was decided that a login and user account system would be necessary to help facilitate fast communication between the server and the application, help with user verification, and provide additional conveniences such as allowing the use of multiple devices to access one account.

When creating a new queue, the user would input information relevant to it, such as the name of the business that the queue is for, the type of service it provides, and the queue's physical address. Once the queue is created, its information would be uploaded and hosted on a server, where it would remain until the user decides to delete the queue.

If a user wishes to join a queue, they will have the option to browse through a list of available queues, search the queue by the business' name, or enter a code that will immediately allow them to join the queue. Once they have joined, they are reserved a position within the queue until it is their turn, where they are able to travel to the location of the business to perform their desired transaction. Once a transaction has been completed, the creator of the queue will tap a button in the application to update the queue, dequeuing the user who has just finished their transaction and moving everyone else in the queue forward by one space.

While designing additional features that would provide additional benefits to using the application, the researchers considered various statistics that would be relevant to users when deciding on whether to join a queue, and when they were currently waiting in the queue. For purposes of providing the user with additional convenience, the product would be designed to have these metrics available to users when joining and waiting within a queue. These metrics included things such as the number of people currently waiting in line, mean waiting time, expected waiting time based on past data and the user's current position, queue throughput, and mean service time, and the number of people currently waiting in line ahead of the user.

For further convenience, the researchers designed the system to prompt the user through app notifications when their turn would be approaching, and when they were next in line to be served. This would grant them sufficient time to travel to the physical location of the queue. Additionally, at any time, users would have the option to delay their position in the queue, allowing a specified number of other users to move forward in the queue to take their place. This is intended to afford users greater flexibility in their waiting times, and should help prevent congestion in case one user is anticipated to be holding up the line.

After establishing the system's basic functionality and special features, the researchers developed the concept for the project's front end using Figma, a prototyping and interface design tool.

All design decisions and other information relevant to the project's creation and development were then compiled in the form of a project proposal to be delivered to the system's stakeholders for consultation and approval.

Coding and implementation

This phase is expected to take the most development time, and will thus be given an appropriate amount of attention so that each of the application's intended functionalities will be properly implemented.

The mobile application's front end is to be built using the Kotlin programming language, using Android Studio as an integrated development environment with the Flutter software development kit. Kotlin and Android Studio were considered to be an appropriate choice due to the developers already being familiar with their use, and the Flutter SDK was selected to ensure the application could be compatible with both Android and iOS operating systems.

The backend will be built using a MySQL database, and the Socket.io framework for NodeJS. MySQL was chosen for database management thanks to its simplicity, speed, and low implementation cost, and the Socket.io framework was chosen due to its reliability and ability to easily scale for multiple connected clients. This database would be used to handle user accounts, queue data, and the metrics for each queue.

Finally, the researchers will also develop a time estimation algorithm that will use historical data to estimate the average waiting time for a given queue, the average service time for each queue, and the expected waiting time for each user given their current position.

It was anticipated that the average waiting time and average service time could be obtained by performing a simple mean operation with the queue's past data. Similarly, the expected waiting time for a given customer given their position in the queue could be calculated by multiplying the user's current position in the queue by the average service time.

Each of these different components will be coded and implemented separately for ease of management and documentation.

Integration and Testing
After each component has been implemented in the previous phase, they will be tested separately using a series of prepared trials to assess their performance. Once each component is confirmed to be functional, they will be integrated into the full system to be tested together. If any issues are identified when testing a component, it will be returned to the coding and implementation phase to be adjusted accordingly.

In the case of the algorithm for estimating queue metrics such as average service time and expected wait time, various sample datasets obtained from the internet will be used to test the algorithm's effectiveness and accuracy.

3.2 Calendar of Activities

Table 3.1 shows a Gantt chart of the activities. Each bullet represents approximately one week worth of activity.

Table 3.1: Timetable of Activities

Activities	Feb	Mar	Apr	May	Jun
Study on Prerequisite knowledge	●●				
Development of the Mobile application	●●	●●●●	●●●●	●●●●	
Development of the online database	●●	●●●			
Implementing the user interface	●●	●●●●	●●●●	●●●	
Development of the login functionality		●●●●	●●●		
Formulation of the time estimation algorithm		●●	●●●●	●●	
Testing individual components		●●	●●●●	●●●●	
Integration of components			●●●●	●●●●	●
Testing integrated system			●●●●	●●●●	●●
Analysis and interpretation of finished system			●●●●	●●●●	●●●
Documentation	●●●	●●●●	●●●●	●●●●	●●●●

Chapter 4

Results

4.1 Database Design

Figure 4.1: All tables within the database

Table	Action							Rows	Type	Collation	Si
entries	☆	Browse	Structure	Search	Insert	Empty	Drop	4	InnoDB	utf8mb4_general_ci	16
queues	☆	Browse	Structure	Search	Insert	Empty	Drop	6	InnoDB	utf8mb4_general_ci	16
users	☆	Browse	Structure	Search	Insert	Empty	Drop	4	InnoDB	utf8mb4_general_ci	32
3 tables	**Sum**							**14**	**InnoDB**	**utf8mb4_general_ci**	**64**

The database outline for the LineUp application is composed of several fields. This encompasses user data, such as name, email, api key, and password, and queueing data, such as queue name, queue address, mean waiting time, registration time, and service time. In order to reduce data redundancy and improve data storage integrity, data normalization was attempted. Categorizing and separating the fields mentioned above, three main tables are used in the database: (1) the Users table, which contains all registered data from users; (2) the Queues table, wherein each row contains the data for a user-created queue; and (3) the Entries table, wherein each row is a connection between a user and a queue.

As seen above in 4.3, the **users** table contains five fields. First, there is the **userId**, which is used as the primary key. This is followed by the **name** field which stores the user's username. The **email** field, which simply refers to the user's email address, serves as a unique identifier for each user and as such

Figure 4.2: Users Table

id	name	email	password	apiKey
1	John Doe	johndoe@johnmail.com	$2y$10$kTfasbW6GG4Sa8E4Gd5dYeHzjo.p4lLa3Tzl6WSGqqh...	ccd2b7e7477b
3	Author	apdeza1@gmail.com	$2y$10$3LgBjzcTBrWBxXRxtqvife34nocOsHpsCtxEJ4/3Qw6...	
6	Additional User	additionaluser@gmail.com	$2y$10$bVm7.8eD604V8tHWfTGNb.oapHlNyflUXg3aNG8gpJq...	
7	Placeholder Name	test@gmail.com	$2y$10$BEq64Sqt.FwUw.EDzgMn..We.NHKzSoAhNL27zSD7OK...	

is given the unique constraint. The **password** field is used to store the user's account password. Lastly, the **apiKey** field is used to store the user's login token each session.

Figure 4.3: Queues Table

queueid	queue_owner	queue_name	queue_address	mean_wait	active
1	0	name	location	*NULL*	1
4	test@gmail.com	name	locale	*NULL*	1
5	test@gmail.com	Last row	home	*NULL*	1
6	test@gmail.com	Q6	Ww	*NULL*	1
8	johndoe@johnmail.com	First Queue	My house	*NULL*	1

Similarly, the **queues** table contains five fields. The first among them would be the **queueId** field, which is used as the table's primary key. This is followed by the **queue_Owner** field which acts as a foreign key to the userId field in users to identify queue ownership. The **queue_Name** field simply stores the designated name for the managed queue. Likewise, the **queue_Address** field simply stores the address of the managed queue. Lastly, the **mean_wait** field stores the computed average waiting time for the queue.

Figure 4.4: Entries Table

entryid	queue	user	register_time	time_in	time_out
0	8	test@gmail.com	2023-05-03 22:27:14	*NULL*	*NULL*
0	4	johndoe@johnmail.com	2023-05-03 23:06:05	*NULL*	*NULL*
0	5	johndoe@johnmail.com	2023-05-03 23:06:24	*NULL*	*NULL*
0	6	johndoe@johnmail.com	2023-05-04 17:36:45	*NULL*	*NULL*

Lastly, there are six fields within the **entries** table. The **entryId** field refers to the primary key of the table. The **queue** field is a foreign key that is used to identify the corresponding **queueId** from the **queues** table. Similarly, the **user** field is a foreign key used to map the corresponding **email** from the users table. The **register_Time** field refers to the user's entry time into the queue. The **time_In** field is used to refer to the beginning of the service time of the user in their transaction. Lastly, the **time_Out** field refers to the end of the user's transaction.

4.2 Time Estimation Algorithms

Two methods of waiting time estimation were tested: a simple arithmetic method, and a logistic regression method. For the initial build of the application, waiting time was calculated based on a simple arithmetic method of taking the previous entries within a certain queue and getting the mean service time. In order to compute for this value, the following expression was used:

$$\bar{x}_{wait} = \frac{\sum_{i=1}^{n} x_1 + x_2 + \ldots + x_n}{n}$$

In translating this expression to the LineUp database, the mean service time (/barx) is computed by dividing the summation of each previous entry's service time.

To get the service time of each entry from the queue, the **time_in** field from the **entries** queue is subtracted from the **time_out** to find how much time the user has spent while in service. Once all service times in a queue have been acquired, the mean service time is computed by finding the total of all entries' service time, and then dividing it by the total number of queue entries. To receive the estimation of a particular user's service time, the mean service time is then simply multiplied by the current queue position to find a rough estimate of that user's expected waiting time.

In the final build of the LineUp application, simple linear regression modeling was attempted to predict the estimated waiting time. The following are the necessary equations used for simple linear regression:

$$y = mx + b$$

$$m = \frac{\sum_{i=1}^{n}(x_i - \bar{x})(y_i - \bar{y})}{\sum_{i=1}^{n}(x_i - \bar{x})^2}$$

$$b = \bar{y} - m\bar{x}$$

With x referring to the position in the queue and y being the waiting time, $\bar{x}$ and $\bar{y}$ were computed as the average of each field, respectively.

4.3 Comparison and Testing

These two methods were tested separately from the application itself by representing them as models within a Google Colab and running them through a dataset containing 200 entries of data on customer's arrival times and experienced waiting times within a queue. Given the data, each model was set to predict individual customers' wait times, and compare the difference to the actual recorded waiting times experienced.

The results are presented in the table below:

Table 4.1: Results for Testing Time Estimation Models

..	Arithmetic Model	Regression Model, Training	Regression Model, Testing
R$\hat{2}$	0.9980185001197762	0.9998542815409349	0.9998341984264935
MSE	594.4569019436219	0.00015093807487779014	0.0001479843612984842

Although the arithmetic method is able to closely fit the model for the dataset ($R^2 = 0.9980185001197762$), its accuracy is extremely poor when it comes to predicting results (MSE = 594.4569019436219). Conversely, the regression method provides much more satisfactory results, with good fit and a high degree of accuracy for both the training ($R^2 = 0.9998542815409349$, MSE = 0.00015093807487779014) and testing ($R^2 = 0.9998341984264935$, MSE = 0.0001479843612984842) datasets.

This shows that the regression method designed for this project will be effective in estimating waiting times for the application's users.

4.4 System Performance

(to be added upon completion of the system)

4.5 Conclusion

(to be added upon completion of the system)

4.6 Recommendations

As the developers were only able to examine an arithmetic and simple linear regression method, it is recommended that other researchers examine multivariate regression as a possible model for estimating waiting time.

Additionally, as the project was only tested using datasets obtained from the Internet, it would be beneficial for data to be gathered from practical usage of the application in the contexts that it was developed for.

Furthermore, while the system itself is functional within a locally hosted database, it is recommended that the application be tested while connected to an online database platform before attempts will be made for launch.

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