Continuous Assessment 05

Group B and I

AM 3038 / AM 3084 / FM 3036
Department of Mathematics, University of Colombo

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1 Problem

Waiting Time Problem

A long queue is observed at the coffee shop of the faculty during rush hours. Propose a model to reduce the waiting time at the coffee shop.

2 Introduction

Our aim is to propose a model to reduce the waiting time at the faculty coffee shop during rush hours, since a long queue can usually be observed there during that time. For this, it is important that we understand the setting of the coffee shop.

Original Venue

The faculty coffee shop is a small-scale coffee shop. The shop is operated by two employers, and the customer base includes the university crowd - students, lecturers, and the non-academic staff. To get an idea about the rush hours and the queue we collected some data, and the summary of the data can be elaborated as follows.

Data Collected from the Employers

- Rush hours : 7.30 - 8.00, 9.00 - 9.30, 12.00 - 1.00, 4.00 - 4.30
- Busiest days : “No rush on Fridays and Saturdays”
- Top-selling food items : Nescafe, coffee, eggrolls, plain-tea, egg rotti
- The average length of the queue during a rush hour : no answer
- The average waiting time for an order during a rush hour : 1 - 2 minutes. However, for items such as egg rotti, the wait time may extend to 4 to 5 minutes, leading to longer queues.

Data Collected from the Customers (SUMMARY)

- Rush hours : 7.30 - 8.00, 9.00 - 9.30, 12.00 - 1.00, 3.00 - 4.00
- Busiest days : Monday, Tuesday, and Wednesday
- Top-selling food items : Nescafe, coffee, eggrolls, plain-tea, ice-cream
- The average length of the queue during a rush hour : 10 students
- The average waiting time of an order during a rush hour : 5 to 7 minutes.

Modified Plan and Venue

By analyzing the data for the original plan, it was evident that we need a way larger amount of data than we expected to give a mathematical solution to our problem other than a mere suggestion.

Collecting that much data from the coffee shop at the time of our analysis was influenced by external factors such as the opening of a new canteen in the Student Service Center. Even though our research forced us to collect way more data we observed a gradual decline in the coffee shop queue. Thus, to provide this problem with the best solution, we had to change our setting.

Our new setting was the Student Service Center canteen where we could observe comparatively long queues.

Therefore, we re-modeled the solution for our problem.

The Student Service Center of the Science Faculty comprises of a canteen and a study area. The canteen can be described as medium scale, compared to the coffee shop. The shop is operated by a team of 5 to 8 employees. There are two counters, one for the staff and one for the students. There's a seating area as well.

This time, since the canteen is newly opened, there was no use asking customers' or employers' opinion on rush hours of the canteen or waiting queues during the rush hours. So, we observed and recorded data. What we specifically collected was the **interarrival times** and the **service times** of customers in the queue. This data and the associated variables will also be discussed in depth in the model development part.

We noticed that the queue at the staff counter in rush hours is considerably low. Hence, there we don't see a waiting time. So, we have used the student's queue at the student's counter to model the problem.

Key Concepts and Models

Our primary goal is to propose a model to reduce the waiting time at the coffee shop. We will be attacking our problem using **Queuing Theory**, which is a mathematical discipline that explores and formulates the act of waiting in queues. Queuing theory was first introduced in the early 20th century by Danish mathematician and engineer *Agner Krarup Erlang*.

Queuing theory examines the entire process of waiting in line, considering factors such as customer arrival rate, server quantity, total customers, waiting area capacity, average service completion time, and queuing discipline.

Queuing discipline refers to the rules governing the queue, such as whether it follows principles like first-in-first-out, last-in-first-out, prioritization, or random order of service.

Queuing theory uses mathematics to help businesses understand and improve waiting lines, like in customer service or transportation. It's important because it guides decision-making, helping allocate resources wisely and plan better for improved system performance. This method not only reduces waiting times for customers, making them happier, but also saves money by using resources efficiently.

3 An Overview of Key Variables

Key Variables of the Problem

- Customer Arrival rate
- Service Rate
- Order Complexity: Off the shelf, pre-prepared food
- Number of Servers
- Waiting Area Design

4 Model Development (Our Original Plan)

An Explanation About a Queue System

Queue key variables when modeling a queueing system,

1. Probability distribution for the arrival process
2. Probability distribution used for the service process
3. The number of servers in the service counters
4. Maximum number of customers that can be in the system, if limited.
5. The size of the population of potential customers, if limited.

A queueing model can be defined in general as **A/S/s/K/N**.

A –Arrival times distribution,

S- service times distribution,

s - Number of servers,

K - the maximum number of customers that can be in the system at any one time,

N - size of the population of potential customers.

General notations for the distributions are,

M - exponential distribution (Markovian),

E_k - Erlang distribution

D -the deterministic distribution (constant times),

G -general distribution.

Inter-arrival time

Inter-arrival time in a queue refers to the amount of time that elapses between the arrival of successive customers, at a queue.

Service rate

Service rate is the rate such that each customer in the queue is served. In our canteen service is provided in a first come first serve discipline.

Choosing exponential distribution

The exponential distribution is memoryless, meaning that the probability of an event occurring in the next instant is independent of the past. In the context of queueing systems, this property implies that the time until the next arrival or the time until the next service is not influenced by how much time has already passed, therefore both arrival times and service times distributions are exponential.

Also, exponential distributions are associated with Markov processes, where the future behavior of the system depends only on its current state and not on how it arrived at that state.

Note: If service or arrival distributions are exponential, we use M in model format as mentioned above.

Modeling the current queue at the canteen

The queue at our canteen also follows an exponential distribution in inter-arrival times. So, we assume the service times also follow an exponential distribution. According to the observations and assumptions, the form of our models would be M/M/s.

Limit of customers

The maximum number of customers in a system has no limit. Also, compared to the number of customers in the queue the population of potential customers is large, since as the potential customers we can consider every single person in the university.

Understanding exponential distribution for Queuing Theory

To begin understanding queues, first it's important to have an idea about exponential and Poisson probability distributions and their link to queues and thus waiting time.

The exponential distribution with parameter λ is given by $\lambda e^{-\lambda t}$ for $t \geq 0$.

If T is a random variable that represents interarrival times with the exponential distribution, then, $P(T \leq t) = 1 - e^{-\lambda t}$ and $P(T > t) = e^{-\lambda t}$. This distribution lends itself well to modeling customer interarrival times or service times for several reasons.

- Exponential function is a strictly decreasing function of t. (after an arrival has occurred, the amount of waiting time until the next arrival is more likely to be small than large)
- No memory property (suggests that the time until the next arrival will never depend on how much time has already passed)

It's also useful to note the exponential distribution's relation to the Poisson distribution. The Poisson distribution is used to determine the probability of a certain number of arrivals occurring in a given time period.

The Poisson distribution with parameter λ is given by,

$$\frac{(\lambda t)^n e^{-\lambda t}}{n!} \quad \text{--------(1)}$$

Where n is the number of arrivals. If we set n=0, the Poisson distribution gives us $e^{-\lambda t}$ which is equal to P(T > t) from the exponential distribution.

Ultimately, we ought to establish a connection between the likelihood of experiencing no arrivals during a specific time interval and the probability associated with the duration of time between consecutive arrivals, known as the interarrival time. In this context, the interarrival time refers to the period with zero arrivals.

Why use the exponential distribution?

Exponential distribution has a history-free property that identifies as a characteristic of arrival time for independent customers of coffee shop. Suppose a time $t_1$passes without an arrival. Then the probability that the next arrival occurs between $t_1$and $t_1 + t$ given by the conditional probability formula,

$$P\{T > t + t_1|T > t|\} = \frac{P\{T>t_1+t\}}{P\{T>t_1\}}$$
$$= \frac{e^{-\alpha(t+t_1)}}{e^{-\alpha t_1}} = e^{-\alpha t} = P\{T > t\}$$
$$\text{-----------------(2)}$$

The formula is given that the next arrival requests a time greater than t 0 when t_1 has already passed. The same as the initial probability that the next arrival required a time greater than the t from the start.

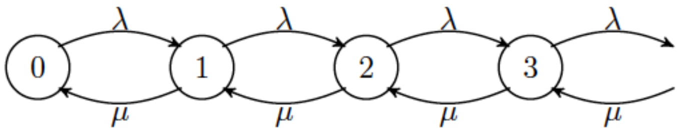
It appears that the history-free property already has and enables us to theoretically analyze queue models.

Modelling M/M/1/∞ /∞ (1 Server 1 Queue Case)

The inter-arrival rate is independent of time, exponentially distributed random variables with parameter λ. The service rate is assumed to be independent of time and exponentially distributed with parameter μ.

figure 4.1: State diagram of the M/M/1 queue

$\mu - service\ for\ the\ customer\ \lambda - \ Arrival\ of\ a\ customer$



Let, $\rho = \frac{\lambda}{\mu}$<1 (arrival-service ratio/traffic intensity)

Let, P_N= Steady-state probability of N customers in the system and P_0= probability of no arrivals.

(Note that, C_N is just a notation for the convenience of calculations)

$C_N = \left(\frac{\lambda}{\mu}\right)^N = \rho^N$ For N=1,2,3,...

$\therefore P_N = C_N\, P_0$

$$\sum_{N=0}^{\infty} P_N = 1$$

$$\left(1 + \sum_{N=1}^{\infty} C_N\right) P_0 = 1$$

$$P_0 = \frac{1}{(1 + \sum_{N=1}^{\infty} C_N)}$$

$$P_0 = \frac{1}{(\rho_0 + \sum_{N=1}^{\infty} \rho^N)}$$

$$P_0 = \frac{1}{(\sum_{N=0}^{\infty} \rho^N)}$$

$$P_0 = \left(\sum_{N=0}^{\infty} \rho^N\right)^{-1}$$

Using the sum of a geometric series concept,

$$P_0 = \left(\frac{1}{1-\rho}\right)^{-1}$$

$$P_0 = 1 - \rho$$

Thus, $P_N = (1-\rho)\rho^N$ for N=0,1,2,3,,..

Average number of customers in the system

$$L_s = \sum_{N=0}^{\infty} NP^N$$

$$L_s = \sum_{N=0}^{\infty} N(1-\rho)\rho^N$$

$$L_s = \rho(1-\rho)\frac{d}{d\rho}\left(\sum_{N=0}^{\infty} \rho^N\right)$$

$$L_s = \rho(1-\rho)\ \frac{1}{(1-\rho)^2}$$

$$L_s = \frac{\rho}{1-\rho} = \frac{\lambda}{\mu-\lambda}$$

Average number of customers in the queue,

$$L_q = \frac{\rho^2}{(1-\rho)}$$

$$L_q = \frac{\lambda^2}{\mu(\mu-\lambda)}$$

Average waiting time in the system,

$$W_s = \frac{\rho}{\lambda(1-\rho)}$$

$$W_s = \frac{1}{(\mu-\lambda)}$$

Average waiting time in the queue,

$$W_q = \frac{\rho}{\mu(1-\rho)}$$

$$W_q = \frac{\lambda}{\mu(\mu-\lambda)}$$

Adding another server parallel to the 1st server

One of our initial guesses was, by adding another server parallel to the 1st server, we can reduce the waiting time in the coffee shop queue. Therefore, we extended the model into M/M/2 (FCFS; inf; inf) state.

Considering the M/M/2(FCFS;inf;inf) queueing system with infinite customers and customers arriving according to the Poisson process with rate λ. . The system has a single queue and two identical servers, one server can serve only one customer at the same time. The total number of potential customers and the system capacity are assumed to be infinite. The system discipline is First come First serve (FCFS). When a customer is serviced by the server, the service time of two servers is an exponential distribution with the parameter of μ .

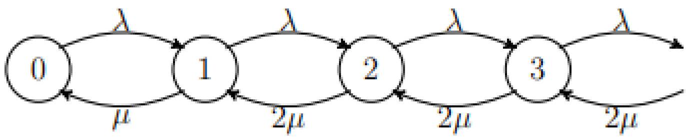


Figure 4.2: State diagram of the M/M/2 queue

The steady-state condition is, Eq. (5)

$$\rho = \frac{\lambda}{2\mu} < 1 \tag{5}$$

From the rate diagram,

$$P_1 = \frac{\lambda}{\mu} P_0 \qquad P_2 = \rho P_1 \qquad P_3 = \rho P_2 \, , \qquad \ldots . \tag{6}$$

$P_0 + P_1 + P_2 + P_3 + \cdots \ldots = 1$ (The sum of probabilities is equal to 1)

$$P_0 + P_1 + \rho P_1 + \rho^2 P_1 + \cdots \ldots \qquad = P_0 + P_1(\rho + \rho^2 + \rho^3 + \cdots . .)$$
$$= P_0 + \frac{P_1}{1-\rho}$$

Using $P_1 = \frac{\lambda}{\mu} P_0 = 2\rho P_0$;

$$P_0 = \frac{1-\rho}{1+\rho}$$

Steady state Queue Length

The steady-state queue length of waiting customers.L_q

In M/M/2 model the queue begins in 3rd state. Using Eq. (6)

$$L_q = 0P_0 + 0P_1 + 0P_2 + P_3 + 2P_4 + \cdots = (1 + 2\rho + 3\rho^2 + \cdots)P_3 = \frac{P_3}{(1-\rho)^2}$$

$$P_1 = \frac{\lambda}{\mu}$$

$$\mathrm{P}_1 = \frac{2\rho(1-\rho)}{1+\rho}$$

$$P_3 = \frac{2\rho^3(1-\rho)}{1+\rho} = \frac{2\rho^3(1-\rho)^2}{1-\rho^2}$$

$$L_q = \frac{2\rho^3}{1-\rho^2} = \frac{\lambda^3}{\mu(4\mu^2-\lambda^2)}$$

Using Little’s Law in queueing theory,

$$number\ of customers\ being\ served = \lambda \times waitting\ time\ of\ service$$

The average length of the system.

$$L_s = L_q + \ steady\ state\ number\ of\ customers$$

$$L_s = \frac{\lambda^3}{\mu(4\mu^2-\lambda^2)} + \frac{\lambda}{\mu} = \frac{4\mu\lambda}{4\mu^2-\lambda^2}$$

Steady-state waiting time

The steady-state waiting time of the queue.(W_q)

Using Little’s Law,

$$W_q = \frac{L_q}{\lambda} = \frac{\lambda^2}{\mu(4\mu^2-\lambda^2)}$$

The average waiting time in the system

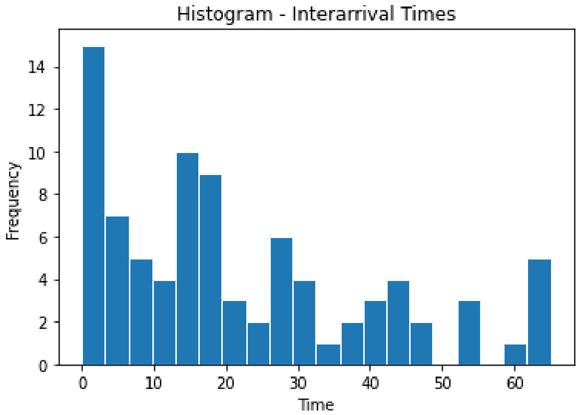
$$W_s = W_q + steady\ state\ waiting\ time\ of service.$$

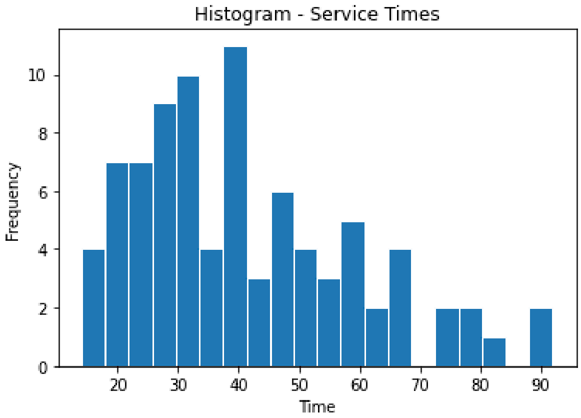
$$= \frac{\lambda^2}{\mu(4\mu^2-\lambda^2)} + \frac{1}{\mu} = \frac{4\mu}{4\mu^2-\lambda^2}$$

5 Observational Data Overview and Analysis

5.1 Data for the Coffee Shop Queue

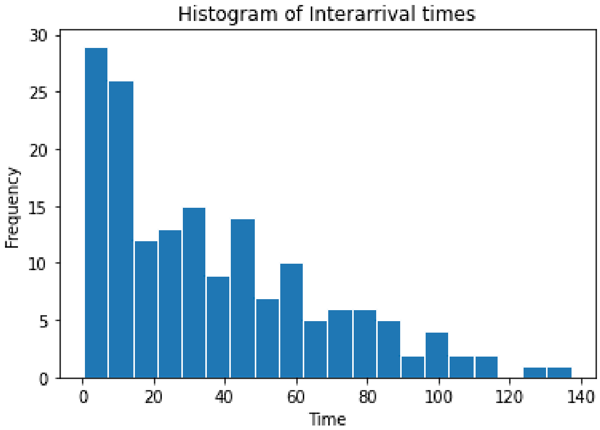
- 86 Total data points were collected during the rush hours of Wednesday, 14th February.
- On average, customers arrived every 21.8 seconds or every 0.363 minutes. Thus, the arrival rate is 2.75 customers per minute.
- Service completion took an average of 41.1 seconds or 0.685 minutes. Thus, the service rate is 1.46 customers per minute.

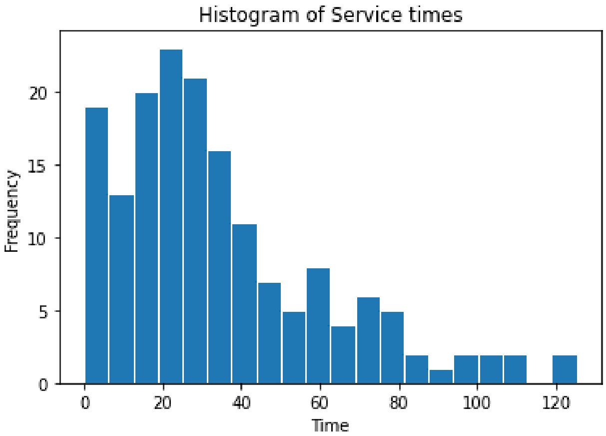




5.2 Data for the Student Service Center Canteen Queue

- 169 data points were collected during the lunch hours of Wednesday, 21st and Thursday, 22nd February.
- On average, customers arrived every 36.75 seconds or every 0.6125 minutes. Thus, the interarrival rate is 1.63 customers per minute.
- Service completion took an average of 34.64 seconds or 0.577 minutes. Thus, the service rate is 1.73 customers per minute.





6 Model Validation

6.1 Model for the Coffee Shop

In order to validate our model for the coffee shop queue, we should first check whether the arrival process and the service process is a Markovian process. That is, we need to check whether they follow an exponential distribution relative to their mean values.

We used a Chi- square goodness of fit test to see whether the interarrival times and the service times follow an exponential distribution.

Chi-square values for each distribution (for 20 classes) is as follows :

	Interarrival Times	**Service Times**	**Critical Value for $\alpha = 0.05$**
Chi- square value	**49.45**	**57.02**	**30.14**

Table 01: *Chi-square values for each distribution*

Since the Chi-square statistics of both interarrival times and service times are greater than the critical value, we cannot accept that they follow an exponential distribution.

Moreover, when we consider the total 86 data points,

Hence, we were not able to use our queuing model to accurately model the queuing process at the coffee shop.

6.2 Model for the Student Service Center Canteen

Similarly, a Chi square test was used for validation and the results are as follows (for 20 classes) :

	Interarrival Times	**Service Times**	**Critical Value for $\alpha = 0.05$**
Chi- square value	**15.56**	**24.26**	**30.14**

Table 02: *Chi-square values for each distribution*

Since the Chi-square statistics of both interarrival times and service times are less than the critical value, we can accept that they follow an exponential distribution.

Hence, we conclude that our model is valid for modelling the queuing process at the SSC canteen.

7 Results

7.1 Mathematical Queuing Theory Results

To evaluate the performance of the queuing model developed above, key performance metrics such as Average waiting time, Average queue length were analyzed under the 2 scenarios:

- One queue : One server – M/M/1 model (Current Situation)
- One queue : Two servers – M/M/2 model

	One queue : One server	One queue : Two servers
Average Waiting Time in the System (W_s)	10.00 minutes	0.74 minutes
Average Waiting Time in the Queue (W_q)	9.42 minutes	0.16 minutes
Average Number of Customers in the System (L_s)	16.30	1.21
Average Number of Customers in the Queue (L_q)	15.36	0.27

Table 03: *Average Waiting Times and queue lengths*

By the above analytical results from the model in Table 03, we can expect up to **92.6%** drop in the average waiting time in the total queueing system and a **92.57%** drop in the average number of customers in the queueing system at given time when another service counter is added to the canteen in rush hours.

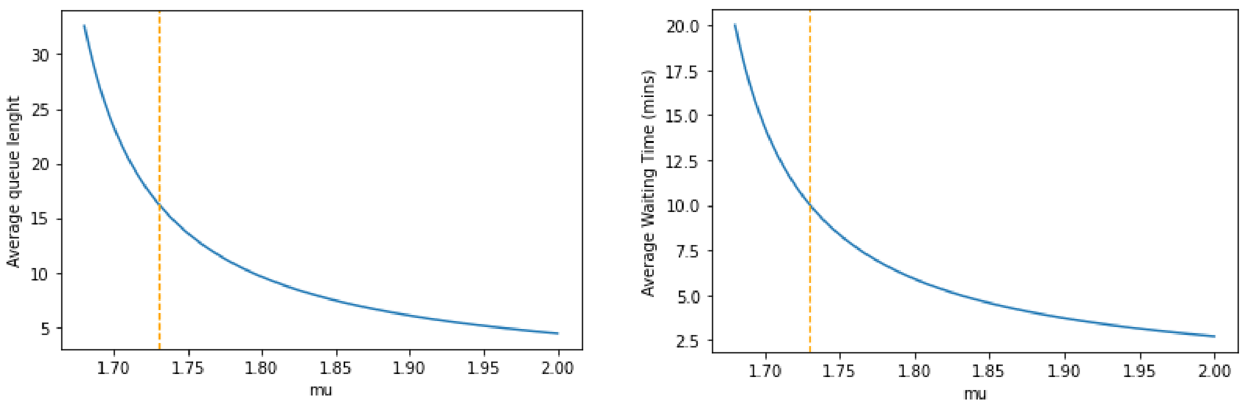


Figure 7-1 Changes with respect to mu(service rate) in Average waiting time and Average queue length

Next, we observe what happens to the Average queue length and the Average waiting time when we change the service rate. As seen in figure 7-1, Both the Average queue length and the Average waiting time reduces significantly with increasing service rate.

7.2 Agent-Based Simulation Results

We developed an Agent-Based model to simulate the queue at the SSC Canteen using AnyLogic. Main aim of this is to compare theoretical results with the simulated results and confirm the validity of the model.

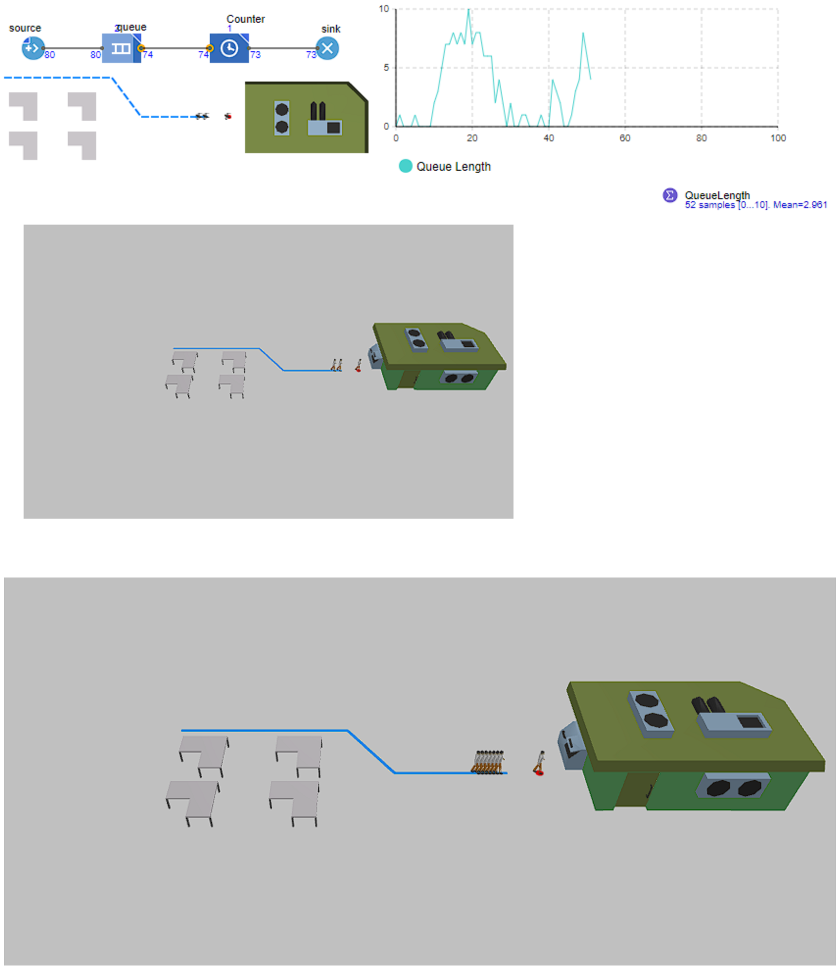


Figure 7-2 : Images of the simulation developed

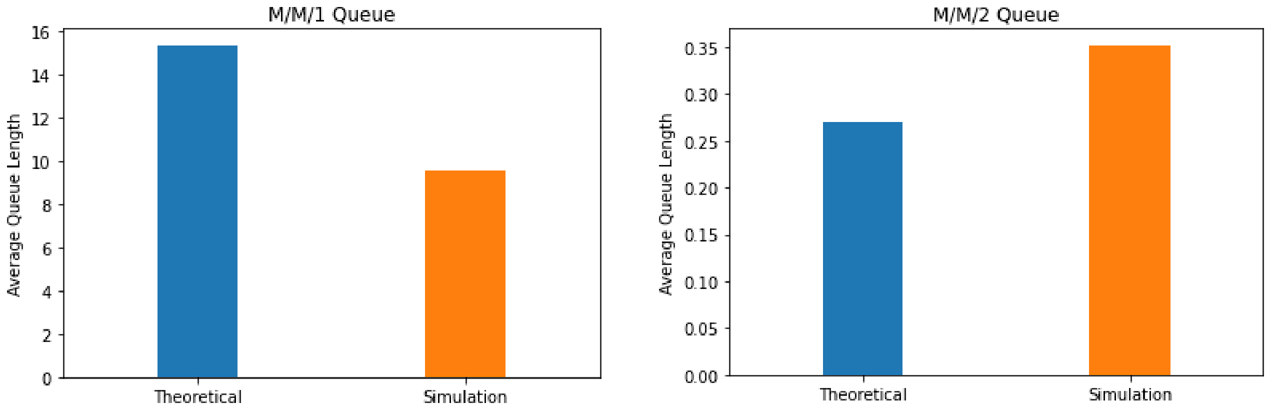


Figure 7-3 -Comparison of Simulation and Theoretical results

Simulations were run 20 times, and the average was plotted against the theoretical results. There seem to be a slight difference in the values. We suspect that this is due to systems not reaching the steady states.

8 Recommended Implementations

8.1 For the Coffee Shop

After analyzing the results of the coffee shop model, we proposed the following suggestions:

- Open another service counter, taking advantage of the coffee shop's structure and location.
- Employ an additional staff member for the new counter during rush hours (consider hiring a student for part-time assistance due to the shop's small scale).
- Implement queue line barriers, tailored to the available space.
- Introduce a QR code system, suitable for the location as it aligns with the university's technological infrastructure.

8.2 For the SSC Canteen

Adding Another Service Counter in Rush Hours

To address long waiting times in the Student Service Center canteen, an additional service counter is proposed. Our model proved that opening another counter can significantly reduce the waiting time.

Unlike the case with the coffee shop’s small space available, this canteen has a large space and therefore can easily accommodate another queue, even making it possible to easily implement a queue line barrier to reduce the waiting time, which we will discuss next.

The calculations prove the validity of our point; therefore, we recommend the canteen to open another counter and effectively manage it to reduce the waiting time in the queue during rush hours.

Queue Line Barrier Implementation

Queue line barriers will guide customers to stay in line.

One of the things we observed in the Student Service Center canteen was the tendency of students to organize as clusters in front of the counter rather than in an organized queue. This created a chaotic situation, consequently contributing to an increased waiting time for orders due to the disorderly organization in front of the counter. This also violates the first-come, first-served basis.

Properly designed queue systems can ensure that customers are served in the order of their arrival, adhering to the principle of 'first come, first served'. When customers are served based on who arrives first, it helps keep things fair and simple. This approach, part of a queue management system, makes the whole process more efficient and reduces waiting times for everyone. The goal is to create a fair and organized system, which is a strategy to make sure customers wait less overall. This not only makes customers happier but also helps the business run more smoothly.

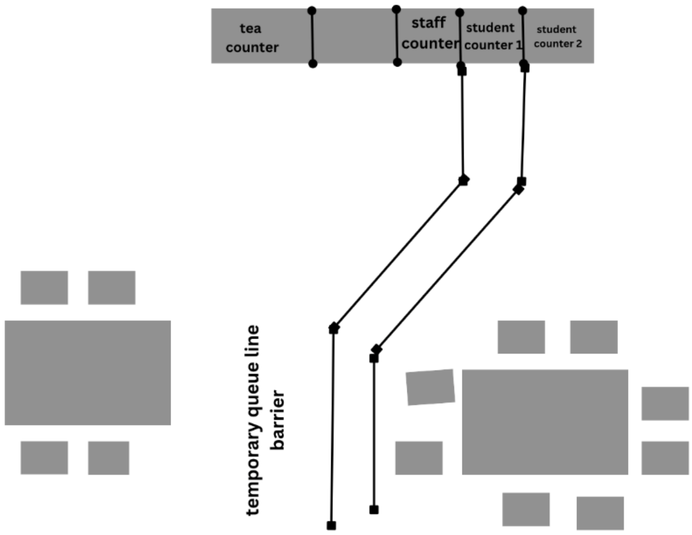


Figure 8.2.1 : the proposed queue barrier system

Efficient Equipment and Technology

Incorporating modern technology can significantly improve service speed and efficiency.

We can allow customers to use their smartphones to scan QR codes of the items they wish to purchase through a mobile application, instead of dealing with the cashier, which speeds up the transaction process. This system should be integrated with a point-of-sale (POS) system that supports such digital transactions. This strategy not only reduces the time customers spend in waiting lines but also encourages customers to become familiar with modern technology.

However, there are a few considerations that come into play along with this suggestion. While contactless ordering, reducing waiting time, improving overall efficiency, menu flexibility, and data collection can be advantages of this method, special attention must be given when addressing a medium-sized university canteen. Ensuring proper training and support for students and staff, maintaining good connectivity, managing implementation and maintenance costs, implementing security measures to protect user data, and providing a wholesome experience to users are essential aspects to consider.

9 Discussion

In tackling the waiting time issue during busy hours, we decided to steer clear of relying solely on the chi-square test for our analysis. We discovered that while the chi-square test is good for checking data fit, it doesn't precisely pinpoint the distribution of waiting times. It is also a fact that passing the chi-square test doesn't tell us exactly what kind of distribution we're dealing with, and we're concerned about a higher chance of making type II errors.

Looking back at our attempts to model the university coffee shop queue, we faced a challenge due to not having enough data. The limited information we had might be the reason our model validation didn't go as planned. To tackle this, we realized we need more comprehensive data to truly understand how the coffee shop queue behaves during busy times. Getting a bigger and more detailed data set is crucial for improving the accuracy and reliability of our models. That's why we re-modeled the situation, changing our venue to the Student Service Center canteen.

Although the Student Service Center canteen had two counters, one exclusively for staff members showed no peak-hour rush and didn't require consideration due to the fact that there is only a small queue if at all. However, the student counter consistently faced high activity, resulting in long queues. The focus, therefore, was on finding a solution for the busy student counter. As per our suggestions, a third counter next to the student counter needs to be opened to control the rush during the peak hours.

The system may not have achieved steady state flow even though the model assumes so.

In our examination of both the university coffee shop and Student Service Center canteen queues, we discovered a potential discrepancy between our model and the simulation. The model assumes a steady-state flow, where the queue's behavior is constant and balanced. However, we acknowledge the possibility that the real-world queues may not be operating in such a stable manner, despite our model assuming otherwise.

Here we assume that the service rates at both counters are equal. That might not be the case.

In our analysis, we assumed an equal service rate at both counters. However, it's crucial to acknowledge that this assumption may not accurately reflect the true operational scenario. Actual canteen counters may have varying service rates at different counters. Our model is not able to capture this property.

10 Conclusions

- Another counter is open in rush hours, in fact there would be 2 counters with one queue.
- By the above-mentioned conclusion the waiting time decreases by 92.6%.
- Increasing the service rate largely decreases the Average waiting time at the queue.

11 References

1. Taha, H.A. (2018). Operations research: an introduction. New York: Collier Macmillan.
2. Winston, W.L. and Goldberg, J.B. (2004). Operations Research. Brooks/Cole.

12 Appendix

Index	Interarrival_times	Service_times	Index	Interarrival_times	Service_times	Index	Interarrival_times	Service_times	Index	Interarrival_times	Service_times	Index	Interarrival_times	Service_times
0	00:10.2	01:08.9	34	00:43.4	00:50.8	68	01:27.3	01:09.5	102	00:04.2	00:00.5	136	00:33.1	00:00.8
1	00:38.7	00:29.2	35	00:14.1	00:13.9	69	00:21.6	02:00.5	103	00:01.2	00:47.2	137	00:22.7	00:52.3
2	00:43.6	00:03.8	36	00:05.8	00:33.8	70	00:28.1	00:50.9	104	00:35.3	00:21.1	138	00:07.0	00:58.5
3	00:17.2	00:42.9	37	00:28.9	00:25.0	71	01:19.7	00:21.3	105	00:48.2	00:59.3	139	00:24.6	00:56.9
4	00:57.3	00:40.8	38	00:27.1	00:57.3	72	00:05.2	01:45.4	106	00:05.4	00:33.4	140	00:09.9	00:27.4
5	00:47.5	00:52.6	39	01:26.9	00:12.4	73	00:08.7	01:26.8	107	00:13.4	00:20.7	141	00:01.2	00:24.8
6	00:42.7	01:19.4	40	00:01.5	00:10.8	74	00:10.0	00:25.3	108	01:44.9	00:15.7	142	00:06.8	00:14.7
7	00:22.9	00:40.6	41	00:55.4	00:32.6	75	00:08.9	01:24.0	109	01:09.9	00:23.2	143	00:07.0	00:26.4
8	00:29.5	01:12.8	42	00:52.1	00:10.4	76	00:26.3	00:24.1	110	00:30.6	00:00.8	144	01:01.1	00:13.2
9	00:34.2	00:25.9	43	00:02.5	00:28.3	77	00:05.4	00:23.6	111	00:11.2	00:21.5	145	00:23.2	00:02.6
10	00:14.1	01:19.9	44	00:53.2	00:29.9	78	00:07.0	00:18.1	112	01:02.7	00:32.0	146	00:18.5	00:34.5
11	00:08.1	00:42.9	45	01:38.4	01:08.7	79	01:27.8	00:17.1	113	00:26.5	00:28.8	147	00:40.3	00:19.9
12	00:51.4	01:46.5	46	01:08.8	00:48.3	80	00:05.6	00:00.1	114	00:00.5	00:20.1	148	00:08.1	00:30.3
13	00:54.7	00:33.1	47	00:20.1	00:16.2	81	01:00.5	00:20.2	115	00:12.7	00:05.6	149	01:18.2	00:09.9
14	00:07.7	01:38.7	48	00:05.6	01:08.3	82	00:28.6	00:18.3	116	00:34.6	00:21.9	150	00:04.1	00:19.7
15	00:20.6	00:28.5	49	00:21.9	00:00.0	83	01:15.3	00:16.0	117	01:09.8	01:07.1	151	00:10.3	00:38.9
16	00:08.8	00:27.9	50	01:07.1	00:32.2	84	00:44.7	01:15.9	118	00:07.9	00:00.6	152	01:17.0	00:24.0
17	00:11.0	00:25.3	51	00:00.6	00:24.0	85	00:00.5	00:16.1	119	00:05.0	00:22.8	153	00:09.9	00:16.6
18	00:06.8	00:59.7	52	01:02.8	01:38.3	86	01:13.5	00:33.6	120	00:27.5	00:40.7	154	00:24.1	00:27.4
19	00:08.4	01:31.8	53	00:40.7	01:12.4	87	00:37.2	00:23.1	121	00:47.2	00:44.8	155	00:13.6	00:20.7
20	00:13.0	00:35.1	54	00:44.8	00:26.6	88	00:27.2	00:17.1	122	01:21.2	00:08.6	156	00:16.1	00:14.5
21	00:02.3	00:12.6	55	00:08.6	01:18.5	89	00:00.6	00:17.1	123	00:59.3	00:43.2	157	02:17.1	00:39.6
22	00:41.7	01:00.7	56	00:43.2	00:49.1	90	00:22.9	00:20.4	124	01:26.5	00:17.4	158	00:17.1	00:32.4
23	00:15.4	00:08.8	57	01:17.4	00:35.0	91	00:56.1	00:11.9	125	00:50.7	00:02.6	159	01:00.2	00:42.7
24	00:37.6	00:33.0	58	00:02.6	01:42.8	92	01:44.4	00:30.6	126	00:15.7	00:35.3	160	00:58.3	00:00.9
25	00:12.9	00:02.5	59	00:35.3	01:08.7	93	00:44.7	00:21.2	127	01:33.2	00:11.5	161	00:36.0	00:08.6
26	00:30.5	00:06.1	60	02:04.5	01:01.4	94	01:17.4	00:12.7	128	01:08.8	00:42.5	162	01:25.9	00:11.5
27	00:30.8	00:27.0	61	00:42.5	00:00.9	95	00:00.5	00:33.5	129	00:51.5	00:00.6	163	00:16.1	00:40.7
28	00:14.8	01:02.2	62	00:00.6	00:12.7	96	00:30.4	00:30.5	130	00:32.0	00:45.7	164	01:33.6	00:32.4
29	00:33.0	00:25.6	63	00:45.7	00:00.9	97	00:00.4	00:12.7	131	00:31.6	00:08.6	165	01:55.1	00:09.6
30	00:09.2	01:11.0	64	00:08.6	02:05.1	98	01:42.3	00:34.6	132	01:50.6	00:53.4	166	00:18.5	00:00.3
31	01:37.8	00:27.0	65	00:07.4	00:00.5	99	00:00.6	00:29.8	133	00:35.6	00:48.8	167	00:18.1	00:22.7
32	00:43.5	01:16.4	66	00:00.4	01:12.6	100	00:52.4	00:27.9	134	01:42.5	00:00.3	168	01:00.2	00:12.4
33	00:32.1	00:47.8	67	01:02.8	01:51.8	101	01:05.1	00:25.0	135	01:00.6	00:18.5			

Table 4 : Data of the SSC Canteen