QUEUEING SYSTEM IN FAIR PRICE SHOP OF KERALA TO MITIGATE WAITING TIME AND OPTIMIZATION OF SERVERS

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Abstract

Queues are a typical occurrence in everyday life, particularly during peak hours in Fair Price Shops (FPS), government offices, banks, post offices, super markets, hospitals, and clinics. The arrival rate, service rate, and server usage all play a role in the queueing process of any system. We expect a balance between waiting time and server utilization in an effective system, with the ideal being less waiting time and maximum server utilization. This paper investigates efficient queue management in FPS using M/M/C queueing model. The major goal of this research is to minimize customer waiting time in the FPS with the minimal number of servers. It demonstrates the application of the simulation modelling as a method for optimizing the number of servers in a specific FPS in Kerala, India. The model was developed to provide the outcomes of system parameters like arrival rate, waiting time and server utilization.

***Keywords*: Fair Price Shop, Markov Model, Optimization, Public Distribution System, Queueing Theory, Server Utilization, Simulation, Waiting Time.**

1. Introduction

Service timings are often believed to be independent of experienced delay in traditional queueing models. Such assumptions about independence are frequently required for the analytical tractability of queueing system operation. A queue is a group of individuals or entities that are waiting to be served in a specific order [Syed Shujauddin Sameer, (2014)]. Customers enter a queue, are finally serviced, and then exit the system under a queueing paradigm. Customers and servers are vital aspects of a queueing system [Sanjay K, (2002)]. Individuals, equipment, vehicles, e-mail cases, patients, cargoes, aircraft, or orders—anything that enters at a place/facility and needs service is referred to as a "customer" [Banks J et al., (2001)]. Any resource that needs the required service such as technicians, computer CPUs, reception staff, repair people, instrument clerks, automatic packers, healthcare officers, automobile storage and retrieval equipment, airport runways, cargo pickers, and washing machines are all instances of "servers". Queues are common in daily life, especially during peak hours, in Fair Price Shop (FPS), governmental institutions, banks, post offices, super markets, hospitals, and pharmacies.

Distinct trends for the probability of states stabilized Markov systems with deficits were identified around the turn of the twentieth century [Bolch et al., (2006)]. Queueing theory aims to limit the count of service providers so that customers do not have to wait in lines or exit the system unnecessarily [Saulius Minkevičius, (2009)]. Customers may recommend leaving the system rather than wait in long lines [Famule, F and Dais F, (2010)]. Customers' demands and expectations that come into the system specifically for that reason are represented by queueing systems [Bahadori M et al., (2014)]. The queueing system encompasses all of the factors that occur between the customer's arrival and exit from the system.

In actuality, however, it has been recognized that the amount of time spent waiting has an impact on service durations. According to research and understanding, customers will frequently leave a shop without buying a product, instead of waiting in a prolonged or slow-moving queue [Anthony Igwe et al., (2014)]. Queue management is a concern for every retail company and store owner, despite substantial technological improvements aimed at reducing wait times. The reality is that poorly managed queues will often result in customer dissatisfaction, reduced sales, and loss of customer loyalty. The discipline of behavioral operations, on a more conceptual level, studies how servers and customers act in an operational setting.

The Public Distribution System (PDS) is the most essential avenue for delivering food security to the public through micro-level government initiatives. PDS allows for the subsidized distribution of food grains to the impoverished, as well as the regulation of open-market rates for items delivered through the system. The government places a high value on the goal of measuring PDS performance in order to guarantee that the equal distribution system provides a means for which it was established. India's PDS system is well-organized, with a network of FPS operating across both rural and urban areas. The efficacy and success of the distribution system are largely dependent on the running of FPS. Under the PDS, these shops serve a critical part in the retail distribution of necessary commodities. As a result, accessibility to PDS resources is contingent on several criteria, the most important of which are administration, organization, and the viability of FPSs. It is a platform for making PDS items accessible to the most vulnerable consumers. It is critical to investigate the ideas and opinions of traders on the feasibility of FPS. People have apprehensions about receiving their monthly grain quotas through the PDS. The restricted time allocated for grocery stores to stay open adds to people's anxiety, driving them to rush to ration shops and collect their grain as soon as possible. Crowding is a problem for shopkeepers as well.

Cost-cutting is a concern and a goal for almost every firm. There are several cost-cutting tools available [Silvia Ďutková et al., (2019)]. The term "optimization" is commonly used in both the industry and economic sectors. Computer simulation is now extensively used as a methodology for optimization. One of the goals of computer simulation is to go beyond the boundaries of methodological approaches and incorporate real-world features and properties that are difficult to represent theoretically. In a system like the FPS queueing system, various random elements cannot be addressed with analytical optimization solutions. As a result, employing a simulation method to make the system model as close as feasible to the real system is strongly recommended.

The goal of this article is to show the reader with an instance of how to employ the simulation method to improve the queue system of an FPS. The queue mechanism of a specific FPS in Kerala, India was chosen for research and analysis. The queueing system of FPS in Kerala can be regarded as a stochastic system with an infinite front, a customer arrival, a specified average time, and a set number of counters. By executing simulation experiments with the provided input parameters, we can acquire the findings of the system's characteristics. During the FPS's opening hours, the system's input settings alter substantially. This allows for the number of service counters to be optimized based on the input parameters [Silvia Ďutková et al., (2019)].

The rest of this article is organized as follows. In Section 2 a brief overview of the existing literature is presented. The description of the model employed in the study is explained in Section 3. Section 4 explained the design of the M/M/C queueing model. Simulation results and findings are given in Section 5 and lastly, in Section 6, we give the conclusions about the research work.

2. Literature Review

A system is a group of entities, such as individuals or robots that behave and communicate to achieve a logical objective. There are two distinct system types. A discrete system has variables that represent values that change instantly at different points. A continuous system's state variables change frequently over time. The queueing system at Kerala's FPS is an example of a discrete system, with state variables varying solely when a consumer enters or exits a service. Through the FPS, the PDS guarantees the availability of food and economic access to beneficiaries by supplying food grains at reasonable prices. [Sharma Anuradha, (1997)] provided a thorough analysis of the organizational behavior scheme of PDSs in Jammu and Kashmir, along with that of FPSs. The study described the main characteristics of PDS, such as its performance in rural areas, the FPS implementation system, and customer reviews, as well as the operational nature of distribution schemes at both the state and national levels. Two Markovian queueing models were examined by [R Bekker et al., (2011)]: one had a single server queue with service frequency dependent on First Customer in Line (FIL) waiting period, and the other had two separate servers and a waiting line, with the secondary server only being enabled when the FIL wait time exceeded a predetermined threshold. The analysis for both models is focused on the first customer in line's waiting time (FIL-process).

[Mohammad Shyfur et al., (2013)] investigated at a variety of prevalent queueing scenarios and constructed mathematical models to examine waiting lines based on some specific assumptions. A queueing model with multiple service channels is depicted in a bank for clients on a level of service, and overall predicted costs are analyzed after a series of operating parameters are determined. They covered the fundamentals of queueing models and demonstrated how linear programming, as well as mathematical modeling in some situations may be employed to determine system performance metrics. A study was carried out by [Bahadori et al., (2014)] targeted at optimizing the governance of the examined outpatient dispensary by establishing queuing model and simulation techniques. An analytical investigation was undertaken in an Iranian military hospital for this purpose. They discovered that by employing multitasking people and reassigning them to the time taking process of writing prescriptions, they could minimize patient waiting time as well as the count of patients waiting to get serviced both in the morning and evening by using queueing theory and simulation approaches.

[Mousavi et al., (2015)] presented a system for modeling healthcare processes that incorporates innovative methodologies as well as traditional methods. They explored the correlation between patient gratification, wait time, employee gratification, and service time. They used a range of frameworks to help them in achieving both perceptual and operational medical objectives. A approach that relies on waiting times is used to determine customer level of satisfaction. The level of employee satisfaction is measured by a model dependent on the service time. Using queueing theory, the Effective Satisfaction Level (ESL) model is offered as an integrated approach to patient and employee satisfaction.

[Shanmugasundaram, S., and Umarani P (2017)] demonstrated a queueing system with several service stations using a simulation table. They examined the hospital's competence by employing Monte-Carlo simulation with various service distributions, as well as the multi-specialty hospital's expectations in both simulation and analysis techniques. [Gurudeep Kaur Ghumaan et al., (2016)] conducted a study to learn about FPS dealers' attitudes toward PDS as well as the constraints that FPS dealers face. Beneficiaries purchase their monthly food grain entitlements from these ration shops at subsidized rates. State governments issue licenses to ration shop owners, who are required to perform specific duties under the strategy [Balani, S, (2013)]. These tasks encompass (i) selling products to ration card members at state-set retail issue rates, (ii) maintaining records and presenting data including the list of (Below Poverty Line) BPL and Antyodaya Anna Yojana (AAY) recipients, entitlements to essential necessities, shop timings, and opening and closing stocks, and (iii) keeping accounts of the actual distribution of basic items and the stocks remaining in the shop during month end [Mahima Gopal Ghabru et al., (2017)].

[Motaghedi et al., (2017)] devised a queueing model that minimizes the time it takes for departing trucks approaching a cross-dock with a consistent arrival time. The suggested method determines how long each truck should expect to wait. The actual count of assigned trucks, as well as the loading time remain constant. After that, the waiting time curve is computed. [Xia Hu et al., (2018)] conducted a review to emphasize queueing theory's contributions and distinction from simulation, as well as to define the latest developments in its use in Emergency Department (ED) settings. They discovered that, while queueing models provide useful information on ED operations, they have significant flaws when contrast to other simulation models. They investigated queueing theory applications from both the supply and demand sides and also various methodological advancements designed to resolve ED operations.

The use of queueing theory in the formation of mathematical models to discover and examine queues to minimize long waiting lines in our FPS will result in better services. Queueing systems are those that cater to the needs of customers who enter the system solely for that purpose. All of the components that occur between the customer's entry into the system and its exit from the system are represented by the queueing system. [Dutkova et al., (2019)] proposed a simulation model and used an optimization method to reduce the number of service counters to save money.

[Gabi Hanukov et al., (2019)] devised a technique centered on matrix geometric (MG) study after modelling the system as a Markovian process. They proposed a two-server architecture, where inactive servers generate and retain preliminary services to lessen waiting time for incoming customers and increase arrival rate of customers. [Reza Alizadeh et al., (2020)] suggested a novel mixed-integer linear programming technique for resolving minor occurrences of the problem. A Genetic Algorithm was used for larger-scale instances. They presented an optimization problem involving non-emergency outpatient scheduling for the appointment, in which a single machine and a minimal number of medical experts are required to address the medical demands of a huge count of patients waiting in the queue.

The Indian PDS is not without flaws. Certain states' administrations are inefficient and dishonest. Severe inventory shortages, fraudulent supply entries in ration cards, commodity diversion for open market sale, longer queue wait times, and bogus ration cards have all been reported in all the states. PDS has received a great deal of public criticism during commodity delivery due to leakage, corruption, and inefficiency. Specific criticisms include inefficient government machinery, long waiting lines, improper inventory control, supplying people with poor quality food grains, a weak vigilance mechanism, and a high level of corruption and theft during goods transportation.

Customers expect short wait times, while service providers would like to maximize resource utilization. Long wait times are not uncommon in many service organizations and they are especially prevalent in many FPS. Customer forms lines because a customer's service may not be provided as soon as the customer arrives at the serving area. Customers would form a waiting line if there was no satisfactory service facility [F. S. Hillier and G. J. Lieberman, (2007)]. The only way to meet service demand is to expand the capacity of the service and enhance the productivity of the prevailing facilities. Minimizing the waiting time in the queues in the FPS with a minimal number of servers is the primary objective of this work. For the research and analysis, the queue mechanism of a particular FPS in Kerala, India was chosen.

3. Model Description

The Chi-Square test was conducted to see if the arrivals were distributed in a Poisson fashion and the services were distributed exponentially. The simulation table allows us to track the state of a system over time in a systematic fashion. The major objective of this work is to ascertain how long a customer should wait in the queue in an FPS, and also to calculate length of the queue in the M/M/C queueing model, how to reduce the customer waiting time in an FPS with the optimal number of servers using simulation technique.

3.1. *Data Collection*

Data on customer arrival patterns and the time taken to serve various customers by the service provider is collected from one of the FPS from Kerala in Kottayam district. The FPS of our study comprises of one server for customers, and it operates in First in First out (FIFO) scheduling to serve the consumers. A significant volume of data was collected to examine the behavior of the queue in the FPS. Data concerning arrivals, departures, and service patterns are recorded from an FPS in Kerala, India for a period of 6 months, during the working periods between 8.30 a.m. to 7.30 p.m. The average arrival rate of customers over a period of 6 months visiting in the particular FPS in every one hour of a day are taken for simulation. The FPS taken in our study is closed for 3 hours from 12. 30 p.m. to 3.30 p.m. Data collection from FPS regarding the arrival pattern of customers was done through the Aadhar Enabled Public Distribution System Kerala (AePDS Kerala) Government Portal.

3.2. *Hypothesis Testing*

Hypothesis testing is performed to determine the plausibility of a hypothesis with the help of sample data. It is mainly used to see if the gathered or modelled data are statistically meaningful at a pre-determined level of significance. It also helps to measure whether the results of research would support rejecting the null hypothesis at a predetermined level of significance. Because it is used to verify if observations fit a predetermined distribution pattern. The data can be tested using a variety of statistical hypothesis testing methods, including the "t-Test," "z-Test," "fTest," "Chi-Square test," and others. We use the Chi-Square test for statistical testing to verify the null hypothesis. It asserts that there is no correlation between the two population parameters. The goal is to demonstrate whether or not the test is justified, which is independent of the investigator's personal values and conclusions.

3.3. *Degree of Freedom*

It is the largest number of theoretically independent variables well with potential to alter in a sample data. The more degrees of freedom there are, the less variation there is and the more accurate the results are.

The degree of accuracy along with the testing technique is indicated by the level of significance; the higher the level of significance, the greater the degree of accuracy; the lower the level of significance, the lower the range of acceptability of deviations in the data gathered. We used a level of significance of 1% with a value of 0.01 for our calculations.

3.4. *Critical Value*

It is described as the highest significance of deviation obtained in Chi-Square test results. The critical value of the Chi-Square test is calculated using a value that corresponds to the corresponding degree of freedom and level of significance. If the computed Chi-Square value is lower than the critical value, the obtained data will follow the tested distribution pattern and the value will be non-significant; otherwise, the value will be significant. Every entity can attain specific circumstances or, in some cases, to be unlimited. To specify the arrival model, utilize the arrival entity. In this scenario, many probability distribution phenomena such as Poisson distribution, normal distribution are all possible. We give a summary of the Poisson distribution for the arrival of an entity. The use of goodness-of-fit tests to assess the adequacy of a proposed input model can be very useful.

The Chi-square goodness-of-fit test is one approach for determining if a sample group of n elements of the random parameter x obeys a particular distribution pattern [Verma S, (2015)]. We can get the results of the system characteristics by running simulation tests using the specified input parameters. During the FPS's business hours, the system's input parameters change dramatically. Although the arrival distributions for the two servers are identical, the service distributions differ [R. Bekker et al., (2011)]. The simulation in the M/M/C queueing framework is employed in this study. Validation of the observed data is done using the Chi-Square test to evaluate the goodness of fit of a distribution sequence and for a variety of other statistical purposes.

3.5. *Procedure*

Customers arrive at a specific FPS in Kottayam district of Kerala, India with the time between arrivals extending from 8.30 a.m. to 7.30 p.m over a course of 6 months is taken for study. The time taken by the server for the service is approximately 5 minutes. Table 1 shows the arrival distribution.

Sl No	Time	Average Arrival Rate	Arrival Rate Min-Max Range
1	8.30 am-9.30 am	1	0 – 4
2	9.30 am-10.30 am	4	0 – 10
3	10.30 am-11.30 am	5	0 - 11
4	11.30 am-12.30 pm	5	0 - 17
5	3.30 pm-4.30 pm	5	0 - 18
6	4.30 pm-5.30 pm	7	0 - 16
7	5.30 pm-6.30 pm	6	0 - 15
8	6.30 pm-7.30 pm	5	0 - 12

Table 1. Arrival Distribution.

Cumulative Average Arrival Rate (Per Day)	38
Cumulative Maximum Arrival Rate (Per Day)	103

Table 2. Cumulative Arrival Rate (Per Day)

In certain days of a month, the crowd in FPS will be more because of festivals, government subsidies due to pandemic, natural calamities, month end etc. So our purpose was to design an efficient system that can handle minimum and maximum crowd visiting in an FPS with optimal utilization of servers. Table 2 shows the cumulative arrival rate of customers visiting per day in the FPS considered in our study.

3.6. *Chi-Square Test*

To perform accurate test, the value of observed frequency in the observed distribution must be higher than or equal to 5. If the observed frequency value in the modelled distribution is less than 5, then the observed frequency values are merged to cross a value larger than 5. Table 3 shows the Chi-Square test conducted for arrivals. The analytical probability distribution of the service length and the frequency of the arrival rate of consumers in the FPS were evaluated using various computations of the specified variable directly at FPS. The Chi-square goodness-of-fit check is one method to see if an arbitrary proportion of size n of the arbitrary variable x adheres to a particular distributional pattern. The test process starts with dividing the n observations into m class intervals or cells.

Time	x	Observed Frequency (Oi)		O(x)	P(x)	Expected Frequency (Ei)		Chi-Square test
8.30 am-9.30 am	0	1	10	0	0.016925	0.64	8.61	0.2244019
9.30 am-10.30 am	1	4		4	0.069037	2.62		
10.30 am-11.30 am	2	5		10	0.1408	5.35		
11.30 am-12.30 pm	3	5	10	15	0.191438	7.27	14.69	1.4973519
3.30 pm-4.30 pm	4	5		20	0.195217	7.42		
4.30 pm-5.30 pm	5	7	7	35	0.159256	6.05	6.05	0.1491736
5.30 pm-6.30 pm	6	6	11	36	0.108266	4.11	6.51	3.0967896
6.30 pm-7.30 pm	7	5		35	0.063087	2.4		
		38		155				

Table 3. Chi-Square Test for Arrival

Null Hypothesis $H0$: The data fits well with the Poisson distribution.

Alternative Hypothesis $H1$: The data does not fit well with the Poisson distribution.

Degree of Freedom (DOF) = (4-1) = 3. Level of significance: α = 0.01

$$P(x) = \frac{e^{-\lambda}\lambda^{x}}{x!} \quad (1)$$

, where P(x) is the theoretical hypothesized probability and "e" has a numerical value of 2.718.
It is given by

$$\chi^2 = \sum_{i=1}^{m} \frac{(Oi - Ei)^2}{Ei} \quad (2)$$

where Oi is the observed frequency and Ei is the expected frequency.

Test Statistic: The tabulated value of χ 2 (Critical value) for DOF= 3 at 1% level of significance is 11.345. Since calculated χ 2 < Critical value; 4.97 < 11.345, we infer that the Poisson distribution best fits the data.

4. Design Of M/M/C/~/~ Queueing Model

Queueing theory is a mathematical method for analyzing queues. The numerous forms of queueing systems are represented by models. Each model's formula specifies how the corresponding queuing system should behave under certain scenarios [Dutkova et al., (2020)]. A queueing model is a technique for discovering the best way to manage a queueing system. Queueing theory, often called random system theory investigates the information of queueing system behavior problems, challenges in optimization, and statistical approaches [Xiao H and Zhang G, (2010)].

The M/M/C model addresses the situation in which many service stations are operating simultaneously and every customer in the line can be served by more than one server [Sundari et al., (2011)]. Consider an M/M/C queue with arrival rate λ, service rate μ, and C number of servers. The utilization factor is given by the ratio is represented Eq. (3).

$$\rho_c = \frac{\rho}{C} = \frac{\lambda}{C\mu} \quad (3)$$

In a queueing system the steady-state distribution is investigated as given below:

$P_n = P(N = n),\ \text{where}\,(n = 0,1,2\ldots)$ is the probability distribution of the length of the queue represented using N. As the system is in a transient state, so we get $\lambda n = \lambda$, where n=0,1,2,…

The following two possibilities may occur if the count of customers in the queue is n at any particular time:

(1) There will be no queue if n<C (the count of customers in the system is less than the server count). Even so, only (C–n) servers will be idle. The resulting merged service rate will be $\mu n = n\mu$; n<C.

(2) All servers will be busy if n≥C, (the count of customers in the system exceeds or is equal to the server count) and the utmost count of customers in the queue will be (n – C). The resulting merged service rate will be $\mu n = c\mu$; n≥C.

The probability of being n customers in the system is calculated using the model is given by the Eq. (4):

$$p_n = \begin{cases} \left(\rho^n / n!\right) p_0 & n \le c \\ \rho^n / \left(c!c^{n-c}\right) Po & n > c \end{cases} \quad (4)$$

Where, P0 is the probability of zero customers in the system computed using

$$P_0 = \left[\sum_{n=0}^{c-1} \frac{1}{n!}\left(\frac{\lambda}{\mu}\right)^n + \frac{1}{c!}\left(\frac{\lambda}{\mu}\right)^c \frac{c\mu}{c\mu - \lambda} \right]^{-1} \quad (5)$$

Average count of the customers waiting in the queue:

$$L_q = \left[\frac{1}{(c-1)!}\left(\frac{\lambda}{\mu}\right)^c \frac{\mu\lambda}{(c\mu - \lambda)^2} \right] P_0 \quad (6)$$

Average count of customers in the system:

$$L_s = L_q + \frac{\lambda}{\mu} \quad (7)$$

Average waiting time of customers in the queue:

$$W_q = \frac{L_q}{\lambda} \quad (8)$$

Average time spent by a customer in the system:

$$W_s = \frac{L_s}{\lambda} \quad (9)$$

While the arrival distributions for the two servers are the same, the service distributions are not [Joshua W.Joseph, (2020)]. An input source generates customers who seek service over time [Salmon A et al., (2018)]. The service mechanism subsequently provides the required service to the customers, and after that the customers exit the queueing system [Adeleke R et al., (2009)].

In this paper, we look at several scenarios for a single model and multi-server using the FIFO (first-in, first-out) queueing system. Simulation can be carried out using a range of tools, both physical and conceptual [S. Raczynski, (2014)]. The key goal of this research is to ascertain customer waiting time in the FPS, the idle server time, and the average length of the queue. To achieve the above goals, the arrival rate of the customers, their service patterns from one of the FPS in Kottayam district of Kerala, India were collected for 6 months and fed into the M/M/C model as input data. The M/M/C queueing model offers Markov behavior, making the system mathematically amenable. Fig. 1 shows a Two-Server Queueing System.

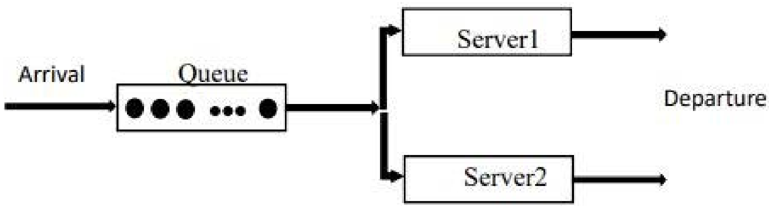

Fig. 1. Two- Server Queueing System

5. Simulation Results and Discussions

Simulation is defined as the method of creating a replica of an actual system and performing investigation on it to better understand the system's behavior [Wijewickrama,A.K.A, (2006)]. Small and large systems can both benefit from simulation. The price of constructing the system is higher, and simulation produces an exact copy of the model with the system's behavior. Direct experimentation would be very expensive compared to simulating the system that is the major reason of simulation. Simulation aids in the delivery of certain critical judgments that the system must make. It is an extremely effective way of resolving complex situations [P.Umarani and S.Shanmugasundaram, (2016)].

Before a system is developed, a simulation can be performed to investigate it during the design stage. As a result, simulation technique may be used as both an evaluation method for forecasting the impact of prevailing system alterations and a developing device for assessing the efficacy of newer technologies under a variety of scenarios [Ashish Kambli et al., (2020)]. In queueing theory, simulation techniques are commonly used [Dagkakis G and Heavey C, (2016)]. A simulation model is used to evaluate the behavior and state of a system as it evolves over time. Matlab includes a Simulink events library that can be used to simulate a system as well as run several parameters needed by the application. The library contains many blocks needed to simulate a discrete-based system.

Fig. 2 depicts the M/M/C queuing system's simulation model. Based on the inter-arrival time of the consumers, this simulation indicates that the optimal server count needed in an FPS will vary. Both servers have a fixed service time of 12 customers per hour.

Customers are assumed to be entities in the system. Entities are discrete elements that can be used to model a system [Banks J et al., (2001)]. Different blocks for the representation of entities are provided by the entity generator library of sim events in Matlab [Syed Shujauddin Sameer, (2014)]. The duration between the formation of two entities is provided by a Time based Generator. The Instantaneous Entity Scope is linked to this generator. A signal scope provides the required result by connecting with the necessary parameter. As shown in Fig. 2, we can estimate the average time frame a customer should wait in the queue and in the system, the queue length, the system length, and the system utilization in the model. The entities appear to be formed at random depending on time. As the simulation time goes on, the number of entities generated rises in a consistent manner. As a result, the count of service counters can be optimized in line with the input values [Dutkova et al., (2019)]. The use of queuing theory such as the design of mathematical models to develop and evaluate waiting lines with the purpose of minimizing long queues in our low-cost stores would result in better service.

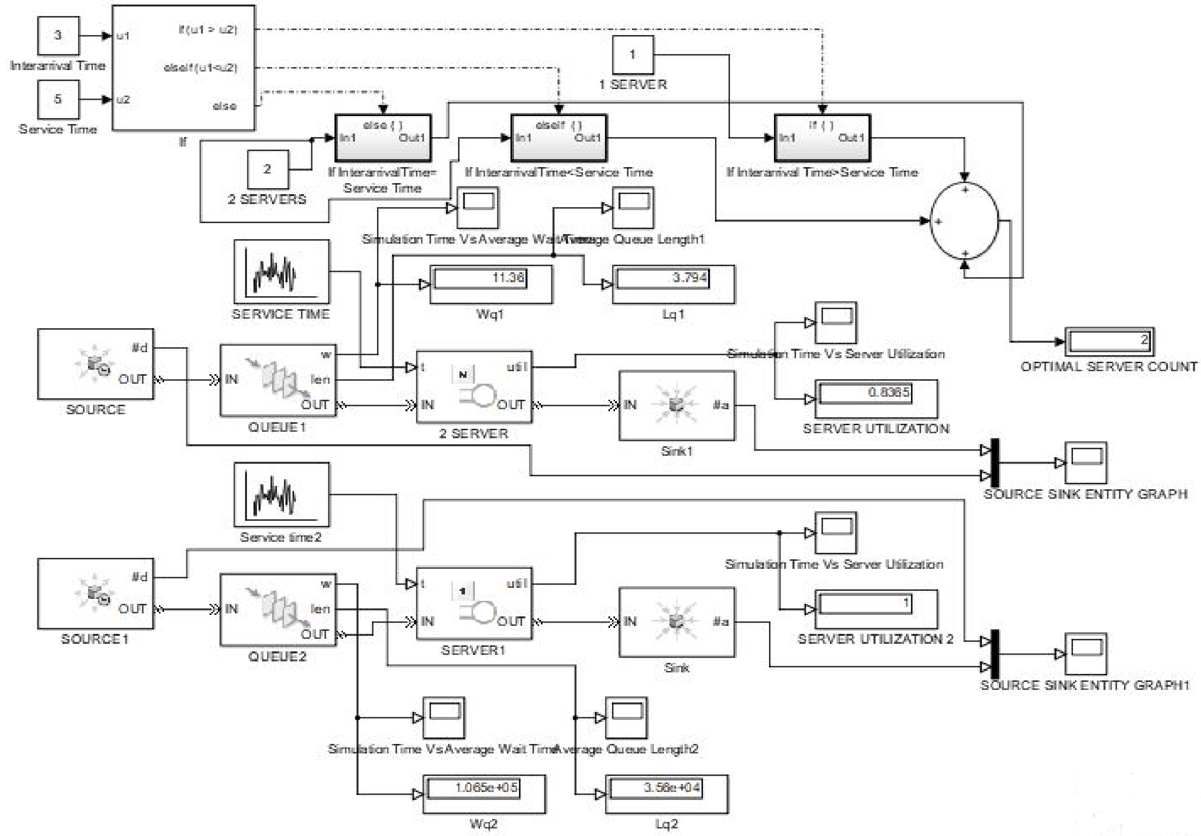

Fig. 2. Simulation of M/M/C Queuing Model

Table 4 shows the simulation result for the Two- Server queueing model. It shows that the optimal number of servers required in an FPS will change based on the inter-arrival time of the customers.

Sl No	Inter-arrival time	Service rate (μ)	Optimal number of servers (C)	Waiting time in the queue (Wq)	Length of the queue (Lq)
1	3	12	2	11.36	4
2	3.5	12	2	5.30	2
3	4	12	2	3.28	1
4	4.5	12	2	2.28	0
5	5	12	2	1.70	0
6	6	12	1	25.3	4
7	7	12	1	12.7	2
8	8	12	1	8.54	1
9	9	12	1	6.4	1
10	10	12	1	5.13	1
11	11	12	1	4.22	0
12	12	12	1	3.65	0

Table 4. Simulation Results for Two-Server Model

It is observed that the entities appear to be formed at random depending on the time. As the simulation time progresses, the number of entities generated rises in a consistent manner. This enables for the count of service lines to be optimized depending on the input variables. The use of queueing theory, such as the creation of mathematical frameworks to analyze and evaluate waiting queues with the purpose of minimizing long queues in our FPS can result in better services.

5.1. *Comparison of Server Utilization of M/M/1 and M/M/C Model*

When the arrival rate in the investigated FPS were computed, it was found that it follows a Poisson distribution. The investigation found that the average service rate was often less. According to analysis, the average amount of time a customer waiting for service was also found to be excessive. A scenario where a customer might have to wait almost 30 minutes to be served reflects badly on the performance of the organization. It is critical to realize that the majority of customers are in a rush for one or the other reason. They expect to be served or handled quickly. According to the findings, "utilization" is far too excessive on the average. Because there was insufficient time for the servers to rest, the input (labor) had been overloaded. The service procedure appeared to be continuous, which may result in the failure of human resources and even inert inputs. In addition, if the server is not provided sufficient time to relax after being used for a long time, it may have a tendency to decline or fall in productivity. Table 5 shows server utilization of a single and multi-server systems based on the arrival rate of customers.

	SERVER UTILIZATION (%)	
ARRIVAL RATE	Single server (M/M/1)	Multi Server (M/M/C) with 2 Servers
20	167	83
17	142	71
15	125	63
13	108	54
12	100	50
10	83	83
9	75	75
8	67	67
7	58	58
6	50	50
5	42	42

Table 5. Server Utilization in Single Server and Multi Server System based on Arrival Rate

It is obvious from the Table 5 that when the customer arrival rate goes beyond 10, then a single server cannot handle the customers as its server utilization exceeds 100%. If the customer arrival rate is greater than 10, our system recommends running two servers in concurrently to minimize customer wait times and make the best utilization of human resources.

Fig. 3 depicts the Arrival Rate vs Server Utilization of M/M/1 and M/M/C queueing model.

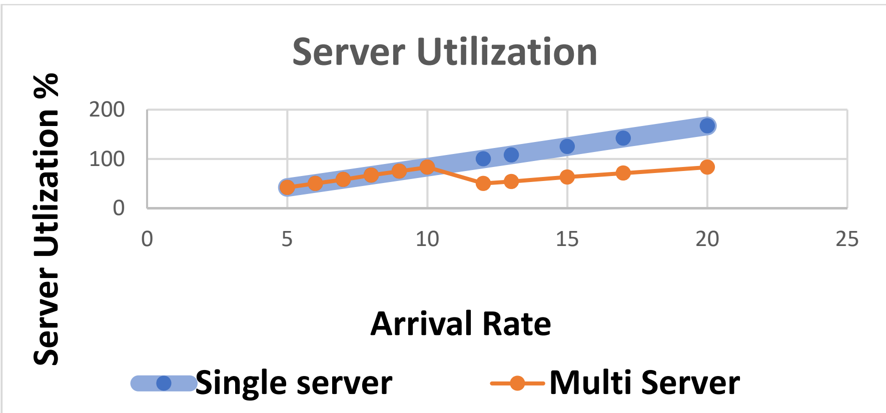

Fig. 3. Rate vs Server Utilization

According to the study, almost all of these FPS were found to have a serious lack of queueing discipline. In light of these observations, the following recommendations may be useful in assisting in reducing the severe impact that these hazards may have on shops in the long run. Primarily these stores' service facilities must be enhanced. Maintenance and cost of replacing were steadily growing. Instead of manual and obsolete facilities, more current, sophisticated equipment and facilities, such as contemporary computers must be delivered to boost labor efficiency. This would also assist to cut down on the amount of time customers have to wait for service. These FPS must have a mechanism in place that is effective and flexible in order to achieve optimal system reliability. This would serve to minimize the likelihood for revenue related with system utilization to increase over time. A server's (worker's) capacity should be limited to a certain amount of hours. To incentivize workers to raise their productivity in the workplace, the inclination to overwork or overstress an input, especially human resources, should be minimized. These recommendations in our perspective will go a long way toward alleviating these organizations' queueing issues, as well as those faced by organizations in underdeveloped nations.

6. Conclusion

The employment of simulation technique in conjunction with queueing theory made it possible to gain and then evaluate the essential features of the FPS system. The initial phase in examining the queueing system is to identify the descriptive components and choose a framework that is appropriate for the system. Numerous system metrics distinguish Markov's model. In terms of setting these metrics, arrival rate of customers and service times of the servers were monitored at FPS. A Chi-Square goodness of fit test was performed to ascertain whether the arrival rate followed the poisson distribution. The test resulted in the acceptance of a null hypothesis stating that system components satisfy to poisson distributions. After all model requirements were satisfied, it was conceivable to apply the system model and run simulations. Several simulation studies have resulted in the optimization of the count of service counters at specific time frames in relation to system components. Such a method essentially helps reduce costs as well as optimization in other aspects.

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Conflicts of interest

The authors have no conflicts of interest to declare.

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