Communication in Physical Sciences, 2023, 9(2):187-192

Determination of the Optimal Number of Servers in Kano Poly Micro Finance Bank

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Received: 13 November 2022/Accepted 28 April 2023/Published 25 May 2023

Abstract: *The study was carried out to determine the optimal number of servers in Kano Poly Micro Finance Bank a survey research design was employed, through the use of an observation data collection method. The population of the study was arrival and service rates recorded for the consecutive 20 days, between the hours of 10 am-3 pm. The mean arrival time for the customers (λ) was 5 customers every 10 minutes i.e30 customers per hour while the mean service time (μ) was 3 customers every ten minutes i.e. 18 customers per hour. The study concludes that a 3- servers queuing system will be the system with the optimal number of servers, sys in the Kano Poly microfinance bank, compared to 2- servers queuing system.*

Keywords: Optimal number of servers, queue solution, queuing model, crowding

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1.0 Introduction

In Nigeria, is something usual to see customer exhausting much of their time in queens waiting to be attended to (Lawan *et al* 2019) Long queue is caused by poor supervision of tellers and facilities when the arrival of customers is at a faster rate than the servers can accommodate the expected queue length increases without limit and crowding occur. This causes the movement of the customer from one bank to the other, where faster banking services could be obtained without much delay, once your customers are disappointed by their home or more poor experiences waiting in line, they are less likely to return to your businesses. Disorganized queues can lead to customer frustration once in the waiting line and in some instances can even completely put people off joining the queue. putting in place good queuing management helps to automate the queuing process whilst improving service, and safety and gaining customer loyalty. An efficient queuing system allows customers to leave with a positive experience while poor queue management wastes time and leaves customers irritated. Therefore this study tries to analyse the problems of a long queue in Kano poly microfinance bank and bring possible solutions to the problems. The present study aimed at the determination of the optimal number of server(s) in kano poly microfinance bank. Consequently, the study shall be achieved through the assessment of (i) the average number of customers in the bank (ii) the average time a customer spends in the bank (ii) the expected number of customers in the queue and (iv) expected time a customer spends in the queue.

Several literature have been published on the investigated issues and most of them involve some theories (Abubakar *et al*., 2022; Doncel and Mancuso, 2021; Feili *et al*., 2012; Muhammad and Adamu, 2022; Samouylov *et al*., 2023; Sirgar *et al*., 2020). The queuing theory was developed to provide mathematical models to predict the behaviour of a system that attempt to provide service for randomly arising demand. Queuing theory is generally considered a branch of operation research because the results are often used when making a business decision about the resources needed to provide services. Queuing theory has its origins in research by Angner Krarup Ireland when he created models to describe the system of the Copenhagen telephone exchange company (Sundarapandian, 2009). The ideas have since seen application in telecommunication, traffic engineering, the design of factories, shops offices and hospitals, as well as in project management (Schlechter et al 2009). A study conducted by Elegalam (1978), found that 59.2% of the 390 persons making withdrawals from their accounts spent between 30 to 60 minutes, while 7% spent between 90 and 120 minutes. Oladapo (1988) revealed a positive correlation between the arrival rates of customers and bank service rates. A lamatu and Ariyo (1983), observed that the mean time spent by a customer in a bank was 53 minutes, but customers prefer a maximum of 20 minutes. They also revealed worse service delays in urban centres, averaging 64.32 minutes compared to 22.2 minutes average in rural areas. Ashley (2006), claimed that as long as arrival and services processes are random, queues still form in a services facility even if the services system can provide service at a faster rate than the customer arrival rate., our focus in this study is to appropriately make use of queuing models to reduce customers waiting time and to determine an optimal number of servers in the bank.

2.0 Materials and Methods

In this study, survey research design was employed. Because it allows us to observe what happens to the sample unit without manipulating them. The population of the study represents arrival and service rates recorded for the consecutive 20 days, between the hours of 10 to 3 pm. Hence the customers arrived at the Kano State Micro Finance Bank according to a poison process and service times have an exponential distribution such that:

- λ=5 Customers every 10 minutes i.e 30 customers/hr
- λ=3 Customers every 10 minutes i.e 18 customers/hr

The system has 2-servers and the data was collected using the observation method of data collection.

3.0 Results and Discussion

3.1 Analysis of the data

The system can be characterized as M/M/2 system with λ=5, M=3 and S=2

Traffic intensity is defined according to equation 1

$$\rho = \frac{\lambda}{s\mu} = \frac{5}{2\times 3} = \frac{5}{6} \quad (1)$$

Since ρ = 5/6 <1, the steady state condition holds and ρ_o computed as:

$$P_0 = \left\{\frac{S^s\, \rho^{s+1}}{S!(1-\rho)} + \sum_{n=0}^{n}\left(\frac{(S\rho\,)^n)}{n!}\right)\right\}^{-1} = \left\{\frac{2^2\ \ (0.83^3)}{2!\left(1-\frac{5}{6}\right)} + \sum_{n=0}^{2}\left(\frac{\left(2\times\frac{5}{6}\right)^n)}{n!}\right)\right\}^{-1} \quad (2)$$

$$\rho_0 = \left[\frac{125}{18} + \frac{\left(2 * {}^{5}/_{6}\right)^0}{0!} + \frac{\left(2 * {}^{5}/_{6}\right)^1}{1!} + \frac{\left(2 * {}^{5}/_{6}\right)^2}{2!}\right]^{-1} = 0.0909 \approx 0.1$$

The remaining steady-state probabilities could be determined as:

$$p_n = \begin{cases} \frac{\lfloor S\rho)^n \rfloor}{n!} P_0 \\ \frac{S^S\ P_0}{S!} \rho^n \end{cases} \quad \text{n} = \ 1,2\ ,3 \ldots \ldots \text{S};\ \text{n} = S+1, S+2 \ldots \ldots \qquad (3)$$

$$P_1 = \left(2 \times \frac{5}{6}\right) 1 \left(\frac{1}{11}\right) = 0.15 \qquad P_3 = \frac{S^S\ P_0}{S!} \rho^n = \frac{2^2\ 0.83^3{}_0}{2!} \frac{1}{11} = 0.11 \qquad (4)$$

$$P_2 = \left(2 \times \frac{5}{6}\right) / 2! \times \left(\frac{1}{11}\right) = 0.13 \qquad P_4 = \frac{S^S\ P_0}{S!} \rho^n = \frac{2^2\ 0.83^4{}_0}{2!} \frac{1}{11} = 0.09 \qquad (5)$$

3.2 Measures of effectiveness

For a queuing system in a steady state, the measures of greatest interest are:
L_s ≡ The average number of customers in the system
L_q ≡ The average length of the queue
W_s ≡ The average waiting time in the system
W_q ≡ The average waiting time in the queue

Therefore, $W_s = W_q + 1/\mu$, $L_s = \lambda W_s$ and $L_q = \lambda W_q$. The average length of the queues (L_q) = $\frac{S^S}{S!(1-p)2} P^{S+1} P_0 = \frac{2^2}{S!(1-p)2} 0.83^3 \times \frac{1}{11}$ =3.8 ≈4 customer
Average waiting time of customers in the queues
$(W_q) = \frac{L_q}{\lambda} = \frac{4}{30}$ = 0.13hr= 8 mins
Consequently, the average waiting time of customers in the system
$(W_s) = W_q + \frac{1}{\mu}$ = 8 mins + $\frac{1}{18}$ x 60 mins = 8 min + $\frac{60}{18}$min ≈ 11mins
The average number of customers in the bank $(L_s) = \lambda W_s = 30\left(\frac{11.3}{60}\right)$= 5.65 ≈ 6 customers

M/M/3

The system can be characterized as 3- a servers system with Poisson inter-arrival and exponential service time patterns λ=5, μ=3 and S=3
Traffic intensity

$$\rho = \frac{\lambda}{S\mu} = \frac{5}{3 \times 3} = \frac{5}{9}$$

Since, ρ = 5/9 < 1, the steady state condition holds and ρ_0 computed as;

$$P_0 = \left(\left\{\frac{S^S\ P^{S+1}}{S!(1-\rho)} + \sum_{n=0}^{S} \frac{(SP)^n)}{n!}\right\}\right)^{-1} \qquad (6)$$

$$P_0 = \left\{\frac{3^3\ 0.56^4}{3!(1-0.56)} + \sum_{n=0}^{3} \frac{(2\times0.56)^n\ )}{n!}\right\}^{-1} \quad (7)$$

$$P_0 = \{3.92\}^{-1} = 0.25 \quad (8)$$

The average length of the queue (L_q) $= \frac{S^s\ \rho^{s+1}\ \ P_0}{S!(1-\rho)2}$ = $\frac{3^3\ (5/9)^{3+1}\ (0.25)}{3!\ (1-5/9)^2}$ = 0.24 ≈ 0

Average waiting time of customers in the queue (W_q) = $\frac{L_q}{\lambda} = \frac{0.24}{30} =$ 0.008hr = 0.5mins

Average waiting time of customers in the system (W_s) = $(W_s + 1/\mu)$ = 0.5 mins + 1/18 x 60 mins = 3.83min ≈ 4mins

The average number of customers in the bank (L_s) = $\lambda W_s = \frac{30(3.83)}{60}$ = 1.92 ≈ 2 customer

Table 1. Presentation of results

s/n	Performance Measures	2 servers	3- servers
1	The probability of the system idle $(\boldsymbol{P_0})$	0.1	0.3
2	The average number of customers in the systems $(\boldsymbol{L_s})$	6 customers	2 customers
3	The average time a customer spends in the system $(\boldsymbol{W_s})$	11minutes	4minutes
4	Average numbers of the customer in the queues $(\boldsymbol{L_q})$	4 customers	0 customers
5	The average time a customer spends in the queue $(\boldsymbol{W_q})$	8minutes	0.5minutes

It has come to our notice that a 3- servers system is better them 2- servers systems in terms of efficiency. The average number of customers in the system and in the queue were 6 customers and 4 customers respectively for the two servers system these were relatively high compared to 3- the servers system whereby the average number of customers in the system and queue were 2 and 0 customers respectively. Hence, when a 3- servers system is being adopted in the bank, there will be no customers waiting in the queue. In the same vein, the average waiting time a customer spend in the system and also in the queue was 11 minutes and 8 minutes for the two-servers system respectively while for 3- the servers system was 4mintues and 0.5 minutes (60 seconds) each. Lastly, the probability that there are no customers in the bank for 2- servers system and 3-server system were 0.1 and 0.3 each. This show that the system is more likely to be empty with 3 servers queuing system.

4.0 Conclusion

The study unveils that a 3- server queuing system will be the system with the optimal number of servers for Kano State Poly Microfinance Bank.

Sequel to the findings and conclusion above, the following recommendations are made:

- The bank stakeholders should try to implement a 3-server queuing system, as it accelerates the speediness of the service in the bank. Therefore, long waiting times in the queue will be diminished

- Improper queuing discipline may lead to crowding around the bank and crowding deteriorates health and well-being, as well as the security of both the customers and the servers in the bank, amidst this situation of high risk of Covid-19, Lassa fever and many other contagious diseases.
- When a 3-server queuing system is adopted in the bank, students and lecturers as well will not spend their precious time queuing in the system. Therefore academics and students will be more committed to their academic activities.
- Due to economic exigencies, customers may not have ample time to spend in the systems, 3-server queuing system takes this into account. When It has been implemented, it may bring about customers loyalty and possibly attract new customers to the Bank

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Consent for publication

Not Applicable

Availability of data and materials

The publisher has the right to make the data

Public

Competing interests

The authors declared no conflict of interest.

.**Funding**

There is no source of external funding

Authors' contributions

UAI, NM, AL and ASMcaried out statistical analysis together. The work was conceived ny UAI and NM and the first draft was jointly written by UAI, NM, AL and ASM