Application of Queuing Model: With Special Reference to Construction and Business Bank Adama Branch Ethiopia

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Abstract -- **In this paper, queuing model is applied to the data collected on construction bank, Adama branch, Ethiopia. The endless customers waiting for service delivery in construction and business bank is a phenomenon that bothers both the management of banking institutions and the customers alike. Thus, the need to optimize total operating cost by determining the optimal balance between the cost of making customers to wait for service and the cost of providing additional service, some studies have claimed that service improvement can be achieved by increasing the number of servers, but to what extent this can be done to minimize overall cost? This study examines the validity of multi-server queuing models for achieving reduction in waiting time and minimization of cost and characteristics of customers. After adding one/two servers, further characteristics of customer were analyzed with help of multiple server model. The average waiting time per customer in a system as well as in the queue were found about 32 minutes and about 29 minutes respectively. It reveals a preference for a multi-server system that determines its usage and suggestions for improvement in service delivery are highlighted.**

Keywords: *Queuing Model, Multi-server System, Service Delivery*

I. INTRODUCTION

QUEUING theory had its beginning in the research work of a Danish engineer named A. K. Erlang. In 1909 Erlang experimented with fluctuating demand in telephone traffic. Eight years later, he published a report addressing the delays in automatic dialing equipment. At the end of World War II, Erlang's early work was extended to more general problems and to business applications of waiting lines.

The study of waiting lines, called queuing theory, is one of the oldest and most widely used quantitative analysis techniques. Waiting lines are an everyday occurrence, affecting people shopping for groceries buying gasoline, making a bank deposit, or waiting on the telephone for the first available airline reservationists to answer. Queues, another term for waiting lines, may also take the form of machines waiting to be repaired, trucks in line to be unloaded, or airplanes lined up on a runway waiting for permission to take off and restaurant study taken in Indonesia (Dharmawirya and Adi, 2011; Sharma *et al.*, 2013). The three basic components of a queuing process are arrivals, service rate, and the actual waiting line.

As the word turns to a global village characterized by intense and ever increasing demand, operation bank managers continue to experience wrenching changes, which they must keep up for their survival. Bank customers have also become increasingly demanding. Today, they require high quality, low price and immediate service delivery and tomorrow, they want additional components of value from their chosen banker. Since service delivery in banks is personal, customers are either served immediately or join a queue (waiting line) if the serving system is busy.

Waiting line is what one experience everywhere in daily life *i.e.* while shopping, checking into hotels, at hospitals and clinics etc. In situations where facilities are limited and cannot satisfy the demand made upon them, bottlenecks occur which manifest as queue but customers are not interested in waiting in queues. When customers wait in queue, there is the threat that excessive waiting time will lead to the loss of some customers to competitors. But allowing them to serve themselves so easily is a key factor in both keeping and attracting customers (Michael, 2001).

Statement of the problem: One of the goals of queuing analysis is finding the best level of service for an organization. When Construction and business bank does have control, its objective is usually to find a high spirits, medium between two extremes. On the one hand, a bank can retain a large number of customers and provide many service facilities. This, however, can become expensive. The other extreme is to have the minimum possible number of teller windows open. This keeps the service cost down but may result in customer dissatisfaction. When the average length of the queue increases then the poor services will result in the loss of customers and goodwill.

When services improve in speed, then the time spent in waiting will decrease. This waiting cost may reflect loss of productivity of workers while their tools or machines are awaiting repairs or may simply be an estimate of the cost of customers lost because of poor service and long queues.

This assessment is going to address the following questions:-

1. Do the customers satisfied with service rate provided by the bank?
2. What are the factors that cause the customers to leave the bank?
3. Does the organization have enough servers to serve the expected customers?
4. How the waiting time will be reduced if there are alterations in the server?

Significance of the Study: The significance of the study is to find the best level of service and provide information concerning queue analysis for Construction and business bank for better customer services at minimum cost.

*Objectives :*The general objective of this study is to know the characteristic of the customers in Construction and business bank at Adama branch. The main objectives of the study are

- To determine the waiting time of customers is likely to experience in a system
- To determine how the waiting time is affected If there is increase in the number of servers
- To offer necessary suggestion if any to the bank based on the analysis of the study

II. DATA AND METHODOLOGY

Method of data collection and Sample size: The study was conducted at Construction and business bank, Adama branch, Ethiopia where the information about the characteristics of customers was collected. It was carried out on the basis of data collection during the period of one week, (i.e. 6 working days from December 24, 2013 to January 6, 2014) through observation, interview and questionnaire methods and the Variables were analyzed by using the Queuing Models.

The variables measured include arrival rate (λ) and service rate (μ). They were analyzed for simultaneous efficiency in customer satisfaction and cost minimization through the use of multi-channel queuing models. These are compared for a number of queue performances such as; the average time spent by each customer in the queue as well as in the system, average number of customers in the queue as well as in the system and the probability of the system being idle.

Primary data in respect of customer arrival rate and service rate were obtained through observations while customer attitude survey was carried out through a questionnaire distributed among 50 customers by using simple random sampling method. Secondary data were collected from the bank, related books and other relevant, and published research journal.

Methods of Data Analysis: To make the data suitable for further analysis, classification and editing was made. The raw data were organized into groups. The data which were collected from the primary and secondary sources were analyzed by using statistical tools and techniques, such as tables, percentages and graphs etc. A single and multiple servers were applied in the simplest form of queuing system.

Definitions of queuing system variables:

- λ = the arrival rate (average number of arrivals per time period)
- μ = the service rate (average number served per time period)
- λ = mean arrival rate;
- μ = mean service rate
- And that $\lambda < \mu$ (customers are served at a faster rate than they arrive), we can state the following formulas for the operating characteristics of a single-server model. (Bernard W. Taylor III 2006, 9th edition)
- Customers must be served faster than they arrive, or an infinitely large queue will build up.
- *Lq = average queue length (average number of customers in queue)*
- *L = average system length (average number of customers in system,* including those being served)
- *Wq = average waiting time in queue (average time a customer spends* in queue)
- *W = average time in system (average time a customer spends in queue* plus service)
- $Lq = \lambda Wq$ *(Little's Law)*$=\lambda 2/\mu(\mu-\lambda)$
- $L = \lambda W$ *(Little's Law)*$=\lambda/\mu-\lambda$
- $L = Lq + \lambda/\mu$
- $W = Wq + 1/\mu = L/\lambda$
- $U = \lambda/\mu$
- $I = 1-u = 1-\lambda/\mu$

$P_0 = (1-\lambda/\mu)$

$P_n = (\lambda/\mu)\, n.p0 == [(\lambda/\mu)n](1-\lambda/\mu)$

The parameters of the multiple-server model are as follows:

- λ=the arrival rate (average number of arrivals per time period)
- μ=the service rate (average number of customers served per time period) per server (channel)
- C=the number of servers
- $C\mu$=the mean effective service rate for the system, which must exceed the arrival rate
- $C\mu > \lambda$= : the total number of servers must be able to serve customers faster than they arrive
- The probability that there are no customers in the system (all servers are idle)

III. RESULTS AND DISCUSSION

Data Analysis And Interpretation: According to Table 1, 56% of the respondents were served in more than 52 minutes, 10%

of the respondents were served within 21-36 minutes, 10% of the respondents were served within 5-20 minutes respectively. This indicates that most of the customer served for more than 52 minutes. It is due large number of customers and traditional methods adopted by the bank in serving the customers.

TABLE 1 — DISTRIBUTION OF THE NUMBER OF RESPONDENTS WITH RESPECT TO THEIR TIME SPENT IN THE BANK

Time spent	No. of respondents	Percentage
5-20 minutes	5	10%
21-36 minutes	5	10%
37-52 minutes	12	24%

TABLE 2 -- DISTRIBUTION OF RESPONDENTS AND THEIR OPINION ABOUT SATISFACTION WITH TIME OF SERVICE

Opinion	No of respondents	Percentage
Yes	16	32%
No	34	68%
Total	50	100%

Table 2 shows that 68% of the respondents were not satisfied with the time of service and 32% were satisfied with time of service. It is observed that the most of the customers were not satisfied with the service provided by the bank. It may be due to lack of ethical and moral behavior among the bank employees towards their customers.

TABLE 3 -- DISTRIBUTION OF RESPONDENTS AND THEIR ATTITUDE TOWARDS LONG QUEUE

Opinion	No of respondents	Percentage
Yes	15	30%
No	35	70%
Total	50	100%

Table 3 reveals that, 30% of the respondents were return back after finding the long queue, 70% of the respondents were served after their arrival at the bank as usual. Therefore it can be observed that bank loses many customers because of the long queue.

Quantitative analysis: Operating characteristics computation for seven servers

TABLE 4 – NUMBER OF CUSTOMERS SERVED WITHIN A WEEK FROM DECEMBER 24, 2013 TO JANUARY 6, 2014

Month	No of customers served per a day
December 24, 2013	1618
December 28, 2013	1306
January 1, 2014	2103
January 3, 2014	1295
January 5, 2014	1388
January 6, 2014	1134
Total	8844

- Computation of mean service rate and arrival rate

Average numbers of customers served

$$= \frac{\text{Total numbers of customers served in a week}}{\text{Total numbers of days in a week}}$$

=8844/6 = 1474

Mean service rate (μ)

μ (mean service rate per hour)

$$= \frac{\text{average numbers of customers served}}{\text{Working hours per day}}$$

1474/9.5 hr. = 155/ hr

μ (service rate per server)

$$= \frac{\text{average numbers of customers served}}{\text{Total No servers=7}}$$

Customers served per server within a day

= 1474/7 =210.57 or 211

Mean arrival rate (λ)

TABLE 5 -- DISTRIBUTION OF ARRIVALS OF CUSTOMER AT THE BANK FOR A WEEK

Selected day	Arrival per hour
December 24	157
December 28	153
January 1	167
January 3	144
January 5	156
January 6	141
Total	918

The average arrival rate $= \frac{167+141+144+156+157+153}{6}$

$= \frac{918}{6}$

$$P_o = \frac{1}{\left[\sum_{n=0}^{n=c-1} \frac{1}{n!}\left(\frac{\lambda}{\mu}\right)^n\right] + {}^1/_{C!}({}^x/_\mu)c\left(\frac{c\mu}{c-\mu\lambda}\right)}$$

λ (mean arrival rate per hour) ⇒ 153/hr

μ ⇒155/hr 155/7hr = 22.14 customers served in each window/ hr. or mean service rate for each server per

C=7

Po= the probability of No customers in the service department

$$P_o = \frac{1}{\left[\sum_{n=0}^{n=c-1} \frac{1}{n!}\left(\frac{\lambda}{\mu}\right)^n\right] + {}^1/_{C!}({}^x/_\mu)c\left(\frac{c\mu}{c-\mu\lambda}\right)}$$

$$\frac{1}{\left[\frac{1}{0!}\left(\frac{15B}{22.14}\right)^0 + \frac{1}{1!}\left(\frac{15B}{22.14}\right)^1 + \frac{1}{2!}\left(\frac{15B}{22.14}\right)^2 + \frac{1}{3!}\left(\frac{15B}{22.14}\right)^3 + \frac{1}{4}\left(\frac{15B}{22.14}\right)^4 + \frac{1}{5!}\left(\frac{15B}{22.14}\right)^5 + \frac{1}{6!}\left(\frac{15B}{22.14}\right)^6 + \frac{1}{7!}\left(\frac{15B}{22.14}\right)^7\left(\frac{7(22.14)}{7(22.14)-15B}\right)\right]}$$

$$\frac{1}{= [1 + (6.91) + 23.88 + 55 + 95.03 + 131.34 + 151.27] + (149.34)(75.5)}$$

$$= \frac{1}{(464.43) + (11275.17)}$$

$$\frac{1}{11739.6}$$

$$= 0.00008518$$

L= the average number of customers in the queuing system is:-

$$L = \frac{\lambda\left(\mu\frac{\lambda}{\mu}\right)^c}{(C-1)!(c\mu-\lambda)^2} P_0 + {}^\lambda/_\mu$$

$$= \frac{153(22.14)\left(\frac{153}{22.14}\right)^7}{(7-1)!(7(22.14)-153)^2}\ 0.00008518+153/22.14$$

$$= \frac{(3387.42)(752656.3)}{720(2)^2}\ 0.00008518+{}^{153}/_{22.14}$$

$$= \frac{2549563004}{2880}.0.00008518 + 153/22.14$$

$$= 75.41 + 153/22.14$$

$$= 82.32 \text{ customers}$$

W= the average time a customer spends in the queue system (waiting and being served) is:-

W=L/λ

=82.32/153 =0.53804hrs (32.2824 minutes)

L_q= the average number of customers in the queue is:-

$$L_q = L - \frac{\lambda}{\mu}$$

$= 82.32 – 153/22.14$

$=82.32-6.91$

= 75.41 customers on average waiting to be served on the line

Wq= the average time a customer spends in the queue, waiting to be served is:-

$$Wq = W - 1/\mu = \frac{Lq}{\lambda}$$

$$= \frac{75.41}{153}$$

$$= 0.492\text{hrs}(29.57)\text{minutes}$$

PW = the probability that a customer arriving the system must wait for the service (i.e. the probability that all the severs are busy

$$P_W = \frac{1}{c!}\left(\frac{\lambda}{\mu}\right)^c \frac{c\mu}{c\mu-\lambda} p_0$$

$$= \frac{1}{7!}\left(\frac{153}{22.14}\right)^7 \frac{(7x22.14)}{(7x22.14)-153}.0.00008518$$

$$= \frac{(752656.3)}{5040}(77.5).\ 0.00008518$$

= 149.34 (77.5). 0.00008518

= 11573.85 x 0.00008518

= 0.9859 Probability that a customer must wait for service.

It was observed that, customers were frustrated by the relatively long waiting time of 32.28 minutes and the 0.9859 probability of waiting.

Operating characteristics of customers when one/two server(s) are added

Operating characteristics computation for eight server/ windows:

When the servers increase from 7 to 8, the service rate also increases from 155 to 177 per hour

μ (mean service rate per hour) = $\frac{1474 + 211}{9.5} = \frac{1685}{9.5}$ = 177/ hr.

μ =177/8= 22.14 customers served in each window /hr. or mean service rate for each server per hour

μ=22.14 Customers served per hour in each window

λ=153 Average customers arrive at the service station in an hour

C= 8 Number of servers

$$P_o = \frac{1}{[613.77]+[129x7.34]}$$

$$= \frac{1}{1561}$$

$$= 0.00064$$

The probability that there is No customer in the service department is 0.00064

$$L = \frac{\lambda\mu\left(\frac{\lambda}{\mu}\right)^c}{(c-1)!(c\mu-\lambda)^2} x\ P_{o} + \frac{\lambda}{\mu}$$

$$= \frac{153x22.14\left(\frac{153}{22.14}\right)^8}{(8-1!)(8x22.14-153)^2} x0.00064+\frac{153}{22.14}$$

$$= \frac{17618931275.703}{314158.18} x0.00064+\frac{153}{22.14}$$

$$= 56{,}083x0.00064+\frac{153}{22.14}$$

$$=36+6.9$$

L= 42.9 customers, on average in the service department

$W=\frac{L}{\lambda}=\frac{42.9}{153}$ = 0.2804hrs or 17 minutes

The average time that the customer spends in the queue system is 0.2804 hr. or 17 minute.

$Lq=L-\frac{\lambda}{\mu}$ $= 42.9-\frac{35.99}{153}$

Lq= 35.99 customers on average waiting to be served on the line

$Wq= W-\frac{1}{\mu}=\frac{Lq}{\lambda}=\frac{35.99}{153}$

Wq= 0.24 hrs. or 14.11minute on average a customer spends in the queue to get the service

$$P_W=\frac{1}{C!}\left(\frac{\lambda}{C}\right)^{c}-\frac{c\mu}{c\mu-\lambda}\ p_0$$

$$=\frac{1}{8!}\left(\frac{153}{22.14}\right)^{8}-\frac{8x22.14}{8x22.14-153}\text{x } 0.00064$$

=129x7.34x0.000.64

P_W= 0.6026 so the probability of all the servers are busy is 0.6026

Operating characteristics computation for nine servers/ windows

C=9 severs

μ (service rate per hour) = $\frac{1474+422}{9.5}=\frac{1896}{9.5}$ =197 /hr

μ =22.14 Customers served in each window /hr.

λ =153 Customers

P_o=0.0008854

L= 8.16 customers on average in the service department

W=0.053hrs or 3.29 minutes. The average time customers spends in the queue system

Lq=1.25 customers on average in the queue. Waiting to be served on the line

Wq=0.00816hr or 0.49 minutes will the customers to be served on a line

P_W= 0.38(38%) so the probability that all severs are busy is 0.38 or 38%.

TABLE 6 -- OPERATING CHARACTERISTICS FOR ALTERNATIVES SERVERS

No. of servers	L	Lq	W	Wq	PW
7	82.32	75.41	32.28m	29.52m	0.9859
8	42.9	35.99	17m	14.4m	0.6026
9	8.16	1.25	3.18m	0.4896m	0.38

Above table indicates that using of 9-server in system is better than both 8 servers and seven servers system in all circumstance. For instance a 9 servers system has 1.25 customers waiting in the queue for service while an 8-servers system and seven servers system has 35.99 and 75.41 customers respectively on the queue. In an 8 and 7 servers system, a customer spends 17 minutes and 32.28 minutes in the system respectively and customer spends 14.4minutes and 29.52minutes on the queue respectively. However, in 9 servers system customer waits in the system for about 3.18 and waits in the queue for 0.4896 minutes.

The probability of being busy for seven -servers system is very high (98.59%) than either of 8 or 9 servers system. Mean numbers of arrivals was 153 customers per hour. The arrival process follow queue discipline and it was first-come-first-served and queue population was infinite. From the above study it was observed that the adoption of 9 servers is better than both 7 and 8 servers in all circumstances.

IV. SUGGESTIONS

Suggestions: Based on the analysis of the study, the following suggestions are given for improvement of efficiency and quality of service to customers of the bank.

- Addition of two service channels will reduce loss of customers.
- Providing TV in the waiting hall, comfortable seats, and toilet facilities for increasing the satisfaction of the customers.
- The bank should educate their front line employee in the application of queuing models for efficient solving of operational problems.
- Bank should enrich employees' job by making them multi-skilled, through continuous training so as to enable them to eliminate unnecessary counter-check handoffs.
- The queue characteristics should be viewed from the customers' point of view i.e. whether the waiting time is reasonable and acceptable or not.
- Reengineering the banking operations through IT solutions e.g. ATM, and online banking etc., to harmonize queuing model.

V. CONCLUSION

Based up on the above discussion it can be concluded that, for rendering better services to the bank customers' modern models should be adopted. The average waiting time per customer in a system as well as in the queue were found about 32 minutes and about 29 minutes respectively, however 2 servers added in the bank, the average waiting time per customer in the system and queue were found about 3.18minutes and 0.4896 minutes respectively. Customer satisfaction is the significant factor for any industry and more to service industry to which all banks belong. Therefore the application of queuing analysis has proved that the adoption of it in the day to day operational activities of the bank will satisfy the customers. Satisfied customers will result in desired growth for the bank and for economy of the country.

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