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On The Application of Queuing Model in Nigeria Banking Sector: a Case Study of Zenith Bank Plc, Abakaliki Branch

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Abstract - This study focused on the queuing system in Nigerian banking sector. The sources of data were primary and were collected from Zenith Bank Plc, Abakaliki Branch at the withdrawal section of the banking hall for four days in a period of one month interval. The data were collected based on the arrival pattern and the service pattern of customers. The methodology employed followed by the birth and death Markovian process. The results obtained showed that the arrival rate is 0.2219 and the service rate is 0.1524. However, the probability that the servers are idle is 0.1574 and the cost incurred from waiting is ₦656.76. Besides, any increment on the number of servers by the bank management will help reduce the time customers spend on queue and also reduce cost incurred from waiting. It was also suggested that the management of the concerned Bank should employ only capable servers as to reduce customers wait on service, that is when the cause of long time taken to serve one customer is not due to network or power supply.

Keywords- Bank, queue, arrival time, service time, incurred cost.

I. INTRODUCTION

Queue is an act of joining a line or waiting. Queues are mostly formed when customers (arrivals) demanding service have to wait because their number exceeds the number of servers available or the facility does not work efficiently or takes more than the time prescribed to service a customer. It is a part of everyday human experience at banks, filling stations, barber shops, salon shops, bus-stops, supermarkets, telephone booths, computing and design of factories, toll gates, food canteens etc. According [1], they described queuing theory as a study that tends to help the owners of different organizations to analyze the percent at which customers wait for their services to be given to them and improve the percentage of services in this manner. [2] a Danish Mathematician did the first study on Queuing theory which resulted into the worldwide acclaimed Erlang telephone model. He examined the telephone network system and tried to determine the effect of fluctuating service demands on calls on utilization of automatic dial equipment. Over the years, there have been technological advancements such as Internet Banking, Mobile or Telephone Banking, Automated Teller Machine (ATM) etc. by banks in attempt to minimize waiting line problem at the withdrawal point and other service points in the bank. These measures have not yielded the much desired result due to frequent breakdown of such computerization and fraudulent activities. The problem of long queue persisted in almost all banking systems. Time is money and waiting is a non-value added activity which can cause prolonged discomfort and economic cost to individuals coming into the system. Therefore, it is always a desire of every customer to obtain an efficient and prompt service delivery from a service system.

II. RELATED WORK

There are many applications of the theory of queues, most of which have been well documented in the literature of probability, Operation research and Management science. Some of the applications are machine repair, tool booths, inventory control, the loading and unloading of ships, scheduling patients in the hospitals, in computer field's etc. However, [3] did a comparative analysis of Service Delivery by ATM in Two Banks with the application of Queuing Theory. The study found that the average arrival rate, average service rate, average time spent in the queue for Access bank are 2.01, 1.65, 0.5 respectively and UBA are 3.28, 1.75, 1.67minutes, respectively. The study concluded that the average number of idle time obtained for the two banks were 3minutes and 7minutes respectively. [4] examined the application of queuing models to customer's management in the banking system using United Bank for Africa, Okpara Avenue Branch Enugu, as a case study. The results obtained from the study showed that the arrival pattern follows a poisson distribution and that the service pattern follows an exponential distribution. The study recommended that the Bank management should increase the number of servers to three so as to help reduce the time customers spend on queue and also reduce cost incurred from waiting. In addition, [5] studied the Imperatives of Customer Relationship Management in Nigerian Banking Industry**.** Findings from the study revealed that there is a direct relationship between customer relationship management and customer loyalty as well as Banks profitability. The study recommended that management of banks should pursue customer relationship management programmes with rigor to achieve the business objectives of the bank. [6] expressed that queuing is common in banking industry that is always characterized by customer's explosion. Waiting-line model has been used as a bail out for banks from this overwhelming customers' excessive demand so as to improve the system performance. A queue system is also applicable to commercial service. Consequently, [7] studied multiple branches of bank, provided empirical evidence that teller waiting times affect customer satisfaction and retention. Their study revealed significant heterogeneity in customer sensitivity to waiting time, some of which could be explained through demographics and the intensity of competition faced by the branch.

III. METHODOLOGY

The aim of this research work is to determine the productivity and efficacy of using different number of servers by the management of Zenith Bank Plc, Abakaliki Branch and also to detect the effect of servers spending more time in serving one customer. The source of data used in this research work is a primary source of data collected at the withdrawal point of Zenith Bank Plc, Abakalik branch. The method applied in collecting data for this experiment is through direct observation at the Bank. The observation was made during the working hours (8:00am – 10:00am) for a period of one month at Zenith Bank Plc, Abakaliki branch. Data were collected only on Mondays and Fridays during the week. Monday and Friday are being considered as the busiest days of the week in Zenith Bank and every other Nigerian Banks.

✓ Formulation of the Model

In formulating the queuing model for this system, the following assumptions must be put into consideration;

- The arrival of customers into the system is discrete from poison distribution with arrival rate.
- There is multi service channel i.e. (M/M/S or C = 2,3,…,5)
- The service channel can only render service of infinite rate exponentially distribution with service rate.
- The order of arrival and departure are the same and we assume FIFO with infinite queue capacity.
- Server will never remain idle if there is one or more jobs in the service node.
- Once service is initiated, service of a job will continue until completion.

The waiting area for the customers in the system is N, which is either limited or unlimited. Hence, the model can be formulated appropriate by using a system for the investment system. Kendall's notation is introduced (V/W/X/Y/Z) as introduced by [8].

V- Which is the arrival distribution or pattern is poisson

W- The service time is exponential.

X- The number of available server S in the system range from two to ten from the assumption above.

Y- This represents the system capacity.

Z- This represents the queue discipline FIFO, which is first in first out.

Considering the above assumptions and approach, the model formulated is

(M/M/S/N/FCFS) by Kendall's notation

✓ Single Servers Queue with M|M|1 Model

The single server model is constructed so that queue lengths and waiting line can be predicted. Single-Channel Queuing Model with Poisson Arrivals and Exponential service times (M/M/1) queue, where the first M indicates the arrival rate, the second M indicates the service rate and the 1 indicates that there is only a single server.

✓ Diagram Representing Single Server System

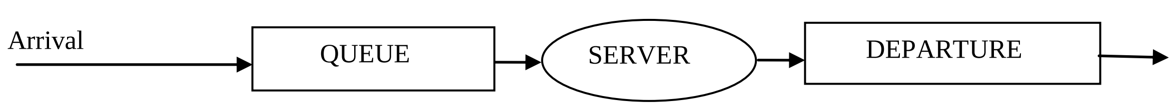

Fig 1: Diagrammatic representation of single server system

✓ Multiple Servers Queue with M|M|S Model

The M|M|S system is a queuing process having Poisson arrival patterns, S server, with S independent, identically distributed, exponential service times (which does not depend on the state of the system). The arrival pattern being stated independent, $\lambda_n = \lambda$ for all n. The service times associated with each server are also independent, but since the number of servers that actually attend to customers (i.e.

are not idle) does depend on the number of customers in the system, the effective time it takes the system to process customer through the service time facility is state dependent.

✓ Diagram Representing Multiple Server System

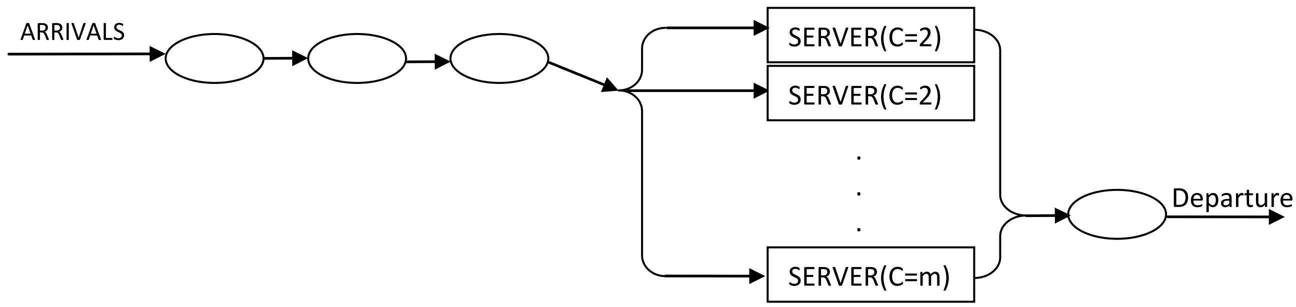

Fig ***2*****:** A multi server queue system

Key

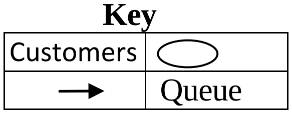

Fig ***3*****:** the key note of the diagram in fig *2* above.

If there are n customers in the queuing system at any point in time, then the following cases may arise:

i. If $n < c$ *or* s, (number), then there will be no queue of customers in the system is less than the number of servers. However, (c *or* $s - n$) number of servers will not be busy. The combined service rate will then be $\mu_n = n\mu$.

ii. If $n \geq c$ *or* s, (number of customers in the system is more than or equal to the number of servers), then all servers will be busy and the maximum number of customers in the queue will be ($n - c$ *or* s). The combined service rate will be $\mu_u = c\mu$.

✓ **The parameters for multiple-server model are as follows:**

λ = Arrival rate
μ= Service rate
c or s = The number of servers
Lq = Queue Length
N = System capacity
$N_{q=}$ Average number in the queue.
$N_{s=}$ Average number in the system.
$T_{q=}$ Waiting time in the queue.
$T_{l=}$ Total time lost on queue
P_n (t) = probability that exactly n customers are in queuing system at time t.
P_0 (t) = probability that there are no customers in queuing system in time t.
ρ = Utility factor
ℓ = Traffic intensity

The formulas for the operating characteristics of the multiple-server model are as follows.

c μ > l : the total number of servers must be able to serve customers faster than they arrive .

The probability of zero customers in the system (P_0) is given by:

$$P_0 = \frac{1}{\dfrac{\left(\lambda/\mu\right)^c}{c![1-\dfrac{\left(\lambda/\mu\right)}{c}]} + 1 + \dfrac{\left(\lambda/\mu\right)}{1}} \quad \ldots (3.1)$$

The capacity utilization in this system is $\frac{\lambda}{c\mu}$

We can use the above equation of $\frac{\lambda}{c\mu} < 1$

If $\frac{\lambda}{c\mu} > 1$, then the waiting line grows larger and larger i.e. becomes infinite if the process runs long enough.

The probability of n customers (p_n) in the queuing system is

$$P_n = \frac{\left(\lambda/\mu\right)^n}{c! \times c^{n-c}} P_0 \text{, for n>c} \quad \ldots (3.2)$$

$$P_n = \frac{\left(\lambda/\mu\right)^n}{c} P_0 \text{, for n≤c} \quad \ldots (3.3)$$

When C = 1 (i.e. there is one service facility), equations (3.3) reduces to

$$P_n = \left(\lambda / \mu \right) \quad \text{... (3.4)}$$

The average number of customers in the queuing system is

$$N_q = \frac{\left(\lambda / \mu \right)^{c+1}}{c \times c! \times \left[1 - \frac{\lambda / \mu}{c} \right]^2} P_0 \quad \text{... (3.5)}$$

The average time a customer spends in the queuing system (waiting and being served) is

$$T_q = \frac{N_q}{\lambda} \quad \text{... (3.6)}$$

The average number of customers in the queue is

$$N_s = N_q + \frac{\lambda}{\mu} \quad \text{... (3.7)}$$

Total time lost at waiting per day

$$T_l = \lambda \times 8 \times T_q \quad \text{... (3.8)}$$

Traffic intensity

$$\ell = \frac{\lambda}{\mu} \quad \text{... (3.9)}$$

NOTE: In the above formulas, if c = 1 i.e. only one server, then it can be used to calculate for single server system.

IV. RESULTS

- ✓ **Parameters Estimation**

Number of customers for four days (N_1, N_2, N_3, N_4)

$N_1 = 54$, $N_2 = 45$, $N_3 = 55$, $N_4 = 57$

$N = N_1 + N_2 + N_3 + N_4 = 211$

Service time: This is the time taken to serve a customer. i.e. service end subtract from service begin.

Arrival time: This is the time at which each customer enters the system.

Inter-arrival time for 211 customers, T=951 Minutes

Time taken by 211 customers to be served, S= 1385 Minutes

Arrival rate, $\lambda = \frac{N}{T} = \frac{211}{951} = 0.2219$

Service rate, $\mu = \frac{N}{S} = \frac{211}{1385} = 0.1524$

Traffic intensity $(\ell) = \frac{\lambda}{\mu} = \frac{0.2219}{0.1524} = 1.456$

This implies that

$\mu = 0.1524$

$\lambda = 0.2219$

4.3 Table of Result

Queue parameters	Two servers	Three servers	Four servers	Five servers
P_0	0.1574	0.2215	0.2312	0.2329
N_q	1.6419	0.1483	0.039	0.0074
N_S	3.0979	1.6043	1.495	1.4634
T_q	7.3993	0.6683	0.1758	0.0333
T_l	13.1352hrs	1.1864hrs	0.312hrs	0.0592hrs
A_c	N656.76	N59.32	N15.6	N2.96

Table 1: A table of result for adopting different number of servers

V. DISCUSSION OF RESULTS

Considering the analytical solution, the capacity of the system under study is 211 customers and the arrival rate is 0.2219 while the service rate is 0.1524. The arrival rate being greater than the service rate implies that customers have to queue up, though the queue will not be long. The probability that the servers are idle is 0.16 which shows that the servers will be 16% idle and 84% busy.

The expected number in the waiting line is 1.6419. The expected number in the system is 3.0979. The expected waiting time in the queue is 7.3993 minutes and the expected total time lost waiting in one day is 13.1352 hours. The average cost lost per day from waiting is ₦656.76 when two servers are in use.

From table 1, the use of three servers shows the expected number in the waiting line is 0.1483. The expected number in the system is 1.6043. The expected waiting time in the queue is 0.6683 minutes and the expected total time lost waiting in one day is 1.1864 hours. The average cost lost per day from waiting is ₦59.32.

Column four represents the use of four servers which communicated that the expected number in the waiting line is 0.039. The expected number in the system is 1.495. The expected waiting time in the queue is 0.1758 minutes and the expected total time lost waiting in one day is 0.312 hours. The average cost lost per day from waiting is ₦15.6

The expected number in the waiting line is 0.0074. The expected number in the system is 1.456. The expected

waiting time in the queue is 0.033 minutes and the expected total time lost waiting in one day is 0.0592 hours. The average cost lost per day from waiting is ₦2.96
However, the average cost per day for waiting is ₦656.76 and from the calculation of the comparing solutions, the average costs per day from waiting

are ₦59.32, ₦15.6, ₦2.96. There had been a saving in the expected cost of ₦656.76 - ₦59.32 = ₦597.44 and ₦656.76 - ₦15.6 = ₦641.16 and ₦656.76 - ₦2.96 = ₦653.8.
From the time spent on serving some customers, we can see that some customers take much time to be served. The cause of this delay could be as a result of network problems or power interruption. But in some cases, these causes could be attributed to ineffectiveness and lack of job experience.

VI. CONCLUSION AND FUTURE SCOPE

From the discussion of results, it could be concluded that any addition made on the number of servers will help reduce the time customers spend on queue and as well help to reduce the cost incurred from waiting, if other factors like human and machine technicalities have been taken care of.
However, the use of single system with multiple server has an edge in the sense that slow server does not affect the movement of the queue. That is customers waiting can move to another server and not wait for the slow server.
The management of Zenith bank Plc, Abakaliki branch can take extra measure in employing experienced workers especially those expected to work at the withdrawal point and take care of other faults which could be attributed to Automated Teller Machines, networks, power irregularities, etc in other to avoid customers being delayed unnecessarily.
Moreover, more effort should be focused on the minimizing the ideal time of the server and considering multiple server not necessarily in sequential ordering.

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