Automated Teller Machine (ATM) Service Optimization: Application of the Queuing Theory

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Abstract
This study applies queuing model to Automated Teller Machine services of Guarantee Trust Bank (GTB) Alabata, Abeokuta, Ogun state, Nigeria. The study sample comprised of 349 customers and the basic data were collected using observational timing of customer entry and service over a period of two weeks. The chi-square goodness of fit test was used to test the arrival pattern to determine if it follows a Poisson distribution and also tested the service pattern to determine if it follows an exponential distribution. Results obtained from the chi-square test showed that the arrival pattern follows a Poisson distribution and that the service pattern follows an exponential distribution, hence it can be analyzed using Markovian process. The raw data were then analyzed using Excel template bearing the multichannel queue model with two servers. Average service rate was found to be (μ) 0.5647 customers/minute (34 customers per hour), the mean arrival rate (λ) was 0.6609 customers/min (39 customers per hour), the probability that servers are idle was 0.4148 and the saving in the expected cost of waiting was N190.775. It was recommended based on the analysis, that the bank management should increase the number of servers to three so as to reduce the time customers spend on queue and also reduce cost incurred from waiting.
Keywords: Queue, Arrival-pattern, Service-pattern, Customers, Servers

Introduction

Life consists of preparing for and waiting for opportunities. Waiting for services is part of our daily routine and it is a common experience in virtually every economic life. There is hardly any economic activity that waiting line is not essential. Customers wait on line to get attention of the Cashiers in the Banks and attendants at the filing stations, bus stops, supermarkets, traffic light, telephone booth, and Automated teller machine facility, also student in registration line. Queues are necessary evil in any organised society. The more society becomes interdependent psychologically, economically and technically, the more individuals encounter waiting lines, or queues in their daily lives. They are formed primarily because the arrival time of someone who needs a service and the time of someone or facility to provide the service vary from a predetermined schedule.

Queuing model is an application of a quantitative model to customers flow management. The theory enables mathematical analysis of several related processes, including arriving at the back of the queue, waiting in the queue and being served by the service facility server(s) at the front of the queue (Taha, 2007).. There is therefore the need for effective and efficient management of queues for optimum service delivery in organisations. An efficient bank pays much attention to arrivals, service times and the order in which arriving customers are served in order to boost patronage. Queuing systems are described by distribution of service times, the number of servers, the service discipline, and distribution of inter- arrival times and the maximum capacity.

Automated Teller Machine indicates the development of information technology in banking sector. It is a computerized telecom device designed to provide effective and efficient financial services to bank customers at the shortest possible time. The service system is sometimes hampered by rowdiness of its customers and their random arrival and service time. This scenario in banks makes customers to form a queue system for an orderly service performance. The major problem faced by these Automated Teller Machines are the long queue of customers at the peak hours and then at the off peak hours the lack of customer entry. The number of customer at most times might be large that customers wait for more than half an hour to get his or her turn but the facilities remain idle that there are no customers to serve depending on the current capacity of each Automated teller machine; many alternate decisions can be made. Thus the problem of Automated teller machine facility is significant.

Research Objectives

The main objective of this study is to apply queuing model/theory to Automated teller machine services of Guaranty Trust bank Alabata, Abeokuta, Ogun state, Nigeria.

The specific objectives are to:

i. determine the mean number of arrivals per hour (λ) at the Automated teller machine facility of Guaranty Trust bank Alabata, Abeokuta.
ii. examine the mean number of customers served per hour (µ).
iii. analyse the relationship between the mean number of arrivals and the mean number of customers served per hour (λ and µ).
iv. evaluate the average time a customer spends waiting in the queue before being served by a facility.

Literature Review

Queuing theory is the construction of mathematical models of the various types of queuing systems to predict how the system will cope with demand made upon it. Queues are formed when the rate of items requiring service are greater than the rate of service. The queue permits the derivation and calculation of several performance measures including the average waiting time in the queue or the system, the expected number waiting or receiving service and the probability of encountering the system in certain states such as empty, full, having an available server or having to wait a certain time to be served. Queuing theory has become one of the most important, valuable and arguable one of the most universally used tool by an operational researcher. It has applications in diverse fields including telecommunications, traffic engineering, computing and design of factories, shops, offices, banks and hospitals. A queuing model of a system is an abstract representation whose purpose is to isolate those factors that relate to the system's ability to meet service demands whose occurrences and durations are random. (Sztrik, 2000). The study of queue deals with quantifying the phenomenon of waiting in lines using representative measures of performance, such as average queue length, average waiting time in queue and average facility utilization (Taha, 2007). Singh, (2011) Some of the analysis that can be derived using queuing theory include the expected waiting time in the queue, the average waiting time in the system, the expected queue length, the expected number of customers served at one time, the probability of balking customers, as well as the probability of the system to be in certain states, such as empty or full. Houda, Taoufik, & Hichem, (2008) emphasized that waiting lines and service systems are important parts of the business world. In their article they described several common queuing situations and presented mathematical models for analyzing waiting lines following certain assumptions.

Those assumptions are that arrivals come from an infinite or very large population, arrivals are Poisson distributed, arrivals are treated on a FIFO basis and do not balk or renege, service times follow the negative exponential distribution or are constant, and the average service rate is faster than the average arrival rate. According to Ford (1980) "Waiting lines develop when "clients" arriving for "service" are delayed prior to being served". If customers are scheduled to visit service facilities, and the scheduling rule strictly adhered to, queues can be avoided. Nevertheless, in reality this is not the case as most of the time customers arrive at these service facilities in a random and uncontrolled manner. Arriving customers who meet a busy server and/or a waiting line of customers, either departs or waits in the queue for his or her turn during which time the customer holds on to the server. After service is completed, customers are generally assumed to leave the system making it available for other customers. Unmanaged queues are detrimental to the gainful operation of service systems and results in a lot of other managerial problems. For instance an ATM that receives and accommodates huge inflow of customers can be detrimental to its smooth running and response time. A slow response would greatly affect the speed at which service is provided to customers. As a results service providers may loss customers who grow impatient and leave the system. Queuing models are used to represent the various types of queuing systems that arise in practice, the models enable in finding an appropriate balance between the cost of service and the amount of waiting (Nafees, 2007). Queuing models provide the analyst with a powerful tool for designing and evaluating the performance of queuing systems (Banks, Carson, Nelson, and Nicol,, 2001). Any system in which arrivals place demands upon a finite capacity resource maybe termed as queuing systems, if the arrival times of these demands are unpredictable, or if the size of these demands is unpredictable, then conflicts for the use of the resource will arise and queues of waiting customers will form.

Davis, (2003) assert that providing ever-faster service, with the ultimate goal of having zero customer waiting time, has recently received managerial attention for several reasons. First, in the more highly developed countries, where standards of living are high, time becomes more valuable as a commodity and consequently, customers are less willing to wait for service. Second, this is a growing realization by organizations that the way they treat their customers today significantly impact on whether or not they will remain loyal customers tomorrow. Finally, advances in technology such as computers, internet etc., have provided firms with the ability to provide faster services.

Researchers have argued that service waits can be controlled by two techniques: operations management or perceptions management (Hall, 2006). The operation management feature deals with the organization of how customers (customers), queues and servers can be coordinated towards the goal of rendering efficient service at the minimum cost. The (Abdul-Wahab & Ussiph, 2014) act of waiting has significant impact on customers' satisfaction. The amount of time customers must spend waiting can significantly influence their satisfaction. Additionally, research has demonstrated that customer satisfaction is affected not just by waiting time but also by customer expectations or attribution of the causes for the waiting. Consequently, one of the issues in queue management is not only the actual amount of time the customer has to wait, but also the customer's perceptions of that wait. Clearly, there are two approaches to increasing customer satisfaction with regard to waiting time: through decreasing actual waiting time, as well as through enhancing customer's waiting experience (Singh, 2011).

In 1909, the first study of queuing theory was done by a Danish mathematician, A.K. Erlang 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. The original problem Erlang treated was the calculation of this delay for one telephone operator and in 1917; the results were extended to the activities of several telephone operators. That was the same year that Erlang published his well-known work "solution of some problem in the theory of probabilities of significance in Automatic Telephone exchanges."

The Automated Teller Machine (ATM) is one of the several electronic banking channels used in the banking industry. According to (Aldajani & Alfares, 2009), automated teller machines are among the most important service facilities in the banking industry. The development of Automated teller machine has gone through many stages, it started from its baby stage in the late 1930s and then geared up for longer runs in the 1960s, and finally a matured and stable stage that we see today. Undoubtedly, most of the ideas and patents contributed for makeover of the Automated teller machine from time to time form the backbone of what was initiated as "holes in the wall".

Today, Automated teller machines hold a strong foothold in the world, offering everyone a better access to their money, be it in any corner of the world. There are about 1.8 million Automated teller machines in use around the world with Automated teller machines on cruise and navy ships, airports, newsagents and petrol stations. Automated teller machines too have been categorized as on and off premise Automated teller machines. On premise Automated teller machines are capable to connect the users to the bank with multi-function capabilities. Off- premise, Automated teller machine machines on the other hand are the "white label automated teller machines" and are limited to cash dispense

Queue characteristics

Queuing systems are characterised by the following components:-

i. the arrival pattern of customers
ii. the service pattern of customers
i. the number of servers.
ii. the capacity of the facility to hold customers
iii. the order in which customers are served

Assumptions of the Model

The single-channel, single-phase model considered here is one of the most widely used and simplest queuing models. It involves assuming that seven conditions exits:

i. Arrivals are served on a FIFO basis.

ii. Every arrival waits to be served regardless of the length of the line; that is, there is no balking or reneging.

iii. Arrivals are independent of preceding arrivals, but the average number of arrivals (the arrival rate) does not change over time.

iv. Arrivals are described by a Poisson probability distribution and come from an infinite or very large population.

v. Service time also varies from one passenger to the next and are independent of one another, but their average rate is known.

vi. Both the number of items in queue at anytime and the waiting line experienced by a particular item are random variables.

vii. Service times occur according to the negative exponential probability distribution.

viii. The average service rate is greater than the average arrival rate.

ix. The waiting space available for customers in the queue is infinite

Limitations of queuing theory

i. No simultaneous arrivals are allowed.
ii. Limited to dealing with situation of finite customers.
iii. Arrival rate may vary with time, weather condition, occurrence of some unusual events. e.t.c
iv. Some customers may be turned away once the queue has reached a certain size.

RESEARCH METHOD

Study Area

This research centered on the waiting area of the Automated teller machine of GTB Alabata, Abeokuta, Ogun State i.e., the withdrawal points of the bank. The bank has two point of withdrawal for this type of transaction in its vicinity. One of the locations is manned by multiple servers which accommodate multiple queues and the other is manned by multiple servers which accommodate a single queue. The researcher decided to adopt the latter because of its high queue discipline. The reason for the choice of this bank is because of its busy schedule. This is due to fact that the bank is located within easy access of two tertiary institutions (Federal University of Agriculture, Abeokuta and Federal College of Education, Osiele, Ogun State, Nigeria).

Research design

The objectives of this research were achieved by a descriptive survey and analysis of the real life observed data, then constructing a new model of system and using statistical analytical tools like Poisson, exponential and chi-square distribution to study pattern and reaction to change in the system. The data was collected primarily by direct observation at the bank Automated teller machine queue. Thus, the researcher recorded the following events as it happened in the system using a wrist watch.

1. The time of arrival of each customer.
2. The time service commences for each customer in the system.
3. The time the customer leaves the system.
4. The number of customers on the waiting line

These events were observed at the withdrawal section of the banking hall during the peak and off peak hours of the bank's operation. A form was designed for this exercise and the above required information was recorded in the form. Two weeks of five working days was spent to collect relevant data making ten days in all. Due to the nature of operation of the bank's facility, an infinite population was considered.

Data Analysis techniques

First the researcher used the chi-square distribution to study the pattern and reactions to change of the system i.e., identification of customers, server and queue characteristics that are apparent in the system. Chi-square is a unique statistical test designed to investigate the agreement of a set of observed frequency and expected frequency on the assumption of a theoretical model for the phenomenon being studied. The test is used for investigating dependency or independency of two attributes of classification.

A measure for the discrepancy existing between observed and expected frequency is supplied by the chi-square (X^2) statistic given by;

$$X^2 = \frac{\sum(f_n - fe_n)^2}{fe_n}$$

where f_n = actual or observed frequency

fe_n = expected frequency

After the data collected from the bank was analysed based on;

i. The time arrival of each customer.

ii. The time service commence for each customer and when each customer leaves the system using the M│M│S model since the system has to do with multiple servers and a single queue.

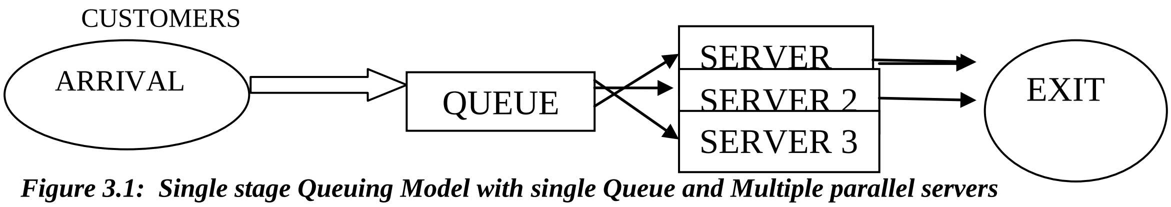

Figure 3.1: Single stage Queuing Model with single Queue and Multiple parallel servers
***Source:** Sheu and Babbar (1996)*

Results and Discussion
Results

Table 4.1 is the table showing the number of arrivals for each respective minute.

We now use the chi square test goodness of fit to test the hypothesis that

H_O = Arrival distribution is not poisson

H_1 = Arrival distribution is poisson

Let n = number of arrivals for each minute

F_n = Observed frequency of number of arrivals

fe_n = Expected frequency of number of arrivals

P_n = Probability of number of arrivals

Table 4.1

N	F_n	NF_n	P_n	fe_n	$f_n - fe_n$	$(f_n - fe_n)^2$	$\frac{(f_n - fe_n)^2}{e_n}$
0	0	0	0.1741	52.5782	-52.5782	2764.47	52.5782
1	168	168	0.3044	91.9288	76.0712	5786.83	62.9490
2	76	152	0.2663	80.4226	-4.4226	19.5593	0.2432
3	37	111	0.1551	46.8402	-9.8402	96.8295	2.0672
4	13	52	0.0678	20.4756	-7.4756	55.8846	2.7293
5	4	20	0.0237	7.1574	-3.1574	9.9692	1.3929
6	3	18	0.00069	0.20838	2.79162	7.7931	37.3985
7	1	7	0.00017	0.05134	0.94866	0.8999	17.5282
	302	**528**					**176.886**

SOURCE: RESEARCHER’S OBSERVATION (2017)

$P_n = \frac{e^{-\lambda} – \lambda^n}{n!}$ Where $\lambda = \frac{\sum nf_n}{\sum f_n} = \frac{528}{302} = 1.7483$ ………………………… (4.1)

$P_n = \frac{e^{-1.7483} – 1.7483^n}{n!}$ ………………………………. (4.2)

$fe_n = (\sum f_n)P_n = 302P_n$

$X^2 \text{ Cal} = \sum\frac{(f_n - fe_n)^2}{fe_n} = 176.886$ ………………………………. (4.3)

To find the X^2 we check the distribution table.

Degree of freedom = number of observed value – number of estimated parameter – 1 = n – 1 – 1

Number of observed is 7 and the number of estimated parameter is 1

Hence the degree of freedom = 7-1-1= 5

Taking α = 5%, from the X^2 distribution table, 0.05 critical value of X^2 for 5 degree of freedom

$X^2 \text{ tab} = X^2_{5, 0.05} = 11.070$

X^2 cal > X^2 tab. Hence H_1 is accepted and thus there is no reason on the basis of this test for doubting that queuing model can be applied to this data. This also implies that the arrival pattern follows a poisson distribution.

We now use the chi square test goodness of fit to test the hypothesis that H_O = Service time distribution is not exponential

H_1 = Service time distribution is exponential

Let T = service time in minute

F_n = Observed frequency of the service times

fe_n = Expected frequency of the service times

P_n = Probability of service time

Table 2

SERVER 1

T	F_n	P_n	fe_n	$f_n - fe_n$	$(f_n - fe_n)^2$	$\frac{(f_n - fe_n)^2}{fe_n}$
$0 \leq T < 3$	280	0.7614	258.876	21.124	446.223	1.7237
$3 \leq T < 6$	53	0.2134	72.556	-19.556	382.437	5.2709
$6 \leq T < 9$	7	0.0116	3.944	3.056	9.339	2.3679
	340					**9.3625**

$fe_{n} = \sum f_n(p_n) = 340P_n$

$P_n = \mu.e^{u\text{-}T}$

Where $\mu = \frac{\text{system capacity}}{\text{Time taken to be served}}$

$\mu = \frac{340}{520} = 0.6538$

$P(a \leq T < b) = \int_a^b \mu.e^{\mu\text{-}T}dT$ ……………………….. (4.4)

$-e^{-\mu b} + e^{-\mu a}$

$e^{-\mu a} - e^{-\mu b}$

$P(0 \leq T<3) = 2.1783^{-0.6135(0)} - 2.1783^{-0.6135(3)} = 0.7614$

$P(3 \leq T<6) = 2.1783^{-0.6135(3)} - 2.1783^{-0.6135(6)} = 0.2134$

$P(6 \leq T<9) = 2.1783^{-0.6135(6)} - 2.1783^{-0.6135(9)} = 0.0116$

$X^2 \text{ Cal} = \sum \frac{(f_n - fe_n)^2}{fe_n} = 9.3625$

to find X^2tab, we check the chi square distribution table

degree of freedom = 3-1-1 = 1

taking α = 5%, from the X^2 distribution table, 5% critical value of X^2 for 1 degree of freedom is

$X^2\text{tab} = X^2_{1,\,0.05} = 3.841$

X^2 cal > X^2 tab. Therefore H_1 is accepted, and this connote that the service time pattern for Server 1 follows an exponential distribution.

Table 3

SERVER 2

T	F_n	P_n	fe_n	$f_n - fe_n$	$(f_n - fe_n)^2$	$\frac{(f_n - fe_n)^2}{e_n}$
$0 \leq T < 3$	277	0.7614	258.876	18.124	328.479	1.2689
$3 \leq T < 6$	58	0.2134	72.556	-14.556	211.877	2.9202
$6 \leq T < 9$	5	0.0116	3.944	1.056	1.115	0.2827
	340					**4.4718**

X^2 Cal = $\frac{\sum(f_n - fe_n)^2}{fe_n}$ = 4.4718

to find X^2tab, we check the chi square distribution table

degree of freedom = 3-1-1 = 1

taking α = 5%, from the X^2 distribution table, 5% critical value of X^2 for 1 degree of freedom is

$X^2tab = X^2_{1, 0.05} = 3.841$

X^2 cal > X^2 tab. Therefore H_1 is accepted, and this connote that the service time pattern for Server 2 follows an exponential distribution.

Estimation of parameters

From the data collected, the total number of customers sampled (N) were 349 customers.

Inter arrival time for 349 customers is 528 minutes.

Time taken for 349 customers to be served by the first facility (SERVER 1) is 655 minutes.

Time taken for 349 customers to be served by the second facility (SERVER 2) is 585 minutes.

Thus,

Arrival rate (λ) = $\frac{349}{528}$ = 0.6609 customer per minute i.e 40 customers per hour

Service rate$_1$ (μ_1) = $\frac{349}{655}$ = 0.5328 customer per minute i.e 32 customers per hour

Service rate$_2$ (μ_2) = $\frac{349}{585}$ = 0.5965 customer per minute i.e 35 customers per hour

This implies that,

$\lambda = 0.6609$

$\mu_1 = 0.5328$

$\mu_2 = 0.5965$

S = 2

$\boldsymbol{\mu} = \frac{\mu_1 + \mu_2}{2} = \frac{0.5328 + 0.5965}{2} = 0.5647$

Model 3 (M/M/s Queue):

Multiple servers, Infinite population, Poisson arrival, FCFS, Exponential service time, Unlimited waiting room

Inputs

Unit of time	**Minute**		
Arrival rate (λ)	0.6609	**customers per**	**minute**
Service rate (μ)	0.5647	**customers per**	**minute**
Number of identical servers (s)	2	**Servers**	

Outputs

Mean time between arrivals	1.513	
Mean time per service	1.77085178	**Minute**
Traffic intensity	0.585177971	**Minute**

Summary measures

Average utilization rate of server (P)	58.5%	
Average number of customers waiting in line (L_q)	0.6095	**Customers**
Average number of customers in system (L_s)	1.77983	**Customers**
Average time waiting in line (T_q)	0.92219	**Minute**
Average time in system (T_s)	2.69304	**Minute**
Probability of no customers in system (P0)	0.4148	**(this is the probability of empty system)**

From the above,
The probability that the servers are idle (P_0) = 0.4148, the expected average number in the waiting line (L_q) = 0.6095, the expected average number in the system {waiting plus in service} (L_s) = 1.77983, the expected average waiting time in the queue (T_q) =0.92219 minute.
If we assume an 8 hours work day, the expected total lost time of customers waiting will be
$T_L = \lambda \times 8 \times T_q$
0.6095 x 8 x 0.92219 = 4.4966hours
Assuming the cost associated with this time lost is N50, the average cost per day from waiting is
4.4966 hours x N50 = N224.83
Now we want to find out if increasing the number of servers can help to reduce the amount of time spent on queue and hence minimize the cost incurred by waiting. Hence we can compare solutions.
Let Arrival rate (λ) = 0.6609
Service rate (μ) = 0.5647, but let the number of identical servers (S) = 3
Now we have;

Model 3 (M/M/s Queue):
Multiple servers, Infinite population, Poisson arrival, FCFS, Exponential service time, Unlimited waiting room

Inputs

Unit of time	[redacted]	
Arrival rate (λ)	0.6609	**customers per minute**
Service rate (μ)	0.5647	**customers per minute**
Number of identical servers (s)	3	**Servers**

[redacted]

Mean time between arrivals	1.553	
Mean time per service	1.8178513	**Minute**
Traffic intensity	0.390171484	**Minute**

Summary measures

Average utilization rate of server (P)	39.0%	
Average number of customers waiting in line (L_q)	0.08509	**Customers**
Average number of customers in system	1.25545	**Customers**

(L_s)		
Average time waiting in line (T_q)	0.12875	**Minute**
Average time in system (T_s)	1.89960	**Minute**
Probability of no customers in system (P_0)	0.6098	

Discussion

From the above, the probability that the servers are idle (P_0) = 0.6098, the expected average number in the waiting line (L_q) = 0.08509, the expected average number in the system {waiting plus in service} (L_s) = 1.25565, the expected average waiting time in the queue (T_q) = 0.13222.

If we assume an 8 hours work day, the expected total lost time of customers waiting will be

$T_L = \lambda \times 8 \times T_q$

0.6609 x 8 x 0.13222 = 0.6811 hours

Assuming the cost associated with this time lost is N50, the average cost per day from waiting is

0.6811 x N50 = N34.055.

Based on the analysis and interpretation of the research hypothesis using chi square goodness of fit test, the result of the findings gives an acceptance of the alternative hypothesis which indicates that the service time follow a poisson distribution and the arrival time an exponential distribution. The arrival rate for the first scenario where the number of servers is 2 and service rate is 34 customers per hour. The system performance parameter are as follows;

Lq= 0.6095. This implies that 0.6095 customers in the queue waiting to be served by the facility.

Ls= 1.77983. This measures the average number of customers in the system. That is, 1.77983 in the system per minute.

Tq= 0.92219. This implies that customers spent 0.92219 minute on the queue waiting to be served by the facility.

Ts= 2.69304. This means that customers spent 2.69304 minute in the system. The time spent before joining the queue, waiting in the queue to be served and time spent after being served before departure.

P= 0.5851. in this case, the facilities are utilized only for 58.5% of time.

Po= 0.4148, which indicate that the facilities are idle only for 41.5% of time. And as a result of a total loss time (T_L) of 4.4966 hours, an average cost of N224.83 is incurred per day from waiting.

Comparing this with the solution of the second scenario where the number of servers were increased to three with arrival and service rate being constant, the system performance parameter indicated the following;

Lq= 0.08514, which implies that 0.08514 customers in the queue waiting to be served by the facility.

Ls= 1.25565, which measures the average number of customers in the system. That is 1.25565 in the system per minute.

Tq= 0.13222, which indicates that customers spent 0.13222 minute on the queue waiting to be served by the facility.

Ts= 1.89960. This means that customers spent 1.89960 minute in the system. The time spent before joining the queue, waiting in the queue to be served and time spent after being served before departure.

P= 0.3902, In this case, the facilities are utilized only for 39% of time, while Po= 0.6098, which indicate that the facilities are idle only for 60% of time. Also, as a result of a total loss time (T_L) of 0.6811 hours, an average cost of N34.055 is incurred per day from waiting.

We see that increasing the facility from two to three servers, resulted in a lower average number in the waiting line (Lq), average number in the system (Ls), average waiting time in the queue (Tq), average time in the system (Ts) and a reduction in the cost incurred due to waiting to per day.

There is also a decrease in the utilization rate which decreases the probability of customers going away.

Conclusion and Recommendation

Queue theory is very useful and relevant for management of business organizations especially in the service industry. It is highly useful in planning and making decisions that will affect the smooth running of business organizations and enhance customer satisfaction. The involvement of human factor in the provision of service affects its variation. Henceforth, high human involvement in a system leads to high variation in the service duration and the lower the human involvement in system, the lower the service variation. One needs to recall that constant time is common when a service is highly mechanized or automated. The management of Guarantee Bank Plc must be conscious that if the queue formed is very large, it will discourage customers and this result to loss of customers to rival banks especially at this period that many banks have commenced operations. This therefore necessitates the bank to observe queue discipline, that is, customers must be served on first come and first served basis. Although, there are other queue disciplines such as Last- In -First -Out, Alphabetical Discipline, etc. In some cases, there are some pre-arranged schedules which is common among doctors. In this situation, customers will be attended to on predetermined arrangement not minding the time of arrival. However, management of the bank must as much as possible use FIFO method that is First Come First Out in attending to their customers. The operator of a service organization should know that queuing theory alone cannot bring solution to congestion problem in an organization. It is not an end but a means to an end. Therefore, manager cannot substitute it with managerial thinking; it can only serve as an aid to congestion problem. Henceforth, the management of the bank must effectively analyze the customers' situation and then complement it with queuing theory. Thus, this study is in support of the work of Odunukwe, (2013) and Yusuf, Blessing and Kazeem (2015) which shows that queuing theory can be used to model bank settings as well as (Abdul-Wahab & Ussiph, 2014)where it was also applied to Automated Teller Machine.

Recommendation

Since the utilization factor (PK) of the bank's Automated Teller Machine staging a single queue and multiple servers is less than 0.5 for the other solution, it is recommended that the management of Guarantee trust bank Alabata, should add one more server. This will help reduce the time customers spend on the queue and as well help to reduce the cost incurred from waiting.

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