IOSR Journal of Business and Management (IOSR-JBM)
e-ISSN: 2278-487X, p-ISSN: 2319-7668. Volume 17, Issue 6.Ver. I (June. 2015), PP 65-69
www.iosrjournals.org

Bank Service Performance Improvements using Multi-Sever Queue System

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Abstract: *Modeling and managing the performances of a service industry is challenged due to the randomness of arrival and service time. This paper considers one bank in Addis Ababa and tries to model its service performances as a multiple server queue structure system. Secondary data related to arrival rate, service time and cost are collected from the same bank for a period of one month. The data was fitted in the model and tested using the enterprise dynamic simulation system. The findings of the study show that both arrival of customers and service time rate of servers follow a Poison exponential probability distribution respectively. Moreover, the optimum number of the servers resulted from the model is found to be five serves but with a low server utilization rate of 0.578. Therefore the bank is recommended to improve its server utilization*
Keywords - *performance, queue, probability distribution, customers* **.**

I. Introduction

Improving the performance of service industries where arrival and service time are random and performed by human employee is a complex decision environment (Ullah et.al, 2014; Azmat 2007). The banking industry is a good example that share the above scenario. To make a better decision and to improve the system performance decision makers assisted themselves by using intelligent system. Among the many others simulation system is one of the intelligent system that helps to model a complex environment. A queue system has long been studied in the commercial application (Zhang, 1998; Bhathawala, 2012; Famule, 2010; Vasumathi, 2010). In this paper the performance of a Bank system which is found in Addis Ababa is taken as a case study, modeled as a queue system and simulated using simulation software. Various scholars have studied banks as a queue system but with different scenarios and implementation approaches: Single server, multiple server, parallel server, different queue discipline, as well as various arrival and service time distributions. This study focuses on the multiple servers queue model approach to model the service performances of the bank system in Addis Ababa. The performances of one of the branch of a private bank is taken as a case study. However, for the purpose of data confidentiality, the name of the bank is not stated in this paper. A one month arrival and service data time was collected from the bank. The collected data was fitted to a model to check the type of probability distribution they follow. Moreover, the average server and waiting time cost of the system were also collected based on the resources used on the service provision. In a similar way, the mean waiting costs of customers were also collected from the different class of customers who enquire the service. The remainder of the paper is organized as follow. In the section 2 the literature review is presented, in section 3 the arrival and service time distribution of the bank is modeled and tested, in section 4 the results and discussions are presented followed by the conclusion.

II. Literature Reviews

Queuing theory had its beginning in the research work of a Danish engineer named Erlang around 1909 (Winsotn, 1991). He conducted an experiment and had observed that the demand in telephone traffic is fluctuating. Latter he published a report addressing the delays in automatic dialing equipment. Soon after his published work and during the end of World War II, Erlang's early work was extended to more general problems and to business applications of waiting lines and to various service industries. Modeling a service industries as a queue system has many advantages such as diagnosing problems, identifying constraints so as to understanding the real systems rather than indicating individual prediction about the system (**Bank, 1999)**

Several studies present various queuing model to analyses the performances of service industries. For example a queue system optimization model is used for the bank system is but used at different scenario (Tian & Tong, 2011; Wang et.al. 2010). Others such as Ullah et.al (2014) model a bank system as a queue model with M/M/s queue structure to improve the utilization of the staff. Generally a queue model is constructed by several key parameters as an input: arrival rate "λ", service rate "μ", along with one or more servers with different queue discipline or implementation approaches. In the literatures different queue models are used to standardize a server configuration. For example M/M/1 represents a single server that has unlimited queue capacity with both service and arrival rate follow a poison distribution (Bhavin and Bhathawala, 2012, Charan, 2012, Famule, 2010). It is the most commonly used queue model representation (Boxma & Cohen, 1997). Moreover, Ahmed (2011) implemented different queuing algorithms that are used in banks to serve the customers, and to improve average waiting time. Others such as Chowdhury (2013) describe several common queuing situations and present mathematical models for analyzing waiting lines. He illustrated using a Bank system to measure customers' satisfaction level on the service using multiple-channel queuing model with Poisson Arrival and Exponential Service Times (M/M/S). Charan (2012) also investigate single server queuing system wherein the arrival of the units follow Poisson process with varying arrival rates in different states and the service time of the units is arbitrary (general) distributed.

In this paper Poison probability distribution for the arrival and exponential probability distribution for the service rate are assumed to fit in the model where several servers involved in the service provision of a bank system using first come first (FCFS) served queue discipline. It is represented as M/M/s where "s" stands the number of servers.

III. Arrival And Service Distribution

With the objective to improve the case bank service system, the following assumptions are considered:

- The arrival of customer is identically independent and follow the Poison probability distribution with parameter λ and given by:

$$P_n(t) = \frac{e^{-\lambda t}(\lambda t)^n}{n!}; \quad n = 1,2,3 \ldots t > 0 \qquad \text{Eq.(1)}$$

  Where $P_n(t)$ indicates the probability of arriving n customers in time interval t

- The service time of customers is identically independent which meets negative distribution with parameter μ and is given by:

$$\mathrm{F(t)} = 1 - \mathrm{e}^{-\mu t}; \quad \mathrm{t} > 0 \qquad \text{Eq. (2)}$$

- The waiting line is characterized by unlimited queue structure and the queue discipline is FCFS.
- Due to the introduction of one window system, each server has similar facilities however, the queue configuration system is with several tellers or servers on duty and customers has to wait in one common line for the first available server.

The multiple channel system considered in this paper is illustrated at Fig.1 and its parametric representation are also summarized and shown in Table1. In this section, the multiple channel queuing system of the bank is molded and explained using diagram as shown in Fig.1. The bank has seven servers or channels to handle or serve arriving customers. It is assumed that arriving customers awaiting service from one single line and then proceed to joining the first available server. Each of this servers or channels has independent and identical exponential service time distribution with mean $1/\mu$. The arrival of customers also following a Poison Probability distribution with mean arrival rate of λ. The implementation of the service system is FCFS and all service are assumed to be performed at the same rate. Let s is the number of servers or channels open, λ is the mean arrival rate of customers and μ is the mean service rate at each server or channel, then the mathematical model given in Table1 is used to determine the basic parameter of the bank's performance.

Further, let L_{qj} the average waiting time of customer j in the queue, L_{sj} is the average waiting time of customers j in the system, C_{wj} is the cost of customer j waiting in the S_j is server j that gives service to customers and C_j the cost of the server. Then the total cost of serving N customers based on waiting (T_{cw}) and the total cost based on the system (T_{cs}) are given by $T_{cw} = \sum_{j=1}^{N} C_j S_j + \sum_{j=1}^{N} C_{wj} L_{qj}$ $T_{cs} = \sum_{j=1}^{N} C_j S_j + \sum_{j=1}^{N} C_{wj} L_{sj}$ respectively. All the queue parameters considered in this paper are presented Tabel1.

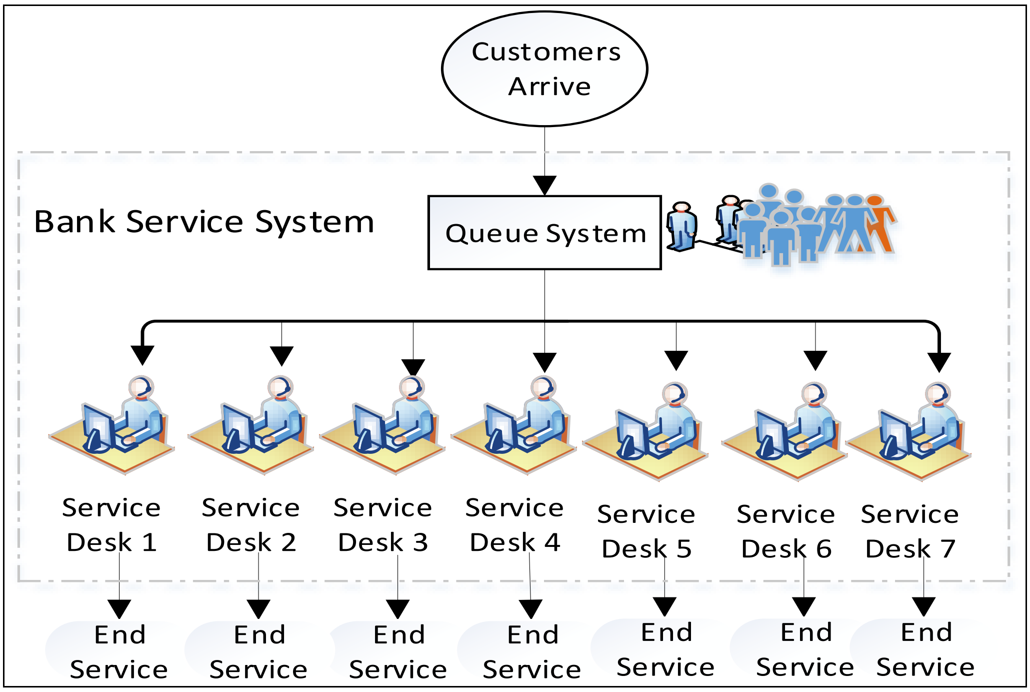

Figure 1. Illustration of multiple channel service system

Table 1. Performance improvement parameters and Equations based on M/M/s

Results	Formula
Average server utilization/efficiency (ρ)	$\rho = \frac{\lambda}{s\mu}$
Average number of customers in the queue(Lq)	$L_q = \frac{\rho^{(s+1)}}{s!s\left(1-\frac{\rho}{s}\right)^2} P_0$
Average number of customers in the system(Ls)	$L_s = \left[\frac{\rho^s}{\mu s!s\left(1-\frac{\rho}{s}\right)^2} P_0 + \frac{1}{\mu}\right]\lambda$
Average waiting time in the queue(Wq)	$W_q = \frac{\rho^s}{\mu s!\,s\left(1-\frac{\rho}{s}\right)^2} P_0$
Average time in the system(Ws)	$W_s = \frac{\rho^s}{\mu s!\,s\left(1-\frac{\rho}{s}\right)^2} P_0 + \frac{1}{\mu}$
Total Cost Based on Waiting (T_{CW})	$T_{cw} = \sum_{j=1}^{N} C_j S_j + \sum_{j=1}^{N} C_{wj} L_{qj}$
Total Cost Based on System (T_{CS})	$T_{cs} = \sum_{j=1}^{N} C_j S_j + \sum_{j=1}^{N} C_{wj} L_{sj}$

In order to formulate a simulation run that fits to the model shown in Fig.1, data is used to get the inter arrival time for customers and the service time for each server. Furthermore, to develop the alternative simulation scenario in terms of cost and various queue parameters, the mean service rate of the seven servers are computed and give to the model. In a queue system basically there are two costs involved. The first one is the costs involving in operating each service facility like the cost of for equipment, materials, labor etc and the second one is the costs associated with causing customers to have to wait in line for some period of time prior to being serviced. These includes the cost of physical discomfort, reduced or lost sales etc. Again based on the data collected from the bank, this paper considered the 10Birr/hr as the operating cost of providing the service and 15Birr/hr as the average waiting cost of customer in the bank.

The data shows that the mean inter-arrival time follows a poison distributed with mean of 0.133hr and the mean service time for all the seven servers follows exponential distribution with mean service time of 2.665, 2.652, 2.707, 2.717, 2.505, 2.535, and 2.328 customers per hour for server desk1 to server desk7 respectively (See Figure1).

IV. Results And Discussions

As presented in Fig.2 and Fig.3 the actual arrival and service rate of the bank are compared with the two distributions: Poisson (expected) and the exponential expected. Fig.2 indicated that the observed customers arrival distribution shape is very similar to the expected Poisson distribution shape which is computed based on probability theory. The finding shows that Poisson probability distribution can be assumed to be valid for this research. The goodness of fit is statistically significant with $\chi^2 = 82.93, df = 14 \; and \; P < 0.001$.

Figure 2 Customers Arrival Rate Distribution at the Bank

A similar approach like the arrival rate analysis was also conducted for the service time rate. A queue theory often assumes that the exponential distribution can be used in conjunction with a Poisson arrival rate. Based on the data collected from the bank, a cumulative probability distribution was constructed. The result indicted that though the exponential probability distribution and the observed number of customers seem apart each other, they show a good fit and statistically significant with $\chi^2 = 749.30, df = 14 \; and \; P < 0.001$. However on should note that the service required by customers are different which ranges from opening a new account, depositing money, withdrawal, money transfer, receiving transferred money and so on. This contributes somehow on the slight deviation of the observed customers served graph and the expected from exponential probability distribution graph.

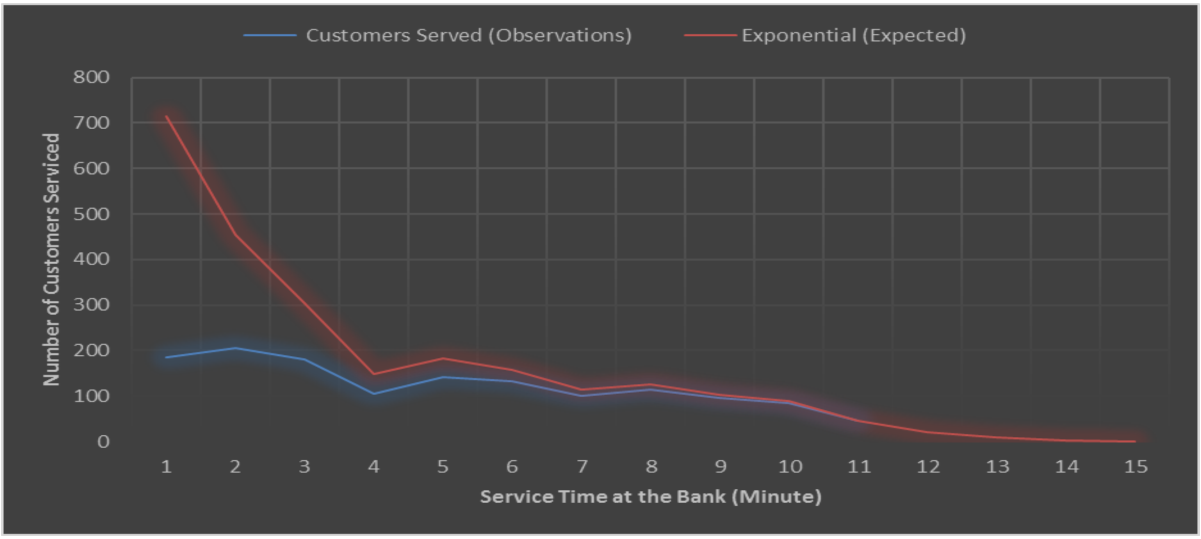

Figure 3. Service Time Distribution at the Bank

From the simulation, as reported in Table2, the findings of the result show that the optimum configuration is realized when the number of servers reach five. With this arrangement, the average proportion of time that each server or teller was busy (Service Utilization) is found to be 0.584. Moreover, the average number of customers' waiting in the queue (L_q) and waiting in the system (L_s) are found to be .305 and 2.23 customers respectively. On average a customer spends .042hrs or (2.52 minutes) in the waiting line and .428 hrs or 25.68 minutes in the bank or system.

Table 2. M/M/s Simulation Result Assuming Poisson Arrivals and Exponential Service Times

		Number of Servers						
Results	Results	1	2	3	4	**5**	6	7
P	0.42	na	na	.974	.730	**.584**	.487	.417
Lq	0.024	na	na	35.33	1.292	**.305**	.085	.024
Ls	2.94	na	na	38.25	4.213	**2.230**	3.01	2.945
Wq	0.00	na	na	4.670	.171	**.042**	.011	.003
Ws	0.39	na	na	5.070	.559	**.428**	.399	.391
TCW	NA	na	na	556.97	59.36	**54.57**	61.27	70.36
TCS	NA	na	na	600.79	103.17	**98.39**	105.09	114.17

$\lambda = 7.539$, $\mu = 2.581$, S = 7 and Unit of Measurement= Hour, na = not available

V. Conclusion

The research tries to develop a practical queue model in line with the working arrangements of the bank. The findings of the research show that the arrival rate of customers follows a Poisson probability distribution and the service rate of the servers follows an exponential probability distribution. Moreover, the simulation run shows that the total cost based on waiting and based on the systems are found to be optimum with five servers with 58.4% server utilization. With five number of servers, the total customers waiting in the systems or in the bank also relatively low as compared with the total number of customers waiting in the systems when the number of servers are four as well as six or seven. Based on the research finding it is recommended that the bank should use five servers so that it can operate with optimum cost. But it needs to improve the utilization of the servers utilization.

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