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APPLICATION OF QUEUING THEORY TO ENHANCE THE OPERATIONAL EFFICIENCY OF THE BANK

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Abstract

This study is to ascertain the contributions and applications of queuing theory in the field of Banking queue management problems. This review proposes a system of classification of queues in the Banking sectors. The goal is to provide sufficient information to an analyzer who is interested in using queueing theory to model an effective queue management process. Customer satisfaction is a concern to service industries as customers expect to get their service promptly when they arrive. Demand for service is highly variable, and it depends on customer's satisfaction. For a service industry like a bank, there is a need for efficient bank Teller scheduling system that takes into account recognizing various customer expectations. This research study involves as to how a bank could provide value added customer service by reducing customer-waiting time to the maximum possible standard. The model takes into account real time system behaviour including changing customer arrival rates throughout the day and customer service manner. This study is centered on the single channel waiting line systems with poisson arrivals and exponential service times in Bank of Ceylon, City office, Bank of Ceylon Kuliyapitiya and Bank of Ceylon Bingiriya. Banking *activities and behavior of these three branches are completely different. They represent stages of customer-flow management processes. Waiting systems are stochastic mathematical models and they represent the describing base of the waiting phenomena, services processes, and prioritization among others. Mathematical models of queuing theory present interest in modelling, designing, and analysing information networks.*

Keywords: *Queuing Theory, Mathematical modeling, Bank*

1. INTRODUCTION

This paper involves as to how a Bank could provide value added customer service by reducing customer-waiting time to the maximum possible standard. The model takes into account real time system behaviour including changing customer arrival rates throughout the day and customer service manner. It provides scheduling rules and the corresponding service levels when demand varies with cost minimization as goals.

Queuing theory is the mathematical study of waiting lines, and it is very useful to define modern information technologies require innovations that based on modeling, analyzing, designing to deals as well as the procedure of traffic control of daily life of human. This paper is centered on the single channel waiting line systems with Poisson arrivals and exponential service times in a Bank. They represent stages of customer-flow management processes.

Waiting systems are stochastic mathematical models and they represent the describing base of the waiting phenomena, services processes, and prioritization among others. Mathematical models of queuing theory present interest in modeling, designing, and analyzing information networks. The expanded networks of a Bank and years of establishment/service should bring about modern technologies of attending to customers in banking halls across the globe thereby increasing their turn out and efficiency of carrying out business. Many commercial banks have made great efforts to increase the service efficiency and customer satisfaction, but most of them are facing serious problems regarding waiting lines of customers. In a bank, the waiting line of customers appears due to low efficiency of the queuing system, and it reflects the lacking of a business philosophy of customer centric, low service rate system. The waiting queues of customers develop because the service to a customer may not be delivered immediately as the customer reaches the service facility. Lack of satisfactory service facility would cause the waiting line of customers to form. The only technique to meet the service demand with ease is to increase the service capacity and the efficiency of the existing capacity to a higher level.

As the service speeds up, time spent waiting on queues decreases. Service cost, however, increases as the number of service stations increase. The goal of managers is to schedule as few employees as possible while maintaining a maximum customer service level. Managers should make every endeavor to make the queues short enough so that customers are not dissatisfied or they will not leave without transacting their business or transact once and never return in the future. However, some waiting can be allowed if the waiting cost is balanced with significant saving in service cost.

In most of the banks, customer and service information is identified generally based on manual observation and personal judgment (Obtained through information from visits to some local banks). This gives inaccurate results and wastes time. It also requires continuous observation by management personnel and thus results in additional cost. These results have greater possibility to make some customers being dissatisfied as customers who came first may be served last. Profit maximization objective may not be easy to achieve in banking, without providing a good level of customer service exceeding their expectations. In other words, the faster they are attended to, the more the customer would be encouraged to keep their money with a bank.

This research and study is completely based on. Queuing theory is a mathematical approach applied to the analysis of waiting lines. It uses models to represent various types of queuing systems. Formula for each model indicates how the related queuing system should perform, under a variety of conditions. The queuing model is a very powerful tool for determining how to manage a queuing system in the most effective manner. Queuing theory is considered as random system theory, which studies the content of the behavior problems, the optimization problem, and the statistical inference of queuing system.

Queuing is a challenge for all the branches in the Banking industry. In the developed world, considerable research has effected on how to improve queuing systems in various Banks. Unfortunately, above situation has not occurred in the case of developing countries like Sri Lanka. This study seeks to contribute to this subject by analyzing the queuing situation in public banks in Sri Lanka and to bring its practical value to how decision-making can be enhanced in banking industry.
Long waiting queues are symptomatic of inefficiency in the banking industry or any other service industry. Unfortunately, this is the case in many public banks in Sri Lanka. Capacity management decisions in banking industry are arrived at on experience and on rule of the thumb rather than with the help of strategic research model-based analysis coupled with good mathematical approach.

All the larger banks in Sri Lanka receive a large number of customers every day and this generally results in long customer waiting times. In response to this challenge, this research study analyses the queuing system of the banking industry in order to develop a model that can help reduce the waiting time of their customers. Specifically, this study seeks to construct a structural model of customer flow within the bank and to model a queuing system using the queuing theory to minimize customers waiting times in the bank.

The objective of queuing analysis is to offer a reasonably satisfactory service to waiting customers. In general, the approach of queuing theory is not an optimization technique, but instead it determines the measure of performances of waiting lines, such as average waiting time in the queue and the productivity of the service facility, which can be used to design the service installation.

The applications of queuing theory extend well beyond waiting in line at a bank. It may take some creative thinking, but if there is any sort of scenario where time passes before a particular event occurs, there is probably some way to develop it into a queuing model. Queues are so commonplace in society that it is highly worthwhile studying them, even to reduce only a few seconds off one's time waiting in a queue.

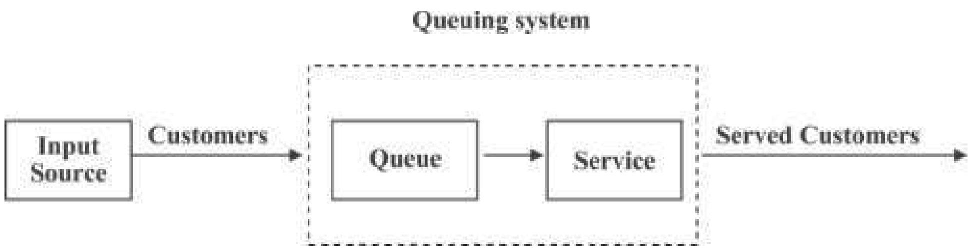


Figure 1: Queuing System

2. QUEUE DISCIPLINE

This means how customers should be selected from the waiting lines. This can happen on one of the four types given below.

i. First in first out (FIFO) or First come first served (FCFS) basis

   That is the customer who has been queuing the longest time is served first. This is the most common and fairest queue discipline.

ii. Last in first out (LIFO) basis

   That is the customer who comes last or the item that was stocked last is taken first.

iii. Service in random order (SIRO) basis

   For example, in telephone exchanges, the operator has no means of telling how long any caller has been trying to make the call and callers are selected at random.

iv. Service in priority order (PRI) basis

   For example, in the telegraph system urgent messages are sent before the ordinary messages.

The queuing behavior of customer plays a role in waiting line analysis.

3. TERMINOLOGY AND NOTATIONS

P_n = Probability of having n customers in the system

N = Number of customers in the system

L_s = Expected number of customers in the system

L_q = Expected number of customers in the queue

W_s = Waiting time of customers in the system

W_q = Waiting time of customers in the queue

λ_n = mean arrival rate (expected number of arrivals per unit time) of new customers is in the system

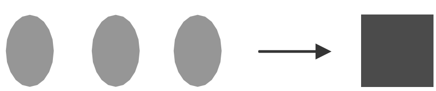
μ_n = mean service rate for overall system. (Expected number of customers completing service per unit time) when n customers are in system

ρ = Traffic intensity (Utilization factor)

s = Number of servers

4. QUEUING MODELS

4.1 Single-server, Single-phase



For M/M/1 system we define the utilization factor (or traffic intensity) as $\rho = \frac{\mu}{\lambda}$,

Where ρ is the expected number of arrival per mean service time. If $\rho < 1$, then steady state probabilities exist and are given by $p_n = \rho^n (1 - \rho)$

4.2 Measures of Model

1. Expected (average) number of units in the system L_s

$$L_s = \sum_{n=1}^{\infty} np_n = \sum n\left(\frac{\lambda}{\mu}\right)^n\left(1-\frac{\lambda}{\mu}\right)$$ This can be simplified as $L_s = \frac{\rho}{1-\rho}$

2. Expected (average) queue length L_q

$$L_q = L_s - \frac{\lambda}{\mu} = \frac{\rho^2}{1-\rho}$$

3. Expected waiting time in the queue

$$W_q = \frac{\rho}{\mu-\lambda}$$

4. Expected waiting time in the system

$$W_s = W_q + \frac{1}{\mu} = \frac{1}{\mu-\lambda}$$

4.3 Multi Server Model

When there are n number of units in the system, may be obtained in the following two situations

(1) if $n \le S$ all the customers may be served simultaneously. There will be no queue. (s-n) number of servers may remain idle and then $\mu_n = n\mu$ n = 0,1,2,3…..S

(ii) If $n \ge S$, all the servers are busy, and the maximum number of customers waiting in queue will be (n-s), then Also $\lambda_n = \lambda$ n = 0,1 2, ,3 …..

4.4 Measures of Model

$\sum_{n=0}^{S-1} P_n + \sum_{n=S}^{\infty} P_n = 1$ This gives the steady state distribution of arrivals.

$$P_n = \begin{cases} \frac{\lambda}{n\mu} P_{n-1} = \frac{\lambda^n}{n!\mu^n} P_0 & \text{for } 1 \le n \le S-1 \\ P_n = \frac{1}{S^{n-S} \times S!} \left(\frac{\lambda}{\mu}\right)^n P_0 & \text{for } n \ge S \end{cases}$$

1. Length of the queue $L_q = P_S \frac{\rho}{(1-\rho)^2}$ where $P_S = \frac{\left(\frac{\lambda}{\mu}\right)^S P_0}{S!}$

2. Length of the system $L_S = L_q + \frac{\lambda}{\mu}$

3. Waiting time in the queue $W_q = L_q / \lambda$

4. Waiting time in the system $W_s = L_s / \lambda$

5. Pro (W> 0) = $\frac{P_S}{(1-\rho)}$ where $P_S = \frac{\left(\frac{\lambda}{\mu}\right)^S P_0}{S!}$

6. Probability that there will be some one waiting = $\frac{P_S \rho}{(1-\rho)}$

Multi server model can be classified as

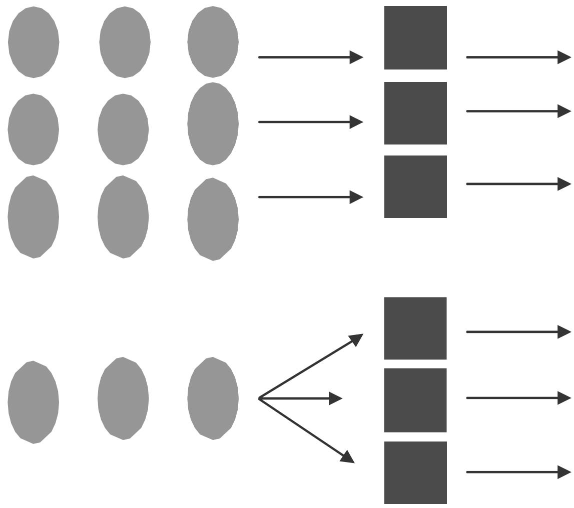


Figure 2: Single line Channel Customer queue at a bank

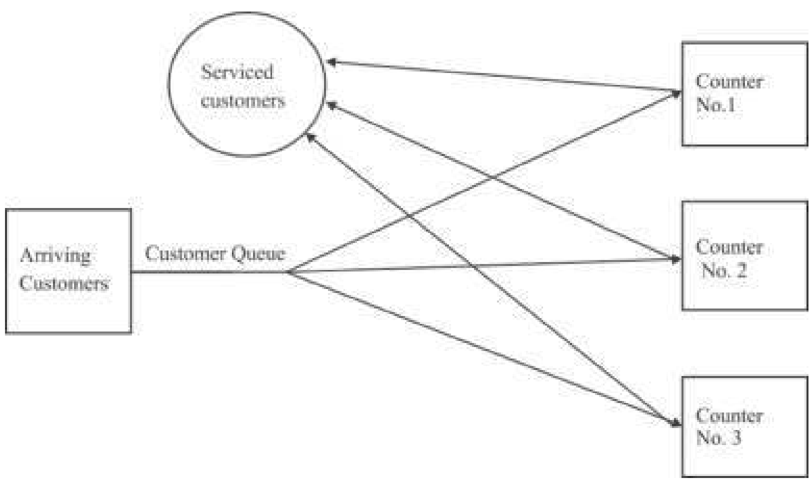


Figure 3: Multiple line Channel Customer queue at a bank

5. DATACOLLECTION

Data has been collected selecting three branches at the Bank of Ceylon. Initially at City office branch in Colombo 1 and then at Kuliyapitiya branch and finally at Bingiriya branch. City office branch is a very busy place in the entire week. There will be three counters at all the branches. Data in respect of customer arrival time and service time have been extracted from the above three branches for a period of two month during the year 2014. Two months' data were taken from all the above branches with the assistance of employees at the banks.

6. ANALYSIS

Table 1: Extracted the following figures from the three branches of the Bank.

	City office branch (A)	Kuliyapitiya branch(B)	Bingiriya branch (C)
Average Customers arrival rate (λ) per hour	50	40	21
Average Service Rate (μ) per hour	40	30	18

By using extracted data at each branch, waiting time and length have been calculated and shown in the tables 2, 3 and 4.

Table 2: Estimated at City office branch

	λ	μ	L_s (customers)	L_q (customers)	W_s (hrs)	Wq (hrs)
One line & two counters	50	40	2.05	0.80	0.041	0.016
Two lines & two counters	25	40	1.67	1.04	0.067	0.041

Table 3: Estimated at Kuliyapitiya branch

	λ	μ	L (customers)	L_q (customers)	W (hrs)	Wq (hrs)
One line & two counters	40	30	2.4	1.067	0.06	0.027
Two lines & two counters	20	30	2.0	1.33	0.1	0.067

Table 4: Estimated at Bingiriya branch

	λ	μ	L (customers)	L_q (customers)	W (hrs)	Wq (hrs)
One line & two counters	21	18	1.77	0.60	0.084	0.029
Two lines & two counters	10.5	18	1.4	0.82	0.133	0.078

6.1 Chi-squared Test for Goodness of Fit

Arrivals during the day
Ho: Number of arrivals is independent of the day. Alternative Hypothesis
Ht: Number of arrivals is not independent of the day. Under Ho, the expected frequencies are E_i

Table 5 : Calculation of Chi-squered test for goodness of Bingiriya Branch

	Monday	Tuesday	Wednesday	Thursday	Friday	Total
Total arrivals(O_i)	416	600	358	504	394	2272
Mean arrivals (E_i)	454.4	454.4	454.4	454.4	454.4	
$\frac{(O_i - E_i)^2}{E_i}$	3.245	46.653	20.451	5.414	8.028	83.792

The observed value of the test statistic $\sum_{i=1}^{n} \frac{(O_i - E_i)^2}{E_i} = 83.792$

$\chi_2^2(5\%) = 5.991$ Since 83.792 > 5.991, rejects Ho at 5% level,it can be concluded that the number of arrivals is not independent of the day of the week.

7. WHY USE THIS MODEL

1. Common queuing system is having a number of counters and a number of queues for those counters. (Many lines)
2. We have proved that having one line is more effective than having many lines and quantitative method for having a number of counters through the queue probability.
3. When using this one line system, definitely the efficiency of the queue will upgrade and it will reduce customer-waiting time at the queue.
4. When practicing this suggested queue probability method, the manager of the branch will be able to open an exact number of counters. This effort will result the manager to obtain optimum service from the other employees at the branch.

8. CONCLUSION

In every above occasion, we found that, in one line and two counters Lq, Ws, and Wq are lesser than in two lines and two counters. Hence, we recommend having one line and a number of counters instead of having seperate queues (lines) for separate counters. Application of queuing theory has assisted to prove this fact. By the example, the results are effective and practical. This strategy will reduce the waiting time of customers in the queues at the bank. This has resulted in increasing customer satisfaction towards the bank.Through this strategy the bank will be able to enhance its operational efficiency.Therefore, one can conclude that this condition will remain despite the change of arrival time and service time.

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