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Analysis of the Cash Transaction Counter of Xyz Bank Using Queuing Simulation

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Abstract:-This paper contains the analysis of Queuing systems for the empirical data of cash transaction counter of XYZ bank as an example. One of the expected gains from studying queuing systems is to review the efficiency of the models in terms of utilization and waiting length, hence increasing the number of queues so customers will not have to wait longer when servers are too busy. In other words, trying to estimate the waiting time and length of queue(s) is the aim of this research paper. This study requires an empirical data which may include the variables like, arrival time in the queue of cash transaction counter (server), departure time, service time, etc. A questionnaire is developed to collect the data for such variables and the reaction of the XYZ bank from the customers separately. This model is developed for a cash transaction counter in XYZ bank.

I. INTRODUCTION

Delays and queuing problems are most common features not only in our daily-life situations such as at a bank or postal office, at a ticketing office, in public transportation or in a traffic jam but also in more technical environments, such as in manufacturing, computer networking and telecommunications. They play an essential role for business process re-engineering purposes in administrative tasks. "Queuing models provide the analyst with a powerful tool for designing and evaluating the performance of queuing systems." Whenever customers arrive at a service facility, some of them have to wait before they receive the desired service. It means that the customer has to wait for his/her turn, may be in a line. Customers arrive at a service facility with several queues, each with one server. The customers choose a queue of a server according to some mechanism (e.g., shortest queue or shortest workload). Sometimes, insufficiencies in services also occur due to an undue wait in service may be because of new employee. Delays in service jobs beyond their due time may result in losing future business opportunities. Queuing theory is the study of waiting in all these various situations. It uses queuing models to represent the various types of queuing systems that arise in practice. The models enable finding an appropriate balance between the cost of service and the amount of waiting.

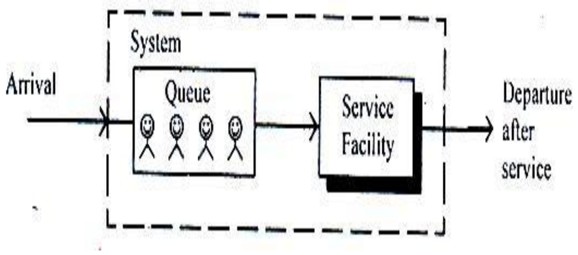
II. KEYWORDS

- Arrival Process: includes number of customers arriving, several types of customers, and one type of customers' demand, deterministic or stochastic arrival distance, and arrival intensity. The process goes from event to event, i.e. the event "customer arrives" puts the customer in a queue, and at the same time schedules the event "next customer arrives" at some time in the future.
- Waiting Process: includes length of queues, servers' discipline (First In First Out). This includes the event "start serving next customer from queue" which takes this customer from the queue into the server, and at the same time schedules the event "customer served" at some time in the future.
- Server Process: includes a type of a server, serving rate and serving time. This includes the event "customer served" which prompts the next event "start serving next customer from queue".

III. CASH TRANSACTION MODEL

The Queuing model is commonly labeled as M/M/c/K, where first M represents Markovian exponential distribution of inter-arrival times, second M represents Markovian exponential distribution of service times, c (a positive integer) represents the number of servers, and K is the specified number of customers in a queuing system.

M/M/1 queuing model



M/M/1 queuing model means that the arrival and service time are exponentially distributed (Poisson process). For the analysis of the cash transaction counter M/M/1 queuing model, the following variables will be investigated:

λ: The mean customers arrival rate

μ: The mean service rate

$\rho = \frac{\lambda}{\mu}$: utilization factor

Probability of zero customers in the bank:

$P_0 = 1 - \rho$

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The probability of having n customers in the bank:

$$P_n = P_0 \rho^n$$

The average number of customers in the bank:

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

The average number of customers in the queue:

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

W_q: The average waiting time in the queue:

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

W_s: The average time spent in the bank, including the waiting time

$$W_s = \frac{L}{\lambda} = \frac{1}{\mu-\lambda}$$

IV. EXPECTED LENGTH OF EACH QUEUE

Here, to find the expected length of each queue, we make use of Little's Theorem. Little's theorem describes the relationship between arrival rate, cycle time and work in process. This relationship has been shown to be valid for a wide class of queuing models. The theorem states that the expected number of customers (N) for a system in steady state can be determined using the following equation.

$L = \lambda T$ --- (1)

Here, λ is the average customers arrival rate and T is the average service rate for a customer.

V. OBSERVATION

We have collected the one month daily customer data by observation during banking time, as shown in Table-1. The data is graphically represented in Fig. 1

Table – 1 [Monthly Customer Counts]

	Mon	Tue	Wed	Thu	Fri	Sat
1st Week	161	142	138	131	110	169
2nd Week	141	130	129	111	98	135
3rd Week	135	129	111	120	100	150
4th Week	120	135	110	115	140	130
Total	557	536	488	477	448	584

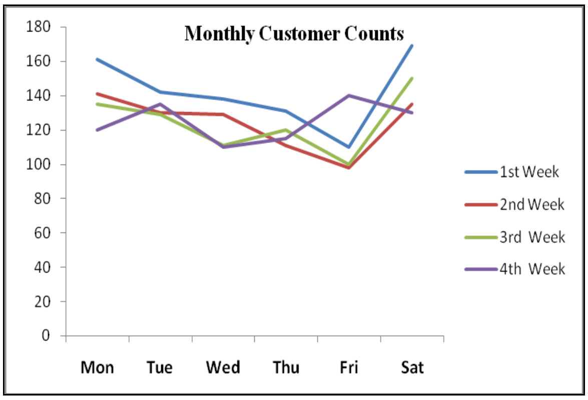

Figure 1

VI. CALCULATION

We investigate that, during first two days of a week, there are on an average 120 people coming to the counter in one hour time period of banking time. From this we can derive the arrival rate as

$\lambda = \frac{120}{60}$ =2 customers/minute (cpm)

We also found out from observation that each customer spends 2 minutes on average on the counter. The queue length is around 5 people on average and the average waiting time is around 3 minutes i.e., 180 seconds.

Theoretically, the average waiting time is

$W_q = \frac{L_q}{\lambda} = \frac{5}{2}$ = 2.5min = 150 seconds

From this calculation, we can see that, the observed actual waiting time does not differ by much when it is compared with the theoretical waiting time.

Next, we will calculate the average number of people in the bank using (1)

L = 2cpm X 2 minutes = 4 customers

We can also derive the service rate and the utilization rate:

$\mu = \frac{\lambda(1+L)}{L} = \frac{2(1+4)}{4}$ = 2.5cpm

Here, $\rho = \frac{\lambda}{\mu} = \frac{2}{2.5}$ = 0.8

This is the probability that, the server is busy to serve the customers, during banking time. So, during banking time, the probability of zero customers in the bank is $P_0 = 1 - \rho = 1 - 0.8 = 0.2$

The probability of having n customers in the bank:

$P_n = P_0 \rho^n = 0.2\,(0.8)^n$

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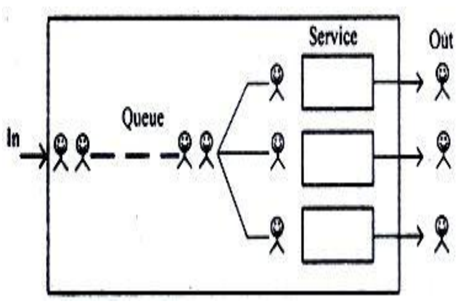
We assume that impatient customers will start to balk when they see more than 5 people are already queuing for the counter. We also assume that the maximum queue length that a patient customer can tolerate is 12 people. As the capacity of the counter is 1 person, we can calculate the probability of 6 people in the system Therefore, the probability of customers going away = P (more than 5 people in the queue) = P (more than 6 people in the bank) is

$P_{7-13} = \sum_{n=7}^{13} P_n$ =0.31131 = 31%

VII. EVALUATION

• The utilization is directly proportional with the mean number of customers. It means that the mean number of customers will increase as the utilization increases.
• The utilization rate at the counter is as high as 0.8. This, however, is only the utilization rate during banking time on Saturdays and Mondays. On weekdays, the utilization rate is almost half of it. This is because the number of customers on weekdays is only half of the number of people on Saturdays and Mondays.
• In case of the customers waiting time is lower; the number of customers that are able to be served per minute will increase. When the service rate is higher, the utilization will be lower, which makes the probability of the customers going away decreases.

➢ Now, we discuss the same for M/M/s Model:



All customers arriving in the queuing system will be served approximately equally distributed service time and being served in an order of first come first serve, whereas customer choose a queue randomly, or choose or switch to the shortest length queue. There is no limit defined for number of customers in a queue or in a system. We will discuss the case for s = 2.

λ: The mean customers arrival rate

µ: The mean service rate

$\rho = \frac{\lambda}{s\mu}$: utilization factor

Probability of zero customers in the bank:

$$P_0 = \left[\sum_{n=0}^{s-1} \frac{(s\rho)^n}{n!} + \frac{(s\rho)^s}{s!(1-\rho)}\right]^{-1}$$

The probability of having n customers in the bank:

$$P_n = P_0 \rho^n$$

The average number of customers in the bank:

$$L_s = L_q + \frac{\lambda}{\mu}$$

The average number of customers in the queue:

$$L_q = P_s \frac{\rho}{(1-\rho)^2}$$

The average waiting time in the queue:

$$W_q = \frac{L_q}{\lambda} = P_s \frac{1}{s\mu(1-\rho)^2}$$

The average time spent in the bank, including the waiting time:

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

VIII. OBSERVATION FOR M/M/2

We have collected the one month daily customer data by observation during banking time, as shown in Table-2 and 3 for the servers 1 and 2 respectively. All results are presented assuming that FIFO is the queuing discipline in all waiting lines and the behavior of queues is jockey.

Table – 2 [Monthly Customer Counts for Server 1]

	Mon	Tue	Wed	Thu	Fri	Sat
1st Week	90	80	75	65	58	95
2nd Week	85	88	72	63	60	58
3rd Week	78	70	65	62	56	80
4th Week	75	62	73	58	60	70
Total	328	300	285	248	234	303

Figure 2

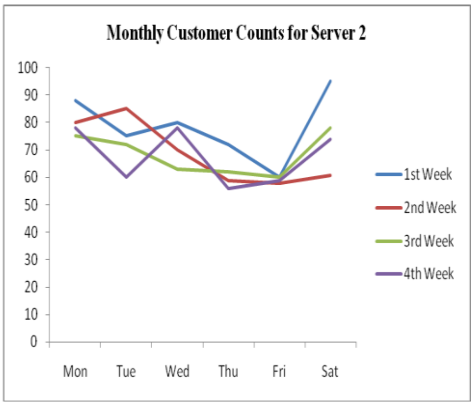


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Table – 3 [Monthly Customer Counts for Server 2]

	Mon	Tue	Wed	Thu	Fri	Sat
1st Week	88	75	80	72	60	95
2nd Week	80	85	70	59	58	61
3rd Week	75	72	63	62	60	78
4th Week	78	60	78	56	59	74
Total	321	292	291	249	237	308

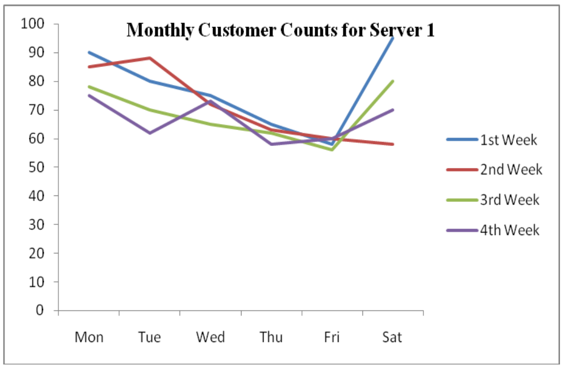

Figure 3

We investigate that, during first two days of a week, there are on an average 60 people coming to each counter in one hour time period of banking time. From this we can derive the arrival rate at each counter as

$\lambda_1 = \frac{60}{60}$ =1 customer/minute (cpm)

$\lambda_2 = \frac{60}{60}$ =1 customer/minute (cpm)

We also found out from observation that each customer spends 2 minutes on an average on the counter. Next, we will calculate the average number of people in the bank using (1) and using arrival rate at each counter:

L_1 = 1cpm X 2 minutes = 2 customers

L_2 = 1cpm X 2 minutes = 2 customers

We can also derive the service rate for each case:

$\mu_1 = \frac{\lambda_1(1+L_1)}{L_1} = \frac{1(1+2)}{2}$ = 1.5cpm

$\mu_2 = \frac{\lambda_2(1+L_2)}{L_2} = \frac{1(1+2)}{2}$ = 1.5cpm

For each counter, the waiting time is W_q = 80 sec as per M/M/1

Now, let us check the difference in waiting time, if there are 2 servers.

So, according to M/M/2,

The average waiting time is

$W_q = \frac{L_q}{\lambda} = = P_s \frac{1}{s\mu(1-\rho)^2}$ = 0.0345min = 2.07 seconds

Here, s = 2. So, the utilization rate is given by $\rho = \frac{\lambda}{s\mu} = \frac{1}{3}$ = 0.33

The probability of zero customers in the bank is P_0 =

$\left[\sum_{n=0}^{s-1} \frac{(s\rho)^n}{n!} + \frac{(s\rho)^s}{s!(1-\rho)}\right]^{-1} = 0.4328$ = 43%

IX. CONCLUSION

This research shows that the waiting time of customers decreases if there are more servers. More the number of servers less is the waiting time. As we discussed in M/M/2, if only one transaction counter works, the waiting time increases, but if both work simultaneously, the waiting time and the length of the queue decreases. This research can help bank to increase its QoS (Quality of Service), by anticipating, if there are many customers in the queue. The result of this paper work may become the reference to analyze the current system and improve the next system because the bank can now estimate the number of customers waiting in the queue and the number of customers going away each day without receiving the expected service. By estimating the number of customers coming and going in a day, the bank can set a target that, how many counters are required to serve in a way that no customers leave without receiving the expected service.

REFERENCES

[1] N. K. Tiwari & Shishir K. Shandilya, Operations Research. Third Edition, ISBN 978-81-203-2966-9. Eastern Economy Edition, 2009.

[2] K. Sanjay, Bose, "An Introduction to queuing system", Springer, 2002. [3] J. D. C. Little, "A Proof for the Queuing Formula: ", Operations Research, vol. 9(3), 1961, pp. 383-387, doi: 10.2307/167570

[3] M. Laguna and J. Marklund, Business Process Modeling, Simulation and Dsign. ISBN 0-13-091519-X. Pearson Prentice Hall, 2005.

[4] T. Altiok and B. Melamed, Simulation Modeling and Analysis with ARENA. ISBN 0-12-370523-1. Academic Press, 2007.

[5] J.D.C. Little, "A Proof for the Queuing Formula: *L=λW*", Operations Research, vol. 9(3), 1961, pp. 383-387, doi: 10.2307/167570.