A STUDY OF QUEUING CHARACTERISTICS IN BANK ATM: ASSESSMENT OF SERVICE RATE AND UTILIZATION RATE

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***Abstract*- Queuing is the typical practice of consumers or individuals to receive the requested service; this may be handled or dispersed one person at a time. Bank ATMs would not lose business because of lengthy lineups. Every branch of the bank originally has one ATM available. However, when clients try to use another bank's ATM after withdrawing money to use one, it defeats the purpose of having one ATM. Therefore, in order to keep clients, the service time must always be improved. We talk about the advantages of doing queuing analysis on a busy ATM as we wrap up the paper. This paper aims to show that queuing theory satisfies the model when tested with a real-case scenario. The authors obtained the data from an ATM in Agra, Uttar Pradesh to derive the arrival rate, service rate, utilization rate, waiting time in the queue, and the probability of potential customers balking. The collected data is analyzed by using Little's Theorem and M/M/1queuing model. The arrival rate at ATM during its busiest period of the day is 0.44 customers per minute (cpm) while the service rate is 0.64 cpm during our study period. The average number of customers in the ATM is 2.2 and the utilization period is 0.687.**

Keywords: **Bank ATM, Little's theorem, M/M/I queuing model, Queue, Waiting lines.**

INTRODUCTION

An extremely popular word A queue is a standing queue or the process of getting in one. The study of queues and waiting lines is known as queuing theory. The expected waiting time in the line, the average time spent in the system, the expected queue length, and the likelihood that the system will be in one of its states—empty or full—are some of the analyses that may be obtained using queuing theory.. This paper uses queuing theory to study the waiting lines in State Bak of India ATM, at Agra,Uttar Pradesh, India. In ATMs, bank customers arrive randomly and the service time is also random. We use Little"s theorem and M/M/I queuing model to derive the arrival rate, service rate, utilization rate, waiting time in the queue. On average, 278 customers are served on weekdays (Monday to Thursday) and 314 customers are served on weekends (Saturday & Sunday) monthly. Generally, on Sundays, there are more customers coming to ATM, during 8 am. to 8 pm.

QUEUING THEORY

The queuing theory was initially been proposed by A.K. Erlang in 1903 to work on the holding times in a telephone switch. He identified that the number of telephone conversations and telephone holding time fit into Poisson distribution and exponentially distributed. This was the beginning of the study of queuing theory. It optimizes the number of service facilities and adjusts the times of services [1]. In this section, we will discuss two common concepts in queuing theory.

A. Little's Theorem

Little's theorem [4] describes the relationship between throughput rate (i.e. arrival and service rate), cycle time, and work in process (i.e. number of customers/jobs in the system). 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 a steady state can be determined using the following equation:

$$L = \lambda T \qquad \text{……………………(1)}$$

Here, λ is the average customer arrival rate and T is the average service time for a customer. Consider the example of an ATM where the customer's arrival rate (λ) doubles but the customers still spend the same amount of time inthe ATM (T). These facts will double the number of customers in the ATM (L). By thesame logic, if the customer arrival rate (λ) remains the same but the customer's service timedoubles this will also double the total number of customers in the ATM. This indicates that inorder to control the three variables, managerial decisions are only required for any two of the three variables. Three fundamental relationships can be derived from Little's theorem [5]:

- L increases if λ or T increases.
- λ increases if L increases or T decreases.
- T increases if L increases or λ decreases.

Rust [7] said that the Little's theorem can be useful in quantifying the maximum achievable operational improvements and also to estimate the performance change when the system ismodified.

B. Queuing Models and Kendall's Notation The client and the server are the main participants in a line-up. When customers arrive at a service facility, they can either begin service right away or, if it's busy, wait in queue. When examining lines of traffic, the time it takes for a client to arrive is called the inter-arrival interval, and the amount of time it takes for a consumer to receive a service is called the service time. Customers' queuing habits influence how long it takes to analyse a line. "Human" consumers could scurry from one queue to the next in an effort to shorten wait times. Because they anticipate a lengthy wait, they can potentially refuse to join a queue at all, or they might decide to drop out because they have been waiting for too long. Most of the time, queuing models can be characterized by the following factors:

Arrival time distribution: The three distribution patterns that inter-arrival times most frequently fit into are Poisson, deterministic, and general distributions. However, the characteristic of a Poisson distribution is that inter-arrival periods are typically believed to be independent and memoryless.

Distribution of service time: This can be exponential, hyper-exponential, hypo-exponential, constant, or general. The inter-arrival time has no bearing on the service time.

Count of servers: Whether there is a single server or several servers in the queue affects the queuing calculations. There is only one server for a single server queue. This is the typical scenario in a bookstore, where each cashier has a queue. In this case, a multiple-server queue makes sense.

Optional Queue Lengths: A system's queue may be modelled as having an infinite or finite length. This also applies to the patrons that are in queue.

Queuing discipline (optional): There are a number of options for how customers are served in terms of arrival order, including random order, LIFO (last in first out), FIFO (first in first out), and SIRO (service in random order).

System capacity (optional): The maximum number of customers in a system can be from1 - infinity.

Kendall, in 1953, proposed a notation systemto represent the six characteristics discussed above. The notation of a queue is written as:

A/B/P/Q/R/Z

A describes the distribution type of the inter-arrival times, B describes the distribution typeof the service times, P describes the number of servers in the system, Q (optional) describes the maximum length of the queue, R (optional) describes the size of the systempopulation and Z (optional) describes the queuing discipline.

ATM Queuing Model

The data was obtained from the ATM through personal observations. The daily number of customers was recorded from there. We also have recorded the number of servers (ATM Machines) and service capacity of the ATM Cabin. Based on this we concluded that the best queuing model for this study is M/M/1. This means that the arrival and service times are exponentially distributed (Poisson process). This ATM service consists of one server.

For the analysis of M/M/1 queuing model, the following variables will be investigated[6]:

- λ = The mean customer's arrival rate
- μ = The mean service rate
- $\rho = \lambda/\mu$: utilization factor
- Probability of zero customers in the ATM:

$$P_0 = 1 - \rho \qquad \text{……………….[2]}$$

- Pn: The probability of having *n* customers in the ATM.

$$P_n = P_n\,\rho^n = (1-\rho)\rho^n \qquad \text{……………….[3]}$$

- L: average number of customers in the ATM.

$$L = \frac{\rho}{1-\rho} = \frac{\lambda}{\mu-\lambda} \qquad \text{……………….[4]}$$

Lq: average number in the queue.

$$L_q = L \times \rho = \frac{\rho^2}{1-\rho} = \frac{\rho\lambda}{\mu-\lambda} \qquad \text{……………….[5]}$$

W: average time spent in Queue, including the waiting time.

$$W = \frac{L}{\lambda} = \frac{1}{\mu-\lambda} \qquad \text{..................[6]}$$

Wq : average waiting time in the queue.

$$W_q = \frac{L_q}{\lambda} = \frac{\rho}{\mu-\lambda} \qquad \text{..................[7]}$$

OBSERVATION AND DISCUSSION

We have collected the one-month data by observation during the Banking time. The collected data has been shown in Table-1. The data has been graphically represented in fig-1 also.

Table-1(one-month data by observation during the Banking time)

	Mon	Tue	Wed	Thu	Fri	Sat	Sun
1st week	314	249	301	347	289	303	358
2nd week	285	297	309	349	234	293	374
3rd week	201	200	288	299	291	201	321
4th week	209	203	296	315	288	285	383

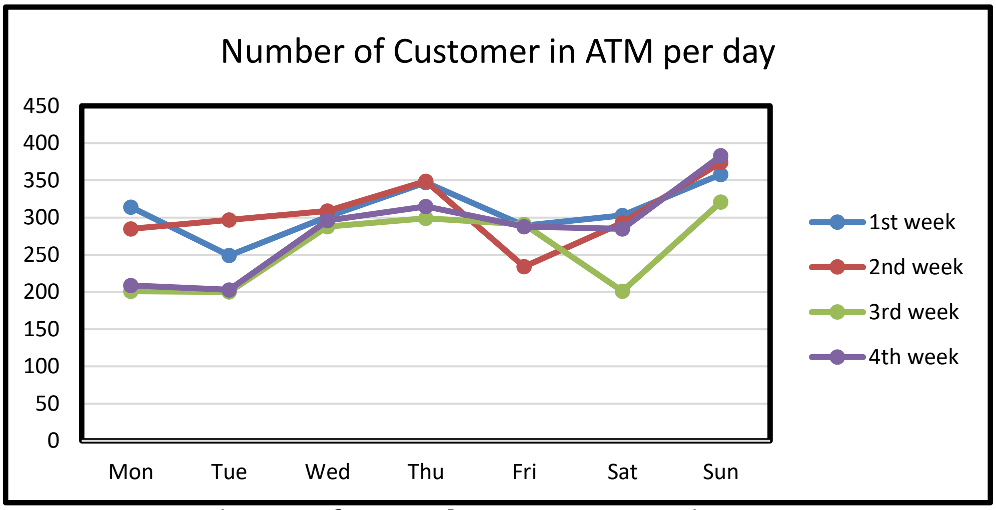

Figure-1- four-week Customer count in ATM

From the above figure –1, we observe that the number of customers on Sundays is double the number of customers on Saturdays during a month. The busiest period for the bank ATM is Sundays and Mondays during banking time (8 am. to 8 pm.). Hence, the time period is very important for the research

CALCULATION

From our observation on Monday there were on average 78 customers arrived in three hours to join the queue for waiting to get service. From this, we can derive the arrival rate as:

λ = 78/180 = 0.44 customers per minute(cpm)

We also found out from the observation that each customer spends 5 minutes on average in the ATM machine (W), the queue length is around 9 people (L_q) on average and the waiting time is around 14 minutes.

It can be shown using [7] that the observed actual waiting time does not differ by much when compared to the theoretical waiting time as shown below.

$$W_q = \frac{9\ customers}{0.44\ cpm} = 20.45\ minutes$$

Next, we will calculate the average number of customers in ATM using [1]

L= 0.44 cpm x 5 mins = 2.2 customers

Utilization rate

$$\mu = \frac{\lambda(1+L)}{L} = \frac{0.44(1+2.2)}{2.2} = 0.64\ cpm$$

$$\rho = \frac{\lambda}{\mu} = \frac{0.44\ cpm}{0.64\ cpm} = 0.6875$$

With the relatively high utilization rate, the probability of zero customers in the ATM is as follows:

$$P_0 = 1 - \rho = 0.313$$

The formula that can be used to calculate the probability of having *n* customers in the ATM is as follows:

$$P_n = (1 - \rho)\rho^n = 0.313(0.687)\hat{}n$$

We assume that potential customers will start to balking when they see more than 5 people are already in the queue. We also assume that the maximum queue length that a potential customer can tolerate is 15 people. As the capacity of the ATM is 1 person. we can calculate the probability of 5 or more than 5 people in the queue:

Probability of customers going away = P (more than 5 people in the queue)

$$P_{5-15} = \sum_{5}^{15} P_n = 0.1516 = 15.16\% \sim 15\%$$

EVALUATION: -

- As the utilization is directly proportional to the mean number of customers. Hence It means that the mean number of customers will increase if utilization increases.
- The utilization rate at the ATM is relatively high at 0.687. Hence it is only the utilization rate during weekends Saturdays, and Sundays due to bank holidays. On weekdays, the utilization rate could be nearly half of it. This is because the number of peoples on weekdays is only half of the number of peoples on weekends, especially Sundays.

BENEFITS OF THE STUDY:

This research can help Banks to increase their Qos (Quality Of Service), by anticipating if there are many customers in the queue.

The result of this study may become the reference to analyse the current system and improve the next system. Because the bank can now estimate of how many customers will wait in the queue and the number of customers that will go away each day.

By estimating the number of customers coming and going in a day, the bank can set a target that, how many ATMs are required to serve people in the main branch or any other branch of the bank.

CONCLUSION

This research paper has discussed the application of queuing theory to the Bank ATM. From the result we have obtained that, the rate at which customers arrive in the queuing system is 0.44 customer per minute and the service rate is 0.64 customers per minute. The probability of buffer flow if there are 5 or more customers in the queue is 15 out of 100 customers. The probability of buffer overflow is the probability that customers will run away because maybe they are impatient to wait in the queue. This theory is also applicable for the bank, if they want to calculate all the data daily and this can be applied to all branch ATMs also. The constraints that were faced for the completion of this research were the inaccuracy of result since some of the data that was in this research just based on assumption or approximation.

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