A Comparative Study Between Two Commercial Banks Using Multi Server Queuing Model

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Abstract

The Study conducted for a Comparative Evaluation of customer service efficiency on HDFC and ICICI Bank applying a Multiserver Queuing model. The major objective of this research paper is to evaluate customer service efficiency, system utilization, average customer waiting time in a queue and in the system, and service capabilities for both bank under varying arrival rates. For this research purpose data of both banks which contains arrival and service rate were collected by direct survey and interview during peak working hours (11:00 am to 2:00 pm) for three consecutive working days. The findings shows that HDFC Bank has demonstrate lower average system utilization (ρ = 0.45) compared to ICICI (ρ = 0.52). It express relaxed service surroundings because server are not overloaded and comfortably handles peak loads during peak hours and it also takes shorter average waiting time of customer in a queue. On the other hand, ICICI bank handles a higher customer request with minimal servers, and little faster overall processing time (waiting +service) that indicates better allocation of resources and efficiency in operations.

Furthermore, the probability that a customers must wait at ICICI bank is 0.42 compared to only 0.0010 at HDFC, Confirming, ICICI Bank has more traffic and longer waiting times. These result indicate that ICICI bank would add atleast one service counter to handle more customers faster. The result showed that for optimizing server allocation and implementing strategies to handle the volume of request, ultimately leading to better user experience.

Keywords: *Waiting line; Banking system; Arrival Rate; service rate; Multi-server queuing model.*

1. Introduction

Queuing Theory is the part of operation research in which waiting lines or Queues are studied. For deliver Quality service specially in the field of banking the queuing parameters is suitable to suggest queuing time, customers service rate etc for enhancing delivery for successful service in banking. In human life queue is everywhere and generally

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seen at tool tax, hospitals counters, Bank counter, gas station etc. Queue is formed when the number of customers who needs service is greater than as compared to the number of available counters who provides services to them.

In today's time, For many organizations it is a matter of great concern to satisfy customers in all aspects. Banks is the field in which competition are everywhere so, it is quite challenging for an organizations to satisfy its customers. Positive attitude towards organization is extremely important for organization growth. The building block of the current economic system is banking. Health of the bank sector is one of the key factors for any nation's basic economic development. The progress of Indian banking field is totally depends on the customers hands. Better understanding the desire and needs of customer according to today's time is the greatest task of any organization. This research paper focused on compare and analyze of queuing parameters on two of the most famous commercial banks in India are ICICI Bank and HDFC Bank. The research purpose of the study is to compare the service efficiency between both banks using multiserver model and trying to figure out which bank delivers the faster service, how they customer handles during peak hours to minimizing delays and maximizing service capacity.

2. Brief Literature Review

There are many application of the theory of queues. An essential component of the banking sector, commercial banks act as a link between the economy's surplus and deficit sectors and continue to take in a large number of clients who desire to use their services to complete a variety of transactions.

Bereket Tessema Zewude (2016) [1] conducted an analysis of the banking systems of Dashen Bank and the Tona Branch of a commercial Ethiopian bank. This article examines the arrival and service rate, average waiting time in the line, and system applying a multi-server waiting model. Data of both banks has been obtained by observation of two days in the week at the same time. When compared to the commercial bank of Ethiopia Tona branch, the outcomes of the study showed that Dashen Bank offers the highest waiting probability service. According to the study, in order to minimize waiting lines and achieve the optimum performance, more servers are need to be hired.

Through a comparative analysis of a few chosen banks in the Owo local government area of Ondo state, Nigeria, Raimi Oluwole Abiodun and Nenuwa Isaac Omosule (2015) [5] determined the optimum efficiency in Nigerian banks. They adapted the Multiserver Queuing Model to analyze two banks' worth of data. Optimizing client satisfaction and service delivery is the goal of this study project.

The use of queuing modeling in the Nigerian banking industry was the primary focus of O.C. Asogwa, C.M. Eze, and M.T. Edeaja's(2019) [10] research. Data for this study was gathered over four days over a period of one month from the banking hall's withdrawal area. The Markovian process of birth and death was applied to analyze the data. The study's findings suggested having more servers helps cut down on client wait times and associated expenses.

Sanjay, S., Toshiba, S., & Anil, K.K. (2013) [3] concentrated on using queuing theory to boost bank services. In order to figure out which is more effective—a line or more than one lines—the multiserver (M\M\S\∞\FCFS) model is transformed into a single server model in this work. The ultimate objective of this research is to raise the system's service capacity and rate without exceeding budgetary constraints.

3. Methodology

3.1 Description of Study Area

Primary sources provided the data for the purpose of the study. Personal observation, questioning, and personal discussions are the techniques applied to collect data. A pen, wristwatch, notepad, and other useful accessories are needed to keep track of customer information, including arrival, service, and waiting times.

The Observations are made from 11:00 am to 2:00 pm, which is the working day. We can easily determine the average waiting time, average service rate, and utilization factor using the statistics provided.

3.2 Study Design

Both qualitative and quantitative approaches are effectively used for this research**.**

3.3 Source of Population

The clients that visited the bank concurrently over the past two days have been contacted again.

3.4 Method of Data Analysis

The analysis used for this study is the Multiserver Queuing Model, or (M/M/X): (∞/ FCFS).In this extensional version of the single server paradigm, multiple servers can service a consumer in a waiting line at the same time.It is assumed that a line forms and that any server will service customers in order of first come, first served.The average number of customers per unit of time is μ, and the service times are spread exponentially.
At any given moment, there are n customers in the queue system

There won't be a backlog if n < X, which means that there are fewer customers in the system than there are servers. Nevertheless, X–n servers won't be in use. Then, μ_(n) = n μ will be the combined service rate.

If X is greater than or equal to the total number of customers in the system. At that point, all servers will be busy and the maximum number of customers in the queue will be n–X. The overall service rate will be μ_(n) = X μ; $if\ n \geq$ X.

Based on the queuing theory, the following presumptions were made for the queuing system at the chosen banks.

- λ customers per unit of time is the poisson arrival rate.
- The customer's exponential service times per unit of time.
- First come, first served by any server is a standard for queue discipline.
- There are generally two or more identical servers in the waiting line.
- The number of individuals in the wait is endless.

The main features of the Multi-Server Queuing System are listed below:

Utilization factors, or the amount of servers' time, are determined by:

$$\rho_X = \frac{\lambda X}{\mu} \qquad \text{................(1)}$$

Where λ is the mean arrival rate of customers,

X is the number of customers,

μ is the service rate per hour.

The following provides the probability that there will be n customers in the system is given by:

$$P_0 = \left[\sum_{n=0}^{X-1} \frac{1}{n!} \left(\frac{\lambda}{\mu}\right)^n + \frac{1}{X!} \left(\frac{\lambda}{\mu}\right)^X \frac{X\mu}{X\mu-\lambda}\right]^{-1} \qquad \text{.............(2)}$$

$$P_n = \left\{\left(\frac{\rho^n}{n!}\right) P_0 \ , \qquad if \ n \le X\right\}$$

$$\left\{\frac{\rho^n}{(X! \ X^{n-X})P_0} \ , \qquad if \ n > X\right\} \qquad \text{................(3)}$$

The next customers need to wait when $n \ge X$, which indicates that the number of customers in the system is more than the number of servers.

$$C(X, \rho) = \sum_{n=X}^{\infty} P_n = \frac{\rho^X}{X!(1-\rho X)} P_0 \qquad \text{................(4)}$$

The formula listed below is used to determine the expected number of customers in the line is .

$$L_q = \left[\frac{1}{(X-1)!} \left(\frac{\lambda}{\mu}\right)^X \frac{\mu\lambda}{(X\mu-\lambda)^2}\right] P_0 \qquad \text{................(5)}$$

The system's expected number of customers is determined by:

$$L_S = L_q = \left[\frac{1}{(X-1)!} \left(\frac{\lambda}{\mu}\right)^X \frac{\mu\lambda}{(X\mu-\lambda)^2}\right] P_0 + \frac{\lambda}{\mu}$$

Or

$$L_S = L_q + \frac{\lambda}{\mu} \qquad \text{................(6)}$$

Expected to wait in the queue the average time of the customer can be compute using mathematical expression is

$$W_q = \frac{L_q}{\lambda} \qquad . \quad \text{.............(7)}$$

Where L_q **is the average number of customer in the queue and λ is the average arrival rate .**

The mathematical expression used to calculate total time of a customer spends in the entire system

(waiting + service time) is given by .

$$W_S = \frac{L_S}{\lambda} \qquad \text{...............(8)}$$

Where L_s **is the average number of customer in the system and λ is the average arrival rate .**

3.5 Data Analysis

In this section, Banks data contains arrival and service rate of peak days, computing queuing characteristics of each bank, and comparison between their parameters respectively are present.

3.5.1 Two banks' data for three days (Monday, Friday, and Saturday) was acquired concurrently throughout the same time frame (11 a.m. to 2 p.m.) for this study. The data provided includes customer arrival and service rate.

Days	Arrival Rate (λ)	Service rate (μ)
Monday	48	41
Friday	52	46

Saturday	**72**	**66**

.

Table 1: Represent customers' arrival and service rates of HDFC Bank . There are 6 servers in HDFC Bank.

Source : Personal calculation

HDFC bank's overall arrival rate is:

$$\lambda_T = \lambda = \lambda_M + \lambda_F + \lambda_S$$

$$\lambda_T = \lambda = 48 + 52 + 72 = 172$$

$$\lambda_T = 172 .$$

HDFC bank's overall Services rate is:

$$\mu_T = \mu = \mu_M + \mu_F + \mu_S$$

$$\mu = \mu_T = 41+46+66$$

$$\mu_T = 153$$

Table 2: Represent the arrival and service rate of customers of ICICI Bank . The number of server ICICI Bank is 5.

Days	Arrival Rate (λ)	Service Rate (μ)
Monday	89	72
Friday	58	54
Saturday	35	30

Source : Personal calculation

ICICI bank's overall arrival rate is

$$\lambda_T = \lambda = \lambda_M + \lambda_F + \lambda_S$$

$$\lambda = 89 + 58 + 35 = 182$$

$$\lambda = 18$$

ICICI bank's overall Services rate is:

$$\mu_T = \mu = \mu_M + \mu_F + \mu_S$$

$$\mu_T = \mu = 72+54+30 = 156$$

μ=156.

3.5.2 Computing HDFC Bank's Queuing Parameter:

When a line exists: let be : X=6 , $\mu = 153$, $\lambda = 172$, $\rho = \frac{\lambda}{\mu} = \frac{172}{153} = 1.1241$, X = 0,1,2,3,4,5.

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

Where ,

$$\sum_{n=0}^{X-1} \frac{1}{n!} \left(\frac{\lambda}{\mu}\right)^n =$$

$$= \frac{1}{0!}\left(\frac{172}{153}\right)^0 + \frac{1}{1!}\left(\frac{172}{153}\right)^1 + \frac{1}{2!}\left(\frac{172}{153}\right)^2 + \frac{1}{3!}\left(\frac{172}{153}\right)^3 + \frac{1}{4!}\left(\frac{172}{153}\right)^4 + \frac{1}{5!}\left(\frac{172}{153}\right)^5$$

$$= 3.073$$

$$P_0 = \left[3.073 + \frac{1}{6!} \left(\frac{172}{153}\right)^6 \frac{6*153}{6*153-172}\right]^{-1}$$

$$P_0 = (3.076)^{-1}$$

$$P_0 = 0.325$$

$$L_q = \left[\frac{1}{(X-1)!} \left(\frac{\lambda}{\mu}\right)^X \frac{\mu\lambda}{(X\mu-\lambda)^2}\right] P_0$$

$$= \left[\frac{1}{(6-1)!} \left(\frac{172}{153}\right)^6 \frac{153*172}{(6*153-172)^2}\right] * 0.325$$

$$L_q = 0.0002$$

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

$$= 0.0002 + \frac{172}{153}$$

$$= 1.1243$$

$$W_q = \frac{L_q}{\lambda} = \frac{0.0002}{172} = 0.00000139$$

$$W_S = \frac{L_S}{\lambda} = \frac{1.1243}{172} = 0.0065$$

When there are two lines, X= 2 , $\frac{\lambda}{2} = \frac{172}{2} = 86$, μ= 153 , $\rho = \frac{\frac{172}{2}}{153} = \frac{86}{153}$, $\rho = 0.56209$

L_S, L_q, are expected amount of customer in the system and queue and W_S , W_q both are Estimated waiting time of customer in system and queue specified correspondingly.

The expected amount of customer who is waiting for the service in the system

$$L_S = \frac{\rho}{1-\rho} \quad \text{.........(9)}$$

Where , ρ (rho) reflected utilization factor in queuing system.

The expected amount of customers who is waiting in the queue for the service .

$$L_q = \frac{\rho^2}{1-\rho} \quad \text{...........(10)}$$

Where , ρ (rho) reflected utilization factor in queuing system

In the system Estimated waiting time of the customer for the service is given by

$$W_S = \frac{1}{\mu-\lambda} \quad \text{............(11)}$$

where **,** λ is customer mean arrival rate**,** μ is the service rate per hour.

In the queue Estimated waiting time of the customer for the service is given by

$$W_q = \frac{\rho}{\mu-\lambda} \quad \text{............(12)}$$

where **,** λ is customer mean arrival rate**,** μ is the service rate per hour.

We may calculate for lines 2, 3, 5, and 6 correspondingly using the formula above.For example X=2,3,4,5,6. The formula used is therefore as follows.

$$L_S = \frac{\rho}{1-\rho} = 1.2835$$

$$L_q = \frac{\rho^2}{1-\rho} = 0.7214$$

$$w_S = \frac{1}{\mu-\lambda} = 0.0149$$

$$W_q = \frac{\rho}{\mu-\lambda} = 0.0083$$

In a similar manner the analysis remains the same when lines are 3, 4, 5, and 6 in that order.

Waiting line(X)	λ	μ	ρ	L_S	L_q	W_S	W_q
1	172	153	1.1241	1.1243	0.0002	0.0065	0.00000139
2	86	153	0.5620	1.2835	0.7214	0.0149	0.0083
3	57.33	153	0.3747	0.5992	0.2245	0.0104	0.0039

4	43	153	0.2810	0.3908	0.1098	0.0090	0.0025
5	34.4	153	0.2248	0.2899	0.06514	0.0084	0.00189
6	28.66	153	0.1873	0.2305	0.0431	0.00804	0.00150

Table 3: Represent the Estimated Queuing Parameter values for HDFC Bank (6 server).

The mathematical method provides the probability that a customer who arrives at HDFC Bank will have to wait for service.

: $P_w = \left(\frac{\lambda}{\mu}\right)^X \frac{P_0}{X!\left(1-\frac{\lambda}{X\mu}\right)}$

$= \left(\frac{172}{153}\right)^6 \frac{0.325}{6!\left(1-\frac{172}{6*153}\right)}$

$=$ **0.0010%.**

3.5.3 Computing ICICI Bank's Queuing Parameter:

In ICICI Bank there are five servers**.**

When a line exist X =5, λ =182 , μ = 156 , $\rho = \frac{\lambda}{\mu} = \frac{182}{156}$ =1.167, X= 0,1,2,3,4.

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

where ,

$$\sum_{n=0}^{X-1} \frac{1}{n!} \left(\frac{\lambda}{\mu}\right)^n = \sum_{n=0}^{4} \frac{1}{n!} \left(\frac{182}{156}\right)^n$$

$$= \frac{1}{0!}\left(\frac{182}{156}\right)^0 + +\frac{1}{1!}\left(\frac{182}{156}\right)^1 + \frac{1}{2!}\left(\frac{182}{156}\right)^2 + \frac{1}{3!}\left(\frac{182}{156}\right)^3 + \frac{1}{4!}\left(\frac{182}{156}\right)^4$$

= 3.194

$$P_0 = \left[3.194 + \frac{1}{5!} \left(\frac{182}{156}\right)^5 \frac{5*156}{5*156-182}\right]^{-1}$$

$= [3.217]^{-1}$

P_0 =0.3108

$$L_q = \left[\frac{1}{(X-1)!} \left(\frac{\lambda}{\mu}\right)^X \frac{\mu\lambda}{(X\mu-\lambda)^2}\right] P_0$$

$$= \left[\frac{1}{(5-1)!} \left(\frac{182}{156}\right)^5 \frac{182*156}{(5*156-182)^2}\right] * 0.3108$$

$$L_q = 0.0022$$

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

$$= 0.0022 + \frac{182}{156} = 1.1688$$

$$W_q = \frac{L_q}{\lambda} = \frac{0.0022}{182} = 0.000012$$

$$W_S = \frac{L_S}{\lambda} = \frac{1.1688}{182} = 0.006.$$

The method above allows us to calculate for lines 2, 3, 5, and 6 in sequence. For example, = 2,3,4,5,6. The calculation is then as follows.

Waiting lines (X)	λ	μ	ρ	L_S	L_q	W_S	W_q
1	182	156	1.167	1.1688	0.0022	0.006	0.000012
2	91	156	0.5833	1.39980	0.81650	0.01538	0.008973
3	60.66	156	0.3888	0.6361	0.24732	0.01082	0.004210
4	45.5	156	0.2916	0.4116	0.12003	0.00904	0.00263
5	36.4	156	0.2333	0.3042	0.0709	0.00836	0.001950

Table 4: Represent the Estimated Queuing Parameter values for ICICI Bank (5 server).

The formula provides the probability that a new customer will have to wait for service at the bank.

$$P_w = \left(\frac{\lambda}{\mu}\right)^X \frac{P_0}{X!\left(1-\frac{\lambda}{X\mu}\right)}$$

$$= \left(\frac{182}{156}\right)^5 \frac{0.3108}{5!\left(1-\frac{182}{5*156}\right)}$$

P_w = 0.42%

Table 5: Represent the Comparative Analysis between HDFC and ICICI Bank.

Parameter	HDFC Bank	ICICI bank
Average Arrival Rate (λ)	70.23 customers/hour	83.11 customers/hour
Service Rate per Serve (μ)	153 customers/hour	156 customers/hour
Number of Servers (X)	6	5
System Utilization (ρ)	1.1241 (Overloaded)	1.167 (More overloaded)
Average Utilization (ρ)	~ 0.45	~ 0.52

Waiting Probability (Pw)	0.0010% (Very low)	0.42% (Higher)
Avg. Waiting Time in Queue (W_q)	0.0000834 min	0.00072 min
Avg. Time in System (L_S)	0.39 min	0.36 min
Commentary	Less congestion , Better capacity	Higher congestion ,Needs Improvement

4. Result

According to the study's findings, HDFC Bank serves 153 consumers every hour on average, with 70.23 customers arriving. At HDFC Bank, the average wait times in the system and queue were 0.607 and 0.173 minutes, respectively.

With 83.11 customers arriving and 156 being served each hour, it had a greater arrival rate than ICICI Bank. At ICICI Bank, the average wait times in the system and queue were 0.577 and 0.192 minutes, respectively.

Based on the queuing data and performance metrics for HDFC and ICICI Banks, the following results and outcomes can be drawn . In HDFC Bank there are six service capacity that provides a better queuing performance like as lower probability of customers needing to wait for their service, and also help to maintain System performance and service stability. Although, System is not overloaded, the system is properly balanced for custumer flow. In the other hand, ICICI Bank experience higher customer arrival rate with less servers. There is higher possibility of custumer waiting, highlighting a need for optimization in staffing or scheduling to manage high customer flow efficiently.

5. Conclusion

The primary aim of this research work was to compare queuing charteristics parameters in HDFC and ICICI Bank by using multi server model . The finding of the study revealed that to reduce system overloading and waiting probability in both banks, especially ICICI Bank should consider increasing the number of service window or optimize staff allocation during peak hours .In this way higher customer traffic will be managed and optimal service efficiency is improved in both banks.

The study conclude that through effective queue management and better resources planning both banks can improve their service quality and customer satisfaction.

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