Cost Analysis for Number of Servers in a Bank using Simulation Method

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Abstract

In Banking industry we saw queue and different number of servers. The complexity in installing the correct number of servers is not a simple task as it contains the needs the study of social, economical and especially the psychological nature associated with queue. In this paper study of all the parameters involved using survey is done and based upon the survey report, manual simulation as well as system simulation process is performed, from the obtained result various types of cost associated and overall profit associated with different number of servers is obtained thereby the required number of servers has been suggested.

Keywords - *Service Cost, Waiting Time Cost , Queuing Model, Number of Servers, Utilization Factor.*

I. INTRODUCTION

In today's throat cut competition for all banking industry, there is always a chase to join more and more customers to attain the sole aim of generating maximum profit and providing the best available service to the customers. Thus it became a difficult task for the manager who governs the operation of the bank to provide the best service considering the ultimate aim of obtaining maximum profit. But for providing such service the cost and the revenue associated with facility providing service have to be analyzed and the optimum profit condition have to be applied. There are mainly two type of costs associated with the service providing activities they are:

A. Service Cost

Service Cost is defined as all the cost associated with service providing activities. As we know that providing service is not free of cost. These costs are directly related with the facility provided to the customers arrived for getting a service. It is a Tangible Cost incurred for the service provider, they are the combination of both fixed as well as variable cost for any service provider, some of them are:

a) Salary of the employee
b) Rent of the office
c) Electricity bill
d) Stationary items required
e) Telephone / Internet connection bill. etc.

B. Waiting Time Cost

Waiting Time Cost consists of all the cost which incurred to the bank caused by the dissatisfaction of the customer's due to wastage of their valuable time as standing in queue for getting the service. Most of the Waiting Time costs are Intangible in nature. The long waiting time of the customer to be served by the bank results to loss of customers for the bank and reduces the revenue of the bank. Such cost associated which can be converted to revenue if sufficient resources are available to the service provider is termed as opportunity cost. It can also be defined as the loss incurred or profit which can be made if there are sufficient resources available to them at the required time. It is an Intangible loss of the Bank Queuing Model. Also it became necessary to reduce this type of cost because it increases continuously and thus causing a huge loss to the bank.

The person who is responsible for the management of all the activities in a bank has to analyze these two type of cost, as both of them are inverse in nature, on reducing one type of the above mentioned two costs the other cost increases and vice versa.

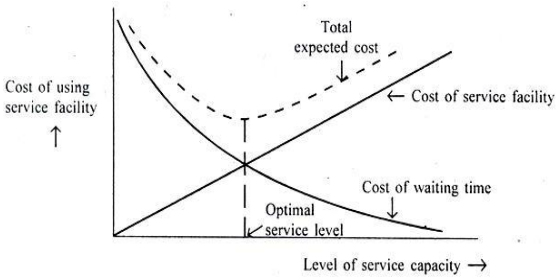

Fig:1- Types of Costs in Queuing Theory

Form the above figure we can clearly observe that Service Cost and Waiting Time Cost are inverse in nature with respect to each other i.e. increase of one results in decrease of other and vice versa.

Total Cost = Service Cost + Waiting Time Cost

The dotted line in above Figure-1 represent the total cost associated with the service providing operations, which initially decreases with increase in service level i.e. Number of Service Station and after a certain point it again starts increases. This point is

called the optimum point and all the managers aims to operate and maintain successfully at this optimum level i.e. Minimum Cost Point. But attaining this point is not an easy task, it requires keen observation and correct decision making capability. There are many methods involved to observe the banking system, some of them associated with analyzing the conditions without contacting the customers, and some of them requires interaction with the customers. Out of the above two available methods the method of interacting with the customers is considered as the best either in the form of Questionnaire, some surveys and many other method because by doing so you can directly know the problem associated and sometimes survey itself gives solution for a major problem. Also by interacting with customers many of the unrevealed issues can be highlighted easily.

Survey

Survey is a method of direct interaction with public or the subject of concern. In survey method, opinions of the associated system are asked the problem with the current system, not only problems are asked but the things which are liked are also been asked alongwith the suggestions to further improve service or product level. Sometime a general survey is also been asked to know the reason behind the dissatisfaction and questions are being asked for a situation when such condition of dissatisfaction will be removed to know their response and taking the required operation. Our method is based upon the above mentioned technique for optimization of Profit by exploring the opinions and thoughts of the customers.

Simulation

Simulation is a limited version of the real life, in simulation modeling, all the parameters and nature of the system are inserted and accordingly different conditions are tested. Simulation is very useful for conditions where cost associated with real operation is high, and also conditions like bank service where wrong experiment leads to greater dissatisfaction of the customers. Hence for such critical conditions all the different parameters involved are tested to obtain the optimum, value. Simulation has a great advantage that due to inserted extreme condition of operating parameters, it shows the condition which leads to failure. With the consideration of these extreme conditions, the optimum value is calculated and maximum profit will be obtained.

For simulation purpose different tools are available like manual simulation model, Excel Spreadsheet and many different simulation software are used. We are using manual simulation model for our analysis and it is validated with the Excel spreadsheet

II. LITERATURE REVIEW

Mohammad Shyfur Rahman Chowdhury et. al (2013) analyzed different common queuing situations and developed mathematical models for analyzing waiting lines with certain assumptions. Those assumptions are that (A) Arrivals are from an infinite source or a very large population, (B) Arrivals are following Poisson's distribution, (C) Arrivals are considered on a FCFS basis and there is a condition of not to consider balking or reneging, (D) Service times follows the negative exponential distribution and (E) The mean service rate is always greater than the average arrival rate [1]. Toshiba Sheikh et al. (2013) focuses on the M/M/Z/∞: FCFS model is converted into M/M/1/∞:FCFS to know which one of the above mentioned two is more efficient, a line or more lines [2]. Donald Hammond et. al (1995) In this paper an attempt was made to arrive bank teller management policies for providing quality service levels at optimal cost [3]. Dr. Prashant Makwana and Gopalkrushna Patel studied the nature of arrival rate and service rate of customers in a restaurant and thereby studied the queue length, waiting time and utilization factor of the restaurant [4]. Dr. Ahmed and S. A. AL-Jumaily et. al (2007) studied the nature of queue and build the automatic queuing system which automatically switches between the various algorithms available for queuing system as per the requirement based upon service rate and arrival rate [5]. M. E. El-Naggar et.al (2010) published the research paper titled "Application of queuing theory to the container terminal at Alexandria Seaport". In this paper author studied the queuing on container terminal at seaport and thereby calculated the required number of containers for proper functioning of the system[6]. Kembe, M. M, Onah, E. S, Iorkegh and S et.al (2012) published a journal paper titled " A Study of Waiting and Service Costs of a Multi-Server Queuing Model In a Specialist Hospital", in this paper author studied the cost associated with waiting time and service provided to the patients in the hospital[7]. S. Barak and M. S. Fallahnezhad et.al (2012) published a journal paper titled "Cost Analysis of Fuzzy Queuing Systems", in this paper author studied and determined the various costs associated with the two queuing models of M/M/1 and M/E2/1 using fuzzy queuing analysis[8].

III. PROBLEM IDENTIFICATION

When it is required to the calculation of number of servers required for successful operation of banking service, many problems encountered like calculation of opportunity cost and cost of adding new servers, also if calculation is done then feasibility study of the number of servers required for optimum profit is a difficult task. Also the problem arises when the arrival pattern and service pattern do not follow the theoretical model of distribution, in such cases data is needed to be collected and base

upon that the study of associated bank queuing system has to be studied.

IV. METHODOLOGY

The method of studying, analyzing and deciding the number of servers required for successful operation of banking to attain the maximum profit consists of a number of sequential steps, one followed by the other. The steps for the method of opportunity cost and the revenue consists of a number of steps mentioned below:

1.) Collection of practical data from the concerned bank for study.
2.) Calculation of all the parameters involved in the banking system.
3.) Survey for collecting opinion of the entire person who is or can be a customer of the bank.
4.) Generation of survey report.
5.) Calculating new values of parameters of banking queue theory based upon the survey report.
6.) Construction of new model as per the new value of parameters obtained from survey method.
7.) Calculation of various cost and profit associated with the different number of servers and selecting the best out of it.
8.) Validation of obtained from the programme made in Excel Spreadsheet.

Step-1.) Collection of data from bank about arrivals pattern of customers and the service time required by service provider to serve different customers and the system by which scheduling process is done in that bank. The bank of our concern consists of a single server (counter) for customers and the bank adopts First in First out (FIFO) scheduling for serving the customers. Large number of data was taken to precisely study the nature of queue in bank, some part of data collected was shown below as sample of data collected in Table 1.

Table-1: Collected Data

A	B	C	D	E	F	G	H	I	J
1.		0	00:00	0		00:00	00:02	2	0
2.		2	00:02	0		00:02	00:04	2	0
3.		2	00:04	0		00:04	00:06	2	0
4.		1	00:05	1		00:06	00:08	2	3
5.		0	00:05	3		00:08	00:09	1	2
6.		0	00:05	4		00:09	00:11	2	1
7.		5	00:10	1		00:11	00:17	6	1
8.		4	00:14	3		00:17	00:20	3	1
9.		6	00:20	0		00:20	00:22	2	0
10.		2	00:22	0		00:22	00:25	3	0
11.		5	00:27	0		00:27	00:29	2	0
12.		2	00:29	0		00:29	00:32	3	0
13.		4	00:33	0		00:33	00:42	9	6
14.		1	00:34	8		00:42	00:44	2	5
15.		0	00:34	10		00:44	00:46	2	4
16.		2	00:36	10		00:46	00:47	1	4
17.		4	00:40	7		00:47	00:50	3	3
18.		0	00:40	10		00:50	00:53	3	4
19.		0	00:40	13		00:53	00:54	1	3
20.		6	00:46	8		00:54	00:57	3	2

NOTATIONS USED IN TABLE 1,5,6&7

A. Customer Number
B. Random Number For Arrivals
C. Time Gap Between Arrivals
D. Clock Reading
E. Waiting Time
F. Random Number for Service Time
G. Service Start Time
H. Service End Time
I. Service Time
J. Queue Length

Step-2.) Calculation of all the parameters involved in the banking system. All the required parameters can be either calculated by using the theoretical formulas as per the Queuing Theory or directly by calculated data. From the above data,
Arrival Rate (λ) = 0.271 customers/minute.
Service Rate (μ) = 0.3623 customers/minute.

Step-3.) Survey for collecting opinion of the entire person who is or can be a customer of the bank: the format for collecting opinion of the entire person is shown below in table. Out of the collected survey detail, half of them is taken in bank and half taken in the premises near the bank. Survey format is shown below in Table-2

Table-2: Survey Format

Sr No.	If the Service is Improved		Account in which another bank	Reason		
	Suggest Friend	Increase Business		Less Facility	More Waiting Time	Other

Step-4.) Generation of survey report: From the survey done with the above format, following report is generated as shown below in table-3

Table-3: Result of Conducted Survey

Sr No.	If the Service is Improved			Account in which another bank	Reason		
	Suggest Friend	Increase Business	Join Bank		Less Facility	More Waiting Time	Other
Bank Premises	34/53	30/53		36/53	23/53	34/53	2
Outside Bank	36/53	17/23	24/53	48/53	43/53	39/53	7/53

Step-5.) Out of 84 people having account in another bank, 73 people consider more waiting time as major problem, i.e. 87 % person opened account in another bank due to long waiting time for service.

Out of 106 people, 87 people, i.e. 82 % shown interest in increasing business, of bank either by New Joining or by Increase Saving or by Suggesting Friend. The opportunity of grabbing these customers can only be achieved if Waiting Time of Customers is reduced.

Hence the new value of Arrival rate of customers = 1.82 X λ = 1.82 X 0.271 = 0.4878 Customers/minute.

Step-6.) Construction of new models as per the new value of parameters obtained from survey method. For deciding service time for every customer, random numbers are used and service time is allotted as per the corresponding random numbers assigned to them. The frequency distribution table for service time is shown below in Table-4.

Table-4: Frequency Distribution Table for Service Time

Service Time	Frequency	Probability	Cumulative Probability	Random No Assigned
1	9	9/85=0.11	0.11	00-10
2	31	31/85=0.36	0.47	11-46
3	26	26/85=0.31	0.78	47-77
4	10	10/85=0.12	0.90	78-89
5	2	2/85=0.02	0.92	90-91
6	3	3/85=0.04	0.96	92-95
7	2	2/85=0.02	0.98	96-97
8	1	1/85=0.01	0.99	98
9	1	1/85=0.01	1.00	99
	∑=85			

Single Server Model - [Arrival Rate (λ) = 0.4878 customer/min, Service Rate (μ) = 0.3623 customers/min]

Table-5: One Server Manual Simulation

A	C	D	E	G	H	I	J
1.	00:00	0	47	00:00	00:03	3	0
2.	00:03	0	15	00:03	00:05	2	0
3.	00:05	0	69	00:05	00:08	3	1
4.	00:07	1	53	00:08	00:11	3	1
5.	00:09	2	96	00:11	00:17	6	3
6.	00:11	6	80	00:17	00:21	4	4
7.	00:13	8	79	00:21	00:25	4	5
8.	00:15	10	96	00:25	00:32	7	8
9.	00:17	15	23	00:32	00:34	2	8
10.	00:19	15	53	00:34	00:37	3	8
11.	00:21	16	10	00:37	00:38	1	8
12.	00:23	15	45	00:38	00:40	2	8
13.	00:25	15	33	00:40	00:42	2	7
14.	00:27	15	02	00:42	00:43	1	7
15.	00:29	14	43	00:43	00:45	2	7
16.	00:31	14	70	00:45	00:48	3	8
17.	00:33	15	16	00:48	00:50	2	7
18.	00:35	15	29	00:50	00:52	2	7
19.	00:37	15	50	00:52	00:55	3	8
20.	00:39	16	87	00:55	00:59	4	9
81.	02:45	64	06	03:49	03:50	1	19
82.	02:47	63	73	03:50	03:53	3	18
83.	02:49	64	37	03:53	03:55	2	17

84.	02:51	64	32	03:55	03:57	2	16
85.	02:53	64	44	03:57	03:59	2	15
86.	02:55	64	05	03:59	04:00	1	14
87.	02:57	63	88	04:00	04:04	4	13
88.	02:59	65	69	04:04	04:07	3	12
89.	03:01	66	58	04:07	04:10	3	11
90.	03:03	67	28	04:10	04:12	2	10
91.	03:05	67	99	04:12	04:21	9	9
92.	03:07	74	69	04:21	04:24	3	8
93.	03:09	75	30	04:24	04:26	2	7
94.	03:11	75	16	04:26	04:28	2	6
95.	03:13	75	09	04:28	04:29	1	5
96.	03:15	74	05	04:29	04:30	1	4
97.	03:17	73	35	04:30	04:32	2	3
98.	03:19	73	07	04:32	04:33	1	2
99.	03:21	72	44	04:33	04:35	2	1
100.	03:23	72	75	04:35	04:38	3	0

Manual simulation of 2 and 3 server model is performed in the same manner and sample of simulation model is shown below in table number 5 and 6 respectively

TWO Server Model - [Arrival Rate (λ) = 0.4878 customer/min , Service Rate (μ) = 2X(0.3623) = 0.7246 customer/min]

Table-6: Two Server Manual Simulation

A	C	D	F	SERVER-1		SERVER-2		I	J
				G	H	G	H		
1.	00:00	0	47	00:00	00:03			3	0
2.	00:03	0	15	00:03	00:05			2	0
3.	00:05	0	69	00:05	00:08			3	0
4.	00:07	0	53			00:07	00:10	3	0
5.	00:09	0	96	00:09	00:15			6	0
-	-	-	-	-	-	-	-	-	-
96.	03:15	0	05	03:15	03:16			1	0
97.	03:17	0	35	03:17	03:19			2	0
98.	03:19	0	07	03:19	03:20			1	0
99.	03:21	0	44	03:21	03:23			2	0
100.	03:23	0	75	03:23	03:24			3	0

Three Server Model - [Arrival Rate (λ) = 0.4878 customer/min , Service Rate (μ) = 3X(0.3623) = 1.0869 customer/min]

Table-7: Three Server Manual Simulation

A	D	E	F	SERVER-1		SERVER-2		SERVER-3		I	J
				G	H	G	H	G	H		
1.	00:00	0	47	00:00	00:03					3	0
2.	00:03	0	15	00:03	00:05					2	0
3.	00:05	0	69	00:05	00:08					3	0
4.	00:07	0	53			00:07	00:10			3	0
5.	00:09	0	96	00:09	00:15					6	0
-	-	-	-	-	-	-	-	-	-	-	-
96.	03:15	0	05	03:15	03:16					1	0
97.	03:17	0	35	03:17	03:19					2	0
98.	03:19	0	07	03:19	03:20					1	0
99.	03:21	0	44	03:21	03:23					2	0
100.	03:23	0	75	03:23	03:24					3	0

Step-7.) Calculation of various cost and profit associated with the different number of servers and selecting the best out of it.

Calculation of Service Costs:

Service Cost = Rs 3,00,000 /- Month.

It was assumed that there are 25 working days in a month on an average.

Hence Service Cost = Rs 12,000 /- per day. Out of which Rs 8000 /- per day is assumed as fixed costs and Rs 4,000 /- per day as the cost of operating one counter. Hence there will be an addition of Rs 4,000 /- per day on increasing each service station.

Calculation of Opportunity Costs: For calculating opportunity costs average revenue earned from a customer has to be calculated.

Revenue Earned from bank per month = Rs 5,00,000 /- per month

Average number of working days are taken as 25, hence revenue Obtained per day = Rs 20,000 /- per day.

Average number of customers served per day = 100, Therefore Revenue earned per customer = Rs 200 /- per day

Thus Opportunity cost is calculated by the number of customers lost multiplied by Rs 200 /- per day.

From Single Server Simulation Model we find that as per new arrival rate the difference between Arrival Time and Service Start time differs by 1 Hours 15 Minutes, and in that time as per the new arrival rate 30 more customers can be able to get service.

Therefore Opportunity Cost = Rs 200 X 30 = Rs 6000 /- per day.

Thus, with the knowledge of all the associated costs and revenues, the profit earned using 1, 2 or multiple server model can be calculated using Manual Simulation done as per new Arrival Rate.

Step-8.) Validation of obtained from the programme made in Excel Spreadsheet.

	A	B	C	D	E
1	Model 5 (M/M/s/b queue):				
2		Multiple servers, Infinite population, Poisson arrival, FCFS, Exponential service time, Limited buffer (b)			
3		Yellow cells need user inputed values			
4	**Inputs**				
5		Unit of time	hour		
6		Arrival rate (lambda)	29.27	customers per	hour
7		Service rate (mu)	21.7	customers per	hour
8		Number of identical servers (s)	1	servers	
9		Buffer (waiting room) size	50	customers	
10					
11	**Outputs**				
12		**Direct outputs from inputs**			
13		Mean time between arrivals	0.034	hour	
14		Mean time per service	0.046082949	hour	
15		Traffic intensity	1.348847926		
16					
17	**Summary measures**				
18		Average utilization rate of servers	100.0%		
19		Average number of customers waiting in line (Lq)	47.1334	customers	
20		Average number of customers in system (L)	48.1334	customers	
21		Average time waiting in line (Wq)	2.1720	hour	
22		Average time in system (W)	2.2181	hour	
23		Probability of no customers in system (P0)	0.0000	(Probability of empty system)	
24		Probability of rejecting a customer (balking rate)	25.86%	(Reject rate)	
25		Effective arrival rate	21.69999868	(Entering rate)	
26					

	A	B	C	D	E
1	Model 5 (M/M/s/b queue):				
2		Multiple servers, Infinite population, Poisson arrival, FCFS, Exponential service time, Limited buffer (b)			
3		Yellow cells need user inputed values			
4	**Inputs**				
5		Unit of time	hour		
6		Arrival rate (lambda)	29.27	customers per	hour
7		Service rate (mu)	21.7	customers per	hour
8		Number of identical servers (s)	2	servers	
9		Buffer (waiting room) size	50	customers	
10					
11	**Outputs**				
12		**Direct outputs from inputs**			
13		Mean time between arrivals	0.034	hour	
14		Mean time per service	0.046082949	hour	
15		Traffic intensity	0.674423963		
16					
17	**Summary measures**				
18		Average utilization rate of servers	67.4%		
19		Average number of customers waiting in line (Lq)	1.1254	customers	
20		Average number of customers in system (L)	2.4743	customers	
21		Average time waiting in line (Wq)	0.0384	hour	
22		Average time in system (W)	0.0845	hour	
23		Probability of no customers in system (P0)	0.1944	(Probability of empty system)	
24		Probability of rejecting a customer (balking rate)	0.00%	(Reject rate)	
25		Effective arrival rate	29.26999999	(Entering rate)	
26					

	A	B	C	D	E
1	Model 5 (M/M/s/b queue):				
2		Multiple servers, Infinite population, Poisson arrival, FCFS, Exponential service time, Limited buffer (b)			
3		Yellow cells need user inputed values			
4	**Inputs**				
5		Unit of time	hour		
6		Arrival rate (lambda)	29.27	customers per	hour
7		Service rate (mu)	21.7	customers per	hour
8		Number of identical servers (s)	3	servers	
9		Buffer (waiting room) size	50	customers	
10					
11	**Outputs**				
12		**Direct outputs from inputs**			
13		Mean time between arrivals	0.034	hour	
14		Mean time per service	0.046082949	hour	
15		Traffic intensity	0.449615975		
16					
17	**Summary measures**				
18		Average utilization rate of servers	45.0%		
19		Average number of customers waiting in line (Lq)	0.1517	customers	
20		Average number of customers in system (L)	1.5006	customers	
21		Average time waiting in line (Wq)	0.0052	hour	
22		Average time in system (W)	0.0513	hour	
23		Probability of no customers in system (P0)	0.2499	(Probability of empty system)	
24		Probability of rejecting a customer (balking rate)	0.00%	(Reject rate)	
25		Effective arrival rate	29.27	(Entering rate)	
26					

Fig : Simulation Result for 1,2 and 3 Server Model

V. RESULTS

From all the cost obtained from above calculations and analysis, cost and profit associated with different numbers of servers are calculated as shown below in table

No of Servers	Queuing Parameters		Operating Cost/ Day	Opportunity Cost/ Day	Revenue/Day	Net Profit/Day	Utilization Factor
	λ/Hour	μ/Hour					
1	29.27	21.74	12000	6000	20000	8000	100 %
2	29.27	43.478	16000	0	26000	10000	67%
3	29.27	65.218	20000	0	26000	6000	45%

Also the value of utilization factor of servers and rejection percentage of customers obtained from Excel Spreadsheet is almost equal to the manual simulation, thereby validating our Cost Analysis approach.

VI. CONCLUSIONS

From the above evaluation of all the costs and profits and utilization factor it was concluded that if the number of servers is changed and maintained to 2, then there will be an optimum profit, hence it is preferable for the concerned bank of interest.

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