International Journal of Mathematics and Computer Research
ISSN: 2320-7167

Volume 07 Issue 06- June 2019, Page no. - 1984-1987
Index Copernicus ICV: 57.55
DOI: 10.31142/ijmcr/v7i6.02

Study of Queuing Model: A Case Study of LIC Nanded Branch

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ARTICLE INFO

Published Online:
15 June 2019

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ABSTRACT

The current research paper is focused on several lines and several servers of policy holders and agent in LIC Nanded Branch in Maharashtra state. This research work studies structure of queuing model, arrival and service pattern probability distribution, queue disciplines, queue behaviors, different measures of queuing system were presented. The different measures of queuing system were evaluated on the basis of reading of the arrival time of customers and service time of server of the queuing system. By assuming cost of each costumer and each server per hour, total cost determined and decided optimal no. of servers in the LIC.

KEYWORDS: costumer, arrival pattern, probability distribution, traffic intensity, queuing model.

Introduction

Waiting line is one of the everyday life problems at different service providing institute.LIC is also one of the corporation that provide life insurance facility to costumers. Now a day's everyone knows the importance of the life insurance to secure our family financially. Due to that why we always see long waiting lines and sometimes the servers are idle also. In first situation waiting cost and in the another one , idle cost is considerable .If the no. of severs are very less than required then the costumers have to wait for service , as well as if the no. of servers are more than required then the servers have to wait for job. So we have to determine appropriate number required severs that maintain the balance between waiting cost and idle cost.

The arrival time pattern of costumer follow the Possion probability distribution and the service time follow the exponential probability distribution. The queue lines formed in the LIC were multi server and multi lines so that represent multiline and multi servers model with infinite capacity of system for infinite population, service were provided on the basis of "first come and first served" service discipline and no balking.

Queue is everyday experience in LIC Nanded Branch. As per Sharma, 2013, queue is formed when either the number of customers requiring service exceeds the number of servers or the servers do not perform efficiently.

Customers waiting lines create worries to management of service providers because of the resulting consequences of balking and reneging by the customers. Long waiting lines generate stress and aggravate mistakes in addition to cost by both the waiting customers and the facility operators; according to Uche and Ugah 2014. In other words, customers lose their precious time and the service providers also lose valuable customers via reneging and balking when a long queue is formed.

Generally, increasing the number of servers by the operator would reduce the waiting time of customers, but increase the operating cost of the services. Yuncheng and Liang 2002 said that the queue problem is a problem about a balance between waiting time of customers and the idle time of the sever. Queuing theory is an effective method used where it is not possible to accurately predict the arrival rate of customers and service rate of servers. It is used to determine the optimal level of servers.

Many authors have done useful works in queue systems in different areas of human events. For instance Ezeliora et al 2014 worked on queuing system management of Shoprite Plaza, Enugu, using single-line multiple server analysis. They recommended a decrease in the number of servers to reduce the operating cost of the system and reduce the idle time of the servers. Adamu 2015 did a work on ECO and First Banks by simulating a single queue- single server and single queue-multi server systems. He noted that First bank should turn multi-tellers multi server system to single queue multi tellers to reduce the overall waiting time of customers from the multiple serving points and also reduce the customers' jockeying problems. For ECO bank, it was noted that the multi-tellers should improve on their turnaround in order to have further reduction of waiting time of customers.

Aims of the study

i) To analyze measures of the queue with different queuing model.
ii) Study the traffic intensity of queuing models.
iii) Determine the waiting and idle cost and make conclusion about optimal level.
iv) Recommend appropriate number of servers.

The M/M/S/∞/∞/FCFS queuing model

The queuing model studied here is M/M/S/∞/∞/FCFS, passion arrival time, exponential service time, multi-servers with infinite capacity for infinite population. In this model there are multiple servers but they are identical, parallel to each other and provide the same facility to all customers. Customers on arrival from the queue and remains there until they got service. That queue is characterized as follows.

i) Arrival times of customers follow the Poisson probability distribution with mean arrival rate λ customers/unit time.
ii) Service time of servers follow the exponential probability distribution with mean service rate μ customers/unit time.
iii) There is infinite capacity of system for infinite population.
iv) The queue discipline is first in first out and neither balking or nor reneging is allowed.
v) If n < s then there will be no queue. It means that the no. of idle servers will be idle n-s. Where n and s are no. of customers and no. of the servers respectively.
vi) If the n≥s then there will be queue formed and the no. of the customers in the queue is s-n.
vii) The total service rate must be more than the total arrival rate. Otherwise the waiting line will be infinitely large.

The Total Cost Function

The cost function for this queuing model, considered both the waiting cost of the customer and operating cost the server. The total cost function is as follows:

$$T = C_w N + C_s S$$

Where T is the total cost, waiting as well as service; C_w is the waiting cost of customers; C_S be the operating cost of server, N is the Average no. of the customers in the system.

The Performance Measures of Queuing System

1. The probability that all the servers are idle is

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

2. The average number of customers waiting in the queue is

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

3. The average number of customers in the system is

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

4. The average time a customer spends waiting in the queue

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

$$W_q = \frac{L_q}{\lambda}$$

5. The average time a customer spends waiting in the system is

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

$$\Rightarrow W_s = \frac{L_s}{\lambda}$$

6. The probability that an arrival customer for services is

$$P(n \geq s) = \frac{\mu\left(\frac{\lambda}{\mu}\right)^S}{(S-1)!(S\mu-\lambda)} P_0$$

7. Utilization factor = $\rho = \dfrac{\lambda}{S\mu}$

Table 1: Arrival and Service time of I^st sever of the LIC

Sr. No.	Arrival Time	Inter Arrival Time (min.)	Service begins	Service Ends	Service Time (min)
1	10.30	----	10.35	10.38	3
2	10.33	3	10.39	10.41	2
3	10.34	1	10.42	10.46	4
4	10.34	0	10.47	10.53	6
5	10.36	2	10.54	10.59	5
6	10.39	3	11.00	11.10	10

7	10.43	4	11.11	11.15	4
8	10.45	2	11.16	11.19	3
9	10.51	6	11.20	11.26	6
10	10.51	0	11.27	11.30	3
11	10.55	4	11.31	11.37	6
12	10.57	2	11.38	11.45	7
13	11.00	3	11.46	11.51	5
14	11.13	13	11.52	11.56	4
15	11.13	0	11.57	12.00	3
16	11.15	2	12.08	12.04	4
17	11.26	11	12.05	12.12	7
18	11.31	5	12.13	12.19	6
19	11.35	4	12.20	12.26	6
20	11.38	3	12.27	12.35	8
21	11.42	4	12.36	12.41	5
22	11.50	8	12.42	12.50	8
23	11.55	5	12.51	12.56	5
24	11.57	2	12.57	13.04	7
25	12.00	3	13.05	13.11	6
26	12.07	7	13.12	13.15	3
27	12.07	0	13.16	13.20	4
28	12.09	2	13.21	13.25	4
29	12.10	1	13.26	13..32	6
30	12.16	6	13.33	13.40	7
31	12.21	5	13.41	13.45	4
32	12.25	4	13.46	13.48	2
33	12.25	0	13.49	13.53	4
34	12.29	4	13.54	13.56	2
35	12.30	1	13.57	14.00	3
Total		**120**			**172**

The average arrival and service time of customers for four days among first ,second ,third and fourth servers summarized in the following table

Table 2. Average arrival and service time of customers for four days among five servers

Day		**Server1**		**Server2**		**Server3**		**Server4**		**Server5**	
		λ_1	**μ_1**	**λ_2**	**μ_2**	**λ_3**	**μ_3**	**λ_4**	**μ_4**	**λ**	**μ**
Monday	**Total**	120	172	143	209	179	213	134	180	151	203
	Av.	3.42	4.91	4.08	5.97	5.11	6.08	3.82	5.14	4.41	5.54
Tuesday	**Av.**	3.59	5.12	4.13	6.33	5.75	6.44	4.15	5.56	5.36	5.12
Wednesda	**Av.**	3.21	5.69	4.72	6.69	5.16	6.56	4.63	5.96	4.25	5.44
Thursday	**Av.**	3.01	5.32	4.15	6.19	5.19	6.43	4.93	5.88	4.33	6.05
Total		13.25	21.06	17.09	25.19	21.22	25.52	17.55	22.55	21.51	22.15
Av. (λ,μ) i ,		3.312	5.26	4.27	6.29	5.30	6.38	4.38	5.63	5.37	5.53

Hence from the above tale we get; λ = 4.3 and μ =5.8

The measures of the systems:

The average arrival rate, λ=4.3 costumers/min.

The average service rate, μ=5.8 costumers/min.

The probability of the servers are idle(empty)

$P_0 = 0.4764$

The average no. of the customers waiting in the queue

L_q =0.0002 costumers

The average no. of the customers waiting in the system

L_s = 0.7416costumers

The average waiting time customers spends in the queue

Wq=0 .000 costumers

The average waiting time customers spends in the system

W_s =0.1725 costumers

Evacuation of the total cost:- Here in this work, the waiting cost and service cost of sever is assumed to be Rs.150 and Rs. 225 per hour respectively i.e. Rs.2.5 and Rs.3.75 per minute respectively. Thus the total cost is

$T= C_w N+C_S S$

=2.5x74.16+3.75x5

=185.4+18.75

=240.15 Rs./min.

Table 3. Summary of the performance measures of the LIC with different number of servers

Num. of servers	P_0	L_S	L_q	W_q	W_S	Utility factor	Servers busy (in %)	Idle time (in %)
1	0.2586	2.8667	2.1253	0.4943	0.6667	0.7414	74.14	25.86
2	0.4591	0.8595	0.1181	0.0275	0.1999	0.3707	37.07	45.91
3	0.4747	0.7554	0.0141	0.0033	0.1757	0.2471	24.71	47.47
4	0.4763	0.7431	0.0017	0.0004	0.1728	0.1853	18.53	47.63
5	0.4764	0.7416	0.0002	0.0000	0.1725	0.1483	14.83	47.64
Total							**169.28**	
Average							**33.85**	

In this table , the waiting time of customers in the system are 0.6667,0.1999,0.1757,0.1728 and 0.1525 minutes for 1^{st},2^{nd} 3^{rd}, 4^{th}, and 5^{th} servers respectively. From this it is clear that as the number of servers increases, the average waiting time of customers in the system decreases and vise varsa.

It is also see that from above table if the more servers in the system, the more idle time of the system and less utility factor of the system. Hence, the appropriate number of servers that would optimize the system is two servers, according to the average above.

Conclusion

The number of five servers being in use by the LIC is working as shown in above table . However, the optimal number of servers for the LIC is two in order to reduce the idle time and cost of the operation.

Recommendation

The queuing analysis have important role in controlling waiting time and idle time. Thus I suggest that always the number of servers used in service provider system will be optimal as per there average utility factor.

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