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Application of Queueing Theory at Super Market Checkout Points

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Abstract : *In many places like shopping mall, ticket booking counters or at banks, there are more than one queue in front of service counters. Customers standing in one queue are tempting to jump to the other short queue, but in majority cases they ended up in the queue which is more time consuming than their previous one. We here come with mechanism which helps the customer to save their time with single queue and multiple server system.*

INTRODUCTION

It is observed at shopping mall that people are very much confused in selection of a queue at check out points. Even at booking counters and other places the jockey behaviour of queue, i.e. people are tempting to jump from current queue to the shortest one. But is this behaviour actually saves their time? The answer is no in most of the cases. We have studied the queue behaviour at one of the reputed supermarket in the city of Gujarat State in India. It is common practice at supermarket that there is one checkout queue per counter. Each counter has its own queue, and this makes more confusing situation that which of the queue to join. To overcome this problem we have proposed single queue multi server model for the supermarkets. We have collected the data for the existing system for 7 days and on an make analysis of that with multi server multi queue model. Also we have convinced the management to apply our proposed method for 7 days and collected data for the same and applied multi server single queue model. In this method only one waiting line is generated and as soon as the checkout point is vacant the first person in queue will go to that counter and next so on. Further in next sections, we have discussed the outcome and results for the data.

MULTI SERVER SINGLE QUEUE MODEL : M/M/1.

The M/M/1 model is representing the arrival rate and service rate are exponentially distributed i.e. we can say the it is Poisson process. The variables and parameter definition for the model are as below

λ = Mean arrival rate

μ = mean service rate

$\rho = \frac{\lambda}{\mu}$ which is utilization factor

The probability of zero customer in queue

$P_0 = 1 - \rho$

The probability of having n customers in queue

$P_n = P_0\rho^n$

The average number of customer in the system

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

The average number of customer in the queue

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

The average waiting time in the queue

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

The average time spent in the system including the waiting time by the customer

$$W_S = \frac{L_S}{\lambda} = \frac{1}{\mu-\lambda}$$

MULTI SERVER MULTI QUEUE MODEL : M/M/s

The variables and parameters of the M/M/s model

λ = Mean arrival rate

μ = mean service rate

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

Probability of zero customer in the system

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

The probability of having n customers in the system

$P_n = P_0\rho^n$

The average number of customer in the system

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

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 system including the waiting time

$$W_S = \frac{L_S}{\lambda} = W_q + \frac{1}{\mu}$$

DATA ANALYSIS AND RESULTS

The data of 7 days shows the following results for the first phase, which is application of M/M/s model. The second phase of 7 days is the application of M/M/1 model. It is assumed that the arrival of the customer follows the Poisson distribution and the customers are served on First Come First Serve (FCFS) base. Also there are no priority customers in the system, the population of the customers is infinite. The service rate of the servers is constant and does not affect by the external forces. There are 3 checkout counters in the supermarket.

The service rate μ is fixed as 15 in each case

Table 1
Waiting Time in Different Time Slot under M/M/1

Time Slot	Arrival Rate λ	L_S	L_q	W_S	W_q
10am to 1pm	12.00	2	1.33	9	6
1pm to 5pm	8.33	0.5	0.1667	4.5	1.5
5pm to 10pm	17.67	5	4.1667	18	15

Now the application of proposed M/M/s queue and result of that is listed below.

Table 2
Waiting Time in Different Time Slot under M/M/s

Time Slot	Arrival Rate λ	L_S	L_q	W_S	W_q
10am to 1pm	36	2.8889	0.8889	4.33	1.33
1pm to 5pm	25	1.0455	0.0455	3.14	0.14
5pm to 10pm	53	6.0112	3.5112	7.21	4.21

From the above results we can easily see that the waiting time is less in the proposed system. Thus we have recommended the supermarket to adopt this proposed system for checkout. Supermarket can make arrangements to such system where only one queue is there and as soon as any counter vacates, next customer will automatically go to that vacant counter.

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