Impact Factor (SJIF): 5.301

International Journal of Advance Research in Engineering, Science & Technology

e-ISSN: 2393-9877, p-ISSN: 2394-2444
Volume 5, Issue 10, October-2018

AN EFFICIENT USES OF QUEUING THEORY BASED ON TOLL PLAZA

Kishankumar C. Bhatasana, Kinjal C. Bhatasana, Ketul S. Kachhia

Asst. Prof. at Ipcowala Institute Of Engineering And Technology,Dharmaj,
Formal Asst. Prof. at N.S.I.T,Jetalpur
Asst. Prof. at Ipcowala Institute Of Engineering And Technology, Dharmaj

Abstract — India is a state with the second largest street network in the world. In India, Traffic obstacle is a state caused by the rising vehicles on the road and the most difficult problem of construction a toll booth is that become more the traffic on highway. In current situation the objective of our study is to consider of traffic blockage at a toll booth of highway. Hence, the management of toll booth should be such that it reduce time that is wasted in the queuing section. At a toll plaza of highway how can we use Queuing theory and get possible solutions to increase the competence in order to minimum the waiting time of the customers. In this curriculum of study, various stages like that problem identification, collection of the information (data), data analysis, results and then chooses toll plaza in Ahmedabad to do the analysis. This paper, we use various parameters like that the Arrival rate, Service rate, Numbers of toll lanes and waiting line. Lastly, possible solutions have been place send which can be recommended on various toll plazas in the country.

Keywords - *Traffic Problem of a toll plaza, Use of Queuing Theory.*

I. INTRODUCTION

A wide network of highways is present in India and toll plazas are present on most of them. Million of drivers pass through this toll booth. Also, with the transportation development and rise in the number of vehicles on Indian's roads. [1] The number of arrival of traffic is always very high near a big city in India. As very high traffic the number of arrival association with the larger service time will increase in long time of vehicles in the queue. Length of Queue or size is a significant pointer of working effectiveness of toll plaza. A toll plaza's queue length or size exactly depends to the long time (waiting time), pattern of the arrival and service time of the vehicles. A vehicles longer waiting times in toll queues the results in fuel cost increase, increase pollution and increase in possibility cost of time wastage.

A customer driving from Ahmedabad to Vadodara everyday through this toll booth can save up to Rs. 2,000 annually fuel cost during the wait at toll plaza. Therefore the aim of our toll plaza problem is optimize or minimize the queue length or size of vehicles and the customer’s time in the queuing system. Thus, it is important that to reduce the length of queue and make sure that the toll plaza could manage the traffic flows with no any problem.

Fig. 1.1: Toll Plaza

II. Problem Description

Toll plaza is present on most top highway. We have considered toll plaza of Ahmedabad consisting of only for two (2) lanes, one lane is incoming traffic and other lane is outgoing traffic. The study will be concentration on the only for one (1) lane from which the traffic is entering the queue system. The incoming traffic will be studied from 10:30 am to 6:30 pm on a non-working day (Sunday) and a working day (Monday). The examination only complete for the busiest hour of both days. A comparison of the traffic flow of both Non-working and Working days is drawn using queuing theory formulas. And hence, implications are made on how to improve the current position.

III. Methodology

To solve the toll plaza problem the answer will be taken by using the Queuing Theory. We are available to carrying the importance the variety of parameter of queuing theory like that the average number of customers arriving to the queuing system per minute, the average number of customers getting served per minute, and the average number of customer wait in the queue.

The various variables used in this problem such as:-

λ = Arrival Rate of the customer, μ = Service Rate of the server

Lq = Average number of customers waiting in the system of queue

Wq = Average waiting time of customers in the system of queue

ρ is known as the utilization (operational) factor of the server

IV. Observations

Time Of Day	Avg. No. Of vehicles on Non-Working Day (Sunday)	Avg. No. Of vehicles on Working Day (Monday)
10:30-11:30	59	68
11:30-12:30	78	73
12:30-01:30	89	111
01:30-02:30	105	86
02:30-03:30	99	137
03:30-04:30	66	89
04:30-05:30	123	148
05:30-06:30	145	168

Table (1.1): Observation

V. Solutions

From the above information we can easily conclude that the busiest time is 5:30 pm-6:30 pm for both the days and our analysis will be focused on this hour. The given information we see that the average number of vehicles crossing the toll plaza on Non-working day is maximum during 5:30 pm-6:30 pm around 145 vehicles. And the average number of vehicles crossing the toll plaza on working day is maximum during 5:30 pm-6:30 pm around 168 vehicles.

The arrival rate on Non-working day is found to be 145 vehicles during 5:30 pm-6:30 pm and the observed service rate is 6 vehicles per minute. The arrival rate on Working day is found to be 168 vehicles during 5:30 pm-6:30 pm and the service rate is 6 vehicles per minute. Since we have analyzed only one (1) server for the incoming traffic and hence the analysis is complete using M/M/1 Queuing Structure. Also it is assumed that a customer wastes fuel of Rs.5 per minute while waiting in Queue.

Since there is only one (1) lane for incoming vehicles, so only single server is considered. And M/M/1 Queuing Model Formulae are used which are mentioned below:-

$\rho = \lambda / \mu$

$Lq = \lambda^2 / \mu (\mu - \lambda) = \rho 2/1 - \rho$

$Wq = \lambda / \mu (\mu - \lambda) = \rho (\rho / 1 - \rho)/\lambda$

A. Performance Analysis (Non- Working day)

From above observations it is see that throughout the busiest hour (5:30 pm to 6:30 pm) 195 vehicles arrived on Non-working day. It was also observed that on an average 3.5 vehicles are served per minute.

Now, λ = 145 customers during 5:30 pm to 6:30 pm

= 145/60 customers per minute

= 2.41 customers per minute

μ = 3.5 customers getting service per minute

Utilization Factor (ρ) = λ/μ = 2.41/3.5 = 0.69047 = 69.047%

Which mean that the server continues busy for 69.047% of the total time.

Average number of customers waiting in the queue (Lq) = $\lambda^2 / \mu (\mu - \lambda)$

$= (2.41)^2 / 3.5(3.5-2.41)$

= 1.522

Average waiting time of customers in the queue (Wq) = $\lambda / \mu (\mu - \lambda)$

= 2.41/3.5(3.5-2.41)

= 0.6315 minutes

= 37.90 Seconds

Now a customer is wasting petrol of Rs.5 per minute while waiting in the Queue System.

Total loss of the customer = 0.6315*5= Rs.3.1575 per journey

B. Performance Analysis (Working day)

From above observations it is see that throughout the busiest hour (5:30 pm to 6:30 pm) 205 vehicles arrived on Working day. It was also observed that on an average 3.5 vehicles are served per minute.

Now, λ = 168 customers during 5:30 pm to 6:30 pm

= 168/60 customers per minute

= 2.8 customers per minute

μ = 3.5 customers getting service per minute

Utilization Factor (ρ) = λ/μ = 2.8/3.5 = 0.8= 80 %

Which means that the server continue busy for 80% of the total time.

Average number of customers waiting in the queue (Lq) = $\lambda^2 / \mu (\mu - \lambda)$

$= (2.8)^2 / 3.5(3.5-2.8)$

= 3.2

Average waiting time of customer in the queue (Wq) = $\lambda / \mu (\mu- \lambda)$

=2.8/3.5 (3.5-2.8)

=1.1428 minutes

= 1 minutes 84 seconds

Now a customer is wasting petrol of Rs.5 per minute while waiting in the Queue System .

Total loss of the customer = 1.1428*5 =Rs.5.714 per journey

Now, comparing the information of non-working day and working day

Parameters	Non working Day	Working Day
Avg. No. of vehicles in queue (L_q)	1.522	3.2
Avg. Waiting time of customer in queue (W_q)	0.6315 min	1.1428 min
Systems Utilization	69.047%	80%
Cost of Waiting per customer per journey	Rs. 3.1575	Rs. 5.714

Table (1.2): parameters

VI. Conclusion

1) On Non-working day during 5:30 pm to 6:30pm, the number of customers in the queue is only1.522 and a customer's has to wait for only 0.6315minitues in the queue and the waiting cost is Rs.3.1575 but these figures changed completely for a working day where the number of customers in the queue is 3.2 and a customers to wait for 1.1428 minutes in the queue and the waiting cost is Rs.5.714

2) On Non-working day the waiting time for a customer in queue, the length of queue, and the cost of waiting is very low so one (1) server (one toll booth) is enough.

3) On Working day the waiting time for a customer in queue, the length of queue and the cost of waiting is very high so one(1)server (one toll booth) is not sufficient to handle the traffic situation.

VII. REFERENCES

[1] The Economic Times," Delhi government mulls measures to check vehicle growth", sep02, 2012, retrieved on March 11, 2014

[2] Introduction part "Operations Research: An introduction" By Humdy a Taha.

[3]The Economic Times,"Toll- Free Ride will make business boom: Industrialists", Feb 20, 2014, retrieved on March 13,2014.

[4] The Economic Times "Remove Toll Plazas as initiatives to ease traffic congestion fail" Census Report (2011)"Size, growth rate and distribution of population"

[5] Hindustan Times "Delhi government mulls measures to check vehicle growth".