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Optimal solution of real time problems using Queueing Theory

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ABSTRACT: Tollway is a public roadway for which one has to pay some fee to get access for the passage. It is implemented in order to recuperate the cost of construction. The drivers have to wait because of the long queue and inefficient collection methods. Queueing theory is employed in this paper to solve the problem and optimize the result. The data is obtained from Economic Times of Delhi-Gurgaon toll plaza. The parameters calculated here are arrival rate, service rate, utilization rate, waiting time in the queue and average number of customers in the queue based on the data using Multi-server Queueing system-M/M/m model. We conclude the paper by discussing the benefits of performing queueing model on a Tollway and then providing an efficient solution to the problem.

***Key words*—Multi-server Queuing system, M/M/m Queueing model, Queue, Tollway**

I. INTRODUCTION

A long waiting line is considered as an indicator of poor quality and there is need for improvement. Queue theory deals with one of the most unpleasant experience of life, waiting. Queuing is quite common in many fields, for example in telephone exchange, in ticket purchasing, in paying electric bills, etc. A mathematical method of analyzing the congestions and delays of waiting in line.

Queuing theory is a mathematical model which is used to analyze for how much time customer has to wait then it gives an idea about what can be done to make system more efficient and easy to serve and increase the number of users that can be served. Actually queue theory comes in role when many customers arrives at the same time then they can be served in a queue. The ultimate objective of the analysis of queueing systems is to understand the behavior of their underlying processes so that informed and intelligent decisions can be made in their management.

A. Multi-server queueing system

The multi- server queuing mathematical model is known in the Kendall's notation as the *M*/*M*/*m* model, where
M signifies a Poisson distribution
m = number of parallel service channels in the system.
The M/M/m model is one of the most commonly used to analyse the queuing problem. This model computes the average wait times and queue lengths, given arrival rates, number of servers and service rates.
The outputs of the model are as follows:

1) Expected waiting time per customer in the system.
2) Expected waiting time of customer in the queue.
3) Expected number of customers in the system.
4) Expected number of customers in the queue.

B. Assumptions

1) Arrival rate obeys Poisson distribution.
2) Service times are exponentially distributed.
3) All the customers in the queue do not leave the queue unemployed.
4) Service is provided on a first come first basis.

II. METHODOLOGY

	QL(vehicles)	WT(mins)
T0	40	5.3
T10	66	8.8
T30	119	15.8
T60	198	26.3

Table 1. Data of Delhi- Gurgaon Toll Plaza

QL= Queue length before a tollgate lane at various times in a peak hour
WT= Waiting time at toll gate at various times in a peak hour
T0= start of peak hour
T10,30,60 = 10,30,60 minutes from the start of peak hour

A. MODEL PARAMETERS

1)UTILIZATION COEFFICIENT

Utilization coefficient is defined as the ratio of average arrival rate (λ)in time domain to the average service rate (μ).Mathematically it is denoted by ρ.

$$\rho=\lambda/\mu$$

The utilization coefficient (ρ) is directly proportional to the length of queue if the utilization coefficient (ρ) is larger then the demand will be more and queue size will longer otherwise it will be shorter.If the arrival time of costumer to system were more than service rate, namely $\lambda>\mu m$, then$\rho>1$, which means the system capacity, is less than the arriving demand, therefore, the queue length is increased.

2) AVERAGE ARRIVAL RATE (λ)

Arrival rate may be defined as the mean number of arrivals per unit time.
$\lambda 1 = (60–40)/10 = 2$ vehicles/minute.
$\lambda 2 = (119–60)/20 = 2.95$vehicles/minute.

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$\lambda 3 = (198-119)/30 = 2.63$ vehicles/minute.
$\lambda(\text{average}) = (\lambda 1+\lambda 2+\lambda 3)/3 = 2.53$ vehicles/minute.

3) SERVICE RATE (μ)
Service rate may be defined as the mean number of customers served per unit time.

4) AVERAGE OF TIME SPENT IN SYSTEM
The average spent time in a system is equal to the total time that a costumer spends in a system, which includes the waiting time and service time, namely:

$W = 1/(\mu-\lambda)$

$5.3 = 1/(\mu-2.53)$

therefore, $\mu=2.71$

5) AVERAGE WAITING TIME IN QUEUE
The average waiting time in queue is equal to the average time which a costumer waits in the queue for getting service, its formula is:

$W_q = \lambda/\mu(\mu-\lambda)$

$W_q = (\lambda/\mu)*W = 5.18$ min.

6) AVERAGE QUEUE LENGTH
The average queue length is composed of the average number of people who are waiting in queue

$L_q = (\lambda*\lambda/\mu(\mu-\lambda))$

$L_q = (\lambda*W_q) = 13.108.$

7) AVERAGE NUMBER OF INDIVIDUL IN THE SYSTEM
The average number of individual in the system is equal to the average number of individual who are waiting in the line or server:

$L = \lambda/(\mu-\lambda)$

$L = L_q*(\mu/\lambda) = 14.04.$

8) THE POSSIBILITY OF NO USERS =P_0=

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

$= 0.198.$

III. RESULTS AND DISCUSSIONS

From the above obtained results it is inferred that the waiting time and service time is very high. In order to reduce this new method has been devised. This solution has been developed to reduce the time of service and the manual labour required.

The toll system involves bar code technology for the payment of toll charges. Every vehicle will have a specific barcode which will be registered under the toll authority. This barcode will be placed on the outer side of the right door below the window. As the figure 1 depicts there will be two readers. A speed breaker is placed before the reader to bring the vehicle's speed to a level such that its barcode can be easily scanned. Reader 1 will scan the barcode of the vehicle entering the toll and register it. This information of the registered barcode will be sent to reader2 station. The vehicle will then pass through reader 2. This will be performing 2 jobs. First it will scan the barcode and match it with information received from the reader 1. If both the scanned data match a signal will be sent to the toll gate and it will open for the vehicle. Second if reader 1 fails to scan the barcode or there is some error in scanning reader 2 will scan the barcode again and register it. After registering a signal will be sent to the toll gate and it will be set open. There will be a manual operator at the toll gate to scan the barcode and register it in case if both the readers fail to scan it. This information of the barcodes registered will be collected from different tolls and a bill will be formed according to the rates of different tolls. This bill will be sent to the address of the toll user every month.

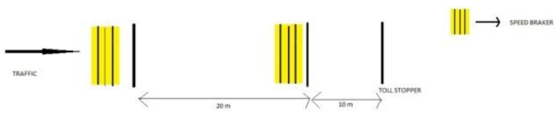

Fig.1 Model of new toll system

IV. CONCLUSION

The main purpose of this study is to develop a new method for efficient collection of money at Toll systems in order to reduce the waiting time of the users. The new bar code method that is suggested would reduce both service time and waiting time, thus providing more efficiency as compared to the regular toll system. Future studies may try to extend this work by considering the cost of the technology and related facilities, as well as other aspects.

REFERENCES

[1] Queuing Theory and its Applications, A Personal View, Janos Sztrik, University of Debrecen, Faculty of Informatics, Hungary, Proceedings of the 8th International Conference on Applied Informatics Eger, Hungary, January 27–30, 2010. Vol. 1. pp. 9–30.

[2] World Applied Sciences Journal 17 (9): 1211-1218, 2012 ISSN 1818-4952 © IDOSI Publications, 2012.Corresponding Author: M. Tabari, Faculty of Management, Qaemshahr Branch, Islamic Azad University, Qaemshahr, Iran. Tel: +98 9111514462.1211.

[3] Application of the Queuing Theory to Human Resource Management M. Tabari, Y. Gholipour-Kanani, M. Seifi-Divkolaii a 1 1 2 nd 3Reza Tavakkoli-Moghaddam.

[4] Operations Research by KantiSwarup, P.K. Gupta, ManMohan, 2005 edition, Page: 415-459.

[5] Case Study for Bank ATM Queuing ModelS. K. Dhar1, Tanzina Rahman2, IOSR Journal of Mathematics (IOSR-JM) e-ISSN: 2278-5728,p-ISSN: 2319-765X, Volume 7, Issue 1 (May. - Jun. 2013), PP 01-05.

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Volume 3, Issue 10, April 2014

[6] Case Study for Bank ATM Queuing Model, Bhavin Patel, PravinBhathawala / International Journal of Engineering Research and Applications (IJERA) ISSN: 2248-9622 Vol. 2, Issue 5, September- October 2012, pp.1278-1284 1278 page.

[7] Application of Simulation Technique in Queuing Model for ATM Facility Vasumathi.A , Dhanavanthan P ,INTERNATIONAL JOURNAL OF APPLIED ENGINEERING RESEARCH, DINDIGUL Volume 1, No 3, 2010,ISSN 09764259.

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