

An Approach to Minimize Traffic Congestion Using Queuing Theory Techniques

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Abstract

In modern days waiting time in the traffic signals is one of the major problem met by our society. Queuing theory is the mathematical theory and method of studying queuing system. This paper is an analyses of traffic signals with various time setup and waiting time in the system .Numerical example is illustrated to study the effect of increasing the duration of green signal in the morning session.

Keywords Queue, queue length, waiting time, M/M/I ,M/M/II model

1. INTRODUCTION

Queues are a part of real life .It facilitates to provide services in an orderly manner .when service facilities are less when compared to the arrival rate of the customer queues are formed . Providing too much service involves excessive costs. But waiting of customer reflects in the loss of business priority and minimum service facility make the customer to move to the another system. Increasing the number of service channels and increasing the efficiency of the existing capacity to a higher level only will provide solution to this problem. In this study a new approach in queuing model is given to reduce the waiting length of a customer. Queuing model is used in a large manner to reduce the congestion. A.C. Charles Selvaraj P. Amudha [1] studied the various approach to Minimize the Traffic Congestion by the Application of Queuing . Manoj Modi [3] and many authors observed the Minimization of Traffic Congestion By applying Queuing Theory . Mala and S.P. Varma [4] studied Minimization of Traffic Congestion by Using Queuing Theory. This paper reflects the usefulness of applying queuing theory in a real case situation

2. Characteristics of a queuing model

Queuing system is characterised in the following ways. Generally queuing theory involves the analysis of the following preliminaries.

Arrival pattern

Mostly arrivals in a service system are random and it is defined by a probability distribution Customer Arrive in batches, instead of one at a time .In such a situation the input is said to occur in bulk (or) batch.

Service pattern

The service pattern involves the ways in which service is rendered .The customer may be served according to arrival time either individually (or) in bulk. The time needed for servicing a single customer (or) batch is called service time rendered by the server.

Queuing discipline

Queue discipline is the selection mechanism in such a way the customers are selected for service when queue has been formed. First come first out(FIFO),Last come first out (LIFO),Service rendered in orderly manner (SIRO), or priority discipline are some of the queuing discipline widely used when queues are formed.

System capacity

It depends on the number of customer in a system (i.e) either a single (or) a bulk of customers.

Service Channel

Queuing system may have many service channels to provide service. It may be arranged in parallel (or)in series depending on the design of the system's service mechanism.

When the system has single server then it is single server model and when the system has two (or) more parallel server it is called as multi server model.

BASIC QUEUING PROCESS

Customers requiring service are generated over time by an input source. The required service is then performed for the customers by the service mechanism, after which the customer leaves the queuing system. We can have following two types of models:

- Single-queue Multiple- Serversmodel.
- Multiple-Queues Multiple-Serversmodel.

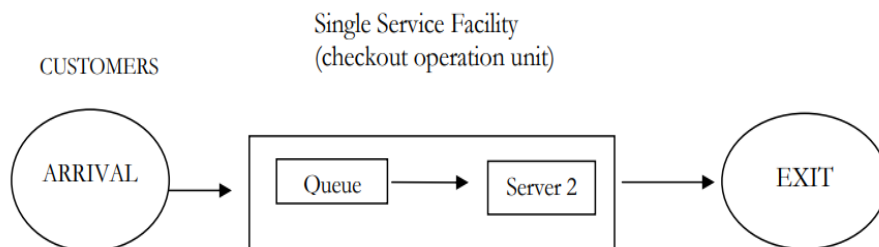


Fig. 1: Single Stage Queuing Model with Single-Queue and Single-Server

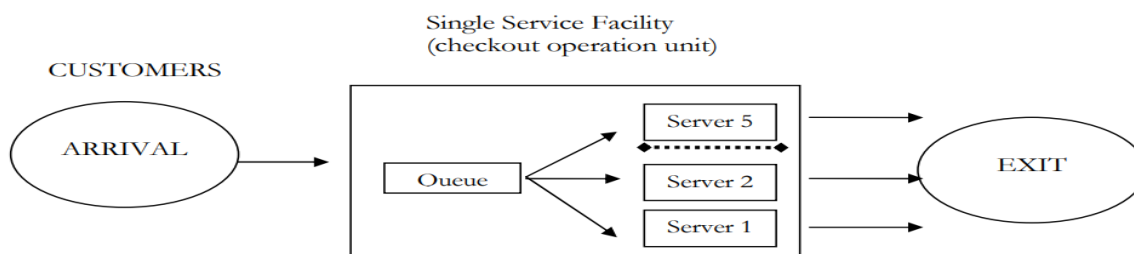


Fig. 2: Single Stage Queuing Model with Single-Queue and Multiple Parallel Servers

3. Terminology and Notation

In Exponential Queuing Model Certain assumptions that will be made are:

- Queue discipline will assume to be first-come-first-serve (FCFS) type.
- Reneging, balking and jockeying of the patients will not be taken into consideration in the study.
- The population source is going to be infinity.
- Infinite number of customers are allowed in the system.

According to Kendall’s notation, the model for the system could be represented as M/M/I: FCFS/∞/∞.

3.1 Single Server Model : (M/M/I Model)

λ : the mean customers arrival rate

μ : the mean service rate

$$\rho = \frac{\lambda}{\mu} : \text{utilization factor}$$

probability of zero customer in the system.

$$p_0 = 1 - \rho.$$

probability of having n customer in the system

$$p_n = (1 - \rho)\rho^n$$

The average number of customer in the system:

The average number of customer in the system is equal to the average number of customer in the queue together with those being serviced.

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

The average number of customer in the queue :

It can be taken as average queue length that is, the average number of customers who are waiting in the queue. It is defined as

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

The average waiting time of the customer in the system:

The average time spent in the system is equal to the total time that a customer spends in a system i.e. waiting time plus the service time. It is denoted by

$$w_S = \frac{1}{\mu - \lambda}$$

The average waiting time of the customer in the queue:

The average waiting time in queue is the average time a customer waits in queue forgetting service. It is represented as

$$w_q = \frac{\rho}{\mu - \lambda}$$

4.Numerical Example

In the popular city during the peak hours in the morning session the analysis were made with the duration of redlight and green light signal . Calculating queuing parameters shows the need of improving service facility i.e increase in the duration of the green light signal to reduce the traffic congestion and queue length.

Analysis of the parameters of the queuing model for the whole system are given below

S. No	Duratio n of Red Light	Num ber of Vehicles Accumulated	Arrival Rate (λ)	Duratio n of Green Light	Num ber of Vehicles Accumulated	Service Rate (μ)	ρ	L_S	L_q	W_S	W_q
1	60	25	0.416	40	18	0.450	0.92	12.23	11.31	29.4	23.11
2	60	27	0.450	40	20	0.500	0.90	9.00	8.10	20.0	18.00
3	60	18	0.300	40	15	0.375	0.80	3.00	3.19	13.0	10.66
4	60	32	0.533	40	24	0.600	0.88	7.95	7.06	14.2	13.25
5	60	40	0.666	40	30	0.750	0.87	7.92	6.97	11.1	10.51
6	60	30	0.500	40	23	0.57	0.87	7.14	6.26	14.2	12.53
7	60	28	0.466	40	20	0.50	0.93	13.7	12.7	29.4	27.4
8	60	42	0.700	40	21	0.775	0.99	9.33	8.43	13.3	12.0
9	60	37	0.610	40	26	0.650	0.93	15.25	14.31	13.3	27.4
10	60	26	0.430	40	20	0.550	0.86	6.14	5.28	14.2	12.28

When the duration of the green light signals were increased the following are the variation observed

S. No	Durati on of Red Light	Numb er ofVehi clesAccumul ated	Arrival Rate (λ)	Durati on of Green Light	Numb er of Vehicl es Accumulate d	Service Rate (μ)	ρ	L_S	L_q	W_S	W_q
1	60	25	0.416	45	21	0.466	0.892	8.32	7.42	20.0	17.85
2	60	27	0.450	45	24	0.533	0.844	5.42	4.57	12.0	10.1
3	60	18	0.300	45	17	0.377	0.795	3.89	3.50	12.9	10.33
4	60	32	0.533	45	29	0.644	0.827	4.80	3.94	9.00	7.45
5	60	40	0.666	45	35	0.777	0.857	6.00	5.14	9.00	7.72
6	60	30	0.500	45	27	0.600	0.833	5.00	4.16	10.0	8.33
7	60	28	0.466	45	24	0.533	0.874	6.95	6.08	14.9	13.0
8	60	42	0.700	45	35	0.777	0.900	9.09	8.19	12.9	11.7
9	60	37	0.610	45	29	0.645	0.947	15.6	14.9	13.4	27.8
10	60	26	0.430	45	24	0.533	0.806	4.17	3.36	10.0	7.89

The above table illustrate that the increase in the time duration of green signal will gradually decrease the waiting time in the queue.

5. Conclusion

Queueing in the peak hours is the major difficulty , therefore in such conditions traffic congestion or traffic jam may occur. To eradicate this problem we can implement the following measures

- Increasing the road capacity by increasing the width of the road.
- Providing separate lanes for specific user groups.
- Variable message signs can be installed along the roadway to advice road users.
- Creating one-ways nearer to the main traffic signals.
- Installing queue length sensitive traffic lights.
- Reducing the red light time and increasing the frequency of the green lights.
- There can be parking restriction for the motor vehicles by the roadside, so that traffic congestion may be reduced.

In this paper the idea of increasing the duration of green light signal was analysed .The result yield by the observation implies the reduction of waiting time in the queue.

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