Performance Evaluation of Dual Service Rate Discrete Time Systems

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Abstract: Telecommunication companies nowadays are mainly focusing on data services because they are on a very high demand than any other telecom services. Today, almost 51% of the total data traffic is of video streaming which constitutes a very bigger part of the traffic since the video contains more data than any other data type. This increased demand and utilization of such services increase the need of higher data rates & increased service rates. In this paper, we will analyze the performance of the network by load management and introducing dual service rate in the system. A queuing system will be made and structured Markov chain is obtained from it. The basic operation will be such to increase the service rate when there is high traffic on the media and simultaneously decreasing arrival rate in order to bound the customers for entering in the system. As the traffic again decreases, the service and arrival rates will again back to their normal rates providing the basis of dual service rate.

Keywords: *Queueing system*; *Load Management; Arrival Rate; Dual; Service Rate*

1. Introduction

Queueing system provides tool for the performance evaluation of the network which possesses dual service as well as dual arrival rates[1][8]. The system switches its service rates in accordance with the traffic thresholds. The basic need for the performance evaluation is the load management. If the load is managed, the customers will get satisfactory quality of services [2].

can provide dual service rate. This is mainly done to avoid congestion in the system and in actual to provide smooth services [3].The basic operation will be such to increase the service rate when there is high traffic on the media as to provide feasible path for the high data to pass through. When the traffic decreases, the service rate will be decreased/back to the initial providing the basis of the dual service rate.

Discrete time systems needs more reliable techniques to evaluate the congestion in the system [4][5].Dual data based system has more complicated evaluation in scalar domain [6][7]. Modeling of telecommunication system having different types of data can be achieved through some scalar domain algorithms [9].

2. Queueing System

The queueing system is a very common procedure which is applied by many systems that have to deal with operations is shown in Fig.1. It is a branch of operations research which represents a powerful tool in modelling and performance analysis of many complex systems, such as computer networks, telecommunication systems, call centers, franchises and elsewhere whose dealing is with customers.

The queueing system consists of a queue of customers which has a defined maximum capacity. The customers are seeking for the services and one or many attendants or servers are there to serve the customers in some pre-defined ways. Also, there must be some technique for the customers to arrive and depart in such a way so that the queue as well as the system must not be disturbed. The customers who have been served will depart and the new customers will arrive at their place so that the total queue will not exceed its pre-defined maximum limit. The customers are actually the flow of entities which can be users, jobs, transactions or programs. Hence, the queueing systems are described by the customers, arrival and service rates, queue capacity, traffic thresholds, type of service and the number of servers.

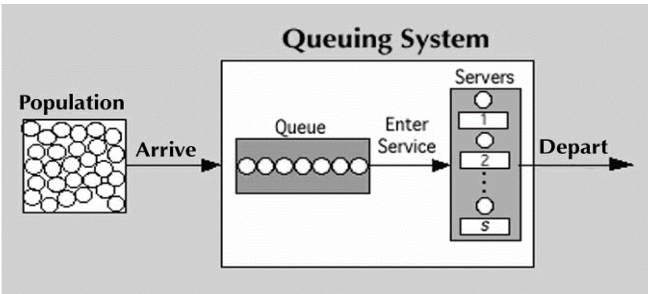


Figure.1. Queueing System

3. MARKOV Chain

The Markov chain is a random probability distribution which is named after the Russian mathematician Andrey Markov. The chain is used to represent the transitions from one state to another. It actually defines a sequence of possible events whose probability of occurrence depends on the state obtained in the previous event. In this regard, a very important tool is the state space which carries all the possible future states. The transition or hopping occurs with a fact that no matter how the process arrived at its present state, the possible future states are fixed.

4. Matrix Geometric Method (MGM)

The matrix geometric method is a process in probability theory which is used for the analysis of quasi birth-death process. A finitesimal generator matrix is obtained using vector domain method whose transitions are shown as a repetitive block structure with rate matrices. The MGM requires a transition rate matrix with tridiagonal block structure.

$$Q = \begin{pmatrix} B_{00} & B_{01} & & & & \\ B_{10} & A_1 & A_2 & & & \\ & A_0 & A_1 & A_2 & & \\ & & A_0 & A_1 & A_2 & \\ & & & A_0 & A_1 & A_2 \\ & & & & \ddots & \ddots & \ddots \end{pmatrix}$$

where each of B_{00}, B_{01}, B_{10}, A_0, A_1 and A_2 are matrices. The generator matrix can be sub-divided into various parts according to the explanation of the desired conditions and definite equations can be extracted through that. In the dual rate system proposed in this paper, this generator matrix is sub-divided into 3 parts

5. Methodology

5.1 System Queueing Model With Dual Service Rate

In this paper, a finite capacity queueing model with dual service rate is constructed which has various state space variables and 2 thresholds. One is low traffic and other is high traffic threshold. There are 2 service / arrival rates: normal & reduced arrival rates and normal and increased service rates, which will switch their conditions according to the traffic on the media.

Initially, when the traffic is low, system works on normal arrival rate up to the high traffic threshold where the arrival rate begins to decrease, simultaneously, the service rate is normal initially but it tends to increase when the traffic increases. At high traffic threshold, the arrival rate is reduced but the customers are being served with high service rate which again goes back to normal rate once the traffic decreases.′αn' is maintained until 'Ht' threshold is reached.Once 'Ht' has reached, system switches to 'αr' up to maximum capacity of queue 'T'.The system will again switch back to 'αn' when the service queue will hit back 'Lt' threshold. The queueing system with dual service rate is shown in Fig.2.

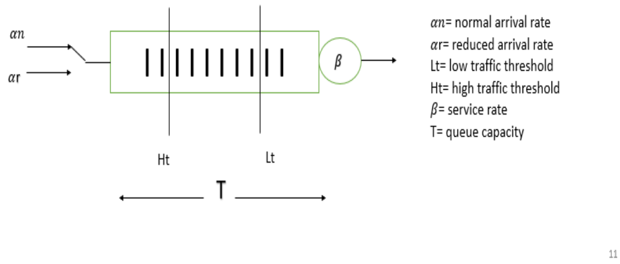


Figure.2. Queueing system of dual service rate DTS

5.2 System MARKOV Chain

The Markov chain of the given system as shown in Fig.3, which clearly shows the 3 possible conditions in the queue. The first condition denotes the situation in which the low traffic threshold has not arrived yet and the system is working on normal arrival rate. Similarly, the second condition shows that the system is either half full or half empty. Hence, this allows that the system can possess both arrival rates. Lastly, the third condition can only tolerate reduced arrival rate because in that condition, the customers have crossed the high traffic threshold. The customer receives service with normal rate before reaching the first threshold. When customers reached first threshold, service rate switched to the increased rate.

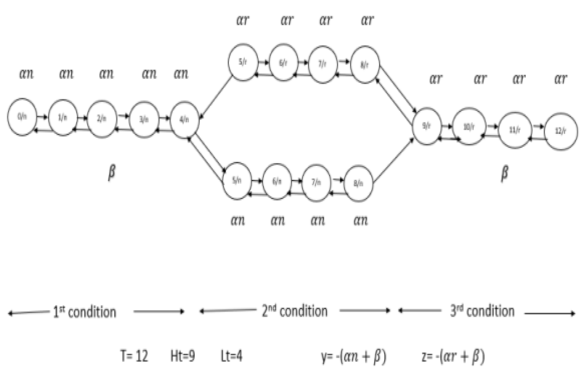


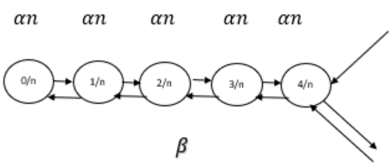
Figure. 3. System Markov chain

5.2.1 Three Conditions Of The Queueing System:

The queueing system has the following three conditions:

1st condition:

Initially, when the system not reached up to the Lt threshold, according to the organization, only normal rate is tolerable. Under this condition, system states are (0/n), (1/n)……… (Lt/n) etc. the partitioned Markov chain as well as the matrix for this condition are shown in Fig. 4.

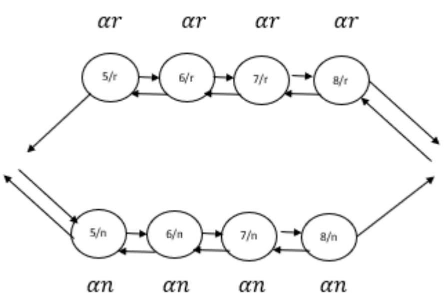


	0	1	2	3	4
0	$-\alpha n$	αn	0	0	0
1	β	y	αn	0	0
2	0	β	y	αn	0
3	0	0	β	y	αn
4	0	0	0	β	y

Figure. 4. First Condition of Queueing system

2nd condition:

As the system moves towards the partially filled and partially empty situations, customers are being served with both rates according to the traffic thresholds. The generator matrix along with the structured Markov chain are shown in Fig. 5.

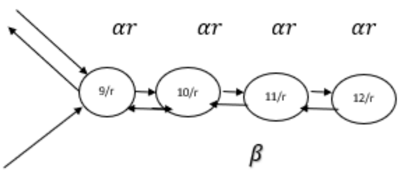


	5n	5r	6n	6r	7n	7r	8n	8r
5n	y	0	αn	0	0	0	0	0
5r	0	z	0	αr	0	0	0	0
6n	β	0	y	0	αn	0	0	0
6r	0	β	0	z	0	αr	0	0
7n	0	0	β	0	y	0	αn	0
7r	0	0	0	β	0	z	0	αr
8n	0	0	0	0	β	0	y	0
8r	0	0	0	0	0	β	0	z

Figure. 5. Second Condition of Queueing system

3rd condition:

Lastly, when 'Ht' has reached, reduced service rate arises which has states (Ht/r), (Ht+1/r)………(T/r) etc. According to the organization, here only reduced service rate is allowable in which there is high traffic up to the fully loaded queue 'T'. The matrix is extracted from the structured Markov chain of 3rd condition is shown in Fig. 6.



	9	10	11	12
9	z	αr	0	0
10	β	z	αr	0
11	0	β	z	αr
12	0	0	β	$-\beta$

Figure. 6. Third Condition of Queueing system

6. Results and Discussion

The results are carried out on MATLAB software with various parameters. The Fig. 7 shows that the number of customers in the queue rapidly increases when customers arrives with normal rate and service rate is also normal for various queue sizes and arrival and service rates upto the first internal threshold. When customers reached and cross the first internal threshold and not reached to the second threshold the service rate becomes increased and the number of customers gradually increased in a queue.

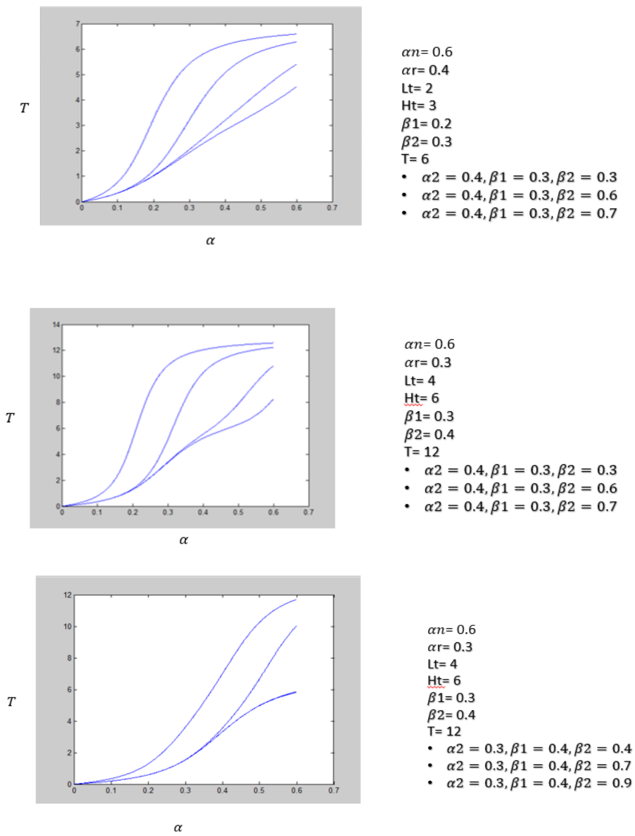


Figure. 7. Mean number in the Queue for various queue sizes and internal thresholds

7. Conclusion

The network with dual service rate along with dual arrival rate that allows network to avoid the congestion whose switching takes place according to the traffic on the media. When there will be high traffic, the network will switch to allow reduced arrival rate and increased service rate which helps to avoid network congestion, simultaneously, the service rate begins to increase.

When the traffic again decreases, the network will switch back to normal rate providing the basis of dual service rate. This phenomenon can be applied to any kind of telecommunication network whose modeling must be done in order to avoid network congestion.

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