Performance Analysis Of M/M/1 Queuing System With Bounded Queue(M/M/1/K)

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***Abstract*—M/M/1 is Kendall notation and describes the queuing system architecture. The first slot characterizes the distribution of the inter-arrival times for the arrival process. The M in this the inter-arrival times are Exponentially distributed.The second M in this slot says that the service times of jobs Exponentially distributed. The third slot indicates the number of servers in the system. For now this is 1. A fourth slot is typically used to indicate an upper bound on the capacity of the system in terms of the total space available to hold packets. Sometimes, however, the fourth slot is used to indicate the scheduling discipline used for the system. The fourth field indicates that the queue is bounded and that the scheduling policy is FCFS.**

In this paper,We analyze the performance measures of M/M/1/K queuing system i.e M/M/1 With bounded Queue and compare the results with M/M/1 Queue and also proposed a framework to evaluate the correctness of the simulation results with calculated results.

I. INTRODUCTION

An M/M/1 queuing system is the simplest non-trivial queue where the requests arrive according to a Poisson process with rate λ , that is the inter-arrival times are independent,exponentially distributed random variables with parameter λ . The service times are also assumed to be independent and exponentially distributed with parameter μ . Furthermore,all the involved random variables are supposed to be independent of each other.

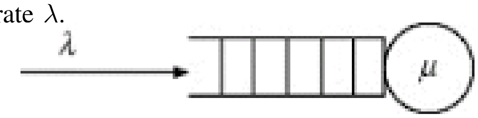
M/M/1/K Queuing system is a system with bounded Queue.

Notation:M/M/1/K/FCFS

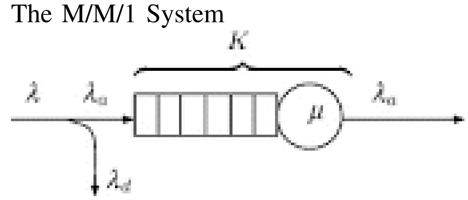
Where K is used for system size and FCFS is Queue Discipline.

The M/M/1/K model generalizes M/M/1 by limiting to K the number of packets that can be held simultaneously in the system. In other words, the waiting queue has a finite storage capacity of K 1 packets, so that the system can hold at most K packets, including the packets under service. packets that arrive when the system is full are denied admission to the system and will be dropped immediately, without being served. This event is referred to as blocking or dropping.

It may be worth remarking that newly arriving packets will continue to be generated according to a Poisson process of rate λ, irrespective of the number of packets in the Queue, but only those who find fewer than K packets already in the QS are actually admitted into the system, whereas the others are refused. Therefore, the average arrival rate λ at which packets are admitted into the system is just a fraction of the arrival rate λ.



The M/M/1 System



The M/M/1/K Queue System

II. NOTATIONS USED FOR EXPERIMENT

Below is the formula which we are using for our experiment.

- Arrival Rate λ
- Service Rate μ
- Utilization ρ
- Number of waiting items (w)
- Queue waiting time (T_w)
- Queue service time (T_s)
- Residency time (T_r)
- $Ts{=}Tq{+}averageservicetime$
- $Tr{=}1/\mu - \lambda$
- $Tw = \rho^2 \ / \ (\ 1 - \rho \ )$
- $r = \rho \ / \ 1 - \rho$

III. DESCRIPTION OF EXPERIMENT

I have made two simulator.Unbounded queue M/M/1 Simulator and M/M/1/K Simulator.The former has no queue size and the latter has queue size of 5,7,8 respectively.

A. *M/M/1/Simulator*

Behaviour

Randomly Arriving Packet
Random Service Time
Random Number of Request

We are trying to find No of items in the queue,No of items waiting in the queue,server utilization,waiting time in the queue and waiting time in the system.

In both simulator arrival rate and service rate are being passed .Based on this value we are calculating waiting time of packets in queue,waiting time of packets in the system.current queue size.Total packet being served by the system.The M/M/1 system is stable.

Events in the simulator

There are mainly two events arrivalEvent and departureEvent.

B. M/M/1 Queue

ArrivalEvent in M/M/1 simulator does the following

Receive the packet and check whether Queue is empty,if Queue is empty it will be directly sent to the server to serve the packet else it will be assigned to the Queue and the packet is served the next item in th epacket will enter into the system. schedule the next packet arrival event

DepartureEvent in M/M/1 simulator does the following if queue is not empty, remove the the head packet and schedule the packet departure event.

M/M/1/K

Arrival Event in M/M/1/K:Receive the packet and check whether Queue is empty ,if Queue is empty it will be directly sent to the server to serve the packet else it will be assigned to the Queue. Once the packet has been served remove it from the head of the Queue and serve the next packet.Otherwise,if the Queue is full drop the packet.

DepartureEvent in M/M/1 simulator:If queue is not empty, remove the head packet and schedule the packet departure event.

C. Brief Description Of Program

Given the arrival rateλ,service rate μ and a run time the simulator will generate arrival events in system based on poisson process.previous time plus exponentially distributed random variable .In case of M/M/1/K ,due to fixed size of queue if there will be no place in queue simulator will discard the packet.and will add the packet only when there is space in the queue. In experiment when queue size was very less then there was more loss of packet. for each of the load i have run 1000 iteration in order to conclude the behavior of the system.

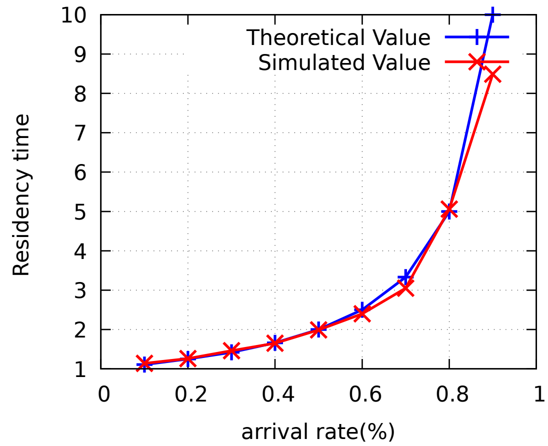
I have considered residency time for simulation i.e

$Ts{=}1/\mu - \lambda$

IV. Result of the Experiment of M/M/1 Queue

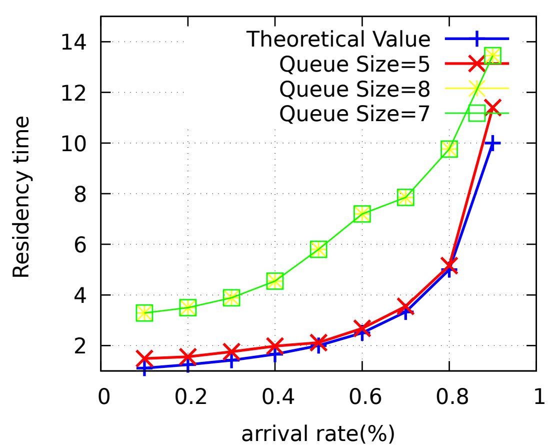
Based on different load rate we can see that as load increases ,the total waiting time also increases. Initially the observed and simulated output are in line with each other but as the load increases deviation occurs between simulated and calculated result.On the basis of several experiment with the simulator we can observe that if we increase the load in short span of time waiting time will increase in infinite queue.

From the M/M/1 Graph we can see that our theoretical and simulated values are almost same.It shows that if arrival rate will increase the residency time will also increase.



Load	Theoretical	Simulated
0.1	1.11	1.414
0.2	1.25	1.25999
0.3	1.42	1.4621
0.4	1.66	1.6543
0.5	2	1.9943
0.6	2.5	2.46
0.7	3.33	3.05
0.8	5	5.0635
0.9	10	8.4932

In finite queue when queue size was small and arrival rate was more then there was many packet loss and when we increased the size there were very few packet less. Below diagram shows the residency time of Queue size 5,7,8.As we can see for Queuesize 7 and 8 most of the values are getting overlapped.Whereas Queue size 5 value is more than theoretical value.



V. Conclusion

For a stable system the average service rate should always be higher than the average arrival rate. Otherwise the queues would rapidly race towards infinity. Thus ρ should always be less than one in M/M/1. We should be careful while choosing the queue size.Because if Queue size will increase and service rate will be same then in that case residency time of packet will increase.Another aspect if we increase the arrival and service rates proportionally in an M/M/1/K system then the system utilization is unchanged. The throughput is increased by a factor of k. The mean number of packets in the system is unchanged. The mean response time drops by a factor of k.Over a longer time period, the service rate should always exceed arrival rate.Queue size should be proportional to the arrival rate else there will be packet loss.We can avoid packet loss if we will increase the service rate.

References

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