# Analysis of M/M/1 Queuing Simulator

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***Abstract— Queuing analysis is the most important tool for computer and network analysis. [2] M/M/1 Queue is the unique, canonical , single-server queueing system with poisson input, exponential service times and unlimited number of waiting positions. In this paper, we analyze the performance measures of M/M/1 queuing system and propose a framework to evaluate the correctness of the simulation results and compare them with the theoretical results. This has been acheived by carefully comparing the genarated empirical results with the results from the formula. A graph is plotted to demonstrate the variations and discussions are made based on the graph.***

***Keywords— Total waiting time, load***

## I. INTRODUCTION

M/M/1 is one of the most widely used queueing system in analysis as pretty much every detail is known about it.
**M**/M/1 stands for Poisson arrival process $\lambda$

M/**M**/1 stands for exponentially distributed transmission $\mu$

M/M/**1** stands for the number of servers.

[1] The central element of the system is a server, which provides some service to items. If the server is idle, an item is served immediately. Otherwise, an arriving item joins a waiting line. When the server has completed serving an item, the item departs. If there are items waiting in the queue, the next in line is immediately dispatched to the server. The server in this model can represent anything that performs some function or service for a collection of items. [2] We have the following assumptions with respect to M/M/1 queue. ( for instance Let us consider customers in the grocery store )

- The number of customers being served is very large.
- All customers are independent.
- The impact of one customer in the performance of the system is very small.

Thus it is an approximation for a large number of systems. This paper makes use of the total waiting time of the system for different set of loads (arrival rate $\lambda$) to discuss the results.

## II. BACKGROUND

The average waiting time in the system, Ts, consists of the average waiting time in the queue (Tq) and the average service time. Thus the average time a customer spends in the system is

Ts = Tq + average service time

$Ts = 1 / \mu - \lambda$

which is the theoretical formula for calculating total waiting time

## III. DETAILED SOLUTION ANALYSIS

### A. *Simulator*

This is a straightforward framework of M/M/1 queue simulator consists of two classes- MM1Simulator.java and Queue.java which runs based on the hard coded inputs.

### B. *Simulation Setup*

Given an arrival rate lambda, a service time $\mu$, and a run time, the simulator will generate arrival events to the system based on a Poisson process - that is each arrival time is set as the previous arrival time added upon some exponentially distributed random variable with input lambda.
The results obtained from the simulation are written to the file which inturn is used to plot the graph, conduct experiments and document the decisions.

### C. *Measures*

The **total waiting time** which includes the service time is the measure used for obtaining results.

## IV. RESULTS AND DISCUSSIONS

The total waiting time with respect to different load rates (load is represented in %)is visualized in Figure 1. It can be seen that as the load increases, the total waiting time increases. There is disparity between the two curves at the load values of 0.7,0.8 and 0.9.

The green phase shows the impact on the observed total waiting time as the load increases. The set of values obtained from the theoretical formula ($Ts = 1 / \mu - \lambda$) represented by the blue phase is used to compare and contrast the results.

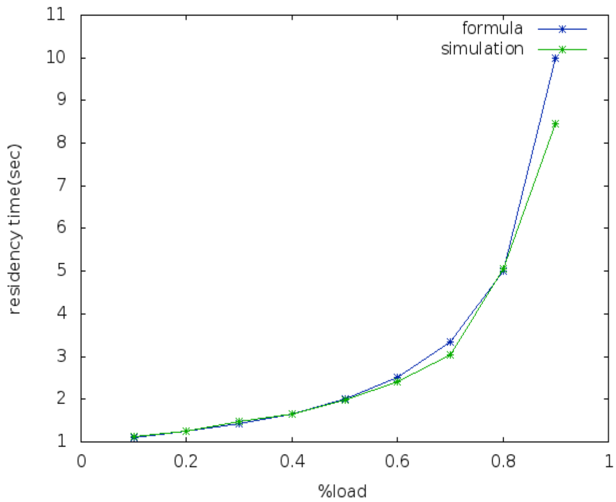

Figure 1: Total Waiting time (including service time) for different loads [Simulation time : 10000 seconds, μ : 1.0 ]

Initially the observed and theoretical values are in line with each other and as the load increases some deviations are noted. Based on several experiments conducted with the simulator, it is observed that increasing the simulation time drastically would result in a situation where the values generated from the observation will perfectly agree with the theoretical values, whereas reducing the simulation time to a very small value produces unsatisfactory results.

| Load(%) | Theoretical Value | Observed Value |
|---|---|---|
| 0.1 | 1.11 | 1.14 |
| 0.2 | 1.25 | 1.26 |
| 0.3 | 1.42 | 1.46 |
| 0.4 | 1.66 | 1.65 |
| 0.5 | 2 | 1.99 |
| 0.6 | 2.5 | 2.4 |
| 0.7 | 3.33 | 3.05 |
| 0.8 | 5 | 5.06 |
| 0.9 | 10 | 8.49 |

Table 1: Tabulated Results of the empirical vs theoretical value

## CONCLUSION

Thus a simple discrete event simulator of an M/M/1 queuing system was built, analyzing and comparing various results for empirical and theoretical values using different simulation times, it can be concluded that the simulation time plays an important role in determining the accuracy of the observed results.

## REFERENCES

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