Simulation Software for a Network Modelling Lab

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Abstract

This paper introduces a software application that simulates the most common types of queues. It also compares the simulations results with the values that the mathematical model predicts for specific types of queues. Thus, the software we have developed has two academic aspects. The first one applies to its ability to simulate most of the queuing processes that take place in computer networks. Therefore someone who studies network modelling or computer performance analysis may use it to derive some practical results in a very convenient way. The second aspect of the software refers to the part of the application that simulates specific types of queue and it can be used as a guide for teaching network modelling. We believe that it is very easy for someone to understand the aspects of queuing theory even though he/she is not familiar with.

1.Introduction

The aim of this application is to compare the mathematical model with the simulation results and to simulate types of queues that are very difficult to model. Therefore this application helps anyone that is interested to gain easily the knowledge of the queuing notation and to understand the way a single queue system work. Moreover it can be used as a supplement to a network or queuing theory course providing a basis for labatory work.

2. Basic concepts of queuing theory

Any queue consists of three components, an arrival process, which determines when a job arrives at the queue and possibly what its characteristics are, a buffer (also referred to as a queue itself) where jobs wait to be served and a service time requirement for each job at the server serving the queue. The term ‘queue length’ includes the jobs currently being served or waiting, if any.

Queuing theorists in order to classify queues use a shorthand notation called the Kendall notation [1]. In Figure 1 common random variables used in analysing of single queues are displayed. Good references for queuing equations are the following: [1], [2], [3], [4], [5].

3. Simulation of queuing processes and comparison with the mathematical model.

The application simulates the process of a single queue system. It consists of two basic components. The first one compares the state probabilities, the response time, the waiting time, the average number in system and the average number in queue that come as a result of the simulation with the ones that derive of the mathematical equations that describe the theoretical model.

In order to generate values for the mean arrival time and the mean service time the following distributions are being used: Normal Distribution, Exponential Distribution, Erlang Distibution, Hyper-exponential Distributio*n*.The algorithms that were used to generate

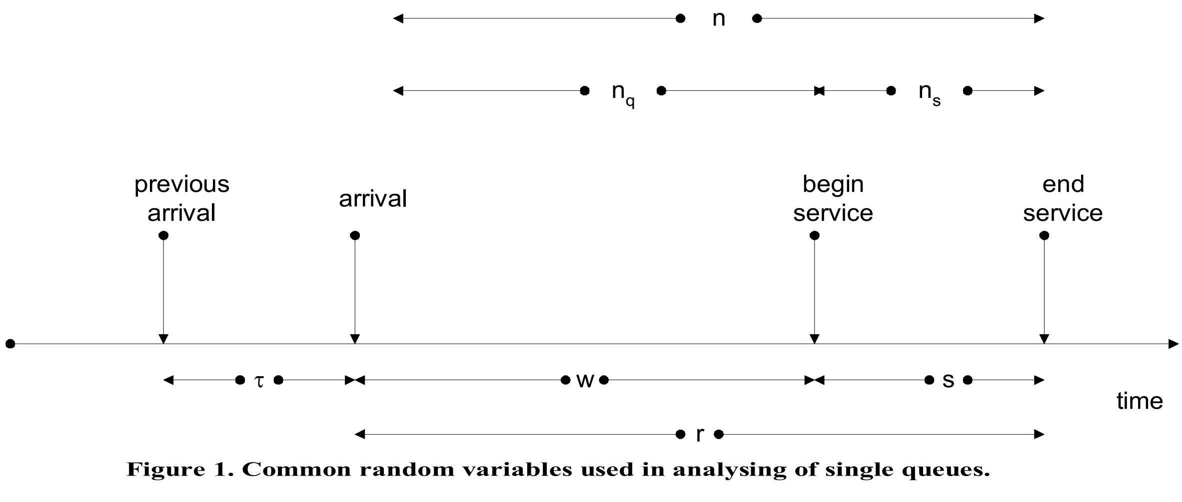

Figure 1. Common random variables used in analysing of single queues.

random numbers can be easily found in the following books: [1], [2], [3], [4].

For the most common type of queue M/M/1, the application for mean arrival time equal to 12 and mean service rate equal to 13, gives results that are presented in Figure 2 comparing theoretical and simulation's state probabilities. It is obvious that they are almost the same and in a lot of cases identical.

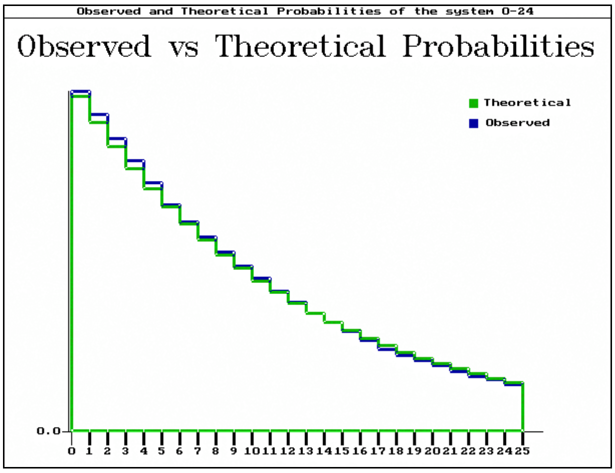

Figure 2
Observed and Theoretical State Probabilities

The following figure shows the comparison and the deviation of response time. As it is shown the deviation between the mathematical model's and simulation's results, is rather insignificant

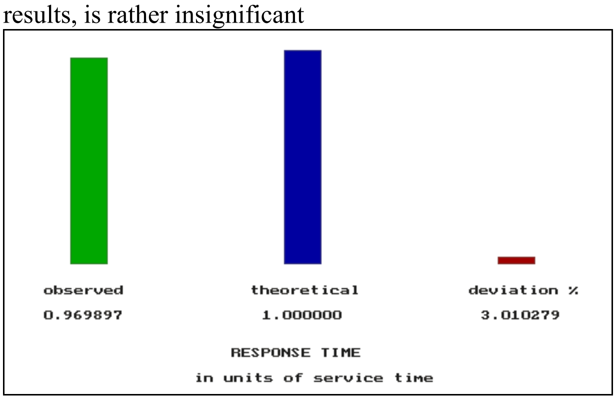

Figure 3 Response Time

The application also shows comparisons between theoretical and simulation's waiting time, average number in system and average number in queue.

The other component of the application simulates any queuing process that are very difficult to model and all the values are estimated 10 times and the mean of each value is finally presented with its standard error. The student or the teacher is asked to give values for the queue type, the arrival distribution, the average mean arrival rate, the service distribution, the average mean service rate, the number of servers and the number of jobs to simulate. All the distributions that generate random numbers are available plus a deterministic one for constant arrival rate or constant service rate. In the following figure the mean average number in system with standard error is displayed.

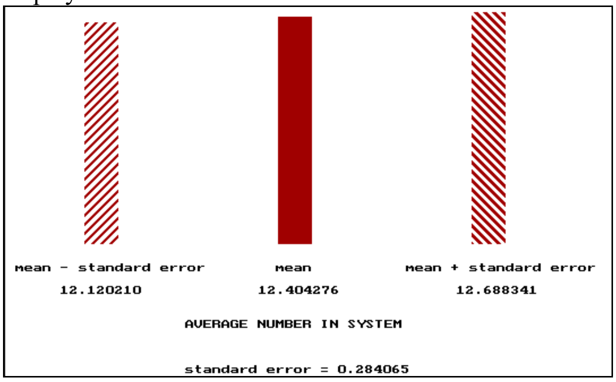

Figure 4 Average Number in System

4. Conclusion

The application that is presented in this paper is developed as a guide for anyone that teaches or studies network modelling or queuing theory. It helps especially students to understand the basic concepts because it provides an environment that can show how different types of queues operate. For example for given arrival rate, it can present if a queue with one server and certain service time gives better response and waiting times than another one that has two servers both with half service times compare to the first one. Therefore someone who has followed the theory course can easily derive some practical results doing labatory work with the application.

5. References

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