Event Probability using Quality of Service Parameters

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ABSTRACT: *This paper studies the computer simulation event probability using Quality of Service parameters. The reference model is built with a single server queuing system when the service disciplines are FIFO and LIFO. Simulation results for the queuing systems [X]/M/1/N M/[X]/1/N and [X]/[X]/1/ N are presented at the end.*

Keywords: Rare Event, Teletraffic Systems, Quality of Service, CLR, .Net

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1. Introduction

In modern communications very important is to estimate such parameters of Quality of Service (*QoS*) parameter as Cell Loss Ratio and packet loss. The values of these parameters are smaller then 1.10-9, and they belong to rare events.

Such problems can't be solve with standard stochastic simulation. The aim of this paper is to solve with rare event simulation queuing network model with single queues.

Under consideration is importance sampling for estimation rare event probability as one of the two basic techniques of rare event simulation - importance sampling and splitting.

The program realization is made on the *.NET* Framework, which includes a large library and provides language interoperability across several programming languages. The *.NET* Framework's Base Class Library provides user interface, data access, database connectivity, cryptography, web application development, numeric algorithms, and network communications. The *.NET* Framework is intended to be used by most new applications created for the Windows platform.

2. Reference Queuing Models

The investigated queuing models are different. The type of investigated queueing systems are with different arrival and service distributions such as discrete and continues: Pareto, Geometrical, Poisson, Erlang. The basic queuing models for rare event simulation, investigated here are classified in three types [*X*]/*M*/1/*N*, *M*/[*X*]/1/*N* and [*X*]/[*X*]/1/*N*. The program realization is made for discipline of service *FIFO* or *LIFO* with a finite buffer size *N*. These types of single queue are necessary, because new telecommunication networks could be investigated with small amount of resources.

A basic reference model for rare event simulation is the single server queuing system *M*/*M*/1/*N*- *FIFO* with a finite buffer size *N*. The arrival rate is λ and the service rate is μ . We are interested in the probability that the buffer content reaches a high level *k* during one busy period (i.e., the time interval between two successive periods in which the buffer is empty). The maximum occupancy is $B = N+1$, and the traffic load is $\rho = \lambda/\mu$. The discrete random variable is describe with stationary complementary distribution function (*c.d.f.*) $G(x) = 1\text{-}F(x)$, for the loss probability $P_B(1)$.

2.1. [*X*]/*M*/1/*N*

The investigated reference model for rare event simulation is the single server queuing system *G*/*M*/1/*N* - *FIFO* with a finite buffer size *N*.

The inter-arrival times are independent and uniformly distributed with arbitrary integral and $f_A(.)$ differential distribution laws.

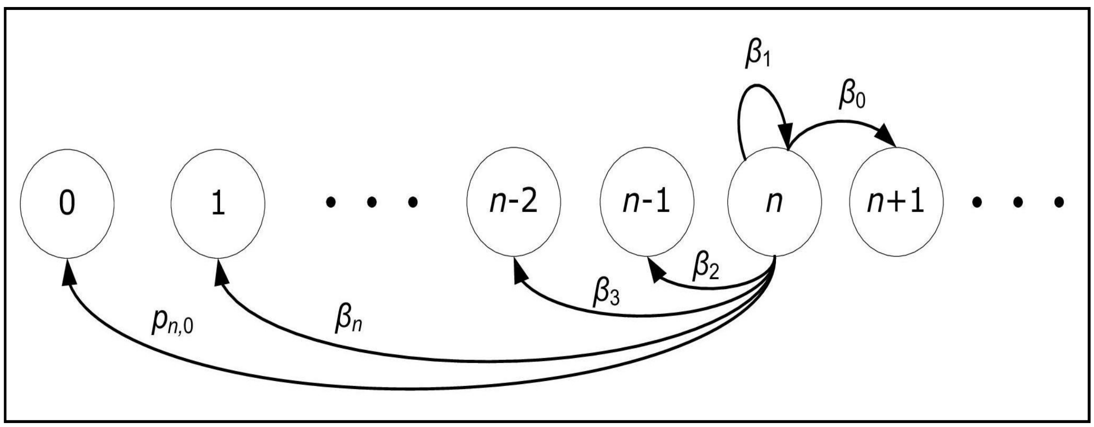


Figure 1. Queuing system *G*/*M*/1

The service rate is exponential $1/\mu$. We are interested in the probability that the buffer content reaches a high level *k* during one busy period (i.e., the time interval between two successive periods in which the buffer is empty). The maximum occupancy is $B = N + 1$, and the traffic load is $\rho = \frac{\lambda(i,x)}{\mu} < 1$. The discrete random variable is describe with stationary complementary distribution function (*c.d.f.*) $G(x) = 1\text{-}F(x)$ the loss probability P_B (1) and the local correlation coefficient Cor_i (2) for the interval $i\text{-}1 \leq x < i, i = 1, \ldots, k$.

2.2. *M*/[*X*]/1/*N*

The other investigated reference model for rare event simulation is the single server queuing system M/[X]/1/N with a finite buffer size *N*.

The service times are exponential distributed, and the service rates are uniformly distributed with arbitrary integral and differential distribution laws.

Queuing system *M*/*Erl*/1/*k* is the right opposite *Erl*/*M*/1/*N*, the arrival rate is exponential distributed, and the service rate is

Erlang distributed. The new client arrives in the left side of the system, then he is serviced in k-stages with $k\lambda$, the function of the arrival rate is defined with (1).

$$f(x) = \lambda e^{-\lambda x} \quad x \geq 0 \tag{1}$$

The service rate is (2).

$$F(x) = \frac{k\mu(k\mu x)^{k-1} e^{-r\mu x}}{(r-1)!} \quad x \geq 0 \tag{2}$$

We consider the Erlang distribution like a part of Geometrical distribution.

2.3. [*X*]/[*X*]/1/*N*

Teletraffic systems with single queue with different distribution as arrival and service rates, represents client behavior in different networks like fast Internet network, optical backbones and multiplex, or even broadband convergence networks. Here, the model of interest for rare event simulation is the single server queuing system $Elr/D/1/N$ with a finite buffer size N, the correlation coefficient is smaller than 1, β is non negative $\beta = t$, the interarrival distribution is $ERL(\alpha, \beta)$, with deterministic process of service D. The arrival rate is determined with (3).

$$F(t) = 1 - e^{-k\mu t} \sum_{i=0}^{k-1} \frac{(k\mu t)^i}{i!} \tag{3}$$

The service rate is defined with k stages of service, Cor_V with (4).

$$\mu = \frac{1}{Cor_V^2 k \overline{X}} e^{-k\mu t}, k = \frac{1}{Cor_V^2} \tag{4}$$

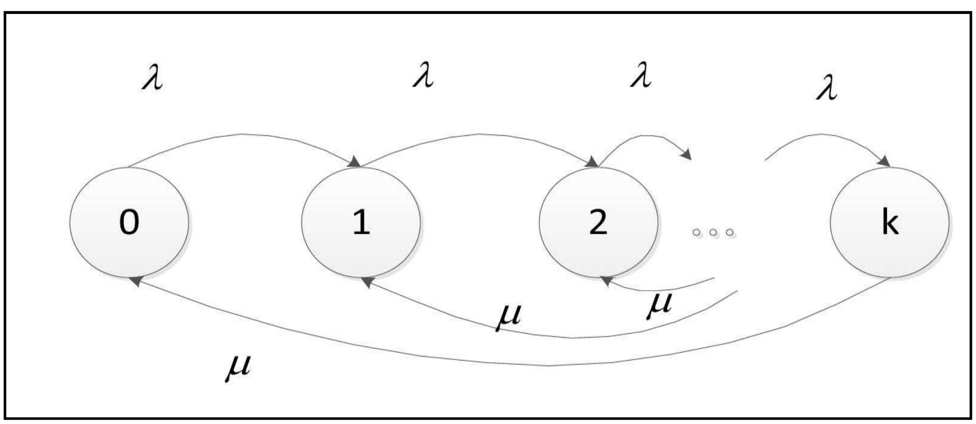
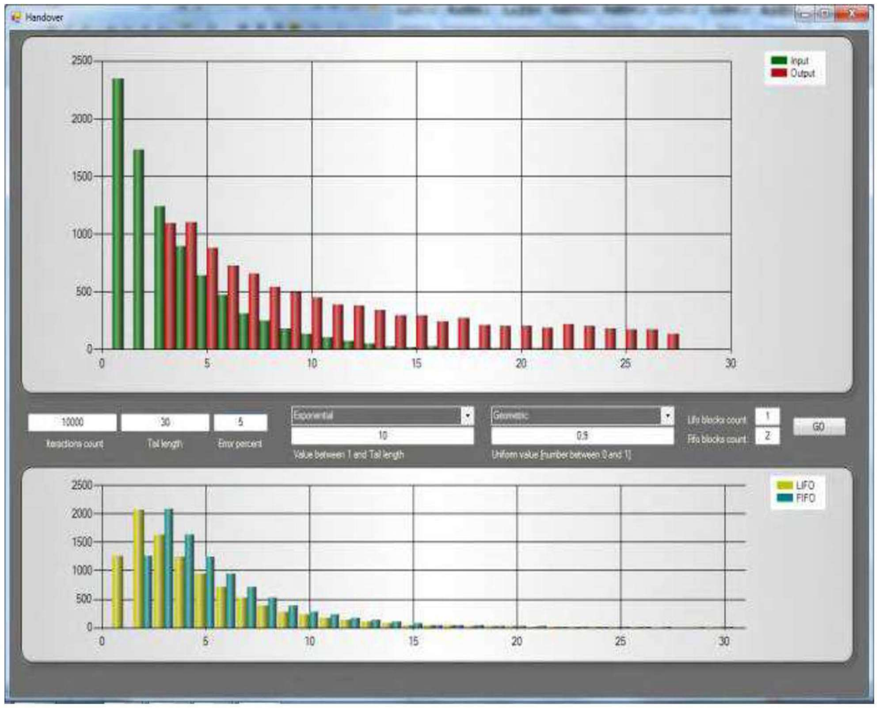


Figure 2. Queuing system $Erl/D/1/k$

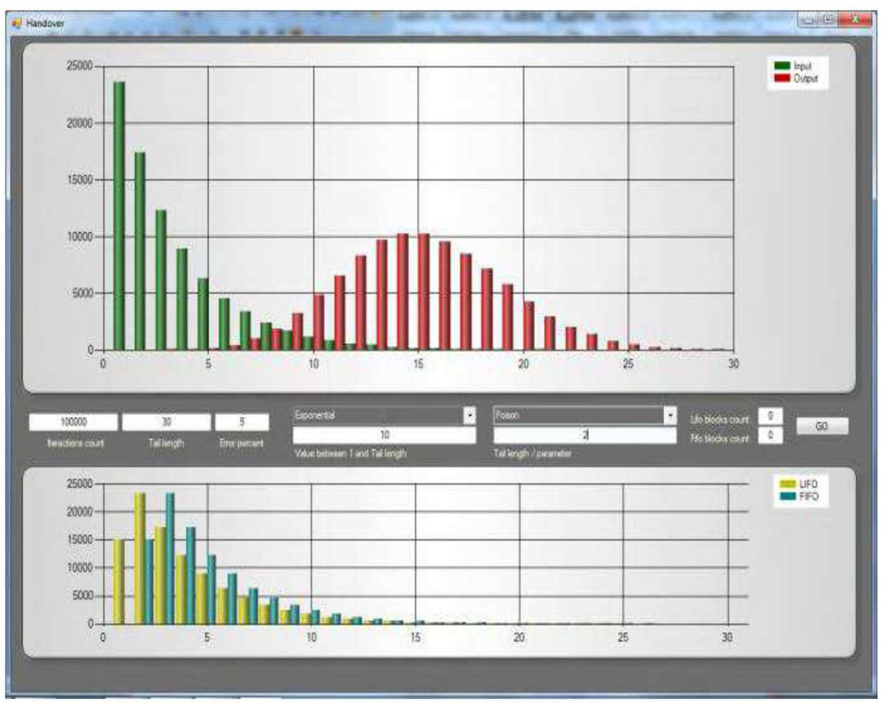
Again, the assumptions about erlang and geometric distributions are made again.

3. Program Realization

The program for Simulation of Rare events in teletraffic systems with single queue is made with the *.NET* Framework, because it is the way that programming will be done on a Microsoft machine from now. And not just on a Microsoft machine. The *ADO.NET* is used for creating web site, and for manipulating databases. This framework create applications for mobile phones and *PDA's* with *.NET*. There is even a project in the making that allow to write a programme on a Windows machine that will then work on a computer *NOT* running Windows. All this is made possible with the *.NET* Framework.



(a)



(b)

Figure 3. Program realization: simulation of rare events in teletraffic systems

The *.NET* Framework is a whole lot of Classes (called Namespaces) and the technology to get those Classes to work. The main component is called the Common Language Runtime.. With *.NET*, more than 15 different programming languages can use the Common Language Runtime. One of these languages is, of course Visual Basic *.NET*. Another is *C#*. They can all use the Common Language Runtime because of something called the Intermediate Language.

One of the most important goal of the program is simulation of different disciplines of service.

The conceptual model for rare event simulation of single queue system starts with Random Number Generator. The *RNGs* are produced different lend of distributions, such as Uniform, Geometric, Paretto, Poisson and Exponential. The distributions are used as arrival rate and service rate at single queue.

The simulation experiments are realized with different queues, with service discipline First In First Out (*FIFO*) and Last In First Out (*LIFO*). Parameters for blocking probability and packet loss are investigated. With the help of Iterations Generator are made simulations for each of queues using different distributions. The received results are shown as diagrams.

The simulation of the three main types of queuing systems is made of the *AMD Athlon* (*tm*) II X2 250 Processor 3.00 *GHz* and 3 *GB RAM*, running 32-*bits* operation system is Windows 7 Professional.

4. Simulation and Results

The simulation of the queuing systems were executed for single server queuing system $M/M/1/N$, $Geo/M/1/N$, $Pareto/M/1/N$ and $M/Geo/1/N$ *FIFO* and *LIFO* as a part of simulation system., error 5% or 10%. The purpose of relative error is to investigate occurred rare event in different systems.

Consider system $M/M/1/N$ with $N = 20$, 30 and 40 place for service in the queue, discipline of service is *FIFO* and *LIFO*, where the arrival and service rate is exponential and Poisson distributed.

The simulation of the buffer content is made for 100 000 observation. The increasing of arrival rate leads to insignificant increasing of rare events. We choose arrival and service rate, to receive appropriate result. As is seen from Table I, rare events in system with *LIFO* are less than the same system with the same parameters *FIFO*.

N	RE, %	Discipline of service	Arrival rate	Service rate	Trials	Rare events
20	5	LIFO	15	5	100000	2
		FIFO	15	5	100000	5
	10	LIFO	15	5	100000	5
		FIFO	15	5	100000	6
30	5	LIFO	15	5	100000	0
		FIFO	15	5	100000	2
	10	LIFO	15	5	100000	3
		FIFO	15	5	100000	4
40	5	LIFO	15	5	100000	1
		FIFO	15	5	100000	2
	10	LIFO	15	5	100000	3
		FIFO	15	5	100000	3

Table 1. Simulation of Rare Events in $M/M/1/N$ System

The system *Geo*/*M*/1/*N* with $p = 0{,}1$ is shown on Table 2. The simulation was used to receive representative and stable results with sequences of 100 000 observations.

N	RE, %	Discipline of service	Arrival rate	Service rate	Trials	Rare events
20	5	LIFO	0,1	5	100000	0
		FIFO	0,1	5	100000	3
	10	LIFO	0,1	5	100000	2
		FIFO	0,1	5	100000	4
30	5	LIFO	0,1	5	100000	0
		FIFO	0,1	5	100000	0
	10	LIFO	0,1	5	100000	1
		FIFO	0,1	5	100000	1
40	5	LIFO	0,1	5	100000	0
		FIFO	0,1	5	100000	0
	10	LIFO	0,1	5	100000	1
		FIFO	0,1	5	100000	2

Table 2. Simulation of Rare Events in *Geo*/*M*/1/*N* System

N	RE, %	Discipline of service	Arrival rate	Service rate	Trials	Rare events
20	5	LIFO	10	0,9	100000	6
		FIFO	10	0,9	100000	8
	10	LIFO	10	0,9	100000	10
		FIFO	10	0,9	100000	16
30	5	LIFO	10	0,9	100000	5
		FIFO	10	0,9	100000	7
	10	LIFO	10	0,9	100000	5
		FIFO	10	0,9	100000	7
40	5	LIFO	10	0,9	100000	1
		FIFO	10	0,9	100000	3
	10	LIFO	10	0,9	100000	6
		FIFO	10	0,9	100000	9

Table 3. Simulation of Rare Events in *M*/*Geo*/1/*N* System

The same simulation is made for *M*/*Geo*/1/*N* queuing systems with exponential characteristics of arrival rate and geometric service rate, the received results for buffer size 20, 30 and 40, are presented on Table 3. The prescribed error is in the range of 5% and 10%. The number of simulation samples is $n = 100\,000$.

N	RE, %	Discipline of service	Arrival rate	Service rate	Trials	Rare events
20	5	LIFO	0,3	0,8	100000	0
		FIFO	0,3	0,8	100000	1
	10	LIFO	0,3	0,8	100000	1
		FIFO	0,3	0,8	100000	1
30	5	LIFO	0,3	0,8	100000	1
		FIFO	0,3	0,8	100000	1
	10	LIFO	0,3	0,8	100000	0
		FIFO	0,3	0,8	100000	0
40	5	LIFO	0,3	0,8	100000	0
		FIFO	0,3	0,8	100000	0
	10	LIFO	0,3	0,8	100000	1
		FIFO	0,3	0,8	100000	1

Table 4. Simulation of Rare Events in *Geo*/*Geo*/1/*N* System

The same simulation is made for Geo/Geo/1/N queuing systems with geometric characteristics of arrival rate and geometric service rate, the received results for buffer size 20, 30 and 40, are presented on Table IV. The prescribed error is in the range of 5% and 10%. The number of simulation samples is n=100 000. The main difference here is the absence of rare events for 100 000 trials, for some of the chosen parameters.

5. Conclusions and Future Work

Simulation of rare events in different teletraffic systems is the target of program realization. The number of rare events defines the simulation probability of blocking different network systems.

The simulation results for the basic reference model, single server queuing system *M*/*M*/1/*N* with *FIFO* and *LIFO* service disciplines, *M*/[*X*]/1/*N*, [*X*]/*M*/1/*N*, and [*X*]/[*X*]/1/*N* systems with a finite buffer size *N*, are very good. The results for the *M*/[*X*]/1/*N*, [*X*]/*M*/1/*N* and [*X*]/[*X*]/1/*N* systems shows that the prescribed error is in the range of 5% and 10%, where the number of simulation samples is *n*=100 000.

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