Journal of Engineering Science and Technology Review
Special Issue on Telecommunications, Informatics, Energy and Management 2019

Conference Article

JOURNAL OF
Engineering Science and Technology Review

www.jestr.org

Defining Significant Parameters in Teletraffic Systems

Elena Ivanova[1], Teodor Iliev[1], Ivailo Stoyanov[2], Grigor Mihaylov[3] and Dimitar Radev[3]

[1]*University of Ruse, Department of Telecommunication, Ruse, Bulgaria*
[2]*University of Ruse, Department of Electrical Power Engineering, Ruse, Bulgaria*
[3]*University of Telecommunications and Posts, Sofia, Bulgaria*

Received 26 September 2019; Accepted 25 February 2020

Abstract

The world in which we live requires ever more rapid introduction of new technologies. The Internet of things is everywhere, in each field of life and business. Technological time for validation of new systems is reduced, so simulation acceleration methods are increasingly needed. The method for defining significant parameters with the RESTART method in the different teletraffic systems will result in lowering the entire technology validation process needed to deliver the final product. The defining of significant parameters in teletraffic systems will speed up simulations.
The systems of new generation are interested in the modelling and performance evaluation of single communication links, networks of queue but and more devices in the whole network. The blocking probability in each point is very important part of studying the systems. Typically, the performance of the whole network containing many links working in parallel or in tandem and interfering with each other is of primary interest. Modeling and simulation implemented in resource management issues, prioriting, interaction and network loading by several types of traffic sources, etc.

Keywords: RESTART/LRE; rare events; blocking probability; teletraffic systems.

1. Introduction

The technological time for validation of new systems is not enough, so simulation acceleration methods are increasingly needed. The method for defining significant parameters with the RESTART/LRE method in the different teletraffic systems will result in lowering the entire technology validation process needed to deliver the final product.

The choosen method for simulation in this analysis is done with one of the most usual splitting methods RESTART, combined with LRE (Limited Relative Error) [1, 2, 3]. The RESTART method is using algorithm with splitting, the chain is splitted when reach the treshold. One of the chains is saved as the original for that level. When any of those copies hits that same level downward, if it is the original one, it continues its path [4].

The method is recursive, and implemented in a depth-first fashion, as follows: there is a split, the non-original copies are simulated completely continuously. After this the simulation process continues for the original chain [5, 6].

RESTART means to split the allowed range of values of λ into regions with the necessary importance for the algorithm. The chosen set of thresholds is marked with L_i, i=0, 1, 2, ..., m. The evaluated system reaches the state L_0, while evaluating the first interval [0, L_0] the system states are saved. When the values for the zero interval are chosen at the time t_0, the simulation restarts from one of the saved states at threshold L_0, that is the reason of naming the algorithm with this name. When the threshold L_0 would be crossed then a restart is started again: one of the saved states is randomly chosen and the system is reloaded with this state. One of the significant choices for the threshold is the parameter of the teletraffic system- customers in the queue. The algorithm is described in details in previous articles [7].

The systems of new generation are interested in the modelling and performance evaluation of single communication links as variation of [M]/[X]/1/N, [X]/[M]/1/N and [X]/[X]/1/N systems, but and combination of network devices in the whole network. The blocking probability in each point is very important part of studying the systems. Typically, the performance of the whole network containing many links working in parallel or in sequence and interfering with each other is of primary interest. This simulation allows the modelling of various resource management issues, ad-mission of system users with different priority, interaction and network loading by several types of traffic sources, etc. [8]

2. Defining the significant parameters

The aim of our research is to recommend significant parameters for the systems and parameters of RESTART/LRE algorithm. The analyzed parameters, which may impact to the simulation results, are:

* E-mail address: tiliev@uni-ruse.bg
ISSN: 1791-2377

- RE relative error;
- *L* number of splitting levels or thresholds;
- *n* number of statistical sample.

The method for defining the significant parameters starts with simulations with M/M/1/N queuing systems, because it was necessary to compare analytical and simulation results, to prove and validate the new results.

We used the multifactor regression analysis and correlation matrix [9], because of defining the impact of parameters on investigated value/parameter – simulation blocking rate [9, 10, 11]. The purpose of conducted simulation studies is to determine the parameters, which accelerate the receiving fastes results of the simulation process for various teletraffic systems.

Initially in investigation methodology are conducted a lot of simulation in order to find out an area with rare events. Sometimes the size of the statistical sample exceeds 1 000 000.

The study algorithm is structured according to type of system in focus. Initial studies are heuristic. The steps of the methodology for those simulation experiments of the RESTART/LRE algorithm and different teletraffic systems, are:

- Calculation of the number of required experiments;
- Intuitive experiments are part of experiments;
- Analytical probabilities for occurring of rare event are calculated in systems, where analytical results can be obtained;
- Experiments with different teletraffic system and their parameters and algorithm RESTART, combined with LRE are conducted
- Experimental and analytical results, along with set parameters should be inputted in software package Statistica v10, in order to obtain:
    - ✓ Correlation matrix for optional parameters against blocking probability;
    - ✓ Multifactor regression analysis for all variable parameters.

Simulation experiments are evaluated statistically with correlation matrix, in order to be verified if there's linear relation between parameters and the evaluation of the correct application of multifactor regression analysis. Correlational matrix for the chosen system is calculated, after the important proof that the parameters of the system and the algorithm are without linear dependence. The values of these parameters don't have such a linear correlation, because the correlation index is not bigger then 0.9.

In dependence of the significance of the conducted experiments, a simulation is continued, through which the area with optimal parameters for RESTART applying in the investigated teletraffic system is specified.

Multifactor regression analysis is applied with variation of investigated parameters for different systems. It is important to be mentioned that the Fisher coefficient along with Steward's criterion is calculated [3]. One of the steps is validation of significant parameters of the RESTART/LRE algorithm for such a system is multifunctional regression analysis. The analysis defines which parameters will have significant influence of final results.

Finally, the speed up algorithm combined with methods of determining the significant parameters is part of the fastest research methods for minimalizing the errors, the blockings and the costs till the end user.

3. Defining significant parameters for different teletraffic systems

3.1 Teletraffic system for single queue

The investigated queuing models are with various distribution functions. 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 realization of the algorithm is made for real 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 [5, 10, 12].

The classical, calculated and predictive teletraffic model for rare event simulation is the single server queuing system M/M/1/N- FIFO with a finite buffer size *N*. The usual parameters for the arrival rate is λ and the service rate is μ.

[X]/M/1/N

The started investigated model for the 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 differential distribution laws (fig. 1).

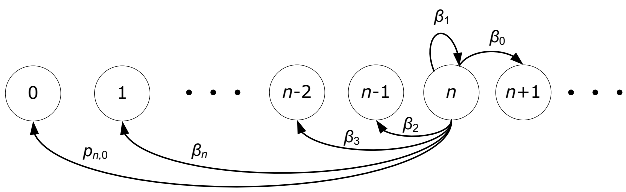

Fig. 1. Queuing system G/M/1

The service rate is exponential $1/\mu$. The intersiting part of investigation is 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 clients in the buffer are *B=N+1*, and the load is $\rho = \frac{\lambda(i,x)}{\mu} < 1$. The DRV (Discrete Random Variable) is given with stationary complementary distribution function (*c.d.f.*) *G(x)=1-F(x)* the loss probability P_B *(1)* and the local correlation coefficient Cor_i (2) for the interval $i\text{-}1 \le x < i$, $i=1,\ldots,k$. [13, 14]

Teletraffic system (Geo/M/1/N) with semi-markov arrival rate and a logarithmic geometric distribution for which the rare event simulation depends on:

- The number of thresholds *L*;
- The rate of arrival geometric distribution λ.

M/[X]/1/N

Another investigated model for RESTART/LRE simulation is the teletraffic 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 (fig. 2). 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).

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

The service rate is (2).

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

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

The efficiency of the simulation is demonstrated by comparing with analytical results for the probability of blocking. An analytically calculated teletraffic system with arrival and service rates with limited queue capacity. An accelerated simulation was applied in a teletraffic system with a Markov arrival rate, as a result of which the basic parameters depending the simulation probability of queue overflow were established:

- The load of the system ρ.
- Number of statistical sample n;

[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 β=t, the inter-arrival distribution is ERL(α,β), with deterministic process of service D. The arrival rate is determined with (3).

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

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

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

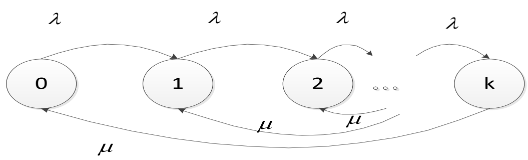

Fig. 2 Queuing system Erl/D/1/k

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

Teletraffic system of type [X]/[X]/1/N, where the distribution of arrival rate is Pareto, is serviced with a geometric distribution, where the parameters determining the significant parameters for the simulation are:

- The length of queue N;
- Number of statistical sample n.

Different teletraffic systems with semi-Markov and Markov distribution laws were studied, with the parameters resulting in high efficiency of the proposed algorithm.

3.2 Teletraffic system for tandem queue

It is normal in real systems, to be used tandems of devices with different parameters and capacities, that's why the evaluated teletraffic network of queue is a complex model of teletraffic systems with two tandem queues. Again the software implementation allows to choose the distributions for arrival and service rates as Normal, Exponential, Pareto, Geometrical and Poisson (fig. 3). The Exponential and Poisson distributions are used for verifying the model and implemented algorithm RESTART/LRE for tandem queues [3, 6, 14].

The states in tandem queue typically could be arranged typically on a grid with as many dimensions as the number of queues. The coordinate shows the number of customers N in each queue. Every transition in this matrix is corresponding to a simple event in the queuing model: an arrival or a service completion at one of the queues. For convenience, in the article will be called "transition events". It is important to be specified, that these transition events are defined independently of the state; i.e., there is only one transition event for a service completion at a given queue, and this single transition event corresponds to a transition out of every state in the DTMC, in which this particular queue is non-empty.

It is obvious that not all transition events are "enabled" in every state: e.g., in a state where a particular queue is empty, the service completion event of that particular queue is not possible, i.e., not enabled.

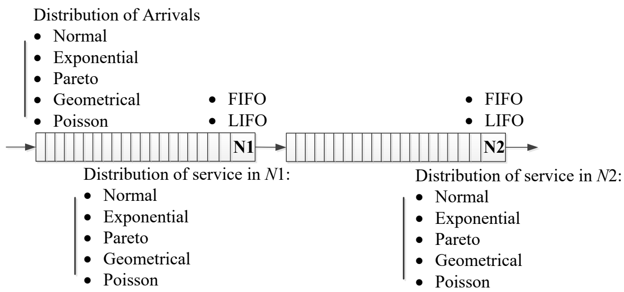

Fig. 3. Two-queue tandem network

The teletraffic system which is simulated with two tandem queues. First queue in the whole system is Geo/Geo/1/N and the second - Geo/M/1/N (fig.3).

The received and analysed data after methodology of statistical experiments define parameters with highest impact as:

- The length of the first queue N_1 and the second N_2;
- Intensity of service rate in second queue μ_2.

3.2 Teletraffic system for parallel queue

After single server systems, let consider a complex model of teletraffic systems with more then one queue- two parallel queues, non-priority classes of arrivals, buffer capacity is N, LIFO or FIFO service. Arrival and service distributions are made to be chosen as Normal, Exponential, Pareto, Geometrical and Poisson (fig. 4) [6].

The result of simulation for reaching rare events in the simulated system is gained by increasing:

- Length of queue *N*;
- Number of thresholds *L*.

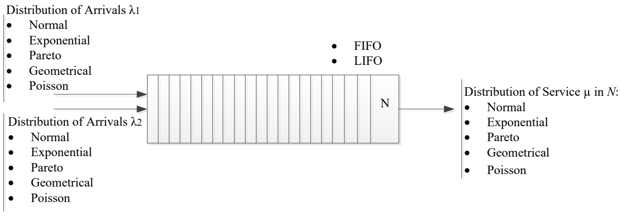

Fig. 4. Two parallel queues

The used logarithmic geometric distribution as incoming regulation for two parallel incoming flows with assigned priorities for service leads to the results, after applying multiple simulation experiments:

- Number of thresholds *L*;
- Size of the statistical sample *n*.

3.4 Teletraffic system for handover

The mobile networks of today's are with heterogeneous types of IP traffic. Thus the handover model keeps its multimedia character [5, 9]. This suggests the presence of two queues in traffic handover in real time with length M_R and for delayed traffic with length M_N (fig. 5). In offered model, the channels in mobile station, which are *N* in number, tackle with two levels of priority [15]. The thresholds of these levels are defined as:

- N_C is the maximum number of channels, which can be used by the new data requests;
- N_N is the maximum number of channels, which can be used by the new voice requests;

New requests are served with intensity - μ. Streams from new requests are set with intensity λ, which has Markov character. Simulation experiments are conducted with size of statistical example more than 1000000 iterations in order to estimate the area for rare events, to find out necessary ratios between sizes of priority channels and sizes of queues in unchangeable intensities of input and serving streams. Important parameters, which impact on effective simulation acceleration are *L* and N_N.

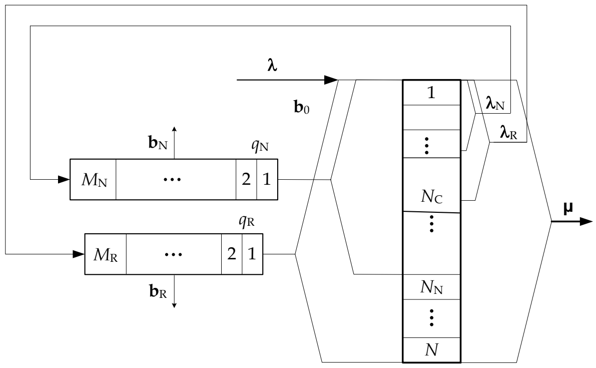

Fig. 5. Teletraffic model of handover with priority channel division and two types of arrivals

4. Conclusions

The factors that can affect the efficiency of RESTART/LRE are reviewed. The aim has focused on the most critical one when the method is applied to different teletraffic systems as single queue, the networks of queue: tandem, parallel, and the model of handover, because of the necessary of verify a simulation method using reference queuing models, whose relevant properties are described by analytically derived formulas.

Conducted simulations, compared with analytical probabilistic parameters, prove that RE has not significantly impacted the simulation probability.

Acknowledgements

This work is also partially supported by: Science Fund of University of Telecommunications and Post, Sofia, Bulgaria under Grant NID-17/26.03.2019 "Establishment of advanced security system for the needs of University of Telecommunications and Post".

.

References

1. M. Garvels, The splitting method in rare event simulation. PhD thesis, University of Twente, 175 p., 2000
2. M. Garvels and D. Kroese, A Comparison of RESTART Implementations, University of Twente, Centre for Telematics and Information Technology, 2005
3. C. Görg and F. Schreiber, "The RESTART/LRE method for rare event simulation", Proceedings of the 28th conference on Winter simulation, , December 08-11, 1996, Coronado, California, United States, p.390-397
4. G. Georgiev, I. Balabanova, S. Kostadinova, R. Dimova, "Structure Synthesis of ANFIS Classifier for Teletraffic System Resources Identification", 2016 IEEE International Black Sea Conference on Communications and Networking (BlackSeaCom), Varna, Bulgaria, 2016, p. 1-5
5. E. Ivanova, R. Raev and D. Radev. "Simulation of Rare Events in Teletraffic Systems with Single Queue", ICEST, Veliko Tarnovo, 2012
6. V. Iversen, Teletraffic engineering and network planning, Technical University of Denmark, 382 p., 2015
7. E. Ivanova: Modelling of Traffic in Broadband Convergence Networks, PhD Thesis, University of Ruse Press, Ruse, 156 p., 2013
8. Ivanova E., T. Iliev, Gr. Mihaylov, R. Rashkov, "Significant Simulation Parameters for RESTART/LRE Method in Teletraffic Systems of Network of Queues", Advances in Intelligent Systems and Computing, Springer, Volume 466, Automation Control Theory Perspectives in Intelligent Systems, 2016, pp. 325-336, DOI: https://doi.org/10.1007/978-3-319-33389-2_31
9. A. Mitkov, Theory of experiments, University of Ruse Press, Ruse, 226 p., 2010,
10. D. Radev, "Modelling of Rare Events in Broadband Digital Networks", Kolbis, Sofia 2006. (in bulgarian)
11. M. Vill´en-Altamirano and J. Vill´en-Altamirano, "Analysis of RESTART simulation: theoretical basis and Sensitivity study". European Transactions on Telecommunications 13 (4) 373, 2002

12. D. Radev, Teletraffic engineering, University of Ruse Press, Ruse. 146 p., 2012. (in bulgarian)
13. E. Ivanova, T. Iliev, G. Mihaylov, V. Keseev, I. Stoyanov Significant Simulation Parameters for RESTART/LRE Method in Teletraffic Systems of Ultra Broadband Convergence Networks. Advances in Intelligent Systems and Computing, vol 860. Springer, 2019, pp. 69-77, DOI: https://doi.org/10.1007/978-3-030-00184-1_7
14. E. Ivanova, T. Iliev, G. Mihaylov, V. Keseev, I. Stoyanov, Significant Simulation Parameters for RESTART/LRE Method in Teletraffic Systems of SDN. Lecture Notes in Networks and Systems, vol 68. Springer, 2019, pp. 265-273, DOI: https://doi.org/10.1007/978-3-030-12450-2_25
15. P. T. Nguyen, Hong Anh Le, Thomas Zinner, "A Context-Aware Traffic Engineering Model for Software-Defined Networks", Proceedings of the International Conference on Nature of Computation and Communication ICTCC 2014: Nature of Computation and Communication. November, 2014, Ho Chi Minh, Vietnam, pp 73-82