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DISTRIBUTED COMPUTER AND COMMUNICATION NETWORKS: CONTROL, COMPUTATION, COMMUNICATIONS

DCCN
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PROCEEDINGS
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MOSCOW
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ISBN 978-5-94836-491-9

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Российская академия наук (РАН)
Институт проблем управления им. В.А. Трапезникова РАН (ИПУ РАН)
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Научно-производственное объединение
«Информационные и сетевые технологии» («ИНСЕТ»)

РАСПРЕДЕЛЕННЫЕ КОМПЬЮТЕРНЫЕ И ТЕЛЕКОММУНИКАЦИОННЫЕ СЕТИ: УПРАВЛЕНИЕ, ВЫЧИСЛЕНИЕ, СВЯЗЬ

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МАТЕРИАЛЫ ДВАДЦАТОЙ МЕЖДУНАРОДНОЙ НАУЧНОЙ КОНФЕРЕНЦИИ
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МОСКВА
ТЕХНОСФЕРА
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УДК 004.7:004.4].001:621.391:007
ББК 32.973.202:32.968
Р 24

Распределенные компьютерные и телекоммуникационные сети: управление, вычисление, связь (DCCN-2017) = Distributed computer and communication networks: control, computation, communications (DCCN-2017) : материалы Двадцатой междунар. науч. конфер., 25–29 сент. 2017 г., Москва: / Ин-т проблем упр. им. В.А. Трапезникова Рос. акад. наук; под общ. ред. В.М. Вишневского. – М.: ТЕХНОСФЕРА, 2017. – 666 с. – ISBN 978-5-94836-491-9.

В научном издании представлены материалы Двадцатой международной научной конференции «Распределенные компьютерные и телекоммуникационные сети: управление, вычисление, связь» по следующим направлениям:

- архитектура и топология компьютерных сетей: управление, проектирование, оптимизация, маршрутизация, резервирование ресурсов;
- аналитическое и имитационное моделирование инфокоммуникационных систем, оценка производительности и качества обслуживания;
- технологии беспроводных сетей сантиметрового и миллиметрового диапазона радиоволн: локальные и сотовые сети 4G/5G;
- RFID-технологии и сенсорные сети;
- приложения распределенных информационных систем: Интернет вещей, анализ больших данных, интеллектуальные транспортные сети;
- распределенные системы и облачные вычисления, программно-определяемые сети, виртуализация;
- вероятностные и статистические модели в информационных системах;
- теория очередей, теория надежности и их приложения в компьютерных сетях;
- высотные беспилотные платформы и летательные аппараты: управление, передача данных, приложения.

В материалах конференции DCCN-2017, подготовленных к выпуску Козыревым Д.В., обсуждены перспективы развития и сотрудничества в этой сфере.
Сборник материалов конференции предназначен для научных работников и специалистов в области теории и практики построения компьютерных и телекоммуникационных сетей.

Текст воспроизводится в том виде,
в котором представлен авторами

Утверждено к печати Программным комитетом конференции

ISBN 978-5-94836-491-9

UDC 004.4

Simulation of finite-source retrial queueing systems with collisions and non-reliable server

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Abstract. The aim of the present paper is to build a simulation program to investigate finite-source retrial queuing system with collision of the customers where the server is subject to random breakdowns and repairs depending on whether it is idle or busy. All the random variables involved in the model construction are assumed to be independent and generally distributed. The novelty of the investigation is to carry sensitivity analysis of the performance measures using various distributions. Several figures show the effect of different distributions on the performance measures such as mean and variance of number of customers in the system, mean and variance of response time, mean and variance of time a customer spent in service, mean and variance of sojourn time in the orbit.

Keywords: simulation, sensitivity analysis, finite-source queuing system, closed queuing system, collision, unreliable server, retrial queue.

1. Introduction

Retrial queues have been commonly used to depict many real situations emerging in telephone switching systems, telecommunication networks, computer networks and computer systems, call centers, wireless communication systems, etc. In many practical situations it is important to bear in mind that the rate of generation of new calls decreases as the number of customers in the system increases. This can be achieved with the use of finite-source, or quasi-random input models. Retrial queues with quasi-random input are recent interest in modeling cellular mobile networks, computer networks and local-area networks with random access protocols, and with multiple-access protocols, see, for example, [6], [7]. In practice a few components of the system are prone to random breakdowns so it is important to study reliability of retrial queues with server breakdowns and repairs. Due to this it has a heavy influence on the performance measures of the system. Finite-source retrial queues with unreliable server have been investigated in several recent papers for example, [1], [2], [3], [4], [5].

In many cases including data transmission from disparate sources there is a possibility to be conflict for a limited number of channels or other facilities. Several sources launching uncoordinated attempts can produce collisions leading to the loss of the transmission and consequently the necessity for retransmission. An essential matter is to develop workable procedures for allaying the conflict and corresponding message delay. There have been recent results on retrial queues with collision in [8], [9].

The aim of the present paper is to investigate such systems with unreliable server which are finite source, and collisions can take place. In this paper we build simulation models using SimPack, a collection of C/C++ libraries and executable programs for computer simulation [10], to receive the desired performance measures. In this collection various algorithms are supported connected with simulation including discrete event simulation, continuous simulation and combined (multi-model) simulation. The novelty of this work is to provide sensitivity analysis using various distributions.

2. System model

Let us consider a finite source retrial queueing system in which the number of sources is denoted by N and each of them can generate request with rate λ/N, that is the source time is exponentially distributed with parameter λ/N. If a customer finds the server idle it enters into service instantly. The service times are supposed to be gamma distributed with parameter α and β. When the server is engaged with a request, an arriving (from the orbit or the source) customer evokes a collision with a customer under service and both requests are directed towards the orbit. From the orbit it retries to be served after an exponentially distributed time with parameter σ/N. It is supposed that the service unit fails after some time which is an exponentially distributed random variable with parameter γ_0 when it is busy and with parameter γ_1 when it is idle. Immediately upon the breakdown it is forwarded for repair and the restoration time is also exponentially distributed random variable with parameter γ_2. We suppose that when the server is unavailable every source is eligible to generate customers and sends it to the unit, and the customers from the orbit may retry to the server. Moreover, in this model we suppose that the interrupted request gets into the orbit instantaneously and all of its services are independent of each other. When the submission is successful, the requests go back to the source. All the random variables involved in the model construction are assumed to be independent of each other. Due to the page limitation in this paper deals with gamma distributed service time, however it should be mentioned that we have further results for non-exponentially distributed source, operating and repair times, too.

3. Simulation results

The following table shows the input parameters (see Table 1).

Table 1

Numerical values of model parameters

Case	**N**	λ/N	γ_0	γ_1	γ_2	σ/N	α	β
1	100	0.01	0.1	0.1	1	0.01	0.5	0.5
2	100	0.01	0.1	0.1	1	0.01	1	1
3	100	0.01	0.1	0.1	1	0.01	2	2

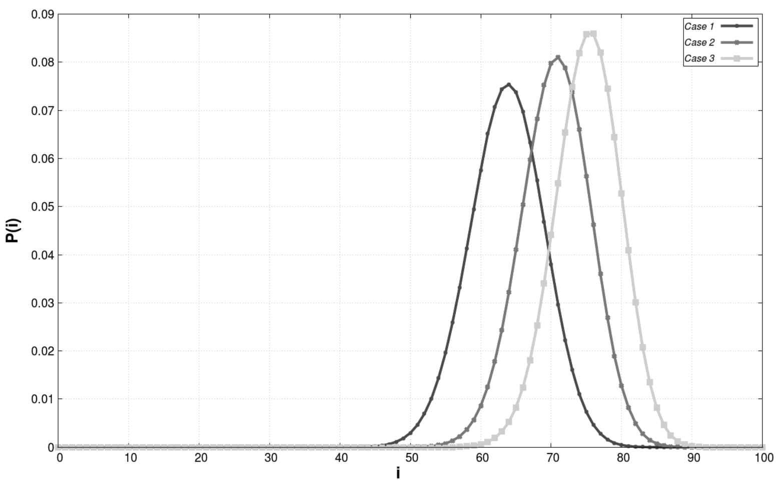

Figure 1. Comparison of steady-state distributions

Figure 1 shows the steady-state distribution of the three investigated cases. It is observed the mean number of customers increases as α and β are getting larger. Case 2 is a special case because when $\alpha = 1$ it represents the exponential distribution. From the shape of the curves it is clearly visible that the steady-state distribution of the cases are normally distributed. The next table presents the considered performance measures in relation with the different cases (see Table 2).

In Table 2 the notations mean the followings: $E(NS)$ and $D^2(NS)$ - mean number and variance of customers, $E(T)$ and $D^2(T)$ - mean and variance of response time, $E(W)$ and $D^2(W)$ - mean and variance of waiting time, $E(S)$ and $D^2(S)$ - mean and variance of successful service time, $E(IS)$ - mean interrupted service time.

Table 2

Numerical results

Case	E(NS)	$D^2(NS)$	E(T)	$D^2(T)$	E(W)	$D^2(W)$	E(S)	$D^2(S)$	E(IS)
1	63.6842	27.9734	175.3073	65657.3454	174.5884	65434.6696	0.3147	0.1979	0.4041
2	70.5912	24.3012	239.9734	105273.4267	238.9734	104918.6389	0.4784	0.2289	0.5217
3	75.1825	21.2439	302.8106	151781.1411	301.5377	151277.6006	0.6472	0.2095	0.6257

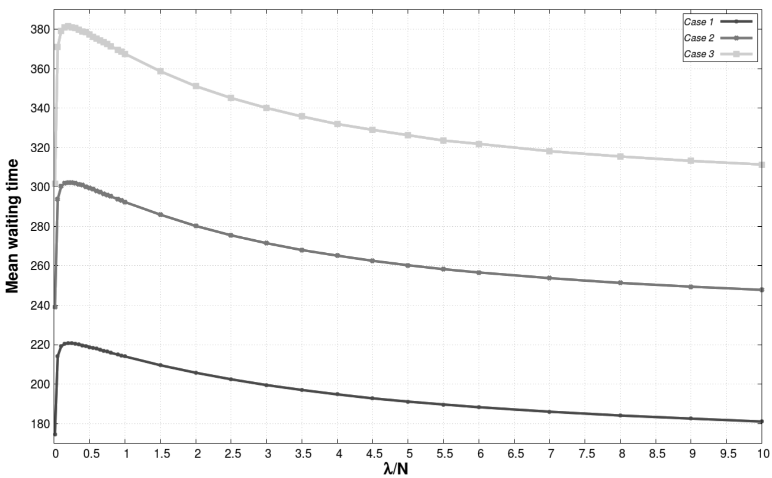

Figure 2. Mean waiting time vs. intensity of incoming customers

Figure 2 represents the conformation of mean waiting time. The same parameters are (see Table 1) used as in case of Figure 1 but here the running parameter is λ/N. As it is expected with the increment of λ/N mean waiting time increases as well but an interesting phenomenon is noticeable namely after λ/N is greater than 0.1 mean waiting time starts to decrease.

4. Conclusions

In this paper a finite-source retrial queueing model was introduced with unreliable server and the possibility of collision. We used SimPack to carry out stochastic simulation showing the effect of different distribution of service times on several main performance measures.

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