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This volume presents selected papers from the XIX International Conference named after A.F. Terpugov. The papers are devoted to new results in the following areas: queuing theory and its applications, data mining and visualization, information technology and software engineering, mathematical and computer modeling of technological processes.

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Some special features of finite-source retrial queues with collisions, an unreliable server and impatient customers in the orbit*

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Queuing systems with repeated calls may competently describe major telecommunication systems, such as telephone switching systems, call centers, CSMA-based wireless mesh networks in frame level. The main feature of a retrial queueing system is that customers remain in the system even if it is unable to find an idle service unit and after some random time it attempts to reach the service facility again. Impatience of the customers is a natural phenomenon and an interesting topic in queueing theory. The process of reneging and balking is extensively studied by many researchers for example in [1–3]. Whenever an arriving customer decides not to enter the system, which is called balking while reneging a customer in the system after waiting for some time leaves the system without being served. In our investigated model reneging customers are considered.

Speaking of communication systems where the available channels or other facilities are very limited thus users (sources) usually need to fight for these resources. This results in a high possibility of conflict because several sources may launch uncoordinated attempts producing collisions. In these cases the loss of transmission takes place and it is necessary to ensure the process of retransmission. So evolving efficient procedures for preventing conflict and corresponding message delay is essential. In case of a collision both calls, the one under service and the newly arriving one go to orbit. A review of results on finite-source retrial queues with collision and an unreliable server has been published in [5].

In many papers of retrial queueing literature, the service unit is assumed to be available steadily. But these assumptions are quite unrealistic because in real-life applications of these systems can break down, different types of

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problems can arise like a power outage, human error, or other failures. Various factors have effect on the transmission rate of the wireless channel in a wireless communication scenario and these are apt to suffer transmission failure, interruptions throughout transferring the packets. Investigating retrial queueing systems with random server breakdowns and repairs has great importance as the operation of non-reliable systems modifies system characteristics and performance measures. In this paper, we assume that in the case of a failure of the server, the request generation from the source continues, and calls go to orbit.

The novelty of this investigation is to carry out sensitivity analysis using different distributions of impatient calls on performance measures. Different Figures help to understand the special features of the system. The paper is a continuation of the works [4, 6].

Mathematical model

A retrial queueing system of type M/M/1//N is considered with a non-reliable server and impatient customers as Fig. 1 illustrates. In the finite-source, N customers reside and each of them can generate calls towards the server with rate λ/N so the inter-request time is exponential with parameter λ/N. A customer cannot generate a new call until the previous call returns to the source. Every incoming customer has an random impatience time which determines how much time the customer spends in the orbit without fulfilling its service requirement. Exceeding this time results that the customer no longer waits for the service unit and departs without being served properly.

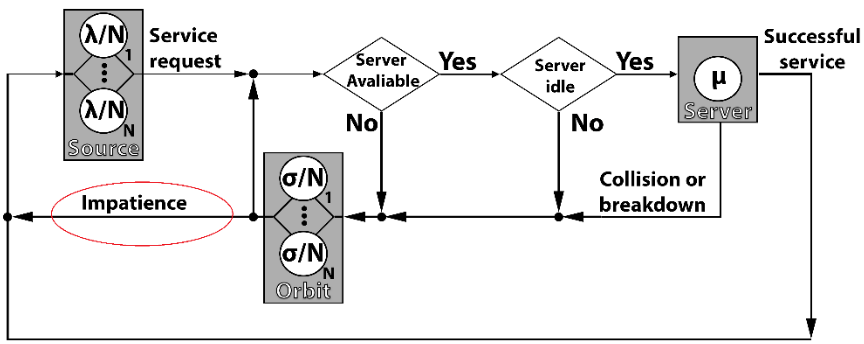

Fig. 1. Operational scheme of the system

This random time follows gamma, hypo-exponential, hyper-exponential, Pareto, and lognormal distribution with different parameters but with the same mean value. In absence of a waiting queue if an incoming customerfinds the server in an idle state its service starts immediately. The service times of the customers are exponentially distributed with parameter μ. After its successful service customers return to the source. Encountering the service unit in a busy state an arriving (primary or repeated) customer involves into collision with customer under service and they both move into the orbit. After an exponentially distributed time with parameter σ/N customers located in the orbit make another attempt to get into the service.

The server is not reliable so from time to time it is supposed to break down. The lifetime is assumed to be an exponentially distributed random variable with a different parameter depending on whether the server is idle or busy, that is γ_0 and γ_1, respectively. In other words, the probability of failure of the server is $\gamma_0 h + o(h)$, $\gamma_1 h + o(h)$ in any time interval $(t, t+h)$, respectively. The repair process starts immediately upon the breakdown that also follows an exponential distribution with parameter γ_2. If server failure takes place during the service of a customer then it is transferred to the orbit. The source, service, retrial, impatience, life, and repair times are supposed to be independent of each other.

We aim to examine how the different distributions of impatient calls have an effect on the performance measure when the mean and variance are equal, respectively. The parameters are chosen in such a way that the squared coefficient of variation would be either greater than one or less than one.

For comparison hyper-exponential, hypo-exponential, gamma, lognormal and Pareto distributions are utilized besides the case when the mean value is constant. Several Figures are generated to illustrate the effect of the type of distribution on some important performance measures.

Simulation examples

In this section, we give some simulation results with the following input parameters. The mean of the impatient time is 500 and the squared coefficient of variation is greater than one.

N	λ/N	γ_0	γ_1	γ_2	σ/N	μ
100	0.01	0.1	0.1	1	0.01	1

Figure 2 shows the comparison of steady-state distribution of number of customers. This distribution can be approximated by a normal distribution, as it was noticed in similar systems, see for example in [5]. However, this Figure displays the difference between the applied distributions. Although the shape of the curves is almost the same the average number of customers in the system varies a little bit especially in the case of Pareto distribution and when the average impatience of calls is constant the mean is more compared to the others.

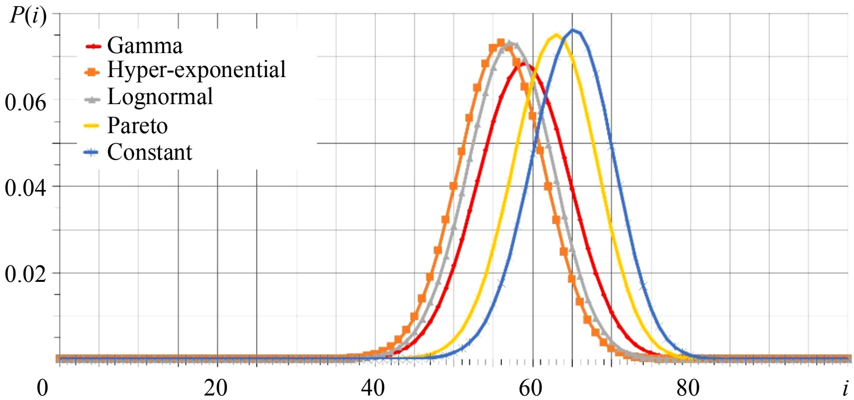

Fig. 2. Comparison of steady-state distributions

The mean response time of a successfully served customer, an impatient customer, and an arbitrary customer are shown in Figures 3 – 5, respectively in the function of arrival intensity. Of course, the mean response time of an arbitrary customer can be obtained with the help of the law of total expectation. The corresponding probabilities can be seen in Fig. 6. Interestingly, differences can be observed even though the first two moments are equal, especially in the case of the gamma distribution. Results clearly illustrate the effect of various distributions. We draw your attention to Fig. 4, where the mean waiting time of an impatient customer is much less than the average of the impatient time distribution that could have been expected.

Despite the increasing arrival intensity, the maximum property characteristic of a finite-source retrial queueing system occurs under suitable parameter settings.

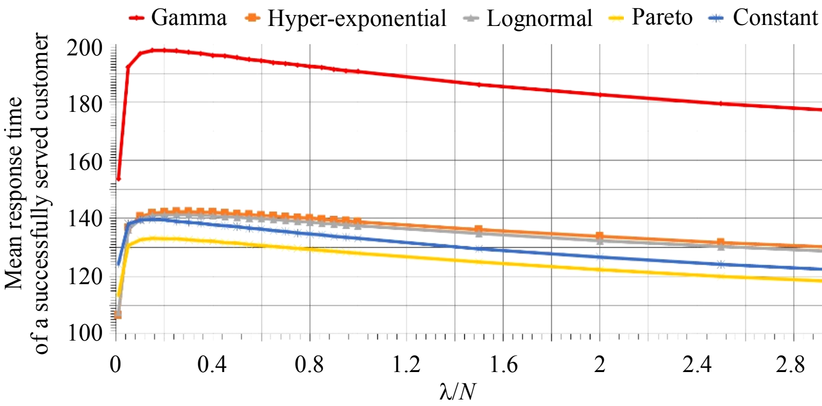

Fig. 3. Mean response time vs arrival intensity using various distributions

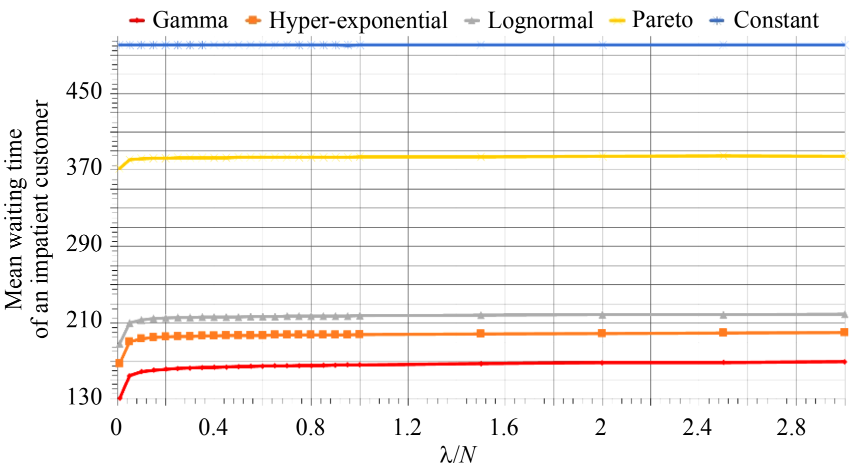

Fig. 4. Mean response time vs arrival intensity using various distributions

Figure 6 demonstrates how the probability of abandonment of a customer changes with the increment of the arrival intensity. By probability of abandonment, we mean the probability that a customer leaves the system without getting its full-service requirement (through the orbit). After a slow increase of the value of this performance measure, it stagnates which is true for every used distribution of impatience of calls but they differ significantly from each other. At gamma distribution, the tendency of leaving the system earlier is much higher than the others especially compared to at constant mean of impatience of calls. Here the disparity is much higher among the applied distributions compared to the previous figures.

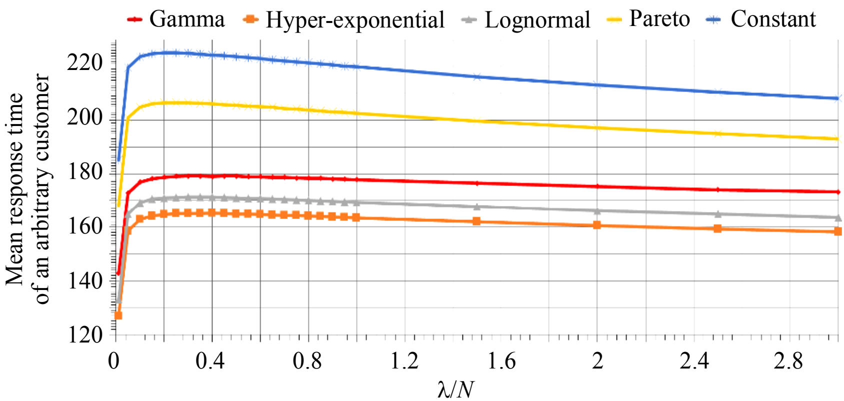

Fig. 5. Mean response time vs arrival intensity using various distributions

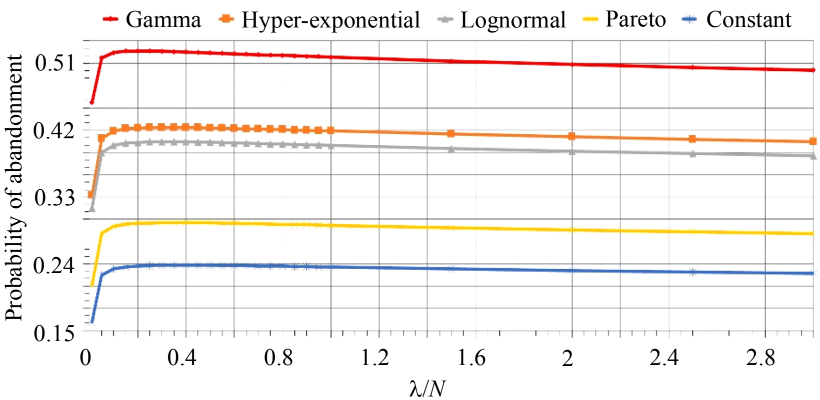

Fig. 6. Probability of abandonment of a customer vs arrival intensity using various distributions

The case when the squared coefficient of variation is less than one hopefully will be an investigation in the extended paper.

Conclusions

In this paper, a finite-source retrial queueing system was presented with a non-reliable server, collisions, and impatient customers in the orbit. The obtained results fully demonstrated how essential is the selection of distribution of impatient calls because it has a great influence on the system characteristics despite the fact that the mean and the variance are the same. Figures in connection with the probability of abandonment clearly assure this phenomenon. Results evidently indicated the distinction was noticeable and significant among the performance measures having the same mean and variance of different distributions when the squared coefficient of variation is greater than one. Soon, we would like to investigate the waiting time distribution of this system with help of asymptotic methods as N tends to infinity and that is the reason why we used rates λ/N and σ/N.

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