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Analysis of the results of the simulation model of the system information security in service networks

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Abstract. Information security systems (ISS) against unauthorized access (UA) are analyzed as mixed-type queuing systems (QS). An algorithm and simulation models for research have been developed. Experiments have been carried out, and results have been obtained that make it possible to construct ISS in queuing networks.

Keywords: *information security systems; protection mechanism; unauthorized access; queuing systems*

1. INTRODUCTION

This work is devoted to the study of the results of the simulation model of the ISS from unauthorized access (UA) in service networks. It is typical for systems with losses, with limited and unlimited buffer memory (BM) [1-3].

An analysis of literary sources, as well as the accumulated experience in the design and operation of a service network shows that the lack of information security in service networks ultimately causes huge losses incurred by corporations [4-6]. An analysis of various scientific works and materials on standardization on a global scale confirms that at present there is no unified system for assessing the security of information in the field of information security and the development of ISS [4-6].

Currently, there are a number of works [4-10], that allow us to partially overcome these difficulties, and at the same time, are an impetus for the development of experience in designing ISS. It should be noted that despite the appearance of these works and companies involved in information security in service networks, this problem has not been studied enough and therefore remains **relevant.**

Note that the presented work is one of the steps towards the creation of a unified system for assessing the security of information and the development of ISS.

In such networks, along with favorable, i.e. normal requests, there is the observed receipt of intentional UA requests for confidential information from illegal users and subsequent unwanted manipulations with this information, which is one of the most obvious reasons for the violation of the ISS [3-6]. In a network, when determining the degree of security, the main determining factor is the service network security class, which determines the set of protection mechanisms (PM) implemented in the network and effective information security protection in service networks [7,8].
The functioning of the PM is described by four possible states - serviceable, faulty, diagnosed, restored. As part of the ISS it can be a hardware or software part.

It should be noted that the PM, influencing the entire process of information security, can function in constant information interaction with other elements of the ISS. In the system, the possibility of some unfavorable event occurring, associated with the reliability characteristics of the PM entailing various kinds of losses, is considered a risk.

Note 1: Here, the approaches associated with the risk arising from the characteristics of the reliability of the PM are not considered in this case since it is assumed (as in [1-3]) that all PM are reliable.

2. STRUCTURE AND CHARACTERISTICS OF ISS

It is assumed that the provided ISS (Fig. 1) provides an opportunity to completely close, with the help of the protection system, all possible channels for the manifestation of threats by ensuring control over the transition of all UA requests through the PM, i.e. all input streams go through the PM for servicing. It should be noted that the considered ISS structure ensures maximum information security of service networks.

Note that this structure can function without buffer memory (i.e., a lossy system), with limited and unlimited buffer memory.

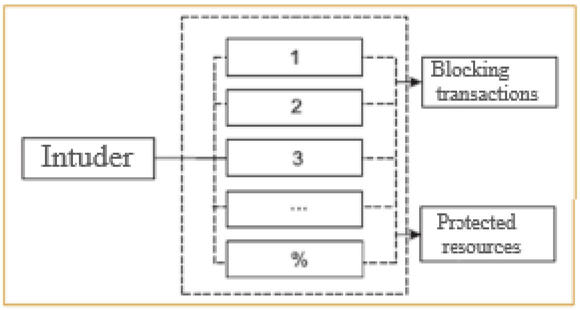

Fig.1. ISS structure

ISS from UA is a hardware and software complex that interacts with streams of random events that are caused by the actions of intruders, incorrect distribution of access rights, use of unauthorized software, and errors in software and hardware complexes of identification and authentication [1-3,8,9-12].

An intruder (intruder, UA requests) at the system input creates various threats with intensity λ .

If we consider the block of the intruder as a source of information and the PM as devices operating in parallel, then the ISS can be considered as a single-phase, multi-channel, mixed-type queuing system. ISS consists of N - the number of PM $\tau_0 = 1/\mu$ that carry out service delays where μ - the intensity of servicing requests for UA.

During maintenance, UA requests are screened out. In the ISS, with the help of the PM, detection with a certain probability and classification of UA attempts are performed, and the functions of blocking or skipping UA requests to protected resources are implemented. Missed (unrecognized) requests can harm protected resources. Protected resources do not perform independent access control functions.

The task of determining the optimal characteristics of the ISS [1-3]:

$$M\ [\mathrm{P}(\lambda,\mu,\mathrm{N})] \rightarrow \min$$

$$\text{when } \lambda \geq \lambda_0, \mu \geq \mu_0, N \geq N_0,$$
$$L_q \leq L^0$$

where M is the sign of the mathematical expectation, $P(\lambda,\mu,N)$ is the probability function of losing UA requests due to failure due to service system overload, L_q is the average value of the queue length, i.e. the value that determines the amount of buffer memory, $\lambda_0, \mu_0, N_0, L^0$ is admissible limit values.

3. ALGORITHM AND RESULTS OF ISS SIMULATION MODEL

To determine the characteristics of the ISS, allowing it to function within limited resources, it is assumed that the input information flow, i.e. UA requests are the simplest, and the service time is subject to exponential, constant and Erlang distribution laws. Adequately for the functioning of the ISS, an algorithm for the simulation model of the ISS has been developed with the following steps:

- In the considered systems, if one of the PM is free, then the UA request enters this free PM and the original UA stream is rarefied with certain probabilities and forms an output stream;
- In a system with losses, in the case of occupancy of all PM, the UA request is lost;
- In systems with limited and unlimited buffer memory, if all PM are occupied, the UA request waits in a queue in the system buffer memory until one of the PM is freed, if there is free space in the buffer memory. After the release of one of the PM, the UA request enters this free PM and, consequently, the original UA stream is rarefied with certain probabilities and forms an output stream..

On the basis of the developed algorithm in the GPSS World (General Purpose Simulation System) language, ISS models have been developed that allow you to $N=\overline{2,5}$ determine the following main characteristics during the simulation:

- number of transactions in PM (ENTRIES);
- average queue length (AVE.C);
- utilization factor MP (UTIL).

4. ANALYSIS OF THE RESULTS ISS SIMULATION MODELS

Based on the execution of the simulation model for the average values $\lambda = 1/3500$ $мс$ and $\mu = 1/1700$ $мс$ the results are obtained for the following cases:

- For ISS without buffer memory.

1.Receipts in the ISS and the service time of transactions are subject to an exponential distribution law.

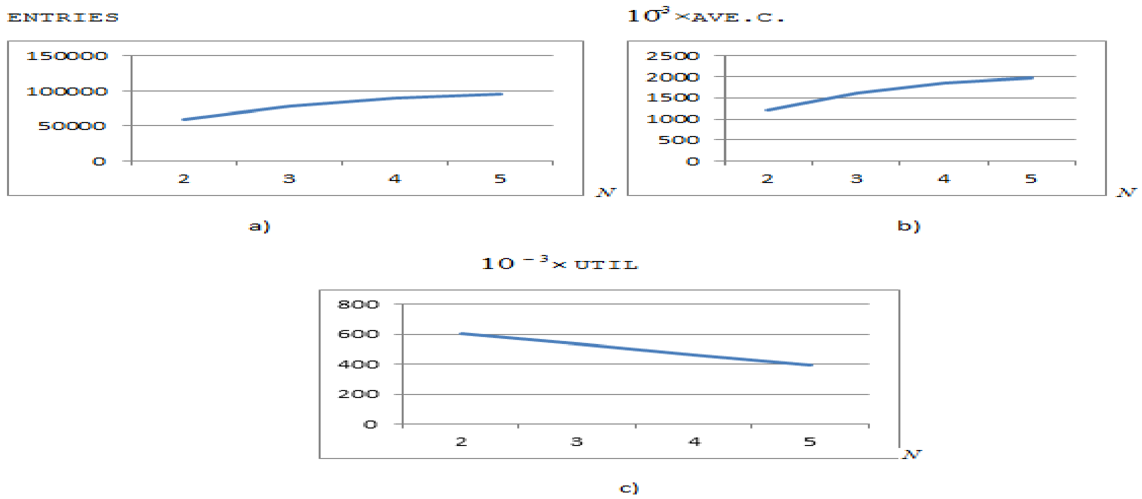

Fig.2. Dependence of the number of transactions in the PM (ENTRIES, Fig. 2a), the average queue length (AVE.C., Fig. 2b), the utilization rate of the PM (UTIL, Fig.2c) on the number of PM (N) during the simulation.

The results obtained in this case show that with an increase in the number of PM from 2 to 5:

- the number of transactions in the PM increases from 59271 to 95838;
- the average queue length increases from 1.215 to 1.986;
- the utilization factor decreases from 0.608 to 0.397.

2. The receipt of transactions in the ISS is subject to an exponential, and the service time to a uniform distribution law,

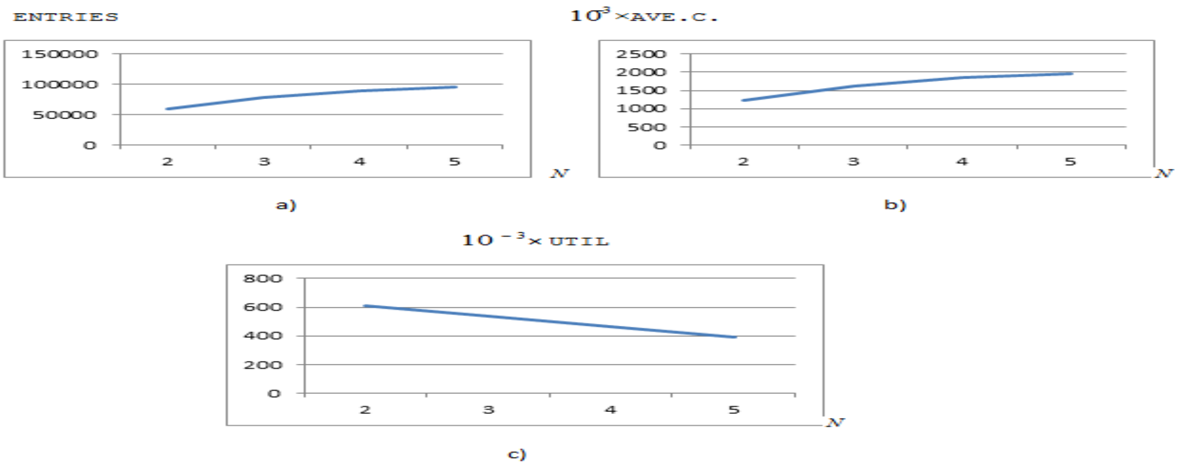

Fig. 3. Dependence of the number of transactions in the PM (ENTRIES, Fig. 3a), the average queue length (AVE.C., Fig. 3b), the utilization rate of the PM (UTIL, Fig.3c) on the number of PM (N) during the simulation.

The results obtained in this case show that with an increase in the number of PM from 2 to 5:
- the number of transactions in the PM increases from 59112 to 95965;
- the average queue length increases from 1.217 to 1.969;
- the utilization factor decreases from 0.609 to 0.394.

3. The receipt of **transactions in the ISS** obeys the exponential distribution law, and the service time obeys the **Erlang distribution** law.

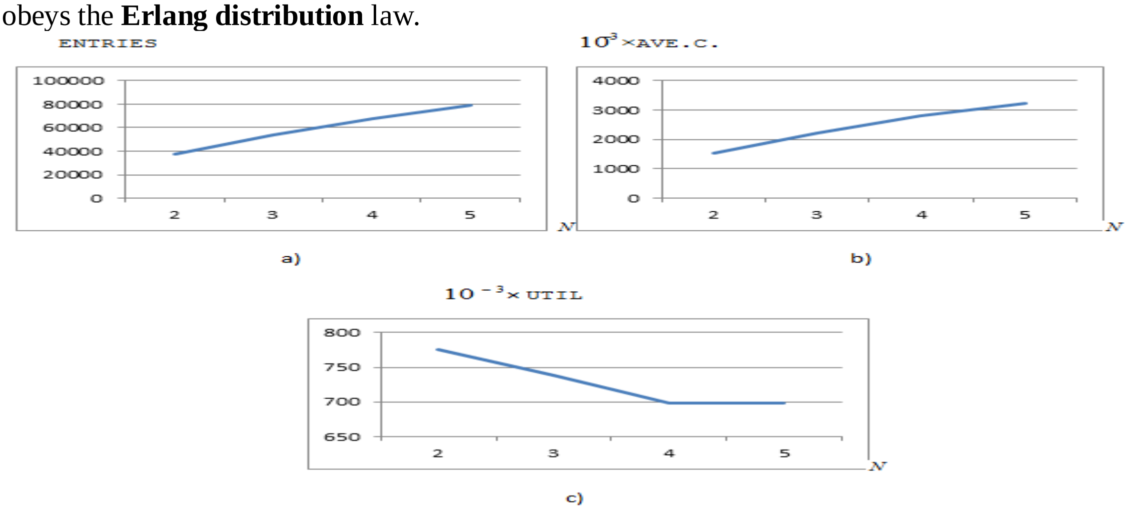

Fig. 4. Dependence of the number of transactions in the PM (ENTRIES, Fig. 4a), the average queue length (AVE.C., Fig. 4b), the utilization factor of the PM (UTIL, Fig.4c) on the number of PM (N) during the simulation.

The results obtained in this case show that with an increase in the number of PM from 2 to 5:
- the number of transactions in the PM increases from 37695 to 79317;
- the average queue length increases from 1.550 to 3.244;
- the utilization factor decreases from 0.775 to 0.649

- **For ISS with limited buffer memory;**

1. The receipts of transactions in the ISS and the service time are subject to an exponential distribution law.

The results obtained in this case show that with an increase in the number of PM from 2 to 5:
- the number of transactions in the PM increases from 90266 to 100002;
- the average queue length increases from 1.866 to 2.070;
- the utilization factor decreases from 0.933 to 0.414.

2. The receipts of transactions in the ISS are subject to an exponential, and the service time to a uniform distribution law,

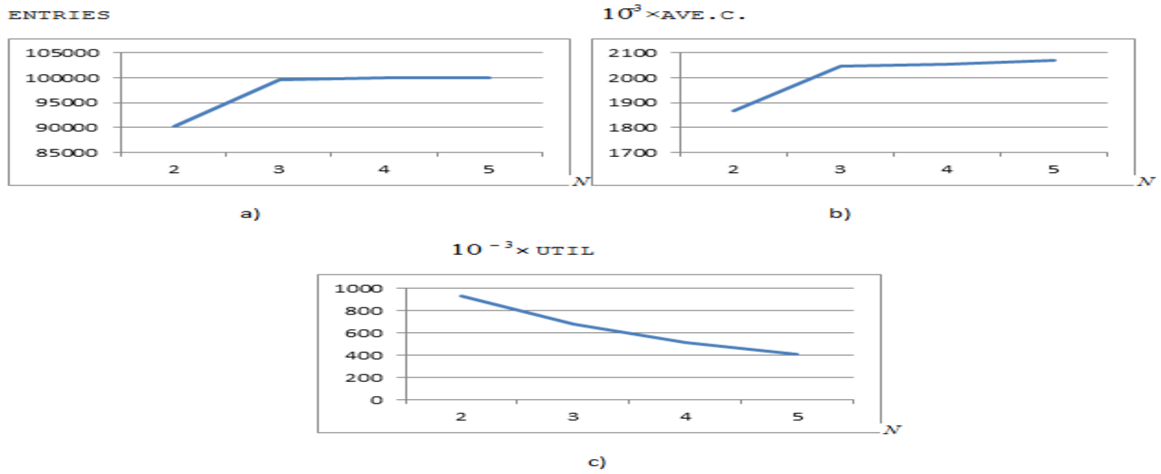

Fig.5. Dependence of the number of transactions in the PM (ENTRIES, Fig.5a), the average queue length (AVE.C., Fig.5b), the utilization rate of the PM (UTIL, Fig.5c) on the number of PM (N) during the simulation.

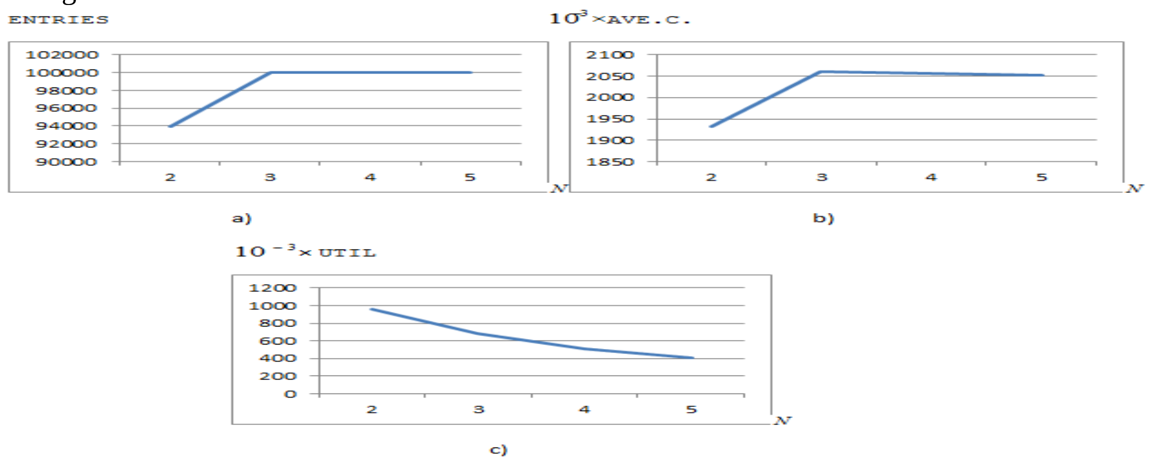

Fig.6. Dependence of the number of transactions in the PM (ENTRIES, Fig. 6a), the average queue length (AVE.C., Fig. 6b), the utilization factor of the PM (UTIL, Fig.6c) on the number of PM (N) during the simulation.

The results obtained in this case show that with an increase in the number of PM from 2 to 5:
- the number of transactions in the PM increases from 93912 to 100002;
- the average queue length increases from 1.932 to 2.053;
- the utilization factor decreases from 0.966 to 0.411.

3. The receipts of transactions in the ISS obey the exponential distribution law, and the service time obeys the Erlang distribution law.

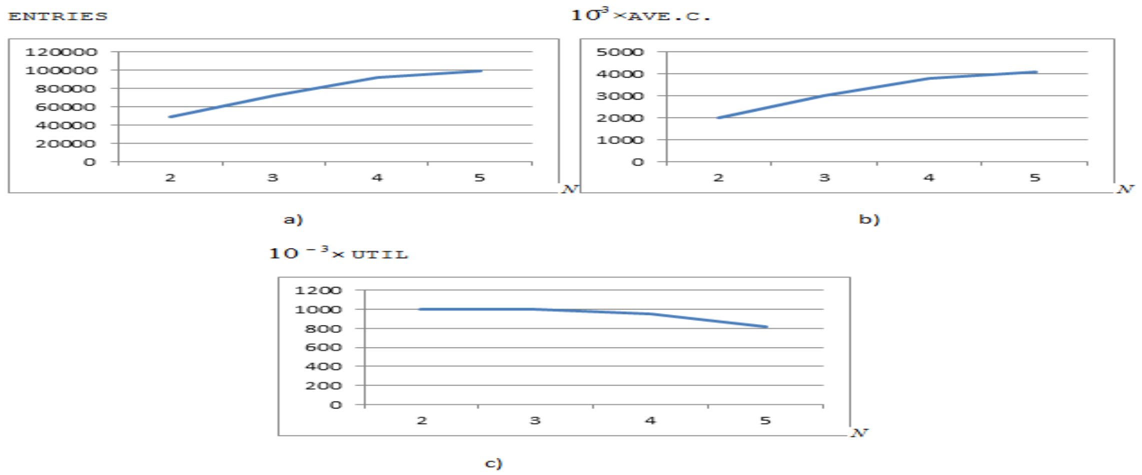

Fig.7. Dependence of the number of transactions in the PM (ENTRIES, Fig. 7a), the average queue length (AVE.C., Fig. 7b), the utilization rate of the PM (UTIL, Fig.7c) on the number of PM (N) during the simulation.

The results obtained in this case show that with an increase in the number of PM from 2 to 5:
- the number of transactions in the PM increases from 48712 to 99143;
- the average queue length increases from 2.000 to 4.086;
- the utilization factor decreases from 1.000 to 0.817.

For ISS with unlimited buffer memory.

1. The receipts of transactions in the ISS and the service time are subject to an exponential distribution law.

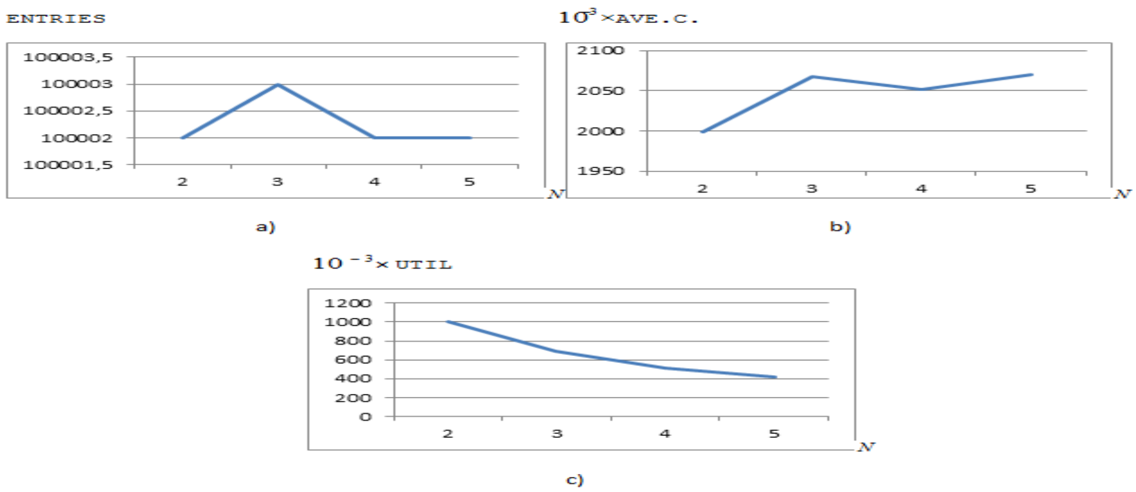

Fig .8. Dependence of the number of transactions in the PM (ENTRIES, Fig. 8a), the average queue length (AVE.C., Fig. 8b), the utilization factor of the PM (UTIL, Fig.8c) on the number of PM (N) during the simulation.

The results obtained in this case show that with an increase in the number of PM from 2 to 5:

- the number of transactions in the PM increases from 100002 to 100003 at $N=\overline{2,3}$, and for $N=\overline{3,4}$ decreases to 100002 and after that for $N=\overline{4,5}$ remains unchanged;

- the average queue length increases from 1.999 to 2.068 at $N=\overline{2,3}$, and for $N=\overline{3,4}$ decreases from 2.068 to 2.052 and then increases to 2.070;

- the utilization factor decreases from 1.000 to 0.414 at $N = \overline{2,5}$.

2. The receipts of transactions in the ISS are subject to an exponential, and the service time to a uniform distribution law,

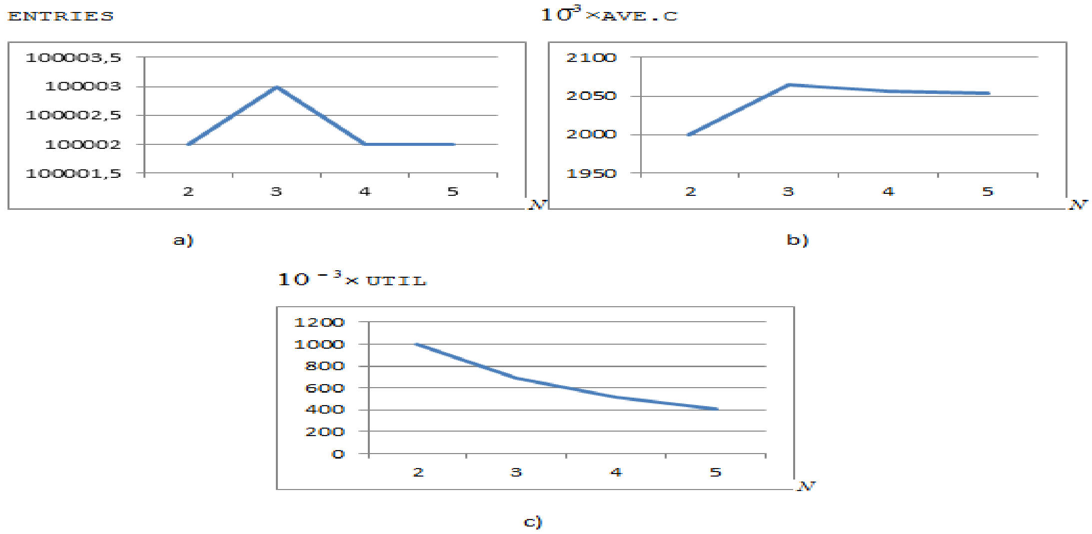

Fig. 9. Dependence of the number of transactions in the PM (ENTRIES, Fig. 9a), the average queue length (AVE.C., Fig. 9b), the utilization factor of the PM (UTIL, Fig.9c) on the number of PM (N) during the simulation.

The results obtained in this case show that with an increase in the number of PM from 2 to 5:

- the number of transactions in the PM increases from approximately 100002 to 100003 at $N = \overline{2,3}$, and for $N = \overline{3,4}$ decreases from 100003 to 100002 and after that for $N = \overline{4,5}$ remains unchanged;
- the average queue length increases from 2.000 to 2.064 , and decreases from 2.064 to 2.053;
- the utilization factor decreases from 1.000 to 0.411.

3. The receipts of transactions in the ISS obey the exponential distribution law, and the service time obeys the Erlang distribution law.

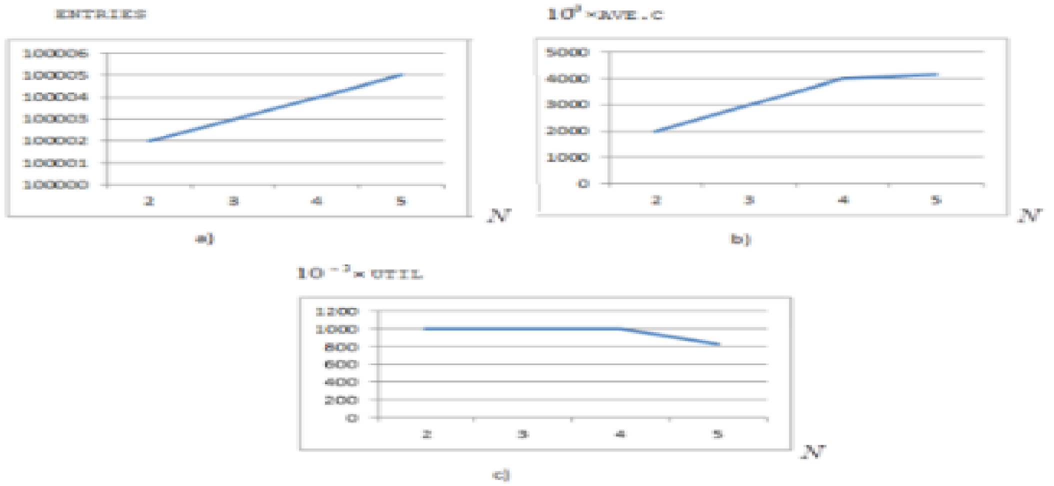

Fig. 10. Dependence of the number of transactions in the PM (ENTRIES, fig.10a), average queue length (AVE.C.,fig.10b), the utilization factor of the PM (UTIL, Fig. 10c) on the number of PM (N) during the simulation.

The results obtained in this case show that with an increase in the number of PM from 2 to 5:

-the number of transactions in the PM increases from 100,002 to 100005 with $\overline{N} = 2{,}5$;

- the average queue length increases from 2.000 to 4.138 at $\overline{N} = 2{,}5$;

- the value of the utilization factor does not change $\overline{N} = 2{,}4$, but decreases at $\overline{N} = 4{,}5$, from 1.000 to 0.828.

The results obtained can be used in modifying existing or building new ISS in service networks for objects of various purposes.

5. CONCLUSION

The paper proposes algorithms for analyzing the characteristics of the ISS as a single-phase, multichannel, mixed-type QS.

Experiments have been carried out, and results have been obtained. These results can be used in the construction of new or modification of existing ISS in networks for servicing objects for various purposes.

This work is an approach to the generalization of the considered problems for systems with losses and limited, or unlimited buffer memory.

References

1. *Исмайлов Б.Г.* Анализ системы безопасности информации в сетях обслуживания объектов нефтегазодобычи //Автоматизация в промышленности, №3, 2020, с. 16-19.
2. *Исмайлов Б.Г.* Моделирование системы безопасности информации в сетях обслуживания объектов нефтегазодобычи //Автоматизация в промышленности, №7, 2020, с. 23-26.
3. *Исмайлов Б.Г.* Анализ системы безопасности информации с неограниченным объемам буферной памяти в сетях обслуживания. Проблеми інформатизації та управління, 65(1)’2021, с. 18-24
4. *Морозова В.И., Врублевский К.Э.* Защи2008- 122 с. та информации в вычислительных системах Под ред. В.И. Морозовой - М.: МИИТ, 2008, 122 с.
5. *Малюк А.А.* Информационная безопасность концептуальные и методологические основы защиты информации, М.:ГЛТ, 2004, 280 с.
6. *Шаньгин В.Ф.* Информационная безопасность и защита информации. М.:ДМК, 2014. 702 с.
7. *Карпова В.В.* Вероятностная модель оценки защищенности средств вычислительной техники с аппаратно-программным комплексом защиты информации от несанкционированного доступа // Программные продукты и системы, №1, 2003, с. 31-36.
8. *Карпова В.В.* Методика синтеза оптимального варианта аппаратно-программного комплекса защиты информации от несанкционированного доступа по критерию защищенности // Программные продукты и системы, № 1, 2003, с. 36-38.
9. *Григорьев В.А., Карпова А.В.* Имитационная модель системы защиты информации // Программные продукты и системы, №2, 2005, с. 26-30.
10. *Карпова А.В.* Оценка защищенности информации от несанкционированного доступа при помощи имитационной модели системы защиты информации // Программные продукты и системы, № 2, 2005, с. 51-54.
11. *Клейнрок Л.* Теория массового обслуживания. Перевод с англ. Пер. И.И. Грушко: ред. В.И. Нейман, М.: Машиностроение, 1979. 432 с.
12. *Б.О. Ахмедов, А.А. Джавадов, С.Ф. Исмайлов, Б.Г. Исмайлов.* Омоделирование и анализе характеристик распределенных мультимикропроцессорных систем//Автоматика и Вычислительная Техника, Рига, 1985, №3, с. 70-74.