Optimization Of Switching Node Parameters In Computer Networks With Priority Service Operating Under A Limited Queue System

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ABSTRACT

In this work, analytical models of queues to multiple servers and to each server have been developed.

In a combined service system, to optimize the number of channels and the number of waiting places, it is necessary to calculate the minimum values of loss cost functions, which depend on specific load values.

The developed algorithms for calculating the optimization of the parameters of a switching node operating on a combined service system allow for determining the most optimal design options for a computer network.

The provided numerical calculations and constructed dependency graphs make it possible to determine the required quality of functioning of a specific computer network with a given number of nodes, the number of waiting spots in specific nodes, and the values of first and second priority loads.

Keywords: computer network, calculation, load, number, waiting places, priority, algorithm, switching devices.

MATERIALS AND METHODS

The aim of this work is to develop methods for determining the quality characteristics of the functioning of modern computer networks with priority service, focused on improving their efficiency and the quality of the communication service provided. The main tasks in this regard are:

- systemic analysis of the current state of the problem and trends in the development of computer networks and the identification of key tasks whose solutions significantly impact the efficiency [9] of their functioning and development;

- development of methods for calculating quality indicators of computer network performance with prioritized handling of incoming packet streams;

$$G(s) = [q_{cd}(s - M_{cbs}) + q_{anr}.\mathrm{M}_{anr} + q_y.W_{(s+k)}.\lambda + q_k.M_{cbs}].T \quad (1)$$

where the $W_{(s+k)}$ − probability that all s channels and k waiting places are occupied by service;

M_{anr} −average number of requests in the queue;

M_{cbs} −caverage number of channels occupied by servicing;

λ − intensity of the incoming request stream;

q_{cd} − the cost per unit of channel downtime;

q_{anr} − the cost of losses associated with requests idling in the queue over time;

q_k − the cost of operating each channel per unit of time;

T − calculation time interval.

In expression (1), the parameters , $W_{(s+k)}$, M_{anr}, M_{cbs} , for a switching node operating under a limited queue system are determined as a function of the distribution of the number (mass service system MSS),of requests in a combined system (loss/waiting) [2]:

$$W_0 = \left[\sum_{j=0}^{s} \frac{\rho^j}{j!} + \sum_{j=(s+1)}^{j=(s+k)} \frac{\rho^j}{s!\, s^{(j-s)}}\right]^{-1} ; \quad (2)$$

$$W_j = \begin{cases} \frac{\rho^j}{j!} W_0, 0 \le j \le s; \\ \frac{\rho^j}{s!\, s^{(j-s)}} W_0, j > s; \end{cases} \quad (3)$$

$$W_{(s+k)} = \frac{\rho^{s+k}}{s^k s!} \cdot W_0 ; \quad (4)$$

$$M_{anr} = \sum_{j=1}^{k} jW_{(s+k)} ; \quad (5)$$

$$M_{cbs} = \sum_{j=1}^{s} jW_j . \quad (6)$$

where ρ − the intensity of the incoming load;

s − number of channels;

k − maximum number of waiting spots in the queue.

Let's consider a numerical example of optimizing the number of channels and the minimum cost for different load values. The algorithm for solving the problem using expressions (2) – (6) is shown in Fig. 1.

The algorithm for optimizing the number of channels in a switching node operating under a combined service system, just like for a switching node operating under a waiting system, consists of sequential calculation of the value of the objective function G(s,k) at various values of the number of communication channels and the number of waiting places. Dependencies of cost on load changes have been determined for different numbers of channels and different numbers of waiting places.

This algorithm for optimizing the cost characteristics of a switching node operating under a combined service system (Fig. 1) has been implemented using Excel 2019.

As the initial data, the regulatory data for 2024 were used [18] (on October 1, 2021, the Ministry of Transport, Communications and High Technologies was renamed the Ministry of Digital Development and Transport.) Ministry of Digital Development and Transport of the Republic of Azerbaijan.

Let's say:

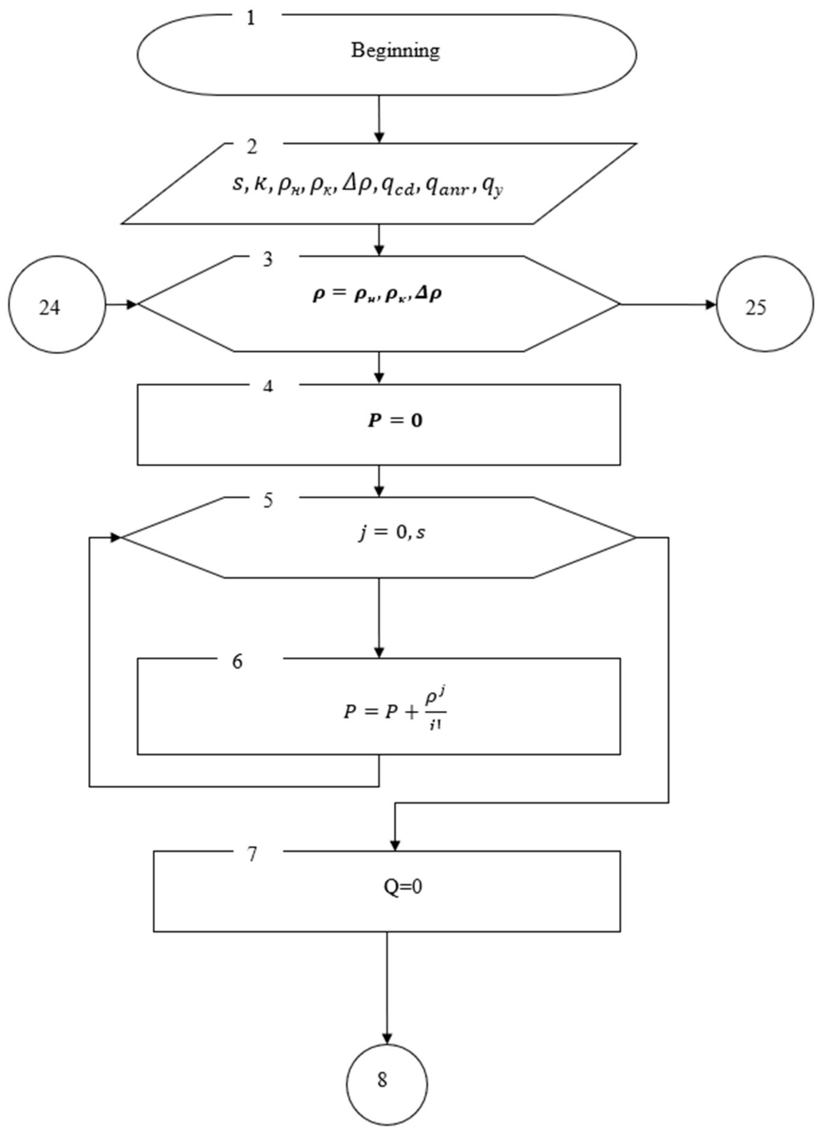
Note: 1 USD = 1.7 manat

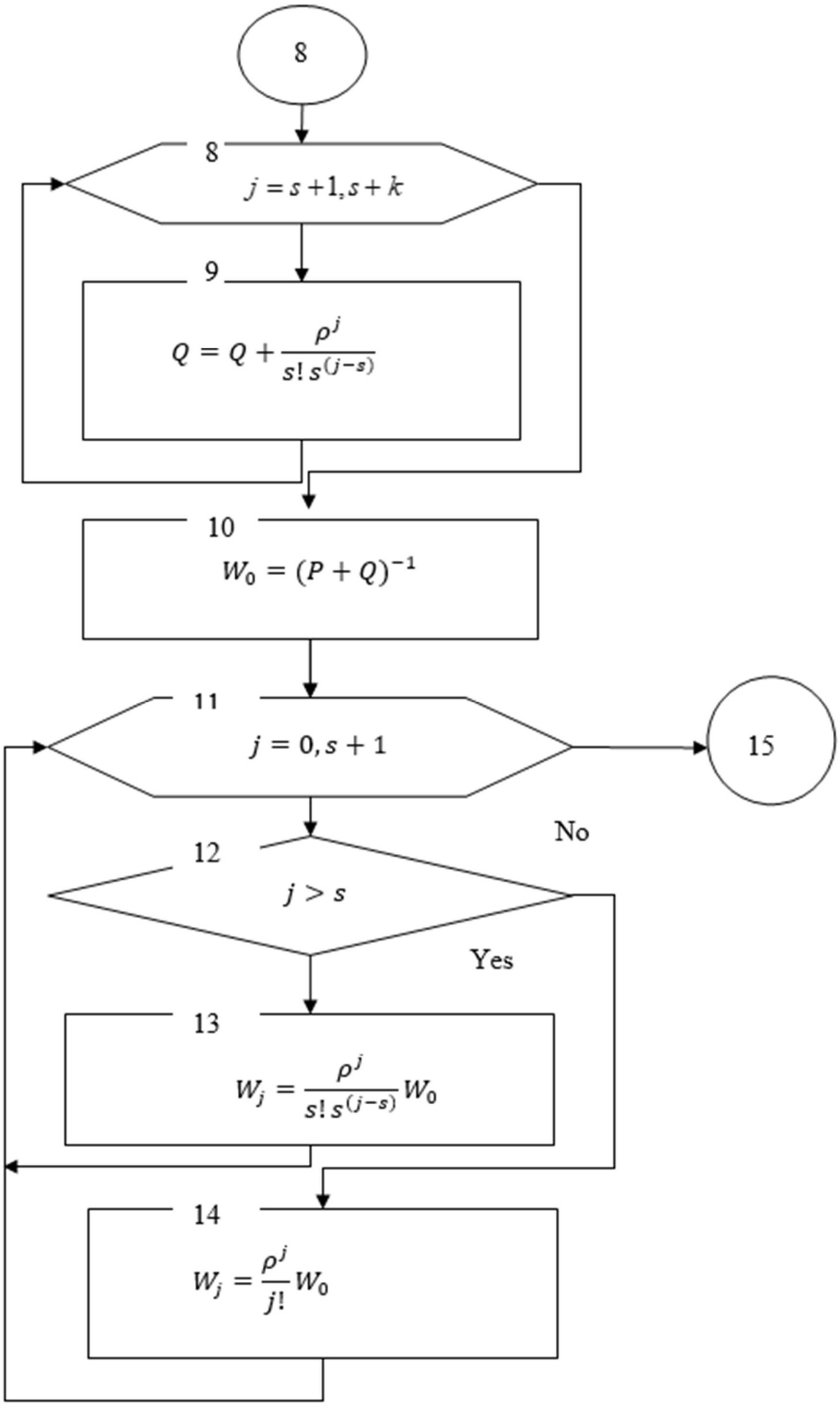
- $q_{cd} = 0{,}445$ manat per minute;
- $q_{anr} = 7{,}42.10^{-4}$ manat per minute;
- $q_y = 0{,}004$ manat per minute;
- $\lambda = 25$ packets/s.

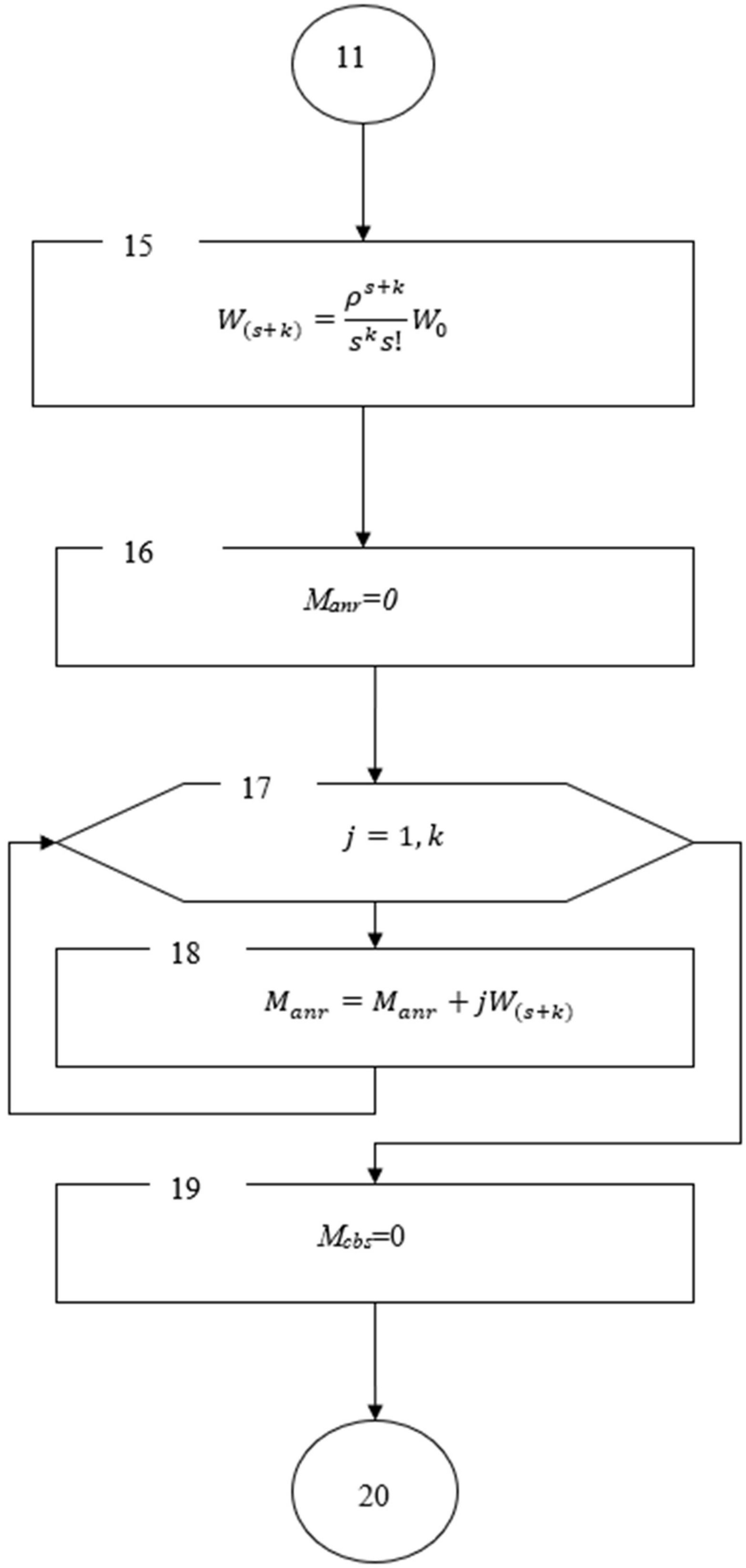
The cost of operating each channel per month is 0.937 manat.

- $q_к = \frac{0{,}937}{30.24.60} = 2{,}17.10^{-5}$ manat per minute;
- The average packet length is 144 bytes = 144.8 = 1151 bits;
- The line speed is 64000 bps.
- The average service time for each package is seconds $T_s = \frac{1152}{64000} = 0{,}018$ c.
- $\rho = \lambda.T_s = 25.0{,}018 = 0{,}75$. Calculations are performed for various load values (ρ).

The results of optimizing the cost characteristic from load changes with different numbers of channels for various numbers of waiting areas are presented in Figures 2 – 6.




8
8
$j = s+1, s+k$
9
$Q = Q + \frac{\rho^j}{s!\,s^{(j-s)}}$
10
$W_0 = (P+Q)^{-1}$
11
$j = 0, s+1$
15
No
12
$j > s$
Yes
13
$W_j = \frac{\rho^j}{s!\,s^{(j-s)}} W_0$
14
$W_j = \frac{\rho^j}{j!} W_0$


11
15
$W_{(s+k)} = \frac{\rho^{s+k}}{s^k s!} W_0$
16
$M_{anr}=0$
17
$j = 1, k$
18
$M_{anr} = M_{anr} + jW_{(s+k)}$
19
$M_{cbs}=0$
20

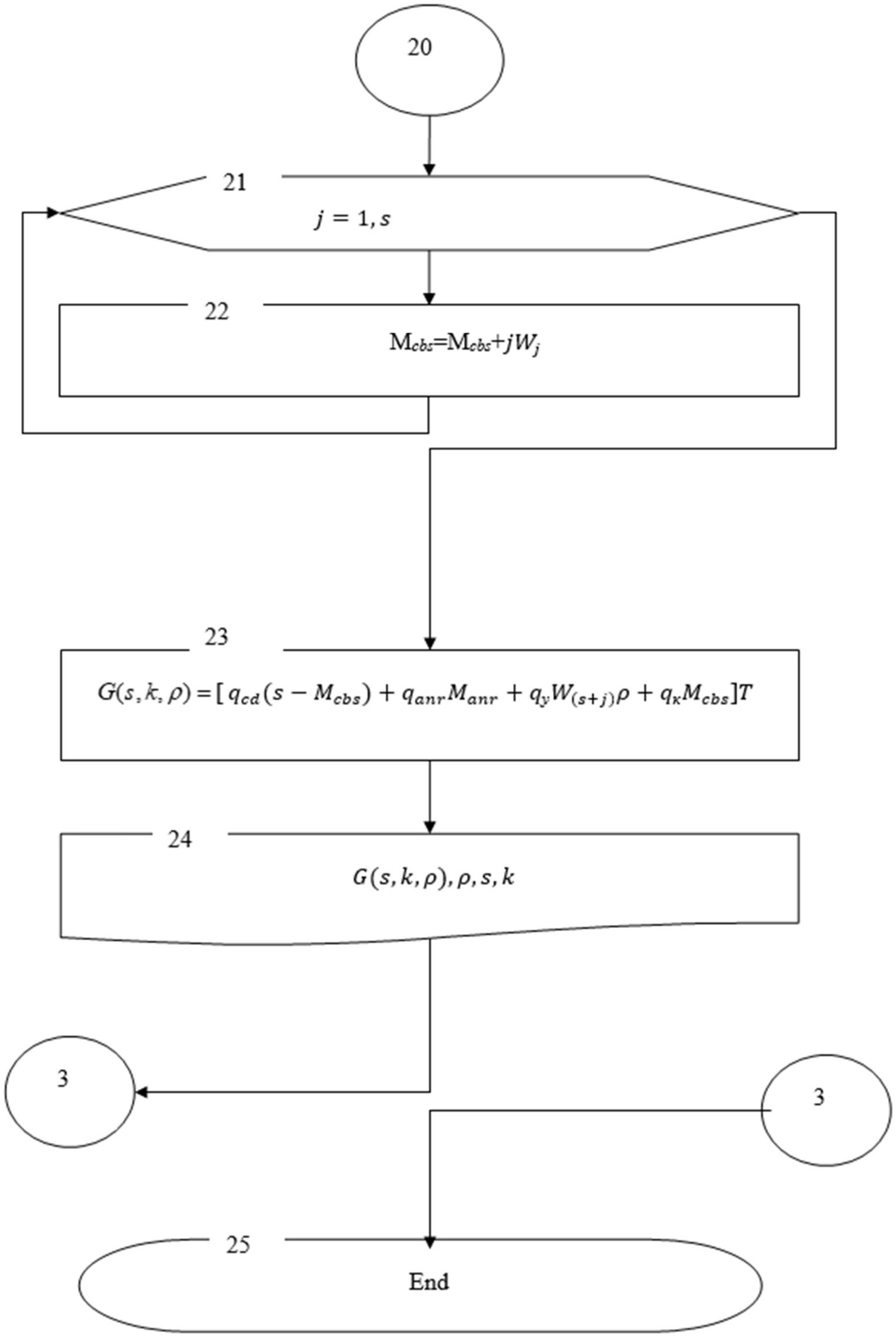


Fig. 1. Algorithm for optimizing the number of channels and the number of waiting spots.

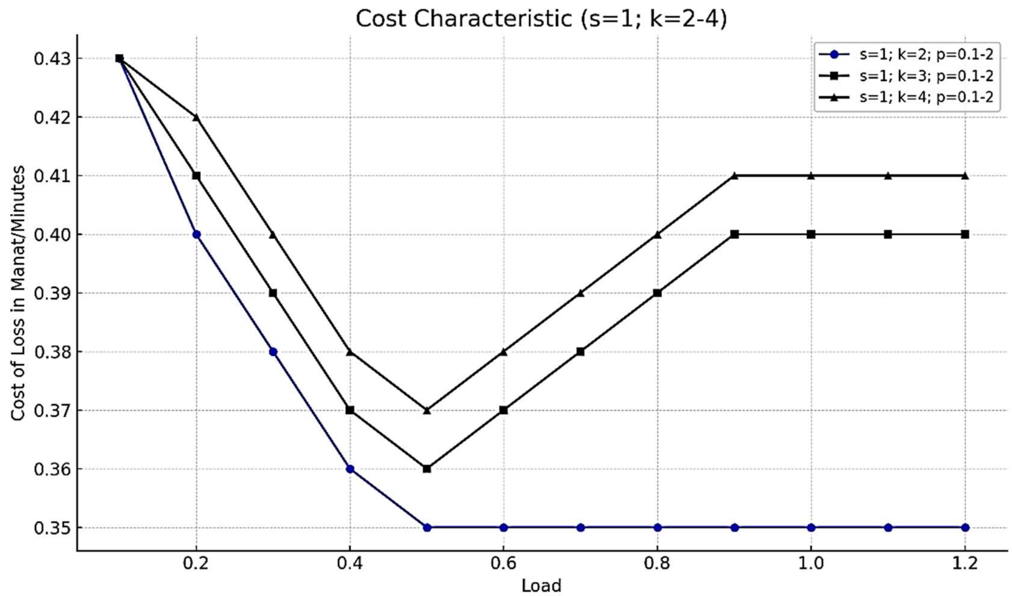


Fig. 2. Dependence of cost on load changes with the number of channels s=1 for different numbers of waiting places (k=2-4)

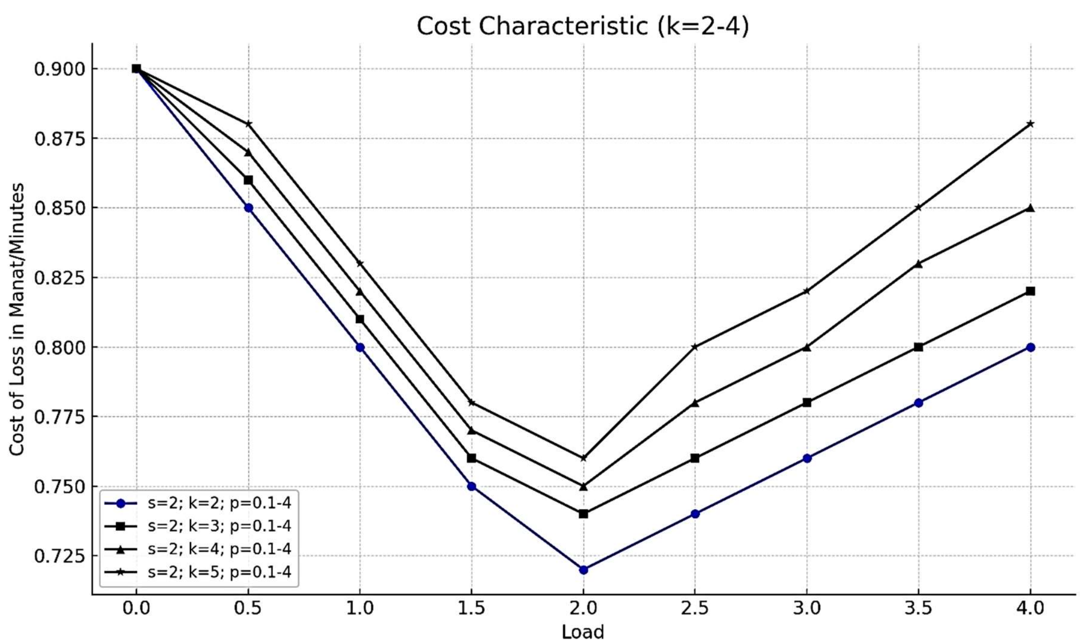


Fig. 3. Dependence of cost on load changes with the number of channels s=2 for different numbers of waiting places (k=2-5)

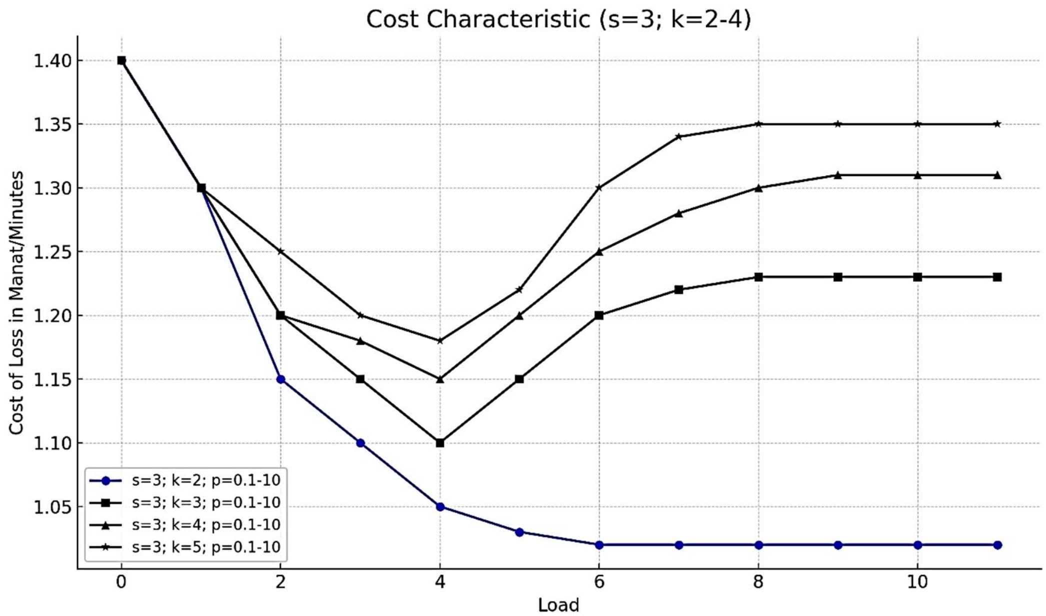


Fig. 4. Dependence of loss cost on load changes with the number of channels s=3 for different numbers of waiting places (k=2-5)

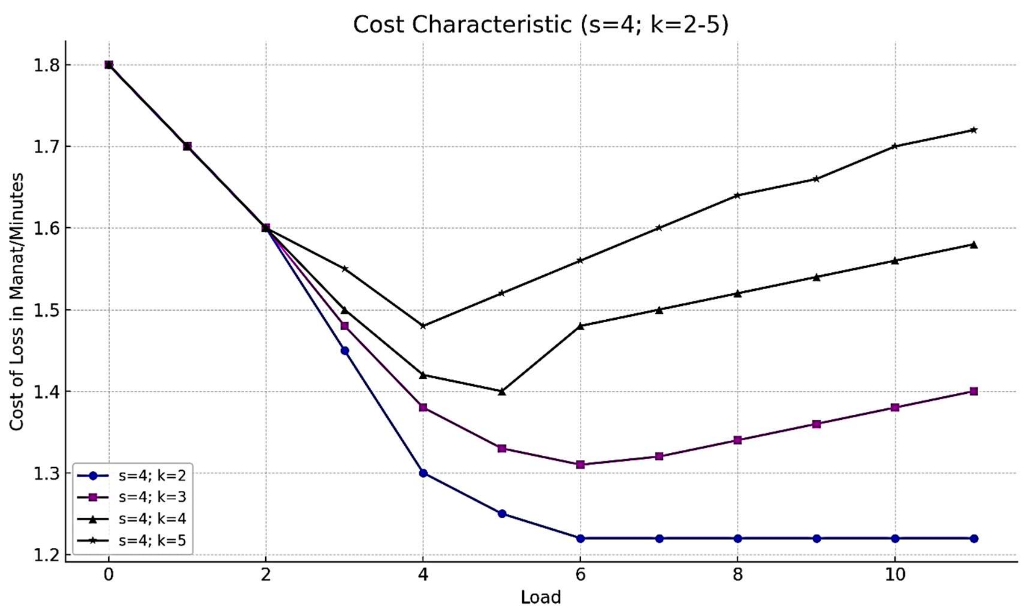


Fig. 5. Dependence of loss cost on load changes with the number of channels s=4 for different numbers of waiting places (k=2-5)

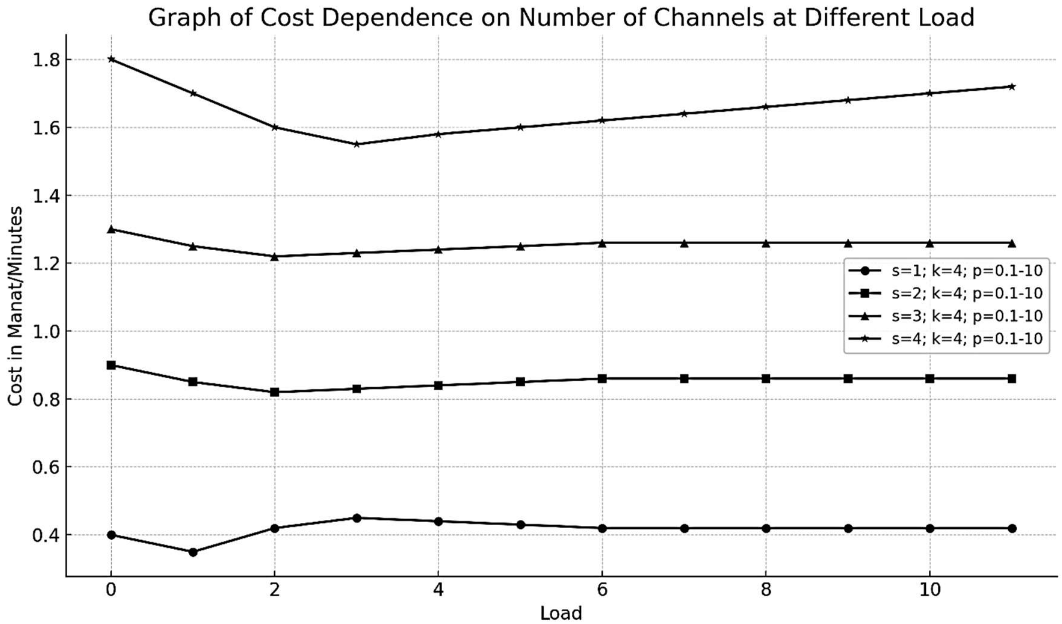


Fig. 6. Dependence of loss cost on load changes with different numbers of channels (s=1-4) for waiting spots k=4

From Figure 4 and Appendix Table 1, it can be seen that with single-channel service (s=1), the minimum values of loss costs decrease with the increase in the number of waiting places (k) and are accordingly equal to:

Table 1

The cost of the channel from load changes with the number of channels s=1 for different numbers of waiting places (k=2-4)

Cost in manats/minutes			
Number of channels s=1			
Load	Number of waiting spots (k)		
ρ	2	3	4
0,1	0.4410	0.4410	0.4410
0,2	0.4312	0.4312	0.4312
0,3	0.4186	0.4186	0.4186
0,4	0.4054	0.4058	0.4060
0,5	0.3931	0.3944	0.3950
0,6	0.3825	0.3854	0.3870
0,7	0.3738	0.3789	0.3821
0,8	0.3668	0.3749	0.3802
0,9	0.3615	0.3729	0.3808
1	0.3576	0.3725	0.3833
1,1	0.3548	0.3734	0.3870
1,2	0.3529	0.3752	0.3915
1,3	0.3517	0.3776	0.3963
1,4	0.3511	0.3804	0.4011
1,5	0.3510	0.3834	0.4058
1,6	0.3513	0.3866	0.4103
1,7	0.3519	0.3897	0.4144
1,8	0.3526	0.3928	0.4181
1,9	0.3536	0.3958	0.4216
2	0.3546	0.3987	0.4247

Table 2
The cost of the channel from changes in load with the number of channels s=2 for various numbers of waiting areas (k=2-6)

Cost of the channel in manats/minutes				
Number of channels s=2				
Loaded	Number of waiting spots (k)			
ρ	2	3	4	5
0,1	0.8897	0.8897	0.8897	0.8897
0.5	0.8659	0.8659	0.8659	0.8659
0.9	0.8073	0.8082	0.8086	0.8088
1.1	0.7761	0.7788	0.7803	0.7811
1.3	0.7482	0.7542	0.7578	0.7601
1.5	0.7248	0.7356	0.7428	0.7477
2.1	0.6808	0.7122	0.7366	0.7561
2.3	0.6728	0.7120	0.7430	0.7679
2.7	0.6633	0.7182	0.7613	0.7949
2.9	0.6610	0.7233	0.7715	0.8079
3.1	0.6598	0.7291	0.7816	0.8198
3.3	0.6595	0.7354	0.7914	0.8305
3.5	0.6599	0.7419	0.8007	0.8400
3.7	0.6608	0.7484	0.8093	0.8482
3.9	0.6622	0.7549	0.8172	0.8553
4.1	0.6639	0.7612	0.8244	0.8614

- when k=2 and ρ=1,5 G_{min}=0,3510 manat per minute;
- when k=3 and ρ=1,0 G_{min}=0.3725 manat per minute;
- when k=4 and ρ=0,8 G_{min}=0.3802 manat per minute.

From Figure 5 and Appendix Table 2, it can be seen that with two-channel service (s=2), the minimum loss cost values are:

- when k=2 and ρ=3,3 G_{min}=0,6595 manat per minute;
- when k=3 and ρ=2,3 G_{min}=0,7120 manat per minute;
- when k=4 and ρ=1,9 G_{min}=0,7334 manat per minute;
- when k=5 and ρ=1,7 G_{min}=0,7440 manat per minute;

From Figure 4 and Appendix Table 3, it can be seen that with three-channel service (s=3), the minimum values of loss costs are:

Table 3
Cost of the channel from load changes with the number of channels s=3 for different numbers of waiting places (k=2-4)

Cost of the channel in manat/minutes				
Number of channels s=3				
Load	Number of waiting spots (k)			
ρ	2	3	4	5
0.1	1.3350	1.3350	1.3350	1.3350
0.6	1.3246	1.3246	1.3246	1.3246
1.1	1.2689	1.2691	1.2691	1.2692
1.6	1.1788	1.1813	1.1826	1.1832
2.1	1.0936	1.1038	1.1105	1.1149
2.6	1.0313	1.0554	1.0734	1.0872
3.1	0.9910	1.0330	1.0670	1.0951
3.6	0.9666	1.0284	1.0802	1.1235

4.1	0.9529	1.0346	1.1033	1.1593
4.6	0.9462	1.0470	1.1300	1.1943
5.1	0.9441	1.0624	1.1565	1.2248
5.6	0.9451	1.0791	1.1811	1.2498
6.1	0.9481	1.0959	1.2030	1.2697
6.6	0.9524	1.1124	1.2221	1.2853
7.1	0.9576	1.1280	1.2385	1.2975
7.6	0.9633	1.1427	1.2525	1.3071
8.1	0.9694	1.1564	1.2645	1.3146
8.6	0.9757	1.1690	1.2746	1.3206
9.1	0.9821	1.1807	1.2833	1.3253
9.6	0.9885	1.1914	1.2907	1.3291
10.1	0.9948	1.2012	1.2971	1.3322
10.6	1.0011	1.2103	1.3025	1.3347

- when k=2 and ρ=5,1 G_{min}=0,9441 manat per minute;
- when k=3 and ρ=3,6 G_{min}=1,0284 manat per minute;
- when k=4 and ρ=3,1 G_{min}=1,0670 manat per minute.

From Figure 6 it is evident that with four-channel service (s=4) the minimum values of the cost of losses are:

- when k=2 and ρ=7,1 G_{min}=1,2137 manat per minute;
- when k=3 and ρ=5,1 G_{min}=1,3291 manat per minute;
- when k=4 and ρ=4,1 G_{min}=1,3839 manat per minute;
- when k=5 and ρ=3,6 G_{min}=1,4162 manat per minute.

Figure 6 and Appendix Table 4 show the dependences of the cost of losses for a different number of channels (s=1-4) and a certain number of waiting places (k=4).

Table 4
Cost of losses from load changes with the number of channels s=1-4 for the number of waiting places k=4

Load ρ	Cost of losses in manat/minutes; Number of waiting places k=4; Number of channels s=1-4			
	1	2	3	4
0.1	0.4410	0.8897	1.3350	1.7800
0.6	0.3870	0.8533	1.3246	1.7780
1.1	0.3870	0.7803	1.2691	1.7557
1.6	0.4103	0.7380	1.1826	1.6908
2.1	0.4274	0.7366	1.1105	1.5943
2.6	0.4377	0.7564	1.0734	1.5002
3.1	0.4437	0.7816	1.0670	1.4324
3.6	0.4475	0.8051	1.0802	1.3954
4.1	0.4499	0.8244	1.1033	1.3839
4.6	0.4516	0.8398	1.1300	1.3905
5.1	0.4527	0.8517	1.1565	1.4085
5.6	0.4536	0.8609	1.1811	1.4329
6.1	0.4542	0.8681	1.2030	1.4603
6.6	0.4547	0.8738	1.2221	1.4885

7.1	0.4551	0.8783	1.2385	1.5159
7.6	0.4554	0.8819	1.2525	1.5419
8.1	0.4557	0.8848	1.2645	1.5659
8.6	0.4559	0.8872	1.2746	1.5879
9.1	0.4561	0.8891	1.2833	1.6077
9.6	0.4562	0.8907	1.2907	1.6255
10.1	0.4563	0.8921	1.2971	1.6415
10.6	0.4564	0.8933	1.3025	1.6557

RESULTS AND DISCUSSIONS

From the presented results, it can be concluded that when designing switching nodes operating under a combined service system, it is necessary to consider the found minimum loss cost values for optimal load values and the number of waiting places in order to optimize the number of channels and the number of waiting places.

The proposed method and numerical example of optimizing the parameters of a switching node operating under a combined service system demonstrate the possibility of selecting the optimal design option.

Based on the developed models, optimization methods, and the presented results of numerical calculations on a PC, the following conclusions can be drawn.

Discussion: Discussing the results and comparing them with the findings of other researchers plays an undeniable role in advancing scientific knowledge and understanding of complex issues of communication network performance. Analysing the data obtained in the previous sections and comparing them with the conclusions of other researchers, it is possible to identify common patterns, key differences, and additional aspects of this problem.

The research problem lies in the search for optimal solutions to ensure the efficient operation of communication networks under various load and traffic conditions. The growth in the number of users, the active use of online services and other factors create a load on network resources and can lead to a decrease in the quality and speed of service to network users.

Previous research in this industry has already discovered some aspects and approaches to solving communication network performance problems. For example, L. Peterson and B. Davie investigated the effect of routing protocols on network performance, showing that some protocols may be more efficient in large networks, and some may interfere with the fast operation of the network [1]. Insufficient attention was paid to the issue of the impact of changing conditions within the network on the effectiveness of different network protocols.

Huseynov Z.N, Mammadov M.I.,Ismayilov T.A. Modelingand analysis of the characteristics of multichannel and multi-node computer networks with priority service. Investigated methods for increasing network bandwidth by optimising resources at different network levels, but did not sufficiently examine the impact of different types of data on the optimisation results [2]. S. Prakash explored the possibility of using cloud technologies to optimise the performance of communication networks [3]. The researcher analysed the advantages and limitations of this approach and made recommendations for their implementation. The paper omitted the issue of the efficiency of cloud storage in conditions of using large amounts of data and a high level of load on them.

The study by A. Tanenbaum and D. Wetherall explored the impact of load growth on the performance of communication networks [4]. They analysed various aspects, including bandwidth and latency, and drew conclusions about effective methods of optimising networks to ensure stable performance. The details of the use of real network loads in different applications were not sufficiently disclosed.

The main research point of the paper authored by Z. Huseynov [5] is modeling and analysing the features of computer networks with prioritized services, analyzed indicators modeling and optimization of a computer corporate network with priority service "Elections". The urgency of designing corporate computer networks and providing quality of service (QoS - Quality of Service) is based on the fact that the work was carried out in accordance with the design plan of the State Automated Information System "Elections" and the application new equipment and technology. The purpose of the work: development of methods for calculating the probability denial of the flood inquiries in corporate computer networks and the probability of timely delivery preparation proposals on the selection and effective use telecommunications equipment when creating corporate computer networks development methods for optimizing the parameters of telecommunication nodes operating with different service systems. Using analytical models of a computer corporate communication network, the probabilities loss and timely delivery of requests are determined. The work of the corporate communication network "Elections" of the Republic of Azerbaijan has been studied.

The paper by Fuente Maria Jose Pardo, David de la Fuente. Optimizing a priority-discipline queueing model using fuzzy set theory. Investigates the possibilities of improving the performance of communication networks by optimising routing [6].

R. Ghimire and R. Noor [7] present two approaches to the study – quantitative and qualitative. The quantitative approach is aimed at analysing the results obtained as a result of experiments, surveys, or simulations, while the qualitative approach is aimed at obtaining a deeper understanding of the problem. The researchers also note the importance of studying the literature to understand the main problems in the field of research. The study of literature is indeed an important stage of research, and the use of both quantitative and qualitative approaches can be useful to get a complete picture of the problem. The researcher analyses the problem and considers the available resources using a qualitative approach. In conclusion, the author suggests further work on the application of the proposed RED algorithm in real time to compare the simulation results with real data. Thus, a comprehensive approach to the investigation of the problem, using both qualitative and quantitative methods, is presented, and the importance of studying the literature to understand the main problems in the field of research is emphasised. The study considers the effectiveness of quality of service (QoS), which is also the basis of this paper. O. Bonaventure [8] provided a comprehensive insight into the principles, protocols, and practices of computer networks. The book is intended for students who want to learn about computer networks, and covers all the material for the first semester course on network technologies for undergraduate or postgraduate students. The author discusses changes in the approach to teaching computer networks in connection with the development of the Internet and the availability of a large amount of information. The researcher notes that today's students are experienced Internet users and can easily check the information received from teachers due to the availability of information on the Internet. The author also notes that there are many challenges for teachers related to teaching students in conditions of availability of a large amount of information. One of the interesting points is the mention that the authors of textbooks on computer networks have begun to revise their approach to learning, starting with the applications that students use, and then explaining the Internet protocols, removing one level after another. This kind of work is a general set of knowledge about the work of the Internet, which is suitable for study by both students and people of a higher technical level.

The main purpose of the study of the document authored by Z.Huseynov et al. [9] The subject of the study is analytical models and methods for calculating the quality indicators of the functioning of computer networks with priority services. Mathematical methods of the theory of queuing systems provide the ability to solve numerous problems of calculating the characteristics of the quality of functioning of various components of computer networks. The resulting tables and functional dependencies make it possible to design a computer network operating with the required quality indicators.

The document [10] authored by M. Kartashov is a mathematical reference book specialising in the section of probability theory. In particular, this source describes the Poisson distribution law, which simplifies the process of calculating the applied characteristics of the network induced in this work.

The paper by H. Khazei [11] describes a model for analysing the performance of data processing centres in cloud computing. The model is designed to analyse the performance of data processing centres with different requests and resources using interacting stochastic models. The document describes the main characteristics of the analytical model, such as the assumption of Poisson arrival of user requests, support for the high degree of virtualisation, consideration of various delays imposed by data processing centres on user requests, and the characterisation of service availability at the data processing centre. The researchers also discuss the importance of considering the maintenance time of virtual machine (VM) tasks on loaded PM, since the maintenance time of tasks increases with the increase in the total load on PM. They suggest using a probability distribution that allows adjusting the coefficient of variation (CoV) independently of the average value to take this factor into account. The author of this study agrees that the consideration of the maintenance time of tasks on busy PM is an important factor for evaluating the performance of cloud computing centres. However, for a more accurate performance assessment, other factors must also be consider, such as the use of different types of VM, network settings, etc. In general, the paper presents an interesting model for evaluating the performance of cloud computing centres, which can be useful for cloud service providers. However, for a more accurate performance assessment, it is necessary to take into account other factors that may affect the performance of cloud computing centres.

The main purpose of the study by L. Yangyong [12] is the use of genetic algorithms to optimise the planning of the distribution network in order to reduce electricity losses. The paper explores how to intelligently optimise the plan by extracting relevant, analysing examples and experimental data, obtaining some data to simulate a real situation using sandbox modelling and genetic algorithm modelling. The thesis that a genetic algorithm can be an effective tool for optimising the planning of power distribution networks is quite interesting and innovative. For more accurate optimisation, it is necessary to take into account not only energy losses, but also other factors such as cost and environmental consequences. In addition, more sophisticated machine learning algorithms, such as neural networks, need to be used for more accurate results. In general, the authors' research is interesting and important in the context of optimising power distribution networks. However, for more accurate results, additional factors must be considered and more complex machine learning algorithms must be used. In the context of this study, the analysis of electrical networks can serve as a basis for monitoring the efficiency of computer networks, the principle of operation of which is similar.

The study by L. Limiao et al. [13] is devoted to optimising cost management for network services, namely, minimising costs and maximising network utility. The document also discusses the problems of energy consumption and data transmission in WBAN networks, and also offers a framework for capturing the stochastic process of energy saving. The researchers emphasised that energy management is an important issue in wireless sensor networks. Using the sleep/wake mode control algorithm can help to increase the operating time of devices and reduce power consumption. In addition, ensuring data integrity is critical to provide the correct operation of the system. This paper offers its own view on the use of electrical resources by networks, which can be applied, in particular, to computer networks.

The main research topic of the book by L. Kleinrock [14] is the creation of a mathematical theory of computer networks, which eventually led to the development of the Internet. The author discusses the key concepts that have made the Internet network technology so powerful, including on-demand access, large shared systems, and distributed management. The author also describes the nature of data transmission and the problems that had to be overcome in order to develop a convincing body of knowledge confirming the need for data transmission networks. Additionally, the author addresses the issue of optimal design of these networks, paying special attention to the choice of bandwidth of each channel, the choice of routing procedures, and topological design. The development of a mathematical model is indeed an important step in optimising the performance of computer networks, and in its course, it is necessary to consider all possible indicators, risks, and limitations. The research is also related to network performance optimisation, and therefore, the ideas presented by L. Kleinrock are interesting, in particular, for this study.

The paper by R. Lyer and L. Kleinrock [15] discusses the problem of ensuring the required quality of service in wireless sensor networks with all kinds of restrictions that may arise in such networks. Due to limited resources such as computing power, memory, bandwidth, and power supplies in sensor networks, providing quality of service in wireless sensor networks is a challenging task. The paper discusses the features of wireless sensor networks that pose problems for quality of service and provides an overview and comparative analysis of routing protocols focused on quality of service in wireless sensor networks. The document also discusses approaches to ensuring the quality of service in wireless sensor networks (WSN) using middleware. At the conclusion of the document, some open problems and directions of future research for ensuring the quality of service in wireless sensor networks are indicated. It is possible to agree with the researchers that ensuring QoS in WSN is a difficult task due to limited resources and the dynamism of the network. However, the authors could consider in more detail the problems associated with data security in the WSN, since this is also an important aspect of QoS provision. In general, the paper is of interest to researchers working in the field of WSN and QoS. It can also be useful for developers who want to create applications using WSN.

The main purpose of the study by R. de Moraes and F. Vasques [16] is to propose and analyse solutions that allow implementing network management systems supported by networks with uncontrolled access, such as packet-switched networks. The paper discusses the assessment of different communication methodologies on the quality of service provided to a particular management application and the influence of communication parameters on management stability. The document also highlights the problems of implementing control systems in distributed, asynchronous network environments and constructing dependable systems from components that may lack reliability. The implementation of network-based management systems that do not require access control is an important task in the management of large-scale communication systems and network-based management systems. However, it is worth noting that some aspects, such as security and data protection in network-based management systems that do not require access control, have not been considered in this paper. Although these aspects are not considered in the context of this study, they are also important and should be taken into account when implementing such systems.

The paper authored by K. Rege [17] is devoted to the theory of multiclass queues and its application in the analysis of the performance of computer systems. The paper presents the outcomes of analytical investigations, along with instances illustrating the application of these findings in practical systems. Models of multiclass queues are described, which allow analysing computer systems with different types of resources and transactions. The paper also discusses the constraints and challenges linked to utilizing such models and suggests methods and approximations to solve them. The author of this study agrees that analytical queue models can be very useful for evaluating the performance of computer systems. However, these models have their limitations and approximate methods and simulations may be necessary to evaluate the performance of more complex systems.

The research carried out in this paper is also related to the analysis of the performance of computer systems, and, therefore, the paper provides valuable information for researchers in this field. Especially interesting is the example which illustrates how analytical results can be used together with approximate methods and simulations to evaluate the performance of complex systems.

Summing up, when analysing the results of this study and comparing them with the findings of other researchers, the importance of an integrated approach to analysing the performance of communication networks is emphasised. Single factors are not sufficient to fully understand the complex dynamics of networks. The conclusions of this study enrich and expand the existing knowledge in this field, providing a deeper understanding of the impact of different parameters on the effectiveness of communication networks. It is crucial to emphasize that the main focus of this study is on the hardware component of computer networks, which is not the only one affecting its speed and efficiency.

CONCLUSION

The practical value of the work lies in the fact that the obtained scientific and theoretical results can be used:

- in the calculation and evaluation of the quality indicators of the functioning of both designed and existing telecommunication nodes with limited queues and prioritized packet flow servicing;

- when calculating the time taken for information to travel from the source to the recipient;

- when evaluating the downtime and utilization rates of network resources;

- when calculating and optimizing the parameters of switching nodes operating under a combined service system.

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