Indicators of the effectiveness of the use of automation systems (SA) to support infocommunications services

I V Khasambiev¹, O V Vlasova ²

¹ Chechen State University named after A.H. Kadyrov, 364015, 17a Dudaev Boulevard, Groznyy, Russian Federation
² Kursk state medical university, 3 Karl Marx str., Kursk, 305029, Russian Federation

E-mail: olgavlasova82@mail.ru

Abstract. Administration of communication networks, according to the Law “On Communication”, is a set of organizational and technical measures aimed at ensuring the trouble-free and coordinated functioning of the communication network. Including traffic regulation, monitoring and control of the state of network elements, transport network channels and interactions of nodes, as well as managing the operation of applications and the provision of new infocommunication services. In this regard, this work is devoted to the study of the topic Indicators of the effectiveness of the use of automation systems to support infocommunications services

1. Introduction
The performance indicator is a quantitative characteristic of infocommunication systems (ICS), considered in relation to certain conditions of its functioning. When assessing the effectiveness of infocommunication systems, the characteristics of the labor activity of a person interacting with a computer and other technical means of the network are taken into account. Hence, the network is viewed as a man-machine system [1-3].

Indicators of the effectiveness of infocommunications are determined by the process of its functioning and are a functional of this process. In accordance with the specification of the concept of efficiency, the indicators of the set can be divided into three groups [4-6].

2. Materials and methods
The choice of indicators of the target efficiency of the network is determined by its purpose, in connection with which there is a large variety of indicators of the group. $W_{TI}$ - the effectiveness of the target indicator. With the help of these indicators, the effect (target result) is assessed, obtained by solving certain applied problems on the computer of the network (using general network resources - hardware, software, information). Various units of measurement are used to quantify this effect: precision $W_p$, reliable $W_r$ and temporary $W_t$ indicators, for example, the probability of calculating a certain task and an estimate of the time to complete this task. Time factors of data transmission are characterized by the efficiency of the ICS network for assessing the target efficiency of infocommunication [17-19].
The efficiency of infocommunications is characterized by the likelihood that data from one network user to another will be delivered within a time period not exceeding a specified one

\[ Q = P\left[(T_{tr} + T_{ot}) \leq T_{gt}\right], \] (1)

where \( Q \) – the efficiency of the ICS; \( T_{tr} \) – time of "clean" data transfer; \( T_{ot} \) – overhead time (typing, error correction, retransmission, etc.); \( T_{gt} \) – a given amount of time, determined by the efficiency of the network. If the reliability and quality of the network are ideal, the efficiency of the ICS is estimated from the queuing theory [3] by the formula

\[ Q = P_0 + P_1, \] (2)

where \( P_0 \) – the probability that the network is free and there are no people waiting.

Probability of network states \( P_0 \) and \( P_1 \) calculated from the queuing theory by the formulas

\[ P_0 = \frac{1}{\sum_{k=0}^{N} \frac{N!}{(N-k)!} y^k}; \quad P_1 = \frac{N y}{\sum_{k=0}^{N} \frac{N!}{(N-k)!} y^k}, \] (3)

where \( N \) – the number of network workstations; \( y \) – network load; \( k \) – sequence of numbers \( k = 0, 1, 2, \ldots, N \); \( y = \lambda T_{tr}, \) where \( \lambda \) – the intensity of calls in the network (traffic).

The effectiveness of the target indicator of the ICS can be estimated by the mathematical expectation of a random variable of its state \( W_{Tf} \), which is an indicator of the feasibility of using the network to perform the specified functions [1]

\[ W_{Tf} = P_0 + P_1 + \left(1 - P_0 - P_1\right) \frac{T_{np}}{T_{np} + T_{aw}}; \quad W_{Tf} \leq 1 \ldots \] (4)

If the reliability and quality of the network are ideal, the target network performance is estimated from the queuing theory [3].

3. Results and Discussion

3.1. Technical performance results

With the help of indicators (2) – (4), the efficiency of the information technology system is assessed as a complex hardware-software-information system when it operates in various modes. At the same time, the effect obtained due to the implementation of the results of solving problems (satisfying the requests) of the users of the ICS is not taken into account.

Group indicators \( W_G \) can be used to quantify the effectiveness of the entire network, its individual systems, subsystems, links, and nodes of the network. When processing an incoming call, the duration of the busyness of workstations (PC) is equal to the average \( \tau_{proc} \), then the probability that during this time it will be necessary to process \( n \) other calls is determined by the formula

\[ P_n = \frac{\left(\lambda \tau_{proc}\right)^n e^{-\lambda \tau_{proc}}}{n!}, \] (5)

where \( \lambda \) – the intensity of calls in the network; \( \tau_{proc} \) – the average time for the development of a managerial decision by the network dispatcher. The system will refuse to process the newly arrived call due to the busyness of all workstations if during the time \( \tau_{proc} \) the number of calls will be received, more
than the number of PCs. If the number of network workstations is $\tau$, then the probability of system refusals in processing a newly arrived call due to the busy RS is determined by the formula

$$P_0 = 1 - \sum_{i=0}^{m-1} \frac{(\lambda \tau)^i}{i!} e^{-\lambda \tau}$$

(6)

The calculation of the number of PCs is reduced to finding the minimum value $\tau$, at which the probability of the system refusing to process the newly arrived call $P_{\text{ref\_arr}}$ less than or equal to the acceptable probability of failure $P_{\text{ref\_acc}}$.

$$P_{\text{ref\_arr}} \leq P_{\text{ref\_acc}}$$

3.2. The results of the efficiency of infocommunications

To assess the efficiency of the entire network or its individual elements and links, two groups of indicators can be used: integral and partial indicators.

With the help of integral indicators, the overall (total, integral) effect is assessed, and then the integral efficiency of infocommunication (element or network link), taking into account all capital and current (operating) costs, and all savings due to the use of infocommunications, that is, for all sources of direct and indirect savings and in all its types.

Private indicators are needed to assess the private economic effect (EE) obtained from individual sources of savings that are created when new hardware, software, information tools, or new technologies of infocommunications are introduced.

As an integral indicator of the economic efficiency of infocommunications, consider the indicator $E_{\text{ann}}$— annual economic effect. The value $E_{\text{ann}}$ we define as the difference between the reduced costs associated with the creation, improvement, and operation of a certain system (the network as a whole, its individual elements, and links) for the basic and considered (investigated) options.

As a generalized indicator of the economic efficiency of infocommunications, let us take the ratio of the given positive result of using infocommunications for a certain period of time [1] to the generalized costs of acquiring, installing, and operating infocommunications.

The generalized positive result of using infocommunications is

$$E_{\text{com}} = E_{\text{ann}} + E_{\text{soc}}$$

(7)

where $E_{\text{soc}}$ – the social result of the introduction of infocommunications.

The reduced costs for the construction and operation of the system are equal

$$C = 0.15 C_{\text{ce}} + C_{\text{co}},$$

(8)

where $C_{\text{ce}}$ – costs for the acquisition, installation, and commissioning of the network; $C_{\text{co}}$ – the cost of operating the network; 0.15 is the standard payback ratio for recalculating one-time costs to one year.

The cost of purchasing, installing, and commissioning infocommunications can be roughly estimated as [1]

$$C_{\text{ce}} = 1.15 \left( m C_{\text{hsc}} + C_{\text{fsc}} + \alpha C_{\text{hscdn}} + C \right),$$

(9)

where $C_{\text{hsc}}$ – the cost of the PC hardware and software complex; $C_{\text{fsc}}$ – the cost of the file server hardware and software complex (including a communication unit, fax modem, etc.); $C_{\text{hscdn}}$ – the cost of the hardware and software complex of dispatching nodes of the network; $m$ – the number of workstations; $\alpha$ – the number of network nodes.

System operating costs $C_{\text{co}}$ (current and preventive maintenance of equipment, the cost of third-party services, maintenance of maintenance personnel, etc.) usually amounts to 3 to 6% per year of the
cost of equipment ICS and is determined by the formula \( C_{co} = k_{co} C_{co} \), where \( k_{co} \) – coefficient taking into account operating costs [6].

Indicator of efficiency of ICS \( W_i \) for \( i \text{ th} (i \neq I) \) of the INK structure variant can be determined by the formula \( W_i = \left( E_{comi} - E_1 \right) / \left( C_i - C_I \right) \). Where \( E_{comi} \) and \( C_i \) – respectively, the generalized positive result of using the INK and the reduced costs for the construction and operation of the system under study for \( i \)-th variant of the network structure. \( E_1 \) and \( C_I \) – respectively, the generalized positive result of the application of the basic version of the infocommunications and the reduced costs for the construction and operation of the basic system.

A system is chosen as the basic one, which is similar (is a prototype) to the system under study in terms of purpose, structure, volume, and nature of the services provided. However, the basic system lacks the latest tools and technologies, the implementation of which increases its efficiency [20]. The considered (investigated) system differs from the basic use of the latest tools and technologies, the effectiveness of which should be assessed [12-16].

The indicated calculation of the reduced costs and the calculation of the annual economic effect can be carried out only in the simplest case, when capital investments are made not at a time, but during the service life of the system under study. This case is reduced to the simplest one using the reduction coefficients [6–7].

4. Conclusion

An assessment of the private economic effect of the introduction of new hardware, software, information tools, or new technologies for the operation of infocommunications is carried out in order to substantiate the economic feasibility of their implementation and compare competing options for the implemented tools and technologies. By particular indicators, since in some cases, these indicators are of decisive importance when choosing this or that option.

References

[1] Conceptual provisions of multiservice networks in VSS Russia, retrieved from: www.minsvyaz.ru/img
[2] Makhrovsky O V 2009 Technologies of multiservice communication networks (Saint-Petersburg: GOUVOPO)
[3] Khasambiev I V, Gakaeva H M, Khazhmuradov M A and Prokhorets S I New generation multiservice networks (in press)
[4] Chekmarev Yu V 2009 Computing systems, networks and telecommunications (Moscow: DMK Press)
[5] Motley A J and Keenan J M P 1998 Personal communication radio coverage in buildings at 900 MHz and 1700 MHz Electronics Letters 24 (12) 763–764.
[6] Grinyak V M, Lavrushina E G and Bogdanova O B 2017 Exhibition of a multi-position observation system for trajectory measurements Territory of new opportunities (Territoriya novykh vozmozhnosti). Bulletin of VSUES 4 (39) 188–200
[7] Martyushev N V, Egorov Y P 2003 Determination of the signal strength with the computer analysis of the material structure. Proceedings of the 9th International Scientific and Practical Conference of Students, Post-graduates and Young Scientists - Modern Techniques and Technologies, MTT 2003, 192–194, 1438190
[8] Pashkov E N, Martyushev N V, Masson, I A 2014 Vessel ellipticity and eccentricity effect on automatic balancing accuracy. IOP Conference Series: Materials Science and Engineering 66(1) 012011
[9] Balanovskiy A E, Shtayger M G, Grechneva M V, Kondrat’ev V V, Karlina A I 2018 Comparative metallographic analysis of the structure of St3 steel after being exposed to different ways of work-hardening. IOP Conference Series: Materials Science and Engineering 411(1) 012012
[10] Daus Yu, Kharchenko V, Yudaev I 2021 Optimizing Layout of Distributed Generation Sources of Power Supply System of Agricultural Object International. *Journal of Energy Optimization and Engineering* **10**(3) 70-84

[11] Kondrat’ev V V, Govorkov A S, Lavrent’eva M V, Sysoev I A, Karlina A I 2016 Description of the heat exchanger unit construction, created in IRNITU. *International Journal of Applied Engineering Research* **11**(19) 9979–9983

[12] Pelenev D N, Abramovich B N, Sychev Y A, Babyr K V 2019 *Study of the efficiency of the invariant protection against single-phase ground faults in the microprocessor terminals*. Paper presented at the Proceedings of the 2019 IEEE Conference of Russian Young Researchers in Electrical and Electronic Engineering, EIConRus 2019, pp. 624-629. doi:10.1109/EIConRus.2019.8657040

[13] Konyukhov V Yu, Permyakova D N, Oparina T A 2021 Numerical simulation of the size, quantity and shape of non-metallic inclusions in rails. *Journal of Physics: Conference Series* **2032** 012071

[14] Suslov K, Piskunova V, Gerasimov D, Akhmetshin A, Lombardi P, Komarnicki P 2019 Development of the methodological basis of the simulation modelling of the multi-energy systems. *E3S Web of Conferences* **124** 01049

[15] Konyuhov V Y, Gorban A V, Gladkikh A M 2019 Investment in the improvement of maintenance service efficiency of processing equipment of an industrial enterprise. *Journal of Physics: Conference Series* **1353** 012102

[16] Konyukhov V Y, Permyakova D N, Oparina T A 2021 Perspective for the use of industrial waste in lubricating compositions to reduce wear in friction pairs. *Journal of Physics: Conference Series* **2061** 012046

[17] Voropai N, Ukolova E, Gerasimov D, Suslov K, Lombardi P, Komarnicki P. 2019 *A Study on Cost-Effectiveness of Energy Supply Based on the Energy Hub Concept*. Proceedings of 2019 IEEE PES Innovative Smart Grid Technologies Europe, ISGT-Europe 2019, 2019, 8905736

[18] Suslov K, Shushpanov I, Buryanova N, Ilyushin P 2020 *Flexible power distribution networks: New opportunities and applications*. SMARTGREENS 2020 - Proceedings of the 9th International Conference on Smart Cities and Green ICT Systems, pp. 57–64

[19] Konstantinova M V, Olentsevich A A, Konyukhov V Y, Guseva E A, Olentsevich V A 2021 Automation of failure forecasting on the subsystems of the railway transport complex in order to optimize the transportation process as a whole. *IOP Conference Series: Materials Science and Engineering* **1064** 012020

[20] Ilyushin Y V, Pervukhin D A, Afanasyeva O V, Kolesnichenko S V, Afanasyev M P 2017 Improving energy efficiency of tunnel furnaces of the pipeline type—the solution of the problem. *ARPN Journal of Engineering and Applied Sciences* **12**(6) 1801–1812

[21] Nguyen T L, Tonkykh M E, Rapatskaya L A, Tokareva O V 2019 Synthetic simulation of NTEM-sounding signals on the target horizon of the White Tiger oilfield. *IOP Conference Series: Earth and Environmental Science* **229** 012008

[22] Rapatskaya L A, Buglov N A, Hao D 2013 The ontogenesis of hydrocarbons in the North-Chinese oil-and gas-bearing basin. Geological Engineering and Mining Exploration in Central Asia, Proceeding Source: The XVIII Kerulien International Conference on Geology, 2013, pp. 407–410