Algorithm for assessing the quality of service in special-purpose networks during operation

N Kireeva¹, V Zastupov¹
¹Povolzhskiy State University of Telecommunications and Informatics (PSUTI)
23 Tolstoy street, Samara, 443010, Russia
¹zeppelinSN@yandex.ru, ²vladimir.zastupov@mail.ru

Abstract. This article is to show an algorithm for assessing the quality of service in special-purpose networks, regardless of the type of traffic being transmitted and the network architecture. This method allows to obtain a detailed assessment of the quality of service, as well as to adjust the values of the characteristics of the network during the evaluation. The values used in the calculations are entered in the database to aid in the design of new networks.

1. Introduction
Based on the tasks performed by special-purpose networks (SPN), they are subject to increased requirements regarding reliability, security, timeliness and quality of service (QoS) in the process of information transfer. When assessing the QoS in SPN, it is often resorted to the methods of general-access telecommunications networks with similar traffic. The existing methods [1-4] of calculating the QoS in specialized networks differ in the choice of characteristics for estimating this parameter, which leads to a number of assumptions and a decrease in the accuracy of the estimation, as well as ignoring the influence of unused network properties on the quality of service indicator [5-8].

The purpose of this article is to develop a method for assessing the QoS that would be suitable for all SPN, regardless of their architecture and the type of traffic being transmitted, as well as using a full set of characteristics that somehow affect the QoS [9-11].

At the initial stage, it is necessary to configure the network so that during its operation the maximum possible load is provided, and also to prepare and record the initial data. After setting up the parameters of the SPN, an algorithm for calculating and evaluating the QoS parameters is started, consisting of several steps [12, 14].

In the framework of this study, characteristics are selected that allow an accurate assessment of the quality of network service, the methods and procedure for calculating them are determined, an algorithm is created for assessing the quality of service in special-purpose networks.

2. Estimation of reliability of a special-purpose network
First of all, the reliability of the used SPN (\(R_P\)). In this case, the reliability parameter is a property of communication that characterizes the ability to provide the required accuracy of message reproduction at delivery points [8]. Reliability is a collection of event probabilities. In this method, the probabilities of such events are used to evaluate this parameter: the transmitted message is accepted / not accepted (\(A_P / N_A\)), by the user, received with an error (\(E_P\)), or non-transferable data is received (\(NT_P\)).

\[
P_R = \{P_A, P_N, P_{EN}, P_{NT}\}
\]

(1)
Comparison of the given probabilities with the established requirements and, if necessary, their normalization will be considered as an estimate of the QoS of the SPN for reliability.

3. Evaluation of network architecture parameters
At this stage, emphasis is placed on the architecture of building a SPN, the number of nodes and branches used, the number of transmission paths, and the directions of communication [13,15]. Based on these properties, the distributed load is calculated on the branches of the network \( Z_i \).

\[
Z_i = Z + 0.6742 \sqrt{Z}
\]

(2)

where \( Z \) – average load;
\( i \) – branch ordinal number.

Next, the probability of loss and load on the direction of communication is determined:

\[
P_e = \sum_{j=0}^{n} P_j \cdot E_j(Z_j)
\]

(3)

where \( n \) – number of channels in the direction of communication;
\( j \) – channel sequence number;
\( P_j \) – probability of presence of effective channels in the direction of communication;
\( E_j(Z_j) \) – probability of loss in service with load \( Z \) on the communication channel.

It is also necessary to calculate the survivability of the network [5-6] \( W_{SN} \) – this is a characteristic of the network's ability to ensure the establishment of connections and the transmission of messages between sources and consumers of information in the event of failure of its elements or areas without standardizing the QoS.

\[
W_{SN} = 1 - \prod_{i=1}^{L} \left( 1 - \prod_{k=1}^{n} W_k \prod_{i=1}^{L} W_i \right)
\]

(4)

where \( I \) – number of independent communication directions;
\( n \) – number of switching centers in transit;
\( W_k \) – probability of survival of the switching center;
\( L \) – the number of branches in the path;
\( W_i \) – probability of branch survival.

Ultimately, the characteristics calculated by the formulas (2), (3) and (4) are compared with the required values to the investigated special-purpose network.

4. Assessment of the general system of quality indicator
At this stage, the QoS is evaluated with respect to information exchange and management, as well as the systems corresponding to them. It forms a general quality indicator system (GQIS):

\[
GQIS = [Y_{IE}, Y_c, Y_{SIE}, Y_{SC}]^T
\]

(5)

where \( Y_{IE} \) – quality information exchange (IE) system;
\( Y_c \) – quality management system;
\( Y_{SIE} \) – system of the quality indicator of the IE system;
\( Y_{SC} \) – quality system of the management system.

Elements from which the GQIS is formed, in turn, depend on the following parameters:
\[ Y_{IE} = \left[ t_{d0}(r), P(t_{d0}(r) \leq t_{ds dm}(r)), P_{d_{se}}, P_{s_{se}}, C_{IE} \right]^T \]  \hspace{1cm} (6)

where \( t_{d0}(r), P(t_{d0}(r) \leq t_{ds dm}(r)) \) – average time and probability of timely delivery of data of different priorities \( r = 1, R \);

\( P_{d_{se}} \) – authenticity of IE;

\( P_{s_{se}} \) – information security indicator while providing IE;

\( C_{IE} \) – vector of resources for IE.

\[ Y_{CC} = \left[ T_{cc}, P(t_{dc} \leq t_{dc dm}), P_{c}, C_{CC} \right]^T \]  \hspace{1cm} (7)

where \( T_{cc} \) – average duration of the communication parameter control cycle;

\( P(t_{dc} \leq t_{dc dm}) \) – timely delivery of management messages;

\( P_{c} \) – an indicator of information security while providing management;

\( C_{CC} \) – resource cost vector for management provision.

\[ Y_{SIE} = \left[ V_{SIE}, H_{SIE}, C_{SIE} \right]^T \]  \hspace{1cm} (8)

where \( V_{SIE} \) – vector of IE system capacity [7];

\( H_{SIE} \) – vector of the stability indicator of the IE system;

\( C_{SIE} \) – vector of resource costs for the construction and operation of the IE system.

\[ Y_{SC} = \left[ V_{SC}, H_{SC}, C_{SC} \right]^T \]  \hspace{1cm} (9)

where \( V_{SC} \) – vector of control system capacity;

\( H_{SC} \) – control stability index vector;

\( C_{SC} \) – vector of resource costs for the construction and operation of a control system.

As an allowed value of the GQIS as a generalized probabilistic indicator, we take the value equal to 0.8.

5. Algorithm

This algorithm of the method for assessing the quality of service in a special-purpose network is shown in the Fig 1.
Figure 1. Algorithm for assessing the quality of service in special-purpose networks

At the initial stage, data is collected on a special purpose network (type, data transmission rate, length, number of communication branches, modulation type, etc.). After all the necessary information for the calculations is provided, the simulation modeling of the future network is launched. If the parameters amenable to preliminary calculation meet the above standards, it is possible to proceed to the organization of a special-purpose network. If any parameter (s) do not meet the specified requirements, an adjustment is made and the choice of the optimal elimination of the nonconformity. To save resources and time, successful network models are stored in a database for use as standards.
6. Conclusion
This method covers such basic segments of a special-purpose network as: a radio relay communication line, a fiber-optic communication line, a telephone communication line, a satellite communication line. Ultimately, a holistic method was developed for assessing the quality of service in special-purpose networks, covering a large area of calculations and parameters used, which increases its accuracy and efficiency.

References
[1] D.I. Mogilevich, S.V. Druzhinin, O.K. Klimovich “Methodology for assessing the quality of service in a special purpose telecommunications network with connection establishment”, Information system, no. 7 (65), 2007, pp. 43-47.
[2] E.N. Chapurin “Methodology for assessing the quality of service provision in a special purpose infocommunication network based on traffic prioritization mechanisms”, Modern problems of science and education, no. 1-1, 2015, pp. 18-26.
[3] P.V. Kolgotin, “Estimation of channel parameters and development of measuring technologies in special purpose communication networks”, Young scientist, 2011. no. 10(33), pp. 34-39.
[4] M. Louta, A. Michalas, V. Loumos, Quality of Service Management in IP networks, Contel. 2003.
[5] L.P. Shcherbina, O.G. Khilko, Reliability and survivability of switched communication networks, L.:VAS, 1977.
[6] Romanov O.I. Yu.V.Gresko, O.K. Klimovich “Probabilistic model of estimation of telecommunication network survival”, Collection of scientific works of VITI NTUU "KPI", 2003, no. 4, pp. 98-111.
[7] G.G. Yanovsky “Modern Problems of Science in the Field of Telecommunications (Evolution and Convergence)”, Electronic Journal of St. Petersburg: SPbGUT name prof. M.A. Bonch-Bruevich, 2008, 163 p.
[8] S. I. Makarenko “Descriptive Model of a Special Purpose Communication Network”, Systems of Control, Communication and Security, 2017, no. 2, pp. 113-164.
[9] Y. Klochkov, and A. Gazizulina, “Improvement of methodology of evaluation of efficiency of the etallurgical complex procebes development”, Key Engineering Materials, vol. 684, 2016, pp. 453-460. 10.4028/www.scientific.net/KEM.684.453
[10] Y. Klochkov, A. Gazizulina, and N. Golovin, “Assessment of organization development speed based on the analysis of standards efficiency”, Proceedings - 2nd International Symposium on Stochastic Models in Reliability Engineering, Life Science, and Operations Management, SMRLO 2016, 2016, pp. 530-532. 10.1109/SMRLO.2016.93
[11] M. Akhin, S. Kolton, and V. Itsykson, “Random model sampling: Making craig interpolation work when it should not”, Automatic Control and Computer Sciences, vol. 49, no. 7, 2015, pp. 413-419. doi:10.3103/S0146411615070020
[12] M. Khludova, “Resource allocation policies for smart energy efficiency in data centers”, Lecture Notes in Computer Science (including subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics), vol. 8638, 2014, pp. 16-28
[13] Kochovski, P., Drobitshev, P. D., & Stankovski, V. (2019). Formal quality of service assurances, ranking and verification of cloud deployment options with a probabilistic model checking method. Information and Software Technology, 109, 14-25. doi: 10.1016/j.infsof.2019.01.003
[14] Musaev, A. A., & Serdyukov, Y. P. (2016). The uncertainty relation between the signals as a criterion for evaluation of the physical data rate. SPIIRAS Proceedings, 2(45), 58-74. doi:10.15622/SP.45.4
[15] Kalinin, M. O., & Pavlenko, E. Y. (2015). Increasing the fault tolerance and availability of software defined networks using network equipment control based on multiobjective optimization by service quality parameters. Automatic Control and Computer Sciences, 49(8), 673-678. doi:10.3103/S014641161508026X