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DECIDED OF THE PROBLEM OF OPTIMAL DISTRIBUTED THE RESOURCES IN THE INFOCOMMUNICATION NETWORK

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Abstract. In this article formalized an optimization problem of distributed the resources allocated to ensure of reliability components of the infocommunication network, based on the methodology of the technical and economic concept of optimization of information systems. This article proposes a resource allocated for the ensuring of reliability indexes of IN, rationally allocate between the levels of the network. Minimized the sum of the expenditure required to improve the reliability and losses of the company, arising from the residual unreliability of network components with its functioning within a certain time *T*. Resulted a formal description of optimization problem. Algorithmic support described problem is a set of interrelated models that have a hierarchical structure. Means of solving the problem is to create a set of mathematical and simulation models based on theory of mass of service. Optimal solution is achieved by combining the models into a single system covering all the tasks.
Keywords: infocommunication network, reliability index, resources minimizing, coefficient of availability, reliability state, vector of structural parameters, description of optimization problem, vector of the service level, algorithmic support, integrated circuit structure, hierarchical structure, stochastic viewing options.

Introduction

In Nishanbayev and Muradova (2014) proposed a model that allows fromsystem position to investigate of reliability indexes of the infocommunication network (IN) with a distributed structure, whose essence consists in the presentation of components of the IN as subsystems representing independent levels and perform particular functions in packet regime with a given quality of service. In this article determined the expediency of reliability indexes of IN on bases of systematic approach taking into account the reliability states of each level of the network.

This article proposes a resource allocated for the ensuring of reliability indexes of IN, rationally allocate between the levels of the network. In other words, it is proposed to minimize the resources available to provide the required reliability of taking into account the cost of IN losses of the company, arising from the residual unreliability of network components.

When the user requests, usually involving all elements of IN and unreliable operation of at least one element can negate all the work performed by other components of the network. Malfunctions and failures in the network canals and gateways, in the centers of routing and switching systems, in the systems of processing and storage of information, as well as systems of management network resources lead to malfunction, both operators and all users (customers), which leads to large losses of companies offering different types of services. Therefore, in the operation of IN required to ensureunrefusal operation of all its components.

Statement of a problem

It is known that the coefficient of availability K_{Γ}characterizing the probability of system performance in a randomly chosen point in time (i.e., characterizing the degree of reliability of the IN) is defined as the product of the coefficients of readiness of its component parts (levels), i.e.

$$K_{г}^{икс} = \prod_{i=1}^{n} K_{г}^{n}, \ (n = 4).$$

In turn, each level of IN is composed of plurality elements (Muradova, 2014), which also have finite values of reliability, i.e. for each *i* – level fair expression:

$$K_{\Gamma}^{i} = \prod_{j=1}^{m_i} K_{\Gamma}^{j}$$

wherem_i – the number of unreliable functioning elements of *i* -th level of IN.

In Nishanbayev and Muradova (2014), the reliability situation in the IN on arbitrary time *t* invited to describe the following vectors:

Z = (X, B, A, Y, V),

where *X* – RS (reliability state) of inputs (gateways of access level); *B* – RSof communication channels of the transport layer and the access level; *A*- RS of blocks (routers and switches of the transport layer); *Y* – RSof inputs (flexible switch-Soft switch), *V*- RS of components of the management services level of IN at time *t.*

To ensure of a given reliability of the IN requires considerable resources and the determination of the minimum resource, providing the required quality of the functioning of the IN is one of the main problems in the design of the network.

Problem decision

This setting appropriate to expand as follows. From the one side, do not adoption of measures to improve the reliability, ultimately leading to an increase in losses of the company due to late and poor service user requests. On the other – the excessive increase of reliability indexes of IN leads to increased costs for improving reliability. Therefore, it is advisable to minimize the sum of the expenditure required to improve the reliability and losses of the company, arising from the residual unreliability of network components with its functioning within a certain time T, that is, to minimize the functional:

$$\mathbf{C\ \{T\} = \{[C_{з}\ (T)] + [C_{п}\ (T)]\}}$$

The following is a formal description of this optimization problem.

And so, let there be given: 1) the structure of the research network, in which known types and placement of its components, as well as the initial values of the parameters determining the reliability; 2) the vector of structural parameters that uniquely characterizes the structure of the access level of IN:

$$\vec{d} = [H(A,B),\ L^{d}]\ ,$$

where $\vec{d}$ €D – the set of feasible options of the structure of the access level, providing different values of the parameters characterizing the elements of reliability indexes of this level; H (A, B) – a resource graph describing the topological structure of the access level; A = {a_1, a_2, ... a_n} – the set of vertices, matched hardware and software of the access level to which connected mainly terminal devices; B = {$b_{i,\ j}$} – the set of edges of the graph, is mapped to the relationship between the access level; L^d =||ℓ_{ij}|| – matrix of branch lengths (channels) of the graph which characterizes the topological structure of the access level. 3) the vector of structural parameters, uniquely characterizes the structure of the transport layer IN:

$$\vec{w} = [G(P,Q),\ L^{t}]\ ,$$

where $\vec{W}$ € W – the set of feasible options for the structure of the transport layer of IN, providing different values of the parameters characterizing the elements of reliability indicators at this level; G (P, Q) – a resource graph describing the topological structure of the transport layer; P = {p_1, p_2, ... p_m} – the set of vertices, matched hardware and software for the transport layer, which connect to the main technical means of access levels and services; Q = {$q_{i,\ j}$} – the set of edges of the graph, is mapped to the transport layer connection. L^t =||ℓ_{ij}|| – matrix of branch lengths (channels) of the graph which characterizes the topological structure of the transport layer 4) The parameter vector of the service level u = {[S], [Y]}, characterizing the options to improve of reliability indexes of software – hardware means of level of the management service of IN, where: [S] = {s_k} – the set of software means of level of the management services; [Y] = {y_x} – the set of hardware (data processing systems and other hardware) level of management services.

It needs to convert the source and determine an IN structure that would ensure compliance with the requirements for reliability performance in its components, while minimizing the amount of the expenditure required for the establishment and functioning reliably functioning IN, and the amount of reduced cost of losses arising due to the unreliability of the residual functioning of its individual components, i.e. to minimize the functional:

$$C\{\vec{d},\ \vec{w},\ \vec{u}\} = [C_з\{\vec{d},\ \vec{w},\ u\} + C_п\{\vec{d},\ \vec{w},\ \vec{u}\}] \qquad \overrightarrow{\min},$$

when the restrictions determined by conditions to ensure the functioning of all the components of the stationary IN and specified requirements on network performance.

Algorithmic support described problem is a set of interrelated models that have a hierarchical structure (figure 1). Means of solving the problem is to create a set of mathematical and simulation models based on theory of mass of service. Optimal solution is achieved by combining the models into a single system covering all the tasks.

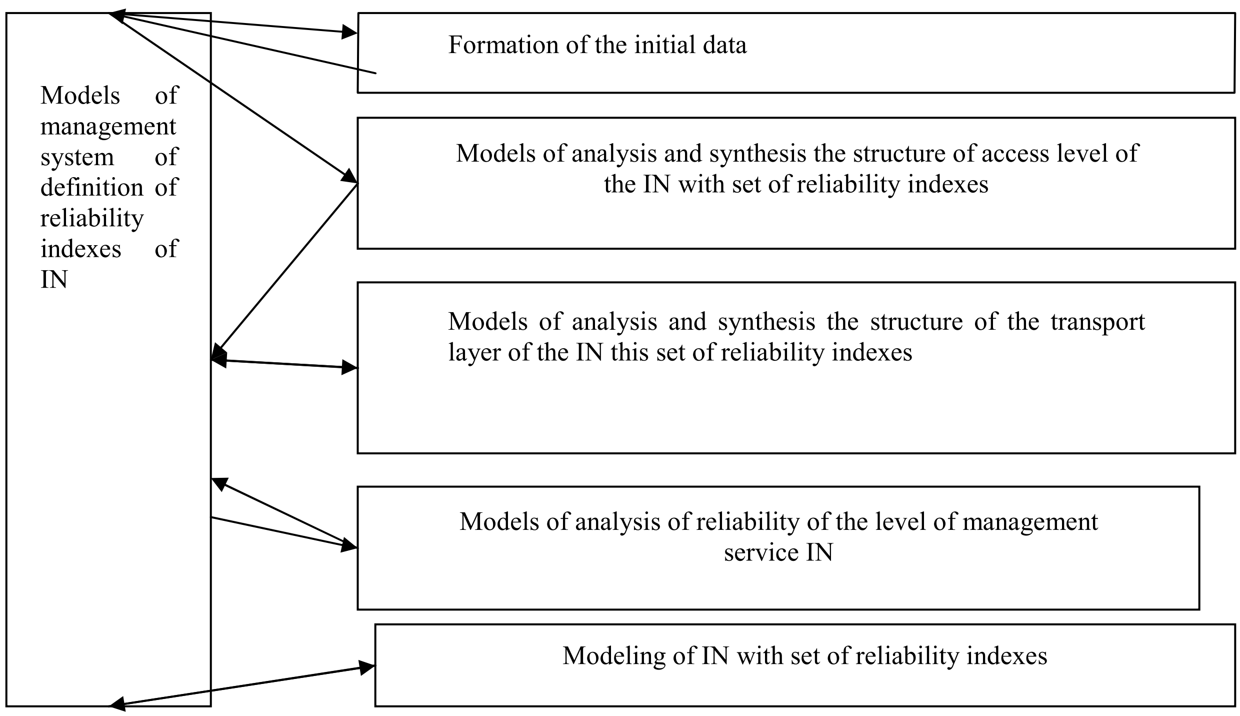

Fig.1. The integrated circuit structure of the IN definition, taking into account its reliability indexes

To solve the problem, please note that the reliability of IN is characterized by two aspects. First – it is a reliable operation of its constituent parts. Second – the ability of network to continue in case of failure of its individual sections. The first characteristic is determined by the reliability coefficient of the network is ready for use. Second – structural solutions that allow traffic to select routes and a processing system that bypass the failed network components. Solution of the problem at the level of individual stages involves a single criterion for the entire network and the decision of individual subtasks on a separate optimization step. Search for the optimal value of the objective function is an iterative process: at each step, select a specific option to improve reliability in the components of IN, which is calculated based on the value of the objective function.

The calculated value of the objective function is compared with that obtained in the previous step, and based on that, select the direction of its further improvement. At each step, a set of interrelated tasks solved with the ultimate goal of improving the definition of variants of reliability indices of components in appropriate levels of IN.

The existing system of feedbacks in a hierarchical structure allows considering complex problems to be solved as a whole and consider the impact on the results of each level of the entire sequence of the previous ones. Such a structure makes it possible to predict the changes in the characteristics, parameters, source data, the search direction, and ultimately to determine the motion of the search for the optimum variant to variant.

Search procedure can be carried out as a combined double search, according to which the search for a global extremum is reduced to a directed stochastic viewing options for the allocation of costs to increase of reliability indices in the components of the network, the resulting directional random search of the desired characteristics of the individual levels in their relationship when the predefined limits. Guided by the principle of search technology described desired version of the network structure, which provides the requirements of the reliability indexes of components of the IN at the appropriate levels with a minimum of the objective function, in its most general form can be represented as follows. The formation of the initial data is preceded by an analysis of the entire structure of IN study, specification type hardware, connectivity of the topological structure, the characteristics of communication channels, reliability performance hardware and software used at levels of IN, the probability distribution of failure-free operation, the possible vulnerabilities that could lead to a deterioration of reliability indices for a reliability parameters IN, etc.

Control system sets the next *i*-version distribution of resources between the levels of the network, i.e.

$$\{C_з\}_i = a_{(д)} * \{C_з\}_i + a_{(т)} * \{C_з\}_i + a_{(п)}\{C_з\}_i,$$

where $a_{(д)}$, $a_{(т)}$, $a_{(п)}$ – the weighting coefficients which characterize the degree distribution of a shared resource between the levels of access, transport and submission services IN, $\sum a_i = 1$.

Model levels of access, transport and submission services on the basis of the resource represented by the control system upgrade its structure and calculate the parameters of the elements of reliability. On the basis of the generated version of IN structure is modeled serve user requests and calculate the network parameters characterizing the quality of service and are determined by the company's losses incurred due to the residual insecurity at its functioning on the basis of the described embodiment of the network structure. Objective function value is calculated and compared with the value obtained in the previous version. If the value is decreased, the results of this option are saved, the results of the previous version is discarded.

Conclusions

If the options for the formation of the network structure are finite all options and choose one that provides the minimum value of the objective function. When considering IN with a complex structure, which contains a lot of options (for example, more than a thousand) minimum search is carried out by applying the methods of directed random search. Results of numerical experiments are presented in the following publications.

References

Jin, T. and Coit, D. (2003). Approximating network reliability estimates using linear and quadratic unreliability of minimal cuts. *Reliability Engineering & System Safety*, [online] 82(1), pp.41-48. Available at: http://dx.doi.org/10.1016/S0951-8320(03)00117-0.

Muradova, A. (2014). Calculation in the NGN Networks of Indexes of Reliability of Tracts of Transmission of Packet Information. *The Advanced Science Journal*, [online] 2014(2), pp.24-28. Available at: http://dx.doi.org/10.15550/asj.2014.02.024.

Musaev, A. and Skvortsov, M. (2014). Methods of parametric reliability optimization of structurally complex technical systems. *Tr. SPIIRAN*, [online] (6), pp.44–50. Available at: http://mi.mathnet.ru/eng/trspy322 [Accessed 7 Oct. 2014].

Nishanbayev, T. and Muradova, A. (2014). The System Research of Reliability Indexes of Infocommunication Networks with Distributed Structure. *The Advanced Science Journal*, [online] 2014(4), pp.59-64. Available at: http://dx.doi.org/10.15550/ASJ.2014.04.059.

Semenov, Y. (2005). *Proyektirovaniye setey svyazi sleduyushego pokoleniya*. St. Petersburg, Russia: Nauka i Tehnika.

Skvortsov, M. (2014). Reliability optimization technique for network structure systems. *Tr. SPIIRAN*, [online] (16), pp.231-242. Available at: http://mi.mathnet.ru/eng/trspy419 [Accessed 7 Oct. 2014].