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Research Article

Estimation Model of Functional Stability of the Local Computer Network

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Abstract: Research existing scientifically grounded approaches to improving the efficiency of complex technical systems, which fully applies to local computer network, allowed to conclude about the formation in recent years a new priority approach associated with providing the system properties of functional stability. A functional criteria and indicators of local computer network stability are proposed. Implementation of functional stability is achieved by using different types of redundancy (structural, temporal, informational, functional, load, etc.) in a complex technical system. The proposed model for estimation the functional stability of the local computer network uses the principle of decomposition of complex procedures to ensure functional stability into simpler steps and offers a methodology for calculating the probability of a generalized indicator of functional stability as a connectivity matrix structure convolution. This approach allows estimating and comparing the different topologies of local computer network and applying them to form techniques of the optimal use of redundancy systems to prevent the consequences of emergency situations.
Keywords: functional stability, redundancy, local computer network.

INTRODUCTION

Research of existing evidence-based approaches for improving the efficiency of complex technical systems, to which is fully applied local computer network (LCN), led to the conclusion about formation within the last years of the new priority approach, which is associated with providing the system properties of functional stability.

The implementation of functional stability is achieved by using a complicated technical system of different types of existing redundancy (structural, temporal, informational, functional, load, etc.) through the redeployment of resources to parry the consequences of emergency situations.

However, some researches in the field of functional stability of complex technical systems makes it difficult to develop common approaches and establish theoretical foundations of stability for functional coatings for LCN. The problem is the lack of a standardized conceptual apparatus of functional stability and uncertainty indicators and criteria optimization of subject area of LCN.

Publication analysis

The concept of functional stability was first introduced by O.A. Mashkov, who proposed the original idea to ensure the survivability of complex dynamic systems based on redistribution of the available surplus. [2] However, indicators and criteria proposed by Mashkov O.A. can not be applied to optimize the LCN because they do not consider many features of complex distributed heterogeneous environments of LCN.

More common can be considered the approach proposed in the works of Barabash E.V., especially in [2], which proposed criteria and indicators for sustainable building systems of data. However, such approach is based only on estimates of connectivity network graphs that too limits its use for functional stability of LCN.

In works of Kravchenko U.V. [3-5] is proposed a slightly different approach to identify and provide stability for functional navigation systems for special purposes based on solving the optimization problem using matroid structures. However, this approach is highly specialized and too difficult to implement due to complexity of description of the elements and parameters of LCN in terms of matroids. A significant contribution to the development of the theory of functional stability did Professor S.M. Nedilko. Specifically, in his works have received further development classic concept of providing functional stability of complex technical systems, characterized by a new strategy to ensure the functional stability of automated air traffic management system [1]. Thus, the problem of determining the parameters and criteria for the LCN functional stability is not yet resolved and should be studied for relevant dependencies and approaches.

The target of article is to develop a system of indicators and criteria to ensure the formalization of functional stability of LCN**.**

MAIN PART

Choosing as a basis the approach proposed in [2] note that a special interest in the theory of functional stability for LCN represents a generalized probabilistic measure of coherence - as convolution matrix of probabilities connectivity.

$$P_{CB} = \begin{bmatrix} 0 & P_{12} & P_{13} & \dots & P_{1n} \\ P_{21} & 0 & P_{23} & \dots & P_{2n} \\ . & . & . & . & . \\ P_{n1} & P_{n2} & P_{n3} & \dots & 0 \end{bmatrix}. \quad (1) \qquad (1)$$

$$F_{LCN} = F(P_{cв}) = \sum_{i=1}^{n} \sum_{j=1,\, j\neq i}^{n} w_{ij} \cdot P_{ij}, \quad (2) \qquad (2)$$

where n - number of units of LCN;

w_{ij} - weights lines, depending on the desired intensity P_{ij} - information transfered between v_i and v_j:

$$w_{ij} = \begin{cases} 2, & if \quad \rho_{ij} \geq M[\rho]; \\ 1, & if \;\; 0{,}1M[\rho] \leq \rho_{ij} < M[\rho]; \\ 1/2, & if \quad \rho_{ij} < M[\rho]. \end{cases} \quad (3) \qquad (3)$$

Expected value of given intensity of information transmission $M[\rho]$ in LCN is based on the following relationship:

$$M[\rho] = \frac{1}{n(n-1)} \sum_{i=1}^{n} \sum_{j=1;\, j\neq i}^{n} \rho_{ij}. \quad (4) \qquad (4)$$

The probability of connectivity of R_{ij} is based on these initial data:

1) structure of LCN, which is given by adjacency matrix AFM;

2) the probability of transmission the information of R_{ij} through L_{ij}.

The simplest method of determining R_{ij} is the decomposition structure of ASUPR on consistent and parallel connection lines. The complex branched structures with crossed connections, can not lead to the basic compounds links in the sense of reliability. In this case it is advisable to apply structural changes to graphs [4]. Their essence lies in the expansion of the structure of LCN to any element by Shannon Moore’s method. As a result of the decomposition the resulting structure can be represented as a series-parallel connections. For example, to calculate the P14, output graph G (Fig. 1) will be converted into two graphs G1 and G2 [2].

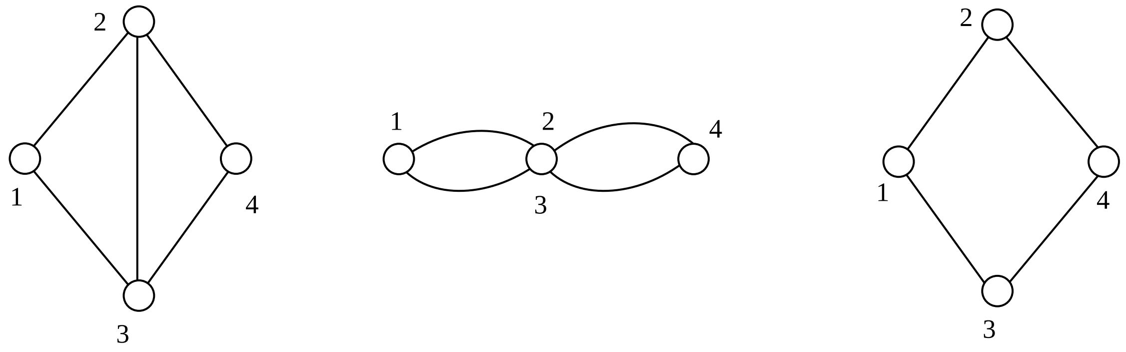

Fig-1: Convert of graph to a series-parallel connection of edges

Graph G1 is obtained by charging rib l23, corresponding to good condition rib l23. Count G2 is obtained after breaking l23, corresponding to its defective condition. The probability of connection of R1,4 for graph G can be calculated by the basic formula of decomposition:

$$P_{14}(G)=p_{23}\cdot P_{14}(G_1)+q_{23}\cdot P_{14}(G_2), \text{ (5)} \qquad (5)$$

where $P_{23} = 1\text{-}q_{23}$ - the likelihood of transmission of information through communication line corresponding to the edge l_{23};
$P_{14}(G_1)$ and $P_{14}(G_2)$ - are determined by the methods of reliability theory as a series-parallel connection elements:

$$P_{14}(G_1)=P_I\cdot P_{II}=(1-q_{12}q_{13})\cdot(1-q_{24}q_{34}); \text{ (6)} \qquad (6)$$

$$P_{14}(G_2)=1-Q_I\cdot Q_{II}=1-(1-p_{12}p_{34})\cdot(1-p_{13}p_{34}). \text{ (7)} \qquad (7)$$

If we take pij = p, qij = q for all i, j = 1,2, ..., n, then P14 expression takes the form:

$$P_{14}(G)=p\cdot\left(1-q^2\right)^2+q\cdot\left[1-\left(1-p^2\right)^2\right]. \text{ (8)} \qquad (8)$$

Expression (8) is identical to the expression $P_{1,4}=p^2\left(1+q^2\right)+2p^3\left(q+q^2\right)$, confirming the convergence of the results with the two methods.

Analyses of Shannon Moore's method of decomposition, reveals the following features:

- method is effective for poorly connected graphs with n≤10 and allows analytical calculations;
- for more complex graphs decomposition, process must be repeated several times;
- as a result of decomposition procedures, the source graph is divided into 2m!!! graphs of series-parallel connections ribs;
- algorithm, which is built by this method has a complexity of O (2m), where m - number of edges, which are carried out by the decomposition.

Another feature of probabilities of connectivity of Rij as a partial indicator of functional stability is its susceptibility to degradation and increasing structures. Removal (rejection) of any link of LCN leads to decreasing the value of R_{ij} , and adding any lines - to increasing of R_{ij} , due to the emergence of new independent information transfer routes.

The impact of the removal and addition of edges of the graph topology coatings can be analyzed in the following example. Consider the example of a model of LCN bipolar structure (Fig. 2).

Fig. 2 shows the output graph. In this case, the probability of connectivity of R_{ij} is calculated on the basis of decomposition of graphs as follows:

$$P_{ij} = p^2\left(1-q^2\right)+q^2p^3\left(2-p^3\right)+2pq\left(1-q^2\right)\left(2p^2-p^4\right). \quad (9)$$

(9)

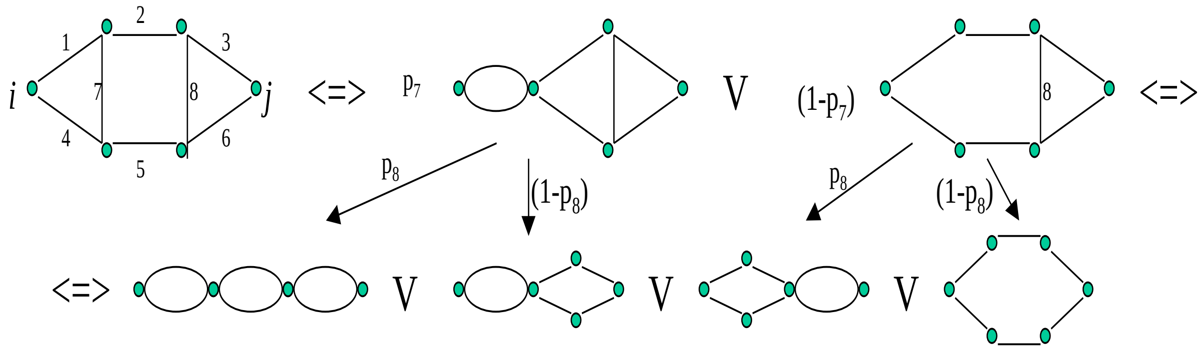

Fig-2: Determining the probability of connectivity by structural changes method

Table. 1 shows the results of calculation for the original structure of the graph (Fig. 2) and the structures obtained after removing and adding some ribs at values of probability information in transfer lines p = 0,9, p = 0,8.

Table 1: The value of the probability of connectivity in the topology of LCN

Structure	Expression for P_{ij}	P_{ij} for p=0,9	P_{ij} for p=0,8
Out.Structure $G(V,L)$	$p^2\left(1-q^2\right)+q^2p^3\left(2-p^3\right)+ +2pq\left(1-q^2\right)\left(2p^2-p^4\right)$	0,966	0,864
$G(V,L) \setminus l_8$	$p^3(1-q^2)(2-p^2)+qp^3(2-p^3)$	0,951	0,821
$G(V,L) \setminus l_2$	$p^3(1+qp)^2$	0,866	0,689
$G(V,L) \setminus \{l_2, l_8\}$	$p^3(1+qp)$	0,795	0,594
$G(V,L) \cup l_{ij}$	$1-q(1-P_{ij})$ (за (9))	0,977	0,973

Analysis of the results (Table. 1) confirms the exponential dependence of the probability of connectivity to the relative number of edges of P_{ij} (m/n), where m and n - power sets of edges and vertices V L graph. Moreover, the m / n> 4/3 probability of P_{ij} exceed the p_{ij} .

To analyze the functional stability of the complex system has particular interest sensitivity of average probability of connectivity in the neighborhood of $P_{ij} = P_{ijzad}$:

$$\xi_{ij} = \lim_{\Delta m_L \to 1} \frac{\Delta P_{ij}\left(m_L / m_V\right)}{\Delta m_L} \cdot m_V, \quad P_{ij}\left(m_L / m_V\right) \to P_{ij}^{ЗАД}. \text{(10)} \qquad (10)$$

The higher ξ_{ij}, the higher the growth rate of functional stability when added to the structure assignment lines. Since the structural transformation method determines the probability of P_{ij}, connectivity between a pair of nodes, then to calculate the probability of connectivity, matrix algorithm must be performed n (n-1) times. At the same time, an alternative to this method is exact and approximate methods, which classification are given in the monograph [2]. It should be noted, that theory of determination of $F_i(t)$ and $R_i(t)$ is sufficiently described in [5]. Thus, as indicators of functional stability of LCN are advisable to choose a ones that determines the chances of some set of functional properties

$$P(F_\tau) = P\{F_\tau[z(t,\alpha), t \le \tau] \in B_{A_1}^{\tau}\}, \quad (11)$$

where $P(F_\tau)$ − set of probability indicators functional stability of LCN.

CONCLUSIONS

The approach to identify indicators and benchmarks of functional stability LCN uses the principle of complex decomposition procedures to ensure functional stability into simpler steps and offers a methodology for calculating the generalized probabilistic indicator of functional stability as convolution matrix structure connectivity. The proposed indicators and criteria can be used in evaluating and comparing different topologies of local networks, and applied to create the optimal use of redundancy in the system parry the consequences of emergency situations.

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