UDK 355.45

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THE STRATEGY OF BUILDING FUNCTIONALLY STABLE INFORMATION-TELECOMMUNICATION SYSTEMS

The article introduces the notion of "functionally stable information-telecommunication system", gives grounds for the need to implement this property into all modern information and telecommunications systems. The strategy and theoretical basis of scientific-methodical apparatus for providing information and telecommunications systems with functional stability properties have been described.

Keywords: *functional stability, information and telecommunication system, reliability, strategy.*

Introduction

The industry associated with information technology is now becoming ever more relevant. It should be emphasized that the study of the existing science-based approaches to the increase of the effectiveness of complex technical systems, including telecommunication ones, brought us to the conclusion on the formation of a new priority approach associated with provision of a system with a functional stability [1-9]. Implementation of a functional stability is achieved by the use of different types of redundancy (instrumental, time, information, functional, capacity, etc.) in a complex technical system, through resource leveling to compensate the consequences of emergency situations. It is fundamental that at the design stage additional redundancy must not be implemented, and compensation of the consequences of emergency situations will be carried through leveling of the existing resources. The problem is to identify such redundancy and to form the signals of recovering control at the required moment aimed at its leveling. This is the main difference between the problem of ensuring a functional stability and the problem of design of structurally redundant systems.

Target Setting. The known properties of complex technical systems, such as stability, reliability, survivability, fault-tolerance characterize functioning of systems under the influence of failures and damage. But they do not allow full description of the functioning processes in the conditions of significant damage, the impact of failures flows, possible terrorist influences, as well as errors of operators and other internal and external destabilizing influences. Therefore, it is advisable to provide the information and telecommunications systems with such property of complex technical systems as a functional stability [1].

Analysis of latst research and publications. Many scientific works have described a functional stability [2], and one of them [3] - the property of functional stability and its general idea for complex technical systems. Our study introduces the notion of a functional stability of a dynamical system as "properties of the system that represent its ability to perform at least a set minimum of its functions in case of a failure in the information, computing and power components of the system, as well as the influences of external factors stipulated by the operating conditions". We propose main stages of the procedure to provide the system with this property, namely: detection and recognition of an emergency situation, with the subsequent compensation of the consequences due to implementation of recovering control. The problem of a functional stability of on-board information and control complex of an aircraft has been considered in more details.

At present, in spite of the available meaningful scientific results of the theory of functional stability, mathematical models of complex systems researched by them fail to adequately describe the functioning of all the existing systems. Therefore, it is relevant to summarize the theory of functional stability of complex technical systems and develop it for specific systems, namely, - for information and telecommunication systems. Analysis of the known scientific provisions of the existing theory of functional stability determines the fact of absence of direct publications concerning the solution of the problem of design of functionally stable information and telecommunications systems.

The paper [4] was the first to define and prove the general difference between a stability of functioning and a functional stability: a stability of functioning characterizes the behavior of the coordinates of an unexcited and excited operation of the system, while a functional stability describes the deviation of the main functions of the coordinates at an unexcited and excited operation. Distributed information system is mathematically described by a random graph, which peaks are connected by a triangle principle. In other words, in case of any emergency situations, the information from each node must reach (albeit not by the shortest path) each node in the system. Our research has offered a necessary and sufficient condition for the functional stability of distributed information systems of special purpose, that means all the switching nodes must be operational and the alternative routes of transmission of information between nodes must be available. We have also proposed a framework of categories and concepts connected with a functional stability, which is a set of mathematical models,

signs, indicators, criteria, stock and areas of a functional stability. The methods to define graph connectedness to be able to calculate indicators of a functional stability of distributed information systems have been generalized and further developed. The sets of methods for the synthesis of a structure of functionally stable distributed information systems have been developed, which include the method of solution of a specific problem and the method of solution of a general problem of synthesis. The technique for identification of emergency situations in functionally stable distributed information systems has been improved, which is based on the principles of the so-called stray diagnostic kernel and does not require additional hardware redundancy to solve the problems of identification.

Kravchenko Yu.V. [2] gave a formalized definition to a functional stability of a pseudo-satellite radionavigation system. Unlike for a distributed information system, the so-called "star" is assumed to be a model for connections between the elements of a pseudo-satellite radionavigation system, and loaded orgraphs - its mathematical model. The problem of synthesis of the system structure was solved on the basis of the theory of matroids, gradient algorithms and the method of sequential increase of the rank of a k-uniform matroid developed by the author. The concept of formation of the structure of pseudo-satellite radionavigation system was offered, which is different from existing approaches to the design of multiway radio-navigation systems due to availability of functional stability through the use of structural redundancy and formation of recovering control in order to compensate the consequences of emergency situations (in case of failures, faults, destructions, combat and other damages of pseudo-satellites) to enable the system to perform the functions of navigation. The implementation of the concept allows to synthesize the system structure taking into account a possible loss of its components, as well as to reduce the number of pseudo-satellites 2-4 times with equal values of the indicator of a functional stability. A framework of categories and concepts of functional stability of the structure of the a pseudo-satellite radionavigation system (a sign, an indicator, a criterion, a boundary, and an area of a functional stability) has been further developed and can be applied to any multiway radio-navigation systems, allowing it to formalize in the mathematical way the objective function and limitations in the problem of the structure optimization, as well as quantitatively and qualitatively evaluate the property of a functional stability of the structures of pseudo-satellite systems. A model for the synthesis of a structure of a pseudo-satellite radionavigation system was developed, which is different from the existing approaches to the synthesis of structures of multiway radionavigation systems due to availability of a functional stability; application of the proposed method of sequential increase of the rank of a k-uniform matroid. The method of determining the value of the indicator of a functional stability of the structure of a pseudo-satellite radionavigation system was developed for the first time, which fully takes into account both the accuracy of the solution of a navigation task by consumers, and a structural redundancy of a pseudo-satellite system, as well as the ability to control a structural redundancy of the system to compensate the consequences of failures, faults, destruction, combat and other damage to pseudo-satellites. Application of these methods allows to have a quantitative evaluation of a functional stability of any structures of multiway radio-navigation systems in the analysis of the existing and the synthesis of advanced systems [5].

A considerable contribution in the development of the theory of a functional stability was made by Professor Nedelko S.M. [6]. Namely, his works gave a further development to the classic concept of ensuring a functional stability of complex technical systems, which is characterized by a new strategy to ensure a functional stability of automated air traffic control systems in the context of itemization of the stage of "compensation" through substages: identifying existing resources (redundancy areas), formation of the procedure of optimum (suboptimum) usage of redundancy and estimation of the system condition after leveling of the resources. Professor Obidin D.M. in his works [7] further developed the existing concept of a functional stability of complex technical systems, which differs from existing approaches by the proposed strategy and the principles of ensuring the functional stability properties for intelligence systems of automatic aircraft flight control in the context of the development of the phase of "recognition" of a classical theory through implementation of the verification of the decentralized unclear database to determine the authenticity of the data elements, and the stage of "compensation" where during the formation of recovering control a subjective character of the data is taken into account through the indicators of reliability of the database elements to compensate the consequences of emergency situations during the aircraft flight.

So, to develop and implement information technologies in the society we must consider the general problem of raising the efficiency of information and telecommunication systems, for which the problem of ensuring a functional stability for the system is a specific one.

The aim of the article is to present the strategy and theoretical background of the methodological framework to ensure functional stability for information and telecommunication systems.

Presentation of the main research material

Functional stability of an information and telecommunication system is its property to be in an operational condition, that is, to carry out at least the required minimum of its functions within a given time interval or its lifelength under the condition of failure of its components in case of external and internal factors due to redistribution of different types of redundancy.

Analysis of requirements to the design of a functionally stable system discovered a conflicting situation, which represents the worsening conflict between the following requirements:

between the requirement to increase the efficiency, that entails additional expenses, and the requirement to reduce the costs while designing and upgrading;

between the requirement to reduce the time on upgrades, which reduces the efficiency of the system, and the requirement to increase the efficiency.

This controversial situation makes the basis for the actual new scientific problem connected with ensuring the properties of a functional stability of information and telecommunications systems. It is possible to solve this scientific problem through the use of the theory of ensuring a functional stability of information and telecommunications systems proposed by the authors of this article. This theory includes a set of logically related conceptual, theoretical and technological bases. The conceptual basis describes a system of views or, in other words, a basic leading idea – the concept of ensuring functional stability properties. The strategy of ensuring the properties of a functional stability is substantiated and developed. A scientific hypothesis that this property will be ensured at the expense of intellectualization of the stages of a "classic" strategy is suggested.

This idea is comprehensively studied in the theoretical basis using new scientific approaches, methods, techniques, algorithms and mathematical models. As a result scientific-methodical apparatus for the analysis and synthesis of a functionally stable information and telecommunications system has been developed. A systematic approach, the theory of artificial intelligence, universal algebra, fuzzy logic and a theory of emergent field make the theoretical basis of the study.

The concepts and theoretical bases of the so-called FS-systems and E-field have been introduced and developed.

FS-system refers to a system of algebra, that represents the grid on which the specified additional binary relation that has some rule-oriented-logical properties was set. The grids in the context of this definition are considered in their broad sense, with their type being specified in particular models. The concept of FS-system is an abstract description of a set-theoretical model of a rule-oriented structure. This generalization is achieved using mathematical grids as the basis for an algebraic system. A binary relation is set on the grid that contains the semantics of a rule-based-logical conclusion.

E-field or an emergent field is a mathematical formalization of the system effect or emergence – one of the important properties of a complex system. Rules of the so-called operations of "emergence addition" and "emergence multiplication" are substantiated and presented. The authenticity of this theoretical result is confirmed by the fact that it was received on the basis of one of the laws of dialectics – the law of transition of quantity into quality.

Conclusions and perspective for future research

Thus, it is expected that the design of functionally stable information and telecommunications systems will enable us to successfully solve many problems of the design and development of new generations of data systems, because these systems allow: significant expansion of the range of application conditions; ensuring a comprehensive optimization of performance of tasks assigned to the functions system; increase in the efficiency of the systems as a whole; significant reduction of time and financial costs connected with development and adoption of individual designs of hardware and software.

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СТРАТЕГИЯ ПОСТРОЕНИЯ ФУНКЦИОНАЛЬНО УСТОЙЧИВЫХ ИНФОРМАЦИОННО-ТЕЛЕКОМУНИКАЦИОННЫХ СИСТЕМ

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В статье уделено внимание научной проблеме обеспечения свойства функциональной устойчивости информационно-телекоммуникационным системам. Решение данной научной проблемы возможно путем использования предложенной автором статьи теории обеспечения функциональной устойчивости информационно-телекоммуникационным системам. Данная теория включают совокупность логически связанных между собой концептуальных, теоретических и технологических основ. В концептуальных основах сосредоточена основная руководящая идея - концепция обеспечения свойства функциональной устойчивости. Излагается стратегия обеспечения свойства функциональной устойчивости. Выдвигается научная гипотеза о том, что данное свойство будет обеспечено за счет интеллектуализации этапов «классической» стратегии. В теоретических основах данная идея всесторонне исследуется на основе новых научных подходов, методов, методик, алгоритмов и математических моделей. В результате разработан научно-методический аппарат анализу и синтеза функционально устойчивой информационно-телекоммуникационной системы. Теоретической основою является системный подход, теория искусственного интеллекта, универсальная алгебра, нечеткая логика и теория эмерджентных полей. Введены понятия и разработаны теоретические основы так называемых FS - систем и E - поля.

***Ключевые слова:** функциональная устойчивость, информационно-телекоммуникационная система, надежность, стратегия.*

СТРАТЕГІЯ ПОБУДОВИ ФУНКЦІОНАЛЬНО СТІЙКІЙКИХ ІНФОРМАЦІЙНО-ТЕЛЕКОМУНІКАЦІЙНИХ СИСТЕМ

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У статті приділена увага науковій проблемі забезпечення властивості функціональної стійкості інформаційно-телекомунікаційним системам. Вирішення даної наукової проблеми можливо шляхом використання запропонованої автором статті теорії забезпечення функціональної стійкості інформаційно-телекомунікаційним системам. Дана теорія включає сукупність логічно зв'язаних між собою концептуальних, теоретичних і технологічних основ. У концептуальних основах зосереджена основна керівна ідея - концепція забезпечення властивості функціональної стійкості. Викладається стратегія забезпечення властивості функціональної стійкості. Висувається наукова гіпотеза про те, що дана властивість буде забезпечена за рахунок інтелектуалізації етапів «класичної» стратегії. У теоретичних основах дана ідея всебічно досліджується на основі нових наукових підходів, методів, методик, алгоритмів і математичних моделей. У результаті розроблений науково-методичний апарат аналізу й синтезу функціонально стійкої інформаційно-телекомунікаційної системи. Теоретичною основою є системний підхід, теорія штучного інтелекту, універсальна алгебра, нечітка логіка й теорія емерджентних полів. Уведені поняття й розроблені теоретичні основи так званих FS - систем і E - поля.

***Ключові слова:** функціональна стійкість, інформаційно-телекомунікаційна система, надійність, стратегія.*

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