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INFORMATION TECHNOLOGY OF MANAGING PARAMETERS OF INFORMATION ANDCOMMUNICATION NETWORK IN THE SYSTEMS OF CRITICAL INFRASTRUCTURE

The subject matter *of the article is the problem of ensuring the requirements for the efficiency and exchange of information with a high level of information security in critical infrastructure systems.* ***The goals*** *of the work is to develop information technology for network structuring, to determine its parameters, to manage the distribution of network traffic, that focus on solving a given set of applications and providing the necessary security of critical infrastructure within the information and communication network. The following* ***tasks were solved*** *in the article: the model of information technology process for managing the parameters of the information and communication network was developed, the block for developing the information structure of the network for the automated control system of technological processes was tested. Such* ***methods*** *as the set-theoretical one and matrix calculations* ***were used****; the process models were presented in IDEF0 notation. The following* ***results were obtained****. The structure of the information technology which contains three main blocks was suggested. The sequence of processes in each block was considered. The model of the block for developing the structure of the information and communication network was developed. The operation of the synthesiser of the network informational structure was considered regarding the software and hardware complex as a part of the automated control system of technological processes as an example. The functional tasks of the software and hardware complex were determined and distributed among the hierarchical levels of the network. According to the structural diagram of the automated control system, elements of the information model of the network structure were determined.* ***Conclusions****: The suggested information technology help solve the following tasks: according to the received parameters of information structure, the requirements for the technical structure of the network can be determined; the adaptive managing the parameters of data flows can be ensured by setting the network to the varied conditions of operation of critical infrastructure system; risks at the stages of structural and parametric synthesis and distribution of network traffic can be assessed and managed.*

Keywords*: information technology, critical infrastructure system, information and communication network, adaptive management, process model, data flow intensity.*

Introduction

Under modern conditions, a high level of information support has become a core driver for achieving the goals of critical infrastructure systems (CIS), which raise specific demands for data processing and transmitting [1]. Ensuring the implementation of complex requirements for the quality of solving application problems is the main goal of CIS management. The basis of CIS information support is a global distributed information and communication network (ICN) based on available and advanced communication networks and data transmission using modern telecommunication technologies, which should provide high technical characteristics [2].

Problem setting

The results of the analysis of current state of telecommunication technologies and major protocol decisions indicated the violent rate of CIS development for creating high-speed multiservice networks [3 – 5]. Despite rapid development of physical and channel technologies, CIS capabilities can be fully implemented only due to efficient management of available network resources in the context of increasing requirements for promptness of information exchange.

Available information technologies (IT), which are the basis for the methods of traffic management in CIS, are incapable to ensure the requirements for information exchange promptness under conditions of increasing amounts of circulating information as well as under the dynamic change of data transmission structure [6].

The analysis of major factors affecting traffic management indicated the necessity for developing information technology that is aimed at adaptive management in order to increase the promptness of information transmission in CIS.

In the context of tough requirements for CIS ICN reliability and capacity, analyzing data flows and determining their parameters should be one of the stages of its design. In order to do this, statistical analysis, mathematical modelling, static and dynamic analysis of data sources and flows are used [7, 8]. Data flow modelling should be based on researching the network information structure [9].

The use of adaptive management of network resources consider researching, analyzing and modelling data flow which arise when applied complements operate and interact at network nodes. At present, this task is insufficiently formalized and requires developing complex mathematical models which represent network

information and technical structure as well as data flows available in ICN.

Requirements for consistency and complexity of security facilities cause major problems today [10]. Using efficient procedures and technologies that are based of assessing the risk of processes help ensure CIS strength required for maintaining its operation, infrastructure critical complements and the continuity of management [11].

Hence, the *goal of the article* is developing information technology of network structuring, determining its parameters, managing network traffic aimed at solving a set of application tasks as well as ensuring necessary CIS security in the context of information and communication network. This task should be solved by developing the methodology of managing network parameters which combine the specificity of the tasks being solved and capabilities of available systems of management, that is the methodology which is adaptive to the conditions of CIS operation.

1. The process model of information technology for managing the parameters of CIS ICN

The suggested information technology implements the sequential operation of three units (Fig. 1):

1) the synthesizer of CIS ICN structure,
2) the adaptive control block of CIS ICN traffic;
3) the block of making decisions on managing ICN risks in order to increase CIS security.

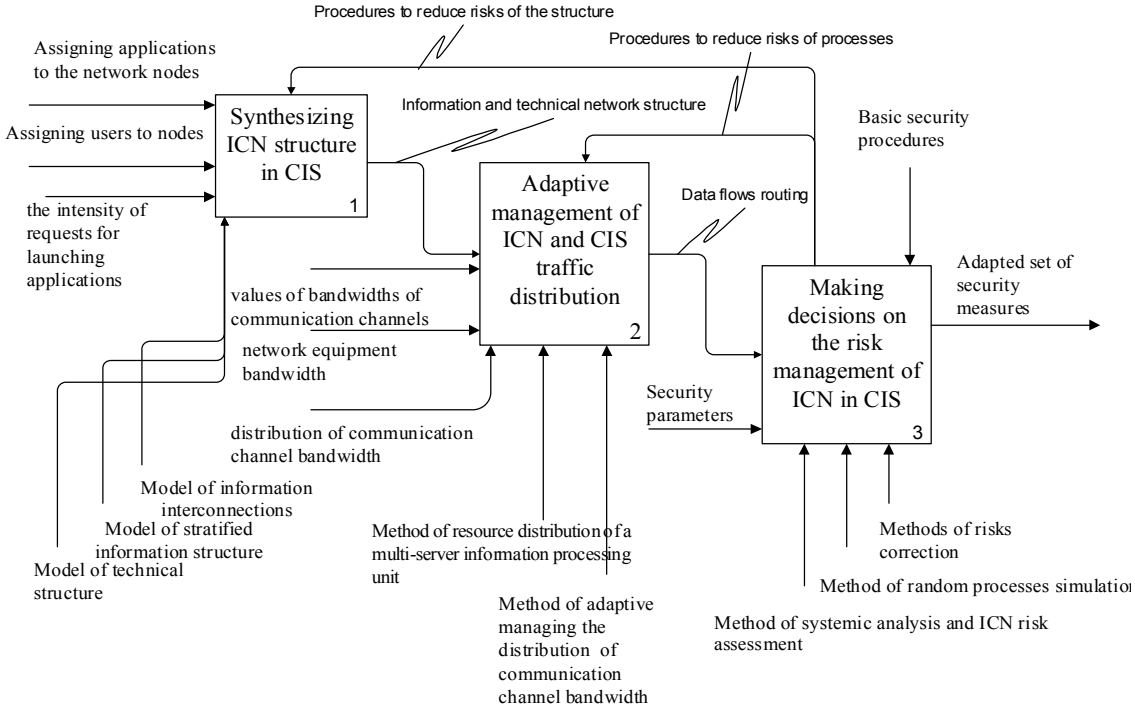

Fig. 1 The model of information technology of managing CIS ICN parameters

To enable the operation of the synthesizer of CIS ICN structure, the sequence of the following processes should be performed (Fig. 2):

- determining the composition of network users;
- determining the composition and parameters of application tasks being solved;
- determining the composition of complements that the network includes as well as requirements for the equipment necessary to implement the complements;
- developing the network information structure;
- analyzing the network information structure;
- determining quality indicators and criteria for solving application tasks;
- determining the composition of network parameters that are used in order to assess the network condition;
- determining the composition of network management parameters;
- determining the threshold of net parameters.

To enable the operation of the adaptive traffic control block, the sequence of the following processes should be performed while preparing and solving management tasks [12]:

- solving the task of network configuration;
- solving tasks of operating control;
- correcting tasks of network configuration and operating control.

Preparation stage is necessary in order to work out basic approaches and requirements for traffic management, on the basis of which the criteria of managing the quality are determined, specific goals and tasks of management are formulated.

The following parameters are considered as input data of information technology for solving tasks of analyzing data flows in the network, downloading communication channels and network equipment:

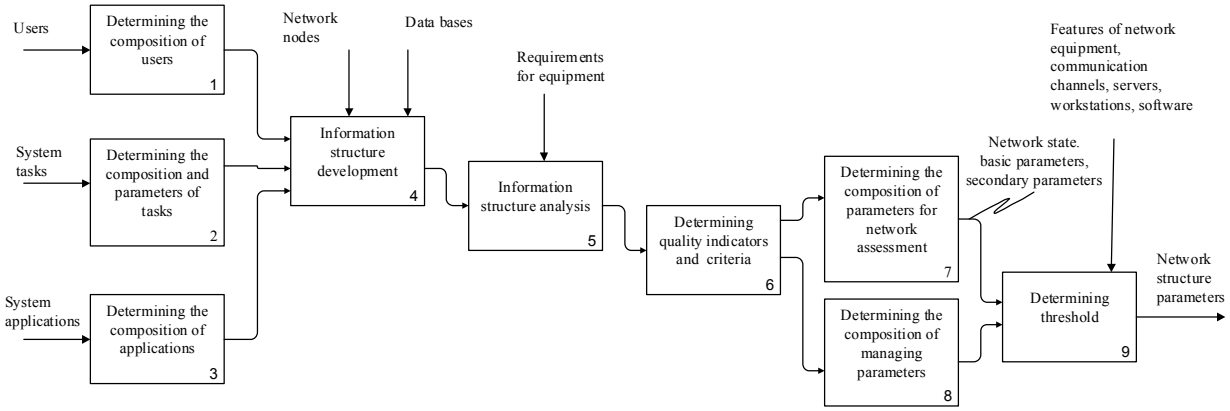

Fig. 2 The model of processes of the synthesizer of CIS ICN structure

- assigning applications to network nodes;
- assigning users to network nodes (workstations);
- the intensity of requests for running applications or tasks;
- network structuring, that assigns communication channels to network equipment and binding workstations and servers to network equipment;
- values of bandwidth of communication channels that are used in the network;
- the bandwidth capacity of the equipment used in the network;
- assigning the bandwidth of communication channels to particular tasks (sets of tasks);
- data flow routing in the network.

At the stage of network channel setting the following sub-processes are performed:

1. determining certain quality factors of network setting.
2. developing and calculating the parameters of data flows of hierarchical information structure of the network; solving the tasks of information structure development is considered as a partial solution of a setting task that result in determining the parameters of information structure and data flows for the information structure with these parameters.
3. determining the composition of network equipment; the equipment composition and its parameters – commutators, servers, client workstations, types of communication channels that are used – are determined according to the analysis of requirements for the equipment parameters, analysis of data flows, conducted for the information structure of network traffic management, possible number of network technical nodes and preprocessing data about network technical structure (a priori assigning users and nodes to subnetworks).

The development of network technical structure results in developing a number of values of basic network parameters as well as the structure of basic network, sub-networks and their composition are also designated. It should be noted that the tasks at this stage can be solved repeatedly, if assigning system applications to the nodes of information structure is changed. After the stage has been finished, a set of values of network parameters is obtained.

2. Developing the information structure of a software and hardware complex

The structure synthesizer operation is considered regarding ICN for automated control system of technological processes (TP ACS) "Domestic solid waste recycling facility with the system of collection, utilization of landfill gas and production of electricity" as an example. This CIS is a multi-functional, distributed, free-programmed automated system that is designed for long-term continuous real-time operation, that comprises necessary functions of collecting, processing and presenting information as well as the functions of managing, controlling, protecting, blocking and signalling.

The software and hardware complex of top level and general station systems (S/HC of TL and GSS) is a constituent part of TP ACS. This complex is designed for automating the management of technological processes of general station and backup systems.

S/HC of TL and GSS is a three-level distributed systems that is designed hierarchically and conforms to technological structure and peculiarities of assembling the object of automation.

The first stage of developing ICN information structure is determining functional tasks of S/HC of TL and GSS, that are broken down into three types and arranged in Table 1.

These functions are assigned to the following levels:

- low level – functions of input / output of analog and discrete input information, logic of management and control, generation of analog and discrete output signals;
- medium level – functions of software downloading and control of lower level operation, database support, remote control of locking, control elements and mechanisms, data display on video terminals of operator and engineering stations, data recording and archiving;
- upper level – functions of data display on video terminals of the stations of management personnel.

Table 1

Functions of S/HC of TL and GSS

F. t.	Functions
Control	- remote control of locking and control elements and mechanisms; - technological protection; - protective and technological interlocking; - automatic control of technological parameters; - remote control of the electric part elements
Information	- collecting input information and checking its validity; - supplying information about TP and the operation of automatic devices; - warning and alarm signalling; - recording information, which is introduced and developed in S/HC; - recording deviations of parameters; - documenting the recorded information; - diagnosing hardware and software of the S/HC; - calculating operational, technical and economic indicators.
Helper	- correcting the parameters of setting systems of automatic control; - supplying information about the operation of real-time control algorithms; - simulating input information for CS testing; - input / output protection and locks; - automated processing and storing the results of metrological certification of measuring channels; - managing the operation of S / HC

The elements of information model of the network structure are determined according to the structural diagram of ACS of TP: a set of network main *users*: $U_{1\text{-}8}$, a set of tasks that are performed by users: $S_{1\text{-}24}$, a set of system complements of the network: $p_{1\text{-}6.}$, a set of system data bank: $d_{1\text{-}10.}$ Matrices of coupling the tasks of ACS of TP to other elements of ICN are developed according to the model of information structure:

- matrix of coupling "user - assignment" with relevant intensity of requests (Λ);
- matrix of coupling "assignment – system complements" (P);
- matrix of coupling "assignment – database" (D),
- matrix of coupling "assignment – users" (U).

Network nodes are placed on five levels according to the structural diagram of TP ACS.

Matrices of coupling the nodes of TP ACS with other ICN elements are developed in order to analyze the load of ICN nodes: matrix of assigning system applications to network nodes (G), matrix of assigning users to network nodes (H), matrix of data coupling to databases (S). The intensities of request flows among the elements of information structure can be calculated on the basis of these data:

1) matrix of intensity of system applications performed by users is calculated:

$$\Gamma = P \times \Lambda .$$

$$\Gamma = \begin{pmatrix} \lambda_{11}+\lambda_{16} & \lambda_{21}+\lambda_{26} & \lambda_{31}+\lambda_{36} & \lambda_{41}+\lambda_{46} & \lambda_{51}+\lambda_{56} & \lambda_{61}+\lambda_{66} & (\lambda_{71}+...+\lambda_{76}) & \lambda_{81}+(\lambda_{88}+...+\lambda_{8,24}) \\ 0 & 0 & 0 & 0 & 0 & 0 & (\lambda_{72}+...+\lambda_{76}) & \lambda_{88}+(\lambda_{8,15}+...+\lambda_{8,18})+\lambda_{8,23} \\ \lambda_{11} & \lambda_{21} & \lambda_{31} & \lambda_{41} & \lambda_{51} & \lambda_{61} & \lambda_{71} & \lambda_{81}+\lambda_{8,13}+\lambda_{8,22}+\lambda_{8,24} \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & \lambda_{89}+\lambda_{8,10} \\ 0 & 0 & 0 & 0 & 0 & 0 & (\lambda_{72}+...+\lambda_{75}) & \lambda_{8,11}+\lambda_{8,19}+\lambda_{8,22} \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & (\lambda_{8,16}+...+\lambda_{8,18})+\lambda_{8,23} \end{pmatrix};$$

2) matrix of fulfilling tasks at the network nodes regarding system applications and coupling to databases is calculated:

$$Z = Z'+Z'' = G \times D + S \times D.$$

3) the intensity of users' requests to nodes considering system applications and tasks is calculated:

$$M = ((U \times P) \times G) \times H.$$

Thus, the following parameters of information structure are obtained: the intensity of system applications, a number of tasks fulfilled at the network nodes, the intensity of requests to the nodes.

Conclusions

Information technology of managing the parameters of CIS ICN is suggested; three blocks operate successively in the context of this technology. The model of processes of information technology is developed. The sequence of processes executed in each block is analyzed. Information technology enables automating solution of the following tasks:

- the network structure regarding application tasks of CIS is developed;
- software and hardware components are distinguished within the structure;
- data flows that are transmitted along the network are researched;
- the network features are calculated.

The requirements for the technical structure of the network are determined according to the obtained parameters of the technical structure.

Information technology that eneables adaptive management of its parameters by means of solving tasks of network configuration is developed. Assessing and managing risks at the stages of structural and parametric synthesis and network traffic distribution are suggested as well.

The operation of synthesizer of ICN information structure is analyzed considering software and hardware complex included into a TP automated control system as an example. Matrices of coupling elements of network information structure are developed. Matrices of intensity of data flows among these elements are calculated on the basis of network information structure. The obtained results constitute grounds for the operation of IT second block – adaptive managing the network traffic distribution.

References

1. Бірюков Д. С. Захист критичної інфраструктури: проблеми та перспективи впровадження в Україні / Д. С. Бірюков, С. І. Кондратов. – К. : НІСД, 2012. – 96 с.

2. Лаврут О.О. Дослідження якості управління потоками інформації у телекомунікаційній системі критичного призначення // Системи озброєння і військова техніка, 2014, № 4(40) – С.89-93.

3. Степанов С.Н. Основы телетрафика мультисервисных сетей. - Эко-Трендз, 2010 – 391с.

4. Основные стандарты сетей передачи даннях [Електроний ресурс] Режим доступу: http://www.gpntb.ru/win/book/5/Doc11.HTML

5. Проектирование телекоммуникационных и информационных средств и систем: Сб. науч. тр. / Под ред. Л.Н. Кечиева. – М. МИЭМ. – 2006. – 302с.

6. Агеев, Д.В. Методика определения параметров потоков на разных участках мультисервисной телекоммуникационной сети с учетом эффекта самоподобия [Електроний ресурс] / Д.В. Агеев, А.А. Игнатенко, А.Н. Копылев // «Проблемы телекоммуникаций», 2011, № 3 (5). – С. 18 – 37. Режим доступа: http://pt.journal.kh.ua/2011/3/1/113_ageyev_method.pdf.

7. Sen, G. Exact approaches for static data segment allocation problem in an information network [Text] / G. Sen, M. Krishnamoorthy, N. Rangaraj, V. Narayanan // Computers & Operations Research. – 2015. – Vol. 62. – P. 282–295.

8. You, L. Cross-layer optimization of wireless multihop networks with one-hop two-way network coding [Text] / L. You, L. Ding, P. Wu, Z. Pan, H. Hu, M. Song, J. Song // Computer Networks. – 2011. – Vol. 55, Issue 8. – P. 1747–1769.

9. Xi, N. Secure service composition with information flow control in service clouds [Text] / N. Xi, C. Sun, J. Ma, Y. Shen // Future Generation Computer Systems. – 2015. – Vol. 49. – P. 142–148.

10. Гончар С.Ф. Шляхи удосконалення державної політики забезпечення інформаційної безпеки критичної інфраструктури України: матеріали круглого столу "Державне реагування на загрози національним інтересам України: актуальні проблеми та шляхи їх розв'язання", 19 лютого 2014 р., Київ, НАДУ при Президентові України (кафедра національної безпеки). – 2014. – С. 92–95.

11. Боярчук А.В. Безопасность критических инфраструктур: математические и инженерные методы анализа и обеспечения / А.В. Боярчук; под ред. В.С. Харченко. – Харьков: НАКУ «ХАИ», 2011. – 641с.

12. Кучук Г.А. Методика синтезу інформаційної технології управління мережевим трафіком / Г.А. Кучук, В.В. Косенко, О.П. Давікоза, С.А. Калкаманов // Системи управління, навігації та зв'язку, 2013, випуск 2(26) – С.138-143.

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ІНФОРМАЦІЙНА ТЕХНОЛОГІЯ УПРАВЛІННЯ ПАРАМЕТРАМИ ІНФОКОМУНІКАЦІЙНОЇ МЕРЕЖІ В СИСТЕМАХ КРИТИЧНОЇ ІНФРАСТРУКТУРИ

В.В. Косенко

Предметом *дослідження в статті є проблема забезпеченні вимог щодо оперативності та обміну інформацією з високим рівнем інформаційної безпеки в системах критичної інфраструктури.* ***Мета*** *роботи – розробка інформаційної технології формування структури мережі, визначення її параметрів, управління розподілом мережевого трафіку, орієнтованих на вирішення заданого набору прикладних завдань і забезпечення необхідної безпеки системи критичної інфраструктури в середовищі інфокомунікаційної мережі. Отримано наступні* ***результати****: Запропоновано структуру інформаційної технології, що містить три основних блока. Розглянуто послідовність процесів в кожному блоці. Розроблено модель роботи блоку формування структури інфокомунікаційної мережі. Розглянуто роботу блока синтезу інформаційної структури мережі на прикладі програмно-технічного комплексу у складі автоматизованої системи управління технологічними процесами.* ***Висновки:*** *За допомогою запропонованої інфомаційної технології можна вирішити такі завдання: у відповідності з отриманими параметрами інформаційної структури визначити вимоги до технічної структури мережі; забезпечити адаптивність управління параметрами потоків даних шляхом налаштування мережі до змінних умов функціонування системи критичної інфраструктури; оцінювати та управляти ризиками на етапах структурно-параметричного синтезу та розподілу трафіка мережі.*

Ключові слова: *інформаційна технологія, система критичної інфраструктури, інфокомунікаційна мережа, адаптивне управління, модель процесів, інтенсивність потоку даних.*

ИНФОРМАЦИОННАЯ ТЕХНОЛОГИЯ УПРАВЛЕНИЯ ПАРАМЕТРАМИ ИНФОКОММУНИКАЦИОННОЙ СЕТИ В СИСТЕМАХ КРИТИЧЕСКОЙ ИНФРАСТРУКТУРЫ

В.В. Косенко

Предмет исследования *в статье – проблема обеспечения требований по оперативности обмена информацией с высоким уровнем информационной безопасности в системах критической инфраструктуры.* ***Цель работы*** *- разработка информационной технологии формирования структуры сети, определение ее параметров, управление распределением сетевого трафика, ориентированных на решение заданного набора прикладных задач и обеспечения необходимой безопасности системы критической инфраструктуры в среде инфокоммуникационной сети.* ***Получены следующие результаты:*** *Предложена структура информационной технологии, она содержит три основных блока. Рассмотрена последовательность процессов в каждом блоке. Разработана модель работы блока формирования структуры инфокоммуникационной сети. Рассмотрена работа блока синтеза информационной структуры сети на примере программно-технического комплекса в составе автоматизированной системы управления технологическими процессами.* ***Выводы:*** *С помощью предложенной информационной технологии можно решить следующие задачи: в соответствии с полученными параметрами информационной структуры определить требования к технической структуры сети; обеспечить адаптивность управления параметрами потоков данных путем настройки сети к изменяющимся условиям функционирования системы критической инфраструктуры; оценивать и управлять рисками на этапах структурно-параметрического синтеза и распределения трафика сети.*

Ключевые слова: *информационная технология, система критической инфраструктуры, инфокоммуникационных сеть, адаптивное управление, модель процессов, интенсивность потока данных.*