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THE ANALYSIS OF TASKS OF DEVELOPMENT AND REENGINEERING PROCESS OF RELIABILITY COMPUTER NETWORKS FOR CRITICAL TECHNOLOGIES

The analysis of tasks of development and reengineering of computer networks of information-control (I&C) systems of critical technologies (CT) using opened network technologies and the commercial network equipment is executed. Formal tasks of development and reengineering of computer networks I&C systems of CT are formulated and the initial data, necessary for their decision are analyzed. The principles of profile formation bases of the computer networks based on open standards, variants of a network structure and their choice are considered in view of the requirements showed to reliability, quality of service, to functional and other characteristics of computer networks. These procedures can be realized as the tool utilities, which allowing to automate the process of computer systems designing.

Keywords: Computer networks, critical technologies, reverse engineering, reengineering, reliability improvement, computer systems profiling

Зроблено аналіз задач розвитку і реінжиніринга комп'ютерних мереж інформаційного контролю (I&C) системи критичних технологій (CT), що використовують відкриті мережні технології і комерційне устаткування. Формальні задачі розвитку комп'ютерних мереж I&C системи CT сформульовані, початкові дані, необхідні для їхнього рішення проаналізовані. Принципи формування профілю комп'ютерних мереж, заснованих на відкритих стандартах, а також варіанти структури мережі і їхній вибір розглядаються в розрізі вимог до надійності, якості обслуговування, до функціональних і інших особливостей комп'ютерних мереж. Ці процедури можуть бути зрозумілі як інструментальні утиліти, що дозволяють автоматизувати процес проектування.

1. Introduction

The solution of the traditional problems, connected with the analysis of time characteristics and calculation probability of non-failure operation of modern computer networks, their optimization, distribution of information streams and structural synthesis in practice is connected with a number of problems.

First of all, it's a problem of a computer network dimension, which especially seriously comes now, when the computer network, even concerning the small enterprise or establishment, can unite from several tens, up to hundreds of computers.

Next problem is profiling of computer networks. Introduction of a technique of profiling in process of computer systems designing is one of conditions of protection against inefficient network decisions which do not meet showed requirements to functional, reliability and to other computer systems characteristics.

Other problem is a problem of uncertainty, which consists in absence of some authentic data for calculations and complexity of their prediction, for example intensity of information streams between the computers in a network. Moreover, the information traffic of modern computer networks is dynamic and is characterized high "explosion alike", i.e. high value of the pulsations coefficient determined as the quotient of the maximal traffic in a network to its average value.

As consequence, some from traditional tasks of the analysis and synthesis of computer networks now do not find practical application as do not reflect a modern level of development of network technologies and the existing network equipment.

Modern computer networks is the complex hierarchical systems constructed on the basis of the commercial network equipment and the software, which correspond to open standardized network technologies.

By results of the analysis which has been lead by firm « IBM Consulting Group » [1], 68 % of network projects exceed scheduled terms, 55 % exceed the scheduled budget, thus of 88 % pass through procedure of repeated designing. Introduction of a technique of profiling in process of designing KC is one of conditions of protection against inefficient network decisions which do not meet showed requirements to functional, reliability and to other characteristics of computer networks, and also restrictions at cost and terms of designing.

Tasks of choosing a route for transferring the information effectively enough are solved by means of standardized reports of routing, which provide an optimality of the chosen route (by various criteria), dynamic reaction to a condition and availability of liaison channels, are characterized by high speed of convergence and provide balance of loading on several routes.

Another bright example is that at use of modern high-speed technologies (speed of transfer up to 10 Gbit / and more) for construction of territorially distributed computer networks the delay of transfer of the information is determined mainly by speed of distribution of an electromagnetic signal in a liaison channel, but not by bit speed of transfer.

At the same time, today we see the tendency of application of the modern network technologies based on opened standards, at designing and modernization of info-control systems of critical technologies (I&C S CT), for example, in atomic energy [2, 3].

FME (C) A (Failure Modes, Effects (and Criticality) Analysis), allowing to present as the systematized list the information on the reasons and kinds of refusals for various component of I&C S CT and their consequences. It can be applied also to support of processes of reengineering of systems which can assume functional, topological and reliability components [4], classification of the Service-Oriented Architecture specific errors and failures, Web Services Development Toolkits [5].

This fact causes an urgency of the new tasks connected with the development and reengineering of computer networks for critical applications at usage of opened standardized network technologies and the commercial network equipment, the analysis and maintenance of their conformity to regulating and normative requirements [6].

The purpose of article is the analysis of development problems and reengineering of computer networks of critical application, profiling of standards of computer networks, which is directed on perfection of process of designing, and formulation of the formalized tasks of their synthesis at usage of opened network technologies.

2. The analysis of initial data for solving tasks of development and reengineering of computer networks

Process of developing the computer networks, based on opened standards, is quite complex and requires to take into account different factors, such as the information about quantity and arrangement of computers (subscribers of a network),

requirements of the customer and normative documents, conditions of network standards and also a number of limiting factors, including

Cost of designing and exploitation of the network, provided level of reliability and quality of service.

Results of the analysis of the initial data, necessary for the solution tasks of development and process reengineering of computer networks are shown in fig. 1.

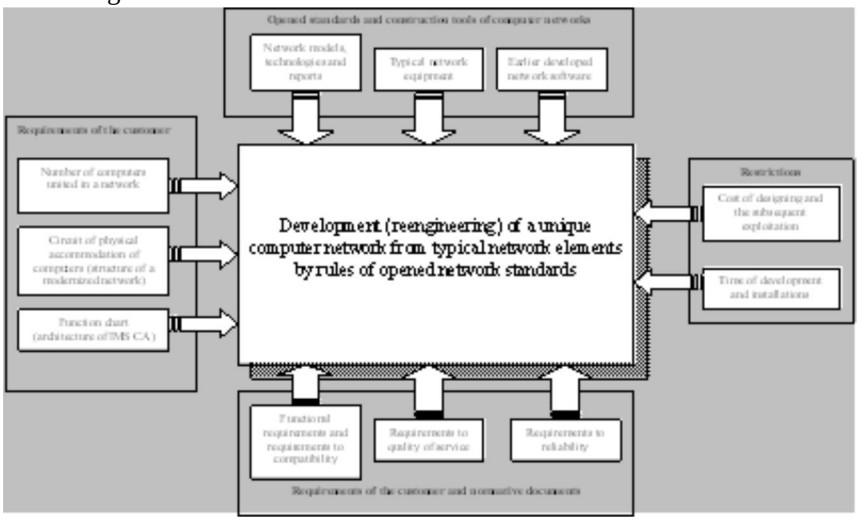

Fig. 1 – The initial data used during development and process reengineering of computer networks

The initial data include set of computers, HOST = {hi} - final units of the future computer network, the circuit of their physical accommodation and a function chart (I&C system architecture), reflecting functional connections and character of interaction between separate computers of information system and their groups. Geographical coordinates of each computer define its site on the circuit of physical accommodation, PhS, and are set by ensemble $\{x_i, y_i, z_i\}$. The function chart, FS, is set usually in any shape with the help of figures and the text description, however can be formally submitted as crossed functional subsets of ensemble HOST:

$$FS = \{F_i\}, F_i \subseteq HOST;$$
$$F_i \cap F_j \neq \varnothing, i \neq j.$$

In some cases as entry conditions can be determined earlier established network components.

After the analysis of functional structure, proceeding from function, application domains and requirements of normative documents, requirements to a projected network are formed - R, including requirements to functional characteristics of a network, the requirement to reliability and quality of service:

$$R = (R_{FUNC.}, R_{REL.}, R_{QUAL.}).$$

On the basis of the analysis of initial data from all set of standards of the computer networks, which make “type forming” base, the choice of the concrete network reports and technologies is being in progress (i.e. the structure of a network is being formed - PR_{NET}) [4], the logic structure of a network is being developed, LS, the nomenclature of the corresponding network equipment is being defined - HW, the software - SW and the basic physical circuit of a network - PhS, which establishes interrelation between the network equipment with binding to geographical coordinates of its accommodation is being formed.

The software of computer networks generally can be divided into earlier developed system - SYS and applied commercial - APP, and also applied specialized - SPEC. Hardware maintenance represents a set of the typical network equipment, including elements of cable system - SCS, concentrators - HUB, switchboards - SWITCH, routers - ROUTER, the network adapters placed in computers - NET CARD, etc.

$$SW = (SYS, APP, SPEC);$$
$$HW = (SCS, HUB, SWITCH, ROUTER, NET\ CARD).$$

Each unit of the network equipment included into one of the specified subsets, except a set of characteristics, the common for the given type of devices, can have a set of individual properties, for example, the concrete model of a router is characterized by the certain quantity and type of ports of the connection, used reports of routing, algorithms of priority processing of packages, algorithms of processing the overloads, etc.

3. Criteria of optimization in tasks of development and reengineering of computer networks

By development and modernization of computer networks it is necessary to consider the fact, that all variety of standards of the network technologies, included into the structure of “type forming” base, forms coherent multilevel hierarchy (in a classical case - seven-layer, according to levels of conceptual model of opened systems interaction - OSI). Each of levels carries out the certain functions by organization of interaction between final computers and has a set of corresponding characteristics, which should be considered while choosing this or that network technology or the report.

Financial expenses by designing a computer network - *C* include cost of the purchased equipment and the software, and also an expense for performance of starting-up and adjustment works (installation of the network equipment, adjustment of hardware and software, etc.). Besides the computer network demands constant financial expenses while it’s servicing for administration, repair or replacement of broken equipment and modernization of a computer network.

As the basic criteria of optimization at designing modern computer networks the following can be allocated:

1) Quality of service;

2) Reliability of functioning;

3) Cost of development and exploitation.

For I&C S CT computer networks the task of optimization by criterion of cost is characteristic at the set level of reliability and the certain requirements to maintenance of service quality. Thus requirements of reliability and quality are expedient concretized by levels of network model of interaction OSI proceeding from features of each level.

In tab. 1 the basic methods of maintenance of reliability and quality of service, which are necessary for taking into account and using at designing computer networks, are submitted.

Table1 – The basic methods of maintenance of reliability and quality of service in computer networks

Methods of maintenance of reliability	Methods of maintenance of quality
Reports with an establishment of connection and acknowledgement for protection from distortion, loss and duplication of the staff (packages). Hardware and reports of diagnostics and reconfiguration of network at refusals and failures; Algorithms of noiseproof coding. Reservation of liaison channels, network adapters and ports of the communication equipment; Application of the shielded and fibre-optical cable for protection against electromagnetic handicaps	Maintenance of overlapping throughput and non-blocking switching (routing); The determined methods of plural access; Priority processing the staff (packages) in switchboards and routers; Reservation of resources of switchboards (routers) and a guarantee of characteristics of quality

Reengineering of I&C S CT computer networks can be completed with the purpose:

1) Increase of reliability and quality of service;

2) Expansion of functional characteristics;

3) Expansion of a computer network (support of the greater number of subscribers);

4) Increase in scale of a computer network.

Result of development or reengineering is the unique computer network adequate to given requirements and constructed according to standards of existing network technologies with usage of typical communication devices and network software developed earlier.

4. Technique of profiling

4.1. The analysis of a problem of computer networks profiling

The computer networks are the integral part of modern information and control computer-based systems. The main function of computer networks is the transmission of information between a geographically-distributed computers and access providing to a shared network resources. For implementation of this function in the I&C S CT, i.e. aerospace computer-based systems, I&C NPPs, etc., traditionally the specialized networks were developed and used. However recently, within the framework of the COTS-approach ("Commercial off the Shelf"), the tendency to usage of commercial network equipment and software based on open standardized network technologies for I&C S CT was outlined. The tasks of the reliability ensuring of computer network based on the open standards and models (for example, the OSI or TCP/IP models) and used for critical technologies according to the COTS approach [7] are decided at various layers of these models.

Introduction of a technique of profiling in process of computer networks designing is one of conditions of protection against inefficient network decisions which do not meet showed requirements to functional, reliability, and to other computer networks characteristics, and also restrictions at cost and terms of designing.

Development of elements of a profiling technique of standards of computer networks, which is directed on process perfection of computer networks designing by formalization of a choice procedures of network technologies, hardware and computer network software.

The purpose of this report is the correspondence analysis between possibilities of the open standardized network technologies and normative requirements to the I&C S CT, and also development of a method of profile design and reliability assessments of computer networks for critical applications.

4.2 Principles of profiling. Formation of profiling bases of computer networks

Profiling is one of effective methods of positions harmonization of various normative documents and their adaptations to concrete information projects [8,9]. Main principles of construction of the OSI -structures of information systems, including the computer networks based on open standards, are incorporated in normative documents ISO/IEC TR 10000-1,2 [10]. According to these documents the developed structure should have уровневую the hierarchy corresponding to a conceptual model of the open systems interaction. The concrete set of the standardized network technologies used in this or that computer network, forms a structure of this network.

Now there is a plenty of the network technologies used for construction of computer networks. Their variety explains an urgency of profiling creation the base including the most full set of systematized standards of network technologies. Thus, creation several specialized (on type or scale of a network) profiling bases, for example profiling bases of network technologies of local and separately global networks can be expedient.

The standards of network technologies included in profiling base structure, can be systematized according to the accepted hierarchy of levels of reference model of the OSI. For this purpose the profiling base network can consist of vertical hierarchy of profiling bases on each of levels of the OSI model. Thus each of levels can be detailed on some sublevels, according to

functional interrelation of network standards, which included in it:

$$PB_{NET} = PB1 \cup PB2 \cup PB3 \cup PB4 \cup PB5 \cup PB6 \cup PB7,$$

Where PB_{NET} - full profiling base network uniting set of all standards of network technologies; *PB1, PB2, PB3, PB4, PB5, PB6, PB7* - profiling bases on levels of conceptual model of the open systems interaction, containing a set of standards of the network technologies concerning to each concrete level.

As a result of the analysis and ordering of existing standards of network technologies the base, which fragment is shown on fig. 2 has been received by profiling.

4.3 Formation and a choice of variants of a network structure

The multilevel approach, based existing network models, assumes independent interaction of the reports which are taking place at different levels of models. However, in practice realization of the "protocol-independent principle" is carried out far from being always, that it is necessary to take into account in selection of the network technologies from of the profiling bases. The analysis of an opportunity of various network standards sharing can be executed by experts in the field of network technologies, and the result of such analysis is submitted in harward graphs, which supplement each other. For this purpose it is offered to use profiling gpaph G_{PROF}, which tops are the standards included in profiling base while edges set a condition of compatibility between standards according to the information contained in matrix M_{COMP}, and also restrictions, superposable on the previous variant of a choice. The structure profiling the graph is submitted on fig. 3.

Levels of model OSI		**Network services, standards of network technologies and protocols**							
7-applied	B	E-mail		File transfer		Analysis and management		Special functions	
	A	FTP	SMTP	POP3	IMAP4	SNMP		NCP	SAP
6-representation									
5-session		TCP			UDP				
4-transport							SPX		
3-network	B	IP					IPX		
	A	RIP		OSPF		EIGRP	RIP IPX		NLSP
2-channel		802.3	802.3u	802.3z		802.5	802.12	FDDI	FDDI-II
1-physical		UTP 3		UTP 5		STP 6		OFC 62,5/125	

Fig. 2 – The fragment of profiling bases of computer networks

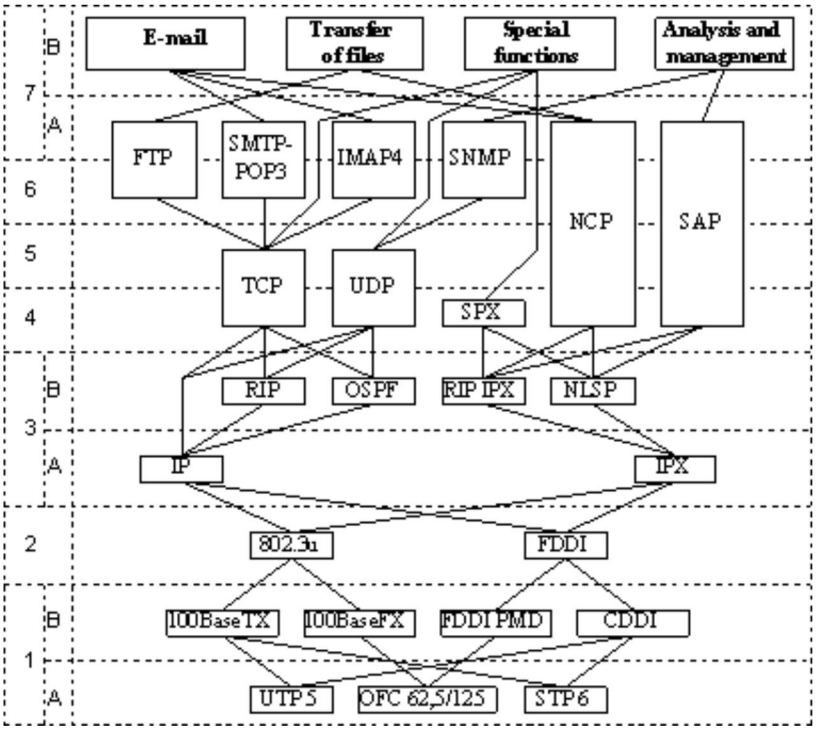

Fig. 3 – Structure of profiling graph G_{PROF}

The routes connecting the uppermost and bottom tops the column and distinguished even by one edge, form set of alternative variants of a network structure. These variants are convenient for fixing as matrix M_{PROF}, dimension *KxM* to which lines corresponds *k*-variants of a network structure, and столбцам - *m*-standards of network technologies and reports $k \, O\overline{1,K}$, $m \, O\overline{1,M}$

The choice of this or that variant of a network structure should be based on the analysis of the initial data (diameter of a network, quantity of computers - subscribers of a network, etc.), and also the requirements showed to functional characteristics of a projected network, reliability and quality of service.

The generalized algorithm of a choice includes the following operations:

1. The cycle on levels (sublevels) of the OSI model from top to down is carried out.
2. At a level *7-B* it is fixed the tops determining necessary kinds of network services. Further at each level the graph is carried out consecutive tops.

3. For each top of the *i-th* level the subset of adjacent tops (network standards), belonging to underlaying levels among which gets out unique, satisfying showed requirements is analyzed.
4. Staying non-withdrawn tops and incidental it edges leave from the graph G_{PROF}.

Received as a result of the listed operations a graph G' *(*being a part of the graph G_{PROF}*)* corresponds to the variant of a structure chosen according to showed requirements

5. Formalization tasks of development and reengineering of computer networks

On the basis of the made researches can be formulated following optimization tasks of development computer networks for I&C S CT:

$$\begin{cases} \text{Functionality}(PhS, SW, HW) = R_{FUNC}; \\ \text{Reliability}(PhS, SW, HW) = R_{REL}; \\ \text{Quality of service}(PhS, SW, HW) = R_{QUAL}; \\ \text{Cost}(PhS, SW, HW) \to \min. \end{cases} \quad \begin{cases} \text{Functionality}(PhS, SW, HW) = R_{FUNC}; \\ \text{Reliability}(PhS, SW, HW) \to \max; \\ \text{Quality of service}(PhS, SW, HW) \to \max; \\ \text{Cost}(PhS, SW, HW) = C. \end{cases}$$

The general task of reengineering of computer networks can be written down as:

$$\begin{cases} \text{Functionality}(PhS, SW, HW) = R_{FUNC-NEW}; \\ \text{Reliability}(PhS, SW, HW) = R_{REL-NEW}; \\ \text{Quality of service}(PhS, SW, HW) = R_{QUAL-NEW}; \\ \text{Measure of network}(PhS, SW, HW) = L_{NEW}; \\ \text{Number of computers}(PhS, SW, HW) = N_{NEW}; \\ \text{Cost}(PhS, SW, HW) \to \min. \end{cases}$$

Conclusions

In the article the analysis of tasks of development and reengineering of computer networks info-control systems of critical technologies with usage of opened network technologies and the commercial network equipment has been made.

Formal tasks of development and reengineering of I&C S CT computer networks have been formulated and the initial data, necessary for their decision have been analyzed.

The profiling base has the multilevel architecture corresponding to conceptual model of the OSI.

Various variants of a network structure and their choice in view of the requirements showed to reliability, quality of service, to functional and other characteristics of computer networks. Besides the offered technique of profiling can be added with results of the analysis of conformity of various variants of structures of the computer networks constructed under open standards, requirements to control systems of critical objects, for example, to informational-managing systems of the nuclear power plants [12].

The further researches can be directed on the way of detailed elaboration of the formulated tasks considering the concrete applied area and development of methods for their accomplishment.

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