Analysis and evaluation of the human factor in the communication and information systems

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***Abstract* – The article presents the generation and processing of flows of information objects associated to the status of the networks and the services in TCP/IP environment. It is explained a discrete-event processing of the flows of the information objects for monitoring and control of the networks and the services. It is shown the control of the communication network in order to optimize the transport and the processing of data flow.**

Keywords – **discrete-event communication and information systems, TCP/IP environment, information objects, event processing, services, monitoring, control**

I. INTRODUCTION

The specifics of the modern telecommunication systems is their transition to a global information society and as a consequence to communication and information systems (CIS) and networks. The technologies, using the principle of commutation of channels are used together with the networks with packet commutation, networks based on different protocols, including protocols of the TCP/IP architecture. Moreover, there is a considerable diversity of the used equipment and technologies, even in the systems of one operator. The development and the mobility of the modern network information services is directed towards an expansion, covering more areas in order to increase the subscriber base and the services provided, and as a consequence - leads to increase of the scale and complexity of the network structure. All this implicitly affects the quality of the provided services, as one of the most important components is the reliability of the network.

The work of the operators becomes more complicated and to the quality of the service are placed higher and higher requirements. Therefore, the effectiveness of the customer service and the increasing of the level of the performance of the operators are key for the increasing of the efficiency of the operation of the centers for monitoring and management of the services (Network Operations Center, NOC, Call center) in the conditions of strong competition.

In this regard, in present time there is an actual scientific and technical task for research and development of monitoring, analysis and management of the quality of the work of the operators in the centers for monitoring and management of the services (network operations center - NOC), the solution of which opens up prospects for the establishing of an uniform methodology for evaluation and rise in the indicators of functioning. The centers for management and monitoring are the most common types of systems, which employ a large number of operators. Over the time they develop as: 1) systems for calls, 2) information centers, 3) call centers, 4) integrated call centers and service management. The mechanisms for the service of the calls in the call centers integrated with Internet are considerably more complex, requiring powerful subsystem of administration management, allowing operative reacting to the changes in the external environment. NOC are technical complexes for reception and processing by operators of a flow of phone calls from subscribers. They accept and serve the incoming and outgoing calls and consist of a certain amount of working places, distributed among several departments. The main functions of these centers are realization of the interaction with the subscribers in the necessary volume and efficient mode.

The maintenance operators of telecommunication systems typically operate in a deficit of time. The quality of their work is determined by various factors, including the training of the operator, the working conditions on the workplace, the duration of the shift, the organization of his activities.

The constantly increasing demand for Call centers in the business, in the banking and in the financial sector, in the insurance, in the telecommunications facilities, etc. requires theoretical and experimental research in order to develop algorithms and tools for monitoring [1,2], mathematical modelling [3], analysis and management of the quality of the work of the operators [4,5].

The purpose of the article is the guideline for the increase of the efficiency of the customer service and reduction of the operational losses in NOC by development of algorithms and tools for monitoring, analysis and management of the quality of the work of the operators.

II. ANALYSIS OF THE PROBLEM AREA AND FORMULATION OF THE PROBLEM.

According to the available literature and the different expert statements, the work of the operators in the communication network is becoming more skilled, strict and stressful as a result of the increasing complexity of the network systems. Many of the studies [4, 6] are exploratory in nature and do not focus on the requirements and the competences assigned to the operators.

Of interest are the decisions of the following problems:

- how the operators / employees / participants / perceive the network as an object of their activity;

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- what skills, knowledge and communication skills and other requirements are laid down to the work of the CIS;
- what is the impact of the human errors on the reliability of the network.

In the most publications, the question of the reporting of the impact of the errors of the human - operator on the operation of the CIS, is rarely touched on, but the practice shows that the effectiveness of the new technique increases, if you take into account the human factor ever since the design stage. When developing the new generation of CIS in connection with the intensive development of the technical and software means, special attention is paid to the improving of the quality and the reliability of the functioning of the communication system, leading to the need for analysis of the reliability of each separate unit, including also that of the human-operator. Telecommunication systems ensure the exchange of information between subscribers, thus the subscriber is not only an user (client), but operator in the process of exchange in the systems and the communication networks. Therefore, CIS can be viewed as a "human-machine" system (HMS), one of which units is the human-operator. In the most cases in practice , the problem of interaction between the human and technical subsystems is ignored, which entails a risk of unforeseen situations. The increasing cost of the mistakes of the operator determine the continued need for seeking of ways and means to ensure the reliable functioning of the human in the communication system [7]. Consequently, one of the new aspects of the problem of the reliability of the CIS became the study of the unpredictable, unforeseen emergency situations caused by errors, inactivity or insufficiently fast - acting of the operator.

The analysis of the nature of the human-machine interaction in the centers for information services allows to increase the level of algorithm development of the activities carried out by the operators and to determine the optimal amount of hierarchical levels in the system. It allows the opportunity to realize a model of group interaction between the operators and to do decomposition of the tasks and of the different types of requests (regulated and not regulated). Generalized structure of a hierarchical human-machine system of this type is shown on Figure 1.

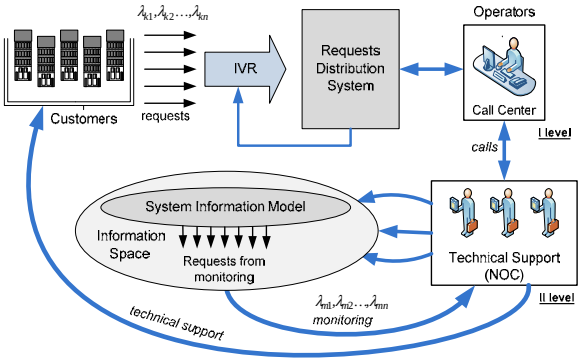

Fig.1. Organization of the system for processing of requests and service in CIS

The output data for the quality of the fulfillment of the individual operations of the activity of the operator at given characteristics of the operators and other factors affecting the environment are considered to be set. The principle of organization of the system for processing of the requests for technical support includes the incoming requests to the center and the monitoring results. The activities of the operators have a defined algorithmic character and for some of the problems, there are alternative algorithms for their service [8].

When analyzing the reliability of the communication and information networks, as well as in the other structurally complex technical systems, there are a variety of methods and solutions. Tasks of this type traditionally occur at any stage of their operation. During the designing, they should be legally set, which means to be defined and justified the selected indicators of reliability for each item and for the CIS as a whole. At the stage of inspection and operation it is necessary to clarify the factual reached reliability, to be compared with the required one and thus, predictions about the reliability to be made. The analysis of the reliability of the CIS is often complicated by the fact that in many of the cases the CIS itself under certain circumstances is modified during the operation. The reliability of the human- operator is determined by his ability to fully perform his assigned functions under certain conditions. The reliability of his activity is characterized by his faultlessness, willingness, recoverability, timeliness and accuracy [9, 10]. For the selection of optimal information support is necessary to take into account the psycho-functional features of the operator, i.e. the degree of tiredness and the informational loading of the person.

The solution of these tasks is impossible without creating a comprehensive system for analysis of the reliability of the CIS, including the various factors affecting the reliability, their identification and classification. As a first level of the classification of these factors can be used the localization of the corresponding sources of influence (in particular, the reasons for failure):

- systemic conditions - create sources of impact in the object during the stages of operation;
- operating conditions –create sources of failure that occur during the operation of the object;
- maintenance conditions - create sources of failures that occur during maintenance.

For the carrying out of an analysis of the loading at the receiving of the requests, it is necessary to have information on:

- the number of the incoming calls;
- the number of the calls distributed;
- the number of the serviced calls;
- the number of the missed calls;
- the average time of conversation.

The indicators of the quality of the work of the operators in the NOC [11] can be conditionally divided into:

- indicators for the quality of the service of the subscribers by the operator;
- indicators for the quality of the service of the NOC;
- indicators for the subscribers satisfaction.

The indicators for the processing of the requests determine the interaction of the operator with the subscriber and consist of several characteristics: orientation to the subscriber, authority and professionalism, but also effectiveness and efficiency [12].

To increase the quality of the work of the operators in the NOC, it is necessary to implement a monitoring. The monitoring of the quality of the work of the operators is conditionally divided into two types [13].

- regular (planned) control of all operators;
- control of particular operators, performed if necessary.

The decision for the carrying out of a control of individual operators is accepted, as a rule, on the base of statistic data on their productivity. For example, the average time to process a call from one operator is significantly worse than of that of another one. The truth is that in this case, it is necessary to do a differentiation of the operators and to determine the average time for the processing of the calls.

III. METHODOLOGY FOR EVALUATION OF THE EFFECTIVENESS OF THE SYSTEM FOR THE PROCESSING OF THE REQUESTS

Since the focus of this exploratory study is to obtain information about the factors that influence the human reliability in the operation of CIS, a Bulgarian telecommunication operator and network service provider with 15 - 20 workplaces and continuous working hours was considered.

To analyze the work on the servicing of the requests, they are divided into two flows. The first flow is from the customers to the operators from first level of the servicing of the requests. The distribution of the requests in the form of phone calls is related to the number and the groups of operators in the center for customer service. This flow of requests can be divided into two flows: λ_{k1}-requests type serviced with a certain delay and of second type λ_{k2} - requests of missed calls. The flow of requests to the staff (technical support at second level), can also be divided into two flows - λ_{p1}-requests that are serviced by the support staff within the expected time for restoration of the service (MTTR) and requests that are missed and the technical problems are not resolved within the expected time λ_{p2}. The probability of omission of the service for the both levels of support of requests are defined as a sum of the probabilities of omission in the different phases of the processing of the requests, by the formulas [14, 15]:

$$P_{k_m} = \lim_{t\to\infty} \frac{A_k(0,t) + A_{k,I}(0,t) + \sum_{j=1}^{V} A_{k,o}(0,t)}{A_{k,inc.}(0,t)} \qquad (1)$$

where: $P_{k,m}$ – probability of omission of requests; A_k – number of refused requests; $A_{k,I}$ – number of not serviced requests of received calls; V – number of operators ; $A_{k,o}$ – not serviced by the operator requests; $A_{k,inc.}$ – number of all incoming requests.

$$P_{p,mis} = \lim_{t\to\infty} \frac{A_p(0,t) + A_{p,d}(0,t) + \sum_{j=1}^{W} A_{p,op}(0,t)}{A_{p,inc.}(0,t)} \qquad (2)$$

where: $P_{p,mis.}$ – probability of omission of information from the monitoring; A_p – number of not serviced requests because of the monitoring; $A_{p,d}$ – number of requests not distributed for operators; W – number of operators; $A_{p,op}$ – not serviced by the operator requests; $A_{p,inc.}$ – number of all incoming requests.

The most advantageous in terms of the probability of failure is the use of large groups of operators. Such groups are difficult to manage and are not economically profitable due to the specialization and the profiling of each group. That is why in practice at overload, the requests are transferred to another group. The escalation of the requests is done also at the automated processing of the telephone calls. With voice menu users are self-serviced at a requirement, at an availability of a problem for which the information is available and is already working over.

The parameter of the quality of the fulfillment of the requests with escalation to the second group is determined by the expression:

$$Q_S = 1 - P_{k,0} P_{k,1} \dots P_{ks} \qquad (3)$$

where S is the number of the organized escalations.

Figure 2 shows the dependence of the parameter of the quality of the probability of failure in a different number of escalations.

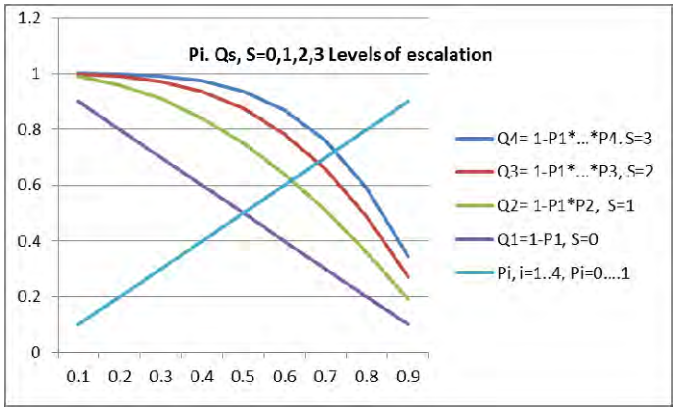

Fig.2. Dependence of the parameter for the quality of the execution of the requests of the probability for omission and the levels of escalation

Such an approach reduces the probability of rejected requests, but at a greater number of levels of escalation, the time for the transfer of the requests to the other level increases. The development of procedures and the automation of the process of escalation reduce this technological time.

The relative share of the probability of escalation of requests (problems) decreases linearly with the time as a result of the experience and the qualification of the operators at all

levels and the improving of the organization of the processing of the requests:

$$Delta(R)/R = -t/T\ , \quad R(0) = R_0\ , \qquad (4)$$

where R is the probability of escalated problems; R_0 - initial value (higher in poorly trained operator).

The role of the human factor for the reducing of the servicing time (training, experience, qualification) is defined by an exponential law:

$$R(t) = R_0\ exp(-t/T)\ , \qquad (5)$$

where R_0 is the initial probability for escalation of the problem by the operator (for poorly trained operators is closer to 1)

T is a temporary parameter which is associated with the training of the operators and the lower values correspond to a higher level of qualification and training.

Figure 3 shows dependences of probability of escalation of problems depending on the training of the operators.

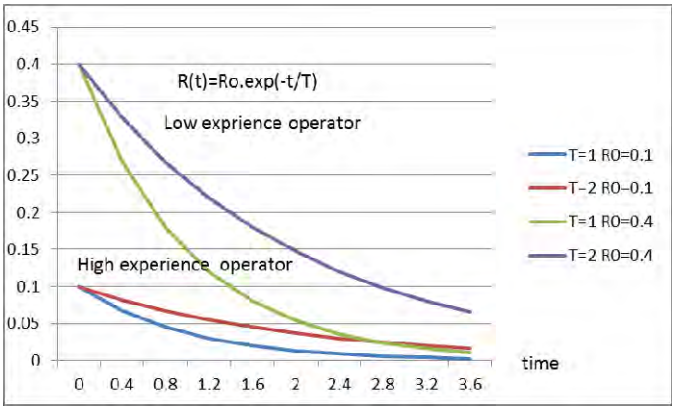

Fig. 3. Probability of escalation of problems depending on the human factor

IV. CONCLUSIONS

The use of escalation of the requests in the model of their processing reduces the probability of omission of requests and provides procedures resulting in their final decision. The increasing of the number of the levels of escalation, including also the procedures for automatic escalation increases the factor for the quality of the servicing of the requests. The role of the human factor is associated with decreasing of the initial probability of escalation of the problems and its timing.

The proposed method has the purpose to reduce the operating costs and to increase the efficiency of the customer service by developing of algorithms for distribution of the requests from the users and the monitoring, analysis and management of the quality of the work of the operators in the communication and information systems.

To follow-up this work, fault diagnosis and recovery processes should be observed and analysed in detail as they occur in practice. This would be valuable for the development of good work practices but also for the development of better network management.

REFERENCES

[1]. Gans N., Koole G, Mandelbaum A. Telephone call centers: tutorial, review, and research prospects // Manuf. & serv. operat. man. - 2003. - P. 79-141

[2]. Бельская Н.М. Исследование и разработка алгоритмов мониторинга и анализа качества работы операторов контакт-центра: дисс., ук. – 2012. – 16 с.

[3]. Виноградов Н.А., Кармазин В.К. Статистические характеристики и математические модели центров обработки вызовов. // Реєстрація, зберігання і оброб. даних. 2002, Т. 4.: № 2, с. 40–50

[4]. Leena Norros, •Ilkka Norros, Marja Liinasuo, Kari Seppanen, Impact of human operators on communication network dependability, ECCE '11 Proceedings of the 29th Annual European Conference on Cognitive Ergonomics Pages 35-42

[5]. Marja Liinasuo, Iina Aaltonen, Hannu Karvonen, Human Operator Perspective to Autonomic Network Management, ACHI 2012 : The Fifth International Conference on Advances in Computer-Human Interactions, 128-134

[6]. Schulman PR, Roe E, van Eeten MJG, de Bruijne M (2004) High reliability and the management of critical infrastructures. J Conting Crisis Manage 12(1):263–280

[7]. Лавров Е., Паско Н., Подход к формализованному описанию дискретной деятельности в системах "человек-техника-среда" // Вісник Сумського державного університету. Сер. Технічні науки. 2012, № 3. с. 55-67

[8]. Su R, Yurcik W (2005) A survey and comparison of human monitoring of complex networks: University of Illinois Urbana-Champaign, NationalCenter for Computing Applications

[9]. Boring Ronald L., David I. Gertman, Human Reliability Analysis for Computerized Procedures, Part Two: Applicability of Current Methods, Human Factors and Ergonomics Society , 2006

[10]. Андонов А., Хубенова З., Функционална устойчивост на информационно-управляващи компрекси в критични приложения, монография, София, 2011

[11]. Kraemer S., and Carayon, P. (2007). Human errors and violations in computer and information security: The viewpoint of network administrators and security specialists. Applied Ergonomics, 143-154.

[12]. Salvendy G. (Editor), Handbook of Human Factors and Ergonomics, Purdue University, 2006, Canada

[13]. Yamamura T, Yata K, Yasushi T, Yamaguchi Y (1989) A basic study on human error in communication network operation. IEEE Xplore, Downloaded 23 June 2009

[14]. Крылов В,В., Самохвалова С.С. Теория телетрафика и её приложения. – СПб, 2005.

[15]. Noah Gans, Ger Koole, and Avishai Mandelbaum. Telephone call centers: Tutorial, 2003, review, and research prospects. Manufacturing and Service Operations Management: p79-141.