Research Efficiency of Integrated Communication Networks with User of Signaling System

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Abstract— **In work analyzes indicators of efficiency of functioning integrated communication networks by transfer useful and signaling (office) traffic. Networks common channel of the signaling system formed by the hardware-software module and signaling (alarm) channels on which basis the new approach calculation of throughput of the signaling system is offered are investigated. The analytical expressions are received, allowing estimating indicators common channel system signaling at performance of the basic, additional and intellectual services.**

Keywords— office traffic; efficiency of functioning; signal channel; quality of service; integrated communication network; signaling network; useful traffic

I. INTRODUCTION

The system-technical analysis shows [1, 2], that efficiency of functioning of modern multiservice communication networks with use of system of the signaling system essentially depends on timely delivery and reliability of transfer of useful and alarm traffic. Among multiservice networks of telecommunication, recently have received wide development integrated communication networks with use of signaling system (of alarm channel).

The carried out researches have shown [3, 4, 5], that the architecture of integrated communication networks represents set of two co-operating networks: an information network (IN) on which the information of users is transferred, and signaling network (SN) with use common channel signaling system (CSS №7 or alarm channel) on which the office information providing an establishment of connections in IN arrives.

The system of CSS №7 under recommendation ITU-T Q.700 represents alarm system on the general channel of universal appointment, defines a management infrastructure digital communication networks at creation of logic alarm channels for an establishment of connection, data transmission and the permission of logic alarm connections [2, 6, 7].

For CSS №7, the basic and actual problem is reliable and timely transfer of alarm messages (packages of data) which switching stations and knots of databases in process connection for granting to subscribers of the basic exchange, additional and intellectual services in telecommunication systems.

For transfer of the multimedia traffic to the integrated communication networks using Next Generation Network (NGN)-technologies among used systems of the alarm system, except CSS №7, a special place alarm system sluices (SG - Signaling Gateway) occupy, terminal H.323, servers SIP (Session Initiation Protocol), and also technologies Sigtran (Signaling Transport).

Researches have shown [3, 4], that the problem of an effective method of the analysis of indicators efficiency of functioning integrated communication networks with use of system signaling by transfer of useful and office traffic, is one of priority directions in development systems of telecommunication.

II. PROBLEM STATEMENTS

Taking into account the above-stated the mathematical formulation of a problem of efficiency of functioning of integrated communication networks by transfer of useful and office traffic on alarm communication channels can be presented the following criterion function [3, 8]:

$$Q_{кф.cc} = F[\max_i (C_i)], \quad i = \overline{1, n} \tag{1}$$

at following restriction

$$\lambda_{cm} \le \lambda_{nm}, \, Y_{зc} \le Y_{зc.adm.}, \rho_{cm} \le 1, C_a \le C_{a.adm.} \tag{2}$$

where λ_{cm}, λ_{nm} are average speed of receipt of the alarm and useful traffics; C_i is the maximum throughput of system of the alarm system at an information transfer of i th useful and office traffic; $Y_{зc}$ is alarm (signaling) loading at level of a link of the alarm system at realization of the basic, additional and intellectual service in hours the greatest loadings (HGL); ρ_{cm} – factor of an effective utilization of the alarm channel by transfer office $L_{п.си}$ and useful $L_{п.пи}$ information; F is the operator of joint transfer of the mixed traffic; C_a is cost of hardware-software and terminal means of communication networks at service of the information and office traffic.

Expressions (1) and (2) define essence of the considered approach - increase of throughput of system of the alarm system by transfer office and the helpful information on alarm communication channels and are simple analytical record of function of a system effectiveness of telecommunication at an estimation of their quality of functioning.

III. THE SCHEME OF FUNCTIONING OF INVESTIGATED MODEL OF A LINK OF A NETWORK

For realization of a task in view and the criterion function (1) characterizing the approach of an estimation of an effective utilization of potentially achievable throughput of the alarm terminal and the channel of integrated networks, the elementary block diagrammed of paths of systems of transfer of the office and useful traffic has been offered.

The offered scheme of functioning of investigated model of a link, consists of sources of the signaling and useful message ($SM_{пт}$ and $IM_{ст}$), switching knot (SK) with the buffer store (BS, N_{bs}), SSP (Service Switching Point), the information and signaling channel (IC and SC), and also signaling terminals (S_rT) for transfer of office traffic on the basis of combined SP/STP, SCP (Service Control Point) which are shown on fig.1.

The given scheme defines structural models of a link of communication networks which allow to consider more precisely the telecommunication processes proceeding in the investigated link of an integrated service digital network - ISDN [8].

If *i*-th the stream of packages of the non-uniform traffic arrives at the moment of time t when there are free alarm channels and terminals (their general number $N_{ск}$) it occupies it on a holding time.

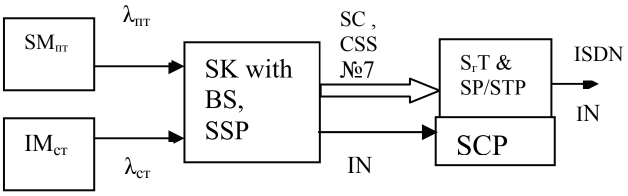

Figure 1. The Structurally functional scheme of paths of systems of transfer

After a threshold of a holding time streams of packages refuse SoMS with probability $P_{i.отк}$. Model SoMS is BS with the limited capacity and in each turn there is a limited number of places of expectation L_i, $i=\overline{1,n}$ in the buffer store. Being in turns, streams of packages are served by rule FIFO (First in, first out). Considering characters of investigated model SoMS, it is necessary to pay special attention on characteristics of throughput of a link of a network with switching of packages for the guaranteed quality of transfer of the non-uniform traffic [5, 6].

From the scheme follows, that entrance streams of packages of traffic $\lambda_{i.вх}$ consist of two components and are defined as follows:

$$\lambda_{i.вх} = \lambda_{i.пт} + \lambda_{i.ст}, \quad i=\overline{1,\,n} \tag{3}$$

IV. ESTIMATION INDICATORS OF EFFICIENCY OF A LINK OF A NETWORK

On known probabilities of conditions of functioning of system on the basis of model of a link of a network of transfer of the non-uniform traffic their indicators of efficiency can be calculated.

Taking into account algorithms of work fig. 1, exit $\lambda_{i.вых}$ и entrance streams of packages of i-th traffic $\lambda_{i.вх}$, throughput of a link of a network of transfer of the non-uniform traffic are defined by expression:

$$C_{\max}(\lambda_{вх}, N_{ck}) = N_{ск}\cdot\sum_{i=1}^{n}\lambda_{i.вых}, \; i=\overline{1,\,n} \tag{4}$$

Having taken advantage of model of system and the diagrammed of conditions [2, 3], it is possible to write out systems of the equations of balance with use of the normalizing equation and to receive following likelihood characteristics of integrated communication network[5]:

$$P_0(\lambda_{вых}) = [1+\sum_{k=1}^{n}\frac{\lambda^k}{k!}\cdot\mu^{-k}]^{-1}, \; k=1,2,\ldots,n \tag{5}$$

where μ is intensity of service of streams of packages.

Expression (5) is an average share of time during which the system is in a free condition and from physical reasons defines relative throughput of a link of a network.

As the condition n is a service condition the alarm channel of as much as possible admissible number of a link of a network probability $P_{отк}$ to the next demand in service, is defined as follows [6]:

$$P_{отк}(\rho_{cm}\le\rho_{\max}, N_{bs}) = 1 - P_0(\lambda_{вых}) \tag{6}$$

Expression (6) defines indicators QoS of integrated communication network at the maximum factor system loadings $\rho_{\max}$ traffic transfers ($\rho_{\max}$=1).

The factor of an effective utilization of a link of a network by means of average length of package L_n is expressed as follows [3]:

$$\rho_{зс} = \frac{\lambda_{вых}}{(N_{ск}+N_{cm})\cdot C_{\max}}\cdot(L_{nm}+L_{cm}) < 1 \tag{7}$$

where L_{nm}, L_{cm} are average length of a transferred useful and office package of the traffic ($L_n = L_{nm} + L_{cm}$).

Taking into account (6), relative throughput of a link of network $C_{\max}^{om}$ is expressed by the formula

$$C_{\max}^{om}(\lambda) = 1 - P_{отк.}(\rho_{cm}\le\rho_{\max}) \tag{8}$$

One of the major characteristics of model SoMS of a link of a network is absolute throughput $N_{\max}^{om}$ is middle number of streams of packages of the traffic which can serve system for a time unit. Then, on the basis of (3) and

(8) it is possible to estimate absolute throughput $C_{\max}^{om}$ of a link of the network equal to product of intensity of a stream of demands for relative throughput, i.e.

$$C_{\max}^{a\delta} = (\lambda_{nm} + \lambda_{cm}) \cdot N_{\max}^{om} \quad (9)$$

On the basis of (9) minimum capacity of the buffer store of knot of switching of a link of network $N_{бн}$ working in a mode «FIFO» it is defined by expression:

$$N_{бн}(V_{i.m}, \lambda_{вх}) = (\lambda_{вх} - C_{\max}^{a\delta}) \cdot T_{nep} + B, \lambda_{вх} \geq C_{\max}^{a\delta}, \quad (10)$$

where T_{nep} is time of transfer of the non-uniform traffic; B is the maximum splash at processing of a stream of packages (burst), measured in the same units, as volume of data.

Let intensity of service of one package of the traffic the office channel and terminal $S_{т}T$ μ. Then the average of packages of the traffic L_{cp}, served by one alarm channel and the terminal, will be

$$E[L_{cp}] = \mu^{-1} \cdot (\lambda_{nm} + \lambda_{cm}) \cdot N_{\max}^{om} \quad (11)$$

The important characteristic of model of a link of the network consisting from $N_{ск}$ of channels, the average of the occupied alarm terminals is. Considering above resulted likelihood characteristics of a link of a network of transfer of a stream of packages of the traffic, an average of the occupied channels and $S_{г}T$ it is defined as follows:

$$E[N_{ck}] = (\lambda_{nm} + \lambda_{cm}) \cdot (1 - P_k) / \mu \quad (12)$$

where P_k is probabilities k-th of conditions of functioning of a link of a network.

The analysis shows, that with growth of number $N_{ск}$ of a link of an integrated network, the probability of refusal of packages decreases also it meets the requirements of quality of service of system of transfer of the non-uniform traffic.

V. Estimation of a Condition of an Effective Utilisation of Alarm Channels and Terminals

For maintenance of a necessary degree of quality of service QoS influencing efficiency of functioning of integrated communication networks of following generation, it is necessary to estimate efficiency of use of channel and terminal resources of a link of a network.

At normal functioning of a link of communication networks when there is no unlimited increase of turn, the factor of an effective utilization of a link of a network should be less units. The factor of an effective utilization of the alarm channel and the terminal by transfer office $L_{п.си}$ and useful $L_{п.пи}$ the information, working in the mixed mode, is defined following by image:

$$\rho_{ck} = (\rho_{cm} + \rho_{nm}) \leq 1 \quad , \quad (13)$$

where $\rho_{ск}$ is factor of an effective utilization of alarm channel SL (Signaling Link) receipt of office and useful streams of packages of the traffic depending on average speed; ρ_{cm}, $\rho_{пм}$ - factors of an effective utilization of the alarm channel and the terminal by transfer office $L_{п.cm}$ and useful $L_{п.пм}$ information also are equal:

$$\rho_{cm} = (\lambda_{cm} \cdot t_{cm}) \leq 1, \quad \rho_{nm} = (\lambda_{пм} \cdot t_{пм}) \leq 1 \quad (14)$$

According to the physical description of quality of functioning of systems of transfer of the office traffic, throughput of system by traffic transfer can be expressed as follows:

$$C_{\max} = \frac{V_{ck}}{L_{nm} + L_{cm}} \cdot (\rho_{np.к} + \rho_{обр.к}) \cdot N_{ck}, \quad (15)$$

where $\rho_{пр.к}$, $\rho_{обр.к}$ are loading factors in a direct and return communication channel; $L_{пм}$, L_{cm} are average length of the useful and office traffic, accordingly.

VI. The Analysis of the Distributed Intellectual Communication Networks

Quality of functioning of an intellectual communication network from the point of view of the alarm system is defined by the whole complex of indicators, such as the alarm loading served by links of the alarm system and knots of a network, average time and a dispersion of a delay of messages in an alarm system link, and also an average waiting time at performance of intellectual service [6, 7].

The increase in number of services ICN N_a, and intensity of their use $\rho(\lambda_a)$ is obvious, that, $a = \overline{1,m}$ increases loading by alarm system $U_{css}(\lambda_a)$, $a = \overline{1,m}$ network that leads to increase in time of a delay at performance of this or that service. Interaction of these parameters can be described the following functional dependence:

$$T_{in}^{ожс}(\lambda_a) = [\rho(\lambda_a), N_a, U_{css}(\lambda_a)], \; a = \overline{1,m} \quad (16)$$

Granting of services ICN leads to substantial growth of volume of the traffic of the alarm system which have been not connected with an establishment of connection. Introduction of new services, as well as maintenance of the existing demands corresponding network resources.

Besides, conditions of the market demand from communication statements of improvement of quality of given services.

The complex decision of the listed problems represents a difficult scientific problem and defines necessity of additional carrying out of the researches connected with the analysis of is likelihood-time characteristics of the alarm traffic in ICN for the purpose of maintenance of demanded quality of service concerning service of calls on the basis of recommendation ITU-T of series Q.774, …, Q.1200.

VII. CONCLUSION

Results of research and the analysis of efficiency of integrated networks of telecommunication by transfer of the office and useful traffic, the received analytical expressions, allow to estimate throughput and is likelihood-time characteristics of a link of a network.

On the basis of researches quality of functioning of a link of a network from the point of view of system of the alarm system for management of transfer of the office traffic is established, that, defined by the whole complex of the indicators providing guaranteed quality of service QoS.

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