INVESTIGATION OF THE QUALITY OF FUNCTIONING OF TERMINAL EQUIPMENT COMMUNICATION NETWORKS

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1. Introduction. Prospects of development of granting of services of new generation and increase in volume of transmitted multimedia appendices demand creation of the uniform universal telecommunication infrastructure known as a multiservice network, formed by terminals of multipurpose and intellectual type with the increased throughput [1].

Intensive growth of requirements of users to quality of services of the communication given by operators of telecommunications networks puts before the manufacturer a complex of the questions connected with creation of the terminal equipment of multiservice networks with switching of packages, providing the guaranteed quality of service (QoS). Access to such services, realized with use of multiservice communication networks, is made by means of the terminal equipment. Constructions of user's and network terminals with the increased productivity for transfer and reception of the heterogeneous traffic will promote increase of an overall performance of a multiservice network and quality of integration of various kinds of service [2, 3].

The research problem of multiservice communication networks with an estimation of quality of functioning of the terminal equipment for the guaranteed quality of given services is the most actual.

2. Problem statement. In [4, 5] it is established, that association of various kinds of communication on the basis of modern unified organizational and technological principles is one of stages of creation of multiservice communication networks of following next generation networks (NGN). In [2, 4.] characteristics of quality of functioning of the terminal equipment of multiservice networks of transfer of the non-uniform traffic are investigated and their some parameters, such as throughput, reliability and cost of system are defined. However, the analysis of these works has shown, that the estimation of quality of functioning of the terminal equipment of multiservice communication networks with set parameter QoS causes many problems by transfer of streams of software packages on unified liaison channels and integration various kinds service of the non-uniform traffic (speech, data, faxes, Internet, video, etc.).

Considering importance of construction of the terminal equipment of multiservice communication networks on the basis of NGN, it is necessary to pay special attention on parameters of quality of functioning of this system. Such system deliver to users an opportunity of multiservice, i.e. an opportunity to transfer, accept and process various the form and volume the information in a package form. Thus, there is an important problem - development of algorithm calculation of parameters quality of functioning of terminal equipment of multiservice communication networks which depends as on algorithm work of the user's and network terminal, and from productivity of separate parts of telecommunication networks which are based on modern technologies – ATM (Asynchronous Transfer Mode) and IP-telephone (Internet Protocol).

It is known, that one of key problems in development of telecommunication is ensuring the quality of service of the heterogeneous traffic of the terminal equipment of multiservice communication network [5, 6]. For guaranteed QoS the heterogeneous traffic of multiservice communication networks it is necessary to provide the certain parameters: the average delay by transfer stream of packages, capacity of buffer stores (BS) of entrance port, throughput, probability of losses by transmitting streams of packages, etc. And each served traffic (speech, data, video) makes the certain demands to parameters.

For algorithm calculation of parameters of the terminal equipment of multiservice communication networks it is necessary to create the scheme of functioning of model of a part

which will consider most exactly telecommunication managerial processes by transfer of stream of the packages proceeding in the considered network by providing the services.

On the basis of research [2, 4] it is established, that parameters of efficiency E_{eff} depends from of some the important parameters of system. The basic role among them is played high-speed parameters of user's and network terminals, the is probability of time characteristics of telecommunication communication networks caused by conditions and the ways of use of system and are described by following functional dependence

$$E_{eff} = \{E\,[\max_i (C_{i.m.n,}\, \eta_i),\ \min_i (T_{i.cp.з}, C_a)],\ i = \overline{1,n}\,\}, \qquad (1)$$

where $C_{i.m.n}$ is the maximal value of peak throughput of the terminal equipment of multiservice communication networks by transfer of *i*-th stream of packages; $T_{i.cp.з}$ is average time of delay by transfer of i-th stream of packages; C_a is cost of equipment rooms and software of the terminal equipment of multiservice communication networks; η_i is factor of an effective utilization of the terminal and network resources, which is necessary for service by transfer of *i-th* stream of packages.

Expression (1) defines the mathematical formulation of problem for an estimation of characteristics of efficiency of the terminal equipment of telecommunication networks by service of the heterogeneous traffic and it can be named a target system efficiency.

3. The scheme of functioning of the model of a party of multiservice communication networks.

For the decision of the task in view, describing qualitative parameters of paths of the system transfer, it is necessary to create the scheme of functioning the model part network which creates a foundation of offered algorithm of calculation of the terminal equipment of multiservice communication networks.

On fig.1. the presented scheme functioning model part network at realization algorithm « End to end », consists from following functional blok-modul systems: the buffer store (BS) of entrance port, switch ATM, the integrated multiplexer (IM) of terminal.

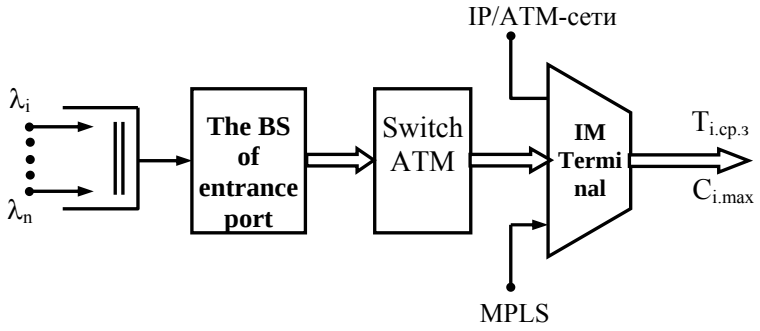

Fig.1. The block diagram of functioning model of the part of multiservice communication networks

The algorithm of functioning part network consists in transfer of the primary information from a source of loading up to the addressee at presence virtual liaison channel. Management of transfer of the traffic begins with entrance port in a network and comes to an end with the integrated multiplexer on an output from a communication network. IM the terminal in paths of systems transfer can allocated and process at first of all packages speech sensitive to delays and video with use protocol MPLS (Multiprotocol Label Switching). By means protocol MPLS transfer of IP-packages on second level ATM that provides to the traffic in real scale high class QoS on a strip of channel $\Delta F_k \geq 4$ KHs, delay $T_{cp.з}$ is realized, etc.

On network level the analysis of processes transfer stream polytypic packages of the traffic, under recommendations forums ATM and ETSI [5], allows to calculate necessary characteristics of quality functioning of user's and network terminals multiservice

communication network of following generation for ensuring guaranteed QoS. These parameters are concerned: the maximal value of peak throughput, BS capacity of entrance port, average time of delay transfer, factor of an effective utilization of network switchboards, etc.

On the basis of (1) and the system-technical analysis of the scheme functioning model part multiservice communication network the effective algorithm calculation considering association of processes different service and multiplexing streams packages of the non-uniform traffic [4,5] is created, allowing to estimate characteristics of paths of systems of transfer.

4. Estimation of characteristic of paths transmission systems of the heterogeneous traffic. For an estimation parameters of paths systems transfer on the basis of the offered it is approach are necessary to pay special attention to demanded speed of transfer parts $V_{i.mr}$, $i = \overline{1,n}$ on the set speed of receipt of entrance stream, loading the system $\rho_i < 1$, a matrix of routes $\Lambda_i = [\lambda_i, \eta_i]$, $\mathrm{i} = \overline{1,\mathrm{n}}$, and to quantity of user's and network terminals $N_{i.m}$, $\mathrm{i} = \overline{1,\mathrm{n}}$.

One of the important parameters of quality functioning paths of system transfers and routings streams of polytypic packages of the traffic is the maximal value of peak-raite throughput, the describing maximal number of packages, which part can transfer in unit of time.

The maximal value of peak throughput by transfer of i-th stream of packages in admissible number of terminal equipment $N_{i.m.adm.}$. In parts of communication networks it is defined by following expression:

$$C_{i.m.n}(\eta_i, N_{i.m.adm}) = \sum_{i=1}^{n} [\, V_{imr} \cdot N_{i.m.adm.}], \qquad \mathrm{i} = \overline{1,\mathrm{n}} \tag{2}$$

From algorithm of work part of communication networks follows, that average time delay of transfer of packages consists of time characteristics of paths systems the traffic transfer and depends on quantity $N_{i.m}$ of blok-module systems of user's and network terminals which result to increase $T_{i.cp.з.}$. Besides turns packages in BS terminal and transfers of the traffic on parts of multiservice networks cause also delays in transfer of packages [5]. Thus capacity BS entrance port $\mathrm{N_{i.bs}}$ is limited by their admissible memory and defined by inequality $N_{i.bs} \le N_{i.bs..adm}$, $\mathrm{i} = \overline{1,\mathrm{n}}$. Considering the given requirements and speeds receipt of entrance stream $\lambda_{\mathrm{i.ip.}}$, capacity BS of entrance port in admissible value $T_{i.cp.з.adm.}$ by transfer of i-th stream of the traffic is defined as follows:

$$\mathrm{N_{i.BS}}(\mathrm{T_{i.cp.з}} \le \mathrm{T_{i.cpз.adm.}}) = (\lambda_{\mathrm{i.ip}} - \mathrm{V_{i.mr}}) \cdot \mathrm{t_{i.з.вп}} + \Delta \mathrm{N_i}, \;\; \lambda_{\mathrm{i.ip}} \ge \mathrm{V_{i.mr}} \tag{3}$$

where ΔN_i is the maximal splash by transfer of i-th stream of packages $i = \overline{1,n}$; $t_{i.з.вп}$ is average time delay by transfer *i*-th stream of the traffic to entrance port $i = \overline{1,n}$.

For ensuring of the guaranteed quality of service streams of speech packages and the video traffic, created by supplement of real time, it is necessary to create conditions that the delay by transfer of any traffic has been limited with admissible size $T_{i.cpзadm.}$, $i = \overline{1,n}$. On the basis of algorithm of work of a network a part by transfer of *i*-th stream of packages of the traffic from a source of loading up to the addressee the minimal value of average time of a delay is defined by an inequality:

$$\mathrm{T_{i.cpз}} = \underset{i}{Arg\,\min} [\mathrm{T_{i+1}}\,(\lambda_{\mathrm{op}}) - \mathrm{T_i}\,(\lambda_{\mathrm{ip}})] \times K_{i.сж}^{-1} \le \mathrm{T_{i.cpз.adm}}, \;\; i = \overline{1,n} \tag{4}$$

where $T_i\,(\lambda_{ip})$ and $T_{i+1}\,(\lambda_{op})$ are times of occurrence of *i*-th stream of the traffic for input BS of entrance port with speed $\lambda_{\mathrm{i.ip}}$ and on an output from the target switchboard of a network with λ_{iop}, accordingly; $K_{i.сж}$ is factor of compression of the traffic *of i-th* stream of packages on the basis of differential algorithms and algorithms of interpolation speech and video signals.

For support of architecture IntServ and DiffServ in multiservice communication networks it is necessary to use terminal and network resources effectively [1, 6]. For normal functioning terminal equipments when there is no unlimited increase of turn and factor of an effective utilization of resources IT of the terminal of multiservice communication networks $\eta_{im.}$ must be less are

$$\eta_{им.}(C_{i.m.n} \le \lambda_{i.вых..}) = \sum_{i=1}^{n} \frac{C_{i.m.n}}{\lambda_{i.вых} \cdot \rho_i} < 1 \ , \qquad (5)$$

Performance of condition (5) allows determine more exactly a reserve of a resource part of multiservice communication networks.

The defined reserve of resources of the terminal equipment in all parts of multiservice networks allows make planned routing of the traffic according to recommendation ITU-T E.529 which is necessary for the guaranteed service of the set streams of packages.

5. Conclusion. Results of researches have shown, that the offered approach can be used for estimation parameters of quality of functioning and defining the size of the resource necessary for transmitting with set quality the heterogeneous traffic of terminal equipment of multiservice communication networks.

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