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STUDY AND EVALUATION OF PERFOMANCE CHARACTERISTICS OF THE ELEEMNT OF TELECOMMUNICATION MULTISERVICE NETWORKS

The performance of the element of telecommunication multi service networks, formed by users and networks terminals, using package technology, is investigated. On the basis of the model, analytically expression, enabling to evaluate the performance characteristics of the element of multi-service network and indices of guarantee quality of non-uniform traffic service has been obtained. Efficiency characteristics of terminal facilities providing the quality of voice transmission service have been analyzed.

Key words: *network performance, multi-service network element, user and network terminal, average delay of the transmission, non-uniform traffic, average probability of package losses.*

Introduction

Rapid development of telecommunication systems and growing requirements of communication operators regarding the increase of processing systems performance on the basis of modern information technologies requires the creation of distributed infrastructures of multi-service communication networks of high performance, providing the transmission of network attachments.

The performance of the element of multi-service telecommunication networks greatly depends on timely delivery and reliable transmission of non-uniform traffic using multifunctional users and network terminals (MUNT) for on-line operation and control of telecommunication processes-transmission, processing and reception of service traffic while performing the procedure of users connection in secondary communication networks. For solution of such problems much attention is paid to creation of multi-service telecommunication networks of high performance for operation of network attachment transmission, that is of great importance in communication control systems.

In communication system network attachments of multi-service telecommunication networks can be divided into three groups [1]: data transmission, package telephony and steam video - so-called Triple Play services.

The analysis carried out show [2, 3], that traffic of communication attachments, related to the first group, is not sensitive to delay, but packages loss can lead to the loss of information or to considerable increase of channel load, due to recurrent transmission. Traffic of communication attachments of the second and third groups requires delivery in real time, i.e.. with minimum delay and jitter.

In [3, 4] characteristics of terminal equipment of multi-service network element, intended for transmission of non-unifrom traffic were investigated, certain indices, such as throughput, probability-time characteristics of the system. However, the analysis of the research has shown, that the evaluation of the performance of terminal equipment of multi-service communication networks with preset QoS (Quality of Service) index causes many problems while transmission of package streams along single communication channels and integration of various types service of non-uniform traffic (speech, data, faxes, Internet, video, etc.).

The given research considers problems dealing with the study of the methods of multi-service networks element characteristics, using package technology, performance of terminal equipment, providing quality of service of voice traffic transmission is analyzed.

Problem set-up

Analysis of the development of modern communication networks shows that nowadays gradual transformation of telephone networks into multi-service networks, built on the basis of Next

Generation Network (NGN), using communication packages takes place.

One of the most complex technical problems while transmission of multimedia attachments in package networks is to provide the quality of service wile data processing. Bad adaptability of the networks with package communication to real time traffic transmission, at it has been mentioned in numerous research, retrains further development of multi-service networks [3, 5].

Taking into account the importance of the construction of terminal equipment of multi-service communication networks on the basis of NGN, special attention should be paid to performance indices of this system. Such system provides the users the possibility of multi-service, i.e. the possibility to transmit, receive and process information of various form and volume in package form. In this case, the important problem emerges – elaboration of the methods intended for computation of performance indices of terminal equipment of multi-service communication networks, this problem depends both on operation algorithm of user's and network terminal, and on the performance of separate elements of telecommunication networks, based on modern technologies of ATM (Asynchronous Transfer Mode) and IP ()Internet Protocol).

Taking into account the above-mentioned, mathematical formulation of the problem of multi-service communication networks element performance on the basis of modern information technologies, can be presented by the following efficiency function:

$$E_{perf} = \sup_{i} [\, E_{i.perf} \,], \qquad i = \overline{1,n}, \tag{1}$$

under the following limitations:

$$T_{i.av,del} \le T_{av.del.ad}, C_{i.a} \le C_{i.a.don.}, P_{i.p.} \le P_{i.n\ don.}, i = \overline{1,n}, \tag{2}$$

where $C_{i.a}$ – is the cost of hardware and software means of terminal equipment of multiservice communication networks while transmission of вартість i-th stream package; $P_{i.p}$ – is average probability of package loss while transmission of i-th traffic; $Ti._{av.del.}$ – is average delay time while transmission of i-th stream of packages.

Expressions (1) and (2) determine mathematic formulation of the problem for evaluation of efficiency characteristics of terminal equipment of telecommunication networks while non-unifrom traffic service, and it can be called the efficiency function of the system.

It is known form [3, 6], that one of the key problems for the development of telecommunication is to provide quality service of non-uniform traffic of terminal equipment of multiservice communication network. For guarantee QoS of non-uniform traffic it is necessary to provide certain indices: average delay while transmission of packages stream, capacity of buffer accumulators of the input port, thought, losses probability while transmission of packages stream, etc. Each serviced traffic (speech, data, video) have certain requirements regarding the performance indices.

For the algorithm intended for computation of performance indices of terminal equipment of multiservice networks it is necessary to create the scheme of element model functioning, which will take into account telecommunication process of packages streams transmission control.

Mathematical description of element model of multi-service communication networks

Fro the solution of the problem, characterizing quality indices of transmission system channels, it is necessary to develop the model of network element, that will create the basis of the suggested algorithm intended for computation of the performance of terminal equipment of multiservice communication networks.

The algorithm of network element functioning comprises the transmission of initial information from the source of load to receiver, if virtual communication channel is available.

Administration of traffic transmission starts from the input port in the network and is completed by integral multiplexer (IM)and limiting router (LR) at the output of the network [4]. IM of the terminal and LR in transmission systems channels can allocated and process first of all speech and

video packages, sensitive to delays, applying Multiprotocol Label Switching (MPLS).

It follows form operation algorithm, that the element of network is multi-line system of mass servicing (SMS), where. Under the influence of random medium in the course of time, at random moments, parameters λ, μ, and N_m simultaneously change. Let us assume, that the number of possible operation modes of the system, differing by the values of these parameters, is finite and equals 1, and duration of i th mode is distributed by exponential law with the parameter b_i ($b_i = \mu_i^{-1};\ i = \overline{1,n}$).

Besides, investigated elements of the networks are SMS of M/M/1/N_6 type, with losses of λ_i, intensity, $i = \overline{1,n}$, of input traffics where $N_{i.m}$ are terminals are available [6].

In i th mode, the simplest stream of traffic of λ_i, parameter arrives at the input of SMS, and durations of request queuing are independent random values, distributed be exponential law with μ_i. parameter. The number of users and network terminals, operating in i th mode, we will denote by $N_{i.m}$.

Then the functioning of network element is described by classic one-dimensional Mrakov's process, being Birth-Death Process (BDP).The following coefficients corresponds to characteristic features of the considered system:

- coefficient of Birth-Death Process is determined in the following way [3, 6]:

$$\lambda_i = 0, if \ \ i \geq N_m \ \ and \ \ i < N_m \ when \lambda_i = \lambda \tag{3}$$

- coefficient of Death process:

$$b_i = \mu_i^{-1}\ ,\ i = \overline{1,n},\ \mu_i = \lambda_i \cdot \rho_i^{-1},\ \rho_i < 1, \tag{4}$$

where μ_i – is duration of i th traffic queuing .

According to recommendations of ATM and ETSI forums [2] the analysis of the processes of various packages traffic stream transmission of network level allows to calculate the required characteristics of functioning quality of users and network terminals of multiservice communication network of the next generation to provide guarantee QoS. These indices are: maximum value of peak throughput, capacity of AB of the input port, average delay time of transmission, coefficient of efficient usage of network switches.

On the basis of (1) and system-engineering analysis of element model of multiservice communication network, the efficient algorithm of calculation is created, it takes into consideration the integration of the processes of various queuing and multiplexing of non-unifrom traffic packages system [3, 6], enabling to evaluate the characteristics of transmission systems channels.

Evaluation of performance characteristic of the element of non-uniform traffic transmission system

For evaluation of performance indices of non-uniform traffic transmission system, based on the suggested model of network element it is necessary to pay attention to the required transmission rate of element $V_{i.mr}$, $i = \overline{1,n}$ at the preset rate of input stream arrival λ_i, system load $\rho_i < 1$, $i = \overline{1,n}$ and number of users and network terminals $N_{i.m}$, $i = \overline{1,n}$ i $N_{i.T} = \sum_j m_{i,j}$, where $m_{i,j}$ – the number of users and network terminals in network elements, traffic of which passes across these terminals.

One of the important indices of network element throughput for routing of non-uniform packages traffic streams is maximum value of peak rate throughput, characterizing maximum amount of packages, the element and transmit per unit of time, it is defined by the expression:

$$C_{i.m.n.}\ (\lambda_i \leq \lambda_{i.ad.}) = \sum_j C_{i,j},\ i = \overline{1,n}, \tag{5}$$

where $C_{i,j}$ – is a throughput provided for users and network terminals j and taking into consideration the efficient algorithms of data compression, it is determined in the following:

$$C_{i,j}(\lambda_i, b) = K_{i.comp} \cdot \frac{\rho_i}{b} \cdot m_{i,j},\ i = \overline{1, n}, \tag{6}$$

where $K_{i.comp}$ – is compression coefficient of the traffic of i th stream of packages on the basis of differential algorithms and algorithms of interpolation of speech and video signals.

One of the key indices of QoS traffic in the element of multiservice network is average probability of package losses for real-time traffic and current traffic. It follows from operation algorithm of communication networks element, that the value of average probability of packages losses depends on the amount of $N_{i.m}$ block-module systems of users and network terminals, variation coefficient (correspondingly, distribution of input stream and time of traffic queuing) and capacity of buffer memory (BM) of network element while performing «End to end» strategy.

Average probability of package losses in direct connection while realization of «End to end» strategy for speech traffic can be defined

$$P_{i.cn.}(p_i < p_{i.ad.}) = 1 - (1 - P_{i.n.l}) \cdot (1 - P_{i.ter.}),\ i = \overline{1, n}, \tag{7}$$

where $P_{i.nl}$ – iare probabilities of network losses while transmission of i th speech stream of packages; $P_{i.ter.}$ – are probabilities of loss at multifunctional user's and network terminal as a result of exceeding admissible delay while transmission of i th speech stream packages.

Proceeding from the research performed [6], it was determined that the causes of $P_{ter.}$ appearance is, first of all, delay jitter, and in this case the exceed of admissible value of delay in the element of multi-service network for speech traffic will be critical $T_{i.av.d} \leq T_{i.av.d.ad}$ taking into account recommendations of ITU-T, G.114.

In the element of multi-service network the load is non-uniform, with different requirements to QoS of the traffic. To provide the guarantee service quality of speech packages streams and video traffic, created by real-time attachments, it is necessary to create the conditions for limitation of the delay while any traffic transmission by the value of $T_{i.av.d.ad.}$, $i = \overline{1, n}$.

Taking into account the operation algorithms of the investigated scheme of non-uniform traffic [6] and characteristic features of network element model while transmission of ith stream of traffic packages from the source of load to receiver, minimum value of average delay time is determined by the expression:

$$T_{av.d} = \sum_{j=1}^{k-1} T_{j.ter} + T_{j.cc} + \frac{L_{j.n}}{C_j}, \tag{8}$$

where $T_{j.ter}$ – is average delay in the queue at the output from j th user's and network terminal; $T_{j.kc}$ – average delay in communication channel by j th and $(j+1)$ th terminal device; $L_{j.n}$ – average length of transmitted package, intended for j communication nodes.

The expression (8) defines, what average delay time while passage of packages streams along transmission routes consist of, and characterizes complete delay while traffic transmission in multi-service network. Non-uniform of the traffic in modern multi-service networks based on ATM, IP-telephony and NGN-technologies stipulates the necessity of differential approach to provide various attachments of networking resources.

To support service quality in communication networks, meeting the requirements of İTU-T E.800, Y.1540 and G.1000, the necessary precondition is availability of resources ion the network. IN multi-service networks, created by users and network terminals, using package technology, the reserve of network element recourse is determined in the following manner

$$R_{res}(\rho_i \leq \rho_{i.ad}) = 1 - \sum_{i=1}^{n} \eta_i,\ 1 \leq i \leq n, \tag{9}$$

where η_i – is the coefficient of efficient usage terminal and network resources, required for servicing while transmission of i-th package stream;

The expression (9) characterizes reservation of system resources, based on RSVR (Resource Reservation Protocol) and enables to define accurately the reserve of multi-service communication network element.

To meet the requirements of certain services the determined reserve of terminal equipment resource in all elements of multiservice networks allows to compose the planned routing of the traffic in accordance with the requirements of ITU-T E.800, що providing (QoS-routing), that satisfies the requirements concerning the quality for the given stream of packages of non-uniform traffic.

Conclusions

On the basis of system-engineering analysis the model, describing functional algorithms of terminal equipment of multiservice network element is created. The results of research, carried out. Showed that the suggested model of network element is the basis for analysis of terminal equipment of network element efficiency and allows to evaluate basic indices of multi-service telecommunication network performance.

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