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Analysis and Selection Performance Indicators Multiservice Communication Networks Based on the Concept NGN and FN

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Abstract. *The performance indicators of multiservice communication networks, built in accordance with the con-cept NGN (Next Generation Network) and FN (Fu-ture Network) based on promising telecommunica-tion and information technologies, have been ana-lyzed. The issues of efficiency transmission useful and service traffic by a multifunctional hardware-software complex in the links multiservice communication networks are considered and their struc-tural and functional diagram is proposed. The prob-lems choosing the necessary performance indica-tors hardware and software systems and terminal facilities are considered, taking into account the probabilistic-temporal and speed characteristics multiservice communication networks based on the concept NGN and FN. Analytical expressions are obtained that make it possible to assess the complex performance indicators network link in the provi-sion multimedia services and when establishing a connection.*

Keywords: *multiservice communication network, SDN, multi-media service, IMS, channel resource, innovative technologies, average delay time, NFV, network and physical resource, throughput.*

I. Introduction and Problem Statement

Development multiservice communication networks based on the architectural concept of NGN and FN using technologies such as SDN (Software-Defined Networking), WDM (Wavelength Division Multiplexing), 5G/IMT-2020, NFV (Network Functions Virtualization), IMS (Internet Protocol Multimedia Subsystem) , LTE (Long Time Evolution), DWDM (Dense WDM), SUN (Smart Ubiquitous Networks) and NR (New Radio) require the creation of unified technical means - multifunctional hardware and software complexes and terminal facilities of the link of multiservice communication networks of general use with packet switching, providing joint transmission of various types of information streams through communication channels [1, 2, 3].

However, multifunctional hardware and software systems and terminal facilities with these indicators do not fully satisfy the efficiency functioning multiservice communication networks and do not provide joint transmission of useful and service traffic when providing multimedia services and applications such as "Tri

ple Play services" (speech, data and video traffic), intelligent services, and Bandwith [3, 4, 5]

The analysis shows [2, 5, 6] that on the basis modern technologies with multimedia applications, SDN, IP (Internet Protocol), NFV and ATM (Asynchro nous Transfer Mode) and IMS, they open up fundamentally new possibilities for integrating processes while jointly servicing useful and service traffic.

This raises the problem - the choice of complex performance indicators of multiservice communication networks based on the concept of NGN and FN using hardware and software systems and terminal facilities, taking into account their probabilistic and temporal characteristics. Further, the heterogeneous resources and speed characteristics of communication networks are taken into account.

In accordance with this, the main task of the proposed work is the issues of effective use of multifunctional hardware and software systems and terminal facilities of the link of multiservice communication networks and its functioning model when jointly servicing heterogeneous traffic, depending on the distribution of physical, network and channel resources, taking into account compression the transmitted message stream.

In this work, the research is devoted to solving the problem of analyzing complex indicators effectiveness of the functioning multifunctional hardware and software complexes and terminal facilities multiservice communication networks based on NGN and FN, using infocommunication technologies SDN, NFV and IMS.

The mathematical formulation of the problem at the first lower - physical, channel, network and transport levels when jointly servicing useful and service traffic using multifunctional hardware and software complexes and terminal facilities multiservice communication networks can be represented by the following functional dependencies:

$$E_{эфф}(\lambda_i)=W[C_{\max}(\lambda_i),K_{сж}(\lambda_i),T_{сз}(\lambda_i),C_{an},N_{бн}(\lambda_i)],\ i=\overline{1,n}\ , \quad (1)$$

where $C_{\max}(\lambda_i)-$ throughput multifunctional hardware and software systems and terminal facilities SDN, IMS and NFV, taking into account the rate of incoming flow during processing $i-$th traffics, $i=\overline{1,n}$;

$K_{сж}(\lambda_i)-$ the compression ratio of the message, taking into account the rate arrival of the incoming stream λ_i when processing $i-$th traffic, $i=\overline{1,n}$;

$T_{сж}(\lambda_i)-$ the average traffic transmission delay time, taking into account the rate arrival of the incoming stream λ_i when processing the $i-$th packet, $i=\overline{1,n}$;

$N_{бн}(\lambda_i)-$ capacity of buffer drives multifunctional hardware and software systems and terminal facilities SDN, IMS and NFV, taking into account the rate of arrival of the incoming stream λ_i when processing $i-$th traffic, $i=\overline{1,n}$;

Ca - cost of multifunctional hardware and software systems and terminal facilities SDN, IMS and NFV link of multiservice communication networks.

Expressions (1) determine the choice necessary performance indicators for hardware and software systems and terminal facilities, taking into account the probabilistic and temporal characteristics of multiservice communication networks based on the concept NGN and FN

The architecture and construction principle multifunctional hardware and software systems and terminal facilities for SDN, IMS and NFV links multiservice communication networks are based on the theory of telecommunications and digital signal processing, combining various switching, operating and multiprocessor systems.

In order to combine multifunctional hardware and software systems and terminal facilities in one complex and integrate various types of services and transfer heterogeneous traffic based on modern SDN, IMS and NFV technologies of a link multiservice communication networks, it is necessary to create a single infocommunication space operating in real time.

For a complete description of the processes combining multimedia traffic and assessing complex performance indicators of the functioning multifunctional hardware and software systems and terminal facilities, we will consider the features and nature of the input traffic flow in the links of a multiservice network. Regardless of the quality network link and its size, a stochastic flow of traffic packets arrives at its input, which is characterized by: the number packets per unit time, the rate arrival packet flows.

To solve this problem, a mathematical model (MM) was developed for combining multimedia traffic [5], which describes the dynamics traffic multiplexing and service processes with an assessment of the effectiveness functioning of multifunctional hardware and software complexes and terminal based on block-modular systems that ensure the transmission and integration of traffic multimedia services and applications.

Taking into account the algorithm of the system operation, a model of the functioning of the network link formed multifunctional hardware and software complexes and terminal where streams of traffic packets are received from various sources at the rate λ_i of useful and service traffic [3, 5, 7].

Based on the basic model [3, 4, 8], it is proposed here to consider multichannel queuing systems with a limited capacity of the buffer storage $N_{бн}(\lambda_i)$, where ($N_{бн}(\lambda_i) < \infty$), $i = \overline{1,n}$.

Suppose that the model has n traffic information flows and the incoming traffic packet flows obeys Poisson's law with the intensity λ_i, $i = \overline{1,n}$ and the required service duration of the $i-$ th traffic flow has an arbitrary distribution function b_i, $i = \overline{1,n}$ and all incoming traffic flows are independent.

Incoming streams traffic packets are served on a lossy model, i.e. if the buffer accumulator is full, they get a failure. Taking into account the algorithms of the network link, the formal procedure for receiving packet streams for transmission can be written as follows [8].

Let be i_n - number of messages $n-$th traffic flow in the buffer storage for transmission, and N_m – the total number of resource units of multifunctional hardware and software systems and terminal facilities of a network link, occupied with control of the transmission of traffic packets streams.

In this case N_m , the value is determined by the following expression [3]:

$$N_m(V_k \le V_{k.don.}) = \sum_{n=1}^{M}(b_n \cdot i_n) \le N_{m.don.}, i = \overline{1,n}, \quad (2)$$

where $V_k -$ speed of operation of multifunctional hardware and software systems and terminal facilities.

From expression (2) it follows that messages of the nth traffic flow are accepted for transmission if the following inequality is satisfied

$$R_{m,n} = (\text{Nm} + \text{bn}) \le \text{Vk.доп.}, \quad (3)$$

Accordingly, the incoming traffic flows are lost without renewal if the conditions are met

$$R_{m,n} = (\text{Nm} + \text{bn}) > \text{Vk.доп.} \quad , \quad (4)$$

The obtained conditions determine the switching reserve resources and the efficiency functioning multifunctional hardware and software complexes and terminal facilities multiservice communication networks when transmitting the flow of useful and service traffic.

II. Analysis of Indicators of the Throughput Multiservice Network

It is known [2, 5, 7] that the most generalized and important purpose of a multiservice network link is to transmit useful and service traffic from a source to a recipient in the presence multifunctional hardware and software systems and terminal facilities and a virtual communication channel.

One of the important and basic characteristics of the link multiservice communication networks when transmitting streams of useful and service traffic packets is the throughput of multifunctional hardware and software systems and terminal facilities.

Based on the model functioning multifunctional hardware and software systems and terminal facilities and a virtual communication channel, the bandwidth of a network link, which is the amount of multimedia traffic service, in general, is expressed as follows:

$$C_{\max}(\lambda_i) = \sum_{i=1}^{n}[\lambda_i - \lambda_{i.om} - \lambda_{i.n}], \; i = \overline{1,n} \; , \quad (5)$$

where λ_i , $\lambda_{i.om}$, $\lambda_{i.n} -$ the intensity of the incoming packet stream, expected and unsaved multimedia traffic, which is a heterogeneous Poisson stream with a parameter λ_i .

The intensity of the incoming packet flow consists of the speed of the incoming useful $\lambda_{i.nm}$ and service traffic $\lambda_{i.nc}$, $i = \overline{1,n}$ and is found as follows:

$$\lambda_i = \sum_{i=1}^{n}\lambda_{i.nm} + \sum_{i=1}^{n}\lambda_{i.nc} \; , \; i = \overline{1,n} \; , \quad (6)$$

The analysis shows that the model combining and functioning multifunctional hardware and software systems and terminal facilities and a virtual communication channel with joint multiplexing of traffic streams is associated with ensuring the highest value of the link bandwidth of multiservice communication networks based on NGN and FN, using innovative technologies SDN, IMS and NFV

Thus, the implementation of this task on the basis of multifunctional hardware and software systems and terminal facilities and a virtual communication channel is an integral assessment of the characteristics for a continuous process at a given time interval $[t_i; t_{i+1}]$, which is written as:

$$H(\lambda)=\int_{t_i}^{t_{i+1}} F\left[C(\lambda,t)\right]dt\,, \qquad (7)$$

where λ - the total intensity of the incoming stream of the packet of useful and service traffic and equally $\lambda=\sum_{i=1}^{n}\lambda_i$, $i=\overline{1,n}$.

Expression (7) determines the largest amount transmitted non-uniform information with the minimum average message delay time at a given time interval $[t_i;t_{i+1}]$.

III. Research and Evaluation of the Effectiveness Communication Network

Taking into account MM, it is possible to more adequately assess the functioning of a communication network link on the basis of multifunctional hardware and software complexes and terminal facilities and a virtual communication channel, where there is a large amount information.

For this, it is advisable to introduce new characteristics - the instantaneous power of multifunctional hardware and software systems and terminal facilities and a virtual communication channel $P_m(\lambda_i)$, which is determined at some point in the time of serving the useful and service traffic and takes into account $C_{\max}(\lambda_i)$ when limiting the admissible $T_{сэ}(\lambda_i)$ capacity of the terminal buffer storage and is expressed as follows:

$$P_m(\lambda_i)=\sum_{i=1}^{n} N_{i.n}\cdot V_{i.k}\,,\ V_{i.k}\le C_{\max}(\lambda_i)\,,\ i=\overline{1,n}\,, \qquad (8)$$

Research shows [2, 4], that the integral characteristics of the instantaneous power of multimedia traffic service characterizes the speed parameters of multifunctional hardware and software systems and terminal facilities and is found by the following expression:

$$P_m(\lambda_i)=T_{сэ}(\lambda_i)\cdot C_{\max}(\lambda_i)\cdot\lambda_{i.\max}\,,\ i=\overline{1,n}\,, \qquad (9)$$

where $N_{i.n}$ – the maximum number of serviced by the i – th stream of packets located in the buffer storage of the terminal; $V_{i.k}$ – maximum transmission rate of the i – th packet stream over communication channels;

$\lambda_{i.\max}$ – the maximum value of the intensity of the amount of the i – th flow of the traffic packet.

Obviously, in order to fully assess the effectiveness of the functioning of multifunctional hardware and software systems and terminal facilities of a link multiservice network, in conditions strong and critical work load $\rho(\lambda)\le\rho_k(\lambda)$, the average power of the system is determined, which is an integral estimate of the system on the time interval [0, T] and is expressed as follows:

$$E[P_{ср.m}]=\frac{1}{T}\int_0^T P_m(\lambda)\,d\lambda\,,\ T_{сэ}(\lambda)\le T_{сэ.доп.}(\lambda)\,. \qquad (10)$$

Expression (10) is determined by an integral characteristic that combines many basic parameters of a communication network link, which reveals the maximum speed capabilities virtual communication channels and is a quadrature form - the power of multifunctional hardware and software systems and terminal facilities.

Expressions (5), (10) characterize the assessment of the quality of service (QoS) multimedia traffic in the communication network and determine their main influencing parameters.

Thanks to the implementation SDN, NFV and IMS technologies, an efficient algorithm for the allocation of heterogeneous resources is being created [1, 3, 5, 7]. In accordance with this coefficient, the effective use of terminal $\eta_m(\lambda_i)$ and channel $\eta_k(\lambda_i)$ resources, respectively, is as follows:

$$\eta_m(\lambda)=\sum_{i=1}^{n}\lambda_i\cdot V_{i.k}^{-1}<1\,,\quad i=\overline{1,n}\quad, \qquad (11)$$

$$\eta_k(\lambda)=\frac{q_и}{V_0}\cdot R_{пи}<1\,,\ i=\overline{1,n}\quad, \qquad (12)$$

where V_0 – speed modulation in the communication channel; qи- parameters of the incoming traffic flow;

$R_{пи}$ – limiting information speed multifunctional hardware and software systems and terminal facilities

Based on the fact that the above analytical ratios show that the higher Cmax(λ_i), $K_{сж}(\lambda_i)$ и $P_m(\lambda_i)$ the less $T_{сж}(\lambda_i)$, $N_{бн}(\lambda_i)$ the more efficient is the proposed algorithm and model of functioning multifunctional hardware and software systems and terminal facilities communication network link while ensuring integration processes with the required reliability of the selected methods for calculating the speed and probabilistic-temporal characteristics multiservice communication network link.

IV. Conclusions

The efficiency functioning multiservice communication networks based on the architectural concepts of NGN and FN has been analyzed and their complex indicators have been investigated. On the basis of the study, a new approach to the construction of a mathematical model for assessing the effectiveness multiservice communication networks using SDN, IMS and NFV technologies is proposed.

The proposed approach for the study complex indicators of the throughput of multifunctional hardware and software systems and terminal facilities, provide new opportunities for resource allocation in network nodes through the joint use SDN, IMS and NFV technologies.

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