THE INVESTIGATION AND EVALUATION MULTISERVICE NETWORK NGN/IMS FOR MULTIMEDIA TRAFFIC

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DOI: 10.36724/2664-066X-2020-6-2-10-13

ABSTRACT

The subject of the study is multiservice communication network using the concept NGN (Next Generation Network) based on the open network architecture IMS (Internet Protocol Multimedia Subsystem), supporting a wide range services. The basis of this architecture is the IMS core, consisting of a set of specialized modules responsible for various functions for customer service. The purpose of the article is to analyze the existing technical capabilities of the IMS multimedia messaging subsystem and perspective solutions for the functioning of the NGN/IMS network efficiency in providing multimedia service. As the efficiency of the system, the capacity NGN/IMS networks is selected using the signaling system and protocols NGN. The capacity NGN/IMS networks during the establishment of a multimedia session was analyzed and the functional architecture of the IMS multimedia messaging subsystem that determine the interaction NGN signaling systems an protocols was explored. Manage the presentation Triple Play services to subscribers and simultaneously modify the media stream within the session allows the protocol for the initialization of the SIP and Diameter sessions, which are the main IMS signaling protocol. One of the important requirements for the IMS subsystem is the maintenance QoS (Quality of Service). A mathematical model for estimating the quality of communication services using a system $GI/G/1/N$ based on the theory diffusion approximation is proposed.

The research presented in this paper is very important for the theory queuing systems, since the article proposes a method for investigating multiservice communication networks with non-Poisson incoming flow and effective results are obtained for NGN/IMS networks. On the basis of the model analytical expressions are obtained, which allow evaluating the performance indicators of the Triple Play service. The proposed mathematical model can be used to solve a wide range of practical problems, including the management multiservice traffic in the process its transmission in multiservice telecommunications networks, taking into account the quality of service classes. Thus, studies NGN/IMS network capacity indicators using SIP protocols are relevant.

KEYWORDS: *throughput, NGN/IMS networks, multimedia session, SIP protocol, IMS subsystem, signaling traffic.*

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Introduction

The constant growth of the volume of transmitted useful and service traffic in multiservice networks with packet switching requires a steady increase in their throughput when establishing a multimedia session, ensuring the quality of service of QoS packets of traffic systems and NGN signaling protocols.

System-technical analysis showed [1-3] that many telecom operators providing multimedia services use service traffic control systems that implement triple play services, such as voice services with the ability to activate multimedia applications, video telephony, IPTV, voice and high-speed access. to the Internet. This approach allows the integration of various services, provides ample opportunities for personalization and increasing the number of multimedia services.

To provide telecommunications operators with the above services in multiservice communication networks, it is necessary to take into account the quality of service QoS of service and useful traffic and perception (Quality of Experience, QoE), which is assessed by several performance criteria [4]. QoS & QoE support is a key requirement for the IMS subsystem and an important indicator of the effectiveness of NGN/IMS networks in establishing a multimedia session. However, this issue has not been studied well enough and remains poorly researched [2-6].

Research problem statement

It is known [3-5] that the connection setup time is the most important QoS indicator of NGN / IMS networks and is determined from the moment when the caller's terminal transmitted all the message necessary to establish the connection until the moment when this terminal equipment (TE) received a signal about the state of the terminal of the called party.

Based on the study, it was determined [2, 4, 6] that the considered NGN/IMS network when servicing traffic packets of systems and signaling protocols is a single-channel queuing system (QS) of the G1/G/1/N type with a limited queue (by designation Kendall-Basharina GI – arbitrary distribution with independent intervals between applications).

Taking into account the nature of the network traffic of NGN/IMS signaling systems and protocols, a mathematical model (MM) of a multimedia service is proposed, taking into account the efficiency indicators of NGN/IMS networks and the features of diffusion approximation methods.

The mathematical formulation of the problem of the proposed MM for assessing the performance indicators of NGN/IMS networks when establishing a multimedia session is described by the following objective function:

$$Q_{эфф.}(\lambda) = W[\arg\max_{i}(C_{i.\max}(\lambda))], \quad i = \overline{1,n}, \qquad (1)$$

under the following restrictions

$$T_{i.ср.з} \le T_{i.ср.з,доп.}, \eta_i \ge \eta_{i.доп.}, , T_{i.ож.} \le T_{i.ож.доп.}, \quad i = \overline{1,n} \qquad (2)$$

where $C_{i.\max}(\lambda)$ – the maximum value of the throughput of NGN / IMS networks with the rate of the incoming stream of service traffic λ when transmitting the *i*-th packet stream; $T_{i.ср.з}$ – average delay time when transmitting the *i*-th packet stream; $T_{i.ож}$ – average waiting time in the queue when servicing the *i*-th packet flow; η_i – efficiency factor of NGN / IMS network resources when transmitting the *i*-th packet stream; $T_{i.ср.з,доп.}$ $\eta_{i.доп.}$ and $T_{i.ож.доп.}$ – accordingly, the admissible values of indicators of NGN / IMS networks when transmitting the i-th packet stream, $i = \overline{1,n}$.

Expressions (1) and (2) define the essence of the considered new approach based on a mathematical model for assessing the quality of communication services.

This paper analyzes a model of the functioning of the efficiency of NGN/IMS networks in the provision of multimedia services, such as voice services with the ability to activate multimedia applications.

The scheme of investigated model functioning of multiservice networks NGN / IMS

Based on the analysis of the quality of work of multiservice communication networks, the functional architecture of IMS was determined, which contains the following levels:

– the level of access and transport;
– sess on management level;
– s rvice and application level.

Figure 1 proposes a diagram of the functioning of the multimedia service traffic model in the NGN/IMS network.

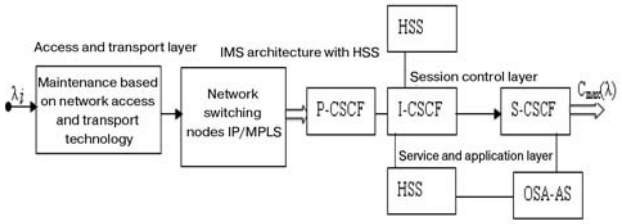

Figure 1. Block diagram of the model functioning servicing traffic in the NGN / IMS network

It follows from the diagram that the algorithm for receiving and serving IMS multimedia traffic begins in the NGN/IMS network at the access network level, as a multi-service access node.

Further, the traffic of the multimedia service is served using the signaling gateway, the core of the IMS network using the HSS-Home Subscriber Server and is transmitted to the AS (Application Server), which interacts with the logical function S-CSGF, I-CSGF and P-CSGF (Serving,

Interrogating, Policy – Call Session Control Function) over SIP.

The analysis shows that the procedure for establishing a multimedia session is initiated by the terminal equipment and the network access gateway, transmitting the INVITE request of the switching nodes using the IP/MPLS protocols through the service access networks and gateways.

Here, SIP is used to establish, control, and disconnect communications. For authorization, authentication and accounting procedures in IMS, the Diameter protocol is also used.

The IMS core using HSS implements request functionality, proxy server functionality, and session management functionality. After receiving and processing, requests and responses of the service by the IMS are sent to the service application server and the service media server.

Evaluation of performance indicators of NGN/IMS networks

From the above described principle of operation of NGN/IMS networks using SIP terminals, it follows that the operation when providing multimedia services and when establishing a session can be considered as a single-phase single-line QS with a finite volume of the buffer storage *N*.

We assume that a stream of traffic packets of signaling protocols with certain characteristics arrives at the input of the buffer storage (BS) of the switching nodes of NGN/IMS networks. Such a model can be analyzed as a general QS *GI*/*G*/1/*N* with a limited queue.

Based on the model, in order to assess the temporal characteristics of NGN/IMS networks when establishing a multimedia session, an approximate analytical method of diffusion approximation can be used, the accuracy of which is within acceptable limits. The idea of the diffusion approximation method is that the distribution Pk of the queue length in the system *GI*/*G*/1/*N* with a limited queue with a total load ρ is approximated by the following distribution [6]:

$$P_k = \begin{cases} 0, & npu \;\; k = 0 \\ (1-\rho\;)(\rho\;)^{k-1}, & npu \;\; k \geq 0 \end{cases} \qquad (3)$$

here P_k – characterizes that at each moment of time k the system has probability distributions of phase states; ρ – load factor of NGN/IMS networks.

In this system, it is assumed that the rate of arrival of service traffic flows λ differs from the Poisson one, and the service process from the exponential distribution law μ. Taking into account the quadratic coefficients of variation of the distribution of intervals C_A^2 between incoming multimedia messages and the distribution of message lengths C_B^2, the load factor of the QS is expressed as follows:

$$\rho \;\; = \exp[(\mu \cdot C_B^2 - \lambda \cdot C_A^2)/2(\lambda - \mu)], \qquad (4)$$

Suppose that due to system failures $\lambda_{обс} = 0$.

Then, the mean $E[T_{отк}]$ the failure time interval is expressed as follows:

$$E[T_{отк}] = \frac{\lambda_{вх} \cdot \lambda_{вых}}{\lambda_{вх} - \lambda_{вых}} \leq T_{отк.доп}, \qquad (5)$$

where $\lambda_{вх}$, $\lambda_{вых}$ – accordingly, the rate of the incoming and outgoing packet traffic of the NGN/IMS protocols when establishing multimedia sessions.

Thus, based on the model $GI/G/1/N_{бн}$ of expression (5), the average failure time is characterized and is an indicator of QoS & QoE.

Determining the capacity of NGN/IMS networks when establishing a multimedia session

Taking into account the features of the general QS type *GI*/*G*/1/*N* with a limited queue, the average queue length $E[L_{ср}]$ in BS switching nodes of NGN/IMS networks can be determined by Little's formula by the following expression:

$$E[L_{ср}] = \lambda_{вх} \cdot \{1 - E[P_{отк}]\} \cdot E[T_{ож}], \qquad (6)$$

Based on the proposed MM, the average time to establish a multimedia session for providing Triple Play services, corresponding to the average stay time of traffic packets in the NGN/IMS switching node, is expressed as follows:

$$E[T_{уст.}] = \{E[T_{ож}] + \mu^{-1}\} \cdot (1 - P_{отк}), \qquad (7)$$

It should be noted that expressions (6) and (7) determine the probabilistic-temporal characteristics of systems and signaling protocols of NGN/IMS networks and are indicators of the quality of service QoS of multiservice traffic.

Taking into account (5), (6) and (7) the maximum value of the throughput of NGN/IMS networks when establishing a multimedia session is determined as follows:

$$C_{\max}(\lambda) = 1/E[T_{уст}(\lambda)], \qquad (8)$$

The last obtained expressions (5), (6), (7) and (8) are an indicator of the effectiveness of NGN/IMS networks in establishing a multimedia session.

Numerical analysis results

Figure 2 shows the dependence of the NGN/IMS network bandwidth on the system load factor and the transmission rate of multimedia traffic.

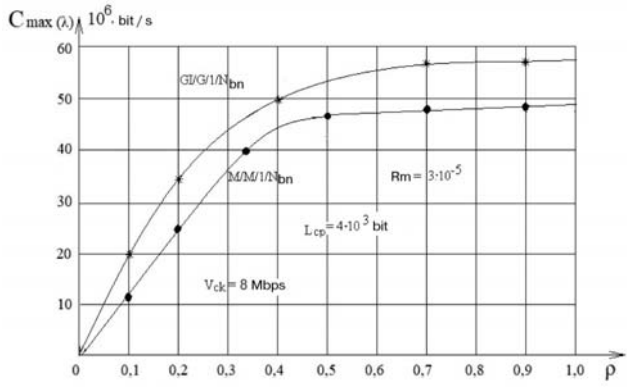

Figure 2. Graphical dependence of NGN/IMS network bandwidth on the system load factor when establishing a multimedia session

Graphical ndency family analysis $C_{\max}(\lambda) = W(\rho, \lambda_{ex}, V_{ck})$ shows that with an increase in the CMO load factor, the NGN/IMS throughput using the HSS home subscriber servers increases, thereby reducing the average multimedia session setup time for a given $V_{ck} = 155$ Mbit/s.

Thus, a comparative analysis of the QS of the general type *GI*/*G*/1/*N* and *M*/*M*/1/*N* shows that the contribution of the IMS core to the delays in establishing a multimedia session is significant and should be taken into account when designing NGN/IMS networks.

Conclusions

As a result of the study, an MM was proposed, in the form of a QS of the general type *GI*/*G*/1/*N* with queues, based on the approximate method of diffusion approximation. Analytical expressions have been obtained that make it possible to assess the quality of service QoS & QoE of multiservice traffic and analyze the characteristics of the NGN/IMS network bandwidth when establishing a multimedia session.

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