ISSN: 2350-0328

International Journal of Advanced Research in Science, Engineering and Technology

Vol. 8, Issue 4 , April 2021

Generalized Request Service Model in IMS Functional Servers

Nurmatova Sevara Batirovna

Tashkent University of information technologies named after Muhammad al-Khwarizmi

ABSTRACT: The analysis of the work on the assessment of the probability-time characteristics of registration, re-registration, connection and the provision of IPTV services in IMS (IP Multimedia Subsystem) is carried out. A generalized model is developed and the probability-time characteristics of servicing various classes of requests in functional IMS servers are evaluated. Based on the developed model, the problems of the optimal distribution of the total computing resource between the IMS functional servers and the assignment of service priorities to various classes of requests are solved.

KEYWORDS: IMS server, registration, re-registration, connection establishment, provision of services, generalized model, quality of service, resource allocation, priority distribution.

I. INTRODUCTION

Currently, the basis for building Next Generation Networks (NGNs) is the concept of integrating various technologies, systems and networks based on IP (Internet Protocol). This concept is also consistent with IMS (IP Multimedia Subsystem) technology, which at the current stage of development of ideas about NGN networks most closely matches them.

The functional diagram of the NGN / IMS network includes: a transport layer that implements access functions on various technologies; Session management level, including CSCF (Call Session Control Function) and HSS (Home Subscriber Server) subscriber database; application layer, which includes PS (Presence Server) and SIP AS (SIP Application Server) application servers. The CSCF module includes three levels (functions) [1]:

1. Proxy CSCF (P-CSCF): the level of interaction with the network - an intermediary for interaction with subscriber terminals. The main tasks are subscriber authentication and account formation.

2. Interrogating CSCF (I-CSCF): the level of switching - a mediator for interaction with external networks. The main tasks are determining the privileges of an external subscriber for access to services, selecting the appropriate application server and providing access to it.

3. Serving CSCF (S-CSCF): the level of service implementation is the central element of the IMS network, processes all signaling messages exchanged between terminal devices.

Functional CSCF servers exchange SIP (Session Initiation Protocol) signal messages, and Diameter is used to access the HSS server (Figure 1). UE (User Equipment) subscriber terminals are connected through the P-CSCF functional elements of the networks in which they are currently located.

ISSN: 2350-0328
International Journal of Advanced Research in Science, Engineering and Technology
Vol. 8, Issue 4 , April 2021

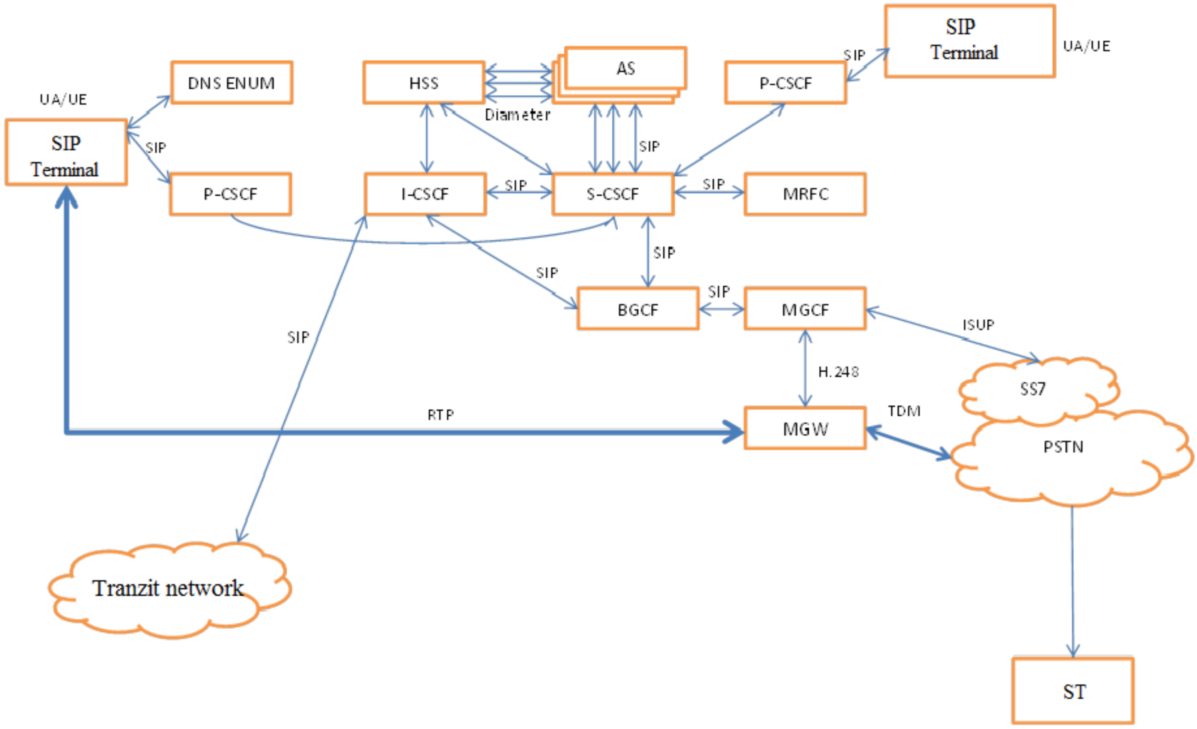

Figure 1. Functional organization of IMS.

The functional organization of IMS allows you to serve many classes of requests: re-registration, registration, establishing an IMS-IMS connection, establishing an IMS-PSTN (Public Switched Telephone Network) connection, establishing an IPTV session, and others [2]. When establishing an IMS-PSTN connection, BGCF (Breakout Gateway Control Function) and MGCF (Media Gateway Control Function) are involved, and MCF (Media Control Function) is involved in the IPTV session.

In the existing works, models of signal traffic [3,4] and estimates of the performance of SIP-servers under congestion conditions [5,6] were developed. Many works analyze the quality of service indicators of only one class of request. For example, a model of the registration procedure [7], a model of the re-registration procedure [8,9], a model for establishing a connection between IMS subscribers (IMS-IMS) [10] and a model for establishing a connection for the provision of IP TV services [11-13] were developed.

This work is a continuation of the studies conducted in [7–13] and its goal is to develop a generalized model for evaluating the probability-time characteristics of serving multiple requests and optimizing the parameters of functional IMS servers.

II.GENERALIZED REQUEST SERVICE MODEL IN IMS

A generalized request service model in IMS is represented as a BCMP network [14]. It will be an open heterogeneous queuing network (CEMO) with several classes of requests and service disciplines M / M / 1 at all nodes of the network: P-CSCF (1), I-CSCF (2), HSS (3), S- CSCF (4), AS (5), BGCF (6), MGCF (7), MCF (8), where the numbers of the nodes (functional servers) are indicated in brackets.

Five request classes are considered: re-registration (1), registration (2), establishing an IMS-IMS connection (3), establishing an IMS-PSTN connection (4) and establishing an IPTV session (5), where the numbers of request classes are shown in brackets. The probability of receipt of the ith request is denoted by p_i. Moreover, it must be taken into account that $\sum_{i=1}^{5} p_i = 1$.

On the basis of the query servicing algorithms described in [15], the formulas for the mathematical expectation of the query flow intensity for each functional server are obtained:

$$M(\lambda_1) = (2 \cdot p_1 + 4 \cdot p_2 + 22 \cdot p_3 + 11 \cdot p_4 + 4 \cdot p_5)\lambda_0;$$

ISSN: 2350-0328
International Journal of Advanced Research in Science, Engineering and Technology
Vol. 8, Issue 4 , April 2021

$$
\begin{aligned}
&M(\lambda_2) = (3 \cdot p_1 + 6 \cdot p_2)\lambda_0;\\
&M(\lambda_3) = (2 \cdot p_1 + 4 \cdot p_2 + 1 \cdot p_3)\lambda_0;\\
&M(\lambda_4) = (2 \cdot p_1 + 4 \cdot p_2 + 45 \cdot p_3 + 22 \cdot p_4 + 4 \cdot p_5)\lambda_0; \qquad (1)\\
&M(\lambda_5) = (22 \cdot p_3 + 11 \cdot p_4 + 4 \cdot p_5)\lambda_0;\\
&M(\lambda_6) = 11 \cdot p_4\lambda_0;\\
&M(\lambda_7) = 11 \cdot p_4\lambda_0;\\
&M(\lambda_8) = 4 \cdot p_5,
\end{aligned}
$$

where λ_0 is the total intensity of requests.

The number of calls per second during NNT is determined by the formula:

$$c = \frac{NY}{P_{обыч} \cdot t_{обыч} + P_{длит} \cdot t_{длит}}, \qquad (2)$$

where N is the number of subscribers, Y is the load $P_{обыч}$ is the probability of a normal conversation, $P_{длит}$ is the probability of a long conversation, $t_{обыч}$ is the duration of a normal conversation, $t_{длит}$ is the length of a long conversation.

The number of IMS-IMS and IMS-PSTN connection establishment requests is determined by the formulas:

$$c_{ims} = c * p_{ims} \qquad (3)$$

where p_{ims} *and* p_{pstn} are the probabilities of IMS-IMS and IMS-PSTN connection establishment requests, with $p_{ims} + p_{pstn} = 1$.

Number of requests for registration and re-registration:

$$c_{reg+rereg} = \frac{N}{T1}, \qquad (4)$$

where timer T1 is 90 seconds [2].

During the registration procedure, HSS sends 5 authentication vectors [16], one of which is used for authentication during registration, 4 remaining ones will be used during re-registration procedures. Thus, after 4 re-registration cycles, a registration procedure is required to obtain new quintuplets. Then the number of requests per unit of time for registration and re-registration:

$$c_{reg} = \frac{c_{reg+rereg}}{5}; \qquad (5)$$

$$c_{rereg} = \frac{c_{reg+rereg} \cdot 4}{5}. \qquad (6)$$

The number of requests per second for establishing an IPTV session is denoted by c_{iptv}.

Thus, the probability of receipt of the ith request is determined by the formula:

$$p_i = \frac{c_i}{c_{rereg}+c_{reg}+c_{sip}+c_{pstn}+c_{iptv}}, \quad i = \overline{1,5}. \qquad (7)$$

The calculation of the probability-time characteristics of the node and network characteristics at $\lambda_0 = c_{reg} + c_{rereg} + c + c_{iptv}$ is carried out according to the well-known formulas of the M / M / 1 model [17].

ISSN: 2350-0328
International Journal of Advanced Research in Science, Engineering and Technology
Vol. 8, Issue 4 , April 2021

Let the IMS network serve 100,000 subscribers, the load is 0.3 Erlang. The average duration of a normal conversation is 3.30 minutes, the average duration of long conversations is 10 minutes. Ordinary conversations: 80%, long conversations 20%. We assume that the number of requests for establishing an IMS-IMS connection is 60% of the requests for establishing connections, and the number of IMS-PSTN requests is 40%. Let 30 requests to establish an IPTV session be received per second. The results of calculations of nodal characteristics are summarized in table 1.

Table 1
Summary table of node characteristics

Characteristics	Nodes (Queuing System MO)							
	1	2	3	4	5	6	7	8
1	2	3	4	5	6	7	8	9
The intensity of applications, λ	4607	4011	2729	6489	1939	452	452	119
The average duration of service applications, b, ms	0,08	0,08	0,1	0,08	1	0,08	0,08	0,08
Node load, ρ	0,37	0,32	0,27	0,52	0,19	0,036	0,036	0,01
Intensity of service, μ	12500	12500	10000	12500	10000	12500	12500	12500
Timeout, w, ms	0,047	0,038	0,037	0,087	0,023	0,03	0,03	0,001
Average residence time of applications in the system, u, ms	0,127	0,118	0,137	0,167	0,123	0,083	0,083	0,081
Average order queue length, $l \cdot 10^{-3}$	216	152	101	565	45	1	1	0,1

Based on the algorithms for servicing the classes of requests in question, formulas are obtained for calculating the average time spent (delay) of requests in the network:

$$U_{rereg} = 2 \cdot u_{p-cscf} + 3 \cdot u_{i-cscf} + 2 \cdot u_{hss} + 2 \cdot u_{s-cscf};$$
$$U_{reg} = 4 \cdot u_{p-cscf} + 6 \cdot u_{i-cscf} + 4 \cdot u_{hss} + 4 \cdot u_{s-cscf};$$
$$U_{ims} = 22 \cdot u_{p-cscf} + 1 \cdot u_{hss} + 45 \cdot u_{s-cscf} + 22 \cdot u_{as}; \quad (8)$$
$$U_{pstn} = 11 \cdot u_{p-cscf} + 22 \cdot u_{s-cscf} + 11 \cdot u_{as} + 11 \cdot u_{bgcf} + 11 \cdot u_{mgcf};$$
$$U_{iptv} = 4 \cdot u_{p-cscf} + 4 \cdot u_{s-cscf} + 4 \cdot u_{as} + 4 \cdot u_{mcf};$$

Figure 2 presents graphs of the dependence of the average request delay time on the load for the requests in question with a uniform distribution of the total computing resource IMS between its functional servers.

ISSN: 2350-0328
International Journal of Advanced Research in Science, Engineering and Technology
Vol. 8, Issue 4 , April 2021

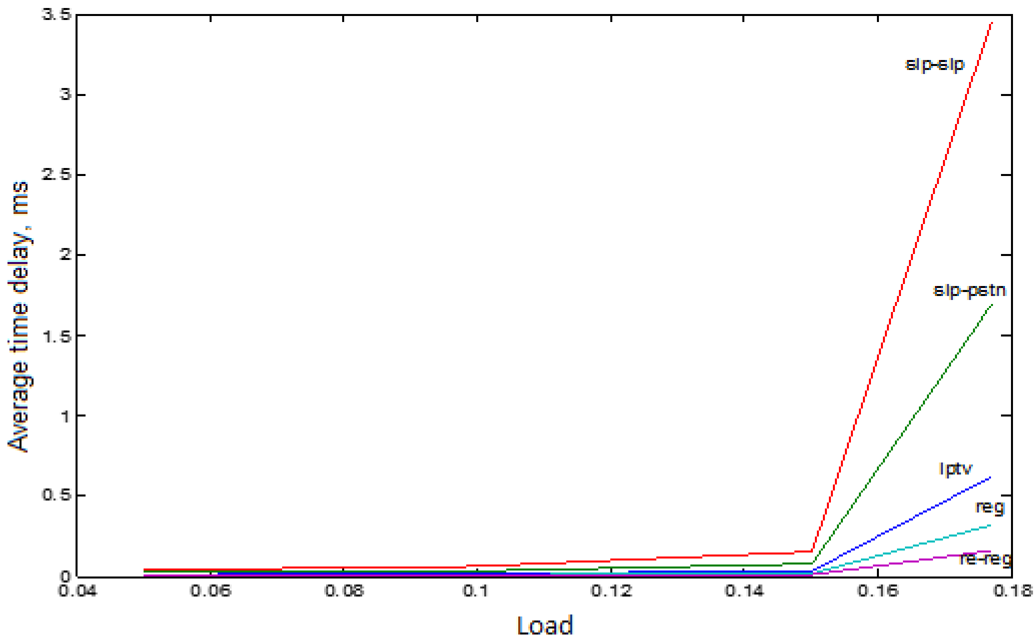

Figure 2 - The dependence of the average time delay of requests from.load at various requests uniform distribution of computing resources.

Figure 2 shows that, with loads greater than 0.17, the average delay values for requests to establish SIP-SIP and SIP-PSTN connections sharply increase. This is because when the distribution of the total computing resource is evenly distributed, the functional IMS servers are loaded unevenly (Figure 3).

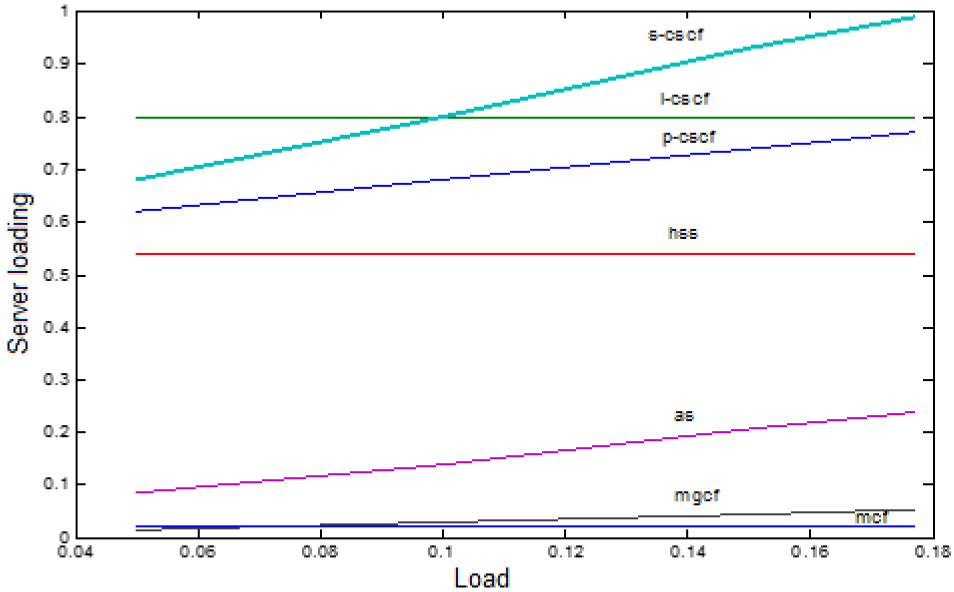

Figure 3 - Dependence graph of the load of functional servers
IMS from load with uniform distribution of the total computing resource.

At a load of 0.18, the S-CSCF load approaches one, while other functional servers are not overloaded.

ISSN: 2350-0328
International Journal of Advanced Research in Science, Engineering and Technology
Vol. 8, Issue 4 , April 2021

The probabilistic-temporal characteristics of request servicing can be improved by optimally distributing the total computing resource between functional servers and assigning priorities to requests when servicing them.

III. OPTIMAL DISTRIBUTION OF SHARED COMPUTING RESOURCES BETWEEN IMS FUNCTIONAL SERVERS

It is necessary to optimally distribute the total computing resource (the total intensity of service requests) in order to balance the load of functional IMS servers.

According to the “square root" rule [18], we determine the optimal values of service intensities μ_{iopt} for applications in IMS functional servers with a total service intensity μ_{sum}:

$$\mu_{iopt} = \lambda_i + \frac{\mu_{sum}(1-R)\sqrt{\lambda_i}}{\sum_{i=1}^{n}\sqrt{\lambda_i}} \quad (9)$$

$$R = \frac{1}{\mu_{sum}}\sum_{i=1}^{n}\lambda_i \quad (10)$$

where: R is the total load of the IMS subsystem;

λ_i- the intensity of requests for input of the i-th functional server.

The result of the determination of μ_{iopt} is an increase in the area of stable functioning of IMS (Figure 4).

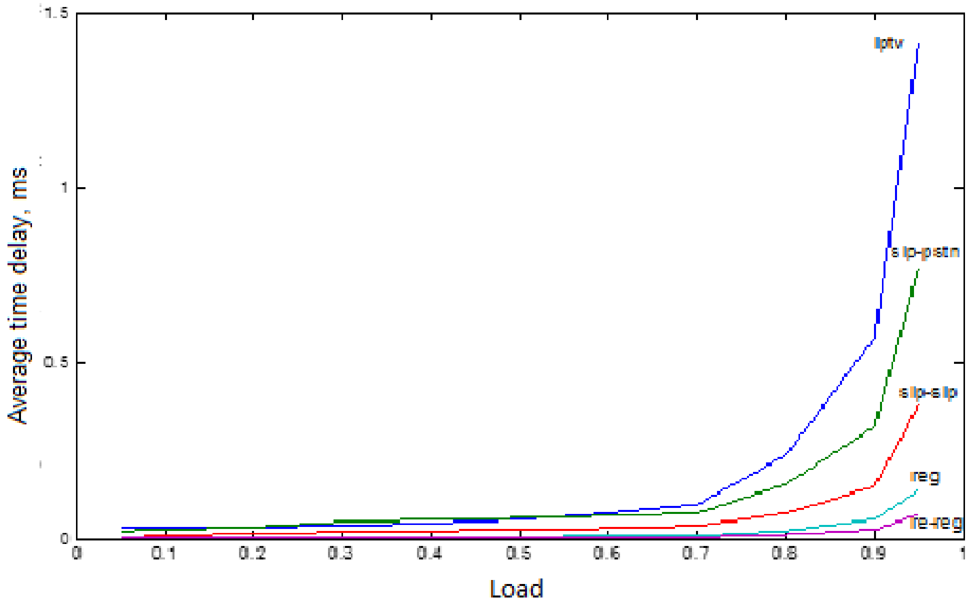

Figure 4 - Graph of the average delay time of requests in IMS from load with optimal distribution of total computing resource.

IV. OPTIMAL PRIORITIZATION OF SERVICE REQUESTS IN FUNCTIONAL IMS SERVERS

In the theory of schedules, it is proved that a minimum of average response time (delay) is provided if the work (request servicing) is performed in increasing order of their complexity. Serving requests in order of increasing their complexity provides a shorter average delay time compared to the average delay time when servicing requests in the order they are received (FIFO). The planning algorithm based on the use of this rule is called the SJF algorithm (Shortest Job First, Shortest Job First) [18]. This position can be used to schedule the servicing of various requests in IMS servers.

Thus, in accordance with the SJF, service requests in the IMS must be performed in increasing order of their complexity. With an increase in the complexity of the request, the time of its servicing increases.

Let M enter the server with the simplest query flows with intensities $\lambda_1, \lambda_2, \dots, \lambda_M$ and the service time of the queries of each query flow has the expected value $b_1, b_2, \dots, b_M$. Each type i stream creates a server load $\rho_i = \lambda_i b_i$ ($\rho_i < 1$). The average waiting time for requests with priorities $k = 1,2, \dots, M$ is determined by the values [17,18]

ISSN: 2350-0328
International Journal of Advanced Research in Science, Engineering and Technology
Vol. 8, Issue 4 , April 2021

$$W_k = \frac{\sum_{i=1}^{n} \rho_i b_i (1+v_i{}^2)}{2(1-R_{k-1})(1-R_k)}\ , \qquad k = 1,2, \dots, M \qquad (11)$$

where: $R_{k-1} = \rho_1 + \rho_2 + \cdots + \rho_{k-1}$ $(R_{k-1} < 1)$ and $R_k = \rho_1 + \rho_2 + \cdots + \rho_k$ $(R_k < 1)$ - downloads created by streams $\lambda_1, \lambda_2, \dots, \lambda_{k-1}$ and $\lambda_1, \lambda_2, \dots, \lambda_k$.

The average delay time of requests with priorities k = 1,2, ..., M, is determined by the values

$$\bar{T}_{zk} = W_k + b_k, \qquad k = 1,2, \dots, M \qquad (12)$$

The total average delay time of all requests is determined as

$$\bar{T}_z = \frac{\sum_{k=1}^{M} \bar{T}_{zk}}{M} \qquad (13)$$

A measure of the complexity can be the number of calls to functional IMS servers when servicing requests. The complexity of the various classes of queries are shown in table 2 [19].

table 2

Query complexity

№	Request Classes	Complexity
1	Re-registration (rereg)	9
2	Registration (reg)	18
3	Establishing a sip-sip connection	45
4	Establishing a sip-pstn connection	66
5	Service Delivery (iptv)	16

The distribution of priorities between request classes during their servicing in IMS functional servers is given in Table 3 [20].

Table 3

Request Service Prioritization

Functional IMS Servers	Request Classes				
	SIP-SIP	SIP-PSTN	reg	re-reg	IPTV
P-CSCF	4	2	3	5	1
I-CSCF			1	2	
HSS	1		2	3	
S-CSCF	5	2	3	4	1
AS	3	2			1
BGCF		1			
MGCF		1			
MCF					1

Based on formulas (11-13), we obtained graphs of the dependence of the total average request delay time on load (see Figure 5).

ISSN: 2350-0328
International Journal of Advanced Research in Science, Engineering and Technology
Vol. 8, Issue 4 , April 2021

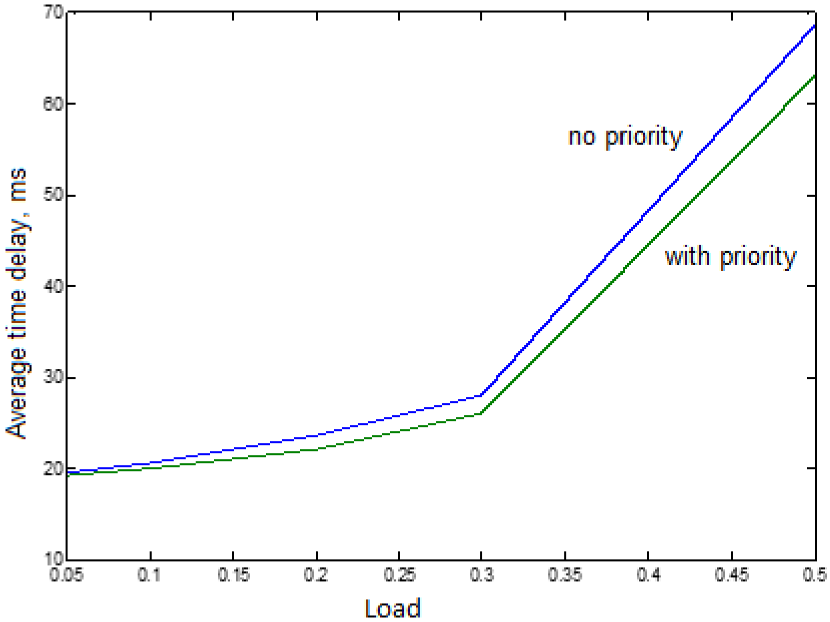

Figure 5 - A graph of the dependence of the total average time delay of requests on the load with a priority and priority discipline of service.

Figure 5 shows that the priority discipline of servicing requests in increasing order of their complexity reduces the overall average latency of requests to 1.2 times compared with the priority discipline of service.

V. CONCLUSION

Based on the results of the study, the following conclusions are formulated:

- when servicing requests, each IMS functional server participates more than once, this causes an increase in the intensity of requests to functional servers; this increase was taken into account in the construction of a generalized model;
- when servicing a request to establish an IMS-IMS connection, during which a stream arrives at the S-CSCF with an intensity of 45 greater than the initial one;
- to increase the efficiency of IMS functioning, the optimal values of the speed of functional servers were determined;
- an approach is proposed for the optimal distribution of priorities for servicing requests in functional IMS servers.

REFERENCES

1. Goldshteyn B.S., Zarubin, Samorezov V.V. Protokol SIP: Spravochnik. - SPb.: BXV-Peterburg, 2014. – 456 s.
2. A. Vemuri, J. Peterson. Session Initiation Protocol for Telephones (SIP-T): Context and Architectures // RFC 3372. IETF. - September, 2002.
3. Abhayawardhana V.S., Baddage R.A. Traffic Model for the IP Multimedia Subsystem (IMS). // IEEE Vehicular Technology Conference, 2007. VTC2007, 22-25 April 2007.-P.783-787.
4. Samuylov K.Ye., Sopin E.S., Chukarin A.V. Otsenka xarakteristik signalnogo trafika v seti svyazi na baze podsistemы IMS //T-Comm – 2010, №7, s.8-13.
5. Samuylov K.Ye., Abaev P.O., Gaydamaka Yu.V. i dr. Analiticheskie i imitatsionnыe modeli dlya otsenki pokazateley funksionirovaniya SIP serverov v usloviyax peregruzok // T-Comm - 2014,№8, s.83-88.
6. Gurbani V., Hilt V., Schulzrinne H. Session Initiation Protocol (SIP) Overload Control // draft-ietf-soc-overload-control-14.-2013.
7. Inichkin A.S. «Modelirovanie protsedurы registratsii abonenta v seti IMS». //Sbornik dokladov Respublikanskoy nauchno-texnicheskoy konferensii «Problemы informatsionnыx i telekommunikatsionnыx texnologiy» 10-11 mart 2016, s. 45-46.
8. Nurmatova S.B. Analiticheskoe modelirovanie protsedurы pereregistratsii v IMS. Jurnal «Potomki Muxammeda Al-Xorezmi», Tashkent -2017 g. № 2(2) -s.13-18.
9. Gamil Abdullax. Otsenka veroyatnosno-vremennыx xarakteristik signalnogo trafika v NGN na baze IMS. «Informatsionnыe seti i sistemы» s.60-65.
10. Samuylov K.Ye., Luzgachev M.V., Plaksina O.N. Razrabotka veroyatnostnoy modeli dlya analiza pokazateley kachestva protokola initsiirovaniya seansov svyazi. Vestnik RUDN. Seriya Matematika. Informatika. Fizika. №3-4. 2007. S. 53-63.

ISSN: 2350-0328
International Journal of Advanced Research in Science, Engineering and Technology
Vol. 8, Issue 4 , April 2021

11. Pshenichnikov A.P., Ali Raad A.M. Otsenka vremeni ustanovleniya soedineniy pri predostavlenii uslug IPTV s ispolzovaniем platformы IMS//T-Comm - Telekommunikatsiya i transport, 2013, №7. -s. 99-101.
12. Mikoczy E., Sivchenko D., Bangan X., Moreno J.I. IPTV Services over IMS: Architecture and Standardization, IEEE Communication Magazine, May 2008, P.128-135.
13. Gaydamaka Yu.V., Zaripova E.R. Otsenka vremeni ustanovleniya soedineniya dlya uslugi IPTV. Vestnik RUDN. Seriya Matematika. Informatika. Fizika. №1. 2014. S. 23-29.
14. Open, Closed, and Mixed Networks of Gueues with Different Classes of Customers / F.Baskett, K.M. Chandy, R.R. Muntz, F.G. Palacios // Jornal of the ACM.- 1975.- Vol. 22, No 2.- Pp. 248-260.
15. 3GPP: Digital celluar telecommunications system (Pnase 2+); Universal Mobile Telecommunication System (UMTS); LTE; IP Multimedia Subsystem (IMS); Stage 2; TS 23.228 version 11.6.0 Release 11.2012.
16. ITU-T Technical Report TRQ.2815 / Q.Sup45 (2003): "Requirements for interworking BICC/ISUP network with originating/destination networks based on Session Initiation Protocol and Session Description Protocol".
17. Kleynrok L. Teoriya massovogo obslujivaniya. Per. s angl. M.: Mashinostroenie, 1979.- 432 s.
18. Osnovы teorii vычislitelnых sistem. Pod red. S.A. Mayorova. M.: «Vыssh. Shkola», 1978,- 408 s.
19. Amirsaidov U.B. Metod raspredeleniya potokov v oblachnых IMS. Trudы Severo-Kavkazkogo filiala Moskovskogo texnicheskogo universiteta svyazi i informatizatsii. Rostov-na-Donu- 2017 g. - S.33-42.
20. Amirsaidov U.B. Prioritetnoe obslujivanie zaprosov na ustanovleniya soedineniya v seti IMS. Respublikanskaya nauchno-texnicheskaya konferensiya «Znachenie informatsionno-kommunikatsionnых texnologiy v innovatsionnom razvitii realnых otrasley ekonomiki». Chast 3. 6-7 aprel. Tashkent – 2017 g. - S.263-265.

AUTHOR'S BIOGRAPHY

Nurmatova Sevara Born in 1977, I work as a senior lecturer at the Tashkent University of Information Technologies. I am working on a scientific dissertation on the topic "Models and methods of increasing the efficiency of the IMS telecommunication network subsystem"