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QoS Analysis in IMS Network

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Introduction

While requirements of telecommunication services users are changing and technologies are developing, a convergence of different networks is recently noticed. Consumers want to get multimedia services on real time and at any accessible device - phone, computer or other device. These needs are already satisfied the latest telecommunications technology - the IP multimedia subsystem IMS.

IMS is basically a network architecture consisting of an IP-based core network connected to multiple access networks to provide a converged service to wired and wireless subscribers [1]. By courtesy of a flexible architecture, the IMS allows easily develop the existing networks - new services are being introduced simply and quickly by reducing their development and operation costs, using packet transmission in the transport layer.

Since the development of telecommunications is evolutionary process, transition from circuit switching to packet switching networks will be sufficiently long, therefore, in the transition period is necessary to ensure IMS interoperability with existing previous-generation networks such as PSTN, PLMN, using the principle of circuit switching. For IMS interoperability with different technology networks, there are network‘s gateways [4], combining the relevant flows. When real-time services are transmiting through the consentaneous devices - gateways, it is important to know what delay there is getting. This affects the quality of real-time services. There are many scientific articles of quality characteristics evaluation in telecomunication networks [2, 5, 6]. Not only user's information transfer, but also connection compose are important for real time services. Therefore, there are two directions in the research works - one for the signaling flows analysis [3, 5], and other - for the user's data flows analysis [2]. Given that last-mentioned is significantly less, this analysis focused in this direction. Qualitative analysis of the service flows of different users groups, distributed into two fixed access networks (PSTN, ADSL2+) is carried out in this work. The aim is to assess average service time dependence on utilization rate in the system also on dispersion.

IMS architecture

The IMS is originally designed by 3GPP (3rd Generation Partnership Project) and later updated by 3GPP, 3GPP2 and TISPAN (Telecoms & Internet converged Services & Protocols for Advanced Networks) [7]. At the beginning, IMS was designed for mobile networks. Starting with the sixth version, interaction with circuit switching networks, other IP networks and with diferent access technologies was realized.

IMS is a network architecture, which effectively is using the principles of next-generation networks with SIP (Session Initiation Protocol) protocol. IMS network has its own features. It is not a separate network but only the functions summation, whitch the system must support. The IMS core network is defined as a layered network (Fig. 1). It consists of:

- Media Transport Layer;
- Control Layer;
- Service or application Layer.

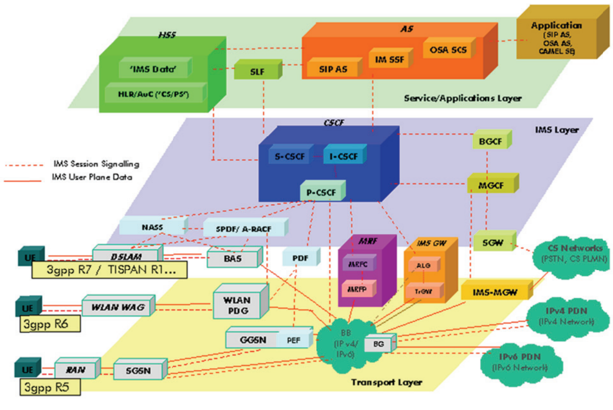

Fig. 1. IMS architecture [2]

Transport layer is responsible for the network access. It allows different IMS devices and user equipments connect to the IMS network. Also there is information transport in this layer. In the control layer there are various control functions (CSCFs) of call session. These two layers provide an integrated and standardized network platform to let the service providers offer various multimedia services in the service layer. Application servers provide the interface with the control layers using the SIP protocol [1].

The IMS network is independent from access technology type, however this analysis is performed in fixed access users group, where multimedia communication services are used. Due to the IMS interoperability with old circuit switching networks the PSTN network was selected. Due to the high popularity and prevalence the ADSL2 + network was selected. Users are divided into two groups by using services - one part of the consumers are using only telephony (PSTN), the other part - all services: voice, data and video providing of one and the same access (ADSL2 +). For the evaluating of access specification, in both networks there are accepted the same number of users (5000).

Interaction of different groups of users with IMS network is carried out via the respective functional blocks. According to Fig. 1., the users access of PSTN network is ensuring through MGW (Media Gateway), whitch belongs to the transport layer. Meanwhile, users of ADSL2+ network are connected to IMS via the DSLAM (Digital Subscriber Line Access Multiplexer) and the BAS (Broadband Access Switch) blocks. As this research focus on these functional blocks, a brief their description is giving below.

The MGW interfaces the media plane of the PSTN or CS network. On one side the MGW is able to send and receive IMS media over the Real-Time Transport Protocol (RTP). On the other side the MGW uses one or more PCM (Pulse Code Modulation) time slots to connect to the CS network. In addition, the MGW performs transcoding when the IMS terminal does not support the codec used by the CS side [8].

The IP *DSLAMs* are letting operators offer both DSL access and traditional two-wire POTS connections using a SIP client in the DSLAM [9].

The *BAS* routes traffic to and from DSLAM. It sits at the core of an IMS network, and aggregates user sessions from the access network. There can be injected policy management and IP Quality of Service (QoS).

The aim of this analysis is to find out what delay is bring in, when users use different services and different access.

The quality indicators of generated flows service in PSTN network's users group

After the analysis of voice information generated flows (when load intensity Y, allowable losses P and required throughput for one communication session B are evaluated), finded out that one type (voice) flow with intensity λ_{PSTN_MGW} = f(Y, P, B) = 11550 pps arrives to MGW, which connects PSTN network with IP.

To ensure stabile work of the system, it is necessary that its utilization do not exceed 50%, i. e. $\rho = 0{,}5$.

Then, according to (1) formula, departure rate is

$$\mu = \frac{\lambda}{\rho} = 23100 \text{ pps}, \tag{1}$$

where ρ – system utilization rate (traffic intensity); λ – arrival rate; μ - departure rate (service rate).

To service this traffic of packets, required packets transfer rate is

$$B = \mu * L_{packet} * 8, \text{ bps}, \tag{2}$$

where B – packets transfer rate; L_{packet} - the total size of packet of voice information. In Ethernet network, when headers of necessary protocols are calculated, L_{packet} equals 238 bytes.

According to formula (2) is getting that B = 44 Mbps. In order to transfer this flow, Fast Ethernet technology, providing up to 100 Mbps speed is necessary.

For this case calculated μ and ρ. Getting that μ = B/(L_{packet} *8) = 52521 pps, ρ = 0,22.

Assuming that the inter-arrival times and service times are exponentially distributed, for analysis of traffic service M/M/1 model can be used. Gateway of voice traffic has large memory enough, so it can be say that buffer size is infinite.

According to Little's formula, application‘s average being time in the system $\bar{T}_S$, wich consist of waiting time in the system and service time, is defined as follows

$$\bar{T}_S = \frac{1}{\mu - \lambda}. \tag{3}$$

Under such conditions $\bar{T}_S$ equals 2,4 *10[-5] s, when Fast Ethernet technology is used.

Realistically system's load can vary for different number of users and their intensity of using services. Therefore $\bar{T}_S$ dependence on system utilization rate ρ is ascertaining (Fig. 2).

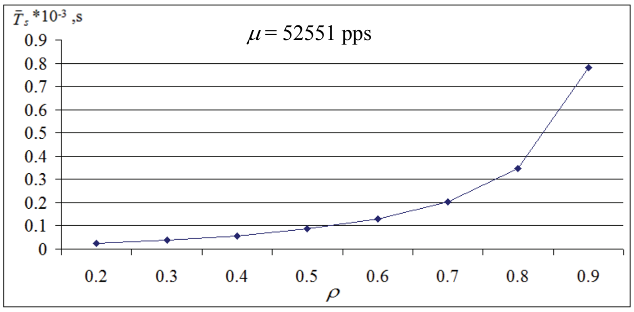

Fig. 2. $\bar{T}_S$ dependence on ρ in PSTN user‘s group

System utilization rate is a measure of the congestion of the system. When it is low (near to zero) - there is very little queuing and in general as system utilization rate increases (to near 1) - the amount of queuing increases. In this case, by utilizing a half capability of the system, ($\rho = 0{,}5$), delay ($\bar{T}_S$) equals 0,087 ms. Considering that the delay does not exceed recommendable 5 ms value in the access, ρ must be ≤ 0,98.

The quality indicators of generated flows service in xDSL network's users group

The calculations are performed using the distributed structure of the devices. 29 blocks of separate DSLAM and BAS there are used. In this case, a lower throughput is required, than using cascade structure, where high throughput not always can be realized.

Three types of flows (voice, data and IPTV) come to the BAS block, which connects DSLAM with IP. With the number of admitted users, getting that:

- Intensity of voice packets - $\lambda_{DSLAM\_BAS\_voice}$ = 1300 pps;
- Intensity of data packets - $\lambda_{DSLAM\_BAS\_PC} = 27709$ pps;
- Intensity of IPTV packets - $\lambda_{DSLAM\_BAS\_IPTV}$ = 2850 pps.

Then the common flow of packets $\lambda_{\Sigma BAS}$

$$\lambda_{\Sigma BAS} = \lambda_{DSLAM\_BAS\_voice} + \lambda_{DSLAM\_BAS\_PC} + + \lambda_{DSLAM\_BAS\_IPTV} = 31859 \text{ pps}, \quad (4)$$

There is probability, that particular service packets will arrive in to the service system

$$P_{service} = \frac{\lambda_{service}}{\lambda_{\Sigma BAS}}. \quad (5)$$

Probabilities of voice, data and video services arrival to the system, presented in Table 1.

Table 1. Values of the services probabilities

Probability	P_v	P_{PC}	P_{IPTV}
Value	0,041	0,87	0,089

When headers of required protocols are calculated in Ethernet network, sizes of services packets are:

- Voice - $L_v = 238$ bytes;
- Data - $L_{PC} = 700$ bytes;
- IPTV - $L_{IPTV} = 1394$ bytes.

Average size of packet, arrived in to the service system $\bar{L}_{pak} = P_v * L_v + P_{PC} * L_{PC} + P_{IPTV} * L_{IPTV} = 743{,}2$ bytes.

Assuming that ρ = 0,5 then departure rate μ = 63718 pps. For this case, required packets transfer rate is B = 379 Mbps. In order to transfer this flow, Gigabit Ethernet technology is necessary, providing up to 1000 Mbps speed.

Recalculated departure rate μ = 168192 pps and system utilization ρ = 0,2.

As in the previous case, assuming, that the inter-arrival times and service times are exponentially distributed, M/M/1 model can be used. Then application's average being time in the system $\bar{T}_S$ equals 7,34 *10^{-6} s. $\bar{T}_S$ dependence on ρ presented in Fig. 3.

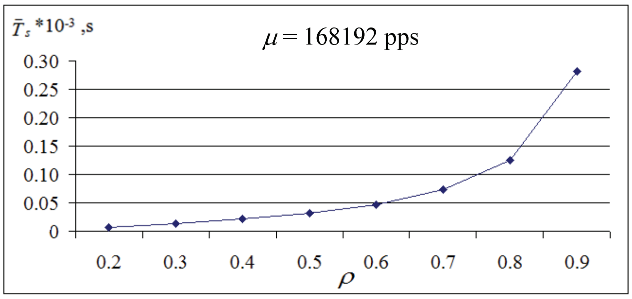

Fig. 3. $\bar{T}_S$ dependence on ρ in ADSL2+ user's group, when exponential distribution is used

Different types of flows, which service times are also different, arrive to the BAS block. Therefore it is appropriate to use M/G/1 model, where application's service time is general distributed. According this model, application's average being time in the system calculated by formula

$$\bar{T}_{sys} = \frac{1}{\mu} + \frac{\lambda * E[X^2]}{2*(1-\rho)}, \quad (6)$$

where $E[X^2]$- common second moment; ρ - system utilization rate (traffic intensity); λ - arrival rate, μ - departure rate (service rate).

For the case, which is mentioned above, the application's service time is exponentially distributed, $E[X^2]$ equals:

$$E[X^2] = 2/\mu^2 = 7{,}07 * 10^{-11}. \quad (7)$$

Under this condition, application's average being time in the system $\bar{T}_{sys}$ = 7,34 * 10^{-6} s.

Due to different flows service time there can be more dispersal, therefore ascertained $\bar{T}_{sys}$ dependence on $E[X^2]$, which presented in Fig. 4.

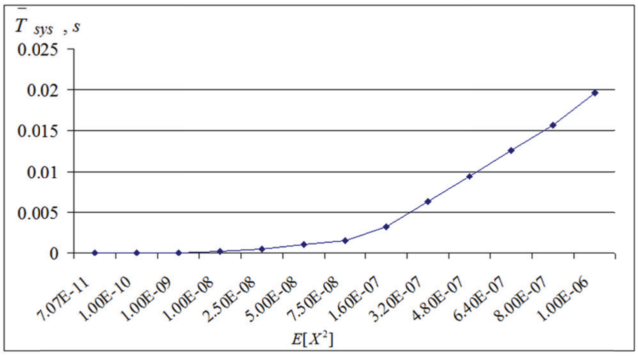

Fig. 4. $\bar{T}_{sys}$ dependence on $E[X^2]$ in ADSL2+ user's group

Assuming that $E[X^2]$ is fixed value, equals to 5*10^{-8}, then ascertained delay dependence on ρ (Fig. 5.).

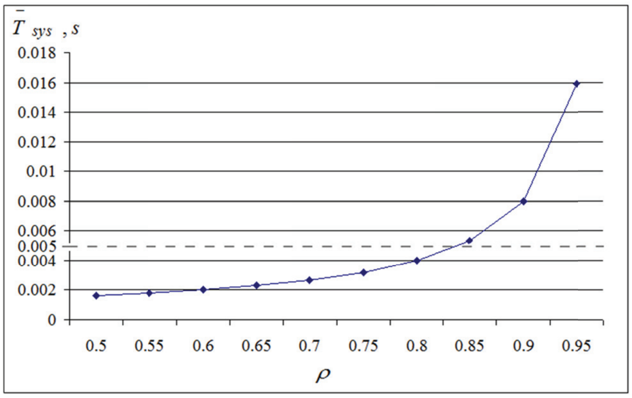

Fig. 5. $\bar{T}_{sys}$ dependence on ρ in ADSL2+ user's group, when common distribution is used

Dependence shows that increasing packet's service time dispersion in the system, delay increases too. When $\rho \le 0{,}84$, delay do not exceed 5 ms in the access. For this case, M/G/1 model let accurately assess the characteristics of the flow service.

Conclusions

1. In the PSTN access with an IP network to ensure voice information delay up to 5 ms, system's load must not exceed 0,98.
2. When different services are used in access networks interaction with IP network, it is better to use common distribution for packet's quality characteristics evaluation. This distribution better evaluates service time dispersal.
3. In the case when different services are used in the access with IP network, information's delay is up to 5 ms, when system's load do not exceed 0,84.

References

1. **Qadeer M. A., Khan A. H., Ansari J. A., Waheed S.** IMS Network Architekture // International Conference on Future Computer and Communication. – India, 2009. – P. 329–333.
2. **Kovacik T., Kotuliak I.** Traffic Characterization in IP Multimedia Subsystem. Systems, Signals and Image Processing // Proc. of 16th International Conference, 2009. – P. 1–4.
3. **Munir A., Gordon–Ross A**. SIP–Based IMS Signaling Analysis for WiMax–3G Interworking Architectures // IEEE Transactions on Mobile Computing, 2010. – Vol. 9. – No. 5. –P. 733–750.
4. **Susan A. White and Mark M. Clougherty**. PSTN Migration Using IMS // Bell Labs Technical Journal, 2008. – No. 13(1). – P. 199–220.
5. **Pranevičius H., Paulauskaitė–Tarasevičienė A., Jarutis A.** Simulation of protocol for initiation of communication sessions using dynPLA model // Electronics and Electrical Engineering. – Kaunas: Technologija, 2010. – No. 5(101). – P. 35–38.
6. **Jarutis A.** Investigation of signalling flow transfer processes based on SCTP protocol // Electronics and Electrical Engineering. – Kaunas: Technologija, 2011. – No. 2(108). – P. 35–38.
7. **Cruz R. S., Nunes M. S., Varatojo G., Reis L.** Push–To–Talk in IMS Mobile Enviroment // Fifth International Conference on Networking and Services. – Valencia, Spain, 2009. – P. 389–395.
8. **Camarilo G., García–Martín M. A.** The 3G IP Multimedia Subsystem (IMS). – John Wiley & Sons Ltd, 2008. – 618 p.
9. **Poikselka M., Mayer G.** The IMS: IP multimedia concepts and services, 3rd ed. – Great Britain: A John Wiley and Sons, Ltd., 2009. – 502 p.

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Fixed-mobile networks convergence and multimedia services supply at any device and any access are enabled in IMS technology. It is a network and layered architecture using packet transmission in the transport layer. For IMS interoperability with different technology networks, there are network gateways, which affects the quality of real-time services. Qualitative analysis of the service flows is carried out in this work. Also there is evaluating fixed access specification and packets service distributions. The delay dependence on utilization rate in the system also on service time dispersion there is assessing in this work. Ill. 5, bibl. 9, tabl. 1 (in English; abstracts in English and Lithuanian).

A. Jarutis, S. Šimkutė. IMS tinklo kokybinių charakteristikų tyrimas // Elektronika ir elektrotechnika. – Kaunas: Technologija, 2011. – Nr. 6(112). – P. 43–46.

Konverguoti įvairialypius tinklus ir bet kokiu įrenginiu per bet kokią prieigą IMS technologija įgalina teikti multimedijos paslaugas. Tai tinklinė daugelio lygmenų architektūra, transportiniame sluoksnyje naudojanti paketinį perdavimo principą. IMS sąveikai su skirtingų technologijų tinklais naudojami tinklų sietuvai, turintys įtakos realaus laiko paslaugų kokybei. Darbe atliekama kokybinė informacijos srautų aptarnavimo analizė, atsižvelgiant į fiksuotos prieigos specifiką bei paketų aptarnavimo skirstinius. Nustatoma vidutinės aptarnavimo trukmės sistemoje priklausomybė nuo sistemos išnaudojimo koeficiento bei aptarnavimo trukmės dispersijos. Il. 5, bibl. 9, lent. 1 (anglų kalba; santraukos anglų ir lietuvių k.).