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# Investigation of SIP Signaling Messages Servicing Time

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## Introduction

As a competitive alternative to traditional telephony is increasingly being used voice over internet protocol VoIP [1]. Although similar tract to transmit voice in case of VoIP than traditional voice telephony is not produced, but it is necessary to realize the conclusion of a communication session using the appropriate signaling protocol. While the end equipment manufacturers use many different protocols, but only a few of them are standardized and recognized by all equipment manufacturers. In the initial phase, the main communication protocol to establish connection has been used H.323 protocol [2], with both positive and negative features. Of the shortcomings that led to its limited use is caused by the complexity and by replacing it with Session Initiation Protocol SIP [2] and the increasing use of multimedia services over IP networks. SIP protocol is a major next-generation networks that use the IP Multimedia Subsystem IMS [3, 4].

In order to identify the characteristics of communication session, analytical [5] and simulation [6] methods are used. However, in both cases it is necessary to know the signaling message handling time statistical characteristics, including their distribution. Often in the theses are accepted, that application service time is distributed according to exponential distribution [5, 6]. At the telephone networks that use circuit switching principle handling exponential distribution is valid for the duration of the call [7], but the IP networks that use packet transfer, it may be wrong. In order to determine the appropriate use real experimental results must be used.

At time voice service is handled, signaling processing nodes accepts the different types of signaling messages and their processing length depends on the complexity of the process and the calculation of nodes resources (CPU, dynamic memory, internal bus) high-speed, productivity, etc.

This work provides statistical characteristics of experimental signaling alarm service servicing at nodes time, used to service voice services, investigations.

## Experimental

At time of individual experiments, using different productivity serving equipment with corresponding software installed, signaling messages service time were tested. Other units involved in the process of implementation of voice services, serve as the signaling messages generators, who generates in accordance with the service (basic voice connections, an intelligent service - free phone) to fulfill the necessary signaling messages and forward them to the respective unit. Adopt signaling messages sent to and served by the appropriate signaling message generator (Fig. 1).

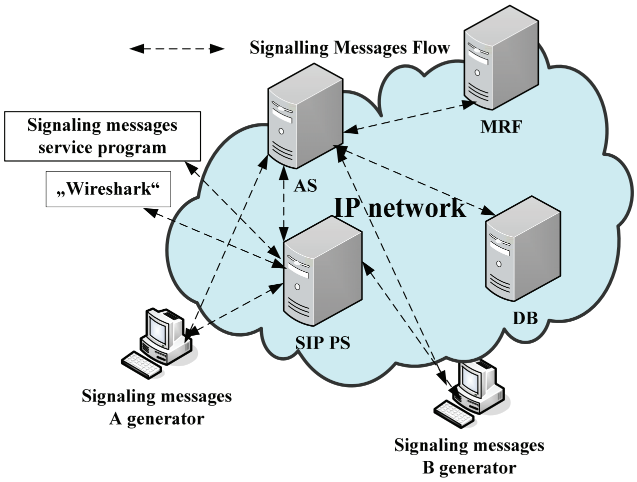


**Fig. 1.** Network scheme that was used during the experiment

Personal computers with installed program "SIPP" [8], generating signaling messages used to realize the generators of signaling messages. Signaling message handling unit is equipped with "Wireshark" [9] program which captures times of signaling message reception and dispatch at server network adapter.

The time interval between the moment $t_{k_{IN}}$, when the signaling message was adopted by server network adapter and the moment $t_{k_{OUT}}$, when he was sent over the network adapter, is a total length of signaling message service on the signaling node. It is the waiting time at unit $W_k$ and the signaling message processing time at communication service processor unit $T_k$ (Fig. 2).

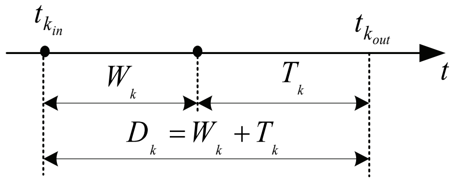


**Fig. 2.** Total signaling message handling time SM

When the signaling massages arrival intensity for a few hundred times smaller than the intensity of the signaling message servicing at server and the intervals between adjacent unit reports the appearance of the moments are constant, the signal message waiting time in buffer size is negligible ($W_k \to 0$) compared to the duration of the message serving time in the processor unit. In such cases, the time interval between the signaling message reception and dispatch can be considered as service time in processor unit ($T_k \approx D_k$).

Experiments were carried out with different characteristics of signaling units. Analyzing signaling message service times, the experiment were carried out in service stations, which have had signaling components software installed. The main characteristics of the servers provided in Table 1. This is done in order to determine whether the server components composition affects the signaling message distribution service times.

**Table 1.** The main characteristics of the server

| 1 | 2 |
|---|---|
| Processor Intel Pentium 4, RAM DDR2, 533 MHz, 1GB | Processor Dual-Core Intel Xeon X5272, 3,4Ghz, RAM DDR2, 667 MHz 4GB |

**Signaling messages servicing times of the SIP PS unit statistical analysis**

The first unit, which serves signaling messages from a VoIP terminal when the network using the SIP signaling protocol, is the SIP PS. This signaling node involved in servicing a number of voice services provided by a VoIP network.

Signaling message handling times and distributions determining the SIP service agent during the experiment station were installed software "OpenSER", which performs the SIP proxy server unit (SIP PS) functions.

"SIPP" generators in A and B personal computers, generating the SIP signaling messages by simulating a basic voice service connection. Within this service are generated the sequence of 6 SIP PS signaling messages ("INVITE", "180 RINGING", "200 OK", "ACK", "BYE", "200 OK (BYE after)). These messages sent by the SIP PS and the other voice services are initiated, such intelligent services.

Intensity of generating service calls is $\lambda_{BP} = 0{,}01$ calls/s. In this case, the general signaling messages flow entering the intensity into SIP PS is $\lambda_{7,j,1} = 0{,}06$ messages/s. If at the time of experiment, the average service times of the signaling message values will be not less than 10 times the time interval between the appearance of the moments of adjacent posts

$$(\Delta t_7 = \frac{1}{6 \cdot 0{,}01} > 10 \cdot T_{i,j,k,m}) \quad (1)$$

the experiment will be repeated at least ten times reduction in the intensity of the calls.

Experiments carried out after the 1000 base-voice connections to each server. There was collected each of the $N_{i,j,m} = 1000$ signal communication service $T_{i,j,k,m}$ values. Where *i* - the appearance of a SIP PS signaling message sequence number, servicing the call (INVITE - 1, 180 RINGING - 2, 200 OK - 3, ACK - 4, BYE - 5, 200 OK (BYE after) - 6), *j* - server number (Table 1), which carried out the experiment, *k* - the connection number, *m* - a signaling unit type number (SIP PS - 1, AS - 2, DB - 3, MRF-4).

As a result of the monitoring report of the results established for each service term average $\overline{T}_{i,j,m}$, standard deviation $\sigma(T_{i,j,m})$ and absolute error $\varepsilon_p(T_{i,j,m})$. The resulting values in Table 2. All determined signaling messages maximum length of service values is more than 100 times lower than those used in the experiment between the time interval of adjacent signal appearance in the SIP PS, so no need to repeat the experiment and can continue to receive the results of statistical analysis.

**Table 2.** Statistical characteristics of signaling messages servicing times

| Message | Ser-ver | $\overline{T}_{i,j,1}$, ms | $\sigma(T_{i,j,1})$, ms | $\varepsilon_{p,i,j,1}$ |
|---|---|---|---|---|
| INVITE | 1 | 18,64 | 0,179 | 0,03 |
| | 2 | 4,54 | 0,058 | 0,02 |
| RINGING | 1 | 16,1 | 0,161 | 0,03 |
| | 2 | 2,3 | 0,028 | 0,01 |
| 200 OK | 1 | 17,21 | 0,160 | 0,03 |
| | 2 | 2,27 | 0,028 | 0,01 |
| ACK | 1 | 20,4 | 0,2 | 0,04 |
| | 2 | 5,23 | 0,028 | 0,01 |
| BYE | 1 | 18,82 | 0,19 | 0,04 |
| | 2 | 4,83 | 0,028 | 0,01 |
| 200 OK (after BYE) | 1 | 16,5 | 0,15 | 0,03 |
| | 2 | 2,38 | 0,028 | 0,01 |
| General | 1 | 18,04 | 1,78 | 0,60 |
| | 2 | 3,59 | 1,29 | 2,58 |

Definable the *i*-th type of signaling message servicing time dependence of the relative error $\Delta(T_{i,j,m})$ of experimental data collected in the amount $N_{i,j,m}$ of confidence $p = 0{,}99$; *i*-th type the average length of applications servicing, using the $j$-th server, the absolute error value has following form

$$\varepsilon_p\left(T_{i,j,m}\right) = z_p \cdot \frac{\sigma\left(T_{i,j,m}\right)}{\sqrt{N_{i,j,m}}}. \quad (2)$$

$i$-th type of signaling messages servicing time, using the $j$-th server, with a relative uncertainty of

$$\Delta\left(T_{i,j,m}\right) = \frac{\varepsilon_{p,i,j,m}}{\overline{T}_{i,j,m}}. \quad (3)$$

Separate signaling message servicing time conclusion of the distributions of values were grouped into $l_{T_{i,j,1}} = 10$ bands, and general service times distribution, determine the interval $l_{T_{i,j,1}} = 13$. Values for each experimental group calculated by dividing the width $\Delta_{T_{i,j,m}}$ of the sample and the clustering step $d_{T_{i,j,m}}$. The probability that falls $T_{i,j,k,m}$ within the range $\left[a_{i,j,k,n}; b_{i,j,k,n}\right)$ has following form

$$P_{Eksper,i,j,m,n}\left(a_{i,j,m,n} \le T_{i,j,k,m} < b_{i,j,m,n}\right) = \frac{z_{i,j,m,n}}{N_{i,j,m}}, \quad (4)$$

where $z_{i,j,m,n} -$ $T_{i,j,k,m}$ mount of the value derived in the range of content.

The test is whether the experimental results obtained are not distributed according to normal or exponential distribution. To calculated the probability that the theoretical distribution of the sample value $T_{i,j,k,m}$ falls within the range $\left[a_{i,j,m,n}; b_{i,j,m,n}\right)$. Verified the hypothesis, the experimentally obtained distribution, corresponds to the theoretical distribution.

The normal distribution of probabilities that there $T_{i,j,k,m}$ is a range $\left[a_{i,j,m,n}; b_{i,j,m,n}\right)$ has following form

$$P_{Normal,i,j,m}\left(a_{i,j,m,n} \le T_{i,j,k,m} < b_{i,j,m,n}\right) = \frac{1}{\sigma_{i,j,m}\sqrt{2\pi}} \int_a^b e^{-\frac{\left(T_{i,j,k,m} - \overline{T}_{i,j,m}\right)^2}{2\sigma_{i,j,m}^2}} dT_{i,j,k,m}. \quad (5)$$

Exponential distribution of probabilities, that $T_{i,j,k,m}$ the range $\left[a_{i,j,m,n}, b_{i.j,m,n}\right)$ is

$$P_{Ekspo,i,j,m}\left(a_{i,j,m,n} \le T_{i,j,k,m} < b_{i,j,m,n}\right) = \frac{1}{\overline{T}_{i,j,1}} \int_a^b e^{-\frac{T_{i,j,k,m}}{\overline{T}_{i,j,m}}} dT_{i,j,k,m}. \quad (6)$$

The calculation results are presented in Fig. 3 and Fig. 4.

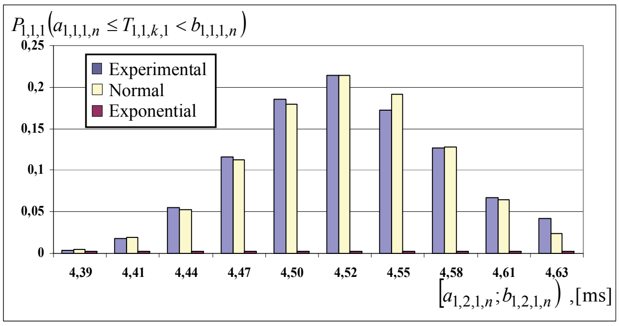


**Fig. 3.** The probability histogram of INVITE message servicing time in SIP PS processor when the second server is used

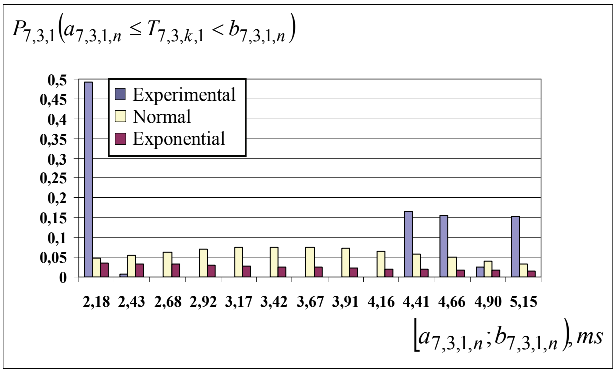


**Fig. 4.** The probability histogram of all type messages service time in SIP PS processor when the second server is used

Experimentally obtained and theoretical distributions is identified in the hypothesis $H_{0,i,j,m}$:

- Experimental data are distributed according to exponential distribution;
- Experimental data are distributed according to normal distribution;

checked, using the $\chi^2$ criteria. The results of calculation are presented in Table 3.

**Table 3.** Hypothesis testing results

| $i$ | $j$ | **Compared distributions** | $X_{i,j,1}^2$ | $\chi_p^2(v)$ | $H_{0,i,j,1}$ |
|---|---|---|---|---|---|
| 1 | 1 | Exper- Normal | 41,19 | 2,17 | False |
| | 2 | Exper- Expon | 75706 | 2,17 | False |
| 7 | 1 | Exper- Normal | 12830 | 3,94 | False |
| | 2 | Exper- Expon | 107839 | 3,94 | False |

According to the results obtained by counting all hypotheses $H_{0,i,j,m}$ must be rejected, because inequality is not satisfied $X_{i,j,m}^2 < \chi_p^2(v)$. Considering the results obtained, analytical models is appropriate to the application service times of the hypotheses considered the "General".

## Signaling messages servicing times of the AS, DB and MRF nodes statistical analysis

The examination of the Applications Server (AS) node with installed software applications "WebLogic" [10], studying the Media Resource Function (MRF) node, media resource function software "Voxpilot" [11].

Database server installed on the realization of the MySQL database.

AS, MRF and DB nodes tested generating signaling messages, simulating the “Short number” and the “Personal assistant” service execution. Each signaling service unit provided only sent to him by the service execution algorithm for signaling messages.

The conclusion of the AS, DB, MRF nodes messages servicing times of the histograms showed that, like the in the SIP PS signaling messages tested, distributed according to length of service distribution close to normal. However, examination of the hypothesis that the experimental data obtained at the AS, DB, MRF nodes are distributed according to exponential or normal distribution, using $\chi^2$ the criteria were rejected as unsatisfactory $X_n^2 < \chi_p^2(v)$ conditions.

## Conclusions

It was determined that service times of signaling messages in SIP PS, AS, MRF, DB processors are distributed not accordingly to mostly used theoretical model exponential distribution but according to distribution that is similar to normal.

Total signaling message distribution services are similar to the one known theoretical distribution. It describes only the average and variance of the distribution.

Signaling nodes of analytical models for appropriate use of analytical models of queuing systems with service time distribution is described by the general average and dispersion.

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**A. Jarutis, R. Gedmantas, V. Grimaila. Investigation of SIP Signaling Messages Servicing Time // Electronics and Electrical Engineering. – Kaunas: Technologija, 2011. – No. 8(114). – P. 35–38.**

SIP is most widely used signaling protocol in IP telephony for communication sessions conclusion. At time of providing voice services, this communications protocol messages fall to specialized network nodes. Service quality depends on their serving at nodes. To assess the temporal characteristics of services, it is necessary to know the signaling message average handling times values of possible deviations of distribution. In this work experimentally were determined statistical handling time characteristics of individual messages and total message flow traffic entering the SIP, PS, AS and DB MRF nodes. It was found that the service times of messages in the form of their distribution are close to normal. However, the hypothesis that the experimentally obtained distribution is normal was rejected by the $\chi^2$ criterion of verification. Therefore in the SIP signaling components analytical studies is proposed to use a general distribution. Ill. 4, bibl. 11, tabl. 3 (in English; abstracts in English and Lithuanian).



**A. Jarutis, R. Gedmantas, V. Grimaila. SIP signalinių pranešimų aptarnavimo trukmių tyrimas // Elektronika ir elektrotechnika. – Kaunas: Technologija, 2011. – Nr. 8(114). – P. 35–38.**

SIP yra plačiausiai naudojamas IP telefonijos signalizacijos protokolas, skirtas ryšio seansams sudaryti. Teikiant balso paslaugas, šio protokolo pranešimai patenka į specializuotus tinklo mazgus. Nuo jų aptarnavimo mazguose priklauso teikiamų paslaugų kokybė. Siekiant įvertinti paslaugų laikines charakteristikas, būtina žinoti signalinių pranešimų aptarnavimo trukmių vidutines vertes, jų galimus nuokrypius, skirstinį. Darbe eksperimentiškai nustatytos pavienių pranešimų bei suminio pranešimų srauto, patenkančio į SIP PS, AS DB ir MRF mazgus, aptarnavimo trukmės statistinės charakteristikos. Nustatyta, kad pranešimų aptarnavimo trukmių skirstinys savo forma artimas normaliniam. Tačiau patikrinus pagal $\chi^2$ kriterijų hipotezė, kad eksperimentais gautas skirstinys yra normalinis, buvo atmesta. Todėl analitiniuose SIP signalizacijos mazgų tyrimuose siūloma naudoti bendrąjį skirstinį. Il. 4, bibl. 11, lent. 3 (anglų kalba; santraukos anglų ir lietuvių k.).