Determination of More Realistic Target 95% Values of Post Selection Delay in Modern Telephone Networks

Vladimir MATIĆ, Aleksandar LEBL, Dragan MITIĆ, Žarko MARKOV

IRITEL AD Beograd, Batajnički put 23, 11080 Beograd, Serbia

vmatic@iritel.com, lebl@iritel.com, mita@iritel.com, zarko.markov@iritel.com

Abstract. *In this paper we present the telephone network and the recommendations, dealing with the greatest target values of Post Selection Delay. It is shown that the Post Selection Delay is the sum of the delays between the network nodes and that it has the smaller dispersion than the one, recommended as the greatest in the recommendations.*

Keywords

Telephone network, Post Selection Delay, probability distribution.

1. Introduction

Besides the quality of speech signal, the telephone network response time is the main indicator of the service quality (QoS). The telephone network response time is expressed by the time needed for some phases of telephone connection set-up and disconnect. Post Selection Delay (PSD, or Post Dialing Delay) is the key indicator of connection set-up response time because of two reasons. This phase is longer than other phases and it is the most important part of the process of connection set-up. The greatest values for the duration of this phase are suggested in [1]. Although they are derived for ISDN network, the values from [1] are also suggested in mixed, [2] and packet network, [3]. In this paper we introduce different view on the values of PSD, suggested in [1].

2. Post Selection Delay in Engineering Practice

PSD is defined for *overlap* and *en bloc* signaling as the time from the moment, when the complete address information about the called subscriber is sent to the network till the moment, when the answer is received from the network. This time is variable according to the network state, i.e. it depends on the traffic load of network nodes and links. It is clear that, because of the random nature of traffic process, PSD is also the random variable, which has its (unknown) distribution of duration probability.

As usual, PSD is in recommendations limited by two values. The first one is the greatest recommended mean value, t_{mm}, and the second one is longest time while the network answer is received in 95% cases, t_{95}. The recommendations are defined for local, transit and international connections. In [1] it is pointed out that $t_{mm} \leq 3$ s, 5 s and 8 s, and $t_{95} \leq 6$ s, 8 s and 11 s for local, transit and international connections (respectively) and normal traffic load (load A). For the high load (load B) these values are $t_{mm} \leq 4.5$ s, 7.5 s and 12 s, and $t_{95} \leq 9$ s, 12 s and 16.5 s for local, transit and international connections. In [1] it is indicated that typical local, transit and international connection passes through 1-4, 5-7 and 8-10 network nodes, respectively. It can be noticed that the ratio between the greatest recommended values t_{95} and t_{mm} is $t_{95}/t_{mm} = 2$ (local connections), $t_{95}/t_{mm} = 1.6$ (transit connections) and $t_{95}/t_{mm} = 1.375$ (international connections).

3. PSD Segments

Mathematically considered, PSD is the sum of time intervals necessary to transfer the messages between adjacent network nodes, along the whole connection. The limiting values of the message transmission time between the adjacent nodes in ISDN network are presented in [4] and [5]. Message processing and transmission between two adjacent network nodes is, also, called subcall, call phase or call segment, [6]. In [4] the time needed for message transferring on subscriber ISDN lines is determined, and in [5] the time needed for signaling CCS No7 network is specified.

The designation t_{mm1} presents the longest mean time of message transferring between two network nodes, i.e. on one section. The designation ${}_1t_{95}$ presents the longest time for transferring 95% messages on one section.

The recommendations for some of the longest time intervals are presented in [4]:

Section 2.3.2.3 Local exchange call request delay, (load A: t_{mm1}= 600 ms, ${}_1t_{95}$= 800 ms; load B: t_{mm1}= 900 ms, ${}_1t_{95}$= 1200 ms)

Section 2.3.3.2.3 Exchange call set-up delay for originating outgoing traffic connections, (load A:

t_{mm1} = 600 ms, $_1t_{95}$ = 800 ms; load B: t_{mm1} = 800 ms, $_1t_{95}$ = 1200 ms)

Section 2.4.3.1 Call set up delay (load A: t_{mm1} = 400 ms, $_1t_{95}$ = 600 ms; load B: t_{mm1} = 600 ms, $_1t_{95}$ = 1000 ms)

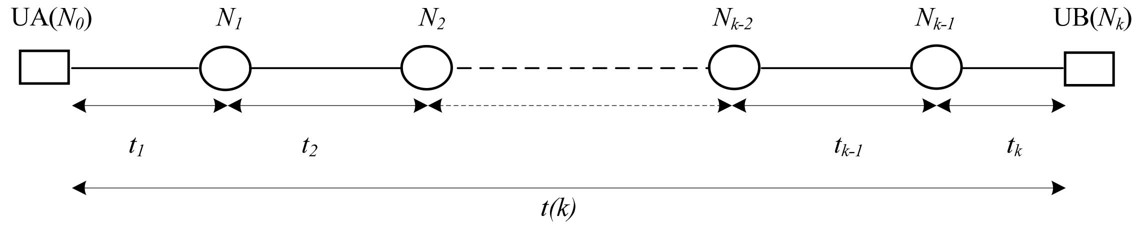
Section 2.4.5 Incoming call indication sending delay (load A: t_{mm1} = 400 ms, $_1t_{95}$ = 600 ms; load B: t_{mm1} = 600 ms, $_1t_{95}$ = 1000 ms)

which recommend that the longest allowed mean time, t_{mm1}, for the activity of one section and one network node is 600 ms (for load A) and 800 ms (for load B). The longest time, while the activity will be performed on one section for 95% connections, $_1t_{95}$, is 800 ms (load A) and 1200 ms (load B). We can notice that the ratio between $_1t_{95}$ and t_{mm1} is $1.25 \leq {_1t_{95}}/t_{mm1} \leq 1.33$ for load A and $1.33 \leq {_1t_{95}}/t_{mm1} \leq 1.66$ for load B.

In [5], for the cross-office transfer time of signaling CCS No7 messages in the case of normal traffic load and complex messages is recommended that the longest mean time is 180 ms and that the longest time, while 95% of signals are transferred, is 360 ms. In these conditions, in the case of complex message content – processing intensive and 30% increased load, it is specified that the longest mean time is 450 ms and the longest time while 95% of signals are transferred is 900 ms. We can notice that here $_1t_{95}/t_{mm1} = 2$.

4. Post Selection Delay as the Random Variable

Let us consider connection set-up in the telephone network, Fig. 1. The connection path consists of k sections.



UA user A (calling), UB user B (called)

Fig. 1. Connection set-up in the telephone network.

The time duration of address information transferring on the section i, i.e. between nodes N_{i-1} and N_i, is designated t_i, (i = 1,2,...,k). The time t_i is a random variable, which depends on traffic load of the node, link, and on the signaling message complexity. That's why the random variables t_i are mutually independent.

Probability density function of the duration t_i, $f(t_i)$, is unknown, but the mean value can be designated by μ_i and the dispersion by σ_i^2. For each random variable t_i the value t_{95i} exists, for which it is

$$\int_0^{t_{95i}} f(t_i) \cdot dt_i = 0.95 . \quad (1)$$

Let us consider now the random variable $t(k)$, which presents PSD. This value is, obviously, the sum of components, i.e. mutually independent random variables t_i, (i = 1,2,...,k). The distribution density of the random variable $t(k)$ can be designated by $f_k(t)$. For this value the mean value $\mu(k)$ and dispersion $\sigma^2(k)$ can be designated. The random variable $t(k)$ also has the value $t(k)_{95}$, for which it is:

$$\int_0^{t(k)_{95}} f_k(t) \cdot dt = 0.95 . \quad (2)$$

It is known that the mean value and the dispersion of the sum of independent random variables can be expressed by:

$$\mu(k) = \sum_{i=1}^{k} \mu_i \ , \quad \sigma^2(k) = \sum_{i=1}^{k} \sigma_i^2 \ . \quad (3)$$

If the independent random variables have also the same distribution, then it is $\mu_i = \mu$, $\sigma_i^2 = \sigma^2$, $t_{95i} = t_{95}$. It follows that $\mu(k) = k \cdot \mu$, $\sigma^2(k) = k \cdot \sigma^2$.

Let us consider the coefficient of variation (CV) as the measure of the dispersion of the random variable about the mean value. The coefficient of variation of the random variable $t(k)$, $CV(k)$, is:

$$CV(k) = \frac{\sigma(k)}{\mu(k)} = \frac{\sqrt{k} \cdot \sigma}{k \cdot \mu} < \frac{\sigma}{\mu} = CV(1) \ , \quad k > 1 \quad (4)$$

where $CV(1)$ is the coefficient of variation of the random variable t_i. As it is expected, the random variable, which is the sum of other random variables, has the lower relative dispersion. Considering this fact, we can conclude that also $\left[t(k)_{95} / \mu(k) \right] < t_{95} / \mu$. In this way, satisfaction of the criteria of the mean time for PSD in table 2/E.721, [1], represents the more stringent criteria than the satisfaction of the criteria for $t(k)_{95}$. Therefore, the more realistic values for t_{95} in table 2/E.721, [1], must be smaller. This fact will be more obvious from the following example.

Example: The relationship $1.375 \leq {_1t_{95}}/t_{mm1} \leq 2$ is supposed for the time duration of transferring information between two network nodes, i.e. on one section [4], [5].

The distribution, which satisfies this relationship in the best way, is the uniform distribution with density:

$$\begin{aligned} &f(t)=0 && t<0 \\ &f(t)=1/t_{\max} && 0\le t\le t_{\max} \\ &f(t)=0 && t_{\max}<t \end{aligned} \qquad (5)$$

This distribution has the following parameters: $\mu = t_{\max}/2$, $\sigma = t_{\max}/\sqrt{12}$, $t_{95} = 0.95\cdot t_{\max}$, $t_{95}/t_{mm} = t_{95}/\mu = 1.9$.

The random variable $t(k)$, which represents the sum of k uniformly distributed random variables (5), can be expressed by Irwin-Hall distribution, by setting $t_{\max} = 1$.

Fig. 2 presents the coefficient of variation $CV(k)=\sigma(k)/\mu(k)$ and the ratio $t(k)_{95}/\mu(k)$ for the Irwin-Hall distribution as the function of the number of sections, which are used for connection setup.

It can be said that, when the number of components constituting PSD increases, the relative dispersion of the sum and the ratio $t(k)_{95}/\mu(k)$ decreases. Let us note that the number of components (k) involves the number of sections when the messages are sent forward (e. g. SETUP, IAM (Initial Address Message), INVITE) and backward (e. g. ALERT, ACM (Address Complete Message), 180 RINGING), i.e. it is much greater than the one presented in Fig. 2. Therefore, the ratio $t(k)_{95}/\mu(k)$ for PSD, presented in [1] and [2], must be much less than the ratio $_1t_{95}/t_{mm1}$ for one section, suggested in [4] and [5].

5. Conclusion

Post Selection Delay is the sum of all delays in signaling messages transfer across the network from the calling to the called subscriber and vice versa. All delay intervals are random variables. That's why the relative variation of PSD, as the sum of components, is less than relative variation of each component. As a consequence, the greatest recommended mean time PSD, suggested in table 2/E.721, [1], appears as the more stringent criteria than the variation of the time interval PSD, expressed by the duration needed to receive the network answer for 95% of all calls. This means that, if the criterion of mean time is satisfied, the criterion t_{95} is also satisfied, but opposite is not valid. In order to equalize both criteria, the time interval needed to receive the network answer for 95% of calls must be decreased on more realistic values, which are less than the ones presented in table 2/E.721, [1]. Our proposal is that the ratio t_{95}/t_{mm} for greatest values of t_{95} and t_{mm} should be 1.6, 1.3 and 1.2 for local, transit and international connections, respectively, instead of 2, 1.6 and 1.375, as stated in [1].

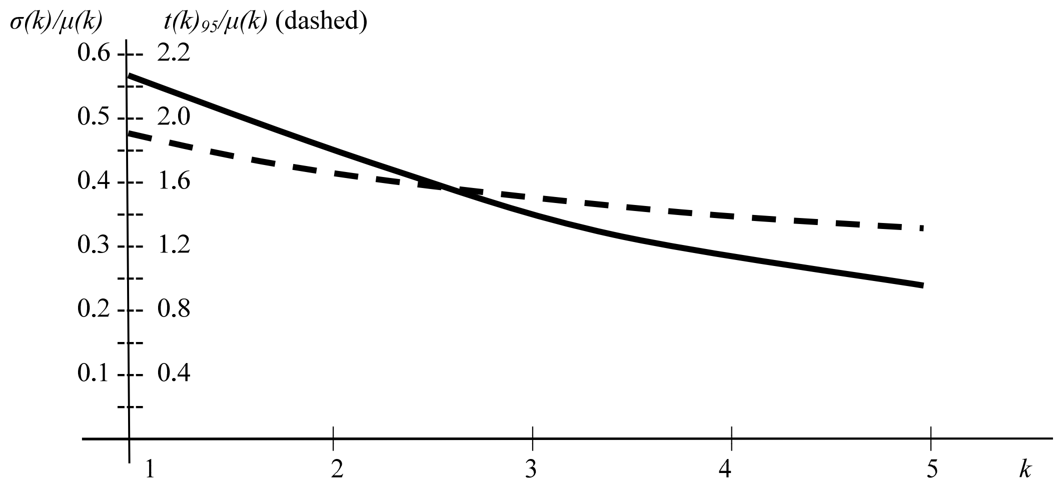


Fig. 2. Coefficient of variation CV(k) and ratio $t(k)_{95}/\mu(k)$ as the function of the number of sections for the sum of uniformly distributed variables.

References

[1] ITU-T. *Recommendation* E.721*: Network grade of service parameters and target values for circuit-switched services in the evolving ISDN.* May 1999.

[2] ITU-T. *Recommendation* E.671*: Post-selection delay in PSTN/ISDN networks using Internet telephony for a portion of the connection.* March 2000.

[3] ARJONA, A., WESTPHAL, C., YLÄ-JÄÄSKI, A., KRISTENSSON, M., MANNER, J. Towards high quality VoIP in 3G networks: an empirical approach. *Int. J. of Communications, Network and System Sciences,* 2008, no. 4, p. 350-361.

[4] ITU-T. *Recommendation* Q.543*: Digital exchange design objectives.* March 1993.

[5] ITU-T. *Recommendation* Q.725*: Signaling System No7 – signaling performance in the telephone application.* March 1993.

[6] LIN, H., SETH, T., BROSCIUS, A., HUITEMA, C. *VoIP Signaling Performance Requirements and Expectations, internet draft, IETF*, October 1999.

About Authors ...

Vladimir MATIĆ was born in Belgrade, Serbia, in 1963. He received his B.Sc. and M.Sc. from the Faculty of Electrical Engineering in Belgrade, Republic of Serbia, in 1989 and 1994, respectively. From 1996 he is employed in the

Radio communications Department of the Institute for Electronics and Telecommunications IRITEL in Belgrade, where now holds the position of project leader. He published 35 scientific papers in international and national journals and conferences and participated in realization of several scientific and research projects of the Ministry of Science and Technology of Republic of Serbia and Institute IRITEL.

Aleksandar LEBL was born in Zemun, Serbia, in 1957. He received his B.Sc. and M.Sc. from the Faculty of Electrical Engineering in Belgrade, Republic of Serbia, in 1981 and 1986, respectively, and his Ph.D. from the Faculty of Technical Science in Novi Sad, in 2009. From 1981 he is employed in the Switching Department of the Institute for Electronics and Telecommunications IRITEL in Belgrade. During years he worked on the project of Digital Switching System for Serbian Telecommunication Industry.

Dragan MITIĆ was born in Belgrade, Serbia, in 1953. He received his B.Sc. and M.Sc. from the Faculty of Electrical Engineering in Belgrade, Republic of Serbia, in 1977 and 1984, respectively, and his Ph.D. from the Faculty of Technical Science in Novi Sad, in 2002. Dr. Mitić is a scientific associate in IRITEL, Institute for Electronics and Telecommunications, Belgrade, Serbia. From 1977 until 1989 he was employed at the Land Forces Military Technical Institute in Belgrade, and since 1989 in IRITEL. Author or coauthor of more than 70 international and national scientific and professional papers. He works on several research projects for equipment of specific applications.

Žarko MARKOV was born in Žitište, Serbia, in 1946. He received his B.Sc., M.Sc. and Ph.D. from the Faculty of Electrical Engineering in Belgrade, Republic of Serbia, in 1969, 1975, and 1976, respectively. Dr Markov is a scientific counselor in IRITEL, Institute for Electronics and Telecommunications, Belgrade, Serbia. Area of work: Switching techniques, Teletraffic theory, Network signaling. Author or co-author of more than hundred papers and six books. At the University of Belgrade, School of Electrical Engineering, Dr. Markov was a professor at the course of Switching techniques and Network signaling.