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

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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 $t_{05}$ 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: $t_{mm1} = 600\ ms, t_{05} = 800\ ms$; load B: $t_{mm1} = 900\ ms, t_{05} = 1200\ ms$)

Section 2.3.3.2.3 Exchange call set-up delay for originating outgoing traffic connections, (load A:
\( t_{\text{mm}} = 600 \text{ ms}, \quad t_{\text{os}} = 800 \text{ ms}; \) load B: \( t_{\text{mm}} = 800 \text{ ms}, \quad t_{\text{os}} = 1200 \text{ ms} \)

Section 2.4.3.1 Call set up delay (load A: \( t_{\text{mm}} = 400 \text{ ms}, \quad t_{\text{os}} = 600 \text{ ms}; \) load B: \( t_{\text{mm}} = 600 \text{ ms}, \quad t_{\text{os}} = 1000 \text{ ms} \))

Section 2.4.5 Incoming call indication sending delay (load A: \( t_{\text{mm}} = 400 \text{ ms}, \quad t_{\text{os}} = 600 \text{ ms}; \) load B: \( t_{\text{mm}} = 600 \text{ ms}, \quad t_{\text{os}} = 1000 \text{ ms} \))

which recommend that the longest allowed mean time, \( t_{\text{mm}} \), 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, \( t_{\text{os}} \), is 800 ms (load A) and 1200 ms (load B). We can notice that the ratio between \( t_{\text{os}}/t_{\text{mm}} \) is 1.25 for load A and 1.25 for load B.

\[ 1.25 \leq t_{\text{os}}/t_{\text{mm}} \leq 1.33 \text{ for load A and } 1.33 \leq t_{\text{os}}/t_{\text{mm}} \leq 1.66 \text{ for load B.} \]

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.

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

If the independent random variables have also the same distribution, then it is \( \mu_i = \mu, \quad \sigma^2_i = \sigma^2, \quad t_{\text{os}} = t_{\text{os}}. \) It follows that \( \mu(k) = k \cdot \mu, \quad \sigma^2(k) = k \cdot \sigma^2. \)

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:

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

where \( CV(1) \) is the coefficient of variation of the random variable \( t \). 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 \( [t(k)_{ct}/\mu(k)] < t_{\text{os}}/\mu \). 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 \( t(k)_{ct} \). Therefore, the more realistic values for \( t_{\text{os}} \) in table 2/E.721, [1], must be smaller. This fact will be more obvious from the following example.

Example: The relationship \( 1.375 \leq t_{\text{os}}/t_{\text{mm}} \leq 2 \) 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:

\[
\begin{align*}
    f(t) &= 0, \quad t < 0 \\
    f(t) &= 1/t_{\text{max}}, \quad 0 \leq t \leq t_{\text{max}} \\
    f(t) &= 0, \quad t_{\text{max}} < t
\end{align*}
\]  

(5)

This distribution has the following parameters:

\[
\mu = t_{\text{max}}/2, \quad \sigma = t_{\text{max}}/\sqrt{12}, \quad t_{05} = 0.95 \cdot t_{\text{max}}, \quad t_{95}/t_{\text{max}} = t_{05}/\mu = 1.9.
\]

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 \(t_{\text{max}} = 1\).

Fig. 2 presents the coefficient of variation \(CV(k) = \sigma(k)/\mu(k)\) and the ratio \(t(k)_{05}/\mu(k)\) 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 \(t(k)_{05}/\mu(k)\) 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 \(t(k)_{05}/\mu(k)\) for PSD, presented in [1] and [2], must be much less than the ratio \(t_{05}/t_{\text{max}}\) 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 \(t_{05}\) 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 \(t_{05}/t_{\text{max}}\) for greatest values of \(t_{05}\) and \(t_{\text{max}}\) 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)_{05}/\mu(k) as the function of the number of sections for the sum of uniformly distributed variables.](image)

References


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