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K.A. POLSCHYKOV, N.V. RVACHOVA, K.N. LUBCHENKO

Military Institute of Telecommunications and Information Technology, Ukraine

TECHNIQUE OF MODELING THE INTENSITY OF THE REAL TIME TRAFFIC IN A TELECOMMUNICATION NETWORK CHANNEL WITH SWITCHING PACKAGES

In this paper, offers a technique of modelling the intensity of the real time traffic in channel telecommunication networks with switching packets which is based on exponential distribution of the moments of the beginning of transfer and duration of transfer of real time streams. The implementation of the specified technique allows creating the adequate models simulating a process of dynamic change of intensity of the real time traffic in channel telecommunication networks with switching packets.

***Ключевые слова**: traffic, real time stream, exponential distribution, technique of modelling, telecommunication networks with switching packets.*

Introduction

In modern telecommunication networks with switching packets (TNSP) at transferring of speech messages and streams of video information the multimedia traffic is formed. The intensity of the information transfer initiated by real time operation of any multimedia application is high enough and close to constant value, therefore such kind of the traffic is frequently called streaming traffic or real time traffic [1 – 3]. For qualitative transfer of streaming traffic it is necessary to minimize a delay of packages and its dispersion (jitter) that is possible at realization of efficient real time streams control in the conditions of presence of the limited network resources [4]. During development the methods of management of real time streams in TNSP it is expedient to use the mathematical models simulating the process of dynamic change of the intensity of the real time traffic in a TNSP channel.

Therefore the scientific problem consisting in development of a technique of creation of adequate models, simulating change in time the size of intensity of the real time traffic in the channel of a telecommunication network with switching packages is actual.

The purpose of the article is to receive by means of mathematical modeling the correct current values which the size of intensity of the real time traffic takes in a TNSP channel.

1. A substantiation of characteristics of the real time streams transmitted by a channel TNSP

For modeling the real time streams transmitted by the channel it is necessary to prove the laws of distribution and the characteristics of random variables S (an interval of time between the moments of the beginning of transfer in this channel of the real time streams) and T (duration of transfer in this channel the real time streams). Within the framework of the theory of mass service we offer the models that adequately describe the functioning of telephone channels switching unit on which the stream of inquiries for establishing connection comes [5 – 7]. The most widespread models of receiving calls in such system and their service assume that the density of distribution of a time interval between receiving calls, and also the density of distribution of duration of their service submit the exponential law. Practical importance of these models is caused by the fact that the values of the basic characteristics of the mass service system calculated on the basis of the above mentioned models will well be coordinated to the results of corresponding measurements in really functioning networks with switching channels.

There is an obvious analogy between the two processes – the service of a call in a traditional telephone system of communication and a transfer of a real time stream in a telecommunication network with switching packages. The doubtless similarity of these processes is that the moments of their beginning and termination are initiated exclusively by the users and are only connected to their subjective needs, instead of technological features of information transfer in one or another network. Therefore the assumption seems to be proved that the density of the distribution of a time interval between the moments of the beginning of real time streams transfer, and also the density of distribution of duration of their transfer satisfies the requirements of the exponential law.

Statement of a problem

We have set:

1) The size – throughput of the channel on which it is required to transfer the real time streams;

2) The set of real time streams $\Omega = \{\omega_i\}$, where $i = \overline{1, I}$ is the number of a stream which is required to be transferred on the channel;

3) The set $\Lambda = \{\lambda_i\}$, where λ_i is the required value of intensity of transfer of a stream ω_1;

4) The set $X_1 = \{x_1\}$, where x_1 is the value of the moment of time corresponding to the beginning of a transfer of a stream ω_1;

5) An interval of time of modeling $\Theta = [0; t_{кон}]$.

It is necessary: to determine the values of intensity of the real time traffic in a TNSP channel in each present situation of time.

Assumptions:

1) The interval of time between the next moments of the beginning of transfer of real time streams on the channel is a random variable S which is distributed on the exponential law and is characterized by an average of distribution $\overline{S}$;

2) Duration of transfer of a real time stream on the channel is a random variable T described by the exponential law of distribution and an average of distribution $\overline{T}$.

2. Development of a technique

The task of receiving the values which are possessed in a present situation of time by the size of intensity of the real time traffic in a TNSP channel is reduced to the definition of size $L(t)$, i.e. the total intensity of the real time streams transmitted on the examined channel at a present situation of time.

At defining the size $L(t)$ it is necessary to take into account, that total intensity of streams simultaneously transmitted on the same channel cannot exceed throughput of this channel. The transfer of a stream at the moment of time is only possible at meeting a condition:

$$m_i(t) \le c, \qquad (1)$$

where $m_i(t)$ is a value of total intensity of real time streams, which are required to be transferred on a TNSP channel at the moment of time.

The value of $m_i(t)$ is defined from the expression:

$$m_i(t) = \begin{cases} l_1(t), & i = 1; \\ m_{i-1}(t) + l_i(t), & 2 \le i \le I, \end{cases} \qquad (2)$$

where $l_i(t)$ is a required value of intensity of transfer of a stream ω_i at the moment of time t. Having defined on the formula (2) the set $\{m_i(t)\}$, it is possible to find the required value $L(t)$ as meeting a condition (1) the greatest value of total intensity of real time streams which are required to be transferred on a TNSP channel at the moment of time t:

$$L(t) = \max\{m_i(t)\}, m_i(t) \le c.$$

In the formula (2) the values $l_i(t)$ are unknown. If at the moment of time it is required to transfer a stream ω_i, the required value of intensity of its transfer to this moment of time will correspond to a predetermined value λ_i, otherwise it will be zero:

$$l_i(t) = \begin{cases} \lambda_i, \text{ if } t \in [x_i; x_i + \tau_i]; \\ 0, \text{ if } t \notin [x_i; x_i + \tau_i], \end{cases} \qquad (3)$$

where x_i is the value of the moment of time when it is required to begin transfer of a stream ω_i; τ_i is the required value of duration of transfer of a stream ω_i.

According to the assumptions, it is known, that the random variable T is distributed on the exponential law. Therefore the density of distribution of required duration of transfer of a stream from the set Ω can be submitted as a function:

$$g(t) = \frac{1}{\overline{T}} e^{-\frac{t}{\overline{T}}}.$$

To receive the values of any random variable during modeling special gauges are used, which, as a rule, generate values of the random variable having an even distribution in an interval (0, 1). In a reality such gauges generate not casual but pseudorandom numbers close enough to them. Having a sequence of evenly distributed random numbers $\{U_n\}$ where $n = \overline{1, N}$, it is possible to calculate the values of random numbers $\{Y_n\}$ with exponential distribution and average value α on the formula [8]:

$$Y_n = -\alpha \ln(1 - U_n).$$

Therefore, using the gauge generating evenly distributed values of random numbers $\{U_i\}$, it is possible to receive values $\{\tau_i\}$ of a random variable T:

$$\tau_i = -\overline{T} \ln(1 - U_i). \qquad (4)$$

In the formula (3) the unknown is the set of values $X = \{x_i\}$. The elements of this set can be found consistently, using the expression:

$$x_i = \begin{cases} x_1, & i = 1; \\ x_{i-1} + s_{i-1}, & 2 \le i \le I, \end{cases} \qquad (5)$$

where s_{i-1} is the size of an interval between the moments of time x_{i-1} and x_i.

As an example the moments of the beginning of transfer of real time streams, the intervals between them and the values of duration of transfer of these streams in the TNSP channel are illustrated in fig. 1.

For the solution of a problem put by it is necessary to receive the set of values $\{s_i\}$.

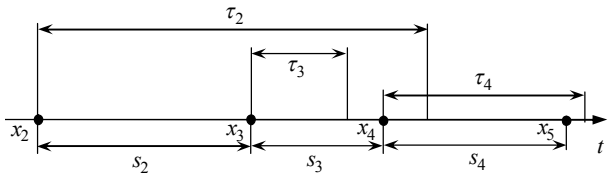

Fig. 1. The moments of the beginning of transfer of real time streams, the intervals between them and the values of duration of transfer of these streams in the channel of a network

It is known, that the density of distribution of the random variable S, corresponding to the exponential law, looks like:

$$f(t) = \frac{1}{\bar{S}} e^{-\frac{t}{\bar{S}}}.$$

Therefore for definition of values $\{s_i\}$ of a random variable S it is possible to take advantage of the expression:

$$s_i = -\bar{S}\ln(1 - U_i). \qquad (6)$$

The technique of modeling of intensity of the real time traffic in a TNSP channel, and the block diagram of a realization algorithm is submitted on fig. 2, it includes the following stages.

1. Input of the initial data (block 1). There have been entered the value of the size c, the predetermined sets of values $\Lambda = \{\lambda_i\}$, $X_1 = \{x_1\}$, the value t_y.

2. Applications setup for the transfer of real time streams on the channel of a network. At this stage the generating numbers $\{U_{ij}\}$ (block 5) and consecutive calculation of values s_i on the formula (6), x_i on the formula (5) and τ_i on the formula (4) (block 6) is carried out. As a result for each application for transfer of a stream ω_i the values are defined for the moments of time x_i when it is required to begin the transfer, and the required duration τ_i of the transfer.

3. Receiving of the required values of intensity of transfer of real time streams in the channel of a network in a present situation of time t. At the given stage with the use of expression (3) the values $l_i(t)$ are calculated (blocks 7 - 9).

4. Calculation of values of total intensity of real time streams which are required to be transferred in the channel of a network at the moment of time t. The essence of this stage is in the receiving by the means of expression (2) the values $m_i(t)$ (block 10).

5. Definition of total intensity of transmitted streams of real time in the channel of a network in a present situation of time t. In the block 11 the fulfillment of a condition (1) is checked. If the given condition is fulfilled, the value of the size $L(t)$ (block 12) which has been originally equal to zero (block 3) is updated. The default of a condition (1) corresponds to a situation when in consequence of limiting congestion of the channel the application for transfer of the stream ω_i, arrived at the moment of time t, receives refusal. Thus the required value of intensity of transfer of a stream ω_i is nulled (block 13).

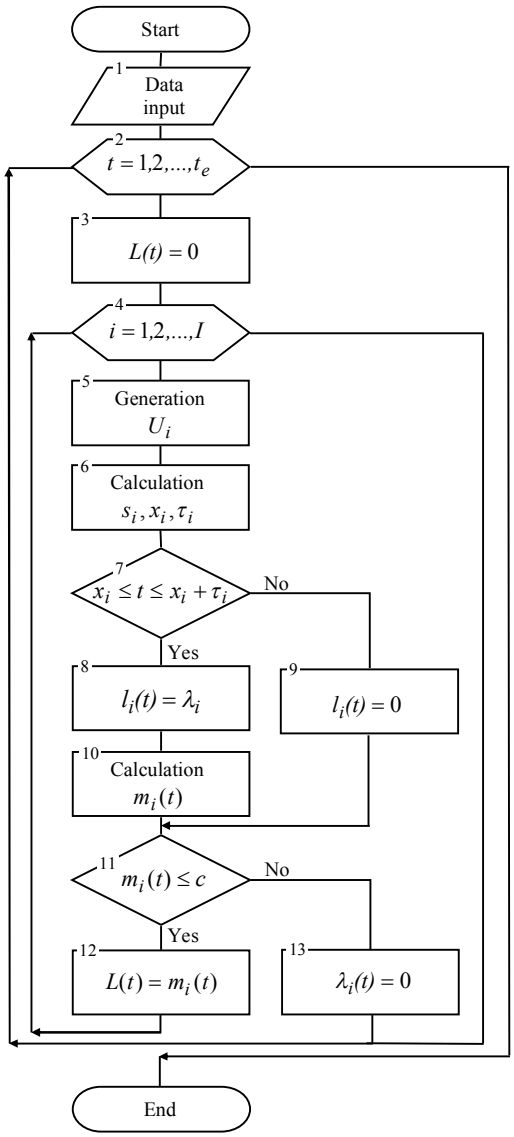

Fig. 2. The block diagram of the algorithm realizing a technique of modeling of intensity of the real time traffic in a TNSP channel

Stages 3 – 5 of the technique are cyclically repeated with the purpose of receiving the resulting values $L(t)$ for each moment of time t.

Conclusions

Thus, the article offers a technique of modelling the intensity of the real time traffic in a TNSP channel which is based on exponential distribution of the mo-

ments of the beginning of transfer and duration of transfer of real time streams.

The implementation of the specified technique allows creating the adequate models simulating a process of dynamic change of intensity of the real time traffic in a TNSP channel.

References

1. Кучерявый Е.А. Управление трафиком и качество обслуживания в сети Интернет / Е.А. Кучерявый – СПб.: Наука и техника, 2004. – 336 с.

2. Куроуз Дж. Компьютерные сети. 2-е изд. / Дж. Куроуз, К. Росс – СПб.: Питер, 2004. – 765 с.

3. Столлингс В. Современные компьютерные сети. 2-е изд. / В. Столлингс – СПб.: Питер, 2003. – 783 с.

4. Вегеша Ш. Качество обслуживания в сетях IP: Пер. с англ. / Ш. Вегеша – М.: Издательский дом «Вильямс», 2003. – 386 с.

5. Вишневский В.М. Теоретические основы проектирования компьютерных систем / В.М. Вишневский – М.: Техносфера, 2003. – 512 с.

6. Поповський В.В. Математичні основи теорії телекомунікаційних систем / В.В. Поповський, С.О. Сабурова, В.Ф. Олійник, Ю.І. Лосєв, Д.В. Агеєв та ін.: За ред. В.В. Поповського. – Х.: ТОВ «Компанія СМІТ», – 2006. – 564 с.

7. Шварц М. Сети связи: протоколы, моделирование и анализ. Ч.1: Пер. с англ. / М. Шварц – М.: Наука, 1992. – 336 с.

8. Крылов В.В. Теория телетрафика и ее приложения. / В.В. Крылов, С.С. Самохвалова – СПб.: БХВ-Петербург, 2005. – 288 с.

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Рецензент: д-р техн. наук, проф. А.Л. Ляхов, зав. кафедрою комп'ютерних інформаційних технологій і систем Полтавського національного технічного університету ім. Ю. Кондратюка, Полтава.

МЕТОДИКА МОДЕЛЮВАННЯ ІНТЕНСИВНОСТІ ТРАФІКУ РЕАЛЬНОГО ЧАСУ В КАНАЛІ ТЕЛЕКОМУНІКАЦІЙНОЇ МЕРЕЖІ З КОМУТАЦІЄЮ ПАКЕТІВ

К.О. Польщиков, Н.В. Рвачова, К.М. Любченко

В роботі запропоновано методику моделювання інтенсивності трафіку реального часу в каналі телекомунікаційної мережі з комутацією пакетів, яка заснована на експоненціальному розподілі моментів початку передачі та тривалості передачі потоків реального часу. Використання представленої методики дозволяє створювати адекватні моделі, що імітують процес динамічної зміни інтенсивності трафіку реального часу в каналі телекомунікаційної мережі з комутацією пакетів.

Ключові слова: трафік, потік реального часу, експоненціальний розподіл, методика моделювання, телекомунікаційна мережа з комутацією пакетів.

МЕТОДИКА МОДЕЛИРОВАНИЯ ИНТЕНСИВНОСТИ ТРАФИКА РЕАЛЬНОГО ВРЕМЕНИ В КАНАЛЕ ТЕЛЕКОММУНИКАЦИОННОЙ СЕТИ С КОММУТАЦИЕЙ ПАКЕТОВ

К.А. Польщиков, Н.В. Рвачева, Е.Н. Любченко

В статье предложена методика моделирования интенсивности трафика реального времени в канале телекоммуникационной сети с коммутацией пакетов, которая основана на экспоненциальном распределении моментов начала передачи и длительности передачи потоков реального времени. Применение указанной методики позволяет создавать адекватные модели, имитирующие процесс динамического изменения интенсивности трафика реального времени в канале телекоммуникационной сети с коммутацией пакетов.

Ключевые слова: трафик, поток реального времени, экспоненциальное распределения, методика моделирования, телекоммуникационная сеть с коммутацией пакетов.

Польщиков Костянтин Олександрович – канд. техн. наук, доцент, докторант науково-організаційного відділу Військового інституту телекомунікацій та інформатизації НТУУ «КПІ», Полтава, Україна, e-mail: konspol@rambler.ru.

Рвачева Наталія Володимирівна – викладач Військового інституту телекомунікацій та інформатизації НТУУ «КПІ», Полтава, Україна.

Любченко Катерина Миколаївна – студентка Військового інституту телекомунікацій та інформатизації НТУУ «КПІ», Полтава, Україна.