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Models and algorithms for evaluating the efficiency of the data link protocols of a telecommunication network based on the Petri net

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ABSTRACT: In the world's telecommunications networks, great attention is paid to the development of algorithms and software-based devices that ensure the transmission of data link through communication channels to the recipient without interruption, delays and completeness. In particular, special attention is paid to the development of models and algorithms for evaluating the effectiveness of data link protocols in the telecommunications network based on the Petri network, as well as improving the hardware and software of the network, as well as tools for adjusting data link protocols.

KEY WORDS: telecommunications, Petri network, protocols, frame, efficiency, data link

I.INTRODUCTION

One of the important tasks of telecommunication networks is to provide complete, accurate and timely information. During the transmission of information through the communication channel, they are under the influence of various interferences of adaptive and multiplicative nature as they propagate in the environment. As a result, the probability of an information error at the point of data reception is 10-1 to 10-3 bits[1].Typically, the transmitted data is divided into frames and transmitted via a communication channel.

The data link ensures error-free delivery of personnel through the communication channel. To do this, the receiving block checks for errors and checks the completeness of the received information. If the data received is error-free, it is transmitted to the information changer[2].

II. SIGNIFICANCE OF THE SYSTEM

Due to the complexity of improving the mathematical and software of telecommunications systems, there is a need to develop new protocols for data processing (data processing) and exchange.

We use an indefinite Petri network mathematical apparatus to evaluate the interference that occurs in the transmission of information on a communication channel and on the basis of which data loss, retention, transmission rate slowdowns and errors, such uncertainty events affect the process and their impact on communication channel protocol performance[3].

III. LITERATURE SURVEY

The analysis shows that a number of approaches are currently used in solving the problems of mathematical modeling of information and telecommunications systems. The most effective of these are graph models and combinatorial computational methods, flow models and methods of network analysis, neural networks, tensor models, as well as the Markov apparatus of controlled random processes. Each method has its own advantages and disadvantages. These issues are addressed using hybrid models based on the use of graph models and public service models[4].

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The simplicity of graph models, as well as the application of controlled random processes in conjunction with new non-standard modeling approaches of the Markov apparatus, still allow them to be successfully used in the study of statistical processes in telecommunications systems and networks[5].

$$\Pi_T = (N, \mu_0, Z_T, S_T),$$

Here $N = (P, T, I, O)$ – the structure of the Petri network of uncertain time; $P = \{p_i\}$, ($i = 1,..., n$; n – number of positions) - set of positions; $T = \{t_j\}$, ($j = 1,\ldots,m$; m—number of passes) - set of passes; $I : P \times T \to \{0,1\}$; $O : T \times P \to \{0,1\}$ – input and output transition functions, respectively; $\mu_0 = (\mu_1^0, \mu_2^0,..., \mu_n^0)$ – initial character vector.

Each component of the vector represents the μ_i^0 triangular indefinite number, i.e. the function of the triangular relation:

$$\mu_i^0 = \left\langle \mu_{1i}^0, \mu_{2i}^0, \mu_{3i}^0 \right\rangle \left(i \in \{1,2,..., n\}\right),$$

$z = (z_1, z_2,..., z_n)$ – the vector of the stop time parameters of the marker at the Petri network positions of indefinite time, Each component of z_i represents a triangular indefinite number:

$$z_i = \left\langle z_{1i}, z_{2i}, z_{.3i} \right\rangle \left(i \in \{1,2,..., n\}\right),$$

$s = (s_1, s_2,\ldots,s_m)$ – as the vector of the operating time parameters of the allowable transitions of indefinite time Petrinetwork,represents a triangular indefinite number of its s_j components, namely:

$$s_i = \left\langle s_{1j}, s_{2j}, s_{3j} \right\rangle \left(i \in \{1,2,..., n\}\right),$$

IV. METHODOLOGY

It is more convenient to bring it to the appearance of a matrix when calculating the structural elements of an indeterminate time Petri network[6]. The algorithm for calculating the elements of the matrix, taking into account the retention time of the frames, is shown in Figure 1.

The input d_{ij}^-, output d_{ij}^+ positions of the matrix, the elements of the d_{ij} joint (incident) are determined by the following formula:

$$d_{ij}^- = \begin{cases} 1, & агар \quad p_i \in I(t_j), \\ 0, & агар \quad p_i \notin I(t_j), \end{cases};$$

$$d_{ij}^+ = \begin{cases} 1, & агар \quad p_i \in O(t_j), \\ 0, & агар \quad p_i \notin O(t_j), \end{cases};$$

$$d_{ij} = \begin{cases} -1 & агар \quad p_i \in I(t_j), \quad p_i \notin O(t_j), \\ 1, & агар \quad p_i \notin I(t_j), \quad p_i \notin O(t_j), \\ 0, & агар \quad p_i \notin I(t_j), \quad p_i \notin O(t_j), \end{cases}$$

When various interruptions occur in the channel, the values of the time spent on data transmission, which is the main indicator of communication channel protocols, are determined.

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The advantage of this method is that it can be used to simulate various interferences by changing the initial markings and to study their effect on the performance of data link protocols.

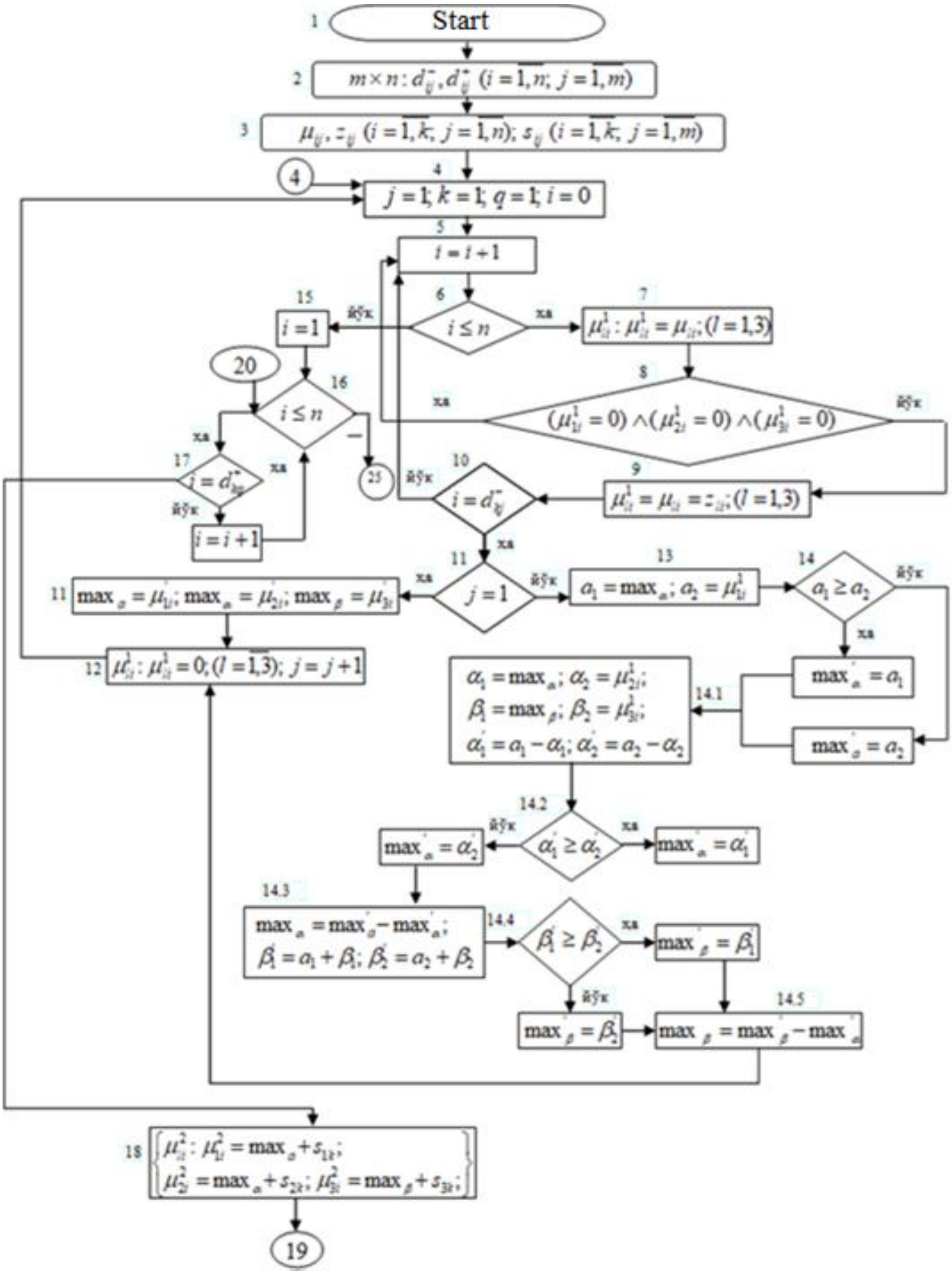

Fig. 1. Construction of an inaccurate time-sensitive Petri network algorithm for data transmission in a communication channel

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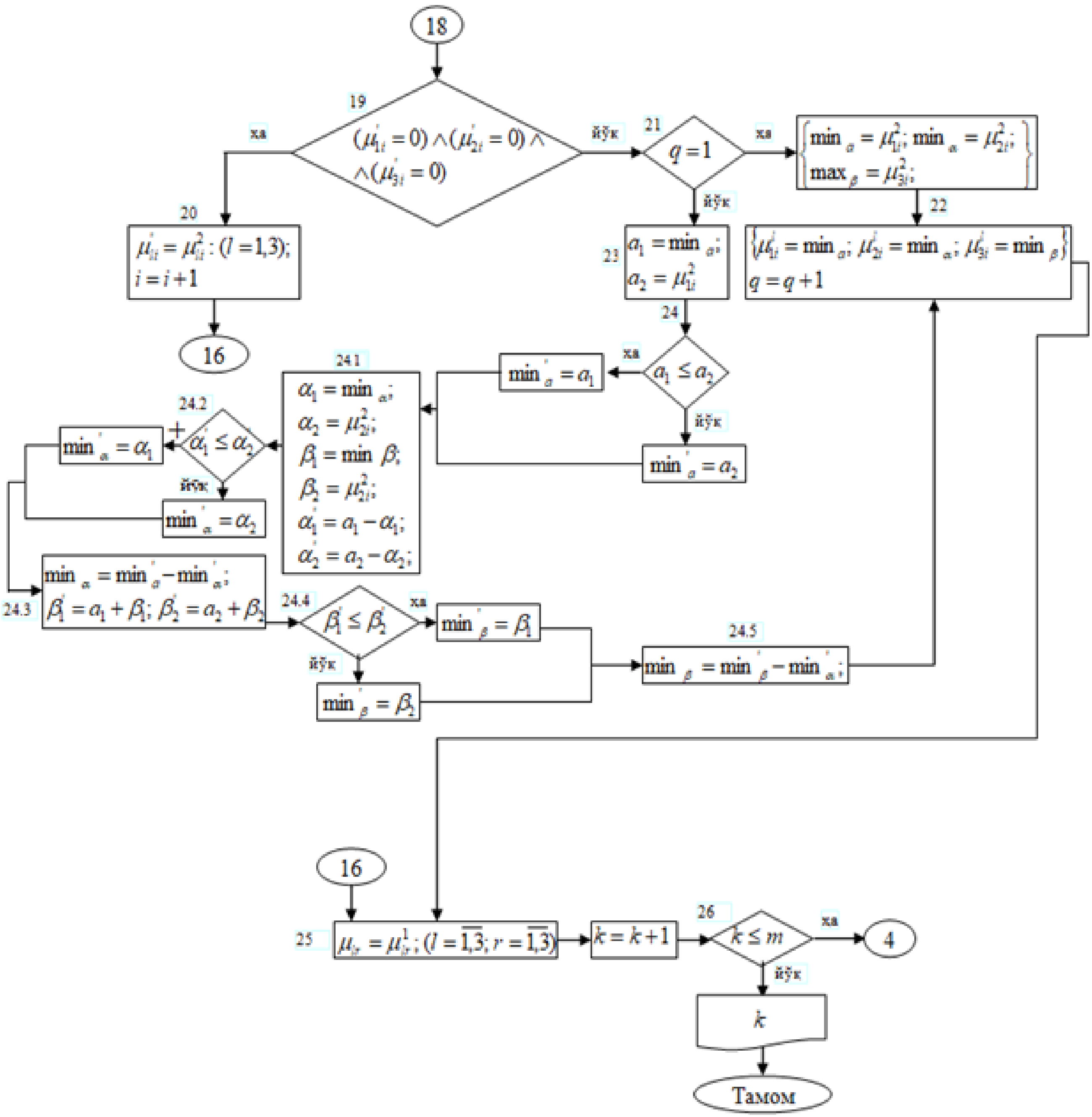

Fig. 1. Construction of an inaccurate time-sensitive Petri network algorithm for data transmission in a communication channel(continued)

V. EXPERIMENTAL RESULTS

Let us consider that the transmission of frames through a communication channel is represented in the form of an indefinite time Petri grid. In this case, the positions and transitions of the Petri network are represented as follows (Figure 2).

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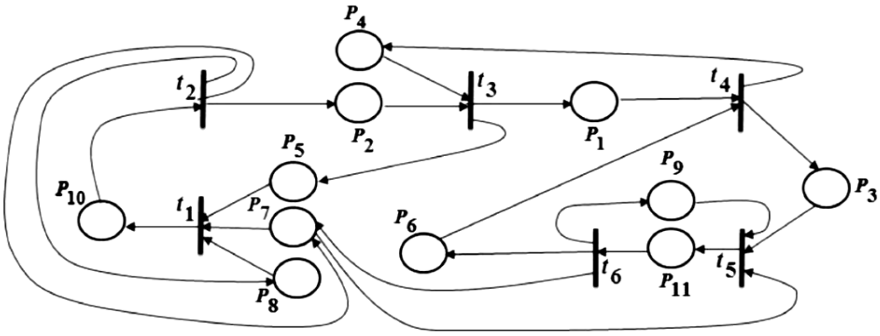

Fig.2.. Petri network model of frame transmission

where p_1 is the channel frame transmission status; p_2 - the position of the frame on the transmission; p_3 - frame signal shape change condition; p_4 - the state of emptying the communication channel; p_5 - readiness to accept the frame; p_6 is the idle state of the signal converter at the receiver; p_7 - the state of readiness of the recipient to receive information;p_8 - the state of placing a flag in the frame; p_9 - the state of transmission of the transmitting frame to the communication channel; p_{10} - the state of arrival at the frame message receiver; p_{11} is the frame error check condition. $T = \{t1,\ldots, t6\}$ - classifies the conditions of operations (transitions), ie: t_1 - the state of the frame transfer process; t_2 - the state of termination of the transfer of the frame to the communication channel; t_3 - the state of admission; t_4 - the state of completion of the recruitment;t_5 - frame error checking condition; t_6 - the state of issuance of a receipt of correct admission of the staff and the readiness of the recipient to receive the next staff. Marking μ corresponds to the state of readiness to perform actions.

In the application of these models, the operation of the system can be seen in the example of the exchange of cases classifying certain events. There is a definite probability for each case. The transition of a system from one state to another is associated with the performance of a certain action, which is explained by the magnitude of the probability according to a certain distribution law.

VI.CONCLUSION AND FUTURE WORK

An obscure time-consuming Petri network model for evaluating the effectiveness of data link protocols for data transmission in information and communication networks has been developed. This model made it possible to assess the impact of interference on data transmission performance.

The application of the developed non-timed Petri network model to evaluate the effectiveness of the data linkprotocol to the data transmission process through the communication channel allowed to reduce the data transmission time by 4.2% -7.5%.

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