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Application of a Generalized Net Model in the Communication of Two Independent Traffic in Faculty of Technical Sciences at Konstantin Preslavski University of Shumen

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Abstract. **In this paper, a generalized net model providing secure communication of two independent network traffic through ISP1 and ISP2 is presented. Also, a generalized net model modelling the communication process in the computer network of the Faculty of Technical Sciences was developed. The aim of the present study is to improve the Faculty network with generalized net model by providing it with greater efficiency and greater flexibility. The main methods in our research are the method of analysis and synthesis and the method of simulation. The application of generalized net in various fields/aspects of science show the possibilities of the mathematical apparatus for modelling various processes. The indexed matrices used provide flexibility for describing and representing the current states of the cores in the positions they fall into.**

Keywords: Communication network, Cores, Generalized net, Independent traffic.

I. INTRODUCTION

Generalized networks as a theory has entered science widely in the last few years. The well-structured mathematical apparatus describing the individual work processes of the given network facilitates the research and scientific activity of many young scientists. Generalized nets are based on the foundation of Petri nets. Modeling systems and processes using Petri nets is based on the concepts of event and condition. Events are the actions that change the states of modeling objects. Conditions are predicates or logical descriptions of the state of systems and/or processes. In order to implement the actions, it is necessary to fulfill the relevant conditions. These are called event preconditions. The occurrence of an event can change the preconditions and trigger the fulfillment of other conditions, sub-conditions. The theory of generalized net was proposed by Prof. Krasimir Atanasov, who added a third parameter to Petri net research. In this way, very accurate descriptions of models are made. Numerous network models have been created describing a variety of problems to be solved in both the field of medicine and in the field of technology. Generalized net are also widely used in artificial intelligence systems for describing parallel processes. Generalized nets are more complex in structure than Petri nets. Their components are theoretically divided into static, dynamic, time and memory. Each generalized network has a timescale, and the activation of its transitions takes place at discrete moments in time. One of the factors determining the possibility or impossibility of activating the transitions is associated predicates. At each model point in time, a specific function determines fidelity values for the predicates [9], [11], [13]. Going through the transitions, the kernels acquire new characteristics by means of a characteristic function. The graphical representation of a transition in a generalized net is a vertical line with a

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triangle above it, the latter indicating a structure containing seven components. [4], [5], [7], [8]

Of course, the application of this method is particularly suitable for the administration of a communication network. This administration process is extremely complex and completely depends on the system administrator who has to plan and build the necessary network for a given organization. The administrator faces problems related to:

- External threats to the communication network;
- The check of the primary system reducers;
- Checking and scanning for available viruses or malicious codes;
- Check for security breaches;
- To manage users on the network.

The main goal of our research in the present article is to create a generalized network model of the communication of two independent traffics in the Faculty of Technical Sciences at the "Konstantin Preslavski" University of Shumen referring to scientific works [1], [2], [6], [10], [12]. This type of model is particularly useful when parallel transmission of different types of data is required, ensuring independence and efficient use of available resources in the faculty network. The present research would also be useful in the improvement of industrial networking and telecommunication networks by providing greater efficiency, greater flexibility and better security. The generalized structural diagram of the network is presented in Fig. 1.

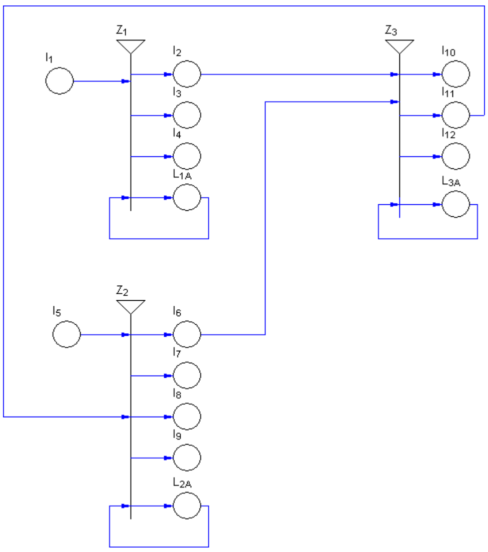

Fig. 1. Generalized net model of the communication network

In addition to the routers, the faculty network also includes logical switches, the settings of which are similar to the switching part of the router. This article does not cover the logical switches, only the routers involved in traffic management for the example network.

The object of research in this paper is the construction and improvement of the faculty network for the following main reasons:

1. Separation of a network that is independent of the university network, specifically all hosts in the building are connected through common switches, which leads to cases of student access to teaching computers. The separate faculty network allows the scientific work of the professors and doctoral students not to be an obstacle for the other faculty.

2. Jumping over an intermediate (proxy) server that is improperly used to access the Internet and hinders the scientific work of doctoral students. Upon inquiry with other universities, it was found that a proxy server is only used to secure internal services offered from university servers.

II. Materials and Methods

The methodology and basic design of the research in this article is the construction of a generalized network. The overall construction refers to sources [2] – [4], [13] and includes:

- Building a static structure of the modeled process;

At each event of the modeled process within the generalized net, the model is mapped to one transition. The conditions for an event to occur are represented in the generalized net model by the presence of cores in the corresponding input positions of the transition modeling the event, the presence of predicates in the transition condition that has a fidelity value of TRUE, and the presence of vacancies in the output positions of the transition.

- Covering the dynamics of the modeled process;

Each real process actually represents a set of separate sub-processes that run parallel in time, and often in competition with each other. By generalized net modeling of such a population, rich information can be obtained about the values of the various parameters associated with these processes.

- Description of the functionality of the modeled process in a time interval;

For the use of global time components in the model, it is necessary that the modeled process starts and runs at a precise point in time and its duration is determined. If this is fulfilled, then an elementary time step must also be specified, with which the time between the two moments fixing the beginning and end of functioning of the modeled process will increase.

- Determination of the data of interest for the modeled network.

Data acquisition for generalized net models is defined as data related to transitions, positions, cores, and the network as a whole. We can specify variables whose values are calculated during the operation of the generalized net model. In this way, data from various parameters can be obtained for the corresponding modeled process. It is important to set appropriate parameters to the characteristic functions that describe the positions. The created generalized net model can serve to simulate a modeled process and for its optimization and management.

In order to use a generalized net model for process simulation, it is necessary to define it by such random functions that set the true values of the predicates of the conditions and the values of the time parameters of the process. Through simulation, statistics can be obtained about the simulated processes. Based on the created model, more models can be built to further develop the original model. Generalized net can be used in modeling and simulating processes to predict future behavior, to control and optimize real-time processes that run very slowly.

After the creation of the generalized net model, there is the question of its accuracy and correctness. In this case, it is necessary to have in advance the necessary and appropriate criteria for comparison. In many cases, the best way is to apply the adaptive method of comparison, and if necessary, the correction of the generalized net model is done iteratively based on the differences between the expected and obtained results. Each process is simulated multiple times and the results are compared, possibly averaged, analyzed and evaluated. Indexed arrays provide flexibility for describing and representing the current states of the cores at the positions they fall into. A generalized net model containing the following set of transitions was developed:

$$A = \{Z_1, Z_2, Z_3\} \tag{1}$$

where transitions describe the following processes:

Z_1 = "incoming packets in router 1 ";

Z_2 = "incoming packets in router 2 ";

Z_3 = "incoming packets to switch from router 1 and router 2".

The transitions have the following description:

$$Z_1 = \langle \{l_1, L_{1A}\}, \{l_2, l_3, l_4, L_{1A}\}, R_1, \vee (l_1, L_{1A}) \rangle \tag{2}$$

Where

$$R_1 = \begin{array}{c|cccc} & l_2 & l_3 & l_4 & L_{1A} \\ \hline l_1 & false & false & false & true \\ L_{1A} & W_{1A,2} & W_{1A,3} & W_{1A,4} & true \end{array} \tag{3}$$

$W_{1A,2}$ – "packets of incoming and outgoing traffic intended for the switch have arrived"

$W_{1A,3}$ – "packages are intended for computer laboratory K3"

$W_{1A,4}$ – "packages are intended for computer lab 401"

Cores coming into position L_{1A} have the characteristic "check packet arrived" after the transition the core can enter positions l_2, l_3, l_4.

$$Z_2 = \langle \{l_5, l_{11}, L_{2A}\}, \{l_6, l_7, l_8, l_9, L_{2A}\}, R_2, \vee (l_5, l_{11}, L_{2A}) \rangle$$

$$R_2 = \begin{array}{c|cccc} & l_6 & l_7 & l_8 & L_{2A} \\ \hline l_5 & false & false & false & true \\ l_{11} & false & false & false & true \\ L_{2A} & W_{2A,6} & W_{2A,7} & W_{2A,9} & true \end{array} \tag{5}$$

$W_{2A,6}$– "packages are intended for Situation Center"

$W_{2A,7}$ – "packages are intended for Siemens computer lab"

$W_{2A,8}$ – "packages are intended for teachers' offices"

$W_{2A,9}$ – "the packages are intended for office teachers"

Cores coming into position L_{2A} have the characteristic "check packet arrived" after the transition the core can enter positions l_6, l_7, l_8, l_9.

$$Z_3 = \langle \{l_2, l_6, L_{3A}\}, \{l_{10}, l_{11}, l_{12} L_{3A}\}, R_3, \vee (l_2, l_6, L_{3A}) \rangle, \tag{6}$$

$$R_3 = \begin{array}{c|cccc} & l_{10} & l_{11} & l_{12} & L_{3A} \\ \hline l_2 & false & false & false & true \\ l_6 & false & false & false & true \\ L_{3A} & W_{3A,10} & W_{3A,11} & W_{3A,12} & true \end{array} \tag{7}$$

$W_{3A,10}$– "The switch has redirected traffic coming from Router 1 to Router 2 when Router 2 does not have access to the Internet."

$W_{3A,10}$ – "The switch has redirected traffic coming from Router 2 to Router 1 when Router 1 does not have access to the Internet."

$W_{3A,12}$ – "packages are intended for teachers' offices"

Cores coming into position L_{3A} have the characteristic "check packet arrived" after the transition the core can enter positions l_{10}, l_{11}, l_{12} .

In the developed generalized net model, the distribution of traffic in the computer network of the Faculty of Technical Sciences is presented. Through the model, the operation of the network is described, which can be used as a tool for researching the processes taking place in computer networks. This new method provides a means of describing the investigated processes, as the developed generalized net model describes the performance of the computer network.

(2)

III. Results and discussion

The described generalized net model was implemented, using two identical Cisco routers RV325 for the network of the Faculty of Technical Sciences at the Konstantin Preslavski University of Shumen. The generalized structural diagram of the network is presented in Fig. 2.

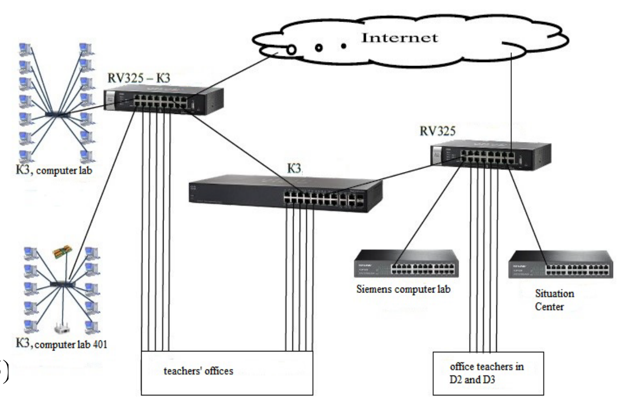

Fig. 2. Structural diagram of the computer network of the Faculty of Technical Sciences

The computer network in Faculty of Technical Sciences was built for two main interrelated reasons:

1. Separation of a network that is independent from the university network, specifically all hosts in the building are connected through common switches, and this leads to cases of student access to faculty computers.

The separate faculty network allows the scientific work of the professors and doctoral students without being an obstacle for the other faculty.

2. Jumping over an intermediate (proxy) server that is improperly used to access the Internet and hinders the scientific work of doctoral students. Inquiring with other universities, it was found that a proxy server is only used to secure internal services offered by University servers. The faculty network is to be extended to the C building in the near future.

IV. Conclusions

Based on the research, a new approach for describing the traffic distribution in the computer network of the Faculty of Technical Sciences is proposed. The model created by us allows to study the processes [5], [6] taking place in the computer network, the ways of forwarding the packets for the given networks and the distribution of their traffic. It is suitable for future developments and is widely used in all types of networks. The results achieved after the creation of the network in the Faculty of Technical Sciences are extremely satisfactory. The proposed model and its approaches provide an additional opportunity in the training of students in the Computer Networks discipline. The implementation of generalized net model supports the construction of communication networks in all sectors of the industry in the field of computer networks. The use of generalized net model supports the design and visualization of practical and theoretical rationale in the construction of independent network traffic and the distribution of their flows. A further objective is to perform an assessment of the network flows used, to make an allocation of the networks used in order to prevent the load on only one of the networks, i.e. when one network is loaded, part of the flow is transferred to the other and vice versa.

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