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# Switched LAN simulation by colored Petri nets

D.A. Zaitsev*

*Department of Communication Networks, Odessa National Telecommunication Academy, Kuznechnaya 1, 65029 Odessa, Ukraine*

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**Abstract**

The methodology of switched LAN models construction in the form of colored Petri net is introduced. For the simulation and analysis of the model the Design/CPN tool is used. The tasks of estimation of LAN switch's buffer size and network response time were solved. The components of the model are switches, servers, and workstations.


*Keywords:* Computer networks; Switch; Petri net; Estimation

## 1. Introduction

In work [4], it is stated that the technology of switching is prospective for bandwidth increase in local and global computer networks. In article [2], the switched network is investigated by means of stochastic nets with queue; the influence of switch buffer size on the quantity of the lost packets and the general productivity of the network is considered. Distinct from pointed models, Petri nets contain facilities for more precise description of network architecture and traffic and allow representation of the interaction within the client–server systems.

For the description of the real world objects it is not usual to apply basic Petri nets [5]. Its play the central role in theoretical investigations. For practical purposes various extended models such as colored, timed, and hierarchical nets are used. The theory of the colored Petri nets was developed in monograph [3], while a formal description of timed nets behavior is the subject of article [7].

In present work, the switched local area network investigation is implemented by means of simulation system Design/CPN [1] and the task of network response time estimation was solved.

* Tel.: +38-0482-348535; fax: +38-0482-236269.
*E-mail address:* zaitsev_dmitry@mail.ru (D.A. Zaitsev).

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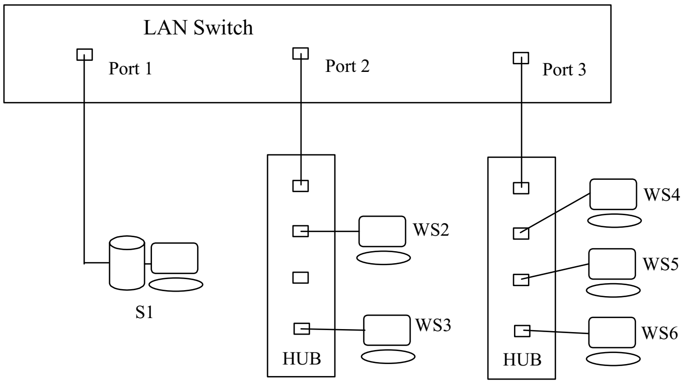


Fig. 1. Scheme of small office switched LAN.

## 2. Description of researched object

The base element of the switched Local Area Network (LAN) Ethernet (IEEE 803.x) is the switch of frames. Logically the switch is constituted by the set of ports [6]. The LAN segment (for example, made up via hub) or the terminal equipment such as a workstation or server may be attached to each port. The task of the switch is the forwarding of incoming frame to the port that the target device is connected to. The usage of the switch allows for a decrease in the quantity of collisions so the frame is transmitted only to the target port and results in an increase bandwidth. Moreover, the quality of information protection rises with a reduction of ability to overhear traffic. The scheme of small office switched network is presented in Fig. 1.

To determine the target port number for the incoming frame a static or dynamic switching table is used. This table contains the port number for each known Media Access Control (MAC) address. Algorithms of dynamic table maintenance are based on traffic listening for the search of unknown source MAC addresses and the creation of new records for such addresses. During the processing of unknown destination address the frame is transmitted to all the switch ports.

## 3. Model of LAN switch

Let us construct the model for a given static switching table. We shall consider separate input and output frame buffers for each port and a common buffer of the switched frames. A model of the switch is presented in Fig. 2. Hosts disposition according to Fig. 1 was used for the testing of the model.

MAC address of the host is represented by the integer number. Moreover, content of the frame is not considered. Data type *frm* describes the frames of the network, data type *swch* represents the switching table records, and data type *swchfrm* describes the switched frames waiting for output buffer allocation. Places *PortX In* and *PortX Out* represent input and output buffers of port *X* accordingly. Place *SwitchTable* models the switching table; each token in this place represents the record of the switching table. Place *Buffer* corresponds to the switched frames' buffer. Transitions *InX* model the processing of input frames. The frame is extracted from the input buffer only in cases where the switching table contains a record

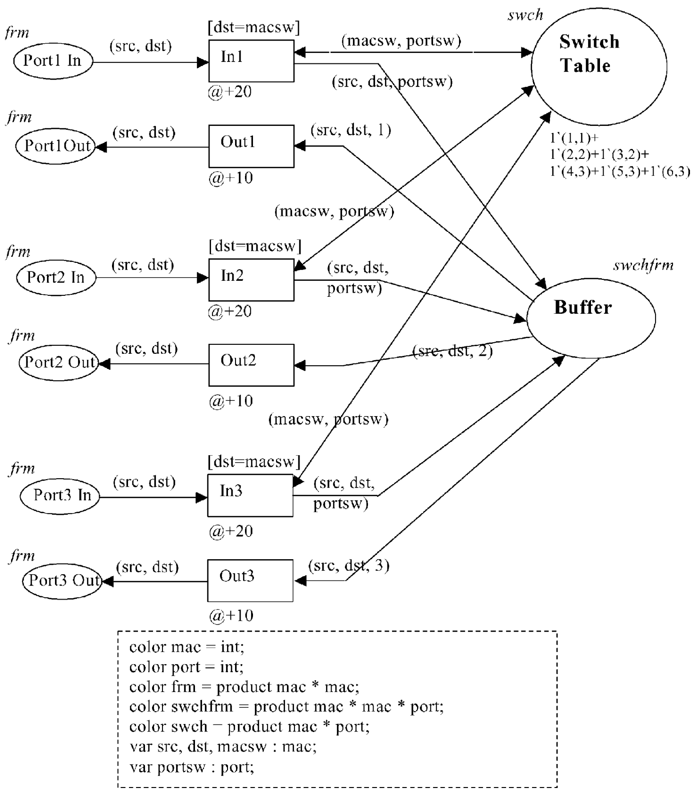


Fig. 2. Model of LAN switch.

with an address that equals the destination address of the frame; during the frame displacement the target port number is stored in the buffer. Transitions *OutX* model the displacement of switched frames to output ports' buffers. Fixed time delays are assigned to the operations of the switching and the writing of the frame to the output buffer.

## 4. Models of workstations and servers

To investigate the frames' flow transmitting through the local area network and to estimate the network response time it is necessary to supply the model constructed with the models of terminal devices attached to the network. The general model assembling may be provided by means of union (fusion) of places.

On the peculiarity of the traffic's form we shall separate workstations and servers. For an accepted degree of elaboration, we shall consider the periodically repeated requests of the workstations to the servers with the random uniform distributed delays. On reply to accepted request the server sends a few packets to the address of the requested workstation. The number of packets sent and the time delays are the uniform distributed random values.

A model of workstation is represented in Fig. 3. Place *LAN* models the segment of the local area network that the workstation is attached to. The workstation listens to the network by means of a transition *Receive*

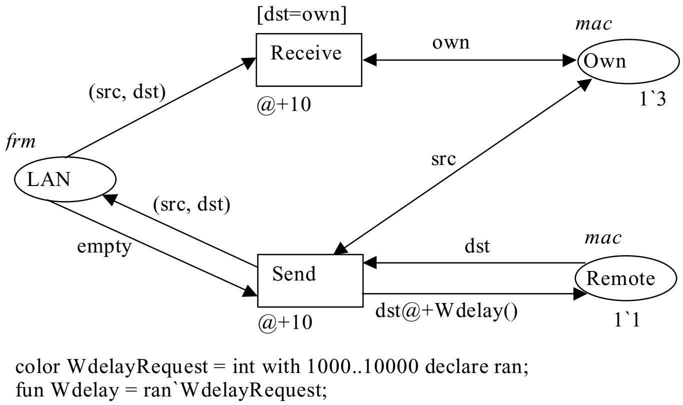


Fig. 3. Model of workstation.

that receives frames with the destination address that equals the own address of the workstation saved in the place *Own*. The processing of received frames is represented by the simple absorption of them. The workstation sends periodic requests to the server by means of transition *Send*. The servers' addresses are held in the place *Remote*. After sending request the usage of the server's address is locked by the random time delay given by the function *Wdelay( )*. The sending of the frame is implemented only if the LAN segment is free. It operates by checking of the place *LAN* for the lack of tokens. In such a manner we may interact with a few servers holding their addresses in the place *Remote*.

A model of the server is represented in Fig. 4. The listening of the network is similar to the model of the workstation but is distinct in that the frame's source address is held in the place *Remote*. Transition *Exec* models the execution of the workstation's request by the server. As a result of the execution request the server generates a random number of the response frames that are held in the place *Reply*. Then these frames are transmitted into the network by the transition *Send*.

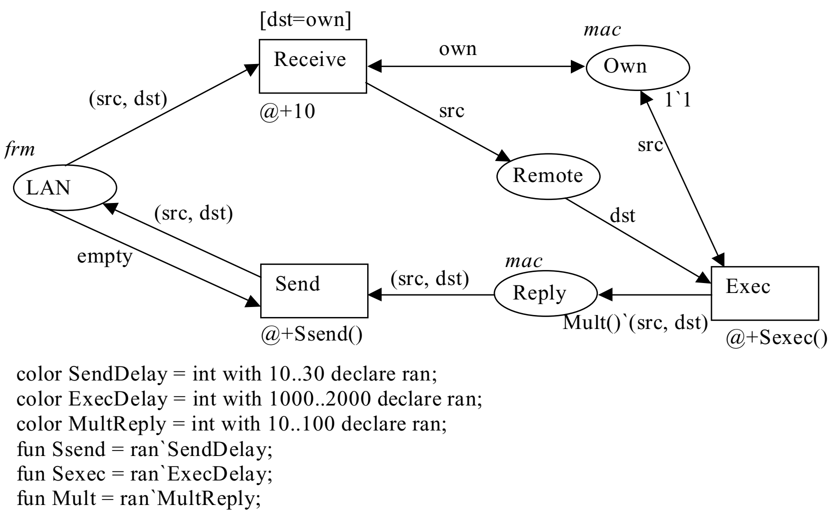


Fig. 4. Model of server.

The assembly of the general local area network model is implemented by the union of the places *LAN* of workstations and servers for each of the segments. The model of the switch is attached to the models of segments by means of additional transitions *ReceiveX* and *SendX* accepting frames into the input buffer and transmitting frames from the output buffer accordingly for each switch port. The developed model is analyzed in interactive and automatic modes of the simulation system Design/CPN. The interval of the model time between sending of the request token and receiving the answer tokens is the estimated network response time.

## 5. Conclusion

Thus, in the present work the technology of the switched local area networks' models development is represented. Also, the principles of the estimation of network response time with the help of the simulation system Design/CPN is described. Colored Petri nets usage allows the peculiarity of interaction within the client–server systems to be taken into account.

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