Simulation of computer network with switch and packet reservation

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Abstract. Simulation model of computer network based on switch Ethernet and redundant transfer is developed and researched. Efficiency of this model using on configurations with different redundancy ratio is defined. The aim of the work is the studying of the redundant transfer in computer networks. The efficiency analysis of the redundant packet transmissions is carried out on the basis of simulation modeling. The complex efficiency of the redundant packet transmission is determined based on the multiplicative index, which takes into account the error-free transmission and the average time margin relative to the maximum permissible transmission delay. The presented results can be used in the design of the high-reliable computer systems including the computer systems providing real-time services. Recommendations for using the presented results are described in the assigned section of this paper and in the conclusion.

Keywords: Simulation modeling, network switch, computer networks, channel aggregation, redundant transfer, OMNeT++.

1 Introduction

Currently, there is important problem of increasing the reliability, fault tolerance, security and performance of distributed computing systems and networks of various application purposes, including those operating in real time under the conditions of possible targeted destructive impact on the channel in order to distort the transmitted data or prevent transmission at all [1-5].

The reliability and fault tolerance assurance of networks [6] with the reduced delays during load balancing is achieved when the communication channels are reserved and aggregated, which is important for the real-time systems. Using high-level protocols, which guaranteed delivery, such as the TCP protocol (Transmission Control Protocol), is impossible, since the relevance of the transmitted data is lost for a period of time during which the packet loss will be higher, and the transfer process will be reinitiated.

Using reservation at service of requests for sending packets is perspective approach to solve the problem of timeliness of data delivery at the link channel. This solution is modification of concept reducing delays of service in computer

systems with cluster architecture [7] based on dynamic redistribution and redundant service of requests in different nodes of cluster. The effectiveness of improving the timeliness of transmissions based on redundancy in networks in a client-server architecture without detailing of the choice of protocols and network equipment is researched in paper.

Efficiency of redundant transmissions at peer-to-peer interconnection in switching net-work is researched in this article.

2 The purpose of this work

The purpose of this work is studying of improving of packets timely delivery probability in the local computer networks based on the switched Ethernet at reservation of network switches and creating copy of packets which will be send for target node via different switch-es. The environment for modeling computer networks OMNeT++ was chosen as a simulation package. This environment provides the user with the ability to build networks based on the real network protocols at all levels of the reference network model. To achieve this goal, it is necessary to develop the computer network models in the OMNeT++ environment, conduct experiments with various options for the channel aggregation, and highlight areas for the rational use of the computer network to improve the efficiency of the computing system in the conditions of unreliable transmissions.

3 The object and objectives of the study

The object of the study is the distributed computer network which consists of n network switches and m peer-to-peer clients connected to switches which generate the data destined to each other at random times. Scheme of considered computer networks and traffic directions are shown at Fig. 1.

The probability of the bit errors in each of the communication channels of this system is B. The data flow generated by each client is the simplest with the intensity . To increase the probability of delivering messages to the server in this system with the channel redundancy the transfer of the packet copy transmissions with multiplicity K is applied, where K shows how many switches are used to deliver the copies of the packet to the server from each client. However, it should be worth considering that switches like other net-work equipment have input and output queues and with increasing redundancy ratio in the system increases the probability of delivery; however the size of queues in switches also in-creases which entails the increase of the total frame stay time in the system. Channel division between clients helps to realize ability of redundant transfer. For ex-ample, if K = 2 then every client send own traffic via two network switches, if K = 3 then client send via three network switches etc. In this way, delivery probability is increasing. Criterion for evaluating the effectiveness of using one or another method of the redundant packet transmission, which is the criterion M = P(t0 T), reflecting the average time of error-free and timely transmitted packets from the client to the server, where P is the probability of

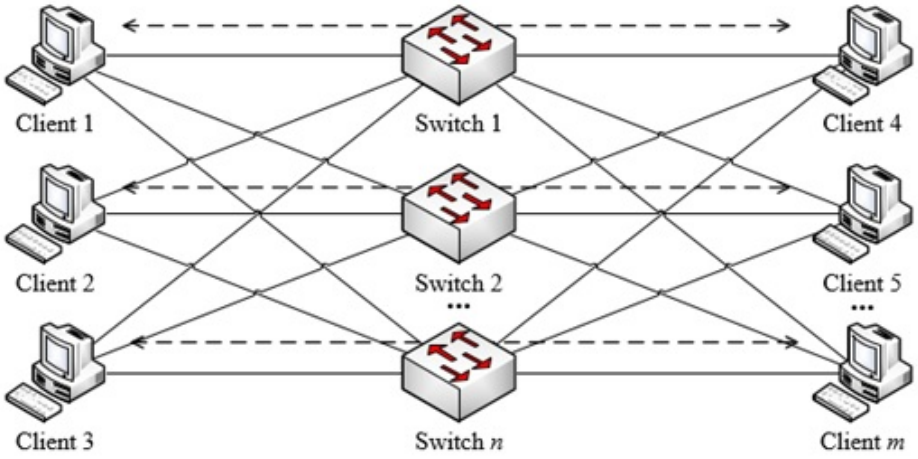

Fig. 1: Computer network system.

the timely and error-free package delivery, defined by simulation, t0 is the time limit for the timely delivery acceptable for a given system, T is the average time the package has been in the system.

4 Developing simulation model

The OMNeT++ simulation environment provides many different network protocols and traffic generators using these protocols. In this work, the UDP protocol (User Datagram Protocol) is used, as it is assumed to transmit the data sensitive to the delay for controlling actions on the real-time system. OMNeT++ environment implements various types of generators and users of UDP traffic. The UDPBasicApp application generates packets of a certain size with a given intensity to the address specified in the configuration file. The UDPSink application listens to the specified port and receives all packets that came to the socket from the source. However the application data models do not assume the use of the redundant transmission: the generator application sends only one packet to a given communication channel, and the recipient application cannot recognize copies of the same packet and receives them all, assuming that they are different packets from the source. The OMNeT++ modeling system is writ-ten in the C ++ programming language and allows to modify the kernel of the system and the developed models. To enable the development of the models with the redundant transmissions, new application classes that extend existing ones have been developed. This classes allow to send copies of packets via different channels for redundant transmissions.

The simulation model of the above system with three switches and six peer-to-peer clients was built after finalizing the components for modeling. This model is based on the EtherSwitch switch model and the StandardHost model, which

represents the clients and server of the simulated system. Fig. 2 shows the constructed model of the system under investigation in the OMNeT ++ environment. The developed model allows to set the parameters in the configuration files and the initialization files of the modeling process for the study and study of various options for the implementation of the transmission redundancy.

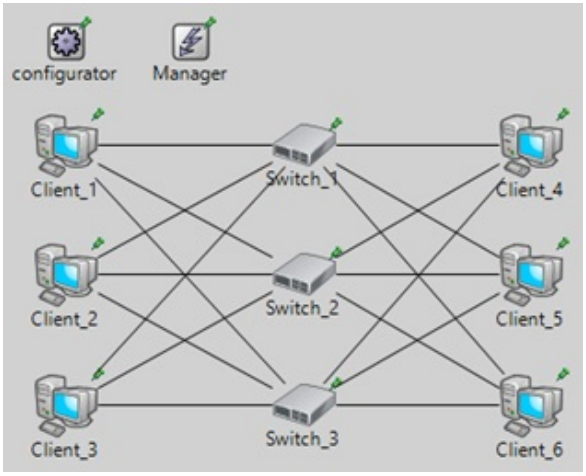

Fig. 2: The simulation model of the network with the possibility of the redundant transfers in the OMNeT ++ environment.

All clients are divided into groups of two, for example Client_1 and Client_4, Client_2 and Client_5 and so on. In every group all clients send and receive traffic. In case of the redundant transmission every switch is used by more than one client.

We will conduct a series of experiments with specified parameters and varying the redundancy ratio: L = 10 Mbit/s - bandwidth of the communication channels connecting clients and the server to the switches, t0 = 0.0005 s - delivery time margin, B = 0.0001 - bit probability channel errors, = 2000 1/s - the packet receipt intensity, the packet length for the entire modeling process is assumed to be 100 bytes.

Fig. 3 shows the chart of the criterion M on the redundancy multiplicity of trans-missions K at a packet arrival rate of 2000 1/s and 5000 1/s. It can be seen from the chart that the selected performance criterion M takes large values at lower intensity, which indicates small queue sizes in network switches. At greater intensity and with an increase in the multiplicity of redundancy due to the transmission of copies of the queue packets in the commutators they grow which leads to an increase in the residence time of packets in the system and reduces the value of the efficiency criterion. Thus, in this network configuration packet trans-mission with less intensity is more efficient.

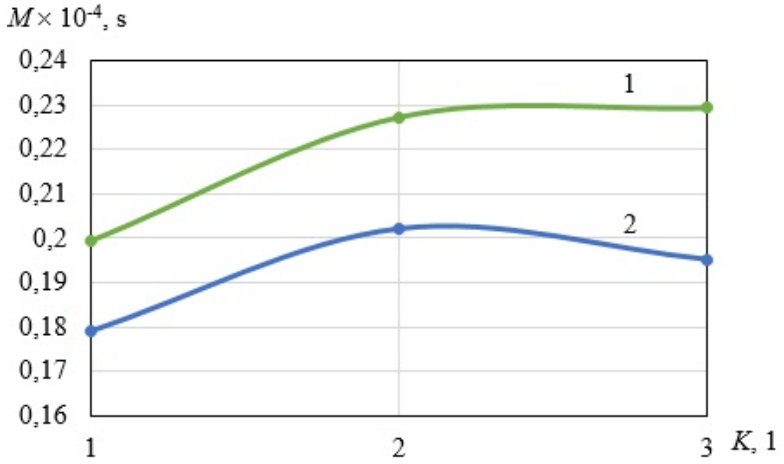

Fig. 3: The dependence of the efficiency criterion M on the redundancy ratio K: at an intensity of 2000 packets per second (curve 1); at an intensity of 5000 packets per second (curve 2).

Fig. 4 shows the chart of the criterion M on the intensity of the packet arrival at various transmission redundancy coefficients. It can be seen from the chart that an increase in the transfer redundancy factor is not effective over the entire range of permissible intensity values. There is a visible area in which transmission with a high redundancy ratio is more efficient in a single network configuration. After overcoming the intensity threshold of 5000 packets per second the redundancy scheme becomes less efficient. The result is due to an increase in the amount of traffic on the network which leads to the emergence of queues in the network switches. Due to delays of the transmitted packets in queues of network switches the residence time of packets in the system is increased and the overall efficiency of the transmission decreases. The probability of the packages delivery increases. To achieve transmission efficiency at an intensity of up to 5000 packets per second the redundant scheme should be used, with an increase in intensity, an unreserved scheme should be used. It is necessary to use the redundant scheme to ensure a greater probability of delivery. However, in this case the aver-age residence time of the packet in the system will increase due to will increase queues in network switches.

5 Conclusion

Simulation model of computer network based on switch Ethernet that allows increasing transmission redundancy is developed via OMNet++ simulation environment. Simulation experiment with different intensity and redundancy ratio are carried out. Areas of applications of transfer redundancy at channel aggregation in computer networks based on switch Ethernet are identified.

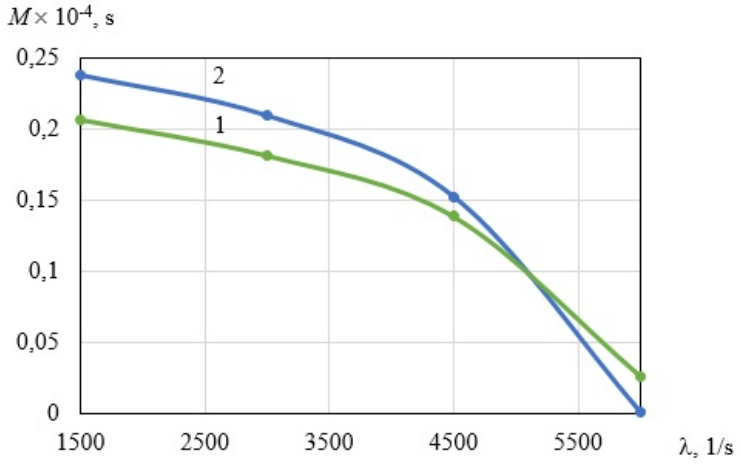

Fig. 4: The dependence of the efficiency criterion M on the intensity of packet arrival: with the multiplicity of the reservation K = 1 (curve 1); with the multiplicity of redundancy K = 3 (curve 2).

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