INCREASING THE EFFICIENCY OF DATA EXCHANGE IN A COMPUTER NETWORKS BASED ON THE PROTOCOL OF TCP/IP SUITE

Samuel Ndueso John
Donetsk National Technical University
Computer and Information Department, Donestk, Ukraine
Johnsam8@hotmail.com

Abstract

John S.N., Increasing the efficiency of data exchange in a computer networks based on the protocol of TCP/IP suite. *Computer networks play an important and ever increasing role in the modern world. The development of Internet, the corporate intranet, and mobile telephones have extended the reach of network connectivity to places that some years ago would have been unthinkable. This intensive development of modern computer networks and realizing their program-hardware systems results in sharp growth, toward increasing of workload and complication of computer networks base on the protocols of TCP/IP. Many protocols are modeled as finite state machines.*

Toward increasing the effectiveness of computer network in computer networks, it is very necessary to work and make research on the factors that really affect the effectiveness of networking connectivity. One of the main factors of it is the adequate mechanism of the protocols that plays great part in data transmission – the TCP/IP (flow and congestion control mechanisms that are used within TCP mechanisms are important in that they directly influence network throughput). The research carried out based on this protocol shows how it can be possible to increase the efficiency of data exchange with increasing network throughput without additional expenses on infrastructure of the network.

This paper will discuss the use of protocols to meet the technology challenge of increasing the efficiency of data exchange in a modern network application and computing network environments based on the protocol of TCP/IP.

Introduction

The Internet has pushed networking technology into the mainstream and it is without doubt the most important network, both in terms of technology advances and social impact, in the world. The number of host computers connected to the Internet continues to increase at unceasingly rate and shows no

sign of slowing down [2]. This growth, illustrated in Figure 1, has placed strain on the network infrastructure that was built on what were, at the time ARPANET created – "experimental technologies".

The Internet uses packet switching technology to transmit data, i.e. data that is to be transmitted over the Internet is split into small chunks, known as packets. These packets are then transmitted one at a time across the Internet where they are reassembled at the receiver.

The basic building blocks of the Internet are the protocols of TCP/IP suite [1, 6], which may be modeled as a stack of protocols split into several layers [2]. The underlying protocol at the network layer, Internet Protocol or IP is a connection-less best effort protocol, meaning it has no connection establishment phase or authentication, and it does not provide a guarantee that the data sent will reach its' destination [1]. Reliable delivery is provided by the Transmission Control Protocol, or TCP of which great emphasis will be laid onto, in this paper.

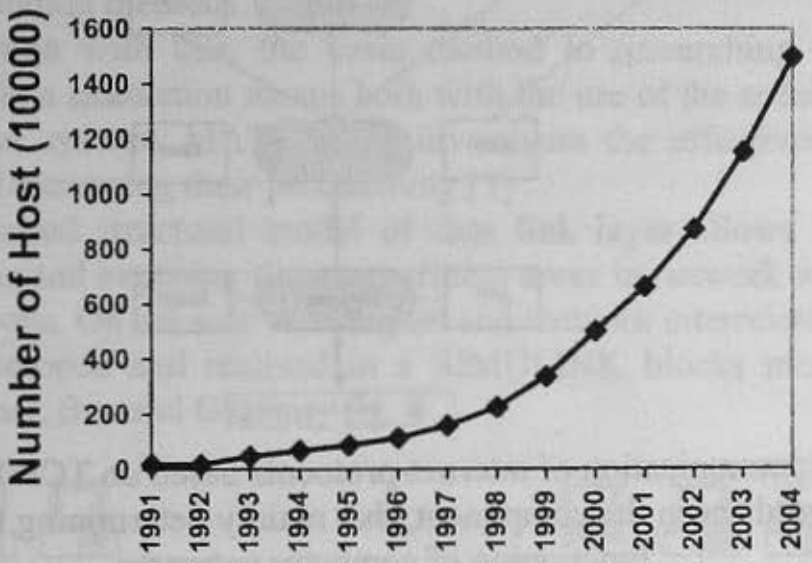

Fig. 1. The rate of computers connected to the Internet (hosts, i.e. having an IP-address) example of corporate network

However, the properties that make the Internet so effective and successful also make it vulnerable to degradation in performance or "Internet Meltdown" or "congestion collapse" [4]. Several aspects of the underlying Internet technology are showing their age and reaching the point where other approaches need to be explored if the growth rate and stability of the Internet is to be maintained. These areas include effectiveness data transmission over a network and congestion avoidance control [3].

Base on the review research, toward the factors affecting the efficiency of data exchange in computer networks through TCP/IP protocols and basic problems in the given aspect will be analyzed in this paper.

Features of network data exchange based on the TCP/IP protocols

Corresponding rate of development and complexity becomes the characteristic in this period and for corporate networks in large firms, organizations and universities. In the 90-ies, thanks to the sudden growth of Internet infrastructure, based on the use of TCP/IP protocols suite starting from formation of large-scale network structures, which presently meet from one high difficult super computer combines hundred of million computers together (fig. 2).

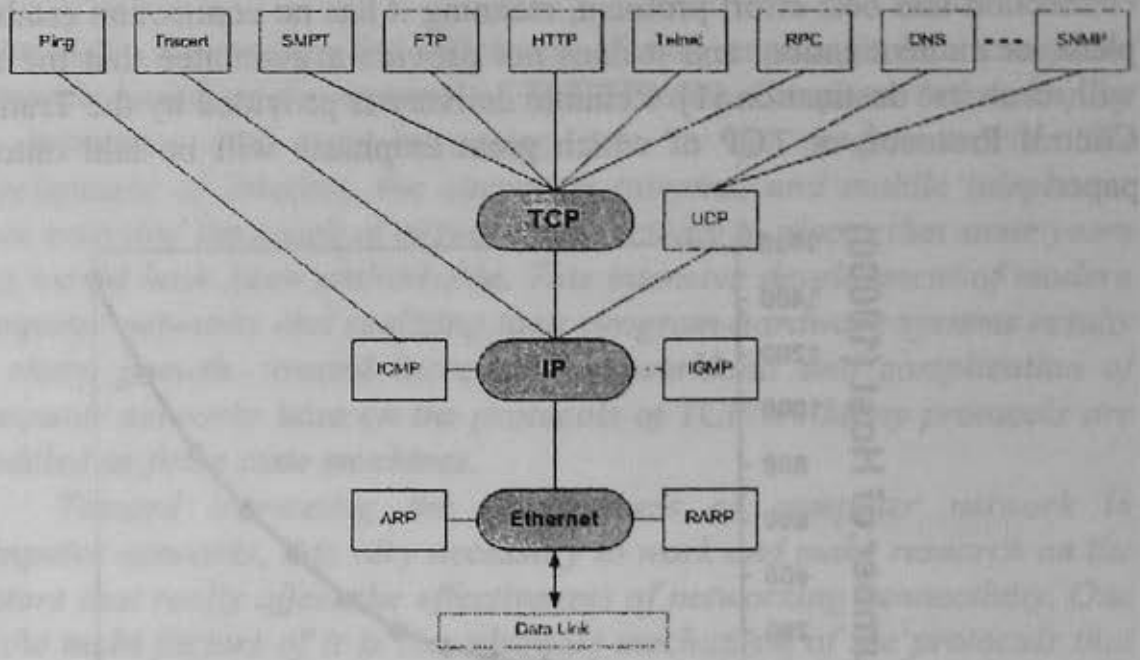

Fig. 2. Intercommunication of internet-protocols based on TCP/IP suite with the selected words been the component, that mainly determining the efficiency functioning of computer networks

In fig. 3. shows the basic listed components problem of a network, which results into ineffectiveness realization or ineffectiveness uses which can negatively affect the network throughput, both all network and separate fragments or network applications.

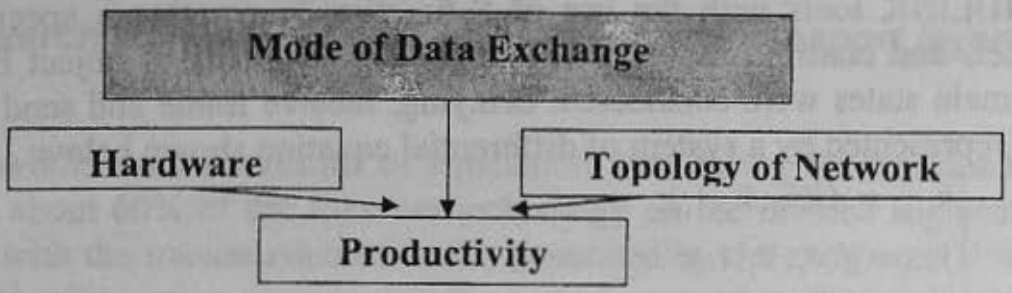

Fig. 3. Factors, determines the bandwidth of a network

The dynamics processes of data exchange in a distributed computer networks is so difficult, that to describe it in a linear or nonlinear analytic aggregation functions way with sufficient accuracy are extremely difficult [6]. Therefore functional communication of network performance with influences on them the factors can be described only in a non-obvious kind with the use of algorithmic simulation methods.

In connection with this, the basic method in researching the network efficiency is using a simulation means both with the use of the specialized tools, and the universal systems MATLAB to investigate the effectiveness of data transmission and increasing their productivity [7] .

The developed structural model of data link layer allows defining the basic descriptions and exposing the most critical areas in network with different modes of operations. On the side of transport and network interrelations layers, a model were developed and realized in a SIMULINK blocks model of three objects types: Host, Bus and Gateway fig. 4

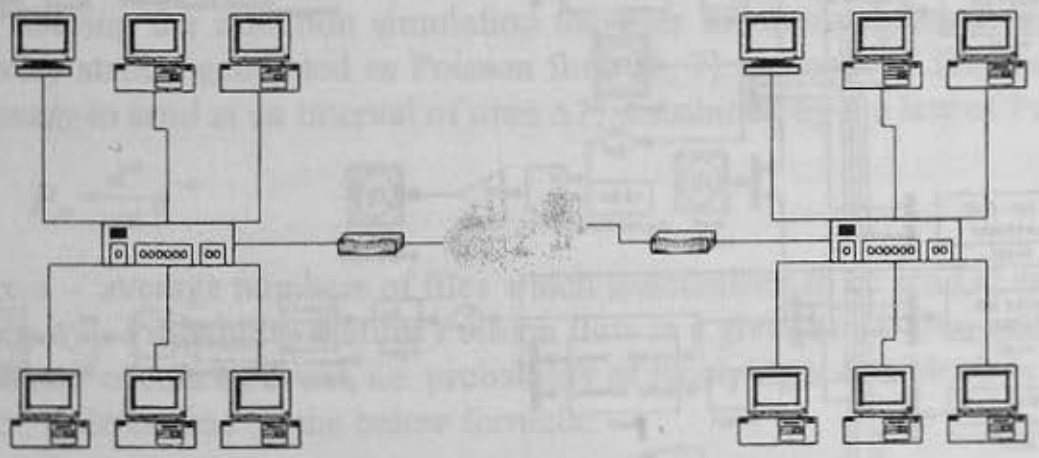

Fig. 4. A fragment model of corporate network on TCP/IP protocols

The element of Host realizes base on the principles and functions of protocol TCP/IP and Ethernet (basic features of CSMA/CD protocol) [6, 7, 9] data from the bus goes into Host which are generated by known principle of data flow – Poisson principle of data flow. The models was realized base on the

SIMULINK tools with the use of S-function in creating a special blocks of models and control programs. In the simulation model of object Host three of it's main states were considered: delaying, receive frame and send frame. Host was represented by a system of differential equation shown below:

$$\begin{cases} \bar{x}_{i+1} = \bar{G}(\bar{u}_i, \bar{x}_i, t_i); \\ \bar{y}_{i+1} = \bar{g}(\bar{u}_i, \bar{x}_i, t_i); \\ t_{i+1} = t_i + \Delta t. \end{cases}$$

where $\bar{x}_{i+1}, \bar{x}_i$ – values of variable state vector of Host;

$\bar{y}_{i+1}$ – value of variable output vector of Host;

$\bar{u}_i$ – value of variable input vector of Host;

$\bar{G}, \bar{g}$ – vector-function;

t_{i+1}, t_i – values of model time;

Δt – step of simulation.

With the use of the offered simulation models on elements of TCP/IP [5, 7] network fig. 5, it is possible to development a simulation models of both local and corporate networks.

The possibly effectiveness of a network data exchange substantially relies on the correct choice of network parameters and this is due to the complication theoretical estimation of the real parameters [5 p. 193], in this case, their values can be appraised by proper simulation models.

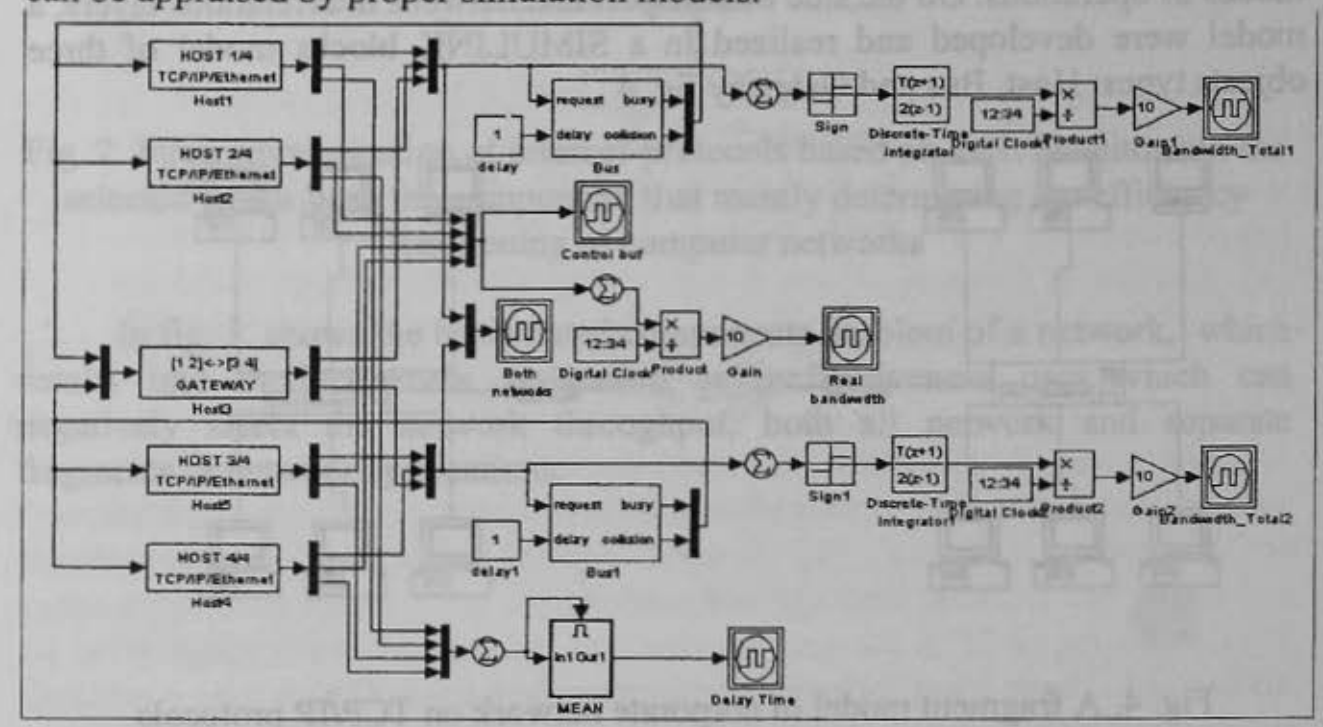

Fig. 5. Model of SIMULINK with two local area networks connected by gateway

In a whole from the results of simulation, that during the workload on a network to about 60% of the Ethernet technology on the divided segment gets well along with the transmission of traffic generated by the end ports. However at the growth of intensive generated traffic to such size, when the coefficient use of the network approaches 1, probability of collision frames is so multiplied, that most frames, which some station tries to send run into other frames, causing collisions, that is displayed on fig. 6.

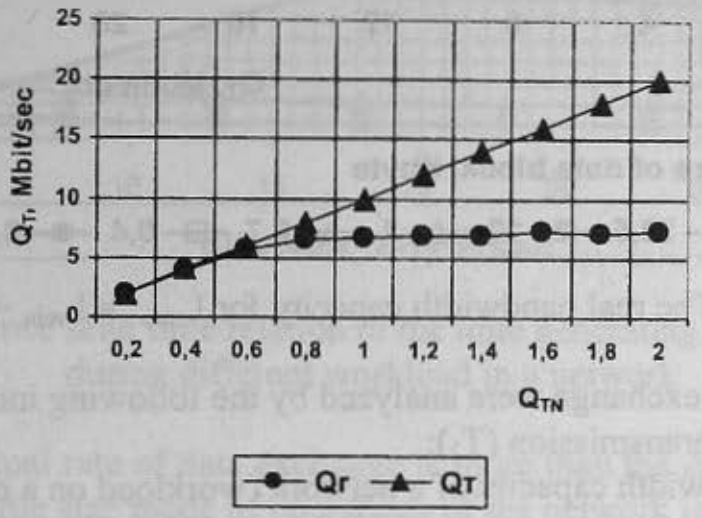

Рис. 6. Shown dependence of bandwidth capacity of the Ethernet network on Q_{TN}

During the imitation simulation the files for transmission were adopted, on every station generated as Poisson flow [4, 7]. Amount of files m, which is necessary to send at an interval of time ΔT, distributed by the law of Poisson:

$$P_m = \frac{a^m}{m!} e^{-a}$$

where a – average numbers of files which is necessary to be send at an interval of time ΔT. Probability that for Poisson flow in a given small area with change in time ΔT occurs an event, i.e. probability of receiving a data block in the TCP buffer, is determine by the below formula:

$$P(\Delta t) \approx \lambda \Delta T$$

The above formula helps in realizing the principle features of protocols TCP/IP when an event takes place at the transport layer down to link layer.

In fig. 7 shows the dependence of the real bandwidth capacity to a network workload over a computer network for L_{max} and L_{min} = const). Analysis of the graph concludes that as the Q_T increase to 10 Mbit/s, the real traffic also increases. Falling of the real bandwidth capacity takes place after exceeding the

standard speed of Ethernet transmission (10 Mbit/s). This shows how irrational file size affects the network performance in a corporate network.

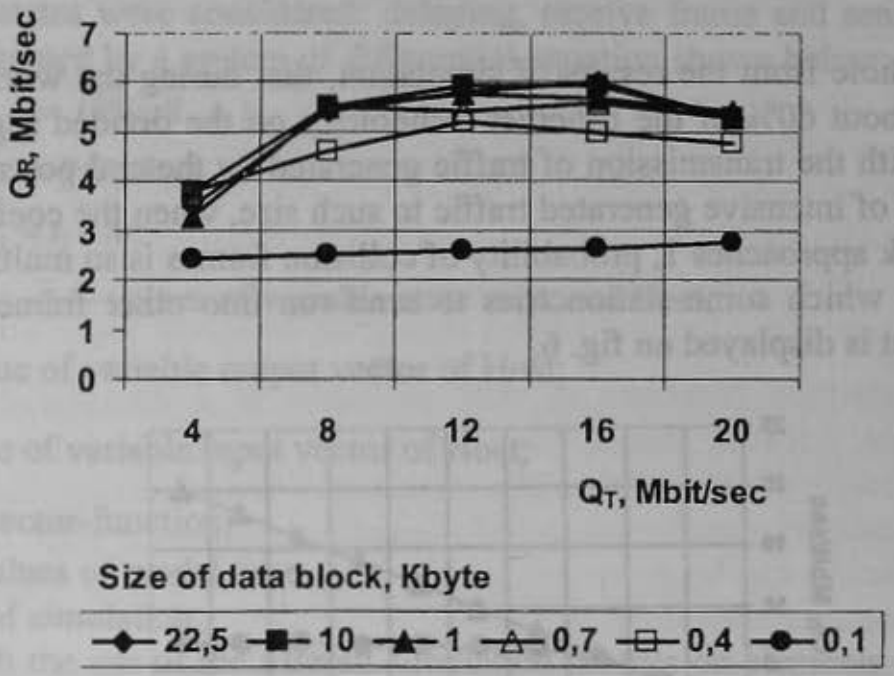

Рис. 7. The real bandwidth capacity for $L_{max.}$ и L_{min} = const.

The modes of files exchange were analyzed by the following indexes:

1. time of data transmission (T_2);
2. require bandwidth capacity of a network (workload on a network) (Q_T):

$Q_T = \frac{I}{T}$, Kbyte/sec, where I – general information subjected to be transmit, Kbytes

T – time of data exchange, sec

Time of data exchange was determined by the following formula:

$$T_2 = (\Delta T + T_{transmission})\, n_f, \text{ sec}$$

where $n_f = I / L$ - quantity of the files passed by every networks, ΔT – time delay at data exchange due to collisions and other problems;

$T_{transmission}$ – spontaneous time of direct data exchange $T_{transmission} = I/Q$.

Then, the optimum condition of fast-action will be $\frac{T_2}{T} = Q_T\left[\frac{1}{Q_N} + \frac{\Delta T}{L}\right] \rightarrow \min$ got from minimizing the correlation of the time of data transmission and time of data exchange.

The analysis of relation on general time needed in data transmission to time (real) (or effective) exchange allows the exposing of three main modes of operations and shown on fig. 8:

First: the real rate of data exchange is below the rate that it's generate and the productivity of the distributed environment is limited by the bandwidth capacity of the network.

Second: actual rate of data exchange corresponds to the set workload, fulfilling the maximum burst performance of the distributed environment.

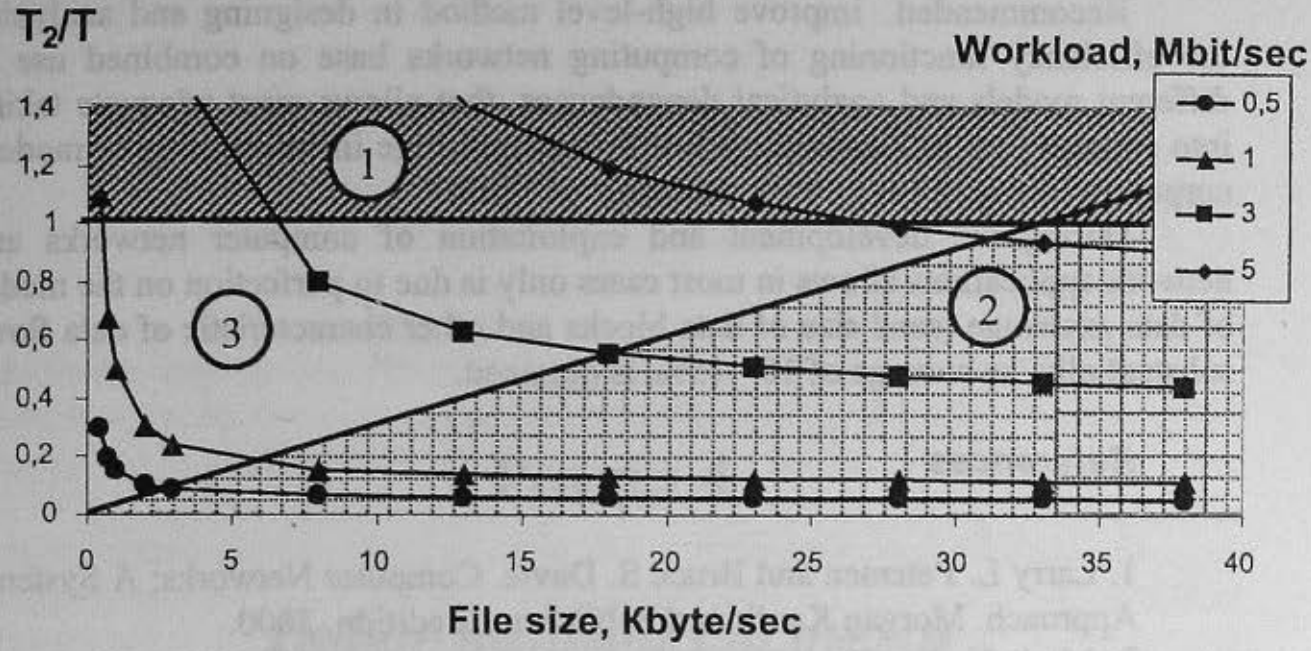

Fig. 8. Dependence send time relation to the time generating data from file size during different workload in a network

Third: actual rate of data exchange is more than the speed generated, but due to irrational file size mode of operations of the network is not optimum.

In the number of other results of simulation confirmed from a well known fact, that workload more than 60% from a nominal data rate in a network distributed environment works in a mode of substantial loss of productivity data exchange.

Conclusion and Suggestion

In this paper we presented a model for generating realistic workload distributions for corporate intranet networks and the Internet using the Matlab/Simulink and NetCracker applications. This model captures the temporal and spatial interactions between sources and the network and the connections themselves.

In education, WWW-based training offers the opportunities to enhance traditional courses encourage life-long learning and enable a more flexible, self paced approach to suit the needs of, for example, disadvantaged members of society or people returning from career breaks. In enhancing this service, an effectiveness use of computer network is important, i.e. the most commonly used protocol TCP/IP.

Eliminate time waiting for acknowledgements and minimizing network traffic gives improvement of network performance through the use of the research results and method recommended.

Recommended improve high-level method in designing and analyzing the efficiency functioning of computing networks base on combined use of different models and analytical dependences, that allows most adequate taking into account the influencing modes of data exchange in functioning of modern corporate networks base on the protocols of TCP/IP.

During the development and exploitation of computer networks and network applications allows in most cases only is due to perfection on the modes of data exchange (send size of data blocks and other characteristic of data flow) substantially, an average of 10 - 15%, is obtained.

References

1. Larry L. Petersen and Bruce S. Davie. Computer Networks: A Systems Approach. Morgan Kaufmann Publishers, 2 edition, 2000.
2. Mark K. Lottor. RFC 1296: Internet Growth (1981-1991). Technical report, Internet Engineering Task Force, 1992.
3. John Nagle. RFC 896: Congestion Control in IP/TCP Internetworks. Technical report, Internet Engineering Task Force, 1984.
4. Klienrok L. Computing systems with queuing. – M.: Peace, 1979. – 600 p.
5. Olifer V.G., Olifer N.A. Computer network. Principles of technologies, protocols – SPB: Publication «Inter», 1999. – 668 p.: illustration.
6. Stevens W.R. TCP/IP Illustrated, Volume1: The Protocols, 1998, 576 p.
7. John S.N., Anoprienko A.Y., Niru A. Multilevel simulation of networks on the base of TCP/IP protocols stack using Matlab/Simulink environment. Matlab/Simulink // Information cybernetic and computing texnika: Publ. 39. scientific journal – Donestk: DonNTU – 2002. – p. 271–297.
8. John S.N., Anoprienko A.Y., Rishka S.V. Simulating of university network infrastructure /Publ. KremeshuK State Technical University. Scientific journal KSTU #2 (11). – Kremenshuk: KSTU – 2001. – p. 271–297
9. Norman Matloff, Some Utilization Analyses for ALOHA and CSMA Protocols. University of California at Davis, 2000.

Дата надходження до редакції 10.06.2005 р.