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TASHKENT UNIVERSITY OF INFORMATION TECHNOLOGIES

CENTRE FOR THE DEVELOPMENT OF SOFTWARE
AND HARDWARE-PROGRAM COMPLEXES

SCIENTIFIC AND TECHNICAL SOCIETY OF RADIO ENGINEERING,
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PERSPECTIVES FOR THE DEVELOPMENT OF INFORMATION TECHNOLOGIES

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THE STATE COMMITTEE FOR COMMUNICATION, INFORMATIZATION AND TELECOMMUNICATION TECHNOLOGIES OF THE REPUBLIC OF UZBEKISTAN

TASHKENT UNIVERSITY OF INFORMATION TECHNOLOGIES

CENTER FOR DEVELOPMENT OF SOFTWARE PRODUCTS AND HARDWARE-SOFTWARE COMPLEXES UNDER THE TUIT

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secure the exchange of key information and establish an encrypted communication channel between them.

In LTE, stored and user authentication methods in relation to the map USIM, as in the conventional mobile communication: the user can lock the phone PIN-code. Provides new functionality for new scenarios, including inter-machine communication (M2M), and single authentication (SSO). In addition, the protection from unauthorized connections over IP-based network multimedia IMS.

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SIMULATION MODEL OF BACKBONE NETWORK

Amirsaidov U.B., Mahmudov S.O.
Tashkent University of Information Technologies
e-mail: u.amirsaidov@tuit.uz, s.o.mahmudov@gmail.com

Abstract: *Conducted simulation and evaluation of QoS packages to backbone networks, obtaining histograms about distribution of delay time of packets, conducted approximation of obtained histograms, proposed empirical formula for calculate the probability of timely delivery.*

Keywords: *next generation network, modeling networks, backbone network, queuing networks and systems, average packet delay, probability timely delivery of packets*

1. Introduction

Networks NGN built on the basis of packet switching technology. Queues are integral attributes of networks with packet-switched. The principle of operation of such networks implies the availability of buffer for each input and output interfaces of network devices (switch, router, bridge, gateway), in communication with which most appropriate mathematical apparatus research of networks NGN is the theory of queues (Queuing theory).

The process of modeling networks NGN, as well as any complex, spatially diverse systems is a complex procedure. For simplify the process of modeling the entire process is broken down into separate steps. At each from steps put a specific task from general list of solved tasks modeling. The results of the i-th stage of the simulation are used as input data for the i+1-th stage. Using such an approach allows to simplify (decomposition method) the modeling process.

In accordance with the decomposition method and queuing theory generalized mathematical model of the networks NGN can presented as interconnected totality of models of queuing networks, modeling processes of functioning components of (segments) network.

The aim of this work is modeling and evaluation of quality indicators service packages in backbone network NGN.

2. Modeling backbone network

Modeling processes of functioning backbone network includes the following steps:

- tasks structure of backbone networks;

- solution problems of routing and flow distribution by priority;

- decomposition of the network into independent components - switching nodes, corresponding communication channels;

- calculation indicators of quality of functioning at specified paths of information transmission.

The structure of the backbone network is described by graph $G = (V, E)$, where V- set of vertices (nodes); E- set of arcs (communication channels). Every arc $(i, j) \in E$ has bandwidth c_{ij}.

Let each node i $(i = \overline{1, N})$ has a buffer memory, capacity which allows us to consider this node with unlimited queue. The flow packets of type k $(k = \overline{1, K})$, emerging at the node i and intended node j is an arbitrary with average intensityλ_{kij}. On based selected routing method is given by matrix probability packet $P = \{p_{ij}\}, (i.j = 1,2, \dots, N)$.

At nodes of network uses the discipline service of packages with relative priority. Distribution service time of packets of type k in node i is an arbitrary with average intensity μ_{ki}.

Necessary to determine the parameters of QoS packages in the backbone network.

Analysis complex network can implement on the basic method of decomposition network. In this network parameters are calculated on basis of node characteristics.

Nodal element of the network is the router packet. The basic components of the router are:

- controller reliability of packet;
- controller "lifetime" of packet;
- classifier of incoming packets;
- shaper of queues packets considering the selected transmission route;
- planner service packets.

Processing packets at the router occurs as follows. Package, by enrolling at the input of the router, falls into controller which will check the reliability of the received packet based on the checksum (CRC). If packet take with errors, then it is deleted (discarded). Next check the "lifetime" of packet in the network. If "Lifetime" of packet expired, packet is discarded. Packet is received without errors and zero "lifetime" is directed to the classifier which is based on packet header identifies its class. Next shaper of queues on the basis of queuing algorithms (RED, WRED, SFQ) distributes the packets on the buffer memory according to the selected route and the classes of packets (traffic view). When forming queues of packets can also be discarded (for example, at overload). Planner on basic algorithms of service (FCFS, WFQ, CB-WFQ, GPS) selects packets from queues and transmits to communication channel in accordance with the selected route.

Probability - temporal characteristics of router is caused by processes of waiting packets in queues, and service packets of controller, shaper of queue and planner. Therefore in the work for simulate the operation of the router using a queuing system (QS) with multi-phase service.

For decomposing network is necessary to determine the intensity of flow packets of type k at each node of the network based on the following balancing equation of intensities of flows at input and output nodes:

$$\lambda_{ki} = \lambda_{0ki} + \sum_{j=1}^{N} p_{ji} \lambda_{kj}, \quad (i = \overline{1, N}), \qquad (1)$$

where, λ_{0ki}- average intensity of the incoming flow type of packet k to node i from the external environment (0).

Coefficients download nodes flow type of packet k define as:

$$\rho_{ki} = \frac{\lambda_{ki}}{\mu_{ki}}, \quad (i = \overline{1, N}) \qquad (2)$$

Coefficients download nodes:

$$\rho_i = \sum_{k=1}^{K} \rho_{ki} \qquad (3)$$

Condition of existence stationary mode functioning network:

$$\rho_i < 1, \ (i = \overline{1, N}) \qquad (4)$$

Average packet delay of type k in the network is:

$$\bar{t}_{kdelay} = \sum_{i=1}^{N} \sum_{j=1}^{N} \bar{t}_{kij} p_{ij}, \qquad (5)$$

where, $\bar{t}_{kij}$- the average time packet delivery of type k from node i to node j

The probability of timely delivery packets type k:

$$Q_{kc} = P(t_{kdelay} \leq T_{kn}), \qquad (6)$$

where, T_{kn}- normalized value of the delay time packets type k.

Exact analytical expressions for (5) and (6) are defined only for the exponential networks consisting of nodes type M/M/m [1].

In this work is conducted analysis of non-exponential networks with using simulations.

Modeling and analysis of nonexponential network is conducted in programm AnyLogic.

Analysis of the results shows that knowing the probability of timely delivery packets into nodes $Q_i (i = \overline{0, N})$ (N- number of nodes in the route of packets transmission), it is impossible to determine the likelihood of the timely delivery of packets in the network Q_c.

For calculating Q_c necessary to determine density distribution of the delay time packets in network:

$$f_c(t) = f_1(t) * f_2(t) * \dots * f_N(t), \qquad (7)$$

where, $f_i(t)$- density distribution of the delay packets at a node ,

* - sign operations of convolution density of distribution.

By simulation modeling obtained histogram of distribution of delay packets in the nodes and the network at various N. Analysis of obtained histogram shows that the density distribution of the delay packets in the network $f_c(t)$ with the increase of N approaches to a normal distribution. Necessary to determine the distribution law $f_c(t)$ (t) for small values of N. Coefficients of variation delay time packets in the network v at different N is less than 1. For approximation of distribution law of random variables with $v \leq 1$ used Erlang distribution k-th order.

Average delay time of packets in nonexponential node i with dependence of the flow is defined as [2]:

$$\overline{t_{delay\, i}} = \frac{1}{\mu_i(1-P_{w\,i})}, \qquad (8)$$

where, μ_i- intensity of service packets in node i;

$P_{w\,i}$ - probability of waiting packets in queue node i, $i = \overline{1, N}$.

The distribution function of the delay time is of view:

$$F_c(t) = 1 - e^{-\frac{kt}{\sum_{i=1}^{N}\left(\frac{1}{\mu_i(1-P_{w\,i})}\right)}} \sum_{i=0}^{k-1} \frac{\left(\frac{kt}{\sum_{i=1}^{N}\left(\frac{1}{\mu_i(1-P_{w\,i})}\right)}\right)^i}{i!}. \qquad (9)$$

Thus, the probability of timely delivery of packets at considered network on the basis of the approximating Erlang distribution of k-th order is defined by the formula:

$$Q_c = F_c(T_{kn}) = 1 - e^{-\frac{kT_{kn}}{\sum_{i=1}^{N}\left(\frac{1}{\mu_i(1-P_{w\,i})}\right)}} \sum_{i=0}^{k-1} \frac{\left(\frac{kT_{kn}}{\sum_{i=1}^{N}\left(\frac{1}{\mu_i(1-P_{w\,i})}\right)}\right)^i}{i!}. \qquad (10)$$

For a single-phase exponential node $P_w = \rho$, $v = 1$ и $k = 1$. Then the formula (10) with the $\mu(1-\rho) = \mu - \lambda$, we obtain the well-known formula for the M/M/1 [1].

3. Conclusion

1. Identified the Empirical distribution delay time of packets in backbone network;

2. Proposed empirical formula for calculating the probability of timely delivery of packets in the network.

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MODELING MULTISERVICE ACCESS NETWORK

Amirsaidov U.B, Ummatov U.A.
Tashkent University of Information Technologies.
e-mail: u.amirsaidov@tuit.uz, uzoqboy@mail.ru

Abstract. *Developed a complex mathematical model of access segment of next generation networks which is different from well-known model that processes in the access segment represented as interrelated models on basis of queuing theory. Developed models and calculation methods of average time of delay and packet loss probability based on the fractal traffic.*

Keywords. *Multiservice access network, access level, level of aggregation, quality of service of packages, queuing networks and queuing systems, fractal traffic, packet delay, packet loss.*

1. Introduction

Provision of combined services «Triple Play» requires a broadband multi-access network (MAN), which is a crucial element of multiservice communication network, determines the level of capability of the operator to provide users with a set of advanced broadband services, is attractive to all market participants, and today is a leading business concept of implementation which is a key task of modern telecommunications company.

It is known that the most important patterns of quality of service are connection establishment process which user receives denial of service and the transmission delay of data streams.

The aim of this work is modeling and evaluation of the quality of service of packages in the multiservice access network.

2. The generalized model of multiservice access network

Object modeling is the future structure of the multiservice access network (Figure 1). Processes the data in the multiservice access network is modeled on the basis of queuing networks (QN), consisting of the following queuing systems (QS) (Figure 2):

- QS1 simulates the transmission of data from the access device to an access node;
- QS 2 simulate the process of transferring data from the access node to node aggregation;
- QS 3 simulate the process of transferring data from node to node aggregation services;
- QS 4 simulate the process of transferring data from node to node of Service aggregation;
- QS 5 simulate the transmission of data from node to node access aggregation;
- QS 6 simulate the transmission of data from the access node to the access device;
- QS 7 simulate the process of transferring data from the aggregation node to the border router line;
- QS 8 simulate the process of transferring data from the edge router to node aggregation.