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# CALCULATIONS OF EXCESS LOAD ON THE NETWORK

**Abstract.** In the modern world, digital technologies have an important role in the development of national economies. Digital technologies have advantages: facilitating public and business access to public services, accelerating the exchange of information, the emergence of new business opportunities, creating new digital products, etc. Accessibility, stability and security of data transmission on the Internet are the technological basis for the development of all industries, as well as the high quality of life of the population. The exchange of information in communication networks in digital form has several advantages such as: a high level of noise immunity and the highest quality in data transmission; the ability to use standard reliable and cheap integrated circuits, which significantly reduces the cost of switching and compaction systems, which are decisive in the cost of the entire network; a great opportunity when combining and processing information of various types in digital form. Currently, most methods for assessing the quality of user service on communication networks used in the design either consider the problem in relation to one-dimensional traffic or do not take into account the influence of a finite number of load sources. This limits its using in solving design problems of multiservice networks, including in areas of subscriber access networks. In this regard, this article discusses a broadband digital network with service integration, based on the ATM technology, which implements an iterative method where the flow distribution is specified by the route matrix, and the load distribution between nodes of each pair of nodes is made through the path tree, obtained by the route matrix when calculating this pair, as well as the development of a mathematical method for calculating the excess load of an asynchronous network when transmitting information traffic by the method of channel switching and packet switching.
**Keywords:** broadband digital network, service integration, asynchronous network, circuit switching, packet switching, switching nodes.

**Introduction.** At the moment, the state program "Digital Kazakhstan" is being implemented. Five main directions have been identified, the third of which is "Implementation of the digital Silk Road", aimed at the development of a high-speed and secure infrastructure for data transmission, storage and processing. The program, which will be implemented in the period 2018-2022, will provide an additional impetus for technological modernization of the country's flagship industries and will form the conditions [1].

As a basis for a high-speed and secure data transmission, storage and processing infrastructure, a broadband digital network with service integration can be used. The increase in the volume of transmitted information and the emergence of broadband channels created the prerequisites for the development of broadband digital networks with the integration of services (services) - W-ISDN (B-ISDN) [2]. Broadband well-protected from interference channels are created thanks to fiber optics. At the same time, the transmission speed of user information can reach tens of Tb/s. Such high-speed modes guarantee high quality of information transfer of various services (television, video on demand, multimedia messages, etc.).

The development of automatic switching technology, the mutual penetration of computer technology into communication technology and communication technology into computer technology led to the development of highly organized adaptive systems for managing communication networks, information flows and processes for servicing subscribers requests for information transfer. Such adaptive control systems ensure on the ATM network the elimination or weakening of the effect of emerging faults of individual network elements and changes in the time flows of information between subscribers and nodes of the network on the quality of customer requests and the quality of information transfer.

The quality of servicing requests for information transfer on the ATM network depends on a number of parameters that, when the ATM network operates, are usually determined in averaged form, and therefore these parameters are often called statistical [3]. The statistical parameters of the ATM network are understood to mean some average physical quantities characterizing the quality of service on the network. For the ATM network, the main statistical parameters are: the capacity of the branches (throughput) of the subnetworks of the circuit switching(CS) and packet switching(PS) in the ATM network, the structural reliability and survivability of the ATM network communication system, the magnitude and nature of the load as incoming to each hybrid node switching in the modes CS and PS [4], and the total load determined on each integral group path of the ATM network, the probability of losses on the branches and between each pair of nodes of the subnetwork CS, as well as the distribution of these losses along the paths and transit network nodes, the value of the average delay in the transmission of messages PC subnet as part of the ATM network.

When developing a model for calculating the statistical parameters of the quality of ATM network service, we will assume that basically this network is intended for transport through multimedia communication channels, that is, mainly for the transmission of video and audio information. This type of information uses the channel switching method, namely, before this information is transmitted, it is necessary to connect virtual channels between the corresponding subscribers of the network. Such a connection of virtual paths is provided by means of special packages called multichannel calls.

Quality of service on the subnetwork CS is usually estimated by the probabilities of losses on the branches of the network and it is known that the quality of incoming calls is characterized by the possibility of connections or the length of waiting for the provision of connections. There are two main ways of servicing incoming calls: lossless and with losses [5,6]. Lossless service is a discipline in which an incoming call is immediately serviced, and with losses, if the incoming call is either denied service or the service is delayed for some time.

**Main part.** Let for some time interval in a node-sender some call flow, destined to a node with the specified address arrives. In general, the address is the coded designation of the point of departure or destination of information data. The address of the object is determined by the number, code, phrase. The list of objects includes registers, memory cells, external devices, communication channels, processes, systems, networks. The recipient objects are usually called recipients. Often the address is associated with the name of the object. As a subnet CS traffic, a random flow of calls arriving in the ATM network to the destination node and intended for the destination node is considered, that is, the call arrival times are random values. In this case, it is assumed that the considered call flow is Poisson (the simplest flow), that is, the ordinary flow without aftereffect. It is known that the simplest call flow is the most common model of the real call flow used in queuing systems, including in teletraffic theory. Using the hypothesis of the Poisson character of the call flow allows one to most adequately reflect the process of processing of each service packet representing the connection request in the CS mode and obtain analytically expressions for calculating all necessary probabilistic and temporal characteristics [7]. Indeed, as noted when considering the principles of classification of call flows, a call flow that transmits in CS mode from a large group of subscribers is characterized by the absence of aftereffects. It can be considered ordinary, and when the time interval is limited and stationary.

One of the most important characteristics of switching systems is their efficiency [8,9]. As indicators of efficiency, along with economic indicators, a technical indicator such as capacity is widely used. Under the capacity of the switching system is meant the intensity of the load serviced by the switching system with a given quality of service. The throughput of the switching system depends on the amount of losses, the capacity of the bundles of lines included in the outputs of the switching system, from the method (scheme) of combining these outputs, the class of the call flow, the structure of the switching system, the distribution of the service time and the service discipline. The amount of losses is normalized either to the switching system as a whole, or for each direction of communication, or for sources of each category. The larger the allowable loss rate, the greater the throughput of the switching system and the poorer quality of communication.

The main purpose of designing a sub-network CS with roundabout directions is to determine the statistical parameters (probabilistic characteristics) that determine the quality of service on the subnet:

– The magnitude and nature of the total load (arriving at each branch or missed for each branch);

– The probability of losses on each branch;

– Loss probabilities between each pair of nodes, as well as the distribution of these losses along the paths and transit nodes of the subnet.

The listed parameters are calculated for the given ATM network structure, the gravity between the pairs of nodes and the static static distribution plan for the subnet of the CS. As a subnet CS flow, the flow of calls arriving in the ATM network to the sender node and intended for the gatekeeper is considered. In general, the address is the coded designation of the point of departure or destination of the data. The address of the object is determined by the number, code, phrase. The list of objects includes registers, memory cells, external devices, communication channels, processes, systems, networks. The recipient objects are usually called recipients. Often the address is associated with the name of the object.

Let $r_i(j)$ be the average intensity of the multichannel calls flow (MC) flowing into the ATM network to the sending node *i* and destined for the gatekeeper *j* [10]. The quantity $r_i(j)$ will be called the input load of the ATM network. It is the average value of the incoming load between the corresponding pairs of nodes in the NNP.

Let $t_i(j)$ – be the average intensity of the total flow of MC passing through the node *i* and destined for the node *j*. The quantity $t_i(j)$ – will be called the node load of the ATM network. It includes both the input load $r_i(j)$, and the loads $t_l(j)$, coming to the node *i* from all adjacent nodes *l*. At the preliminary stage of calculating the probabilistic characteristics of CS on the subnet, the following assumptions are usually assumed [11]:

– The initial call flows arriving at the network in the considered time interval are stationary and Poisson;

– The Poisson nature of the fluxes is retained both for excess and for missed loads;

– The system is in a state of statistical equilibrium;

– System with obvious losses;

– Losses in switching and control devices are not taken into account;

– Connection establishment time is 0.

These listed assumptions determine the degree of approximation of the model under consideration to the real subnetwork of the CS and the accuracy of calculating its characteristics. The initial data when determining the quality of service parameters on the subnet of the CS are (without taking into account the subnet of the PS):

– ATM network structure (location of nodes, capacity of branches);

– Input load for servicing in hour of maximum load between nodes of each pair of nodes;

– Plan for the distribution of flows on the subnet of the CS;

– The probability of loss between the nodes of each pair.

During the calculations, the following parameters are determined for the CS subnetwork [12, 13]:

– Probability of losses on branches;

– Probability of load maintenance by each branch;

– The values of the total load (arriving at each branch, missed by each branch and excessive for each branch);

– Probability of losses in the average on the network (the ratio of the load lost on the whole network to the incoming for maintenance);

– The values of the loads served and lost in each transit node and the entire network as a whole.

Of the listed parameters, the most important are the probability of losses on branches or the probability of servicing by each branch [14, 15], since the remaining parameters can be easily calculated through these quantities.

The order of selecting outgoing directions from the node *i* for transferring the load $t_i(j)$ to all other neighboring nodes, *i*. E. the plan for its distribution is represented by the matrix of routes M for the node *i*.

$$M_i = \begin{array}{c} \\ ik_1 \\ ik_2 \\ . \\ ik_{S_i} \end{array} \begin{array}{c} \begin{matrix} 1 & 2 & \dots & n \end{matrix} \\ \begin{bmatrix} \mu_{ik_1,1} & \mu_{ik_1,2} & \cdots & \mu_{ik_1,n} \\ \mu_{ik_2,1} & \mu_{ik_2,2} & \cdots & \mu_{ik_2,n} \\ . & . & \cdots & . \\ \mu_{ik_{S_i},1} & \mu_{ik_{S_i},1} & \cdots & \mu_{ik_{S_i},n} \end{bmatrix} \end{array}$$

In the matrix of routes, the number of columns is equal $n-1$ (the column in the matrix $M_i$ for the node *i* is absent), and the number of rows are the number of nodes $S_i$, incident with the node *i*. The $M_i$ matrix element $\mu_{ik_{S_i},j}$ is the sequence number of the branch selection $(ik_{S_i})$ when connecting to the node *j*, i.e. $\mu_{ik_{S_i},j} \in \{1,2,..., S_i\}$. If a set of routing matrices $\{M_i, i = 1, n\}$, is specified, this means that an information distribution plan is defined for the entire subnet of the CS. With a static information distribution plan, static (fixed) routing in the CS subnetwork is performed [16]. However, the most efficient use of network resources is achieved with adaptive routing, when the information distribution plan changes in accordance with changing network conditions (overloads in certain directions or sections of the network, damage to canals or their bundles, damage to CS, etc.).

Let's assume that the switching nodes and the communication branches are absolutely reliable. Between each pair of nodes *i* and *j* the network, a number of routes for transmitting loads $L_{ij}, i = 1, n, j = 1, n,$ of the subnetwork of the CS are defined, which form a fully accessible beam. The load $t_i(j)$ can be serviced by any route $l_{ik}$, where the node $k$ is an adjacent node $k$ with respect to the node $i$, $k = 1,2,....$ . The order of routes is determined by the route matrix. Each next route is handled if it is impossible to service the previous route route route. In each branch $L_{ij}$ entering the route when servicing one message, one unused device is simultaneously engaged. In the absence of free instruments and any branch of one route, the path is considered to be blocked [17]. If all routes of the set $l_{ik}$ are blocked, the load $t_i(j)$ receives a denial of service. Under the assumed assumptions, the subnetwork of the CS is a Markov system with a finite phase space whose state changes occur at discrete instants of time corresponding to the arrival times of messages to the subnetwork of the CS.

Let be the $U_d$ set of admissible strategies for managing a network in a state $E_d \in E$. For a subnetwork with failures, two strategies are typical, since each $E_d \in E$ can accept one of the control (service) strategies - to service the message on a certain route matrix route, or for lack of free channels - to refuse service. We will assume that the management of the network $U = \{U_d, d = 0,1,2,...\}$ is Markov, then the functioning of the network can be represented as a controlled Markov process.

For more efficient use of the temporary channels of the path, modern automatic switching systems located on the nodes make it possible to use the roundabout ways (the paths of the subsequent elections) in addition to the main ways of establishing the connection (the way of the first choice) [16]. Assume that the branch ($ik_1$) is part of the path of the first choice. Then the bulk of the load distributed to this branch will be served by time channels $m_{ik_1}$, or we will say that the load is serviced by a branch ($ik_1$). At times when all the temporary branch channels ($ik_1$) are occupied, some of this load remains un-served and a branch ($ik_2$) that enters the path of the second choice is used for its servicing. As a result, the branch ($ik_2$), serves the total load, consisting of loads, both intended for it directly under the plan, and not served by the branch ($ik_1$). If the time channels of the branch ($ik_2$) are not able to completely serve this total load, then its remainder is transferred to the branch ($ik_3$), etc. This process will continue until all the outgoing directions *i* are used. If all these branches are occupied, the resulting load balance on the last direction will be lost. A load served by a branch is called missed, and vice versa, a load that is not serviced by a branch is not missing or redundant.

For clarity, the above described use of bypass directions of load transfer of the subnet CS will be illustrated on a fragment of the network, consisting of the *i*-th switching node and outgoing from it to neighboring nodes $k_1, k_2, k_3$ the direction of the load transfer $t_i$ (figure 1). Assume that the branches (ik$_1$), (ik$_2$) and (ik$_3$) and are part of the path of the first, second and third choice, respectively. Then the bulk of the load $t_i$ with probability $p_{ik}$ will be served by temporary channels, or in this case we will say that the load is serviced by a branch (ik$_1$). At the point in time when all the time channels of the branch (ik$_1$) are occupied, some $t_i(1-p_{ik_1})$ of the load $t_i$ will be served by the branch (ik$_1$) and this part will reach the node $k_1$. The other, the remaining part $t_i$, $p_{ik_1}$, from the load $t_i$ will be blocked by the branch $(ik_1)$ and for its servicing the branch (ik$_2$), entering the path of the second choice is used.

As a result, the branch (ik$_2$) serves the total load, consisting of loads, both intended for it directly according to the plan, and unloaded (ik$_1$) by the load $t_i$ $p_{ik_1}$. If the time channels of the branch (ik$_2$) are not able to fully service this total load, then its maintenance balance $t_i$ $p_{ik_1}$ $p_{ik_2}$ is transferred to the branch (ik$_3$). Since the branch is the last possible direction of transmission, the remainder of the load $t_i$ $p_{ik_1}$ $p_{ik_2}$ $p_{ik_3}$ after its maintenance is lost.

We introduce the following notation. Let K$_i$(j) - be an ordered set of such nodes $k$, which for address *j* form all outgoing from the node *i* of the direction of transmission (ik). In what follows, for quantities indicated by means of an index $k$, it is considered as $k \in K_i(j)$. The ordering of the elements of the set K$_i$(j) is made in accordance with the choice for the $j$ - the outgoing direction of the priority order in the route matrix $M_i$. For example, let from the node $i$ -network, represented in Figure 1, the order of load distribution t$_i$(j) is specified by the route matrix:

$$M_i = \begin{matrix} (ik_1) \\ (ik_2) \\ (ik_3) \\ (ik_4) \end{matrix} \overset{\textstyle j}{\begin{bmatrix} \cdots & 3 & \cdots \\ \cdots & 4 & \cdots \\ \cdots & 1 & \cdots \\ \cdots & 2 & \cdots \end{bmatrix}}$$

In accordance with the elements of this matrix, the branch of the first choice path (ik$_3$) is first used. When it is overloaded, an excess flow is generated, which is served by a sequence of branches $(ik_3)$, $(ik_4)$ $(ik_1)$ and $(ik_2)$. Then set $K_i(j) = \{k_3, k_4.k_1, k_2\}$.

The amount of the missed or overload depends on the probability of loss of traffic t$_i$(j), distributed to the branch (ik). Let $j \in J$, where is $J$ - the set of all destination nodes. Then for the multicast case, i.e. when the number of addresses $|J| > 1$, is assumed that the load balancing system CS located at each node operates in the mode of divided service (for each addressee separately). This means that on the branch (ik) the number of time channels m$_{ik}$ is divided into bits $m_{ik}(j)$, each of which is a group of serving devices in the time cycle necessary for transferring the load only at the destination *j*.

We denote by p$_{ik}$(j) – the probability of loss of load t$_i$(j) on the branches (ik). Since the subnetwork CS is represented by a maintenance system with obvious losses, the value p$_{ik}$(j) takes values in the interval (0; 1] for each branch (ik), participating in the load t$_i$(j) transfer. If the branch(ik) does not participate in the transfer of the load $t_i(j)$, or $(ik) \notin L$, in this case, we assume that $p_{ik}(j) = 0$. The value $p_{ik}(j)$ will depend on the load distributed to the branch (ik) and the time channels $m_{ik}$ allocated for its servicing.

The main purpose of constructing a subnet model of the CS is to determine the probability of losses $p_{ik}(j)$, on each branch (ik), according to which it is possible to calculate all the quality parameters of this subnet. Calculation of the probability of loss relative to each addressee in the CS sub-network with bypass directions is complicated by the fact that these probabilities in the general case depend on the loss probabilities in all other branches. This dependence, taking into account the given plan for the distribution of information flows, is represented by a complex system of nonlinear equations, which will be described below.

To simplify the form of writing such a system of equations, we introduce the following quantity. Let $\varphi_{ik}(j)$ – the parameter characterizing the value of the excess load of the subnet of the CS for all branches preceding the direction, as desired (ik). In other words, the value $\varphi_{ik}(j)$ is the fraction of the load $t_i(j)$, coming into the branch (ik) in accordance with the distribution plan. It is equal to 0 if the branch (ik) is not used in any of the paths connecting nodes $i, j$ and is equal to 1 if the branch (ik) is a branch of the path of the first choice. The share of the share $\varphi_{ik}(j)$ includes the probability of loss of all preceding branches (ik) of the trend. Let us denote $\overline{K}_i(j)$ by the set of such nodes $\overline{k}$, that from the node $i$ form all outgoing branches (ik) outgoing directions. The value $\varphi_{ik}(j)$ represents the probability of employment by referral service (ik), i.e.

$$\varphi_{ik}(j) = \varphi_{i\overline{k}}(j)p_{i\overline{k}}(j) = \prod_{\overline{k}\in\overline{K}_i(j)} p_{i\overline{k}}(j) \tag{1}$$

Since $p_{ik}(j) \in (0;1]$, then $\varphi_{ik}(j) \in (0;1]$, for all $(ik) \in L$. For example, for the network shown in figure 2, according to the elements of the route matrix, the values $\varphi_{ik}(j)$ are:

$$\varphi_{ik_3}(j) = 1, \qquad \varphi_{ik_4}(j) = \varphi_{ik_3}(j)\cdot p_{ik_3}(j) = p_{ik_3}(j);$$
$$\varphi_{ik_1}(j) = \varphi_{ik_4}(j)\cdot p_{ik_4}(j) = p_{ik_3}(j)\cdot p_{ik_4}(j);$$
$$\varphi_{ik_2}(j) = \varphi_{ik_1}(j)\cdot p_{ik_1}(j) = p_{ik_3}(j)\cdot p_{ik_{34}}(j)\cdot p_{ik_1}(j).$$

*The results.* The product $\varphi_{ik}(j) * p_{ik}(j)$ is the proportion of the excess load on the branch (ik), which, depending on the load distribution plan, will be transmitted to other directions that are free for node i, and in the absence of such directions, it will generally be lost at the node*i*. In this case, the load $t_i(j)$ is considered lost in the node*i*, if the time channels are occupied on all outgoing directions (ik), $k \in K(j)$, где $K(j) = \{k_1, k_2, ..., k_s\}$, where $s$ - the number of directions originating from the node $i$. In this case, the probability of $t_i(j)$ load loss $\Pi_i(j)$ in a node $j$ is determined by the formula

$$\Pi_i(j) = \prod_{i=1}^{s} p_{ik}(j), \qquad \Pi_i(j) \in (0;1). \tag{2}$$

Depending on the load condition of each of the subnets included in the ATM network, it is possible to calculate the necessary parameters for the operation of each of the subnets, thereby determining the network resources of the ATM network in a given mode of servicing the subscribers connected to it. Thus, due to the effective redistribution of the bandwidth of the integrated circuits of the network, it is possible to achieve optimal parameters for the quality of service for subscribers of the ATM network; in this case the performance of the subnets CS and PS that are part of the ATM network is growing.

All these factors mentioned above, connected with the problem of optimal allocation of bandwidth between the subnets of the CS and the PS, ultimately significantly improve the efficiency of the integrated network, communication as a whole, and this actually makes the transition to the creation of more economical networks.

Note that since $p_{ik}(j) \in (0;1]$, then $\Pi_i(j) \in (0;1]$.

**Discussions.** Studies of the distribution of the probability of load losses of the CS mode over permissible paths and transit nodes of an asynchronous network using bypass directions for transferring excess loads have been carried out. Building a tree of paths by route matrices. Let the network shown in Figure1 and the route matrix for each node be given.

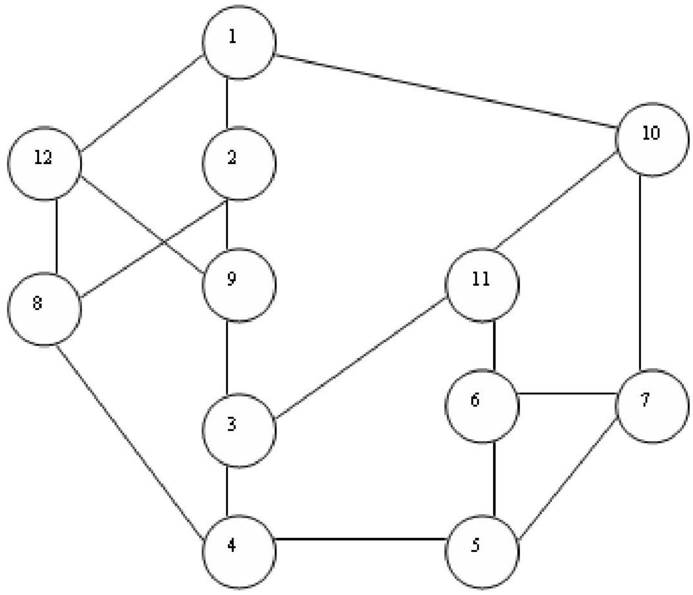


Figure 1 – Transmission network

The rows of the route matrix correspond to the numbers of outgoing directions in the order of their choice, and the columns correspond to the numbers of destination nodes [18]. The matrix element is the number of the neighboring node in the ith bypass direction to the jth node. We construct a path tree for a pair of nodes (1,2), assuming that the length of each path does not exceed four transit sections. To build a tree, we select the corresponding columns of the route matrices of the initial and transit nodes:

$$M_1 = \begin{matrix} l_1 \\ l_2 \\ L_3 \end{matrix} \overset{1\ 2 \ldots\ 12}{\begin{bmatrix} 2\ldots\ldots\ldots \\ 12\ldots\ldots\ldots \\ 10\ldots\ldots\ldots \end{bmatrix}};$$

From the matrix Mi we determine the branches 1 and 2 of the tree, ending in nodes 2 and 12, respectively (figure 2).

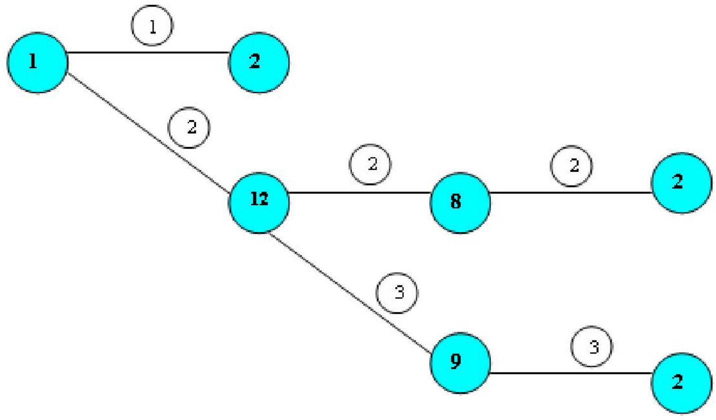


Figure 2 – Tree of paths between pairs of nodes (1,2)

In the figure, unpainted circles indicate the numbers of the IHT. The throughput and the number of channels for each path is = 10 bits / s, = 50. The service time of one call to the QC network is j = 60 sec.

The direction through the node 10 is not selected, since the path length through this node to the node 2 exceeds four transit sections (see. Fig. 3). At node 12, the procedure is repeated and nodes 8 and 9 are selected, and so on.

Findings. The distribution of excess load on the path tree. For each pair of nodes, the load distribution along the path tree is based on the probability of loss on the branches calculated at the previous iteration. An assumption is made that the probability of losses on each branch characterizes some statistical properties of this branch as a service system and does not depend on the probabilities of losses on other branches and on the size of the distributed load (in the distribution process).

$g^{1}_{12}(2)= t^{1}_{1}(1,2)* h_{12}(2);$

$g^{1}_{12}(2)= t^{1}_{1}(2,2)* h_{12}(2)_{2};$

$g^{1}_{12}(2)= t^{1}_{1}(2,2)* h_{12}(2)_{3};$

$t^{1}_{1}(1,2)_{1}= t^{1}_{1}(1,2)* h_{12}(2);$

$h_{12}(2)_{1}=r_{1}(2) * \varphi_{12}(2)_{2} * \varphi_{12}(2)_{3} * (1-p_{12}(2));$

$h_{12}(2)_{2}=r_{1}(2) * \varphi_{12}(2)_{1} * \varphi_{12}(2)_{3} * (1-p_{112}(2))*(1-p_{128}(2)) *(1-p_{82}(2));$

$h_{12}(2)_{3}=r_{1}(2) * \varphi_{12}(2)_{1} * \varphi_{12}(2)_{2} * (1-p_{112}(2))*(1-p_{129}(2)) *(1-p_{92}(2));$

This article explores in detail the subnetwork switching channels, using the bypass direction of the flow of multi-channel calls. At the same time for subnetting the commutation channel is given the initial data of the problem of calculating probabilistic characteristics, list the characteristics that are determined in the process of solving the problem and describes some assumptions that allow to adequately approximate the study of such a model to the functioning of a real network. As a result, we obtained a mathematical model for calculating the loss probabilities, both for the communication channels and for the nodes of the circuit switching subnetwork that is part of the ATM network. Here was calculated the probabilities of load losses of the CS mode of an asynchronous network using bypass directions to transfer excess loads.

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## ЖЕЛІДЕГІ АРТЫҚ ЖҮКТЕМЕНІ ЕСЕПТЕУ

**Аннотация.** Қазіргі әлемде сандық технологиялар елдер экономикасын дамытуда маңызды рөл атқарады. Цифрлық технологиялардың төмендегідей артықшылықтары бар: халықтың және бизнестің мемлекеттік қызметтерге қол жеткізуін жеңілдету, ақпарат алмасуды жеделдету, бизнесті жүргізу үшін жаңа мүмкіндіктердің пайда болуы, жаңа сандық өнімдер құру және т.б. Интернет желісінде деректерді берудің қолжетімділігі, тұрақтылығы және қауіпсіздігі – бұл барлық салаларды дамытудың технологиялық негізі, сондай-ақ халықтың өмір сүруінің жоғары сапасы. Байланыс желілерінде ақпарат алмасу цифрлық нысанда бірқатар артықшылықтарға ие: бөгеуіл орнықтылығының жоғары деңгейі және деректерді берудің неғұрлым жоғары сапасы; стандартты сенімді және арзан интегралды схемаларды пайдалану мүмкіндігі, бұл бүкіл желі құнында анықтаушы болып табылатын коммутация және тығыздау жүйелерінің құнын едәуір төмендетеді; әртүрлі түрдегі ақпаратты цифрлық нысанда біріктіру және өңдеу кезінде үлкен мүмкіндік. Қазіргі уақытта жобалау кезінде пайдаланылатын байланыс желілерінде пайдаланушыларға қызмет көрсету сапасын бағалау әдістерінің көпшілігі бір өлшемді трафикке қатысты тапсырманы қарастырады немесе жүктеме көздерінің соңғы санының әсерін ескермейді. Бұл мультисервистік желілерді жобалау міндеттерін шешу кезінде, соның ішінде желілердің абоненттік қатынау учаскелерінде оларды қолдануды шектейді. Осыған байланысты, осы бапта қызметтердің интеграциясы бар кеңжолақты цифрлық желі қарастырылады, онда ағындарды бөлу маршруттар матрицасымен берілетін итерациялық әдіс іске асырылатын АТМ-технология негізінде, ал әрбір бу тораптарының тораптары арасындағы жүктемені бөлу осы буды есептеу кезінде маршруттар матрицасы бойынша алынатын жолдар ағашы бойынша жүргізіледі, сондай-ақ арналар мен коммутациялық пакеттер коммутациясы әдісімен ақпараттық трафикті беру кезінде асинхронды желінің артық жүктемесін есептеудің математикалық әдісін әзірлеу.

**Түйін сөздер:** кең жолақты цифрлық желі, қызметтерді интеграциялау, асинхронды желі, арналарды коммутациялау, пакеттерді коммутациялау, түйіндер коммутациялары.

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## РАСЧЕТЫ ИЗБЫТОЧНОЙ НАГРУЗКИ В СЕТИ

**Аннотация.** В современном мире цифровые технологии играют важную роль в развитии экономики стран. Цифровые технологии имеют преимущества: облегчение доступа населения и бизнеса к государственным услугам, ускорение обмена информацией, появление новых возможностей для ведения бизнеса, создание новых цифровых продуктов и т. д. Доступность, стабильность и безопасность передачи данных в сети Интернет – это технологическая основа развития всех отраслей, а также высокое качество жизни населения. Обмен информации в сетях связи в цифровой форме имеет ряд преимуществ, таких как: высокий уровень помехоустойчивости и наиболее высокое качество в передачи данных; возможность использования стандартных надежных и дешевых интегральных схем, что значительно снижает стоимость систем коммутации и уплотнения, которые являются определяющими в стоимости всей сети; большую возможность при объединении и обработки информации различных видов в цифровой форме. В настоящее время большинство методов оценки качества обслуживания пользователей на сетях связи, используемых при проектировании, либо рассматривают задачу применительно к одномерному трафику, либо не учитывают влияния конечного числа источников нагрузки. Это ограничивает их применение при решении задач проектирования мультисервисных сетей, в том числе на участках абонентского доступа сетей. В связи с этим, в данной статье рассматривается широкополосная цифровая сеть с интеграцией служб на основе АТМ-технологии, в которой реализуется итерационный метод, где распределение потоков задается матрицей маршрутов, а распределение нагрузки между узлами каждой парой узлов производится по дереву путей, получаемому по матрице маршрутов при расчете данной пары, а также разработка математического метода расчета избыточной нагрузки асинхронной сети при передаче информационного трафика методом коммутации каналов и коммутационных пакетов.

**Ключевые слова:** широкополосная цифровая сеть, интеграция служб, асинхронная сеть, коммутация каналов, коммутация пакетов, узлы коммутации.

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## REFERENCES

[1] «www.primeminister.kz».

[2] Olifer V. Computer networks. Principles, technologies, protocols: A textbook for university students. SPb.: Peter, 2012. 944 p. ISBN 978-5-459-00920-0.

[3] Stollings V. Computer networking with internet protocols and technology. SPb.: Peter, 2005. 817 p. ISBN 5-94157-508-4.

[4] Stollings V. Data and computer communications: textbook / 6th ed. M.: Williams, 2002. 920 p. ISBN 5-8459-0311-4.

[5] Zaker K. Upgrading & Troubleshooting. Networks: The Complete Reference. SPb.: Peter, 2003. 988 p. ISBN 5-94157-042-2.

[6] Zaitsev S.S. Description and implementation of computer network protocols. M.: Nauka, 1989. 270 p. ISBN 5-02-013971-8.

[7] Voronov A.A. Telecommunication networks and systems. Tutorial; St. Petersburg State Electrotechnical University named after IN AND. Ulyanov (Lenin) "LETI". SPb.: Publishing House SPbGETU "LETI", 2010. 88 p. ISBN 978-5-7629-1035-4.

[8] Walrand J. Telecommunication and Computer Networks. Introductory course. M.: Postmarket, 2001. 477 p. ISBN 5-901095-06-5.

[9] Semenov Yu.A. Internet Protocols. Encyclopedia. Hotline-Telecom, 2001. 1099 p. ISBN 5-93517-019-1.

[10] Ashigaliev D.U., Kalimoldaev M.N., Kemelbekova Zh.S. Optimal distribution of channel resources for the transmission of mixed traffic over an integrated network // Proceedings of international scientific-practical conference "problems of control and information technologies" of national Academy of Sciences. NAS of the Kyrgyz Republic. Bishkek: IAIT, 2010. N 2. P. 12-16.

[11] Shuvalova V.P. Telecommunication systems and networks: Textbook for universities / 3rd ed. M.: Hotline-Telecom, 2003. ISBN 5-93517-109-0.

[12] Schwartz M. Communication networks: protocols, modeling and analysis: in 2 hours. M.: Nauka, 1992. 336 p. ISBN 5-02-014510-6.

[13] Litvinenko A., Mamyrbayev O., Litvinenko N., Shayakhmetova A. Application of bayesian networks for estimation of individual psychological characteristics // PRZEGLAD ELEKTROTECHNICZNY. 2019. Vol. 95(5). P. 92-97.

[14] Kruk B.I., Popantonopulo V.N., Shuvalov V.P. Modern technologies: Tutorial. 2003. 647 p. ISBN 5-93517-088-4.

[15] Mamyrbayev O.Zh., Shayakhmetova A.S., Seisenbekova P.B. The methodology of creating an intellectual environment of increasing the competence of students based on a bayesian approach // News of the National academy of sciences of the Republic of Kazakhstan. Series physico-mathematical. 2019. Vol. 4(326). P. 50-58. https://doi.org/10.32014/2019.2518-1726.43

[16] Fratta L., Lazarev VG, Parshenkov N.Ya. Adaptive management of channel resources in the integrated digital communication network. Networks of packet switching of computers // IV council-italian seminars enbekteri. M.: Nauka, 1984. P. 59-63.

[17] Sembiev O.Z., Kemelbekova Zh.S. Integration of information and communication services in Kazakhstan // Proceedings of the international scientific and practical conference "Auezov oyulary-10". Shymkent, 2009. Vol. 5. P. 246-250.

[18] Joldasova M.S., Kemelbekova Zh.S., Sembiev O.Z. Distribution of channel resources on the network by workarounds of transfer of loads in the channel switching mode // Proceedings of the international scientific and practical conference "Auezov oqulary-10". Shymkent, 2011. Vol. 7. P. 184-188.