Summary

The method of direction information steams management in multiservice networks is developed. The commutation center functioning on the provider edge (PE) was considered. The method of information steams distribution between output lines was suggested. Therefore efficiency of hybrid traffic transmission in provider edge of packet switched network is raised. Thanks of obtained scientific results and implementation theirs in practice there is the possibility to solve the problem of processing multiservice traffic in complex, to decrease packet loss for all traffic types.

Keywords: self-similar traffic, nodal routing, point-to-point routing, PWE3

1. Introduction

The problem of customer service quality in mobile networks for operators is one of the most important because there is a business competition between telecommunication companies. If the subscriber is not satisfied with the provided services, then he can change telecommunication operator. Therefore, the operator should be able to support declared level of service quality.

The problem is complicated by the fact that the number and types of services is expanding every day. If in 90-th years of last century mobile communications were used for transmission of telephone traffic then today more and more subscribers order interactive video services, access to the worldwide Internet network, etc. It demands information transfer of large volumes and various types with different requirements to transmission quality.

The growth of traffic volumes became the problem connected with the efficiency of the information steams transport. It’s considered that the decision of this problem for radiochannel is using the protocol PWE3 (Pseudowire Edge to Edge Emulation). This protocol provides emulation of pseudowire (PW) services for transmission over a packet switched network (PSN) between provider edges. The base stations are on the one edge and the base station controller is on another edge. Pseudowire emulation ensures the quality of service when using such technologies like ATM, Fast Ethernet, Frame Relay, etc.

In some scientific researches are shown that the nature of incoming flows can’t be described by classical models of elementary stream. The video traffic, Internet traffic is self-similar streams, but telephone traffic is a Poisson stream. Thus, when modelling the process of information flows management in the telecommunication systems it’s necessary to consider these traffic features. The theory of self-similar traffic runs out early stage of development. Most problems haven’t theirs solutions yet.

However, advanced models and methods of information flows managing have to consider the heterogeneous nature of transferred traffic and should be adapted to the transmission protocol.
In this case, the problem connected with the efficiency of the information streams transport via radiochannel can be solved by modelling the process of the self-similar information flow transmission using transport protocol PWE3 in mobile operators networks to find an optimal routing way in the switching centre on provider edge (PE), which is the boundary between base stations and network packet switching.

2. The QoS problems when PWE3 network simulation

PWE3 is packet switching network. When providing the services with required QoS using services ATM, Fast Ethernet, etc., it is necessary to take into account the quality of customer service. In PWE3 the mechanisms of QoS assurance are used. These mechanisms should be used when PWE3 network is simulated.

Taking into account the limited network resources (buffer space for network nodes, transmission paths bandwidth and time for decision making) in multiservice network it has to include effective means of QoS providing. The term "quality of services" in the ITU recommendation E.800 is accepted as some integrated assessment, which determines the user satisfaction degree of provided service. In PWE3 networks the QoS tasks solution can be realized on the each of three levels – the sub-administer management, maintenance management and dynamic control [8]. The efficiency of the telecommunication network functioning depends on the correct solution of QoS problem.

Made analysis has shown there are three main types of service by the assurance level: Best effort Service, Differentiated Service and Guaranteed Service.

For the QoS problem solving it is necessary to solve the concurrent complex of following tasks:

- The network structure modification by insertion or removal of the some network elements (such as network nodes and transmission paths);
- Growth of the network nodes operability and throughput of the channel;
- Reconfiguration of the network equipment;
- Changing routing policies for information flows;
- Redistribution mechanisms of priority processed packets on all or part of network nodes;
- Access to network resources reorganization.

Typical problem QoS solving covers the following areas:

- Traffic classification;
- Traffic volume determination transferred via the each channel;
- Incoming flow limitation, Active Queue Management (AQM);
- Queue management with the processed packets scheduling on network nodes;
- Routing of network traffic.

When the QoS problem is solved for efficient networking the set of management mechanisms and protocols should be mutually coordinated. For example, traffic classification determines solving of other problems such as routing, distribution channel resources, etc.

For each type of networks, access networks or backbone networks, the probability of packet loss is specified. For each switch can be computed value $T_j$, which determines delay of IP-packets. When packets switching the variable $T_j$ is used. It is considered like the random variable and defined by the number of the packets waiting in the queue and time of packets processing.
3. Problem definition

It’s known that the switching centre PE is the bottleneck when PWE3 protocol is used for information flows transport through the Packet Switched Network (PSN) which is leased by the mobile communication operators. In switching centre PE the information packets flows are formed to be transmitted through pseudowire (PW) channels. The quality of information transfer through the PSN depends on how effectively the information packets flows were shaped. The scheme of switching centre which is used by the mobile operators is shown on fig.1.

A pseudowire channel emulates a point-to-point or point-to-multipoint link and provides a single service which is perceived by its user as an unshared link or a circuit of the chosen service. It is not intended that an emulated service will be indistinguishable from the service that is being emulated. The paper deals with the ATM technology, which is used in broadband networks to ensure adequate service quality for multi-information flow. The ATM technology imitation assumes supporting SONET/SDH encapsulation and the SONET/SDH overhead configuration and physical layer alarms. ATM interfaces support permanent virtual path and permanent virtual channel (PVP/PVC). ATM cell transport help to link the earlier ATM or ISP networks through the PSN network without adding new ATM devices and changing the ATM customer edge (CE) configurations. ATM CE routers consider the ATM cell transport service as the TDM (Time Division Management) leased line.

The paper deals with the problem of the flows distribution to organize virtual channels and virtual path between PW. Even distribution of the flows which take into account traffic class will reduce the packets loss in output queues PW as well as packets losses when they are passing PSN.

Thus, the suggested method of combined traffic control in the switching centre PE includes the some improvements of the existing system functioning:

1. Modification of the switching centre functioning scheme. Taking into account the specificity of information transmission from one edge PSN network to another (PE2) (routing “point-to-point”) it’s suggested to remove the classification traffic process before switching process. It gives the possibility to even fill the queues of the all traffic types of output PW channels (Fig. 2). The problem of performance difference between the switching and classification units can be solved by increasing the number of classification units to the number of output channels (one channel – one
unit of classification). After classification process the flow transmission service is implemented according to traffic class.

2. Solving the problem of nodal routing.
To solve the tasks necessary to suggest:
1) a criterion for estimating the quality of the suggested method functioning for the information flow control system with the protocol PWE3,
2) the basic mathematical models that describe the information flow for the given criterion.

All this requires a system approach to the method of traffic management in PE switching centre developing to ensure quality of service for information traffic.

4. Mathematical model of ATM self-similar traffic

In [1, 2, 3] describes experiments that show that streams multimedia and Internet streams are self-similar processes. Classic models can not describe long-term dependences between incoming packets of information arising from the transfer of video and Internet streams. Most mathematical models are designed based on the assumption that the incoming traffic is described by Poisson distribution with parameter \( \lambda \) (arrival density). Poisson process is a special case of self-similar process for which Hearst parameter \( H = 0,5 \).

On the qualitative level the self-similarity is visualized in the fact that there is the dependence between the slow flowing down traffic values in different points of time, and that traffic is aggregated into data packs and these packs look statistically similar in the wide range of scale variation on a time scale.

Modelling self-similar traffic (Fig. 3) are based on two features: a message transmission time cannot be less than the given value, that’s the message transfer time \( \bar{T} \) distributed on the Pareto law, it is assumed that the coming packet points for servicing time \( t \) follow the Poissonian law with parameter \( \lambda \).
Literature research has shown that accurate estimation of buffer-overflow probability (the probability of packet loss) for self-similar traffic is non-trivial task, which currently has no answers. The most appropriate solution is a model that was proposed by B. Tsybakov and N. Georganas [4], which allows estimating the upper bound of the overflow queue. This probability can be calculated using the equation (1).

\[ P_{\text{over}} \leq \frac{c_0 \lambda R^\alpha}{\alpha(\alpha - 1)(C - \lambda R M \tau)} h^{-\alpha + 1} \]  

(1)

where \( P_{\text{over}} \) – upper bound of the overflow queue in the output channel
\( \lambda \) – arrival density of the flow that goes into the input channel;
\( R \) – rate of information source transfer;
\( h \) – length of the queue in the output channel;
\( C \) – information transfer rate in a transmission channel;
\( c_0 \) – minimum length of the message;
\( M \tau \) – average length of the message;
\( \alpha \) – parameter of self-similar traffic is calculated from the equation: \( M \tau = c_0 \sum_{i=1}^{\infty} l_i^{-\alpha} \).

It is necessary to say that this estimation of upper-bound to buffer-overflow probability is not suitable for exact computing of the required channel resources for information flows transmission, but for evaluating the effectiveness of channels PW resource distribution and for optimisation virtual path (channels) resources distribution between outgoing PW the proposed evaluation is quite satisfactory.
5. The calls dynamic distribution method and discipline of information flows servicing

If we consider that one base station is independent on customer edge, then the information flow distribution according PWE3 protocol from a base station into single tunnel PW is inefficient (Fig. 4). Such a scheme can not be effective because the base stations load may vary depending on time.

Relevant observations led to the problem of effective network channel resource distribution that is efficient transmission for total information flow from all base stations into all the tunnels between two switching centres PE1 and PE2.

The calls processing in switching centre PE is similar to calls processing of any switching centre (Fig. 5).

The scheme of the switching centre processing is shown on fig. 5. It confirms that all incoming flows, which are received, at first are switched (distributed between outputs PW) and after that they are classified and they are scheduled according to traffic type. Thus, if there is a working load splash for given type calls then packet loss from overdriven queue are increased.

Recent research shows that packet removing has major redundant effects and traffic control mechanisms don’t solve the global problem of overload.
Traffic classification before the switching process allows to control filling of the given traffic class queues in the output channels. When queue is overflow the nodal routing task solution can be effective.

6. The nodal routing task

Consider $P_{\text{over } ij}$ – the upper bound of buffer-overflow probability, which is a function of the arrival load intensity ($x_{ij}\lambda_i$);

$P_i$ – maximum allowable packet loss for $i$-th type traffic;

$s_i$ – information slot volume of $i$-th type which is divided between output channels.

Let’s $s_{ij}$ – ATM-sells number of $i$-th type in the output slot $s_i$ that goes to $j$-th channel.

It is necessary to find the distribution coefficients $x_{ij}$ ($x_{ij} = \frac{s_{ij}}{s_i}$ – normalized value of the $i$-th type information flow, which goes to the $j$-th channel). The coefficients $x_{ij}$ minimize the target additive function which is the loss packet number of given traffic class in the output channels of switching centre PE1 (Fig. 6)

Restrictions: $\sum_{j} x_{ij} = 1, \ x_{ij} \geq 0$.

$W_{\text{over}}(\lambda) = \sum_{j=1}^{d} x_{ij} P_{\text{over } ij} \Rightarrow \min_{\{x_{ij}\}}$,

where $P_{\text{over } ij} = \frac{c_{\text{ij}}x_{ij}\lambda_i^\alpha_i}{\alpha_i(\alpha_i - 1)(C - x_{ij}\lambda_i R \tau_i) h^{-\alpha_i + 1}}$. 

\[ \begin{align*}
&\lambda_1 \rightarrow x_1 \rightarrow \lambda_2 \\
&\lambda_2 \rightarrow x_2 \rightarrow \lambda_3 \\
&\vdots\\
&\lambda_d \rightarrow x_d \rightarrow \lambda_d \\
&\lambda_d \rightarrow x_d \rightarrow \lambda_d \\
&\vdots
\end{align*} \]

Figure 6. Scheme of nodal routing

If the monitoring system signalise about buffer-overflow for $i$-th type of traffic ($P_{\text{over } ij} > P_i$) then optimization task of finding $x_{ij}$ is run. It minimizes the target function $W_{\text{over}}$.
In this case the information flows are in quasi steady state. This optimization task solution solves the problem of PW channel selection. For this PW channel the virtual connection will be organized during calls transmission time.

The interpretation of the results of the optimization task solution is shown on Fig. 7 a) and b), where O – the moment of peak load, $P_q$, $P_i$ – the maximum allowable packet loss for $q$-th and $i$-th traffics, $k$ – number of output channels. The behavior of packet loss dependence for $q$-th traffic from time is shown on fig. 8 a). For this $q$-th traffic the overflow was fixed in the channel $j$. On fig. 8 b) it shows the dependence for packet loss of $i$-th traffic from the time.

Consider $i$ such as $(i \neq q, k = 1, N)$ and $(i = q, k = 1, j - 1, j + 1, N)$.

![Figure 8. The behaviour of packet loss dependence from the time](image)

After the signal about overloading there is the redistribution of information flows between the PW output channels. For this the nodal routing task is used. This gives the possibility to reduce packet loss and to smooth out the packet loss distribution for all traffic in all output channels.
7. Summary

The method of managing data flow in the switching centres PE is suggested. This method enables to control packet loss caused by buffer-overflow and exceeded the allowable time delay for interactive traffic packets at the expense of even distribution of virtual connection between output PWs according the traffic type. The system uses the nodal routing optimization on the criterion of the total packet loss minimization.

Optimization problem of information flow distribution in provider edge switching centre between outgoing channels PW for one traffic class was introduced. It is the basis for decision the multi-services traffic class optimization problem. The proposed method efficiency of using for information flows distribution in optimal way during overloading time is proved. It allows improving management processes in the PE switching centre.

Bibliography

**ROUTING WĘZŁOWY Z KLASYFIKACJĄ RUCHU**

Streszczenie


**Słowa kluczowe:** ruch samopodobny, routing węzłowy, routing point-to-point, PWE3

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