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SERVICE-ORIENTED RESOURCE PLANNING FOR MULTISERVICE IP NETWORKS

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Abstract: This work proposes the analysis of service quality parameters for packet networks. The algorithm of packet processing has been developed. Research into delay and jitter for the proposed processing method has been carried out.

Key words: self-similar traffic, traffic distribution system, simulation.

Introduction

In modern multimedia telecommunication networks there is an important challenge of securing the service quality (QoS). The traffic in these networks is self-similar. That is why there are no adequate analytic models for this kind of stochastic processes.

The QoS securing for multimedia traffic while using analytic methods leads to serious inaccuracy. Thus, the only appropriate method is that of statistic simulation.

It is important to use an appropriate traffic model to obtain accurate QoS parameters.

The main service quality parameters are as follows [1]:

- packet delay – a time gap between the transmission and receiving moments;
- variation of delay (jitter) – the difference between the delay for a single packet and the normal delay of a packet for a particular service.
- packet loss percentage – the ratio of lost packets to the total packets number;
- capacity of network channels – the total capacity of channel resources which is enough for a particular service throughout the whole transmission path;
- throughput – the maximum speed of data transmission through network channels.

Objective

The hierarchical structure of multiservice IP networks is caused by the requirement of high scalability and the diversification of access, aggregation, and content distribution challenges. Its conceptual structure is shown in Fig. 1.

The direct result of the use of this kind of structure causes the difference of traffic properties at each level of the network model. Consequently, the parameters of the nodes might be different to provide appropriate QoS parameters. So, choosing the node parameters is a very important task in securing the service quality.

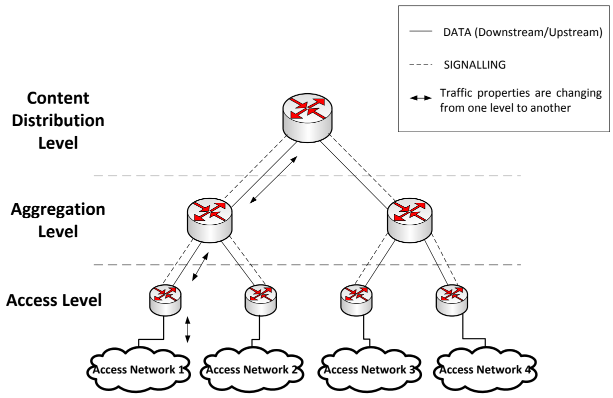

Fig. 1. A hierarchical structure of the developed method

Traffic Generation and Processing

It is very important to use adequate traffic models to calculate the node parameters that have been discussed earlier.

This work proposes a method of traffic generation. The packet duration is modeled by a uniform distribution and the gap between the packets is modeled by the fractional Brownian motion. By using the algorithm shown in [2], the traffic shown in Fig. 2 has been generated.

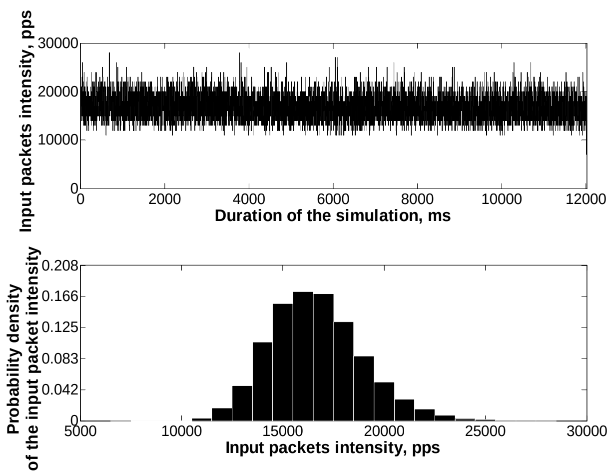

Fig. 2. Input packets intensity

An algorithm to process the generated traffic for analyzing the QoS parameters [3] has been developed.

The output traffic profile and its probability density are shown in Fig. 3.

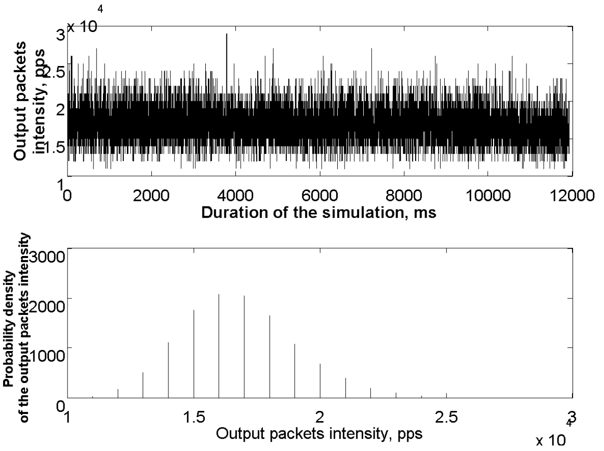

Fig. 3. Output packets intensity

In the previous research papers a simulation model was designed for multiservice networking research. This model is based on the statistical analysis of network traffic and uses a mathematical approach to the analysis of self-similar processes. The described method allows analyzing a complex network structure and its processes with some simplification. The main challenge in that case is to guarantee the adequacy of the traffic model. The solution to this task was reached in [4].

The self-similar properties of multiservice traffic were discovered and researched by such scientists as Boris Tsybakov, Nicoals D. Georganas, Kihong Park, Walter Willinger etc. Those scientists pointed out the difference between probability density of multiservice traffic and of homogenous one. The peak-factor and, as a result, the standard deviation for multiservice traffic are much larger than the same values for single-service traffic. Thus, the well-known probability density laws do not represent the character of the self-similar processes with the acceptable inaccuracy.

Network traffic is generated by combining two laws of probability density. The packets durations are generated in accordance with the uniform distribution, and the gap between the packets is formed in accordance with the fractional Brownian motion which is characterized by the Hurst parameter equal to 0.7. The packets lengths vary between 64 and 1500 bytes.

The self-similar profile feature of resulting traffic has been proved due to the R-S analysis. The traffic profile and its probability density are shown in Fig. 2.

The generated traffic in [2] enters the processing node [5]. It consists of a buffer, an internal input bus, a processor, and an internal output bus. Service intensity is determined every 1ms.

The algorithm of traffic processing and its simulation model were demonstrated in [5].

The modeling time is distributed with the constant step and specific states simultaneously. This approach positively influences the time parameters' determination of the traffic.

The model supposes the packet to consist of a constant signaling part and a variable data part. The constant part is processed by a servicing node. Thus, the processing time for every single packet is a constant value. But the packets' transfer through internal buses continues during variable stochastic periods due to the variable data capacity. The post-reading time is defined as instantaneous.

Every single model element introduces uncertainty to the service quality. In the proposed work the main attention is paid to different kinds of packet delay.

The service quality parameters were studied on the basis of the developed model. The main results are shown in the following works [2, 3 and 5].

The important scientific result of the previous works is the development of prediction methods of buffer utilization for the multiservice distribution system. The research was done on the basis of the simulation model by using automatic termination of its operation [2].

In Fig. 4 the instantaneous values of the buffer utilization with the 1ms period are shown. Thus, the buffer capacity can be defined as the average buffer utilization with the double stocking (see Fig. 4). Besides, the buffer capacity of a network node depends on the utilization of neighboring network domains.

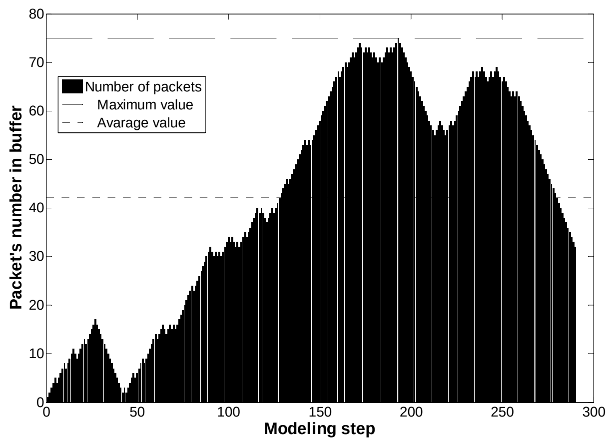

Fig. 4. Buffer utilization during the modeling period

The developed model allows us to do research into the networking traffic behaviour and the impact of a processing mode.

The impact of servicing nodes emerges due to the varying of structural and functional parameters of the processing system [5].

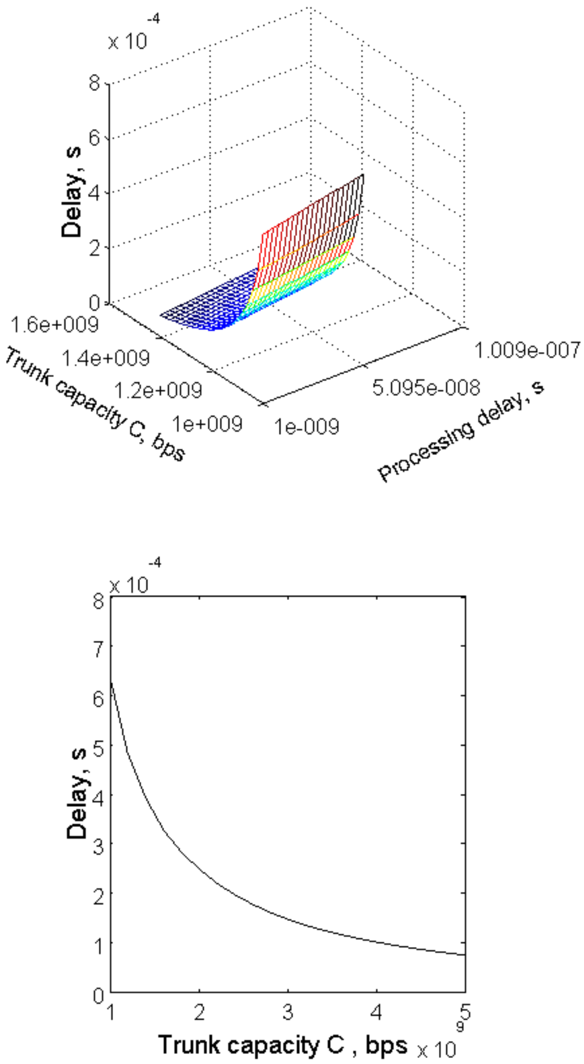

Fig. 5. Delay research

Fig. 5 shows the 3-dimentional dependence between the total packet's delay, the processing delay and the internal bus performance. The nature of that dependence is constant with channel throughput varying (except the absolute values of the delay).

The total delay dependence on the processing delay is linear. With bus performance growing the total delay decreases exponentially.

Fig. 6 depicts the same dependences as in the previous figure, but intended only for packet jitter.

The shown dependences of service quality parameters on structural and functional node parameters allow us to solve the tasks of resource planning and QoS securing for the multiservice traffic distribution system.

The simulation model of the network nodes considers the follow network resources: a buffer capacity, an internal input and output buses performance and a processing delay.

As we can see in Fig. 1, the correct resource planning at every single level of the hierarchical network structure is the key task in the process of the quality oriented service transmission.

The task of securing the service quality for a subscriber may be done choosing minimal node resources on the basis of the dependences obtained (Figures 5 and 6).

For multiservice traffic it is important to define the maximum service quality requirements for a particular application in the common flow. These parameters have to be accepted as basic in the process of the network's resource planning.

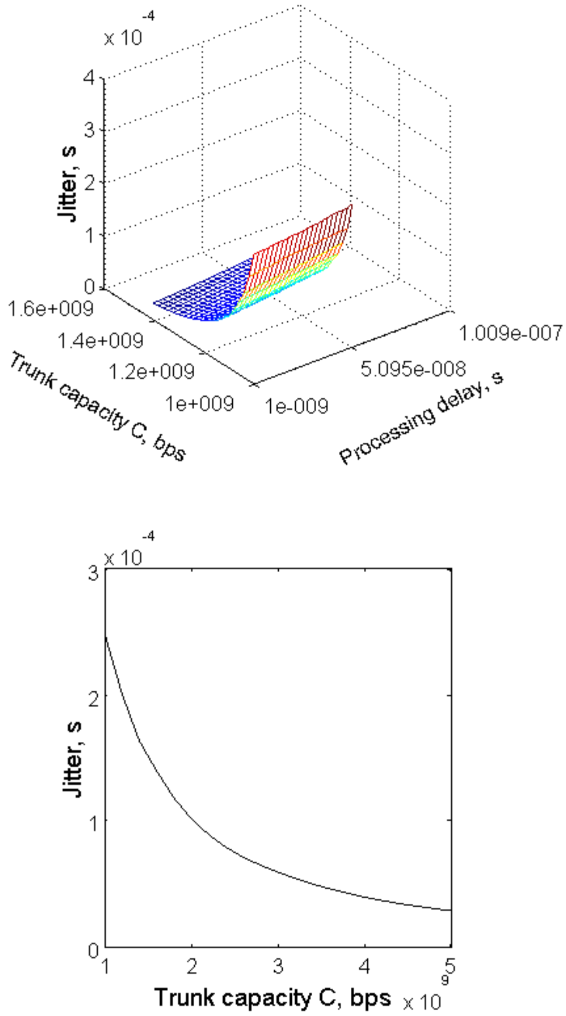

Fig. 6. Jitter research

Resources Utilization by Multiservice Flows

Let's us consider the problem of resources utilization for each service quality parameter in more detail. The generalized model of traffic distribution is shown in Fig. 7. This scheme demonstrates forming a multiservice packet flow and its processing by a servicing network node.

Every application of an end-user generates the ordered sequence of the packets with equal processing priorities. The aggregation of these arranged sequences in the single multiservice flow occurs at the next stage. The processing priorities in this flow are different. And the total sequence has stochastic applications allocation.

The servicing node gives proper resources to guarantee the quality of service.

Thus, the model can also perform the task of specifying the number of applications in the multiservice flow or, if the number of applications is fixed, it answers the question about the total amount of multiservice flows which can be processed by the node.

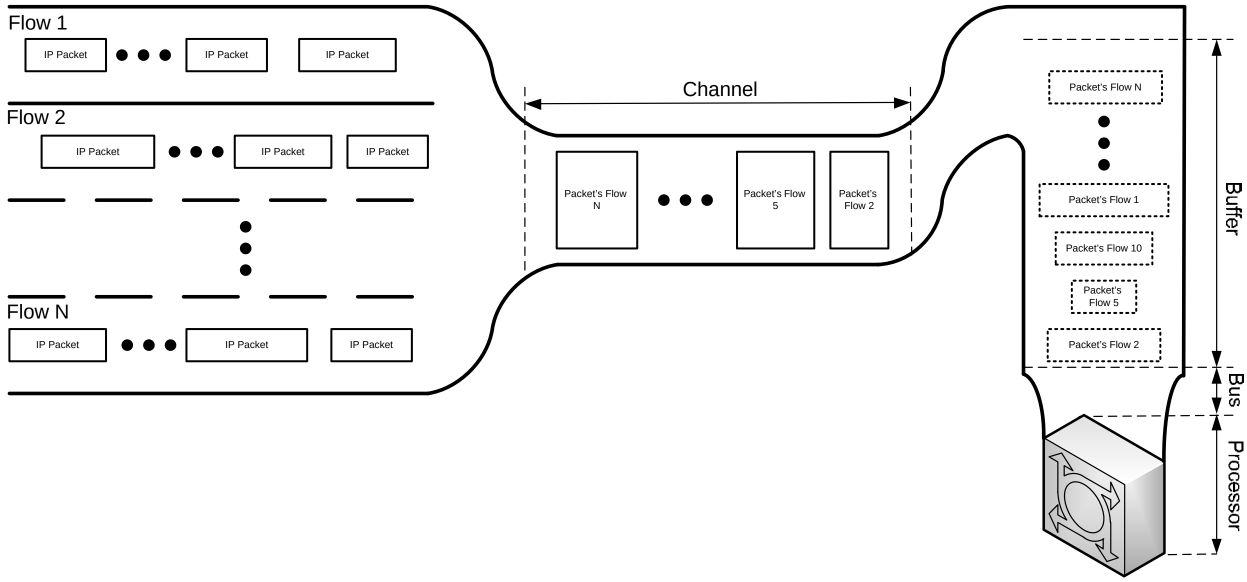

Fig. 7. Multiservice traffic distribution model

We propose to differentiate the two modes of the multiservice flow forming.

The first one is similar to the virtual channel switching. It is represented in Fig. 8. The total flow is the effect of consequent resource utilization by each application flow. In this kind of servicing system there are no priorities for different packets and they are lost only in the crisis situation (some crashes).

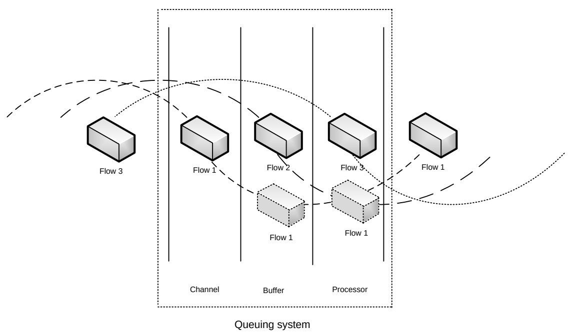

Fig. 8. Multiservice flow formation within a virtual channel mode

The second one represents the situation of simultaneous packet generation by applications and their combination into a single flow. In that case different packets of a particular service may use different node resources at the same time (see Fig. 9). This process is absolutely stochastic. Thus, service quality parameters cannot be guaranteed.

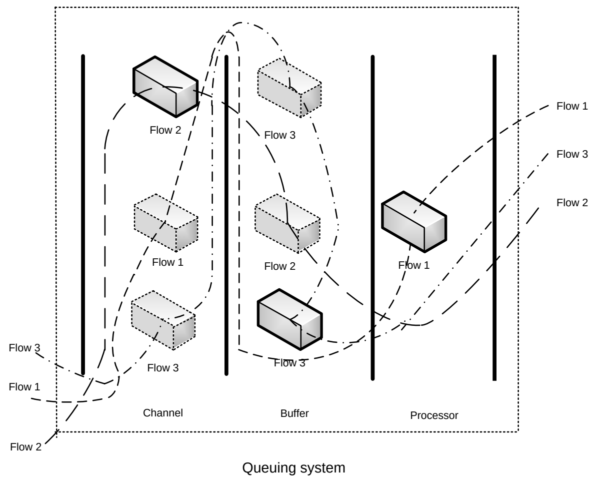

Fig. 9. Parallel packets' generation and their combination into a single flow

We must say that the service quality parameters for particular traffic may be provided by the selection of appropriate structural and functional parameters of a servicing node. Physical network resources have to be chosen in accordance with the theoretical dependences shown in Figures 4-6 to provide the quality of service.

Conclusions

This work offers a method of QoS parameters securing on the basis of self-similar traffic statistic simulation and its single-channel servicing by a queue order.

The service algorithm involves packets' durations, a queue state, and the performance of a bus and an internal processor.

A total packet delay consists of a partial delay of packet processing and a buffer-waiting delay. Jitter is calculated as deviation between the average delay and the delay of each packet.

This paper demonstrates that self-similarity of traffic is reached when the gap between packets is modeled by the fractional Brownian motion with the Hurst parameter equal to 0,7.

The model gives the possibility to change structural and functional parameters of a servicing node in order to have influence on the QoS within the proposed algorithm.

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СЕРВІСНО-ОРІЄНТОВАНЕ ПЛАНУВАННЯ РЕСУРСІВ МУЛЬТИСЕРВІСНИХ IP МЕРЕЖ

М. Климаш, О. Лаврів, Б. Бугиль

Запропоновано метод проектування мультисервісної мережі на основі IP платформи із забезпеченням параметрів якості обслуговування. Здійснено декомпозицію структури IP мережі за рівнями ієрархії, на підставі якої розроблено модель гарантування якості обслуговування.

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