VoIP Traffic Shaping In All IP Networks

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***Abstract* - Traffic shaping is a phenomenon of any change of the traffic characteristics due to the active or passive management. Shaping techniques are considered very important for quality of service support. This paper represents analyses of shaping effect in devices that apply the three mostly used QoS management techniques – IntServ, DiffServ and RSVP. Special attention is paid to the Voice over IP traffic. The results show how VoIP traffic changes its shape starting from the traffic source and passing first access device that apply QoS technique.**

***Keywords* - Voice over IP, Quality of Service, shaping, DiffServ, RSVP.**

I. INTRODUCTION

IP networks are one of the most challenging areas for investigation as they become the only common transmission technology. This increases the demand for Quality of Service (QoS) support. There are plenty of papers and books that try to gather with QoS in IP network [2], [3], [8], [9]. In this paper we demonstrate the shape of the VoIP traffic starting from traffic source and ending at the core network. Furthermore, we show how this shape can be manipulated with the three mostly used QoS management techniques – IntServ, DiffServ, and RSVP. The analyses are made on the basis of the three popular services – VoIP, LAN emulation, transaction exchange. The stress in this paper is on VoIP as the most delay sensitive service. The shaping effect is estimated without implementation of special shaping techniques that can be also supported by softswitches and routers.

The reason is to investigate the effect that can be reached without application of the expensive shaping devices using only queues and priorities specific for the IntServ, DiffSerf, and RSVP. This fractional shaping is important in all IP network and can help estimation of the necessity of special shaping device. The simulation model can be also useful to demonstrate where to apply shaping device in the connection, how many devices to apply and how to make their configuration useful for the overall network performance.

II. TRAFFIC SOURCES

Three types of traffic sources are assumed in an example metropolitan area network – Voice over IP, LAN emulation and transaction exchange. Some assumptions are made for every traffic type. In Voice over IP (VoIP) service silence and talk intervals are exponentially distributed with equal mean values. Some authors use talk to silence ratio of ½. Others do prefer to use on-off model for voice service. The limits for waiting times are calculated under consideration of end-to-end delay limits for every service [4], [5], [6], [7]. The same is valid for queue length. Servicing times per packets are fixed due to the typical transmission line requirements. Table I represents all the parameters for traffic sources in the model. Values are taken from the references or approximated.

TABLE I
TRAFFIC SOURCES PARAMETERS

Parameter	VoIP	LAN	Transac-tions
Pear rate, packets per second	10	164	0
Mean call/ session duration, sec	180	20	10
Mean duration between calls/sessions, sec	360	10	15
Mean talk/ silence duration, sec	20	5	2
Distribution of call/series duration	Expo-nential	Expo-nential	Exponential
Maximal waiting time, sec	0.00071 6	0.6	1
Maximal number of waiting packets	210	1804	2
Traffic sources	5000	500	1500
Priorities	High	Mediu m	Low
Packet length, bytes	800	800	800

LAN emulation is specific with its sessions. Sessions are established for any Internet connections. Packet rate is higher in comparison to the VoIP. Session duration is low. The traffic source is behaving as on-off model with exponential duration of the silence and transmission intervals.

Transaction exchange is specific with few packets exchange. The service is not time demanding. Sessions are short.

Number of traffic sources is taken from the typical image in a business area. Packets are taken to be long. In VoIP traffic 800 bytes carry up to 80 milliseconds voice. This means that quality voice can be transmitted only in the area using up to 2-3 hops. End-to-end delay for VoIP traffic usually should not exceed 150 ms. More precise investigation can be done with 200 bytes voice packets.

III. INTEGRATED SERVICES

Integrated Services (IntServ) is a complex technique often called protocol that ensures end-to-end Quality of Service in IP networks.

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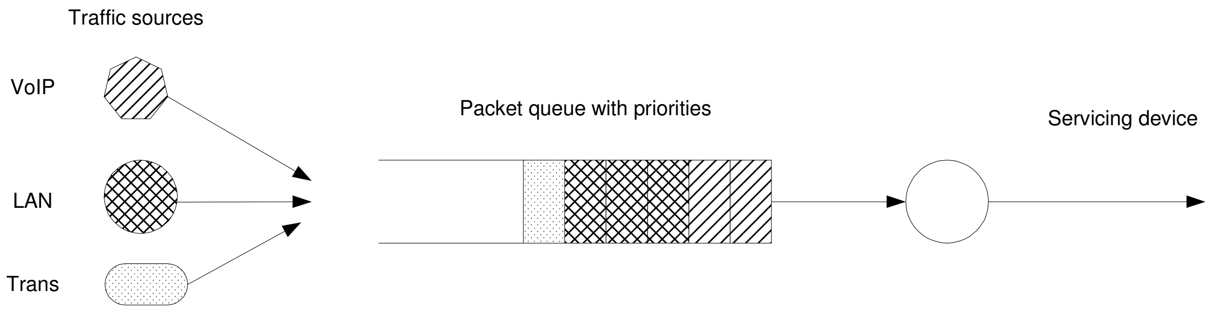

Fig. 1. IntServ model with input data, bounds in waiting times and queue length specific to every service type

IntServ is applied usually in access routers or switches and tried to serve packets from different services in a different ways depending on the quality requirements. IntServ classifies services into three main classes depending on the traffic requirements:

- Elastic applications;
- Tolerant real-time applications;
- Intolerant real-time applications.

Elastic applications are served in a "best effort" way. There is no guarantee for quality level like transaction exchange. Tolerant real-time applications are delay sensitive and usually require high bandwidth. Token bucket model with peak rate control is a good model for such traffic. LAN emulation is usually modeled this way. Some authors propose token bucket with series length and mean rate control as a model for more accuracy. Many others propose the two token buckets to be connected in a cascade configuration.

Intolerant real-time applications require low delays, almost guaranteed bandwidth. The model with two cascaded token bucket is compulsory for such traffic [2]. VoIP service is intolerant to the quality degradation service. IntServ simulation model is based on two cascaded token buckets that bound peak rate, series length and mean rate of the traffic (Fig. 1). The original model is quite complicated and due to this reason it is approximated as a black box that changes the characteristics of the data into output data in specific for IntServ way. As a result after approximation and few calculations it is easy to derive simpler model with one FIFO queue with priorities, fixed rate at the output and different limits for waiting times in the queue [10]. This is the model that has been simulated further. Table II represents main data for model behavior after simply calculations with token bucket formula.

TABLE II
MODEL CHARACTERISTICS IN INTSERV.

Parameter	Value
Queue length, packets	2016
VoIP queue length fraction, packets	210
LAN queue length fraction, packets	1804
Transaction queue length fraction, packets	2
Maximal waiting time for VoIP, sec	0,000716
Maximal waiting time for LAN, sec	0,6
Maximal waiting time for transactions, sec	1
Priority for VoIP	Highest
Priority for LAN	Medium
Priority for transactions	Low

IV. DIFFERENTIATED SERVICES

Differentiated Services (DiffServ) is another quality management technique that is more applicable for core networks. After appropriate marking of the aggregated packets they are gathered in the way that is defined for their class. There are three main types of services we try to highlight in this paper:

- Premium service – low delays, low losses, guaranteed bandwidth like VoIP;
- Assured service – less requirements to the delays and losses in comparison to the premium service like LAN emulation;
- Olympic service – no time requirements at all like transaction exchange.

The model from Fig. 1 that represents IntServ technique is applied again here but with DiffServ procedure in mind. After few calculations again simple FIFO queue with priorities and limits for waiting times per service is derived. Main system parameters are shown on Table III.

TABLE III
MODEL CHARACTERISTICS IN DIFFSERVS.

Parameter	Value
Queue length, packets	1840
VoIP queue length fraction, packets	200
LAN queue length fraction, packets	1640
Transaction queue length fraction, packets	2
Maximal waiting time for VoIP, sec	0,0303
Maximal waiting time for LAN, sec	0,27876
Maximal waiting time for transactions, sec	1
Priority for VoIP	Highest
Priority for LAN	Medium
Priority for transactions	Low

V. RSVP

Resource Reservation Protocol (RSVP) is a technique that is similar to the channel switching reservation. It is especially useful for delay sensitive traffic like VoIP. There are again three main types of services identified for RSVP like:

- Wildcard filter – applied to gather maximal requirements for given interface like LAN emulation;
- Shared explicit – applied to gather maximal requirements for the interface taking into account called address. Transaction exchange is modeled as shared explicit service;
- Fixed filter – full reservation for quality sensitive services like VoIP.

Model simplification with IntServ and DiffServ procedures is applied for RSVP and characteristics of the derived model are shown on Table IV.

TABLE IV
MODEL CHARACTERISTICS IN RSVP.

Parameter	Value
Queue length, packets	1840
VoIP queue length fraction, packets	200
LAN queue length fraction, packets	1640
Transaction queue length fraction, packets	2
Maximal waiting time for VoIP, sec	0,07508
Maximal waiting time for LAN, sec	0,69
Maximal waiting time for transactions, sec	1
Priority for VoIP	Highest
Priority for LAN	Medium
Priority for transactions	Low

VI. RESULTS

Simulation is performed on C++ language. The pseudo exponential pseudo deterministic characteristics of the traffic sources are reached after usage of combination between many random generators. The queue behavior is complex due to the priorities and limits on waiting times. Many parameters have been derived from the model like time and space loss probabilities, probabilities to wait for different types of traffic, probability distribution functions and probability density functions of the packets intervals, queue lengths, waiting times at many interface points in the model like output of the traffic sources, input and output of the queue. Statistical accuracy of the derived results is proven by Student criterion.

IntServ, DiffServ and RSVP have different ways to gather with packets and this influences the way they drop packets and shape them. On Fig. 2 we demonstrate the deterministic character of the traffic at the output of the traffic source. The pdf function of VoIP, LAN and transaction traffic is shown for comparison. The pdf format is chosen for easy comparison with other results.

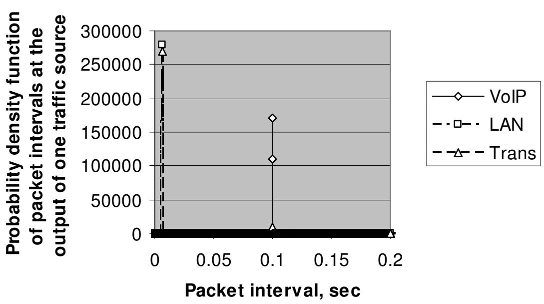

Fig. 2. Probability density function of packet intervals at the output of one traffic source

On Figs. 3, 5, and 7 probability density functions of packet intervals at the input of the queue for IntServ, DiffServ and RSVP is shown. The traffic is accumulated for many deterministic sources like the one shown on Fig. 2. The cumulative traffic has different characteristics and acts as an input traffic for softswitches and routers. It is interesting also for shaping estimation. On Figs. 4, 6, and 8 the pdf of packet intervals at the output of the queue for IntServ, DiffServ and RSVP is shown. The effect of fast servicing in RSVP is visible. The delay variation of the packet intervals is becoming smoother and tends to constant value. Because the VoIP traffic has highest priority and the buffer space for VoIP packets is enough it is visible that the queue acts as a pure multiplexer and shapes the traffic by means of its output packet delivery interval. These interesting results can directly influence interfaces and queue management of the next devices in the network [1]. The three services: VoIP, LAN emulation and transaction exchange are simulated and their queue fraction is also observed and shown in [1].

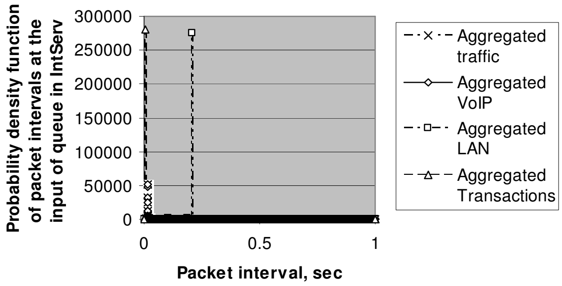

Fig. 3. Probability density function of packet intervals at the input of queue in IntServ

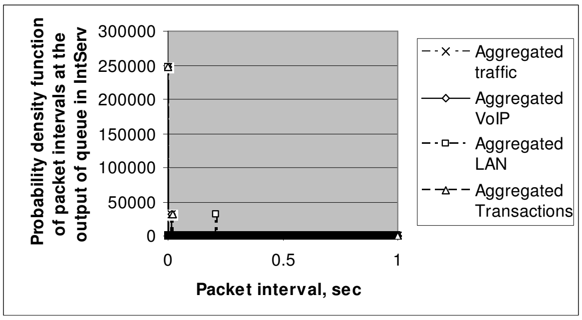

Fig. 4. Probability density function of packet intervals at the output of queue in IntServ

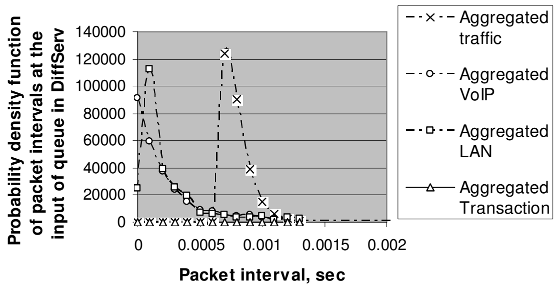

Fig. 5. Probability density function of packet intervals at the input of queue in DiffServ

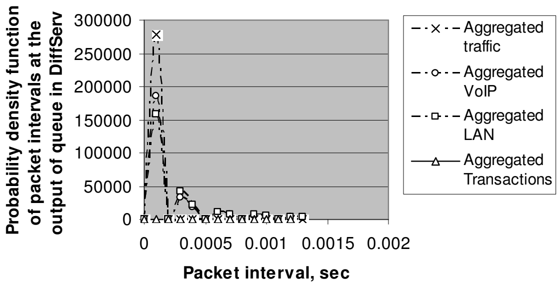

Fig. 6. Probability density function of packet intervals at the output of queue in DiffServ

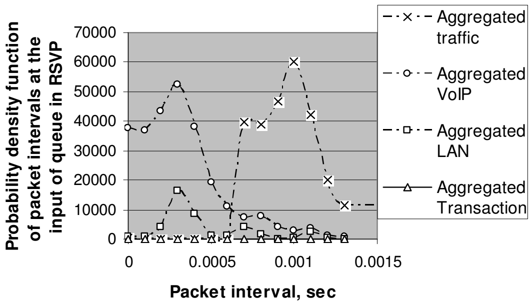

Fig. 7. Probability density function of packet intervals at the input of queue in RSVP

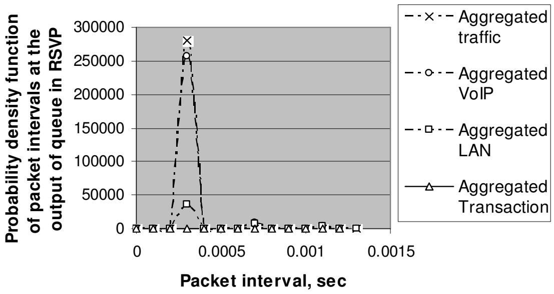

Fig. 8. Probability density function of packet intervals at the output of queue in RSVP

Table V represents mean values of the queue lengths per discipline and per service. They can be used for approximate planning of the time and space limits in the router interfaces.

Because the VoIP traffic has highest priority and the buffer space for VoIP packets is enough it is visible that the queue acts as a pure multiplexer and shapes the traffic by means of its output packet delivery interval. These interesting results can directly influence interfaces and queue management of the next devices in the network [1]. The three services: VoIP, LAN emulation and transaction exchange are simulated and their queue fraction is also observed and shown in [1]. Table V represents mean values of the queue lengths per discipline and per service. They can be used for approximate planning of the time and space limits in the router interfaces.

TABLE V

MEAN QUEUE LENGTH.

Mechanism	Mean queue length, packets	Mean queue length of VoIP fraction, packets	Mean queue length of LAN fraction, packets	Mean queue length of Trans fraction, packets
IntServ	37.98	1	35	2
DiffServ	1586.96	2.24	1583.56	1.98
RSVP	1798.41	156.90	1639.67	2

VII. CONCLUSION

In this paper we show probability density functions of the packet intervals at the output of the traffic sources, at queue input and queue output as well as probability density function of queue length per service type. These results demonstrate the specific characteristics of the queue as a packet shaper in three QoS management algorithms: IntServ, DiffServ, and RSVP. The deterministic nature of the packets streams suppress shaping and increase losses. The statistical multiplexing effect is very limited due to the deterministic streams. Special attention is paid to the VoIP traffic as one of the most delay sensitive traffic.

The results demonstrate the capability of IntServ to define excellent service for VoIP. It is promising in access networks. DiffServ shows excellent resource management and utilization and therefore is better for core services. RSVP is a good counterpart of IntServ in access networks for VoIP. Its future development to NSIS protocol is going to be the most famous and powerful protocol next few years.

The authors refine the simulation model with more traffic sources and more precise generation of the packets from these sources based on the observation of the real traffic. Smaller VoIP packets and variable LAN packet length are under consideration. Limits criteria for queue management are also under investigation.

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REFERENCES

[1] R. Goleva, M. Goleva, D. Atamyan, K. Golev, P. Merdjanov, *Traffic Shaping Analyses In Metropolitan Area Network*, CSNDSP Conference, University of Patra, Patra, Greece, 2006 (applied paper).
[2] S. Jha, M. Hassan, *Engineering Internet QoS*, Artech House, 2002.
[3] T. Janevski, *Traffic Analysis and Design of Wireless IP Networks*, Artech House, 2003.
[4] L. Kleinrock, *Queueing Systems, Volume I: Theory,* John Wiley and Sons, 1976, ISBN 0-471-49111-X (v. 1).
[5] L. Kleinrock, *Queueing Systems, Volume II: Computer Application*, John Wiley and Sons, 1976, ISBN 0-471-49111-X (v. 2).
[6] V. Iversen, *Teletraffic Engineering Handbook*, ITU-D, 2005.
[7] S. Lavenberg, Editor, *Computer Performance Modeling Handbook*, Academic Press, 1983, ISBN 0-12-438720-9.
[8] J. Pitts, J. Schormans, *Introduction to IP and ATM Design and Performance*, John Wiley&Sons, Ltd., 2000.
[9] V. Ralsanen, *Implementing Service Quality in IP Networks*, John Wiley & Sons, Ltd., 2003.
[10] A. Tanenbaum, *Computer Networks, Second Edition*, Prentice-Hall International, Inc., 1989, ISBN 0-13-166836-6