LAN Traffic Shaping Analyses in Metropolitan Area Networks

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Abstract - **This paper represents LAN traffic shaping analyses in routers that apply the three QoS management techniques – IntServ, DiffServ and RSVP. The results show queue management and packet stream shaping based on simulation of the mostly demanded services – VoIP, LAN emulation and transaction exchange.**

Keywords - **Packet network, IP, Quality of Service, shaping.**

I. Introduction

IP networks are becoming new complex communication facility nowadays. They are enough easy for implementation and with high demand of Quality of Service (QoS) support. Last 10 years there were strong talks concerning QoS level but the price of its support was very high. Recently most of the routers and gateways that are not among the cheapest production set support such functionality. In this paper we analyze the traffic shaping effect of the three mostly used techniques IntServ, DiffServ, RSVP. The analyses are made on the basis of the three popular services – VoIP, LAN emulation, transaction exchange [1], [2], [6], [7]. The shaping effect is estimated on all services. The presented results are mostly on the LAN traffic that is second low priority traffic in comparison to the real time traffic from VoiP and video over IP. The model uses queues and priorities specific for the IntServ, DiffSerf, RSVP. This fractional shaping phenomenon is important in small to medium Metropolitan Area Networks (MAN) that grows rapidly and new customers appear almost every day.

II. Traffic sources

Three types of traffic sources are assumed in an example metropolitan area network – Voice over IP, LAN emulation and transaction exchange. LAN traffic is lower priority in comparison to the VoIP traffic and with higher priority in comparison to the transaction traffic. The there services are mixed together with some assumptions. In Voice over IP (VoIP) service silence and talk intervals are exponentially distributed with equal mean values [1]. In some papers on-off model is proposed [6].

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The limits for waiting times are calculated under consideration of end-to-end delay for every service [5]. Servicing times per packets are fixed on 100 Mbps line interface. Table I represents all the parameters for traffic sources in the model.

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	Exp.	Exp.	Exp.
Maximal waiting time, sec	0.00072	0.6	1
Maximal number of waiting packets	210	1804	2
Traffic sources	5000	500	1500
Priorities	High	Medium	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 [5]. Transaction exchange is specific with few packets exchange. The service is not time demanding.

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. More precise investigation can be done with 200 bytes or less voice packets.

III. Integrated Services

Integrated Services (IntServ) is a complex technique often called protocol that ensures Quality of Service in IP networks. It is applied usually in access routers or gateways 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 as elastic, tolerant real-time and intolerant real-time [2].

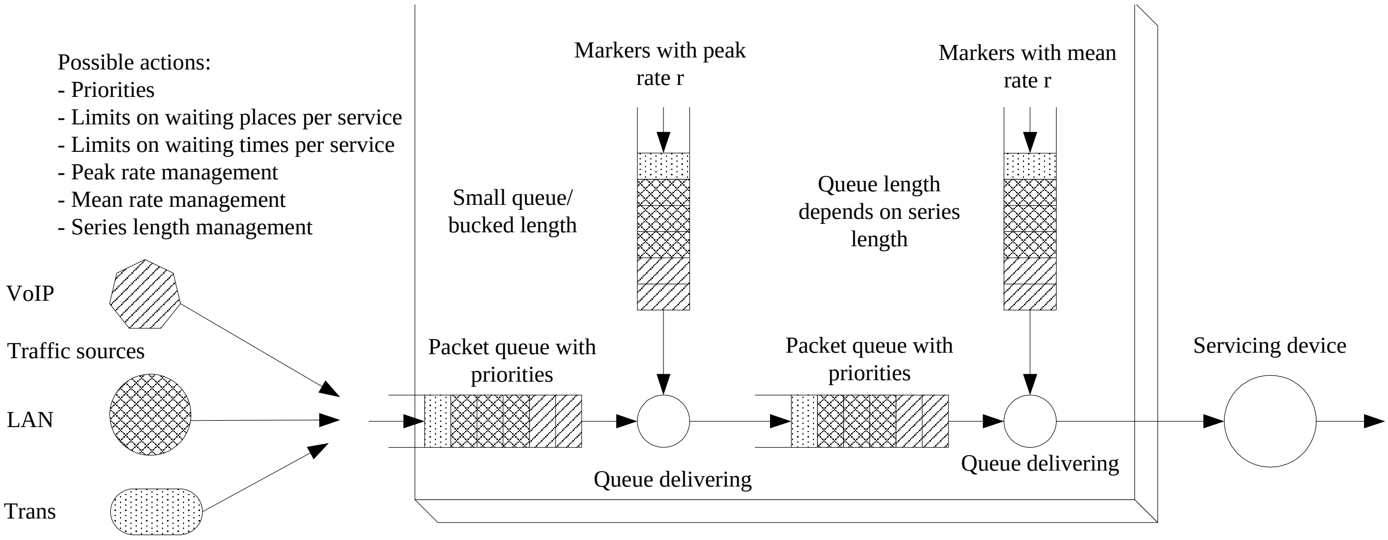

Fig. 1. Black box IntServ model approximation

Elastic applications are served in a “best effort” discipline [8]. They are served without any guarantee of 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 proper model for such traffic. LAN emulation is usually modeled this way. Some authors propose token bucket with series length and mean rate control for more accuracy (Fig. 1). Many authors propose the two token buckets to be connected in a cascade [7]. Intolerant real-time applications require low delays and almost guaranteed bandwidth. The model with two cascaded token bucket is compulsory for such traffic [1]. 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) [9]. The model from Fig. 1 is quite complicated for simulation. 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, priorities, fixed rate at the output and different limits for waiting times in the queue. This is the model that has been simulated further. Table II represents main data for model behavior.

IV. Differentiated Services

Differentiated Services (DiffServ) is another quality management technique that is more applicable for core networks. Due to its nature DiffServ applies its rules on aggregated traffic. 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 [6]: premium service with low delay, low loss, guaranteed bandwidth like VoIP; assured service with less requirements to the delay and loss in comparison to the premium service like LAN emulation; olympic service with no time requirements at all like transaction exchange.

The model from Fig. 1 is simplified with DiffServ procedure in mind. Simple FIFO queue with priorities and limits for waiting times per service is derived. System parameters are shown on Table II.

V. RSVP

Resource Reservation Protocol (RSVP) is a technique useful for delay sensitive traffic like VoIP. Three types of services are identified for RSVP like: wildcard filter with maximal requirements for given interface like LAN emulation; shared explicit with maximal requirements for the interface taking into account called address (transaction exchange is modeled as shared explicit service); fixed filter with full reservation for quality sensitive services like VoIP (Table II).

TABLE II
Model characteristics.

Parameter	IntServ	DiffServ	RSVP
Queue length, packets	2016	1840	1840
VoIP queue length fraction, packets	210	200	200
LAN queue length fraction, packets	1804	1640	1640
Transaction queue length fraction, packets	2	2	2
Maximal waiting time for VoIP, sec	0,000716	0,0303	0,07508
Maximal waiting time for LAN, sec	0,6	0,27876	0,69
Maximal waiting time for transactions, sec	1	1	1
Priority for VoIP	Highest	Highest	Highest
Priority for LAN	Medium	Medium	Medium
Priority for transactions	Low	Low	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 [3], [4], [5]. 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 way to gather with packets and this influences the way they drop packets and shape them. On Fig. 2, Fig. 3 and Fig 4 probability density function of packet intervals at the input and output of the queue is shown for all services. It is interesting for shaping estimation. The effect of fast servicing in RSVP can be seen from Fig. 2. The delay variation of the packet intervals is becoming smoother and tends to constant value. Similar result is visible for IntServ on Fig 3. On Fig 4 shaping of the IntServ and DiffServ is seen again.

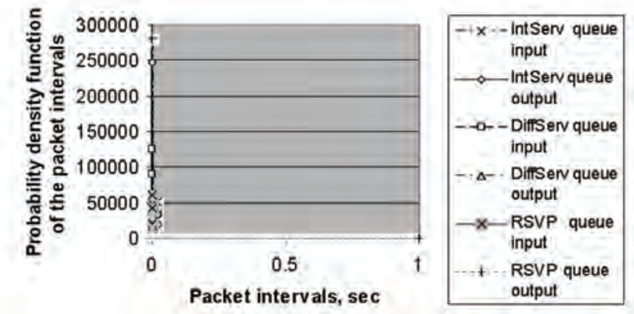

Fig. 2. Delay variation reduction in RSVP

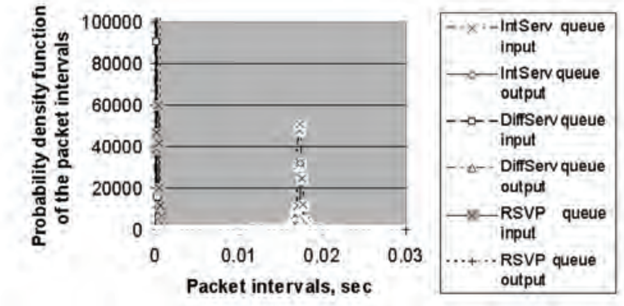

Fig 3. Delay variation reduction in IntServ

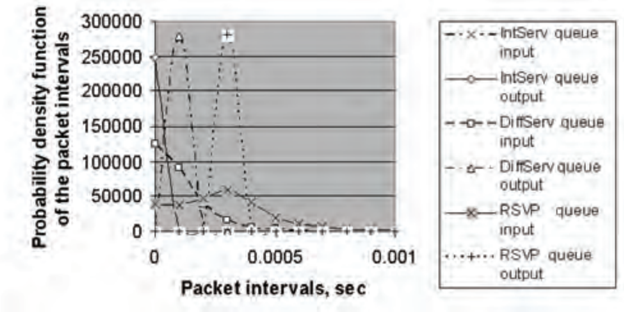

Fig 4. Delay variation reduction in IntServ and DiffServ

Fig. 5 and Fig. 6 represent probability density function of the packet intervals at input and output of the queue only for LAN traffic. The effect of low delay is visible for IntServ and DiffServ. The queue is full and the overall effect of traffic acceleration is compensated by bigger traffic delays for anothre type of traffic. This is visible from Fig. 7. The deterministic nature of the traffic is still kept.

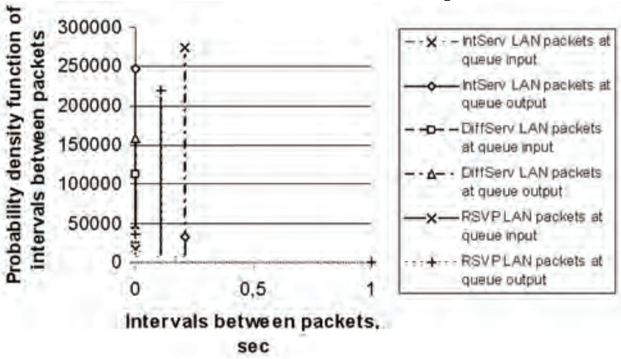

Fig. 5. Probability density function of queue intervals at queue input and output for IntServ, DiffServ and RSVP for LAN traffic.

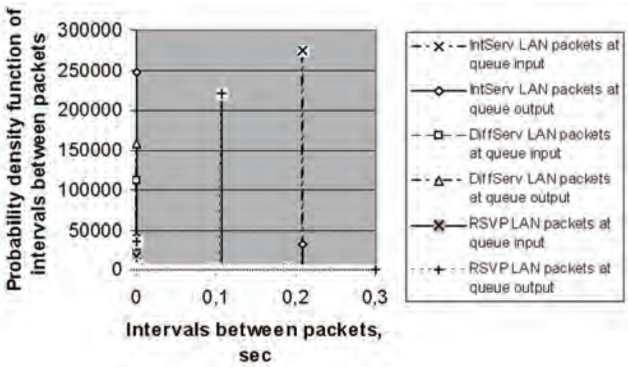

Fig. 6. Probability density function of queue intervals at queue input and output for IntServ, DiffServ and RSVP for LAN traffic.

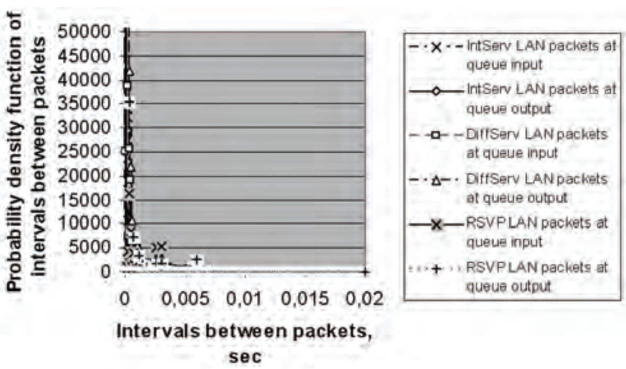

Fig. 7. Probability density function of queue intervals at queue input and output for IntServ, DiffServ and RSVP for LAN traffic.

The mean values for the intervals of LAN traffic at queue input and output for IntServ, DiffServ and RSVP model for different services are shown on Table III, Table IV and Table V. The dispersion and mean squire deviation are high for the rare traffic events. This means that special attention is needed to be paid to the more precise estimation of the status of the queues if necessary. The three QoS techniques distribute the queue resource in a different way. This is the reason to see different mean values. The acceleration effect visible from the graphs is explained more precisely by these tables. The acceleration effect for given traffic (e.g. VoIP on Table

IV) is due to the delay efferct for another traffic. The overall results are always with delay.

TABLE III
INTERVALS BETWEEN PACKETS IN QUEUE INPUT AND OITPUT FOR INTSERV

Traffic source	Mean value	Disperssion	Mean squire deviation
Overall at queue input	0.01726 sec	0	0.00678
VoIP at queue input	0.01732 sec	0	0.00055
LAN at queue input	0.2067 sec	0.00005	0.01255
Transactions at queue input	0.00459 sec	0	0
Overall at queue output	0.01732 sec	0	0
VoIP at queue output	0.01733 sec	0	0.00096
LAN at queue output	0.2076 sec	0	0.00231
Transactions at queue output	0.01937 sec	0	0

TABLE IV
INTERVALS BETWEEN PACKETS IN DIFFSERV

Traffic source	Mean value	Disperssion	Mean squire deviation
Overall at queue input	0.00014 sec	0	0.02628
VoIP at queue input	0.00038 sec	0	0.49381
LAN at queue input	0.00053 sec	0.00005	0.20726
Transactions at queue input	0.00494 sec	0	0.0628
Overall at queue output	0.00015 sec	0	0.02037
VoIP at queue output	0.00037 sec	0	0.43854
LAN at queue output	0.00055 sec	0.00005	0.23368
Transactions at queue output	0.01609 sec	0	0.02573

VII. CONCLUSION

In this paper we show probability density functions of the packet intervals at the 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, 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.

TABLE V
INTERVALS BETWEEN PACKETS IN RSVP

Traffic source	Mean value	Disperssion	Mean squire deviation
Overall at queue input	0.00035 sec	0	0.01637
VoIP at queue input	0.00054 sec	0	0.47737
LAN at queue input	0.08488 sec	0.00173	0.18633
Transactions at queue input	0.00396 sec	0	0
Overall at queue output	0.00038 sec	0	0
VoIP at queue output	0.00054 sec	0	0.38552
LAN at queue output	0.08555 sec	0.00164	0.17985
Transactions at queue output	0.00608 sec	0	0

The results demonstrate the capability DiffServ to support excellent resource management and utilization. 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. MMPP or geometric/ Weibull distributions are also considered. Limits criteria for queue management is also under investigation.

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