SOME TCP TRAFFIC SHAPING SIMULATION ANALYSES IN ATM NETWORKS

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Keywords: Traffic Shaping, ATM, TCP, VSA , GCRA, Network Simulation

ABSTRACT

In this paper, the results of some TCP traffic shaping simulation analyses realized in high-speed ATM networks are presented. A sample ATM network is used, comprising two ATM switch and four TCP connections share the bandwidth of a bottleneck link with some background traffic. The effect of the background traffic on the TCP protocol performance is examined, taking four TCP connections with different lengths as well as the bit rate that each TCP connection is allowed to use through the generic cell rate algorithm (GCRA) shaping function.

I. INTRODUCTION

In the long time periyod, the data traffic is expected to be a relevant part of the load in ATM networks. TCP is now the standart protocol in the LAN,WAN and MAN areas. And TCP will be used transport protocol in ATM environment. This work considers the effect that the heterogeneous traffic (background traffic) present in the network may have on the TCP performance. The importance of the presence of background traffic is the reduction of the bandwidth available to TCP. The results presented in this paper are obtained via simulation, implementing a TCP layer within an ATM network simulator named CLASS (ConnectionLess ATM Services Simulator). CLASS[1] was developed at Politecnico di Torino-Italy for the performance study of data services in ATM networks.

II. THE PURPOSE OF TRAFFIC SHAPING

Traffic shaping has three main purposes. These are:

1. The characteristics of a flow of cells that has endured a shaping process are much easier to be described, thus the shaping of the traffic allow the user to negotiate the transmission parameters more easily.
2. If the shaping algorithm is known to the network too, it helps also the network in the management of the call acceptance because it can more easily predict the behavior of the generator.
3. Monitoring of the traffic on the network side, i.e. traffic policing, is much easier and reliable if the input flow has known characteristics[2].

The traffic control algorithm that has been chosen for the inclusion in this study is the Virtual Scheduling Algorithm, described in the recommendation I.371 of ITU[3]. This algorithm is basically a token bucket . Each time a cell becomes available for transmission, the Virtual Scheduling Algorithm determines whether the cell is conforming with the Traffic Contract of the connection. The VSA not only provide to control the traffic characteristics, but also provide a means for the formal definition of traffic conformance to the Traffic Contract. The VSA requires only the definition of two parameters: the time increment between cells T and the time limit τ . The time increment between cells is clearly the time that should pass between two consecutive cells if the traffic was generated at constant bit rate. τ is the time jitter that is allowed and is clearly related to the parameter generally called ``cell delay variation''. The VSA keeps track of a Theoretical Arrival Time (TAT ), which is the ``nominal'' arrival time of the next cell assuming equally spaced cells when the source is active. If the actual arrival time of a cell is not ``too'' early relative to the TAT , in particular if the actual arrival time is after TAT time of the first cell be t_a (1). In this case the cell is transmitted immediately and the TAT is initialized to the [t_a (1) + T] .

There are several possibilities for shaping algorithm implementation. The easiest solution is to perform the shaping at the front end on the transmitter, negotiating the traffic parameters for all the traffic generated by the user The shaping policies applied to the users in this study is VP-based shaping policy[4]. According to this policy, the users grouped under this category perform the shaping of the traffic at the interface between the user buffer and the transmission link. This means that these users have only a single “traffic shaper”, that operates upon the whole traffic generated by the user, without considering the destination, VCI or traffic relation. According to this, there is only one group and the output multiplexer is not present, all the VC are grouped together and the multiplexing among the VCs is done at the message level, i.e. all the cells of the same message are in any case transmitted sequentially one after the other without interleaving with cells of other messages. The user negotiates the bandwidth needed for the transmission of the whole traffic with the node, and sets accordingly the traffic parameters. The other parameter needed by the VSA, namely T, is computed as follows[1,4]:

$$T = C / B_w .\beta$$

C = Link capacity

B_w = Mean bandwith required by the user

β = Bandwidth allocation factor

III. THE SIMULATION RESULTS AND DISCUSSION

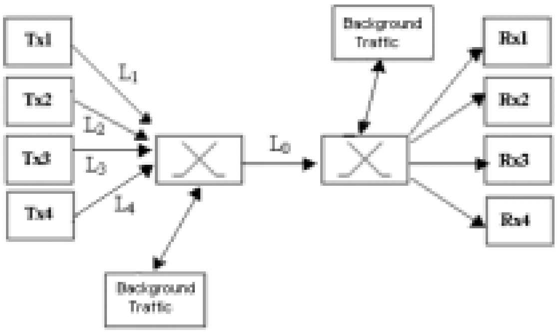

Figure 1. The simulated ATM network topology

We use a simple network, sketched in Fig. 2, comprising only two ATM switches. The data rate on each channel is 150 Mbit/s, and channel L0, linking the two ATM switches, is the system bottleneck. Four unidirectional TCP connections share the network resources with a variable amount of background traffic which contains 5 ON-OFF source. The background traffic messages are generated according to a Poisson process. The mean value of background traffic messages is 30 cells. The burstiness of both the TCP connections and the background traffic can be controlled with a shaping device that operates according to VSA (an adaptation of the GCRA) recommended by ITU-T . When the background traffic is shaped, we assign to each connection $\beta = 1.2$ and $\tau = 0$ values. We assume that three TCP transmitters have a maximum window size equal to 30 segments and the remaining TCP connection has 60 segments. TCP protocol always transmits segments of the the maximum possible size (9180 bytes). Numerical results in this study are presented as curves referring to two performance indices. These indices are:

1. The useful throughput which is called goodput, at the TCP receivers, obtained considering the received data, but discarding all the faulty and the retransmitted segments.
2. The efficiency of the TCP connections, i.e., the ratio between the goodput and the total offered load of TCP connections[5].

The performance of this considering ATM network scenario was studied as a function of some variables: the background traffic load and traffic characteristics the TCP traffic shaping parameters .

In the simulations , we consider four TCP connections with different lenght. This stuation may be quite prevalent condition in reality. The goodput and the efficiency of each TCP connection are separately plotted in this scenario. The simulation results presented in Fig. 2, 3, 4 and 5 are obtained when lenghts of the links L1, L2, L3, L4 in Fig. 2 have 1 km, 10 km, 100 km, 1000 km lengths respectively, while the links from the second ATM switch to the TCP receivers are assumed to have negligible length. Thus the lenghts of the TCP connections are 401km., 410 km, 500 km, 1400 km respectively. The results are presented as a function of the background traffic load, for the value of the node buffer size in front of the congested link, L0, 5000 cells, with the background traffic unshaped or shaped at 35 Mbit/s.

The goodput and the efficiency of each TCP connection when the traffic on TCP connections is unshaped are presented in Fig. 2 and Fig. 3 respectively. As expected, when no shaping is performed on the TCP traffic, that is, when the TCP connections are unshaped , the value of TCP goodput obtained by the connections is resulted inversely proportional to the connection length, decreases with increasing background traffic, except the TCP connection with 10 km (see Fig. 2). The reason of this, the TCP throughput is to be inversely proportional to the round trip delay. This unfair situation between TCP connections with different lengths can be corrected by appropriating a 35 Mbit/s shaping.

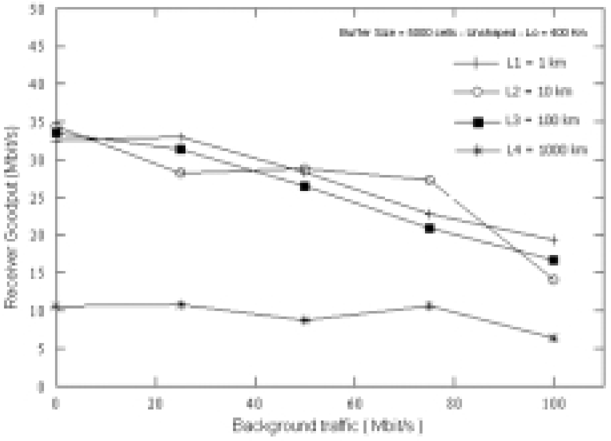

Figure 2. Average receiver goodput of TCP connections for the simulated scenario (unshaped situation)

The simulation results of TCP goodput and efficiency when the traffic on TCP connections is shaped at 35 Mbit/s are presented in Fig. 4 and Fig. 5, assuming $\tau = 0$. The results show that straightening the burstiness of the traffic offered to the network allows TCP connections to better exploit the available resources.

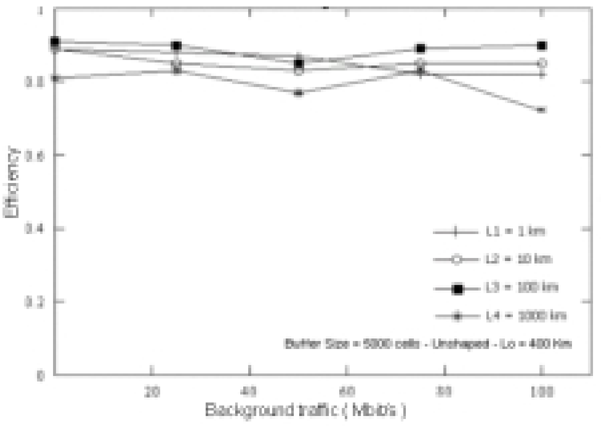

Figure 3. Average receiver efficiency of TCP connections for the simulated scenario (unshaped situation)

The shaping value correspond to 7/30 of bottleneck link capacity. In particular, when a 35 Mbit/s shaping is enforced on TCP connections and no background traffic is present, the TCP connections completely saturate the link capacity. In the low and average load cases, the goodput achieved with a 35 Mbit/s shaping is always greater than the unshaped goodput. And especially, the resulting goodput of the TCP connection with 1400 km length gives better results in comparison with unshaping situation (see and compare Fig. 2 and Fig. 4).

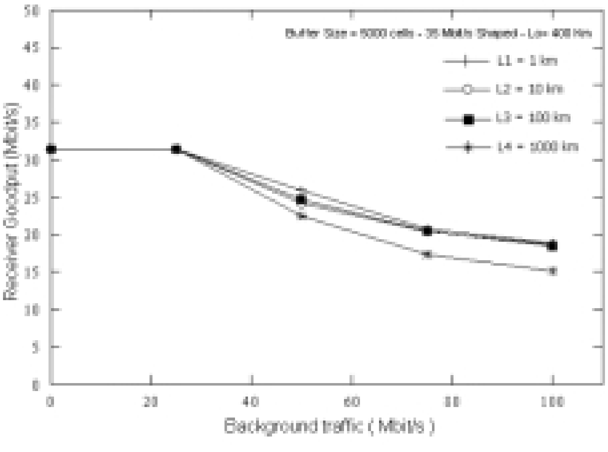

Figure 4. Average receiver goodput of TCP connections for the simulated scenario (35 Mbit/s shaped situation)

In the 35 Mbit/s shaping case, the goodput difference between the TCP connections is negligible, while the TCP connection with length 1000 km still gets a lower bandwith in the high background loads. But in the low background loads, this difference becomes less significant.

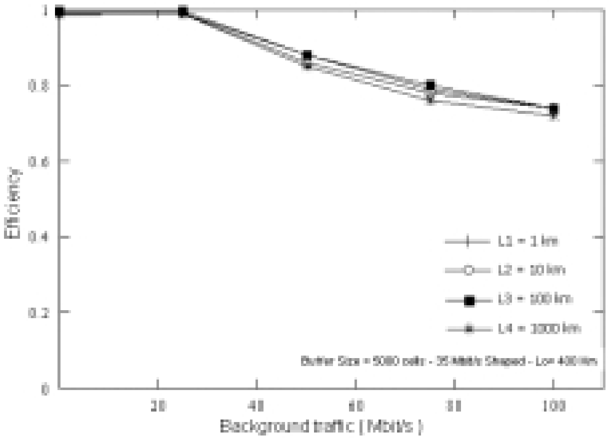

Figure 5. Average receiver efficiency of TCP connections for simulated scenario (35 Mbit/s shaped situation)

As a result of our simulation results, the efficiencies of TCP connections are independent from connection length. This means that the losses due to buffer overflow are roughly proportional to the bandwith grasped by the connection. And especially in the high background loads, shaping gives better efficiency results in comparison with unshaped TCP connections. (see and compare Fig. 3 and Fig. 5)

IV. CONCLUSION

The numerical results of our simulations indicated that shaping the traffic on the TCP connections greatly improves the TCP goodput and efficiency performance in comparison with unshaped TCP connections. Shaping implied the negotiation of a traffic contract between the network and the TCP protocol entities at connection setup. In brief, the simulation results in this paper proved that limiting the rate of TCP connections with different length provides quite a benefical impact on the ATM network performance without requiring any substantial modification to the TCP protocol.

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