# Priority Traffic Shaping Analyses in ATM Networks

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*Abstract* – **In this paper the traffic shaping analyses of voice, data and video traffic sources with priorities are given. ATM traffic sources are specified by their quality class. Shaping techniques with and without priorities are implemented and compared. Results show the delay distribution and its influence on end-to-end cell delay.**

*Keywords* – **ATM, traffic source, traffic shaping, ATM multiplex, QoS, priority**

## I. Introduction

ATM technology is the unique technology in the world that may fully support so called traffic contract with end-users. This specific and useful feature is important when the user would like to commit and be sure on the Quality of the Service (QoS) received. ATM technology is going to be blown away from the market by IP network, but the work necessary to support QoS in IP-based network is still far away from the really comparative status.

The network establishes a separate traffic contract with the user of each ATM Virtual Path Connection (VPC) or Virtual Channel Connection (VCC). It is regarding a set of traffic parameters of the cell flow including Quality of Service (QoS) parameters. One of the major problems is the high bandwidth that usually the end-users ask for. There are many different approaches already known from the literature on decreasing the bandwidth. The most prominent but still not well implemented is traffic shaping. Because of lack enough collected experience traffic shaping devices are almost not available on the market.

It is considered that new generation ATM (Asynchronous Transfer Mode) terminals will obtain shaping functionality. Traffic shaping may influence significantly on the Quality of Service. It may play with the balance between cell delay and cell loss in real-time and non-real-time services and optimize the load to the transmission lines and ATM switches. Therefore, it is expected that the overall price will decrease due to the offered optimization.

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Network Performance (NP) parameters have significance only at network side. The mapping between Network Performance and Quality of Service parameters is performed at Service Access Reference Point (SAP).

## II. Traffic Sources

When the end-user signs traffic contract many QoS parameters might be identified as: Cell Delay (CD) – the delay of the cell at given node of the network; end-to-end Cell Delay – the delay of the cell between two end-terminals; Cell Delay Variation (CDV) – the variation of the cell delay arrival times at given network node. Cell delay and cell delay variation have an great impact on the traffic shaping. The ATM forum has defined QoS classes and has specified certain values for the QoS parameters for each class. The classification is as follows:

- Service class A – connection-oriented service, circuit emulation, Constant Bit Rate (CBR) applications like voice, video, audio, etc.;
- Service class B – connection-oriented service, Variable Bit Rate (VBR) sources like audio and video;
- Service class C – connection-oriented data transfer, VBR sources like Frame Relay data source, LAN emulation source, etc.;
- Service class D – connectionless data transfer with VBR sources for WWW, email, etc.

QoS classes identified also by the ATM Forum are five:

- Class 0 – unspecified quality for protocols like “Best effort”. It is implemented now in Internet;
- Class 1 – specified quality for service class A;
- Class 2 – specified quality for service class B;
- Class 3 – specified quality for service class C;
- Class 4 – specified quality for service class D.

All the other QoS classes without class 0 directly map to the service classes. QoS class 0 is a special case of lack of quality negotiation. Furthermore, a simulation of voice and data traffic sources is presented. Voice traffic is delay and delay variation sensitive. Data traffic is loss sensitive. The main problem with data traffic is its self-similarity. That means that the burstiness of the data traffic remains almost the same even after few ATM multiplexes. It is seen that the data traffic congested the transmission line and suppressed the voice traffic.

## III. Traffic Shaping

In order the user to derive maximum benefit from the quaranteed QoS from ATM, the device connecting to the network should ensure that the cells sent to the network conform with the parameters in traffic contract. Traffic shaping is used accordingly to reorder and shift service cells in the way to satisfy all the contracts simultaneously. A network may also employ shaping, when transferring a cell flow to another network in order to meet the conditions of a network-to-network traffic contract, or in order to ensure that the receiving user application operates in an acceptable way. Traffic shaping might be also applied by different network nodes in order to avoid congestion or cell loss.

There are many algorithms for traffic shaping and some of them are: buffering; Leaky Bucket buffering; spacing; scheduling; burst length limiting; source rate limitation; framing.

## IV. Delay and Loss Priority Control

Priority control helps achieving the full range of QoS loss and delay parameters required by the applications. Delay priority involves the use of separate queues served in a prioritized manner. Loss priority involves thresholds within the buffers for different traffic types and Cell Priority (CLP) bit in the cell header.

Priority queuing implements multiple queues in the switch, such that traffic on certain Virtual Path Connection/Virtual Channel Connection that are not tolerant on delay can go ahead of those that are more tolerant on delay. ATM switches employ priority queuing between VPCs and VCCs in different QoS classes or service categories to meet different delay and loss priorities simultaneously (Fig. 1).

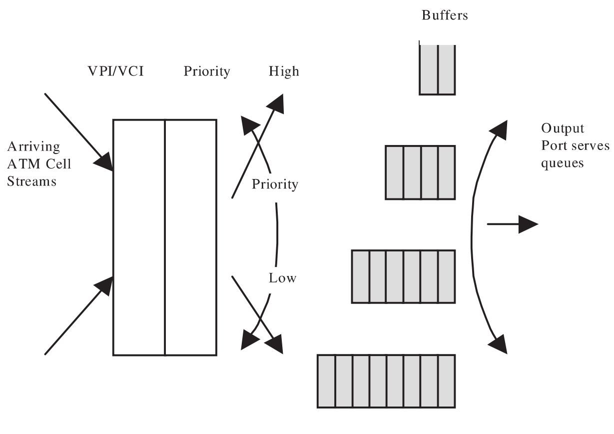


Fig. 1. ATM switch port

In the example shown on figure 1 the priority queuing function operates on the output port of an ATM switch. The switch takes arriving cell streams from multiple input ports, looks up an internal priority value. It directs the cell to one of several corresponding queues on the output port. The output side of the ATM port serves each of the queues according to a particular scheduling algorithm.

In some algorithms the cells from the highest priority nonempty queue are served first. Then the cells in the lower priority queue are served. The process continues for each successively lower priority queue. Thus it is ensured that the highest priority buffer has the least loss, delay, and delay variation. As a result lower priority queues may experience significant delay variation.

Other algorithms spread out the variation in delay across the multiple queues. For example, a schedular could send out cells just before reaching the maximum delay variation value for cells in the higher priority queues. Thus delay variation in the lower priority queues is decreased.

## V. Priority Discard

The priority order of cells can be determined by discard thresholds. On the switch port each delay priority queue may be segmented into several regions via the thresholds. Arriving cell streams have the CLP bit. The switch port consults a lookup table to determine the Queue Loss Priority with a value of either high (H) or low (L). For example, when we use four thresholds they determine the priority order for cell discard based upon buffer occupacy as follows. Starting from right to left the first cells to be discarded are with Queue Loss Priority – QLP=L, CLP=1. Next come for QLP=H, CLP=1 cells, following by QLP=L, CLP=0 cells and finally cells with QLP=H, CLP=0 are discarded only if the entire buffer is full. Other choices of discard thresholds are also possible.

## VI. Results and Conclusion

Traffic shaping phenomena is simulated on computer by Visual Basic program. Different priority schema is applied for different services as well as its influence on the probability density function (pdf) of cell delay. The main results from this simulation are an investigation of the self'similarity of the traffic, shaping effect on voice, data, and mixed voice and data traffic. On Fig. 2 the probability density function of the cell delay for 25 data sources at the entrance of the ATM multiplex is shown.

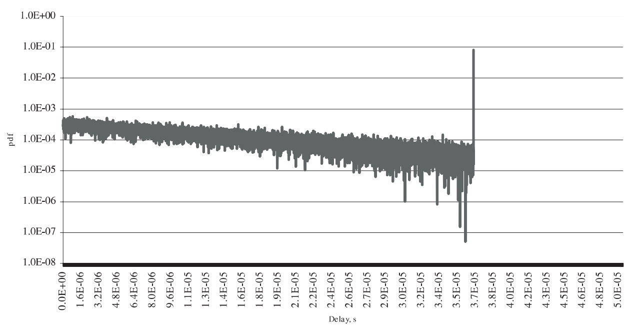


Fig. 2. Pdf function of the delay distribution of 25 data sources before ATM multiplex

Figure 3 shows the pdf function of the same traffic mixture after pure FIFO queue. The shaping is very limited. Figure 4 represents the pdf of the delay of the source with the highest

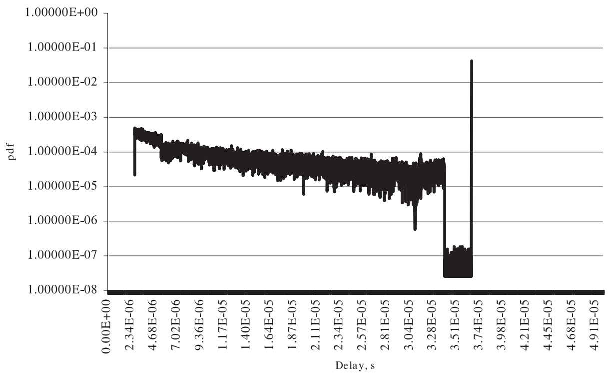


Fig. 3. Pdf function of the delay distribution of 25 data sources after ATM multiplex

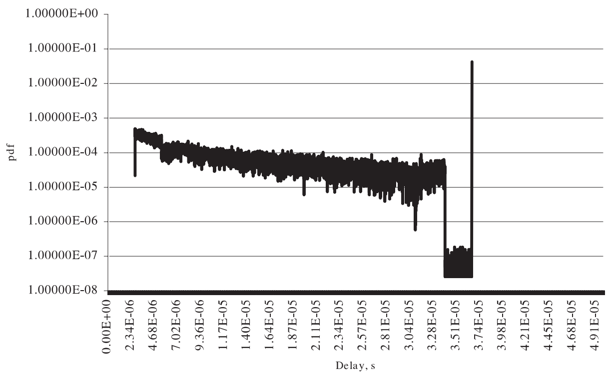


Fig. 4. Pdf function of the delay distribution of the first data source after ATM multiplex

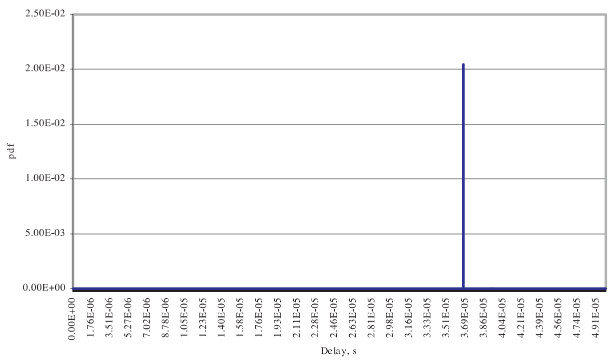


Fig. 5. Pdf function of the delay distribution of the last data source after ATM multiplex

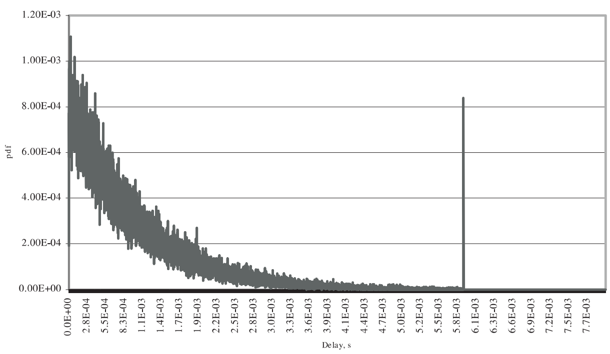


Fig. 6. Pdf function of the delay distribution of the 25 voice sources before ATM multiplex

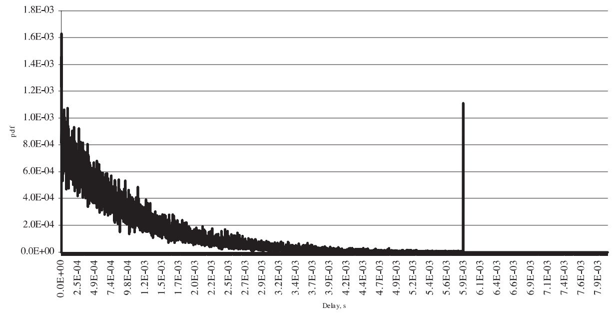


Fig. 7. Pdf function of the delay distribution of the 25 voice sources after ATM multiplex

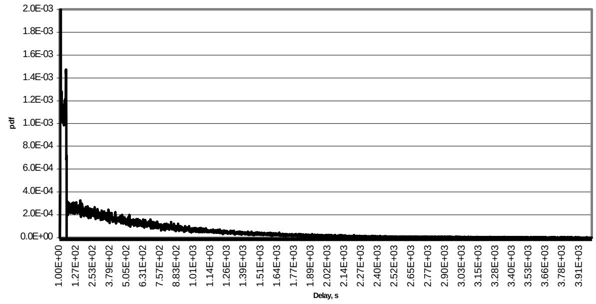


Fig. 8. Pdf function of the delay distribution of the 1 data and 50 voice sources after ATM multiplex

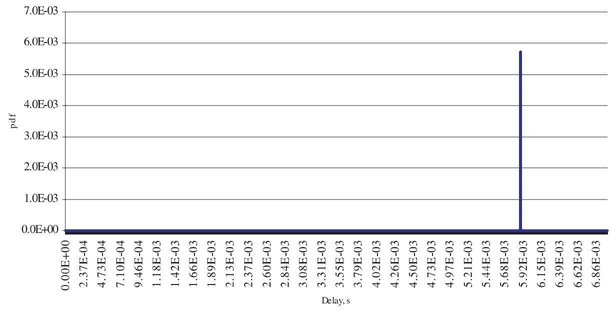


Fig. 9. Pdf function of the delay distribution of the first voice source among 1 data and 50 voice sources after ATM multiplex

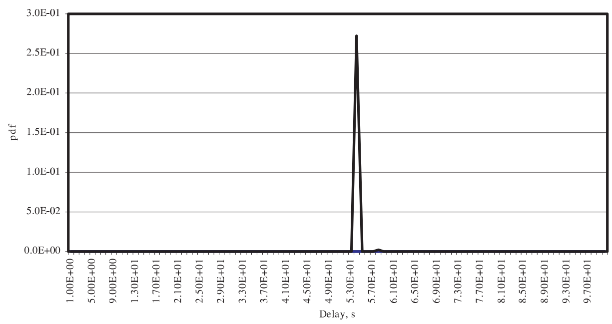


Fig. 10. Pdf function of the delay distribution of the data source among 1 data and 50 voice sources after ATM multiplex

priority as well as Figure 5 shows the pdf of the source with the lowest priority of the same traffic sample.

Pdf of the delay before and after the ATM multiplex of the sample of 25 voice sources is represented on figures 6 and

7. The peak in the figures is due to the packetization delay. Figure 8 shows the mixture of the typical office traffic of 50 voice and 1 LAN emulation data sources. Voice traffic has the highest priority.

Figure 9 and 10 represents the pdf of the delay of the first (with highest priority) voice source and the data (with the lowest priority) source.

The authors continue to work on the problem trying to estimate cell delay variation and its derivatives. The problem is also referred to pure packet switching networks like IP based networks.

## References

[1] Collivignarelli, M., A. Daniele, G. Gallassi, F. Rossi, G. Valsecchi, L. Verri, System and Performance Design of the ATM Node UT-XC, IEEE Selected Areas On Communication, 1994.

[2] Kadrev, V., R.Goleva, Analyses of ATM Multiplex Behavior Influenced by Different Types of Traffic Sources, Proceedings from Telecom’98, Varna, Bulgaria, 1998.

[3] Goleva, R., Analyses of Traffic Shaping and its Influence on Quality of Service in BISDN, Proceedings from Telecom’2001, Varna, Bulgaria, 2001 (on publishing)

[4] Kadrev, V., R.Goleva, Analyses of Cell Servicing in ATM Multiplex with Deterministic Traffic Sources, Proceedings of ITC Sponsored St. Petersburg Regional International Teletraffic Seminar “Teletraffic Theory as a Base for QoS: Monitoring, Evaluation, Decisions”, LONIIS, Saint- Petersburg, June-1 -7, 1998, pp. 377-388.

[5] Kadrev, V., R.Goleva, Cell Delay and Cell Loss Ratio with Different Type of Traffic Sources in ATM Multiplex, Proceedings from Telecom’98, Varna, Bulgaria, 1998.

[6] Kim, Y. C., Dong Eun Lee, Bong Ju Lee, Dynamic Channel Reservation Based on Mobility in Wireless ATM Networks, IEEE Communications Magazine, Nov. 1999.

[7] McDysan, D., ATM Theory and Application, McGraw-Hill, 1999.

[8] Information Technologies and Sciences, COST 224, Performance Evaluation and Design of Multiservice Networks, Edited by J. W. Roberts, Oct. 1991.