# Traffic Shaping Analyses in ATM Networks

Rossitza Ivanova Goleva[1] and Kostadin Atanasov Golev[2]

*Abstract* -**In this paper the traffic shaping analyses of voice and data traffic sources are given. ATM traffic sources are specified by their quality class. Shaping techniques are presented. The most simple shaping is implemented. Results show the delay distrinbution before and after ATM multiplex and influence on end-to-end cell delay.**

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

## I. Quality of Services in BISDN

Broadband Integrated Services Digital Network (BISDN) is deployed slowly to the end-users due to its high service and investigation price. Recently many telecommunication operators offer broadband service over ADSL[1] subscriber lines. However, BISDN network is the unique existing solution that supports Quality of Service (QoS) negotiation, renegotiation, management, guarantee [1], [2], [3], [4], [5], [6]. 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[2] 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. In BISDN, at the moment of service origination the end-user signs virtually so-called traffic contract with the operator. This contract sets many QoS parameters that have to be kept during the connection or until their renegotiation. The network maps QoS parameters with so called Network Performance (NP) parameters.

[1] Rossitza Goleva is an Assistant-Professor in the Department of Telecommunications at Technical University of Sofia, Kl. Ohridski blvd 8, 1756, Sofia, Bulgaria, Email: rig@vmei.acad.bg, Member of IEEE

[2] Kostadin Golev is a student in the Department of Telecommunications at Technical University of Sofia, Kl. Ohridski blvd 8, 1756, Sofia, Bulgaria, Email: kotseto@hotmail.com

NP parameters have significance only at network side. The mapping between NP and QoS 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. This variation is accumulated usually through network nodes. This is the reason to keep CDV in given thresholds not only at any network node but also end-to-end. The delay parameters are negotiated in the traffic contract. Cell delay and cell delay variation have an great impact on the traffic shaping.

BISDN traffic sources are classified by the ITU-T[3] and ATM Forum as follows:

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

QoS classes identified also by the ATM Forum are five:

0) Class 0 – unspecified quality for protocols like "Best effort". It is implemented now in Internet;
1) Class 1 – specified quality for service class A;
2) Class 2 - specified quality for service class B;
3) Class 3 - specified quality for service class C;
4) 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. In this paper 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. Furthermore, it will be

[1] Available Digital Subscriber Line
[2] Asynchronous Transfer Mode

[3] International Telecommunication Union – Telecommunication Sector

seen that the data traffic congested the transmission line and suppressed the voice traffic.

## III. TRAFFIC SHAPING

There are many ways to shape the traffic known from the literature [6], [8], [7]. Some of them are already applied by many telecom operators in ATM core and access networks. For example Leaky Bucket multiplex and Multi-Protocol Label Switching (MPLS) routers compete successfully noway on the market. Actually ATM obtains many advantages both in access and core transmission networks. MPLS has many advantages in core network when the Internet traffic is separated from the other types of traffic.

Many algorithms for traffic shaping are known from the literature like:

➢ ***Buffering.*** All the cells from the traffic sources enter one FIFO[4] queue or sequence of many FIFO queues without priorities. Fig. 1 shows one queue in the example with data, voice and video traffic sources. The problem with pure FIFO queue is that the effect of cell shaping is small. Data traffic with high burstiness will not be effectively touched by one or two consecutive FIFO queues. In the case with many consecutive queues any queue in the chain will add its fraction of the traffic shaping. In order to reach real reduction of the burstiness in 30 or more percent the traffic should pass many queues or circle many times in the output buffers of the terminal or Network Termination devices. This algorithm is also called **unforced shaping**. The effect of statistical multiplexing can be seen only in case with long queues and with the traffic sources of equal type. Cell loss might be seen only in case of lack of space in the queue.

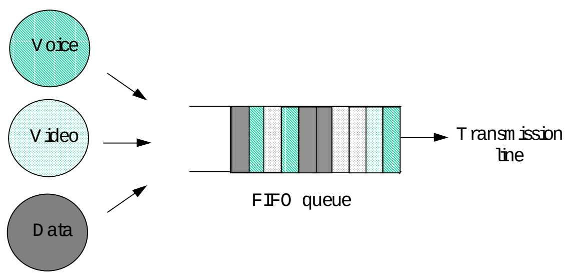


Fig. 1. FIFO queue as an ATM multiplex.

Different version of buffering algorithm with priorities is shown on Fig. 2. There are 2 levels of priorities applied for different types of traffic sources. High priority is set for the traffic sources sensitive to the cell delay and cell delay variation like voice and video. Data traffic remains with low priority. Then data cells will stay longer in the queue. More levels of priority can be used too. It is difficult to be done at ATM level because of just one priority bit in the header of the cell.

[4] First Input First Output

➢ **Leaky Bucket and Buffering**. Leaky Bucket uses thresholds for different traffic sources. Therefore it applies FIFO queue with priorities. Cells with equal priority enter the specific part of the queue. These parts are limited by so called thresholds. Cells do not violate the traffic contract until Leaky Bucket admits them. Leaky bucket is one of the most useful technology for traffic admission control.

➢ **Spacing**. Spacing means to add extra space between the cells at source level purposely. It decreases Cell Delay variation but increases cell delay. Cells with high CDV will be discarded at the source level.

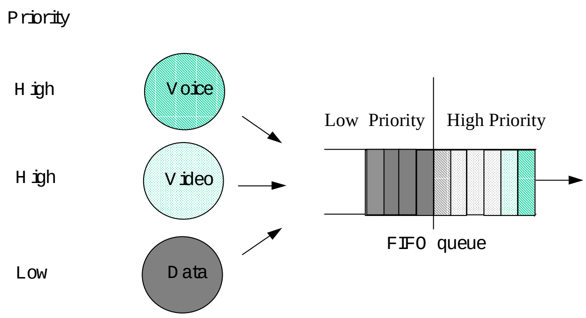


Fig. 2. FIFO queue with 2 levels of priorities.

➢ **Peak Cell Rate Reduction**. It forces the end terminal to work at the rate less than the confirmed peak cell rate. The bursts are buffered and the output rate of the buffers is kept less that the peak cell rate. This technology is not applicable to the real-time services.

➢ **Scheduling.** Many separate queues are organized for different types of traffic sources. In fact the traffic is distinguished at end-user terminal there is no problem to organize separate queues for different types of sources. The problem appears when the traffic is already mixed.

➢ **Burst Length Limiting.** It limits the length of the burst at the source level. This technology is similar to the peak cell rate reduction. The bursts are buffered and the output rate of the buffer is controlled. The buffer is not allowed to send continuously cells for more that predefined time interval without break. This technology is not applicable to the real-time services.

➢ **Source Rate Limitation**. It forces the source to limit the peak and mean rates. The limitation is supported by buffers with output rates less then the peak rate at the entrance and with overall limit on the mean rate.

➢ **Framing**. This technology is similar to reservation schema known from the local data networks. Fig. 3 presents partial reservation technology for the traffic sources. Few time slots are left unreserved purposely. All the traffic sources that face lack of bandwidth may compete for these time slots. Partial reservation is in practice full reservation for the part of the frame and contention for the rest part of the same frame. It is applied in inverse ATM multiplexing.

Shaping can be **forced** and **unforced**. Unforced type of shaping means that we use ATM multiplexes in order to collect the ATM streams in one common stream and as a matter of side effect we can gain traffic shaping. Forced shaping means that we apply the ATM multiplexes and their cell ruling algorithms mainly for shaping effect.

The easiest traffic-shaping device is FIFO queue without priorities. It is good for smooth traffic sources like voice, video traffic but it has no shaping effect on the data traffic. When many ATM FIFO multiplexes in sequence are applied it is seen some smoothing process on the traffic but are not able to avoid self-similarity of the data traffic. That is because of the contention in the ATM queue and small length of the queue. When the buffers are small shaping is done at cell level. When the buffers are big enough shaping is performed at bursts level. Actually, when the traffic is shaped the bursts are expanded. Therefore, bigger cell delay and less cell delay variation are paid by the price of burst expansion [3].

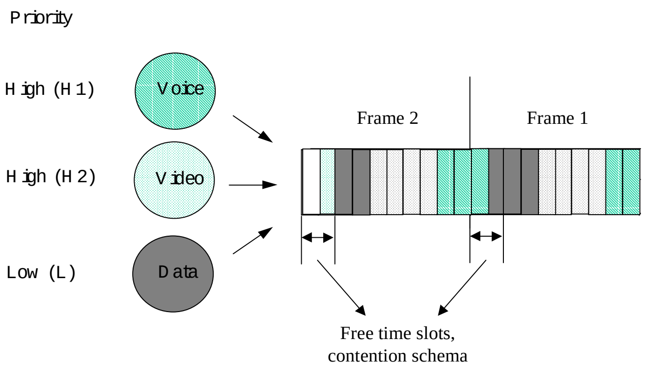


Fig. 3. Framing with partial reservation.

In this paper one ATM multiplex is simulated with voice and data traffic sources. When the servicing discipline is without priorities the queue acts as pure FIFO. In case of the priorities applied the queue is FIFO for different types of priority classes. High-level priority cells overcome all low-level priority cells. ATM multiplex serves only one cell at given moment. New cells arriving at the same moment wait in the queue or are lost in case of full queue. Voice cells are coming with constant bit rate of 64kbit/s and obtain high priority. Data cells are coming with low priority and with the rate of 10Mbit/s. Therefore, a typical application like small to medium office with many telephone lines and LAN connection to the Internet is presented.

## IV. Results and Conclusion

The main results from this simulation are an investigation of the self'similarity of the traffic, shaping effect on voice traffic, on data traffic, on mixed voice and data traffic. On the Fig. 4 the probability density function of the cell delay for 50 voice sources at the entrance of the ATM multiplex is shown. When this cell flow passes the ATM queue the result shown on Fig. 5 is valid. The main fraction of additional delay is due to the voice packetisation. The second order fraction of this additional delay is due to the rate of the transmission line. The shaping effect after one pure FIFO queue is almost negligible.

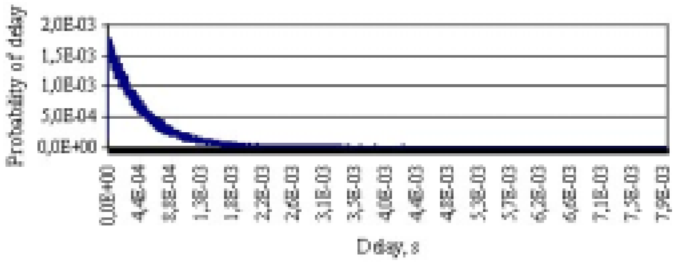


Fig. 4. Cell delay distribution after 50 voice traffic sources.

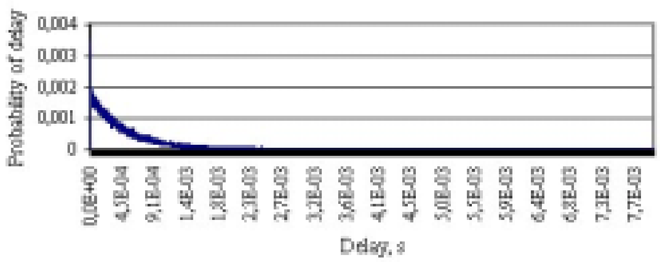


Fig. 5. Cell delay distribution after ATM multiplex with 50 voice traffic sources.

On Fig. 6 the probability density function of cell delay is shown again for the mixed traffic of 50 voice and 1 data sources. Fig. 7 presents the same function after the ATM multiplex. It is visible that the data traffic even with low priority suppresses the voice traffic. The gain of traffic shaping is small. The specific peak on cell delay equal to 3,9E-05 is due to the packetisation delay of data cells.

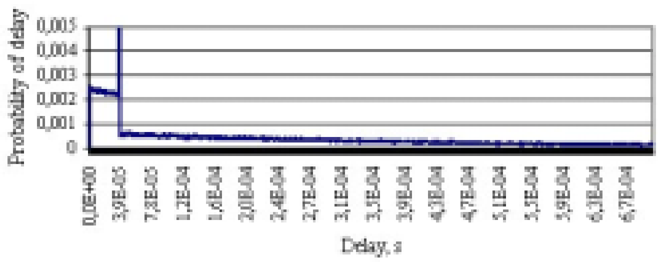


Fig. 6. Cell delay distribution after 50 voice and 1 data traffic sources.

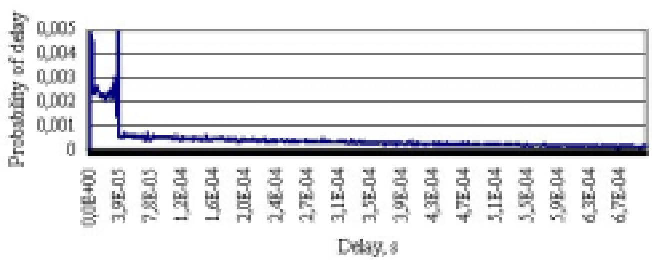


Fig. 7. Cell delay distribution after ATM multiplex with 50 voice and 1 data traffic sources.

Because of the high influence of the data traffic the same experiment is also performed for the 55 data sources. Fig. 8 represents the probability density function of the cell delay before queue. The peak is again a result from packetisation delay. Fig. 9 represents the same function after the queue. The peak on the left is due to the rate of transmission line. The peak of the right is due to the packetiosation delay.

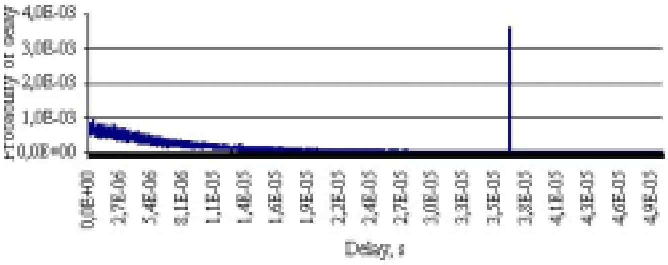


Fig. 8. Cell delay distribution after 55 data traffic sources.

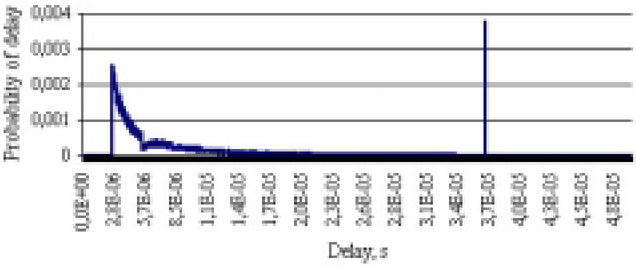


Fig. 9. Cell delay distribution after ATM multiplex with 55data traffic sources.

This paper presents the traffic shaping and delay analysis in ATM multiplex that serves voice and data traffic sources. Special attention is paid to the data traffic sources because of the self-similarity of the data cell rates. The most typical case of small office is considered and results might be seen from Figs. 6 and 7. It is clear that real traffic shaping effect cannot be reached with pure FIFO queues. Forced shaping must be considered instead.

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