# Quality of Service and Optimal Selection of Traffic Control Scheme in ATM Network

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## ABSTRACT

**The aim of our paper is to present comparison of Quality of Service provision for video traffic by two connection admission control methods in ATM network. Introduction briefly presents traffic control and QoS issues. The next part of the paper is dealing with modeling of traffic and simulation of selected admission control schemes. In the third part we present achieved results based on the simulations in MATLAB environment. Final part is dealing with optimal selection of admission control method.**

## I. INTRODUCTION

Today, the capability of Quality of Service (QoS) provision for customers is the necessary requirement for modern broadband networks. So, the customer can choose required QoS level and pay only for what he really need. The traffic control mechanism, traffic management, should be implemented in the network to ensure QoS [1-3].

Broadband networks based on the Asynchronous Transfer Mode (ATM) technology offer the most sophisticated mechanisms for Quality of Service provision. The ATM technology ensures QoS by various traffic control functions. The connection admission control is one of these traffic control functions [4].

Connection Admission Control CAC is the preventive function of traffic control, which determines if a new incoming connection can be accepted to the network or it should be rejected. Decision process is based on the various traffic parameters, such as current traffic load, values of characteristic parameters (e. g. mean and peak cell rates), availability of network resources, required QoS of existing and new connections.

In this paper we present our comparison of two CAC methods for video traffic from Quality of Service point of view.

## II. MODELING AND SIMULATION

Our selection of connection admission control methods is based on the performed analysis in the field of traffic control functions. The method selection is based on the following criteria – the same input parameters for comparison purposes, acceptable computation requirements and simple implementation in real solutions. Two methods from the group of statistical methods best fit to these criteria – Method of effective bandwidth and Method based on diffusion approximation. Both methods were described in detail in [5]. Maximum number of accepted connections we have chosen as main parameter for their comparison from the Quality of Service point of view. Our presented simulations were oriented to:

- impact of buffer size to number of accepted connections,
- impact of required cell losses to number of accepted connections.

In our simulations we assumed ATM switch with $N$ input links, one output link with capacity $C$ = 155,520 Mbit/s (STM-1) and finite buffer of size $B$ for output link. For particular simulations we used one class of connections, so that all incoming connections have the same traffic parameters (peak cell rate, sustainable cell rate and mean cell burst size). Simulations were performed in simulation environment Matlab 7.1.

### *TRAFFIC SOURCES*

As the input traffic sources we have used sources with parameters that satisfy to real video sources [6]. Traffic sources we have described by two-state Markov ON-OFF models [7]. Parameters of the traffic sources are stated in the table 1. Source no. 1 represents characteristics of film Jurassic Park 1, source no. 2 represents characteristics of film Total Recall.

Table 1: Parameters of selected traffic sources.

| **Source no.** | **PCR [Mbit/s]** | **SCR [Mbit/s]** | **Activity factor** | $N_{min}$ | $N_{max}$ |
|---|---|---|---|---|---|
| **1** | 4,237680 | 0,512126 | 0,121 | 36 | 303 |
| **2** | 6,988320 | 1,000126 | 0.143 | 22 | 155 |

$N_{min}$ – lower boundary of accepted connections $C$ / $PCR$, $N_{max}$ – upper boundary of accepted connections $C$ / $SCR$, $PCR$ – Peak Cell Rate, $SCR$ – Sustainable Cell Rate.

## III. RESULTS AND DISCUSSION

### *Buffer Size vs. Admitted Connections*

In the following simulations of CAC methods performance we have examined cases in which buffer size of ATM switch was in the range from 2 to 64 kB (circa 40 – 1240 ATM cells). It represents small and middle sized buffer. Dependency between maximum number of accepted connections and buffer size of ATM switch we have examined for three values of required cell loss ratio *CLR*. In the figures 1 – 4 we can see achieved results for dependencies between number of accepted connections and buffer size stated in the ATM cells (1 ATM cell = 53 bytes). Size of ATM switch buffer was increased with step of 5 cells. In the graphs for the method based on diffusion approximation (figures 1 and 3), for better visibility, the buffer size is shown only in the range 0-500 (0-250) ATM cells, because further increase of buffer size has no impact on the accepted connections due to upper boundary of accepted connections was yet reached.

We found out that estimations of the diffusion method (figures 1 and 3) in the whole investigated range of buffer size converge to upper boundary of number of accepted connections $N_{max}$.

The most significant effect of buffer size is in the range of small values, approximately up to 30 ATM cells. This effect is reduced with rising activity factor of the traffic source. From the results it is obvious that method based on diffusion approximation offers excellent bandwidth utilization. But it brings problem in case when some connection violate agreed broadcast cell rate. In this case there need not be enough spare bandwidth to handle increased requirements and link congestion can occur.

Considerably different situation is in the case of method based on equivalent bandwidth. In the figures 2 and 4 we can see high relation between number of accepted connections, buffer size and required cell loss ratio. In the case of the lowest buffer size, the estimations of this method approach to the lower boundary of accepted connections $N_{min}$. With the rising buffer size the number of accepted connections is gradually increasing, but in the investigated boundaries but it is not approaching the estimations of diffusion method. We can see noticeable lower number of accepted connections compared to diffusion method. Also it is obvious the strict Quality of Service requirements (in this case cell loss ratio) the lower number of accepted connections in whole examined range of buffer size.

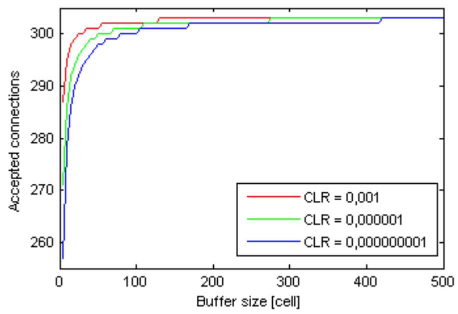


Figure 1: Dependency between maximum number of accepted connection by diffusion method and buffer size of ATM switch for source no. 1 and three values of required *CLR*.

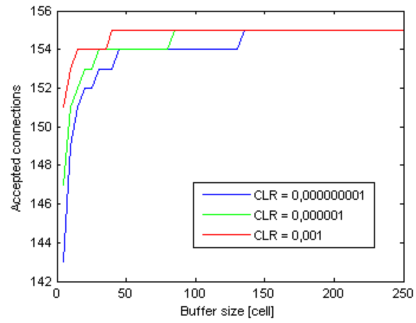


Figure 3: Dependency between maximum number of accepted connection by diffusion method and buffer size of ATM switch for source no. 2 and three values of required *CLR*.

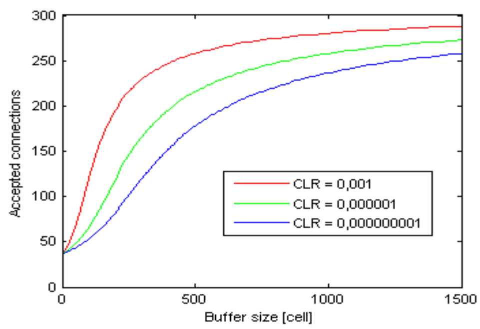


Figure 2: Dependency between maximum number of accepted connection by method of effective bandwidth and buffer size of ATM switch for source no. 1 and three values of required *CLR*.

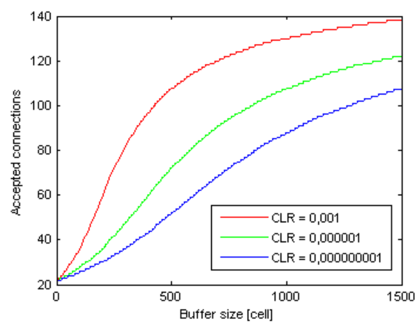


Figure 4: Dependency between maximum number of accepted connection by method of effective bandwidth and buffer size of ATM switch for source no. 1 and three values of required *CLR*.

Method based on the effective bandwidth offers significantly worser bandwidth utilization, especially in the low values of buffer size of ATM switch. On the other hand, effective bandwidth method offer better Quality of Service guarantee for individual connections, because if any connection violate agreed traffic parameters, there is enough bandwidth reserve on the transmission link to handle unexpected increase of transmission rate of some connections.

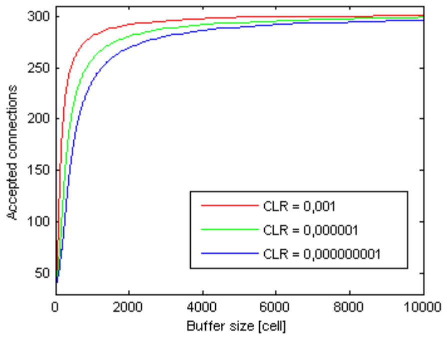


Figure 5: Maximum number of accepted connections by effective bandwidth method for high values of buffer size (up to 512 kB) for source no. 1.

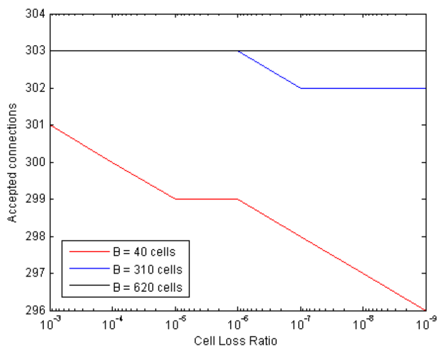


Figure 6: Maximum number of accepted connections by diffusion method in relation with required cell loss ratio *CLR* for source no. 1.

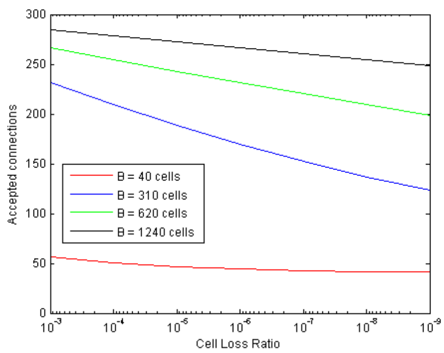


Figure 7: Maximum number of accepted connections by effective bandwidth method in relation with required cell loss ratio *CLR* for source no. 1.

The previous figures for effective bandwidth method have shown that the upper boundary of accepted connections was not reached in whole investigated range of buffer size of ATM switch (up to 64 kB, i.e. 1240 ATM cells). In the figure 5 we can see relation between maximum number of accepted connections and buffer size for higher values of the buffer size, approximately up to 512 kB (10000 ATM cells). The results are for traffic source no. 1.

As we can see the effect of required cell loss ratio on the number of accepted connections is minimized at the high values of buffer size. Achieved simulation results confirm the assumption that effective bandwidth method is more conservative in accepting of new connections than method based on the diffusion approximation, but on the other hand it offers higher guarantee of arranged Quality of Service level.

### *Cell Loss Ratio vs. Admitted Connections*

Cell loss ratio *CLR* represents parameter that determines reliability of the connection. It is one of the main Quality of Service parameters. Some services, like voice transmission, can accept relative high cell loss ratio (cca $10^{-3}$).

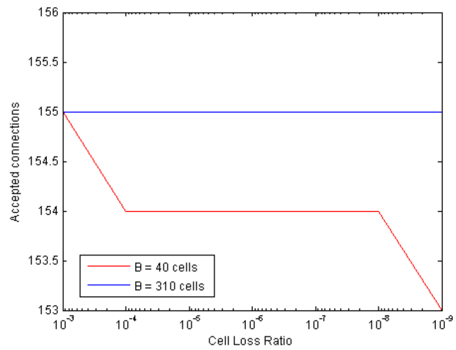


Figure 8: Maximum number of accepted connections by diffusion method in relation with required cell loss ratio *CLR* for source no. 2.

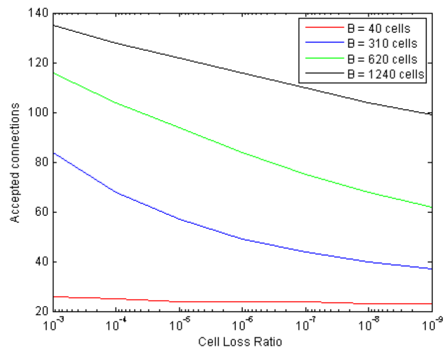


Figure 9: Maximum number of accepted connections by effective bandwidth method in relation with required cell loss ratio *CLR* for source no. 2.

But the majority of modern high-speed broadband services require significantly lower information losses. They typically require cell loss ratio in the range from $10^{-6}$ to $10^{-9}$. In the following simulations we have examined dependencies between admitted connections by both CAC methods and required cell loss ratio. Numbers of accepted connections we have examined for required cell loss ratio from $10^{-9}$ to $10^{-3}$. Simulations we have performed also for various values of buffer size (20, 310, 620 and 1240 ATM cells). Simulation results are graphically presented in the figures no. 6 and 7.

Figures no. 6 and 8 represents achieved simulation results for method based on diffusion approximation. For both traffic sources we have found out only little dependency between accepted connections and required cell loss ratio. In all cases the estimations of diffusion method converge to upper boundary of maximum accepted connections $N_{max}$, or they tightly approaching this boundary with lowering of QoS requirements. Only 3 respectively 2 dependencies are displayed in the graph, because it was found out that in the case of larger buffer size the number of accepted connections is identical with upper boundary $N_{max}$. We can see slight decrease of admitted connections for the lowest values of cell loss ratio.

In the figures no. 7 and 9 we can see relation between the number of admitted connections and required cell loss ratio for effective bandwidth method. Now we can see the significantly higher dependency between the estimations of accepted connections and required cell loss ratio in comparison with diffusion method. In the case of the lowest value of buffer size (40 ATM cells) the number of accepted connections is closely above the lower boundary of accepted connection $N_{min}$ for given traffic source. In this case the sensibility of admitted connections to required cell loss ratio is minimal in whole range of examined cell loss ratio. For values of buffer size equal to 310 and 620 ATM cells (16 and 32 kB) we have found out the highest dependencies between the admitted connections and required cell loss ratio. With the rising requirements on cell losses the estimation of maximum accepted connections of equivalent bandwidth method is lowering by tenths of connections. In the case of the highest buffer size (1240 ATM cells) the fall of accepted connections is slightly less than in the case of middle-sized buffers for all examined traffic sources.

## IV. CONCLUSION

The connection admission control method based on the diffusion approximation has proven the better link bandwidth utilization then effective bandwidth method. At the same time the diffusion method doesn't exhibit heavy dependency on the Quality of Service parameters that were examined in this paper. The disadvantage of the excellent bandwidth utilization by diffusion method is the higher liability to network congestion in the case if any of accepted connections unexpectedly will increase the transmission cell rate. This may cause the violation of the arranged Quality of Service of some connections. On the contrary, effective bandwidth method has shown very high dependency on the examined QoS parameters in the whole chosen range of these parameters. The more tighten QoS requirements the less admitted connections by effective bandwidth method. The advantage of such method behavior is the higher guarantee of the Quality of Service contrary to the diffusion based method that offers link bandwidth utilization almost to 100%.

Following the achieved results we can say that the effective bandwidth method can be appropriate used in the situations, when we have users that require high guarantee of arranged Quality of Service and the lower effectiveness of bandwidth utilization can be for example compensated by higher cost for users. On the contrary, the use of diffusion approximation based method is appropriate in the situation when we need the better bandwidth utilization, e.g. to accommodate as many connections on the transmission link as possible while considering the higher QoS requirements (cell losses, buffer size of ATM switch). But in this case there is the higher probability of network congestion. This can be for example compensated by lower cost of service for users compared to previous case.

## ACKNOWLEDGEMENT

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