CAC CONTROLLED SERVICES SHARING A LINK WITH CONNECTIONLESS DATA SERVICES IN AN ATM NETWORK: A PERFORMANCE EVALUATION STUDY

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ABSTRACT

In the B-ISDN there is a provision for four classes of services, all of them supported by a single transport network (the ATM network).

Three of these services, the Connected Oriented (CO) ones, permit Connection Access Control (CAC) but the fourth, the ConnectionLess Oriented (CLO) one, does not. Therefore, when CLO service and CO services have to share the same ATM link, a conflict may arise. This is because a bandwidth allocation to obtain maximum statistical gain can damage the contracted ATM Quality of Service (QOS); and vice versa, in order to guarantee the contracted QOS, the statistical gain have to be sacrifice.

This paper presents a performance evaluation study of the influence of the CLO service on a CO service (a Circuit Emulation service or a Variable Bit-Rate service) when sharing the same link.

I. INTRODUCTION

In the Broadband Integrated Services Digital Network (B-ISDN) three main blocs may be distinguished: The *services network* (the applications), the adaptation platform, and the transport network (6).

The services network is the side of the B-ISDN that may be seen by the end user.

The adaptation platform adapts the characteristics of the different applications that form the services network to the offer of a single transport provider. The adaptation platform gives service to the services network and gets the carrier service from the transport network.

The transport network works in the Asynchronous Transfer Mode (ATM), and the adaptation platform may be seen as performing the ATM Adaptation Layer (AAL) functions.

In the B-ISDN there are four services declared on the AAL: Circuit Emulation (Class A), Variable Bit Rate service (Class B), Connection Oriented Data service (Class C) and ConnectionLess Data service (Class D) (1). A number of AAL protocols are being defined by the CCITT as type 1 to 5 which are in consonance with the service classes -type 1 for Class A service, type 2 for Class B, types 3 and 5 for Class C, and type 4 and also 5 for Class D (5). We will focus our attention on the services rather than the protocols.

Class A serves constant bit-rate (CBR) sources that communicate between each other in a connection oriented manner. Class A service generates a cell stream with a constant intercell distance towards the ATM network. From the CAC point of view, this traffic is very easy to deal with because only constant amounts of bandwidth have to be managed.

Both Class B and Class C serve variable bit-rate (VBR) sources. The difference between Class B and Class C services is that Class B provides the destination with a timing reference of the source, and Class C does not. Class B is designed for managing VBR real time traffic (compressed coded voice, sound or image traffic) while Class C was designed for data communications traffic. Optimum bandwidth allocation of the *requirements of these* two services is strongly dependent on the CAC mechanism selected. CAC can take advantage of the statistical characteristics of the VBR traffic.

Class D is similar to Class C service. Class D manages VBR traffic and does not provides timing reference between source and destination. But Class D differs from Class C service in offering a connectionless oriented service. Thus, admission control cannot be applied as usual. CAC can only be applied in the service contracting phase, but in addition admission control at the burst level may be applied. It works as follows: when contracting the Class D service a maximum bit-rate is negotiated, but this maximum bit-rate may be renegotiated at each activity period if necessary. Several protocols have been proposed for Boyer and Tranchier (2), Hui (3) and Ohnishi et al (4).

The service offered by the ATM network is based on Virtual Circuits (VC) -in this paper no distinction between Virtual Channels and Virtual Path will be made-. In order to deal with the CO services (Class A, B and C), the AAL asks the ATM network to establish a VC when necessary. In contrast, to deal with the CLO service (Class D) the AAL uses permanently (or semi-permanently) established VCs (those VCs that were negotiated at the contracting phase).

Some links of the ATM network, and in particular the ATM network access ones, may have to allocate both permanent and non-permanent *(ephemeral) VCs. Permanent* VC allocation implies permanently reserving part of the link capacity. Thus, VCs for CO service incoming demands have to be allocated in the remaining link capacity.

This paper presents a performance evaluation study of the bandwidth use on links that have to allocate permanent and ephemeral VCs, that is, a performance evaluation study of bandwidth use on links shared by CLO and CO services.

The paper is organized as follows: Section II reviews the most usual CAC algorithms discussed in the literature to be adopted in ATM networks. Section III gives an accurate formulation of the problem. Section IV describes the environment where the study is carried out. And in Section V the results are presented and discussed.

II. THE CAC SCHEMES

The ATM transport network is based on packet switching using small fixed-size packets. ATM permits flexible bandwidth allocation, so an important objective is to obtain the maximum statistical gain on a physical channel. A system of traffic control is therefore required

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to ensure adequate Quality of Service; the CAC control is a tool designed for this purpose.

The CAC is a procedure that decides whether a new connection can be accepted by the ATM network. The decision is based on the resources occupied by the existing connections and the characteristics of the new connection. An essential requirement of the ATM network is efficient bandwidth allocation. CAC attempts to maximize the statistical gain under a given congestion probability which is the probability of exceeding link capacity (congestion probability is also called link blocking probability).

There are four well known algorithms that are being considered for performing this function in the ATM network: 1) peak rate allocation, 2) the linear CAC procedure, 3) the two-moment allocation scheme, and 4) the convolution approach.

Peak Rate Allocation reserves for each connection its maximum required bandwidth. With this approach there are no benefits to be had from adopting a statistical multiplexing gain approach.

The linear CAC Procedure is supported by numerical results showing that for many traffic mixes the boundary of the admissible load region can be approximated by a linear function.

The Two-Moment Allocation Scheme is based on the assumption that the distribution of the required bandwidth of all existing connections can be approximated by a normal distribution function with the same mean and variance.

The Convolution Approach is based on the probability density function of the instantaneous bandwidth requirements of each established connection. This is the most accurate method, but it is highly dependent of the source model (parameters or characterization). In other words, when the behavior of the sources does not correspond with the adopted model, the results may not be precise.

III. THE CASE

The aim of this paper is to analyze the case in which a link has to be shared by the CLO service (the Class D service) and one of the CO services (a Class A, B or C service).

The point where the link is attached (any node of the ATM network or the adaptation interface when performing multiplexing functions), must reserve part of the link capacity (establish a permanent VC) for CLO service use, and apply the selected CAC mechanism to allocate the CO service demands (establish ephemeral VCs) in the remaining capacity.

As a result, the bandwidth allocation performance of this link will depend on four aspects, namely: 1) The amount of bandwidth reserved for the permanent VC, 2) The way in which the reservation for the permanent VC is made (peak allocation, linear or convolution approach, etc.), 3) The CAC algorithm applied to the CO demand of VCs to allocate them in the remaining bandwidth, and 4) The allowed congestion probability.

Regarding the first point (bandwidth reservation for CLO service use), two strategies may be followed:

a) To consider that the reservation of bandwidth for the CLO service is made on the assumption that the totality of the sources attached to this service will be continuously active. When some of the CLO sources are not active (which is the most probable case), this strategy leads to losing statistical gain. Nevertheless, the allowed probability of congestion will never be exceeded.

b) To estimate the actual bandwidth required for the CLO service. This means to estimate the maximum number of sources attached to the CLO service that will be simultaneously active. When this number is under-estimated, the allowed probability of congestion may be exceeded. This may lead to a loss of QOS.

The latter strategy seems to be the most appropriate because the possible loss of QOS could be prevented by using an admission control mechanism at burst level. But this is beyond our scope.

The present paper considers a bandwidth allocation scheme that does not incorporate any access control at the burst level. The objective is to analyze the influence of the above four aspects on the bandwidth allocation performance of the links described.

IV. WORKING SCENARIO

Figure 1 shows the working scenario. The main blocks are: 1) sources attached to A, B, C and D services, 2) the Terminal Adapter for each class of service 3) the ATM access link, and 4) the ATM network. The Terminal Adapter provides AAL functions and multiplex traffic generated by the sources through the ATM access link.

The performance evaluation of the bandwidth allocation presented in this paper was carried out on the ATM access link with the Terminal Adapter performing the bandwidth allocation function. This means that this unit is responsible for reserving the CLO service bandwidth and applying the CAC algorithm to CO service demands in order to allocate them in the remaining bandwidth.

Two cases have been studied: 1) Class D service in conjunction with Class A service, and 2) Class D service in conjunction with Class B service.

In both cases the amount of bandwidth reserved for the Class D service contracts is computed by convolution.

The CO demand bandwidth allocation is done as follows:

In case 1, since Class A serves CBR sources, bandwidth may be directly allocated. Regarding case 2, Class B demands of bandwidth might be allocated by applying any CAC algorithm (see Section II). In this paper only the convolution approach has been considered.

For the source modeling, three different configurations were adopted for Class A, B and D services corresponding to the GMDP (General Modulated Determinist Process) model. This model describes the behavior of a traffic source at cell and burst level. In each state a distributed number of cells are sent with regular inter-arrival times (constant rate) during the corresponding sojourn time. From mean sojourn times we readily obtain the state probabilities.

Sources attached to Class A service have only one state, and its associated rate (R) has been set to 2 Mbps (with probability (P) = 1). This is adequate for CBR video, voice, etc.

Sources attached to Class B service have modeled three states with the following associated characteristics: (0-state) R = 1

Mbps with P = 0.7, (1-state) R = 2 Mbps with P = 0.2, and (2-state) R = 10 Mbps with P = 0.1. This configuration permits modeling of a VBR video source of 2.1 Mbps.

Sources attached to Class D connectionless services have been modeled by two states and different configurations are studied. The associated probabilities have been evaluated to obtain a mean rate equal to 2 Mbps for any configuration. For example: (OFF state) R = 0 with P = 0.92 and (ON state) R = 25 Mbps with P = 0,08, these values correspond to a mean rate equal to 2 Mbps and a peak rate equal to 25 Mbps.

In the working scenario, the capacity of the link C is equal to 150 Mbps.

V. RESULTS

Figures 2 and 3 have been obtained assuming an allowed congestion probability of 1E-4.

Figures 2 and 3 show the maximum number of demands for CO services (Class A and Class B respectively) that can be allocated by varying the peak-rate contracted by the Class D service for each of the N sources which are attached to it. The different results presented in these figures correspond to different values of N.

As was expected, Figures 2 and 3 show that the peak-rate contracted by the Class D service has a great influence on the maximum number of CO service demands that can be accepted. This effect is more accentuated when sources attached to the CO service are VBR (Figure 3).

Also, Figures 2 and 3 allow us to quantify the wasted bandwidth when the bandwidth reserved for the Class D service has been performed assuming that all the N sources attached to this service will be continuously active (strategy (a) of Section III), and this is not true.

Take for example the case of CBR connections (Figure 2).Let us suppose that there are 10 CLO contracts of 15 Mbps of peak-rate, then only a maximum of 12 Class A service demands can be accepted. Now, supposing that actually only 7 of the CLO contracts are active, this would permit the allocation of 25 Class A service connections in the remaining bandwidth. This means that 13 (25-12) possible incoming Class A service demands would be rejected unnecessarily.

According to the strategy (b) discussed in section III, N must be considered has an estimation of the maximum number of sources attached to the CLO service that will be simultaneously active. Underestimation of N can affects the bandwidth allocation performance of the ATM access link. Now the question is: How?.

Figures 4 and 5 show the bandwidth allocation performance in terms of probability of congestion versus the actual number of sources attached to Class D service which are simultaneously active. In this case the scale parameter is the peak-rate contracted by the Class D service.

Both Figures show the behavior of the congestion probability in the range 10E-5 to 10E-3 when a certain number (10 in both cases) of demands of the CO service (Class A in Figure 4 and Class B in Figure 5) are already accepted.

Also, as of was expected, two main results may be observed:

1) Congestion probability performance degrades when N grows.

2) Degradation becomes stronger in proportion to the growth of CLO source burstiness (peak-rate to mean-rate ratio).

As an example of the significance of these points, let us take Figure 4. Let us assume the following: 1) the allowed probability of congestion is 10E-4, 2) Class D contracts of a peak-rate = 25 Mbps, 3) it was estimated that N would always be under 12 sources. Then, for N reaching the maximum estimated value when 10 Class A connections are already accepted, the congestion probability takes the allowed value, and an increase of 5 Class D sources (i.e. an underestimation of 5 sources, N = 17) is needed to rise to a congestion probability of 10E-3.

The same degradation is produced with an increase of only two sources when the Class D contracted peak-rate is 50 Mbps. See in Figure 4 that for N = 3 the congestion probability is 10E-4, and when increasing N to N = 5 (the number of CLO sources simultaneously active is greater than that estimated in two units) this probability rises to 10E-3.

CONCLUSIONS

This paper presents a performance evaluation study of the bandwidth allocation in an ATM access link of 150 Mbps when supporting traffic of a CO service and the CLO service.

By analyzing the results, significant reductions in the CO service admission capabilities are observed when non-adequate estimation of CLO service bandwidth requirements is performed.

The study of the bandwidth allocation performance may be useful to determine the feasibility of including an admission control mechanism at burst level to control the rate or the admission of the new incoming bursts of the CLO service.

REFERENCES

1. Le Boudec J. Y., 1992, "The Asynchronous Transfer Mode: A Tutorial", Computer Networks and ISDN Systems, pp. 279-309.

2. Piere E. Boyer and Didier P. Tranchier. 1992. "A reservation principle with apllications to the ATM traffic control". Computer Networks and ISDN Systems 24, pp. 321-334.

3. Joseph Y. Hui. "Resource Allocation for Brodband Networks". 1988. IEEE Journal on Selected Areas in Communications, pp.1598-1608.

4. H. Ohnishi, T. Okada and K. Noguchi. 1988. "Flow Control Schemes and Delay/Loss Tradeoff in ATM Networks", IEEE Journal on Selected Areas in Communications, pp.1609-1616.

5. Wells D., December 1992, "Asynchronous Transfer Mode: The future for WANs and LANs", Telecommunicatios, pp. 40-46.

6. Woodruff G. M., 1988 "A Congestion Control Framework for High-Speed Integrated Packetized Transport", Proc. of the Globecom, pp. 203-207.

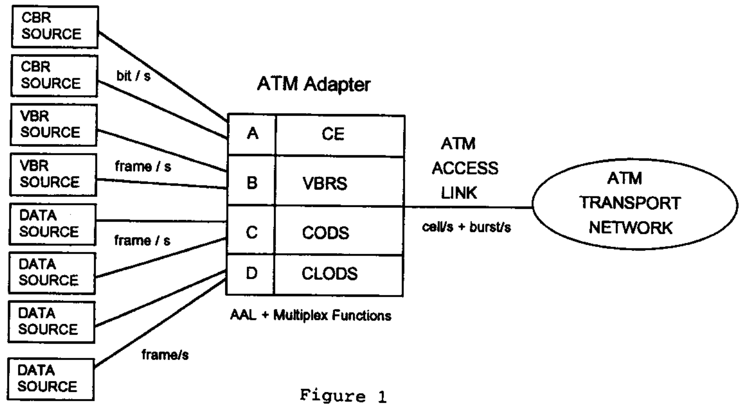

Figure 1

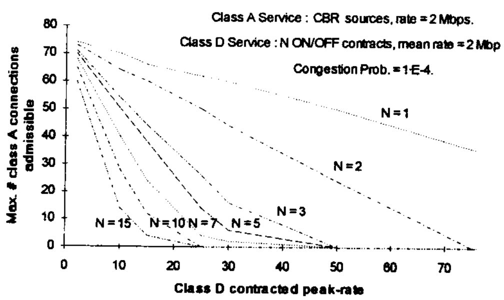

Figure 2

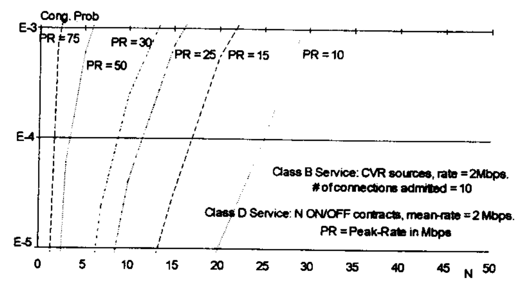

Figure 4

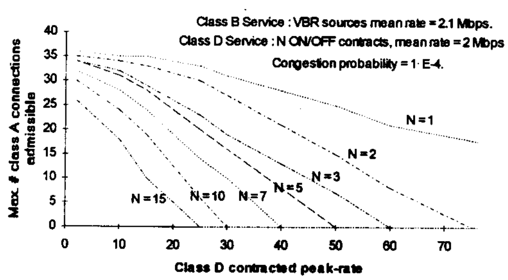

Figure 3

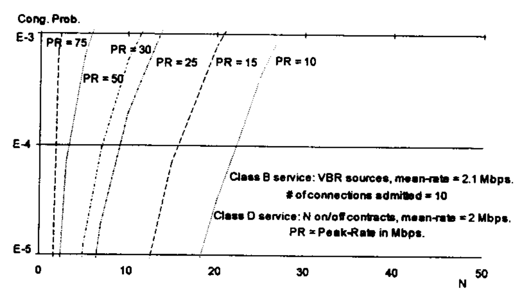

Figure 5