

# Bandwidth allocation in ATM Network for different QOS Requirements

H. El-Madbouly

**Abstract**—For future Broad band ISDN, Asynchronous Transfer Mode (ATM) is designed not only to support a wide range of traffic classes with diverse flow characteristics, but also to guarantee the different quality of service QOS requirements. The QOS may be measured in terms of cell loss probability and maximum cell delay.

In this paper, ATM networks in which the virtual path (VP) concept is implemented are considered. By applying the Markov Deterministic process method, an efficient algorithm to compute the minimum capacity required to satisfy the QOS requirements when multiple classes of on-off are multiplexed on to a single VP. Using the result, we then proposed a simple algorithm to determine different combinations of VP to achieve the optimum of the total capacity required for satisfying the individual QOS requirements (loss- delay).

**Keywords**—Bandwidth allocation, Quality of services, ATM Network, virtual path.

## I. INTRODUCTION

ATM Broad-band Service Digital Network (B-ISDN) has received much attention in the future due to increased demand for different communication services. The advantages of B-ISDN are its ability to support a wide range of services with diverse performance or quality of service (QOS) requirements. The services range from delay sensitive applications such as voice and video to loss sensitive applications such as data and image file transfer.

ATM is a fast packet switching and multiplexing technique, is suitable for ISDN applications because its flexibility in bandwidth allocation to virtual connections through its fixed packet (cell). The virtual path concept can guarantee the different Quality of Service (QOS) requirements in ATM networks as well [1], [2].

The simplest approach of VP bandwidth from the VP traffic management viewpoint is the integration approach which provides a single VP on which all classes of services are multiplexed and QOS of this VP should be set for the most demanding virtual circuits. The other alternative is the segregation approach, which provides multiple and different QOS classes of VP, and all traffic classes with the same flow characteristics and the same QOS are integrated for statistically multiplexing on single VP [2-3].

## II. ALGORITHMS USED AND PROPOSED MODEL

In ATM networks different classes with different flow characteristics and QOS requirements are statistically

multiplexed to increase the utilization of the network bandwidth [4].

For homogenous traffic flow, two simple approaches to virtual traffic management can be taken. One is to provide a single VP on which all the traffic classes are integrated and the QOS of this VP should be set for the most demanding circuits. The second is to provide multiple VPs with different QOS classes, and all traffic classes with the same QOS are integrated for statistically multiplexing on a single VP. Therefore the VP classes are segregate and managed individually. Fig. 1 and Fig. 2 show the two approaches.

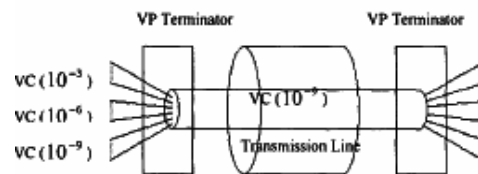


Fig. 1 Integration Approach [8]

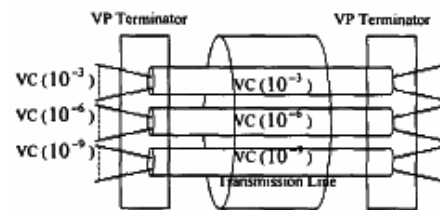


Fig. 2 Segregation Approach [8]

For the case of heterogeneous traffic flow, the problem is more complicated by the fact that when different traffic classes are multiplexed on a VP, the QOS experienced by each traffic classes differs due to the difference in flow characteristics.

In this paper, firstly, the efficiency of five different static VP bandwidth management is evaluated using the Markov modulated deterministic process (MMDP) [5], [6] and the algorithm developed in [7] to compute the minimum and sufficient bandwidth satisfying the QOS requirements of various traffic classes multiplexed together on single VP.

### A. Static VP Combination

Consider N on-off traffic classes multiplexed in an ATM multiplexer. Each sources of traffic class  $i=1,2,...,N$ , generate cells at a peak rate of  $\Delta_i$ .

When it is in the on state and demands a cell loss probability (QOS requirement) of Q, three classes on-off sources ,namely data ,still image and voice (N=3) with different flow characteristic. Therefore, there are five VP combinations under consideration as in Table I.

H. El-Madbouly is with academic of special studies, Technology department, Worker University, Alexandria, 21544, Egypt(e-mail: h\_elmadbouly@yahoo.com).

TABLE I  
VP COMBINATION SCHEME UNDER CONSIDERATION

VP Combination Scheme		Buffer Size	Capacity
Integration	Integration		
Complete	-	K	C
-	Complete	K1+K2+K3	C1+C2+C3
Data, Still Image	Voice	K1+K2	C1+C2
Data, Voice	Still Image	K1+K2	C1+C2
Still Image, Voice	Data	K1+K2	C1+C2

For each VP combination, we can find a(C, K) pair for each within the VP combination such that C and K are the minimum capacity and buffer size respectively, required to satisfy all the QOS. Requirement supported by the individual VP. One of these five VP combinations will give the minimum total capacity required and this corresponds to the optimal capacity VP combination. The flow characteristics of our sources, namely data, still image and voice, are the threshold in Table II. The cell length is 53 bytes, the maximum delay of each traffic classes is calculated and the maximum number of each traffic classes that are on at time t is 10 ( $M_i=10$ ).

TABLE II  
TRAFFIC CHARACTERISTIC OF ON-OFF SOURCES

Traffic Classes	Peak Rate, $\Delta_i$ (Mbps)	Burstiness, $b_i$	Burst length, $L_i$ (cells)
Data	10	10	339
Still Image	2	23	2604
Voice	0.064	3	58

### B. Static Time Priority

In this paper the static-time-priority is considered where the priority is assigned on-per-class basis and the priority level is constant for the same class. All classes are multiplexed together into a common buffer. Fig. 3 each traffic utilizes an individual VP with dedicated capacity  $c$ , and buffer  $k$ , where  $i$  is the priority number with  $i = 1$  being the highest priority.

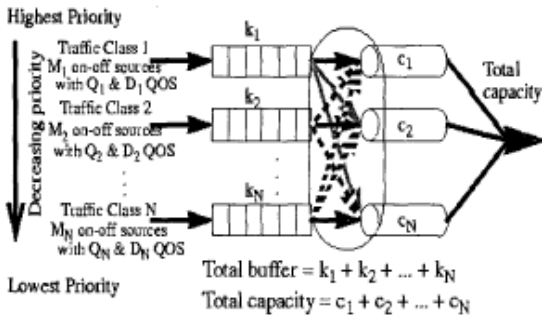


Fig. 3 Dynamic Bandwidth Allocation with Priority Scheme

Let  $N$  is the total number of traffic class and assumes  $M_i$  is an independent on-off sources in class  $i$  with parameter  $\lambda_i, h_i$ ,

$v_i$ , and  $\gamma_i$  the call arrival rate, the mean holding time, data speed, and data activity rate for class  $i \in I$  respectively.

Then the input traffic load is  $a$  and the utilization  $\rho_{co}$  of the transmission line is given by [9]

$$a = \sum_{j \in I} \lambda_j h_j \quad (1)$$

$$\rho_{co} = (1 - B) \frac{L_c}{L_p} \frac{1}{c} \sum_{j \in I} \lambda_j h_j v_j \gamma_j \quad (2)$$

Where  $B$  is the connection blocking probability,  $L_c$  is the cell length (53 bytes),  $L_p$  is the payload length (48 bytes), and  $C$  is the transmission speed.

Here, let us take  $B$  as the call level QOS requirement, which is given by:

$$B = \frac{a^s / J!}{\sum_{i=0}^s a^i / J!} \quad (3)$$

Where  $s$  is the number of virtual channels (VCs) assigned to the transmission line.

The cell loss rate  $f_i(c)$  and the mean cell delay  $D_c$  are calculated as follows [9]

$$f_i(c) = 1 - \frac{c}{1 - \rho_{co} c} \quad (4)$$

$$D_c = \frac{hc}{1 + \rho_{co} c} \left[ mc - \rho_{co}^{-1} \sum_{k=1}^m (m - k + 1) c_k \right] \quad (5)$$

Where  $hc = L_c / c$  is the cell transmission time,  $c = \sum_{j=0}^m c_j$ ,

with  $c_0 = 1$

Denote  $f_i(c_1, \dots, c_N)$  the cell loss probability of traffic class  $i$ ,  $i \in I = \{1, 2, \dots, N\}$ , it is required that the cell loss probability  $Q_i$ , and the maximum delay  $D_i$  are satisfied for all  $i$

$$\text{i.e. } f_i(c_1, \dots, c_N) \leq Q_i \forall i \quad \text{and} \quad \frac{k_i}{c_i} \leq D_i \forall i \quad \text{for}$$

$i = 1, \dots, N$ , each  $c_i$  can be calculated for some loads utilization.

Therefore, the bandwidth allocation problem is equivalent to determine the optimal solution (i.e.,  $c = (c_1, \dots, c_N)$  and  $k = (k_1, \dots, k_N)$ ) so as to minimize the total amount of bandwidth allocated, subjected to the condition that all the QOS requirements of all traffic classes are satisfied. The corresponding optimization problem is:

$$\text{Minimize } ce^T, e = (1, 1, 1, \dots, 1)$$

$$\text{Subject to } f_i(c_1, \dots, c_N) \leq Q_i \forall i \quad \text{and} \quad \frac{k_i}{c_i} \leq D_i \forall i, i \in I$$

Where the following equations are used to determine  $f_i(c)$ ,  $D_c$

$$f_i(c) = 1 - \frac{c}{1 - \rho_{co}c}$$

$$D_c = \frac{hc}{1 + \rho_{co}c} \left[ mc - \rho_{co}^{-1} \sum_{k=1}^m (m - k + 1) c_k \right] \quad (6)$$

### C. Iterative Algorithms

- 1- Initialize  $c^1 = (c^1_1, \dots, c^1_N)$  and  $k^1 = (k^1_1, \dots, k^1_N)$  to any initial values and let  $g \leftarrow 1$ .
- 2- Calculate the  $f_1(c)$
- 3- For  $i = 1, 2, 3, \dots, N$  to check  $Q_i \forall_i$  for  $c^g = (c^g_1, \dots, c^g_N)$ 
  - if  $c^g_i = 0$  and  $f_i(c) \leq Q_i$  then  $\varepsilon_i = 0$ ;
  - if  $c^g_i = 0$  and  $f_i(c) > Q_i$  then  $\varepsilon_i = 1$ ;
  - if  $c^g_i = 0$  and  $f_i(c) \leq Q_i$  then  $\varepsilon_i = \frac{|f_i(c^g) - Q_i|}{Q_i}$
- 4- if  $\max(\varepsilon_1, \varepsilon_2, \dots, \varepsilon_N) > \varepsilon$ , go to step (2)
- 5-  $c^g$  is the optimal solution  $c^*$  with the buffers  $(k^g_1, \dots, k^g_N)$  and terminate

### III. RESULTS AND DISCUSSION

In this study, each QOS component is varied independently between  $10^{-2}$  to  $10^{-9}$ . Therefore altogether there are 512 different QOS combination.

Fig. 4, 5, and 6 shows the relation between the capacity and the buffer size of the segregation approach of VP carries Voice, Data and still image these figures can be deduced. It is found that the buffer size increases with the increasing of total capacity for the three classes of services, also the still image service need more buffer size and capacity than that needed for data and voice.

Fig. 7 shows that the integration VP carries the three classes of services needs more buffer size and link capacity than that needed for the same arrival rates and QOS values for each service independently.

Fig. 8 shows that the still image service is transferred via segregation VP and (data and voice) services is transferred via the integration VP, this is better than results declared in Fig. 7 because the small amount of traffic of still image service is multiplexed with high QOS through a segregation VP and the two big amounts of traffic of data and voice are multiplexed with low QOS through an integration VP.

Fig. 9 shows that voice is multiplexed via the integration approach and (data and image) are transferred through the segregation VP, this is declared more capacity and buffer size needed.

Fig. 10 shows that voice and image are transferred via the segregation VP and data is transferred through the integration

VP, this is declared more capacity and buffer size needed in Fig. 8.

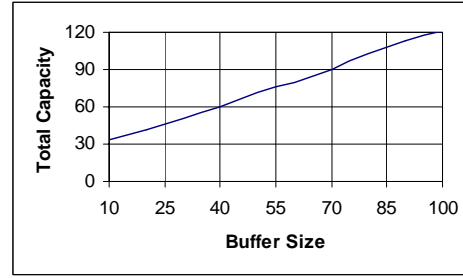


Fig. 4 Segregation "Data"

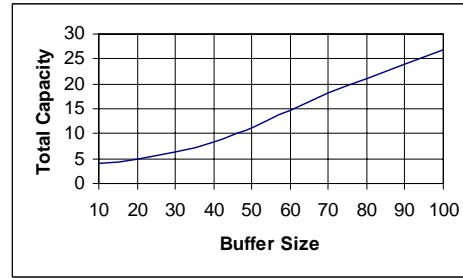


Fig. 5 Segregation "Voice"

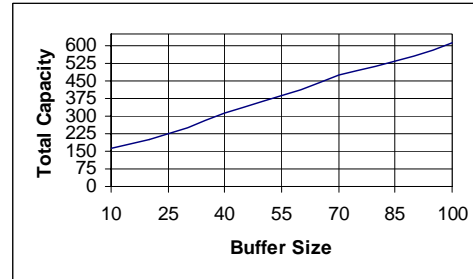


Fig. 6 Segregation "Still Image"

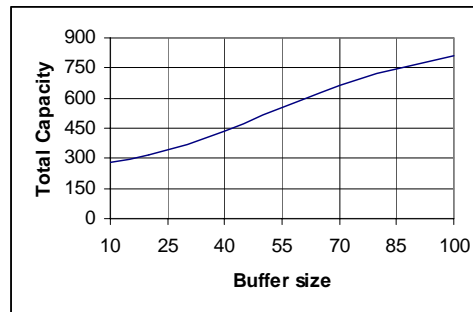


Fig. 7 Integration "Voice, Data and still image"

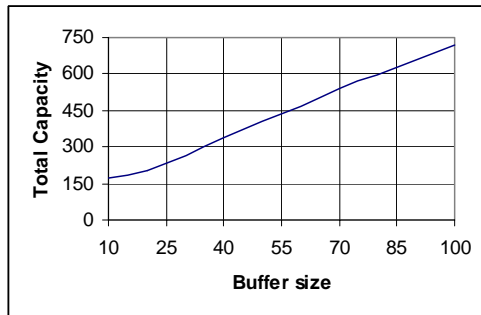


Fig. 8 Segregation VP (still image) and integration VP (data and voice)

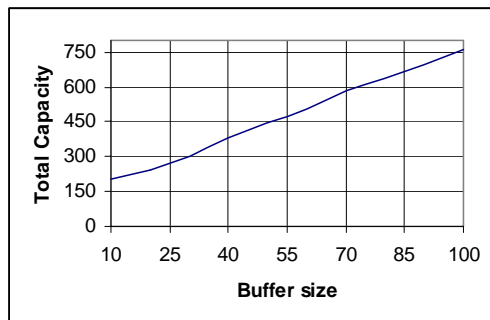


Fig. 9 Segregation VP (data and still image) and integration VP (voice)

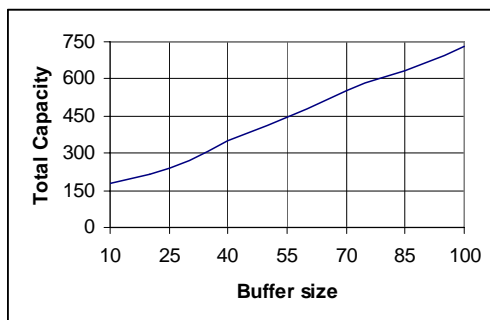


Fig. 10 Segregation VP (voice and still image) and integration VP (data)

#### REFERENCES

- [1] Castelli, P., Cavallero, E., and Tonietti, A., "Policing and call admission problems in ATM networks", *Queueing, Performance and Control in ATM ITC-13*, 1991, pp. 847- 852, 1991.
- [2] Chan, J., and Tsang, D., "Bandwidth Allocation of Multiple QoS classes with maximum delay constraints in ATM environment", *Proceedings of IEEE INFOCOM 94*, pp. 267-271, 1994.
- [3] Chan, J., and Tsang, D., "Comparison of static and Dynamic Bandwidth Allocation Schemes for Multiple QoS classes in ATM Networks", *Proceedings of IEEE ICCS 94*, pp. 728-732, 1994.
- [4] Jabbari, "A Bandwidth Allocation Technique for High Speed Networks", *Proceedings of GLOBECOM 90*, pp. 267-271, 1994.
- [5] Lin, Y., and Silvester, J., "Priority Queueing Strategies and Buffer Allocation Protocols for Traffic Control at an ATM Integrated Broadband Switching System", *IEEE Journal on Selected Areas in Communication*, Vol. 9, No.9, pp. 1524-1536, December 1991.
- [6] Yasuhiro, K., and Toshikazu, K., "QoS control in an ATM network considering virtual path concept", *Proceedings of IEEE INFOCOM 90*, pp. 704. 1.1-701. 4.7, 1990.
- [7] Yei, J., and Yang, T., "Analysis of a Dynamic Bandwidth Allocation Scheme for ATM based BISDN", *Working paper. Technical University of Nova Scotia*, Halifax, Canada, 1993.
- [8] Teerapat Sanguankotchakorn and Bhichate Chiewthanakul "Bandwidth Allocation Scheme in ATM Networks Based on Virtual Path for Different Quality of Service (QoS) Requirements", *Proceedings of IEEE 2001*, pp. 523-528, 2001.
- [9] H. El-Madbouly "Performance and Dimensioning of Nonpreemptive Priority for ATM Communication Systems," *Minufia Journal of Elec. Eng. Research*, Vol. 13 No. 1 Jan. 2003, pp. 65-72.

#### IV. CONCLUSION

It is apparent from these results that no model of VP bandwidth allocations better than the others for all different QoS combination. It depends on various factors such as the type of the source of the most stringent QoS, the type of VP scheme. For example, when the data source is the most stringent QoS, static Integration VP has better bandwidth and buffer allocation than the other static VP scheme. In the case that voice source is the most stringent QoS; the static Integration VP scheme gives quite low efficiency. This can be improved by using complete Segregation scheme or Data and Still Image Integration and Voice Segregation scheme. When the most String QoS is still image source and its value is quite high, the only optimal static VP scheme is Data and Voice Integration and Still Image Segregation.