CONTROL MECHANISM FOR FAIRNESS AMONG TRAFFICS ON ATM NETWORK

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ABSTRACT

One of the major attractive of Asynchronous Transfer Mode (ATM) networks is its ability to exploit the multiplexing gains of packet switching while providing Quality of Service (QoS) guarantees. An ATM based switch can intermix all classes of traffic such as interactive video, graphics, image, and data, on the same transmission and switching fabric, with a guaranteed QoS.

This paper proposed a control mechanism method in order to achieve efficient and fairness among Video and Data traffics in an ATM network. The results confirm its efficiently and simplicity.

INTRODUCTION

Asynchronous Transfer Mode (ATM) is a high speed packet switching technology for high speed Broadband Integrated Services Digital Network (B-ISDN), in which various kinds of communication services are such as interactive video, graphics, image, and data are transmitted over high speed links [1,2]. The recent emergence of ATM technology makes available a unique driving technology for high-speed communication platforms, with line speeds that will scale to interfaces in the gigabit range [3].

It is not yet clear what types of services and applications will come to dominate in the future multimedia communications environment. Therefore the architecture for ATM network, serving as the infrastructure for future multimedia service should be adaptable to charge in different communication bit rates service categories communication modes, etc [4,5]. Cell sequence on a virtual channel is preserved, a very low cell loss probability must be guaranteed ($< 10^{-2}$), and intensive error and flow control protocols are specified with nominal rates of 155.52 Mbps and 622.08 Mbps [6,7]. Many architectures have been proposed [8], all approaches point to the need of a very high speed hardware switch because of the involved high transfer rates. On the other hand, due to the statistical multiplexing, buffering is also required in order to avoid packet loss whenever there are multiple input packets arriving simultaneously on different input ports and destinated for the same output. Only one packet at a time can be transmitted over an output link, the rest must be temporarily stored in a buffer for late transmission. This paper proposed a method namely "Control mechanism" to provide fairness among video and data traffics, it confirms its effectiveness for fairness of traffic on the ATM Ring network. Our main goal of the study is to estimate the effect of the load on the Mean Waiting Time (MWT) and Maximum Buffer Size (MBS).

VP-BASED ATM NETWORK

The proposed ATM network is the modified to that in [9], and more details are in [10]. The Virtual Path (VP) concept is primarily used for nodal addressing for supporting different traffics routing.

Figure 1 shows a SONET/ATM Ring architecture using point-to-point VP's. The VP is used in the point-to-point VP Add-Drop Multiplexing (VP-ADM) scheme carries Virtual Channel (VC) connections between the same two ring nodes.

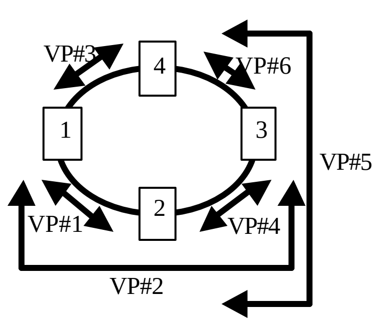

Figure 1 VP-Based ATM Ring network.

The main goal of ADM design is to minimize the cost of evolution from the previous SONET ADM's to ATM ADM's. In this architecture, each ring node pair is preassigned a duplex VP. For example, in Figure 1, VP#2 and VP#2' (not shown in the Figure) carry all VC connections from Nodes 1 to 3 and from Node 3 to Node 1, respectively. The physical route assignment for the VP depends upon the type (Unidirectional or Bidirectional) of the considered SONET Ring. If the considered Ring is a Unidirectional Ring two diverse routes which form a circle are assigned to each VP. For example, in Figure 1, two physical routes 1-2-3 and 3-4-1 are assigned to VP#2 and VP#2' (not shown in the figure) for Unidirectional ring. For Bidirectional ring, only one route is assigned to each duplex VP (e.g., route 1-2-3 is assigned to both the VP#2 and VP#2'), and demands between Nodes 1 and 3 are routed through route 1-2-3 bidirectionally, references [11,12] provide more details on SONET Unidirectional and Bidirectional Ring architectures. In order to avoid the VP translation at intermediate ring nodes of a VP connection, the Virtual Path Identifier (VPI) value is assigned on a global basis. The ATM cell add-drop or pass-through at each ring node is performed by checking the cell's VPI value. Since the VPI value has global significance and only one route is available for all outgoing cells, it doesn't need to translate at each intermediate ring node. Thus, no VP cross-connect capability is needed for the ATM ADM of this ring architecture. The ATM ADM for the ring architecture can be implemented in different ways depending on physical SONET STS-Nc terminations. The most commonly proposed ATM STS-Nc terminations are STS-3c, STS-12c, and STS-48c, although only the STS-3c ATM termination has been specified in current CCITT Recommendations.

The global VPI value assignment presents no problem here, since only one route exists for all outgoing ATM cells and the number of nodes supported by a ring is usually limited. For example, the 12-bit VPI field in the Network-to-Network Interface (NNI) ATM cell represents up to 4096 VPI values available for use. Thus, the maximum number of ring nodes is 91; this is by considering N is the number of ring nodes. Then, the maximum number of ring nodes is the number to be satisfying the following equation :

$$[N (N - 1)] / 2 <= 4096 \qquad (1)$$

The obtained maximum number of nodes is enough to practically support interoffice requirements and loop rings. If the point-to-point VP ring is used to support present DS1 (1.544 Mbps) services (via circuit emulation), each DS1 comprises a VC connection and is assigned a VPI/VCI (Virtual Channel Identifier) based on its addressing information and the relative position of the DS1 within all the DS1's terminating at the same source and destination on the ring. For example, VPI= 2 and VCI = 3 represents a DS1 that is the third DS1 of the DS1 group terminating at Node 1 and Node 3.

THE PROPOSED CONTROL METHOD

In the previous control methods [9], there are fixed ratio among traffics along with the time. That is caused some weak results. However, when the offered load of data traffic is more than the video traffic, unfairness among the traffics appears. In the proposed control mechanism method, the number of cells to be service from a particular queue depending on its offered load.

We have assumed that the ratios of video, and data traffics are V:D respectively. To obtain these ratios, firstly get Min_{ol} (Minimum offered load of each traffic), then, substitute in equations 2 and 3 to find the ratio of V and D.

$$\textbf{Set V} = \frac{videoofferedload}{Min_{ol}}, \qquad (2)$$

$$\textbf{Set D} = \frac{dataofferedload}{Min_{ol}}. \qquad (3)$$

The proposed control mechanism method fairly serviced both traffics on the network. If the offered load of both traffics is the same, then the ratio will be also the same. However, if it is different such as 0.25 and 0.10 respectively, then the ratio will be 2:1 for Video and Data respectively.

SIMULATION RESULTS

We have considered that the network consists of a single ATM ring ADM under video and data traffics. The transmission frame is fixed at 44 cells as payload depending on the channel speed at 155.52 Mbps according to the SONET standard. Simulation check point is presented here by adjusting the simulation model closed to the analytical (queue) model [13]. We have considered the service time as effective service time (0.0625ms) as shown in Figure 2. The simulation model works as the server service cells out from the queue by the rate of 352 cell/ms through the time interval of 0.0625 ms, then no cell service through the next interval of 0.0625 ms, and so on. The comparison between the results of the simulation and the analyshown in Figure 3. The simulation and analytical results, indicate that as the Offered Load (OL) increases, the Mean Waiting Time (MWT) and Buffer Size (B_{siz}) are also increase up to saturation limit. Beyond the saturation limit, MWT and B_{siz} rapidly increase due to the large number of cells and queuing delay.

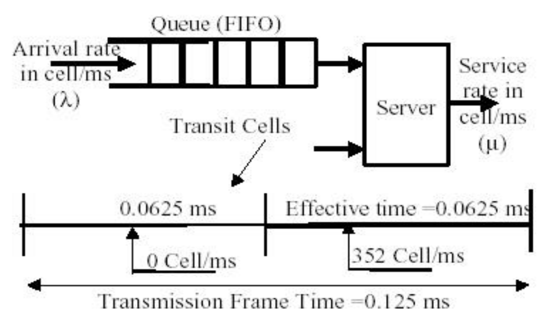

Figure 2 Queue Model for ADM/ATM Node

It is to be mentioned here that at a certain OL, the MWT and B_{siz} of both simulation and analytical models are closed, this is because the service time is equal to the effective service time (0.0625ms).

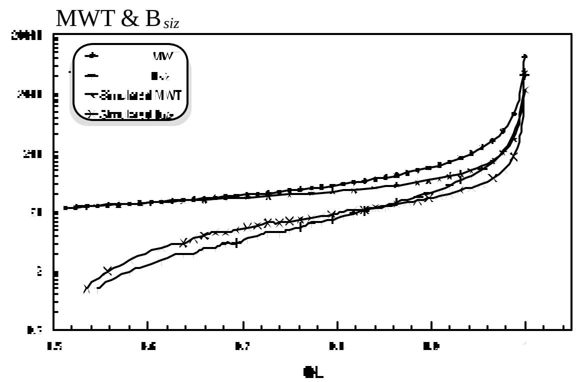

Figure 3 Simulation and Analytical Results

Our main goal of the study is to estimate the effect of the load on the Mean Waiting Time (MWT) and Maximum Buffer Size (MBS). Then, find out the maximum load capacity that can be carried by the proposed network.

The study of the maximum number of video sources (N_{vi}) depending on the generation rate of video (GR_{vi}) and data (GR_{da}) traffics. The calculation of the ideal values of N_{vi} depending on GR_{vi} in cell/ms, transmission rate (R_T)=352 cell/ms (this is because the SONET physical transmission), and transit rate in cell/ms, as shown in equation (4).

$$\text{Ideal } N_{vi} = \frac{[352(cell/ms) - transit\_rate(cell/ms)] - GR_{da}}{GR_{vi}} \quad (4)$$

Figure 4 illustrates MWT of video and data versus number of video sources (N_{vi}), for R_{vi} =1.5 Mbps, μ =5 ms and (Message Size) M_{siz}=100, 200, and 400 cells. For both video and data traffics, MWT slightly increases with the increasing of N_{vi} up to the saturation limit. Beyond the saturation limits, MWT sharply increases due to the large number of cells and queuing delay. The saturation limit which represents the maximum number of video sources in which it decreases with the increasing of M_{siz}.

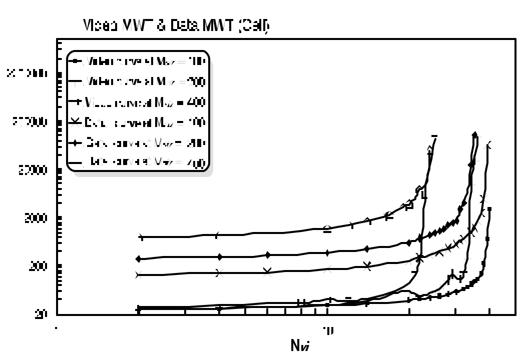

Figure 4 Video MWT & Data MWT versus N_{vi}, with R_{vi} = 1.5 Mbps, and μ =5 ms.

Table 2 shows the ideal and the actual maximum number of video sources with MWT.

M_{siz} (cells)	Ideal N_{vi}	N_{vi}	Video MWT	Data MWT	OL
100	39	37	135.81	2556.15	0.98
200	34	32	148.29	4005.80	0.98
400	24	22	269.40	7526.24	0.98

Table 2

Figure 5 illustrates MBS for video and data versus number of video sources (N_{vi}), for the same parameters used in Figure 2. The behavior is similar to that of Figure 2. So, the MBS of both video and data traffics slightly increases with the increasing of N_{vi} up to the saturation limit, and after that the MBS of both video and data traffics sharply increases due to the large number of cells waiting for transmission. Table 3 shows the ideal and the actual maximum number of video sources with MBS.

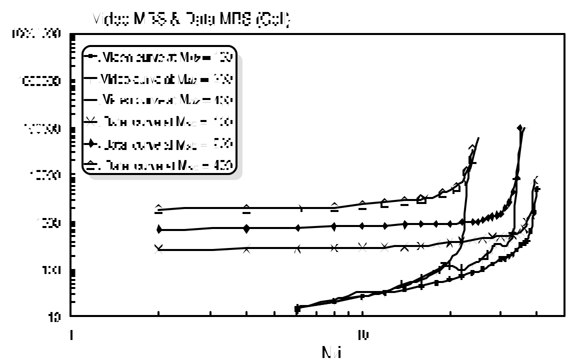

Figure 5 Video MBS & Data MBS versus N_{vi}, with R_{vi} = 1.5 Mbps, and μ =5 ms.

M_{siz} (cells)	Ideal max. N_{vi}	N_{vi}	Video MBS	Data MBS	OL
100	39	37	412	1004	0.98
200	34	32	370	2563	0.98
400	24	22	380	7201	0.98

Table 3

Figure 6 shows Throughput of video (TP_{vi}) and data (TP_{da}) versus N_{vi}, with R_{vi} of 1.5 Mbps, μ of 5 ms, M_{siz} of 100 cells and constant GR_{da}. The Figure clearly shows that TP_{vi} increases linearly with the increases of N_{vi}, this is due to the increases of number of cells. Meanwhile, TP_{da} is constant at 19.5 cells/ms up to the maximum (saturation) limit of N_{vi}, then, TP_{da} is slightly decreases with the increasing of N_{vi}, this is because the chance of transmission data decreases, resulting in low data throughput (TP_{da}).

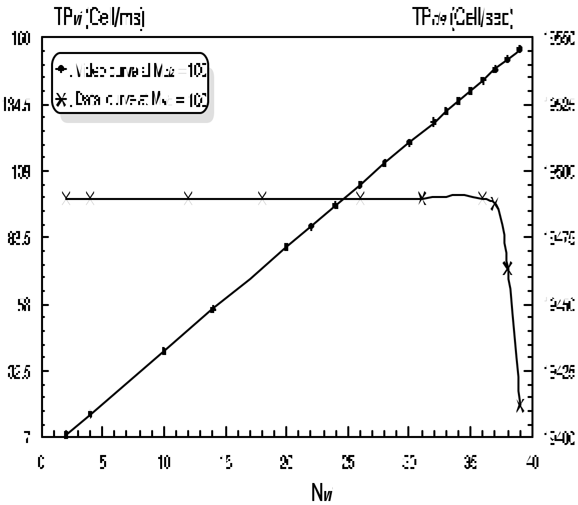

Figure 6 TP_{vi} & TP_{da} versus N_{vi}, with R_{vi} = 1.5 Mbps, and μ =5 ms.

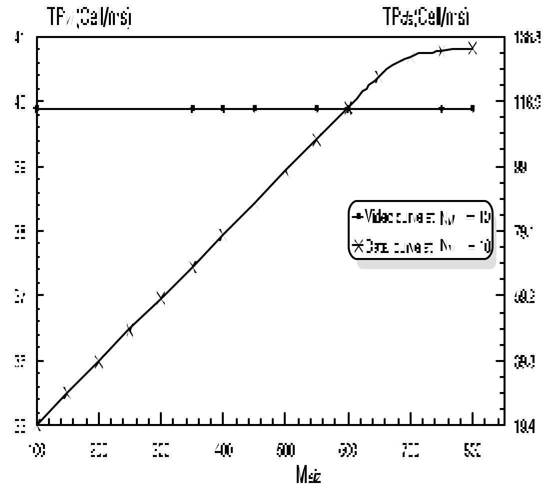

Figure 8 TP_{vi} & TP_{da} versus M_{siz}, with R_{vi} = 1.5 Mbps, and μ =5 ms.

Figure 7 illustrates TP_{vi} and TP_{da} versus N_{vi}, with R_{vi} of 1.5 Mbps, *m* of 5 ms and M_{siz} of 200 cells. The behavior is similar to that of Figure 6, the difference is only on the saturation limit which occurred with less number of N_{vi}, this is because the M_{siz} is larger than that in Figure 6.

Figure 8 indicates TP_{vi} and TP_{da} versus M_{siz}, with R_{vi} of 1.5 Mbps, *m* of 5 ms and N_{vi} of 10 sources, the increasing of M_{siz} has no effect on TP_{vi}, but TP_{da} increases with the increasing of M_{siz} up to the optimum M_{siz} then TP_{da} is remaining constant.

Figure 9 shows TP_{vi} and TP_{da} versus M_{siz}, with R_{vi} =1.5 Mbps, *m* =5 ms and N_{vi} =20 sources. The characteristics are similar to that of Figure 8, the values are different because the number of video sources are increased to 20.

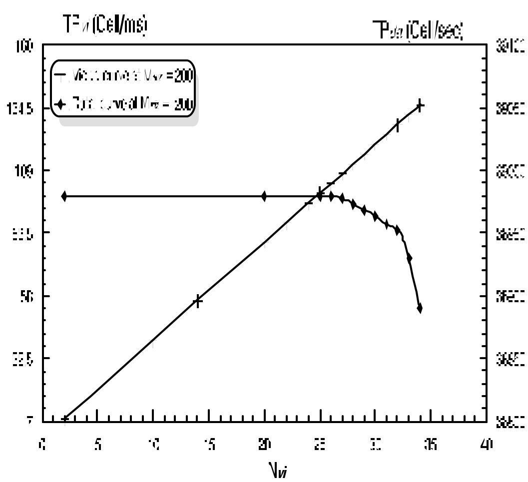

Figure 7 TP_{vi} & TP_{da} versus N_{vi}, with R_{vi} = 1.5 Mbps, and μ =5 ms.

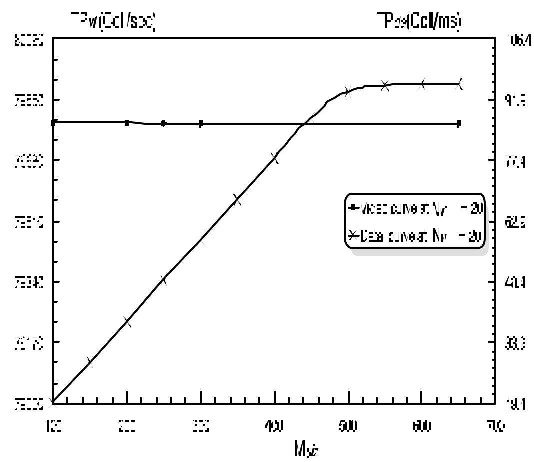

Figure 9 TP_{vi} & TP_{da} versus M_{siz}, with R_{vi} = 1.5 Mbps, and μ =5 ms.

CONCLUSION

To achieve efficient and fairness among video and data traffics on ATM network, we have proposed a control mechanism method.

The proposed control mechanism bears an acceptable characteristic for the integration of video and data traffics on the proposed ATM network. The simulation results clearly show that it is an efficient and simple control mechanism which adapts the ratios of the video, and the data traffics on the network .

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