A Study of ATM Buffer Management Scheme for Multi-QoS Services in ATM Switching Systems

***Jisoo Park°, **Changhwan Oh, *Hakyong Kim,**
***Suwon Lee, *Aftab Ahmad, and *Kiseon Kim**

* Department of Information & Communication, KJIST
** Electronics and Telecommunications Research Institute (ETRI)
Department of Information & Communications, Kwang-Ju Institute of Science and Technology (KJIST)
572 Ssang-am Dong, Kwang-san Gu, Kwang-Ju 506-712, South Korea
Phone: +82-62-970-2265, Fax: +82-62-970-2264, E-MAIL: jspark@geguri.kjist.ac.kr

Abstract

In an ATM network, there are many kinds of calls which require various qualities with real time services and non-real time services according to the required Quality of Service (QoS) for each connection. In this paper, we propose an ATM buffer management scheme with scalable priority allocation method to guarantee various Quality of Service such as CBR, rt-VBR, nrt-VBR, ABR, and UBR and to make efficient use of system resources in ATM switching systems. With our proposed method, each cell transmitted by end users is divided into logically separated buffer according to the required QoS characteristics such as Cell Loss Rate (CLR), Cell Transfer Delay (CTD), and it is dynamically read out with our cell service scheduling algorithm in the ATM switch. We also describe the proposed dynamic cell service scheduling method to maintain a required QoS with logically separated buffer in ATM switching systems.

1. Introduction

ATM is potentially capable of supporting all classes of traffic (e.g., voice, video, data), multiple services at extremely high speed and fast decreasing cost, and satisfying the QoS requirement. To use an ATM network as a flexible infrastructure for multimedia service, the ATM switch has to provide various QoS levels which the end user can request. However, various QoS requirements could imply a complex and expensive infrastructure from the viewpoint of ATM switching system manufacturing and network operation. In recognizing such needs for the QoS management, this paper discusses the proposed ATM buffer management scheme for Multi-QoS in ATM switching system.

ATM Forum has defined real-time service categories such as Constant Bit Rate(CBR) and Real-time Variable Bit Rate(rt-VBR) as well as non-real-time service categories such as Non-Real-Time Variable Bit Rate(nrt-VBR), Available Bit Rate(ABR), and Unspecified Bit Rate(UBR) according to traffic characteristics and QoS requirements to the network behavior. Real-time traffic for CBR or rt-VBR such as voice and high resource video has tolerance for some loss but not delay, and non-real-time traffic, especially ABR, such as computer data and file transfer, has tolerance for some delay but not loss [1].

In this paper, we propose a new ATM buffer management scheme to guarantee Multi-QoS for real-time services as well as non-real-time services and to make efficient use of system resources in ATM output buffer switching systems. Generally, the output buffer type among ATM switches has the superior performance for throughput and cell delay while dealing with this classified traffic [2].

In our proposed buffer management method, real-time service has high priority to achieve minimum cell delay time, and non-real-time services have priorities according to the following order : nrt-VBR, ABR, and UBR. Since ABR service is not tolerable for cell loss, buffer for ABR service, which has threshold in order not to make cell loss, has Count Indicator (CI) for ABR cell only. In addition, buffers for real-time service have Time Indicator (TI) which notifies scheduler that an incoming cell has been delayed excessively in the buffer. Then scheduler removes a cell exceeding delay threshold in order to compensate for delay time.

2. ATM Buffer Management Scheme for Multi-QoS Services

2.1 Existing Scheme for Quality Control

In this section, we will compare the following ATM buffer allocation schemes[3][4][5][6].

- *Fixed Slot Allocation Scheme*

In this method, each priority class is assigned to a fixed slot according to the QoS requirement. The scheduler assigns cell readout times to each priority class periodically. The drawback of this method is that even if there is no cell in the buffer of the allocated class, no cell is readout from the other buffer. Therefore this scheme may run to waste of preemptive slots.

- *Priority Slot Allocation Scheme*

In this method, each class cell is stored into priority buffer according to QoS. A cell in a higher priority class is read out at any time before the cells with lower priorities. The lower priority cell is read out if there are no cells with the higher priority in the buffer. The scheduler selects the cell with the highest priority for readout. However, the lower priority cells may have long cell delay time or more cell loss. Thus this scheme is not ideal for ABR service which is not tolerant to cell loss. This is shown in the following simulation results (Figure 5).

Above schemes are two examples of priority systems. In the fixed slot allocation scheme, priority is defined by allocating a certain number of slots. In the second scheme, it is achieved by preemptive service principle. In the following, we will describe a new type of priority mechanism in which the priority changes in order to keep the QoS parameters in tact. We call it Scalable Priority Allocation Scheme (SPAS)

2.2 Buffer management scheme with Scalable Priorities

As shown in Figure 1 and Figure 2, the proposed buffer management scheme with mixing Fixed Slot Allocation Scheme and Priority Slot Allocation Scheme consists of functionally classified Address Buffers (AB : real-time cell AB, nrt-VBR cell AB, ABR cell AB, UBR cell AB) according to the service type, Time Indicator(TI), Count Indicator(CI), Write Controller(WC), Read Controller(RC), Common Memory(CM), and Scheduler(S). Cells sent by users are stored in CM and WC records its address and class information on AB according to the service type. Scheduler requests RC to assign sending cell into the slot with our proposed dynamic scheduling algorithm. RC sends the cells assigned by the scheduler to the output link.

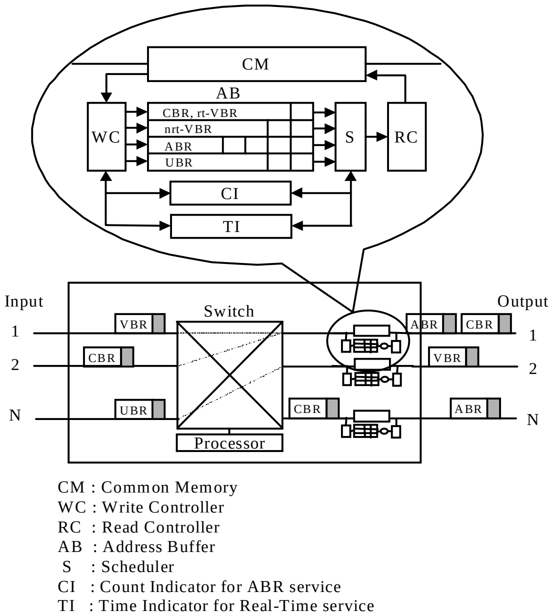


Figure 1. ATM output buffer switch and buffer management scheme with scalable priorities for supporting Multi-QoS

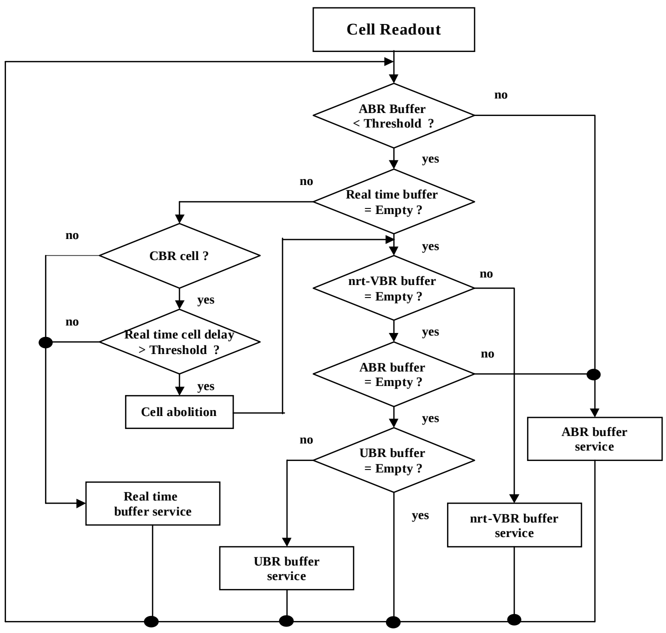


Figure 2. Scalable Priority Allocation (SPA) Algorithm

In our proposed buffer management method with scalable priorities, real-time services have high priority to achieve minimum cell delay time and non-real-time services have priority according to the following sequence : nrt-VBR, ABR, and UBR. Since ABR service is sensitive to cell loss, buffer for ABR service has Count Indicator(CI) in order not to make cell loss for ABR cell only. In addition, buffer for real-time service has Time Indicator(TI) which notifies scheduler whether a incoming cell has excessive delayed time or not. Then the scheduler removes a cell exceeding delay threshold in order to compensate for delay time (Figure 2). Also the scheduler assigns cell readout times to each priority class dynamically. If there is no stored cell in buffer for a class at the assigned time, a cell stored in the other buffers can be read out.

3. Simulation Results

3.1 Simulation Model

In this paper, the simulation model has four priorities in the following priority order : real-time buffer class, nrt-VBR buffer class, ABR buffer class, and UBR buffer class. The link speed is assumed 150Mbps (353,774 cells/sec). The cell buffer is divided physically for each priority class. The readout of cells from the priority classes is determined by the scheduler. The buffer size of each class is 20 cells. The traffic source of CBR service is modeled by Bernoulli traffic. The traffic source of all the other service is modeled by ON/OFF traffic model with the fixed cell interval, and Peak Cell Rate (PCR) of 10Mbps. The number of cells generated for ON-duration is 10 on average, and the OFF-duration is assumed as 14 on average. The output buffer switch with size 8x8 is used in this simulation.

3.2 Performance Evaluation

In Figure 3, real-time service cells (CBR and rt-VBR) show better performance for cell delay time than non-real-time service cells because real-time service cells have higher priorities. By using Time Indicator (TI) in order to avoid extreme cell delay time in real-time buffer class, we can reduce cell delay time on overall services for QoS requirement. These simulation results in Figure 4 prove preceding explanation. Since we can intuitively know that the fixed slot allocation scheme has bad performance for cell delay and loss, we did not compare with the fixed slot allocation scheme. However, we compared with the priority slot allocation scheme for cell loss probability in Figure 5 and Figure 6. As shown in Figure 5, when the priority slot allocation scheme is applied individually to output buffer ATM switching system, cell losses occur for ABR because ABR service is not protected from cell loss. In the proposed scheme, however, using Count Indicator (CI) with the cell threshold to avoid ABR cell loss, ABR service never has the cell loss. As shown in Figure 7, cell delay time for the proposed scheme is similar to that for the priority slot allocation scheme. However, as shown in Figure 6, cell loss probability for the proposed scheme is little bit smaller than that for the priority slot allocation scheme. From the above results, we can find out that it is possible to implement our proposed buffer management scheme with scalable priorities supporting Multi-QoS requirement for a high class application like as multimedia service in the ATM output buffer switching system.

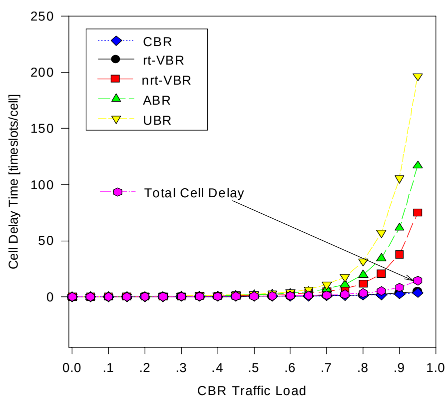


Figure 3. Cell delay time for each service

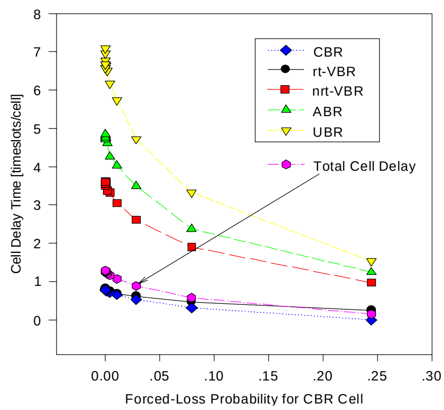
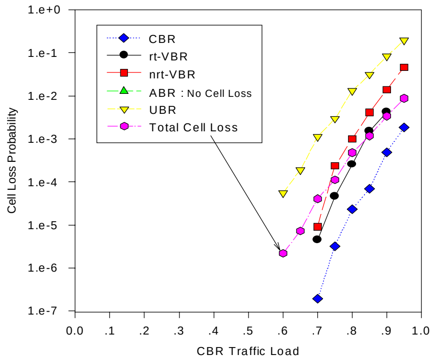
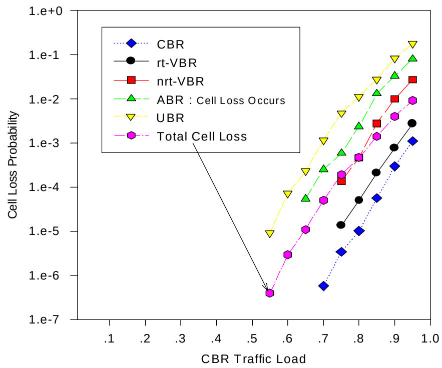


Figure 4. Cell delay time in making forced-loss for CBR cell (CBR traffic load : 0.65)



(a) Our Scalable Priority Allocation Scheme (SPAS)



(b) Priority slot allocation scheme

Figure 5. Cell loss probability for each service

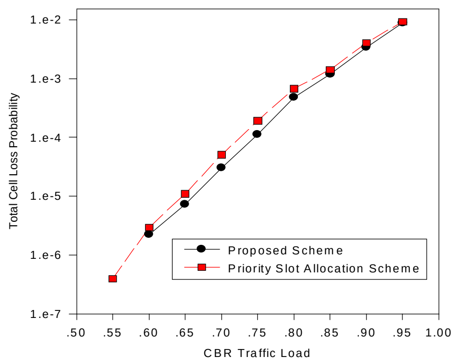


Figure 6. Total mean cell loss probability

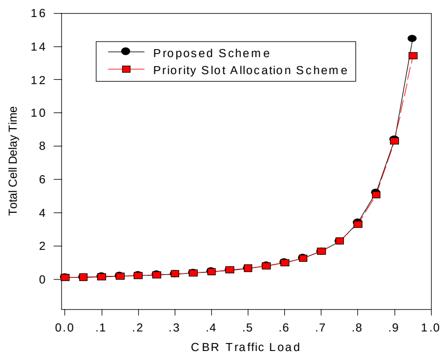


Figure 7. Total mean cell delay time

4. Conclusions

ATM is considered as a promising transport platform for multimedia communication. ATM switching systems have to handle Multi-QoS of traffic with efficient buffer management techniques. In this paper, we have proposed an ATM buffer management scheme and dynamic cell readout algorithm with Scalable Priority Allocation Scheme (SPAS) to satisfy Multi-QoS in ATM switching systems. The proposed scheme is especially suitable and efficient for the allocation of slot (Bandwidth) for Multi-QoS requirement. When we consider that at least two different QoS classes need to guarantee the Cell Transfer Delay (CTD) or Cell Loss Probability (CLP) objective values, the introduction of the proposed ATM buffer management method with Scalable Priority Allocation Scheme (SPAS) for Multi-QoS services into the ATM switching system is a reasonable and feasible solution.

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