Chapter 2

A System Model

In this chapter, we review the system introduced in [3]. The system has a transmission link shared by an ABR application for non-real time traffic and a VBR application for real time traffic. The network access node is assumed to have a finite buffer of capacity C for the temporary storage of the sources. If the buffer is full, however, the ABR cells will be blocked and cleared from the system.

Asynchronous transfer mode (ATM) is the first switching technology that can support both fixed bandwidth services similar to circuit switching, and highly variable bandwidth services similar to packet switching, in a single integrated environment [5]. The ABR service in ATM networks is intended for non-real time traffic, where delay can be tolerated. Yet, it can also efficiently coexist with other service classes such as constant bit rate (CBR) and VBR which are intended for real time traffic. Since CBR and VBR traffic rates will fluctuate in time, the ABR sources need to adjust their rates according to fluctuations in order to utilize the entire remaining capacity or avoid cell losses. Therefore, it is necessary to control the ABR traffic sources. In this system, a feedback carrying information about the available bandwidth is transmitted to the ABR source when the bandwidth availability for the ABR source changes. The ABR transmission rates are then determined by the feedback based on the VBR transmission rates. Yue et al. [1] applied the schemes utilized in [6] and [2] to propose a multi-traffic network system under a new feedback control method for ABR service to fulfill service-specific Quality of Service requirements of different service classes offering traffic.

In this system, we consider that VBR traffic has a higher transmission priority than the ABR traffic. If VBR and ABR cells arrive at the same time, then the VBR cells will be transmitted first, while the ABR cells will enter the buffer and wait to be transmitted. If there are no VBR cells to transmit, the ABR cells can be transmitted according to a first-in first-served discipline.

The time axis is slotted and the frame has a fixed length of L slots. It is assumed that cell departures occur at the beginning of a slot and the cells arrivals occur at the end of a slot. The maximum delay of VBR is that if the system is busy, a cell arriving at a slot will wait a slot until it is available. The objective is to study the departure process of this system. In this thesis, we present performance analysis and evaluation for departure time at multi-traffic networks with priority control. The results obtained in this thesis also include simulation experiments.

In specific, the first and second moment of the inter-departure time are derived. This system is formulated by a MMBP/D/1/C model where VBR has higher priority with non-preemption. Let t_k denote the beginning time instant of the kth frame, $k = 1, 2, \ldots$, and let $s_k = 0, 1$ be a random variable to denote the VBR source activity status. For example: $s_k = 1$ denotes the traffic at a heavier level and $s_k = 0$ denotes the traffic at a lighter level at t_k. We call s_k the status of the VBR source. Changes of the status s_k occur only at the beginning of the frame. Let $r(s_k)$ denote the probability of transmitting one source by the VBR source in a slot of the kth frame when the status of the VBR source is s_k at the kth frame.

Define,

$$
\begin{aligned}
r(0) &= Pr\{\text{the VBR cell arrive in a slot of the } k\text{th frame} \\
&\quad \text{when the status of the VBR cell is } s_k = 0\}, \quad (2.1) \\
r(1) &= Pr\{\text{the VBR cell arrive in a slot of the } k\text{th frame} \\
&\quad \text{when the status of the VBR cell is } s_k = 1\}. \quad (2.2)
\end{aligned}
$$

In general, it can be assumed that $r(1) > r(0)$. The cell arrival process of the VBR is modelled as a Markov Modulated Bernoulli Process (MMBP). The VBR cell can arrive in an arbitrary slot.

In this system, the ABR source has multiple status and the number of source transmitted by the ABR source is controlled by the feedback based on the congestion status of the buffer. They assume the ABR traffic source to have M status. They call $z_k = 1, 2, \ldots, M$ the status of the ABR source at the kth frame. The number of ABR cells are transmitted according to the status of the ABR source. The higher level of status of the ABR cells at buffer is, the larger number of ABR cells transmitted will be. When the status of the ABR cells at buffer is in z_k, then the ABR source can transmit a block of $z_k B$ cells, where the batch size $B \geq 0$ is a system parameter that is an integer. The status of ABR source are controlled by the feedback based on the buffer status of the system. It is assumed that the changes in the ABR status occur only at frame boundaries in accordance with the feedback.

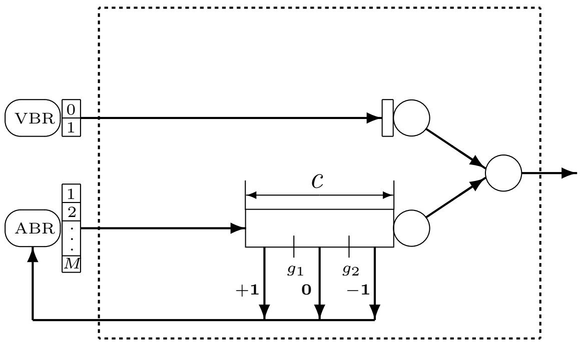
Yue et al. [3] proposed a new feedback control method to control the flow of the ABR traffic. They use two critical number g_1 and g_2 to characterize the congestion of the buffer of ABR, where $0 \leq g_1 \leq g_2 \leq C$. If the queue length of the buffer is less than or equal to g_1, then it sends signal $+\mathbf{1}$. If the queue length of the buffer is greater than g_1 and less than or equal to g_2, then it sends signal $\mathbf{0}$. If the queue length of the buffer is larger than g_2, then it sends signal $-\mathbf{1}$. Assume that the

ABR source is in status z_k at the kth frame. It gives

$$z_{k+1} = \begin{cases} z_k + 1, & \text{if } 0 \le q_k \le g_1, \\ z_k + 0, & \text{if } g_1 \le q_k \le g_2, \\ z_k - 1, & \text{if } g_2 < q_k \le C. \end{cases} \tag{2.3}$$

That is if the ABR source receives the signal **1**, it will be in status $z_k + 1$ at next frame for $z_k = 1, 2, \ldots, M-1$, and in status M for $z_k = M$. If it receives the signal $-\mathbf{1}$, it will be in status $z_k - 1$ at next frame for $z_k = 2, 3, \ldots, M$, and it will be in status 1 for $z_k = 1$. If it receives the signal **0** or does not receive new signals, then it will be in status z_k at next frame. A queueing model of the network access node is shown in Figure 2.1.

Figure 2.1: A queueing model of network access node.



By using the semi-Markov chain method, we establish a tractable analytical model for the system. Based on the analysis, we calculate the loss probability and the utilization of the network system, and obtain mean and variance of VBR (or ABR). The impact of several parameters on the system performance is presented through some simulation results. The transmission time of a cell over a channel is assumed one time unit. The set of all service times is assumed independent of the arrival streams.