Chapter 12
Bandwidth Management Algorithms by Using Game Models

ABSTRACT

In spite of the emergence of high network infrastructures, bandwidth is still an extremely valuable and scarce resource. Therefore, all performance guarantees in communication networks are conditional on currently available bandwidth capacity. In view of the remarkable growth in the number of users and the limited bandwidth, an efficient bandwidth management is very important and has been an active area of research over the last decade. Bandwidth management is the process of measuring and controlling the communications (traffic, packets) on a network link to avoid filling the link to capacity or overfilling the link, which would result in network congestion and poor performance of the network. The objective of these mechanisms is to maximize the overall network performance. This chapter discusses bandwidth management.

QOS-AWARE BANDWIDTH ALLCATION (*QSBA*) SCHEME

Bandwidth is an extremely valuable and scarce resource in multimedia networks. Therefore, efficient bandwidth management is necessary in order to provide high Quality of Service (QoS) to users. Recently, S. Kim proposed a new QoS-aware Bandwidth Allocation (*QSBA*) scheme for the efficient use of available bandwidth (Kim, 2010). By using the multi-objective optimization technique and Talmud allocation rule, the bandwidth is adaptively controlled to maximize network efficiency while ensuring QoS provisioning. In addition, the *QSBA* scheme adopts the online feedback strategy to dynamically respond to current network conditions.

Development Motivation

In recent years, the explosive growth of new services and the rapid and widespread proliferation of multimedia data have necessitated the development of an efficient network management system. The network system is expected to provide diversified traffic services and enhance network performance simultaneously. Usually heterogeneous multimedia data can be categorized into

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two classes according to the required Quality of Service (QoS): class I (real-time) services and class II (non-real-time) services. Different multimedia services over networks not only require different amounts of bandwidth but also have different QoS requirements (Yang, Ou, Guild, & Chen, 2009).

During network operations, the limited bandwidth has to be shared by several users. Therefore, fairness is another prominent issue for the network management. If the concept of fairness is not considered explicitly at the design stage of bandwidth allocation algorithm, different allocation requests can result in very unfair bandwidth allocations. However, fairness-oriented allocation methods may lead to a system inefficiency, which degrades total network performance quite seriously.

The *QSBA* scheme is developed as a new bandwidth allocation algorithm for multimedia networks. To approximate an optimal network performance, the developed algorithm has focused on the basic concept of online decision process. Based on the Modified Game Theory (MGT) (Mehmet, & Ramazan, 2001), the bandwidth is adaptively allocated to satisfy different QoS requirements. In addition, by using the Talmud allocation rule (Li, & Cui, 2009), a weight parameter is adjusted periodically to ensure the allocation fairness. Therefore, the system dynamically re-estimates the current network condition and iteratively adapts control decisions. Under dynamically changing network environments, this online strategy can find the best solution for conflicting objectives.

Network Control Algorithms in the *QSBA* Scheme

Recent advances in network technologies have made it possible to provide heterogeneous multimedia services. However, multimedia service makes the problem more complex, since each service requires different bandwidth allocation and has different characteristics according to the required QoS. Class I data services require real-time deliveries. Therefore, the system should guarantee a fixed amount of bandwidth allocation. However, class II data services are more flexible; they need only to guarantee their time deadlines. Therefore, between the start time and the deadline, class II services are amenable to adaptation with variable bandwidth allocation. The *QSBA* scheme defines Ψ as the set of accepted service requests (*sr*) by the network, $\Psi = \{sr_{1,}\ sr_{2,}\ sr_{3,,,,}\ sr_{i,,}\ sr_n\}$, where n is the total number of running services, i.e., $n = \|\Psi\|$. During real world system operations, n is dynamically changed. The class II service request i is characterized by $\{a_{i,}\ d_{i,}\ t\_c_i\}$ where a_i is the arrival time, d_i is the deadline, and t_c_i is the total workload of service sr_i to be completed. However, the class I service request j is characterized only by $\{b_j\}$ where b_j is the requested bandwidth during the operation of service.

To estimate QoS provisioning for each service, the *QSBA* scheme defines two QoS functions (F_{class_I} and F_{class_II}). By using the adaptive online manner, the F_{class_I} and F_{class_II} evaluate the QoS for class I and class II services, respectively. In order to implement these functions, the *QSBA* scheme partition the time-axis into equal intervals of length *unit_time*. In the developed algorithm, a control parameter is adjusted periodically, every *unit_time*, in order to maintain well-balanced network performance considering conflicting QoS criteria. At the current time (c_t), the F_{class_I} and F_{class_II} are given by

$$\begin{cases} F_{class_I}(ct) = 1 - \left[\sum_{k \in U_1} (b_k \times A(k)) \Big/ \sum_{k \in U_1} b_k \right] \\ F_{class\_II}(ct) = D\_M_{II} \Big/ \sum_{k \in U_{II}} (\mathrm{A(k)}) \end{cases} \tag{1}$$

where

$$A(k) = \begin{cases} 1, & if\ request\ k\ is\ allocated(b_k)\ or\ accepted(t\_c_k) \\ 0, & otherwise \end{cases}$$

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