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Predictive and measurement-based dynamic resource management and QoS control for videos

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Abstract

In this paper, we propose a new dynamic resource allocation and call admission control method for the VBR video sources to meet the user's quality of service requirements and at the same time to achieve an efficient resource management in networks. Without any prior knowledge of the user's traffic statistics, the proposed mechanism dynamically adjusts the necessary bandwidth by the networks based on the provided quality of service satisfaction degree of each connection in respect to the user's requirements in terms of loss ratio and average delay. Using traffic prediction and simple QoS measurements, the next required bandwidth for each video connection is computed. To avoid quality decreasing by new incoming calls, we present a call admission control based on the provided QoS for existing connections. Simulation results show that our proposed dynamic method is able to provide the desired level of quality of service and high network utilization.

Keywords: Dynamic; Bandwidth allocation; Call admission control; Traffic prediction; QoS control; Real-time video; Variable bit rate

1. Introduction

With the large scale deployment of ATM and fast IP networks, variable bit rate (VBR) video traffic is expected to be one of the major applications that need to be supported by broadband packet-switched networks. In transporting VBR video traffic, achieving efficient use of the network resources while providing quality of service (QoS) guarantees is not trivial, due to the complex and bursty characteristics of VBR video traffic.

There has been a lot of research in the literature on the resource allocation and call admission control (CAC) for VBR video services in ATM networks. Most of the studies have addressed modeling of video sources with a few traffic parameters to characterize source traffic variations and to decide the necessary bandwidth and buffer size for the user's QoS requirements [1]. ITU-T and ATM Forum have defined leaky bucket based traffic descriptors (peak packet rate, sustainable packet rate, and maximum burst size) for VBR service class. For more accurate representation of the very complex video traffic characteristics, Markov, autoregressive, histogram, and some other models have been proposed [2–4]. In the conventional traffic management schemes that use model parameters to provide QoS guarantees, at the call set-up, the CAC is performed based on the traffic descriptors declared by the user and QoS requests. After admission, the user is allocated a fixed bandwidth for the duration of the call, meanwhile usage parameter control (UPC) monitors the user traffic to ensure the agreed traffic parameters are not violated.

However, the application of this type of approach to MPEG video services involves several problems. First, in the case of interactive on-line video applications, the source traffic characteristics may not be known ahead of time. Characterizing the input video traffic prior to the call set-up is only possible for video applications that use pre-recorded streams, such as video on demand. Second, it is well known that modeling MPEG video traffic with only a few parameters is very difficult due to its complex traffic characteristics [5,6]. Third, the high burstiness of the variable-bit-rate video traffic produces an over-allocation of network resources and low utilization [6].

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For real time interactive video services without any prior traffic descriptions, a few dynamic bandwidth allocation methods using prediction techniques have been proposed [7–14]. Rather than using the model-and-parameter method to determine a fixed bandwidth at the call set-up, a dynamic approach uses a real-time measurement to adaptively determine the bandwidth share for each user. A prediction of next input traffic that is derived from the previous traffic may be implemented by a filter [7–10] or neural network [7]. These prediction-based dynamic bandwidth allocation methods are suitable to the on-line applications and can improve the network utilization. However, most of the previous proposals are mainly interested in the accurate traffic prediction and their queueing behaviors. To date no dynamic method has the ability to tightly control the QoS for such complex traffic as transmission of VBR video. Therefore, we need a new mechanism that not only dynamically allocates bandwidth, but also meets the user's desired QoS.

In this paper, we have distinguished a soft QoS control from a strict QoS control. In the strict QoS control, networks guarantee the user's QoS requirements strictly during the entire connection period if input traffic conforms to the declared traffic descriptions at the call set-up time. While in the soft QoS control, which is newly defined, networks maintain the provided QoS to the desired QoS level very closely without any prior traffic descriptions. However, in the worst case, for short time intervals, networks may not provide the user's QoS requirements. In fact, the basic concept of the soft QoS control is similar with that of the soft real-time system. A soft real-time system is one that has timing requirements, but occasionally missing them has negligible effects, as application requirements as whole continue to be met. A soft real-time system may often carry meta requirements such as a stochastic model of acceptable frequency of late computations. In the soft QoS control that is defined in this paper, services are also provided statistically in terms of average delay and loss ratio. For the soft QoS control, we propose a new dynamic bandwidth allocation and CAC method for VBR video sources.

This paper is organized as follows. In Section 2, we present architecture for the dynamic resource allocation and QoS control. In Section 3, we propose an adaptive bandwidth allocation and CAC scheme, which is based on the currently provided quality degree by the networks. Some simulation results are discussed in Section 4. Finally, we conclude this paper in Section 5.

2. A dynamic resource allocation and QoS control architecture

2.1. General

Our dynamic bandwidth allocation and QoS control method uses not only a traffic prediction but also a real-time quality of service measurement to achieve both high network utilization and accurate QoS support.

Fig. 1 shows the proposed dynamic resource allocation and QoS control architecture. In the packet switched

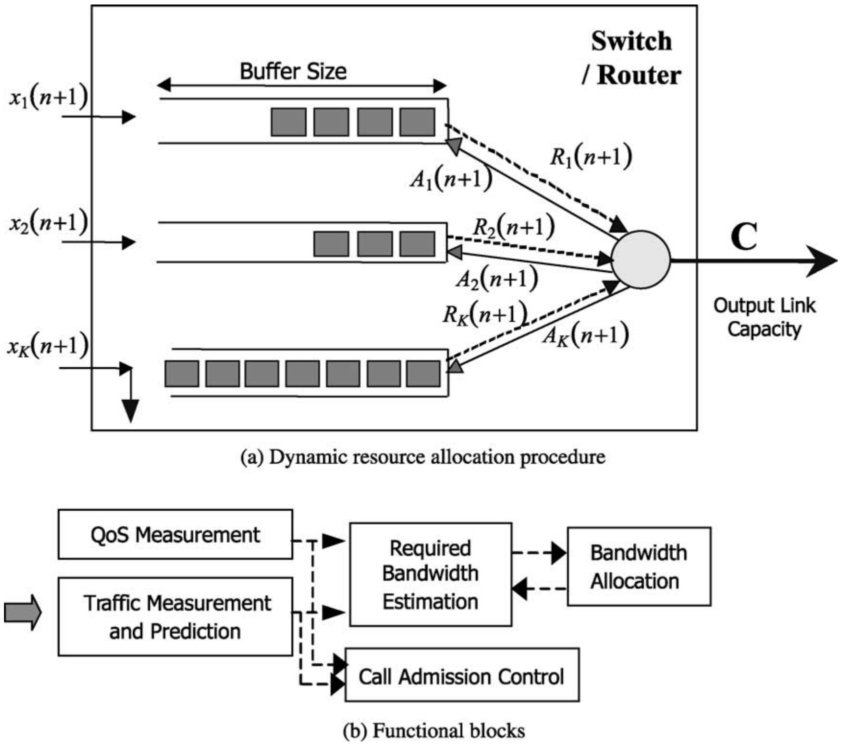

Fig. 1. Proposed dynamic resource allocation and QoS control architecture.