行政院國家科學委員會專題研究計畫成果報告

支援 ATM 網路中 ABR 資料流動態回饋式傳輸率控制-理論與實務

Dynamic Multi-threshold Rate Control Mechanisms for Supporting ABR Traffic in ATM Networks

計畫編號 ： **NSC87-2213-E-009-006**
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一、中文摘要

目前在 ATM 網路中支援 Available Bit Rate(ABR)服務的回饋式傳輸率控制，都是在每一個交換點上，採用單一靜態的緩衝區門檻來當作其阻塞的預警。在這篇報告中，首先說明我們新設計的回饋式傳輸率控制器的架構。接著我們提出一個 continuous-based adaptive 的控制器出制，出這個出制邏輯上來說，可以使用無限個數的門檻。每個點基於一個同時滿足 loss-free 足 starvation-free 需求的模組，定期地決定緊鄰的 upstream node 所允許的傳輸率 (permitted rate)。這個方法，可以證明確實在資料流量大時能達到 high-utilization 足 low cell loss probability 的到求。

Abstract

Existing feedback-based rate control schemes supporting the Available Bit Rate (ABR) service in ATM networks mostly employ a single static buffer threshold at each switching nodes as the forewarning of congestion. In this report, we first present the architecture of our newly-designed feedback-based rate controller. We then propose a continuous-based adaptive rate control mechanism which employs, logically, an infinite number of thresholds. Each node periodically determines the precise explicit permitted rate (ER) of immediate upstream nodes based on a simple fluid model aiming at satisfying both loss-free and starvation-free criteria. The scheme, as will be shown, achieves high utilization and low (zero) cell loss probability under highly bursty traffic.

Keywords: Available Bit Rate (ABR), Quality of Service (QOS), Feedback-based rate control, Explicit Rate (ER), Binary rate control, Cell Loss Probability (CLP), Fluid model.

二、Motivation and Objective

The Available Bit Rate (ABR) [1] service in ATM networks has been deployed to allow efficient use of available bandwidth without degrading the Quality of Service (QOS) of admitted traffic. While the QOS of admitted traffic is guaranteed through admission control and bandwidth allocation, the ABR service has been realized via the feedback-based rate control [2,3].

Feedback-based rate control deals with the dynamic adjustment of the granted rates of ABR sources as network loads fluctuate in an attempt to minimize the performance degradation of QOS-guaranteed services. Existing rate control mechanisms operate either on an end-to-end [6,8,11] or hop-by-hop [7] basis. While both classes of control mechanisms possess individual performance merit, hop-by-hop-based control has been considered to be more promising due to its speed reaction to the fluctuation of network loads [9-10].

Most hop-by-hop-based schemes adopt static buffer threshold [7,9] at each switching node as the forewarning of congestion. In these schemes, a switching node sends feedback messages to its immediate upstream nodes should the buffer occupancy exceed the pre-determined threshold. The up-stream nodes in turn adjust the cell departure rates on either a simple binary rate (i.e., start and stop)[7] or a specified rate [9] basis. Mishra, *et al.* [9] proposed a predictive rate control scheme for determined the permitted rate and illustrated that the buffer occupancy and throughput of a control connection converge to a desired operating point. Kawahara, *et al.* [7] developed an analytical model based on binary rate control and showed significant performance improvement, in terms of Cell Loss Probability (CLP) and resource utilization, of the congested node but at the expense of signaling overhead.

Exhibiting various performance credits, these schemes, however, result in improper rate determination due to the employment of one static threshold. The goal of the project is to propose a feasible feedback-based rate controller augmented with the precise ER determinator.

三、Approach and Results

In this report, we first present the architecture of our newly-designed feedback-based rate controller. As shown in Figure 1, each switching node on which feedback-based rate control operates consists of a finite buffer and a Rate-Based Controller (RBC). In principle, in accordance with the buffer occupancy, the RBC of a switching node at each time unit determines the Updated Permitted transfer Rate (UPR) for all immediate up stream nodes through sending feedback messages incorporating such rates. This rates then becomes the Outbound Permitted Rate (OPR) of those immediate upstream nodes or the Inbound Permitted Rate (IPR) of this current node throughout the next time unit. The RBC is composed of a Flow Estimator, a Rate Determinator, and a Rate Regulator. At each time unit, the Flow Estimator predicts the aggregate flow of future incoming traffic based on the previous UPR and the current buffer occupancy. The Rate Determinator in turn determines the new UPR achieving two performance criteria, based on a rate control flow. Finally, the Rate Regulator ensures that the transfer rate never exceeds the granted OPR.

We then focus on the design of the Rate Determinator. We have proposed a continuous-based adaptive rate control mechanism which employs, logically, an infinite number of the thresholds. Each node periodically determines the precise permitted rate of immediate upstream nodes based on a simple fluid model aiming at satisfying both loss-free and starvation-free criteria. We carried out simulation for CLP and system throughput under various burst lengths, based on continuous-based rate control. We notice that, under deterministic traffic, loss-free (CLP=0) transmissions and a system throughput of unity can be achieved as was justified by the analysis. Under bursty traffic, on the other hand, the mechanism yields non-zero CLP and system throughput of less than one. In particular, the higher the burstiness, the greater the CLP and the smaller system throughput. This is because an increase in traffic burstiness results in a decrease in statistical multiplexing gain.

四、Merit Review of the Project

In terms of technical superiorsly, our approach offers precise computation of ER, compared to the existing approaches which result in improper rate determination due to the employment of one static threshold. In terms of publication, a simple version of the report has published in Proc. Of GLOBECOM’97 and published in IEEE Transaction on Industrial Electronics, 1998.

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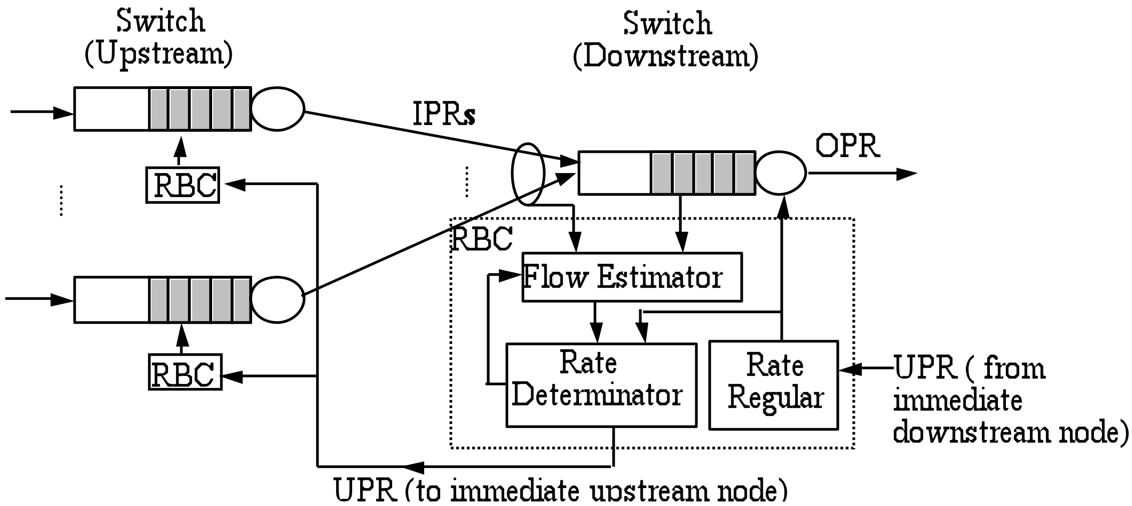

Legend:
RBC: Rate Based Controller; OPR: Outbound Permitted Rate;
UPR: Updated Permitted Rate; IPR: Inbound Permitted Rate;

Figure 1. System architecture.