Bounding the Loss Rates in a Multistage ATM Switch *

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Abstract

We study the cell loss rates in a multistage ATM switch. We present some numerical computations for small configurations which prove that first order approximation may not be accurate. We present stochastic bounds for these loss rates using simple arguments which lead to models easier to solve. For ill-balanced configurations these models give good estimates of loss rates.

1 Introduction

We study the cell loss rates in a multistage ATM switch. Such a switch is decomposed into several queues with feed-forward routing; and external arrivals always take place at the first stage. We assume a discrete-time switching as the ATM cells have a constant size. All the queues are finite. Thus losses occur in all queues due to the variability of the input processes. Loss rates are very important as they may be part of the contract on the quality of service (QoS) between the user and the network provider. Unfortunately such a network of discrete-time queues with losses does not have a known analytical solution. However, the topology suggests to use a decomposition to find loss rates stage by stage.

The analysis of the first stage is not very difficult. Several solutions may be considered according to the arrival process. If we assume i.i.d batch arrivals or Markov modulated batch arrivals (MMBP), we can easily build a Markov chain of one buffer. Let $B$ be the size of the buffer, if we consider i.i.d. batch process, the chain has $B + 1$ states. For a MMBP with $n$ states for the modulation,

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the size of the chain is $n \times (B + 1)$. Thus, the numerical computation is always possible. If we restrict ourselves to less general processes, analytical solutions may also be obtained (see Beylot's Phd thesis for some results on Clos networks [1]).

However, the second stage is much more difficult to analyze. Indeed, it is quite impossible to know exactly the arrival process into a buffer in the second stage even if we assume a simple i.i.d batch arrival process at the first stage. The output process of the first stage is usually unknown due to the losses at the first stage and the superposition of such processes is unknown even if we assume independence. It may be possible that under some restricted assumptions, some asymptotic results may be established. We do not try to prove such a result here, but we hope that we will be able to combine asymptotic results and bounds in the near future.

Usually such a decomposition method based on the routing uses an approximation for the arrival process into the queues. A first order approximation means that the approximate arrival process is chosen according to one parameter: in general, the expected number of arrivals per slot (in discrete time) or the interarrival time (in continuous time). The process is selected among a family of well known processes (for instance Poisson or Geometric processes). We have used such an approximation to analyze a simple model of three buffers. The results may be quite inaccurate as the relative errors on the loss rates may be as large as $10^5$ as it could be seen in section II.

We advocate that stochastic bounds may lead to better estimates of the loss rates. In this paper, we develop an idea proposed by Truffet in his thesis [8] to model such a switch: replace the buffers by sources or by buffers easier to model. We define two families of models which give upper and lower bounds for the loss rates. Our method applies to the other stages of the buffer as well. Thus, it may be possible to warrant a quality of service in terms of loss rates in the switch and the network.

The paper is organized as follows. Section II presents a simple first order approximation and shows that the results are inaccurate. In section III, we propose two models which provide stochastic bounds for the loss rates, while in section IV, we present numerical results which show that for ill-balanced loads the results may be quite good.