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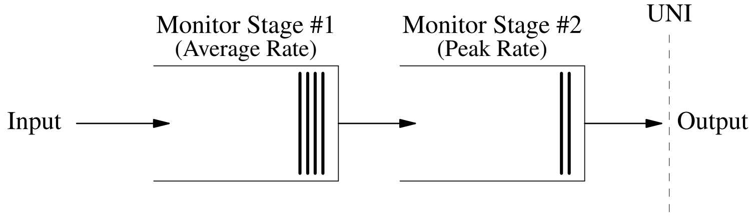
Analytic Methods for Dynamic Network Management

Congestion appears in a network as the rate at which service is requested approaches the *service capacity* of the network. The onset of congestion is signaled by an increase in the delay in delivering cells and in the loss of data. *Flow control* is the generic antidote to congestion; the term refers to techniques for regulating the number of cells allowed to enter the network.

A B-ISDN network's decision to accommodate a new ATM connection is based in part on sustained and peak cell rate and peak duration declared by the user in the connection request. As these traffic descriptors are only *projections* of the traffic, connection admission control must be supplemented by input rate control in order to monitor and regulate the *actual* traffic. None of the proposed input rate control schemes enforces multiple traffic parameters. Additionally, traffic shaping at the UNI based on regulating average and peak rates may enhance statistical multiplexing performance.

The research supported by this NSF Award focused on the performance analysis of the two-stage entry monitor combining a sticky buffer *policer* with a *spacer*. The first stage enforces the sustained rate R/T negotiated in the connection request; the spacer shapes the traffic and controls burstiness by further ensuring that cells enter the network at least S slots apart.

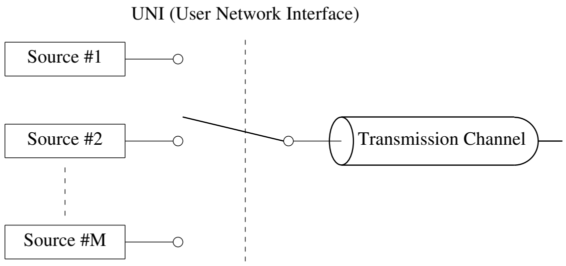


We derive the probability generating function for the combined queue length distribution and evaluate numerically *(i)* the manner in which S and burstiness affect the cell-loss probability and *(ii)* the performance penalty caused by enforcing two rates.

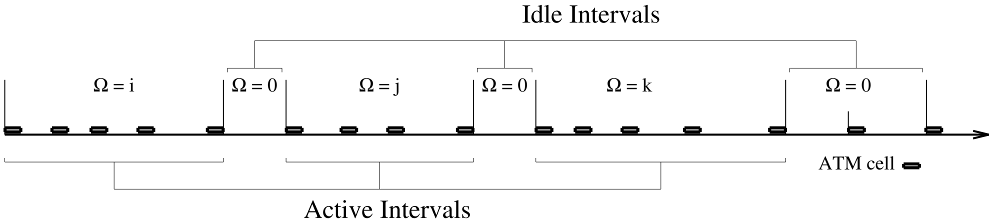
The principal contribution of this paper is the calculation of the buffer size required to police two parameters subject to a specified cell-loss ratio. We conclude *(i)* the increase in buffer size needed to police both the peak and sustained rate is minimal and it (ii) the leaky bucket and the single stage sticky buffer have comparable performance.

Management of a broadband network will require measurements of the actual traffic. Reactive and adaptive schemes must be *at least* capable of measuring the rate at which users deliver ATM-cells to the network.

This NSF Award also supported research on models for the estimation of the rates of heterogeneous traffic generated by $M > 1$ sources containing a fixed VCI/VPI identifier entering the broadband network at the *user network interface* (UNI).

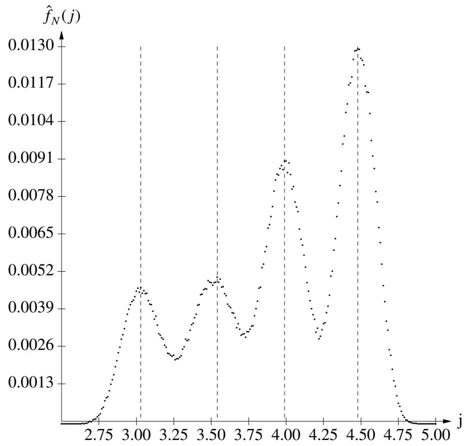


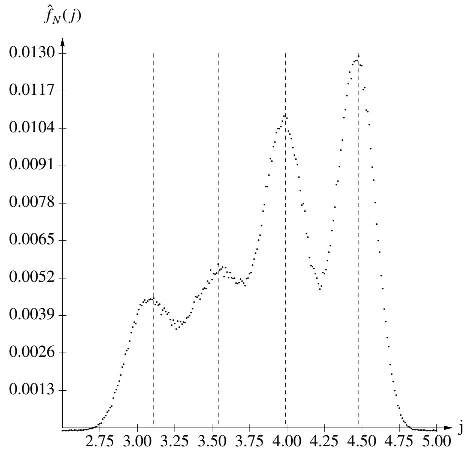
The traffic model consists of the interleaving of sources.



The objective is to estimate the *bandwidth faction* BW_j, the fraction of slots used by the $jsupth$-source. Measurements of the cell interarrival times $\{T_n\}$ are combined to define an estimator $U_n = U_n(\vartheta)$; the parameter $\vartheta \in [0,1]$ progressively lessens the influence of the past $\{T_k : k < n\}$ on the current estimate U_n.

We prove that as $n \to \infty$, $U_n(\vartheta)$ is unbiased and show how the components of heterogeneous traffic may be identified. Using $\mathcal{U} = \{U_n\}$ we indicate how the bandwidth fractions may be estimated.
In the example next, measurements on $M = Z$ sources are processed.





The peaks of the combination of unimodal empiric densities correspond to the component traffic rates.

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