Traffic Shaping by Statistical Characterization in ATM Networks

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ABSTRACT

ATM (Asynchronous Transfer Mode) was created in order to provide a network that is capable of handling all current and future applications independently of their bandwidth requirements. Multimedia is today’s trend combining sound, images, text and moving pictures, in order to teach, entertain or inform. Heavy and diversified data creates the problem of congestion in the ATM networks. It is shown that TCP performs poorly over ATM networks when congestion leads to loss of packets in ATM networks which in turn result in the corrupted data packets and performance degradation. Usage Parameter Control (UPC) parameters for traffic shaping generally specifies characterizing the cell stream (data) entering the network. In this paper a method is developed for finding the good estimator for UPC based on statistical characteristics of the data.

Keywords: statistical characteristics, Usage Parameter Control, traffic descriptor

Introduction:

ISDN is based on the digitized telephone network, which is characterized by 64 kbit/s channel. But as the demand for higher transmission rate was required e.g. video, ITU-T in its recommendation (1993) defined the word Broadband. Now B-ISDN is considered as a universal network. Several techniques for the switching and multiplexing schemes (transfer mode) are proposed for B-ISDN. These schemes include circuit switched based Synchronous Transfer Mode (STM) and packet switching based Asynchronous Transfer Mode (ATM). Asynchronous word is used for ATM layer and not for the physical layer that is the multiplexing of cells on the physical medium is asynchronous, and no slot is reserved for a logical channel and cells are transmitted as and when they arrive. This makes the transfer of the cells for a particular channel non-periodic that is why ATM is an asynchronous transfer mode

ITU-T recommendations define ATM as: “Asynchronous transfer mode (ATM) is the transfer mode for implementing B-ISDN.”

ATM is characterized by very high transmission rate on network links, and a simple, hardwired node-to-node protocol that matches the fast channel speed of the network. Unlike traditional packet switching, protocols within an ATM networks are simplified. Simplified protocols make it possible to implement the switching function in hardware. ATM provides service to sources with different traffic characteristics by statistical multiplexing the cells, which are fixed length packets of 53 bytes.
ATM CELL STRUCTURE:

<table>
<thead>
<tr>
<th>Bits</th>
<th>Byte</th>
</tr>
</thead>
<tbody>
<tr>
<td>7  6  5  4  3  2  1  0</td>
<td></td>
</tr>
<tr>
<td>Generic Flow Control</td>
<td>1</td>
</tr>
<tr>
<td>Virtual Path Identifier</td>
<td>1</td>
</tr>
<tr>
<td>Virtual Path Identifier</td>
<td>1</td>
</tr>
<tr>
<td>Virtual Channel Identifier</td>
<td></td>
</tr>
<tr>
<td>Virtual Channel Identifier</td>
<td>1</td>
</tr>
<tr>
<td>Payload Type Identifier</td>
<td>1</td>
</tr>
<tr>
<td>CLP (Cell Loss Priority)</td>
<td>1</td>
</tr>
<tr>
<td>Header Error Check</td>
<td></td>
</tr>
<tr>
<td>Payload (Data)</td>
<td>48</td>
</tr>
</tbody>
</table>

Traffic Mechanism:

Traffic Shaping is a mechanism that alters the traffic characteristic of a stream of cells on a connection to achieve better network efficiency, which meeting the QoS objective or to ensure conformance at a subsequent interface. This way traffic shaping makes the traffic characteristic more predictable. Shaping increases the chance of a traffic conforming to the traffic contrast, which was agreed on connection setup. Traffic shaper is usually applied before the user traffic enters the network boundary. A shaper typically delays excess traffic using a buffer or queuing mechanism to hold packets and shape the flow when the data rate of the source is higher than expected. Traffic shaping smoothes traffic by storing traffic above the negotiated rate in a queue. When a packet arrives at the interface for transmission, the following happens:

If the queue is empty, the traffic shaper processes the arriving packet. If possible, the traffic shaper sends the packet; otherwise, the packet is placed in the queue. When there are packets in the queue, the traffic shaper removes the numbers of packets it can transmit from the queue every time interval.

Usage Parameter Control:

Traffic shaping is performed in conjunction with suitable Usage parameter control (UPC) function. UPC form a traffic descriptor used by the CAC for admission criteria and traffic enforcement. UPC parameters are negotiated at the call set up time when a source is required negotiate a set of
characteristics. UPC function then controls the incoming traffic of cells emitted by the user either by
discarding or delaying the non-conforming cells. Usage parameter monitoring includes the following
functions:

- Checking the validity as VPI/VCI values
- Monitoring the traffic entering the network from all active VP & VC connection to ensure
  that the agreed parameters are not violated.

Approximate Statistical Traffic Characterization:

In this paper we have developed a statistical characterization of a cell stream based on UPC
descriptors denoted by $C_S$, which can be obtained by statistical characterization. Suppose that the cell
stream is offered to a bank of constant rate queues with rates $\mu$, which lies in the range $\lambda_a < \mu < \lambda_p$,
where $\lambda_p$ and $\lambda_a$ are, respectively, the peak and mean rates of the offered cell stream. The traffic
characterization records statistics of the queuing behaviour of queues, each of which is offered the given
cell stream as input.

Let $W$ denote the steady-state waiting time, in queue, for an arbitrary cell arriving to the queue. We
approximate the complementary waiting time distribution with the exponential form

$$P(W > t) \approx a(\mu) e^{-b(\mu)t}; \quad t \geq 0$$

Where $a$ and $b$ are written as function of $\mu$, $t$ is time measured in seconds. For small-to-
moderate buffer sizes, Markovian models [4] have been found to give sufficiently accurate solutions for
a wide class of traffic types, including the self-similar traffic models. This approximation has been found
to be reasonably accurate (i.e., useful for resource allocation) for moderate to large values of $t$ when the
number of independent sources composing the arrival process is small. However, the approximation can
deteriorate as the number of independent sources increases. Above equation is an approximation for an
ATM cell stream modeled as a general Markovian source. Over the relatively short observation windows
of interest (on the order of seconds), our approximations are fairly robust for a large class of real traffic
sources.

The pair of values $(a(\mu), b(\mu))$ provides a statistical characterization of the effect of the cell
stream when offered to a queue with constant service rate $\mu$. A more complete characterization of the
cell stream records the values $(a(\mu), b(\mu))$ for all $\mu$ in the range $(\lambda_a, \lambda_p)$ as follows:

$$\hat{C}_S = [\lambda_p ; \lambda_a ; (a(\mu), b(\mu)) ; \lambda_a < \mu < \lambda_p ]$$

We choose values of $(a(\mu), b(\mu))$ such that waiting time holds approximately for values of $t$
in our range of interest

Based on the observations of the cell stream over a real time interval $T$ UPC parameters are
estimated. If $\tau$ is the $i^{th}$ ($i = 1,2,..M$) equal subinterval of $T$ and $n_i$ is the number of cells arriving in
the $i^{th}$ interval, and $A$ is the total number of cells arrived in the interval $T$. Then the,
Peak rate is estimated by $\lambda_p = \max \{ n_i / \tau \}$
And average rate is estimated by $\lambda_a = A/T$
Let n samples are taken from a queue over the time period of T. Following quantities are noted for jth sample:

\[ Q_j = \text{Number of customers in queue} \quad (j=1,2,...,n) \]
\[ S_j = \text{Number of customers in service} \]
\[ T_j = \text{Remaining time of the one customer in service} \]

These quantities are estimated by their sample means as given below

\[ \hat{a} = \frac{1}{M} \sum_{j=1}^{M} S_j, \]
\[ \hat{q} = \frac{1}{M} \sum_{j=1}^{M} Q_j, \]
\[ \hat{t}_r = \frac{1}{\hat{a}M} \sum_{j=1}^{M} T_j \]

Then, \( \hat{b} \) is computed as

\[ \hat{b} = \frac{\hat{a}\mu}{\mu \hat{t}_r \hat{a} + \hat{q}} \]
\[ = \frac{\hat{a}\mu}{\hat{a}/2 + \hat{q}} \]

where \( \hat{t}_r \) is approximated by \( 1/2\mu \).

The approximate statistical characterization is given by,

\[ \hat{C}_s = [\hat{\lambda}_p, \hat{\lambda}_q, \{\hat{a}(\mu), \hat{b}(\mu)\}] \]

The cell loss probability is the probability that an arbitrary cell when arrived is found to be non-conforming so it is discarded. Hence the cell loss probability is

\[ P_{\text{loss}} = P\left(W > \frac{(B)}{\mu}\right) = a(\mu) e^{-b(\mu) (B)/\mu} \]

And the cell delay is given as

\[ \bar{D} = a(\mu) / b(\mu) e^{-b(\mu) (B)/\mu} \]

**Conclusion:**

In this paper we have tried to develop a methodology for the selection and renegotiation of UPC to control the congestion at bottlenecks in the ATM networks and maximize the utilization of the resources.

**References:**


Authors:

