Analysis of Leaky Bucket Policing Mechanisms with Bursty Arrivals

D.S. Holtsinger *

Department of Electrical and Computer Engineering, and Center for Communications and Signal Processing North Carolina State University Raleigh, NC 27695-7914 (919) 851-6953

Abstract

The leaky bucket policing mechanism has been proposed for use as part of an overall preventive congestion control strategy in high-speed networks. In this paper, we analyze the leaky bucket assuming that the traffic source behaves as a two-state on/off arrival process with arbitrary distributions for the time spent in each state. We show that the assumption of geometrically distributed holding times leads to overly pessimistic results. Our analysis suggests that incorporating the maximum burst length and the minimum silence length into the traffic descriptor should improve the ability of the leaky bucket to restrict non-compliant traffic sources.

*Supported in part by BellSouth, GTE Corporation, and NSF and DARPA under cooperative agreement NCR-8919038 with the Corporation for National Research Initiative.
1 Introduction

The design of congestion control mechanisms for high-speed networks has remained a difficult task because of the large propagation delays in these networks. These delays may give rise to long periods between the onset and detection of congestion conditions by the appropriate network control elements [16].

Congestion conditions may be aggravated by the large bandwidth-delay product of the communication links between nodes, since these links may deliver a large number of cells to a congested node before the network control elements can throttle the offending source [2].

These problems may be avoided if connections are allocated their peak rate, but the resulting low bandwidth utilization may not be desirable since the network will support fewer connections. For these reasons, efforts have been focused on the development of preventive congestion control mechanisms for high-speed networks, rather than reactive controls [17].

The policing mechanism is an important component of a preventive congestion control strategy. The policing mechanism ensures that the traffic source does not submit excessive traffic into the network. A resource allocation algorithm operates in conjunction with the policing mechanism by allocating network resources to the connection [8]. Resources
Analysis of Leaky Bucket Policing Mechanisms with Bursty Arrivals, D.S. Holtsinger

such as buffers and bandwidth may be allocated once during the setup of a connection, or allocated dynamically during the call.

The traffic characteristics of the source form the basis of a traffic contract between the source and the network, which is enforced by the policing mechanism. The parameters of the traffic contract will typically include the mean rate, peak rate, and some notion of the "burstiness" of the traffic source.

As long as the source complies with the limits of the traffic contract, the policing mechanism should remain transparent to the source. If the source violates the limits of the traffic contract, then the policing mechanism should operate on the cell stream so as to prevent the source from inducing congestion conditions in the network.

In this paper, we analyze the leaky bucket policing mechanism [15] assuming that the source behaves as two-state on/off arrival process with arbitrary distributions for the amount of time spent in each state. During the active state, one cell arrives per slot, and during the inactive state, no cells arrive. We show that the assumption of geometrically distributed holding times for each state leads to overly pessimistic results. By incorporating the maximum burst length and the minimum silence period into the traffic descriptor, the ability of the leaky bucket to police non-compliant sources can be improved.

The outline of this paper is as follows. In section 2 we describe the leaky bucket policing mechanism and provide an approximate analysis of the cell loss probability of the leaky
bucket, assuming that the traffic source behaves as a two-state on/off arrival process with arbitrary distributions for the time spent in each state. In section 3, we present some numerical results, and finally in section 4, we present our conclusions.

2 The Leaky Bucket Policing Mechanism

2.1 Description of the Leaky Bucket

Many policing mechanisms have been proposed and analyzed in the literature (for example, see [3, 11, 12]), but the leaky bucket policing mechanism appears to have received the most attention [1, 4, 5, 6, 7, 10, 13, 14]. The leaky bucket policing mechanism is shown in figure 1. The leaky bucket is normally located at the user-network interface, where it polices the cell stream that is submitted into the network. Cells which arrive to the leaky bucket are required to consume a token from the token pool before proceeding into the network. If a cell arrives and there are no tokens in the token pool, then the cell is dropped, otherwise the cell departs immediately with a token.

Time is slotted, and a maximum of one cell may arrive per slot. Every $N$ slots, a token is added to the token pool, which holds a maximum of $K$ tokens. If the token pool is full upon a token arrival, then the token is dropped. A variation of the leaky bucket [13] provides a cell queue in addition to the token pool. The cell queue provides waiting room
Analysis of Leaky Bucket Policing Mechanisms with Bursty Arrivals, D.S. Holtsinger 4

for cells when there are no tokens available in the token pool. In this paper, we shall only deal with leaky buckets without a cell queue, which we will call “unbuffered” leaky buckets.

![Diagram of Leaky Bucket](image)

Cell Arrivals (Slotted) → Token Pool (K) → One Token Arrival Every N Slots

Figure 1: The Leaky Bucket

The token interarrival time $N$ and the token pool size $K$ allow for a variety of configurations. By using the analysis in this paper, we can determine the cell loss probability for this system, given the parameters $N$ and $K$. Thus, by fixing one of the parameters, the other parameter is determined in a straightforward manner, assuming that the cell loss probability requirement for a compliant source is specified.

### 2.2 Conditional TokenAcceptance

Before proceeding with the analysis, we first introduce a modification to the leaky bucket known as “conditional token acceptance”. This modification improves the ability of the
leaky bucket to police the burstiness of a traffic source and its ability to detect long-term overload. If a token arrives and finds the token pool empty, then the arriving token will be accepted into the pool only if there are no cell arrivals before the arrival of the next token. If any cell arrives during this period, then both the cell and the arriving token are dropped. Once the token pool becomes empty, it will remain empty as long as cells continue to arrive to the leaky bucket. Thus the acceptance of a token that arrives to an empty token pool is conditioned on the absence of cell arrivals.

An analysis of conditional token acceptance [9] assuming that the source behaves as a two-state markov modulated arrival process shows that it requires the leaky bucket to be configured with a slightly larger token pool for a given cell loss probability requirement. However, when a bursty non-compliant source is applied to the leaky bucket, the modification causes the cell loss probability to increase substantially over a leaky bucket without conditional token acceptance. In addition, this modification has the advantage of completely shutting off non-compliant sources which attempt to submit a continuous stream of cells into the network.

2.3 Analysis of the Leaky Bucket

The system we shall analyze is shown in figure 1. The traffic source is modeled as a two-state on/off arrival process, as shown in figure 2. The arrival process alternates
between the active and inactive states. When the process is in the active state, one cell is generated per slot. During the inactive state, no cells are generated. A burst of cells is generated after the arrival process moves from the inactive state to the active state. The times spent in the active and inactive states are assumed to be independent and can be arbitrarily distributed.

\[ w_i = P\{\text{Active Period lasts } i \text{ slots}\} \]

\[ s_i = P\{\text{Inactive Period lasts } i \text{ slots}\} \]

Figure 2: Two-state on/off Arrival Process

Our analysis of the leaky bucket is based upon a Markov chain embedded immediately before the beginning of a burst. The state of the system is represented by the amount of unfinished work in a token pool immediately before the beginning of a burst. The amount of unfinished work at the beginning of burst \( n \) is defined as as the number of
Analysis of Leaky Bucket Policing Mechanisms with Bursty Arrivals, D.S. Holtsinger 7

<table>
<thead>
<tr>
<th>State</th>
<th>0</th>
<th>1  ...  N</th>
<th>N+1  ...  2N</th>
<th>...</th>
<th>KN-N-1  ...  KN</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of Tokens</td>
<td>K</td>
<td>K - 1</td>
<td>K - 2</td>
<td>...</td>
<td>0</td>
</tr>
<tr>
<td>Token Arrival Time</td>
<td>N</td>
<td>1  ...  N</td>
<td>1  ...  N</td>
<td>...</td>
<td>1  ...  N</td>
</tr>
</tbody>
</table>

Table 1: Relationship between the states and the unfinished work slots remaining until the token pool is completely filled with tokens, assuming that no cells arrive. As shown in table 1, the state of the system can be interpreted as the number of tokens in the token pool along with the number of slots remaining until the next token arrives. The sequence of events in a slot is: token arrival (if any), cell arrival (if any), followed by a state transition.

Each cell which consumes a token causes the amount of unfinished work in the system to increase by \( N \), since it takes \( N \) slots to generate a token. Each token arrival causes the amount of unfinished work to decrease by \( N \). Since a token arrives every \( N \) slots, the token generation process causes the amount of unfinished work to decrease by one during each slot. Thus, during the burst period when cells pass through the leaky bucket, the amount of unfinished work increases by \( (N - 1) \) at each slot. During the silence period when no cells arrive, the amount of unfinished work decreases by one at each slot (see figure 3).

We assume that if a cell arrives to a full token pool (state 0), then the amount of unfinished work in the leaky bucket increases by \( N - 1 \) irrespective of the residual token
arrival time. Also, if a cell arrives to an empty token pool (states $KN - N - 1$ through $KN$), then the amount of unfinished work is assumed to become $KN$ irrespective of the residual token arrival time. These approximations help simplify the solution of the model in section 2.4. Through simulation we have found that these approximations introduce a negligible amount of error in many instances.

We define the following random variables:

\[
X_n = \text{Amount of unfinished work at the beginning of the } n\text{th burst period}
\]

\[
\dot{W}_n = \text{Amount of unfinished work arriving during the } n\text{th burst period}
\]

\[
W_n = \text{Length of the } n\text{th burst period in slots}
\]
$S_n = \text{Length of the } n\text{th silence period in slots}$

The system evolves according to the following equation:

$$X_{n+1} = \lfloor \min(X_n + \hat{W}_n, KN) - S_n \rfloor^+$$  \hspace{1cm} (1)

with $X_n$ taking on values from 0 to $KN$. Let $P_i(n)$ be the probability that $X_n = i$ at the beginning of the $n$th burst, and let $\bar{P}(n)$ be the associated state probability vector.

Letting $q_{l,i}$ represent the transition probability from state $l$ to $i$, and denoting $Q$ as the matrix of transition probabilities $[q_{l,i}]$, we can write $\bar{P}(n + 1) = \bar{P}(n)Q$. If we let

$$P_i = \lim_{n \to \infty} P_i(n),$$

then we can solve a linear system of equations

$$\bar{P} = Q \bar{P}$$  \hspace{1cm} (2)

by replacing one of the equations with the condition that $\sum_i P_i = 1$.

To derive the transition probabilities $q_{l,i}$, we note that the interval between embedded points consists of an active period followed by an inactive period. The time spent in each active period (and silence period) is independent and identically distributed, so the subscript $n$ can be dropped from the random variables $W_n, \hat{W}_n,$ and $S_n$. Now we define

$$\hat{w}_i = P(\hat{W} = i) = P(W(N - 1) = i)$$
Analysis of Leaky Bucket Policing Mechanisms with Bursty Arrivals, D.S. Holtsinger

\[ w_i = P(W = i) \]

\[ s_i = P(S = i) \]

(Recall that \( W \) is the random variable representing the length of the burst period in slots, and where \( S \) is the random variable representing the length of the silence period).

Now we can write

\[ q_{l,i} = w_{KN-l} s_{i} + \sum_{j=1}^{KN-l} \hat{w}_j s_{l+j-i} \quad l = 0, \ldots, KN \quad i = 1, \ldots, KN \quad (3) \]

\[ q_{l,0} = w_{KN-l} s_{KN} + \sum_{j=1}^{KN-l} \hat{w}_j s_{l+j} \quad l = 0, \ldots, KN \quad (4) \]

where

\[ \hat{w}_i = P(\hat{W} > i) \]

\[ = 1 - \sum_{j=1}^{i} \hat{w}_j \]

\[ \hat{s}_i = P(\hat{S} > i) \]

\[ = 1 - \sum_{j=1}^{i} s_j \]

(Note that the state \( KN \) cannot be reached from any other state). The above solution produces a state space of size \((KN + 1)\), which may be too large to solve efficiently for some configurations. Therefore we have developed an alternate solution method which relies on aggregating the states, and results in reducing the size of the state space to \( O(K) \). The subsequent analysis assumes that the state probabilities are solved using this alternate solution method.
2.4 Alternate Solution Method

During the active state, the system moves from state $i$ to state $(i + N - 1)$ during each slot. We lump states together such that the system will now move from the aggregate state $i$ to the aggregate state $(i + 1)$ during each slot. We write,

<table>
<thead>
<tr>
<th>Original States</th>
<th>Aggregate State</th>
</tr>
</thead>
<tbody>
<tr>
<td>$0, \ldots, N-2$</td>
<td>0</td>
</tr>
<tr>
<td>$N-1, \ldots, 2N-3$</td>
<td>1</td>
</tr>
<tr>
<td>$\ldots$</td>
<td>$\ldots$</td>
</tr>
<tr>
<td>$i(N-1), \ldots, (i+1)(N-1)-1$</td>
<td>$i$</td>
</tr>
<tr>
<td>$\ldots$</td>
<td>$\ldots$</td>
</tr>
<tr>
<td>$M(N-1), \ldots, KN$</td>
<td>$M$</td>
</tr>
</tbody>
</table>

where $M$ is the largest aggregate state, and it is defined as the largest integer $M$ such that $M(N-1) \leq KN$. Note that the aggregate state $M$ may contain less than $N-1$ original states.

Let $\hat{X}$ denote the random variable representing the state in the aggregated system, and let $\hat{P}_i$ denote the probability that $\hat{X} = i$ at the embedded point. We define the following random variables in the aggregated system:

$$\hat{W} = \text{Amount of aggregate unfinished work arriving during the burst period}$$
\[ \tilde{S} = \text{Amount of aggregate unfinished work that is finished during the silence period} \]

and the associated probability distributions are

\[ a_i = P(\tilde{W} = i) \]
\[ b_i = P(\tilde{S} = i). \]

During the burst period, the system moves from state \( i \) to state \( i + 1 \) at each slot, and so \( P(\tilde{W} = i) \) is simply the probability that the burst period lasts \( i \) slots, which we have defined previously as \( w_i \), hence \( a_i = w_i \).

We make the assumption that when the system is in aggregate state \( i \), the probability that it is actually in one of original states \( i(N-1) \) through \( (i+1)(N-1)-1 \) is \( 1/(N-1) \) (i.e. uniformly distributed among the original states). Using this approximation, we can write the transition probabilities corresponding to the silence period as:

\[ b_i = P(\tilde{S} = i) \]
\[ b_i \approx \sum_{j=0}^{N-2} \left[ \frac{j}{N-1} s_{(i-1)(N-1)+j} + \frac{N-1-j}{N-1} s_{i(N-1)+j} \right] \quad i = 0, 1, 2, \ldots \quad (5) \]

where we recall that \( s_i \) is the probability that the silence period lasts \( i \) slots.

The state transition probabilities \( \tilde{q}_{i,i} \) for the aggregated system take the same form as equations (3) and (4), but with \( KN \) replaced by \( M \), \( \tilde{w}_i \) replaced by \( a_i \), and \( s_i \) replaced
by \( b_i \).

\[
\tilde{q}_{l,i} = \tilde{a}_{M-l} - l b_{M-i} + \sum_{j=1}^{M-l} a_j b_{l+j-i} \quad l = 0, \ldots, M \quad i = 1, \ldots, M \tag{6}
\]

\[
\tilde{q}_{l,0} = \tilde{a}_{M-l} - l b_M + \sum_{j=1}^{M-l} a_j \tilde{b}_{l+j} \quad l = 0, \ldots, M \tag{7}
\]

where we define

\[
\tilde{a}_i = P(\tilde{W} > i) = 1 - \sum_{j=1}^{i} a_j
\]

\[
\tilde{b}_i = P(\tilde{S} > i) = 1 - \sum_{j=1}^{i} b_j
\]

While the probabilities \( a_i \) and \( b_i \) cannot be obtained explicitly, it is only necessary to compute a finite number of these probabilities.

### 2.5 Cell Loss Probability

The cell loss probability \( P_{\text{loss}} \) is defined as the fraction of cells which are dropped by the leaky bucket, and it is determined assuming that the state probabilities are computed using the alternate solution method. The proportion of cells which arrive during a burst period of length \( i \) is written as

\[
\frac{iP(\text{burst length } = i)}{\sum_i iP(\text{burst length } = i)}
\]
Analysis of Leaky Bucket Policing Mechanisms with Bursty Arrivals, D.S. Holtsinger

or

\[
\frac{ia_i}{E[W]} \quad (8)
\]

where \(E[W]\) is the expected length of a burst period in slots. The leaky bucket will drop cells during a burst period of length \(i\) if \((i + k) > M\), where \(k\) is the state of the leaky bucket at the beginning of a burst, and \(M\) is the size of the state space. During a burst of length \(i\) in which cells are dropped, \(i + k - M\) cells are rejected. The probability that a given cell in a burst of length \(i\) is dropped is given by

\[
\frac{i + k - M}{i} \quad (9)
\]

Let \(P_{\text{loss}}(k)\) represent the probability that a given cell is lost in a burst, given that the system state is \(k\) at the beginning of a burst period. This probability is written using equations (8) and (9) as

\[
P_{\text{loss}}(k) = \sum_{i=M-k+1}^{\infty} \frac{ia_i}{E[W]} \frac{i + k - M}{i}
= \sum_{i=M-k+1}^{\infty} \frac{(i + k - M)a_i}{E[W]}
\]

The cell loss probability can now be written as

\[
P_{\text{loss}} = \sum_{k=0}^{M} \tilde{P}_k P_{\text{loss}}(k)
= \frac{1}{E[W]} \sum_{k=0}^{M} \tilde{P}_k \sum_{i=M-k+1}^{\infty} (i + k - M)a_i
\]
which after some manipulation leads to

\[
P_{\text{loss}} = 1 - \frac{M - E[\tilde{X}] - \sum_{k=0}^{M} \tilde{P}_k \sum_{i=1}^{M-k} (M - k - i)a_i}{E[W]} \tag{10}
\]

where we denote \( E[\tilde{X}] = \sum_k k\tilde{P}_k \) as the expected value of the system state at the beginning of a burst, and \( E[W] \) is the expected length of a burst period. Equation (10) has a simple interpretation. The term \( M - E[\tilde{X}] \) is the expected number of cells that can be accepted by the leaky bucket at the beginning of a burst period, and the summation is the expected number of cells that can be accepted at the end of the burst period. Thus, the numerator is the expected number of cells in a burst that are accepted by the leaky bucket during a burst period, which divided by the denominator gives the fraction of cells that are accepted.

Equations (6), (7) and (10) illustrate that the cell loss probability does not depend on the form of the tail probabilities for the length of the burst and silence periods. (However, the distribution of the time between cell losses will depend on the tail probabilities). This suggests that the expected length of the burst period may be adequate for characterizing the effect of the tail probabilities. If applications generate correlated or non-stationary traffic, or if they are sensitive to the distribution of time between cell losses, then more detailed traffic characterizations may become necessary.
3 Results

The effect of imposing a maximum burst length and a minimum silence length on the arrival process is examined in this section. Given a fixed mean burst and silence period duration, we examine how the cell loss probability is affected by imposing these restrictions on the arrival process.

For purposes of comparison, we define a discrete-time alternating renewal arrival process with parameters $p$, $q$, $T_{\text{max}}$ and $T_{\text{min}}$, called the truncated geometric arrival process (TGAP). The arrival process alternates between two states, the burst and silence states. While the process is in the burst state, one cell is generated per slot, and while in the silence state, no cells are generated. The distribution of the time that is spent in the burst state is defined as

\[
P(W = i) = \begin{cases} 
(1 - p)p^{i-1} & i = 1, \ldots, T_{\text{max}} - 1 \\
p^{T_{\text{max}}-1} & i = T_{\text{max}} \\
0 & \text{otherwise}
\end{cases}
\]

with a mean burst period duration of

\[
E[W] = \frac{1 - p^{T_{\text{max}}}}{1 - p}
\]

The parameter $T_{\text{max}}$ represents the maximum number of consecutive cells that may arrive during a burst period. The silence period distribution for the arrival process is defined
Analysis of Leaky Bucket Policing Mechanisms with Bursty Arrivals, D.S. Holtsinger

as

\[ P(S = i) = \begin{cases} 
0 & i = 0, \ldots, T_{\text{min}} - 1 \\
(1 - q)q^{i-T_{\text{min}}} & i = T_{\text{min}}, \ldots, \infty 
\end{cases} \]

with a mean silence period duration of

\[ E[S] = \frac{q}{1 - q} + T_{\text{min}} \]

The parameter \( T_{\text{min}} \) represents the minimum amount of time that the arrival process must be spend in the silence period. If we let \( T_{\text{max}} \to \infty \) and set \( T_{\text{min}} = 1 \) in the truncated geometric arrival process, then we have the two-state markov modulated arrival process shown in figure 4, which has been used in previous analyses of the leaky bucket \([5, 6, 12]\).

Our goal is to vary the values of \( T_{\text{max}} \) and \( T_{\text{min}} \) in the truncated geometric arrival process while keeping the mean burst and silence period durations fixed, and examine the effect on the cell loss probability of the leaky bucket. Given the values of \( E[W], E[S], T_{\text{max}}, \) and \( T_{\text{min}} \), we can easily determine the values of \( p \) and \( q \) using the previous equations.

Figures 5 and 6 show the cell loss probability as a function of the token pool size \( K \) for token interarrival times of \( N = 2 \) and \( N = 8 \), respectively, assuming that the mean burst period length is \( E[W] = 10 \) and the mean silence period length is \( E[S] = 90 \).

We compare the cell loss probability that results when the source behaves as a markov modulated arrival process shown in figure 4 \( (T_{\text{max}}, T_{\text{min}}) = (\infty, 1) \), and as the truncated geometric arrival process (TGAP). For a given cell loss probability, the TGAP requires
a substantially smaller token pool size than the markov modulated arrival process. For a given token interarrival time, a smaller token pool size allows the leaky bucket to police non-compliant sources more effectively, since less traffic "burstiness" is able to pass through the leaky bucket [6, 12].

For example, if the cell loss probability requirement is less than $10^{-5}$ and the token interarrival time is 8, imposing a maximum burst limit of $T_{\text{max}} = 65$ cells reduces the token pool size from 370 to 260, a 42% reduction. For the markov modulated arrival process used in this example, the probability that the burst period is longer than 65 slots is approximately $10^{-3}$. If the traffic source generates very long bursts of cells relatively infrequently, then dynamic bandwidth allocation protocols may be more appropriate for controlling these types of sources than policing mechanisms.

There are two effects which cause the cell loss probability to be significantly higher for
Figure 5: Cell Loss Probability, Mean Burst Length=10, Mean Silence Length=90, N=2
Figure 6: Cell Loss Probability, Mean Burst Length=10, Mean Silence Length=90, N=8
Analysis of Leaky Bucket Policing Mechanisms with Bursty Arrivals, D.S. Holtsinger

the Markov modulated process than the TGAP for a given leaky bucket configuration. When the compliant source is modeled as a two-state Markov modulated arrival process, it is theoretically possible for a very long sequence of consecutive arrivals to occur while in state 1 with some probability $\epsilon$. As shown in figure 7, this sequence of consecutive arrivals may consume all of the tokens in the leaky bucket at time $t_1$, and as a consequence, cells which arrive after $t_1$ during the burst period will be subject to rejection. These cell arrival sequences may occur with a very small probability, but when they do occur, the cell loss can be significant. By imposing a maximum burst length $T_{\text{max}}$ on the compliant source, the effect of these long bursts on the cell loss probability can be lessened.

The second effect is illustrated in figure 8. If the silence period lasts one slot, then the effect is to concatenate two burst periods, since sufficient tokens cannot be added to the token pool during the silence period to “recover” before the next burst period begins. This event may occur with some small probability $\eta$, but the potential for cell loss can be significant. The imposition of a minimum silence period lessens the effect of these short silence periods on the cell loss probability.

4 Conclusions

Our results suggest that the maximum burst length and the minimum silence length should be incorporated into the traffic descriptor for the purposes of configuring the
Figure 7: Effect of long burst periods on cell loss

Figure 8: Effect of short silence periods on cell loss
leaky bucket policing mechanism. If a network user can specify these traffic limits, then the token pool size required to achieve a given cell loss probability will be lower than if these characteristics are left unspecified. As a consequence of the smaller token pool size, the network does not have to over-allocate as much resources to the connection to safeguard against congestion conditions caused by a non-compliant source.

While not all network users will be able to specify these limits on the traffic source, those that are able to do so will provide the network with greater opportunities to increase the utilization of network resources. Sources which cannot be characterized by a maximum burst length and a minimum silence length may benefit more from dynamic bandwidth allocation based on the peak traffic rate rather than through policing and statistical multiplexing. We have shown that sources with no restrictions on the duration of the burst and silence periods can require substantially larger token pool sizes, and hence require greater over-allocation of network resources than sources with restrictions on the burst/silence period, if policing and statistical multiplexing are to be used.

Our hope is that simple traffic characterizations may prove adequate for configuring a policing mechanism when more detailed traffic source models are not available. If a bursty on/off traffic source is non-stationary or has correlated burst and silence periods, then more sophisticated policing strategies may become necessary for controlling these sources.
References


Analysis of Leaky Bucket Policing Mechanisms with Bursty Arrivals, D.S. Holtsinger 25


Analysis of Leaky Bucket Policing Mechanisms with Bursty Arrivals, D.S. Holtsinger

