"Experimental Evaluation of the Use of Large Deviation Asymptotics for the QoS Management in ATM Networks"

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Outline

- Introduction
- Large deviation asymptotic results
- Experimental evaluation
  - model
  - results
- Effective Connection Admission Control
- Conclusions

Introduction

- ATM networks support a variety of services
- *Traffic and Congestion Control* mechanism:
  - maximise resource usage
  - maintain Quality of Service (QoS)
- *Connection Admission Control* function:
  decides, in real time, if a request for a connection can be satisfied without having QoS degradation in the network
- We limit our attention to **Cell Loss Probability (CLP)**

Introduction (cont.)

Connection Admission Control can be based on:

- Deterministic procedures:
  - adopted to date by the ATM Forum
  - simple to implement
  - are based on a worst case analysis
  - the network is significantly under-utilised
- **Statistical procedures**:
  - take advantage of the benefits of statistical multiplexing
  - the network can derive higher revenues
  - require further study

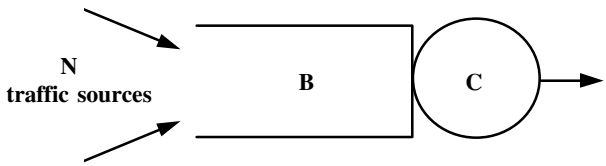
Introduction (cont.)

Statistical procedures are justified by:

- Queueing theory:
  - An analytical CLP form is derived for GI/D/1/K, MMPP(2)/D/1/K, MMPP(J)/E_L/1/K models
  - the above arrival processes are inadequate to characterise the superposition of real traffic sources
- **Large deviation theory**:
  - capture essential aspects of multiplexing different types of traffic
  - fairly accurate calculation of CLPs for many complex traffic models
  - become **asymptotically** exact for **large systems**

Large Buffer asymptotic result

- output link model:



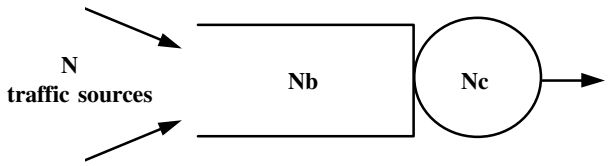
Φ(B) = Cell Loss Probability

- Gibbens and Hunt (1990), Kelly (1991), Whitt (1993), Elwalid and Mitra (1993), DeVeciana and Walrand (1994), Courcoubetis and Weber (1994)

  For large buffer: $\Phi(B) \cong e^{-B \cdot H(c)}$

Many Sources asymptotic result

- output link model:



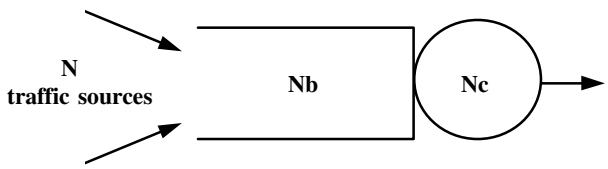
Φ(N) = Cell Loss Probability

- Weiss (1986), for ON/OFF Markov fluid models
  Courcoubetis and Weber (1994), for general stationary sources

  For many sources: $\Phi(N) \cong e^{-N \cdot I(b,c)}$

Small Buffer heuristic

- output link model:



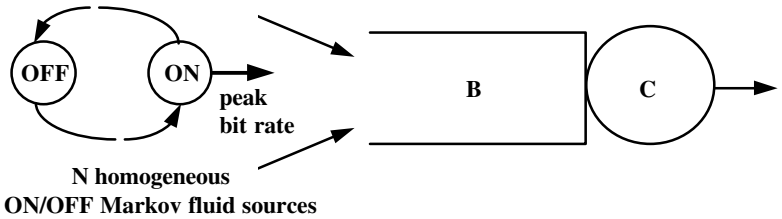
Φ(N) = Cell Loss Probability

- based on many sources asymptotic result.
  Hsu and Walrand (1994), for ON/OFF Markov fluid models

  For small buffer and any number of sources: $\Phi(N) \cong g_1 \cdot e^{-N \cdot \left(I(c) + g_2 \sqrt{b}\right)}$

Experimental Evaluation

- model of our experiments



ON/OFF Markov fluid model has been used to characterise:

- a voice source
- a videotelephone mini-source
- a data source (interconnecting LANs)

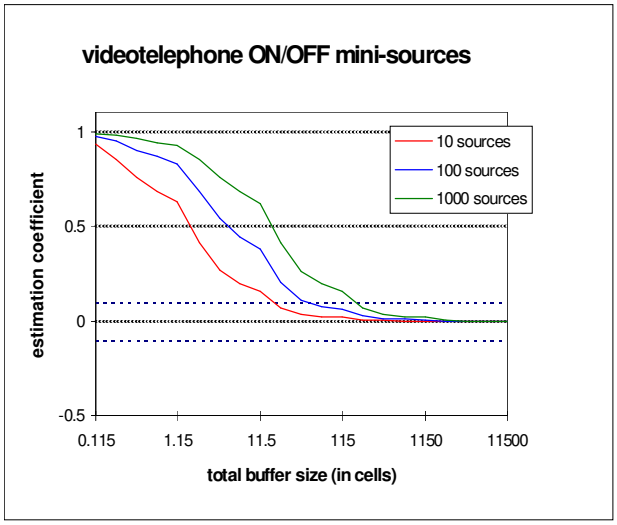
Experimental Evaluation (cont.)

- Φ_{exact} : exact CLP (is obtained using Anick, Mitra, Sondhi numerical method)
- Φ : computed CLP (is obtained using a asymptotic result)

- estimation coefficient $R = \dfrac{-\log(\Phi_{exact}) + \log(\Phi)}{-\log(\Phi_{exact})}$

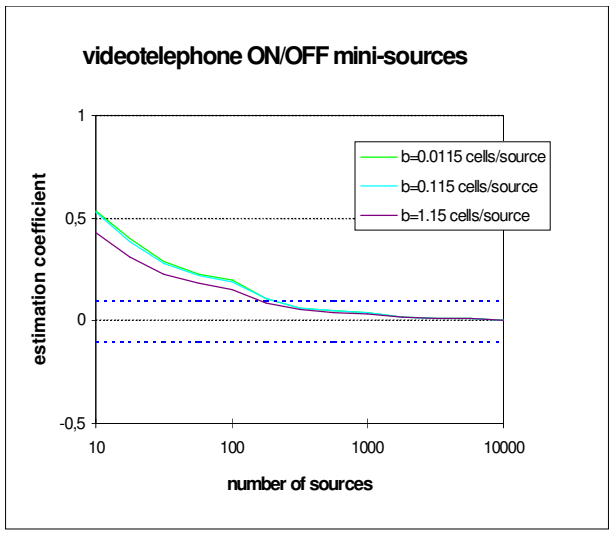
  - if $R=0$ then Φ is accurate
  - if $-0.1 < R < 0.1$ then Φ is in 20% confidence interval of Φ_{exact}
  - if $R > 0$ then Φ is over-estimating
  - if $R < 0$ then Φ is under-estimating

Large buffer asymptotic evaluation



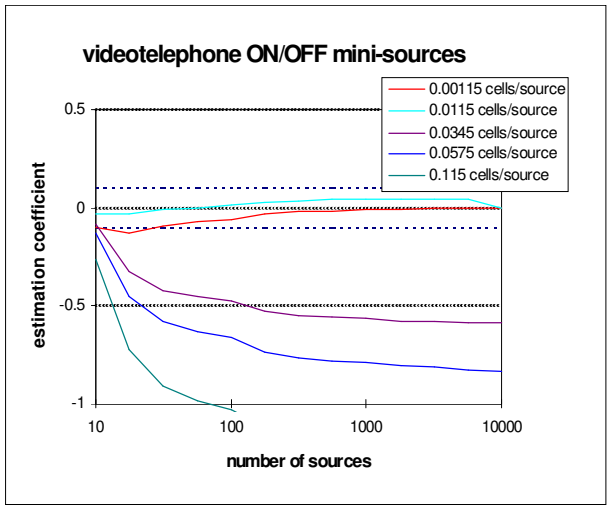
- $R > 0$, so CLP is over-estimated
- for small buffer sizes, CLP is overly over-estimated
- If more sources are multiplexed, then Φ converges more slowly to the exact values

Many sources asymptotic evaluation



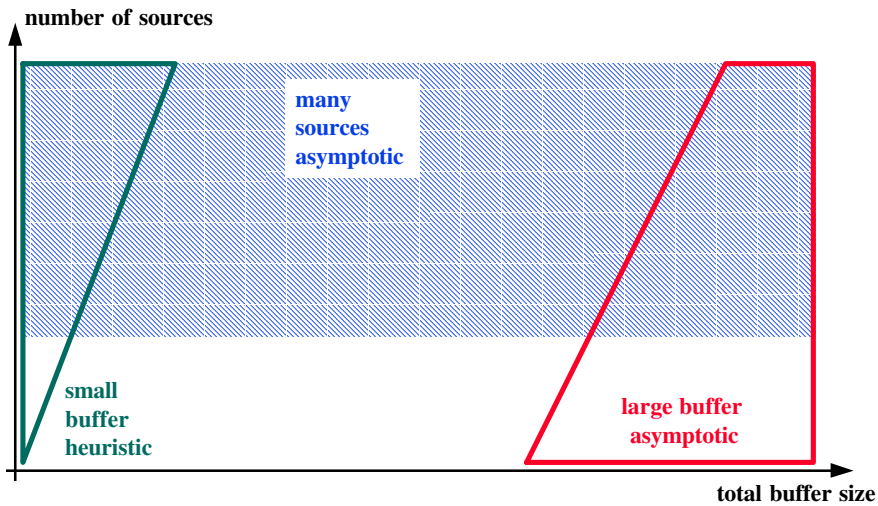
- $R > 0$, so CLP is over-estimated
- CLP is not overly over-estimated for few sources
- Φ converges with the same slope for different buffer sizes per source

Small buffer heuristic evaluation

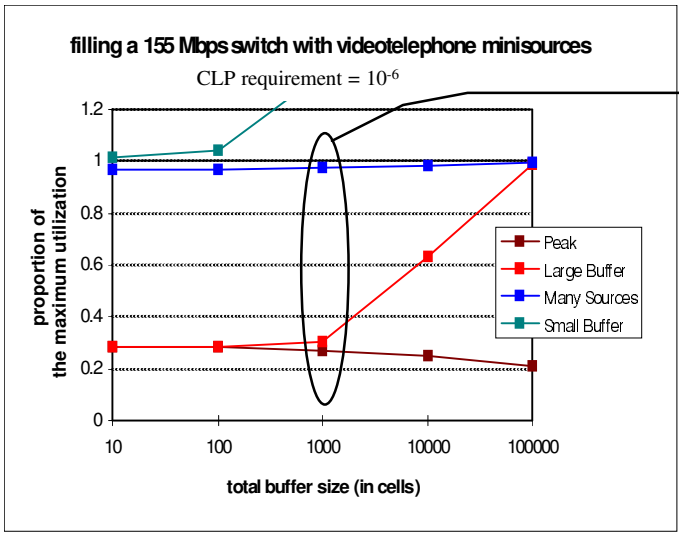


- Φ is accurate even for small number of sources
- for moderate buffer sizes per source, CLP is overly under-estimated
- If larger buffer is used, then Φ diverges more quickly from the exact values

Experimental Evaluation (cont.)



Effective Connection Admission Control



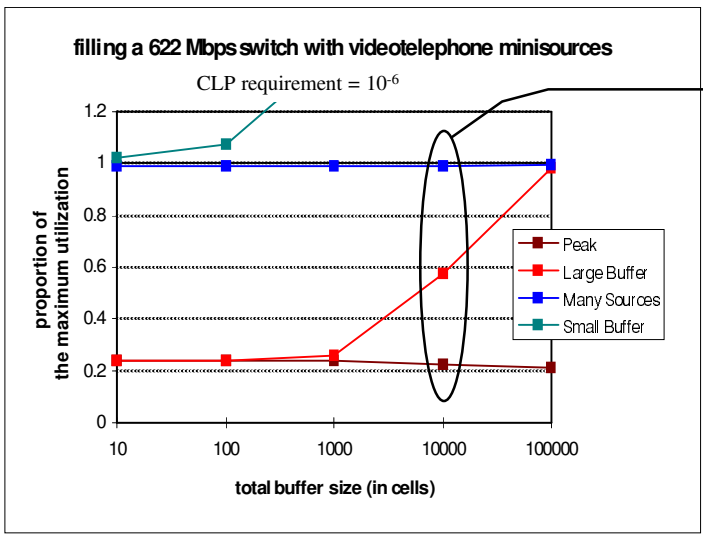
exact = **604**

many sources asymptotic = **588**

large buffer asymptotic = **182**

peak = **164**

Effective Connection Admission Control



exact = **2893**

many sources asymptotic = **2861**

large buffer asymptotic = **1668**

peak = **658**

Conclusions

- By adopting statistical procedures the network can derive higher revenues
- Large deviation asymptotic techniques can be used for effective Connection Admission Control
- Many sources asymptotic result is the most promising
  - we propose an **on-line estimation methodology** for the Cell Loss Probabilities in ATM links
  - we intend to implement that methodology in an ATM switch (ACTS project ASICCOM)