

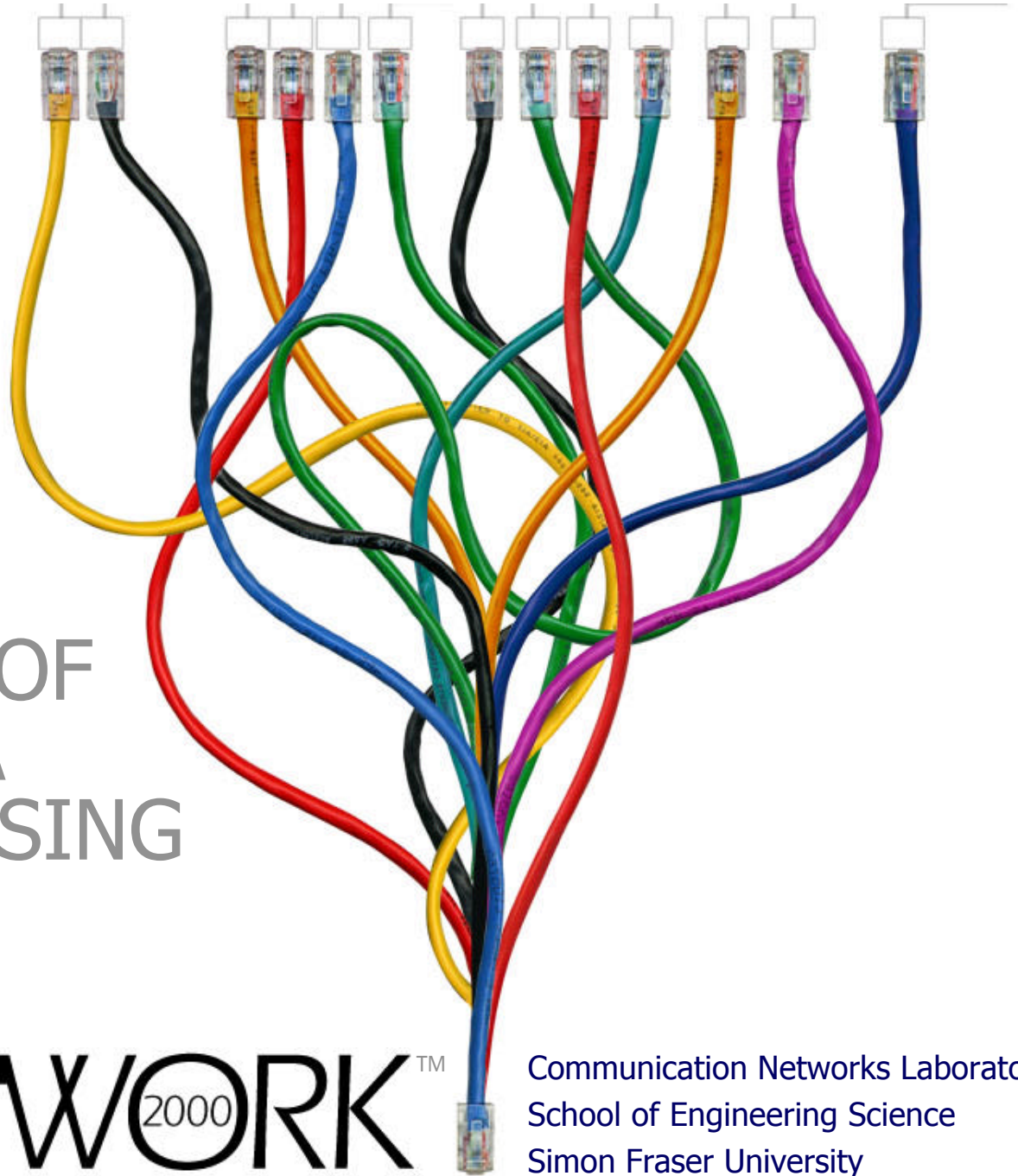
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SIMULATION OF PACKET DATA NETWORKS USING OPNET



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Road map

- Introduction
- Fiber Distributed Data Interface (FDDI)
 - hub configuration
 - client-server configuration
- Asynchronous Transfer Mode (ATM)
 - ATM service categories
- Leaky bucket policing algorithm
 - leaky bucket process model
 - leaky bucket in an ATM network model
- Concluding remarks

Introduction

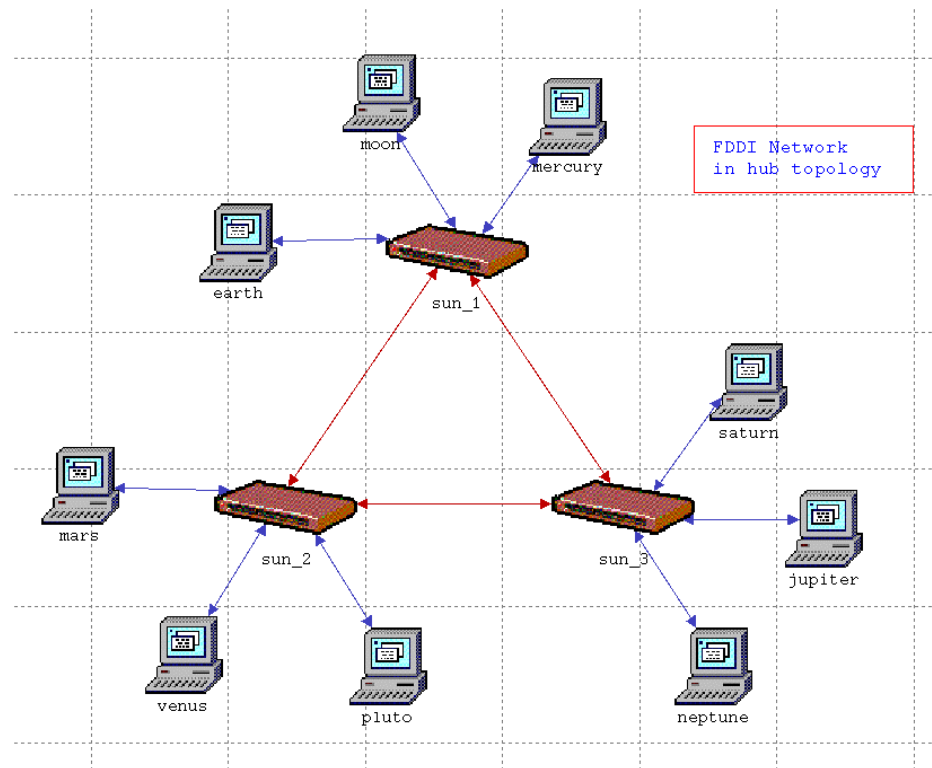
■ FDDI

- LAN technology that supports 100 Mbps rate.
- up to 500 communicating stations configured in a hub or ring topology.
- uses a timed-token access protocol.

■ ATM

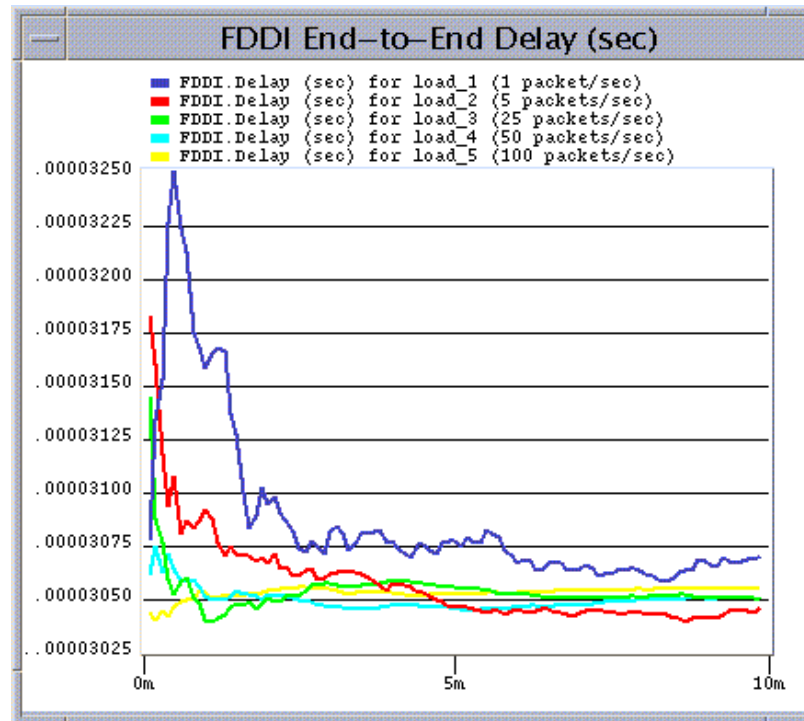
- emerging technology for backbone support in high-speed networks.
- five different service categories: CBR, ABR, RT_VBR, NRT_VBR, and UBR.
- different applications require different QoS and therefore different service categories.
- channels do not have fixed bandwidths → congestion in network → cell loss.
- leaky bucket and dual leaky bucket are policing mechanisms for CBR and VBR traffic, respectively.

FDDI hub configuration



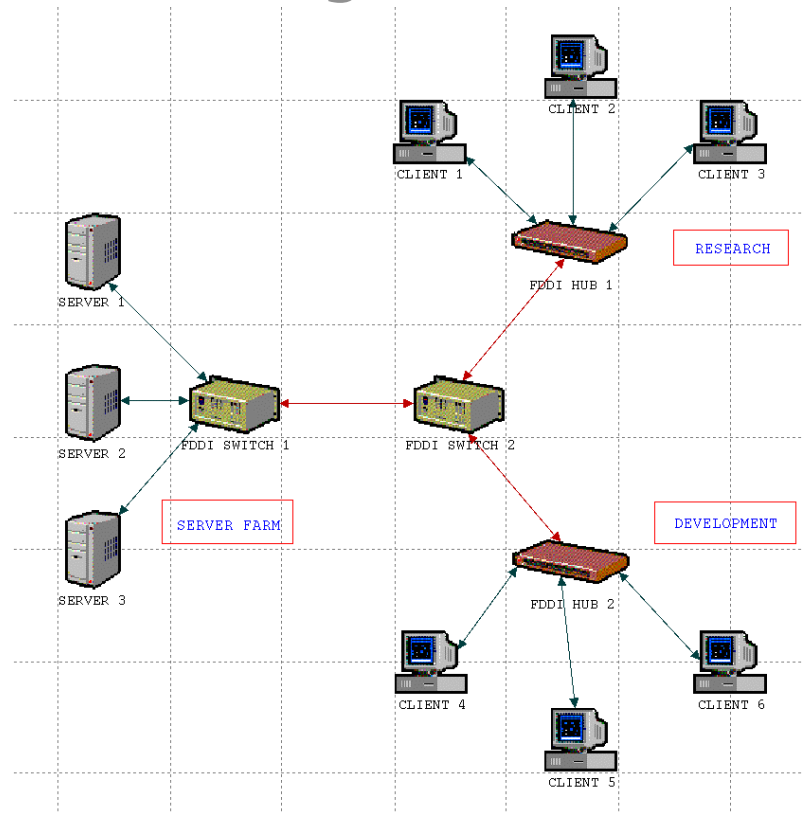
Network consists of 3 concentrators (connected with FDDI duplex links) and 9 stations (connected to the ring via concentrators).

FDDI hub configuration (cont.)



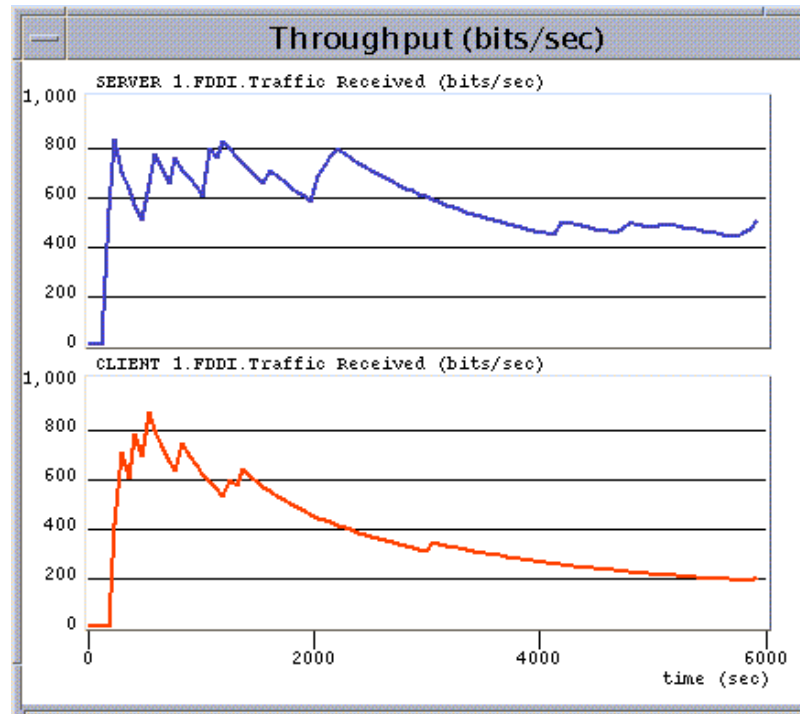
End-to-end delay (sec) plots, with load parameter varying from 1 to 100 packets per second. As the load increases, end-to-end delay in the network decreases.

FDDI client-server configuration



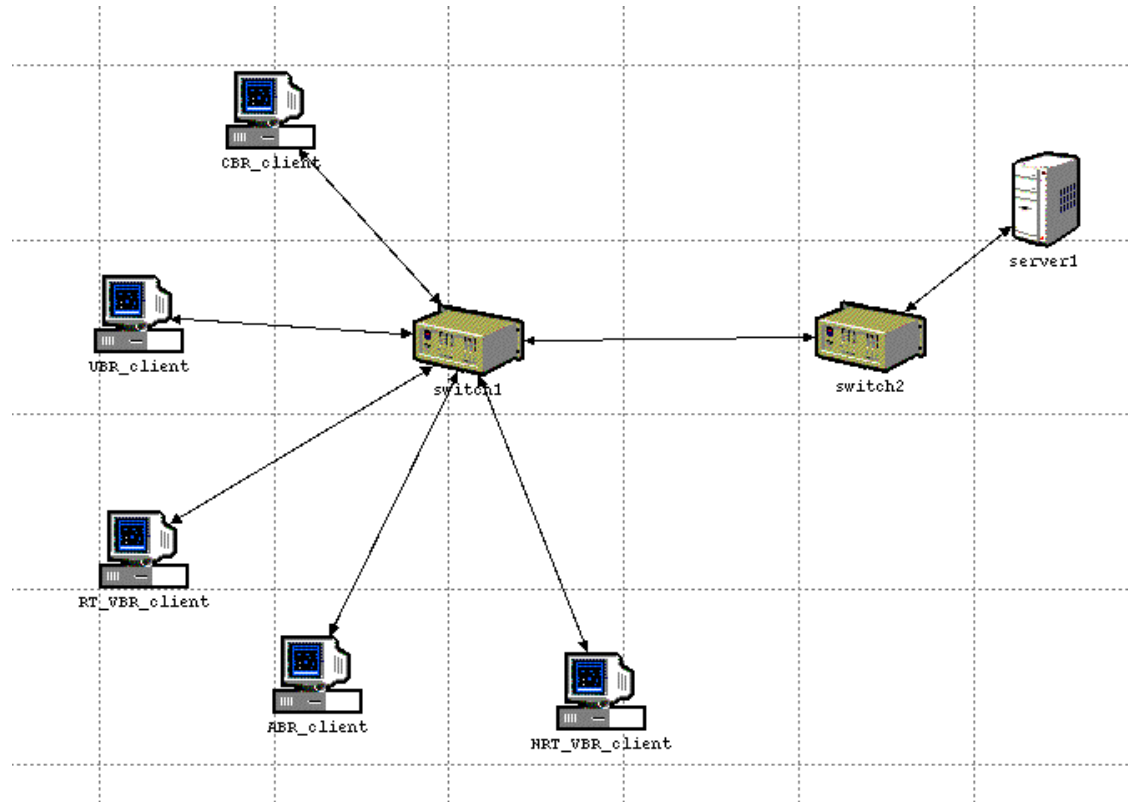
Clients are connected to the network via hubs. Hubs and servers at different locations are connected via two FDDI switches.

FDDI client-server configuration (cont.)



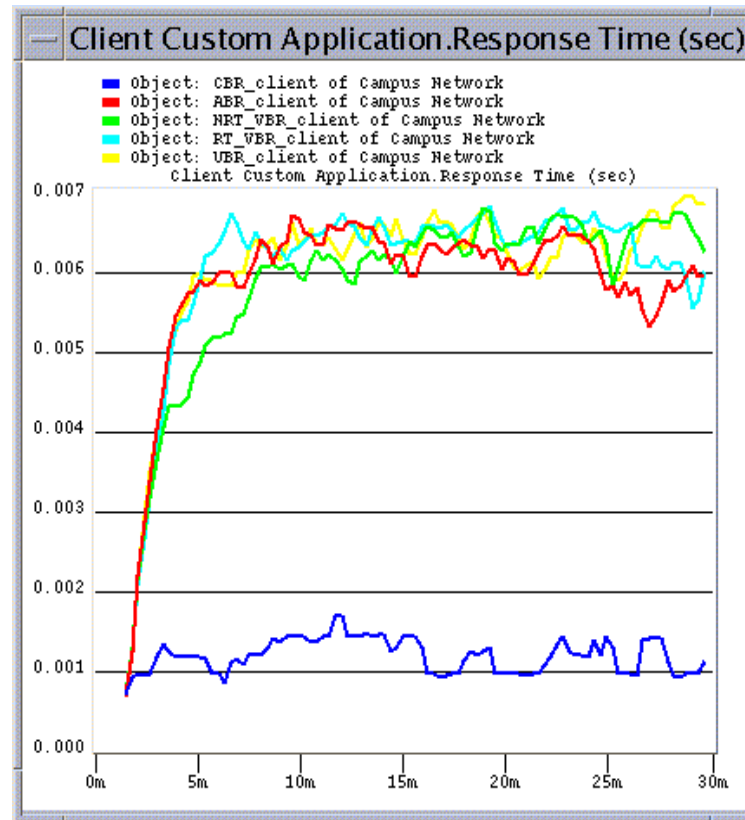
Throughput (bits/sec) plots of Server 1 (top) and Client 1 (bottom). Once stabilized, server's throughput is twice as large as the client's throughput, which is to be expected because the number of servers is smaller than the number of served clients.

ATM client-server network



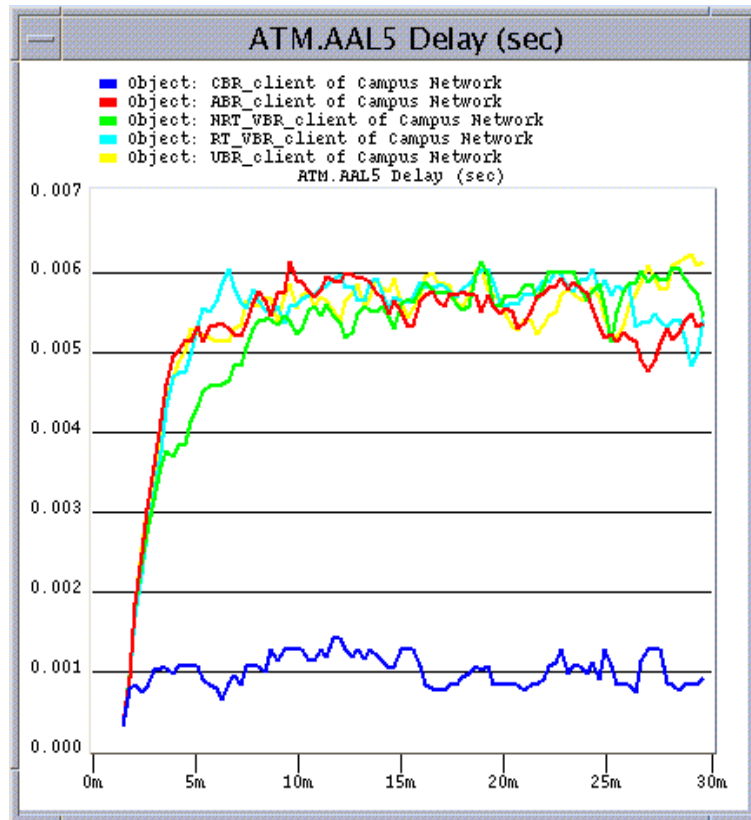
Network consists of two switches, an ATM server, and five clients requesting five distinct service categories. Traffic received by CBR client has a constant bit rate, while all other clients receive bursty traffic.

ATM client-server network (cont.)

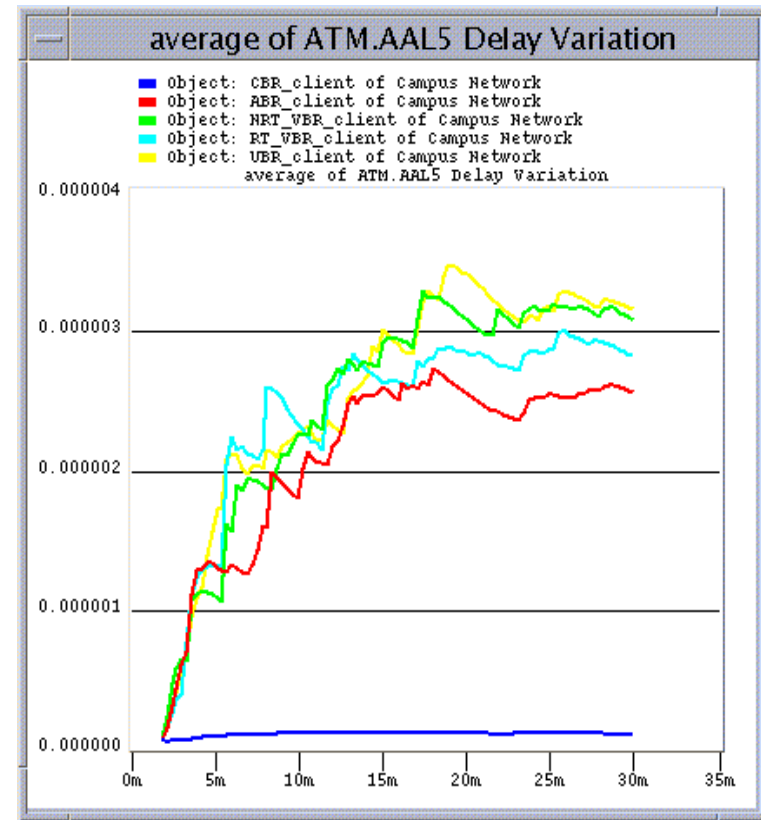


Response time (sec) for each client is the time it takes from sending a request to the server and receiving a response from it. The CBR client has the smallest response time and hence the best QoS.

ATM client-server network (cont.)

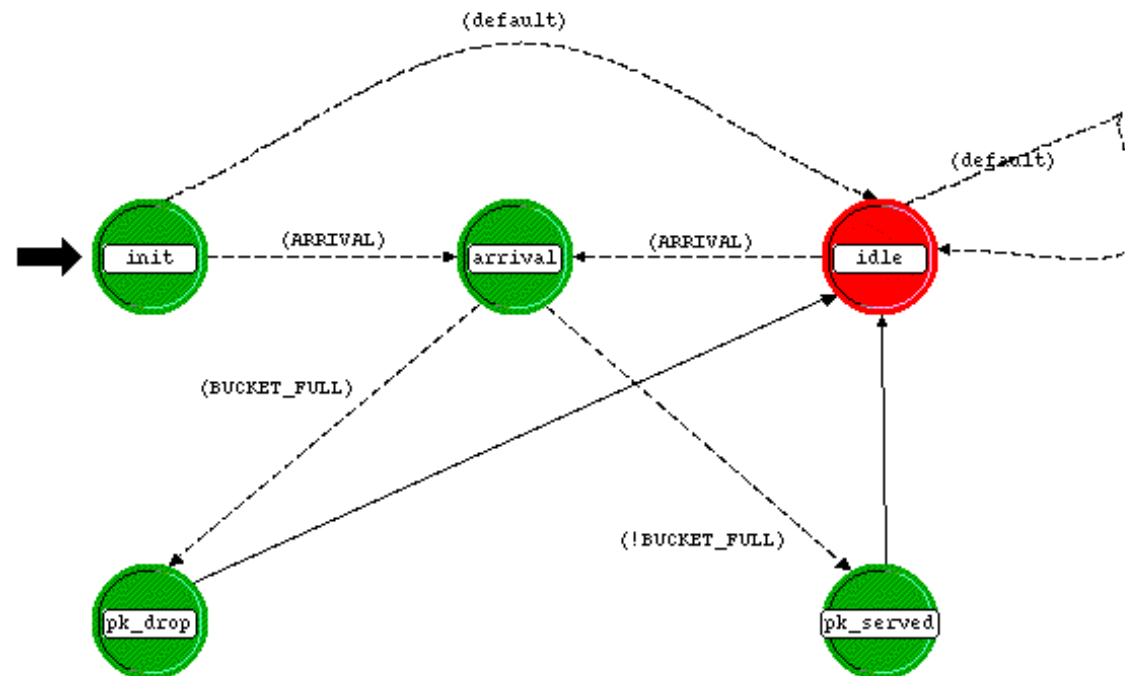


Propagation delay (sec) is the smallest for the CBR source, which has the best QoS.



Average delay jitter is almost zero for the CBR source, which has the best QoS.

Leaky bucket process model



State transition diagram for the leaky bucket process model.

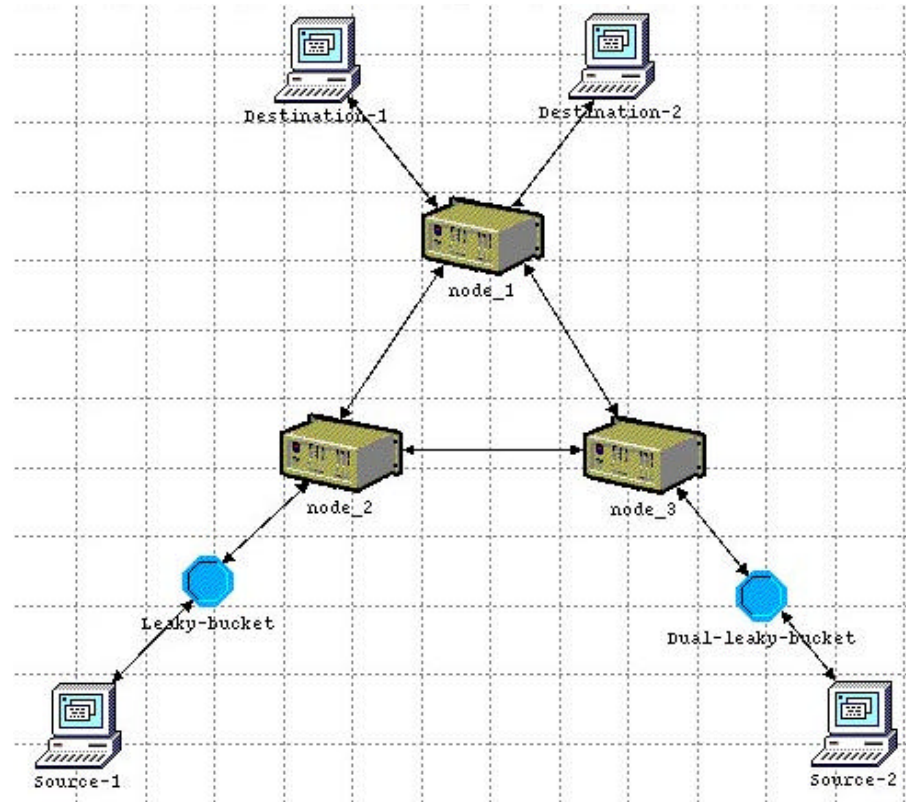
Leaky bucket mechanism

- Single leaky bucket:
 - used to police CBR sources.
 - the leaking rate is equal to the negotiated MCR (Mean Cell Rate) of the source.
 - the bucket size should be:
 - small enough to limit the size of the bursts allowed into the network.
 - large enough, so that cells from well behaving sources are not discarded.

Leaky bucket mechanism (cont.)

- Dual leaky bucket:
 - used to police VBR sources.
 - build from two concatenated single buckets.
 - the leaking rate of the first and the second bucket are set to the negotiated PCR (Peak Cell Rate) and MCR (Mean Cell Rate) of the source, respectively.
 - the first bucket's size is a function of PCR and delay jitter.
 - the second bucket's size is set to the maximum burst accepted by the network.

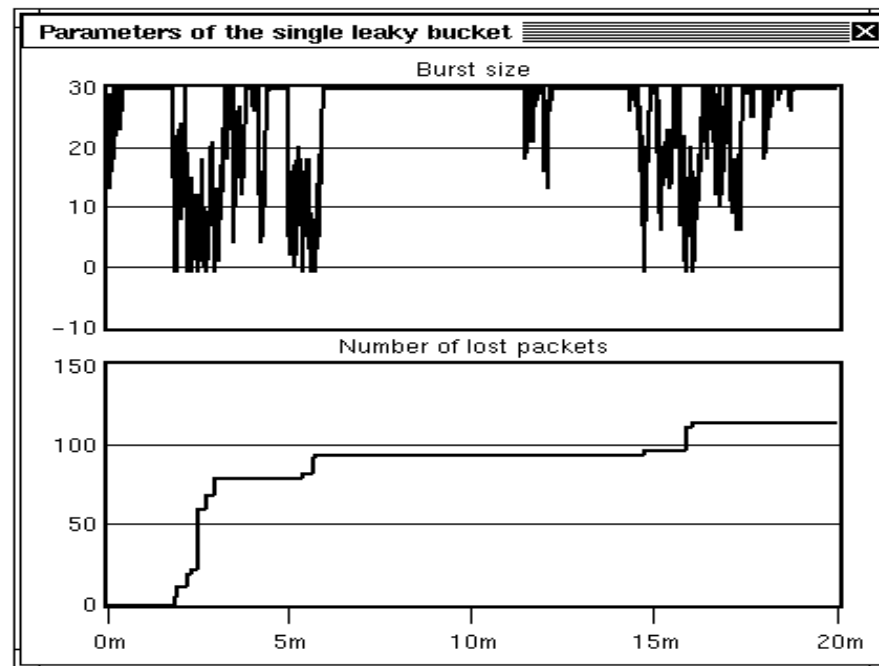
ATM network model



The model consists of CBR (Source-1) and VBR (Source-2) ATM sources, three ATM switches, and two destinations. Source-1 is policed by a single and Source-2 is policed by a dual leaky bucket.

Simulation results

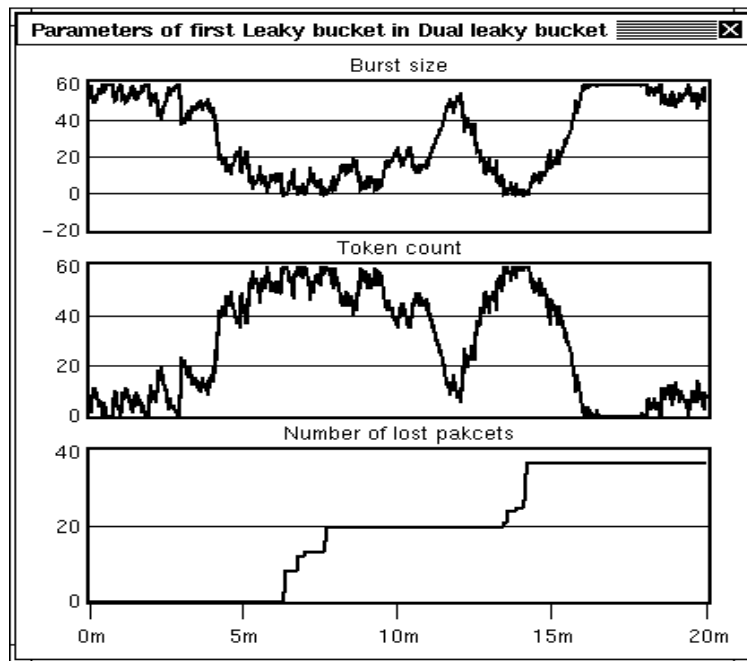
Single leaky bucket



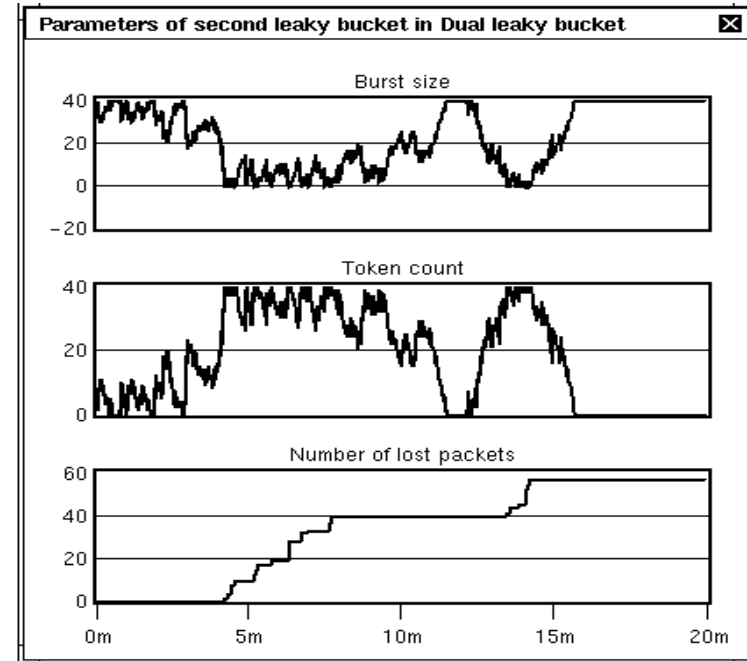
Top: Burst size (cells) allowed into the network. Bottom: Number of lost cells. Burst size is limited by the bucket size (30 cells). The number of lost cells is a function of the leaking rate and the bucket size.

Simulation results (cont.)

First leaky bucket



Second leaky bucket



Dual leaky bucket: Burst size (top), number of tokens in the bucket (middle), and number of lost cells (bottom). Burst size is limited by the bucket size.

Concluding remarks

- We simulated two commonly used packet data network technologies: FDDI and ATM.
- Two FDDI and two ATM network scenarios were implemented.
- We used simulations to compare the performance of various service categories in ATM networks.
- Our major contribution is a process model for the leaky bucket policing mechanism in ATM networks.
- The model named "leaky bucket" is available from the OPNET Contributed Model Depot.
- We employed this leaky bucket model to analyze its performance in a source-destination network scenario.

References

- [1] ANSI X3.139-1987, Fiber Distributed Data Interface (FDDI) - Token Ring Media Access Control (MAC): <http://www.ansi.org>.
- [2] I. Katzela, Modeling and Simulating Communication Networks: A Hands-On Approach Using OPNET, Upper Saddle River, NJ: Prentice Hall, 1999, pp. 91-102.
- [3] ATM Forum, Traffic Management Specification: Version 4.0: <ftp://ftp.atmforum.com/pub/approved-specs/af-tm-0056.000.pdf>.
- [4] E. P. Rathgeb and T. H. Theimer, "The policing function in ATM networks," Proceeding of the International Switching Symposium, Stockholm, Sweden, June 1990, vol. 5, pp. 127-130.
- [5] G. Niestegge, "The leaky bucket policing method in asynchronous transfer mode networks," International Journal of Digital and Analog Communication Systems, vol. 3, pp. 187-197, 1990.
- [6] OPNET Contributed Model Depot: <http://www.opnet.com/services/depot/home.html>.