Quality of Service and Performance Issues for an IP over ATM Service

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Outline

Introduction

Design Issues

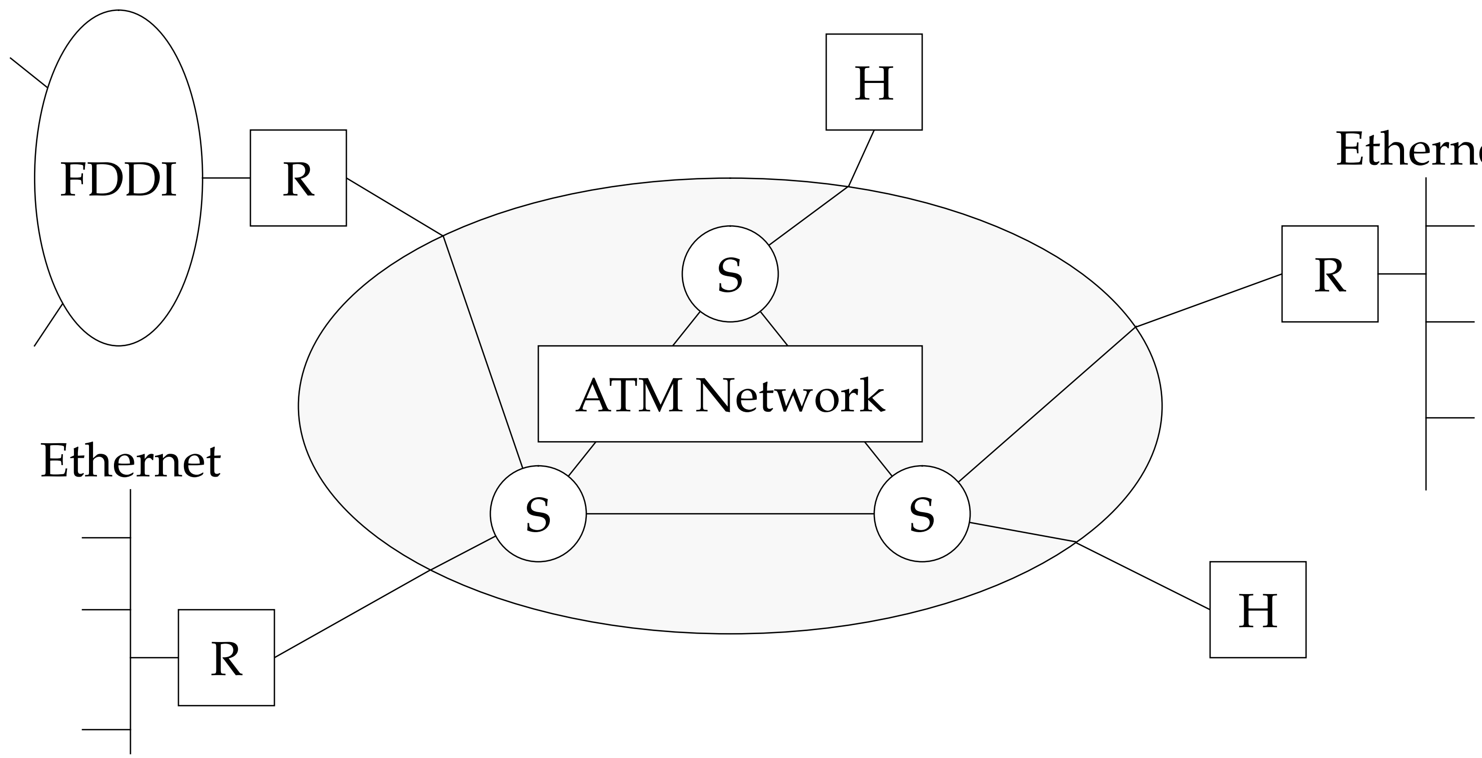
Performance Evaluation

INSANE

Status

Summary

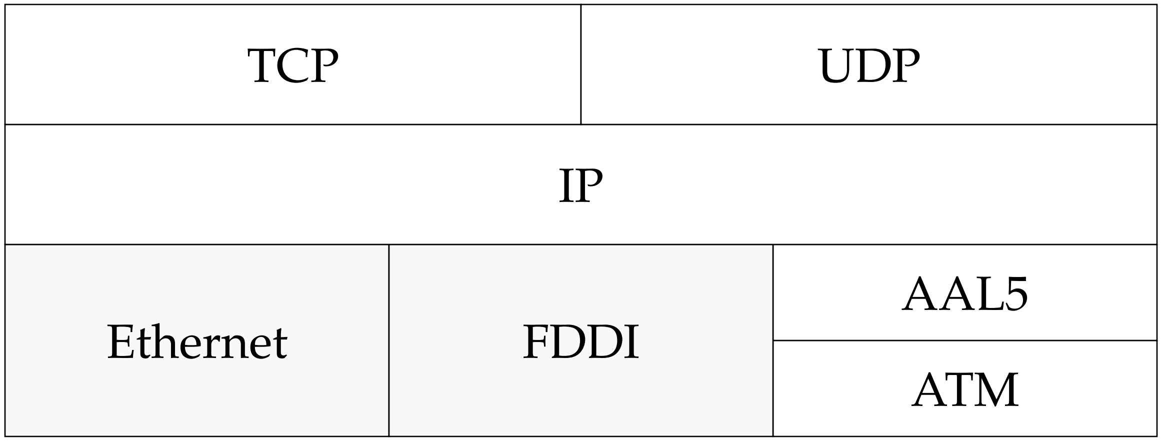
Environment: A Heterogeneous IP Internet



ATM network provides performance guarantees

Internetwork carries a mix of data and multimedia traffic

IP over ATM



IP layer uses ATM protocol stack as a datalink layer

How can we best use ATM to support IP?

Research Issues

Using ATM Virtual Circuits for IP

- How to map a stream of IP datagrams onto a virtual circuit?
- What QOS to assign to each virtual circuit?

Multiplexing

- How and when should multiple conversations share a virtual circuit?

Virtual Circuit Management

- When should virtual circuits be created and torn down?

Mapping IP Datagrams onto a Virtual Circuit

"IP Conversation"

- A stream of related IP datagrams between common endpoints with some definable set of QOS parameters
- Hosts and routers use protocol headers to determine conversations
- Packets of a conversations travel over a single ATM virtual circuit

For example:

- All packets for a given `telnet` connection
- All NFS packets between a client and its server
- All ICMP messages between a host pair

Determination of Requirements

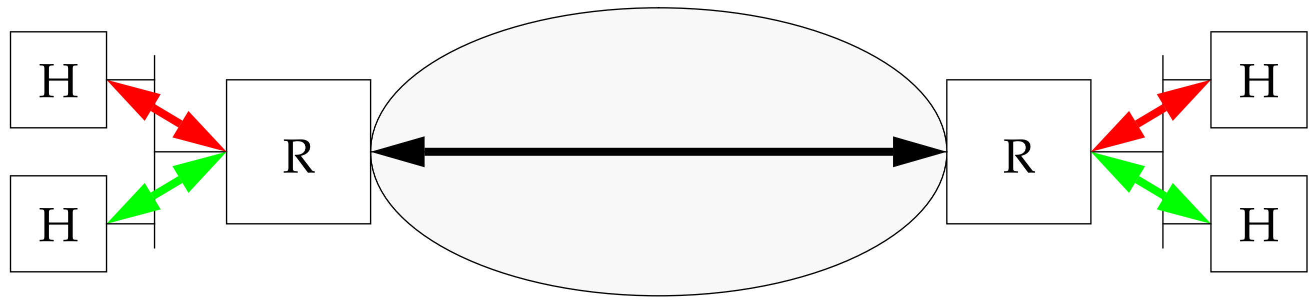
- Pre-defined per application
  - For well-known applications (e.g. `telnet`)
- Monitoring traffic
  - Adapt to bandwidth requirements (e.g. variable-bitrate video)
- Explicit signalling
  - In-band (e.g. IP options)
  - Out-of-band with a signalling protocol (e.g. RCAP, RSVP)

Multiplexing with QOS Considerations

Tradeoff

- Protection of individual IP conversations
- Increased utilization of reserved resources due to statistical multiplexing

Virtual Circuit Per Router Pair



All traffic between a pair of routers routed over same virtual circuit

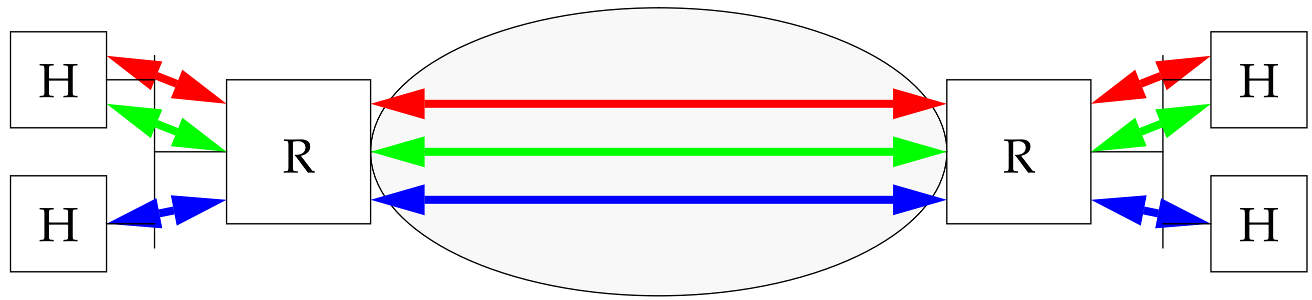
Statistical multiplexing of conversations over virtual circuit

No protection among conversations sharing a router pair

Uses:

- Low-bitrate or bursty traffic (ICMP)
- Background best-effort traffic (electronic mail)

Virtual Circuit Per Conversation



Each IP conversation seen by a router uses a separate virtual circuit

IP conversations protected from each other over ATM subnet

No statistical multiplexing gain within virtual circuit

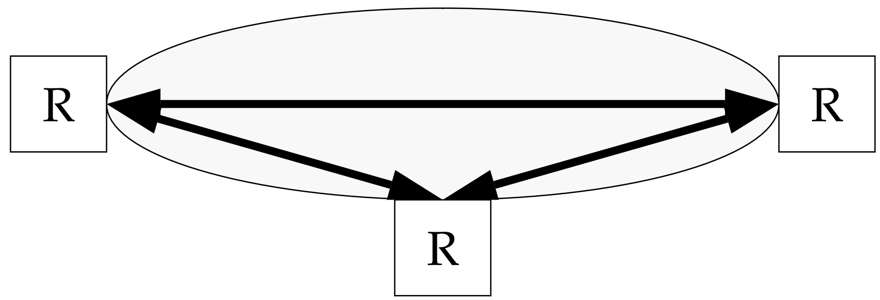
Uses:

- Real-time video
- Interactive file transfer

Virtual Circuit Management with QOS Considerations

- Paradigm shift: ATM connections vs. IP datagrams
  - When to set up and tear down connections for datagrams?
- Tradeoff
  - Long-lived virtual circuits: Tie up resources
  - Short-lived virtual circuits: Connection setup latency and processing

Permanent Virtual Circuits



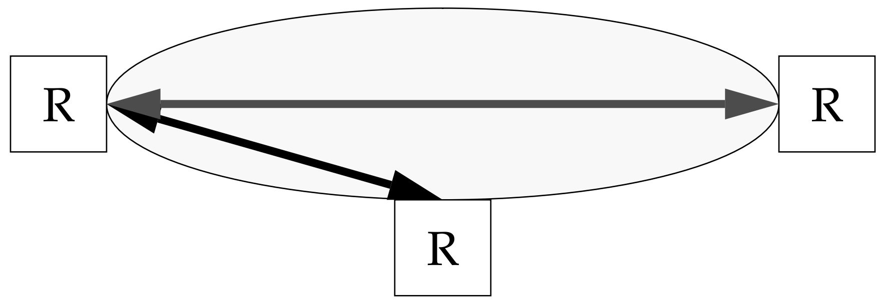
No connection setup latency

Resources always reserved

Not flexible enough to handle changes in load

Scalability a problem: $O\left(n^2\right)$ connections and resources

Switched Virtual Circuits



Establish virtual circuits on demand

Tear down connections when not used

Connection setup latency incurred

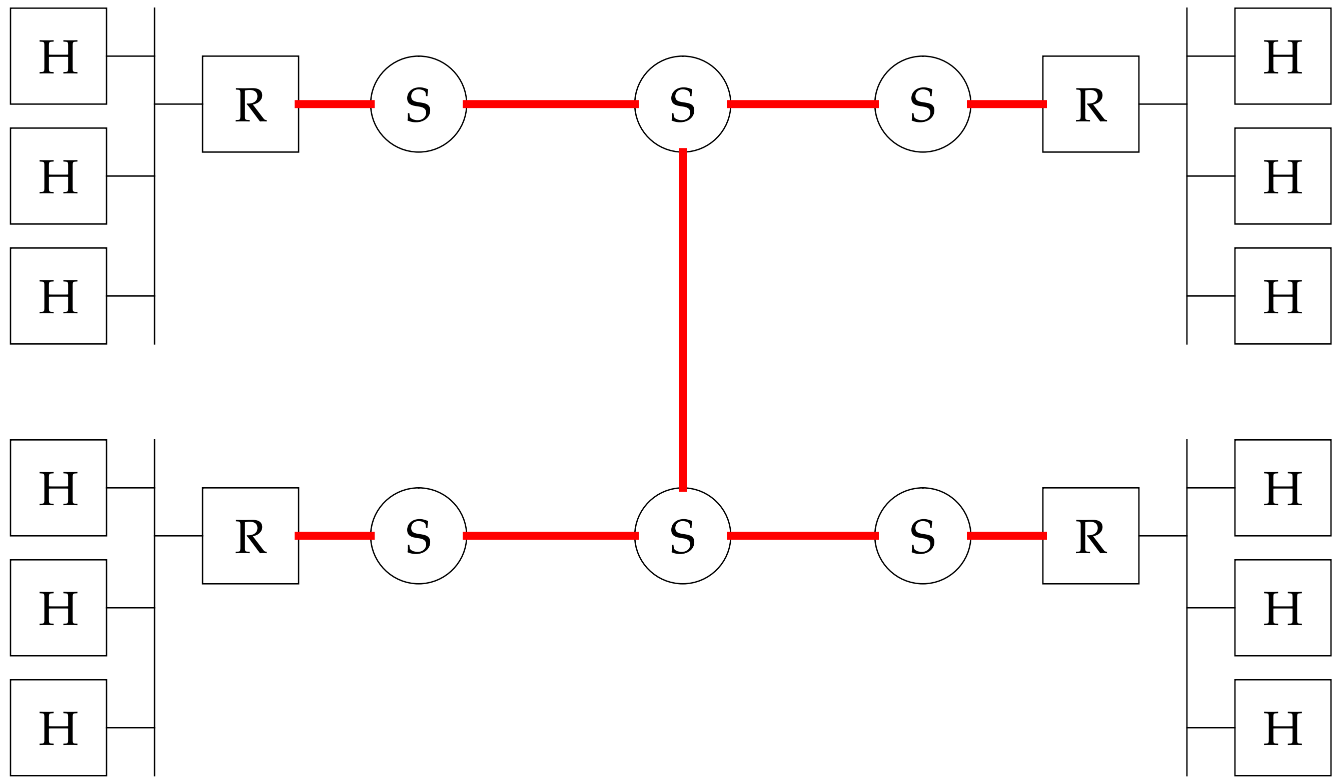
- For first packet of conversation
- For other packets if SVC closed too early

Enhancement: connection caching for other IP conversations

Evaluation Methodology

- Compare performance of different IP-over-ATM policies
  - Event-driven simulation
  - Workload derived from “real” traffic
  - Measure performance of these applications
- Alternatives
  - Analysis
  - Implementation

Simulation Environment

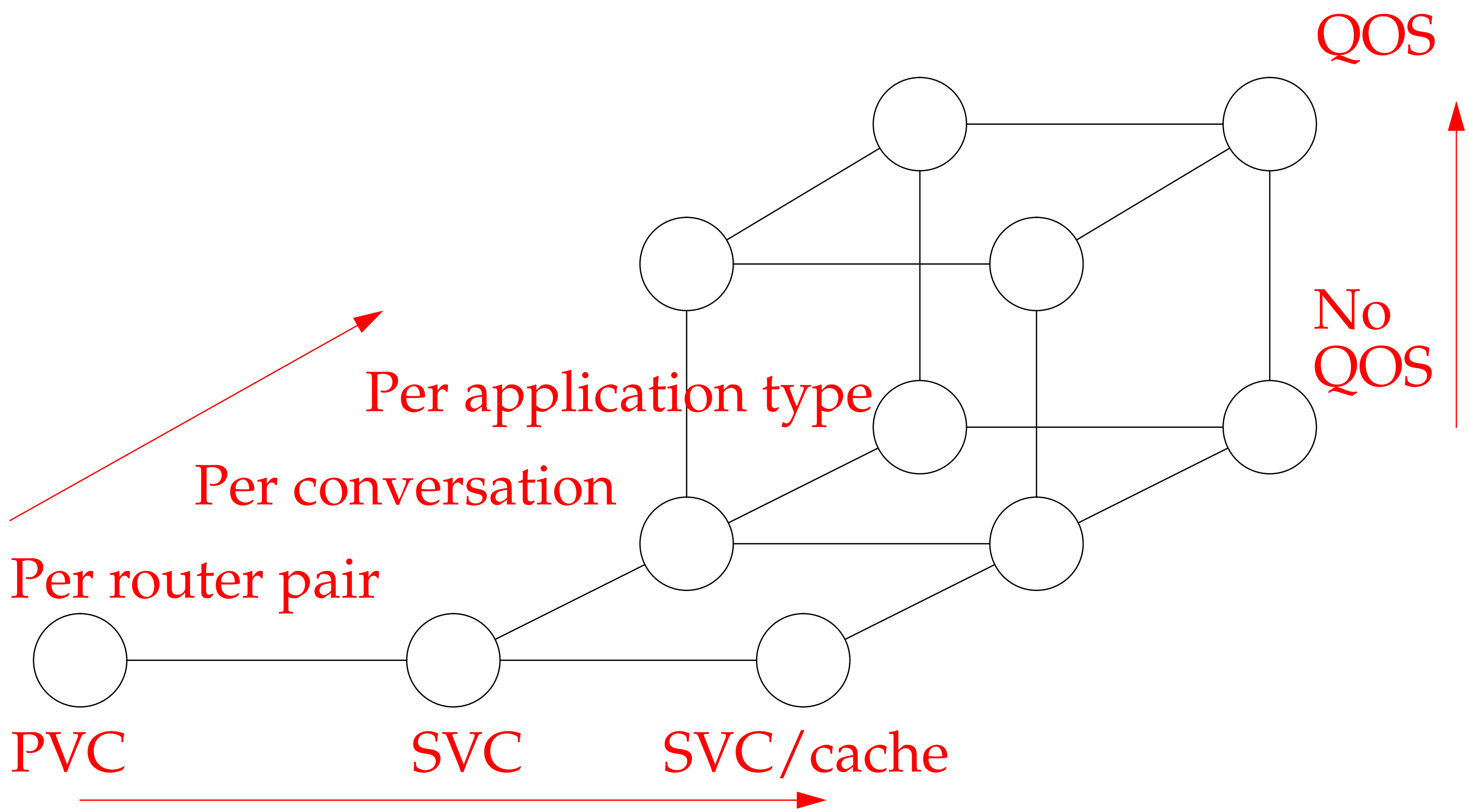


ATM WAN (backbone) connecting LANs (like XUNET)

IP-over-ATM "Policy Space"

- QOS Mapping
  - All best-effort
  - Map applications onto QOS parameters (fix one mapping)
- Multiplexing
  - Virtual circuit per router pair
  - Virtual circuit per conversation
  - Virtual circuit per application
- Virtual circuit management
  - PVC
  - SVC (fix timeouts)
  - SVC with caching (fix timeouts)

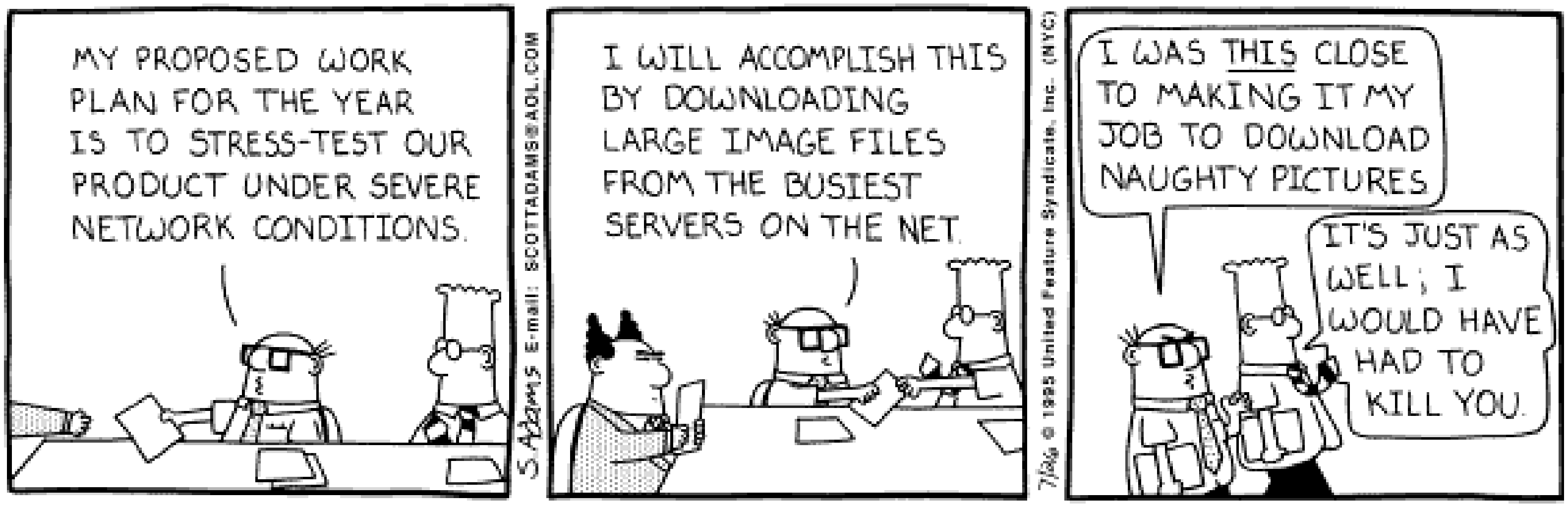
IP-over-ATM "Policy Space"



Workload

- Simulate traffic patterns of common W AN applications
  - `http` (Web) – Fast growing application on the Internet
  - `ftp` – Traditional data traffic
  - `telnet/rlogin` – Traditional interactive traffic
  - `nv/vic` – Digital video
- Use models derived from traffic traces (e.g. `tcplib`)

Aggregate Workload



What's "typical"?

- Internet traffic varies in time...
- ...and by site

Evaluation Criteria

`http`

- Response time
- Throughput

`ftp`

- Throughput
- Response time may be important too

`telnet/rlogin`

- Response time

`nv/vic`

- Throughput, jitter

An Internet Simulated ATM Networking Environment (INSANE)

- Event-driven simulator
- Object-oriented
- C++
  - Simulation “core” infrastructure
  - Atomic objects
- Tcl
  - Composite objects
  - Configuration file
  - Command line interface

Building an Output-Queued ATM Switch

Primitive objects (C++)

- `Sig` – Signalling entity (runs RCAP-like protocol)
- `GoBackN` – Reliable retransmission for control messages
- `SwitchModule` – VCID translation and switching
- `CellInputPort` – Input processing
- `CellQueueFifo` – Output queue

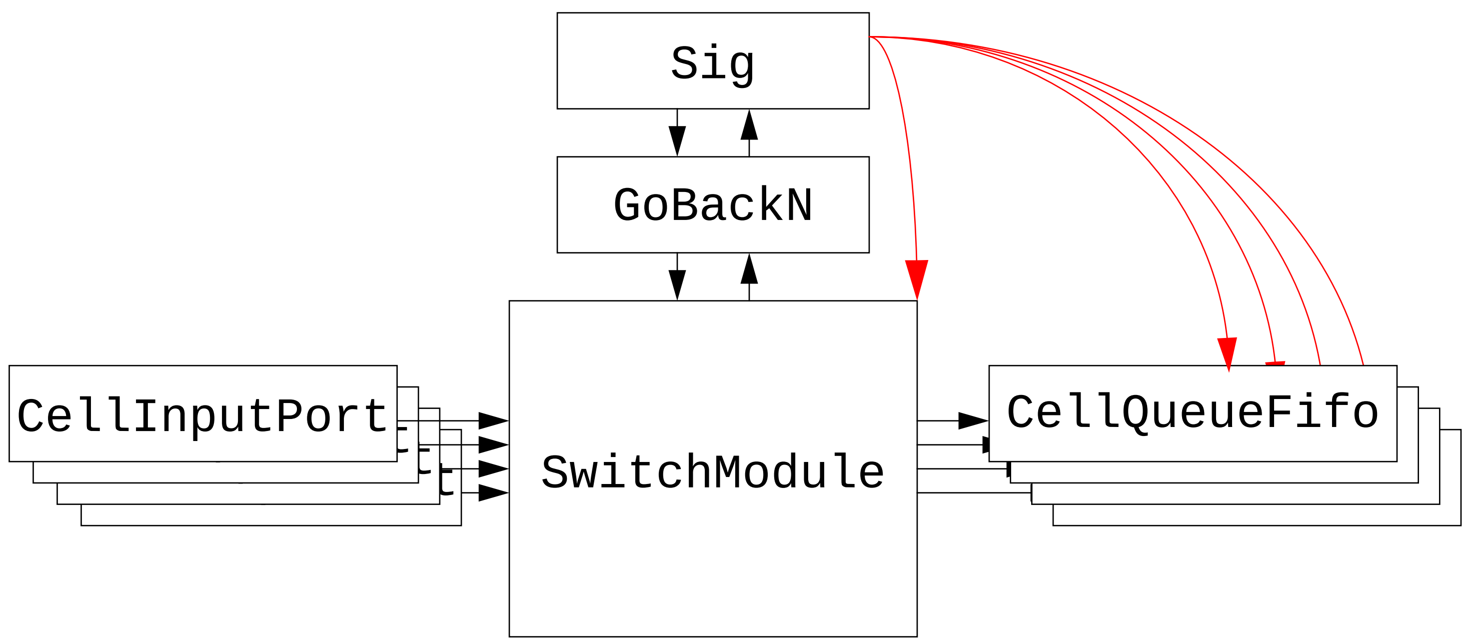
Tcl commands create instances of objects

```
SwitchModule sm 8 1024
```

Instances manipulable via new Tcl commands

```
sm output 0 port0
```

ATM Switch Composite Object



Composite objects created by invoking Tcl scripts

```
SwitchFifoN switch 8 1024 1000000
```

Interaction with Objects

Command line interface like debugger

Interact with objects and examine state

```
] router1.ip netstat -r
Destination      Mask             Gateway          Flags
128.32.150.0     255.255.255.0    128.32.150.254
128.32.131.0     255.255.255.0    128.32.131.254
127.0.0.1        255.0.0.0        127.0.0.1
] router1.ip netstat -i
Name             Address          Netmask          Ipkts Ierrs Opkts Oerrs
router1.lan1     128.32.150.254   255.255.255.0        0     0     1     0
router1.lan0     128.32.131.254   255.255.255.0        1     0     0     0
router1.lo0      127.0.0.1        255.0.0.0            0     0     0     0
```

Current Status

XUNET implementation

- IP multiplexing policies
- IP over SVCs

INSANE

- IP and ATM layers completed
- TCP and application simulators in progress

Summary

Idea: Use QOS guarantees for an IP-over-ATM service

- Use of virtual circuits with QOS parameters to carry IP data
- Multiplexing
- Virtual circuit use and management

Evaluation

- Event-driven simulation
- Comparison of performance of different policies

INSANE

- A new C++/Tcl network simulator