# Traffic Management over Satellite ATM Networks: Recent Issues

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**1**. Buffer size for satellite links

**2**. Guaranteed Frame Rate (GFR) design issues

3. GFR with FIFO

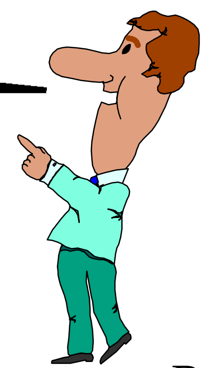
**4**. Point-to-Multipoint connections

**5**. Multipoint-to-point connections

# Our Goal

- Ensure that the new ATM Forum TM 4.0/5.0 specs are "Satellite-friendly"
- There are no parameters or requirement that will perform badly in a long-delay satellite environment
- Users can use paths going through satellite links without requiring special equipment
- Develop optimal solutions for satellite networks

This work is sponsored by NASA Lewis Research Center.



# Our Recent Past Projects

- Performance of Internet Protocols on ATM over Satellite: ABR vs UBR
- Optimization of performance of TCP/IP over satellite ATM networks
- Multipoint to point ABR
- Guaranteed Rate Service

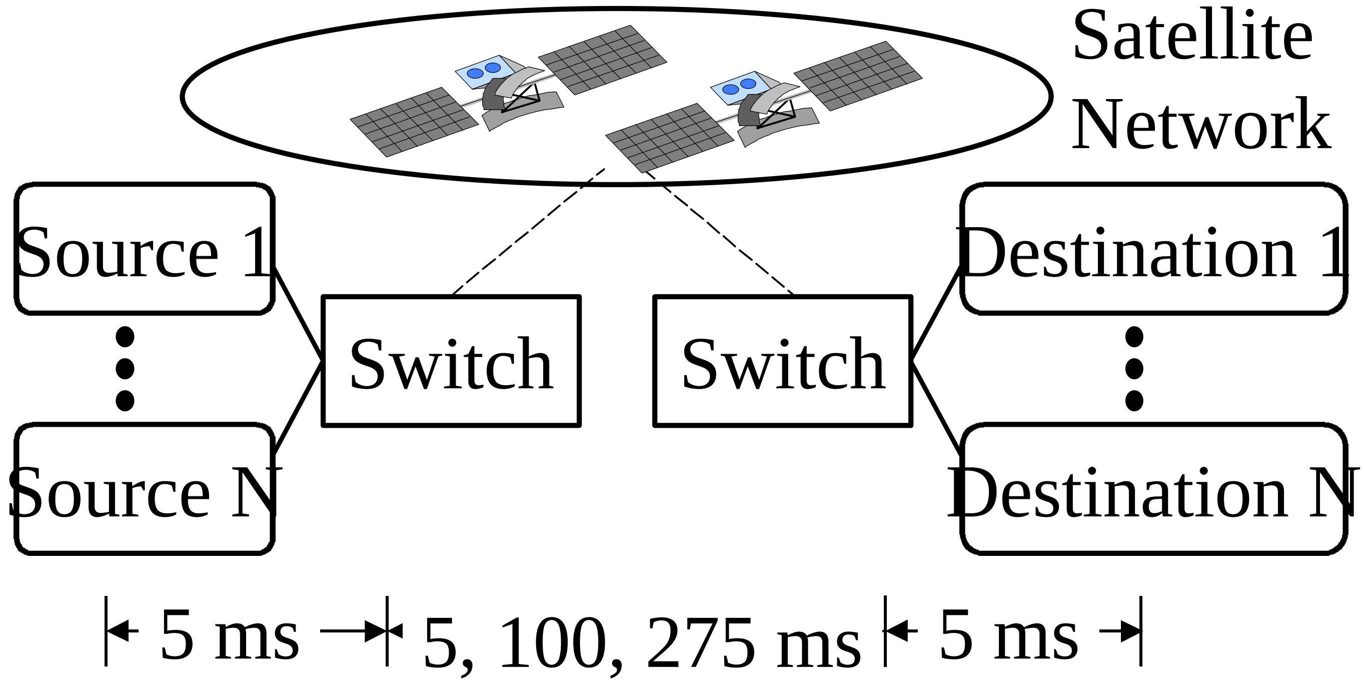
Ref: "ATM Traffic Management over Satellite Networks: Recent Issues," TIA, July 15, 1997, http://www.cis.ohio-state.edu/~jain/talks/nas9707.htm

# 1. UBR Buffer Study: Goals

- Assess buffer requirements for TCP over UBR for satellite latencies
- How does TCP throughput increase with increasing network buffers?
- How well can we do with less than 1 RTT buffers?

Ref: "UBR Buffer Requirements for TCP/IP over Satellite Networks," ATM Forum/97-0616, July 1997, http://www.cis.ohio-state.edu/~jain/atmf/a97-0616.htm

# Simulation Model

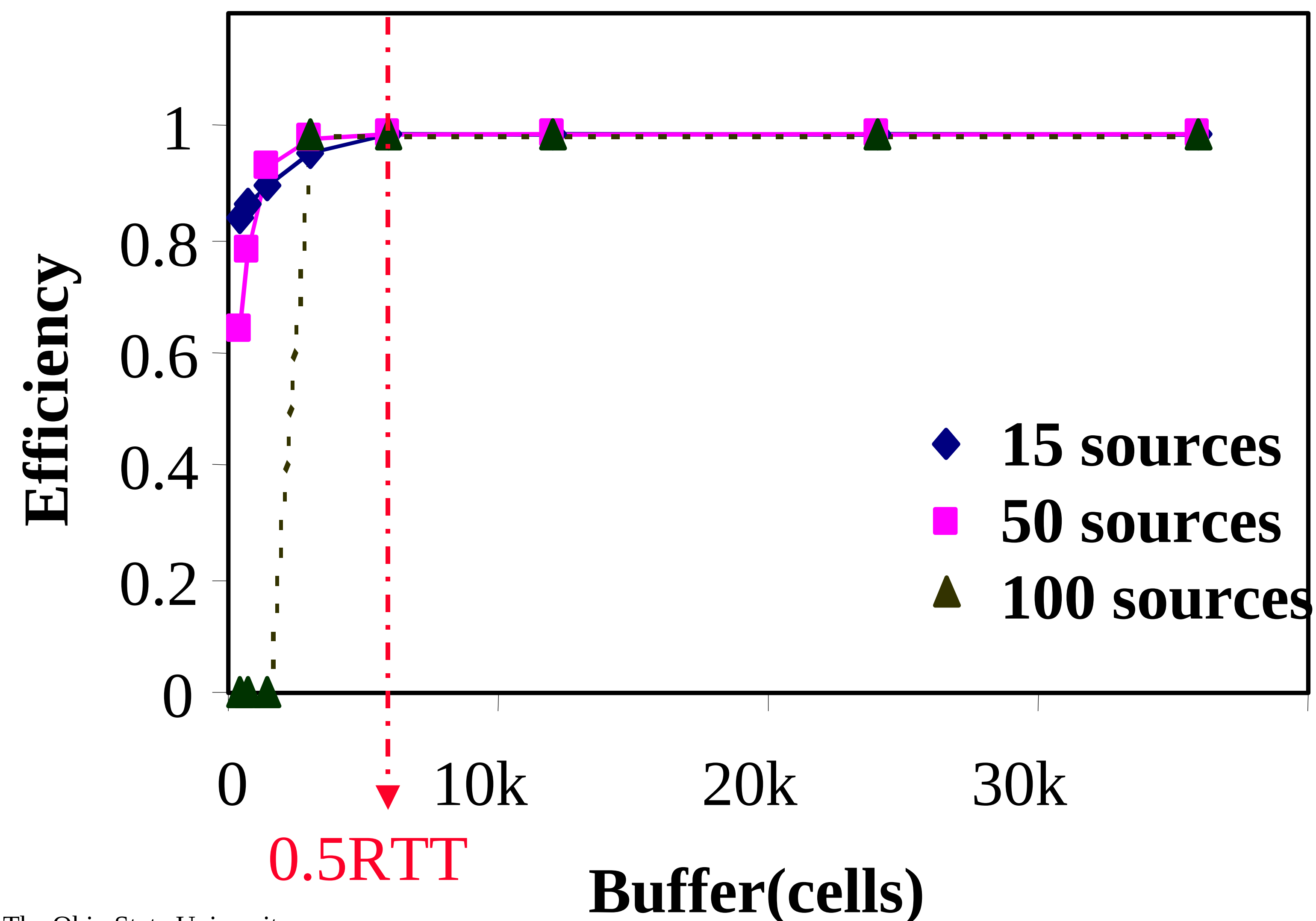



- N identical infinite TCP sources, SACK TCP
- Link Capacity = PCR = 155.52 Mbps
- Per-VC buffer management in switches (sel. drop)
- Simulation time = 100 s

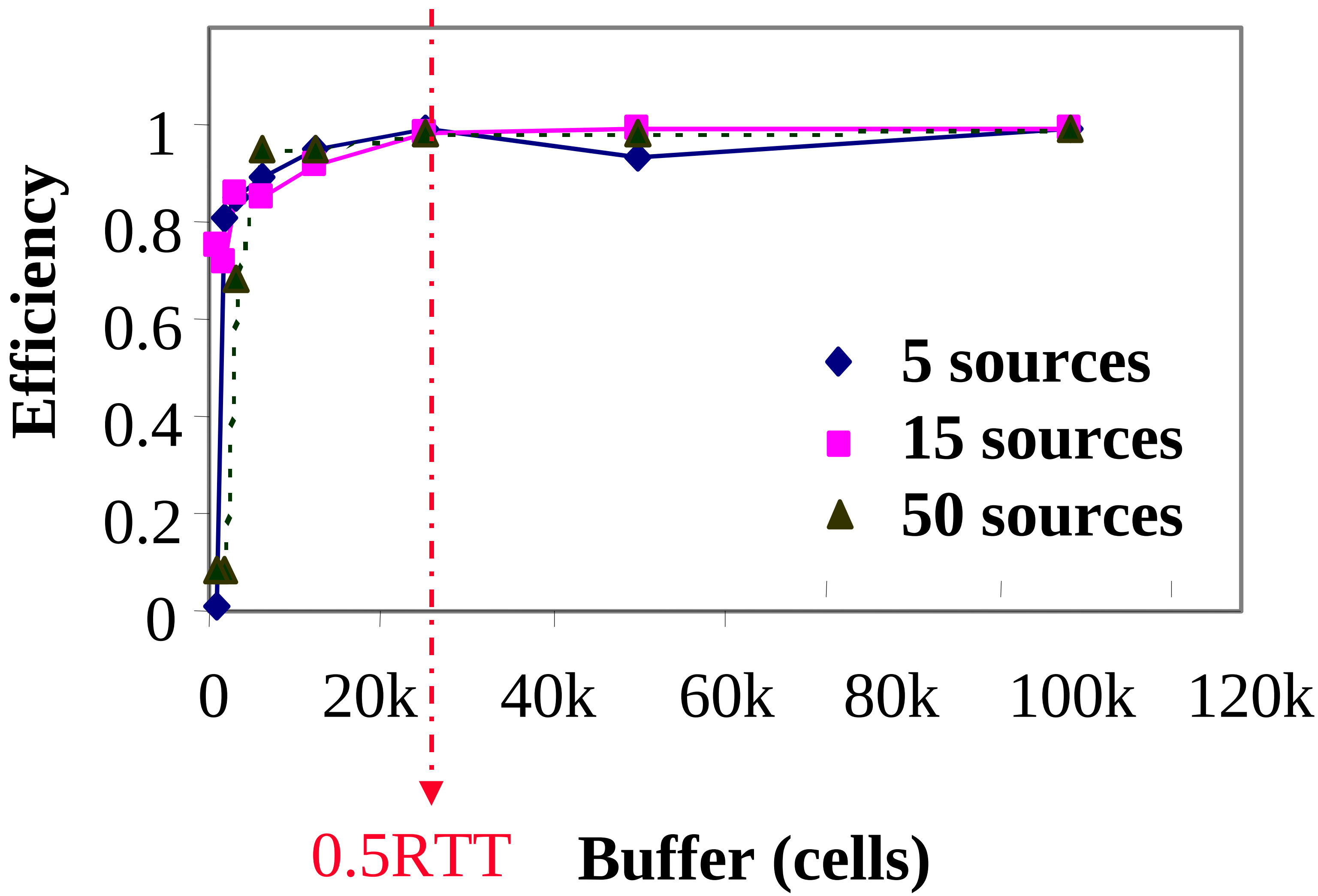
# Parameters

- Latency between earth stations via satellite (1 way)
  - Single hop LEO: 5ms
  - Multiple hop LEO: 50 ms
  - Single hop GEO: 275 ms
- Number of Sources
  - Single hop LEO: 15, 50, 100
  - Multiple hop LEO, single hop GEO: 5, 15, 50
- Buffer Size
  - $RTT \times 2^{-k}$, $k = -1, 0, 1 \ldots 6$

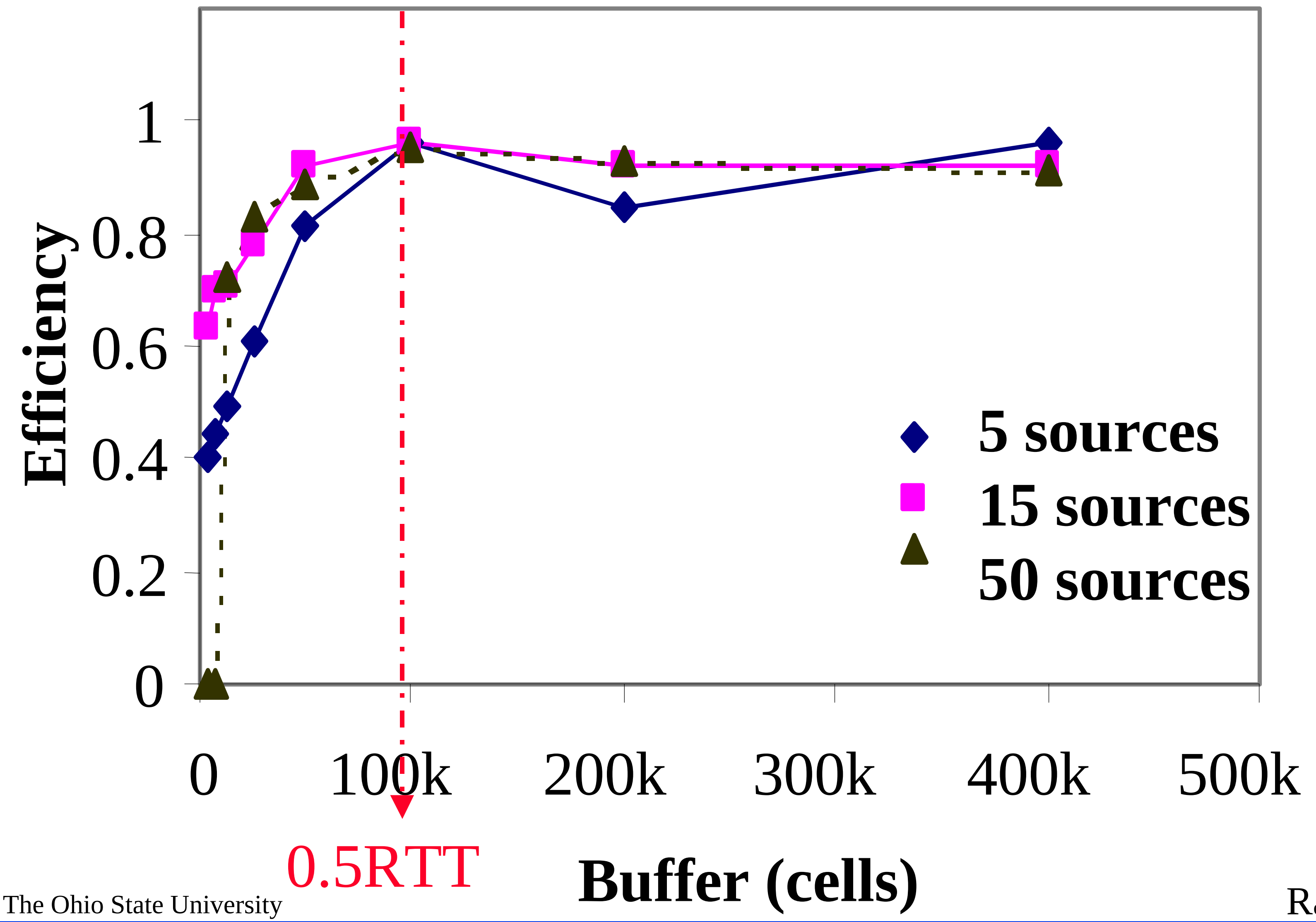
# Single hop LEO



# Multiple hop LEO



# Single hop GEO



# UBR Buffer: Results

- Very small buffer sizes result in low efficiency
- Moderate buffer sizes (less than 1 RTT)
  - Efficiency increases with increase in buffer size
  - Efficiency asymptotically approaches 100%
- Buffer size = 0.5*RTT results in very high efficiency (98% or higher) even for a large number of sources
- 0.5*RTT buffers provide sufficiently high efficiency for TCP over UBR even for a large number of TCP sources

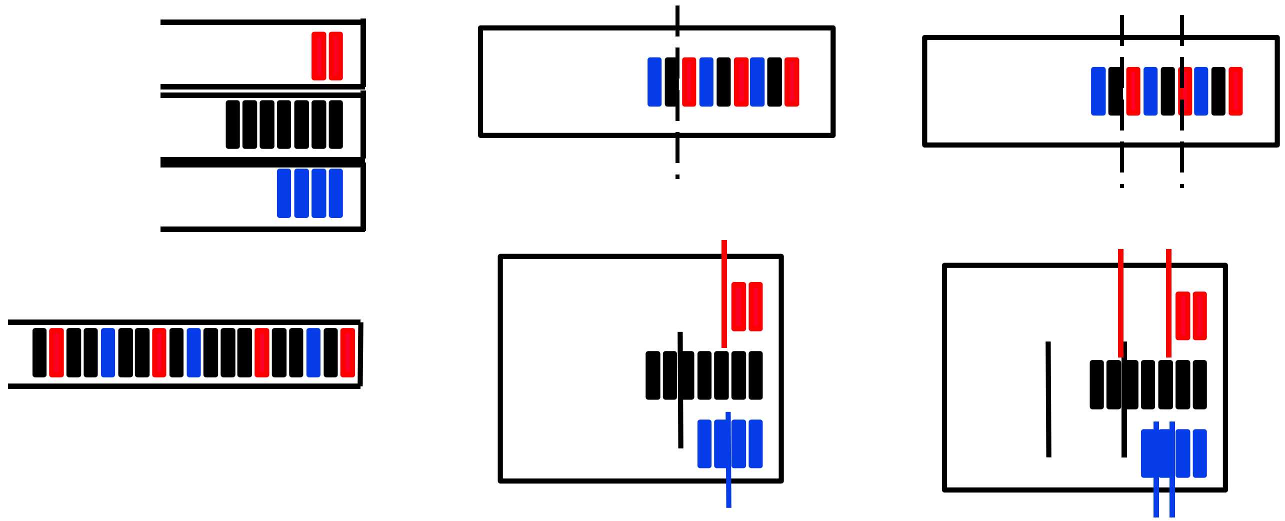
# 2. Guaranteed Frame Rate (GFR)

- UBR with min cell rate (MCR) ⇒ UBR+
- Frame based service
  - Complete frames are accepted or discarded in the switch
  - Traffic shaping is frame based.
    All cells of the frame have CLP=0 or all cells have CLP=1
  - All frames below MCR are given CLP =0 service.
    All frames above MCR are given best effort (CLP=1) service.

# GFR Study I: Goals

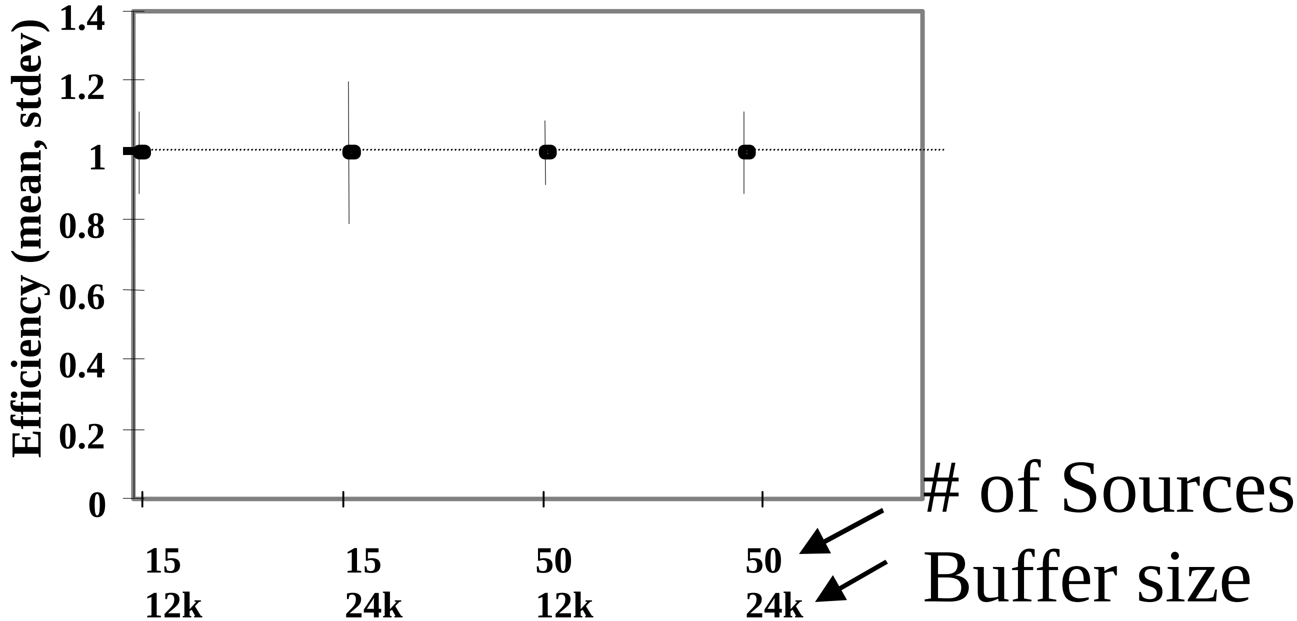
- Explore three options for providing GFR
  - Tagging (policing)
  - Buffer Management
  - Queuing
- Ref: "Simulation Experiments with Guaranteed Frame Rate for TCP/IP traffic," ATM Forum/97-0607, July 1997, http://www.cis.ohio-state.edu/~jain/atmf/a97-0607.htm

# GFR Options



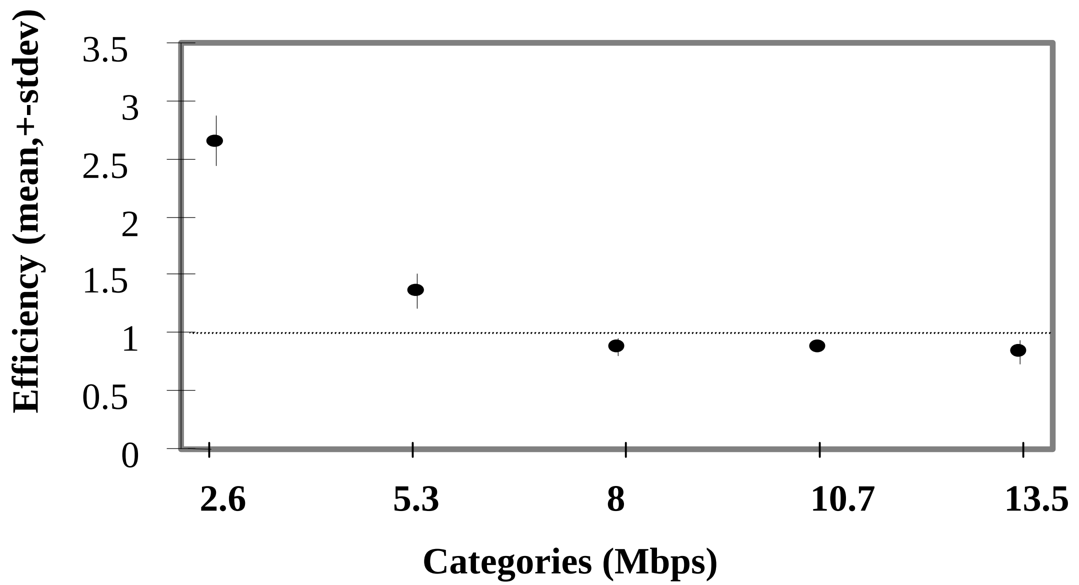
| | | |
|---|---|---|
| **Queuing** | Per-VC | FIFO |
| **Buffer Management** | Per-VC Thresholds | Global Threshold |
| **Tag-sensitive Buffer Mgmt** | 2 Thresholds | 1 Threshold |

# Equal Rate Allocations



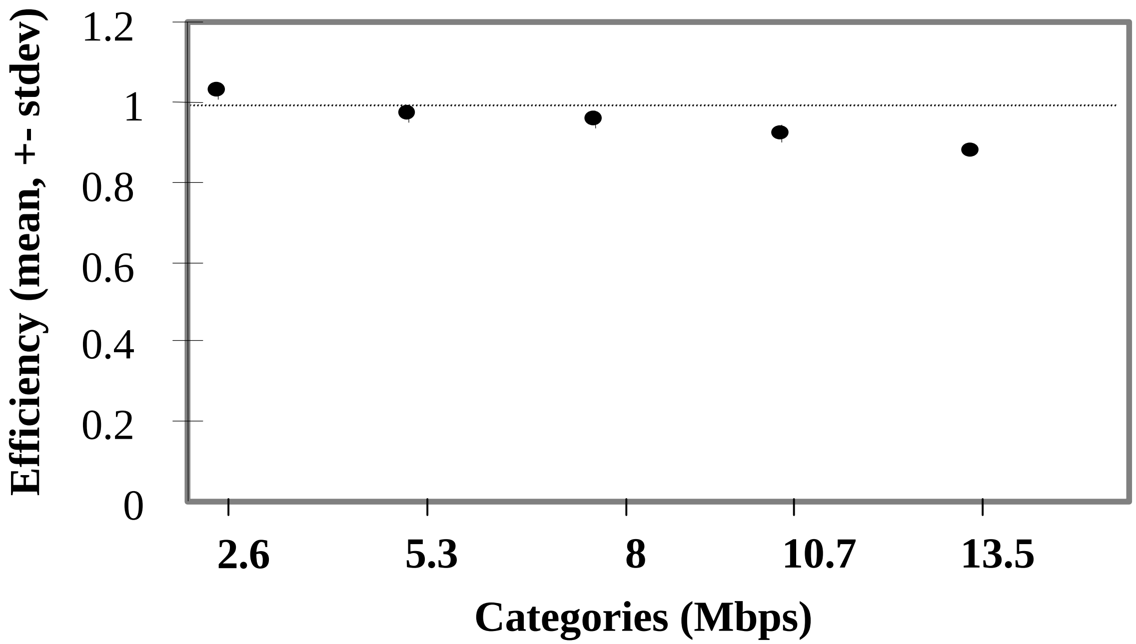

- Used only per-VC buffer management (sel. drop) with FIFO queuing
- Bars = standard deviation. Large bars Þ Unfairness
- May allocate equal rates for symmetrical TCP sources with per-VC buffer management

# Unequal Rate Allocations



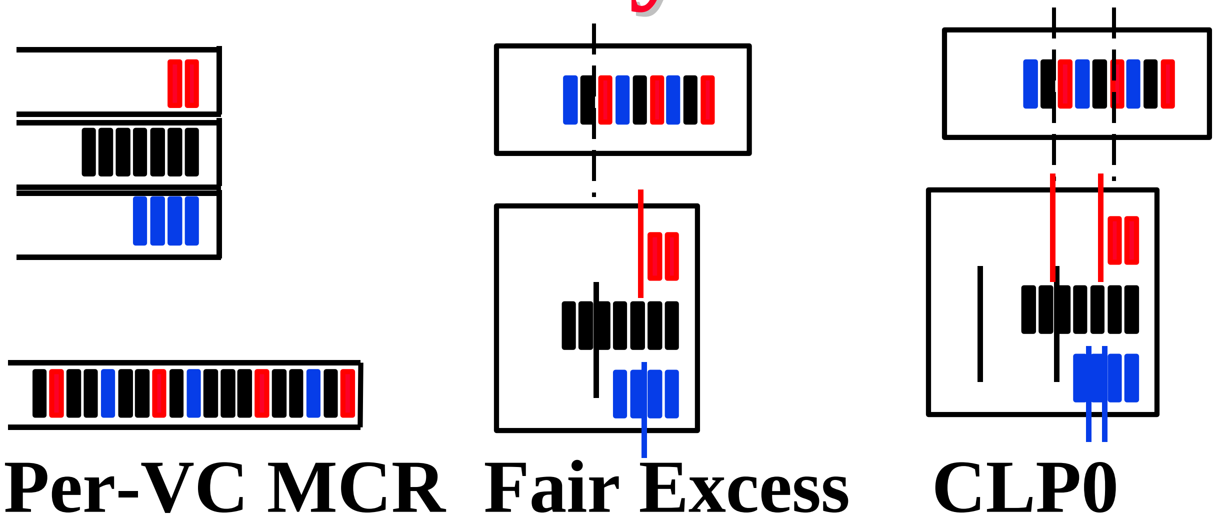

- Used per-VC tag sensitive buffer management (WBA) with FIFO queuing
- Number of sources : 15.
- 5 Groups with rates = 2.6, 5.3, 8, 10.7, 13.5 Mbps
- Cannot allocate unequal rates with FIFO queuing

# Unequal Rate Alloc




- Used only per-VC queuing/scheduling and a single global EPD threshold (not tag sensitive)
- Number of sources : 15.
- 5 Groups with MCR = 2.6, 5.3, 8, 10.7, 13.5 Mbps
- Can allocate unequal rates with per-VC queuing

# GFR Study I: Results




- Per-VC queuing and scheduling is necessary for per-VC MCR. (FIFO + anything cannot do)
- FBA and proper scheduling is necessary for fair allocation of excess bandwidth
- One global threshold is sufficient for CLP0+1 guarantees
  Two thresholds are necessary for CLP0 guarantees

# 3. GFR Study II: Goals

- Provide minimum rate guarantees with FIFO buffer for TCP/IP traffic.
- Guarantees in the form of TCP throughput.
- How much network capacity can be allocated before guarantees can no longer be met?
- Study rate allocations for VCs with aggregate TCP flows.

REF: "GFR --Providing Rate Guarantees with FIFO Buffers to TCP Traffic" ATM Forum/97-0831, Sep 1979, http://www.cis.ohio-state.edu/~jain/atmf/a97-0831.htm

# GFR Study II: Results

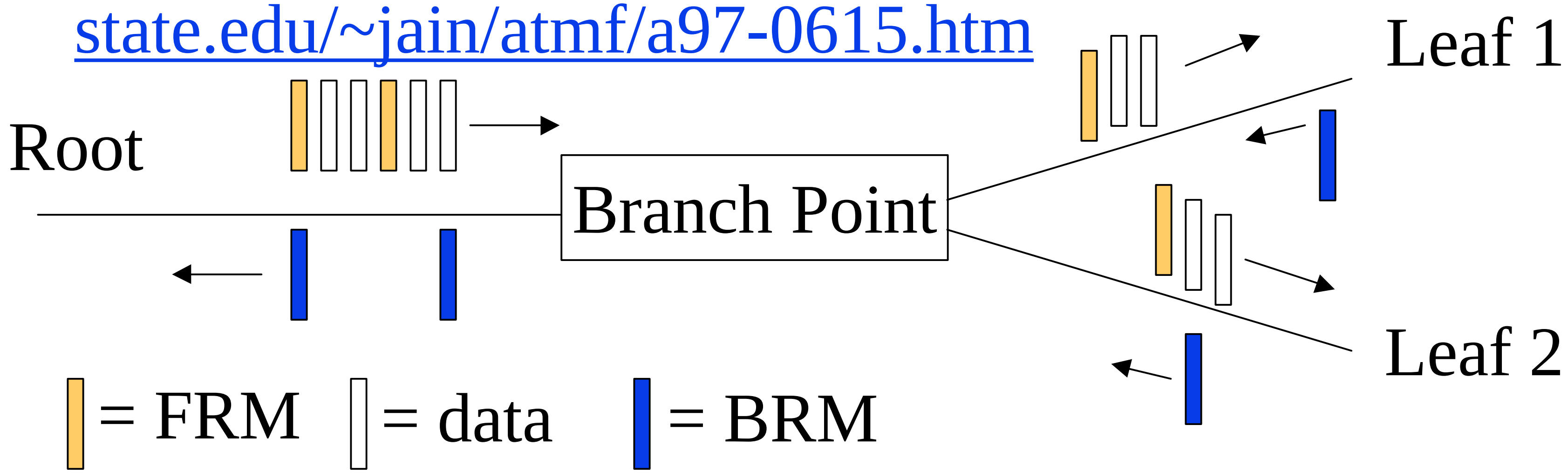
- SACK TCP throughput may be controlled with FIFO queuing under certain circumstances:
  - TCP, SACK (?)
  - $\Sigma$ MCRs < Uncommitted bandwidth
  - Same RTT (?), Same frame size (?)
  - No other non-TCP or higher priority traffic (?)

# GFR: Future Work

- Other TCP versions.
- Effect to non-adaptive (UDP) traffic
- Effect of RTT
- Effect of tagging
- Effect of frame sizes
- Parameter study
- Buffer threshold setting formula?
- How much buffer can be utilized?

# 4. Multipoint Consolidation Operation

- Necessary to prevent feedback implosion: too many BRMs per FRM at the root
- Ref: "Feedback consolidation algorithms for ABR point-to-multipoint Connections," ATM Forum/97-0615, July 1997, http://www.cis.ohio-state.edu/~jain/atmf/a97-0615.htm



# Performance Comparison

- Studied 4 existing and 3 new algorithms.

| Algorithm | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|
| Complexity | **High** | **High** | Low | Med | >Med | >Med | >>Med |
| Transient Response | Fast | Med | Med | **Slow** | Fast for overload | | Very fast for overld |
| Noise | High | Med | **High** | Low | Low | Low | Low |
| BRM:FRM | 1 | < 1 | ≤ 1 | ≤ 1 | **may>1** | lim=1 | lim=1 |
| Sensitivity to branch points and levels | High | High | Low | Med | >Med | Med | Med |

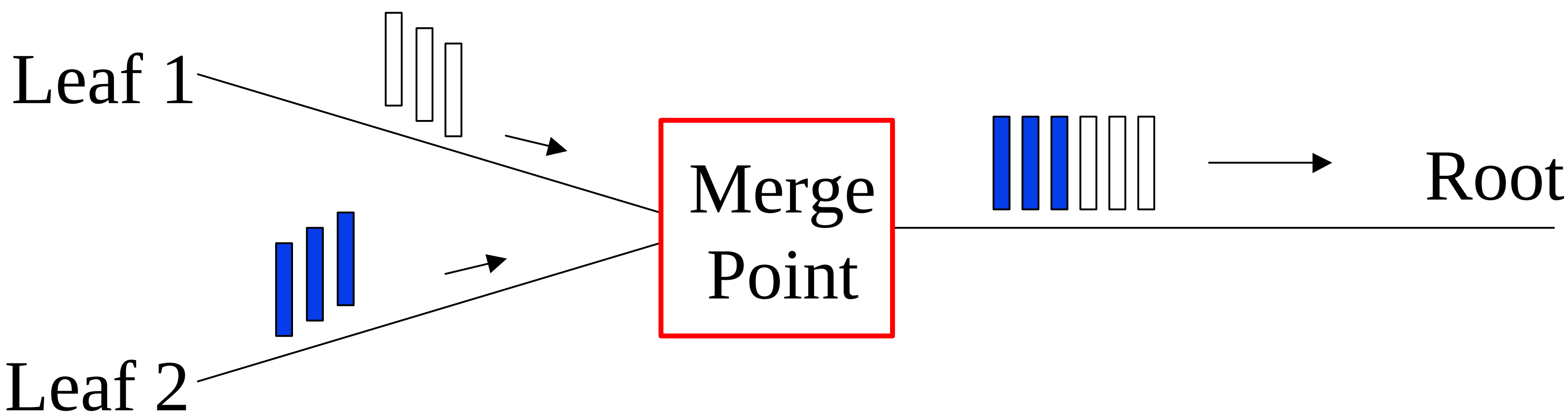
# Multipoint Consolidation: Results

- Consolidation algorithms offer tradeoffs between complexity, transient response, noise, overhead and scalability
- The new algorithms 6 and 7 speed up the transient response, while eliminating consolidation noise and controlling overhead

# 5. Multipoint-to-Point VCs

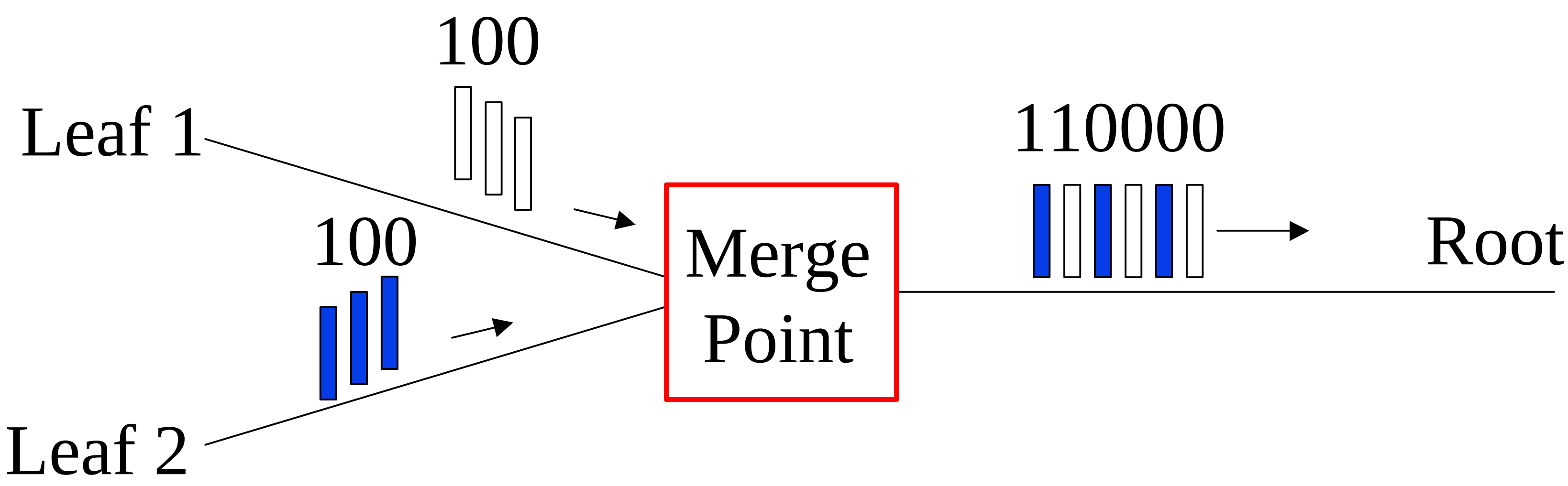
- How can bandwidth be allocated fairly?

Ref: "Fairness for ABR multipoint-to-point connections," ATM Forum/97-0832, Sep 1997, http://www.cis.ohio-state.edu/~jain/atmf/a97-0832.htm

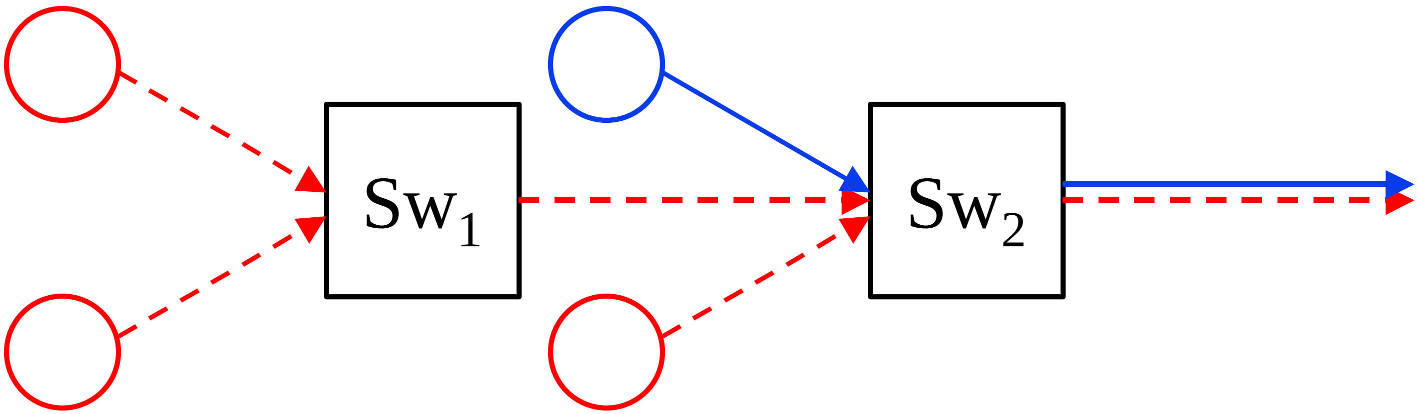


# Cell Interleaving Solutions

- VP merge: VCI = sender ID
  VPs are used for other purposes.
- VC merge: Buffer at merge point till EOM bit = 1.
  Requires memory and adds to traffic burstiness and latency.



# Sources, VCs, and Flows



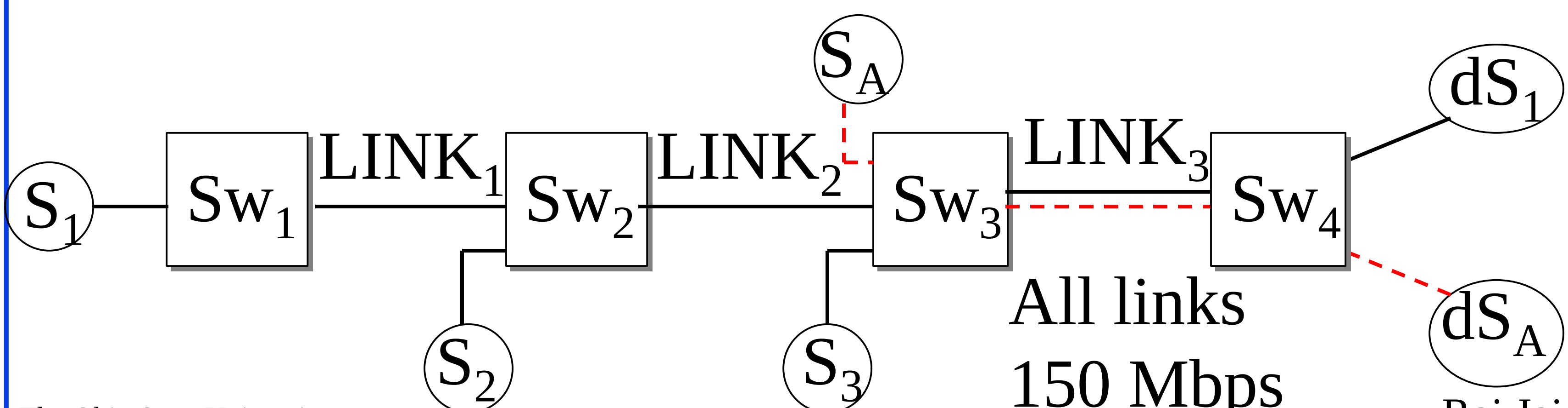

- $Sw_2$ has to deal with
  - Two VCs: Red and Blue
  - Four sources: Three red sources and one blue source
  - Three flows: Two red flows and one blue

# Fairness Definitions

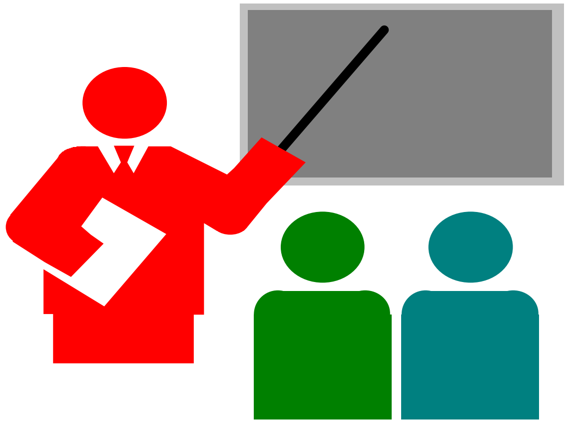
- Source-based: N-to-one connection
  = N one-to-one connections
  ⇒ Use max-min fairness among sources
- VC/Source-based:
  1. Allocate bandwidth fairly among VCs
  2. For each VC, allocate fairly among its sources
- Flow-based: Flow = VC coming on an input link.
  Switch can easily distinguish flows.
- VC/Flow-based: Allocate bandwidth fairly among VCs
  2. For each VC, allocate fairly among its flows

# Example

- How is the bandwidth of LINK3 allocated?
- Source: {S1, S2, S3, SA}←{37.5, 37.5, 37.5, 37.5}
- VC/Source: {S1, S2, S3, SA}←{25, 25, 25, 75}
- Flow: {S1, S2, S3, SA}←{25, 25, 50, 50}
- VC/Flow: {S1, S2, S3, SA}←{18.75, 18.75, 37.5, 75}



# Summary



- One-half of RTT buffers are OK with SACK
- GFR guarantees, in general, require per-VC queueing
- GFR guarantees may be possible w SACK TCP
- Point-to-mpt extensions to ABR switch algorithms
- Sources, VCs, and flows are different in Mpt-to-pt VCs

# Our Contributions and Papers

All our contributions and papers are available on-line at http://www.cis.ohio-state.edu/~jain/

- See Recent Hot Papers for tutorials.