97-0607: Simulation Experiments with Guaranteed Frame Rate for TCP/IP Traffic

Rohit Goyal, Raj Jain, Sonia Fahmy,
Bobby Vandalore, Shivkumar Kalyanaraman

The Ohio State University

Sastri Kota, Lockheed Martin Telecommunications

Pradeep Samudra, Samsung Telecom America, Inc.

Contact: jain@cis.ohio-state.edu

http://www.cis.ohio-state.edu/~jain/

- Guaranteed Frame Rate
- Goals
- Options: Tagging, Buffer Management, Queuing
- Simulation Results
- Summary
- Recommendations

Guaranteed Frame Rate (GFR)

- Minimum rate guarantee for frames
- Fair share of unused capacity
- GCRA like conformance definition
- Two proposed methods:
  - FIFO queuing with tagging
  - Per-VC queuing with per-VC buffer management

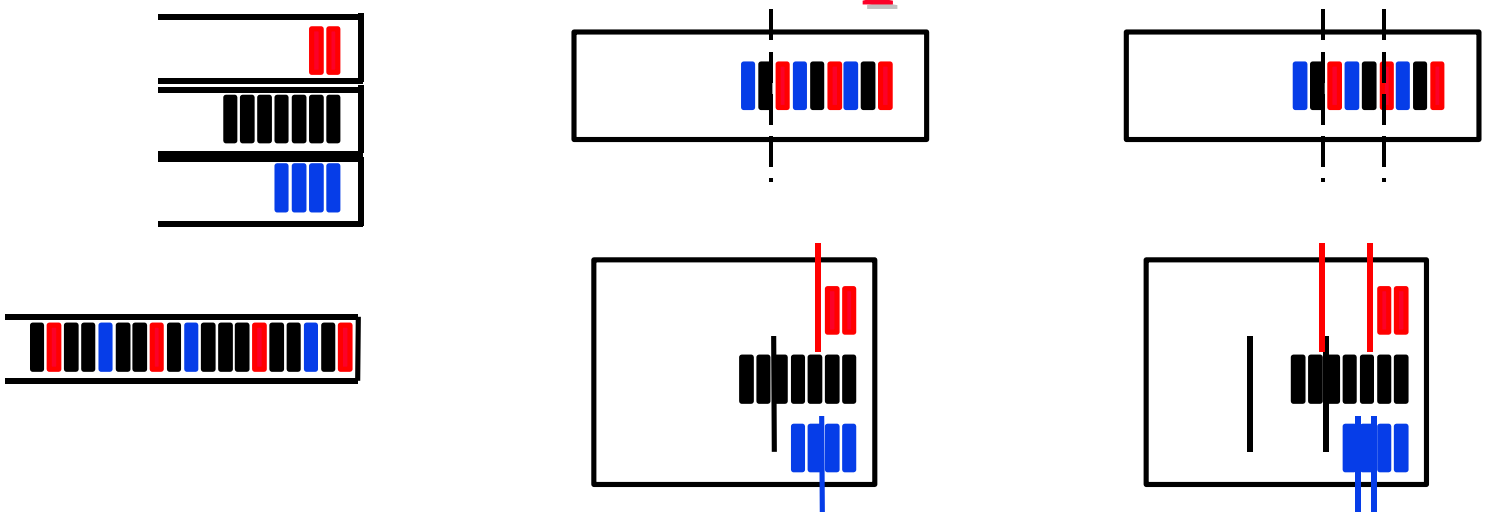
GFR (Cont)

- In April meeting it was shown
  - Difficult to do GFR for TCP traffic with FIFO queuing and tagging
  - Can do GFR with per-VC queuing and tagging
- Per-VC based buffer management was not studied

Goals

- Explore three options for providing GFR
  - Tagging (policing)
  - Buffer Management
  - Queuing
- Compare network based tagging vs end system tagging?
- Compare MCR guarantee to CLP0 vs MCR guarantee CLP0+1?

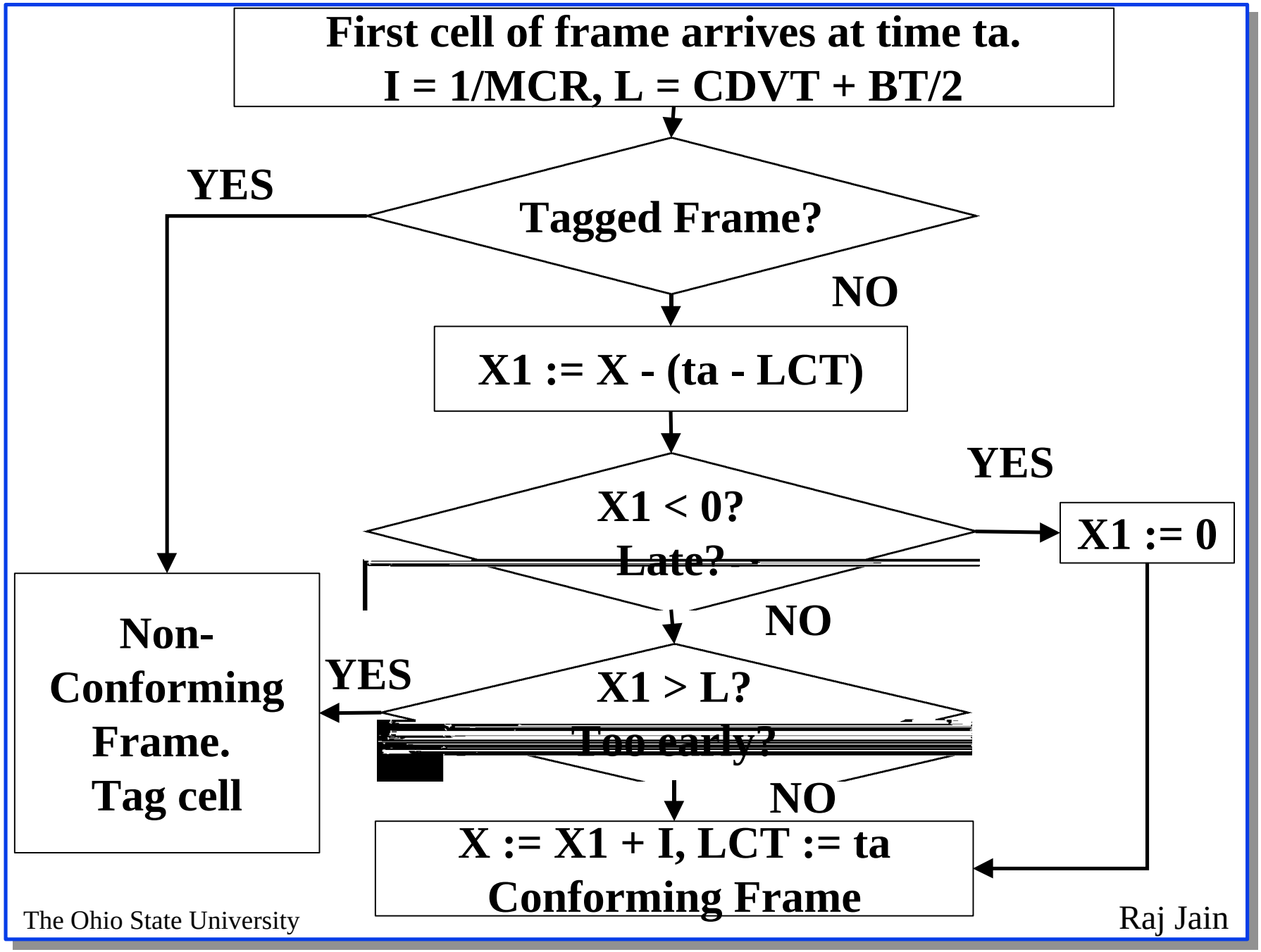
GFR Options

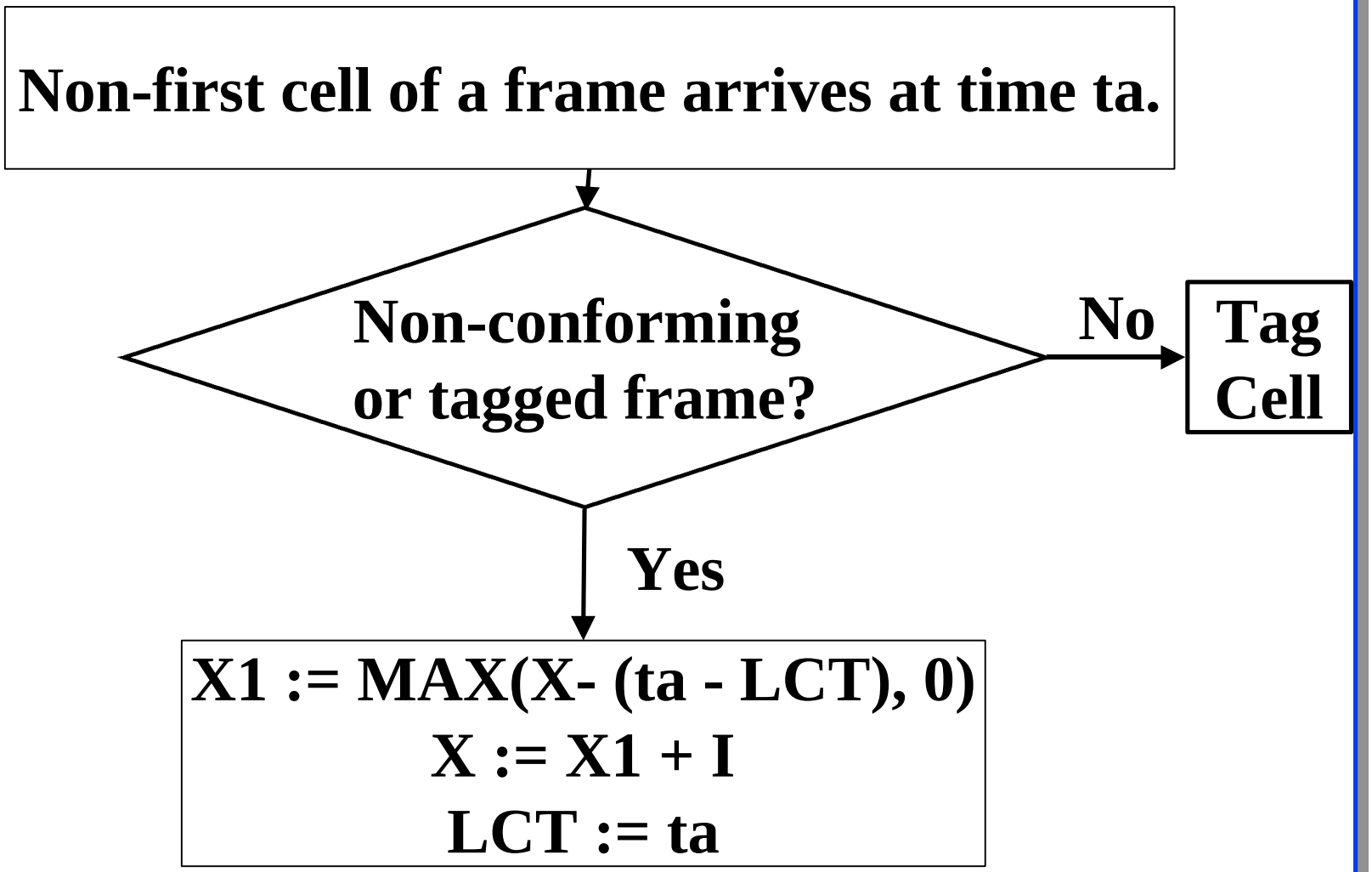


Queuing	Per-VC	FIFO
Buffer Management	Per-VC Thresholds	Global Threshold
Tag-sensitive Buffer Mgmt	2 Thresholds	1 Threshold

Tagging

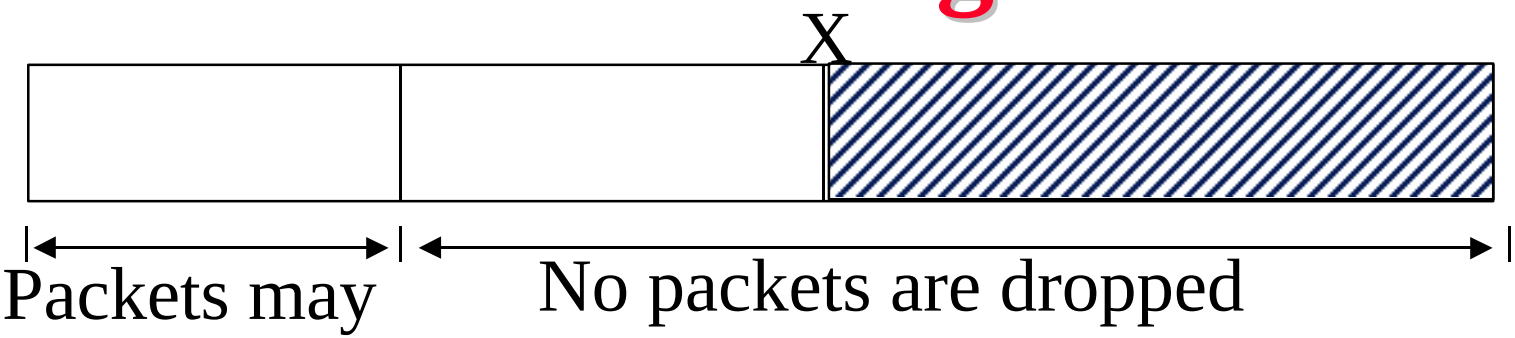
- Network based tagging = Policing
- Continuous state leaky bucket version of the GFR conformance definition:
  - MCR = Frame rate in cells/sec
  - MBS = 2 × CPCS – SDU size
  - BT = (MBS – 1)/(1/MCR – 1/PCR)
  - LCT = Last Compliance Time
  - CDVT = Tolerance for MCR
  - X = Leaky bucket counter (nominal arrival time for next cell)
  - X1 = Local variable


First cell of frame arrives at time ta.
I = 1/MCR, L = CDVT + BT/2
Tagged Frame?
YES
NO
X1 := X - (ta - LCT)
X1 < 0?
Late?
YES
X1 := 0
NO
X1 > L?
Too early?
YES
NO
Non-Conforming Frame. Tag cell
X := X1 + I, LCT := ta
Conforming Frame



- Do not drop the last cell of a frame regardless of CLP state unless you drop the entire frame.

Buffer Management



- K = Buffer Size (cells)
- R = Congestion Threshold, X = Buffer Occupancy
- Yi = Buffer Occupancy of VCi
- Li = Number of untagged cells of VCi in buffer
- Wi = Weight of VCi (based on MCR)
- Na = Number of active VCs
- Z = Fairness threshold

Weighted Buffer Allocation

- When the first cell of a frame arrives:

```
IF (X < R) THEN
    Accept cell and frame
ELSE IF (X > R) THEN
    IF ((Li < R*Wi) AND (Untagged)) THEN
        Accept cell and frame
    ELSE IF ((Yi-R*Wi)Na < Z(X-R)) THEN
        Accept cell and frame
    ELSE Drop cell and frame
```

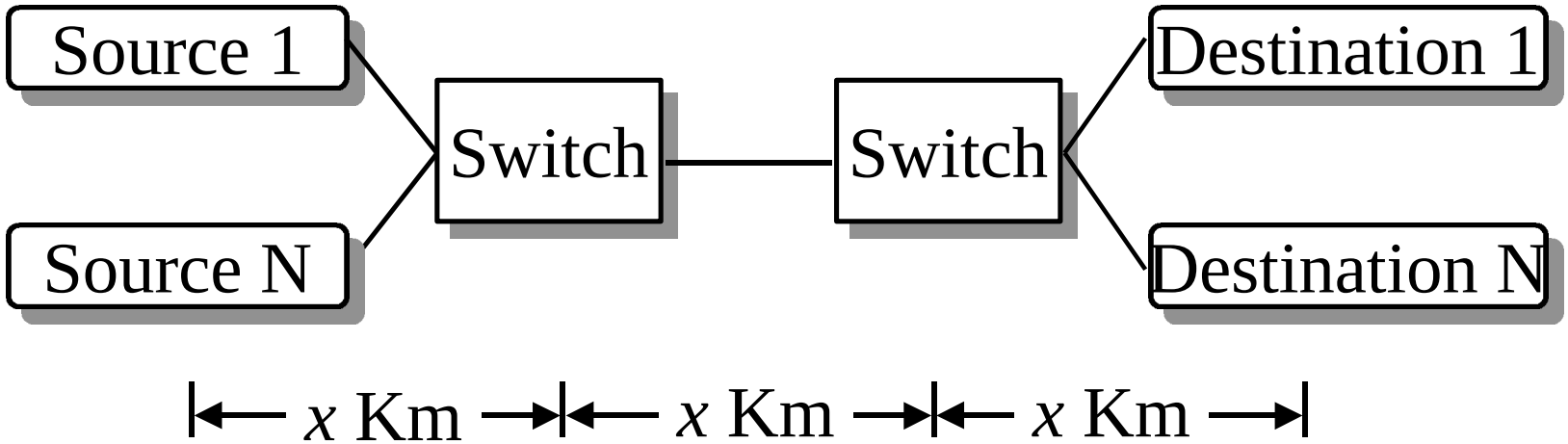
Buffer Management (Cont)

- Per-VC buffer management controls the entry of frames into the switch buffers.
- In the absence of network based tagging and per-VC buffer management, VCs that send excess untagged traffic do better than those that tag all their non-conforming traffic
  $\Rightarrow$ Per-VC buffer management is needed in the absence of network based tagging

Queuing

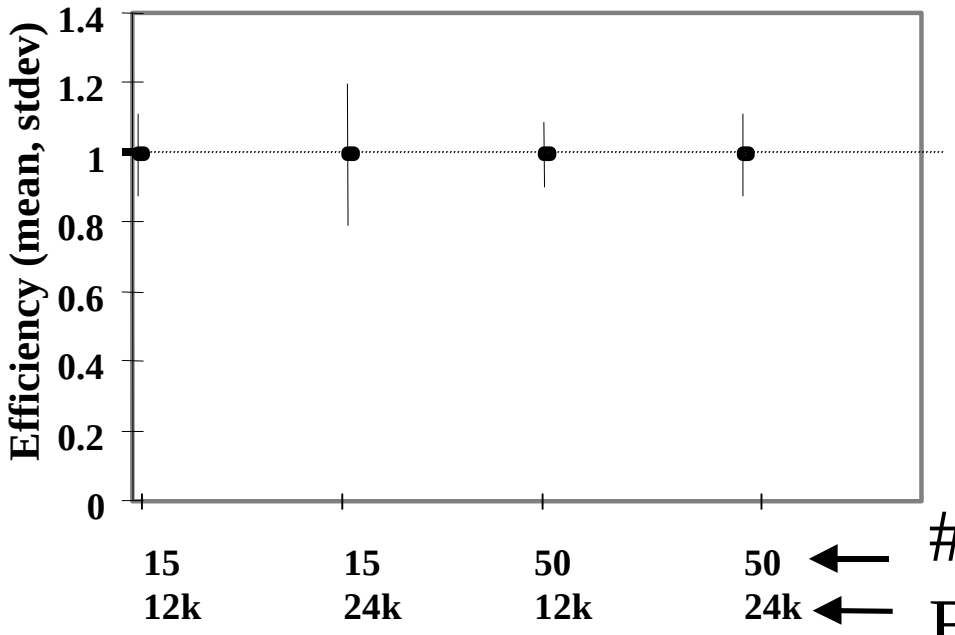
- FIFO versus Per-VC queuing
- We implemented a WFQ like scheduling policy

Simulation Experiment



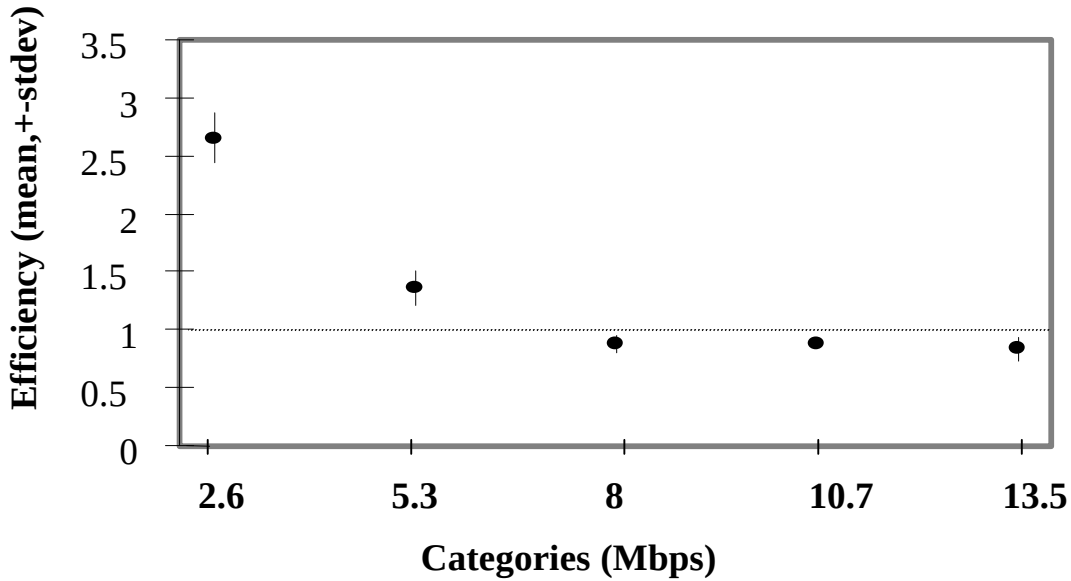
- N identical infinite TCP sources
- Link Delay: 5 ms.
- Link Capacity = PCR = 155.52 Mbps (147.9 Mbps after SONET overhead)
- Tried both equal and unequal MCR allocations to TCP sources

Equal Rate Allocations



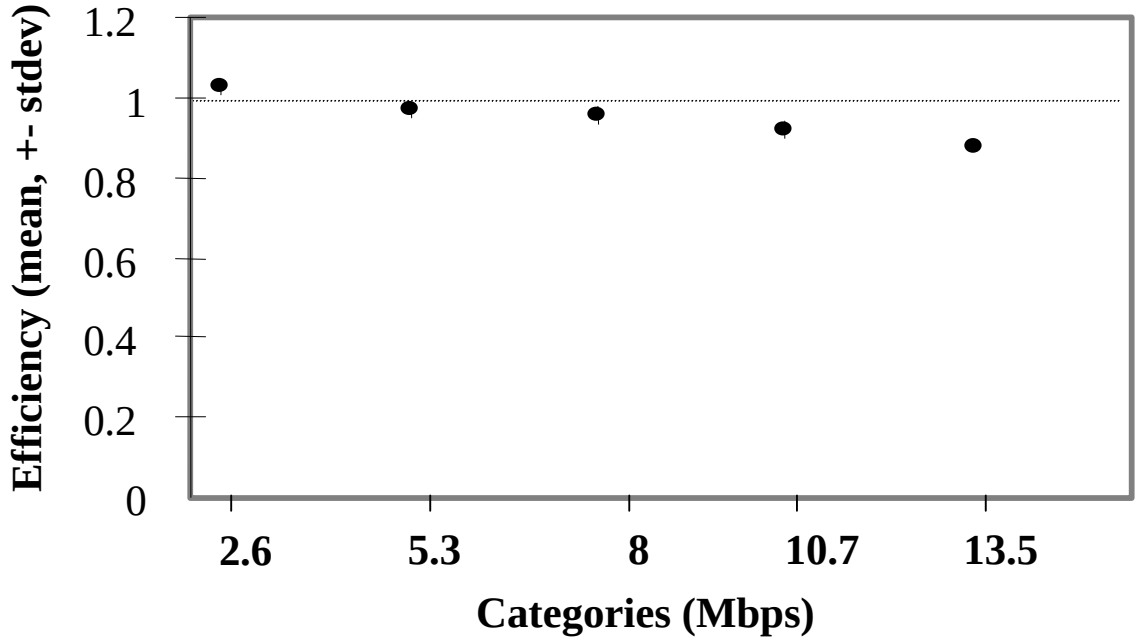
- Used only per-VC buffer management (sel. drop) with FIFO queuing
- Bars = standard deviation. Large bars ⇒ Unfairness
- May allocate equal rates for symmetrical TCP sources with per-VC buffer management

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 (Cont)



- 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

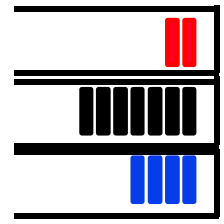
The Role of Tagging

- End system tagging:
  - Semantic priority for untagged frames
  - CLP0 stream has meaning for the end to end performance
- Network Based tagging:
  - Conformance of frames
  - CLP0 stream does not have any special meaning for the end to end performance
- Network may tag all frames of some VCs to indicate low priority VCs.

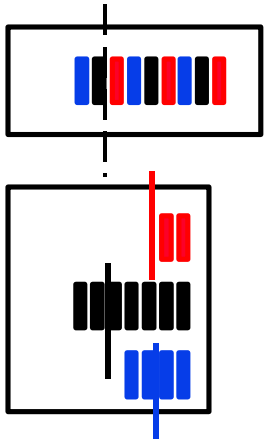
Tagging (Cont)

- Per-VC queuing is needed to make per-VC MCR guarantees
- FBA + scheduling is needed for fair allocation of excess bandwidth.
- If guarantees are made to CLP0+1 stream THEN Per-VC queuing + scheduling + FBA is sufficient
- If guarantees are made to the CLP0 stream THEN Per-VC tag sensitive buffer management is necessary
- CLP0 may not have any "meaning" if the network performs tagging

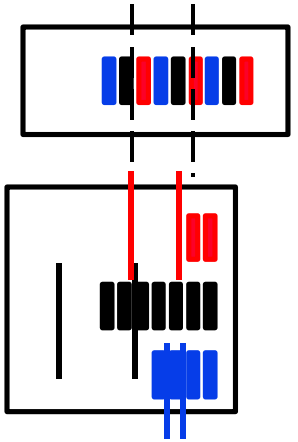
Summary



Per-VC MCR



Fair Excess



CLP0

- 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