Adaptive Packet Marking for Providing Differentiated Services in the Internet

Wu-chang Feng, Debanjan Saha, Dilip Kandlur, Kang Shin

October 13, 1998

QoS and the Internet

- RSVP: signaling protocol for resource reservation
- IntServ: services provided to applications
- Advantages:
  - Per-flow end-to-end guarantees to applications
- Disadvantages
  - Overheads
    - Control-path: per-flow signaling and state
    - Data-path: per-flow packet handling
  - Complexity
    - ISPs and deployment

Differential Services

- Provide service levels based on priority marking of packets
- DiffServ WG
- Advantages
  - No per-flow overheads
  - Deployment simple
- Disadvantages
  - Difficulty in providing end-to-end per-flow guarantees

Current Status

- EF - Expedited Forwarding
  - Low loss, low delay forwarding behavior
  - Used to implement a virtual leased line service
- AF - Assured Forwarding
  - Low loss forwarding behavior
  - Used to implement assured bandwidth service
- Current EF/AF Services
  - Service models require end-to-end signaling and/or connection setup
  - Control path overhead
  - Service agreements bilateral, not end-to-end

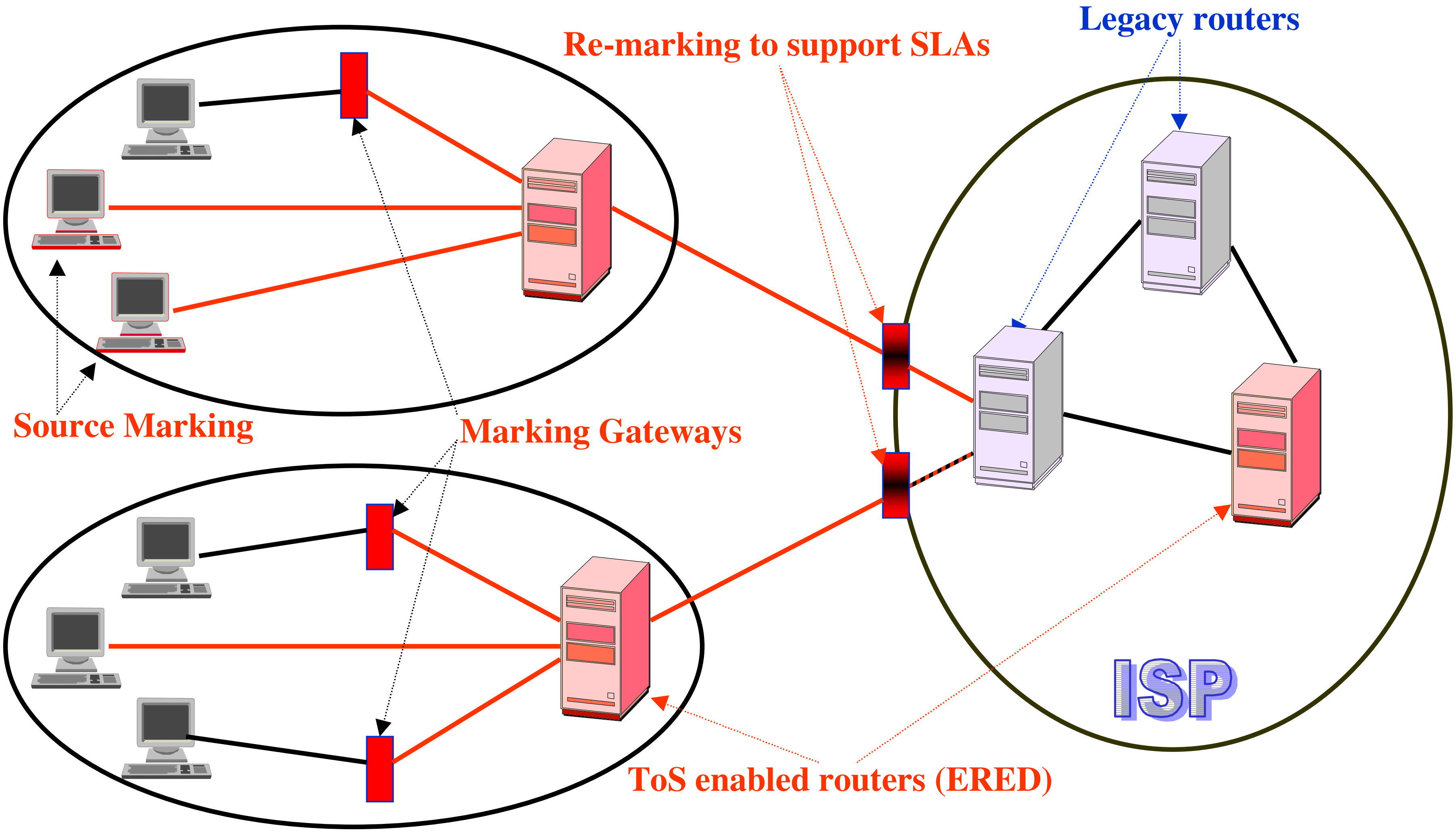
This work

- Provide an architecture and mechanisms for using AF to provide soft bandwidth assurances
  - No end-to-end signaling
  - Rely on adaptation on the edges

Adaptive Packet Marking

- Per-flow or per-aggregate bandwidth requirement
- Adaptively mark packets at edges until desired level is obtained
- Marking at the source or in the network
- Re-marking at boundaries to support service level agreements
- Priority-aware queuing in routers (ERED)

Packet Marking Architecture



Re-marking to support SLAs

Legacy routers

Source Marking

Marking Gateways

ToS enabled routers (ERED)

Advantages

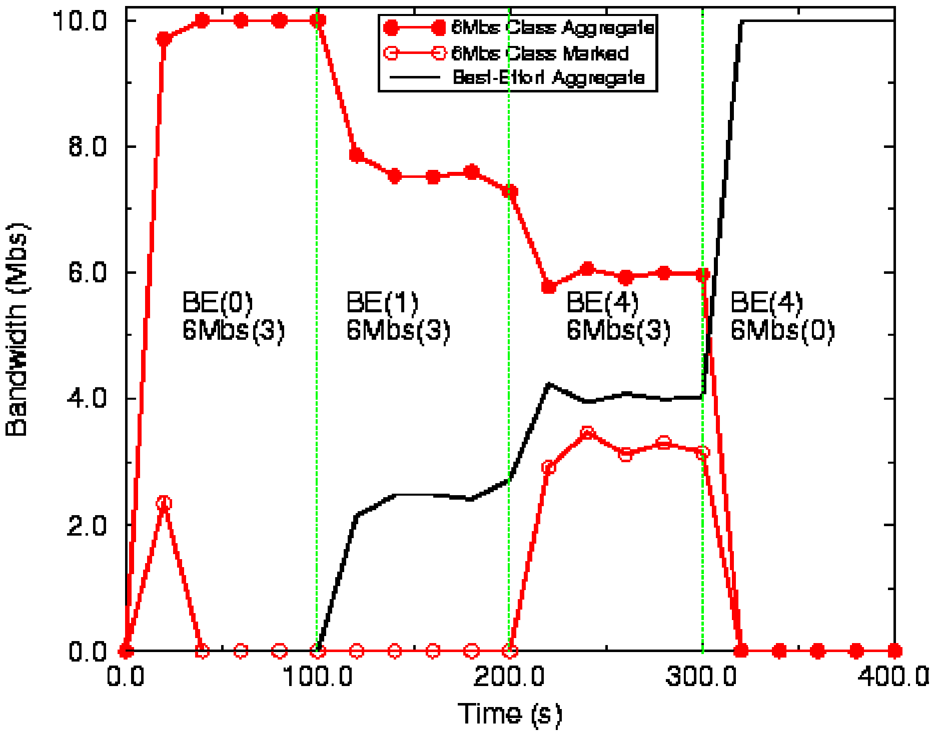
- ISP deployment
  - Simple augmentation of SLAs to include additional priority
  - No end-to-end signaling
  - Service model (soft guarantees) allows for incremental deployment

Packet Marking Gateway (PMG)

- Increase marking probability if below target
- Decrease marking probability if above target
- Change conservatively to prevent bursts
- Implemented and simulated in **`ns`**

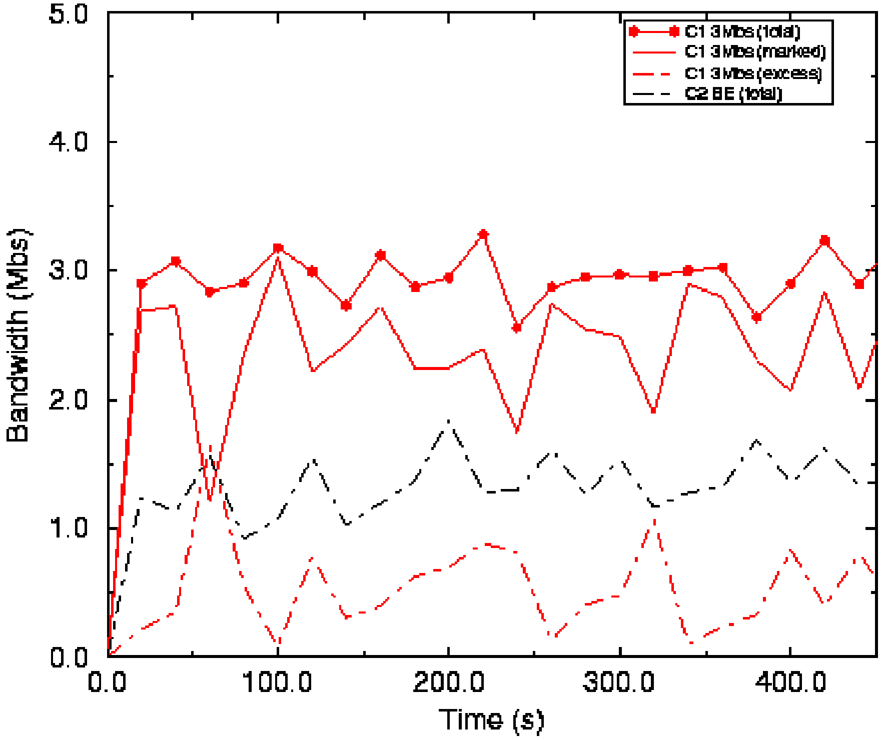
PMG Example

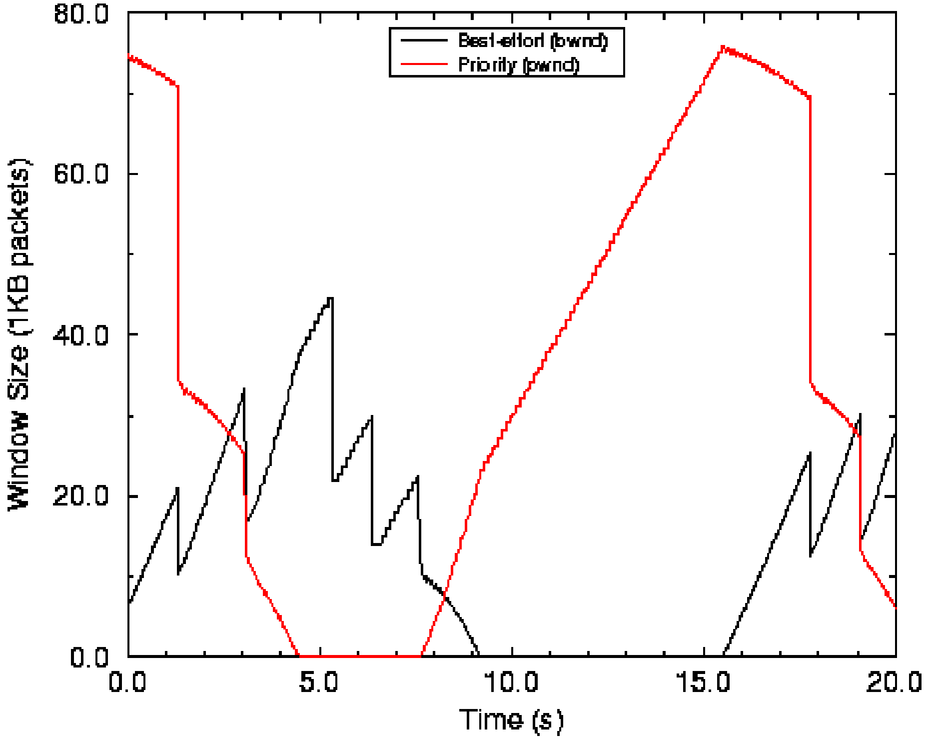
- Aggregate with 6 Mbs target (up to 3 sources)
- Other sources best-effort (up to 4 sources)
- 10 Mbs bottleneck link



PMG and Bandwidth Sharing

- One 3 Mbs connection, five best-effort sources
- Ideally: `Target = Priority + Best-effort share`
- Problem: Excess marking





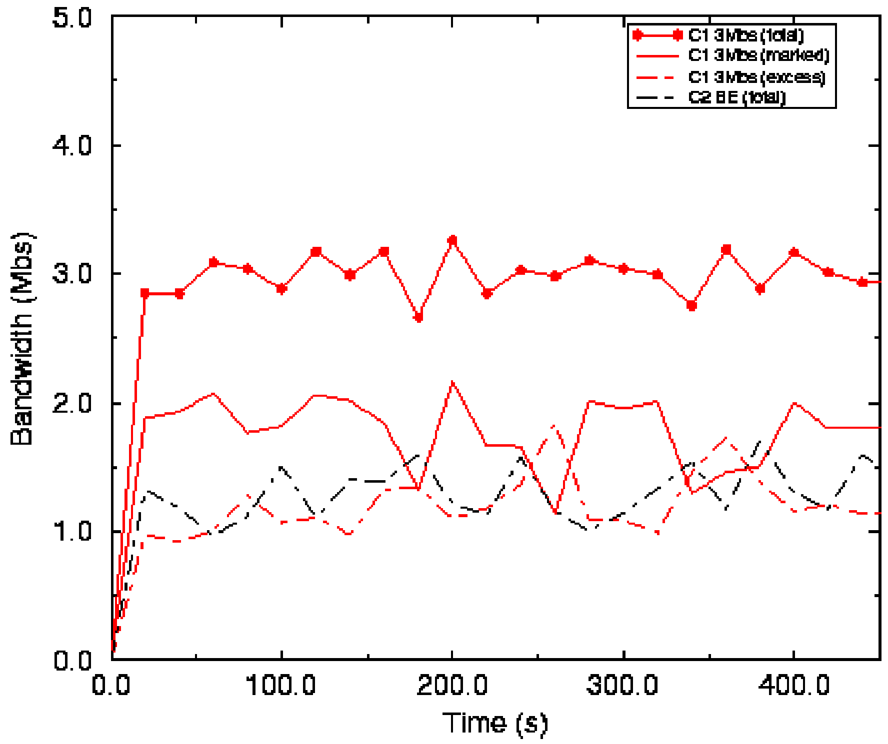
Problems with PMG

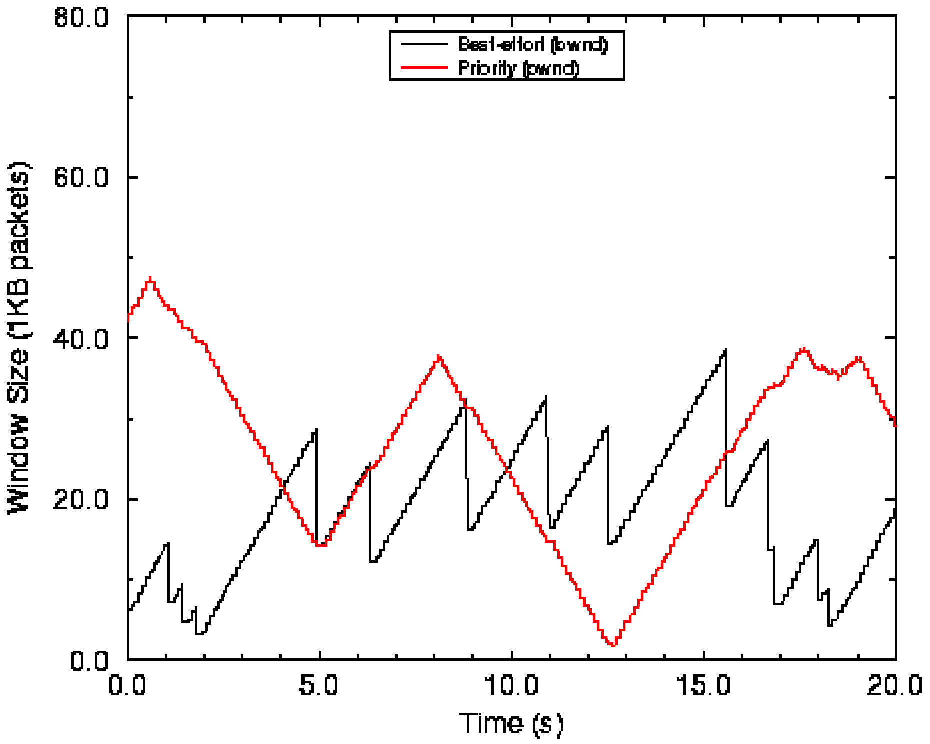
- Excess marking
  - Impacts pricing of services
  - Impacts ERED performance
  - Limits bandwidth sharing between connections

Source Integrated Marking

- TCP cognizant of packet marking
- Two separate windows
  - priority window (pwnd)
  - best-effort window (bwnd)
- Grow and shrink according to TCP dynamics
- Provides bandwidth sharing with an optimal (minimal) amount of marking

Source Integrated Marking





Deployment Considerations

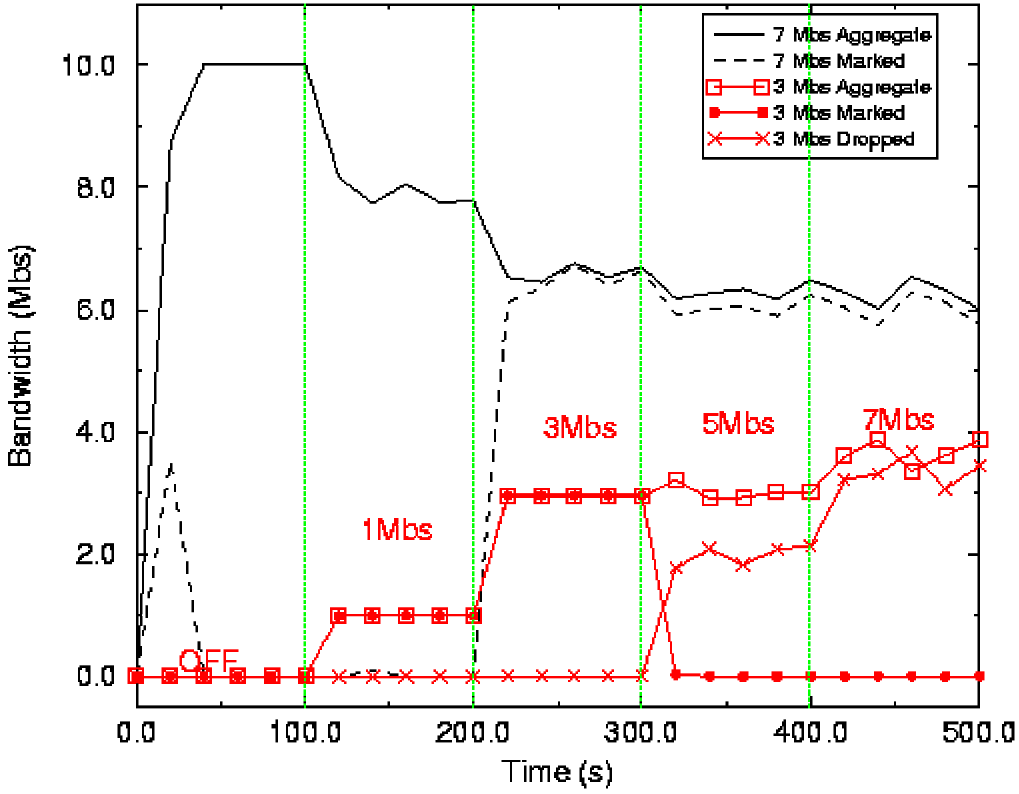
- Non-responsive flows
  - Protection against malicious flows
  - Reduce marking to zero
  - Provides a disincentive for being malicious
- Heterogeneity
  - Detect lack of service differentiation
  - Back-off marking and windowing
- Over-subscription
  - Fall back on TCP sharing
  - Use of additional priority bits and/or queues

Non-responsive Flows

- All packets counted towards target
- Incentive to send deliverable packets
- Experiment with PMG
  - One 7 Mbs aggregate with 4 connections
  - One 3 Mbs aggregate with non-responsive flow

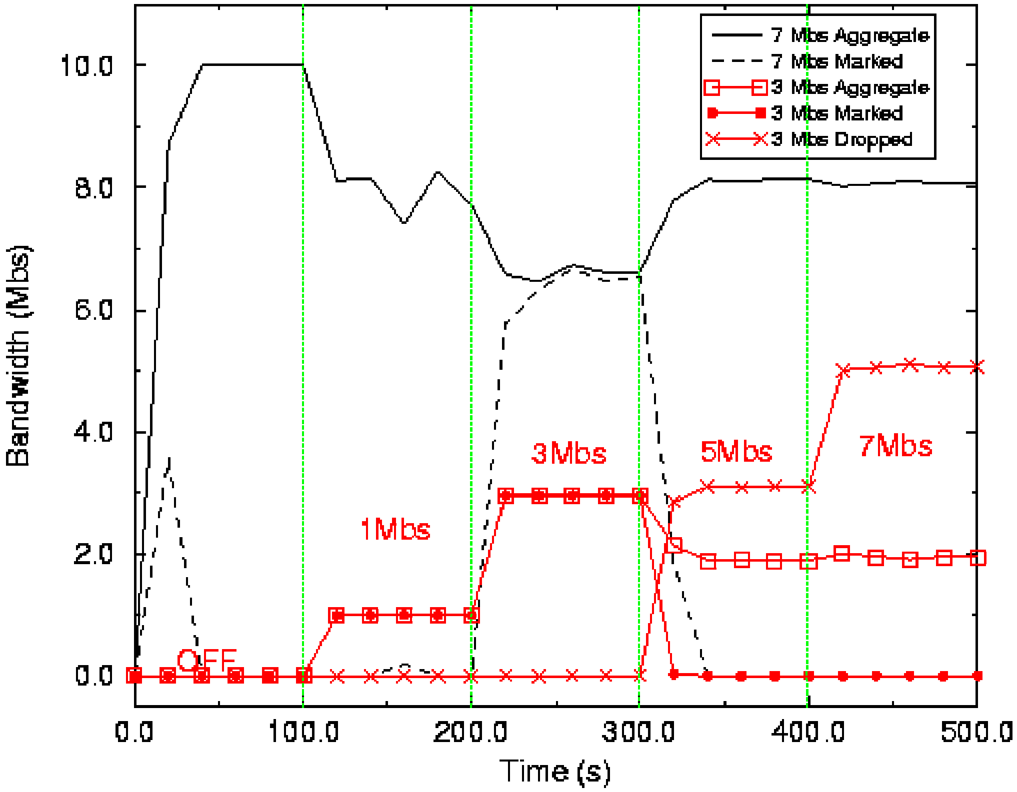
Non-responsive Flows

- PMG reduces marking to 0 Mbs
- Problem: Flow consumes all best-effort bandwidth



Non-responsive Flows

- Use “Fair” ERED
- Allocates best-effort bandwidth equally

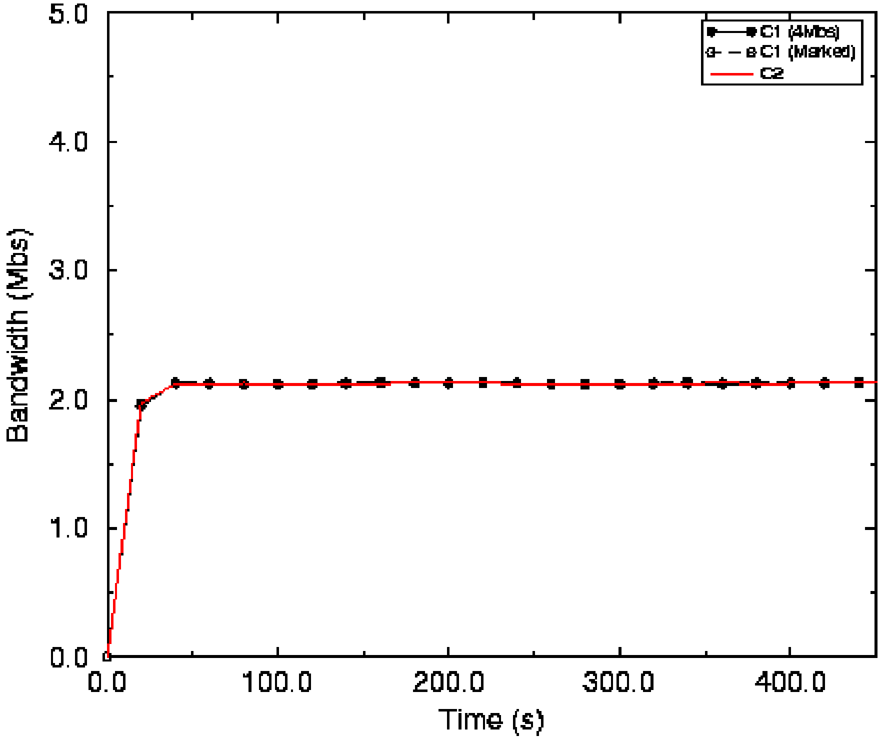


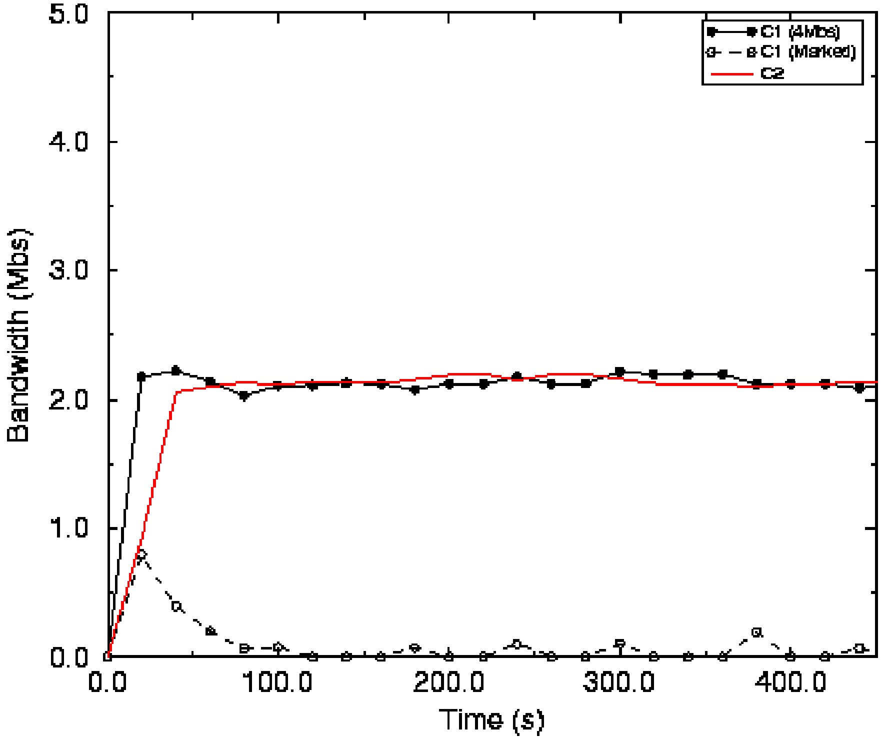
Heterogeneity

- Legacy hardware and routers
- PMG
  - No changes to end-host
  - Marking ignored
  - No clean way to turn off marking
- Source-integrated
  - Connection treated as two separate connections
  - Potentially twice as aggressive
  - Turn off packet marking and windowing
    - Use inter-drop times (in packets)
    - Exponential back-off mechanism

Heterogeneity

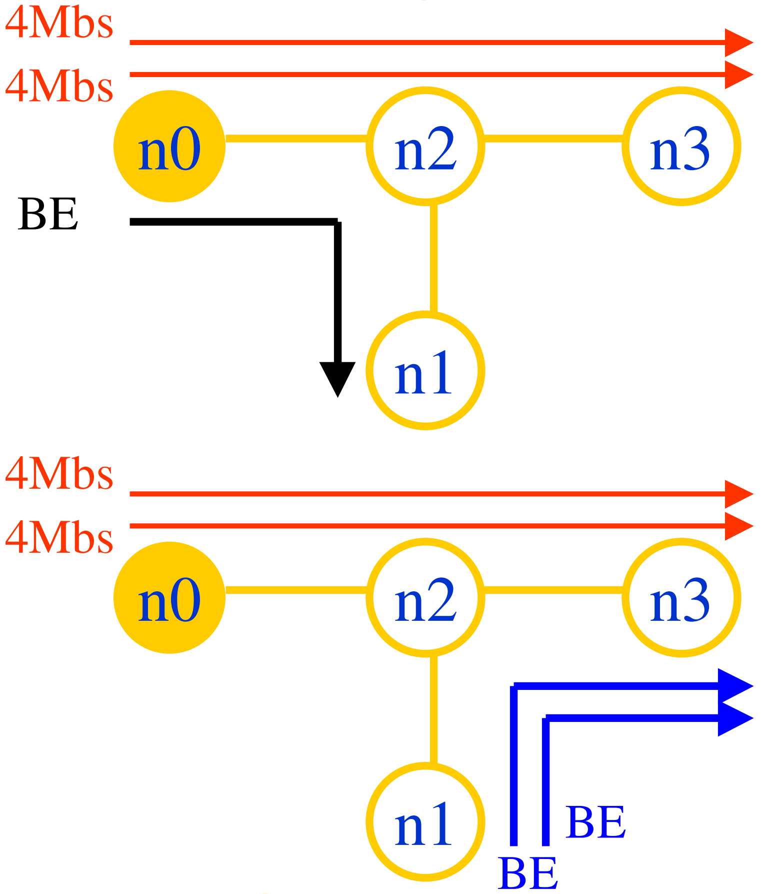
- 4 best-effort sources over legacy 10 Mbs link
- 1 source with 4 Mbs target rate

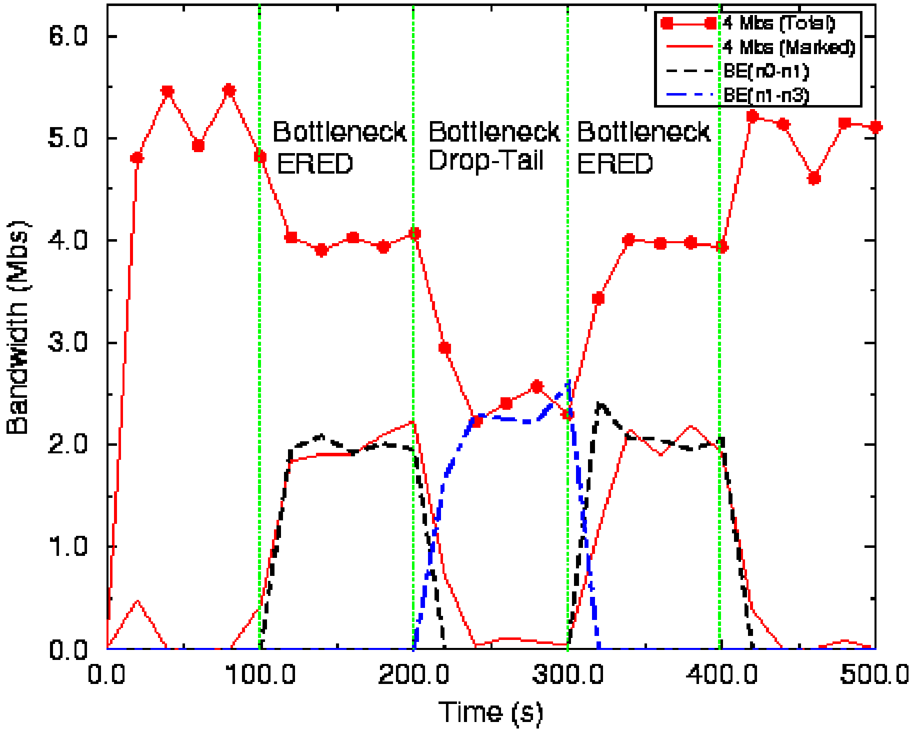




Heterogeneity

- Detecting network changes



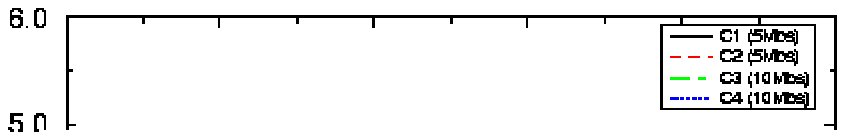


ERED ●

Drop-tail ○

Over-subscription

- PMG: End-host
- Source-Integrated:
  - Windowing independent of target rate
- Two 10 Mbs connections
- Two 5 Mbs connections
- 10 Mbs bottleneck



Over-subscription

-

- Same experiment with CBQ

  70% Class A Class B

-
- Priority schemes in conjunction with intelligent control mechanisms at the edges

    Low overhead
  - Ease of deployment
-
  - http://www.eecs.umich.edu/~wuchang/