QCN: Improving Transient Response

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Outline of presentation

- Statement of problem
- Algorithm for improving transient response of 2-QCN
- A principle underpinning the algorithm
- Trade-offs: Milking the principle further

Transient response of 2-QCN

- When bandwidth is available
  - 2-QCN takes longer to grab it
  - Qs: Is 2-QCN fundamentally handicapped by a lack of positive feedback? Or, can a source detect and grab available bdwdth in a simple manner?

- A key issue
  - Any attempt at improving transient response should not harm steady-state stability

Algorithm

- Estimate congestion at the source
  - Maintain an estimate of Fb, say Fb-hat, at each RL
  - Fb-hat is counted using a 5- or 6-bit saturation counter
  - Fb-hat is thought of as a source's estimate of congestion

- Updating Fb-hat
  - For every Fb recd by RL: Fb-hat <-- Fb-hat + Fb
  - For every 50 pkts transmitted: Fb-hat <-- Fb-hat/2 (just right shift)

- Using Fb-hat: cycle-shrinking
  - Every time we begin a cycle of FR or AI…
    - If Fb-hat is small (e.g. 0 or 1): reduce length of cycle to 50 pkts from 100 pkts

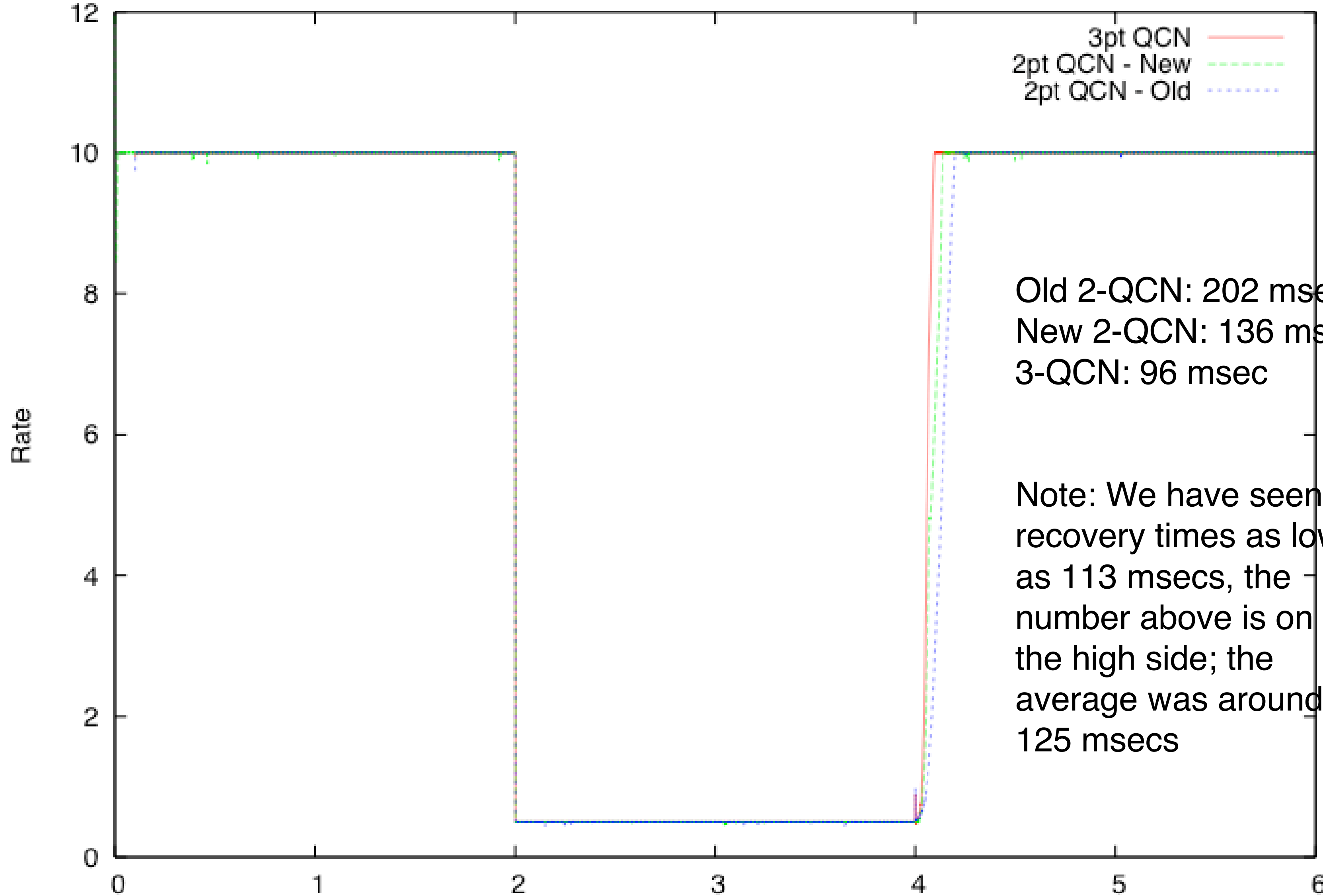
- Idea: small Fb-hat implies no dings for a while, hence it is likely there is no congestion; so a source can quickly get to AI and grab extra bdwdth
  - Note: in equilibrium, Fb-hat will be more than 1, hence no cycle-shrinking will occur, hence stability is preserved

Simulation Comparison

- Parameters
  - 10 sources sharing a link; RTT = 40 microseconds
  - Buffer size = 100 pkts; Qeq = 22
  - Link BW: 10G during 0--2 sec and 4--6 sec; 0.5G during 2--4 sec
  - Fb-hat saturated at 31
  - FR cycle-shrinking: 50 pkts if Fb-hat is 0 or 1, 100 pkts otherwise
  - AI: also 50 or 100 pkts depending on Fb-hat as above
  - AI amount: 25 Mbps

- Note on choice of cycle-shrinking
  - We have chosen non-aggressive parameters above for cycle-shrinking
    - E.g. we have also tried shrinking cycle lengths to 25, 50 or 100 pkts depending on Fb-hat
    - We have also used gentle rate increases during AI
  - More aggressive choices certainly improve recovery time a lot, but we need to keep the basic trade-offs in mind
    - Complexity vs performance
    - Responsiveness vs stability margin
  - But, there is good potential for exploiting Fb-hat better (more later)

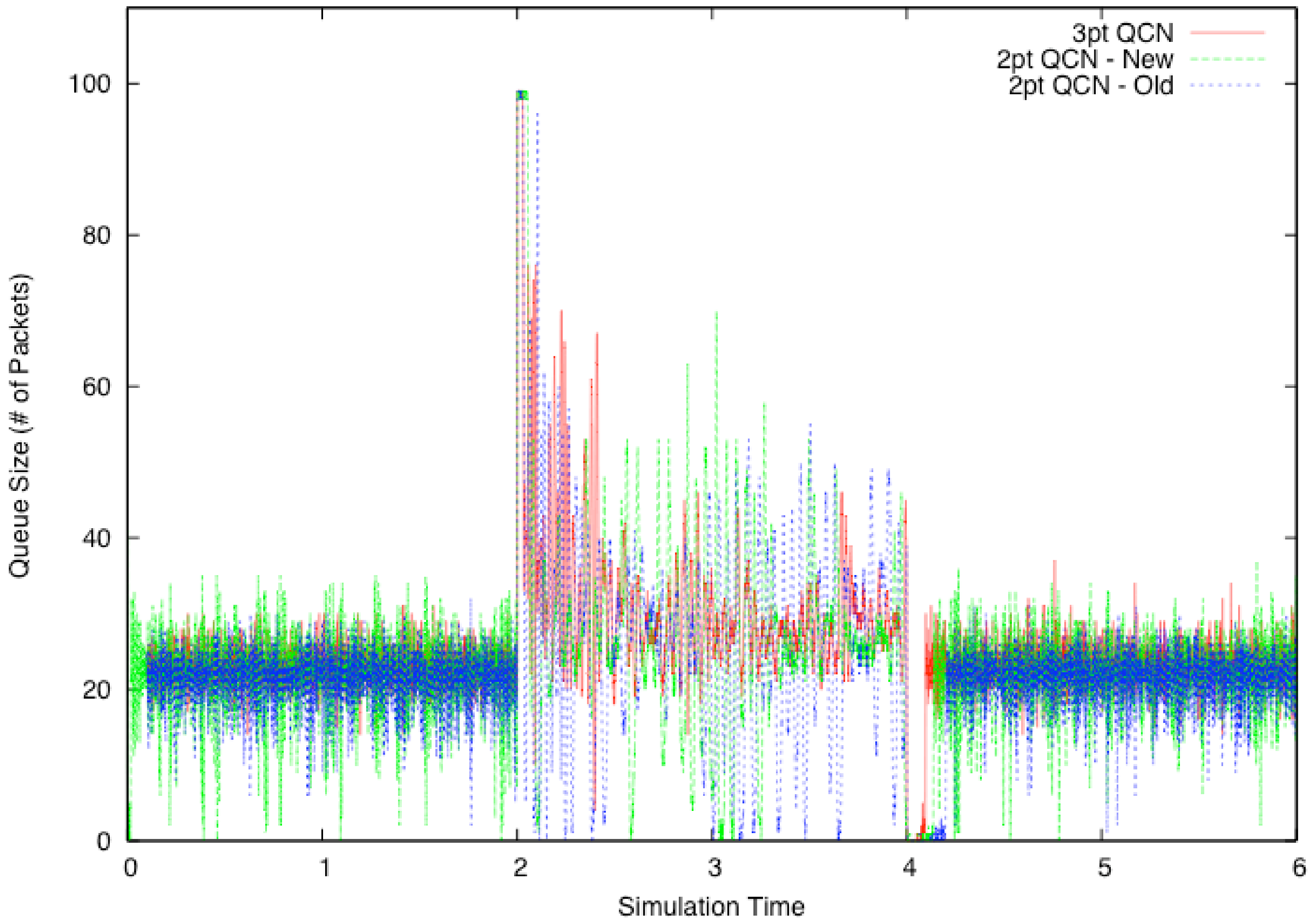
0.5G Bottleneck: Rate



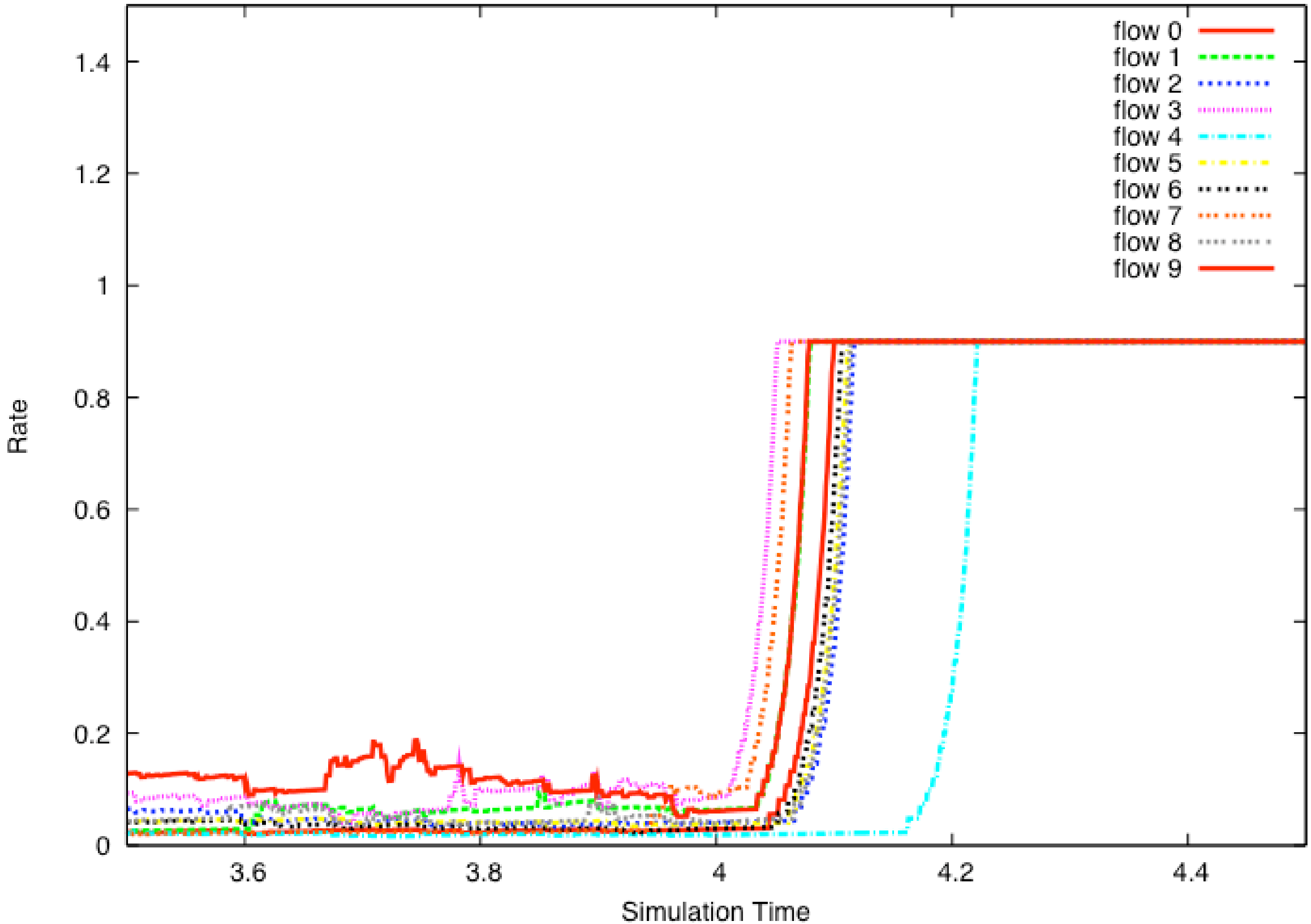
Old 2-QCN: 202 msec
New 2-QCN: 136 msec
3-QCN: 96 msec

Note: We have seen recovery times as low as 113 msecs, the number above is on the high side; the average was around 125 msecs

0.5G Bottleneck: Queue

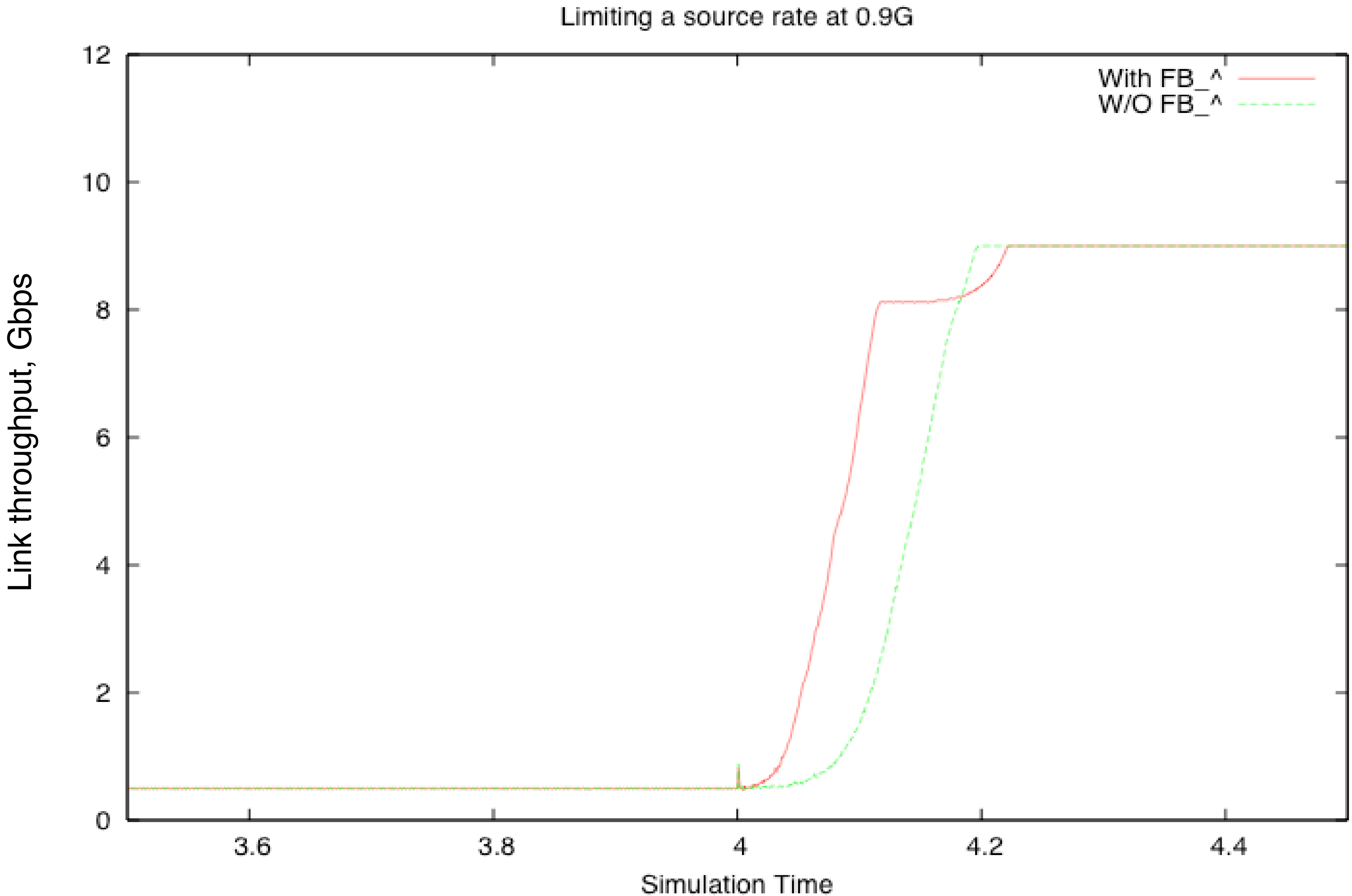


0.5G Bottleneck, Max source rate: 0.9G Straggler

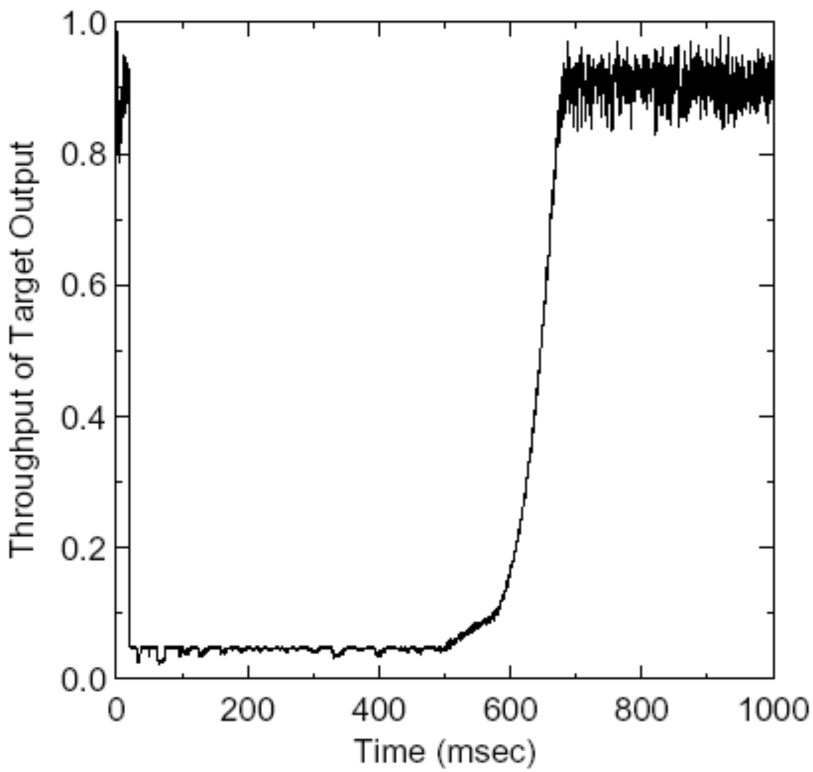


Most sources recover around 100 msecs, one source takes 200 msec

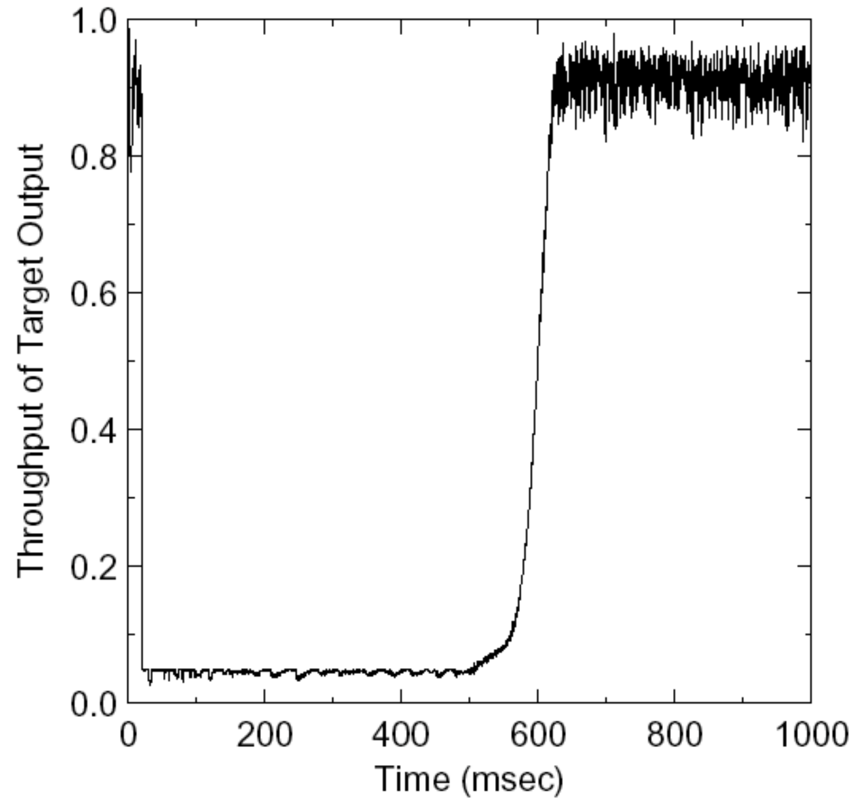
0.5G Bottleneck, Max source rate: 0.9G
Effect of straggler (this is random)



0.5G Bottleneck: Rate
Bernoulli sources, max offered rate 0.85G

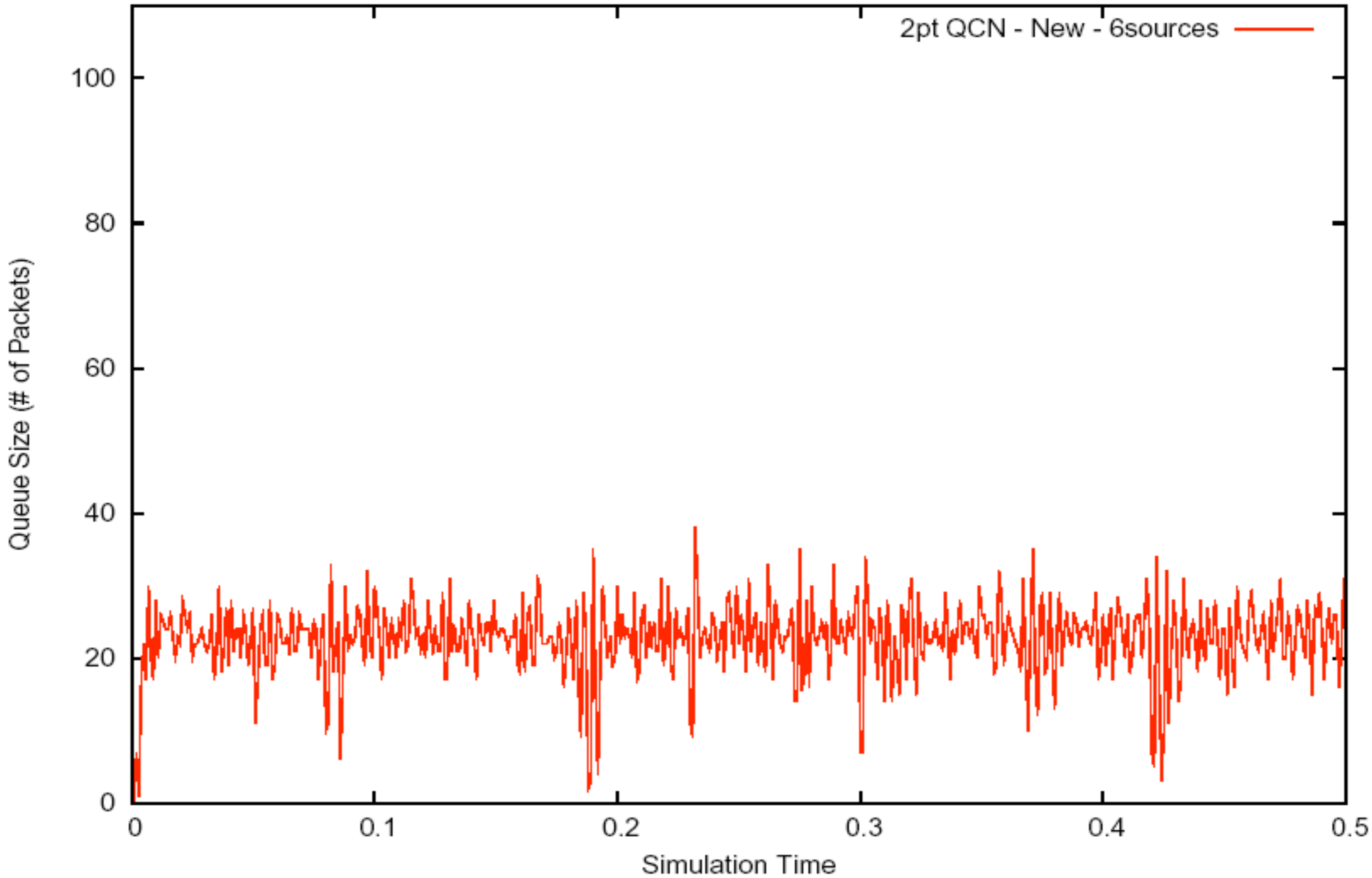


Without Fb-hat: 180 msec

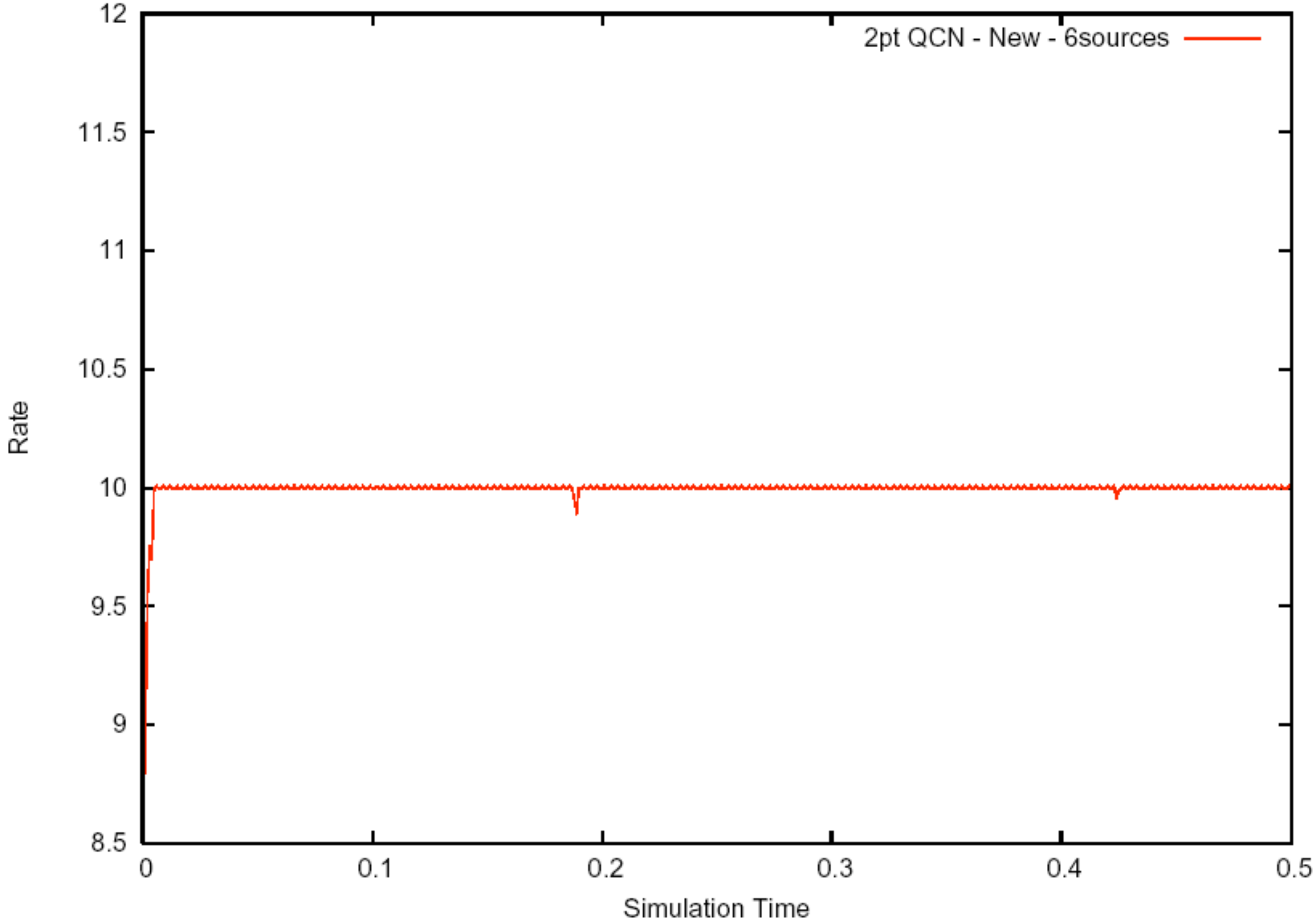


With Fb-hat: 110 msec

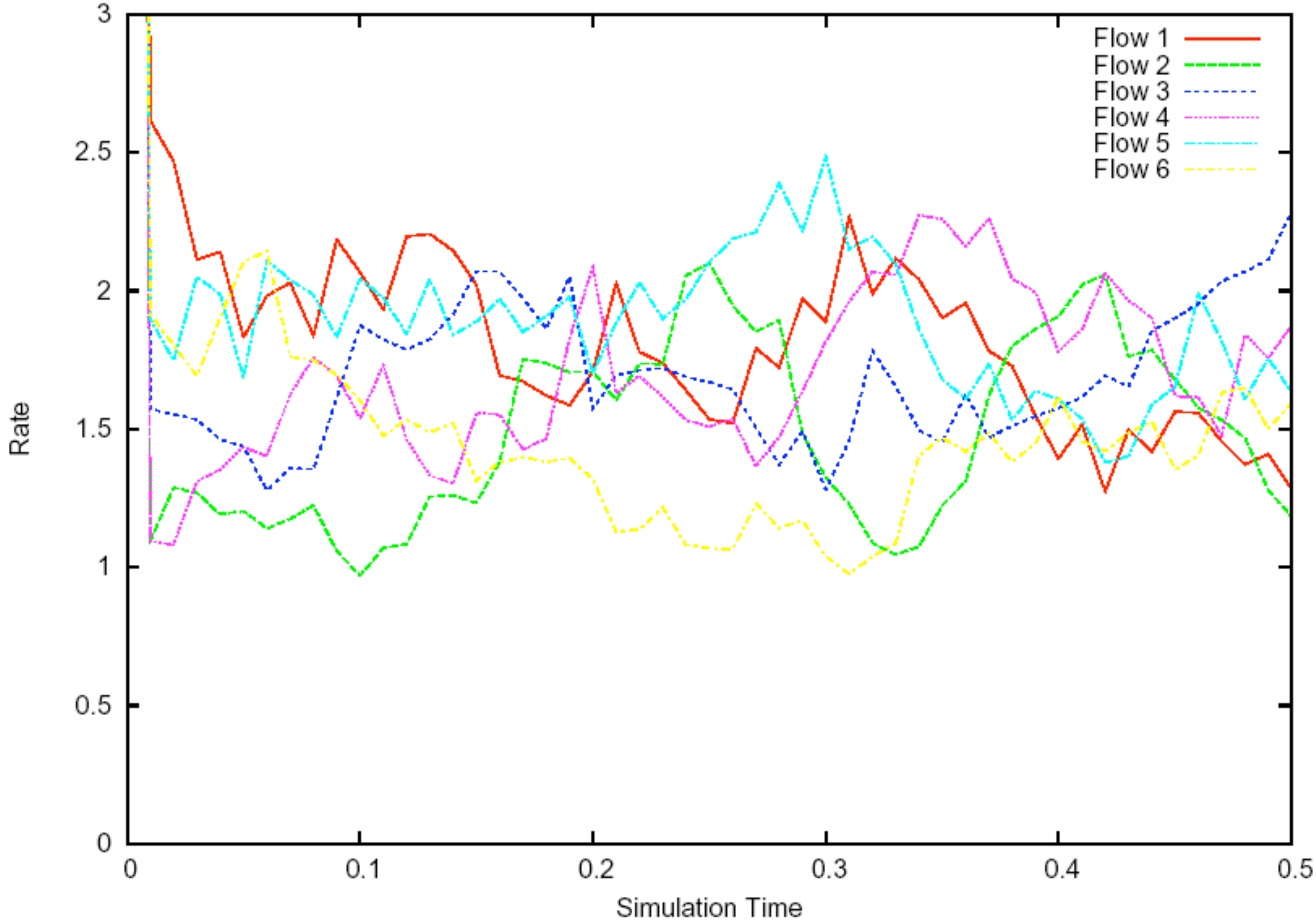
Sanity check: 6 sources sharing 10G link Queue size with cycle-shrinking



Sanity check: 6 sources sharing 10G link
Rate with cycle-shrinking



Sanity check: 6 sources sharing 10G link
Individual rates



A principle

- Introducing Fb-hat symmetrizes the source and switch behavior
  - Switch
    - Has input: Packets or source rates
    - Observes: Qoff, Qdelta
    - Goal: Drive Q to Qeq and Qdelta to zero
    - Action taken to achieve goal: Send Fb signals to sources
  - RL
    - Has input: Fb signals from network
    - Observes: Fb-hat
    - Goal: Drive Fb-hat close to zero (i.e. just above 1, the threshold)
    - Action taken: Change transmission rate

- This is like a primal-dual algorithm for congestion management
  - Primal variable, source rate: Input to switch but output from RL
  - Dual variable, Fb: Input to RL but output from switch

Distributed control

- A principle: The switch and source (or RL) pass just the right signals to each other so as to solve the global bandwidth partitioning problem in a distributed fashion

- Clearly, other algorithms can be obtained from this principle; e.g. we have tried
  1. Cycle lengths of 25, 50 and 100 pkts depending on Fb-hat values
  2. Stretching cycle lengths to 150 pkts if Fb-hat is large
  3. Letting Fb-hat go negative; this lets source know with more certainty that bdwdth is available

- As mentioned, these improvements reduce the transient response further (e.g. we had roughly 85 msec recovery time using option 1)
  – But they introduce slightly more work at the source and may affect the stability margin

- Overall, the approach promises to lessen the impact of not receiving explicit positive feedback at the source

Other work done

- Check stability with large number of sources (100, 200, 500…)
  - Want to ensure that cycle shrinking is essentially inactive in equilibrium; hence it is primarily useful only in transience
  - We have found this is indeed the case (sims next week)

- In conclusion, the principle of primal-dual control yielded a simple Fb-hat based algorithm for improving transient response
  - Refinements may improve the performance even more
  - However, it is good to be cautious and draw the line somewhere in trade-off space