Simulation Study of AQM Performance in DOCSIS 3.0

Greg White, CableLabs

ICCRG - IETF86

Simulation Overview

- Ns-2 simulation of a DOCSIS 3.0 CM provisioned with:
  - 20Mbps (DS) x 5Mbps (US) service,
  - Powerboost up to 50Mbps (DS) x 20Mbps (US)
- 255 test runs (each simulating 2 hours):
  - 5 different upstream buffer management algorithms
  - 17 total traffic/loading scenarios
  - 3 levels of upstream shared-link congestion
- 4 Application Metrics
  - Gaming traffic (latency/loss statistics)
  - Web Surfing (page load time)
  - VoIP Audio Quality (MOS)
  - TCP throughput (Mbps)

Buffer Mgmt Algorithms Tested

- "**Bufferbloat**" – A DOCSIS 3.0 modem with 610 kBytes of buffering
  - 1000 ms latency at provisioned data rate
- "**Buffer control**" - A DOCSIS 3.0 modem with Buffer Control enabled
  - 50 ms max latency (at provisioned rate)
- "**CoDel**" - A DOCSIS 3.0 modem w/ CoDel
  - 10ms target, 150ms interval
- "**SFQ-CoDel**" - A DOCSIS 3.0 modem w/ sfq_codel
  - 32 bins, 300byte quantum, 10ms target, 150ms interval
- "**PIE**" – A DOCSIS 3.0 modem w/ PIE AQM
  - 5 ms delay reference

Traffic/Loading Scenarios

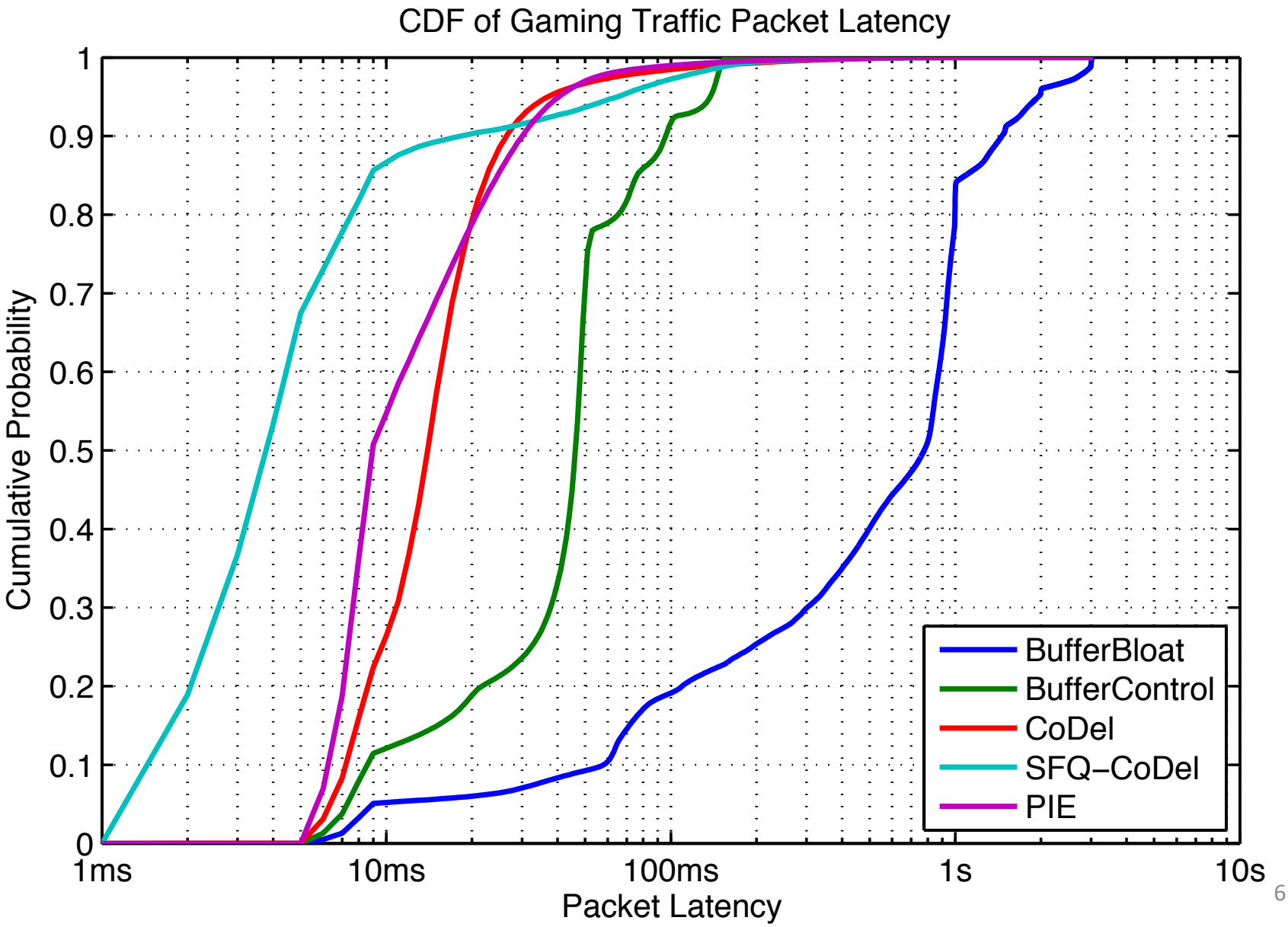
- Traffic Types
  - VoIP/gaming – 218 byte UDP pkts @ 20ms (87.2 kbps)
  - Web browsing – client downloads a 700 kB page (101 resources, 4 servers)
  - FTP – various TCP uploads
  - CBR – 1000 byte UDP pkts @ 8ms (1 Mbps)
  - BitTorrent – using LEDBAT congestion avoidance

- 17 different combinations, subdivided into three groups
  - Light Traffic (7 traffic scenarios), e.g.
    - 1 VoIP/gaming, 1 Web client
    - 1 VoIP/gaming, 1 Web client, 1 continuous FTP upload
  - Moderate Traffic (4 traffic scenarios), e.g.
    - 1 VoIP/gaming, 1 Web client, 5 simultaneous & repetitive FTP uploads
    - 1 VoIP/gaming, 1 Web client, 1 CBR, 5 simultaneous & repetitive FTP uploads
  - Heavy Traffic (6 traffic scenarios), e.g.
    - 4 VoIP/gaming, 4 Web client, 10 simultaneous & repetitive FTP uploads
    - 4 VoIP/gaming, 1 Web client, 32 BitTorrent sessions

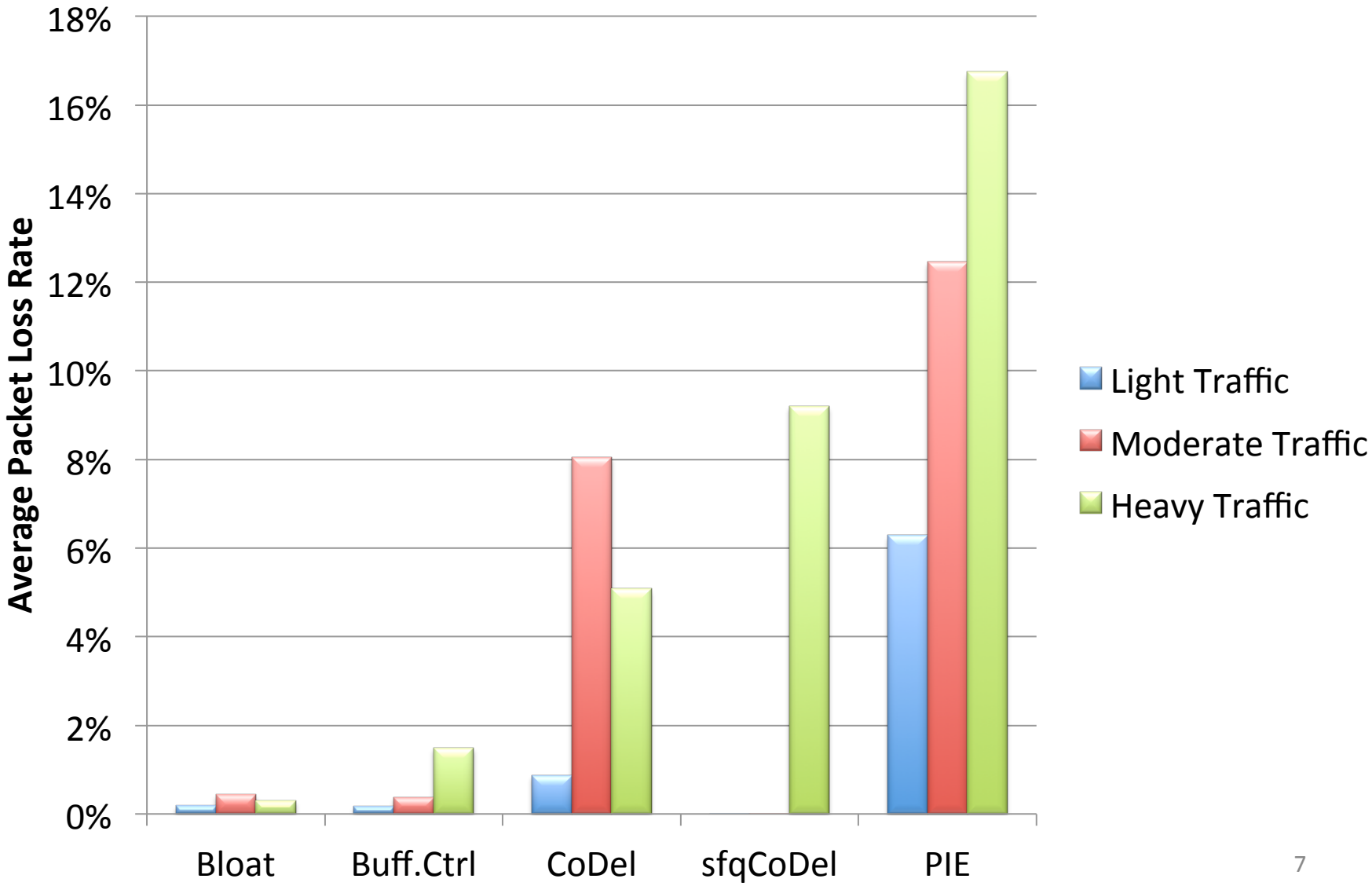
Shared-Link Congestion Model

- Competing upstream traffic from other cable modem customers
- 3 different scenarios:
  - No congestion
    - User is only limited by their provisioned data rates (5 Mbps w/ 20Mbps powerboost)
  - "Light congestion"
    - Free capacity on the upstream channel varies across 2.5 Mbps, 5 Mbps, 12.5 Mbps, 20 Mbps (average capacity 10 Mbps)
  - "Moderate congestion"
    - Free capacity on the upstream channel varies across 1.7 Mbps, 3.3 Mbps, 5 Mbps, 12.5 Mbps (average capacity 5.625 Mbps)

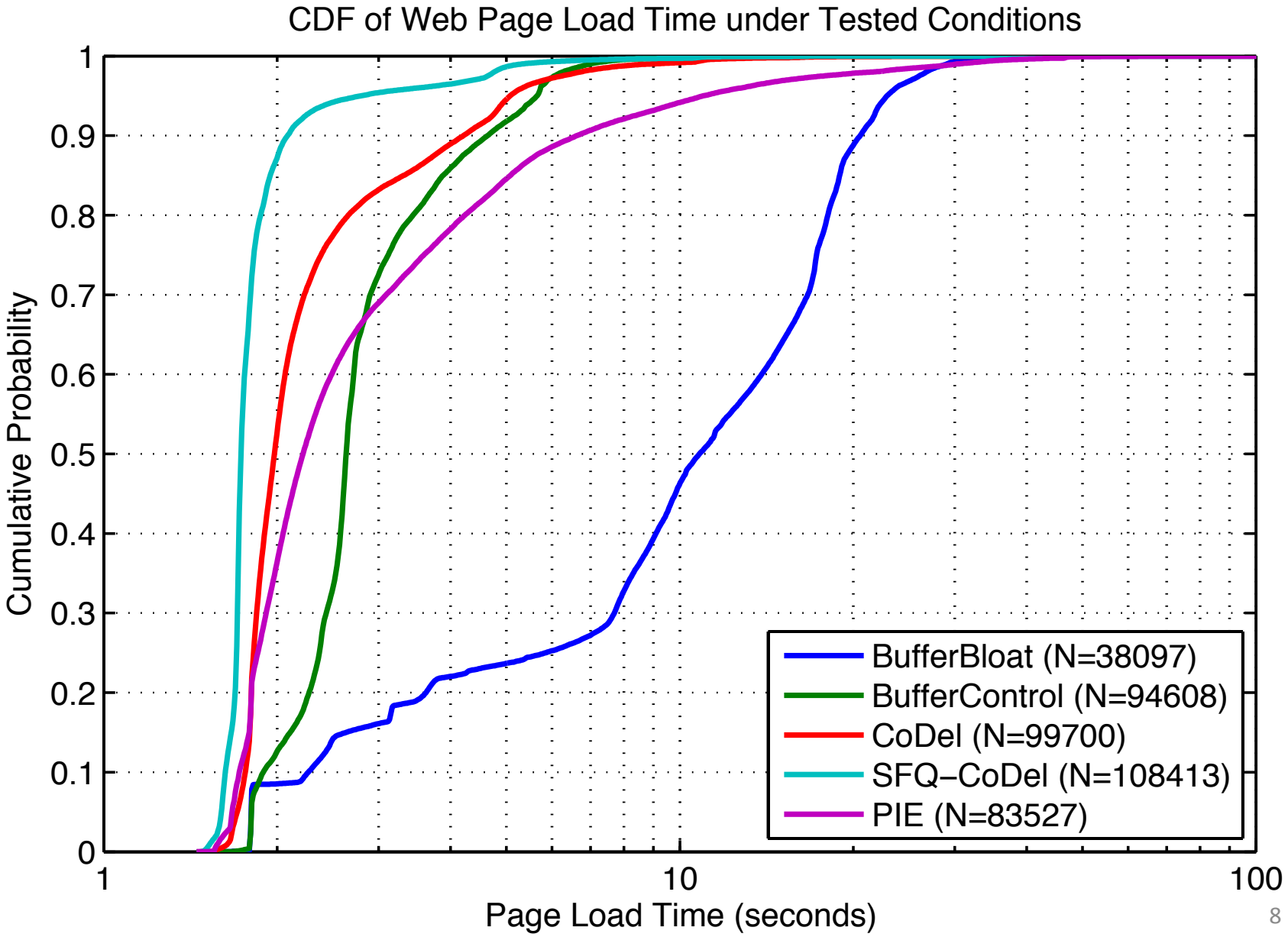
Gaming Latency



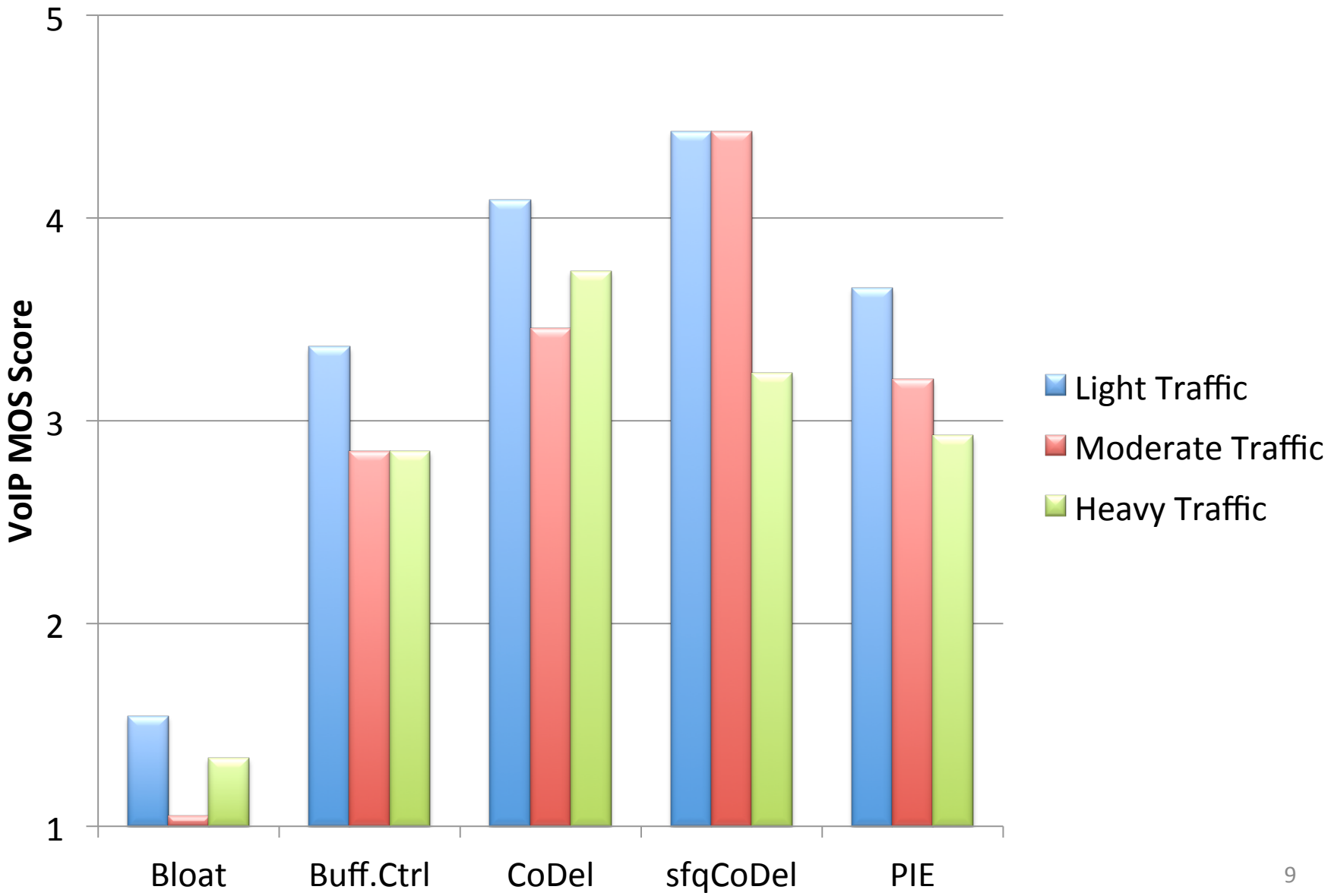
Gaming Packet Loss



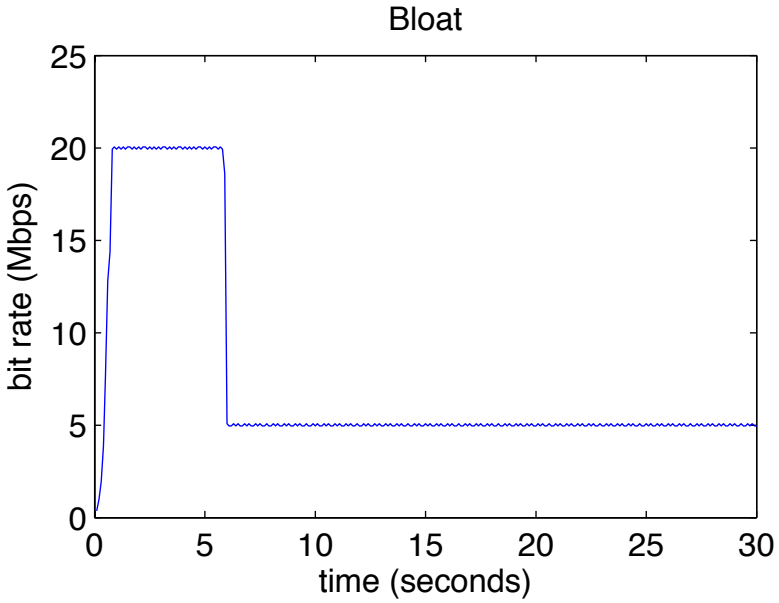
Web Page Load

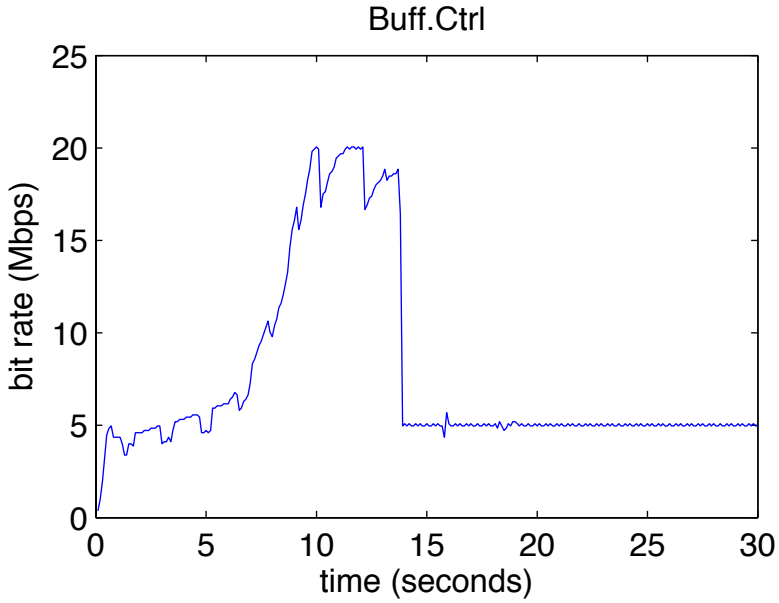


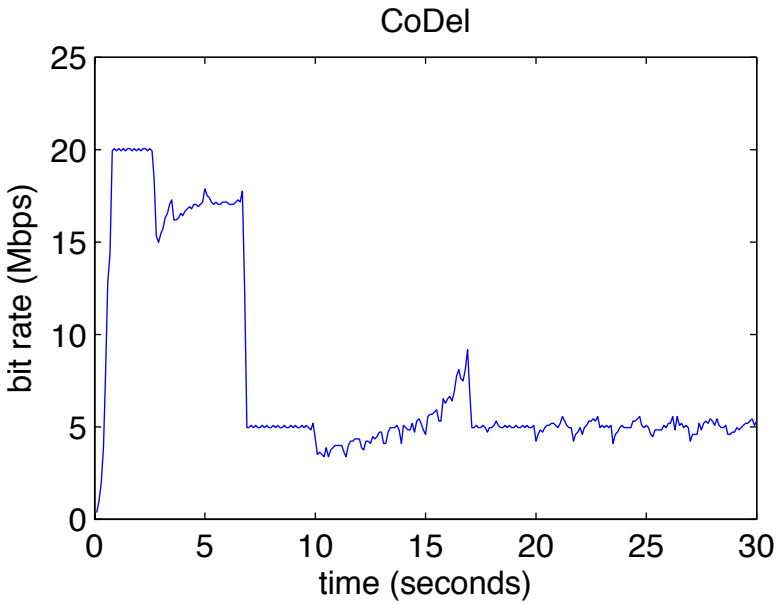
VoIP Audio Quality

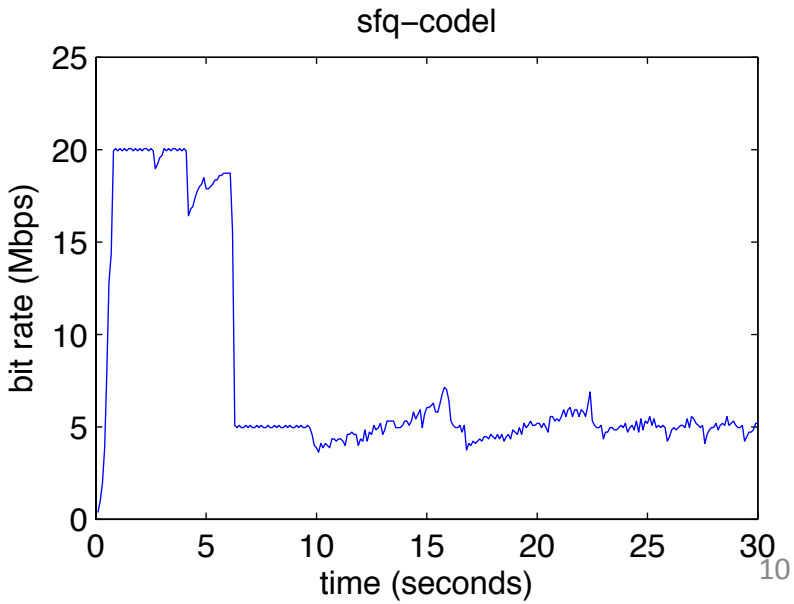


TCP short time scale

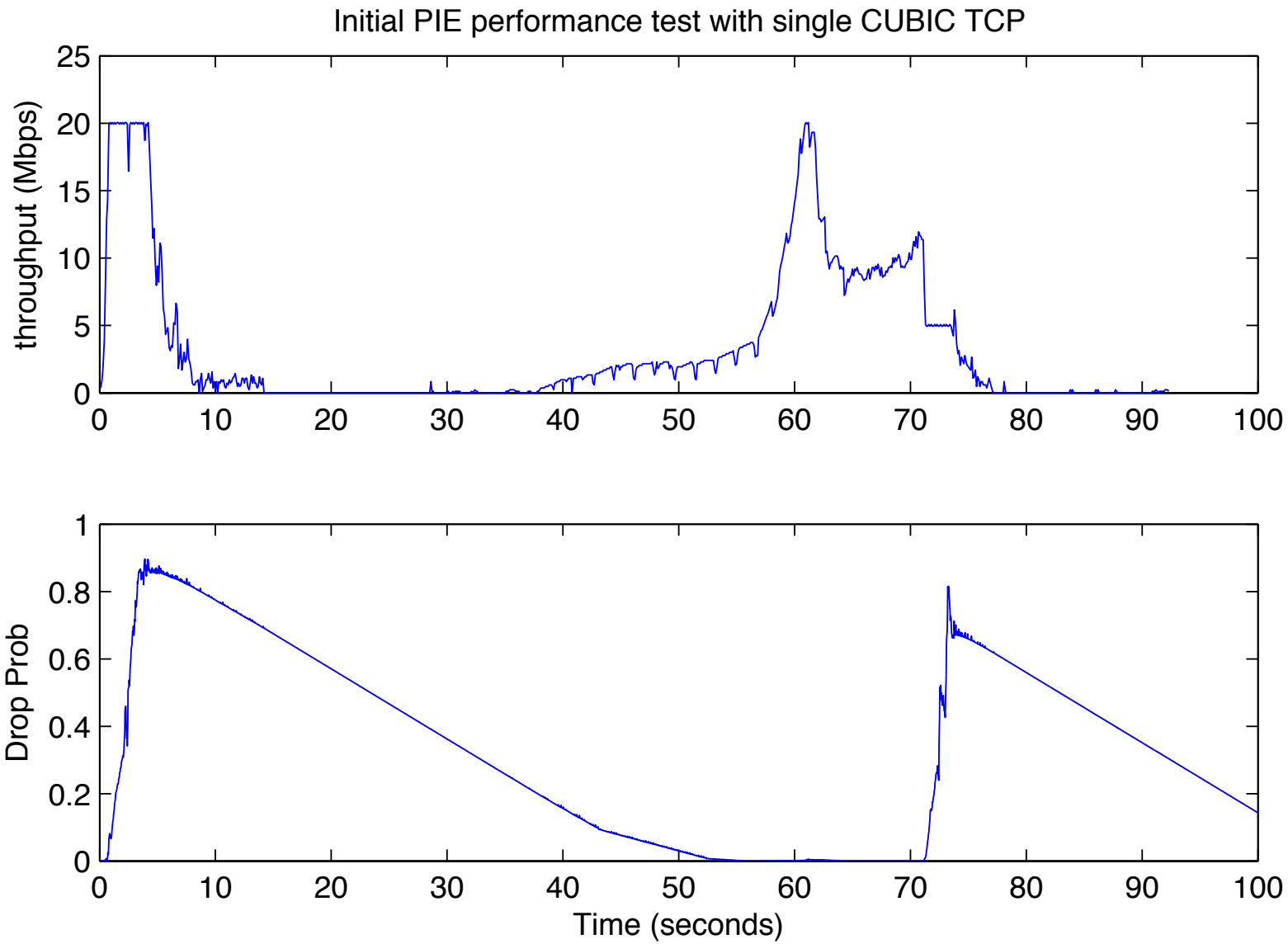




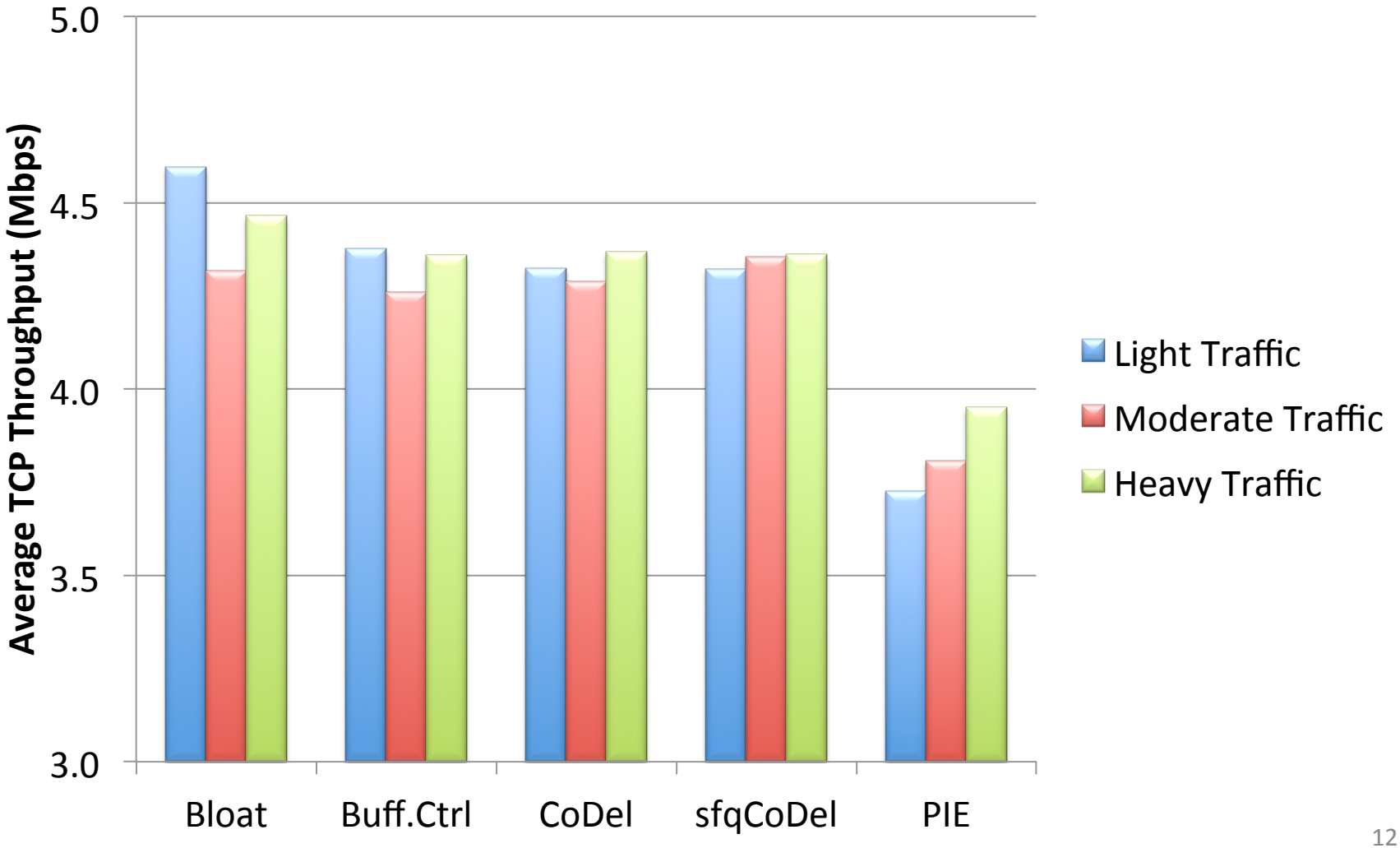




Initial TCP results with PIE



TCP Long Time Scale Performance



Wrap-up

- sfq-codel shows a lot of promise for improving user experience in cable networks
  - Issues with BitTorrent need further investigation
- More work is necessary to see if PIE can be made to work well for this application