ENSC 835: HIGH-PERFORMANCE NETWORKS
CMPT 885: SPECIAL TOPICS:
HIGH-PERFORMANCE NETWORKS

FINAL PROJECT PRESENTATIONS
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TCP Fairness Analysis of CUBIC TCP Simulated by NS-2

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Road Map

- Introduction
- Advanced TCP for High speed network
  - Approaches
  - BIC and CUBIC TCP
  - Brief review of TCP NEW RENO
- TCP Fairness
  - Fairness
  - Effects of Queuing Management
- Simulation
- Conclusions
- Future Work
- Reference

Introduction

- High Speed Network
  - The bandwidth of network rises up to 10Gbps
  - The network covers the long distance
  - ESNet, Abilene
- Current TCP faces difficulties in high speed network
  - Efficiency degrades when bandwidth-delay product increases
  - Oscillation problem
  - Problems with short flows

Approaches

- Improve congestion control based on current TCP
  - HSTCP, STCP

    HSTCP-S. Floyd, AIMD-based, STCP-Tom Kelly, MIMD-based
  - Fast TCP

    Steven H. Low's team, California Institute of Technology, delay based
  - BIC TCP, CUBIC TCP

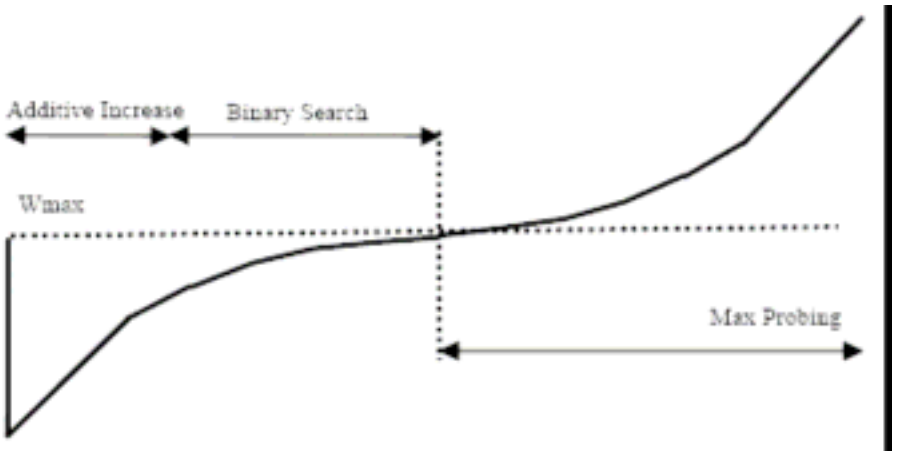
    Injong Rhee and Lisong Xu, North Carolina State University
  - HTCP

    D. Leith and R.N. Shorten, Hamilton Institute. Two modes: High speed and slow speed.
- Others
  - SABUL
  - XCP

BIC TCP

- Binary search
  1. When loss happens, calculate CWNDmin after loss using multiplicative decrease, CWND=CWNDmin
  2. Calculate a mid point between CWNDmax (CWND just before loss) and CWNDmin
  3. Set the mid point as target, Target=(CWNDmas+CWNDmin)/2
  4. If Target-CWND>Max setting, CWND=CWND+Max setting
  5. If Target-CWND<=Max Setting, CWND=Target, CWNDmin =Target, repeat step 2 to 5
  6. If CWNDmax-CWNDmin<Min Setting, CWND=CWNDmax and Binary search completes
- Two Stages
  - Max. Probe stage
  - Binary search stage
- Window Growth Pattern

(http://www.csc.ncsu.edu/faculty/rhee/export/bitcp/index.htm)



CUBIC TCP

- Cubic TCP is developed on BIC TCP
- Main reasons
  - The window control algorithm of BIC is too complicated.
  - BIC TCP could be too aggressive in slow network with short round trip time.
- Improvements
  - Use a cubic function to search CWnd
  - Involve a elapsed time since last loss when calculate CWnd

CUBIC TCP (Continue)

- Algorithm
  - When receive an ACK

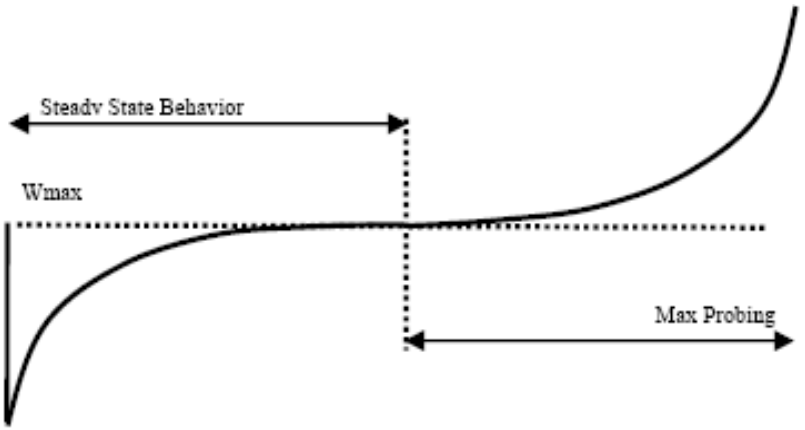
$$cwnd \leftarrow C(t-K)^3 + cwnd_{\max} \qquad K = \sqrt[3]{cwnd_{\max}\beta / C}$$

  - When loss happens

$$cwnd \leftarrow \beta \times cwnd_{\max}$$

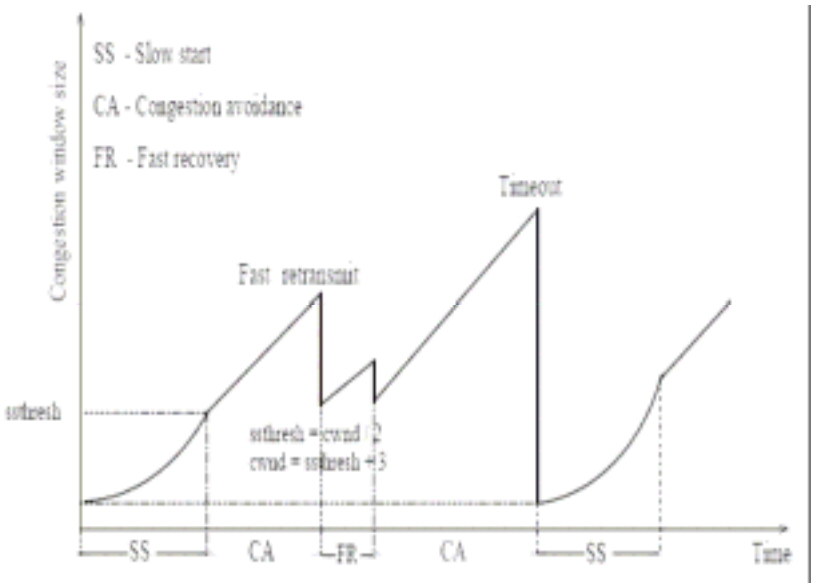
- Window Growth Pattern

(http://www.csc.ncsu.edu/faculty/rhee/export/bitcp/index.htm)



Brief Review of TCP New Reno

- TCP New Reno
  - Traditional congestion control algorithm
  - AIMD
  - Four Stages
    - Slow Start
    - Congestion Avoidance
    - Fast retransmit
    - Fast recovery



TCP Fairness

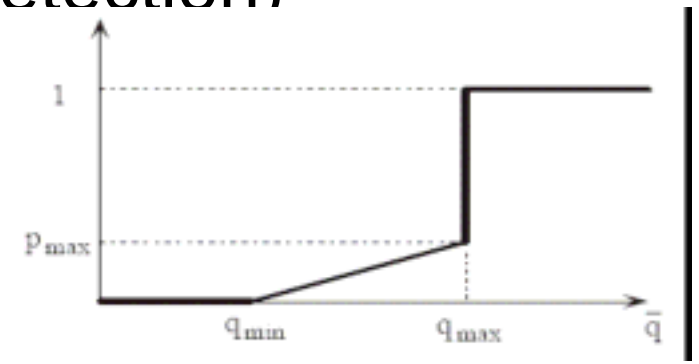
- TCP Fairness
  - When n flows connect to one link, each flow will share 1/n of total bandwidth
- Fairness ratio of two flows

$$FR_{ij} = Thru_i / Thru_j$$

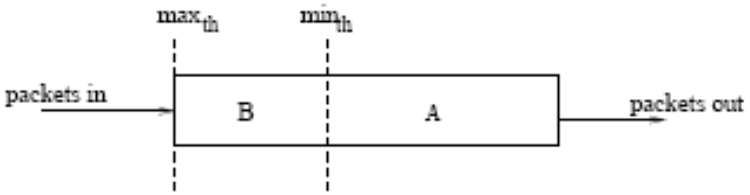
- Factors that affect Fairness
  - RTT: Throughput ratio of two flows is inversely proportional to the ratio of their RTTs
  - Queuing management
  - Link Capability

Queuing Management' Effect on TCP Fairness

- RED (Random Early Detection)
  - Algorithm:



  - Queue model



  - Effects on fairness
    - Flow with larger sending rate will have higher drop possibility

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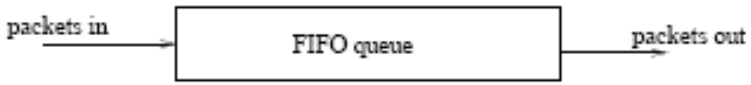
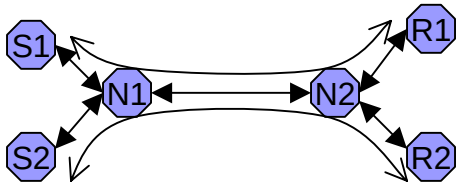
- Drop Tail
  - Algorithm
    - No packet drop if queue is not full
    - Drop all packet if queue is full
  - Queue model



  - Effects on fairness
    - Flow with higher sending rate will have more packets in queue

Simulation

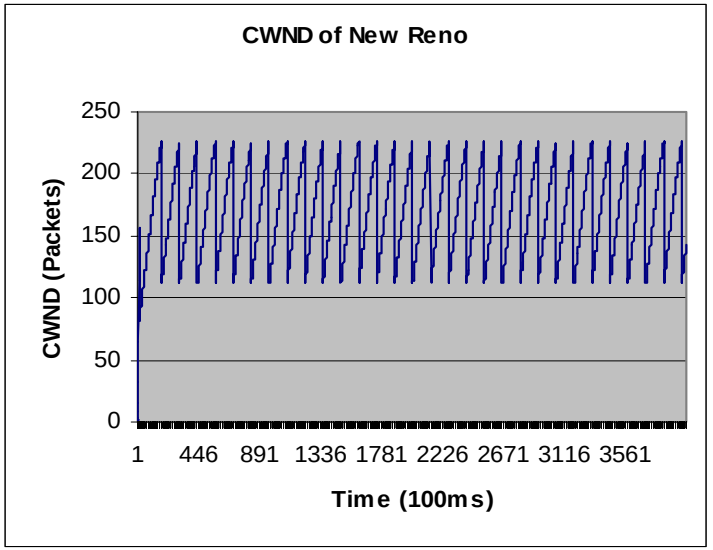
- Tool: NS-2.26 with CYGWIN
- Topology and assumption:
  - Two flows have same RRT

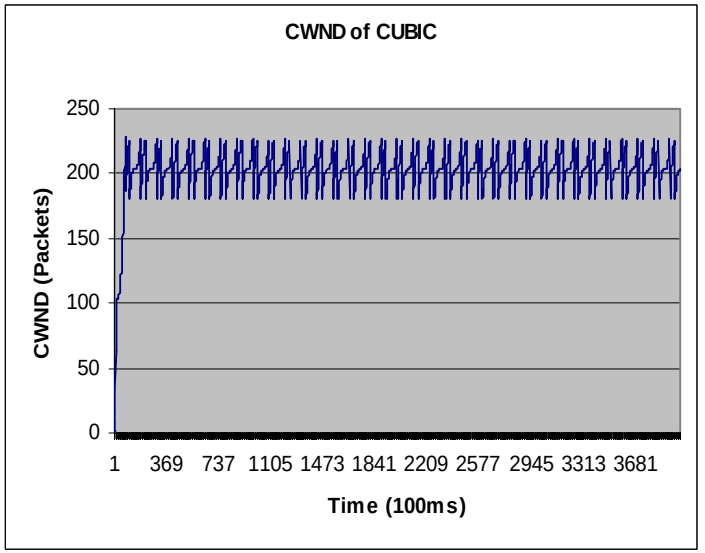


- What will be analyzed
  - Congestion window, throughput, fairness and link utility
- Scenarios and cases
  - 1. Validation
  - 2. RED and Drop tail
  - 3. Three cases with different start time.
  - 4. Two different bandwidths: 20MBPS and 1GBPS

Validation

Congestion Window Growth w.r.t. time:





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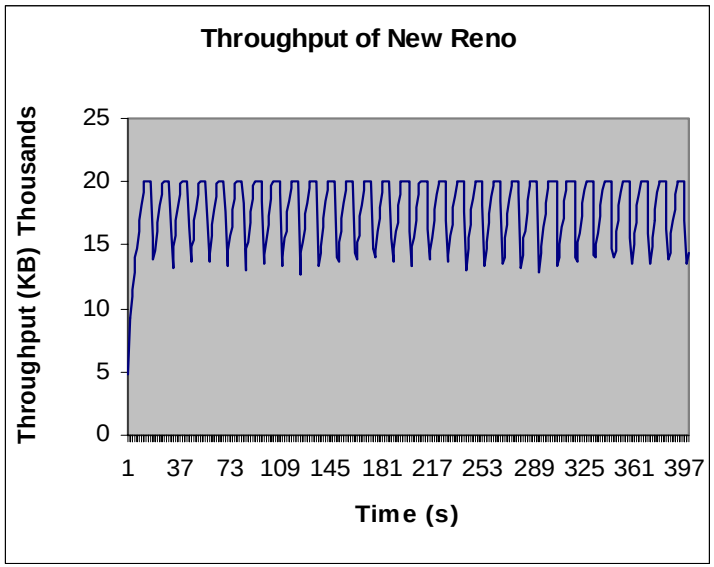
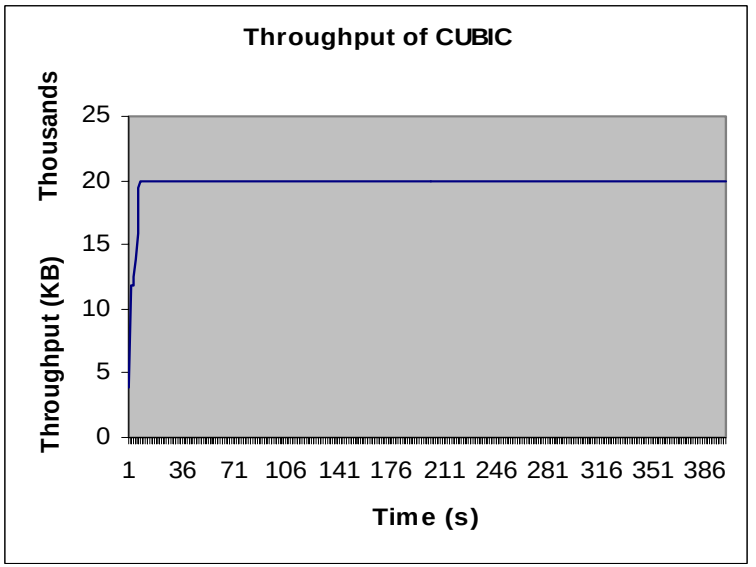
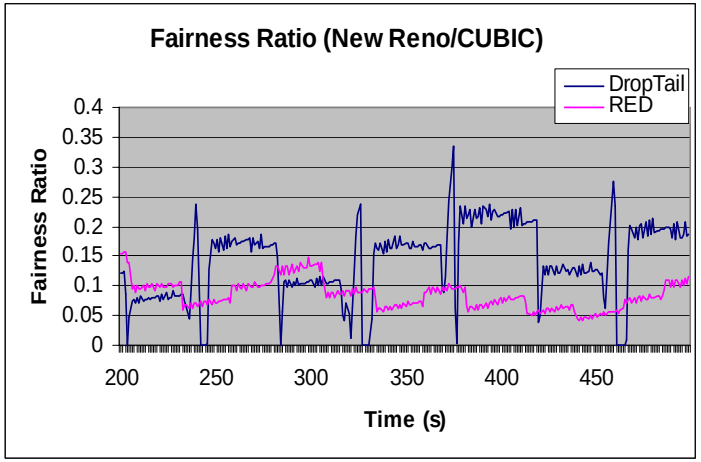
Link Utility: The average link utility of Cubic is 99.4%, the average of link utility of New Reno is 89.4%

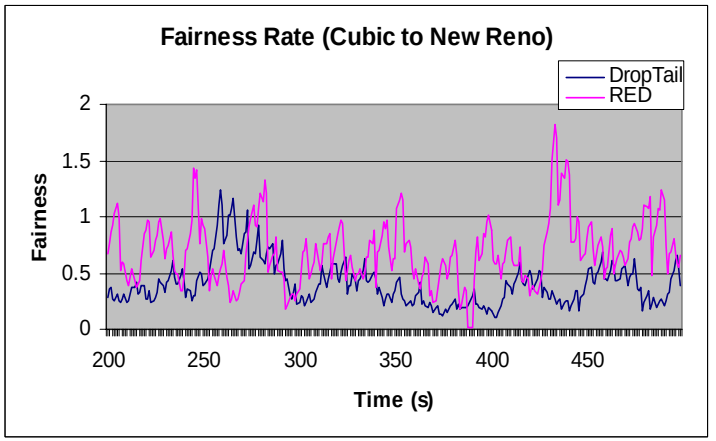




Simulation Result

- Fairness:
  - 1GBPS bandwidth, 100ms RTT
    - With RED: 0.09
    - With DropTail: 0.14
  - 20MB bandwidth, 100ms RTT
    - With RED: 0.69
    - With DropTail: 0.40





Conclusion

- The performance of CUBIC is better than that of TCP New Reno in oscillation and link utility
- In middle speed network, TCP fairness of CUBIC is better than that in high speed network
- Fairness will be a problem for CUBIC in high speed network
- Fairness of CUBIC with RED is a little bit better than that with DropTail in middle speed network but a bit worse in high speed network

Future Work

- Analyze fairness performance with other configuration of TCP parameters and queue type
- Compare fairness of other advanced TCP protocol

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