Experimental Evaluation of Gentle HighSpeed TCP

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Outline

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- Backgrounds of HSTCP & gHSTCP
- Why to evaluate in emulation networks
- Refined algorithm of gHSTCP
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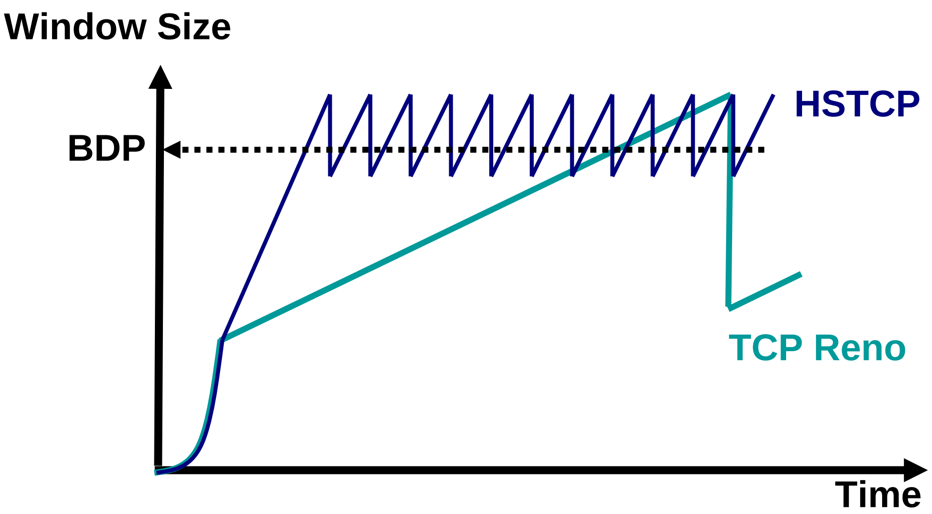
Introduction

- What’s wrong with TCP?
  - TCP was designed when T1 was a fast network.
  - It doesn’t perform well in fast long-distance networks (FLDNs) because of congestion window (CWND) algorithms.
- Solutions:
  - Traditional method: parallel TCP mechanism
  - New methods: new algorithms for updating CWND, e.g., HSTCP, Scalable TCP, FAST TCP.

HighSpeed TCP [3] (HSTCP)

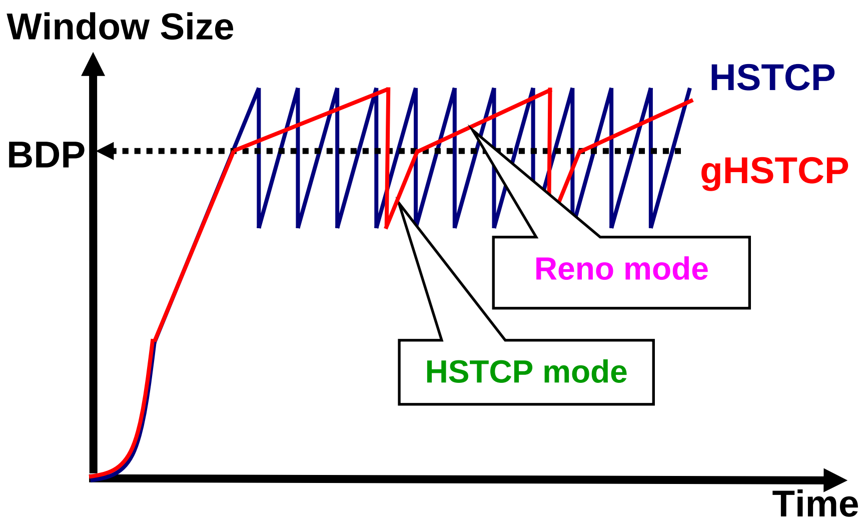
- HSTCP: a representative of high speed protocols.
- It uses the Additive Increase and Multiplicative Decrease (AIMD) principle.
- It may be easily deployed in the Internet.
- Currently, HSTCP is the only protocol recommended by *IETF* for FLDNs.
- However, unfairness is a drawback.



[3] S. Floyd, "HighSpeed TCP for large congestion windows," *RFC 3649*, December 2003.

Gentle HighSpeed TCP [1] (gHSTCP)

- gHSTCP addresses the issues of HSTCP.
- Based on HSTCP, using the observation of the packet transmission time and its RTT.
- Two modes in congestion avoidance phase:
  - positive correlation → Reno mode
  - otherwise → HSTCP Mode



[1] Z. Zhang, G. Hasegawa, and M. Murata, "Performance analysis and improvement of HighSpeed TCP with TailDrop/RED routers," *Proc. of MASCOTS 2004*, October 2004.

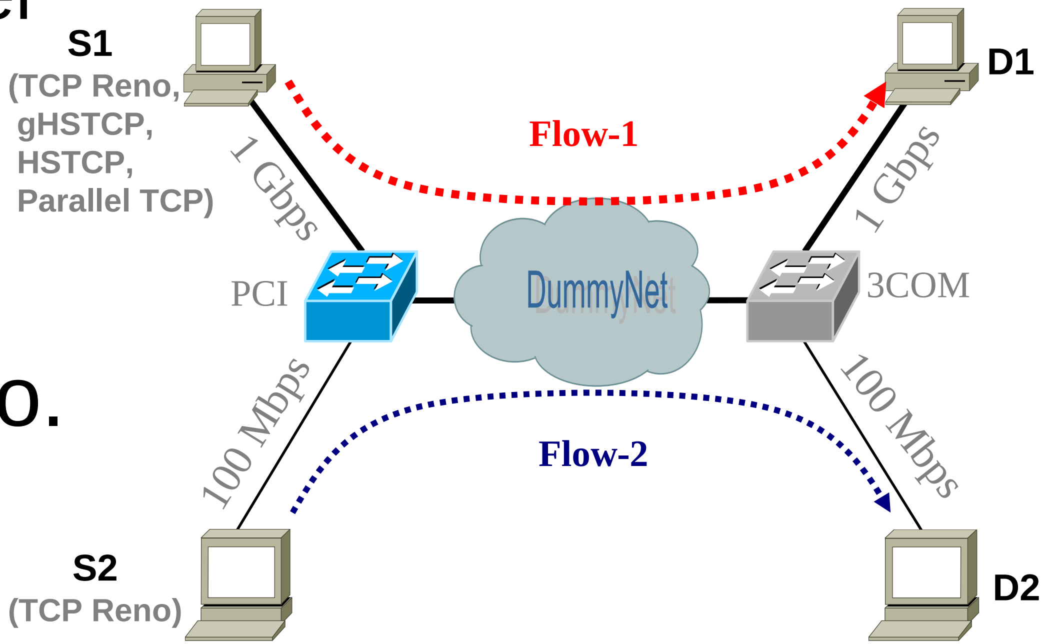
Simulation vs. Emulation (real network)

- Simulation condition is relatively ideal compared to real networks.
- gHSTCP is evaluated only by simulations [1].
- Is it suitable for real networks?
  – The heterogeneity of real networks, such as individual links, network equipments, protocols and applications.
  – Emulation network is more similar to a real network.
  – For applying in real networks, it is necessary to evaluate gHSTCP in emulation networks.

[1] Z. Zhang, G. Hasegawa, and M. Murata, “Performance analysis and improvement of HighSpeed TCP with TailDrop/RED routers,” *Proc. of MASCOTS 2004*, October 2004.

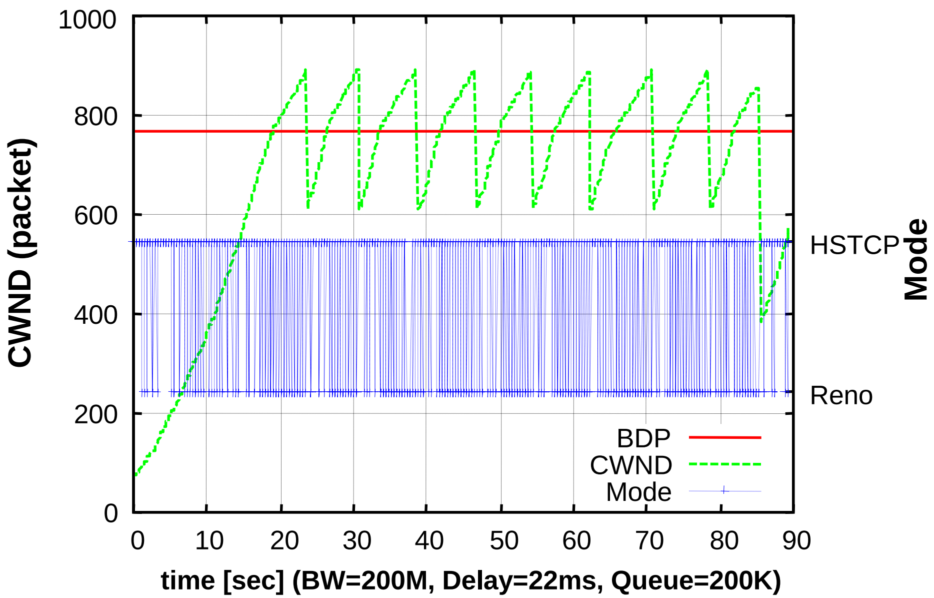
Settings of the emulation network

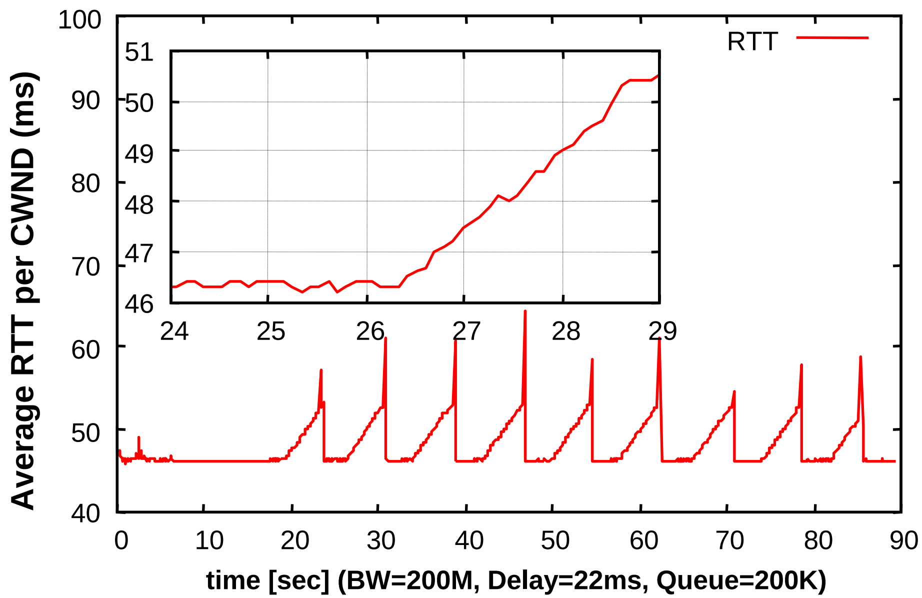
- Dummynet is used as the infrastructure.
- It can emulate:
  - bottleneck link bandwidth
  - bottleneck link delay
  - buffer size of router
- TCP stack of S1 is different in each experiment.
- S2 uses TCP Reno.



Validation of the gHSTCP algorithm

- Only Flow-1 exists, S1 uses gHSTCP.
- Problem: RTT's oscillations lead to unnecessary mode switching behavior.
- Lower ability for catching bottleneck link bandwidth and unfairness against competing TCP Reno traffic.





Refined algorithm of gHSTCP

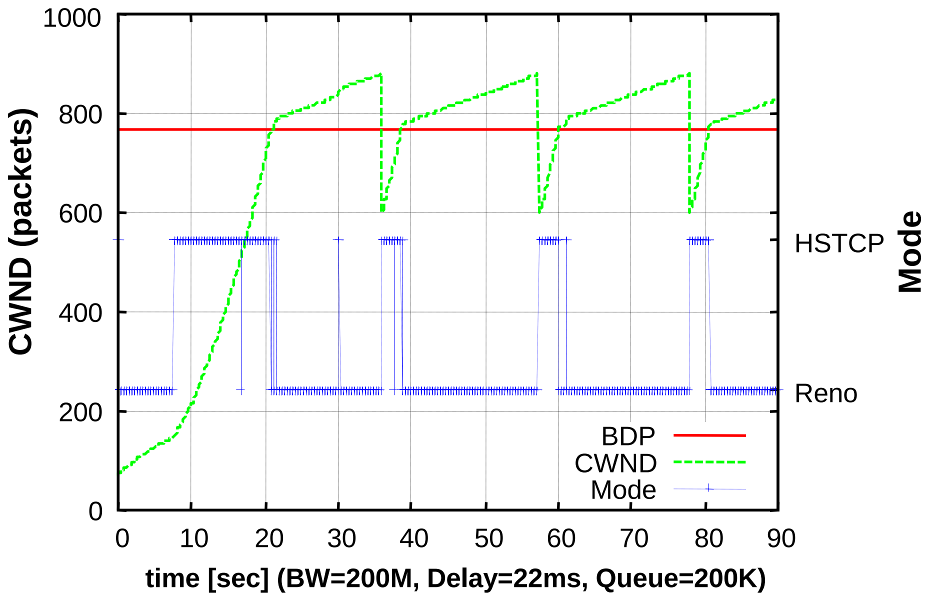
Idea: RTT is larger than propagation delay
when link bandwidth is fully utilized.

Notation: RTT_min is minimum of average RTT in 1-cycle.
RTT_std is standard deviation of RTT.

If RTT < RTT_min + 2*RTT_std
HSTCP mode is used.
If RTT >= RTT_min + 2*RTT_std and
RTT < RTT_min + 4*RTT_std
(using the original algorithm of gHSTCP)
the mode is decided by the RTT trend.
If RTT >= RTT_min + 4*RTT_std
Reno mode is used.

Result of the refined algorithm

- If CWND < BDP
  - gHSTCP can catch link bandwidth as quickly as the original HSTCP.
- If CWND > BDP
  - gHSTCP can provide better fairness with respect to competing TCP Reno flows.



Test gHSTCP in emulation network

- Metrics of evaluation:
  - Throughput
  - Utilization
  - Fairness (Jain's fairness index)
- Two scenarios
  - Scenario-1: BW = 100 Mbps, delay = 23 ms, buffer of router = 200 Kbytes.
  - Scenario-2: BW = 200 Mbps, delay = 23 ms, buffer of router = 500 Kbytes.
- Flow-1 uses TCP Reno/gHSTCP/HSTCP/parallel TCP
- There are 2 TCP Reno connections in Flow-2. The socket buffer size is set to 64 KB or 512 KB in each experiment, respectively.

Results (Scenario-1)

- BW of bottleneck = 100 Mbps, Buffer of router = 200 Kbytes.
  - Exp-1: S1 uses TCP Reno
  - Exp-2: S1 uses gHSTCP
  - Exp-3: S1 uses HSTCP

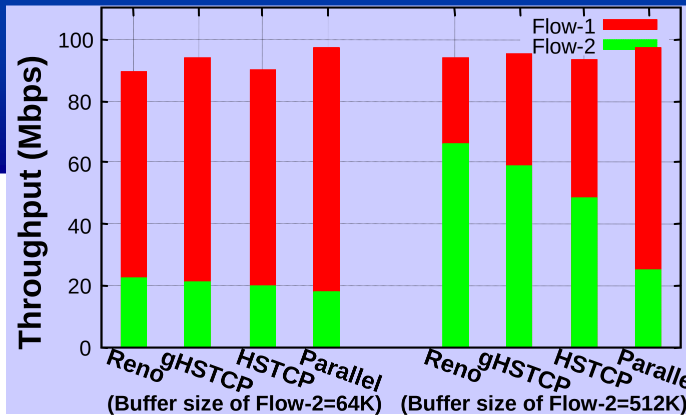
When the buffer size of S2 is set to 512 Kbytes:

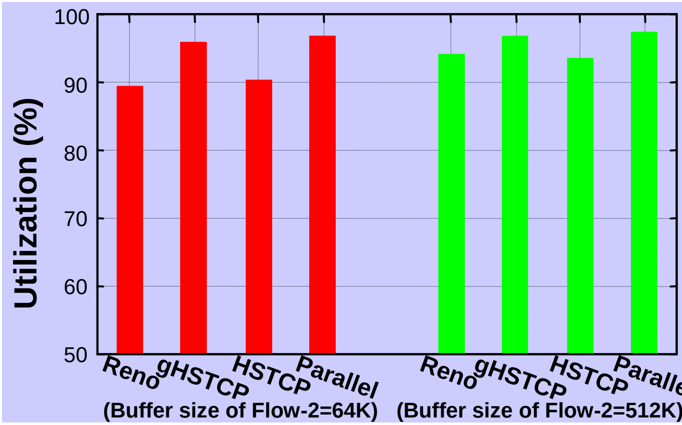
• All of utilization is larger than 90%.

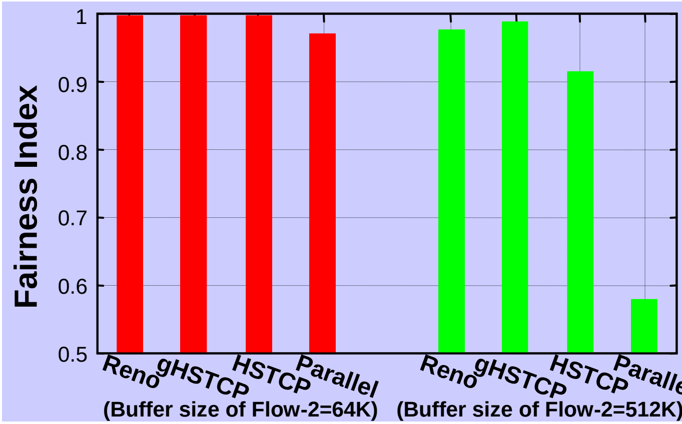
• The fairness is determined by the algorithms of TCP and the competing flows.

• The fairness is very poor when parallel TCP is used.

• gHSTCP outperforms HSTCP in terms of utilization and fairness.







Results (Scenario-2)

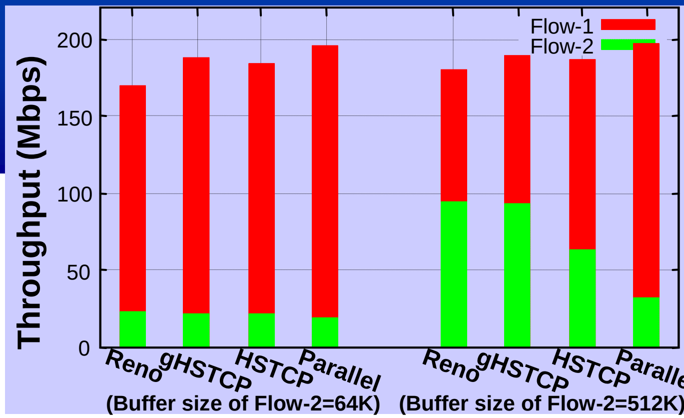
- BW of bottleneck = 200 Mbps,
- Buffer of router = 500 Kbytes.
  - Exp-5: S1 uses TCP Reno
  - Exp-6: S1 uses gHSTCP

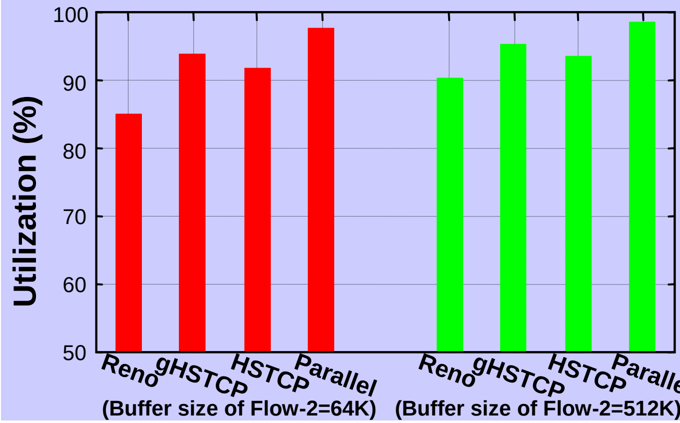
On the whole, the utilization and fairness trends are the same as those demonstrated in Scenario-1.

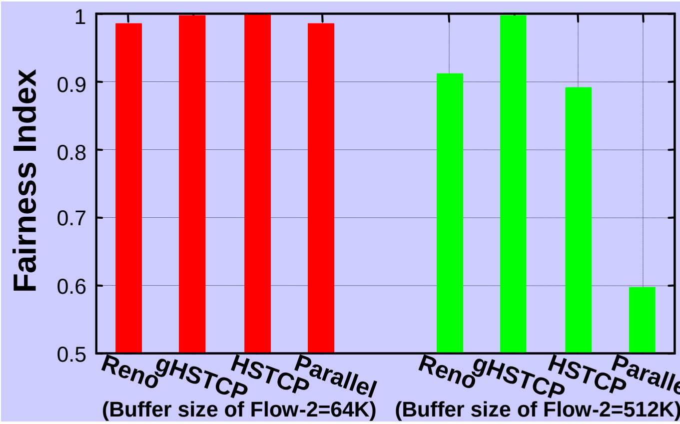
• Parallel TCP achieves the best utilization, but the worst fairness.

• gHSTCP offers higher utilization and better fairness than the other protocols.

• That is, gHSTCP is the best tradeoff in terms of link utilization and fairness.







Conclusions & Future works

- The refined gHSTCP algorithm is proposed.
- The performances of TCP Reno, HSTCP and gHSTCP are evaluated experimentally.
- The parallel TCP mechanism is evaluated as a candidate for FLDNs.
- gHSTCP offers the best tradeoff in terms of utilization and fairness.
- Future works
  - Test with Active Queue Management (AQM).
  - Test in a higher speed network and the Internet.
  - Evaluate parallel TCP by analysis.