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Characterizing Slow Start in High Speed Networks

Kazumi Kumazoe (HMC), Dirceu Cavendish
Masato Tsuru, Yuji Oie

Kyushu Institute of Technology, Japan

Mario Gerla

University of California, Los Angeles, USA

Motivation

Motivation

Characterize Slow Start impact on transactional applications in high speed network scenarios. Previous slow start efforts focused on avoiding large packet losses at the Slow Start to Congestion Avoidance transaction.

Previous effort

Conservative Slow Start
- Initially ramps up exponentially, as in Reno.
- Collects RTT information from segments sent, to measure the level of congestion.
- Reduces the congestion window speed of growth, once congestion build up is detected

Goal

Investigate the impact of speeding up and slowing down slow start on applications' performance.

dirceu@ndrc.kyutech.ac.jp Dirceu Cavendish

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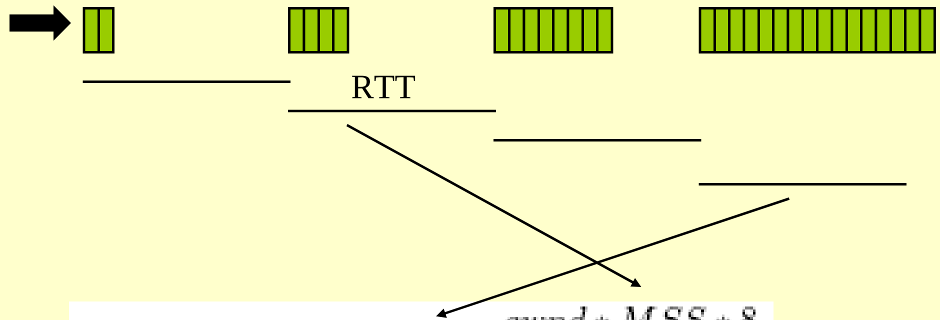
Anatomy of Slow Start

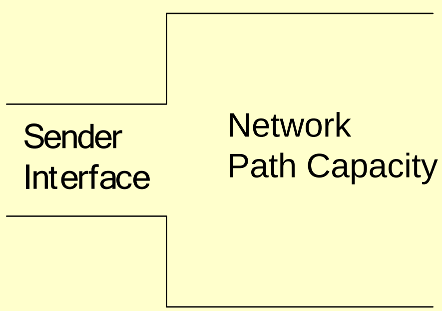
ON/OFF ramp up



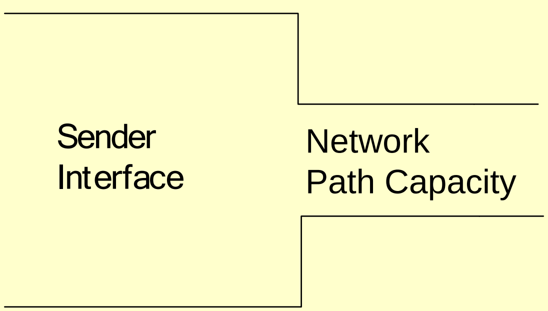
Throughput

$$th(cwnd) = \max(intSpeed, \frac{cwnd * MSS * 8}{RTT})$$

Path Capacity Scenarios



Capacity expansion



Capacity reduction

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Slow Start Variants

Quick Start with no pacing

- -Path capacity
  - -By design – quick start without pacing
- -Congestion window adjustment
  - Single session: $cwnd = \frac{intSpeed * RTT}{MSS * 8}$

Explicit Rate/Quick Start

-Signaling protocol inquires about a specific rate that is appropriate early in the session set up.

-With pacing.

Limited Slow Start

- Slower than Jacobson's cwnd ramp-up

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Slow Start Experiments

Application
- -Http transactions of 1GByte files.
- -Httperf for HTTP traffic generation

High Speed Transoceanic Experiments
- -Kyushu (Japan) to Chicago and North Carolina end points – 180/220msec RTT
- -100M, 1G, 10G interfaces

Performance Measurers
- -Transaction completion time
- -Packet losses/retransmissions

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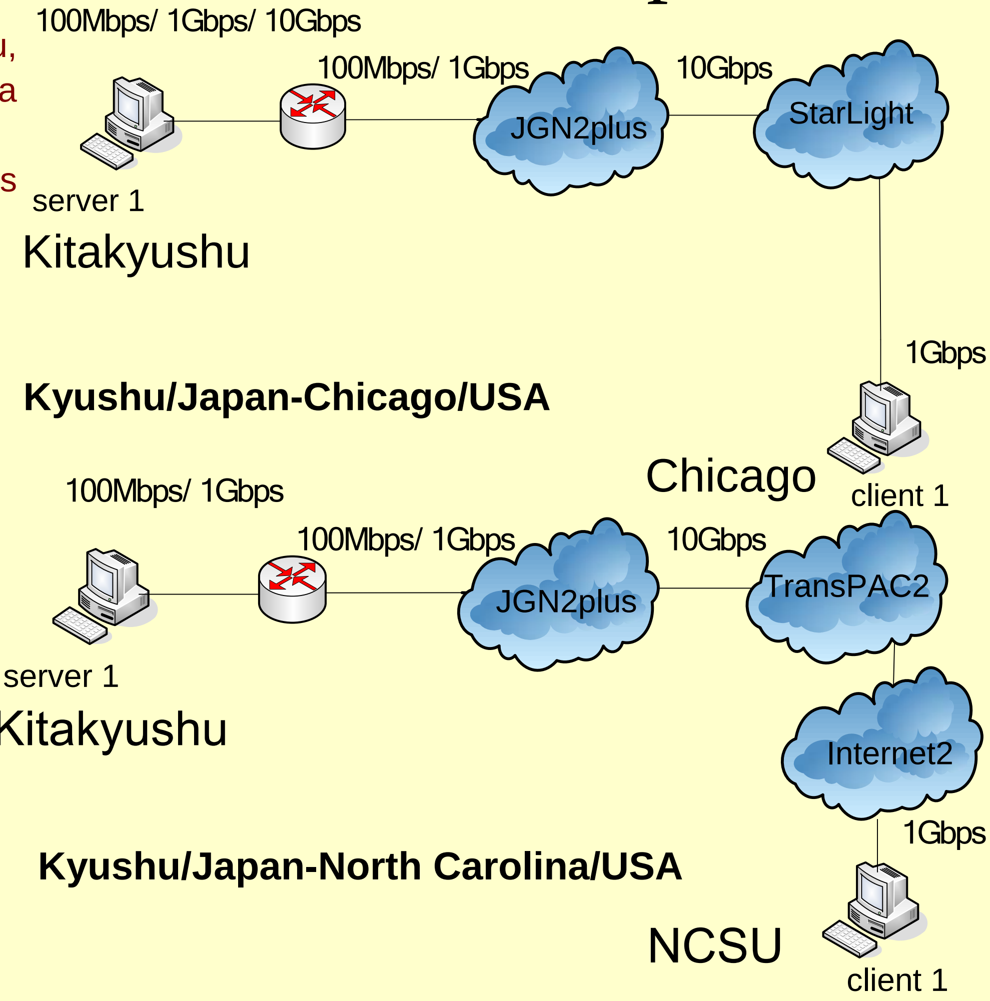
Transoceanic Experiments

Three sites: Kitakyushu, Chicago, and North Carolina

RTTs of 180-220msecs



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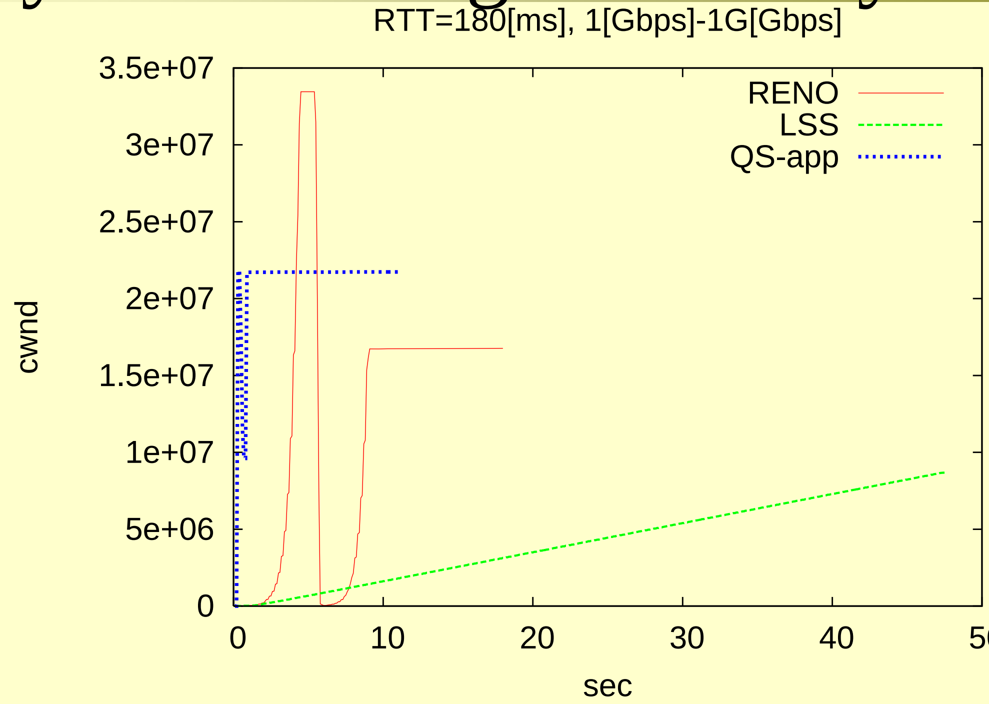
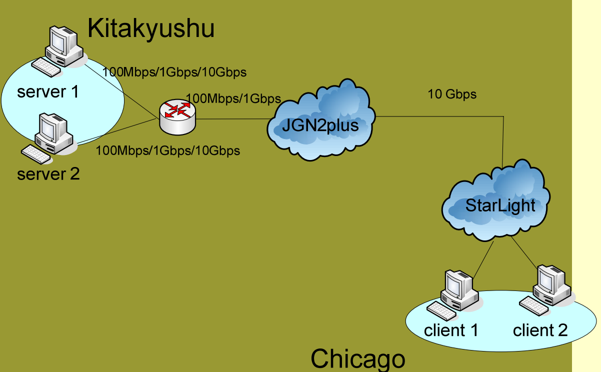
Kyushu-Chicago: cwnd dynamics

Uniform Path Capacity Scenario





NETWORK SCENARIO
1Gbps narrowest link
Short/long RTTs
-KIT/Chicago : 180msecs

Single flow traffic scenario
Large socket buffers
Httperf application

-Capacity expansion scenario

-Quick Start (no pacing) completion time is half of Reno, and one fourth of Limited Slow Start.

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Transaction Completion Time

Motivation & Goal

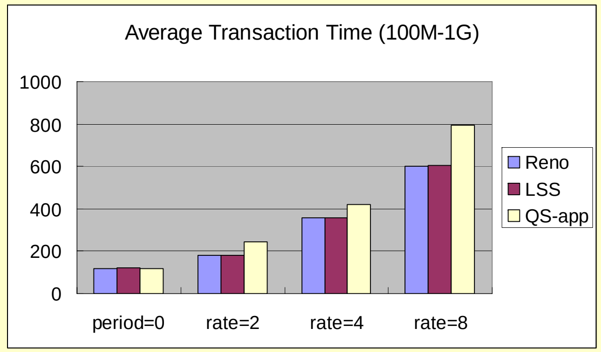
Anatomy of Slow Start

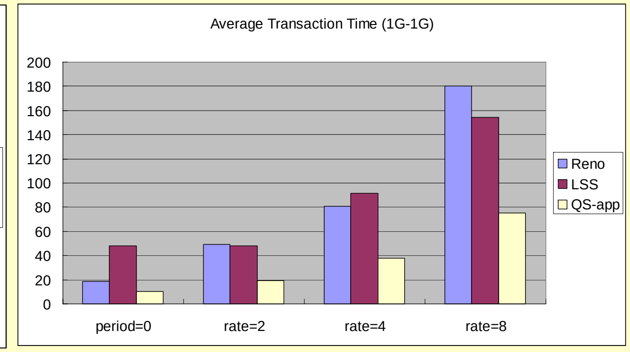
Slow Start Variants

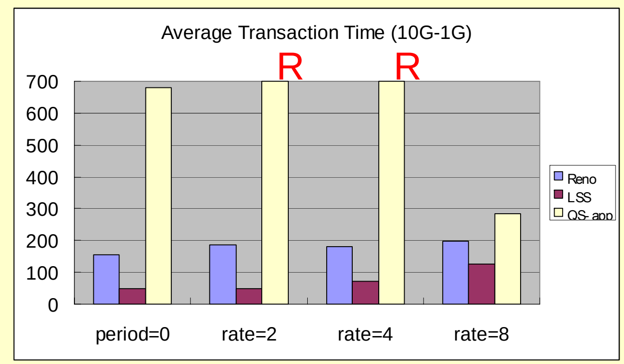
High Speed Experiments

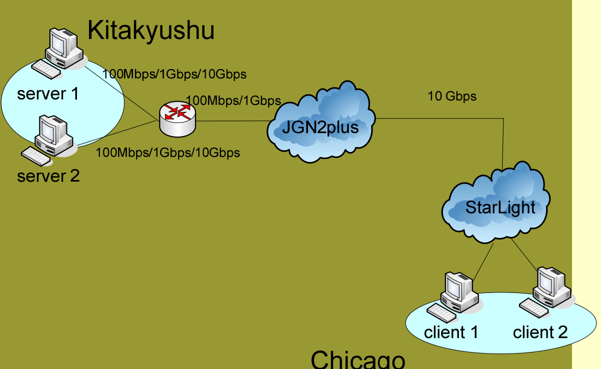
Evaluating Pacing

Final Remarks









NETWORK SCENARIOS
100M, 1G, 10Gbps bottleneck link
Long RTTs
-KIT/Chicago : 180msecs
Large socket buffers
Httperf application

-Capacity expansion scenario

-Quick ramp-up shortens transaction completion time

-Capacity reduction scenario

-Large transaction completion time if cwnd is set too high

-TCP sometimes does not recover from losses – it resets for QS-app

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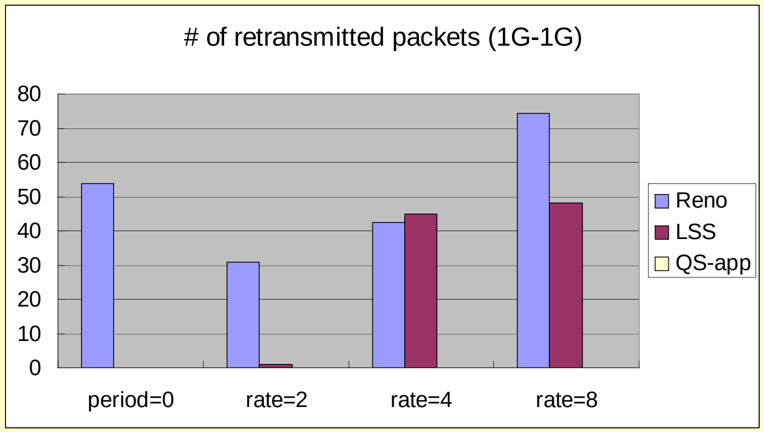
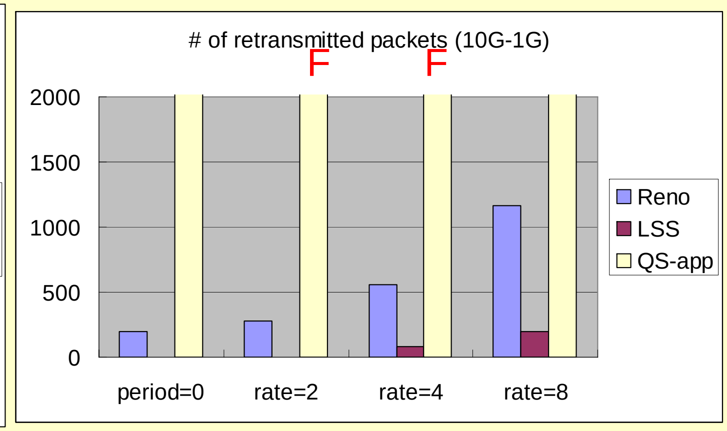
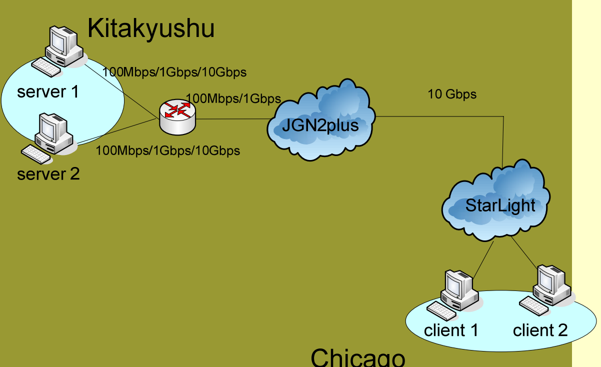
Packet Retransmissions







NETWORK SCENARIOS
100M, 1G, 10Gbps bottleneck link
Long RTTs
-KIT/Chicago : 180msecs
Large socket buffers
Httperf application

-Capacity expansion scenario

-Reno has more retransmissions, because cwnd reaches larger values (exp increase) than LSS and QS-app.

-Capacity reduction scenario

-Large number of retransmissions if cwnd is set too high

-LSS has least number of retransmissions

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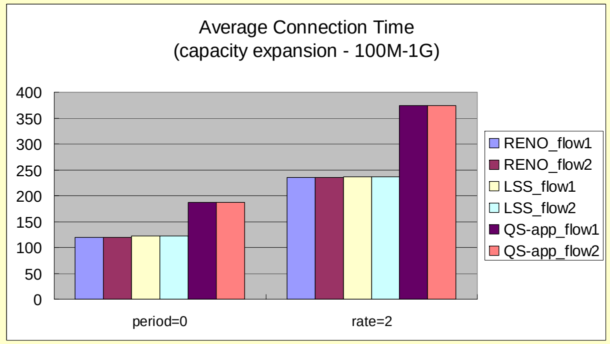
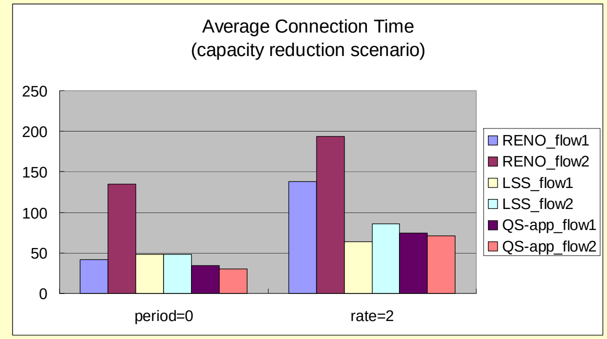
Multiple Server Scenario

Transaction Completion Time





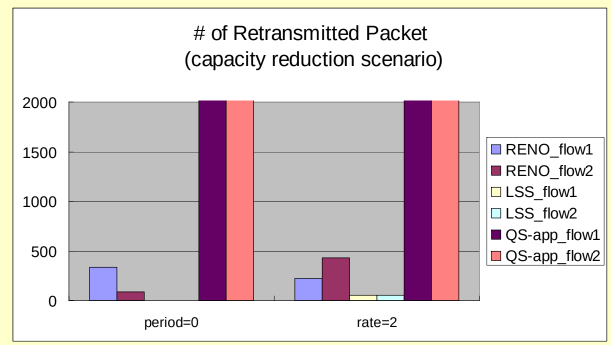
Packet Retransmission

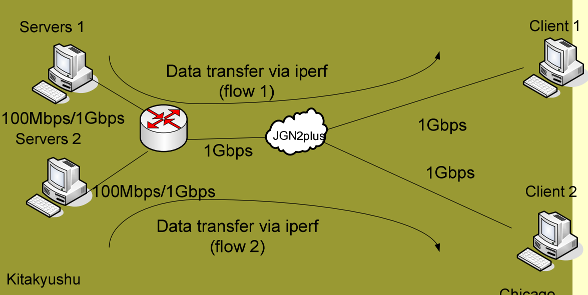
-Capacity expansion scenario

-Reno and LSS perform similarly

-Capacity reduction scenario

-Limited Slow Start has lowest packet loss/retransmissions





NETWORK SCENARIOS
100M, 1G, 10Gbps bottleneck link
Long RTTs
Flow1 first
-KIT/Chicago : 180msecs
Large socket buffers
Httperf application

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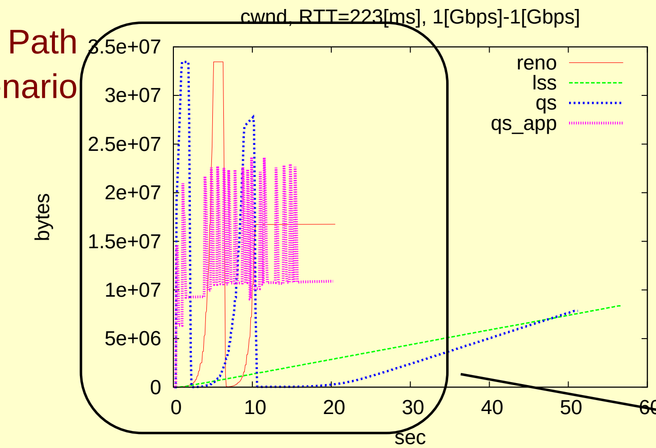
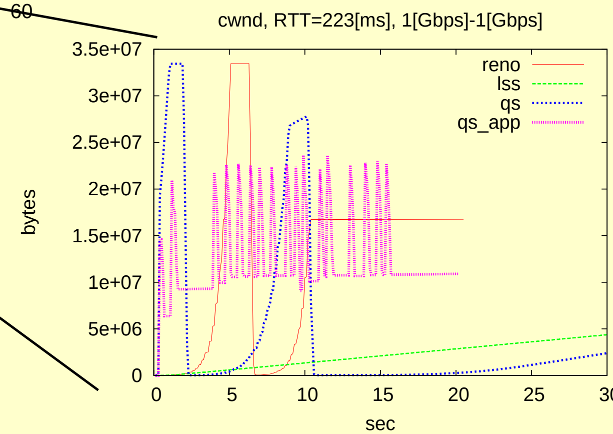
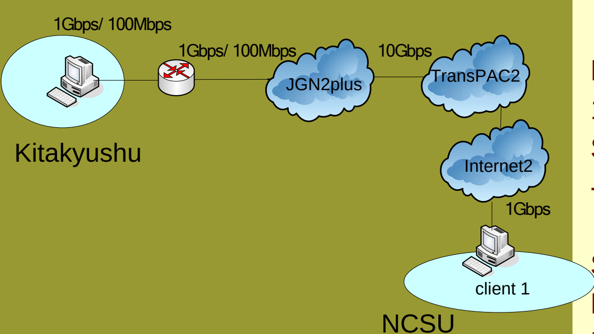
Kyushu-North Carolina: cwnd dynamics

Favorable Path Capacity Scenario







NETWORK SCENARIO
1Gbps narrower link
Short/long RTTs
-KIT/NCSU : 220msecs

Single flow traffic scenario
Large socket buffers
Httperf application

Capacity expansion scenario

-Quick Start and LSS have largest transaction completion time

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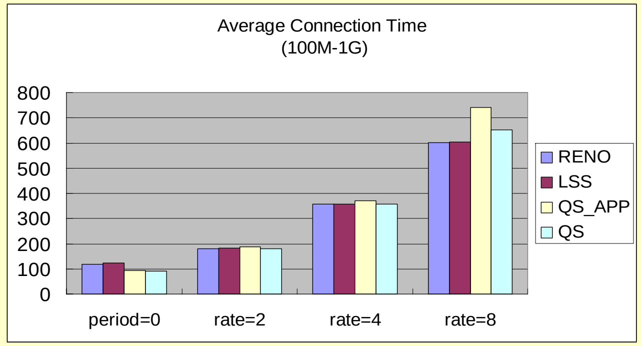
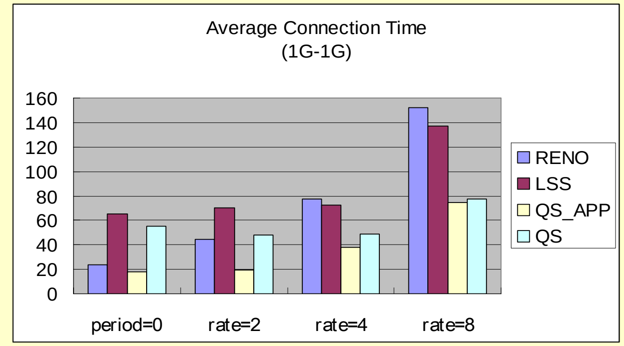
Transaction Completion Time



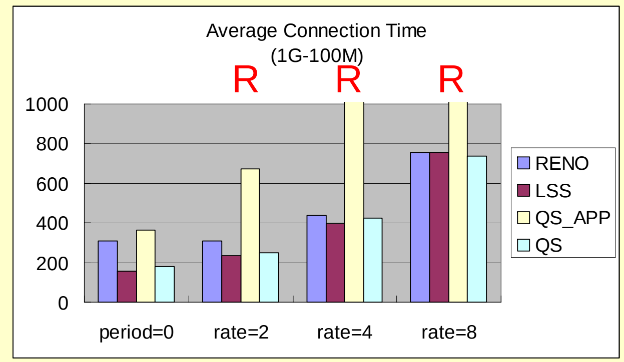


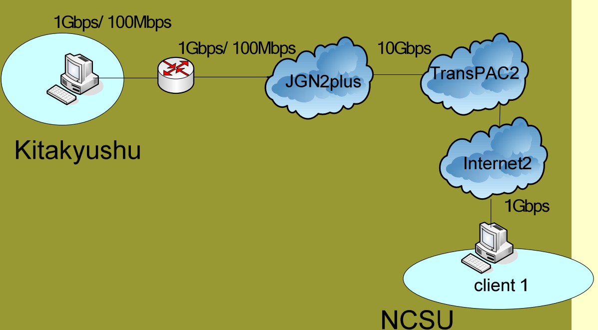
-Capacity expansion scenario

-All SSs have similar transaction completion times

-Capacity reduction scenario

-QS-app has largest transaction completion times – sometimes resets TCP session.





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Packet Retransmissions

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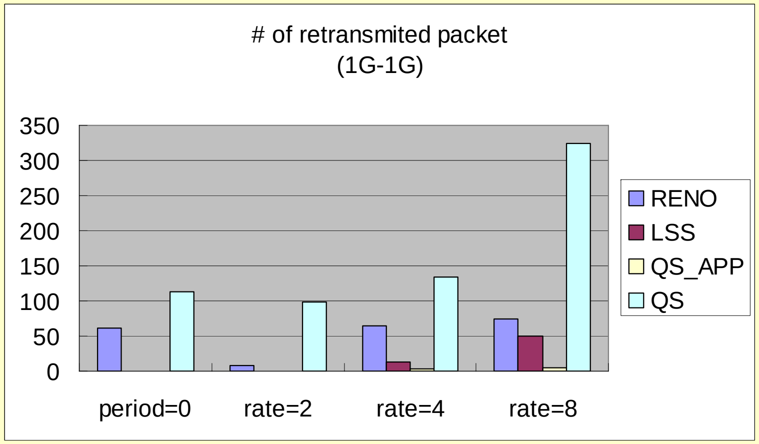

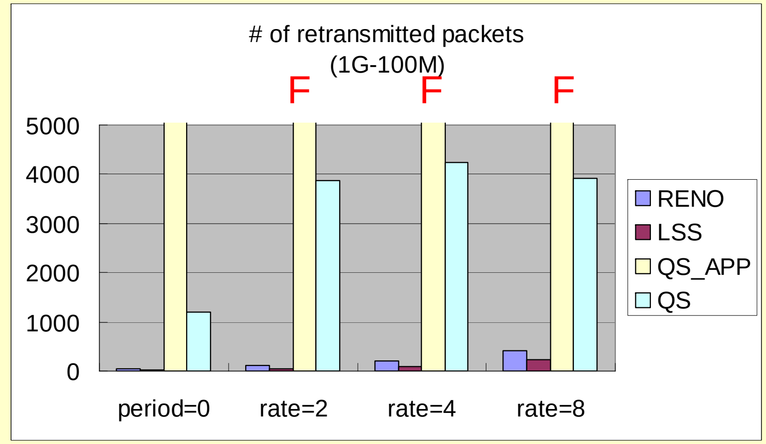

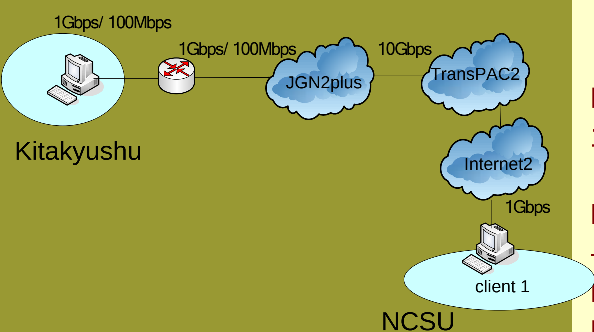

NETWORK SCENARIOS
100M, 1Gbps
bottleneck link
Long RTTs
-KIT/NCSU : 220msecs
Large socket buffers
Httperf application

-Capacity expansion scenario
- -QS has largest number of retransmissions
- -LSS has increasing number of retransmissions with simultaneous sessions

-Capacity reduction scenario
- -QS-app has largest retransmissions
- -QS with pacing still sustain large retransmissions, as compared with Reno and LSS

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Slow Start - Final Remarks

Slow Start Impact on Applications

- Back-to-back packet transmission may cause large packet loss, with subsequent adverse impact on application performance.
    - -High server network interface speed may increase transaction completion time.

-For underutilized path capacity expansion scenarios, it is irrelevant how quickly cwnd ramp up is performed.

Remarks

-Speeding up Slow Start may cause resets, if there is no pacing.
-Slowing down Slow Start may cause poor application performance.
-For all Slow Start mechanisms, there are favorable and unfavorable network scenarios
- -Dynamic detection of network and path scenarios

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Thank you !

Collaborators

Kazumi Kumazoe – HMC/KIT
Tsuru Masato – KIT
Yuji Oie - KIT
Mario Gerla – UCLA

References

[Kumazoe09] K. Kumazoe, M. Gerla, D. Cavendish, M. Tsuru, Y. Oie, "Improving Performance of the transactional Internet", Submitted for publication 2008.