Measurement and Performance Study of PERT for On-demand Video Streaming

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Outline

Motivation

- Current TCP is not suitable for video streaming applications.
- In the Internet, many other services (HTTP, FTP, P2P) compete for bandwidth.

Related Work . . .

Boyden et al, 2007

- TCP can function adequately with a 1.5 higher bandwidth than required stream rate in unconstrained streaming.

Wang et al, 2008

- TCP generally provides good streaming performance when the achievable TCP throughput is roughly twice the media bitrate, with only a few seconds of startup delay.

Problem

How well can TCP support streaming, when T/$\mu \leq$ 2.0?

- *T* is the achievable TCP throughput.
- μ is the video playback bitrate.

Previous Work . . .

PERT = Probabilistic Early Response TCP

Sumitha et al, 2007

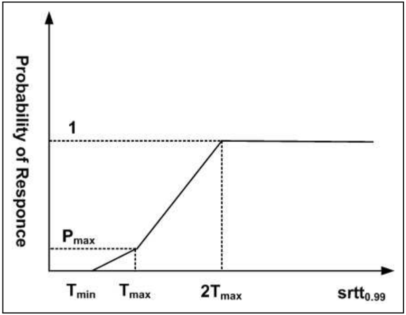
- explored the performance of PERT in homogeneous environment.

Kiran et al, 2008

- made PERT adaptive to heterogeneous environments.

Probabilistic Early Response

PERT learns about network congestion by measuring delay



Window Adjustment Mechanism ...

Aggressive Window Increasing

- $W = W + \alpha$
- $\alpha \geq 1$

Window Adjustment Mechanism ...

3 modes

$T_{compete} = 0.65$ * maximum queuing delay

- When $T < T_{min}$, high-speed mode
- When $T > T_{compete}$, TCP-compete mode
- When $T_{min} < T < T_{compete}$, safe mode

Window Adjustment Mechanism ...

High-speed mode

- $\alpha = \alpha_{max} = 32$

TCP-compete mode

- $\alpha = 1 + p'/p$
  - p' is the early response probability
  - p is the congestion loss probability

Safe mode

- $\alpha = \alpha_{min} = 1$

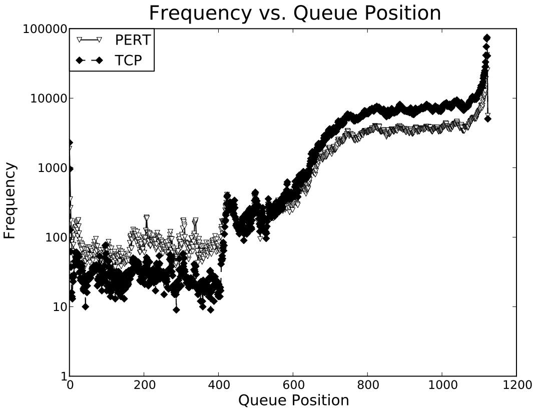
Window Adjustment Mechanism

Conservative Window Decreasing

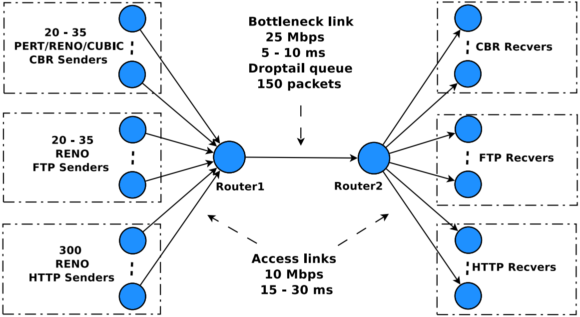
- $W = W \times (1 - \beta)$
- $\beta = q'/(q' + q)$
    - q' is the estimated queuing delay
    - q is the maximum queuing delay
- so $W \geq W/2$

Queuing Behavior

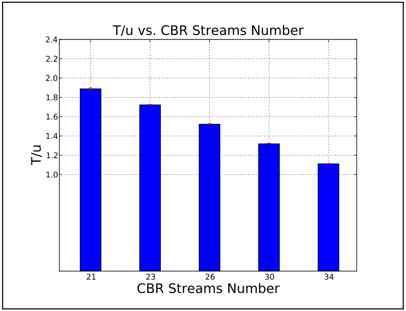
PERT enqueues more packet earlier and less later ...

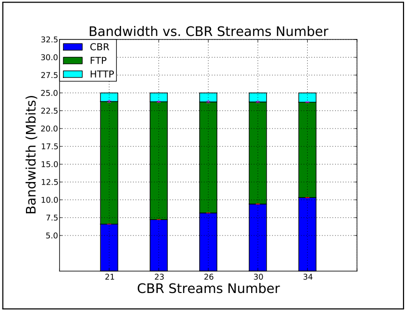


Setup


20 - 35
PERT/RENO/CUBIC
CBR Senders
20 - 35
RENO
FTP Senders
300
RENO
HTTP Senders
Bottleneck link
25 Mbps
5 - 10 ms
Droptail queue
150 packets
Router1
Router2
Access links
10 Mbps
15 - 30 ms
CBR Recvers
FTP Recvers
HTTP Recvers

Parameters Exploration



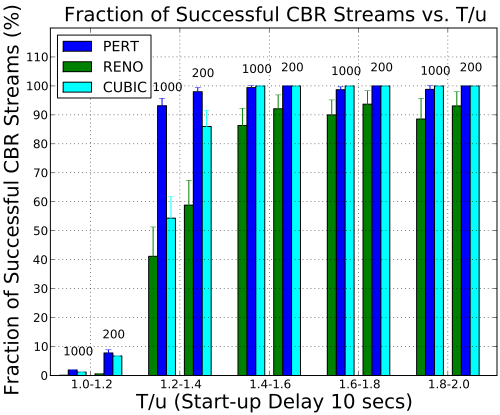


Performance Metric

- CBR stream is successful if fraction of late packets $< 10^{-4}$
- Video streaming quality is evaluated by fraction of successful CBR streams

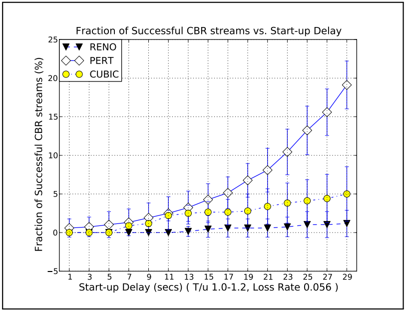
Simulation Results . . .

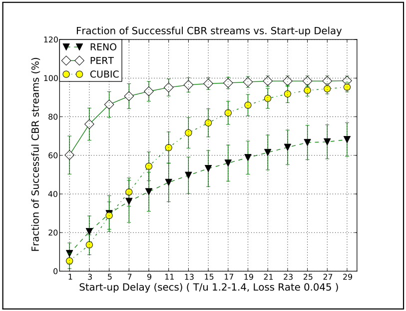
In low range [1.0-1.4], it drops drastically as T/μ decreases
In high range [1.4-2.0], it changes slightly as T/μ increases



Simulation Results . . .

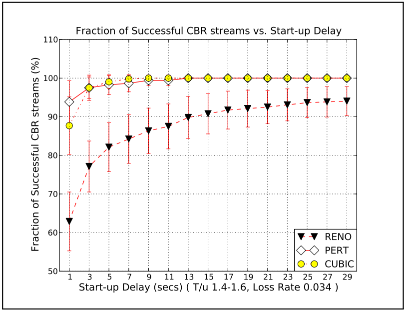
PERT > RENO and CUBIC in T/μ range [1.0 - 1.4]

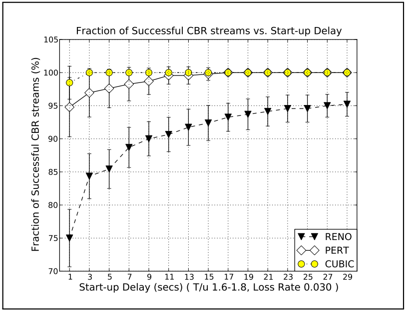




Simulation Results . . .

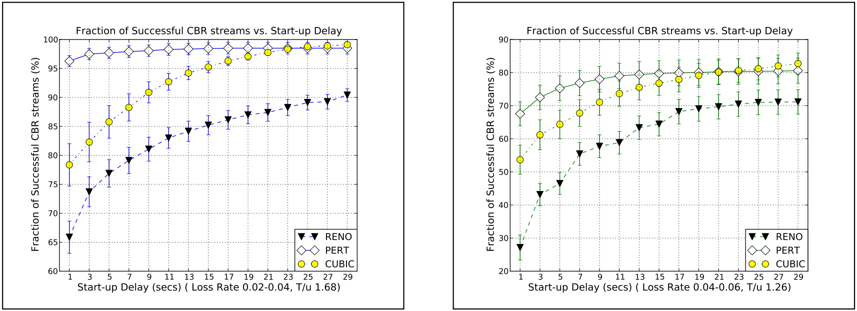
PERT > RENO & PERT $\approx$ CUBIC in T/μ range [1.4 - 1.8]





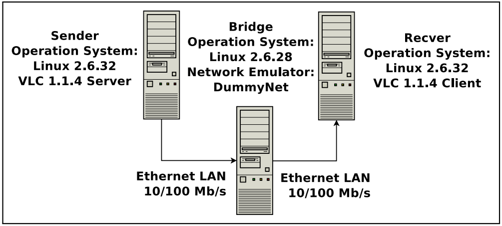
Simulation Results

PERT > RENO and CUBIC in loss rate range [0.02 - 0.06]



Test Bed

Bandwidth 15 Mbps
Delay 45 ms
Buffer 500 Kb
Avatar 1080p
HTTP streaming



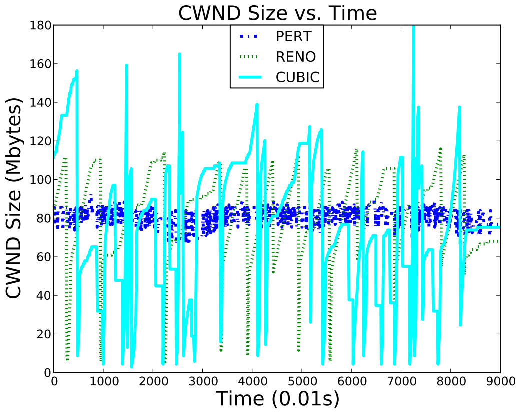
Test Results . . .

PERT helps to reduce the playback glitches

TCP Variants	PERT	RENO	CUBIC
Late Picture Skipping #	5.5	33.5	30.5
Audio Output Starving #	3.0	11.0	7.5

Test Results

PERT responses early before packet loss.
PERT adjusts the window smoothly.



Conclusions

- PERT and CUBIC push T/μ constraint to roughly 1.4.
- PERT > RENO, over all T/μs, loss rates and start-up delays.
- PERT > CUBIC, over low T/μs, high loss rates and strict start-up delays constraints.

Future Work

- Carry out more evaluations and comparisons against other protocols.
- Deploy and measure PERT in error-prone wireless networks.

Thank You !

Probabilistic Early Response Parameters

The parameters are currently fixed, and can be chosen adaptively

- $T_{min} = 5ms$
- $T_{max} = 10ms$
- $P_{max} = 0.05$

α adjustment

Steady state throughput equations:
$\beta_{PERT}(p + p' - p * p')/\alpha_{PERT} = \beta_{TCP} * p/\alpha_{TCP}$

- $\alpha_{TCP} = 1$
- $\beta_{PERT} = \beta_{TCP}$
- So $\alpha_{PERT} = p + p' - p * p'/p \approx 1 + p'/p$