TCP Emulation At the Receivers (TEAR)

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Properties

• TCP-friendly
• Receiver-based rate estimation
• Emulates TCP at the receivers
  - slow start
  - triple duplicate ACKs
  - timeout
• Sender-based rate regulation
Operation

- Each receiver maintains cwnd
- RTT is estimated for each receiver
- rate = cwnd / RTT
- receivers send feedback to sender
- sender regulates sending rate

Maintenance of cwnd

- If no packet loss for one RTT, then
  - Slow start : cwnd = 2*cwnd
  - Congestion avoidance : cwnd = cwnd + 1
- cwnd < ssthresh : slow start
- cwnd > ssthresh : congestion avoidance
Packet loss
Detecting triple duplicate ACKs (TD) event

 sender

 Packet
 lost

 receiver

 Received packets

 Loss detected
 when this packet
 is received

 Packet Loss

 - Gap in sequence numbers
   - cwnd = cwnd / 2
   - ssthresh = cwnd
   - don’t change cwnd for one RTT
     (ignore multiple packet losses)
   - after 1 RTT enter congestion
     avoidance
Timeout

Timeout receiver

\[ T(\text{recv}) = T(\text{send}) + t + 4\text{Dev} \]

Latest time to send ACK before timeout

\[ TO = T(\text{recv}) - d_1 + t + RTT + 4\text{Dev} - d_2 \]
\[ TO = T(\text{recv}) + t + 4\text{Dev} \]

Timeout

\[ d_1 - d_2 = (y_1 - x_1) - (y_2 - x_2) \]

Calculate one-way-delay deviation using \((y_i - x_i)\) as samples

\[ RTT\text{Dev} = \sqrt{2} \times (\text{one-way-delay deviation}) \]
Timeout

- $Ssthresh = \frac{cwnd}{2}$
- $cwnd = 1$
- don’t change $cwnd$ for one RTT
- after 1 RTT enter slow start

What does receiver do?

- Estimates available rate by $cwnd / RTT$
- Calculates average rate in some history
- Sends feedback to the sender
What does sender do?

- Finds min(average rate), sets the sending rate to this value
- Sets the sending rate to the rate of the receiver with minimum average rate

Simulations

sources
TCP 0
TCP 1
TEAR
TCP N

receivers
TCP-Sink 0
TCP-Sink 1
TEAR-Sink
TCP-Sink N
Simulations

Throughput
1 TEAR - 16 TCPs

Throughput
4 TEARs - 16 TCPs
Simulations

8 TEARs - 32 TCPs

- TEAR(lowest)
- TEAR(highest)
- TCP(lowest)
- TCP(highest)

Simulations
Simulation

Simulations

1 TEAR - 94 TCPs
Simulations

Throughput
1 TEAR - 94 TCPs

Normalized throughput

TEAR  TCP(lowest)  TCP(highest)