Equation-Based Congestion Control for Unicast Applications

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End-to-End Congestion Control

- Additive Increase/Multiplicative Decrease approach
 - Congestion control used by TCP
 - If congestion is detected (e.g. packet drop), multiplicatively decrease congestion window size (CWZ = CWZ / 2)
 - Otherwise, additively increases congestion window size (CWZ = CWZ+ 1)
- · Equation-based congestion control approach
 - Adaptively controls sending rate according to control equation
 - Slow response to the congestion

End-to-End Congestion Control

	Advantage	Disadvantage
AIMD (TCP congestion control)	Effective for bulk data transfer	Multiplicative decrease is not suitable for real-time applications (e.g. streaming multimedia)
Equation-based congestion control	Change of transmission rate is smooth over time (appropriate for real-time applications)	Not able to respond to the abrupt increase immediately

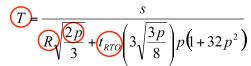
- TCP-friendly Rate Control (TFRC)
 - Proposed equation-based congestion control for unicast application
 - Smooth change of sending rate in response to congestion

TCP-Friendly Rate Control (TFRC)

- TFRC is "TCP-compatible"
 - If TCP and TFRC were competing, there is no significant starvation in FIFO queue
 - TFRC uses TCP response function (it reflects the steady-state sending rate of TCP)
- Design principles
 - 1. Not aggressive for sending more data
 - 2. Be responsive to packet losses in sufficiently long term

TFRC Protocol

TCP response function



T: upper bound of sending rate

R: round-trip time computed by sender or receiver p = steady-state loss event rate

t_{RTO} = retransmit timeout can be computed using R

TFRC Protocol

$$T = \frac{s}{R\sqrt{\frac{2p}{3}} + t_{RTO}\left(3\sqrt{\frac{3p}{8}}\right)p(1+32p^2)}$$

- Receiver
 - Computes p (loss event rate) and transfer it to the sender
- Sender
 - Compute T based on p and R
 - Controls transmission rate based on T

TFRC Protocol

• Loss event rate (p)

- Different from loss fraction which is $\frac{\pi \text{ packets rost}}{\# \text{packets transferred}}$
- Loss event rate counts a event loss per packet round-trip time
- Loss event rate models TCP protocols
- Average Loss Interval method is used. (Averaging the loss rate over the previous loss intervals with dynamic weights)
- Average Loss Interval

Summary

- · Equation-based Congestion control is proposed for real-time applications
- Sender determines the transfer rate (*T*) based on the control equation
- · Receiver computes loss event rate which is transferred to sender and used to compute T
- · TFRC provides congestion control mechanism which is less variable in response to congestion