CSc 461/561
Multimedia Systems
Multimedia Congestion Control

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What we have so far

- Multicast
  - IP multicast, IGMP, multicast routing
- Resource reservation
  - RSVP, IntServ, DiffServ
- Transport
  - RTP and RTCP
- Signaling
  - SIP

What still missing

- End-to-end flow, error, congestion control
  - how to coordinate sender, receiver, network
  - how to detect, correct, recover errors
- For TCP/IP-based data applications
  - TCP flow, error, congestion control
  - embedded and integrated
- For multimedia applications
  - TCP is not the best choice!

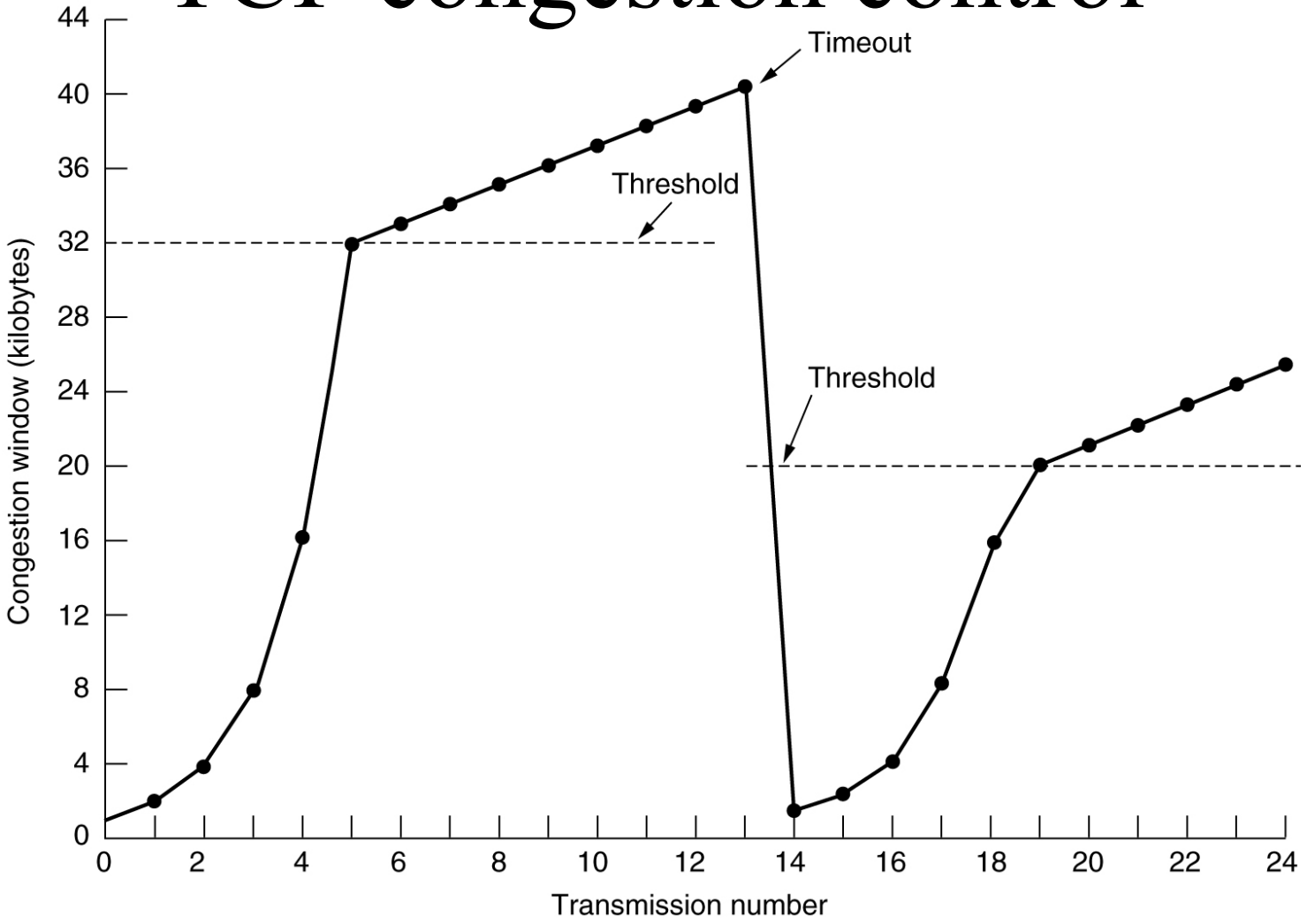
Multimedia traffic control

- Flow, error, congestion control
  - should be separate, flexible, adaptive
  - due to diverse application requirements
- Flow control
  - window control, rate control, bucket-controlled
- Error control
  - redundancy, forward correction, retransmission
- Congestion control

TCP-friendly congestion control

- What is TCP-friendly?
  - in a comparatively long term, TCP-friendly flows should not exceed TCP flows in achieved throughput under the same circumstance
- Why TCP-friendly?
  - the majority is still TCP-transported
  - fair competition btw TCP and non-TCP flows
  - important for network stability w/o reservation

TCP congestion control

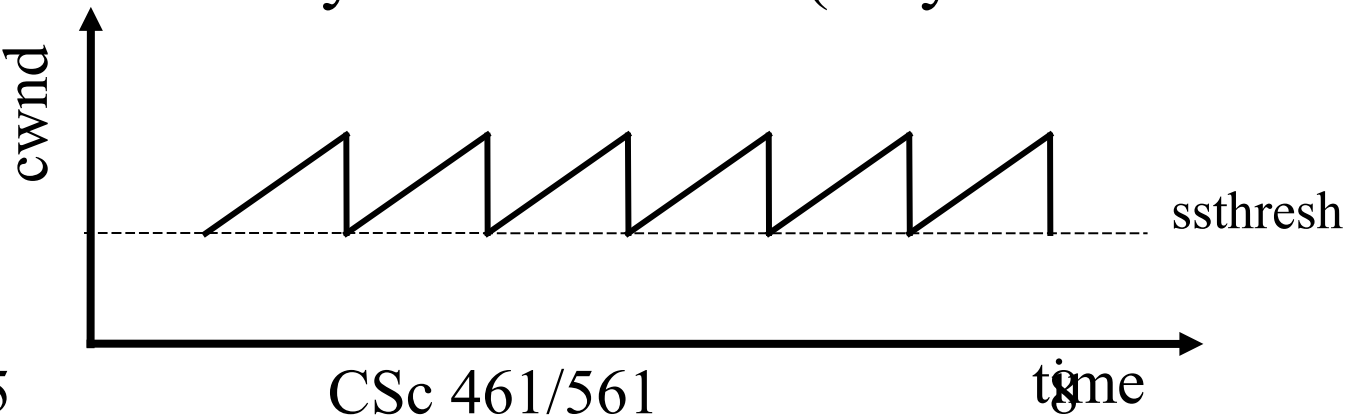


Congestion control mechanisms

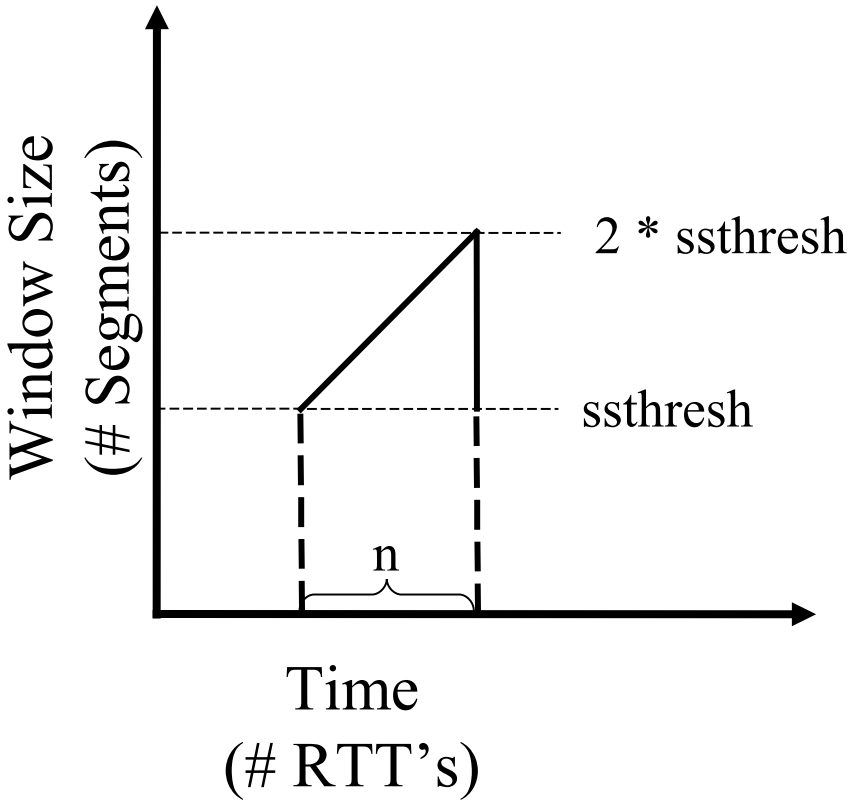
- Slow-Start
- Congestion Avoidance
  - increase congestion window size linearly
- Timeout Retransmit
- Fast Retransmit
- Fast Recovery
  - reduce congestion window size to half

AIMD

- Additive-Increase-Multiplicative-Decrease
  - why? [hint: fairness and stability]
- TCP: AIMD (1, 0.5)
  - congestion avoidance: increase by 1
  - fast recovery: reduce to 0.5 (why bad for MM?)



TCP throughput



- Throughput (T)
  - data_sent/time_used
- Data transmitted
  - 1.5 n^2 MSS
  - packet loss rate: p
- Time used
  - n RTT
- T = sqrt(1.5/p) MSS/RTT

Generic AIMD

- GAIMD
  - no congestion: cwnd increased by a ($a > 0$)
  - congestion: cwnd reduced to b ($0 < b < 1$)
- Multimedia GAIMD
  - b close to 1 as much as possible
  - but still responsive to network congestion
  - to reduce instantaneous fluctuation
  - good for smooth multimedia playback

TCP-friendly GAIMD

- TCP: AIMD (1, 0.5)
- GAIMD (a, b)
- TCP-friendliness
  - $T_{AIMD} <= T_{TCP}$ in a comparatively long term
- Result: $a = 3\ (1-b)/(1+b)$
  - ref: slide 9 and [CSPM05]
- Examples
  - (1, 0.5) ~ (0.75, 0.6) ~ (0.53, 0.7) ~ (0.33, 0.8)

TCP-friendly CC: more examples

- RAP: rate adaptation protocol
  - apply AIMD to inter-packet gap
- TFRC: TCP-friendly rate control
  - equation-based rate control, with
  - a more sophisticated TCP throughput equation
- Binomial congestion control
  - no congestion: $cwnd_{i+1} = cwnd_i + a\ cwnd_i^{-x}$
  - congestion: $cwnd_{i+1} = cwnd_i - b'\ cwnd_i^{y}$

This lecture

- TCP-friendly congestion control
  - TCP congestion control
  - AIMD and generic AIMD
  - TCP-friendly congestion control
- Explore further
  - http://www.icir.org/floyd/tcp_friendly.html
  - [CSPM05] Cai, Shen, Pan, Mark, "Performance analysis of TCP-friendly AIMD algorithms for multimedia applications," *IEEE Trans on Multimedia*, 7(2):339-355, April 2005.

Next lecture

- Multimedia error control