

CSc 450/550
Computer Networks
TCP Congestion Control

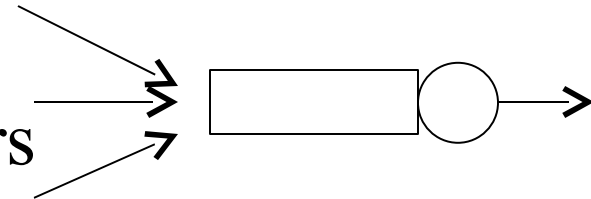
Jianping Pan
Summer 2006

Review: TCP mechanisms

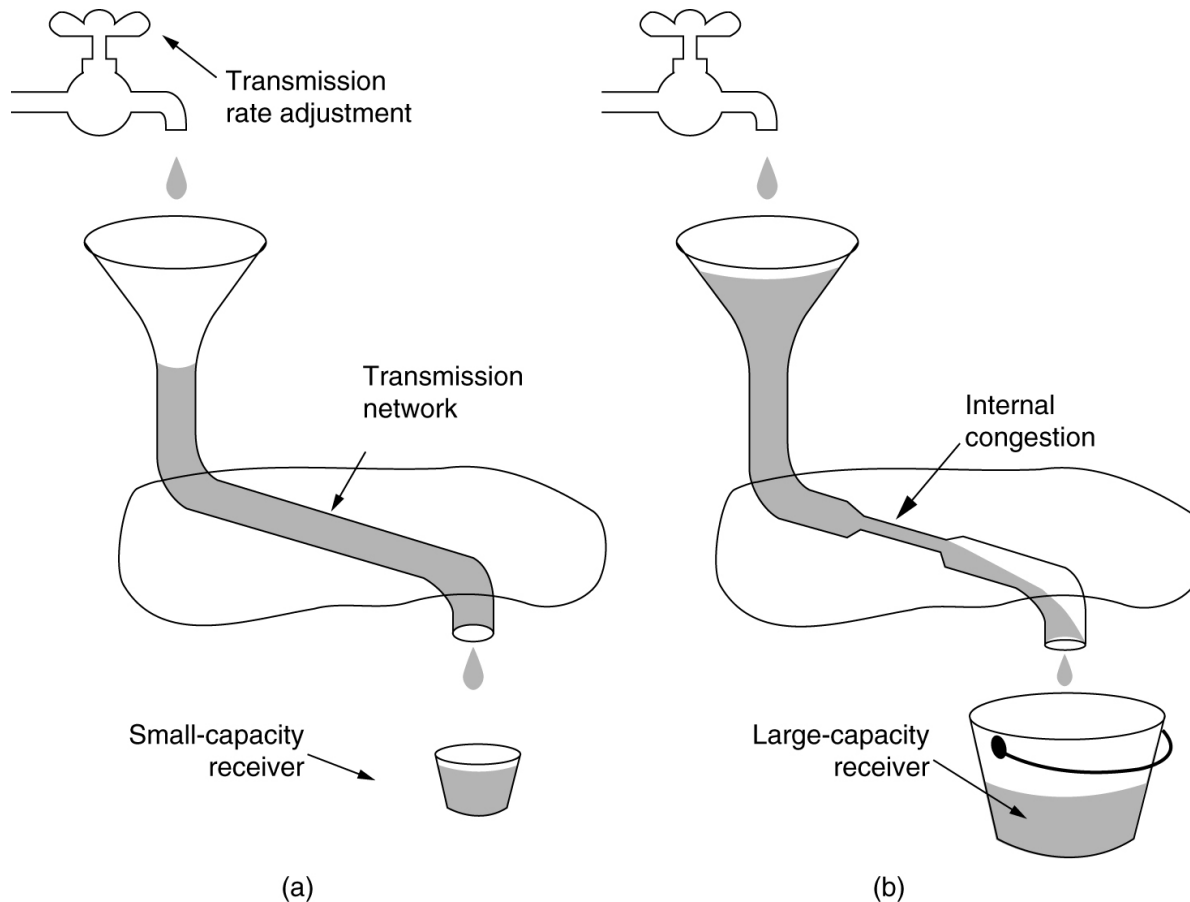
- Connection management
 - packet handshake
- Flow control
 - sliding variable window
- Error control
 - error detection
 - error recovery

Why congestion control?

- Flow control
 - coordinate sender and receiver (buffer)
- Network congestion
 - coordination between the sender and network
 - avoid a sender to overflow a router
 - coordination among many senders
 - traffic aggregation from many senders
 - congestion syndrome
 - increasing queuing delay, packet drop



Flow vs congestion control



Congestion control

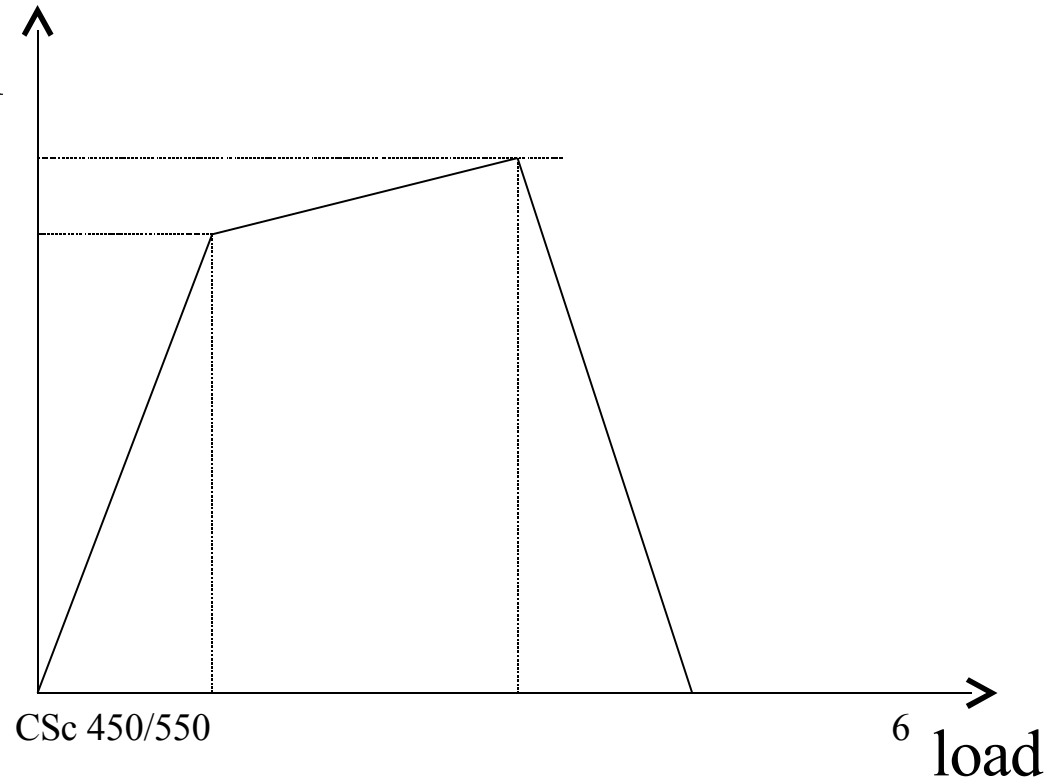
- Congestion detection
 - end-to-end approach
 - packet loss
 - also can be caused by transmission error
 - increasing round-trip time
 - also can be caused by alternative routes
 - network-assisted approach
 - ICMP source quenching
 - explicit congestion notification (ECN)

Congestion control: more

- Congestion recovery

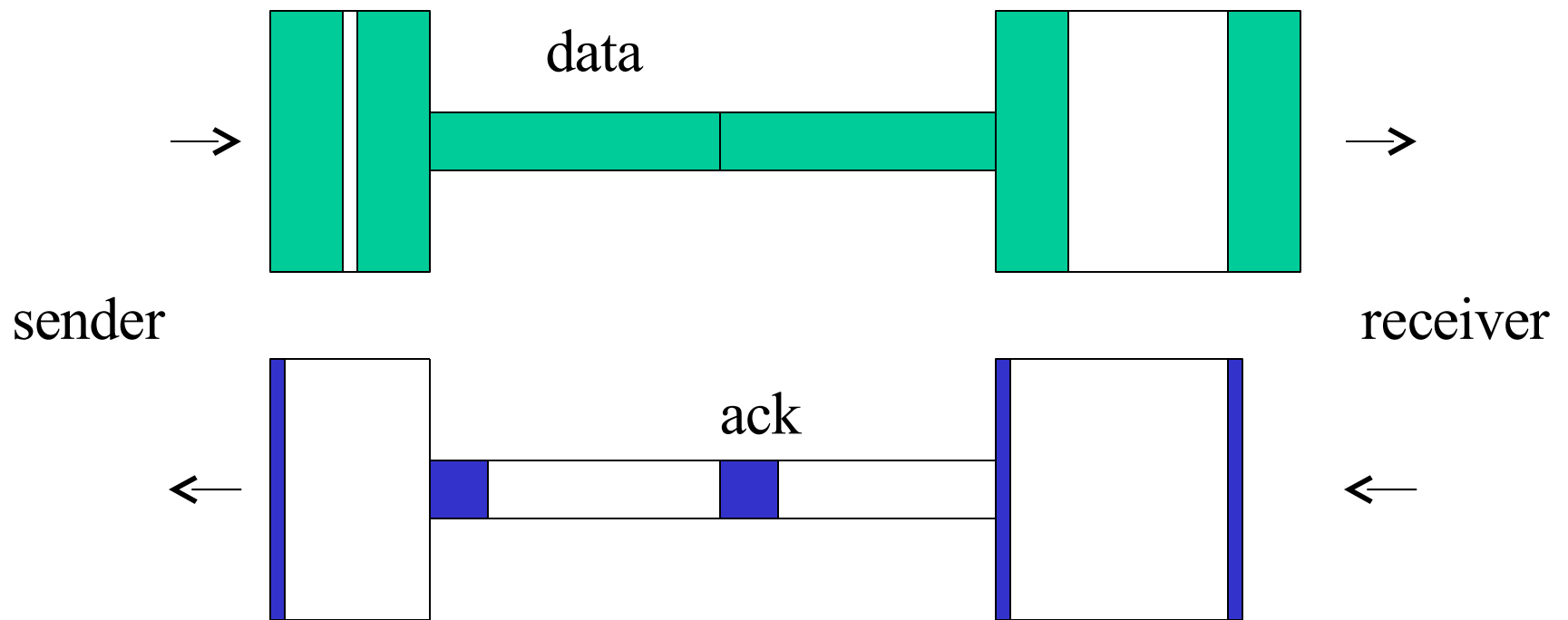
- load-gain curve

- low-load gain
 - mid-load
 - hi-load



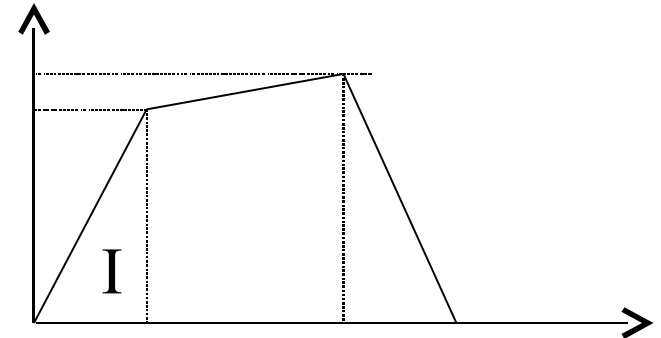
TCP congestion control

- Principle: acknowledgment self-clocking



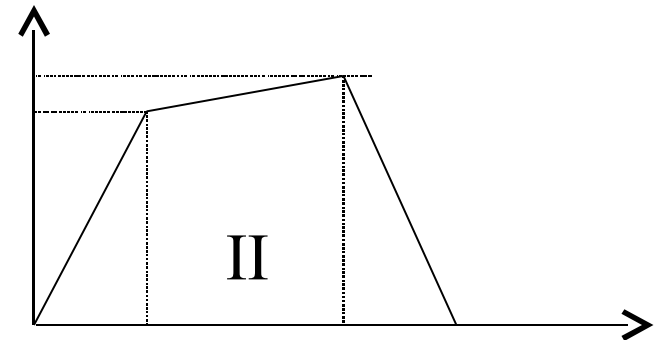
TCP CC mechanisms

- Sender variables
 - congestion window (cwnd)
 - sender window = $\min \{ \dots, \dots, \text{cwnd} \}$
 - initially, $\text{cwnd} = 1 \text{ MSS}$
 - slow-start threshold (ssthresh)
- Slow start
 - when $\text{cwnd} < \text{ssthresh}$
 - on each new ack
 - $\text{cwnd} += 1 \text{ MSS}$
 - effectively doubling cwnd every RTT



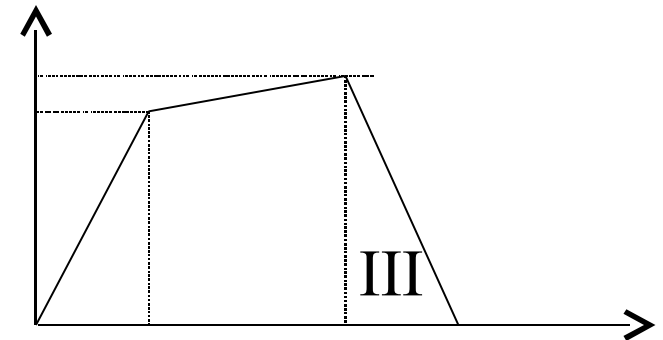
TCP CC: more

- Congestion avoidance
 - when $\text{cwnd} > \text{ssthresh}$
 - on each new ack
 - $\text{cwnd} += \text{MSS}^2 / \text{cwnd}$
 - effectively $\text{cwnd} += 1 \text{ MSS}$ every RTT
 - linear increment



TCP CC: further

- On packet loss
 - timeout
 - 3 duplicate acknowledgments
- Congestion control
 - $ssthresh = cwnd / 2$
 - $cwnd = 1 \text{ MSS}$
- Error control
 - retransmit packet
 - backoff timer



This lecture

- TCP congestion control
 - purpose
 - mechanisms
 - detection
 - recovery
 - TCP: slow-start, congestion avoidance
- Explore further
 - TCP congestion control [RFC2581]

Next lecture

- TCP variants
 - read CN Chapter 6
 - <http://www.icir.org/floyd/>