Computer Communication Networks

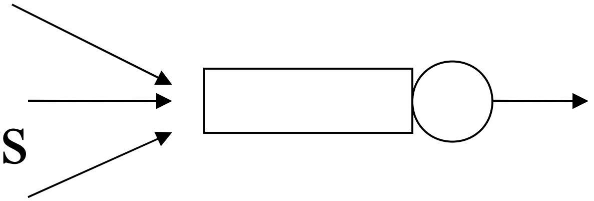
TCP Congestion Control

Review: TCP mechanisms

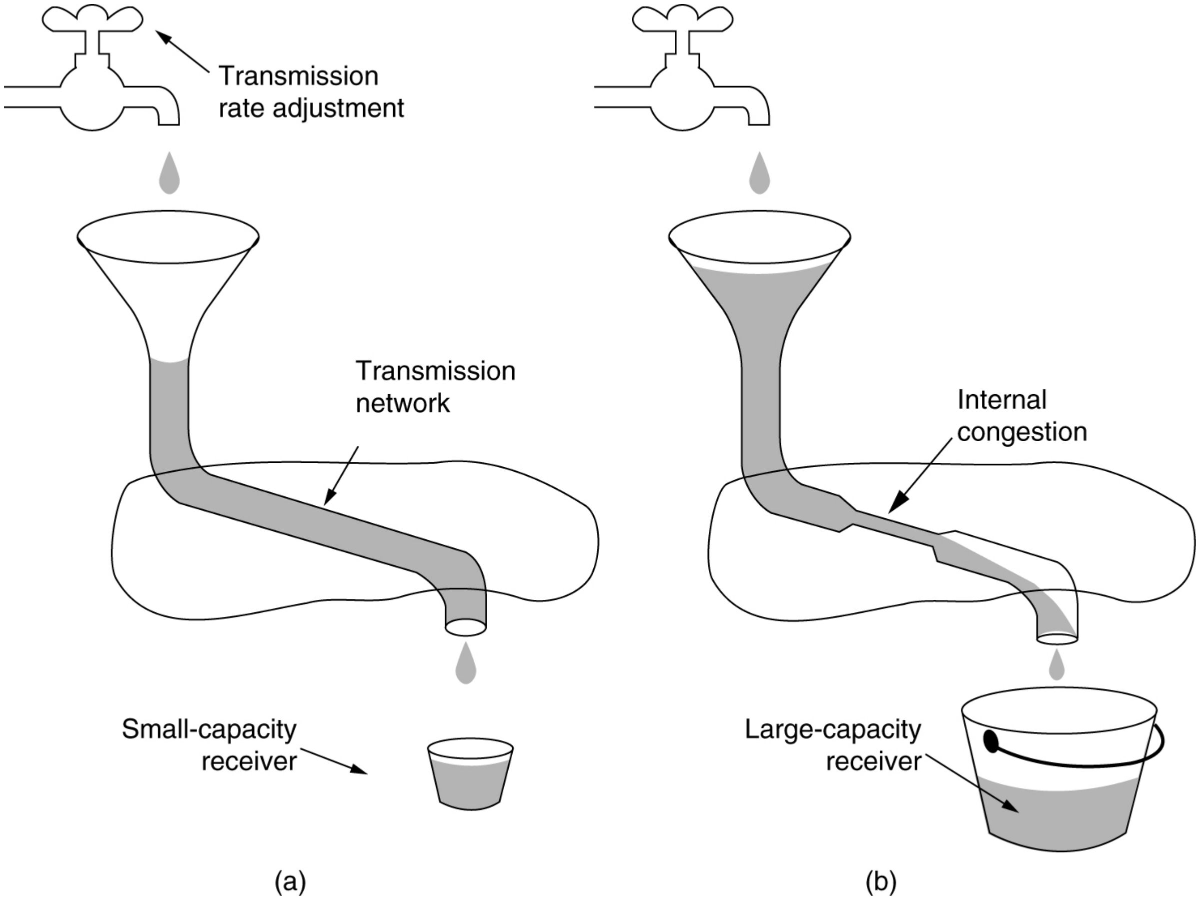
- Connection management
  - packet handshake
- Flow control
  - sliding variable window
- Error control
  - error detection
  - error recovery

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

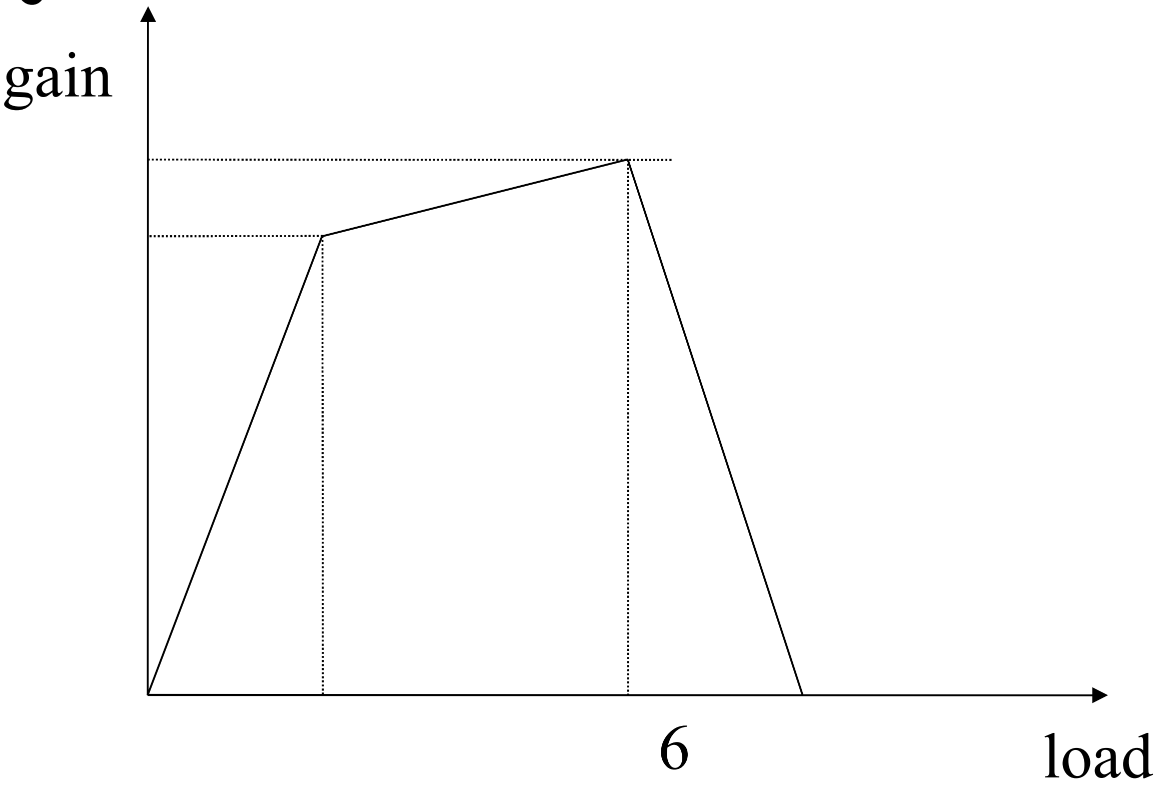


Congestion control

- 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)

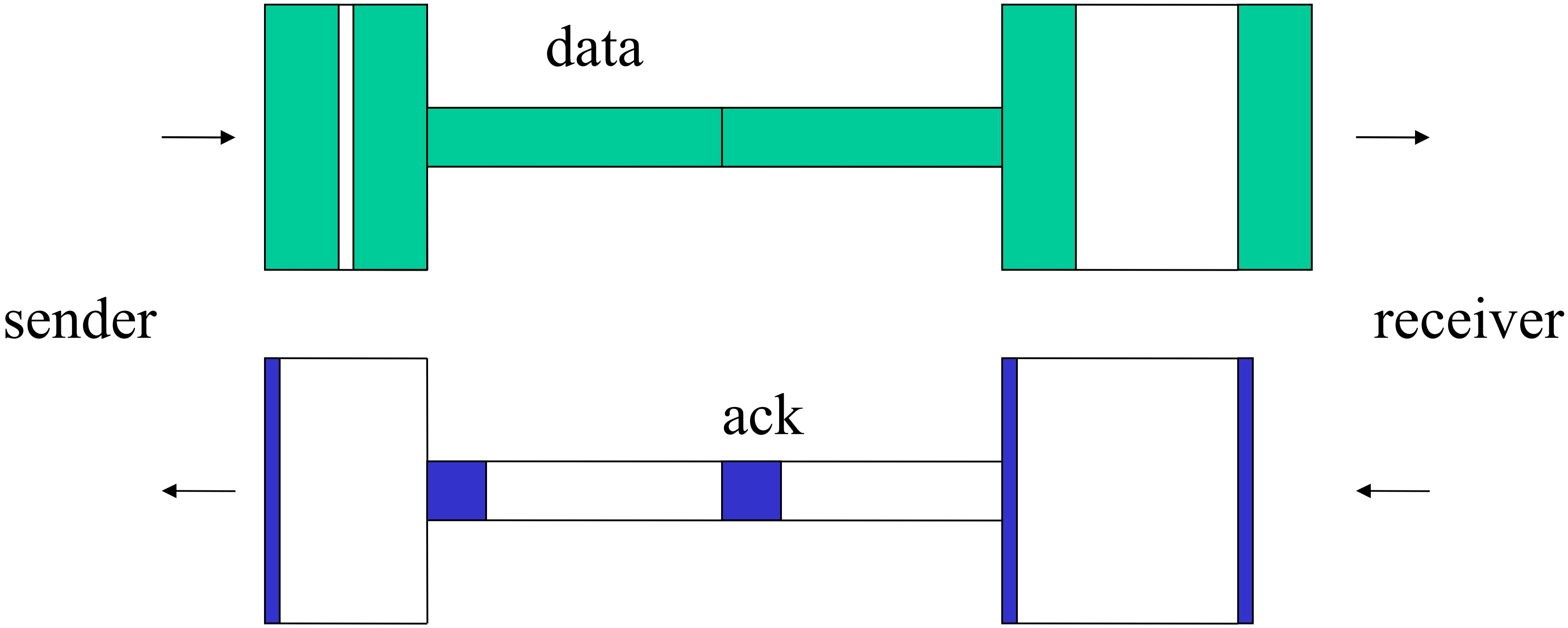
Congestion control: more

- Congestion recovery
  - load-gain curve
    - low-load
    - mid-load
    - hi-load



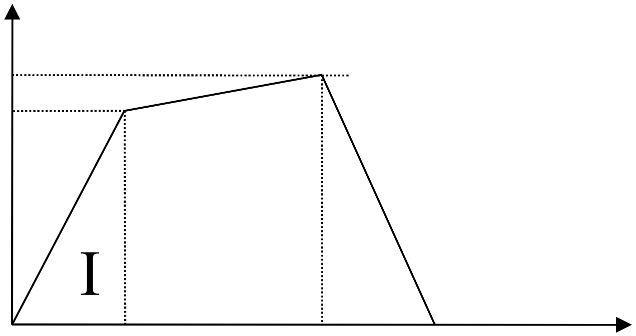
TCP congestion control

- Principal: acknowledgment self-clocking



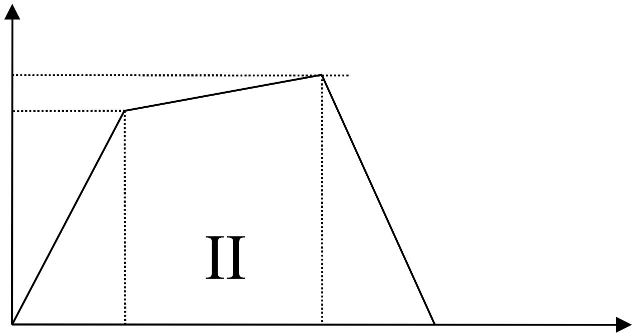
TCP CC mechanisms

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



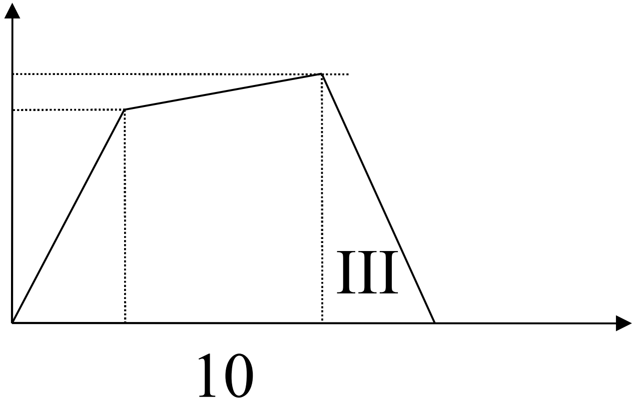
TCP CC: more

- Congestion avoidance
  - when cwnd > ssthrehsh
  - on each new ack
    - cwnd += (MSS/cwnd) MSS
    - effectively cwnd += 1 MSS every RTT
    - linear increment



TCP CC: further

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



Summary

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

Next

- TCP variants
  - http://www.icir.org/floyd/