

CSc 450/550

Computer Networks

TCP Error Control

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Review: TCP flow control

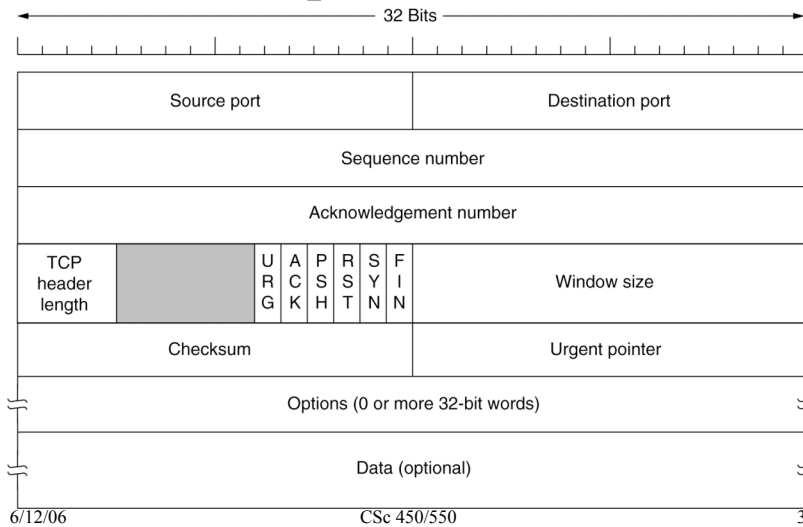
- Purpose
 - to avoid overflow
- Mechanism
 - sliding window
 - variable window

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TCP packet header



What can go wrong?

- IP packet delivery
 - duplicated
 - deleted by referring to sequence number; done
 - lost
 - *transmission error* or network congestion
 - reordered
 - rearranged by referring to sequence number; done
 - corrupted
 - arrived but in “bad shape”

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Error detection

- Corrupted packets
 - detected by TCP checksum
 - action: drop!
- Lost packets
 - how do you tell if something *is* already lost?
 - TCP sender
 - timer
 - TCP receiver (cumulative acknowledgment)
 - duplicate acknowledgment

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TCP/IP checksum

- Algorithm: 16-bit one compliment of one's compliment sum with carry
 - 16-bit: padding when necessary
 - cover: TCP header, payload, pseudo header
 - calculate: pad, sum, carry, compliment
 - verify: $\text{sum} == 0$?
- IP pseudo header
 - to detect misdelivered packets by IP layer
 - include: IP addresses, protocol ID, segment length

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TCP sender timer

- TCP sender
 - start a timer when sending out a packet
 - in reality: one timer per a window of packets
 - on acknowledgment “covering” this packet
 - cancel the timer and setup another one
 - if timer timeouts: *indicate* packet may be lost
- Timeout value
 - too soon: unnecessary transmission
 - too late: “slow response”

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TCP timeout value

- RTO: based on round-trip time (RTT)
 - RTT: from sending a packet to receiving its ack
 - smoothed RTT (SRTT)
 - exponentially weighted moving average (EWMA)
 - $SRTT_{i+1} = SRTT_i + a (RTT - SRTT_i)$; $a = 1/8$
 - RTT variance (RTTV)
 - $RTTV_{i+1} = RTTV_i + b(|RTT - SRTT_i| - RTTV_i)$; $b = 1/4$
 - RTO
 - $RTO = d (SRTT + c RTTV)$; c : initially 2 now 4
 - d : backoff factor; normally 1, doubled when timeout

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Duplicate acknowledgment

- TCP acknowledgment
 - cumulative acknowledgment
 - example
 - rcv: [0, 500), [500, 1000), [1500, 2000), [2000, 2500)
 - ack: 500, 1000, 1000 (1st dupack), 1000 (2nd dupack)
- Enough duplicate acknowledgments
 - *indicate* packet loss may have occurred
 - ack: 500, 1000, 1000, 1000, 1000 (3rd dupack)
 - packet [1000, 1500) is considered lost

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Error recovery

- End-to-end retransmission
 - go-back-N (GBN)
 - retransmit from ackno and upward
 - selective retransmission
 - only retransmit those “known” to be lost
- TCP’s error recovery
 - mostly GBN
 - also regulated by congestion control
 - explore further: TCP selective acknowledgment

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This lecture

- TCP error control
 - purpose
 - mechanisms
 - detection
 - recovery
- Explore further
 - TCP selective acknowledgment (SACK)
 - <http://www.icir.org/floyd/>

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Next lecture

- TCP congestion control
 - read CN Chapter 6

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