

W10
(2C)

Computer Networks II

Transmission Control Protocol (TCP)

Amitangshu Pal

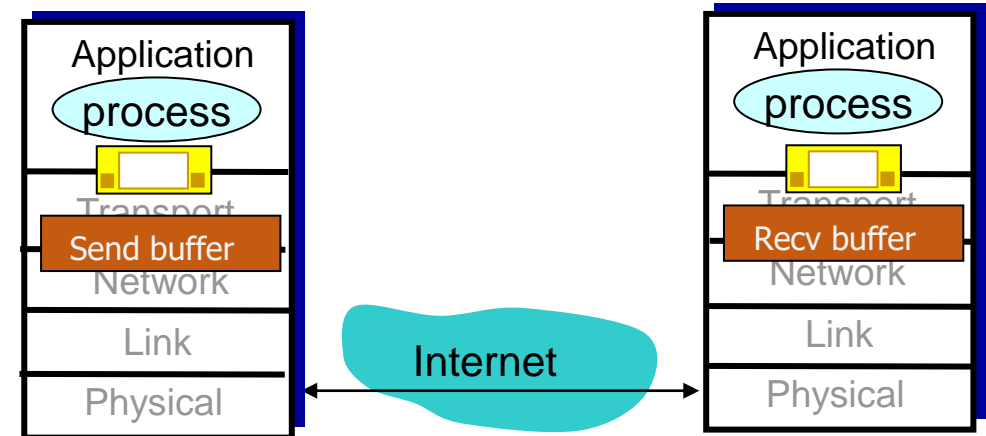
Computer Science and Engineering

IIT Kanpur

TCP: Overview

RFCs: 793, 1122, 2018, 5681, 7323

- **Point-to-point**
 - One sender, one receiver
 - Does not support multicasting/broadcasting
- **Connection-oriented byte stream protocol**
 - No message boundaries
- **Full duplex data transfer**
 - Bi-directional data flow in same connection

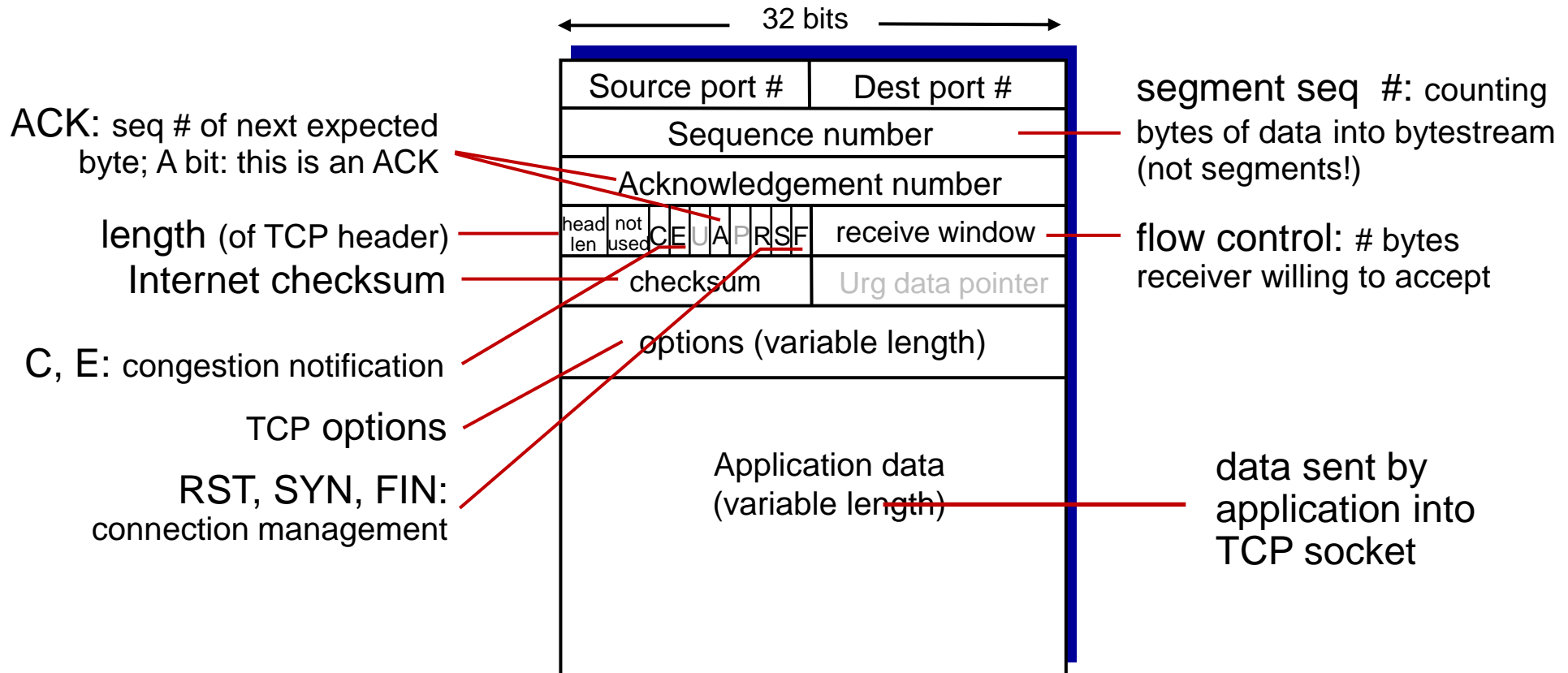


TCP Services

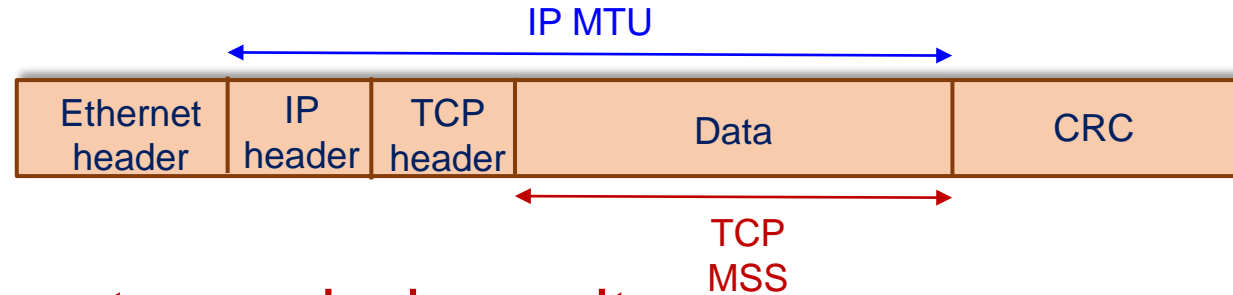
- Multiplexing/demultiplexing
 - Reliable, in-order delivery
 - Flow control
 - Sender will not overwhelm receiver
 - Congestion control
 - Sender will not overwhelm the network
-

TCP Segment Structure

TCP Segment Structure



MTU vs MSS



- **MTU: Maximum transmission unit**
 - Maximum amount of data that a link-layer frame can carry
 - 1500 bytes for Ethernet (i.e. Ethernet payload size)
 - **MSS: Maximum segment size**
 - Maximum amount of **application-layer data** in the segment
 - **Decided during the connection setup**
 - If a host does not use this option → it defaults to a 536 byte payload
-

TCP Sequence Numbers and ACKs

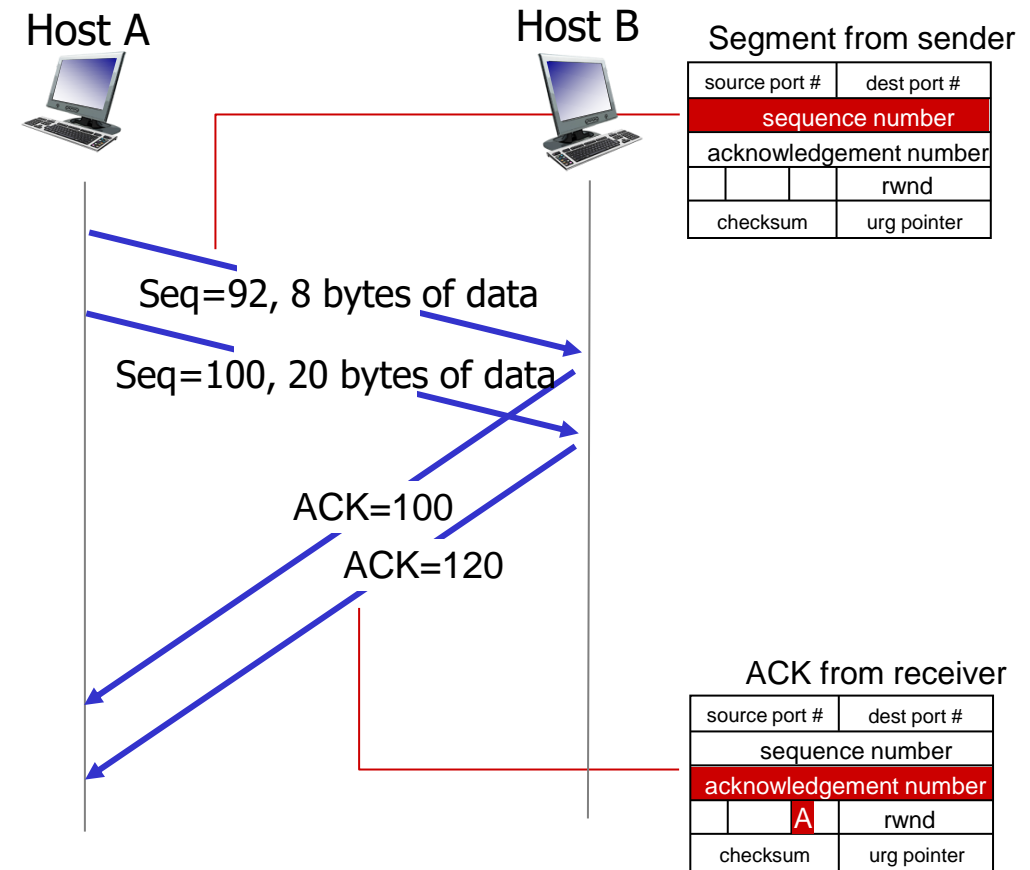
Reliable byte-stream service

Sequence numbers:

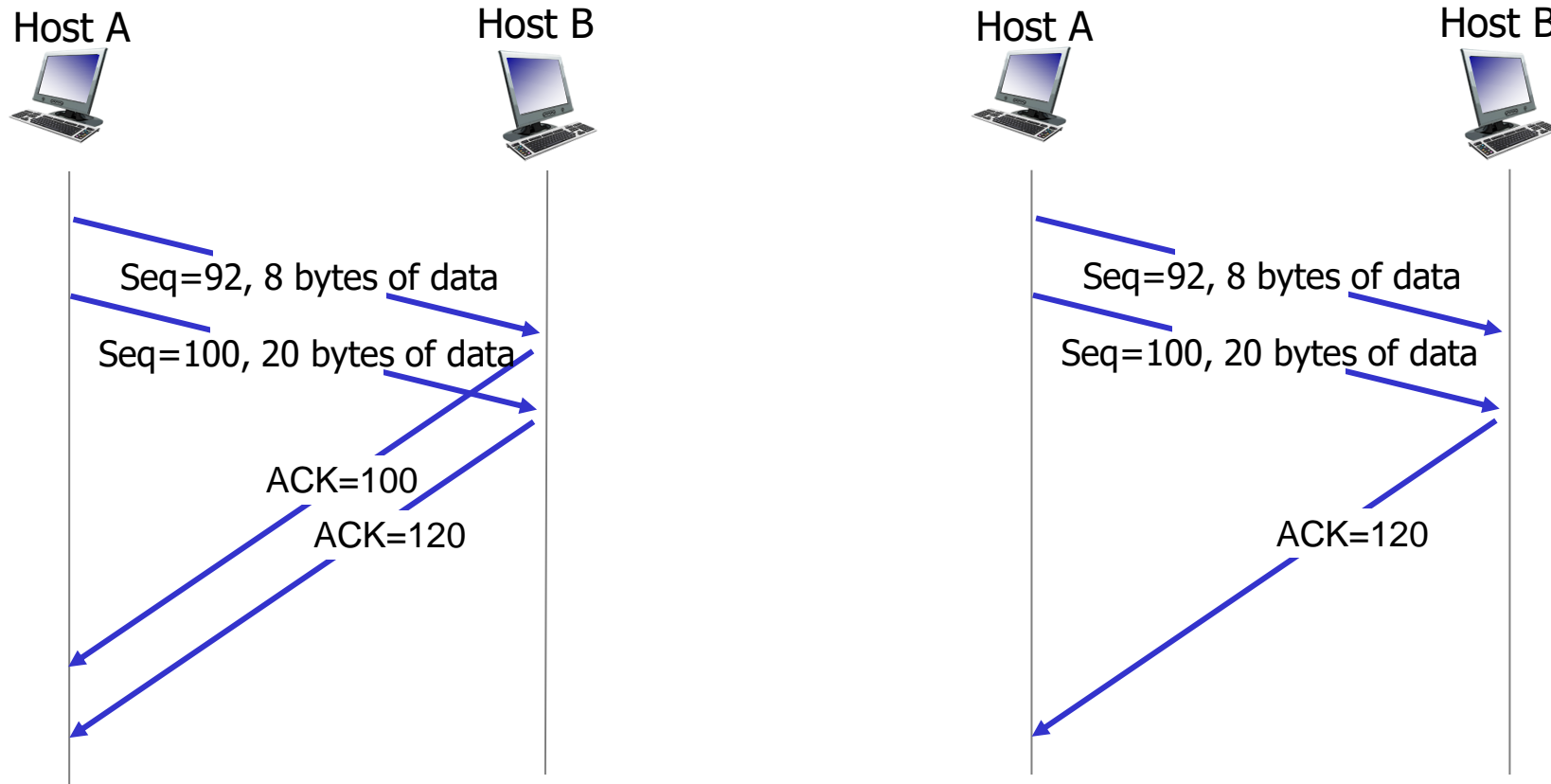
- Byte stream “number” of first byte in segment’s data

Acknowledgements:

- Seq # of next byte expected from other side
- Cumulative ACK



TCP Sequence Numbers and ACKs



TCP Receiver: ACK generation [RFC 5681]

Event at receiver

TCP receiver action

Case-1

- Arrival of in-order segment with expected seq # → no gap.
- Everything earlier already ACKed

- Delayed ACK. Wait up to 500ms for next segment.
- If no next segment arrive → send ACK

Case-2

- Arrival of in-order segment with expected seq # → no gap.
- One other segment has ACK pending

- Immediately send single cumulative ACK → ACKing both in-order segments

Case-3

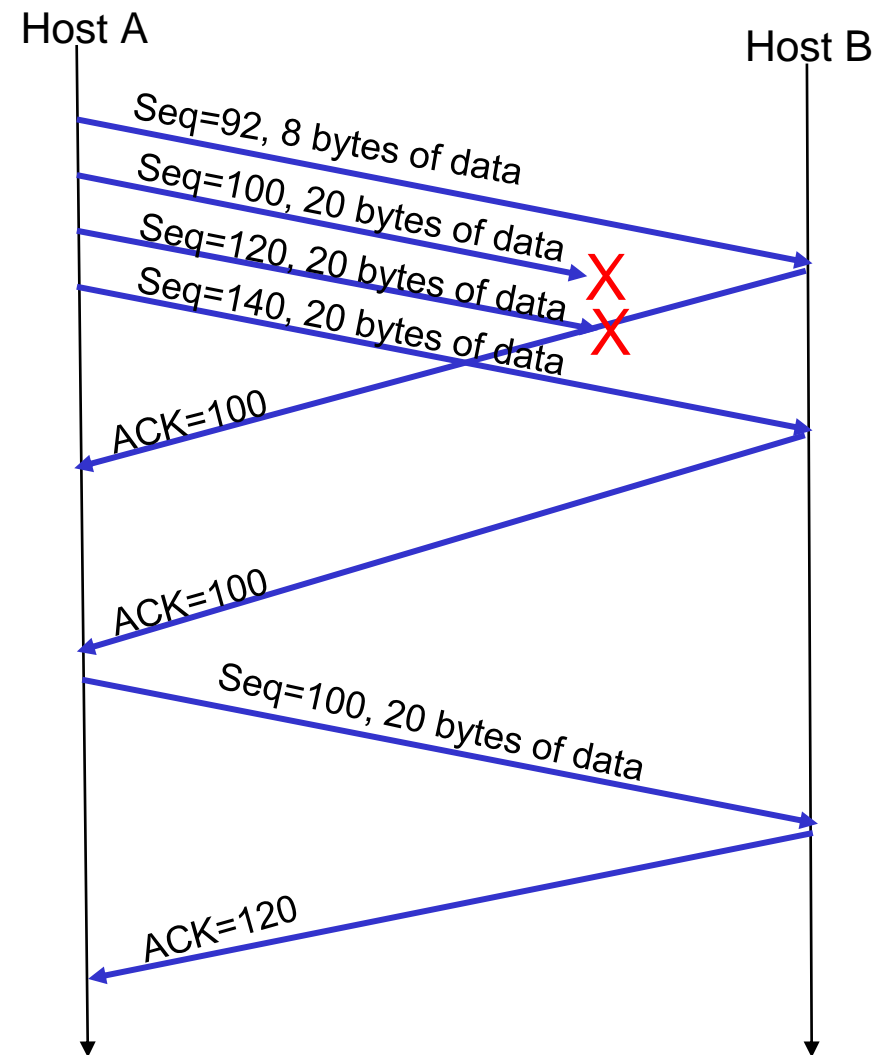
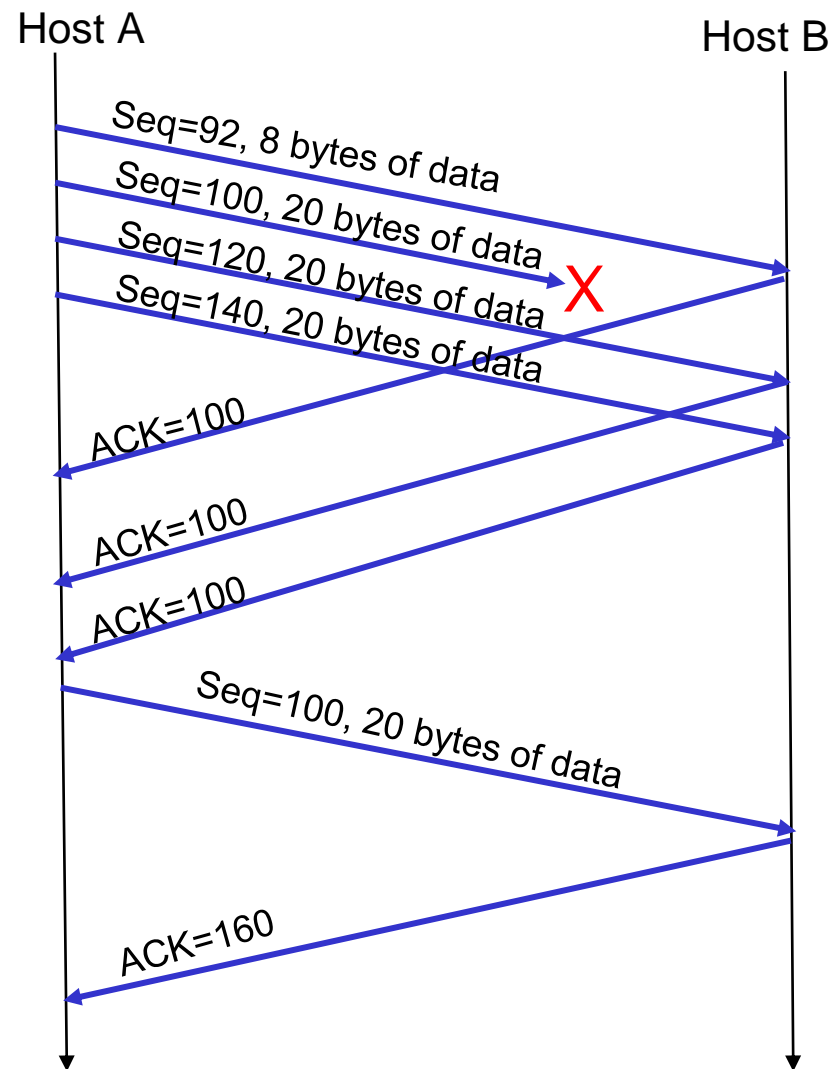
- Arrival of out-of-order segment higher-than-expect seq. # → Gap detected

- Immediately send **duplicate ACK**, indicating seq. # of next expected byte

Case-4

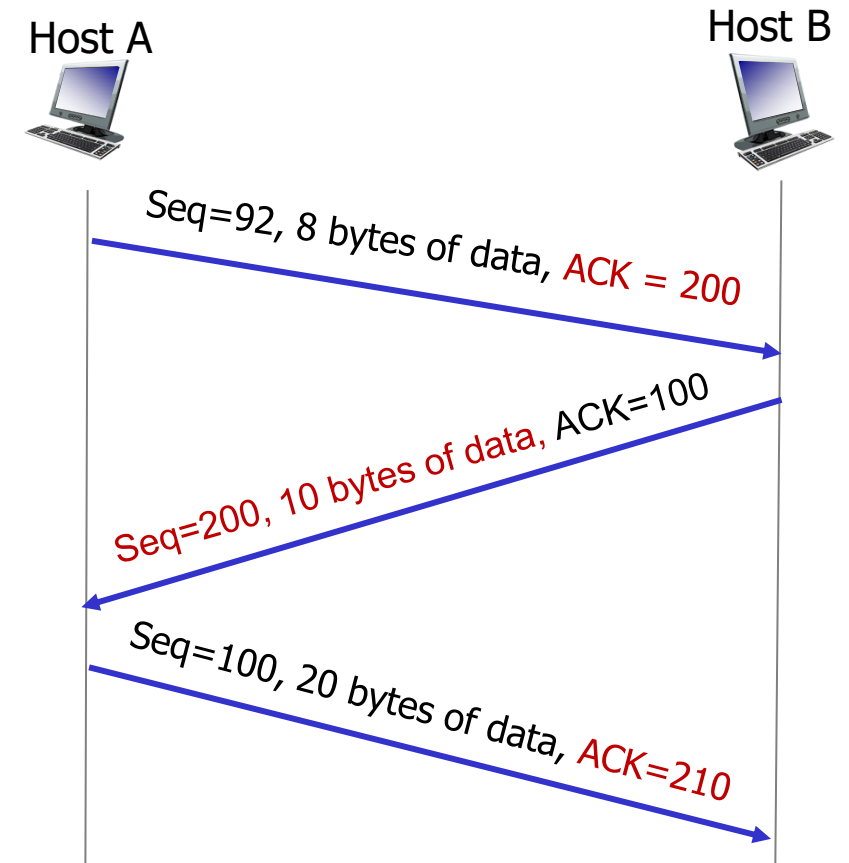
- Arrival of segment that partially or completely fills gap

- Immediate send ACK, provided that segment starts at lower end of gap



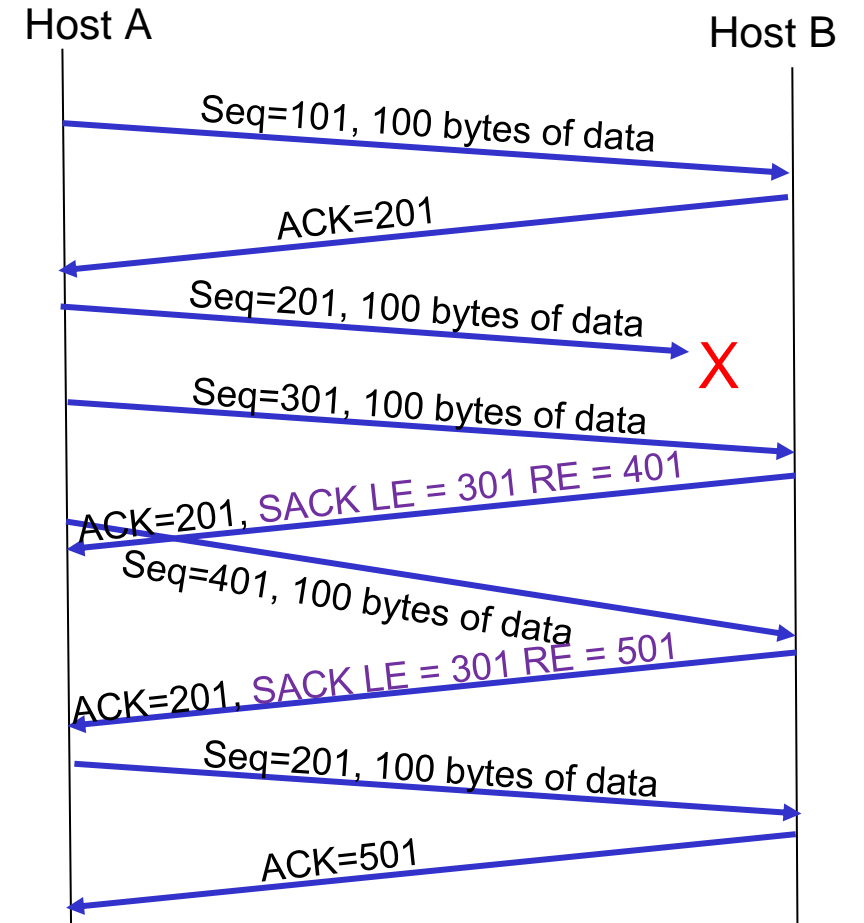
TCP Sequence Numbers and ACKs

- **Full duplex data transfer**
 - Bi-directional data flow in same connection
 - ACK is piggybacked on data segments in the reverse direction



Selective ACKs (SACKs)

- **Selective ACK is optional**
 - Give hints for the receiver buffer state
 - List up to 3 ranges of received bytes



Summary

- Transmission control protocol (TCP):
 - Connection-oriented service
 - TCP segment structure
 - TCP sequence number and ACKs
-