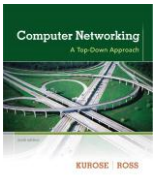
Chapter 3
Transport Layer



Computer Networking: A Top Down Approach
6th edition
Jim Kurose, Keith Ross
Addison-Wesley
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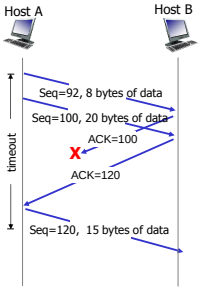
Thanks and enjoy! JFK/KWR

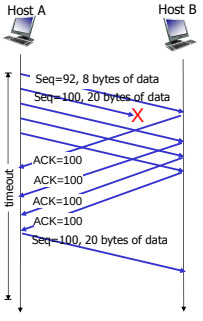
The course notes are adapted for Bucknell's CSCI 363
Xiannong Meng
Spring 2016

TCP: retransmission scenarios



cumulative ACK

TCP retransmit scenario



What does it mean if the sender receives multiple ACKs for the same packet?

An earlier packet is lost!

Fast retransmit after sender receipt of triple duplicate ACK

TCP fast retransmit

- time-out period often relatively long:
  - long delay before resending lost packet
- detect lost segments via duplicate ACKs.
  - sender often sends many segments back-to-back
  - if segment is lost, there will likely be many duplicate ACKs.

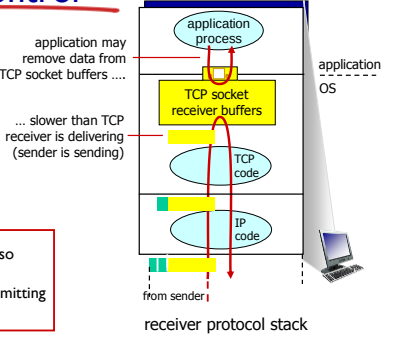
TCP fast retransmit
if sender receives 3 ACKs for same data ("triple duplicate ACKs"), resend unacked segment with smallest seq #
- likely that unacked segment lost, so don't wait for timeout

Chapter 3 outline

3.1 transport-layer services
3.2 multiplexing and demultiplexing
3.3 connectionless transport: UDP
3.4 principles of reliable data transfer
3.5 connection-oriented transport: TCP
- segment structure
- reliable data transfer
- flow control
- connection management

3.6 principles of congestion control
3.7 TCP congestion control

TCP flow control

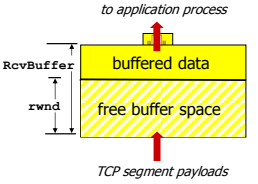


receiver protocol stack

flow control
receiver controls sender, so sender won't overflow receiver's buffer by transmitting too much, too fast

TCP flow control

- receiver "advertises" free buffer space by including **`rwnd`** value in TCP header of receiver-to-sender segments
  - **`RcvBuffer`** size set via socket options (typical default is 4096 bytes, see *setsockopt()* and *socket(7)*)
  - many operating systems autoadjust **`RcvBuffer`**
- sender limits amount of unacked ("in-flight") data to receiver's **`rwnd`** value
- guarantees receive buffer will not overflow



receiver-side buffering

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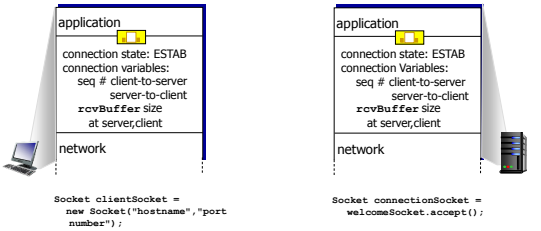
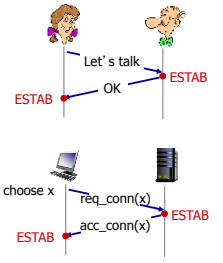
Connection Management

before exchanging data, sender/receiver "handshake":
- agree to establish connection (each knowing the other willing to establish connection)
- agree on connection parameters



Agreeing to establish a connection

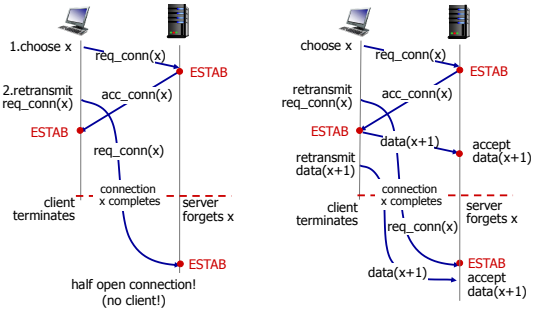
2-way handshake:



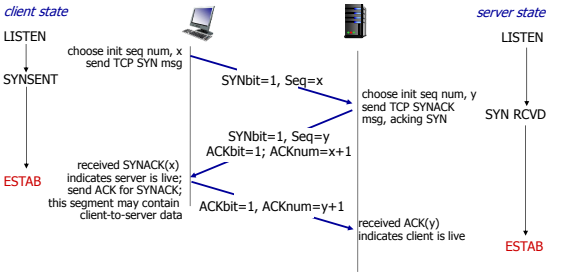
Q: will 2-way handshake always work in network?
- variable delays
- retransmitted messages (e.g. req_conn(x)) due to message loss
- message reordering
- can't "see" other side

Agreeing to establish a connection

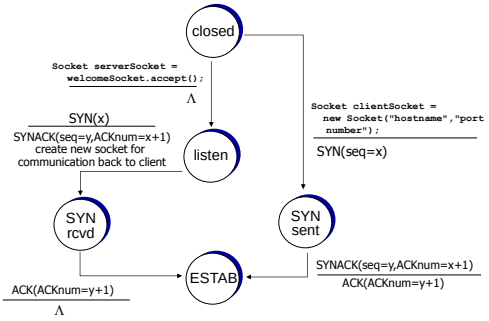
2-way handshake failure scenarios:



TCP 3-way handshake



TCP 3-way handshake: FSM



TCP: closing a connection

- client, server each close their side of connection
  - send TCP segment with FIN bit = 1
- respond to received FIN with ACK
  - on receiving FIN, ACK can be combined with own FIN
- simultaneous FIN exchanges can be handled

TCP: closing a connection