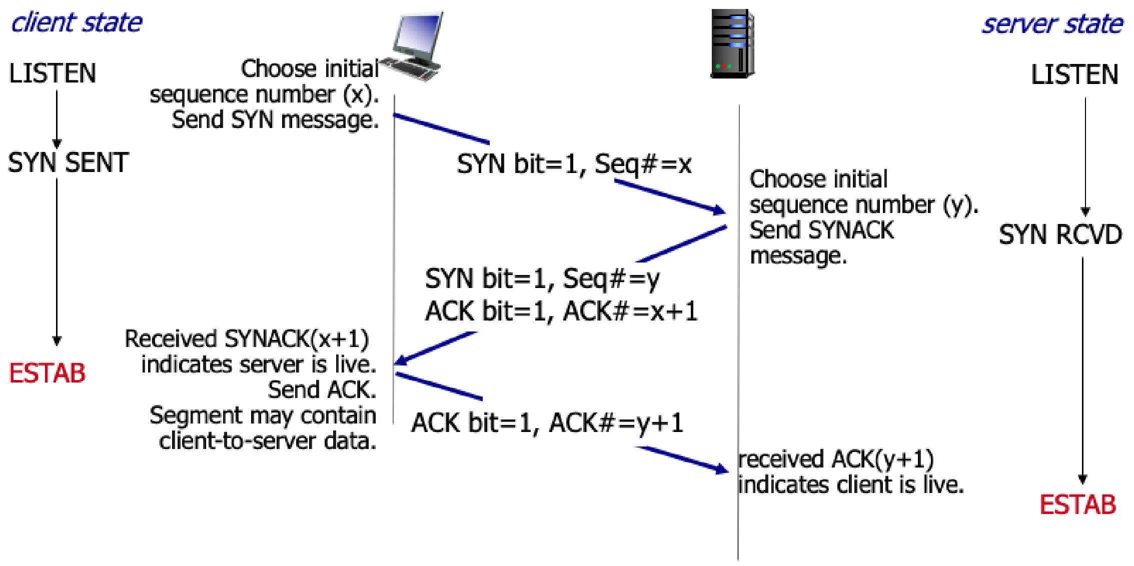
Exploration: TCP Connections and Network Fairness

Introduction

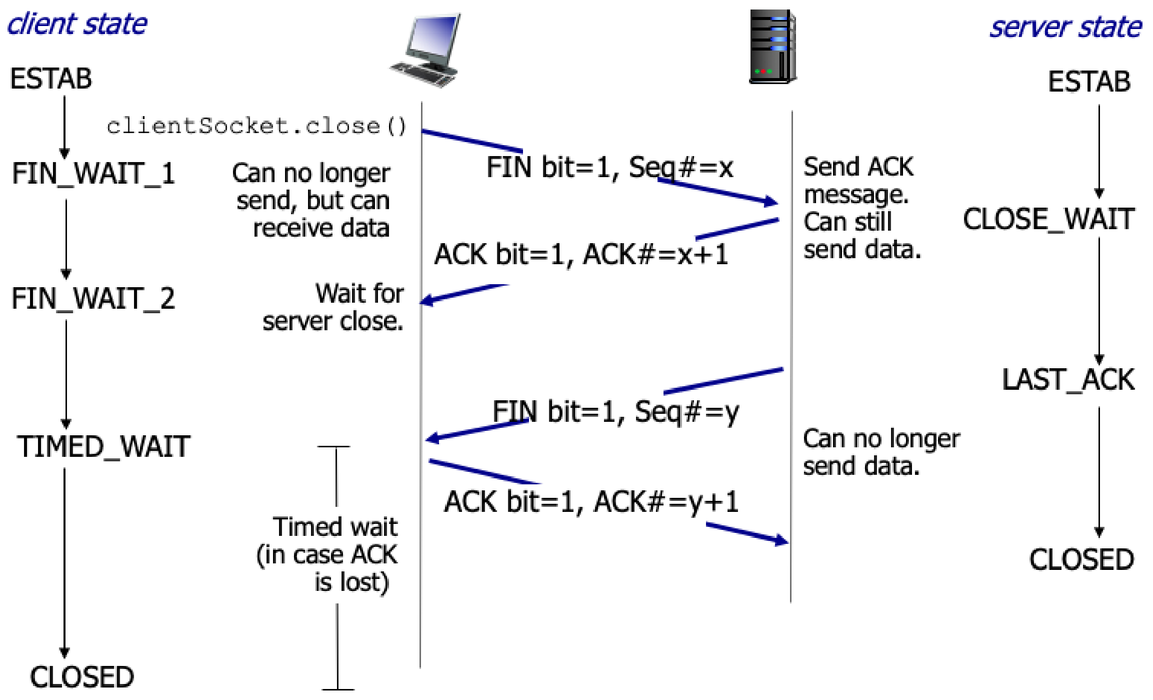
In this final exploration of the Transport Layer, we take a closer look at how TCP connections are managed, and also examine fairness when it comes to hosts and bandwidth.

TCP connections (socket connections) are set up and torn down by exchanging messages between hosts. To setup a connection requires 3 messages to be sent between a client and server. First, the client sends a packet with the SYN bit (synchronize flag) set. The server accepts the packet, and sends an ack packet with SYN and ACK bits set. Finally, the client sends a final ack packet back to the server. Note that the final ack may also include client data. It is important to note, that both the client and server maintain state machines during this process, which completes with the socket connection fully initialized on both hosts.


client state
LISTEN
SYN SENT
ESTAB
Choose initial sequence number (x). Send SYN message.
SYN bit=1, Seq#=x
server state
LISTEN
Choose initial sequence number (y). Send SYNACK message.
SYN RCVD
SYN bit=1, Seq#=y
ACK bit=1, ACK#=x+1
Received SYNACK(x+1) indicates server is live. Send ACK. Segment may contain client-to-server data.
ACK bit=1, ACK#=y+1
received ACK(y+1) indicates client is live.
ESTAB

The well-known "TCP 3-way handshake" to setup a socket connection.

The process to tear-down a TCP socket connect is similar. In this process, the server receives a packet with the FIN bit set. It responds with an ack, but because there may still be data left to send, it may continue to do so. Once all of the data is sent, the server will send a final ack with the FIN bit set, and the client will respond. Note that both the server and client maintain timers through this process, mainly because TCP connection teardown is somewhat unpredictable. It is unpredictable, because either host may terminate the communicating process before the teardown has a chance to complete.



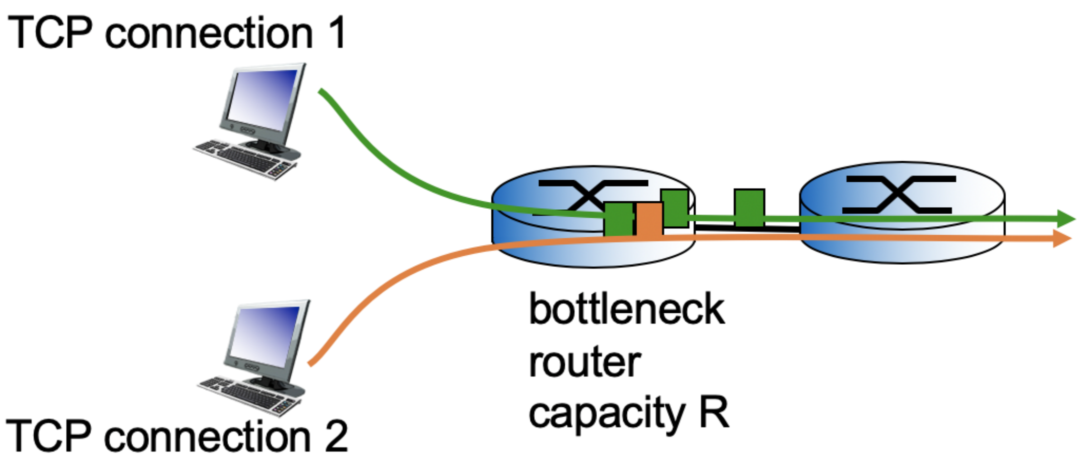
The less-well-known “TCP teardown handshake” to close a socket connection.

Next, let’s discuss TCP fairness:

Fairness Goal

If n TCP connections share the same bottleneck link of bandwidth R, then each should have an average rate of R/n.

What this means in practice, is that TCP is fair to each connection. While this is true, you may have already spotted the loophole: All a process has to do, is open multiple TCP connections, and Voilà! More bandwidth! In fact, your internet browser will do this to speed up web page downloads.



TCP is fair to each socket connection, but not to each process, or each host

This concludes our discussion of TCP connection management and fairness. Be sure to watch the video lecture below for more details on TCP connections, and then test your knowledge with the included Self-Check exercises.

Video Lecture

Transport Layer Wrap-up

CS 372 Lecture

The Transport Layer:

- Reliable data transfer with TCP
  - Connection setup/teardown
  - Fairness
  - Wrap up TCP/UDP

Note: Many of the lecture slides are based on presentations that accompany *Computer Networking: A Top Down Approach*, 6th edition, by Jim Kurose & Keith Ross, Addison-Wesley, 2013.

(PDF (https://oregonstate.instructure.com/courses/1798856/files/83165091/download?wrap=1) (https://oregonstate.instructure.com/courses/1798856/files/83165091/download?wrap=1) |PPT (https://oregonstate.instructure.com/courses/1798856/files/83165268/download?wrap=1) (https://oregonstate.instructure.com/courses/1798856/files/83165268/download?wrap=1))

Self-Check Exercises

List and describe the 3 steps of the TCP connection setup

Turn

Card 1 of 3

Drag the words into the correct boxes

Given a 1 Gbps link with TCP applications A, B, and C. Application A has 3 TCP connections to a remote web server; application B has 1 TCP connection to a mail server; application C has 4 connections to a remote web server. According to TCP “fairness” … during times when all connections are transmitting, how much bandwidth should each application have?

A gets Mbps.
B gets Mbps.
C gets Mbps

500 375 125

Resources