EE 3315 Tutorial: Application Layer

Review Questions:

1. For a communication session between two hosts, which host is the client and which is the server?

   The process which initiates the communication is the client; the process that waits to be contacted is the server.

2. What information is used by a process running on one host to identify a process running on another host?

   The IP address of the destination host and the port number of the destination socket.

3. Why do HTTP, FTP, SMTP, POP3 and IMAP run on top of TCP rather than UDP?

   The applications associated with those protocols require that all application data be received in the correct order and without gaps. TCP provides this service whereas UDP does not.

4. Consider an e-commerce site that wants to keep a purchase record for each of its customers. Describe how this can be done with HTTP authentication. Describe how this can be done with cookies.

   When the user first visits the site, the site returns a cookie number. This cookie number is stored on the user's host and is managed by the browser. During each subsequent visit (and purchase), the browser sends the cookie number back to the site. Thus the site knows when this user (more precisely, this browser) is visiting the site.

Problems:

1. Suppose within your web browser you click on a link to obtain a web page. Suppose that web page associated with the link contains exactly one object, a small amount of HTML text. Let RTT denote the round trip time between the local host and the server containing the object. Further suppose the page references three very small objects. Assuming zero transmission time of the objects, how much time is needed from when the client clicks on the link until the client receives all the three referenced objects with
   - a) non-persistent HTTP with parallel TCP connections?
   - b) non-persistent HTTP with no parallel connections?
   - c) persistent HTTP with pipelining?

1. a) $2RTT + 2RTT = 4RTT$.

   b) $2RTT + 3 \cdot 2RTT = 8RTT$.

   c) $2RTT + RTT = 3RTT$.

2. Suppose that the average object size is 900,000 bits and that the average request rate from the institution's browsers to the origin servers is 1.5 requests per second. Also suppose that the amount of time it takes from when the router on the Internet side of the access link forwards an HTTP request until it receives the response is two seconds on average. Let the average response time be the sum of the average access delay and the average internet delay. For the average access delay, use $\Delta / (1 - \Delta \beta)$, where Δ is the average time required to send an object over the access link and β is the arrival rate of objects to the access link.

   a) Find the average response time.
   b) Now suppose a cache is installed in the institutional LAN. Suppose the hit rate is 0.4. Find the average response time.
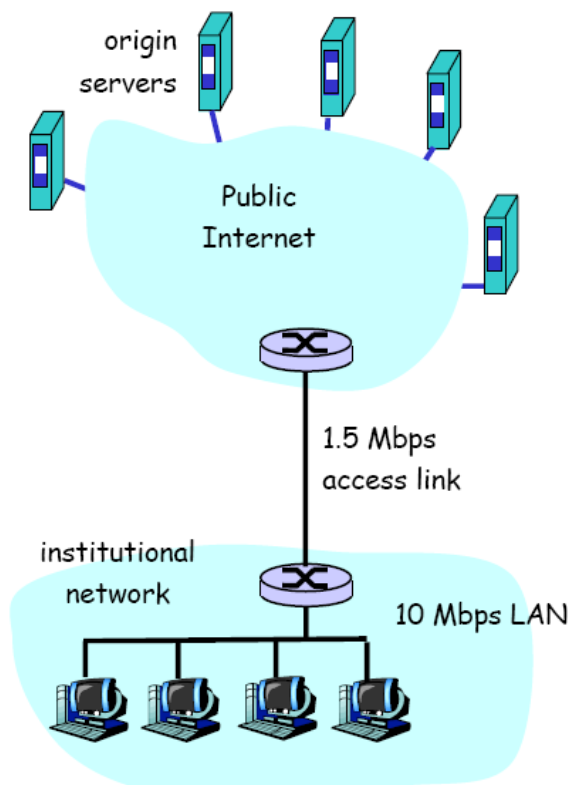
a) $\Delta = (900,000 \text{ bits}) / (1.5 \text{ Mbps}) = .6 \text{ sec}$
     $\beta = 1.5 \text{ requests} / \text{sec.}$
     $\Delta/(1 - \Delta \beta) = .6 / (1 - .6 \times 1.5) = 6 \text{ sec.}$
     Average response time $= 6 + 2 = 8 \text{ sec.}$

b) $\beta = 1.5 \times .6 = .9 \text{ requests/sec.}$
     $\Delta/(1 - \Delta \beta) = .6 / (1 - .6 \times .9) = 1.3 \text{ sec.}$
     Average response time $= .6 \times (2 + 1.3) + .4 \times 0 = 1.98 \text{ sec.}$

     Note: The response time is approximately zero if the request is satisfied by the cache (which happens with probability 0.4)

3. Why is it said that FTP sends control information "out-of-band"?

Control information and user data are sent using different TCP connections.

4. Suppose Alice, with a Web-based e-mail account (such as Hotmail), sends a message to Bob, who accesses his mail from his mail server using POP3. Discuss how the message gets from Alice's host to Bob's host. Be sure to list the series of application-layer protocols that are used to move the message between the two hosts.

Message is sent from Alice's host to her mail server over HTTP.
Alice's mail server then sends the message to Bob's mail server over SMTP.
Bob then transfers the message from his mail server to his host over POP3.