94.521 Homework assignment 1

Due March 19. th in class

From the book **High Performance Communication Networks** by J. Walrand and P. Varaiya, do the following problems on pages 99, 100, and 101 (Chapter 2): 19, 20, 21, 22, 23, 25

From the book : **Computer Networking: A Top-Down Approach Featuring the Internet** by J. Kurose and K. Ross do the following problems:

1. In Figure 3.31, we see that TCP waits until it has received three duplicate ACK before performing a fast retransmit. Why do you think the TCP designers chose not to perform a fast retransmit after the first duplicate ACK for a segment is received?
2. Suppose TCP increased its congestion window by two rather than by one for each received acknowledgement during slow start. Thus, the first window consists of one segment, the second of three segments, the third of nine segments, etc. For this slow-start procedure:
   (a) Express K in terms of O and S.
   (b) Express Q in terms of RTT, S, and R.
   (c) Express latency in terms of $P = min(K-1, Q)$, O, R, and RTT.
3. With persistent HTTP, all objects are sent over the same TCP connection. As we discussed in Chapter 2, one of the motivations behind persistent HTTP (with pipelining) is to diminish the effects of TCP connection establishment and slow start on the response time for a Web page. In this problem, we investigate the response time of persistent HTTP. Assume that the client requests all the images at once, but only when it has received the *entire* HTML base page. Let $M + 1$ denote the number of objects and let O denote the size of each object.
   (a) Argue that the response time takes the form $(M+1)O/R + 3RTT + latency$ due to solw-start. Compare the contribution of the RTTs in this expression with that in nonpersistent HTTP.
   (b) Assume that $K = log_2(O/S + 1)$ is an integer; thus the last window of the base HTML file reansmits an entire window's worth of segments, that is, window K

transmits $2^(k-1)$ segments. Let $P^{'} = min(Q, K^{'} - 1)$ and

$$K^{'} = log_2((M+1)\frac{O}{S} + 1)$$

Note that $K^{'}$ is the number of windows that cover an object of size $(M+1)O$ and $P^{'}$ is the number of stall periods when sending the large object over a single TCP connection. Suppose (incorrectly) the server can send the images without waiting for the formal request for the images from the client. Show that the response time is that of sending one large object of size $(M+1)O$:

$$Approx\ response\ time = 2RTT + \frac{(M+1)O}{R} + P^{'}(RTT + \frac{S}{R}) - (2^{p^{'}} - 1)\frac{S}{R}$$

(c) The actual response time for persistent HTTP is somewhat larger thant he approximation. This is because the server must wait for a request for the images before sending the images. In particular, the stall time between the K^{th} and the $(K+1)^{st}$ window is not $(S/R + RTT + 2^{K-1}(S/R))^{+}$ but is instead RTT. Show that:

$$Response\,time = 3RTT + \frac{(M+1)O}{R} + P^{'}(RTT + \frac{S}{R}) - (2^{p^{'}} - 1)\frac{S}{R} - (S/R + RTT - 2^{K-1}(S/R))^{+}$$

Note that the last 3 problems require a bit of reading from your side with focus on the TCP issues of chapter 3 in particular section 3.7 of chapter 3. Also some reading of chapter 2 may be necessary