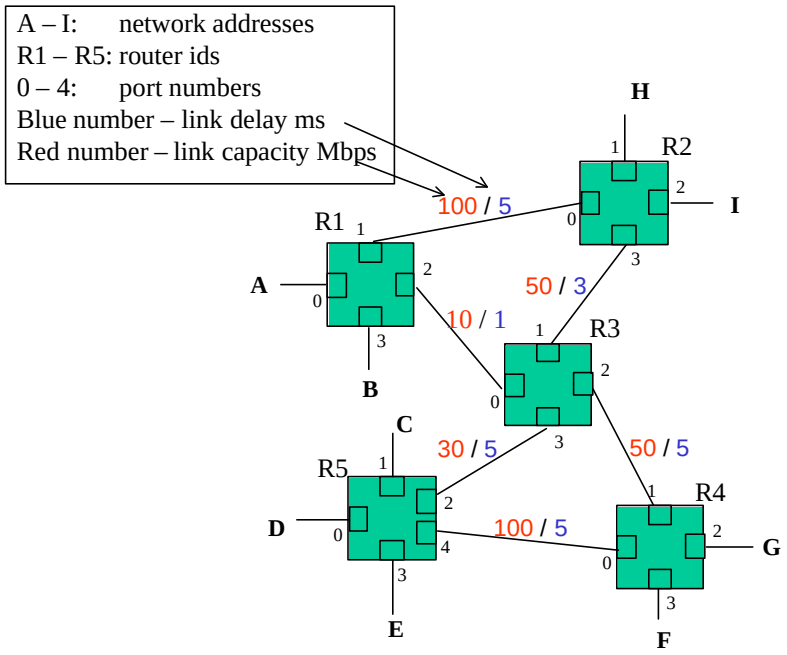
Homework 1 of CS4550, Spring 2002

Due date: 5:00pm, August 15 (firm)

1. Consider the network below.



   (a) (5 points) Assume that datagram routing is used in the network and the routing algorithm always selects a path with the least total link delay. If the objective is to have each host able to reach any other host. Write out the necessary routing tables for R3 and R5.
   (b) (5 points) How should R3 and R5 update their tables when the link between R3 and R5 is down?
   (c) (5 points) Assume that virtual circuit routing is used in the network and this time the routing algorithm always selects a path with the most capacity. The connection IDs are nonnegative integers from 0 to 255 allocated independently by each router. Write out the routing tables of R1, R2 and R3 after the following connections are established in turn: F to A, I to A, D to A, B to A, and A to I.

2. Consider sending a large file of F bits from Host A to Host B. There are two links and one switch between A and B, and the links are uncongested (that is, no queuing delays). Host A segments the file into segments of S bits each and adds 40 bits of header to each segment, forming packets of L = 40 + S bits. Each link has a transmission rate of R bps.
   (a) (5 points) Give the expression for total delay of moving the file from Host A to Host B. Neglect propagation delay.
   (b) (5 points) Find the value of S that minimizes this delay.

3. Suppose client A initiates an FTP session with server S. At about the same time, client B also initiates an FTP session with the same server. Provide possible source and destination ports for
   (a) (3 points) the segments sent from A to S.

(b) (2 points) the segments sent from B to S.
(c) (3 points) the segments sent from S to A.
(d) (2 points) the segments sent from S to B.
(e) (3 points) If A and B are at different hosts, is it possible that the source port numbers in the segments from A to S are the same as those from B to S?
(f) (2 points) How about if they are at the same host?

4. Consider the TCP procedure for estimating RTT. Suppose that x = 0.1. Let $SampleRTT_1$ be the most recent sample RTT. Let $SampleRTT_2$ be the next most recent sample RTT, etc.
   (a) (5 points) For a given TCP connection, suppose 4 acknowledgements have been returned with corresponding sample RTTs $SampleRTT_4$, $SampleRTT_3$, $SampleRTT_2$, and $SampleRTT_1$. Express EstimatedRTT in terms of the four sample RTTs.
   (b) (5 points) Generalize your formula for n sample RTTs.
   (c) (5 points) Let n approach infinity. Comment on why this averaging procedure is called an exponential moving average.

   [Hint: It may help to use a simpler notation for the samples: e.g., y_i instead of $SampleRTT_i$.]

5. You are hired to design a reliable byte-stream protocol that uses a sliding window (like TCP). This protocol will run over a 100-Mbps network. The RTT of the network is 100 ms, and maximum segment lifetime is 60 seconds.
   (a) (5 points) How many bits would you include in the RcvWindow and SequenceNumber fields of your protocol header?
   (b) (5 points) How would you determine the numbers given above, which values might be less certain?

6. (10 points) Suppose, in TCP's RTT estimation mechanism, that EstimatedRTT is 4.0 ms at some point and subsequent sampled RTTs all are 1.0 ms. How many RTT samples does it take before the Timeout value falls below 4.0 ms? Assume a plausible initial value of Deviation; how sensitive is your answer to this choice? Use x = (1/8).

7. Assume that TCP implements an extension that allows window sizes much larger than the current maximum of 64Kbytes. Suppose you are using this extended TCP over a 1-Gbps link with a propagation latency of 100 ms to transfer a 10-MB file, and the receiver has buffer space of 1MB. If TCP sends 1-KB segments (excluding TCP header), there is no congestion and no lost packet, and the receiving application reads segments as fast as they come in:
   (a) (5 points) How many RTTs does it take until slow start opens the send window to 1MB?
   (b) (5 points) How many RTTs does it take to send the file?
   (c) (5 points) If the time to send the file is given by the number of required RTTs multiplied by the link propagation latency, what's the effective throughput, (Total Bytes Sent / Send Time), for the transfer? What percentage of the link bandwidth is utilized?

8. Suppose two TCP connections share one of router R's links. The queue size for the shared link is six segments; each connection has a stable congestion window of three segments. No congestion control is used by these connections. A third TCP connection now is attempted, also using the same link. The third connection does not use congestion control either.
   (a) (5 points) Describe a scenario in which, for at least a while, the third connection gets none of the available bandwidth, and the first connections proceed with 50% each.
   (b) (5 points) Does it matter if the third connection uses slow start?