Computer Networks (CS 453), Spring 2011
Homework 1
Instructor: V. Arun

Assigned: 1/31/11, Due: 2/09/11

Note: Please show as much of your work as you can. *Whenever possible, use variable names before plugging in numerical values*. Even if you get the answer wrong, you can get partial credit if you show your approach clearly. It will help us tell you where you made a mistake. If you plug in numbers right upfront and your answer is wrong, you will not get partial credit.

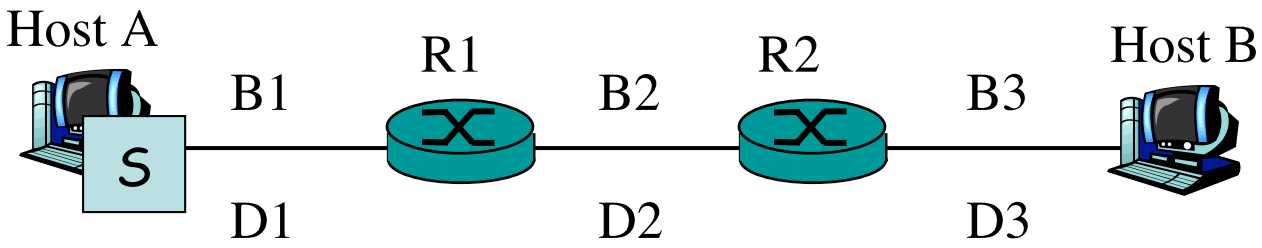
Problem 1: Quickies (18 points)

A. Give one advantage and one disadvantage of circuit switched networks over packet switched networks.
B. List four factors that contribute to the end-to-end delay in a packet-switched network. Which of these are constant and which of these depend on the load in the network?
C. What is the key difference between a tier-1 ISP and a tier-2 ISP?
D. Give two differences between TCP and UDP.
E. What is the difference between a virus, a worm, and a Trojan horse?
F. Suppose you would like to urgently deliver 40 terabytes data from Boston to Los Angeles. You have available a 100Mbps dedicated link for data transfer. Would you prefer to transmit the data via this link or instead use Fedex overnight delivery? Explain.

Problem 2 (Circuit vs. packet switching, 20 points): Consider a network with a capacity of C = 3 Mbps. Suppose that each user requires a fixed rate R=150kbps when transmitting, but each user independently transmits only 10% of the time or with probability p=0.1.

A. Using circuit switching, how many users can be supported? (4)
B. For the rest of this problem, assume packet switching is used with a total of N=40 users. What is the probability the users 1, 3, and 7 are active and the rest inactive? (4)
C. What is the probability that exactly K=20 users are active? (4)
D. What is the probability that more than K users are active? (8)

Problem 3 (Packet switching delays, 34): Consider the figure below. Suppose host A has a packet of size S=1500B to send to host B at time t=0. Let B1=10 Mbps, B2=20 Mbps, B3=30Mbps be the bandwidth capacities of the three links respectively. Let D1, D2, and D3 be the corresponding lengths of the three links and let V denote the speed of light. Assume that processing delays are negligible at all nodes. In the questions below, leave the final answer in terms of the variable names.



A. At what time T1 does the packet leave R1? (3)
B. At what time T2 does the packet leave R2? (3)
C. At what time T3 does the packet reach host B? (4)
D. Now suppose host A has a second packet also of size S to be sent to host B and it sends the two packets back to back. At what time T4 does the second packet reach R1? Is this before or after time T1 when the first packet left R1? Will the second packet experience queuing at R1? (4)
E. At what time T5 does the second packet reach R2? Is this before or after the time T2 when the first packet left R2? Will the second packet experience queuing at R2? (4)
F. At what time T6 does the second packet arrive at host B? (4)
G. Now suppose the link B3 has capacity 5Mbps (instead of 30 Mbps as above). Does the second packet experience any queuing at R2? Recalculate T5 and T2 to arrive at the answer. (8)
H. For the case when B3=5 Mbps as in part F, recalculate the time T6 when the second packet arrives at host B. (4)

Problem 4 (File and packetization delays, 14 points): Suppose host A and host B are separated by D=2000 Kms and are connected by a direct link of R=2 Mbps. Suppose the propagation speed over the link is C=2.5x10^8 m/s.

A. Consider sending a file of size S=800,000 bits from host A to host B. Suppose the file is sent continuously as one large message. What is the maximum number of bits on the link at any time? Hint: this value is also called the bandwidth-delay product. (4)
B. Now suppose the file is chopped up into packets each of which is of size L=1500B. Suppose the sizes of the link layer, network layer, and transport layer headers are each H=20B long. Assume that the packets are sent back-to-back and no packets are lost. At what time is the transfer complete? (4)
C. Now suppose that host A must send a packet and wait for an acknowledgment before it can send the next packet. Assume that the transmission time of the acknowledgment (but not the propagation time) is negligible. How long does it take to transfer the entire file? (6)

Problem 5 (HTTP connections, 14 points): Consider a web page whose base file is of size S1 = 10 KB. Assume that the web page consists of N=20 inline objects each of size S2 = 100 KB. Assume that the round-trip time to the web server is T = 100ms and the bottleneck capacity is C=10Mbps. Ignore any packetization delays and header overhead similar to part A in the previous problem.

A. Assuming HTTP/1.0 is used, how long does it take to download the web page? (4)
B. Assuming pipelined HTTP/1.1 is used, how long does it take to download the web page? (4)
C. Assuming non-pipelined HTTP/1.1 with two parallel connections is used, how long does it take to download the web page? (6)