15-441 Computer Networks

Homework #1

Out: 1/27/05 Due: 1:30 pm 2/3/05

Instructions: Please type or *neatly* handwrite a solution to each of the following questions. For full credit, please explain how you derived an answer; don't just give the final result. Papers are due at the beginning of class on Thursday, February 3, 2005.

1. Consider sending a file of size $F = M * L$ bits over a path of Q links. Each link transmits at R bps. The network is lightly loaded so that there are no queuing delays. When a form of packet switching is used, the $M * L$ bits are broken up into M packets (i.e., each packet has L bits) and all the devices in the network are store-and-forward (i.e., they must receive all of the packet before transmitting it). Assume propagation delay and processing time are negligible. [This question adapted from question 1.5 in Kurose and Ross]

    a. Suppose the network is a packet-switched virtual circuit network. [We haven't gone over what a packet-switched virtual circuit network is, so I'll explain briefly. If A wants to send a message to B, it first contacts the networks, which sets up a path between A and B, the circuit, taking a certain amount of time. Once the circuit is set up, A breaks its message into packets, appends a header with the circuit identifier to each one, and sends them off into the network, where they are delivered to B.] Denote the virtual circuit (VC) set-up time by t_s seconds. Suppose the sending layers add a total of h bits of header to each packet. How long does it take to send the file from source to destination?

    b. Suppose the network is a packet-switched datagram network and a connectionless service is used. Now suppose each packet has $4h$ bits of header. How long does it take to send the file?

    c. Repeat 1b, but assume message switching is used. That is, $4h$ bits are added to the message, and the message is not segmented–it is sent through as one massive packet.

    d. Finally, suppose the network is a circuit-switched network like the telephone network. Further suppose that the transmission rate of the circuit between the source and destination is R bps. Assuming t_s set-up time and h bits of header appended to the entire file, how long does it take to send the file?

    e. In the previous questions, you came up with algebraic expressions for the latency of the file transfer. To get a feel for the actual wall-clock times involved, substitute in the following values which are typical of today's Internet. R=5.2Gbps (an imaginary link speed, but within range), Q=10 hops (typical for a path from a CMU computer to a U Pitt computer), M=1000packets and L=8000bits so F=1 million bytes (just under 1MB), h=40bits, t_s=0.1 seconds.

f. Referring to 1e, what values of M and F would give a faster transfer time over a packet switched virtual circuit network than a packet switched datagram network?

2. Consider a simple protocol for transferring files over a link. After some initial negotiation, A sends data packets of size 1 KB to B; B then replies with an acknowledgement. A always waits for each ACK before sending the next packet; this is known as *stop-and-wait*. Packets that are overdue are presumed lost and are retransmitted. [Problem 1.32 from Peterson and Davie]

   a. In the absence of any packet losses or duplications, explain why it is not necessary to include any "sequence number" data in the packet headers.
   b. Suppose that the link can lose occasional packets, but that packets that do arrive always arrive in the order sent. Is a 2-bit sequence number (that is, N mod 4) enough for A and B to detect and resend any lost packets? Is a 1-bit sequence number enough?
   c. Now suppose that the link can deliver out of order, and that sometimes a packet can be delivered as much as 1 minute after subsequent packets. How dos this change sequence number requirements?

3. Imagine you are advising a company that owns a large database and has customers distributed across the USA. The company wants to give its customers the lowest possible latency when accessing its database and has asked you to recommend a strategy for them to pursue as they upgrade their servers and network. Briefly describe three questions you would ask the company or experiments you would perform in order to assemble a strategy for them. Explain how each question is relevant to the goal of reducing access latency. There are many, many issues that need to be considered – this question only expects you to brainstorm to come up with a few of the networking-related ones.

4. Assume that a SONET receiver resynchronizes its clock whenever a 1 bit appears; otherwise, the receiver samples the signal in the middle of what it believes is the bit's time slot. [Problem 2.10 from Peterson and Davie]

   a. What relative accuracy of the sender's and receiver's clocks is required in order to receive correctly 48 0 bytes (one ATM AAL5 cell's worth) in a row?
   b. Consider a forwarding station A on a SONET STS-1 line, receiving frames from the downstream end B and retransmitting them upstream. What relative accuracy of A's and B's clocks is required to keep A from accumulating more than one extra frame per minute?