Data Networks, Summer 2007
Homework #1

Assigned May 16, 2007
Due May 21, 2007 in class

Name: _____

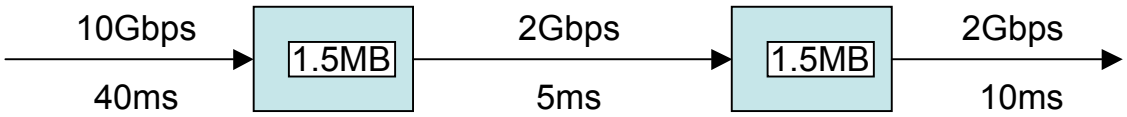
Email: _____

Student ID: _____

Problem	Points
1	
2	
3	
4	
Total	

In this homework, for simplicity, K means 10^3, M means 10^6, and G means 10^9. But read the green box on page 44-46 of Peterson & Davie to understand the precise meaning of these notations in different contexts. Show your work when appropriate, do not just write down a single number as your answer if you want full credit.

Problem 1 (25 points)– Consider the following network path with 3 links and two store-and-forward packet switches. The speeds and the delays of the links are as indicated in the picture. Packets flow from left to right. Note that each switch has 1.5MB of memory for doing store-and-forward.



(a) Assume that the path is completely empty initially, what's the total time required to transmit a 500KB packet across this path (i.e. the time from the first bit is injected until the last bit emerges)? (6 points)

(b) Assume that someone has just finished injecting a 500KB packet into the first link before you start transmitting your 500KB packet. In this case, what is the total time required to transmit your 500KB packet across the path? (7 points)

(c) Given that other arbitrary network traffic can exist to compete for transmission, if a 500 KB packet is successfully transmitted across the path, what is the maximum (worst case) time it could have taken? (6 points)

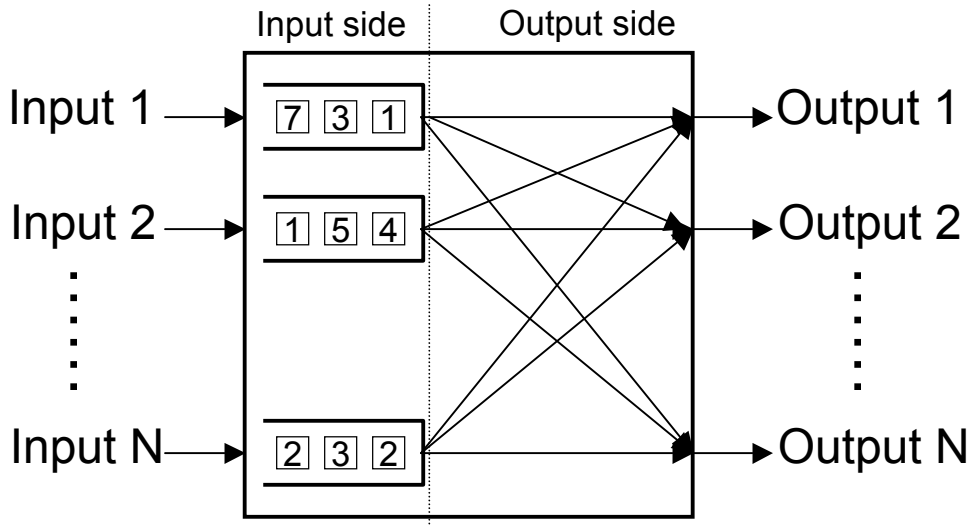
(d) What's the maximum number of bits of data this network path carries at any moment? A MP3 file is roughly 4MB, how many MP3 files can the path carry at any moment? (6 points)

Problem 2 (30 points) – (This is adopted from Peterson & Davie p.59, #25 (a) and (b)) Assume you wish to transfer an n-byte file along a path composed of the source, destination, five point-to-point links, and four switches. Suppose each link has a propagation delay of 1 ms, bandwidth of 3 Mbps, and that the switches support both circuit and packet switching. Thus you can either break the file up into 1 KB packets, or set up a circuit through the switches and send the file as one contiguous bit stream. Suppose that packets have 24 bytes of packet header information and 1000 bytes of payload, that store-and-forward packet processing at each switch incurs a 1 ms delay after the packet has been completely received, that packets may be sent continuously without waiting for acknowledgements, and that circuit setup requires a 1 KB message to make one round-trip on the path incurring a 1 ms delay at each switch after the message has been completely received. Assume switches introduce no delay to data traversing a circuit. You may also assume that file size is a multiple of 1000 bytes.

(a) For what file size n bytes is the total number of bytes sent across the network less for circuits than for packets? (15 points)

(b) For what file size n bytes is the total latency incurred before the entire file arrives at the destination less for circuits than for packets? (15 points)

Problem 3 (25 points) – Abstractly, a router (or switch) has some input ports and some output ports. When a packet arrives at an input port, it is forwarded to the correct output port for outbound transmission. A router typically has memory buffers for queueing packets that are waiting to be forwarded or transmitted. In one type of router, called input queueing router, the memory buffers exist only at the input side. A queue is called FIFO (first-in-first-out), if the packets leave the queue in the order they arrived. The figure below depicts a simple input queueing router with a FIFO queue at each input port. The small numbered boxes inside the FIFO queues denote packets destined for the corresponding numbered output port. Assume that the transmission paths indicated by the arrows have the same transmission speed. Assume also that the input elements can coordinate to eliminate collisions at the output port.



(a) This simple input queueing router design is known to achieve very poor utilization. That is, the output ports are often not kept busy transmitting as much as possible. Explain why you think this design has such a low utilization problem. (10 points)

(b) How would you change the design of the input side of the router to reach higher utilization? A critical objective here is that the time it takes to insert or remove a packet from memory should not depend on the number of packets in memory. Drawing your design may help with your explanation. (15 points)

Problem 4 (20 points) – Simple networking tools. Login to a Unix machine in the CIP pool. Do the following:

(a) Run “man ping”, skim the manual page that is displayed. In a couple of sentences, describe what the “ping” tool does. (2.5 points)

(b) Now, run “ping www.mpi-sws.org”. Stop it after a few seconds by hitting “Control-C”. What information is reported by the “ping” tool? (2.5 points)

(c) Now, try “ping www.cs.cmu.edu”. Stop it after a few seconds by hitting “Control-C”. What are the most important differences between this result and what you saw in part (b)? (2.5 points)

(d) What network problems do you think “ping” can help diagnose? (2.5 points)

(e) Run “man traceroute”, skim the manual page that is displayed. In a couple of sentences, describe what the “traceroute” tool does. (2.5 points)

(f) Now, run “traceroute loki10.mpi-sws.org”. Let it run until it has finished. What information is reported by the “traceroute” tool? If you are not permitted to run traceroute on your CIP machine, use traceroute servers at www.traceroute.org. (2.5 points)

(g) Now, run “traceroute www.cs.cmu.edu”. Let it run until it has finished. What are the most important differences between this result and what you saw in part (f)? (2.5 points)

(h) What network problems do you think “traceroute” can help diagnose? (2.5 points)