New Mexico State University
Dept. of Computer Science
CS 584 (Spring 2004)
Homework set 1

1. Consider a 10 Mbps Ethernet where the longest path between two hosts pass through three store-and forward switches. The size of a data packet is 5000 bits.

   (a) Calculate the latency (from the first bit sent to the last bit received), assuming that each link introduces a propagation delay of 10 μs and that each switch begins retransmitting immediately after it has finished receiving the packet.

   (b) Calculate the latency again, assuming that the switches implement "cut-through" switching: they become able to retransmit the packet after the first 200 bits have been received.

   (c) Calculate the effective bandwidth in (a) assuming that there is a steady supply of 5000 bit data packets and switches can send packets on one link while receiving on the other.

   (d) Calculate the effective bandwidth again, but with the sender having to wait for a 50 byte acknowledgement packet after sending each 5000 bit data packet.

2. Assume that you wish to transfer an n-byte file along a path composed of the source, the destination, seven point-to-point links and five switches. Suppose each link has a propagation delay of 2 ms, bandwidth of 4Mbps, and that the switches support both circuit switching and packet switching. Thus, you can either break the file up into 1 KB packets, or set up a circuit through the switches or send it as one contiguous bit stream. Suppose that the packets have 24 bytes of packet header information and 1000 bytes of payload, that store-and-forward packet processsing at each switch incurs a 1 ms delay at each switch after the message has been completely received. Assume also that switches introduce no delay to data traversing a circuit. You may assume that file size is a multiple of 1000 bytes.

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

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

3. Consider a commercial PEP (Performannce Enhancing Proxy) that has been installed within the satellite modem that provides the WAN connection to your SOHO router with standard 10/100 Mbps Ethernet interfaces. The PEP combines outgoing packets and splits incoming packets by doing some kind of flow identification. The packet size on the Ethernet segment is 1500 bytes. The the RTT to the GEO satellite is 600 ms, whereas a typical value of RTT on transcontinental Internet backbone is 100 ms. Upto a maximum of 256 Kbps uplink speed and 40 Mbps downlink speed can be supported.

   (a) What are outbound (uplink) and inbound (downlink) packet sizes the proxy must use to support effective upload speed of 100 Kbps and download speed of 1 Mbps?

   (b) What would be the observed upload and download speed if any end-to-end encryption (IPSec or VPN) is used?

4. A router with two WAN interfaces serves as the Internet gateway to a high-speed LAN connected to n hosts, each of which injects outbound (from the LAN) packets following a Poisson process with a net rate of λ per second. Assume that the packet sizes are small in comparison to the LAN speed, so that the chance of collision is minimal. Also, the Poisson process reflects the combined effect of collision-free transmission and retransmission.

   (a) Show that the aggregated stream of outbound packets that the router gets after statistical multiplexing also follows a Poisson process, with an effective rate $n\lambda$ per second.

   (b) Suppose both the WAN interfaces have the same bandwidth and delay characteristics. Thus, for load balancing, the router randomly places the packets coming from the LAN onto those two connections with equal probability. Show that the outbound packet stream in each WAN connection is a Poisson process with rate $\frac{n\lambda}{2}$. What can you say about the stochastics of the packet inter-arrival times?

   (c) Suppose that the router deterministically places alternate packets onto those two WAN interfaces. By characterizing the inter-arrival process on one of those links, determine if those two packets streams still remain Poisson processes (Quantitative justification/proof needed).