University of Pittsburgh

School of Library and Information Science
Telecommunications

Course : TelCom 2310 - Computer Networks
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Homework 1

Problem 1.

Consider a path in a store-and-forward network. The path goes through ten nodes. At each node, the packets are stored in a buffer before they are transmitted over the link to the next node. The packets contain 1,000 bits, and the transmission rates are equal to 56 kbps. The total propagation time over the links along the path is 15 ms. Assume that a packet is sent along that path and that it finds an average of five packets when it arrives at each buffer. How long does it take for the packet to go through the path if the nodes transmit from each buffer on a first come first served basis? How long is the packet travel time if it is transmitted as expedited data? (Upon arrival, expedited data are moved to the head of the queues of packets that are waiting to be transmitted.)

Problem 2.

To transmit packets with virtual-circuit transport, we first set up a virtual-circuit and then we transmit the packets. The network is lightly loaded, and packets do not face any queueing delay. The virtual-circuit setup time is 400 ms. The packets travel over a path that goes through 10 nodes, and the links transmit at 56 kbps. Each packet has 400 bits of data, a header of 5 bytes to indicate the virtual-circuit number and the packet sequence number, and a trailer of 2 bytes that contains bits used for error detection. When we use datagram transmission, no virtual-circuit is set up but each packet needs a header of 10 bytes instead of 5 to indicate the full destination address and source address, in addition to packet sequence number. These packets also have the 2-byte trailer. Assume that datagrams also happens to follow the same path through 10 nodes. How long does it take to transmit N packets when using virtual-circuit transport and when using datagram transport? For what values of N is it faster to use virtual-circuit transport?

Problem 3.

Packets arrive in pairs every second at a transmitter equipped with a buffer. The transmission rate is 56 kbps, and each packet is 1,000 bits long. What is the average delay per packet through the buffer and transmitter? Assume now that packets arrive in pairs every 0.5 second and that the transmission rate is 122 kbps. What is the new average delay per packet? Think of the second model as being the statistical multiplexing of two packet streams sharing one 122-kbps transmitter, and the first model as resulting from the division of 112 kbps link into two 56-kbps channels (by FDM, say) used by one packet stream each. What conclusion can be drawn with respect to the efficiency of statistical multiplexing and FDM/TDM in achieving smaller delays? Discuss the limitations of this model and how the conclusions can be shown to be valid under more general assumptions.

Problem 4.

Packets arrive at a node to be transmitted. The packets arrive at random times T_1, T_2, .. and are transmitted in the order in which they arrive. Packets that cannot be transmitted immediately are stored in a buffer until they can be. Assume that each packet is P bits long and the transmission rate is R bits per second. Draw a diagram showing how many bits are stored in the node buffer as a function of time. That number is zero before time T_1. At time T_1, that number is assumed to jump instantaneously to P. Between T_1 and T_2, the number of bits stored decreases by R bits every second, and so on. Using your diagram, determine the delay faced by the first, second and third packets as a function of (T_1, T_2, T_3). Note that the delay a packet is the sum of the transmission time $\frac{P}{R}$ and some queueing delay. Give a simple condition on the arrival times (T_1, T_2, T_3) for the queueing time to be zero. Exhibit arrival times $\{T_n, n \geq 1\}$ that lead to a very large average queueing time per packet, even though the average arrival rate, in packets per second, is very small. (Hint: consider infrequent arrivals of large batches of packets).