# Homework 1 for CSE/EE 461 (Winter 2001)

**Due: Wed, Jan 17, 2001, at the beginning of class. (Out: Wed, Jan 10, 2001.)**

Note: be sure to show how you derived answers so that you are eligible for partial credit.

**1. Multiplexing.** Peterson Ch1, Ex10

**2. Statistical Multiplexing.** Suppose that users of a computer network are idle 90% of the time, and when not idle require 1Mbps of bandwidth. Assume that the users act independently. To answer the questions below, you will want to leverage the formula that gives the probability that K of N users are active at a given time, assuming independent users who are active with probability p. (This is just the binomial distribution.)

$$\text{Prob}(K) = N!/(K!(N-K)!) \times p^{K} \times (1-p)^{N-K}$$

a) Suppose the network is owned by a bank, which requires that the network always have sufficient capacity to support its users. How much network capacity is needed to support 10 users?
b) Suppose the network is owned by an ISP, which decides that satisfying user demand 99% of the time is sufficient. How much network capacity is needed to support 10 users now?
c) An ISP marketing a higher quality product targets sufficient capacity for demand 99.9% of the time. Again, how much capacity is needed to support 10 users?
d) What is the "cost per user" relative to the ISP in part b) for the bank in part a) and for the ISP in part c)?
e) Suppose that the users are not independent 10% of the time, to model effects such as when all users demand access at a popular time, such as a stock market crash. What is your answer now to parts a), b) and c)?

**3. Protocols and Layering.**

a) State one advantage of protocol layering (more specifically than "modularity").
b) State one disadvantage of protocol layering (more specifically than "overhead").
c) Draw a picture of a packet as seen "on the wire" after it has passed through a stack of three protocols, A, B and C (in that order). Assume each protocol layer adds both a header (before the higher data) and a trailer (after the higher layer data). For each of the three protocols indicate which portion of the packet is the Application Data Unit (ADU), header, trailer, and Protocol Data Unit (PDU).

**4. Encoding.** Peterson, Ch2, Ex 2. For the NRZI signal, draw a picture.

**5. Framing.** Practical byte stuffing algorithms are slightly more complicated than we discussed in class because of the need to distinguish between back-to-back frames. Consider the following two schemes.

**PPP** Here, the byte 0x7E is added at the sender to mark the end of the previous packet and the beginning of the current one. Within the payload, the sender replaces 0x7E with 0x7D, 0x5E. Occurrences of 0x7D must also be escaped; they are replaced with 0x7D, 0x5D. At the receiver, 0x7D and the following byte are replaced with one byte which is the XOR of the second byte with 0x20. Thus 0x7D, 0x5D is replaced with a single 0x7D and 0x7D, 0x5E with a single 0x7E, reversing the process.

**COBS** Here, the byte 0x00 (that is, zero) is added at the sender to mark the end of the previous packet and the beginning of the current packet. Zeros must now be removed from the payload. First, a start byte is added to indicate the number of bytes until a zero is encountered. That zero is replaced with the number of bytes until the next zero, and so forth until the end of the packet. To handle the last zero in the packet, we pretend that there is an extra zero just off the end of the real packet. For example, the packet 0x22, 0x00, 0x00, 0x55 becomes 0x00, 0x02, 0x22, 0x01, 0x02, 0x55. We must also handle the situation in which there are no zeros in the payload. To do this we use 0xFE to indicate a run of 253 consecutive non-zero bytes without a following zero. (0xFF is a codeword used for another purpose.) After the 253 bytes there is a count of bytes until a zero or a another 0xFE. At the receiver the reverse process is performed.

a) Draw a picture of the payload 0x01 0x7E 0x03 0x 00 0x04 framed with both schemes.
b) What is the worst case expansion of a packet of length L using PPP and COBS? In what scenario do these worst cases occur?
c) What is the best case expansion of a packet of length L using PPP and COBS? In what scenario do these best cases occur?

**6. Bandwidth and Latency.** Peterson, Ch1, Ex 5, a) to c) (so skip the last part)

**7. Bandwidth and Latency.** Peterson, Ch1, Ex11. By "how wide" the question means how "wide" in time (seconds) and by "how long" the question means how "long" in space (meters).