Reading

Peterson and Davie, Chapter 1 and Chapter 2.

Objectives

The purpose of this assignment is to reinforce your understanding of channels, bandwidth, multiplexing, latency, throughput, framing techniques, and error detection.

Problem 0. Do exercises 5, 6, 7, 12, 13, 22, and 25 at the end of Chapter 1 of the text. In exercise 7, “bandwidth” means channel capacity (bits/sec).

Problem 1. Suppose you have a pipe and an infinite supply of marbles of eight different colors: red, blue, yellow, green, purple, orange, black, and white. The marbles are just small enough to fit in the pipe; friction limits the rate at which you can put them in the pipe to 3 marbles/second.

a. If you send marbles through the pipe at the maximum rate, what is the maximum rate (in bits per second) at which you can send information through this pipe? (You can only use the given colors.)

b. Suppose that each marble is 1 cm in diameter, the pipe is 3 meters long, and it slopes uphill from you, so that marbles only emerge from the far end by being pushed out. If you are sending marbles at the maximum rate, what is the latency of the pipe?

Problem 2. Do exercises 4, 8, 10a, 15, and 21a at the end of Chapter 2 in the text.

Problem 3. Suppose bit-oriented framing is in use with the delimiter 01111110. Valid frames are those preceded and followed by a complete delimiter sequence (which may be “shared” with the preceding or following frame).

a. You are implementing the transmitter side of the protocol. You are given the data (without delimiters) to transmit: 1111101011111101000000 Show the complete transmitted frame, including starting and ending delimiters.

b. Suppose you are the receiver of the framing protocol, and the first sequence of bits you receive is

01111110110111110011111011001110

What data frame(s), if any, do you deliver to the higher layer?

Problem 4. Consider the following proposal for implementing framing on a channel that can transmit 256 different symbols (you can think of it as a marble channel with 256 distinct colors): Two out of 256 symbols are set aside to be used as starting and ending delimiters; these two symbols are not allowed to appear in the data. Every group of symbols that is immediately preceded by the start delimiter symbol and followed immediately by the end delimiter symbol is a frame.
a. Describe a method of using this channel, with the given framing scheme, to transmit binary data. That is, you are given a string of bits and you have to encode the string as a sequence of symbols chosen from the channel’s set of 256. Describe in detail the steps taken by sender and receiver. Your scheme should try to minimize the number of symbols transmitted per bit of the given frame.

b. Comment on the advantages/disadvantages of the given channel + framing scheme for transmitting binary data that is always a multiple of 8 bits long.

Problem 5. A CRC code is in use with the generator polynomial \( G(x) = x^3 + x^2 + 1 \).

   a. If the frame to be transmitted is 1011100101 before the CRC is added, what frame is actually transmitted?

   b. **Design Problem:** A CRC code in which the received message is checked for divisibility by the generator polynomial can never detect the addition of any number of leading or trailing zeros; explain why. Can you suggest a modification to the basic error-detection “property” that would allow such modifications to be detected?

Problem 6. A certain data-transfer protocol uses a 10-byte header on every packet, and has a flexible packet size. Suppose we send 1 million (1,000,000) bytes using this protocol by breaking it into equal-sized packets. Suppose also that one byte of data is corrupted, so the whole packet containing it is lost, and has to be retransmitted (once). Give the total number of bytes transmitted (including overhead) if each packet contains the following amounts of user data: 1000, 2000, 5000, and 10000 bytes. (Thus the total packet sizes are 1010, 2010, etc.) What size is optimal?