CSE 123 Fall 2010 Homework 1

Due 10/7/2010 beginning of class.

Exercise 1

"Dry loop DSL" is a DSL connection that does not include a POTS (plain old telephone service) connection - this frees up some "room" on the line for more bandwidth to your DSL modem, in some cases enough for an additional 256 kbit/s of capacity.

Use Shannon's theorem to show the necessary signal-to-noise ratio for 3,000 Hz of bandwidth that will provide (a) 256 kbps, and (b) 128 kbps.

solution

$$
\begin{aligned}
C &= B \log_2(1 + S/N) \\
256 \times 1000 &= 3000 \log_2(1 + S/N) \\
85.3 &= log_2(1 + S/N) \\
2^{85.3} &= 1 + S/N \\
4.76 \times 10^{25} &= 1 + S/N \\
4.76 \times 10^{25} &\approx S/N
\end{aligned}
$$

$$
\begin{aligned}
dB &= 10 \times log_{10}(S/N) \\
dB &= 10 \times log_{10}(4.76 \times 10^{25}) \\
dB &= 10 \times 25.7 \\
dB &= 257
\end{aligned}
$$

same computation applies for 128kbps, 128 dB solution.

Exercise 2

Consider a variation of the 4B/5B NRZI encoding scheme which sends the first 4 bits of the data unchanged, and sets the 5th bit to the value one no matter what. What design considerations/features of the 4B/5B encoding in the book does this scheme not provide? Which does it provide?

solution

This encoding does not include the additional "leftover" codes that book 4B/5B uses for line idle, line dead, and other control symbols.

Strings of up to four zeroes in a row can be transmitted in this scheme, whereas the book 4B/5B guarantees to only transmit at most three in a row. NRZI negates the effect this has on baseline wander (these strings of four zeroes can be either low or high depending on the initial voltage before the 1 preceding the string of zeroes).

This scheme and book 4B/5B both use 4 of every 5 symbols as data bits and are thus both 80% efficient.

The hard-coded '1' every 5 bits in NRZI encoding guarantees a voltage change every 5 bits to allow clock recovery, (as opposed to every 4 for book 4B/5B).

Exercise 3

Your boss has tasked you with implementing an Intrusion Detection System at Layer 1, using nothing but an oscilloscope and a tap on the wire, held together with duct tape. This widget reads every voltage change off of the wire and sends them to your program, absent of any bad samples or bit errors. As a first iteration, you will want to detect repetitions of the character `0x90` two or more times. `0x90` is the x86 NOP instruction, long repeated strings of this character can indicate an exploit attempt. Illustrate the bit sequence corresponding to hexadecimal value `0x9090` for NRZ, Manchester, and 4B/5B encoded NRZI signal for this bit sequence.

solution
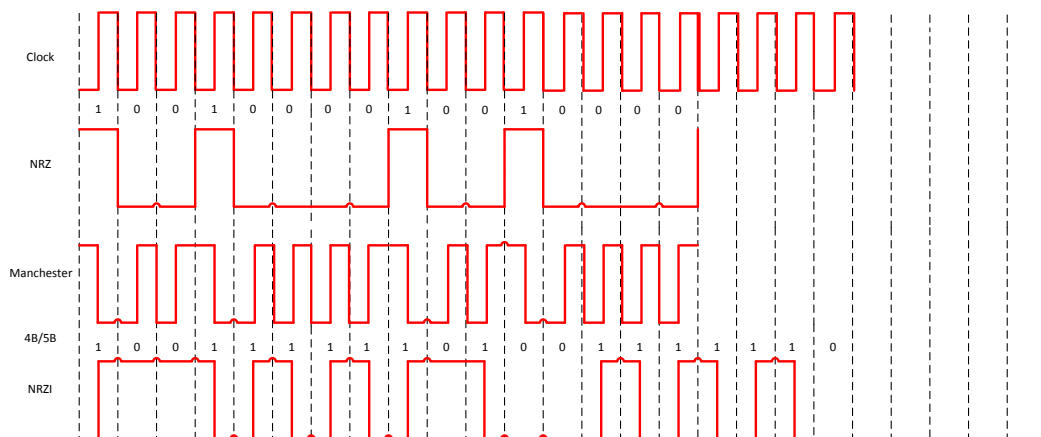
Exercise 4

USB uses a 5 bit CRC with polynomial $x^5 + x^2 + 1$. Find a pair of distinct values that share the same CRC value, and show that they are the same either via a mathematical argument or polynomial long division as in the book. You ma y find it helpful to write the CRC portion of the project, modify it for this CRC length and polynomial, and use that code as part of a program that searches for CRC value pairs.

solution

A mathematical argument would be to just to take the polynomial itself as the value - the remainder after polynomial division by itself is zero, and then find the second value by squaring the original value: this is also a factor of the divisor, and also has a remainder of zero. For the given polynomial, this solution is 100101 and 10000010001. Long division proceeds as in the book.