

Homework 1: Link Layer

Due: 11:59 PM, Oct 2, 2017

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1 How long?

Assume the straight-line distance between NYC and Providence is 250Km, and the driving distance is 300Km. The speed of light in vacuum (and in the air) is $c = 3 \times 10^8 m/s$, and the speed of light in fiber is $2 \times 10^8 m/s$ (two thirds of c).

If we were to start an HFT (high frequency trading) company in Providence we would need to minimize the time it takes to receive and send information between NYC and Providence. Assume that we have 2 options: using a radio link which goes along the direct air path (it has a bandwidth of 10Mbps, and has 5 repeaters along the path (every repeater adds 0.1 ms to the latency of the line), or using a fiber cable which was laid along the road (it has a bandwidth of 1Gbps and no repeaters are necessary).

Assume that the path is symmetric, and you are using a stop-and-wait protocol in which the acknowledgments have negligible size. Also, don't worry about losses.

1. Which of the two links would you choose if all messages on the link are of size 100B?
2. How many such messages would you need to send in a sliding window protocol to fully utilize the link? Draw a time diagram similar to the ones we saw in class to illustrate your calculations.
3. Which of the two links would you choose if all messages on the link are of size 1000B? If the message size is 1000B, then t changes, but not l .

Explain and show the calculations for your answers.

2 Modulation

Suppose you are designing a scheme for transmission of a wireless signal, and you need to send data at 1Gbps (10^9 bits/s). The bandwidth of the channel is 80MHz, and you measure the noise floor to be -90dBm (dBm is a way to express power as a logarithmic ratio to a reference power of 1mW: $p \text{ dBm} = 10 \log_{10} \frac{P \text{ mW}}{1 \text{ mW}}$). Thus, $P(\text{mW}) = 10^{\frac{p \text{ dBm}}{10}}$, and $-90 \text{ dBm} = 10^{-9} \text{ mW}$).

1. Given the channel bandwidth, what is the minimum number of levels (M) that you need to be able to achieve the desired rate? (M should be an integer power of 2).
2. What is the minimum signal strength at the receiver, in mW, to enable this number of levels in your transmission?

3 Error correction

Parity bits

In the slides we describe a 2-D parity code that works like this: for each group of 7 bits, add a parity bit. Then, add a parity byte after the last byte, to check the parity of the columns.

```
0 0 1 1 0 1 0 1
1 1 0 1 1 1 0 1
0 1 1 0 1 1 0 0
1 1 1 0 0 1 1 1
0 0 0 1 1 0 1 1
1 1 1 1 1 1 0 0

1 0 0 0 0 1 0 0
```

1. Starting from a valid encoding (one in which all the parity bits are correct), what is the smallest number of bits you can flip to go to another valid encoding? (Remember you can also flip parity bits, as in, errors could also corrupt the parity bits).
2. Use this number to justify the error correction / detection abilities of this code.
3. Can you give an example of a 4 bit error that this code cannot detect, as well as an example of a 4 bit error that this code can detect?
4. What is the rate of this particular code (the number of useful bits divided by the total number of bits)? This code will work for any matrix size starting at 2x2. This example is a 7x6 matrix. If you fix that you want lines of 8 bits (7+1), what factors would you take into account in selecting the number of rows in the matrix? (Assume you have a long message, and that you will then add the extra line every r bytes). Hint: you have to assume something about the environment.

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