Homework 1: Link Layer

Due: 11:59 PM, Sep 29, 2016

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1 Errors

Suppose your friend develops a scheme to add redundancy to a protocol. The idea is to add, to every two bits, one extra bit: a 1 if the 2-bit number is odd (i.e., 01, 11), a 0 if it is even (i.e., 00, 10). Assume errors can affect every bit with the same probability.

1. Can this code detect any 1-bit error?
2. Can this code detect all 1-bit errors? Why or why not? Explain using the Hamming distance argument.
3. Can this code correct any 1-bit error?
4. Can this code correct all 1-bit errors? Why or why not? Explain using the Hamming distance argument.
5. Is there a pattern of errors that makes this code good? (Assume you control the Universe and can dictate how errors affect the bits in your transmissions.)

2 Reliability at multiple layers

Now suppose your friend designs a link layer that employs a retransmission scheme on each link to provide (bounded) reliability.

1. You read that it might be useful sometimes to provide some functionality in a lower layer, even if it has to be provided anyway in a higher layer. What is a potential reason?

   Let's explore this with some numbers. Suppose that you have a path with 4 links, each link with a 10% chance of dropping a packet (you can assume that acknowledgments are not dropped).

2. What is the probability that a packet sent by the first node arrives at the 5th node (after the 4 links), if there are no retransmissions?

3. Now let's think about one link in isolation. If you employ a scheme that re-sends each packet up to 3 times and waits for an acknowledgment, what is the probability that the packet is not dropped on this link? (It may be easier to think about 1 - the probability of the complementary event.)

4. If you assume that all four links employ the scheme in (3), what then is the probability that a packet sent by the first node arrives at the 5th node?

3 Modulation

Wifi standards can use various modulation schemes, from 2 levels (BPSK) up to 256 levels (256-QAM) modulation.

Suppose that a wireless client measures the noise floor of -90dBm, and the strength of the signal it receives from an access point is -70dBm. (dBm is a way to express power as a logarithmic ratio to a reference power of 1mW: p dBm $= 10 \log_{10} \frac{PmW}{1mW}$. Thus, $P(\text{mW}) = 10^{\frac{p\text{dBm}}{10}}$, and -50dBm = 0.00001mW). The SNR this client sees is 20dB, or a ratio of 100.

1. What is the power in mW of the noise in this scenario?

2. How many levels of modulation (M) can the transmitter use in this scenario? (The answer should be a power of 2.)

3. If the noise floor is kept the same, what would the receive signal strength have to be to allow the use of 256-QAM modulation (M=256)? Use the formulas given in the lecture, even though they are approximations and don't take some factors into account. Give the answer both in mW and in dBm.

4 Medium Access

1. Give one advantage and one disadvantage of a partition-based medium access control.

2. Give one advantage and one disadvantage of a random-access medium access control.

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