

Ve489 Computer Networks

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Homework Set 1

Due date: June 6, 2023

1. Considering an analog audio signal has a bandwidth of 6KHz, what is the minimum sampling rate that is needed for digitization?
2. For samples in problem 1, if we need to quantize them with a requirement of 55dB signal to quantization noise ratio, then how many bits are needed to quantize each sample? What is the final bit rate of the digital audio signal?
3. What is the process of digital modulation? Explain it.
4. If the number of bits per symbol increases in modulation, then the bit rate could keep increasing. However, the bit rate is actually limited in a communication channel. Why?
5. Given a channel bandwidth (baseband) of 20 MHz, if the SNR of the channel is 25 dB, then what is the maximum transmission rate that can be achieved in this channel for reliable communications?
6. If the bandwidth in problem 5 is passband, then what is the maximum transmission rate?
7. Consider a Hamming code with $m = 3$, $k = 4$. It can be designed in different ways. Suppose the parity check is done as follows:

$$b_5 = b_2 + b_3 + b_4$$

$$b_6 = b_1 + b_3 + b_4$$

$$b_7 = b_1 + b_2 + b_3$$

What is the parity check matrix of this (7,4) Hamming coding?

8. The Hamming code can be interpreted in the following way. In a Hamming codeword, the parity check bits are located in bit positions that are powers of 2 (i.e., 1, 2, 4, 8, 16, ...). The information bits are in other bit positions (i.e., 3, 5, 6, 7, 9, ...). Each parity check bit forces the parity of a collection of bits (including itself) to be even. Such a collection of bits come from multiple

information bits, and similarly an information bit may also be checked by several parity check bits. To find out the relationship, we represent the position of an information bit as a sum of the powers of 2. For example, information bit 7 is checked by parity check bits 1, 2, 4, because $7 = 1 + 2 + 4$. Similarly, information bit 3 is checked by parity check bits 1 and 2. Thus, the parity check bit 1 checks information bits 3, 7, and so on.

Considering the above procedure, what is the parity check matrix of the Hamming code if the codeword length is 15 bits?