

Computer Networking and IT Security (INHN0012)

Tutorial 3

Problem 1 Quantization and channel noise

In this task, a temperature curve is to be digitized and the influence of noise on signals is to be investigated. For this purpose, temperatures in the range of $-40\text{ }^{\circ}\text{C}$ to $70\text{ }^{\circ}\text{C}$ are to be considered. The measured values are to be mapped linearly, with a step size of at most $0.5\text{ }^{\circ}\text{C}$.

- a)* Explain the difference between sampling and quantization.
- b)* What is the minimum number of bits required to digitize a single temperature value? Give reasons for your answer.
- c) According to the Subproblem b), which step size can be used to determine the temperature based on the number of bits used?
- d) Determine the maximum quantization error with respect to the calculated step size from Subproblem c) assuming that mathematical rounding is used.

If you have not solved previous subproblems, assume 256 quantization levels.¹

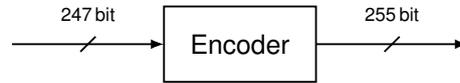
The baseband signal used uses exactly one symbol for each temperature level. A channel capacity of 10 kbit/s should be achieved.

- e) Determine the minimum bandwidth required for a noise-free channel if the specified channel capacity is to be achieved.
- f) To what value would the channel capacity decrease for the same bandwidth if an SNR of 35 dB were applied?

¹In the written exam, tasks basically build on each other, i. e., intermediate results of previous subproblems are to be used. For longer tasks, we — when appropriate — sometimes give substitute values so that reentry is possible.

Problem 2 Channel Coding

In the previous sheet we saw that the frame error probability can become a problem with poor channel quality. For the radio channel with a bit error probability $p_e = 10^{-4}$, the success probability for a frame of length 1500 B was only about 30%. To counter the high bit error rate, a block code is now used on Layer 1:



This allows the decoder on the receiver side to correct any bit error in a channel word of length $n = 255$ bit *any*. If two or more bit errors occur, the decoder's decision is wrong and all the information of the channel word is lost.

- a)* Determine the code rate.
- b)* What does the code rate mean?
- c)* Since the frame is larger than a block of 247 bit, it must be divided into several blocks. Determine the number N of channel words that must be transmitted.
- d) Padding is included in the last channel word. Determine the percentage overhead of the padding in relation to the possible user data in the channel words.
- e)* Determine the probability that a single channel word is decoded incorrectly.
- f) Now determine the probability that a frame will be transmitted correctly — that is, none of the channel words that make up the frame will be transmitted incorrectly.