Chair of Distributed Systems and Security
School of Computation, Information and Technology
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Computer Networking and IT Security (INHN0012)

Tutorial 3

Problem 1 Probability of frame errors

The lecture introduced bit error probabilities for radio links as about $p_{e,1} = 10^{-4}$ and for Ethernet over copper cable as about $p_{e,2} = 10^{-8}$. We assume that bit errors occur independently and uniformly distributed through noise with constant power over time. Thus, the channel characteristics do not change over time. For simplicity, we omit other interfering factors. Let the frame length be equal 1500 B.

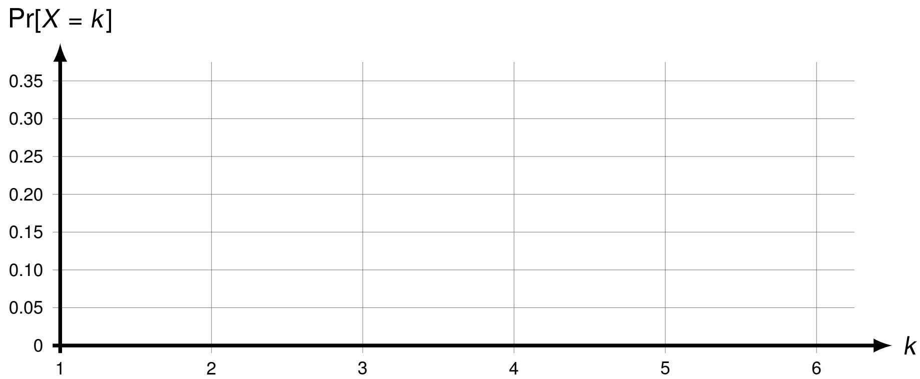
a)* For both types of transmission, determine the probability that a frame will be transmitted without errors.

From here on, we will only consider the wireless connection. Since the frame error probability is relatively high, a protocol on the link layer provides acknowledgements for correctly transmitted frames. If no acknowledgement is received for a previously sent message, the sender assumes that the transmission was not successful. For the sake of simplicity, we assume that confirmations are not lost.

b)* Is there a maximum number of repetitions until a certain frame is guaranteed to have been transmitted correctly?

c)* Determine the probability that the frame must be transferred exactly k times.

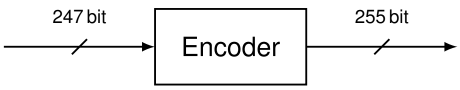
d)* Sketch the probability from subtask c) for $k \in \{1, ..., 6\}$.



e) Assume that the responsible protocol on the link layer aborts the retransmission if the third transmission attempt was unsuccessful. What is the probability that a frame cannot be transmitted?

Problem 2 Channel Coding

In the previous task 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. 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 express?

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.

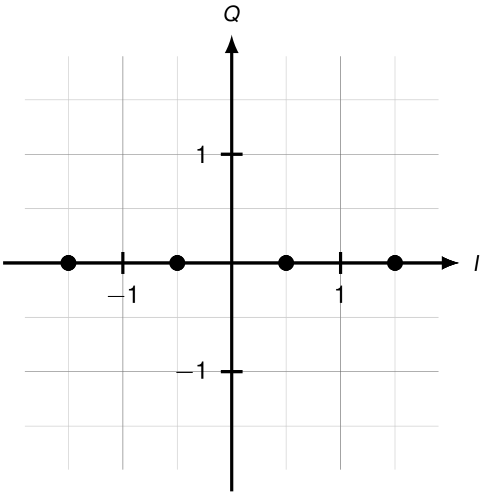
e)* Determine the probability that a single channel word is decoded incorrectly.

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.

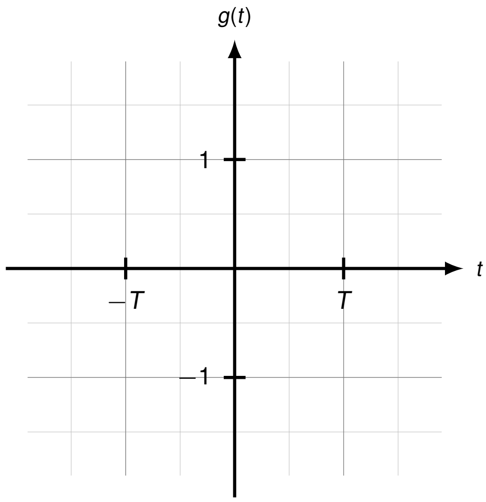
Problem 3 Digital Modulation Schemes

In this exercise, we analyze the processes of pulse shaping in the baseband and the subsequent modulation. Figure 3.1 shows the signal space of a digital modulation scheme. The bit sequence to transmit is `01111001`. As the basic pulse for the baseband signal, the rectangular pulse rect(t) is used.

$$\mathrm{rect}(t) = \begin{cases} 1 & -T/2 \leq t < T/2 \\ 0 & \text{otherwise} \end{cases}$$



(a) Signal space



(b) Transmit pulse

Figure 3.1: Signal space and transmit pulse

a)* Which modulation scheme is shown?

b)* Assign valid codewords to the signal points in Figure 3.1a.

c)* Sketch the transmit pulse $g(t)$ in Figure 3.1b.

d)* Now sketch the corresponding baseband signal for the given bit sequence in Figure 3.2.

The baseband signal from the previous subproblem is now used to modulate the cosine carrier

$$s(t) = \cos(2\pi t/T).$$

e) Now sketch the modulated signal in Figure 3.2.

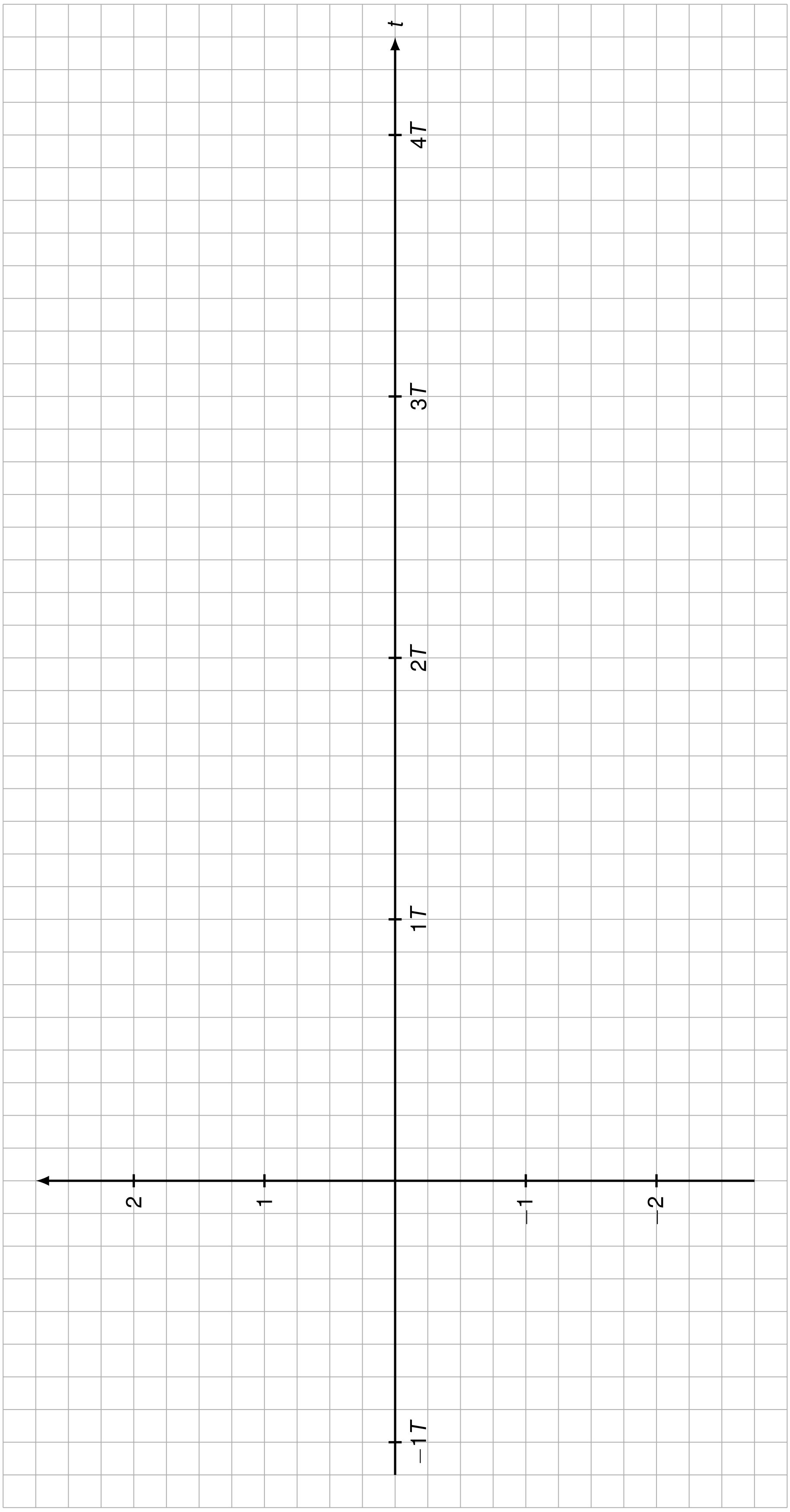


Figure 3.2: Solution sheet for subproblems d) and e)