FS 2018 Prof. R. Wattenhofer

Computer Engineering II

Exercise Sheet Chapter 5

We categorize questions into four different categories:

Quiz Short questions which we will solve rather interactively at the start of the exercise sessions.

Basic Improve the basic understanding of the lecture material.

Advanced Test your ability to work with the lecture content. This is the typical style of questions which appear in the exam.

Mastery Beyond the essentials, more interesting, but also more challenging. These questions are **optional**, and we do not expect you to solve such exercises during the exam.

Questions marked with $^{(g)}$ may need some research on Google.

Basic

1 MAC Addresses vs. IP Addresses

a) List a few differences between MAC addresses and IP addresses.

b) Why don't we only use MAC addresses?

c) Why don't we only use IP addresses?

2 Escape Sequences

Recall Definition 5.34 from the lecture:

Definition 1 (Escape Sequences)**.** *Given some critical byte* `X`*, we choose a byte* `Y` $\neq$ `X` *as* escape byte *and use it to define two* escape sequences *consisting of two bytes each, say,* `YA` *and* `YB` *(*`A` $\neq$ `X`*,* `B` $\neq$ `X`*,* `A` $\neq$ `B`*). The sender replaces every* `Y` *in the original body with* `YA` *and every* `X` *with* `YB`*. The receiver in turn performs the substitution in reverse.*

If we perform such a substitution in a string, we say we *escape* the string.

a) When is it possible to tell whether a given (character) string has been escaped by a given escaping scheme?

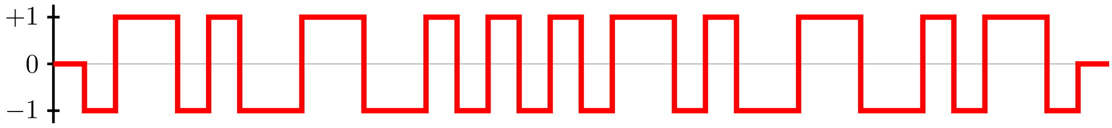
b) In software, it is common to drop the conditions `A` $\neq$ `X` and `B` $\neq$ `X`. When is this possible?

c) Escape the following string using `X` = `"`, `Y` = `\`, `A` = `\`, `B` = `"`:

```
"Oh no," Jon said, "my cat \"Garfield\" is locked outside in the rain!"
```

3 Manchester Decoding

Decode the message in the following Manchester encoded byte string.
Hint: `ascii('a') == 97`.

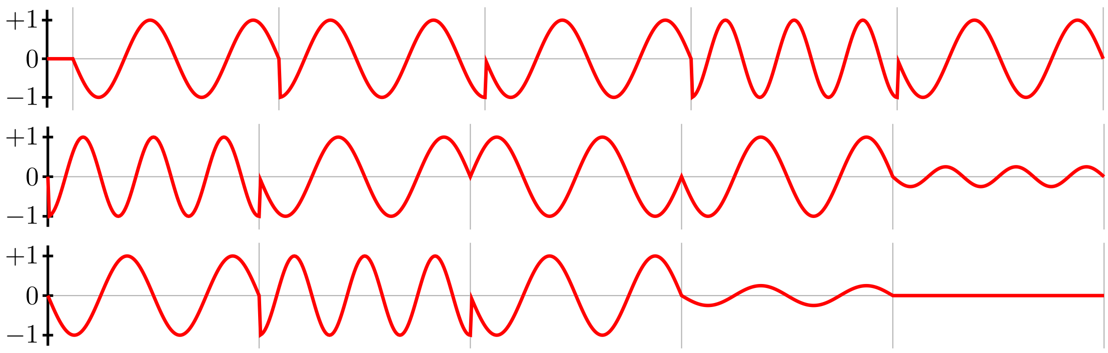


4 AM/FM/PM Demodulation

A mad scientist has decided to combine all three types of modulation! Each symbol now consists of 4 bits. The first sets the frequency, the second sets the amplitude and the last two determine the phase shift. The following table shows all combinations:

Symbol	Frequency f	Amplitude a	Phase ϕ
0000	2	0.25	± 0
0001	2	0.25	$+\pi/2$
0010	2	0.25	$\pm\pi$
0011	2	0.25	$-\pi/2$
0100	2	1.00	± 0
0101	2	1.00	$+\pi/2$
0110	2	1.00	$\pm\pi$
0111	2	1.00	$-\pi/2$
1000	3	0.25	± 0
1001	3	0.25	$+\pi/2$
1010	3	0.25	$\pm\pi$
1011	3	0.25	$-\pi/2$
1100	3	1.00	± 0
1101	3	1.00	$+\pi/2$
1110	3	1.00	$\pm\pi$
1111	3	1.00	$-\pi/2$

The signal at time t is given by $a \cdot \sin(f \cdot t + \phi)$. Decode their message from the following signal:



5 SINR

Imagine two wireless nodes, s_A and s_B, transmitting at the same time. Two other nodes, r_1 and r_2, are listening. The table below shows the powers of each of the incoming signals at each of the receivers. Apply the SINR model with $\beta = 4$ to determine which signals each receiver can successfully decode.

	s_A	s_B	Noise Floor
r_1	7 nW	31 nW	0.01 nW
r_2	52 nW	10 nW	5 nW

Advanced

6 Bit Stuffing

Consider the scenario of transmitting a packet as a string of bits. The string `S` = `011110` will be prepended and appended to the packet to be used as a synchronization header resp. footer.

a) Propose a bit stuffing technique for transforming the packet such that it does not contain `S` as a substring.

b) By prepending and appending `S` to the bit stuffed packet additional instances of `S` may appear. When does this occur?

Does your bit stuffing technique from a) prevent these? (probably not)
Extend your technique to prevent the combined string from containing `S` as substring anywhere but the once at the start and the end each.

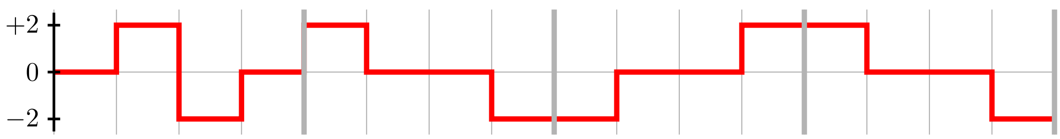
7 Code Division Decoding

In this task, we will decode multiple input streams using code division from a single received signal. All senders will use codes from W_2. Recall: W_2 consists of these 4 codes:

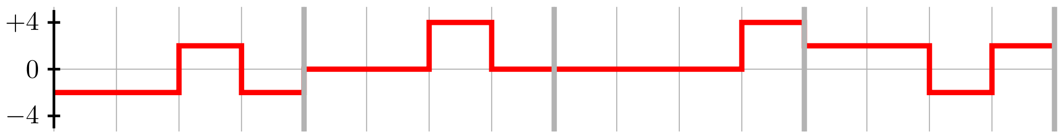
$$(+,+,+,+)$$
$$(+,+,-,-)$$
$$(+,-,+,-)$$
$$(+,-,-,+)$$

a) This received signal is the sum of 2 equally strong signals from 2 different senders using 2 different codes from W_2. You may assume the different codes are aligned. Which codes were used and what data bits were transmitted by each sender?

Hint: By multiplying each code with each segment and sum up the values, you can obtain a measure of correlation.



b) This received signal consists of 4 senders, using all 4 codes from W_2. You may again assume the different codes are aligned. What data bits were transmitted by each sender?

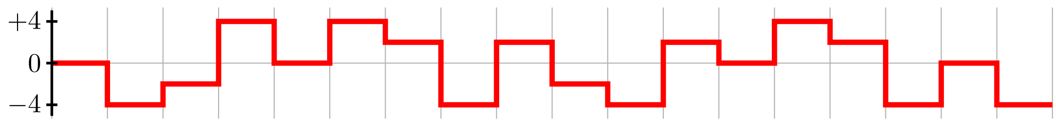


c) Decoding misaligned signals, i.e., signals whose codes are shifted temporally against each other, is not always possible when using W_2. Explain.

d) In practice, code division is often used to avoid the overhead of coordination between senders, and thus misaligned signals are the default. Propose a set of codes less susceptible to problems stemming from misaligned signals.

e) In the received signal below, once again 4 senders using all codes from W_2 have contributed, but this time, the codes are not aligned. Try to figure out what was sent anyway!

   Hint: Computing correlation values for all possible offsets will not yield the correct solution. You need to come up with a different approach.

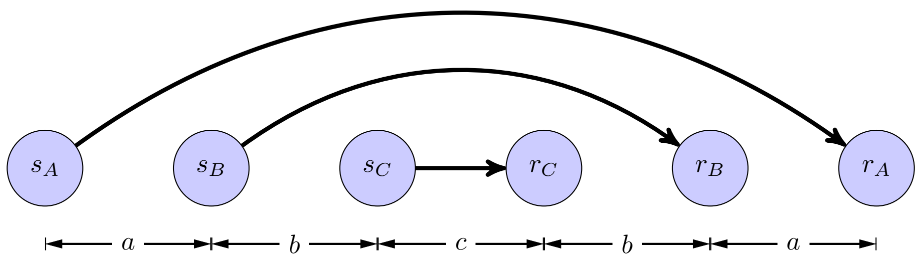


Mastery

8 Path Loss Sandwich

A common way to avoid measuring the signal strength for every sender-receiver pair is to model a link's quality based on the distance between sender and receiver. With direct line of sight, a signal's received strength is proportional to $\frac{1}{d^\alpha}$, where d is the distance traveled and α is the *path loss exponent*. In vacuum, α is 2.

Together with adjustable transmission power control, path loss can lead to some rather unintuitive results. For example, in the situation shown below, with all 6 nodes on a straight line, it is possible for all 3 shown links to successfully transmit simultaneously.



a) Assuming no noise and an SINR threshold of $\beta = 4$, can you find a suitable set of node distances (a, b and c) and transmission power values (P_A, P_B, P_C) for path loss with $\alpha = 2$?

   Hint 1: First choose c and P_C and work your way out from there.

   Hint 2: Use your calculator, Matlab, or similar to quickly try different values.

b) What issues does such a setup face in practice?