ETH

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Distributed
Computing

FS 2019   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`.
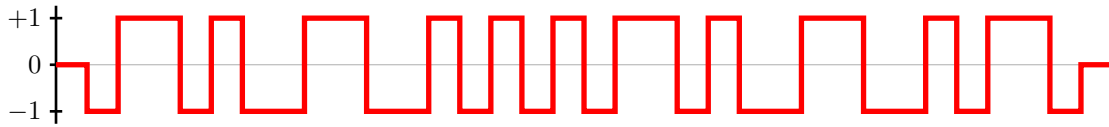
4 AM/FM/PM Demodulation

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:
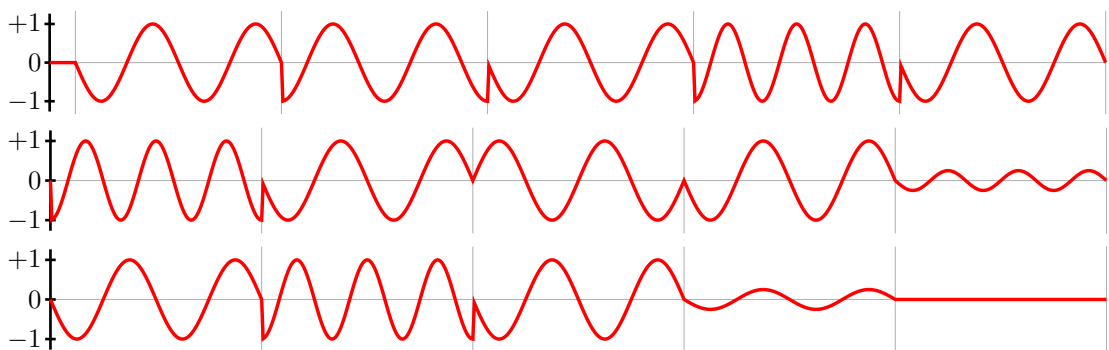
5 SINR

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 Wireshark for Packet Inspection

Wireshark is a free packet analyzer that can capture network traffic, and with the help of parsers and UI elements, let users analyze this traffic at the level of bytes. Wireshark's executable can be downloaded from `https://www.wireshark.org/download.html`. In some systems Wireshark needs root permissions to capture packets.

After you launch Wireshark, you will see a list of available network interfaces to monitor, like Bluetooth, Wireless, Ethernet, etc. Select one of the available types of interfaces, and Wireshark will start capturing packets on that interface for analysis. Packet capture can be stopped, and dumps can be stored for later usage.

We have two such packet capture dumps, and they are available as a "pcapng" files here: `http://virt13.ethz.ch/captured.pcapng` and `http://virt13.ethz.ch/captured2.pcapng`. These dumps can be opened directly in Wireshark using the command on Linux, say:

```
wireshark captured.pcapng
```

7.1 Ethernet

The file captured.pcapng has 24 frames that correspond to one network command that was issued from a Linux desktop.

a) How many bytes were captured in Frame No. 1?

b) In Frame No. 1, the protocols in question are: "eth:ethertype:ip:[XXX]:dns". What does XXX stand for?

c) The application protocol that was used in this request has the notion of a transaction ID. Wireshark helps parse it out for us in, say, Frame No. 1. What is its size?

d) What is your best guess on the terminal command run to generate this packet dump?

7.2 Bluetooth

The file captured2.pcapng has 21 frames from a ping command issued to a bluetooth device connected to a computer.

a) Every MAC address's first 3 bytes are assigned to a specific manufacturer. Which manufacturer has the prefix "000A28" assigned to them?

b) Bluetooth's Host Controller Interface layer (HCI) specifies that the packet type for data is 0x02. Based on the number of such data packets, can we say how many ping requests were issued in this dump?

c) What 3 frames correspond to the device disconnecting from the host?

d) The echo command uses a 44 byte payload. Is this specified somewhere in the L2CAP packet? If so, in what format?

8 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.
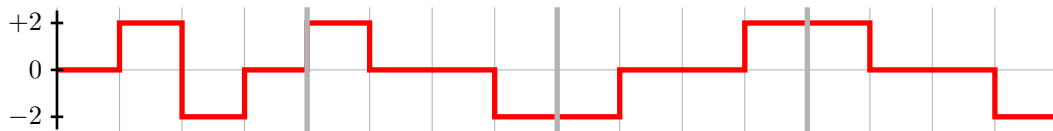
b) This received signal consists of 4 senders, using all 4 codes from W_2. You may again assume the different codes are aligned. What data bits were transmitted by each sender?
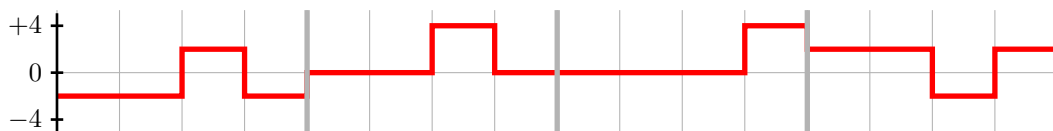

c) Decoding misaligned signals, i.e., signals whose codes are shifted temporally against each other, is not always possible when using W_2. Explain.

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.
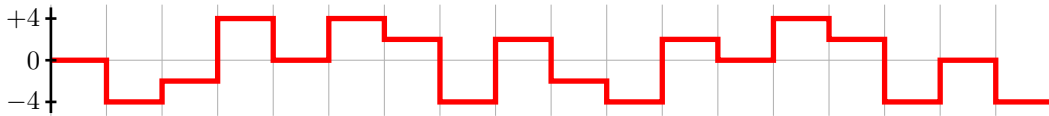
9 Path Loss Sandwich

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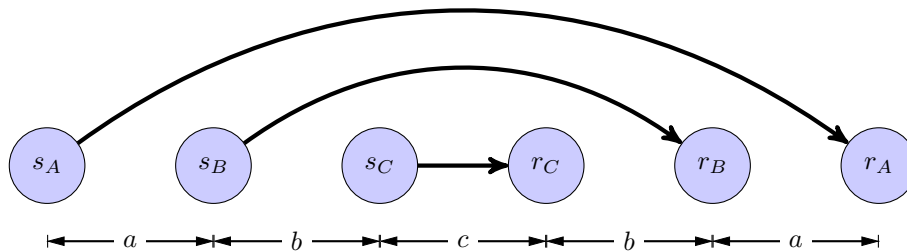
a) Assuming no noise and an SINR threshold of $\beta = 4$, can you find a suitable set of node distances (a, b and c) and transmission power values (P_A, P_B, P_C) for path loss with $\alpha = 2$?

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?