Number:	4. Assignment
Issued:	11.11.09
Tutorial:	18.11.09
Lecturer:	Prof. Dr. Güneş, Dipl.-Inf. Blywis
Contact:	{guenes, blywis}@inf.fu-berlin.de

Exercise 1, Important Physical Layer Issues:

If you have fully understood the physical layer chapter of the lecture, you should be able to answer the following questions:

1. What are the differences between analogue and digital signals?
2. What does the term bandwidth describe in the context of the frequency spectrum?
3. How can square waves signals be created?
4. How is a frequency shift keying represented in a constellation diagram?
5. How do amplitude and phase errors, e.g., due to noise affect a modulation point in a constellation diagram?
6. QAM-64 is specified as one of three modulation schemes that can be used with DVB-T. Unfortunately, most often QAM-16 is applied. Explain why fewer modulation points are used compared to DVB over cable or satellite.
7. How many times higher is the bit rate that can be achieved with QAM-64 compared to QAM-16?
8. Why are we able to transmit data and voice at the same time over a telephone line?
9. Why are we able to transmit data at higher data rates than with modems several years ago?

Exercise 2, Cyclic Redundancy Checksum:

Determine if the following bit sequences have been transmitted error-free. Use the generator polynomial G to apply a CRC check.

$$G(x) = x^4 + x + 1$$

If you find an error in a bit sequence, assume that the checksum bits contain the error. Re-calculate the checksum.

	Data + CRC
1.	0111 0110 0010
2.	0101 0010 1001
3.	1111 0110 1100

Exercise 3, Result of the Polynomial Division:

Up until now, we were only interested in the remainder of the polynomial division and how it is calculated. How do you actually calculate the result of the polynomial division?

Exercise 4, Undetected Errors:

As you should have learned, the cyclic redundancy checksum approach is not perfect and some errors will remain undetected. How can this problem be solved? Read and discuss the publication “When The CRC and TCP Checksum Disagree”.

Exercise 5, CRC Modifications:

1. For the polynomial division, the data bits are extended by several bits that will eventually contain the CRC checksum. How does the the remainder of the polynomial division change if the appended bits are initialized with '1s' instead of '0s'? Explain the advantage of this modification.

2. Some CRC algorithms inverse the remainder before it is appended to the data and transmitted. What does the receiver get as remainder of the polynomial division if the frame was transmitted without errors? Explain the advantage of this modification.

Exercise 6, Transmission with HDLC:

The *High Level Data Link Protocol* (HDLC) is a protocol of the data link layer (DLL). One of its tasks besides flow control is to enable the detection of errors by check-summing.

1. Consider the bit sequence 110111110101. This sequence is to be transmitted including its CRC checksum. Compute the checksum by using the following generator polynomial instead of CCITT CRC-16:
$$G(x) = x^4 + x + 1$$

2. Sketch the HDLC frame that is created to transfer the bit sequence from 5.1 from host A to B. Assume that the sequence number counters have been initialized with the value zero. The frame shall also be used to signal host B that the first two frames from B to A were received successfully. The address of host B is 11111111_2. Ignore the P/F bit and set it to 0. Use the checksum calculated in 5.1.

Exercise 7, Hamming-Code:

Two entities have agreed to use the following encoding to transmit characters:

Character	Code Word
A	10000
B	01000
C	11000
D	00100
...	...
Z	01011

1. How many check bits are required to correct all 1-bit errors in messages with a length of m bits?

2. A Hamming Code with 4 check bits shall be used in the following. Create the code words which represent the word HAMMING.

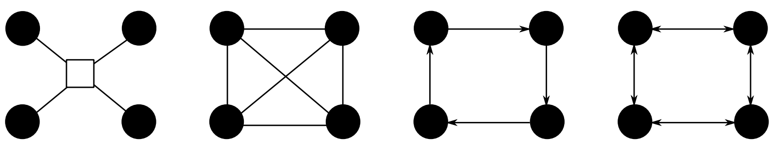
3. Consider the following code words have been received:

   010101000 111001000 010101001 001011000 111111100 001001100

   Decode this sequence, mark the blocks that contain an error, and correct the errors if possible.

Exercise 8, Network Topologies:

Consider the following four network topologies, each with n nodes: Specify formulas to calculate the minimum, maximum, and average number of hops between any two nodes for any number n.



(a) Star (b) Full Mesh (c) Unidirectional Ring (d) Bidirectional Ring