Karlsruher Institut für Technologie

ITIV

Examination WS 2013/2014

Communication Systems and Protocols

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Communication Systems and Protocols
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Prerequisites for the examination

Aids

- Allowed aids for the examination are writing utensils, a ruler, a non-programmable calculator and a single sheet of A4 paper with self- and hand-written notes. Writing may be on a single side of the paper only. The use of own concept paper is not allowed.
- Use only indelible ink - use of pencils and red ink is prohibited.
- Other material than that mentioned above, is strictly forbidden. This includes any type of communication to other people.

Duration of the examination

120 minutes

Examination documents

The examination comprises 17 pages (including title page). Answers may be given in English or German. A mix of language within a single (sub)-task is not allowed. In your solution mark clearly which part of the task you are solving. Do not write on the backside of the solution sheets. If additional paper is needed ask the examination supervisor.

You will not be allowed to hand in your examination and leave the lecture hall in the last 30 minutes of the examination.

At the end of the examination: Stay at your seat and put all sheets into the envelope. Only sheets in the envelope will be corrected. We will collect the examination.

Task 1 Error Protection

Task 1.1 CRC-Calculation

In figure the simplified implementation of a CRC module is given.

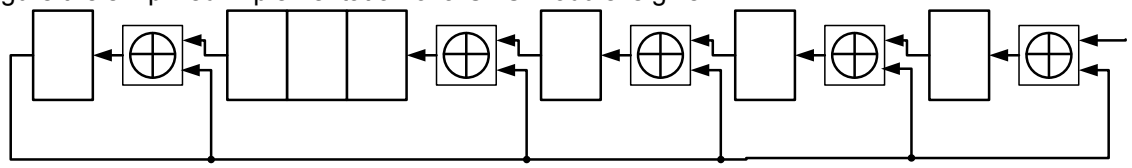


Figure 1.1: Simplified CRC Module

A) Name the polynomial g(x) used by the implementation

B) The dataword 11011011 is to be sent using the CRC protection as implemented in Figure 1.1. Give the bitstring as it is send over the bus. Give all steps of your solution.

Task 1.2 CRC-Error Protection

A) How and when does a receiving node detect a transmission error?

B) What possibilities exist in a CRC protection scheme to detect the position of the bit error within the received bitstream? Give a short explanation for your answer.

C) In a system, messages are sent over a bus with a datafield length of 17 bits. Each message is protected using CRC. If the datafield length is extended to 32 bits, in what way is it necessary to change the CRC implementation in order to still generally detect transmission errors? Explain your answer shortly.

Task 1.3 Error Handling

A) Name three different methods how a receiver reacts to detected errors. Name one advantage and one disadvantage of each method.

B) Given are the following communication scenarios. What is the most suitable method for error handling for each scenario? Give a short reason for each of your choices (2-3 sentences).

Scenario 1: Terrestrial Radio Reception

Scenario 2: Sending control commands to the mars rover

Scenario 3: Data transmission for an online banking application

Scenario 4: Sending commands from a remote control to a TV

Task 2 Media Access

Task 2.1 Arbitration

A) What is arbitration? Why and in which cases is it necessary? Explain in 2-5 sentences.

B) Draw a schematic of the system setup using decentralized polling as an arbitratrion scheme. Assume that there are 5 nodes in total in the system. Label each element in the schematic and give all bit widths.

C) Name three arbitration schemes that enable a fair arbitration by construction. Explain in one sentence per scheme why it is fair.

Task 2.2 CSMA/CA

A communication system comprises four communication nodes that use CSMA/CA as arbitration scheme. In order to transmit data a node transmits a dominant start bit (‚0') followed by a 10 bit message identifier. After that, 7 bits of payload data is sent. The message identifiers are unique for each node and all data is sent MSB first.

A) Carry out the CSMA/CA arbitration assuming that the following data is to be send.
Node 1: Payload Data: 0x11 / Message ID: 1001011011
Node 2: Payload Data: 0x02 / Message ID: 1001111010
Node 3: Payload Data: 0x09 / Message ID: 1000101011
Node 4: Payload Data: 0x07 / Message ID: 1000111111

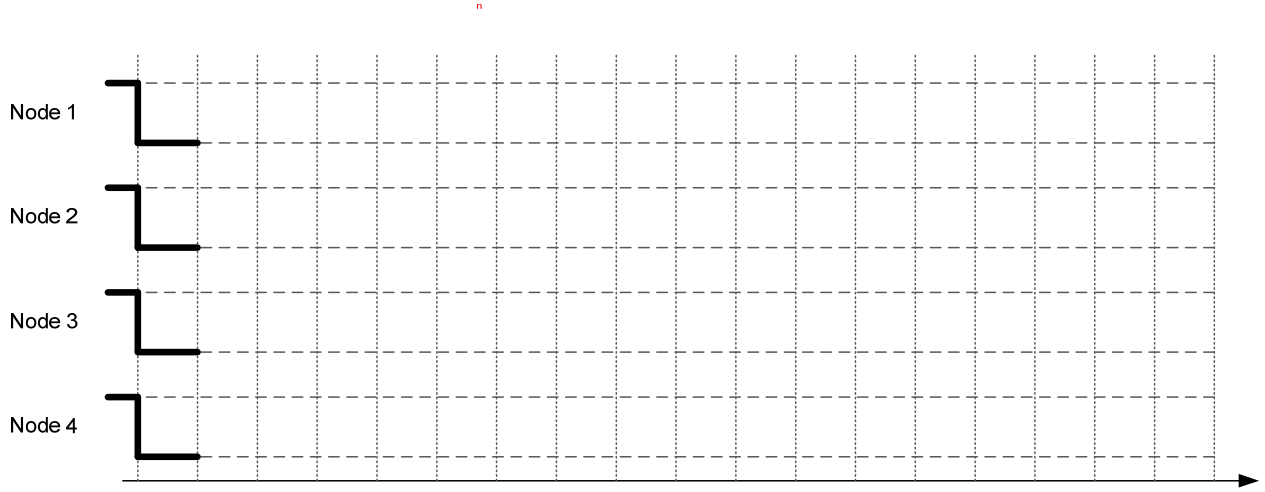


Figure 2.1: CSMA/CA Arbitration

Task 3 Synchronization

Task 3.1 General Questions

A) What is the goal of synchronization in a communication system? Explain in 1-2 sentences.

B) Name one suitable synchronization method for each of the quadrants given below

	Synchronous Transmission	Asynchronous Transmission
Serial Transmission		
Parallel Transmission		

Task 3.2 Implementation of a synchronized node

Given is a distributed measuring system. A number of sensors have to transmit data over to a central control station. A serial transmission system is implemented, without a dedicated clock line. To avoid long sequences of ‚1's and ‚0' a bitstuffing scheme is implemented that inserts a ‚1' after 6 sequential ‚0's and a ‚0' after 5 sequential ‚1's.

Assume that 10 kbits/s of sensor data has to be transmitted. Per clock cycle exactly one bit is transmitted. The following clock generators are available for physical implementation of the nodes. Besides cost, the maximum frequency, the precision of the generator is given (the number of clock cycles after which the generator's frequency has drifted so much, that a bit cannot be detected correctly anymore).

A) Determine the best clock generator under technical and economical aspects. Justify your choice. (Hint: 1kbit = 1024bit)

CLK generator	Precision [clock cycles]	max. Frequency [kHz]	Cost [Euro]
A	5	40	1,25
B	10	20	2,20
C	9	30	2,10
D	7	10	2,10

Table 1: Clock Generators available

Reasoning:

Task 3.3 Timing of a Synchronization Method

The half-duplex II (with busy signal) method is used for synchronization. A transmitting node puts out data sequentially. Each bit is put out for at least 10ms by the sender. The busy signal is sampled with a frequency of 1kHz. In between each bit an idle time of 4ms is mandatory for the bus to settle.
The receiving nodes can detect a valid signal immediately. They need 2.4 ms to sample the data off the bus and an additional 4.6 ms to store the data. The receivers have no knowledge of the timing behavior of the sender.
(Hints: 1 kHz = 1000 Hz | Assume that all signals are effective immediately, raise and fall times of signals are nonexistent)

A) What is the earliest time point at which the busy signal may be asserted if t_0 is the start of the transmission? Justify your answer.

B) In general what is the theoretical minimum and maximum length of any busy signal? Justify your answer.

C) What is the theoretic maximum guaranteeable data rate of the system given? Justify your answer

D) Assume that an additional receiving node is introduced into the system. The node needs 8.3 ms to sample the data off the bus and an additional 14.1 ms to be ready for a new transmission cycle. Does this change the guaranteeable data rate? If yes: to what datarate? If not: Why not?

Task 4 Data Transmission

Task 4.1 General Questions

A) Describe the difference between node based adressing and message based adressing.

B) In what scenario is a node based adressing scheme andvantagous over a message based adressing scheme and vice versa? Give a short example for both cases and give the reason why your choice has advantages over the second possibility.

Task 4.2 Line Codes

A) Name two line codes that do not demand a separate clock line within a communication system. Justify your answer.

B) The figure below shows the signal diagram of a transmission. What coding scheme has been used in the transmission? Give the data being transmitted.

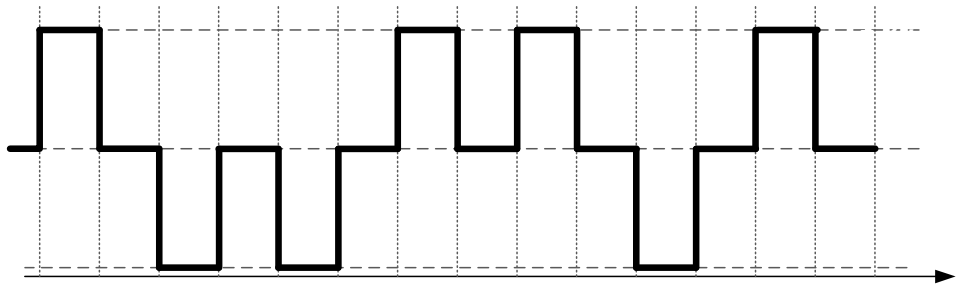


Figure 4.1: Signal Diagram

C) Encode the same data using the differential manchester code in the diagram given below. Mark the bits and their value in the diagram.

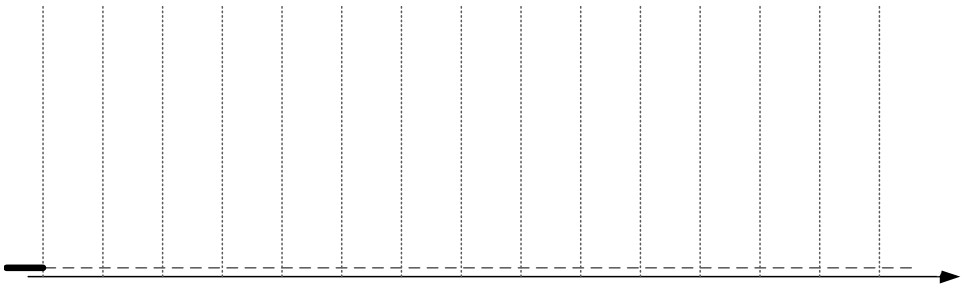
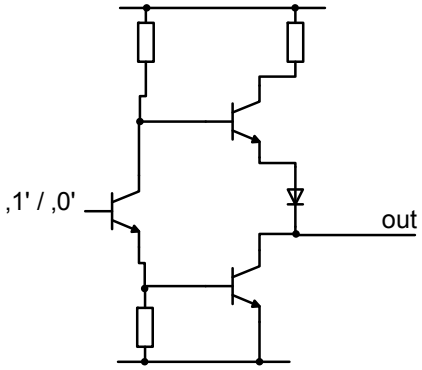


Figure 4.2: Differential Manchester Code

Task 5 Physics

Task 5.1 General Questions

The figure below shows a TTL driver for bus systems.



A) Give one advantage of TTL drivers and one disadvantage.

B) How can the main disadvantage of TTL drivers be overcome?

C) What is the benefit of signal modulation?

D) A QAM-4 modulation is given. How much may phase (φ) and amplitude (A) of the signal vary without introducing errors into the transmission. Justify your answer.

E) Differential signaling is implemented. A logic ‘1’ is detected with a ΔU1 = +4.2 V...+5V. A logic ‘0’ is detected with ΔU2 = -4.0 V...-5.5V. Due to EMR issues voltage spikes are introduced onto the signaling lines.
What is the minimal voltage of the spikes that results in the misinterpretation of a ‘0’ bit being send over the bus line? Explain your answer!

Task 5.2 Oversampling

A communication system uses oversampling and majority voting to compensate for errors introduced by physical sources (crosstalk, EMR, etc). The duration of one bit is 5 ms. The frequency at which errors occur is 1 Hz.

A) How much of one bit time may be corrupted if the nodes shall still be able to read the correct bit value? Give the maximum value per bit.

B) Under the assumption that only a single error with a maximum duration of 1.2ms occurs during on bit time:
What is the minimal number of samples per bit time in order to be able to detect a correct value by majority voting?
What is the minimal sampling frequency needed?
Justify your answer.

Task 6 Practical Aspects of Communication Systems

Seven different control units are interconnected over a bus. They each send out cyclic messages consisting of 32 bits, including payload data and and all overhead. The cycle frequency for the transmission is 100 Hz.

A) Using baseband transmission on an ideal channel with unlimited bandwidth, TDMA (Time Division Multiple Access) is implemented as a bus access and scheduling scheme. With what minimal frequency has a sender to be able to change the level on the bus (switching frequency)? Justify your answer and give all calculation steps to your solution.

B) Under the same assumptions, what is the minimal frequency that a receiver has to sample the bits with? (Hint: Assume error free transmission).

C) CDMA with Walsh codes is now used as a bus access and scheduling scheme. All nodes shall send their data simultaneously. With what minimal frequency has a sender to be able to change the level on the bus (switching frequency)? Justify your answer and give all calculation steps to your solution.

Task 7 Networks

Task 7.1 OSI Layers

A) Name all the layers of the OSI model. Give the name and the number of each layer.

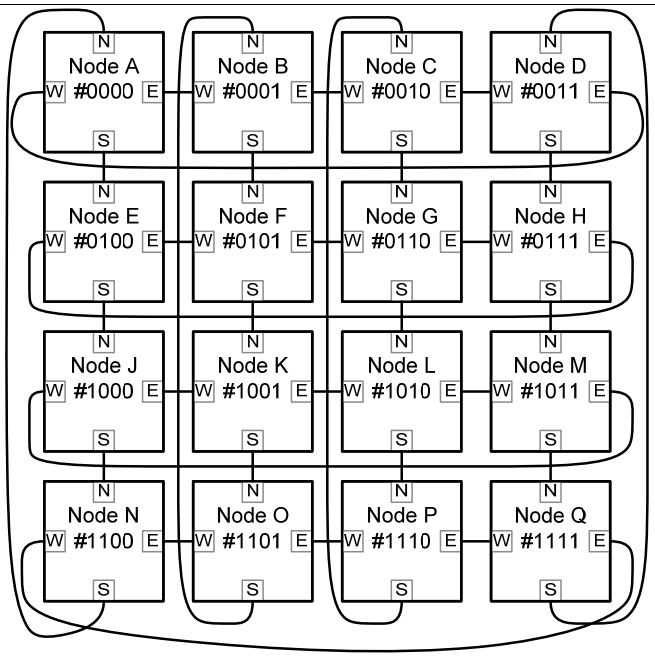
Data with an 8 bit destination address and 8 bit of payload data is send over a network. Framing consists always of a 4 bit header and a 2-8 bit trailer segment. A node transmits a payload of 10011011 over the network. The following message can be seen on the network:

0101 0010 0101 0001 0100 0100 0111 1001 1011 1011 0001 1100 1110 01

B) How many layers of the OSI have been implemented in the system? Justify your answer

Task 7.2 Routing

A) What is a disadvantage of using circuit switching in a network, if the number of hops is increasing?



In the network structure given above the routing control is embedded into the messages send over the network. For each routing decision a header is appended to the data packet. A node will read the first routing information, remove the header and send the data packet according to the command that has been removed.
The routing commands are the following:

000	Send data to North (N)
010	Send data to East (E)
100	Send date to South (S)
110	Send data to West (W)
111	Send data to Network Adapter

Node F sends out the following stream: 010100010010000111110000111

B) Give the sequence of the nodes as they are passed by the message

C) What is the content of the message?