Examination Winter Term 2015/2016
Communication Systems and Protocols

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Communication Systems and Protocols
Date: 15.02.2016
Name:
Matr. ID:
ID:

Lecture Hall:
Seat:

Prerequisites for the examination

Aids:

- Additional aids allowed are:
  - Pocket calculator
  - One DIN-A4 sheet of handwritten notes
- 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:
The exam duration is 120 minutes.

Examination documents:
The examination comprises 29 pages (including title page, 7 blocks of tasks).
Answers may be given in English or German. A mix of language within a single (sub)-task is not allowed.
Please check your matriculation number and id on every page before processing the tasks.
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.

End of Exam:
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 (including this title page) into the envelope. Only sheets in the envelope will be corrected. We will collect the examination.

		Page	≈ Pts. [%]	Points
Task 1:	Physical Basics	2	17	
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Task 3:	Data Transmission	10	12	
Task 4:	Error Protection	13	14	
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				$\sum$

Task 1: Physical Basics

Task 1.1: TTL-Logic

A) Insert the logic level (HIGH, LOW) of the output and the state of the transistors (open, closed) into the table according to the input configuration x_1 and x_2 at the standard TTL output driver.

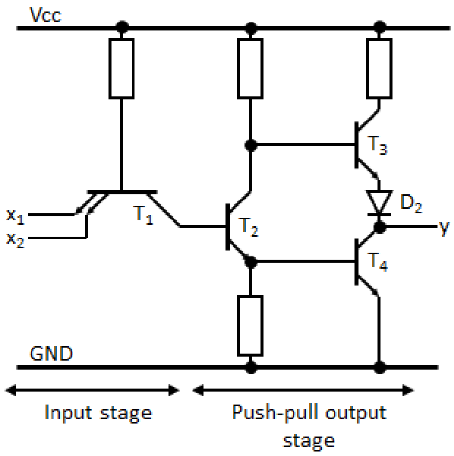


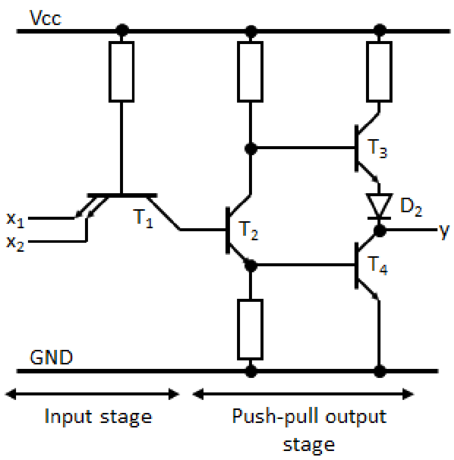
Figure 1.1:

x_1	x_2	T_1	T_2	T_3	T_4	y
0	0					
0	1					
1	0					
1	1					

B) How would a transmission setup width TTL technology look like? (Drawing is not necessary, but when using a description, it has to be clear and distinct)

C) List two advantages when using TTL drivers.

D) How would it be possible to overcome the disadvantage of possible short circuits of a TTL driver? Which part of the TTL driver needs to be modified? Modify the drawing to get the solution and describe the purpose of te adjustments made.



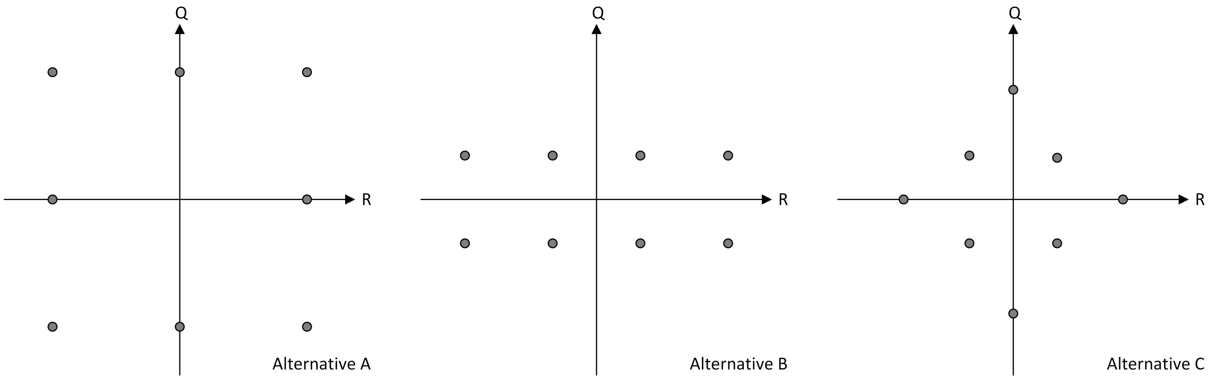
Task 1.2: Differential Signals

A) How could differential signal generation be realized?

B) What are the advantages for differential signal transmission? Name two.

Task 1.3: Modulation

Now consider the following constellation diagrams for 8-QAM. All diagrams are drawn with the same scaling of the axes.



A) If you had to realize a communication system using QAM modulation, which alternative would you choose? Give reasons for your decision

B) Briefly describe PSK modulation and give one advantage.

Task 1.4: Channel capacity, Bandwidth

A digital transmission system with a bandwidth of $B = 1,5 * 10^6 Hz$ has a channel capacity of $C = 5Mbit/s$ (according to Shannon).

A) What is the minimum for the signal to noise ratio (SNR) in dB?

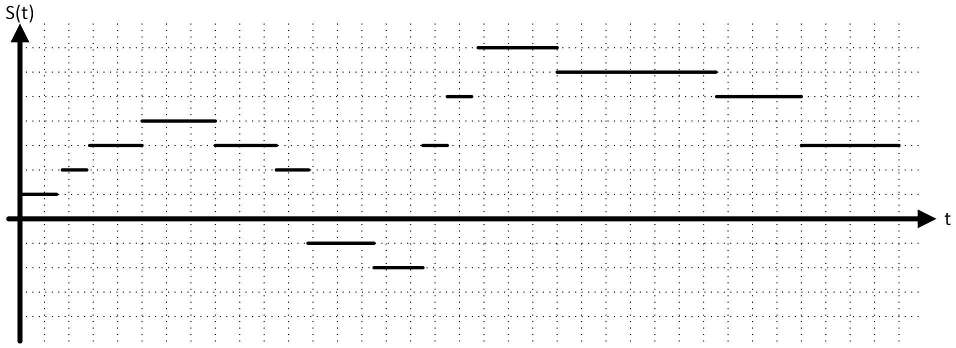
B) Give the definition for the Cut-Off-Frequency:

Task 1.5: Signal Conversion

A) When converting analog signals into digital signals, what has to be considered in order to be able to achieve an unambiguous reconstruction of the signal (name and formula)?

B) One can distinguish four different classes of signal. What are the parameters that are changed to form these classes? Give the combination of parameters that are characteristic for each class.

C) Which signal class does the following signal belong to? Briefly describe where this type of signal can be used.



Task 2: Wiring

Task 2.1: General Questions

A) What is a symmetric line? Name one disadvantage of symmetric signaling.

B) How does the wire length affect the wave impedance Z_W in a lossless case?

C) Name four causes for distortions of real data signals.

D) Name the four different possible cases of the reflection factor r and describe shortly their mechanical analogue.

Task 2.2: Reflection on wires

You have found a transmission link in the basement and want to find out the wave impedance. With the setup given in Figure 2.2 you make the measurements that can be seen in Figure 2.2. The signal source U_S is stuck at an unknown output voltage and has an internal resistance of 33Ω. The termination resistance is $R_T = 200\Omega$. You can assume that the DC resistance is zero. When using numbers from Figure 2.2, only use one decimal place and only use values where the voltage is mostly constant.

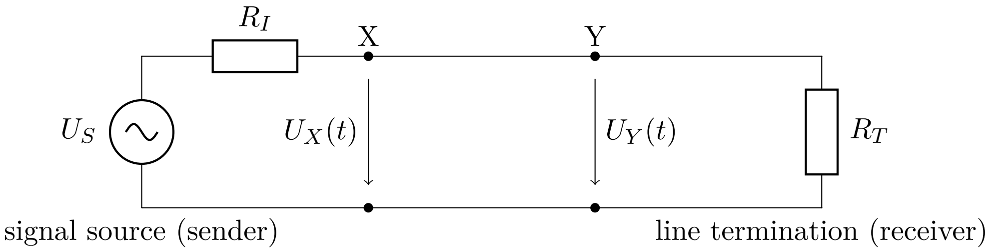


Figure 2.1: Test setup

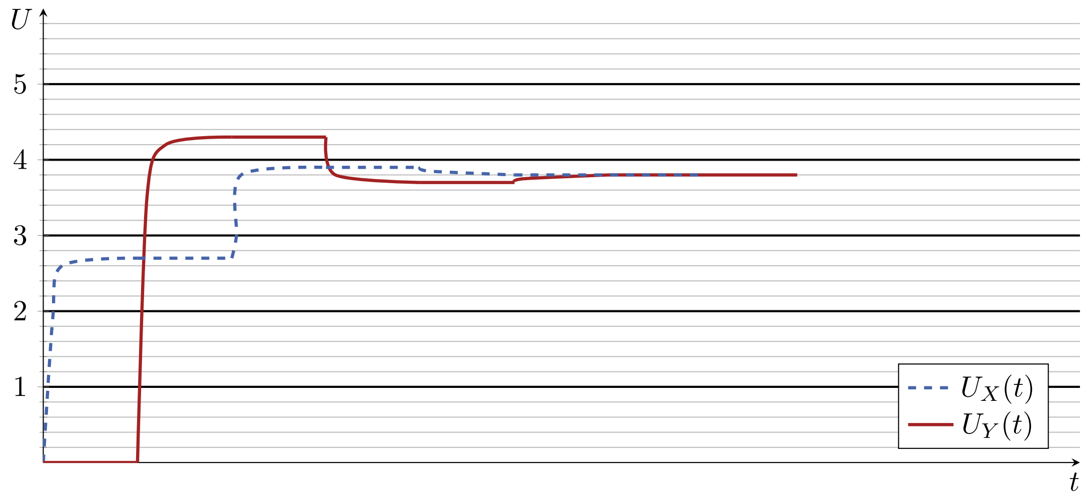


Figure 2.2: Measurement

A) How would you divide the timeline? Explain and mark at least four points on the timeline

B) Without calculation, make a quantitative statement about the reflection factors at the start and at the end.

C) Calculate the wave impedance (characteristic impedance) Z_W and the reflection factors at the start and at the end.

D) Calculate the internal sender voltage U_s

Task 3: Data Transmission

Task 3.1: Line Codes

A) Explain the Manchester Code encoding schemes and name one general application where it is applied.

B) Draw the digital signals for the bit string 010 101 111 000 011 using each of the NRZ, Manchester, and differential Manchester digital encoding schemes. Use figure 3.1.

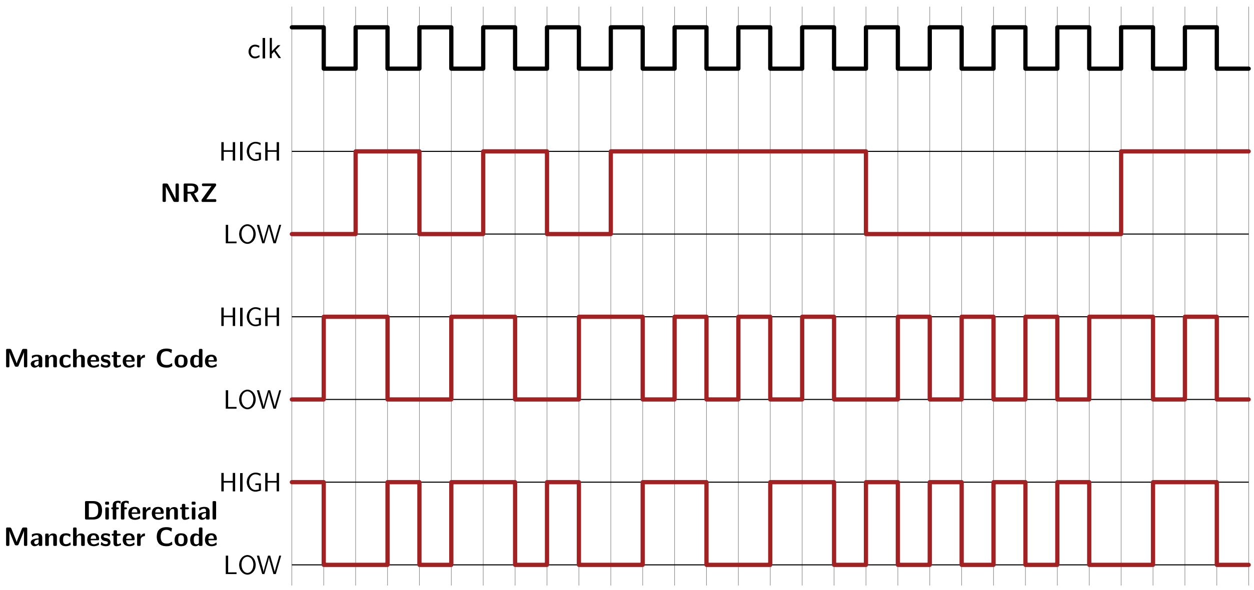


Figure 3.1: Line codes

Task 3.2: CDMA

A) What are the requirements for spreading codes used by CDMA?

Sender node	Function
A	$(+1,+1,-1,-1,+1,+1,-1,-1)$
B	$(+1,+1,+1,+1,-1,+1,-1,+1)$
C	$(+1,+1,-1,-1,-1,-1,+1,+1)$

Table 3.1: Functions for sender nodes

B) Table 3.1 shows the functions of several sender nodes. Show that these functions fulfill the requirements and can be used to transmit data using CDMA.

C) An additional node D should also be able to send data at the same time. Find another function for node D and show that your function is valid.

Task 3.3: Symbol Stuffing

You want to transmit formatted text but due to limitations of your transmission system you can only use the uppercase letters A-Z and whitespace. However, it should be possible to transmit italic, bold and strike-through text.
To achieve this, the command character “C” is used which denotes the beginning and the end of a command sequence. The commands are then applied to all following characters until the command sequence is repeated. If the character “C” is to be sent as part of the text, it therefore has to be escaped by doubling it at sender site. Available commands are “B” for bold text, “I” for italic text, “L” for lowercase letters and “S” for strike-through text.

A) Format the following text according to these rules:

This task is **~~stupid~~** *COOL*

B) What could happen if you did not use commands with an additional separating command word?

Task 4: Error Protection

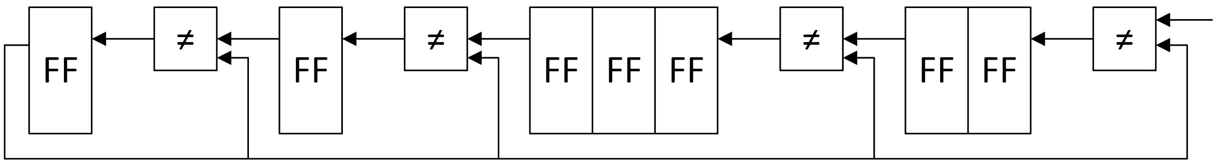
Task 4.1: Error Detection

A) What is the general difference between Safety and Security in relation to errors?

B) Name two properties of a good hash function for communication purposes.

Task 4.2: CRC-Calculation

To protect data transmissions, the given CRC scheme is implemented using linear feedback registers with XOR operations.



A) Determine the used generator polynomial.

B) Calculate the data stream that will be transmitted if the following bit string is to be protected: **10101110**

C) With a transmission system that uses CRC for error detection, a sender transmits the following bitstream: **1001 1101 0001**
Carry out the CRC error detection scheme of the receiver, assuming that the generator polynomial $x^4 + x^1 + 1$ has been used to generate the checksum at the sender. What does the receiver conclude from the result?

Task 4.3: Comparison of LRC and CRC

In Longitudinal Redundancy Check (LRC), a block of bits is organized in a table with rows and columns. Then the parity bit for each column is calculated and used to create a new row of an additional parity data word. After that, the newly calculated parity bits are attached to the original data and sent to the receiver.

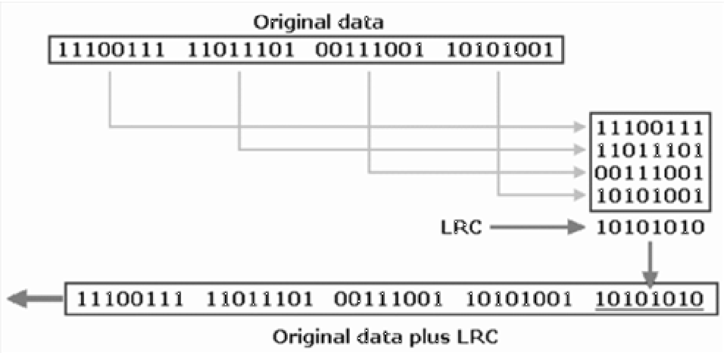


Figure 4.1: Example for LRC generation

A) We now consider a transmission system that uses LRC with four datawords with six bits each. Even parity is applied. Using this system, the following bitstream was received: **1001 1000 1111 1011 0000 0100 0000 01**
Carry out the LRC error detection of the receiver. What does the receiver conclude from the result?

B) Assume that there where disturbances during transmission so that the following bitstream is received instead of the original one: **1101 1001 1111 1011 0000 0100 0000 01**
Would these errors be detected by using LRC? What is the Hamming Distance (HD) of the LRC method?
Note: Hamming Distance (HD) is the lowest weight of any undetectable error. For example, HD=4 means that **all** 1, 2 and 3 bit errors can be detected.

C) Could the errors in task B) be detected by using CRC with a well chosen CRC polynomial? If so, give the shortest possible CRC polynomial from the table below where CRC would guarantee detection of these errors. Explain your answer.

#	CRC Polynomial	Guaranteed HD	Up to max. data length (in bits)
1	CRC-3 ($x^2 + 1$)	HD=2	2048
2	CRC-4 ($x^3 + 1$)	HD=3	1
3	CRC-5 ($x^4 + x^1$)	HD=3	26
4	CRC-5 ($x^4 + x^2 1$)	HD=4	10
5	CRC-8 ($x^7 + x^4 + x^3 + x^1 + 1$)	HD=4	119
6	CRC-8 ($x^7 + x^4 + x^3 + x^2$)	HD=5	9

D) Compare LRC against CRC on the following criteria:

- Error detection capabilities
- Implementation complexity

Which detection scheme would you prefer regarding these criteria? Explain your answer.

Task 5: Media Access

Task 5.1: CSMA/CD

In this task we have a look at a bus system with arbitration that is derived from CSMA/CD. The following rules apply:

- All nodes want to send as many messages as possible. The length of each message is given in table 5.1
- A node is not allowed to send twice in a row. After each successful transmission it has to wait until another node has finished its transmission. The values of the assigned waiting times for each node are given in table 5.1.
- If a node willing to send detects that the bus is occupied it withdraws and waits for the time specified in table 5.1 (waiting time) until it will retry to transmit. Any ongoing transmission is not influenced.
- If two or more nodes want to start a transmission on the free bus at the same time there is a collision. All involved nodes withdraw from the bus and wait for the time given in table 5.1.

Node	Packet length	Waiting time
A	1	2
B	2	2
C	3	2

Table 5.1: Specification of nodes

A) Fill in the signal sequence of the bus nodes, resulting from the specification as given above (use Figure 5.1). Mark waiting times and collisions that occur.

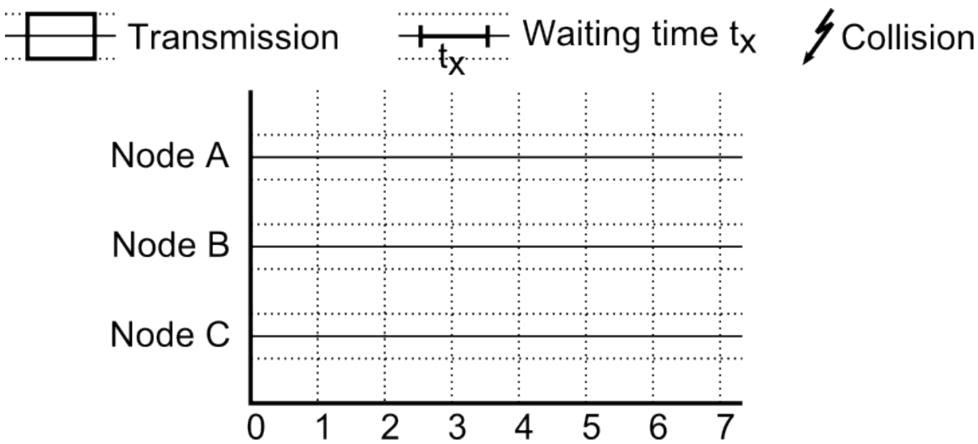


Figure 5.1: Signal sequence

B) Which problem occurs and how could it be solved?

C) The packet length is unchanged and node C has the highest priority. Modify the waiting times so that all nodes have send data after nine clock cycles (use table 5.2). The waiting times should be as short as possible. Fill in the signal sequence of the bus nodes, resulting from the modified waiting times (use Figure 5.2). Mark waiting times and collisions that occur, label which graph should be evaluated with a cross.

Node	Packet length	Waiting time
A	1	
B	2	
C	3	

Table 5.2: Modified waiting time

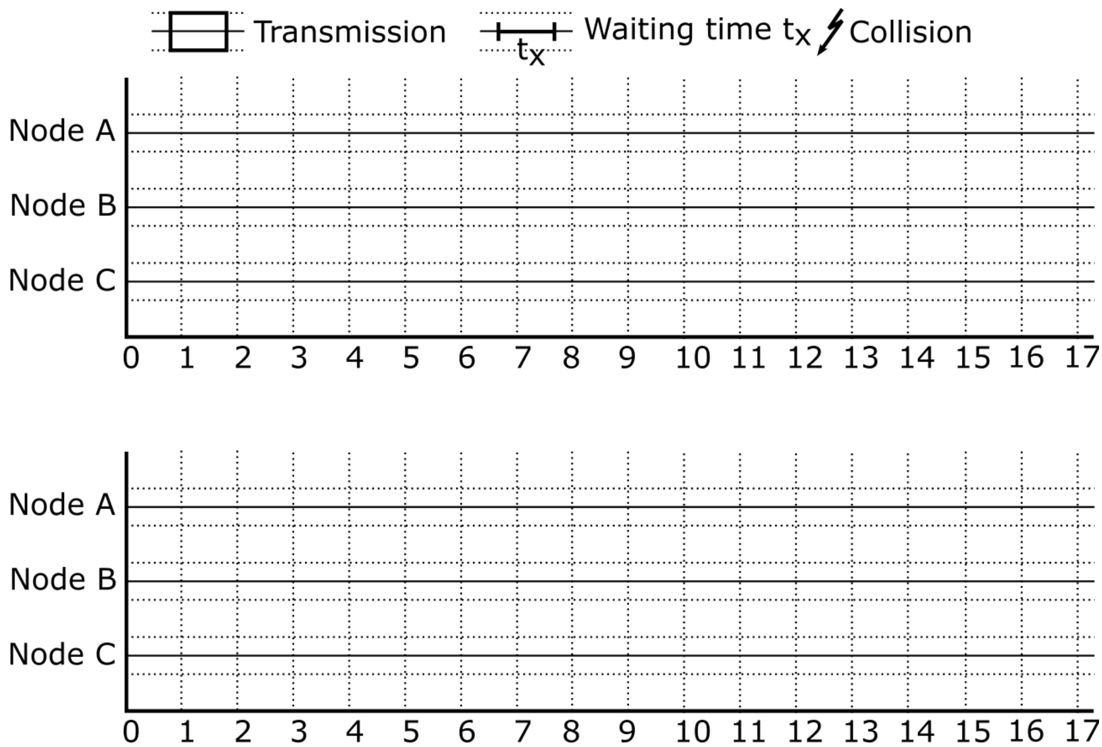


Figure 5.2: Signal sequence

Task 5.2: CSMA/CA

A communication system comprises five communication nodes that use CSMA/CA as arbitration scheme. In order to transmit data a node transmits a dominant start bit (‚0‘) for synchronization purpose. After that a 5 bit message identifier followed and 10 bits of payload data is sent. The message identifiers are unique for each node and all data is sent MSB first. The bus has to cover a maximum distance of $500m$.

A) Name two advantages and two disadvantages of CSMA/CA.

B) Which requirements have to be fulfilled in order to guaranty a faultless function of the system? What are the implications for the transmission rate?

C) Calculate the maximum payload data rate of this bus. Assume a propagation time of $0.66c$ ($c = 3 \cdot 10^8 \frac{m}{s}$).

D) Figure 5.3 shows a timing diagram for the bus system described above. Indicate the identifiers of the given nodes as far as possible (use Table 5.3). Mark undetermined identifiers bits as X!

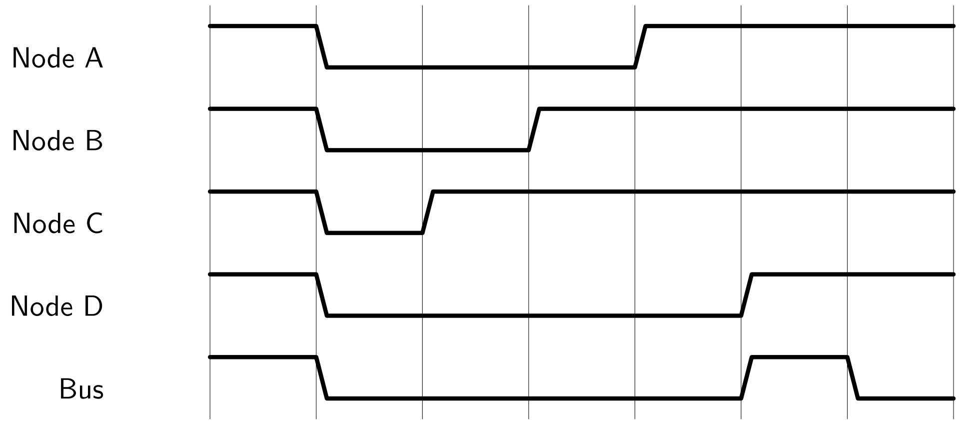


Figure 5.3: Bus Access

Node	**Bit 0**	**Bit 1**	**Bit 2**	**Bit 3**	**Bit 4**
A					
B					
C					
D					

Table 5.3: Identifiers of the nodes

E) Which node is granted exclusive access to the bus?

Task 6: Practical Aspects of Communication Systems

Task 6.1: General Questions

A student wants to transmit data over a very long distance. Because of budget reasons, a connection with one single wire has to be used for this transmission. The transmission should use Aloha with unipolar NRZI.

A) How can clock recovery be done for the above network?

B) The transmitted data will have variable length. Name two ways of determining the data field length within a transmission:

C) What needs to be changed in order to make the network real time capable?

Task 6.2: Physical Layer of Customized Bus

A customized bus should code the raw data with Manchester. The voltage level on the bus is generated by an inductivity. This inductivity is driven by an open-collector that is connected to the output stage of the microcontroller. The transmission is initialized by a logical Zero (start-bit) and ended by a logical One (stop-bit).

A) What is the advantage of the induced voltage levels?

B) Can the clock be recovered within this system? Justify your answer. If clock recovery is not working give a possible solution.

C) Draw the Manchester coded and raw data (information) transmitted over the wire in Figure 6.1. Please write down the transmitted data. The figure shows the transmission of a complete frame.

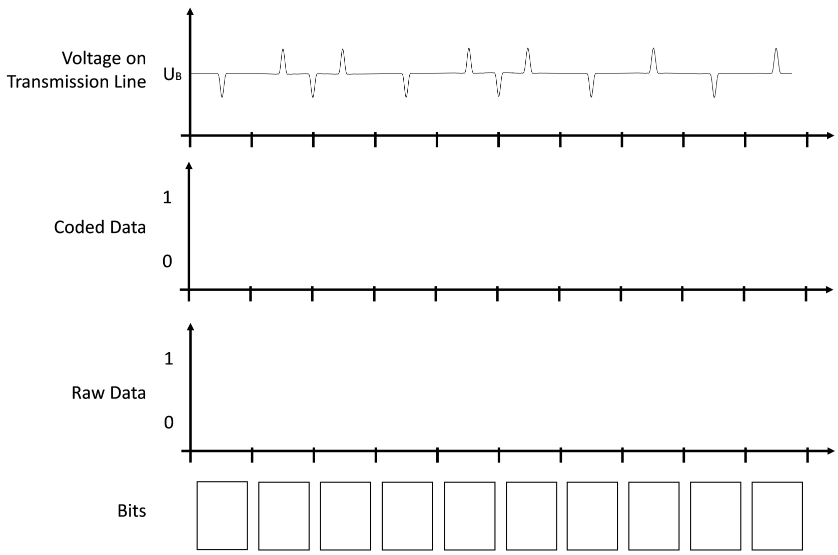


Figure 6.1: Transmission on customized bus

D) How can data integrity be checked purely on physical layer? (Name two)

E) Because of license reasons Manchester coding cannot be used. Why can't differential Manchester be used for the system? Please name the Problem and a possible solution.

Task 6.3: FireWire

A) Different FireWire structures were built during a student laboratory. During test phase you notice that not all FireWire systems are working correctly. Please state if the FireWire systems given below are working correct. Mark the roots, if the systems are correct. Give a reason, if the FireWire system is not working correctly.

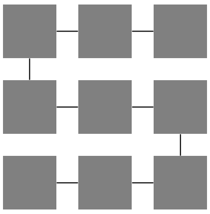
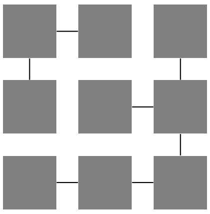
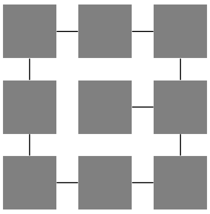
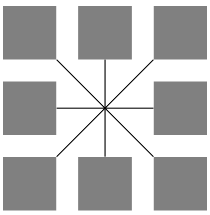
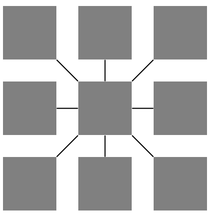
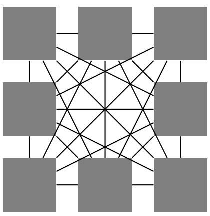
	Correct	Wrong	Reason
			
			
			
			
			
			

Table 6.1: FireWire structures

Task 7: Networks

Task 7.1: General Questions

A) Your task is to decide on which type of connection to be used in a network consisting of components in need of predictable latencies. Justify your decision.

B) Your task is to decide on which type of connection to be used in a network consisting of components that mainly communicate by streaming data, thus in need of high and guaranteed throughput. Justify your decision.

C) Name the three components of a network on chip node in the basic setup and their respective task.

D) How do networks and busses differ from each other?

Task 7.2: Routing

Figure 7.1 shows a 4x4 meshed network with bidirectional links for wormhole packet-switching communication.

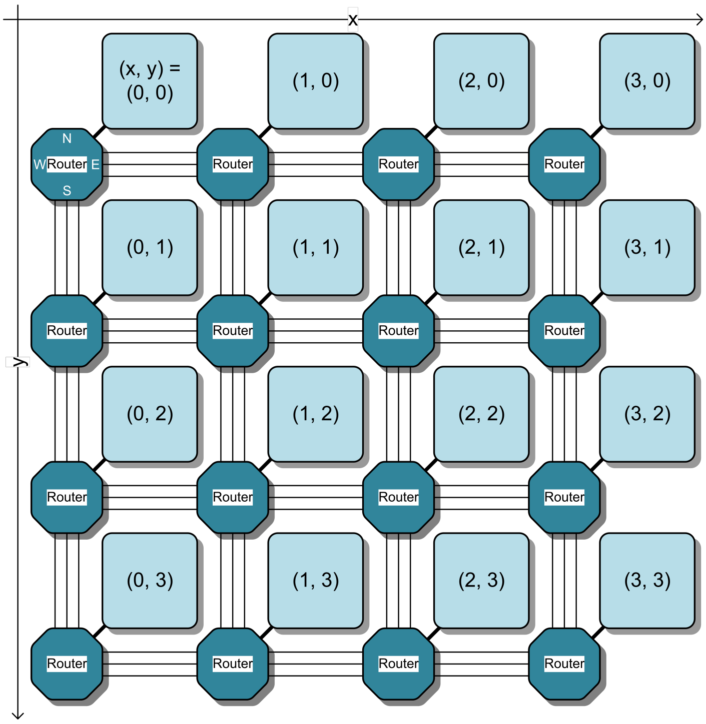


Figure 7.1: 4x4 meshed network

A) Which routers are passed by a packet sent from $(x, y) = (1, 0)$ to $(3, 3)$ using XY-Routing. Please provide the coordinates of the passed router in the order given by the transmission process.

B) The routers $(1, 0)$ and $(2, 1)$ are experiencing heavy traffic towards their east port, such that packets have to wait before being forwarded. As an alternative "hot potato XY-Routing" is used. If a port is occupied the opposite dimension is used, so in case of X towards Y and in case of Y towards X. If no heavy traffic is present common XY Routing is used. Which routers are passed by a packet sent from $(x, y) = (1, 0)$ to $(3, 3)$ for that routing?

C) Which classes of routing algorithms is hot potato XY-Routing associated with?

D) Describe two scenarios: one in which common XY Routing is preferable and one in which "hot potato XY Routing".

E) Instead of XY-Routing, Flooding is considered for the given network. How many times is a packet forwarded when flooding is used, with router $(1, 0)$ being the origin and router $(2, 2)$ the destination?

F) How many times is a packet forwarded by routers, using Flooding with a time to live of 2, when router $(1, 0)$ is the origin and router $(2, 2)$ the destination?

G) What is the minimal time to live for a packet sent by router $(1, 0)$ to reach router $(2, 2)$?

Task 7.3: Communication Models

This task focuses on Communication Models like the OSI reference model.

A) The (notional) company “Simple Communications” has taken the position that layered communication models are unnecessary. Name one reason why they would fare better with a layered model and justify your answer.

B) What is the purpose of the presentation layer in the OSI reference model?

A data transmission scenario is illustrated in figure 7.2. The latencies for data processing within each layer of the OSI reference model are shown in Table 7.1.The latencies can be assumed for all devices in this scenario.

#	Layer	Latency
1	Physical Layer	$1\mu s$
2	Data Link Layer	$10\mu s$
3	Network Layer	$100\mu s$
4	Transport Layer	$500\mu s$
5	Session Layer	$1ms$
6	Presentation Layer	$1.5ms$
7	Application Layer	$2.5ms$

Table 7.1: Latencies

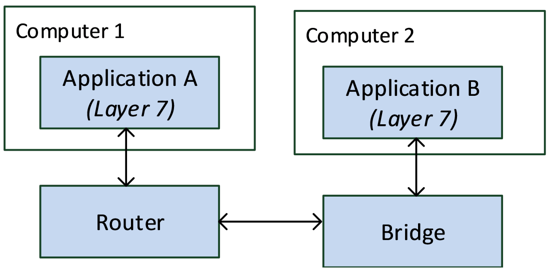


Figure 7.2: Data transmission scenario

C) Calculate the communication latency for the router, bridge and for Computer 1. The payload size can be assumed as small. Thus, data transmission latency is assumed to be independent from the payload size.