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# Question 1)

Points: .....

Maximum points: 2+5+1+1+1=10

- a) Explain the difference between serial data transmission and parallel data transmission.

*A single data line exists, when serial data transmission is used. The bits are transmitted one after another via the bus.*

*Separate data lines exist, when parallel data transmission is used.*

- b) Several network topologies (Bus, Ring, Star, Mesh, Tree and Cellular) exist. Write into the following table in each row one network topology that matches the respective statement.

Statement	Topology
Mobile phones (GSM standard) used this topology	<i>Cellular</i>
This topology contains a single point of failure	<i>Bus, Star, Cellular</i>
Thin Ethernet and Thick Ethernet use this topology	<i>Bus</i>
WLAN with Access Point uses this topology	<i>Cellular</i>
WLAN without Access Point uses this topology	<i>Mesh</i>
Token Ring (logical) uses this topology	<i>Ring</i>
A cable failure causes a complete network failure	<i>Ring, Bus</i>
This topology contains no central component	<i>Bus, Ring, Mesh</i>
Modern Ethernet standards use this topology	<i>Star</i>
Token Ring (physical) uses this topology	<i>Star</i>

*Each correct answer results in 0.5 points. Each wrong answer results in 0 points.*

- c) Name two systems, that operate according to the simplex principle.

*Radio, TV, pager, satellite, GPS, radio clock signal.*

- d) Name two systems, that operate according to the full-duplex principle.

*Ethernet via twisted pair cables, telephone.*

- e) Name two systems, that operate according to the half-duplex principle.

*Networks with fiber-optic cables or coaxial cables, Wireless networks with just a single channel.*

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## Question 2)

Points: .....

Maximum points: 3

A MP3 file with a size of  $30 * 10^6$  bits must be transferred from terminal device A to terminal device B. The signal propagation speed is 200,000 km/s. A and B are directly connected by a link with a length of 10,000 km. The file is transferred as a single message, that has a size of  $30 * 10^6$  bits. No network protocol headers or trailers exist.

Calculate the transfer time (latency) of the file, when the data rate of the computer network between both terminal devices is 1 Mbps.

File size: 30,000,000 Bits

Data rate: 1,000,000 Bits/s

Propagation delay = 10,000,000 m / 200,000,000 m/s = 0.05 s

Transmission delay = 30,000,000 Bits / 1,000,000 Bits/s = 30 s

Waiting time = 0 s

Latency = propagation delay + transmission delay + waiting time  
= 0.05 s + 30 s = 30.05 s = approx. 30 s.

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## Question 3)

Points: .....

Maximum points: 2+2+2+2=8

- a) Why is the outer conductor (the shield) of coaxial cables kept at ground potential and does completely surround the inner conductor?

*The shielding of the signal-carrying conductor by the shield, that is kept at ground potential, reduces electromagnetic interferences.*

- b) What is a Transceiver?

*Via Transceivers, terminal devices are connected with the transmission medium.*

- c) Why is this equation useful in computer networks?

*(For what purpose is this equation used?)*

$$((+\text{Payload Signal}) + (\text{Noise})) - ((-\text{Payload Signal}) + (\text{Noise})) = 2 * \text{Payload Signal}$$

*With this equation, twisted-pair cables filter out interfering signals.*

- d) Why is it impossible to connect different buildings with shielded cables?

*Shields must be electrically grounded on both sides of the cable. If only one end of a shielded cable is grounded, an antenna effect occurs, which results in a compensation current.*

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## Question 4)

Points: .....

Maximum points:  $2+2+1.5+1+0.5+0.5+0.5=8$

- a) Name two advantages of using a Hub.

*Better reliability, because the failure of individual cable segments does not result in a complete network failure.*

*Network devices can be attached and detached without interrupting the network.*

- b) What is a collision domain?

*The collision domain is a network or a section of a network where multiple network devices use a shared transmission medium. It includes all network devices which compete for accessing a shared transmission medium.*

- c) What says the 5-4-3 rule?

*In a collision domain, not more than 5 segments can be connected. For this, a maximum of 4 Repeaters are used. Only at 3 segments, active senders (terminal devices) can be connected.*

- d) Why does the 5-4-3 rule exist?

*Hubs cannot be cascaded infinitely. The round-trip time (RTT) must not be exceeded. If the network is too large, the RTT will become too high. Then collisions occur more frequent and undetected collisions are possible.*

- e) The format of what addresses is defined by Data Link Layer protocols?

physical network addresses       logical network addresses

- f) How are physical network addresses called?

*MAC addresses (Media Access Control).*

- g) What protocol uses Ethernet for the address resolution?

*Address Resolution Protocol (ARP).*

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## Question 5)

Points: .....

Maximum points:  $1+1+1+1+1+2+2=9$

- a) Name two line codes that use two signals levels.

*NRZ, NRZI, Unipolar RZ, Manchester, Manchester II, Differential Manchester*

- b) Name two line codes that use three signals levels.

*MLT-3, RZ, AMI, B8ZS*

- c) Name two line codes that ensure a signal level change for each logical 1 bit?

*NRZI, MLT-3, Unipolar RZ, AMI, B8ZS, Manchester, Manchester II, Diff. Manchester*

- d) Name two line codes that ensure that the signal levels are equally distributed?

*AMI, B8ZS, Manchester, Manchester II, Diff. Manchester*

- e) Why do not all line codes ensure a signal level change for each transmitted bit?

*When a each transmitted bit causes a signal level change, the efficiency of the line code is bad.*

- f) What is a scrambler and for what purpose is it used?

*A scrambler is a device, which modifies a data stream according to a simple algorithm in a way that it is easy to reverse.*

- g) How is the efficiency of a line code calculated?

*Efficiency = ratio of bit rate (payload in bits per time) and baud rate (signal changes per second).*

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# Question 6)

Points: .....

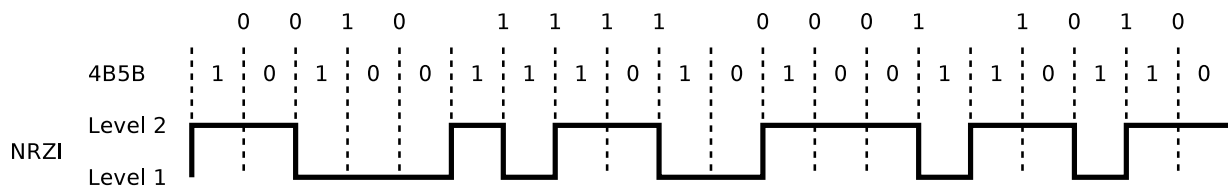
Maximum points: 4

a) Encode the bit sequence with 4B5B and NRZI and draw the signal curve.

- 0010 1111 0001 1010

Attention: Please assume that the initial signal level of NRZI is signal level 1 (low signal).

Label	4B	5B	Function
0	0000	11110	0 hexadecimal
1	0001	01001	1 hexadecimal
2	0010	10100	2 hexadecimal
3	0011	10101	3 hexadecimal
4	0100	01010	4 hexadecimal
5	0101	01011	5 hexadecimal
6	0110	01110	6 hexadecimal
7	0111	01111	7 hexadecimal
8	1000	10010	8 hexadecimal
9	1001	10011	9 hexadecimal
A	1010	10110	A hexadecimal
B	1011	10111	B hexadecimal
C	1100	11010	C hexadecimal
D	1101	11011	D hexadecimal
E	1110	11100	E hexadecimal
F	1111	11101	F hexadecimal



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## Question 7)

Points: .....

Maximum points:  $1+2+1+1+1=6$

- a) What information is stored in forwarding tables of Bridges?

*The information, which network devices are accessible via which port in local forwarding tables.*

- b) What happens, if for a network device, no entry exists in the forwarding table of a Bridge?

*This is not a problem because the table is only used for optimization. If for a network device no entry in the forwarding table exists, the Bridge forwards the frame to every port, which is connected to a physical network.*

- c) What protocol use Bridges to handle loops?

*Spanning Tree Protocol (STP).*

- d) What is a spanning tree?

*It is a subgraph of the graph, which covers all nodes, but it is cycle-free, because edges have been removed.*

- e) What is a switched network?

*In a switched network, each port of the switches is connected with just a single network device.*



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## Question 8)

Points: .....

Maximum points: 4

Transmission errors can be detected via CRC checksums. If it is important to not only recognize errors, but also to be correct them, then the data to be transmitted must be encoded in a way, that error-correction is possible. Error correction can be realized e.g. via the Simplified Hamming Code we discussed in the computer networks course.

Verify, if the following message was transmitted correctly: 00111101

```
Received data: 1 2 3 4 5 6 7 8
                0 0 1 1 1 1 0 1
```

```
      0011 Position 3
      0101 Position 5
XOR 0110 Position 6
-----
      0000 Parity bits calculated
XOR 0011 Parity bits received
-----
      0011 => Bit 3 ist defective!
```

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## Question 9)

Points: .....

Maximum points: 2+2+2+2=8

- a) Which two special characteristics of the transmission medium in wireless networks cause undetected collisions at the receiver?

*Hidden terminal problem and Fading.*

- b) What is the Network Allocation Vector (NAV) for what purpose is it used?

*The NAV is a counter variable which is maintained by each node itself. It contains the expected time when the transmission medium will be occupied. It reduces the number of collisions when CSMA/CA is used.*

- c) What is the Contention Window (CW) for what purpose is it used?

*When using WLAN, after the NAV and another DIFS with an idle transmission medium has expired, a backoff time is created from the CW. The backoff time is calculated by using a random value between the minimum CW and maximum CW and multiplying this random value with the slot time. After the backoff time has expired, the frame is transmitted. The CW prevents that all stations which wait for a free transmission medium, start their transmissions at the same time.*

- d) Name a benefit and a drawback of using the control frames Request To Send (RTS) and Clear To Send (CTS)?

*Advantage: It reduces collisions because it solves the problem of hidden terminals.*

*Drawbacks: Delays occur, which are caused by the reservation of the transmission medium. The RTS and CTS frames, which are used to reserve the transmission medium, are overhead.*

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## Question 10)

Points: .....

Maximum points: 2+2+2+2=8

- a) What is the purpose of Routers in computer networks?

*(Also explain the difference to Layer-3-Switches.)*

*They forward packets between networks with different logical address ranges and provide a WAN interface.*

- b) What is the purpose of Layer-3-Switches in computer networks?

*(Also explain the difference to Routers.)*

*They are Routers too which means they forward packets between networks with different logical address ranges but they do not provide a WAN interface.*

- c) What is the purpose of Gateways in computer networks?

*They enable communication between networks, which base on different protocols.*

- d) Why are Gateways in the network layer of computer networks seldom required nowadays?

*Modern computer networks operate almost exclusively with the Internet Protocol (IP). For this reason, a protocol conversion at the Network Layer is mostly not required.*

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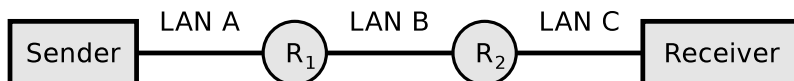
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# Question 11)

Points: .....

Maximum points: 10

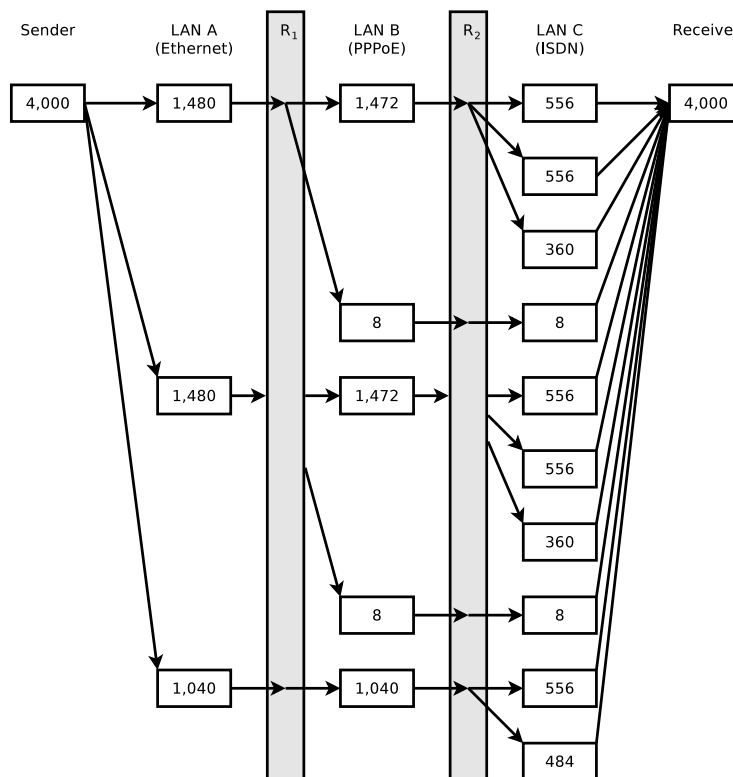
4,000 bytes payload need to be transmitted via the IP protocol.



The resulting packet must be fragmented, because it is transmitted over multiple physical networks, whose MTU is < 4,000 bytes.

	LAN A	LAN B	LAN C
Network technology	Ethernet	PPPoE	ISDN
MTU [bytes]	1,500	1,492	576
IP header [bytes]	20	20	20
max. payload [bytes]	1,480	1,472	556

Display graphically the way, the packet is fragmented, and how many bytes of payload each fragment contains.



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## Question 12)

Points: .....

Maximum points: 2+2+1+1=6

- a) Describe two examples, where using the Transport Layer protocol TCP makes sense.  
*TCP is used for Email transmission, file transmission and web page transmission because no part of the information is allowed to get lost.*
- b) What is a socket?  
*Sockets are the platform-independent, standardized interface between the implementation of the network protocols in the operating system and the applications. A socket consists of a port number and an IP address.*
- c) What specifies the Seq number in an TCP segment?  
*The sequence number of the current segment.*
- d) What specifies the Ack number in an TCP segment?  
*The sequence number of the next expected segment.*

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## Question 13)

Points: .....

Maximum points:  $2+2+2=6$

- a) Describe the silly window syndrome and its effect.

*Scenario: A receiver is overloaded and his receive buffer is completely filled. Once the application has read a few bytes (e.g. 1 byte) from the receive buffer, the receiver sends a segment with the free storage capacity of the receive buffer. For this reason, the sender transmits a segment which contains just 1 byte payload.*

*Effect: Many tiny segments are transmitted and the protocol overhead rises.*

- b) Describe the Functioning of silly window syndrome avoidance.

*The receiver notifies the sender about free storage capacity in the receive window not before 25% of the reception buffer is free or a segment size of size MSS can be received.*

- c) Why does the sender maintain two windows and not just a single one?

*The Advertised Receive Window avoids congestion of the receiver.*

*The Congestion Window avoids congestion of the network.*