Written examination in Computer Networks

February 13th 2023

Last name: _____

First name: _____

Student number: _____

Mit dem Bearbeiten dieser schriftlichen Prüfung (Klausur) bestätigen Sie, dass Sie diese alleine bearbeiten und dass Sie sich gesund und prüfungsfähig fühlen. Mit dem Erhalt der Aufgabenstellung gilt die Klausur als angetreten und wird bewertet.

By attending this written exam, you confirm that you are working on it alone and feel healthy and capable to participate. Once you have received the examination paper, you are considered to have participated in the exam, and it will be graded.

- Use the provided sheets. Do *not* use own paper.
- You are allowed to use a *self prepared*, *single sided DIN-A4 sheet* in the exam. Only *hand-written originals* are allowed, but no copies.
- Do *not* use a red pen.
- Time limit: *90 minutes*
- Turn off your mobile phones!

Grade: _____

Questions:	1	2	3	4	5	6	7	8	9	**Σ**
Maximum Points:	15	9	8	9	16	8	9	9	7	90
Achieved Points:										

1.0: 90.0-85.5, **1.3**: 85.0-81.0, **1.7**: 80.5-76.5, **2.0**: 76.0-72.0, **2.3**: 71.5-67.5,
2.7: 67.0-63.0, **3.0**: 62.5-58.5, **3.3**: 58.0-54.0, **3.7**: 53.5-49.5, **4.0**: 49.0-45.0, **5.0**: <45

Question 1)

Points: ..... of 15

4 Points

(1) An image has a size of 3840x2160 pixels (Ultra HD) with true color (3 Bytes per pixel are used for the color information). Calculate how long it takes to transmit the uncompressed image via a 100 Mbps ($= 100 * 10^6$ Bits per second) DSL connection.

11 Points

(2) Fill out all empty fields.
(Fill in each empty cell only <u>one</u> correct answer!)

ISO/OSI Reference Model

Layer	Protocol	Device	Sort of Data (data unit)	Addresses
7			Message	
6				
5				
4		(VPN-)Gateway		
3				
2				
1				

Question 2)

Points: ..... of 9

1 Point (1) Explain the difference between serial and parallel data transmission.

½ Point (2) Computer networks usually implement...

☐ *Serial data transmission* ☐ *Parallel data transmission*

½ Point (3) Data Link Layer protocols specify the format of...

☐ physical network addresses ☐ logical network addresses

1 Point (4) Explain what the physical topology of a computer network describes.

1 Point (5) Explain what the logical topology of a computer network describes

½ Point (6) Name the topology that is used by modern Ethernet standards.

½ Point (7) Name the topology that is used by Thin and Thick Ethernet.

½ Point (8) Name the topology that is used by Token Ring (physical).

½ Point (9) Name the topology that is used by Token Ring (logical).

½ Point (10) Name the topology that is used by WLAN without an Access Point.

½ Point (11) Name the topology that is used by WLAN with an Access Point.

½ Point (12) Name <u>one</u> topology that contains a single point of failure.

½ Point (13) Name the topology that is used by mobile phones (GSM standard).

½ Point (14) Name <u>one</u> topology where a cable failure causes the entire network to fail.

½ Point (15) Name <u>one</u> topology that has no central component.

Question 3)

Points: ..... of 8

4 Points

(1) Error Detection via CRC: Check, if the received frame was transmitted correctly.

`Received frame: 1101001111100` `Generator polynomial: 100101`

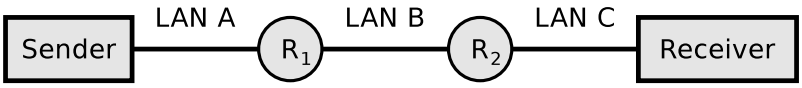
4 Points

(2) 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`

Question 4)

Points: ..... of 9



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

The payload 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	WLAN
MTU [bytes]	1,500	1,492	2,312
IP header [bytes]	24	20	28
max. payload [bytes]			

Hint: In practice, the fragment offset is counted in 8-byte increments; therefore, the payload in a fragment must be a multiple of 8. However, for the sake of simplicity, you can also create fragments that are not multiples of 8 in this task.

1½ Points (1) Calculate the max. payload [bytes] per network and fill the values into the table.

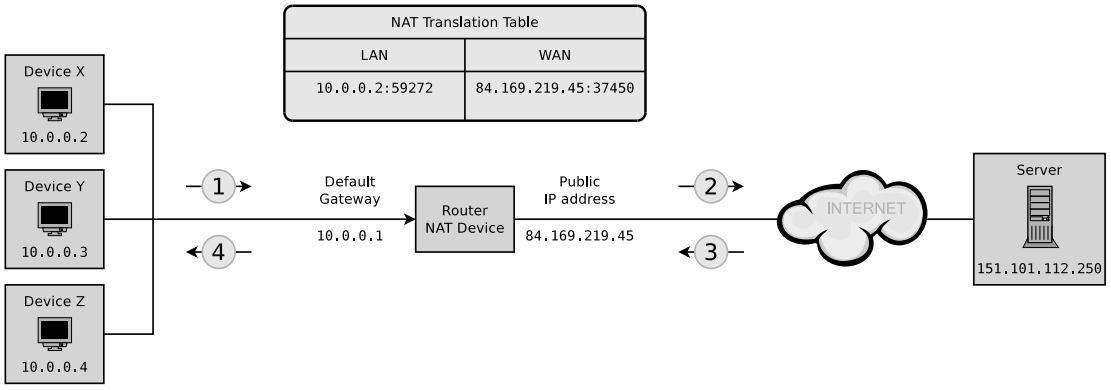
7½ Points (2) Display graphically the way, the payload is fragmented, and how many bytes of payload each fragment contains.

Question 5)

Points: ..... of 16

8 Points

(1) Fill the missing IP addresses and port numbers into the figure that describes a NAT scenario where device X sends a request for a web page to a web server process that runs on the server and can be accessed via port number 80.



Source Destination

(Message 1) ___.___.___.___:_____ --> ___.___.___.___:_____

(Message 2) ___.___.___.___:_____ --> ___.___.___.___:_____

(Message 3) ___.___.___.___:_____ --> ___.___.___.___:_____

(Message 4) ___.___.___.___:_____ --> ___.___.___.___:_____

2 Points

(2) Simplify this IPv6 address:
`21da:00d3:0000:0000:02aa:00ff:fe28:9c5a`

2 Points

(3) Simplify this IPv6 address:
`2001:0db8:0000:0000:5a6b:0000:0001:678a`

2 Points

(4) Provide all positions of this simplified IPv6 address:
`2001:db8:84a2::8a2e:70:4`

2 Points

(5) Provide all positions of this simplified IPv6 address:
`2001:cdba::18:2`

Question 6)

Points: ..... of 8

4 Points

(1) Split the class B network `189.23.0.0` for implementing 20 subnets. Calculate the subnet mask and fill in the missing numbers.

```
Network ID:  10111101.00010111.00000000.00000000   189.23.0.0

Number of bits for subnet IDs: ___________________________________

Subnet mask: ________.________.________.________   ___.___.___.___

Number of bits for host IDs:  ___________________________________

Number of host IDs per subnet:  _________________________________
```

4 Points

(2) Split the class C network `195.3.128.0` into subnets which contain 60 hosts each. Calculate the subnet masks and fill in the missing numbers.

```
Network ID:  11000011.00000011.10000000.00000000   195.3.128.0

Number of bits for host IDs: ____________________________________

Number of bits for subnet IDs: __________________________________

Number of possible subnets: _____________________________________

Subnet mask: ________.________.________.________   ___.___.___.___
```

binary representation	decimal representation
10000000	128
11000000	192
11100000	224
11110000	240
11111000	248
11111100	252
11111110	254
11111111	255

Question 7)

Points: ..... of 9

4 Points

(1) Encode the bit sequence with 4B5B and NRZI and draw the signal curve:
`0010 1111 0001 1010`
(!!! Use signal level 1 (low signal) as initial signal level of NRZI !!!)

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

Label	4B	5B	Function
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

5 Points

(2) Encode the bit sequence with 5B6B and NRZ and draw the signal curve.
`11010 11110 01001 00010 01110`

5B	6B neutral	6B positive	6B negative
00000		001100	110011
00001	101100		
00010		100010	101110
00011	001101		
00100		001010	110101
00101	010101		
00110	001110		
00111	001011		
01000	000111		
01001	100011		
01010	100110		
01011		000110	111001
01100		101000	010111
01101	011010		
01110		100100	011011
01111	101001		

5B	6B neutral	6B positive	6B negative
10000		000101	111010
10001	100101		
10010		001001	110110
10011	010110		
10100	111000		
10101		011000	100111
10110	011001		
10111		100001	011110
11000	110001		
11001	101010		
11010		010100	101011
11011	110100		
11100	011100		
11101	010011		
11110		010010	101101
11111	110010		

Question 8)

Points: ..... of 9

1 Point (1) Mark the label of Twisted Pair Cables that have no cable and no pair shielding.
☐ *ATP* ☐ *FTP* ☐ *STP* ☐ *UTP* ☐ *XTP* ☐ *ZTP*

2 Points (2) Explain the meaning of the information `24AWG`, `26AWG`, and `28AWG` on cables and explain the effect on the attenuation and installation.

2 Points (3) Explain the meaning of the information `SOLID` and `STRANDED` on cables and explain the effect on the installation.

4 Points (4) A scientific experiment produces 35 PB ($35 * 10^{15}$ Byte) of data per year, which need to be stored. Calculate the height of the stack of storage media, if for storing the data CDs with 650 MB ($650 * 10^{6}$ Byte) capacity and 1.2 mm thickness are used?

Question 9)

Points: ..... of 7

2 Points (1) Name and describe the two special characteristics of the transmission medium in wireless networks that cause undetected collisions at the receiver.

2 Points (2) Name a benefit and a drawback of using the control frames Request To Send (RTS) and Clear To Send (CTS).

1 Point (3) Explain what the function of the Address Resolution Protocol (ARP) is.

1 Point (4) Explain what the ARP cache is and why it is used in practice.

1 Point (5) Explain why loops on Data Link Layer can cause malfunctions in the network.