Sample solution of the written examination in

Computer Networks

March 1st 2019

Last name: _____

First name: _____

Student number: _____

I confirm with my signature that I will process the written examination alone and that I feel healthy and capable to participate this examination.
I am aware, that from the moment, when I receive the written examination, I am a participant of this examination and I will be graded.

Signature: _____

- Use the provided sheets. Own paper must *not* be used.
- You are allowed to use a *self prepared*, *single sided DIN-A4 sheet* in the exam. Only *handwritten originals* are allowed, but no copies.
- You are allowed to use a non-programmable calculator.
- Do *not* use a red pen.
- The time limit ist *90 minutes*.
- Turn off your mobile phones!

Result:

Question:	1	2	3	4	5	6	7	8	9	**Σ**	Grade
Maximum points:	6	11	8	9	24	6	9	9	8	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

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Question 1)

Points: .....

Maximum points: 6

a) What describes the physical topology of a computer network?
It describes the wiring.

b) What describes the logical topology of a computer network?
It describes the flow of data between the network devices.

c) Name the topology that is used by modern Ethernet standards.
Star

d) Name the topology that is used by Thin and Thick Ethernet.
Bus

e) Name the topology that is used by Token Ring (physical).
Star

f) Name the topology that is used by Token Ring (logical).
Ring

g) Name the topology that is used by WLAN without an Access Point.
Mesh

h) Name the topology that is used by WLAN with an Access Point.
Cellular

i) Name <u>one</u> topology that contains a single point of failure.
Bus (the medium!), Ring (the medium!), Star, Cellular

j) Name the topology that is used by mobile phones (GSM standard).
Cellular

k) Name <u>one</u> topology where a cable failure causes the entire network to fail.
Ring, Bus

l) Name <u>one</u> topology that has no central component.
Bus, Ring, Mesh

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Question 2)

Points: .....

Maximum points: 2+4+5=11

Imagine, NASA sent a spacecraft to planet Mars, which landed there. A 128 kbps (kilobit per second) point-to-point link is set up between planet Earth and the spacecraft.

The distance between Earth and Mars fluctuates between approx. 55,000,000 km and approx. 400,000,000 km. For the further calculations, we use the 55,000,000 km, which is the distance from Earth to Mars, when they are closest together.

The signal propagation speed is $299,792,458$ m/s, which is the speed of light.

a) Calculate the Round Trip Time (RTT) for the link.
(*RTT = (2 * distance) / signal propagation speed*)

```
RTT = (2 * distance) / signal propagation speed
    = (2 * 55,000,000,000 m) / 299,792,458 m/s
    = 110,000,000,000 m / 299,792,458 m/s
    = 366.920504718 s
```

b) Calculate the bandwidth-delay product for the link to find out what is the maximum number of bits, that can reside inside the line between the sender and receiver?
(*It is a point-to-point link* $\Longrightarrow$ *Transmission delay = 0 s and Waiting time = 0 s*)

Signal propagation speed = 299.792.458 m/s
Distance = 55.000.000.000 m
Transmission delay = 0 s and Waiting time = 0 s

```
                     55,000,000,000 m
Propagation delay = ------------------ = 183.460252359 s
                       299,792,458 m/s

     128,000 Bits/s * 183.460252359 s = 23,482,912.302 Bits = approx. 23.48 Mbits
```

c) A webcam at the surface of planet Mars sends pictures to Earth. Each image has a size of 10 MB (1 MB = 2^{20} Byte). How quickly, after a picture is taken, can it reach Mission Control on Earth?

```
File size: 10 MB = 10,485,760 Bytes = 83,886,080 Bits
Data rate: 128,000 Bits/s
Propagation delay = 55,000,000,000 m / 299,792,458 m/s
                  = 183.460252359 s
Transmission delay = 83,886,080 Bits / 128,000 Bits/s
                   = 655.36 s
                   = 10 m 55.36 s
Waiting time = 0 s
Latency = propagation delay + transmission delay + waiting time
        = 183.460252359 s + 655.36 s + 0 s
        = 838.820252359 s
        = 13 m 58,82 s
```

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Question 3)

Points: .....

Maximum points: 4+4=8

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

```
Received frame: 1101001111100          Generator polynomial: 100101

1101001111100
100101|||||||
------v||||||
 100011||||||
 100101||||||
 ------vvv|||
    110111|||
    100101|||
    ------v||
     100101||
     100101||
     ------vv
           00 => Transmission was error-free
```

b) 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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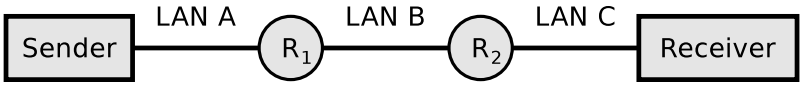
Question 4)

Points: .....

Maximum points: 9

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

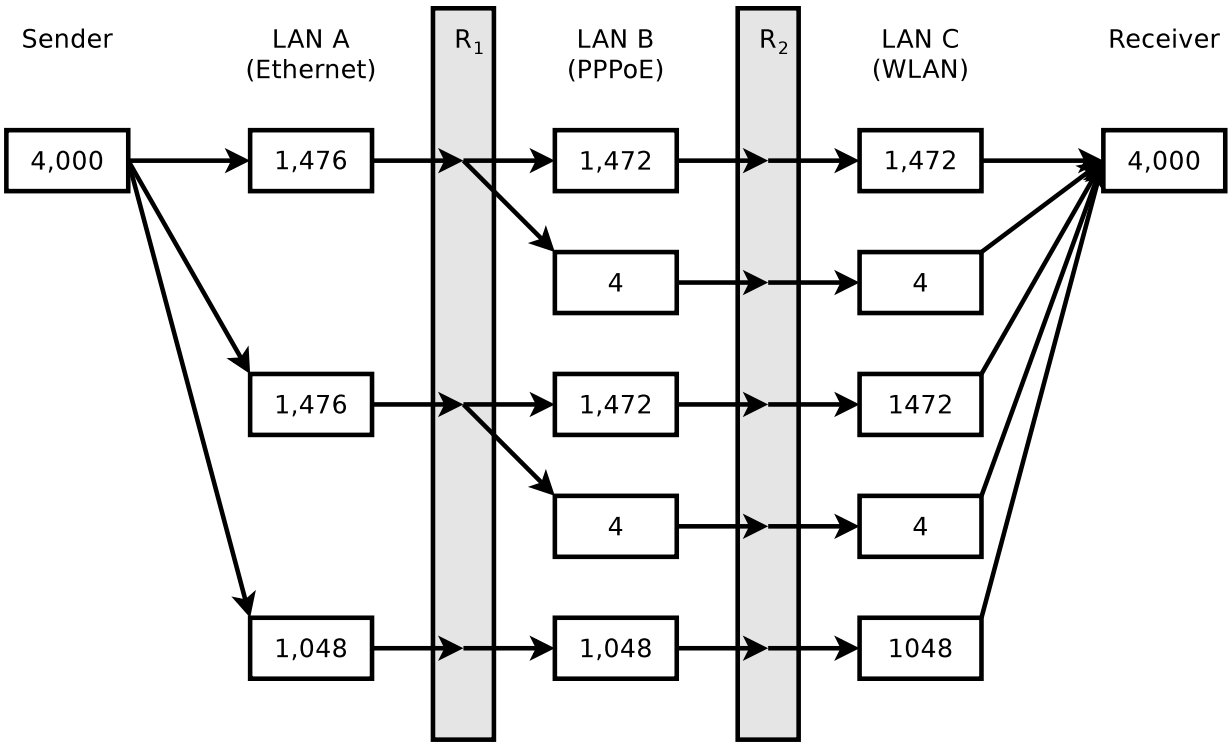


The payload must be fragmented, because it is transmitted over multiple physical networks, whose MTU is $< 4,000$ bytes.

	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]	1.476	1.472	2,284

a) Calculate the max. payload [bytes] per network and fill the values into the table.

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



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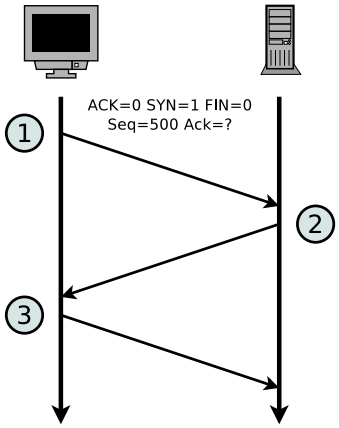
Question 5)

Points: .....

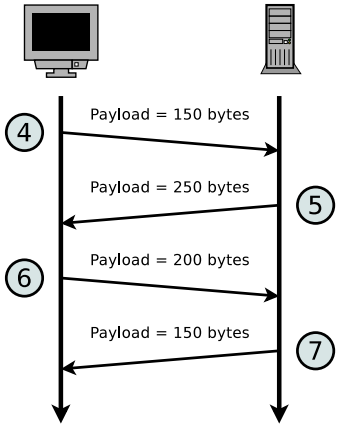
Maximum points: 6+9+9=24

a) The diagram shows the establishment of a TCP connection. Complete the table.



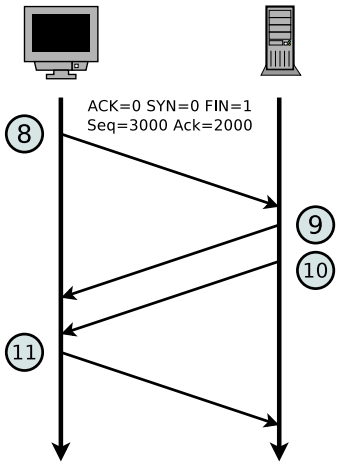
Message	ACK flag	SYN flag	FIN flag	Payload length	Seq number	Ack number
1	0	1	0	0	500	irrelevant
2	1	1	0	0	800	501
3	1	0	0	0	501	801

b) The diagram shows an excerpt of the transmission phase of a TCP connection. Complete the table.



Message	ACK flag	SYN flag	FIN flag	Payload length	Seq number	Ack number
4	0	0	0	150	1000	1300
5	1	0	0	250	1300	1150
6	1	0	0	200	1150	1550
7	1	0	0	150	1550	1350

c) The diagram shows the termination of a TCP connection. Complete the table.



Message	ACK flag	SYN flag	FIN flag	Payload length	Seq number	Ack number
8	0	0	1	0	3000	2000
9	1	0	0	0	2000	3001
10	0	0	1	0	2000	3001
11	1	0	0	0	3001	2001

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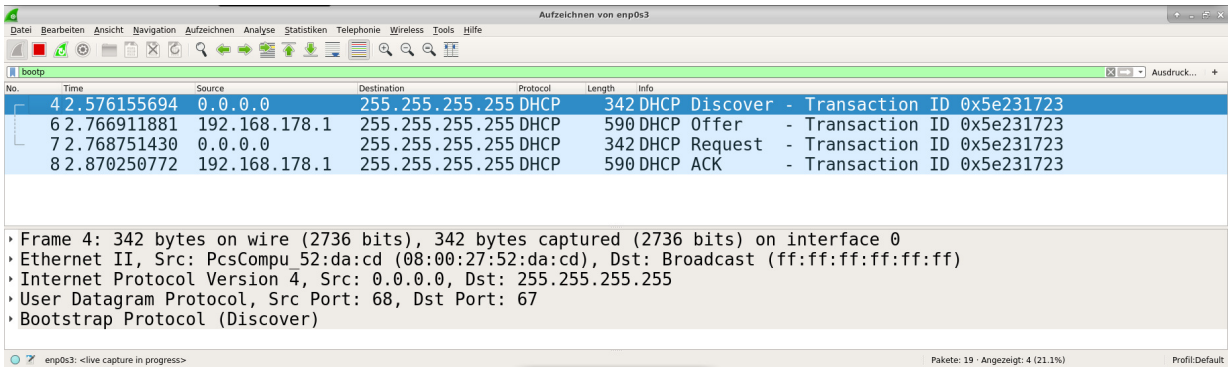
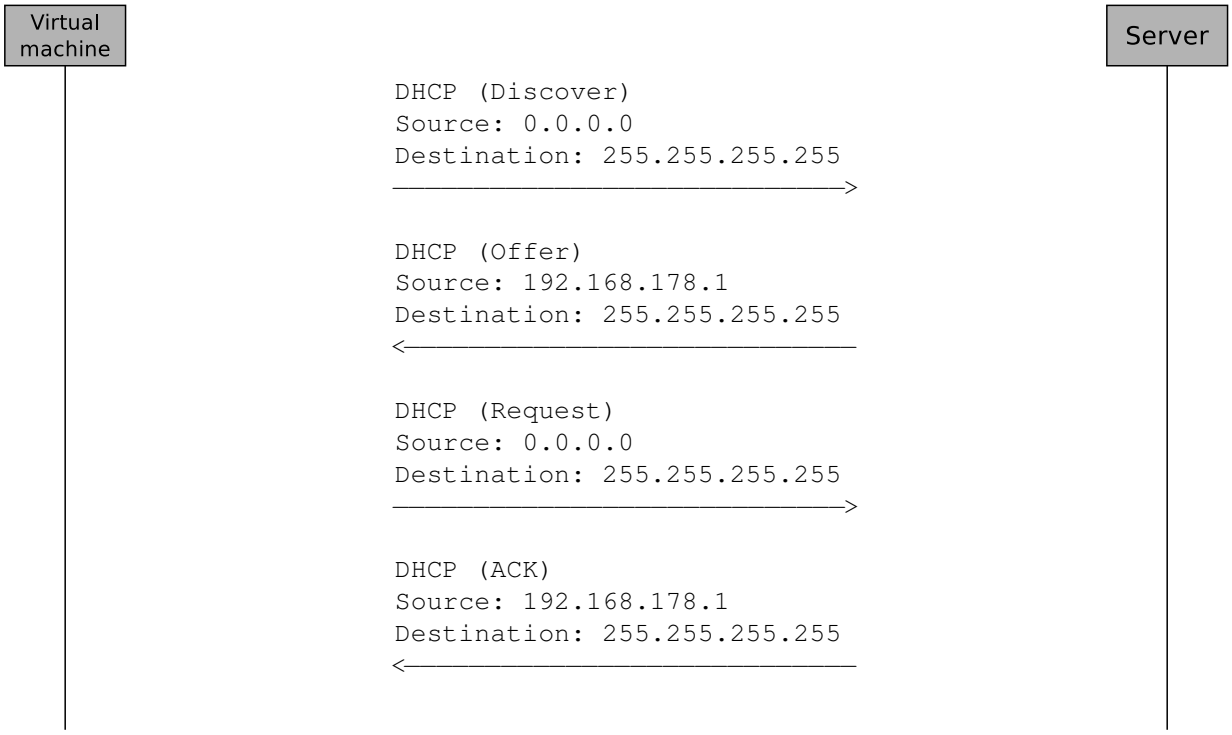
Question 6)

Points: .....

Maximum points: 6



a) Sketch inside the Message Sequence Chart (MSC) the sequence of the IPv4 address assignment by using DHCP. Specify for each transmitted message the transmission direction, IP addresses of sender and receiver, as well as DHCP message name.



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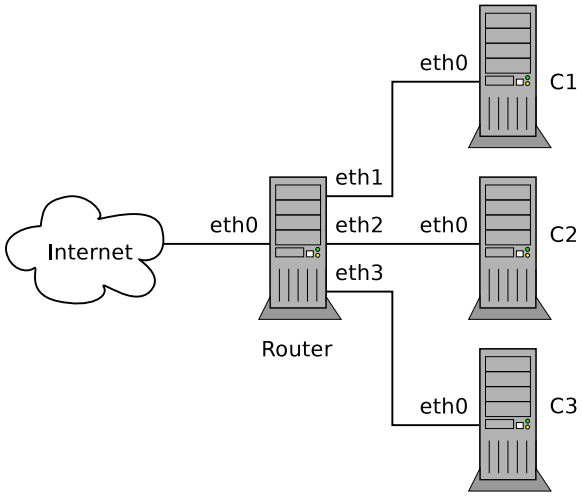
Question 7)

Points: .....

Maximum points: 9




```
# /etc/network/interfaces
# of the Router machine

# WAN Interface
auto eth0
iface eth0 inet dhcp

# LAN 1
auto eth1
iface eth1 inet static
  address 192.168.32.1
  netmask 255.255.255.0
  broadcast 192.168.32.255

# LAN 2
auto eth2
iface eth2 inet static
  address 172.16.0.1
  netmask 255.255.224.0
  broadcast 172.16.31.255

# LAN 3
auto eth3
iface eth3 inet static
  address 10.22.0.1
  netmask 255.255.128.0
  broadcast 10.22.127.255
```

Assign valid network configurations for the computers **C1**, **C2**, and **C3** (see the Figure). Make the configurations in such a way, that a connection between the **Router** and machines **C1**, **C2** and **C3** is established.

Assign the IP addresses statically in a way that packets can be forwarded!

```
auto eth0
iface eth0 inet static
address 192.168.32.10
netmask 255.255.255.0
gateway 192.168.32.1
```

`/etc/network/interfaces` of **C1**

```
auto eth0
iface eth0 inet static
address 172.16.22.10
netmask 255.255.224.0
gateway 172.16.0.1
```

`/etc/network/interfaces` of **C2**

```
auto eth0
iface eth0 inet static
address 10.22.120.120
netmask 255.255.128.0
gateway 10.22.0.1
```

`/etc/network/interfaces` of **C3**

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Question 8)

Points: .....

Maximum points: 3+1+1+1+3=9

a) Explain the purpose of the sequence number inside the ICMP header.

The Sequence Number is used to match each reply to its corresponding request.

b) Describe the function of the Address Resolution Protocol (ARP).

The Address Resolution Protocol (ARP) is used to convert IP address of the Network Layer to MAC address of the Data Link Layer.

c) Describe what the ARP cache is and what it stores.

The ARP cache is a table, which contains IP addresses and MAC addresses, that belong together.

The APR cache stores the IP address and MAC address information of the machines inside the local network. ARP uses this information in order to resolute IP addresses to physical MAC addresses. The stored information prevents an ARP Broadcast for each IP packet transmitted.

d) Name one virtualization technology or virtualization software you used for the lab exercises.

KVM, Xen, VirtualBox, VMware, etc...

e) Explain the consequence when the IP address(es) of a device are assigned statically and the file `/etc/resolv.conf` does not exist or lacks useful content and the parameter `dns-nameservers` is not specified in the file `/etc/network/interfaces`.

The the resolution of domain names into IP addresses (e.g. www.google.com → 8.8.8.8) can not be established.

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Question 9)

Points: .....

Maximum points: 8

a) 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.