Exercise Sheet 5

Exercise 1 (IPv4 Addressing in the Network Layer)

Calculate for each subtask of this exercise the **first and last host addresses**, the **network address** and the **broadcast address** of the subnet.

IP Address:	151.175.31.100	10010111.10101111.00011111.01100100
Subnet mask:	255.255.254.0	11111111.11111111.11111110.00000000
Network address?	___.___.___.___	________.________.________.________
First host address?	___.___.___.___	________.________.________.________
Last host address?	___.___.___.___	________.________.________.________
Broadcast address?	___.___.___.___	________.________.________.________
IP Address:	151.175.31.100	10010111.10101111.00011111.01100100
Subnet mask:	255.255.255.240	11111111.11111111.11111111.11110000
Network address?	___.___.___.___	________.________.________.________
First host address?	___.___.___.___	________.________.________.________
Last host address?	___.___.___.___	________.________.________.________
Broadcast address?	___.___.___.___	________.________.________.________
IP Address:	151.175.31.100	10010111.10101111.00011111.01100100
Subnet mask:	255.255.255.128	11111111.11111111.11111111.10000000
Network address?	___.___.___.___	________.________.________.________
First host address?	___.___.___.___	________.________.________.________
Last host address?	___.___.___.___	________.________.________.________
Broadcast address?	___.___.___.___	________.________.________.________

Exercise 2 (Inter-Networking)

1. Calculate for the **subnet ID of sender and receiver** and specify whether the IP packet **leaves the subnet during transmission** or not for the following two examples.

   a)

Sender:	11001001.00010100.11011110.00001101	201.20.222.13
Subnet mask:	11111111.11111111.11111111.11110000	255.255.255.240
Receiver:	11001001.00010100.11011110.00010001	201.20.222.17
Subnet mask:	11111111.11111111.11111111.11110000	255.255.255.240

   - Network address for the sender?
   - Network address for the receiver?
   - Does the IP packet leave the subnet [yes/no]?

b)
```
Sender:       00001111.11001000.01100011.00010111    15.200.99.23
Subnet mask:  11111111.11000000.00000000.00000000    255.192.0.0

Receiver:     00001111.11101111.00000001.00000001    15.239.1.1
Subnet mask:  11111111.11000000.00000000.00000000    255.192.0.0
```

- Network address for sender?
- Network address for the receiver?
- Does the IP packet leave the subnet [yes/no]?

2. The forwarding table of a computer (Windows or Unix) can be queried with the command `netstat -rn`. An exemplary output may look like this:

```
Kernel IP routing table
Destination     Gateway         Genmask         Flags   MSS Window  irtt Iface
0.0.0.0         10.2.0.1        0.0.0.0         UG        0 0          0 eth0
10.2.0.0        0.0.0.0         255.255.255.0   U         0 0          0 eth1
10.204.0.0      0.0.0.0         255.252.0.0     U         0 0          0 wlan0
10.200.0.0      0.0.0.0         255.248.0.0     U         0 0          0 eth2
172.17.8.15     0.0.0.0         255.255.255.255 UH        0 0          0 eth2
192.168.23.0    0.0.0.0         255.255.255.0   U         0 0          0 wlan1
192.168.42.0    0.0.0.0         255.255.255.240 U         0 0          0 eth3
```

Specify the particular interface the kernel will choose for each destinations with following IPv4 addresses and explain why:

a) `192.168.23.14`

b) `192.168.42.17`

c) `192.168.42.15`

d) `10.2.0.255`

e) `10.207.51.4`

f) `172.17.8.18`

g) `172.17.8.15`

h) `10.202.4.3`

i) `10.216.168.23`

Exercise 3 (Subnetting)

Calculate for each subtask of this exercise the **subnet masks** and answer the **questions**.

1. Split the class C network `195.1.31.0` for implementing 30 subnets.

```
Network ID:     11000011.00000001.00011111.00000000    195.1.31.0
Number of bits for subnet IDs?
Subnet mask:    ________.________.________.________    ___.___.___.___
Number of bits for host IDs?
Number of host IDs per subnet?
```

2. Split the class A network `15.0.0.0` for implementing 333 subnets.

```
Network ID:     00001111.00000000.00000000.00000000    15.0.0.0
Number of bits for subnet IDs?
Subnet mask:    ________.________.________.________    ___.___.___.___
Number of bits for host IDs?
Number of host IDs per subnet?
```

3. Split the class B network `189.23.0.0` for implementing 20 subnets.

```
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. Split the class C network `195.3.128.0` into subnets, which contain 17 hosts each.

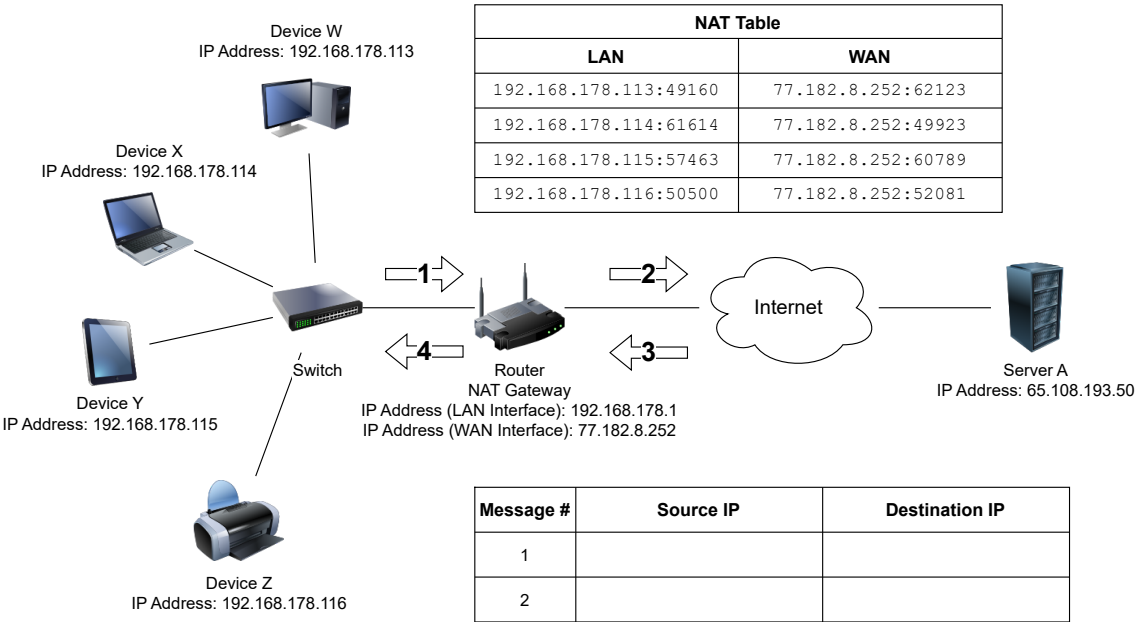
```
Network ID:     11000011.00000011.10000000.00000000    195.3.128.0
Number of bits for host IDs?
Number of bits for subnet IDs?
Number of possible subnets?
Subnet mask:    ________.________.________.________    ___.___.___.___
```

5. Split the class B network `129.15.0.0` into subnets, which contain 10 hosts each.

```
Network ID:     10000001.00001111.00000000.00000000    129.15.0.0
Number of bits for host IDs?
Number of bits for subnet IDs?
Number of possible subnets?
Subnet mask:    ________.________.________.________    ___.___.___.___
```

Exercise 4 (Network Address Translation)

The figure below describes a NAT scenario. Fill the missing IP addresses and port numbers into the figure when device Y sends a request to an web server process that runs on server A that can be accessed at port number 443.

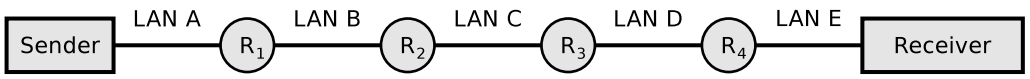


NAT Table	
LAN	**WAN**
192.168.178.113:49160	77.182.8.252:62123
192.168.178.114:61614	77.182.8.252:49923
192.168.178.115:57463	77.182.8.252:60789
192.168.178.116:50500	77.182.8.252:52081

Message #	Source IP	Destination IP
1		
2		
3		
4		

Exercise 5 (Fragmenting IP Packets)

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



	LAN A	LAN B	LAN C	LAN D	LAN E
Network technology	Ethernet	PPPoE	ISDN	Ethernet	WLAN
MTU [bytes]	1,500	1,492	576	1,400	2,312
IP-Header [bytes]	20	20	20	20	20
maximum payload [bytes]	1,480	1,472	556	1,380	2,292

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

Exercise 6 (Address Types and Spaces)

1. Name the three private IPv4 address spaces.
2. What is the prefix for a link-local address in IPv4 and IPv6 networks?
3. Which of the following IPv4 addresses are multicast addresses?
   - ☐ 222.1.2.3
   - ☐ 224.1.2.3
   - ☐ 242.0.0.0
   - ☐ 234.23.23.23
4. How can an IPv6 anycast address be distinguished from a unicast or a multicast address?
5. Which IPv6 address can you use in order to *ping* all stations in a local network?
6. What type of address is given with `fd04:2342:0815:1:6770:37ca:7a5c:f408/64`? What is its purpose?
7. What type of address is given with `ff02::1:ff5c:f408`? What is its purpose?

Exercise 7 (IPv6 Address Representation)

1. Simplify these IPv6 addresses:
   - `1080:0000:0000:0000:0007:0700:0003:316b`

     Solution: _____
   - `2001:0db8:0000:0000:f065:00ff:0000:03ec`

     Solution: _____
   - `2001:0db8:3c4d:0016:0000:0000:2a3f:2a4d`

     Solution: _____
   - `2001:0c60:f0a1:0000:0000:0000:0000:0001`

     Solution: _____
   - `2111:00ab:0000:0004:0000:0000:0000:1234`

     Solution: _____

2. Provide all positions of these simplified IPv6 addresses:

   - `2001::2:0:0:1`

     Solution: `____:____:____:____:____:____:____:____`

   - `2001:db8:0:c::1c`

     Solution: `____:____:____:____:____:____:____:____`

   - `1080::9956:0:0:234`

     Solution: `____:____:____:____:____:____:____:____`

   - `2001:638:208:ef34::91ff:0:5424`

     Solution: `____:____:____:____:____:____:____:____`

   - `2001:0:85a4::4a1e:370:7112`

     Solution: `____:____:____:____:____:____:____:____`

Exercise 8 (Do some research)

1. The transition from IPv4 to IPv6 may indicate that one IP version number has been skipped. What happened to **IPv5**?

2. Explain the meaning of the fields `Flags`, `MSS`, `Window`, and `irtt` in the forwarding table as shown in task 2.

3. In IPv6 different scopes are defined. Figure out which of the originally defined scopes has been declared as deprecated (and why).

4. Describe the purpose of the following address blocks:

   - 192.0.2.0/24
   - 198.51.100.0/24
   - 203.0.113.0/24

Exercise 9 (Lab Exercise: IP Forwarding)

The goal of this task is to configure IPv4 addresses and inspect the forwarding.

1. Connect all four PCs in one table row as shown in the figure. I.e., use a dedicated twisted pair cable to connect each computer to its neighbors. As a consequence, you need to connect two interfaces on the hosts *Host 2* and *Host 3*, and one interface on the hosts *Host 1* and *Host 4*.

2. List all interfaces on the computer with the command
   `ip link show`
   Hint: You can use the command `ethtool -p <INTERFACE>` to led the LEDs of the corresponding interface blink.

3. Activate the connected interfaces using the command
   `ip link set <INTERFACE> up`
   while replacing `<INTERFACE>` with the correct interface name (e.g., `enp1s0f0`).
   Hint: You can verify whether you have activated the interface correctly using the command `ip link show <INTERFACE>`
   If it reports `state UP`, the interface has been activated successfully.
   Hint: Only properly connected interfaces, can be activated, i.e., the interface at the other end of the cable needs to be activated as well.

4. Configure the corresponding IPv4 addresses to the connected interfaces, using the command:
   `ip address add <IPv4 ADDRESS> dev <INTERFACE>`
   while replacing `<IPv4 ADDRESS>` with the correct IP address and `<INTERFACE>` with the correct interface names. Replace the `X` in the IP address with the number of your table.
   Hint: Make sure to specify the IPv4 address in CIDR notation, i.e., including the trailing *slash (/)* character plus the length of the associated network mask.

5. What happens if you try to *ping* from *Host 1* to *Host 4*?

6. Inspect the output of the command `ip route show` on all four computers. Try to interpret the output.

7. Open the file the `/etc/sysctl.conf` in the editor of your choosing (*Hint:* root privileges are required.) and make the necessary adjustments. The command `sudo sysctl -p` to make the settings in `/etc/sysctl.conf` effective afterwards (i.e., after you have written the modified file back to the disk).

8. Configure the forwarding rules per host as follows:

- **Host 1**
  `sudo ip route add default via 10.20.30.0`
- **Host 2**
  `sudo ip route add 10.0.0.0/8 via 10.10.10.X`
- **Host 3**
  `sudo ip route add 10.20.30.0/24 via 10.10.20.X`
- **Host 4**
  `sudo ip route add 10.10.0.0/16 via 10.11.12.X`
  `sudo ip route add 10.20.30.0/24 via 10.11.12.X`

9. Try to ping *Host 4* from *Host 1* again.