# Exercise Sheet 4

## Exercise 1 (Routers, Layer-3-Switches, Gateways)

1. Explain the purpose of **Routers** in computer networks.
   (*Also explain the difference to Layer-3-Switches.*)
2. Explain the purpose of **Layer-3-Switches** in computer networks.
   (*Also explain the difference to Routers.*)
3. Explain the purpose of **Gateways** in computer networks.
4. Explain why **Gateways** in the Network Layer of computer networks are seldom required nowadays.

## Exercise 2 (Collision Domain, Broadcast Domain)

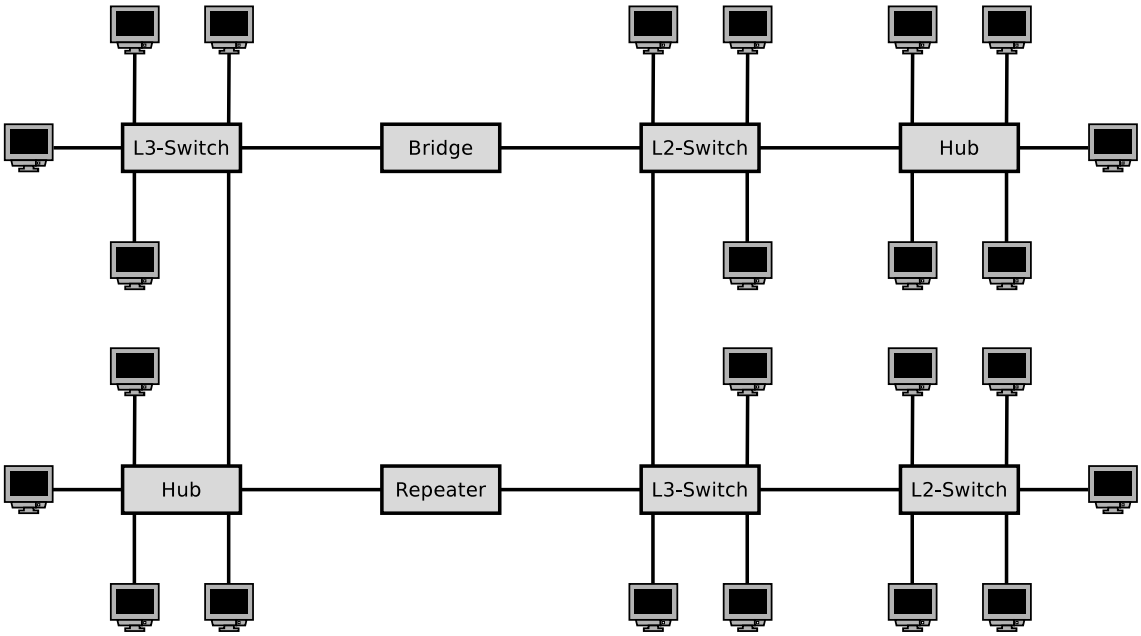
1. Mark the devices that **divide the collision domain**.

   ☐ Repeater ☐ Bridge ☐ Router
   ☐ Hub ☐ Layer-2-Switch ☐ Layer-3-Switch

2. Mark the devices that **divide the broadcast domain**.

   ☐ Repeater ☐ Bridge ☐ Router
   ☐ Hub ☐ Layer-2-Switch ☐ Layer-3-Switch

3. Sketch in the diagram all **collision domains** and all **broadcast domains**.




# Exercise 3 (Addressing in the Network Layer)

1. Explain the meaning of **Unicast** in the Network Layer of computer networks.
2. Explain the meaning of **Broadcast** in the Network Layer of computer networks.
3. Explain the meaning of **Anycast** in the Network Layer of computer networks.
4. Explain the meaning of **Multicast** in the Network Layer of computer networks.
5. Explain why the IPv4 **address space** does contain only 4,294,967,296 addresses.
6. Explain why **Classless Interdomain Routing (CIDR)** was introduced.
7. Describe in simple words the **functioning of CIDR**.
   *Focus on the way, how IP addresses are treated and subnets are created.*

# Exercise 4 (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? | ___.___.___.___ | ________.________.________.________ |

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

# Exercise 5 (Addressing in the Network Layer)

In each subtask of this exercise, a sender transmits an IP packet to a receiver. Calculate for each subtask the **subnet ID of sender and receiver** and specify whether the IP packet **leaves the subnet during transmission** or not.

```
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



       Subnet ID of sender?

       Subnet ID of receiver?

       Does the IP packet leave the subnet [yes/no]?


Sender:      10000100.10011000.01010011.11111110    132.152.83.254
Subnet mask: 11111111.11111111.11111100.00000000    255.255.252.0


Receiver:    10000100.10011000.01010001.00000010    132.152.81.2
Subnet mask: 11111111.11111111.11111100.00000000    255.255.252.0



       Subnet ID of sender?

       Subnet ID of receiver?

       Does the IP packet leave the subnet [yes/no]?


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



       Subnet ID of sender?

       Subnet ID of receiver?

       Does the IP packet leave the subnet [yes/no]?
```

# Exercise 6 (Addressing in the Network Layer)

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:    ________.________.________.________    ___.___.___.___
```

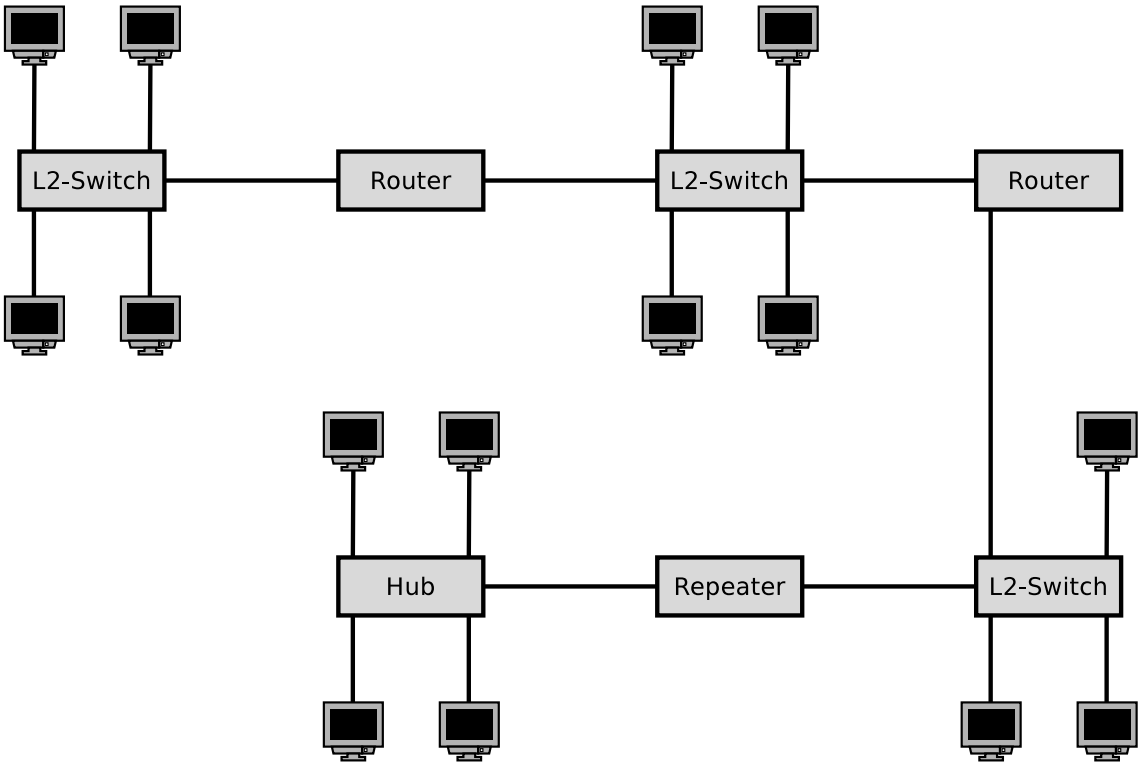
5. Split the class B network `129.15.0.0` into subnets, which contain 10 hosts each.

```
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:    ________.________.________.________    ___.___.___.___
```

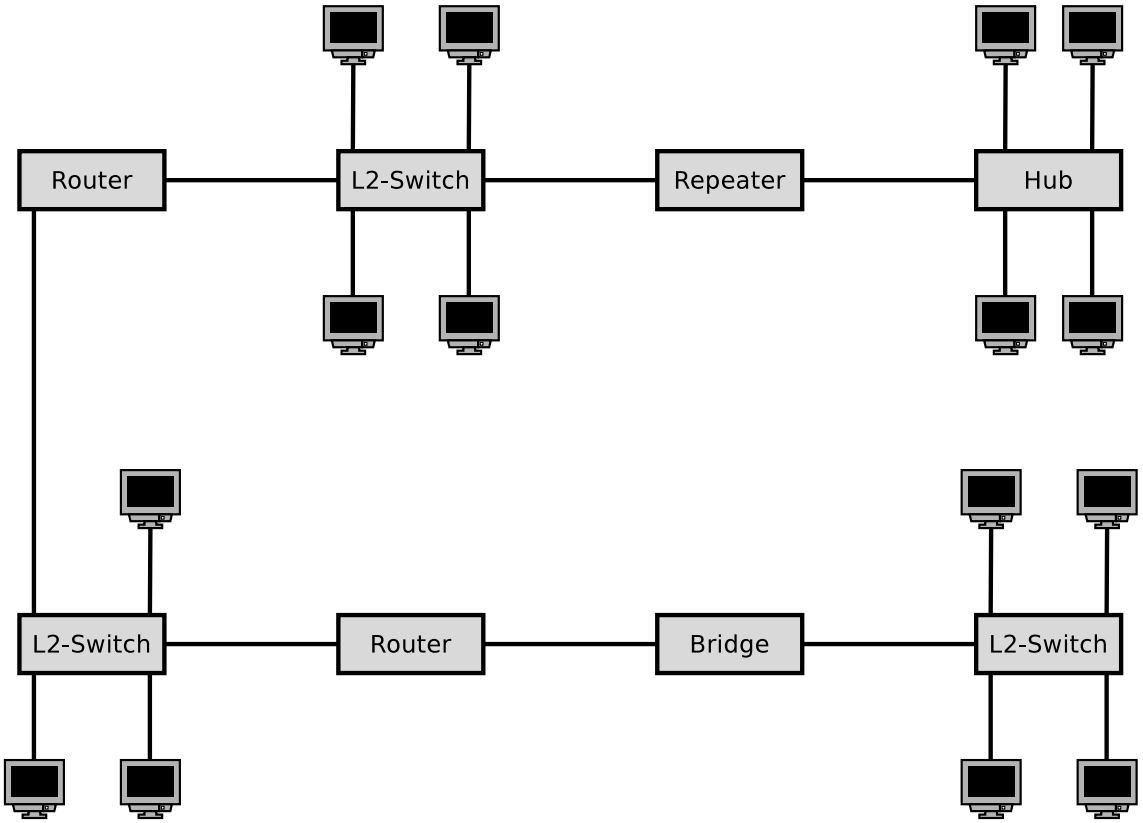
| binary representation | decimal representation | binary representation | decimal representation |
|---|---|---|---|
| 10000000 | 128 | 11111000 | 248 |
| 11000000 | 192 | 11111100 | 252 |
| 11100000 | 224 | 11111110 | 254 |
| 11110000 | 240 | 11111111 | 255 |

# Exercise 7 (Collision Domain, Broadcast Domain)

1. Sketch in the diagram of the network topology all **collision domains** and all **broadcast domains**.

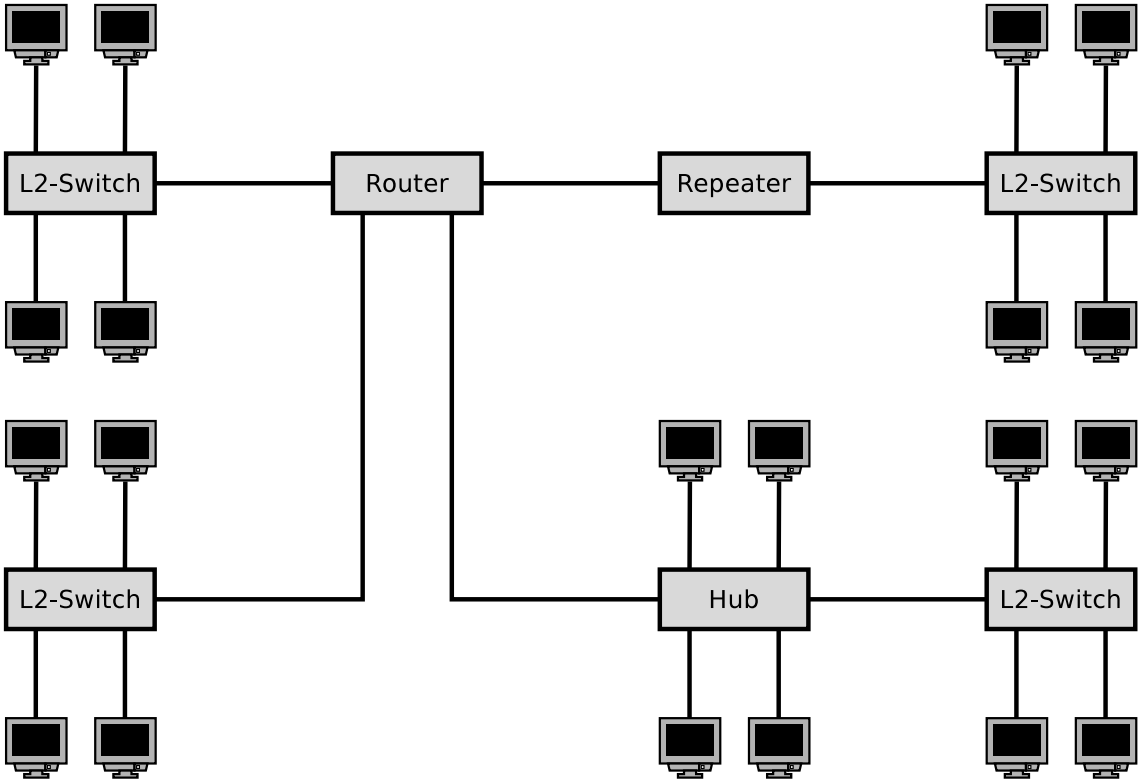



2. Sketch in the diagram of the network topology all **collision domains** and all **broadcast domains**.




# Exercise 8 (Broadcast Domain)

1. Sketch in the diagram of the network topology all **broadcast domains**.
2. What is the **required number of subnets** for this network topology?




# Exercise 9 (Private IP Address Spaces)

Name the three private IPv4 address spaces.

# Exercise 10 (Addressing in the Network Layer)

Calculate for each network configuration in the table whether an IP packet, which is sent from the given IP address to the destination address, **leaves the subnet during transmission** or not.

| IP address | Subnet mask | Destination address | Leaves the subnet [yes/no] |
|---|---|---|---|
| 201.20.222.13 | 255.255.255.240 | 201.20.222.17 | |
| 15.200.99.23 | 255.192.0.0 | 15.239.1.1 | |
| 172.21.23.14 | 255.255.255.0 | 172.21.24.14 | |
| 210.5.16.198 | 255.255.255.252 | 210.5.16.197 | |
| 210.5.16.198 | 255.255.255.252 | 210.5.16.201 | |
| 5.5.5.5 | 255.254.0.0 | 5.6.6.6 | |

*(A part of the solution is the calculations performed. Where no calculation is required, you need to give a reason for your answer. Answering the question with just "yes" or "no" is not sufficient!)*

*Source: Jörg Roth. Prüfungstrainer Rechnernetze. Vieweg (2010)*

# Exercise 11 (Addressing in the Network Layer)

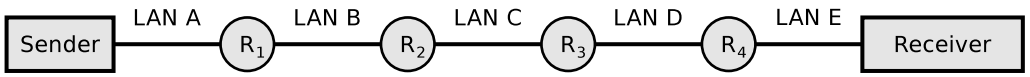
Specify for each subtask of this exercise the correct **subnet mask**.

1. A maximum number of subnets with 5 hosts each in a class B network.
2. 50 subnets with 999 hosts each in a class B network.
3. 12 subnets with 12 hosts each in a class C network.

*Source: Jörg Roth. Prüfungstrainer Rechnernetze. Vieweg (2010)*

# Exercise 12 (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.




| | **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 |
| max. payload [bytes] in theory | 1,480 | 1,472 | 556 | 1,380 | 2,292 |
| Multiple of 8 | | | | | |
| max. payload [Bytes] in practice | | | | | |

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

# Exercise 13 (Forwarding and Path Calculation)

1. Name the two major classes of **routing protocols**.
2. Name the **algorithms for best path calculation**, the routing protocol classes from subtask 1 do implement.
3. Explain what an **autonomous system** is.

4. The **Border Gateway Protocol** (BGP) is a protocol for...

   ☐ Intra-AS routing ☐ Inter-AS routing

5. Name the **routing protocol class** from subtask 1 that does the BGP implement.

6. **Open Shortest Path First** (OSPF) is a protocol for...

   ☐ Intra-AS routing ☐ Inter-AS routing

7. Name the **routing protocol class** from subtask 1 that does the OSPF implement.

8. The **Routing Information Protocol** (RIP) is a protocol for...

   ☐ Intra-AS routing ☐ Inter-AS routing

9. Name the **routing protocol class** from subtask 1 that does the RIP implement.

10. When RIP is used, each Router only communicates with its **direct neighbors**. Name **advantages** and **drawbacks** of this method.

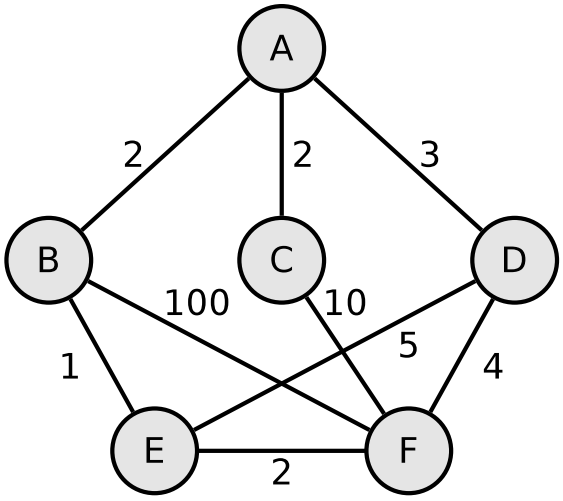
11. When RIP is used, the path cost (metric) only depends on the number of Routers (**hops**), which need to be passed on the way to the destination network. Name a **drawback** of this method.

12. When OSPF is used, **all Routers** communicate with each other. Name **advantages** and **drawbacks** of this method.

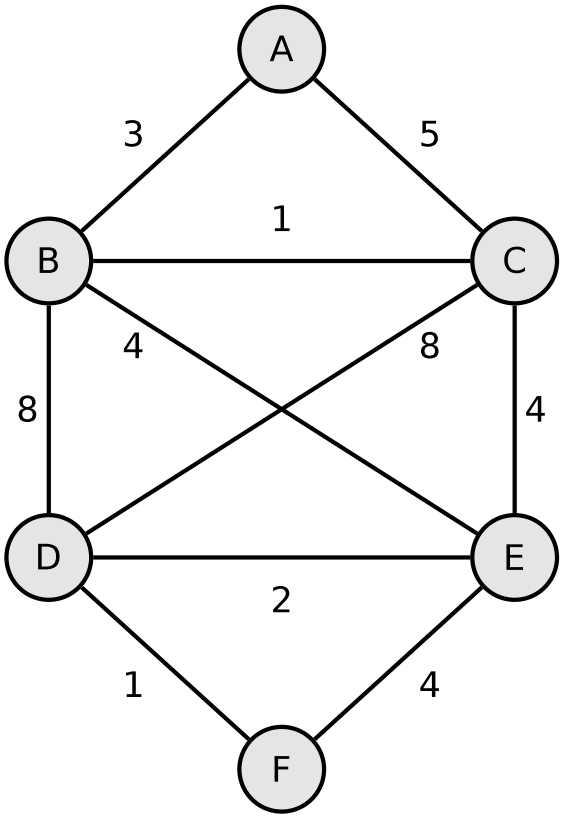
# Exercise 14 (Dijkstra's Algorithm)

1. Calculate the shortest path from node A to all other nodes using Dijkstra's algorithm.

*Source: Jörg Roth. Prüfungstrainer Rechnernetze. Vieweg (2010)*



2. Calculate the shortest path from node A to all other nodes using Dijkstra's algorithm.




## Exercise 15 (Internet Control Message Protocol)

1. Explain the purpose of the Internet Control Message Protocol (ICMP).
2. Give two examples for command line tools, which use ICMP.

## Exercise 16 (IPv6)

1. Explain the concept of Scopes in IPv6.
2. Explain what the Host Scope is.
3. Explain what the Link-Local Scope is.
4. Explain what the Unique-Local Scope is.
5. Explain what the Global Scope is.
6. Explain what the IPv6 address `::1/128` addresses.
7. Give the name of the scope of the IPv6 address `::1/128`.
8. Give the name of the scope of addresses that have the prefix `fe80::/10`.

9. Give the name of the scope of addresses that have the prefix `fc00::/7`.
10. Give the name of the scope of addresses that have the prefix `2000::/3`.
11. IPv6 has no broadcast addresses but for some purposes, a broadcast-like functionality is required. Explain how IPv6 emulates the broadcast functionality.
12. Give the prefix of Multicast addresses.
13. Name three ways of setting the Interface-ID.
14. Explain what Stable Privacy Addresses is and why it is used sometimes in the context of setting the Interface-ID.
15. Explain what Privacy Extension is and why it is used sometimes in the context of setting the Interface-ID.
16. If a node has created an Interface-ID via SLAAC, if must validate that no other node in the network has the same Interface-ID. Explain how this is done in practice.
17. Give a short explanation for a concrete use-case of the ICMPv6 message Router Advertisement (RA) in practice.
18. Give a short explanation for a concrete use-case of the ICMPv6 message Router Solicitation (RS) in practice.
19. Give a short explanation for a concrete use-case of the ICMPv6 message Neighbor Solicitation (NS) in practice.
20. Give a short explanation for a concrete use-case of the ICMPv6 message Neighbor Advertisement (NA) in practice.
21. Give an explanation how a node learns if it is supposed to use a DHCPv6 server for requesting a address configuration (stateful address configuration) or if it is allowed to create an Interface-ID by itself (stateless address configuration).

# Exercise 17 (IPv6 – Simplification)

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:* `____:____:____:____:____:____:____:____`