

Exercise Sheet 4

Exercise 1 (Routers, L3-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 and Broadcast Domain)

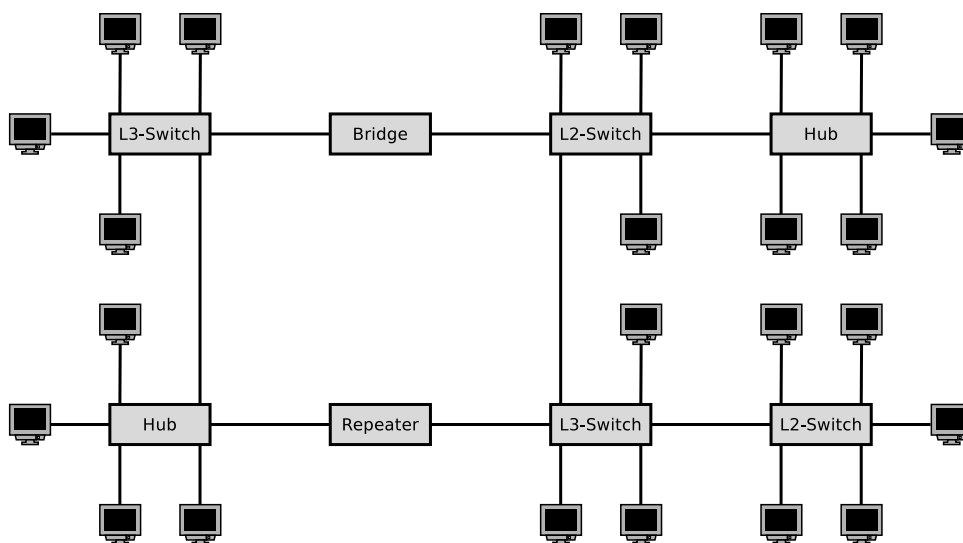
1. Mark the devices that divide the collision domain.

- | | | |
|-----------------------------------|---|---|
| <input type="checkbox"/> Repeater | <input type="checkbox"/> Bridge | <input type="checkbox"/> Router |
| <input type="checkbox"/> Hub | <input type="checkbox"/> Layer-2-Switch | <input type="checkbox"/> Layer-3-Switch |

2. Mark the devices that divide the broadcast domain.

- | | | |
|-----------------------------------|---|---|
| <input type="checkbox"/> Repeater | <input type="checkbox"/> Bridge | <input type="checkbox"/> Router |
| <input type="checkbox"/> Hub | <input type="checkbox"/> Layer-2-Switch | <input type="checkbox"/> 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]?

Sender: 11010010.00000101.00010000.11000110 210.5.16.198
Subnet mask: 11111111.11111111.11111111.11111100 255.255.255.252

Receiver: 11010010.00000101.00010000.11000101 210.5.16.197
Subnet mask: 11111111.11111111.11111111.11111100 255.255.255.252

Subnet ID of sender?
Subnet ID of receiver?
Does the IP packet leave the subnet [yes/no]?

Sender: 11010010.00000101.00010000.11000110 210.5.16.198
Subnet mask: 11111111.11111111.11111111.11111100 255.255.255.252

Receiver: 11010010.00000101.00010000.11001001 210.5.16.201
Subnet mask: 11111111.11111111.11111111.11111100 255.255.255.252

Subnet ID of sender?
Subnet ID of receiver?
Does the IP packet leave the subnet [yes/no]?

Sender: 00000101.00000101.00000101.00000101 5.5.5.5
Subnet mask: 11111111.11111110.00000000.00000000 255.254.0.0

Receiver: 00000101.00000110.00000110.00000110 5.6.6.6
Subnet mask: 11111111.11111110.00000000.00000000 255.254.0.0

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 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, with 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: _____ . _____ . _____ . _____

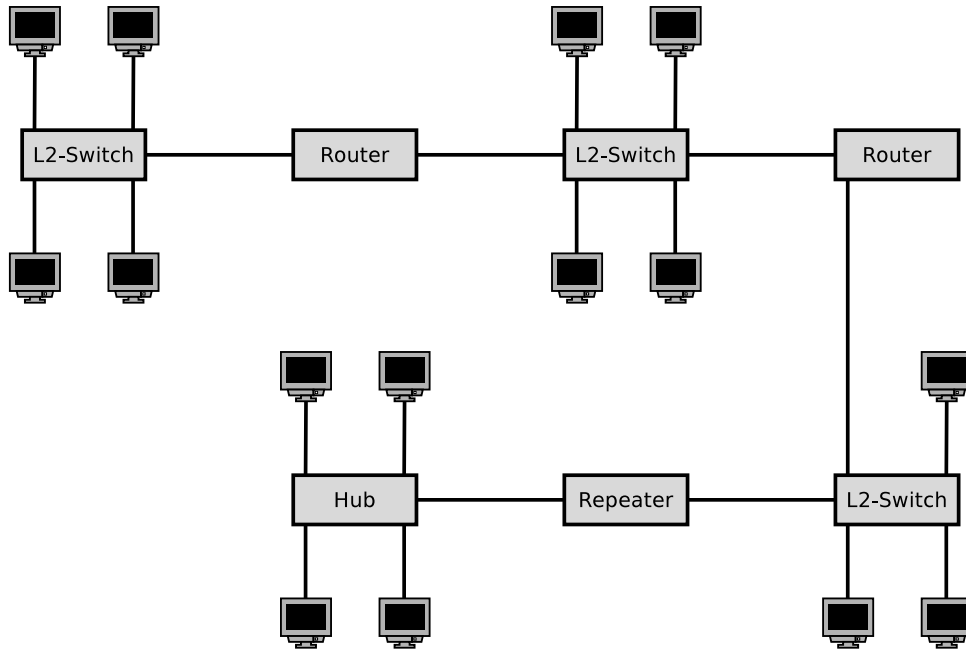
5. Split the class B network 129.15.0.0 into subnets, with 10 hosts each.

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: _____ . _____ . _____ . _____

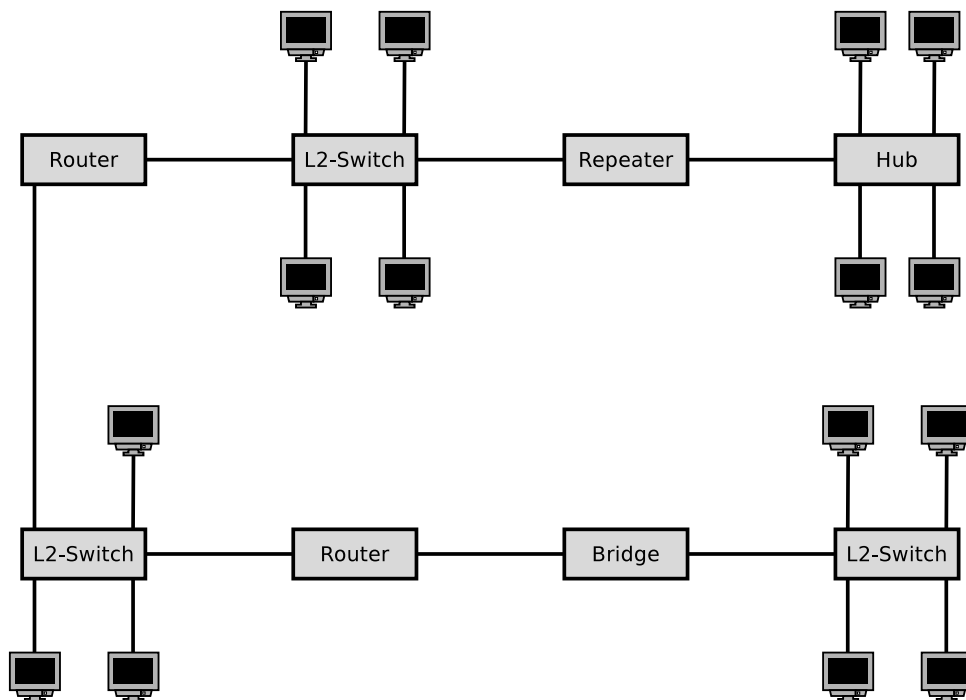
| binary representation | decimal representation | binary representation | decimal representation |
|-----------------------|------------------------|-----------------------|------------------------|
| 10000000 | 128 | 11111000 | 248 |
| 11000000 | 192 | 11111100 | 252 |
| 11100000 | 224 | 11111110 |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

Exercise 7 (Collision and Broadcast Domain)

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

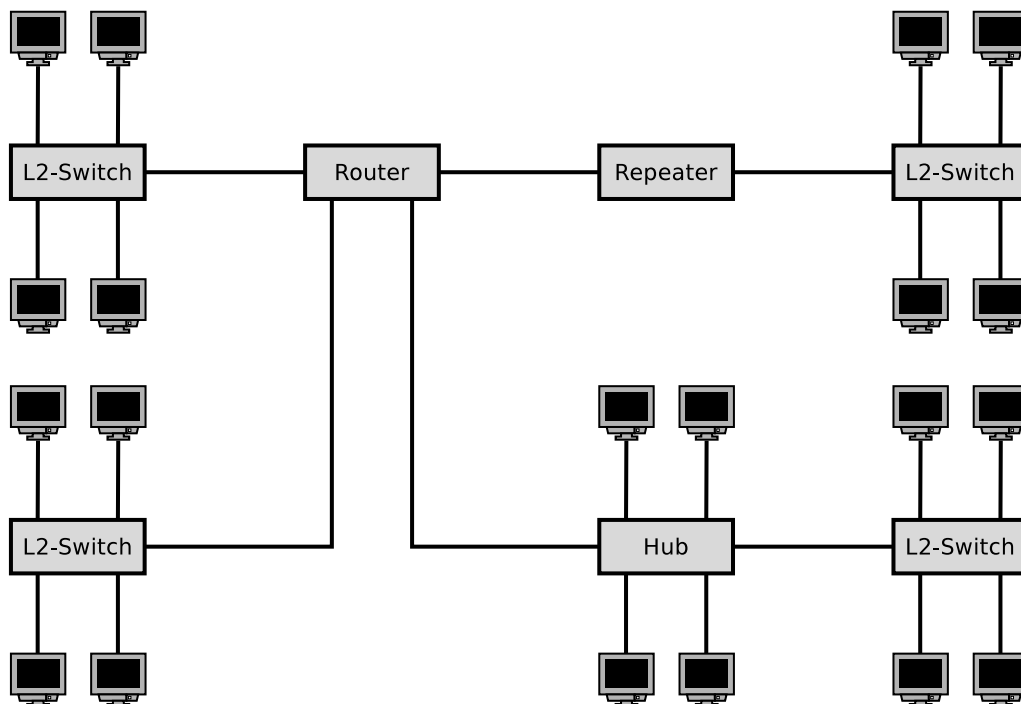


2. Sketch in the diagram of the network topology all collision domains and all broadcast domains.



Exercise 8 (Broadcast Domain)

1. Sketch in the diagram of the network topology all broadcast domains.
2. Give the required number of subnets for this network topology.

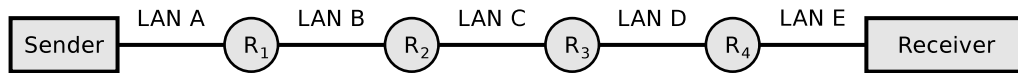


Exercise 9 (Private IP Address Spaces)

Name the three private IPv4 address spaces.

Exercise 10 (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.

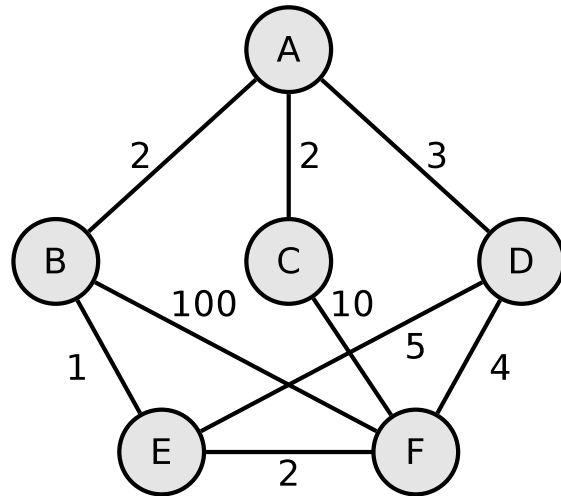
Exercise 11 (Forwarding and Path Calculation)

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.

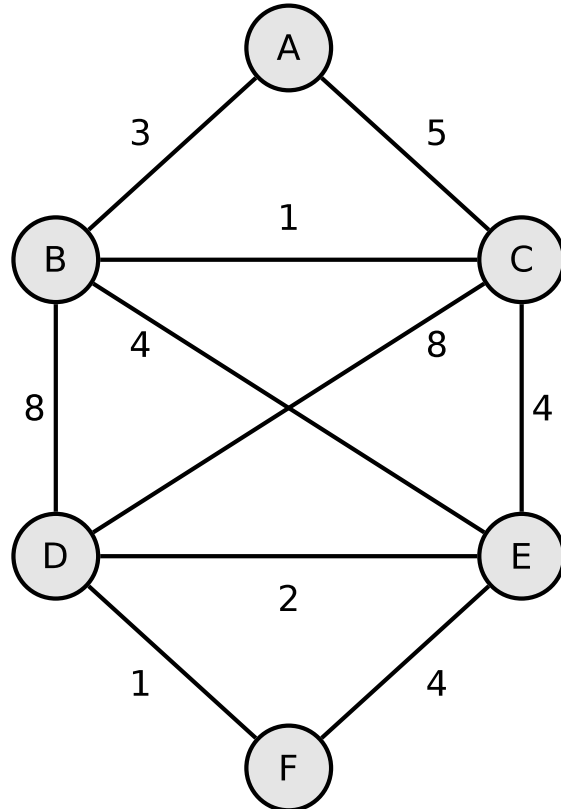
Exercise 12 (Dijkstra's Algorithm)

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 13 (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 14 (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, it 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 15 (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: ____:____:____:____:____:____:____:____