22.1 IP Addresses

22.1.1 IPv4 Address Representation

What is the 32-bit binary equivalent of the following IP addresses?

- 192.0.2.1
- 223.1.3.27
- 10.244.47.255

22.1.2 IPv4 Addresses

Consider the following IPv4 networks. How many addresses does each network have? What is the lowest and what is the highest address of each network?

- 134.96.8.0/22
- 131.246.18.128/27

22.1.3 IPv6 Address Representation

a. Consider the following IPv6 addresses and write them *as short as possible* using concatenation.

- fd91:2f23:17b1:0000:0000:0187:aff0:ffff
- 2001:aff0:0000:aab9:0815:0000:0000:0104
- ff80:0041:8e6c:0011:4589:0000:1000:fc91

b. Consider the following concatenated IPv6 addresses and write them *without concatenation*.

- fe80::7254:d2ff:fe7b:7adb
- 2a03:2880:2040:7f83:face:b00c:0:25de
- 2a00:1450:400e:803::2003

22.1.4 IPv6 Addresses

Consider the following IPv6 networks. How many addresses does each network have? What is the lowest and what is the highest address of each network?

- 2a01:4f8:a0:54c8::/64
- fda0:9bdc:4cac::/65

22.2 Network Layer

22.2.1 Routers

Do Routers have IP Adresses? If so, how many?

22.2.2 IP Protocols

Suppose *Host A* sends *Host B* a TCP segment using IP. When *Host B* receives the datagram, how does its network layer determine the correct transport layer protocol (i.e. TCP) to handle the segment?

22.2.3 Forwarding Table

Consider a datagram network using 32-bit host addresses. Suppose a router has four links, numbered 0 through 3, and packets are to be forwarded to the link interfaces as follows:

Destination Address Range	Link Interface
11100000 00000000 00000000 00000000 through 11100000 00111111 11111111 11111111	0
11100000 01000000 00000000 00000000 through 11100000 01000000 11111111 11111111	1
11100000 01000001 00000000 00000000 through 11100001 11111111 11111111 11111111	2
otherwise	3

a. Provide a forwarding table that has four entries, uses longest prefix matching, and forwards packets to the correct link interfaces.

b. Describe how your forwarding table determines the appropriate link interface for datagrams with destination addresses:

- 11001000 10010001 01010001 01010101
- 11100001 01000000 11000011 00111100
- 11100001 10000000 00010001 01110111

22.3 Link Layer

22.3.1 MTU

In the lecture we heard that different link-layer technologies support different MTUs. Consider a wireless LAN with a data rate of 11Mbit/s.

a. What is the difference in transmitting a frame if a station uses an MTU of 1500byte compared to a station using an MTU of 576byte?

b. What are the implications for other stations in the same BSS?

c. Are these implications also applying if we exchange the wireless LAN with a wired LAN using Hubs? How about a wired LAN using store-and-forward switches? Justify your answer.

d. What is the advantage of bigger MTUs? Is there a disadvantage?

22.3.2 Link-layer parameters

Discuss which MTU (higher or lower) might be beneficial for certain applications such as

- Datacenter storage network
- Voice over IP network
- Video teleconferencing system

22.4 Security

22.4.1 Firewalls

a) Assume you are the network administrator of the university. Imagine a network containing:

- Multiple clients (students, professors, etc.)
- two Web servers (intranet and a publicly accessibly Web server)
- an authoritative DNS server
- a DNS resolver (for internal use)
- an email server

The clients are allowed to communicate to any host, but should not be reachable from the outside. All servers should be reachable on their standard ports (e.g., TCP/UDP 53 for DNS, no portmapping). The mail server operates on TCP port 25 and 587, but mail submission should only be allowed by the clients (and not the outside world).

Draw a network diagram detailing how hosts are connected and design a firewall that realizes this policy.

Quickly justify your network layout, and give the ruleset(s) implementing your policy using iptables syntax for the firewall(s).

b) Verify whether the following iptables commands do what they should do. Assume that all tables are initially empty for each case and the default policy is to drop packets. Furthermore, assume that the firewall is deployed at the host that should be protected (host-based firewall). Explain errors that you find, or if there is no error, describe what the rules do.

Case A): Only SSH, not more.

```
# allow SSH connections
iptables -t filter -I INPUT 1 -p tcp --dport 22 -j ACCEPT
# allow all established connections
iptables -t filter -I INPUT 1 -m state --state ESTABLISHED -j ACCEPT
# drop the rest
iptables -t filter -I INPUT 1 -j DROP
```

Case B): SMTP server

```
# allow SMTP (both mail transfer and mail submission)
iptables -t filter -I INPUT 1 -p udp --dport 25 -j ACCEPT
iptables -t filter -I INPUT 1 -p udp --dport 587 -j ACCEPT
```

Case C): Allow access to particular IP address, except SSH.

```
# allow all TCP traffic to the servers listening on 1.2.3.4 ...
iptables -t filter -A INPUT -p tcp -d 1.2.3.4 -j ACCEPT
# ... but block SSH
iptables -t filter -A INPUT -p tcp -d 1.2.3.4 --dport 22 -j DROP
```

22.5 Subnets and Address Planning

You are a network consultant and asked by your customer to set up the network at a new site. The customer's ISP has allocated the IPv4 Subnet 192.0.2.0/24 for the site. The customer has 3 servers, 15 workstations and 3 printers. The customer also wants visiting sales people to be able to access the Internet using a wireless LAN for guests. Employees may also use the wireless LAN for their mobile phones. Traffic from the servers, the office and the guest network should be separated. On an average day there are 20 employees as well as 5 sales people present at a time.

a. Design an IP address plan and suggest subnets to the customer. Give the subnet addresses, their masks and number of usable addresses. Quickly explain why you designed your address plan the way you did.

b. A month later the customer exchanges their traditional phones with a state-of-the-art VoIP system. You decide to add an extra network to separate office traffic from the VoIP traffic. Assume there are as many phones as there are employees. Modify your address plan accordingly.

c. Another two months later the customer is hosting a trade fair at the site. They expect roughly 30 exhibitors. All of them requested access to the Internet to access their product catalog and place orders. You decide to give them access to the WiFi. Do you need to change your address plan? If so, why?

d. What, in your opinion, are the challenges when designing an address plan? What do you need to keep in mind when designing one? Do the challenges stay the same when using IPv6 instead of IPv4?