Network Address

A network address is an identifier, which is assigned to a network node, which has to be indentifiable. To serve that purpose, the address is supposed to be unique. The uniqueness has to be achieved within the given network; but ome addresses are (technically) unique for devices on the global level (MAC address, public IPv4 address, most IPv6 addresses, telephone numbers ...).

MAC Addresses

- 6 Bytes long
- Physical address
- Unique serial number of a networking device
- 2 sections:

Vendor Specific Code (3 Bytes)	Network Interface Controller Specific (3 Bytes)

  Vendor Specific Code – each company, which produces network interfaces, has one or more identifiers assigned – the MAC address can be used to determine that producer (e.g. by online tools like http://www.macvendorlookup.com/).
- The human readable versions of MAC addresses are written as hexadecimal representations of individual bytes:
  - 12:34:56:78:90:AB,
    or
  - 12-34-56-78-90-AB
    or
  - 1234567890AB (uncommon)
- There is a specific MAC address each computer of the LAN segment has to answer - **broadcast address** `FF:FF:FF:FF:FF:FF`
- The MAC address is used in communication between 2 directly connected network devices (over a wire, WiFi, or switch) in the same network.
- *How does a device know, if the other one is in the same network? Using IP addresses and subnet masks.*

IP Addresses

The IP address is a **unique identifier of a networking device**, which works on the 3rd or higher level of OSI model. It is denoted as logical address, since it can be modified to match different networks (in contrast to physical addresses like MAC address, which – in theory – remains stable for any network connection).

It is a series of 0s and 1s – their count depends on the version of the IP protocol:

IPv4 – IP version 4

- 1st version of the IP protocol, which was widely adopted in networking.
- Length: 32 bits (= 4 B)
- Representation: 4 decimal numbers separated by dots – each number represents the value of 1 Byte, e.g.:

1 1 0 0 0 0 0 0 1 0 1 0 1 0 0 0 0 0 0 0 1 0 0 1 0 0 0 0 1 0 1 1 0

11000000 10101000 00010010 00010110

192 168 18 22

192.168.18.22

- 1 Byte – it can store numbers from 0 to 255 only – these are the only values permitted for each IPv4 field.
- There 2 groups of IP addresses[1]:
  - **Public** – A public IP address is any valid address, or number, that can be accessed over the Internet. Internet standards groups, such as the Network Information Center (NIC) or the Internet Assigned Numbers Authority (IANA), are the organizations responsible for registering IP ranges and assigning them to organizations, such as Internet Service Providers (ISPs).
  - **Private** - A private IP address is any number or address assigned to a device on a private TCP/IP Local Area Network that is accessible only within the Local Area Network. For a resource inside the Local Area Network to be accessible over the Internet, a device within the Local Area Network must be connected to the Internet with a public IP address, and the networking must be appropriately configured. The same Internet standards organizations have reserved the following three IP address ranges that will never be registered publicly:
    - 10.0.0.0 – 10.255.255.255
    - 172.16.0.0 – 172.31.255.255
    - 192.168.0.0 – 192.168.255.255
  - The private network addresses can be repeatedly used in any private LAN (home, office, school etc.)
  - These 2 groups were established to solve one inconvenient problem: IPv4 supports 2^{32} addresses – i.e. almost 4,3 billion addresses. When the IPv4 was designed, it seemed to be sufficient for very long time; however, nowadays there are far more devices

[1] Source: http://supportcenter.verio.com/KB/questions.php?questionid=655

connected than the previously mentioned number. The repeated use of private addresses prevents that address exhausting, but it brings many technical difficulties and limitations of the use.

- In jurassic times the IPv4 addresses were grouped into 5 classes – sometimes it still good to know them:
    - **Class A** – very large networks; IP address starts with MSB set to 0 (i.e. the first byte is between 0 and 126 – 127 has a special purpose – **loopback address** – when used on a computer, it refers to the computer itself); 126 such networks may exist, in each 2^{24} – 2 hosts possible; IBM has got such huge range of IPs available;
    - **Class B** – large networks; IP address starts with bits 10; there can be 16 384 class B networks, each may have up to 65 534 hosts;
    - **Class C** – small networks; IP address starts with bits 110; more than 2 million networks with 254 hosts at most;
    - **Class D** – multicasting;
    - **Class E** – experimental purposes only.
- This attitude was very inefficient – there were hundreds of thousands companies, which needed more than 254 IP addresses, but B class networks would have been depleted too soon.
- Solution → **CIDR** – subnetting+supernetting by masks.

IPv6 – IP address version 6

- Newer and longer identifier of the network devices and definitive solution (perhaps) of the IPv4 limitations.
- Length: 128 bits
- Available addresses: 2^{128} – approximately 3,4 . 10^{38} addresses Representation:
    - 128 bits = 16 B → each byte is represented in hexadecimal system – 32 hexadecimal digits, grouped by 4 digits →8 groups separated by colon (:)
    - Example:

FE80:0000:0000:0000:0202:B3FF:FE1E:8329

IPv6 usage is increasing, but it is still a fraction of the Internet traffic (e.g. the Google servers were visited by 3 % of users over IPv6 in February 2014).

Subnet Mask

- If the network devices want to communicate, they have to know IP addresses of the source and destination. If they are in the same network, the communication can be direct; however, if they are in different networks, they have to pass the data to routers.
- *Problem: how do the computers know, if they are in the same network or not?*
- Solution: split the address into 2 parts:

- **Network ID = NETWORK PREFIX** – the same for computers in the same network
- **Host ID** – identification of the device in the network

- Tool: network mask – it splits the network address into 2 parts:

IP address:	11000000101010000000	01001000010110
Mask:	11111111111111111111	00000000000000
	Network ID	Host ID

  - The number of bits from the IP address, which represent the network, is indicated by the series of 1s in the mask; then there are 0s only for the part, which represents the host ID.
  - The mask in IPv4 may have the form of IPv4 address – **dot-decimal notation**:

11111111	11111111	11000000	00000000
255	**255**	**192**	**0**

255.255.192.0

  - Another option: IP address is followed by the count of 1s (after the slash) – **CIDR notation**, e.g.:

IP address:	11000000101010000000	01001000010110
Mask:	11111111111111111111	00000000000000

192.168.18.22**/18**

The subnet mask is also used to overcome limitations of the original clasess (A, B, C, D, E).

Subnet ID and Broadcast Address

The first address of each subnet (**subnet ID**) is the netmask of the subnet. It can be easily obtained from any address and netmask using the bitwise AND – e.g.:

192.168.18.22/18

11000000 10101000 00	010010 00010110
AND	
11111111 11111111 11	000000 00000000
11000000 10101000 00	000000 00000000

Subnet ID: 192.168.0.0

Basically, it copies bits from the IP address at positions, where the mask bits are 1s, and 0 at positions, where the mask bits are 0s.

The subnet ID is used for example in the case, when a computer with IP1 wants to connect another device with IP2. If the subnet ID is the same for both, then they are in the same network; otherwise they are in different networks and they have to communicate over routers.

The **broadcast address** is used by the nodes, whenever they want a packet to be delivered to all the nodes in a given subnet (e.g. ARP in IPv4). It can be obtained from the subnet ID by setting 1s to bits, whose positions in the subnet mask are zeroes, e.g.:

11000000	10101000	00	010010	00010110
		AND	
11111111	11111111	11	000000	00000000
11000000	10101000	00	000000	00000000
11000000	10101000	00	111111	11111111

Broadcast address: 192.168.63.255

Since both addresses have special meanings, they cannot be assigned to any device.

Exercises

1. A DHCP server assigned your device this IP address: 192.168.32.39/27.
    a. What is the subnet mask in the dot-decimal notation? [*255.255.255.224*]
    b. What is the LAN network prefix? [*192.168.32.32*]
    c. What is the first usable IP address? [*192.168.32.33*]
    d. What is the last usable IP address? [*192.168.32.62*]
    e. What is the broadcast address? [*192.168.32.63*]
2. A network already comprises 12 devices with IP addresses. How many new devices can be connected, if the subnet mask is defined as follows: 255.255.255.192? [*50*]