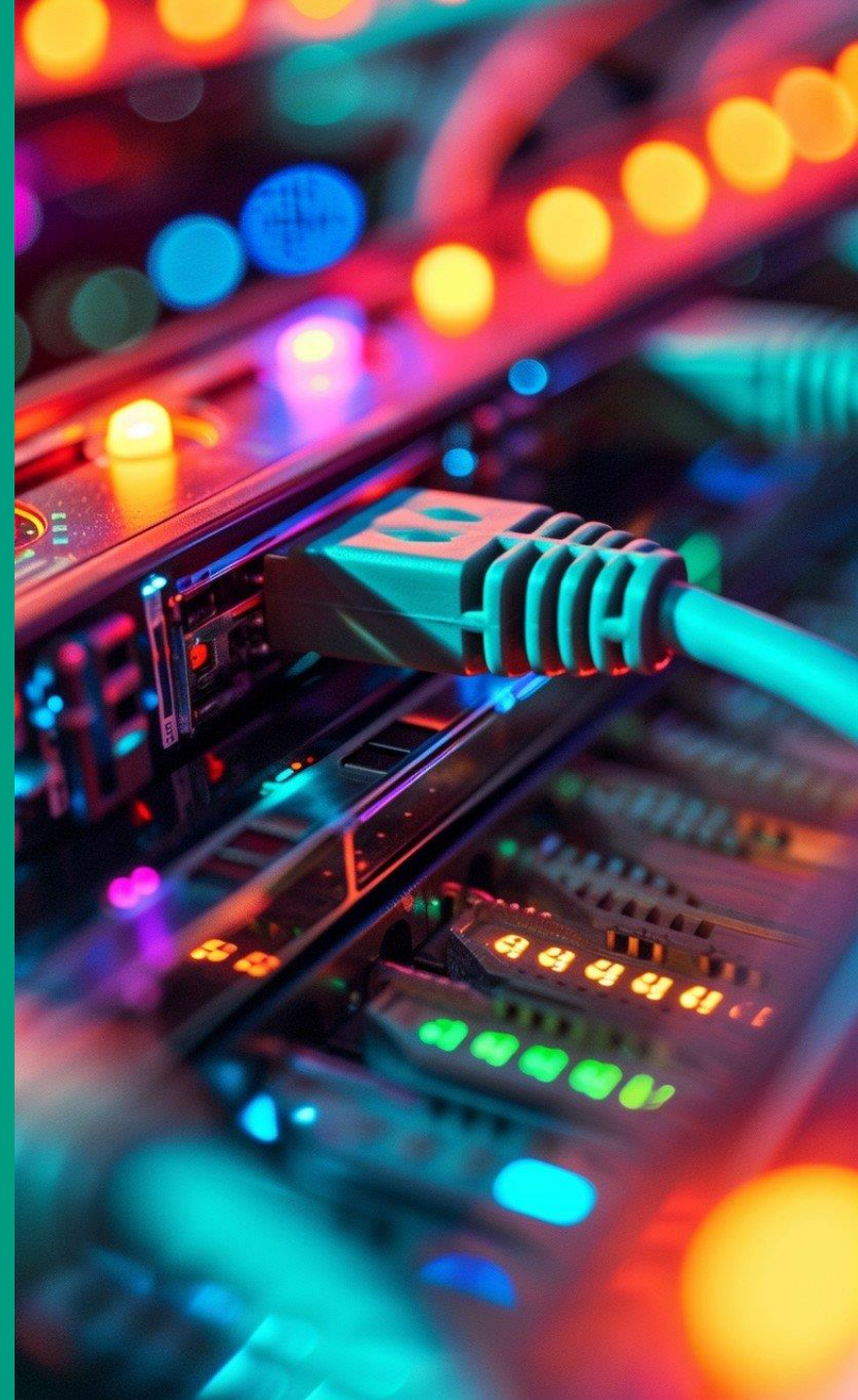Week 4

Networking

Agenda
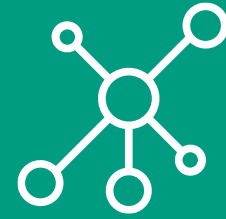
Introduction to Networks
and
OSI model

The IP address
Closer examination

Dynamic Host Configuration
Protocol (DHCP) &
Domain Name System
(DNS)

Networking in
VMware
Workstation
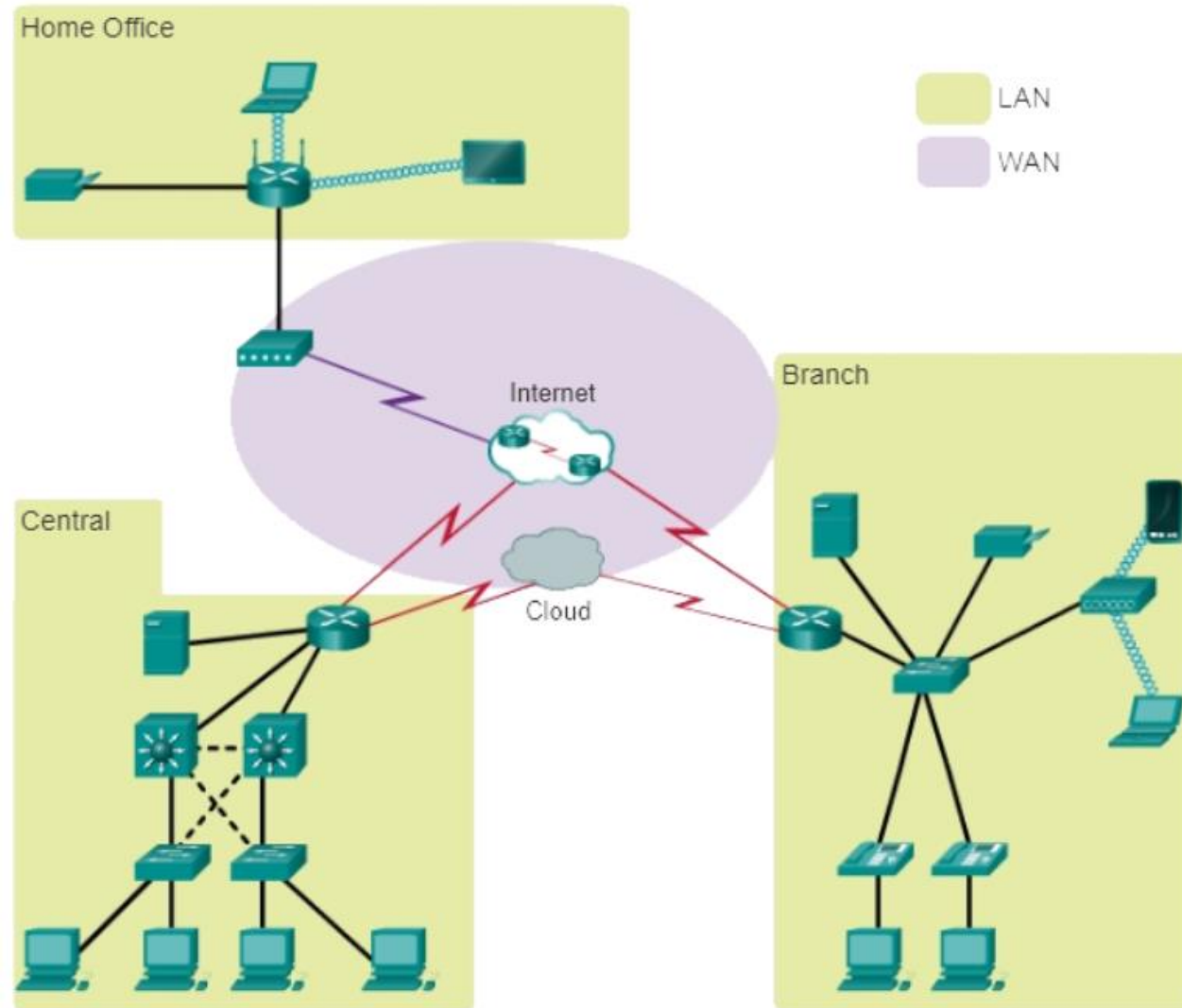
Why is this important?

- More conceptual knowledge of networks

- Many security problems due to network design

- Connection problems: How do we solve it?

- Link the network to the virtual environment (e.g. VMware workstation).

Introduction to Networks and OSI model

Computer network

LAN

WAN

Home Office

Internet

Cloud

Branch

Central

Very Complicated

How can we better understand this?
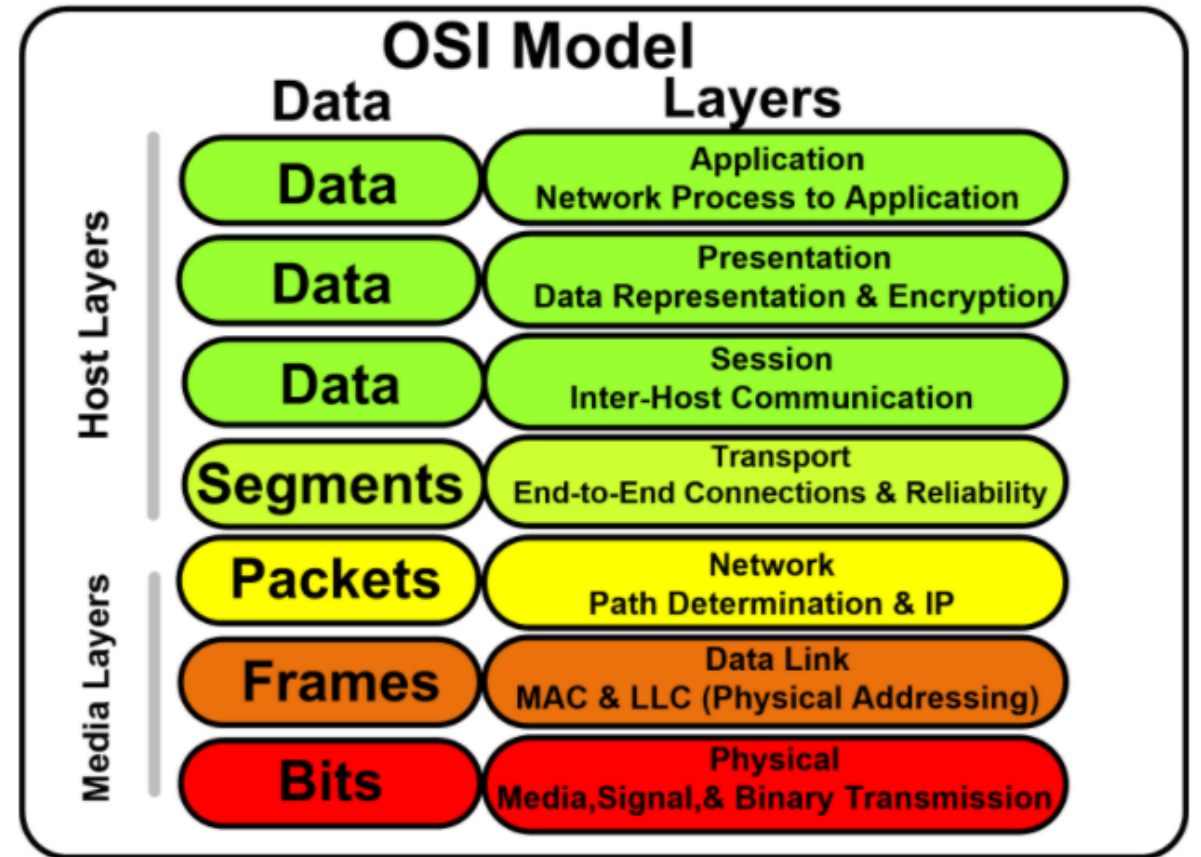
Answer:
The OSI-model

The OSI model

- **OSI**: Open System Interconnection

made by International Standard Organisation (ISO)

Standard intended to:

- Making complex networks simpler.

- Have equipment communicate with each other from different vendors.

- Understanding networks, detecting errors.

OSI Model

	Data	Layers
Host Layers	Data	Application — Network Process to Application
	Data	Presentation — Data Representation & Encryption
	Data	Session — Inter-Host Communication
	Segments	Transport — End-to-End Connections & Reliability
Media Layers	Packets	Network — Path Determination & IP
	Frames	Data Link — MAC & LLC (Physical Addressing)
	Bits	Physical — Media, Signal, & Binary Transmission

Troubleshooting: why does OSI knowledge help?

Browser on users computer

Web server

What is the cause of this error message (and which OSI layer is involved)?

1) The name saxion.nl could not be resolved
2) You are disconnected from the network
   - After checking, it appears that a static IP address has been set.
   - After checking, it appears that DHCP is set.
     - No IP address has been obtained
     - An IP address has been obtained.
3) Internal Server error

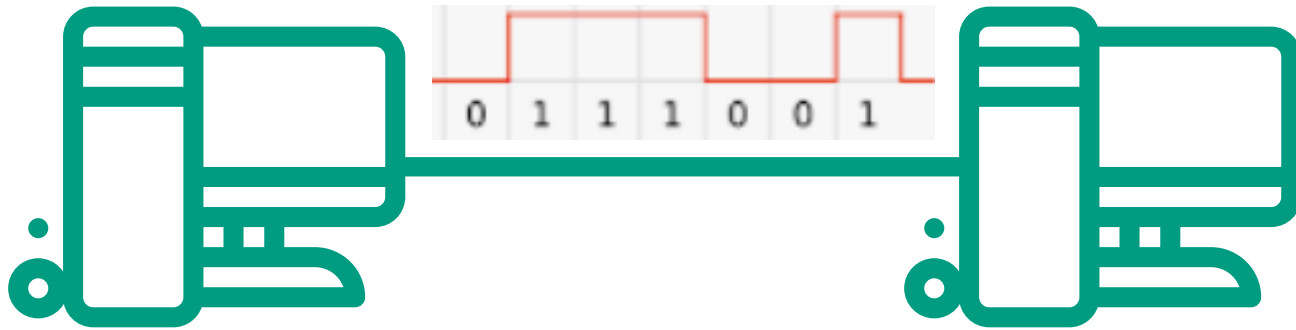Answer at the end of class!

What does each layer of OSI do?

Layer 1: Physical layer

Bits

Physical
Media, Signal and
Binary Transmission

Layer 1: Physical layer

- We'll start with two computers.

- 1st prototype:

Needed:

- Network card

Defined in OSI model:
- Cable types,
- Coding etc.

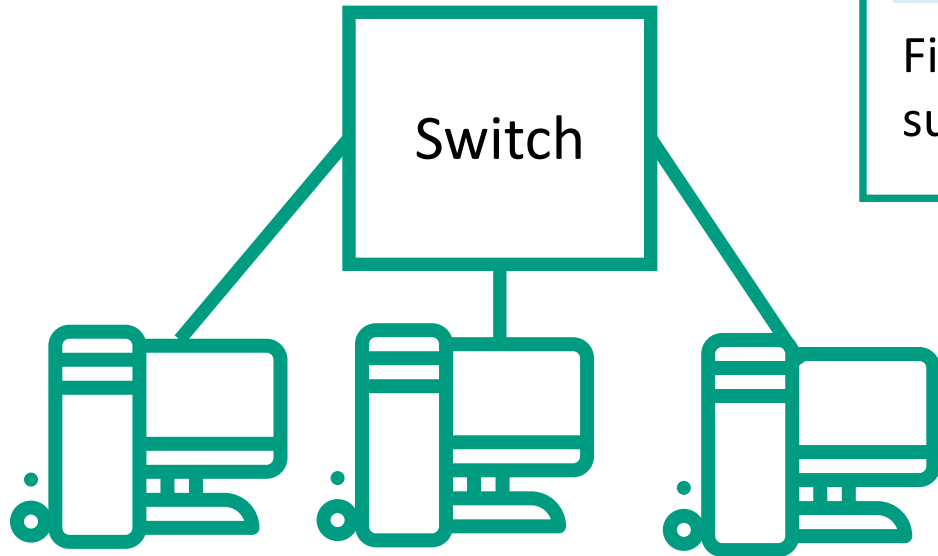Fiber cable   UTP cable

Layer 2: Data link layer

Frames

Bits

Data Link
MAC and LLC
(Physical addressing)

Physical
Media, Signal and
Binary Transmission

Layer 2: Data link layer

- Now multiple computers.

MAC address format:
48 bits long
E.g. 00:0C:6E:D2:11:E6

Media Access Control Address
| 00 | 1A | 3F | F1 | 4C | C6 |

First part unique per supplier

Needed:

- Addresses for computers.

Has become:
- Physical address defined on network card. Unique to each network card.

Has been called:
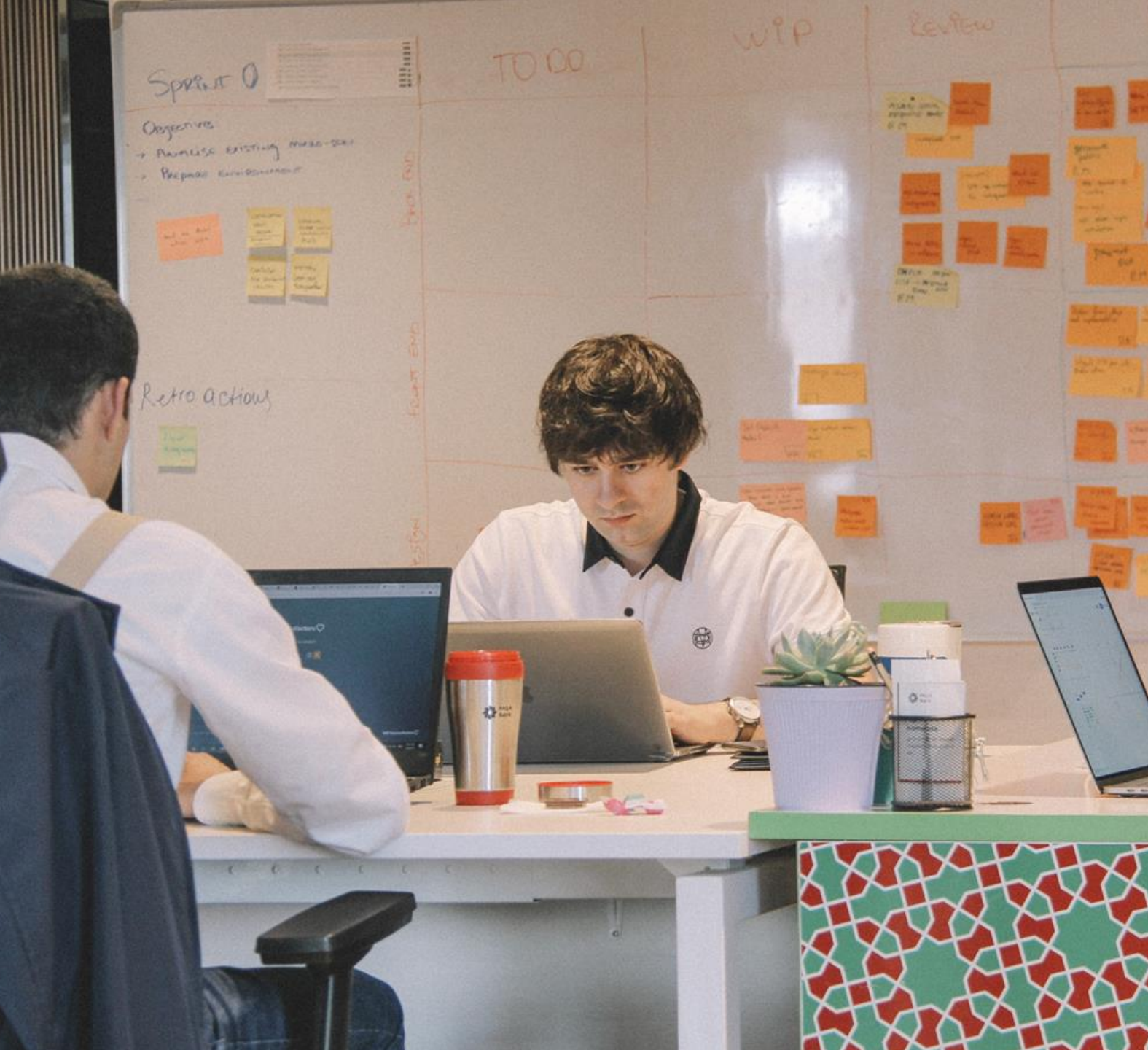- MAC address (Media Access Control)

Switch

Layer 2: Data link layer

Important to remember:

- Each network card has its own unique **MAC address**.

    (Caution! sometimes duplicates)

- A computer can have multiple network cards.

- MAC address is physical address (linked to hardware)

- Replace network card then different MAC address.

- This network is called a **LAN** (Local Area Network). (e.g. your home network)

- Packs bits into frames (number of bits grouped together) and sends frame as a whole.
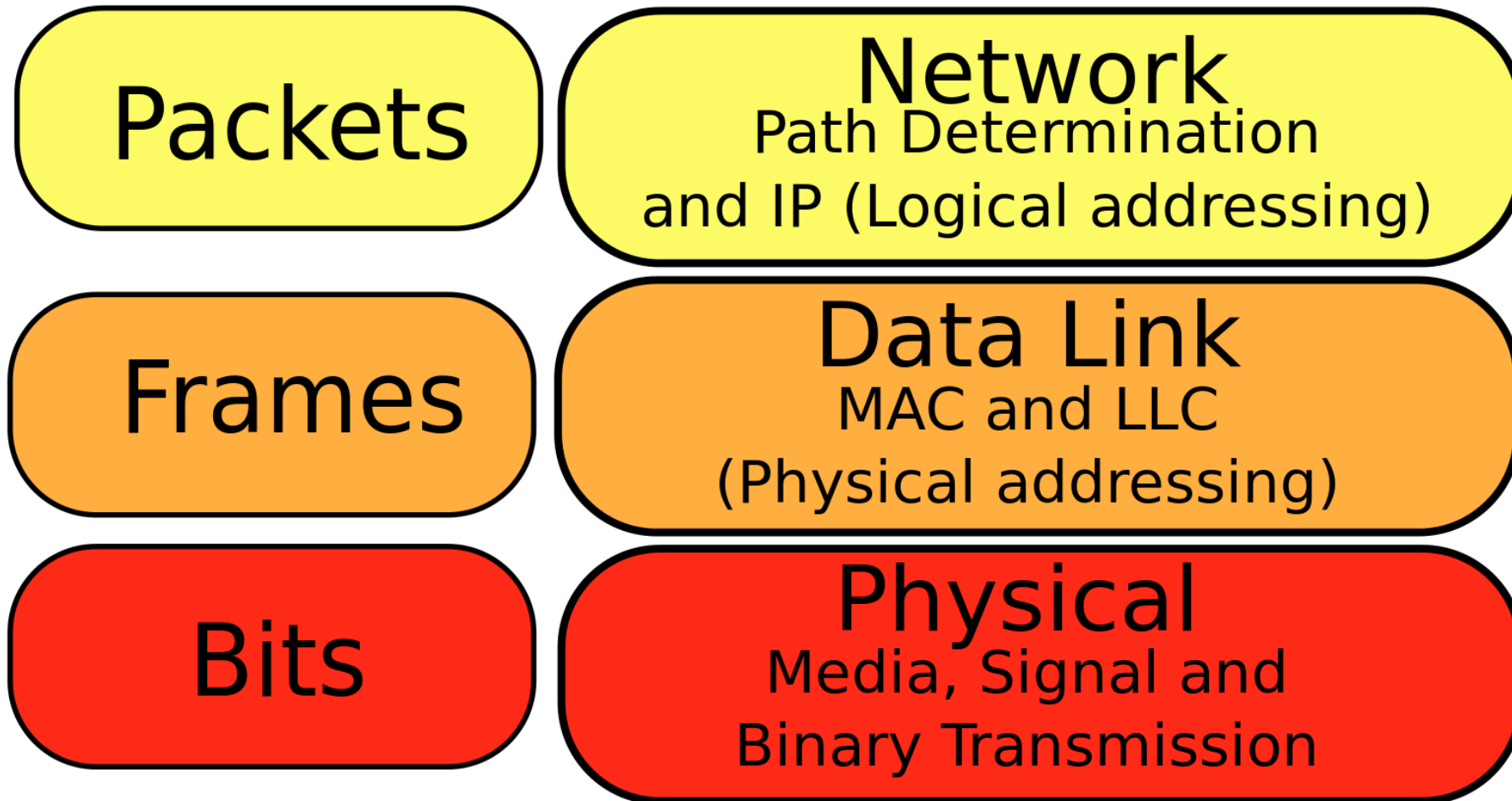
- Allows one system to transmit at a time.
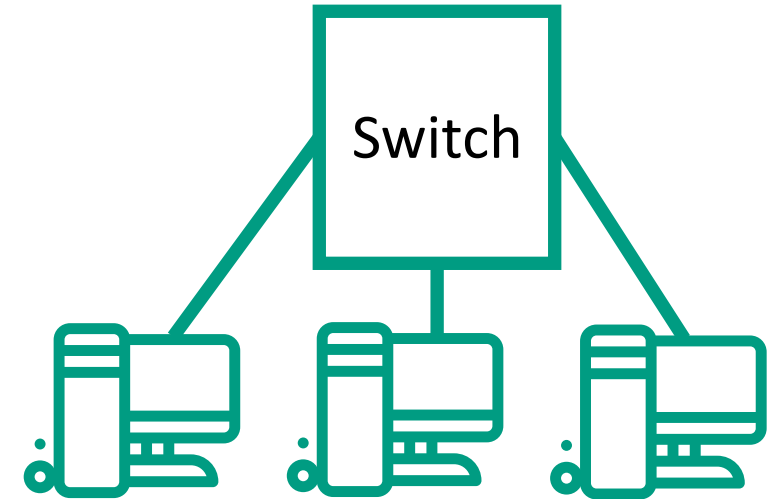
Activity

Research your own PC:
- What network cards are there?
  - Ethernet card?
  - Wi-Fi?
  - What MAC address are you seeing?

- Based on the first part part of the MAC address are you able to find the supplier?

Layer 3: Network layer

Packets

Network
Path Determination
and IP (Logical addressing)

Frames

Data Link
MAC and LLC
(Physical addressing)

Bits

Physical
Media, Signal and
Binary Transmission

Layer 3: Network layer

- Replace network card **->** Other address: **Clumsy**
- Web server as an example: Address should not change after hardware changes.
- MAC address not suitable for connecting systems worldwide (i.e. LANs).

- Therefore introduced in layer 3: logical address.
- The **IP address** (IP = Internet Protocol).

- Compare this with postal code:
  MH Tromplaan 28 Enschede (physical address) and postal code 7513 AB house nr 28. (logical address)

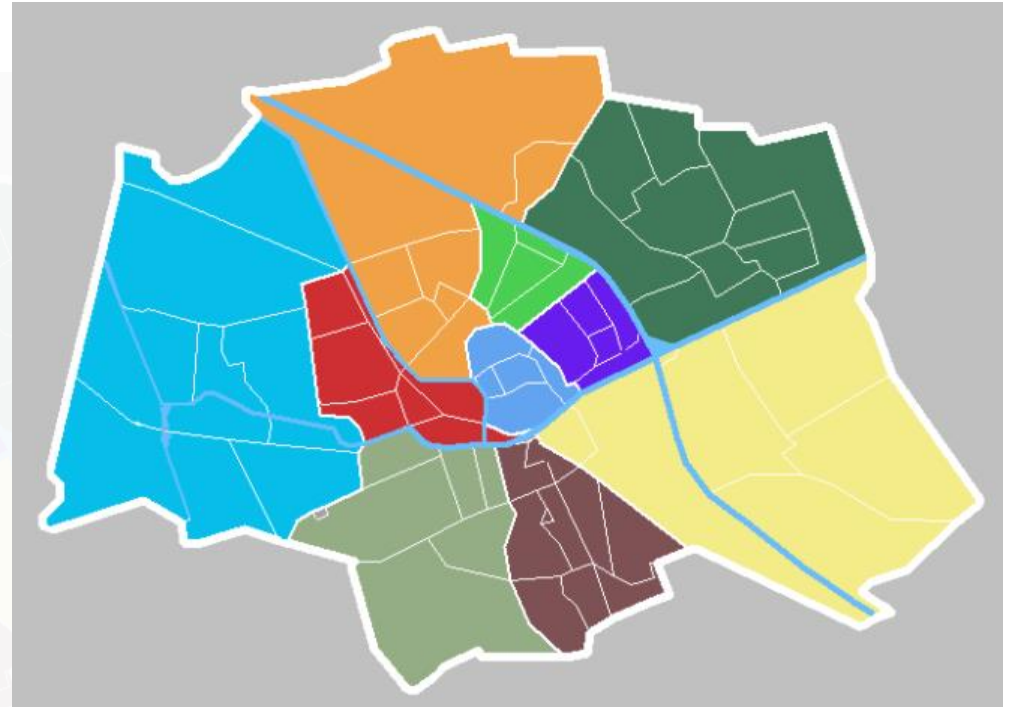Switch
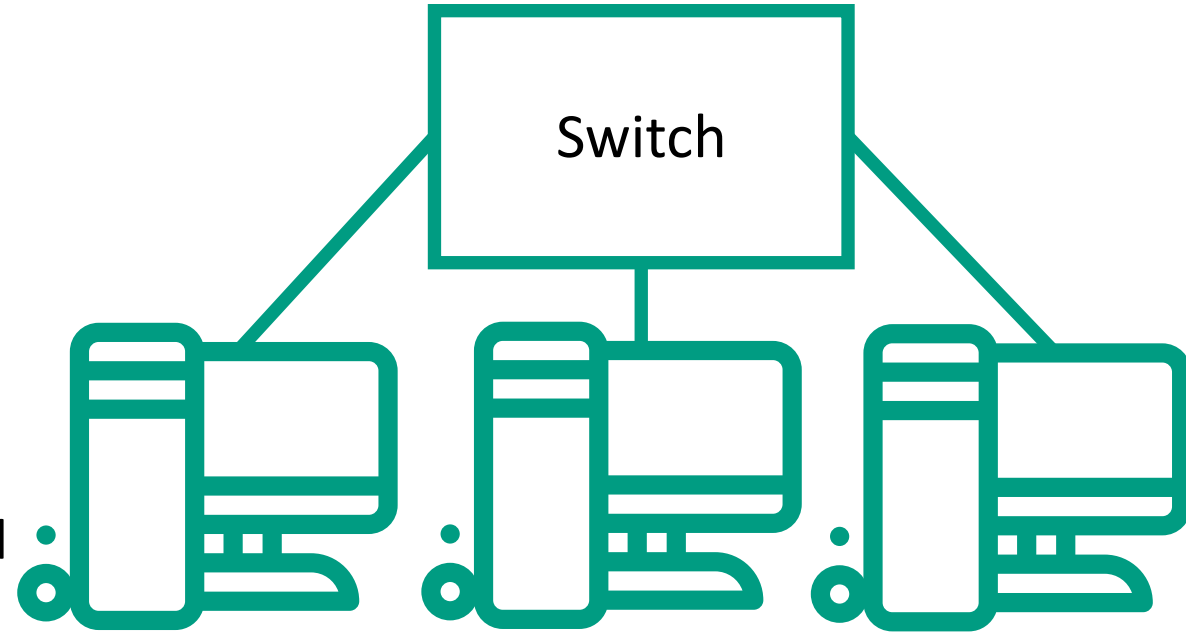
Zip code comparison

- Each **district** has a unique postcode. (e.g. 7513 AB)
- Each **house** has a unique number.

How is the mail routed?

- Does the mail have to go to another district:
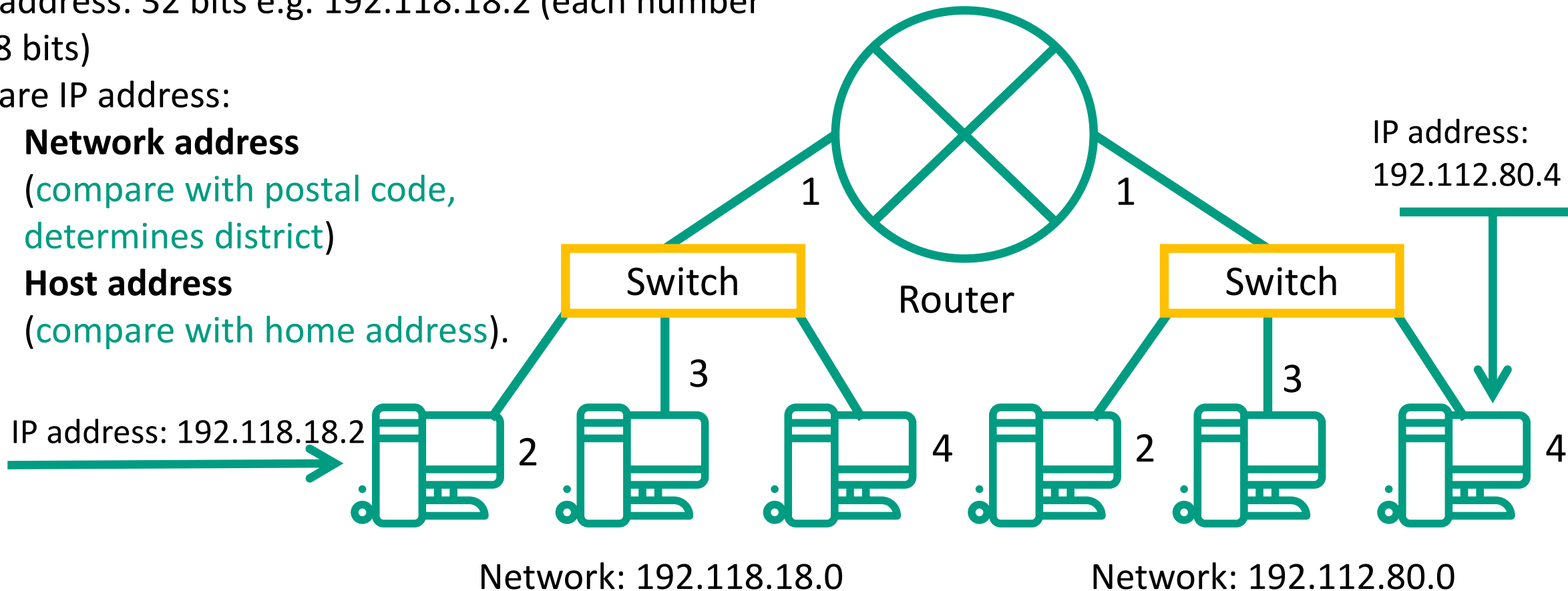 (compare network)

Then Use only the postal code:
(compare IP address)

Whitin a district the postman per district then uses
the house number:
(compare MAC address)

Layer 3: Network layer

- Linking several LANs
  (compare each LAN with a neighbourhood).

- IP address: 32 bits e.g. 192.118.18.2 (each number is 8 bits)
- Share IP address:
  - **Network address**
    (compare with postal code, determines district)
  - **Host address**
    (compare with home address).

Router

1   1

Switch   Switch

3   3

IP address: 192.118.18.2

2   4   2   4

IP address: 192.112.80.4

Network: 192.118.18.0   Network: 192.112.80.0

 Remember

- Router is a network device at layer 3.

  Routes between networks based on IP address.

- A router forms the boundary between networks.

- Switch is a network device at layer 2. Sends frames within network based on MAC address

- IP address server (e.g. web server) **never** changes (always in the same network)

- IP address of client **does** change
  (IP address is different from your home Other network).

Client At
Home
??.??.??.??

Client Saxion
145.76.??.??

www.saxion.nl
145.76.2.92
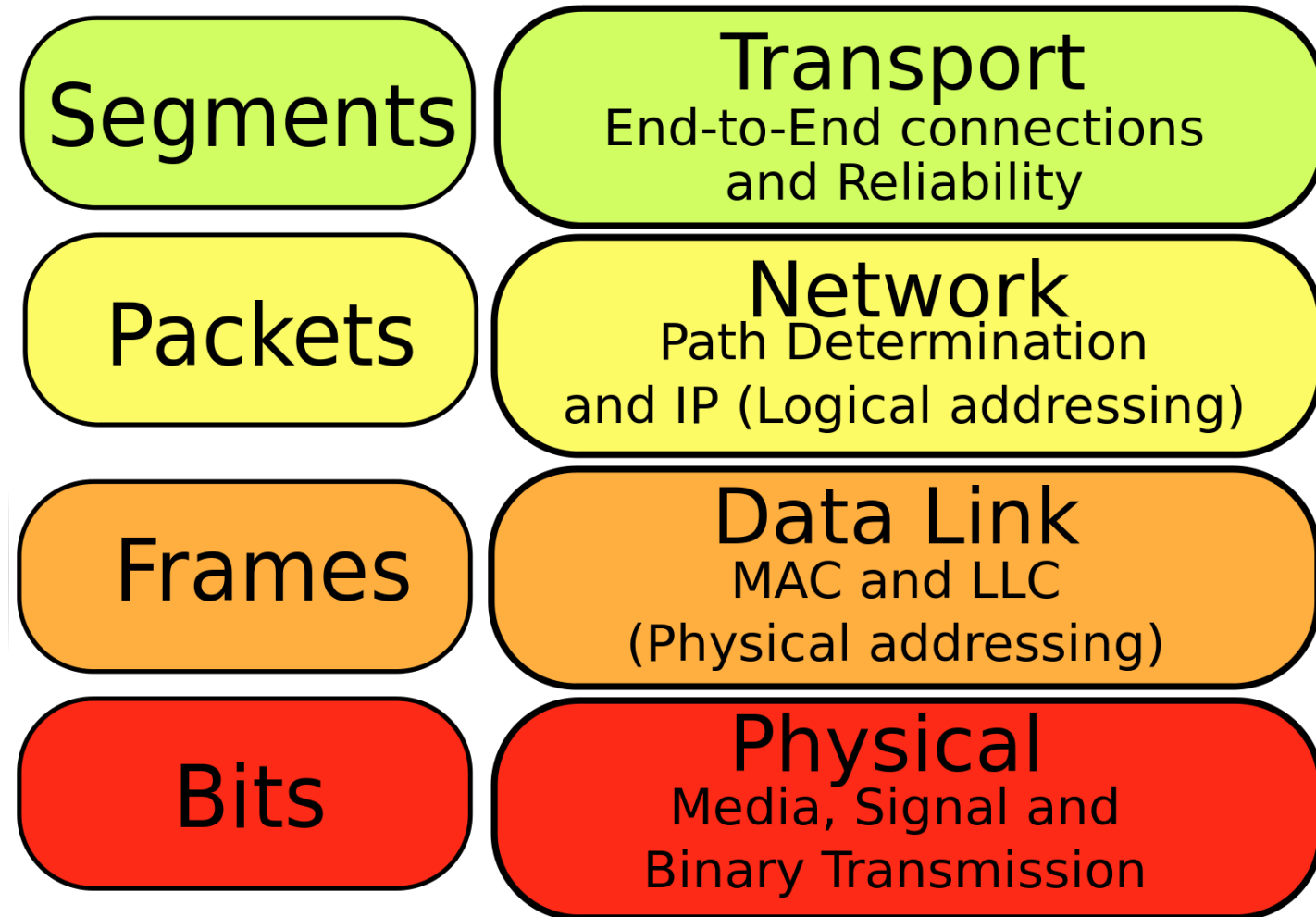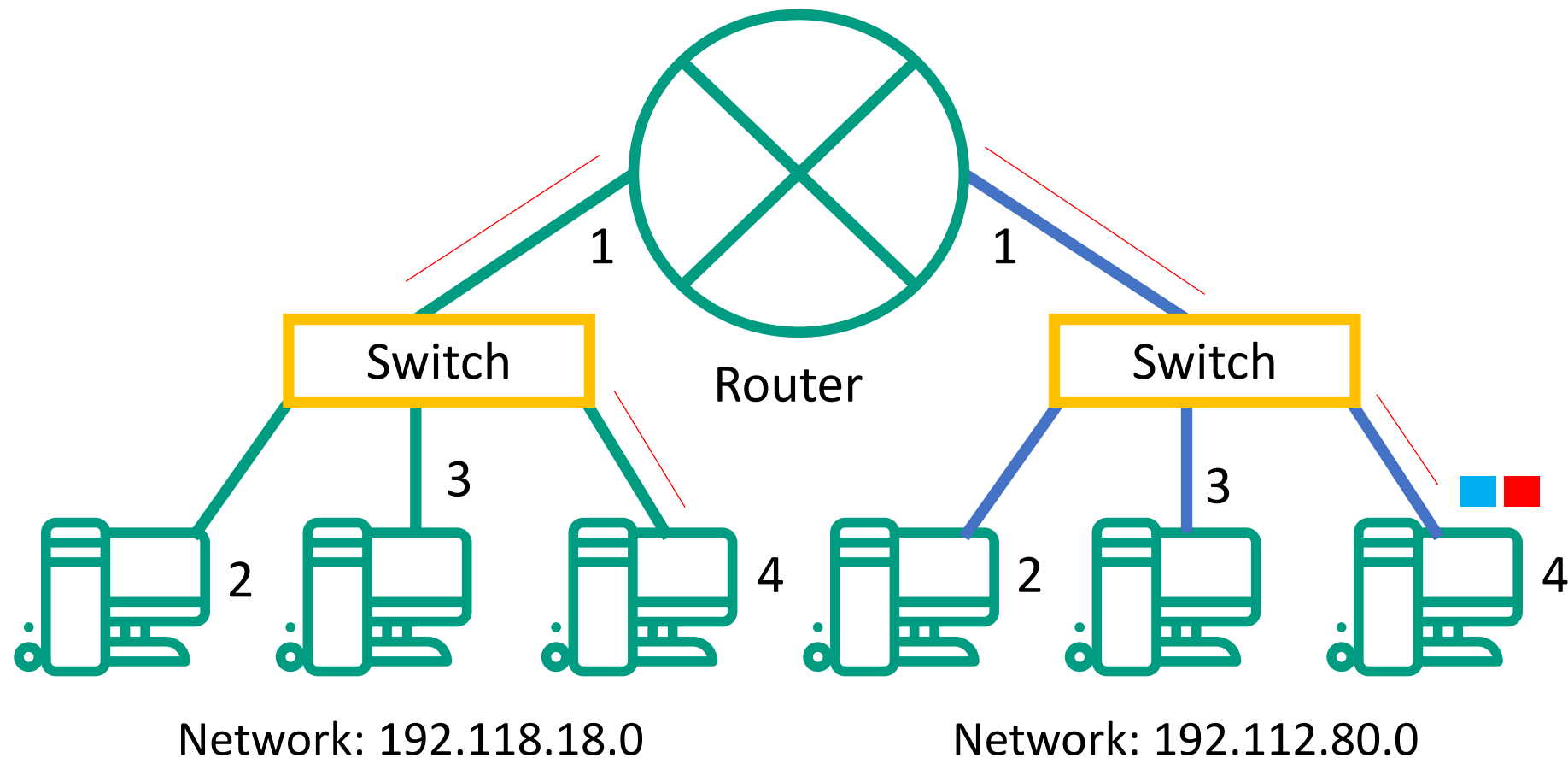
SAXION
Link na
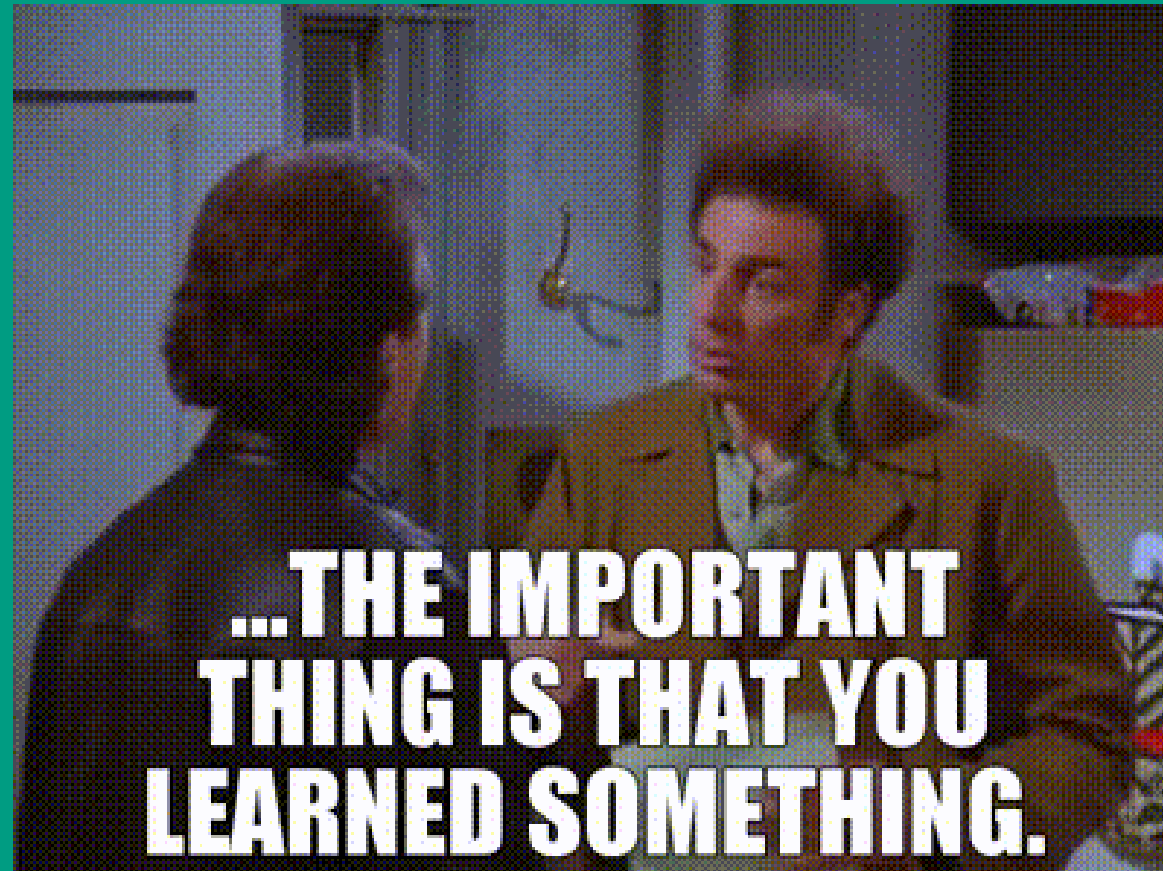
Activity

Activity

- Check which Wifi IP address your PC has at Saxion

- Does that start with 145.76?

- Check that at home later. What's your IP address there?

- Access the Saxion website at address 145.76.2.92. Is that address correct?

Layer 4: Transport layer

Segments	**Transport** End-to-End connections and Reliability
Packets	**Network** Path Determination and IP (Logical addressing)
Frames	**Data Link** MAC and LLC (Physical addressing)
Bits	**Physical** Media, Signal and Binary Transmission

Layer 4: Transport layer

- We can now have systems (hosts) communicate with each other.

Network: 192.118.18.0   Network: 192.112.80.0

Layer 4: Transport layer

- What if there are multiple applications (servers) running on one system (host)?

- How do you reach an individual application (server) on that?

- Compare with student house: 1 address, multiple individual rooms per address

Layer 4: Transport layer

- Introduced: Port numbers. Each host has thousands of ports (provided by operating system)

- Full application address = host address + port number.
  For example - Saxion webserver: **145.76.2.92:80**

- Known committed port numbers:
- Web server: 80 or 443 (encrypted)
- Time server: 37 (to retrieve time)
- FTP 21 (File transport protocol)
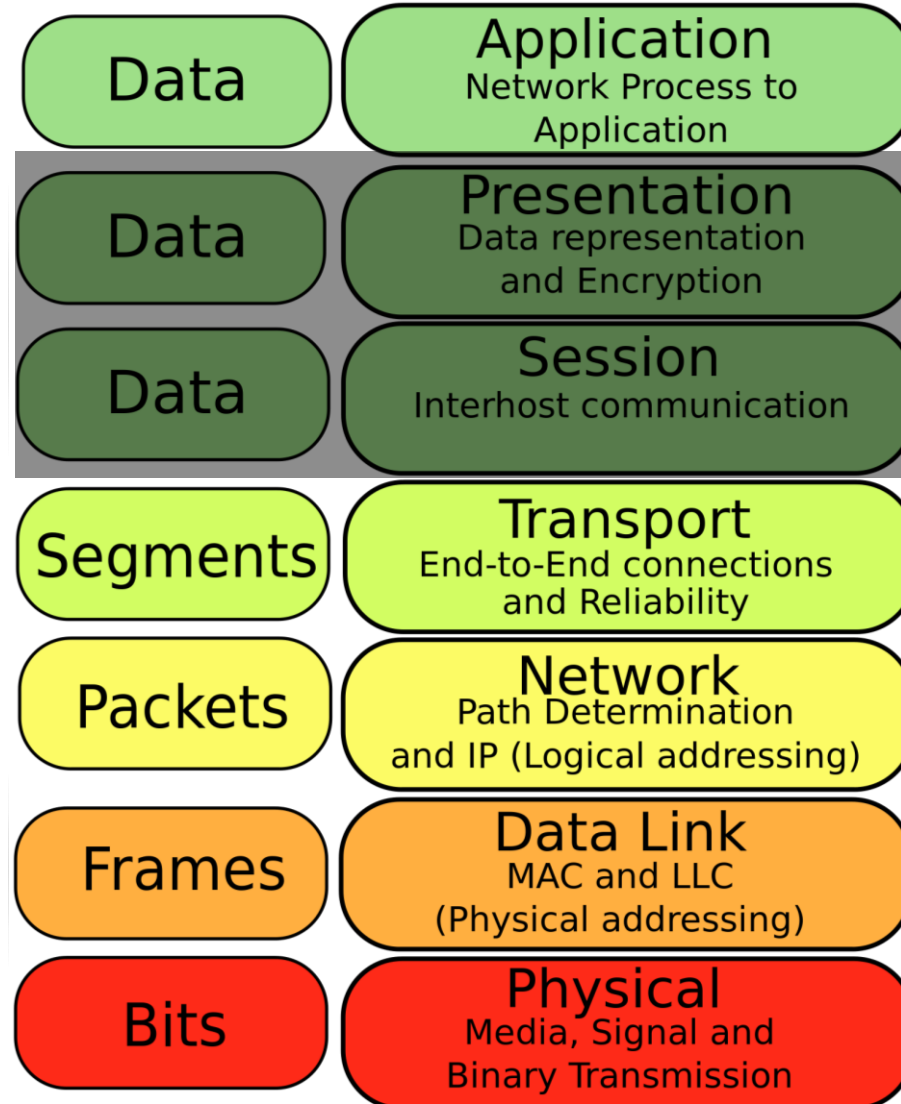- SSH: 22 (remote login to host)

Segments

Transport
End-to-End connections
and Reliability

Layer 7: Application layer

Data	Application — Network Process to Application
Data	Presentation — Data representation and Encryption
Data	Session — Interhost communication
Segments	Transport — End-to-End connections and Reliability
Packets	Network — Path Determination and IP (Logical addressing)
Frames	Data Link — MAC and LLC (Physical addressing)
Bits	Physical — Media, Signal and Binary Transmission

- We skip layers 5 and 6 (not necessary for understanding networks)

Layer 7: Application

- Defines used protocol used by applications.

  Example webserver: protocol http (default port 80) or https (secure, default port 443)).

  Fully address webserver → http://IP-adres:poortnr or https://IP-adres:portnr.

- Example Saxion.nl: http://145.76.2.92:80 (:80 can be skipped: default for http) or

  https://145.76.2.92:443 (:443 can be skipped; default for https).

  Example ftp server: protocol ftp

- FTP server University Twente:

  - ftp://ftp.snt.utwente.nl/pub

  - ftp://ftp.snt.utwente.nl:21/pub

Activity
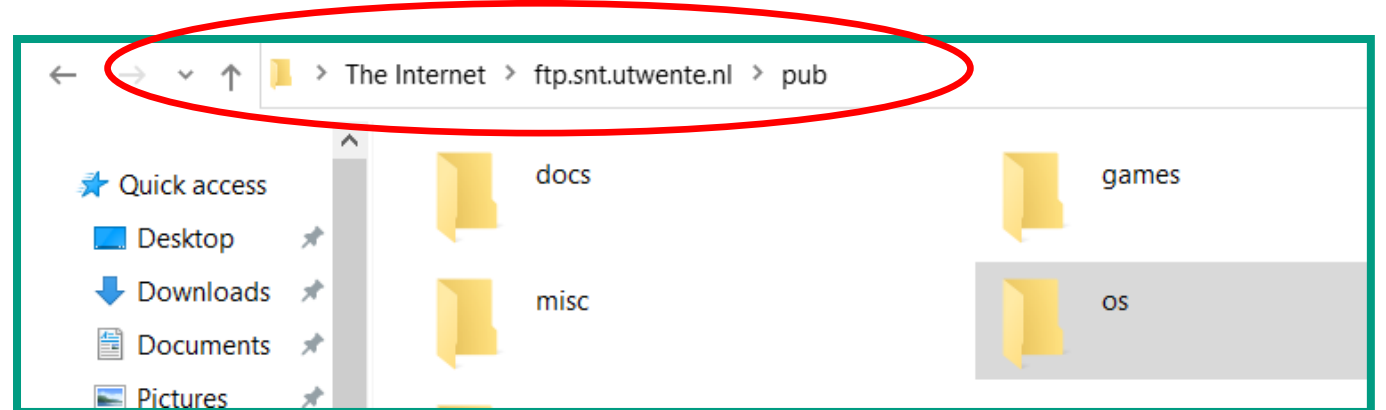
- Check if
  http://145.76.2.92:80 and
  https://145.76.2.92:443
  works just like
  www.saxion.nl or
  http://www.saxion.nl
  or http://www.saxion.nl:80

- Open file explorer and open
  ftp://ftp.snt.utwente.nl/pub
- Look in the folder os-> linux->
  Ubuntu releases and check
  if you can download a version
  of Ubuntu 20.04.

The IP address further explored

What do we want to learn?
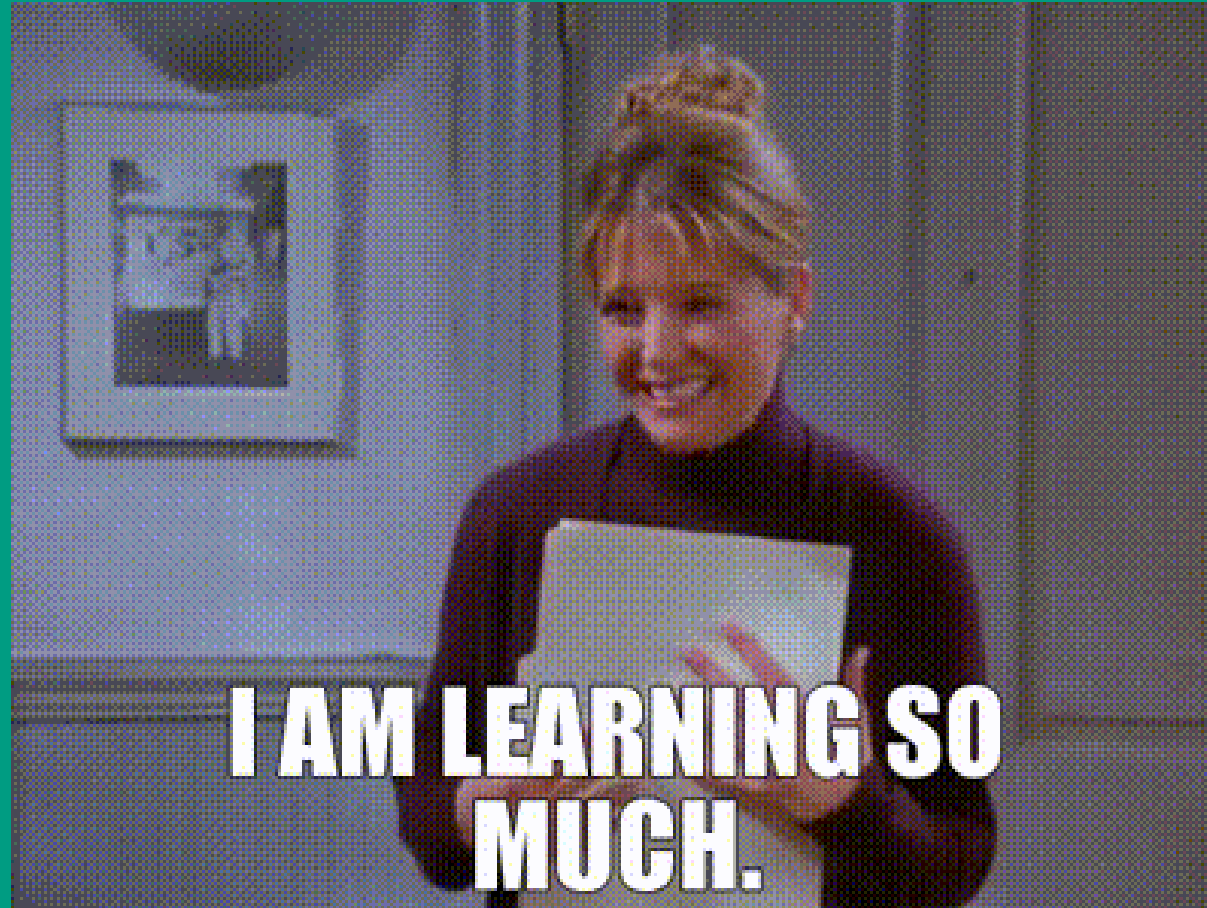
What do we want to learn?

- IP address structure: what you need to know to set up an IP address:

  - **Subnet mask**

  - **Default gateway**

  - What is a local IP address and when do you use it?

- What addresses do we use at home?

- Do I always need an IP address on my computer?

- How do you get an IP address or set it up?

IP address and subnetwork mask structure

- IP address consists of 32 bits

- IP address consists of 2 parts: Network part and Host part.

Class	IP address range (1st Octet)	Network Mask	Prefix	Number of Networks	Number of Hosts
A	1. - 127.	255.0.0.0	/8	125	16,777,214
B	128. - 191.	255.255.0.0	/16	16,382	65,534
C	192. - 223.	255.255.255.0	/24	2,097,150	254

IPv4 address in dotted-decimal notation

172 . 16 . 254 . 1

10101100 . 00010000 . 11111110 . 00000001

8 bits

32 bits (4 bytes)

Byte 1 | Byte 2 | Byte 3 | Byte 4

NET ID | HOST ID

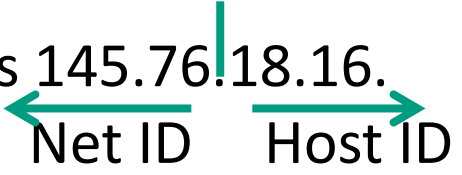NET ID | HOST ID

NET ID | HOST ID
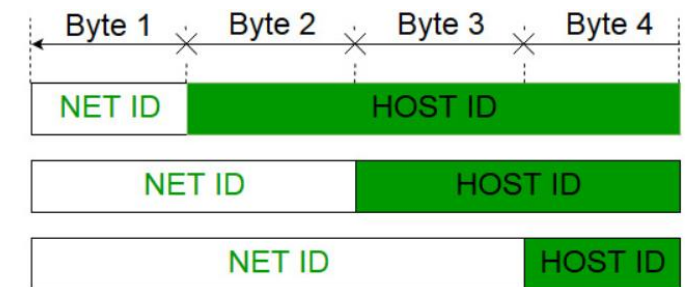
How can I tell what is the network part and what is the host part?

Answer:

Using the subnet mask. Without subnet mask the IP address is incomplete!

IP address and subnetwork mask structure

- Saxion has been granted the network 145.76.0/16

  Space for over 65000 hosts.

- So, all Saxion IP-addresses start with **145.76**.

- Example Saxion address: 145.76.18.16 /16 or 145.76.18.16 mask 255.255.0.0

- That means 145.76.18.16.

  ← Net ID   Host ID →

- In addition to Class A, B and C networks, 'Classless routing' has been added.
- Subnet mask is not only /8, /16 or /24 but can also be /17.

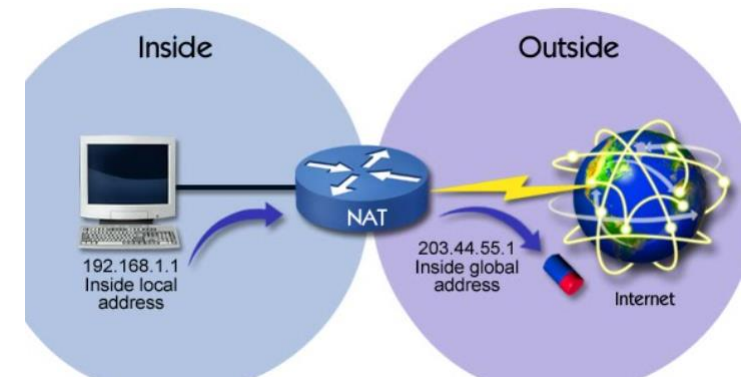# IP address and subnetwork mask structure

- Home setting:
  - Subnetmask /24 or 255.255.255.0
  - Network 192.168.1.0/24

- This is a **local** network address.
  - Many use it at home, yet no conflict
  - Local address is **never** routed on the internet!!!

- With an address like that, you can:
  - Connect to the internet
  - Not connect to this address directly from the Internet
- Router performs NAT (Network Address Translation).
- Other local address: 10.x.x.x

You can get IP settings assigned automatically if your network supports this capability. Otherwise, you need to ask your network administrator for the appropriate IP settings.

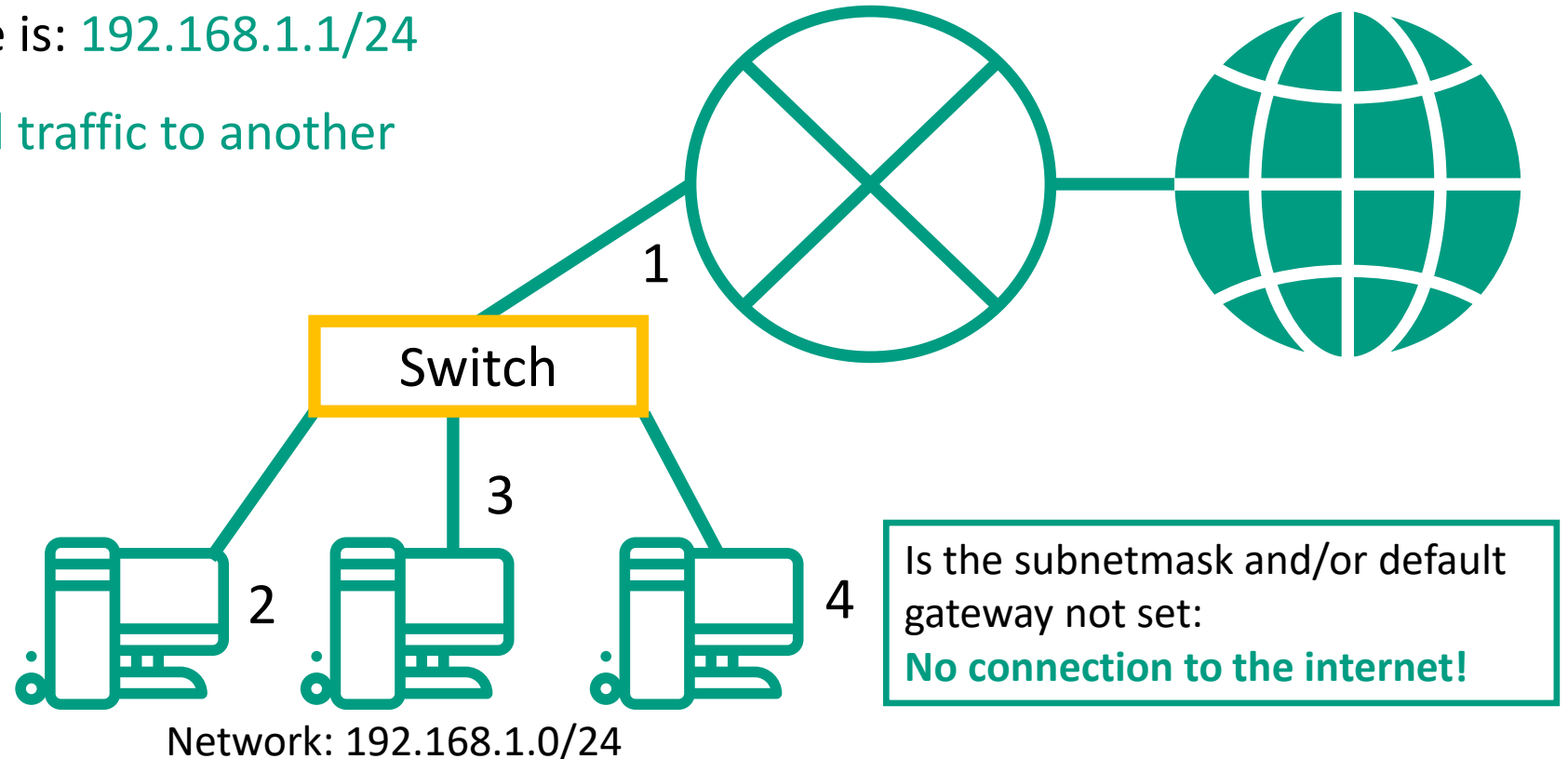- ○ Obtain an IP address automatically
- ⦿ Use the following IP address:

IP address:	192 . 168 . 1 . 2
Subnet mask:	255 . 255 . 255 . 0
Default gateway:	192 . 168 . 1 . 1

Inside

Outside

192.168.1.1
Inside local
address

NAT

203.44.55.1
Inside global
address

Internet

Default gateway

- Translation: default output

- So: IP address router

- So, the Default gateway here is: 192.168.1.1/24

  Required if you want to send traffic to another

  network

- Set up on each PC in

  local network

You can get IP settings assigned automatically if your network supports
this capability. Otherwise, you need to ask your network administrator
for the appropriate IP settings.

○ Obtain an IP address automatically
◉ Use the following IP address:

IP address: 192 . 168 . 1 . 2
Subnet mask: 255 . 255 . 255 . 0
Default gateway: 192 . 168 . 1 . 1

1

Switch

3

2

4

Is the subnetmask and/or default
gateway not set:
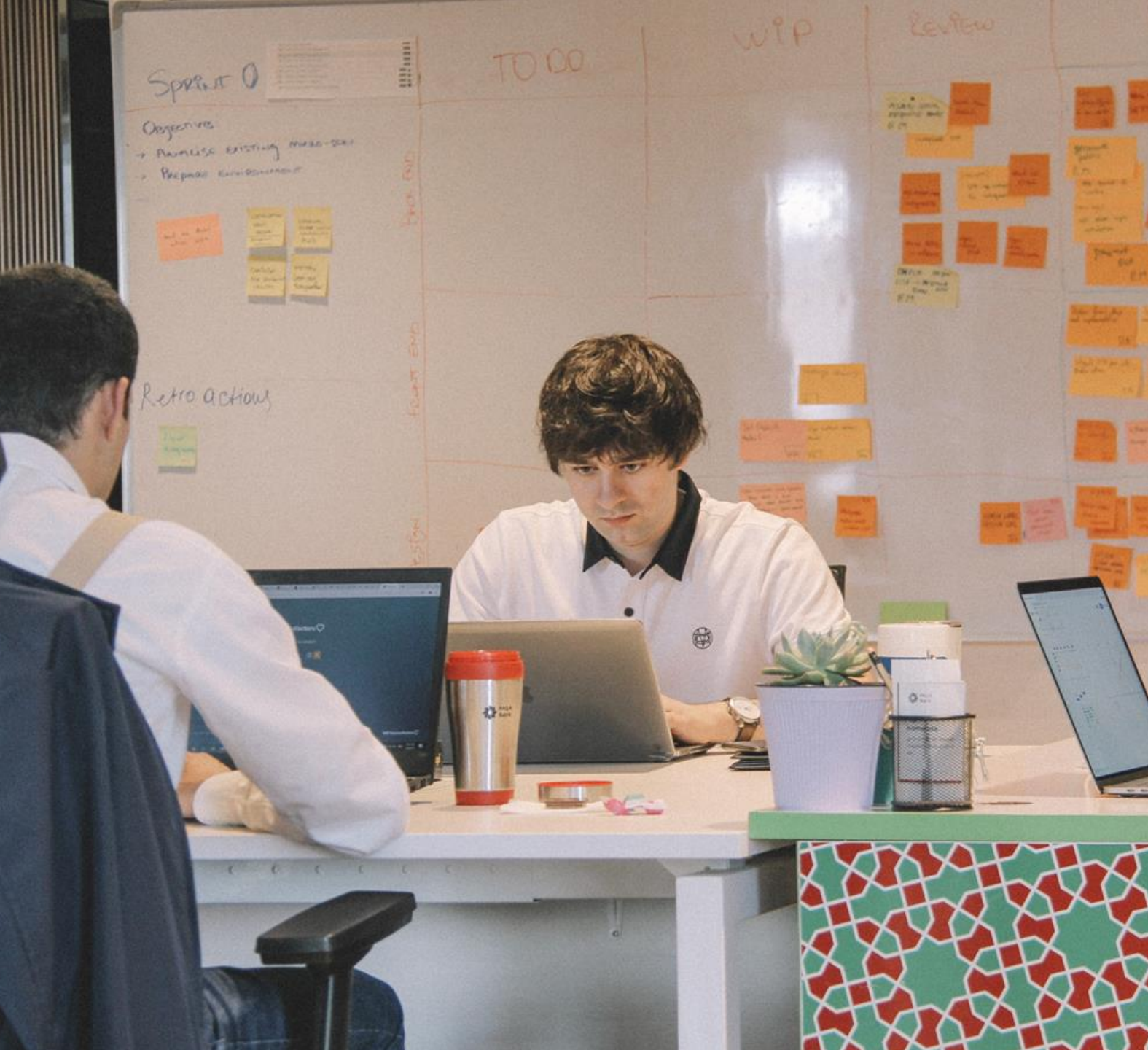**No connection to the internet!**

Network: 192.168.1.0/24

Important commands to know

Important commands to know

- Check IP address (and mac address):

  - On Windows: **ipconfig (ipconfig /all)**

  - On Linux: **ifconfig (ip addr show)**

- Check if two machines can reach each other in

  layer 3 OSI model:

  - On Windows and Linux: **ping <ip-address>.**

Activity

- On your own system, check the setting of the subnetmask and the default gateway.

  Use the command ipconfig on Windows.

- Do that at home and at Saxion.

- Do you see what you expect?

Dynamic Host Configuration Protocol (DHCP) & Domain Name System (DNS)
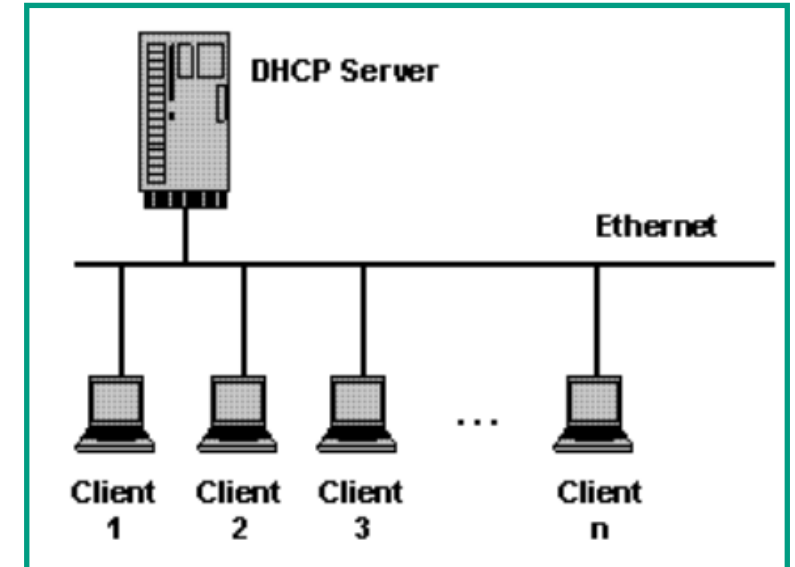
DHCP and DNS

- **Problem 1: Setting the IP address manually**

- IP address depends on network you are on.

  Other network: Set other IP address.

  - In a network there should never be 2 machines with

    the same IP address.
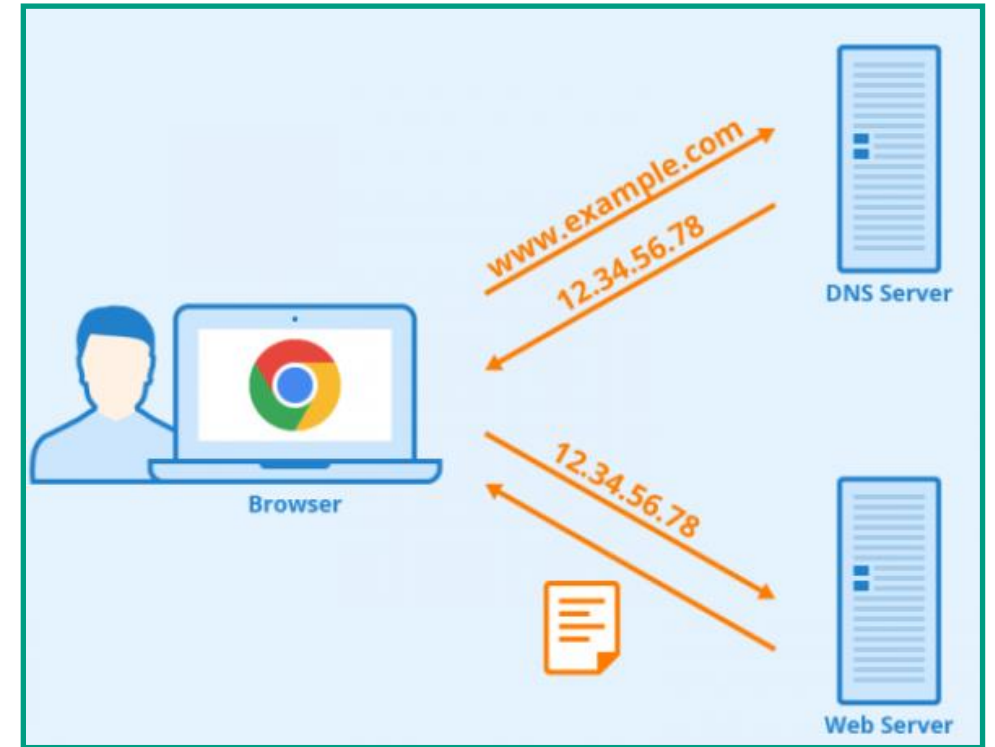
  - Which IP address to take?

    Solution: DHCP server. Configures automatically
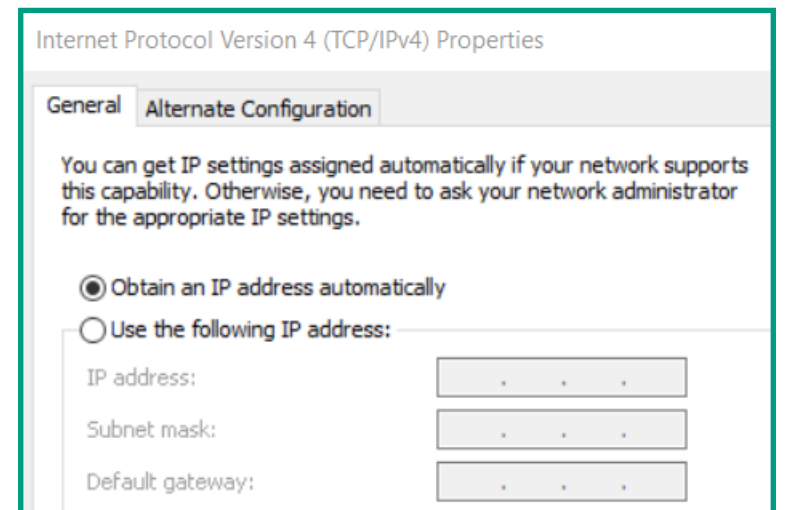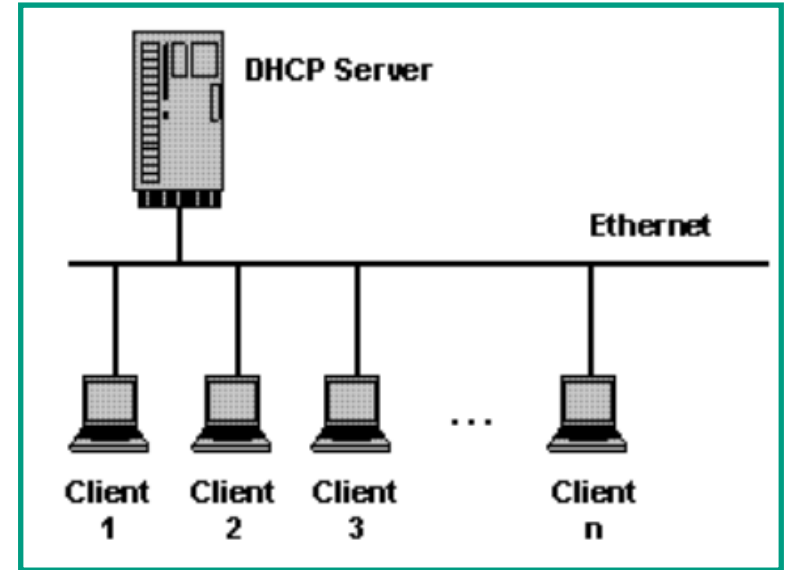
    network settings.

DHCP and DNS

- **Problem 2: Accessing servers by IP address:**

- We're bad at numbers, better at names.

  - www.google.nl is easier than 172.217.168.227.

  - Solution: DNS server.

   Convert names to IP numbers.

DHCP

- **DHCP server (Dynamic Host Configuration Protocol)**

  - For automatically configuring network settings

  - Almost always used for clients

  - Almost not for servers (then manually set fixed IP address)

- **DHCP server knows:**

  - The network range, the subnet mask and the default gateway.

  - Which addresses are still available.

- **If client network is set as DHCP**

  - When the client starts it looks for the DHCP server

  - Then asks for IP setting

- There is a DHCP server in your home network and at Saxion.

DHCP Server

Ethernet

Client 1 Client 2 Client 3 ... Client n

Internet Protocol Version 4 (TCP/IPv4) Properties

General | Alternate Configuration

You can get IP settings assigned automatically if your network supports this capability. Otherwise, you need to ask your network administrator for the appropriate IP settings.

○ Obtain an IP address automatically
○ Use the following IP address:

IP address:

Subnet mask:

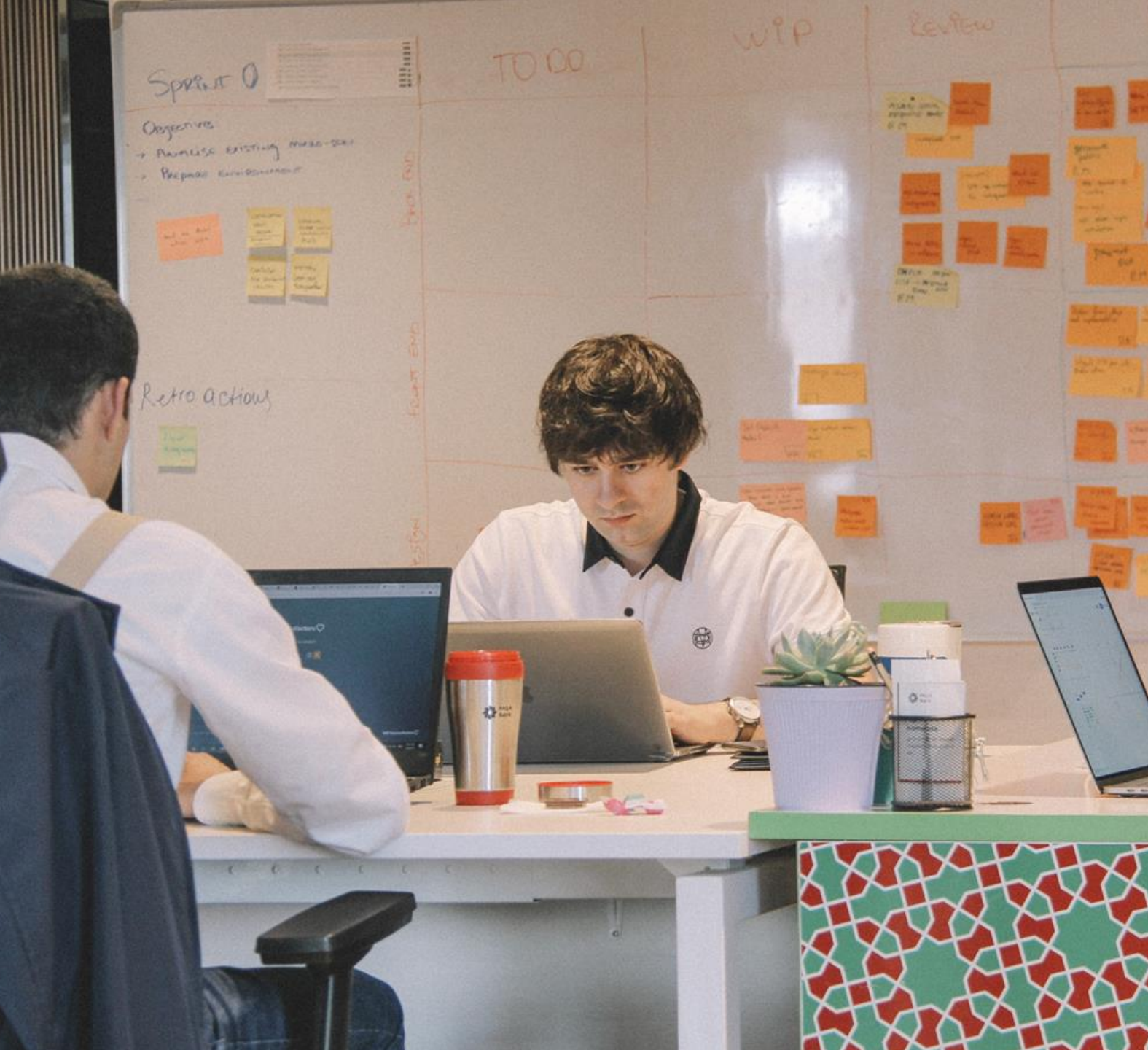Default gateway:

DNS server (Domain Name Server)

- Is database with all the domain names in the world as:

  - Saxion.nl

  - Google.com

  - Etc.

- Distributed on computers worldwide

- If we go to www.saxion.nl then the DNS server is consulted first.

  Retrieves the IP address for contacting the server.

- So when setting IP address, always set IP address of the

  DNS server also (or let DHCP do it).
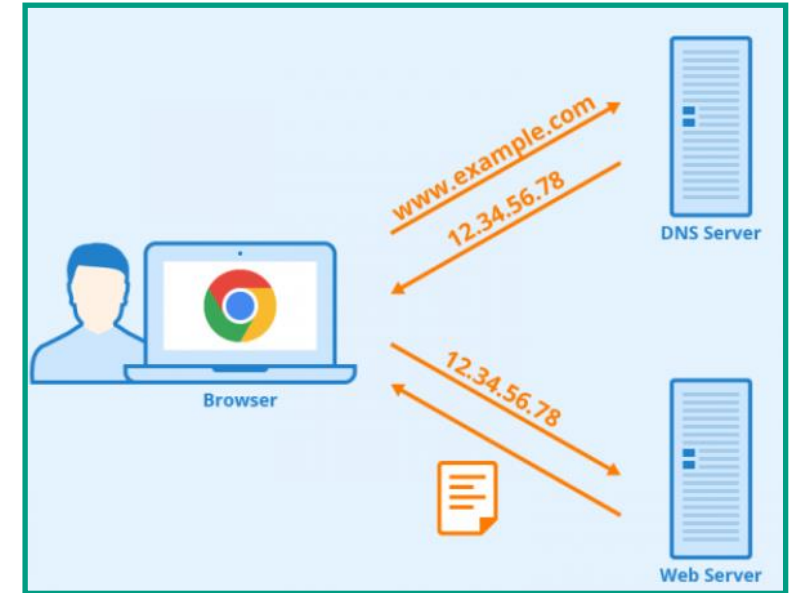
DHCP and DNS: In application layer OSI model

Activity

- On your own system, check that DHCP is enabled.

- Find IP addresses of DNS servers that are used

DMZ – Demilitarized Zone

Definition

- A perimeter network that protects the internal network (LAN) from untrusted traffic.

Why

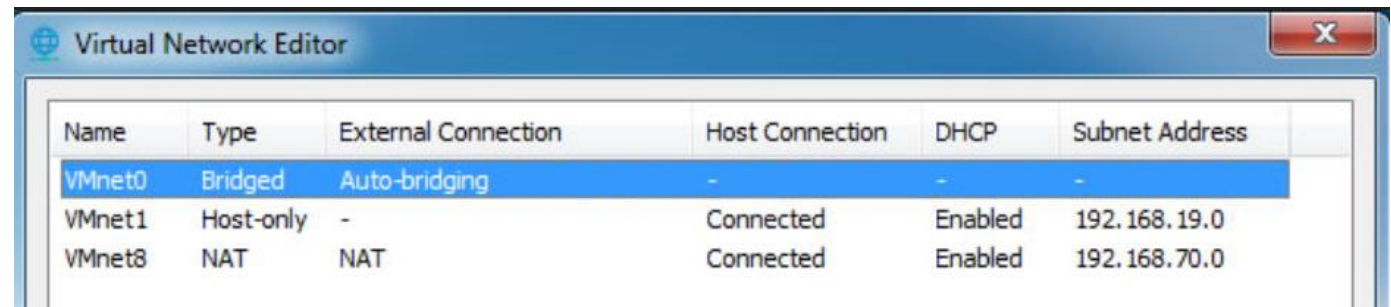- Protect your resources from the public.

Networking in VMware Workstation

Types of networking in VMware workstation

- VMware workstation has three types of networks:

  - NAT networking (default); looks like your home

    network.

  - Bridged

  - Hostonly

- A network of each type is available

  - VMnet0 (bridged)

  - VMnet1 (Host-only)

  - VMnet8 (NAT)

- New VM is connected by default to network VMnet8
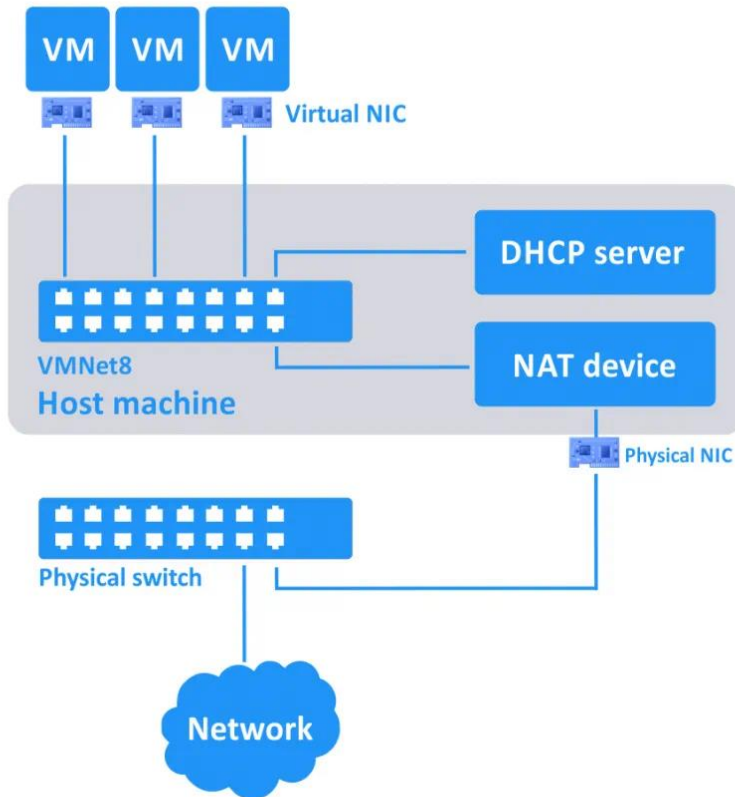
  (and thus uses NAT)

Workstation: NAT

NAT Network Mode

VM VM VM
Virtual NIC

DHCP server

NAT device

VMNet8
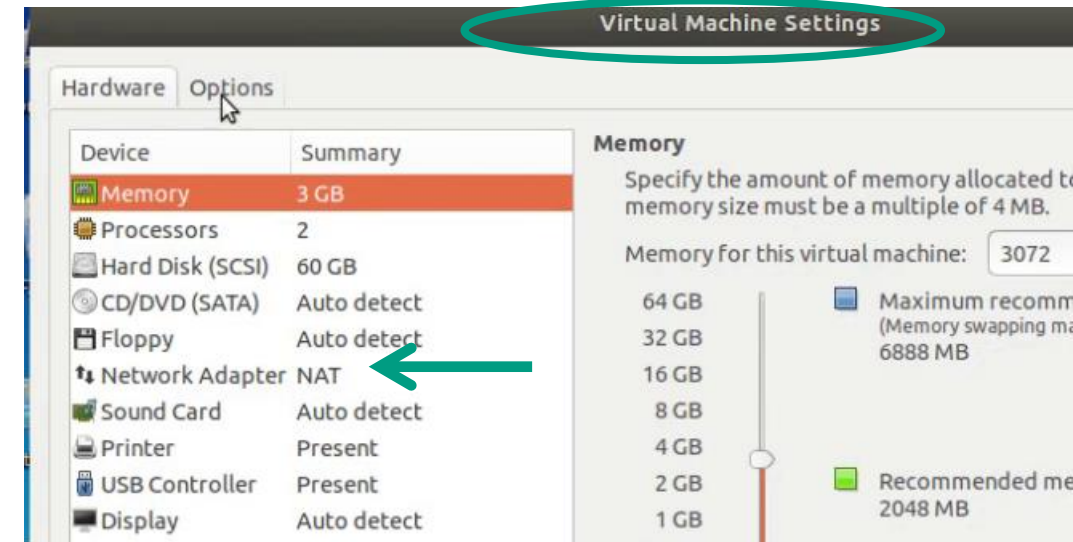**Host machine**

Physical NIC

Physical switch

Network

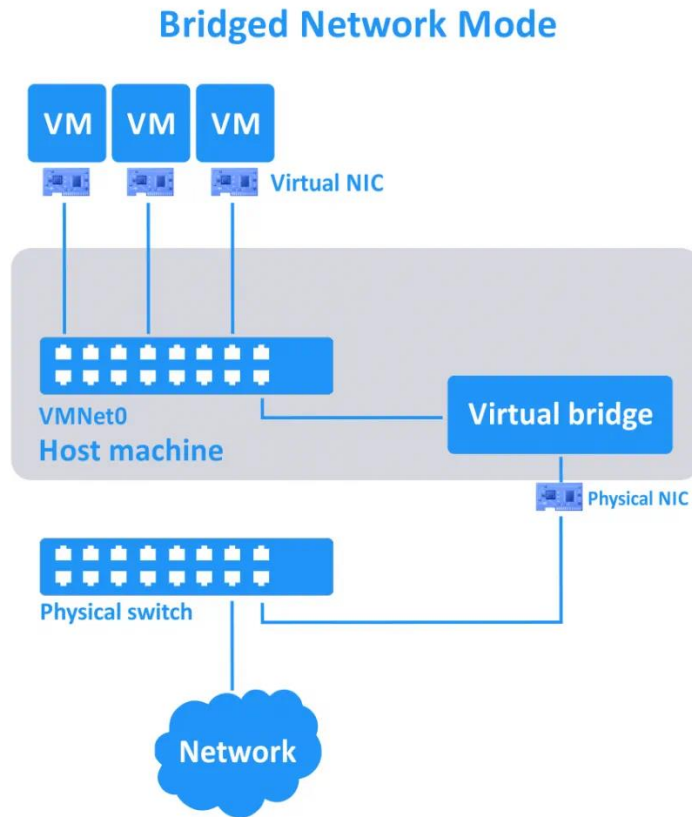VM can use DHCP for network configuration

Remember

At NAT:
- VM has **internet connection**.
- VMs in the network can reach each other
- VM can be reached from Host (own PC).
  Host has additional adapter in this network.

Virtual Machine Settings

Hardware	Options	
Device	Summary	
Memory	3 GB	
Processors	2	
Hard Disk (SCSI)	60 GB	
CD/DVD (SATA)	Auto detect	
Floppy	Auto detect	
Network Adapter	NAT	
Sound Card	Auto detect	
Printer	Present	
USB Controller	Present	
Display	Auto detect	

Memory
Specify the amount of memory allocated t
memory size must be a multiple of 4 MB.

Memory for this virtual machine: 3072

64 GB
32 GB
16 GB
8 GB
4 GB
2 GB
1 GB

Maximum recomm
(Memory swapping ma
6888 MB

Recommended me
2048 MB

Workstation: Bridged

Bridged Network Mode
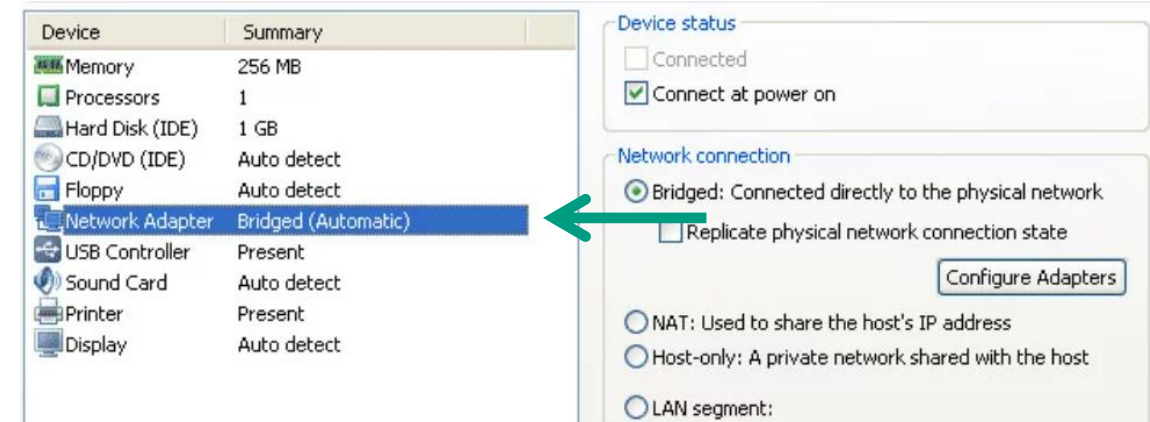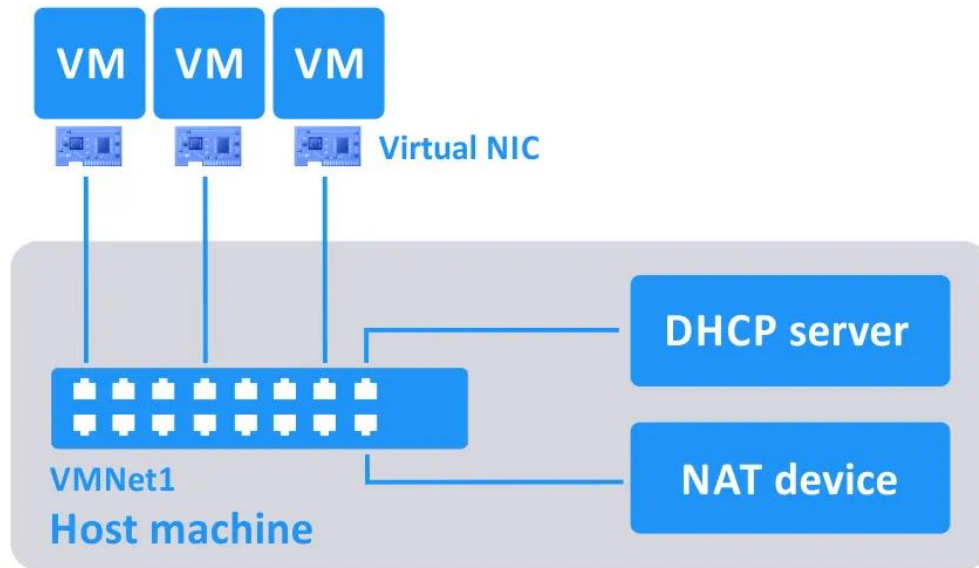

Remember
At Bridged:
- VM has **internet connection**.
- VMs in the network can reach each other.
- From Host (own PC) VM can be reached.

- VM can use DHCP for network configuration
- Then host's DHCP server is used (if there is one and if it wants to allow VMs).
- Connection to PC sometimes fails (check firewall)

Workstation: hostonly

Host-only Network Mode

VM   VM   VM

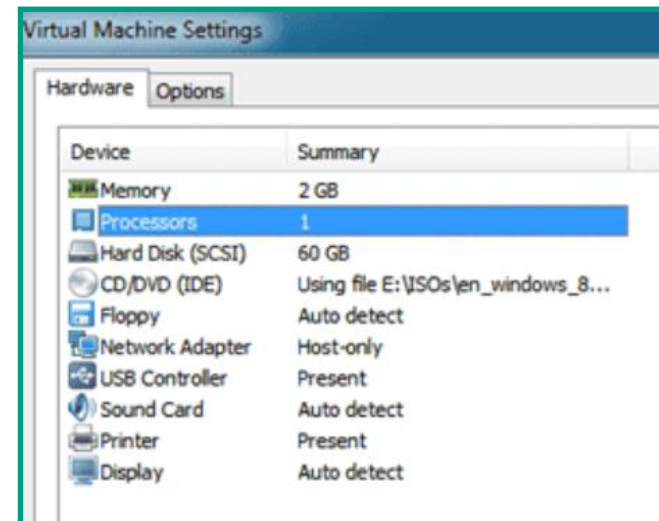Virtual NIC

DHCP server

NAT device

VMNet1
Host machine

VM can use DHCP for network configuration

Remember

At Hostonly:
- No internet connection from VM.
- VMs in the network can reach each other.
- From Host (own PC) VM can be reached (via added virtual network card host.

Virtual Machine Settings

Hardware | Options

| Device	Summary
Memory	2 GB
Processors	1
Hard Disk (SCSI)	60 GB
CD/DVD (IDE)	Using file E:\ISOs\en_windows_8...
Floppy	Auto detect
Network Adapter	Host-only
USB Controller	Present
Sound Card	Auto detect
Printer	Present
Display	Auto detect

Troubleshooting Network connection VMware workstation

Troubleshooting Network connection VMware workstation

- Not the right connection?
  - Check settings on VM:
    is Network Adapter connected?
  - Does it have the correct setting
    (hostonly, bridged versus NAT)?
- Check Networking settings in
  Workstation:
  - Virtual Network Editor
  - Check VMnet0, VMnic1 and VMnic8
    - DHCP setting etc.
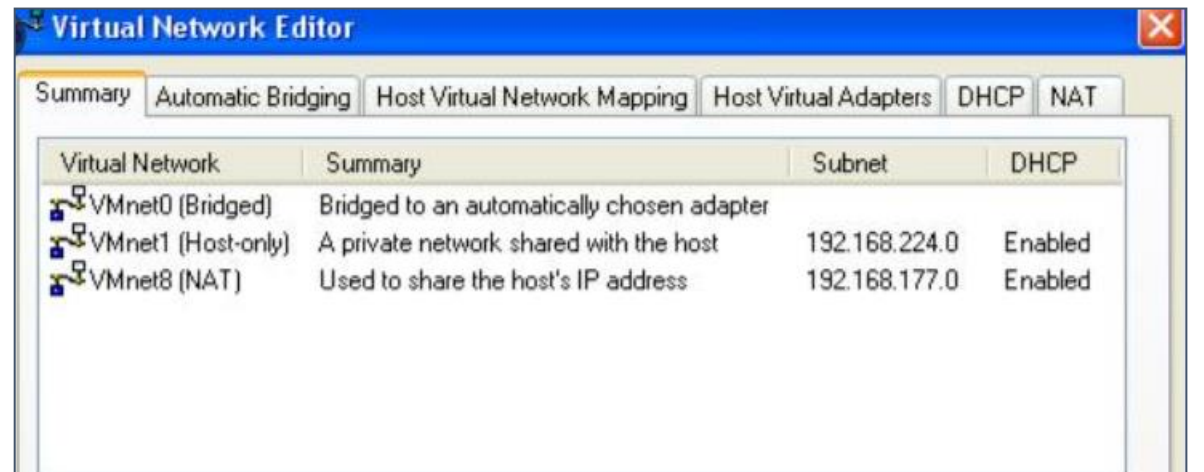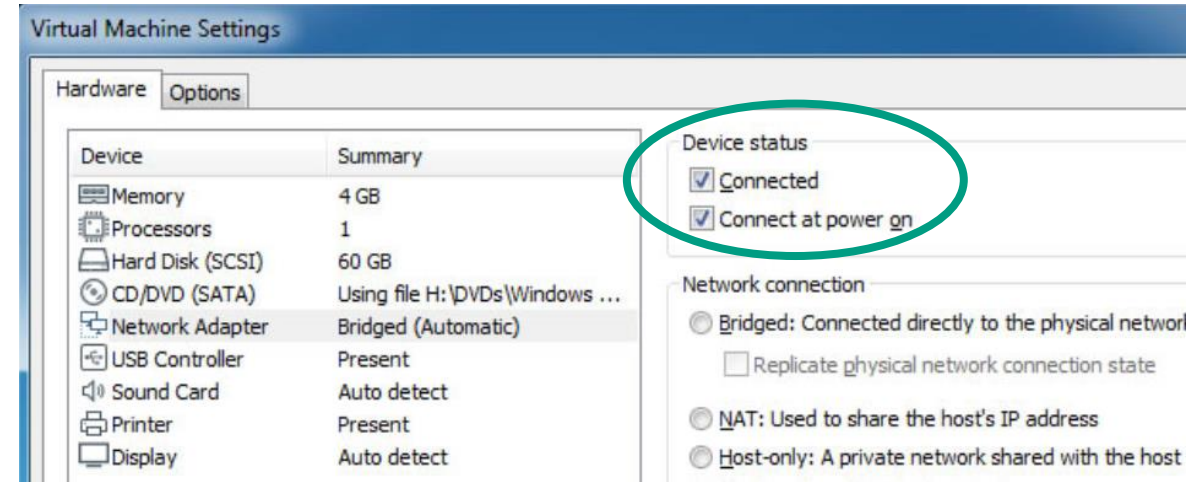
Troubleshooting: why does OSI knowledge help?

Browser on users computer

ERROR.

Web server

What is the cause of this error message (and which OSI layer is involved)?

1) The name saxion.nl could not be resolved
2) You are disconnected from the network
   - After checking, it appears that a static IP address has been set.
   - After checking, it appears that DHCP is set.
     - No IP address has been obtained
     - An IP address has been obtained.
3) Internal Server error

Working on the case

Case

- Do the assignments of week 4

Please consult the assignments document and the template report for more details.

Any questions?