École Pour l'Informatique et les Techniques Avancées - EPITA

BSc L1 – 19 April 2024

Course: Introduction to Computer Networks

Course instructor: M Salman Nadeem
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Introduction to Computer Networks

Course schedule (tentative)

Date & Time	No.	Topics	Duration (hours)
Fri 19/04/24 – 10:00–13:00	**1**	**Primer, Network protocols, types, topology, architecture**	**3**
Fri 26/04/24 – 10:00–13:00	2	Network models, TCP/IP model, Packet switching	3
Sat 27/04/24 – 10:00–13:00	3	Physical Layer (Function, Signals, Modulation, Multiplexing, Transmission media & Hardware, Optical networks)	3
Sat 27/04/24 – 14:00–17:00	4	Data Link Layer (Function, Framing, Protocols, Flow control, Access control, Error correction, Hardware)	3
Fri 03/05/24 – 14:30–17:30	5	Network Layer (Function, IP addressing and subnets)	3
Sat 04/05/24 – 10:00–13:00	6	Network Layer (Routing algorithms and protocols), Internet Control Message Protocol	3
Fri 17/05/24 – 14:00–17:00	7	Network Layer (IGP & EGP), Autonomous System, Border Gateway Protocol	3
Fri 18/05/24 – 14:00–17:00	8	Transport Layer (Function, Flow and congestion controls, Protocols)	3
Fri 24/05/24 – 10:00–13:00	9	Application Layer (Function, Protocols)	3

Introduction to Computer Networks

Course schedule (tentative)

Date & Time	No.	Topics	Duration (hours)
Mon 27/05/24 - 10:00-13:00	10	Cross-layer process: Access Control Lists	3
Wed 29/05/24 - 14:30-17:30	11	Cross-layer process: Network Address Translation	3
Thu 30/05/24 - 09:00-11:00	12	Review / Open-session	2
		Total	***35***
Fri 31/05/24 - 14:30-15:30		EXAM	1

GRADING criteria :

- Class participation comprising **attendance** & **reactivity**): 10%
- **Exercises** (practical work): 40%
- Final evaluation (**Quiz** & **Exercises**): 50%

Check policies in the course outline

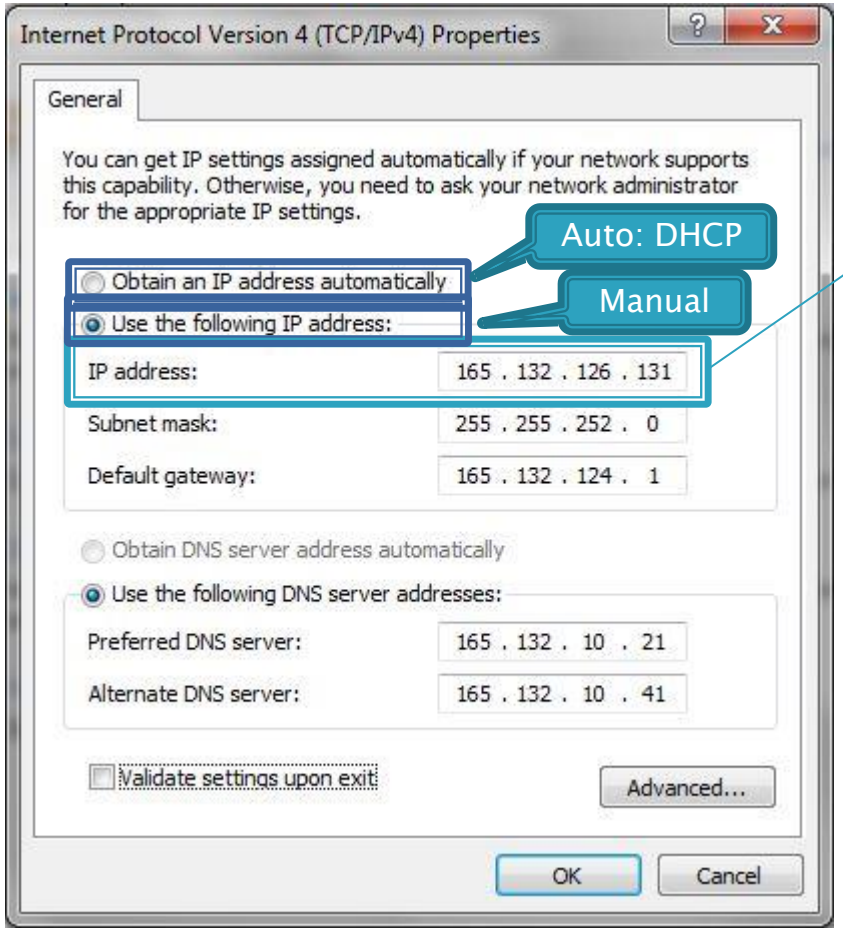
Notes & Collaboration

- MS Teams Channel:
  "**Introduction to Computer Networks - Spring 2024 | BSc**"
  - Course specific channel to collaborate
    - You must join using this code: **lt5c2te**
  - Will be used for:
    - Course related announcements
    - Share course slides/material
    - Carry out assignments & quizzes
- Course Mindmap:
  - For better organization and easy refreshing of course topics
  - Access link (read-only):
    https://www.mindomo.com/mindmap/f7369916224e4015bdc19c048368e824

Lecture 1 Outline

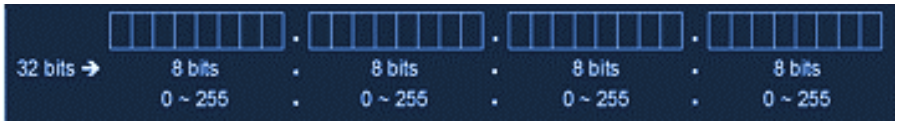
- **Primer**
  - **IPv4 Network connection setup**
  - **IP Address Assignments (IPv4, Subnet mask, Default gateway, DNS Server)**
  - **Physical setup (Dial-up, DSL, Cable)**
  - **Class exercise 1**
- Computer networks
  - Protocols
  - Types
  - Topologies
  - Architecture
  - Class exercise 2
- TCP/IP & OSI Model
  - Introduction
  - Layered network architecture properties
  - Connection approaches

IPv4 Network connection setup (1/2)



IP address is assigned to an interface port

- Device Internet interface: 165.132.126.131
- IPv4: 32 bits (4 bytes)/4 Octets address format



8 bits: 00000000 ~ 11111111 (binary)
= 0 ~ 255 (decimal)

8bits = 1 Byte = 1 Octet

IPv4 Network connection setup (2/2)

- Identifiers representation (Decimal and Binary):

165.132.126.159
(Dotted decimal notation)

10100101.10000100.01111110.10000011
(Dotted binary notation)

- Equivalent decimal value?

2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0	
1	1	1	1	1	1	1	1	← Binary form
128	64	32	16	8	4	2	1 = 255	← Decimal form

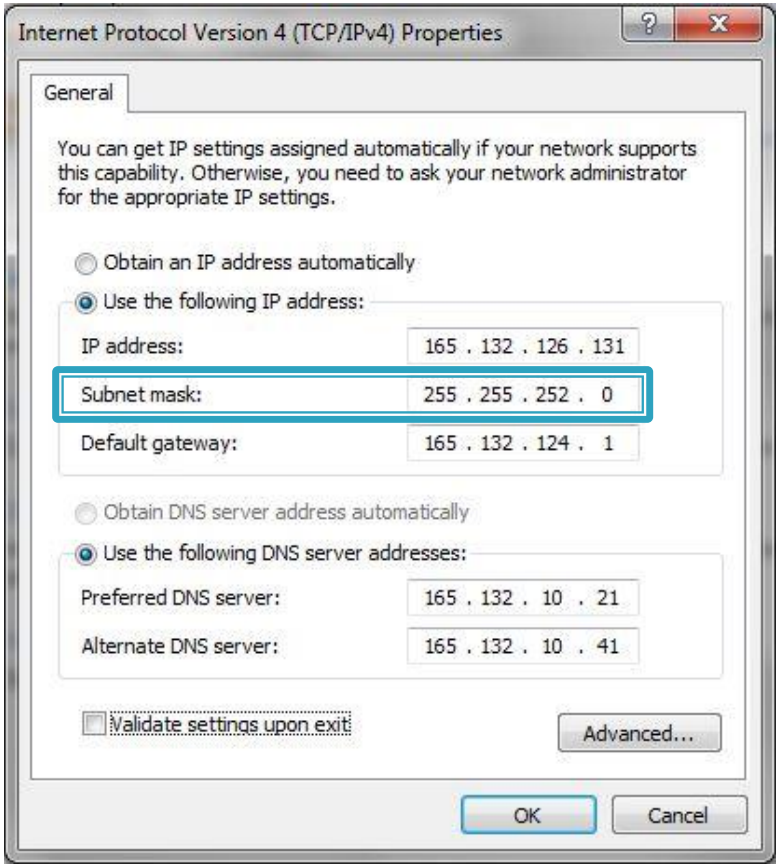
The largest decimal number that can be stored in an IP address octet is **255** (the significance of this should become evident later in this course).

- IP Address Assignments
  - Devices may have multiple Interfaces, and each can have its own IP address e.g. smartphone:
    - Mobile communication standards
      - 2G – Global System for Mobile (GSM)
      - 3G – Universal Mobile Telecommunications System (UMTS)
      - 4G – Long Term Evolution (LTE)
      - 5G – New Radio (NR), …
    - Wi-Fi -> Specific IP address
      - IEEE 802.11 a/b/g/b/ac (2.4, 5 GHz)

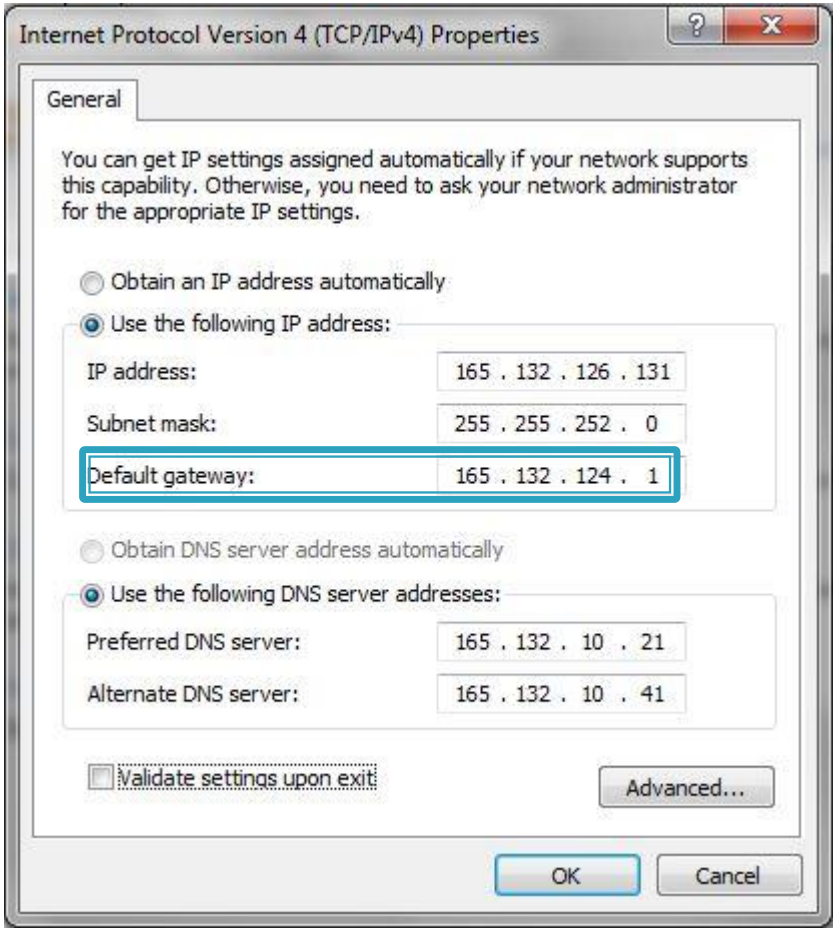
- Other examples?
  - Server e.g., having multiple NICs
  - VLAN (e.g., sub-interface)
  - Perimeter and DMZ isolation
  - …

Subnet Mask

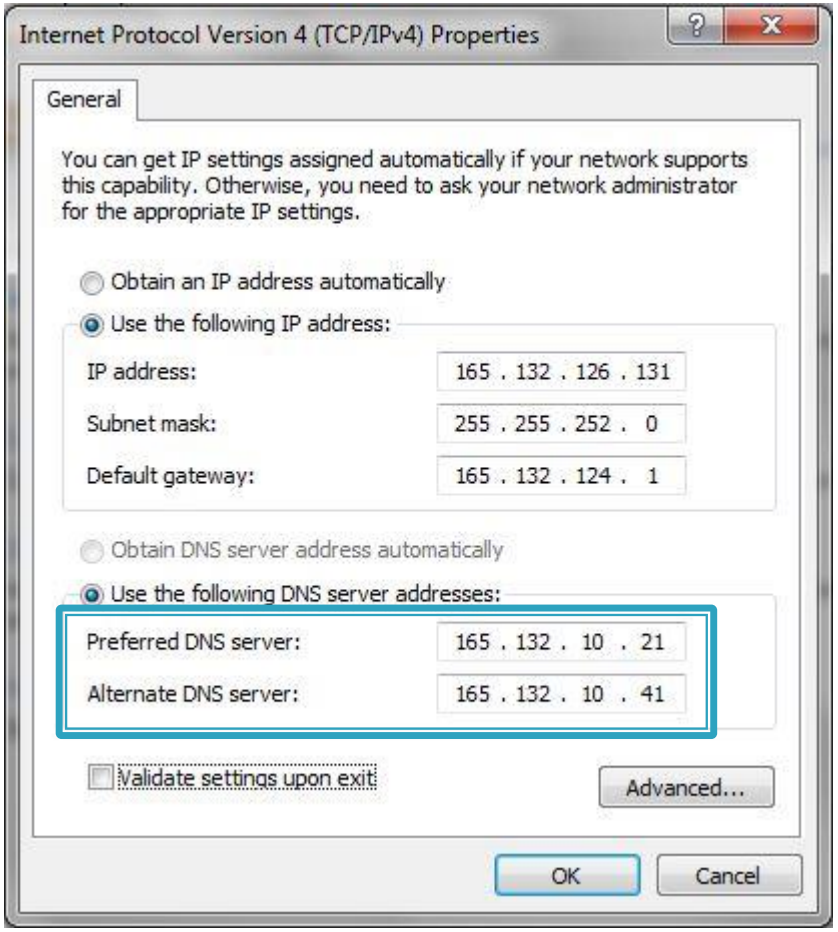
- Internet is divided into Subnets, and Subnets are divided into smaller Subnets…
  - Subnet Mask is based on the size of the Subnet that the Client (device) is connected to
- Used to mask (filter) the IP address (in IP packets) to determine the respective subnet
  - 255.255.252.0
    = 11111111.11111111.111111**00**.00000000
    Network part (2^{22}) | Host part (2^{10})
- Subnet Mask can be used to find the Subnet size e.g.
  - 2^{10} = 1,024 IP addresses are on this subnet



- Default Gateway:
  - The dedicated Internet Router that will send and receive all Internet IP packets for this device
  - Device will access the Internet (i.e., send and receive all IP packets) through this Gateway



- DNS (Domain Name Server)
  - DNS is a server that converts hostnames in to IP addresses
  - 'Preferred' is the main one, 'Alternate' one is the backup
  - Hostname examples
    - E-mail address: ???@epita.fr
    - Domain name: www.epita.fr



- **Can we change it ?**
  - **Why?**
  - **How?**

ℹ For more info: https://dnsprivacy.org/wiki/

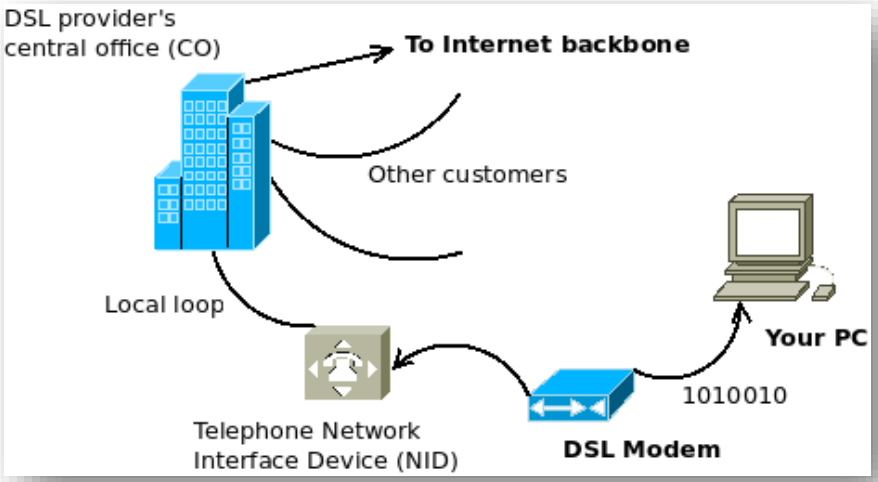
Is that it?

- How do we actually connect to the internet?

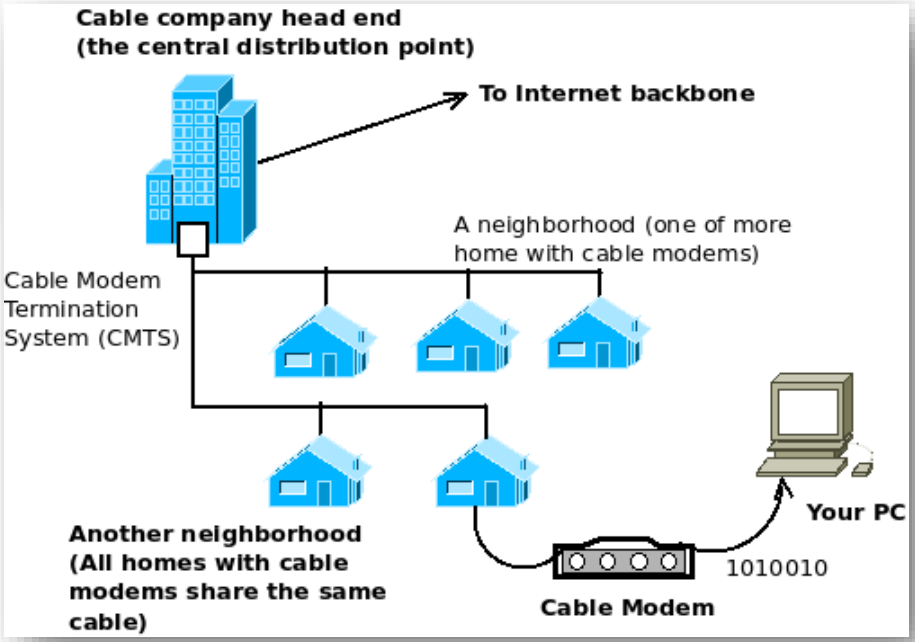
Feature	Method		
	Dial-up	DSL	Cable
Equipment	Modem	DSL modem, Ethernet card	DSL modem, Ethernet card
Requires	Phone service and ISP	Service and local or short distance to ISP office	Cable connection
Connection type	Dial to connect	Always on, dedicated	Always on, shared
Typical speed	56 Kbps (max)	Varies based on DSL type (e.g., b/w 128 Kbps and 24 Mbps	Varies by provider

Physical setup (1/2)

DSL



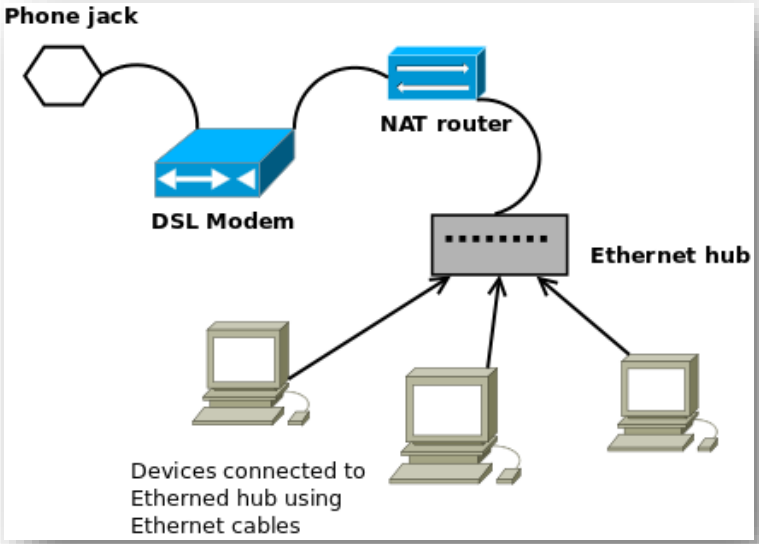
Cable modem



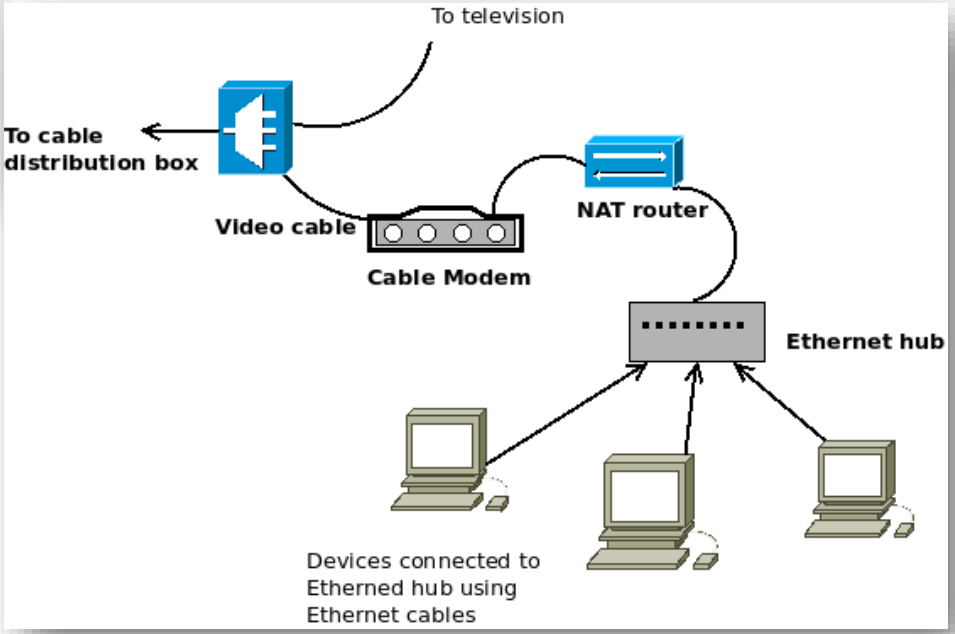
That seems nice, but will it protect your connection from intruders ?

Physical setup (2/2)

DSL (with NAT)

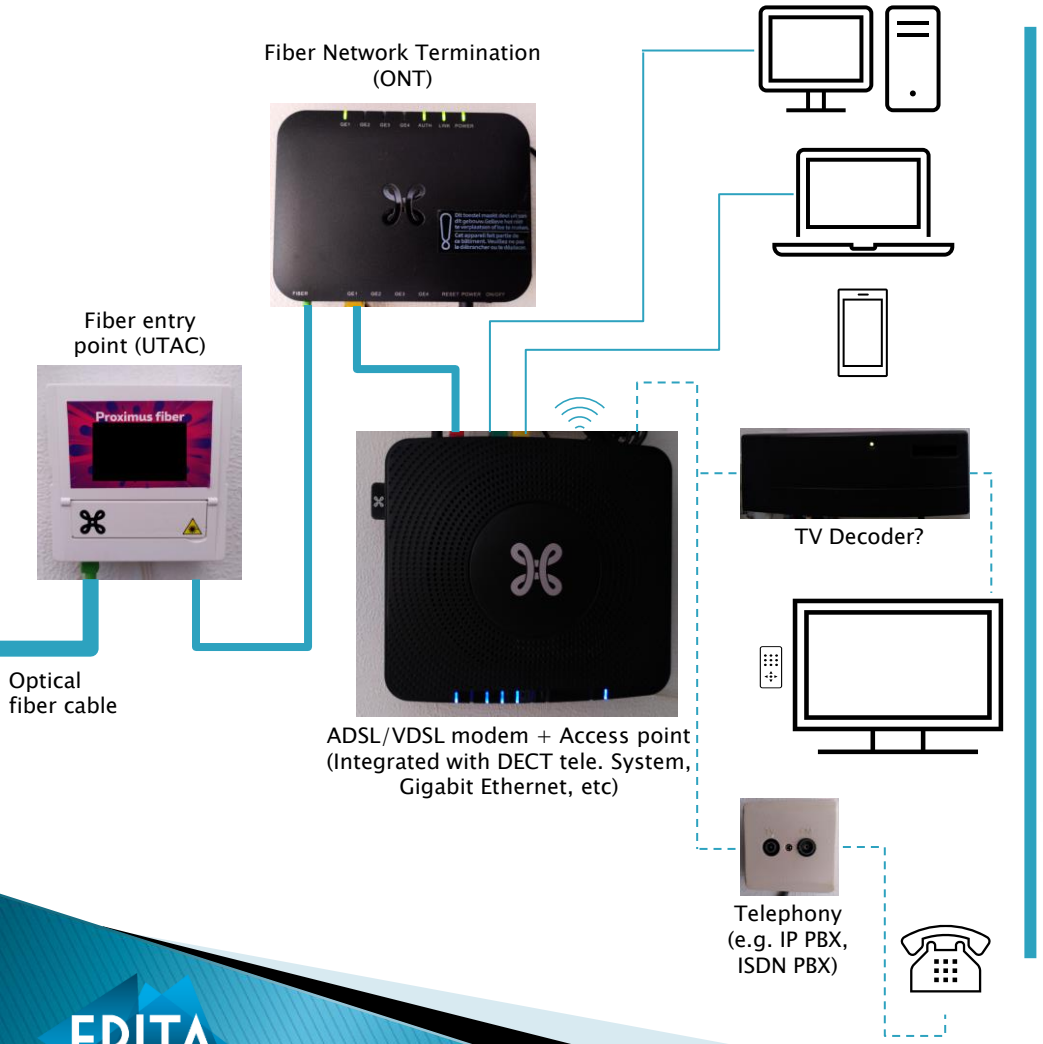


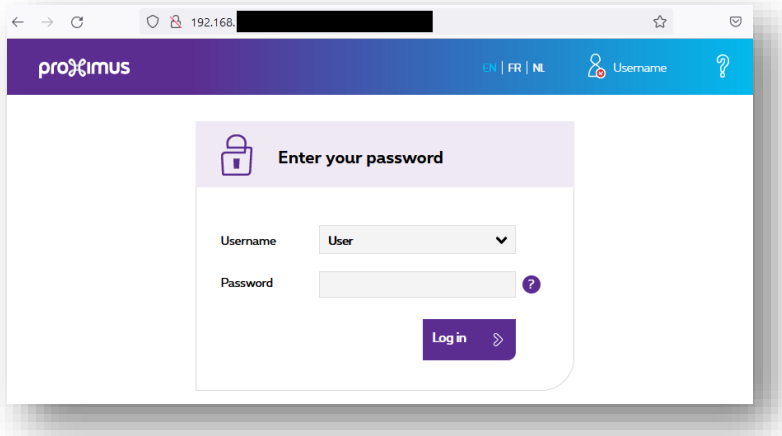
Cable modem (with NAT)



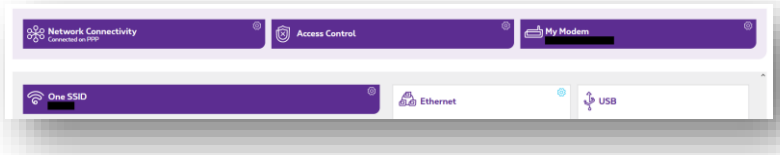
ℹ NAT: Will hide your internal IP address(es) from outside networks

Connection (physical) setup – what is what?





ADSL/VDSL modem + Access point (local) Interface



ADSL/VDSL modem + Access point (local) Interface Dashboard

Exercise 1: Practical work

- Answer following questions:
  1. Highlight each parameter of your TCP/IP connection configuration (IPv4)?
  2. Does your device has multiple IP assignments? (if yes, then highlight them)
  3. DNS server:
     - What is your DNS server?
     - Why is it preferable to protect DNS traffic?
     - Change your DNS server to other DNS server of your choice? (for the purpose of this exercise)
  4. Which connection (physical) setup (e.g., DSL, Cable model, …) are you directly connected to? **(visualize your answer)**
     -> see slide no.14 as an example

     -> Or use network simulator e.g. Cisco Packet Tracer (direct link)

     Others: https://nil.uniza.sk/network-simulation-virtualization-software-list

     - Would you like to switch to a different connection setup? If yes then, why?

Deadline: See 'Teams' Assignment section

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  - Class exercise 1
- **Computer networks**
  - **Protocols**
  - **Types**
  - **Topologies**
  - **Architecture**
  - **Class exercise 2**
- TCP/IP & OSI Model
  - Introduction
  - Layered network architecture properties
  - Connection approaches

Computer network?

- A group of interconnected devices, such as computers, printers, servers, and other network-enabled devices, that communicate and share resources with each other
  - Internet: A global system of interconnected computer networks
  - Network protocols can be completely different in nature
  - TCP/IP (5-layer model) is what links them
- **Protocols** allow networks to exchange data
  - Prescribed guide for conduct or action/or series of actions
  - Devices know in advance about the data to be exchanged along with its precise format
  - They are standards that specifies:
    - The format of the messages
    - How to handle errors

Who defines protocol as a standard?

Network types

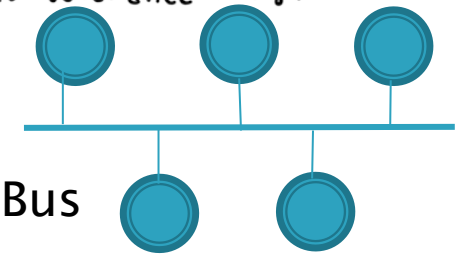
- There are numerous types of Networks (as per their **size** and **reach**)
  - LAN (Local Area Network): **Close devices/nodes** are connected using Ethernet cables/wireless media (e.g., Home network, same building network, ...); **0-2 km**
  - MAN (Metropolitan Area Network): It is **bigger than LAN** e.g., usually spans all over the city using copper wires/high speed fiber-optics, ...; **2-50 km**
  - WAN (Wide Area Network): It is **made up of multiple MAN's** and should span over 30 miles by convention/definition. It uses satellites, fiber-optics, copper wires etc; **50+ km**
  - VPS (Virtual Private Network): Private networks which contains clients (using VPN client application) from different locations under a Virtual Network
  - ... **Can you provide examples?**

What is network type is Internet?

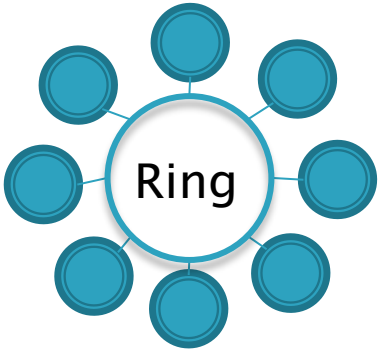
Network topologies

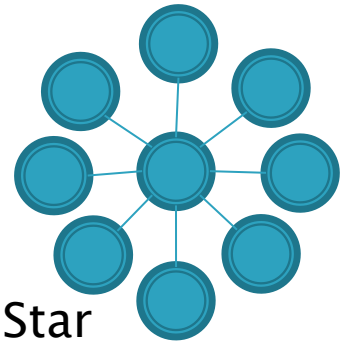
- Every network type (e.g., LAN, MAN, WAN, etc.) has a topology (physical layout) for each of its parts or as a whole
- Desirable aims (when choosing/building):
  - High speed (and bandwidth), High Fault-tolerance, Low cost

1) cost ↓ low
2) fault tolerance ↑ high.

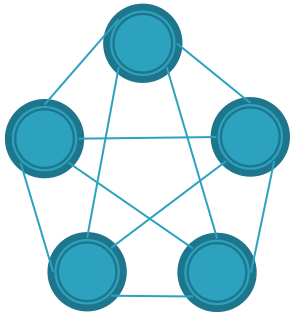


Bus

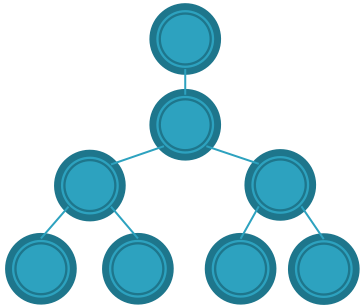




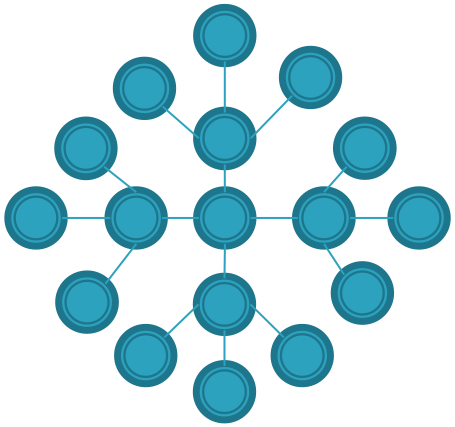
Star



Mesh



Hierarchical

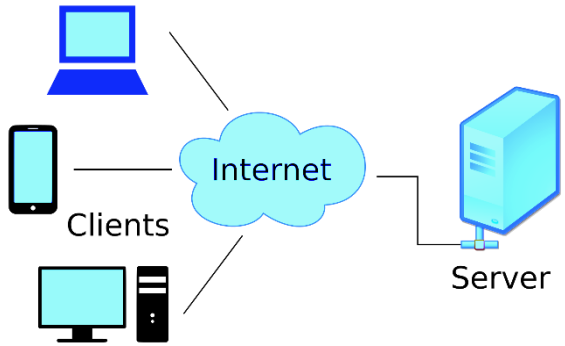


Extended star

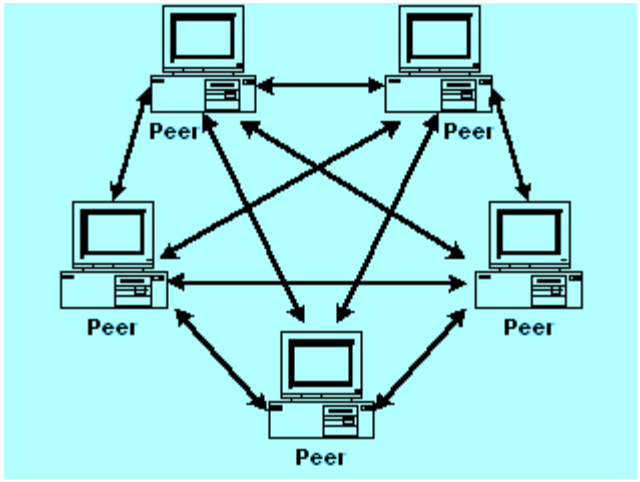
? What is network topology of the Internet?

Network architecture

- Each of the Network or its part has a **logical architecture** and works accordingly
- Predominantly, we have:



- Client/Server architecture (centralized)



- Peer-to-peer architecture (de-centralized)

Exercise 2: Practical work

- Based on your **existing** internet connection, answer following questions:
  1. Which protocol are you using to connect to the internet?
  2. What is the most probable network topology of your connection?
     - Make an informed guess!
  3. What is the logical network architecture of your connection? (in relation with your ISP)

Deadline: See 'Teams' Assignment section

Lecture 1 Outline

- Primer
  - IPv4 Network connection setup
  - IP Address Assignments (IPv4, Subnet mask, Default gateway, DNS Server)
  - Physical setup (Dial-up, DSL, Cable)
  - Class exercise 1
- Computer networks
  - Protocols
  - Types
  - Topologies
  - Architecture
  - Class exercise 2
- **TCP/IP & OSI Model**
  - **Introduction**
  - **Layered network architecture properties**
  - **Connection approaches**

Introduction

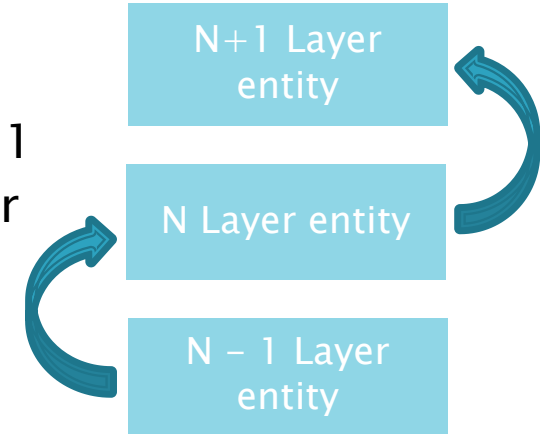
OSI 7 layer model	TCP/IP 5 layer model	Protocols	Protocol Data Unit (PDU)	Layer addressing
Application layer	Application layer	IMAP, FTP, SMTP, DNS, Telnet, SNMP, …	Data	Data
Presentation layer				
Session layer				
Transport layer	Transport layer	TCP, UDP, …	Segment (TCP), Datagram (UDP)	Port address
Network layer	Internet layer	IP, …	Packets	IP address (Source, Destination)
Data link layer	Network access layer	Ethernet, Wi-fi, Bluetooth, 3G, LTE, …	Frames	MAC address
Physical layer	Physical layer	Copper, Fiber optic cables, Wireless transmitters	Bits	n/a

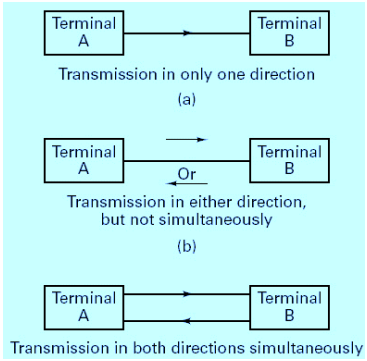
Open System Interconnection (OSI): ITU-T standard X.200 (ISO/IEC 7498-1)

DoD Model: Currently Maintained by IETF

Layered network architecture

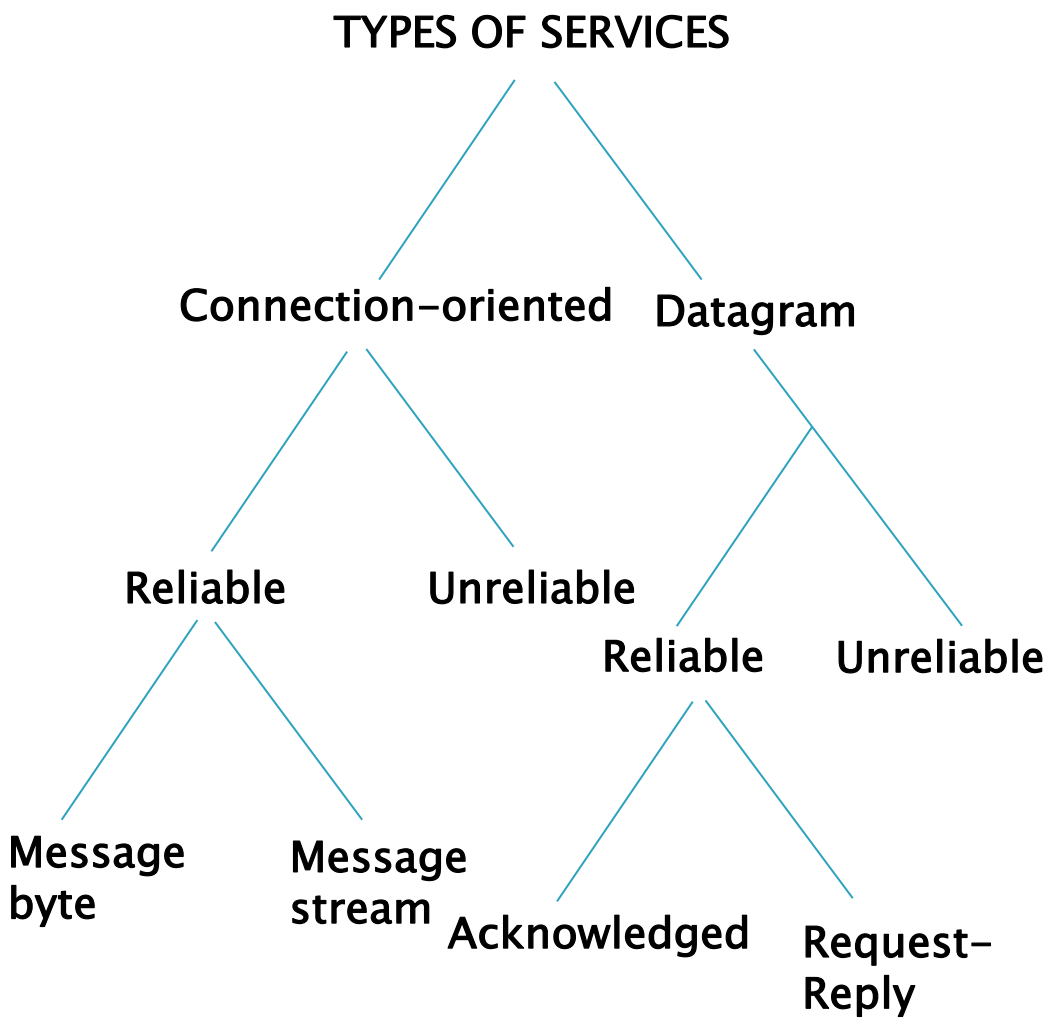
- Services are grouped in layered hierarchy
  - An entity of layer N uses only services of layer N-1
  - An entity of layer N provides services only to layer N+1
  - **TCP/IP model (however) does not require strict layering**
- Communication Transmission/Duplexity:
  - Simplex mode: Unidirectional e.g., Loudspeaker, TV…
  - Half-duplex mode: Either direction but only one-way at a time e.g., Walkie-talkie, police radio
  - Full-duplex mode: Both direction at same time e.g., Telephone





Connection approaches

- Connection-oriented: *Telephone system*
  - Path setup before data is sent
  - Data do not need addressing. Circuit number is used
  - Virtual circuits: Multiple circuits on one wire
- Connectionless: *Postal system (also known as datagram)*
  - Complete address on each packet
  - The address decides the next hop at each routing point



Open Exercise: Cisco IOS (1/3)

- Install Cisco Packet Tracer:

  LINK: https://www.netacad.com/courses/packet-tracer -> **Create an account**

  Alternate link: https://mailfence.com/pub/docs/MSalman/web/Emulator-Simulator/

- Cisco IOS System
  - IOS (Internetwork Operating System) comes in NOS (Network Operating System) category
  - Works on router and cisco switch
  - Use to configure, the monitoring and to detect problems
  - Works with Specific CPU (Motorola 68030, Orion/R4600...)

You can use any other program of your choice:
https://nil.uniza.sk/network-simulation-virtualization-software-list

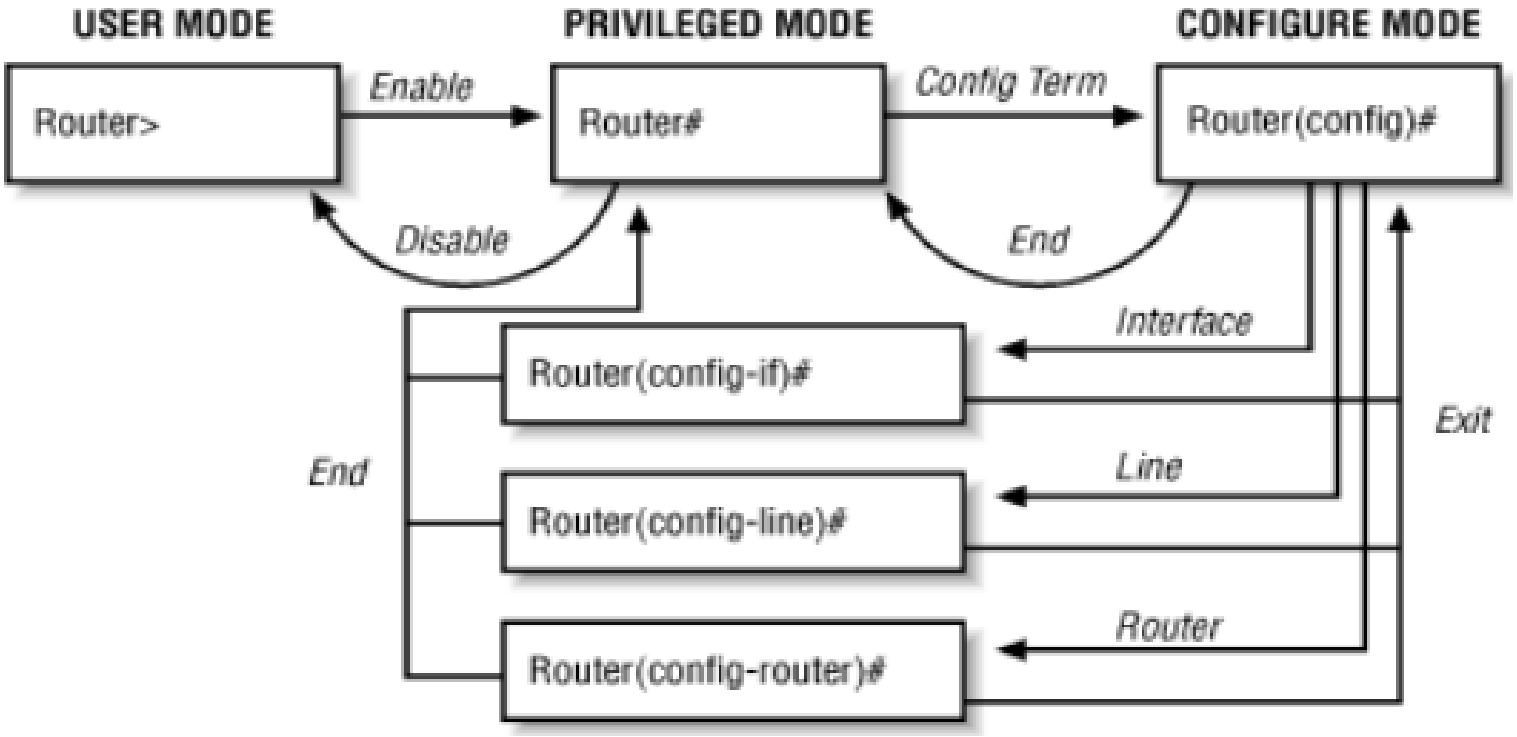
Open Exercise: Cisco IOS (2/3)

- Get yourself familiar:
  - Console port, using a physical access
  - Auxiliary port, for a connection through a modem
  - VTY (virtual TTY), access with Telnet or SSH
  - WEB
- Single mode (read only): hostname>
- Privilege mode (read,write): hostname #
- Configuration mode: hostname(config)#
- Special configuration mode:

  hostname(config-if)#

  hostname(config-router)#

Open Exercise: Cisco IOS (3/3)



Cisco lab: make backup if you have to switch off to make changes.

2) In Cisco CLI, use Tab to autocomplete commands

Lecture 1 ends here

- Course Slides: Go to MS Teams:
  'Introduction to Computer Networks - Spring 2024 | BSc'
  -> Files section

- Send your questions by email:
  mohammad-salman.nadeem@epita.fr
  OR via direct message using MS Teams

- Thank You!