

Information Technology Essentials — Lecture 11

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Networks

Computer Networks (Part 2)

Computer Networks

Definition

Computer Network is a collection of computer systems connected together that share resources and communicate with each other. It consists of two or more computers connected by communication lines. A computer network can be local (LAN) or wide (WAN).
A **Communication Protocol** is a set of standard rules, regulations, and procedures that define how the communication between two devices will reliably take place (initialization, communication, and termination):

In

There're various communication protocols out there. Each protocol provides **some services** to the connected computer. E.g.,:

- **HTTP.** HyperText Transfer Protocol, is used by a computer to transfer web pages ([your browser will generate HTTP messages](#)).
- **HTTPS.** HyperText Transfer Protocol — Secure, is used by a computer to transfer web pages securely.
- **FTP.** File Transfer Protocol, is used by a computer to transfer (download and upload) files over a network. [You can still use other protocols to download files](#) (e.g., HTTP, HTTPS, SFTP, etc).

Computer Networks

Definition

Communication Protocol Is a set of standard rules, regulations, and procedures that define how the communication between two devices will reliably take place (initialization, communication, and termination):

In

- **DHCP.** Dynamic Host Configuration Protocol, is used by a computer to obtain an IPv4 address so that it can communicate.
- **SMTP.** Simple Mail Protocol, is used by a computer to send emails.
- **POP3.** Post Office Protocol v3, is used by a computer to retrieves emails ([your mail client application will retrieve the emails for you](#)).
- **IMAP.** Internet Message Access Protocol, is used by a computer to retrieves emails while keeping copies.

Computer Networks

Definition

Computer Network is a collection of computer and other devices that are connected by a communication link that allows them to exchange data and share resources.

Communication Protocol Is a set of standard rules, regulations, and procedures that define how the communication between two devices will reliably take place (initialization, communication, and termination):

In

- **DNS.** Domain Name System, is used by your computer to resolve domain names into IPV4 address. Certain connected computer are identified by a human-readable name, called domain name (e.g., www.ensia.edu.dz). Your computer needs to know the IPv4 address of that computer given its domain name — it uses DNS.
- **Telnet.** Is used by a computer to connect to a remote computer and execute commands. It uses username and password in plaintext.
- **SSH.** Secure Shell, is used by a computer to securely connect to a remote computer and execute commands.

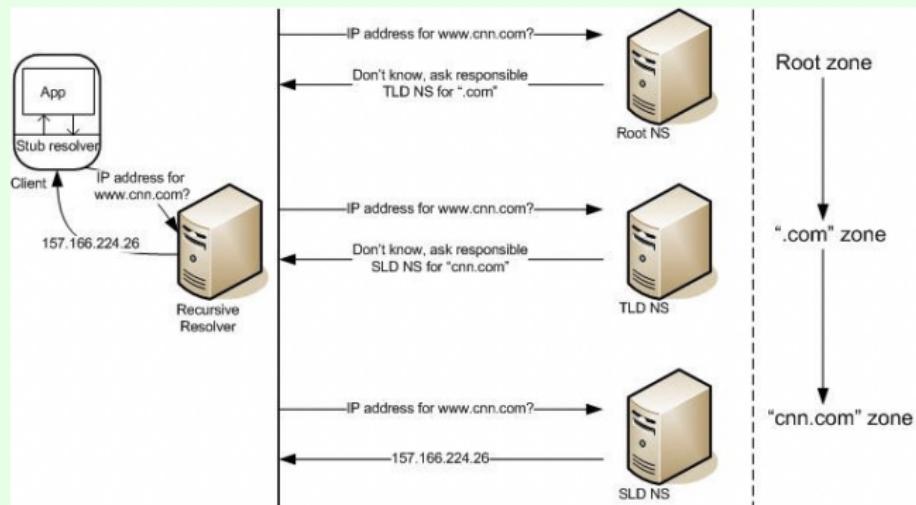
Computer Networks

Definition

Computer Networks are collections of computer systems connected by a network.

- ☞ **DNS** is used by your computer to resolve domain names into IPV4 address. The string **www.cnn.com** is composed of a subdomain **www** of the domain **cnn.com**, of the top-domain **.com**.

In



Computer Networks

Definition

Communication Protocol Is a set of standard rules, regulations, and procedures that define how the communication between two devices will reliably take place (initialization, communication, and termination):

- **IP.** Internet Protocol, is used by your computer as a carrying protocol for HTTP, HTTPS, DNS, Telnet, SSH, FTP, POP3, etc, so that the packets reliably arrive to destination (**it adds IPv4 addresses**).
- **TCP.** Transmission Control Protocol, is used by a computer reliably establish end-to-end connection. **Allows a local application to talk to another application on a remote computer.** **Runs on top of IP.**
- **Ethernet.** Is a protocol that allows two network devices to communicate using a direct link (**It adds the physical MAC addresses**).

Networking (Exercise)

Answer the following questions:

- How do we call the information that is added by each protocol to the packet we want to send over the network?
- Which protocol allows a computer to be assigned an IPv4 address?
- How do we call the process that allows the use of multiple protocols?
- Which protocol allows secure access to website?
- Which protocol allows a computer to securely establish a connection with a remote computer and run commands?
- Which protocol allows packets to be carried out to destination?
- Which communication protocol allows a computer to retrieve the IPv4 address of a webserver?

Networking Devices

Networking Devices

There are various networking devices (here the symbol ~ refer to analogy):

- ① **Servers.** Computers that are configured to provide users with services.
~ road network: shops, gas station, parking lots, and offices in a city
- ② **Routers.** These are devices responsible for directing packets.
~ road network: road directional signs (to cities)
- ③ **Switches.** These are devices responsible for directing packets.
~ road network: facilities directional signs (e.g., restaurant, shops, police office, parking lot, bus station, school, etc)



Networking Devices

There are various networking devices (here the symbol ~ refer to analogy):

① **Servers.** Computers that are configured to provide users with services

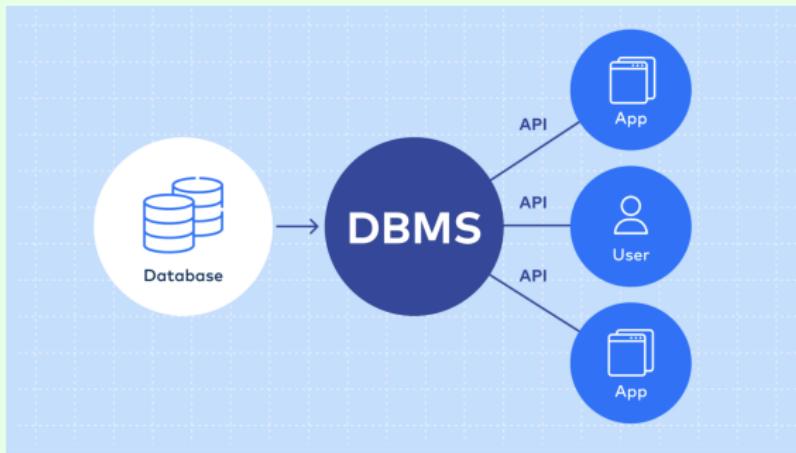
- ① **Servers.** Computers that provide users with services, such as:
 - **File Server.** Manages and provides access to files.
 - **Web Server.** Hosts and serves webpages.
 - **Database Server.** Manages and provides access to databases.
 - **Application Server.** Manages and provides access to applications.
 - **Mail Server.** Manages and transfers emails.
 - **Print Server.** Manages a set of printers.
 - **DNS Server.** Resolves domain names to IP addresses.
 - **DHCP Server.** Assigns and manages IP addresses in a network.
 - **DB Server.** Provides access to a database through a DBMS.
 - And more ...

Networking Devices

There are various networking devices (here the symbol ~ refer to analogy):

- **Servers.** Computers that are configured to provide users with services

- ☞ **Database Server.** Is a server that runs a database management system (e.g., MySQL) to manage and provide access to a database.



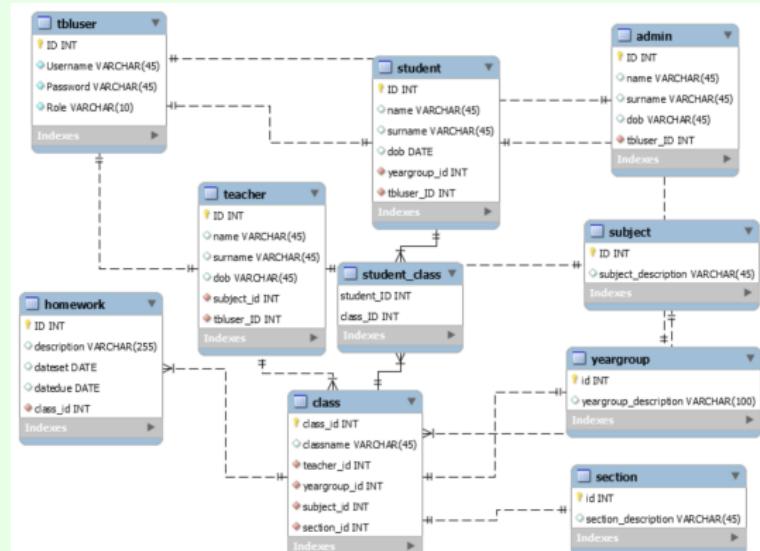
- And more ...

Networking Devices

There are various networking devices (here the symbol \sim refer to analogy):

• **Servers.** Computers that are configured to provide users with services

Database. A collection of logically-related files, containing organized information about specific entities, in particular field, and is stored in a way that allows easy retrieval, management, and updating of information.

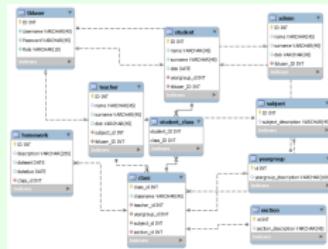


Networking Devices

There are various networking devices (here the symbol ~ refer to analogy):

💡 **Servers.** Computers that are configured to provide users with services

Database. A collection of logically-related files, containing organized information about specific entities, in particular field, and is stored in a way that allows easy retrieval, management, and updating of information.



If the database is of type relational (i.e., uses tabular structure to store data), you can **query** a database using **SQL** (Structured Query Language) to retrieve information from the database. E.g.,

Select * from student where name=“Abdeallah”

Networking Devices

There are various networking devices (here the symbol ~ refer to analogy):

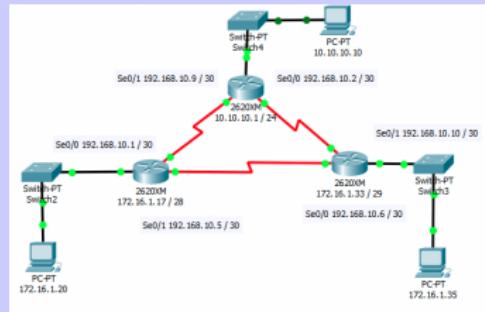
① **Servers.** Computers that are configured to provide users with services

② **Routers.** Computers responsible for directing packets (**routing**) to the right direction so that the packets reach the correct destination:

In this figure, the devices labeled by 2620XM represent routers.

The router maintains a data structure, called **routing table**, which dictates to the router where to send a packet (which router's exit interface) so that the packet goes to the right direction.

An entry in the routing table would typically contain: the **IPv4 address** of a remote network and the router's **output interface** toward that network.



Networking Devices

There are various networking devices (here the symbol ~ refer to analogy):

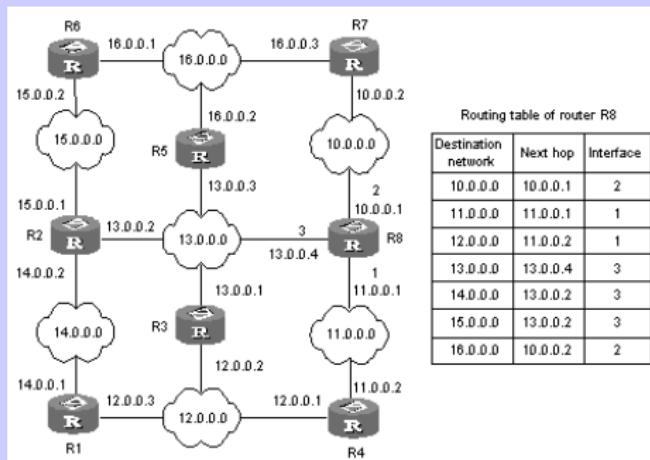
① **Servers.** Computers that are configured to provide users with services

② **Routers.** Computers responsible for directing packets (**routing**) to the right direction so that the packets reach the correct destination:

The figure below illustrates the routing table of Router 8:

The router constructs its routing tables either, manually by the **network administrator** (**root** in Unix-like OSs), or dynamically, using a **routing protocol**.

There are various routing protocols, e.g., RIP, OSPF, BGP, ISIS, etc.



Networking Devices

There are various networking devices (here the symbol ~ refer to analogy):

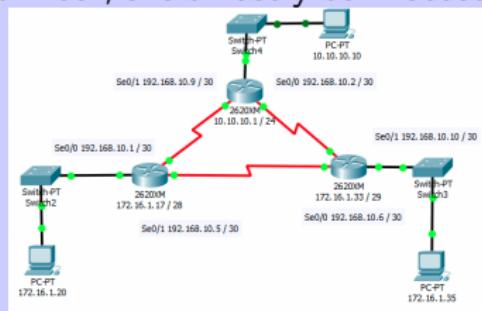
① **Servers.** Computers that are configured to provide users with services

③ **Switches.** Devices responsible for directing packets to the right destination within a local network:

End-point devices, e.g., computers, server, printer, are directly connected to a network through a switch, via the switch's **RJ45 ports**.

When a switch receives a packet, it delivers it to the right destination based on the destination MAC address.

The switch maintains a data structure, known as the **MAC table**, that stores (MAC address, RJ45 port).



Networking Devices

There are various networking devices (here the symbol ~ refer to analogy):

- ④ **Hubs.** Devices responsible of broadcasting packets to all
 - ~ road network: a town square where everyone gathers
- ⑤ **Repeaters.** Devices responsible for extending packets reachability.
 - ~ road network: thumb-lifting, taxi, bus, ...
- ⑥ **Gateways.** These are devices responsible for connecting two networks of different types
 - ~ road network: country boarders and costumers



Networking Devices

There are various networking devices (here the symbol ~ refer to analogy):

① **Servers.** Computers that are configured to provide users with services

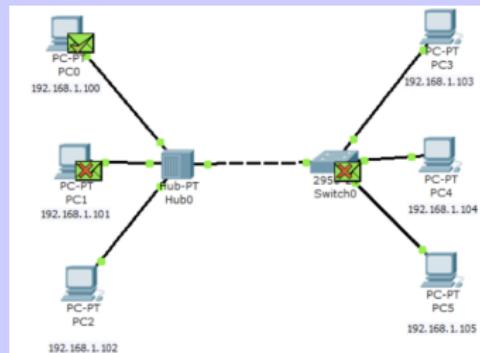
④ **Hub.** Devices responsible for broadcasting a packet to all computers connected to it:

End-point devices, e.g., computers, ..., server, can directly be connected to a network through a hub (**RJ45**).

When a hub receives a packet, it broadcasts it to all output port (except source).

A hub does not have the capabilities to read MAC addresses as the switch does.

The hub is an old device and has been replaced by switches.



Networking Devices

There are various networking devices (here the symbol ~ refer to analogy):

① **Servers.** Computers that are configured to provide users with services

⑤ **Repeater.** Devices responsible for **amplifying** a signal so that the latter reaches longer distances:

Routers, switches, hubs, and computer can be connected to a repeater to extend their reachability.

When a repeater receives a signal (that represents a packet), it amplifies it so that the signal can travel a longer distance than the default distance.



There are wired and wireless repeaters.

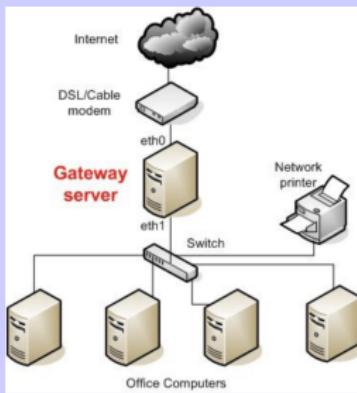


Networking Devices

There are various networking devices (here the symbol ~ refer to analogy):

➊ **Servers.** Computers that are configured to provide users with services

➋ **Gateway.** A computer that connects two different (or same) type of networks, e.g., an Internet network with a cellular network (4G):



Here, the gateway is used to connect an Ethernet network to a DSL network.

Networking Devices

There are various networking devices (here the symbol \sim refer to analogy):

- ⑦ **Wireless routers.** Devices responsible for directing (routing) packets among multiple networks.
~ road network: GPS application — Google Maps
- ⑧ **Wireless access points.** Used to allow wireless access to networks.
~ road network: An access point is like a ticket booth at an event. It controls access to a specific area.
- ⑨ **Bridges.** Allow to extend a network beyond its covered area.
~ road network: bridges linking two locations



Networking Devices

There are various networking devices (here the symbol \sim refer to analogy):

1 **Servers.** Computers that are configured to provide users with services

- 7 **Wireless router.** Is a normal router but has wireless capabilities. I.e., it can communicate with other devices using the radio medium. It can also act as a **wireless access point**.
- 8 **Wireless access point.** Is a device that allows to create a wireless network, e.g., Wi-Fi network (viz., next slide).
- 9 **Bridge.** It is a device to bridge two networks of same type. It can be a wired bridge as well as a wireless bridge.

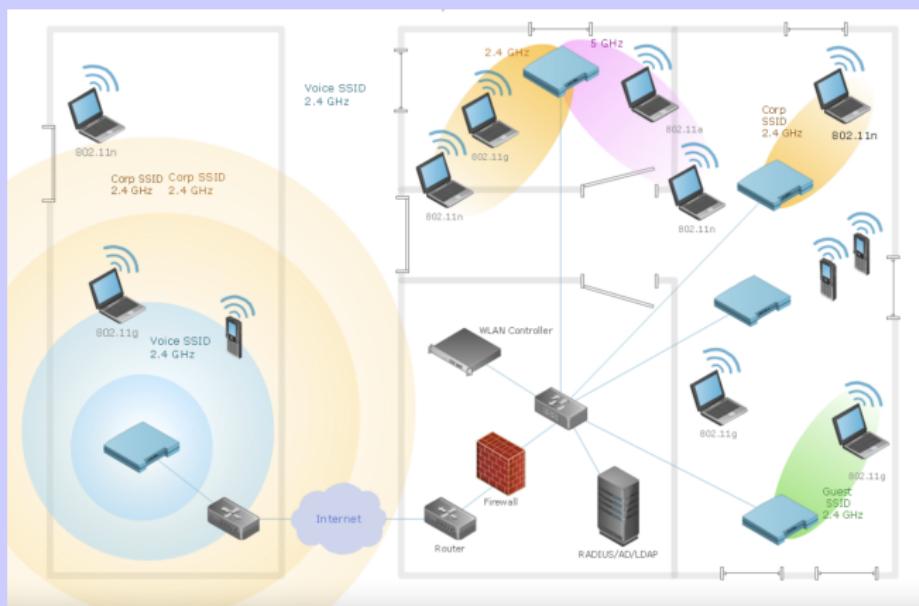
A **Wi-Fi** network is characterized by a name, called **SSID**, a **password-based security mechanism** (e.g., WEP, WPA, WPA2, WPA3), a **radio channel** (e.g., 1, 2, ..., 13), an **operational mode** (infrastructure or AdHoc), a **range** (e.g., 50m-radius sphere), and other.



Networking Devices

There are various networking devices (here the symbol ~ refer to analogy):

💡 **Servers**: Computers that are configured to provide users with services



Proxy Servers

Proxy server. Is an intermediate server that acts as a gateway between a user's computer and the Internet (i.e., web-sites or web-services).



Instead of connecting directly to a website or other Internet resources, the user's computer first connects to the proxy server, and then the proxy server connects to the destination (website or web-service) on behalf of the user.



☞ Note that there are **forward proxies** and **reverse proxies**.

Proxy Servers

Proxy server. Is an intermediate server that acts as a gateway between a user's computer and the internet (i.e., web-sites or web-services).

Proxies can be used for various purposes:

① **Bypassing Geo-restrictions.** If the user is blocked from directly accessing a website, they can go through the proxy to access that website..

- If the country hosting a website is blocking some source IPv4 addresses, but allowing some proxies (installed in their lands or allies lands).
- If a country is blocking access to some websites, but allowing proxy connections (Access to website will be established in a **tunnel**).

② **Proxy DNS.** Instead of using the ISP's servers, you could configure your own DNS server at home (e.g., using piHole and OpenDNS) to protect your families. This would allow you to perform:

- Content Filtering and Access Control.
- Caching proxy servers can store copies of frequently accessed resources locally, reducing the need to fetch them from the Internet each time.

Proxy Servers

Proxy server. Is an intermediate server that acts as a gateway between a user's computer and the internet (i.e., web-sites or web-services).

Proxies can be used for various purposes:

③ **Improving Security.** Proxies can be used to implement **VPNs** (Virtual Private Networks), i.e., secure communication tunnels.

- Proxy servers can act as an additional layer of security, inspecting and filtering incoming and outgoing traffic for malicious content.
- They can be part of a defense-in-depth strategy to protect against various online threats.

④ **Enhancing Privacy and Anonymity.** Users can use proxy servers to hide their IP addresses and enhance their online privacy (where users don't want their identity or location to be easily traced).

- Use **VPN** client software, e.g., HotSpot Shield, Tor Browser, etc.

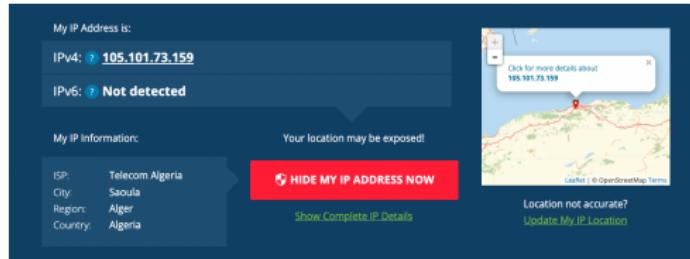
⑤ **Load-Balancing.** Reverse proxy servers can distribute incoming network traffic across multiple servers to ensure that no single server is overwhelmed (e.g., try **\$ nslookup www.youtube.com**).



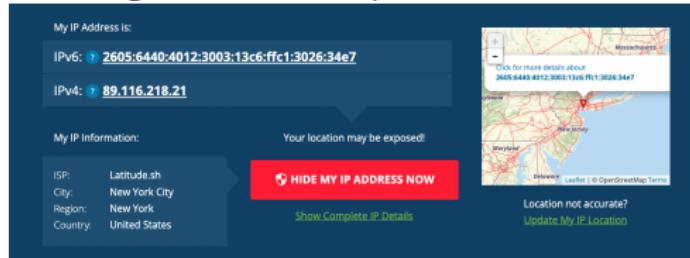
Proxy Servers

Proxy server. Is an intermediate server that acts as a gateway between a user's computer and the Internet (i.e., web-sites or web-services).

This is an example of using HostSport Shield VPN client software:



We got them, oops, we lost them

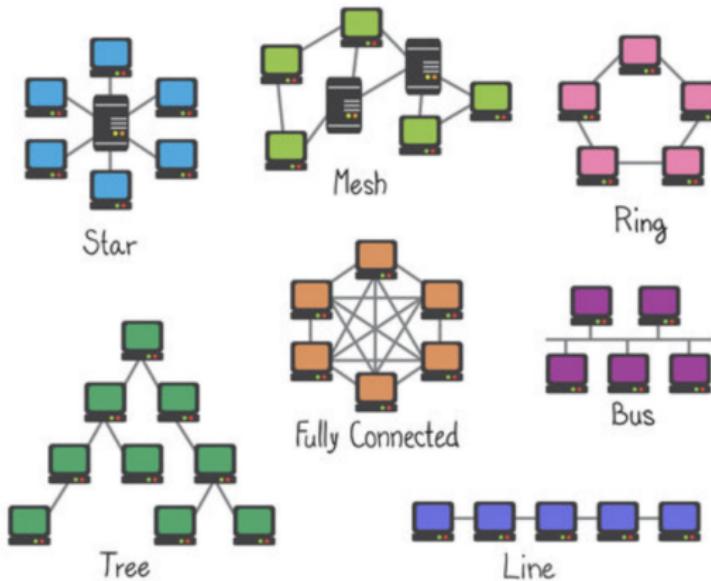


You can try that yourself at: <https://whatismyipaddress.com/>

Network Topologies

Network Topologies

Networks may take various geometric forms, such as point-to-point, bus (multi-point), star (ring), mesh and full mesh, tree (hierarchical), and hybrid.



Networking (Exercise)

Answer the following questions:

- What is the difference between a switch and a hub?
- What is the main function of a router?
- Which device should be used to extend the range of a signal?
- Which device is used to link the CCP network to Internet?
- Which device can be used to create a Wi-Fi network?
- Which device does not understand IPv4 and MAC addresses?
- Which network topology is used by DNS?
- Which devices allows users to go anonymous over the Internet?

Network Coverage

Network Coverage

The range of a network spreads out over a geographic area. Based on covered area, we distinguish (PAN, LAN, MAN, and WAN):

- **Personal Area Network.** This network spreads out to a radius of few meters, like in a office or room.

When a wireless technology is used, we call it a WPAN: Bluetooth

- **Local Area Network.** This network spreads out to a radius of 300m, like in house, entreprise, university, establishment, factory, etc.

When a wireless technology is used, we call it a WLAN: Wi-Fi network

- **Metropolitain Area Network.** This network spreads out over a city.

When a wireless technology is used, we call it a WMAN: WiMax

- **Wide Area Network.** This network spreads out over a country's land, continent, or wolrd. E.g., the **Internet**.

When a wireless technology is used, we call it a WWAN: cellular network (GSM, 3G, 4G, etc), Starlink, ect

Network Communication Technologies

Network Communication Technology

Network technology in the context of computer networks defines the mechanisms, techniques, tools, and communication protocols to facilitate the communication between the nodes of the network (two categories):

Wired Communication Technologies. Facilitate communication and data access using wires and cables:

- **Ethernet:** used to implement LANs.
 - **DSL and ADSL:** uses PSTN (Telephone lines) to access Internet.
 - **Optical fiber:** uses optical fiber cable to access Internet (higher rate).
 - **Token-Ring:** was once used to implement LANs.
- ☞ These technologies aim to guarantee a certain level of reliable communication, fast communication, secure communication, and global communication (**The Backbone of Internet**).

Network Communication Technology

Network technology in the context of computer networks defines the mechanisms, techniques, tools, and communication protocols to facilitate the communication between the nodes of the network (two categories):

Wireless Communication Technologies. Facilitate communication and data access using electrical and electromagnetic radio waves:

- **Satellites:** Use cooperative satellites to broadcast information.
 - **Cellular technologies:** Includes, GSM (2G), GPRS (2.5G), EDGE (2.75G), UMTS (3G), and LTE (4G), used to implement wireless telephone networks (voice only, data only, and then voice + data).
 - **Wi-Fi:** used to create wireless LANs.
 - **Bluetooth:** used to create wireless PANs.
 - **RFID:** used for wireless authentication purposes.
- ☞ These technologies aim to guarantee a certain level of fast communication, secure communication, flexible communication, cheap communication, and **mobile communication**.

The Internet

Internet. Is the **Interconnection of Networks**. It is the network that connects all public and private networks (that are connected) together.



- The Internet (1989) originated from the **ARPANET** (1969).
- Internet uses protocols such as **IP** and **TCP** to enable communication.
- Internet consists of all types of network devices, topologies, and technologies we've discussed so far, enabling **global access to information**.

- End.