Fundamentals of Computer Engineering

Module II - Unit 7
Network.

Teachers: Moisés Martínez (1ºA English)

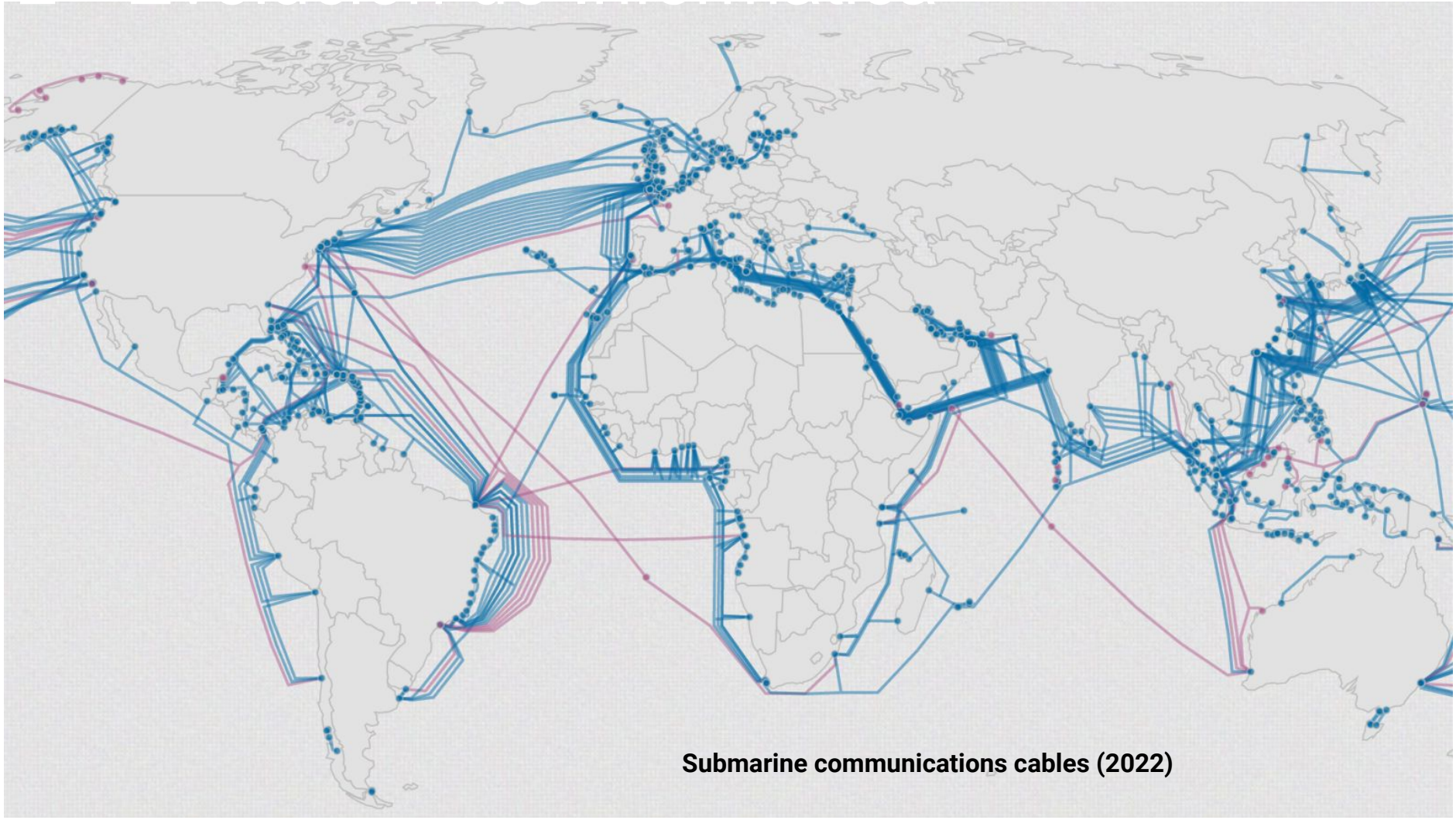
Year: 2022 - 2023

Universidad Francisco de Vitoria
UFV Madrid

Grado en Ingeniería Informática
Escuela Politécnica Superior

What is a Network?

What is a network?



Submarine communications cables (2022)

https://qz.com/657898/this-map-shows-the-explosive-growth-of-underwater-cables-the-power-the-global-internet/

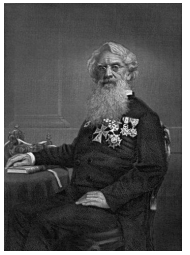
Universidad Francisco de Vitoria
UFV Madrid

Networks - Basic concepts

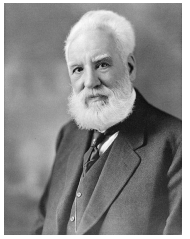
Networks - Basic Concepts

A network is the combination of two or more devices and their connecting links to send information between them.

- Telegraph (Samuel Morse, 1832 - 1844): Message communication network.



- Telephone (Alexander Graham Bell, 1876): telephone (voice) communication network.



- Radio (Guglielmo Marconi, 1896): Wireless communication network.

Networks - Basic Concepts

Voice and data communications were based on methods of **circuit switching** wherein each telephone call is allocated a dedicated, end to end, electronic connection between the two communicating stations.

The first version of Arpanet (1969) connected 4 universities:

- UCLA
- Stanford
- University of California-Santa Barbara
- University of Utah.

The ARPANET in December 1969

The **first message sent consisted in "LO"** which was an attempt to send "LOGIN".

Networks - Basic Concepts

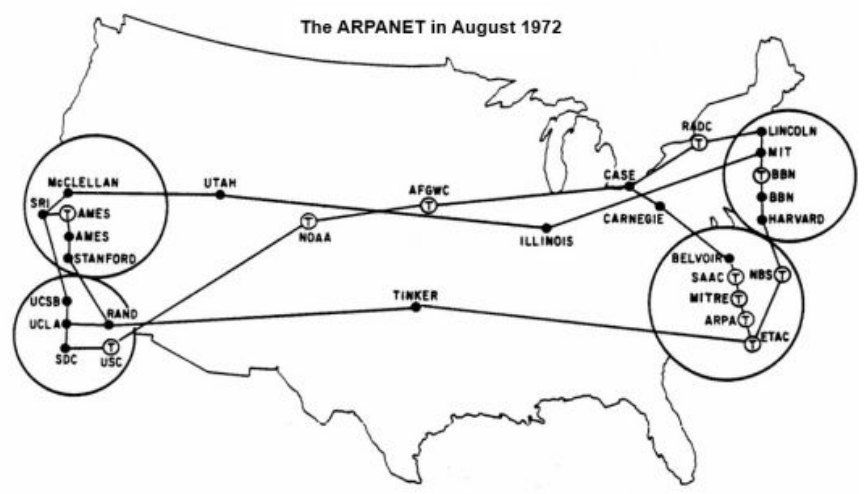
Voice and data communications were based on methods of **circuit switching**, as exemplified in the **traditional telephone network**, wherein each telephone call is allocated a dedicated, end to end, electronic connection between the two communicating stations.

UCLA, Stanford, University of California-Santa Barbara and University of Utah created the first real network **sending a first message consisted in "LO"** which was an attempt to send "LOGIN".

Networks - Basic Concepts

ARPANET was presented in the First International Conference on Computers and Communication en Washington DC (1972) showing a network of 40 connected points in different locations in the US.

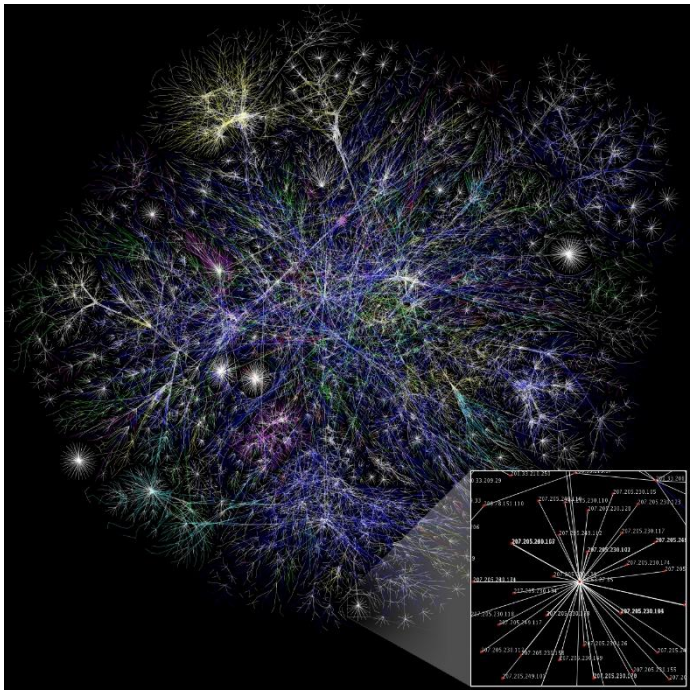
- Telenet (1974): Commercial version of ARPANET.
- Usenet (1979): Open system focused on e-mail and still works.
- Bitnet (1981): Linked American universities using IBM systems.
- Eunet (1982): It united the United Kingdom, Scandinavia and the Netherlands.



Networks - Basic Concepts

Internet (1990) is a decentralized set of interconnected networks that use the TCP/IP model, which guarantees that the heterogeneous physical networks that comprise it constitute a single logical network with a global reach.

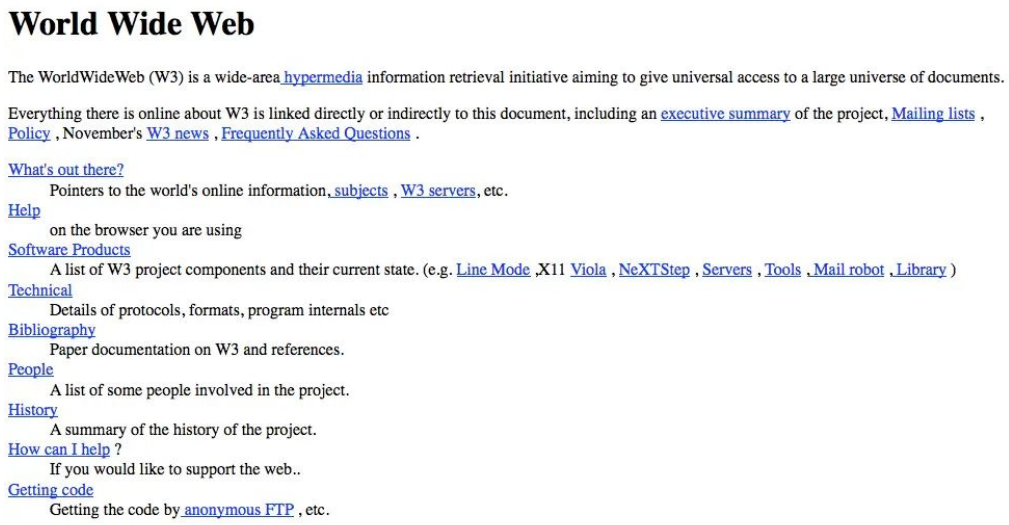
- Massive increase in Client/Server type applications.
- Wide spread of applications and services due to the appearance of the first websites.
- New types of services appear that you require from distributed systems.



Networks - Basic Concepts

The World Wide Web (WWW), commonly known as the Web, is an information system enabling interlinked hypertext documents and other web resources to be accessed over the Internet.

- Web 1.0 was the “read-only web.
- Web 2.0 was the “read-write”. We can create content and interact with other web users in real time.
- Web 3.0 is the “read-write-execute.” It is called the semantic web.



World Wide Web

The WorldWideWeb (W3) is a wide-area hypermedia information retrieval initiative aiming to give universal access to a large universe of documents.

Everything there is online about W3 is linked directly or indirectly to this document, including an executive summary of the project, Mailing lists , Policy , November's W3 news , Frequently Asked Questions .

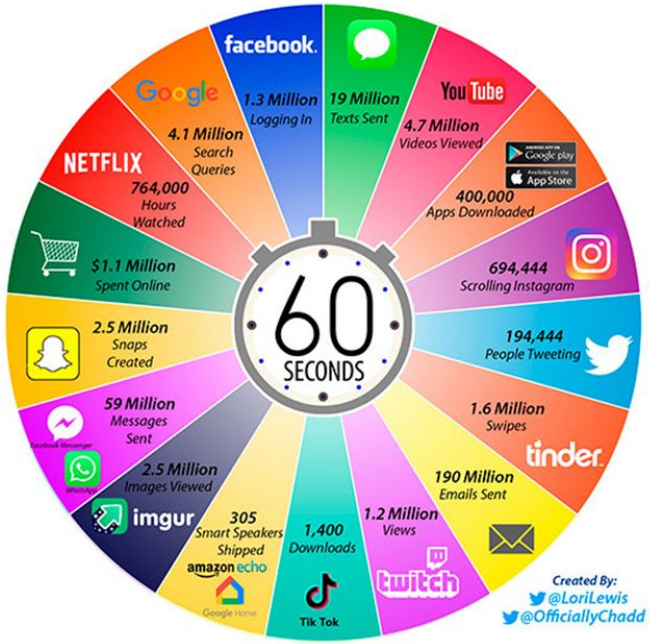
What's out there?
Pointers to the world's online information, subjects , W3 servers, etc.
Help
on the browser you are using
Software Products
A list of W3 project components and their current state. (e.g. Line Mode ,X11 Viola , NeXTStep , Servers , Tools , Mail robot , Library)
Technical
Details of protocols, formats, program internals etc
Bibliography
Paper documentation on W3 and references.
People
A list of some people involved in the project.
History
A summary of the history of the project.
How can I help ?
If you would like to support the web..
Getting code
Getting the code by anonymous FTP , etc.

Copy of the original page taken in 1992: info.cern.ch

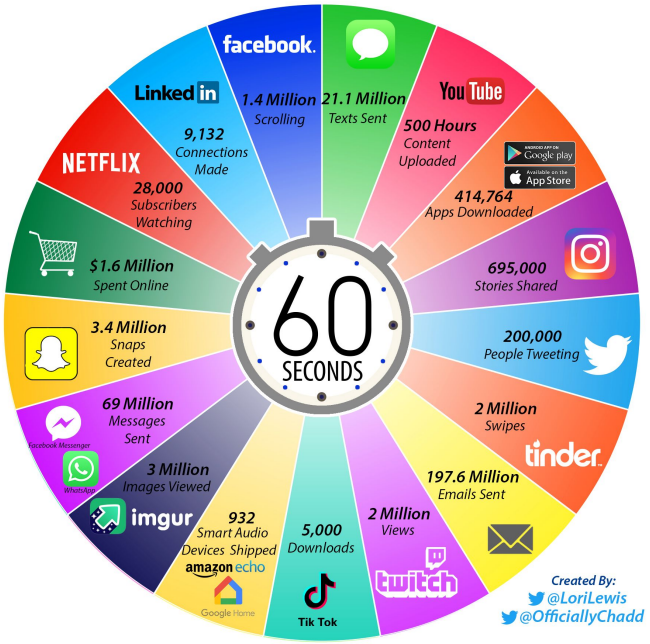
It was was invented by **Tim Berners-Lee** (England) at **CERN**, and originally conceived as a document management system.

¿Cuánta información generamos los humanos en un minuto?

2020



2021



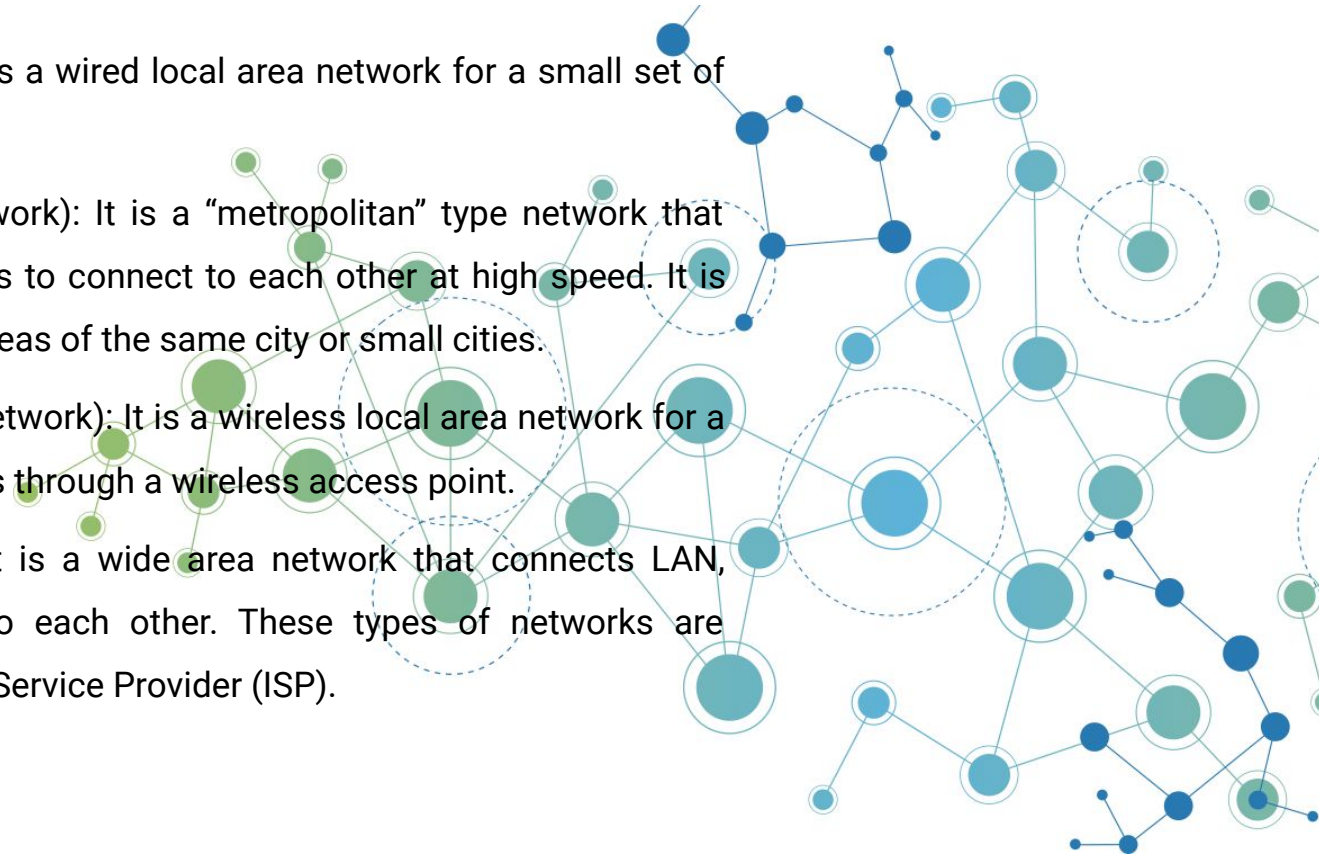
Universidad
Francisco de Vitoria
UFV Madrid

Networks

Networks

A computer network is a group of computers linked to each other that enables the computer to communicate with another computer to share their resources, data, and applications.

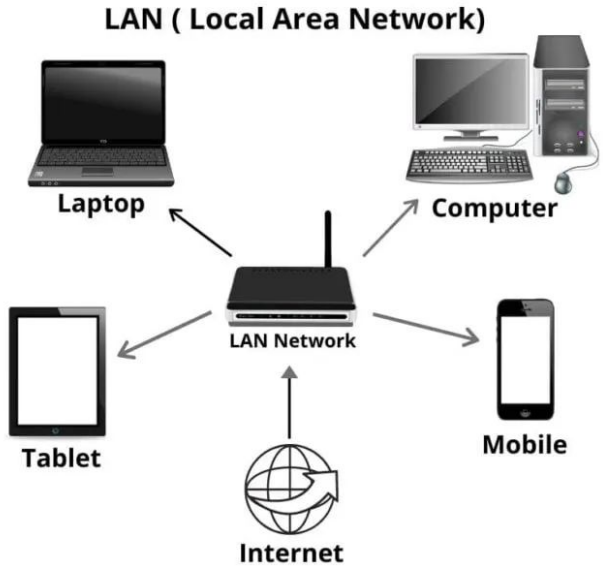
- LAN (Local Area Network): It is a wired local area network for a small set of computers.
- MAN (Metropolitan Area Network): It is a “metropolitan” type network that allows LAN or WLAN networks to connect to each other at high speed. It is usually deployed to connect areas of the same city or small cities.
- WLAN (Wireless Local Area Network): It is a wireless local area network for a small set of systems to access through a wireless access point.
- WAN (Wide Area Network): It is a wide area network that connects LAN, WLAN and MAN networks to each other. These types of networks are normally deployed by Internet Service Provider (ISP).



Networks

LAN (Local Area Network): It is a wired local area network for a small set of computers.

- This network is commonly used for connecting two or more personal computers. It covers a range between 10 to 1500 ms.
- LAN network uses twisted pair, coaxial cable, etc.
- It is less costly as it is built with inexpensive hardware such as hubs, network adapters, and ethernet cables.
- The data is transferred at an extremely faster rate in Local Area Network.
- Local Area Network provides higher security.

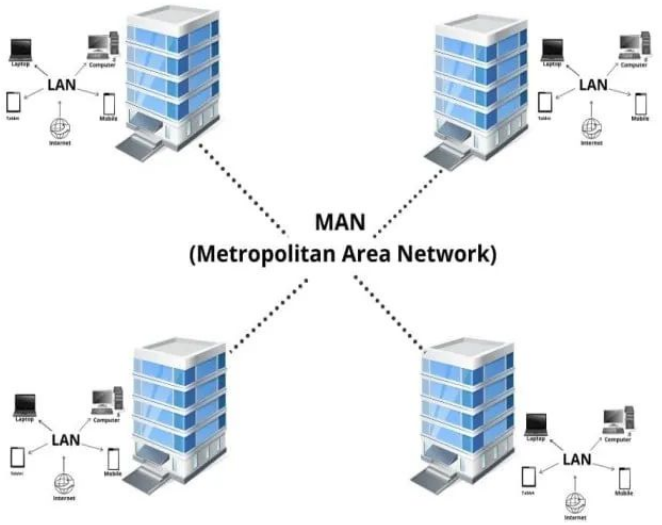


WLAN is an extension of LAN network but using wireless technologies such as WiFi, Bluetooth.

Networks

MAN (Metropolitan Area Network): It is a “metropolitan” type network that allows LAN or WLAN networks to connect to each other at high speed. It is usually deployed to connect areas of the same city or small cities.

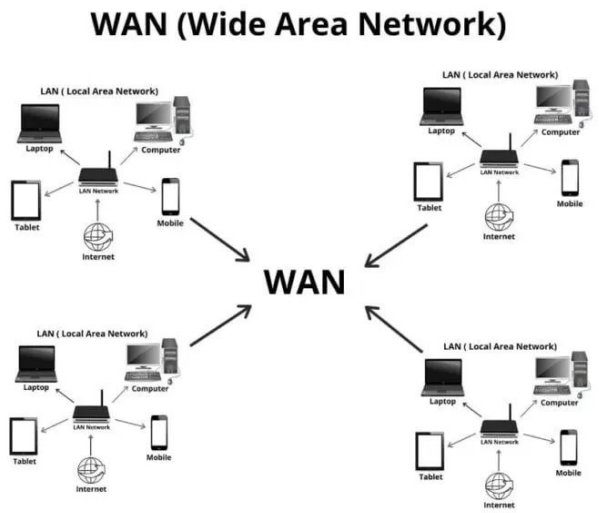
- This network covers a larger geographic area by interconnecting a different LAN to form a larger network. It covers a range between 5 to 60 kms.
- MAN network provides high-speed communication via fiber optic cable.
- Government agencies use MAN to connect to the citizens and private industries.
- The most widely used protocols in MAN are RS-232, Frame Relay, ATM, ISDN, OC-3, ADSL, etc.



Networks

WAN (Wide Area Network): It is a wide area network that connects LAN, WLAN and MAN networks to each other. These types of networks are normally deployed by Internet Service Provider (ISP).

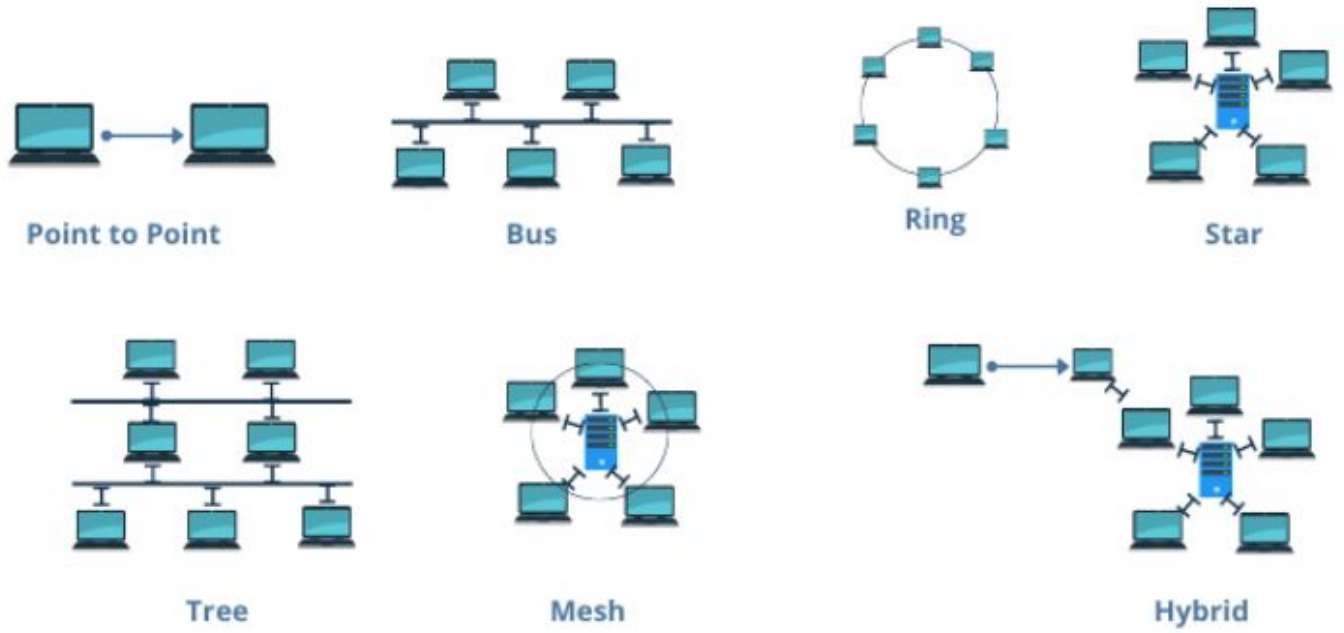
- This network covers a large geographical area such as states or countries.
- This network is not limited to a single location, but it spans over a large geographical area through a telephone line, fibre optic cable or satellite links.
- The Internet is probably the biggest WAN in the world.



Networks

Network topology is the schematic description of the structure of a network. A network can have one **physical** topology and multiple **logical** topologies at the same time.

- Point to point.
- Bus.
- Ring.
- Star.
- Mesh.
- Tree.
- Hybrid.



Universidad Francisco de Vitoria
UFV Madrid

Network protocols

Network protocols

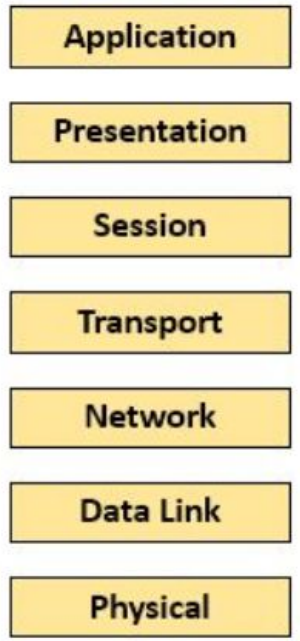
The implementation of all the tasks involved in the transmission of information through networks is organized in functions or **protocols organized in layers**, so that each layer implements its functions based on the protocols of the lower layer.

- Open System Interconnection (OSI) model.
- TCP/IP model.

Network protocols

Open System Interconnection (OSI) Reference Model is a conceptual model that provides a common basis for the coordination of [ISO] standards development for the purpose of systems interconnection.

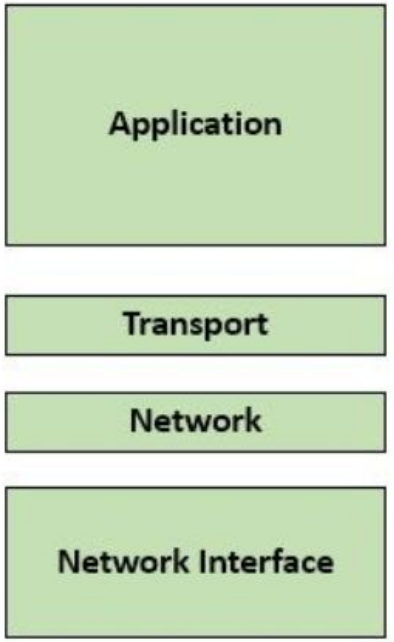
Layer	Name	Protocols
Layer 7	Application	SMTP, HTTP, FTP, POP3, SMTP, DNS
Layer 6	Presentation	MPEG, ASCH, SSL, TLS
Layer 5	Session	NetBIOS, SAP, NFS, SCP
Layer 4	Transport	TCP, UDP
Layer 3	Network	IPV4, IPV6, ICMP, IPSEC, ARP, MPLS, IGMP
Layer 2	Data Link	RAPA, PPP, Frame Relay, ATM, Fiber Cable, etc
Layer 1	Physical	RS232, 100BaseTX, ISDN, 11



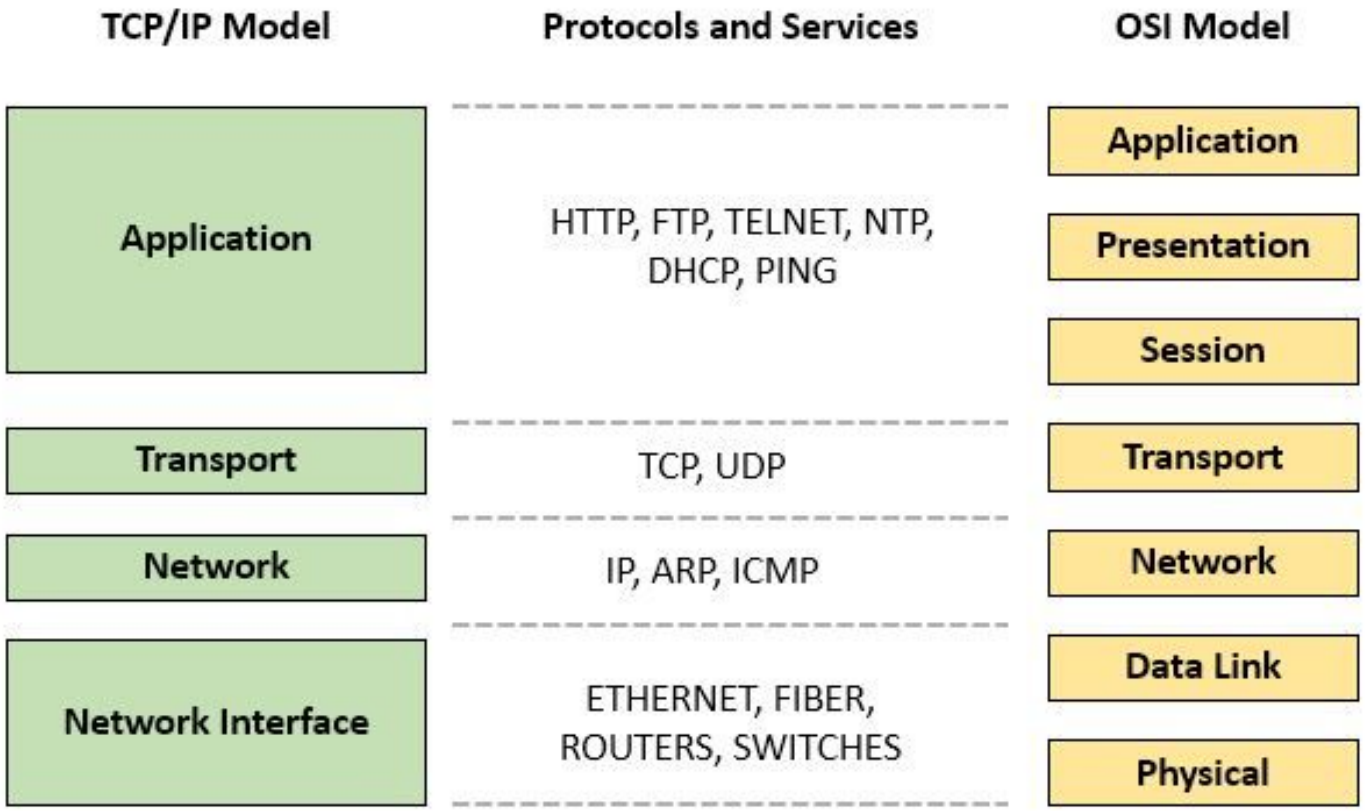
Network protocols

The Internet protocol suite, commonly known as TCP/IP, is the set of communication protocols used in the Internet and similar computer networks. This is the facto standards used for all applications.

Layer	Name	Protocols
Layer 4	Application	SMTP, HTTP, FTP, POP3, SMTP, DNS, MPEG, ASCH, SSL, TLS, NetBIOS, SAP, NFS, SCP
Layer 3	Transport	TCP, UDP
Layer 2	Network	IPV5, IPV6, ICMP, IPSEC, ARP, MPLS, IGMP
Layer 1	Interface	RAPA, PPP, Frame Relay, ATM, Fiber Cable, RS232, 100BaseTX, ISDN, 11, etc



Network protocols



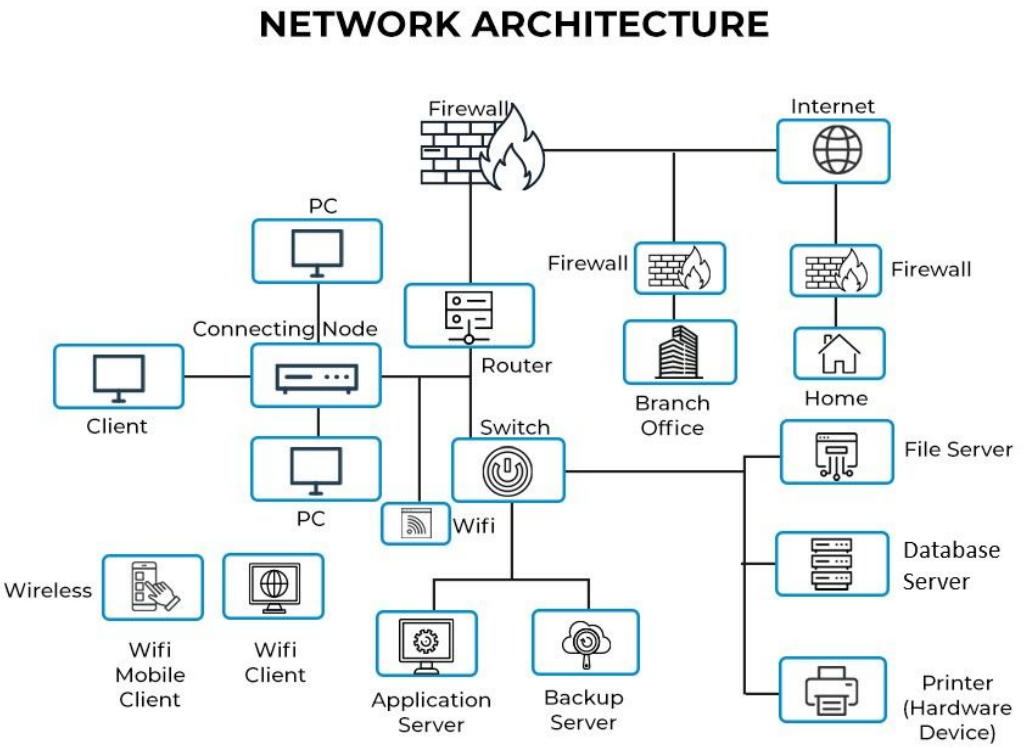
Universidad Francisco de Vitoria
UFV Madrid

Network hardware

Network hardware

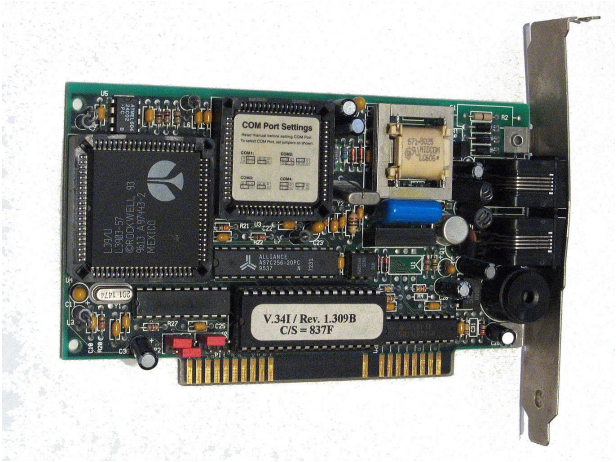
Network hardware is a set of physical devices that are essential for interaction and communication between computers on a network.

- Modems.
- Routers.
- Hubs, bridges, and switches.
- Network interface cards.
- Network cables.
- Firewalls.



Network hardware

A modulator-demodulator or modem is a hardware network device that enables a computer to connect to the internet via a telephone line. The modem at one end converts the computer's digital signals into analog signals and sends them through a telephone line.



Network hardware

A router is a hardware network device that connects two or more networks. One common use of the router is to connect a home or office network (LAN) to the internet (WAN).

Network hardware

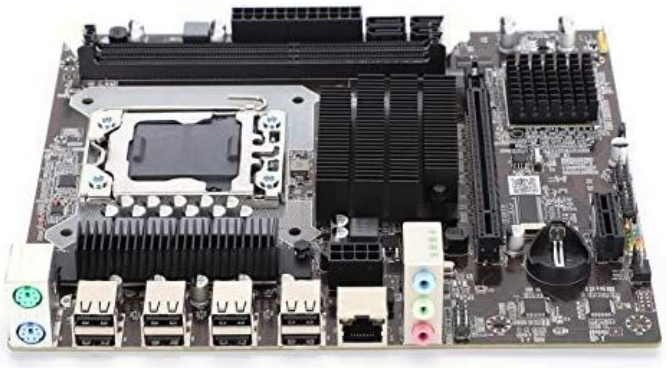
Hubs, bridges, and switches are hardware network devices that allow multiple devices to connect to the router and enable data transfer to all devices on a network.

- A hub broadcasts data to all devices on a network.
- A bridge connects two separate LAN networks.
- A switch is more powerful than a hub or a bridge but performs a similar role.

Network hardware

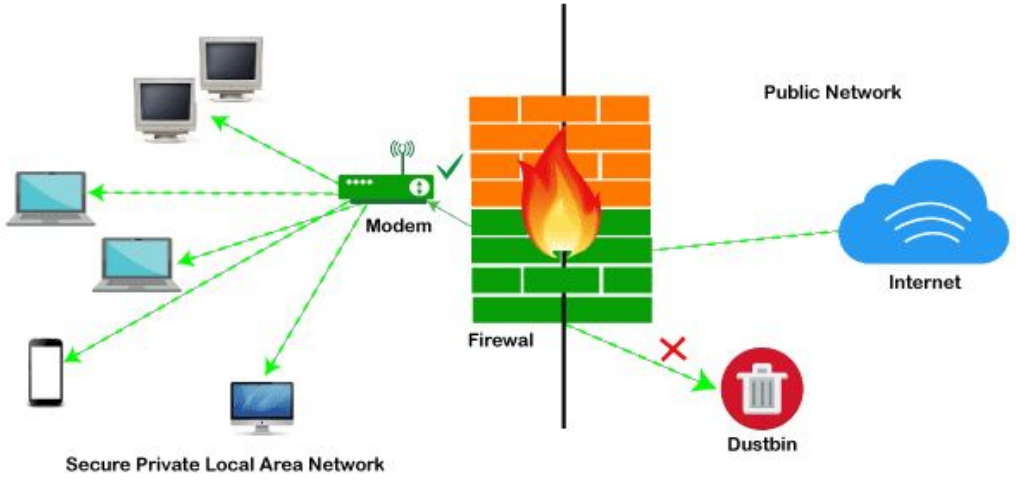
A network interface card (NIC) is a hardware network installed on a computer, which allows it to connect to a network.

- NICs are built into the motherboards.
- NICs are connected using an extra expansion card in the form of a small circuit board is added externally



Network hardware

A firewall is a hardware or software device between a computer and the rest of the network open to attacks or hackers.



LAN networks can be protected from hackers by placing a firewall between the LAN and the internet connection.

Universidad Francisco de Vitoria
UFV Madrid

Network software

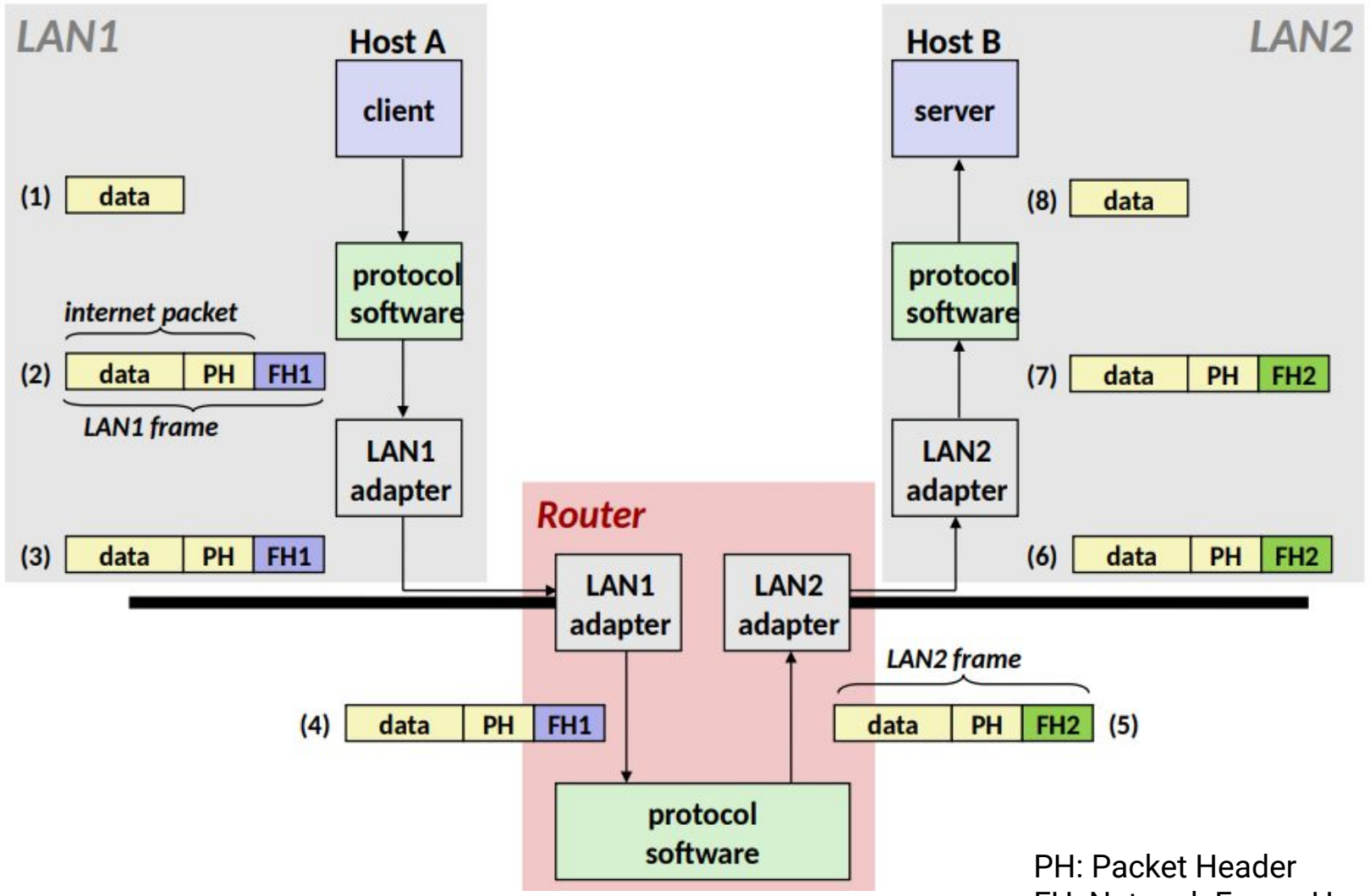
How is it possible to send information across different kind of networks?

Network software

A **Protocol** is a set of rules that governs how hosts and routers should cooperate when they transfer data from network to network.

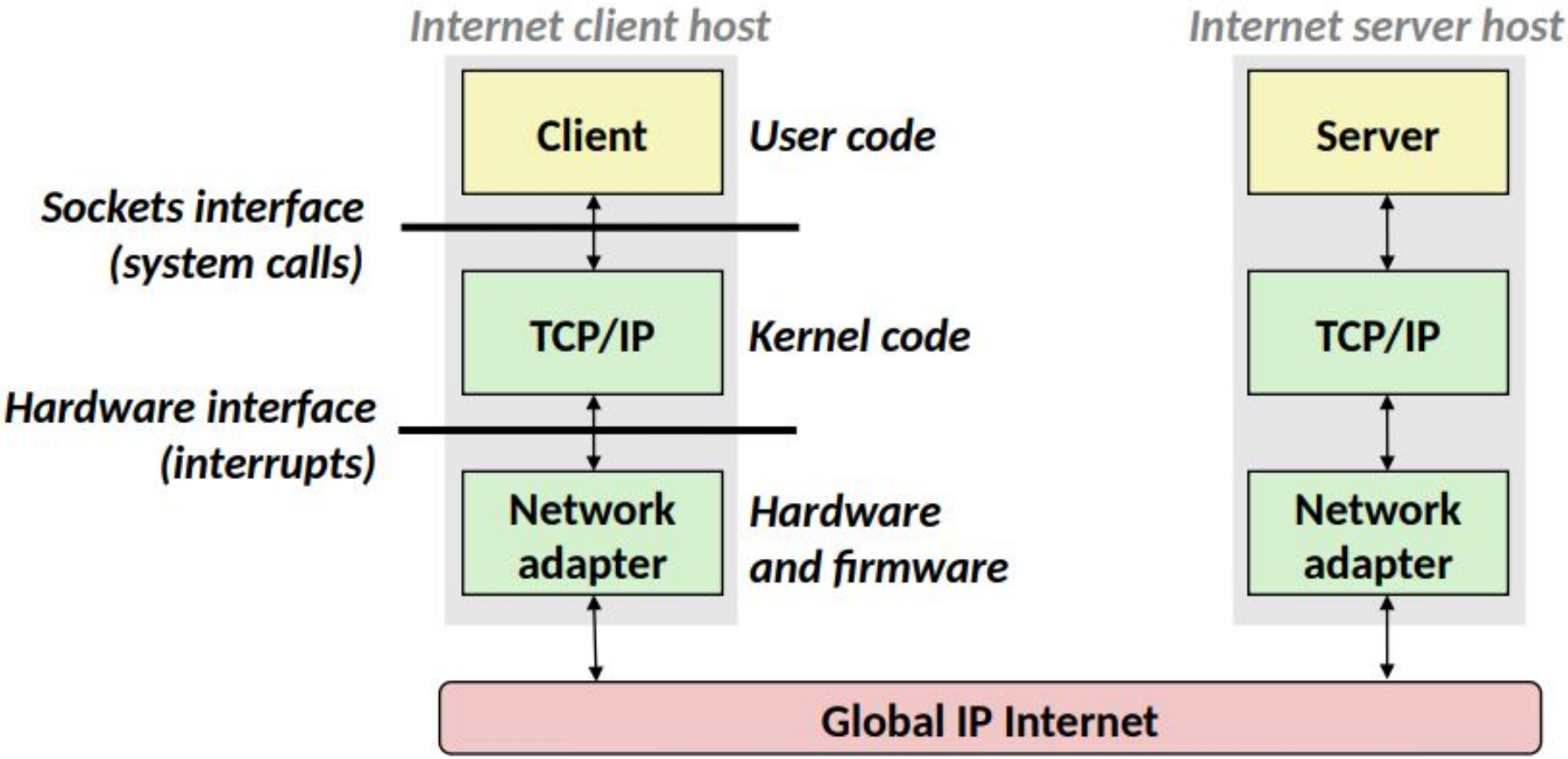
- An internet protocol defines a uniform format for host addresses (naming scheme). Each host (and router) is assigned at least one of these internet addresses that uniquely identifies it.
- An internet protocol defines a standard transfer unit (packet). Packets are composed of header and payload.

Network software



PH: Packet Header
FH: Network Frame Header

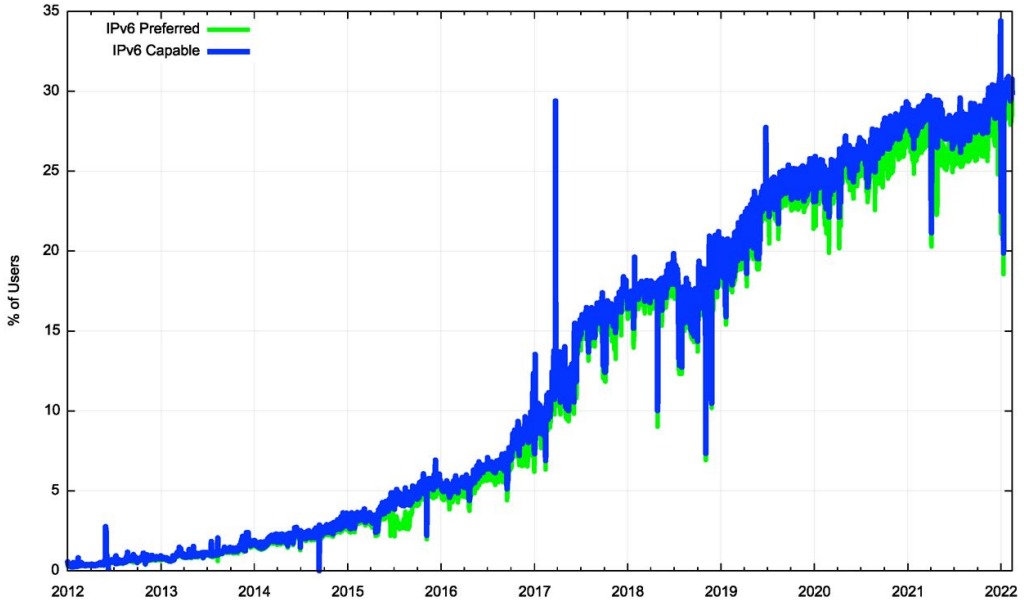
Network software



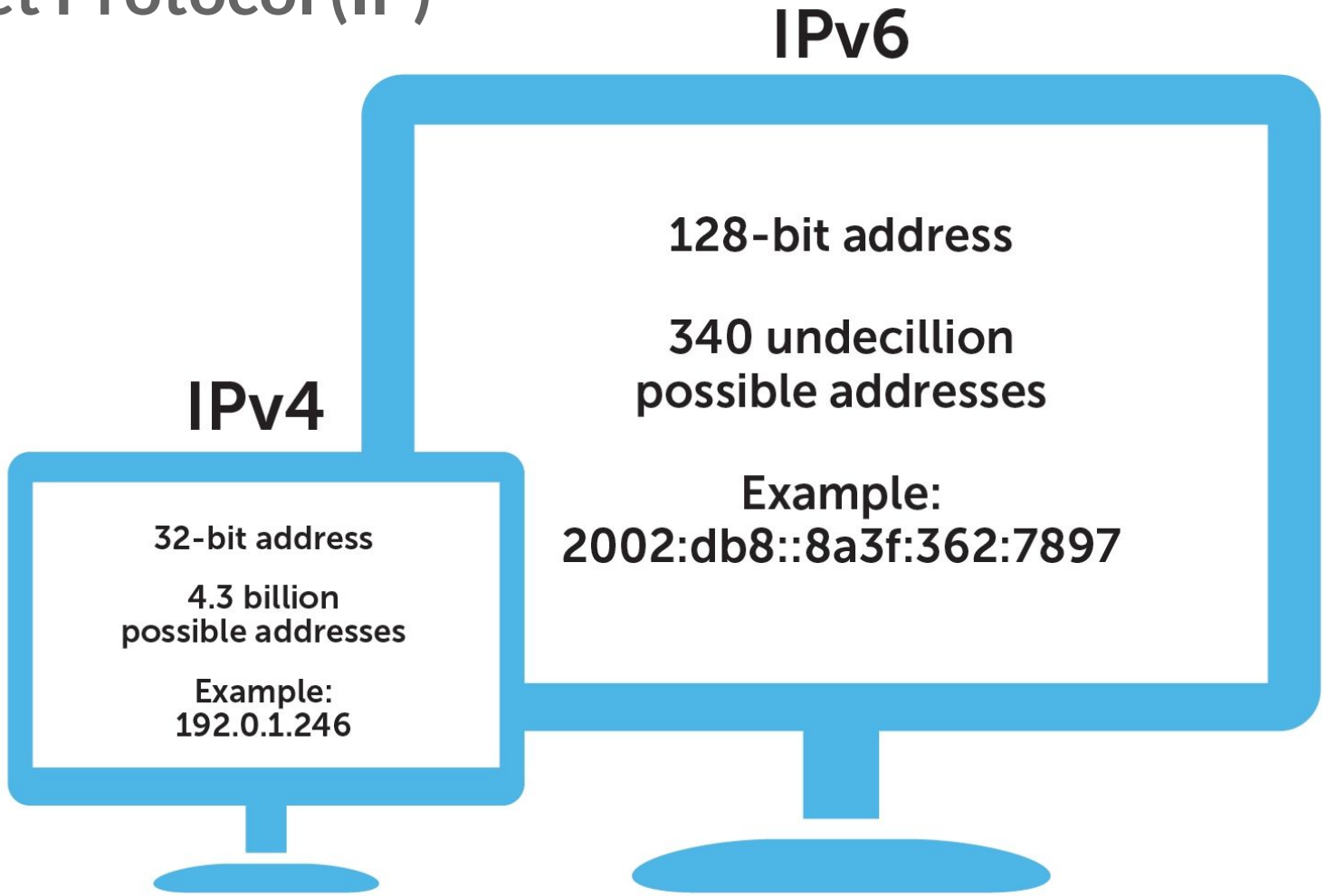
Internet Protocol (IP)

The Internet Protocol (IP) is a set of rules, for routing and directing data packets so that they can travel across networks and reach the correct destination. The original Internet Protocol, with its 32-bit addresses, is known as Internet Protocol Version 4 (IPv4).

Internet Protocol Version 6 (IPv6) with 128-bit addresses was introduced in 1998 to solve the problem of **IP address exhaustion**.

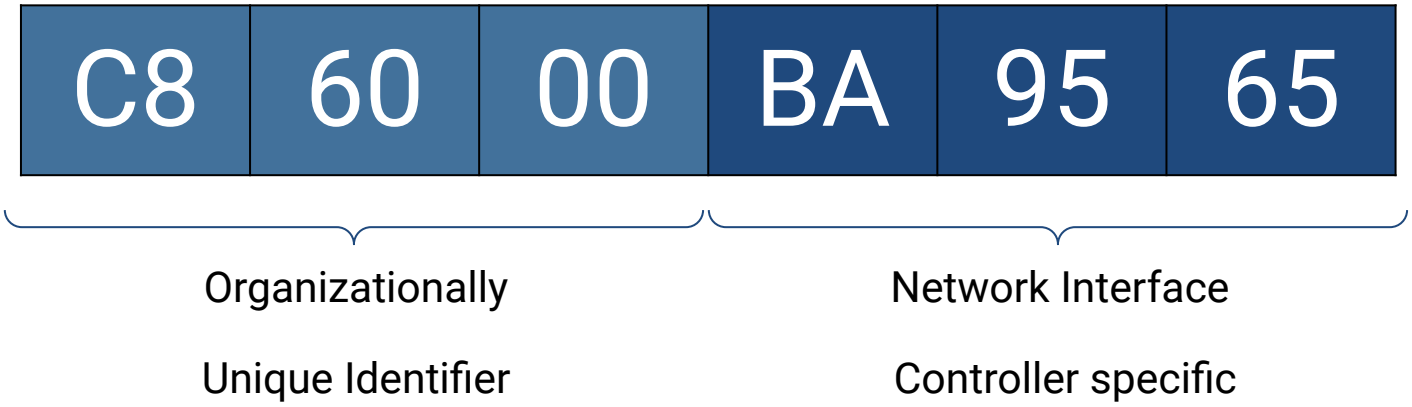


Internet Protocol (IP)



Physical address

A Media Access Control (MAC) address, sometimes referred to as a hardware or physical address, is a unique, 12-character alphanumeric attribute that is used to identify individual electronic devices on a network.



C8-69-CD is one of the Organizationally Unique Identifier assigned to Apple devices.

Network address

A network host is a computer or other device connected to a computer network. Hosts are assigned at least one **network address**.

- Hosts are mapped to a set of 32-bit IP addresses: **18.192.134.29**
- The set of IP addresses is mapped to a set of identifiers called Internet domain names

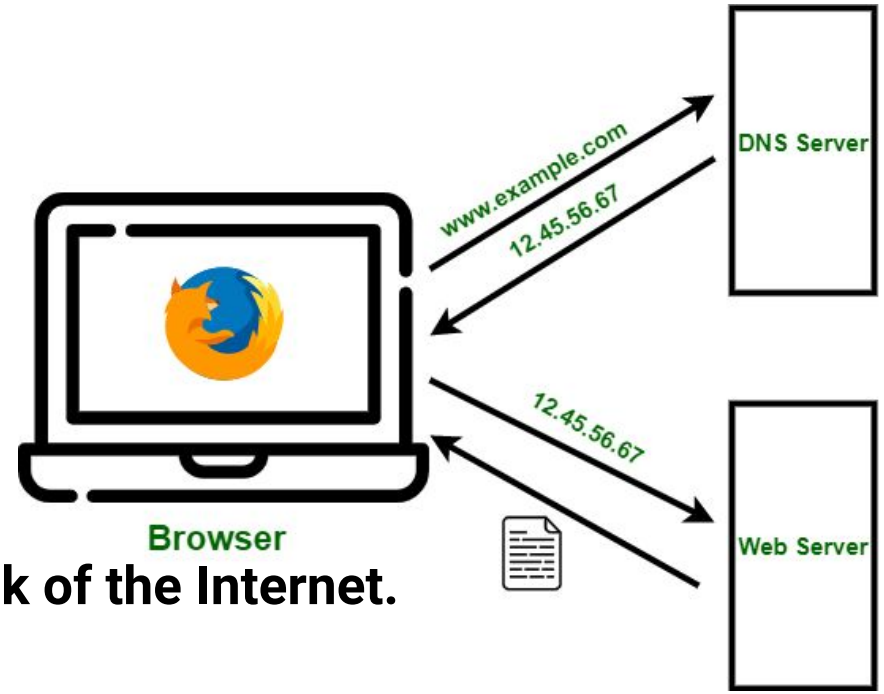
  18.192.134.29 is mapped to www.ufv.es

- A process on one Internet host can communicate with a process on another Internet host over a connection.

DNS

The Internet maintains a mapping between IP addresses and domain names in a huge worldwide distributed database called Domain Name System (DNS).

- Each domain name is associated to an IP address.
- Multiple domain names mapped to the same IP address.



DNS can be considered like the phonebook of the Internet.

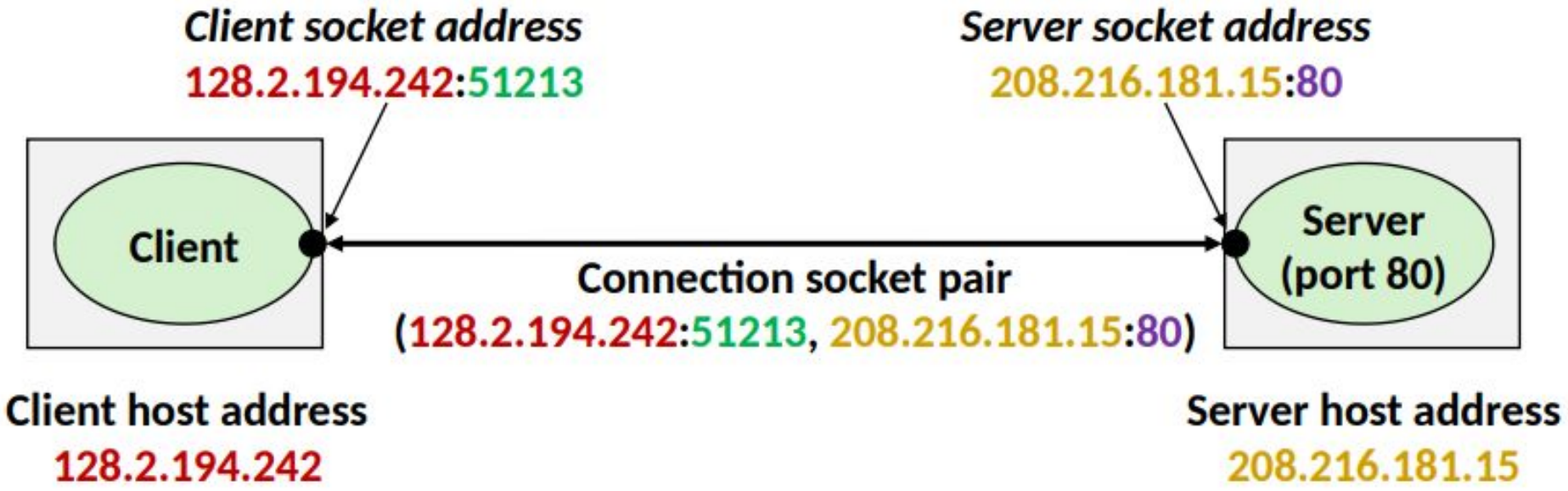
Communication

- Clients and servers communicate by sending streams of bytes over connections.

  Each connection is:
  - Point-to-point: connects a pair of processes.
  - Full-duplex: data can flow in both directions at the same time,
- A socket is an endpoint of a connection:
  - Socket address is an IPaddress:port pair.
- A port is a 16-bit integer that identifies a process:
  - Ephemeral port: Assigned automatically by client kernel when client makes a connection request.
  - Well-known port: Associated with some service provided by a server (e.g., port 80 is associated with Web servers)

Communication

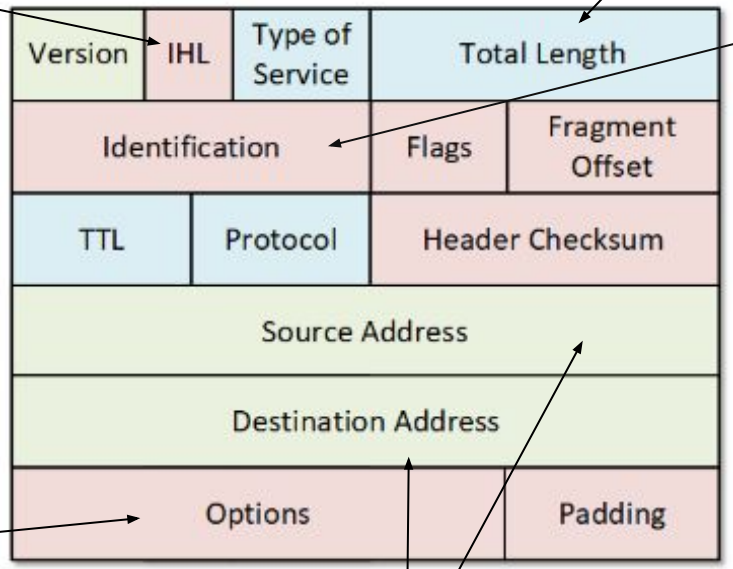
A connection is uniquely identified by the socket addresses of its endpoints (connection socket pair).



IPv4 datagram

Packet size (bytes): IP header + payload.

Header size (bytes)

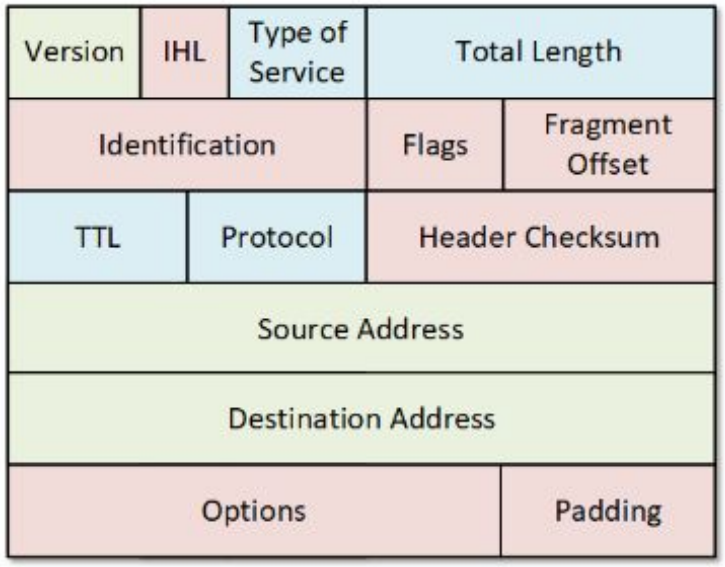


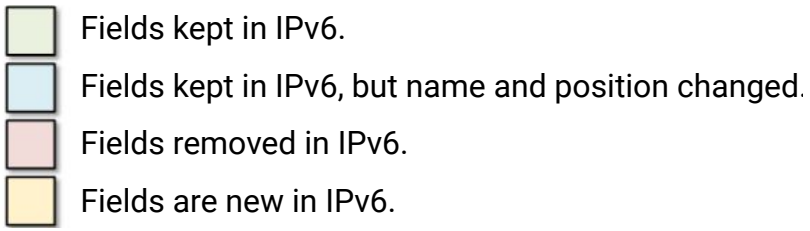
Number that identifies the datagram (if the datagram is fragmented when passing through different networks, each fragment carries the same identifier in order to assemble them and recover the original datagram at the destination).

It contains information for the upper layer protocols (TCP, UDP, HTML, etc).

IP addresses (32 bits)

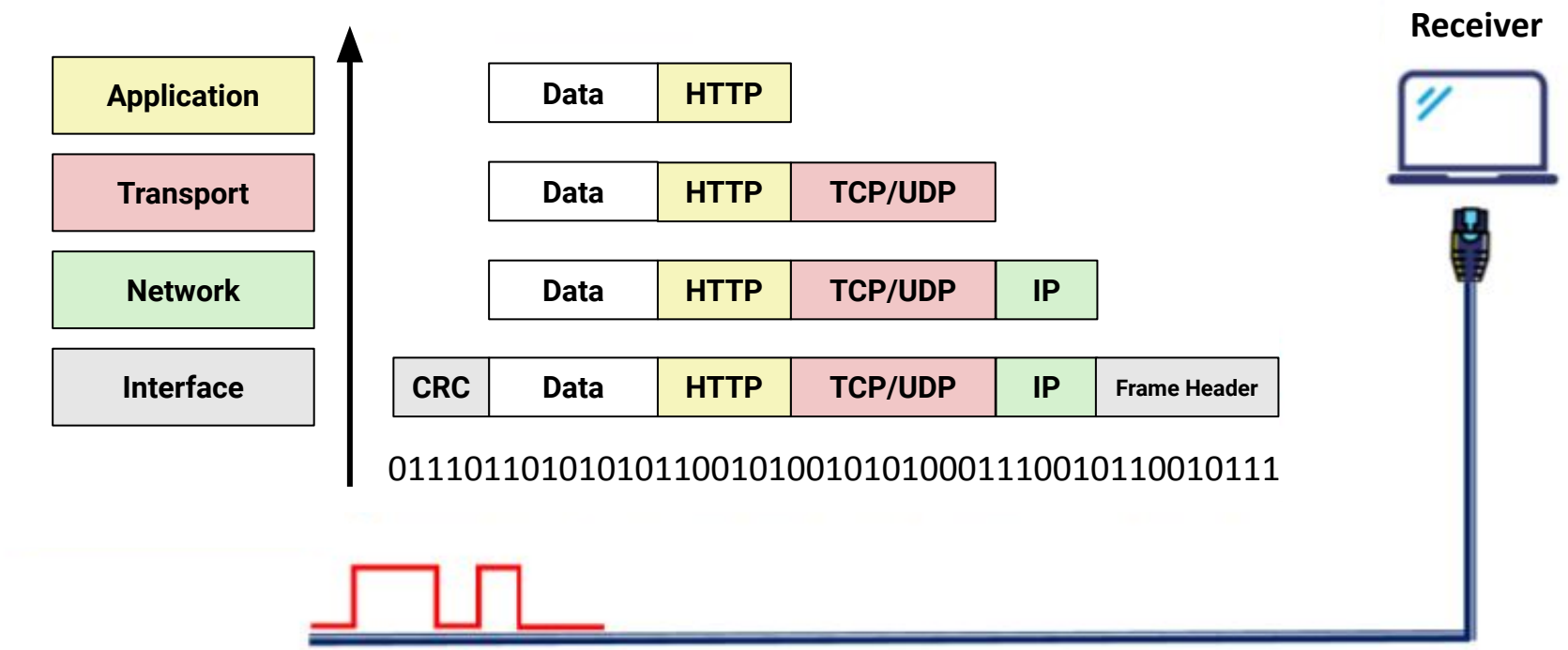
IPv4 datagram vs IPv6 datagram





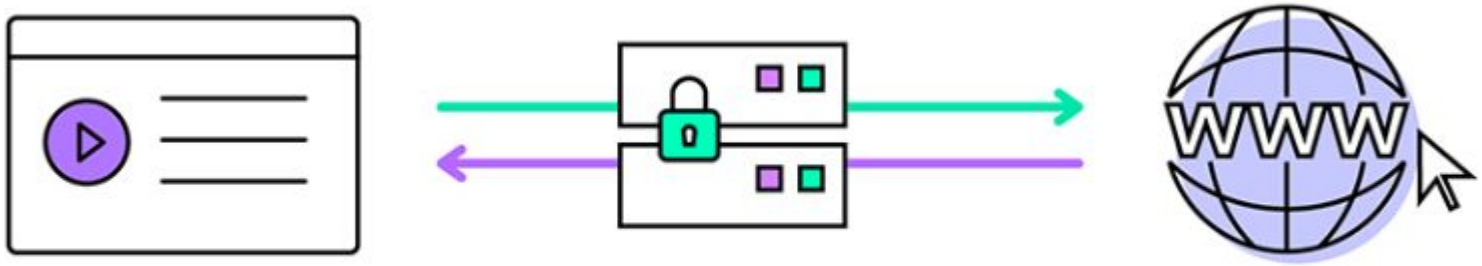
Data encapsulation

Packets are called **datagrams** at the network layer and **frames** at the interface layer.



Proxy

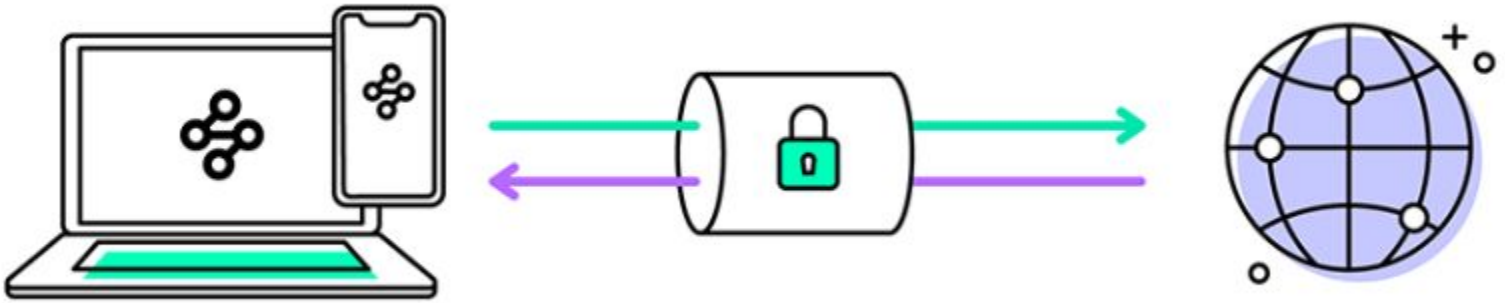
A proxy server is a server application that acts as an intermediary between a client requesting a resource and the server providing that resource.



- Provides caching.
- Provides access control and security (in combination with firewall).
- Address translation service (NAT).

VPN

A virtual private network (VPN) extends a private network across a public network and enables users to send and receive data across shared or public networks as if their devices were directly connected to the private network.



- Bypass Geo-locked Content.
- Provide Safety Through Anonymity.
- Provides secure Connection.