Communication Networks Course

Networks: Definitions, Classifications, Architectures

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Presentation Overview

Introduction and definitions

- Teleinformatics:
  - Discipline that combines computer science and telecommunications techniques
  - Goal: to allow users to remotely exploit the processing capabilities of the computer.

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- Teleinformatics:
  - Discipline that combines computer science and telecommunications techniques
  - Goal: to allow users to remotely exploit the processing capabilities of the computer.
- Computer network:
  - set of hardware or software components connected to each other,
  - located in a certain geographical area,
  - enabling a communication service to be provided.

How does it work?

- Purpose of the network:
  - to allow the exchange of information or in other words communication.
- But who says exchange of information, says rules.
- Example: let's suppose that a teacher needs to urgently contact the parents of a student:
  - he must find a way to contact them telephone.
  - he searches in the students' files for the number or he will ask the secretariat to give it to him.
  - To be able to speak with them, they must speak the same language or have a translator.
  - he must communicate his own telephone number to be kept informed.

How does it work?

- Well, a computer network has the same needs. To be usable, it needs:
  1. A physical means for information to transit.
  2. Services that exchange information
  3. A common language (independent of its operating system) so that everyone can understand each other.
  4. Addresses to know who to talk to and who to respond to.
- The set of rules forms a protocol.
- This protocol is called TCP/IP.
- It will provide us with a form of address for each of the computers on a network and a language common to all and this in a form simple enough to transit over a cable.

How does it work?

- Concretely, a network will therefore be made up of:
  - client computers and
  - one or more server computers (instead of computers we will often speak of hosts).
- The servers have service programs that the programs of the client computers query to carry out the desired operations.

What do networks provide?

Networks allow:

- Sharing files.
- File transfer.
- Application sharing: compiler, database management system (DBMS).
- Printer sharing.
- Interaction with connected users: messaging and electronic conferencing, etc.
- Data transfer in general (computer networks).
- Speech transfer (telephone networks).
- Speech, video and data transfer (integrated services or multimedia networks).

Basic vocabulary

- Workstation: any machine capable of sending data to networks. Each workstation has its own interface card (network card).
- Node: it is a workstation, a printer, a server or any entity that can be addressed by a unique number. The uniqueness of the address is guaranteed by the manufacturer of a network card which gives a unique number that cannot be changed by a person.
- Server: central repository of a specific function: database server, calculation server, file server, messaging server, etc.

Basic vocabulary

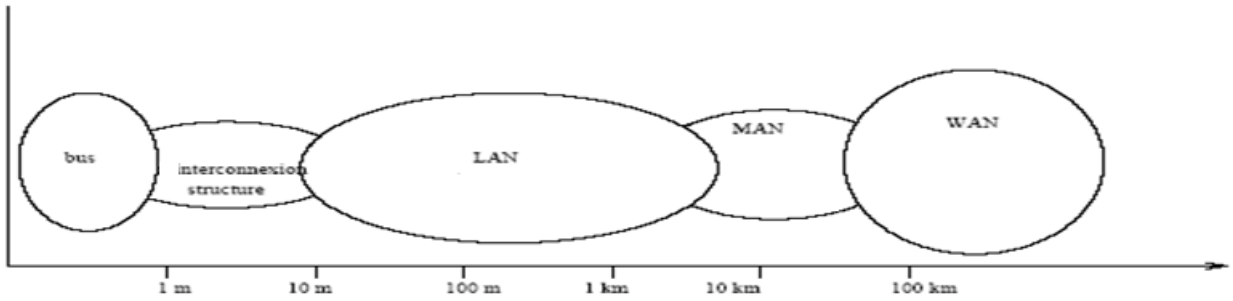
- Packet: This is the smallest unit of information that can be sent over the network. A packet generally contains the address of the transmitter, the address of the receiver and the data to be transmitted.
- Topology: physical and logical organization of a network. The physical organization concerns the way in which the machines are connected (Bus, Ring, Star, Mesh, Tree, ...). The logical topology shows how information circulates on the network (broadcast, point to point).

Classification

- According to size (geographic scope)
- According to the topology

According to size (geographic scope)

- The buses found in a computer to connect its various components (memories, input-output peripherals, processors, etc.) can be considered as networks dedicated to very specific tasks.
- The interconnection structures are very high-speed networks, but of small extent, and group together the pre- and post-processors of vector computers for example. Indeed, the use of a supercomputer (Cray in particular) requires a computer, called a front-end, which prepares the data and collects the results.



According to size (geographic scope)

- A local area network (LAN) can extend from a few meters to a few kilometers and corresponds to the network of a company. It can develop over several buildings and can satisfy all the internal needs of this company.
- A metropolitan area network (MAN) interconnects several places located in the same city, for example the different sites of a university or an administration, each having its own local network.
- A wide area network (WAN) allows communication on the scale of a country, or the entire planet, the physical equipment can be terrestrial through laid cables, or spatial using telecommunications satellites.

According to the topology

- Broadcast mode networks

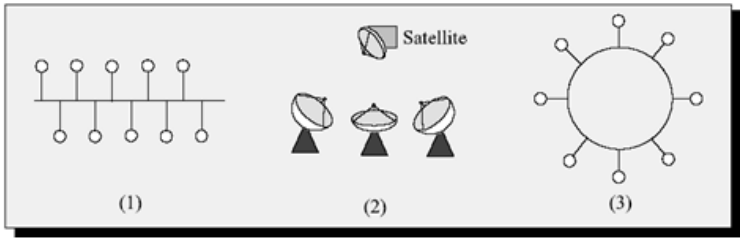


Figure: 1: bus, 2: satellite or radio, 3: ring

- Point-to-point mode networks

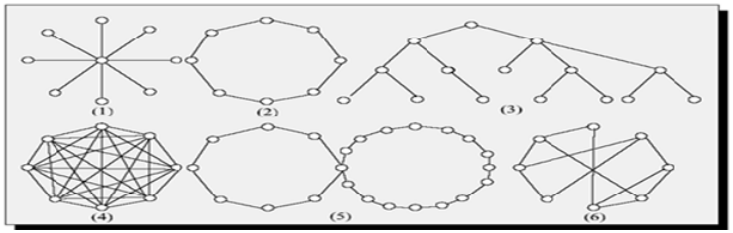


Figure: 1: star, 2: ring, 3:tree, 4:regular mesh, 5: ring interconnection, 6: irregular mesh

According to the topology

Broadcast mode networks

- Involves sharing a single transmission medium.
- Each message sent by a device on the network is received by all the others.
  - It is the specific address placed in the message that will allow each device to determine whether the message is addressed to it or not.
- At any time, only one device has the right to send a message on the medium,
  - so it must first "listen" to see if the channel is free; if this is not the case, it waits according to a protocol specific to each architecture.

According to the topology

Broadcast mode networks

- Local networks mostly adopt broadcast mode on a bus or ring architecture and satellite or radio networks also follow this mode of communication.
- In such a configuration, the breakage of the medium causes the network to stop, on the other hand, the failure of one of the elements does not (in general) cause the overall failure of the network.

According to the topology

Point-to-point networks

- In this mode, the physical medium (the cable) connects a pair of devices only.
  - When two elements not directly connected to each other want to communicate, they do so through the other nodes of the network.
- In the case of the star, the central site receives and sends all the messages,
  - the operation is simple, but the failure of the central node paralyzes the entire network.
- In a simple loop, each node receiving a message from its neighbor forwards it to its neighbor.
  - So that the messages do not rotate indefinitely, the sending node removes the message when it returns to it.
  - If one of the network elements fails, then everything stops. This problem is partially solved by the double loop, each of which rotates the messages in an opposite direction.

According to the topology

Point-to-point networks

- In the regular mesh, the interconnection is total, which ensures optimal reliability of the network,
  - however, it is an expensive solution in physical cabling. If the wiring plan is lightened, the mesh becomes irregular and reliability can remain high but it requires message routing according to sometimes complex algorithms.
  - In this architecture it becomes almost impossible to predict the transfer time from one node to another.

Network architecture

- The OSI model (Open Systems Interconnection).
- The TCP-IP model (Transmission Control Protocol – Internet Protocol).

The OSI model

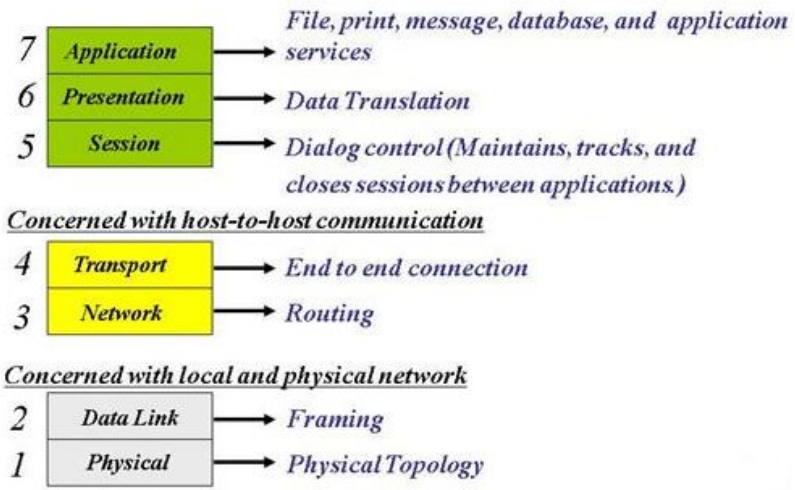
- This model was developed by the ISO (International Standard Organization).
- The OSI reference model is the primary model for network communications. Although there are others,
- The OSI reference model has seven numbered layers,
  - each illustrating a specific network function.
  - This division of network functions is called layering.

The OSI model

The advantages of dividing the network into seven layers are:

- It allows network communications to be divided into smaller, simpler pieces, making them easier to understand.
- It standardizes network elements to enable multi-constructor development and support.
- It allows different types of network hardware and software to communicate with each other.
- It prevents changes to one layer from affecting other layers, allowing for faster development.

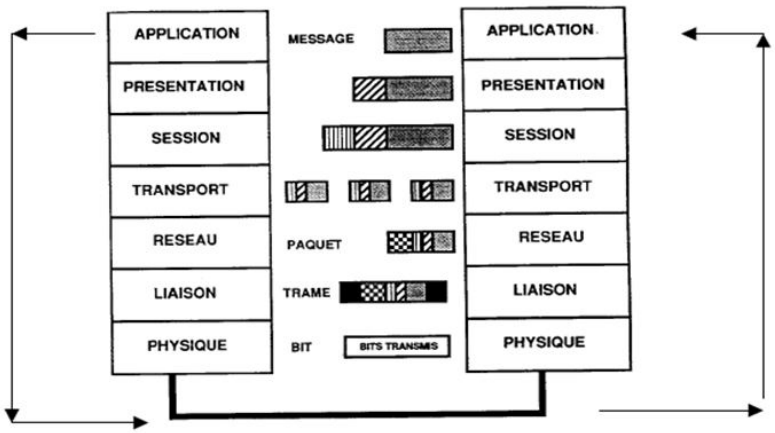
OSI Layer and functions



- The application, presentation, and session layers are the upper layers of the OSI model and provide user-oriented services.
- The lower layers (transport, network, data link, and physical) are concerned with reliable end-to-end communication. They consider the transport layer to provide a reliable channel for communication and add additional features for applications.

Data across OSI layers

- Two layers of the same level never talk to each other directly, only the lower layers of two computers, i.e. the physical layers, communicate "directly" with each other.
- At each layer, the data of the previous layer is "encapsulated" by specific information in the form of headers and tails. Each header and tail of layer N can only be used by the layer of similar level N on the computer with which we are communicating.
- Which could schematically give the following sequence:



The application layer

- This is the layer closest to the user. It provides network services to the user's applications. It differs from other layers in that it does not provide services to other OSI layers, but only to applications outside the OSI model.
- Examples of applications include word processing or banking terminal software, etc.
- The application layer provides the application process with the means to access the OSI environment and provides all the services that the application can directly use, namely: information transfer, resource allocation, integrity and consistency of accessed data, synchronization of cooperating applications
- **To easily remember the functions of layer 7, think of browsers.**

The Presentation Layer

- The presentation layer ensures that the information sent by the application layer of one system is readable by the application layer of another system. If necessary, the presentation layer translates different data representation formats using a common format.
- The presentation layer therefore takes care of the syntax and semantics of the information transported, in particular by taking care of the data representation.
- On transmission, the presentation layer converts the data sent by the application layer into a format that can be used by the lower layers.
- On reception, it converts the format received from the lower layers into a format that can be used by the computer's application layer.
- **To easily remember the functions of layer 6, think of a common data format.**

The Session Layer

- This is to allow applications running on different computers to establish and use a connection called a session. As its name suggests, the session layer opens, manages, and closes sessions between two communicating host systems.
- This layer provides services to the presentation layer. It also synchronizes the dialogue between the presentation layers of the two hosts and manages the exchange of data. The session layer also ensures efficient data transfer and management of the communication process (who transmits, when, how long, what to do in case of interruption, etc.)
- **To easily remember the functions of layer 5, think of dialogs and conversations.**

The Transport Layer

- This layer is responsible for the proper transmission of application layer messages, and to do this it divides long messages into several packets and groups short messages into one to allow more efficient transmission over the network.
- By providing a communication service, the transport layer establishes and connects virtual circuits, in addition to ensuring their maintenance. Providing a reliable service allows it to ensure error detection and correction, as well as control the flow of information.
- The transport layer also takes care of controlling the transport of data between the sender and the recipient. This function is performed by the TCP (Transmission Control Protocol) and UDP (User Datagram Protocol) protocols of the TCP/IP protocol family

The Transport layer

- TCP thus establishes a connection-oriented protocol to ensure the transmission of data.
  - This type of communication guarantees the security of the transmission by confirming the reception of the data by the recipient. The protocol thus waits for an acknowledgement of receipt of each data packet before transmitting the next packet.
  - If the acknowledgement is not received after a certain time, the packet concerned is retransmitted to the recipient.
- The UDP protocol allows the function of this layer to be carried out by a connectionless protocol.
- In this case, the recipient does not transmit an acknowledgement. The sender therefore cannot know whether the data packets have been correctly received by the recipient. However, the UDP protocol allows for faster data transfer, by eliminating the need for an acknowledgement.

The Network layer

- This is a complex layer that ensures connectivity and path selection between two host systems. This layer therefore manages transmission in the network. It is responsible for routing packets that can pass through several intermediate nodes.
- When sending, it can combine different data that is too small to be sent alone on the network, or on the contrary, split into small pieces data that is too large to be sent on the network.
- When receiving, it reconstitutes the data packets to restore their initial size.Computer addressing is done in this layer by logical addresses (IP addresses)
- **To easily remember the functions of layer 3, think of path selection, routing and addressing.**

The Data Link Layer

- The Data Link Layer ensures reliable data transit over a physical link. It gathers the bits of the physical layer to make a data structure, that is, a logical packet in which data can be placed, which is called a frame.
- The Data Link Layer takes care of physical addressing, which is done by addresses that are fixed on network cards. In the case of Ethernet cards, this address is called an Ethernet address or hardware address. This layer also takes care of network topology, network access, error reporting, ordered delivery of frames, and flow control. The Data Link Layer is materialized and executed by software residing in ROM on the network card
- **To easily remember the functions of Layer 2, think of frames and MAC addresses.**

The Physical Layer

- The Physical Layer defines the electrical, mechanical, procedural, and functional specifications for activating, maintaining, and deactivating the physical link between end systems. Characteristics such as voltage levels, timing of voltage changes, physical data rates, maximum transmission distances, and other similar attributes are defined by the Physical Layer.
- It is the layer that sends the bits in the physical cable. It defines how the cable is connected, what its nature is (twisted pair or optical fiber, coaxial, etc.) and therefore is concerned with defining how to encode a bit (nature and characteristics of the electrical pulse, etc.). The Physical Layer is represented by the hardware of the network card.
- **To easily remember the functions of Layer 1, think of signals and media.**

The TCP/IP (Transmission Control Protocol – Internet Protocol) model

- The American defense (in 1979), decided to define its own architecture. It therefore proposed a layered architecture like that of the OSI model, it is the TCP / IP architecture.
- The TCP / IP protocol family is particularly suitable for the implementation of large-scale networks (WAN). TCP / IP is today, among the standardized protocols, the most complete and most widely used protocol for corporate networks.

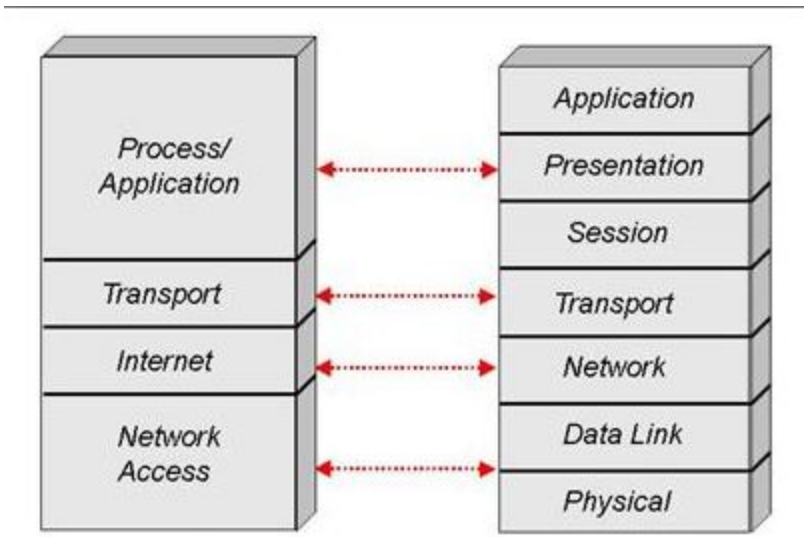
The TCP/IP (Transmission Control Protocol – Internet Protocol) model

TCP/IP includes the following components:

- Internet Protocol (IP). It transports data from one computer to another.
- Internet Control Message Protocol (ICMP). This basic protocol adds status information to the Internet Protocol such as error messages and routing information.
- Address Resolution Protocol (ARP). This protocol is responsible for converting hardware addresses into logical addresses of the network.
- Transmission Control Protocol (TCP). This protocol, which is based on the Internet Protocol (IP), establishes a virtual link to the remote computer and takes care of the security of data transmission.
- User Datagram Protocol (UDP). Based on the Internet Protocol (IP), this protocol supports the unsecured transmission of datagrams.

TCP/IP Model VS OSI Model

Compared to the classic 7-layer OSI model, the model presenting TCP/IP is composed of only 4 layers.



TCP/IP Architecture

- TCP/IP software is structured into four layers of protocols that rely on a hardware layer

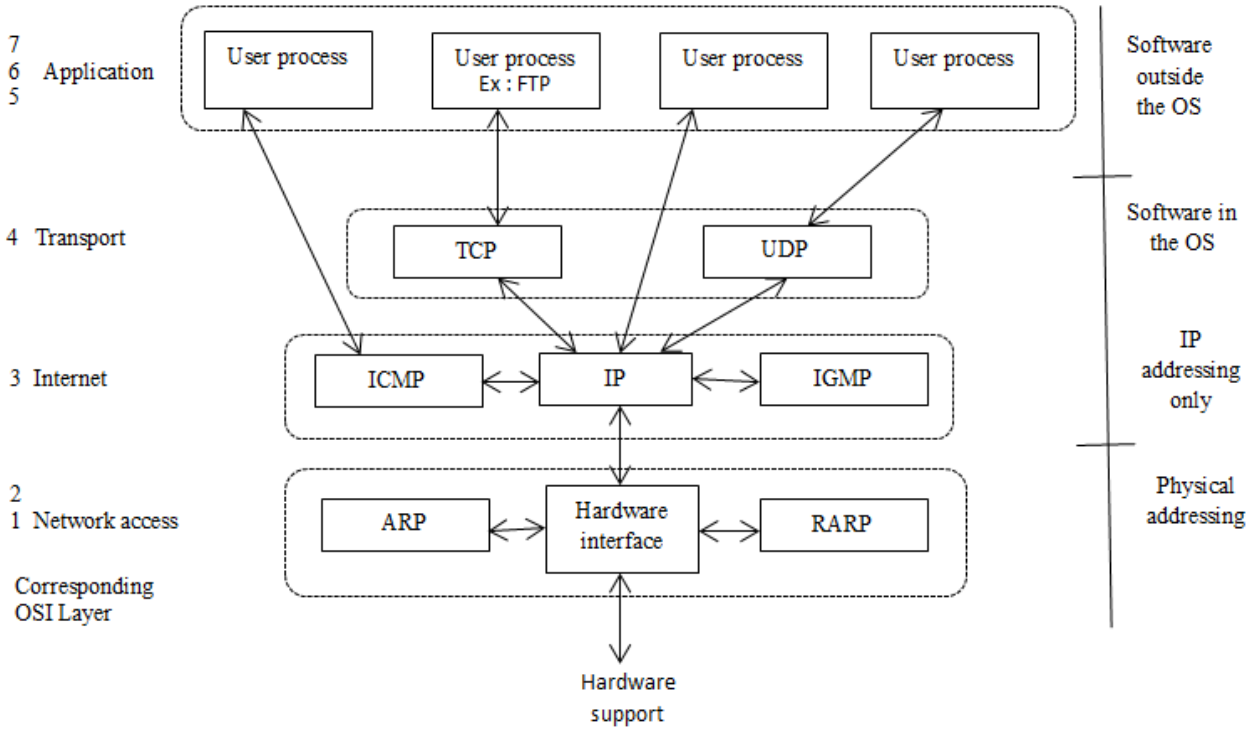


Figure: Enter Caption

Network Access layer

- Supports physical communication with the network,
- it is the interface with the network and,
- consists of an operating system driver and a computer interface card with the network (network card, modem,...)

The Internet layer or IP layer

- Manages the flow of packets through the network by ensuring their routing.
- It also includes the ICMP (Internet Control Message Protocol) protocols for implementing controls on the transport of IP packets and reporting errors. . . and IGMP (Internet Group Management Protocol).

The transport layer

- First of all, it ensures end-to-end communication by ignoring the intermediate machines between the sender and the recipient.
- It takes care of regulating data flows and ensures reliable transport (data transmitted without error and received in the order of their transmission but with a relatively low throughput due to checks) in the case of TCP (Transmission Control Protocol) or unreliable (but with a higher throughput due to the absence of checks) in the case of UDP (User Datagram Protocol). For UDP, it is not guaranteed that a packet (called a datagram in this case) arrives at the right port; it is up to the application layer to ensure this.

The application layer

- Is that of user programs such as:
  - Telnet (connection to a remote computer), Virtual Terminal Management Protocol (allows you to obtain software from another computer through the network).
  - FTP (File Transfer Protocol), file transfer
  - SMTP (Simple Mail Transfer Protocol), electronic mail
  - SNMP (Simple Network management Protocol), network management
  - HTTP (Hyper Text Transfer Protocol), web servers