

1. GENERAL ASPECTS OF COMMUNICATION SYSTEMS

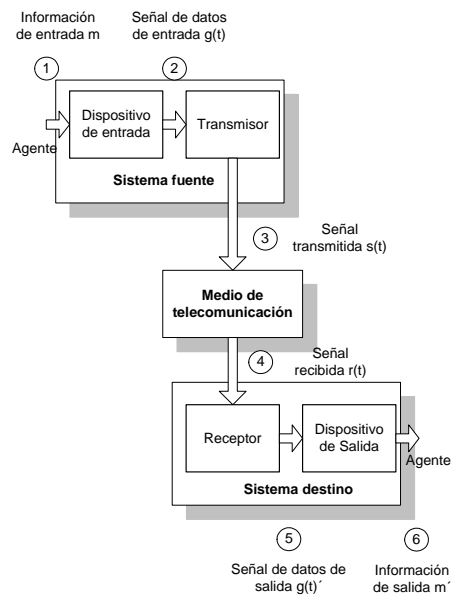
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- a. Data transmission
- b. Networks and their criteria
- c. Protocols and standards

a. Data transmission

General Data Communication System



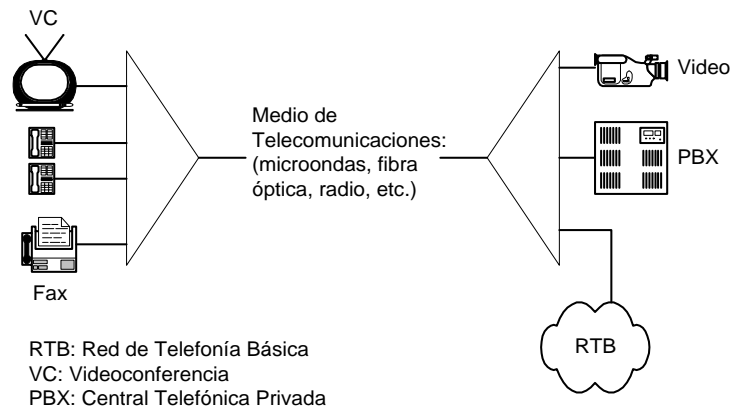
Tasks of a Data Transmission System

1	Utilización del sistema de transmisión
2	Interface
3	Generación de señales
4	Sincronización
5	Administración de intercambios
6	Detección y corrección de errores
7	Control de flujo
8	Direccionamiento y enrutamiento
9	Recuperación
10	Formato del mensaje
11	Protección
12	Administración del sistema

1. Use of the Transmission System

Telecommunication media are expensive, even more so if the distance to be covered is long. Thus, maximum use should be made of the bandwidth to enable the transmission of all types of information in the form of data, voice and video. To this end, TDM or statistical multiplexors may be used, as shown in Figure A.1.

Statistical multiplexors to optimise the use of a communication medium

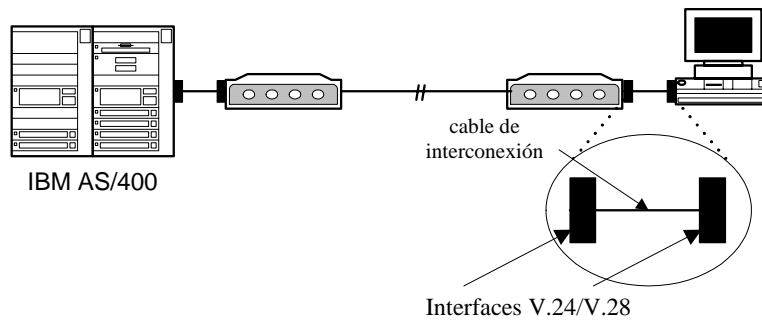


2. Interface

Computer and telecommunication equipment require fully compatible interfaces in order to interconnect and communicate with each other and with their respective environments (computer and telecommunications environments).

The following figure illustrates the interconnection interfaces between modems and computers in a point-to-point link.

Application of interfaces in a point-to-point link

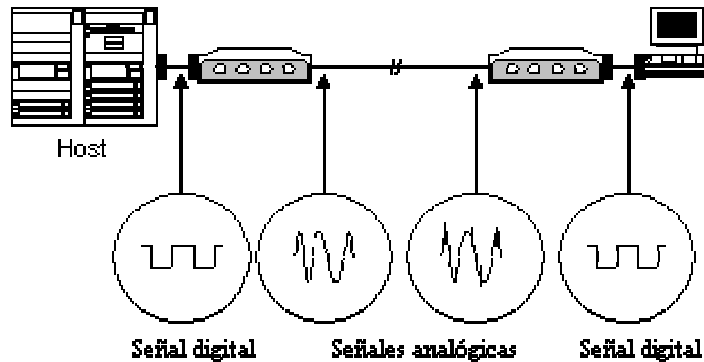


3. Generation of Signals

Computer systems are not suited to communicate directly with telecommunication media, and thus require intermediate devices to generate analog or digitally-coded signals to adapt the bits to these media.

The following figure illustrates the process whereby a modem converts bits into frequency-modulated signals.

Example of a modem converting digital to analog signals and *vice versa*



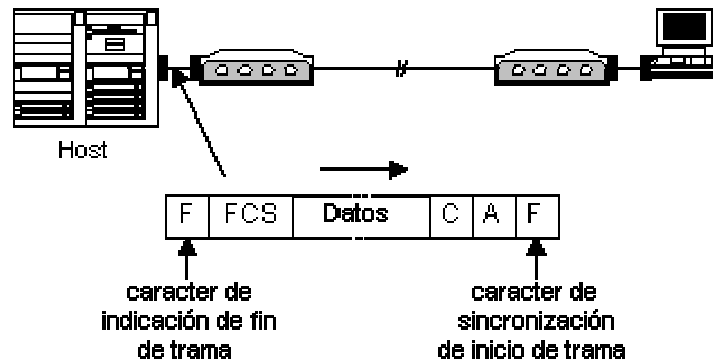
4. Synchronization

Through this process, the receiver may identify the beginning of a character or a sequence of bytes.

The example shows a communication using the HDLC protocol.

In this graph, the beginning of the frame is identified with a start flag, and the end with an end flag.

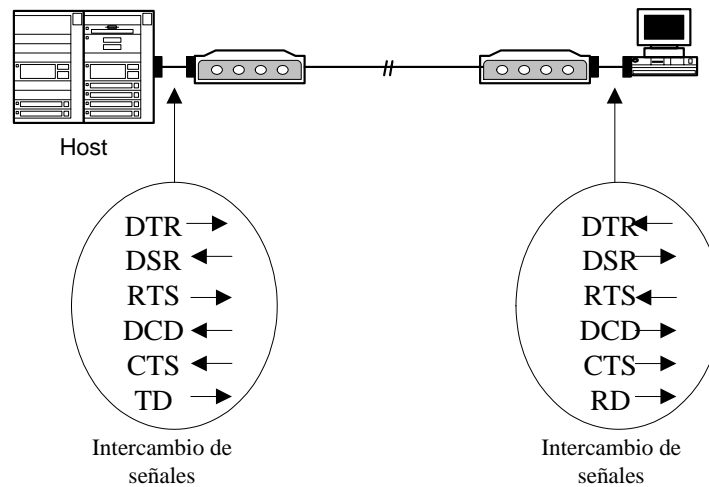
Example of HDLC protocol synchronization



5. Signal exchange management

For a modem to be able to transmit computer signals, it must coordinate the action to be taken at the right moment; to this end, it needs to exchange control signals.

Simple diagram showing the exchange of V.24 interface control signals between a computer and a modem



6. Error detection and correction

Every means of communication has noise, both intrinsic (the noise of the system itself) and external (generated by sources such as humans, the universe, etc).

The noise may cause distortion or radical changes in the signal, causing errors in the signal received.

6. Error detection and correction

These errors must be detected by both the device used for adapting to the communication medium and the computer system.

In addition to detecting the errors, these must be corrected using Automatic Request (ARQ) and Forward Error Correction (FEC) techniques.

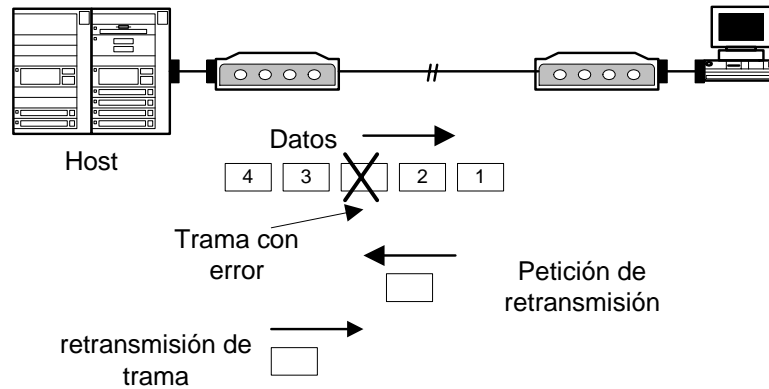
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Error detection and correction using the FCS and the automatic request (ARQ) technique

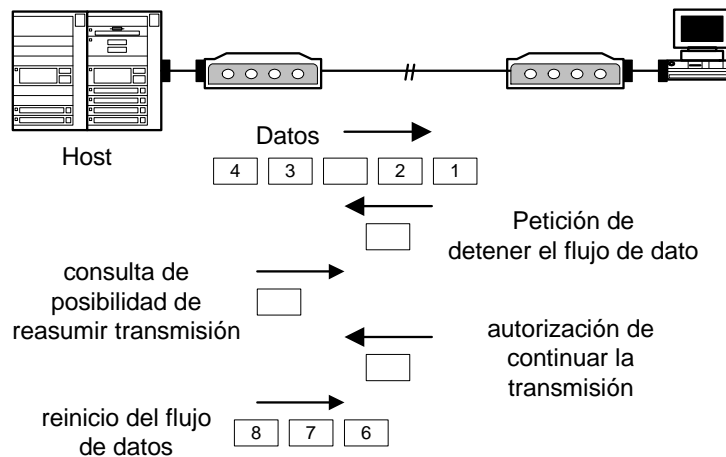


7. Flow control

This task is very important in order to avoid loss of information when the receiver is overloaded with various tasks and cannot continue processing the signals sent by the source of transmission.

To solve this problem, there are control mechanisms like the RNR and RR frames of the HDLC protocol.

Flow control mechanisms in a point-to-point data transmission



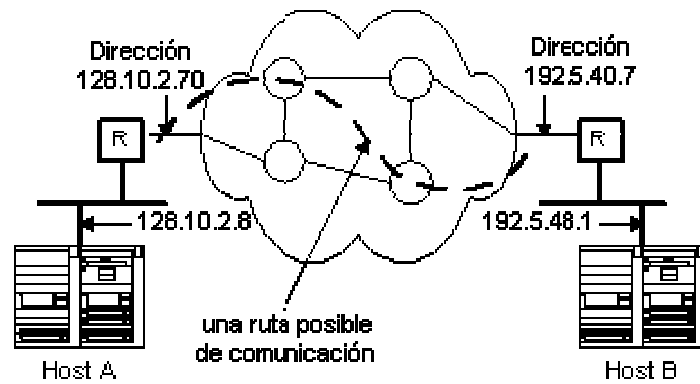
8. Addressing and routing

A computer needs to know two things in order to communicate with another remote computer. First, it needs the address of the remote computer in order to gain access to it.

In this case, an IP address, 192.5.40.7, is given to the remote computer (the address of the local computer is 128.10.2.70).

With the address, the two computers may communicate through various routes. The optimum route will be determined based on the routing algorithms used by the routers, which operate under a given criterion (delay, cost, rate of errors).

Example of addressing and routing in a communication between two computers through the Internet



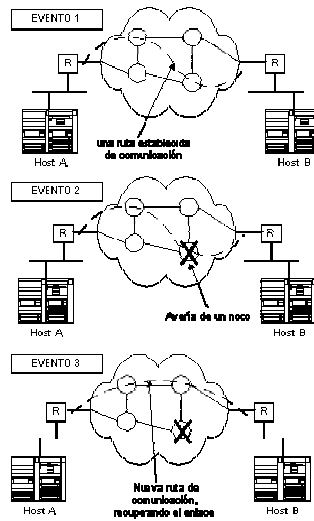
9. Recovery

This concept applies to WAN communications and consists in the reestablishment of communications following the failure of a network node or trunk link.

The following figure shows this procedure in the case of failure of a node.

It should be noted that subscribers or users normally will not lose communication or information.

Link recovery following a node failure. Event 1: Active communication link operating normally. Event 2: Failure of a node that is part of the active link. Event 3: Recovery of the link through a new route.



10. Message format

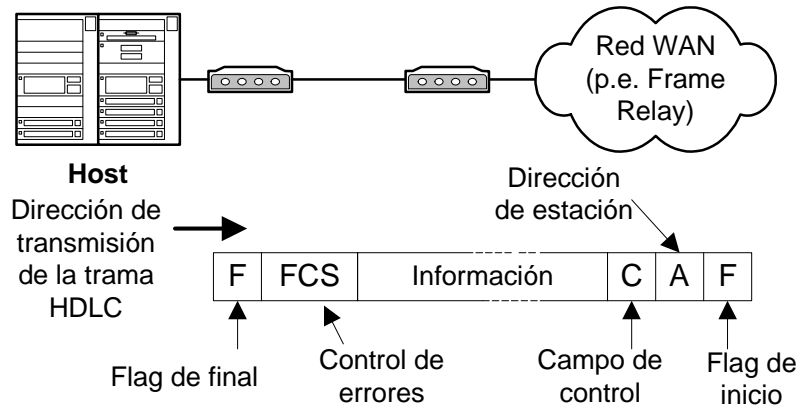
The data to be exchanged between two computers must normally have the same "form"; that is, they must have the same format.

If a terminal is asynchronous, its counterpart must operate or understand these asynchronous characters.

If a computer uses the HDLC protocol (level 2), the node to which it is connected must also use this protocol.

The following graph shows the transmission of a frame in the HDLC protocol format.

HDLC frame transferring information through a WAN



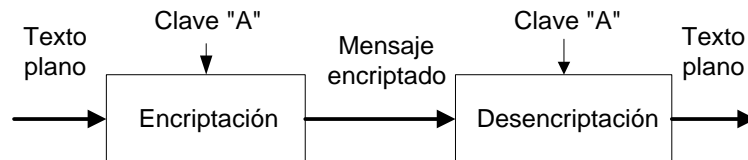
11. Protection

As we know now, information is a very valuable asset and must be protected when being transmitted through a public data network.

To this end, several safety mechanisms may be used, such as encryption.

The following graph shows the use of encryption to protect data transmitted *via* a public network to ensure confidentiality.

Use of encryption



12. System management

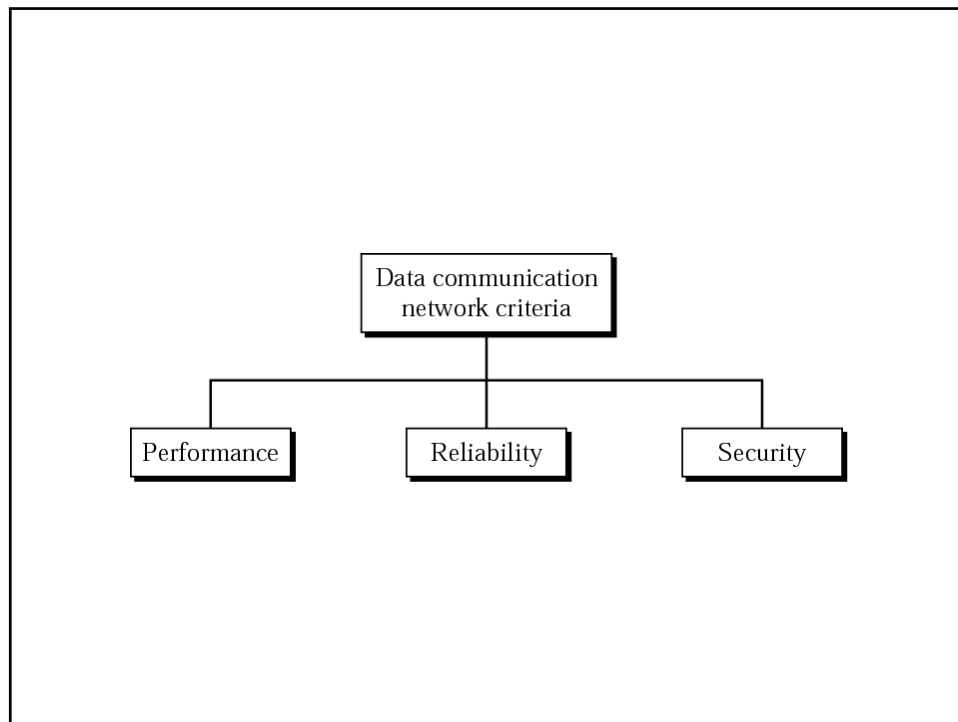
After a data communication network has been implemented according to a project, it must be managed in order to achieve a harmonious development and provide optimum performance to its users.

There are mechanisms, such as SNMP (Simple Network Management Protocol), for monitoring the various components in terms of failure, performance, general condition, etc.

b. Networks and their criteria

Network criteria

1. Performance: Flow rate and delay
2. Reliability
3. Security



1. Performance: Flow rate and delay

Network performance may be measured in different ways, such as: transit time and response time.

Transit time is the amount of time it takes for a message to go from one device to another through the network.

Response time is the time elapsed between a request and the response to it.

1. Performance: Flow rate and delay

Network performance depends on factors such as :

- Number of nodes
- Number of users
- Type of transmission medium
- Capacity of node hardware and users
- Capacity of node software and users

1. Performance: Flow rate and delay

Performance is assessed using two metrics:

- Flow rate
- Delay

Normally, the requirement is for more flow rate and less delay.

However, these two criteria are in conflict, for if we increase the flow rate through a network by increasing the number of users, the delay will also increase.

2. Reliability

This criterion is measured by the frequency of failures in the network and the time it takes to recover, and how well a network withstands a catastrophe.

3. Security

This criterion includes:

- Protection of information from unauthorised access
- Protection of data from damage
- Development and implementation of policies and procedures to recover from a loss of data.

c. Protocols and standards

Protocols

- Concepts of entity, system and protocol
- General model that comprises the functions and characteristics of any protocol
- General classification of protocols
 - Synchronous
 - Asynchronous

Bit-oriented protocols

They are designed to meet a wide variety of data line requirements, including:

- Point-to-point and multipoint links
- Half-duplex and full duplex operation
- Primary-secondary (*e.g.*, host-terminal) and peer-to-peer (*e.g.*, computer-computer) interaction
- Long-distance (*e.g.*, satellite) and short-distance (direct connection) links.

Objectives of protocols

- **Code-independent:** Capable of using any set of codes or bit patterns in the data it transmits.
- **Adaptable:** The format should support different types of links and changing requirements.
- **Highly efficient:** The format should minimise header bits and permit an efficient error and flow control.
- **Highly reliable:** The protocol should have a powerful set of error detection and correction processes.

Protocols - Characteristics

The concept of distributed processing and computer networks implies that entities in different systems need to communicate. We use the terms “entity” and “system” in a very general sense.

Examples of **entities**: user applications, file transfer packages, database management systems, e-mail facilities and terminals.

Examples of **systems**: computers, terminals and remote sensors.

Note that, in some cases, the entity and the system hosting it are coextensive, as in the case of terminals.

Protocols - Characteristics

In general, an entity is anything capable of sending or receiving information, and a system is a physically distinct object that contains one or more entities.

For two entities to be able to communicate successfully, they must speak the same language. The entities involved must agree on a set of conventions concerning what is communicated, how it is communicated and when it is communicated.

This set of conventions is known as a protocol, which can be defined as a set of rules governing the exchange of data between two entities.

Elements of a protocol

- **Syntax:**
Data format, coding and signal levels.
- **Semantics:**
Control information for purposes of coordination and error management.
- **Timing:**
Speed adjustment and sequencing.

HDLC is an example of a protocol

- Data to be exchanged must be sent in frames in a specific format (syntax).
- The control field provides a variety of placement functions, such as the placement of a mode and the establishment of a connection (semantics).
- Timing provisions for flow control must be followed.

Protocol functions

Let us now consider a small set of functions that are the basis of any protocol.

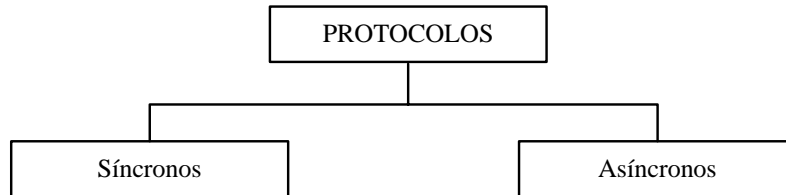
Not all protocols have all these functions, because it would be a duplication of effort.

Sometimes, however, the same type of function is present in protocols of different levels.

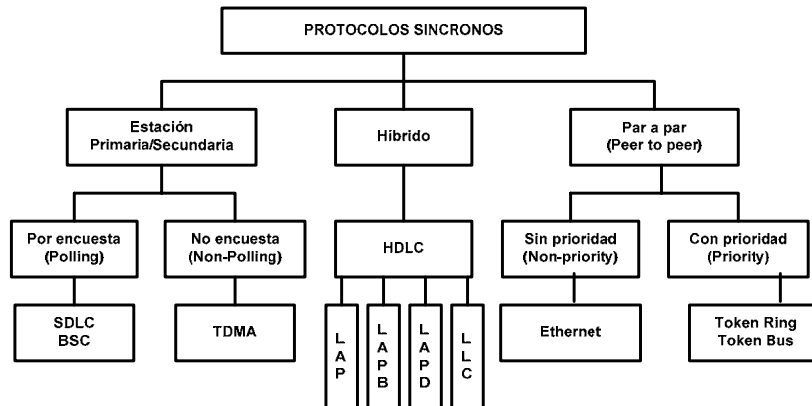
Protocol functions

1. Segmentation and reassembly
2. Encapsulation
3. Connection control
4. Flow control
5. Error control
6. Synchronization
7. Sequencing
8. Addressing
9. Multiplexing
10. Transmission services

Classification of protocols



Classification of synchronous protocols



Protocols with primary/secondary station: SDLC and BSC

- **SDLC:**
Is a subset of the HDLC protocol. Understanding of the HDLC protocol entails knowledge of SDLC.
- **BSC:**
Is a byte- or character-oriented protocol. Very popular in the 60's but seldom used today, since HDLC-based protocols are more efficient.

Protocols with primary/secondary station Non-polling: TDMA

- The Time-Division Multiple Access protocol is a sophisticated form of Time-Division Multiplexing (TDM).
- Here, a station is designated as primary station (frequently called *reference station*).
- The reference station is responsible for accepting requests from secondary stations, which are an indication that a secondary station wishes to use the channel.
- Requests are sent as part of the outgoing transmissions of secondary stations within a special control field.

Peer-to-peer protocols: Priority

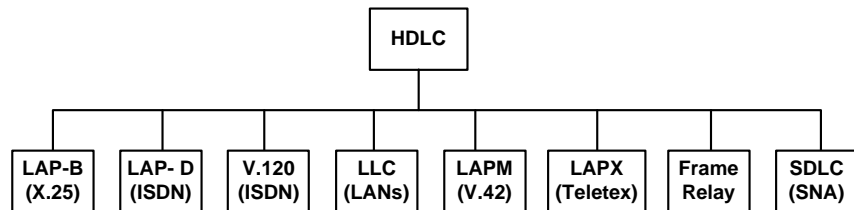
- TOKEN BUS: Deterministic protocol used in local area networks, IEEE 802.4. Used in manufacturing applications.
 - Uses a bus-type topology, but gives access to the channel as if it were a ring, using the same principle as the TOKEN RING protocol.
- TOKEN RING: Deterministic protocol, governed by IEEE standard 802.5, and is used in IBM LAN networks.
 - Uses a token to give a station an opportunity to transmit.

Peer-to-peer protocols: Priority

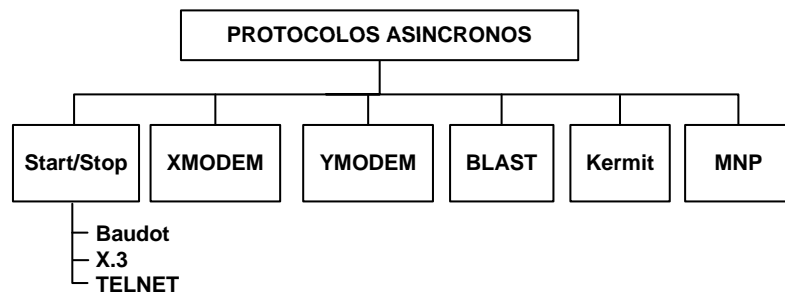
- CSMA/CD. Probabilistic protocol IEEE 802.3, known as Carrier Sense Multiple Access with Collision Detection (CSMA/CD).
- CSMA/CA. Probabilistic protocol IEEE 802.11, known as Carrier Sense Multiple Access with Collision Avoided (CSMA/CD).

HDLC hybrid protocol

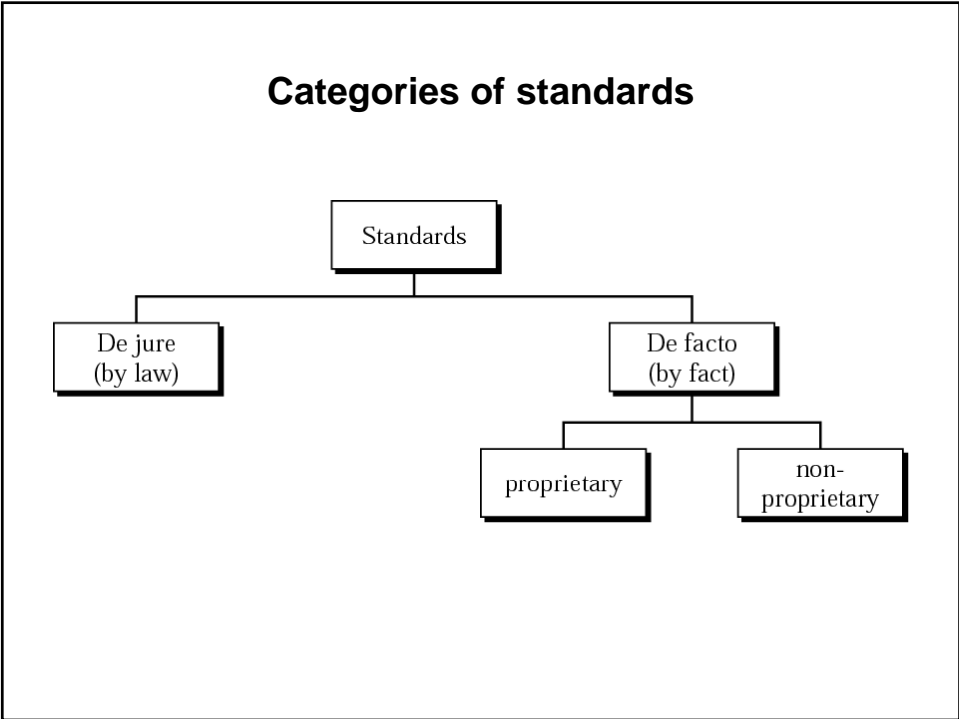
Protocol that serves as a basis for more than 8 types of protocols.



Classification of asynchronous protocols



Standards



Regulatory organizations

- ISO
- ITU – T (former CCITT)
- ANSI
- IEEE
- EIA
- TIA
- FCC
- ETSI
- IETF

International Organization for Standardization (ISO)

A non-governmental voluntary regulatory organization composed of standard organizations of participating nations and non-voting observer organizations.

Fonded in 1946, it has issued more than 5,000 standards in a wide range of areas.

It promotes the development of standardization to facilitate the international exchange of goods and services.

The ISO Technical Committee TC97, responsible for information technologies, developed the OSI model and the standards for each layer of the OSI architecture.

ITU - T

A regulatory body formalized as part of the International Telecommunication Union (ITU) in 1956, of which it is currently a committee.

The ITU was established in 1865, and is member of the United Nations Organization (UN).

It issues recommendations on technical, operational and tariff aspects concerning telegraphy and telephony.

Previously, they were published in a period of 4 years in a series of books, which were identified by the colour of their cover in the following order: red, blue, white, green, orange and yellow.

ITU - T

Serie	Alcance de la serie
A	Organización del CCITT
B	Definiciones, Símbolos clasificaciones
C	Estadísticas generales de Telecomunicaciones
D	Principios Generales de Tarifas
E	Red Telefónica: Operación, Administración de red e Ingeniería de Tráfico
F	Servicios de Telegrafía, Telemática, Mensajería y Directorio
G	Sistemas y medios de transmisión. Redes y sistemas digitales
H	Transmisión en línea de señales no telefónicas (radio y televisión)

ITU - T

Serie	Alcance de la serie
I	Red Digital de Servicios Integrados
J	Transmisión de Radioprogramas y señales de televisión
K	Protección contra perturbaciones
L	Construcción, Instalación y protección de cables. Elementos de planta externa
M	Mantenimiento: Circuitos internacionales de transmisión, circuitos telefónicos, circuitos telegráficos, circuitos arrendados y facsímil
N	Mantenimiento: Transmisiones radiofónicas y Circuitos de televisión
O	Especificaciones de instrumentos de medición

ITU - T

Serie	Alcance de la serie
P	Calidad de transmisión Telefónica.
Q	Conmutación y señalización telefónicas
R	Transmisión Telegráfica
S	Equipos terminales para servicios de telegrafía
T	Equipo Terminal y protocolos para los servicios de Telemática
U	Conmutación Telegráfica
V	Transmisión de Datos sobre Red Telefónica Conmutada (RTC)
X	Redes de comunicación de datos
Z	Lenguajes de programación

American National Standards Institute - ANSI

US-based non-profit and non-governmental organization made up by:

- Manufacturers
- Consumer groups
- Communication carriers
- Professional associations
- Purchase associations
- Governmental and regulatory groups

It was formed in 1918. It mainly deals with LANs and WANs

American National Standards Institute - ANSI

ANSI does not develop standards directly, but rather accredits those issued by other organizations, approving them and assigning them numbers when published.

It has accredited four Accredited Standards Committees:

- IEEE
- EIA
- ECSA (Exchange Carriers Standards Association)
- CBEMA (Computer Business Equipment Manufacturers Association -Committee X3)

Institute of Electrical and Electronics Engineers (IEEE)

Professional organization member of ANSI.

It was formed in 1963 by the merger of the American Institute of Electrical Engineers – AIEE (formed in 1884) and the Institute of Radio Engineers.

Its main objective is to advance the theory and practice of engineering in the fields of electricity and electronics, which include information technology and telecommunications.

It addressed layers 1 and 2 of the IEEE 802 OSI model for local area networks (LANs).

Specialized divisions of the IEEE

- Circuits and devices
- Industrial applications
- Communication technology
- Electromagnetism and radiation
- Computers
- Engineering and human environments
- Power engineering
- Signals and their applications
- Systems and control

Electronic Industries Alliance (EIA)

Alliance of electronics firms and member of ANSI

Its members vary in size, from suppliers of small components to multinational organizations that serve the defence industry.

Was founded in 1924 as the Radio Manufacturers Association.

It deals with data communication standards in the physical layer of the OSI model (level 1), that is, in the hardware. The most widely know is RS-232-C.

Telecommunications Industries Association (TIA)

In 1988, the EIA telecommunications sector merged with the US Telecommunications Suppliers Association (USTSA) to form the TIA.

Among its main standards are TIA 568 A and TIA 568 B, governing the structured cabling of computer networks.

Federal Communications Commission – FCC

US government agency charged with regulating wireline or radio traffic in the United States.

Responsible for issuing licences within the United States, and has generated the spread spectrum standard in particular.

European Telecommunications Standards Institute (ETSI)

Telecommunications standardization body based in France.

Created in 1988 for the purpose of establishing European regulations on telecommunications.

In collaboration with the European Broadcasting Union (EBU) and the CEN/CENELEC, it issues broadcasting and IT standards.

Internet Engineering Task Force (IETF)

Standards organization that deals with the Internet and related technologies. Manufacturers are very much involved.

Frame Relay Forum

Consortium of 300 members, made up by vendors and carriers.

It regulates and promotes Frame Relay.

ATM Forum

Consortium of vendors whose main objective is to regulate ATM.

It has more than 800 members, including vendors, carriers and consultants.

Network Management Forum

Consortium of vendors dealing with the development of network management.

It has more than 200 members, 80% of which are telecommunication companies and their suppliers.