

Computer Networks - *Xarxes de Computadors*

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Slides: <http://studies.ac.upc.edu/FIB/XC>

Outline

- **Course Syllabus**
- Unit 1: Introduction
- Unit 2. IP Networks
- Unit 3. Point to point protocols -TCP
- Unit 4. LANs
- Unit 5. Data transmission

Course Syllabus

Course Organization

- 2 x 2h lectures/week: theoretical + problems
 - Print the **collection problems** (raco FIB)
 - Try to do the problems beforehand
 - Solve **assessments** and final **exams**! (web)
 - Find textbooks and related links at the web page. Not necessary to follow the course.
- 1 x 2h laboratory/week
 - Buy the manual. Study and prepare sessions beforehand.
 - 2 laboratory sessions are devoted to problems: you can participate and obtain **0,2 points** over the final exam.

web page: <http://studies.ac.upc.edu/FIB/XC>

Course Syllabus

Evaluation:

$$F = 0.20 * L + 0.80 * \max\{E; (0.15 * C + 0.85 * E)\}$$

Where:

- **F** = Final mark
- **L** = Laboratory: 25% Mini-assessments of 15 min. at each session (except the first), and 75% a final laboratory exam.
- **E** = Final exam
- **C** = Control, 1 hour duration (week 8~9)

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Unit 1: Introduction

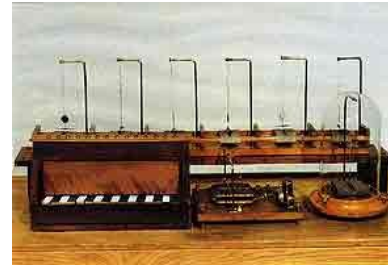
Outline

- **Brief history of Computer Networks and Internet**
- Introduction to Internet
- Standardization Organizations and OSI Reference Model
- Client-Server Paradigm

Unit 1: Introduction

Brief history of Computer Networks

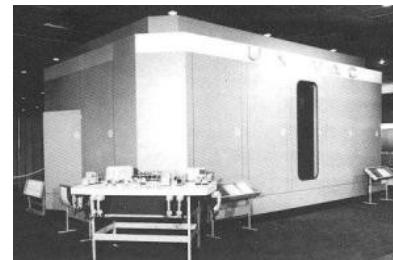
- 1830: **Telegraph**
- 1866: First **transatlantic** telegraph cable
- 1875: Alexander Graham Bell invented the **telephone**
- 1951: First commercial **computer**
- 1960: Concept of **Packet Switching**.
- 1960s: **ARPANET** project, origins of the Internet.
- 1972: First International and commercial Packet Switching Network, **X.25**.
- 1990s: The **Internet** is opened to the general public.



Pavel Shilling Telegraph, 1832.



Major Telegraph Lines, 1891.



UNIVAC: First commercial computer, 1951



New York Telephone Cabling, 1888



Telephone Central Office in London, 1926

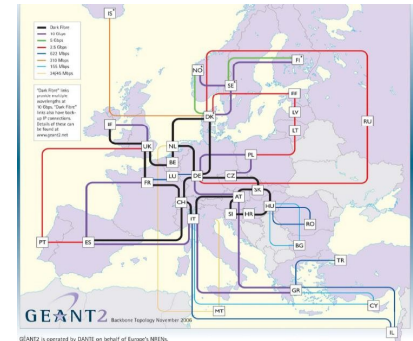


Today's Networking Equipment.

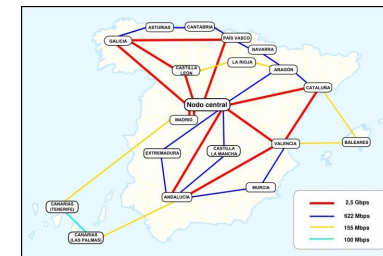
Unit 1: Introduction

Brief History of the Internet

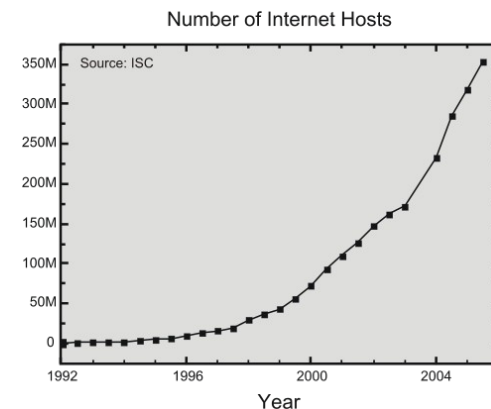
- 1966: Defense Advanced Research Projects Agency (DARPA). **ARPANET** project.
- ARPANET connected **Universities** and military centers. Military portion separated in 1983.
- 1970s: End-to-end reliability was moved to hosts, developing **TCP/IP**. TCP/IP was ported to UNIX Berkeley distribution, BSD.
- 1990s: The **Internet** is opened to commerce and the general public by the Internet Service Providers, ISP.



<http://www.geant2.net>



<http://www.rediris.es>



Unit 1: Introduction

Outline

- Brief history of Computer Networks and Internet
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- Client-Server Paradigm

Unit 1: Introduction

Bitrate

t_b is the transmission time of 1 bit.

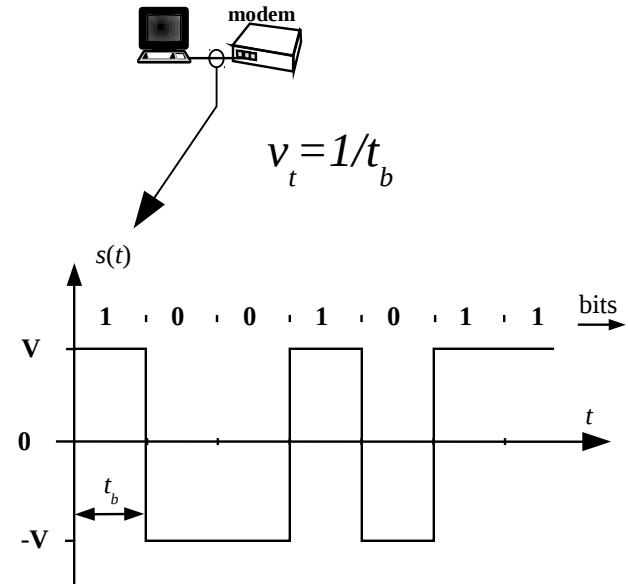
- $v_t = 1/t_b$ is the **line bitrate** in bits per second (**bps**)

- typical bitrate prefixes:

- **k**, kilo: 10^3
- **M**, Mega: 10^6
- **G**, Giga: 10^9
- **T**, Tera: 10^{12}
- **P**, Peta: 10^{15}

- Examples:

- Public Switched Telephone Network (PSTN) **modem**: 56 kbps
- **ADSL**: 4 Mbps
- **LAN** Ethernet: 10 Mbps, 100 Mbps, 1Gbps, 10 Gbps.
- **Carrier** lines E3: 34 Mbps, OC-192: 9,9 Gbps, ...

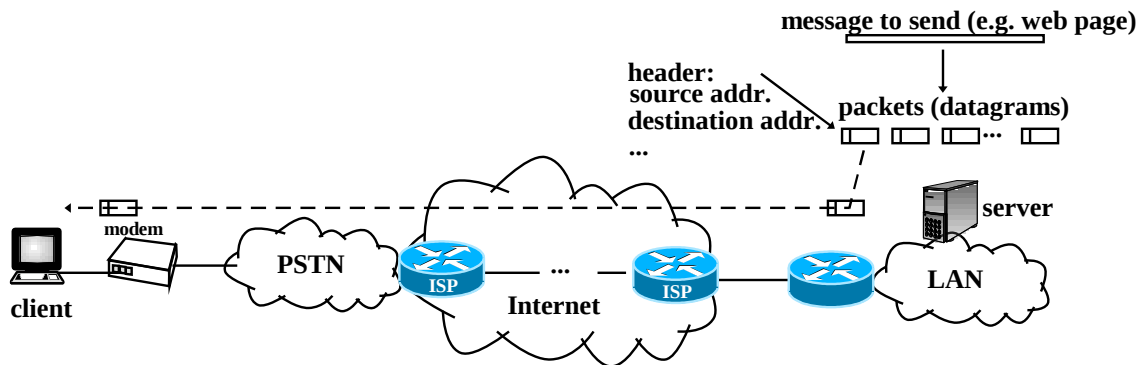


NRZ signal

Unit 1: Introduction

Types of Switching

- Circuit switching, e.g. PSTN
- Packet switching:
 - Virtual Circuit, e.g. X.25, ATM.
 - Datagram: Internet.



Datagram packet switching

Unit 1: Introduction

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Unit 1: Introduction

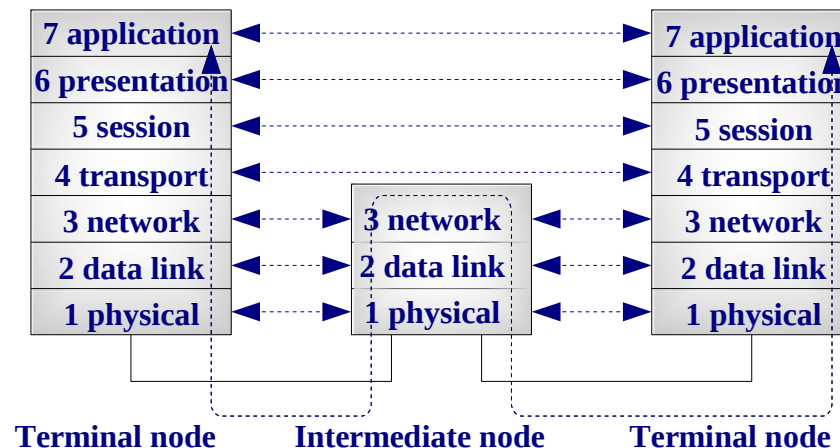
Standardization Bodies

- International Telecommunication Union, **ITU**: WAN standards.
<http://www.itu.org/>.
- International Organization for Standardization, **ISO**: Industrial standards. <http://www.iso.org/>.
- Institute of Electrical and Electronics Engineers, **IEEE**: LAN standards.
<http://www.ieee.org/>.
- European Telecommunications Standards Institute, **ETSI**: Mobile phone standards (GSM). <http://www.etsi.org/>.
- Electronic Industries Alliance, **EIA**: Cabling standards.
<http://www.eia.org/>.
- Internet Engineering Task Force, **IETF**: Internet standards.
<http://www.ietf.org>. Standardization proposals are done through *Request For Comments*, **RFCs**. They are mirrored around the world, e.g.
<http://www.rfc-editor.org>
- World Wide Web Consortium (**W3C**). <http://www.w3.org>

Unit 1: Introduction

ISO Open System Interconnection (OSI) Reference Model

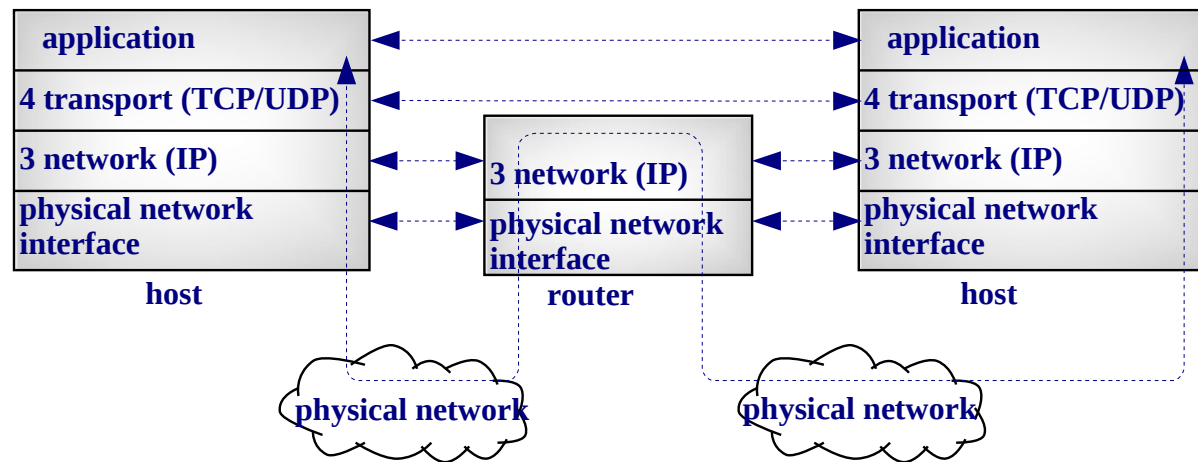
- *Layers or Levels*: Physical or **Layer 1** (L1), ...
- Peer layers communicate using a *protocol*.
- Protocols from different layers are independent.
- Layer i offers **services** (e.g. send a datagram to a given address) to layer $i+1$: *Service Access Points* (**SAP**).
- Peer layers exchange *Protocol Data Unit* (**PDU**), which consists of a *header* and *payload*.



Unit 1: Introduction

TCP/IP Architecture

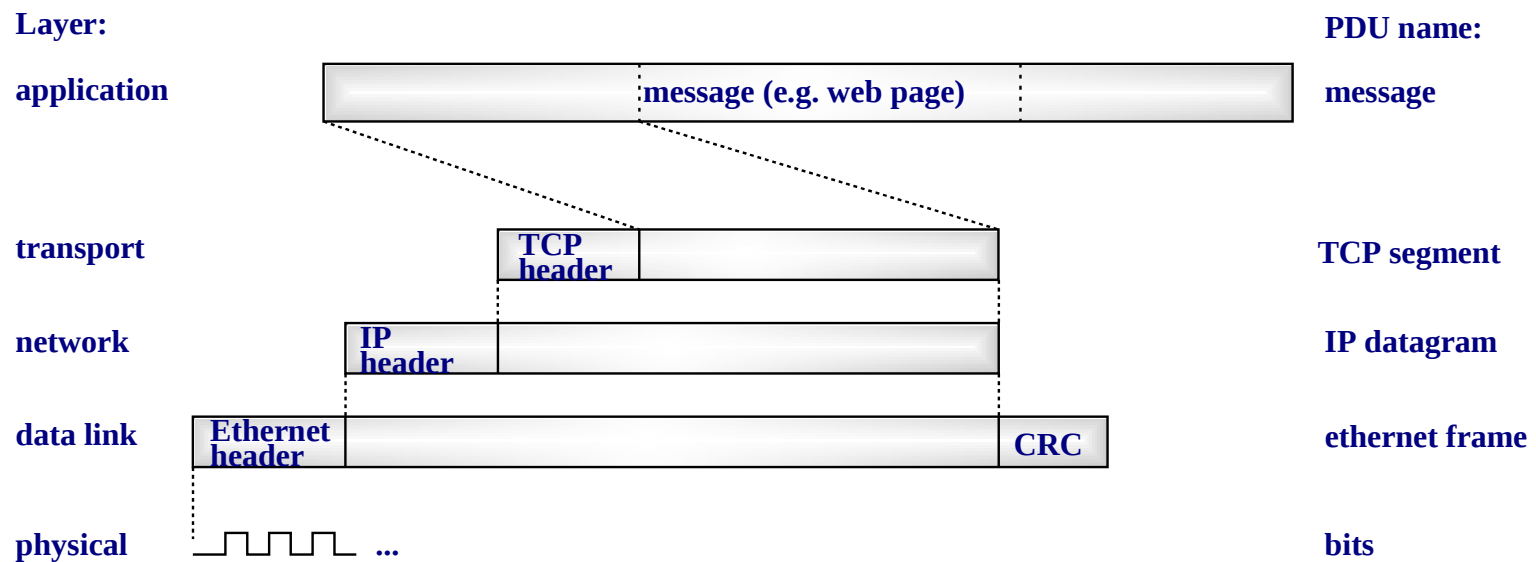
- **No RFC** specifies the TCP/IP model.
- Networking literature usually identifies the **layer model**:



Unit 1: Introduction

Encapsulation

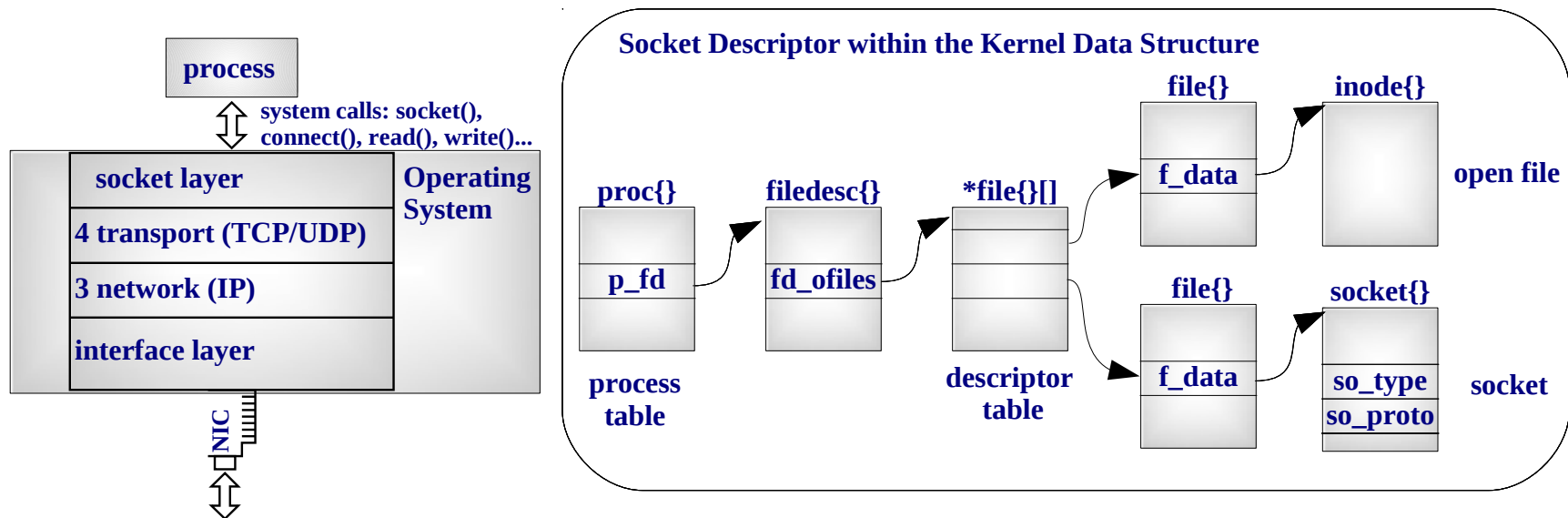
- Each layer adds/removes the **PDU header**.



Unit 1: Introduction

TCP/IP Implementation

- TCP/IP **networking code** is part of the Operating System kernel.
- **Socket interface**: Is the Unix networking interface for the processes. It was first implemented in Berkeley Software Distribution, BSD.
- The **socket system call** creates a **socket descriptor** used to store all information associated with a network connection, similarly as an inode descriptor for a file.



Unit 1: Introduction

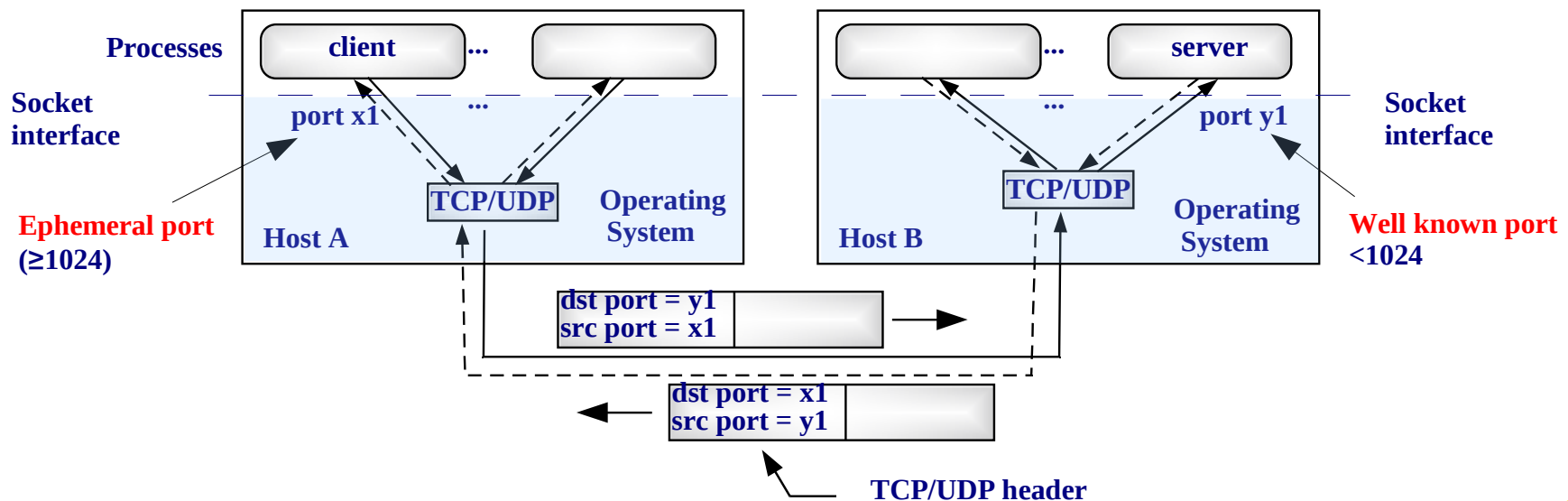
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Unit 1: Introduction

Client Server Paradigm

- How connection is established among processes?
- The client always initiates the connection towards a known IP address, in the IP header, and a **well known port** (< 1024), in the TCP/UDP header.
- Well known ports are standardized by IANA in RFC-1700 (**Assigned Numbers**). In a unix machine can be found in /etc/services.
- The server is a **daemon** waiting for client requests.



Unit 1: Introduction

Client Server Paradigm – UNIX /etc/services File

- Enables server and client programs to convert service names to well known ports.

```
linux> cat /etc/services
# Network services, Internet style
# Note that it is presently the policy of IANA to assign a single well-known
# port number for both TCP and UDP; hence, most entries here have two entries
# even if the protocol doesn't support UDP operations.
# This list could be found on:
#      http://www.iana.org/assignments/port-numbers
# *****
# WELL KNOWN PORT NUMBERS
# The Well Known Ports are assigned by the IANA and on most systems can
# only be used by system (or root) processes or by programs executed by
# privileged users.
#
# Keyword   Decimal   Description
# -----
echo        7/tcp    Echo
echo        7/udp    Echo
discard     9/tcp    # Discard
discard     9/udp    # Discard
daytime     13/tcp   # Daytime (RFC 867)
daytime     13/udp   # Daytime (RFC 867)
chargen     19/tcp   # Character Generator
chargen     19/udp   # Character Generator
ftp-data    20/tcp   # File Transfer [Default Data]
ftp-data    20/udp   # File Transfer [Default Data]
ftp         21/tcp   # File Transfer [Control]
ssh         22/tcp   # SSH Remote Login Protocol
ssh         22/udp   # SSH Remote Login Protocol
telnet      23/tcp   # Telnet
telnet      23/udp   # Telnet
...
```