Computer Networks - *Xarxes de Computadors*

Teacher: Llorenç Cerdà

Slides: http://studies.ac.upc.edu/FIB/grau/XC

Outline

- **Course Syllabus**
- Unit 1: Introduction
- Unit 2. IP Networks
- Unit 3. TCP
- Unit 4. LANs
- Unit 5. Network applications

Course Syllabus

Course Organization

- 2+1h lectures/week: theoretical + problems
  - Print the problems manual (available in the racó).
  - Try to do the problems beforehand.
  - Find textbooks and related links at the web page.
- Laboratory sessions of 2h on selected weeks + 2 non classroom labs
  - Buy laboratory manual in Repography.
  - Study and prepare sessions before hand.
  - Minicontrol held at the end of each session.
  - Required submitting a report at the beginning of the session. Otherwise, the minicontrol cannot be done.

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

Course Syllabus

Evaluation:

NF = 0.25 * NL + 0.75 * NT

Where:

- NF = Final grade.
- NL = Laboratory: 25% average of lab sessions, and 75% a final lab. exam.
- NT = Theory grade.

- NT can be obtained:
  - Continuous evaluation: NC = 0.4 * C1 + 0.4 * C2 + 0.2 * C3. If NC≥5 then NT=NC.
    - C1: Units 1,2 (introduction+IP),
    - C2: Unit 3 (TCP+LANs),
    - C3: Units 4,5 (Apps)
  - Final Exam (EF). NT=max(NC, EF).
    - If with NC it is NF≥5, you must send an email to the coordinator if you want to do the EF (to increase grade).

Course Syllabus

Incentive to study:

The final grade (NF) will be increased 1 point to students who meet the following conditions:

- Deliver on time the tracking problems (*exercicis de seguiment*) that will be proposed during the course.
- Obtain a grade ≥ 5 at least 1 of the Controls.
- Have a theory grade (NT) and lab (NL) greater than or equal to 5: NT,NL ≥ 5.

Autonomous learning (*transversal competence*):

- Two non classroom labs (home labs) will be proposed in the Racó.
- Evaluated with a specific final lab exam.

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Unit 1: Introduction

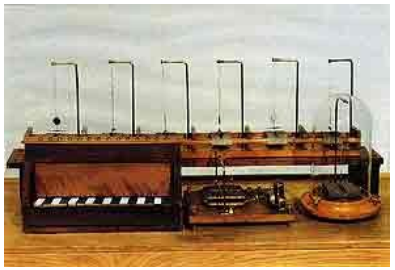
Outline

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

Unit 1: Introduction

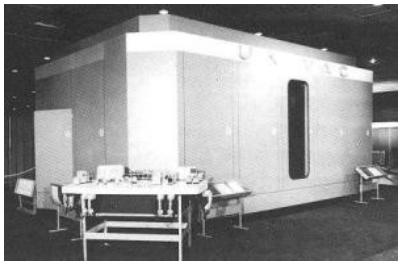
Brief history of Computer Networks

- 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.

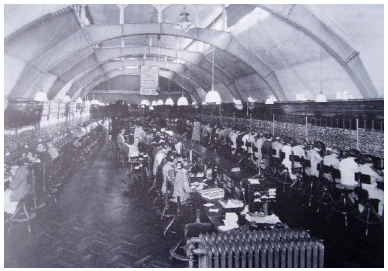
Major Telegraph Lines, 1891.



UNIVAC: First commercial computer, 1951

Source: wikipedia

New York Telephone Cabling, 1888



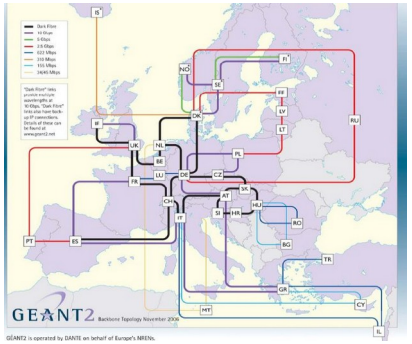
Telephone Central Office in London, 1926

Today's Networking Equipment.

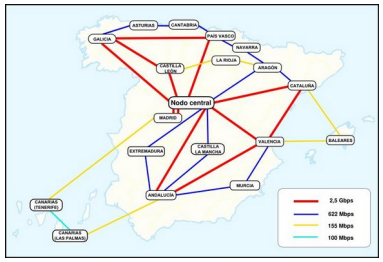
Unit 1: Introduction

Brief History of the Internet

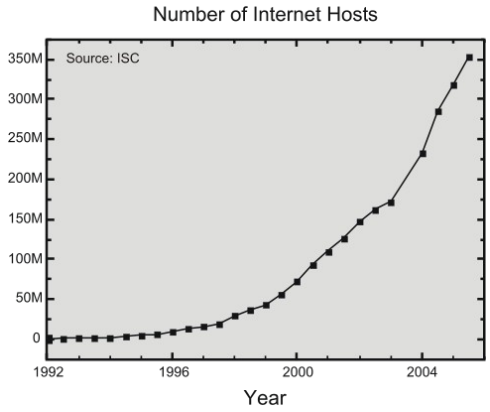
- 1966: Defense Advanced Research Projects Agency (DARPA). ARPANET project.
- ARPANET connected Universities, research labs and military centers. Military portion separated in 1983.
- 1970s: End-to-end reliability was moved to hosts, developing TCP/IP. TCP/IP was ported to UNIX Berkeley distribution, 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



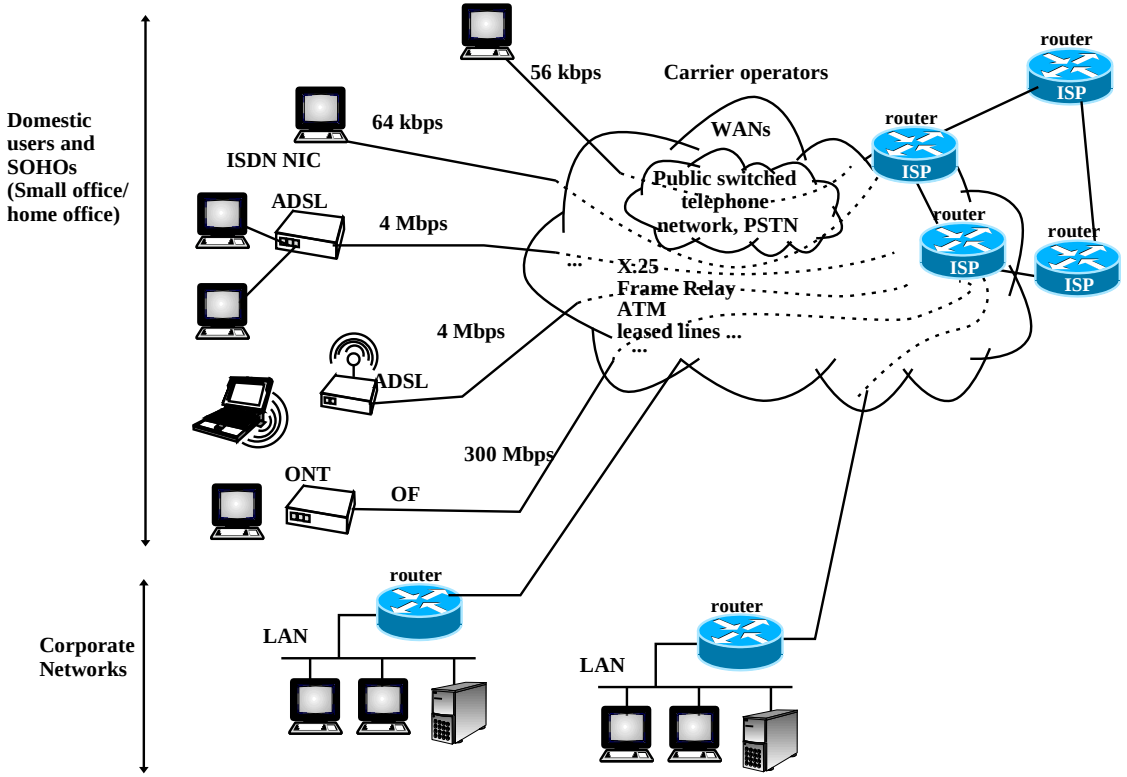
Unit 1: Introduction

Outline

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

Unit 1: Introduction

- Host
- Access Network
- LAN
- WAN
- Telephone company, telco, or carrier.
- Router
- Line Bitrate
- Bits per second, bps.

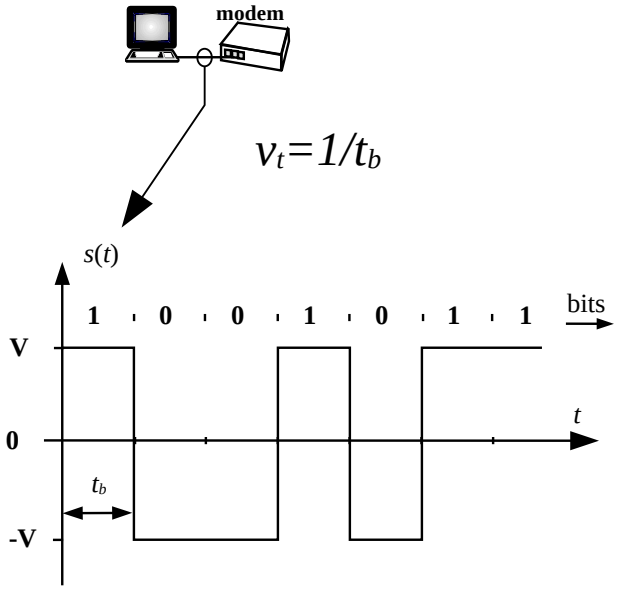


Unit 1: Introduction

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 Gpbs, ...

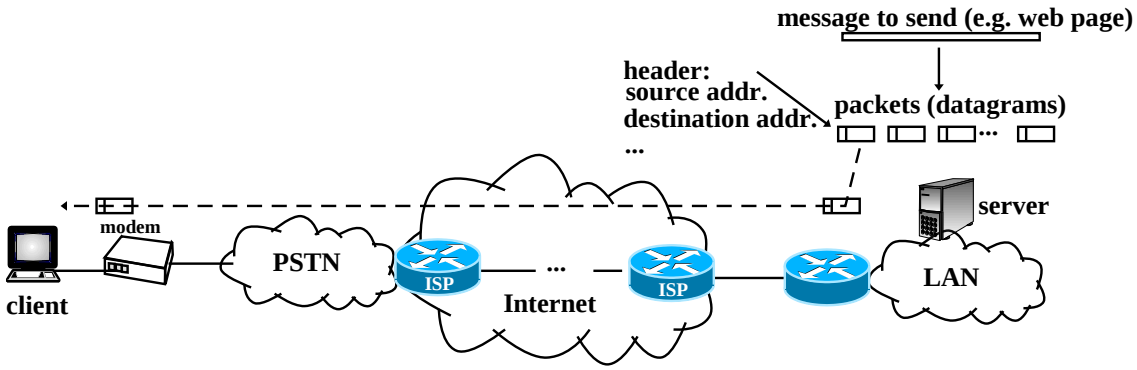


NRZ signal

Unit 1: Introduction

Types of Switching

- Circuit switching, e.g. PSTN (Public Switched Telephone Network)
- Packet switching:
  - Virtual Circuit, e.g. X.25, ATM.
  - Datagram: Internet.



Datagram packet switching

Unit 1: Introduction

Outline

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

Unit 1: Introduction

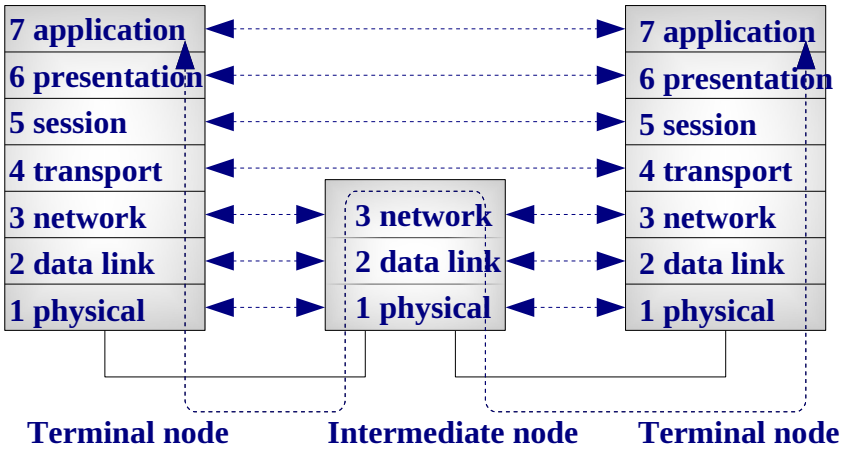
Standardization Bodies

- 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 Systems 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*.



Brief description of Layers:

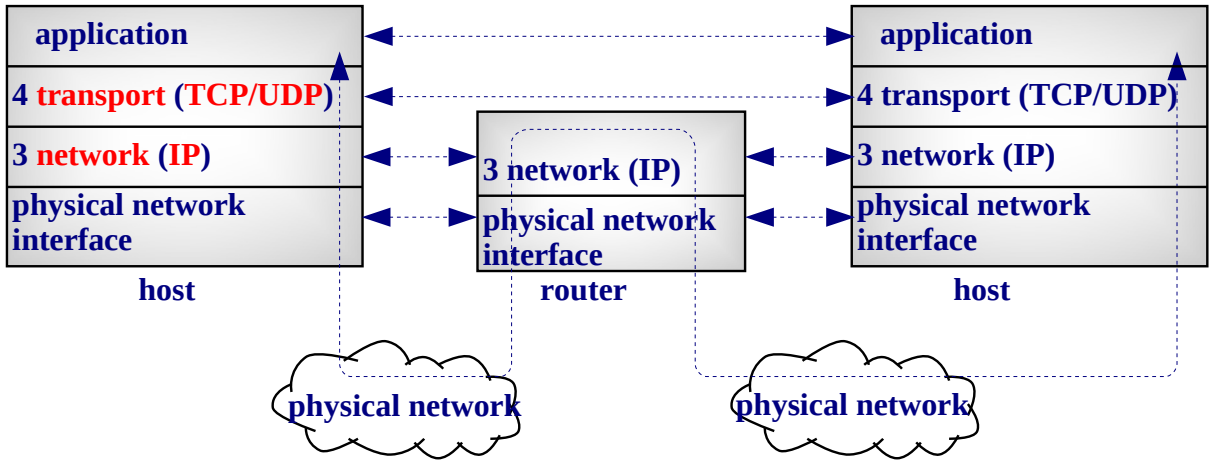
7. Application: Processes using network services (web, email...)
6. Presentation: Encoding of text, numbers...
5. Session: "Login" type service.
4. Transport: End to end data transfer.
3. Network: Routing.
2. Data link: Structured transport of bits.
1. Physical: Electric and mechanical.

*Internet jargon: Layer 8: the user.

Unit 1: Introduction

TCP/IP Architecture

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

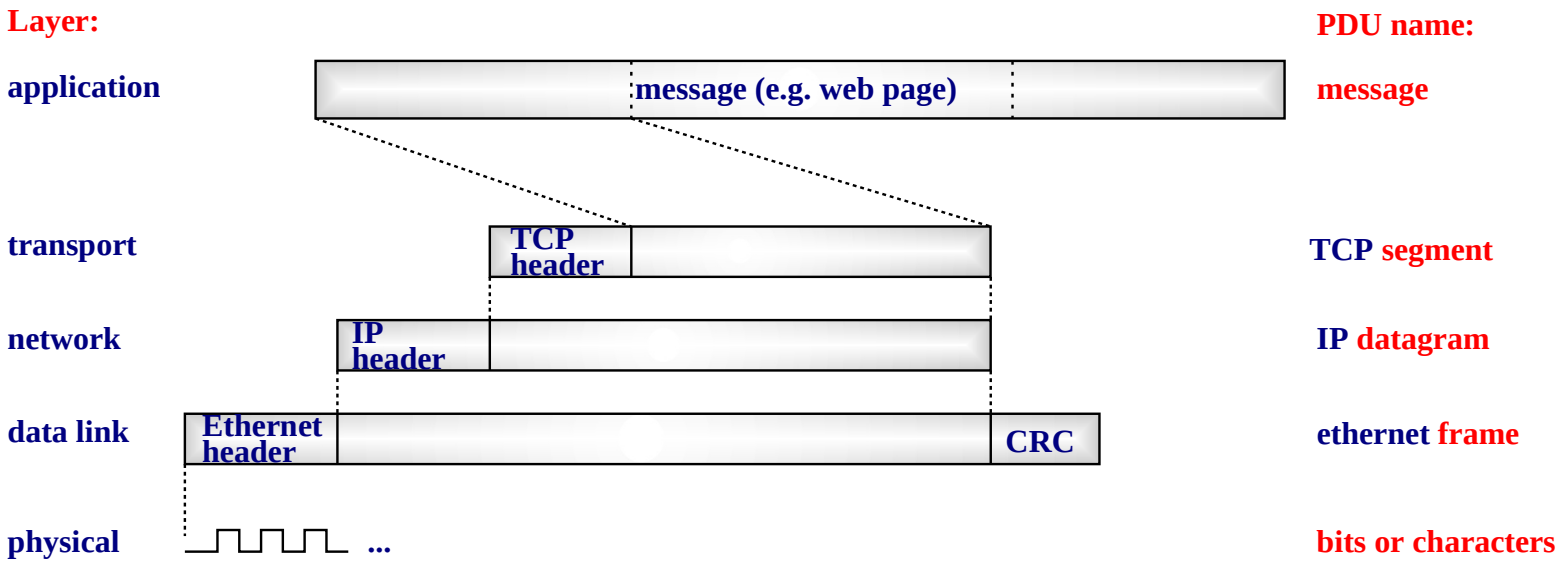


Physical network (Internet jargon): Any network that transport datagrams (not the OSI physical layer!)

Unit 1: Introduction

Encapsulation

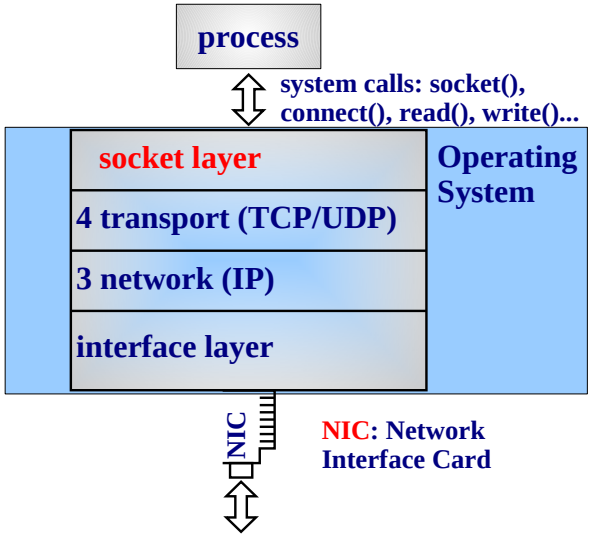
- Each layer adds/remove the PDU header.

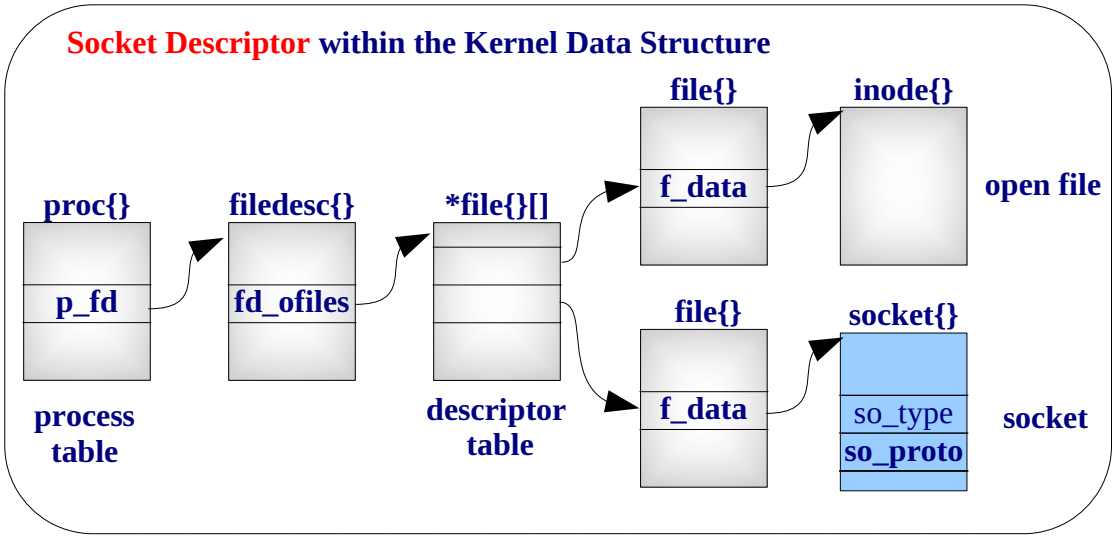


Unit 1: Introduction

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.





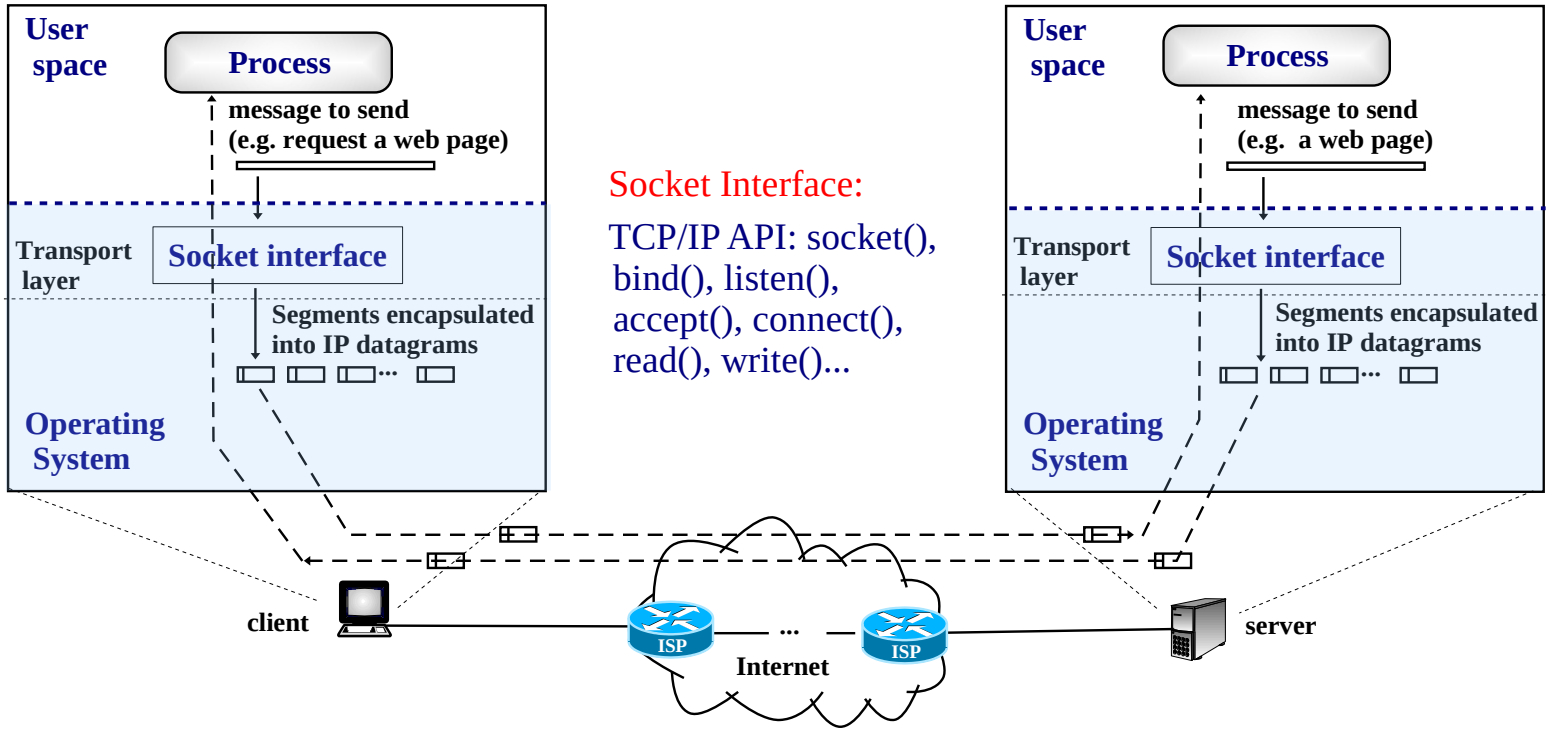
Unit 1: Introduction

Outline

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

Unit 1: Introduction

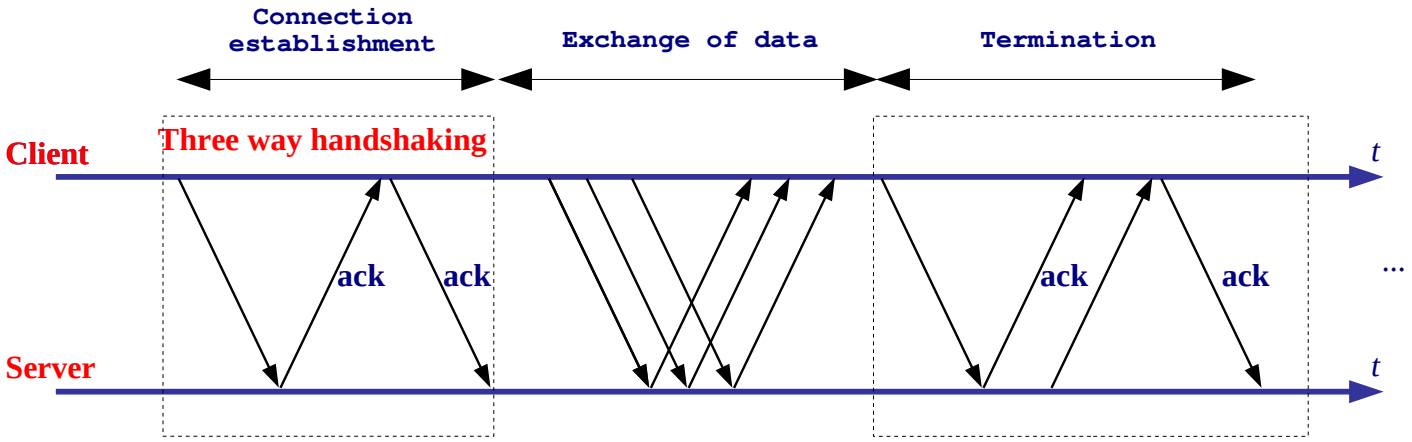
Client Server Paradigm: Processes, messages, sockets segments and IP datagrams



Unit 1: Introduction

Client Server Paradigm: The Internet Transport Layer

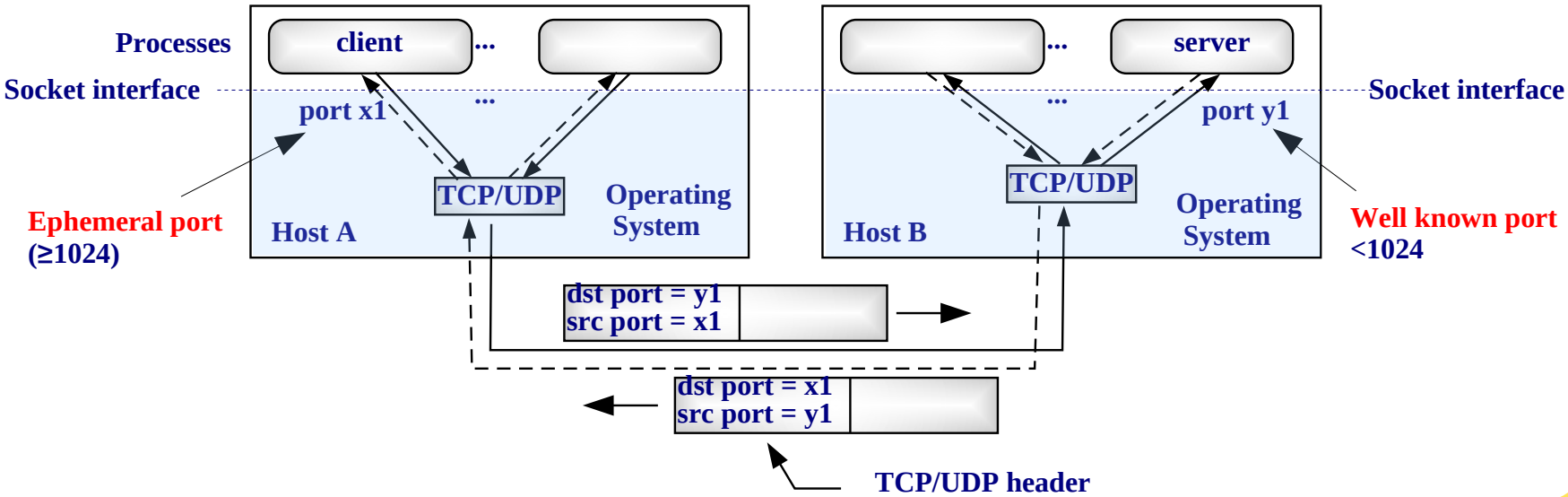
- Two protocols are used at the TCP/IP transport layer: User Datagram Protocol (UDP) and Transmission Control Protocol (TCP).
- UDP offers a *datagram service* (non reliable). It is connectionless.
- TCP offers a reliable service (correct segments are acknowledged, ack, lost segments are retransmitted). It is connection oriented (covered in detail in Unit 3).
- TCP connection:



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
...
```

Unit 1: Introduction

Client Server Paradigm – Network applications

- Remote commands
  - telnet
  - ssh
- Exchange of documents
  - ftp, sftp
  - peer-to-peer
- Web based applications
- Email
- Network management
- Real time
  - Voice over IP
  - Video streaming
- ...