

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

- See the web page: <http://studies.ac.upc.edu/FIB/grau/XC>

Computer Networks - *Xarxes de Computadors*

Outline

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

Unit 1: Introduction

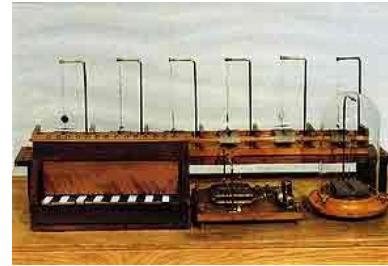
Outline

- **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.



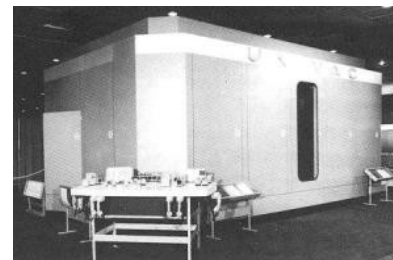
New York Telephone Cabling, 1888



Major Telegraph Lines, 1891.



Telephone Central Office in London, 1926



UNIVAC: First commercial computer, 1951

Source: wikipedia

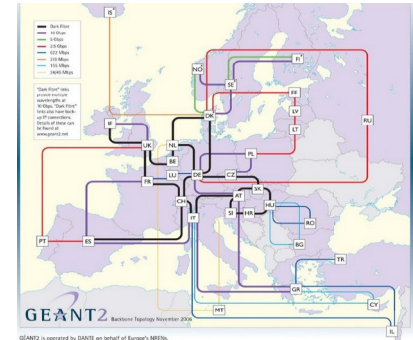


Today's Networking Equipment.

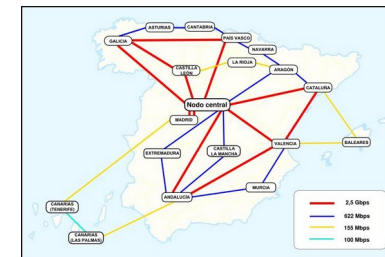
Unit 1: Introduction

Brief History of the Internet

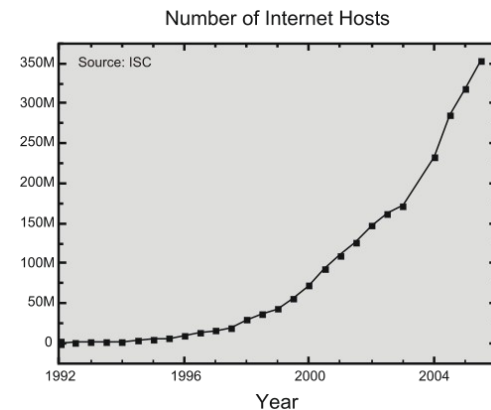
- 1966: Defense Advanced Research Projects Agency (DARPA). **ARPANET** project.
- ARPANET connected **Universities, research labs and military centers**. Military portion separated in 1983.
- 1970s: End-to-end reliability was moved to hosts, developing **TCP/IP**. TCP/IP was ported to **UNIX Berkeley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



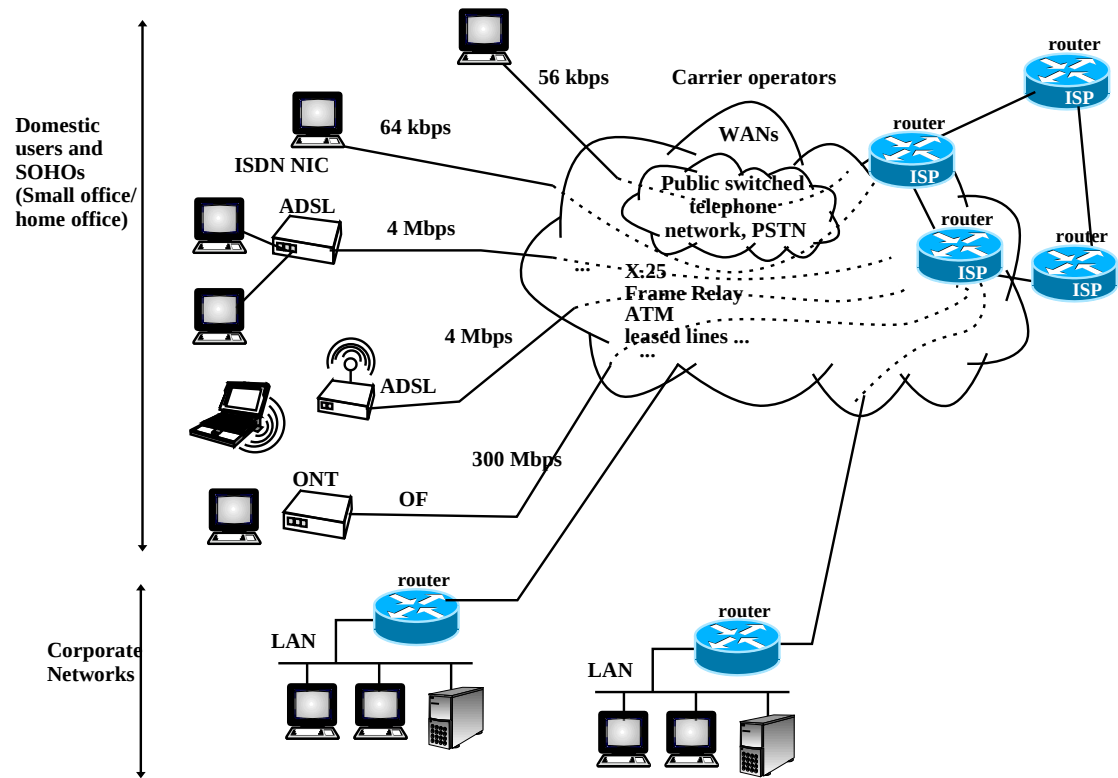
Unit 1: Introduction

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.

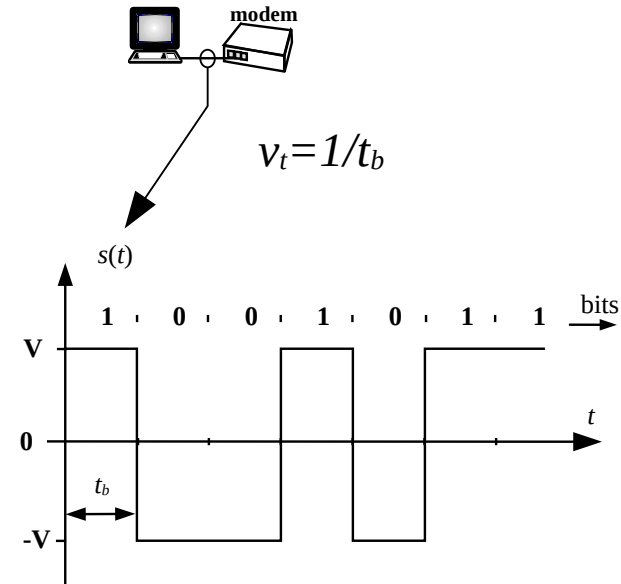
- $v_t = 1/t_b$ is the **line bitrate** in bits per second (**bps**)

- 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, ...

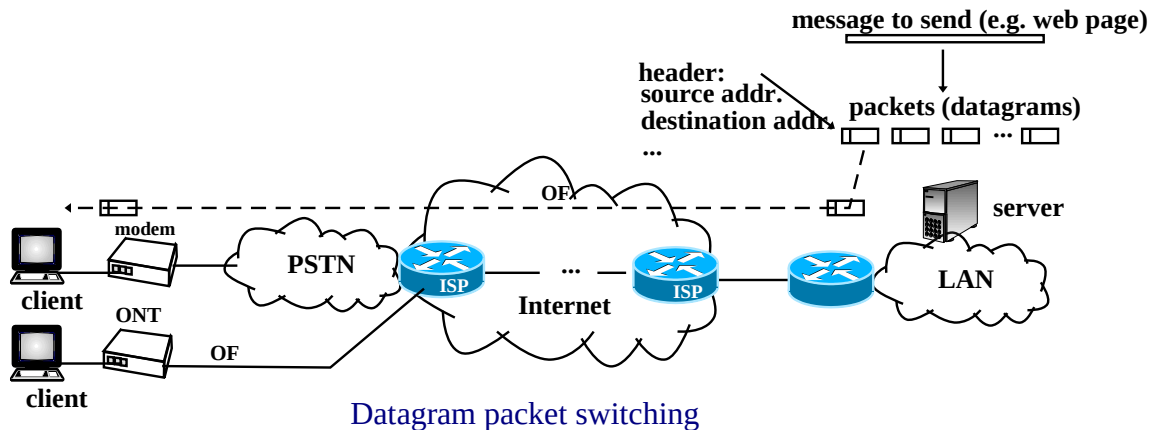


NRZ signal

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.



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

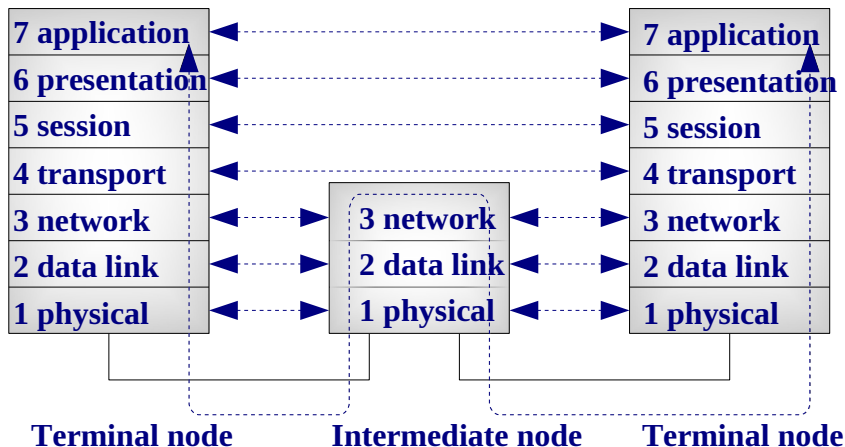
ISO Open Systems Interconnection (OSI) Reference Model

- *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.

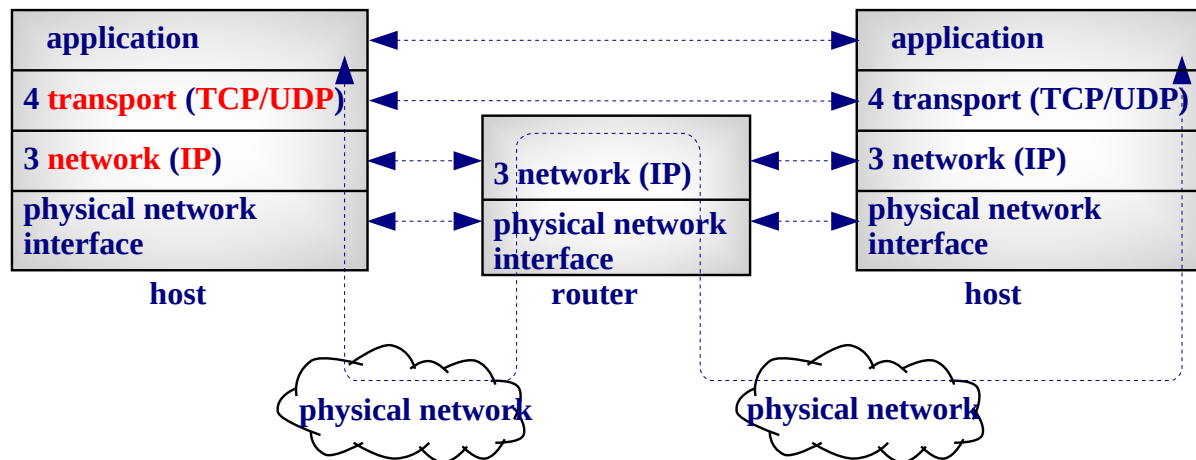
*Internet jargon: Layer 8: the user.



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

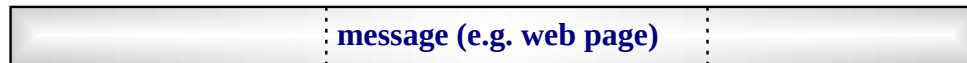
Encapsulation

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

Layer:

PDU name:

application



message

transport



TCP segment

network



IP datagram

data link



ethernet frame

physical

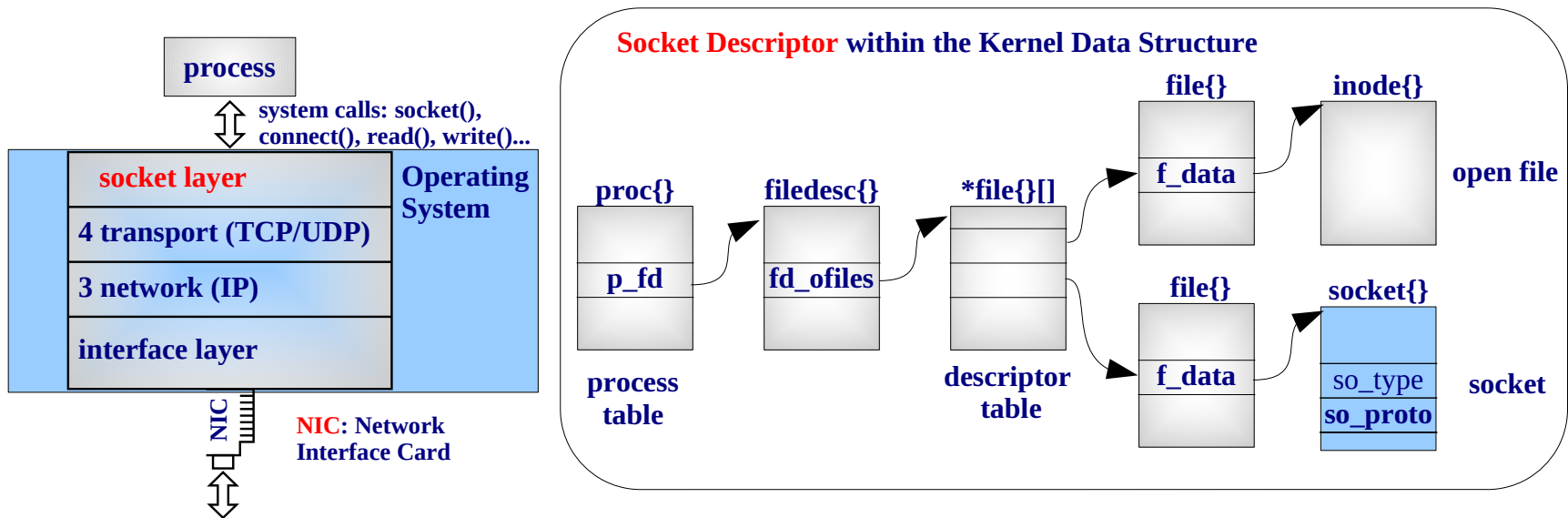


bits or characters

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.



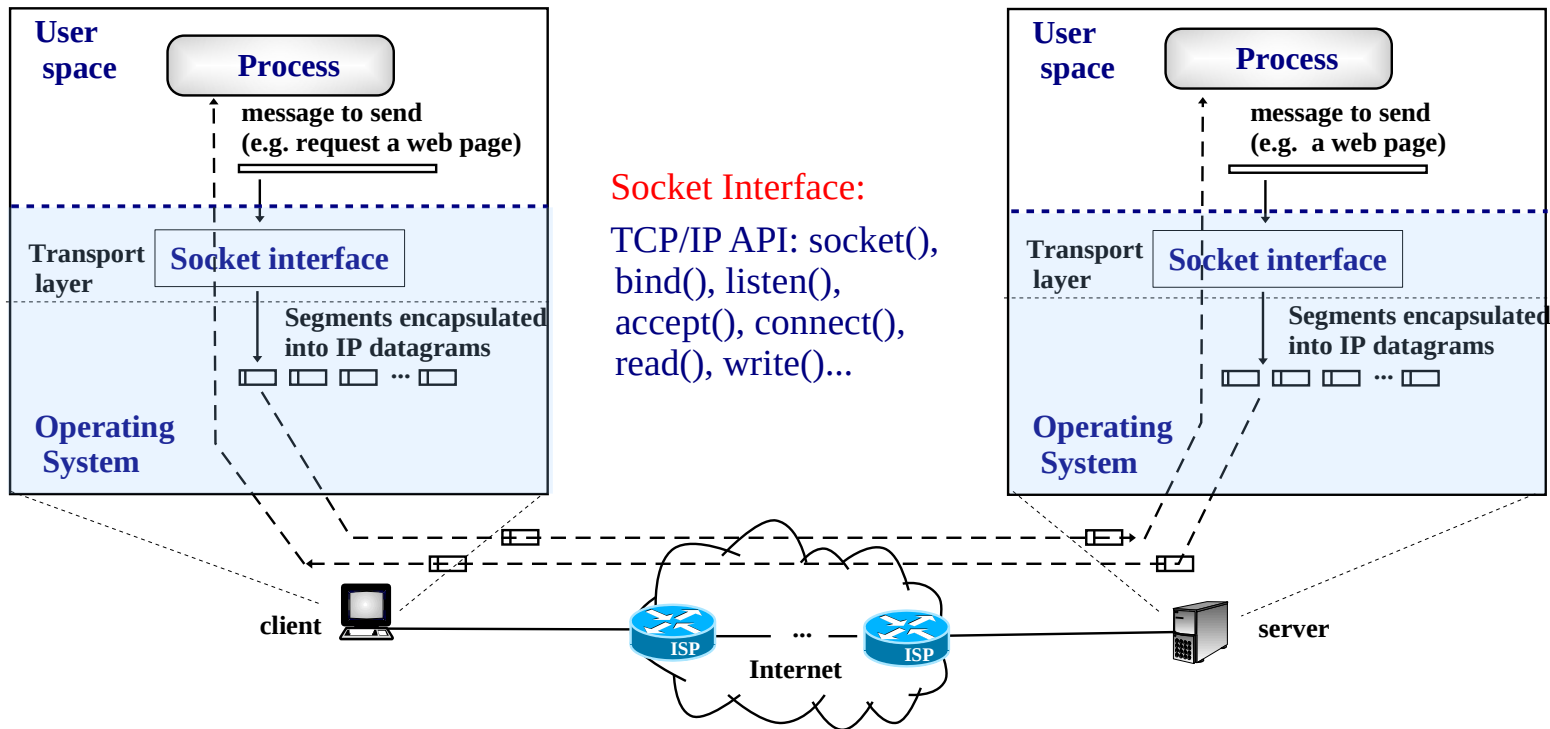
Unit 1: Introduction

Outline

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

Unit 1: Introduction

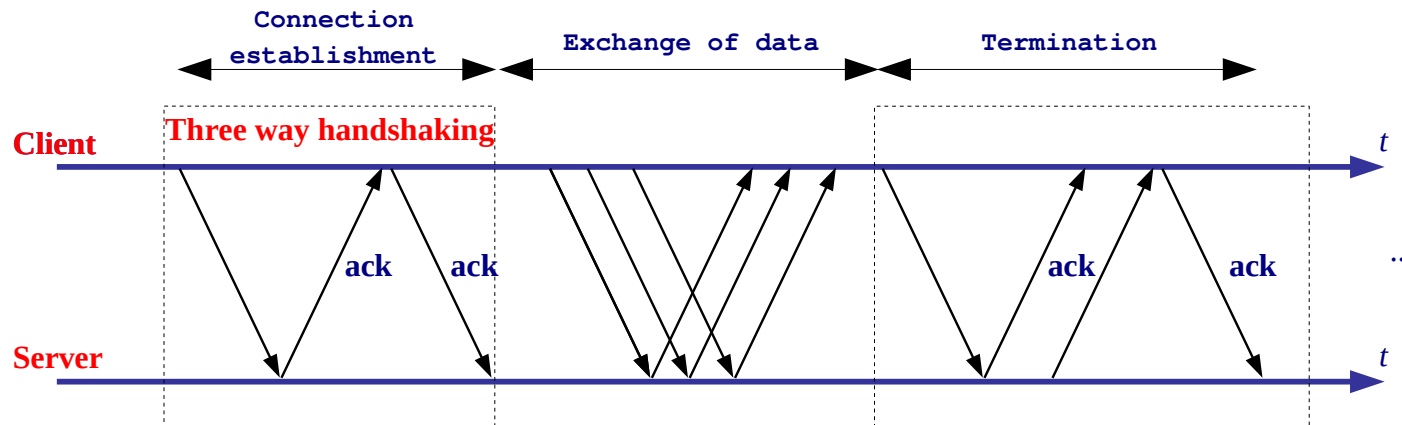
Client Server Paradigm: Processes, messages, sockets segments and IP datagrams



Unit 1: Introduction

Client Server Paradigm: The Internet Transport Layer

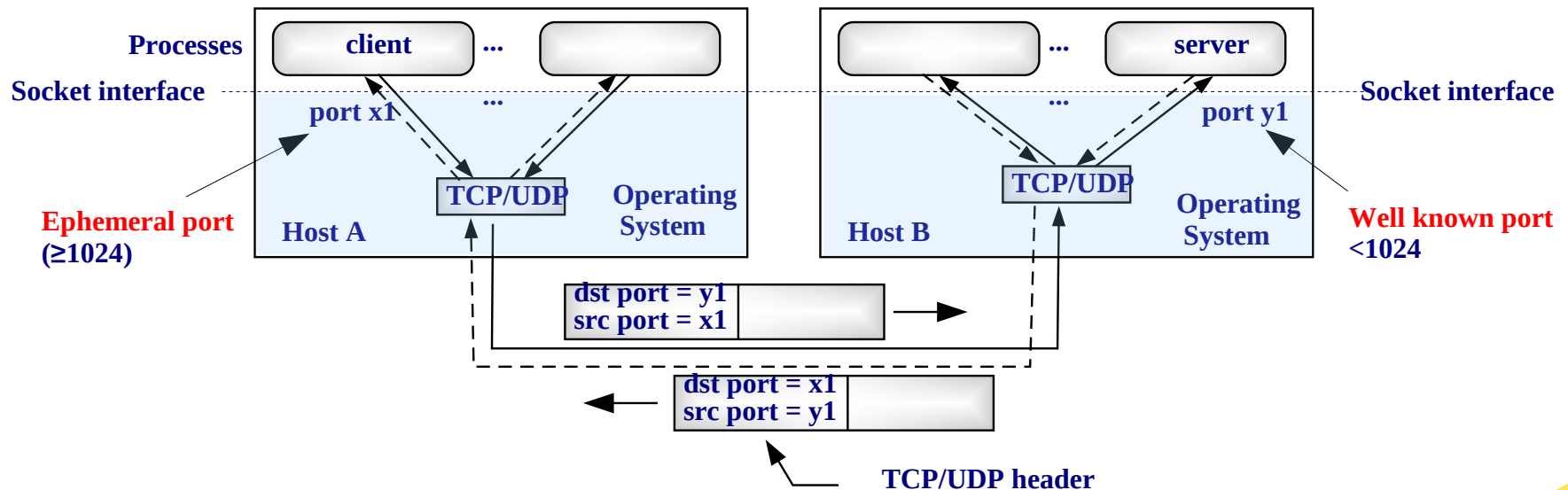
- Two protocols are used at the **TCP/IP** transport layer: **User Datagram Protocol (UDP)** and **Transmission Control Protocol (TCP)**.
- **UDP** offers a *datagram service* (non reliable). It is **connectionless**.
- **TCP** offers a **reliable** service (**correct** segments are acknowledged, **ack**,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