Computer Networks - Xarxes de Computadors

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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.

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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 \geq 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 \geq 5, you must send an email to the coordinator if you want to do the EF (to increase grade).
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 $\geq 5$ at least 1 of the Controls.
- Have a theory grade (NT) and lab (NL) greater than or equal to 5: $NT, NL \geq 5$.

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

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- 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.
- 1990s: The Internet is opened to the general public.

Source: wikipedia
Unit 1: Introduction

Brief History of the Internet

- 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.
Unit 1: Introduction

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Organization of the Internet and Terminology

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

- **Circuit switching**, e.g. PSTN (Public Switched Telephone Network)

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

Diagram:

- Client (modem) connects to PSTN
- Message to send (e.g. web page) is broken into packets (datagrams)
- Each packet contains a header with source and destination addresses
- Packets travel through the Internet (ISP) to reach the server

 Datagram packet switching
Unit 1: Introduction

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Standardization Bodies

- 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
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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.
2. Data link: Structured transport of bits.
1. Physical: Electric and mechanical.

*Internet jargon: Layer 8: the user.*
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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!)
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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.

![Diagram of Socket Descriptor within the Kernel Data Structure](image-url)
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Unit 1: Introduction

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

Socket Interface:
TCP/IP API: socket(), bind(), listen(), accept(), connect(), read(), write...
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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:
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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.
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Client Server Paradigm – UNIX /etc/services File

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

```bash
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
- ...