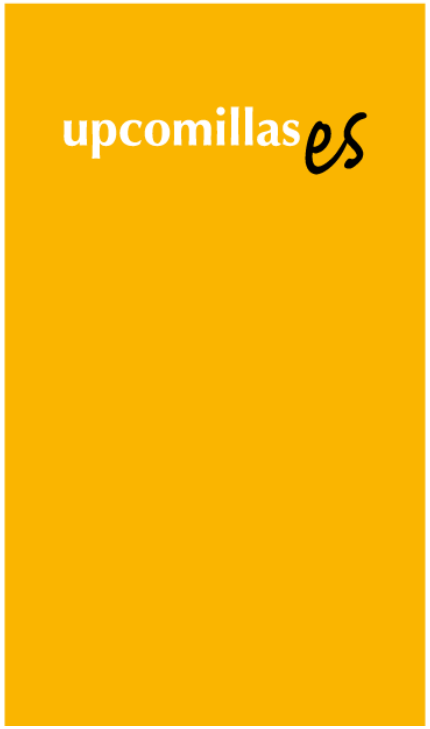


6-Programming Languages

Advanced Computing Tools for Applied Research

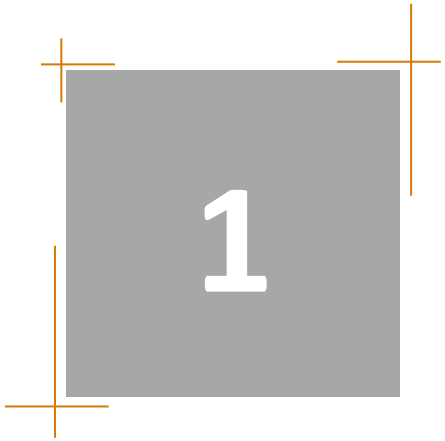
(***Herramientas Computacionales Avanzadas para la Investigación Aplicada***)

Rafael Palacios, Jaime Boal

Contents

Implementing computational tools

1. Brief history of computers
2. Storage systems
3. Programming approaches
4. Computer architectures



Brief history of computers

First computer

- There is no global agreement on the definition of "computer".
- Several concepts: Electronic, binary, programmable, etc.

- Z3 (Konrad Zuse, Berlin 1941) is considered the first "operational computer".
  - Not fully electronic (used 2000 relays, 10Hz).
  - binary arithmetic.
  - Program code and data were stored on punched film

First computer: ENIAC

ENIAC (US Army 1946) is considered the first general-purpose, programmable, electronic computer.

- Based on previous systems (notably Atanasoff–Berry Computer (ABC))
- Used decimal arithmetic
- Inflexible programming architecture which essentially required rewiring

2

Storage systems

Why do we need storage?

Temporary storage

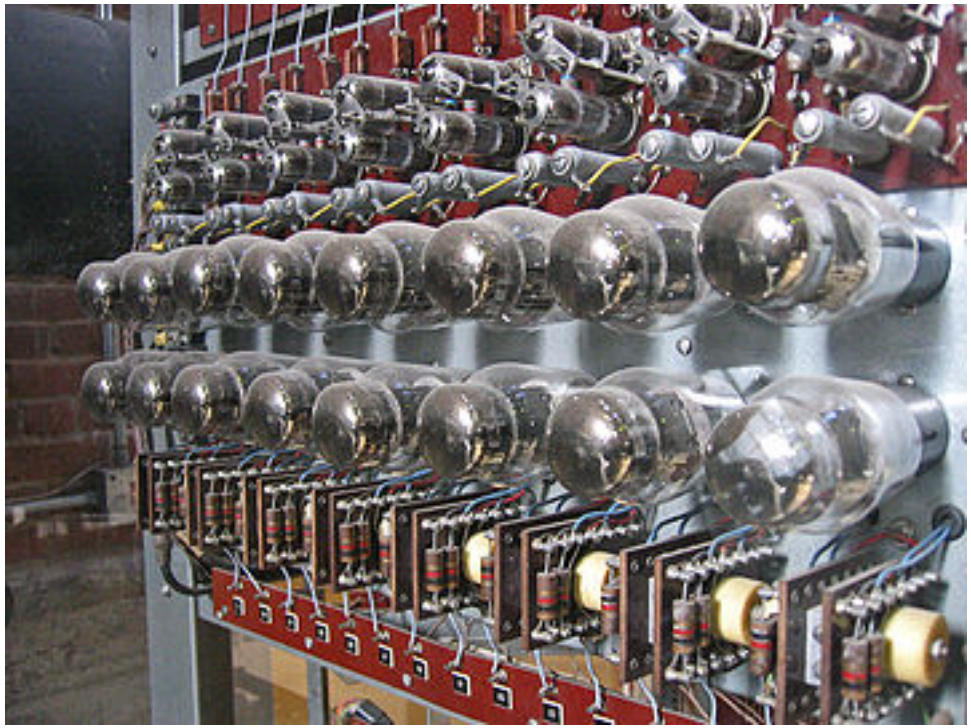
- Temporary data: Variables
- Program code

Permanent storage

- Permanent data: Databases, documents
- Applications: code, libraries
- Operating system
- BIOS

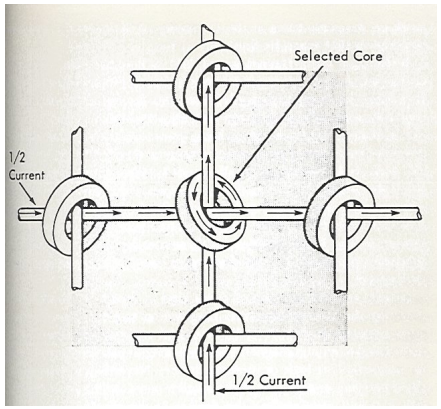
Original electronic memory

- Vacuum tubes

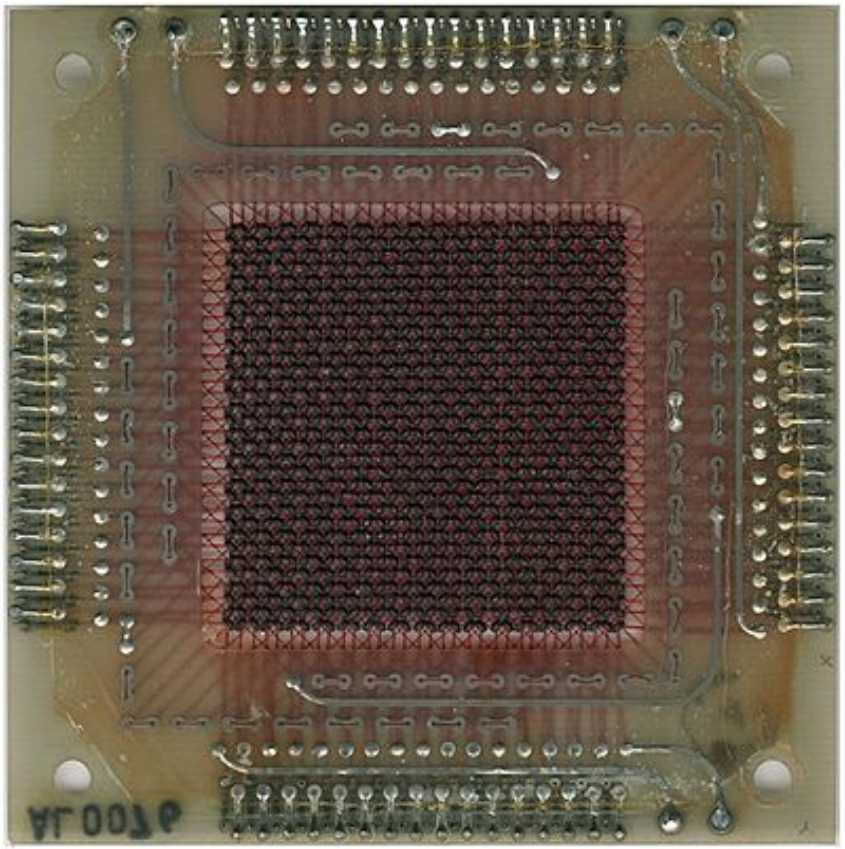


Core memory

- The revolution in electronic storage
  - Made of electromagnetic cores (magnetic rings) and electric wires
  - Developed mainly in 1951 by Wang and Jay Forrester

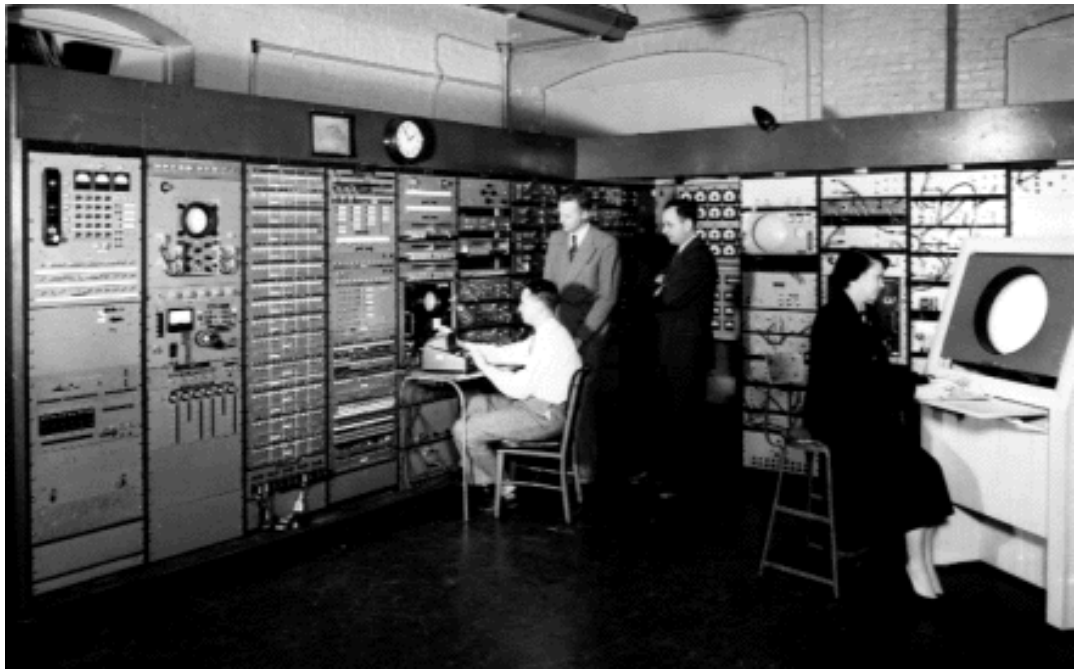


1024 bit Apollo memory module



Whirlwind Computer (1949)

- General purpose digital computer developed by Forrester.
- The project originated with a contract from the U.S. Navy for MIT to develop an "aircraft stability and control analyzer" (ASCA)
- Included many innovations: 16-bit parallel, operated in real time, used video displays for output, incorporated core memory.
- Precursor of PDP-1 (Digital Equipment Corporation) (1960)



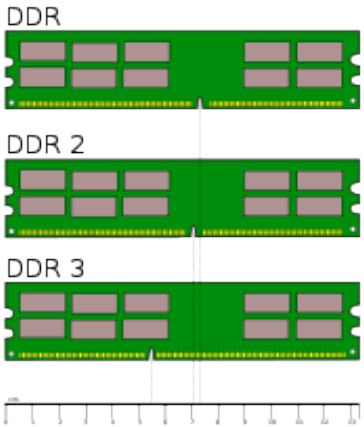
Temporary storage: RAM

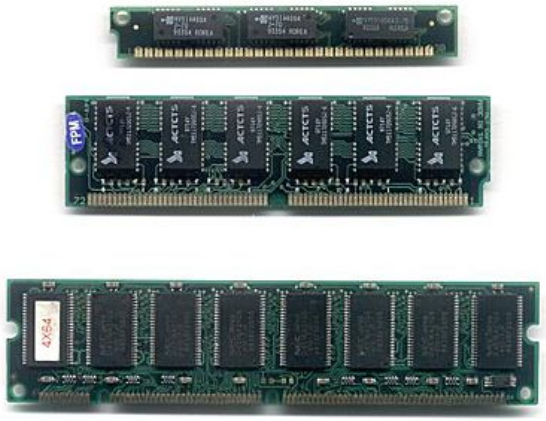
- RAM=Random Access Memory
- DRAM is a type of RAM that stores each bit of data in a separate capacitor. (old SIMM modules)
- Current technology is DDR3-SDRAM

(double-data-rate 3 synchronous dynamic random access memory)

DDR transfer rates:

```
DDR-200  100MHz  1600  MB/s
DDR2     100MHz  3200  MB/s
DDR3     100MHz  6400  MB/s
```

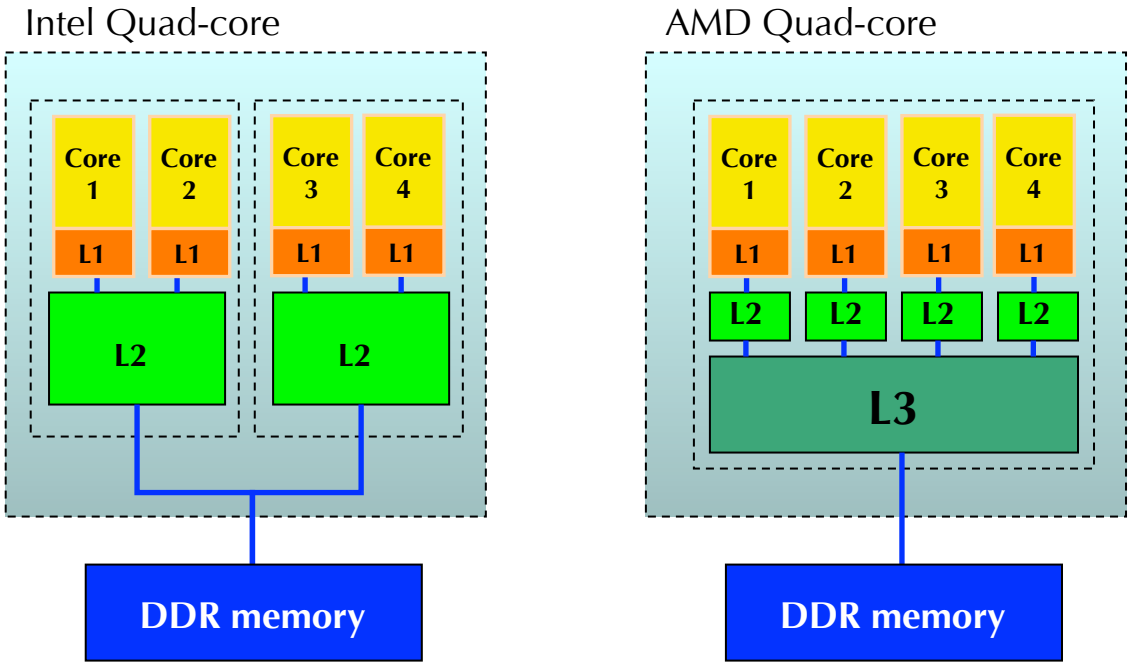




SIMM (30-pin), SIMM (72-pin), DIMM (168-pin)

Temporary storage: Cache memory

- Cache is a small but very fast memory.
- It increases performance, but the final result depends mostly on the application and also on the configuration/size of the cache.
- Nowadays there is L1, L2 and L3 cache memory



Note:
The new Intel i7 Extreme also has independent L2, and L3:
L2: 4x256 kB
L3: 8 MB

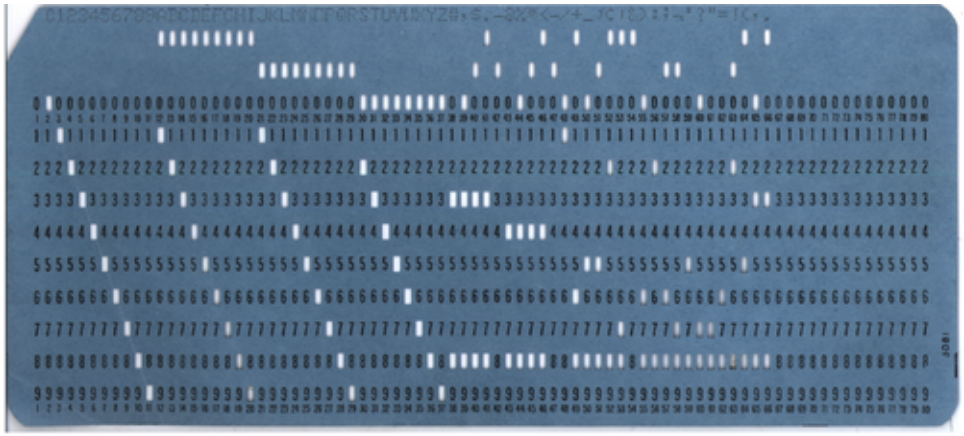
Permanent Storage

- Internal storage
  - Hard drive
  - SSD (Solid-State drive)

- External storage
  - Punched Cards
  - Punched tapes
  - Magnetic tapes
  - Robotic data storage device
  - Portable: Diskettes, CD-ROM, DVD, Flash Drive
  - Server-based storage

Punched Cards

- Based on 19th century textile looms
- Applied by Hollerith to store data for the 1890 US census
- Hollerith founded Tabulating Machine Company (1896), which eventually became IBM.
- 1 byte per columns (80 characters/card)



Punched tapes

- Origins in teleprinter communications
- Storage medium for minicomputers in the 1970'
- At the time it was smaller and less expensive that cards and magnetic tapes.

FAA's Honolulu flight service station in 1964

Magnetic Tapes

- Based on magnetizing ferromagnetic tape (same principle as the core memory)
- Characteristics:
  - Sequential data access
  - Large capacity for the time
  - Fully automatic

Modern robotic data storage system
Interesting off-line storage. Useful for:
•Disaster recovery
•Slow access/long term storage

Hard drive

- Faster and more reliable than tapes.
- Random access
- Increasing storage capacity with time
- Sample access times:

Typical access times:

		Read	Latency		
4200	rpm	15	+ 8.3	= 23.3	ms
5400	rpm	12	+ 5.6	= 17.6	ms
7200	rpm	9	+ 4.2	= 13.2	ms
10000	rpm	4	+ 3	= 7	ms
15000	rpm	3.5	+ 2	= 5.5	ms

Portable

- Diskette, or Floppy disk
- CD-ROM (640 MB)
- DVD (4.7 GB)
- Flash drive

8-inch, 5¼-inch, and 3½-inch floppy disks

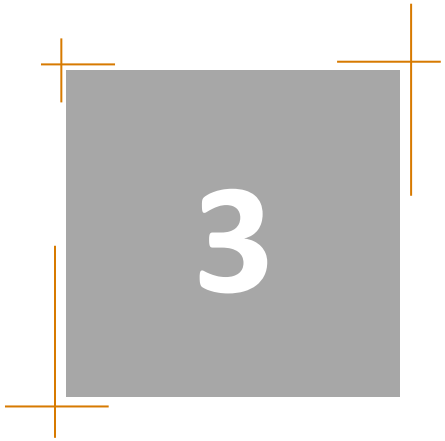
Solid-State Drive

- Based on Flash memory. SSD is also called flash storage.
- Fastest access time (same transfer speed)
- More reliable, especially for laptops

Server-based storage

- Data is stored on servers, directories are shared
- Local network protocols: NFS, SMB, AFP
- Internet: WebDAV, sshfs

- Characteristics
  - Slower than local hard-drives
  - Allows for distributed access
  - Easier to implement automated backup
  - Possible to implement high-availability



Programming approaches

UNIVERSIDAD PONTIFICIA
ICAI ICADE
COMILLAS
MADRID

Programming approaches

- Old programming(?) approaches:
  - Wired circuits.
    - Example: Relay-based elevator circuit
    - Circuits that use a set of sensors, buttons and actuators
  - Wired program
    - Apollo Guidance Computer (AGC)
    - The code was wired in read-only memory
    - It had 1K of 16 bit words of erasable (RAM) core memory and 12K of read-only memory (ROM)

- Normal computers
  - Program code
  - Real-time data
  - External communications

Programming approaches

- CPU approach
  - Single program with access to memory
  - Ex. Normal program running in a computer, phone, or microprocessor.

- Client-Server model
  - Two programs running at the same time and some sort of communication between them.
  - It is a distributed application structure
  - Ex. Database server
  - Ex. Web-based application
  - Ex. Web services
  - Ex. eMail client

Programming languages

- It is difficult to classify programming languages

- Basic Classification:
  - Compiled (usually more performance)
  - Interpreted (usually easier to implement, maintain)

Programming languages

- Compiled
  - FORTRAN (1950, now Fortran 2003). IBM, San Jose, CA
  - COBOL (1959, now Cobol 2002). Grace Hopper, US Navy
  - BASIC (1964). Dartmouth College , NH.
  - Pascal (1970). Switzerland
  - C (1972, now C99). Bell labs, NJ
  - C++ (1983, now C++ 2003). Bell labs, NJ
  - Java (1994). Sun microsystems, CA

According to langpop.com, in 2008 the 10 most cited programming languages are (in alphabetical order): **C, C++, C#, Java, JavaScript, Perl, PHP, Python, Ruby, and SQL**.

Programming languages

- Interpreted
  - Unix scripts: sh, bash, csh
  - JavaScript (AJAX=Asynchronous JavaScript and XML)
  - PHP
  - Python
  - Perl
  - Ruby
  - Matlab
  - ASP

According to langpop.com, in 2008 the 10 most cited programming languages are (in alphabetical order): **C, C++, C#, Java, JavaScript, Perl, PHP, Python, Ruby, and SQL**.

Programming language characteristics

- Modular programming
  - Programs are written in modules (functions).
  - Imposes boundaries to tasks and data.
  - Improves testing, maintainability.

- Object Oriented Programming
  - Programming paradigm based on objects.
  - Improves testing, code reuse, and collaboration.

Most modern programming languages include OOP capabilities, but maybe C and Java are the most important ones.

User Interface

- Some programming languages are more suitable to develop interactive applications.

- Single CPU
  - Object Oriented Programming is considered more suitable for applications with heavy user interfaces.
  - JAVA is the most standard and portable language for GUI apps.
  - C++ is used in most integrated development environments, such as MS Visual Studio, Anjuta, and Xcode.
  - IDE are usually specific to one operating system.
  - IDE may support different programming languages.

User Interface

- Client-Server model
  - Client-server model can be used to provide high performance computation, and nice & easy user interface.
  - Scalability: could be local or web based.
  - Several clients can be developed for different computer architectures.
  - Best compatibility, Mobile friendly.
  - Web services is one approach

4

Computer architectures

UNIVERSIDAD PONTIFICIA ICAI ICADE COMILLAS MADRID

Single Task

- One CPU, memory
- Single user
- Only one program running
  - Ex. Calculator
  - Ex. Standard cell phone (event support may imitate multitasking behavior).
  - Ex. DOS operating system

Multitask/Multiuser

- Multitasking
  - Several processes running at the same time in a time-sharing model.
  - All tasks share common components: CPU, memory and I/O devices.
  - The task scheduler is in charge of controlling which process must run and how long.
  - There is a false sense of parallelism.

- Multiuser
  - A multitasking operating system may be multiuser
  - Multiuser means that several users can work on the same computer simultaneously (typically via a remote connection).

Multitask/Multiuser

- Some examples

Operating System	Multitasking	Multiuser
MS-DOS	No	No
Windows	Yes	No
Windows Server	Yes	Yes
Unix (Solaris, HP-UX, Linux, MacOS)	Yes	Yes

Real-Time

- Real-time operating systems must ensure execution in a predefined time
- Real-time systems involve a capable hardware, RT operating system, and RT algorithms
  - Some computing algorithms cannot guaranty a fixed execution time. Maximum execution time must be limited.
  - Some hardware/operating systems/drivers may not return control on time (too long time-outs)
- Real-Time operating systems
  - RTLinux. Linux based, GPL2 license (RTLinuxFree.com)
  - VxWorks. Designed for embedded systems. (windriver.com)
  - QNX. Also mainly for embedded systems. (qnx.com)

Parallel systems

- Systems in which several programs run in parallel

- Shared memory architectures
  - Multi-core processors
  - Multi-processor computers
  - Computer clusters

- Distributed memory
  - Grid computing
  - Cloud computing
  - GPU computing

Instituto de Investigación Tecnológica
C/ Santa Cruz de Marcenado, nº 26
28015 Madrid
Tel +34 91 542 28 00
Fax + 34 91 542 31 76
info@iit.upcomillas.es

www.iit.upcomillas.es

UNIVERSIDAD PONTIFICIA ICAI ICADE COMILLAS MADRID