OPERATING SYSTEMS

Introduction
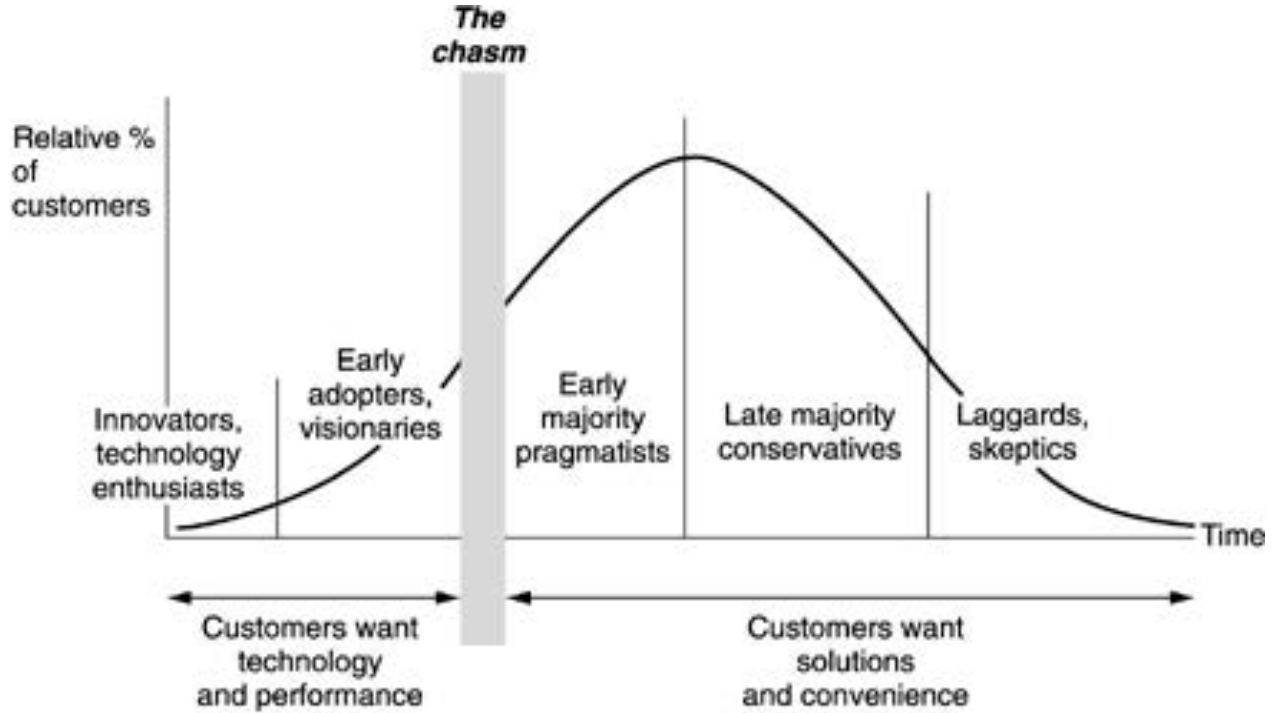
The life cicle of a technology

D. Norman, The Invisible Computer, 1998

Product performance

Level of performance required by average users

Unfilled need

Excess quality
Most customers uninterested in this region

Technology is "good enough" and therefore irrelevant. User experience dominates.

Time

High technology.
Consumers want more technology, better performance

Consumer commodity.
Consumers want convenience, reliability, low cost ...

Transition point
where technology delivers basic needs

The life cicle of a technology

D. Norman, The Invisible Computer, 1998

The chasm

Relative % of customers

Innovators, technology enthusiasts

Early adopters, visionaries

Early majority pragmatists

Late majority conservatives

Laggards, skeptics

Time

Customers want technology and performance

Customers want solutions and convenience

An examples from Apple products

Newton (1993-1997)
http://www.msu.edu/~luckie/newtgal.htm

iPhone (2007)

Consumerization

- Current scenario
Many new technologies are deployed for the mass market

- Companies typically lag behind, as it takes time to renew / upgrade the equipment and devices

A short history of computers

- **Mechanical calculators**
  - **Pascal** (1642): sum and subtraction
  - **Leibniz** (1700): the 4 basic arithmetic operations

- **Innovations 150 years later!**
  - **Babbage** (1834): the **analytical engine**, the first programmable computer.
    It executed sequences of operations through a set of simple instructions.

- **This was the first general purpose computer**
  - The same device can be programmed to perform different tasks (text processing, image processing, musical composition, scientific computations and simulations, etc.)

Milestones

| Year	Name	Manufacturer	Description
1834	Analytical Engine	Babbage	First example of a *general-purpose* computer (mechanical)
1936	Z1	Zuse	First electromechanical. computer
1943	COLOSSUS	UK Government	First electronic computer
1944	Mark I	Aiken	First general-purpose US computer
1946	ENIAC I	Eckert/Mauchley	This computer is considered as the beginning of the modern era of computers
1949	EDSAC	Wilkes	First computer with in-memory program
1951	Whirlwind I	M.I.T.	First real-time computer
1952	**IAS**	**Von Neumann**	**The vast majority of modern computer is based on the so-called Von Neumann architecture**
1957	ELEA	Olivetti	First computer of the ELEA series
1960	PDP-1	DEC	First minicomputer (50 examples)
1961	1401	IBM	Small computer that was sold to small enterprises
1962	7094	IBM	This computer was popular among scientists in the '60s

The first modern computers

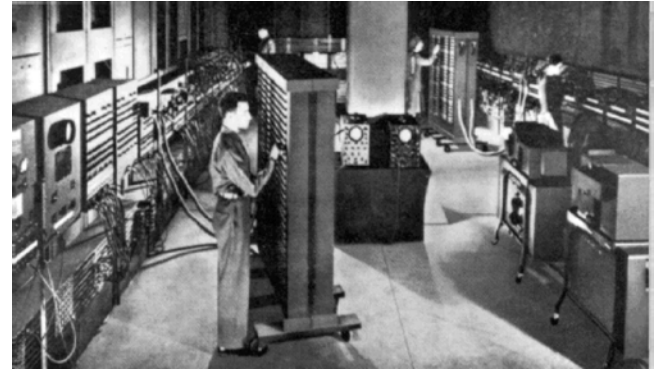John Von Neumann
1903 - 1957
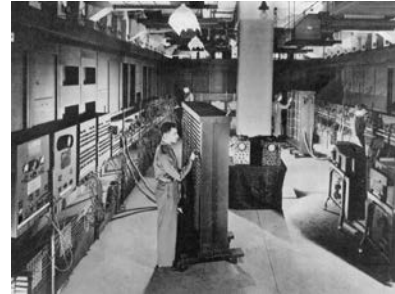
ENIAC
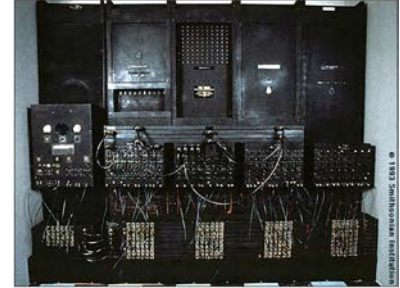
PDP-1

ELEA

IBM 1401
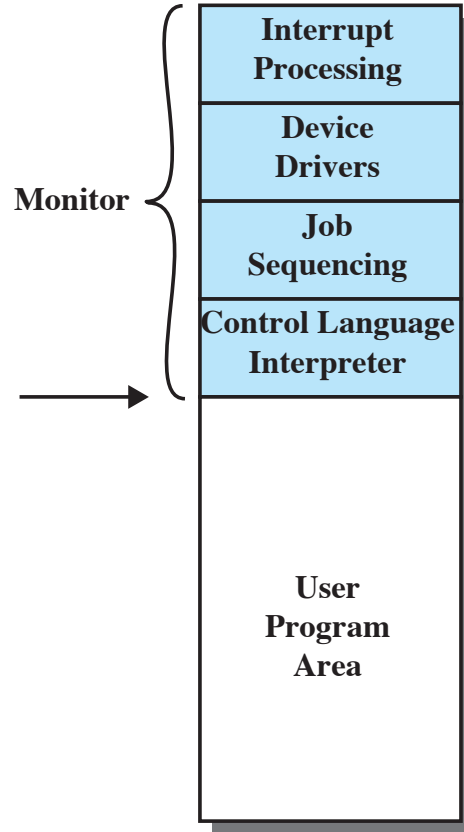Control Panel

Serial Processing ('40s and '50s)

- Computers were controlled from a console
  - lights
  - switches
  - keyboard
  - printer

- **No operating system**

- The computer was operated by humans

Operating Systems

Batch Systems ('50s)

- **Monitor** (in the second part of the '50s, General Motors, IBM 701)
  - Piece of software that controls the **automatic execution** of a **sequence of programs**

- All **jobs** that have to be processed are stored in the right **sequence** on a **tape**

- After completion, each job **returns** the control do the monitor

- The task of the monitor is to start processing the next job

- The resident monitor is stored in the main memory and it is always available to be **called**

Resident Monitor

Monitor	Interrupt Processing
	Device Drivers
	Job Sequencing
	Control Language Interpreter

User Program Area

- **Job Control Language (JCL)**
- This special programming language contains instruction for the monitor, such as
  - The compiler to use for a specific job
  - The set of data that will be processed, etc.

Hardware requirements to implement a monitor

- **Memory protection**
  - The area of the memory area that contains the monitor cannot be accessedd by any other program

- **Privileged instructions**
  - Instructions that are available to the monitor only

- Two **modes of execution**: user and kernel

- **Timer**
  - To avoid that one job steals the system

- **Interrupts**

1962…

… This sentence from John W. Mauchly (one of the designers of ENIAC) was reported by the NYT

There is no reason to suppose

the average boy or girl

cannot be master

of a personal computer

…1977

There is no reason

anyone

would want a computer

in their home

Ken Olson, president, chairman and founder of DEC

PROGRAMMA 101
THE FIRST PERSONAL COMPUTER

The '60s in Italy

Pier Giorgio Perotto
P101. Quando l'Italia inventò il personal computer (1995)

Giorgio Garuzzo
Quando in Italia si facevano i computer (2015)

- 1962-1964: Olivetti developed the very first *personal* computer designed by Pier Giorgio Perotto

- 1965-1971: Olivetti delivered 44k units of P101 (Programma 101)

P101

The computer that doesn't make you wait.

olivetti

COMPUTER ON DESK TOP

BUSINESS WEEK

'Desk-top' computer is typewriter size

Keyboard Computer Sits on Desk

Journal American

A DESK TOP COMPUTER

Milestones

Year	Name	Manufacturer	Description
1963	B5000	Burroughs	The first computer to be programmed in a high-level language
1964	360	IBM	The first *family* of computers
1964	6600	CDC	The first scientific supercomputer
1965	PDP-8	DEC	The first minicomputer for the mass market (more than 50k items were sold)
1967	GE 115	GE	This computer was designed in Italy, after GE acquired the electronic division of Olivetti
1970	PDP-11	DEC	This computer had a dominant position in the minicomputer market in the '70s
1974	8080	Intel	The first *general-purpose* 8-bit CPU on chip
1974	CRAY-1	Cray	The first supercomputer for vector manipulations
1977	Apple	II	The first computer with a graphical interface
1978	VAX	DEC	The first 32-bit superminicomputer
1981	IBM PC	IBM	The beginning of modern personal computers
1981	Xerox	Star	*Personal computer* with a graphical interface
1985	MIPS	MIPS	The first commercial RISC computer
1987	SPARC	Sun	The first RISC workstation with a SPARC processor
1990	RS6000	IBM	First superscalar computer
…	…	…	…

'60s and '70s

IBM 360

VAX

IBM Disk Drive Unit

Apple II

'80s

SUN SPARCStation

IBM PC-AT

ZX Spectrum

Fairlight CMI
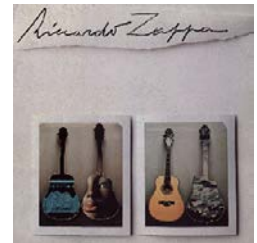
Some PCs of the '8os

Apple Macintosh 1984

Apple Lisa 1983

Osborne Compaq (portatile) 1983

Xerox Star 1981

Nowadays…

The next challenge…

IEEE Spectrum
July 2012

What is an Operating System?

Computer architecture

user 1 | user 2 | user 3 | ... | user n

compiler   assembler   text editor   ...   database system

system and application programs

operating system

computer hardware

coordination and control of the use of the computer resources
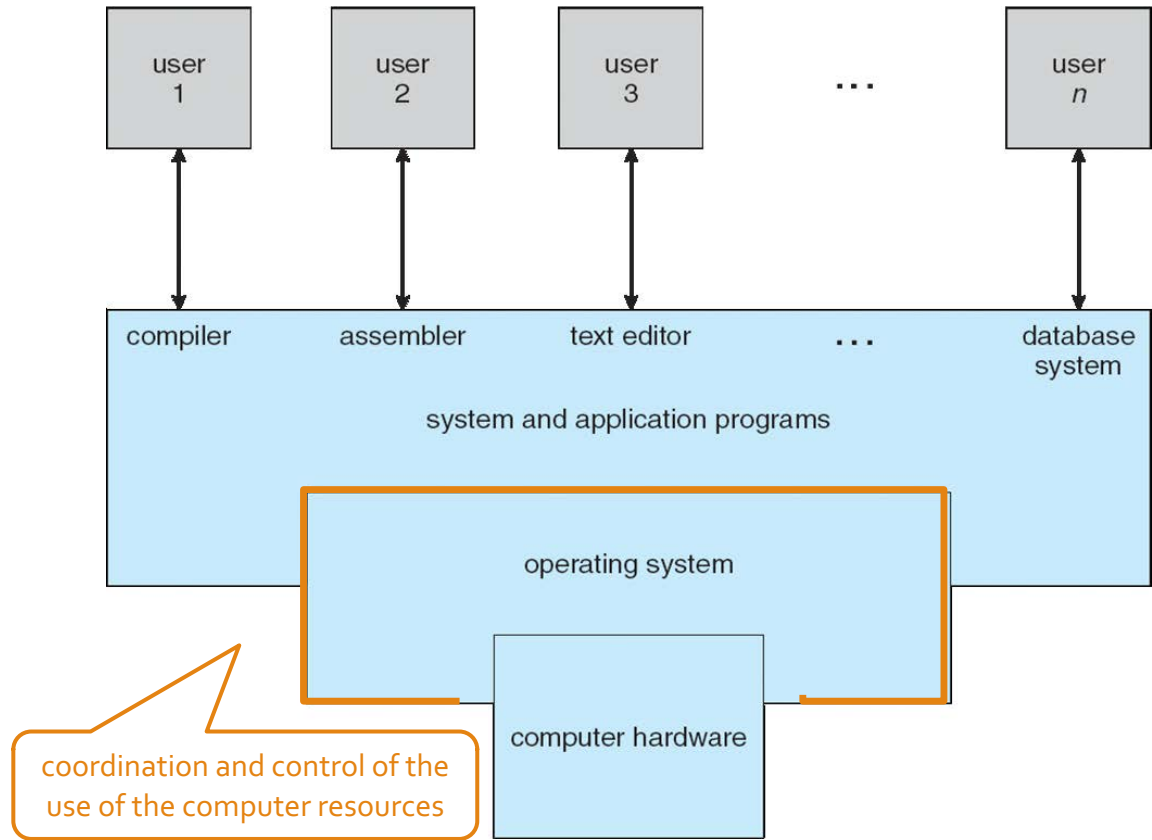
The OS…
…from a user's perspective

- The OS is a *computer program* that allows a simple and possibly intuitive interaction with the computer and its devices
  - Personal computer
  - Server
  - Workstation
  - Mobile devices
  - etc.

- In the case of *embedded systems*, both the computer and the operating system are hidden from the user's viewpoint

The OS…
…from a user's perspective

- Among the most important aspects
  - Human-Machine Interaction mechanisms
    - input: touch-screen, gestures, voice, etc.
    - output: graphical interfaces, voice, sound, physical actions, etc.
  - Response time

- Less important aspects
  - maximisation of the use of the resources

User interfaces: the command interpreter

- The OS **waits** for user's commands that are given as strings of text
  - Command interpreter (part of the OS)
  - External programs (not part of the OS)

- In UNIX and Linux systems commands are given through a **shell**
  - C-shell, bourne-shell, k-shell, etc.

- This is the typical interactive interface used by system administrators

User interfaces: graphical interphaces

- Developed in the '70s at **Xerox** labs (Palo Alto)
  - First used in Xerox Alto and Apple Macintosh computers
- Based on well-known **metaphors** (desktop, file, trash-bin, etc.) and **icons**
- The *mouse* and *touchpad* as external devices for point-and-click actions
- Different graphical organizations
  - Mac
  - Windows
  - KDE, Gnome, etc. in Linux distro
  - iOS
  - Android

Xerox Alto

The OS...
...from the system perspective

- The OS acts as a *middleman* between
  - the needs of users' programs in terms of computing resources
    - main memory, CPU, devices
  - and the resources that are available in the system

- The OS provides an **interface** for the use of the resources
  - ensure that each resource is used according the specifications
  - avoid errors that can cause the system to be blocked

The OS…
…from the system perspective

- Applications interact with the OS that provides an **abstract view** of the underlying physical machine

- The OS enforce resource management polices and techniques aimed at
  - avoiding conflicting requests
  - exploiting the available system resources as much as possible

First definition of Operating System

- There isn't a unique definition of what is an operating system

- The OS can be roughly defined as a computer program that allows the use of a computing device (hardware)
  - by multiple programs
  - by multiple users

- Please note that the OS is a *computer program*…

  …aimed at controlling *users' programs*…

OS Evolution
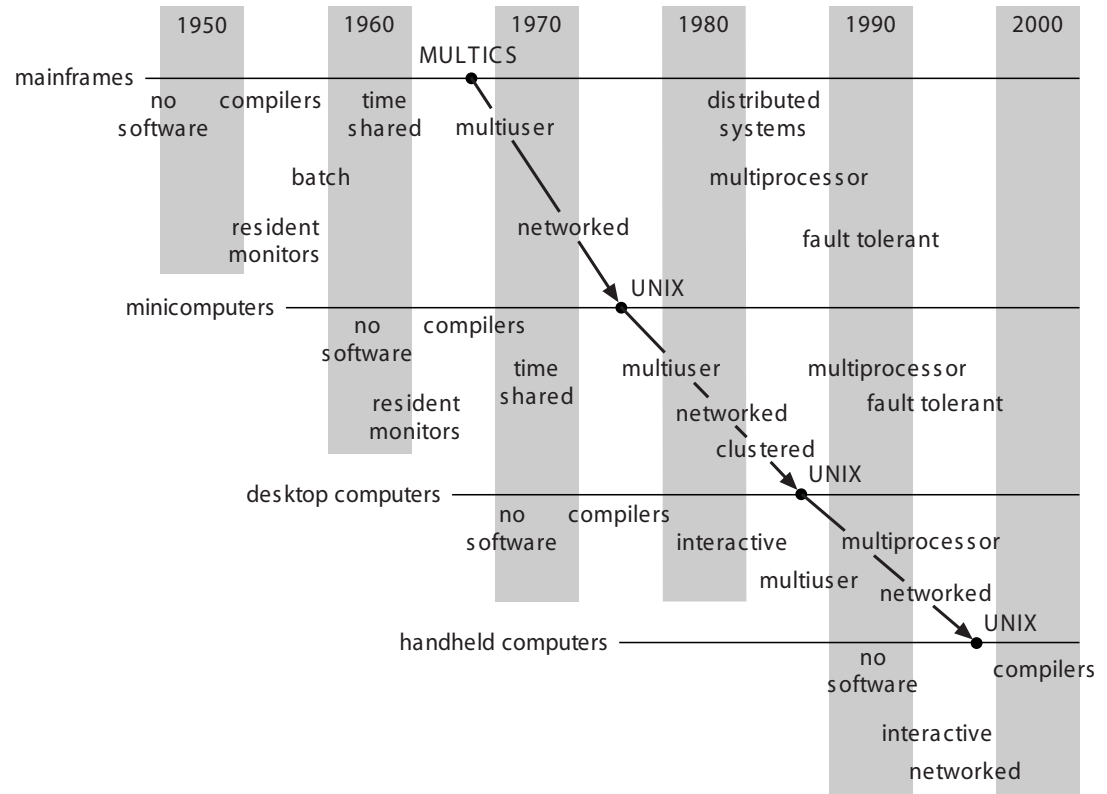
OS Evolution

Paraphrasing a famous quote by the evolutionist Ernst Haeckel

Ontogeny Recapitulates Phylogeny

For each new less-powerful computing device
the evolution of the OS follows a path similar to that
followed by the OS of more powerful devices

Case Studies

UNIX

- The need for **Operating Systems** emerged in the '**60s**.

- Many companies and research labs started developing their own OS

- **MIT**, **Bell Labs** and **General Electric** joined forces to develop **MULTICS** (Multiplexed Information and Computing Service)

- During the development, Bell Labs decided to leave the project. Nonetheless, **Ken Thompson** (one of the researchers of Bell Labs involved in the development od MULTICS) decided to continue working on a less ambitious OS, that could be executed in a minicomputer

- **Brian Kernigham** (Bell Labs) named the project **UNICS** (Uniplexed Information and Computing Service)
  - UNICS sounds like "eunuchs"

- This new project raised the interest of Bell Labs, and **Dennis Ritchie** started working on the project
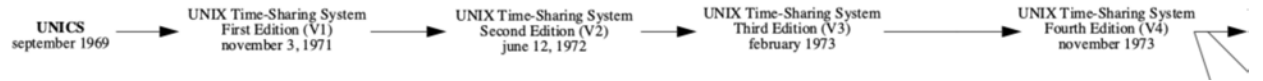
UNIX

- To properly write the OS code, they started designing a tailored **high-level programming language**
  - The programming lanuage proposed by Thomson was called **B**, but it was not successful
  - The evolution of B proposed by Ritchie was called **C**, and eventually it was selected for writing UNIX
- In **1974**, Ritchie and Thompson published a scientific paper on UNIX
  - Many universities were interested in working on UNIX. As the Bell Labs were part of AT&T (regulated monopoly for telecommunication services), they were non entitled to sell computers or computer software, so they gave out UNIX for a ridiculous price.
  - A large community of researchers grew around UNIX as it was better than many other *homemade* OSs

Ritchie (standing) and Thompson when porting UNIX on a PDP-11 machine

UNIX Milestones

- 1976: First version publicly available (V6)
- 1978: V7, most modern versions of UNIX derived from this version
- 1985: AT&T released System V
- 1993: AT&T sold UNIX to Novell
- 1995: Novell sold UNIX to Santa Cruz Operation (SCO)
- At that time the University of California at Berkeley developed its own version (BSD – Berkley Software Distribution)
- POSIX (Portable Operating System) represent the

| UNICS september 1969 | UNIX Time-Sharing System First Edition (V1) november 3, 1971 | UNIX Time-Sharing System Second Edition (V2) june 12, 1972 | UNIX Time-Sharing System Third Edition (V3) february 1973 | UNIX Time-Sharing System Fourth Edition (V4) november 1973 |

Linux

- **1991** - Linus Torvalds, a Finnish computer science student, distributed a preliminary version of the UNIX *kernel* adapted for PC-IBM machines
  - The starting point was MINIX, a simple POSIX compliant OS, running on PC-IBM machines, developed by Prof. Andrew Tanenbaum to teach Operating Systems

- The success of UNIX for servers and workstations was the key for the success of Linux in the desktop computer environment.

- A very large community of developers joined the project worldwide, contributing to the development of different distros.

  - Linux is currently available for a wide range of application environments.

Apple Macintosh Operating Systems

- The OS for the Apple Macintosh was developed in 1984
  - Graphical interface
    - Desktop, file, folders, trash-bin, etc.
  - Named System 1 to System 7 (1991)
  - Renamed as Mac OS in 1998
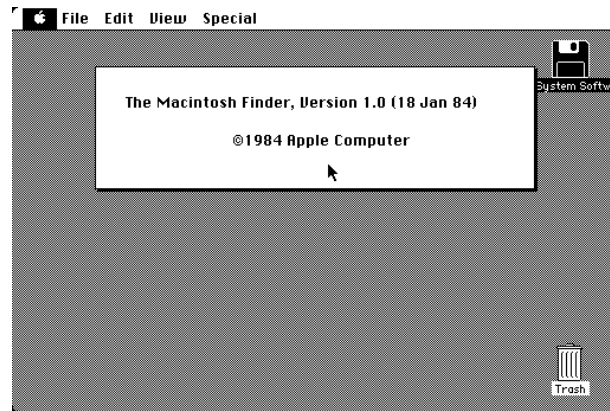
- Mac OS X (now macOS) replaced the *classic* Mac OS in 2001
  - the kernel is based on UNIX BSD

Microsoft Operating Systems

- In 1974 Intel developed CP/M, a command-line operating system for the family of 80xx processors

- In 1981 Microsoft developed a clone of CP/M that was sold to IBM. IBM used the operating system developed by Microsoft for its personal computer
  - The OS was named PC-DOS for IBM computers
  - MS-DOS was the name for IBM-compliant PCs

- DOS (Disk Operating System) had a text-only interface, can use up to 640kB of RAM and did not provide support for network connections

- Windows appeared in 1985 as a graphical interface on top of DOS

Evolution of Microsoft WIndows

- 1990: Windows 3.0, still a graphical interface for DOS
  - To use the network, you need to install a third-party app such as the Trumpet Winsock
- 1993: Windows NT
  - Brand new OS with no relationship with MS-DOS
- 1995: Windows 95
  - Evolution of Windows 3 with network support, virtual memory management, multiprogramming, process management
- 1998: Windows 98
  - Improvement of the graphical interface and Internet integration
- Windows 2000, XP e Vista all rooted on Windows NT
- Current versions
  - Windows 10
  - Windows Server 2019