Computers Programming
Introduction

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Contents

- Overview of the computer systems
- Operating Systems

Note:

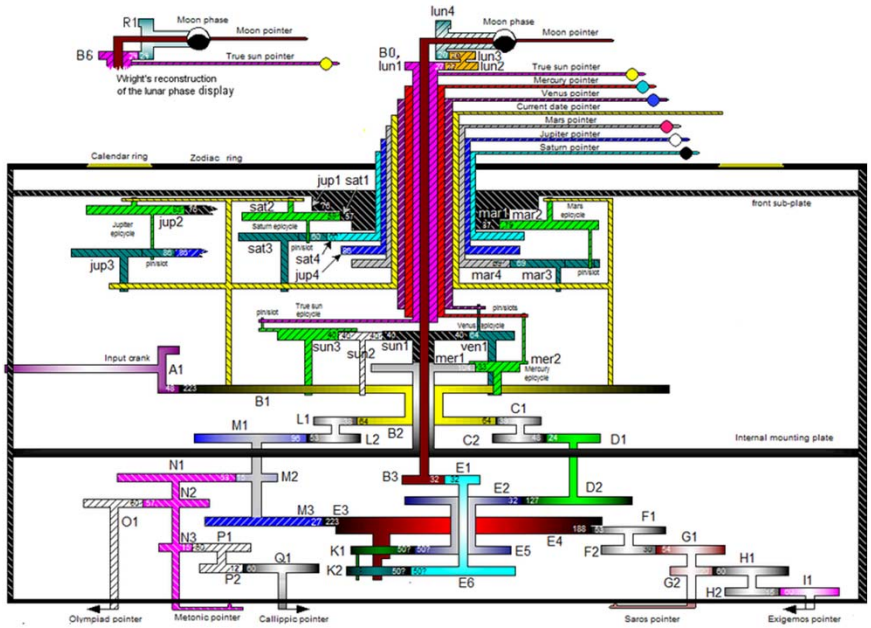
- Electronic files (in pdf format) can be downloaded from the website :

http://www.euroqual.pub.ro/programarea-calculatoarelor/#download

- How many cornerstones can we define in the computing systems development?

Oldest computing machines

- The **Sumerian abacus -** designed around 2500 BC
- The **Antikythera mechanism** is an ancient analog computer.
- The instrument has been dated between 150 and 200 BC.
- We suppose that it was designed to predict astronomical positions and eclipses for calendrical and astrological purposes, as well as the cycles of the ancient Olympic Games.



It is a complex clockwork mechanism composed of at least 30 meshing bronze gears. A team at Cardiff University used modern computer x-ray tomography and high resolution surface scanning to image inside fragments of the crust-encased mechanism.

Historical Highlights

- 1614 John Napier – invention of logarithms
- 1642-1645 Blaise Pascal - first mechanical calculator - Pascaline (50 prototypes by 1652)
- 1673 Gottfried Wilhelm von Leibniz – first computer with 4 operations
- 1830 Charles Babbage first mechanical calculator with "programs" for polynomial computing
- 1854 George Boole – developed the Boolean algebra
- 1954 Claude Shannon and Alan Turing – established the foundations for modern computers

- **In the mid of 20th century there were premises for big changes...**

Key factors in the development of electronic computers

- 1948 - Bardeen, Brattain and Shockley - invented the transistor
- 1959 - first integrated circuit (IC) – Texas Instruments
- 1969 - first memory (of 1 KB)
- 1971 – first microprocessor (I 4004)

Generations of computers

- G I – 1946-1952 – use electronic tubes, serial architecture
- G II – 1951-1963 – ferrite memories, transistors and diodes
- G III – 1962-1975 – SSI circuits, memories of a few KB
- G IV – 1975-today – LSI + VLSI circuits, microprocessors
- G V - has began in 1982 with the aim to create computers using massively parallel computing/processing.

Generation V

- Requirements:
  - Intelligent interface
  - Ability to solve new problems
  - Use of a large database

The emergence of Generation IV

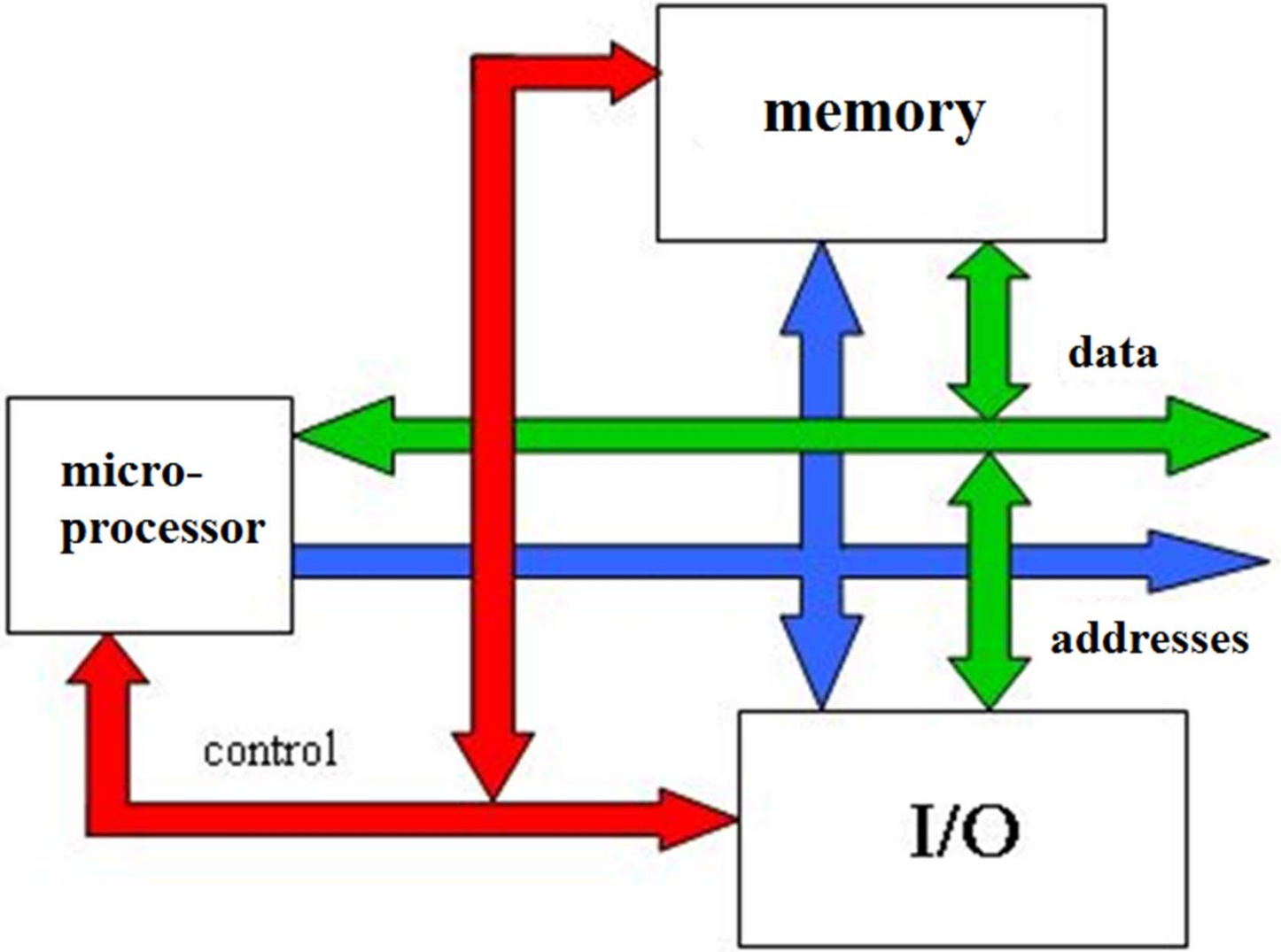
- 1975 – IBM 5100
- 1976 – Apple I
- 1977 – Apple II
- 1981 – IMB PC

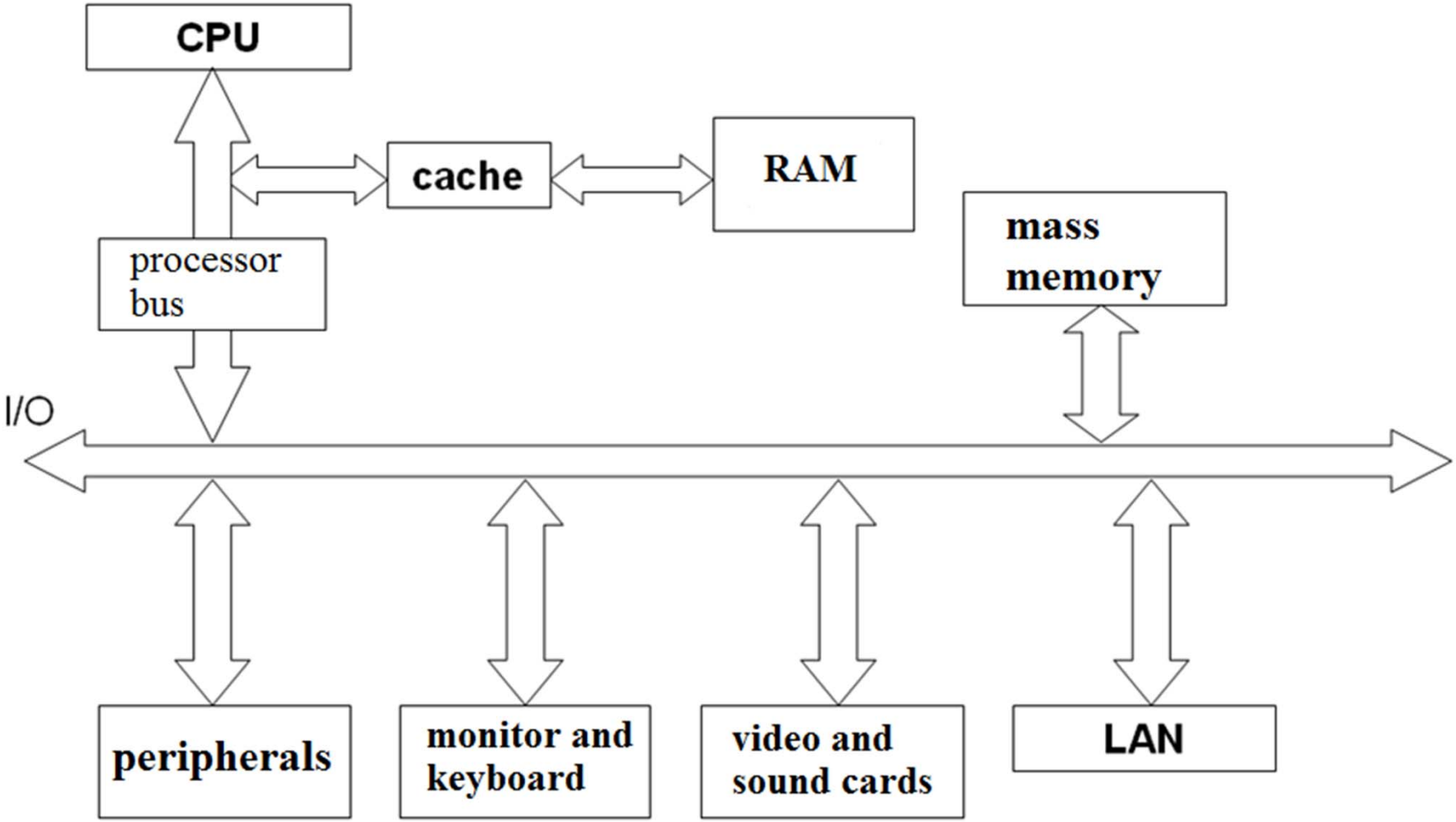
- **How can we define a generic computer from generation IV ?**

Components of a computer system

- **motherboard**:
  - microprocesor
  - RAM and BIOS
  - the chipset of motherboard
  - bus connectors
- **Power supply + PC case**
- **Input - Output devices** :
  - keyboard,
  - monitor,
  - video card,
  - HDD, etc.

The general structure of a computer system



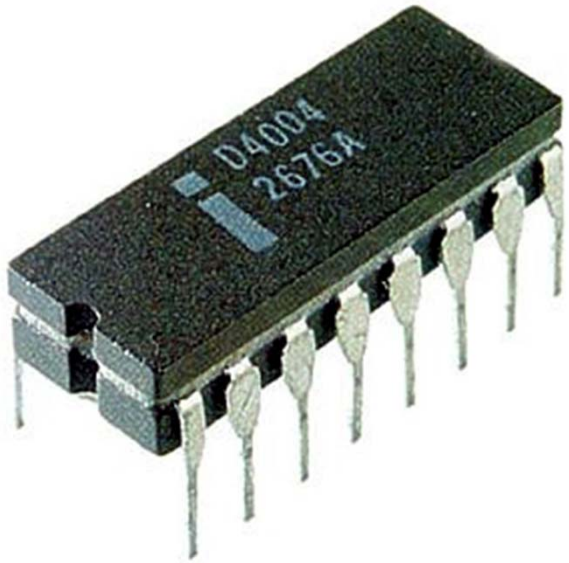

CPU
cache
RAM
processor bus
mass memory
I/O
peripherals
monitor and keyboard
video and sound cards
LAN

Microprocessor

- A microprocessor incorporates the functions of a computer's central processing unit (CPU) on a single integrated circuit (IC)

First microprocessor

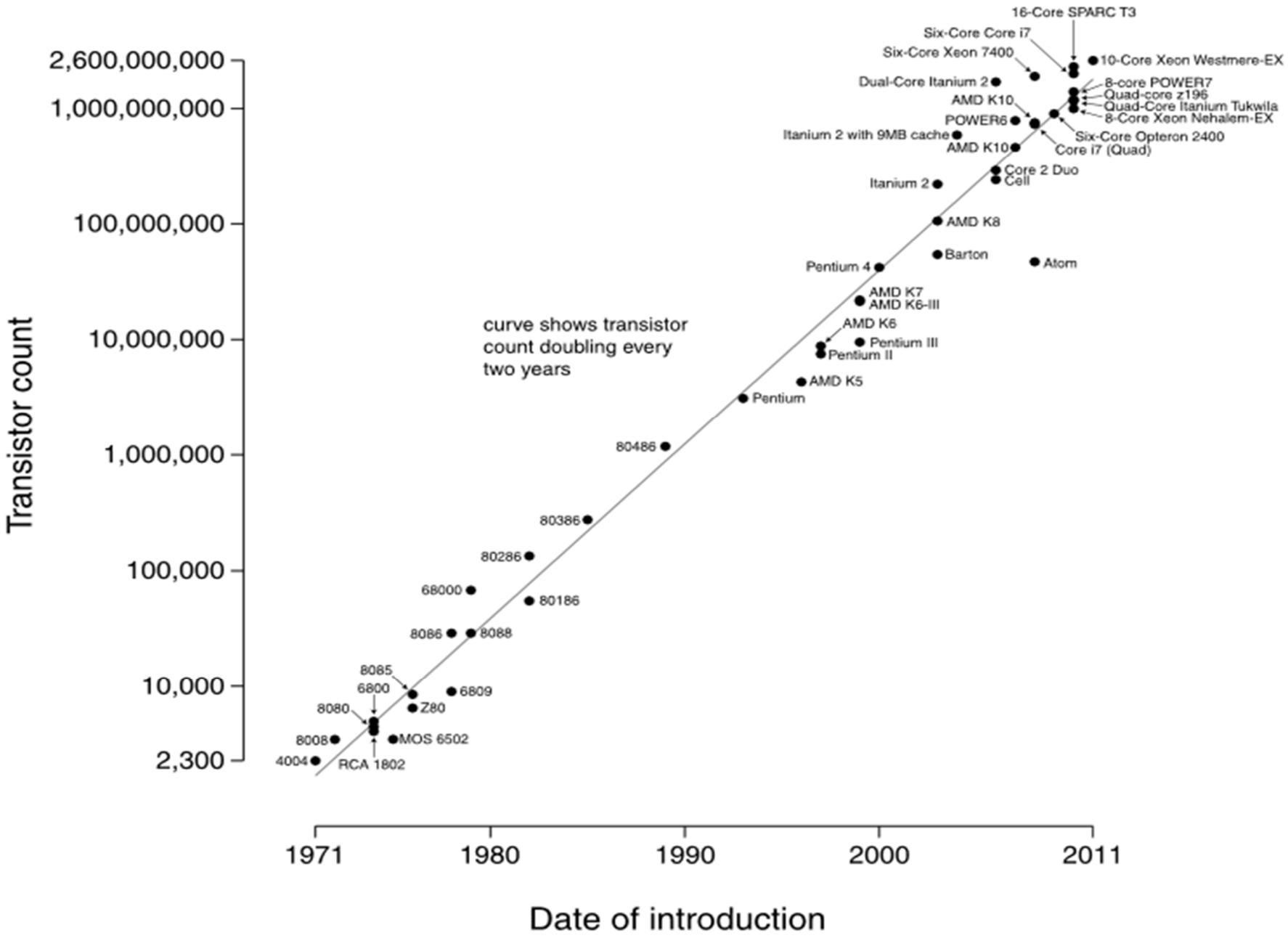
- 1971 – Intel 4004, the first commercial microprocessor (based on a four bit bus)
- 1972 – Intel 8008 (8 bit)



Examples of microprocessors

- Intel 80286
- Intel 80386
- Intel 80486
- Intel Pentium
- AMD ATHLON
- Intel Pentium Pro
- Intel P7
- Intel Core Solo and Intel Core Duo, the latter with two cores
- Intel Core 2 Solo și Intel Core 2 Duo, the latter with two cores in 48nm technology
- Intel Core i3
- Intel Core i5 and Intel Core i7, with 4-8 cores in 45nm–20nm (even 14nm) technology
- Intel Atom, for laptops
- Intel Xeon - for servers (additional features in multiprocessing)
- 2017 - Samsung Galaxy S8 uses Samsung's version of a "10 nm" processor.
- September 2018 - one of the first 7 nm mobile processor, the A12 Bionic, was announced by Apple.

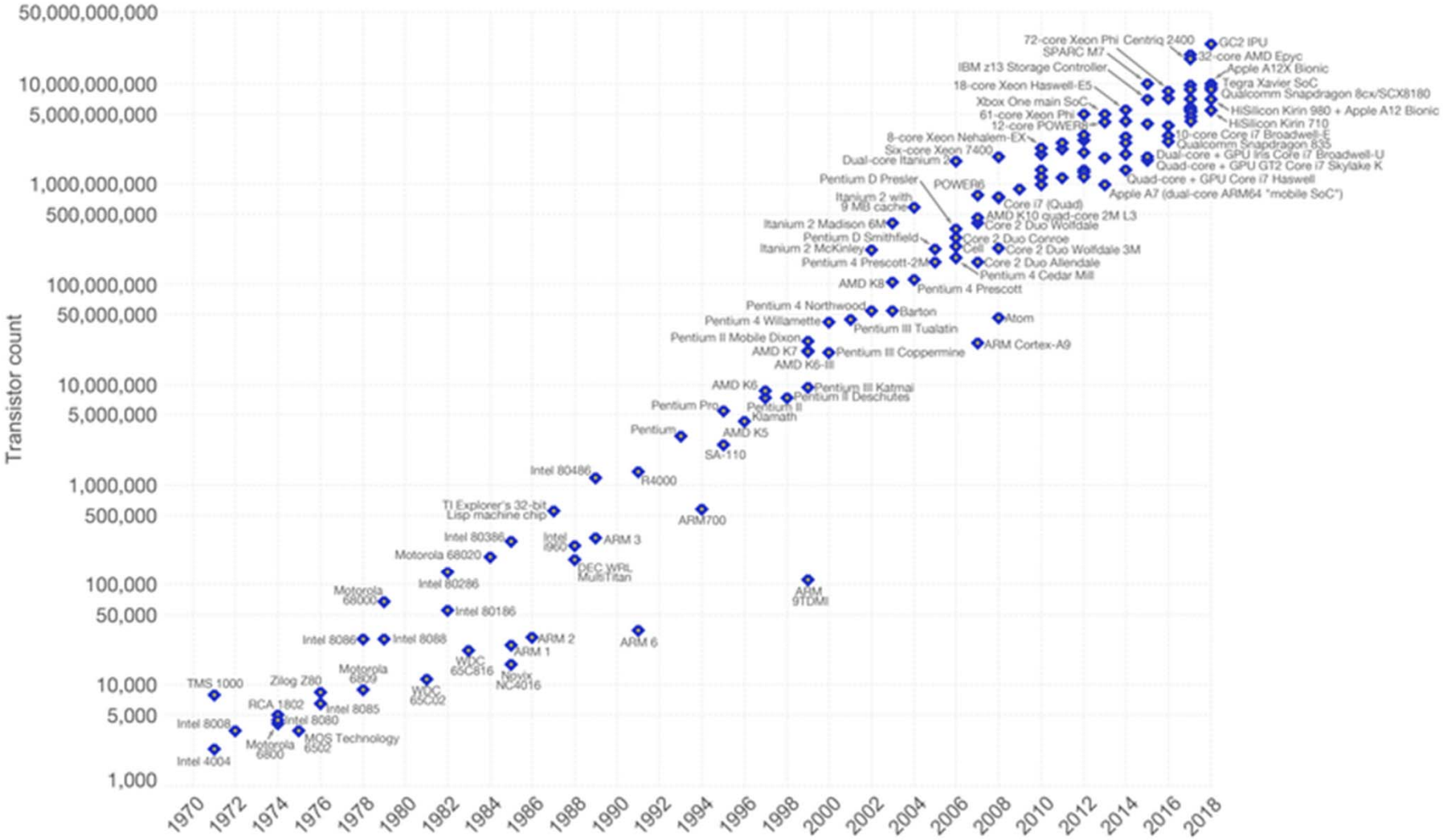
Microprocessor Transistor Counts 1971-2011 & Moore's Law



Moore's Law – The number of transistors on integrated circuit chips (1971-2018)

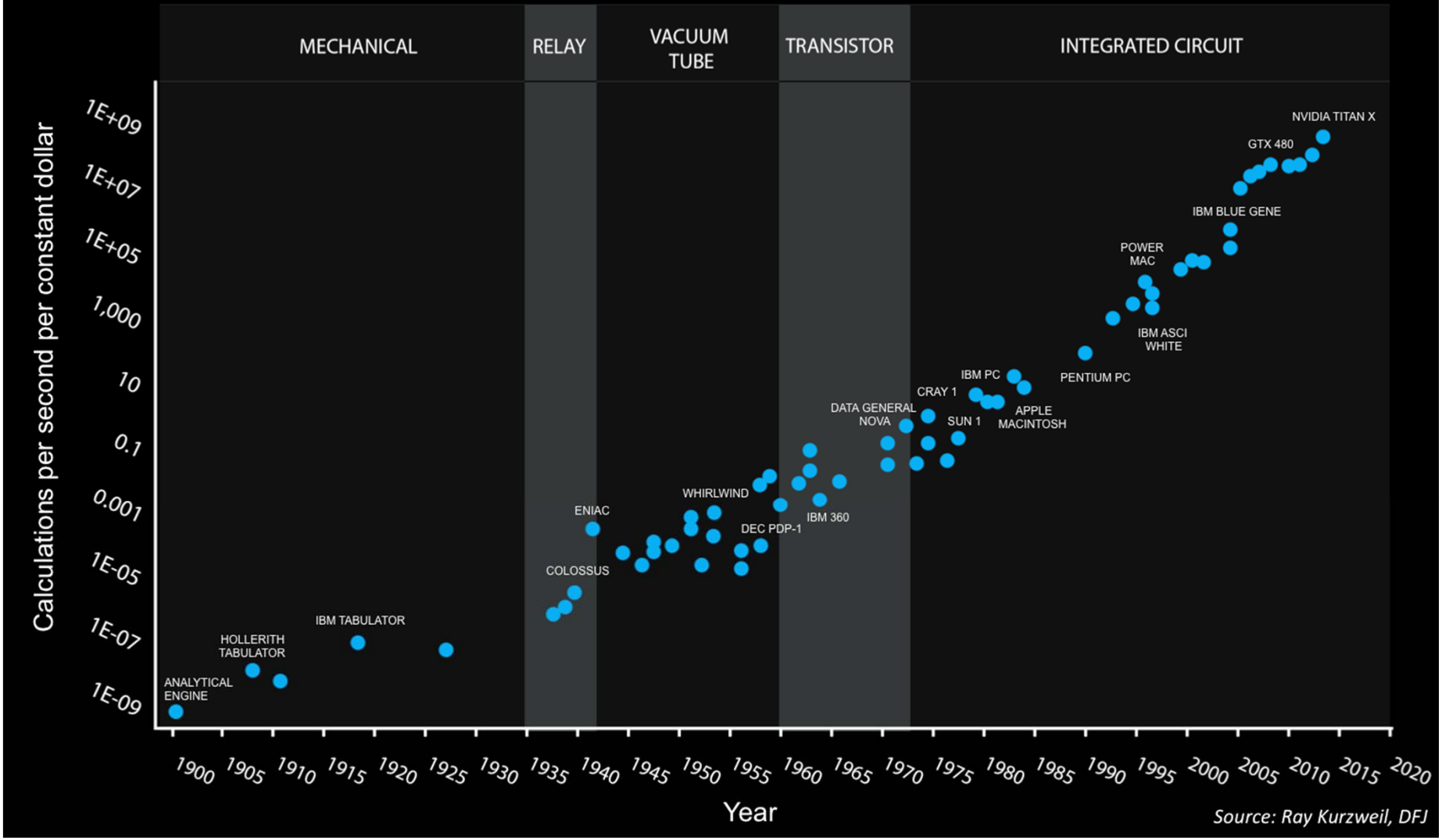
Our World in Data

Moore's law describes the empirical regularity that the number of transistors on integrated circuits doubles approximately every two years. This advancement is important as other aspects of technological progress – such as processing speed or the price of electronic products – are linked to Moore's law.



Data source: Wikipedia (https://en.wikipedia.org/wiki/Transistor_count)
The data visualization is available at OurWorldinData.org. There you find more visualizations and research on this topic.

120 Years of Moore's Law



Reducing the dimension of electronic components

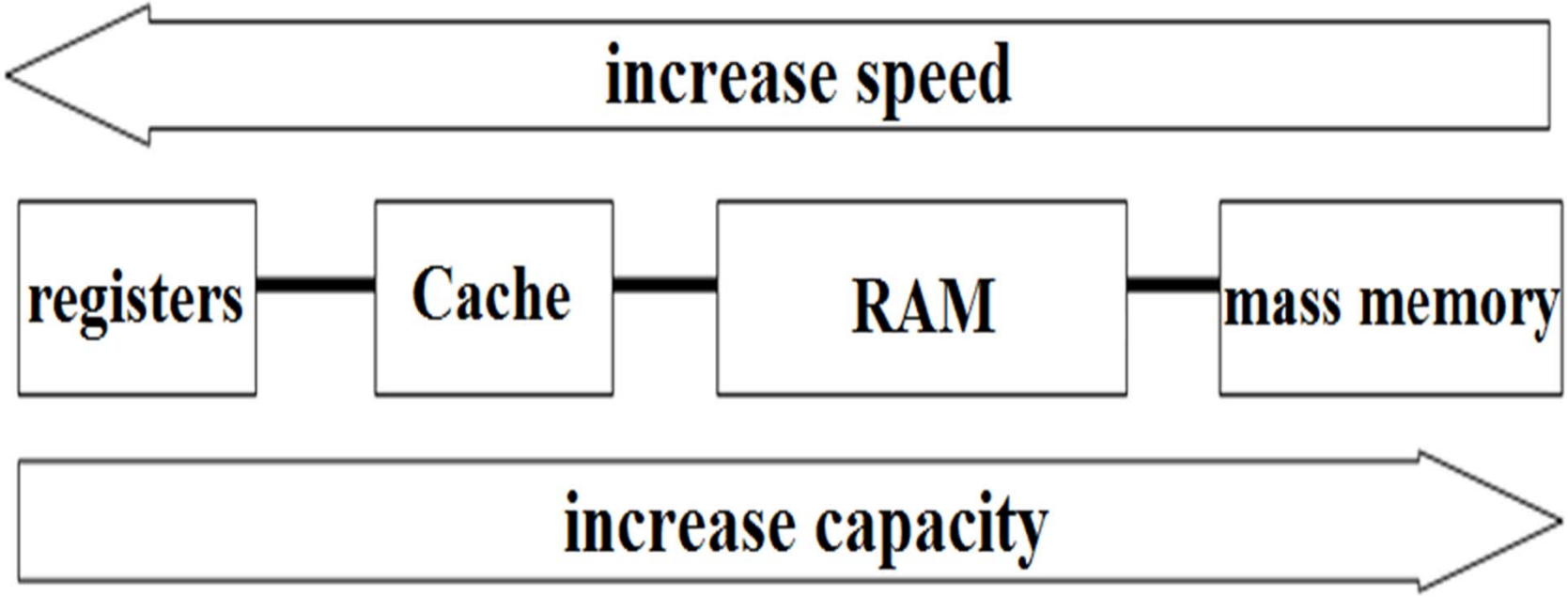
- Recently, Intel announced that the Moore's law somehow lost its strength during the last years and it will probably be invalidated during the next years.
- Now, it seems that the 10 nm technology can provide the best performance. The first 10nm scale devices were shipped to consumers by Samsung in late 2016.

Technology evolution

- 10 µm – 1971
- 6 µm – 1974
- 3 µm – 1977
- 1.5 µm – 1982
- 1 µm – 1985
- 800 nm – 1989
- 600 nm – 1994
- 350 nm – 1995
- 250 nm – 1997
- 180 nm – 1999
- 130 nm – 2001
- 90 nm – 2004
- 65 nm – 2006
- 45 nm – 2008
- 32 nm – 2010
- 22 nm – 2012
- 14 nm – 2014
- 10 nm – 2017
- 7 nm – 2018
- 5 nm – 2019
- 3 nm - ~ 2021

The memory of a computer system

- Memory registers
- Cache Memory
- RAM
- Mass memory (mass storage)


increase speed
registers
Cache
RAM
mass memory
increase capacity

RAM

RAM (Random-access memory)

- The two main forms of modern RAM are:
  - static RAM (**SRAM**) - a bit of data is stored using the state of a six transistor memory cell
  - dynamic RAM (**DRAM**) - a bit of data is stored using a transistor and capacitor pair

Common types of DRAM

- dynamic random access memory (DRAM)
- *Fast Page Mode DRAM* (*FPM DRAM*),
- *Extended Data Out DRAM* (*EDO DRAM*),
- *Burst EDO DRAM* (*BEDO RAM*),
- *Rambus DRAM* (RDRAM),
- At present S*ynchronous DRAM* (SDRAM), with variants:
  - *Double Data Rate SDRAM* (*DDR SDRAM*)
  - *DDR2 SDRAM, DDR3, and DDR4 (released to the market in 2014)*
  - *JEDEC announced its plan for the DDR5 specification release in 2019 (… available in 2020).*

Usual types of graphics card memory

- *Video RAM* (VRAM),
- *Windows RAM* (WRAM),
- *Synchronous Graphics RAM* (SGRAM),
- *GDDR3*
- GDDR4
- *GDDR5* SGRAM (Graphics Double Data Rate type five Synchronous Graphics Random-Access Memory)
- GDDR5X at 1275MHz is the fastest graphics memory commercially used by now.
- Nvidia officially released the first consumer graphics cards using ***GDDR6***, the Turing-based GeForce RTX 2080 Ti, RTX 2080 & RTX 2070.

Note: These are versions of optimized DRAM that efficiently work as video memory.

Top speed for RAM devices

- **GDDR6** targets a transfer rate of 12 to 16 GB/s per pin, twice that of GDDR5.

- The second generation of High Bandwidth Memory (**HBM 2**) specifies up to 8 dies per stack and doubles pin transfer rates up to 2 TB/s. HBM2 is predicted to be especially useful for performance sensitive consumer applications such as virtual reality.

New developments for mass memory

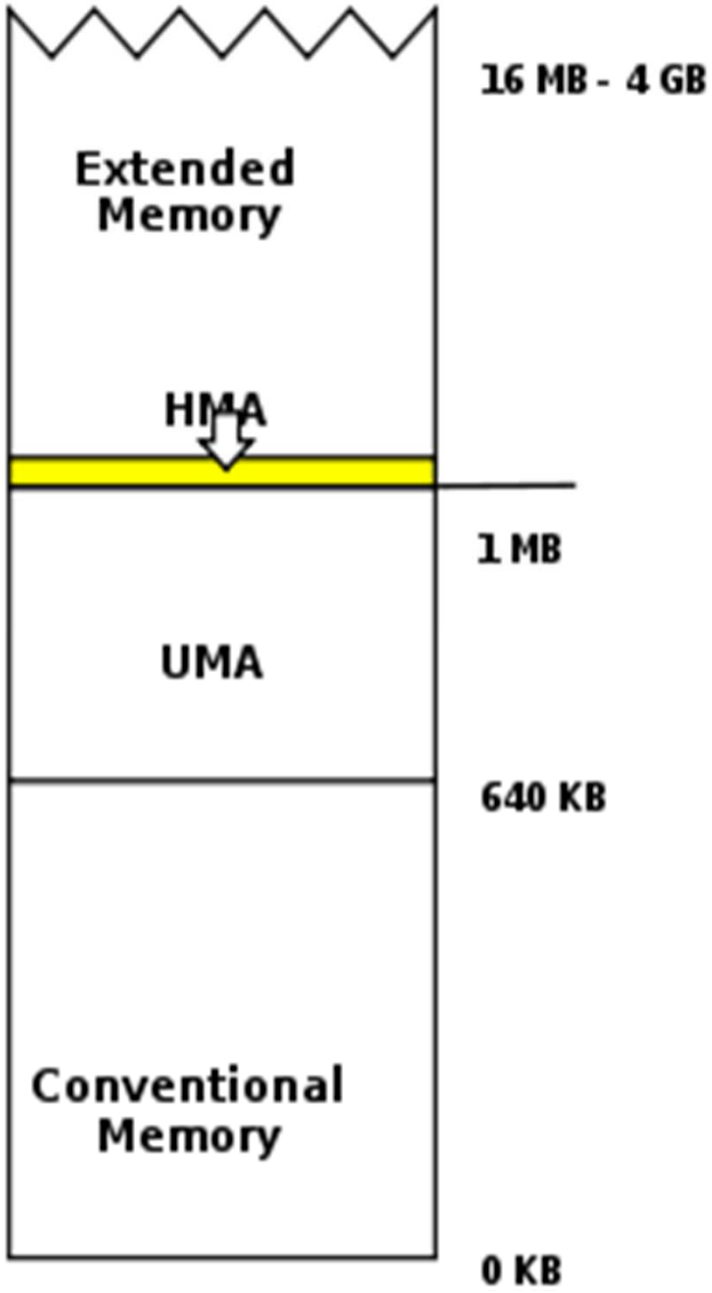
- Since 2006 - "solid-state drives“ or SSD (based on flash memory) with capacities exceeding 256 gigabytes
- their performance far exceeds the traditional disks (HDD)
- now SSD greater than 30 TB (to even 100 TB) become available

Surprises in the mass memory domain

- state-of-the-art tape systems provide a native cartridge capacity of up to 15 TB - greater than the highest-capacity hard drives on the market (even though both kinds of equipment take up about the same amount of space).

- A new technology can handle an areal density of 201 gigabits per square inch. Assuming that one cartridge can hold 1,140 meters of tape, this areal density corresponds to a cartridge capacity of a whopping 330 TB. That means that a single tape cartridge could record as much data as a wheelbarrow full of hard drives.

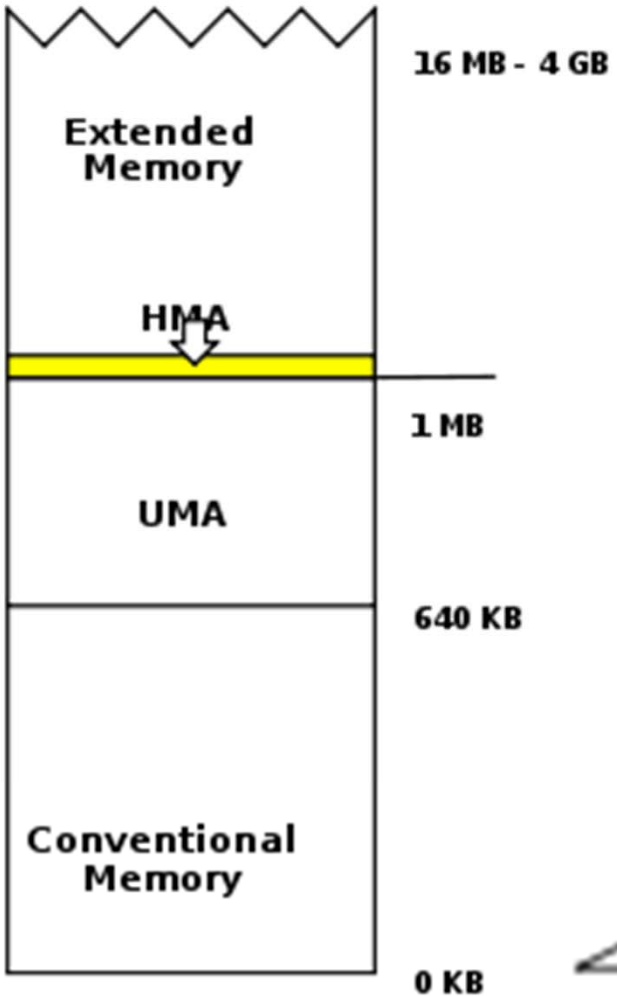
https://spectrum.ieee.org/computing/hardware/why-the-future-of-data-storage-is-still-magnetic-tape



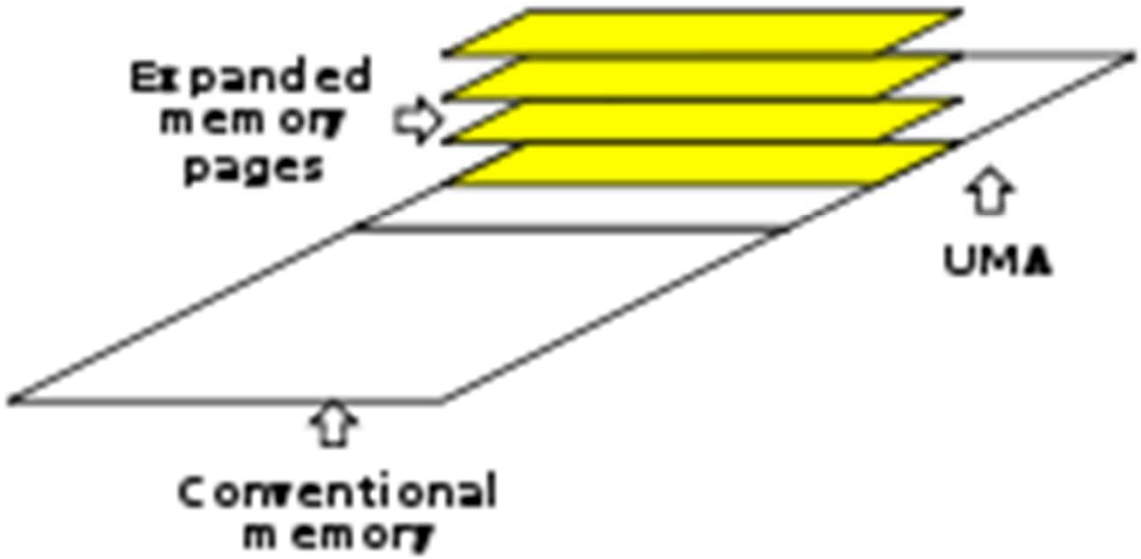
Back to RAM

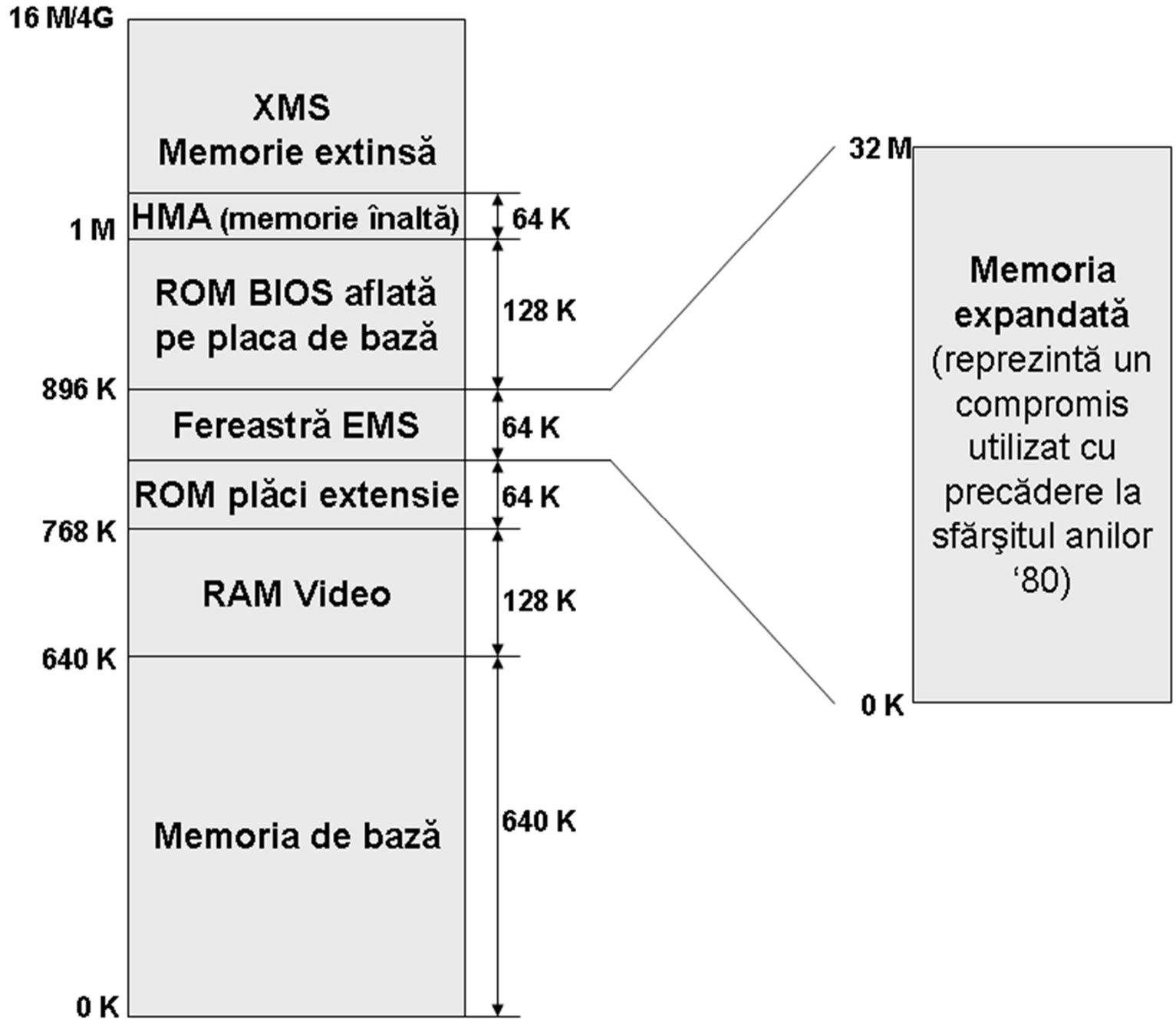
In real mode, the segmentation architecture of the Intel 80286 and subsequent processors identifies memory locations with 16-bit segment and 16-bit offset, which is resolved into a physical address via (segment) x 16 + (offset).

In DOS memory management, the high memory area (HMA) is the RAM area consisting of the first 64 kilobytes (2^{16} bytes) (KB), minus 16 bytes, of the extended memory on an IBM AT or compatible microcomputer.

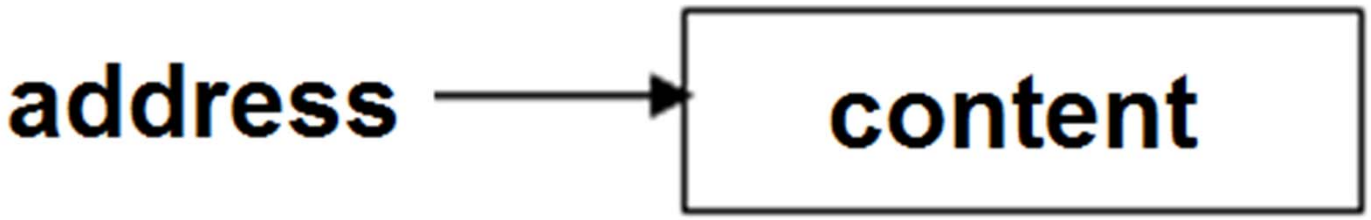


The use of expanded memory (up to 32 MB) became common with some programs in the late 1980s through the mid-1990s, but its use declined as users switched from DOS to 32-bit operating systems such as Microsoft Windows.




16 M/4G
XMS
Memorie extinsă
1 M
HMA (memorie înaltă)
64 K
ROM BIOS aflată
pe placa de bază
128 K
896 K
Fereastră EMS
64 K
ROM plăci extensie
64 K
768 K
RAM Video
128 K
640 K
Memoria de bază
640 K
0 K
32 M
Memoria
expandată
(reprezintă un
compromis
utilizat cu
precădere la
sfărşitul anilor
‘80)
0 K

- Each memory location is characterized by:
  - address
  - its content



The instruction set of a processor

- Specific instructions are recognized at the processor level

Note:

- The **instruction set architecture (ISA),** is the part of the computer architecture related to programming, including the native data types, instructions, registers, addressing modes, memory architecture, interrupt and exception handling, and external I/O.

- An ISA includes a specification of the set of opcodes (machine language), and the native commands implemented by a particular processor.

Example

- We are briefly presenting a series of instruction categories for a generic 16-bit processor, which has 8 registers. Instructions are encoded on 16 bits (which means 6 octal numbers).

Numerical example: The bit encoding of an instruction

- Assume a series of 16 bits:

  0 1 1 1 0 1 0 0 0 1 1 0 0 0 0 0

- Split in 6 octal numbers

  0 / 111 / 010 / 001 / 100 / 000

- Equivalent with:

  0 / 7 / 2 / 1 / 4 / 0

Kinds of instructions

1) *Instructions with two operands in memory or registers*

Op. Code	L.Ad.M.	L.R.	R.Ad.M.	R.R.
XX	X	X	X	X

<dest.> ← <src.> α <dest.>

2) *Instructions with an operand in registers and another operand in memory or registers*

Op. code	R	R.Ad.M.	R.R.
XXX	X	X	X

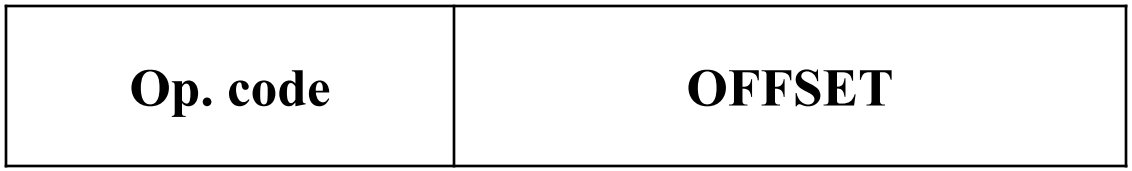
3) *Instructions with only one operand in memory or registers*

Op. code	Ad. Mode	R
XXXX	X	X

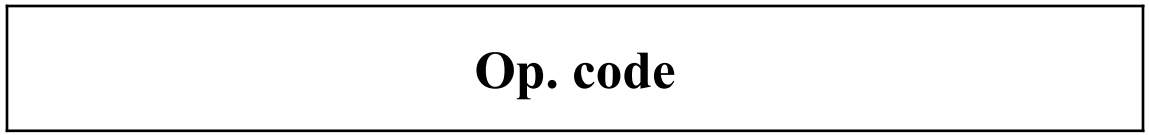
4) *Instructions with single operand in a register*

X X X X X **X**

5) Jump instructions



6) *Command instructions*



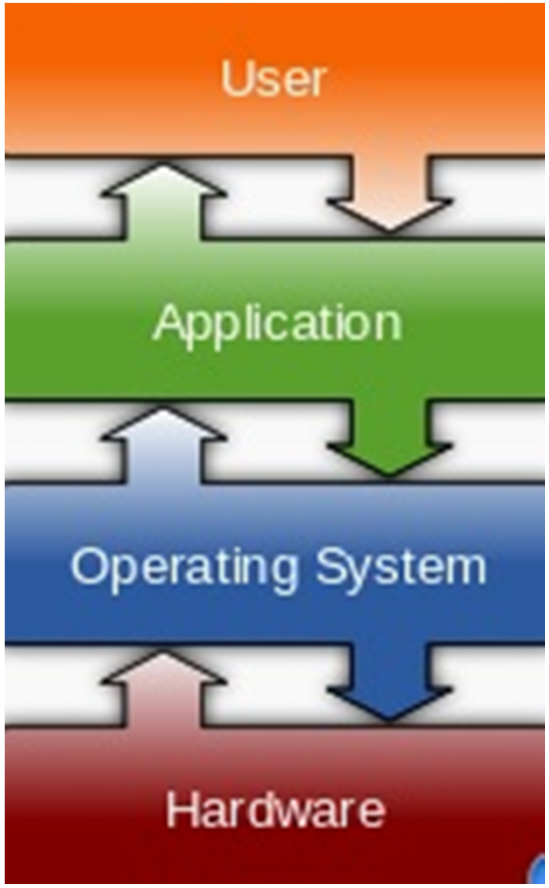
Memory addressing modes are:

- direct (even numbers);
- indirect (odd numbers).

direct addressing	Mode 0
indirect addressing through register	Mode 1
direct addressing with self-increment	Mode 2
indirect addressing with self-increment	Mode 3
direct addressing with self-decrement	Mode 4
indirect addressing with self-decrement	Mode 5
direct addressing with index	Mode 6
indirect addressing with index	Mode 7

Operating Systems

- The operating system is an essential component in a computer.



Definition:

An operating system consist of a set of procedures that allow a user (or a group of users) to efficiently use (and eventually simultaneously use) the computing machine, which is available.

Main tasks of an OS:

1. Preparing and launching the programs;
2. Control the evolution of a running program;
3. Notification of exceptional events that may occur during execution;
4. Hardware resource allocation between different processes;
5. User/ programs' access to software resources;
6. Providing protection among programs, and between different software and the operating system;
7. Access control and security for information;
8. Providing techniques for communication between processes, and synchronization of these communications.

OS Classification

- **batch processing**;
- **multiprogramming**;
- **time sharing**;
- **multiprocessing**.