POLITECNICO DI TORINO
Dipartimento di Automatica e Informatica

Unit T2: Computer Architecture

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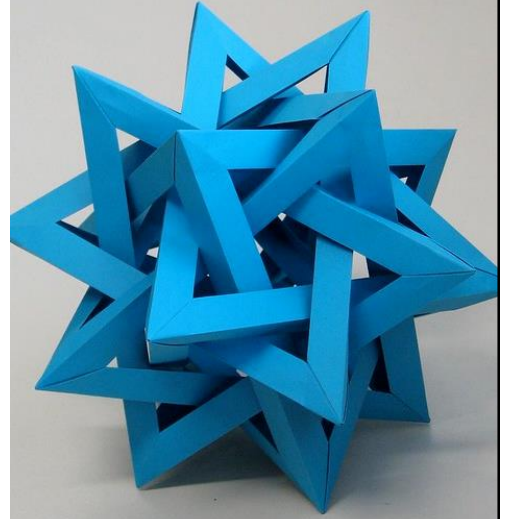
Politecnico di Torino, 2020/21   INFORMATICA / COMPUTER SCIENCES   **1**

1

BUT FIRST . . .

Computer Ar

Politecnico di Torino, 2020/21

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Survey on the Computer Sciences course

We ask you to share your experience on the Computer Science course, so that we can understand what worked well and what worked less well, and improve the course in the future.
The information provided is absolutely anonymous.
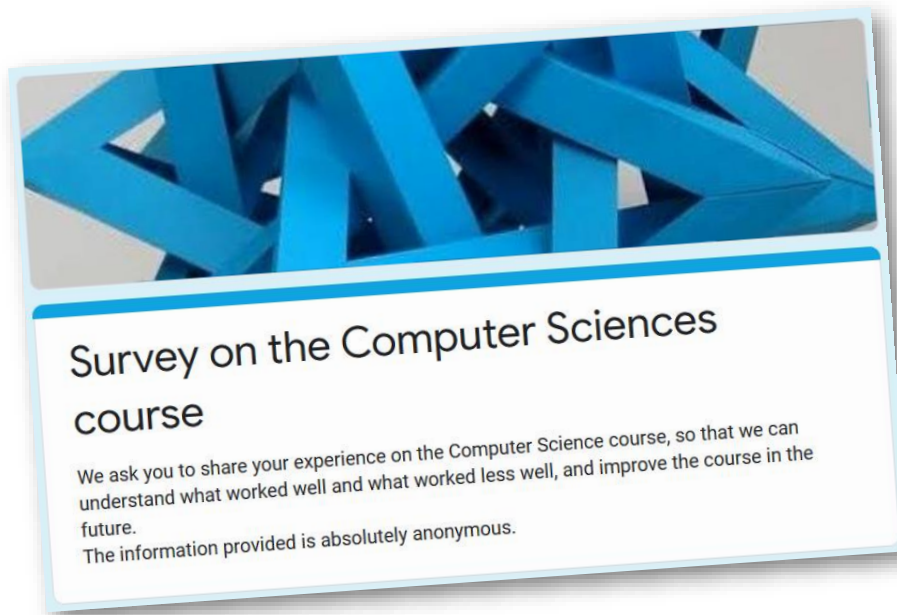
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Computer Architecture

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Overview
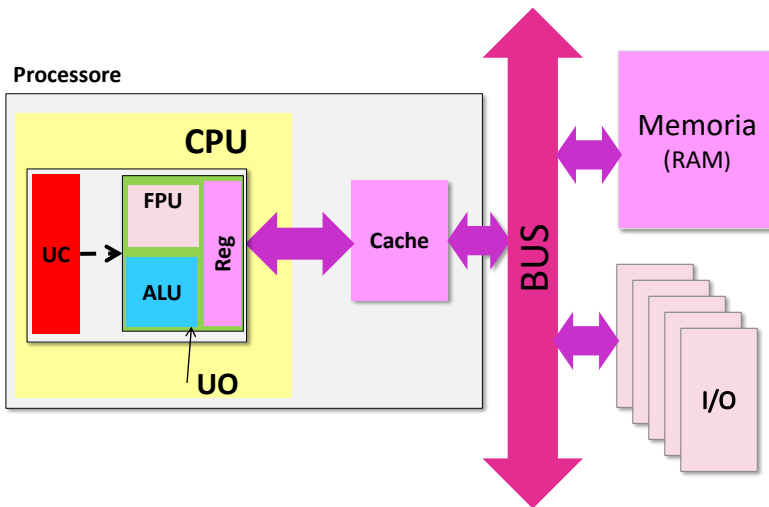
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Microprocessor performance growth
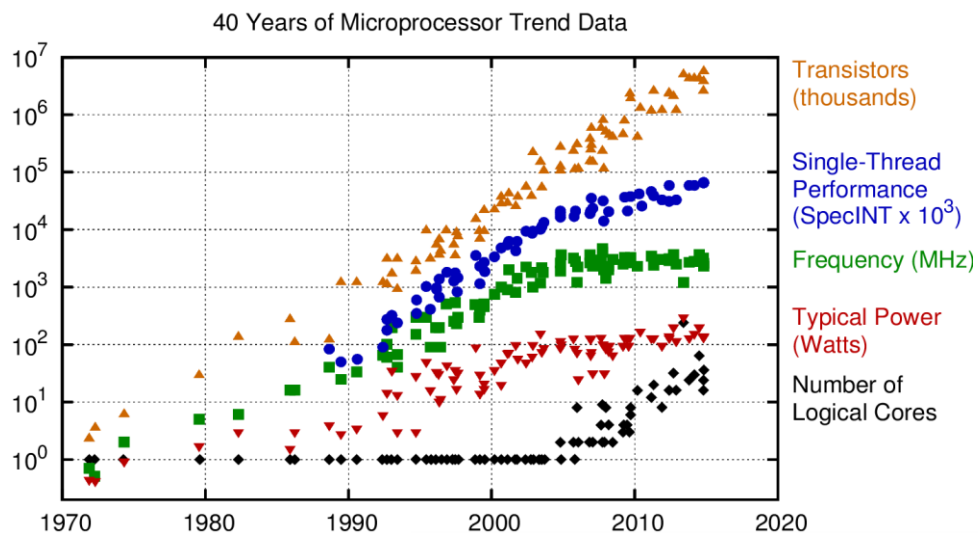
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I blocchi fondamentali dell'elaboratore

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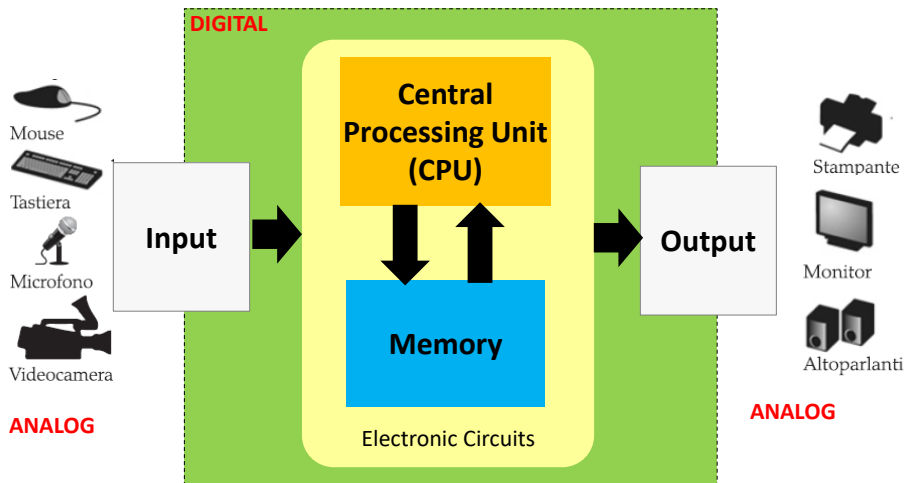
Input/Output (I/O) devices

- Enable the interaction of the computer with the external world, by means of synchronized digital signals.
  - Input: From the external world to the system
    - Examples: Keyboard, Mouse, Microphone, etc.
  - Output: From the system to the external world
    - Examples: Monitor, Printer, Loudspeakers, etc.

- The human body uses asynchronous analog signals.

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Central Processing Unit (CPU)

Memory and I/O

Operating Unit

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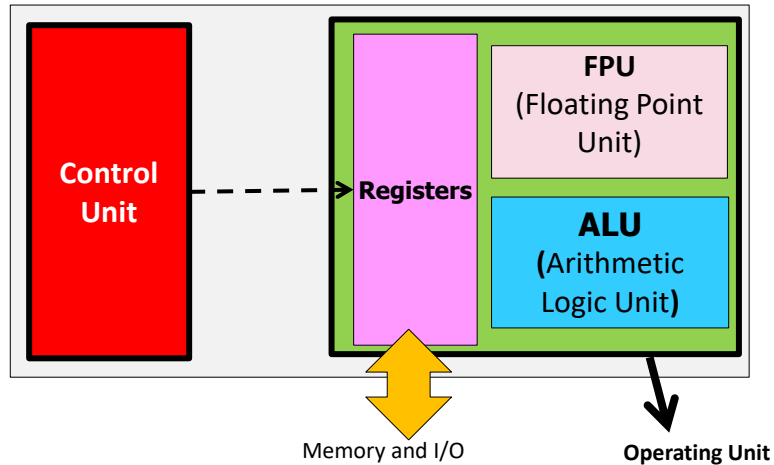
Central Processing Unit

- It performs all the required elaborations (arithmetic, logic, graphic, ...).

- It is composed by:
  o Control Unit
  o Registers
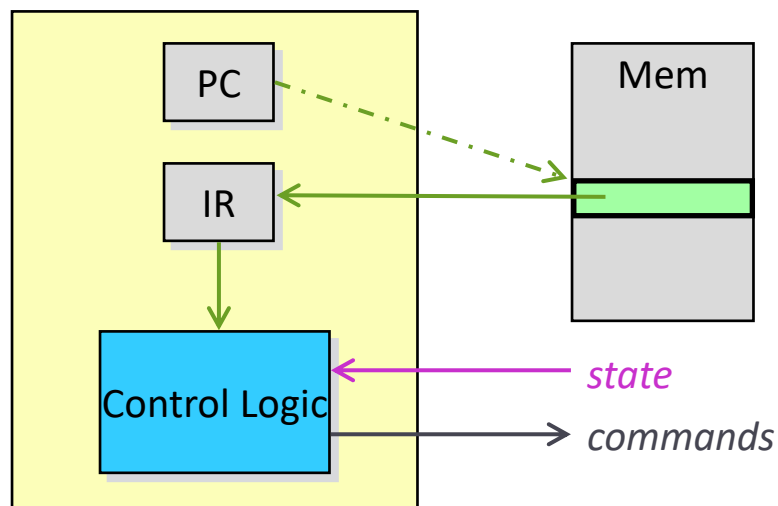 o Flags
  o ALU/FPU

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Control Unit

- It is the computer heart:
  - According to the provided program...
  - And the state of all the units...
  - Schedules the operations to be executed...
  - And issues the corresponding instructions

- Main elements
  - Program Counter
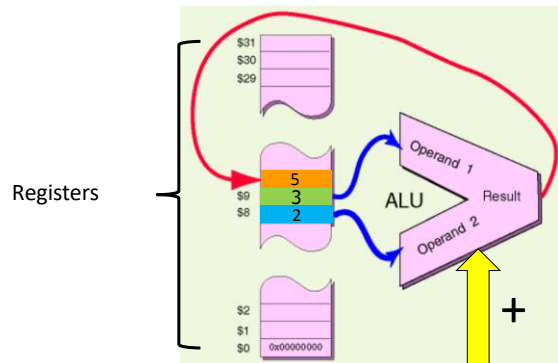 - Instruction Register
  - Control Logic

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Control Unit

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Registers

- Local memory elements used for storing data temporally (ex. Partial results).

- Small number (8...128)

- word dimension (8...64 bit)

Registers

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Flag

- State indicator of the ALU operation result

- single bit (0=false, 1=true)

- usually grouped into a register

- Most common flags:
  Z (zero)   V (overflow)
 CY (carry)   N (negative)

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ALU & FPU

- Usually composed by combinational circuits
- ALU (Arithmetic-Logic Unit)
  o It performs all **integer** computations (arithmetic and logic)
- FPU (Floating Poiunt Unit)
  o It performs all **floating point** computations
- Note:
  o Multimedia extensions (MMX)
  o 3DNow!
  o Streaming SIMD Extensions (SSE)
  o Advanced Vector Extensions (AVX)

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Computer Instruction Cycle

Fetch one instruction
from the main memory

Decode the instruction
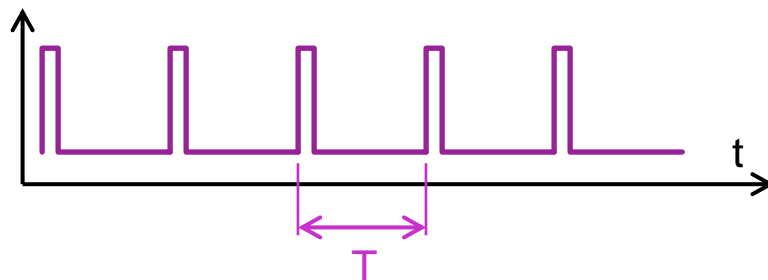
Execute the instruction
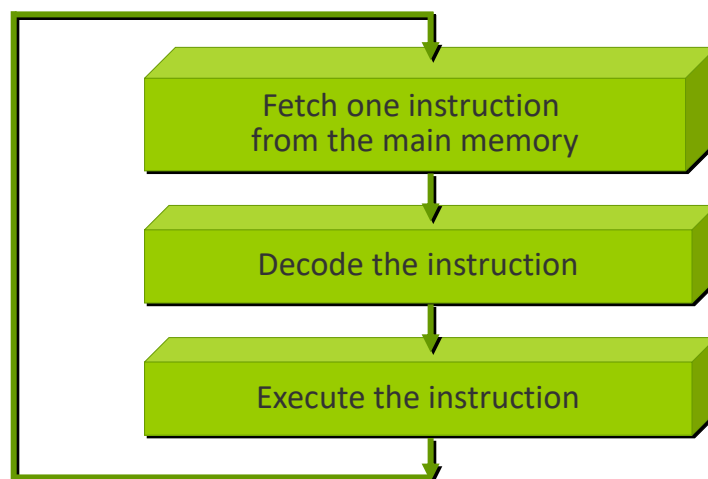
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The clock

All the computers have a timing element (namely ***clock***) generating a temporal reference common for all the elements that are part of the elaborating system.

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The clock

- T = clock *period*
  - Measure unit = s
- f = clock *frequency* (= 1 / T)
  - Measure unit = s^{-1} = Hz (cycles/s)

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Note

- In an Intel Core i7-2700 the clock frequency is 3.5 GHz
  - Note that in 3.5 millionth of a second, light runs about 1 m (104.93 cm)
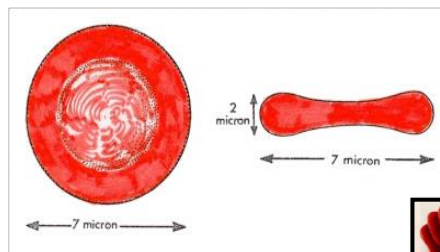

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Note 2

- Some Intel Core i7 and i5 are made using 32 nm technology
  - The cesium atom diameter lengths 0.5 nm
  - A red blood cell is 2,000 nm X 7,000 nm
  - Human hair sizes about 100,000 nm

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Instruction timing

- A *machine-cycle* is the time interval where the basic operation is executed and it is an integer multiple value of the clock period

- The execution requires an integer number of machine cycle variable according to the kind of instruction
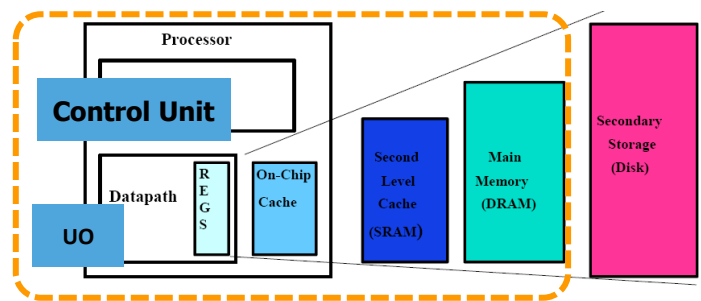
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Memory

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Memory

- It stores data and instructions that the computer needs to execute.

- Features:
  o Addressing
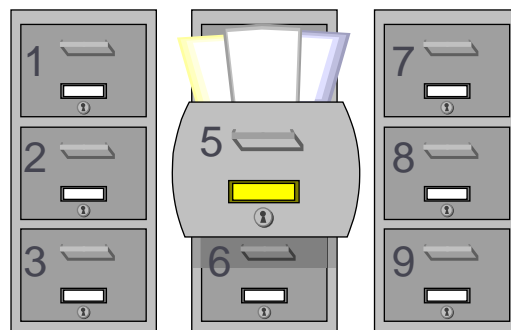 o Parallelism
  o Access (sequential or random)

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Addressing

- Memory is organized in cells (minimum directly accessible unit). An address (number) is assigned to each cell for uniquely identifying it.

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Parallelism

- Each memory cell contains a fixed quantity of bit:
- Same for all the cells (of a certain memory unit)
- Accessible with a unique instruction
- It is a multiple of a byte
- At least 1 byte (typically a word for the main memory supporting the OU)

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Internal Memory

- Inside the computer
- Solid state (chip)
- Usually volatile
- Fast (nanoseconds, 10-9s)
- Limited quantity (some GB)
- Not removable
- Expensive (0.1 € / MB)

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External Memory

- External to the computer
- Sometime removable
- Not electronic (e.g., magnetic, optical)
- Permanent
- Slow (milliseconds, 10^{-3} s)
- Large quantity (some TB)
- Cheap (0.1 € / GB)

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Maximum internal memory

- The Abus dimension determines the max number of addressable memory cells
- The Dbus dimension "suggests" the dimension of a memory cell (bigger cells, requiring two or more data transfer on the Dbus, are also possible)
  - max mem = 2|Abus| x |Dbus| bits
  - max mem = 2|Abus| bytes

byte bīt ▶

n. A unit of data equal to eight bits. Computer memory is often expressed in megabytes or gigabytes.

n. A set of bits constituting the smallest unit of addressable memory in a given computer, typically eight bits.

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Intel 80286

- The Intel 80286 is a 16-bit microprocessor that was introduced on February 1, 1982.
  - |Dbus| = 16 bit
  - |Abus| = 24 bit

- The Intel 80286 had a 24-bit address bus and was able to address up to 16 MB of RAM (16,777,216 bytes, 2^{24})
  - The smallest unit of addressable memory is eight bits (1 byte = 1 octet)
  - Registers are 16-bit, thus able to operate on 2 bytes at the same time
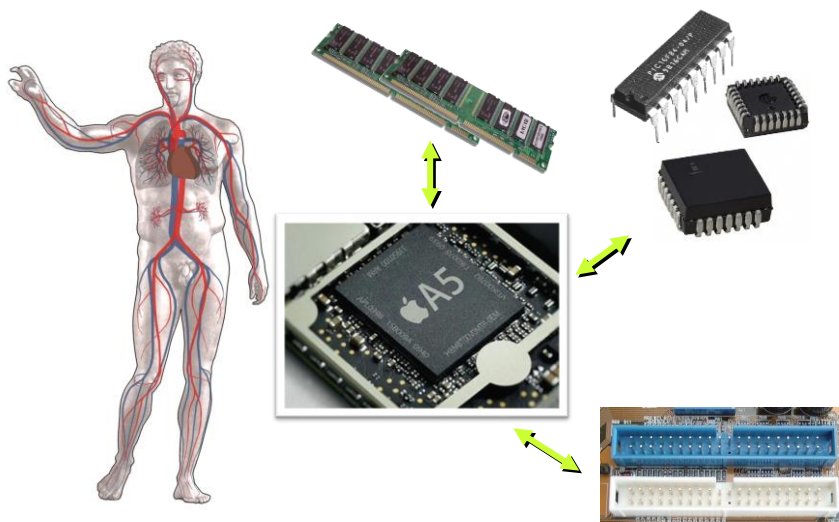 - The databus can transfer 2 bytes at the same time

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Maximum External Memory

- The external memory (ex. disk) does not depends on Abus because it is considered as a peripheral (input and/or output)

- The maximum external memory quantity depends on the I/O bus (where peripherals are connected)
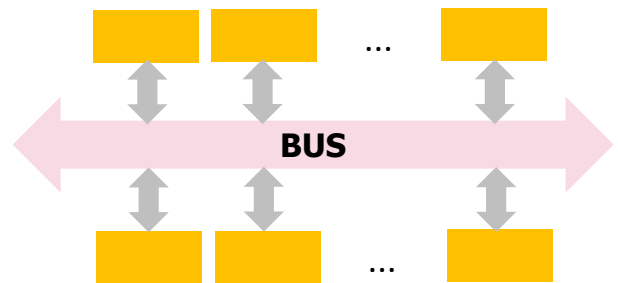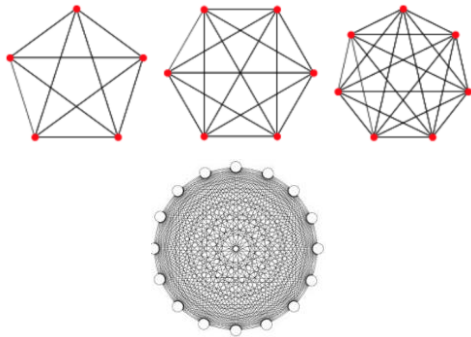
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Interconnections (BUS)

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System Bus (PC Circulatory system)

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Bus features

- A single data is transported at time
- frequency = n. data transported at in a second
- Width = n. di bit composing a single data
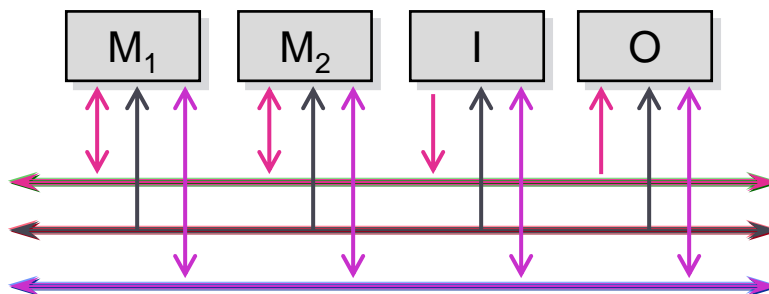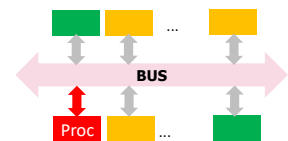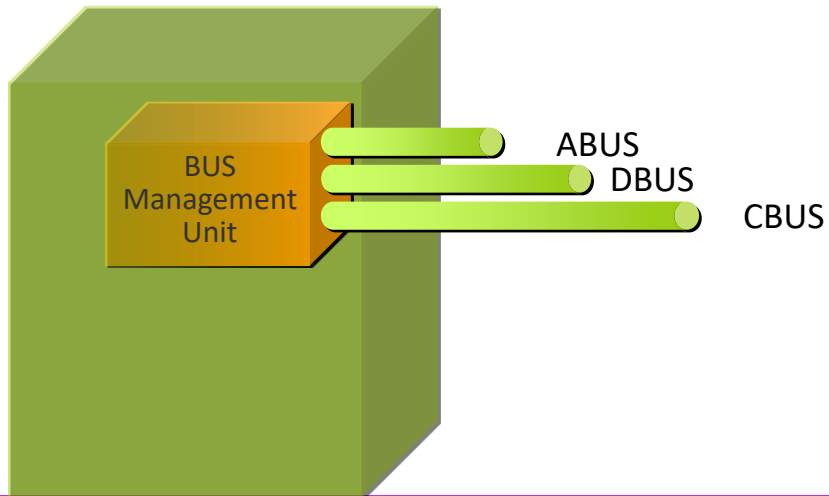- If not properly dimensioned, it could be a bottleneck

BUS

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Bus types

- A single bus is composed of the following buses:
  - Data bus (DBus)
  - Address bus (ABus)
  - Control bus (CBus)

M_1 M_2 I O

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Microprocessor core bus system

ABUS
DBUS
CBUS

BUS Management Unit

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Overview

Processore

CPU

FPU

UC

ALU

Reg

UO

Cache

BUS

Memoria (RAM)

I/O

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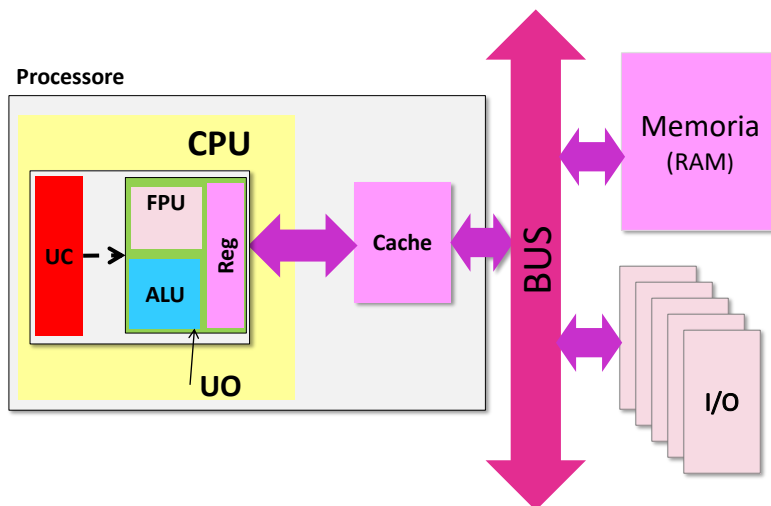
Internet & Privacy

Are you frightened?

Yes

Not nearly frightened enough