Spring 2017

CSE 101:
Introduction to Computer Science & Programming Methodology

LECTURE-3: BASIC COMPUTER ARCHITECTURE

Computer Generations

Generation in computer terminology is a change in technology a computer is/was being used.

Initially, the generation term was used to distinguish between varying hardware technologies.

But nowadays, generation includes both hardware and software, which together make up an entire computer system.

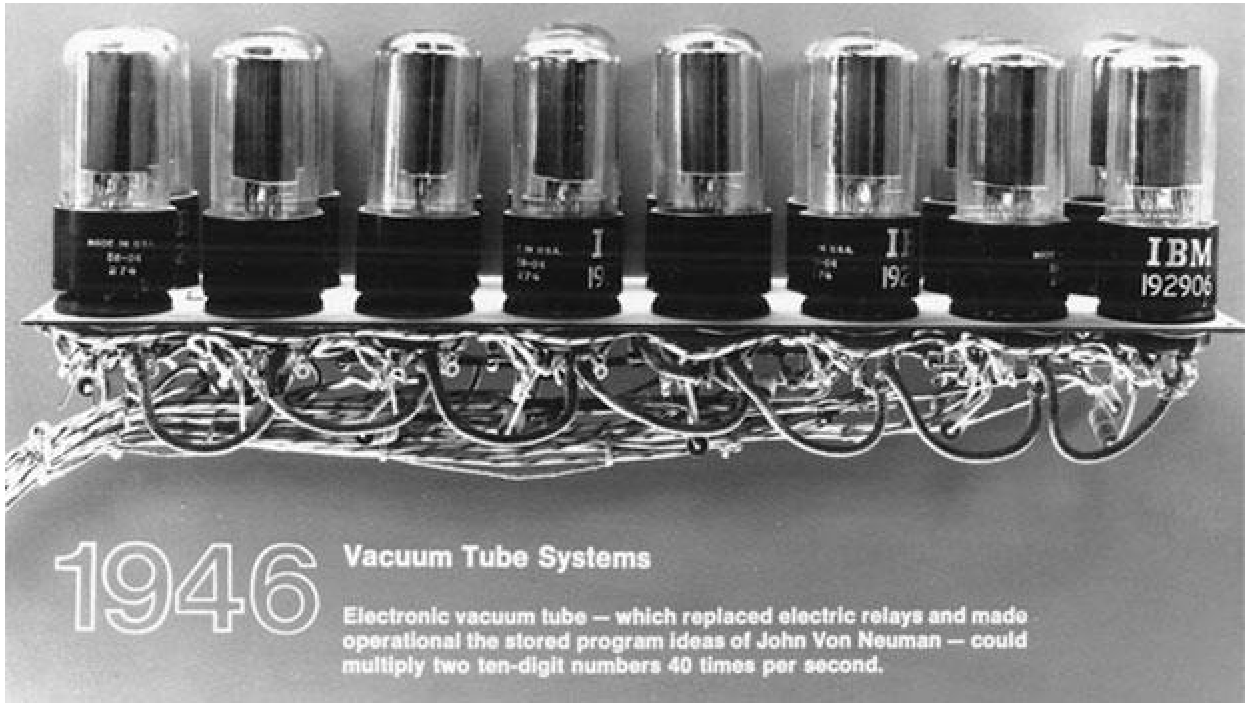
There are totally five computer generations known till date.

Computer Generations-II

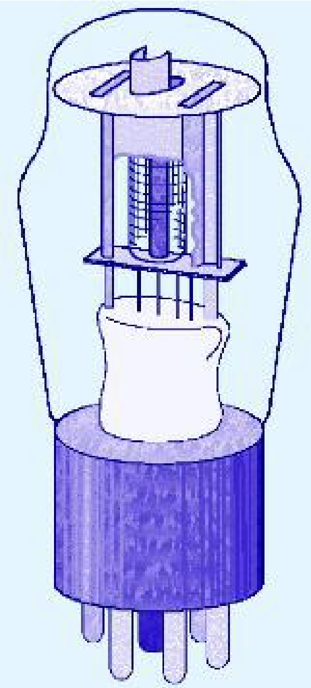
S.N.	Generation & Description
1	First Generation The period of first generation: 1946-1959. Vacuum tube based.
2	Second Generation The period of second generation: 1959-1965. Transistor based.
3	Third Generation The period of third generation: 1965-1971. Integrated Circuit based.
4	Fourth Generation The period of fourth generation: 1971-1980. VLSI microprocessor based.
5	Fifth Generation The period of fifth generation: 1980-onwards. ULSI microprocessor based

BRIEF HISTORY OF COMPUTERS

The First Generation: Vacuum Tubes



The First Generation: Vacuum Tube Computers (1945 - 1953)



ENIAC - background

Electronic Numerical Integrator And Computer

Eckert and *Mauchly* proposed to build a general-purpose computer using vacuum tubes for the BRL’s application.

At university of Pennsylvania

It was the world’s first general purpose electronic digital computer.

Started 1943

Finished 1946

- Too late for war effort

Used until 1955

ENIAC - details

The *ENIAC* was a decimal rather than a binary machine. Numbers were represented in decimal form, and arithmetic was performed in the decimal system.

Its memory consisted of 20 accumulators of 10 digits number.

It had to be programmed manually by setting switches and plugging and unplugging cables.

The resulting machine was enormous, **weighing 30 tons, occupying 1500 square feet of floor space, and containing more than 18,000 vacuum tubes.**

When operating, it consumed 140 kilowatts of power.

The Second Generation Transistors

The first major change in the electronic computer came with the replacement of the *vacuum tube* by the *transistor*.

The transistor is smaller, cheaper, and dissipates less heat than a vacuum tube, but can be used in the same way as a vacuum tube to construct computers.

Unlike the vacuum tube, which requires wires, metal plates, a glass capsule, and a vacuum, the transistor is a *solid-state device, made from silicon.*

It was invented in 1947 at Bell Labs.

Transistor Based Computers

The use of the transistor defines the *second generation of computers*.

IBM again was not the first company to deliver the new technology. NCR and RCA were the front-runners with some small transistor machines.

IBM followed shortly with the *7000 series*.

The second generation is noteworthy also for the appearance of the *Digital Equipment Corporation (DEC).*

DEC was founded in 1957 and, in that year, delivered its first computer which is called the *PDP-1*.

The Third Generation
Integrated Circuits - Microelectronics

In 1958 came the achievement that revolutionized electronics and started the era of *microelectronics*: the invention of the *integrated circuit*.

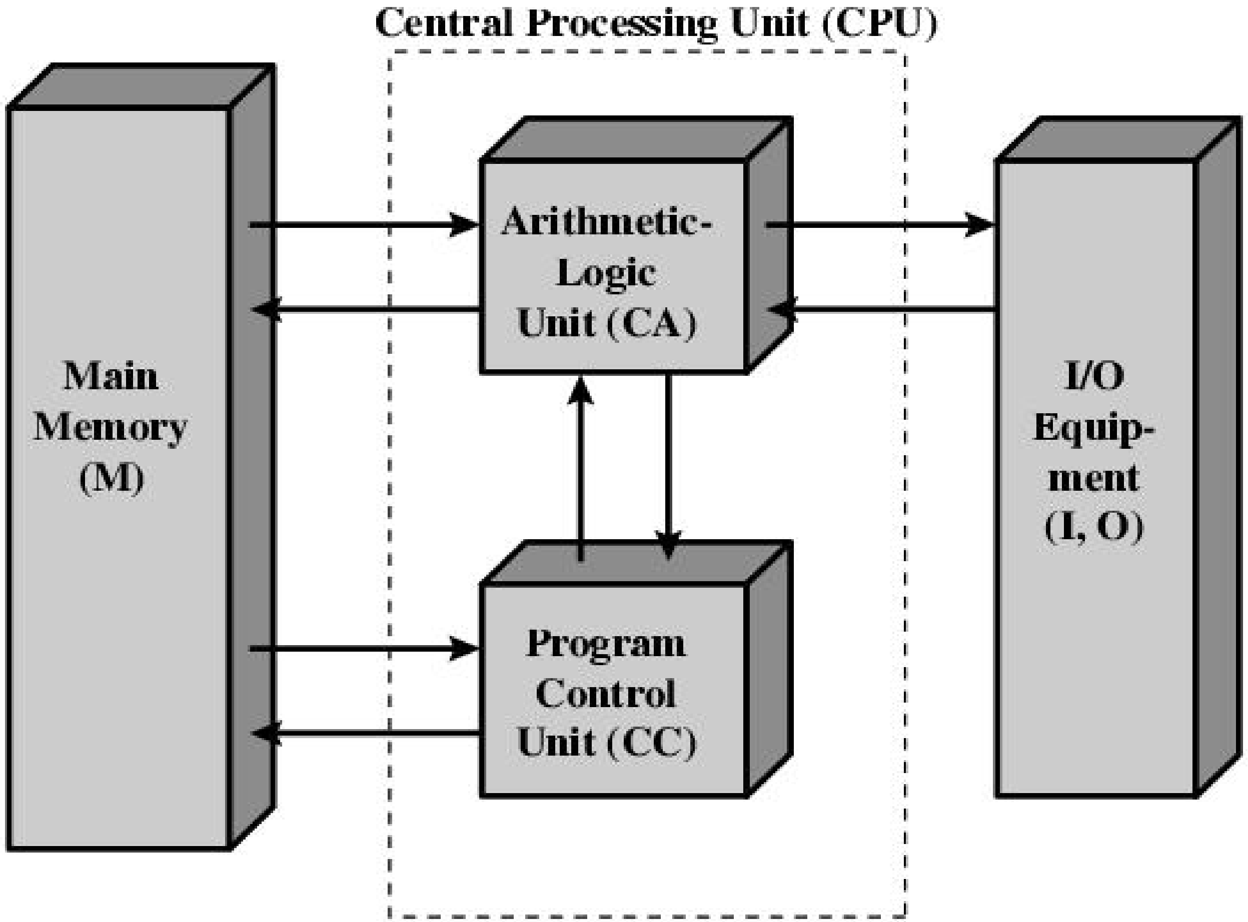
It is the integrated circuit that defines the *third generation of computers.*

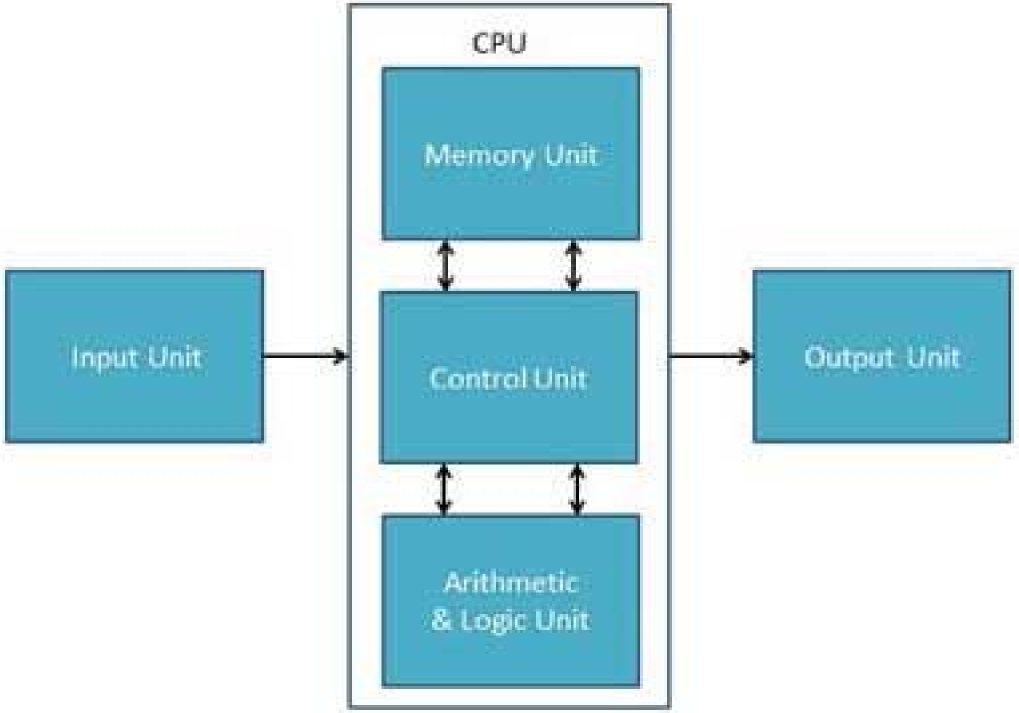
Microelectronics means "small electronics."

Since the beginnings of digital electronics and the computer industry, there has been a persistent and consistent trend toward the reduction in size of digital electronic circuits.

A computer is made up of gates, memory cells and interconnections.

Structure of The IAS (Institute for Advanced Studies) Computer




CPU
Memory Unit
Input Unit
Control Unit
Output Unit
Arithmetic
& Logic Unit

Input Unit

- This unit contains devices with the help of which we enter data into computer. This unit makes link between user and computer. The input devices translate the information into the form understandable by computer.

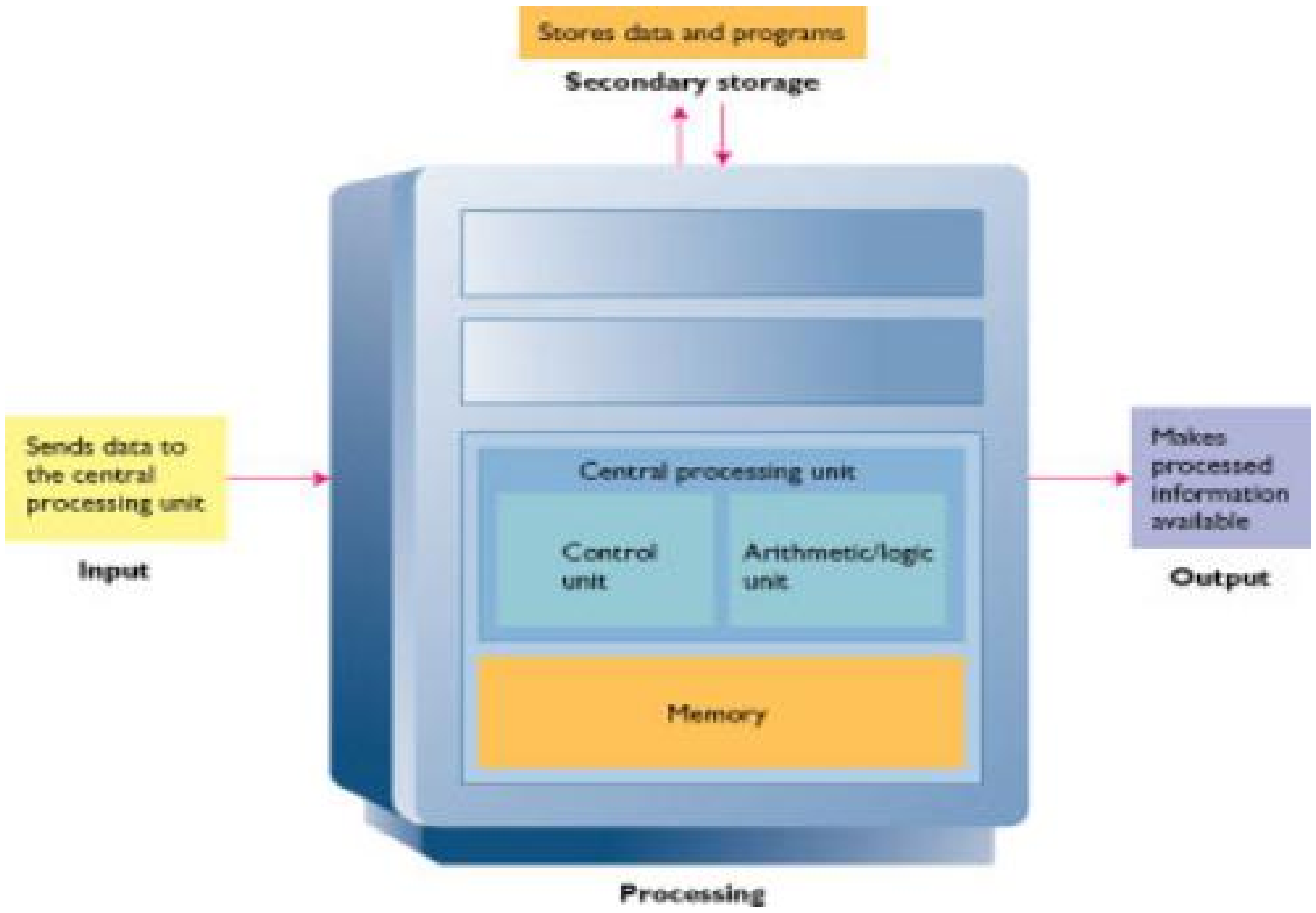
CPU (Central Processing Unit)

- CPU is considered as the brain of the computer. CPU performs all types of data processing operations. It stores data, intermediate results and instructions(program). It controls the operation of all parts of computer.
- CPU itself has following three components
  - ALU(Arithmetic Logic Unit)
  - Memory Unit
  - Control Unit

Output Unit

- Output unit consists of devices with the help of which we get the information from computer. This unit is a link between computer and users. Output devices translate the computer's output into the form understandable by users.

The General Architecture



The CPU

Converts data into information

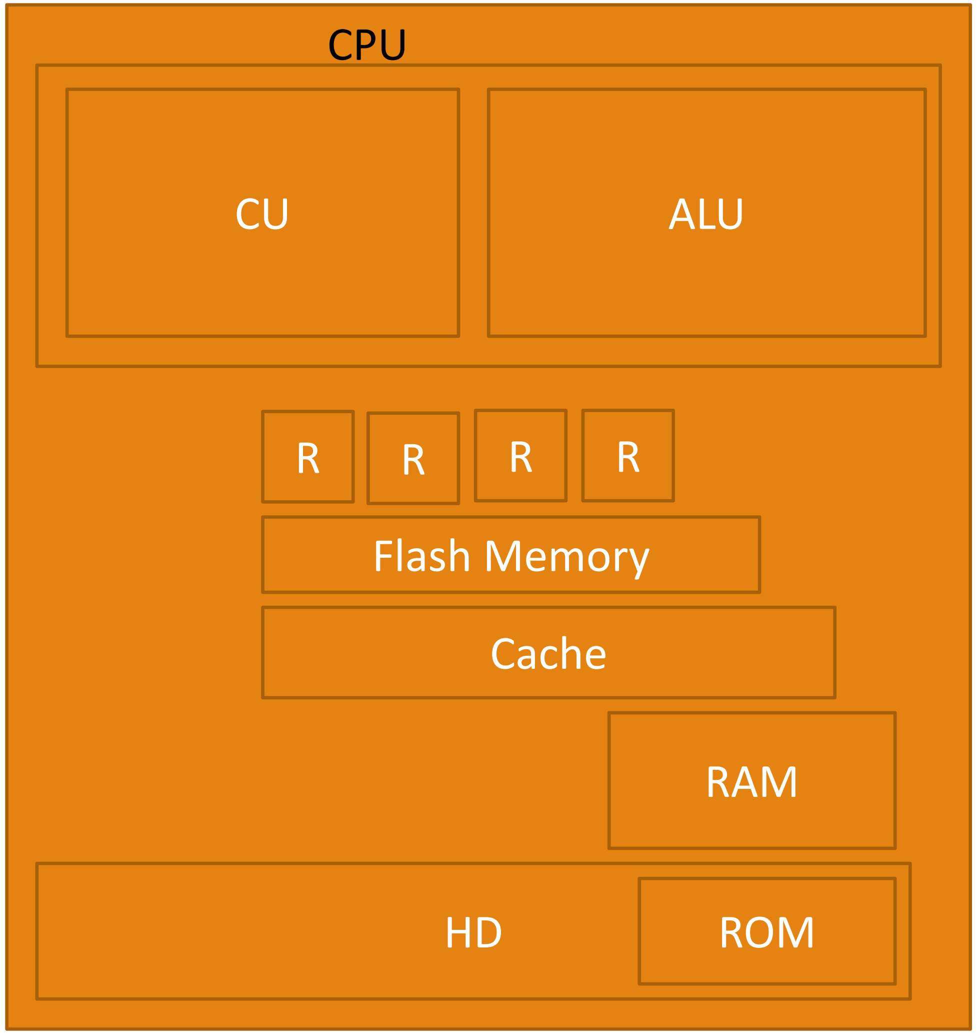
Control center

Set of electronic circuitry that executes stored program instructions

Two parts

- Control Unit (CU)
- Arithmetic Logic Unit (ALU)

Slightly broad view(CPU+Memory)



Control Unit (*CU*)

Part of the hardware that is in-charge

Directs the computer system to execute stored program instructions

Communicates with other parts of the hardware

Arithmetic / Logic Unit (*ALU*)

Performs arithmetic operations

Performs logical operations

Executing Programs

CU gets an instruction from RAM .

CU decodes the instruction

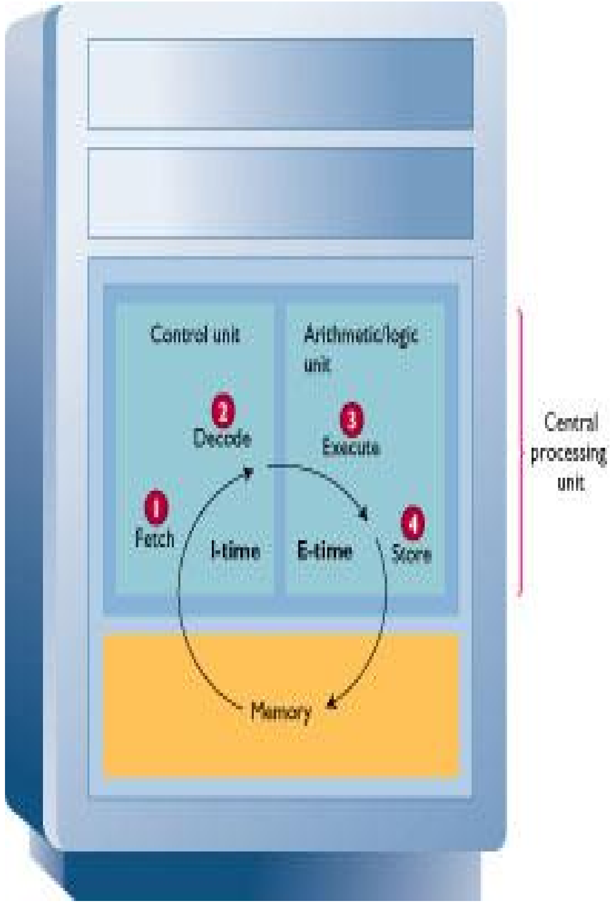
CU notifies the appropriate part of hardware(ALU) to take action

Control is transferred to the appropriate part of hardware(ALU)

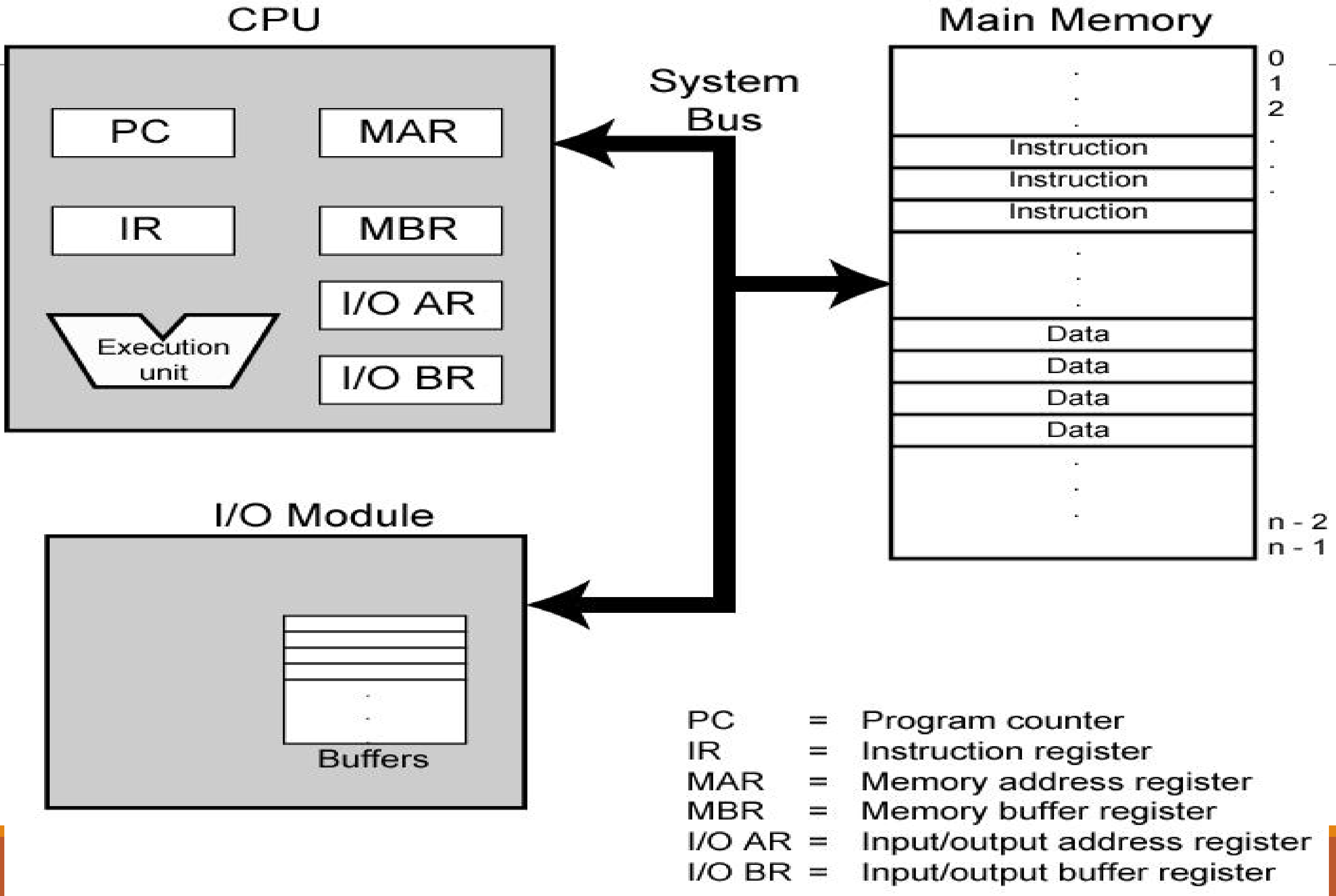
Task is performed by ALU

If necessary , results are stored in HD

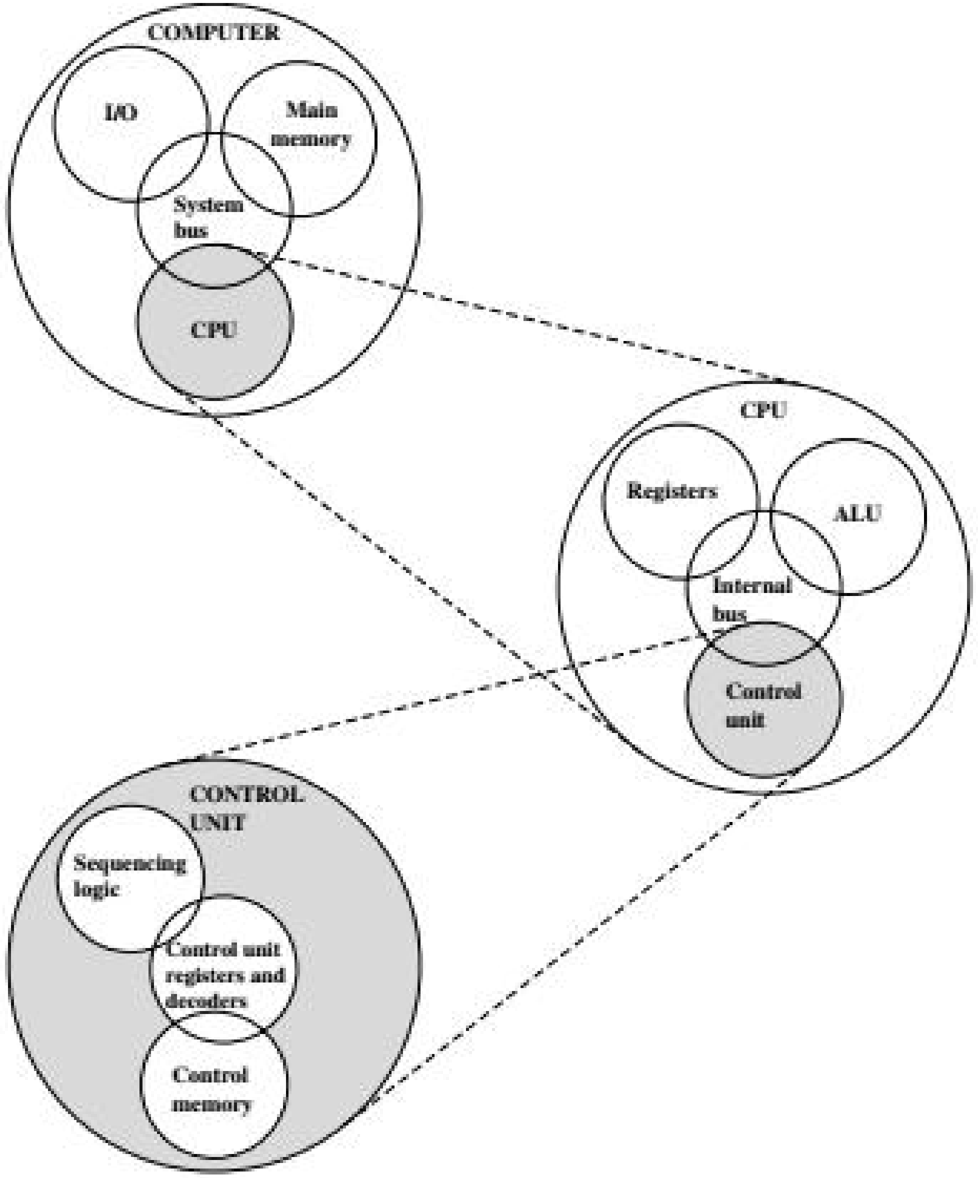
Control is returned to the CU



Computer Components: Top Level View



2 The Computer: Top-Level Structure



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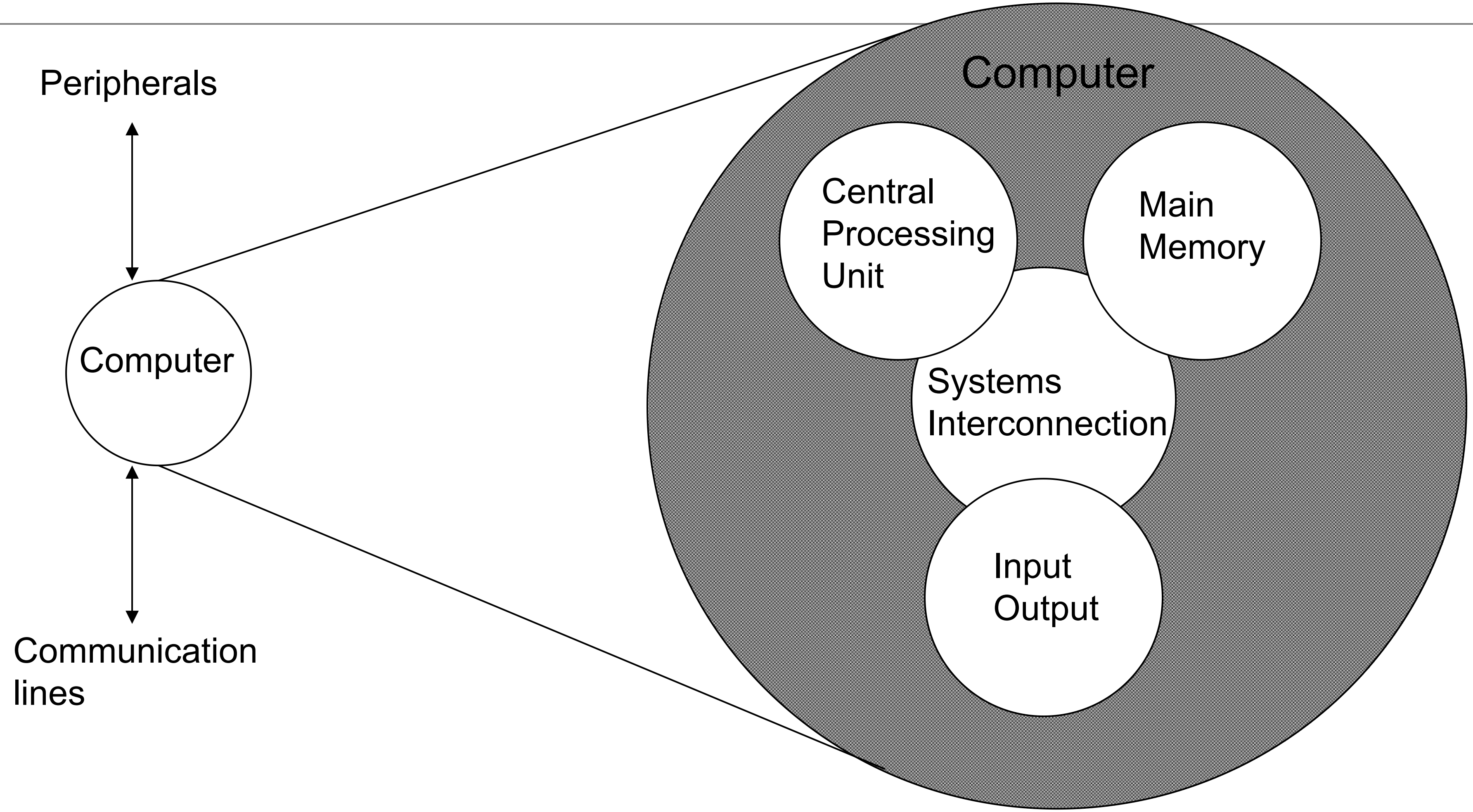
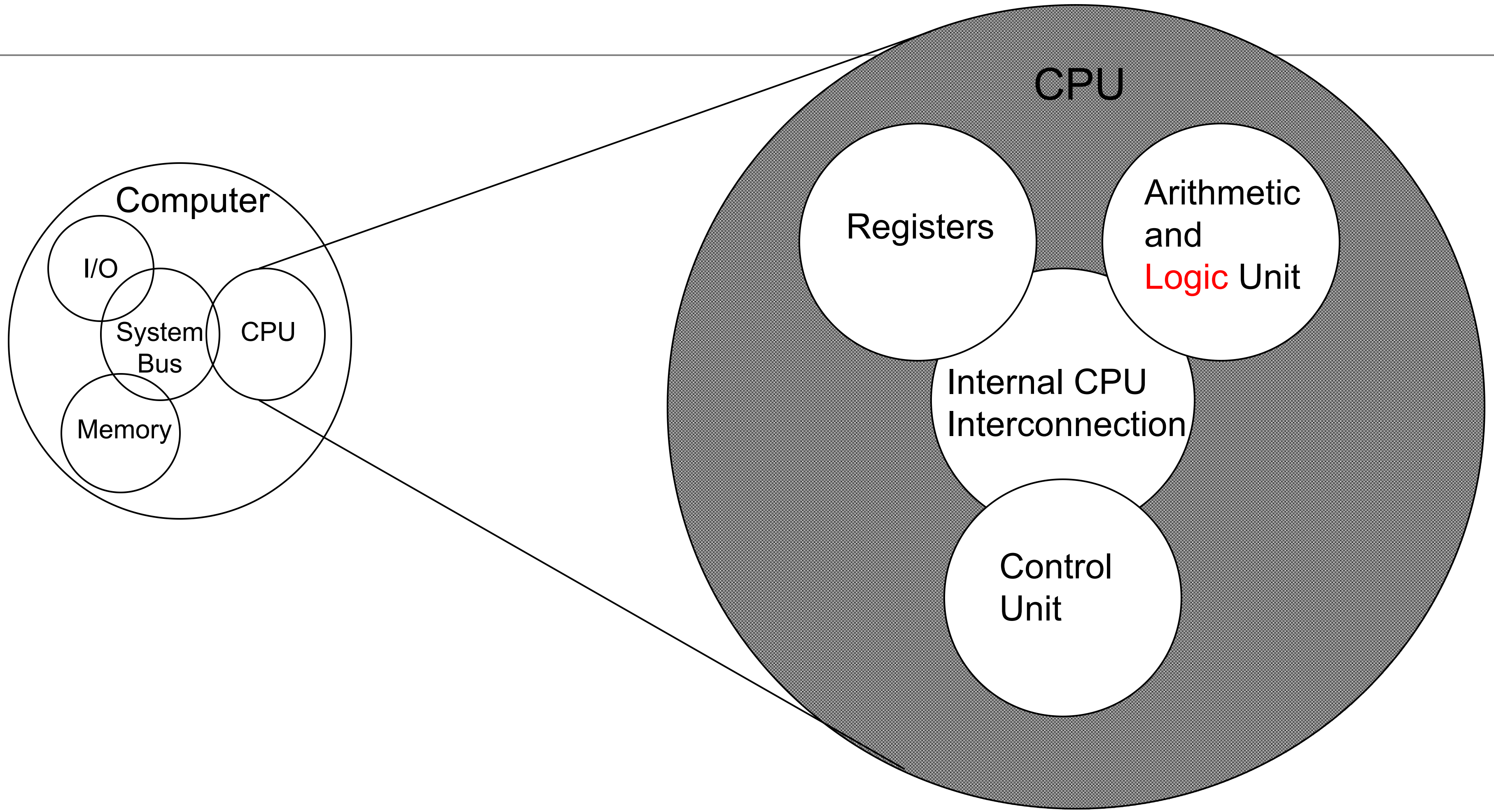
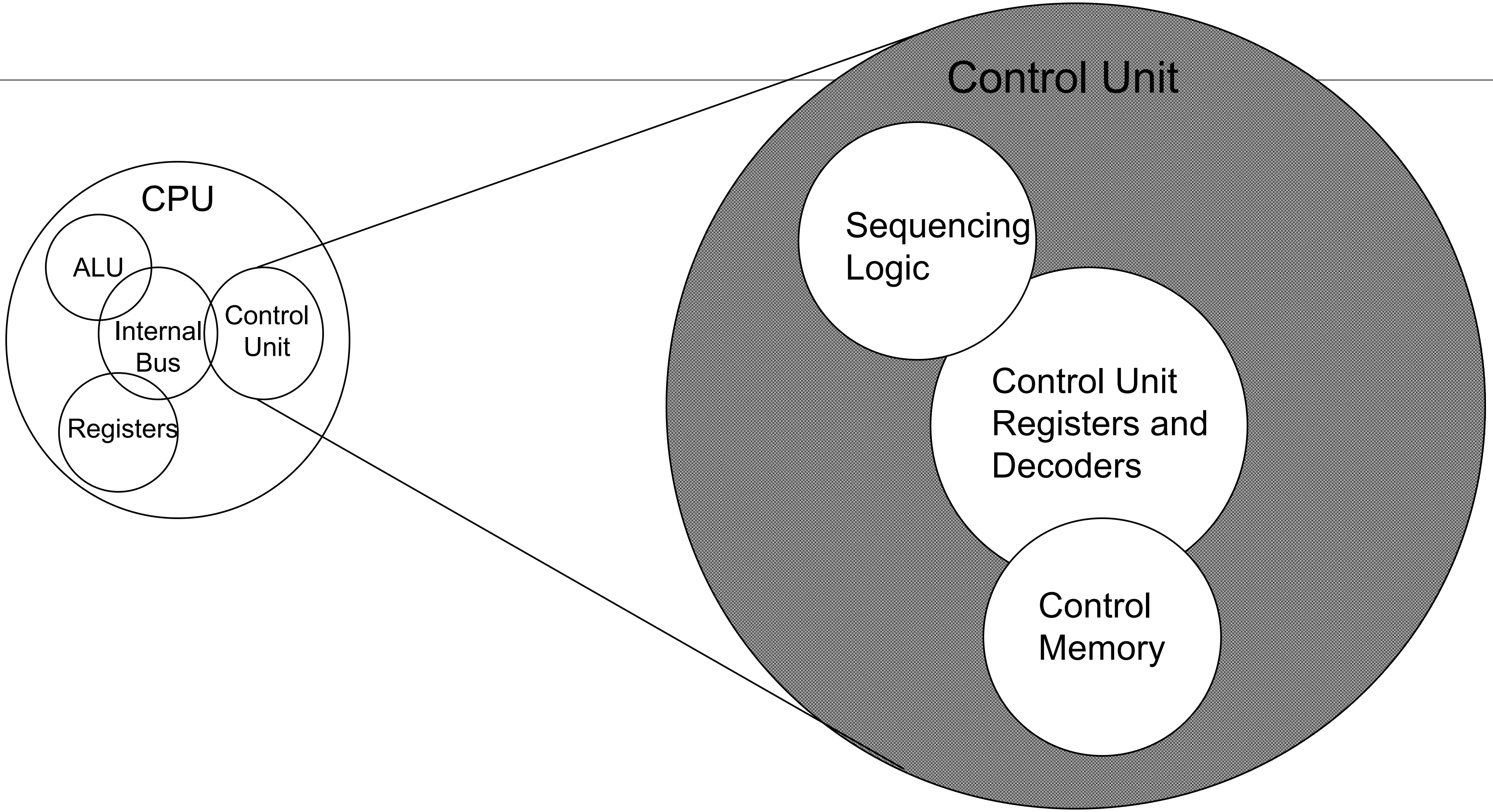


2 Structure: CPU




CPU
ALU
Internal Bus
Control Unit
Registers
Control Unit
Sequencing Logic
Control Unit Registers and Decoders
Control Memory

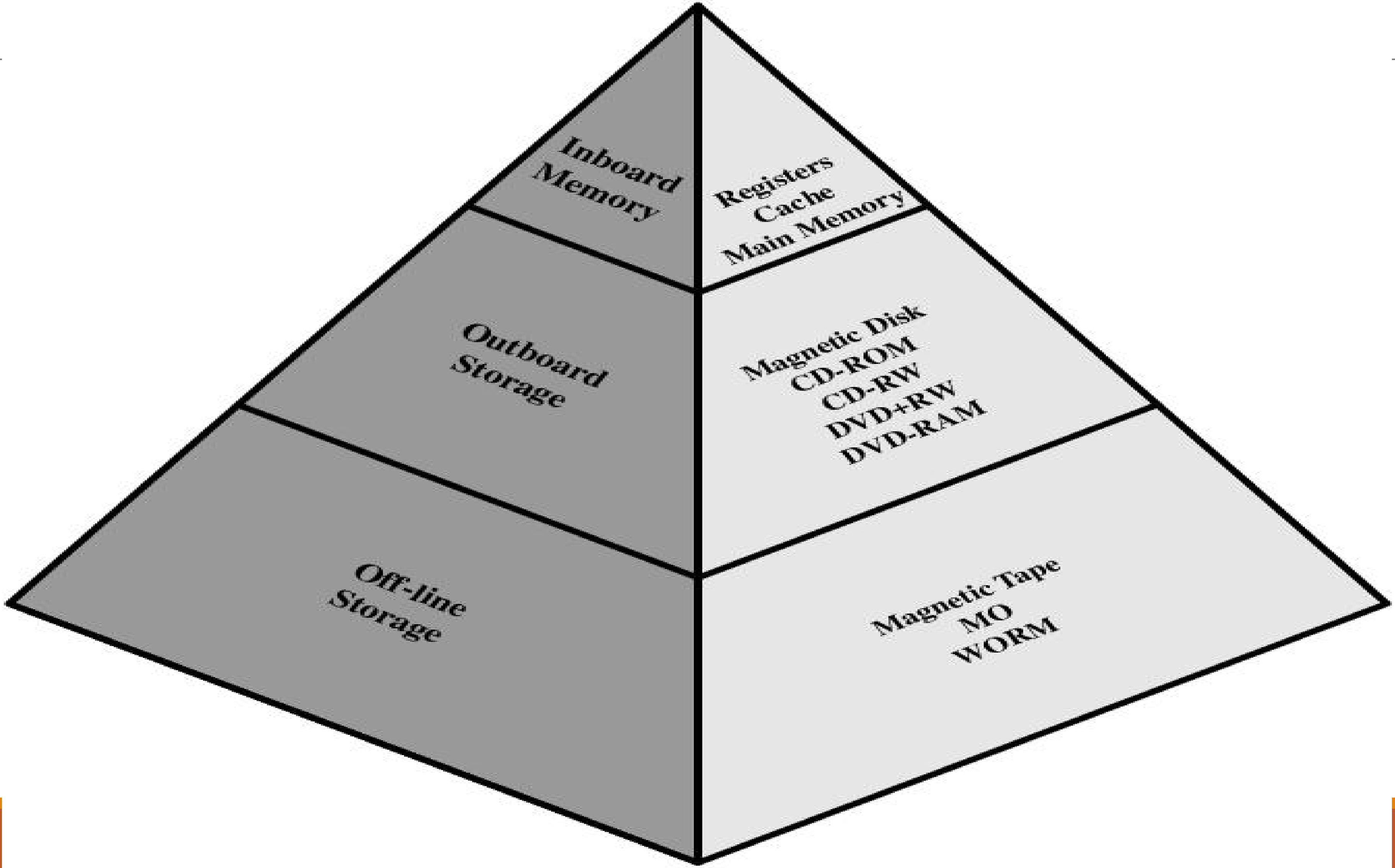
Types of Storage

Secondary
- Data that will eventually be used
- Long-term

Primary
- Data that will be used in the near future
- Temporary
- Faster access than storage

Registers
- Data immediately related to the operation being executed
- Faster access than memory

Memory Hierarchy - Diagram



The Memory Hierachy

The design constraints on a computer’s memory can be summed up by three questions:

- How much? How fast? How expensive?
- How much?
  - Capacity.
- How fast?
  - Time is money.
- How expensive?
  - Cost.

To achieve greatest performance, the memory must be able to keep up with the processor.

A variety of technologies are used to implement memory systems, and across this spectrum of technologies, the following relationships hold:

- Faster access time, greater cost per bit.
- Greater capacity, smaller cost per bit.
- Greater capacity, slower access time.

As one goes down the hierarchy such as in figure 4.1, the following occur:

- a. Decreasing cost per bit.
- b. Increasing capacity.
- c. Increasing access time.
- d.Decreasing frequency of access of the memory by the processor.

Hierarchy List

Registers

Cache

Main memory

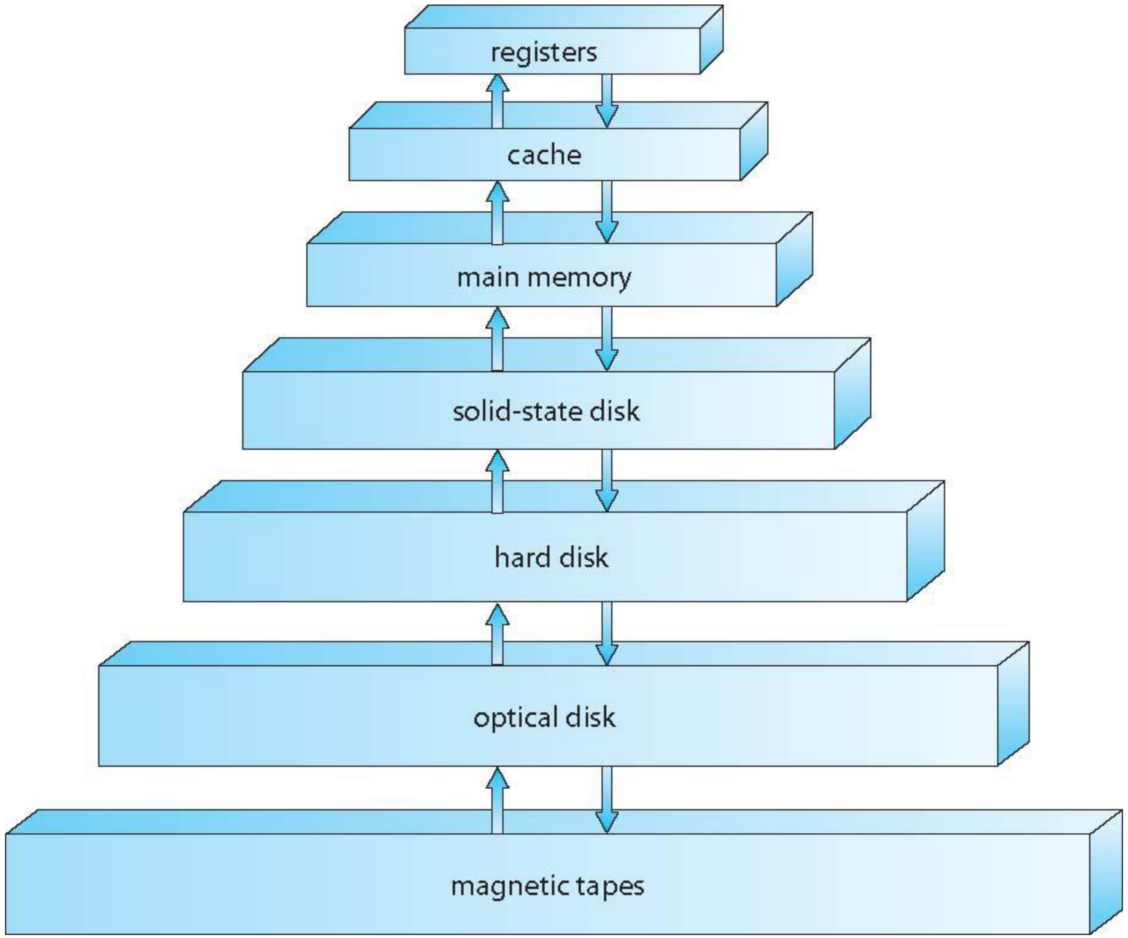
Disk cache

Disk

Optical

Tape

Storage-Device Hierarchy



Registers

- Special-purpose
- High-speed
- Temporary storage
- Located inside CPU

Instruction register	*Data register*
Holds instruction currently being executed	Holds data waiting to be processed Holds results from processing

Primary Memory

RAM(Random Access Memory)

ROM(Read Only Memory)

ROM

Non-volatile

Instructions for booting the computer

Data and instructions can be read, but not modified

Instructions are typically recorded at factory

RAM

Requires electricity to retain values

Volatile

Data and instructions can be read and modified

Users typically refer to this type of memory

Memory Type	Category	Erasure	Write Mechanism	Volatility
Random-access memory (RAM)	Read-write memory	Electrically, byte-level	Electrically	Volatile
Read-only memory (ROM)	Read-only memory	Not possible	Masks	Nonvolatile
Programmable ROM (PROM)	Read-only memory	Not possible	Electrically	Nonvolatile
Erasable PROM (EPROM)	Read-mostly memory	UV light, chip-level	Electrically	Nonvolatile
Electrically Erasable PROM (EEPROM)	Read-mostly memory	Electrically, byte-level	Electrically	Nonvolatile
Flash memory	Read-mostly memory	Electrically, block-level	Electrically	Nonvolatile

Secondary Storage

- Magnetic media
  - Tape
  - Disks

- Optical Media
  - Compact Discs
    - CD-R, WORM (Write Once, Read Many)
    - CD-RW
  - DVD
    - DVD-R
    - DVD-RW

Hard Disk Fragmentation

- When files are deleted, their blocks are open for writing.

- What if the next file which is written in the same blocks is larger than the file which was originally written there?
  - The system has to break the file up into pieces throughout the filesystem

- This is called fragmentation. It considerably slows the access of files.

- Most modern Filesystems contain automatic defragmentation utilities.

Filesystems

- Files are managed within a “filesystem”

- The filesystem defines how and where files are stored within a hard disk (or partition)

- Common filesystems include:
    - FAT16 (MSDOS)
    - VFAT (Windows 95)
    - FAT32 (Windows 98)
    - NTFS (Windows NT)
    - UFS (UNIX)
    - ext2/ext3 (Linux)
    - ISO9660 (CD Roms)

External Devices

Human readable (human interface).
- Screen, printer, keyboard, mouse.

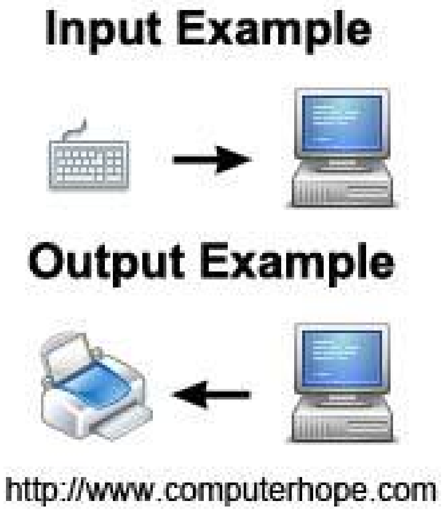
Machine readable.
- Disks, tapes.
  - Functional view of disks as part of memory hierarchy.
  - Structurally part of I/O system.
- Sensors, actuators.
- Monitoring and control.

Communications.
- Modem.
- Network Interface Card (NIC).
- Wireless Interface card.

Peripheral device, Input and Output

Peripheral device, also known as **peripheral, computer peripheral,input-output device,** or **input/output device**, any of various devices (including sensors) used to enter information and instructions into a computer for storage or processing and to deliver the processed data to a human operator or, in some cases, a machine controlled by the computer. Such devices make up the peripheral equipment of modern digital computer systems.

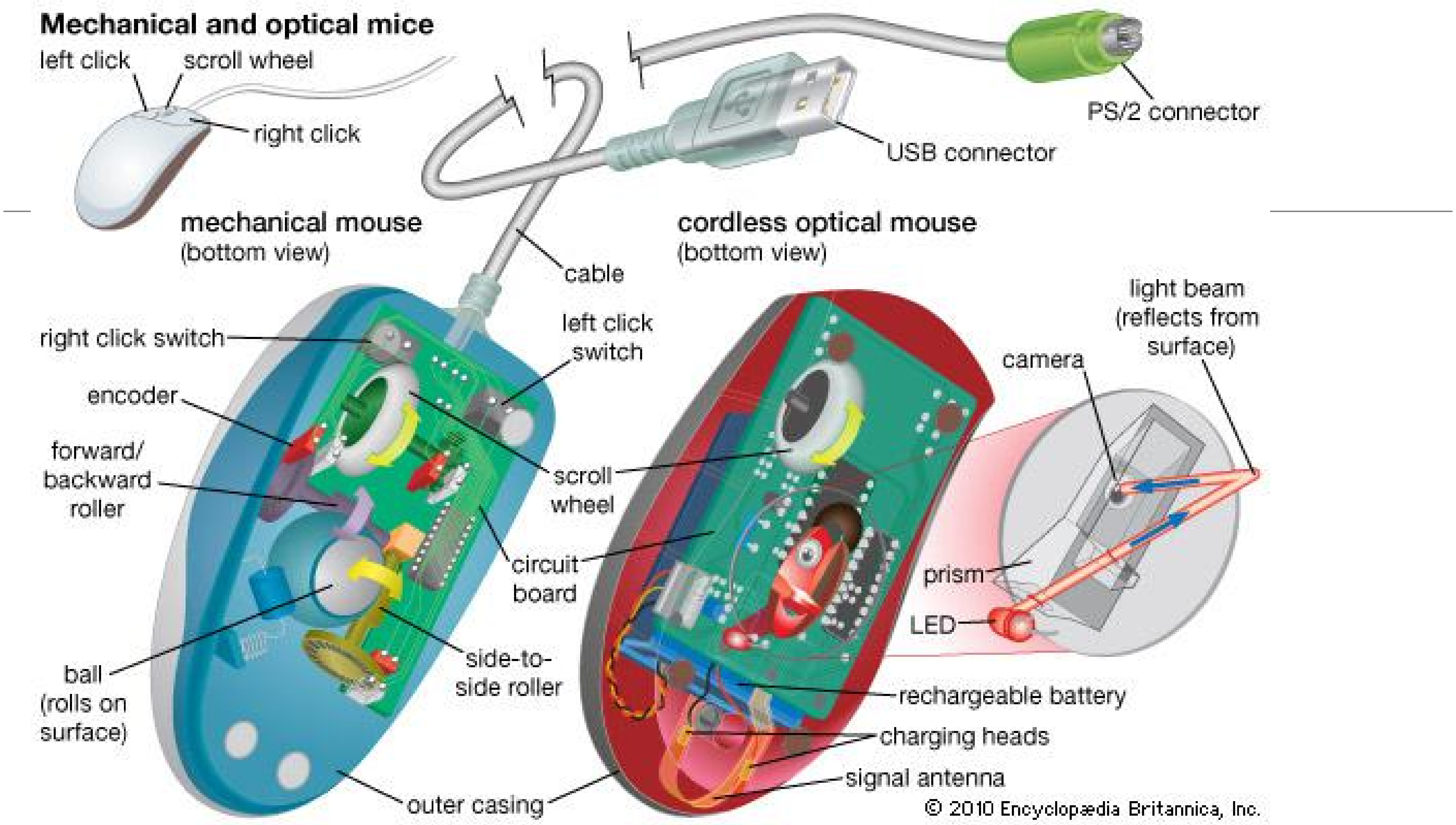
An input device sends information to a computer system for processing, and an output device reproduces or displays the results of that processing. Depending on the interaction, a device can be both, referred to as an input/output or I/O device.



An **input** device can send data to another device, but it cannot receive data from another device. Examples of an input device include a computer keyboard and mouse, which can send data (input) to the computer, but they cannot receive or reproduce information (output) from the computer.

An **output** device can receive data from another device, but it cannot send data to another device. Examples of an output device include a computer monitor, projector, and speakers, which can receive data (output) from the computer, but they cannot send information (input) to the computer.

An **input/output** device can send data to another device and also receive data from another device. Examples of an input/output include a computer CD-RW drive and USB flash drive, which can send data (input) to a computer and also receive data (output) from a computer



Mechanical and optical mice
left click
scroll wheel
right click
PS/2 connector
USB connector
mechanical mouse
(bottom view)
cable
cordless optical mouse
(bottom view)
right click switch
left click
switch
encoder
forward/
backward
roller
scroll
wheel
circuit
board
ball
(rolls on
surface)
side-to-
side roller
outer casing
light beam
(reflects from
surface)
camera
prism
LED
rechargeable battery
charging heads
signal antenna
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Embedded Systems ARM

Embedded system. A combination of computer hardware and software, and perhaps additional mechanical or other parts, designed to perform a dedicated function. In many cases, embedded systems are part of a larger system or product.

An alternative approach to processor design in the reduced instruction set computer (RISC).

The ARM architecture is used in a wide variety of embedded systems and is one of the most powerful and best-designed RISC-based systems on the market.

Embedded Systems ARM

The ARM architecture refers to a processor architecture that has evolved from RISC design principles and is used in embedded systems.

ARM evolved from RISC design.

Used mainly in embedded systems

- Used within product
- Not general purpose computer
- Dedicated function
- E.g. Anti-lock brakes in car

Embedded Systems Requirements

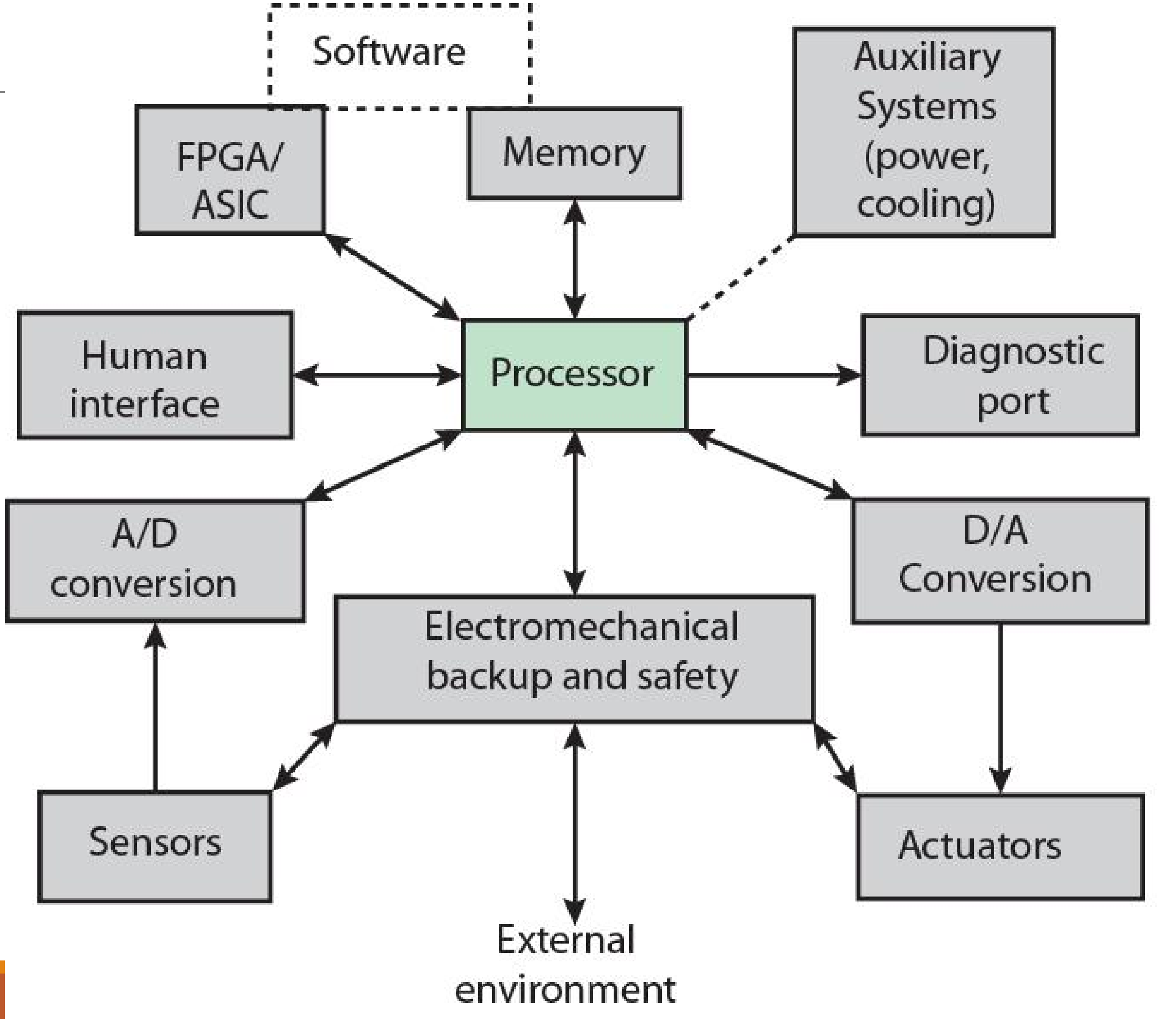
Different sizes

- Different constraints, optimization, reuse

Different requirements

- Safety, reliability, real-time, flexibility, legislation
- Lifespan
- Environmental conditions
- Static v dynamic loads
- Slow to fast speeds
- Computation v I/O intensive
- Discrete event v continuous dynamics

Possible Organization of an Embedded System



Raspberry Pi

The **Raspberry Pi** is a series of credit card-sized single-board computers developed in the United Kingdom by the Raspberry Pi Foundation to promote the teaching of basic computer science in schools and developing countries

All models feature a Broadcom system on a chip (SoC), which includes an ARM compatible central processing unit (CPU) and an on chip graphics processing unit (GPU, a VideoCore IV). CPU speed ranges from 700 MHz to 1.2 GHz for the Pi 3 and on board memory range from 256 MB to 1 GB RAM.


HDMI