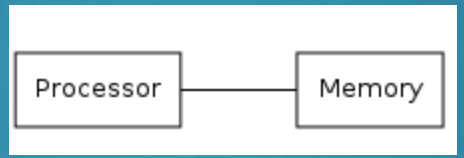
Session#02
TOPIC:
Computer Architecture

What computer does do?

- The processor can read and write items in the memory according to some list of instructions, while the memory simply remembers the data it has been given. The list of instructions executed by the processor are known as a **computer program**.



Basically, a machine is universal if it is able to do the following:

- Read a value from memory.
- Based on the read value, determine a new value to write to memory.
- Based on the read value, determine which instruction to execute next.

Computer Architecture

- **Computer architecture** describes how a machine is logically organized and how its instruction set is actually implemented.
- One of the most important architectural decision made in designing a computer is how its memory is organized, and how programs are loaded into the machine.
- In the early history of computers, there was a distinction between stored program and hardwired computers.
- Rewiring a machine simply takes too long when compared to the process of simply loading new data into the machine.
- In the current era of computing, almost all computers are stored program computers. In this book, we will be focusing on stored program computer architectures.

Historical Development

- The evolution of computing machinery has taken place over several centuries.
- The evolution of computers is usually classified into different generations according to the technology of the era.

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- Generation Zero: Mechanical Calculating Machines (1642 - 1945)
  - Calculating Clock - Wilhelm Schickard (1592 - 1635).
  - Pascaline - Blaise Pascal (1623 - 1662).
  - Difference Engine - Charles Babbage (1791 - 1871), also designed but never built the Analytical Engine.
  - Punched card tabulating machines - Herman Hollerith (1860 - 1929).

Hollerith cards were commonly used for computer input well into the 1970s.

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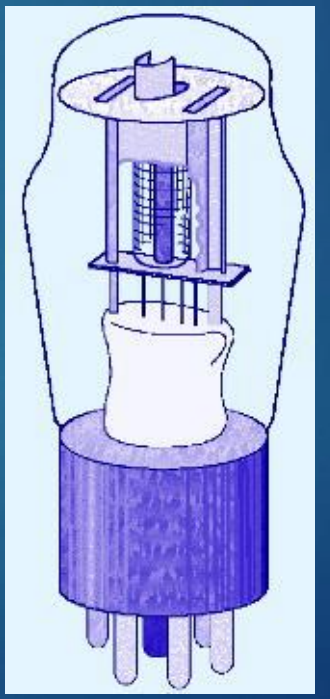
- The First Generation: Vacuum Tube Computers (1945 - 1953)
  - Atanasoff Berry Computer (1937 - 1938) solved systems of linear equations.
  - John Atanasoff and Clifford Berry of Iowa State University.



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- The First Generation: Vacuum Tube Computers (1945 - 1953)
  - Electronic Numerical Integrator and Computer (ENIAC) by John Mauchly and J. Presper Eckertat the University of Pennsylvania, 1946
  - The IBM 650 first mass-produced computer. (1955). It was phased out in 1969.

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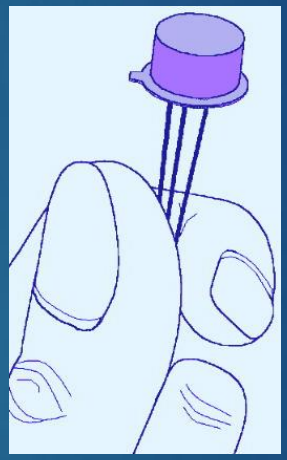
- The Second Generation: Transistorized Computers (1954 - 1965)
  - IBM 7094 (scientific) and 1401 (business)
  - Digital Equipment Corporation (DEC) PDP-1
  - Univac 1100
  - Control Data Corporation 1604.
  - . . . and many others.



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- The Third Generation: Integrated Circuit Computers (1965 - 1980)
  - IBM 360
  - DEC PDP-8 and PDP-11
  - Cray-1 supercomputer
  - . . . and many others.
- By this time, IBM had gained overwhelming dominance in the industry.
  - Computer manufacturers of this era were characterized as IBM and the BUNCH (Burroughs, Unisys, NCR, Control Data, and Honeywell).

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- The Fourth Generation: VLSI Computers (1980's)
  - Very large scale integrated circuits (VLSI) have more than 10,000 components per chip.
  - Enabled the creation of microprocessors.
  - The first was the 4-bit Intel 4004.
  - Later versions, such as the 8080, 8086, and 8088 spawned the idea of "personal computing."

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- The Fifth Generation: (1985 - Present)
  - In the fifth generation, VLSI technology became ULSI (Ultra Large Scale Integration) technology, resulting in the production of microprocessor chips having ten million electronic components.
  - This generation is based on parallel processing hardware and AI (Artificial Intelligence) software.
  - AI is an emerging branch in computer science, which interprets the means and method of making computers think like human beings.
  - All the high-level languages like C and C++, Java, .Net etc., are used in this generation.

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- The main features of fifth generation are −
  - ULSI technology
  - Development of true artificial intelligence
  - Development of Natural language processing
  - Advancement in Parallel Processing
  - Advancement in Superconductor technology
  - More user-friendly interfaces with multimedia features
  - Availability of very powerful and compact computers at cheaper rates
- Some computer types of this generation are −
  - Desktop
  - Laptop
  - NoteBook
  - UltraBook
  - ChromeBook

Types Of Computer Architecture

1. **Von Neumann Architecture**
2. **Harvard Architecture**

Von Neumann Architecture

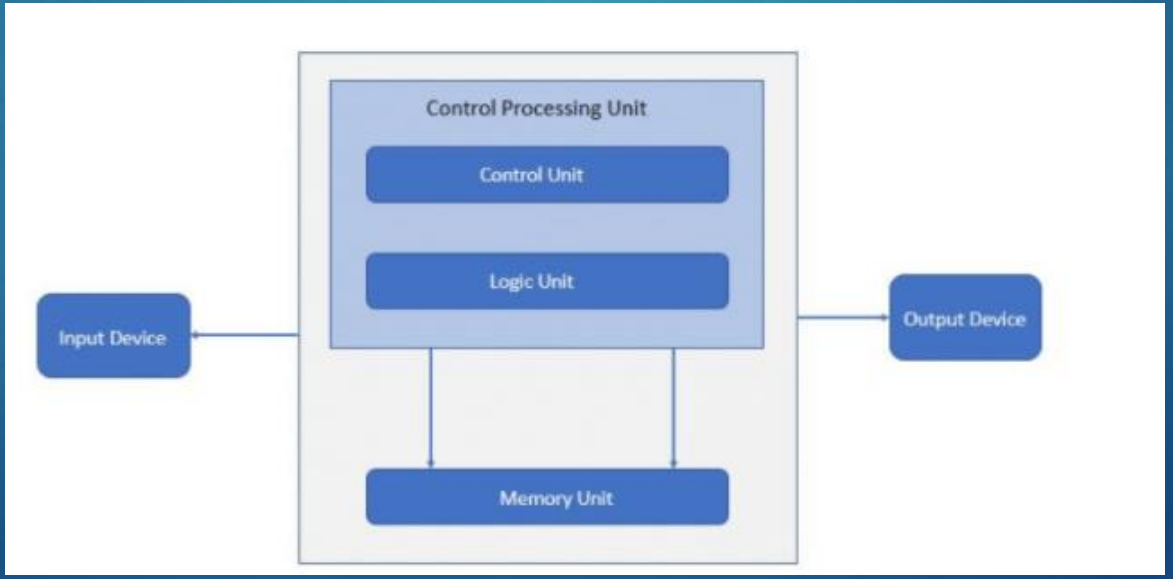
- The invention of stored program computers has been ascribed to a mathematician, John von Neumann, who was a contemporary of Mauchley and Eckert.
- Stored-program computers have become known as **Von Neumann Architecture** systems.

- Today's stored-program computers have the following characteristics:
  - Three hardware systems:
    - A central processing unit (CPU)
    - A main memory system
    - An I/O system

  - The capacity to carry out sequential instruction processing.
    - A single data path between the CPU and main memory.
    - This single path is known as the *von Neumann bottleneck*.

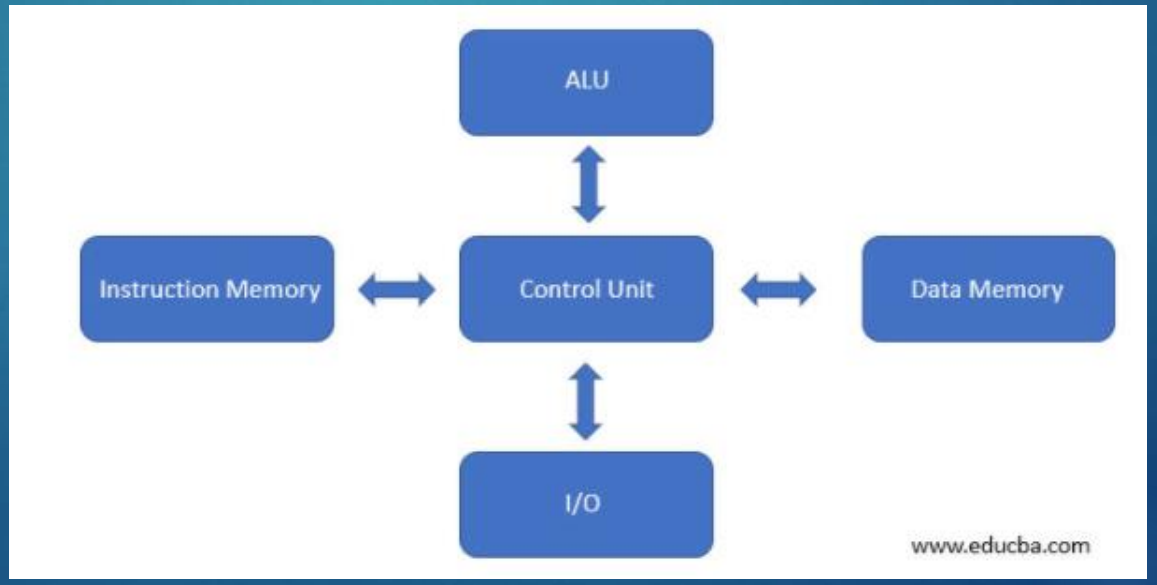
Von Neumann Architecture

- The **Von Neumann Architecture** is, by far, the most common architecture in existence today. PCs, Macs, and even Android phones are examples of Von Neumann computers.
- There is a bus (address bus/data bus/control bus) used for the instruction and data code execution.



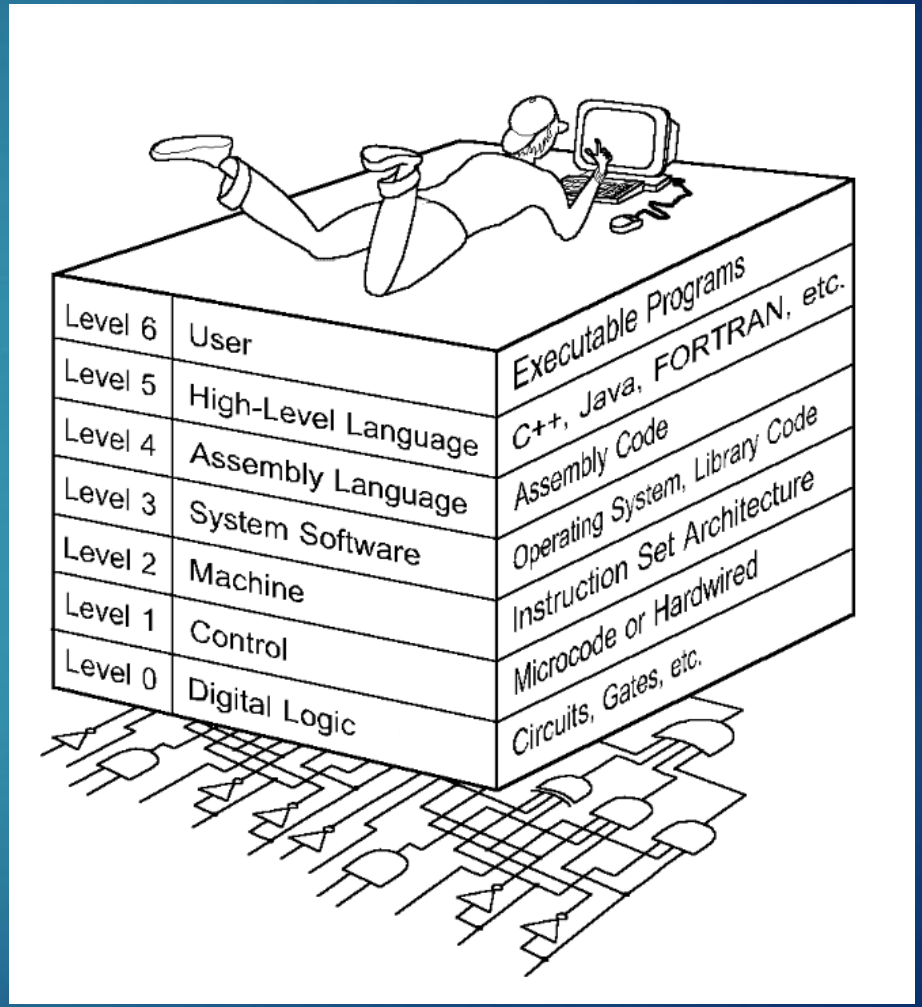
Harvard Architecture

- Harvard architecture is used when data and code is present in different memory blocks.
- A separate memory block is needed for data and instruction.
- Data can be accessed by one memory location and instruction can be accessed by a different location.
- It has data storage entirely contained within the central processing unit (CPU). A single set of clock cycles is required.
- We can observe in the below image, there are separate data and instruction memory that is a bus available to perform operations.



The Computer Level Hierarchy

- Each virtual machine layer is an abstraction of the level below it.
- The machines at each level execute their own particular instructions, calling upon machines at lower levels to perform tasks as required.
- Computer circuits ultimately carry out the work.



The Computer Level Hierarchy

- Level 6: The User Level
  - Program execution and user interface level.
  - The level with which we are most familiar.
- Level 5: High-Level Language Level
  - The level with which we interact when we write programs in languages such as C, Pascal, Lisp, and Java.

The Computer Level Hierarchy

- Level 4: Assembly Language Level
  - Acts upon assembly language produced from Level 5, as well as instructions programmed directly at this level.
- Level 3: System Software Level
  - Controls executing processes on the system.
  - Protects system resources.
  - Assembly language instructions often pass through Level 3 without modification.

The Computer Level Hierarchy

- Level 2: Machine Level
  - Also known as the Instruction Set Architecture (ISA) Level.
  - Consists of instructions that are particular to the architecture of the machine.
  - Programs written in machine language need no compilers, interpreters, or assemblers.

The Computer Level Hierarchy

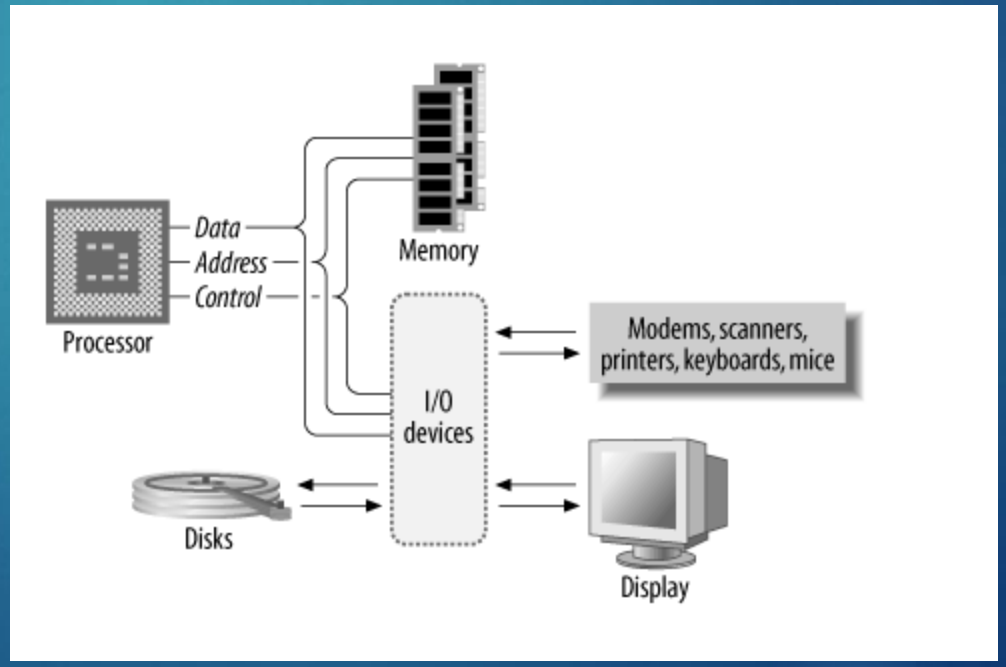
- Level 1: Control Level
  - A control unit decodes and executes instructions and moves data through the system.
  - Control units can be micro programmed or hardwired.
  - A micro program is a program written in a low-level language that is implemented by the hardware.
  - Hardwired control units consist of hardware that directly executes machine instructions.

The Computer Level Hierarchy

- Level 0: Digital Logic Level
  - This level is where we find digital circuits (the chips).
  - Digital circuits consist of gates and wires.
  - These components implement the mathematical logic of all other levels.

Basic System Architecture

- The processor alone is incapable of successfully performing any tasks. It requires memory (for program and data storage), support logic, and at least one I/O device ("input/output device") used to transfer data between the computer and the outside world.
- The basic computer system architecture is shown

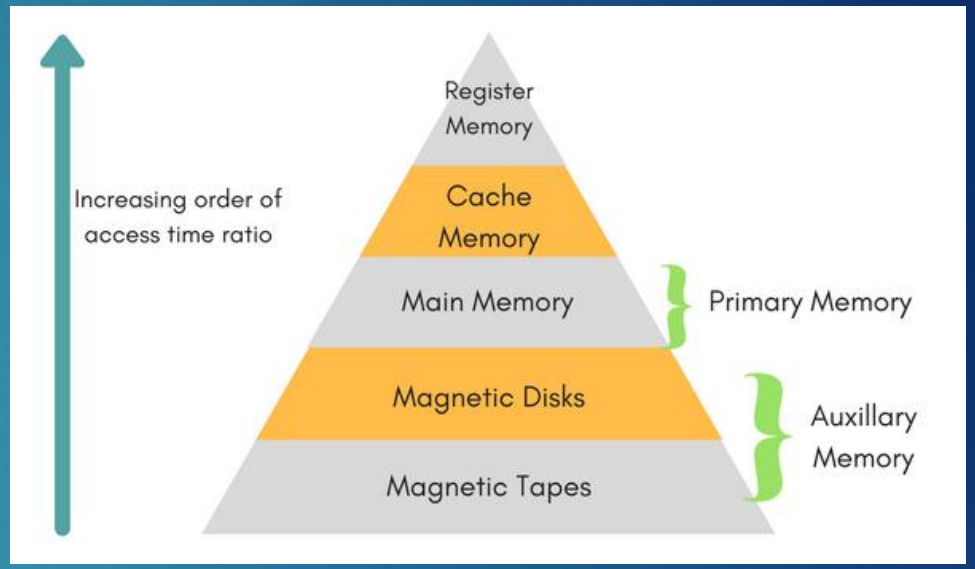


Processor

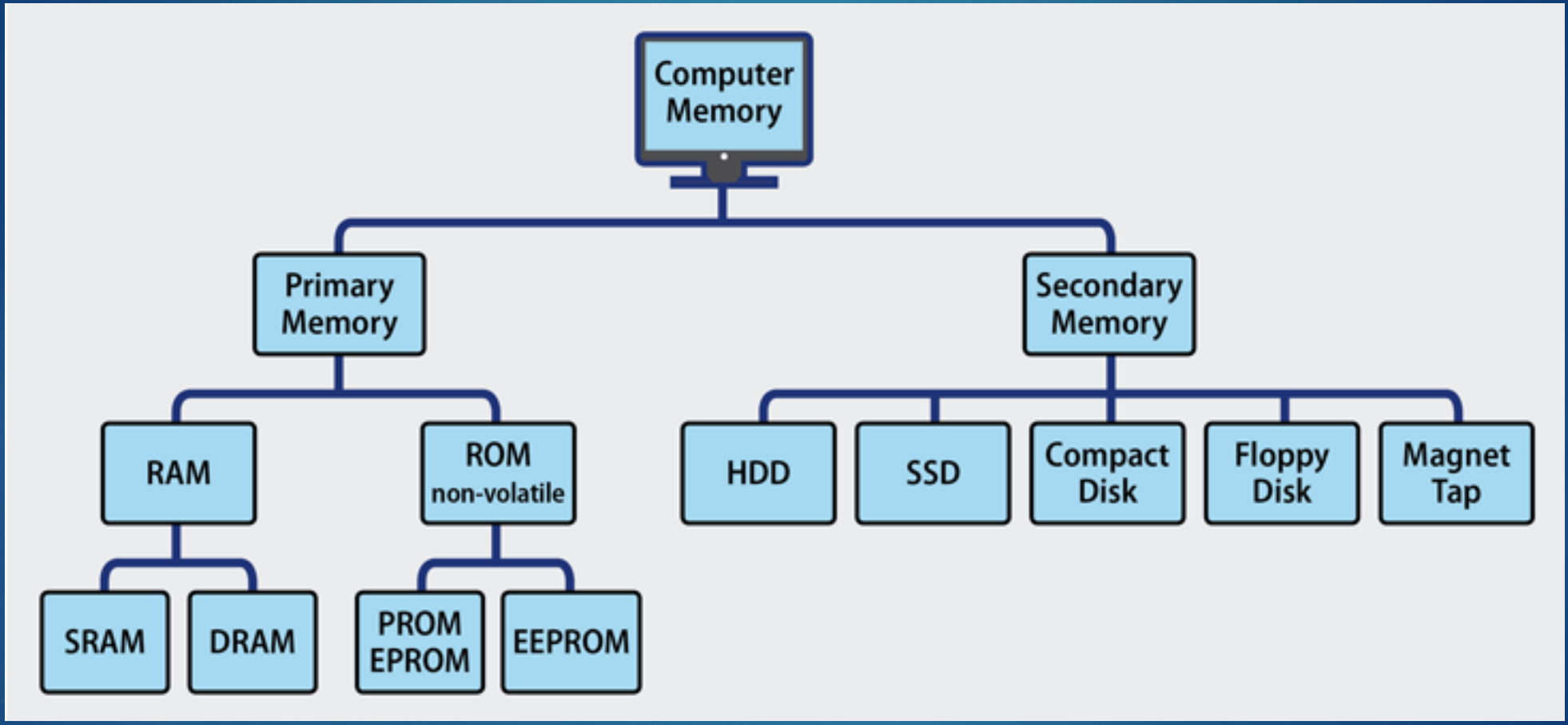
- The processor is the most important part of a computer, the component around which everything else is centered.
- In essence, the processor is the computing part of the computer.
- A processor is an electronic device capable of manipulating data (information) in a way specified by a sequence of instructions.
- The instructions are also known as *opcodes* or *machine code* .
- This sequence of instructions may be altered to suit the application, and, hence, computers are programmable. A sequence of instructions is what constitutes a program.

Memory

- Memory is used to hold data and software for the processor.
- There is a variety of memory types, and often a mix is used within a single system. Some memory will retain its contents while there is no power, yet will be slow to access.
- Other memory devices will be high-capacity, yet will require additional support circuitry and will be slower to access.
- Still other memory devices will trade capacity for speed, yielding relatively small devices, yet will be capable of keeping up with the fastest of processors.



Types of Main Memory



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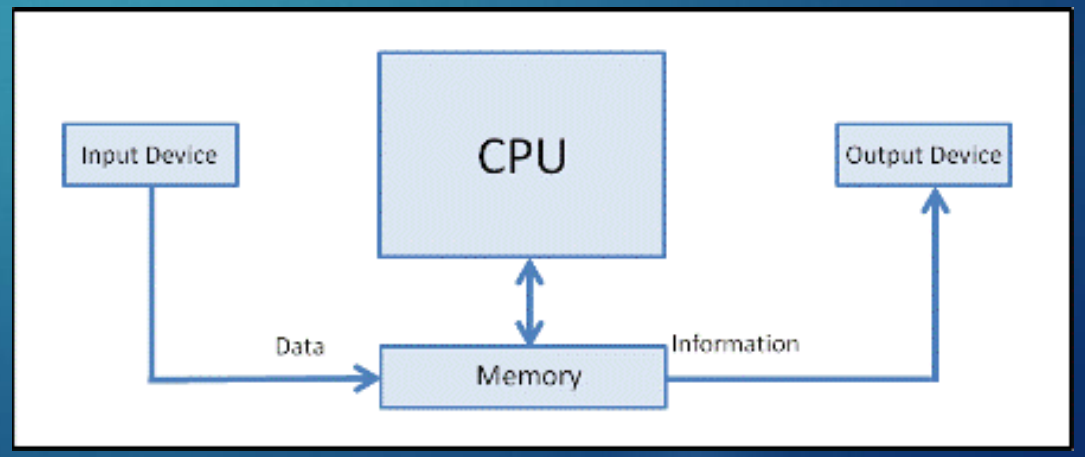
- RAM
  - It is where the processor may easily write data for temporary storage. RAM is generally *volatile*, losing its contents when the system loses power.
  - SRAM
    - SRAMs use pairs of logic gates to hold each bit of data. SRAMs are the fastest form of RAM available, require little external support circuitry, and have relatively low power consumption.
    - Their drawbacks are that their capacity is considerably less than DRAM, while being much more expensive.
  - DRAM
    - DRAMs are the highest-capacity memory devices available and come in a wide and diverse variety of subspecies.
    - Most processors with large address spaces include support for DRAMs.

Continue

- ROM
  - ROM stands for *Read-Only Memory*.
  - ROMs are *nonvolatile memory*, requiring no power to retain their contents.
  - They are generally slower than RAM, and considerably slower than fast static RAM.
  - The primary purpose of ROM within a system is to hold the code (and sometimes data) that needs to be present at power-up
  - EPROM
    - Short for **Erasable Programmable Read-Only Memory**, **EPROM** is a non-volatile memory chip that can only be read.
  - PROM
    - PROM stands for Programmable Read-Only Memory, during the manufacturing process, a PROM is manufactured in an empty state and then programmed later using a PROM programmer or burner.
  - EEPROM
    - EPROM stands for Electrically Erasable Programmable Read-Only Memory, and the distinction between EPROM and EEPROM is that the latter can be erased and written to by the computer system it is installed in.

Input/output

- The address space of the processor can contain devices other than memory.
- These are input/output devices (I/O devices, also known as *peripherals*) and are used by the processor to communicate with the external world.
- Some examples are serial controllers that communicate with keyboards, mice, modems, etc.; parallel I/O devices that control some external subsystem; or disk-drive controllers, video and audio controllers, or network interfaces.



Conclusion

- This chapter has given you an overview of the subject of computer architecture.

Thank you

Q/A