UNIT-I INTRODUCTION

- **Computer architecture**
  - Refers to those **attributes of a system visible to a programmer** or, put another way, those attributes that have a direct impact on the logical execution of a program.
  - Examples of architectural attributes include the instruction set, the number of bits used to represent various data types (e.g., numbers, characters), I/O mechanisms, and techniques for addressing memory.

- **Computer organization**
  - Refers to the operational units and their interconnections that realize the architectural specifications.
  - Organizational attributes include those hardware details transparent to the programmer, such as control signals; interfaces between the computer and peripherals; and the memory technology used.

✓ For example, it is an architectural design issue whether a computer will have a multiply instruction. It is an organizational issue whether that instruction will be implemented by a special multiply unit or by a mechanism that makes repeated use of the add unit of the system.

- **The components from which computers are built, i.e., computer organization.**
- **In contrast, computer architecture is the science of integrating those components to achieve a level of functionality and performance.**

Basic Terminology

- ✓ **Input** Whatever is put into a computer system.
- ✓ **Data** Refers to the symbols that represent facts, objects, or ideas.
- ✓ **Information** The results of the computer storing data as bits and bytes; the words, numbers, sounds, and graphics.
- ✓ **Output** Consists of the processing results produced by a computer.
- ✓ **Processing** Manipulation of the data in many ways.
- ✓ **Memory** Area of the computer that temporarily holds data waiting to be processed, stored, or output.
- ✓ **Storage** Area of the computer that holds data on a permanent basis when it is not immediately needed for processing.

Basic Terminology

Assembly language program (ALP) –Programs are written using mnemonics

Mnemonic —Instruction will be in the form of English like form

Assembler —is a software which converts ALP to MLL (Machine Level Language)

HLL (High Level Language) –Programs are written using English like statements

Compiler -Convert HLL to MLL, does this job by reading source program at once

Interpreter —Converts HLL to MLL, does this job statement by statement

Operating system –Collection of routines responsible for controlling and coordinating all the activities in a computer system

Computers have two kinds of components:

Hardware, consisting of its physical devices (CPU, memory, bus, storage devices ...)

Software, consisting of the programs it has (OS, applications, utilities, ...)

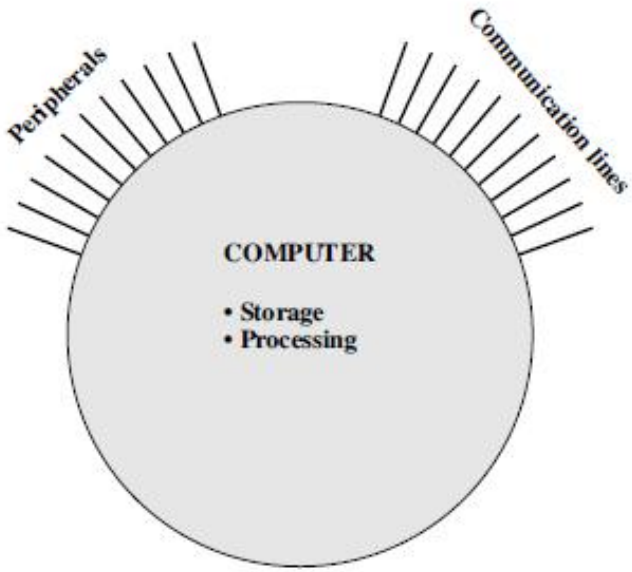
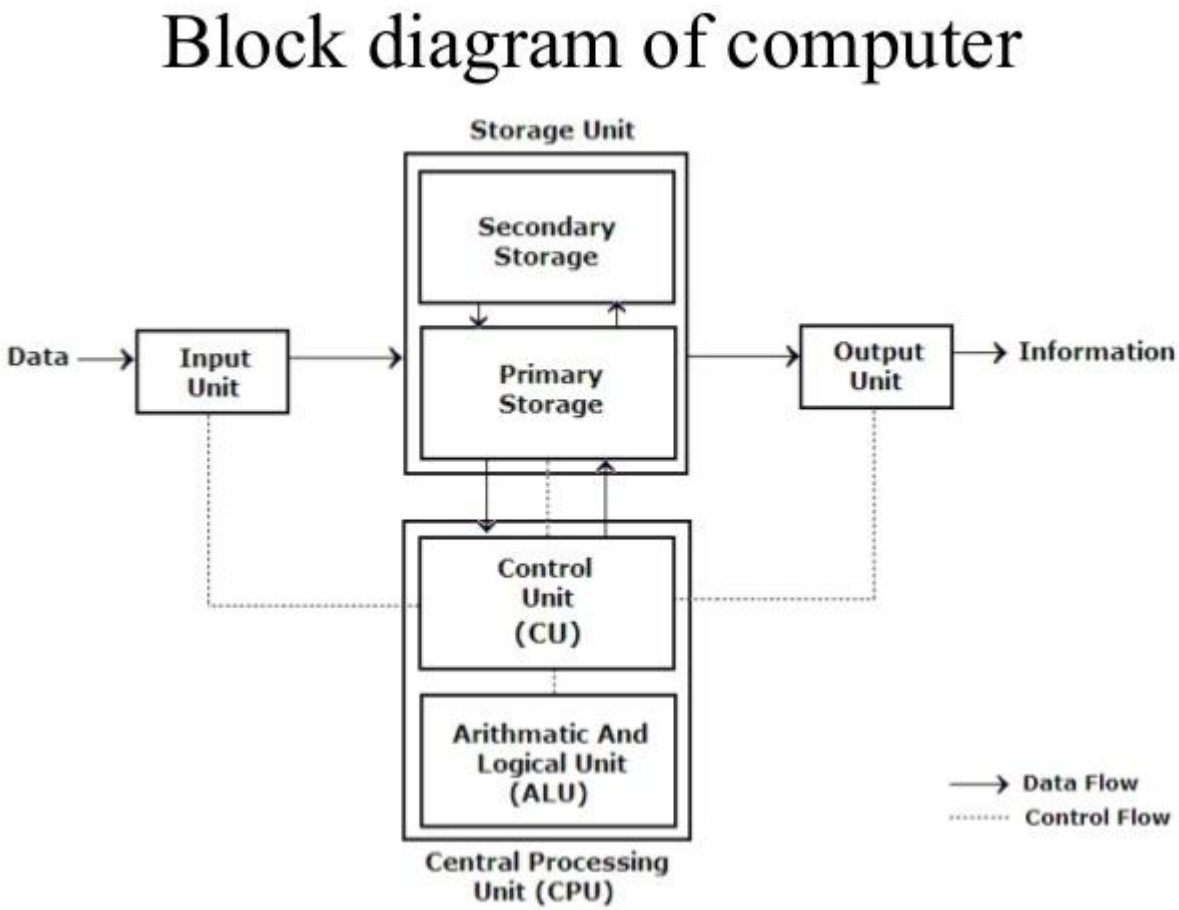


Figure 1.3 The Computer

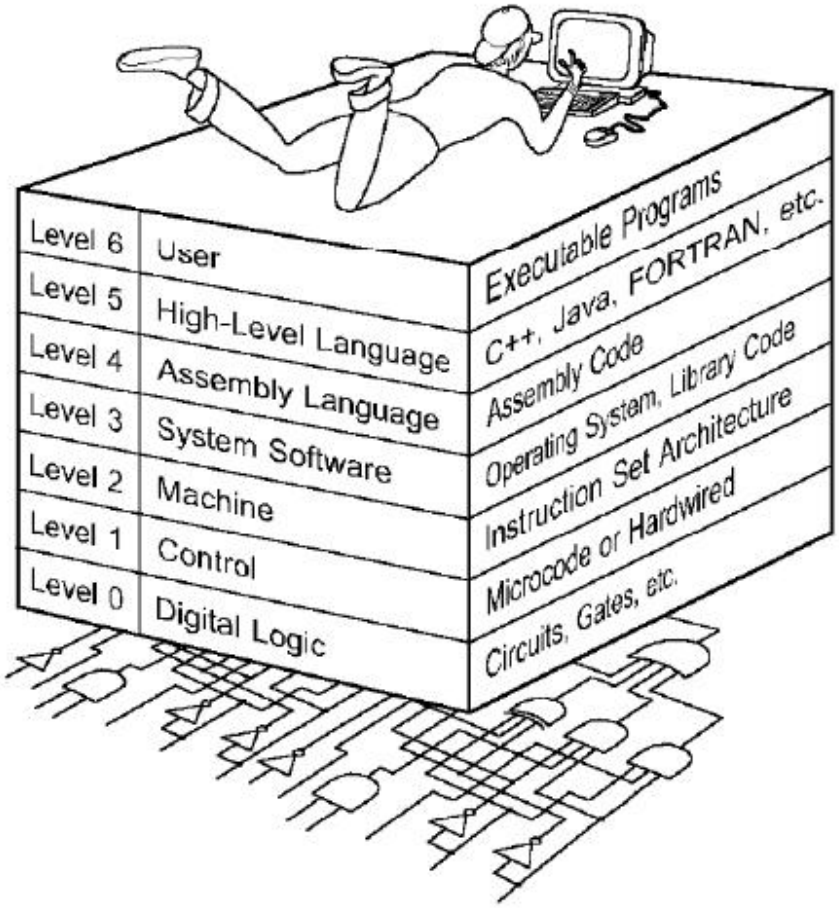
Block diagram of Computer

The computer block diagram holds the following 4 major units:

- Input Unit
- Output Unit
- Central processing Unit (ALU and Control Units)
- Memory



Computer Level Hierarchy



Program Execution

Translation: The entire high-level program is translated into an equivalent machine language program. Then the machine language Program is executed.

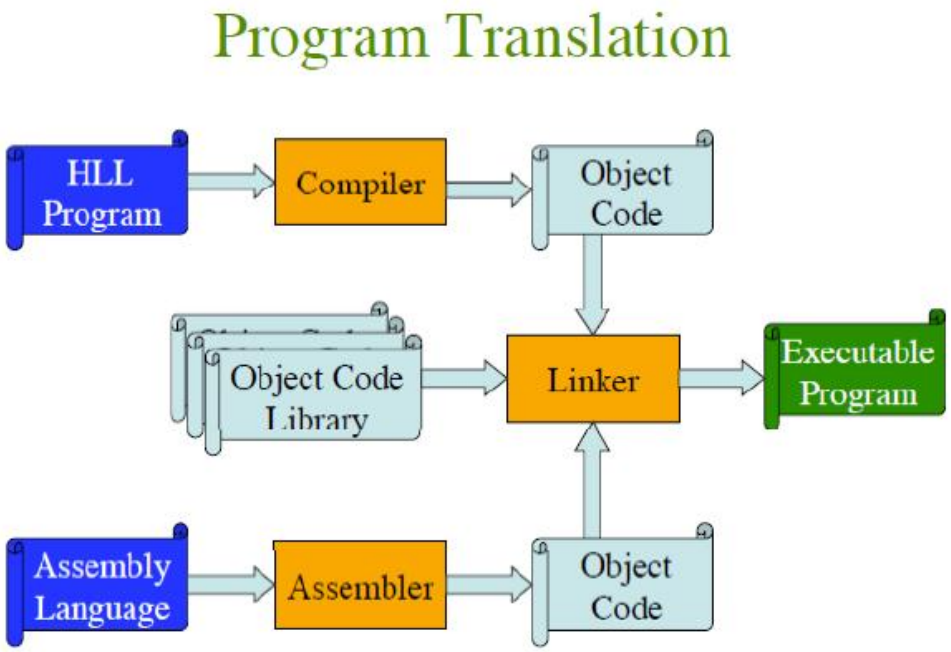
Interpretation: Another program reads the high level program instructions one-by-one and executes an equivalent series of Machine language instructions.

Program translation uses a collection of tools to perform the translation

Compiler: Translates high level language programs into a lower level language often called object code.

Assembler: Translates assembly language instructions into object code.

Linker: Combines collections of object code into a single executable machine language program.



Structure: The way in which the components are interrelated
Function: The operation of each individual component as part of the structure

There are four main functions of a computer:

- Data processing
- Data storage
- Data movement
- Control

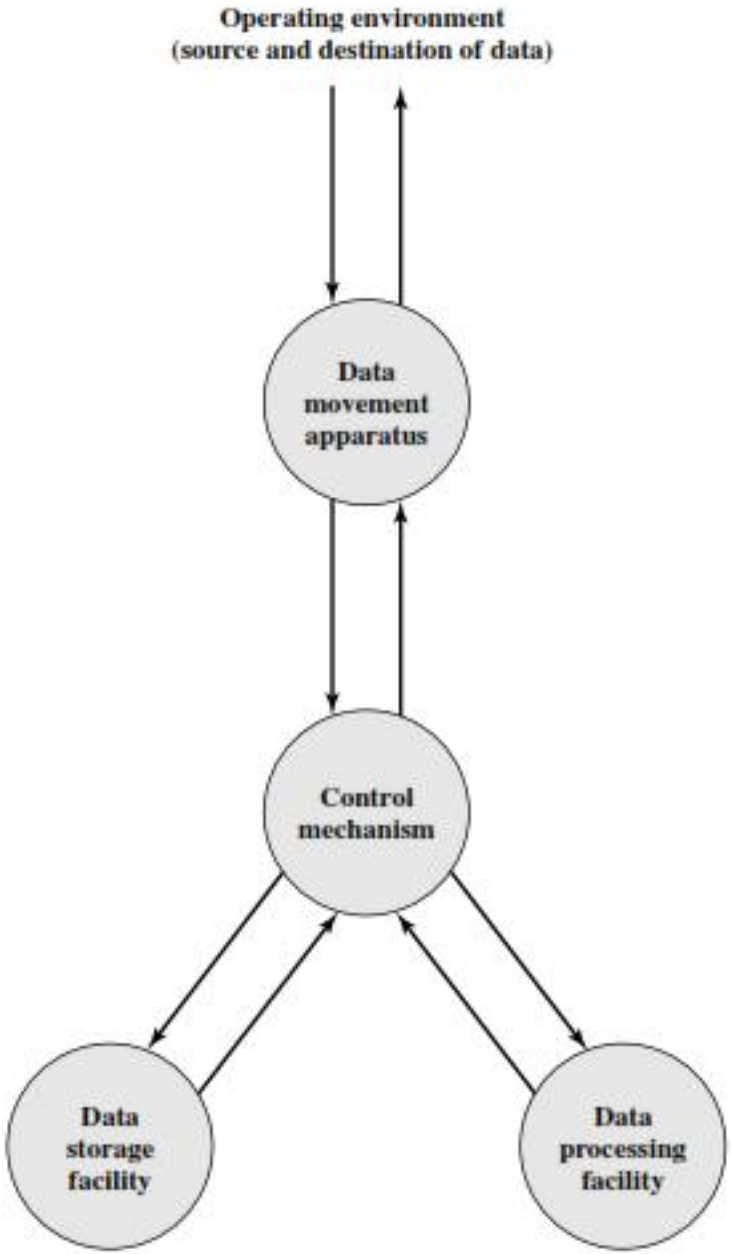


Figure 1.1 A Functional View of the Computer

MAIN STRUCTURAL BLOCKS/PARTS:

Central Processing Unit (CPU): Controls the operation of the computer and performs its data processing functions. Often simply referred to as processor.

Main Memory: Stores data.

I/O: Moves data between the computer and its external environment.

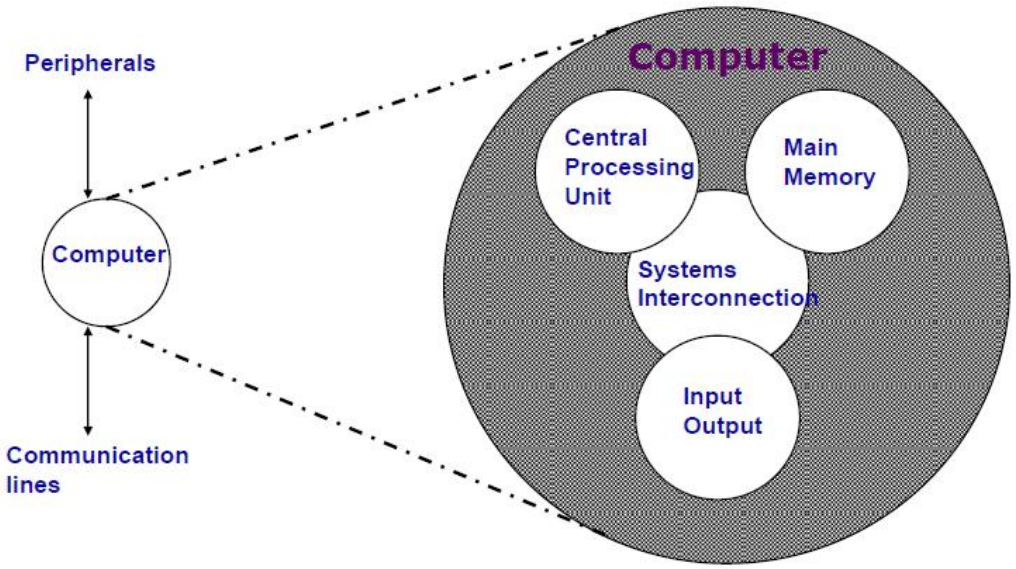
System Interconnection: e.g. BUS for communication among CPU, main memory, and I/O.

The major structural components of a CPU are:

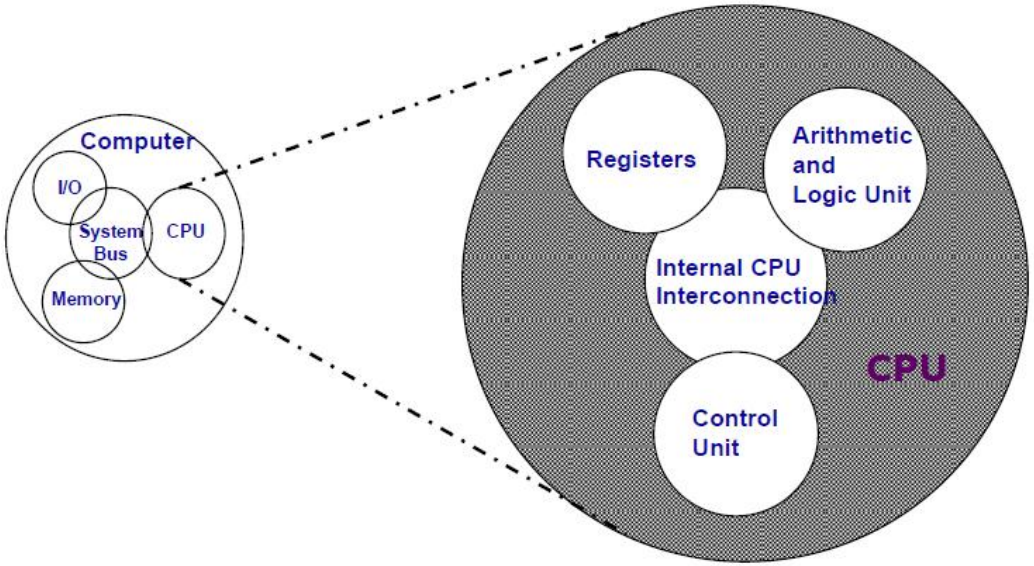
- **Control Unit (CU):** Controls the operation of the CPU and hence the computer.
- **Arithmetic and Logic Unit (ALU):** Performs computer's data processing functions.
- **Register:** Provides storage internal to the CPU.

CPU Interconnection: communication among the control unit, ALU, and register.

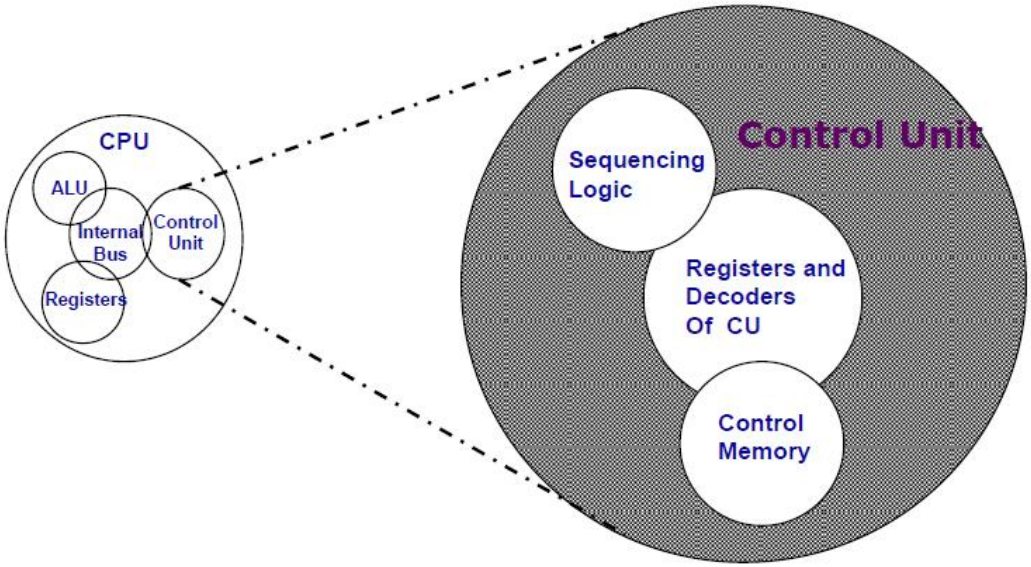
Structure - Top Level



Structure - The CPU



Structure - The Control Unit



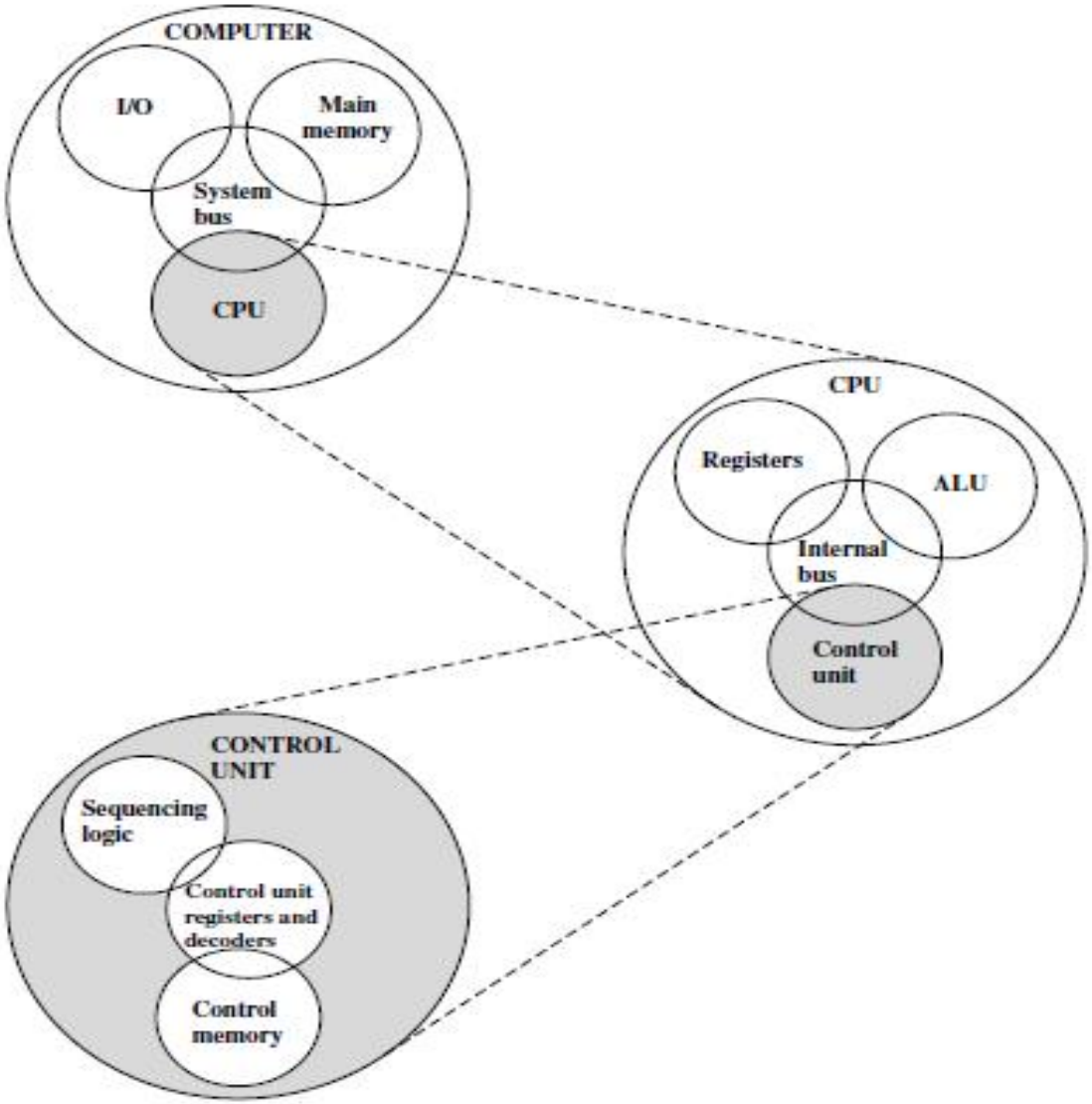
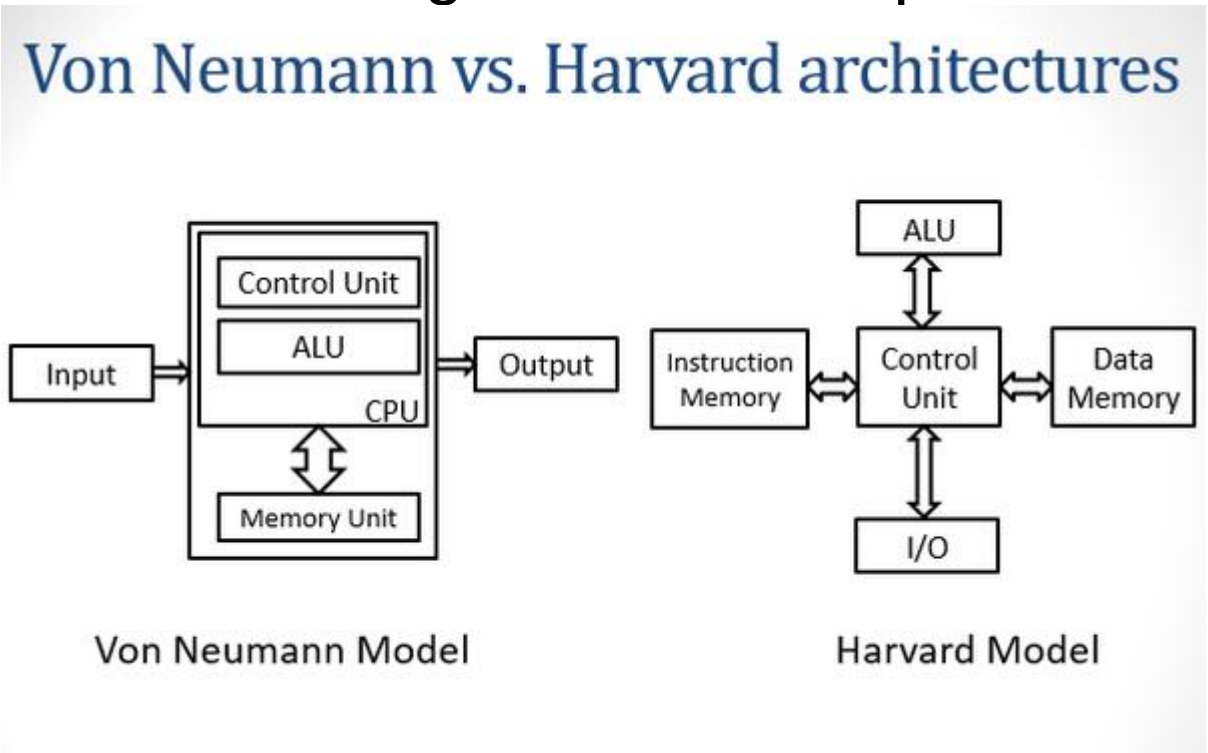
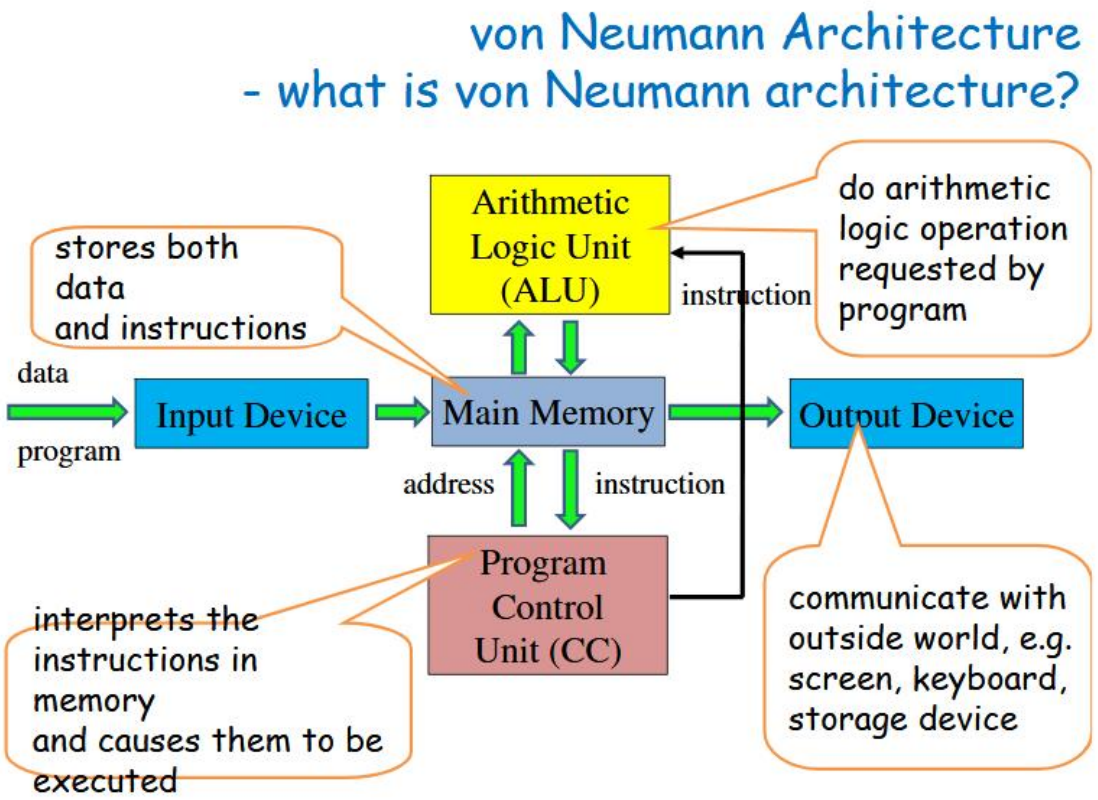


Figure 1.4 The Computer: Top-Level Structure

Stored Program Concept





- **In the 1940s**, a mathematician called **John Von Neumann** described the basic arrangement (or architecture) of a computer. Most computers today follow the concept that he described although there are other types of architecture. When we talk about the Von Neumann architecture, we are actually talking about the relationship between the hardware that makes up a Von Neumann-based computer.

- A Von Neumann-based computer is a computer that:
    - Uses a single processor.
    - Uses one memory for both instructions and data. A von Neumann computer cannot distinguish between data and instructions in a memory location! It 'knows' only because of the location of a particular bit pattern in RAM.
    - Executes programs by doing one instruction after the next in a serial manner using a fetch-decode-execute cycle.

Von Neumann bottleneck

- Whatever you do to improve performance, you cannot get away from the fact that instructions can only be done one at a time and can only be carried out sequentially. Both of these factors hold back the efficiency of the CPU. This is commonly referred to as the 'Von Neumann bottleneck'. You can provide a Von Neumann processor with more RAM, more cache or faster components but if real gains are to be made in CPU performance then a major review needs to take place of CPU design.

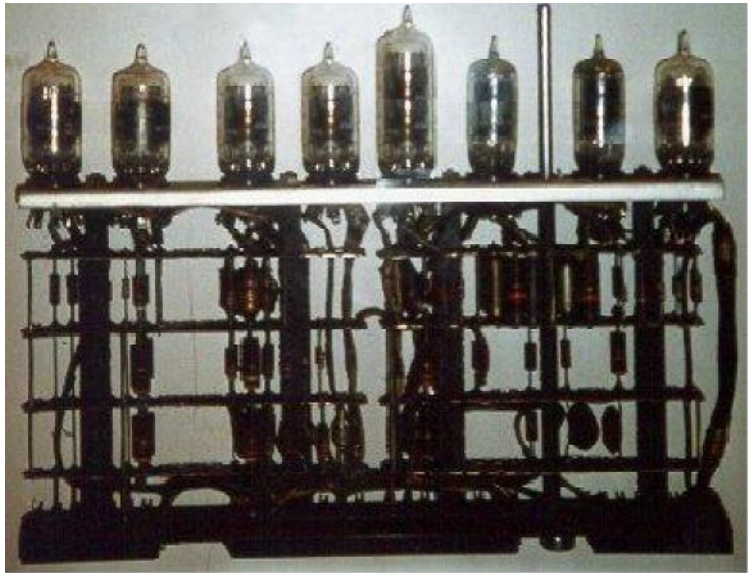
1 GENERATION OF COMPUTERS

The first electronic computer was designed and built at the University of Pennsylvania based on vacuum tube technology. Vacuum tubes were used to perform logic operations and to store data. Generations of computers has been divided into five according to the development of technologies used to fabricate the processors, memories and I/O units.

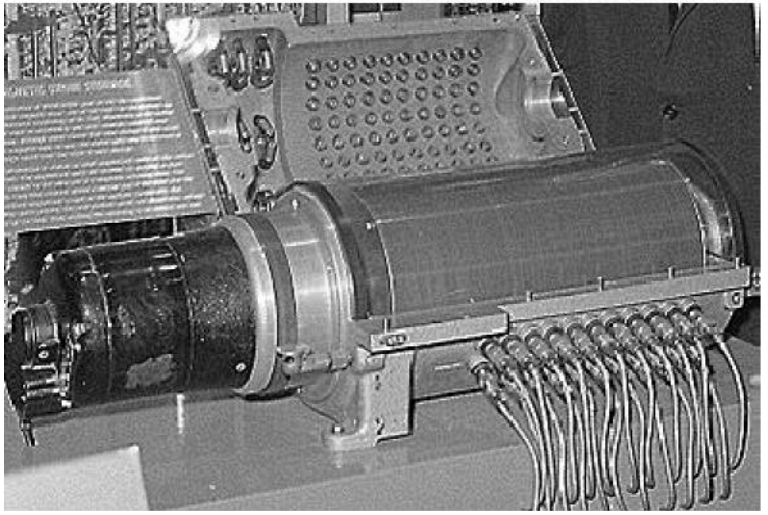
I Generation : 1945 – 55
II Generation : 1955 – 65
III Generation : 1965 – 75
IV Generation : 1975 – 89
V Generation : 1989 to present

First Generation (ENIAC - Electronic Numerical Integrator And Calculator
EDSAC – Electronic Delay Storage Automatic Calculator
EDVAC – Electronic Discrete Variable Automatic Computer
UNIVAC – Universal Automatic Computer
IBM 701)

- Vacuum tubes were used – basic arithmetic operations took few milliseconds
- Bulky
- Consume more power with limited performance
- High cost
- Uses assembly language – to prepare programs. These were translated into machine level language for execution.
- Fixed point arithmetic was used
- 100 to 1000 fold increase in speed relative to the earlier mechanical and relay based electromechanical technology
- Punched cards and paper tape were invented to feed programs and data and to get results.
- Magnetic tape / magnetic drum were used as secondary memory
- Mainly used for scientific computations.



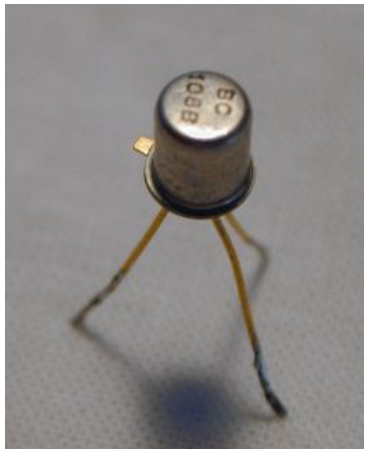
Vacuum Tubes



Magnetic Drum

Second Generation (Manufacturers – IBM 7030, Digital Data Corporation's PDP 1/5/8 Honeywell 400)

- Transistors were used in place of vacuum tubes. (invented at AT&T Bell lab in 1947)
- Small in size
- Lesser power consumption and better performance
- Lower cost
- Magnetic ferrite core memories were used as main memory which is a random-access nonvolatile memory
- Magnetic tapes and magnetic disks were used as secondary memory
- Hardware for floating point arithmetic operations was developed.
- Index registers were introduced which increased flexibility of programming.
- High level languages such as FORTRAN, COBOL etc were used - Compilers were developed to translate the high-level program into corresponding assembly language program which was then translated into machine language.
- Separate input-output processors were developed that could operate in parallel with CPU.
- Punched cards continued during this period also.
- 1000 fold increase in speed.
- Increasingly used in business, industry and commercial organizations for preparation of payroll, inventory control, marketing, production planning, research, scientific & engineering analysis and design etc.

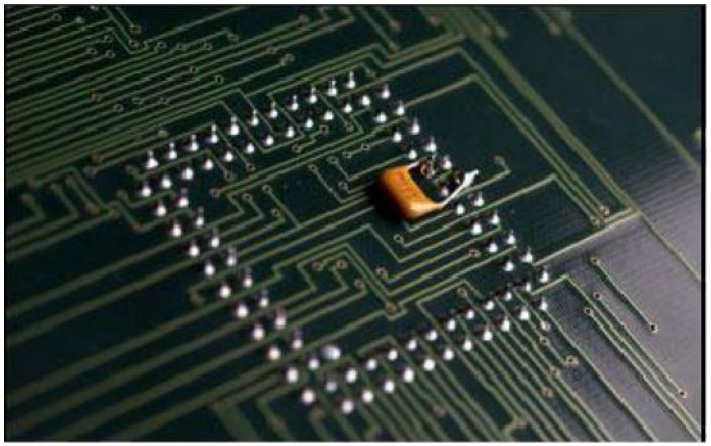


Transistors

Third Generation (System 360 Mainframe from IBM, PDP-8 Mini Computer from Digital Equipment Corporation)

- ICs were used
- Small Scale Integration and Medium Scale Integration technology were implemented in CPU, I/O processors etc.
- Smaller & better performance
- Comparatively lesser cost
- Faster processors
- In the beginning magnetic core memories were used. Later they were replaced by semiconductor memories (RAM & ROM)
- Introduced microprogramming

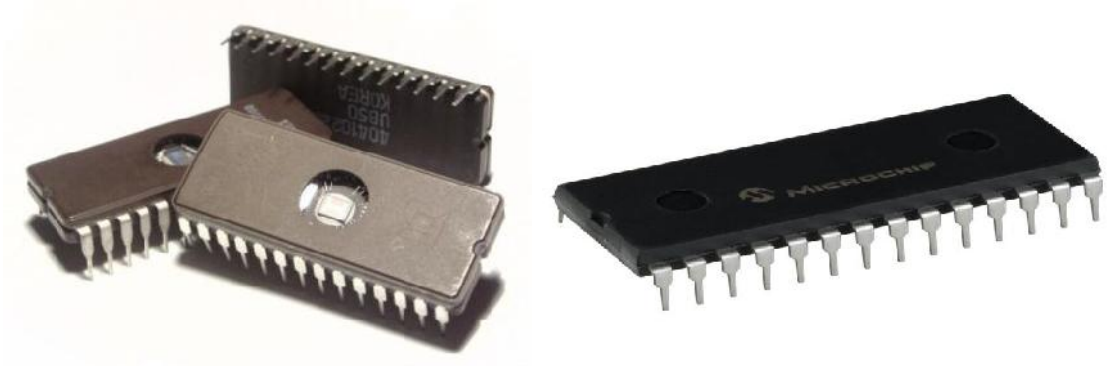
- Microprogramming, parallel processing (pipelining, multiprocessor system etc), multiprogramming, multi-user system (time shared system) etc were introduced.
- Operating system software were introduced (efficient sharing of a computer system by several user programs)
- Cache and virtual memories were introduced (Cache memory makes the main memory appear faster than it really is. Virtual memory makes it appear larger)
- High level languages were standardized by ANSI eg. ANSI FORTRAN, ANSI COBOL etc
- Database management, multi-user application, online systems like closed loop process control, airline reservation, interactive query systems, automatic industrial control etc emerged during this period.



Integrated Circuits

Fourth Generation (Intel's 8088,80286,80386,80486 .., Motorola's 68000, 68030, 68040, Apple II, CRAY I/2/X/MP etc)

- Microprocessors were introduced as CPU– Complete processors and large section of main memory could be implemented in a single chip
- Tens of thousands of transistors can be placed in a single chip (VLSI design implemented)
- CRT screen, laser & ink jet printers, scanners etc were developed.
- Semiconductor memory chips were used as the main memory.
- Secondary memory was composed of hard disks – Floppy disks & magnetic tapes were used for backup memory
- Parallelism, pipelining cache memory and virtual memory were applied in a better way
- LAN and WANS were developed (where desktop work stations interconnected)
- Introduced C language and Unix OS
- Introduced Graphical User Interface
- Less power consumption
- High performance, lower cost and very compact
- Much increase in the speed of operation



Microprocessors ICs

Fifth Generation (IBM notebooks, Pentium PCs-Pentium 1/2/3/4/Dual core/Quad core.. SUN work stations, Origin 2000, PARAM 10000, IBM SP/2)

- Generation number beyond IV, have been used occasionally to describe some current computer system that have a dominant organizational or application driven feature.
- Computers based on artificial intelligence are available
- Computers use extensive parallel processing, multiple pipelines, multiple processors etc
- Massive parallel machines and extensively distributed system connected by communication networks fall in this category.
- Introduced ULSI (Ultra Large Scale Integration) technology – Intel's Pentium 4 microprocessor contains 55 million transistors millions of components on a single IC chip.
- Superscalar processors, Vector processors, SIMD processors, 32 bit micro controllers and embedded processors, Digital Signal Processors (DSP) etc have been developed.
- Memory chips up to 1 GB, hard disk drives up to 180 GB and optical disks up to 27 GB are available (still the capacity is increasing)
- Object oriented language like JAVA suitable for internet programming has been developed.
- Portable note book computers introduced
- Storage technology advanced – large main memory and disk storage available
- Introduced World Wide Web. (and other existing applications like e-mail, e Commerce, Virtual libraries/Classrooms, multimedia applications etc.)
- New operating systems developed – Windows 95/98/XP/…, LINUX, etc.
- Got hot pluggable features – which enable a failed component to be replaced with a new one without the need to shutdown the system, allowing the uptime of the system to be very high.
- The recent development in the application of internet is the Grid technology which is still in its upcoming stage.
- Quantum mechanism and nanotechnology will radically change the phase of computers.

Summary - Generations of computers

1. **Vacuum tube** (1939)
2. **Transistor** (invented in 1947, used in IBM 7090 in 1958)

3. **Integrated circuit** or chip (invented in 1959, used in IBM 360 in 1964)
- A small wafer of silicon that has been photographically imprinted to contain a large number of transistors together.

4. Large-scale integration: **microprocessor** (1975)
- `Entire processing unit on a single chip of silicon`

5. **Fifth Generation (Present and Beyond) Artificial intelligence** some applications, such as voice recognition, use of parallel processing and superconductors, The goal of fifth-generation computing is to develop devices that respond to natural language input and are capable of learning and self-organization.

1.2 TYPES OF COMPUTERS with cost, speed and application supported