Microprocessor

Chapter 1

Introduction

1.1 Introduction

- **What is microprocessor?**
  - Multipurpose, clock driven, register based electronic device
  - Digital electronic component with miniaturized transistors fabricated on a single integrated circuit (IC) using LSI and VLSI techniques.
  - Reads binary instructions from memory, accepts binary data as input, processes data according to those instructions and provide results as output
  - Brain of any electronic devices

- **Characteristics of microprocessor**
  - Three basic characteristics that differentiate microprocessors are:
    - Instruction set: The set of instructions that the microprocessor can execute
    - Bandwidth: The number of bits processed in a single instruction
    - Clock Speed: Determines how many instructions per second the processor can execute

1.1 Introduction

- **History:** The evolution of microprocessor is dependent on the development of integrated circuit technology from single scale integration (SSI) to giga scale integration (GSI).

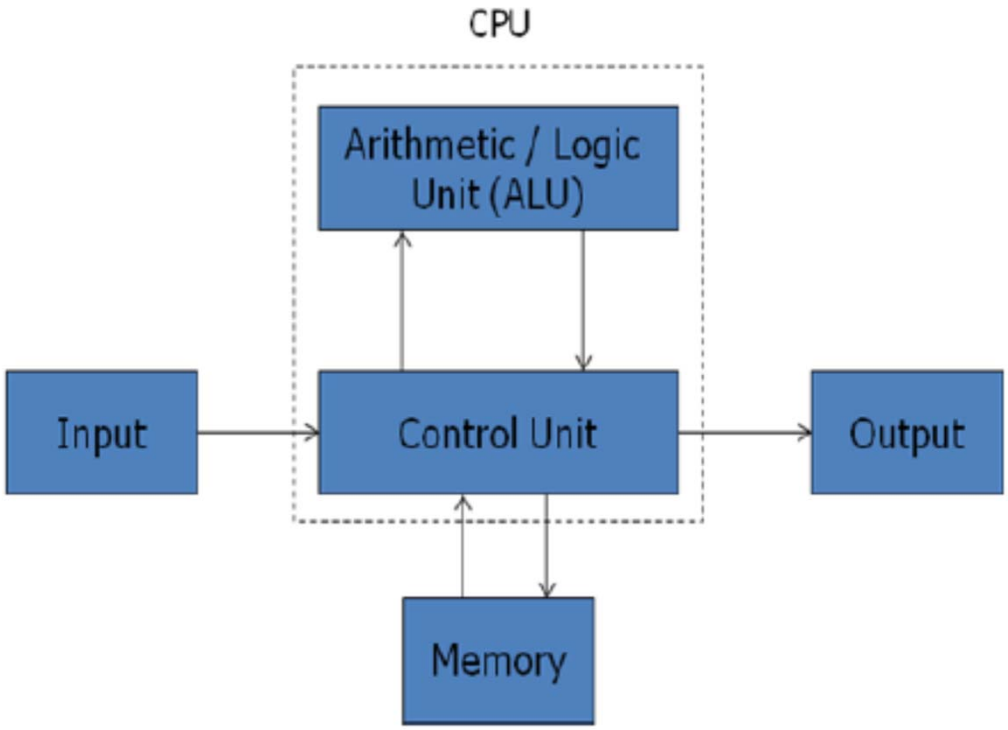
Date	Microprocessor	Data bus	Address Bus	Memory
1971	4004	4-bit	10-bit	640 Bytes
1972	8008	8-bit	14-bit	16k
1974	8080	8bit	16bit	64k
1976	8085	8bit	16b it	64k
1978	8086	16bit	20bit	1M
1979	8088	8bit	20bit	1M
1982	80286	16bit	24bit	16M
1985	80386	32bit	32bit	4G
1989	80486	32bit	32bit	4G
1993	Pentium	32/64bit	32bit	4G
1995	Pentium pro	32/64bit	36bit	64G
1997	Pentium II	64bit	36bit	64G
1998	Celeron	64bit	36bit	64G
1999	Pentium III	64bit	36bit	64G
2000	Pentium IV	64bit	36bit	64G
2001	Itanium	128 bit	64bit	64G
2002	Itanium 2	128 bit	64bit	64G
2003	Pentium M/Centrino (wireless capability) for Mobile version e.g. Laptop			
	Core 2: X86 – 64 Architecture			

1.1 Introduction

- **Application**
  - Computers
  - Measurement and Testing Equipment: Multimeter, Oscilloscope, Signal Generator
  - In Industries: Attendance System, Surveillance System, Automatic doors
  - In Medicals: X-Ray Machines, ECG Machines

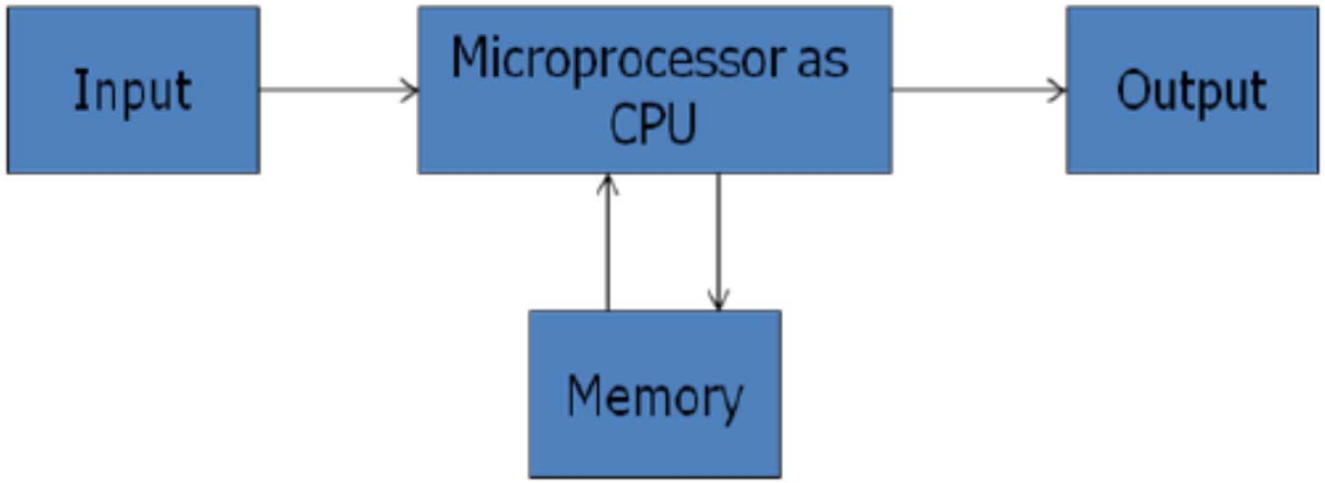
1.2 Basic Block Diagram of a computer

- Traditionally, the computer is represented with four components: memory, input, output and central processing unit (CPU) which consists of arithmetic logic unit (ALU) and control unit (CU).



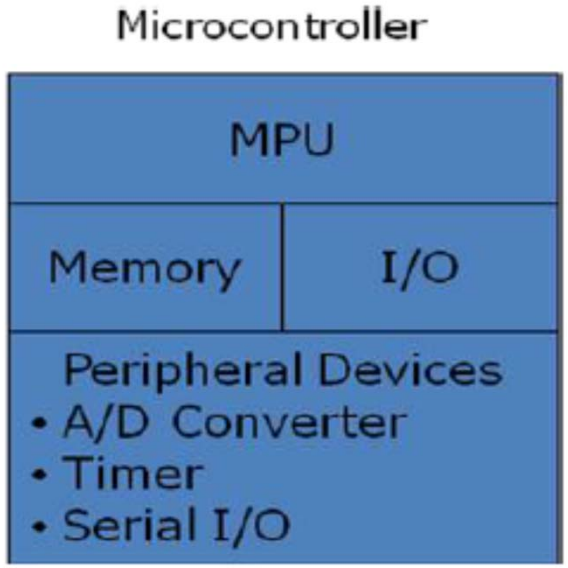
1.2 Basic Block Diagram of a computer

- Later on around late 1960's, traditional block diagram can be replaced with computer having microprocessor as CPU which is known as microcomputer. Here CPU was designed using integrated circuit technology (IC's) which provided the possibility to build the CPU on a single chip.



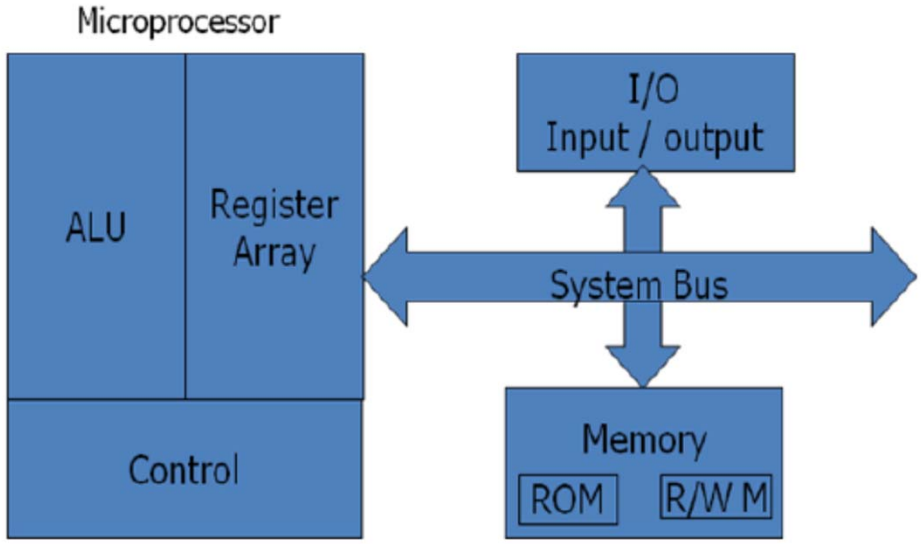
1.2 Basic Block Diagram of a computer

- Advancement of semiconductor fabrication technology allows manufacturers to place not only MPU but also memory and I/O interfacing circuits on a single chip known as microcontroller, which also includes additional devices such as A/D converter, serial I/O, timer etc.



1.3 Organization of Microprocessor Based System

- Microprocessor base system includes three components
  - Microprocessor
  - Input/output
  - Memory
- These components are interconnected with common communication path called bus



1.3 Organization of Microprocessor Based System

- Microprocessor
  - Arithmetic/Logic unit: It performs arithmetic operations as addition and subtraction and logic operations as AND, OR & XOR.
  - Register Array: The registers are primarily used to store data temporarily during the execution of a program and are accessible to the user through instruction.
  - Control Unit: It provides the necessary timing and control signals to all the operations in the microcomputer. It controls the flow of data between the microprocessor and memory & peripherals.
- Memory
  - stores instructions and data in binary format and provides that information to the microprocessor whenever necessary
  - Read only Memory (ROM): Used to store programs that do not need alterations and can only read.
  - Read/Write Memory (RAM): Also known as user memory which is used to store user programs and data. The information stored in this memory can be easily read and altered.

1.3 Organization of Microprocessor Based System

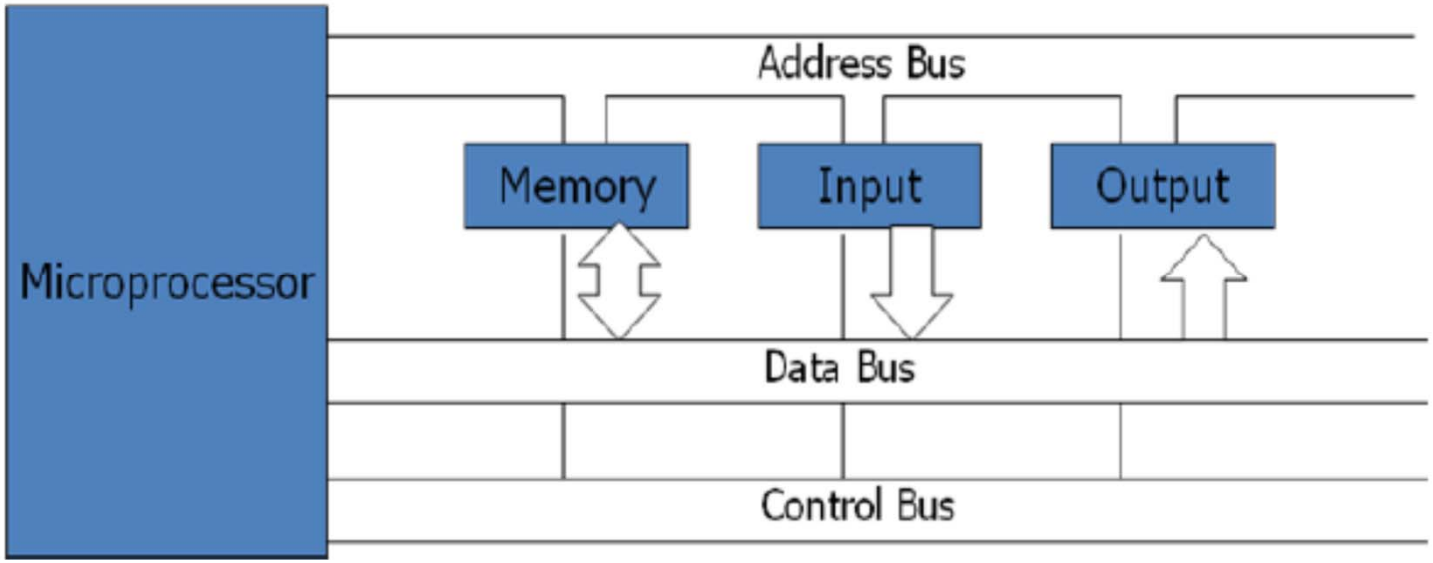
- Input/Output
  - Communicates with outside world with input and output devices
  - Input devices: keyboard, switches
  - Output devices: monitor, LED, printer
- System Bus
  - a communication path between the microprocessor and peripherals
  - it is nothing but a group of wires to carry bits

1.4 Bus Organisation

- Bus is a common channel through which bits from any sources can be transferred to the destination
- Number of wires will be excessive if separate lines are used between each register and all other registers in the system
- A bus structure consists of a set of common lines, one for each bit of a register
- Control signals determine which register is selected by the bus during each particular register transfer.

1.4 Bus Organisation

- The data lines provide a path for moving data between system modules. These lines are collectively called data bus.
- The address lines carry the address of source and destination od data
- The control lines are used to control the access and the use of the data and address lines.

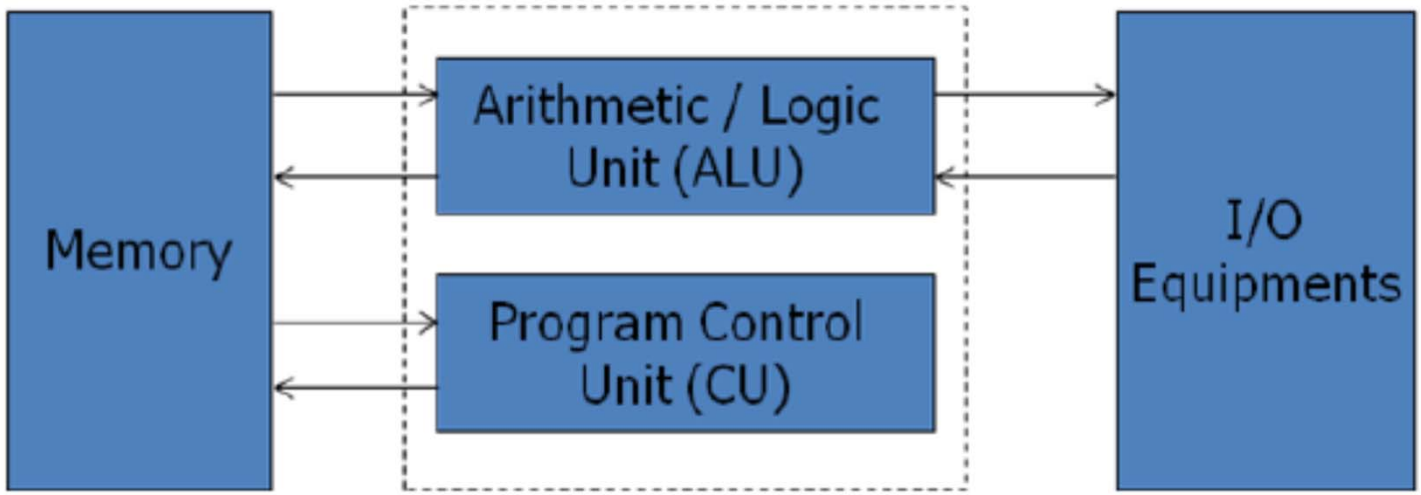


1.5 Stored Program Concept and Von Neumann Machine

- In earlier computers, entering and altering the program were very tedious.
- Done by plugging and unplugging the wire and turning the switch on and off.
- It could be facilitated if the program could be represented in a form suitable for storing in memory alongside the data.
- So the computer could get its instructions by reading from the memory and program could be set or altered by setting the values of a portion of memory.
- This approach is known as 'stored- program concept' was first adopted by John Von Neumann and such architecture is named as von-Neumann architecture.

1.5 Stored Program Concept and Von Neumann Machine

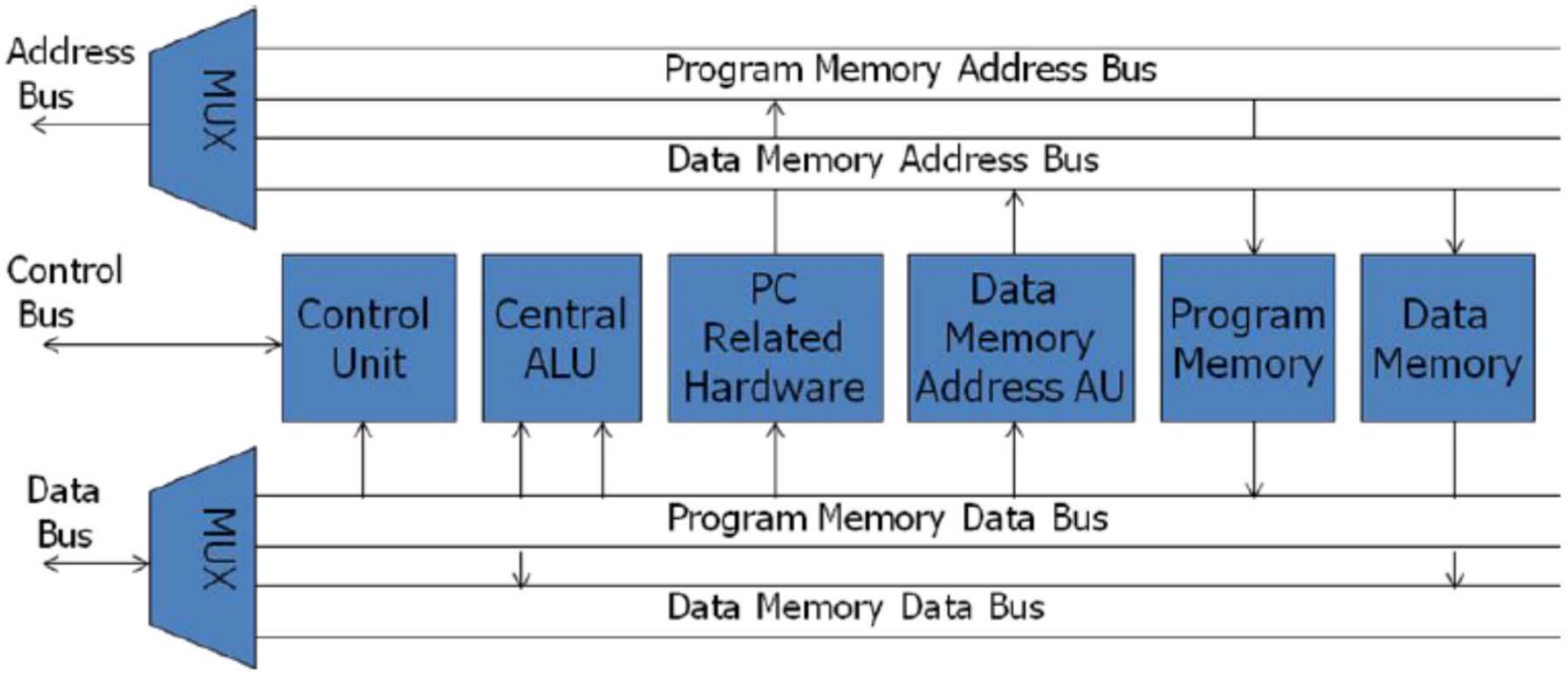
- Von–Neumann architecture is the fundamental basis for the architecture of modern digital computers.
- consists of 1000 storage locations which can hold words of 40 binary digits and both instructions as well as data are stored in it. The storage location of control unit and ALU are called registers and the various models of registers are MAR (Memory Address Register), MBR (Memory Buffer Register), IR (Instruction Register) etc.



Harvard Architecture

- In von-Neumann architecture, the same memory is used for storing instructions and data and single bus is used for reading data and instructions from or writing to memory. These factors limit the processing speed for computers
- Harvard architecture based computer consists of separate memory spaces for the programs (instructions) and data. Each space has its own address and data buses. So instructions and data can be fetched from memory concurrently and provides significance processing speed improvement

Harvard Architecture



1.6 Processing Cycle of a Stored Program Computer

- Also called instruction cycle
- total time required to read an instruction from memory and execute that to perform a specific operation of that instruction
- divided into two basic sub-cycles
  - **Fetch Cycle:-** total time required to read an opcode from memory and place that into the instruction register (IR)
  - **Execute Cycle:-** total time required to execute or perform the corresponding operation of an instruction once it is identified by the microprocessor after fetch and decode. *A*n execute cycle is the combination of zero or more machine cycles. A machine cycle can be one of the followings
    - Memory read cycle
    - Memory write cycle
    - I/O read cycle
    - I/O write cycle

1.7 Microinstructions and Hardwired/Microprogrammed Control Unit

- **Microinstructions**
  - A computer executes a program consisting instructions.
  - Each instruction is made up of shorter sub-cycles as fetch, indirect, execute cycle, and interrupt.
  - Performance of each cycle has a number of shorter operations called micro-operations
  - These micro-operations are represented by lower instruction level patterns called microinstructions
  - Example for mov r1,r2

Fetch Cycle

- T1: MAR <- PC
- T2: MBR <- [MAR]
- T3: IR <- MBR, PC <- PC +1

Execute Cycle

- T1: MAR <- Address of r2
- T2: MBR <- [MAR]
- T3: MAR <- Address of r1
- T4: [MAR] <- MBR

1.7 Microinstructions and Hardwired/Microprogrammed Control Unit

- **Hardwired Control Unit**
  - This type of control unit is essentially a combinational circuit
  - We have to derive the Boolean expression for each control signal as a function of input
  - It has faster mode of operation
  - hardwired control unit needs rewiring if design has to be modified
- **Microprogrammed Control Unit**
  - In micro-programmed control unit, the control information is stored in control memory
  - The control memory is programmed to initiate required sequence of operations
  - Use sequences of instructions to perform control operations
  - It is cheaper and simple than hardwired CU but slower than hardwired CU