Microprocessor

Engineering_Nepal

Unit 1

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Introduction

- A microprocessor is a general purpose programmable logic device.
- A thorough understanding of the microprocessor demands concept and skills from two different disciplines: -
  - Hardware concept from electronics
  - Programming skills from computer science
- Microprocessor systems are discussed in terms of four components: -
  - Processor (ALU+CU)
  - Memory
  - Input
  - Output

and their communications

Background:

Bit- a binary digit, 0 or 1.

Byte- A group of 8-bits.

Nibble- a group of 4 bits.

Word – A group of bits used for special purpose, foe e.g. a 4-bit computer may have word of 4-bits.
Instruction – A command in binary that is recognized and executed by a computer to accomplish a task.
Program – A set of instruction in a sequential order to accomplish a given task.

Machine language - Binary medium of communication.
Low level language – A medium of communication that is machine dependent or specific to the computer. The machine and assembly language are low level language. Programs written in those languages are not transferable.
High level language – it is independent to the given computer. Programs are written in English like words that can be executed on a machine using a translator.
Compiler – A program that translates the high level language into low level/machine language. A compiler reads source code, translates it into the machine language, called object code.
Interpreter – It translates English like statement of high level language into machine language of computer. It translates one line at a time from the source code to object code.
Process: a series of actions or steps taken to achieve an end result.
Processor: a machine that completes process.
IC: multi-function circuit are combined in a single chip.

Microprocessor:

Arithmetic and logic unit(ALU), Control Unit(CU), and registers integrated into a single chip using LSI and VLSI technique, then the resulting processor is known as Microprocessor unit(MU) or simply Microprocessor.

- It is a multipurpose, programmable, clock-driven, register-based electronic device that reads binary instruction from a storage device (called memory), accepts binary as input and processes data according to those instructions and provides result as output.
- Each MP communicates and operates in the binary number 0 and 1, called bits.
- Each MP has fixed sets of instructions in the form of binary pattern called a machine language.
- Generally, one or more microprocessor serves typically as a CPU.

Applications

- Test instruments
- Communications
- Computer
- Industries
- Aerospace

Basic characteristics

- **Instruction set:** total no of instructions that a Microprocessor can handle.
- **Bandwidth:** the total no of bits processed in a single system. E.g.: 32 bit (x86), 64 bit (x64).
- **Clock speed:** No of instructions that processor can execute per second. Unit of clock speed is MIPS (Millions Of Instructions per seconds).

Evolution of Microprocessor (Intel Series)

Processor	Year Of Introduction	No. Of Transistors	Intial Clock Speed	Address Bus	Data Bus(in bit)	Addressable Memory
4004	1971	2300	108 kHz	10 bit	4	640 bytes
8008	1972	3500	200 kHz	14 bit	8	16 k
8080	1974	6000	2 MHz	16 bit	8	64 k
8085	1976	6500	5 MHz	16 bit	8	64 k
8086	1978	29000	5 MHz	20 bit	16	1 M
8088	1979	29000	5 MHz	20 bit	8	1 M
80286	1982	134000	8 MHz	24 bit	16	16 M
80386	1985	275000	16 MHz	32 bit	32	4 G
80486	1989	1.2 M	25 MHz	32 bit	32	4 G
Pentium	1993	3.1 M	60 MHz	32 bit	32/64	4 G
Pentium Pro	1995	5.5 M	150 MHz	36 bit	32/64	64 G
Pentium II	1997	8.8 M	233 MHz	36 bit	64	64 G
Pentium III	1999	9.5 M	650 MHz	36 bit	64	64 G
Pentium 4	2000	42 M	1.4 GHz	36 bit	64	64 G

Evolution of Intel Microprocessors, Cont.

Recent Processors

	Pentium III	Pentium 4	Core 2 Duo	Core i7 EE 4960X	Core i9-7900X
Introduced	1999	2000	2006	2013	2017
Clock speeds	450–660 MHz	1.3–1.8 GHz	1.06–1.2 GHz	4 GHz	4.3 GHz
Bus width (data)	64 bits	64 bits	64 bits	64 bits	64 bits
Number of transistors	9.5 million	42 million	167 million	1.86 billion	7.2 billion
Feature size (nm)	250	180	65	22	14
Addressable memory	64 GB	64 GB	64 GB	64 GB	128 GB
Virtual memory	64 TB	64 TB	64 TB	64 TB	64 TB
Cache	512 kB L2	256 kB L2	2 MB L2	1.5 MB L2/ 1.5 MB L3	14 MB L3
Number of cores	1	1	2	6	10

Microcomputer

- It is a computer with a CPU as a MP designed for personal use.
- It contains MP, memory and I/O unit.
- It is smaller than mainframe and minicomputer.

Microcontroller

- Microprocessor that is embedded into a larger system for controlling purpose.
- It is a small single chip computer or single IC containing MP, memory and programmable I/O peripherals.
- E.g. 89c51 microcontroller
- 8051 processor
- 128X8 bit RAM
- 4 KB flash memory.

Q. Distinguish between microprocessor and microcontroller.

Basic Block Diagram of a computer:

- Traditional
- with four components such as
  - memory,
  - input,
  - output and
  - central processing unit (CPU)

  which consists of arithmetic logic unit (ALU) and control unit (CU).

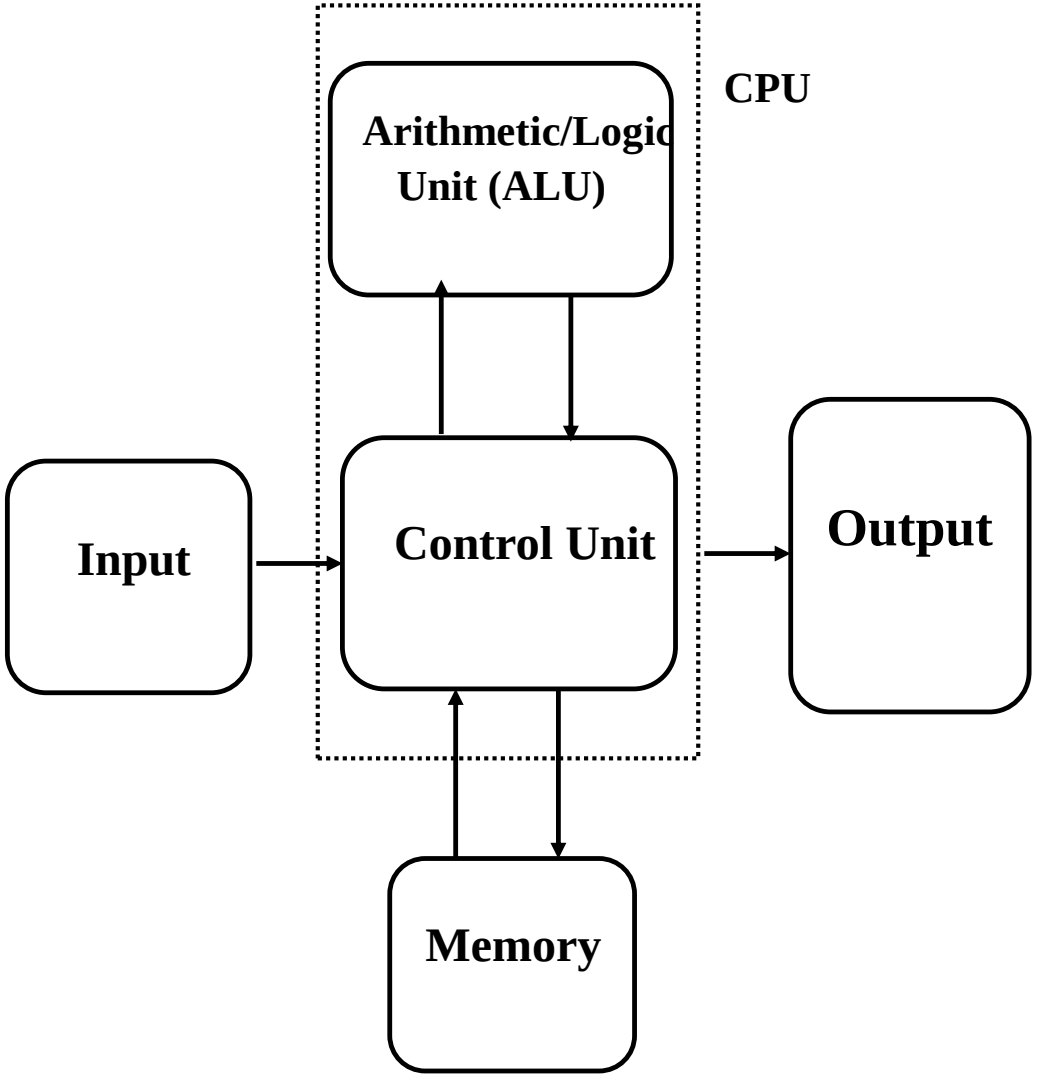


Fig: Traditional block diagram of a computer

- Around late 1960s,

traditional block diagram

was replaced with computers

having microprocessor as CPU

which is known as microcomputers.

- CPU was designed using

integrated circuits (IC) technology

which provides the possibility to build the CPU on a single chip.

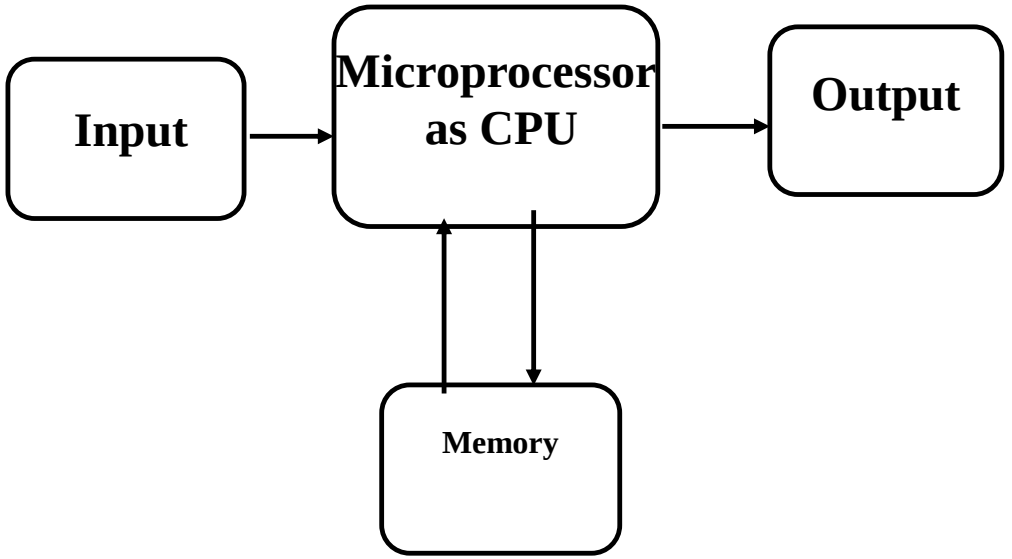


Fig: Block Diagram of a computer with the microprocessor as CPU

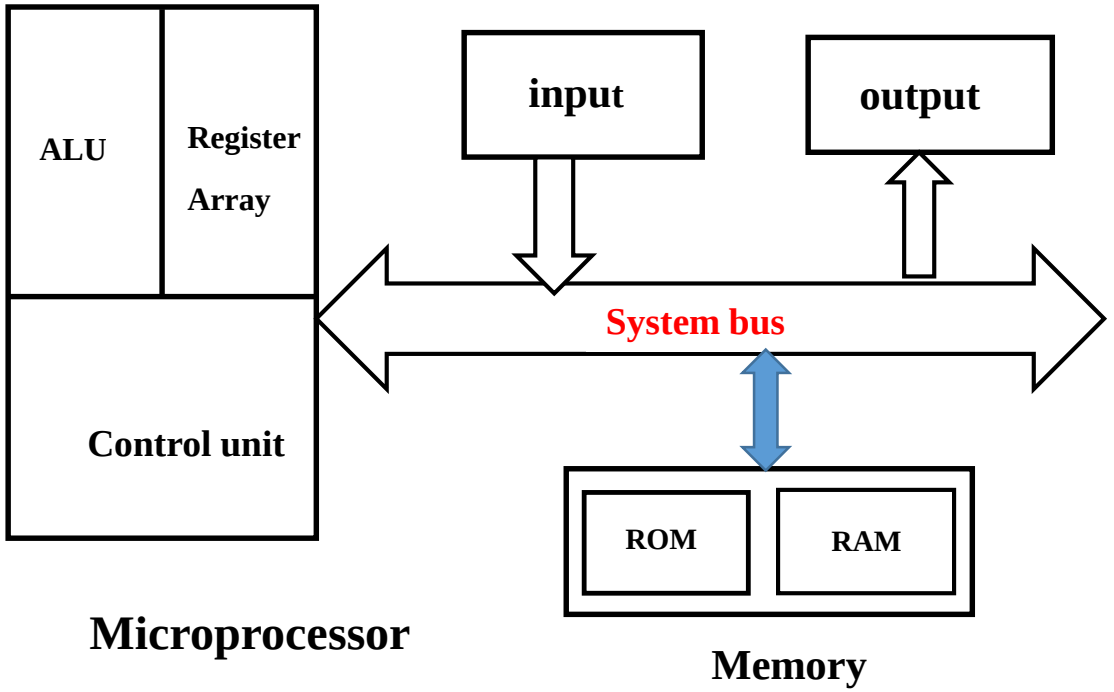
Organization of Microprocessor Based System

1. Microprocessor (MP):

The microprocessor unit can be divided into three segments:

i. **ALU**

- This unit performs all arithmetic and logical operations as specified by instruction set; and produces output.
- The results of addition, subtraction, and logical operations (AND, OR, XOR etc.) are stored in the registers or in memory unit or sent to output unit.



ii. **Register unit**

- Consists of various registers.
- Used for temporary storage of data during execution of program and are accessible to user with the help of instruction.

iii. **CU**

- Controls the operations of different instructions.
- Provides necessary timing and control signals to all the operations in the MP and peripherals including memory.

2. **Memory**
   - Stores binary information such as instruction and data, and provide this information to MP when required.
   - To execute programs, the MP reads data and instructions from memory and performs the computing operations.
   - ROM is used to store the program and data which need not to be modified.
   - RAM is used to store the program and data that can be rewrite and modified frequently as per the requirement.

3. **System bus**
   - The system bus is a communication path between MP and peripherals.
   - It is used to carry data, address and control signals.
   - It consists:
   - Data bus: carries data
   - Address bus: carries address
   - Control bus: carries control signals

4. **I/O bus**
   - Input unit is used to input instruction or data to the MP externally.
   - Output unit is used to carry out the information from the MP unit.

Bus Organization

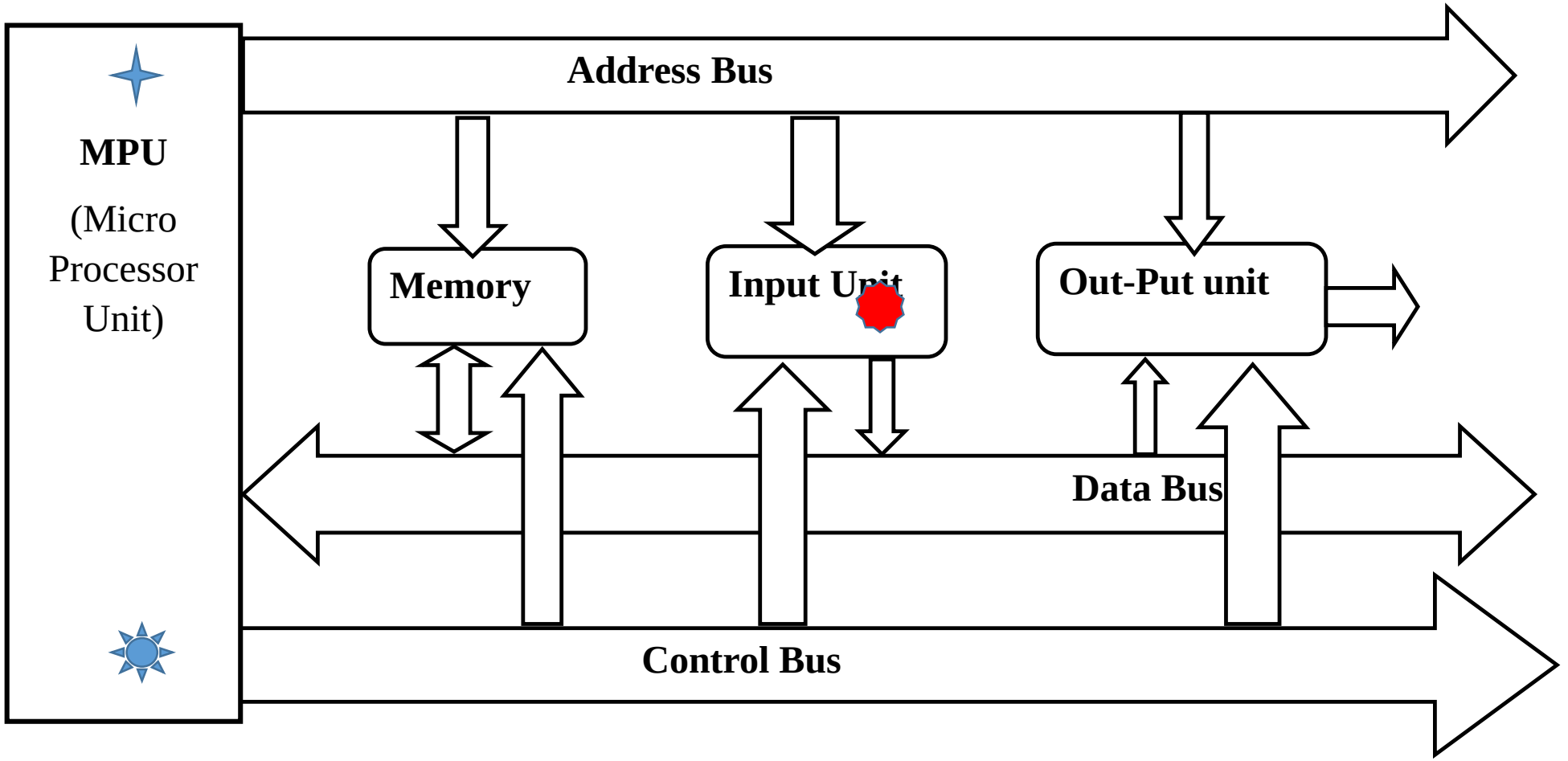


Fig: Typical Block diagram of Bus Organization of 8085 Microprocessor

Address Bus:

- It is a unidirectional bus (single ended), consists of 16, 20, 24, 32, 64 parallel lines.
- MPU sends address of memory or I/O to operate.
- Number of bits in address bus determines maximum memory size that a MP can address.
- No. of memory location =2^ no of bits of address bus
- For 16 bit = 2^16 =65536

Data Bus:

- It is a bidirectional bus, consists of 8, 16 or 32 parallel lines.
- Used to carry data to and from the memory and peripheral devices.
- The bits in a data bus determine the speed and maximum data flow of a processor at given constant clock speed.
- Many devices are connected to the data bus but only one operates at a time.
- Devices connected to the data bus through Tri-State Buffer can be disabled if not in use.
- E.g.: 8-bit data bus, 16-bit data is to be carries, should be done in two cycle.

Control Bus:

- Consist of 4 to 10 parallel lines.
- Use to control the access to and the use of data and address bus.
- Transmit both command and timing signals.
- Command specifies the operation to be done.
- Timing indicates the validity of data and address information.
- Control bus is connected to each and every component of the system.
- E.g.: memory read/ write, I/O read/write, Bus request, Bus grant etc.

Von Neumann machine and Harvard architecture

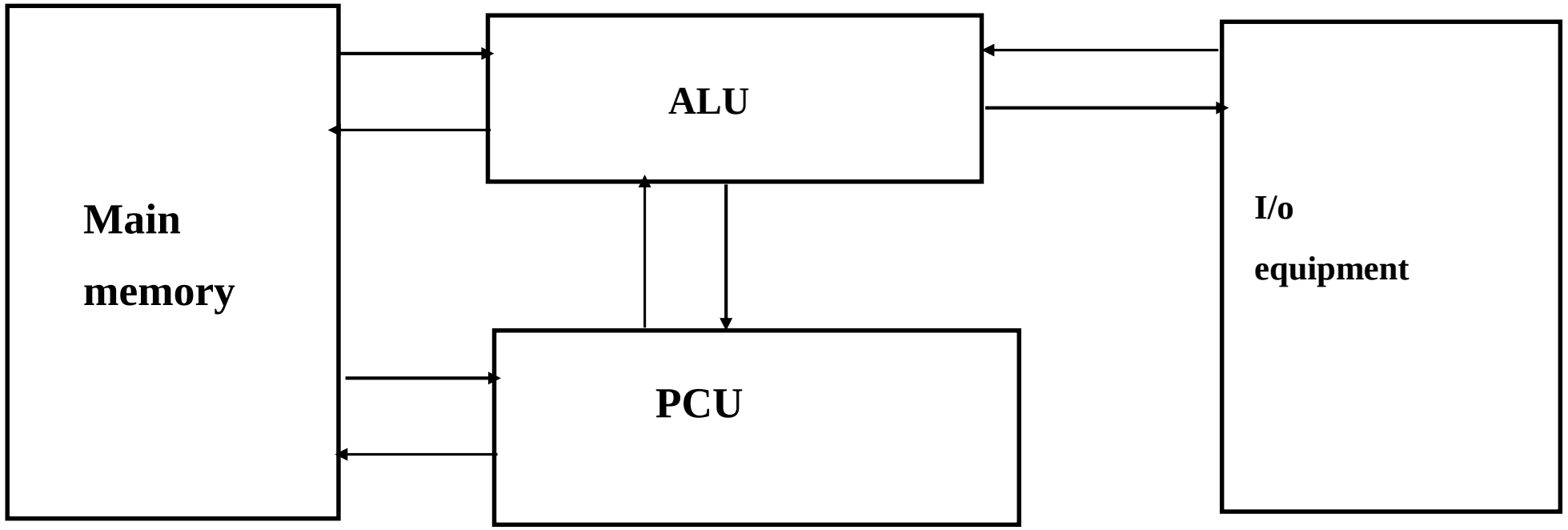


Fig: Von Neumann Architecture

Q. What is stored program concept? How this lead to the evolution of modern computers?

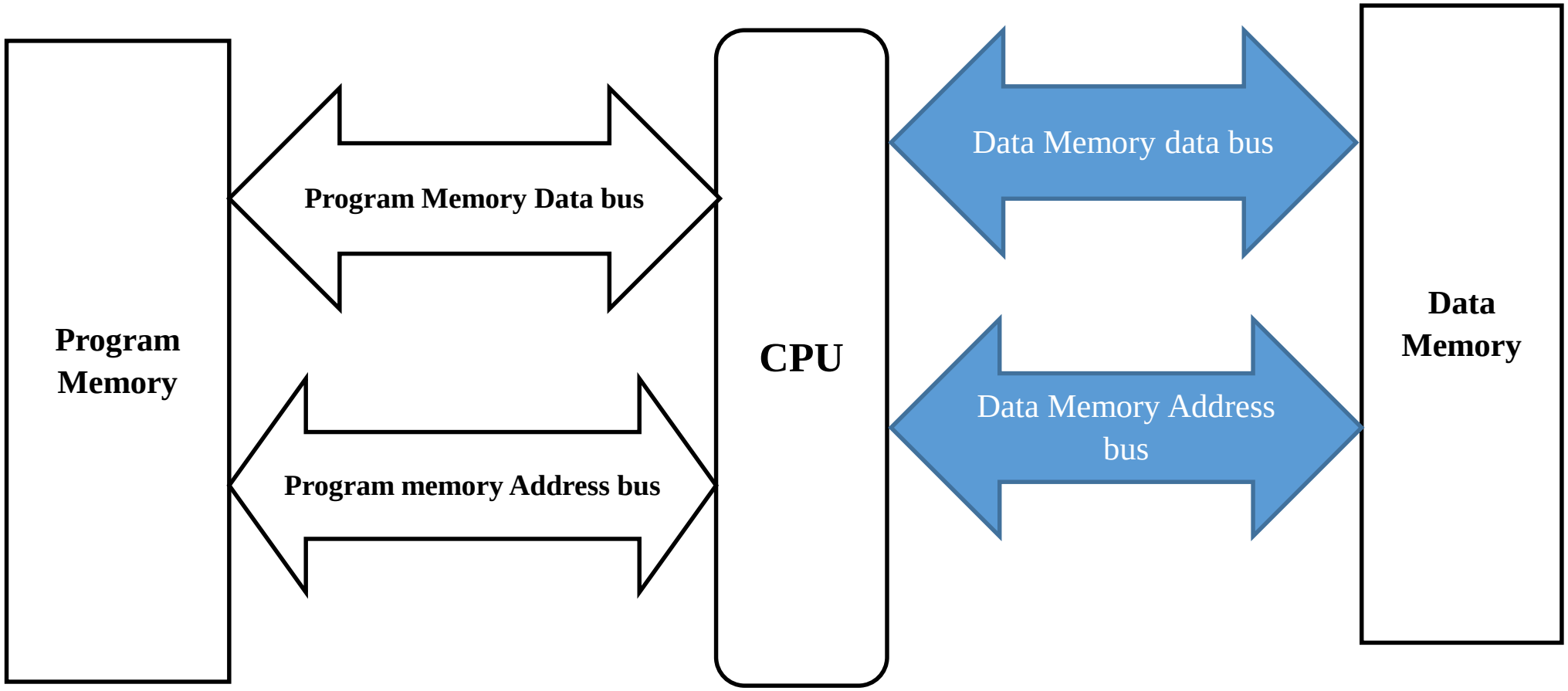


Fig: Harvard Architecture

Processing Cycle of a Stored Program Computer:

- Fetch
- Identify
- Fetch data
- Process
- Write back

Microinstructions and Hardwired/Microprogrammed Control Unit:

- 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.**
- Each instruction is characterized with many machine cycles and each cycle is characterized with many T-states.
- The lower instructions level patterns which are numerous sequence for a single instruction are known as **microinstruction.**

Fetch Registers:

- Memory Address register (MAR):
  - connected to address bus
  - specifies address for read and write op-code
- Memory Buffer Register (MBR):
  - Connected to data bus
  - Holds data to write
- Program Counter (PC):
  - Holds the address of next instruction to be fetched
- Instruction Register (IR):
  - Holds the last instruction fetched

Fetch Sequence:

- Address of next instruction is in PC
- Address (MAR) is placed on address bus
- Control unit issues READ command
- Result (data from memory) appears on the data bus
- Data from data bus copied into MBR
- PC incremented by 1 (in parallel with data fetch from memory)
- Data (instructions) moved from MBR to IR
- MBR is now free for further data fetch

T1: MAR ← PC

T2: MBR ← (memory or MAR)

T3: PC ← PC+1

IR ← MBR

"OR"

T1: MAR ← PC

T2: MBR ← (memory or MAR)

PC ← PC+1

T3: IR ← MBR

Control unit:

- heart of CPU.
- gets instruction from memory.
- decides what the instructions mean and directs the necessary data to be moved from memory to ALU.
- coordinates all activities of processor unit, peripheral devices and storage devices.
- Two types:
  1. **Hardwired control unit**
  2. **Micro-programmed control unit**

1. **Hardwired control unit**

   Control signals are generated by the implementation of conventional logic design. It uses finite number of gates, flip-flops, decoders, and other digital circuits.

- This control unit is essentially a combinational circuit. It's input logic signals are transformed into a set of output logic signals which are control signals.
- It performs different operations on the basis of op-codes.
- We have to derive the Boolean expression for each control signal as a function of input.
- Since modern processor needs a Boolean equation, it is very difficult to build a combinational circuit that satisfies all the operations.
- It has faster mode of operations.
- A hardwired control unit requires rewiring if design has to be modified.

1. **Micro-programmed control unit**

   An alternative to hardwired CU. A systematic and elegant approach for controlling the micro-operations sequences. In micro-programmed control unit, the control information is stored in control memory. The control memory is programmed to initiate required sequence of operation. Modification can be done easily by modifying control information.

- Use sequence of instructions to perform control operations (micro-operations), these sequence of operations is called microprogram and are stored permanently in ROM.
- Control address register contains the address of the next micro instruction to be read.
- As it is read, it is transformed to control buffer register.
- Sequencing unit loads the control address register and issues a read command.
- It is cheaper and simple than hardwired CU.
- It is slower than hardwired CU.

Register Transfer Language (RTL):

- Symbolic notation used to describe the micro-operation transfers among registers is called register transfer language (RTL).
- The term ‘register transfer’ implies the availability of hardware logic circuit that can perform a stated instruction and transfer the data.
- RTL is the convenient tool for the describing the internal organization of digital computers in concise and precise manner.
- Ex:

1) **MVI A, 32H**

Fetch:

T1: MAR ← PC
T2: MBR ← [MAR]
T3: IR ← MBR
PC ← PC +1

Execute:

T4: MBR ← IR [address of immediate data]
T5: MAR ← IR [address of A]
T6: A ← MBR

2) **LXI B, F010H**

Fetch:

T1: MAR ← PC
T2: MBR ← [MAR]
T3: IR ← MBR
PC ← PC +1

Execute:

T4: MBR ← IR [address of immediate data]
T5: MAR ← IR [address of C]
T6: C ← MBR
T7: MBR ← IR [address of immediate data (MSB)]
T8: MAR ← IR [address of (B)
T9: B ← MBR