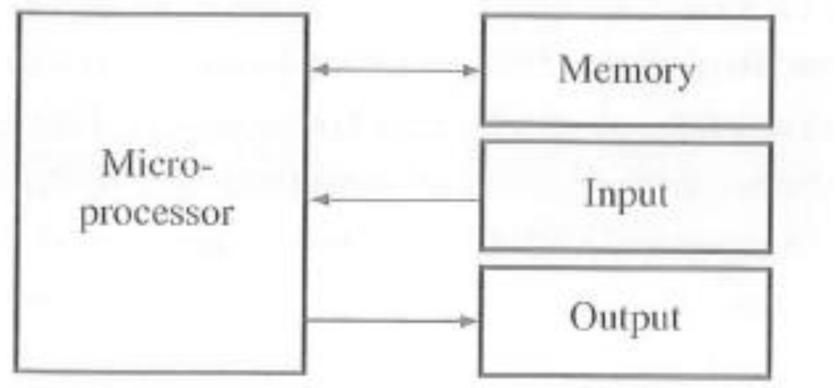
Introduction to Microprocessor

Introduction

- A microprocessor is an multipurpose, programmable, clock-driven, register-based electronic device that reads binary instruction from a storage device called **memory** , accepts binary data an **input** and **process** data according to those instructions, and provides results an **output**.
- Programmable machine can be represented with four components: microprocessor, memory, input and output.



- The basic blocks of a computer are the central processing unit (CPU), the memory, and the input/output (I/O).
- **Computer hardware** includes such components as memory, CPU, transistors
- **Computer software** consists of a collection of programs that contain instructions and data for performing a specific task.
- a translator is necessary to convert such a program into binary and this is achieved using a translator program called a **compiler**.

- **Microprocessor is** fabricate a CPU on a single chip
- Both metal-oxide semiconductor (MOS)and bipolar technologies are used in the fabrication process.
- Along with the microprocessor chip, appropriate memory and I/O chips can be used to design **a microcomputer**.
- **Microcontrollers** include a microcomputer, timers, and A/D (analog-to- digital) and D/A (digital to analog) converters, all on a single chip.

Terms of Microprocessor

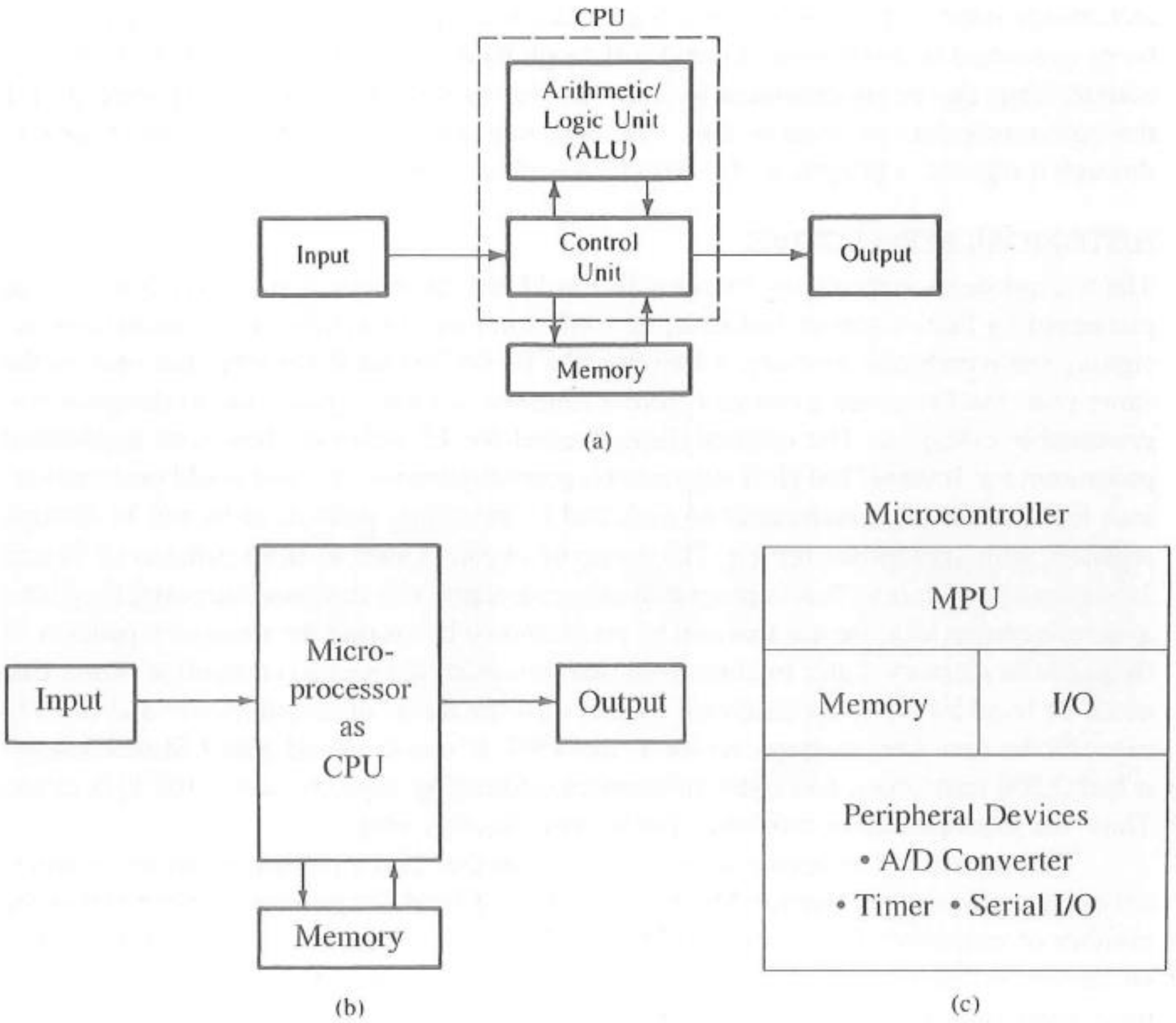
- CPU: - Central processing unit which consists of ALU and control unit.
- Microprocessor: - Single chip containing all units of CPU.
- Microcomputer: - Computer having microprocessor as CPU.
- Microcontroller: single chip consisting of MPU, memory, I/O and interfacing circuits.
- MPU: - Micro processing unit – complete processing unit with the necessary control signals.

- An **Address** is a pattern of 0’s and 1 ’s that represents a specific location in memory or a particular I/O device. Typical 8-bit microprocessors have 16 address lines, and, these 16 lines can produce unique 16-bit patterns from 00 00 00 00 00 00 00 00 to, 11 11 11 11 11 11 11 11 representing 65,536 different address combinations.
- **Addressing mode** is the manner in which the microprocessor determines the operand(data) and destination addresses during execution of an instruction.

- **An Arithmetic-logic unit (ALU)** is a digital circuit that performs arithmetic and logic operations on two n-bit digital words.
- **Bit** is an abbreviation for the term binary digit. A binary digit can have only two values, which are represented by the symbols 0 and 1.
- **Bit size** refers to the number of bits that can be processed simultaneously by the basic arithmetic circuits of a microprocessor. A number of bits taken as a group in this manner is called a word. For example, a 32- bit microprocessor can process a 32-bitword. An 8-bit word is referred to as a byte , and a 4-bit word is known as a nibble.

- **A bus** consists of a number of conductors (wires) organized to provide a means of communication among different elements in a microprocessor system.
- **Cache Memory** is a high-speed, directly accessible, relatively small, semiconductor read/write memory block used to store data/instructions that the microprocessor may need in the immediate future.
- The **instruction set** of a microprocessor is a list of commands that the microprocessor is designed to execute.
- **Pipelining** is a technique that overlaps instruction fetch (instruction read) with execution.

1. a) Traditional block diagram of a computer
2. b) Block diagram of a computer with the microprocessor as CPU
3. c) Block diagram of a microcontroller



Traditional Block diagram of a computer

- The CPU contains various registers to store data, the ALU to perform arithmetic and logical operations, instruction decoders, counters and control lines.
- The CPU reads instructions from memory and performs the tasks specified. It communicates with input/output (I/O) devices either to accept or to send data, the I/O devices is known as peripherals.
- 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.

Block Diagram of a computer with the Microprocessor as CPU

Later on semiconductor fabrication technology became more advanced, manufacturers were able 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

Evolution of Microprocessor

- The Intel Corporation is generally acknowledged as the company that introduced the first microprocessor successfully into the marketplace.
- The 4004 is the first processor, was introduced in and evolved from a development effort while making a calculator chip set
- In 1973, second-generation microprocessors (8-bit microprocessors) such as the Motorola 6800 and the Intel 8080

- A third generation microprocessor (16-bit microprocessors)introduced in 1978 is typically represented by the Intel 8086 and the Motorola , which are 16-bit microprocessors.
- During the 1980’s, fourth-generation(32-bit microprocessor,
- Since 1985, more 32-bit microprocessors have been introduced. These include Motorola’s68020, 68030, 68040, 68060, PowerPC, Intel’s , 80486, the Intel Pentium family, Core Duo, and Core2 Duo microprocessors..

- The original Pentium processor was introduced by Intel in 1993, and the name was changed from to Pentium because of copyright laws.
- latest speed of 233 MHz.

TABLE 1.2 **Intel 80386/80486/Pentium Microprocessors.**

Features	80386DX	80386SX	80486DX	80486SX	80486DX2	Pentium (original)
• Introduced	October 1985	June 1988	April 1989	April 1991	March 1992	March 1993
• Maximum Clock Speed (MHz)	40	33	50	25	100	233
• MIPS*	6	2.5	20	16.5	54	112
• Transistors	275,000	275,000	1.2 million	1.185 million	1.2 million	3.1 million
• On-chip cache memory	Support chips available	Support chips available	Yes	Yes	Yes	Yes
• Data bus	32-bit	16-bit	32-bit	32-bit	32-bit	64-bit
• Address bus	32-bit	24-bit	32-bit	32-bit	32-bit	32-bit
• Directly addressable memory	4 GB	16MB	4 GB	4 GB	4 GB	4 GB
• Pins	132	100	168	168	168	273
• Virtual memory	Yes	Yes	Yes	Yes	Yes	Yes
• On-chip memory management and protection	Yes	Yes	Yes	Yes	Yes	Yes
• Floating point unit	387DX	387SX	on chip	487SX	on chip	on chip

* MIPS means million of instructions per second that the microprocessor can execute. MIPS is typically used as a measure of performance of a microprocessor. Faster microprocessors have a higher MIPS value.

TABLE 1.3 Pentium vs. Pentium Pro.

Pentium	Pentium Pro
• First introduced March 1993	• Introduced November 1995
• 2 instructions per clock cycle	• 3 instructions per clock cycle
• Primary cache of 16K	• Primary cache of 16K
• Original clock speeds of 100, 120, 133, 150, 166, 200, and 233 MHz	• Original clock speeds 166, 180, 200 MHz
• More silicon is needed to produce the chip	• Tighter design reduces silicon needed and makes chip faster (shorter distances between transistors)
• Designed for operating systems written in 16-bit code	• Designed for operating systems written in 32-bit code.

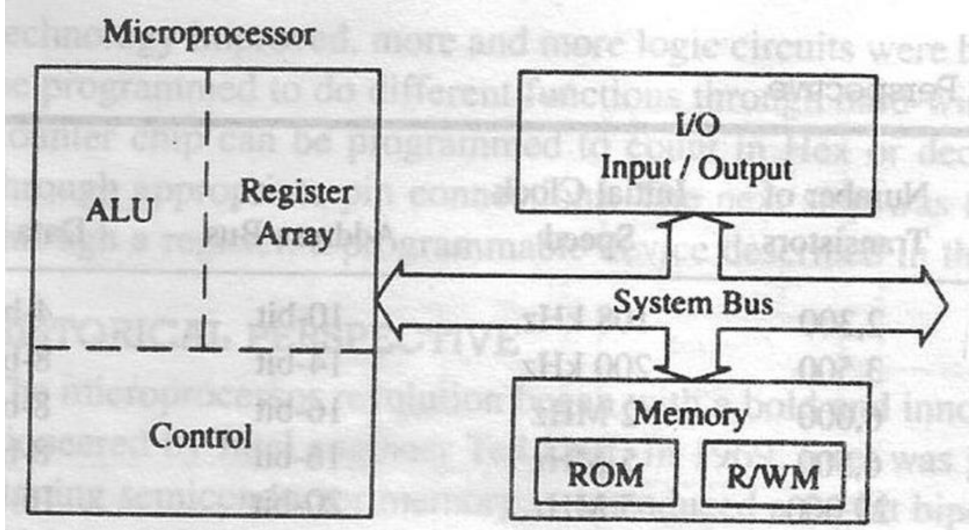
- **Pentium II** It basically takes attributes of the Pentium Pro processor plus the capabilities of MMX technology to yield processor speeds of 333, 300, 266, and 233 **MHz**.
- **MMX** (matrix math extensions)is intended for efficient multimedia and communications operations.
- The Intel Celeron processor speed up to333 **MHz**

- The Pentium III operates at 450 MHz and 500 MHz.
- The Pentium IIII currently available at 1.30, 1.40, 1.50, and 1.70 GHz.
- Intel introduced the 32-bit Pentium M microprocessor in It was designed specifically for the mobile computing market.
- In 2006, Intel introduced the 64-bit Core Duo microprocessor that ran at a speed of 1.66 to GHz.
- The original Core 2 Duo ran at a speed of to 2.93 GHz.

Organization of a microprocessor based system

Microprocessor based system includes there components microprocessor, input/output and memory (read only and read/write). These components are organized around a common communication path called a bus.

Microprocessor: It is clock driven semiconductor device consisting of electronic logic circuits manufactured by using either a large scale integration (LSI) or very large scale integration (VLSI) technique. It is capable of performing various computing functions and making decisions to change the sequence of program execution. In large computers, a CPU implemented on one or more circuit boards. It can be divided in to three segments: Arithmetic/Logic unit, Register Array, Control Unit



A. **Arithmetic/Logic unit**: It performs arithmetic operations as addition and subtraction and logic operations as AND, OR & XOR.
B. **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. The registers can be identified by letters such as B, C, D, E, H and L.
C. **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.

- **What is the relationship among the Programmer's Instruction (binary pattern of 0s and 1s), the ALU, and the Control Unit (CU)?**

This can be explained with the example of a full adder circuit. A full adder circuit can be designed with registers, logic gates, and a clock. The clock initiates the adding operation. Similarly, the bit pattern of an instruction initiates a sequence of clock signals, activates the appropriate logic circuits in the ALU, and performs the task. This is called microprogramming, which is done in the design stage of the microprocessor. In many ways, this is similar to the process of how our brain operates. In early childhood, we learn a word, "sit," and physical motions needed for the action are embedded in our brain. When we hear the word "sit," our brain activates a series of actions for our muscles and bones and we sit down. In this analogy, the word "sit" is like an instruction in a microprocessor, and actions initiated by our brain are like microprograms.

The bit patterns required to initiate these microprogram operations are given to the programmer in the form of the instruction set of the microprocessor. The programmer selects appropriate bit patterns from the set for a given task and enters them sequentially in memory through an input device. When the CPU reads these bit patterns one at a time, it initiates appropriate microprograms through the control unit, and performs the task specified in the instructions.

Memory:

Memory stores binary information as instructions and data, and provides that information to the microprocessor whenever necessary. To execute programs, the microprocessor reads instructions and data from memory and performs the computing operations in its ALU. Results are either transferred to the output section for display or stored in memory for later use. Memory has two sections.

A. Read only Memory (ROM): Used to store programs that do not need alterations and can only read. The monitor program of a single board microprocessor is generally stored in the ROM. This program interprets the information entered through a keyboard and provides equivalent binary digits to the microprocessor.

B. Read/Write Memory (RAM): Also known as user memory which is used to store user programs and data. In single board microprocessor, the monitor program monitors the Hex keys and stores those instruction and data in the R/W memory. The information stored in this memory can be easily read and altered.

Input/Output:

- It communicates with the outside world using two devices input and output which are also Known as peripherals.
- The input device such as keyboard, switches, and analog to digital converter transfer binary information from outside world to the microprocessor.
- The output devices transfer data from the microprocessor to the outside world. They include the devices such as LED, CRT, digital to analog converter, printer etc.

System Bus:

- It is a communication path between the microprocessor and peripherals; it is nothing but a group of wires to carry bits. All peripherals (and memory) share the same bus; however, the microprocessor communicates with only one peripheral at a time. The timing is provided by the control unit of a microprocessor.

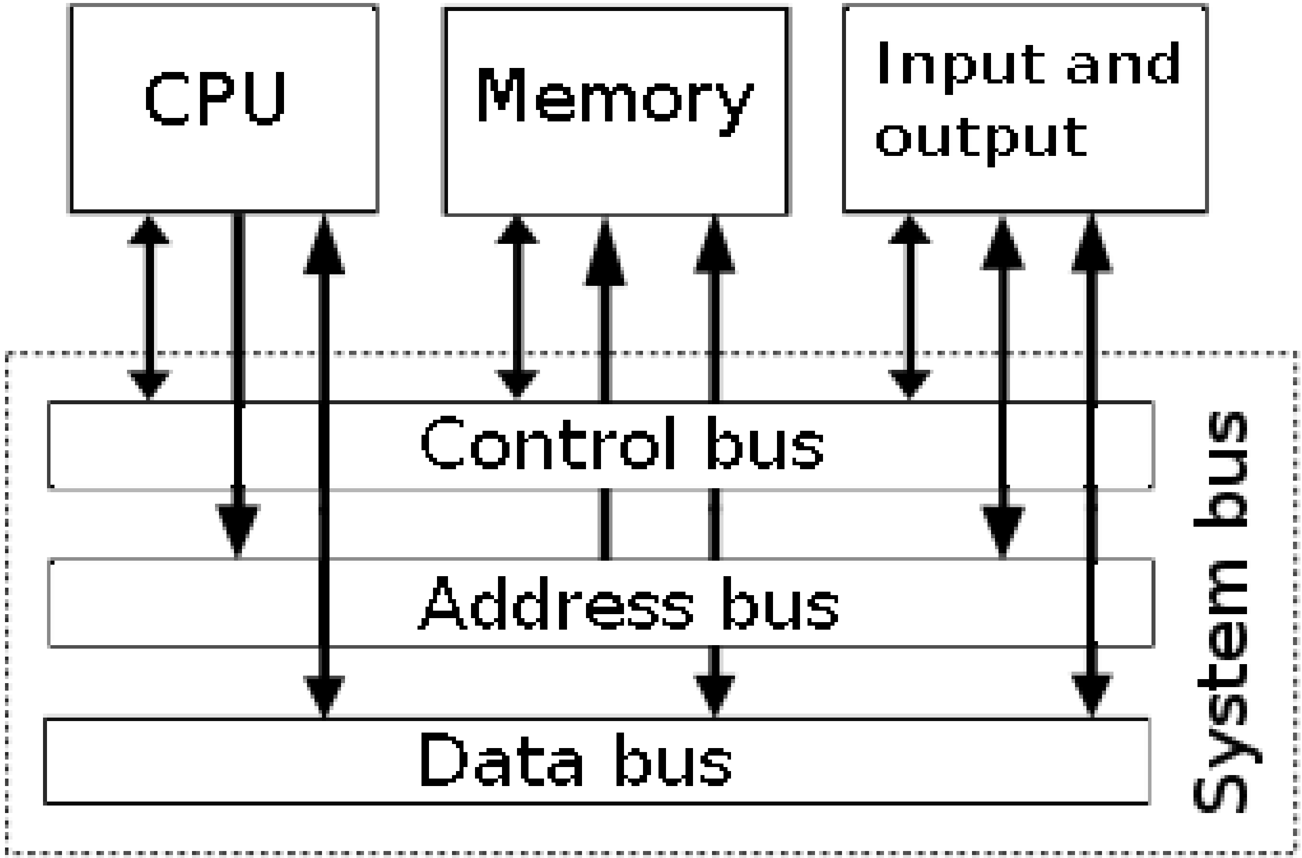
Bus organization

- Bus is a common channel through which bits from any sources can be transferred to the destination.
- A typical digital computer has many registers and paths must be provided to transfer instructions from one register to another.
- The number of wires will be excessive if separate lines are used between each register and all other registers in the system.

- A more efficient scheme for transferring information between registers in a multiple register configuration is a common bus system.
- A bus structure consists of a set of common lines, one for each bit of a register, through which binary information is transferred one at a time. Control signals determine which register is selected by the bus during each particular register transfer.
- A very easy way of constructing a common bus system is with multiplexers. The multiplexers select the source register whose binary information is then pleased on the bus.

- A system bus consists of about 50 to 100 of separate lines each assigned a particular meaning or function.
- Although there are many different bus designers, on any bus, the lines can be classified into three functional groups; data, address and control lines. In addition, there may be power distribution lines as well.

- System bus usually is separated into three functional groups
    1. Data Bus
    2. Address Bus
    3. Control Bus



Data Bus

- A collection of wires through which data is transmitted from one part of a computer to another.
- Data Bus can be thought of as a highway on which data travels within a computer.
- This bus connects all the computer components to the CPU and main memory.
- The data bus may consist of 32, 64, 128, or even more separate lines.
- The number of lines being referred to as the width of the data bus.
- Because each line can carry only 1 bit at a time, the number of lines determines how many bits can be transferred at a time.

- It is a bidirectional bus.
- The size (width) of bus determines how much data can be transmitted at one time.
  - E.g.
    - A 16-bit bus can transmit 16 bits (2 bytes)of data at a time.
    - 32-bit bus can transmit 32 bits(4 bytes) at a time.
- The size (width) of bus is a critical parameter in determining system performance.
- The wider the data bus, the better, but they are expensive.

Address Bus

- A collection of wires used to identify particular location in main memory is called Address Bus.
- Or in other words, the information used to describe the memory locations travels along the address bus.
- Clearly, the width of the address bus determines the maximum possible memory capacity of the system.
- N address lines directly address 2^N memory locations.

- It is an unidirectional bus.
- The CPU sends address to a particular memory locations and I/O ports.
- The address bus consists of 16 , 20 , 24 or more parallel signal lines.

- 8086: 20 address lines
  - Could address 1 MB of memory
- Pentium: 32 address lines
  - Could address 4 GB of memory
- Itanium: 64 address lines
  - Could address 264 bytes of memory

Control Bus

- Because the data and address lines are shared by all components, there must be a means of controlling their use.
- The control lines regulates the activity on the bus.
- Control signals transmit both command and timing information among system modules.
- The control bus carries signals that report the status of various devices.

- Typical control bus signals are :
  - Memory Read : causes data from the addressed location to be placed on the data bus.
  - Memory Write : causes data on the bus to be written into the addressed location
  - I/O write: causes data on the bus to be output to the addressed I/O port
  - I/O read: causes data from the addressed I/O port to be placed on the bus

- Control lines also include :
  - Transfer ACK: indicates that data have been accepted from or placed on the bus.
  - Bus request: indicates that a module needs to gain control of the bus.
  - Bus grant: indicates that a requesting module has been granted control of the bus.
  - Interrupt request: indicates that an interrupt is pending.
  - Interrupt ACK: acknowledges that the pending interrupt has been recognized.
  - Reset: initializes all modules.

Summary of Bus

- The data lines provide a path for moving data between system modules. These lines are collectively called data bus.
- The address lines are used to designate the source/destination of data on data bus.
- The control lines are used to control the access to and the use of the data and address lines. Because data and address lines are shared by all components, there must be a means of controlling their use. Control signals transmit both command and timing signals indicate the validity of data and address information. Command signals specify operations to be performed. Control lines include memory read/write, I/O read/write, bus request/grant, clock, reset, interrupt request/acknowledge etc.