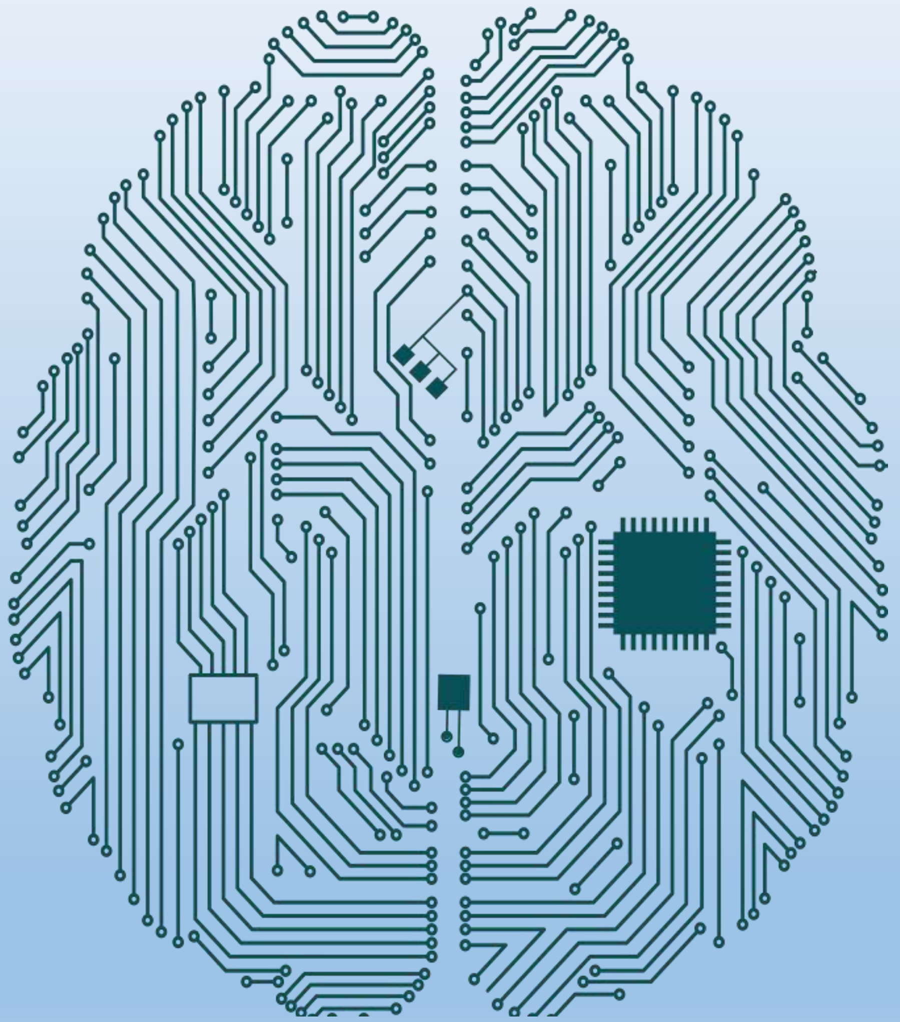


Computer Organization & Architecture

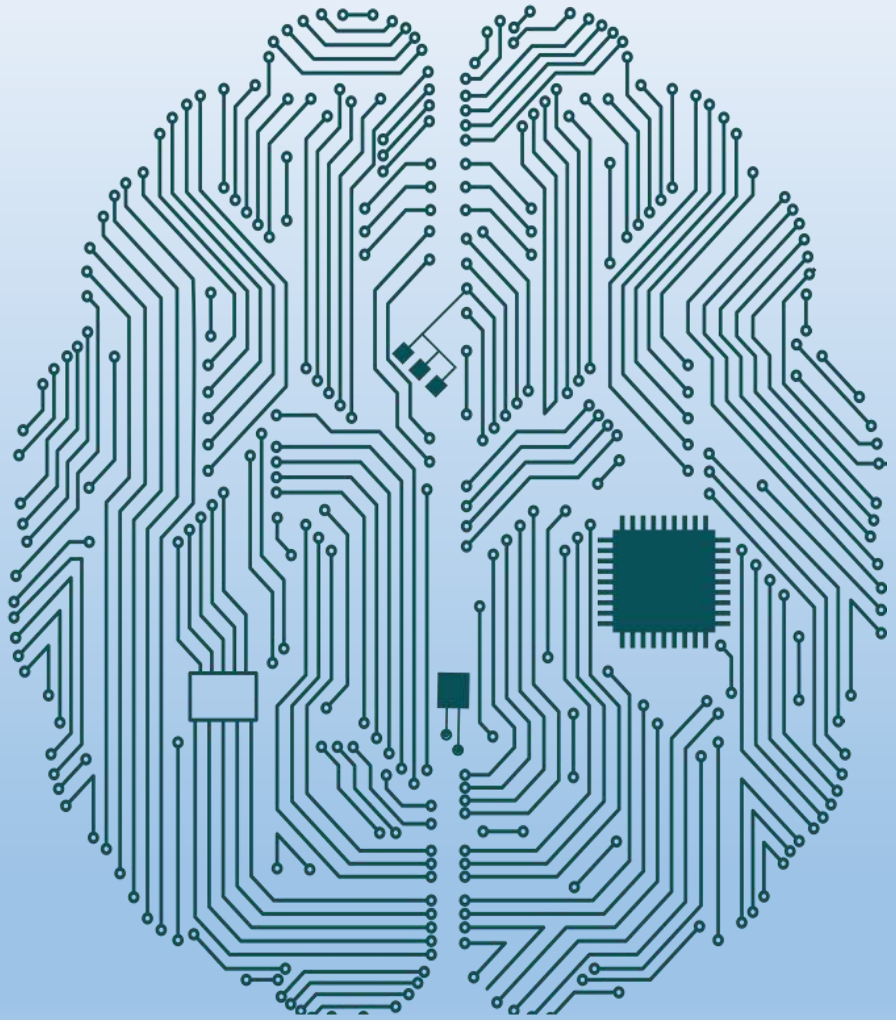
Code: 4350701

Teaching Scheme

Theory Marks		Practical Marks		Total Marks
CA	**ESE**	**CA**	**ESE**	
30	70	25	25	150

Course Outcomes

- **CO1:** Analyze computer systems at the hardware level, including CPU components & circuits, buses, and registers considering trade-offs and the evolution of processors.
- **CO2:** Examine 8085 Architecture and its working.
- **CO3:** Perform Assembly language programming using 8085 Instruction Set.
- **CO4:** Characterize need of various Memory types in hierarchy.
- **CO5:** Visualize CPU-I/O Communication and working.



Basics of Computer Organization & Processor Evolution

Unit - I

Microprocessor and its Evolution

- The most important part of the computing system. It is an electronic circuit that executes the instructions and generates the output.
- We can classify in following types based on the generation:
  - First Generation
  - Second Generation
  - Third Generation
  - Fourth Generation
  - Fifth Generation
  - Sixth Generation
  - Seventh Generation
  - Eighth Generation

First Generation Microprocessor

- First microprocessor by Intel Corp. in 1971 : Intel 4004.
  - With 2300 transistors,
  - Data bus of 8 bits, and addressable memory of 640 bytes.
- Intel released 8008 in 1972 and than 8080 in 1974.
  - 8080 contained 8 bit data bus, and 64KB of memory.
- Intel 8085 in 1976,
  - With 6500 transistors,
  - Data bus of 8 bits, and addressable memory of 64KB.
- Intel 8086 in 1978,
  - With 29000 transistors,
  - Data bus of 16 bits, and addressable memory of 1MB.

Second Generation

- Intel 80286, introduced in 1982.
- Used in IBM PC.

Third Generation

- Intel 80386, introduced in 1985, full 32 bit processor.
- Multitasking, high speed processor.

Fourth Generation

- Intel 80486, faster execution speed with 16-133MHZ of clock speed.
- Introduction of Cache memory .

Fifth Generation

- Intel Pentium, introduced in 1992.
- Twin pipeline for parallel instruction execution, superscalar technique.

Sixth Generation

- Intel Pentium Pro, Pentium 2, Pentium 3, Pentium Xeon.
- Introduction to L2 Cache.

Seventh Generation

- Intel Pentium 4, in 2000.
- Hyperpipeline, Branch prediction, Larger Cache memory.

Eighth Generation

- Itanium, the first Intel 64 bit processor, introduced in 2001.
- Core based microprocessor, Core2Duao, DualCore, QuadCore, i3, i5, i7
- Multiple cores to perform the multiprogramming.

Topics to be covered…

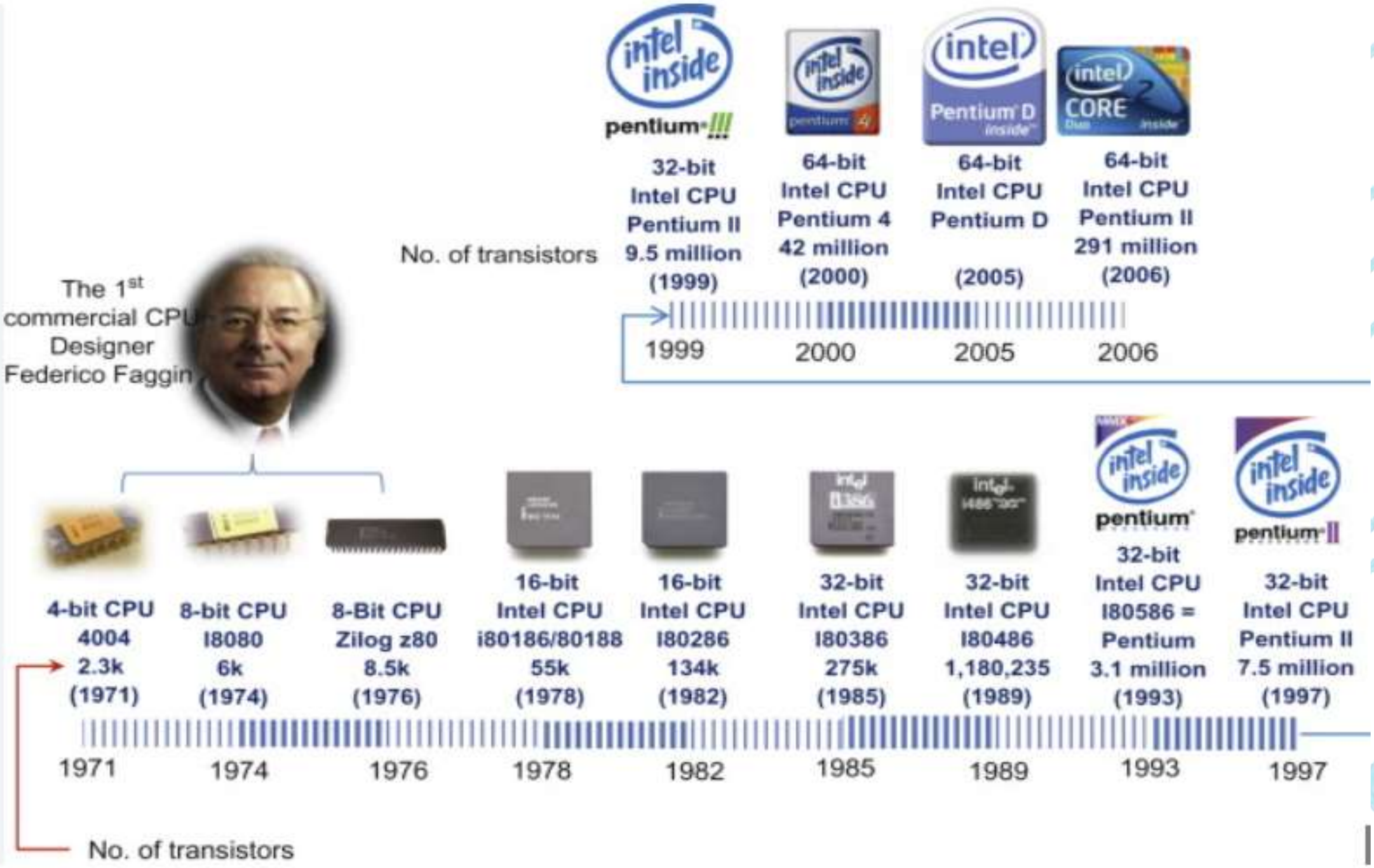
- Observe the Characteristics of Intel Processors
  - Intel 4004 to Intel Core i9
- Basic CPU Structure
  - CU
  - BU
  - ALU
- Various Registers in CPU
  - AC, DR, AR, PC, MAR, MBR, IR
- Types of Buses
  - Common/Shared Bus and Dedicated Bus
  - Serial Bus and Parallel Bus

Processor Evolution

Sr. No.	Processor Name	Invention Year	Word Size	Size of Physical Memory	Virtual Memory Supported?	What's New?
1	Intel 4004	1971	4-bit	640 bytes	No	First microprocessor
2	Intel 8008	1972	8-bit	16 KB	No	8-bit CPU for general computing
3	Intel 8080	1974	8-bit	64 KB	No	Extended instruction set
4	Intel 8085	1976	8-bit	64 KB	No	Improved 8080 architecture
5	Intel 8086	1978	16-bit	1 MB	Yes	16-bit registers, protected mode
6	Intel 80186	1982	16-bit	1 MB	Yes	Integrated peripherals
7	Intel 80286	1982	16/32-bit	16 MB	Yes	Protected mode, virtual memory
8	Intel 80386	1985	32-bit	4 GB	Yes	32-bit registers, paging

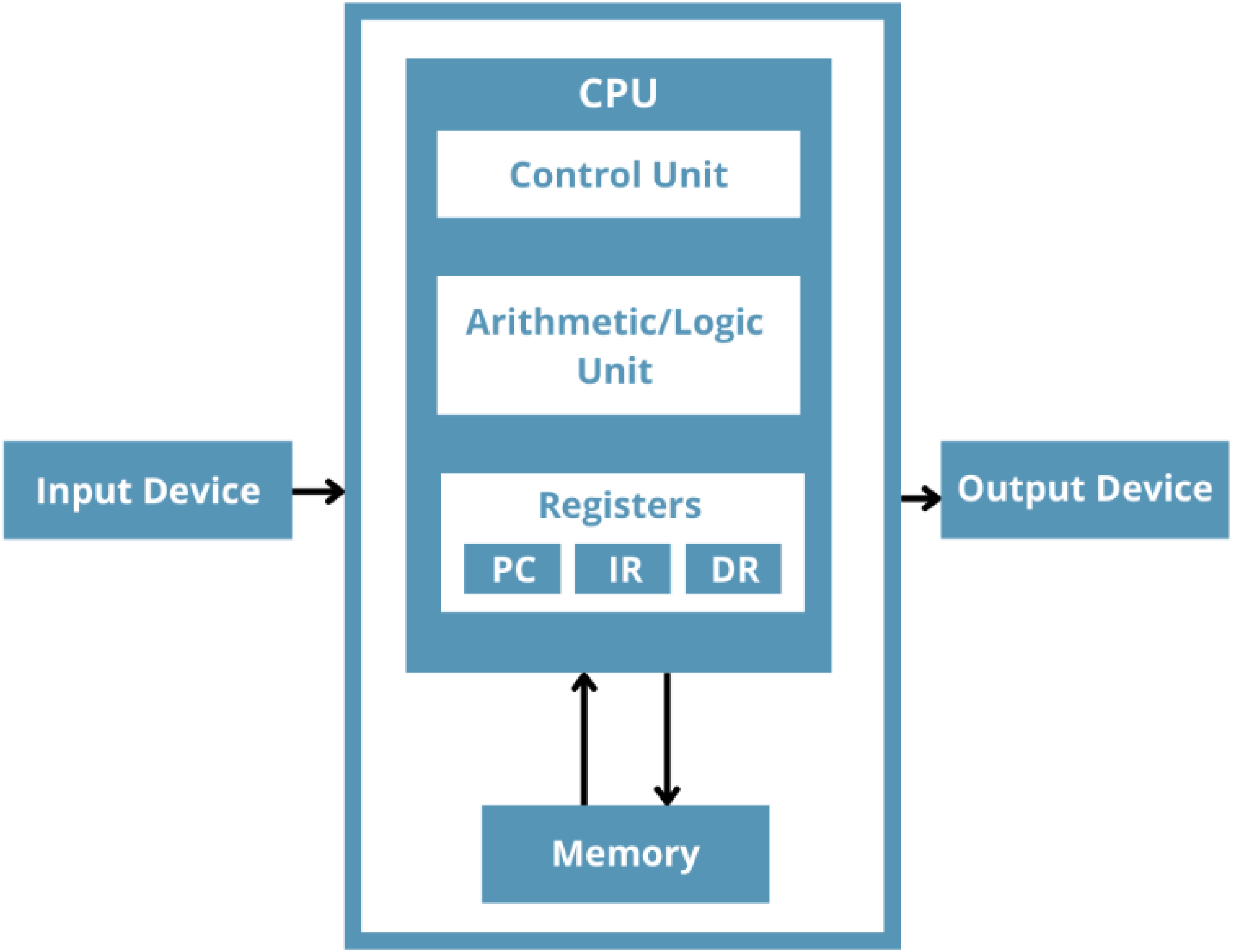
Processor Evolution

Sr. No.	Processor Name	Invention Year	Word Size	Size of Physical Memory	Virtual Memory Supported?	What's New?
9	Intel 80486	1989	32-bit	4 GB	Yes	Built-in cache, pipelining
10	Intel Pentium I	1993	32-bit	4 GB	Yes	Superscalar architecture
11	Intel Pentium II	1997	32-bit	64 GB	Yes	MMX technology
12	Intel Pentium III	1999	32-bit	64 GB	Yes	SIMD instructions
13	Intel Pentium IV	2000	32-bit	4 GB	Yes	Hyper-Threading Technology
14	Intel Core i3	2010	64-bit	Varies	Yes	Hyper-Threading Technology
15	Intel Core i5	2009	64-bit	Varies	Yes	Turbo Boost Technology
16	Intel Core i7	2008	64-bit	Varies	Yes	Multi-core architecture
17	Intel Core i9	2017	64-bit	Varies	Yes	High-performance computing


No. of transistors
32-bit Intel CPU Pentium III 9.5 million (1999)
64-bit Intel CPU Pentium 4 42 million (2000)
64-bit Intel CPU Pentium D (2005)
64-bit Intel CPU Pentium II 291 million (2006)
1999
2000
2005
2006
The 1st commercial CPU Designer Federico Faggin
4-bit CPU 4004 2.3k (1971)
8-bit CPU I8080 6k (1974)
8-Bit CPU Zilog z80 8.5k (1976)
16-bit Intel CPU i80186/80188 55k (1978)
16-bit Intel CPU I80286 134k (1982)
32-bit Intel CPU I80386 275k (1985)
32-bit Intel CPU I80486 1,180,235 (1989)
32-bit Intel CPU I80586 = Pentium 3.1 million (1993)
32-bit Intel CPU Pentium II 7.5 million (1997)
1971
1974
1976
1978
1982
1985
1989
1993
1997
No. of transistors

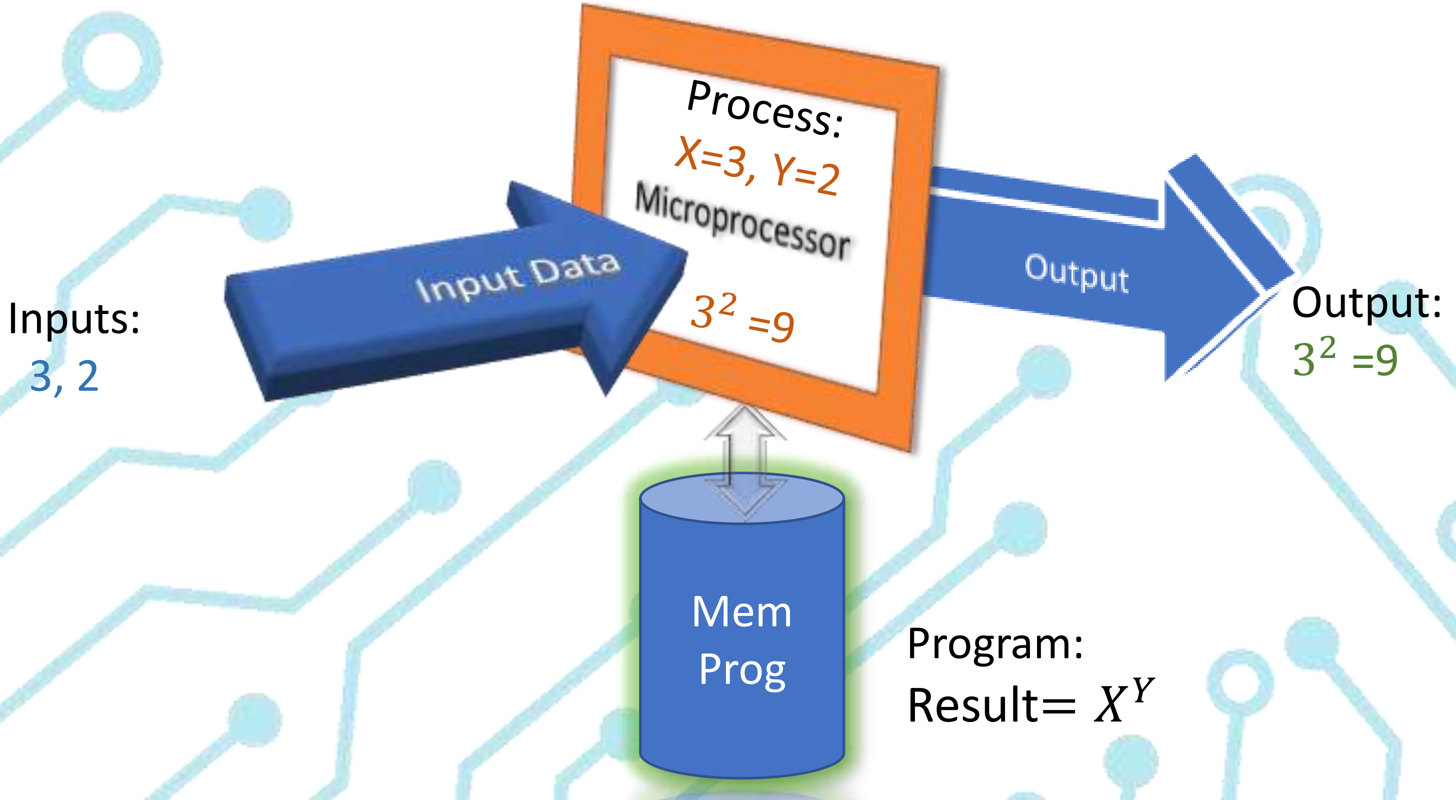
Basic CPU Structure

- The CPU is known as a Central Processing Unit of the computer it mainly consists of 3 Components namely: **ALU, CU & MU**.
  - **ALU: Arithmetical and Logical Unit –** Responsible for performing all the calculative tasks.
  - **CU: Control Unit** – Responsible for generating set of signals periodically, suggesting each and every component of the processor and peripherals to do their tasks timely.
  - **MU: Memory Unit –** Responsible for holding small amount of temporary user data, which can be accessed parallelly by the ALU for processing in the form of CPU Registers.


CPU
Control Unit
Arithmetic/Logic Unit
Registers
PC
IR
DR
Input Device
Output Device
Memory

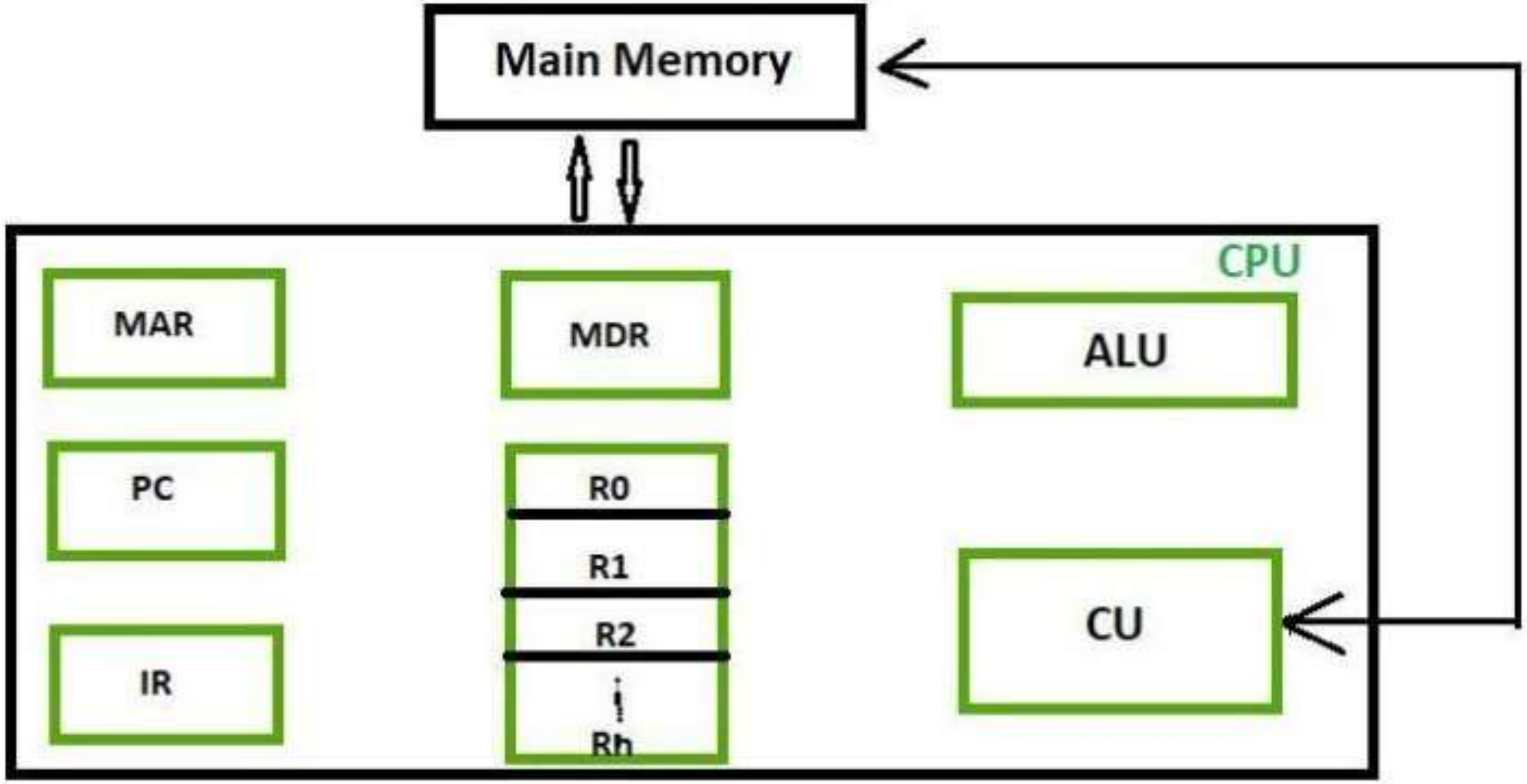
Basic CPU Structure

- The microprocessor is a programmable device that takes in numbers, performs on them arithmetic or logical operations according to the program stored in memory and then produces other numbers as a result.

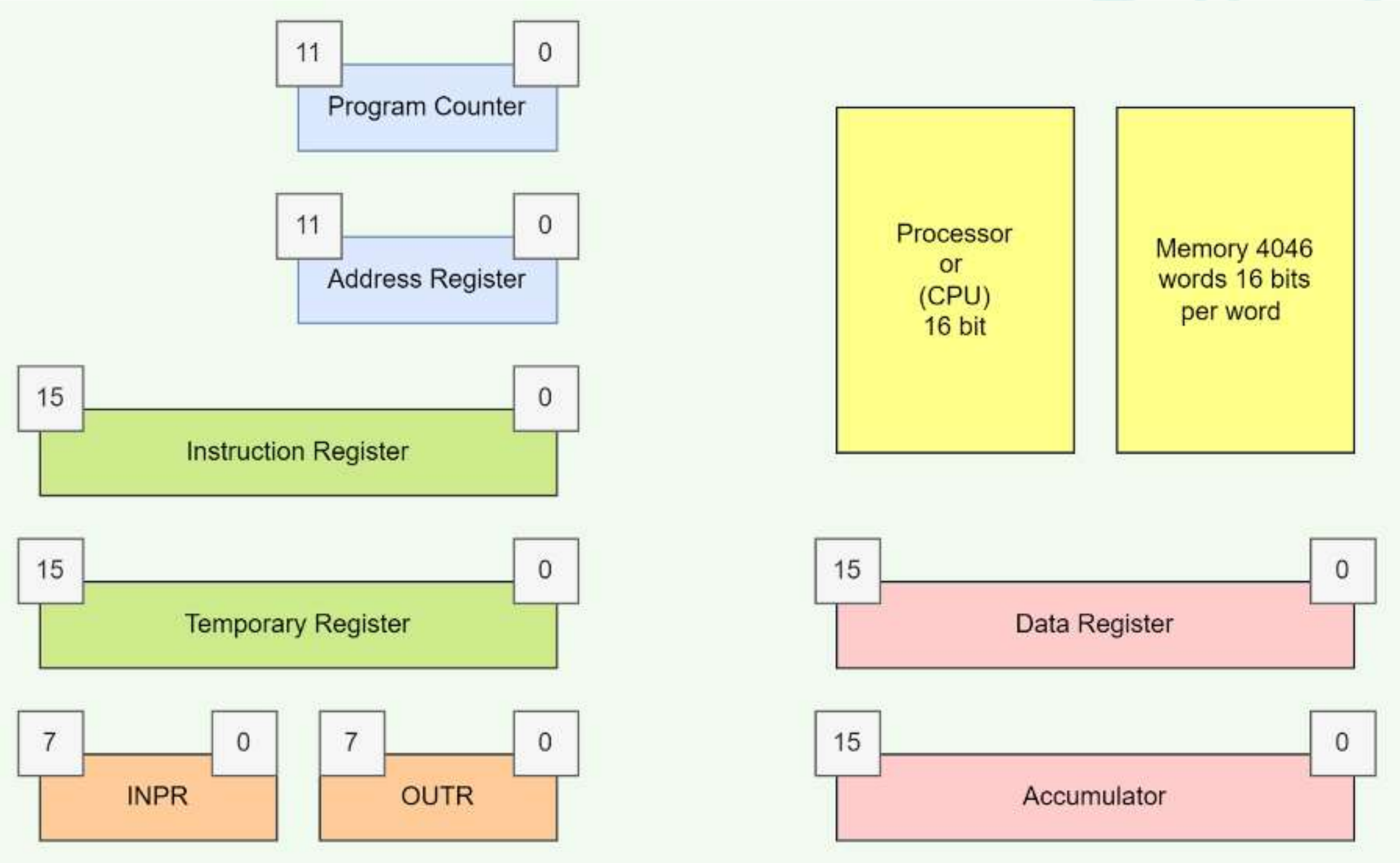


Various Registers

- Registers are used by Microprocessor to store some data temporarily and access it for processing.
- Advantage of using registers to store the data is to be able to fetch the data parallelly from inside the microprocessor itself **(Much Faster)**. No need to go outside to find the data needed **(Slow Process)**.
- Various registers are used to store various types of data:
  - **General Purpose Registers:** Used to store user data temporarily.
  - **Special Purpose Registers:** Used to store some temporary information, which is not simple user data.
- To identify each register individually, they are given various labels according to their usage, but those label varies from processor to processor.



Types Of CPU Registers



11
0
Program Counter
11
0
Address Register
15
0
Instruction Register
15
0
Temporary Register
7
0
INPR
7
0
OUTR
Processor
or
(CPU)
16 bit
Memory 4046
words 16 bits
per word
15
0
Data Register
15
0
Accumulator

Usage of: AC, DR, AR, PC, MAR, MBR, IR

- These are some of the generic names given to some special purpose registers in the Microprocessor.
- **AC: Accumulator –** The default register used to perform all ALU Operations. The size of AC is usually the word size of the processor.
- **DR: Data Register –** Used to store simple user data temporarily.
- **AR: Address Register –** Used to store any type of Addresses.
- **PC: Program Counter –** Used to store the address of the next instruction to be executed in the given program.
- **IR: Instruction Register –** Used to Store the opcode of the instruction to recognize the instruction and further decode it.

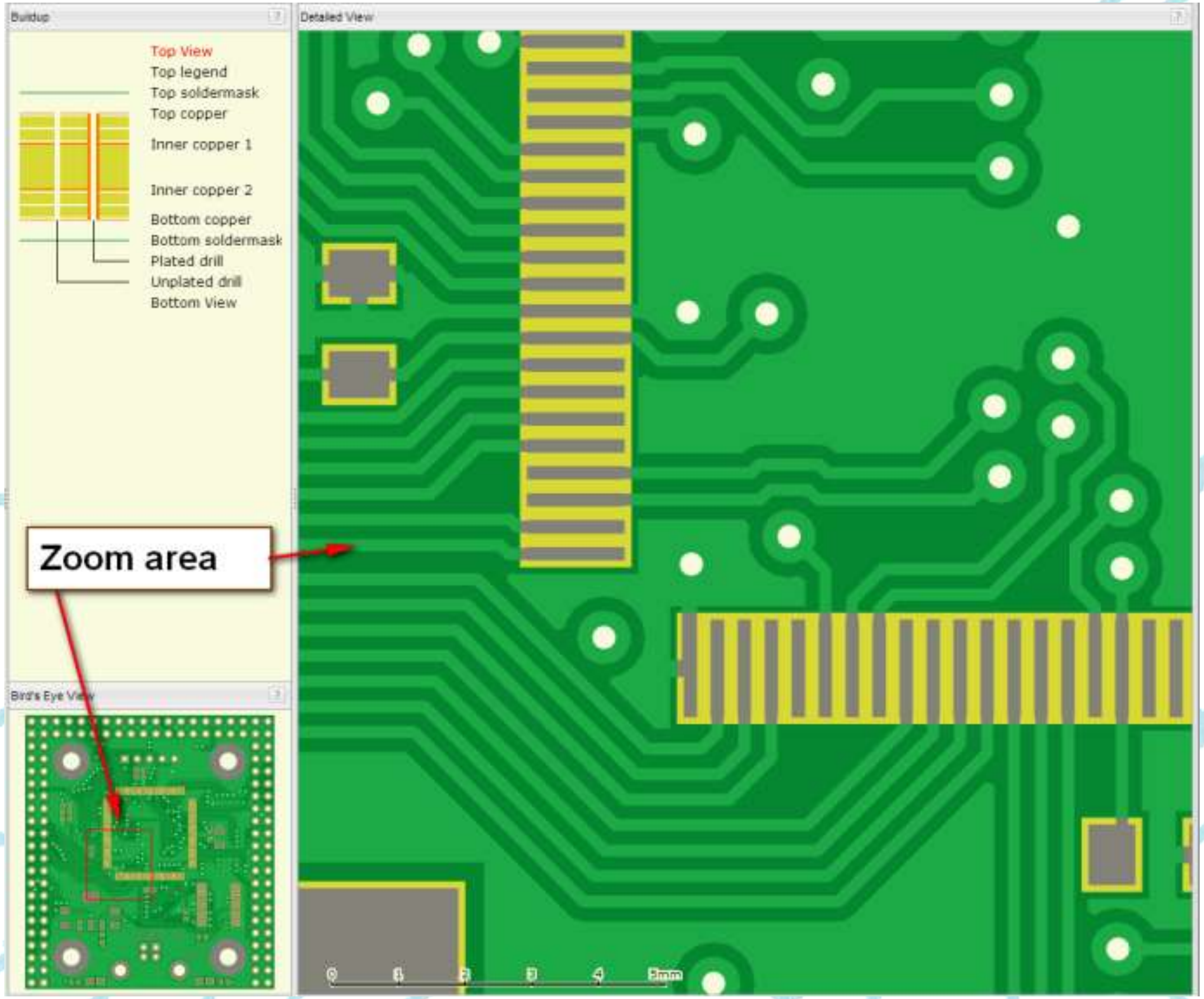
- **MAR: Memory Address Register –** Used to store address of some data in Main Memory.
- **MDR: Memory Data Register –** It contains data to be written into or to be read out from the addressed location.

  MAR and MDR (Memory Data Register) together facilitate the communication of the CPU and the main memory.
- **General Purpose Registers**: These are numbered as R0, R1, R2….Rn-1, and used to store temporary data during any ongoing operation.
- **Stack Pointer (SP):** The stack pointer points to the top of the stack, which is a part of the memory used to store function calls and other operations.

Types of Buses

- **Bus:** A set of parallel electrical or logical connections that allow for the transfer of data, control signals, and memory addresses between components within a computer system, facilitating communication and coordination among these components.
- Classification of the buses can be done in following manners:
  - Based on the ownership of the bus
    - Common / Shared Bus
    - Dedicated Bus
  - Based on the mode of data communication provided by the bus
    - Serial Bus
    - Parallel Bus

Types of Buses



Common/Shared Bus v/s Dedicated Bus

Sr. No.	Criteria	Common/Shared Bus	Dedicated Bus
1	**Purpose**	Used to connect multiple components, enabling shared communication	Reserved for exclusive communication between specific components
2	**Usage**	Shared by CPU, memory, and I/O devices	Exclusively connects specific components or functions
3	**Access Control**	Components contend for access, requiring arbitration mechanisms	No contention for access, reducing bus conflicts
4	**Performance**	May lead to bottlenecks and reduced performance due to contention	Offers better performance for dedicated components
5	**Complexity**	Simplifies system architecture but can become complex due to contention	May introduce complexity but provides optimized paths
6	**Examples**	Memory bus shared by CPU, RAM, and I/O devices	CPU-GPU bus dedicated to high-speed graphics transfer
7	**Flexibility**	Offers flexibility as components can dynamically access the bus	Provides less flexibility due to dedicated use

Serial Bus v/s Parallel Bus

Sr. No.	Criteria	Serial Bus	Parallel Bus
1	**Data Transmission**	Sends data bit by bit sequentially.	Sends multiple bits simultaneously in parallel.
2	**Number of Wires**	Requires fewer wires, typically 2 (transmit and receive).	Requires more wires (8, 16, 32, etc., depending on data width).
3	**Data Rate**	Slower data transfer rates compared to parallel buses.	Offers faster data transfer rates due to parallelism.
4	**Complexity**	Simplifies cabling and reduces signal interference.	Increases complexity due to more wires and potential signal interference.
5	**Distance**	Suitable for longer-distance communication.	Limited to shorter distances due to signal degradation in parallel cables.
6	**Cost**	Generally more cost-effective due to fewer wires and connectors.	Can be more expensive due to the cost of additional wires and connectors.
7	**Applications**	Commonly used in applications like serial communication protocols (USB, Ethernet).	Historically used in internal computer buses (e.g., IDE, SCSI).
8	**Scalability**	Easier to scale for long-distance communication.	Limited scalability due to signal degradation.
9	**Example**	USB, Ethernet, SATA (Serial ATA)	Parallel ATA (PATA), parallel printer ports

1.3.2 Serial Bus V/S Parallel Bus :

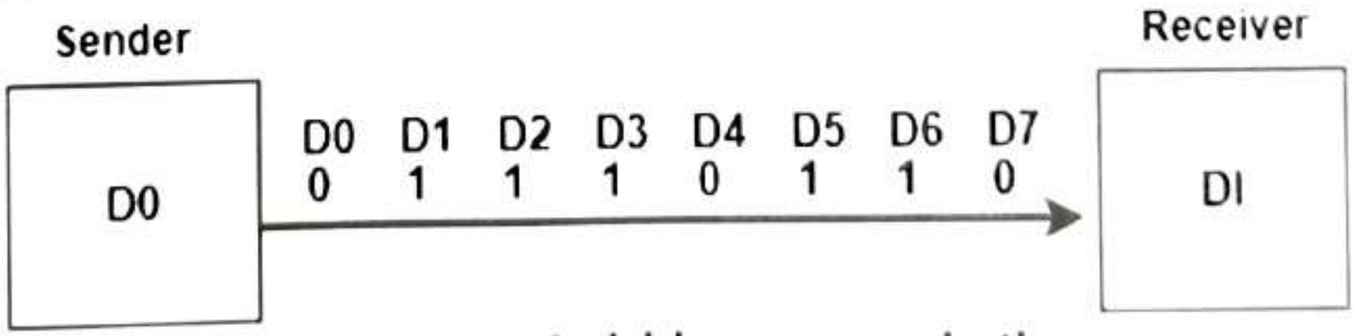


Figure 1.3 : Serial bus communication

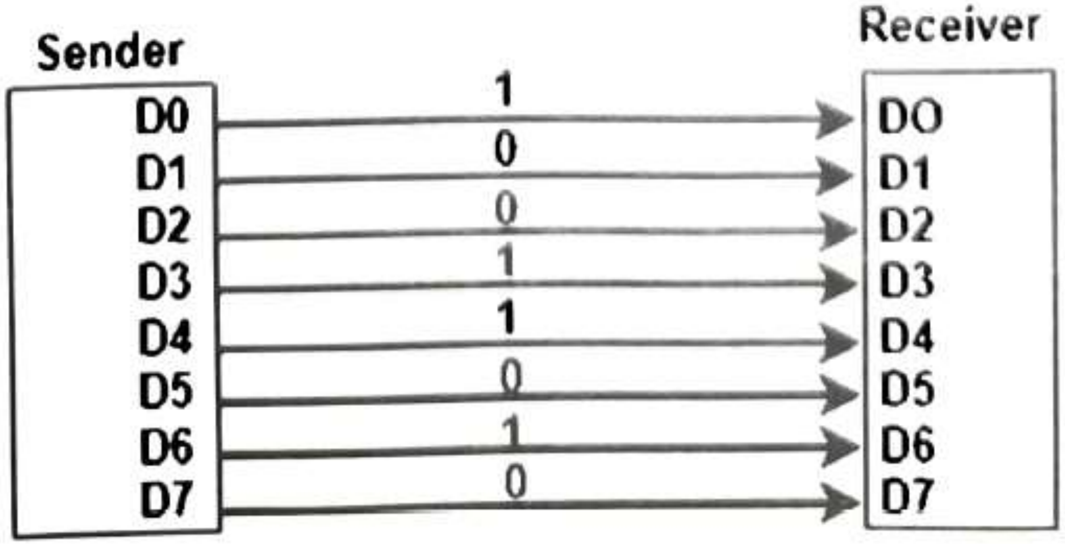


Figure 1.4 : Parallel bus communication

Features of Processor

Clock speed: One of the earliest features of microprocessors was the clock speed, which refers to the speed at which the processor can execute instructions. Over time, clock speeds have increased, with modern processors capable of speeds in the billions of cycles per second (GHz).

Instruction set architecture: Microprocessors have evolved to support different instruction set architectures, including CISC (complex instruction set computer) and RISC (reduced instruction set computer), which affect the efficiency and complexity of processing.

Cache memory: Microprocessors now include a cache memory, which is a small amount of high-speed memory that stores frequently used data for quicker access.

Multi-core processors: Modern microprocessors have multiple cores, allowing for multiple tasks to be executed simultaneously, increasing performance and multitasking capabilities.

Virtualization: Microprocessors now support virtualization, which enables multiple operating systems to run on the same physical hardware.

Power management: Modern processors include power management features, which reduce power consumption and improve energy efficiency.

Graphics processing: Many modern microprocessors include integrated graphics processing units (GPUs), which allow for faster and more efficient handling of graphics-intensive tasks.

Security features: Microprocessors now include security features, such as hardware-level encryption and secure boot, to protect against malware and hacking.

Internet connectivity: Microprocessors now include built-in networking capabilities, such as Wi-Fi and Ethernet, which allow for seamless internet connectivity

Advantages of the microprocessor -

1. High processing speed
2. Compact size
3. Easy maintenance
4. Can perform complex mathematics
5. Flexible
6. Can be improved according to a requirement

Disadvantages of microprocessors -

1. Overheating occurs due to overuse
2. Performance depends on the size of the data
3. Large board size than microcontrollers
4. Most microprocessors do not support floating-point operations