# Introduction to Processors

# Outline

Microprocessors

Central Processing Unit

Digital Signal Processor

Graphical Processing Unit

Coprocessor

Multiprocessing

Parallelism

# Processor

# Definition

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- It is a logic circuitry that responds to and processes the basic instructions that drive a computer
- The term is frequently used to denote “The central processing unit”
- It combines a number of specialised processors

# Primary Functions of a Processor

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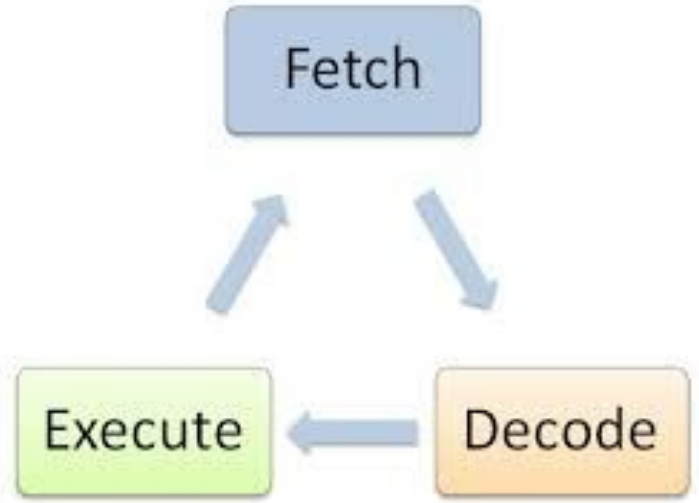
- Fetch
- Decode
- Execute
- Writeback



# Basic Elements of a Processor

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1. Arithmetic logic unit(ALU)
2. The floating point unit(FPU)
3. Registers
4. Cache Memory

# Multicore Processor

# Core

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A core is a processing unit which receives instructions and performs calculations, or actions based on those instructions

A set of instructions can allow a software program perform a specific functions

Processors may have single core or multiple cores

# Multicore - An Introduction

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IC contains two or more processors for:

1. Enhanced performance
2. Reduced power consumption
3. Simultaneous processing of multiple tasks.

Different processors are installed to the same socket for the connection to become faster

# Single Core Processor

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A single core is the single calculations unit or processing unit that executes the calculations

It is a microprocessor with a single core on a chip, running single thread(task) at a time

# Advantages and Disadvantages

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**Advantages:**

1. Uses less power
2. Runs cooler
3. Sufficient for more softwares

**Disadvantages:**

1. Runs slower
2. Freezing

# Dual Core Processor

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Dual-core refers to a CPU that includes two complete execution cores per physical processors.

It has combined two processors and their caches and cache controllers onto a single integrated chip.

It is well suited for multi-tasking.

# Advantages and Disadvantages

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**Advantages:**

1. Performs tasks faster
2. Reduced costs

**Disadvantages:**

1. Wasted computer power
2. Compatibility with software

# Quad Core Processor

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It is a processor with four individual units called cores that read and execute the CPU instructions such as add, move data, branching etc.

Each core operates in conjunction to other circuits

Each processor can run multiple instructions  at the same time, increasing the overall speed for computing, compatible with parallel processing

# Advantages and Disadvantages

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**Advantages:**

1. Multitasking.

2.Run intensive applications.

3. Less heat and power consumption.

4. Use for long run.

**Disadvantages:**

1.Lowers battery life.

2.Available software.

3.Hardware compatibility

# Central Processing Unit

# Definition

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The computer component that's responsible for interpreting and executing most of the commands.

CPUs exist in many kinds of device apart from computers

# Components of a CPU

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1) **Arithmetic Logical Unit** - Performs arithmetic and logical operations

2) **Control Unit** - reads and interprets instructions from memory and transforms them into a series of signals to activate other parts of the computer

3) **Cache memory** - where instructions can be carried to and retrieved

# Location of a CPU

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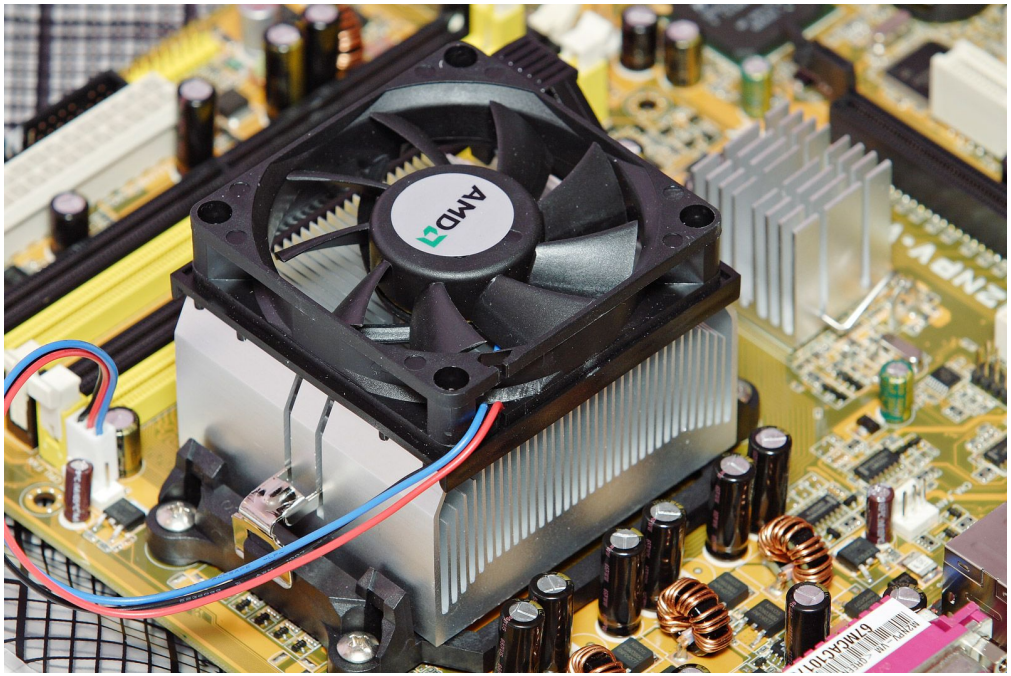
The processor is attached directly to a slot on the motherboard

CPUs can get very hot




Inside a processor, we can store zeros and ones using transistors.one if a current passes through and a zero if a current does not pass through

# Clock Speed

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The clock speed determines how many calculations it can perform in one second of time

The higher the speed, the more calculations it can perform, thus making the computer faster

# Microprocessors

# Definition

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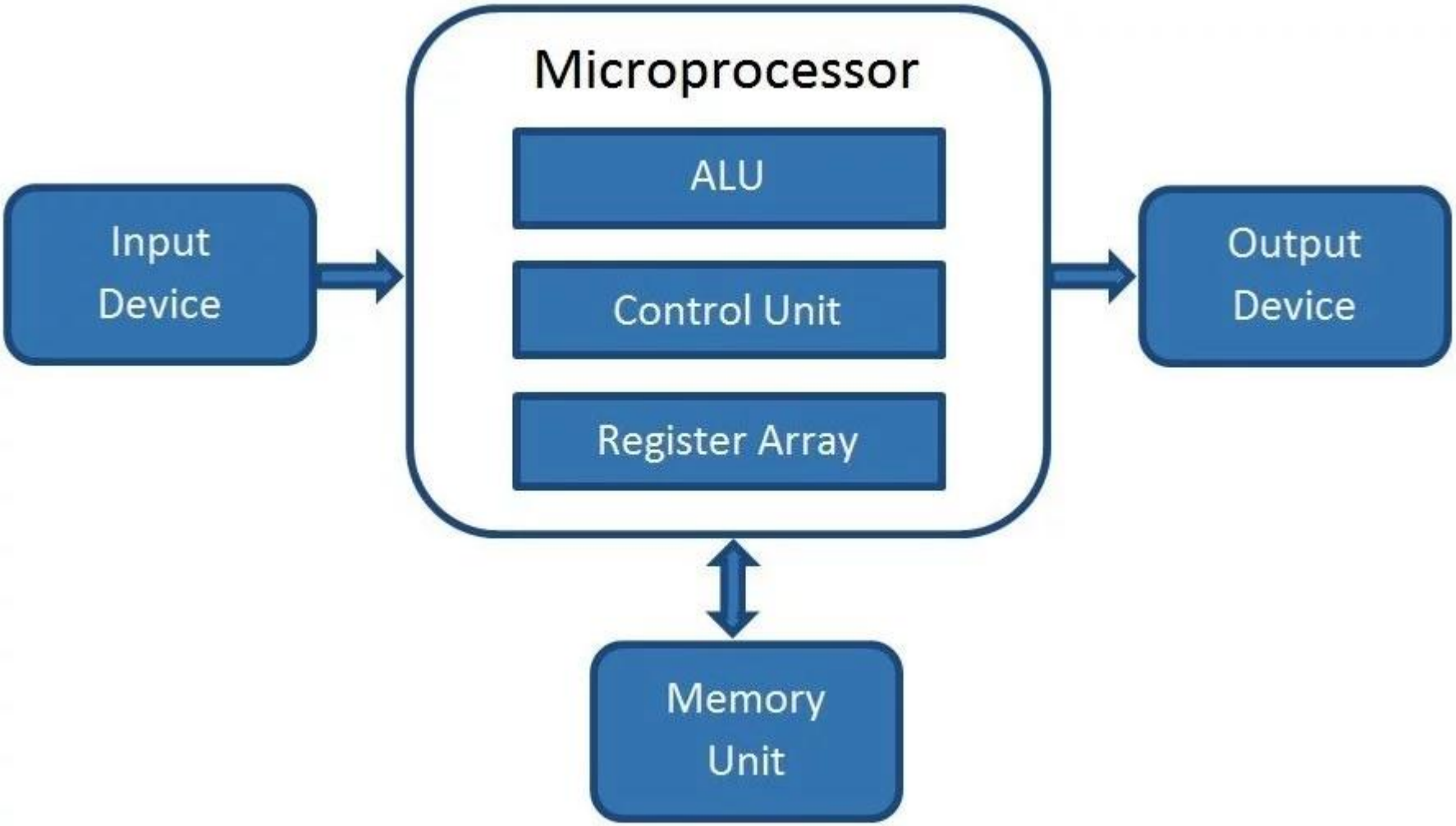
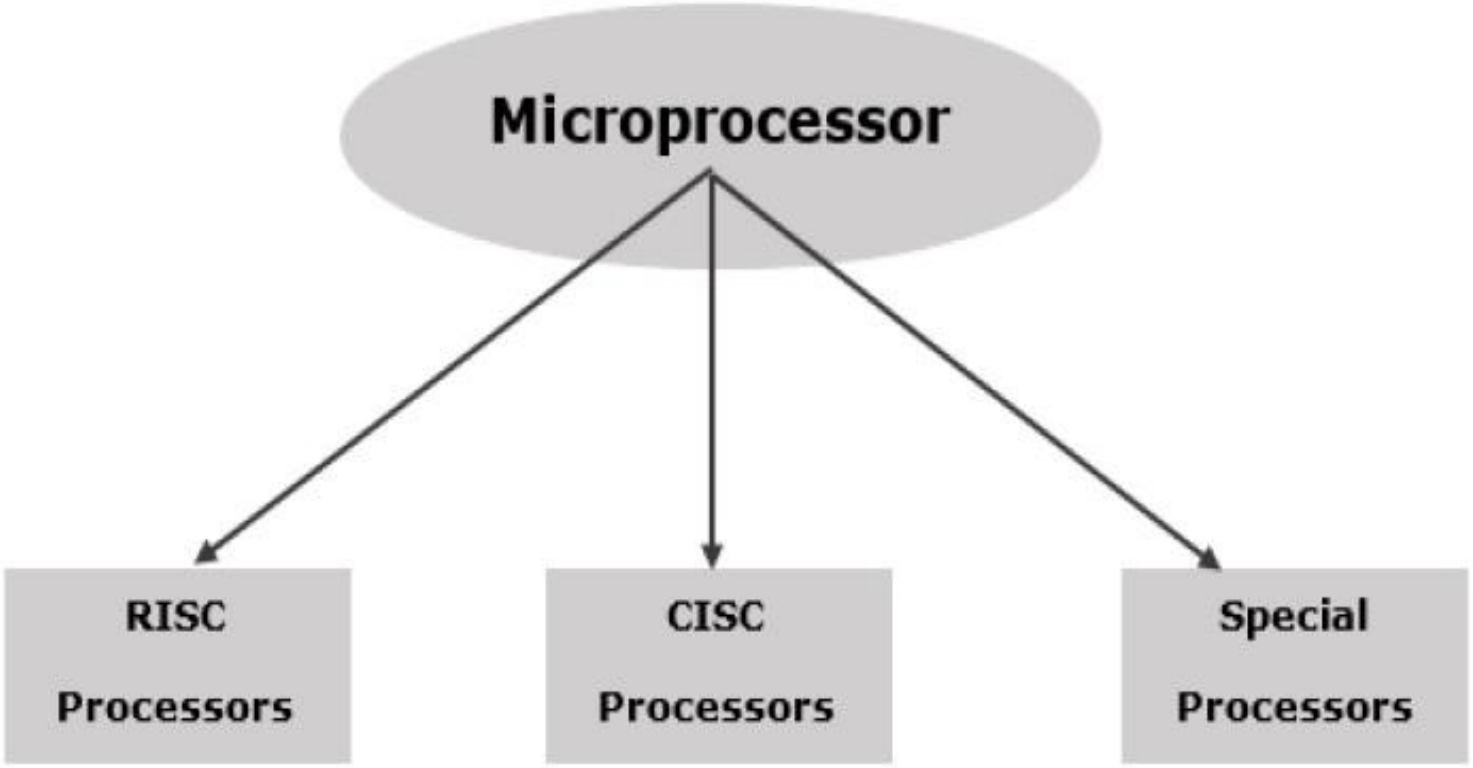
A microprocessor is an integrated circuit which incorporates the core functions of a computer’s Central Processing Unit

Programmable multi purpose silicon chip that accepts binary data as input and provides output after processing it as per the instructions


Microprocessor
ALU
Control Unit
Register Array
Input Device
Output Device
Memory Unit

# Classification



# RISC Processor

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- RISC stands for Reduced Instruction Set Computer
- Used in portable devices due to its power efficiency
- Designed to reduce the execution time by simplifying the instruction set of the computer
- Each instruction requires only one clock cycle to execute results in uniform execution

# Characteristics

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- Simple Instructions
- Supports few simple data types and synthesize complex data types
- Simple addressing modes and fixed length instructions for pipelining
- Permits any register to use in any context
- One Cycle Execution Time
- The amount of work that a computer can perform is reduced by separating “LOAD” and “STORE” instructions

# Characteristics

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- Pipelining is easy as the execution of all instructions will be done in a uniform interval of time i.e. one click
- More RAM is required to store assembly level instructions
- Reduced instructions need a less number of transistors
- Consists of larger number of registers

# CISC Processors

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- CISC stands for Complex Instruction Set Computer
- Designed to minimize the number of instructions per program, ignoring the instructions cycles per instruction
- Emphasis on building complex instructions directly into the hardware
- Designed to decrease the memory cost
- IBM 370/168,VAX 11/780, INTEL 80486

# Characteristics

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- Variety of addressing modes
- Larger number of instructions
- Variable length of instruction formats
- Several cycles may be required to execute one instruction
- Instruction-decoding logic is complex

# RISC vs CISC

# Multiplying Numbers

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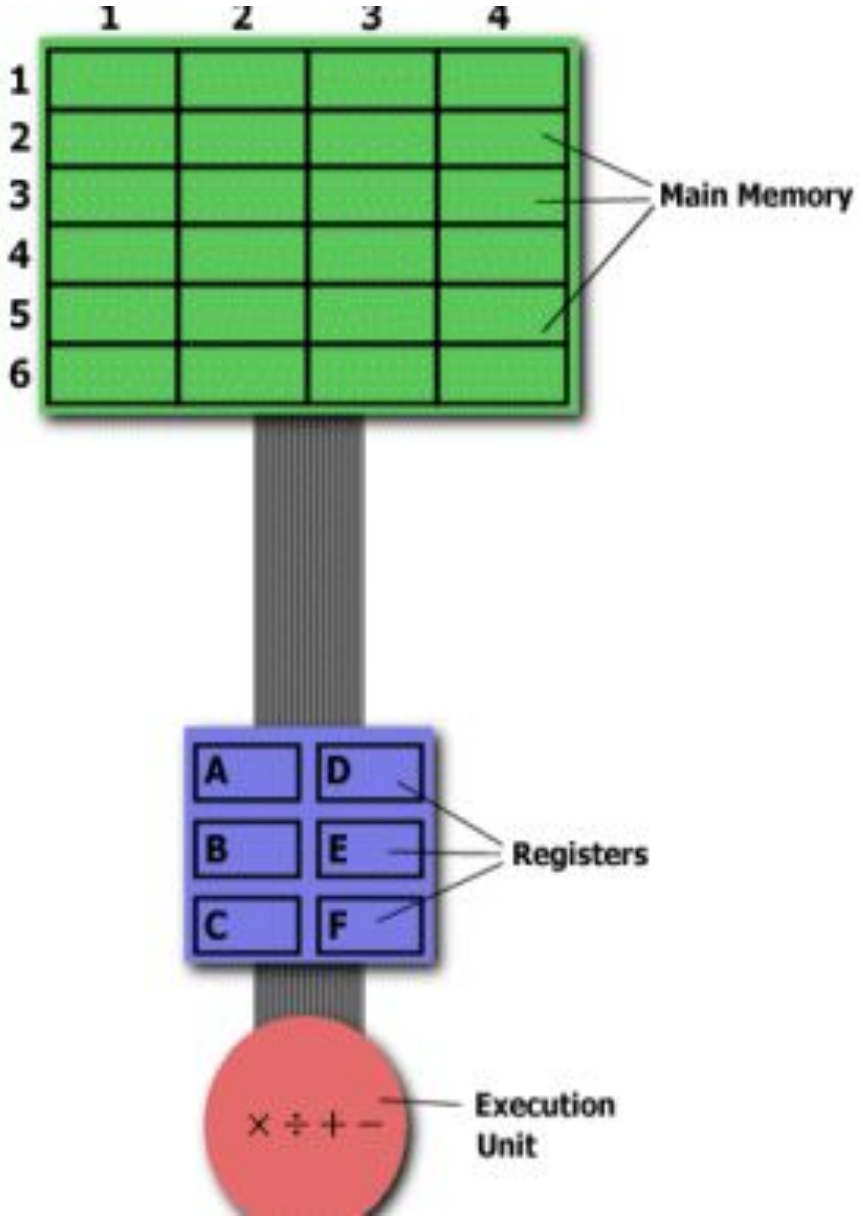
Let's say we want to find the product of two numbers - one stored in location 2:3 and another stored in location 5:2 - and then store the product back in the location 2:3



# The CISC approach

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- The primary goal of CISC architecture is to complete a task in as few lines of assembly as possible

- The entire task of multiplying two numbers can be completed with one instruction
    - **MUL 2:3, 5:2**

# The RISC Approach

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- RISC processors only use simple instructions that can be executed within one clock cycle

- In order to perform the exact series of steps described in the CISC approach, a programmer would need to code four lines of assembly:
    - **LOAD A, 2:3**
    - **LOAD B, 5:2**
    - **PROD A, B**
    - **STORE 2:3, A**

# Advantages of RISC

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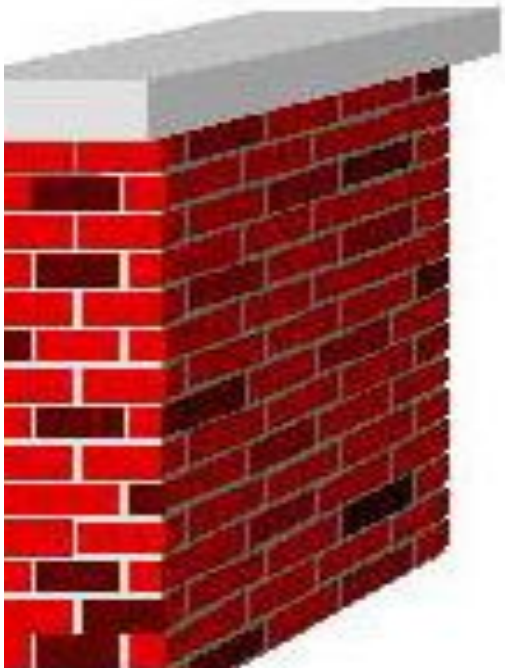
- Each instruction requires only one clock cycle to execute
- Requires less transistors of hardware space than the complex instructions
- Separating the "LOAD" and "STORE" instructions actually reduces the amount of work that the computer must perform

# RISC roadblocks



# A Special Processor

| | Data Manipulation | Math Calculation |
|---|---|---|
| Typical Applications | Word processing, database management, spread sheets, operating sytems, etc. | Digital Signal Processing, motion control, scientific and engineering simulations, etc. |
| Main Operations | data movement ($A \rightarrow B$)<br>value testing (*If* $A=B$ *then* ...) | addition ($A+B=C$)<br>multiplication ($A \times B=C$) |

# Digital Signal Processor

# Definition

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A **digital signal processor** (**DSP**) is a specialized microprocessor, with its architecture optimized for the operational needs of digital signal processing.

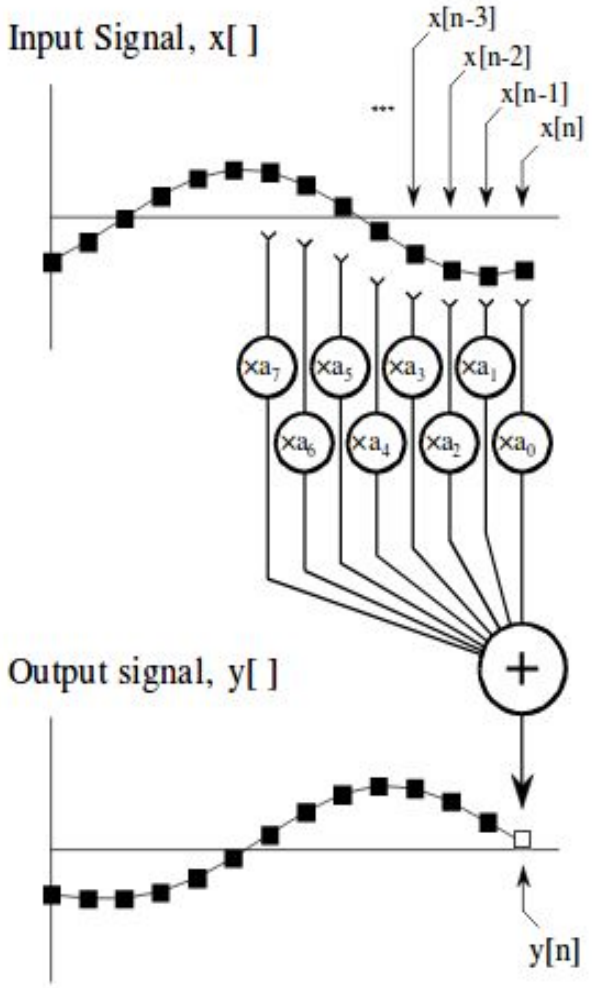

A DSP Chip in a Guitar Effects Unit

# Block Diagram

# Goals

- Measure, filter or compress continuous real-world analog signals
- Execute digital signal processing algorithms
- Maintaining power efficiency
- Reduce constraints on **latency**

# Working of DSP




$$y[n] = a_0 x[n] + a_1 x[n-1] + a_2 x[n-2] + a_3 x[n-3] + a_4 x[n-4] + \cdots$$

# Circular Buffering

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- **Off-line Processing**

  Entire input signal resides in the PC

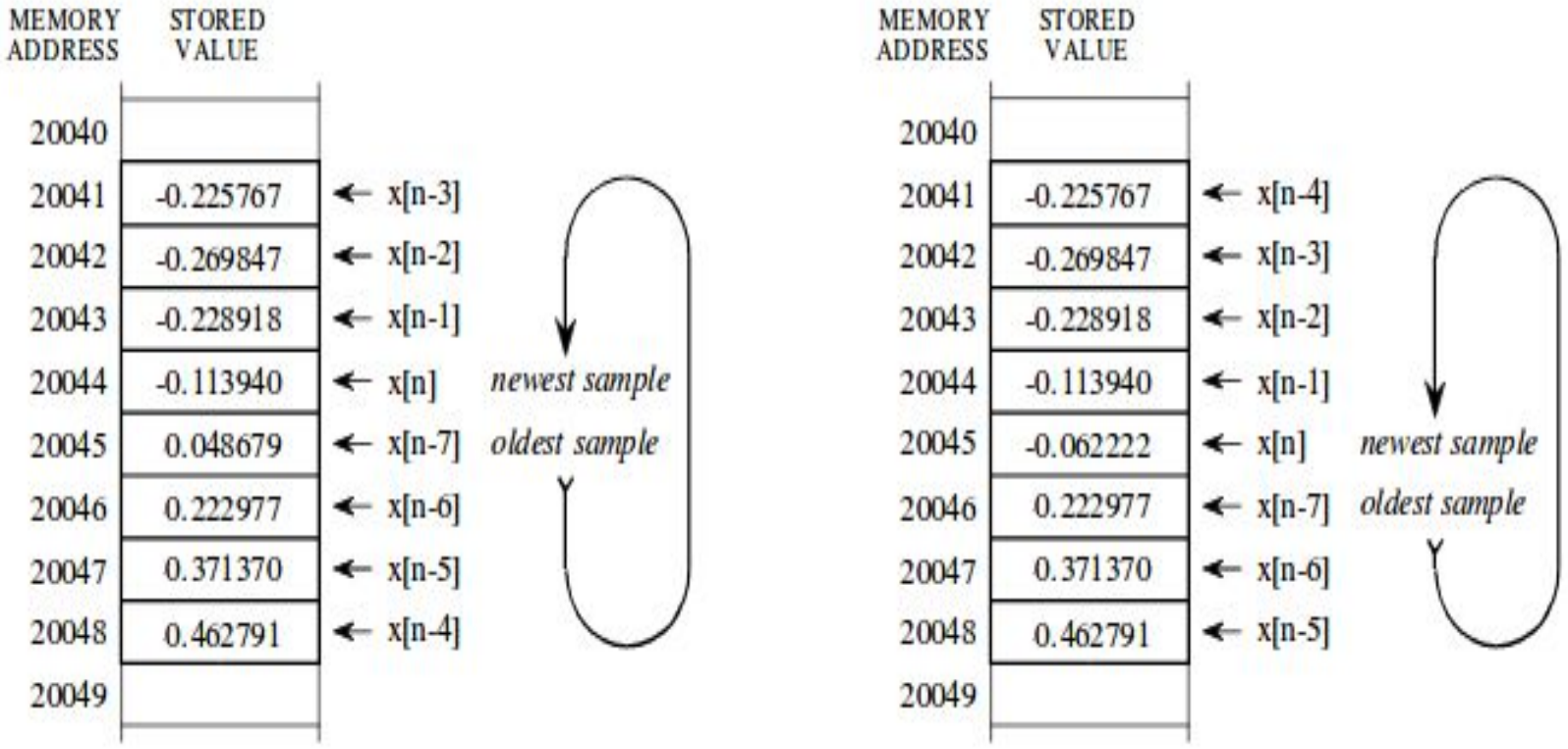
  Common in Scientific research and Engineering

- **Real-Time Processing**

  Output signal is produced at the same time that the input signal is being acquired

  Used in telephone communication, hearing aids and radar

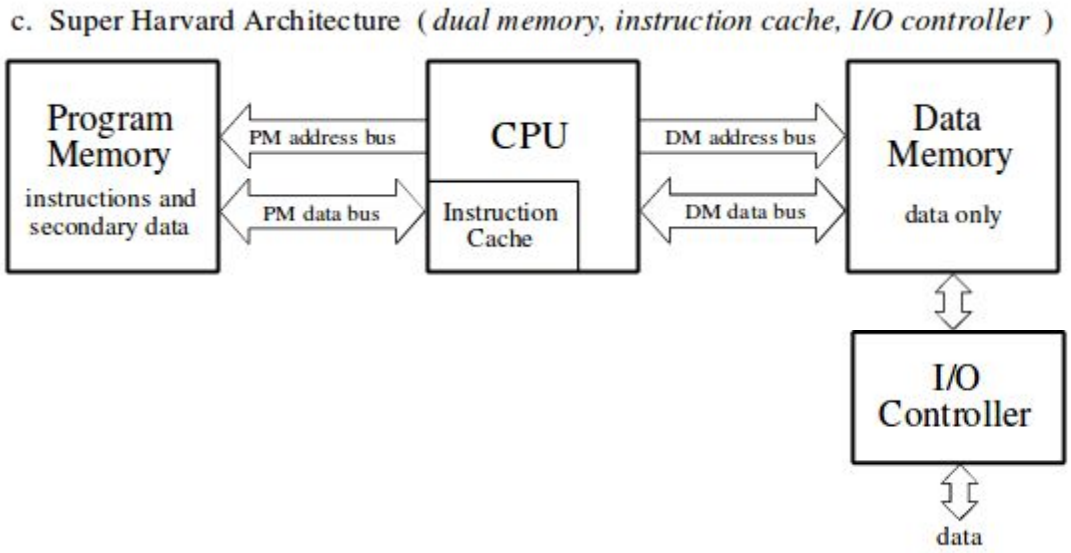
# Circular Buffering Operation

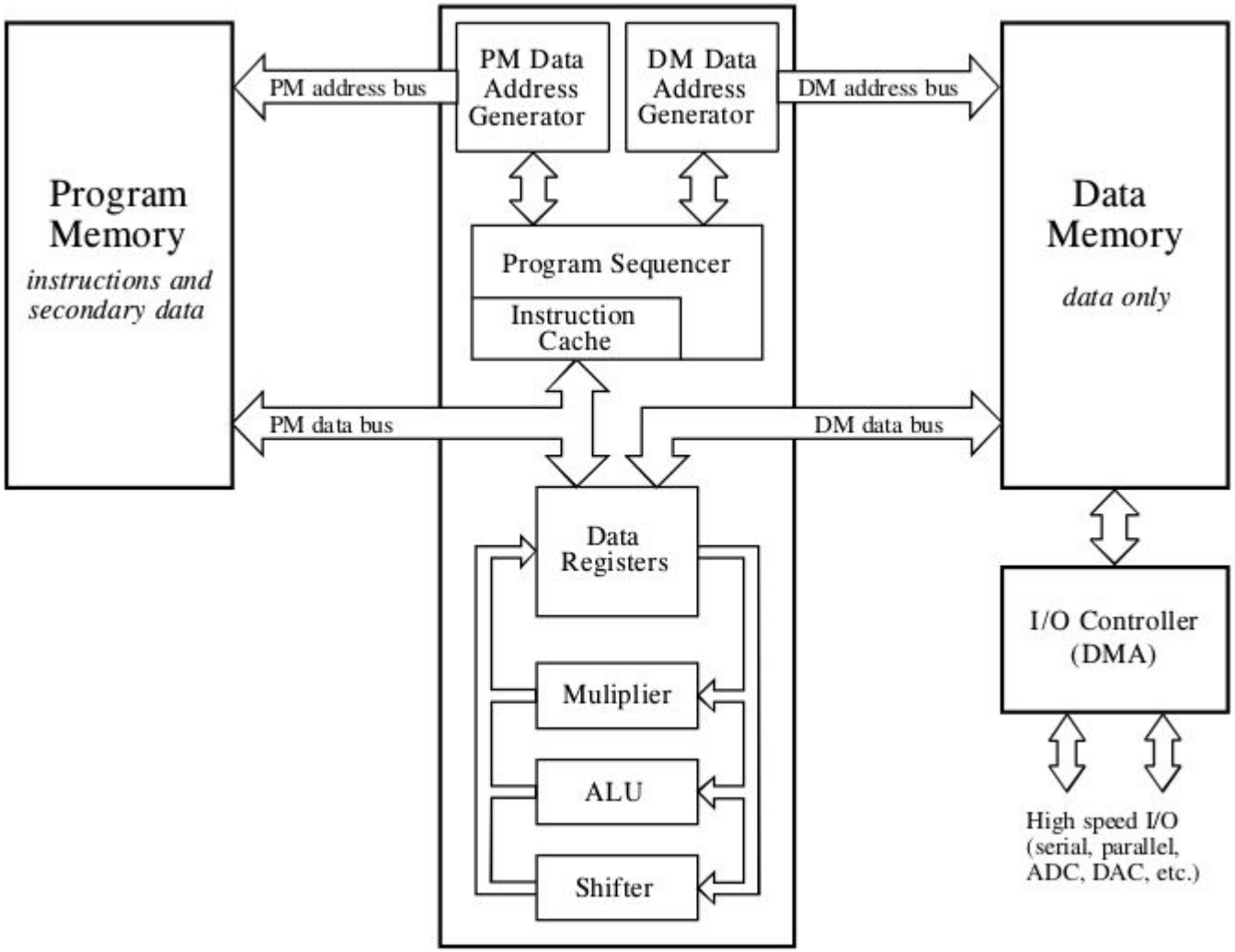



a. Circular buffer at some instant

b. Circular buffer after next sample

# SHARC Architecture




Program Memory
instructions and secondary data
PM address bus
PM Data Address Generator
DM Data Address Generator
DM address bus
Data Memory
data only
Program Sequencer
Instruction Cache
PM data bus
DM data bus
Data Registers
Muliplier
ALU
Shifter
I/O Controller (DMA)
High speed I/O (serial, parallel, ADC, DAC, etc.)

# Graphical Processing Unit

“The sheer power of NVIDIA's next generation GPU gives us greater freedom when designing characters and worlds. The technology not only allows us to incorporate unbelievably detailed visuals, but it also offers the ability to add more robust artificial intelligence, level design, and more. In short, it's the next giant step in gaming."

# Technical Definition

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**GPU** - A single chip processor with integrated **transform**, **lighting**, triangle setup/clipping, and **rendering** engines that is capable of processing a minimum of 10 million **polygons** per second.

# Rendering

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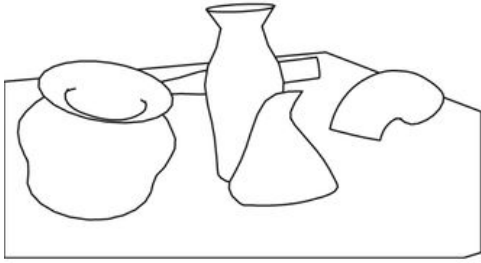
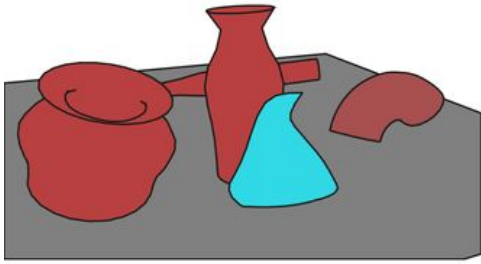
**Rendering** is the automatic process of generating an image from a 2D or 3D model (or models in what collectively could be called a ***scene* file**) by means of computer programs.





# Equality among Rendering Chips

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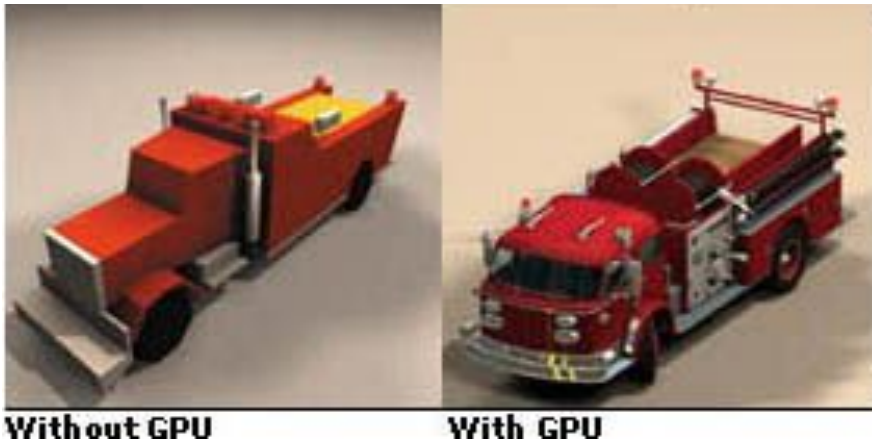
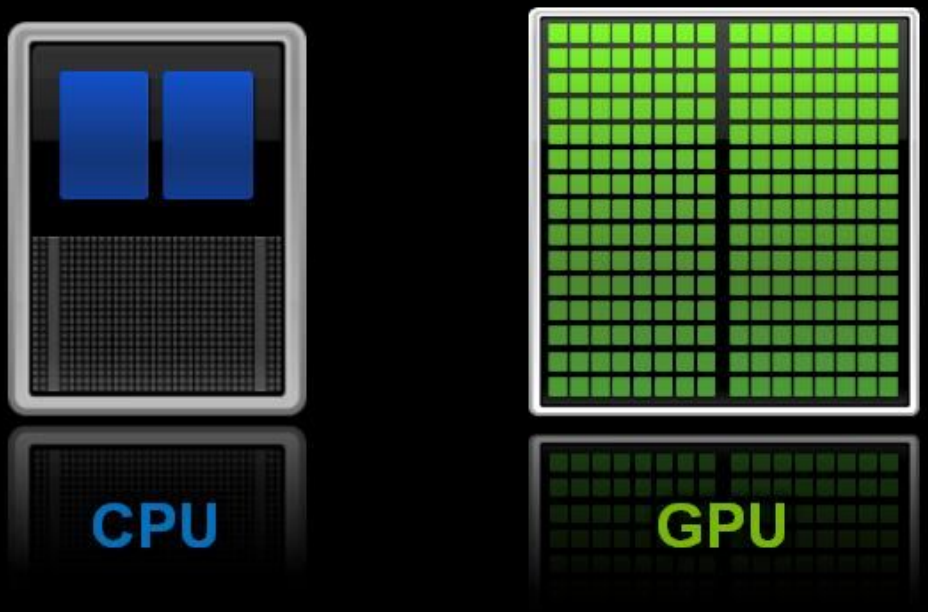
- All PCs have chips that render the display images to monitors
- All these chips are not created equal



# GPU

The Soul of a PC

# *The Difference between a CPU and GPU*

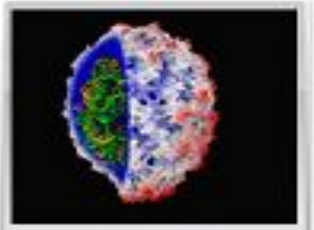


# How GPU Acceleration Works

# Speedups Using GPU vs CPU

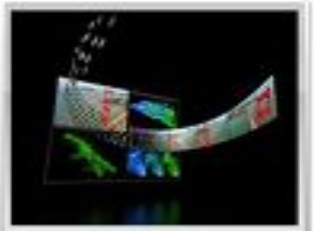
**146X**

Interactive visualization of volumetric white matter connectivity[1]



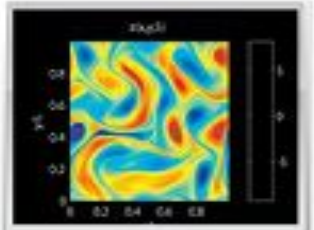
**36X**

Ionic placement for molecular dynamics simulation on GPU[2]



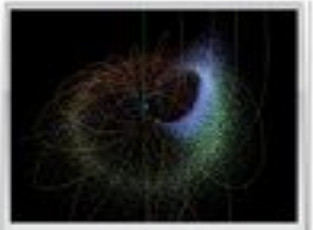
**18X**

Transcoding HD video stream to H.264 for portable video[3]



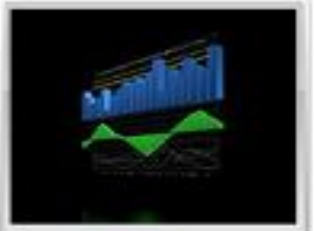
**17X**

Simulation in Matlab using .mex file CUDA function[4]



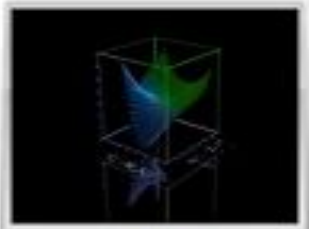
**100X**

Astrophysics N-body simulation[5]



**149X**

Financial simulation of LIBOR model with swaptions[6]



**47X**

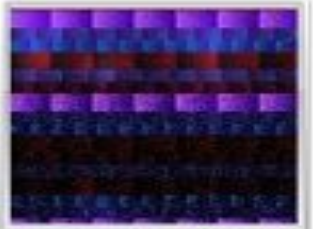
GLAME@lab: M-script API for linear Algebra operations on GPU[7]

**20X**

Ultrasound medical imaging for cancer diagnostics[8]

**24X**

Highly optimized object oriented molecular dynamics[9]



**30X**

Cmatch exact string matching - find similar proteins & gene sequences[10]

# Applications

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- 3D game rendering
- Financial Modeling
- Scientific research
- Oil and Gas Exploration

# Coprocessor

# Definition

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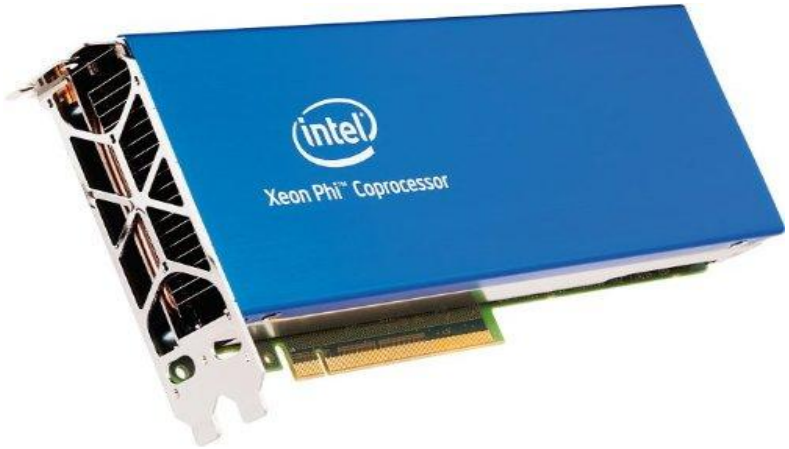
A Coprocessor is a special set of circuit in the microprocessor chip used to supplement the functions performed by the primary processor(CPU)/

Eg: Floating point arithmetic, signal processing ,string processing,graphics,encryption or I/O interfacing with peripheral devices



# Working

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Coprocessor vary in their degree autonomy(self managing character of a processor)

Generally a coprocessor is installed to reduce the burden(math functions and displaying graphics on the screen)on the CPU thereby allowing it to carry out main functions like transferring data and handling multiple tasks

Eg: Math processors,video processors

# Multiprocessor

# Definition

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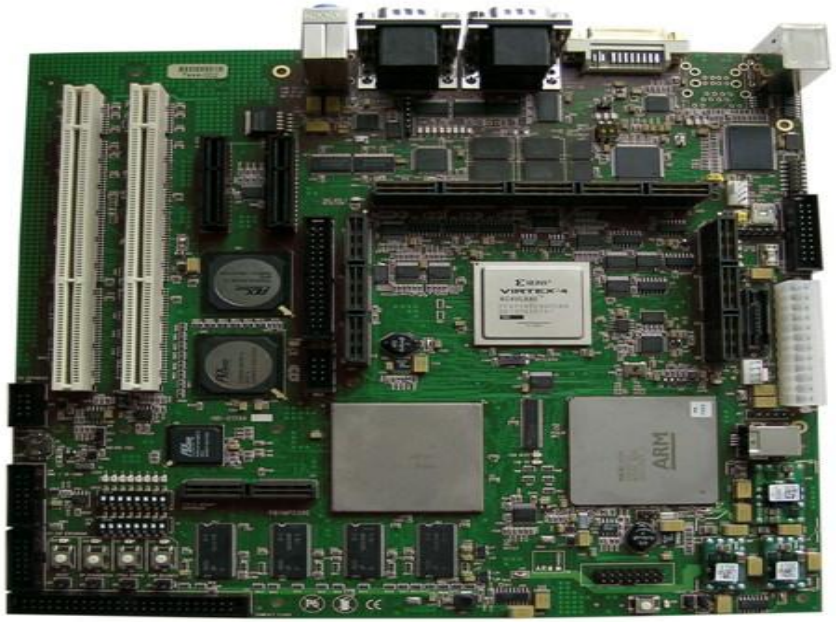
A multiprocessor is a computer system having two or more processing units(multi processors) each sharing the main memory and the peripherals for simultaneous work.



# Multiprocessor Symmetry

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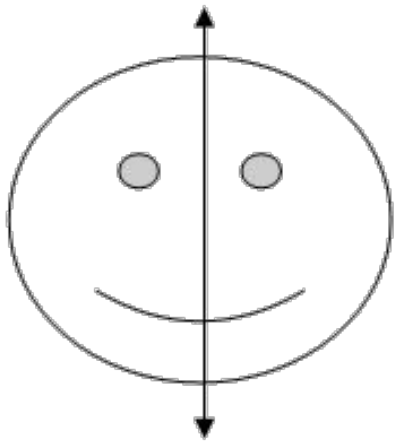
•In a multiprocessing system, all CPUs may be equal, or some may be reserved for special purposes.

•A combination of hardware and operating-system software design considerations determine the symmetry.



# Types of Instructions and Data Streams

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1)Single sequence of instruction in a single context (SISD)

2)Multiple sequences of instruction in single context(MISD)

3)Multiple sequences of instruction in multiple contexts(MIMD)

# Processor Coupling

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1) Tightly coupled multiprocessor system: (shared memory)

> Multiple CPU's connected at the bus level

> CPU's may have access to the central shared memory(Symmetric multiprocessing)

2) Loosely coupled multiprocessor system: (Distributed memory)

> Based on multiple standalone single or dual processors interconnected via high speed communication system,such as Gigabit Ethernet

# Shared Memory

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Shared memory is a memory that can be accessed by various programs with an intent of providing communication between them

Shared memory is an efficient means of passing data between programs

Types:

1)**Uniform memory access(UMA):**

All the processors share the physical memory uniformly

2)**Non Uniform memory access(NUMA):**

Memory access time depends on the memory location relative to a processor

# Parallel Computing

# Definition

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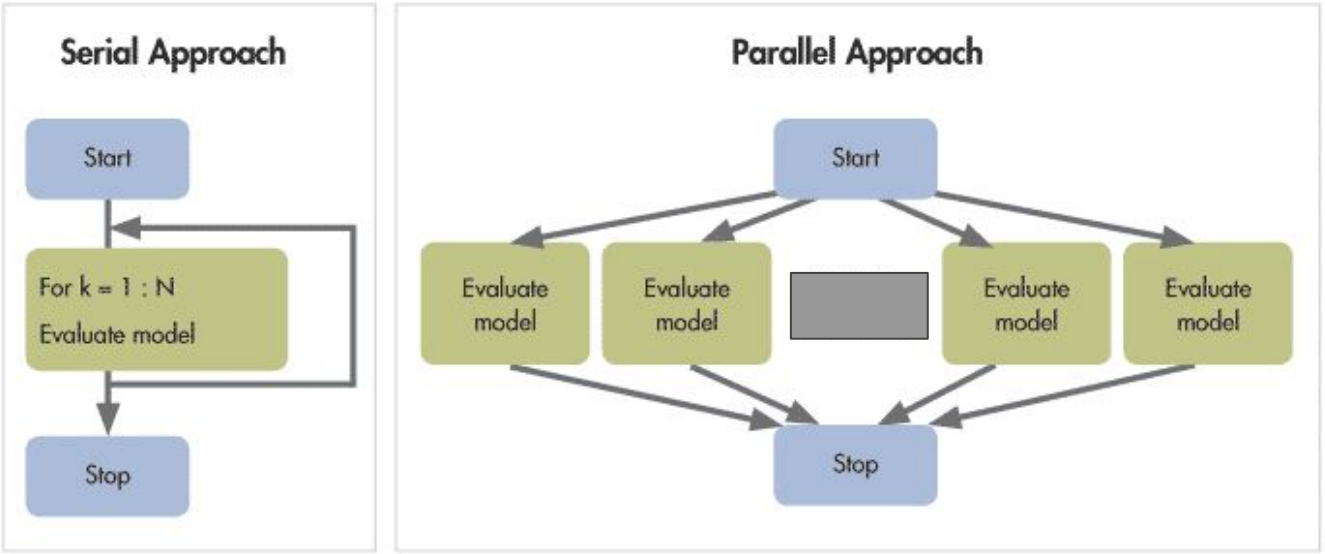
**Parallel Computing** is a type of computation in which many calculations or the execution of processes are carried out simultaneously.



# Frequency Scaling

The reason for the growth of interest in Parallel Computing

# References

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Computer System Architecture, M Morris Mano

The Scientist and Engineer’s guide to Digital Signal Processing, Steven W Smith

www.nvidia.in

www.wikipedia.org

# Queries

# thankyou.asm

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```
name "end"
org 100h
jmp start

msg:    db      "Thank You!", 0Dh,0Ah, 24h

start: mov      dx, msg
       mov      ah, 09h
       int      21h

       mov      ah, 0
       int      16h

ret
```