Computer Fundamentals

Lecture # 5:

Microprocessor

Today's Objectives:

- To study Microprocessor and its various Subsystems

Microprocessor:

- The Brain of the computer
- Silicon Chip (IC)
- Latest Pentium-4 has around 125 million transistors
- Performs Billions of Instructions per second
- Combines with other devices such as Memory and I/O to form a **“Microprocessor system”**

Microprocessor Models:

- The "Calculator" Model
- Should be able to
  - Take Data
  - Decode
  - Execute
  - Give Results

Components Required for the "Calculator" Model

- **Control Unit:** for decoding signals and activate the devices (memories, buses, registers) in a proper sequence

- **Arithmetic Unit:** to perform mathematical calculations

Machine Cycle

- The series of steps taken by the CPU to execute an instruction is called ‘Machine Cycle’
  - Two smaller Cycles
    - Instruction Cycle
    - Execution Cycle
- Instruction Cycle
  1. Fetching: Fetching a command from memory
  2. Decoding: Map the command to Instructions

Machine Cycle

- Execution Cycle
  1. Executing: CPU converts the instructions into microcode and carries them out
  2. Storing: (Optional) The CPU stores the result somewhere in the memory

Components of a Microprocessor

- **Memory;** stores data and instructions
- **Bus Interface Unit;** transfers data in and out of the Processor, instructions into the Processor
- **Instruction Decoder;** Decodes Instructions
- **Arithmetic and Logic Unit;** Performs Math, Comparisons and Logical Operations on Integers
- **Control Unit;** Controls and Manages all the Processing

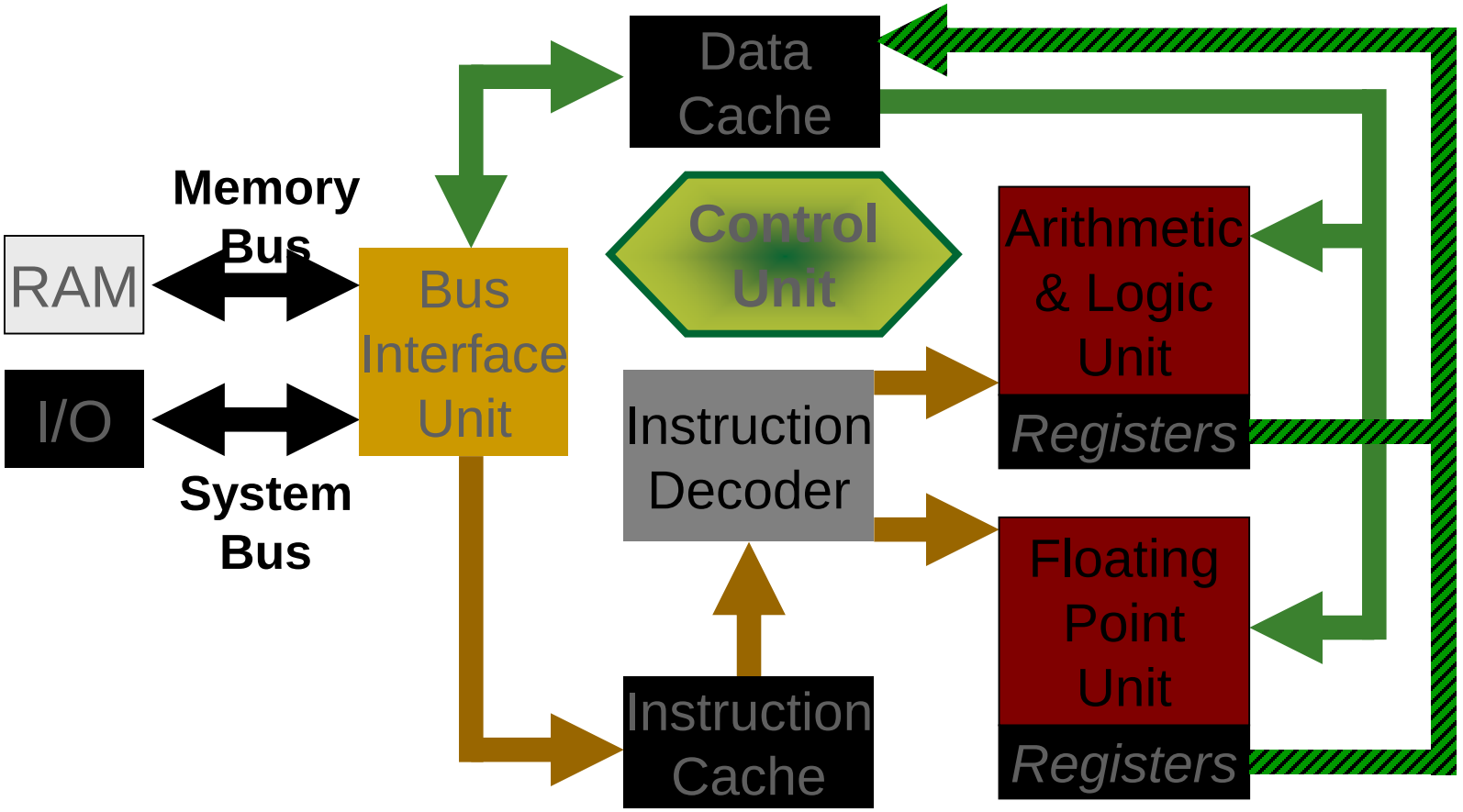
The Memory Bottleneck:

- Accessing RAM for Data/Instructions is slow
- Solution:
  - Registers attached to the ALU (for data currently in use)
  - Cache Memory (for most frequently used data)
    - Internal Cache (on processor chip)
      - Instruction Cache
      - Data Cache
    - External Cache (on motherboard)

The "Real Numbers" Processing:

- Real Numbers
- Use in Computing
- Floating Point Unit; Processes the Real Numbers faster than an ALU

The Final Picture:



The Instruction Set:

- A Microprocessor's Language; Low-Level, Single Step Instructions
- Also called Program code, Binary code or Machine code
- Difficult to change after implementation
- Architecture dependant
- Design Issues:
  - Silicon Real Estate
  - Cost
  - Expandability
  - Legacy Support
  - Complexity
  - Power Consumption
- Deign Types
  - CISC (Complex Instruction Set Computer)
  - RISC (Reduced Instruction Set Computer)

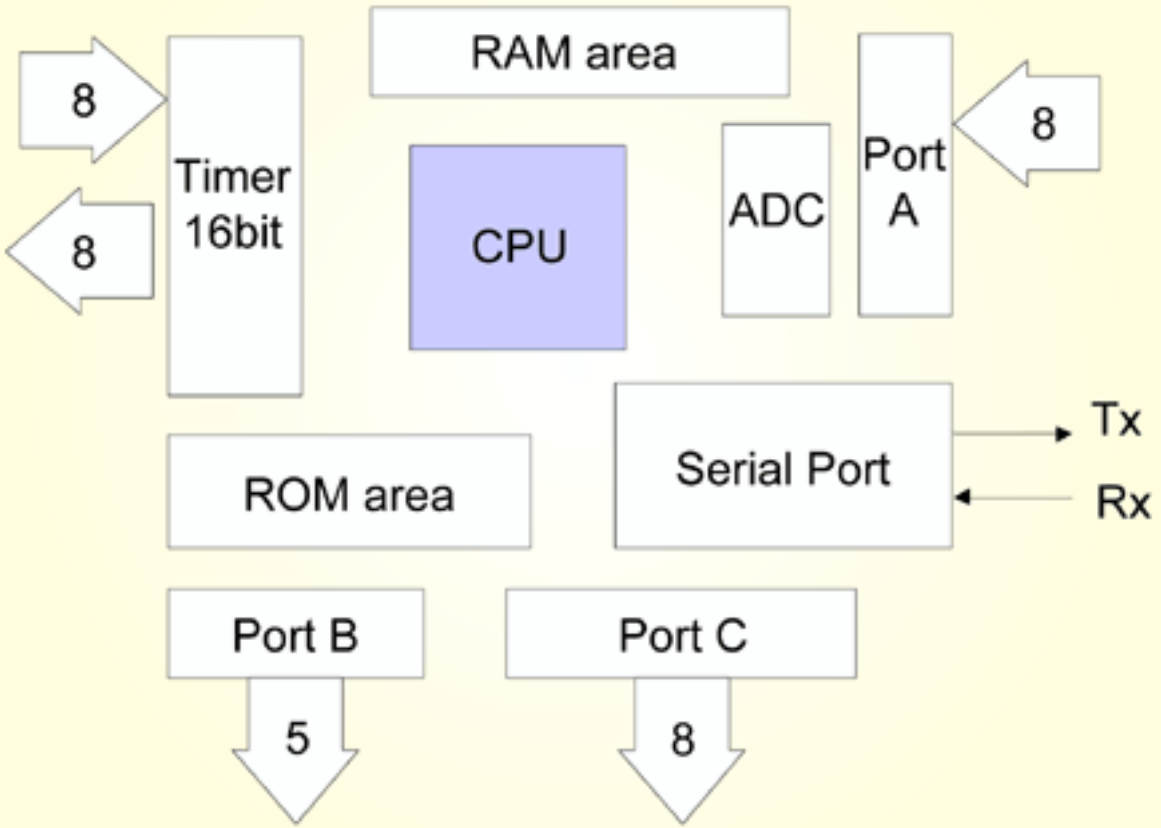
Microcontroller (A Microprocessor system):

- Basic components of a microprocessor system combined on a single chip
  - The CPU core
  - RAM and ROM
  - I/O ports (Parallel & Serial)
  - Timers and Interrupts
  - Analogue to Digital Converter (ADC), etc

Microcontrollers

- Used in Autonomous Systems
  - ovens, ATMs, vehicles
- Advantage:
  - Compact integrated design on single chip
  - Reduced interface

A Single Chip Microcontroller



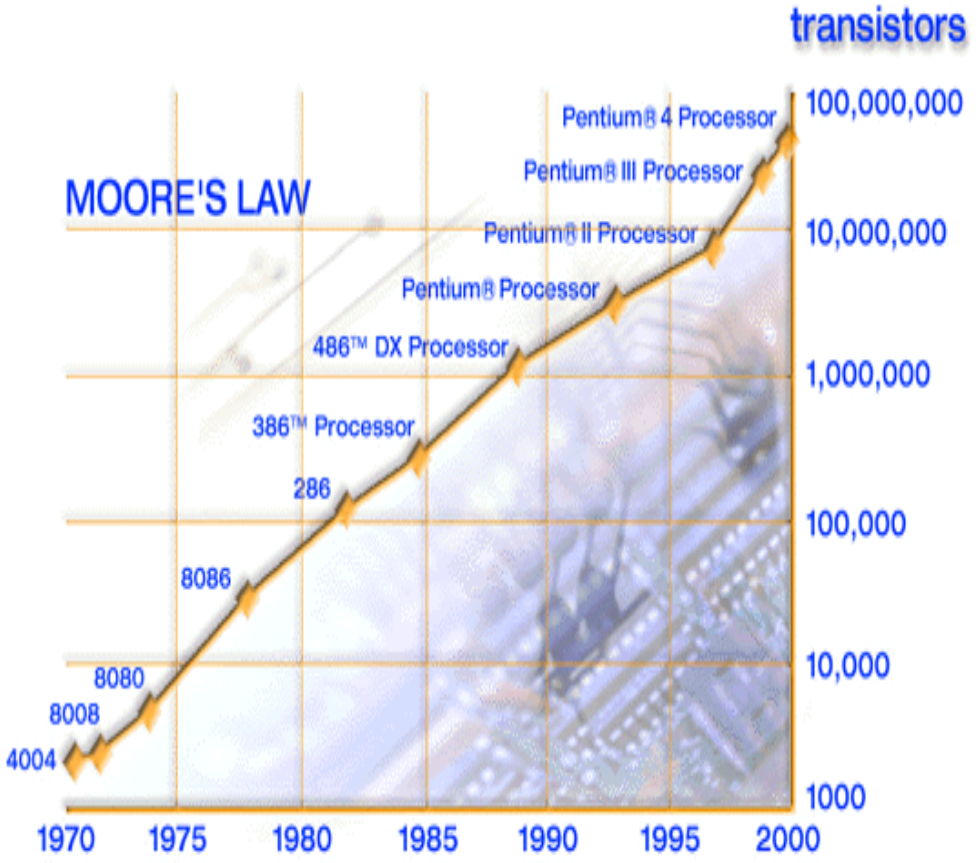
CPU: The processing module of the microcontroller

Microprocessor, Yesterday and Today:

- Busicom's Desk Calculators
- 1971, Intel's 1st Microprocessor-4004
  - 2250 Transistors
  - 740 KHz, 60,000 Op/sec
  - 16 pins
  - 10 Microns
  - As Powerful as ENIAC
- 2001, Intel's P4 – Today's Processor
  - 55 Million Transistors
  - 32-bit Word size
  - 2.2 GHz
  - 2 ALUs
  - 128 bit FPU
  - 0.13 Micron

Moore's Law:

- Presented by Gordon Moore, 1965, Intel Corp.
- No. of Transistors on the Processor Chip Will Double in 18 months



Better Future Processors?

- Capabilities should Include:
  - Higher Clock Frequency
  - Greater Word Width
  - More Functioning Units
  - Better Caching Algorithm
  - Right Cache Size
  - What else?