CSC 3210

Computer Organization and Programming

Chapter 2: x86 Processor Architecture

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X86 Processor Architecture

- One step **before using assembly language**
  - What is the selected processor **Internal architecture and capabilities**.
- What **is the underline hardware** associated with X86?
- Assembly language is **a great tool** for learning **how a computer works**.
  - It require you to have working knowledge of **computer hardware**

You should have some basic knowledge about **the processor** and the **system architecture** in order to effectively program in **the assembly language**.

Outline

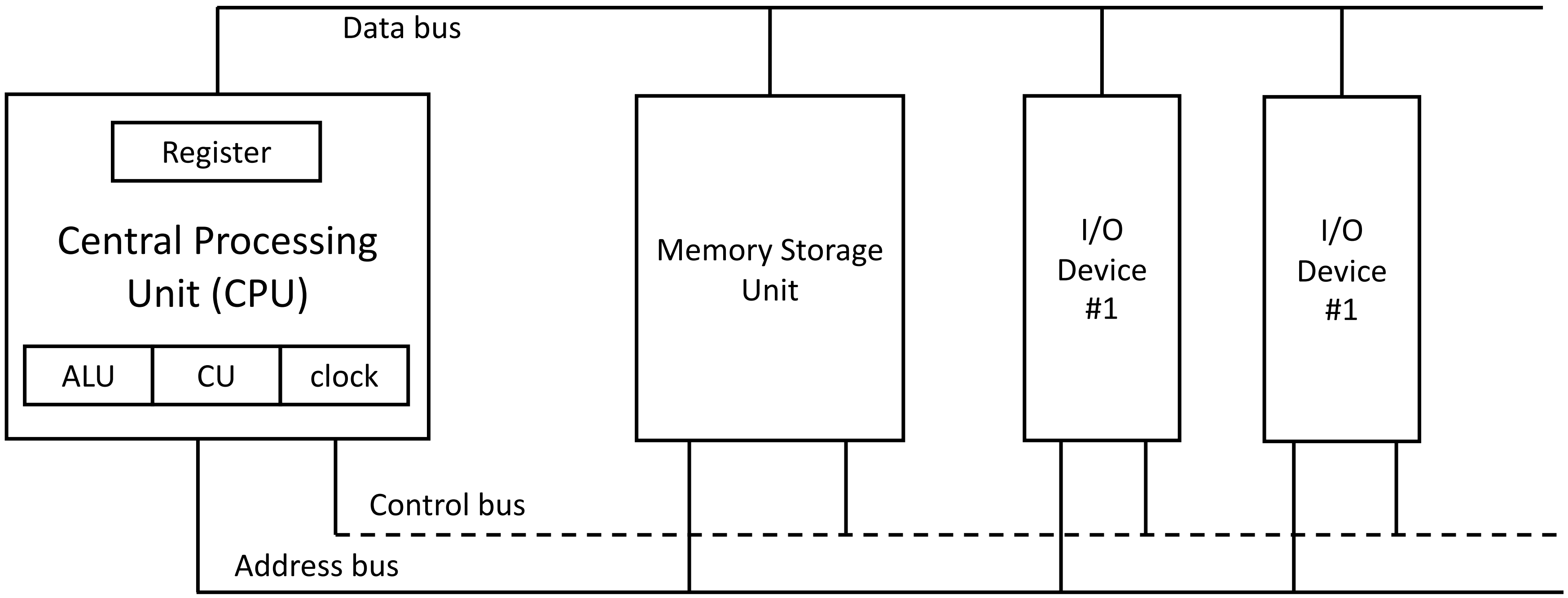
- **General Concepts**
- IA-32 Processor Architecture
- IA-32 Memory Management
- 64-bit Processors
- Components of an IA-32 Microcomputer
- Input-Output System

General Concepts

- **Basic microcomputer design**
- Instruction execution cycle
- Reading from memory
- How programs run

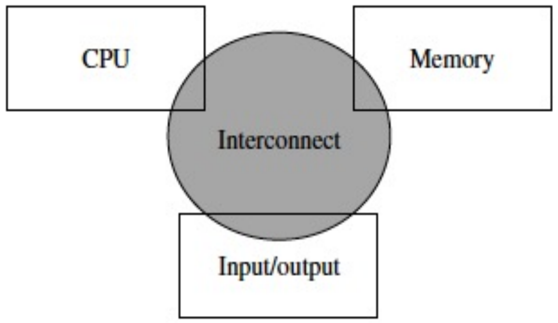
General Concepts: Basic Microcomputer Design

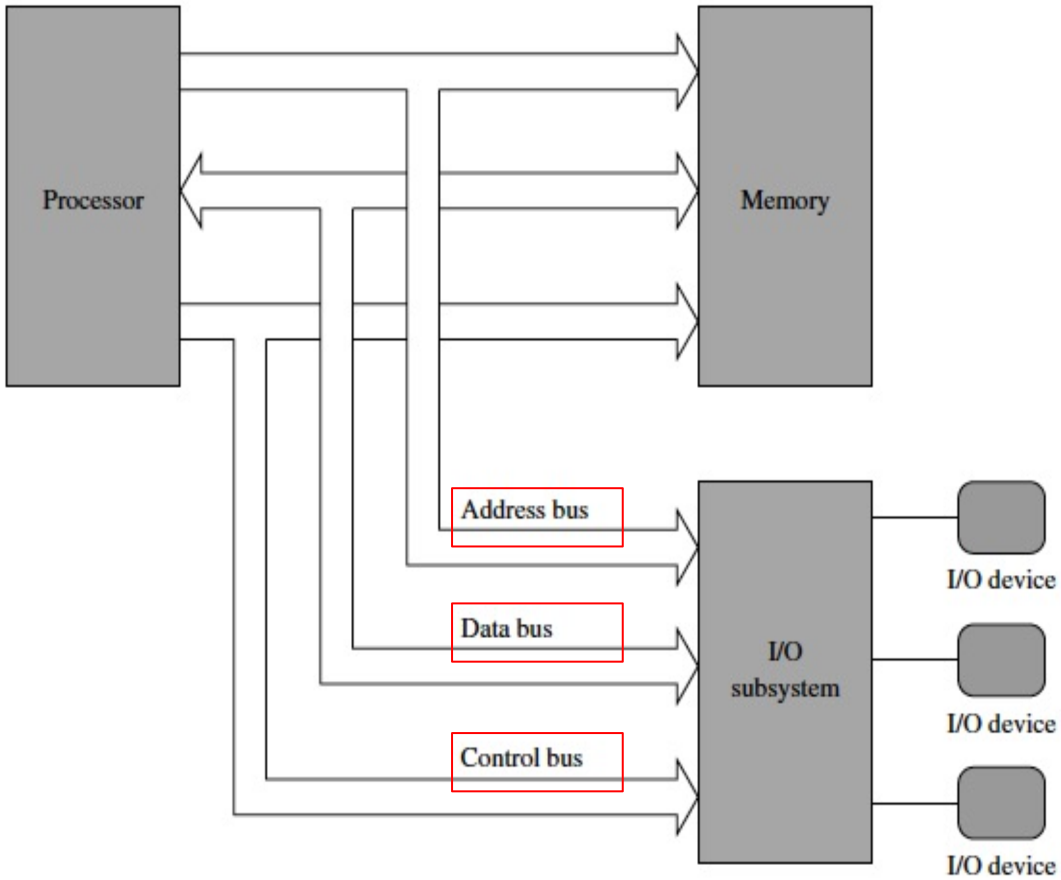
- **ALU** performs **arithmetic** and **logical** (bitwise) operations
- **Control unit (CU) coordinates** sequence of **execution steps**
- **Clock** synchronizes CPU **operations** with other **system components**



General Concepts: Basic Microcomputer Design

- A **bus**: a group of parallel wires that **transfer data**
  - bus types:
    - address
    - data
    - control



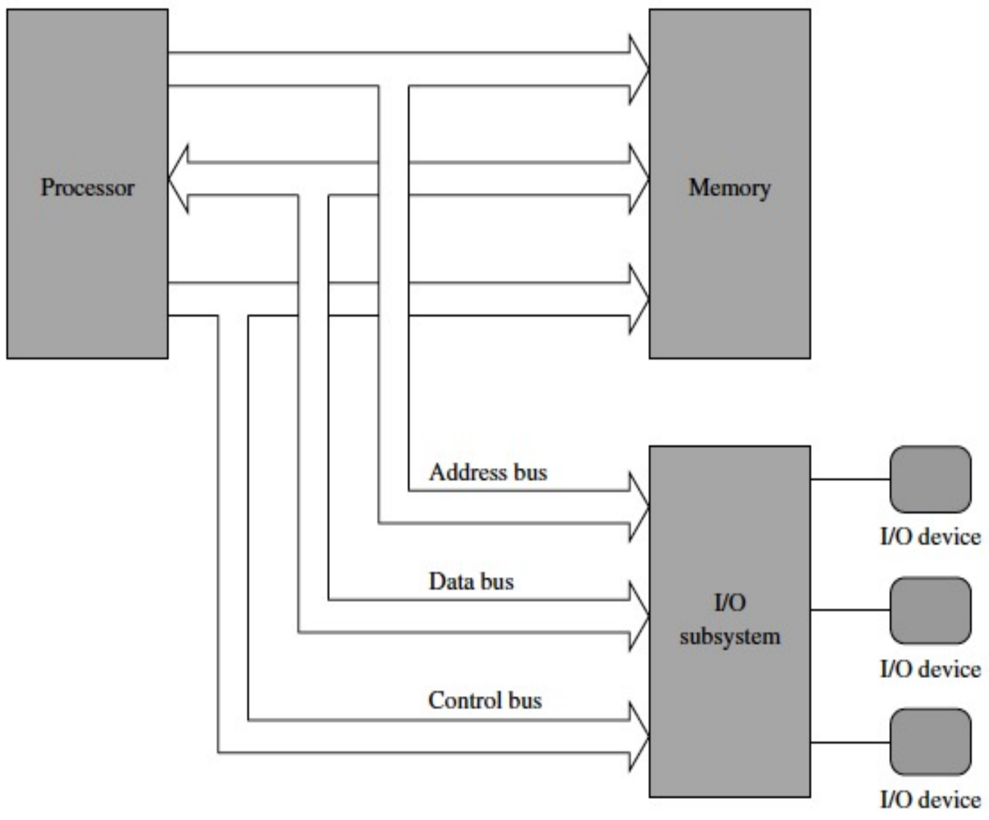


General Concepts: Basic Microcomputer Design

- The **Address bus** **holds the addresses** of instructions and data, when the currently executing instruction transfers data between the CPU and memory.

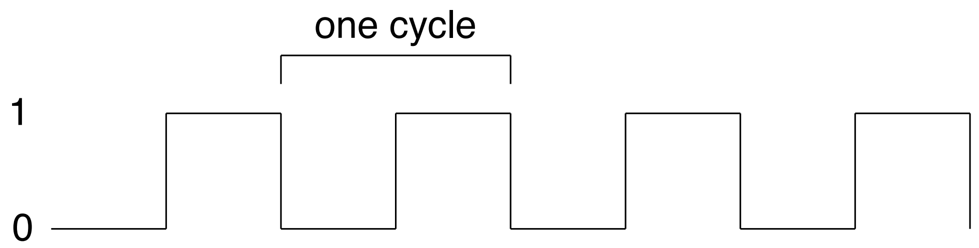
- The **Data bus** **transfers** **instructions** and **data** between the CPU and memory.

- The **Control bus** uses binary signals to **synchronize actions** of all devices attached to the system bus.



General Concepts: Clock

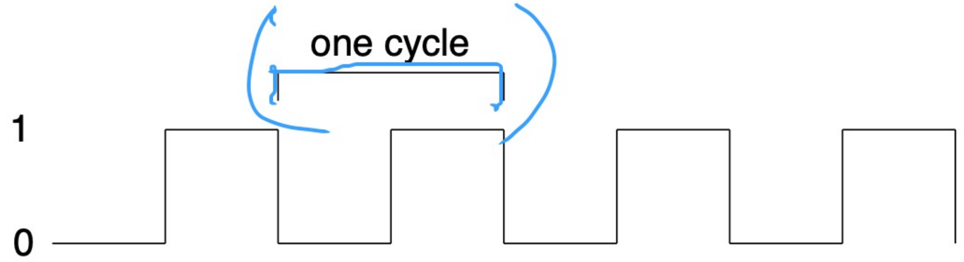
- The system clock provides **a timing signal** to synchronize the **operations** of the system.
  - Synchronizes all CPU and BUS **operations**
- A **clock** is a sequence of **1's** and **0's**



The frequency:
is the number of cycles that happens each second

General Concepts: Clock

- The clock frequency is measured in the number of cycles per second.
- This number is referred to as **Hertz** (Hz: the unit of frequency, defined as one cycle per second).
    - **MHz** and **GHz** represent 10^6 and 10^9 cycles per second
- The **system clock** defines ~~the speed~~ at which the system operates.



10^6 cycle → 1 sec.

1 cycle → $\frac{1}{10^6}$ sec. (clock period)

General Concepts: Clock

- **Ex: transfer of data** from a memory location to X86 (Pentium) takes **three clock cycles**.
- The **clock period** is defined as the length of time taken by one clock cycle .

$$\text{Clock period} = \frac{1}{\text{Clock frequency}}$$

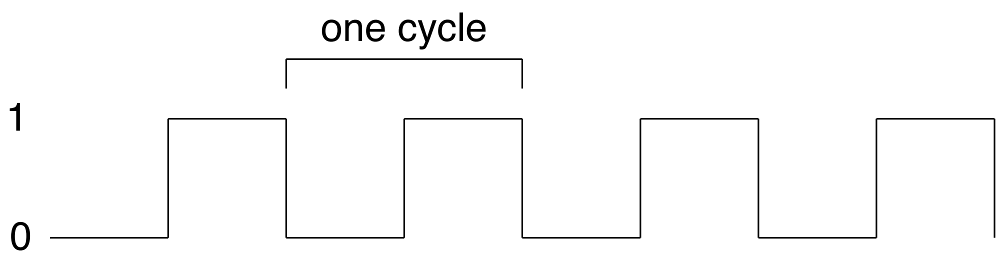
For example, a clock frequency of 1 GHz yields a clock period of

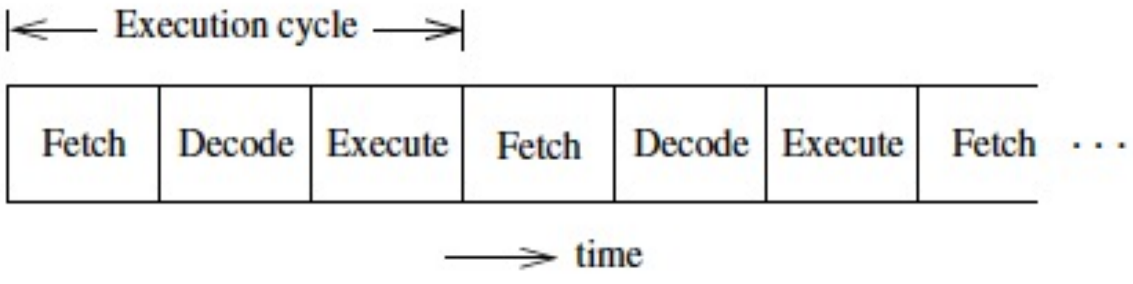
$$\frac{1}{1 \times 10^9} = 1 \text{ ns}$$

- If it takes three clock cycles to execute an instruction, it takes 3 X 1 ns = 3 ns.
- Machine **(clock) cycle** measures time of a single operation
- Clock is used to trigger events

General Concepts: Clock

- A **machine instruction** requires one clock cycle to execute, few require 50 clocks
- Instructions require memory access: Empty clock cycle, **wait states, Why?**
  - CPU, system bus, and memory circuits





Clock per Instruction (CPI)

- Is an effective average.
- It is the average number of clocks required by the instructions in a program.
- In a program 60% instructions takes 4 clock cycles and the rest of the instructions takes 1 clock cycles.
- CPI = 0.6 * 4 + 0.4 * 1 = 2.8 clocks per instruction.

Million Instructions Per Second

- **Step 1:** Perform Divide operation between no. of instructions and Execution time.
- **Step 2:** Perform Divide operation between that variable and 1 million for finding millions of instructions per second.
- For example,
  - if a computer completed 2 million instructions in 0.10 seconds
  - 2 million/0.10 = 20 million.
  - No of MISP=20 million/1 million
  - =20