COE 205: Computer Organization & Assembly Language
Introductory Experiment-B

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Introduction

A computer system consists mainly of three components: **a Central Processing Unit (CPU)**, **a memory** and **Input/Output (I/O) devices**. These three components are interconnected by **a bus system**. A conceptual arrangement of such system can be seen in Fig 1.

As an assembly programmer, you need to know some basic information about the hardware you are programming. In this experiment, you will learn the basics of the above-mentioned components and you will be able to extract some information about them devices from your PC. You will also be able to comprehend the extracted information and use them to get more information about your PC. The theme of this experiment is to see how your program runs and affects those components.

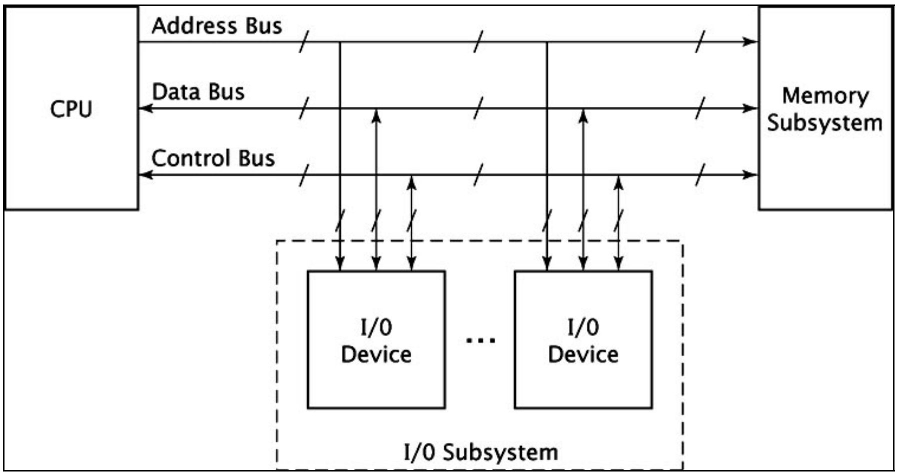

Fig 1: Abstract Computer System.

The Bus System

The bus is simply a set of wires. The bus system consists of three buses: **a data bus**, **an address bus** and **a control bus**. I will use the term "bus system" when referring to the three buses together and the term "bus" to refer to a single bus. The bus system connects the CPU, memory and I/O devices. The term **bus cycle** refers to a single transaction on the bus. As examples, memory read, memory write and I/O read and I/O write are all bus transactions or bus cycles.

The data bus is used to transfer data between the CPU and memory or the CPU and the I/O devices. Notice in Fig.1 that the data bus and the control are **bidirectional** which means that data can move in both directions. The address bus however is **unidirectional.** The width of the data bus determines the size of the data that can be transferred at one time. For example, the 8086 has a 16-bit data bus, which means we can transfer at most 16-bit in one bus cycle. If we have 32-bit data in the CPU and we would like to move it to memory, then we need two bus cycles.

The width of the address bus determines the amount of the memory accessible by the CPU. For example, the 8086 has a 20-bit address bus, which means that we can access up to 2^{20}, or 1 MB, of memory. The address bus is used by the CPU to indicate the location the CPU would like to read from or write into.

The control bus is used to indicate the type of the requested operation. For example if the CPU would like to read from memory, then it places a memory read on the control bus. In case of I/O read on the other hand, it places an I/O read and so on.

Processor	Estimated Clock Rate	Data Bus Width	Address Bus Width
8086	4.7 MHz	16-bit	20-bit
8088	4.7 MHz	8-bit	20-bit
80286	8 MHz	16-bit	24-bit
80386	40 MHz	32-bit	24-bit (Also 32-bit)
80486	75 MHz	32-bit	32-bit
Pentium	3 GHz +	64-bit	32-bit (Also 36-bit)

Table 1: A Compression Between Different Processors

The Central Processing Unit (CPU)

The CPU -also called the processor- is the heart of any computer system. The CPU is driven by **a clock** that synchronizes all events inside the computer system. Consider a Pentium 4 with 2 GHz clock. Such a clock generates 2 X 10^9 clock cycles per a second, this quantity is called the **clock speed** or **clock frequency** (f). Each clock cycle takes a period (*T*) that is calculated as

$$T = \frac{1}{f} = \frac{1}{2 \times 10^9} = 0.5 \ ns$$

The CPU fetches instructions and data from memory, decodes the instructions, executes them and finally writes the results back into memory. This process is repeated forever and is called the **fetch-execute** cycle.

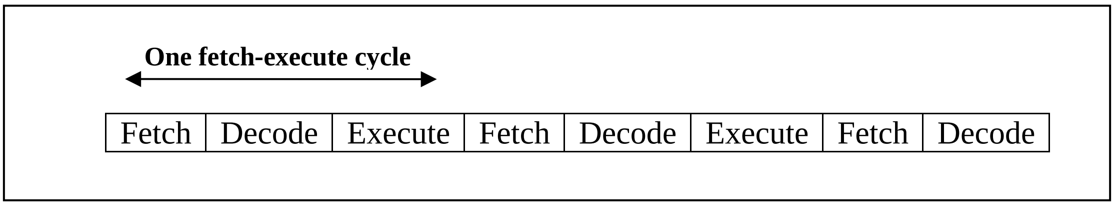

Fig 2: Fetch-Execute Cycle.

Fetching an instruction means reading it from memory. To do this, the CPU places the address of the memory location it wishes to read. Place a memory read on the control bus. The memory responds by placing the data on the data bus. The CPU in turn reads the data from the data bus.

Decoding the instruction means interpreting the meaning of the instruction. By looking into the **opcode** which is a part of the binary representation of the instruction, the CPU can recognize whether the require operation is an addition, subtraction, multiplication etc.

Executing the instruction is done by special hardware inside the CPU. The CPU contains an Arithmetic and Logic Unit (ALU) that performs arithmetic operations such as addition and multiplication, and logical operations such as AND and XOR. The CPU also conations a control unit the controls the timing of the events required to complete certain operation.

The CPU contains a set of registers. Some registers are used to store data temporarily while executing instructions. Examples of such registers are general purpose registers such as AX, BX. Other registers are used to control the CPU operations. An example is the IP register which tells the CPU about address of the next instruction to be executed. Others registers include the flag register that contains information about the current state of the CPU. In the 8086, registers are 16-bit, while in the Pentium they are 32-bit. Refer to the textbook for more details about registers.

Memory

Memory stores data and instruction required to manipulate the data. Two operations are provided by the memory. The first operation is the **read operation**, in which the content of a specific location in memory, determined by the value on the address bus, is read and placed on the data bus. The other operation is the **write operation** where a value that is available on the data bus is written on a specific location in memory indicated on the address bus.

As we said earlier, the size of the addressable memory is determined by the size of the address bus. For most systems, the available memory is less than the addressable one. Also the memory differentiates between a read and write operation by reading the value of control bus.

I/O Devices

The I/O devices work as an interface between the outer world and computers. These devices allow human to interact with computers in a convenient way. Examples of such devices are monitor, mouse, keyboard and printer. These devices are connected with the computer using different interfaces. Examples of such interfaces include serial port, parallel port, Universal Serial Bus (USB). These I/O ports are, in turn, interfaced to the system bus through an I/O controller.

Student Name: **ID#**

Exercises

1. You can view your system information by going to

   Start> Programs> Accessories> System Tools> System Information

   Or

   Right click the **My Computer** icon on you desktop and select **Properties**

   Use this tool to fill the following table.

Processor	
Processor Speed	(MHz/GHz)
Memory Size	MB
Operating System	

Now, use the information you collected to answer the following questions.

a- Calculate the duration of one clock of your PC.

b- What is the size of the **data bus** and the **address bus**?

Data Bus:

Address Bus:

c- What is the maximum amount of data that can be transferred on the data bus in one cycle?

d- What is the maximum amount of memory that your PC can address?