جامعة ألأنبار

كلية علوم الحاسوب وتكنولوجيا المعلومات

قسم أنظمة شبكات الحاسوب

المرحلة الثانيه

Computer Architecture

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MARIE: An Introduction to a Simple Computer

- In this chapter, we first look at a very simple computer called MARIE: A Machine Architecture that is Really Intuitive and Easy.
- The objective of this chapter is to give you an understanding of how a computer functions.

4.1 CPU Basics and Organization

- A computer must manipulate binary-coded data. Memory is used to store both data and program instructions (also in binary).
- Somehow, the program must be executed and the data must be processed correctly.
- The central processing unit (CPU) is responsible for fetching program instructions, decoding each instruction that is fetched, and performing the indicated sequence of operations on the correct data.
- All computers have a central processing unit. This unit can be divided into two pieces.
- **The first is the data path**, which is a network of storage units (registers) and arithmetic and logic units (for performing various operations on data) connected by buses (capable of moving data from place to place) where the timing is controlled by clocks.
- **The second CPU component is the control unit**: A module responsible for sequencing operations and making sure the correct data is where it needs to be at the correct time.
- Together, these components perform the tasks of the CPU: fetching instructions, decoding them, and finally performing the indicated sequence of operations.

4.1.1 The Registers.

- Registers are used in computer systems as places to store a wide variety of data, such as addresses, program counters, or data necessary for program execution.
- A register is a hardware device that stores binary data.

- Registers are located on the processor so information can be accessed very quickly.
- To build a 16-bit register, we need to connect 16 D flip-flops together.
- At each pulse of the clock, input enters the register and cannot be changed (and thus is stored) until the clock pulses again.
- Data processing on a computer is usually done on fixed size binary words that are stored in registers.
- Common sizes include 16, 32, and 64 bits.
- The number of registers in a machine varies from architecture to architecture, but is typically a power of 2, with 16 and 32 being most common.
- Registers contain data, addresses, or control information.
- Some registers are specified as ″special purpose″ and may contain only data, only addresses, or only control information.
- Other registers are more generic and may hold data, addresses, and control information at various times.
- In modern computer systems, there are many types of specialized registers: Registers to store information, registers to shift values, registers to compare values, and registers that count.
- There are ″scratchpad″ registers that store temporary values, index registers to control program looping, stack pointer registers to manage stacks of information for processes, status registers to hold the status or mode of operation (such as overflow, carry, or zero conditions), and general purpose registers that are the registers available to the programmer.

4.1.2 The ALU

- The arithmetic logic unit (ALU) carries out the logic operations (such as comparisons) and arithmetic operations (such as add or multiply) required during the program execution.
- Generally, an ALU has two data inputs and one data output.
- Operations performed in the ALU often affect bits in the status register (bits are set to indicate actions such as whether an overflow has occurred).
- The ALU knows which operations to perform because it is controlled by signals from the control unit.

4.1.3 The Control Unit

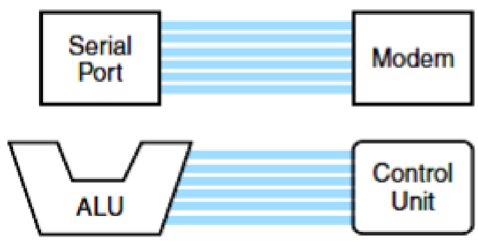
- The control unit is the “policeman” or “traffic manager” of the CPU.
- It monitors the execution of all instructions and the transfer of all information.
- The control unit extracts instructions from memory, decodes these instructions, making sure data is in the right place at the right time, tells the ALU which registers to use, services interrupts, and turns on the correct circuitry in the ALU for the execution of the desired operation.
- The control unit uses a program counter register to find the next instruction for execution and a status register to keep track of overflows, carries, borrows, and the like.

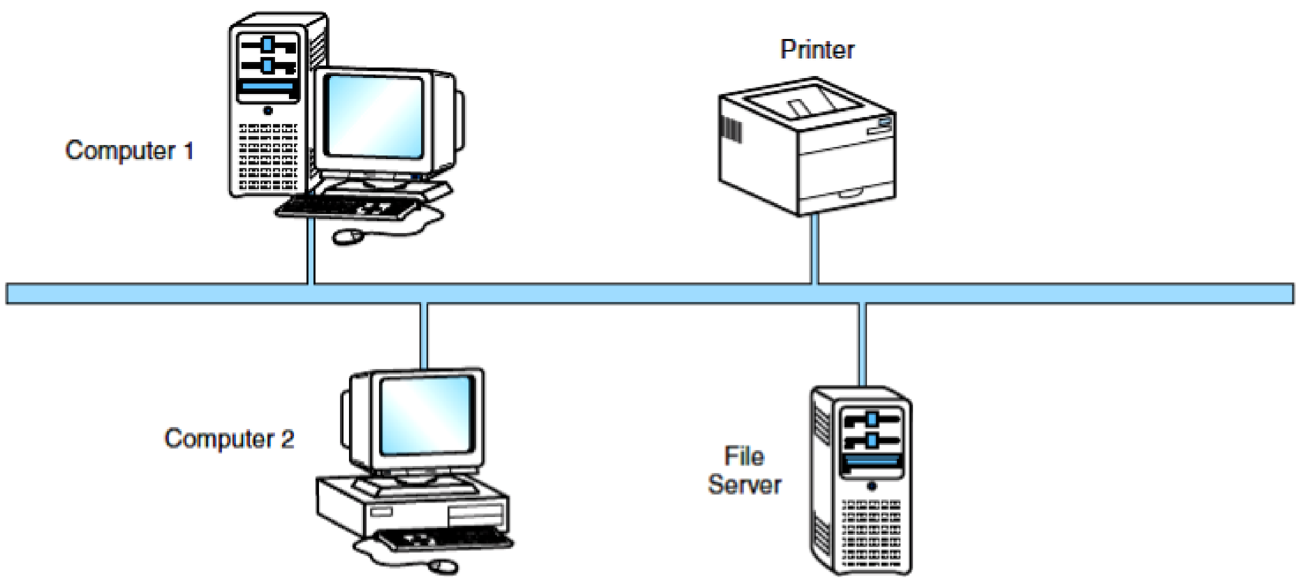
4.2 The Bus

- The CPU communicates with the other components via a bus.
- A bus is a set of wires that acts as a shared but common data path to connect multiple subsystems within the system.
- It consists of multiple lines, allowing the parallel movement of bits.
- Buses are low cost but very versatile, and they make it easy to connect new devices to each other and to the system.

- At any one time, only one device (be it a register, the ALU, memory, or some other component) may use the bus.
- However, this sharing often results in a communications bottleneck.
- The speed of the bus is affected by its **length** as well as by the **number of devices sharing it**.
- Quite often, devices are divided into master and slave categories, where a master device is one that initiates actions and a slave is one that responds to requests by a master.
- A bus can be **point-to-point**, connecting two specific components (as seen in Figure 3.1a) or it can be a **common pathway** that connects a number of devices, requiring these devices to share the bus (referred to as a multipoint bus and shown in Figure 3.1b).

(a)





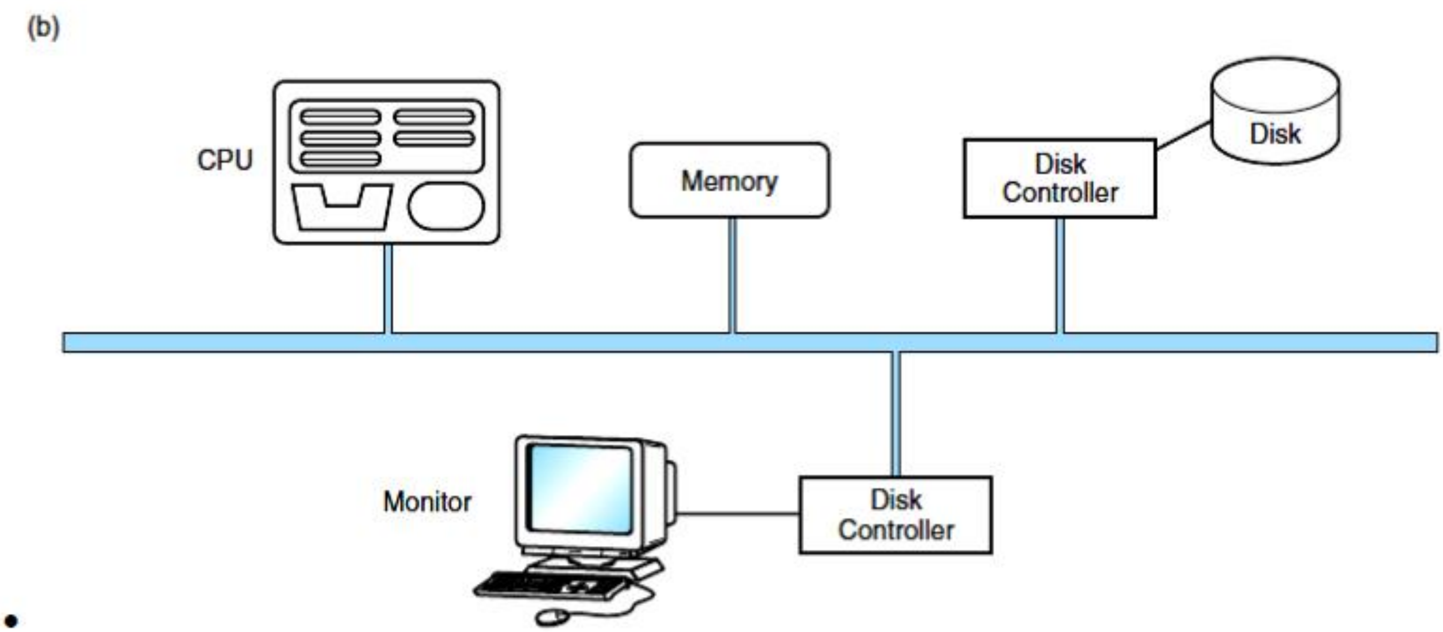


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Fig.(3-1) a) Point to Point Buses b) A Multi-Point Buses

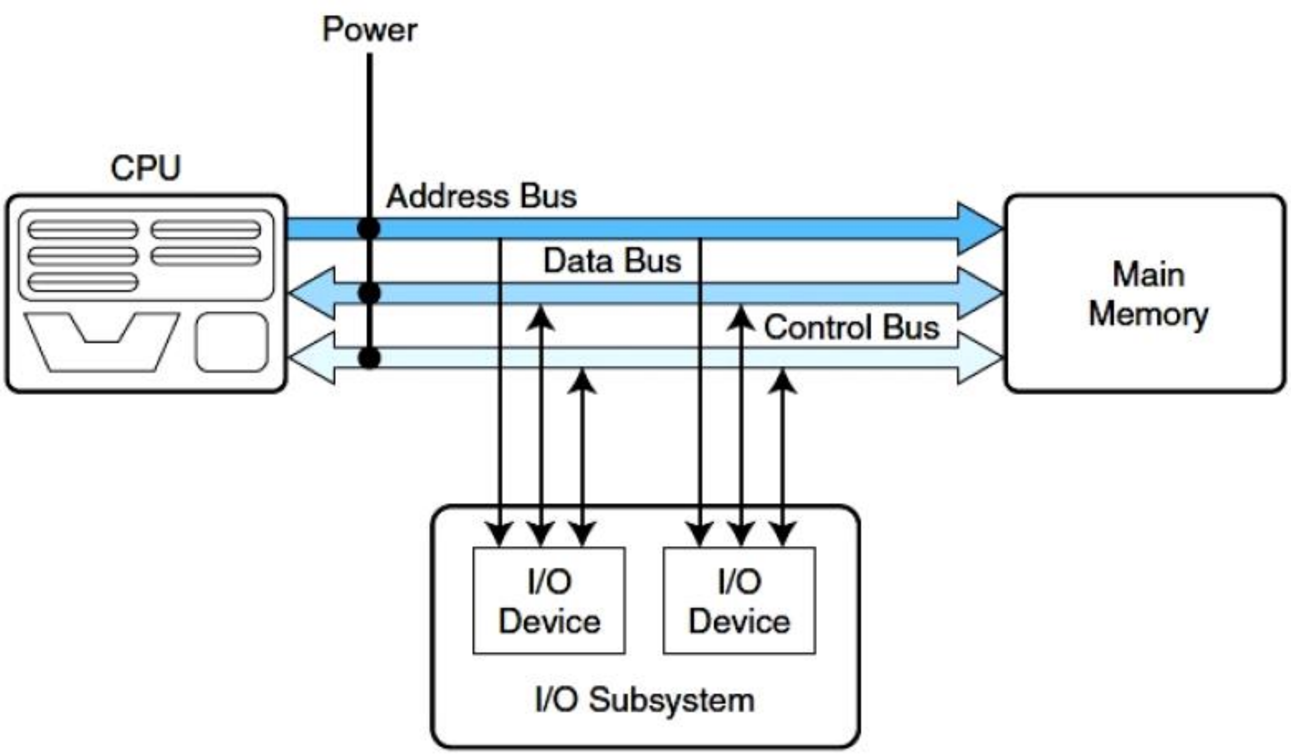

FIGURE 3.2 The Components of a Typical Bus

- Because of this sharing, the bus protocol (set of usage rules) is very important.
- Figure 3.2 shows a typical bus consisting of data lines, address lines, control lines, and power lines.
- Often the lines of a bus dedicated to moving data are called the data bus.
- **Data lines**: Contain the actual information that must be moved from one location to another.
- **Control lines**: Indicate which device has permission to use the bus and for what purpose (reading or writing from memory or from an I/O device, for example).
- Control lines also transfer acknowledgments for bus requests, clock synchronization signals, and interrupts.
- **Address lines**: Indicate the location (in memory, for example) that the data should be either read from or written to.
- **The power lines** provide the electrical power necessary.
- Typical bus transactions include sending an address (for a read or write), transferring data from memory to a register (a memory read), and transferring data to the memory from a register (a memory write).
- In addition, buses are used for I/O reads and writes from peripheral devices.
- Each type of transfer occurs within a bus cycle, the time between two ticks of the bus clock.

4.3 Clocks.

- Every computer contains an internal clock that regulates how quickly instructions can be executed.
- The clock also synchronizes all of the components in the system.
- As the clock ticks, it sets the pace for everything that happens in the system.

- The CPU uses this clock to regulate its progress, checking the otherwise unpredictable speed of the digital logic gates.
- The CPU requires a fixed number of clock ticks to execute each instruction.
- Therefore, instruction performance is often measured in clock cycles—the time between clock ticks—instead of seconds.
- The clock frequency (sometimes called the clock rate or clock speed) is measured in MHz.
- The clock cycle time (or clock period) is simply the reciprocal of the clock frequency.
- For example, an 800MHz machine has a clock cycle time of 1/800,000,000 or 1.25ns.
- If a machine has a 2ns cycle time, then it is a 500MHz machine.