Chapter 5

Computer Organization

Figure 5-1

Computer hardware :: Review

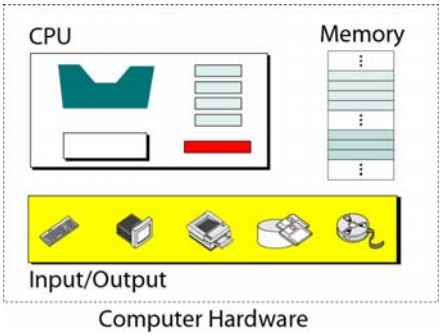
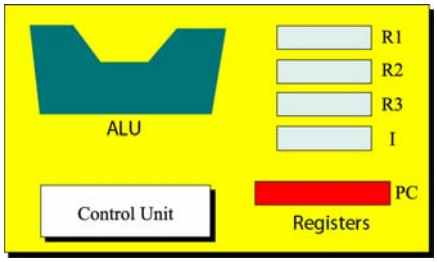


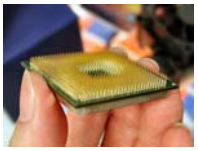
Figure 5-2

CPU :: Review



CPU:: Review

- Registers are fast stand-alone storage locations that hold data temporarily
- Data Registers
- Instructional Registers
- Program Counter
- Control Unit

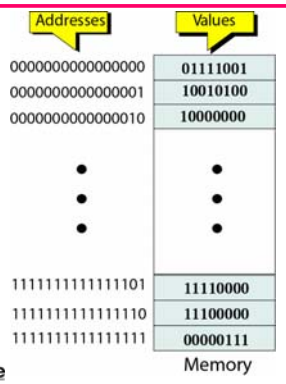


Main Memory :: Review

- Main memory is a collection of storage locations, each with a unique identifier called the address
- Word – a group of 8, 16 ,32, 64 bits
- Address space – the total number of uniquely identifiable locations in memory

Figure 5-3

Main memory :: Review

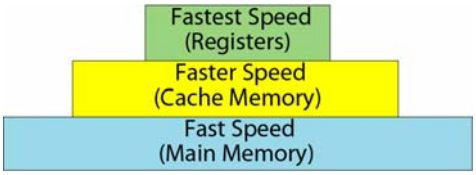


Memory Types :: Review

- RAM (random access memory): write and read, volatile;
- ROM (read only memory): content is written by manufacturer, it's nonvolatile;

Figure 5-4

Memory hierarchy :: Review



OBJECTIVES

- Understand how each input/output device works.
- Understand the systems used to connect different components together.
- Understand the program execution and machine cycles.

Continued on the next slide

Reading

- Ch5: 5.1, 5.2, 5.3 (skip magnetic tape, skim through the process of creation for CD-R, CD-RW), 5.4 (p 83-85), 5.5 (87-89)

5.3 INPUT / OUTPUT

Input/Output

- Non-storage devices: keyboard and monitor, printer
- Storage devices: magnetic or optical; cheaper than main memory and nonvolatile

Magnetic Storage Devices

- Magnetic storage devices use magnetization to store bits of data (magnetized – 1, not magnetized - 0);
- Magnetic disk is one or more disks stacked on top of each other;
- The disks are coated with magnetic film;
- Information is stored and retrieved using read/write head for each surface on disk;

Figure 5-6

Physical layout of a magnetic disk

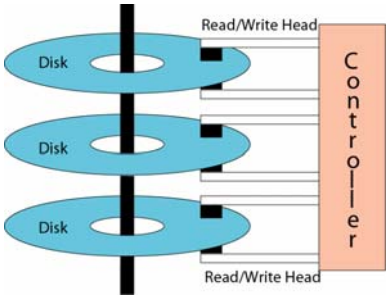
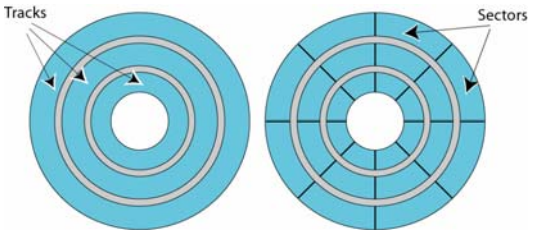


Figure 5-7

Surface organization of a disk



Optical Storage Devices

- Optical storage devices use light to store and retrieve data
- Devices that use this technology include CD-ROM, CD-Rs, CD-RWs and DVDs
- The CD-ROM is read using a low-power laser beam coming from the computer drive
- Low-power laser beam passes in front of the simulated pits and lands
- For a land, the beam reaches the reflective layer and is reflected
- For a simulated pit, the spot is opaque and not reflected

Figure 5-10

Creation and use of CD-ROM

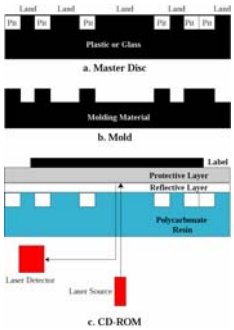


Figure 5-11

CD-ROM format

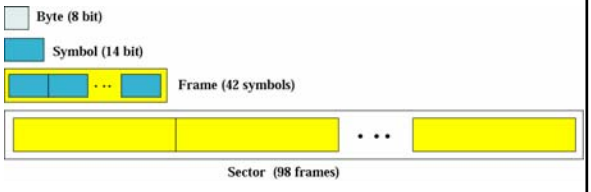


Table 5.2 CD-ROM speeds

Speed	Data Rate		Approximation
1x	153,600	bytes per second	150 KB/s
2x	307,200	bytes per second	300 KB/s
4x	614,400	bytes per second	600 KB/s
6x	921,600	bytes per second	900 KB/s
8x	1,228,800	bytes per second	1.2 MB/s
12x	1,843,200	bytes per second	1.8 MB/s
16x	2,457,600	bytes per second	2.4 MB/s
24x	3,688,400	bytes per second	3.6 MB/s
32x	4,915,200	bytes per second	4.8 MB/s
40x	6,144,000	bytes per second	6 MB/s

DVD

- The capacity of CD-ROM is about 650-750 Mb; it's insufficient to store the data;
- The latest optical memory storage device is DVD (digital versatile disc);
- It uses the similar technology with some differences: the pits are smaller (0.4 microns), the tracks are closer to each other; the beam is red instead of infrared, DVD uses one or two recording layers, and it can be single-sided or double-sided

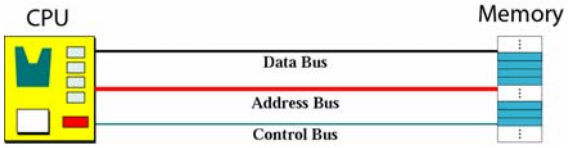
Table 5.3 DVD capacities

Feature	Capacity
single-sided, single-layer	4.7 GB
single-sided, dual-layer	8.5 GB
double-sided, single-layer	9.4 GB
double-sided, dual-layer	17 GB

5.4 SUBSYSTEM INTERCONNECTION

Figure 5-14

Connecting CPU and memory using three buses



Buses

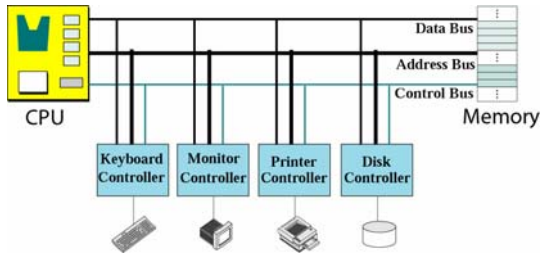
- ***Data bus***: several wires, each for 1 bit, number of wires depends upon the size of the word, e.g. if the word is 32 bits you need 32 wires;
- ***Address bus***: allows access to the particular word in memory, the number of wires depends on the address space of memory (if the memory has 2^n words, the address bus needs to carry n bits at a time);
- ***Control bus***: communication between CPU and memory, number or wires used in the control bus depends on the total number of control commands a computer needs (if a computer has 2^m control actions, you need m wires)

Connecting I/O devices

- I/O devices can not be connected directly to the buses;
- I/O devices are electromechanical, whereas the CPU and memory are electronic devices;
- I/O devices operate at much slower speed than CPU/memory;
- Thus, I/O devices are attached to the buses using input/output controllers;
- There is one specific controller for each input/output device
- A controller can be a serial or parallel device
- Parallel controller has several connections to the device, whereas serial has only one wire connection to the device.

Figure 5-15

Connecting I/O devices to the buses



Controllers

- SCSI (small computer system interface), has parallel interface, uses 8, 16 or 32 wires;
- FireWire has high-speed serial interface that transfers data in packets, achieving a transfer rate of up to 50 MB/sec;
- USB (universal serial bus) is used to connect slower devices like keyboard and mouse. It can transfer up to 1.5 MB/sec. It has 4-wire bus, two carry power to the device.

Figure 5-16

SCSI controller

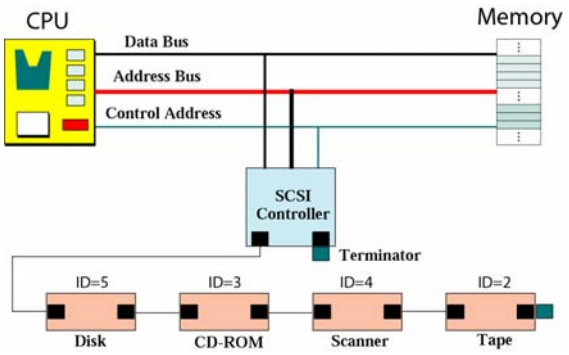


Figure 5-17

FireWire controller

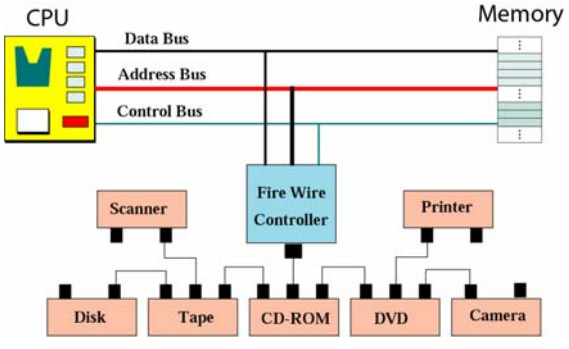
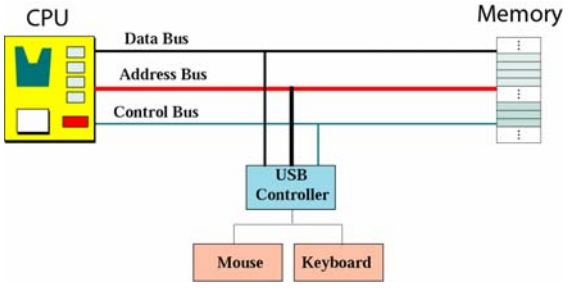


Figure 5-18

USB controller

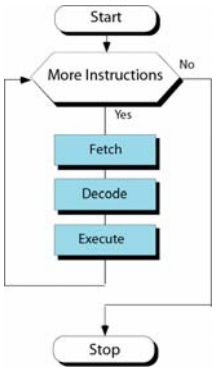


5.5

PROGRAM EXECUTION

Figure 5-21

Steps of a cycle



Program Execution

- **Fetch:** control unit orders the system to copy the next instruction into the instruction register in the CPU; after copying the program counter is incremented to refer to the next instruction in memory;
- **Decode:** instruction gets decoded by the control unit, the result of this decode step is binary code for some operation that the system will perform;
- **Execute:** after the instruction is decoded, the control unit sends the task order to a component in the CPU. E.g. CPU can tell ALU to add two numbers.

Figure 5-22

Contents of memory and register before execution

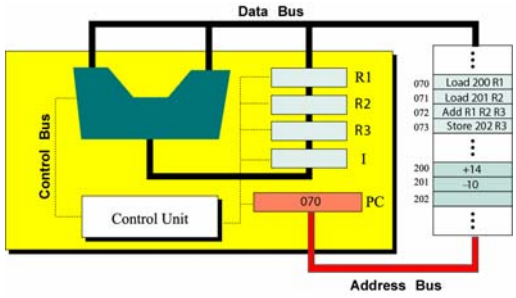
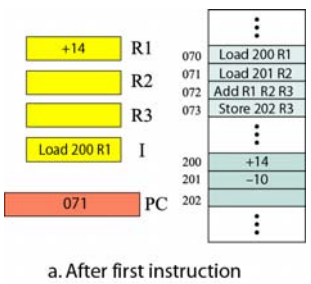


Figure 5-23.a

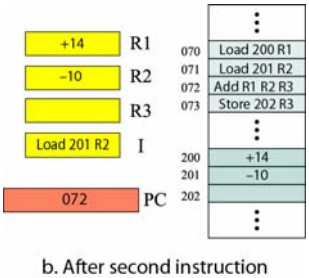
Contents of memory and registers after each cycle



a. After first instruction

Figure 5-23.b

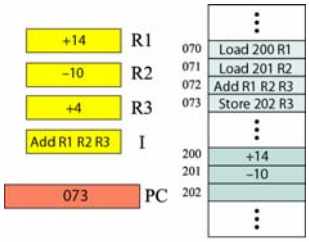
Contents of memory and registers after each cycle



b. After second instruction

Figure 5-23.c

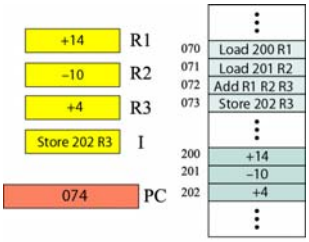
Contents of memory and registers after each cycle



c. After third instruction

Figure 5-23.d

Contents of memory and registers after each cycle



d. After fourth instruction

Input/Output Operation

- We need to transfer data from I/O devices to the CPU and memory;
- I/O devices are slow comparing to CPU, thus they must be synchronized somehow;
- There are three methods that have been created to do that: programmed I/O, interrupt-driven I/O, and direct memory access (DMA).

Summary

- A computer has three subsystems: the CPU, main memory, and the input/output subsystem
- The CPU performs operations on data and has an ALU, a control unit, and a set of registers
- The ALU performs arithmetic and logical operations
- The registers are stand-alone storage devices that hold data temporarily
- The control unit oversees operations in a computer
- Main memory is a collection of storage locations

Summary

- RAM provides the bulk of the memory in a computer
- The input/output subsystem is a collection of devices that allow a computer to communicate with the outside world
- The keyboard, monitor and printer are examples of non-storage devices
- A magnetic disk is a storage device with each disk on the stack divided into tracks and sectors
- CD-R is an optical storage device in which the user burns the data onto the disk. The data cannot be erased.
- CD-RW: the data can be erased and rewritten multiple times.
- A DVD is a high-capacity optical storage device

Summary

- A data bus, an address bus and a control bus connect the CPU and memory
- A controller handles the I/O operations between the CPU/memory and much slower I/O devices
- Most popular controllers: SCSI, FireWire, USB
- To run an instruction in a program, the CPU first fetches the instruction, decodes it and then executes it
- There are three methods to synchronize the CPU with the I/O device: programmed I/O, interrupt-driven I/O and DMA