嫦娥

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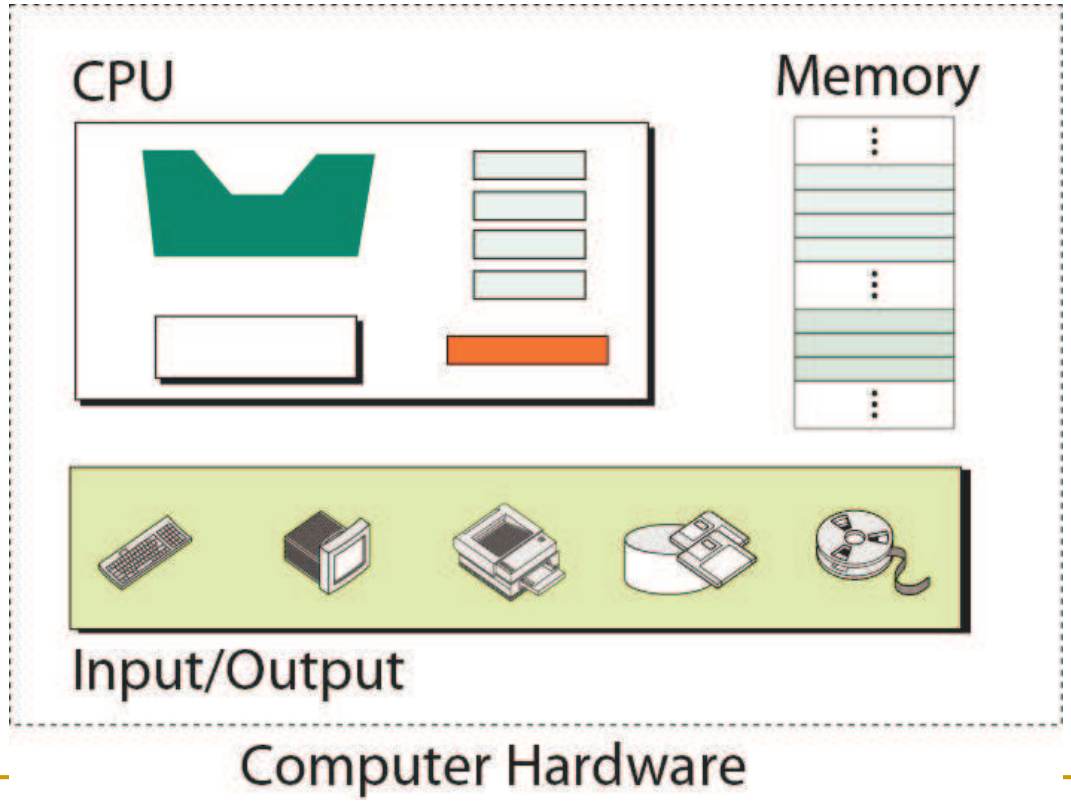
Chapter 5: Computer Organization

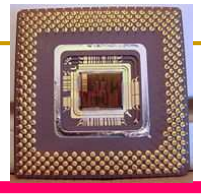
Computer hardware (subsystems)

A computer has three subsystems: the CPU, main memory, and the input/output subsystem.

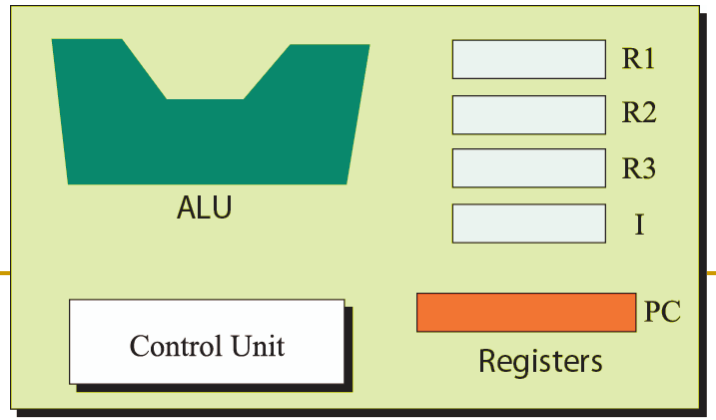


5.1 CENTRAL PROCESSING UNIT (CPU)

CPU



- The CPU performs operations on data and has an arithmetic & logic unit (ALU), a control unit, and a set of registers.
- The ALU performs arithmetic and logical operations.
- The registers are stand-alone storage locations that hold data temporarily.
- Registers can hold data, instructions, and also program counter.
- The control unit oversees operations in a computer.

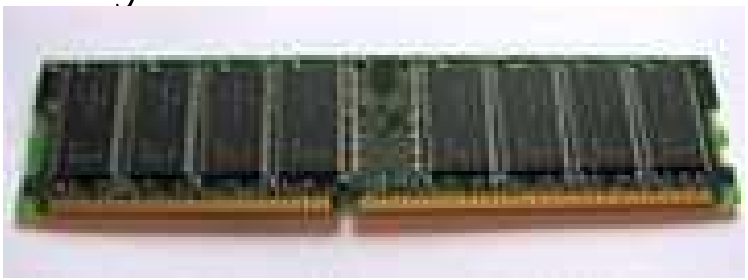


5.2

MAIN MEMORY

Main memory

- Main memory is a collection of storage locations.

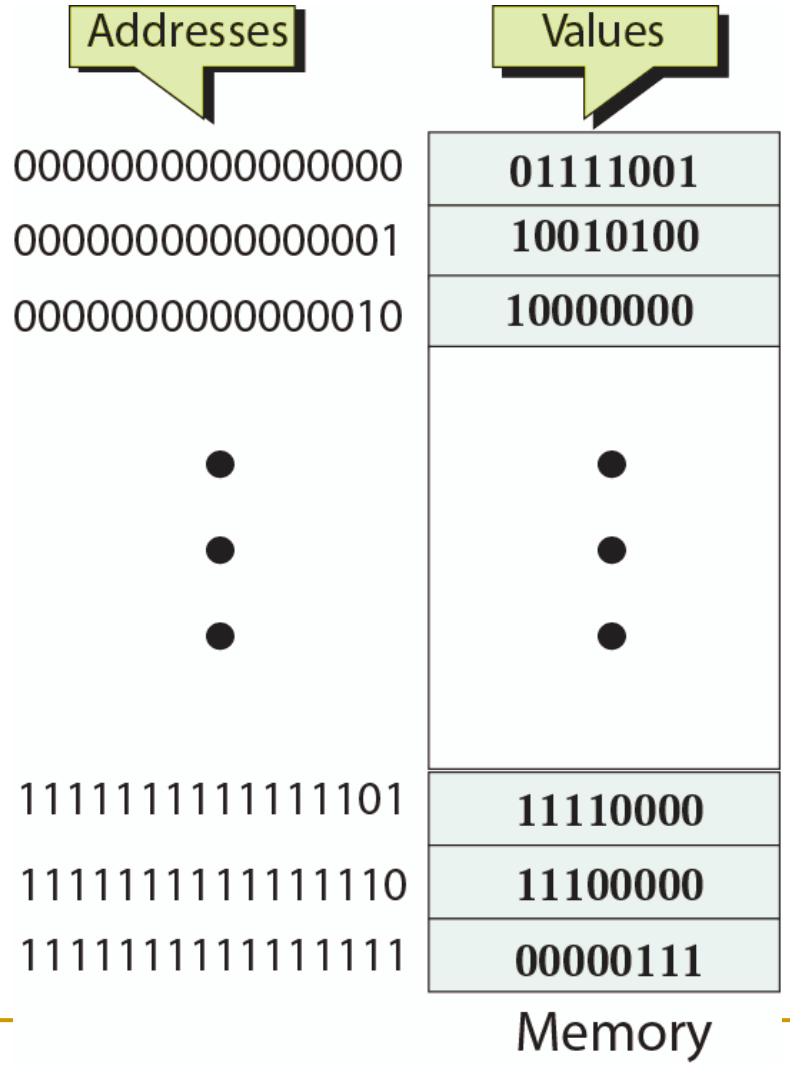


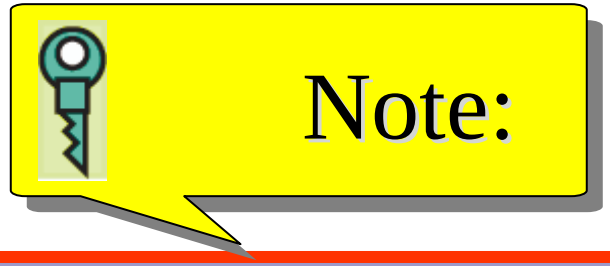
Unit	Exact Number of bytes	Approximation
kilobyte	2^{10} bytes	10^{3} bytes
megabyte	2^{20} bytes	10^{6} bytes
gigabyte	2^{30} bytes	10^{9} bytes
terabyte	2^{40} bytes	10^{12} bytes
petabyte	2^{50} bytes	10^{15} bytes
exabyte	2^{60} bytes	10^{18} bytes

Memory units

Main memory

- Data are transferred to and from memory in groups of bits called **word**s.
- The total number of uniquely identifiable locations (words) in memory is called the address space.
- Because computers operate by storing numbers as bit patterns, the address itself is also represented as a bit pattern.





Memory addresses are defined using unsigned binary integers.

Example 1

A computer has 32 MB (megabytes) of memory. How many bits are needed to address any single byte in memory?

Solution

The memory address space is 32 MB, or 2^{25} (2^5 x 2^{20}). This means you need $\log_2 2^{25}$ or 25 bits, to address each byte.

Example 1a

A school has 14 students. How many bits are needed if student ids are encoded in binary digits 0 and 1?

Solution

We need $\lceil \log_2 14 \rceil$
or 4 bits, to address each student.

Example 2

A computer has 128 MB of memory. Each word in this computer is 8 bytes. How many bits are needed to address any single word in memory?

Solution

The memory address space is 128 MB, which means 2^{27}. However, each word is 8 (2^3) bytes, which means that you have 2^{24} words. This means you need $\log_2 2^{24}$ or 24 bits, to address each word.

Memory types

- Two types of memory are available: RAM and ROM
- RAM (random access memory) provides the bulk of the memory in a computer, can be read from and written to by the user.
  - The information (program or data) is lost after the system is powered off.
- The contents of ROM (read-only memory) come from the manufacturer; users are only allowed to read from it, but not write to it.

5.3

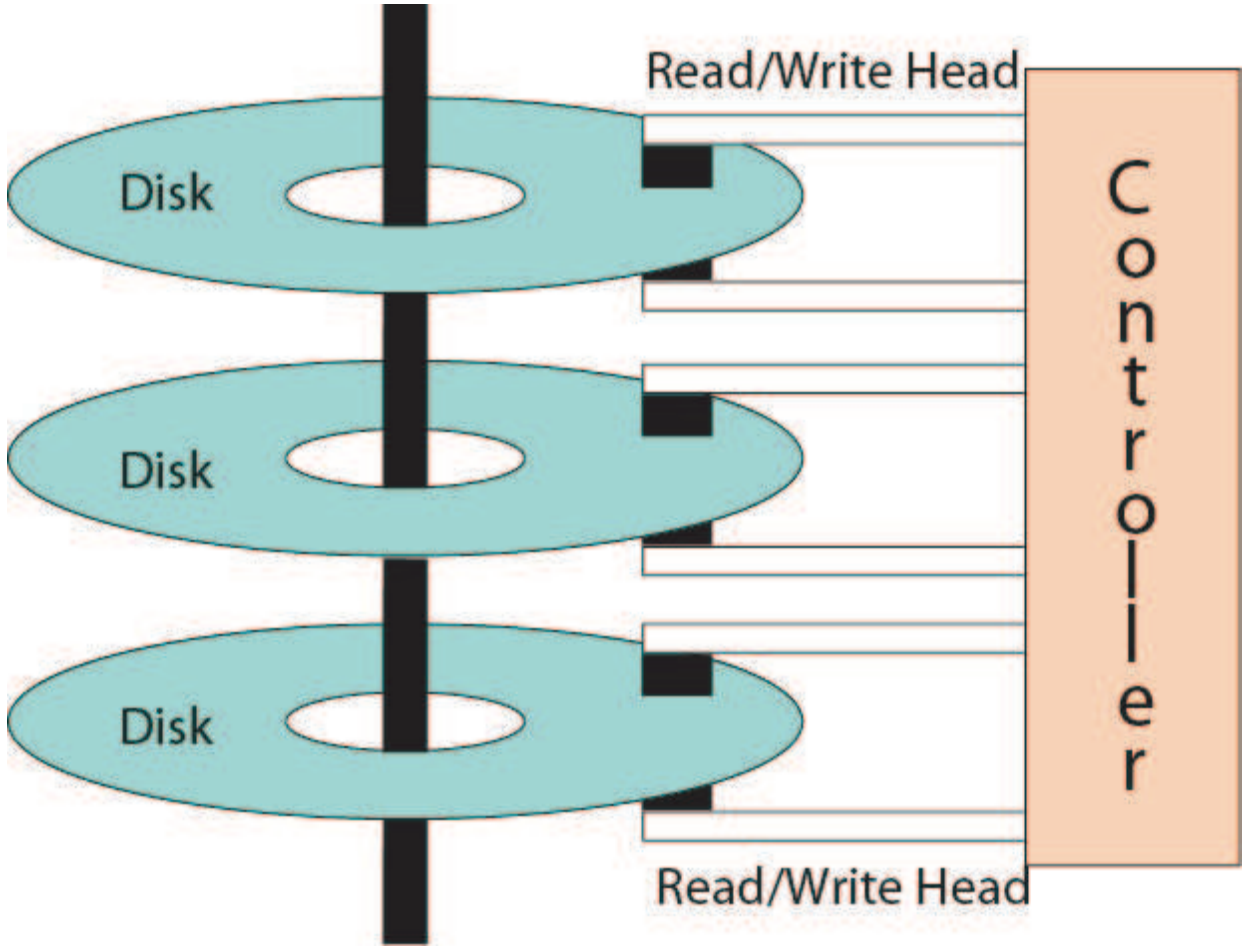
INPUT / OUTPUT

Input/output

- The input/output subsystem is a collection of devices that allows a computer to communicate with the outside world. These devices are either nonstorage devices or storage devices.

- The keyboard, monitor, and printer are examples of nonstorage devices.
- Storage devices include magnetic disks, magnetic tapes, and optical disks.
  - They are cheaper than main memory, and their contents are nonvolatile.

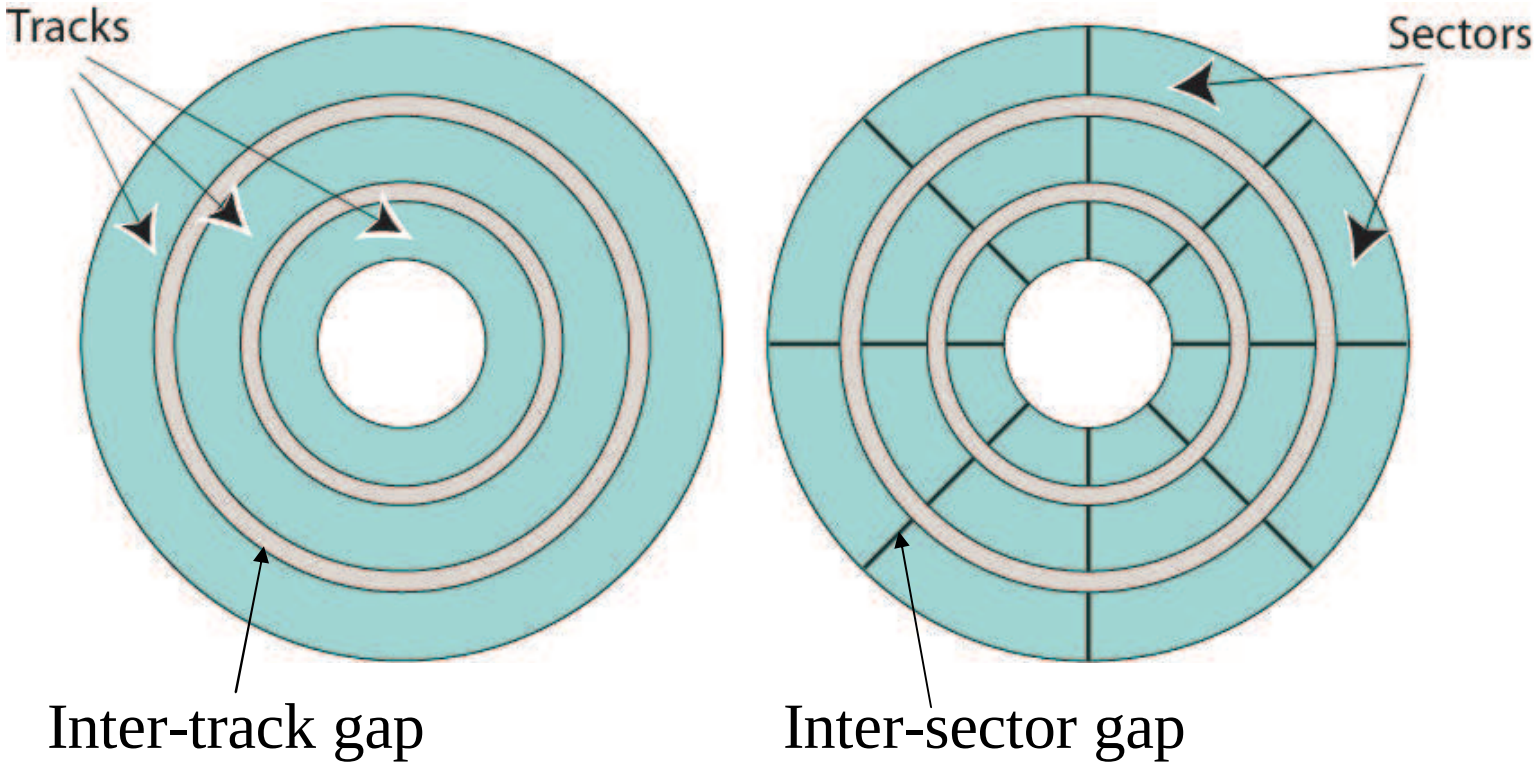
Physical layout of a magnetic disk



Surface organization of a disk

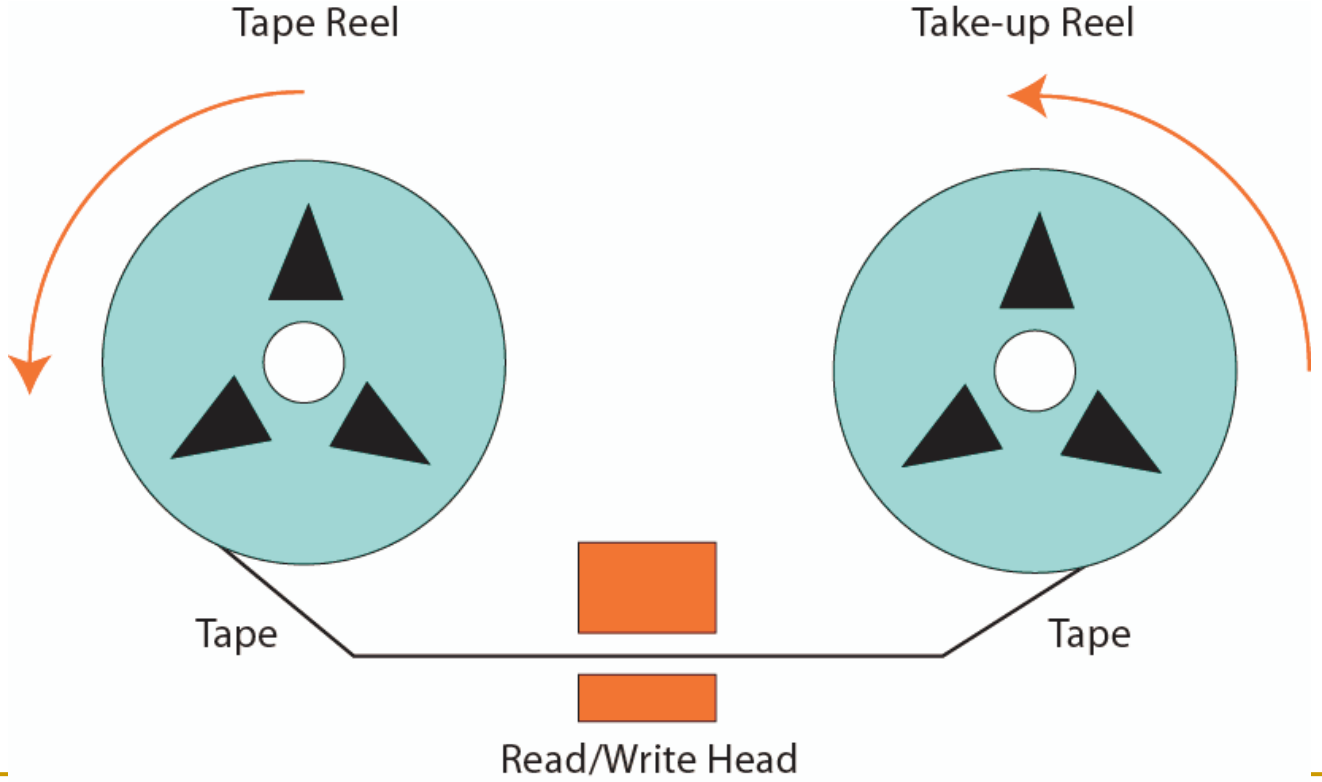
Performance:

access time = seek time + rotational time + transfer time

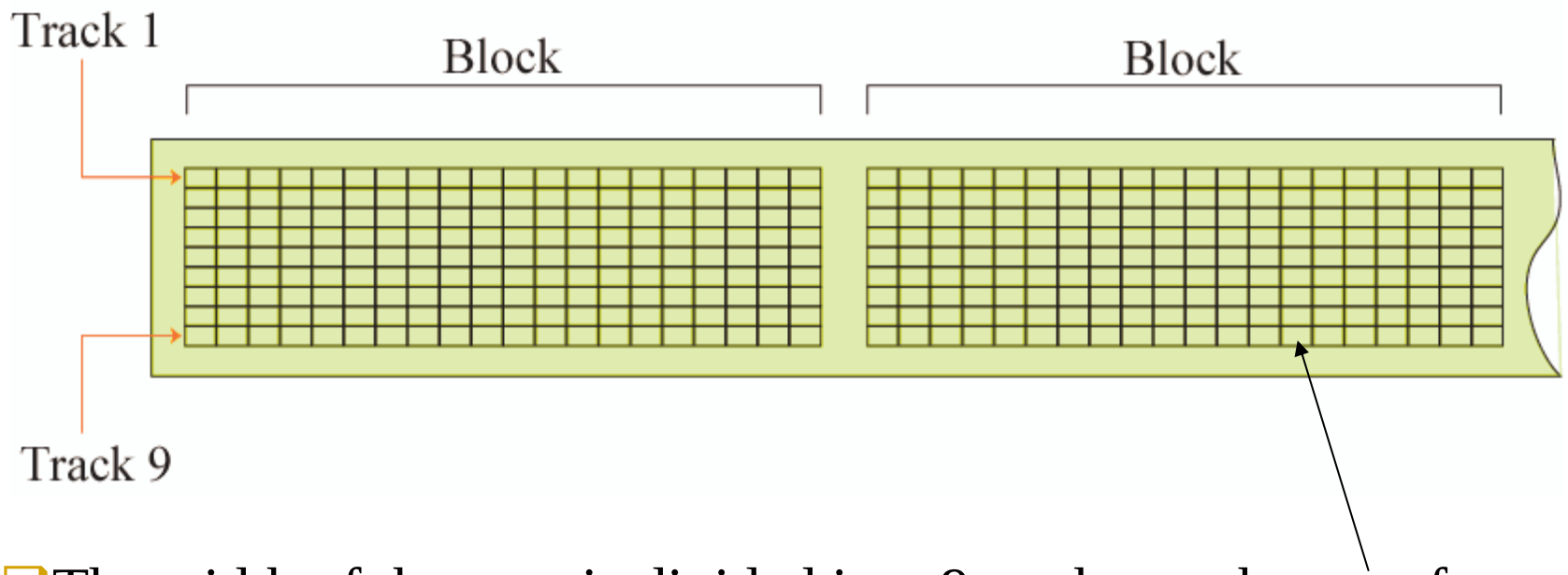


Mechanical configuration of a tape

Magnetic tape is a storage device with the tape divided into tracks. Access to the data is sequential.

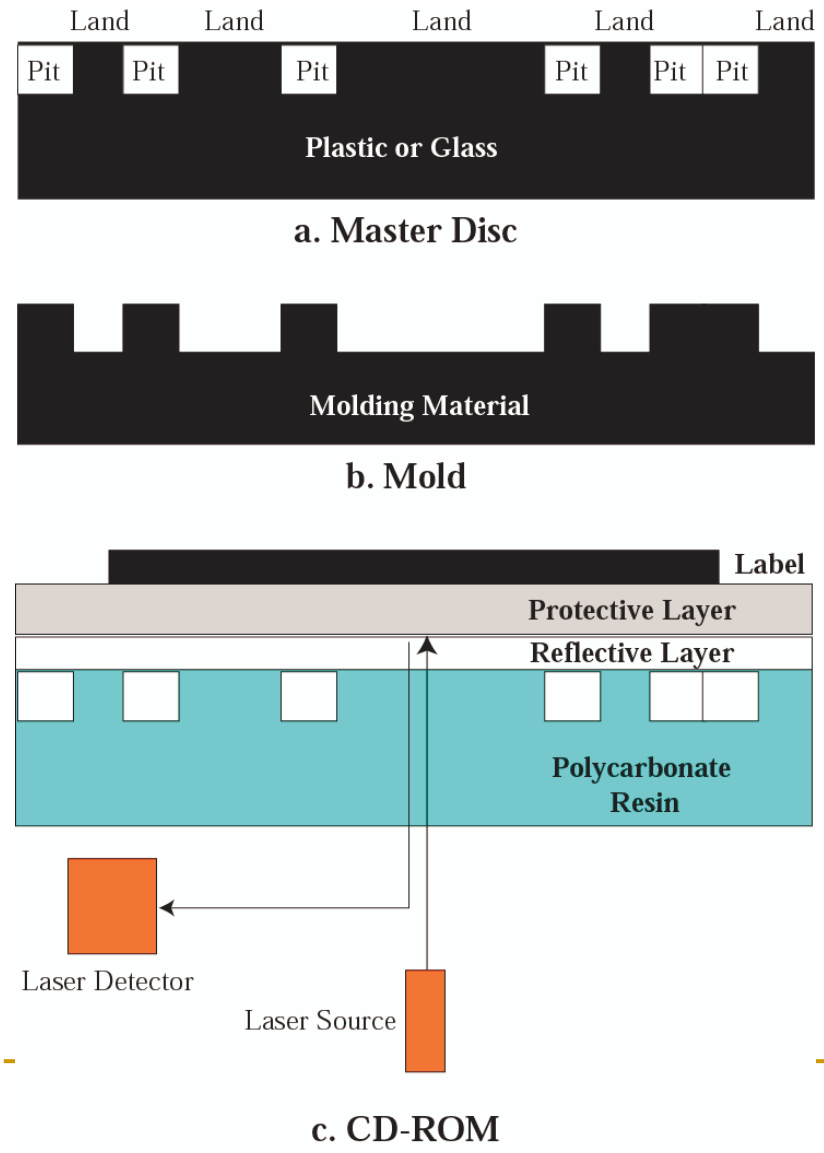


Surface organization of a tape



- The width of the type is divided into 9 tracks; each spot of a track can store 1 bit of information. Nine vertical spots can store 8 bits of information related to a byte plus a parity bit for error detection.
- To retrieve a specific block on the tape, you need to pass through all of the previous blocks.

Creation and use of CD-ROM



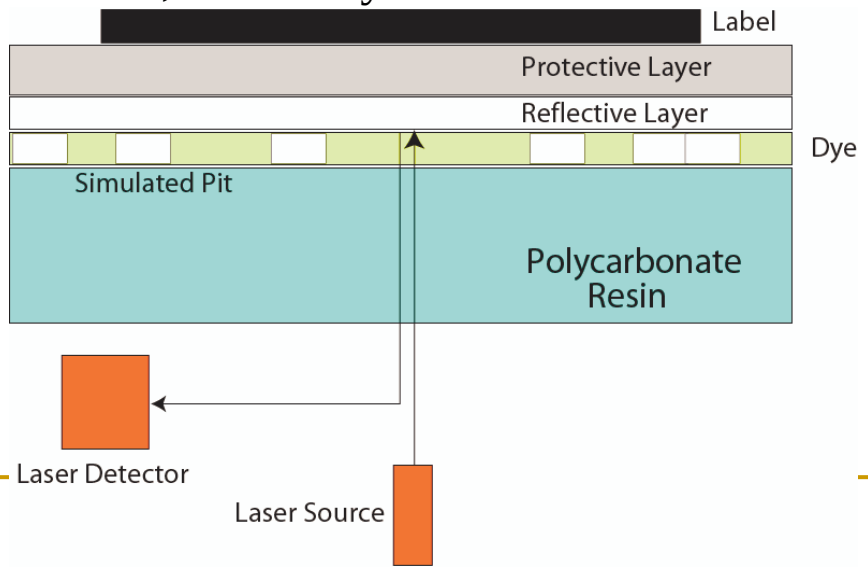
- A CD-ROM is an optical storage device in which the manufacturer burns the data onto the disk. The data cannot be erased.
- Using high-power infrared laser to make bit patterns on coated plastic. pit→0, land→1
- In the mold, the pits are replaced by bumps
- Molten polycarbonate resin is injected into the mold to produce the same pits as the master disc.
- Reading: using a lower-power laser beam

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

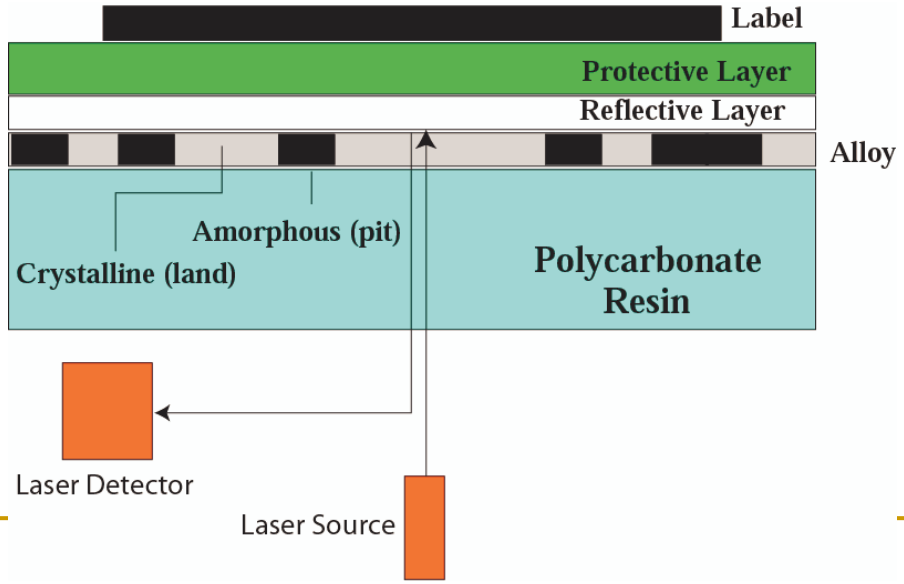
Making a CD-R

- User can write once to the disc, but it can be read many times.
- Differences:
  - No master disc or mold
  - Reflective layer is made of gold instead of aluminum.
  - To simulate pits and lands, an extra layer of dye is added.
    - A high-power laser beam makes a dark spot in the dye, simulating a pit.
  - High power laser beam, created by the CD burner of the drive



Making a CD-RW

- Erasable (rewritten multiple times) optical disc
- Differences:
  - Instead of dye, uses an alloy. This alloy has two stable states: crystalline (transparent) and amorphous (nontransparent)
  - High power lasers change it from crystalline to amorphous.
  - A medium-power laser beam can change a spot from amorphous to crystalline.



DVD capacities

- The capacity of CD-ROM (650MB) is insufficient to store video information
- Differences:
  - The pits are smaller: 0.4 microns
  - The tracks are closer to each other
  - The beam is red laser instead of infrared
  - DVD uses one to two recording layers, and it can be single-sided or double-sided

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

Connecting CPU and memory

A data bus, an address bus, and a control bus connect the CPU and memory.

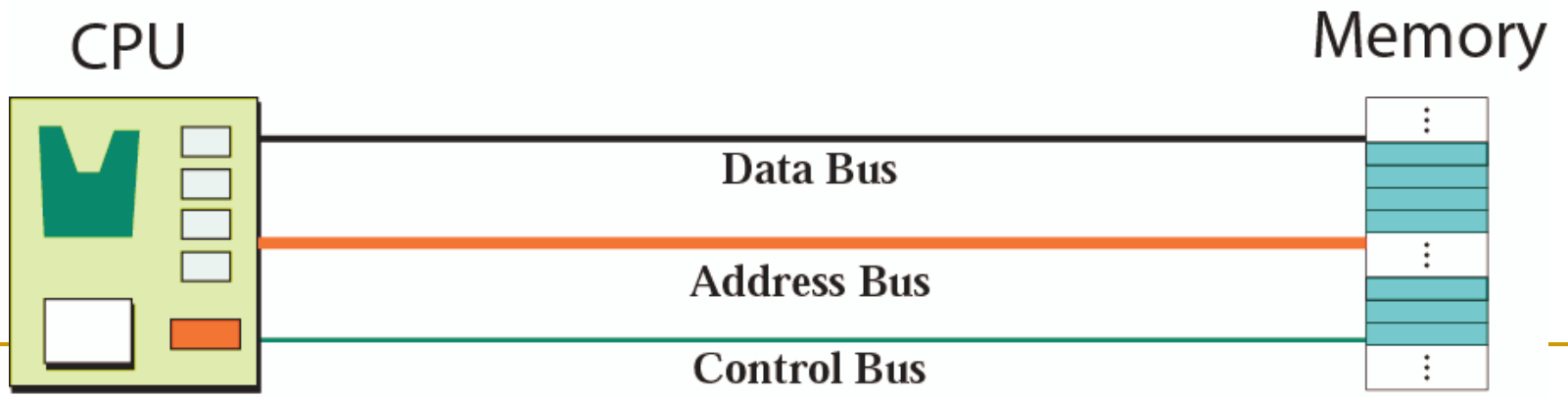
Bus: a group of wires, each carrying 1 bit at a time

Number of wires of each bus

•Size of the word

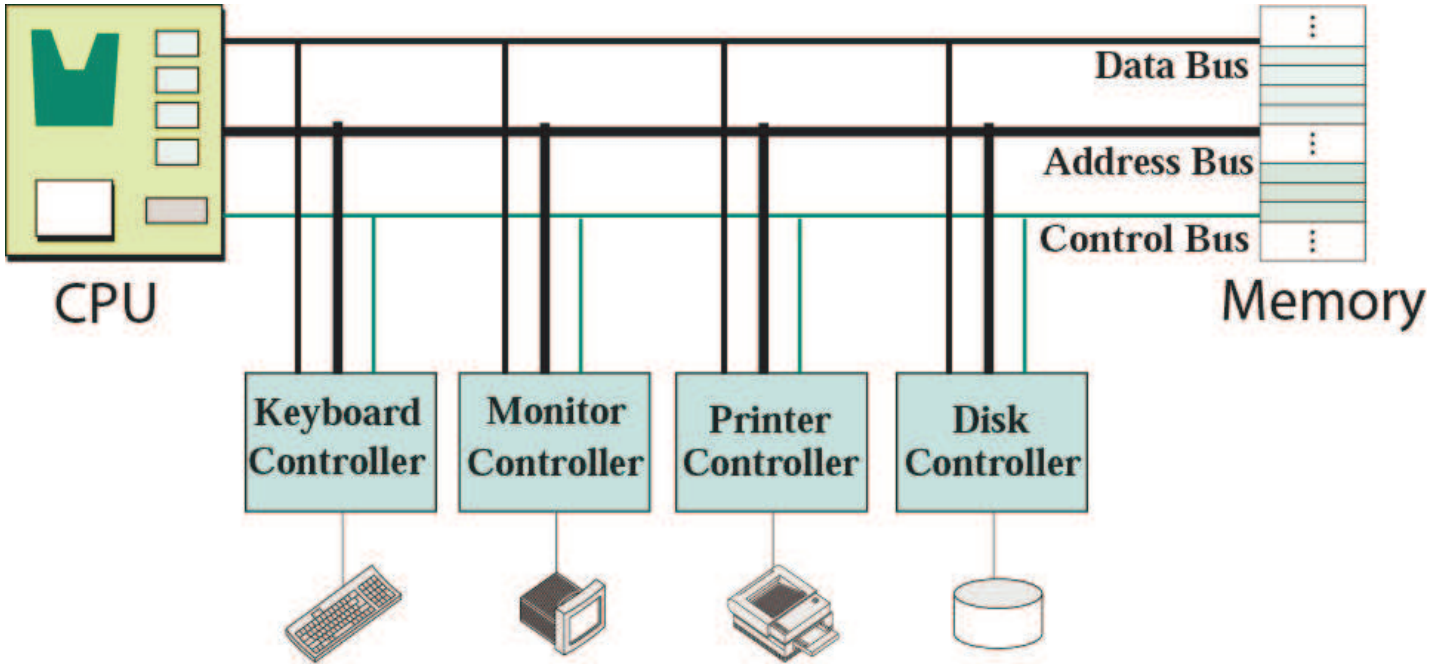
•Address space of memory

•Total number of control commands



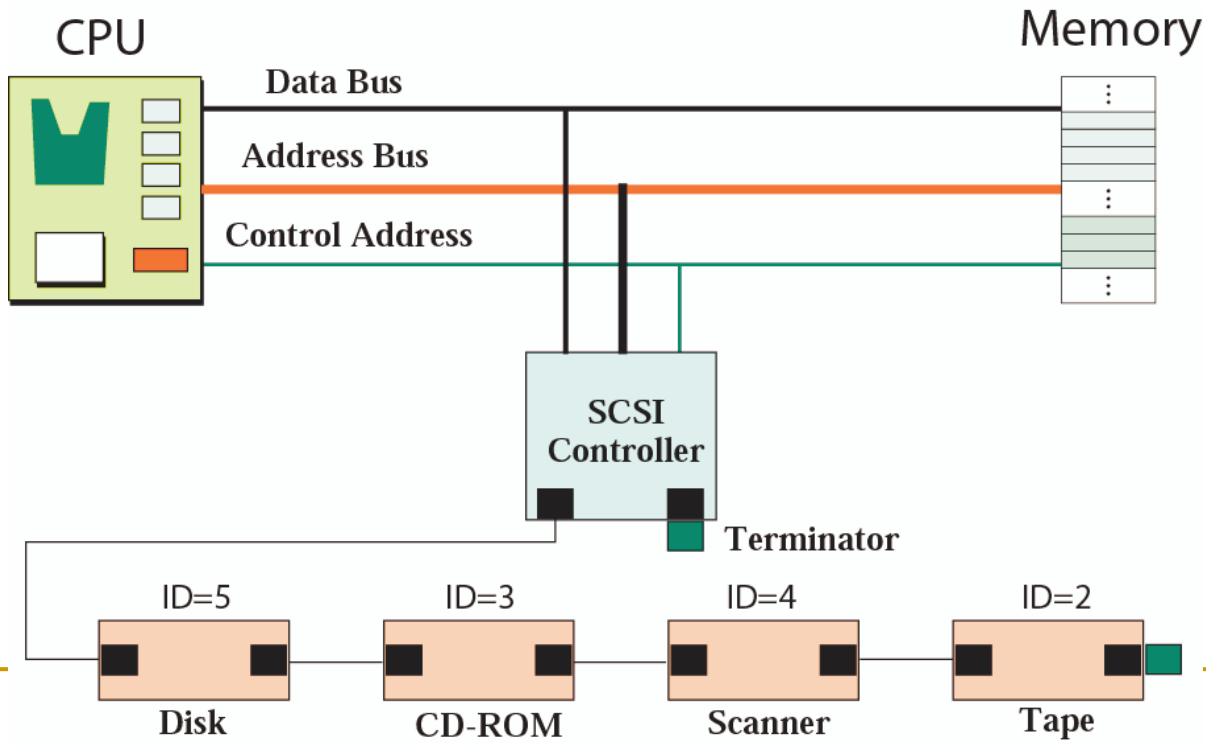
Connecting I/O devices to the buses

A controller handles the I/O operations between the CPU/memory and the much slower I/O devices. SCSI, FireWire, and USB are common controllers.



SCSI controller

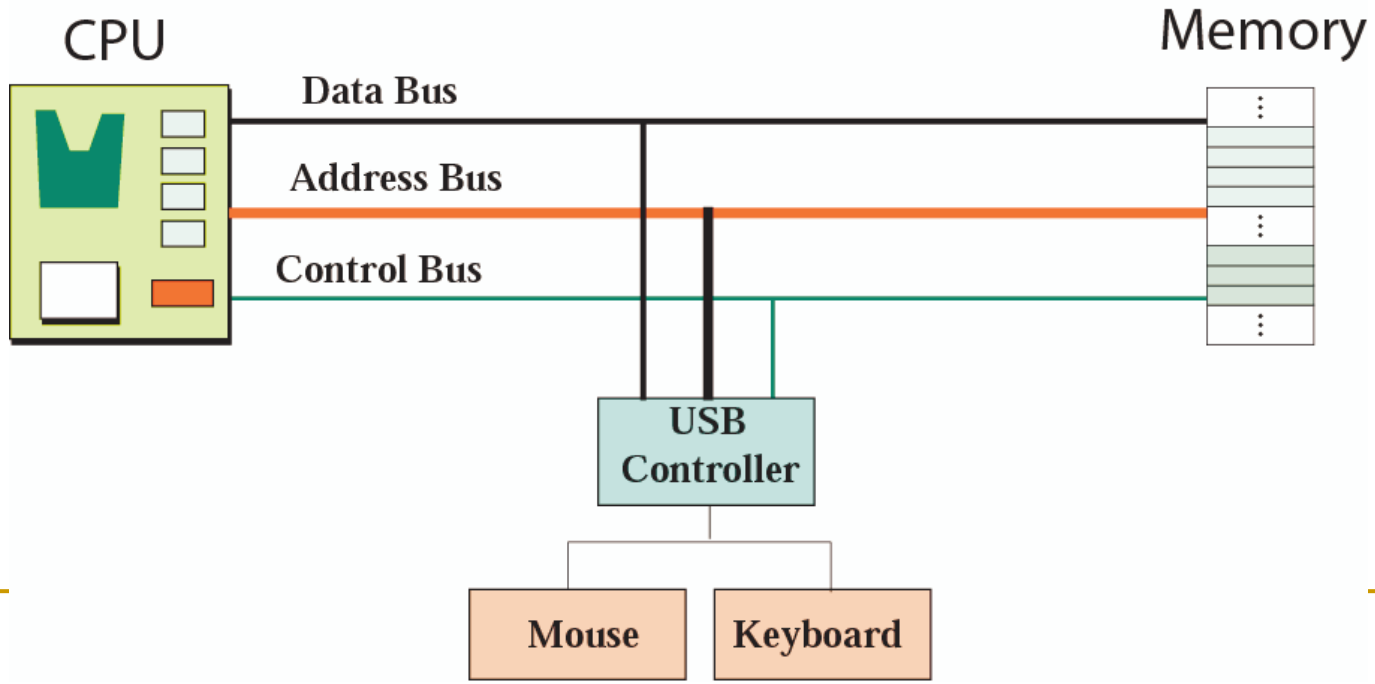
- It has a parallel interface with 8, 16, or 32wires.
- Provide a daisy chained connection
- Each device must have a unique address.
- Transfer rate:
  - SCSI-1: 5MB/s
  - Ultra-320: 320MB/s



USB controller

- Serial controller used to connect slower devices such as the keyboard and mouse to a computer
  - Low Speed: 192KB/s
  - Full Speed: 1.5MB/s
  - Hi-Speed: 60MB/s

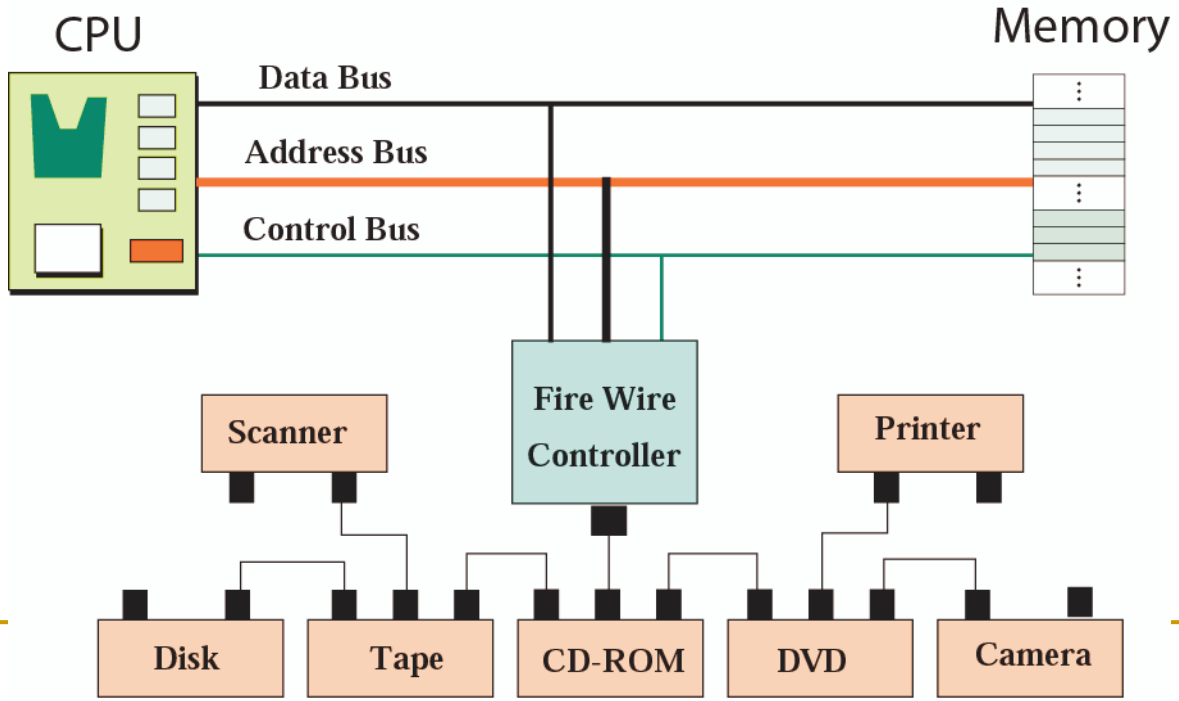
- Has four-wire bus, two carry power to the device



FireWire controller

- High-speed serial interface that transfers data in packets, also known as IEEE 1394.
  - FireWire 400 (IEEE 1394a): 50MB/sec
  - FireWire 800 (IEEE 1394b): 100MB/sec

- Connect up to 63 devices in a daisy chain or a tree connection



OBJECTIVES

After reading this chapter, the reader should be able to:

- Distinguish between the three components of a computer hardware.
- List the functionality of each component.
- Understand memory addressing and calculate the number of bytes for a specified purpose.
- Distinguish between different types of memories.
- Understand how each input/output device works.
- Understand the mechanisms used to connect different components together.