

# Chapter 6

## Memory Organization

# Memory hierarchy

- A computer system is equipped with a hierarchy of memory subsystems.
- There are several memory types with very different physical properties.
- The important characteristics of memory devices are cost per bit, access time, data transfer rate, alterability and compatibility with processor technologies.
- Design constraints: How much? How fast? How expensive?

# Main Memory:

- ▶ The main memory (RAM) stores data and instructions.
- ▶ the capacity of the memory is 128 words of 8 bits (one byte) per word.
- ▶ RAMs are built from semiconductor materials.
- ▶ Semiconductor memories fall into two categories, SRAMs (static RAMs) and DRAMs (dynamic RAMs).

# Cont...

## **dynamic ram (dram):**

- is made with cells that store data as charge on capacitors.
- The presence or absence of charge in a capacitor is interpreted as a binary 1 or 0.
- Because capacitors have a natural tendency to discharge, DRAMs require periodic charge refreshing to maintain data storage.

## **static ram (sram)**

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- A static RAM will hold its data as long as power is supplied to it.

# static ram (sram)

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- ▶ A static RAM will hold its data as long as power is supplied to it.
- ▶ Static RAM's are faster than dynamic RAM's.

# Dynamic Verses Static RAM

## Dynamic RAM

- It requires periodic refreshing.
- Each cell stores bit with a capacitor and transistor.
  - Large storage capacity
  - Needs to be refreshed frequently.
  - Used to create main memory.
  - Slower and cheaper than SRAM.

# Static RAM

- ▶ a bit of data is stored using the state of a flip-flop.
- ▶ Applying power is enough (no need for refreshing).
- ▶ Retains value indefinitely, as long as it is kept powered.
- ▶ Mostly uses to create cache memory of CPU
- ▶ Faster and more expensive than DRAM

# ROM

- ▶ ROM is used for storing programs that are permanently resident in the computer and for tables of constants that do not change in value once the production of the computer is completed
- ▶ Types of ROM
- ▶ ROM
- ▶ PROM
- ▶ EPROM
- ▶ EEPROM



# Connection of RAM and CPU

- ▶ Data transfer between the main memory and the CPU register takes place through two registers namely MAR (memory address register) and MDR (memory data register).
- ▶ The CPU initiates a memory operation by loading the appropriate data into registers MDR and MAR, and setting either Read or Write memory control line to 1. When the required operation is completed the memory control circuitry sends Memory Function Completed (MFC) signal to CPU.

# Cont...

- ▶ The time that elapses between the initiation of an operation and completion of that operation is called memory access time.
- ▶ The minimum time delay between two successive memory operations is called memory cycle time.

# Cache Memory:

- ▶ Cache memory is a small, high-speed RAM buffer located between the CPU and main memory.
- ▶ The main purpose of a cache is to accelerate your computer while keeping the price of the computer low.
- ▶ The cache is the fastest component in the memory hierarchy
- ▶ When CPU needs to access memory, the cache is examined

# Types of Cache Mapping

- There are three cache mapping mechanism
  1. Direct Mapping
  2. Associative Mapping
  3. Set Associative Mapping

# Replacement Algorithms of Cache Memory

- ▶ Replacement algorithms are used when there are no available space in a cache in which to place a data. Four of the most common cache replacement algorithms are described below:
- ▶ Least Recently Used (LRU):
- ▶ First-In-First-Out (FIFO):
- ▶ Least Frequently Used (LFU):
- ▶ Random:

# Writing into Cache

- ▶ When memory write operations are performed, CPU first writes into the cache memory.
- ▶ two popular cache write policies (schemes) are:
  1. Write-Through and
  2. Write-Back.

# Virtual Memory

- ▶ The term virtual memory refers to something which appears to be present but actually it is not.
- ▶ virtual memory is the concept that gives the illusion to the user that they will have main memory equal to the capacity of secondary storage media.
- ▶ The memory management unit (MMU) transfers the currently needed part of the program from the secondary memory to the main memory for execution.
- ▶ The to and fro movement of instructions and data (parts of a program) between the main memory and the secondary memory is called Swapping.

# Address Space And Memory Space.

- ▶ Virtual address is the address used by the programmer and the set of such addresses is called the address space or virtual memory.
- ▶ An address in main memory is called a location or physical address.
- ▶ The set of such locations in main memory is called the memory space or physical memory.



# Secondary memory:

secondary storages are, Devices that provides backup storage

- ▶ They are also called auxiliary memory
- ▶ It is non-volatile storage media
- ▶ It stores information that is not necessarily in current use.
- ▶ It is slower and having higher capacity than primary memory.
- ▶ This kind of memory is large, slow and inexpensive.
- ▶ Examples of secondary memory are: Magnetic tape, floppy disk, hard disk and optical disk

# Magnetic Disk

A disk is a circular platter constructed of non-magnetic material called the substrate coated with a magnetisable material.

Magnetic disks are the foundation of external memory on virtually all computer systems.

Commonly used direct-access secondary storage device.

- ▶ We can randomly access the data.
- ▶ Magnetic disks can also be erased & reused indefinitely.

# cont.....

- ▶ It stores large amount of data.
- ▶ The magnetic disks come in different sizes.
- ▶ Due to large storage capacity of magnetic disks and lesser failures the use of these devices increasing day by day.
- ▶ Suitable for both on-line and off-line storage of data
- ▶ Data transfer rate for a magnetic disk system is normally higher than a magnetic tape system.

# Magnetic Read and Write Mechanisms

- ▶ Data are recorded on and later retrieved from the disk via a conducting coil named the head;
- ▶ in many systems, there are two heads, a read head and a write head.
- ▶ The head is a relatively small device capable of reading from or writing to a portion of the platter rotating beneath it.

# Characteristics of magnetic disks

- ▶ Major physical characteristics that differentiate among the various types of magnetic disks.
  - ❑ Head motion
  - ❑ Platters
  - ❑ Disk portability
  - ❑ Head mechanism
  - ❑ Sides

There are two types of Magnetic Disks: **HARD DISK & FLOPPY DISK**

# Hard disk

- ▶ Round, flat piece of rigid metal (frequently aluminium) disks coated with magnetic oxide
- ▶ It is a storage device that contains one or more inflexible, circular patterns that store data, instructions & information.
- ▶ We can store documents, presentation, database, e-mails, messages, music, video, software etc.
- ▶ Come in many sizes, ranging from 1 to 14-inch diameter.
- ▶ Hard disk of capacities 10GB, 20GB, 40GB and even more are easily available.

# Floppy disks

**Floppy disks** are

- Most popular and inexpensive secondary storage medium
- used in small computers.
- compact and light in weight. Hence they are easy to handle and store.
- Very large amount of data can be stored in a small storage space.
- Also known as floppies or diskettes

# Cont.....

- ▶ It is a portable storage medium .
- ▶ it consists of thin, circular, flexible plastic Mylar film.
- ▶ Standard floppy disk has storage capacity up to 1.44MB.
- ▶ **Types of Floppy disks:**
- ▶ 5¼-inch diskette, whose diameter is 5¼-inch.
- ▶ 3½-inch diskette, whose diameter is 3½-inch.



# Advantages and Disadvantages

## **Advantages**

- ▶ Reusable, portable, Handy.
- ▶ Very low price
- ▶ Provide random access of data

## **Disadvantages**

- ▶ Not Durable and Prone to damage
- ▶ Very low Capacities

# RAID (Redundant Array of Independent Disks)

- ▶ RAID is a set of physical disk drives viewed by the operating system as a single logical drive.
- ▶ Data are distributed across the physical drives of an array.
- ▶ Redundant disk capacity is used to store parity information, which guarantees data recoverability in case of a disk failure.

# Cont....

- ▶ To achieve greater performance and higher availability, servers and larger systems use RAID disk technology.
- ▶ the RAID array creates significant performance and reliability gains.

# Optical Disk

- ▶ Is a Laser beam technology for recording and reading of data on the disk.
- ▶ it can store extremely large amounts of data in a limited space.
- ▶ The optical disk became the preferred medium for music, movies and software programs.
- ▶ Compact, lightweight, durable and digital,
- ▶ the optical disk also provides a minimum of 650 MB of data storage.

# Optical Disk Types:

- ▶ CD: Compact Disk:
- ▶ CD-ROM: Compact Disk Read-Only Memory
- ▶ CD-R: CD Recordable
- ▶ CD-RW
- ▶ DVD: Digital Versatile Disk
- ▶ DVD-R: DVD Recordable
- ▶ DVD-RW: DVD Rewritable

# Advantage of Optical Disk

- ▶ The cost-per-bit of storage
- ▶ Optical disk drives do not have any mechanical read/write heads to rub against or crash into the disk surface.
- ▶ This makes optical disks a more reliable storage medium than magnetic tapes or magnetic disks.
- ▶ Optical disks have a data storage life in excess of 30 years. This makes them a better storage medium for data archiving as compared to magnetic tapes or magnetic disks.

# Cont...

- As data once stored on an optical disk becomes permanent, danger of stored data getting inadvertently erased/overwritten is removed
- Due to their compact size and light weight, optical disks are easy to handle, store, and port from one place to another
- Music CDs can be played on a computer having a CDROM drive along with a sound board and speakers.
- This allows computer systems to be also used as music systems

# Limitation of Optical disk

- ▶ Data once recorded, cannot be erased and hence the optical disks cannot be reused.
- ▶ The data access speed for optical disks is slower than magnetic disks.
- ▶ Optical disks require a complicated drive mechanism.



# The Blu-ray Disc

## The Blu-ray Disc

- ❑ is a technology platform that can store sound and video while maintaining high quality and also access the stored content in an easy way to-use.

## Advantage of Blu-ray Disc's

- ❑ high-speed data transfer rate 36 Mbps.
- ❑ Large recording capacity up to 27 GB.
- ❑ Easy to use disc cartridge.

# Magnetic Tape

Magnetic Tape is a plastic ribbon which is usually  $\frac{1}{2}$  inch or  $\frac{1}{4}$  inch wide & 50 to 2400 feet long.

- ▶ It is coated with iron-oxide material.
- ▶ It is similar to the tape of audio cassettes of tape recorders.
- ▶ Data is stored as binary digits
- ▶ Magnetic tape was the first kind of secondary memory.
- ▶ It is still widely used as the lowest-cost, slowest-speed member of the memory hierarchy.

# Advantages and Disadvantages:

## Advantages:

- ▶ Store data up to few gigabytes
- ▶ Low cost
- ▶ Magnetic tape used by both mainframes and microcomputers

## Disadvantages:

- ▶ Sequential access so searching becomes difficult.
- ▶ We can either read or write data at one time