اللهم صل وسلم وبارك على سيدنا محمد وعلى
آله وصحبة وسلم تسليماً كثيراًطيباً مباركاً فيه

File Organization

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File Structures & Organization



Secondary Storage and System Software

Lecture No. 4

Contents

Cont. Magnetic Storage Technology

Clusters, Extents, and Fragmentation

- The **file manager** is the part of the operating system responsible for managing files

- The file manager maps the logical parts of the file into their physical location

- A **cluster** is a fixed number of contiguous sectors

  So One cluster = a group of sectors

- The file manager allocates an integer number of clusters to a file.

Clusters, Extents, and Fragmentation

- **An example:** Sector size: 512 bytes, Cluster size: 2 sectors
- If a file contains 10 bytes, a cluster is allocated (1024 bytes).
- There may be unused space in the last cluster of a file.
- This unused space is called internal fragmentation

  Even though the file needs only 10 bytes, it takes the whole cluster (1024 bytes).

  So 1014 bytes unused space → internal fragmentation

Clusters, Extents, and Fragmentation

- Clusters are good since they improve sequential access: reading bytes sequentially from a cluster can be done in one revolution, seeking only once.

- The file manager maintains a file allocation table (FAT) containing for each cluster in the file and its location in disk
  - ✔ Where each file starts
  - ✔ Where the next part of the file is located

It is like the index of a book, helping the OS find file data on disk.

- An **extent** is a group of contiguous clusters. If file is stored in a single extent then seeking is done only once.
- If there is not enough contiguous clusters to hold a file, the file is divided into 2 or more extents.

Fragmentation

- Due to records not fitting exactly in a sector
  - Example: Record size = 200 bytes, sector size = 512 bytes

    So, how many records can be stored in one sector?
    512 ÷ 200 = only 2 records (because the third would require additional space exceeding the sector).
    2 × 200 = 400 bytes used
    Remaining 512 - 400 = 112 bytes unused (wasted) within each sector.

  - To avoid that a record span 2 sectors we can only store 2 records in this sector (112 bytes go unused per sector)

  - The alternative is to let a record span two sectors, but in this case, two sectors must be read when we need to access this record)
- Due to the use of clusters
  - If the file size is not multiple of the cluster size, then the last cluster will be partially used.

How to Choose Cluster Size

- Some OS allow the system administrator to choose the cluster size.

- When to use large cluster size?
  - When disks contain large files likely to be processed sequentially.
  - Example: Updates in a master file of bank accounts (in batch mode)

- What about small cluster size?
  - When disks contain small files and/or files likely to be accessed randomly
  - Example : online updates for airline reservation

Organizing Tracks by Blocks

- Disk tracks may be divided into user-defined blocks rather than into sectors.

Organizing Tracks Using Blocks

So far, we talked about how data is organized on disk using sectors and clusters. Now we move to a higher level of organization called blocks.

What is a Block?

A block is a group of records stored together and read from the disk in one I/O operation.

Blocks are used to improve the efficiency of reading/writing data because reading larger chunks is faster than reading many small pieces.

Cont. Organizing Tracks by Blocks

- The amount transferred in a single I/O operation can vary depending on the needs of the software designer

- A block is usually organized to contain an integral number of logical records.

Blocking Factor = number of records stored in each block in a file

Blocking Factor (BF)

The blocking factor tells us how many records can fit inside one block.

$$\text{Blocking Factor} = \frac{\text{Block Size}}{\text{Record Size}}$$

- No internal fragmentation, no record spanning two blocks

Cont. Organizing Tracks by Blocks

Example:

Block size = 1000 bytes

Record size = 100 bytes

$$BF = \frac{1000}{100} = 10 \text{ records per block}$$

So one block can store **10 records**.

- No internal fragmentation, no record spanning two blocks
- Why Use Blocks?

Advantage	Explanation
Faster access	Fewer disk reads (one block at a time instead of many records)
Less overhead	Reduce and saves time in file access
Works well with sequential reading	Efficient for large files

Cont. Organizing Tracks by Blocks

- A block typically contains subblocks:
  - Count subblock: contains the number of bytes in a block (Stores number of bytes in the block)
  - Key subblock (optional): contains the key for the last record in the data subblock (disk controller can search for key without loading it in main memory (Stores last key value to help searching))
  - Data subblock: contains the records in this block (Stores the actual file records).

Count subblock	**Key subblock**	**Data subblock**

block

Cont. Organizing Tracks by Blocks

- **Example:** The file is stored as a set of records or a set of blocks. Let us assume a database for an import and export company that contains three tables: the Supplier table, the Parts table, and the Supplier-Parts table (Sp), as shown in the figure.

(1) Supplier (S):

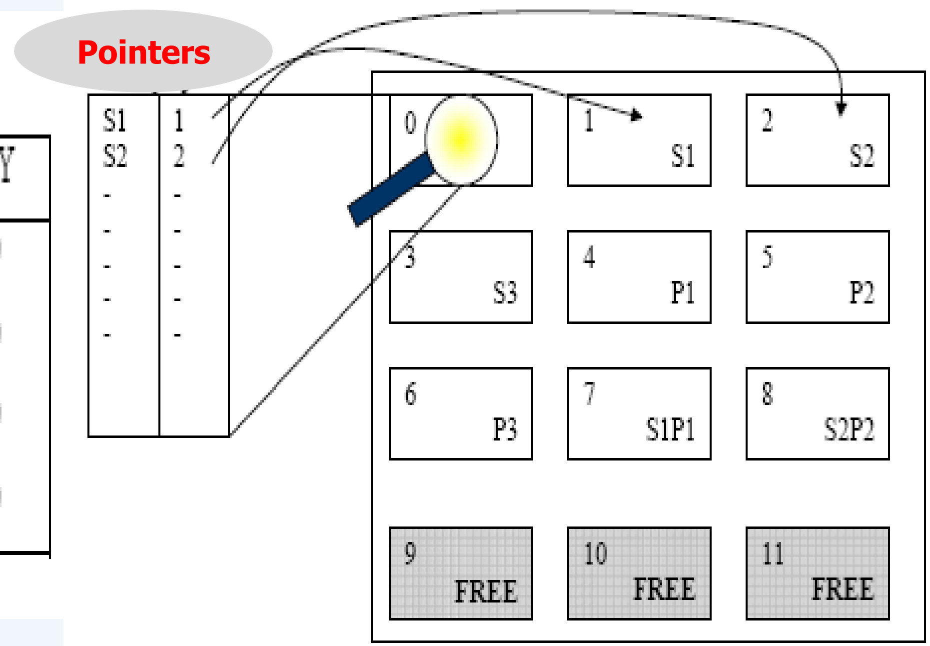
S#	Sname	address
S1	ABC	....
S2	ABE	...
S3	.	
.	.	
.	.	
.	.	

(2) Parts (P):

P#	Partnam	color
P1	screen	....
P2	pins	...
P33	CD	
.	.	
.	.	
.	.	

(3) SP:

S#	P#	QTY
S1	P1	200
S1	P2	300
S2	P1	400
S3	P3	500



Nondata Overhead

- Amount of space used for extra stuff other than data

- Sector-Addressable Disks
  - At the beginning of each sector some info is stored, such as sector address, track address, condition (if sector is defective);
  - There is some gap between sectors

- Block-Organized Disks
  - subblocks and interblock gaps is part of the extra stuff; more nondata overhead than with sector-addressing

Solved Example

- Disk characteristics
  - Block-addressable Disk Drive
  - Size of track = 20.000 bytes
  - Nondata overhead per block = 300 bytes

- File Characteristics
  - Record size = 100 bytes

- How many records can be stored per track for the following blocking factors?
  1. Block factor = 10
  2. Block factor = 60

Solved Example

- Blocking factor is 10

  Data in block=10×100=1000 bytes
- Size of data subblocks = 1000

  Total block size=Data+Overhead=1000+300=1300 bytes
- Number of blocks that can fit in a track =

$$\left\lfloor \frac{20000}{1300} \right\rfloor = \lfloor 15.38 \rfloor = 15$$

  Total records per track=15×10=150 records
- Number of records per track = 150 records

Solved Example

- Blocking factor is 60

  Data in block=$60\times100=6000$ bytes

- Size of data subblocks = 6000

  Total block size=$6000+300=6300$ bytes

- Number of blocks that can fit in a track =

$$\left\lfloor \frac{20000}{6300} \right\rfloor = \lfloor 3.17 \rfloor = 3$$

  Total records per track=$3\times60=180$ records

- Number of records per track = 180 records

Comparison

Blocking Factor (BF)	Records per Block	Blocks per Track	Total Records per Track
10	10	15	150
60	60	3	180 ☐ (better use of disk space)

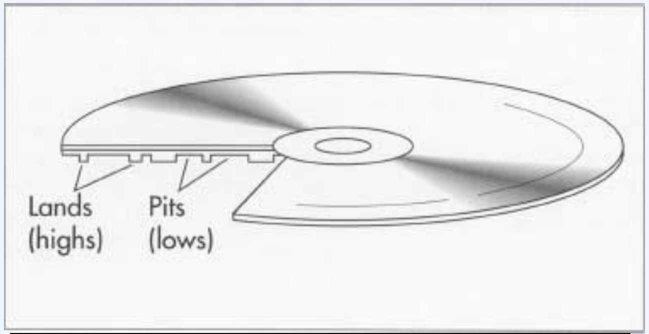
- ✓ Bigger blocks increase storage efficiency
- ✓ Fewer I/O operations → **better performance**

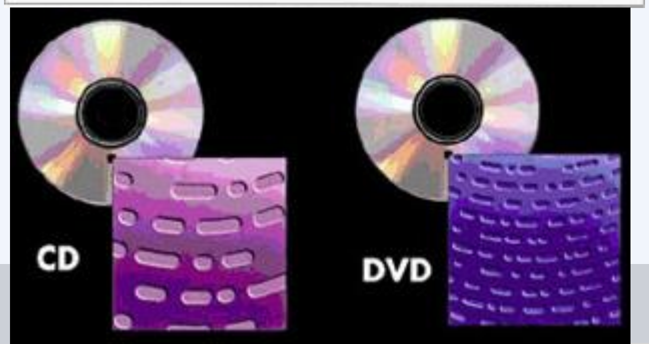
Optical Storage Technology

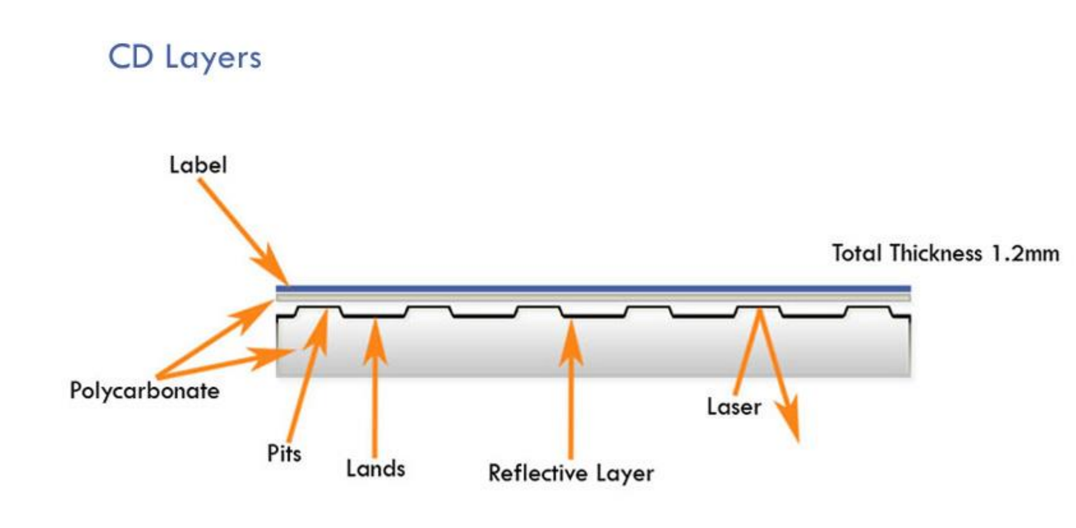
Optical Storage Technology

- CD, DVD, and Blu-ray technologies are classified as **optical storage**, which stores data as microscopic light and dark spots on the disc surface.

- The dark spots are called pits. The lighter, non-pitted surface areas of the disc are called lands.



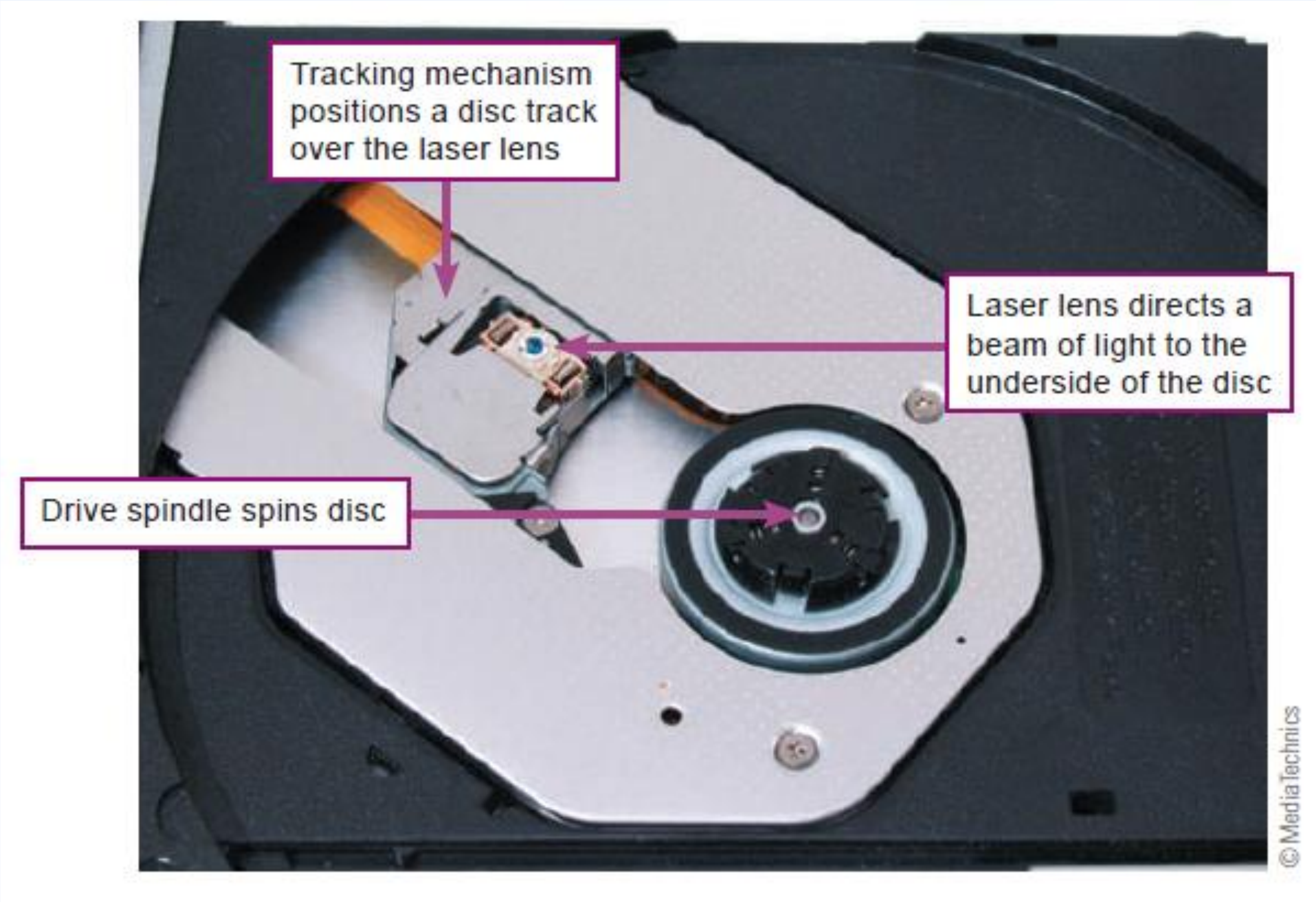




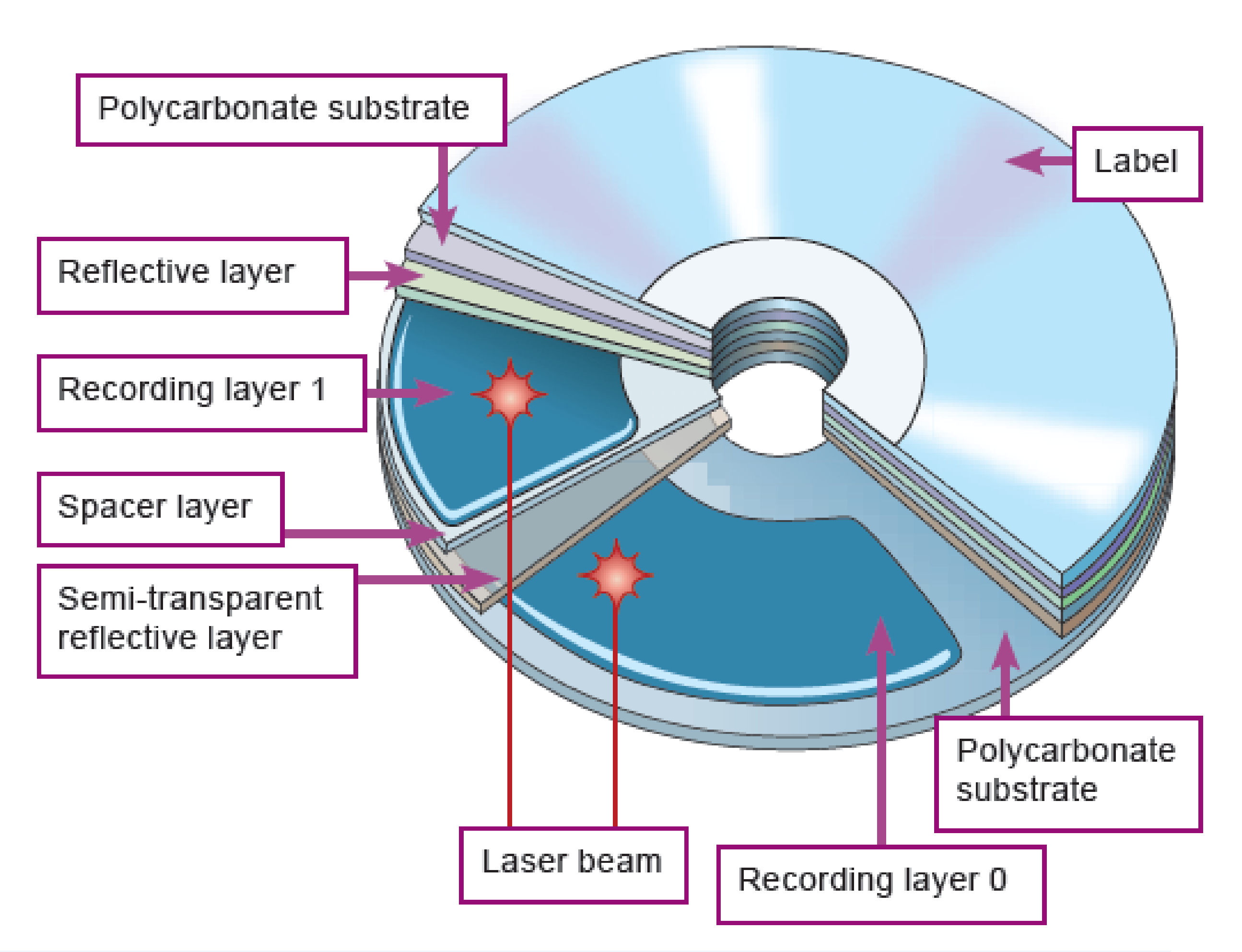
Optical Storage Technology

- Optical drives contain a spindle that rotates the disc over a laser lens.
- The laser directs a beam of light toward the underside of the disc.
- The dark pits and light lands on the disc surface reflect the light differently.
- As the lens reads the disc, these differences are translated into the 0s and 1s that represent Data

Optical Storage Technology



Optical Storage Technology



Optical Storage Technology

Layer	Function	Description
Label	The printed top surface	Used to show the title or design of the disc.
Polycarbonate substrate	The main transparent base	Provides the disc's shape and supports other layers.
Reflective layer	Reflects the laser light	Allows data reading from the laser.
Recording layer 0	First data layer	Stores the first set of data (closest to the laser).
Semi-transparent reflective layer	Partially reflects and partially passes the laser	Lets the laser reach the second layer below.
Spacer layer	Separates the two recording layers	Keeps them at the right distance apart.
Recording layer 1	Second data layer	Stores additional data (farther from the laser).
Laser beam	Reads or writes data	The laser focuses on layer 0 or layer 1 depending on what is being read.

Optical Storage Technology

- Optical technologies are grouped into three categories: read-only, recordable, and rewritable.

Read-only

Read-only Technology (ROM)

You cannot write to a -ROM disc, which left the factory with data already on it. A -ROM drive can read discs but not write to them, and has no use at all for a blank disc.

Recordable

Recordable Technology (R)

You can write to one of these discs once (provided you have an -R drive). But when you're done, it's effectively a -ROM disc

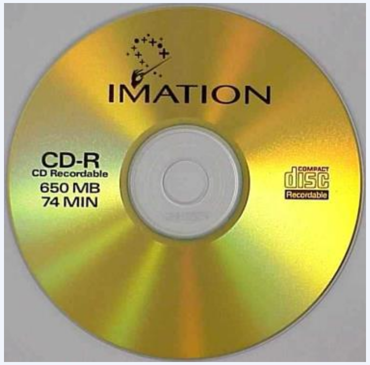
Rewritable

Rewritable Technology (RW)

You can write to these discs, erase them, and write to them again.
The term re-recordable (RE) is sometimes used instead of rewritable

CD (Compact Disc)

- **CD (Compact Disc)** technology was originally designed to hold 74 minutes of recorded music.
- The original CD standard was adapted for computer storage with capacity for 650 MB of data.
- Later improvements in CD standards increased the capacity to 80 minutes of music or 700 MB of data.



DVD (Digital Video Disc)

- **DVD (Digital Video Disc or Digital Versatile Disc)** is a variation of CD technology that was originally designed as an alternative to VCRs, but was quickly adopted by the computer industry to store data.

- The initial DVD standard offered 4.7 GB (4,700 MB) of data storage.

- A double layer DVD has two recordable layers on the same side and can store 8.5 GB of data.

Blu-ray

- **Blu-ray** is a high-capacity storage technology with a 25 GB capacity per layer.

- The name Blu-ray is derived from the blue-violet colored laser used to read data stored on Blu-ray discs.

- DVD technology uses a red laser; CD technology uses a near infrared laser

Optical Storage Technology

Optical Disc Capacities

Type	Storage Capacity	Use
CD	650–700 MB	Music, simple files
DVD	4.7 GB (single layer), 8.5 GB (dual layer)	Movies, software
Blu-ray	25 GB (single layer), 50 GB (dual layer)	High-definition movies, large games

- Blu-ray uses a **blue laser** (shorter wavelength → more storage), while CD/DVD use **red lasers**.

Solid State Storage Technology

Solid State Storage Technology

- **Solid State Storage** (sometimes called flash memory) is a technology that stores data in erasable, rewritable circuitry, rather than on spinning disks or streaming tape.

- It is widely used in portable consumer devices, such as digital cameras, portable media players, iPads, and cell phones.

- It is also used as an alternative for hard disk storage in some laptop computers.

Solid State Storage Technology

- Solid state storage contains a grid work of circuitry.
- Each cell in the grid contains two transistors that act as gates to hold the 1s and 0s that represent data
- Very little power is required to open or close the gates, which makes solid state storage ideal for battery-operated devices, such as digital cameras and media players.

Solid State Storage Technology

- Solid state storage has the following advantages:
  - Fast access to data because it includes no moving parts.
  - Very durable; it is virtually impervious to vibration, magnetic fields, or extreme temperature fluctuations.

- However, the capacity of solid state storage does not currently match that of hard disks.

- The cost per megabyte of solid state storage is slightly higher than for magnetic or optical storage.

Solid State Storage Technology

- Several types of solid state storage are available to today’s consumers: memory cards, solid state drives, and USB flash drives.

Memory Cards

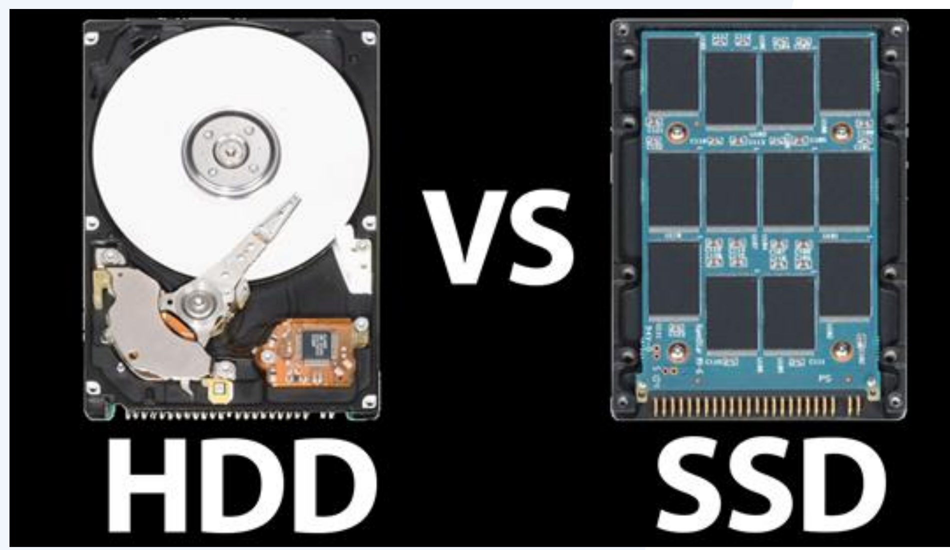
- A **memory card** is a flat, solid state storage medium commonly used to transfer files from digital cameras and media players to computers.

- A **card reader** is a device that reads and writes data on solid state storage.

Solid State Drive (SSD)

- A **solid state drive (SSD)** is a package of flash memory that can be used as a substitute for a hard disk drive.

- Some solid state drives are about the same size as a microprocessor chip, whereas others are about the size of a small hard disk drive.



USB Flash Drives

- A **USB flash drive** is a portable storage device that plugs directly into a computer's system unit using a built-in connector.

- USB flash drives have capacities ranging from 16 MB to 256 GB.

- Flash drives are slower than hard disk drives.

Advantages & Disadvantages of Different Storage Technology

Storage Type	Cost of Device	Capacity	Data Transfer Rate	Technology	Removable
USB Flash Drive	$$	2–256 GB	Medium	Solid state	Yes
CD-RW	$	700 MB	Slow	Optical	Yes
DVD+RW	$	8.5 GB	Slow	Optical	Yes
Blu-ray	$$$$	50 GB	Slow	Optical	Yes
Floppy Disk	$	1.44 MB	Glacial	Magnetic	Yes
Hard Drive (Internal)	$$$	80 GB–2 TB	Fast	Magnetic	No
Hard Drive (External)	$$$	80 GB–2 TB	Fast	Magnetic	Yes
Solid State Drive (Internal)	$$$	32 GB–256 GB	Fast	Solid state	No



Thank You !