

Chapter 3

Storage Systems

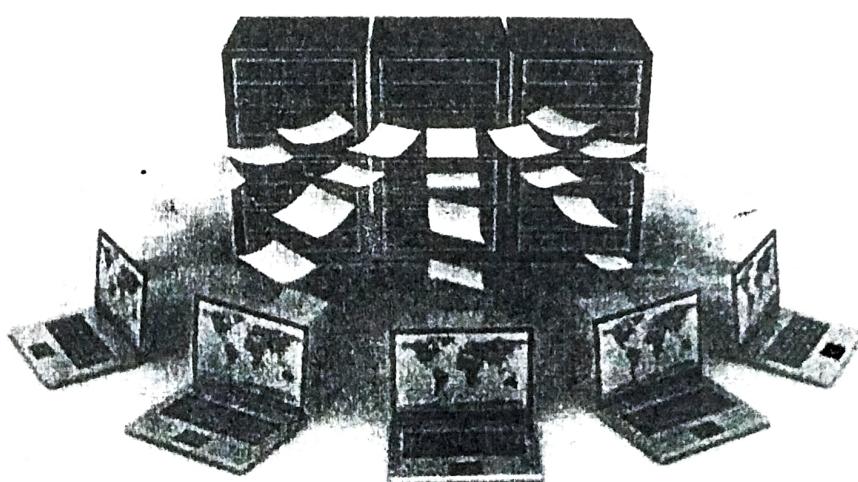
Introduction

This chapter introduces the different types of storage systems that are used to permanently store the data and programs. Any storage system consists of two parts; the storage medium and the storage device (driver). The chapter starts with introducing the common characteristics of the storage systems. The magnetic disks (floppy and hard) are discussed first because they are considered the prime systems. Then, the optical disks and some other types of storage systems are explained. Finally, a comparison between the different types of storage systems is given.

The general objectives of this chapter are:

After completing this chapter, you will be able to:

- Identify the overall characteristics of storage systems.
- Explain how magnetic disk systems work.
- Explain how optical disc systems work.
- Describe the flash memory systems and how they are used.
- Discuss some other types of storage systems.
- Compare between storage alternatives.



Storage Systems Characteristics

All storage systems have specific characteristics such as:

1. Having a storage medium and a storage device.
2. Portability.
3. Volatility.
4. How data is accessed and represented.
5. The type of storage technology used.

➤ Storage media and storage devices:

Any storage system consists of two parts; storage medium and storage device.

➤ Storage medium:

It is the hardware where data is actually stored such as Floppy disk, CD or DVD, etc. It can be removable or non removable from the storage device.

➤ Storage device:

It is the device into which storage medium is inserted to be used such as Floppy disk drive, CD or DVD drive, etc. Devices are identified by name or letter and can be internal, external, or remote.

➤ Volatility:

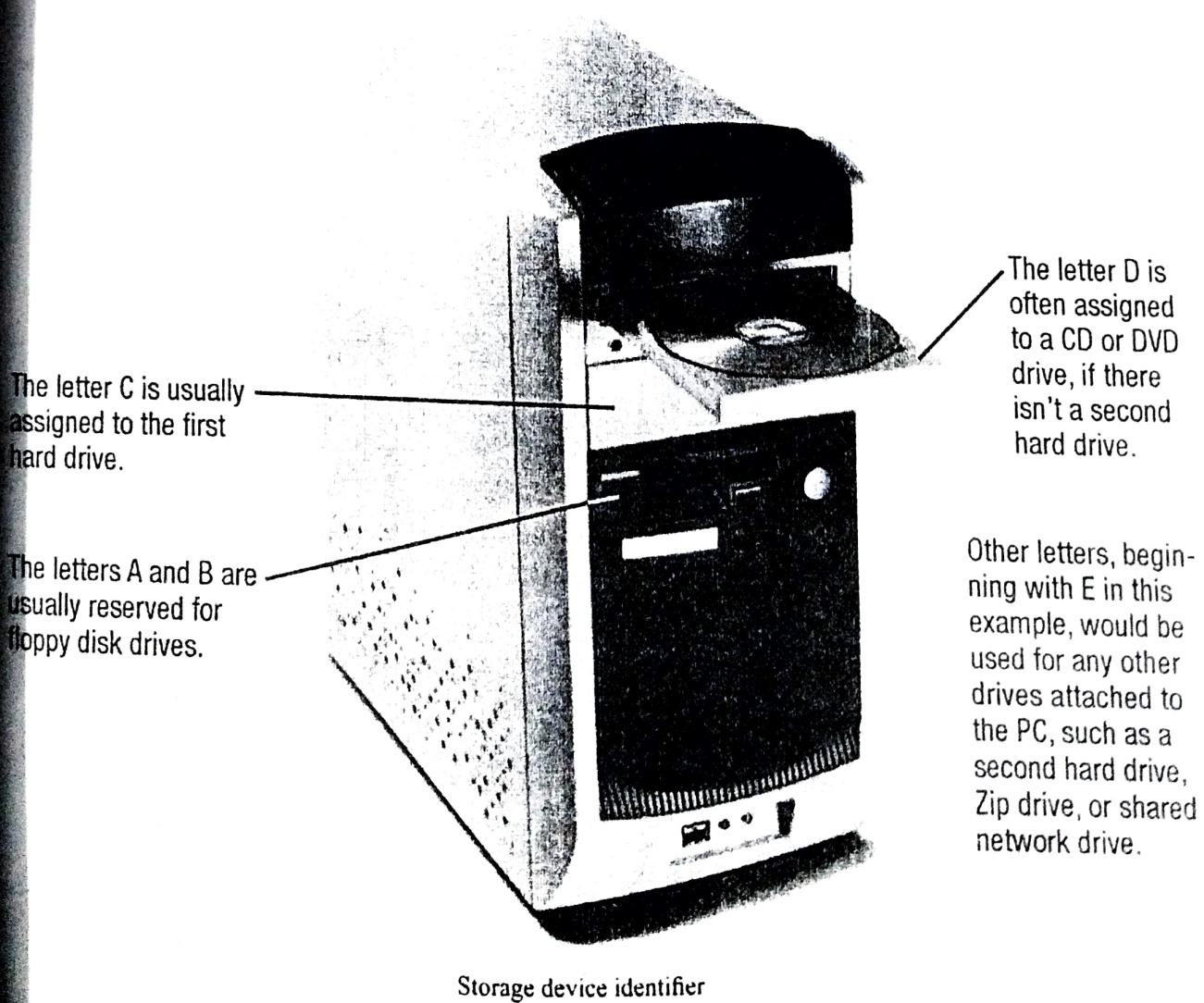
All storage media are **nonvolatile** which means that when power to the device is shut off, data stored on the medium remains. This is in contrast to most types of memory, which are **volatile** because the data on them is removed when the power is shut down.

Data Access

There are two basic methods for data access on the different storage systems; they are random access and sequential access.

- **Random access (direct access):** data can be retrieved directly from any location on the storage medium, in any order.
- **Sequential access:** data can only be retrieved in the order in which it is physically stored on the medium (tape drive).

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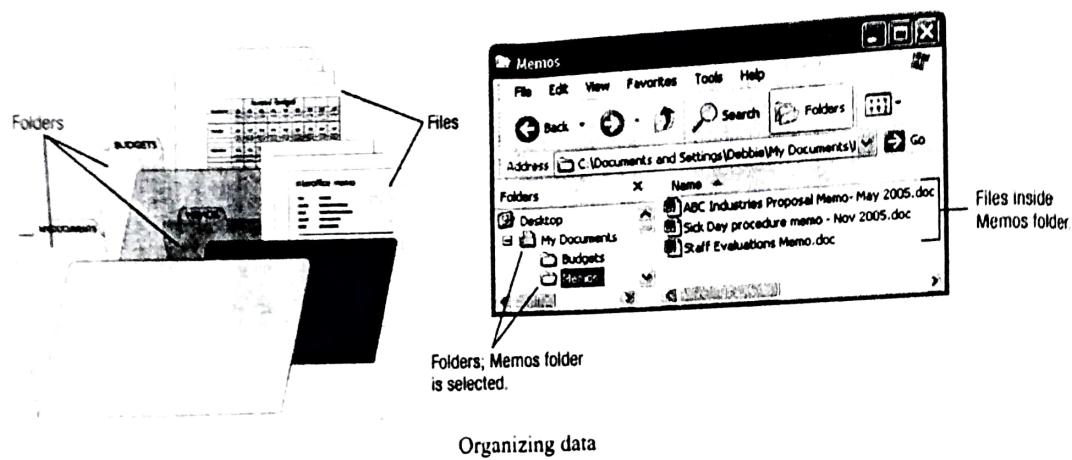


Note:

Logical file representation

Refers to the user's view of the way data is stored.

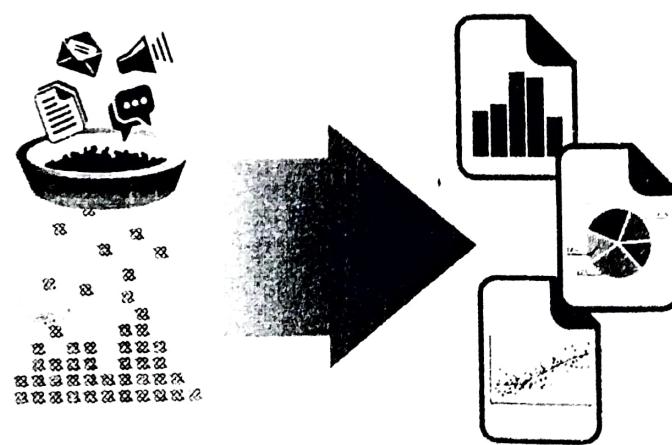
- **File:** something stored on a storage medium, such as a program, document, or image.
- **Filename:** name given to a file by the user.
- **Folder:** named place on a storage medium into which files can be stored.



Note:

Physical file representation

Actual physical way the data is stored on the storage media as viewed by the computer.



Data analysis

Types of storage technology used

Data is stored magnetically or optically on many types of storage media.

- With magnetic media, such as floppy disks, data is stored magnetically; the data (0s and 1s) is represented using different magnetic alignments.
- Optical storage media (such as CDs and DVDs) store data optically using laser beams.
- Another technology for data storage depends on representing data using electrons such as flash memory storage systems.



Types of storage technology

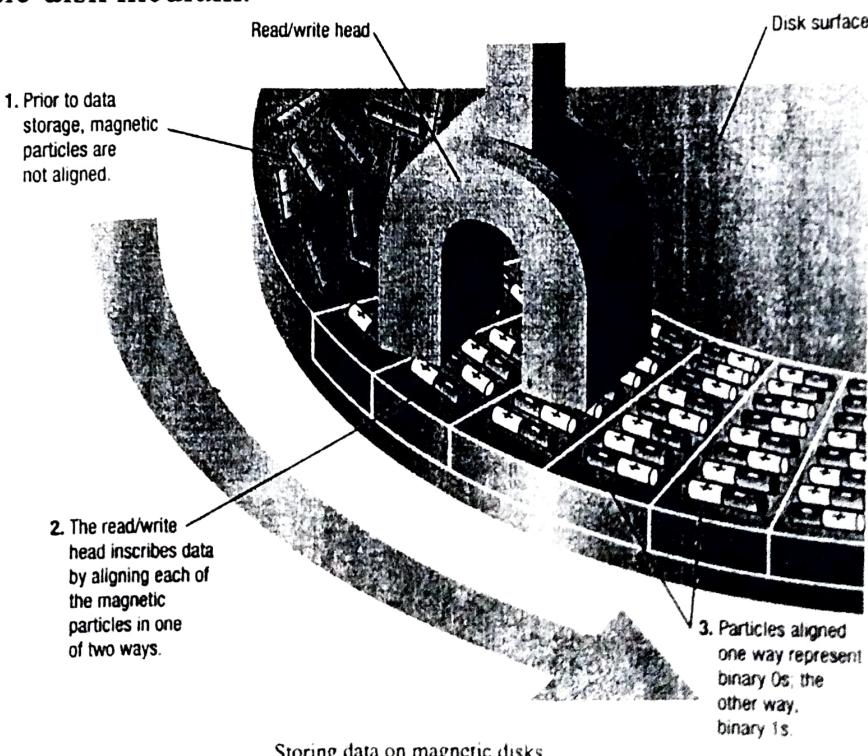
Magnetic Disk Systems

- **Magnetic disk:**

Storage medium that records data using magnetic spots on disks made of flexible plastic or rigid metal. It is the most widely used storage medium on today's computers.

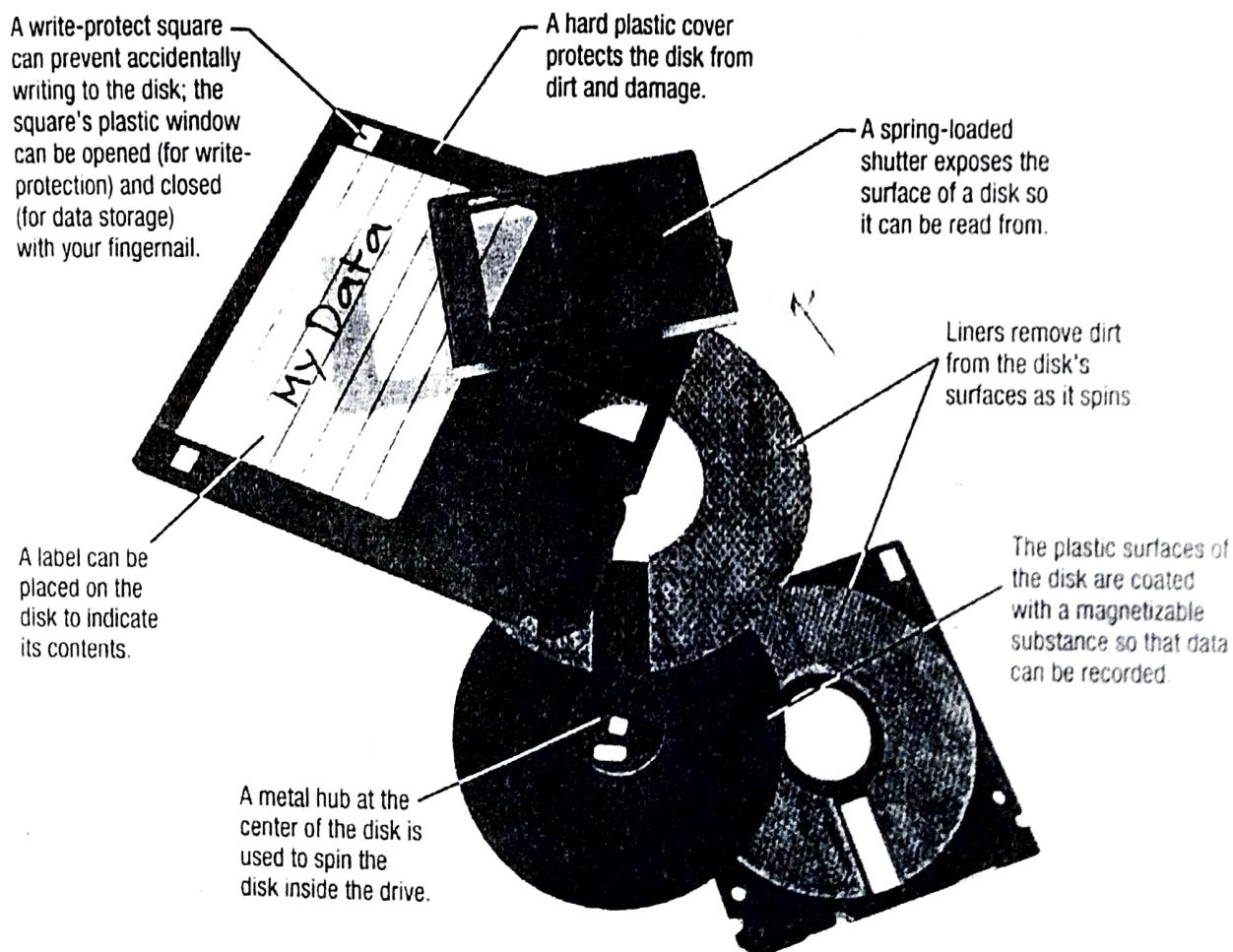
- There are two common types of magnetic disk systems:
 - **Floppy disks** (common removable storage medium in the past; not widely used today).
 - **Hard disks:** (Included on nearly all PCs today).

Data is written to the magnetic disks by read/write heads, which magnetize particles a certain way on the surface of the disks to represent that data's 0s and 1s. The particles retain their magnetic orientation until the orientation is changed again, so files can be stored, retrieved, rewritten, and deleted as needed. The following Figure illustrates how the data are represented magnetically on the magnetic disk medium.



Floppy Disks and Drives

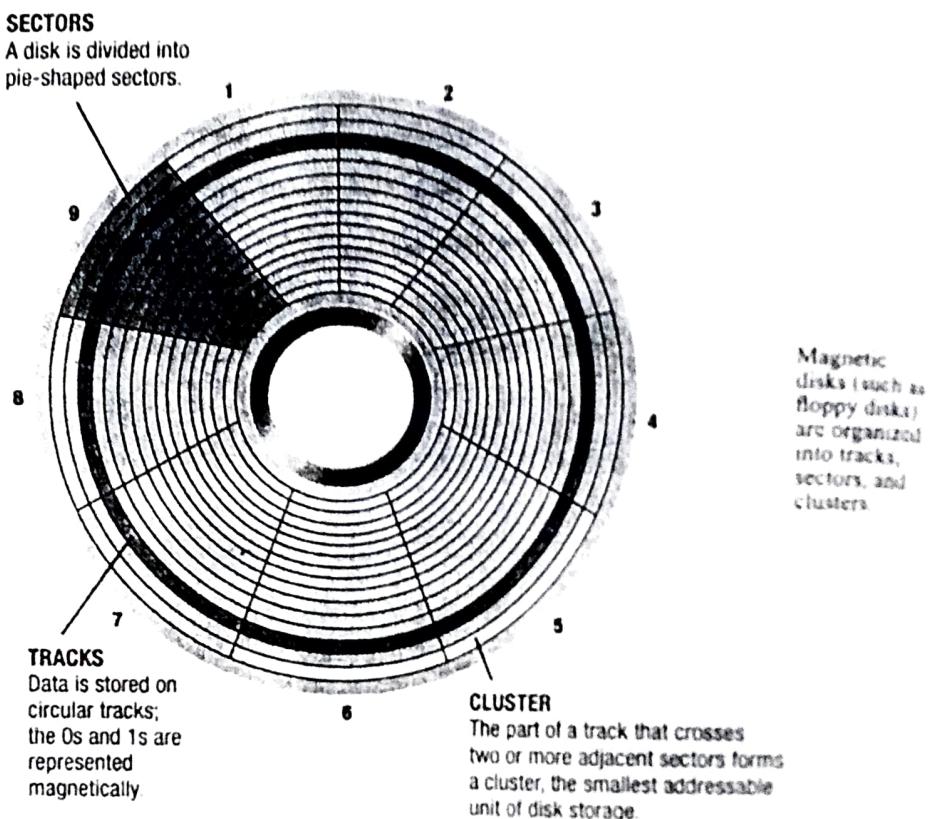
- **Floppy disk:** low capacity, removable magnetic disk made of flexible plastic permanently sealed inside a hard plastic cover.
- **Floppy disk drive:** storage device that reads from and writes to floppy disks.
- Sometimes referred to as a legacy drive and not included on all new PCs today.

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The anatomy of the floppy disks

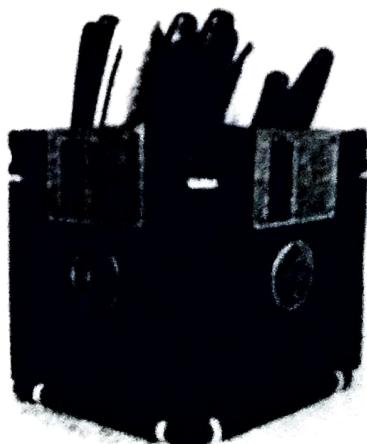
- **Floppy disk characteristics:**

- 3½ inches in diameter.
- Holds 1.44 MB of data.
- Disk organized into **tracks**, **sectors**, and **clusters**.
- All files take up at least one cluster of space on the disk.



- **Using floppy disks:**

- Must be inserted into a floppy drive (face up and with the disk shutter closest to the drive door).
- Should not be removed when the disk is being accessed.
- If a disk is not formatted, the user must format it first before it can be used.



Floppy disks

Hard Disk Drives

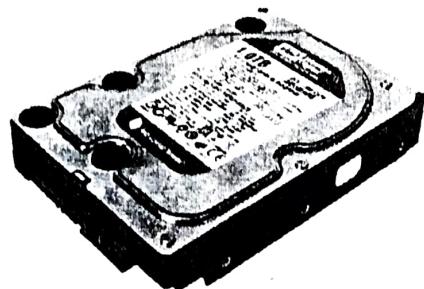
The hard disk is the primary storage system in most of the personal computers except those depends on using the network storage devices such as network computers. There are two types of hard drives:

- **The internal hard drive:**

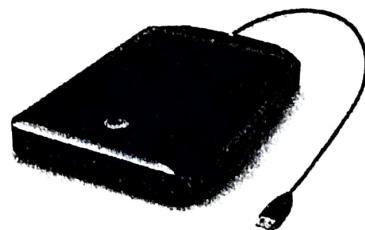
They are the hard drives that are located inside the system unit and they are not designed to be removed unless they need to be repaired or replaced.

- **The external hard drive:**

They are the hard drives that are connected to the computer via a USB or and are frequently used for additional storage, backup, and to move data between computers.



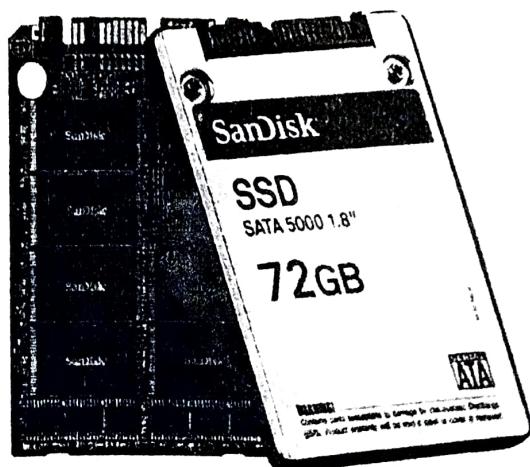
The internal hard drive



The external hard drive

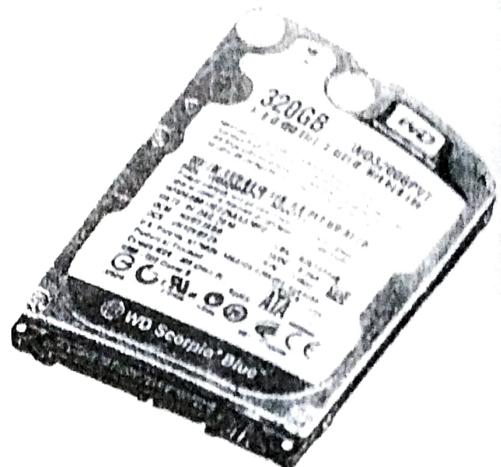
➤ Magnetic hard drives and solid-state drives (SSDs):

Traditional hard drives are magnetic hard drives that contain magnetic hard disks, read/ write heads, and an access mechanism. Data is written to the magnetic hard disks by read/write heads by the same way as explained earlier in the floppy disks.



Solid-state drives

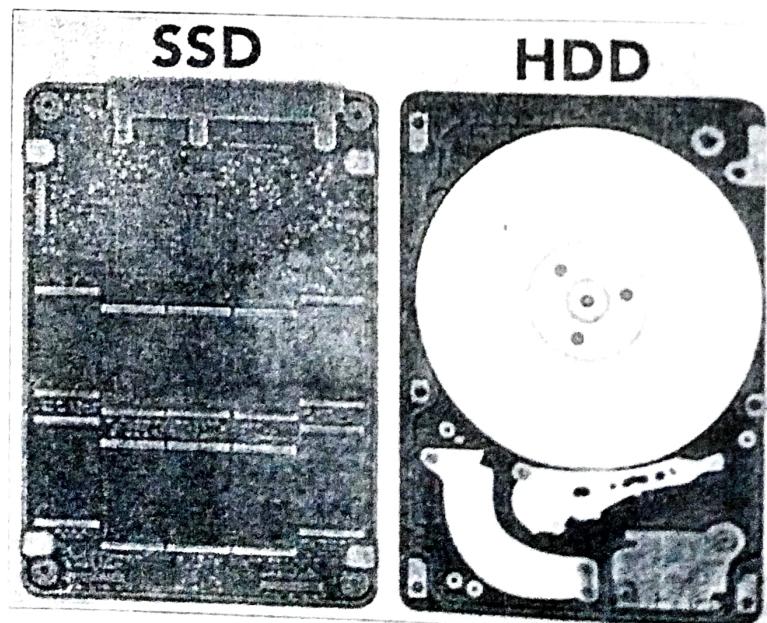
A new type of hard drive is the solid-state drive (SSD) that uses flash memory technology instead of magnetic technology to store data. While magnetic hard drives are currently less expensive and are currently available in larger capacities than SSD, the use of SSD is growing rapidly, especially with portable computers like notebook and netbook computers.



Hard drives

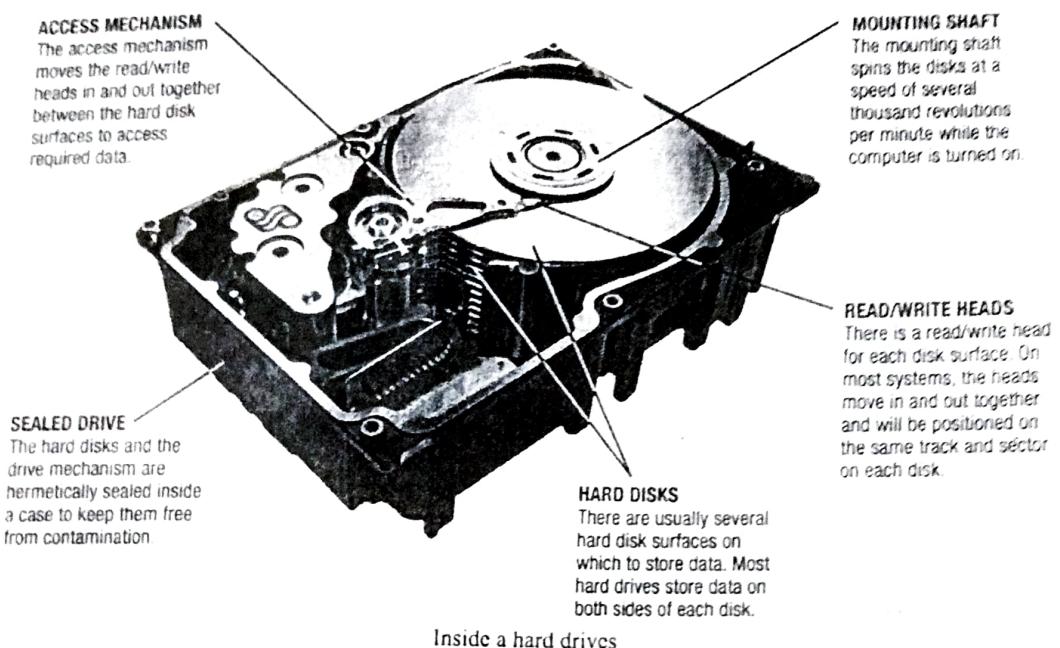
This is because flash memory technology that SSDs are based on has the following features:

- They allow for faster operation (nine-fold increase in performance over conventional magnetic hard drives).
- They reduce the power consumption (SSDs use at least 50% less power than magnetic hard drive).
- They have increased shock-resistance because there are no movable parts.



➤ Magnetic Hard Drives:

It is a storage system consisting of one or more metal magnetic disks permanently sealed with an access mechanism inside its drive.

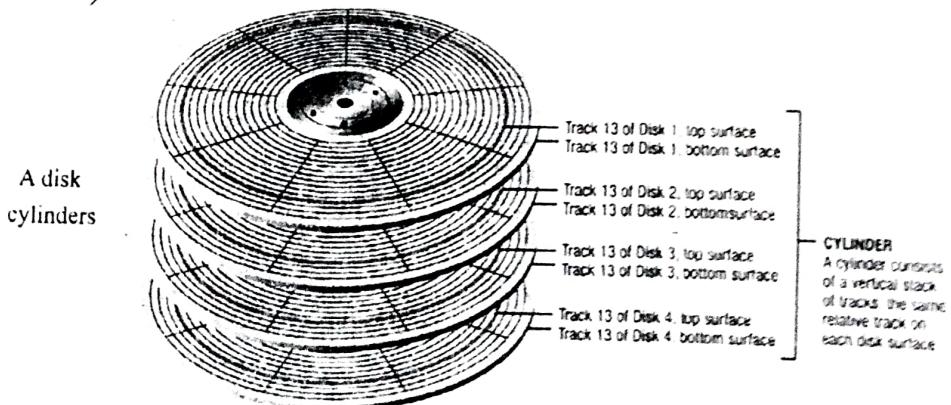


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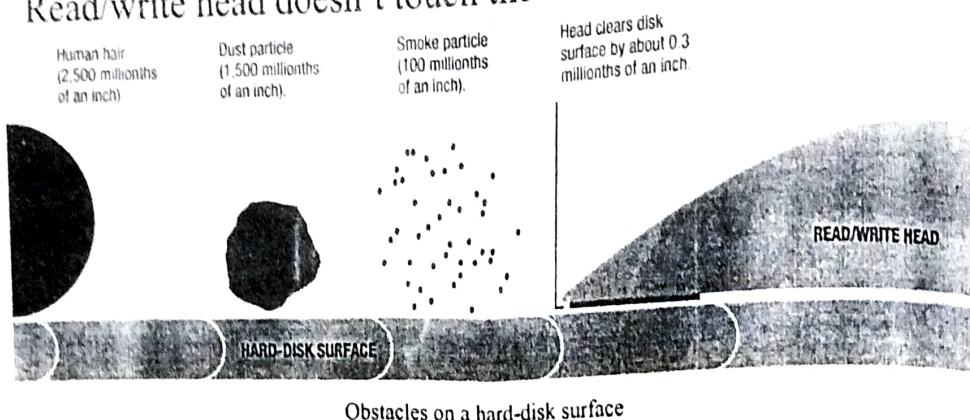
➤ Magnetic hard drive characteristics:

- Stores data magnetically.
- One or more disks made out of metal.
- Disks are permanently sealed inside the hard drive to avoid contamination and to enable the disks to spin faster.
- Organized into clusters, sectors, tracks, and **cylinders** (the collection of tracks located in the same location on a set of hard disk surfaces).



Note:

- Read/write head doesn't touch the surface of the disk.



- If the PC is bumped while the hard drive is spinning or a foreign object gets onto the surface of the disk, a head **crash** occurs, which may permanently damage the hard drive.

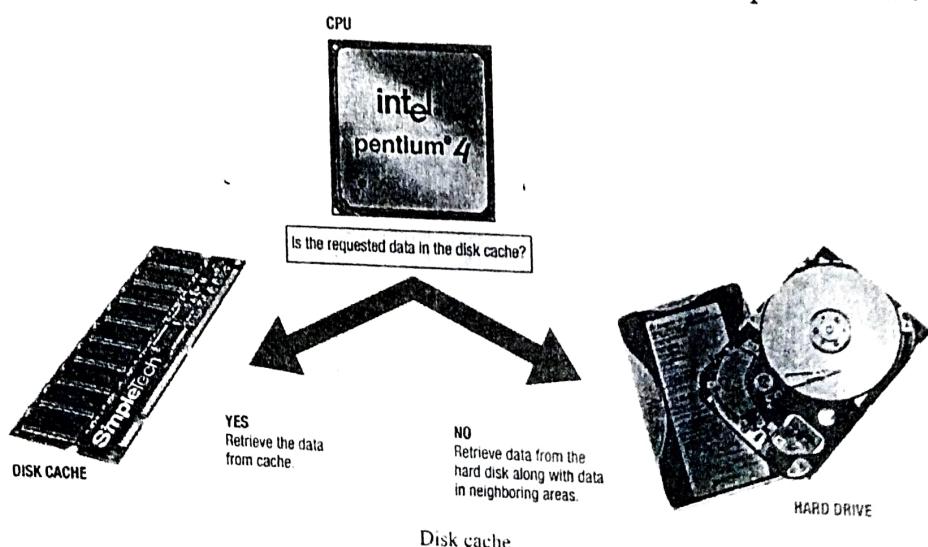
➤ Hard drive speed:

Disk access time: total time that it takes for a hard drive to read or write data.

Consists of **seek time, rotational delay, data movement time.**

➤ Hard disk cache:

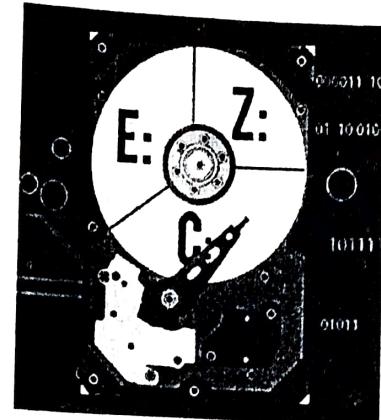
A dedicated part of RAM used to store additional data adjacent to data retrieved during a disk fetch to improve system performance.



➤ Partitioning:

Partitioning enables you to logically divide the physical capacity of a single drive into separate areas, called partitions or logical drives. It is Used to:

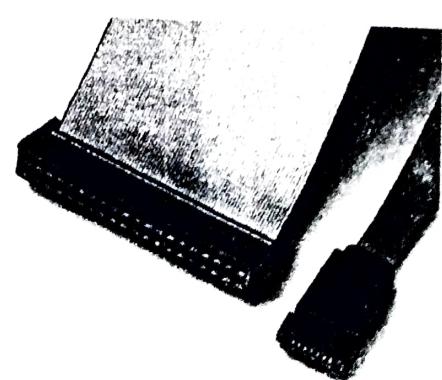
- Install more than one operating system.
- Create a recovery partition.
- Create a new logical drive for data.
- Increase efficiency (smaller drives can use smaller cluster sizes).
- The cluster size, maximum drive size, and maximum file size are determined by the file system being used.



Partitioning

➤ Hard drive interface standards:

- Determine how drive connects to the PC and other characteristics.
- Most common, for PCs:
 - Serial ATA(Advanced Technology Attachment) (SATA) and serial ATA II (SATA II).
 - SCSI (Small Computer System Interface)and the newer serial attached SCSI (SAS).
 - Fiber Channel.
- Hard drives can also connect via USB or FireWire.
- Usually are installed inside system unit but can also be external and portable.

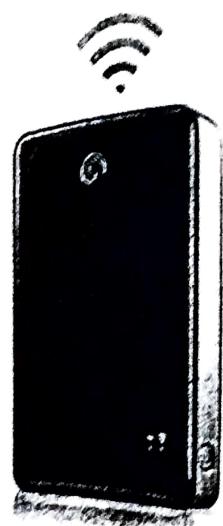


Serial ata

➤ External hard drives:

Connect to an external port on the PC (typically USB, FireWire, or via a wireless connection)

- The entire drive can be moved from one PC to another PC when needed.
- Good for backup purposes.

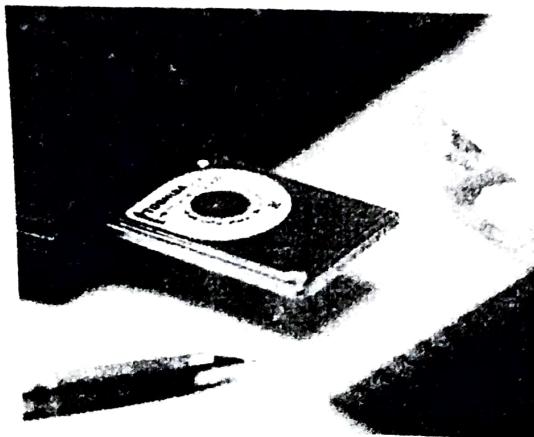


External hard drives

➤ Portable hard drives:

- Specifically designed to be carried around and moved from one PC to another.

The following Figure shows some types of portable hard drives.



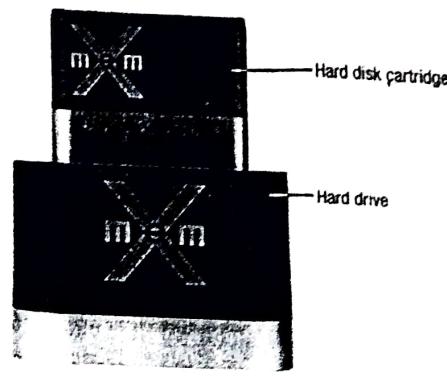
PC CARD DRIVES

Notebook PCs often use portable hard drives that are inserted into, or have a connector to plug into, the PC card slot.



USB AND FIREWIRE DRIVES

Both desktop and notebook PCs can use external hard drives that connect via a USB or FireWire port.



HARD DRIVES WITH
REMOVABLE CARTRIDGES
With these drives, only the cartridges are moved from PC to PC.

Portable hard drives

➤ Super diskettes:

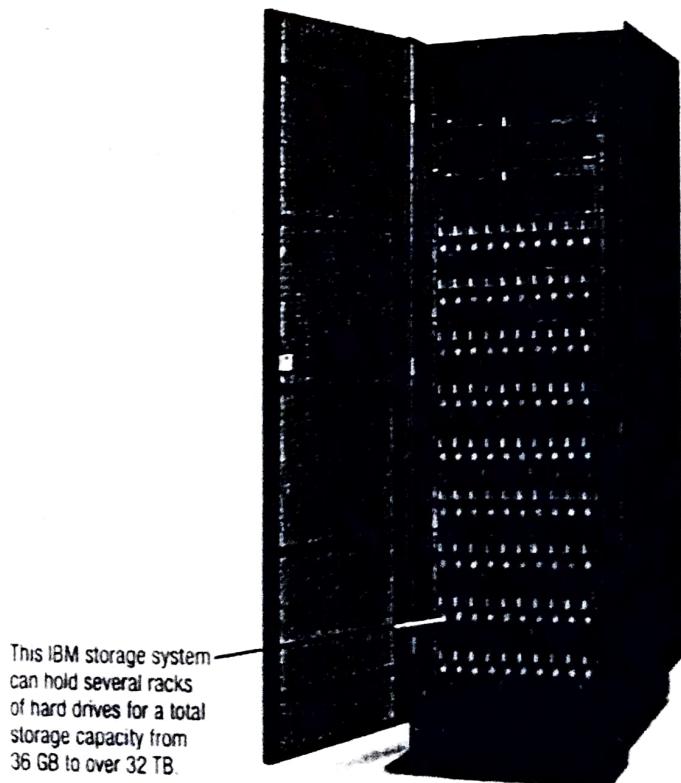
High-capacity removable storage media, usually proprietary (can only be used with their respective drives).

- Most widely used = Zip disk; holds 100, 250, or 750 MB.

➤ Hard disk cartridges:

Removable hard disk so higher capacity, but also proprietary.

- REV disk is one example; holds 35 GB.



This IBM storage system can hold several racks of hard drives for a total storage capacity from 36 GB to over 32 TB.



Each rack typically holds multiple hard drives. Capacities for the hard drives range from approximately 18 GB to nearly 150 GB each.

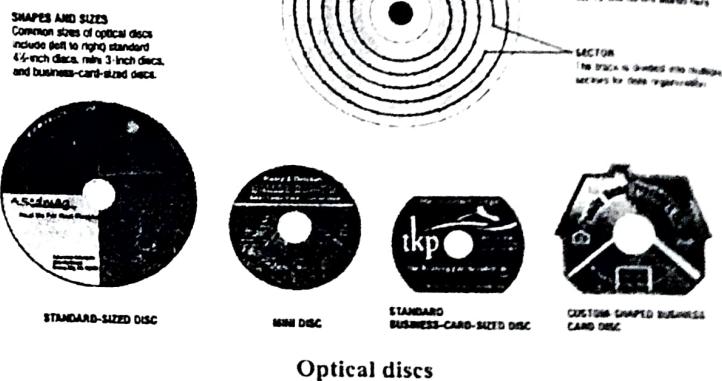
Storage for larger computer systems

Optical Disc Systems

- **Optical discs (such as CDs and DVDs)**

Store data optically using laser beams instead of magnetically.

- Typically 4½-inch circles, although smaller discs and custom shapes are also available.
- Divided into tracks and sectors like magnetic disks but use a single grooved spiral track.
- Can be read-only, recordable, or rewritable.
- High-capacity
(usually at least 650 MB).



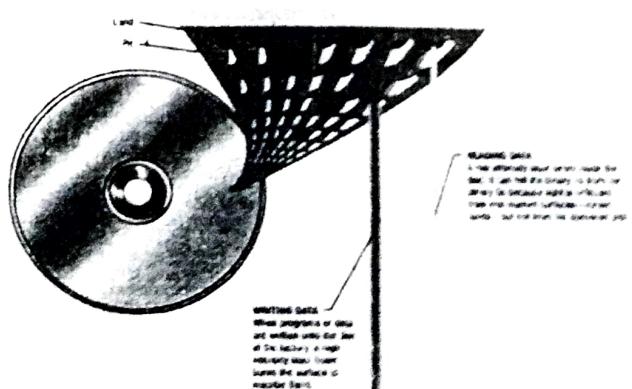
Optical discs

Note:

- **Burning:**

Burning is defined as the process of recording data onto an optical disc.

- Spots on the disc (pits) are used to represent the data's 1s and 0s; the unchanged areas on the disc are called lands.
- Pits can be molded into the disc surface or created by changing the reflectivity of the disc.
- The transition between a pit and a land represents a 1; no transition represents a 0.



How recorded optical disks work

➤ Read-Only Discs: CD-ROM and DVD-ROM Discs:

- Can be read from, but not written to, by the user .
- CD-ROM (compact disc read-only memory) disc.
 - Usually holds about 650 MB.
- DVD-ROM (digital versatile disc read-only memory) disc.
 - Holds 4.7 GB (single-sided); 8.5 GB (double-sided).

➤ Recordable Discs:

CD-R, DVD-R, DVD+R, and DVD+R DL Discs

- Can be written to, but cannot be erased and reused.
- Recordable CDs are typically **CD-R discs**; recordable DVDs are either **DVD-R discs** or **DVD+R discs**.
- CD-R discs are commonly used for back up, sending large files to others, and creating custom music CDs.
- DVD-R/DVD+R discs are used for similar purposes when more storage space is needed, such as large backups and for home movies and other video files.
- **DVD+R DL discs** use two recording layers (8.5 GB capacity).

➤ Rewritable Discs:

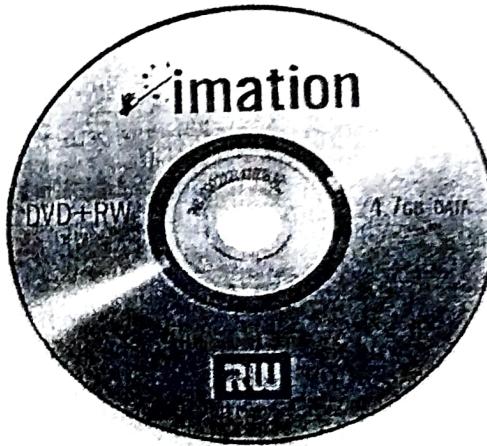
CD-RW, DVD-RW, DVD+RW, DVD-RAM, and Blue Laser

Discs:

- Can be written to, erased, and overwritten just like magnetic disks.
- Most common: **CD-RW**, **DVD-RW**, and **DVD+RW** discs.
- The newest rewritable technology uses *blue lasers* instead of *infrared* (CDs) or *red* (DVDs) *lasers* to store data more compactly (23 GB+).
- To record and erase rewritable optical discs, *phase-change* technology is used.



RECORDABLE CD-R DISC
Holds 700 MB.



REWRITABLE DVD+RW DISC
Holds 4.7 GB.



REWRITABLE DVD-RAM DISC
Holds 9.4 GB.



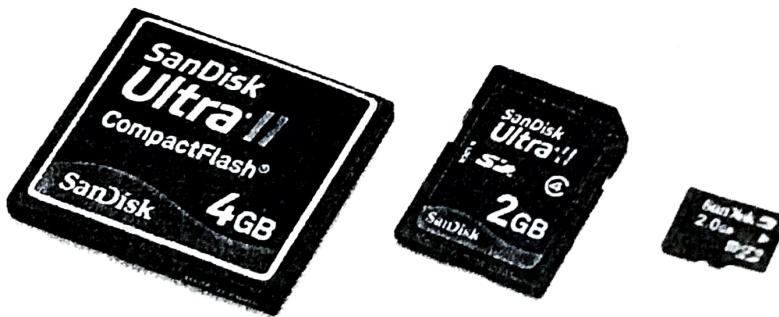
REWRITABLE BLUE LASER DISC
Holds 23.3 GB.

Recordable and rewritable CDs and DVDs

Flash Memory Systems

Flash memory is a chip-based storage medium that represents data using electrons. It is used in a variety of storage systems, such as the SSDs and some other storage systems shown in the following Figure. Flash memory systems use flash memory media. The advantages of flash memory systems are:

- No moving parts so more resistant to shock and vibration and require less power (solid state)
- Very small and so are very appropriate for use with digital cameras, digital music players, handheld PCs, notebook computers, smart phones, etc.



Flash memory card

➤ Flash memory card

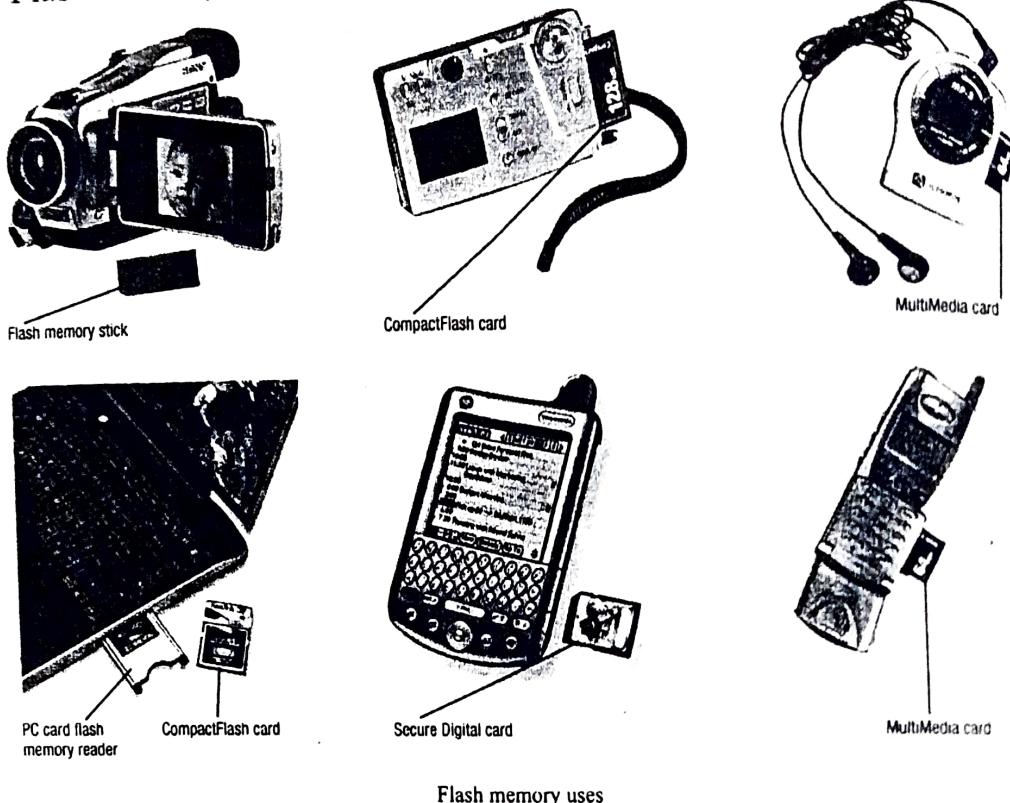
A small card containing flash memory chips and metal contacts to connect the card to the device or reader that it is being used with the following:

- CompactFlash(CF).
- Secure Digital (SD).
- Secure Digital High Capacity (SDHC).
- Secure Digital Extended Capacity (SDXC).
- MultiMedia Card (MMC).
- xD Picture Card (xD).
- Memory Stick (MS).

Note

The following Figure shows some examples of systems that use Flash memory card.

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Flash memory uses

Note:

➤ Read by flash memory card reader:



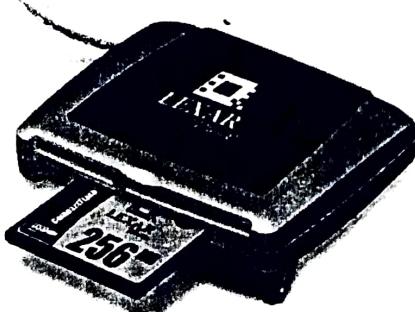
COMPACTFLASH CARD



SECURE DIGITAL (SD) CARD



XD PICTURE CARD



FLASH MEMORY CARD READER
This reader connects to a USB port and can be used with CompactFlash, SmartMedia, Memory Stick, MultiMedia, Secure Digital (SD), and XD cards.

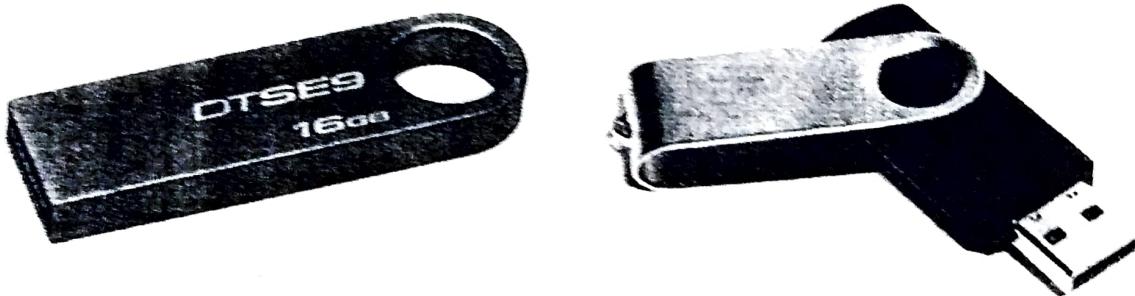
Flash memory cards and a multicard reader

Flash Memory Drives

➤ Flash memory drives:

Consist of flash memory media and a reader in a single self-contained unit.

- Typically portable drives that connect via a USB port.
- Also called USB mini drives, USB flash drives, thumb drives, jump drives, and key drives.



Flash memory usb

Other Types of Storage Systems

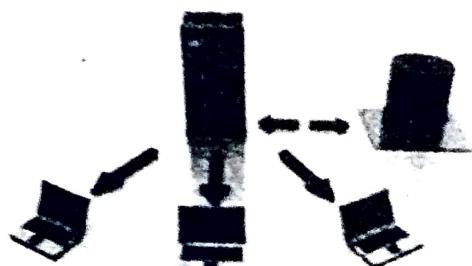
There are some other types of storage systems used with PCs and business computers such as remote storage, smart cards and holographic storage.

➤ Remote storage:

This type refers to systems that use a storage device which is not directly connected to the computer. In this type, the device is accessed through a local network or through the internet.

The types of remote storage are:

- 1) Network storage.
- 2) Online storage or Cloud storage.



1- Network storage:

Network storage is accessible through a local network. They work as the same as local storage systems (the storage devices and media that are directly attached to the user's computer). This type is used in business or home to share files on the computers connected to a network. Two common types of network storage used today; namely, they are **Network Attached Storage (NAS)** devices and **Storage Area Networks (SANs)**:

- **Network attached storage (NAS):** high-performance storage server individually connected to a network to provide storage for computers on that network.
- **Storage area network (SAN):** network of hard drives or other storage devices that provide storage for another network of computers.

Storage systems for large computer systems and networks, *cont'd*

RAID (redundant arrays of independent disks): storage method that uses several small hard disks in parallel to do the job of a larger disk.

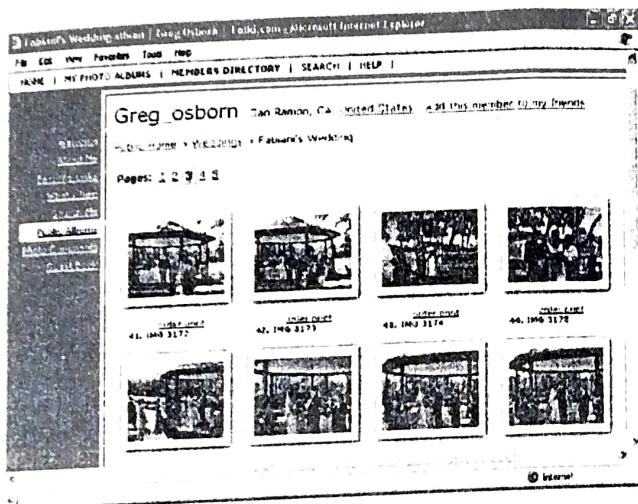
- Usually involves recording redundant copies of stored data.
- Helps to increase fault tolerance.
- Different levels of RAID, use combination of disk striping and disk mirroring.

2- Online storage or Cloud storage:

Online storage is accessed via the Internet and it is used for:

- Backup.
- Transferring files to others or to another PC.
- Sharing files with others (online photo sites, etc.).

Example for online storage applications are Google Docs, Flickr photo sharing service and social networking sites like Facebook.



ONLINE PHOTO SHARING COMMUNITY

This site is designed to host online photo albums to be shared with others. Although albums can be password protected, many, such as the one shown here, are set up to be viewed by anyone

SHARING FILES

The contents of the marked folder will be shared with a specific individual, once his or her e-mail address is supplied.

LOGGING ON
This site requires users to log on before seeing their personal files stored on the site's server.

SECURE ONLINE STORAGE
This site is designed to securely store files for backup or to be shared with others. After logging on, users can upload, download, or delete files, as well as designate who is allowed to access files.

➤ Smart card:

Credit card-sized piece of plastic that contains some computer circuitry (processor, memory, and storage).

- Store small amount of data: about 256 KB or less.
- Commonly used to store prepaid amounts of *digital cash* or personal information.
- Smart card readers are built into or attached to a PC, keyboard, vending machine, or other device.
- Some smart cards store biometric data.

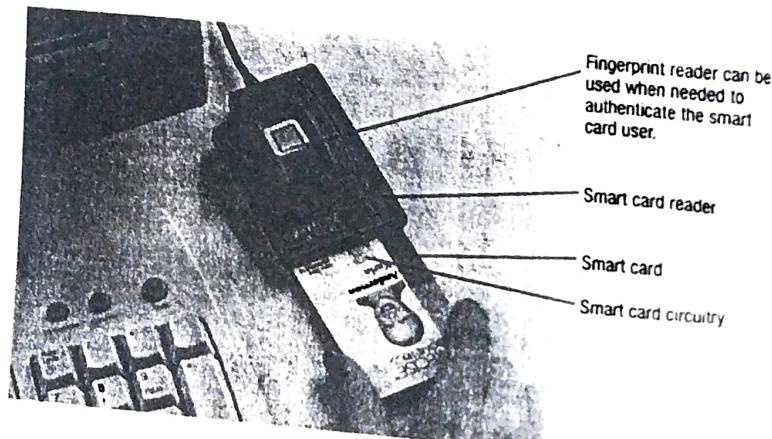
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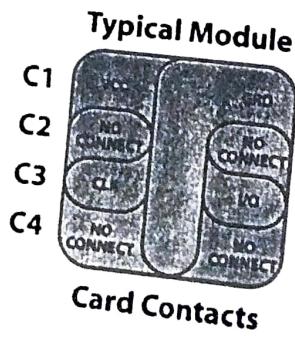


WHAT IS A SMART CARD?

A smart card looks like an ordinary credit or debit card, but typically contains a wafer-thin chip and circuitry for processing and storage. When inserted into a reader, the information stored on the card can be accessed and updated. Some readers use biometric data stored on the cards to authenticate the user.



WHAT ARE SMART CARDS USED FOR?
Smart card applications abound, such as a replacement for cash in vending machines, for identifying individuals for access or medical treatment, and for securely paying for goods and services online.



The contacts on the surface of the device are connected...

Smart card technology uses a computer and software with 100s of built-in security features.



Smart card



...to wires running from a computer chip under the surface.

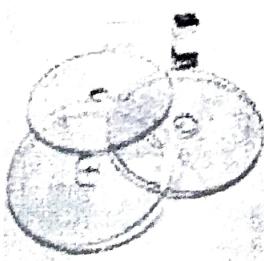
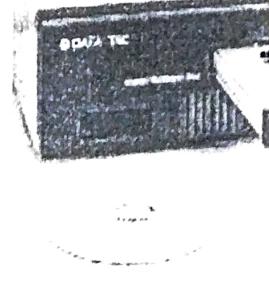
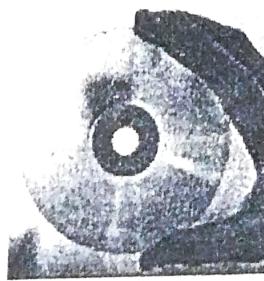
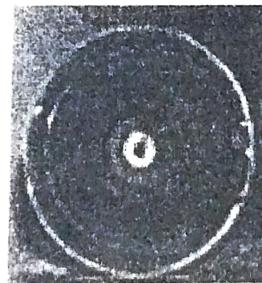
The whole piece is embedded into a plastic card or USB token.

➤ Holographic storage:

They are emerging type of 3D storage technology. Holographic drives typically connect to a computer via a serial attached SCSI (SAS) or Fibre channel interface.

- Uses multiple blue laser beams to store data in three dimensions.
- Potential initial applications for holographic data storage systems include:
 - High-speed digital libraries.
 - Image processing for medical, video, and military purposes.
 - Any other applications in which data needs to be stored or retrieved quickly in large quantities but rarely changed.

Examples of 3D optical data storage media. Top row - Written Call/Recall media; Mempile media.
Middle row - FMD; D-Data DMD and drive.
Bottom row - Landauer media; Microholas media in action.



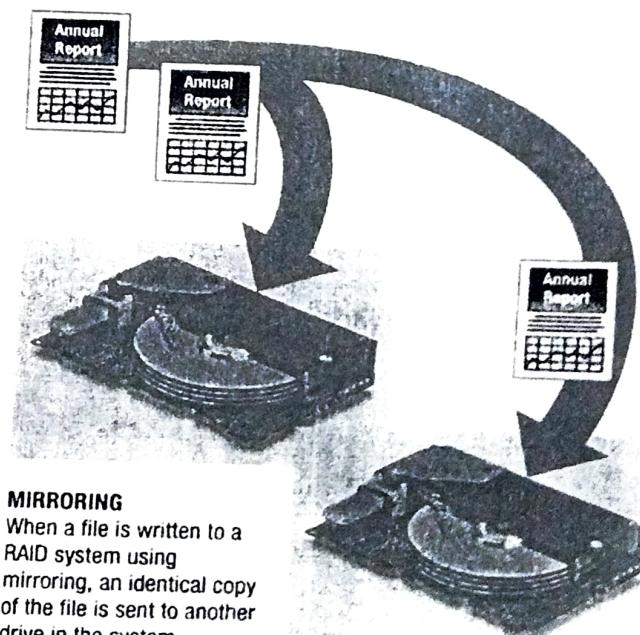
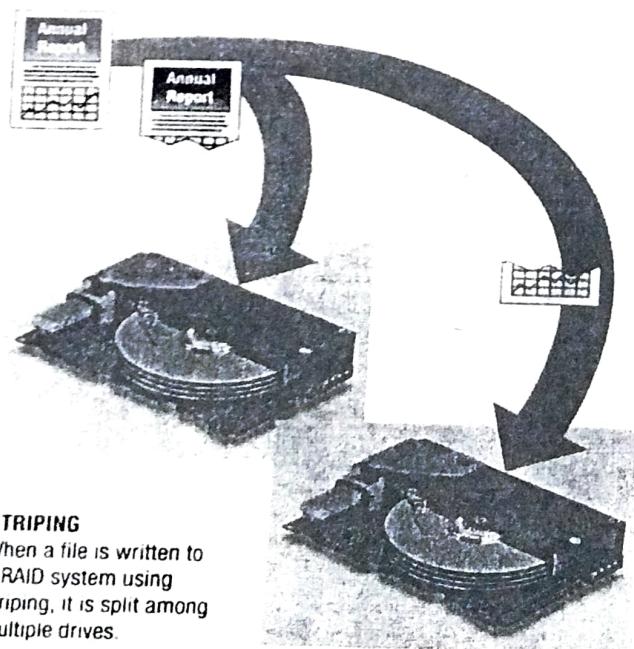
Storage Systems for Large Computer Systems

➤ Redundant Array of Independent Disks (RAID)

It is a method of storing data on two or more hard drives that work together. It is used to:

- Increase the performance by storing more than one copy of the data that can help in reconstructing data.
- Protect the critical data on a storage server.

Two types of RAID are used as shown in the following Figure, they are striping and mirroring.

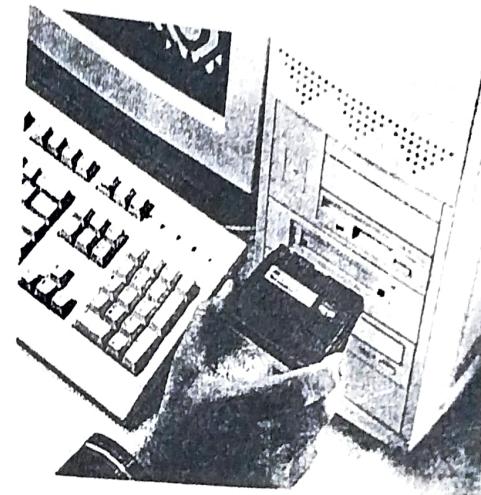


Redundant Array of Independent Disks

➤ Magnetic tape:

They are plastic tape with a magnetizable surface that stores data as a series of magnetic spots:

- Uses: primarily for backup and archival purposes (sequential access only).
- Advantage: low cost per megabyte.
- Most tapes today are in the form of cartridge tapes.
- Read from and written to via a tape drive.



Magnetic tape

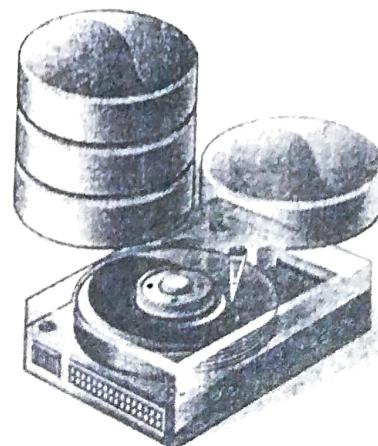
Comparing Storage Alternatives

Factors to consider:

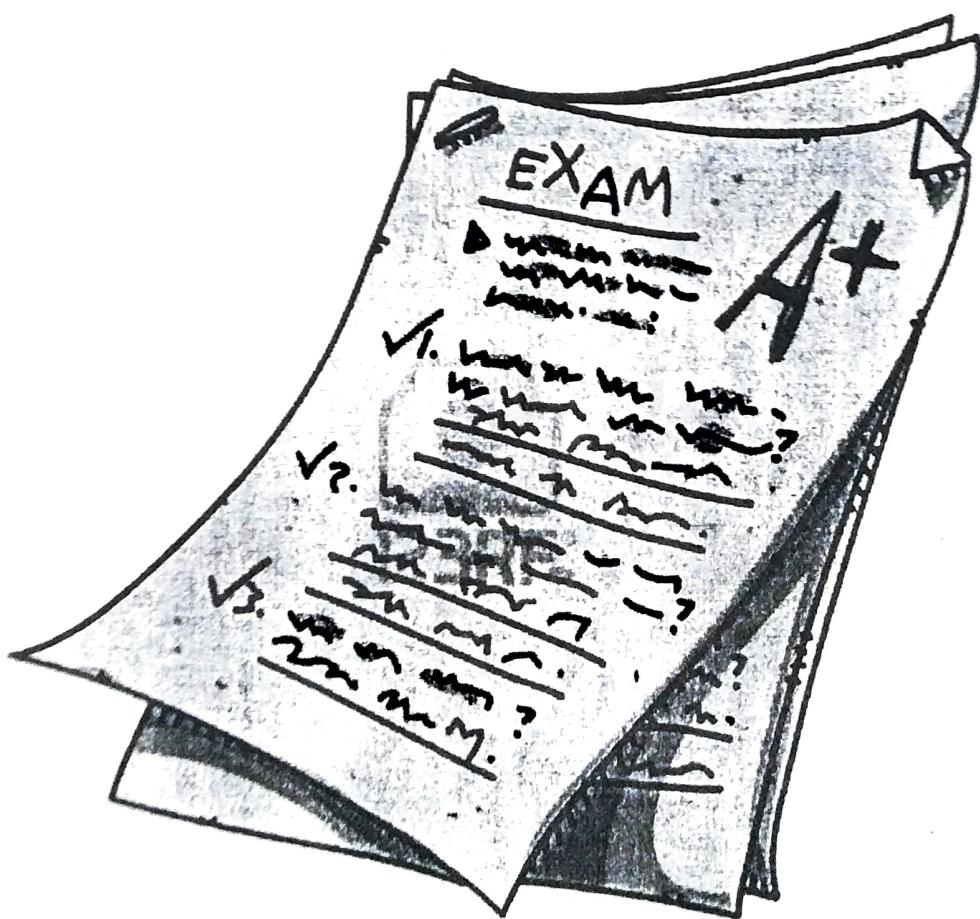
- Speed.
- Compatibility.
- Storage capacity.
- Convenience.
- Portability.

Most users require:

- Hard drive.
- CD or DVD drive.
- Flash memory card reader and USB port for flash memory drive.



Exercises



1- Match each key term on the left with the definition on the right that best describes it.

| Key term matching | Description |
|----------------------------|--|
| a. disk cache | 1- A named place on a storage medium into which files can be stored to keep the files stored on that medium organized. |
| b. file | 2- A hard drive that uses flash memory media instead of metal magnetic hard disks. |
| c. flash memory card | 3- An emerging type of storage technology that uses multiple blue laser beams to store data in three dimensions. |
| d. folder | 4- A small, rectangular flash memory medium, such as a Compact Flash (CF) or Secure Digital (SD) card; often used with digital cameras and other portable devices. |
| e. hard drive | 5- A storage device designed for large computer systems and that typically contains multiple high-speed hard drives. |
| f. holographic storage | 6- A storage device that is not directly connected to the computer being used, such as one accessed through a local network or the Internet. |
| g. RAID | 7- A storage method that uses several hard drives working together, typically to increase performance and/or fault-tolerance. |
| h. remote storage | 8- Memory used in conjunction with a magnetic hard drive to improve system performance. |
| i. solid-state drive (SSD) | 9- Something stored on a storage medium, such as a program, a document, or an image. |
| j. storage server | 10- The primary storage system for most computers; used to store most programs and data used with that computer. |

2- Circle T if the statement is true, F if the statement is false, or write the best answer in the space provided.

- a. T F A computer system with a C drive and a D drive must have two physical hard drives.
- b. T F The smallest amount of space a file on a disk can take up is one cluster.
- c. T F External hard drives typically connect via a flash memory reader.
- d. T F A CD-R disc can be written to by the user.
- e. T F A hybrid hard drive contains both magnetic hard disks and optical discs.

1 / 20
Date _____

3- Write the best answer in the space provided.

- a). The drive letter that would most likely be assigned to the primary hard drive on a typical personal computer is
- b). Storage media are not , meaning they do not lose their contents when the power is shut off.
- c). A single-sided, single-layer CD disc typically holds
- d). A(n) looks similar to a credit card but contains a chip and other circuitry that can store data.
- e). Secure Digital (SD) cards are one type of medium.