

Internet and Information Technology

Lecture 3

ITC202

The System Unit: Storage

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Chapter 3:
The System
Unit: Storage

Storage Systems Characteristics

Storage Media and Storage Devices

Logical vs. Physical Representation

Type of Storage Technology Used

Hard Drives

Magnetic Hard Drives and Solid-State Drives

Hard Drive Speed

Hard Drive Partitioning and File Systems

Optical Discs

Optical Disc Characteristics

CD-ROM, DVD-ROM, and BD-ROM

CD-R, DVD-R, and BD-R

CD-RW, DVD-RW, DVD+RW, and BD-RE

Flash Memory

Flash Memory Cards

USB Flash Drives

Other Types of Storage Systems

Network Storage and Online/Cloud Storage Systems

Smart Cards

Holographic Storage

Evaluating Your Storage Alternatives

Learning Objectives

1. Name several general properties of storage systems.
2. Describe the two most common types of hard drives and what they are used for today.
3. Discuss the various types of optical discs available and how they differ from each other.
4. Identify some flash-memory-based storage devices and media and explain how they are used today.
5. Summarize the storage alternatives for a typical personal computer.

How computer memory works

How computer memory works

Storage System Characteristics

Storage Media and Storage Devices

- **Device:** DVD drive, flash memory card reader, etc.
- **Medium:** DVD disc, flash memory card, etc.
- Medium is inserted into device to be used.
- Storage devices can be *internal* (located inside the system unit), *external* (plugged into an external port on the system unit), or *remote* (located on another computer, such as a network server).
- **Internal devices** have the advantage of requiring no additional desk space and are usually faster than their external counterparts.
- **External devices** can be easily transported from one location to another

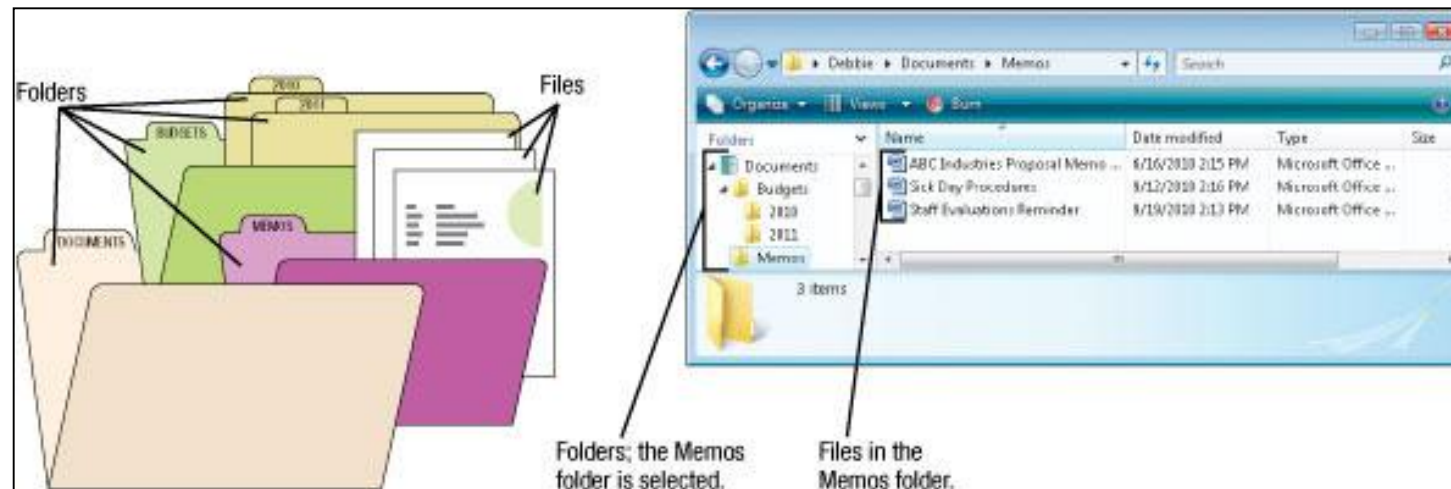


Storage System Characteristics

- **Logical file representation:** The user's view of the way data is stored.
- **Physical file representation:** The actual physical way the data is stored on the storage media as viewed by the computer.
- Storage technologies:
 - Magnetic (conventional hard drives).
 - Optical (optical discs).
 - Electrons (flash memory media).

Logical vs. Physical Representation

- **File:** Anything stored on a storage medium, such as a program, document, digital image, or song.
- **Filename:** Name given to a file by the user.
- **Folder:** Named place on a storage medium into which files can be stored.



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Hard Drives

- **Hard drive:** Used to store most programs and data.
 - Can be internal and external.
 - Can be encrypted.
- **Magnetic hard drives:**
 - Use metal hard disks.
 - Read/write heads magnetize particles to represent the data's 0s and 1s.
- **Solid-state drives (SSDs):**
 - Use flash memory technology.
 - Use less power and have no moving parts.
 - Particularly appropriate for portable computers.

How Do Hard Drives Work



How Do Hard Drives Work



Hard Drives

SECTORS

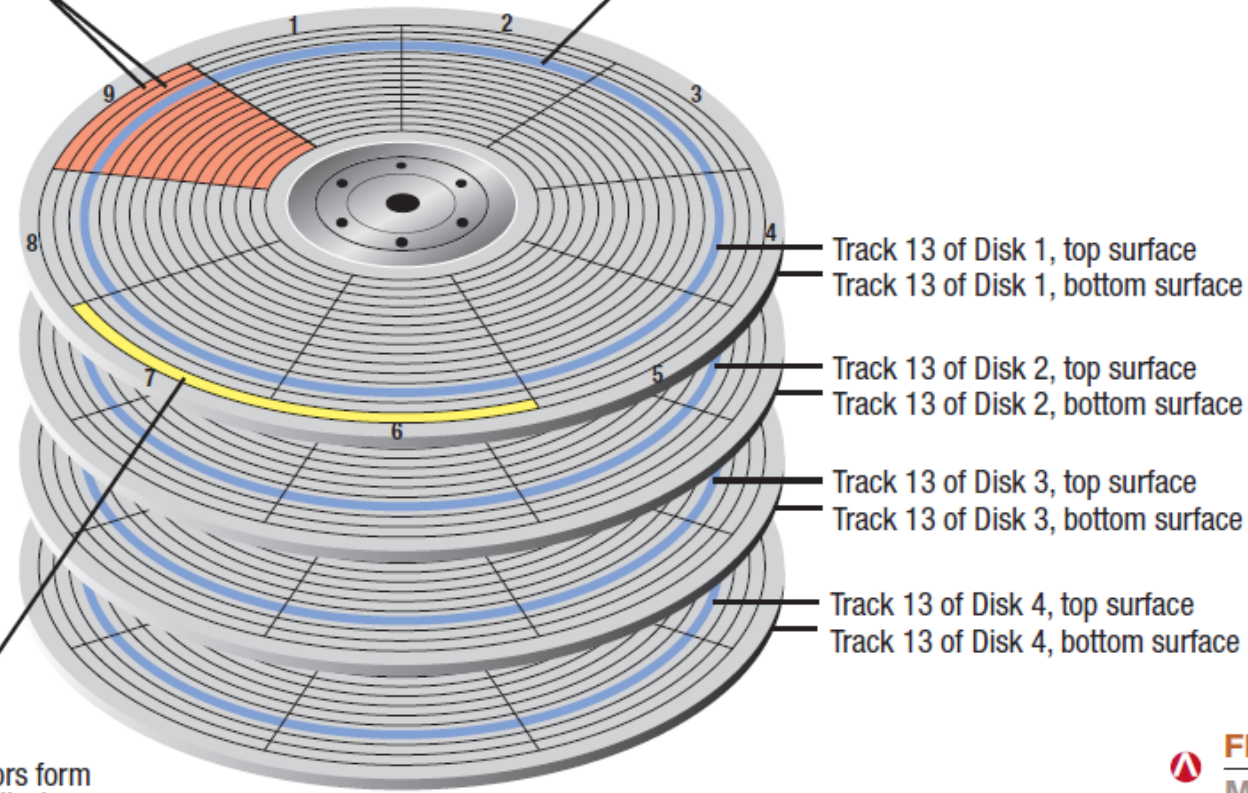
Each disk is divided into pie-shaped groups of sectors.

TRACKS

Data is stored on circular tracks; the 0s and 1s are represented magnetically.

CLUSTERS

One or more sectors form a cluster, the smallest storage area on a disk.



CYLINDER

A cylinder consists of a vertical stack of tracks, the same relative track on each disk surface.



FIGURE 3-5

Magnetic hard disks are organized into

Hard Drives

Solid-State Drives (SSDs)

- **Solid-state drives (SSDs)** are hard drives that use flash memory technology, data is stored as electrical charges on flash memory media and SSDs have **no moving parts** and are not subject to **mechanical failures** like magnetic hard drives and also more resistant to shock and vibration.
- They consume **less power**, make **no noise**, and **boot faster**.

Solid State Drives (SSDs)



Hard Drives

Hard Drive Speed

- The hard disks inside a magnetic hard drive typically spin continually at a rate of between 7,200 and 15,000 revolutions per minute. The total time that it takes for a hard drive to read or write data is called the **disk access time** and requires the following three steps:
 1. Move the read/write heads to the cylinder that contains (or will contain) the desired data—called **seek time**.
 2. Rotate the hard disks into the proper position so that the read/write heads are located over the part of the cylinder to be used—called **rotational delay**.
 3. Move the data, such as reading the data from the hard disk and transferring it to memory, or transferring the data from memory and storing it on the hard disk— called **data movement time**.

Hard Drives

Hard Drive Speed

- A typical disk access time is around **8.5 milliseconds**
- Because SSDs do not have to move any parts to store or retrieve data, they don't require seek time or rotational delay and their access time is much faster than magnetic hard drives—essentially instantaneous at about **0.1 ms** on some benchmark tests.

Fragmentation and Defragmentation

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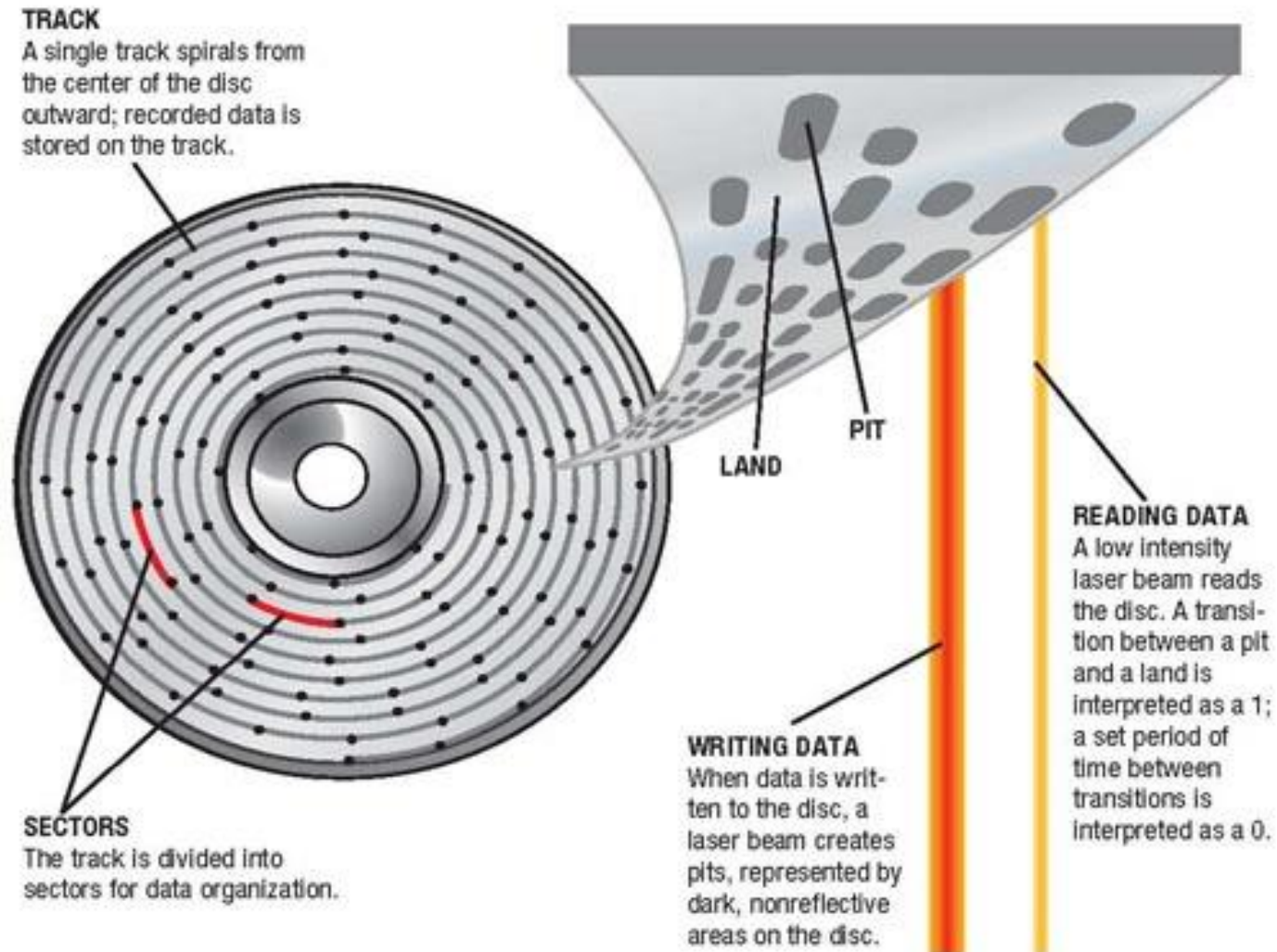
CD, DVD, Blu-ray



Optical Discs

- **Optical discs:** store data optically (using laser beams).
discs use a **single spiral** track (groove).
 - Data is stored in 0s and 1s.
- **Pits** and **lands** are used to represent 1s and 0s.
- Can be:
 - **Read-only:** Surface is molded or stamped to represent the data.
 - **Recordable** or **rewritable:** Reflectivity of surface is changed by a laser.

Optical Discs



Optical Discs

Optical Drives

- **Optical drives:** Designed for type of disc: CD, DVD, or Blu-Ray Disc (BD):
 - Can be read-only, recordable, or rewritable.
 - Downward compatible.
- **Burning:** Recording data onto disc:
 - CD discs: Use infrared lasers; hold 650 MB.
 - DVD discs: Use red lasers; hold 4.7 GB
 - BD discs: Use blue-violet lasers; hold 25 GB

Optical Discs

Read-Only Discs

- **Read-only disc:** Can be read from, but not written to, by the user.
 - **CD-ROM** (Compact Disc Read-Only Memory).
 - **DVD-ROM** (Digital Video Disc Read Only Memory).
 - **BD-ROM** (Blu-ray Disc Read Only Memory).
- Normally come pre-recorded:
 - Software programs.
 - Clip art and other graphics.
 - Music.
 - Movies.
 - Games (UMD, Wii, Xbox, etc..)

Recordable Discs

- **Recordable disc:** Can be written to, but cannot be erased and reused
 - CD-R
 - DVD-R
 - BD-R
- Used for back up, sending large files to others, creating custom music CDs, storing home movies, etc.



CD-R DISCS
Hold 650 MB.



DVD+R DL DISCS
Hold 8.5 GB.



BD-R DL DISCS
Hold 50 GB.

Rewritable Discs

- **Rewritable disc:** Can be recorded on, erased, and overwritten just like magnetic discs.
 - CD-RW.
 - DVD-RW.
 - BD-RE; can be dual layer.
- Use phase-change technology:
 - Heating and cooling process is used to change the reflectivity of the disc.
 - Can be changed back to erase the disc.

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Flash Memory Systems

- Chip-based storage medium:
 - No moving parts so more resistant to shock and vibration, require less power, make no sound.
 - Solid-state storage system.
- Most often found in the form of:
 - Flash memory cards.
 - USB flash drives.
 - Solid-state drives.
- Very small and so are very appropriate for use with digital cameras, digital music players, GPS devices, notebook computers, mobile devices, etc.

Flash Memory Cards

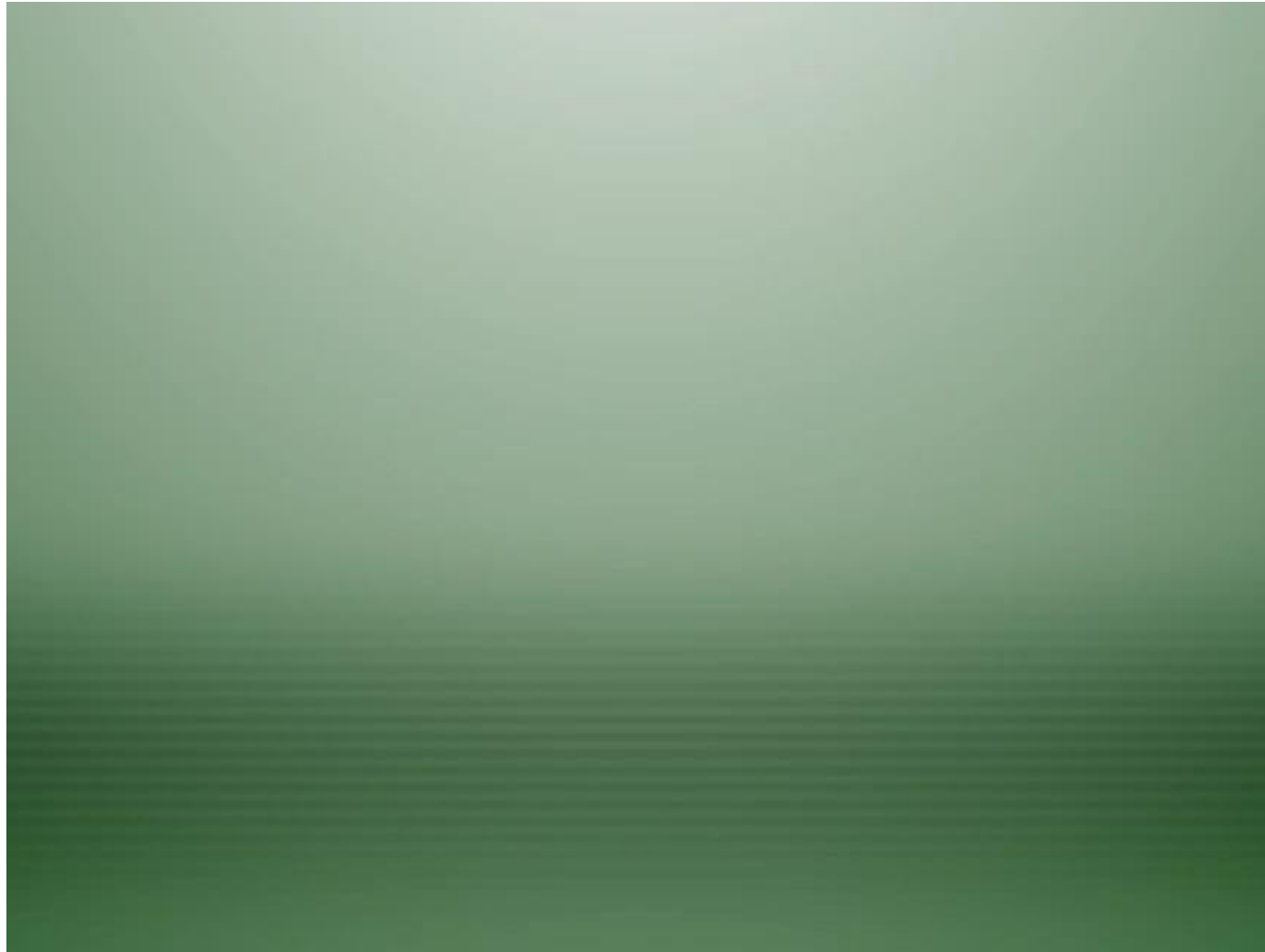
- **Flash memory card:** A small card containing one or more flash memory chips, controller chips, and metal contacts to connect the card to the device or reader that it is being used with.
 - Secure **D**igital (SD).
 - Secure Digital **H**igh **C**apacity (SDHC).
 - Secure Digital **E**xtended **C**apacity (SDXC).
 - Secure Digital **U**ltra **C**apacity (SDUC).
- Read by flash memory card reader.

Flash Memory Cards

SD Card Form Factors



USB Flash Drives



USB Flash Drives

- USB flash drives: Consist of circuite board, memory chips and controller.
 - Typically portable drives that connect to and are powered by a USB port.
 - Also called USB flash memory drives, thumb drives, jump drives.



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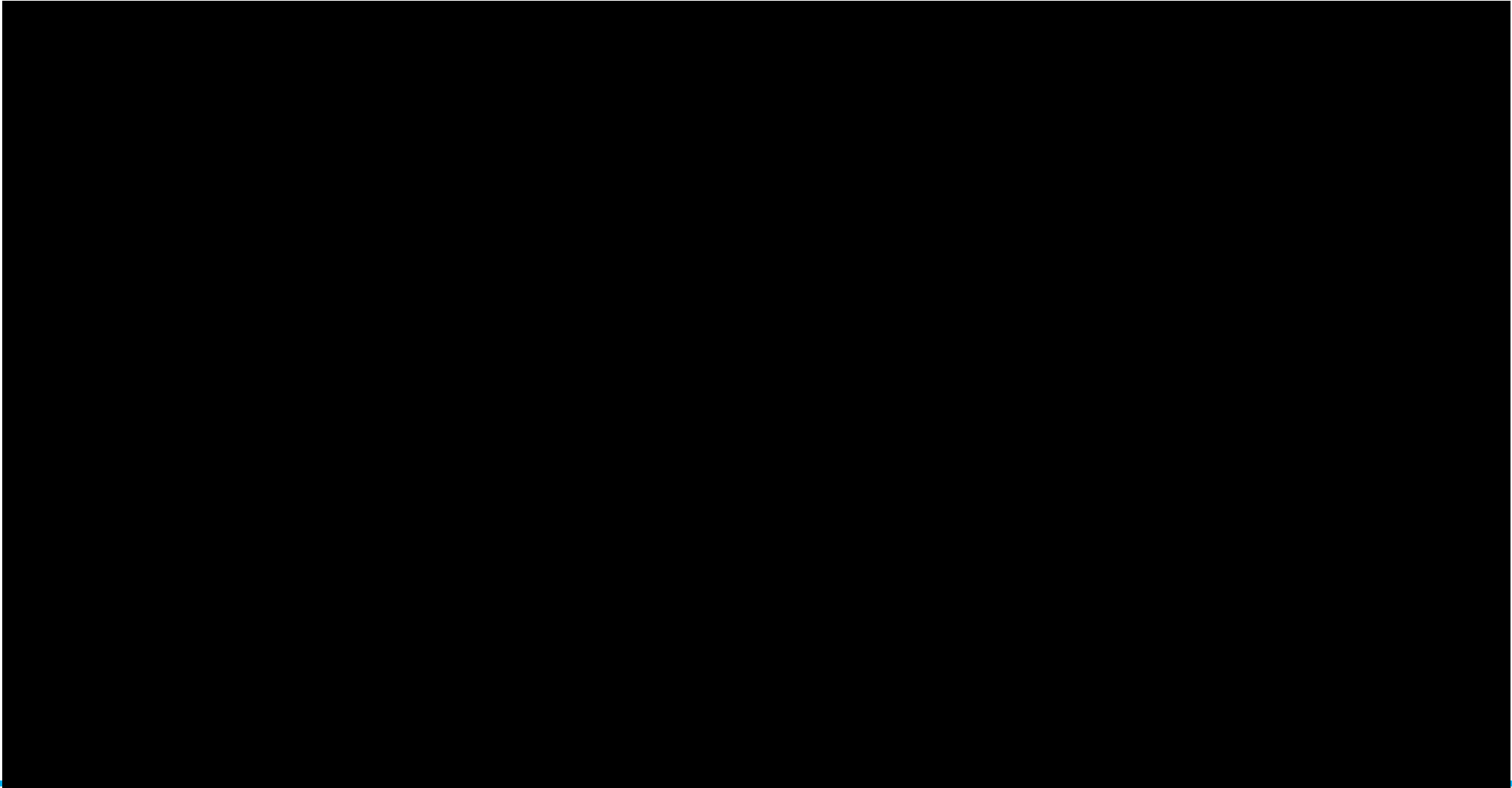
Evaluating Your Storage Alternatives

Other Types of Storage Systems

Remote storage

- **Remote storage:** Using a storage device not directly a part of the computer being used.
 - Network storage: Via a local network.
 - **Network Attached Storage (NAS):** Connected directly to a network.
 - **Storage Area Network (SAN):** Separate network of hard drives or other storage devices which is attached to the main network.
 - Online storage or cloud storage: Accessed via the Internet

SAN vs. NAS



Other Types of Storage Systems

Smart Cards

- **Smart card:** Credit card-sized piece of plastic that contains some computer circuitry (processor, memory, and storage).
 - ❖ Stores **small** amount of data (about 64 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 computer, keyboard, vending machine, or other device.

How smart card work



Top 4 Future Data Storage



Comparison of Storage Technologies

Storage Type	Speed	Capacity	Cost	Durability	Use Cases
Magnetic Hard Drive (HDD)	Moderate (mechanical read/write)	High (up to 20TB+)	Low per GB	Moderate (moving parts prone to wear)	Desktop PCs, servers, backup storage
Solid-State Drive (SSD)	Very High (electronic read/write)	Moderate to High	Higher per GB than HDD	High (no moving parts)	Laptops, gaming PCs, performance-critical systems
Optical Discs (CD/DVD/BD)	Low	Low to Moderate	Very Low	Moderate (can degrade over time)	Media distribution, archival storage
Flash Memory (USB/SD Cards)	High	Low to Moderate	Moderate	High	Portable storage, cameras, mobile devices
Cloud Storage	Depends on internet speed	Virtually unlimited	Subscription-based	Very High (redundant backups)	Remote access, collaboration, enterprise data
Smart Cards	Very Low	Very Low	Low	High	Authentication, secure access
Holographic Storage	Experimental	Extremely High	Very High	Unknown (still in development)	Future archival systems, scientific data

Evaluating Your Storage Alternatives

- **Factors to consider:**

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

- Most users **require:**

- ❖ Hard drive.
- ❖ DVD or BR drive.
- ❖ Flash memory card reader.
- ❖ USB port connecting USB devices.

Economic Aspects of Storage Technologies

Understanding the Financial Impact of Data Storage Choices

- Storage technologies are not just technical decisions—they are **strategic economic choices** that affect individuals, businesses, and governments. This section explores how different storage solutions influence **cost structures, operational efficiency, and long-term financial planning**

Economic Aspects of Storage Technologies

Cost per Gigabyte Over Time

- Historically, the cost of storage has **dropped dramatically**:
 - In the 1980s, 1GB of HDD storage cost thousands of dollars.
 - Today, 1TB HDDs are available for under \$50.
- SSDs are more expensive per GB than HDDs, but their **performance benefits** often justify the cost in high-demand environments

Year	HDD Cost/GB	SSD Cost/GB
2000	\$10	N/A
2010	\$0.10	\$2.00
2025	\$0.02	\$0.08

Economic Aspects of Storage Technologies

Total Cost of Ownership (TCO)

- When evaluating storage, organizations must consider more than just the purchase price:
 - ❖ **Initial Cost:** Hardware, installation, licenses.
 - ❖ **Operational Cost:** Power consumption, cooling, maintenance.
 - ❖ **Upgrade Cost:** Replacing outdated systems.
 - ❖ **Risk Cost:** Data loss, downtime, security breaches.
- **Example:**
 - ❖ A company using SSDs may pay more upfront, but save money long-term due to:
 - ❖ **Faster** data access (less employee idle time).
 - ❖ **Lower energy** consumption.
 - ❖ **Fewer** hardware failures.

Economic Aspects of Storage Technologies

Cloud vs. Local Storage Economics

Factor	Cloud Storage	Local Storage
Initial Investment	Low (subscription-based)	High (hardware purchase)
Scalability	Easy and flexible	Requires physical upgrades
Maintenance	Managed by provider	Requires in-house IT
Security	Depends on provider	Full control locally
Long-Term Cost	Can accumulate	Fixed after purchase

Insight:

Startups often prefer cloud storage for its low entry cost, while large enterprises may invest in hybrid systems to balance control and scalability.

Economic Aspects of Storage Technologies

Economic Trade-offs in Storage Decisions

- **Speed vs. Cost:** SSDs offer speed but at a higher price.
- **Capacity vs. Reliability:** HDDs offer more space but are prone to mechanical failure.
- **Flexibility vs. Control:** Cloud storage is flexible, but may lack full data sovereignty.

Economic Aspects of Storage Technologies

Economic Impact on Different Sectors

Sector	Storage Priority	Economic Concern
Healthcare	Security & reliability	Compliance costs
Education	Accessibility	Budget constraints
Media	High capacity & speed	Storage scalability
Finance	Data integrity	Risk mitigation

Summary

- **STORAGE SYSTEM CHARACTERISTICS** Storage systems make it possible to save programs, data, and processing results for later use.
- They provide **nonvolatile** storage, so when the power is shut off, the data stored on the storage medium remains intact.
- All storage systems involve two physical parts: A **storage device** (such as a DVD drive) and a **storage medium** (such as a DVD disc).

Summary

- Drives are typically assigned letters by the computer; these letters are used to identify the drive.
- **files** stored on a storage medium are given a filename and can be organized into folders. This is referred to as **logical file representation**. **Physical file representation** refers to how the files are **physically** stored on the storage medium by the computer.

Summary

- **Hard drives** are used in most computers to store programs and data.
- **Magnetic hard** drives contain metal hard disks that are organized into concentric tracks encoded with magnetized spots representing 0s and 1s.
- A separate read/write head that corresponds to each disk surface is used to read and write data.
- **Solid-state drives (SSDs)** are increasingly used for portable computers because they are more shock-resistant and energy-efficient.
- The total time it takes for a magnetic hard drive to read from or write to disks is called **disk access time**.

Summary

- **Optical discs**, such as CD discs, DVD discs, and Blu-ray Discs (BDs), store data optically using laser beams, and they can store data much more densely than magnetic disks.
- They are divided into tracks and sectors like magnetic disks, but they use a single spiral track instead of concentric tracks.
- Data is represented by pits and lands permanently formed on the surface of the disk.
- Optical discs are available in a wide variety of sizes, shapes, and capacities and are read by optical drives, such as CD or DVD drives.
- CD-ROM discs come with data already stored on the disc.
- CD-ROM discs cannot be erased or overwritten—they are **read-only**.

Summary

- DVD-ROM discs are similar to CD-ROM discs, but they hold much **more** data (at least 4.7 GB instead of 650 MB).
- High-capacity read-only optical discs designed for high-definition content are **BD-ROM discs**.
- **Recordable discs** (CD-R, DVD-R/DVD+R, and BD-R discs, for example) and **rewritable disks** (CD-RW, DVD-RW/DVD+RW, and BD-RE discs, for instance) can all be written to, but **only rewritable** discs can be **erased** and **rewritten** to, similar to a hard drive.
- Recordable CDs and DVDs store data by burning permanent marks onto the disc, similar to CD-ROM and DVD-ROM discs; rewritable discs typically use phase change technology to temporarily change the reflectivity of the disc to represent 1s and 0s.

Summary

- **Flash memory** is used in a variety of storage systems.
- **Flash memory cards**, one of the most common types of flash memory media, are commonly used with digital cameras, portable computers, and other portable devices, as well as with desktop computers.
- Flash memory cards come in a variety of formats—the most common is Secure Digital (SD) cards.
- USB flash drives connect to a computer or other device via a USB port and are a convenient method of transferring files between computers.
- They can also provide other capabilities, such as to lock a computer or control access to the data stored on the USB flash drive.

Summary

- **Remote storage** involves using a storage device that is **not directly** connected to your computer.
- One example is using a network storage device, such as a network attached storage (**NAS**) or storage area network (**SAN**).
- Another is online storage or cloud storage; that is, storage available via the Internet.
- **Smart cards** contain a chip or other circuitry usually used to store data or a monetary value.
- **Holographic storage**, which uses multiple blue laser beams to store data in three dimensions, is now available for high-speed data retrieval applications.

Summary

- Most personal computers today include a hard drive, some type of optical drive, a flash memory card reader, and multiple USB ports that can be used to connect USB-based storage devices, such as external hard drives and USB flash drives, as well as other USB hardware.
- The type of optical drive and any additional storage devices are often determined by weighing a number of factors, such as cost, speed, compatibility, storage capacity, removability, and convenience

Reference

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Deborah Morley