STORAGE DEVICES AND MEDIA

Lecture 11

TOPICS COVERED IN LAST LECTURE

- Output Devices and Their Uses
  - Cathode Ray Tube (CRT) Monitor
  - LED Screens
  - LCD Screens
  - Touchscreens
  - Multimedia Projectors
  - Laser Printers
  - Inkjet and Dot Matrix Printers
  - Plotters and 3D Printers
  - Speakers
  - Actuators

TODAY'S TOPICS

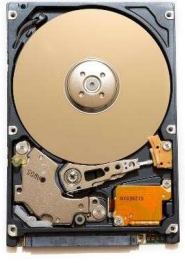
- Storage devices and media
  - Learning Objectives
  - Intro to Storage Media and Devices
  - How do we measure storage capacity?
  - Classification of storage media according to size
  - How is data accessed from these drives?
  - Different magnetic media and magnetic storage devices; magnetic disk and tapes
  - Optical media and optical storage devices
  - Solid-state media and solid-state storage devices
  - Cloud storage
  - Redundant Array of Independent Disks (RAID)
  - Storage Area Network (SAN)

Learning Objectives

- Understand the characteristics, advantages and disadvantages of different **Magnetic media and devices**; magnetic disk and tapes
- Understand the characteristics, advantages and disadvantages of different **Optical media and devices**; CD, DVD and Blu-ray
- Understand the characteristics, advantages and disadvantages of different **Solid state media and devices**; SD cards, flash disk, SSD etc
- **Cloud storage**

Intro to Storage Media and Devices

- **Storage media** is the **hardware on which data is actually stored** permanently. e.g. CDs, DVD, etc
- **Storage device** is the **hardware used to read from or write to** the storage Medium. e.g. CD/DVD reader, the HDD read/write head etc



Magnetic media rely on properties of magnetism for electronic data storage; magnetized area is a binary 1-value, demagnetized area is a binary 0-value

Optical media rely on the optical properties of laser light to read data from or write data on the surface of a disk

Solid state media employs solid state technology for data storage by controlling the movement of electrons within NAND chips

How do we measure storage capacity?

- Storage capacities or file sizes are measured in:

Kilobytes(KB), Megabytes(MB), Gigabytes (GB), Terabytes (TB), Petabytes (PB)

1 byte = 8 bits

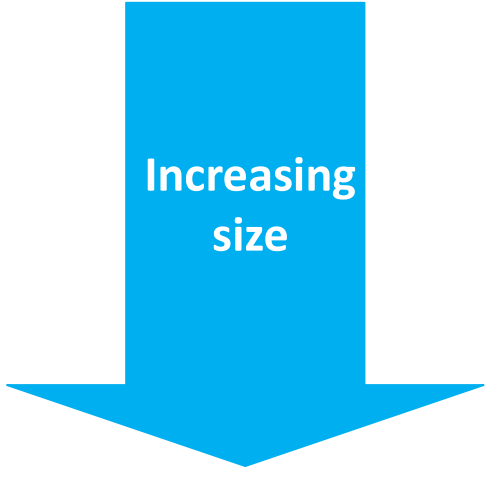
1 KB = 1000 bytes

1 MB = 1000 KB

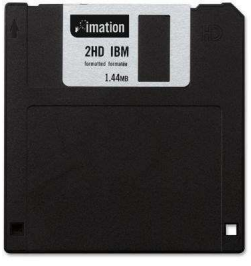
1 GB = 1000 MB

1 TB = 1000 GB

1 PB = 1000 TB



Classification of storage media according to capacity



Floppy Disk
1.44 MB

CD-ROM
700 MB

DVD
Up to 4.7 GB

Blu-Ray
25 GB – 128 GB

Hard Drive / SSD
8 TB

Magnetic Tape
Up to 185 TB

How is data accessed from these drives?

❑Serial (Sequential) access

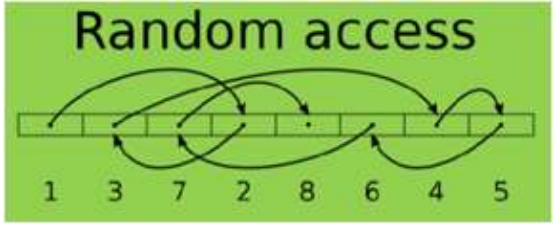
- Data is read from the device sequentially in the same order in which it was written to the device.

  e.g: Magnetic tapes use serial access.

❑Direct (Random) access

- Data is read instantly; the required data is read directly from the storage location without following any hierarchy.

  e.g: HDDs, DVDs, Blu-ray, flash drives use direct access.



Magnetic Media and Storage Devices
Magnetic Disk and Tapes

❑Magnetic tape drives

- A **thin strip of plastic** coated in thin magnetic (ironoxide) layer.
- Has vast storage **capacities** (up to 185 TB) and suitable for offline or batch processing.
- Used by large organizations for **long-term vast data storage**

Advantages of Magnetic tapes	Disadvantages of magnetic tapes
• Less expensive per byte than HDDs • Very robust technology • Vast data storage capacities • Fast data transfer rates	• Uses serial access, thus very slow data access time. • Strong magnetic fields can lead to corrupt data.

Magnetic Media and Storage Devices
Magnetic Disk and Tapes

❑Hard disk drives (HDD)

- Most **common fixed** storage device in computers with large storage capacities.
- Actuators are used to move the read/write head during operation.

• Advantages of fixed HDDs	• Disadvantages of fixed HDDs
• Very fast data transfer rates • Fast data access times; uses direct access • Large storage capacities	• Fragile; they can easily get damaged • Many moving parts which can affect reliability of the device • They can be quite noisy compared to SSDs

Magnetic Media and Storage Devices
Magnetic Disk and Tapes

❑ Portable hard disk drive

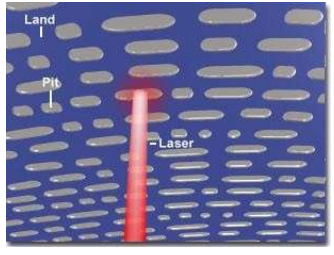
- **Portable external** HDDs that can be connected to the computer via USB
- Used as **back up** devices to prevent data loss
- In some cases, they are used for **transfer** of large software/information between computers.

• Advantages of portable HDDs	• Disadvantages of portable HDDs
• Large storage capacities • Handy for large software/information transfer between computers	• Fragile; they can easily get damaged if not properly ejected or if dropped. • They can be quite noisy compared to SSDs

Optical Media and Storage Devices

CDs and DVDs

- Red **laser** light is used to read from and write on the optical disk
- Data is stored in **pits and lands** on spiral tracks
- For improved storage capacities like in DVDs, **dual-layering technology** is used
- DVDs generally have larger storage **capacities** than CDs



Optical Media and Storage Devices
CDs and DVDs

❑CD-R (Compact disk-Recordable) and DVD-R (Digital Video Disk-Recordable)

- Can only be **written to once** and they become Read only
- Used for home audio/video recordings and data storage

Advantages of CD-R and DVD-R	Disadvantages of CD-R and DVD-R
• Cheaper than RW disks • Permanent storage medium.	• Recording is done just once. • if an error occurs disk will be thrown away.

Optical Media and Storage Devices
CDs and DVDs

❑CD-RW and DVD-RW

- RW-disk can be written to, read, erased and **rewritten many times**
- Uses: recording of TV programs, CCTV systems for recordings, Backing up of files

Advantages of CD-RW and DVD-RW	Disadvantages of CD-RW and DVD-RW
• Can be reused (written) many times. • Can store different file formats, and not wasteful like R formats	• Relatively expensive technology • Data can be accidentally overwritten

Optical Media and Storage Devices
CDs and DVDs

❑CD-ROM/DVD-ROM

- **Read-only** memory which can not be written but can only be read from
- Can **store data permanently** especially to prevent deletion or copying
- CD-ROM is used for storage of music files, software etc
- DVD-ROM are used for storing films, files and games

Advantages of CD-ROM and DVD-ROM	Disadvantages of CD-ROM and DVD-ROM
• Less expensive than HDDs • Permanent storage device	• Slower data transfer rates an access times • Compared to HDDs

Optical media and Storage Devices

❑Blu-ray discs

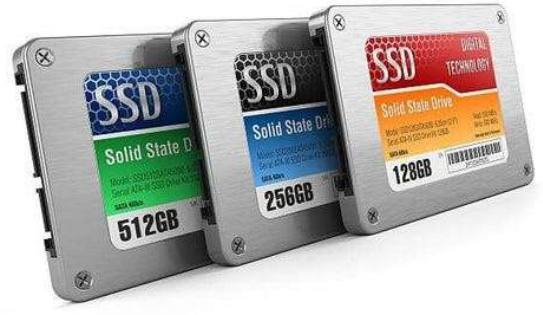
- Data is read from or written to these discs using **blue laser** light on Blu-ray optical storage device
- They can store up to five times **more data than DVDs** due to smaller pits and lands for data storage and use of blue light
- Have secure **encryption** system to prevent piracy and copyright infringement
- Used in home video consoles, storing movies and backing up data

Advantages of Blu-ray discs	Disadvantages of Blu-ray discs
• Very large storage capacities • Fast data transfer rate and access speeds • Secure encryption to prevent piracy	• Relatively expensive • Encryption challenges when used to store videos.

Solid-state media and Storage Devices

❑Solid-state drives (SSD)

- Stores data as 1s and 0s in millions of tiny **transistors** by controlling the movements of electrons within NAND chips
- Use solid-state media for backing up, storage of files, software and computer applications
- Mostly used as storage media **in laptops, smartphones, tablets** etc



Advantages of solid-state drives	Disadvantages of solid-state drives
• More reliable than HDDs; no moving parts • They consume less power • very fast access times; only 0.1 milliseconds compared to 10 milliseconds for HDD.	• SSD endurance; most SSDs have limited write operations over a period of about 3years limiting their use in areas with high numbers of write operations. • Expensive per GB

Solid-state media and Storage Devices

❑Pen Drives (memory sticks)

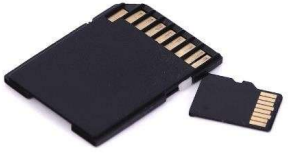
- Very **small, lightweight portable solid state** storage devices mainly use for **backup and file transfer** between computers
- Used as **security device** in some cases to prevent software piracy

Advantages of pen drives	Disadvantages of pen drives
• Small, lightweight and very portable • Very robust • Not affected by magnetic fields.	• Due to small size it is easy to lose • Might get damaged or data corrupted if not well ejected from a computer.

Solid-state media and Storage Devices

❑Memory cards

- Uses solid-state technology and comes in various **formats**:
  - **SD cards** (secure digital card); used in most portable devices (e.g phones)
  - **XD cards** (extreme digital card); design for use in digital cameras
  - **CFast card** (compactfast card); use in digital cameras with higher-end digital photo and video.

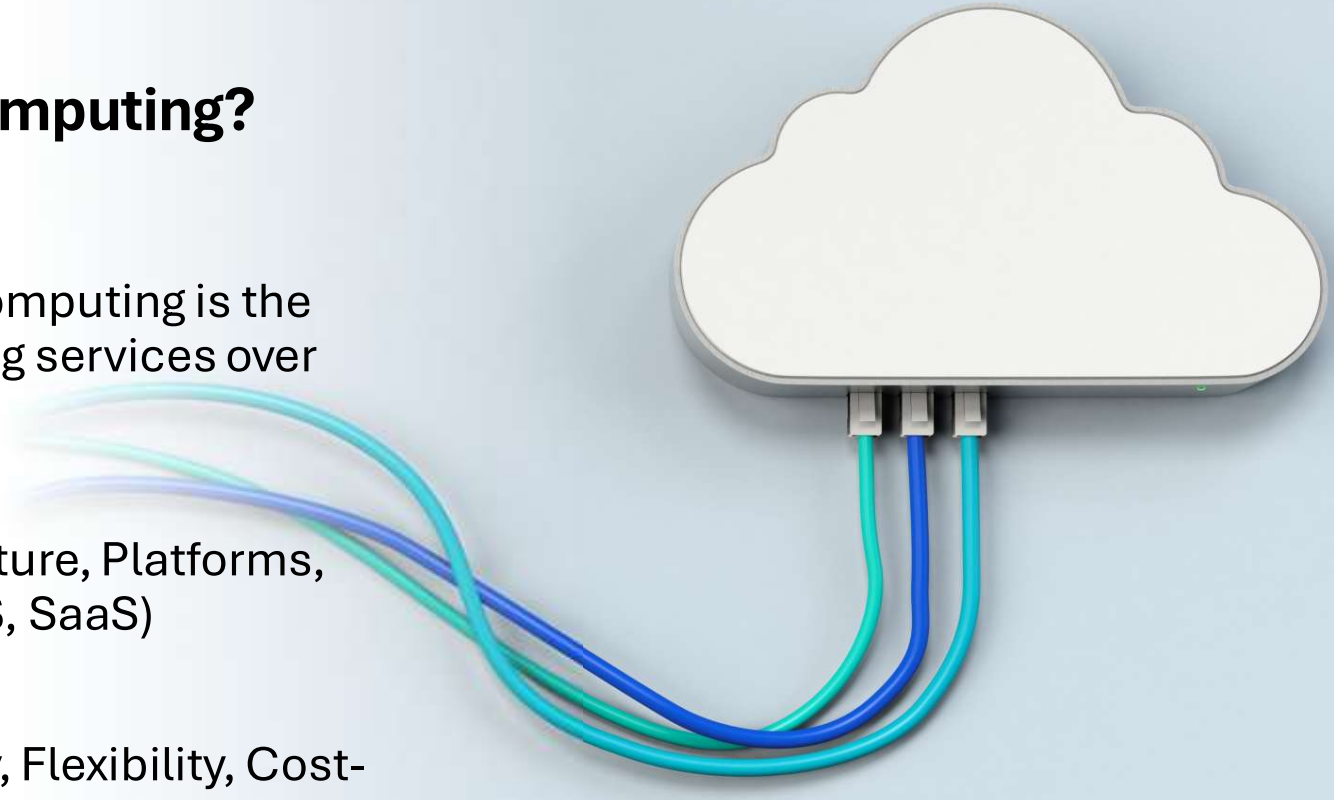


Advantages of memory cards	Disadvantages of memory cards
• They are very compact, can be easily removed and used in other devices • Very durable; no moving parts	• They are expensive per gigabyte • Short life span due to limited read and write operations.


Intro to Cloud Computing

What is Cloud Computing?

- **Definition:** Cloud computing is the delivery of computing services over the internet
- **Services:** Infrastructure, Platforms, Software (IaaS, PaaS, SaaS)
- **Benefits:** Scalability, Flexibility, Cost-effectiveness



Cloud Computing Deployment Models

- **Public Cloud:** Shared resources, open access (e.g., AWS, Azure)
- **Private Cloud:** Dedicated resources, restricted access (e.g., company-owned)
- **Hybrid Cloud:** Combination of public and private clouds
- **Community Cloud:** Shared resources, specific community (e.g., research institutions)

Cloud Computing Applications

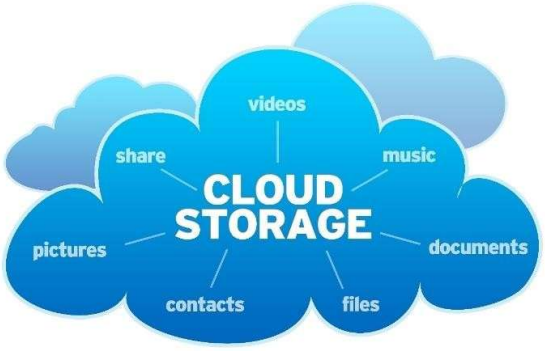
Examples: Social media, online storage (Google Drive), productivity software (Microsoft Office 365)

Industries: Healthcare, finance, education, gaming

Benefits: Collaboration, accessibility, scalability

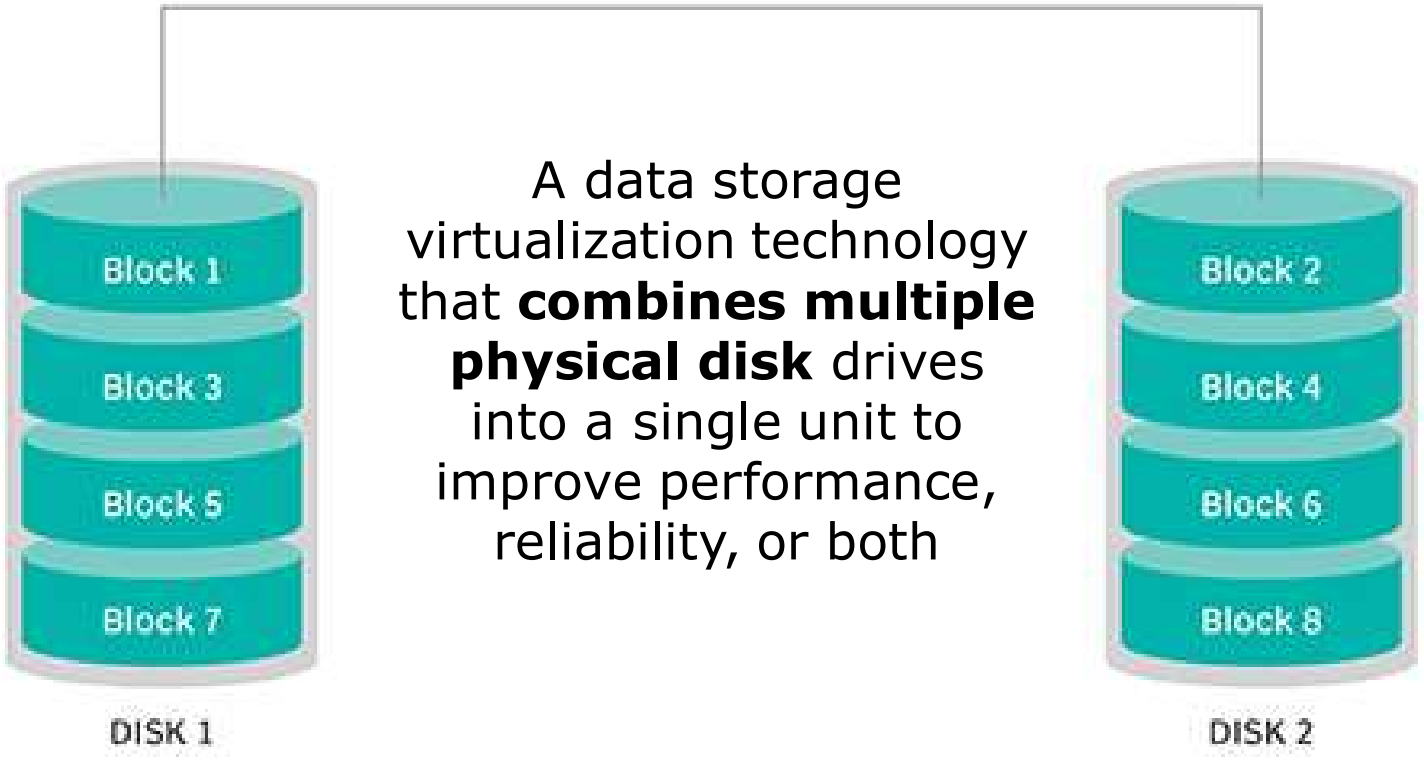
❑Cloud storage

- Storage of data in a remote location **online**
- The cloud storage system makes use of **servers** to store data which can be accessed by users through the internet
- People can now stream their favorite music, movies, TV programs from cloud storage



Advantages of cloud storage	Disadvantages of cloud storage
• Data can be accessed anywhere with internet connection • Storage space can be upgraded easily without investing in hardware	• Data can be hacked if not properly secured. • Lack of internet can limit data access • You data can be sold to third parties.

RAID (Redundant Array of Independent Disks)



A data storage virtualization technology that **combines multiple physical disk** drives into a single unit to improve performance, reliability, or both

Key Concepts of Redundant Array of Independent Disks (RAID)

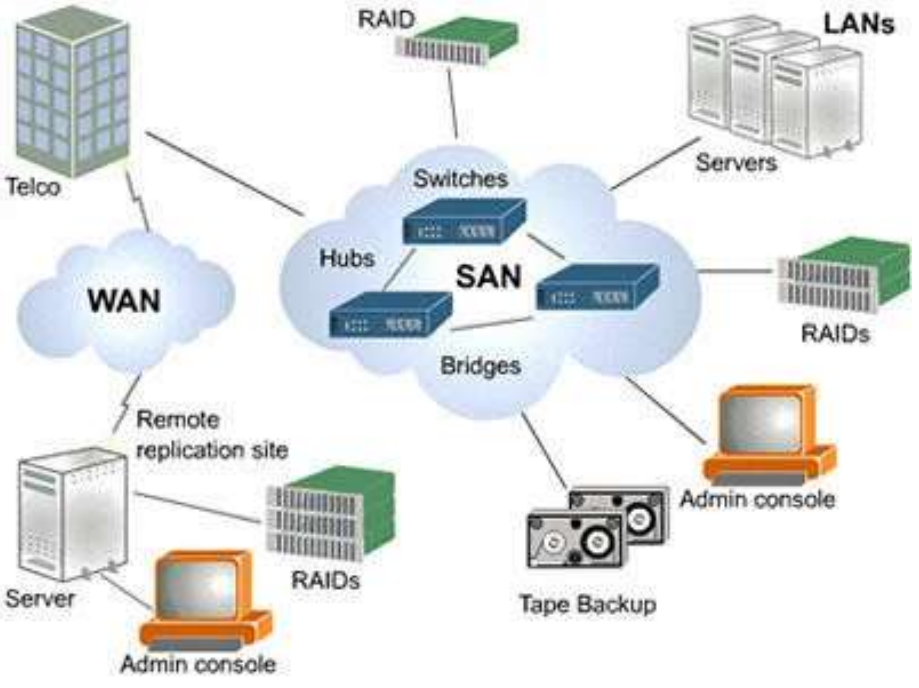
1. **Data Redundancy:** RAID ensures data protection by storing copies of data across multiple disks, so if one disk fails, data can still be recovered.
2. **Striping:** This technique splits data across multiple disks, enhancing performance by allowing simultaneous read/write operations.
3. **Mirroring:** RAID mirroring duplicates data on two or more disks, providing a real-time backup to prevent data loss.
4. **Parity:** Parity information is used in certain RAID levels to reconstruct lost data without full duplication, offering a balance between redundancy and storage efficiency.
5. **RAID Levels:** Different RAID levels (e.g., RAID 0, 1, 5, 6, 10) provide varying degrees of performance, fault tolerance, and storage capacity, tailored to different needs.

Key Benefits of Redundant Array of Independent Disks (RAID)

1. **Improved Data Reliability:** RAID increases fault tolerance by duplicating or distributing data across multiple disks, protecting against data loss in case of disk failure.
2. **Enhanced Performance:** RAID configurations like striping (RAID 0) allow for faster data access by distributing read and write operations across multiple disks simultaneously.
3. **Increased Storage Capacity:** By combining several smaller drives into a larger virtual volume, RAID allows for efficient use of disk space, especially in levels like RAID 5 and RAID 6.
4. **Fault Tolerance:** Certain RAID levels (e.g., RAID 1, 5, 6) can withstand one or more disk failures without data loss, ensuring system availability and minimizing downtime.
5. **Hot Swapping:** Many RAID systems support hot swapping, allowing failed disks to be replaced without powering down the system, ensuring continuous operation.

A **Storage Area Network (SAN)** is a specialized, high-speed network that provides network access to storage devices.

SANs are typically composed of hosts, switches, storage elements, and storage devices that are interconnected using a variety of technologies, topologies, and protocols.



Key Concepts of Storage Area Network (SAN)

1. **Block-Level Storage:** SAN provides direct access to disk blocks, allowing for efficient data storage and retrieval. This makes it ideal for high-performance applications like databases and virtual machines.
2. **Dedicated Network:** SAN operates on a separate, high-speed network that connects servers to storage devices, ensuring that data traffic is isolated and optimized for storage tasks.
3. **Use of Optical Fibre:** Fibre Channel is a common protocol in SANs, and it often uses optical fibre cables for high-speed, reliable data transfer over long distances, supporting up to several kilometers with minimal signal loss.
4. **Scalability:** SANs are easily scalable, enabling organizations to increase storage capacity without compromising performance, making it suitable for growing data needs.
5. **High Availability:** SANs are designed for redundancy and failover, ensuring continuous data availability even in case of hardware or network failures, supporting mission-critical applications.

Key Benefits of Storage Area Network (SAN)

1. **Centralized Storage Management:** SAN allows centralized management, enabling efficient control, allocation, and monitoring of storage resources across multiple servers.
2. **High Performance:** SANs deliver fast data transfer rates, especially when using Fibre Channel or iSCSI, ideal for data-intensive applications like databases and virtualization.
3. **Scalability:** SANs can be easily expanded by adding more storage devices without impacting performance, supporting growing storage needs seamlessly.
4. **Improved Data Availability:** With features like redundancy and failover, SANs ensure continuous data availability, reducing downtime and supporting mission-critical applications.
5. **Efficient Resource Utilization:** SAN optimizes storage use by consolidating storage resources, eliminating isolated or underutilized storage, and improving overall efficiency.
6. **Support for Disaster Recovery:** SANs often integrate with data replication and backup solutions, making it easier to implement disaster recovery strategies across multiple locations.

Case Study 1: Secure Storage for a Hospital

Background:

A hospital needs to store large volumes of patient records, medical images (X-rays, MRIs), and daily operational data. The storage system must provide:

- **High availability** (data always accessible)
- **Fault tolerance** (no data loss if a disk fails)
- **Scalability** (ability to grow with future needs)

Question:

Which storage solution discussed in this lecture is most suitable for the hospital's needs?

Case Study 1: Secure Storage for a Hospital

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- **High availability** (data always accessible)
- **Fault tolerance** (no data loss if a disk fails)
- **Scalability** (ability to grow with future needs)

Question:

Which storage solution discussed in this lecture is most suitable for the hospital's needs?

Answer:

Storage Area Network (SAN) – because it provides centralized, high-speed, fault-tolerant, and scalable storage, making it ideal for mission-critical environments like healthcare.

Case Study 2: Storage Needs of a Large Bank

Background:

A large bank processes **millions of daily transactions**, customer records, and financial reports. The bank's IT system requires:

- **High-speed access** to critical data for real-time processing.
- **Centralized storage management** across multiple servers.
- **Fault tolerance and redundancy** to prevent data loss.
- **Scalability** to handle growing data requirements every year.

The bank is considering the following options:

- **Magnetic Disks** – cheap but limited performance and prone to failures.
- **Optical Storage** – reliable for archiving but too slow for real-time banking operations.
- **Cloud Storage** – accessible but may raise security/regulatory concerns.
- **Storage Area Network (SAN)** – centralized, high-speed storage system with redundancy.

Case Study 2: Storage Needs of a Large Bank

Question:

Which storage solution is most suitable for the bank's requirements, and why?

Case Study 2: Storage Needs of a Large Bank

Question:
Which storage solution is most suitable for the bank's requirements, and why?

Answer:
Storage Area Network (SAN) – because it provides **high-speed centralized storage**, fault tolerance, scalability, and secure data handling — all critical for a bank's real-time financial operations.

Learning Outcome:

- Invokes **critical thinking** by weighing security, speed, and reliability.
- Encourages **problem solving** (choosing the only option that meets *all* requirements).
- Engages **comparative analysis** with contemporary technologies (SAN vs. cloud, optical, or magnetic storage).

Case Study 3: Designing Storage for a Video Streaming Company

Background:

A video streaming company (similar to Netflix) is setting up a new data center.

The company expects:

- **Petabytes of video content** to be stored
- Thousands of users **accessing and streaming videos simultaneously**
- **High-speed access** to ensure smooth playback without buffering
- **Fault tolerance and redundancy** because losing even part of a movie or show can affect customer trust
- **Scalability** to add more storage easily as the company grows
- **Cost efficiency** — the company cannot overspend but must ensure reliability

Case Study 3: Designing Storage for a Video Streaming Company

Background:

The IT team is evaluating different storage options:

1. Magnetic Disks / Tapes
2. Optical Media (CD/DVD/Blu-ray)
3. Solid-State Drives (SSD) Cloud Storage
4. RAID (Redundant Array of Independent Disks)
5. Storage Area Network (SAN)

Case Study 3: Designing Storage for a Video Streaming Company

Question:

If you were part of the IT decision-making team, **which storage solution would you recommend for the video streaming company and why?** Compare the alternatives and justify your answer.

Case Study 3: Designing Storage for a Video Streaming Company

Answer:

The best solution is a **Storage Area Network (SAN)**.

Why not Magnetic Disks or Tapes?
They are cheap and reliable for backup but too slow for real-time video streaming. They cannot handle simultaneous requests from thousands of users efficiently.

Why not Optical Media?
Optical media like DVDs or Blu-rays are outdated for such large-scale requirements. They are not rewritable at scale, slow to access, and physically impractical for cloud-like streaming.

Case Study 3: Designing Storage for a Video Streaming Company

Answer:

Why not SSDs?

Solid-state drives are very fast and would reduce buffering, but at petabyte scale they are prohibitively expensive. For a company with massive storage needs, this is not cost-effective.

Why not Cloud Storage?

Cloud storage offers scalability, but it comes with recurring costs, reliance on third-party vendors, and possible legal issues regarding content ownership and compliance. The company may prefer to have direct control of its data center.

Case Study 3: Designing Storage for a Video Streaming Company

Answer:

Why not RAID?

RAID provides fault tolerance and performance boosts, but it is limited to server-level configurations. On its own, RAID cannot scale to the level required for enterprise-wide video distribution.

Why SAN?

SAN offers centralized, **high-speed access** to petabytes of data, supports **thousands of concurrent connections**, and ensures **redundancy and fault tolerance**. It is scalable, reliable, and purpose-built for enterprise environments like video streaming. SAN integrates well with RAID technologies under the hood, giving both speed and fault tolerance.

Case Study 3: Designing Storage for a Video Streaming Company

Answer:

Conclusion:

The only storage technology that satisfies **all requirements simultaneously** is **Storage Area Network (SAN)**. It balances speed, scalability, fault tolerance, and cost, making it the most suitable solution for the video streaming company.

SUMMARY

- In this module, we explored different types of storage devices and media, focusing on how data is stored and accessed.
- Key topics included measuring storage capacity and classifying storage by size, covering magnetic (disks, tapes), optical (CDs, DVDs), and solid-state devices (SSDs, USB drives).
- We also introduced cloud storage for scalable, online data solutions.
- Advanced topics included RAID for data redundancy and improved performance; SAN allows centralized management, enabling efficient control, allocation, and monitoring of storage resources across multiple servers.

Thank You !