

## Chapter 7 Secondary Storage

### Lecture Guide

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- **Learning Objectives**

- Distinguish between primary and secondary storage.
- Identify the important characteristics of secondary storage including media, capacity, storage devices, and access speed.
- Describe hard disk platters, tracks, sectors, cylinders, and head crashes.
- Compare internal and external hard drives.
- Compare performance enhancements including disk caching, RAID, file compression, and file decompression.
- Define optical storage including compact discs, digital versatile discs, and Blu-ray discs.
- Define solid-state storage including solid-state drives, flash memory cards, and USB drives.
- Define cloud storage and cloud storage services.
- Describe mass storage, mass storage devices, enterprise storage systems, and storage area networks.

### Chapter Outline

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- **Storage**

- The ability to save, to back up and even to transport files consisting of data or programs from one location or computer to another.
- Random-access memory (RAM) holds or stores data and programs that the CPU is currently processing. RAM is sometimes referred to as primary storage. Unfortunately, most RAM provides only temporary or volatile storage – its contents are lost as soon as there is no electrical current going into the system.
- Secondary storage provides permanent or nonvolatile storage. Using secondary storage devices, data and programs can be retained after the computer has been shut off.
- Important characteristics of secondary storage
  - **Media** are the physical material that holds the data and programs.
  - **Capacity** measures how much a particular storage medium can hold.
  - **Storage devices** are hardware that reads data and programs from storage media. Most also write to storage media.
  - **Access speed** measures the amount of time required by the storage device to retrieve data and programs.

- **Hard Disks**

- Are sensitive instruments.
- Save files by altering the magnetic charges of the disk's surface to represent 1s and 0s.
- Retrieve data and programs by reading the charges from the magnetic disk.

- Density refers to how tightly these charges can be packed next to one another on the disk.
- Rigid metallic platters that are stacked one on top of another.
- Store and organize files using tracks, sectors, and cylinders.
  - Tracks are rings of concentric circles on the platter.
  - Each track is divided into invisible wedge-shaped sections called sectors.
  - A cylinder runs through each track of a stack of platters. Cylinders are necessary to differentiate files stored on the same track and sector of different platters.
- A head crash occurs when a read/write head makes contact with the hard disk's surface or with particles on its surface.
- A head crash is a disaster for a hard disk.
- Two basic types of hard disks:
  - **Internal hard disk (fixed disk)**
    - Located inside the system unit.
    - Almost all of today's powerful applications are designed to be stored on and run from an internal hard disk. To ensure adequate performance of your internal hard disk, you should perform routine maintenance and periodically make backup copies of all important files.
  - **External hard drives**
    - Slower access
    - Typically connected to a USB or Thunderbolt port on the system unit, are easily removed, and effectively provide an unlimited amount of storage.
    - Use the same basic technology as internal hard disks and are used primarily to complement an internal hard disk.
    - Other uses for external drives include backing up the contents of the internal hard disk and providing additional hard-disk capacity.
- **Performance Enhancements**
- Three ways to improve the performance of hard disks are:
  - Disk caching
    - Improves hard-disk performance by anticipating data needs.
    - Improves processing by acting as a temporary high-speed holding area between a secondary storage device and the CPU.
    - Requires a combination of hardware and software.
    - Frequently used data is read from the hard disk into disk (cache). When needed, the data is then accessed directly from memory.
    - The transfer rate from memory is much faster
    - Increases system performance by 30 percent
  - Redundant arrays of inexpensive disks (RAID)
    - Improves performance by expanding external storage, improving access speed, and providing reliable storage.

- Several inexpensive hard-disk drives are connected to one another. These connections can be by a network or within specialized RAID devices.
- The computer system interacts with the RAID system as though it were a single large-capacity hard-disk drive.
- The result is expanded storage capability, fast access speed, and high reliability.
- File compression and file decompression
  - Increase storage capacity by reducing the amount of space required to store data and programs.
  - File compression is not limited to hard disks systems.
  - File compression helps speed up transmission of files from one computer system to another.
  - File compression programs scans files for ways to reduce the amount of required storage.
  - In file compression repeated patterns are replaced with a token, leaving enough tokens so that the original can be rebuilt or decompressed.
  - File compression programs often shrink files to a quarter of their original size.
  - Windows and Mac operating systems provide compressions and decompression utilities
  - For more advanced compression you can use specialized utilities, such as WinZip
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- **Optical Discs**
  - Can hold over 128 gigabytes of data.
  - A laser beam alters the surface of a plastic or metallic disc to represent data. Optical discs use reflective light to represent data.
  - The 1s and 0s are represented by flat areas called lands and bumpy areas called pits on the disc surface.
  - Disc is read by an optical disc drive using a laser that projects a tiny beam of light on these areas. The amount of reflected light determines whether the area represents a 1 or a 0.
  - Optical discs typically use a single track that spirals toward the center of the disk. This single track is divided into equally sized sectors.
- **Compact Disc**
  - Store 700 MB (megabytes) of data on one side of a CD.
  - Three basic types of CDs:
    - Read only—CD-ROM - cannot be written on or erased by the user.
    - Write once—CD-R - can be written to once.
    - Rewriteable—CD-RW – can be written to many times.

- **Digital Versatile Disc**
  - DVD stands for digital versatile disc or digital video disc
  - Can store 4.7 GB (gigabytes) on one side of a DVD disc
  - Capacity is 7 times that of a CD.
  - Three basic types of DVDs:
    - Read only—DVD-ROM - cannot be written on or erased by the user.
    - Write once— DVD+R, DVD-R - can be written to once.
    - Rewriteable— DVD+RW, DVD-RW, DVD-RAM – can be written to many times.
    - Applications range from storing video from camcorders to developing multimedia presentations
- **Blu-ray Disc**
  - Have a greater capacity than DVDs.
  - Next generation of optical disc is called hi def (high definition)
  - The hi definition standard is Blu-ray Disc (BD).
  - Blu-ray Discs have a capacity of 50 GB on one side
  - Capacity is 10 times that of a standard DVD.
  - Three basic types of Blu-ray:
    - Read only—BD - cannot be written on or erased by the user.
    - Write once—BD - can be written to once.
    - Rewriteable—BD – can be written to many times.
- **Solid State Storage**
  - Solid state devices have no moving parts
  - Data and information are stored and retrieved electronically
  - **Solid-State Drives (SSDs)**
    - Designed to be connected inside a personal computer system.
    - Contain solid-state memory instead of magnetic disks to store data.
    - Faster and more durable than hard disks.
    - Require less power
    - More expensive and generally have a lower capacity than hard disks
    - Widely used for tablet PCs
  - **Flash Memory Cards**
    - Credit card–sized solid-state storage widely used in portable devices such as laptops, smartphones, digital media players and GPS navigation systems. Other cards provide removable storage.
  - **USB drives**
    - Connect directly to a computer’s USB port to transfer files.
    - Can have capacities ranging from 1 GB to 256 GB
    - Convenient size and large capacities make USB devices very popular for transporting data and information between computers, specialty devices, and the Internet.

- **Cloud Storage**
  - Cloud computing and cloud storage
    - Cloud computing where the Internet acts as a “cloud” of servers that supply applications as a service rather than a product.
    - These servers provide cloud storage, also known as online storage
    - No installation on local computer, only need Internet ready device to display results
      - Google docs
  - Benefits of cloud computing are numerous
    - Maintenance - the cloud service will take care of disk defragmentation, back-ups, encryption and security.
    - Hardware upgrades - the cloud service will never run out of disk space, can replace failed hard disks without interruption to the user, and handles RAID disk issues for the user.
    - File sharing and collaboration - users can share documents, spreadsheets, and files with others from anywhere with an Internet connection.
  - There are some disadvantages of cloud storage. Two primary concerns are:
    - Access speed - the data transfer rate is dependent upon the speed of your Internet connection which most likely is not as fast as a user's internal network.
    - File security - users are dependent upon the cloud service's security procedures which may not be as effective as your own.
- **Making IT Work For You**
  - Cloud Storage
    - Go to [www.dropbox.com](http://www.dropbox.com) and click the Download Dropbox button
    - Enter your information to create a new account, Select the free option and choose Typical setup
    - Install the free app on a tablet or smartphone to access your files
    - Setup to share the link to the Dropbox
- **Mass Storage Devices**
  - **Mass storage** refers to the tremendous amount of secondary storage required by large organizations.
  - **Mass storage devices** are specialized high-capacity secondary storage devices designed to meet organizational demands for data storage.
  - These mass storage solutions allow large corporations and institutions to centralize their maintenance and security of data thereby reducing costs and personnel
  - **Enterprise Storage Systems** are used to promote efficient and safe use of data across organizational networks within their organizations. Some mass storage devices that support this strategy include:
    - **File servers**—dedicated computers with very large storage capacities that provide users access to fast storage and retrieval of data.

- **Network attached storage (NAS)** – similar to a file server except simpler and less expensive; widely used for home and small business storage needs.
  - **RAID systems**—larger versions of the specialized devices discussed earlier in this chapter that enhance organizational security by constantly making backup copies of files moving across the organization’s networks.
  - **Tape library**—device that provides automatic access to data archived on a large collection or library of tapes.
  - **Organizational cloud storage** - high-speed Internet connection to a dedicated remote storage facility.
    - these facilities contain banks of file servers to offer enormous amounts of storage.
- **Storage Area Network (SAN)**
- Architecture to link remote computer storage devices, such as enterprise storage systems, to computers such that the devices are as available as locally attached drives.
  - In a SAN system, the user’s computer provides the file system for storing data, but the SAN provides the disk space for data.
  - Key to a SAN is:
    - High-speed network, connecting individual computers to mass storage devices.
    - Special file systems prevent simultaneous users from interfering with each other.
    - Provide the ability to house data in remote locations and still allow efficient and secure access.
- **Careers In IT**
- **Disaster recovery specialists**
    - Responsible for recovering systems and data after a disaster strikes an organization.
    - Create plans to prevent and prepare for such disasters. A crucial part of that plan is to use storage devices and media in order to ensure that all company data is backed up and, in some cases, stored off site.
    - Bachelor's or associate's degree in information systems or computer science.
    - Experience in networking, security, and database administration is desirable.
    - Annual salary: \$70,000 to \$103,000.
    - With so many types of threats facing organizations, demand for these types of specialists is expected to grow.

- **A Look to the Future**

- **Next-Generation Storage**

- At some point, hard drives will no longer be able to increase in capacity, and companies may run out of the physical space to keep adding more. Therefore, researchers are looking into new technology to increase the capacity of existing storage solutions, as well as reduce the size of current storage media.
  - The first product that will receive a huge improvement is the hard drive.
  - Advancements in chemistry have led to the speculation that circuits and storage media could soon be working with carbon-containing molecules. Researchers have discovered that a group of compounds known as metallofullerenes can be oriented in various ways, allowing them to represent 0 and 1 bits just as other storage media currently do. The biggest advantage of working with organic molecules involves size. These molecules are so small, that storage devices created with them could be extremely tiny, allowing for the creation of much smaller computers and gadgets.

## Teaching Tips

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- **Storage**
    - Discuss the important characteristics of secondary storage and compare the different types of storage using these characteristics:
      - **Media** or medium, which is the actual physical material that holds the data and programs.
      - **Capacity** measures how much a particular storage medium can hold.
      - **Storage** devices are hardware that read data and programs from storage media.
      - **Access speed** or access time measures the amount of time required by the storage device to retrieve data and programs.
  - **Hard Disks**
    - Most students have used these and know their capabilities.
    - If you don't have a hard drive to dissect, you can go to the Website [www.mhhe.com/ce2015](http://www.mhhe.com/ce2015) to find examples of how they work, or use Figure 7-1 as an illustration of an internal hard disk.
    - You can use Figure 7-4, also, as a good illustration of the size of a read/write head and to help illustrate the problem of a head crash.
      - Internal hard disk (fixed disk)
        - It is good to discuss access time (speed) with the students. These things are stated when they purchase some computers and students don't always know what it means and why it is important.
  - **Performance Enhancements**
    - Briefly cover these aspects.
      - Disk caching
      - Redundant arrays of inexpensive disks (RAID)
      - File compression and decompression
        - Files compressed before storing and then decompressed before being used again; improves performance through efficient storage
    - As a lab exercise, ask students to do a search on the Internet to find free software that they can use to do file compression/decompression. As well as find these programs, ask students to also “zip” a file and then “unzip” it using Windows and/or Mac utilities.
- **Optical Discs**
  - Most students are familiar with these types of storage devices, so you can concentrate on the new/emerging technologies.
  - Compact disc - Stores from 700 MB
    - Read only—CD-ROM - it cannot be written on or erased by the user.
    - Write once—CD-R - it can be written to once.
    - Rewriteable—CD-RW - can be written to many times.
  - Digital Versatile Disc - greater capacity than CDs - 4.7 GB on one side
  - High-Definition - Blu-ray Disc - the next standard optical disc
    - Greatest capacity - 50 GB on one side

- **Solid-State Storage**
  - Ask students to describe each of the following:
    - Solid-State Drives – similar to internal hard drives
    - Flash Memory Cards – credit card-sized and widely used in portable devices such as smartphones, digital media players, and GPS navigation systems. Other cards provide removable storage.
    - USB drives – flash drives; connect to USB port; used for transferring files
    - As an exercise, ask students if they have any mobile devices with them, and if so ask them to explain what type of solid-state storage they may be using on them.
- **Cloud Storage**
  - Online storage services
  - Cloud computing where the Internet acts as a “cloud” of servers that supply applications to clients as a service.
  - Web based
    - No installation
    - Review Dropbox
- **Making IT Work for You**
  - Many students have used Google docs. Ask the students their experience with using this type of cloud computing or other experiences with cloud storage or computing.
- **Mass Storage Devices**
  - Enterprise storage system – use of data across networks to promote efficient and safe use of data across the networks within their organizations.
  - Devices
    - File servers
    - Network attached storage (NAS)
    - RAID systems
    - Tape libraries
    - Storage facilities
  - As an exercise, divide the students into groups. Have each group discuss how their school could make use of each of the following storage devices.

## Key Terms

Key Term	Definition
access speed	Measures the amount of time required by the storage device to retrieve data and programs.
Blu-Ray Disc (BD)	The next generation of optical format (high definition) that has a capacity of 25 to 100 gigabytes.
capacity	How much a particular storage medium can hold.
CD (compact disc)	One of the most widely used optical formats.
CD-R (CD-recordable)	A CD that can be written to only once.
CD-ROM (compact disc-read only memory)	A CD that cannot be written on or erased by the user.
CD-RW (compact disc rewritable)	A CD that can be written to many times. (See also erasable optical disc)
cloud computing	Service where the Internet acts as a “cloud” of servers that supply application services
cloud storage	Internet servers that supply applications as a service for online storage.
cylinder	A part of a hard disk that runs through each track of a stack of platters.
density	How tightly the bits (electromagnetic charges) can be packed next to one another on a diskette.
Disaster recovery specialist	Are responsible for recovering systems and data after a disaster strikes an organization. They create plans to prevent and prepare for disasters.
disk caching	A hard disk performance enhancement that improves processing by acting as a temporary high-speed holding area between a secondary storage device and the CPU.
DVD (digital versatile disc or digital video disc)	A newer optical format that has replaced CDs as the standard; similar to CDs except that more data can be packed into the same amount of space.
DVD player	DVD ROM drive.
DVD -R (DVD recordable)	A type of DVD write-once format.
DVD +R (DVD recordable)	A type of DVD write-once format.
DVD-RAM (DVD random-access memory)	A type of DVD rewriteable format.
DVD-ROM (DVD-read only memory)	A DVD format that the user cannot write to.
DVD -RW (DVD rewritable)	A type of DVD rewriteable format.
DVD +RW (DVD rewritable)	A type of DVD rewriteable format.
enterprise storage system	A type of system that large organizations use to promote efficient and safe use of data across the networks within their organizations.
erasable optical disc	A CD that can be written to many times. (See also CD-RW compact disc rewritable)
external hard drive	Removable hard drives used the same as internal disks.

file compression	A hard disk performance enhancement that increases storage capacity by reducing the amount of space required to store data and programs.
file decompression	Rebuilding a file that has been compressed.
file server	A dedicated computer with very large storage capacity that provides users access to fast storage and retrieval of data.
flash drive	Credit card–sized solid-state storage devices widely used in notebook computers.
flash memory card	Credit card-sized device used to store and transfer images and digital media.
hard disk	Enclosed disk drive containing one or more metallic disks. Hard disks use magnetic charges to record data and have large storage capacities and fast retrieval times.
head crash	When a hard disk’s read/write head makes contact with the hard disk’s surface or with particles on its surface resulting in a catastrophic loss of data.
hi def (high definition)	The next generation of optical disc.
internal hard disk	A magnetic secondary storage device that is located inside the system unit.
land	Flat areas that optical discs use to represent 1s and 0s.
mass storage	The tremendous amount of secondary storage required by large organizations.
mass storage devices	Specialized high-capacity secondary storage devices designed to meet storage requirements of large organizations.
media	An actual physical material that holds data and programs.
network attached storage (NAS)	Similar to a file server except simpler and less expensive.
online storage	Internet servers that supply applications as a service for storage (See also Cloud Storage)
optical disc	A storage device that uses a laser beam to alter the surface of a plastic or metallic disc to represent data.
optical disc drive	A device with a laser that projects a tiny beam of light on a disc to reflect the light to determine a pit or land.
organizational cloud storage	High-speed Internet connection to a dedicated remote organizational cloud storage server.
pit	Bumpy areas that optical discs use to represent 1s and 0s.
platter	A component of a hard disk made of a rigid metallic material and stacked one on top of another.
primary storage	RAM or memory, where data is stored before being processed.
RAID system	A system that enhances organizational security by constantly making backup copies of files moving across the organization’s networks.
redundant array of inexpensive disks (RAID)	Improve performance by expanding external storage, improving access speed, and providing reliable storage.
secondary storage	Provides permanent or nonvolatile storage.

secondary storage device	Hardware where data and programs can be retained after the computer has been shut off. (see also storage device)
sector	Section shaped like a pie wedge that divides the tracks on a disk.
solid-state drive (SSD)	Designed to be connected inside a microcomputer system but contains solid state memory instead of magnetic disks to store data.
solid-state storage	Storage devices with no moving parts. Data and information are retrieved electronically.
storage area network (SAN)	SAN is a mass storage development to link remote computer storage devices to computers such that the devices are as available as locally attached drives.
storage device	Hardware where data and programs can be retained after the computer has been shut off. (see also secondary storage device)
track	Rings of concentric circles without visible grooves, part of how files are stored and organized on a flexible disk.
USB drive	The size of a key chain; these hard drives connect to a computer's USB port enabling a transfer of files.

## Answers to End-of-Chapter Materials Chapter 7

Num	Multiple Choice Answers (Book)	Matching Answers (Book)	Multiple Choice Answers ( <a href="http://www.mhhe.com/ce2015">www.mhhe.com/ce2015</a> )	Matching Answers ( <a href="http://www.mhhe.com/ce2015">www.mhhe.com/ce2015</a> )
1	A	E	A	J
2	C	I	B	I
3	A	J	A	A
4	A	F	D	C
5	A	B	C	D
6	C	A	A	F
7	A	C	B	B
8	A	G	B	E
9	C	D	A	G
10	C	H	A	H

### Open Ended Questions:

1. **Compare primary storage and secondary storage and discuss the most important characteristics of secondary storage.**

Storage is the ability to save, to back up and even to transport files consisting of data or programs from one location or computer to another.

- **Primary storage** - Random-access memory (RAM) holds or stores data and programs that the CPU is currently processing. RAM is sometimes referred to as primary storage. Unfortunately, most RAM provides only temporary or volatile storage – its contents are lost as soon as there is no electrical current going into the system.
- **Secondary storage** provides permanent or nonvolatile storage. Using secondary storage devices, data and programs can be retained after the computer has been shut off.
- Important characteristics of secondary storage
  - **Media** - are the actual physical material that holds the data and programs.
  - **Capacity** - measures how much a particular storage medium can hold.
  - **Storage devices** - are hardware that reads data and programs from storage media. Most also write to storage media.
  - **Access speed** or access time - measures the amount of time required by the storage device to retrieve data and programs.

2. **Discuss hard disks including density, platters, tracks, sectors, cylinders, head crashes, internal, external, and performance enhancements.**

- Hard disks save files by altering the magnetic charges of the disk's surface to represent 1s and 0s. Hard disks retrieve data and programs by reading the charges from the magnetic disk.
  - **Density** - refers to how tightly these charges can be packed next to one another on the disk.
  - **Platters** - Rigid metallic platters that are stacked one on top of another.
  - Store and organize files using tracks, sectors, and cylinders.
    - **Tracks** are rings of concentric circles without visible grooves.
    - **Sectors** - Each track is divided into wedge-shaped sections called sectors.
    - **Cylinders** - A cylinder runs through each track of a stack of platters. Cylinders are necessary to differentiate files stored on the same track and sector of different platters.
  - **Head crash** - A head crash occurs when a read/write head makes contact with the hard disk's surface or with particles on its surface.
  - Two basic types of hard disks:
    - **Internal hard disk (fixed disk)**
      - Located inside the system unit.
      - Almost all of today's powerful applications are designed to be stored on and run from an internal hard disk. To ensure adequate performance of your internal hard disk, you should perform routine maintenance and periodically make backup copies of all important files.
    - **External hard drives**
      - Typically connect to a USB or FireWire port on the system unit, are easily removed, and effectively provide an unlimited amount of storage.
      - Use the same basic technology as internal hard disks and are used primarily to complement an internal hard disk.
  - **Performance Enhancements** - Three ways to improve the performance of hard disks are:
    1. Disk caching
      - Improves hard-disk performance by anticipating data needs.
      - Improves processing by acting as a temporary high-speed holding area between a secondary storage device and the CPU.
      - Requires a combination of hardware and software.
      - Frequently used data is read from the hard disk into disk (cache). When needed, the data is then accessed directly from memory.
      - The transfer rate from memory is much faster
      - Increases system performance by 30 percent

2. Redundant arrays of inexpensive disks (RAID)
  - Improves performance by expanding external storage, improving access speed, and providing reliable storage.
  - Several inexpensive hard-disk drives are connected to one another. These connections can be by a network or within specialized RAID devices.
  - The computer system interacts with the RAID system as though it were a single large-capacity hard-disk drive.
  - The result is expanded storage capability, fast access speed, and high reliability.
  
3. File compression and file decompression
  - Increase storage capacity by reducing the amount of space required to store data and programs.
  - File compression is not limited to hard disks systems.
  - File compression helps speed up transmission of files from one computer system to another.
  - File compression programs scans files for ways to reduce the amount of required storage.
  - In file compression repeated patterns are replaced with a token, leaving enough tokens so that the original can be rebuilt or decompressed.
  - File compression programs often shrink files to a quarter of their original size.
  - Can be done with Windows and Mac utilities and special utilities such as WinZip

3. **Discuss optical discs including pits, lands, CDs, DVDs, Blue-ray, and hi def.**

- **Optical Discs**

- Can hold over 128 gigabytes of data.
- A laser beam alters the surface of a plastic or metallic disc to represent data. Optical discs use reflective light to represent data.
- **Pits and lands:** The 1s and 0s are represented by flat areas called lands and bumpy areas called pits on the disc surface.
- Disc is read by an optical disc drive using a laser that projects a tiny beam of light on these areas. The amount of reflected light determines whether the area represents a 1 or a 0.
- Optical discs typically use a single track that spirals toward the center of the disk. This single track is divided into equally sized sectors.

**Compact Disc (CD)** –

- Store 700 MB (megabytes) on one side of a CD.
- Three basic types of CDs:
  - Read only—CD-ROM - cannot be written on or erased by the user.
  - Write once—CD-R - can be written to once.
  - Rewriteable—CD-RW – can be written to many times.

### **Digital Versatile Disc (DVD)**

- DVD stands for digital versatile disc or digital video disc
- Can store 4.7 GB (gigabytes) on one side of a DVD disc
- Capacity is 7 times that of a CD.
- Three basic types of DVDs:
  - Read only—DVD-ROM - cannot be written on or erased by the user.
  - Write once— DVD+R, DVD-R - can be written to once.
  - Rewriteable— DVD+RW, DVD-RW, DVD-RAM – can be written to many times.

### **Blu-ray Disc (BD)**

- Have a greater capacity than DVDs.
- Next generation of optical disc is called hi def (high definition)
- The hi definition standard is Blu-ray Disc (BD).
- Blu-ray discs have a capacity of 50 GB on one side.
- Capacity is 10 times that of a standard DVD.
- Three basic types of Blu-ray:
  - Read only—BD - cannot be written on or erased by the user.
  - Write once—BD - can be written to once.
  - Rewriteable—BD – can be written to many times.

4. **Discuss solid-state storage, including solid-state drives, flash memory, and USB drives.** **Solid-state drives** are designed to be connected inside a microcomputer system the same way an internal hard disk would be but contain solid-state memory instead of magnetic disks to store data, as with hard disks.

- **Solid State Storage**
  - Solid state devices have no moving parts
  - Data and information are stored and retrieved electronically
- **Solid-State Drives (SSDs)**
  - Designed to be connected inside a micro computer system.
  - Contain solid-state memory instead of magnetic disks to store data.
  - Faster and more durable than hard disks.
  - Require less power
  - More expensive and generally have a lower capacity than hard disks
  - Widely used for tablets, such as the iPad.
- **Flash Memory Cards**
  - Credit card–sized solid-state storage devices widely used in portable devices.
  - Some of the cards are used within devices such as smartphones, digital media players, and GPS navigation systems. Other cards provide removable storage.

- **USB drives**
  - Connect directly to a computer's USB port to transfer files.
  - Can have capacities ranging from 1 GB to 256 GB
  - Convenient size and large capacities, make USB devices very popular for transporting data and information between computers, specialty devices, and the Internet.

5. **Discuss cloud computing and cloud storage.**

- **Cloud Computing**
  - Many applications that would have required installation on your computer to run have moved to the Web. Web sites provide application services. This is known as cloud computing, where the Internet acts as a “cloud” of servers that supply applications to clients as a service, rather than a product.
- **Cloud Storage**
  - Servers provide cloud storage, also known as online storage.
  - No installation on local computer, only need Internet ready device to access applications and data.

6. **Describe mass storage devices including enterprise storage systems, file servers, network attached storage, RAID systems, organizational cloud storage, and storage area network systems.**

- **Mass storage** refers to the tremendous amount of secondary storage required by large organizations.
- **Mass storage devices are** specialized high-capacity secondary storage devices designed to meet organizational demands for data.
  - **Enterprise Storage Systems** are used to promote efficient and safe use of data across organizational networks within their organizations. Some mass storage devices that support this strategy include:
    - **File servers**—dedicated computers with very large storage capacities that provide users access to fast storage and retrieval of data.
    - **Network attached storage (NAS)** – similar to a file server except simpler and less expensive; widely used for home and small business storage needs.
    - **RAID systems**—larger versions of the specialized storage devices that enhance organizational security by constantly making backup copies of files moving across the organization's networks.
    - **Organizational cloud storage** - high-speed Internet connection to a dedicated remote organizational Internet drive site.

- **Storage Area Network (SAN)**
  - Architecture to link remote computer storage devices, such as enterprise storage systems, to computers such that the devices are as available as locally attached drives.
  - In a SAN system, the user's computer provides the file system for storing data, but the SAN provides the disk space for data.
  - Key to a SAN is:
    - High-speed network, connecting individual computers to mass storage devices.
    - Special file systems prevent simultaneous users from interfering with each other.
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