STORAGE

Application of Information and Communication Technologies

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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. List at least three other types of storage systems.
6. Summarize the storage alternatives for a typical personal computer.

Overview

- This chapter covers:
  - Common characteristics of storage systems
  - Primary storage for most personal computers, the hard drive
  - Optical disc systems; how they work and the various types
  - Flash memory systems and how they work
  - Other types of storage systems
  - Storage alternatives for personal computerss

Storage System Characteristics

- Consist of a storage device and a storage medium
  - 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 are typically identified by letter

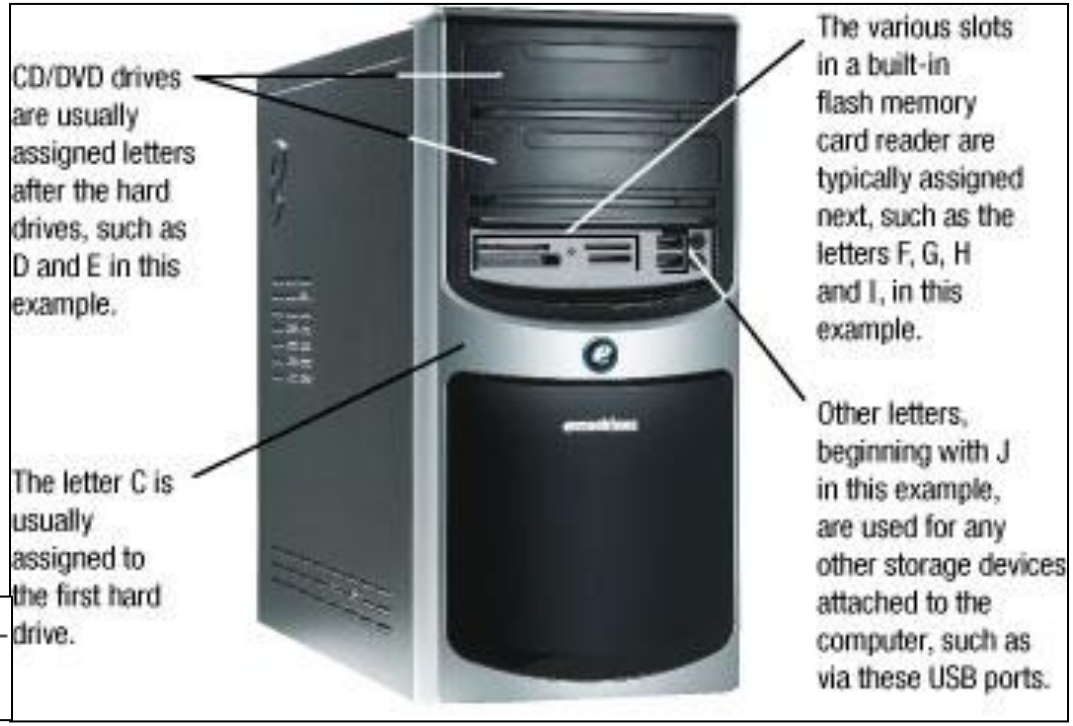


FIGURE 3-1
Storage device identifiers.

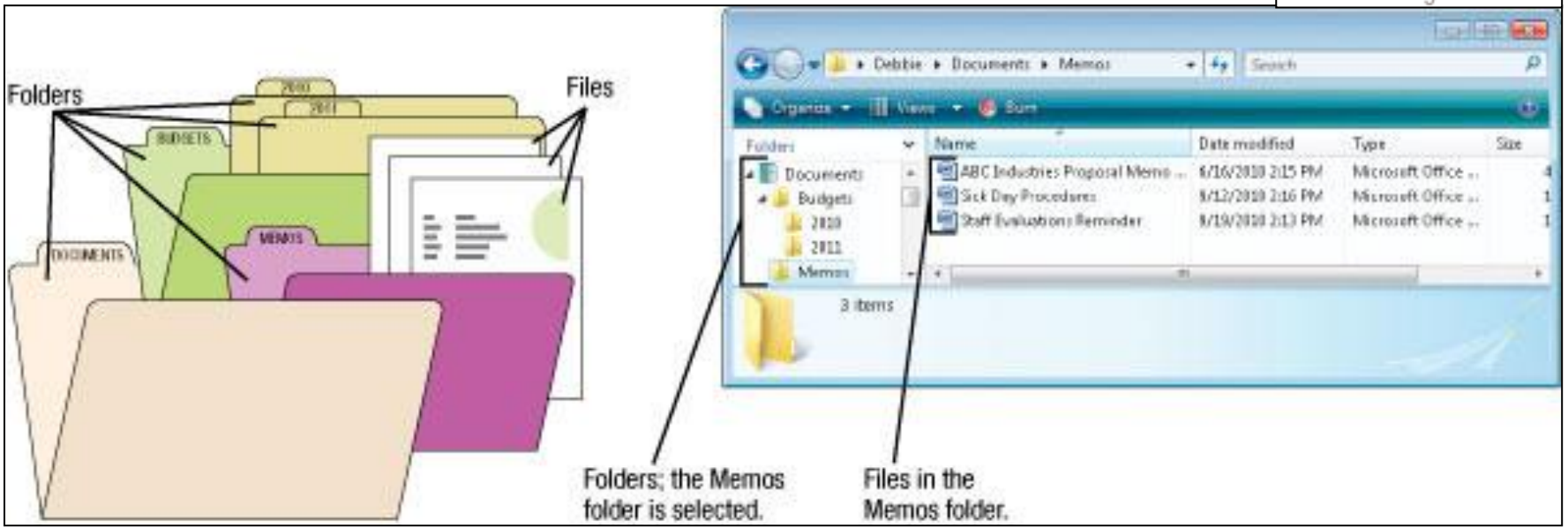
Storage System Characteristics

- Can be internal, external, or remote
- Are nonvolatile
- Usually use random access; can be sequential
- 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

FIGURE 3-2
Organizing data. Folders are used to organize related items on a storage medium.



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

Magnetic Hard Drives

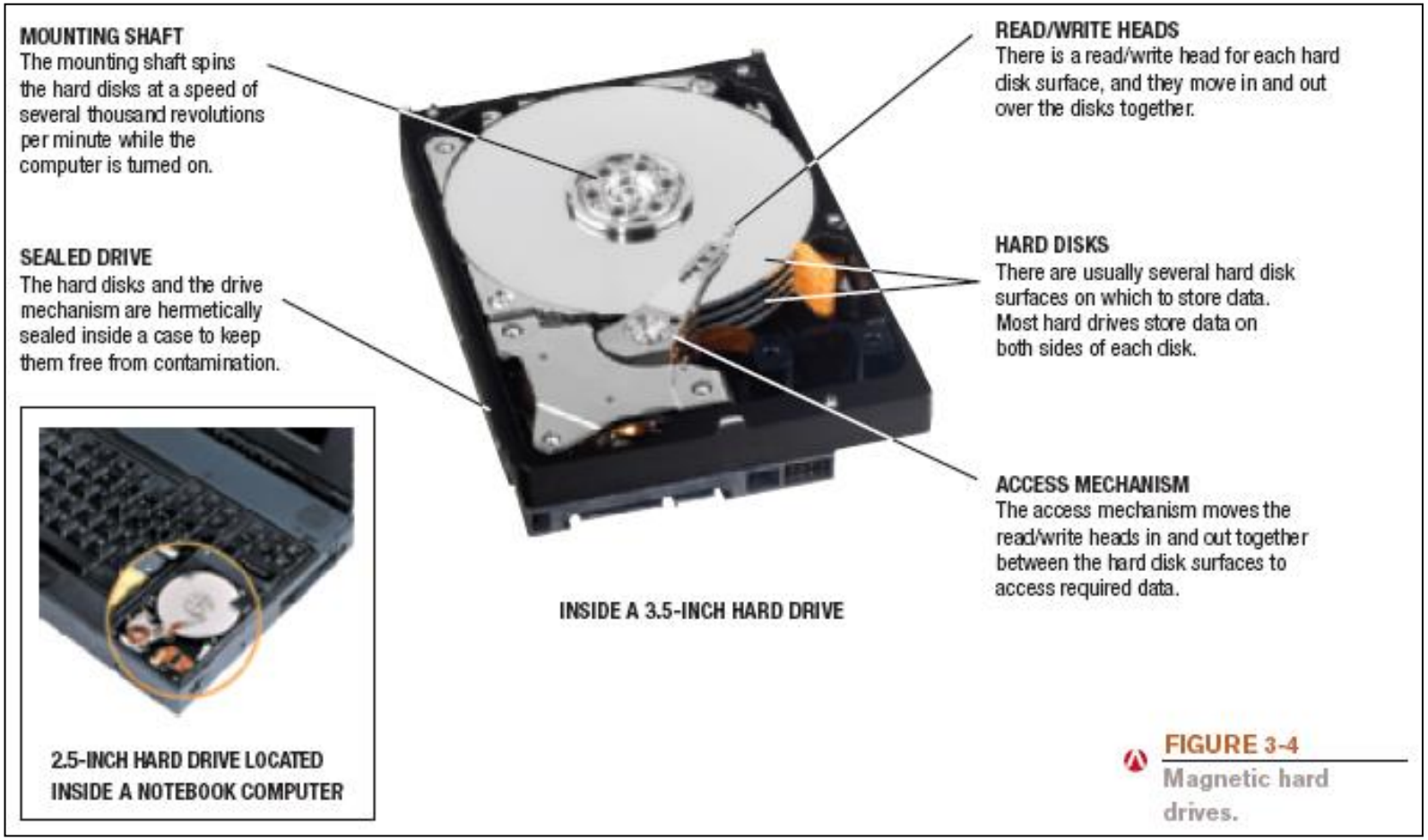


FIGURE 3-4
Magnetic hard drives.

Magnetic Hard Drives

- Hard disks are divided into
  - Tracks
  - Sectors
  - Clusters
  - Cylinders

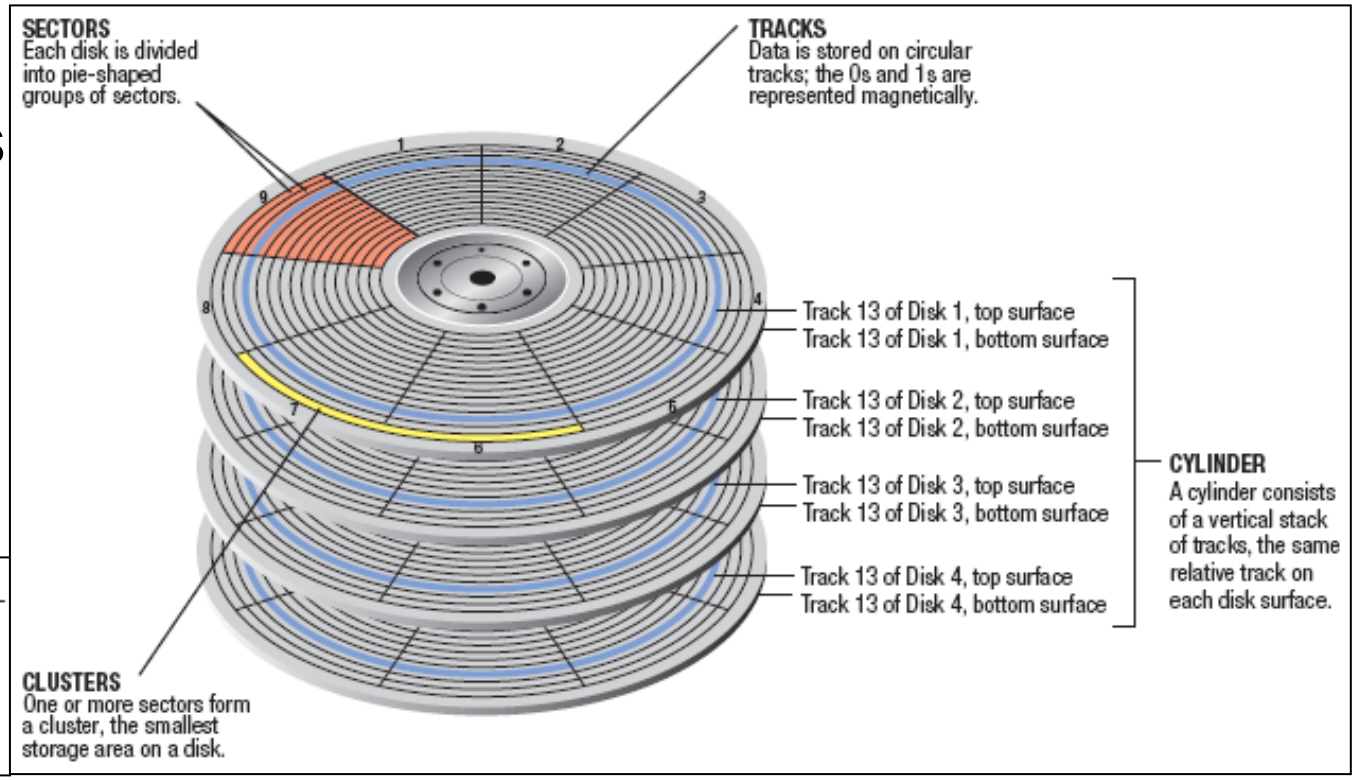
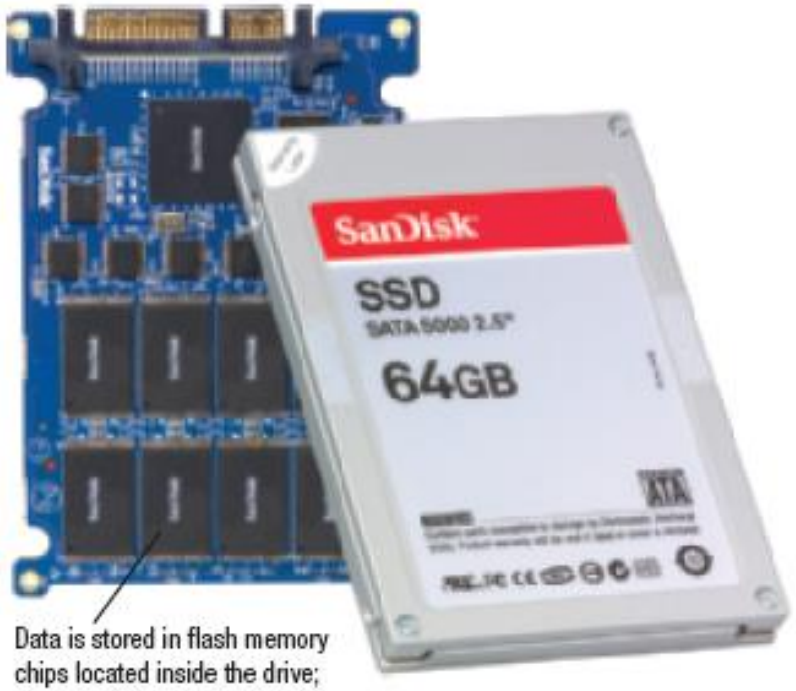


FIGURE 3-5
Magnetic hard disks are organized into sectors, tracks, clusters, and cylinders.

Solid State Drives (SSDs)



Data is stored in flash memory chips located inside the drive; there are no moving parts like in magnetic hard drives.

FIGURE 3-6
Solid-state drives (SSDs).

External Hard Drives

FIGURE 3-7
External hard drives.

FULL-SIZED EXTERNAL HARD DRIVES
Are about the size of a 5 by 7-inch picture frame, but thicker; this drive holds 1.5 TB.

PORTABLE HARD DRIVES (MAGNETIC)
Are about the size of a 3 by 5-inch index card, but thicker; this drive holds 500 GB.

PORTABLE HARD DRIVES (SSD)
Are about the size of a credit card, but thicker; this drive holds 18 MB.

EXPRESSCARD HARD DRIVES
Fit into an ExpressCard slot; this drive holds 32 GB.

Hard Drive Speed and Caching

- Disk access time: Total time that it takes for a hard drive to read or write data
  - Consists of seek time, rotational delay, and data movement time
- Disk cache: Dedicated part of RAM used to store additional data adjacent to data retrieved during a disk fetch to improve system performance
- Hybrid hard drive
  - Combination of flash memory and magnetic hard drive
  - Uses flash memory for cache
  - Allows encryption to be built into the drive

Hybrid Hard Drives

FIGURE 3-8
Hybrid hard drives. Hybrid hard drives contain both magnetic hard disks and a large quantity of flash memory for increased performance.

MAGNETIC HARD DRIVE
This drive contains 2 hard disks and 4 read/write heads that operate in a manner similar to a conventional hard drive.

FLASH MEMORY DISK CACHE
This drive uses 256 MB of flash memory disk cache to duplicate data as it is stored on the hard disks so the data can be accessed when hard disks are not spinning.

Partitioning and File Systems

- Partitioning: Logically divides the physical capacity of a single drive into separate areas, called partitions
  - Partitions function as independent hard drives
  - Referred to as logical drives
  - Increase efficiency (smaller drives use smaller clusters)
- Partitions used to:
  - Create a recovery partition
  - Create a new logical drive for data
  - Create a dual boot system
- File system: Determines the cluster size, maximum drive size, and maximum file size
  - FAT, FAT32, and NTFS

Partitioning and File Systems

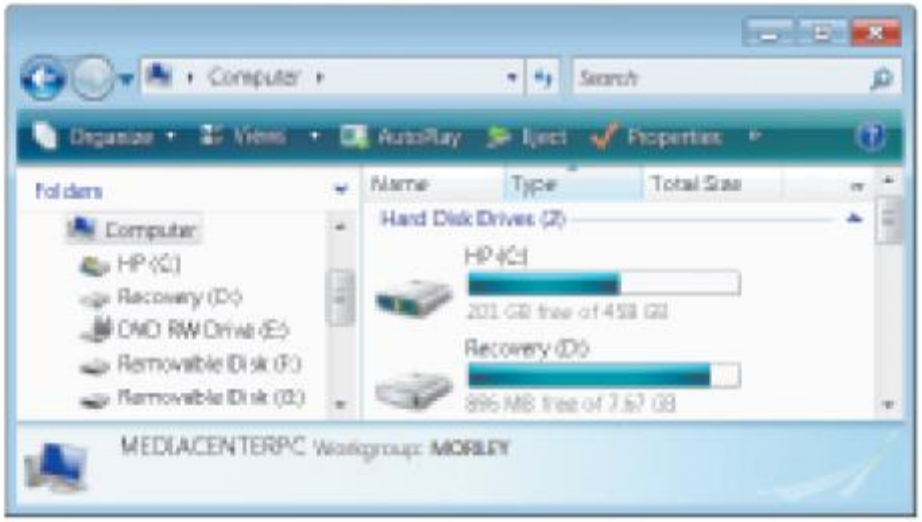


FIGURE 3-9
Hard drive partitions. New personal computers today often come with the primary hard drive divided into two partitions.

Hard Drive Interface Standards

- Hard drive interface standards: Determine how a drive connects to the computer
- Common standards:
  - Parallel ATA (PATA): older, slower standard
  - Serial ATA (SATA)
  - eSATA: uses USB or Firewire via expansion card for faster speeds
  - SCSI and the newer serial attached SCSI (SAS)
  - Fibre Channel
  - Fibre Channel over Ethernet (FCoE)
  - Internet SCSI (iSCSI)

Quick Quiz

1. Of the following three options, the storage media that would hold the most data is a(n) _____.
   a. internal hard drive
   b. USB flash memory drive
   c. portable hard drive
2. True or False: Hard drives typically contain more than one metal hard disk.
3. The circular rings on a magnetic disk on which data is stored are called _____.

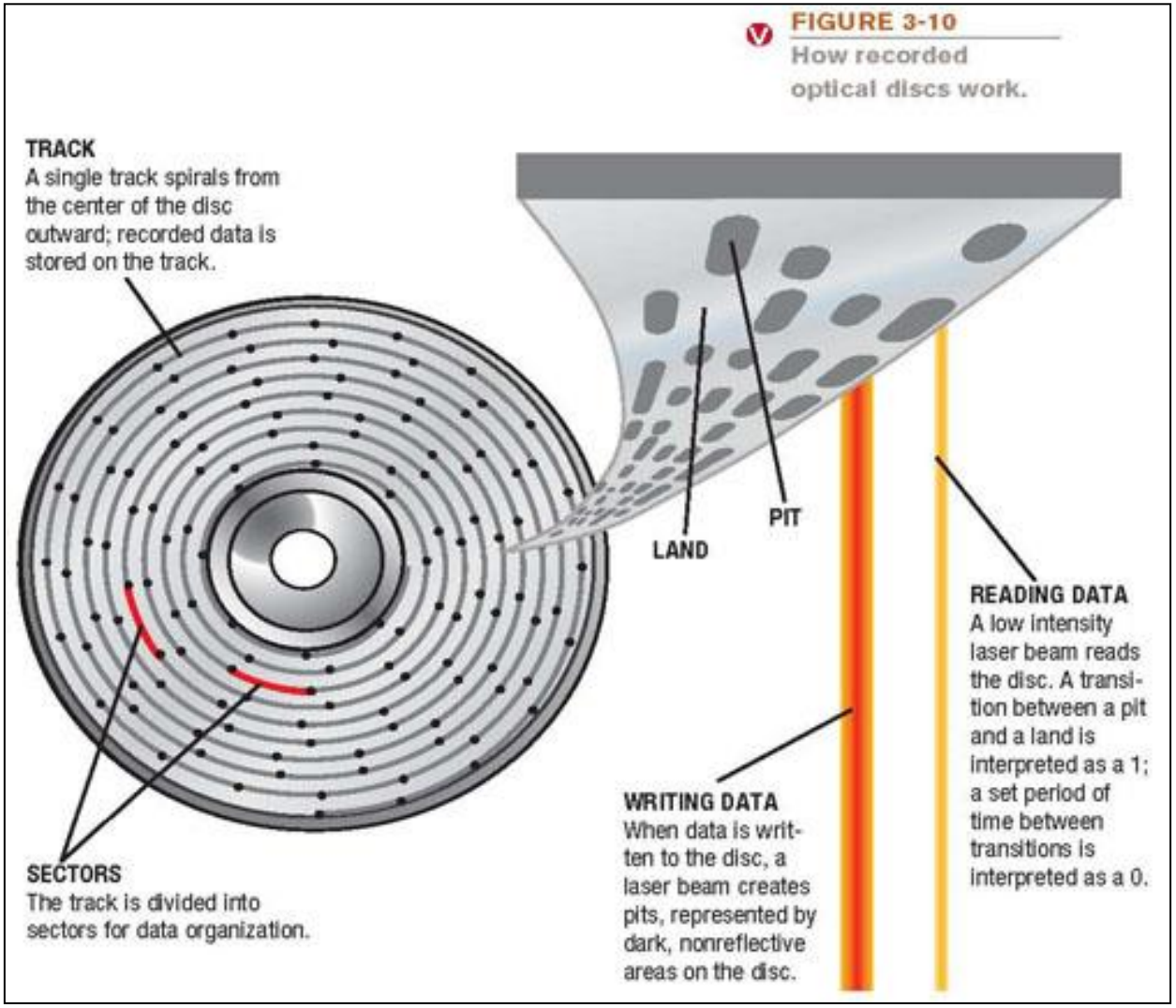
Answers:

1) a; 2) True; 3) tracks

Optical Discs

- Optical discs: store data optically (using laser beams)
  - Divided into sectors like magnetic discs but use a single spiral track (groove)
  - Data is stored in 0s and 1s
- Pits and lands are used to represent 1s and 0s, the transition between a pit and a land represents a 1; no transition represents a 0
- 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 Drives

- Optical drives: Designed for the type of disc: CD, DVD, or Blu-Ray Disc (BD)
  - Can be read-only, recordable, or rewritable
  - Downward compatible
  - Can support single or dual-layer discs
- Burning: Recording data onto disc
  - CD discs: Use infrared lasers; hold 650 MB
  - DVD discs: Use red lasers; hold 4.7 GB (single-layer)
  - BD discs: Use blue-violet lasers; hold 25 GB (single-layer)
- Can be internal or external drives
  - External drives typically USB

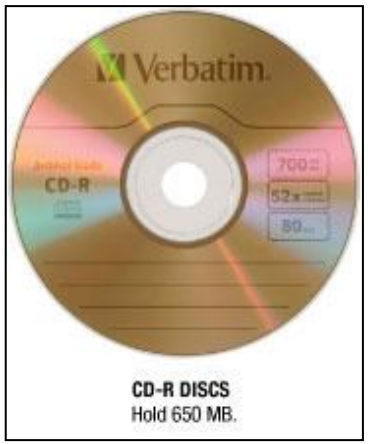
Read-Only Discs

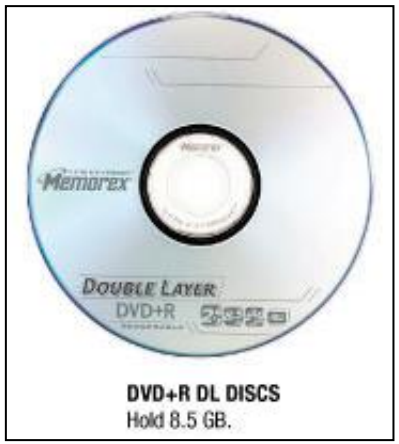
- Read-only disc: Can be read from, but not written to, by the user
  - CD-ROM (compact disc read-only memory)
  - DVD-ROM (digital versatile disc read-only memory)
  - BD-ROM (Blu-Ray disc read-only memory)
- Normally come pre-recorded
  - Software programs
  - Clip art and other graphics
  - Music
  - Movies
  - Games (UMD, Wii, Xbox, etc.)

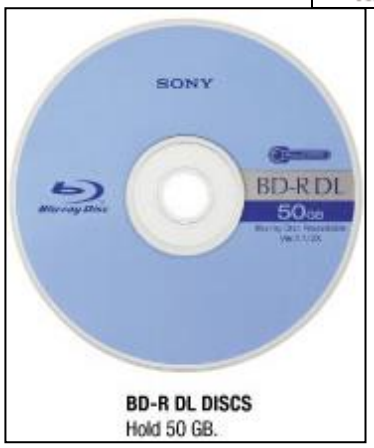
Recordable Discs

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

FIGURE 3-14
Recordable CDs and DVDs.







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

Quick Quiz

1. The capacity of the typical CD disc is _____.
   a. 50 GB
   b. 650 MB
   c. 4.7 GB
2. True of False: A DVD-RW disc can be written to and rewritten to.
3. The tiny depressions, dark areas, or otherwise altered spots on an optical disc that are used to represent data are called _____.

Answers:

1) b; 2) True; 3) pits

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
  - Hybrid hard 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 Systems

EMBEDDED FLASH MEMORY
Flash memory is often embedded into consumer products, such as this digital media player, for storage purposes.

FLASH MEMORY CARDS AND READERS
Flash memory cards are often used to store data for digital cameras and other devices; the data can be transferred to a computer via a flash memory card reader, as needed.

USB FLASH DRIVES
USB flash drives are often used to store data and transfer files from one computer to another.

FIGURE 3-15
Flash memory systems. Flash memory is used in a variety of storage systems today.

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
  - CompactFlash
  - Secure Digital (SD)
  - Secure Digital High Capacity (SDHC)
  - Secure Digital Extended Capacity (SDXC)
  - MultiMedia Card (MMC)
  - xD Picture Card
  - Memory Stick
- Read by flash memory card reader

Flash Memory Cards

FLASH MEMORY CARD READERS
Can be built-in or external and usually support several different types of flash memory media; external readers such as this one typically connect to a computer via a USB port.

COMPACTFLASH (CF) CARDS

MEMORY STICKS

SECURE DIGITAL (SD) CARDS

XD PICTURE CARDS

FIGURE 3-16
Flash memory cards. Shown here are some of the most widely used types of flash memory cards and a multicard reader.

USB Flash Drives

- USB flash drives: Consist of flash memory media and a reader in a single self-contained unit
  - Typically portable drives that connect to and are powered by a USB port
  - Also called USB flash memory drives, thumb drives, jump drives

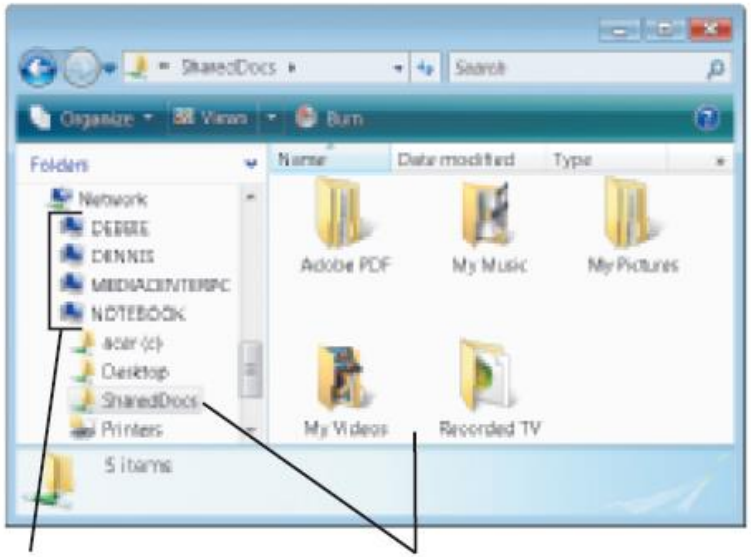
FIGURE 3-17
USB flash drives.

CONVENTIONAL USB FLASH DRIVES | USB FLASH DRIVE WRISTBANDS | USB FLASH DRIVE WALLET CARDS

Other Types of Storage Systems

- 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
    - Via Web sites (Flickr, Facebook, Google Docs, etc.)
    - Via online storage sites (Box.net, SkyDrive, etc.)

Remote Storage Systems



Computers on this network.

Items in the SharedDocs folder on the computer called NOTEBOOK.

SHARED FOLDERS
Shared folders on network computers appear and are accessed in a manner similar to local folders.

NETWORK ATTACHED STORAGE (NAS) DEVICES
This wireless NAS device holds 1 TB of data and provides storage for all computers on the network.

FIGURE 3-18
Network storage.

Smart Cards

- Smart card: Credit card-sized piece of plastic that contains some computer circuitry (processor, memory, and storage)
  - Stores the 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 another device
  - Some smart cards store biometric data
  - Can be used in conjunction with encryption and other security technologies

Smart Cards

FIGURE 3-20
Smart cards. Smart cards can be used to log on to computers and networks, access facilities, pay for goods and services, and so forth.

Storage Systems for Large Computer Systems and Networks

- Storage server: Hardware device containing multiple high-speed hard drives
- Businesses have to store tremendous amounts of data
  - Business data
  - Employee and customer data
  - E-discovery data

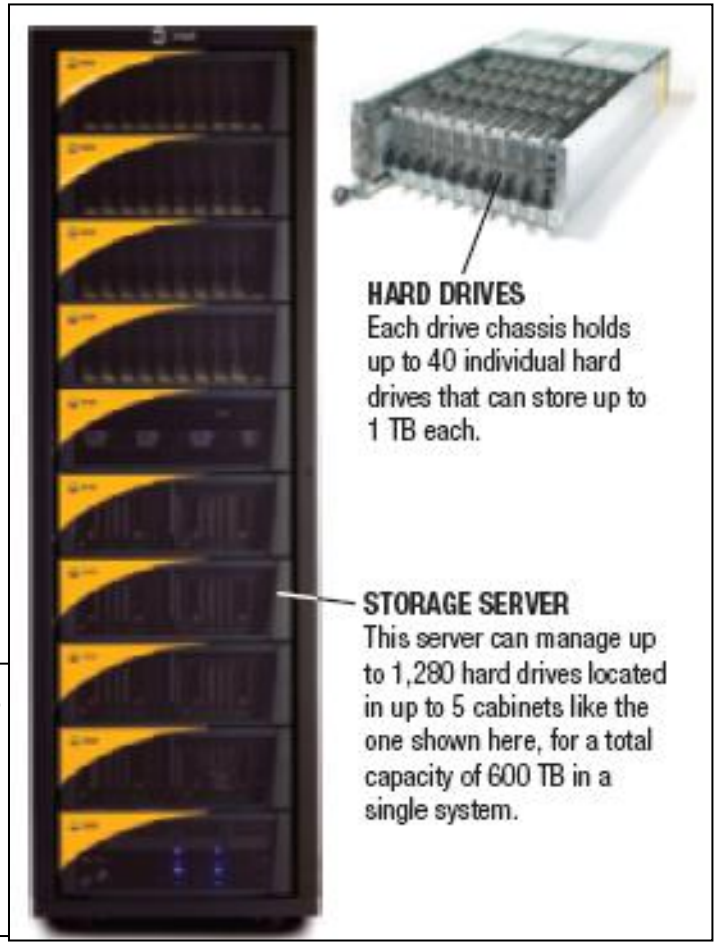


FIGURE 3-22
Storage servers. Storage servers are usually scalable so additional hard drives can be added as needed.

RAID

- RAID (redundant arrays of independent discs): Method of storing data on two or more hard drives that work together to do the job of a larger drive
  - Usually involves recording redundant copies of stored data
  - Helps to increase fault tolerance
  - Different levels of RAID:
    - RAID 0 = disk striping (spread files over two or more hard drives)
    - RAID 1 = disk mirroring (duplicate copy)
    - Other level use a combination or striping and mirroring

RAID

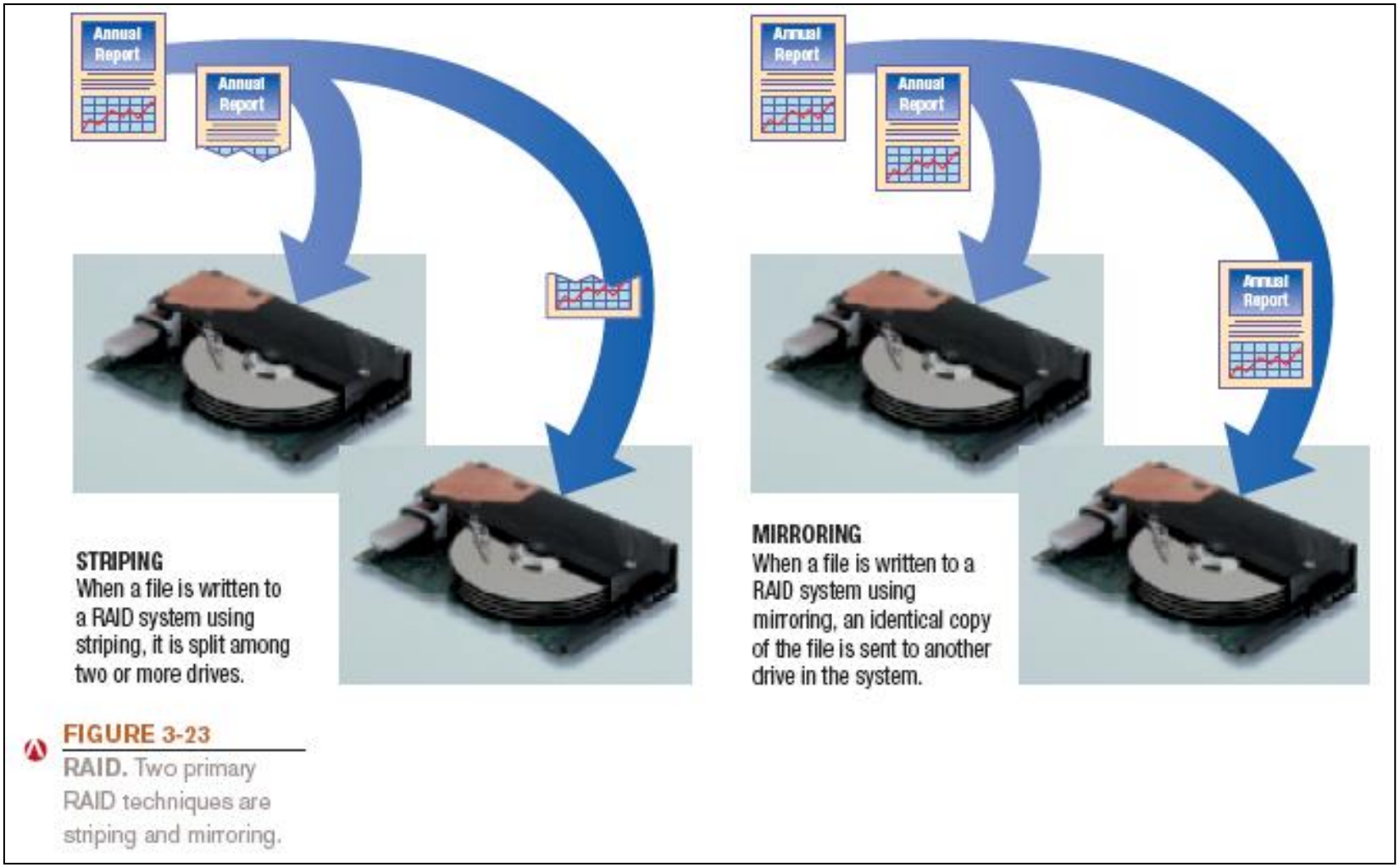


FIGURE 3-23
RAID. Two primary RAID techniques are striping and mirroring.

Magnetic Tape Systems

- Magnetic tape: Plastic tape with a magnetizable surface that stores data as a series of magnetic spots
  - Primarily used for backup and archival purposes
  - Sequential access only
  - Low cost per megabyte
  - Most tapes today are in the form of cartridge tapes
  - Read from and written to via a tape drive

FIGURE 3-25
A magnetic tape cartridge.

Evaluating Your Storage Alternatives

- Factors to consider:
  - Speed
  - Compatibility
  - Storage capacity
  - Convenience
  - Portability
- Most users require:
  - Hard drive
  - CD or DVD drive
  - Flash memory card reader
  - USB port connecting USB devices

Quick Quiz

1. An online photo sharing site is an example of _____.
   a. RAID
   b. remote storage
   c. holographic storage
2. True of False: Flash memory storage systems are called solid-state storage systems because they are nonvolatile.
3. A type of sequential storage that sometimes used today for backup purposes is _____.

Answers:

1) b; 2) False; 3) magnetic tape

Summary

- Storage Systems Characteristics
- Hard Drives
- Optical Discs
- Flash Memory
- Other Types of Storage Systems
- Evaluating Your Storage Alternatives