Input/Output & Storage
Output Devices: Engaging Our Senses

• Printers (con’t.)
  o Laser (nonimpact)
    • Use electrostatic reproductive technology to produce high-quality output
    • Advantages:
      o High-resolution
      o Print faster than inkjet printers
      o Black-and-white printing costs less per page than inkjet printing
    • Disadvantages
      o Color laser printers more expensive
Output Devices: Engaging Our Senses

• **Printers (con’t.)**
  - **Dot-matrix** (impact)
    - Older, less popular
    - Used mostly for printing multipart forms and backup copies
    - **Advantages**
      - Able to print 3,000 lines per minute
    - **Disadvantages**
      - Poor print quality
      - Noisy
Output Devices: Engaging Our Senses

- **Printers (con’t.)**
  - Thermal-transfer (dye sublimation printers)
    - Thermal-wax or direct thermal
    - Use heat process
    - Advantages
      - High-quality images from the high-quality thermal-wax printers
      - Popular for mobile printing
    - Disadvantages
      - High-quality thermal printers expensive
Output Devices: Engaging Our Senses

- **Printers (con’t.)**
  - **Photo**
    - Uses special ink and paper
    - Often are inkjet printers
    - Prints directly from a digital camera or memory card
  - **Plotters**
    - Produce images through moving ink pens
    - Used for making oversized prints (i.e., maps, charts, blueprints)
Output Devices: Engaging Our Senses

• Other output devices include:
  o Speakers
  o LCD projectors
  o DLP (digital light-processing) projectors
  o Multifunction devices
Storage: Holding Data for Future Use

• **Storage**
  o Process of saving software and data
  o Also called **mass storage, auxiliary storage, or secondary storage**
Storage: Holding Data for Future Use

- **Storage devices**
  - Hardware that contains the tools to place data on the **recording media**
  - **Recording media**—hold data
    - Hard disks
    - Floppy disks
    - Flash memory
    - CDs and DVDs
Storage: Holding Data for Future Use

- Hard drive with enclosure opened
- Flash memory card in reader
- USB drive
- DVD
Storage: Holding Data for Future Use

• **Memory (RAM) versus storage**
  - Storage devices retain data even if power is turned off
  - Data stored in memory (RAM) will be lost
  - Storage devices are less expensive than memory

<table>
<thead>
<tr>
<th></th>
<th>Access Speed</th>
<th>Cost per MB</th>
<th>Storage Capacity</th>
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<td>Memory</td>
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<tr>
<td>Cache memory</td>
<td>Fastest</td>
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<td>RAM</td>
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<td>CD-R disc</td>
<td>Slow</td>
<td>Low</td>
<td>700 MB</td>
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</tbody>
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Storage: Holding Data for Future Use

• **Memory (RAM)**
  - Primary memory
  - Temporary holding area for items in use
  - Primary storage

• **Storage devices**
  - Required during the computer system’s start-up operations
  - Used as an output device for saving data
Storage: Holding Data for Future Use

• Hard disk drive (hard drive)
  o Most important storage device
  o High-capacity, high-speed device
  o Considered secondary storage (online; fixed storage), compared with memory/RAM, which is categorized as primary storage
  o Random access storage devices—permit direct retrieval of desired data
  o Contain a coating of magnetic material used for data storage
Storage: Holding Data for Future Use

- **Platters**—rapidly rotating disks on which programs, data, and processed results are stored
- **Tracks**—concentric bands on which data is recorded
  - Are divided into **sectors**
  - Two or more sectors is a **cluster**.
Storage: Holding Data for Future Use

Tracks
Data is recorded in concentric circular bands called tracks.

Sector
Each track is divided into pie-shaped wedges called sectors.

Clusters
Two or more sectors form a cluster.
Storage: Holding Data for Future Use

• The computer’s operating system stores a file’s name and its location on the disk in a table.

• New technology file system (NTFS)
  o The present system used for tracking file locations in:
    • Windows NT
    • Windows 2000
    • Windows XP
    • Windows Vista
    • Windows 7
Storage: Holding Data for Future Use

- **Partitions**
  - Portion of a hard disk set aside as if it were a physically separate disk
  - Often used to house different operating systems
  - Allows users to use programs developed for different systems
Storage: Holding Data for Future Use

• **Hard disk performance**
  
  o Affected by **bad sectors**—damaged portions of the disk that cannot reliably hold data

  o **Positioning performance**—how quickly the read/write head can get into position to transfer data

  o **Transfer performance**—how quickly the transfer is made from the disk to storage
Storage: Holding Data for Future Use

- **Hard disk performance (con’t.)**
  - **Disk cache**—type of cache memory
    - CPU looks here first before the hard disk
    - Using the disk cache speeds up data retrieval
Storage: Holding Data for Future Use

- **Network attached storage (NAS)**
  - Permits retrieval or storage of data by any computer connected to the network

- **Remote storage (Internet hard drive)**
  - Storage on a server that is available through the Internet
Storage: Holding Data for Future Use

• **Flash drive** *(solid-state drive [SSD])*  
  o Storage devices that use solid-state circuitry; have no moving parts  
  o Increasing in use

• **Flash memory**  
  o Nonvolatile electronic memory stored in **blocks** on a chip  
  o Limited to 100,000 write cycles
Storage: Holding Data for Future Use

• **Hybrid hard drives (HHDs)**
  - Incorporate flash technology to speed up the boot process

• **USB flash drives (memory stick, thumb drive, jump drive)**
  - Popular *portable* or *removable storage devices*
  - Replace legacy technology of floppy disks and Zip disks
  - Do not require a device driver
  - Should be removed only when not actively in use
Storage: Holding Data for Future Use

• **CD drives and DVD drives**
  - Optical storage devices
  - Use laser beams to store data through:
    - **Pits**, the indentations, a binary 0
    - **Lands**, the flat reflective areas, a binary 1

• **Optical discs**
  - **CD-ROM** or **DVD-ROM** (compact or digital video disc read-only memory)
  - Data can be read, not altered
  - Most popular, least expensive
Storage: Holding Data for Future Use

When the laser beam strikes a pit, light is scattered. Because no light is reflected, the light-sensing diode sends no signal, or 0, back to the computer.

When the laser strikes a land, light is reflected. The light-sensing diode sends a digital signal of 1 to the computer.
Storage: Holding Data for Future Use

Additional types of optical storage

- CD-R (CD-recordable)
- CD-RW (CD-rewritable)
- DVD+R (DVD recordable; plus)
- DVD-R (DVD recordable; dash)
- DVD+RW (DVD rewritable; plus)
- DVD-RW (DVD rewritable; dash)
- BD-ROM (Blu-ray Disc read only)
- BD-R (BD recordable)
- BD-RE (BDisc rewritable)
Storage: Holding Data for Future Use

• **Solid-state storage devices**
  - No moving parts
  - Nonvolatile

• **ExpressCard**
  - Notebook accessory—size of a credit card
  - Can be used as a modem, as extra memory, or as a network adapter
Storage: Holding Data for Future Use

- **Flash memory cards**
  - Solid-state storage device
  - Used with MP3 players, smartphones, digital cameras

- **Flash memory reader**
  - Slot or compartment allows access to files stored on the card
Storage: Holding Data for Future Use

• **Smart card/chip card/integrated circuit card (ICC)**
  - Combines flash memory with a small microprocessor
  - Stores and processes information
  - **Digital cash system**—smart card application enables users to purchase a prepaid amount of electronically stored money