Storage
Storage

- Storage holds data, instructions, and information for future use.
- The operating system and applications are loaded into memory from storage.
- Storage requirements among users vary.
Storage

- A storage medium is the physical material on which a computer keeps data, instructions, and information.

- Examples: Hard disks, solid state drives, memory cards, USB flash drives, ExpressCard modules, optical discs, smart cards, magnetic stripe cards, and microfilm.

- Cloud storage is another storage option, in which the actual storage media used is transparent to the user.
Storage
Storage

- Capacity is the number of bytes (characters) a storage medium can hold.
- A typical hard disk has 320 GB (320 billion bytes) of storage capacity.

<table>
<thead>
<tr>
<th>Storage Term</th>
<th>Approximate Number of Bytes</th>
<th>Exact Number of Bytes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kilobyte (KB)</td>
<td>1 thousand</td>
<td>$2^{10}$ or 1,024</td>
</tr>
<tr>
<td>Megabyte (MB)</td>
<td>1 million</td>
<td>$2^{20}$ or 1,048,576</td>
</tr>
<tr>
<td>Gigabyte (GB)</td>
<td>1 billion</td>
<td>$2^{30}$ or 1,073,741,824</td>
</tr>
<tr>
<td>Terabyte (TB)</td>
<td>1 trillion</td>
<td>$2^{40}$ or 1,099,511,627,776</td>
</tr>
<tr>
<td>Petabyte (PB)</td>
<td>1 quadrillion</td>
<td>$2^{50}$ or 1,125,899,906,842,624</td>
</tr>
<tr>
<td>Exabyte (EB)</td>
<td>1 quintillion</td>
<td>$2^{60}$ or 1,152,921,504,606,846,976</td>
</tr>
<tr>
<td>Zettabyte (ZB)</td>
<td>1 sextillion</td>
<td>$2^{70}$ or 1,180,591,620,717,411,303,424</td>
</tr>
<tr>
<td>Yottabyte (YB)</td>
<td>1 septillion</td>
<td>$2^{80}$ or 1,208,925,819,614,629,174,706,176</td>
</tr>
</tbody>
</table>
Storage

- A storage device is the computer hardware that records and/or retrieves items to and from storage media.
- Writing is the process of transferring data, instructions and information from memory to a storage medium.
- Reading is the process of transferring these items from a storage medium into memory.
Storage

• Access time measures
  ◦ The amount of time it takes a storage device to locate an item on a storage medium, or
  ◦ The time required to deliver an item from memory to the processor.

• The access time of storage devices is slow, compared with the access time of memory.
  ◦ Memory: billionths of a second (nanoseconds)
  ◦ Storage: thousandths or millionths of a second (milliseconds or microseconds)
Hard Disks

- A hard disk, also called a hard disk drive or hard drive, is a storage device that contains one or more inflexible, circular platters that use magnetic particles to store data, instructions and information.
Hard Disks

- Depending on how the magnetic particles are aligned, they represent a 0 or 1 bit.
- Current personal computer hard disks have storage capacities from 160GB to 1.5TB.
- Older disks used longitudinal recording, newer disks use perpendicular recording for storage capacities about 10 times greater.
Characteristics of a Hard Disk

- The platter is made of aluminum, glass, or ceramic and is coated with an alloy material that allows items to be recorded magnetically on its surface.
- Formatting is the process of dividing the disk into tracks and sectors, so that the operating system can store and locate data and information on the disk.
Characteristics of a Hard Disk

- A track is a narrow recording band that forms a full circle.
- A sector is a pie-shaped section, braking the tracks into arcs.
- A cluster is the smallest unit of disk space that stores data and information.
Characteristics of a Hard Disk

- Side view of a platter
- Cylinder passes through all platters
- Read/write head reads top of top platter
- Track forms full circle around disk
- Sides
Characteristics of a Hard Disk

- Platters most often have a form factor, or size, of approximately 3.5 inches in diameter.
- On mobile devices, the form factor is 2.5 inches or less.
- While the computer is rudding, the platters in the hard disk rotate at a high rate of speed, usually 5,400 to 15,000 revolutions per minute (rpm).
Characteristics of a Hard Disk

- The read/write heads are kept at a distance of about two millionths of an inch away from the disk.
- If the read/write head touches the surface of a platter, a head crash occurs, usually resulting in a loss of data or sometimes the entire disk.
- A backup is a duplicate of a file, program, or disk placed on a separate storage medium that you can use in case the original is lost, damaged or destroyed.
Characteristics of a Hard Disk
Characteristics of a Hard Disk

- Disk cache consists of a memory chip(s) on a hard disk that stores frequently accessed items.
- Today, the size of disk cache ranges from 2MB to 32MB.
RAID

- A group of two or more integrated hard disks is called a redundant array of independent disks, or RAID.
- The disks in a RAID function, together, as one large disk.
NAS

- A network attached storage (NAS) device is a server connected to a network with the sole purpose of providing storage.
External or Removable Hard Disks

- An external hard disk is a separate free-standing hard disk that connects with a cable to a USB port or FireWire port on the system unit.

- A removable hard disk is a hard disk that you insert and remove from a drive.

- Although both are usually slower than internal hard disks, they offer advantages, such as transporting, backing up, and securing data.
Miniature Hard Disks

- Used for both internal and external storage.
- Have form factors of 1.8 inch, 1 inch, and 0.85 inch.
- Used in some devices such as portable media players, digital cameras, and smart phones.
Hard Disk Controllers

- A disk controller consists of a special-purpose chip and electronic circuits that control the transfer of data from a disk to and from the system bus.
  - SATA (serial advanced technology attachment)
  - EIDE (enhanced integrated drive electronics)
  - SCSI (small computer system interface)
  - SAS (serial-attached SCSI)
Flash Memory Storage

- Flash memory chips are a type of solid state media, which means they consist entirely of electronic components, such as integrated circuits, and contain no moving parts.
- The lack of moving parts makes them more durable and shock resistant than other types of media.
Solid State Drives

- A solid state drive (SSD) is a storage device that typically uses flash memory to store data.
- Form factors from 3.5 inches, 2.5 inches, and 1.8 inches.
- Used in all types of computers: servers, desktops, and notebooks.
- Storage capacities from 16GB to 256GB.
Solid State Drives

- Access times of SSDs are about 0.1 ms, which is about 80 times faster than a hard disk.
- Faster transfer rates.
- Generate less heat and consume less power.
- Last more than 50 years, as opposed to 3-5 years for hard disks.
Memory Cards

- A memory card is a removable flash memory device, usually no bigger than 1.5 inches in height or width.
Memory Cards

- Memory cards can last from 10 to 100 years.
- They are quite price, per byte, than hard disks.
  - A 16GB CompactFlash card can cost as much as a 640GB external hard disk.
USB Flash Drives

- A USB flash drive, also called a thumb drive, is a flash memory storage device that plugs in a USB port on a computer or mobile device.
- Convenient for mobile users because they are easy to transport.
- Current capacities ranging from 512MB to 100GB.
ExpressCard Modules

- An ExpressCard module is a removable device that fits in an ExpressCard slot.
- About 75mm long and 34mm wide, or L-shaped with a width of 54mm.
- They are commonly used in notebook computers.
Cloud Storage

- Cloud storage is an Internet service that provides storage to computer users.
- Some services provide storage for specific types of files.
- Many offer additional services such as encryption and passwords.
- Users subscribe to cloud storage to: access files on the Internet from any computer, store large files on the Internet, allow others to access their files, and store backups of data.
Optical Discs

- An optical disc is a type of storage media that consists of a flat, round, portable disc made of metal, plastic, and lacquer that is written and read by a laser.
- Optical discs are 4.75 inches in diameter and less than one-twentieth of an inch thick.
- Smaller, 3 inch, mini discs exist for smaller computers and game consoles.
Optical Discs

- They can be used to store software, data, photos, movies, and music.
- Some are read-only and some are read/write, which allows users to save.
- Nearly all personal computers have some sort of optical disc drive.
Optical Discs

- Optical discs store items by using microscopic pits (indentations) and lands (flat areas) that are in the middle layer of the disc.

How a Laser Reads Data on an Optical Disc

**Step 1**
A laser diode shines a light beam toward the disc.

**Step 2**
If light strikes a pit, it scatters. If light strikes a land, it is reflected back toward the laser diode.

**Step 3**
Reflected light is deflected to a lightsensing diode, which sends a digital signal of 1 to the computer. Absence of reflected light is read as a digital signal of 0.
Optical Discs

- Optical Discs commonly store items in a single track that spirals from the center of the disc and is divided into evenly sized sectors.
Care of Optical Discs

- DO store the disc in a jewel box when not in use.
- DO NOT eat, smoke, or drink near a disc.
- DO NOT expose the disc to excessive heat or sunlight.
- DO hold a disc by its edges.
- DO NOT touch the underside of the disc.
- DO NOT stack discs.
**CDs**

- A CD-ROM (compact disc read-only memory) is a type of optical disc that users can read but not write or erase.
- They typically hold from 650MB to 1GB of data.
- To read a CD-ROM, insert the disc in a CD-ROM drive.
- They use an X to denote the original transfer rate of 150 KBps.
  - A 48X CD-ROM drive has a transfer rate of 7200 KBps.
CD-Rs and CD-RWs

- A CD-R (compact disc-recordable) is a multisession optical disc on which users can write, but not erase, their own data.
  - Multisession means you can write on part of the disc at one time and another part later.
- A CD-RW (compact disc-rewritable) is an erasable multisession disc you can write on multiple times.
- A CD-RW drive is used to write to CD-RWs and CD-Rs.
DVDs and Blu-ray Discs

- Although the size and shape are similar to a CDs, each store data in a different manner to achieve a higher capacity.
- A DVD-ROM (digital versatile disc-read-only memory) is a high-capacity optical disc on which users can read but not write or erase.
- Capable of storing 4.7-17GB of data.
- A DVD-ROM drive or DVD player is required to read a DVD-ROM.
DVDs and Blu-ray Discs

- A Blu-ray Disc-ROM (BD-ROM) has storage capacities up to 100GB, as of today, and expecting up to 200GB.
- Blu-ray Disc (BD) drives and players are backward compatible with DVD and CD formats.
Recordable and Rewritable DVDs

- DVD-R and DVD+R are competing DVD-recordable formats, storing up to 4.7GB.
- DVD-RW, DVD+RW, and DVD+RAM are three competing rewritable DVD formats, storing up to 4.7GB.
- Before investing in equipment, check to be sure it is compatible with the media on which you intend to record.
Tape

- Tape, one of the first storage media used, is a magnetically coated ribbon of plastic capable of storing large amounts of data and information at a low cost.
- A tape drive reads and writes data on a tape.
- Tape is no longer used as a primary method of storage.
- Tape uses sequential access, which means reading or writing data consecutively.
  - As opposed to random access, which is used by hard disks and flash memory, since they can both locate a particular data item immediately.
Magnetic Stripe Cards and Smart Cards

- A magnetic stripe card is a credit card, entertainment card, bank card, or other similar card, with a stripe that contains information identifying you and the card.
- A smart card is similar in size to a credit card or ATM card and stores data on a think microprocessor embedded in the card.
Microfilm and Microfiche

- Both store microscopic images of documents on roll or sheet film.
- Microfilm is a 100 to 215 foot roll of film.
- Microfiche is a small sheet of film, usually about 4x6 inches.
- They are used mainly for archiving purposes.
- They are inexpensive and have the longest life of any storage media.
Enterprise Storage

- To meet their large-scale needs, enterprises use special hardware geared for heavy use, maximum availability, and maximum efficiency.
- One or more servers on the network have the sole purpose of providing storage to connected users.
- In an enterprise, some storage systems can provide more than 185TB of storage capacity.
Enterprise Storage

- **Server Count**
  - Intel: 100,000
  - Facebook: 60,000
  - Verizon: 25,788
  - Time Warner Cable: 24,817
  - AT&T: 20,268

- **Estimated Server Count**
  - Google: 450,000
  - Microsoft: 218,000
  - Amazon: 40,000 just for web services
  - eBay: 50,000
  - Yahoo: 50,000