CSC 170 – Introduction to Computers and Their Applications

Lecture #5 – Storage and
Input/Output

Storage Basics

- *Storage* is a term used for the components of a digital device designed to hold data permanently.
- A data storage system has two main components: a *storage medium* and a *storage device*
  - **Storage medium** – the hard drives, CDs, DVDs, flash drives, solid state drives, and memory cards that contains data
  - **Storage device** – the mechanical apparatus that records and retrieves data from a storage medium

Storage Basics

- Each storage technology has its advantages and disadvantages, so review its durability, dependability, speed, capacity, and cost before buying.

Storage Basics - Durability

- *Durability* is the resistance to damage from handling and environmental factors such as dust, humidity, heat, and cold.
- Can be measured in lifespan or in write cycles (the number of times data can be written and revised).

Storage Basics - Dependability

– Dependability is being available when needed; not subject to breakdown, malfunction, network outages, or service interruptions.

– Can be measured by mean time between failures (MTBF is the time a device is expected to function before failing).

– Cloud storage service dependability can be measured by uptime (the percent of time the service is accessible).

Storage Basics - Speed

– Speed is the rate at which data can be stored or accessed. Faster is better.

– Can be measured by data transfer rate (the number of megabytes per second that are read or written by the storage device).

Storage Basics

- Capacity
  - The amount of data that can be stored, usually measured in gigabytes (GB) or terabytes (TB).
- Cost
  - The price of the storage device and media, usually expressed per gigabyte (GB).

Storage Basics
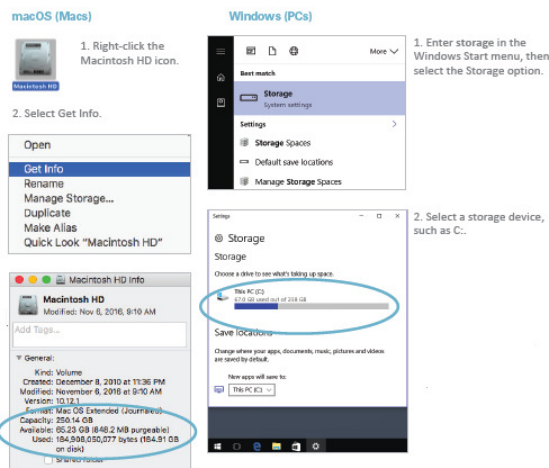
Magnetic Storage Technology

- *Magnetic storage technology* is used for desktop and laptop hard disk drives, as well as the storage devices used in enterprise computing installations and cloud services.

Magnetic Storage Technology

- **Magnetic storage** represents data by magnetizing microscopic particles on a disk or tape surface
- A **hard disk drive** contains one or more platters and their associated read-write heads
- A **hard disk platter** is a flat, rigid disk made of aluminum or glass and coated with magnetic iron oxide particles
- A **read-write head mechanism** in the disk drive magnetizes particles to write data, and senses the particles' polarities to read data

Magnetic Storage Technology
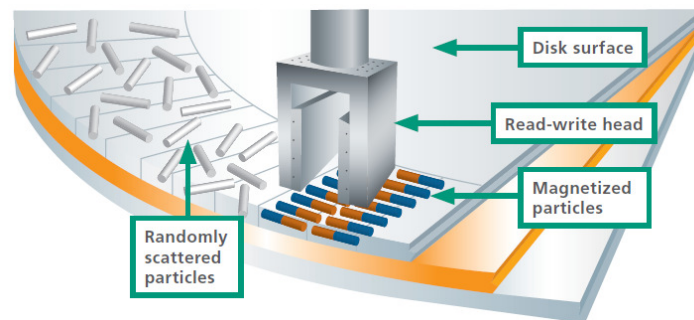
- Before data is stored on a hard disk, particles on the disk surface are scattered in random patterns. The disk drive's read-write head orients them in a positive (north) or negative (south) direction to represent 0 and 1 bits, respectively.

Magnetic Storage Technology

- Hard disk drive specifications include:
  - Access time – the average time it takes a computer to locate data on the storage medium and read it
  - Data transfer rate – the amount of data a storage device can move per second from the storage medium to RAM

Optical Storage Technology

- *CD*, *DVD*, and *Blu-ray* (BD) technologies are classified as *optical storage*, which represents data as microscopic light and dark spots on the disc surface
- An *optical drive* contains a laser that directs a beam of light toward the underside of the disc
- Reflected light is collected by a lens and converted into 0s and 1s that represent data

Optical Storage Technology

- A single optical drive typically handles CDs, DVDs, and Blu-ray discs, but the costs and capacities of these discs vary
  - CD 650 MB 15 ₡
    - CD (compact disc): Designed to hold 74 minutes of recorded music, then adapted for computer storage with capacity for 650 MB of data. Later improvements in CD standards increased the capacity to 80 minutes of music or 700 MB of data.

Optical Storage Technology

- DVD 4.7 GB 25 ₵
  - DVD (digital video disc or digital versatile disc): Designed with the capacity to hold a feature-length film. A single-sided DVD offers 4.7 GB (4,700 MB) of data storage. A double-layer DVD has two recordable layers on the same side and can store 8.5 GB of data.
- Blu-ray 25 GB 50₵
  - **Blu-ray (BD):** Designed to hold high-definition 1080p video by offering 25 GB storage capacity. The name *Blu-ray* is derived from the blue-violet colored laser used to read data. DVD technology uses a red laser; CD technology uses a near infrared laser.

Optical Storage Technology

- Optical technologies are grouped into three categories: read-only, recordable, and rewriteable
  - **ROM. Read-only** technology stores data permanently on a disc, which cannot be later added to or changed; can potentially store data for 100 years.
  - **R. Recordable** technology uses a laser to change the color in a dye laser sandwiched beneath the clear plastic disc surface; the laser creates dark spots that are read as pits.
  - **RW. Rewritable** technology uses phase change technology to alter a crystal structure on the disc surface; altering this structure creates patterns of light and dark spots resembling pits and lands.

Solid State Storage Technology

- *Solid state storage* (sometimes called flash memory) stores data in erasable, rewritable circuitry, rather than on spinning disks or streaming tape.
- Once the data is stored it is *non-volatile*, meaning the circuits retain data without an external power source.

Solid State Storage Technology

- A *memory card* is a flat, solid state storage medium commonly used to transfer files from digital cameras and media players to computers.


Card reader

Memory cards are available in several formats and capacities.

Many digital devices are equipped with a card reader for transferring data to and from solid state memory cards.

Solid State Storage Technology

- A *solid state drive* (SSD) is a package of flash memory that can be used as a substitute for a hard disk drive.
- A *USB flash drive* is a portable storage device that plugs directly into a computer's system unit using a built-in USB connector.
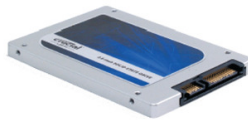
35₵ cost per GB

SSDs are widely used as the main storage device in smartphones and tablet computers. Some laptops also include an SSD instead of hard disk drive

Cloud Storage

- *Remote storage* is housed on an external device that can be accessed from a network
- Remote storage can also be available as an Internet service, in which case it is called *cloud storage.*
- Cloud storage is provided to individuals by services such as Apple iCloud, Microsoft OneDrive, Google Drive, and Dropbox.
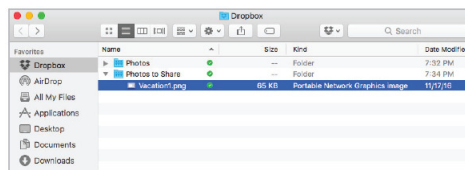
Cloud Storage

- Some cloud implementations offer a synchronization feature that automatically duplicates files stored on a local device by also saving them in the cloud.
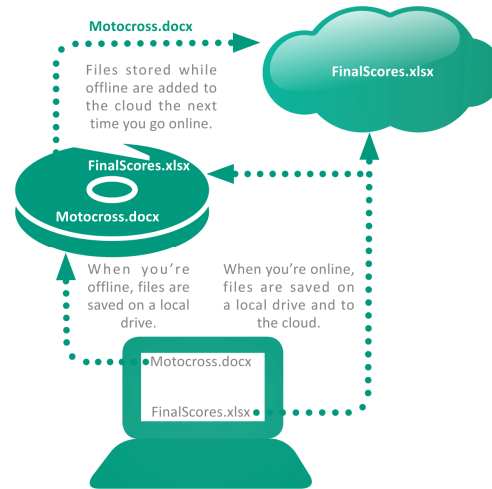
Motocross.docx

Files stored while offline are added to the cloud the next time you go online.

FinalScores.xlsx

FinalScores.xlsx

Motocross.docx

When you're offline, files are saved on a local drive.

When you're online, files are saved on a local drive and to the cloud.

Motocross.docx

FinalScores.xlsx

Cloud Storage

- **<u>Security and privacy risks</u>** – the more places your data is stored and the more networks on which it travels, the more susceptible it becomes to intercepts from hackers and government spying agencies.
- **<u>Service outages</u>** – when a cloud storage site has an outage, all the data stored there becomes temporarily inaccessible.
- **<u>Discontinuation of service</u>** – some cloud storage providers have closed down their services with little warning .
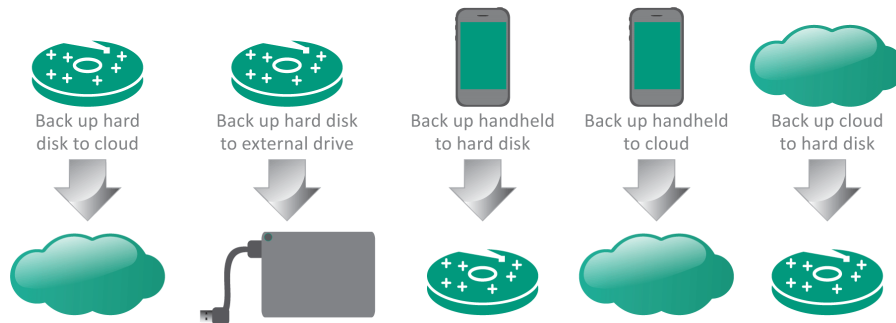
Backup

- A *backup* is a copy of one or more files that is made in case the originals become damaged or lost
- Figuring out what to backup is important; backing up everything isn't always practical
  - *Operating system*: The operating system is required to start your device, but a backup copy might not run if it is unauthorized.
  - *Software*: Most devices are populated with preinstalled software, and you've probably downloaded and installed many additional apps. If these are wiped out when a storage device fails, the process of downloading and reinstalling them can be time consuming.

Backup

  - **Data files:** Your documents, photos, music, videos—all the goodies that you've created and gathered—can be difficult or impossible to reconstruct from scratch.
  - **Settings, accounts, and profiles:** How much time did you spend customizing your home screen, entering contacts, choosing passwords, and setting preferences for your favorite apps? No one wants to have to do that all over again!

Backup

- When deciding on what to back up, know what's important and ensure that current versions exist on more than one storage device.

Back up hard disk to cloud

Back up hard disk to external drive

Back up handheld to hard disk

Back up handheld to cloud

Back up cloud to hard disk

Backup

- Tools you'll need for backups:
  - *Recovery drive* (system repair disc) – contains parts of the OS necessary to boot your computer and diagnose system problems
  - *Copy command* – allows you to make copies of essential files
  - *File History* – allows for automated data backup and *file synchronization* to make copies of files from your Documents, Music, Picture, Pictures, and Videos folders
  - *System image* – Windows includes a *disk image* option called System Image; a bit-for-bit copy of the data from all sectors of a hard disk

Input/Output – Add-on Devices

- There are lots of options available for gadgets that accompany your digital devices

Keyboards	Fitness trackers	Printers
Mice	Touchscreens	Headphones
Touchpads	Home security systems	Speakers
Game controllers	MIDI instruments	Projectors
Scanners	Home control systems	Monitors
Microphones	Audio headsets	Robots
Credit card scanners	VR headsets	
Barcode readers	Haptic gloves	
Biometric scanners		

Expansion Ports

- Many digital devices have ports in the system unit for connecting cables and various add-ons; these ports are called *expansion ports* because they expand the options for input, output, and storage.

- When you plug in a USB flash drive or insert a memory card, you are using an expansion port.

Expansion Ports

Thunderbolt USB Mini USB Lightning FireWire

USB 3.0 USB-C

General-purpose ports are used to connect a variety of gadgets. Small devices, such as smartphones, might use a single Lightning connector that does double duty as a recharging cable and a connector for peripheral devices. The Lightning port resembles a USB-C port, but their cables are not interchangeable.

VGA DVI HDMI Mini DisplayPort

Some display devices, such as external display screens and projection devices, are designed to connect to USB ports, but other display devices use specialized video ports, such as HDMI, DVI, VGA, and DisplayPort. Using a specialized video port leaves USB ports free for other gadgets.

Audio In Audio Out Ethernet Wireless antenna

Most devices have at least one Audio Out port for a headset or earbuds. There may be an additional Audio In port for connecting a microphone.

An Ethernet port handles wired network connections. Wireless network connections are usually built in, but an antenna can be inserted in a USB port.

Expansion Ports

- If you want to connect more devices than the available number of USB ports, you can use a *USB hub*.

USB hub

Bluetooth

- A common wireless technology for connecting peripherals is *Bluetooth*.
- Bluetooth is a low-power technology, so it is ideal for mobile devices that don't have big batteries.
- Bluetooth is used to connect wireless headsets to smartphones and is built into many smartphones, tablets, laptops, and desktops.

Device Drivers and Apps

- A *device driver* is software that helps a peripheral device establish communication with its host device.
- For example, the device driver for an HP printer sets up data streams from RAM to the printer and makes sure that the data is formatted in a way that the printer can work.
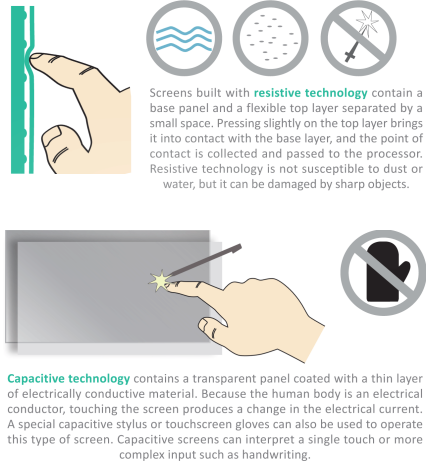
Display Devices

- A computer display device that simply displays text and images is classified as an output device.
- Touchscreens, however, can be classified as both input and output devices because they accept input and also display output.
- *LCD* (liquid crystal display) technology produces an image by filtering light through a layer of liquid crystal cells.

Display Devices

- Factors that affect image quality are:
  - **Screen size** – the measurement in inches from one corner of the screen diagonally across to the opposite corner.
  - **Response rate** – the time it takes for one pixel to change from black to white then back to black.
  - **Dot pitch (dp)** – the LED's that form an image on the screen are spaced in a grid; dp is the distance in millimeters between like-colored LEDs.
  - **Screen resolution** – the number of horizontal and vertical pixels that a device displays on the screen.

Display Devices

- Tablet computers, handheld devices, retail store self-checkouts, and ATMs display output and collect input from a *touchscreen.*

- They can also display a *virtual keyboard* for devices that are not connected to a physical keyboard.

Screens built with **resistive technology** contain a base panel and a flexible top layer separated by a small space. Pressing slightly on the top layer brings it into contact with the base layer, and the point of contact is collected and passed to the processor. Resistive technology is not susceptible to dust or water, but it can be damaged by sharp objects.

Capacitive technology contains a transparent panel coated with a thin layer of electrically conductive material. Because the human body is an electrical conductor, touching the screen produces a change in the electrical current. A special capacitive stylus or touchscreen gloves can also be used to operate this type of screen. Capacitive screens can interpret a single touch or more complex input such as handwriting.
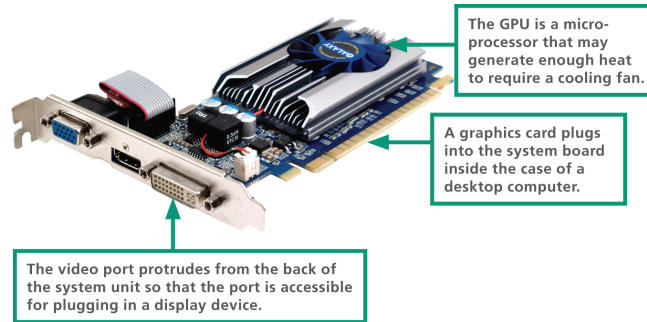

Display Devices

- Display devices require graphics circuitry to generate and transport the signals for displaying an image on the screen.

- One type of graphics circuitry, referred to as *integrated graphics*, is built into a computer's system board.

Display Devices

- A second option, called ***dedicated graphics***, is graphics circuitry mounted on a small circuit board called a graphics card (or video card).

The GPU is a micro-processor that may generate enough heat to require a cooling fan.

A graphics card plugs into the system board inside the case of a desktop computer.

The video port protrudes from the back of the system unit so that the port is accessible for plugging in a display device.

Display Devices

- A graphics card contains a ***graphics processing unit*** (GPU) and a special video memory, which stores screen images as they are processed but before they are displayed.

In a device with integrated graphics, image data is processed by the main CPU, then sent to the graphics circuits that stream the image to the display device.

In a device with a GPU, image data is processed by the GPU, freeing the CPU for other tasks.

CPU

CPU GPU
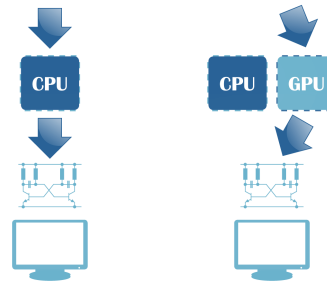
Printers

- Today's best-selling multifunction printers use ink jet or laser technology and can also serve as scanners, copiers, and fax machines.
- An *ink jet printer* has a nozzle-like print head that sprays ink onto paper to form characters and graphics.
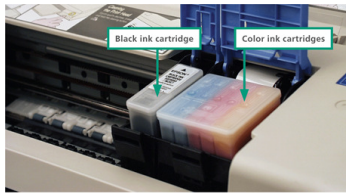
Most ink jet printers use CMYK color, which requires only cyan (blue), magenta (pink), yellow, and black inks to create a printout that appears to contain thousand of colors.

Things

- The utopian vision for the Internet of Things (IoT) is a busy hive of **smart sensors** that work behind the scenes to collect data and use it to improve just about anything.
  - Sound - "Your dog is barking."
  - GPS - "Your car is not in your driveway."
  - Motion - "A person or animal approached your cabin last night."
  - Light - "It's 10 pm; your porch light isn't on."

Autonomous Vehicles

- Cars, trucks, trains, drones, planes, and machines that are usually piloted by humans become autonomous as the vehicles, rather than the humans, take over control of speed, braking, and steering.
- In general, autonomous vehicles use sense-plan-act algorithms that emerged with the development of robotic systems.
- **Sense-plan-act algorithms** gather data, analyze it, and then carry out the required actions.
- Multiple sense-plan-act loops operate simultaneously.

Autonomous Vehicles

- **<u>Sense</u>** - Sensors on the vehicle gather raw data about the nearby environment and the status of the vehicle itself.
- **<u>Plan</u> -** Based on its interpretation of sensor data, the onboard computer applies a series of rules to determine the best course of action.
- **<u>Act</u> -** After the computer determines a course of action, it sends signals to the vehicle's control systems to initiate a lane change or to avtivate the braking system.