CS1102
Lecture 5
Computer System Hardware

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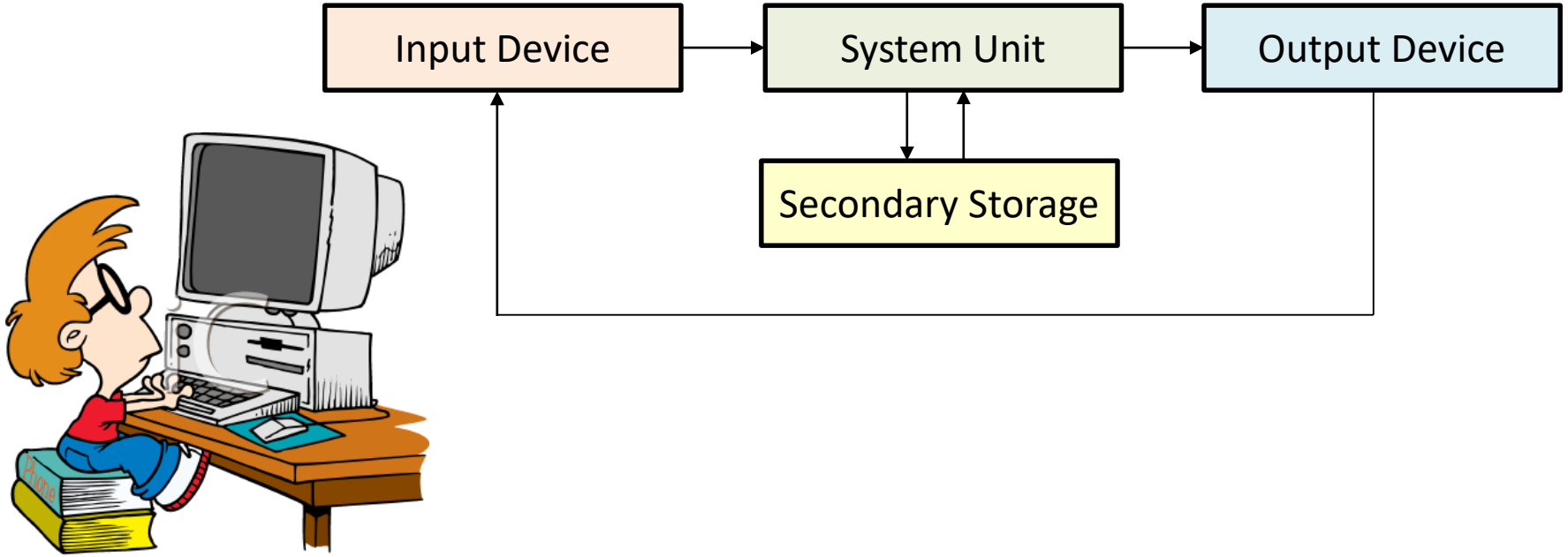
Semester A, 2020-2021
Department of Computer Science
City University of Hong Kong

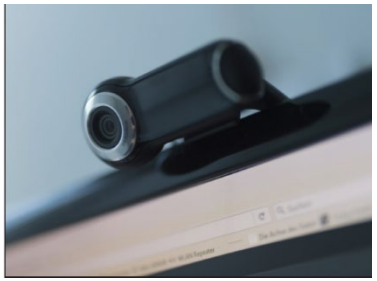
Computer System

- Computers are electronic devices that can follow instructions to accept input, process data, and produce information



Input

- Input is any data or instructions entered into a computer
- Input devices are hardware used to translate words, numbers, sounds, images, and gestures that people understand into a form that the system unit can process





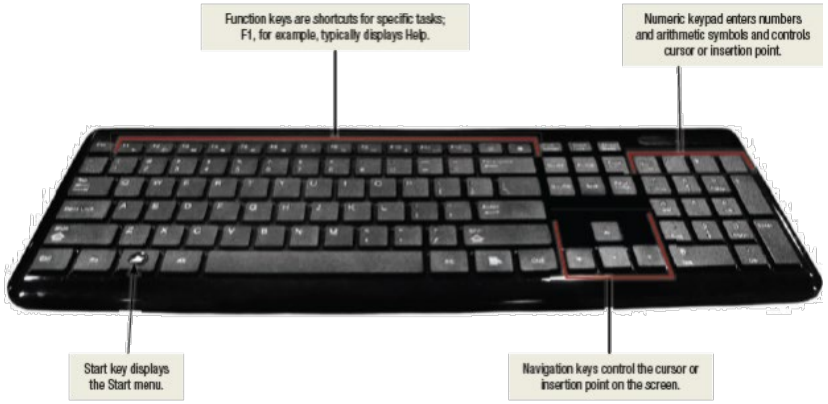






Keyboard

- A keyboard converts numbers, letters, and special characters that people understand into electric signals



Arrangement of Keys

- You are used to this layout for the keyboard (QWERTY):

Have you ever wondered why the keyboard was not designed like this?

http://trendsupdates.com/fast-finger-keyboard-a-keyboard-with-a-difference/

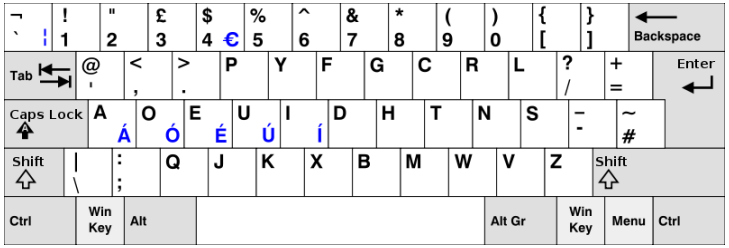
Arrangement of Keys (cont.)

- The design is originated from mechanical typewriter

It would jam if neighboring arms are pressed at the same time or in rapid succession so the arrangement of the keys is designed to avoid this as much as possible

Did you know that the word "typewriter" can be typed by using only the top row of the QWERTY keyboard?

- Computer keyboards do not have the jamming problems so new keyboard layout such as Dvorak keyboard (aka simplified keyboard) has been designed to reduce finger travel distance



Shorter finger travel distance means faster typing speed and reduction of repetitive strain injuries but it takes time for users to get used to the new key arrangement

Mouse

- A mouse controls a pointer that is displayed on the monitor. An optical mouse is the most widely used device which emits and senses light to detect mouse movement

Mouse buttons are used to select command options and to control the mouse pointer on the monitor

A wheel button can be rotated to scroll through information that is displayed on the monitor

A touch pad operates by moving or tapping your finger on the surface of a pad

Optical Scanners

- An optical scanner, also known simply as a scanner, accepts documents consisting of text and/or images and converts them to machine-readable form

Optical scanners recognize light, dark, and colored areas that make up individual letters or images. Optical character recognition (OCR) software can then be applied to recognize the text from the scanned document but most likely the recognition result is not perfect, i.e., resulting with errors

3D scanners use lasers, cameras or robotic arms to record the shape of an object

Bar Code and RFID Readers

Bar code readers contain photo electric cells that scan or read **bar codes**, or the vertical zebra-striped marks printed on product containers

RFID (radio-frequency identification) tags are tiny chips containing electronically stored information and they can be embedded and read by RFID reader located at a distance

Bar Code Applications:
Checking out in grocery store, routing packages for shipping companies

RFID Applications:
Tracking pets, updating/controlling inventories, reading passports

Other Input Device Examples

- Input devices may acquire input from the user's finger/hand/body movement, audio, video, etc.
- Sometimes recognition techniques may be applied to better understand the input data, e.g., gesture recognition, voice recognition

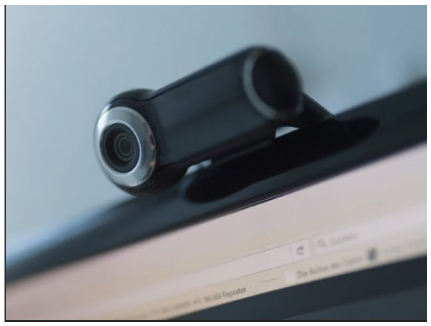
Stylus

Joystick

Gaming Mouse

Gamepad

Web Cam



Motion Sensing Device

Output

- Output is processed data or information
- Typical output takes form of
  - Text
  - Graphics
  - Photos
  - Audio
  - Video
- Output devices are any hardware used to provide or to create output. They translate information that has been processed by the system unit into a form that humans can understand

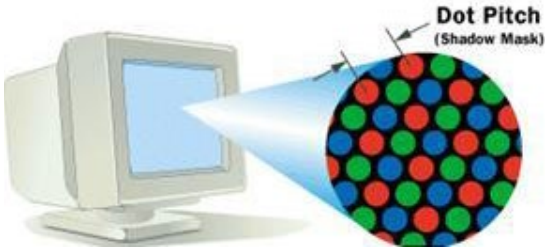
Monitor

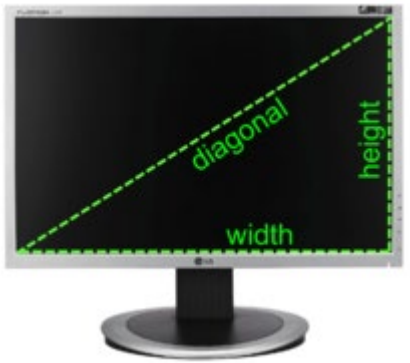
- Monitors, also known as display screens, present visual images of text and graphics
- Flat-Panel Monitors
  - Most widely used type of monitor
  - **Almost** all flat-panel displays are back-lit, meaning that a common source of light is dispersed over all the pixels on the screen
  - 3 basic types of flat-panel monitors:

1. LCD (Liquid Crystal Display)
   - Widely used for older monitors and is typically less expensive
2. LED (Light-Emitting Diode)
   - Use similar technology with a more advanced backlighting technology
   - Produce better-quality images, are slimmer, and are more environmental friendly as they require less power and fewer toxic chemicals to manufacture
3. OLED (Organic Light-Emitting Diode)
   - Replace the LED monitor's backlighting technology with a thin layer of organic compound that produces light
   - By eliminating the backlight, OLED monitors can be even thinner with better power efficiency and contrast ratios

Clarity

- Clarity refers to the quality and sharpness of the displayed images. It is a function of the following factors:
- **Resolution** is expressed as a matrix of dots or pixels, e.g., 1920×1080
  - The higher a monitor's resolution (more pixels), the clearer the image produced
- **Dot (pixel) pitch** is the distance between each pixel, e.g., 0.3mm
  - The lower the dot pitch (shorter distance between pixels), the clearer the image produced
- **Contrast ratios** indicate a monitor's ability to display images and compare the light intensity of the brightest white to the darkest black, e.g., 500:1
  - The higher the contrast ratio, the better the monitor
- **Size** or **active display area**, is measured by the diagonal length of a monitor's viewing area, e.g., 24 inches
- **Aspect ratio** indicates the proportional relationship between a display's width and height, e.g., 4:3, 16:9

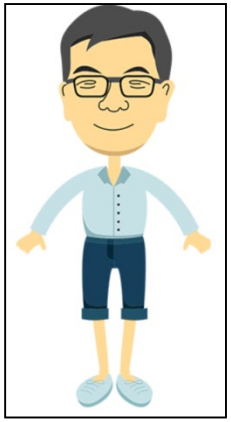




Printers

- A printer translates information that has been processed by the system unit and present the information on paper
  - Printer output is called hard copy (as opposed to soft copy, electronic document stored as a computer file)
  - Landscape or portrait orientation

landscape



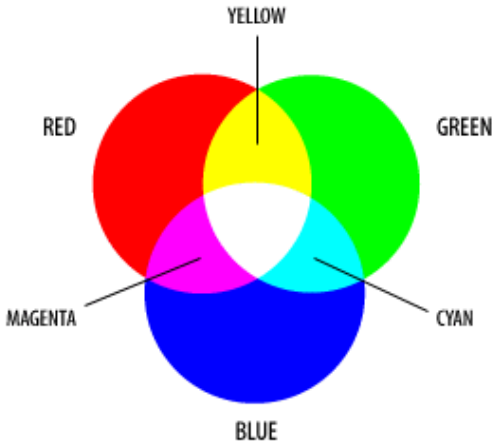
portrait

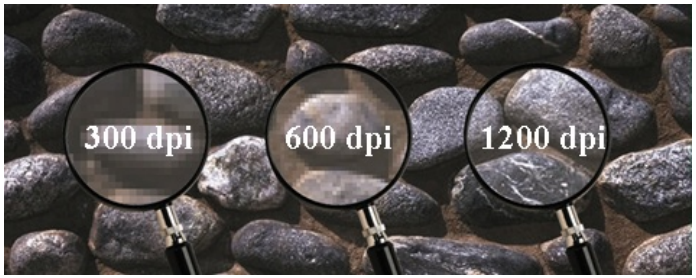
Common Types of Printers

- Inkjet Printers
  - Spray ink at high speed onto the surface of paper
  - Produce high-quality images in a variety of colors
  - Relatively inexpensive with the ink cartridges being the most costly aspect, thus most users specify black ink for the majority of print jobs and use the more expensive color printing for selected applications
- Laser Printers
  - Use a laser light beam to produce images with excellent letter and graphics quality
  - More expensive and faster than inkjet printers
- Thermal Printers
  - Use heat elements to produce images on heat-sensitive paper

Printer Features

- Resolution
  - Measured in dots per inch (dpi)
- Color or Grayscale
  - Printing with color is more expensive than with black ink
- Speed
  - Measured in pages per minute (ppm)
- Memory
  - Used to store printing instructions and documents waiting to be printed
- Duplex printing
  - Allows automatic printing on both sides of a sheet of paper





Ergonomics

- Ergonomics is defined as the study of human factors related to things people use
  - Fitting the task to the user rather than forcing the user to contort to do the task
  - Designing input and output devices to increase ease of use and to avoid health risks
- To avoid physical discomfort such as
  1. Eyestrain and headache
     - Take a 15 minute break every hour or two
     - Keep everything you are focusing on at about the same distance
     - Clean the screen of dust from time to time
  2. Back and neck pain
     - Make sure your equipment is adjustable
     - Monitor should be at eye level or slightly below eye level
     - Use a foot rest if necessary to reduce leg fatigue

Correct Sitting Posture

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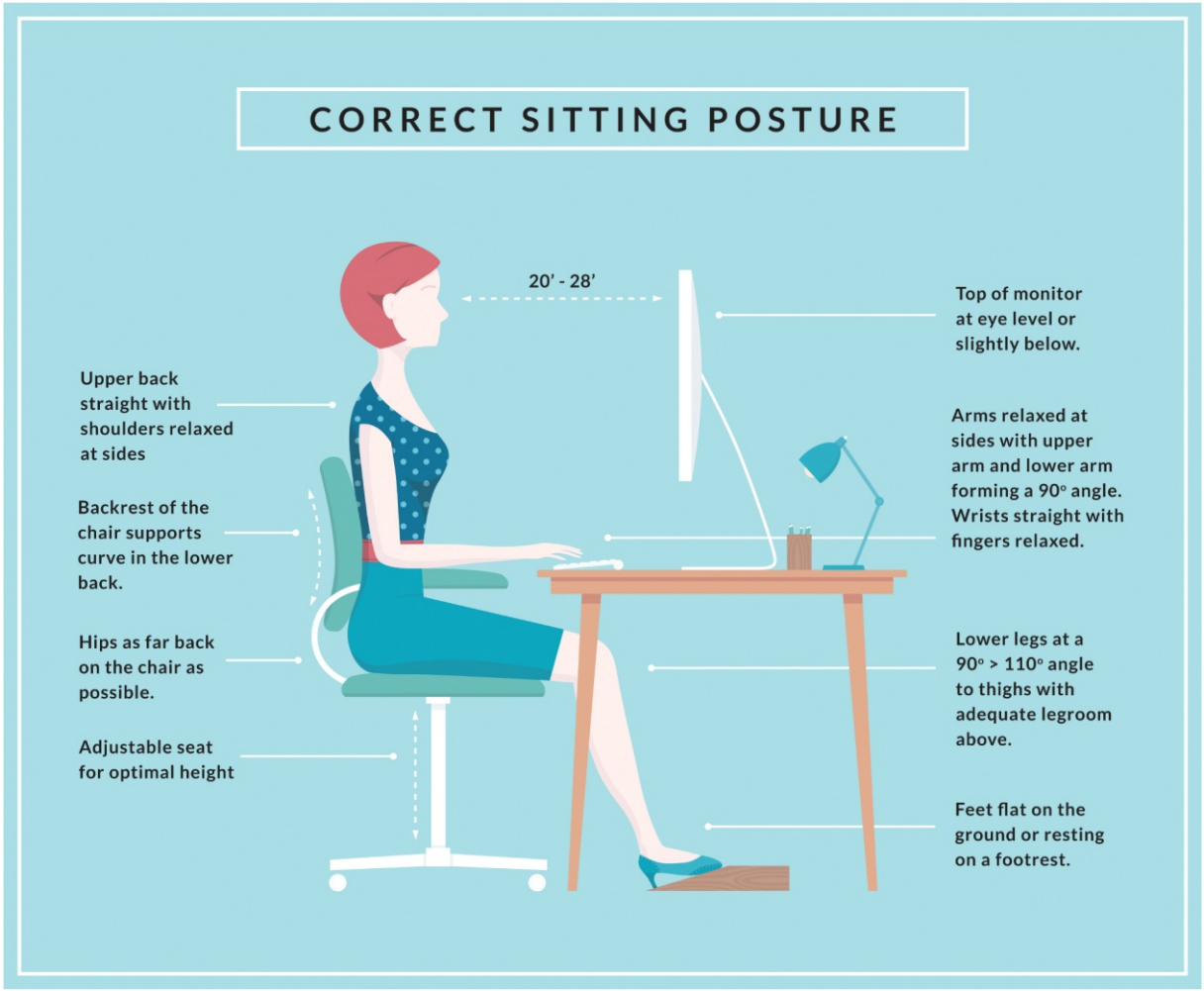

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Repetitive Strain Injury (RSI)

- Repetitive Strain Injury (RSI) is any injury that is caused by fast, repetitive work that can generate neck, wrist, hand, and arm pain
- One particular type of RSI is carpal tunnel syndrome that is found among heavy computer users and consists of damages to nerves and tendons in the hands
  - Some victims report the pain is so intense that they cannot open doors or shake hands
- To help prevent injury from heavy computer use
  - Use ergonomic keyboards
  - Take frequent short rest breaks and gently massage your hands

System Unit

- System unit is a container that houses most of the electronic components that make up a computer system
- Although all devices come in many shapes and sizes they have similarities such as
  - System boards
  - Microprocessors
  - Memory

Desktop

Laptop

Tablet

Smartphone

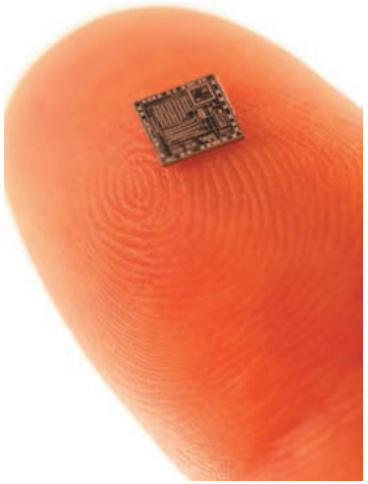
Wearable

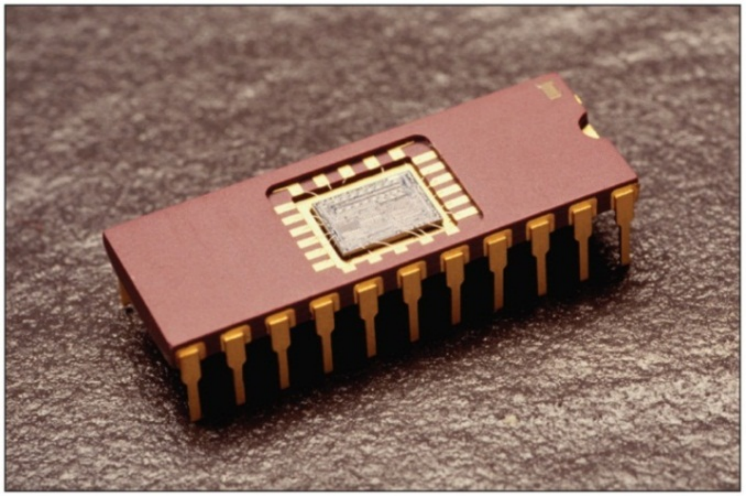
Motherboard

- Motherboard, also known as system board or mainboard
  - controls communications for the entire computer system
  - acts as a data path and traffic monitor, allowing various components to communicate efficiently with one another
- All devices and components connect to the motherboard, including external devices such as keyboards and monitors; and internal components such as hard disks and microprocessors

Sockets and Chips

- Sockets provide a connection point for small specialized electronic parts called chips
- Chips consist of tiny circuit boards etched onto squares of sand-like material called silicon
- A chip is also called a silicon chip, semiconductor, or integrated circuit
- Chips typically are mounted onto chip carriers. Chip carriers plug either directly into sockets on the motherboard or onto cards that are then plugged into slots on the motherboard





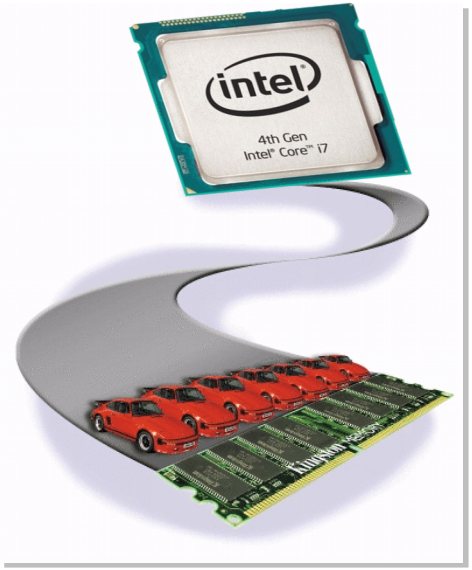
Additional Motherboard Components

- Slots provide a connection point for specialized cards or circuit boards which provide expansion capability for a computer system, e.g., wireless network card

- Bus lines are connecting lines that provide pathways to support communication among various electric components that are either located on the motherboard or attached to the motherboard

Bus

- Bus Line, also known simply as Bus,
  - connects the parts of the CPU to each other
  - also links the CPU to various other components on the motherboard
- A bus is a pathway for bits representing data and instructions
- The number of bits that can travel simultaneously down a bus is known as the bus width
  - A 64-bit bus can move twice as much information at a time as a 32-bit bus



Microprocessor

- In most personal computer systems, the central processing unit (CPU) or processor is contained on a single chip called the microprocessor
- Microprocessor is the "brain" of the computer and has 2 basic components: control unit and arithmetic-logic unit
- Control unit
  - tells the rest of the computer system how to carry out a program's instructions by
  1. directing the movement of electronic signals between memory and ALU
  2. directing control signals between CPU and the input and output devices
- Arithmetic-logic unit (ALU)
  - performs 2 types of operations: arithmetic and logical
  1. Arithmetic operations are the fundamental math operations: addition(+), subtraction(–), multiplication(×), and division(÷)
  2. Logical operations consist of comparisons such as whether one item is equal to (=), less than (<), or greater than (>) the other

Microprocessor Chips

- Chip processing capacities are often expressed in word sizes (Refer to Lecture 2, slide 21)
  - A word is the number of bits that can be accessed at one time by the CPU
- The processing speed of a microprocessor is typically represented by its clock speed, which is related to the number of times the CPU can fetch and process data or instructions in a second
- Multicore processors can provide 2 or more separate and independent CPUs
  - E.g., a quad-core processor (4 processors) could have the followings running at the same time:
    1. core 1 computing a complex Excel spreadsheet
    2. core 2 creating a report using Word
    3. core 3 locating a record using Access
    4. core 4 running a multimedia presentation
  - For multicore processors to be used effectively, computers should perform parallel processing, i.e., divide tasks into parts that can be distributed across each core

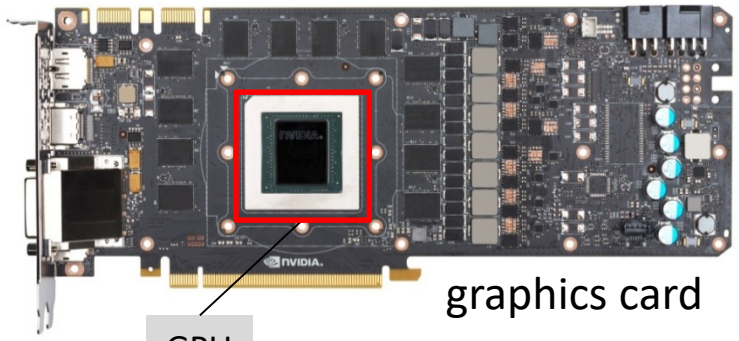
HP 8300 Elite Small Form Factor Desktop Computer (Intel Core i5-3470 3.2GHz Quad-Core 8GB RAM, 500GB SATA, Windows 10 Pro

- Operating System: **Windows 7 Professional, Windows 10 Professional**
- Cpu Model Family: **core i5**
- Computer Memory Size: **8.0 GB**
- Hard Disk Size: **500.0 GB**
- Graphics Coprocessor: **Intel HD 2500**

Coprocessor

- Coprocessors are specialty chips designed to improve specific computing operations
- One widely used coprocessor is graphics coprocessor, also called a GPU (Graphics Processing Unit), designed to handle a variety of specialized tasks such as displaying 3D images and encrypting data
  - In some computer systems, GPU is directly connected to motherboard
  - In some cases, GPU is connected through a graphics card

AMD calls the CPU + GPU chip APU
- Accelerated Processing Unit



- Powerful GPUs are a standard feature in gaming computers to support fast processing of virtual environments

Memory

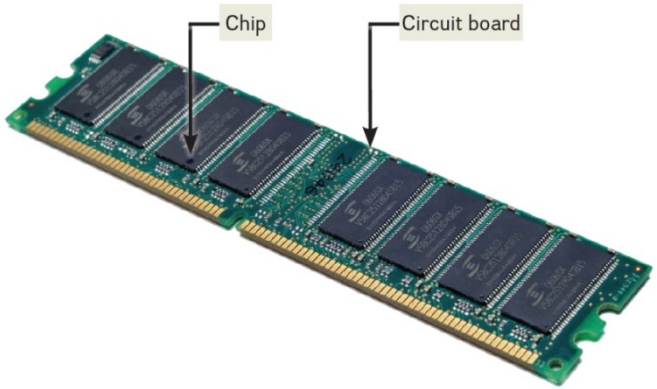
- Memory is a holding area for data, instructions and information
- Memory is contained in chips connected to the motherboard

Volatile

Stored information is lost when computer is turned off (or power failure)

Random Access Memory (RAM)

- RAM chips hold the program (sequence of instructions) and data that CPU is presently processing



Non-Volatile

Stored information remains when computer is turned off

Read-Only Memory (ROM)

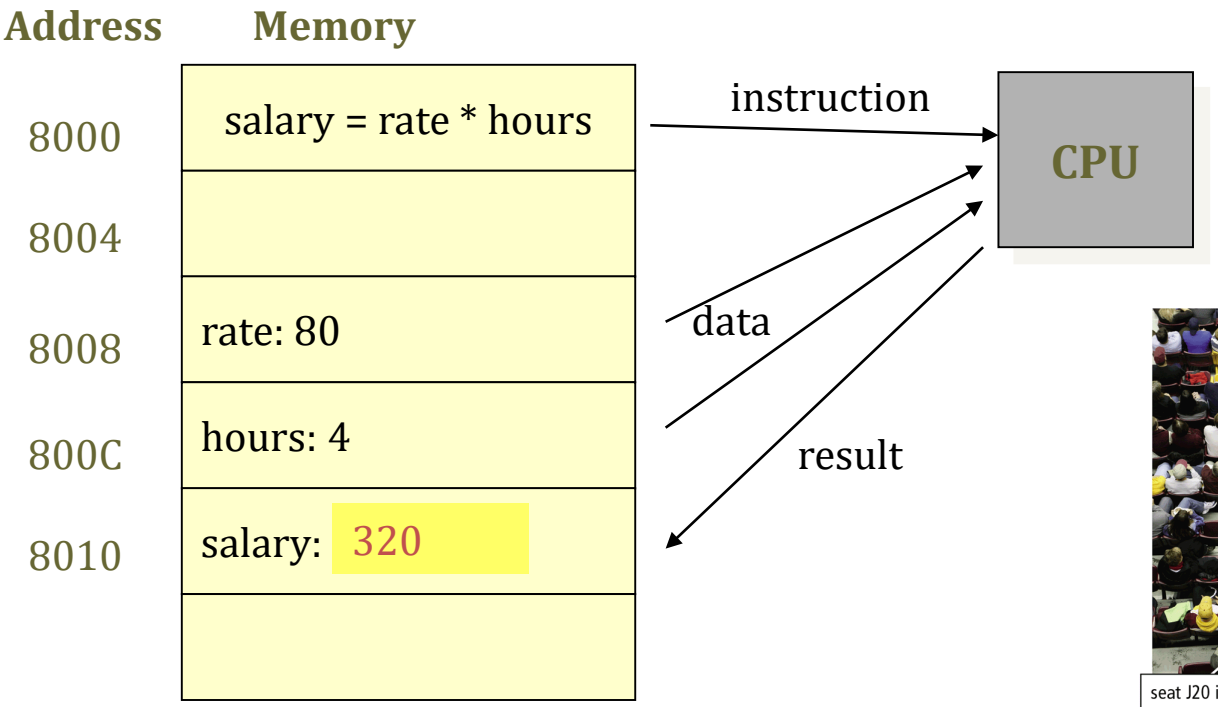
- ROM chips have information stored in them by manufacturer
- Computer can read or retrieve data and programs written on ROM but cannot write or change information in ROM
- Typically used to contain almost all instructions for basic computer operations but recently flash memory chips have replaced ROM chips for many applications

Flash Memory

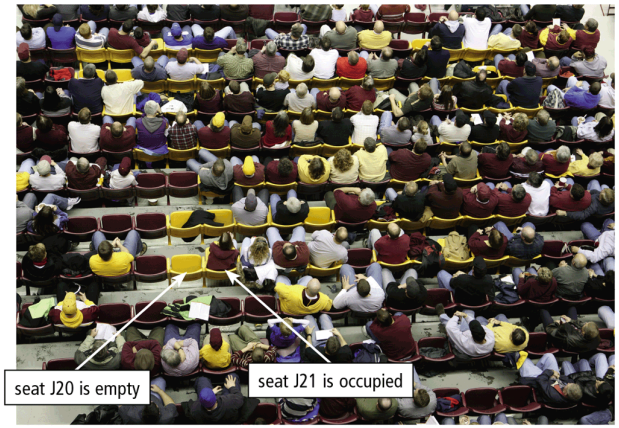
- Flash memory offers a combination of the features of RAM and ROM: can be updated to store new information and does not lose information when power to computer system is turned off
- Can be used to store the start-up instructions for a computer called BIOS (Basic Input/Output System) which includes specifics concerning amount of RAM and type of keyboard, mouse and secondary storage devices connected to the system unit

How RAM Works?

- The location in memory for each instruction and each piece of data is identified by an address
- Each location in memory has a unique address number

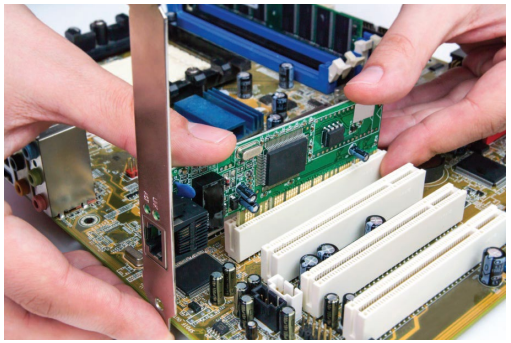


Analogy

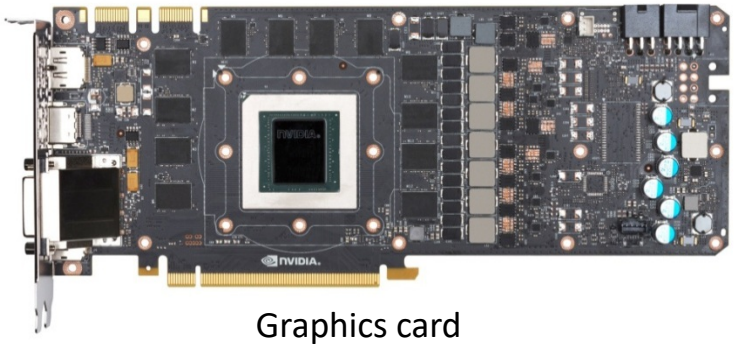


Expansion Slots and Cards

- Expansion slots expand the system capabilities
- Expansion cards are optional devices that can be inserted in expansion slots
  - Graphics card provides high-quality 3D graphics and animation for games and simulations
  - Network Interface Card (NIC), also known as network adapter card, connects a computer to a network



Network Interface Card



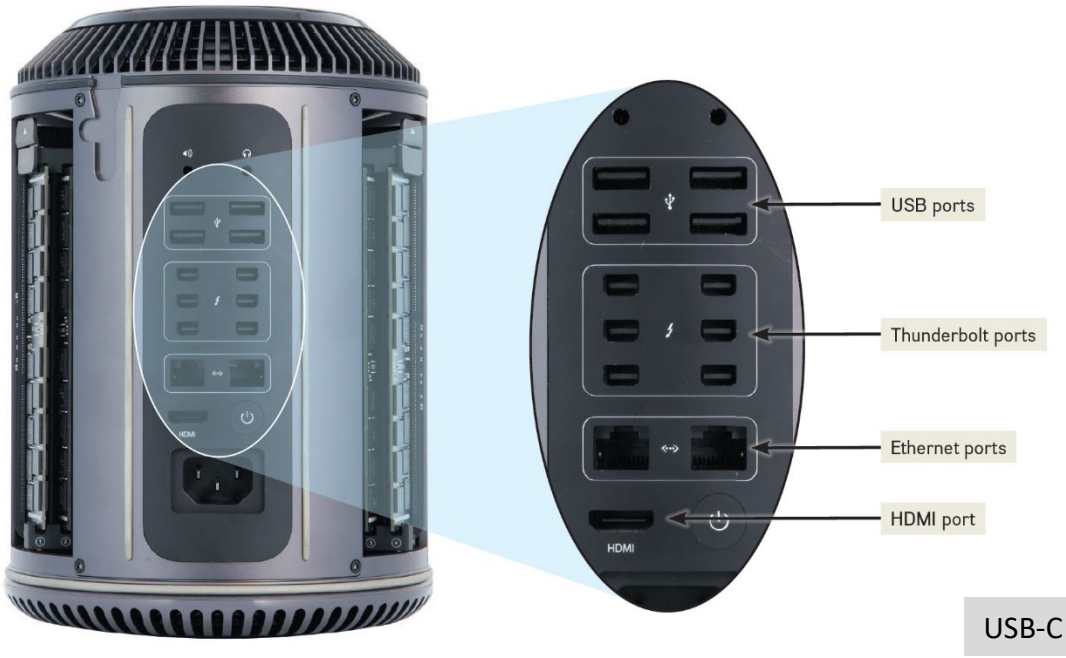
Graphics card

Expansion card with 3 ports

- Ports on expansion cards allow cables to be connected from the expansion cards to devices outside the system unit

Ports

- A port is a socket for external devices to connect to the system unit
  - Some ports connect to the motherboard
  - Other ports connect to cards that are inserted into slots on the motherboard



Universal Serial Bus (USB) ports are widely used to connect keyboards, mice, printers, storage devices, etc.

Thunderbolt ports, first introduced in Apple's MacBook Pro computer, provide high-speed connections

Thunderbolt 1 or 2 port

Thunderbolt 3 port

USB-C

Ethernet ports are a high-speed networking port that has become a standard for many of today's computers

High Definition Multimedia Interface (HDMI) ports provide high-definition video and audio

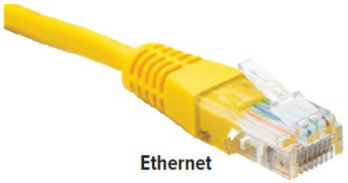
Cables and Power Supply

- Cables are used to connect exterior devices to the system unit via the ports


USB


HDMI


Thunderbolt


Ethernet

- Computers require direct current (DC) to power their electronic components which can be provided indirectly by converting alternating current (AC) from standard wall outlets or directly from batteries

Power Supply Unit


AC Adapter

Storage

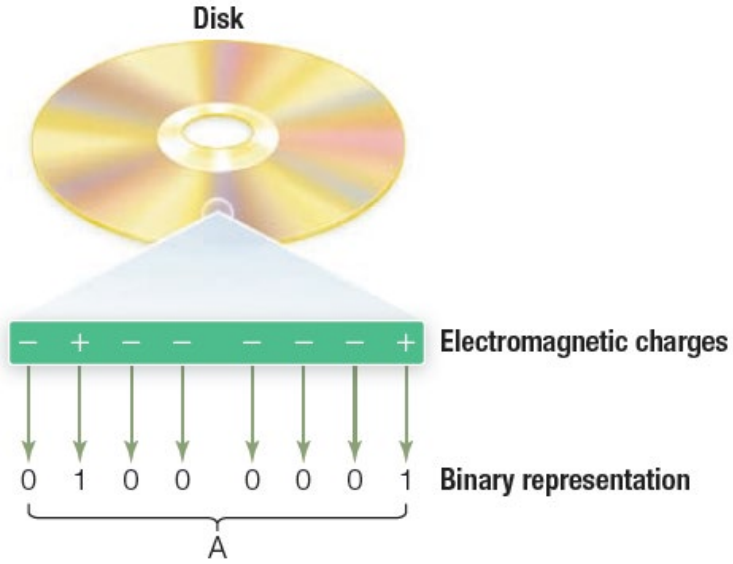
- Primary Storage
  - Refers to RAM, as it is the location to store data or program before they can be run
  - Volatile
- Secondary Storage
  - Non-volatile
  - E.g., hard drive
  - Writing is the process of saving information to storage
  - Reading is the process of accessing information from storage

Characteristics of Secondary Storage:

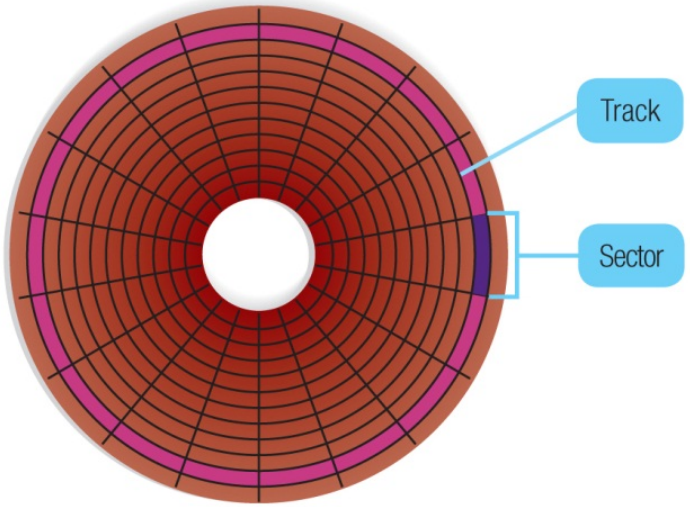
- Media: physical material that holds the data and programs
- Capacity: measures how much a particular storage medium can hold
- Storage devices: hardware that reads data and programs from storage media. Most also write to storage media
- Access speed: measures the amount of time required by the storage device to retrieve data and programs

Hard Disks

- Save files by altering the magnetic charges of the disk's surface to represent 1s and 0s
  - Use rigid, metallic platters that are stacked one on top of one another
  - Store and organize files using tracks, sectors, and cylinders



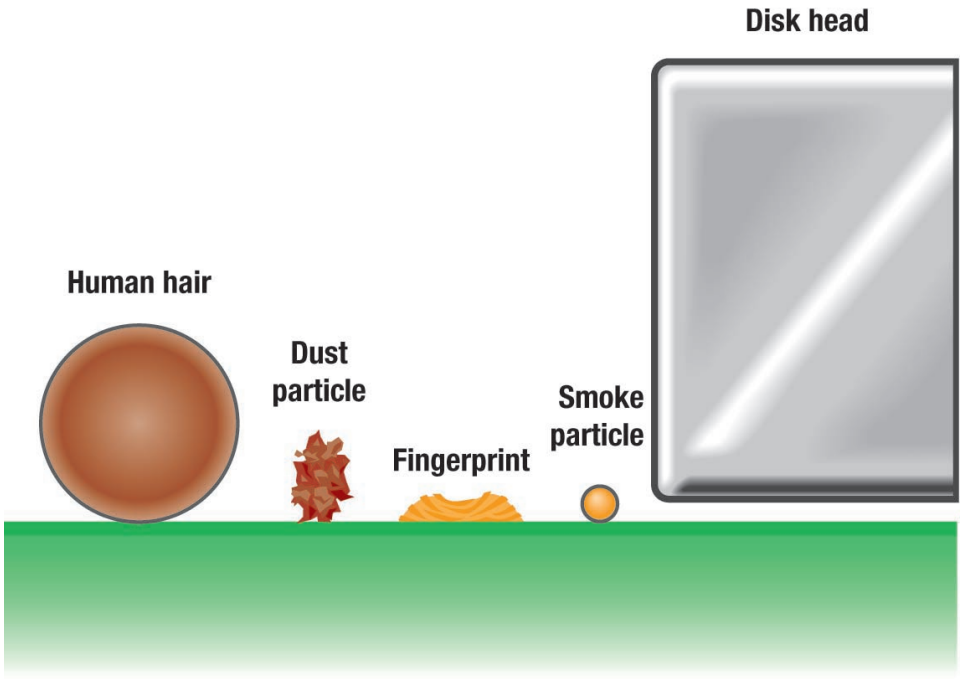
How charges on a disk surface store the letter A



Tracks and Sectors

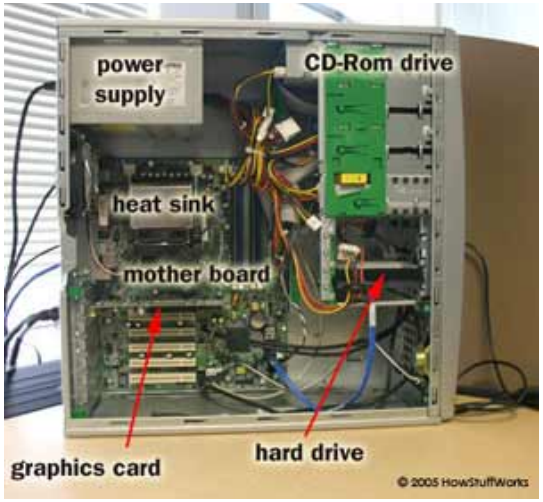
Head Crash

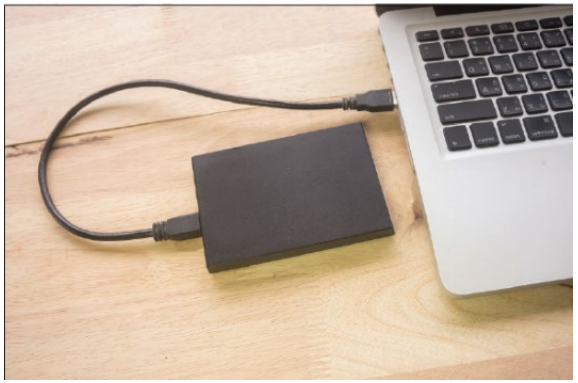
- Occurs when read-write head makes contact with the hard disk's surface (whereas the read/write head rides on a cushion of air about 0.000001 inch thick in normal scenario) or with particles on its surface
  - Disaster for hard disk: disk surface is scratched, and some or all of the data is destroyed



Internal and External Hard Disks

- Internal Hard Disk
  - Located inside the system unit
  - Able to store and retrieve large quantities of information quickly
  - Store operating system and major applications
- External Hard Disk
  - Provide slower access
  - Typically connected to a USB or Thunderbolt port on the system unit and can be easily removed
  - Useful to protect or secure sensitive information
  - Can also be used to back up contents of internal hard disk

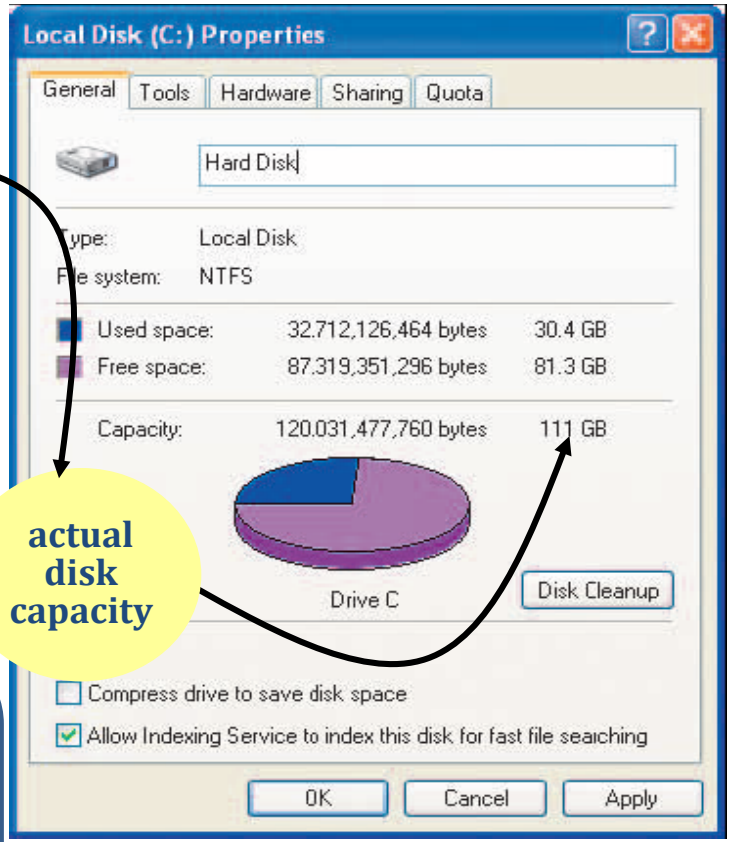




Hard Disk Measurement

Sample Hard Disk Characteristics

Capacity	120 GB
Physical size	3.5'' for desktop,
	2.5'' for notebook
	1.8'' for mp3 player
Revolutions per minute	7,200 rpm
Transfer rate	120 to 300 MB/s
Seek time	5ms to 15ms
Cache	2 to 16 MB



To hard drive manufacturer,
1KB = 1000 bytes, 1MB = 1000KB, 1GB = 1000MB
So hard drive manufacturer thinks that
120GB = 120GB × 1000MB/GB × 1000GB/KB × 1000 bytes
= 120, 000, 000, 000 bytes

To Windows OS,
1KB = 1024 bytes, 1MB = 1024KB, 1GB = 1024MB
So Windows OS thinks that 120, 000, 000, 000 bytes
= 120,000,000 bytes × 1KB/1024bytes × 1MB/1024KB × 1GB/1024MB
= 120,000,000,000/1024/1024/1024 GB = 111.76GB

Performance Enhancement

- 3 ways to improve the performance of hard disks

1. Disk caching – Anticipation of data needs
   - during idle processing time, frequently used data is automatically identified and read from the hard disk into the disk cache
   - when needed, the data is then accessed directly from memory which is much faster than from the hard disk
2. Redundant Arrays of Inexpensive Disks (RAID)
   - Expanding external storage, improving access speed, and providing reliable storage
   - Several inexpensive hard-disk drives are connected to one another by a network or specialized RAID devices
3. File Compression/Decompression
   - Increase of storage capacity by reducing the amount of space required to store data and programs

Solid State Storage

- Solid-state storage devices have no moving parts and provide access to flash memory, also known as solid-state storage
- Data and information are stored and retrieved electronically directly from these devices much as they would be from conventional computer memory

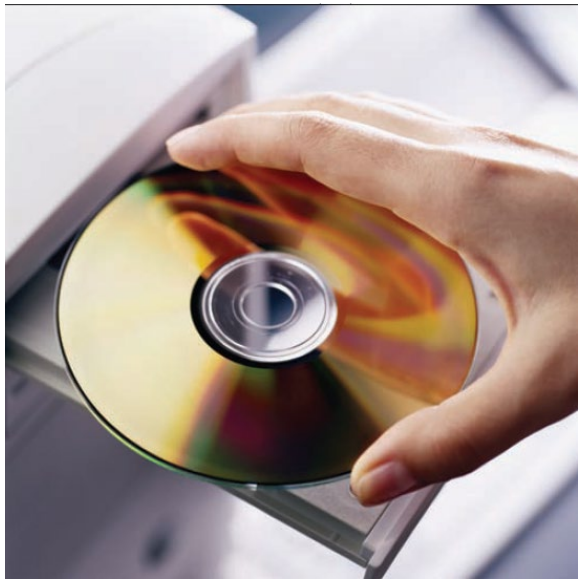
Flash Memory Cards
- Small solid-state storage devices widely used in portable devices

USB Drives
- Connect directly to a computer's USB port to transfer files

Solid-State Drives
- Faster and more durable but more expensive and generally lower capacity than hard drives

Optical Discs

- A laser beam alters the surface of a plastic or metallic disc to represent data
- The 1s and 0s are represented by flat areas called lands and bumpy areas called pits on the disc surface
- A laser produces a tiny beam of light on these areas and the amount of reflect light determines whether the area represents 1 or 0
- Most widely used optical discs are CD, DVD and Blu-ray discs



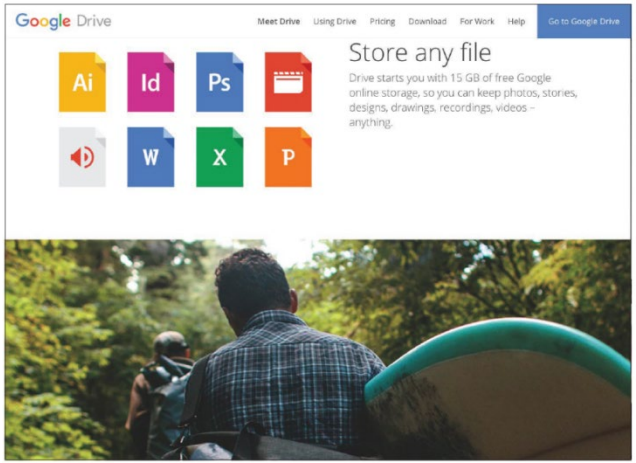
Compact Discs (CDs)
- First widely available optical format for PC users
- Typical capacity: 700MB

Digital Versatile Discs (DVDs)
- Standard optical discs in PC
- Typical capacity : 4.7GB

Blu-ray Discs (BDs)
- a special blue-colored laser is used to read the discs
- Typical capacity : 50GB

Cloud Storage

- Internet acts as a "cloud" of servers that supply applications to clients and provide cloud storage, also known as online storage
- Advantages:
  - Maintenance (e.g., backup, encryption, security) handled by cloud server
  - Hardware upgrades: cloud service will not run out of disk space and can replace failed hard disks without interruption to the user
  - File sharing and collaboration among users from anywhere with Internet connection
- Disadvantages:
  - Access speed: dependent upon the speed of Internet connection
  - File security: dependent upon the cloud service's security procedures

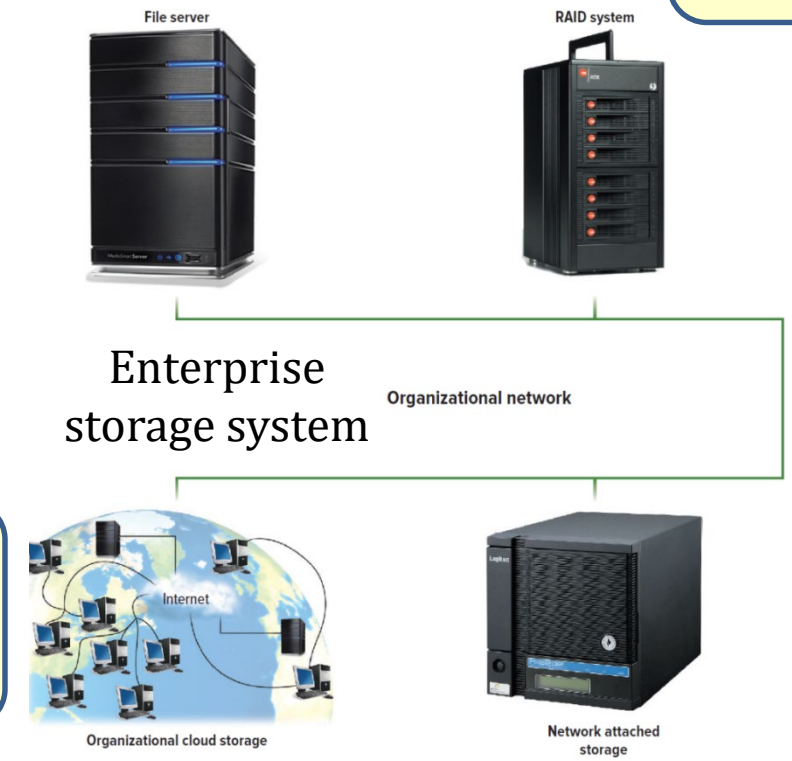


Mass Storage Devices

- 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
  - Centralize maintenance and security of data
  - Reduce costs and personnel

File Servers
- Dedicated computers with very large storage capacities that provide users access to fast storage and retrieval of data

RAID Systems
- Constantly making backup copies of file moving across the organization's networks



Organizational Cloud Storage
- High-speed Internet connection to a dedicated remote storage facility

Network Attached Storage (NAS)
- A type of file server that is less expensive, easier to set up and easier to manage than most file servers but does not include powerful management tools and features

Lesson Summary

- Computers are electronic devices that can follow instructions to accept input, process data, and produce information. They include input devices, output devices, system unit and secondary storage working together
- Input devices are hardware used to translate words, numbers, sounds, images, and gestures that people understand into a form that the system unit can process
- Output devices are any hardware used to provide or to create output. They translate information that has been processed by the system unit into a form that humans can understand
- System unit is a container that houses most of the electronic components that make up a computer system
- Secondary storage can be used for reading and writing data in a non-volatile way

Reading

- Computing Essentials 2019
  - Chapters 5, 6, 7

Reference

[1] HowStuffWorks.com – How Computer Mice Work

- http://computer.howstuffworks.com/mouse.htm

[2] HowStuffWorks.com – How Scanners Work

- http://computer.howstuffworks.com/scanner.htm

[3] Wikipedia - Computer display standards

- http://en.wikipedia.org/wiki/Computer_display_standard

[4] HowStuffWorks.com – How Laser Printers Work

- http://computer.howstuffworks.com/laser-printer.htm

[5] HowStuffWorks.com – How Inkjet Printers Work

- http://computer.howstuffworks.com/inkjet-printer.htm

Reference (cont.)

[6] Vic Fay-Wolfe - How Computers Work: The CPU and Memory

- http://homepage.cs.uri.edu/faculty/wolfe/book/Readings/Reading04.htm

[7] Wikipedia - Multi-core Processor

- http://en.wikipedia.org/wiki/Multi-core_processor

[8] HowStuffWorks – Hard Disk

- http://computer.howstuffworks.com/hard-disk.htm

[9] HowStuffWorks - CD

- http://computer.howstuffworks.com/cd.htm

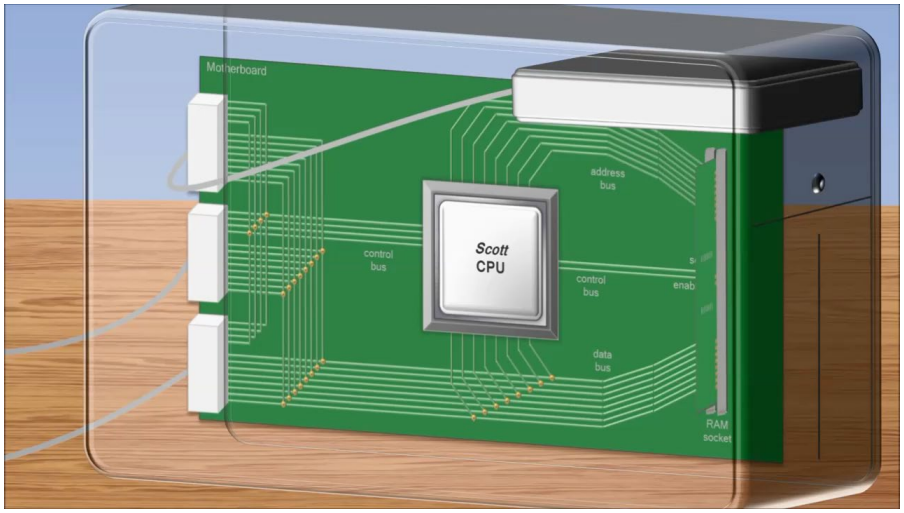
[10] Videohelp - DVD

- http://www.videohelp.com/dvd

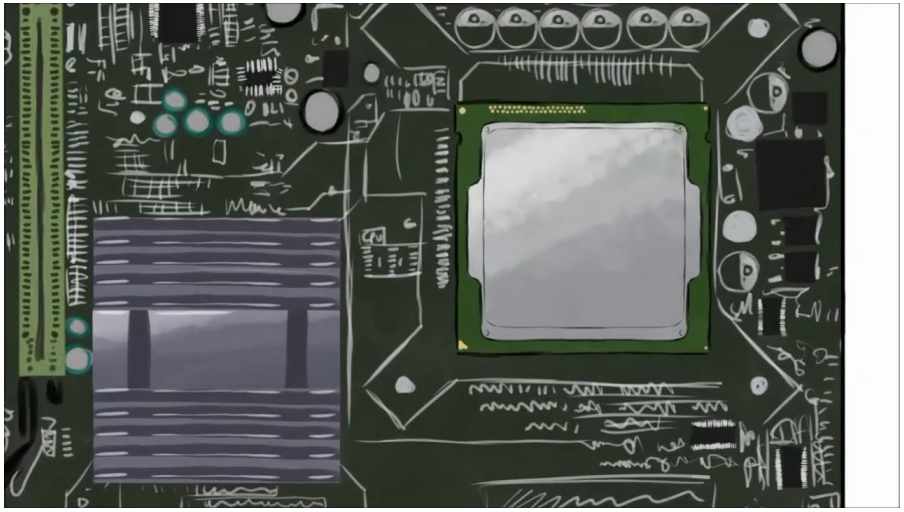
[11] HowStuffWorks – Solid State Drives

- http://computer.howstuffworks.com/solid-state-drive.htm

Video



How a CPU works
https://www.youtube.com/watch?v=cNN_tTXABUA



How computer memory works
https://www.youtube.com/watch?v=p3q5zWCw8J4