Computer Basics

Introduction

Steve Jobs explained that a computer is like a bicycle for the mind: https://www.youtube.com/watch?v=2hXSfS1i4jU. By that he meant computers can act as a tool for our minds that makes humans perform much better like a bicycle makes people able to move faster and more efficiently than any other animal.

Computers are everywhere these days. It is almost easier to ask what is not a computer. Computers are not only our desktop computers and laptops but also our cell phones and tablets. Computers are in our ovens, cars, watches and many other devices in our lives. Many of these connect to the Internet which is known as the "Internet of Things".

I want to explain some of the basic things about computers so you can understand a bit about how they work and some of the terms and TLA's (three letter acronyms) that are so popular in the computer field.

So at a high level, what is inside a computer? At a very high level, a computer is made up of three types of things:
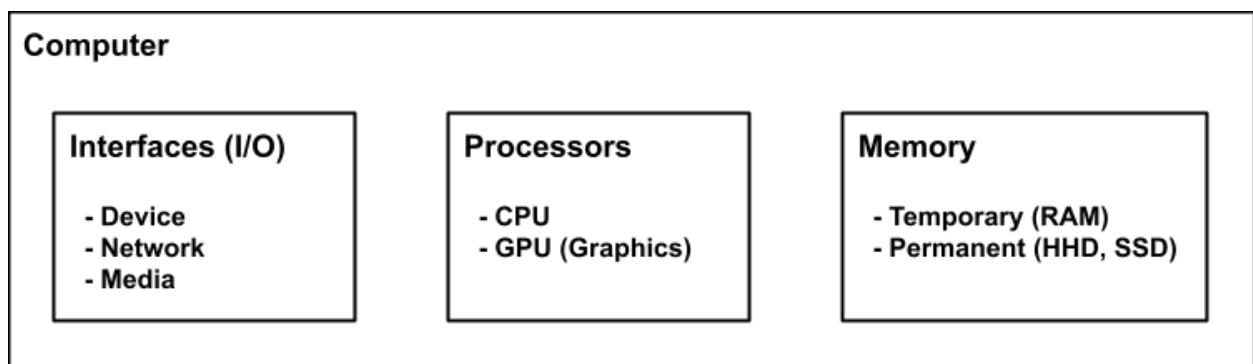
Processors

Most computers have a **CPU** or Central Processing Unit. This does most of the work we think of like running programs or "apps" which can do things like add numbers or help you write documents or talk with you.
Many computers also contain a special graphics processor called a **GPU** which is used to speed up display processing.

Memory

There are basically two types of memory in a computer. Permanent memory is not lost when the computer is turned off. This can be a spinning magnetic Hard Disk Drive (**HDD**) or a memory chip called a Solid State Disk (**SSD**). Many Modern computers use solid state disks which are like a giant thumb drive. These are much faster that the hard drives which were common in earlier computers.

SSD memory is more expensive than HDD so desktop computers and inexpensive laptops use a HDD or a combination of both hard drives and solid state devices. Portable computers like tablets and cell phones use solid state disks to save space.

Temporary memory is very fast but is not saved when the computer is turned off or powered down. It is normally called Random Access Memory (**RAM**). It is normally much smaller than the permanent memory in a computer. For example, a typical laptop might have 4 or 8 gigabytes (billions of characters) of RAM and 256 or 512 gigabytes of HDD or SSD (or more).

When you start a program, the processor (CPU) loads the program from the permanent storage and puts it into the temporary or RAM storage. It stays there until you quit the program. This is why starting up a program can be a bit slower than reactivating it.

Data Sizes

Memory is measured in bytes which roughly correspond to characters. Computers use a system of ones and zeros called "binary" to store data.

We normally use numbers where each digit has ten values (0, 1, 2, 3, 4, 5, 6, 7, 8, or 9) but in a computer each digit has two values (a 1 or 0). For our normal (base 10) numbers the digits (going right to left) are 1s, 10s, 100s, 1000s, etc. Binary digits go up by factors of 2: 1, 2, 4, 8, 16, 32, 64, 128, 256, etc. but the concept is the same.

Computer terms for data sizes use the metric system:

- Byte (B) - 8 bits (1 character)
- Kilobyte (KB) - thousand bytes (1,000 characters)
- Megabyte (MB) - million bytes (1,000,000 characters)
- Gigabyte (GB) - billion bytes (1,000,000,000 characters)
- Terabyte (TB) - trillion bytes (1,000,000,000,000 characters)

Computer memory is often measured in the binary versions of these terms which are slightly bigger but the normal definition using the decimal system is close enough for most uses.

- KB = 1,024 bytes
- MB = 1,048,576 bytes (1024 KB)
- GB - 1,073,741,824 bytes (1024 MB) and
- TB = 1,099,511,627,776 bytes (1024 GB)

Common uses of these terms:

- Bytes: text messages, short email messages without attachments
- Kilobytes: larger email messages, documents, small images
- Megabytes: images, short videos
- Gigabytes: long videos
- Terabytes: often used to measure larger disks

A byte (8 bits) can have up to 256 values and is normally used to store one alphanumeric character (in English) along with punctuation characters. Characters in other languages can take multiple bytes.

Cell phones and cameras measure their resolution in Megapixels (millions of pixels or points). This is the height of the image (rows of dots) multiplied by the width (columns of dots).

Each pixel is actually 3 bytes of data in an uncompressed form (a byte of red, green and blue) but images are normally stored in compressed data file format like JPEG (.JPG) or Portable Network Graphics (.PNG) which makes them much smaller.

Data Transfer Rates

Data transfer rates measure how fast data can move from one device to another. This is often measured in **Mbs** or megabits per second. A megabit is a million bits and there are eight bits per byte (roughly a character). This means that if your Internet connection is 10Mbs you can transfer up to 1.25 Mb (megabytes or million characters) in a second. There is some overhead involved so the actual transfer rate will be less.

For example, you can measure your Internet speed with an app or a website like **https://www.speedtest.net** which will send data back and

forth between your device and a server on the Internet. It measures three speeds:

- Ping - how fast your computer can make a connection to the remote server. This is measured in milliseconds (Ms) or millionths of a second.

- Download - how fast you can transfer data from the remote server to your computer

- Upload - how fast you can transfer data from your computer to the remote server

Most Internet connections have much faster download speeds than uploads speeds. They are set up this way because most of the time you are downloading data (particularly large data files) rather than uploading them. This can happen when you are watching a video, opening a large email attachment or viewing a website with lots of pictures.

Video transfers are often done with a technique called "**streaming**". Rather than download the whole large video file, your computer will start by reading the beginning of the video and then download more of it as you are watching it. In most cases, it does not need to save the video data you have already viewed so you will notice a pause when you go back to an earlier part of a video or move forward to a later section.

Browser programs use two other techniques to display websites faster. The first is to display as much of the webpage as possible as soon as the data is available. This is sort of like streaming for videos. The second technique, called "**caching**" saves the data for web pages in permanent memory in an area called a "**cache**" so that parts of a webpage that have not changed do not need to be transferred from the Internet to your computer. This can help with web pages that have lots of large photos.

Interfaces

Some people describe a computer as basically an input / output machine. It takes in input from various devices (keyboard, mouse, trackpad, microphone, network, etc.) and produces output (via a display, sound, printer, network data, etc.)

The computer interfaces with these devices through interface hardware in the computer. There are several different types:

- Network interfaces
    - Wi-Fi - fast wireless connection to the Internet
    - Ethernet - wired connection to the Internet
    - Cell - cellular connection used by cell phones
    - Bluetooth - used to wirelessly connect to nearby devices

- Device interfaces
    - **USB** (Universal Serial Bus) - for keyboard, mouse, webcams, printers, external storage drives, etc.)
    - Thunderbolt - connection used in Mac computers
    - **HDMI** (High-Definition Multimedia Interface) for monitors

- Media interfaces
    - Audio - for microphones and speakers
    - Video - for internal displays on laptops and other devices

The purpose of the interface is to transfer data between the computer and the device. These devices may be built into the computer like the display, microphone and speaker on a cell phone or laptop. They may be external devices like a USB mouse that connects with a wire or a wireless mouse that connects to the computer via Bluetooth.

Types of Data

As mentioned above, all data in a computer is stored as binary numbers in a specific format. The data format depends on how it is used. It may be simple text (like in an email message) or an image format for a picture or a video format for a movie.

A computer deals with both permanent data (stored in permanent storage) and temporary data stored in temporary storage.

Permanent data is in the form of files. On a computer, you can see these as icons on your desktop by using a program like Finder on the Mac or File explorer on a PC.

There are many types of files:

- Applications ("programs" or "apps") - contains computer instructions for running a specific program, e.g. Chrome.

- Folders - files which contain other files and folders. All permanent data is stored in a hierarchy of folders and files.

- Application data

    - Word processing (e.g. .DOCX files for Microsoft Word)
    - Spreadsheets (.e.g. .XLSX for Microsoft Excel)
    - Image (.JPG, .PNG, .GIF, .TIFF, etc.)
    - Video (.MOV, .WMV, etc.)
    - Emails (.EML, .MBOX, etc.)
    - Contacts (.VCF, etc.)
    - Web pages (.HTML)
    - *There are many, many other types*

Temporary data can be either active programs or application data that has been loaded into RAM from application files or created by the program.

Copying and Moving Text and Other Objects

Computers also use data in temporary storage called a "clipboard" to save data and move it from one program to another or from one part of a document to another. This is done by the Copy, Cut and Paste functions in most applications. The clipboard can contain text with formatting, images, etc. The data will stay in the clipboard until you do another copy or cut operation so you can paste the same data to multiple places.

Copying data is normally done in four steps:

1. Select the data to be copied
2. Execute the **copy** command in the program
3. Select the location to copy the data to
4. Execute the **paste** command in the program

Moving data is also done in four steps

1. Select the data to be copied
2. Execute the **cut** command in the program
3. Select the location to copy the data to
4. Execute the **paste** command in the program

On desktop computers and laptops, you normally select the data you want by clicking the mouse or trackpad or holding down the mouse button and dragging across the area to be copied. With a two button mouse, the left button is used for selecting things. The right button is used for popping up a menu of functions that apply to what you're currently doing.

On a phone or tablet, selection is often done by double tapping or holding down your finger on the text or other object you want to select. Selection tabs will appear that you can drag to control the area being selected.
On an iPhone these look like lines with a circle on the top and bottom. You start by double tapping on word:
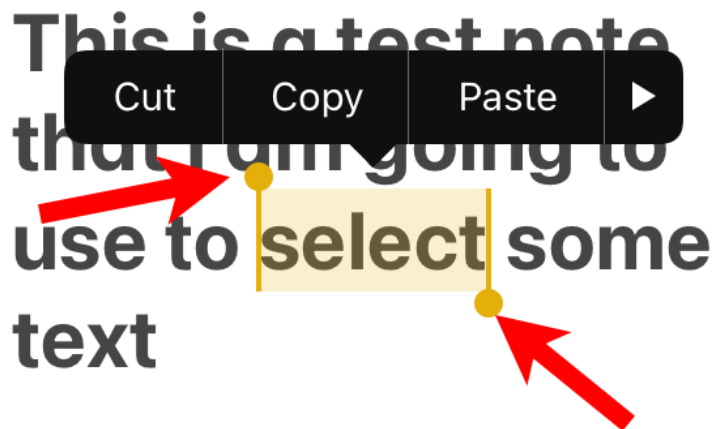

You can then drag the selection markers to expand or contract the section. You move the marker with the circle on top to the beginning of the text you want to select and move the marker with the circle on the bottom to the end and then tap on the "Copy" or "Cut" button in the black bar that appears during this process.

You can also copy links from an email message or documents by long-pressing or holding your finger on the link. The iPhone will show you a preview of the link webpage with options to copy or open the link:
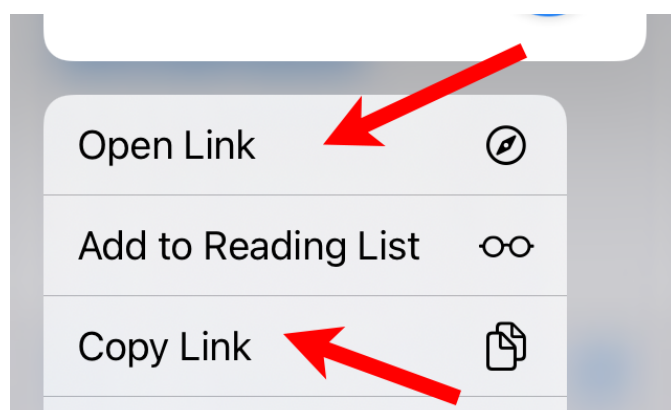
You can then go to where you want to paste the text or link, tap to select a location and a menu will pop up with a Paste button, e.g.:
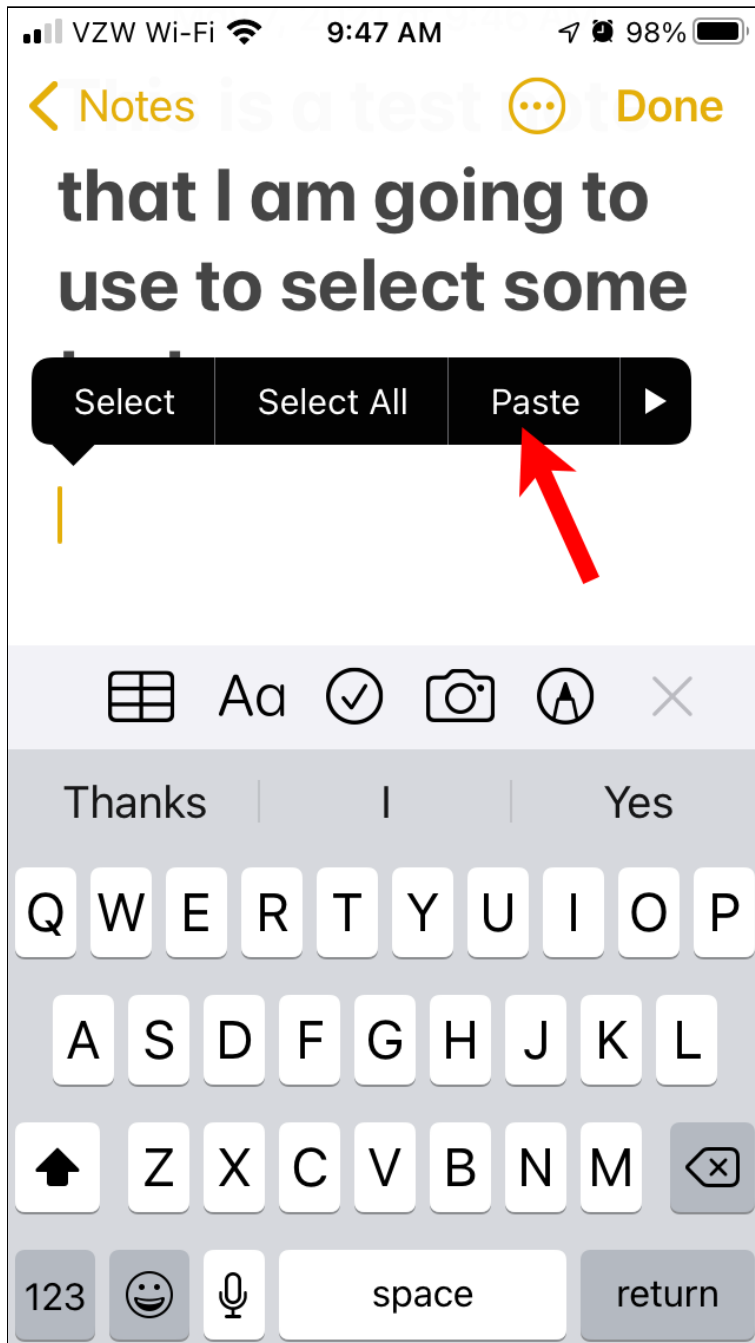
The exact techniques for selecting text and other objects vary from one device type to another. All iPhones and iPads work the same way.

Operating Systems and Application Software

The operating system is computer software that runs in the CPU and manages all hardware and software on the device. The operating system is used to start and stop all application programs. It provides a range of services to the applications like reading and writing data on a network or to and from a storage device along with many other functions.

Some popular operating system today are:

Desktop and Laptop Computers:

- Microsoft Windows - runs on PC computers

- Apple macOS - runs on Mac Computers

- Google Chrome OS - runs on Chrome computers

- Linux - runs on PC and Mac hardware

**Portable Devices (Phones and Tablets):**

- Google Android - runs on android phones and tablets

- Apple IOS - runs on iPhones and iPads

The operating system is the interface between the hardware and the applications. That means that if an application runs on a device with a specific operating system, like Windows 10, it should run on any device that runs that operating system.

Some applications have versions available for multiple operating systems while others do not. Web browsers like Google Chrome and Mozilla Firefox are available on almost all operating systems while there are some

programs that only run on Microsoft Windows or Apple macOS. Some phone apps run only on Android phones or Apple IOS phones and tablets but not both.

Here is a way of thinking about the hardware, operating system and applications:

Browser   Calendar   Phone   Mail   Messages   Maps...
System and Application Software
Operating System
Hardware
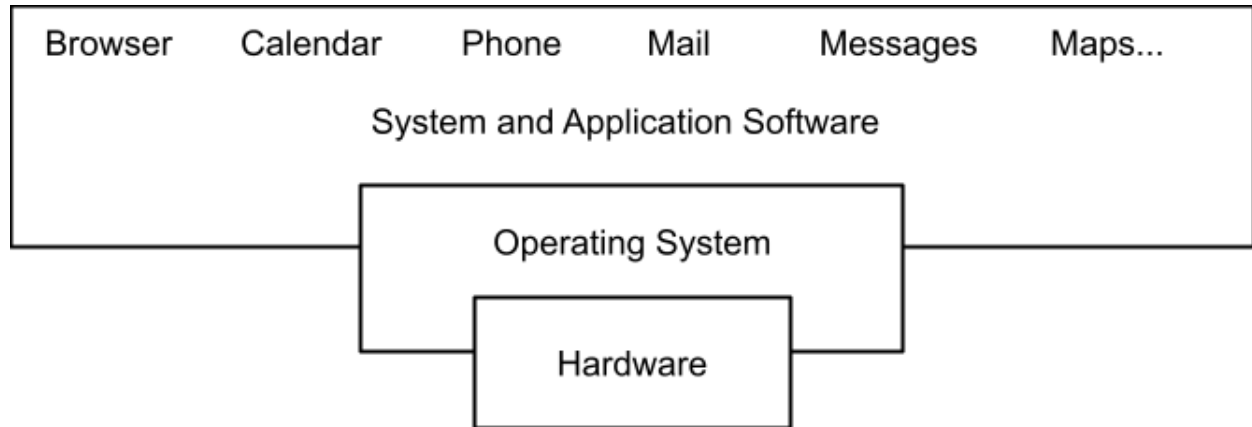
The operating system hides the hardware from the applications and performs all necessary hardware functions for them. The user normally interacts with one application at a time ("the active application"). User input like keystrokes or touches are sent from the hardware through the operating system to the current application.

The other applications can be running in the background and can send you notifications or do other functions. There are various ways of switching between applications depending on the hardware and operating system.

For example, in Windows 10 or macOS, the active window is displayed on top (in front) of the other windows. If you click on one of the other windows it will be brought to the top (in front of the others) and become the active application. You can also click on its icon in the taskbar or dock. There is also a keyboard shortcut for switching between applications (Control / Tab on PCs and Command / Tab on Macs).

On phones and tablets there are several ways of switching between applications, either through gestures, buttons or tapping on the screen.

The simplest way to switch between applications on a phone or tablet is to click the home button, if the phone has one, and tap on the app you want to switch to. On phones and tablets without a home button, there is a gesture (normally swiping up from the bottom of the screen) to return to the home page.

On the iPhone and iPad you can swipe left to view the last active application. On the iPhone this is done by holding your finger down on the left edge of the screen and dragging your finger towards the right. On the iPad, this is done by dragging four fingers to the right right.

On iPhones or iPads you can view all applications you have started by double clicking on the home button or gesturing (normally dragging down from the top left corner of the screen). You can also quit applications when viewing this task display by swiping up on them.

Android phone user interfaces differ in the details between the various manufacturers. There are usually three buttons or icons at the bottom for them: Back, Home and Recent Apps but this varies between different Android phones. The Back button can be used to go back to the last active application. The Recent Apps button shows you applications you have used recently and you can tap on one to switch to it. You can also enable gestures for switching betweens apps. It is best to consult your manual or do a web search for details for your Android phone.

References

So How do computers actually work? Hugo Sanchez
https://medium.com/@SchezHugo/so-how-do-computers-actually-work-911bd3681dbd

File format reference for Microsoft Word, Excel and Powerpoint
https://docs.microsoft.com/en-us/deployoffice/compat/office-file-format-reference

Internet Transfer Time Calculator
https://www.expedient.com/knowledgebase/tools-and-calculators/file-transfer-time-calculator/

Different Type of Computer Cables
https://www.makeuseof.com/tag/computer-cable-types-user/

PC Magazine: Thunderbolt 3 vs. USB
https://www.pcmag.com/news/thunderbolt-3-vs-usb-c-whats-the-difference

PC Magazine: What is Thunderbolt 4
https://www.pcmag.com/how-to/what-is-thunderbolt-4-why-this-new-interface-will-matter-in-pcs-in-2021

Digital Camera Resolutions
https://electronics.howstuffworks.com/cameras-photography/digital/digital-camera3.htm

Camera Resolution Explained
https://photographylife.com/camera-resolution-explained

Image Size Versus Resolution

https://ifactory.com.au/insights/the-difference-between-image-size-and-image-resolution/

How Do Internet Speed Tests Work?

https://www.howtogeek.com/426757/how-do-internet-speed-tests-work-and-how-accurate-are-they/

How much is 1 byte, kilobyte, megabyte, gigabyte, etc.?

https://www.computerhope.com/issues/chspace.htm

How to Copy and Paste Text, Links, and Photos on Android

https://www.howtogeek.com/692515/how-to-copy-and-paste-text-links-and-photos-on-android/

Get around on your Android phone

https://support.google.com/android/answer/9079644?hl=en

PC Magazine: Android vs. iOS: Which Mobile OS Is Best?

https://www.pcmag.com/comparisons/android-vs-ios-which-mobile-os-is-best