# Operating Systems

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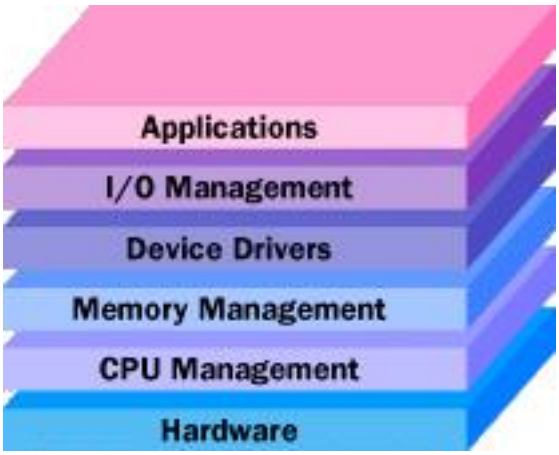
All questions are from the course syllabus (Wilson, 2016).

## Operating Systems Definition

"1. In your own words, please describe what an "operating system" is."

An operating system is the program that controls everything the computer does. This includes running other programs (such as the word processor and Web browser that are currently open to enable this report to be typed), sending information to and obtaining information from peripherals (e.g., printer, external hard drive, monitor, mouse, keyboard, *etc*.), and controlling the computer itself (e.g., allocating Random Access Memory (RAM) to various functions and software being used), storing data in and maintaining the internal hard drive, controlling the central processing unit (CPU), controlling any additional devices connected to the computer, managing the network which allows users to interface with multiple users to access a single device or computer and allows users to access multiple devices/computers (including the Internet/World Wide Web), and maintaining the internal file system so that everything works as seamlessly as possible. The operating system is like the non-physical aspect of the brain that controls everything from feeling happy to making sure our bodies move as well as our physical beings allow.




"The operating system controls every task your computer carries out and manages system

resources." (diagram and quote: Franklin & Coustan, 2000).

Computers can exist physically without operating systems, but they would just take up space without doing anything. It is the operating system that allows a computer to work, given that nothing is wrong with any of the physical aspects of the computer and none of the additional software (i.e., applications) has become corrupted. This report is being typed on a laptop, using a word processing application. The operating system is running in the background. It allocates RAM to itself, the word processing program, the anti-virus application that also runs on this computer, and various additional tasks such as automatic upgrades of the applications the computer is running. The operating system also interprets each keystroke and combination on the keyboard and sends data to the monitor. If I were working on a terminal connected to a multi-user server, a multi-user operating system would be in charge of keeping each user's data separate and allocating RAM and hard disk space to each user. The operating system is often considered to be the most important program on the computer; when it is not working properly, neither is anything else.

The operating system is stored on the computer's hard disk, but it is copied to RAM (Random Access Memory) when computers start up (J, 2012). The central processing unit accesses the operating system directly from the RAM, not the slower hard drive. It is this process that gives the operating system function. When the computer is turned off, the copy of the operating system in the RAM, along with all other data in the RAM, gets destroyed. Since the operating system in RAM is only a copy, and the original remained in the Hard Drive, the operating system remains safe and will be used again the next time the computer is turned on. Before operating systems, the first computers could not preform most of the tasks that we expect from them every time we turn on our computers at home and at work.

## Multiprocessing, Multitasking, and Multithreading Operating Systems

"2. Please compare and contrast the following, including in your answer an actual example of each:

Multiprocessing

Multitasking

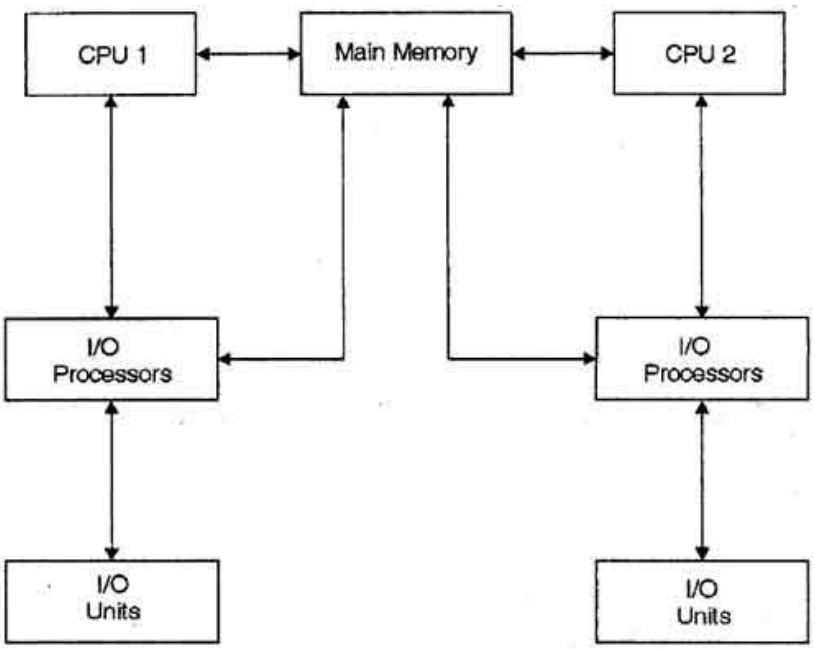
Multithreading"

### Multiprocessing

A multiprocessing operating system is controls two or more central processing units (CPUs) to increase the power and speed of the computer. There may be more than one set of input/output paths, like in the diagram below, or the CPUs may be coupled together to give additional processing power to a single user with only one input/output station. Having multiple CPUs is different from having multiple cores in a single processing unit. Even the small laptop (11" screen) that is being used to type this paper has two cores in its CPU, but it only has one CPU. Computers that need multiprocessing operating systems computers actually contain two or more CPU chips that have to be controlled by the operating system. Some examples of multiprocessing operating systems are the professional version of recent Windows systems, Unix, Linux, and MAC OS X. In recent years, only the professional systems, such as Windows 10 Professional, can support multiple CPUs. "Windows 10 Home (Maximum processor sockets used = 1), Windows 10 Professional (Maximum processor sockets used = 2+)" (Darmilatron, 2015). Some of the past home versions of Windows operating systems, such as Windows XP, could interface with two cores. Additional information about all of these operating systems, as well as additional operating systems, is in the fifth section below.

One configuration used by businesses that run multiprocessing operating systems is

shown in the diagram on the next page (Thakur, no date). In this diagram, the processor works from the main memory (as copied from the hard drive into the RAM – Random Access Memory). The operating system controls two or more distinct




CPUs and input/output (I/O) channels (e.g., workstations that include a keyboard, mouse, monitor, and possibly other devices needed to complete a job). Many other configurations are possible. For instance there might be eight CPUs and forty input/output units or four CPUs and only one input/output system. But all computer systems that use multiprocessing operating systems have two or more CPUs.

"A computer that has two or more free-standing processors connected to the same motherboard is a multiprocessor system," (Stone, 2015). While the operating system needs to be able to recognize and interface with more than one CPU, the physical motherboard to which the CPUs are attached also has to accept and support more than one CPU. The other physical aspects of the computer need to be able to provide for two or more processors, or the multiprocessing operating system will be useless. For instance, there is only room for one CPU inside this laptop and the motherboard can only support one CPU. Although I am using MAC OS X, which can be used for multiprocessing, this laptop will never access that functionality of its operating system. The same goes for my old Windows XP laptop. Multiprocessing operating systems can run

multiple CPUs, but many can also run the typical single chip used by many people, especially in their homes.

**Multitasking**

As the name implies, multitasking operating systems allow the computer to preform two or more tasks simultaneously. Multitasking operating systems can be used in computers designed for one user at a time or for servers used my multiple users. Some examples of multitasking operating systems are Windows, Linux, and MAC OS X (Teach-ICT, no date). Multiprocessing operating systems allocate memory (RAM) and processing power to more than one application at a time to enable background tasks to run at the same time as a primary task and to allow users to quickly access two or more primary processes such as multiple applications. For instance, my computer might be running an antivirus scan, a timer, and a word processing application all at the same time. I also have both a browser window and a word processing application open at the same time; I can switch between the two without ant noticeable delay. My multiprocessing OS allows all of this to happen with out any noticeable interruptions as I type.

Multi-user computer configurations require even more power from their multiprocessing operating systems. These systems have to be able to handle the demands of each user, including background applications, making sure that each user's tasks are preformed without interrupting other users or crossing channels. It would not be good for me to type on a computer terminal that was hooked up to a multi-user multiprocessing server and see someone else's work on my monitor. This type of multiprocessing operating system keeps each input/output chain safe while allowing multiple users to run multiple tasks at the same time.

The mechanism by which operating systems handle multiple processes has changed over time. Early multiprocessing operating systems used a bit of code that scheduled RAM and

processing time to each application, depending on applications being written to voluntarily relinquish priority, thus sharing computer resources. More recently, "preemptive multitasking" has developed in which applications are forced to share, thus eliminating the possibility of one application taking over the computer and not allowing other processes to run on the computer. This has greatly increased multitasking effectiveness and reduced computers' freezing because one process took over then stalled. (The Linux Information Project, 2006)

**Multithreading**

Multithreading operating systems process multiple parts of the same program simultaneously (Bell, 2013 and Multithreading in OS, 2016). Threads are individual request that must be processed. One example of multithreading is the CPU's ability to process the word processor that I am currently using. The word processor accepts my input (keyboard strokes) and places each individual piece of data (letter, number, space, symbol, *etc*.) into the predefined format that I am using while showing me organized output on my screen. The application is also running spelling and grammar checks in the background then underlining words in red for misspellings and green for perceived grammar errors. The application knows that I want it to check for updates weekly, silently runs these checks, then notifies me if there are updates that I need to install. My CPU can process the multiple tasks required in allocating memory to these functions, which is an example of multithreading on the kernel level. A multithreading operating system is required to allow all of these tasks to run smoothly so that all I perceive is that when I type the words appear on my computer screen in my desired format. Some of the operating systems that use multithreading include Windows, Macintosh OS X, Linux, and Unix.

## My Operating System

"3. In the computer system you use personally, does your operating system offer any of the

above. Please explain."

I am using a MacBook Air to type this paper, but I also own a MacBook Pro. Both laptops are currently running MAC OS X 10.11.6 (El Capitan). MAC X can perform all of the above functions: multiprocessing, multitasking, and multithreading. Although this computer only has one CPU (with dual cores), MAC OS X is capable of using multiple CPUs. As previously stated, I regularly use the multitasking and multithreading capabilities of my operating system. I remember my brother's first computer and the first computers I used at work. These computers could do none of these processes. They generally had two large floppy disk drives (5.25 inches), one drive held the current software and the other stored data. Personal computers have come a long way since then. I can now have a browser window open and run a word processing application at the same time (my younger self: what is a browser? window?), which is a common form of multitasking that I use every day. My browser can simultaneously run video, audio, and text aspects of Web sites. I can search on one tab while maintaining Web pages on several other tabs. Multithreading is behind these processes. I can also use a keyboard and a mouse or track pad together (or use the click and movement aspects of the mouse or track pad) to highlight text and make changes (younger self: okay, why do you have a mouse near the computer and are you actually touching it?). In fact, multiprocessing and multithreading seem to be behind almost everything my computer does.

## My Work Computers

"4. In the computer system you might use in your organization, which of the above three activities does your organization operating system offer. (If you do not use any organization or institution computer in your job, then go to your local library or university library, use their computer and answer the question)."

The computers at my school are stand-alone computers that can run as individual units and access the central servers via the Internet or the organization's Intranet. I must be at work, and to access a few of the more sensitive information on the servers via the Intranet. For instance, I occasionally need to download computer software. This is password protected and only accessible at work to prevent people from downloading something such as Microsoft Office onto their home computers (which would be theft under copyright laws and my organization's license with Microsoft). The server needs to be accessed by many people at the same time from throughout the city that I live in, and sometimes from additional locations. To do this, a giant system of mainframe computers is used. This system has to incorporate multiprocessing, multitasking, and multithreading or we would be unable to preform aspects of our work that are centrally located.

Each individual workstation in my school is generally an Apple iMac or a Lenovo personal computer running Windows. We also still have a few older computers that were purchased when Dell had the PC contract instead of Lenovo. All of these individual units have only one core (usually duo cores, but some current quad cores are *finally* being purchased), and they all run systems that regularly multitask and multithread. We have become a computer-based organization, and I could not run current productivity and educational software without multitasking and multithreading capabilities.

## Specific Operating Systems

"5. Please go to the Internet and/or any other sources and present to us a lively summary in your own words concerning the following operating systems. Your answer should look at the features, including the size of the application file, some of the major features that it is known for, a comparison of ease of use, and the manufacturers principle selling point (in other words why

should one choose this or that operating system). Please consider the latest or current version of these 10 systems"

**Apple OS, now known as MacOS**

The current version of the Apple operating system is macOS Sierra (also known as version 10.12) (Apple 2017, b). Apple's key selling point is that their voice interface "personal assistant," "Siri," is now available for computers. Siri can help users multitask by preforming functions while users are doing other tasks, such as typing. For instance, people can now use Siri to send a message while they are typing a document. Siri can also help users find documents just by telling the computer what they are looking for (the name or parameters such as with whom it was shared). Apple also claims to have increased the ease in which Apple computers and Apple mobile devices can share data and expanded ApplePay to the Safari browser on computers. There are also some changes to Apple's photo storage and editing application, "photos," and the ability to save old unused files in "iCloud" so to free up space on the hard drive.

The MAC OS is specifically for Apple computers, but it is a free upgrade if a user has an Apple computer that meets the system requirements. Computers need 2 GB RAM memory and 8.8 GB of hard disk storage space. The computer needs to be at least late 2009 to late 2010, depending on the type of computer (e.g., iMac needs late 2009 or newer, MacBook Air needs late 2010 or newer, etc.). Some aspects of macOS Sierra require more modern Apple computers (Apple 2017, c). macOS Sierra is a free upgrade available from the computer's App Store.

After looking over all of the material, and with my experience in running an Apple computer lab for the past eighteen years, I would never put Sierra on anything that old. We have computers in my school that only have 2 GB RAM and they are constantly freezing when running modern Web sites. I could be wrong, but I do not see how this operating system could be

effective on computers that barely meet the system requirements. There is also the issue of software compatibility. The distributer of some of the software that I use with my students who have severe developmental delays has told me that the software will not be upgraded to run on macOS Sierra. I am hanging on to my iMacs and MAC OS X 10.11 (El Capitan) until they are too old to run the Web sites that my more advanced students use. Right now, I can please both groups of students.

**Microsoft Windows**

The Windows operating system runs on a much wider selection of computers. The current version of Windows is Windows 10. One of its highlights is "Cortana," Windows' voice activated "personal assistant" (Microsoft, 2017 b). Like Apple's Siri, Cortana can communicate across devices, help find files on your computer, and set reminders. Unlike Siri, "Cortana is available for Windows, Android and iOS devices" (Microsoft, 2017). Voice activated personal assistants have improved computer access for people with some types of disabilities, and many non-disabled people really like the convenience, but I keep the one on my phone turned off unless I need it for a specific task. Some of the other selling points include a "dark mode" that makes items on the screen more visible in low light conditions; the ability to control music that is already playing from the lock screen; Windows Hello, that unlocks the computer using facial recognition or your fingerprint; and native support for 4K screen resolution.

Windows 10 can run on many computers that currently have Windows 7 SP1 or Windows 8.1 Update (Microsoft, 2017), provided they meet the system requirements. The minimum system requirements are: processor – "1 gigahertz (GHz) or faster processor or SoC", RAM – "1 gigabyte (GB) for 32-bit or 2 GB for 64-bit" hard disk space – "16 GB for 32-bit OS 20 GB for 64-bit OS", graphics card – "DirectX 9 or later with WDDM 1.0 driver", and monitor

– “800x600”. There is a large amount of fine print on the page that should be read by anyone before purchasing Windows 10 (it is not free). Windows 10 can also be installed on new computers that meet the requirements but do not yet have an operating system.

Like with mac OS Sierra, I would be hesitant about installing Windows 10 on computers that barely meet the system requirements; make sure that the computer is powerful enough to run all needed applications and go on the Web. Who cares if Windows 10 will run on a computer that is so old the user cannot check his or her email. Just like MACs, my school has many old PCs that cannot access the Web sites that teachers want to use in their classrooms.

**Linux**

Linux is an open source operating system that can be used by servers and stand-alone computers. Most versions are free, including many of the complete server packages. Linux’ key selling points are general reliability, fewer viruses and other malware, and system stability even in server versions. “And, on the off chance, one service on the server requires restarting, re-configuring, upgrading, etc… most likely the rest of the server won’t be affected,” (The Linux Foundation, 2017). Linux calls their different variations “distributions.” While most distributions are free, some of the server versions come with support and have to be purchased. For the most part, Linux developers do not require any fee to download their operating systems and install on as many computers as desired. Each distribution is different in how it looks and how it is installed, but Linux offers a comparison at https://www.linux.com/learn/how-choose-best-linux-desktop-you.

Most of the installation interfaces walk the user through the installation process step-by-step. There are also applications that each distribution has available on platforms similar to widely used app stores. The available applications, system requirements, and download

procedures are available from each distribution's developer. This paper will discuss installation in greater depth in the next sections. I have rearranged the list of operating system to place the Linux distributions ahead of unrelated operating systems. An interesting side note is that Linus Torvalds, who initially developed the Linux kernel, had been working on a version of Unix (the last item on the reordered list), 'Minix', when he felt that his ideas for improvements were not being taken seriously and went on to develop the Linux kernel and to actively seek out input from other developers.

**Linux Mint**

Linux Mint is currently on version 18.1 (Linux Mint Institute. (2017). Linux Mint is a distribution of Linux that "works out of the box," supports multimedia, and is user-friendly. Everything is included, no antivirus or antispyware are needed. Linux Mint is free, but there is a donations portal on their Web site for people who want to help financially. Web site ad space also helps pay the bills. Linux Mint encourages user input to help improve the operating system and has a variety of ways that people can provide input and join the community on the Get Involved page on their Web site (https://www.linuxmint.com/getinvolved.php).

"Sarah" Cinnamon has become the most common version of Linux Mint, "Sarah." The following is from the Linux Mint blog (Clem, 2016).

> "**System requirements:** 512MB RAM (1GB recommended for a comfortable usage), 9GB of disk space (20GB recommended), 1024×768 resolution (on lower resolutions, press ALT to drag windows with the mouse if they don't fit in the screen).
>
> Notes: The 64-bit ISO can boot with BIOS or UEFI. The 32-bit ISO can only boot with BIOS. The 64-bit ISO is recommend for all modern computers

(Almost all computers sold in the last 10 years are equipped with 64-bit processors)."

**Ubunto**

Ubunto is another Linux distribution that has both desktop and server versions. There is even a Cloud-based version for mobile devices (Canonical Ltd, 2017). One key selling point of Ubunto is its support of containers for a virtual server experience. To install Ubunto on a desktop computer, the computer would need "2 GHz dual core processor or better, 2 GB system memory, 25 GB of free hard drive space, Either a DVD drive or a USB port for the installer media, Internet access is helpful." Standard server requirements for Ubunto 16.04 LTS are Intel x86, AMD64 or ARM; 1 GHz CPU, 512 MB RAM, 1 GB free space in the hard drive for the basic system or 1.75 GB for the entire package. I was unable to locate system requirements for the cloud-based virtual operating system that is available for mobile devices.

**Fedora**

Fedora is another free distribution of Linux. It is available for individual computers, servers, and Linux-Docker-Kubernetes (LDK) application stacks. Fedora claims to have "less setup, more innovation" (Red Hat, 2017c). The Fedora Foundation is a global community of Fedora users and developers working together. There are also variations of Fedora that are tailored to specific needs. The "Fedora Media Writer" is needed to install Fedora onto individual computers (workstations) (Red Hat, 2017a). Fedora can be downloaded directly from https://getfedora.org/en/workstation/download/ and https://getfedora.org/en/server/download/. The current version of Fedora is Fedora 25. The system requirements for Fedora workstation and server versions are 1 GHz processor, 1 GB RAM, and 10 GB free hard drive space. A USB flash drive with at least 1.3 GB of free space is also needed to house the downloader workstation

downloader. The server downloader can run from a DVD or USB flash drive. Both the workstation and the server downloads can be purchased from outside vendors for users who do not have the ability to download large files and save them onto DVDs or USB drives. Fedora Atomic is available to businesses that want a container-style system and is available from https://getfedora.org/en/atomic/download/.

**Red Hat**

Along with developing Fedora, Red Hat also has its own business-oriented operating system, Red Hat Enterprise Linux (Red Hat, 2017 b). Red Hat claims to be "The world's leading enterprise Linux platform." The current version is for businesses that need support for cloud-based computing. Red Hat is not free, but their main selling point is the "services and support" they provide. Red Had also is available for individual workstations.

Red Hat Virtualization (Red Hat, 2017 d) is another system offered by Red Hook. "Virtualization can vastly improve efficiency, free up resources, and cut costs—without sacrificing performance, security, and existing investments."

I was unable to locate the current version number/name and system requirements on the Red Hat Web site. I found some information elsewhere, but an unsure if it is about the most recent version.

**Google Chrome OS**

Chrome OS was developed by Google for their Chromebooks. All Chromebooks have Chrome OS pre-installed, so there is no concern about system requirements. Chrome OS is designed for individuals who have easy access to the Web; everything is Web-based, including the use of Google's online document tools (Google Docs, Sheets, Slides *etc*.) (Google, 2017 b). People access their work by signing onto their Google accounts. Google's Web-based tools are

available to everyone, but the Google Chrome OS was specifically designed to streamline the process of Web-based productivity. There are also Web-based apps that are designed specifically for businesses and for education. Some Google applications can work off-line on the Chromebook, but the big selling point is a seamless Web experience.

Google Chrome OS and the Google Chrome Web browser share version numbers (Google Chromebook Help, 2014).). I just updated my Google Chrome Web browser and checked the version number; it is version 57.

**Elementary OS**

Elementary OS is the final Linux distribution to be discussed in this paper. One of the first things on the Web page is a donations portal; users can pay what they want then download the software (elementary LLC, 2017 b). I tried $0 and it worked; I received the download button, but I did not actually download the file. Speed and the ability to run on older computers are also highlighted near the top of the page. Elementary OS also has its own app store, AppCenter, which makes it easy to download new apps and update apps already on the computer. Additional highlights are "Open Source," "No Ads. No Spying," and "Safe & Secure."

The current version of Elementary OS is 0.4 Loki (also referred to as Loki 0.4). The minimum system requirements are "Intel i3 or comparable dual-core 64-bit processor, 1 GB of system memory (RAM), 15 GB of disk space, Internet access" (elementary LLC, 2017 a). A USB drive with at least 1.32 GB free space is needed to house the installation file. Separate downloads are available for current users of Windows, macOS, and Ubuntu.

**A Final Linux Note**

A quick search of the Web found at least a dozen articles written by people trying to help potential users decide which distribution (variation) of Linux to pursue. Each distribution is

generally produced and distributed by a different organization or company, but some companies have created more than one distribution (e.g., Red Hat). I would suggest beginning research on the specifics with links Linux Web site itself, https://www.linux.com/what-is-linux (The Linux Foundation, 2017). There is a currently a section to help new users start the choosing process about half way down the page (as of this writing). As mentioned above in the Linux section, desktop users can find some additional information at https://www.linux.com/learn/how-choose-best-linux-desktop-you. The Linux Web site also suggests looking at "the top 100 distributions" at http://distrowatch.com (DistroWatch, 2017). Some Linus distributions offer trial versions. Each person, organization, or company's needs and capabilities are different; and there are a wide variety of Linux distributions to meet those criteria.

**Unix**

The Open Group is a consortium of informational technology leaders from around the world. Among its duties are setting UNIX standards and certifying UNIX vendors (The Open Group, 2017) to ensure UNIX "compatibility across platforms." UNIX was originally developed at Bell Labs in a collaborative effort headed by Ken Thompson and Dennis Ritchie (The Open Group, 2016). The Open Group has been certifying UNIX vendors' products since 1995 to make sure that UNIX vendors maintain The Open Group's Single UNIX Specification standard. The Open Group claims that "procuring UNIX certified systems and software ensures the highest level of availability, scalability, and maintainability for those who of disruption in their global IT environments." UNIX has been used in computers working on everything from ARPANET (which became the World Wide Web) to the human genome project. Currently, The Open Group is also marketing UNIX as the ideal operating system to run Cloud computing environments. The long list of operating systems based on UNIX includes Apple's mac OS Sierra, the first item in

this list of operating systems. There us no unified list of system requirements because each individual operating system has its own requirements.

## Installing an Operating System

"6. Installing an Operating System. In the pdf file How to Install an Operating System, please discuss the following:

a. Why should you research software compatibility, and why is this important.

b. Method 2, #7 mentions that for a Linux installation, you need your hard drive to be formatted in the Ext4 format. What does it mean to format your disk or partition, and what is the Ext4 format??

c. Method 2 #11 mentions "drivers". What are drivers and where can you get them?

d. Look at your printer model or a printer model in the library or in your organization. Assume you just bought a new computer. How and where can you obtain the drivers for your printer. In answering this question, please specify the computer operating system, and identify the specific driver needed for your operating system and printer model. Then state where to find the driver on the internet and give the link where you can download it."

### Software Compatibility

Before installing a new operating system (or updating the current on) on a computer, it is important to make sure that all software that you want to use will run on the new system. As WikiHow (no date) states, Microsoft Office will not run on Linux. There may be appropriate substitutions, but if you need specific software (including games), then you need to make sure that the system you choose runs that software. I've found that the same goes for upgrading. When a new major upgrade comes out, I'm always emailing people in my school to hold off until they are sure that the software they need will either run on the upgraded system or has been

updated itself. There is often someone who does not take my advice then complains that something is not working correctly. I've been a computer teacher for almost twenty years. If I say, "Wait six months, Smart Boards will not run on the upgrade, but Smart is working on it," maybe my colleagues should listen.

**Formatting Disk**

In some installation processes, the hard drive (or a partition) needs to be formatted prior to installing the new operating system. Formatting the hard drive erases all of its contents and lays down a basic code that will allow it to accept data, including a new operating system. Sometimes, formatting is a natural early step in the installation process, but other times I have to format a hard drive before it will accept a new operating system (not needed for general upgrades). It is very important that users back up every important file. I have often had complaints about photos or music being lost because the teacher forgot to save them to an external drive. If a user has an email application that saves emails on the computer, those files also need to be backed up (another common mistake).

Hard drives may need to be formatted using a specific protocol before they can accept an operating system. For instance, if I'm performing a clean installation of a system on an Apple computer (not an upgrade), about 90% of the time everything works as planned and I have a clean hard drive with the new operating system and all applications that have been loaded with the system. The rest of the time, I need to go back, erase the hard drive, format it using "Mac OS Extended (Journaled)," and then attempt the to install the operating system again. According to the WikiHow article, hard drives need to be formatted in the Ext4 format before Linux can be installed. Most Linux distributions use the Ext4 file system; if the hard drive or partition will only have Linux, than it should most often be formatted as Ext4 before the operating system is

installed (Garrison, no date). Ext4 is the fourth version of the "Extended File System" that was created specifically for Linux. Ext4 is a very stable file system with a low risk of data corruption and other problems.

**Drivers**

Drivers are software applications that run peripherals such as printers, scanners, cameras, interactive white boards, *etc*. If you have a device without a driver, that device will not function. Some drivers are included with particular operating systems. Some operating systems try to locate drives. If neither of these is the case, drivers can be downloaded from the device manufacturer's Website. I strongly urge everyone to go directly to the device's manufacturer and not a third-party distributer. Many third-party distributers rely on the honesty of the people who post the drivers. I have even heard of viruses getting through C-Net, which is often considered to be highly reliable.

**Printer Drivers**

The printer in my computer lab is a Lexmark CS510. The lab computers are all Apples and run MAC X 10.11 (El Capitan). Many Lexmark printer drivers are included with Macintosh operating systems, but probably not the CS510 because it is an older (obsolete) printer. The driver I need is on the Lexmark Website at http://support.lexmark.com/index?docLocale=fr_FR&page=content&id=DR22672&locale=en&userlocale=EN_US or by using the search function at http://support.lexmark.com/index?page=driverSupport&locale=EN&userlocale=EN_US. I noticed a couple of interesting things: I had to use the term "Lexmark CS510" instead of just "CS510" in order to get a result, and Lexmark did not make a macOS Sierra version of the driver. I suppose that Lexmark did not update the driver because the printer is obsolete. The

driver's file name is "CS510Series_Print_1.1.0_10.6orLater_forIntel.dmg" and it works on MAC OS X 10.6.8 – 10.11 computers. If I was running 10.12 (mac OS Sierra), I would attempt the driver before getting rid of the printer. Often there is enough backwards compatibility for older drivers to run on newer systems, so it is worth trying. Lexmark has other drivers for older Apple computers and for other operating systems.

## Operating System Emulators

"7. An Operating System emulator allows one operating system to run software meant for another operating system. Please give a specific example of an operating system emulator, describing the software, what it does, and how it allows one operating system to run software meant for another."

One type of an operating system emulator allows Windows to run on Apple computers. A common Windows emulator for MACs is Parallels. Parallels runs Windows simultaneously with the Mac operating system (Parallels, 2017). Once Parallels is purchased and installed on a Macintosh computer, Windows and Windows-only applications can be installed (Windows is a separate purchase). Running Parallels (or any other Windows emulator) will slow down the computer because it has to process the two operating systems, the Parallels emulator, and all open MAC and Windows applications at the same time. But if a user has enough RAM and processing speed, and can afford the extra cost, the convenience of Parallels may out-weigh the hassles of having separate boot partitions (created in Apple's built-in Boot Camp utility) which only allow the computer to run MAC OS or Windows at one time, depending on which partition is the computer's current boot partition (Markman, *et al*, 2015). I do not use either option since I have no need to run Windows on my Apple computer.

## Operating System Emulator Situation

"8. Can you think of what situation or why you might want or need an operating system emulator?"

Sticking with my theme of running a Windows emulator on an Apple computer, I can think of a couple of reasons that an Apple computer user may want run applications that are built for Windows only. Microsoft's Access and Publisher are only available for Windows computers. If a MAC user will be sharing documents created in Access and/or Publisher with Windows users, then similar applications created for MACs may be less convenient than having a Windows emulator. Along these same lines, businesses may require their employees to use specific software that is created only for Windows computers. Another, more fun, reason for a MAC to run a Windows emulator is to play Windows-only games. While many computer games are cross-platform, some are only created for Windows computers. I am not a gamer, but I would assume that it would be cheaper to install Parallels, than to buy a new computer if I wanted to run a game that only runs on Windows. Gamers might do better with a Windows boot partition created in the Boot Camp utility because fully booting into Windows would provide additional speed and power that could be needed by today's multimedia intensive gaming platforms.

## Cross-Platform Capability

"9. From Caleb Curry video, please describe in your own words 'cross-platform capability'."

"When an application is designed to run on multiple systems it, is said to gave cross platform compatibility" (Curry, 2015). Curry uses the example of applications that are designed to run on Linux, which is designed to run on a variety of computers by different manufacturers, without requiring adaptations for each type computer hardware. Cross-platform capability also refers to software that is designed to run on multiple computer systems by interfacing with the

different operating systems ("platforms") instead of directly with the computer. Many applications, such as my Lexmark printer driver mentioned earlier and the word processing program that I am currently using, can run on a variety of operating systems. For example, the Lexmark CS510 print driver is available for Macintosh, Windows, Linux, and Unix operating systems (International. (2000-2017). I can share the same printer among computers using different operating systems because they can all accept a version of the same printer driver. I can also share this Microsoft Word document, without any loss of information or format, with any MAC or Windows user that has the MS Word software (provided I use a common font – font substitutions can disrupt aspects of formatting such as text boxes or the number of pages). I will soon convert this document to a pdf file that has even wider cross platform capabilities and can be read by many more computers without the often expensive MS Word application or MS Office suite.

## Primary Operating System Functions

"10. From the 7-video Shaun Stone set, please describe the primary functions of the Memory Manager, Process Manager, Device Manager, and File Manager. No need to make your answer too complicated, just hit the high points."

### Memory Manager

One task of the operating system is to allocate/deallocate memory (RAM) resources. The memory manager verifies the authenticity of the request, assigns active sections of software code (formally entire applications) to available memory spaces, and removes software that does not have to run at that moment from RAM (Stone, 2013-2014). The memory manager also assigns pieces of currently running software to the hard disk as virtual memory. Because the hard drive is slower, software running in virtual memory will be slower than software allocated to RAM.

For this reason, it is a good idea to have as much RAM as your computer can use and your budget can tolerate. I buy the maximum amount of RAM available whenever I purchase a new laptop, even if it means waiting a year, because I will get more longevity out of computer and it is more cost-effective and less time-consuming than adding RAM later on. My school does the opposite because they always want to maximize the number of teachers who receive new computers (which ends up costing them future money in purchasing addition RAM and/or replacing computers more quickly).

**Process Manager**

The process manager is in charge of allocating jobs and their various processes to the central processing unit (the computer's "brain"), including the CPU's cache (Stone, 2013-2014). The process manager manages "each job as it enters the system" (job scheduler) and each of the multitude of individual processes within those jobs (process scheduler). The device manager needs to allocate processes in a manner that allows everything to run effectively so that no one process can monopolize the CPU, preventing other processes from beginning. To do all of that, the device manager keeps track of the status of each process of the jobs ("hold, ready, run, wait, and finish"). Stone also noted that different CPUs have different clock speeds, but that architecture efficiency and CPU bandwidth are also determining factors in a CPU's processing results. Again, I tend to purchase the most efficient processor available, hoping to get an extra year or two out of the computer, while my school tends to obtain computers with lower end processors to be able to distribute limited resources as widely as possible.

**Device Manager**

The device manager monitors devices, channels, and control units in order to determine the "most efficient way to allocate all of the system devices that are connected to the computer"

(Stone, 2013-2014). The main functions of a device manager are to "1) monitor the status of each device, 2) enforce processes to determine which processes will get a device and how long for, 3) allocation, and 4) deallocation. The device manager does the same job for devices that the process manager does for applications. It makes sure that there are no stoppages of information to and from each connected device and that all device processes work as effectively as possible. Device managers work with dedicated devices that process individual jobs one at a time, shared devices that are accessed by multiple processes simultaneously by interweaving the processes' requests, and virtual devices that are a combination of the two and use techniques such as spooling to determine the order of the processes. Device managers also need to control a wide variety of storage devices. At various times, my computers at work may be connected the printer, a camera, a camcorder, a USB flash/thumb drive, an external CD/DVD RW drive, an external hard drive, an iPad, or an interactive white board (e.g., a Smart Board), a keyboard, and a mouse, and possibly adaptive students used by my students with more severe disabilities. I rarely have more than four devices attached to my computer at a time, but I do keep a few USB hubs (yet another device) in my file cabinet just in case the need arises.

**File Manager**

The file manager oversees all of the files on the computer, including setting permissions for who can view, write to, and use each file (Stone, 2013-2014). Files include data, installed applications, compilers, and program files. Similar to the other managers, the file manager has four duties: keeping track of the storage location of each file, using a policy to determine the method of file storage, allocating files to approved users, and deallocating files. It is the file manager that gave me permission to use the word processor, found and retrieved the application and document files (allocation from storage), allowed me to see this document (read), allowed

me to make changes to the document (write), and will put the modified files back into storage when I am finished (deallocation). This example is a bit simplistic, but it basically demonstrates some file manager tasks.

## Mobile Operating Systems

Mobile devices are being used more frequently in educational settings. They are also being used as assistive devices for people with some types of disabilities. I added a blog about Apple's iOS (Apple, 2017 a) and Google's Android (Google, 2017 a) operating systems to my WordPress Web site (https://jeannestorkspecialeducationinstructionaltechnology.wordpress.com/2017/03/16/mobile-operating-systems-ios-and-android/) because they are outside the realm of this paper.

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