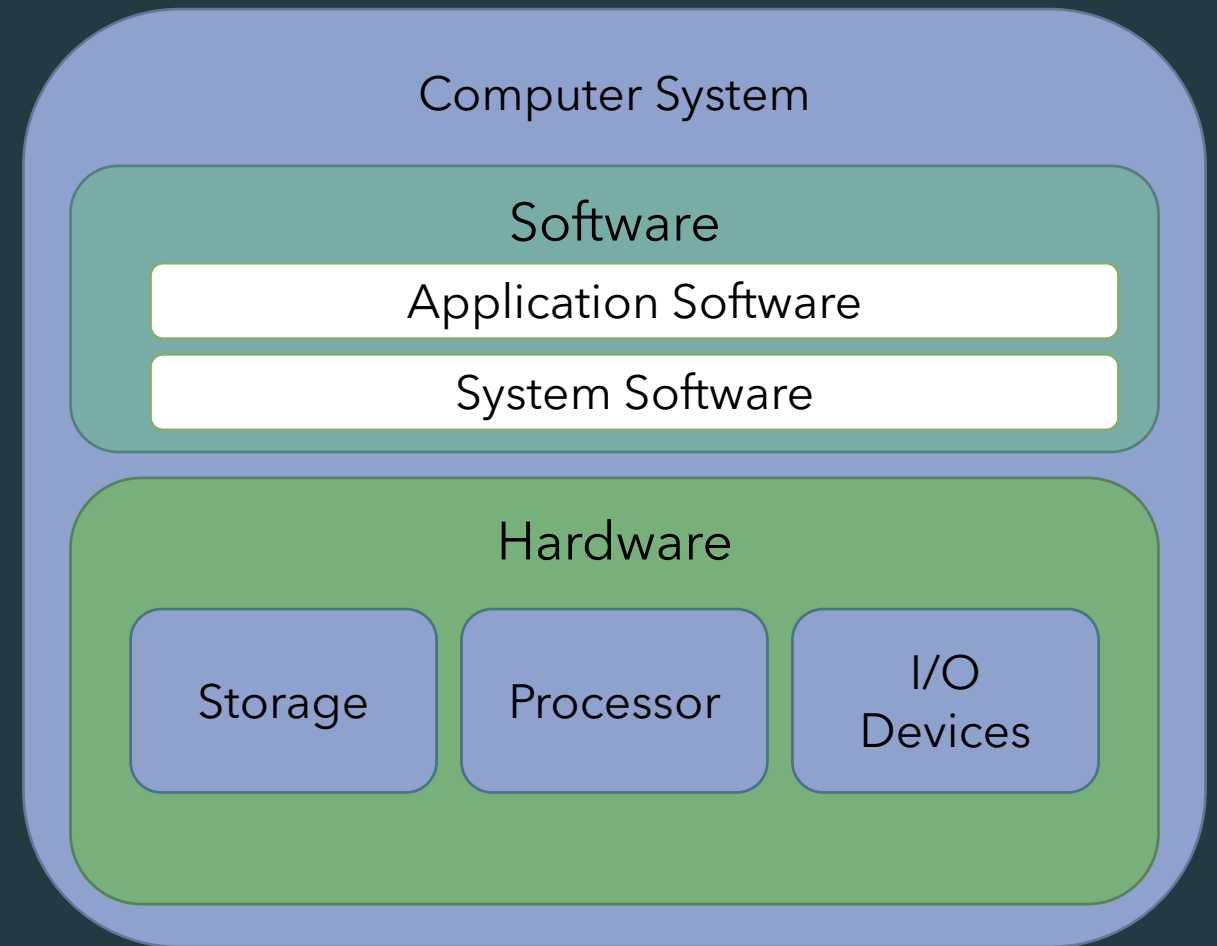




Computer Software (System Software)

Recall

- A computer needs software to perform a complex translation process that bridges two gaps:
 - Translate human native language to binary computer language
 - Convert a high-level task request from a human to low-level detailed instructions for the CPU to produce a result
- Computer software includes:
 - System software
 - Application software





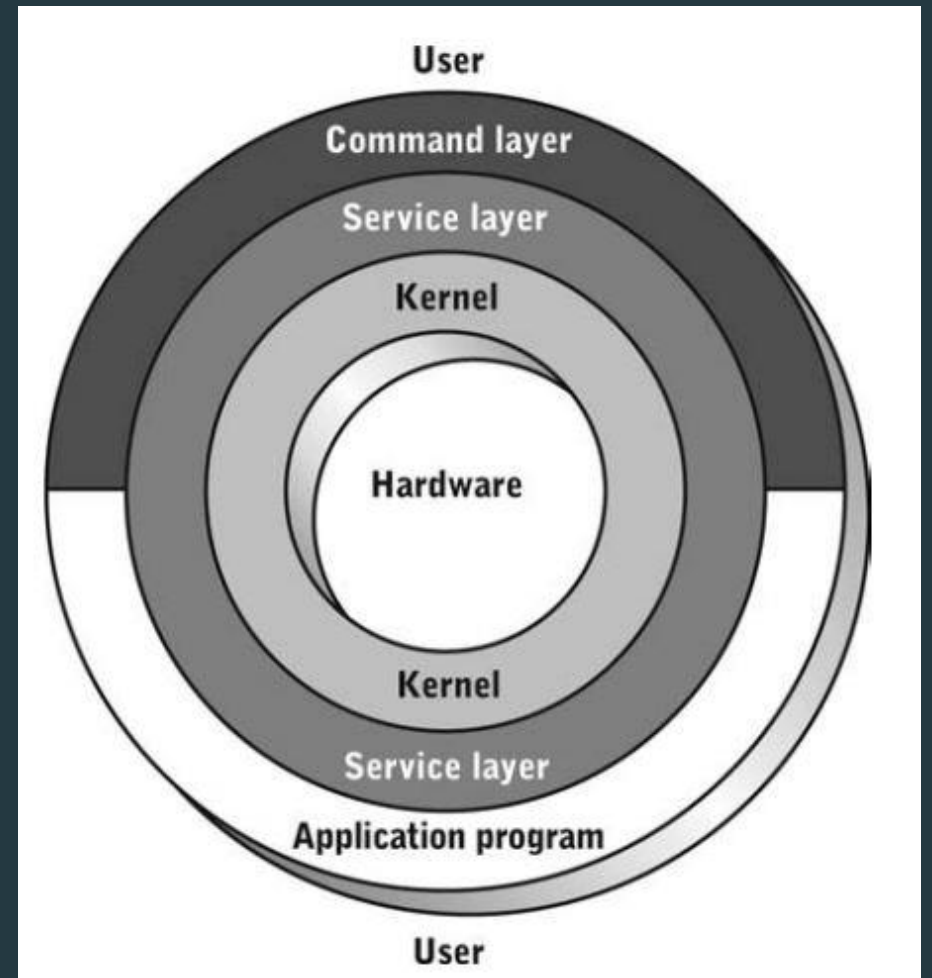
Operating Systems

Operating Systems

- The **operating system (OS)** is the most important software component installed on any computer system
- Performs low-level tasks on behalf of users and application programs
 - Manages the computer's hardware, including the processor, memory, and storage devices, as well as peripheral devices such as the printer
 - Provides a consistent means for application software to work with the central processing unit (CPU)
 - Is responsible for the management, scheduling, and coordination of tasks

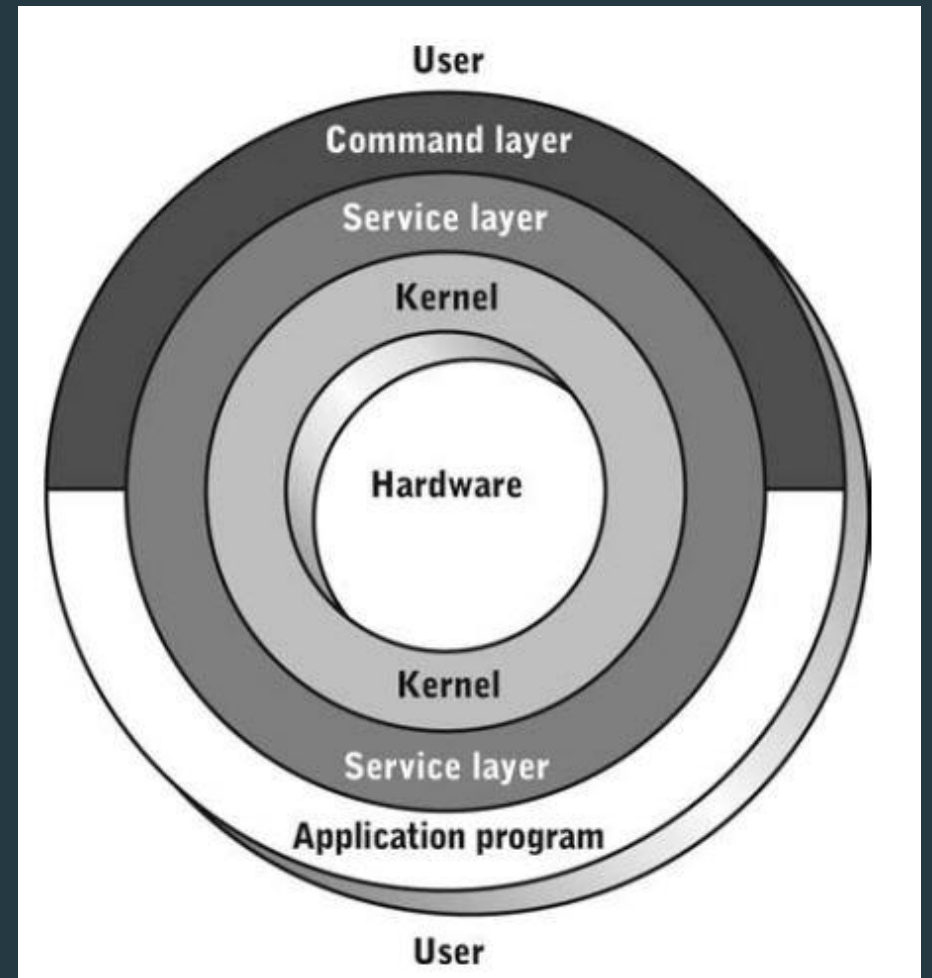
Operating System Layers

- An OS is organized internally into layers
 - Makes OS easier to maintain because functions in one layer can be modified without affecting other layers.
 - Outermost layers provide services to application programs or directly to end users.
 - Innermost layer encapsulates hardware resources for controlling and managing access

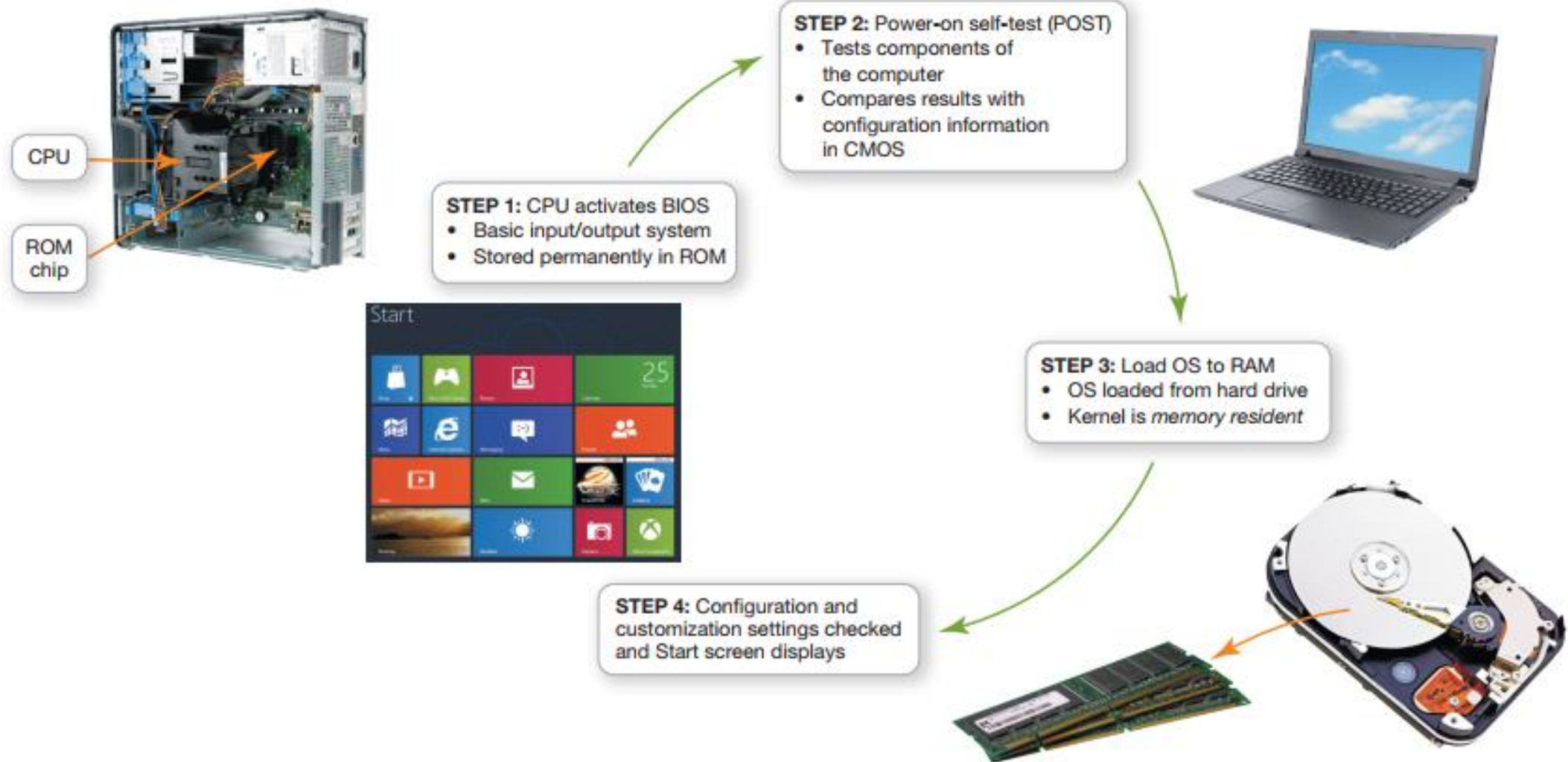


Operating System Layers

- The **Command Layer** is the user interface to the OS through which a user can run applications and manage system resources,
- The **Services Layer** contains reusable components that provide basic operations (e.g. file and folder manipulation, I/O access, starting and stopping programs) accessible through **service calls**
- The **Kernel** manages resources and interacts directly with computer hardware



Boot Up Process



Boot Up Process

- Step 1: Activating BIOS
 - The CPU activates the **basic input/output system (BIOS)**, a small program stored in ROM on the motherboard that manages the exchange of data between the OS and all the input and output devices attached
- Step 2: Performing the POST
 - BIOS performs the **power-on self-test (POST)** to ensure that essential peripheral devices are attached and operational

Boot Up Process

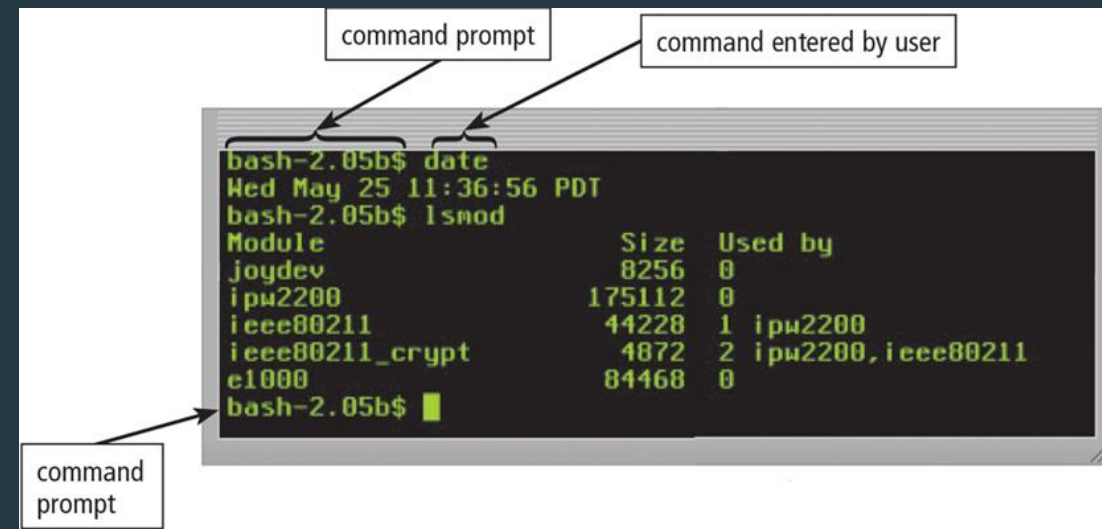
- Step 3: Loading the OS
 - BIOS goes through a preconfigured list of devices to search for the drive that contains the main files of the OS (**system files**)
 - The kernel of the booted OS is loaded into RAM and the OS takes over control of the system
 - In systems that have more than one OS installed (e.g. **dual boot**), the BIOS follows its **boot priority** to determine which OS to load into RAM.
- Step 4: Applying further configurations and customizations
 - Once booted, the OS loads any software settings and user configurations



OS Functions

User Interface

- The user interface (UI) provides a means through which a user can run applications and utility programs, and manage system resources.
- The UI can be implemented as:
 - A **graphical user interface (GUI)** allows interaction using menus and visual images
 - A **command line interface (CLI)** accepts user input using commands represented by short keywords or abbreviations



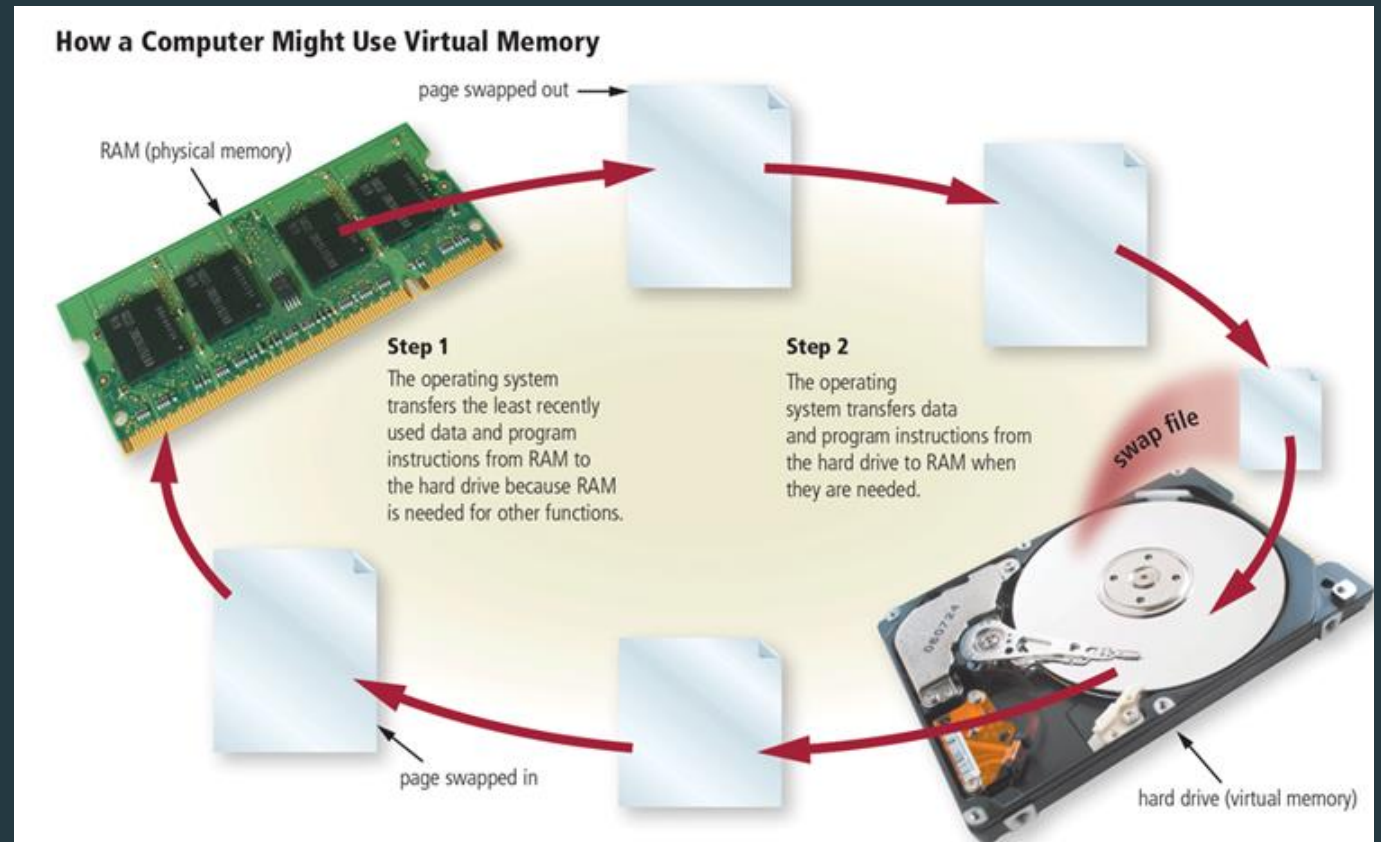
Memory Management

- Memory management optimizes the use of the computer or device's internal memory
- The only portions of a program that must be in RAM at any point during execution are the next instruction to be fetched and any data it is using.
- Most OS minimize the amount of code and data stored in RAM at one time, so that the remaining space in memory can be used by other programs
- **Virtual memory** is a portion of a secondary storage functioning as additional RAM

Memory Management

- Virtual memory management

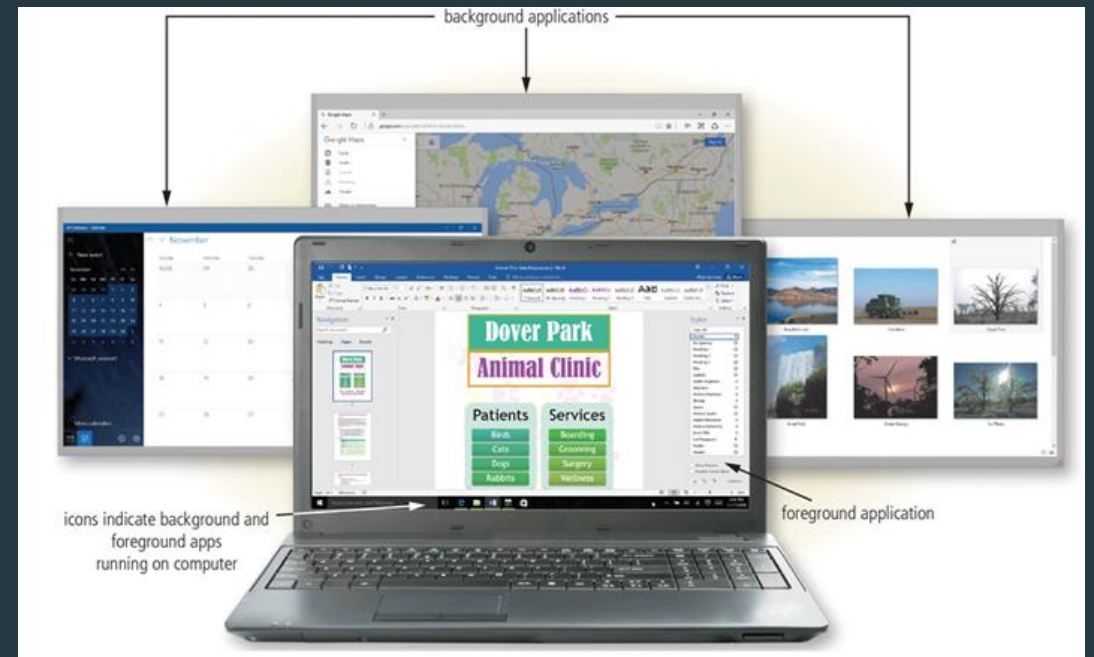
- Divides a program into fixed-size portions called **pages**.
- A reserved area in secondary storage, called the **page file** or **swap space** is used to temporarily hold program pages that are not in use during program execution.
- The OS regularly moves program pages between RAM and the page file as needed



Task Coordination

How an operating system handles programs directly affects your productivity

- **Single tasking** (run 1 program at a time) or **multitasking** (run multiple programs simultaneously)
- **Foreground** (run with user interaction) and **background** (run without user interaction)
- **Single user** (serve 1 user at a time) and **multiuser** (serve multiple users simultaneously)

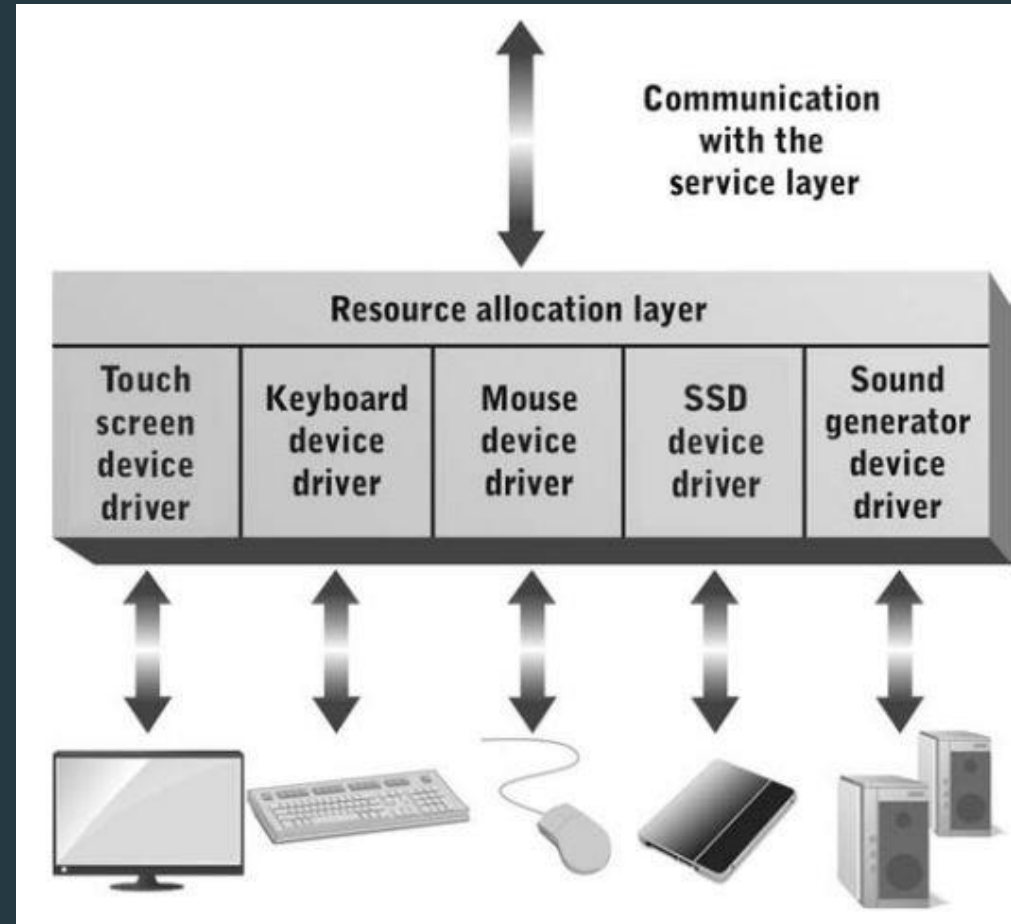


Task Coordination

- The operating system determines the order in which tasks are processed.
- A multitasking OS allows multiple programs to share computer resources within a timeframe
- Programs and devices use **interrupts** to signal to the OS that they require resources
- The **OS scheduler** makes rapid decisions to determine which program receives resource control and for how long control is retained based on their **priority**.
- The ability to quickly switch between different tasks and allow them to appear as if they were occurring at the same time gives an OS its **multitasking** capability

Device Configuration and Control

- A **device driver** is a special program that allows the OS to control a device by translating the device's specialized commands into commands the OS can understand, and vice versa.
- **Plug and Play (PnP)** automatically configures new devices as you install or connect them
- Non-PnP devices require their drivers to be manually installed by the user





Types of OS



Types of Operating Systems

- There are different categories of OS depending on the type of computer system they are used on and the kind of usage they are suited for

| Category | Popular Examples |
|-----------|---|
| Desktop | Windows macOS Linux |
| Server | Windows Server macOS Server UNIX Linux |
| Mobile | Google Android Apple iOS Windows (Mobile Edition) |
| Real Time | Contiki OS VxWorks Windows Embedded |

Desktop Operating Systems

- A **desktop operating system** typically has the following characteristics:
 - Serves a single user at a time
 - Runs on personal devices like laptops and desktop computers
 - Runs with a GUI by default
 - Contains user application software (e.g. browsers, games, productivity software)

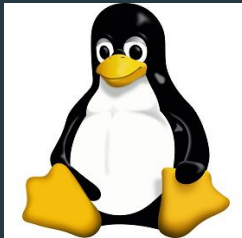
Some Desktop Operating Systems



- **Windows** is the most popular desktop OS known for its customizability and support from a wide selection of software



- The Macintosh operating system (**MacOS**) has earned a reputation for its ease of use and runs exclusively on devices made by Apple computer



- **Linux** is an open source OS with several variants available and is known for its versatility in working on different types of computer systems (desktops, servers, embedded systems)

Server Operating Systems

- A **server operating system** typically has the following characteristics:
 - Serves multiple users simultaneously
 - Runs on servers and mainframes
 - Contains software that provide services commonly through a network (e.g. web hosting, file hosting, etc)
 - Often managed by a dedicated **system administrator**
- Windows, macOS and Linux have their own server versions

Mobile Operating Systems

- A **mobile operating system** typically has the following characteristics:
 - Runs on mobile devices and consumer electronics
 - Built to be more power-saving
 - User interface design optimized for touch screens

Some Mobile Operating Systems



- **Android** is an open source, Linux-based mobile operating system designed by Google for smartphones and tablets



- **iOS**, developed by Apple, is a proprietary mobile operating system specifically made for Apple's mobile devices



- **Windows (Mobile Edition)**, developed by Microsoft, is a proprietary mobile operating system that runs on some smartphones

Real-Time Operating Systems

- A **real-time operating system** or **RTOS** typically has the following characteristics:
 - Runs on machinery that perform repetitive series of specific tasks in an exact amount of time (e.g. vehicles, automated factories, appliances)
 - Require minimal user interaction; hence usually no UI
 - Designed to respond very quickly to external events



Utility Programs

Utility Programs

- Utility programs perform a special functions and can be obtained as part an OS or installed as standalone programs

Power
Management

Display
Utilities

Application
Management

File
Compression

PC
Maintenance

Backup and
Restore

Power Management

Power management utilities allow a user to enter different modes of computer operation.

- **Sleep mode** saves any open documents and running programs or apps to RAM, turns off all unneeded functions, and then places the computer in a low-power state
- **Hibernate mode** saves the state of any open documents and running programs, and all contents of RAM to secondary storage before removing power from the computer or device

Display Utilities

Display utilities often provide the following:

- Personalizing of the look and feel of the OS GUI through colors, backgrounds and themes
- Customizing lock screens and screensavers

Application Management

- **Application management utilities** provide a menu to:
 - Enable / disable OS features
 - Install / Uninstall application software
 - Update the OS and application software
- Examples:
 - Programs and features (Windows)
 - Package managers (Linux)

File Compression

- **File compression** utilities can make a large file more compact to occupy less storage or allow them to be easier to transfer
- How does file compression work?
 - Some compression programs look for repeated patterns of data , replace them with a shorter placeholder, and store the placeholders with their corresponding patterns in a **dictionary** (often used for documents or software)
 - Some compression programs remove parts of the file that allow the file to still be opened with some data loss that humans do not easily perceive (often used for images, video and music)

System Maintenance

- **System maintenance utilities** perform a wide variety of general control tasks over the OS
- Examples:
 - Recycle bin - temporarily holds deleted files
 - Disk cleanup - removes temporary Internet files to free up storage
 - Task / process managers - allows monitoring and forced stopping of running software
 - Disk Defrag - reorganizes data on hard drives so that they occupy continuous sectors for faster retrieval

Backup and Restore

- **Backup and restore utilities** create an image of the current disk contents including the OS, applications, and user files so that they can be later used to recover the system in case of failure

Summary

- An **operating system** is a system software that manages a computer's hardware resources and allocates them to users and applications as needed
- An OS has 3 layers: **command layer**, **services layer**, and **kernel**
- During bootup, a computer loads the BIOS, performs a POST, loads the OS then finally applies user and software configurations
- An OS performs a wide variety of functions, including: memory, and task management; device control and configuration; and providing a UI.

Summary

- An OS may provide a **graphical user interface (GUI)**, **command line interface (CLI)** or both for user interaction
- The **OS scheduler** allows the OS to switch between and allocate system resources to various running tasks
- **Device drivers** are software that allow an OS to control computer hardware
- **Virtual memory** extends memory capacity by allocating space in secondary storage and using this to hold parts of running software that are not immediately in use

Summary

- OS are generally categorized as desktop OS, server OS, mobile OS and real time OS
- Utility software provide additional functionality to an OS. Some common types are: power management, display , application management, system maintenance, file compression, and backup and restore programs