16th Edition

Understanding Computers

Today and Tomorrow

Comprehensive

Chapter 5

System Software: Operating Systems and Utility Programs

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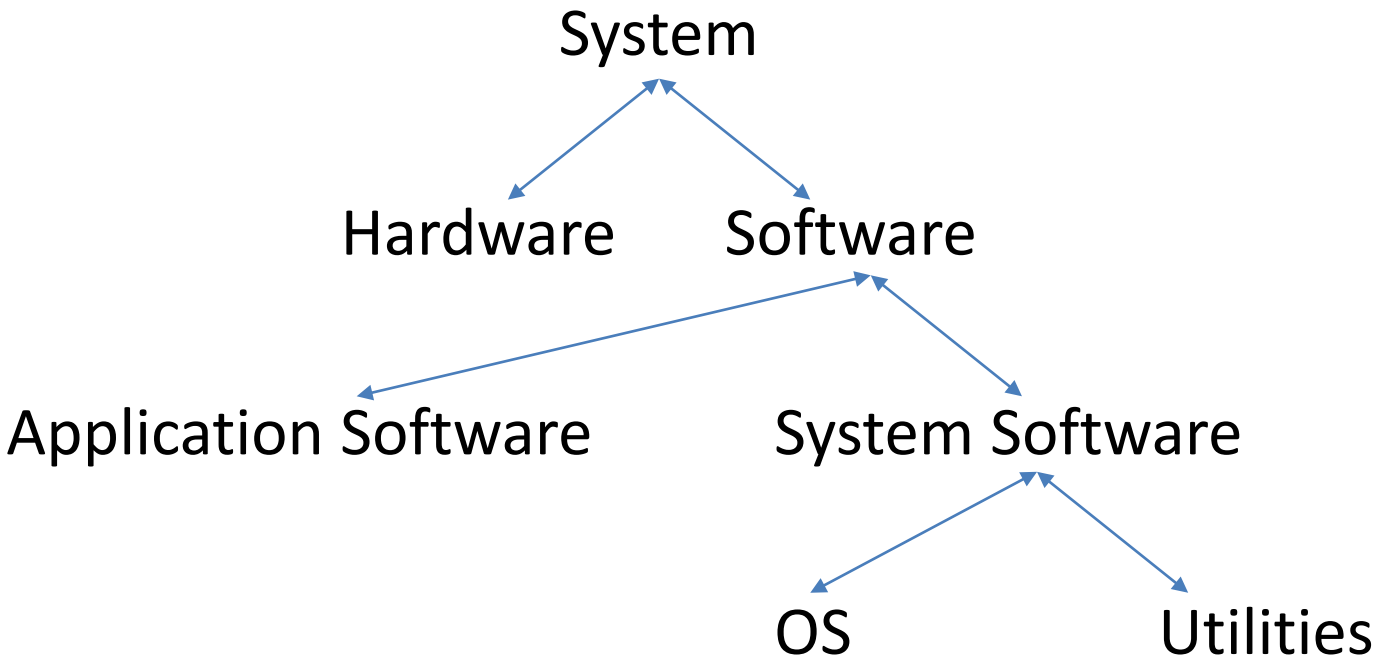
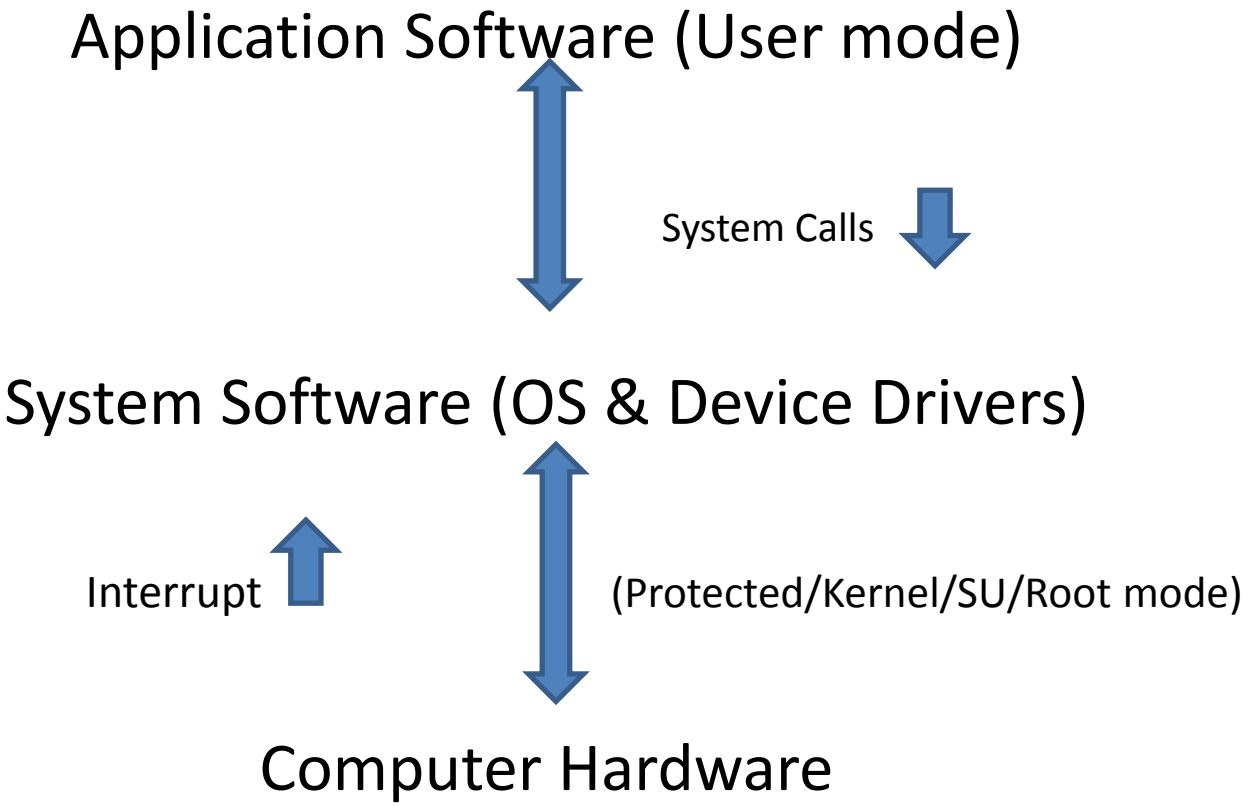
Classification Big Picture



Architecture Software Stack



System Software vs. Application Software

- **System software** refers to the operating system and utility programs that control a computer system and allow you to use that system
  - Enables the boot process, launches applications, transfers files, controls hardware configuration, manages files on the hard drive, and protects from unauthorized use
- **Application software** refers to programs that allow a user to perform specific tasks on a computer
  - Word processing, playing games, browsing the Web, listening to music, etc.

The Operating System

- A computer's **operating system** is a collection of programs that manage and coordinate the activities taking place within a computer *(OS is critical CS knowledge)*
  - Acts as an intermediary between the user and the computer and between the application programs and system hardware *(Abstraction, Transformation, Multiplexing)*

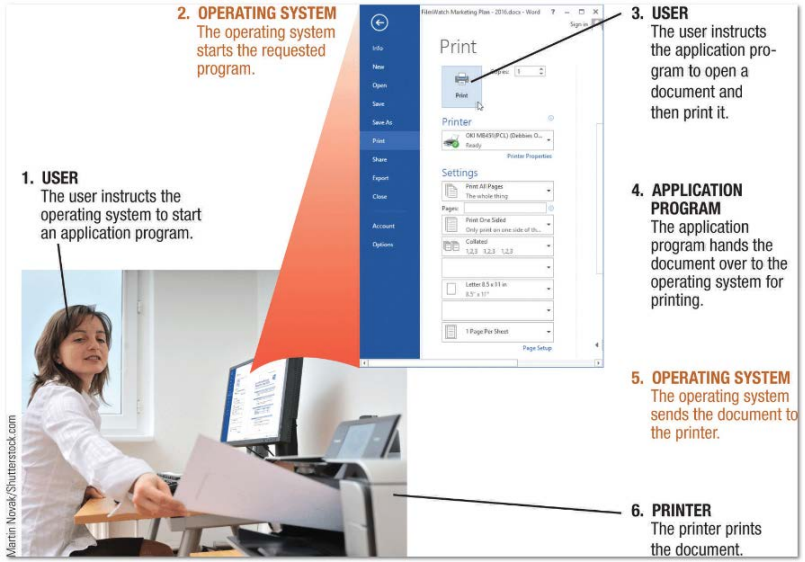


FIGURE 5-1
The intermediary role of the operating system.

Utility Programs

- A **utility program** performs a specific task, usually related to managing or maintaining the computer system
  - Many utilities are built into operating systems (for finding files, viewing images, backing up files, etc.)
  - Utilities are also available as stand-alone products and as suites

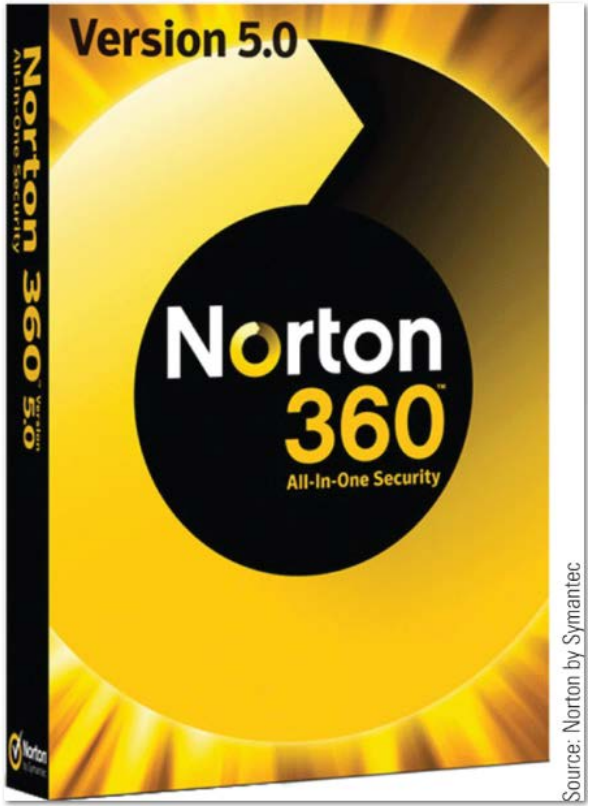


FIGURE 5-20
Utility suites contain a number of related programs.

Functions of an Operating System: Interfacing with Users and Booting the PC

- Interfacing with users (typically via a GUI)
- Booting the computer (BIOS based UEFI next slide)
  1. Power on self test (POST) - Determines the hardware connected to computer
  2. Loads Basic Input/Output System (BIOS)
  3. Loads the essential part of operating system (**kernel**) into memory (uses Master Boot Record - MBR)

Text also states

- Startup programs are launched automatically
  - Windows users can control via the Task Manager
- Other instructions are stored in the Windows registry

UEFI

- Unified Extensible Firmware Interface (UEFI)
  - Windows 10 – UEFI is firmware bootloader passes control to OS
  - Replaces the legacy Basic Input/Output System (BIOS)
    - (BIOS 16 bit)
  - Supports drives over 2 TB
  - Supports 32/64 bit modes Supports graphics
  - Support remote diagnostics and repair of computers, even with no operating system installed

OS Resource Mgmt and Security

OS Manages and monitors resources for problems and tries to correct any that arise

* OS/managers also provide necessary abstraction

1. Device Manager => Device Management
   - Makes resources available to users, programs (agents) & devices
2. Memory Manager => Memory Management
   - Manages processes/resources in memory
3. File Manager => File Management
   - Keeps track of stored files on computer so they can be retrieved when needed
   - Full Path shows folders from root to desired item
     - Fully qualifies/identifies item
   - File extensions indicate type of file*
     - *OS support/implementation varies
4. CPU Manager => Scheduler
   - Manages CPU allocation to processes
5. Security Management
6. Network Management

1. Device Management

- Configuring devices so they operate properly
  - **Device drivers** communicate with peripheral devices
  - Most operating systems look for and recognize new devices each time the computer boots
  - Device drivers can be updated and reinstalled as needed

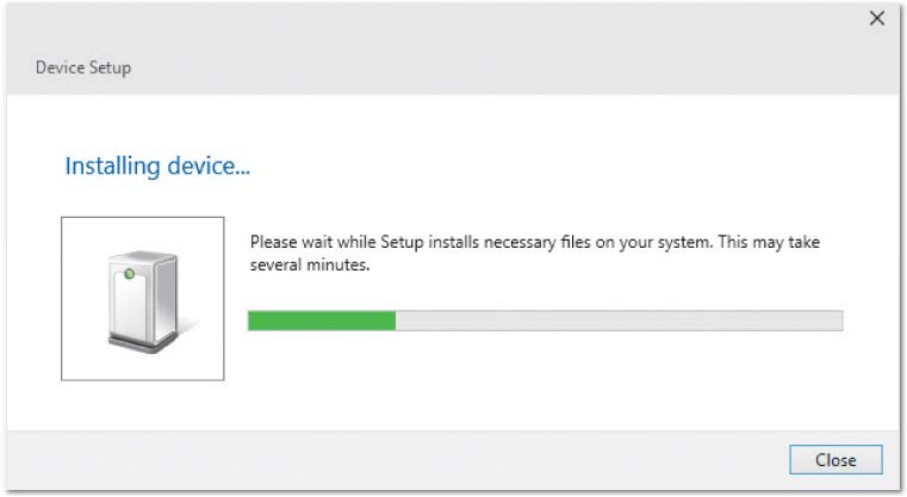
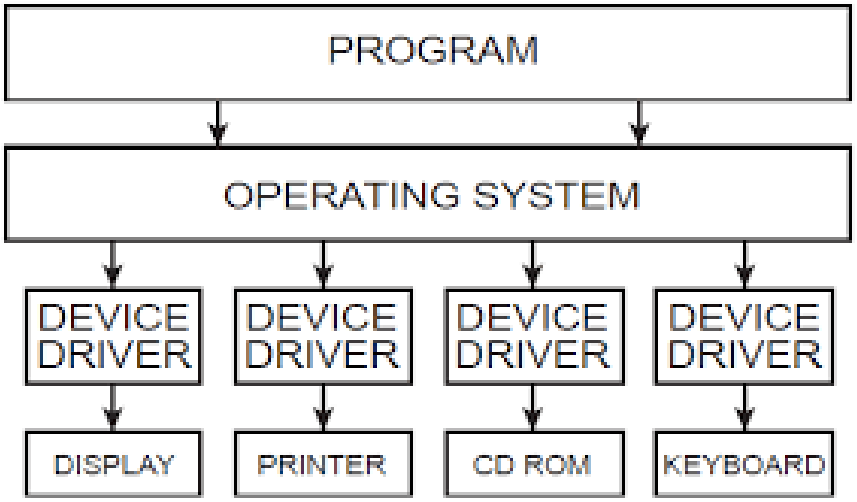


FIGURE 5-3
Finding new hardware. Most operating systems are designed to detect new hardware and to try to configure it automatically.

Device Drivers



2. Memory Management

- Memory management optimizes the use of main memory (RAM)
  - Helps speed up processing
  - **Virtual memory** is a memory-management technique that uses hard drive space as additional RAM

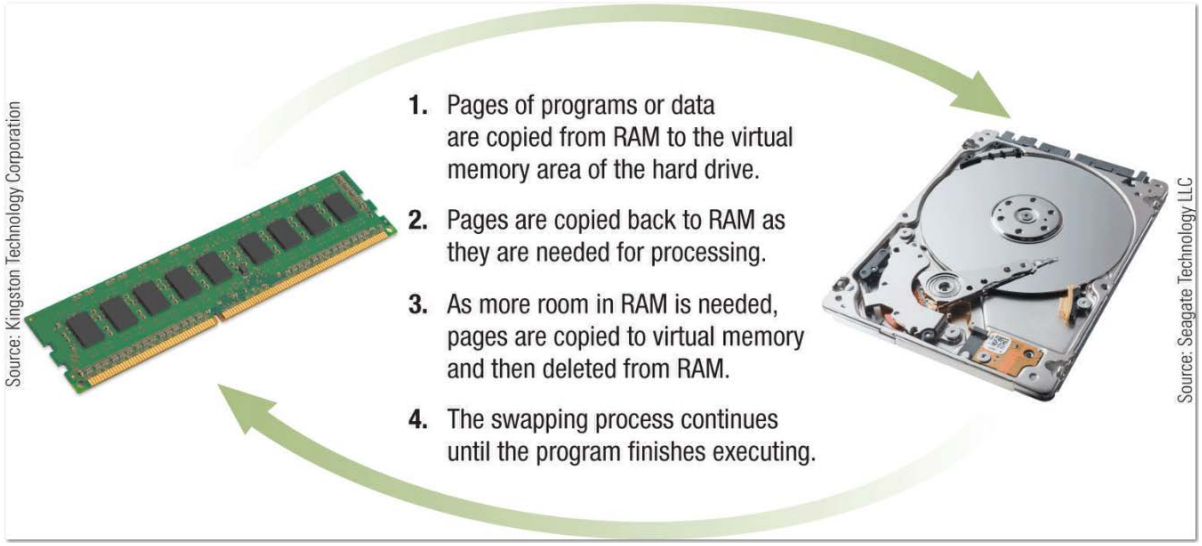


FIGURE 5-8
How virtual memory works.

Buffering and Spooling

- Buffering/Spooling used => printers & peripheral devices
    - Direct Memory Access DMA vs. Programmed I/O (PIO)
- A **buffer** is an area in RAM or on the hard drive designated to hold data that is waiting to be used by the computer
- **Buffering** or **spooling** places items in a buffer so they can be retrieved by the appropriate device when needed

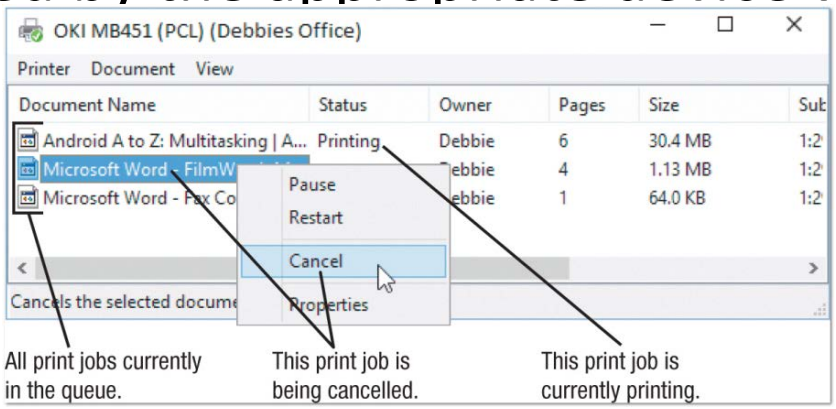


FIGURE 5-9
A print queue.

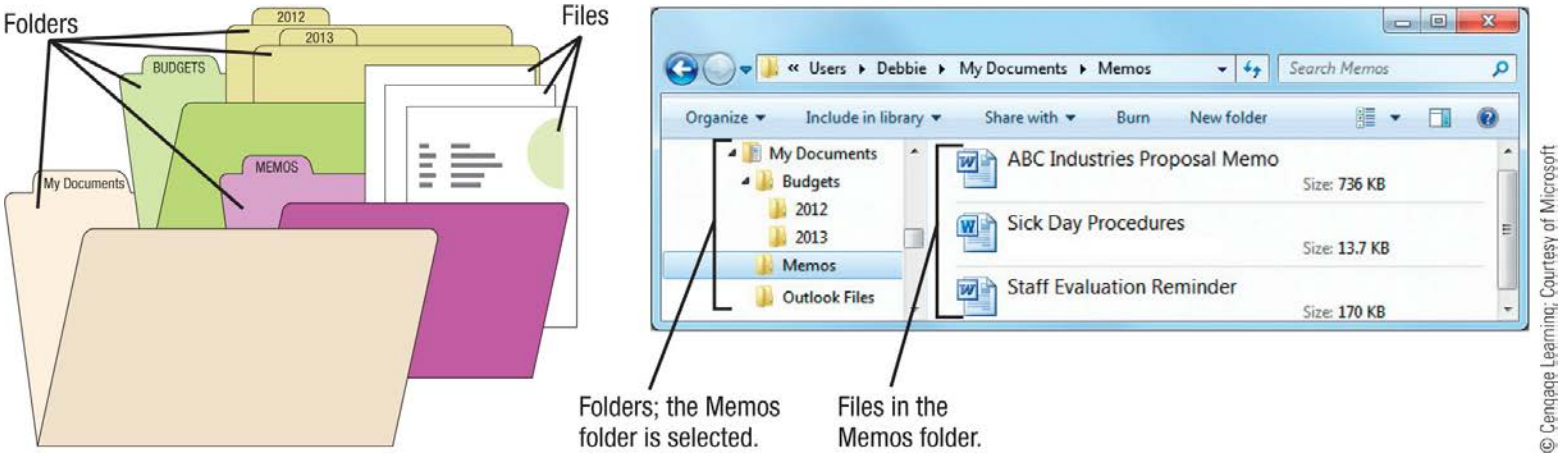
3. File Management

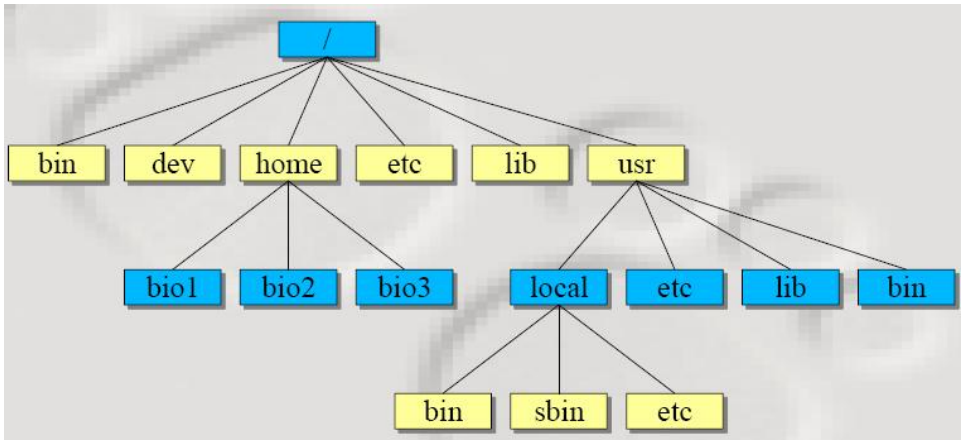
File Management

- Namespace – within single container (directory) => all identifiers unique
- May associate extensions/applications
- Keeps track of stored files so they can be retrieved when needed (some type of file allocation table)
    - Note files are typically physically fragmented to some extent
- Keeps track of free space to use for storing files
- Files/Directories usually viewed in a hierarchical format

**Don't use MyDocuments*

Graphical File Depictions





Different etc's in different paths

/etc

/usr/etc

/usr/local/etc

The Operating System

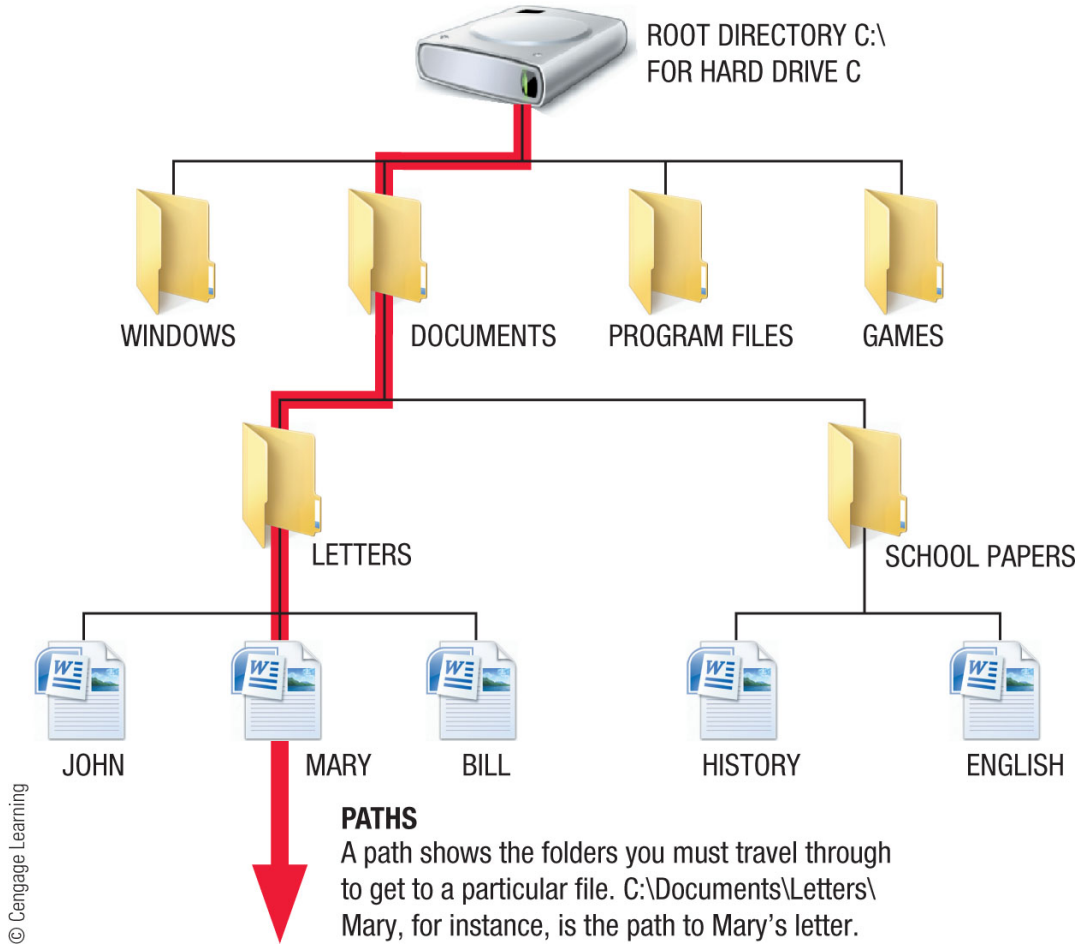


FIGURE 5-5
A sample hard drive organization.

File Management Utility Programs

- **File management utilities** enable the user to perform file management tasks
  - Looking at the folders and files stored on a computer or device
  - Copying and moving files and folders
    - Copy or cut to the Clipboard, and then paste
  - Renaming files and folders
  - Deleting files and folders
    - Deleted files go to the Recycle Bin and can be restored until the Recycle Bin is emptied
- Current versions of Windows include **File Explorer**

File Utilities => Search Tools

- **Search tools** are designed to search for documents and other files on the user's hard drive
  - Can specify search criteria
  - Can search in File Explorer
  - Can search via the Windows 10 taskbar search box

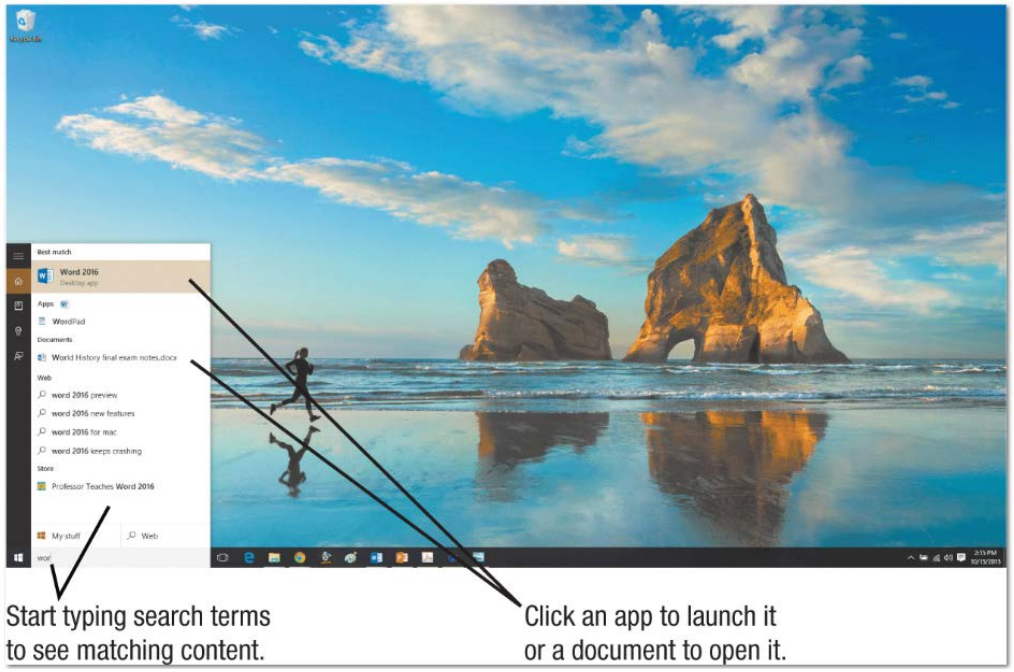


FIGURE 5-23
Using the taskbar search box in Windows 10.

File Utilities => Diagnostic and Disk Management

- Diagnostic programs evaluate your system and make recommendations for fixing any errors found
- Disk management programs diagnose and repair problems related to your hard drive
  - Check hard drive for errors
  - Disk defragmentation

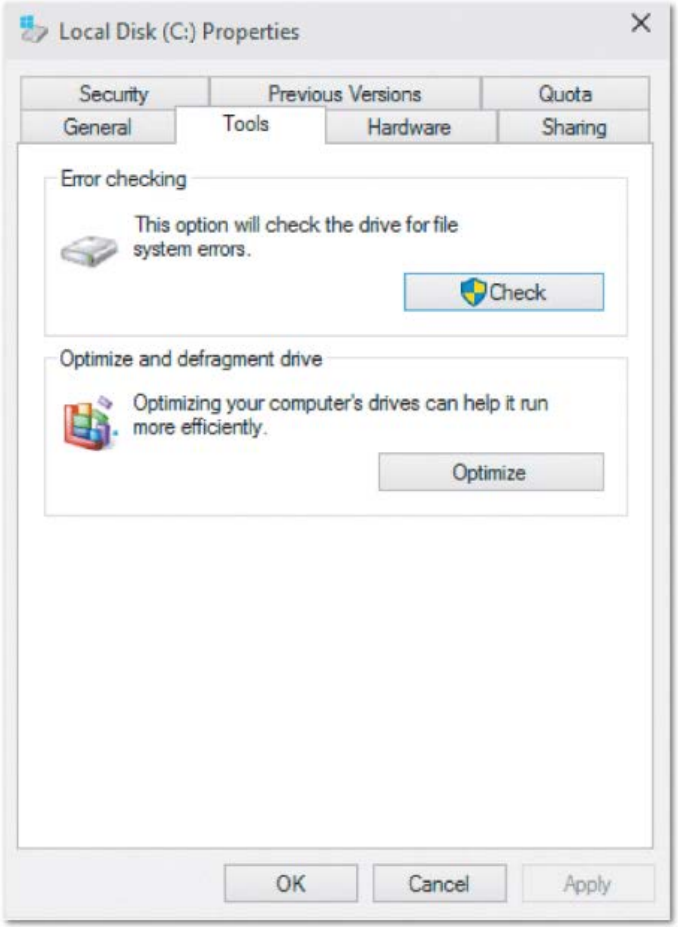


FIGURE 5-24
Windows disk tools.

File Utilities => Uninstall and Cleanup

- Uninstall utilities remove programs from your hard drive without leaving bits and pieces behind
  - Important to properly uninstall programs, not just delete them
  - Built into operating systems and included with some programs
- Cleanup utilities delete temporary files
  - Recycle Bin, temporary Internet and installation files, etc.
  - Windows Disk Cleanup
  - Registry cleaners delete unnecessary items in the Windows registry

File Utilities => Compression Programs

- **File compression programs (lossless)** reduce the size of files to optimize storage space and transmission time
  - Both zip and unzip files
  - Built into recent versions of Windows
  - WinZip Stuffit

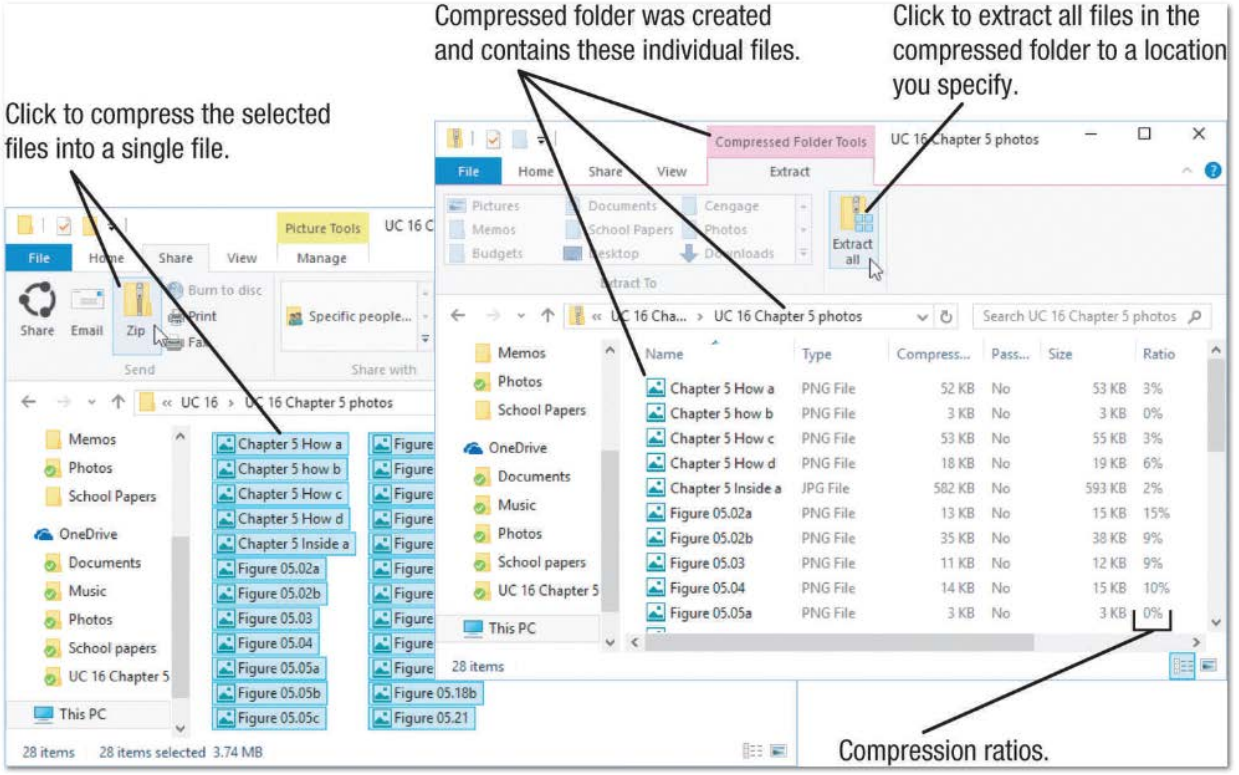


FIGURE 5-25
File compression. Reduces the size of files so they can be more efficiently stored or transmitted.

File Utilities => Backup and Recovery

- Creating a **backup** means making a duplicate copy of important files so they can be restored if needed
  - Can backup an entire computer or just certain files
  - Can be stored on a recordable or rewritable DVD disc, a USB flash drive, an external hard drive, or in the cloud
  - Backup media should be secured
- Backup and recovery utilities make the backup and restoration process easier
- Regular backup procedures are critical for businesses
- Individuals should back up any important data and important files before they are modified

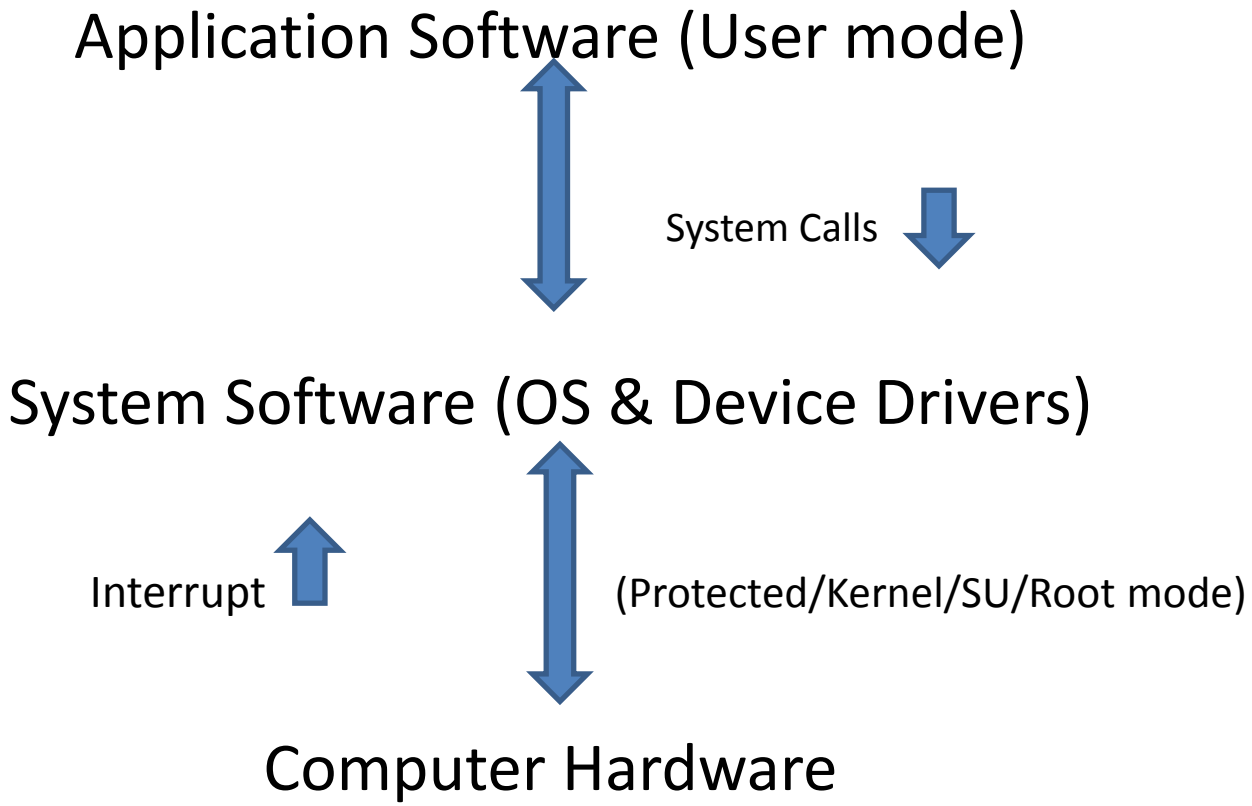
Backup Refresher

- Full (or Reference) Backup
  - Backs up entire/selected files
  - File A, B, C
- Incremental Backup
  - Provides a backup of files that have changed or are new since the last incremental backup.
  - File A, B, C and then B’, B’’, B’’’, C’
- Differential Backup
  - Provides a backup of files that have changed since a full backup was performed
  - Files A, B, C and B’’’, C’
- Now - What are the performance issues of each backup and restore?

4. CPU Management - Scheduling

- Pre-emptive vs Non-preemptive
  - Pre-emptive can interrupt running processes
    - CPU time slices (time slice expires)
    - High Priority Processes (& real time systems)
    - I/O (I/O is bursty)
- Interrupt vs Polling
  - Interrupt is pre-emptive

Architecture Software Stack



Optimizing efficiency

- Processing Techniques for Increased Efficiency
  - Multitasking
    - The ability of an operating system to have more than one program (task/process) open/in memory
      - CPU rotates between tasks (Scheduler/Time Slices)
      - Switching is done quickly (Context Switch)
      - Appears to user as though all programs executing at the same time

Efficiency cont.

- Multithreading
  - The ability to rotate between multiple threads so that processing is completed faster and more efficiently
  - Thread
    - Lightweight Process
    - Sequence of instructions within a program that is independent of other threads
    - Shared address space
      - faster than inter-process communication IPC

Multiprocessing and Parallel Processing

- Multiple processors (or multiple cores) are used in one computer system to perform work more efficiently
- Both involve using two or more CPUs or CPU cores in one computer to perform work more efficiently
  - Multiprocessing: Each CPU or core typically works on a different job
    - Used with computers and devices that have multi-core CPUs and/or multiple CPUs
  - Parallel processing: The CPUs or cores typically work together to complete one job more quickly
    - Used most often with supercomputers
- In either case, tasks are performed simultaneously

Sequential vs. Simultaneous Processing

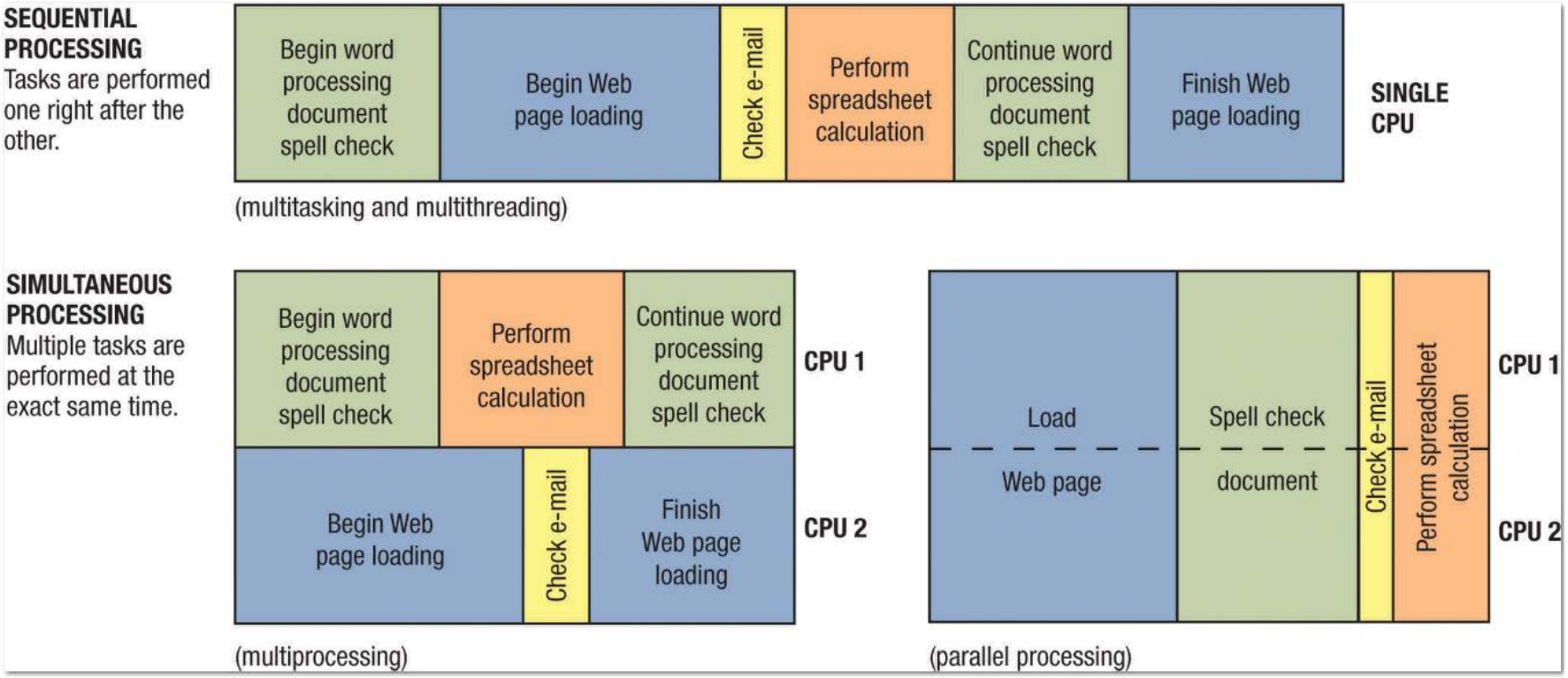


FIGURE 5-7
Sequential vs. simultaneous processing.

5. Security

- Security
  - Uses passwords, biometric characteristics and other security procedures to limit access to system resources
- Identification/Authentication – 3 levels
  - Passwords
    - Admin/root
    - Users
  - Possessed objects
  - Biometric characteristics
- Firewalls (SPI)
- *Updates

Utilities => Antivirus, Antispyware, Firewalls, and Other Security Programs

- Security concerns
  - Viruses, spyware, identity theft, phishing schemes
- Security programs protect computers and users and it is essential that all computer users protect themselves and their computers
  - Antivirus, antispyware, and firewall programs
  - Operating systems are including security software integrated into the operating system
    - Windows Defender, Windows SmartScreen, and Windows Firewall

6. Networking

- OS Manages network connections
  - Contains the TCP/IP stack (coming in networking)
  - Manages wired connections to home or office network
  - Manages wireless connections at home, school, work, or on the go
  - Can troubleshoot and repair networking connections when needed

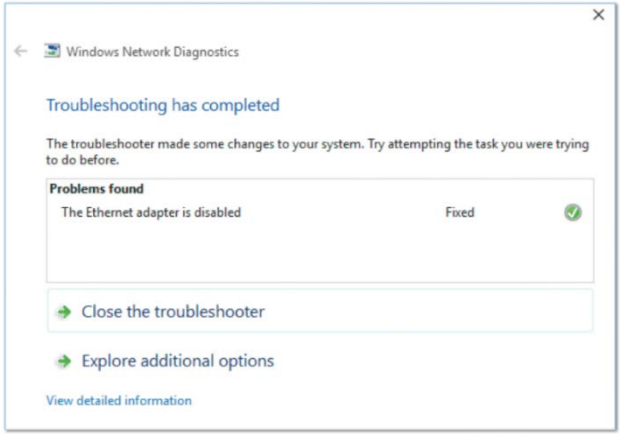


FIGURE 5-4
Network connections. Most operating systems can repair network connections when needed.

Example of How Network Operating Systems Work

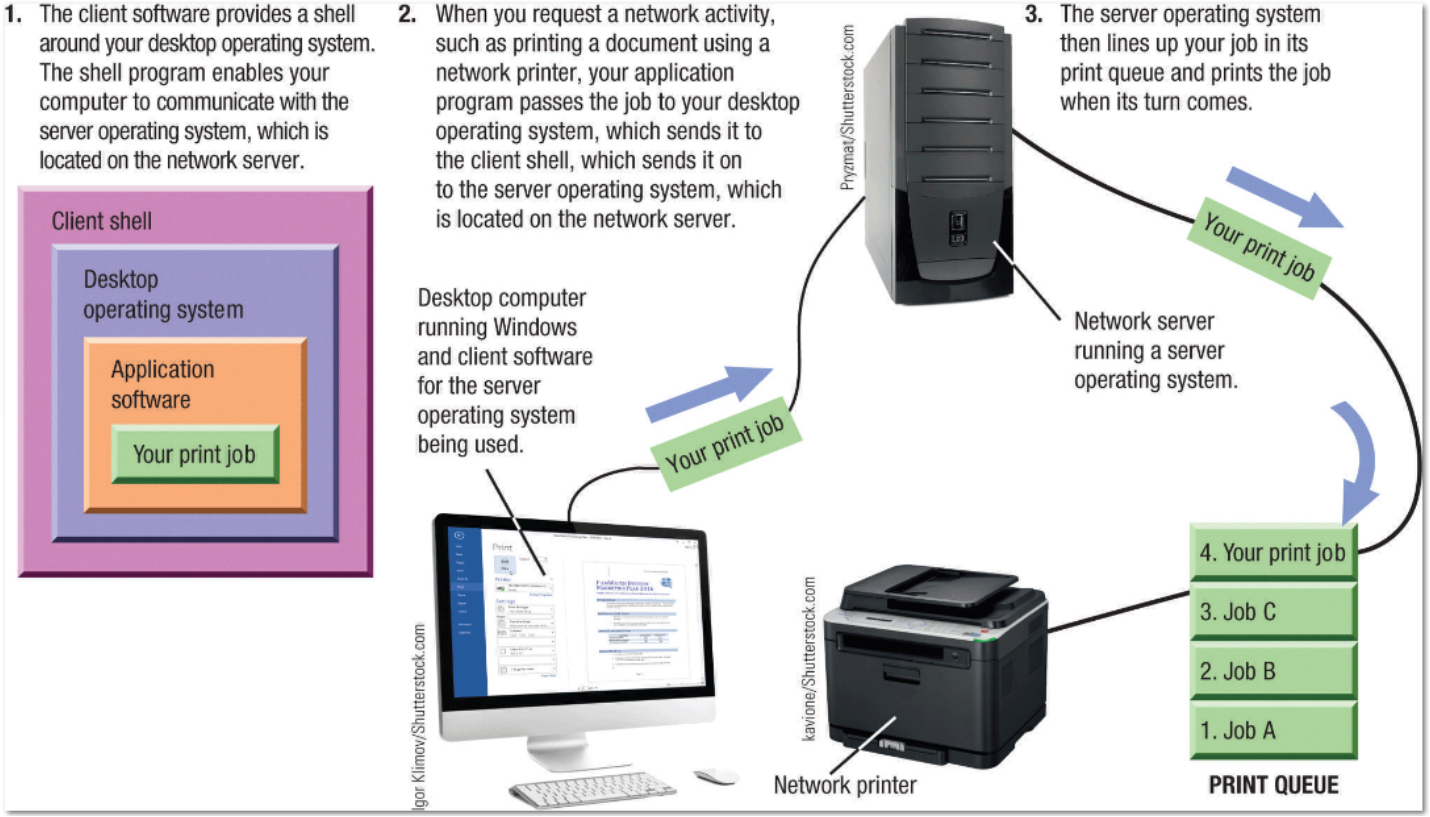


FIGURE 5-11
How network operating systems work.

Categories of Operating Systems

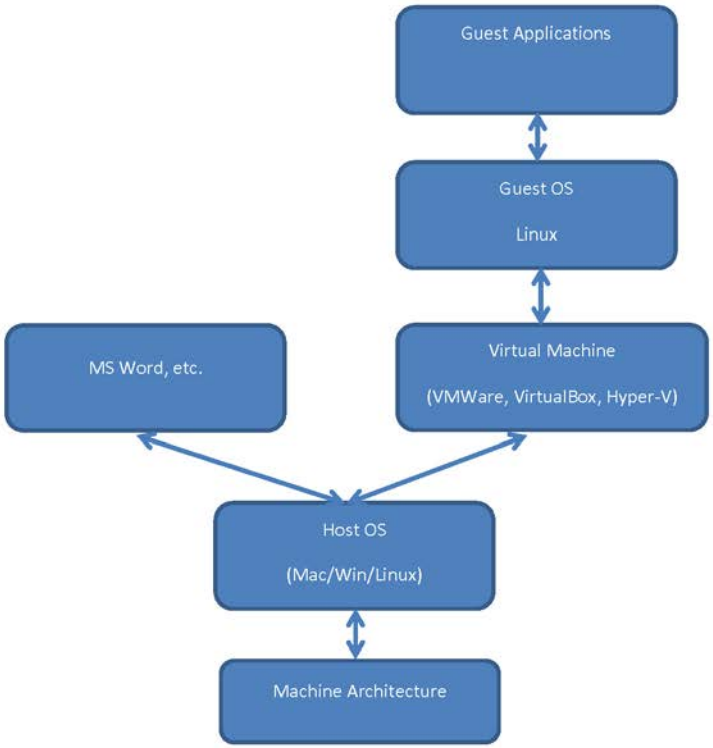
- **Personal (desktop) operating systems** are designed to be installed on a single computer
- **Server (network) operating systems** are designed to be installed on a network server
  - Client computers still use a personal operating system
  - Server operating system controls access to network resources
- **Mobile operating systems** are used with smartphones and other mobile devices
- **Embedded operating systems** are built into devices (cars, kiosks, consumer electronics, etc.

Types of Processors Supported and Support for New Technologies

- Most operating systems are designed for a specific type of processor
  - Desktop, mobile, or server processors
  - 32-bit or 64-bit CPUs
- Operating systems must respond to new technologies or trends
  - New CPU characteristic or new type of bus
  - Virtualization
  - Mobility and wearables
  - Security concerns
  - Power-consumption concerns
  - Touch and gesture input
  - The move to cloud software

Virtualization Stack

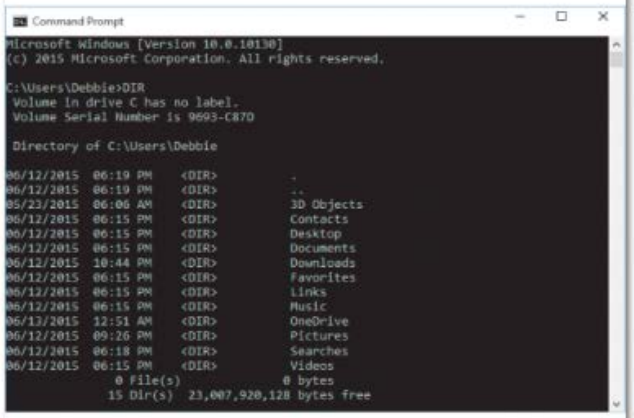
Host Applications =>



Graphical vs. Command Line Interface

- A **graphical user interface (GUI)** has icons, buttons, and other objects that the user selects to issue commands
  - Used by most operating systems
- A **command line interface** requires the user to input text-based commands using the keyboard

GRAPHICAL USER INTERFACE
Objects (such as icons, buttons, menus, and tiles) are selected with the mouse, pen, or finger to issue commands to the computer.



COMMAND LINE INTERFACE
Commands are entered using the keyboard.

FIGURE 5-10
Graphical user vs. command line interfaces.

Operating Systems for Personal Computers and Servers: DOS

- **DOS (Disk Operating System)**
  - DOS traditionally used a command-line interface
  - Dominant operating system in the 1980s and early 1990s
  - PC-DOS
    - Created originally for IBM microcomputers
  - MS-DOS
    - Created for use with IBM-compatible computers
  - Can enter DOS commands in Windows using the Command Prompt

Example of Entering DOS Commands via the Command Prompt

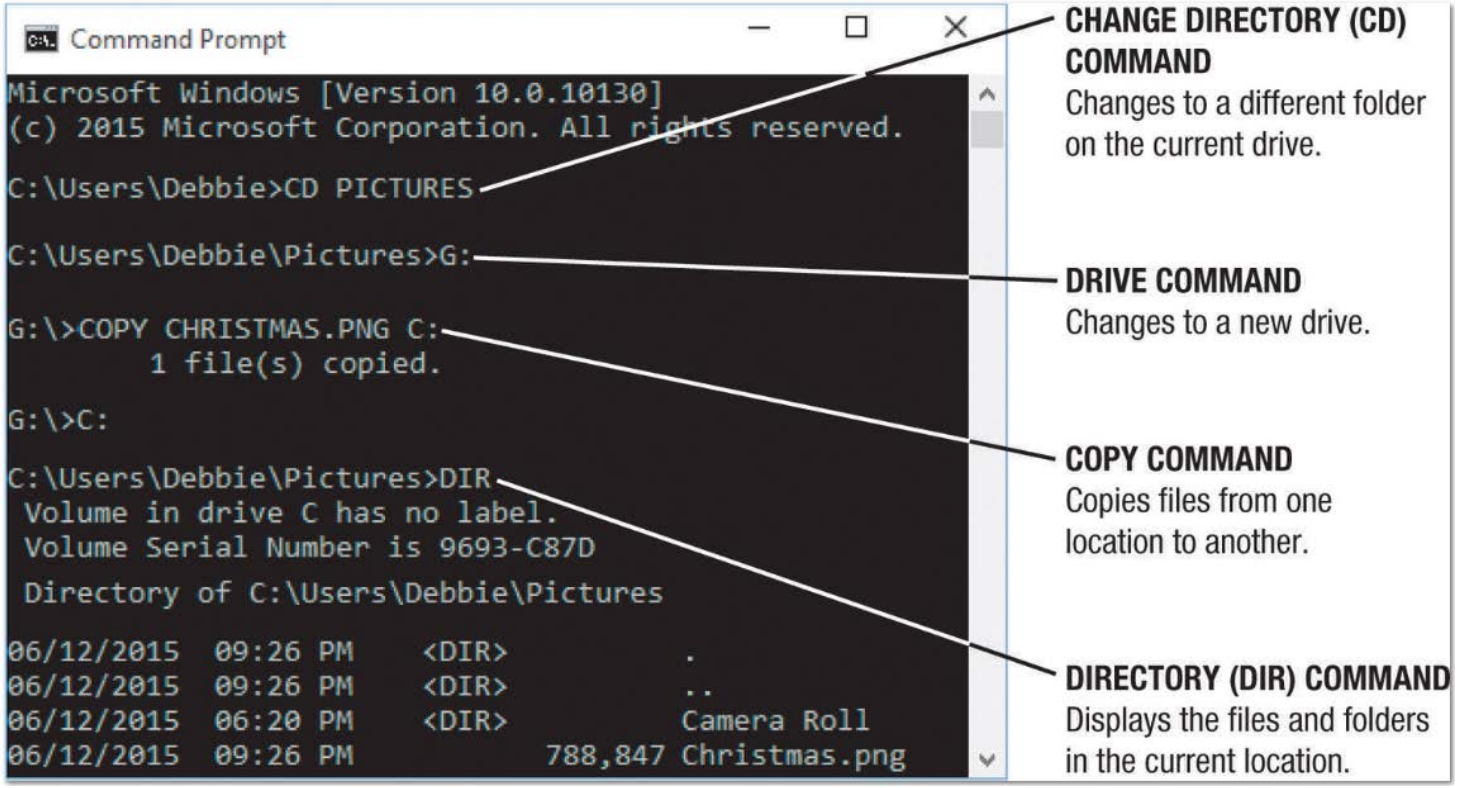


FIGURE 5-12

DOS. Even though DOS has become technologically obsolete, Windows users can still issue DOS commands via the Command Prompt.

Windows

- **Windows** is the predominant personal operating system developed by Microsoft Corporation
- History
  - Windows 1.0 released in 1985
    - Windows 1.0 through Windows 3.x were operating environments for DOS
  - Windows after 3.11 were full-fledged operating systems
  - Windows 95, Windows 98, and Windows ME
    - Designed for personal computers
  - Windows NT (New Technology) and Windows 2000
    - Designed for high-end workstations and servers

More Recent Versions of Windows

- Windows XP
  - Support for new hardware, networking, and the Internet
- Windows Vista
  - Introduced the Aero interface and Sidebar feature
- Windows 7
  - Required less memory and processing power; designed to run well on netbooks and tablets
- Windows 8
  - Designed to be used with a wide range of deviceSupports multi-touch input
  - Includes Start screen, tiles, and charms bar
- There are also server versions of these operating systems (Windows Server and Windows Home Server)

Windows 10

- **Windows 10** is the latest version of Windows
  - Is a universal operating system that will run on any device
    - Replaces all previous versions of Windows
    - Looks and feel are consistent
    - Experience is optimized to match the device being used
  - Looks similar to Windows 8 but has new features
    - The **Start menu** contains a menu and tiles
    - Apps run in resizable windows
    - Task View allows personalized, virtual desktops
    - Edge Web browser
    - Cortana virtual assistant

OS X

- **OS X** is the proprietary operating system for computers made by Apple Corporation
  - Designates a unique name for each version
    - Text => OS X El Capitan, OS X Yosemite, etc.
    - Present => Sierra, High Sierra, Mohave, Catalina, Big Sur
  - Based on the UNIX operating system
  - Originally set the standard for graphical user interfaces
  - High level of multimedia functions and connectivity
  - Includes the Safari Web browser and a Dock
  - Recent features are the Notification Center and Continuity feature
    - Continue work from one device to another and sync all your Apple devices via iCloud
  - OS X Server is the server version of OS X
  - Watch changes coming due to Apple M1 chip

UNIX

- **UNIX** is an operating system developed in the late 1960s for midrange servers
  - Multiuser, multitasking operating system
  - More expensive, requires high level of technical knowledge; harder to install, maintain, and upgrade
  - "UNIX" initially referred to the original UNIX operating system, now refers to a group of similar operating systems based on UNIX
  - Many UNIX flavors are not compatible with each other
    - Single UNIX Specification is a standardized UNIX programming environment

Linux

- **Linux** resembles UNIX but was developed independently by Linus Torvalds in 1991
  - Open-source software; has been collaboratively modified by volunteer programmers all over the world
  - Originally used a command line interface, most recent versions use a GUI
  - Strong support from mainstream companies, such as IBM, NVIDIA, HP, Dell, and Novell
  - Reasons to switch to Linux
    - Cost
    - More control over the computer
    - Faster

Linux GUI Desktop

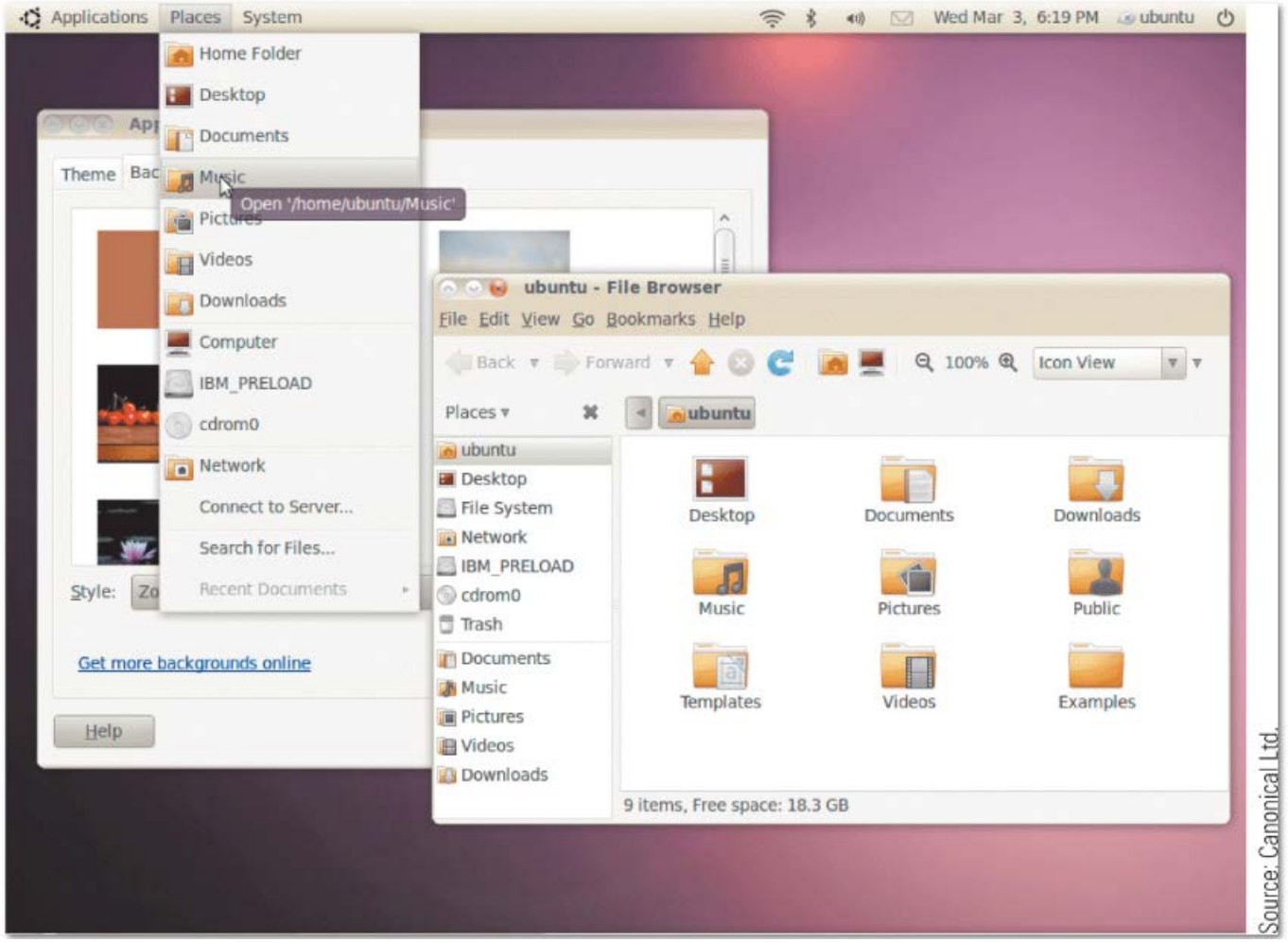


FIGURE 5-16

Linux. This version is Ubuntu, one of the most widely-used Linux operating systems.

Chrome OS

- Chrome OS is the first cloud operating system
  - Is essentially the Chrome Web browser redesigned to run a computer
  - Replaces traditional desktop operating systems
  - Designed for devices that are used entirely online
  - Currently only available preinstalled on Chrome devices
    - Chromebooks

Operating Systems for Mobile Devices

- Notebook and other portable personal computers typically use the same operating systems as desktop computers
- Mobile devices typically use a mobile operating system
  - Mobile version of a personal operating system (Windows or Linux)
  - Special operating system designed for mobile devices (Android or Apple iOS)
- Embedded operating systems used with everyday objects
- Users should consider the operating system when selecting a smartphone, tablet, or other mobile device

Android

- **Android** is a Linux-based operating system created with current mobile device capabilities in mind
  - Developed by Google and the Open Handset Alliance
  - Open platform but must adhere to specifications to call a device “Android compatible”
  - Jan 2021 version is Android 11.0, (text 6.0)
    - Supports multi-touch input and has a variety of built-in Google apps
    - Google Now and Google on Tap
    - Android Device Manager
    - Android Pay
- Android Wear, Android TV, and Android Auto

iOS

- **iOS** is designed for Apple mobile devices
  - Supports multi-touch input
  - Jan 2021 version is IOS 14 (text 9)
    - Safari Web browser
    - Siri virtual assistant
    - Facetime video calling
    - Touch ID and Apple Pay
    - Find My iPhone
    - Support for Apple Watch
- watchOS (Apple Watch) and tvOS (Apple TV)

BlackBerry OS and Mobile Linux

- BlackBerry OS and BlackBerry PlayBook OS
  - Designed for BlackBerry devices
- Additional Linux-based mobile operating systems besides Android and iOS
    - Ubuntu
    - webOS
    - Firefox OS
    - Tizen

Operating Systems for Larger Computers

- Larger computers sometimes use operating systems designed solely for that type of system
  - IBM's z/OS is designed for IBM mainframes
- Windows, UNIX, and Linux are also used with servers and mainframes
- Linux is also used with supercomputers
- Mainframes and supercomputers may also use a customized version of UNIX or another conventional operating system

Summary

- System Software vs. Application Software
- The Operating System
- Operating Systems for Personal Computers and Servers
- Operating Systems for Mobile Phones and Other Devices
- Operating Systems for Larger Computers
- Utility Programs
- The Future of Operating Systems