# INTRODUCTION TO LINUX

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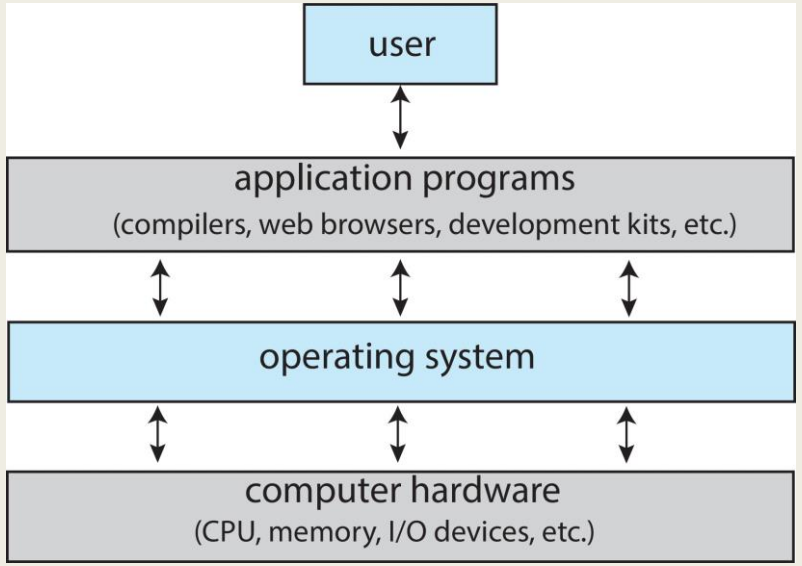
# Agenda

- Computer-System Structure
- What is an Operating System
- Benefits of having an operating system
- Operating system applications
- Operating system types

# *Overview of Computer System Structure*

# Computer System Structure

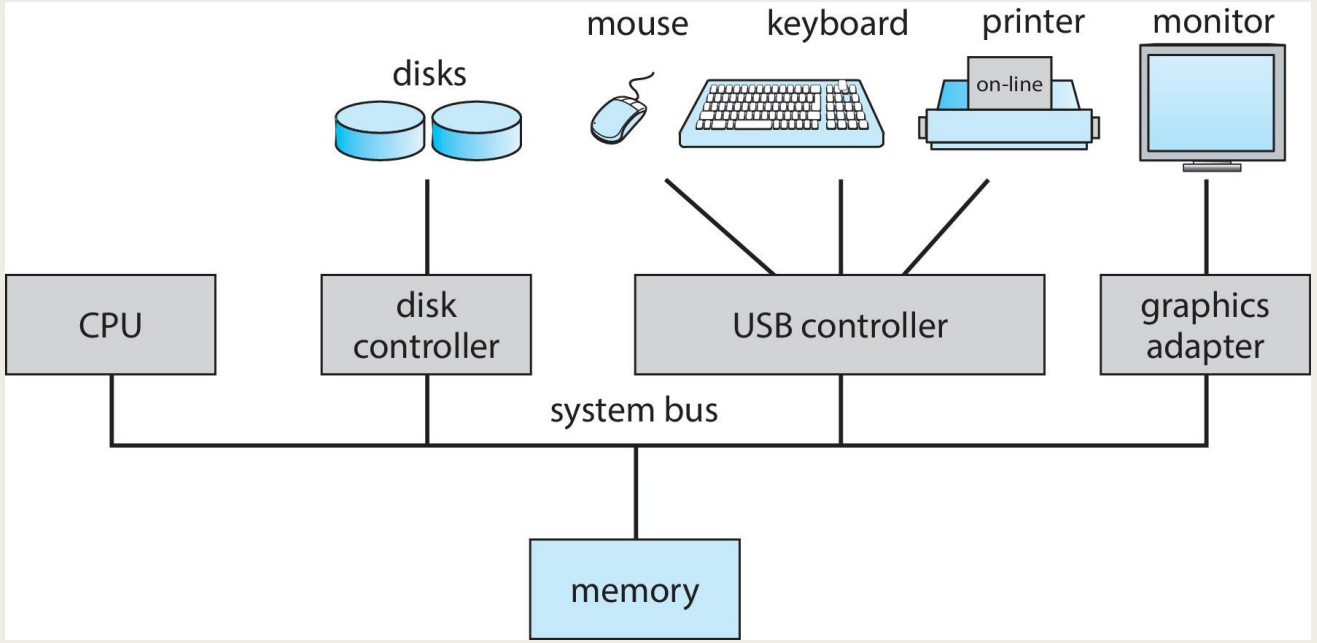
- Computer system can be divided into four components:
  - ***Hardware*** *– provides basic computing resources*
    - CPU, memory, I/O devices
  - ***Operating system***
    - Controls and coordinates use of hardware among various applications and users
  - ***Application programs*** *– define the ways in which the system resources are used to solve the computing problems of the users*
    - Word processors, compilers, web browsers, database systems, video games
  - ***Users***
    - People, machines, other computers




Abstract View of Components of Computer

# Computer System Organization

- Computer-system operation
  - *One or more CPUs, device controllers connect through common **bus** providing access to shared memory*
  - *Concurrent execution of CPUs and devices competing for memory cycles*



# Computer-System Architecture

- Most systems use a single general-purpose processor
  - *Most systems have special-purpose processors as well*
- **Multiprocessors** systems growing in use and importance
  - *Also known as **parallel systems**, **tightly-coupled systems***
  - *Advantages include:*
    1. **Increased throughput**
    2. **Economy of scale**
    3. **Increased reliability** – graceful degradation or fault tolerance
  - *Two types:*
    1. **Asymmetric Multiprocessing** – each processor is assigned a specie task.
    2. **Symmetric Multiprocessing** – each processor performs all tasks

# Types of processor

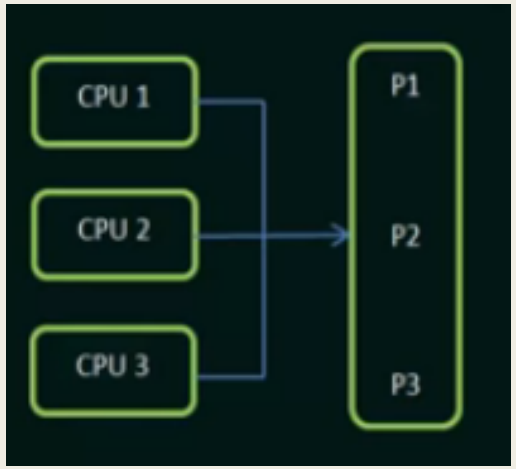
- **Single Processor Systems**
  - *One main CPU can execute a general-purpose instruction set including instructions from user processes.*
  - *Other special-purpose processors are also present which perform the device-specific task*

**2- Multiprocessor Systems**

- *Has two or more processors in close communication, sharing the computer bus, memory and peripheral devices.*
- *Advantages:*
  - Increased throughput
  - Economy of scale
  - More reliable

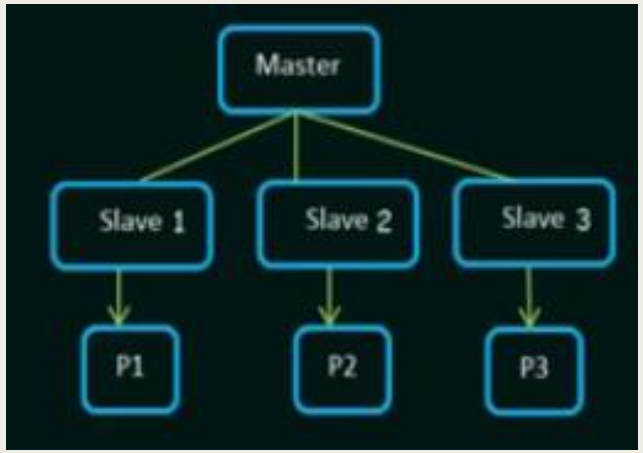
# Types of Multiprocessor

## Symmetric Multiprocessing




All processors are the same (peers)

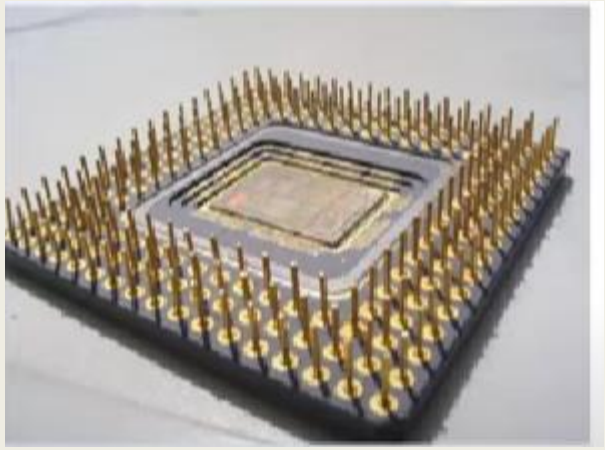
## Asymmetric Multiprocessing




One processor is master(monitor), others are slave

# Processor performance

- A microprocessor's performance is affected by several factors:
  - *Clock Speed*
  - *Bus Speed*
  - *Word Size*
  - *Cache Size*
  - *Instruction Set*
  - *Number of Cores*
  - *Processing Techniques*



# Processor comparison

- **Core i3**
  - Two cores
  - Smaller cache
  - Uses less power
  - Less $$$!


- **Core i5**
  - 2-4 cores.
  - Improved
  - graphics
  - Turbo Boost (more efficient )


- **Core i7**
  - 2-8 cores
  - More cache
  - Faster turbo boost
  - graphics

# Storage Structure

- Main memory – only large storage media that the CPU can access directly
  - ***Random access***
  - *Typically* ***random-access memory*** *in the form of* ***Dynamic Random-access Memory (DRAM)***
- Secondary storage – extension of main memory that provides large **nonvolatile** storage capacity.
- **Hard Disk Drives** (**HDD**) – rigid metal or glass platters covered with magnetic recording material
  - *Disk surface is logically divided into* ***tracks****, which are subdivided into* ***sectors***
  - *The* ***disk controller*** *determines the logical interaction between the device and the computer*
- **Non-volatile memory** (**NVM**) devices– faster than hard disks, nonvolatile
  - *Various technologies*
  - *Becoming more popular as capacity and performance increases, price drops*

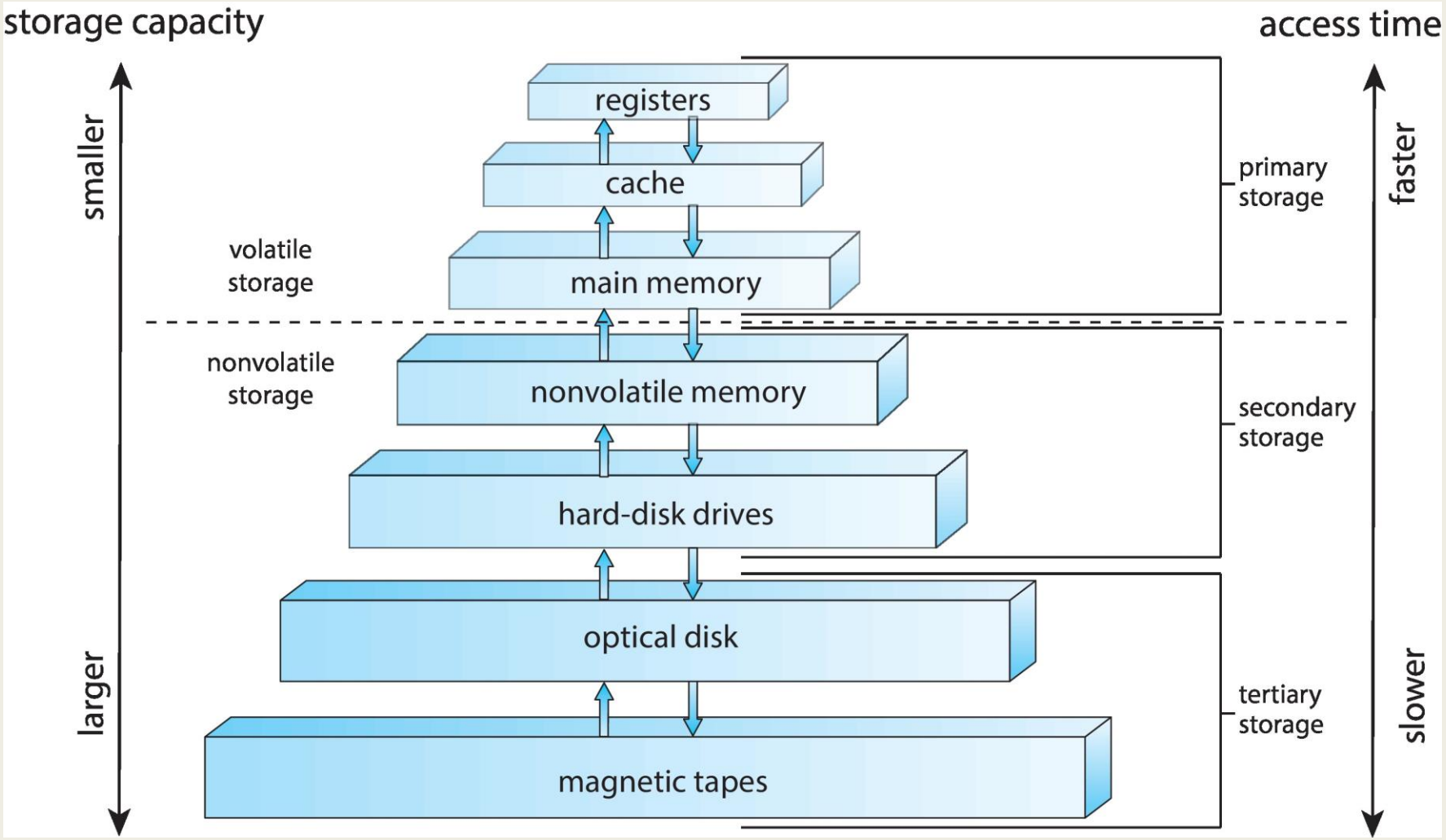
# Storage Hierarchy

- Storage systems organized in a hierarchy
  - *Speed*
  - *Cost*
  - *Volatility*

- **Caching** – copying information into faster storage system; main memory can be viewed as a cache for secondary storage.

- **Device Driver** for each device controller to manage I/O
  - *Provides uniform interface between controller and kernel*

# Storage-Device Hierarchy



# Direct Memory Access Structure

- Used for high-speed I/O devices able to transmit information at close to memory speeds
- Device controller transfers blocks of data from buffer storage directly to main memory without CPU intervention
- Only one interrupt is generated per block, rather than the one interrupt per byte

# Computer-System Operations

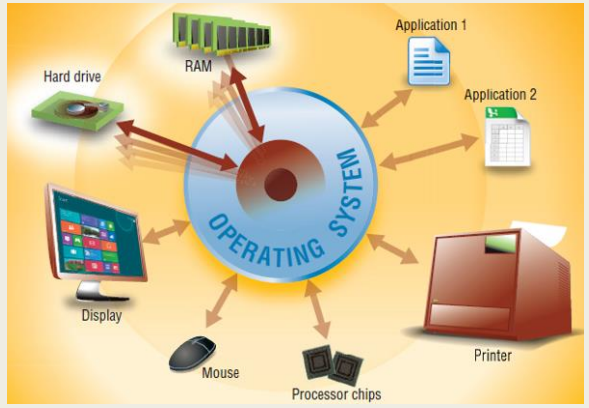
- I/O devices and the CPU can execute **concurrently**
- Each device controller is in charge of a particular device type
- Each device controller has a local **buffer**
- Each device controller type has an operating system **device driver** to manage it.
- CPU moves data from/to main memory to/from local buffers
- I/O is from the device to local buffer of controller
- Device controller informs CPU that it has finished its operation by causing an **interrupt**

- What is the main purpose of an Operating system?
- What types of operating systems is commonly used in our school?
- When using multi-tasking can be helpful?
- And how can it be helpful?

# What is an Operating System?

- **System software:** includes the operating system that is designed to work with the hardware as well as a set of utility programs
  - ***operating system (OS) program:*** *provides the user interface that allows you to work with the computer, manages all of the hardware resources, and provides the platform for managing files and application programs*

- **Operating system goals:**
  - *Execute user programs and make solving user problems easier*
  - *Make the computer system convenient to use*
  - *Use the computer hardware in an efficient manner*



# What Operating Systems Do

- Users want convenience, **ease of use** and **good performance**
  - *Don’t care about **resource utilization***
  - *Operating system is a **resource allocator** and **control program** making efficient use of HW and managing execution of user programs.*
- Users of dedicate systems such as **workstations** have dedicated resources but frequently use shared resources from **servers.**
- **Mobile devices** like smartphones and tables are resource poor,  optimized for usability and battery life.
- Some computers have little or no user interface, such as **embedded computers** in devices and automobiles
  - *Run primarily without user intervention*

# Operating-System Operations

- **Bootstrap program** is loaded at power-up or reboot
  - *Typically stored in ROM or EPROM, generally known as **firmware***
  - *Initializes all aspects of system*
  - *Loads operating system kernel and starts execution Starts **system daemons** (services provided outside of the kernel)*
- Kernel **interrupt driven** (hardware and software)
  - *Hardware interrupt by one of the devices*
  - *Software interrupt (**exception** or **trap**):*
    - Software error (e.g., division by zero)
    - Request for operating system service – **system call**
    - Other process problems include infinite loop, processes modifying each other or the operating system

# Benefits of having an operating system

- the device is able to multi-task.
- the hardware can be changed or upgraded without the application code needing to be changed.
- it is easier to add new applications.
- changes to the functionality of the system can be implemented by upgrading the operating system without the need to change the hardware.
- the entire OS can be replaced by another e.g. replacing Windows with Linux.

# Benefits of having an operating system

Utilities in Your OS Package for Maintaining System Performance:

- **Windows Explorer:** the file manager in Windows 7
- **File Explorer:** the file manager in Windows 8
- **Folder:** a placeholder name for the location where you want to store related files

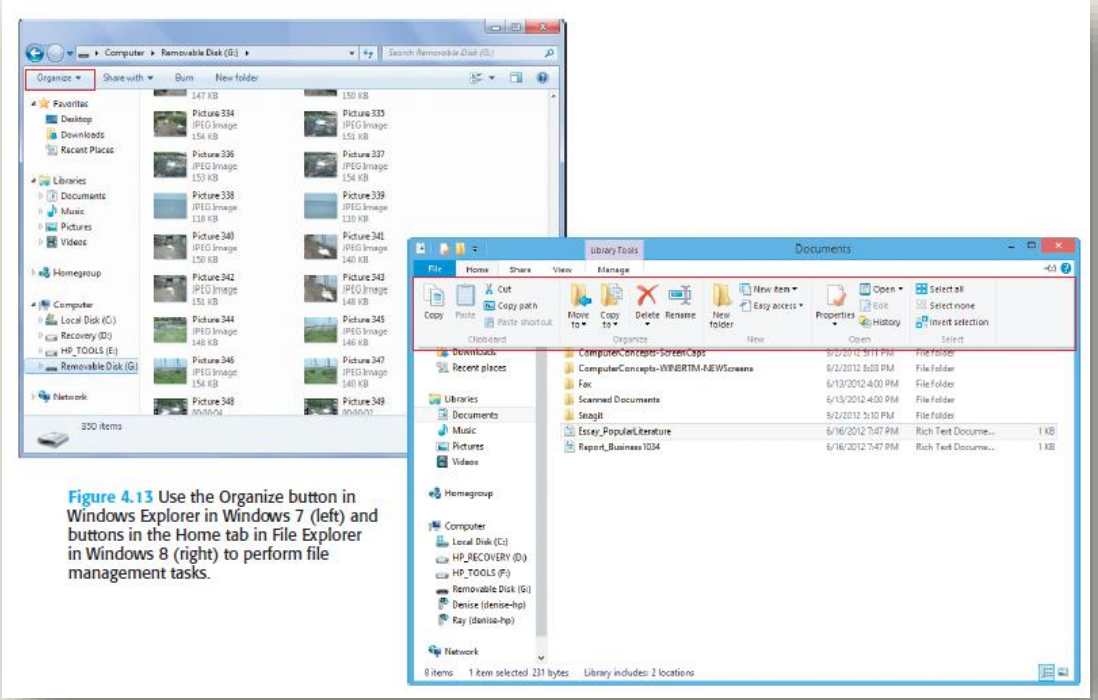


Figure 4.13 Use the Organize button in Windows Explorer in Windows 7 (left) and buttons in the Home tab in File Explorer in Windows 8 (right) to perform file management tasks.

# Benefits of having an operating system

Utilities in Your OS Package for Maintaining System Performance.

- **Disk Cleanup:** a Windows utility that allows you to scan a particular storage device or drive to select various types of files to be deleted

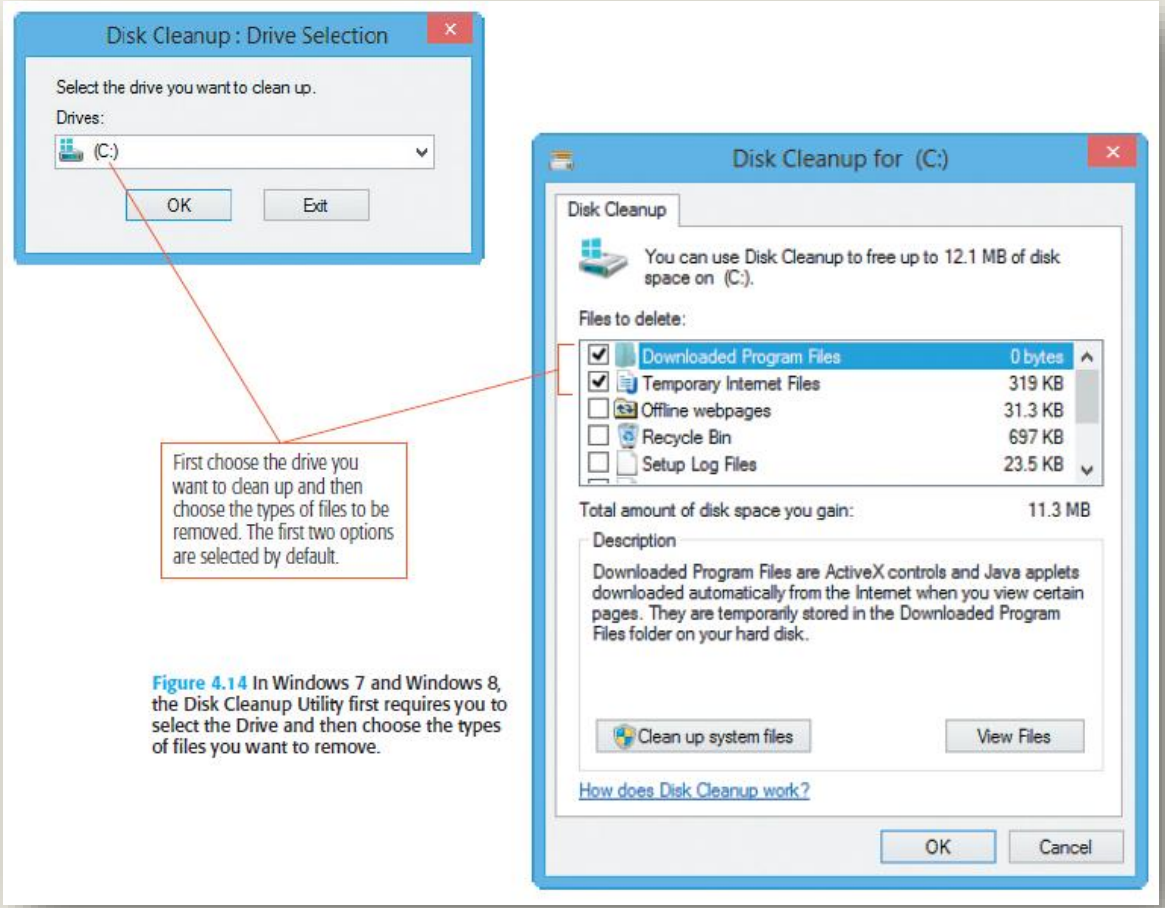
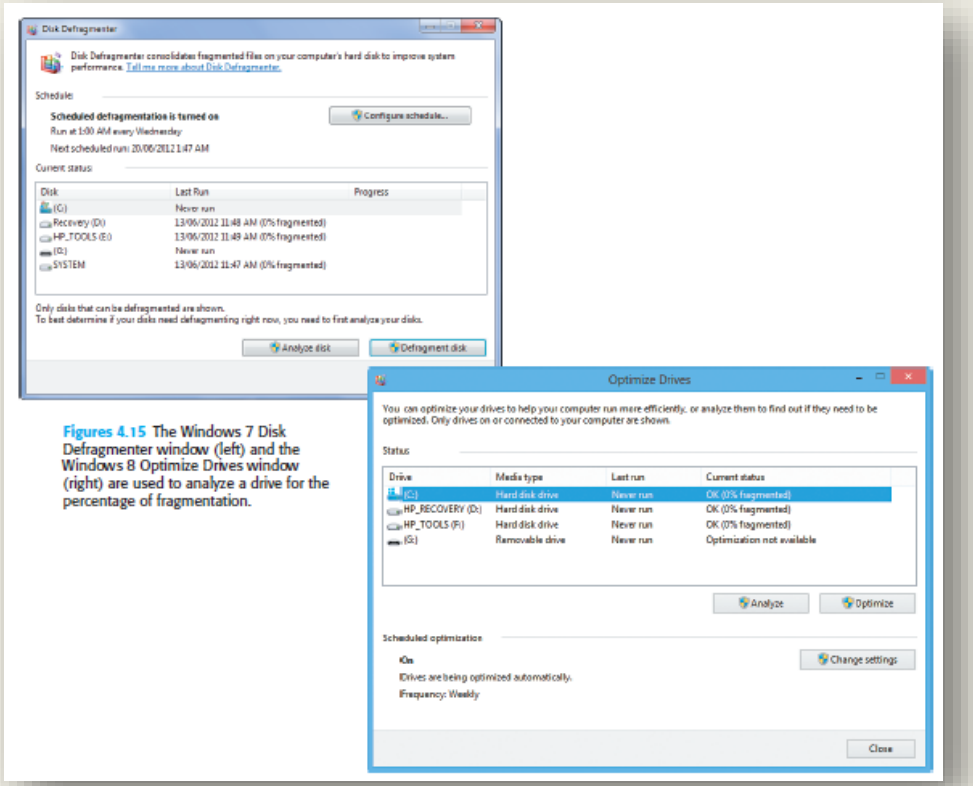



Figure 4.14 In Windows 7 and Windows 8, the Disk Cleanup Utility first requires you to select the Drive and then choose the types of files you want to remove.

# Benefits of having an operating system

Utilities in Your OS Package for Maintaining System Performance

- **Fragmentation:** the clusters needed for a document are not stored adjacent to each other
- **Disk defragmenter:** rearranges the fragmented files back together to improve file retrieval speed and efficiency

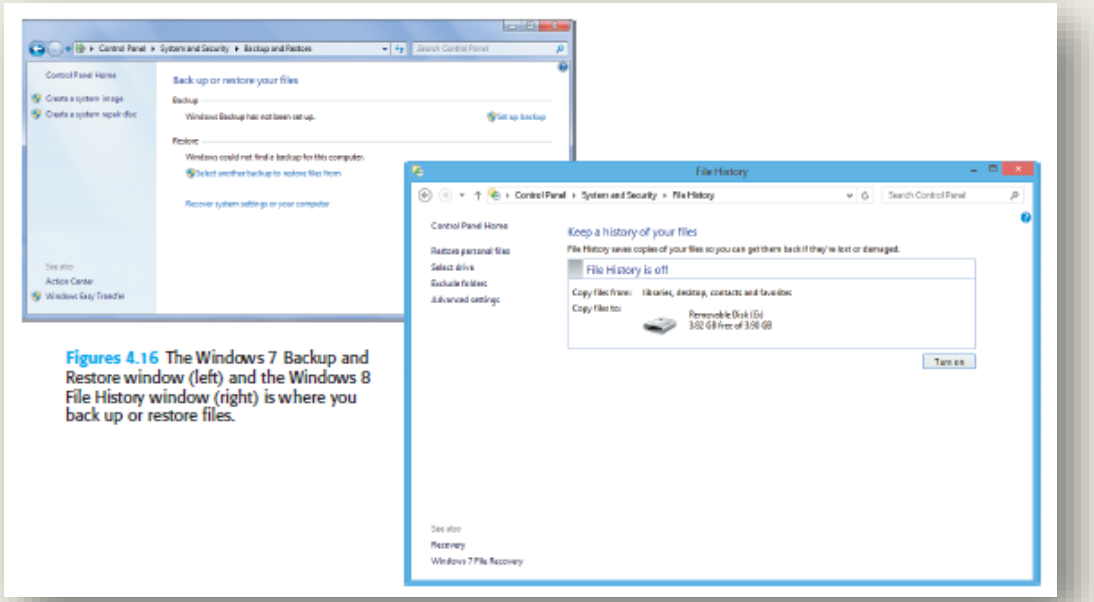



Figures 4.15 The Windows 7 Disk Defragmenter window (left) and the Windows 8 Optimize Drives window (right) are used to analyze a drive for the percentage of fragmentation.

# Benefits of having an operating system

Utilities in Your OS Package for Maintaining System Performance:

- **Backup utility:** a program that allows you to back up selected files or an entire disk to a removable storage medium
- **Restore utility:** open if you need to copy files from backup storage to a disk drive to recover the original state of the files



Figures 4.16 The Windows 7 Backup and Restore window (left) and the Windows 8 File History window (right) is where you back up or restore files.

*Operating system applications*

# Memory Management

- To execute a program all (or part) of the instructions must be in memory
- All  (or part) of the data that is needed by the program must be in memory
- Memory management determines what is in memory and when
  - *Optimizing CPU utilization and computer response to users*
- Memory management activities
  - *Keeping track of which parts of memory are currently being used and by whom*
  - *Deciding which processes (or parts thereof) and data to move into and out of memory*
  - *Allocating and deallocating memory space as needed*

# File-system Management

- OS provides uniform, logical view of information storage
  - *Abstracts physical properties to logical storage unit - **file***
  - *Each medium is controlled by device (i.e., disk drive, tape drive)*
    - Varying properties include access speed, capacity, data-transfer rate, access method (sequential or random)

- File-System management
  - *Files usually organized into directories*
  - *Access control on most systems to determine who can access what*
  - *OS activities include*
    - Creating and deleting files and directories
    - Primitives to manipulate files and directories
    - Mapping files onto secondary storage
    - Backup files onto stable (non-volatile) storage media

# Mass-Storage Management

- Usually disks used to store data that does not fit in main memory or data that must be kept for a “long” period of time
- Proper management is of central importance
- Entire speed of computer operation hinges on disk subsystem and its algorithms
- OS activities
  - *Mounting and unmounting*
  - *Free-space management*
  - *Storage allocation*
  - *Disk scheduling*
  - *Partitioning*
  - *Protection*

# Caching

- Important principle, performed at many levels in a computer (in hardware, operating system, software).
- Information in use copied from slower to faster storage temporarily.
- Faster storage (cache) checked first to determine if information is there
  - *If it is, information used directly from the cache (fast)*
  - *If not, data copied to cache and used there*
- Cache smaller than storage being cached
  - *Cache management important design problem*
  - *Cache size and replacement policy*

# Characteristics of Various Types of Storage

| Level | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| Name | registers | cache | main memory | solid-state disk | magnetic disk |
| Typical size | < 1 KB | < 16MB | < 64GB | < 1 TB | < 10 TB |
| Implementation technology | custom memory with multiple ports CMOS | on-chip or off-chip CMOS SRAM | CMOS SRAM | flash memory | magnetic disk |
| Access time (ns) | 0.25-0.5 | 0.5-25 | 80-250 | 25,000-50,000 | 5,000,000 |
| Bandwidth (MB/sec) | 20,000-100,000 | 5,000-10,000 | 1,000-5,000 | 500 | 20-150 |
| Managed by | compiler | hardware | operating system | operating system | operating system |
| Backed by | cache | main memory | disk | disk | disk or tape |

Movement between levels of storage hierarchy can be explicit or implicit

# I/O Subsystem

- One purpose of OS is to hide peculiarities of hardware devices from the user.
- I/O subsystem responsible for:
  - *Memory management of I/O including buffering (storing data temporarily while it is being transferred), caching (storing parts of data in faster storage for performance), spooling (the overlapping of output of one job with input of other jobs)*
  - *general-purpose computer system consists of CPU and multiple device controllers that are connected through a common bus*
  - *Drivers for specific hardware devices*

# Protection and Security

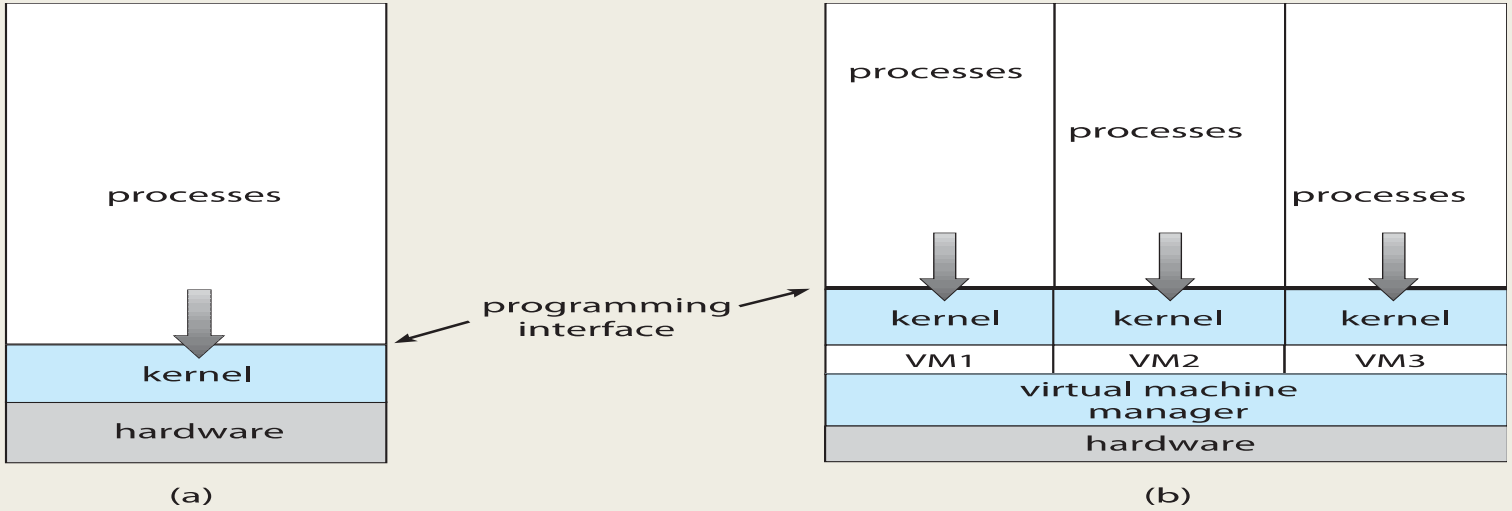
- **Protection** – any mechanism for controlling access of processes or users to resources defined by the OS.
- **Security** – defense of the system against internal and external attacks
  - *Huge range, including denial-of-service, worms, viruses, identity theft, theft of service.*
- Systems generally first distinguish among users, to determine who can do what
  - *User identities (**user IDs**, security IDs) include name and associated number, one per user*
  - *User ID then associated with all files, processes of that user to determine access control*
  - *Group identifier (**group ID**) allows set of users to be defined and controls managed, then also associated with each process, file*
  - ***Privilege escalation** allows user to change to effective ID with more rights*

# Virtualization

- Allows operating systems to run applications within other OSes
  - *Vast and growing industry*
- **Emulation** used when source CPU type different from target type (i.e. PowerPC to Intel x86)
  - *When computer language not compiled to native code – **Interpretation***
- **Virtualization** – OS natively compiled for CPU, running **guest** OSes also natively compiled
  - *Consider VMware running WinXP guests, each running applications, all on native WinXP **host** OS*
  - ***VMM** (virtual machine Manager) provides virtualization services*

# Virtualization (cont.)

- Use cases involve laptops and desktops running multiple OSes for exploration or compatibility
  - *Apple laptop running Mac OS X host, Windows as a guest*
  - *Developing apps for multiple OSes without having multiple systems*
  - *Quality assurance testing applications without having multiple systems*
  - *Executing and managing compute environments within data centers*



# Distributed Systems

- Collection of separate, possibly heterogeneous, systems networked together
  - ***Network*** *is a communications path,* ***TCP/IP*** *most common*
    - **Local Area Network** (**LAN**)
    - **Wide Area Network** (**WAN**)
    - **Metropolitan Area Network** (**MAN**)
    - **Personal Area Network** (**PAN**)
- **Network Operating System** provides features between systems across network
  - *Communication scheme allows systems to exchange messages*
  - *Illusion of a single system*

# *Overview of Operating system types*

# Popular Operating Systems

- **Windows:** created by Microsoft Corporation; the most popular operating system.

- **Mac OS:** a proprietary OS created by Apple.

- **UNIX:** an operating system that has been around since the late 1960s and is designed for servers
- **Linux:** created by Linus Torvalds in 1991 and is based on UNIX
  - ***open source program:*** *the source code is available to the public and can be freely modified or customized*

# Popular Operating Systems for Mobile Devices

- **Mobile operating system:** an operating system designed specifically for a mobile device
  - ***Android:*** *the OS is based on Linux, making it an open source OS.*
  - ***iOS:*** *developed by Apple as the mobile operating system for its iPhone, iPod Touch, and iPad.*
  - ***BlackBerry OS:*** *developed by Research in Motion (RIM) as the operating system designed for BlackBerry devices.*
  - ***Windows Phone:*** *developed by Microsoft as the mobile operating system that replaced its earlier OS, Windows Mobile, which was used on Windows smartphones*
    - live tiles stream updates to the user's mail, calendar, and web apps

BlackBerry was popular with businesses because of its superior security and popular BBM messenger tool; however, recently it has experienced declining sales.

Apple's iPad 3

Windows Phone uses a live tile interface.

# Types of operating system

| Type | Definition | Example of Use |
|---|---|---|
| Batch OS | Data or programs are collected grouped and processed at a later date. | Payroll, stock control and billing systems. |
| Interactive OS | Allows the user and the computer to be in direct two-way communication | Select from a menu at ATM. |
| Real-time OS | Inputs immediately affect the outputs. Timing is critical | Control of nuclear power plants, air traffic control systems. |
| Network OS | Allow a computer on a network to serve requests from other computers for data and provide access to other resources such as printer and file systems. | Manage simultaneous access by multiple users |
| Multiuser OS | Handle many people running their programmes on the computer at the same time | A number of terminals communicating with a central computer which allocates processing time to each terminal in turn. |
| Multiprogramming OS | Ability to run many programmes apparently at the same time. | Mainframe systems. Each job is allocated a small amount of processing time (*time slice*) in turn. |
| Multitasking OS | The ability to hold several programmes in RAM at one time but the user switches between them. | Usually uses GUI's. Facilitates import and export of data. |

# Free and Open-Source Operating Systems

- Operating systems made available in source-code format rather than just binary **closed-source** and **proprietary**
- Counter to the **copy protection** and **Digital Rights Management** (**DRM**) movement
- Started by **Free Software Foundation** (**FSF**), which has “copyleft” **GNU Public License** (**GPL**)
  - *Free software and open-source software are two different ideas championed by different groups of people*
    - **https://www.gnu.org/philosophy/open-source-misses-the-point.en.html**
- Examples include **GNU/Linux** and **BSD UNIX** (including core of **Mac OS X**), and many more
- Can use VMM like VMware Player (Free on Windows), Virtualbox (open source and free on many platforms - http://www.virtualbox.com)
  - *Use to run guest operating systems for exploration*

# *Embedded operating system*

# Embedded Operating Systems and Cloud Operating Systems

- **Embedded operating system:** smaller and interacts with fewer resources to perform specific tasks fast and reliably


Smart appliances, such as this refrigerator, will help you manage food purchases.

# Embedded Operating Systems and Cloud Operating Systems…continued

- **Windows Embedded:** a family of operating systems based on the familiar Windows operating system designed for use in a variety of devices.
- **Embedded Linux:** applications that can be found running smart appliances, in-flight entertainment systems, personal navigation systems, and a variety of other consumer and commercial electronics.
- **Android:** an operating system based on Linux and is a popular choice for electronic devices beyond smartphones such as tablets, set-top boxes, and netbooks

# Embedded Operating Systems and Cloud Operating Systems…continued

- **Cloud operating systems:** operating systems that operate like a virtual desktop
  - ***web-based operating systems:*** *not true operating systems (such as Windows) because you still need a standalone operating system on the computer you are using to access the web browser*

# Embedded Operating Systems and Cloud Operating Systems…continued

- **iCloud:** Apple's iCloud is built into every new iOS device


Figure 4.11 After logging in with your Apple ID, the iCloud website connects you to Mail, Contacts, Calendar, Find My iPhone, and Documents from any other Apple device or PC.

# Embedded Operating Systems and Cloud Operating Systems…continued

- **Chrome OS**: Google's Chrome OS is a Linux-based operating system available on specific hardware called Chromebooks

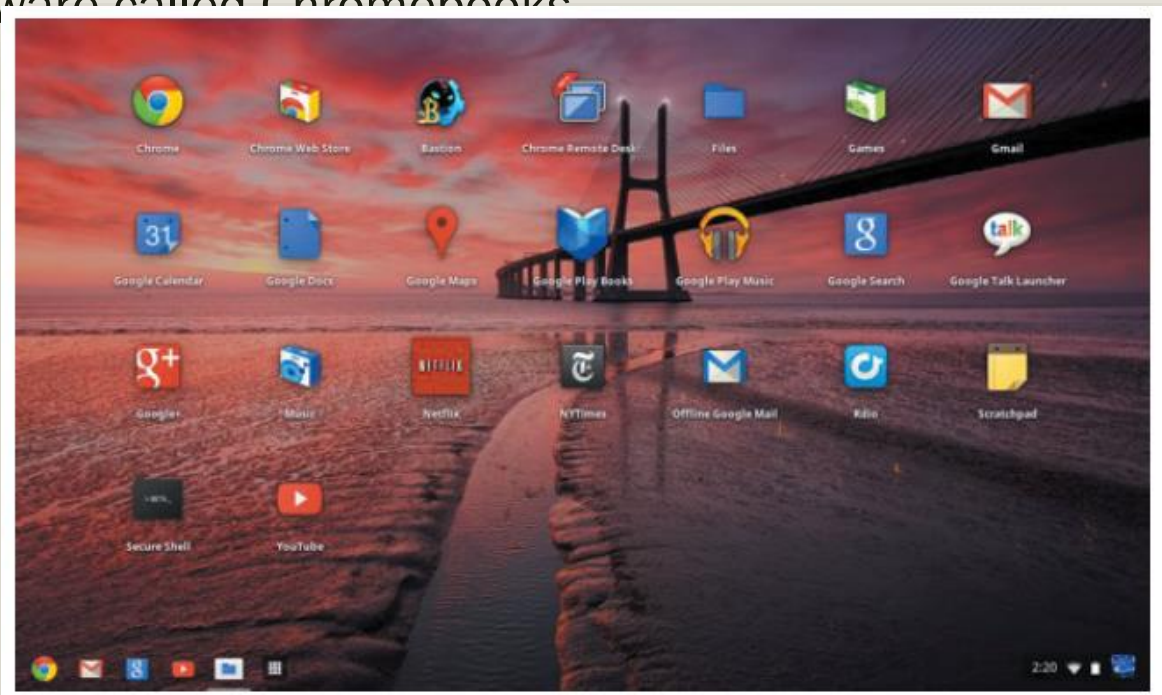



Figure 4.12 A desktop image from version 19 of Google's Chrome OS