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ROYAL UNIVERSITY OF PHNOM PENH

CHAPTER 3 ▸ Hardware and Mobile Devices

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Chea Daly

Why Learn About Hardware?

- Organizations invest in computer hardware to:
    - Improve worker productivity
    - Increase revenue, reduce costs
    - Provide better customer service
    - Speed up time to market
    - Facilitate collaboration among employees
- Computer hardware Should be selected to meet specific user and business requirements

Why Learn About Hardware?

- Managers:

  - Are expected to help define the business needs that the hardware must support.

  - Must be able to evaluate options when considering hardware investments for their areas of the business.
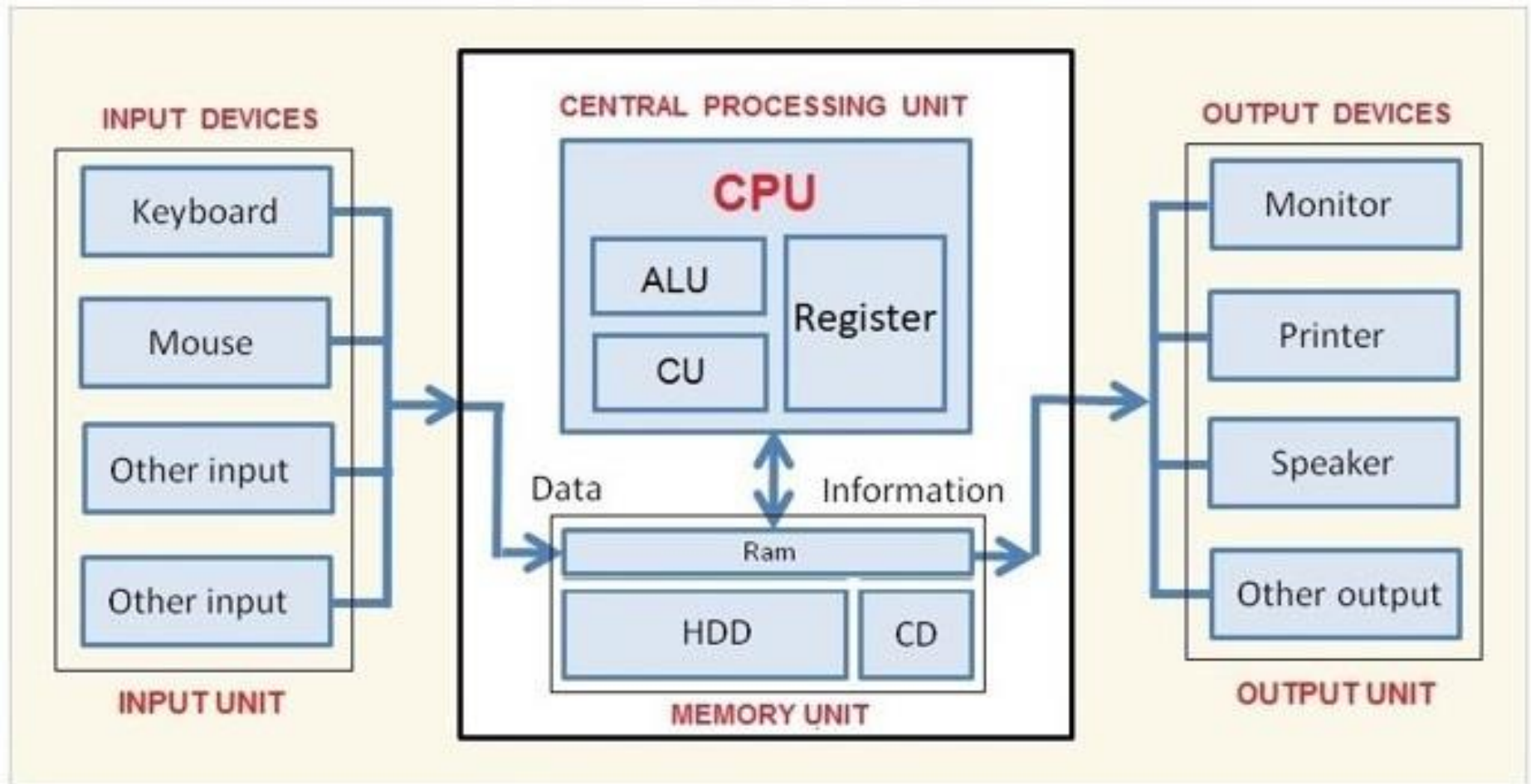
Hardware

- This chapter focuses on the hardware components of a computer-based information system (CBIS).

- When making hardware-purchasing decisions, the consideration should be how hardware can support the objectives of the information system (IS) and the goals of the organization.

Computer System Architecture

Central Processing Unit (CPU)

- CPU or simply processor can be thought of as the brain of the computer.

- Most of the processing takes place in CPU.

- For personal computers, the term Microprocessor and CPU are used interchangeably.

Basic Components of a CPU

CPU itself can be divided into different functional units:

- **Registers** are high-speed storage devices that temporarily hold small units of program instructions and data which the CPU is working with.

- **Arithmetic Logic Unit (ALU)** performs arithmetic operations (addition, subtraction, etc.) as well as logical operations (AND, OR, NOT, etc.), and stores the result in an output register.

- **Control Unit (CU)** tells the ALU what operation to perform on that data. It coordinates the flow of data in and out of the ALU, registers, primary storage, and even secondary storage and various output devices.
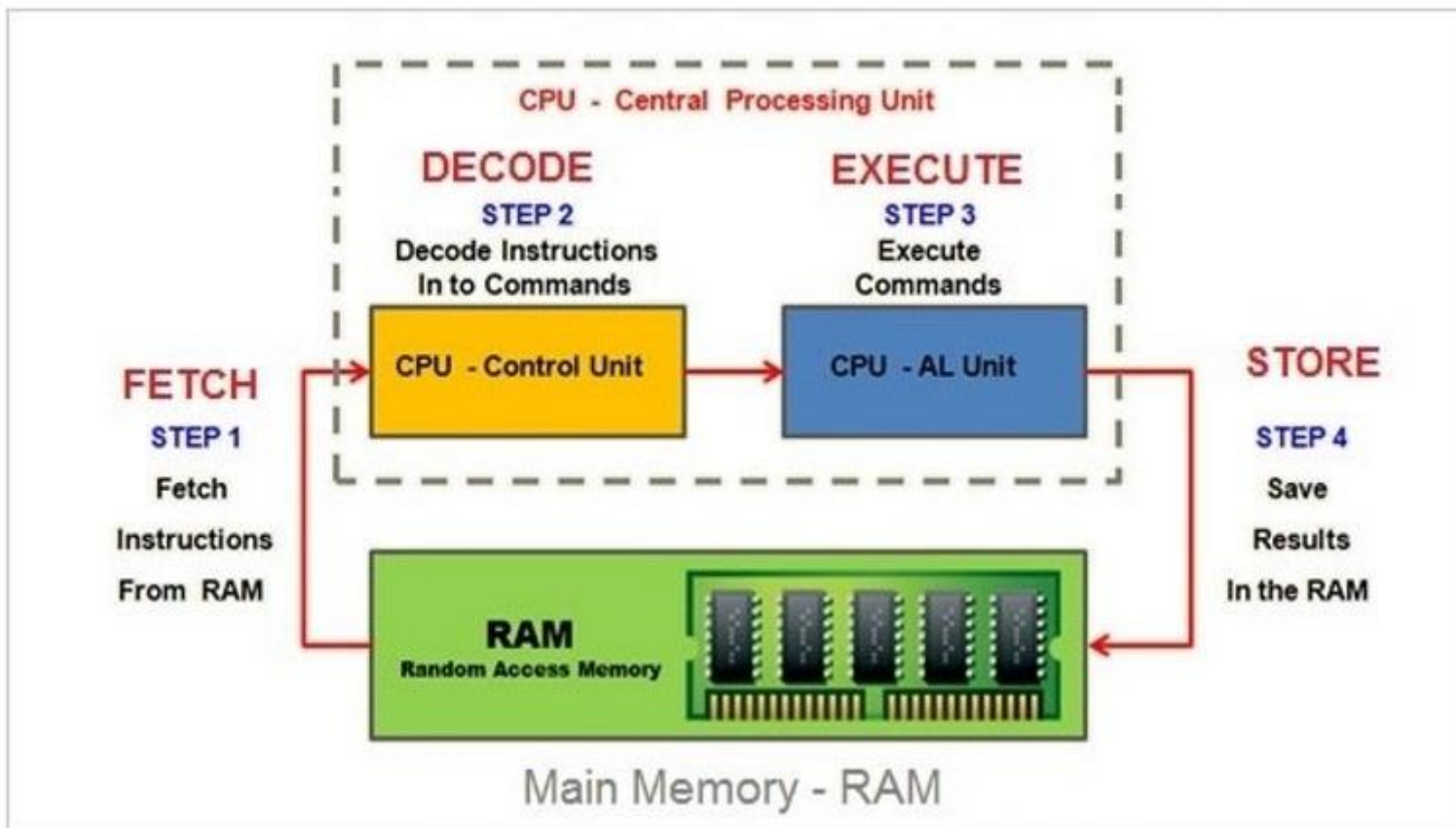
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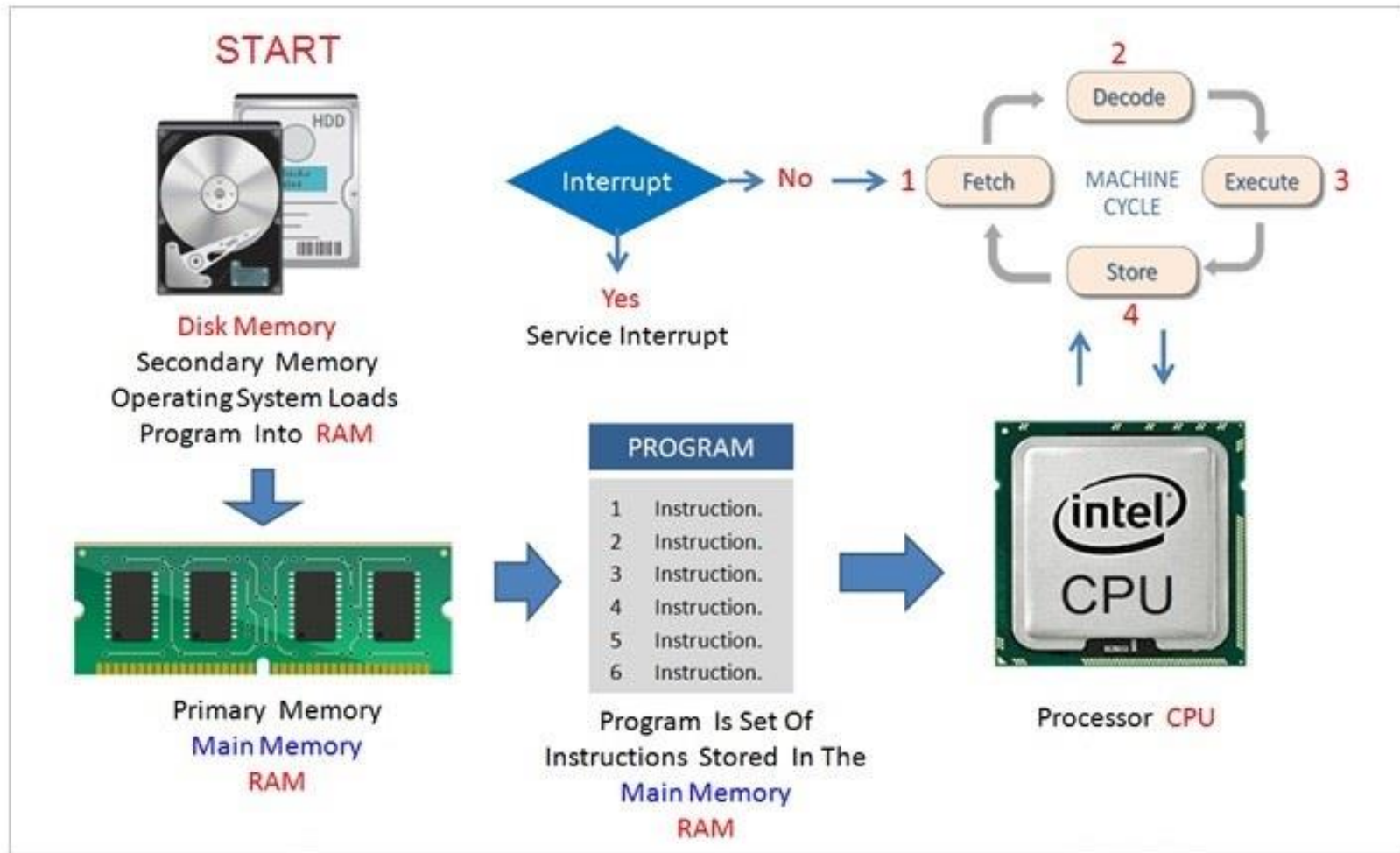
Machine Cycle (Instruction Cycle)

CPU Speed

- Every computer comprises of an internal clock, which emits electronic **pulses** at a constant rate.

- The speed of CPU, is determined by the **Clock Cycle**, which is the amount of time between two pulses.

- Each instruction takes one or more clock cycles to execute.

- The higher the clock speed, the shorter the interval between pulses and the faster instructions can be completed.

CPU Speed

- Hertz (Hz) is the basic unit of CPU's clock frequency.
    - 1 hertz = 1 cycle per second.
- CPU speed or Clock speed is typically measured in megahertz (MHz) or gigahertz (GHz).
    - 1 megahertz = 1 million cycles per second.
    - 1 gigahertz = 1 billion cycles per second.
- Many of today's personal computers operate in the 1 to 4 GHz range.

CPU Speed

□ Unfortunately, the faster the clock speed of the processor, the more heat the processor generates.

□ Thus, processors that run at higher temperatures need bigger heat sinks (a device or substance for absorbing excessive heat), fans, and other components to eliminate the excess heat. This increases the size and weight of the computing device.

Multicore Processor

□ Nowadays, multiple processors are embedded together on a single integrated-circuit chip, known as multicore processor.

□ A multicore processor has two or more independent processing units, called cores, e.g. a dual-core processor, quad-core processor, etc.

□ The multiple cores can run multiple instructions at the same time.

Memory Unit

- Computers need to store instructions and data temporarily or permanently.

- The Memory Unit consists of one or more storage devices.

- A storage device or memory device is any type of computer hardware that is used for storing data or information temporarily or permanently.

  - They may be internal or external to a computer.

Types of Memory

- CPU uses registers exclusively to store and manipulate data and instructions during the processing.

- Apart from registers, there are mainly two types of memory that are used in a computer system.

  - **Primary Memory**
  - **Secondary Memory**

Primary Memory

- **Primary Memory**, aka. Primary Storage, or Main Memory

- Primary Memory is the area where data and instructions are stored while the program is being executed.

- Primary Memory is accessed directly by the processor.

Types of Primary Memory

- Random access memory (RAM)
- Cache Memory
- Read-only memory (ROM),

Random Access Memory (RAM)

- Instructions or data can be temporarily stored in and read from RAM.

- As currently designed, RAM chips are volatile storage devices, meaning they lose their contents if the current is turned off.

- These RAM chips consist of millions of switches that are sensitive to changes in electric current.
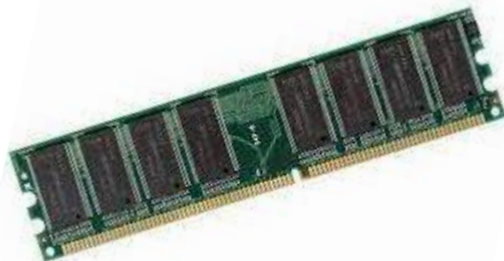
Cache Memory

- The older CPU has only Registers as the memory but modern CPUs also contains the Cache Memory.

- **Cache Memory** (pronounced as "cash") is another kind of primary memory increasingly used in modern computers.

- Cache Memory is an extremely fast memory type used to reduce the average time to access data from the Main memory (RAM).

Cache Memory
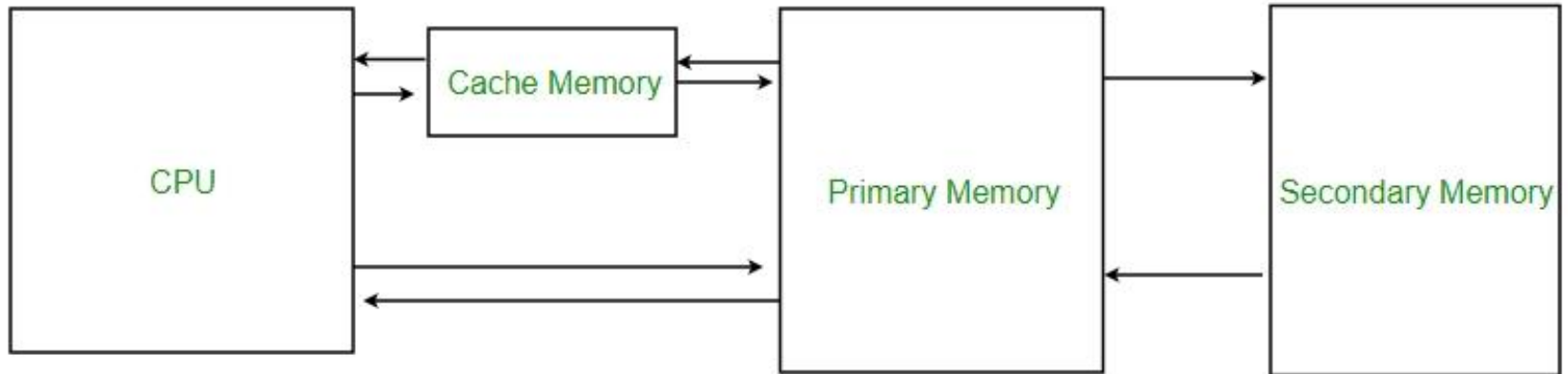
□ Cache Memory acts as a buffer between RAM and the CPU. It holds frequently requested data and instructions so that they are immediately available to the CPU when needed.

Read-only Memory (ROM)

- Read-only memory (ROM), another type of memory, is nonvolatile, meaning that its contents are not lost if the power is turned off or interrupted.

- ROM contains permanent program instructions for execution by the CPU.

- ROM provides permanent storage for data and instructions that do not change, such as programs and data from the computer manufacturer, including the instructions that tell the computer how to start up when power is turned on.

Secondary Memory

☐ Secondary Memory or Secondary Storage is not directly accessible by the CPU. Instead, computers usually use input/output channels to access secondary storage and then transfer the desired data to intermediate areas in primary storage.

Secondary Memory

- Secondary Memory permits the storage of computer data permanently.

- Secondary memory provides a large storage capacity at a lesser cost than primary memory devices.

- However, the access time in secondary memory is much larger than in primary memory.
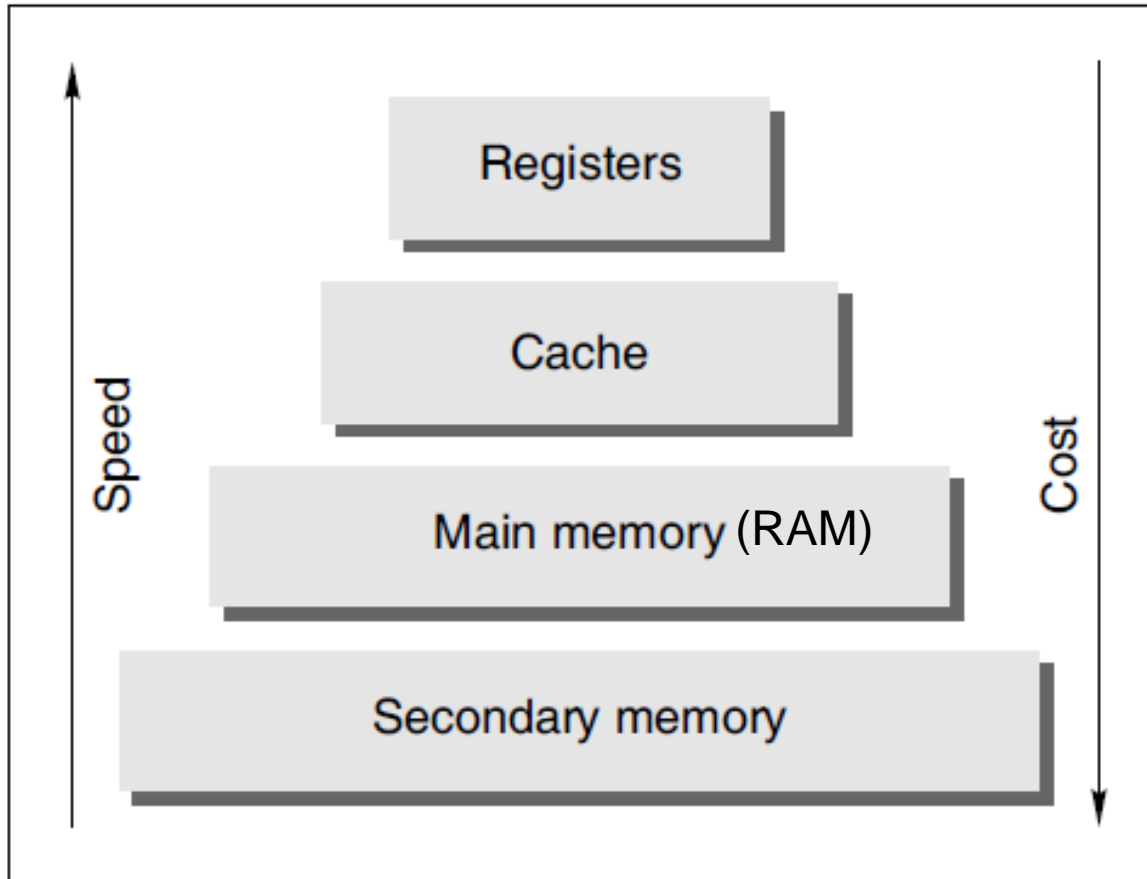
Secondary Storage Devices

- Usually have larger storage capacity.

- Store data permanently.

- Inexpensive

- Can be either internal or external to the computer.

- Example: Floppy disk, Hard Disk Drive (HDD), CD, DVD, USB Flash Drive.

Memory Hierarchy

Secondary Data Storage

- Computer systems can store larger amounts of data and instructions in secondary storage.

- Storing data safely and effectively is critical to an organization's success.

- IBM, which is investing heavily in technologies (such as Watson, its cognitive computer system) that can help organizations manage all that unstructured data, estimates that more than 80 percent of the 2.5 billion gigabytes of data created every day comes in the form of unstructured data.

Secondary Data Storage

- Putting an organization's data online involves a serious business risk— the loss of critical data can put a corporation out of business.

- Thus, organizations now require that their data storage devices be fault tolerant. In response, disk manufacturers are continually developing new technologies that will improve the performance and reliability of their hard disk drives.

Enterprise Storage Options

□ Businesses need to store the large amounts of data created throughout an organization. Such large-scale secondary storage is called enterprise storage and comes in four forms:

   □ Attached storage

   □ Network-attached storage (NAS)

   □ Storage area networks (SANs)

   □ Storage as a service / Cloud computing storage

Attached Storage

- Attached storage:
  - Methods include the tape, hard disks, etc.
  - Here, the storage is attached to a single computer, such as a computer's hard drive. The access too thus becomes limited because to access the storage from another computer, will require you to detach the storage from the hardware/ hard drive and then attach it to the new computer.

Network-attached storage (NAS)

- Network-attached storage (NAS):
  - Hard disk storage that is set up with its own network address rather than being attached to a computer.
  - In NAS, the server can be installed with an operating system, so that data is made accessible to all the internal networks.
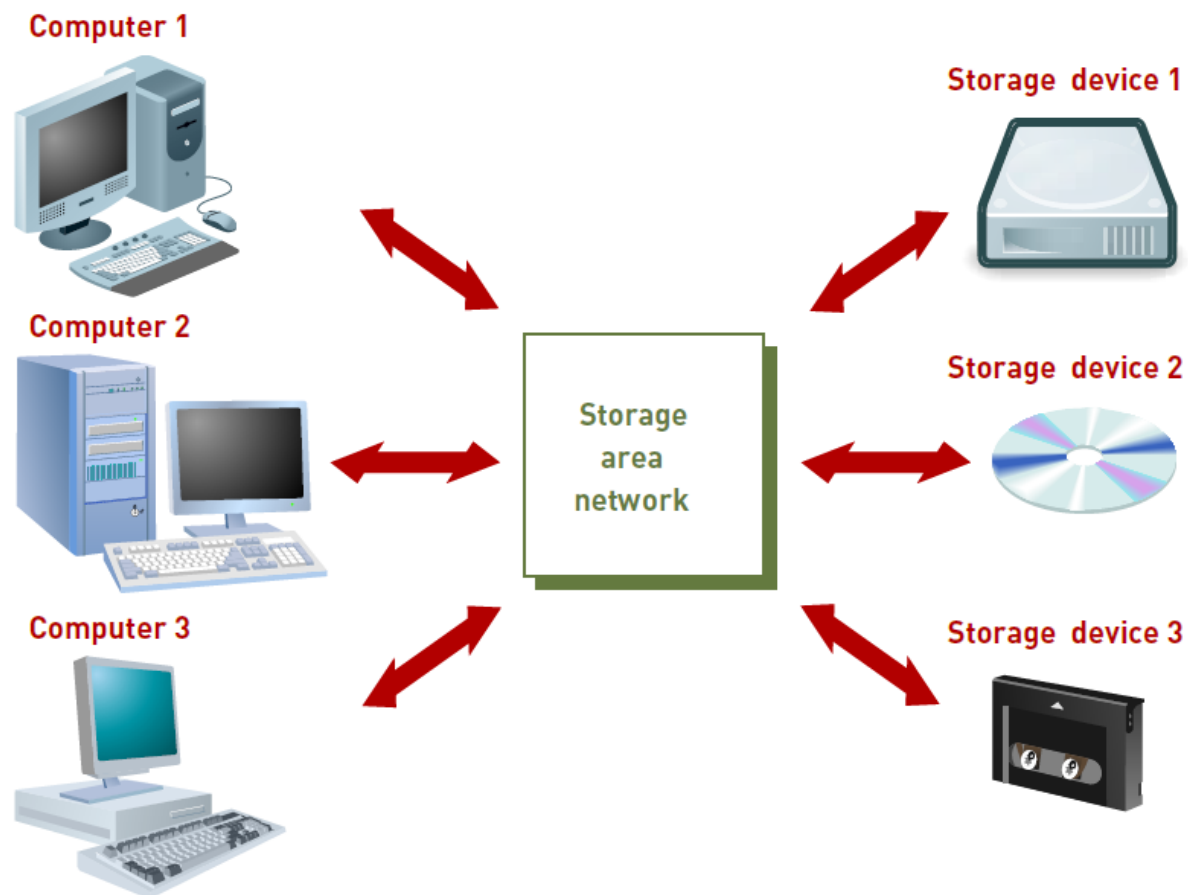
Storage area network (SAN)

- Storage area network (SAN):

  - Special-purpose, high-speed network that provides direct connections among data-storage devices and computers.

  - It integrates different types of data storage devices (e.g., hard disk drives, magnetic tape, etc., into a single storage system and connects that to computing resources across an entire organization.

Storage area network (SAN)

FIGURE 3.7

Storage area network

A SAN provides high-speed connections among data storage devices and computers over a network.

Storage as a Service

- A data storage model where a data storage service provider rents space to people and organizations

- Providers:
  - AT&T, Aviva, Amazon.com
  - EMC, Google, Microsoft, and ParaScale

☐ Organizations should select a type of storage based on their needs and resources. In general, storing large amounts of data and information and providing users with quick access make an organization more efficient.

Input and Output Devices

- Input and output devices are the gateways to the computer system—you use them to provide data and instructions to the computer and receive results from it.

- Input and output devices are part of a computer's user interface, which includes other hardware devices and software that allow you to interact with a computer system.

Input Unit

- Computer need to receive data and instruction in order to perform any task or solve any problem. Therefore we need to input the data and instructions into the computers.

- The input unit consists of one or more input devices.

Input Devices

□ The data and instructions are typed, submitted, or transmitted to a computer through input devices.

□ An Input Device is any computer hardware that sends data to a computer.

□ Example: Keyboard, Mouse, Scanner, Barcode Reader, etc.

Input Devices

- Speech-recognition technology

- Motion-Sensing Input Devices

- Pen input devices

Input Devices

□ Chip-and-PIN cards

□ Contactless Payment Cards

□ …

Output Unit

- Output unit delivers information from the computer to an external device or from internal storage to external storage.

- The output unit consists of one or more output devices.

Output Devices

- An Output Device is any computer hardware that receives data or information from a computer, usually for displaying information in human-readable form (text, graphics, audio, or video).

- Example: Monitor, Printer, Projector, Speakers, etc.
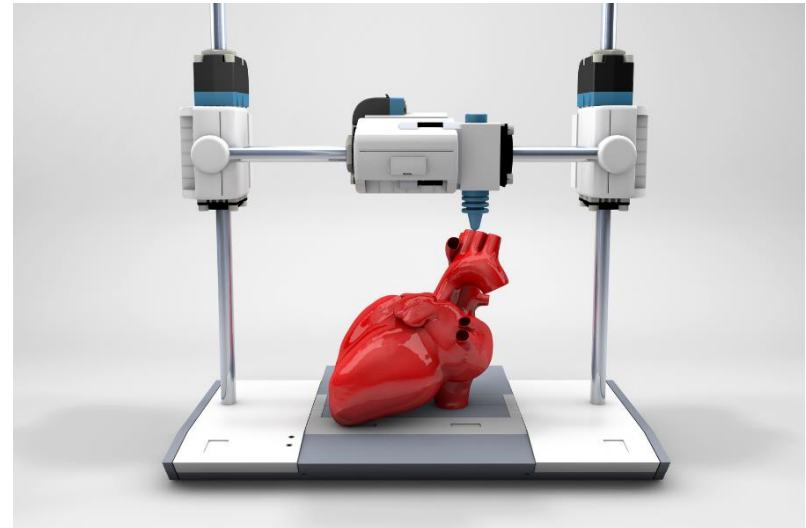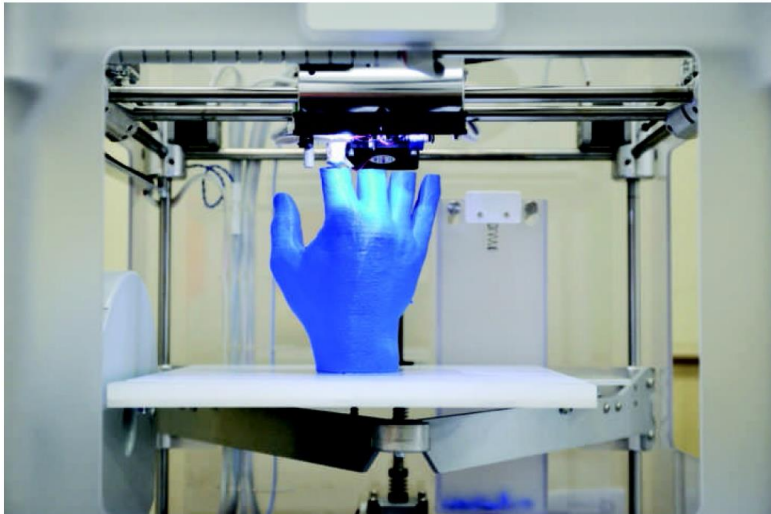
Output Devices

- Digital Audio Players

- E-Book Readers

Output Devices

- ☐ 3D Printers

- ☐ …

Both Input-Output Devices

▢ Example: Digital Camera, CD/DVD, Headset, Touchscreen, etc.

Input and Output Devices

- Organizations:
  - Should keep their business goals in mind when selecting input and output devices
- In general, businesses want input devices that let them accurately and rapidly enter data into a computer system, and they want output devices that let them produce timely results.
- Some organizations have very specific needs for input and output, requiring devices that perform specific functions.

Data Entry and Input

- Data can be human-readable or machine-readable.

- Getting data into a computer—input—often requires transferring human-readable data, such as a sales order, into a computer system.

- "Human-readable data" means data that people can read and understand.

- An example of machine-readable data is the universal barcode on many grocery and retail items that indicates the stock-keeping identification number for that item.

A1234567890A

Data Entry and Input

- Getting data into the computer system is a two-stage process:
  - Data entry: Converts human-readable data into machine-readable form.
  - Data input: Transfers machine-readable data into system.
- In many cases, the terms "data entry" and "data input" are used interchangeably.

Data Entry and Input

- Data entry:
    - Is the process of transferring data from manual records to a digital database.
    - you make information available to computer systems in a manner and form where it can be understood.
    - The information by itself is perhaps relevant and useful in many different ways but that can only be realized if it becomes computer readable.

Data Entry and Input

- Data input
    - Is the process of providing relevant information to a software program so that it can produce output.
    - The input enables the computer to do what is designed to do and produce an output. Thus, the word or phrase that you type into the text box of your search engine is the input which it will process and produce an output for you.

Source Data Automation

- **Source data automation** involves capturing and editing data where it is originally created and in a form that can be directly entered into a computer, thus ensuring accuracy and timeliness.

- For example, using source data automation, salespeople enter sales orders into the computer at the time and place they take the orders. Any errors can be detected and corrected immediately. If an item is temporarily out of stock, the salesperson can discuss options with the customer.

Source Data Automation

- Prior to source data automation, orders were written on paper and entered into the computer later (usually by a clerk, not by the person who took the order).

- Often the handwritten information was not legible or, worse yet, order forms were lost. If problems occurred during data entry, the clerk had to contact the salesperson or the customer to "recapture" the data needed for order entry, leading to further delays and customer dissatisfaction.

Portable Computers

- Many computer manufacturers offer a variety of portable computers, those that are small enough to carry easily.

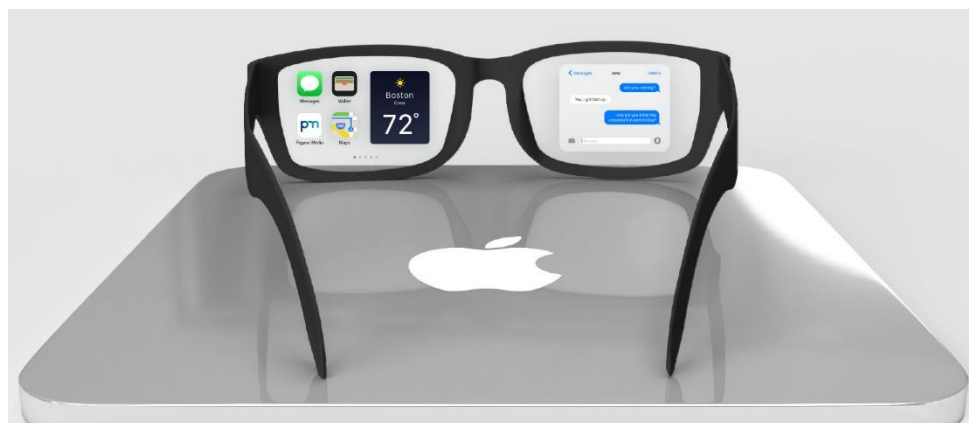- Portable computers include wearable computers, smartphones, laptops, notebooks, ultrabooks, and tablets.

Portable Computers

- Wearable Computers
  - incorporated into a person's clothing or personal accessories.
  - Example: health-tracking wrist bands or smart watches, fitness bands, etc.
- Smartphones
- Mobile Computers
  - Laptop, Tablet.

Wearable Computers

Wearable Computers

- Around one-half to two-thirds of U.S. employers with 15 or more workers have implemented some sort of employee wellness program.

- One-half of fitness band sales in the United States are to organizations that pass these devices along to its employees, often at no charge.

Anatomy of a Smartphone
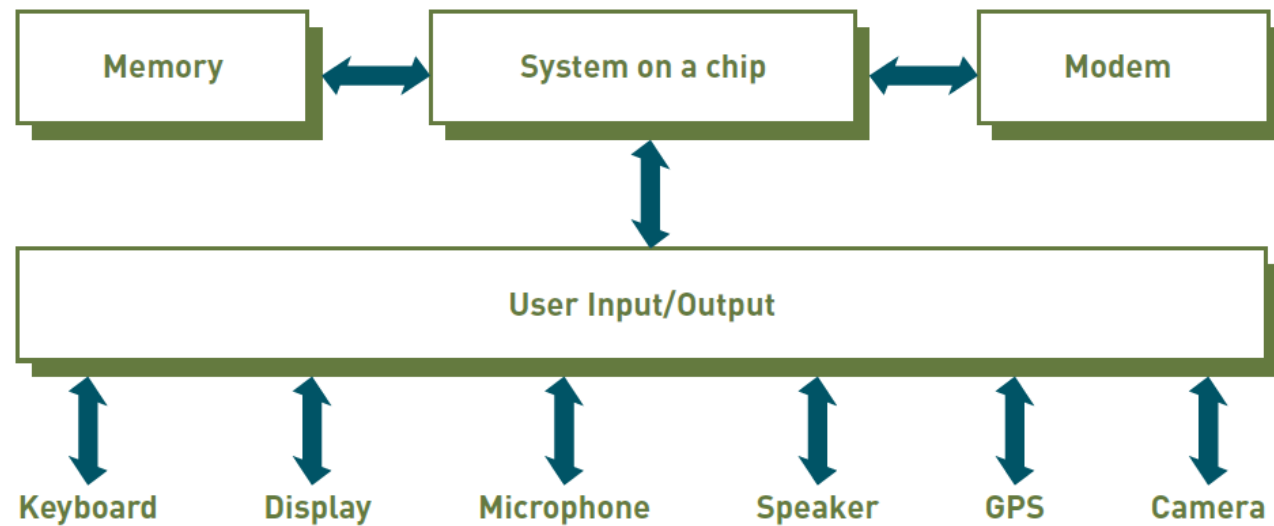
FIGURE **3.12**

Anatomy of a smartphone

Smartphones employ a combination chipset called a "system on a chip," which includes processor cores, RAM and ROM memory, interface controllers, and voltage regulators.

Nonportable Single-User Computers

- Thin client:
  - Low-cost, centrally managed computer with no extra drives.

- Desktop computers:
  - Single-user computer systems that are highly versatile

Thin Clients

A thin client is a computer that is connected to a server computer. Unlike a normal computer, it does not have local memory and is thus nothing can be saved in its drive. It can process data remotely from the server computer when connected to it.

Nonportable Single-User Computers

- Nettop computer:
  - Inexpensive desktop computer designed to be smaller, lighter, and consume much less power than a traditional desktop computer.
  - It is for basic tasks such as web browsing, accessing web-based applications, document processing, and audio/video playback.

Nettop Computer

Nonportable Single-User Computers

- Workstations:
  - More powerful than personal computers but still small enough to fit on a desktop.

Multiple-User Computer Systems

- ## Server:
  - Used by many users to perform a specific task, such as running network or Internet applications

- ## Scalability:
  - The ability to increase the processing capability of a computer system so that it can handle more users, more data, or more transactions

- ## Blade server:
  - Houses many computer motherboards

Multiple-User Computer Systems

- Mainframe computer:
  - Large, powerful computer shared by dozens or even hundreds of concurrent users connected to the machine over a network

- Supercomputers:
  - The most powerful computers with the fastest processing speed and highest performance

Mainframe Computers

Supercomputers

Supercomputers

TABLE 3.7 Five most powerful operational supercomputers (July 2015)

Rank	Name	Manufacturer	Research Center	Location	Number of Cores	Speed (Petaflops)
1	Tianhe-2	NUDT	National University of Defense Technology (NUDT)	China	3.1 million	33.9
2	Titan	Cray	Oak Ridge National Laboratory	United States	0.56 million	17.6
3	Sequoia	IBM	Lawrence Livermore National Laboratory	United States	1.5 million	17.2
4	K	Fujitsu	Riken Advanced Institute for Computational Science	Japan	0.75 million	10.5
5	Mira	IBM	Argonne National Laboratory	United States	0.8 million	8.6

Source: Lendino, Jamie, "China's Tianhe-2 Still the Fastest Supercomputer in the World, but the US Is Catching Up," *Extreme Tech*, July 13, 2015, *www.extremetech.com/extreme/209704-chinas-tianhe-2-still-the-fastest-supercomputer-in-the-world-but-the-us-is-catching-up*.

Server Farm

□ A server farm is a collection of computer servers – usually maintained by an organization to supply server functionality far beyond the capability of a single machine.

□ A server farm is also called a server cluster since the servers combine to act as one powerful distributed server.

Server Farms

Server Farm

- A server farm can be as small as a few servers or a large as thousands of servers, again all connected together across their local network.

- Server farms that consist of thousands of computers require a large amount of power to run and to keep cool.

Server Farms

- Apple, Google, Microsoft, the U.S. government, and many other organizations have built billion-dollar server farms in small rural communities where both land and electricity are cheap.

- Low power usage is a critical factor for organizations that run server farms made up of hundreds or even thousands of servers.

- The annual power savings from such low-energy usage servers can amount to tens of thousands of dollars for operators of a large server farm.

Data Centers

□ A data center is a climate-and-access-controlled building or a set of buildings that houses the computer hardware that delivers an organization's data and information services.

□ Largest Data Centers In The World In 2021

Data Center Vs Server Farm

- A data center is a physical building with redundant power, cooling, and Internet connectivity.

- A server farm is a grouping of servers. For example, you might have a server farm that supports your website comprised of web, app, and database servers, but likely you have a different server farm that handles other services such as email, etc. All these different server farms can reside at the same data center.

Data Centers

Google spends on the order of $4 billion a year on building data centers in an attempt to keep up with the rapid growth of demand of its existing and new customers. Apple is spending $2 billion to build one data center in Mesa, Arizona, to serve as a command center for its global networks.

Data Centers

- The need for additional data storage capacity is another factor driving the growth in data centers. According to one study, somewhere between one-third and one-half of all data centers will run out of space in the next several years.

- Of those organizations needing more database capacity, about 40 percent indicated that they would build new data centers, about 30 percent said they would lease additional space, and the rest indicated that they would investigate other options, including the use of cloud computing.

Data Centers

☐ In a further attempt to lower ongoing operating costs, many organizations are locating their data centers in areas with milder climates and lower energy rates and land costs.

☐ For organizations in the United States, this translates to rural locations in the south and the northwest. Apple's $1 billion data center, Google's $600 million data center, and Facebook's $450 million data center are all located in rural North Carolina.

Data Centers

- The ability to absorb the impact of a disaster (e.g., hurricane, earthquake, terrorism attack, or war) and quickly restore services is a critical concern.

- As a result, data centers of large information systems service organizations are often distributed among multiple locations in different areas of the country or even different countries to ensure continuous operations in the event of a disaster.

- Globally, IBM (the best known computer company in the world) has more than 400 widely distributed data centers to meet the needs of its customers.

Electronic-waste

- Electronic devices such as computer hardware and smartphones contain hundreds or even thousands of components. The components, in turn, are composed of many different materials, including some that are known to be potentially harmful to humans and the environment, such as beryllium, cadmium, mercury, selenium, etc.

- A study by Queensland University, Australia, indicates that sitting in front of a printer all day is almost equal to smoking.

Electronic-waste

- While new computers are being made every day, old computers are being discarded- thus creating a lot of e-waste.

- When we throw away our old computers to buy new ones, we are just adding to the e-waste.

Electronic-waste

Electronic-waste

- Burning the waste e-products will release harmful gases.

- Care must also be taken when recycling or destroying these devices to avoid polluting the environment.

- Countries Generate the Most Electronic Waste

Green Computing

- **Green computing** is concerned with the efficient and environmentally responsible design, manufacture, operation, and disposal of IS-related products, including all types of computing devices (from smartphones to supercomputers), printers, printer materials such as cartridges and toner, and storage devices.

- Many business organizations recognize that going green is in their best interests in terms of public relations, safety of employees, and the community at large.

Green Computing

- Green computing has three goals:
  - Reduce the use of hazardous (risky, dangerous) material.
  - Enable companies to lower their power-related costs.
    - Example: Make sure devices come with power management options enabled. Sleep mode significantly reduces energy usage.
  - Enable the safe disposal or recycling of some 700,000 tons of computers each year.

Green Computing

☐ It is estimated that 51.9 million computers, 35.8 million monitors, and 33.6 million hard copy devices (printers, faxes, etc.)—representing a total of 1.3 million tons of waste—were disposed of in the United States in 2010 alone.

Green Computing

- Because it is impossible for manufacturers to ensure safe recycling or disposal, the best practice would be for them to eliminate the use of toxic substances, particularly since recycling of used computers, monitors, and printers has raised concerns about toxicity of some of the substances.

- In many cases, recycling companies export large quantities of used electronics to companies in undeveloped countries. Unfortunately, many of these countries do not have strong environmental laws, and they sometimes fail to recognize the potential dangers of dealing with hazardous materials.

Green Computing

☐ Some electronics manufacturers have developed programs to assist their customers in disposing of old equipment. For example, Dell offers a free worldwide recycling program for consumers. It also provides no-charge recycling of any brand of used computer or printer with the purchase of a new Dell computer or printer. This equipment is recycled in an environmentally responsible manner, using Dell's stringent and global recycling guidelines. HP, which offers a similar program, has recovered 2.8 billion pounds of products since 1987.

Green Computing

- Computer manufacturers are using green computing as a new business strategy to distinguish themselves from the competition.

- Apple claims to have the "greenest lineup of notebooks" and is making progress at removing toxic chemicals from its manufacturing process.

- Dell is focused on becoming "the greenest technology company on Earth."

- Hewlett-Packard often highlights its long tradition of environmentalism and is improving its packaging to reduce the use of materials. It is also urging computer users around the world to shut down their computers at the end of the day to save energy and reduce carbon emissions.

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- **Reynolds, George Walter, Stair, Ralph M.** "Principles of information systems", 13e – 2017