

Chapter 2: Inside the Computer System

Objectives

- ☺ Understand how computers represent data.
- ☺ Understand the measurements used to describe data transfer rates and data storage capacity.
- ☺ List the components found inside the system unit and explain their use.

Objectives

- ☺ List the components found on the computer's motherboard and explain their role in the computer system.
- ☺ Discuss (in general terms) how a CPU processes data.
- ☺ Explain the factors that determine a microprocessor's performance.

Objectives

- ☺ List the various types of memory found in a computer system and explain the purpose of each.
- ☺ Describe the various physical connectors on the exterior of the system unit and explain their use.

How Computers Represent Data

- **Binary numbers**

- Only 0s and 1s

- **Bit**

- Smallest piece of data a computer can work with
- Either “on” or “off,” a 0 or a 1
- Eight bits—**byte**—a single unit of storage

How Computers Represent Data

Data storage is in bytes

- Kilobyte (KB)—one thousand bytes
- Megabyte (MB)—one million bytes
- Gigabytes (GB)—one billion bytes
- Terabyte (TB)—one trillion bytes

Converting from Binary to decimal and vice-versa

$$\square (101)_2 = 5$$

$$\square (1001)_2 = 9$$

$$\square (11011)_2 = 27$$

$$2^0 = 1, 2^1 = 2, 2^2 = 4, 8, 16, 32, 64, 128, 256, \dots$$

How Computers Represent Data

- **Characters**

- Letters, numbers, and symbols—converted into numbers the computer understands

- **Character code**

- Performs the conversion
 - American Standard Code for Information Interchange (ASCII)
 - Extended Binary Coded Decimal Interchange Code (EBCDIC)
 - Unicode

Introducing the System Unit

- **System unit**

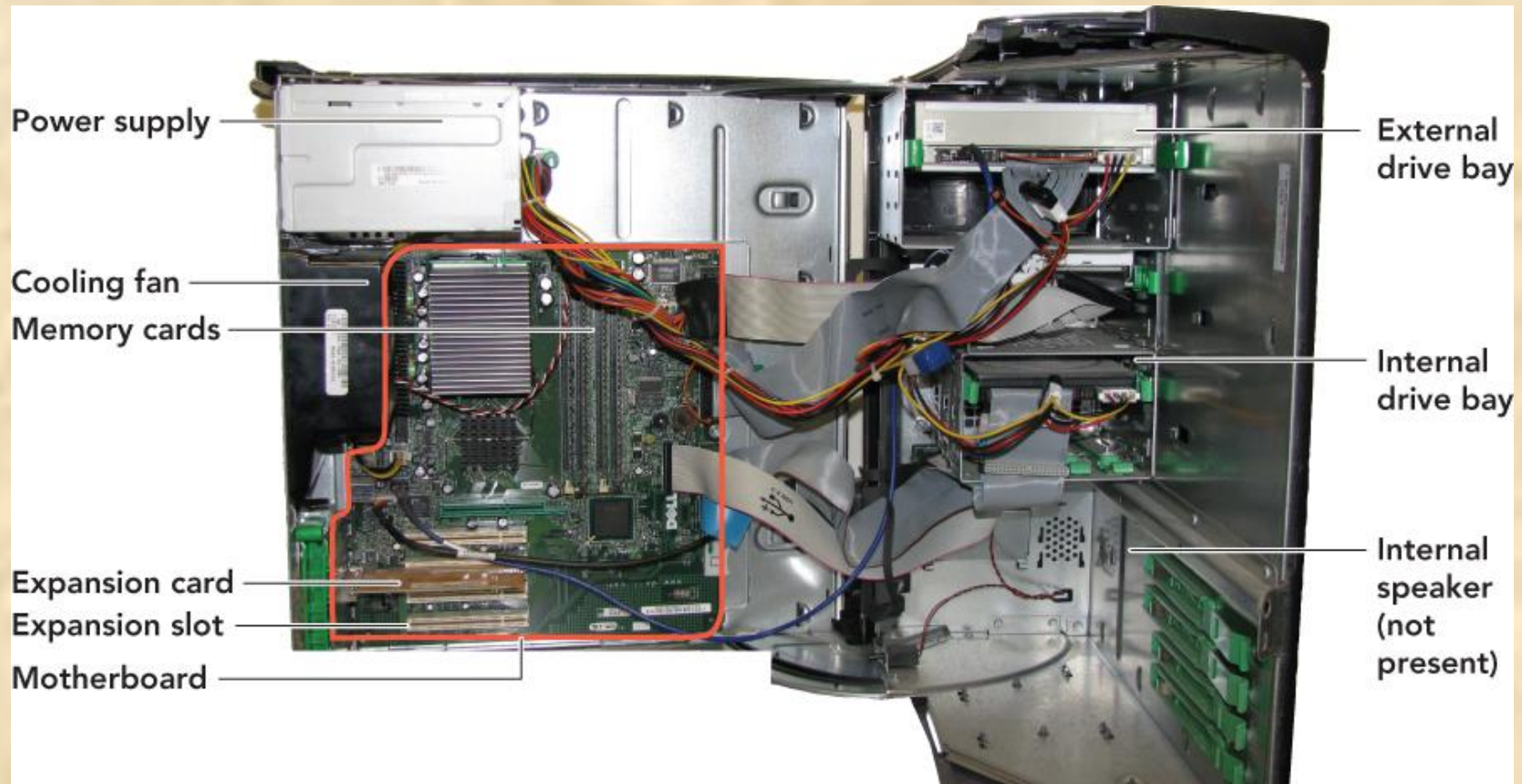
- Case that contains the major hardware components of a computer
- Come in different styles

Form factor—specifies how the internal components are located within the system unit.

Inside the System Unit

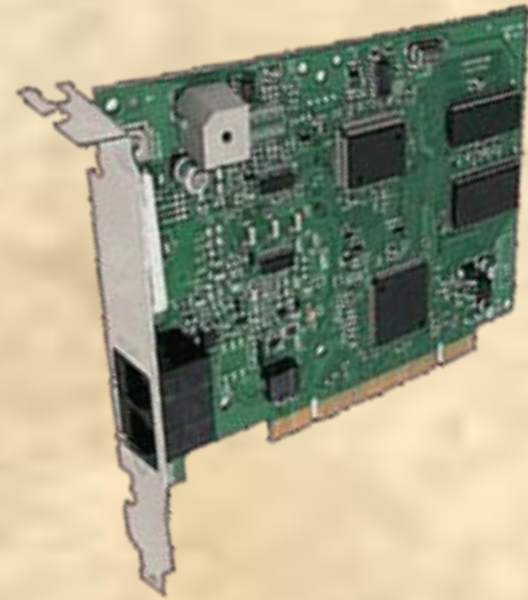
- System unit main components
 - Motherboard
 - CPU
 - Power supply
 - Cooling fan
 - Internal speaker
 - Drive bays
 - Expansion slots

Inside the System Unit

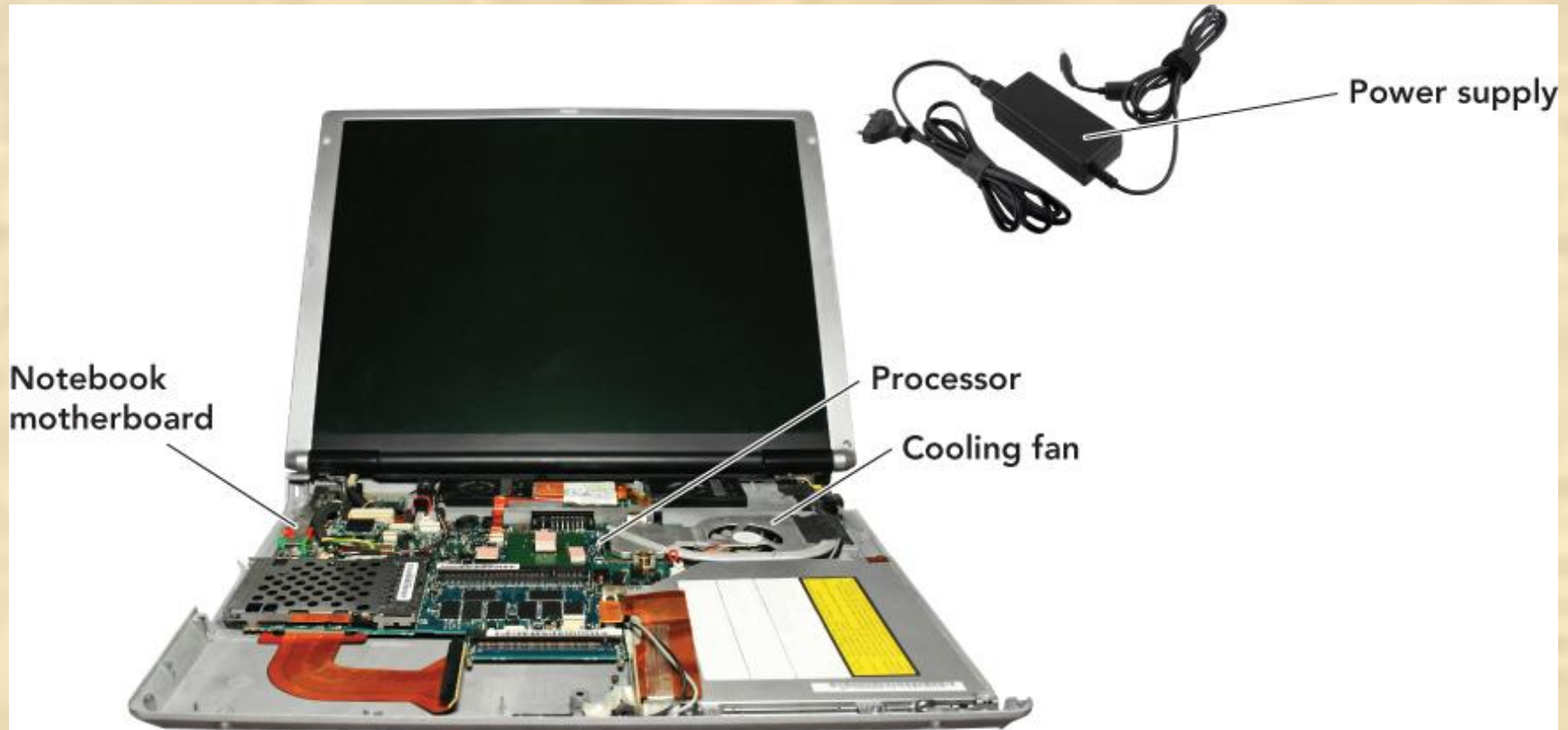


Expansion Cards

- Adds functions
- Provides new connections for peripheral devices
- Common types:
 - Sound
 - Modem
 - Video (VGA)
 - Network (NIC)

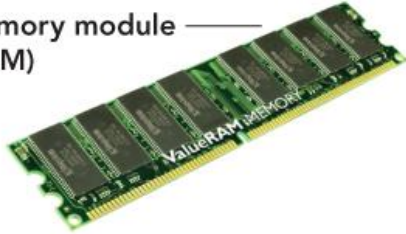


Inside the System Unit



What's on the Motherboard?

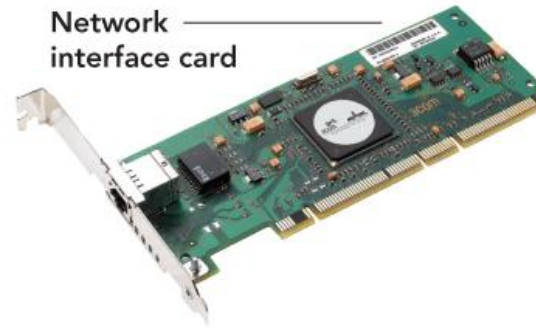
Memory module (RAM)



Modem card



Network interface card



Sound card



Video card



What's on the Motherboard?

Motherboard

- Circuit board that contains the electrical circuitry for the computer
- The majority of parts found on the motherboard are **integrated circuits**.
 - Includes millions of **transistors** and carries electrical current

What's on the Motherboard?

- **Central processing unit (CPU)**
 - Integrated circuit chip that processes electronic signals
 - Also known as a microprocessor or processor

What's on the Motherboard?

- **CPU (con't.)**

- Is usually covered by a **heat sink**
 - A heat-dissipating component that drains heat from the chip
- **Instruction**—An operation performed by the CPU and assigned a specific number
- **Instruction set**—The list of CPU instructions for the operations

What's on the Motherboard?

- **CPU (con't.)**

- **Control unit**

- Retrieves instructions from memory
 - Interprets and performs those instructions
 - Manages the **machine cycle** or **processing cycle**, the four-part process performed by the CPU

- **Arithmetic logic unit (ALU)**

- Performs arithmetic and logical operations
 - Involve adding, subtracting, multiplying, dividing
 - Logical operations involve comparisons between two or more data items.

- **Registers**

- store data when it must be temporarily stored in the CPU

Machine cycle

The computer can only do one thing at a time. Each action must be broken down into the most basic steps. One round of steps from getting an instruction back to getting the next instruction is called the **Machine Cycle**.

Fetch -

get an instruction from Main Memory

Decode -

translate it into computer commands

Execute -

actually process the command

Store -

write the result to Main Memory

Machine cycle

Machine cycle

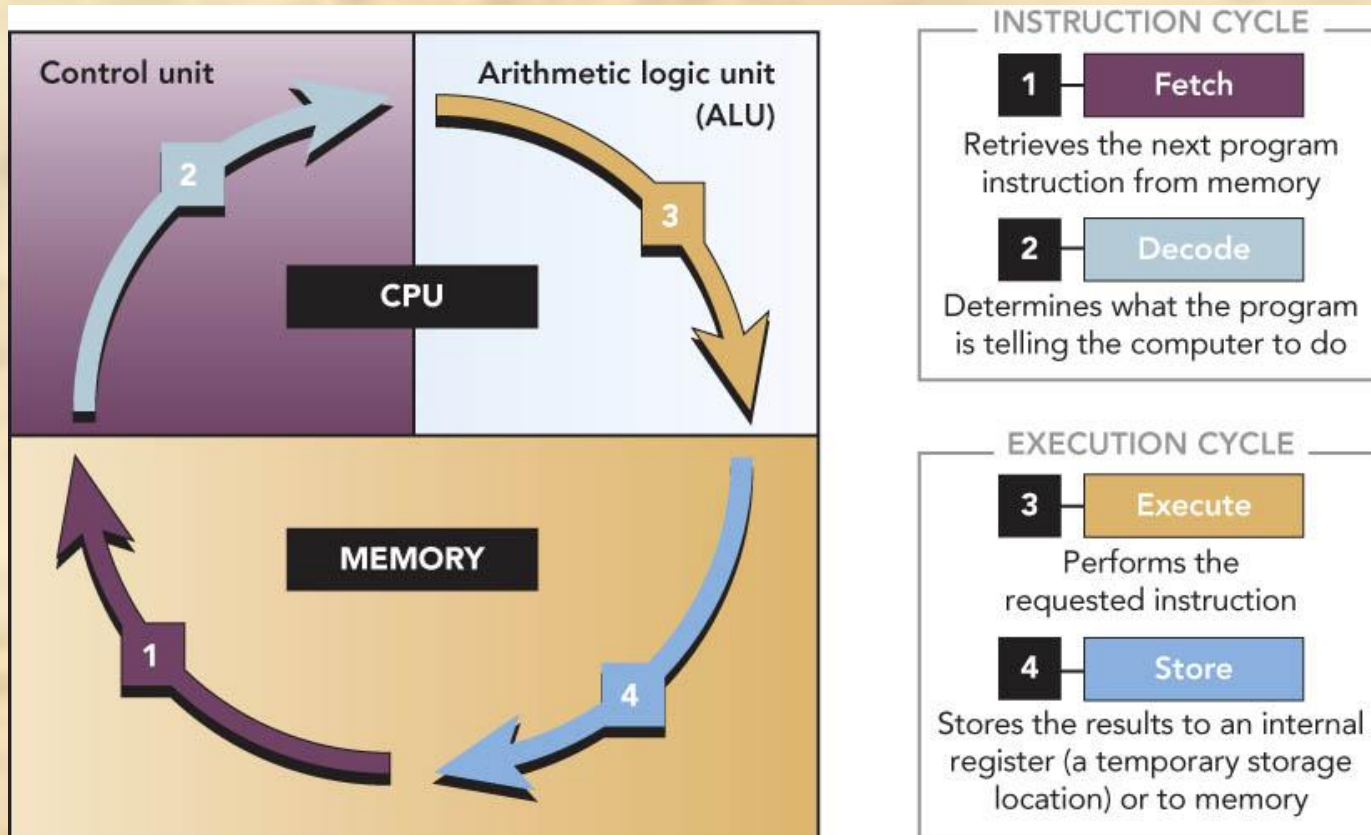
- **Instruction cycle**

- **Fetch:** Retrieves program instructions
- **Decode:** Determines what the program is telling the computer to do

- **Execution cycle:**

- **Execute:** Performs the requested action
- **Store:** Stores the results to an internal register

Machine cycle



For example,

to add the numbers 5 and 6 and show the answer on the screen requires the following steps:

- | | | |
|---|---------------------|--|
| 1. | Fetch instruction: | "Get number at address 123456" |
| 2. | Decode instruction. | |
| 3. | Execute: | ALU finds the number. (<i>which happens to be 5</i>) |
| 4. | Store: | The number 5 is stored in a temporary spot in Main Memory. |
| 5 - 8 Repeat steps for another number (= 6) | | |
| 9. | Fetch instruction: | "Add those two numbers" |
| 10. | Decode instruction. | |
| 11. | Execute: | ALU adds the numbers. |
| 12. | Store: | The answer is stored in a temporary spot. |
| 13. | Fetch instruction: | "Display answer on screen." |
| 14. | Decode instruction. | |
| 15. | Execute: | Display answer on screen |

Factors that affect the performance of a CPU include:

- Number of existing transistors
- Data bus width and word size
- Clock speed
- Operations per microprocessor cycle
- Use of parallel processing
- Type of chip

What's on the Motherboard?

Data bus

- Group of parallel wires that connect the CPU's internal components
- Width measured in bits
- Maximum number of bits the CPU can process at once is called the **word size**
- Determines which operating systems and software a CPU can run

What's on the Motherboard?

- **System clock**

- Electronic circuit that produces rapid pulses and coordinates the computer's internal activities.
- **Clock speed**—measurement of the electrical pulses generated by the system clock, usually measured in gigahertz (GHz)

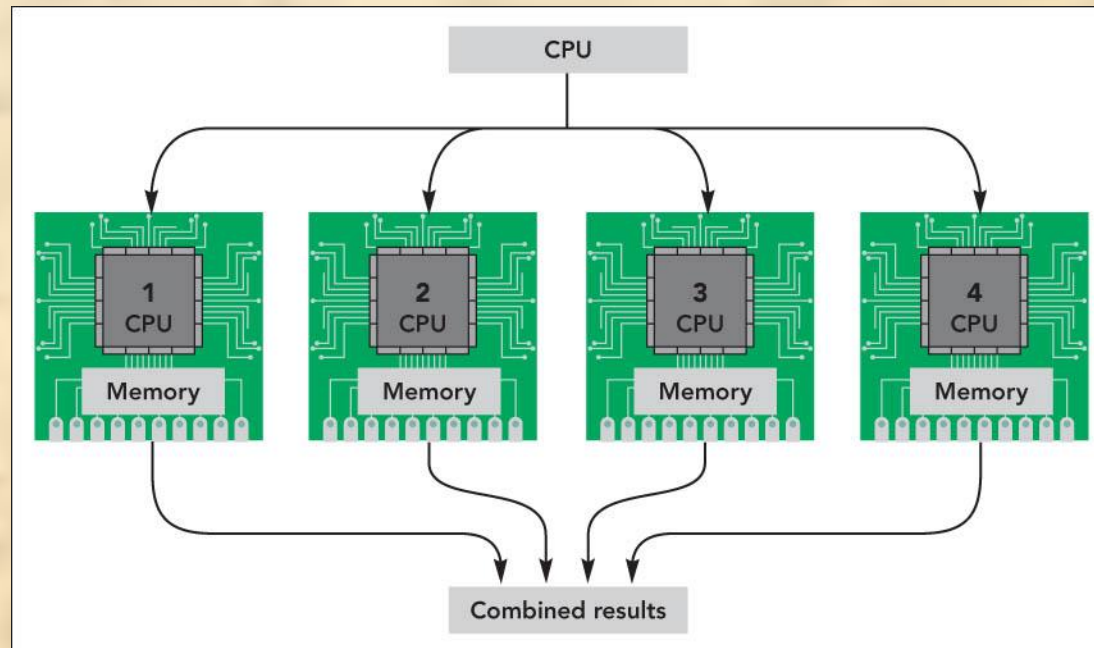
What's on the Motherboard?

- **System clock (con't.)**

- **Superscalar architecture**—enables the CPU to perform more than one instruction for each clock cycle
- **Pipelining**—enables the CPU to process more than one instruction at a time improving performance

Parallel processing

- Method where more than one processor performs at the same time—faster processing



Instruction pipeline

Basic five-stage pipeline machine

- IF = Instruction Fetch
- ID = Instruction Decode
- EX = Execute,
- MEM = Memory access
- WB = Register write back.
- In the fourth clock cycle (the green column), the earliest instruction is in MEM stage, and the latest instruction has not yet entered the pipeline.

Instr. No.	Pipeline Stage						
	IF	ID	EX	MEM	WB		
1	IF	ID	EX	MEM	WB		
2		IF	ID	EX	MEM	WB	
3			IF	ID	EX	MEM	WB
4				IF	ID	EX	MEM
5					IF	ID	EX
Clock Cycle	1	2	3	4	5	6	7

What's on the Motherboard?

- **Multi-core processing**

- Access time reduced
- Processing time improved
- Each core handles incoming streams of data or instructions at the same time
- Two basic types:
 - **Dual core**
 - **Quad core**

What's on the Motherboard?

- **Chipset**

- Set of chips that supply the switching circuitry the CPU requires to move data throughout the computer
- The CPU and the **input/output (I/O) bus** linked through the chipset
 - Provides a means to communicate with input and output devices

What's on the Motherboard?

- **Memory**

- Chips on the motherboard or within the CPU that retain instructions and data

- **Random access memory (RAM)**

- Temporarily stores data and instructions for the CPU
- Volatile—contents erased after computer is shut off
- Allows CPU to access or store data and instructions quickly through RAM's **memory address** feature
 - Identifies and locates stored data

What's on the Motherboard?

- **RAM (con't.)**

- Comes in the form of memory modules or memory cards
- **Memory modules (memory cards)**—small circuit boards that hold several RAM chips and fits into special slots on the motherboard
- Types of RAM:
 - **Dual inline memory modules (DIMM)**—most common today
 - 168-pin connector
 - 64-bit transfer rate
 - **Single inline memory modules (SIMM)**—older technology
 - 72-pin connector
 - 32-bit transfer rate

What's on the Motherboard?

- **Memory footprint**

- Amount of RAM the operating system uses while it operates

- **Virtual memory**

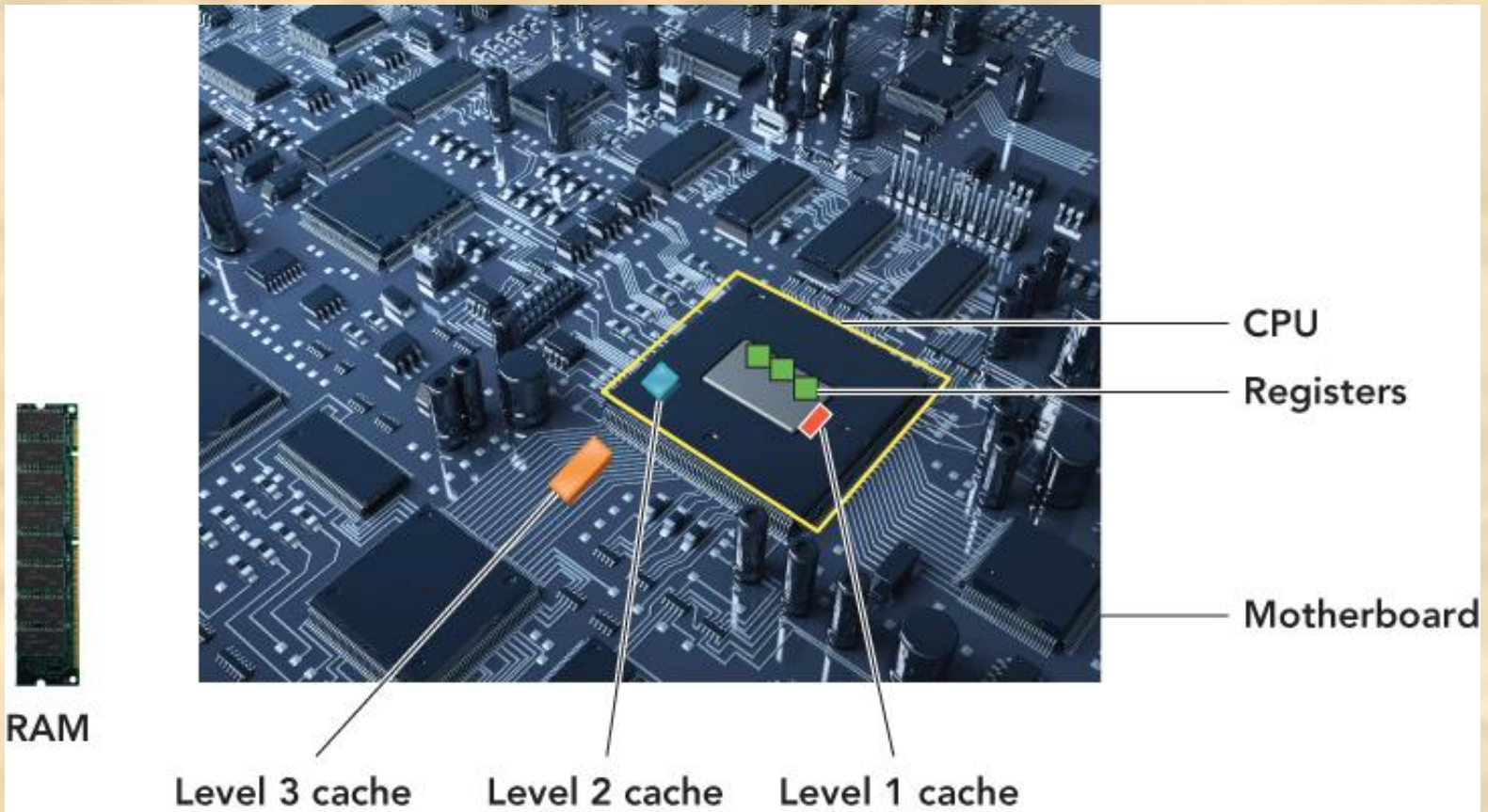
- Section of the hard drive set aside to use when RAM gets full

What's on the Motherboard?

- **Cache memory**

- Small unit of ultrafast memory built into or near the processor
- Used to store frequently or recently access program instructions or data
- Faster than RAM
- More expensive than RAM
- Three levels of cache on a system:
 - Level 1 (L1) cache (primary cache)
 - Level 2 (L2) cache (secondary cache)
 - Level 3 (L3) cache
 - Found on some newer microprocessors
 - Primarily used in servers and workstations

What's on the Motherboard?



What's on the Motherboard?

- **Read-only memory (ROM)**

- Contains prerecorded instructions to start the computer
- Nonvolatile—contents stored when CPU power off

- **Basic input/output system (BIOS)**

- First code run when the system is powered on

- **Power-on self-test (POST)**

- Checks circuitry and RAM, marking defective locations

What's on the Outside of the Box?

- **Front panel**
 - **Power switch**
 - Used to turn the computer on
 - **Drive activity light**
 - Advises the user that the hard drive is retrieving data
 - **Power-on light**
 - Shows whether the power is on

The Front Panel

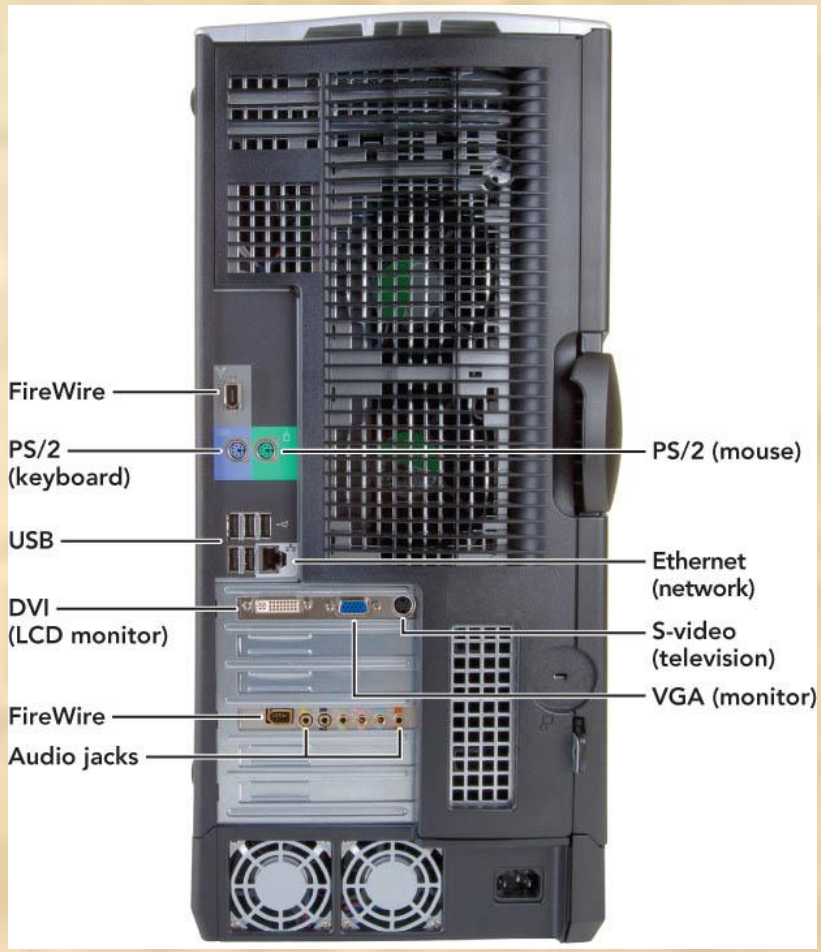
- Drive Bays
- Memory card reader
- Floppy Drive
- Productivity Ports
- Power Button
 - Reset, standby
 - Warm/cold boot



What's on the Outside of the Box?

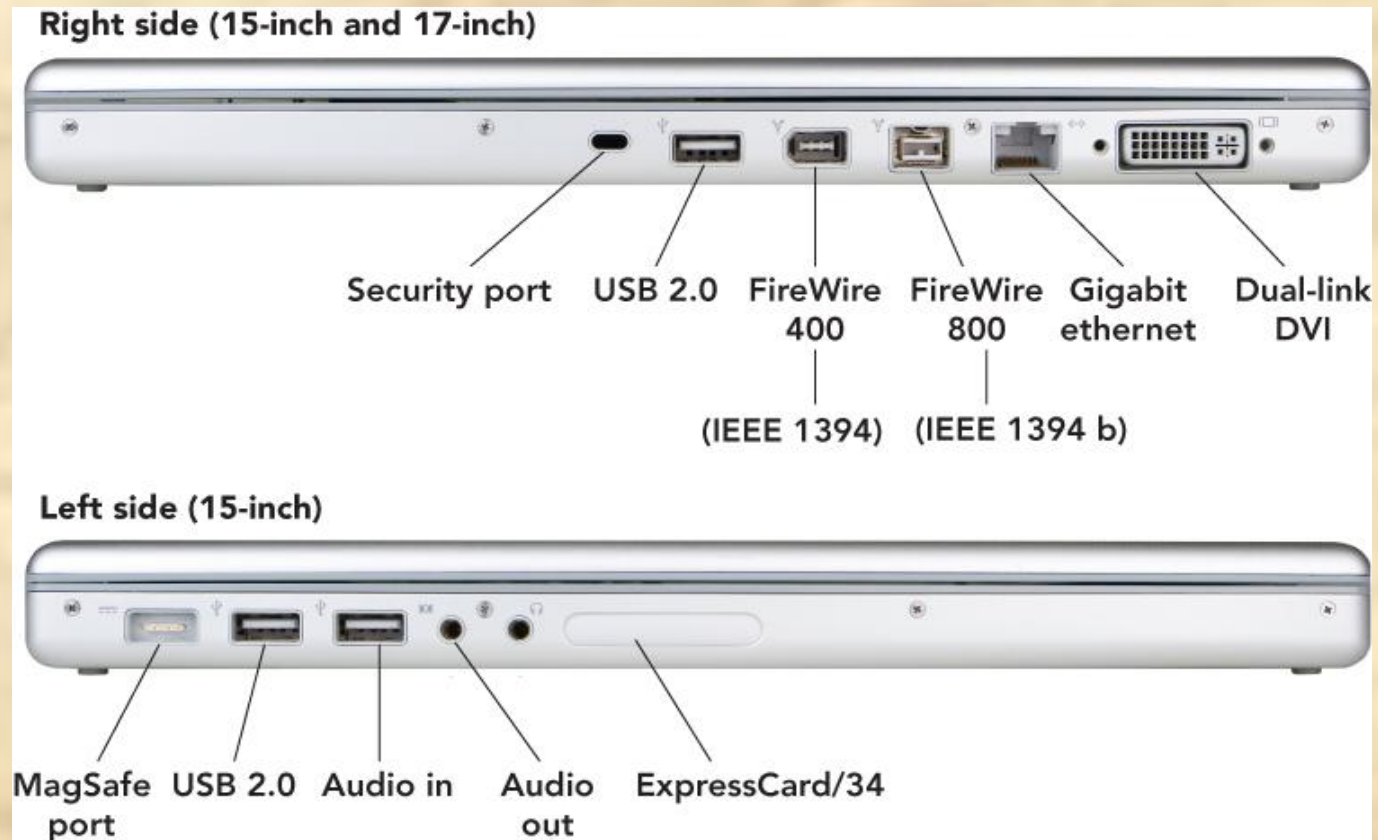
- **Outside a system unit**
 - **Connector**—physical receptacle used to plug a peripheral device into the computer
 - Example: telephone jack
 - **Port**—electronically defined pathway used to send data into and retrieve data from the computer
 - Example: USB port

What's on the Outside of the Box?



What's on the Outside of the Box?

Connectors on a notebook may vary



What's on the Outside of the Box?

- **USB (universal serial bus) ports**
 - Connects up to 127 peripheral devices
 - **USB 2.0 (high-speed USB)**—fully compatible with USB 1.1 products, cables, and connectors
 - Designed to replace older parallel and serial ports
 - Connects a variety of devices to the computer, including:
 - Keyboards
 - Mice
 - Printers
 - Digital cameras



What's on the Outside of the Box?

- **USB 2.0**

- Uses an external bus
- Supports data transfer rates of 480 Mbps between the computer and the peripheral device
- Supports **hot swapping**—ability to connect and disconnect devices without shutting down the computer
- **Plug-and-play (PnP)**—allows computers to automatically detect the device when you plug it in

- **USB hub**

- Device that plugs into existing USB port
- Contains four or more additional ports



What's on the Outside of the Box?

Video connectors

□ **VGA (video graphics array) port**

- 15-pin male connector—works with standard monitor cables
- Transmits analog video signals
- Used for legacy technology cathode ray (CRT) monitors

□ **DVI (Digital visual Interface) port**

lets LCD monitors use digital signals

□ **Onboard video port**

- video circuitry built into the motherboard where the video connector is on the back of the system unit case

What's on the Outside of the Box?

- **Additional connectors**

- Telephone
- Network
- PC card slot
 - PC card
 - ExpressCard
- Sound card
- Game card
- TV/sound capture board

What's on the Outside of the Box?

- **Legacy technology**
 - Older technology that is being phased out
 - Examples:
 - Serial ports
 - Parallel ports
 - PS/2 ports
 - SCSI (small computer system interface) ports

Summary

- Understand how computers represent data.
- Understand the measurements used to describe data transfer rates and data storage capacity.
- List the components found inside the system unit and explain their use.

Summary

- List the components found on the computer's motherboard and explain their role in the computer system.
- Discuss (in general terms) how a CPU processes data.
- Explain the factors that determine a microprocessor's performance.

Summary

- List the various types of memory found in a computer system and explain the purpose of each.
- Describe the various physical connectors on the exterior of the system unit and explain their use.



This work is protected by United States copyright laws and is provided solely for the use of instructors in teaching their courses and assessing student learning. Dissemination or sale of any part of this work (including on the World Wide Web) will destroy the integrity of the work and is not permitted. The work and materials from it should never be made available to students except by instructors using the accompanying text in their classes. All recipients of this work are expected to abide by these restrictions and to honor the intended pedagogical purposes and the needs of other instructors who rely on these materials.

All rights reserved. No part of this publication may be reproduced, stored in a retrieval system, or transmitted, in any form or by any means, electronic, mechanical, photocopying, recording, or otherwise, without the prior written permission of the publisher. Printed in the United States of America.