

***Digital Planet:
Tomorrow's Technology
and You***

George Beekman • Ben Beekman

Tenth Edition

Digital Planet: Tomorrow's Technology and You

Chapter 2 Hardware Basics Inside the Box

Chapter 2 Objectives

- ✓ Explain in general terms how computers store and manipulate information
- ✓ Describe the basic structure and organization of a computer
- ✓ Discuss the computer system's main internal components and the ways they interact
- ✓ Explain why a computer typically has different types of memory and storage devices

What Computers Do

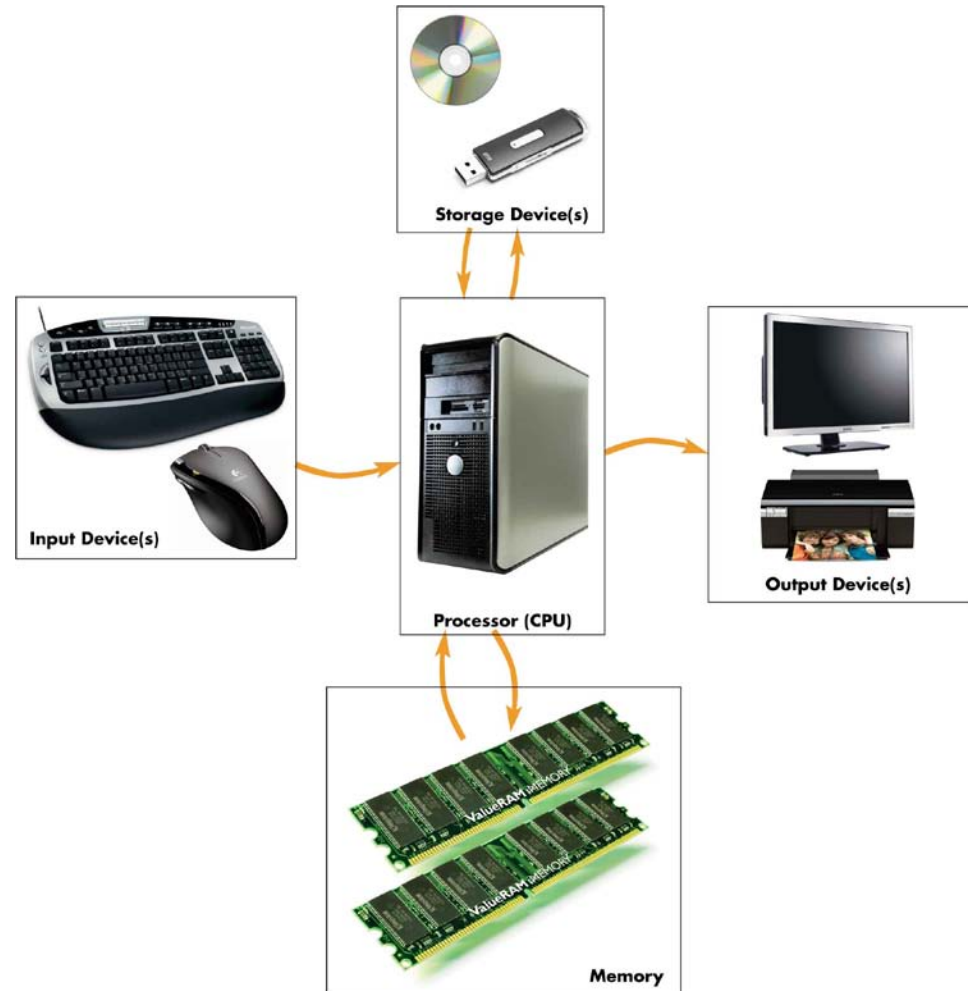
Four basic operations:

- ✓ ***Receive input:*** Accept information from outside world
- ✓ ***Process information:*** Perform arithmetic or logical operations on information
- ✓ ***Produce output:*** Communicate information to outside world
- ✓ ***Store information:*** Store and retrieve information from memory and storage devices

What Computers Do (cont.)

Hardware components

- *Input devices*
- *Output devices*
- *Microprocessor (CPU)*
- *Memory and storage devices*
 - Primary storage
 - Secondary storage
- *Peripherals*



A Bit About Bits

✓ **Information:** Communication that has value because it informs

or

✓ **Information:** Anything that can be communicated, whether it has value or not

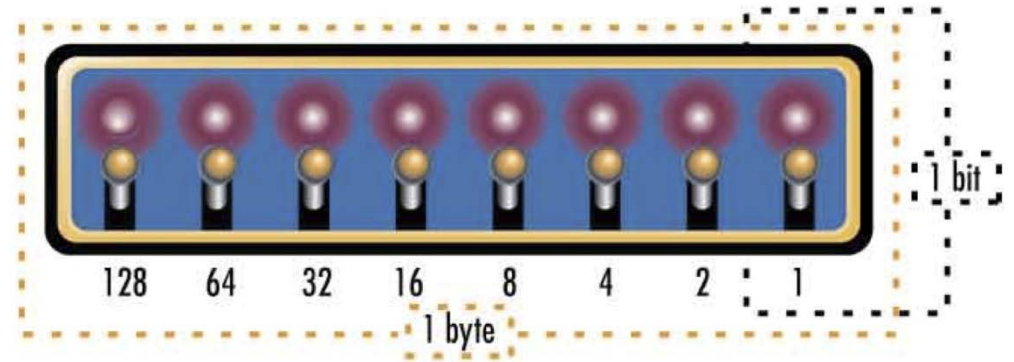
Bit Basics

✓ *Bit*: From Binary digit

- Smallest unit of information computer can process
- Can have one of two values: 0 or 1

✓ *Byte*

- Collection of 8 bits
- Can represent 256 different messages ($256 = 2^8$)



Bits as Numbers

- ✓ Denotes all numbers with combinations of 0s and 1s
- ✓ Decimal numbers automatically converted to binary
- ✓ Binary number processing hidden from user

| Decimal | Binary | Decimal | Binary |
|---------|--------|---------|--------|
| 0 | 0000 | 5 | 0101 |
| 1 | 0001 | 6 | 0110 |
| 2 | 0010 | 7 | 0111 |
| 3 | 0011 | 8 | 1000 |
| 4 | 0100 | 9 | 1001 |

Binary Arithmetic & Conversions

- ✓ Convert the binary number 1011 to decimal
- ✓ Add 1011 and 1011
- ✓ Convert 25 to binary

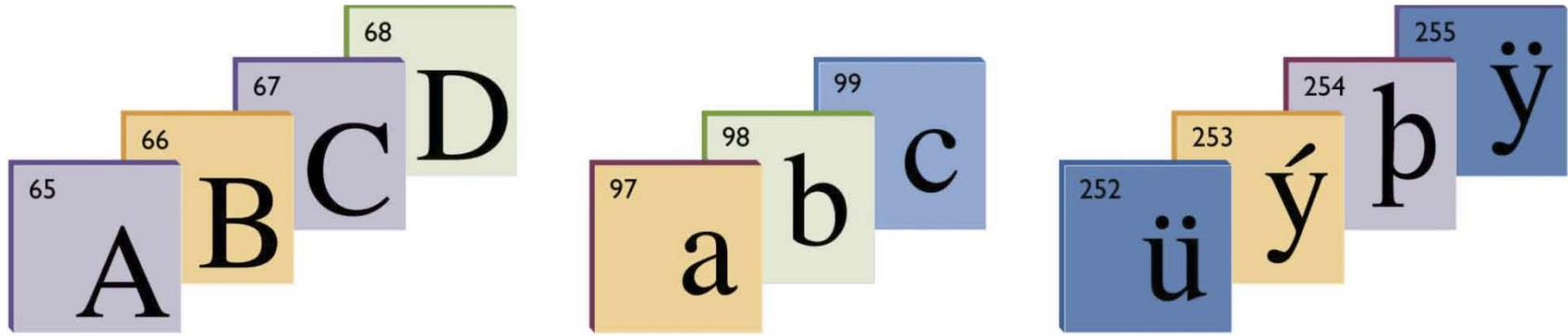
Bits as Codes

- Codes represent each letter, digit, and special character
- **ASCII:** Most widely used
 - Each character is a unique 8--bit code
 - 256 unique codes for 26 letters, 10 digits, special characters
- **Unicode:** Supports more than 100,000 unique characters

| Character | ASCII binary code |
|-----------|-------------------|
| A | 01000001 |
| B | 01000010 |
| C | 01000011 |
| D | 01000100 |
| E | 01000101 |
| F | 01000110 |
| G | 01000111 |
| H | 01001000 |
| I | 01001001 |
| J | 01001010 |
| K | 01001011 |
| L | 01001100 |
| M | 01001101 |
| N | 01001110 |
| O | 01001111 |
| P | 01010000 |
| Q | 01010001 |
| R | 01010010 |
| S | 01010011 |
| T | 01010100 |
| U | 01010101 |
| V | 01010110 |
| W | 01010111 |
| X | 01011000 |
| Y | 01011001 |
| Z | 01011010 |
| 0 | 00111000 |
| 1 | 00111001 |
| 2 | 00111010 |
| 3 | 00111011 |
| 4 | 00111100 |
| 5 | 00111101 |
| 6 | 00111110 |
| 7 | 00111111 |
| 8 | 00111000 |
| 9 | 00111001 |

The World's Languages

- ✓ ASCII character set was originally designed to include only English-language characters from 0 to 127



- ✓ Unicode's international standard character set allows for more than 100,000 distinct codes to include Chinese, Korean, Japanese, and Arabic characters

Bits, Bytes, and Buzzwords

Byte = 8 bits or one character in ASCII

- *Kilobyte* (KB, K) \approx 1,000 bytes
- *Megabyte* (meg, MB) \approx 1,000 KB or 1 million bytes
- *Gigabyte* (gig, GB) \approx 1,000 MB or 1 billion bytes
- *Terabyte* (TB) \approx 1 million MB or 1 trillion bytes
- *Petabyte* (PB) \approx 1 quadrillion bytes

The Computer's Core: CPU and Memory

- ✓ A digital computer is a collection of on/off switches designed to transform information from one form to another.
- ✓ The user provides the computer with patterns of bits—*input*—and the computer follows instructions to transform that input into a different pattern of bits—*output*—to return to the user.

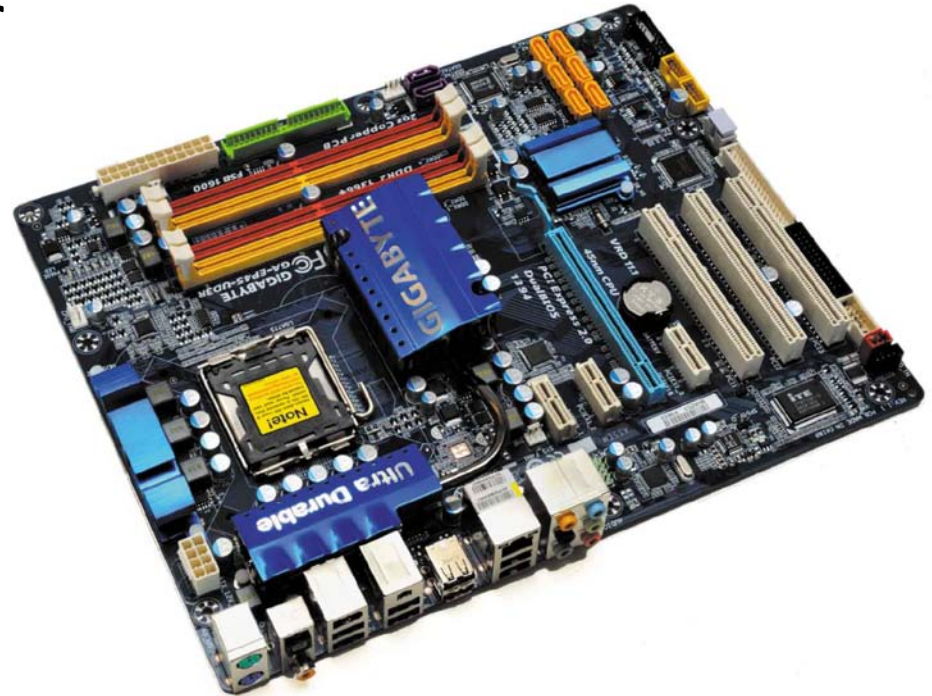
The CPU: The Real Computer

- ✓ CPU often called “processor”
- ✓ Performs transformations of input into output
- ✓ Interprets and executes instructions in programs
- ✓ Performs arithmetic and logical data manipulations
 - ALU – Arithmetic and Logic Unit
- ✓ Communicates with other parts of the computer system indirectly through memory

The CPU: The Real Computer (cont.)

✓ Modern Microprocessor

- Complex collection of electronic circuits
- CPU housed with other chips on circuit board
- Circuit board containing computer's CPU is called *motherboard*



The CPU: The Real Computer (cont.)

- ✓ Choosing a Computer
 - Type of CPU is important part of decision
 - Two important factors to consider:
 - Compatibility
 - Performance

Compatibility

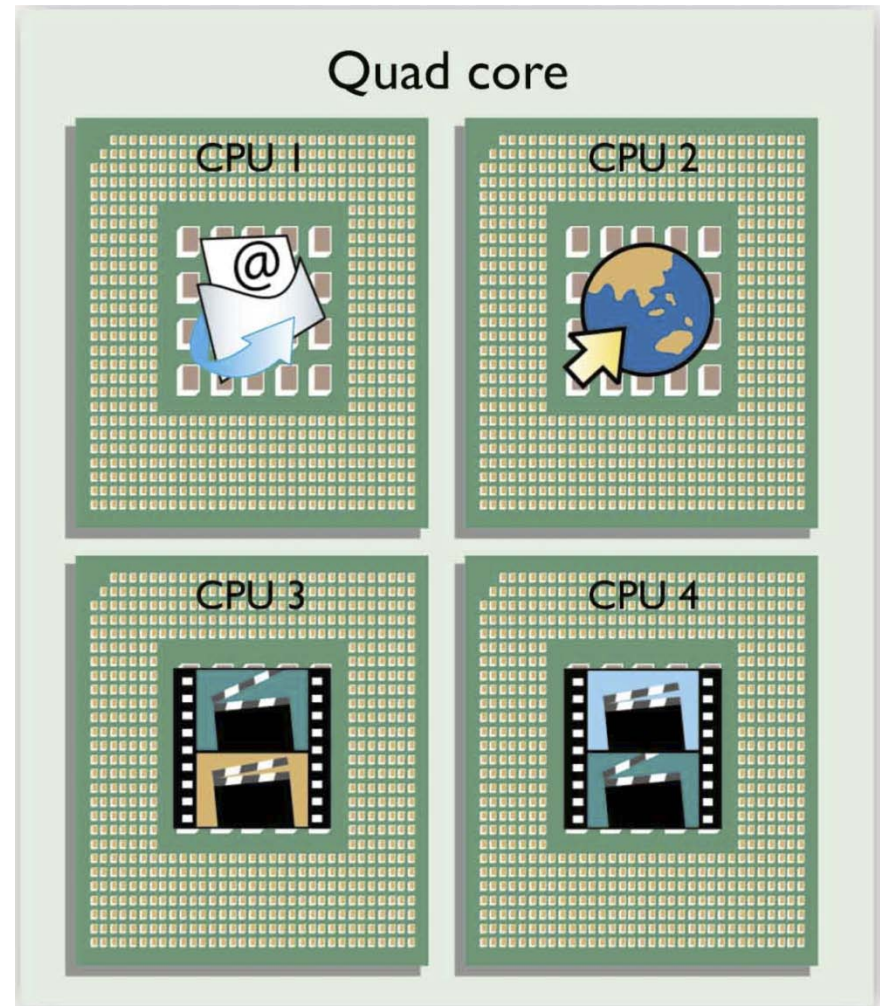
- ✓ Not all software is *compatible* with every CPU.
- ✓ Every processor has built-in set of instructions.
- ✓ CPUs in same family are generally *backward compatible*.
 - Designed to process instructions handled by earlier models
- ✓ AMD processors made to be compatible with Intel.
- ✓ Also, software compatible with one operating systems won't work on a different operating system
 - Programs written for Linux can't run on Windows.

Performance

- ✓ Some processors faster than others
- ✓ Performance is determined by:
 - Speed of internal *clock*—measured in *gigahertz* (GHz)
 - *Architecture* of processor
 - Number of bits processor can process at one time
 - Typically 32 or 64 bits—called *word size*
- ✓ Heat generated increases with clock speed

Performance (cont.)

- ✓ Multicore Processors
 - Single chip contains multiple CPUs (cores)
 - Run simultaneously
 - Divide work
 - Most new PCs have at least two cores.
 - Quad core becoming common
 - Manycore – hundreds of CPUs per chip.



Performance (cont.)

- ✓ Special Purpose Processors
 - Supplement basic CPU
 - Typical CPU contains graphics-processing unit (GPU) which handles:
 - 3-D graphics rendering
 - Other visual calculations
 - Frees main CPU to work on other tasks

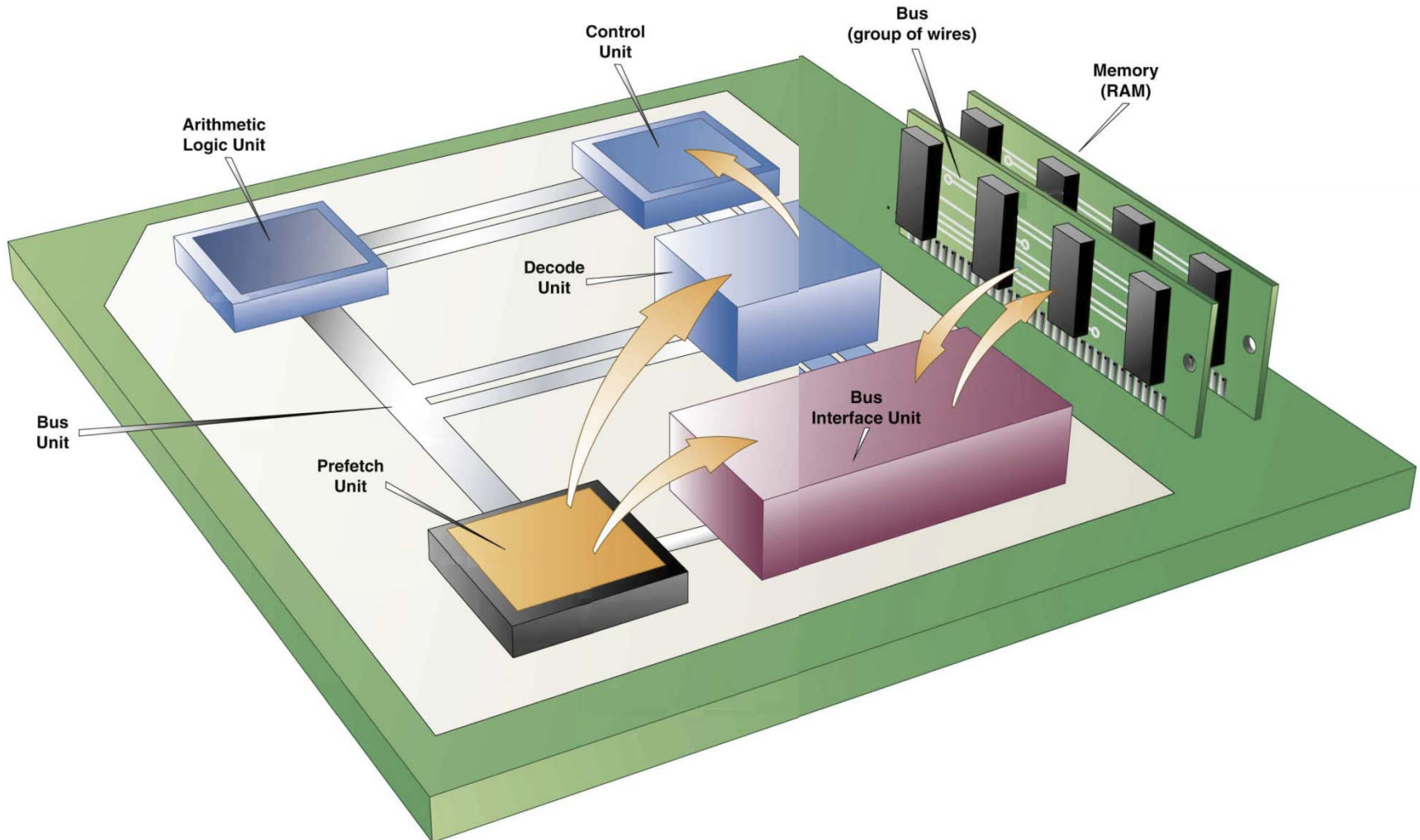
From Multicore to Cluster

- ✓ Performance enhancing techniques aren't confined to the insides of CPU chips.
- ✓ Instead of adding more cores, a large system might simply add more machines to a network.
- ✓ *Parallel processing* has been used in high-end servers and workstations for some time.
- ✓ Threaded processing in multicore CPUs is like a microscopic version of parallel processing used in some of the world's biggest computing networks.

The CPU

- ✓ Typical CPU is divided into several functional units:
 - Control unit
 - Arithmetic logic unit (ALU) includes registers
 - Decode unit – About 100 distinct main instructions
 - Programs often consist of millions of instructions
 - Bus unit
 - Prefetch unit
- ✓ These units work together to complete the execution of program instructions.

The CPU (cont.)



Green Computing

- ✓ When compared to other industries the computer industry is relatively easy on the environment.
- ✓ The manufacture and use of computer hardware and software does have a significant environmental impact.
- ✓ You have some control over the environmental impact of your computing activities.

Green Computing (cont.)

- Buy green equipment
- Use a laptop
- Take advantage of energy saving features
- Turn off your computer when you are away
- Save energy, not screens
- Avoid moving parts
- Print only once
- Use a green font
- E-cycle your waste products
- Pass it on
- Send bits not atoms
- Consider hidden environmental costs

The Computer's Memory

✓ *Random access memory (RAM)*

- Most common type of primary storage
- Stores program instructions and data temporarily
- Memory locations have unique addresses
- Volatile—disappears when power is turned off

The Computer's Memory (cont.)

✓ *Read-only memory (ROM)*

- Information is etched on chip when manufactured
- Stores start-up instructions and other critical information

✓ *Complementary metal-oxide semiconductor (CMOS)*

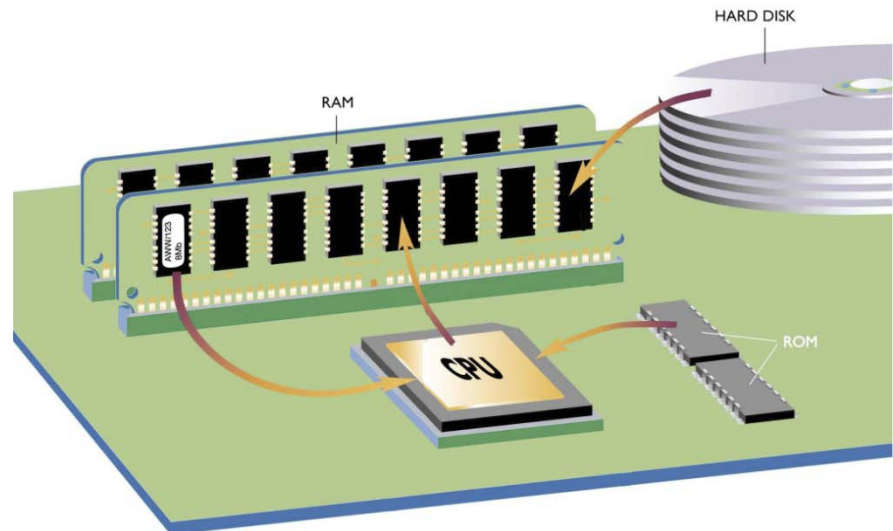
- Special low-energy type of RAM

✓ *Flash memory*

- Can be written and erased repeatedly
- Used for digital cameras, cell phones, handheld computers

Memory

1. When you turn on the computer, the CPU automatically begins executing operating system instructions stored in ROM.
2. The executing instructions help the system start up and tell it how to load the operating system—copy it from disk into RAM.
3. Once instructions for the operating system are loaded into RAM, the CPU is able to execute them.



Buses

- ✓ Information travels between components on the motherboard through wires called *internal buses* or just *buses*.
- ✓ Buses: Bridges between processor and RAM
- ✓ Buses connect to:
 - Storage devices in bays
 - *Expansion slots*
 - External buses and ports

Ports

- ✓ Computer has variety of ports to meet diverse needs
 - Video port(s) to connect monitors
 - Audio ports to connect speakers and/or headphones
 - **USB ports** to connect keyboards, pointing devices, printers, cameras, disk drives, portable storage devices, and more
- ✓ Some ports connected directly to system board
- ✓ Others connected to **expansion cards**

Peripherals

- ✓ Slots and ports make it easy to add peripherals to computer system.
- ✓ Some peripherals, such as keyboards and printers, serve as communication links between people and computers.
- ✓ Other peripherals link computer to other machines.
- ✓ Still others provide long-term storage media.

How Memory Works

- ✓ Memory can be thought of as millions of tiny storage cells in a row with successive addresses.
- ✓ Each tiny cell contains 8 bits or one byte of information.
- ✓ The information may include program instructions, numbers (integers, reals, extended precision reals), text characters, digital code for pictures, and other data.

Memory (cont)

- ✓ RAM chips are usually grouped on small circuit boards called dual in-line memory modules (DIMMs)
- ✓ These are plugged into the mother board.
- ✓ RAM memory is volatile and is lost when the power is turned off.

ROM and Operating System

- ✓ ROM contains permanent programs (called firmware) that include part of the operating system.
- ✓ When the computer is started, the CPU starts executing the operating system instructions in ROM
- ✓ These ROM instructions are used to start up the system and to copy the rest of the operating system from disk into RAM.
- ✓ Once the instructions from the operating system are in RAM, the CPU can start executing them.

Chapter 2 Summary

- ✓ A computer manipulates patterns of bits represented by two symbols: 0 and 1.
- ✓ Bits can be grouped into coded messages that represent alphabetic characters, pictures, colors, sounds, and other kinds of information.
- ✓ The microprocessor follows software instructions to perform calculations and logical manipulations that transform input data into output.

Summary (cont.)

- ✓ Not all CPUs are compatible with each other.
- ✓ Modern CPUs employ multicore or many core processing systems that speed calculations.
- ✓ The CPU uses RAM (random access memory) as a temporary storage area.
- ✓ ROM (read-only memory) contains unchangeable information.

Summary (cont.)

- ✓ The CPU and main memory are housed in silicon chips on the motherboard and other circuit boards inside the computer.
- ✓ Buses connect to slots and ports that enable the computer to communicate with internal devices and external peripherals.



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.