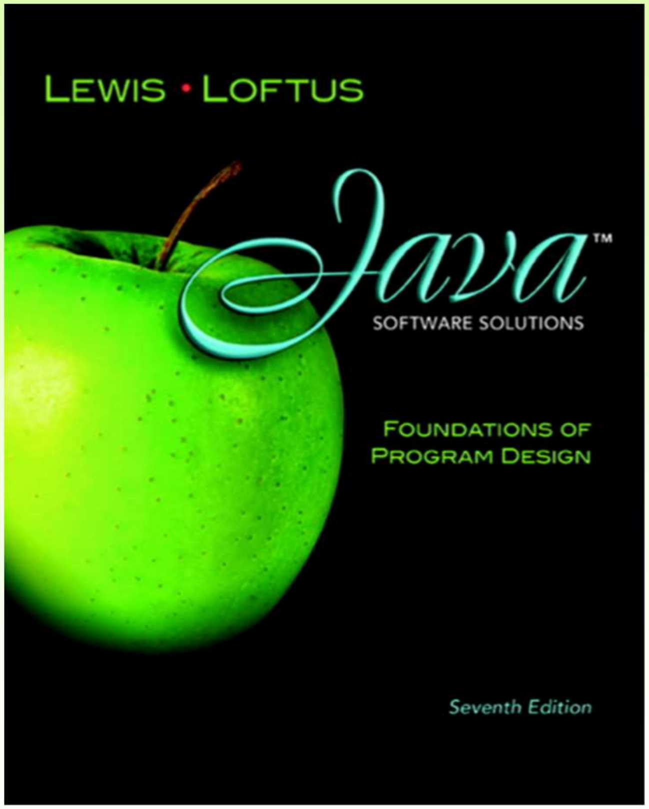
Chapter 1
Introduction



Java Software Solutions

Foundations of Program Design

Seventh Edition

John Lewis
William Loftus

Addison-Wesley
is an imprint of
PEARSON

Focus of the Course

- Object-Oriented Software Development
  - problem solving
  - program design, implementation, and testing
  - object-oriented concepts
    - classes
    - objects
    - encapsulation
    - inheritance
    - polymorphism
  - graphical user interfaces
  - the Java programming language

Introduction

- We start with the fundamentals of computer processing
- Chapter 1 focuses on:
  - components of a computer
  - how computers store and manipulate information
  - computer networks
  - the Internet and the World Wide Web
  - programming and programming languages
  - an introduction to Java
  - an overview of object-oriented concepts

Outline

⇨ **Computer Processing**

Hardware Components

Networks

The Java Programming Language

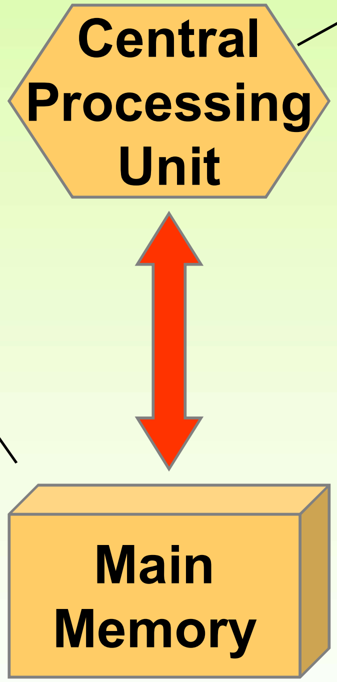
Program Development

Object-Oriented Programming

Hardware and Software

- Hardware
  - the physical, tangible parts of a computer
  - keyboard, monitor, disks, wires, chips, etc.
- Software
  - programs and data
  - a *program* is a series of instructions
- A computer requires both hardware and software
- Each is essentially useless without the other

CPU and Main Memory

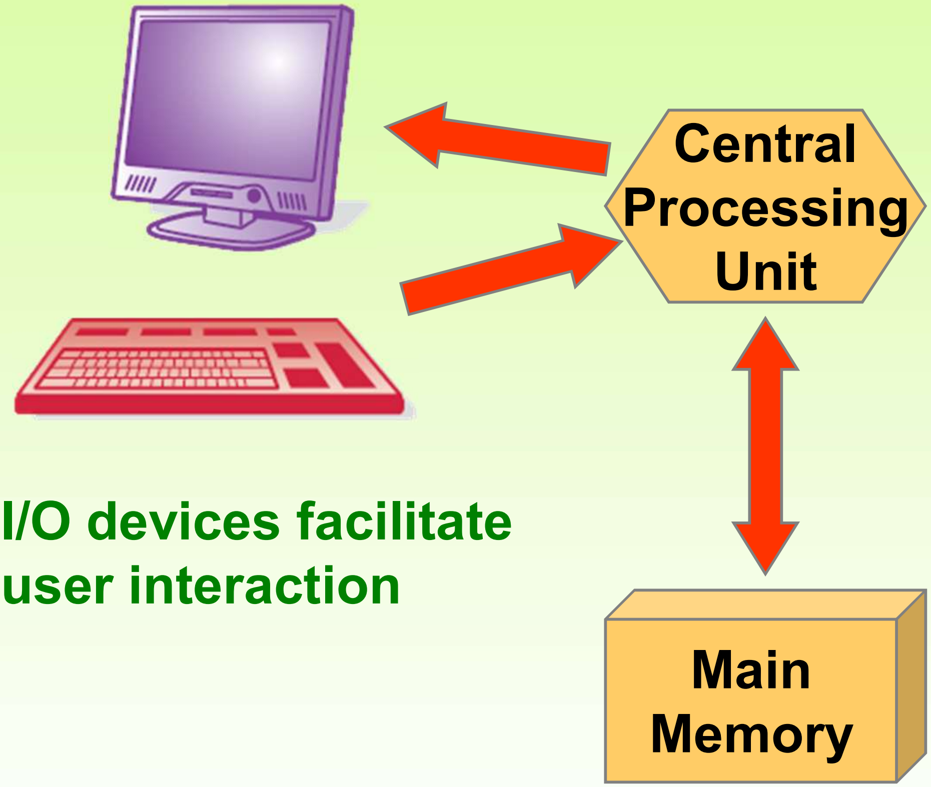


Chip that executes program commands

Primary storage area for programs and data that are in active use

Synonymous with RAM

Input / Output Devices



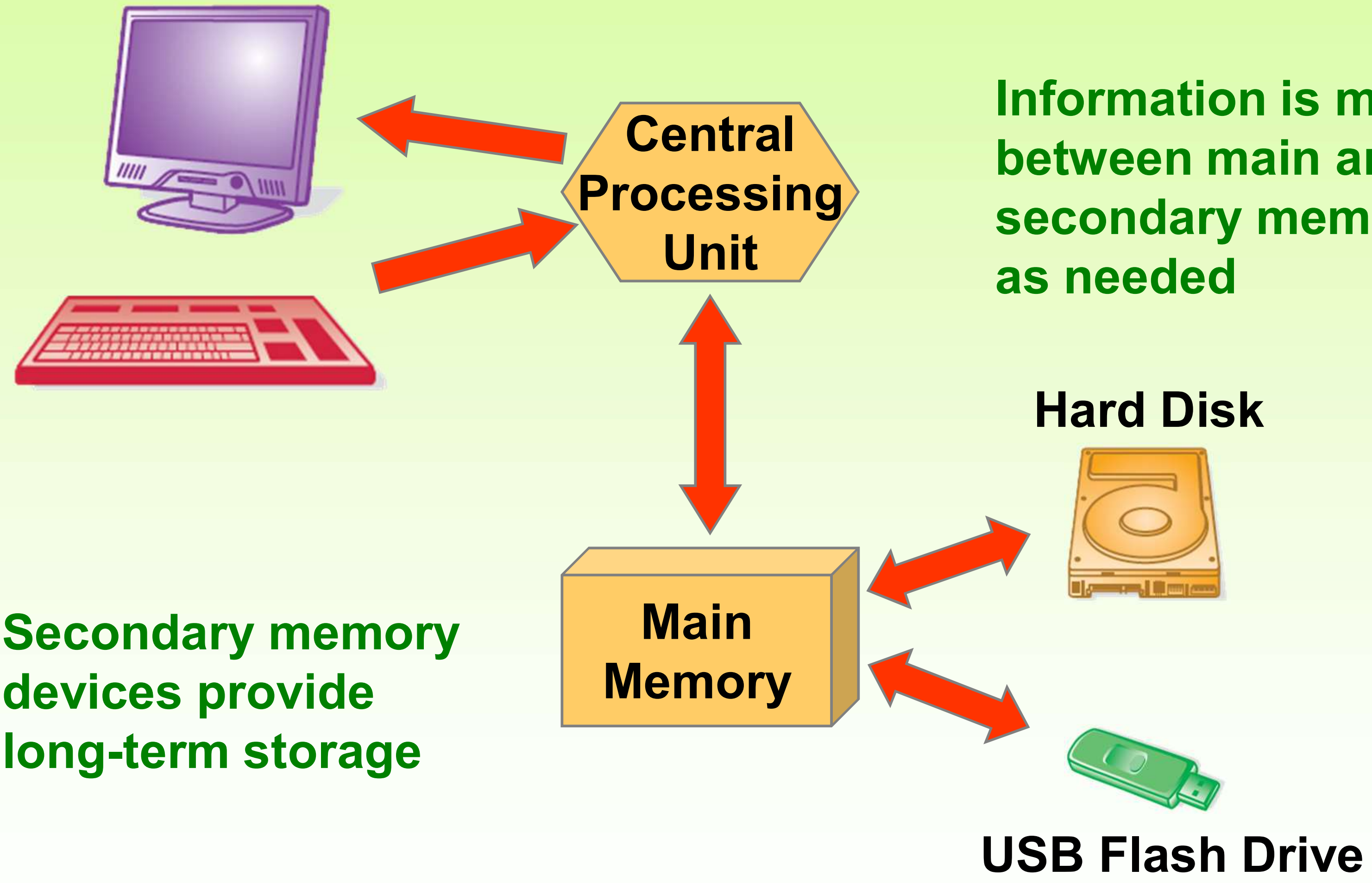
Central Processing Unit

Main Memory

Monitor screen
Keyboard
Mouse
Touch screen

I/O devices facilitate user interaction

Secondary Memory Devices



Central Processing Unit

Main Memory

Hard Disk

USB Flash Drive

Information is moved between main and secondary memory as needed

Secondary memory devices provide long-term storage

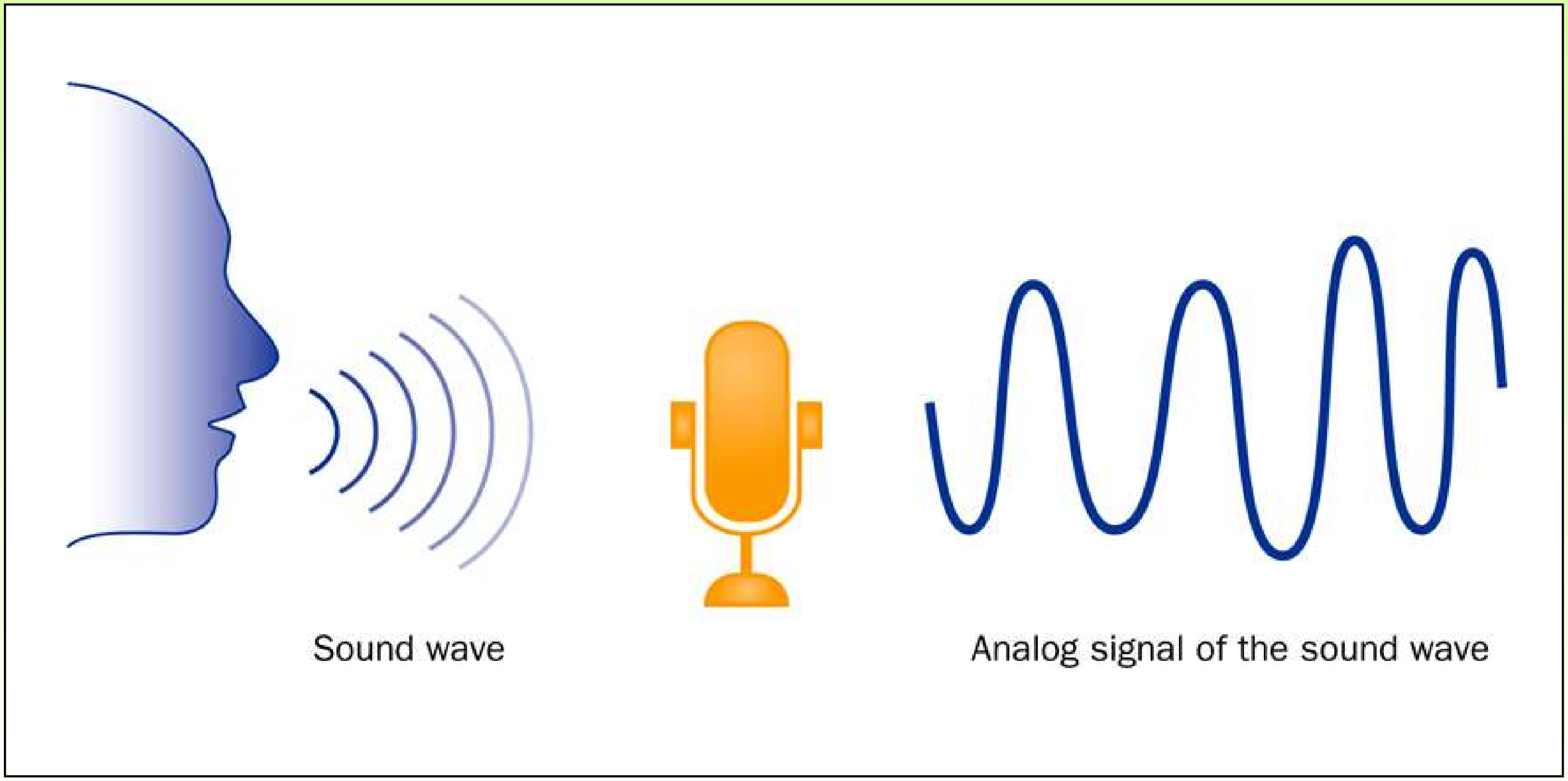
Software Categories

- Operating System
  - controls all machine activities
  - provides the user interface to the computer
  - manages resources such as the CPU and memory
  - Windows, Mac OS, Unix, Linux,
- Application program
  - generic term for any other kind of software
  - word processors, missile control systems, games
- Most operating systems and application programs have a *graphical user interface* (GUI)

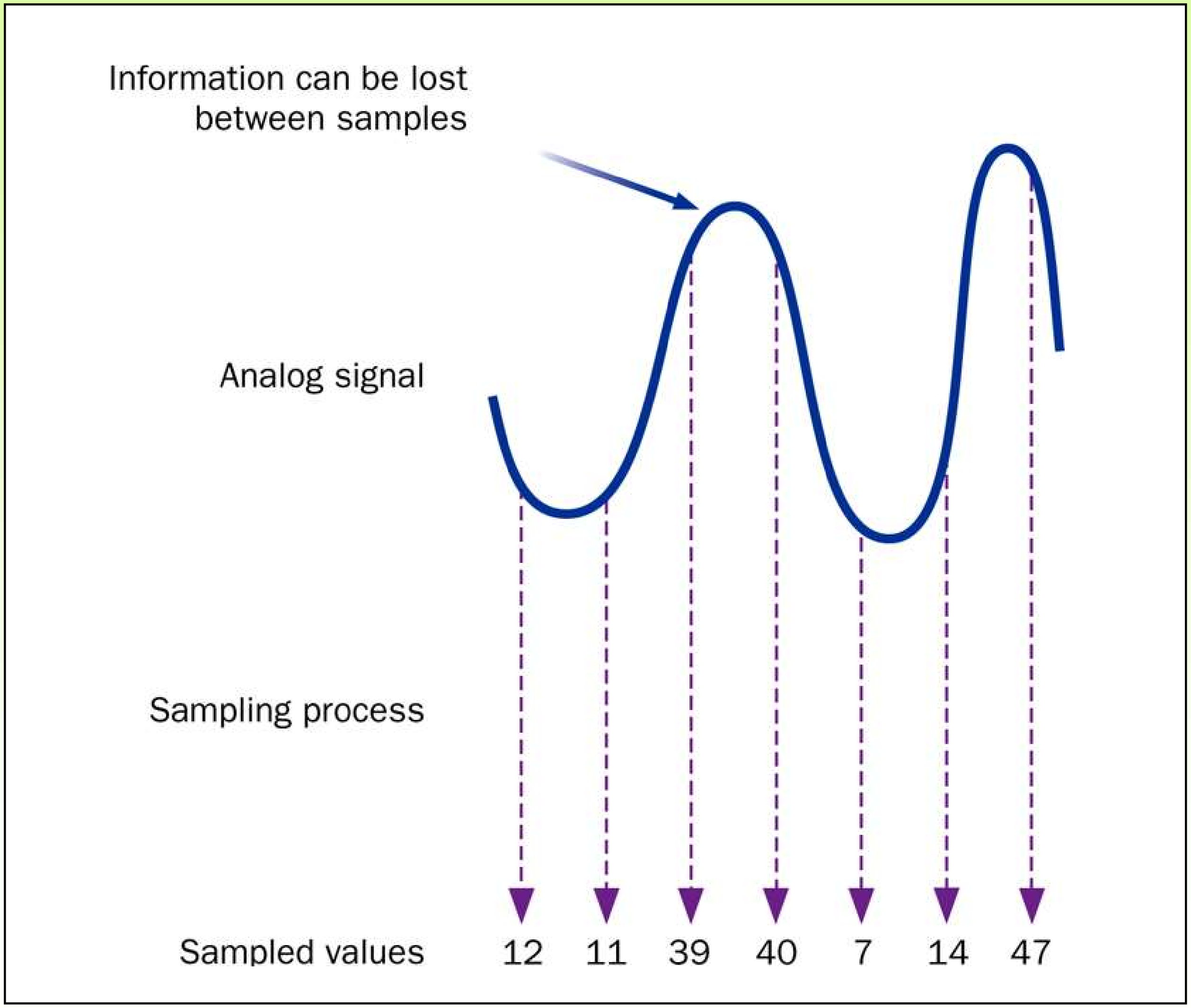
Analog vs. Digital

- There are two basic ways to store and manage data:
- *Analog*
  - continuous, in direct proportion to the data represented
  - music on a record album - a needle rides on ridges in the grooves that are directly proportional to the voltages sent to the speaker
- *Digital*
  - the information is broken down into pieces, and each piece is represented separately
  - *sampling* – record discrete values of the analog representation
  - music on a compact disc - the disc stores numbers representing specific voltage levels sampled at specific times

Analog Information



Sampling

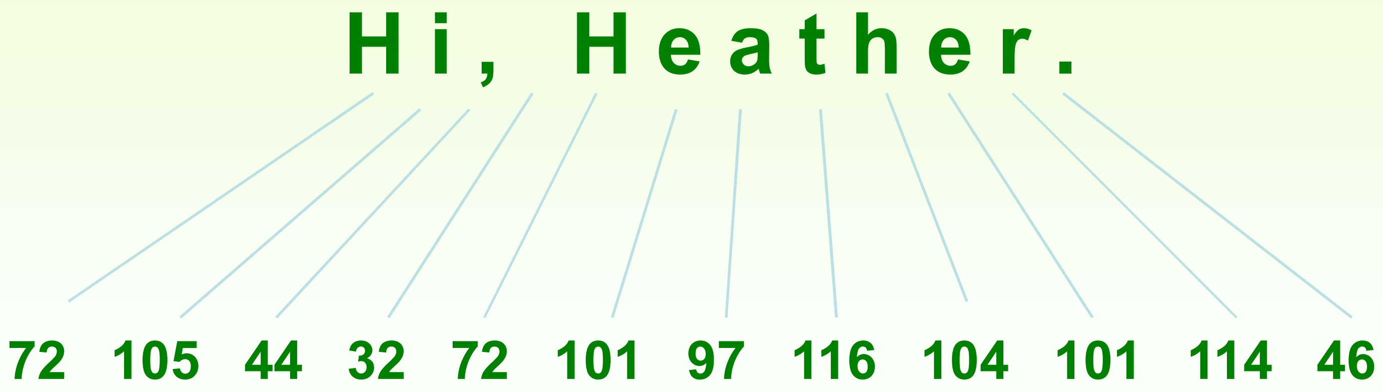

Information can be lost between samples
Analog signal
Sampling process
Sampled values
12
11
39
40
7
14
47

Digital Information

- Computers store all information digitally:
  - numbers
  - text
  - graphics and images
  - audio
  - video
  - program instructions
- In some way, all information is *digitized* - broken down into pieces and represented as numbers

Representing Text Digitally

- For example, every character is stored as a number, including spaces, digits, and punctuation
- Corresponding upper and lower case letters are separate characters



Hi, Heather.

72 105 44 32 72 101 97 116 104 101 114 46

Binary Numbers

- Once information has been digitized, it is represented and stored in memory using the *binary number system*
- A single binary digit (0 or 1) is called a *bit*
- Devices that store and move information are cheaper and more reliable if they have to represent only two states
- A single bit can represent two possible states, like a light bulb that is either on (1) or off (0)
- Permutations of bits are used to store values

Bit Permutations

1 bit	2 bits	3 bits	4 bits	
0	00	000	0000	1000
1	01	001	0001	1001
	10	010	0010	1010
	11	011	0011	1011
		100	0100	1100
		101	0101	1101
		110	0110	1110
		111	0111	1111

Each additional bit doubles the number of possible permutations

Bit Permutations

- Each permutation can represent a particular item
- There are 2^N permutations of N bits
- Therefore, N bits are needed to represent 2^N unique items

How many items can be represented by

1 bit ?	2^1 = 2 items
2 bits ?	2^2 = 4 items
3 bits ?	2^3 = 8 items
4 bits ?	2^4 = 16 items
5 bits ?	2^5 = 32 items

Quick Check

How many bits would you need to represent each of the 50 United States using a unique permutation of bits?

Quick Check

How many bits would you need to represent each of the 50 United States using a unique permutation of bits?

Five bits wouldn't be enough, because 2^5 is 32.

Six bits would give us 64 permutations, and some wouldn't be used.

000000	Alabama
000001	Alaska
000010	Arizona
000011	Arkansas
000100	California
000101	Colorado

etc.

Outline

Computer Processing

⇨ Hardware Components

Networks

The Java Programming Language

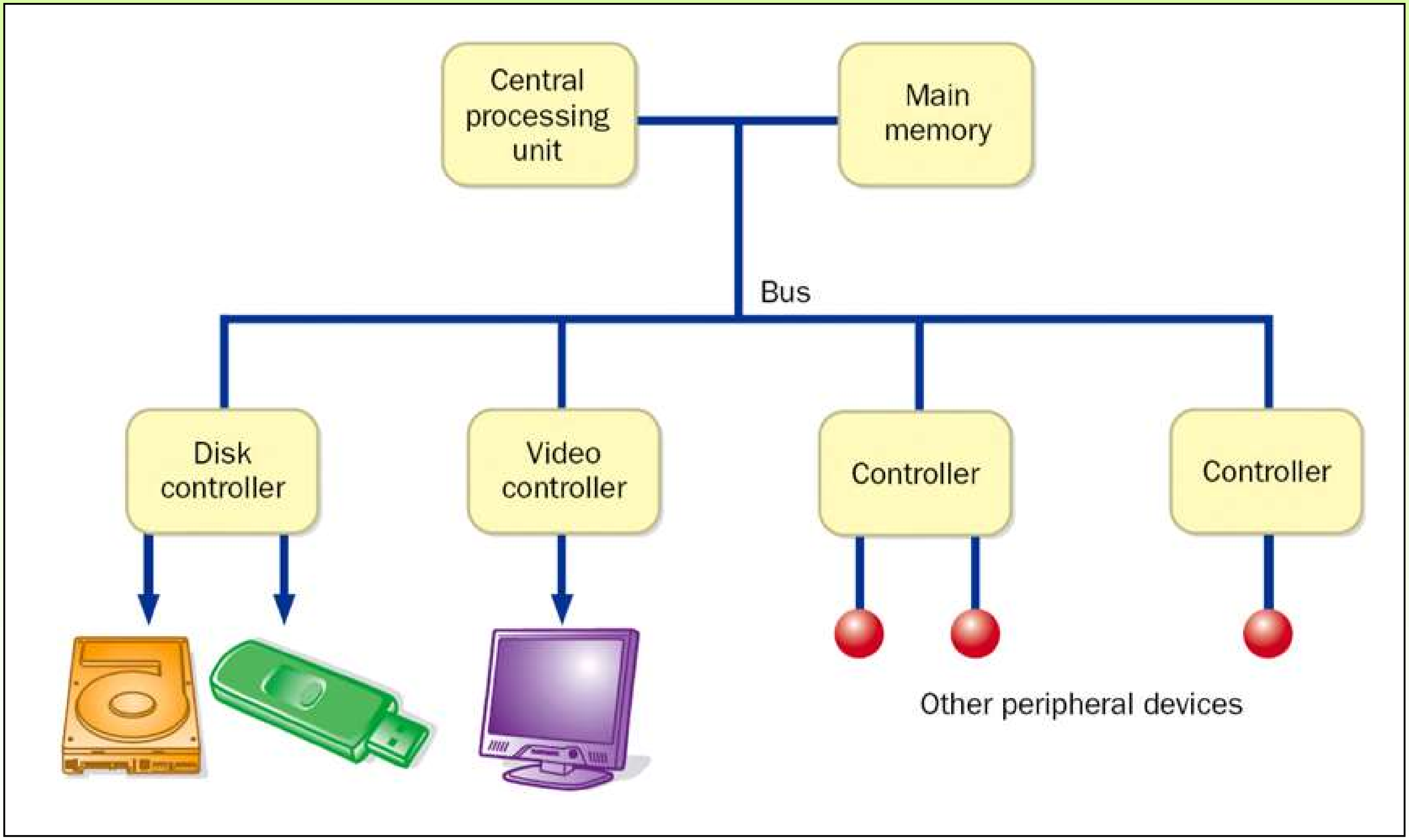
Program Development

Object-Oriented Programming

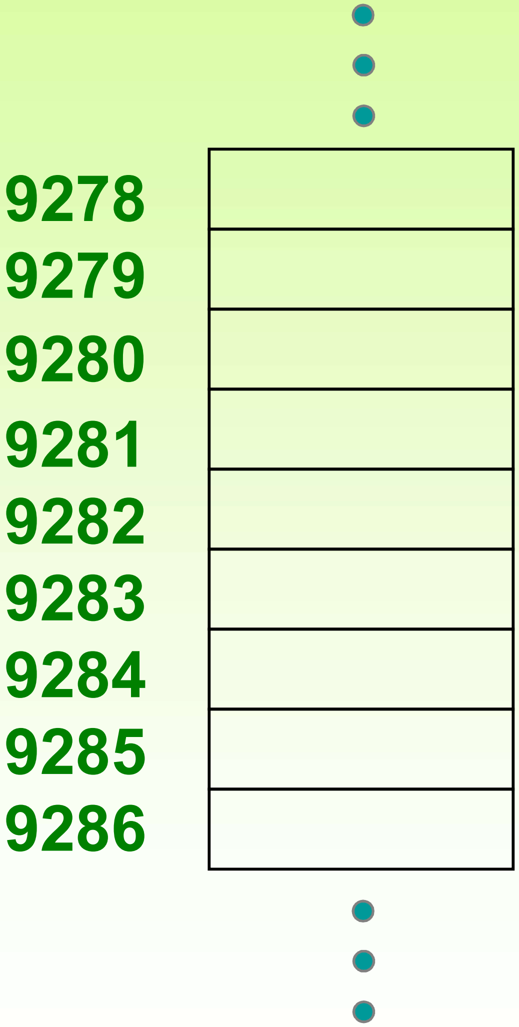
A Computer Specification

- Consider the following specification for a personal computer:
  - 3.07 GHz Intel Core i7 processor
  - 4 GB RAM
  - 750 GB Hard Disk
  - 16x Blu-ray / HD DVD-ROM & 16x DVD+R DVD Burner
  - 17” Flat Screen Video Display with 1280 x 1024 resolution
  - Network Card

Computer Architecture



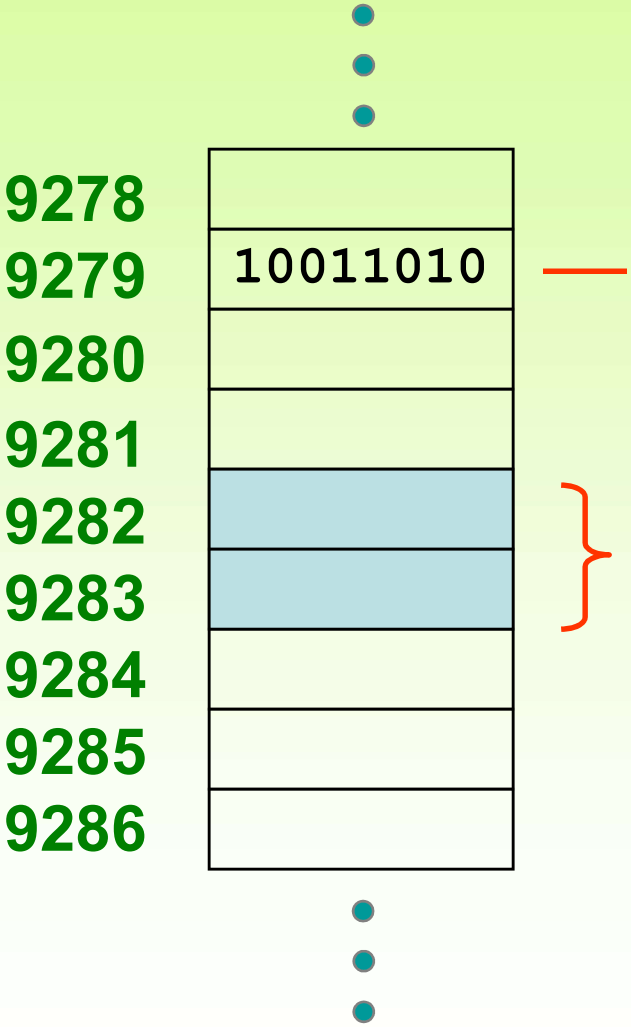
Memory



Main memory is divided into many memory locations (or *cells*)

Each memory cell has a numeric *address*, which uniquely identifies it

Storing Information



Each memory cell stores a set number of bits (usually 8 bits, or one *byte*)

Large values are stored in consecutive memory locations

Storage Capacity

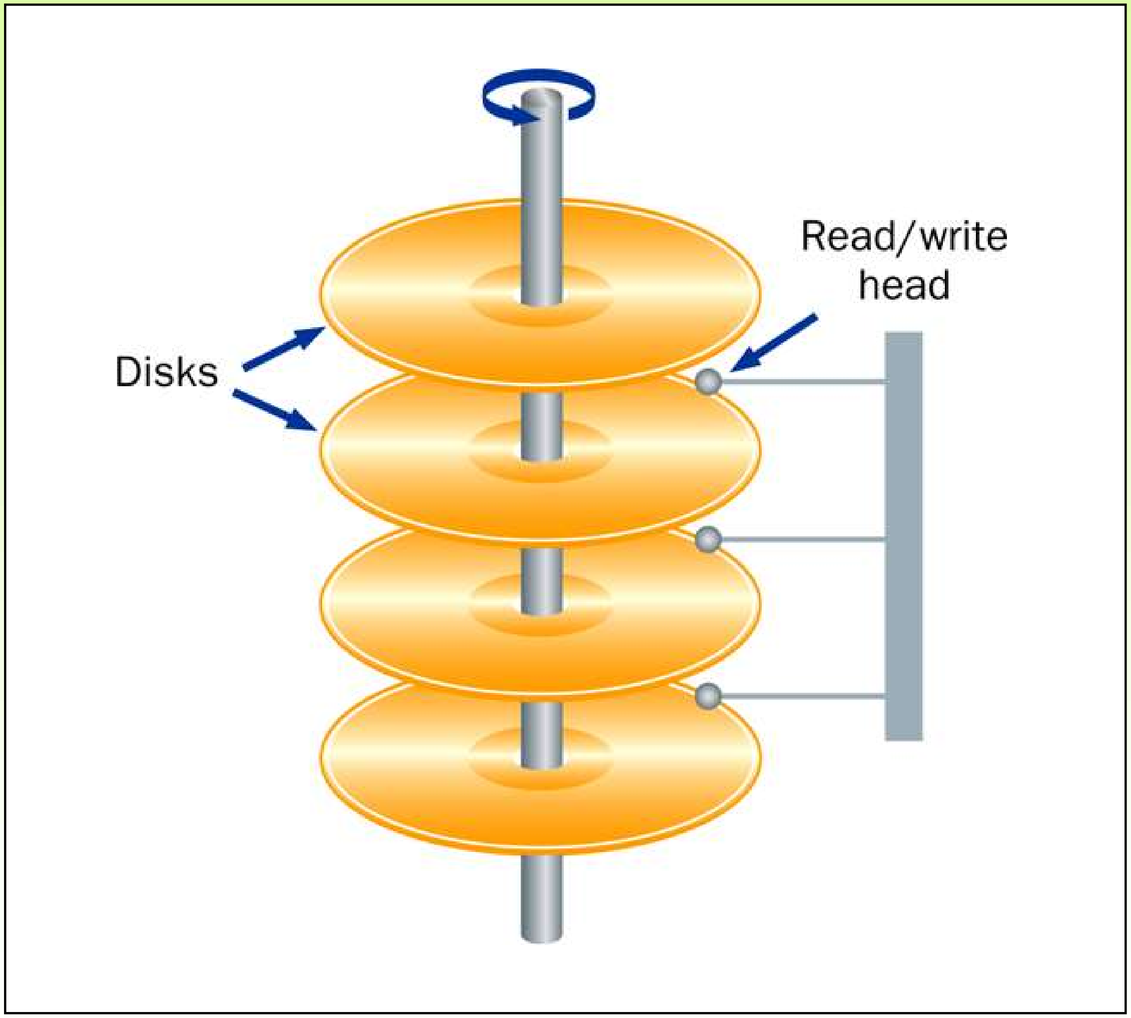
- Every memory device has a *storage capacity*, indicating the number of bytes it can hold
- Capacities are expressed in various units:

Unit	Symbol	Number of Bytes
kilobyte	KB	2^{10} = 1024
megabyte	MB	2^{20} (over one million)
gigabyte	GB	2^{30} (over one billion)
terabyte	TB	2^{40} (over one trillion)
petabyte	PB	2^{50} (a whole bunch)

Memory

- Main memory is *volatile* - stored information is lost if the electric power is removed
- Secondary memory devices are *nonvolatile*
- Main memory and disks are *direct access* devices - information can be reached directly
- The terms *direct access* and *random access* often are used interchangeably
- A magnetic tape is a *sequential access* device since its data is arranged in a linear order - you must get by the intervening data in order to access other information

Hard Disk Drive



RAM vs. ROM

- *RAM* - Random Access Memory (direct access)
- *ROM* - Read-Only Memory
- The terms RAM and main memory are basically interchangeable
- ROM could be a set of memory chips, or a separate device, such as a CD ROM
- Both RAM and ROM are random (direct) access devices!
- RAM probably should be called Read-Write Memory

Compact Discs

- A CD-ROM is portable read-only memory
- A microscopic pit on a CD represents a binary 1 and a smooth area represents a binary 0
- A low-intensity laser reflects strongly from a smooth area and weakly from a pit
- A CD-Recordable (CD-R) drive can be used to write information to a CD once
- A CD-Rewritable (CD-RW) can be erased and reused
- The speed of a CD drive indicates how fast (max) it can read and write information to a CD

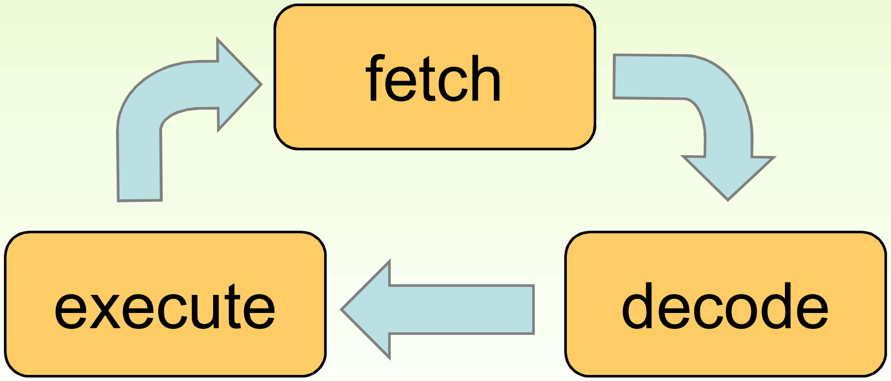
DVDs

- A DVD is the same physical size as a CD, but can store much more information
- The format of a DVD stores more bits per square inch
- A CD can store 650 MB, while a standard DVD can store 4.7 GB
  - A double sided DVD can store 9.4 GB
  - Other advanced techniques can bring the capacity up to 17.0 GB
- Like CDs, there are DVD-R and DVD-RW discs

The Central Processing Unit

- A CPU is on a chip called a *microprocessor*
- It continuously follows the *fetch-decode-execute cycle:*

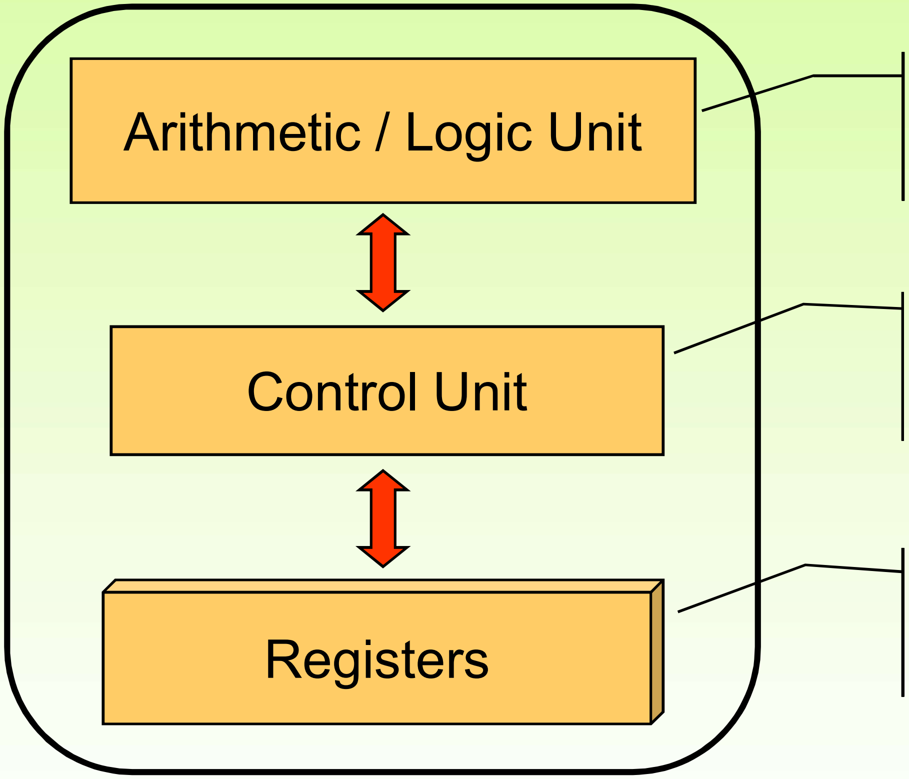
Retrieve an instruction from main memory



Carry out the instruction

Determine what the instruction is

The Central Processing Unit



Arithmetic / Logic Unit

Control Unit

Registers

Performs calculations and makes decisions

Coordinates processing steps

Small storage areas

The Central Processing Unit

- The speed of a CPU is controlled by the *system clock*
- The system clock generates an electronic pulse at regular intervals
- The pulses coordinate the activities of the CPU
- The speed is usually measured in *gigahertz* (GHz)

Monitor

- The size of a monitor (17") is measured diagonally, like a television screen
- A monitor has a certain maximum *resolution* , indicating the number of picture elements, called *pixels*, that it can display (such as 1280 by 1024)
- High resolution (more pixels) produces sharper pictures

Outline

Computer Processing

Hardware Components

⇨ Networks

The Java Programming Language

Program Development

Object-Oriented Programming

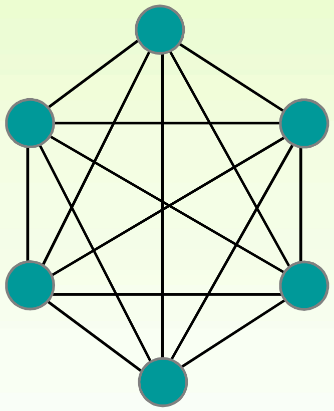
Networks

- A *network* is two or more computers that are connected so that data and resources can be shared
- Most computers are connected to some kind of network
- Each computer has its own *network address*, which uniquely identifies it among the others
- A *file server* is a network computer dedicated to storing programs and data that are shared among network users

Network Connections

- Each computer in a network could be directly connected to every other computer in the network
- These are called *point-to-point* connections

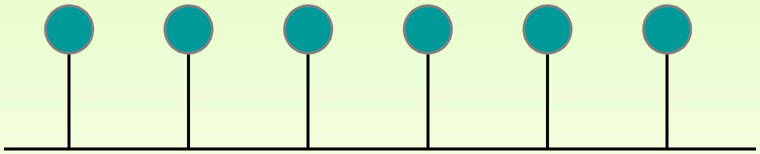
Adding a computer requires a new communication line for each computer already in the network



This technique is not practical for more than a few close machines

Network Connections

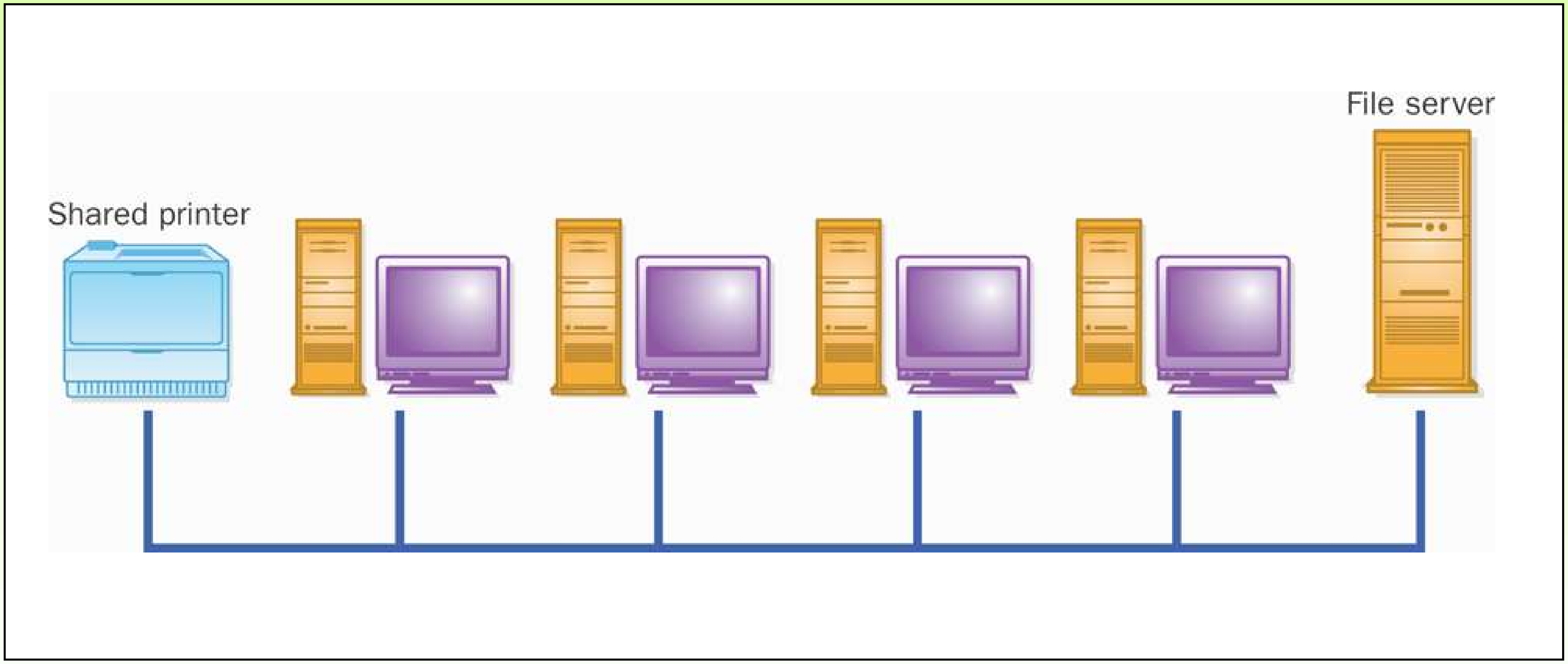
- Most networks share a single communication line
- Adding a new computer to the network is relatively easy



Network traffic must take turns using the line, which introduces delays

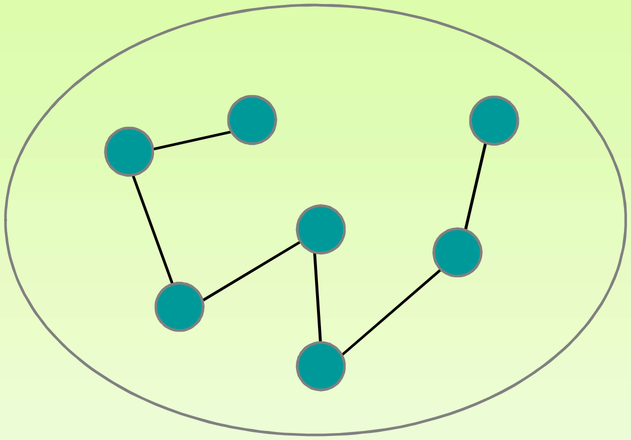
Often information is broken down in parts, called *packets*, which are sent to the receiving machine and then reassembled

A Computer Network



Local-Area Networks

A *Local-Area Network* (LAN) covers a small distance and a small number of computers

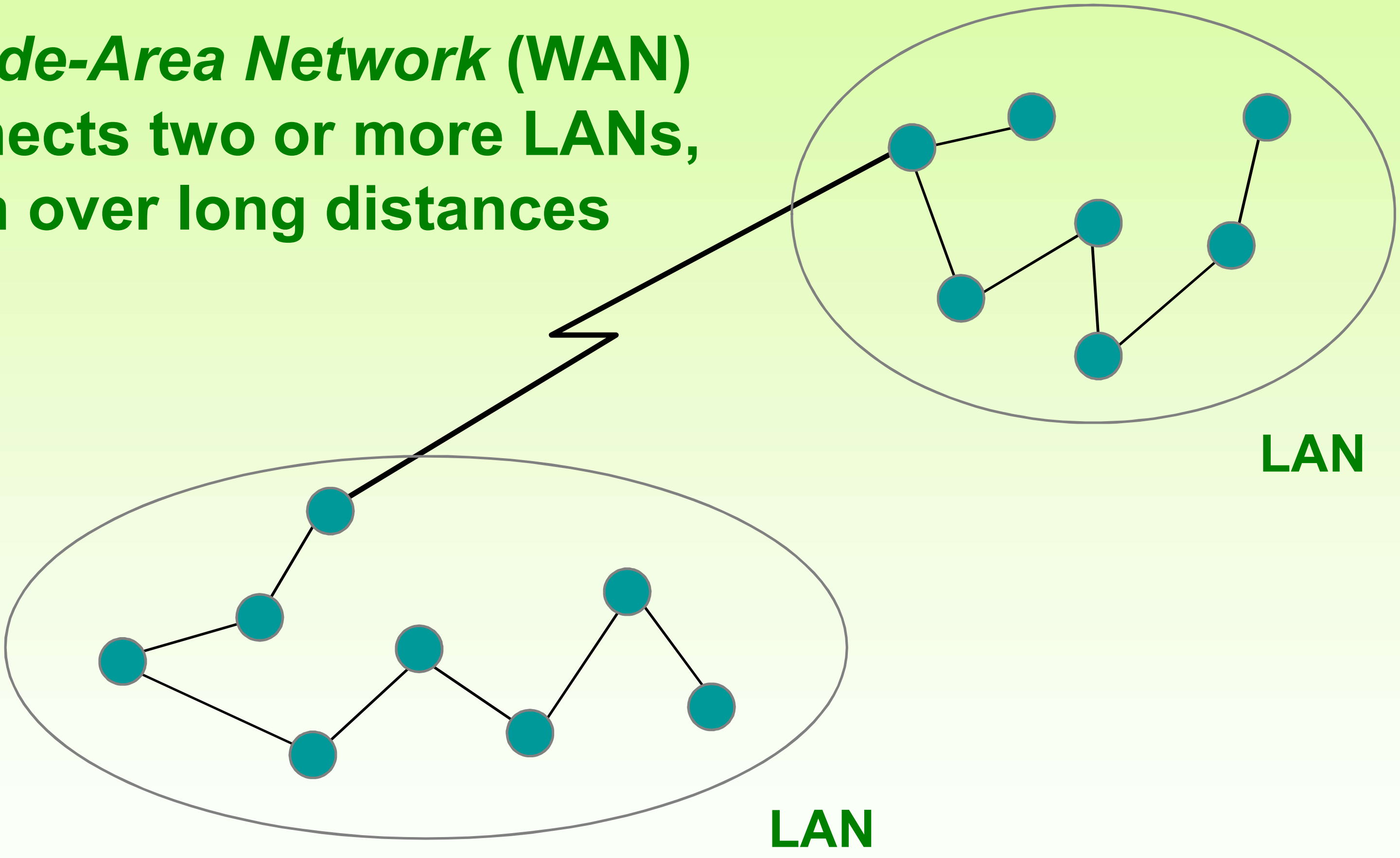


LAN

A LAN often connects the machines in a single room or building

Wide-Area Networks

A *Wide-Area Network* (WAN) connects two or more LANs, often over long distances



The Internet

- The *Internet* is a WAN which spans the planet
- The word Internet comes from the term *internetworking*
- It started as a United States government project, sponsored by the Advanced Research Projects Agency (ARPA)
  - originally it was called the ARPANET
- The Internet grew quickly throughout the 1980s and 90s

TCP/IP

- A protocol is a set of rules that determine how things communicate with each other
- The software that manages Internet communication follows a suite of protocols called *TCP/IP*
- The *Internet Protocol* (IP) determines the format of the information as it is transferred
- The *Transmission Control Protocol* (TCP) dictates how messages are reassembled and handles lost information

IP and Internet Addresses

- Each computer on the Internet has a unique *IP address*, such as:

```
204.192.116.2
```

- Most computers also have a unique Internet name, which also is referred to as an *Internet address*:

```
hector.vt.edu

kant.gestalt-llc.com
```

- The first part indicates a particular computer (`hector`)
- The rest is the *domain name*, indicating the organization (`vt.edu`)

Domain Names

- The last part of a domain name, called a *top-level domain* (TLD), supposedly indicates the type of organization:

edu	**educational institution**
com	**commercial entity**
org	**non-profit organization**
net	**network-based organization**

Sometimes the suffix indicates the country:

uk	**United Kingdom**
au	**Australia**
ca	**Canada**
se	**Sweden**

Additional TLDs have been added:

biz, info, tv, name

Domain Names

- A domain name can have several parts
- Unique domain names mean that multiple sites can have individual computers with the same local name
- When used, an Internet address is translated to an IP address by software called the *Domain Name System* (DNS)
- There is no one-to-one correspondence between the sections of an IP address and the sections of an Internet address

The World Wide Web

- The *World Wide Web* allows many different types of information to be accessed using a common interface
- A *browser* is a program which accesses network resources and presents them
  - Popular browsers: Internet Explorer, Safari, Firefox
- Resources presented include:
  - text, graphics, video, sound, audio, executable programs
- A Web document usually contains *links* to other Web documents, creating a *hypermedia* environment
- The term Web comes from the fact that information is not organized in a linear fashion

The World Wide Web

- Web documents are often defined using the *HyperText Markup Language* (HTML)
- Information on the Web is found using a *Uniform Resource Locator* (URL):

```
http://www.cnn.com

http://www.vt.edu/student_life/index.html

ftp://java.sun.com/applets/animation.zip
```

- A URL specifies a protocol (http), a domain, and possibly specific documents

Outline

Computer Processing

Hardware Components

Networks

➡ The Java Programming Language

Program Development

Object-Oriented Programming

Java

- The Java programming language was created by Sun Microsystems, Inc.
- It was introduced in 1995 and it's popularity has grown quickly since
- A *programming language* specifies the words and symbols that we can use to write a program
- A programming language employs a set of rules that dictate how the words and symbols can be put together to form valid *program statements*

Java Program Structure

- In the Java programming language:
  - A program is made up of one or more *classes*
  - A class contains one or more *methods*
  - A method contains program *statements*
- These terms will be explored in detail throughout the course
- A Java application always contains a method called `main`
- See `Lincoln.java`

```java
//********************************************************************
//  Lincoln.java       Author: Lewis/Loftus
//
//  Demonstrates the basic structure of a Java application.
//********************************************************************

public class Lincoln
{
   //-----------------------------------------------------------------
   //  Prints a presidential quote.
   //-----------------------------------------------------------------
   public static void main (String[] args)
   {
      System.out.println ("A quote by Abraham Lincoln:");

      System.out.println ("Whatever you are, be a good one.");
   }
}
```

Output

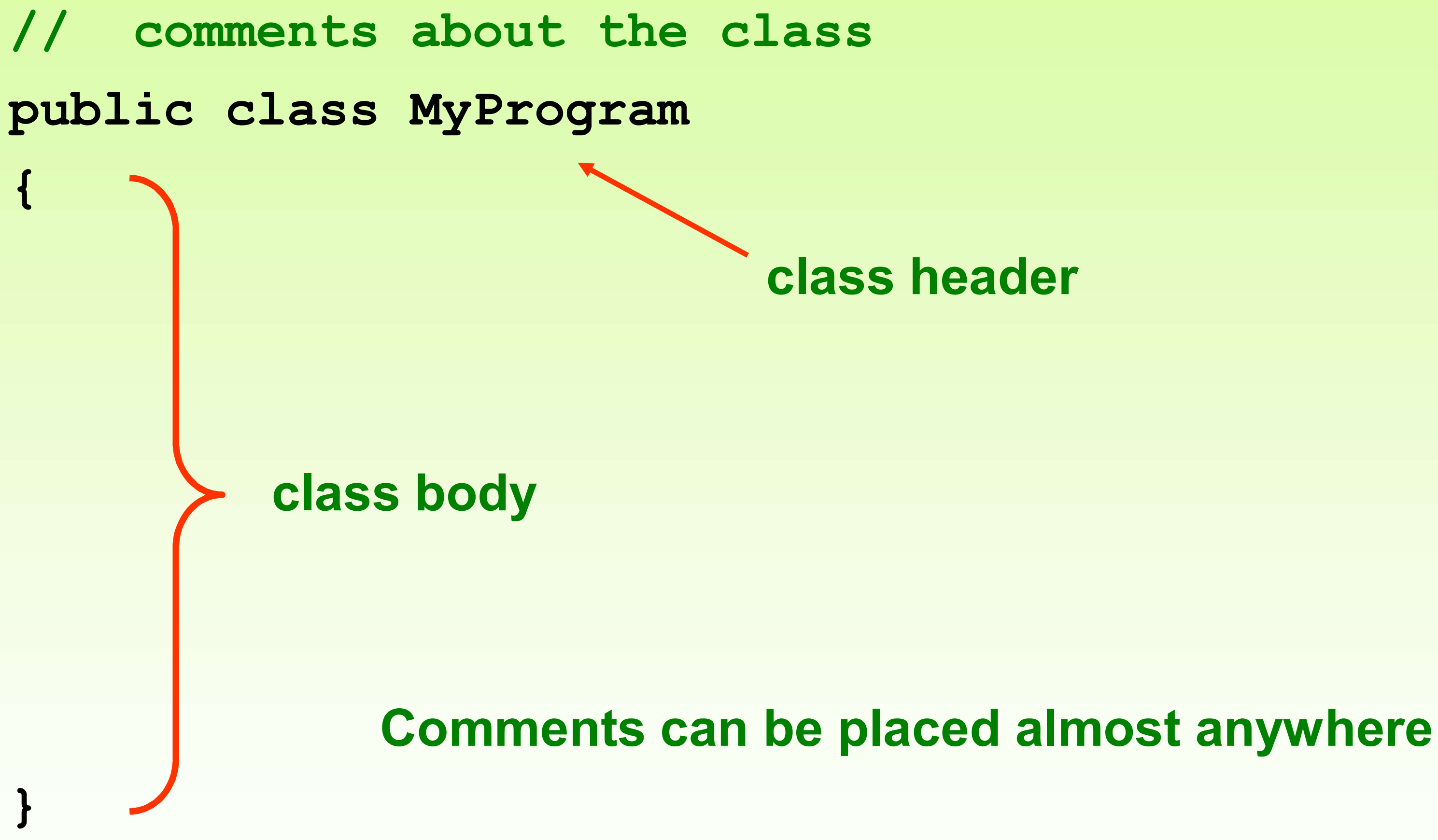
```
A quote by Abraham Lincoln:
Whatever you are, be a good one.
```

```java
//********                                                      **********
//  Lincol
//
//  Demons
//*******************************************************************

public class Lincoln
{
   //----------------------------------------------------------------
   //  Prints a presidential quote.
   //----------------------------------------------------------------
   public static void main (String[] args)
   {
      System.out.println ("A quote by Abraham Lincoln:");

      System.out.println ("Whatever you are, be a good one.");
   }
}
```

Java Program Structure



```
//  comments about the class
public class MyProgram
{



}
```

class header

class body

Comments can be placed almost anywhere

Java Program Structure

```
//  comments about the class
public class MyProgram
{

   //  comments about the method
   public static void main (String[] args)
   {

   }

}
```

method body

method header

Comments

- Comments should be included to explain the purpose of the program and describe processing steps
- They do not affect how a program works
- Java comments can take three forms:

```
// this comment runs to the end of the line

/*   this comment runs to the terminating
     symbol, even across line breaks        */

/** this is a javadoc comment   */
```

Identifiers

- *Identifiers* are the "words" in a program
- A Java identifier can be made up of letters, digits, the underscore character (_), and the dollar sign
- Identifiers cannot begin with a digit
- Java is *case sensitive*: `Total`, `total`, and `TOTAL` are different identifiers
- By convention, programmers use different case styles for different types of identifiers, such as
  - *title case* for class names - `Lincoln`
  - *upper case* for constants - `MAXIMUM`

Identifiers

- Sometimes the programmer chooses the identifer(such as `Lincoln`)
- Sometimes we are using another programmer's code, so we use the identifiers that he or she chose (such as `println`)
- Often we use special identifiers called *reserved words* that already have a predefined meaning in the language
- A reserved word cannot be used in any other way

Reserved Words

- The Java reserved words:

```
abstract
assert
boolean
break
byte
case
catch
char
class
const
continue
default
do
double
else
enum
extends
false
final
finally
float
for
goto
if
implements
import
instanceof
int
interface
long
native
new
null
package
private
protected
public
return
short
static
strictfp
super
switch
synchronized
this
throw
throws
transient
true
try
void
volatile
while
```

Quick Check

Which of the following are valid Java identifiers?

```
grade
quizGrade
NetworkConnection
frame2
3rdTestScore
MAXIMUM
MIN_CAPACITY
student#
Shelves1&2
```

Quick Check

Which of the following are valid Java identifiers?

grade	Valid
quizGrade	Valid
NetworkConnection	Valid
frame2	Valid
3rdTestScore	Invalid – cannot begin with a digit
MAXIMUM	Valid
MIN_CAPACITY	Valid
student#	Invalid – cannot contain the '#' character
Shelves1&2	Invalid – cannot contain the '&' character

White Space

- Spaces, blank lines, and tabs are called *white space*
- White space is used to separate words and symbols in a program
- Extra white space is ignored
- A valid Java program can be formatted many ways
- Programs should be formatted to enhance readability, using consistent indentation
- See `Lincoln2.java` and `Lincoln3.java`

Outline

Computer Processing

Hardware Components

Networks

The Java Programming Language

➡ Program Development

Object-Oriented Programming

Program Development

- The mechanics of developing a program include several activities:
  - writing the program in a specific programming language (such as Java)
  - translating the program into a form that the computer can execute
  - investigating and fixing various types of errors that can occur
- Software tools can be used to help with all parts of this process

Language Levels

- There are four programming language levels:
  - machine language
  - assembly language
  - high-level language
  - fourth-generation language

- Each type of CPU has its own specific *machine language*

- The other levels were created to make it easier for a human being to read and write programs

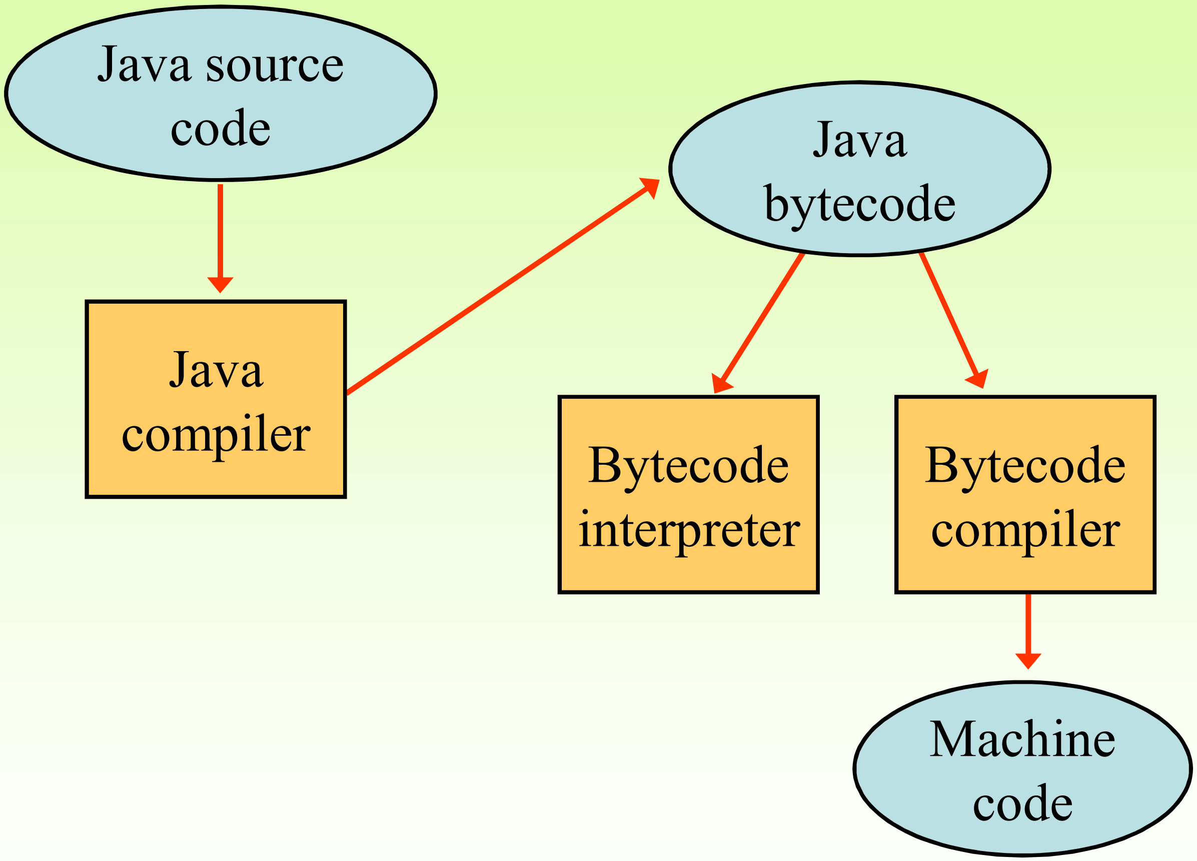
Programming Languages

- Each type of CPU executes only a particular *machine language*
- A program must be translated into machine language before it can be executed
- A *compiler* is a software tool which translates *source code* into a specific target language
- Often, that target language is the machine language for a particular CPU type
- The Java approach is somewhat different

Java Translation

- The Java compiler translates Java source code into a special representation called *bytecode*
- Java bytecode is not the machine language for any traditional CPU
- Another software tool, called an *interpreter*, translates bytecode into machine language and executes it
- Therefore the Java compiler is not tied to any particular machine
- Java is considered to be *architecture-neutral*

Java Translation



Development Environments

- There are many programs that support the development of Java software, including:
  - Java Development Kit (JDK)
  - Eclipse
  - NetBeans
  - BlueJ
  - jGRASP
- Though the details of these environments differ, the basic compilation and execution process is essentially the same

Syntax and Semantics

- The *syntax rules* of a language define how we can put together symbols, reserved words, and identifiers to make a valid program

- The *semantics* of a program statement define what that statement means (its purpose or role in a program)

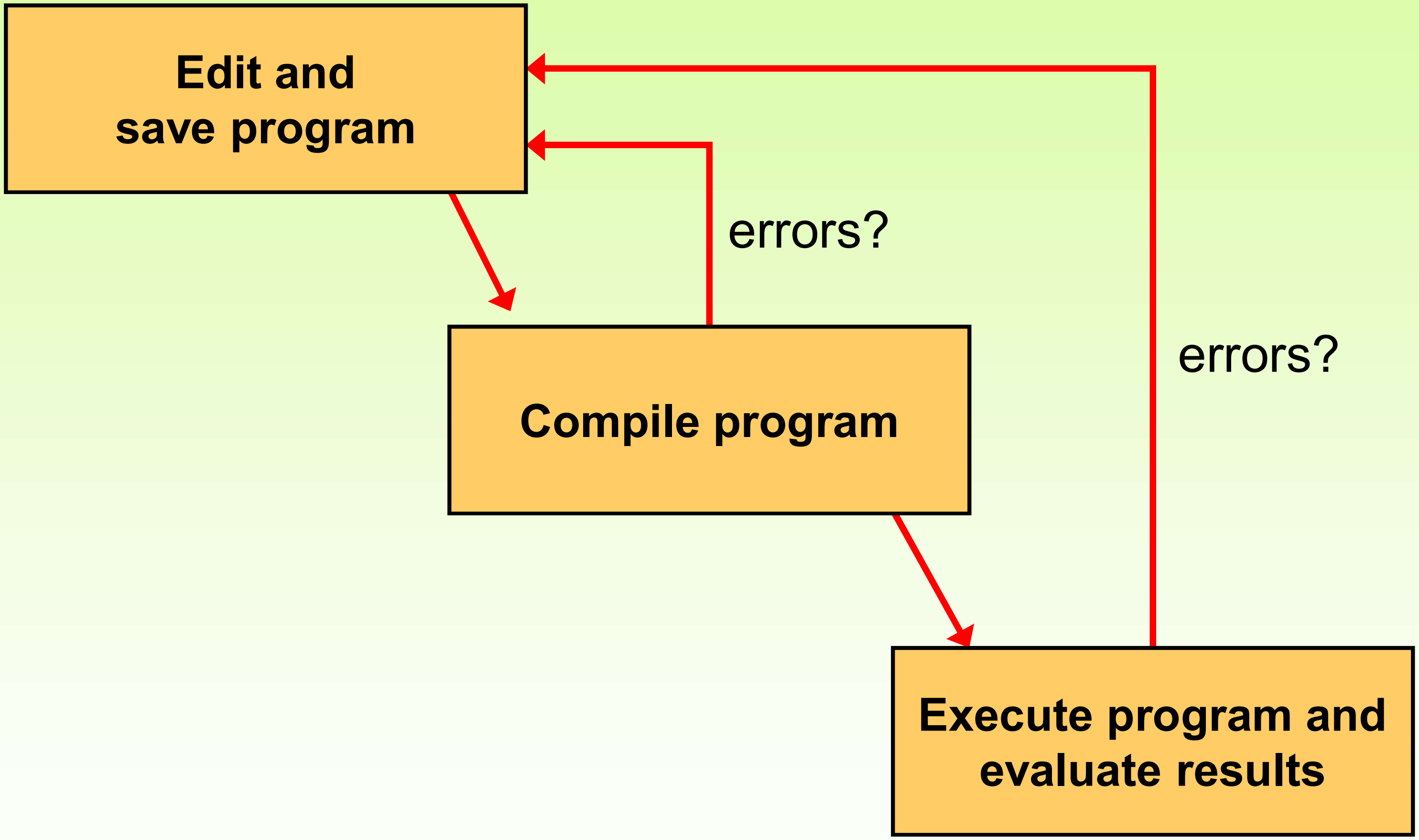
- A program that is syntactically correct is not necessarily logically (semantically) correct

- A program will always do what we tell it to do, not what we meant to tell it to do

Errors

- A program can have three types of errors
- The compiler will find syntax errors and other basic problems (*compile-time errors*)
  - If compile-time errors exist, an executable version of the program is not created
- A problem can occur during program execution, such as trying to divide by zero, which causes a program to terminate abnormally (*run-time errors*)
- A program may run, but produce incorrect results, perhaps using an incorrect formula (*logical errors*)

Basic Program Development



Edit and save program

Compile program

Execute program and evaluate results

errors?

errors?

Outline

Computer Processing

Hardware Components

Networks

The Java Programming Language

Program Development

⇨ Object-Oriented Programming

Problem Solving

- The purpose of writing a program is to solve a problem
- Solving a problem consists of multiple activities:
  - Understand the problem
  - Design a solution
  - Consider alternatives and refine the solution
  - Implement the solution
  - Test the solution
- These activities are not purely linear – they overlap and interact

Problem Solving

- The key to designing a solution is breaking it down into manageable pieces
- When writing software, we design separate pieces that are responsible for certain parts of the solution
- An *object-oriented approach* lends itself to this kind of solution decomposition
- We will dissect our solutions into pieces called objects and classes

Object-Oriented Programming

- Java is an object-oriented programming language
- As the term implies, an object is a fundamental entity in a Java program
- Objects can be used effectively to represent real-world entities
- For instance, an object might represent a particular employee in a company
- Each employee object handles the processing and data management related to that employee

Objects

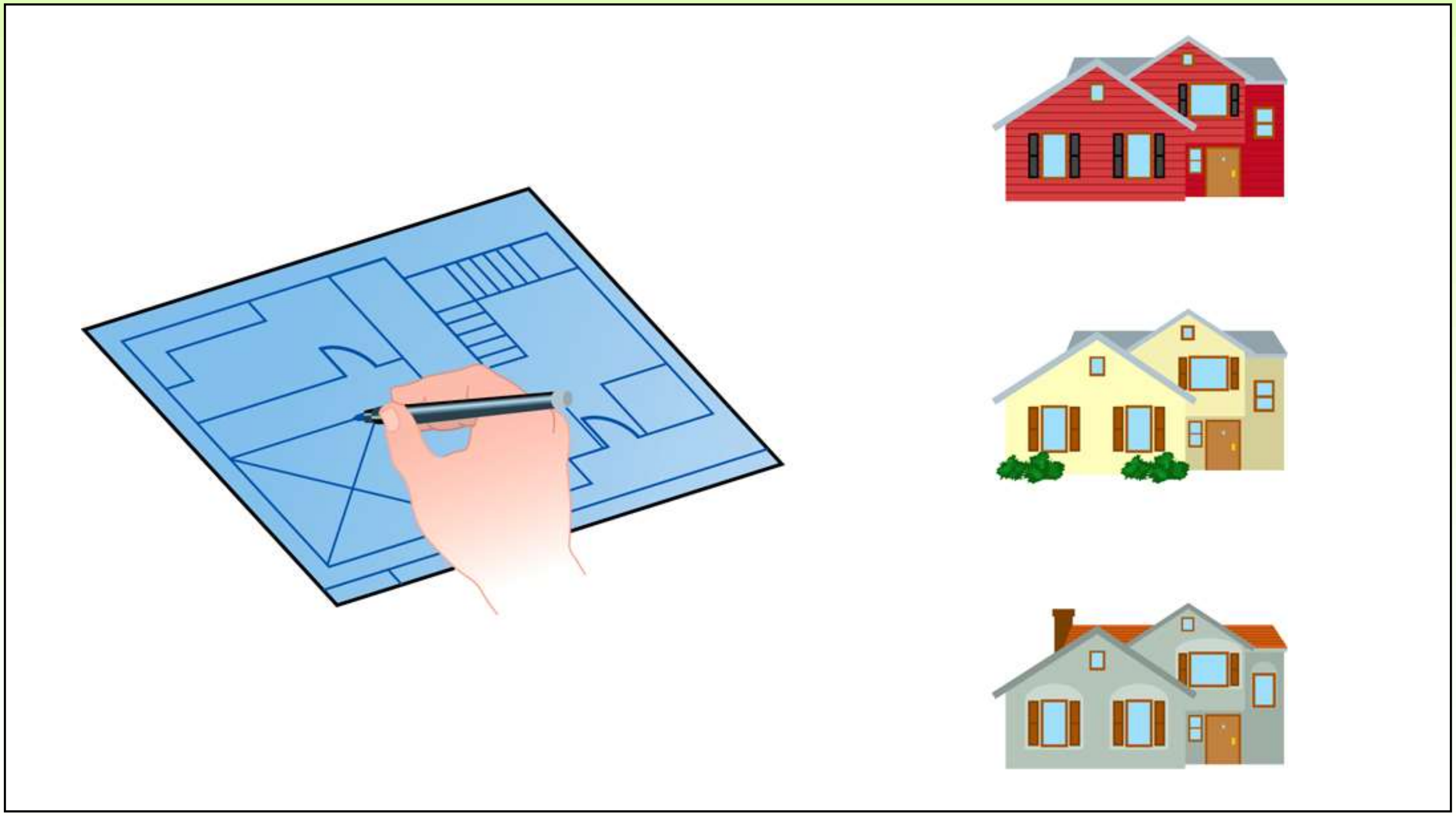
- An object has:
  - *state* - descriptive characteristics
  - *behaviors* - what it can do (or what can be done to it)
- The state of a bank account includes its account number and its current balance
- The behaviors associated with a bank account include the ability to make deposits and withdrawals
- Note that the behavior of an object might change its state

Classes

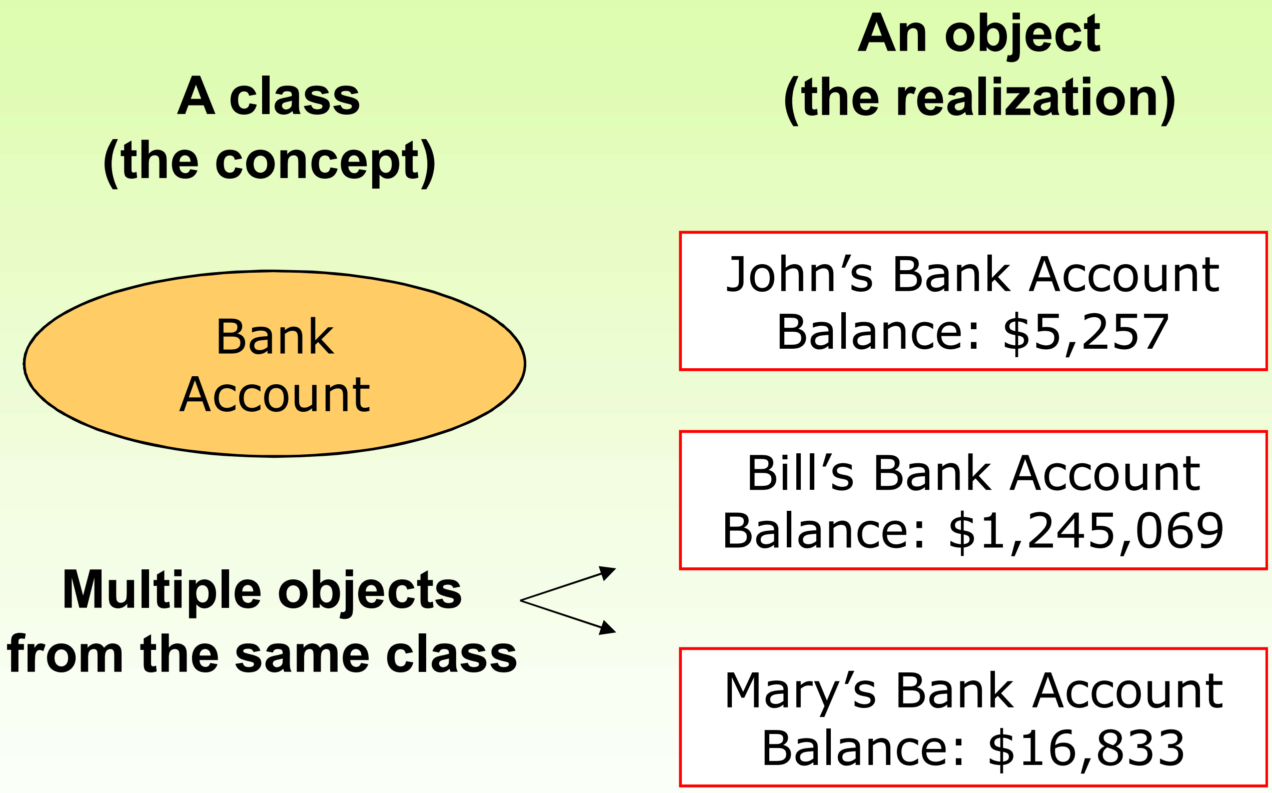
- An object is defined by a *class*
- A class is the blueprint of an object
- The class uses methods to define the behaviors of the object
- The class that contains the main method of a Java program represents the entire program
- A class represents a concept, and an object represents the embodiment of that concept
- Multiple objects can be created from the same class

Class = Blueprint

- One blueprint to create several similar, but different, houses:



Objects and Classes



A class
(the concept)

An object
(the realization)

Bank
Account

John's Bank Account
Balance: $5,257

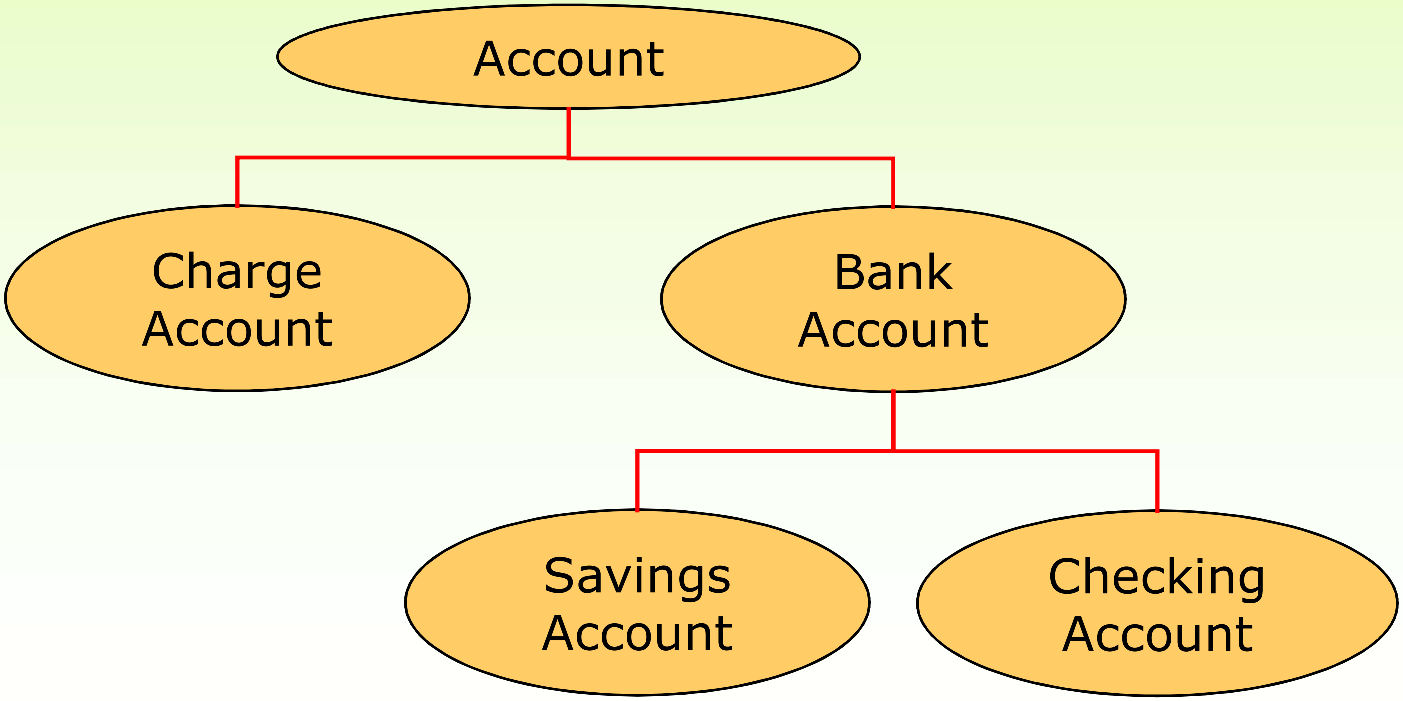
Bill's Bank Account
Balance: $1,245,069

Mary's Bank Account
Balance: $16,833

Multiple objects
from the same class

Inheritance

- One class can be used to derive another via *inheritance*
- Classes can be organized into hierarchies



Summary

- Chapter 1 focused on:
  - components of a computer
  - how those components interact
  - how computers store and manipulate information
  - computer networks
  - the Internet and the World Wide Web
  - programming and programming languages
  - an introduction to Java
  - an overview of object-oriented concepts