Chapter 5: Enhancing Classes

Presentation slides for

Java Software Solutions

for AP* Computer Science A
2nd Edition

by John Lewis, William Loftus, and Cara Cocking

Java Software Solutions is published by Addison-Wes ley

Enhancing Classes

- Now we can explore various aspects of classes and objects in more detail
- Chapter 5 focuses on:
  - object references and aliases
  - passing objects references as parameters
  - the static modifier
  - exceptions
  - interfaces
  - nested classes and inner classes
  - dialog boxes
  - GUI components, events, and listeners

References

- Recall from Chapter 2 that an object reference variable holds the memory address of an object
- Rather than dealing with arbitrary addresses, we often depict a reference graphically as a "pointer" to an object

```
ChessPiece bishop1 = new ChessPiece();
```

The null Reference

- An object reference variable that does not currently point to an object is called a *null reference*
- The reserved word `null` can be used to explicitly set a null reference:

```
name = null;
```

or to check to see if a reference is currently null:

```
if (name == null)
   System.out.println ("Invalid");
```

The null Reference

- An object reference variable declared at the class level (an instance variable) is automatically initialized to null
- The programmer must carefully ensure that an object reference variable refers to a valid object before it is used
- Attempting to follow a null reference causes a `NullPointerException` to be thrown
- Usually a compiler will check to see if a local variable is being used without being initialized

5

Assignment Revisited

- The act of assignment takes a copy of a value and stores it in a variable
- For primitive types:

```
num2 = num1;
```

7

The this Reference

- The `this` reference allows an object to refer to itself
- That is, the `this` reference, used inside a method, refers to the object through which the method is being executed
- Suppose the `this` reference is used in a method called `tryMe`
- If `tryMe` is invoked as follows, the `this` reference refers to `obj1`:

```
obj1.tryMe();
```

- But in this case, the `this` reference refers to `obj2`:

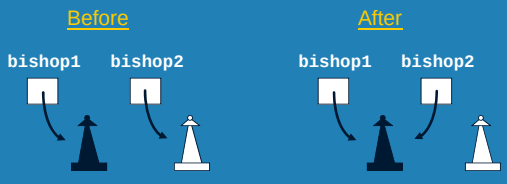
```
obj2.tryMe();
```

6

Reference Assignment

- For object references, assignment copies the memory location:

```
bishop2 = bishop1;
```



8

Aliases

- Two or more references that refer to the same object are called *aliases* of each other
- One object (and its data) can be accessed using different reference variables
- Aliases can be useful, but should be managed carefully
- Changing the object's state (its variables) through one reference changes it for all of its aliases

9

Testing Objects for Equality

- The == operator compares object references for equality, returning `true` if the references are aliases of each other

```
bishop1 == bishop2
```

- A method called `equals` is defined for all objects, but unless we redefine it when we write a class, it has the same semantics as the == operator

```
bishop1.equals(bishop2)
```

- We can redefine the `equals` method to return `true` under whatever conditions we think are appropriate

10

Objects as Parameters

- Parameters in a Java method are *passed by value*
- This means that a copy of the actual parameter (the value passed in) is stored into the formal parameter (in the method header)
- Passing parameters is therefore similar to an assignment statement
- When an object is passed to a method, the actual parameter and the formal parameter become aliases of each other

11

Passing Objects to Methods

- What you do with a parameter inside a method may or may not have a permanent effect (outside the method)
- See ParameterPassing.java (page 269)
- See ParameterTester.java (page 270)
- See Num.java (page 266)
- Note the difference between changing the reference and changing the object that the reference points to

12

The static Modifier

- In Chapter 2 we discussed static methods (also called class methods) that can be invoked through the class name rather than through a particular object
- For example, the methods of the `Math` class are static:

```
Math.sqrt (25)
```

- To write a static method, we apply the `static` modifier to the method definition
- The `static` modifier can be applied to variables as well
- It associates a variable or method with the class rather than with an object

13

Static Variables

- Static variables are also called *class variables*
- Normally, each object has its own data space, but if a variable is declared as static, only one copy of the variable exists

```
private static float price;
```

- Memory space for a static variable is created when the class in which it is declared is loaded
- All objects created from the class share static variables
- The most common use of static variables is for constants

14

Static Methods

- The order of the modifiers can be interchanged, but by convention visibility modifiers come first
- Recall that the `main` method is static; it is invoked by the system without creating an object
- Static methods cannot reference instance variables, because instance variables don't exist until an object exists
- However, a static method can reference static variables or local variables

16

Static Methods

```
class Helper
```

```
public static int triple (int num)
{
   int result;
   result = num * 3;
   return result;
}
```

Because it is static, the method can be invoked as:

```
value = Helper.triple (5);
```

15

The static Modifier

- Static methods and static variables often work together
- See CountInstances.java (page 273)
- See Slogan.java (page 275)

17

Exceptions

- An *exception* is an object that describes an unusual or erroneous situation
- Exceptions are *thrown* by a program, and may be *caught* and *handled* by another part of the program
- A program can be separated into a normal execution flow and an *exception execution flow*
- An *error* is also represented as an object in Java, but usually represents a unrecoverable situation and should not be caught

18

Exception Handling

- Java has a predefined set of exceptions and errors that can occur during execution
- A program can deal with an exception in one of three ways:
  - ignore it
  - handle it where it occurs
  - handle it an another place in the program

19

Exception Handling

- If an exception is ignored by the program, the program will terminate abnormally and produce an appropriate message
- The message includes a *call stack trace* that indicates the line on which the exception occurred
- The call stack trace also shows the method call trail that lead to the attempted execution of the offending line
- See Zero.java (page 277)

20

The throw Statement

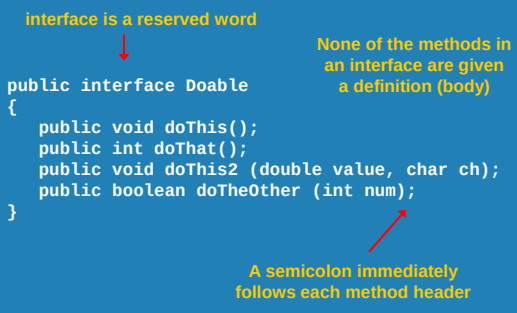
- Exceptions are thrown using the *throw* statement
- Usually a throw statement is nested inside an if statement that evaluates the condition to see if the exception should be thrown
- The following statement throws a `NoSuchElementException`:

```
throw new NoSuchElementException();
```

- See Throwing.java (page 278)

21

Interfaces



23

Interfaces

- A Java *interface* is a collection of abstract methods and constants
- An *abstract method* is a method header without a method body
- An abstract method can be declared using the modifier `abstract`, but because all methods in an interface are abstract, usually it is left off
- An interface is used to establish, as a formal contract, a set of methods that a class will implement

22

Interfaces

- An interface cannot be instantiated
- Methods in an interface have public visibility by default
- A class formally implements an interface by
  - stating so in the class header
  - providing implementations for each abstract method in the interface
- If a class asserts that it implements an interface, it must define all methods in the interface

24

Interfaces

```
public class CanDo implements Doable
{
   public void doThis ()
   {
      // whatever
   }

   public void doThat ()
   {
      // whatever
   }

   // etc.
}
```

implements is a reserved word

Each method listed in Doable is given a definition

Interfaces

- A class that implements an interface can implement other methods as well
- See Complexity.java (page 279)
- See Question.java (page 281)
- See MiniQuiz.java (page 282)
- In addition to (or instead of) abstract methods, an interface can contain constants
- When a class implements an interface, it gains access to all its constants

Interfaces

- A class can implement multiple interfaces
- The interfaces are listed in the implements clause
- The class must implement all methods in all interfaces listed in the header

```
class ManyThings implements interface1, interface2
{
   // all methods of both interfaces
}
```


Interfaces

- The Java standard class library contains many helpful interfaces
- The `Comparable` interface contains an abstract method called `compareTo`, which is used to compare two objects
- The `String` class implements `Comparable`, giving us the ability to put strings in lexicographic order
- The `List` interface is implemented by classes that represent an ordered collection of elements.
- The `Iterator` interface contains methods that allow the user to move easily through a collection of objects

The Comparable Interface

- The `Comparable` interface provides a common mechanism for comparing one object to another

```
if (obj1.compareTo(obj2) < 0)
    System.out.println ("obj1 is less than obj2");
```

- The result is negative is `obj1` is less that `obj2`, 0 if they are equal, and positive if `obj1` is greater than `obj2`
- When a programmer writes a class that implements the `Comparable` interface, it should follow this intent
- It's up to the programmer to determine what makes one object less than another

29

The List Interface

- The `List` interface represents an ordered collection of elements
- The `size` method returns the number of elements in the list
- The `add` method adds an element to the list
- The `iterator` and `listIterator` methods return iterators of the elements in the list

30

Iterator and ListIterator Interfaces

- The `Iterator` and `ListIterator` interfaces provide a means of moving through a collection of objects, one at a time
- The `hasNext` method returns a boolean result (true if there are items left to process)
- The `next` method returns the next object in the iteration
- The `remove` method removes the object most recently returned by the `next` method
- The `ListIterator` interface has additional methods (`add` and `set`) that insert or replace an element in the list

31

Identifying Classes and Objects

- During the design stage, classes and objects need to be identified
- As a start, examine the program requirements
- Objects are generally nouns
- A class represents a group of objects with similar behavior
- For example, to represent products, we may need a class called `Product`
- Strike a good balance between classes that are too general and those that are too specific

32

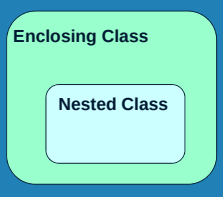
Designing Classes

- When designing a class, there are two pieces of information to think about:
  - State (how an object is represented)
  - Behavior (what an object does)
- The state becomes the instance variables of an object
- The behavior becomes the methods
- When thinking about behavior, you should think about how others might want to use the object

33

Nested Classes

- In addition to containing data and methods, a class can contain other classes
- A class declared within another class is called a *nested class*



34

Nested Classes

- A nested class has access to the variables and methods of the enclosing class, even if they are declared private
- In certain situations this makes the implementation of the classes easier because they can share information easily
- Furthermore, the nested class can be protected by the enclosing class from external use
- This is a special relationship and should be used with care

35

Nested Classes

- A nested class produces a separate bytecode file
- If a nested class called `Inside` is declared in an outer class called `Outside`, two bytecode files are produced:

```
Outside.class
Outside$Inside.class
```

- Nested classes can be declared as static, in which case they cannot refer to instance variables or methods

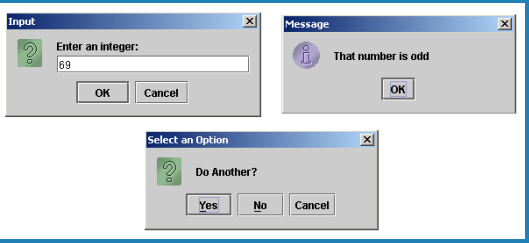
36

Inner Classes

- A nonstatic nested class is called an *inner class*
- An inner class is associated with each instance of the enclosing class
- An instance of an inner class can exist only within an instance of an enclosing class

37

The EvenOdd Program



39

Dialog Boxes

- A *dialog box* is a graphical window that pops up on top of any currently active window for the user
- The Swing API contains a class called `JOptionPane` that simplifies the creation and use of basic dialog boxes
- There are three categories of `JOptionPane` dialog boxes
  - A *message dialog* displays an output string
  - An *input dialog* presents a prompt and a single input text field
  - A *confirm dialog* presents the user with a simple yes-or-no question
- See EvenOdd.java (page 294)

38

Graphical User Interfaces

- A Graphical User Interface (GUI) is created with at least three kinds of objects
  - components
  - events
  - listeners
- A GUI *component* defines a screen element to display information or allow the user to interact with the program
  - buttons, text fields, labels, menus, etc.
- A *container* is a special component that holds and organizes other components
  - dialog boxes, applets, frames, panels, etc.

40

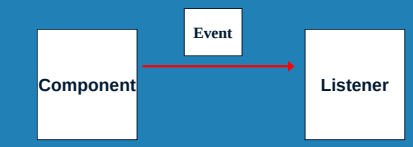
Events

- An *event* is an object that represents some activity to which we may want to respond
- For example, we may want our program to perform some action when the following occurs:
  - the mouse is moved
  - a mouse button is clicked
  - the mouse is dragged
  - a graphical button is clicked
  - a keyboard key is pressed
  - a timer expires
- Events often correspond to user actions, but not always

Events and Listeners

- The Java standard class library contains several classes that represent typical events
- Components, such as an applet or a graphical button, generate (fire) an event when it occurs
- Other objects, called *listeners*, wait for events to occur
- We can write listener objects to do whatever we want when an event occurs
- A listener object is often defined using an inner class

Events and Listeners



This object may generate an event

This object waits for and responds to an event

When an event occurs, the generator calls the appropriate method of the listener, passing an object that describes the event

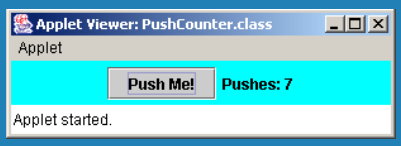
Listener Interfaces

- We can create a listener object by writing a class that implements a particular *listener interface*
- The Java standard class library contains several interfaces that correspond to particular event categories
- For example, the `MouseListener` interface contains methods that correspond to mouse events
- After creating the listener, we *add* the listener to the component that might generate the event to set up a formal relationship between the generator and listener

Creating GUIs

- To create a program with a GUI:
  - define and set up the components
  - create listener objects
  - set up the relationships between the listeners and the components which generate events of interest
  - define what happens in response to each event
- A *push button* is a component that allows the user to initiate an action with the press of the mouse button
  - defined by the `JButton` class
  - generates an *action event*
- A *label* is a component that displays a line of text (or an image, or both)
  - defined by the `JLabel` class

The PushCounter Program



Creating GUIs

- The `init` method of an applet can be used to set up the GUI and add each component to the applet container
- The Swing version of the `Applet` class is called `JApplet`
- In a `JApplet`, components are added to the applet's *content pane*
- The content pane is retrieved using the `getContentPane` method
- A `JButton` generates an *action event*
- See PushCounter.java (page 297)

Action Listeners

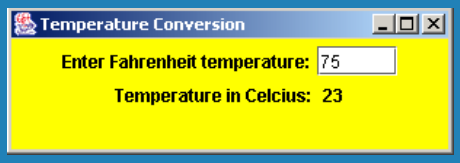
- The interface corresponding to an action event is called `ActionListener`, which defines only one method, called `actionPerformed`
- The `ButtonListener` inner class implements the `ActionListener` interface in the `PushButton` program
- When the button is pushed, the `JButton` object invokes the `actionPerformed` method, passing it an `ActionEvent`
- The listener method may or may not make use of the event object passed to it

GUI Applications

- A *frame* is a container component used for stand-alone GUI-based applications
- A *panel* is a container, but unlike a frame, it cannot be displayed on its own
  - it must be added to another container
  - it helps organize the components in a GUI
- See Fahrenheit.java (page 300)
- See FahrenheitGUI.java (page 302)

49

The Fahrenheit Program



50

Summary

- Chapter 5 has focused on:
  - object references and aliases
  - passing objects references as parameters
  - the static modifier
  - exceptions
  - interfaces
  - nested classes and inner classes
  - dialog boxes
  - GUI components, events, and listeners

51