Chapter 5: Enhancing Classes

Presentation slides for

Java Software Solutions

Foundations of Program Design
Second Edition

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Enhancing Classes

- We can now explore various aspects of classes and objects in more detail
- Chapter 5 focuses on:
  - object references and aliases
  - passing objects as parameters
  - the static modifier
  - nested classes
  - interfaces and polymorphism
  - events and listeners
  - animation

References

- Recall from Chapter 2 that an object reference 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();
```

Assignment Revisited

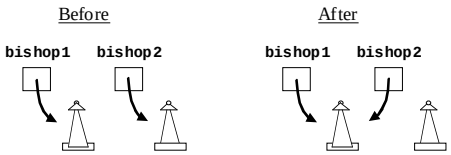
- The act of assignment takes a copy of a value and stores it in a variable
- For primitive types:

```
num2 = num1;
```

Reference Assignment

- For object references, assignment copies the memory location:

```
bishop2 = bishop1;
```



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 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

Garbage Collection

- When an object no longer has any valid references to it, it can no longer be accessed by the program
- It is useless, and therefore called *garbage*
- Java performs *automatic garbage collection* periodically, returning an object's memory to the system for future use
- In other languages, the programmer has the responsibility for performing garbage collection

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Passing Objects to Methods

- 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 essentially an assignment
- When an object is passed to a method, the actual parameter and the formal parameter become aliases of each other

Passing Objects to Methods

- What you do to a parameter inside a method may or may not have a permanent effect (outside the method)
- See ParameterPassing.java (page 226)
- See ParameterTester.java (page 228)
- See Num.java (page 230)
- Note the difference between changing the reference and changing the object that the reference points to

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
- To make a method static, 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 an object

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Static Methods

```
class Helper

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

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

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

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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, they can reference static variables or local variables

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Static Variables

- Static variables are sometimes called *class variables*
- Normally, each object has its own data space
- 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 as soon as the class in which it is declared is loaded

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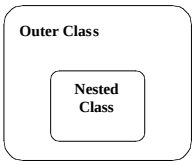
Static Variables

- All objects created from the class share access to the static variable
- Changing the value of a static variable in one object changes it for all others
- Static methods and variables often work together
- See CountInstances.java (page 233)
- See MyClass.java (page 234)

Nested Classes

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



Nested Classes

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

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 will be produced:

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

- Nested classes can be declared as static, in which case they cannot refer to instance variables or methods
- A nonstatic nested class is called an *inner class*

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, it is usually left off
- An interface is used to formally define a set of methods that a class will implement

Interfaces

interface is a reserved word

None of the methods in an interface are given a definition (body)

```
public interface Doable
{
   public void doThis();
   public int doThat();
   public void doThis2 (float value, char ch);
   public boolean doTheOther (int num);
}
```

A semicolon immediately follows each method header

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 or the compiler will produce errors.

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 Speaker.java (page 236)
- See Philosopher.java (page 237)
- See Dog.java (page 238)
- A class can implement multiple interfaces
- The interfaces are listed in the implements clause, separated by commas
- The class must implement all methods in all interfaces listed in the header

Polymorphism via Interfaces

- An interface name can be used as the type of an object reference variable

```
Doable obj;
```

- The `obj` reference can be used to point to any object of any class that implements the `Doable` interface
- The version of `doThis` that the following line invokes depends on the type of object that `obj` is referring to:

```
obj.doThis();
```

Polymorphism via Interfaces

- That reference is *polymorphic*, which can be defined as "having many forms"
- That line of code might execute different methods at different times if the object that `obj` points to changes
- See Talking.java (page 240)
- Note that polymorphic references must be resolved at run time; this is called *dynamic binding*
- Careful use of polymorphic references can lead to elegant, robust software designs

Interfaces

- The Java standard class library contians many interfaces that are helpful in certain situations
- The `Comparable` interface contains an abstract method called `compareTo`, which is used to compare to objects
- The `String` class implements `Comparable` which gives us the ability to put strings in alphabetical order
- The `Iterator` interface contains methods that allow the user to move through a collection of objects easily

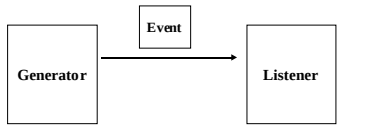
Events

- 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
- Often events correspond to user actions, but not always

Events

- The Java standard class library contains several classes that represent typical events
- Certain objects, such as an applet or a graphical button, generate (fire) an event when it occurs
- Other objects, called a *listeners*, respond to events
- We can write listener objects to do whatever we want when an event occurs

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

Mouse Events

- The following are *mouse events*:
  - *mouse pressed* - the mouse button is pressed down
  - *mouse released* - the mouse button is released
  - *mouse clicked* - the mouse button is pressed and released
  - *mouse entered* - the mouse pointer is moved over a particular component
  - *mouse exited* - the mouse pointer is moved off of a particular component
- Any given program can listen for some, none, or all of these
- See Dots.java (page 246)
- See DotsMouseListener.java (page 248)

Mouse Motion Events

- The following are called *mouse motion events*:
  - *mouse moved* - the mouse is moved
  - *mouse dragged* - the mouse is moved while the mouse button is held down
- There is a corresponding `MouseMotionListener` interface
- One class can serve as both a generator and a listener
- One class can serve as a listener for multiple event types
- See RubberLines.java (page 249)

Key Events

- The following are called *key events*:
  - *key pressed* - a keyboard key is pressed down
  - *key released* - a keyboard key is released
  - *key typed* - a keyboard key is pressed and released
- The `KeyListener` interface handles key events
- Listener classes are often implemented as inner classes, nested within the component that they are listening to
- See Direction.java (page 253)

Animations

- An animation is a constantly changing series of pictures or images that create the illusion of movement
- We can create animations in Java by changing a picture slightly over time
- The speed of a Java animation is usually controlled by a `Timer` object
- The `Timer` class is defined in the `javax.swing` package

Animations

- A `Timer` object generates and `ActionEvent` every n milliseconds (where n is set by the object creator)
- The `ActionListener` interface contains an `actionPerformed` method
- Whenever the timer expires (generating an `ActionEvent`) the animation can be updated
- See Rebound.java (page 258)