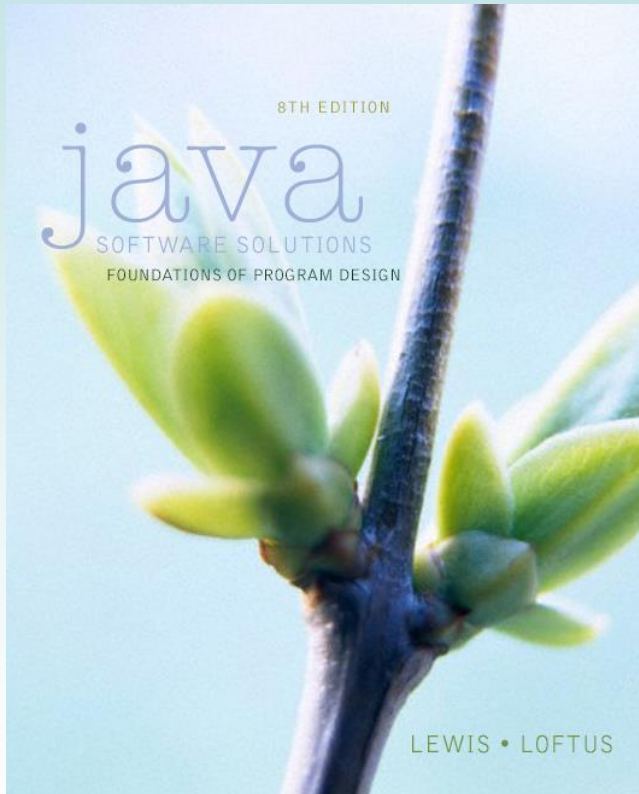


Chapter 9

Inheritance



Java Software Solutions

Foundations of Program Design

8th Edition

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William Loftus

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Inheritance

- Inheritance is a fundamental object-oriented design technique used to create and organize reusable classes
- Chapter 9 focuses on:
 - deriving new classes from existing classes
 - the `protected` modifier
 - creating class hierarchies
 - abstract classes
 - indirect visibility of inherited members
 - designing for inheritance
 - the GUI component class hierarchy
 - extending listener adapter classes
 - the `Timer` class

Outline



Creating Subclasses

Overriding Methods

Class Hierarchies

Visibility

Designing for Inheritance

Inheritance and GUIs

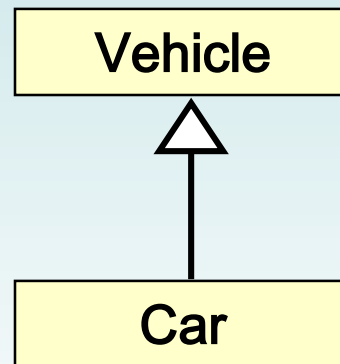
The Timer Class

Inheritance

- *Inheritance* allows a software developer to derive a new class from an existing one
- The existing class is called the *parent class*, or *superclass*, or *base class*
- The derived class is called the *child class* or *subclass*
- As the name implies, the child inherits characteristics of the parent
- That is, the child class inherits the methods and data defined by the parent class

Inheritance

- Inheritance relationships are shown in a UML class diagram using a solid arrow with an unfilled triangular arrowhead pointing to the parent class



- Proper inheritance creates an *is-a* relationship, meaning the child *is a* more specific version of the parent

Inheritance

- A programmer can tailor a derived class as needed by adding new variables or methods, or by modifying the inherited ones
- One benefit of inheritance is *software reuse*
- By using existing software components to create new ones, we capitalize on all the effort that went into the design, implementation, and testing of the existing software

Deriving Subclasses

- In Java, we use the reserved word `extends` to establish an inheritance relationship

```
public class Car extends Vehicle
{
    // class contents
}
```

- See `Words.java`
- See `Book.java`
- See `Dictionary.java`

```

//*****
//  Words.java          Author: Lewis/Loftus
//
//  Demonstrates the use of an inherited method.
//*****

public class Words
{
    //-----
    //  Instantiates a derived class and invokes its inherited and
    //  local methods.
    //-----
    public static void main(String[] args)
    {
        Dictionary webster = new Dictionary();

        System.out.println("Number of pages: " + webster.getPages());

        System.out.println("Number of definitions: " +
                           webster.getDefinitions());

        System.out.println("Definitions per page: " +
                           webster.computeRatio());
    }
}

```


Output

```
Number of pages: 1500
Number of definitions: 52500
Definitions per page: 35.0
```

```
//*****
// Words.java
//
// Demonstrates
//*****
```

```
*****
*****
```

```
public class Words
```

```
{
    //-----
    // Instantiates a derived class and invokes its inherited and
    // local methods.
    //-----
    public static void main(String[] args)
    {
        Dictionary webster = new Dictionary();

        System.out.println("Number of pages: " + webster.getPages());

        System.out.println("Number of definitions: " +
                           webster.getDefinitions());

        System.out.println("Definitions per page: " +
                           webster.computeRatio());

    }
}
```

```
//*****
//  Book.java      Author: Lewis/Loftus
//
//  Represents a book. Used as the parent of a derived class to
//  demonstrate inheritance.
//*****
```

```
public class Book
{
    protected int pages = 1500;

    //-----
    //  Pages mutator.
    //-----
    public void setPages(int numPages)
    {
        pages = numPages;
    }

    //-----
    //  Pages accessor.
    //-----
    public int getPages()
    {
        return pages;
    }
}
```

```

//*****
//  Dictionary.java          Author: Lewis/Loftus
//
//  Represents a dictionary, which is a book. Used to demonstrate
//  inheritance.
//*****

public class Dictionary extends Book
{
    private int definitions = 52500;

    //-----
    //  Prints a message using both local and inherited values.
    //-----
    public double computeRatio()
    {
        return (double) definitions/pages;
    }
}

```

continue

continue

```
//-----  
//  Definitions mutator.  
//-----  
public void setDefinitions(int numDefinitions)  
{  
    definitions = numDefinitions;  
}  
  
//-----  
//  Definitions accessor.  
//-----  
public int getDefinitions()  
{  
    return definitions;  
}  
}
```

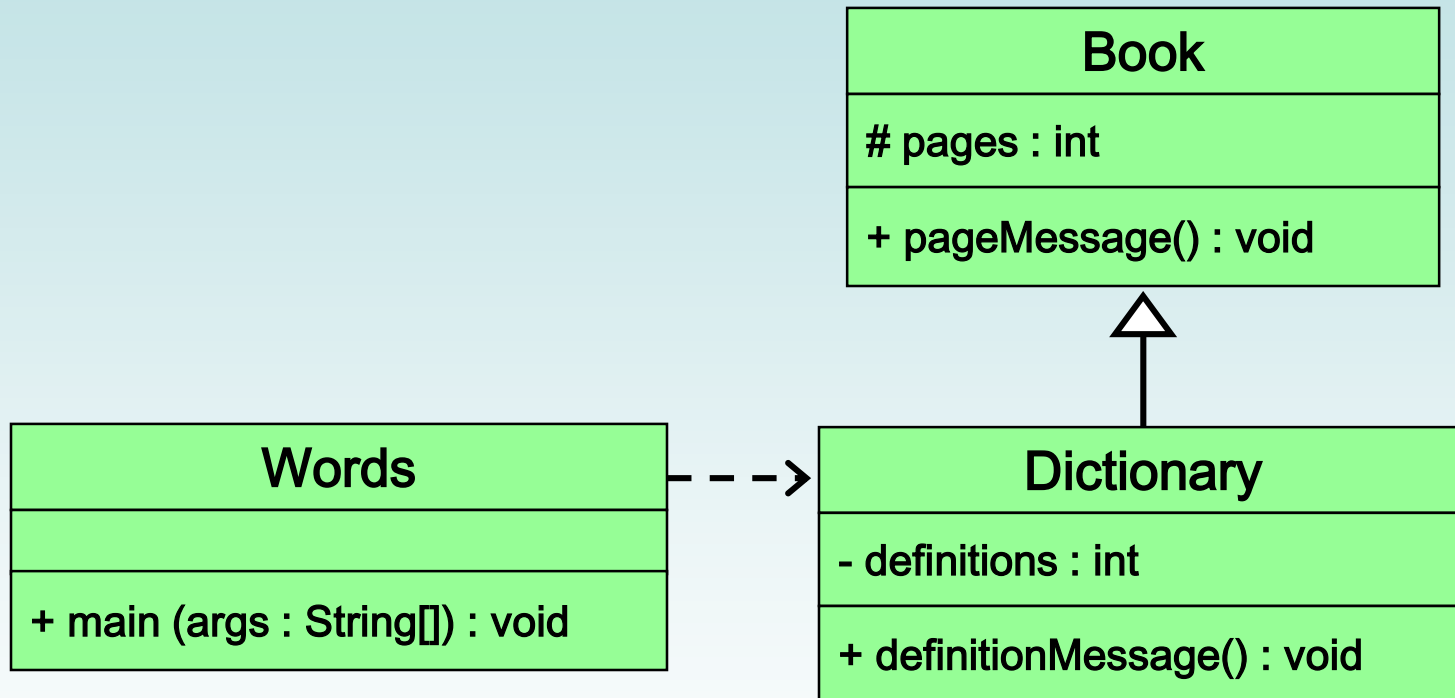
The protected Modifier

- Visibility modifiers affect the way that class members can be used in a child class
- Variables and methods declared with private visibility cannot be referenced in a child class
- They can be referenced in the child class if they are declared with public visibility -- but public variables violate the principle of encapsulation
- There is a third visibility modifier that helps in inheritance situations: `protected`

The protected Modifier

- The `protected` modifier allows a child class to reference a variable or method in the child class
- It provides more encapsulation than public visibility, but is not as tightly encapsulated as private visibility
- A protected variable is also visible to any class in the same package as the parent class
- See Appendix E for details of all Java modifiers
- Protected variables and methods can be shown with a `#` symbol preceding them in UML diagrams

Class Diagram for Words



The super Reference

- Constructors are not inherited, even though they have public visibility
- Yet we often want to use the parent's constructor to set up the "parent's part" of the object
- The `super` reference can be used to refer to the parent class, and often is used to invoke the parent's constructor
- A child's constructor is responsible for calling the parent's constructor

The super Reference

- The first line of a child's constructor should use the `super` reference to call the parent's constructor
- The `super` reference can also be used to reference other variables and methods defined in the parent's class
- See `Words2.java`
- See `Book2.java`
- See `Dictionary2.java`

```

//*****
//  Words2.java          Author: Lewis/Loftus
//
//  Demonstrates the use of the super reference.
//*****

public class Words2
{
    //-----
    //  Instantiates a derived class and invokes its inherited and
    //  local methods.
    //-----
    public static void main(String[] args)
    {
        Dictionary2 webster = new Dictionary2(1500, 52500);

        System.out.println("Number of pages: " + webster.getPages());

        System.out.println("Number of definitions: " +
                           webster.getDefinitions());

        System.out.println("Definitions per page: " +
                           webster.computeRatio());
    }
}

```

Output

Number of pages: 1500
Number of definitions: 52500
Definitions per page: 35.0

```
//*****  
// Words2.java  
//  
// Demonstrates  
//*****
```

```
*****
```

```
*****
```

```
public class Words2
```

```
{
```

```
//-----  
// Instantiates a derived class and invokes its inherited and  
// local methods.  
//-----
```

```
public static void main(String[] args)
```

```
{
```

```
    Dictionary2 webster = new Dictionary2(1500, 52500);
```

```
    System.out.println("Number of pages: " + webster.getPages());
```

```
    System.out.println("Number of definitions: " +  
                        webster.getDefinitions());
```

```
    System.out.println("Definitions per page: " +  
                        webster.computeRatio());
```

```
}
```

```
}
```

```
//*****  
// Book2.java          Author: Lewis/Loftus  
//  
// Represents a book. Used as the parent of a derived class to  
// demonstrate inheritance and the use of the super reference.  
//*****
```

```
public class Book2  
{  
    protected int pages;  
  
    //-----  
    // Constructor: Sets up the book with the specified number of  
    // pages.  
    //-----  
    public Book2(int numPages)  
    {  
        pages = numPages;  
    }  
}
```

continue

continue

```
//-----  
//  Pages mutator.  
//-----  
public void setPages(int numPages)  
{  
    pages = numPages;  
}  
  
//-----  
//  Pages accessor.  
//-----  
public int getPages()  
{  
    return pages;  
}  
}
```

```
//*****  
// Dictionary2.java      Author: Lewis/Loftus  
//  
// Represents a dictionary, which is a book. Used to demonstrate  
// the use of the super reference.  
//*****
```

```
public class Dictionary2 extends Book2  
{  
    private int definitions;
```

```
    //-----  
    // Constructor: Sets up the dictionary with the specified number  
    // of pages and definitions.  
    //-----
```

```
    public Dictionary2(int numPages, int numDefinitions)  
    {  
        super(numPages);  
  
        definitions = numDefinitions;  
    }
```

continue

continue

```
//-----  
// Prints a message using both local and inherited values.  
//-----  
public double computeRatio()  
{  
    return (double) definitions/pages;  
}  
  
//-----  
// Definitions mutator.  
//-----  
public void setDefinitions(int numDefinitions)  
{  
    definitions = numDefinitions;  
}  
  
//-----  
// Definitions accessor.  
//-----  
public int getDefinitions()  
{  
    return definitions;  
}  
}
```

Multiple Inheritance

- Java supports *single inheritance*, meaning that a derived class can have only one parent class
- *Multiple inheritance* allows a class to be derived from two or more classes, inheriting the members of all parents
- Collisions, such as the same variable name in two parents, have to be resolved
- Multiple inheritance is generally not needed, and Java does not support it

Outline

Creating Subclasses



Overriding Methods

Class Hierarchies

Visibility

Designing for Inheritance

Inheritance and GUIs

The Timer Class

Overriding Methods

- A child class can *override* the definition of an inherited method in favor of its own
- The new method must have the same signature as the parent's method, but can have a different body
- The type of the object executing the method determines which version of the method is invoked
- **See** `Messages.java`
- **See** `Thought.java`
- **See** `Advice.java`

```

//*****
//  Messages.java          Author: Lewis/Loftus
//
//  Demonstrates the use of an overridden method.
//*****

public class Messages
{
    //-----
    //  Creates two objects and invokes the message method in each.
    //-----
    public static void main(String[] args)
    {
        Thought parked = new Thought();
        Advice dates = new Advice();

        parked.message();

        dates.message();  // overridden
    }
}

```

Output

I feel like I'm diagonally parked in a parallel universe.

Warning: Dates in calendar are closer than they appear.

I feel like I'm diagonally parked in a parallel universe.

```
//-----  
//  Creates two objects and invokes the message method in each.  
//-----
```

```
public static void main(String[] args)
```

```
{
```

```
    Thought parked = new Thought();
```

```
    Advice dates = new Advice();
```

```
    parked.message();
```

```
    dates.message();  // overridden
```

```
}
```

```
}
```

```

//*****
//  Thought.java          Author: Lewis/Loftus
//
//  Represents a stray thought. Used as the parent of a derived
//  class to demonstrate the use of an overridden method.
//*****

public class Thought
{
    //-----
    //  Prints a message.
    //-----
    public void message()
    {
        System.out.println("I feel like I'm diagonally parked in a " +
                           "parallel universe.");

        System.out.println();
    }
}

```

```

//*****
//  Advice.java          Author: Lewis/Loftus
//
//  Represents some thoughtful advice. Used to demonstrate the use
//  of an overridden method.
//*****

public class Advice extends Thought
{
    //-----
    //  Prints a message. This method overrides the parent's version.
    //-----
    public void message()
    {
        System.out.println("Warning: Dates in calendar are closer " +
                           "than they appear.");

        System.out.println();

        super.message(); // explicitly invokes the parent's version
    }
}

```

Overriding

- A method in the parent class can be invoked explicitly using the `super` reference
- If a method is declared with the `final` modifier, it cannot be overridden
- The concept of overriding can be applied to data and is called *shadowing variables*
- Shadowing variables should be avoided because it tends to cause unnecessarily confusing code

Overloading vs. Overriding

- Overloading deals with multiple methods with the same name in the same class, but with different signatures
- Overriding deals with two methods, one in a parent class and one in a child class, that have the same signature
- Overloading lets you define a similar operation in different ways for different parameters
- Overriding lets you define a similar operation in different ways for different object types

Quick Check

True or False?

A child class may define a method with the same name as a method in the parent.

A child class can override the constructor of the parent class.

A child class cannot override a `final` method of the parent class.

It is considered poor design when a child class overrides a method from the parent.

A child class may define a variable with the same name as a variable in the parent.

Quick Check

True or False?

A child class may define a method with the same name as a method in the parent.

True

A child class can override the constructor of the parent class.

False

A child class cannot override a `final` method of the parent class.

True

It is considered poor design when a child class overrides a method from the parent.

False

A child class may define a variable with the same name as a variable in the parent.

True, but
shouldn't

Outline

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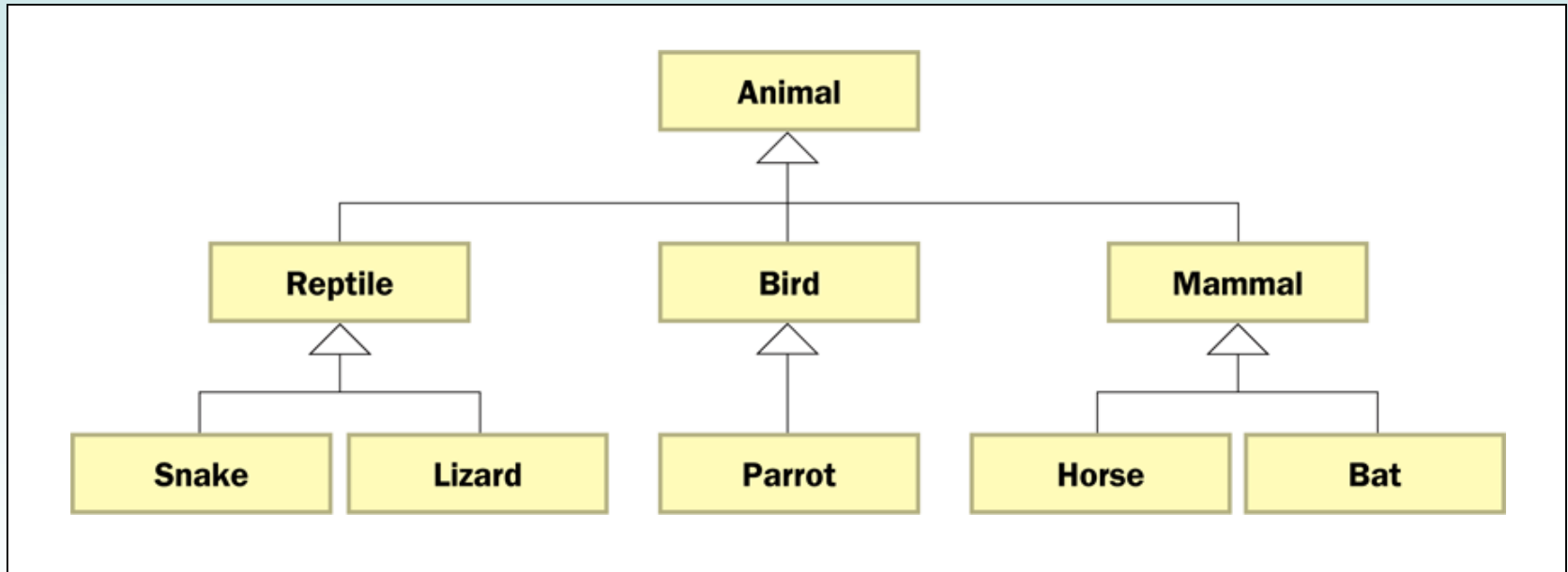
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Class Hierarchies

- A child class of one parent can be the parent of another child, forming a *class hierarchy*



Class Hierarchies

- Two children of the same parent are called *siblings*
- Common features should be put as high in the hierarchy as is reasonable
- An inherited member is passed continually down the line
- Therefore, a child class inherits from all its ancestor classes
- There is no single class hierarchy that is appropriate for all situations

The Object Class

- A class called `Object` is defined in the `java.lang` package of the Java standard class library
- All classes are derived from the `Object` class
- If a class is not explicitly defined to be the child of an existing class, it is assumed to be the child of the `Object` class
- Therefore, the `Object` class is the ultimate root of all class hierarchies

The Object Class

- The `Object` class contains a few useful methods, which are inherited by all classes
- For example, the `toString` method is defined in the `Object` class
- Every time we define the `toString` method, we are actually overriding an inherited definition
- The `toString` method in the `Object` class is defined to return a string that contains the name of the object's class along with a hash code

The Object Class

- The `equals` method of the `Object` class returns `true` if two references are aliases
- We can override `equals` in any class to define equality in some more appropriate way
- As we've seen, the `String` class defines the `equals` method to return `true` if two `String` objects contain the same characters
- The designers of the `String` class have overridden the `equals` method inherited from `Object` in favor of a more useful version

Abstract Classes

- An *abstract class* is a placeholder in a class hierarchy that represents a generic concept
- An abstract class cannot be instantiated
- We use the modifier `abstract` on the class header to declare a class as abstract:

```
public abstract class Product
{
    // class contents
}
```

Abstract Classes

- An abstract class often contains abstract methods with no definitions (like an interface)
- Unlike an interface, the `abstract` modifier must be applied to each abstract method
- Also, an abstract class typically contains non-abstract methods with full definitions
- A class declared as abstract does not have to contain abstract methods -- simply declaring it as abstract makes it so

Abstract Classes

- The child of an abstract class must override the abstract methods of the parent, or it too will be considered abstract
- An abstract method cannot be defined as `final` or `static`
- The use of abstract classes is an important element of software design – it allows us to establish common elements in a hierarchy that are too general to instantiate

Interface Hierarchies

- Inheritance can be applied to interfaces
- That is, one interface can be derived from another interface
- The child interface inherits all abstract methods of the parent
- A class implementing the child interface must define all methods from both interfaces
- Class hierarchies and interface hierarchies are distinct (they do not overlap)

Quick Check

What are some methods defined by the `Object` class?

What is an abstract class?

Quick Check

What are some methods defined by the `Object` class?

```
String toString()  
boolean equals(Object obj)  
Object clone()
```

What is an abstract class?

An abstract class is a placeholder in the class hierarchy, defining a general concept and gathering elements common to all derived classes. An abstract class cannot be instantiated.

Outline

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Visibility

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Visibility Revisited

- It's important to understand one subtle issue related to inheritance and visibility
- All variables and methods of a parent class, even private members, are inherited by its children
- As we've mentioned, private members cannot be referenced by name in the child class
- However, private members inherited by child classes exist and can be referenced indirectly

Visibility Revisited

- Because the parent can refer to the private member, the child can reference it indirectly using its parent's methods
- The `super` reference can be used to refer to the parent class, even if no object of the parent exists
- See `FoodAnalyzer.java`
- See `FoodItem.java`
- See `Pizza.java`

```

//*****
//  FoodAnalyzer.java          Author: Lewis/Loftus
//
//  Demonstrates indirect access to inherited private members.
//*****

public class FoodAnalyzer
{
    //-----
    //  Instantiates a Pizza object and prints its calories per
    //  serving.
    //-----
    public static void main(String[] args)
    {
        Pizza special = new Pizza(275);

        System.out.println("Calories per serving: " +
                           special.caloriesPerServing());
    }
}

```

Output

Calories per serving: 309

```
//*****  
//  FoodAnalyzer.  
//  
//  Demonstrates private members.  
//*****
```

```
public class FoodAnalyzer  
{  
    //-----  
    //  Instantiates a Pizza object and prints its calories per  
    //  serving.  
    //-----  
    public static void main(String[] args)  
    {  
        Pizza special = new Pizza(275);  
  
        System.out.println("Calories per serving: " +  
                           special.caloriesPerServing());  
    }  
}
```

```

//*****
//  FoodItem.java          Author: Lewis/Loftus
//
//  Represents an item of food. Used as the parent of a derived class
//  to demonstrate indirect referencing.
//*****

public class FoodItem
{
    final private int CALORIES_PER_GRAM = 9;
    private int fatGrams;
    protected int servings;

    //-----
    //  Sets up this food item with the specified number of fat grams
    //  and number of servings.
    //-----
    public FoodItem(int numFatGrams, int numServings)
    {
        fatGrams = numFatGrams;
        servings = numServings;
    }
}

```

continue

continue

```
//-----  
//  Computes and returns the number of calories in this food item  
//  due to fat.  
//-----  
private int calories()  
{  
    return fatGrams * CALORIES_PER_GRAM;  
}  
  
//-----  
//  Computes and returns the number of fat calories per serving.  
//-----  
public int caloriesPerServing()  
{  
    return (calories() / servings);  
}  
}
```

```

//*****
//  Pizza.java          Author: Lewis/Loftus
//
//  Represents a pizza, which is a food item. Used to demonstrate
//  indirect referencing through inheritance.
//*****

public class Pizza extends FoodItem
{
    //-----
    //  Sets up a pizza with the specified amount of fat (assumes
    //  eight servings).
    //-----
    public Pizza(int fatGrams)
    {
        super(fatGrams, 8);
    }
}

```

Outline

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Visibility



Designing for Inheritance

Inheritance and GUIs

The Timer Class

Designing for Inheritance

- As we've discussed, taking the time to create a good software design reaps long-term benefits
- Inheritance issues are an important part of an object-oriented design
- Properly designed inheritance relationships can contribute greatly to the elegance, maintainability, and reuse of the software
- Let's summarize some of the issues regarding inheritance that relate to a good software design

Inheritance Design Issues

- Every derivation should be an is-a relationship
- Think about the potential future of a class hierarchy, and design classes to be reusable and flexible
- Find common characteristics of classes and push them as high in the class hierarchy as appropriate
- Override methods as appropriate to tailor or change the functionality of a child
- Add new variables to children, but don't redefine (shadow) inherited variables

Inheritance Design Issues

- Allow each class to manage its own data; use the `super` reference to invoke the parent's constructor to set up its data
- Override general methods such as `toString` and `equals` with appropriate definitions
- Use abstract classes to represent general concepts that derived classes have in common
- Use visibility modifiers carefully to provide needed access without violating encapsulation

Restricting Inheritance

- If the `final` modifier is applied to a method, that method cannot be overridden in any derived classes
- If the `final` modifier is applied to an entire class, then that class cannot be used to derive any children at all
- Therefore, an abstract class cannot be declared as `final`

Outline

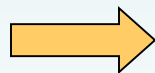
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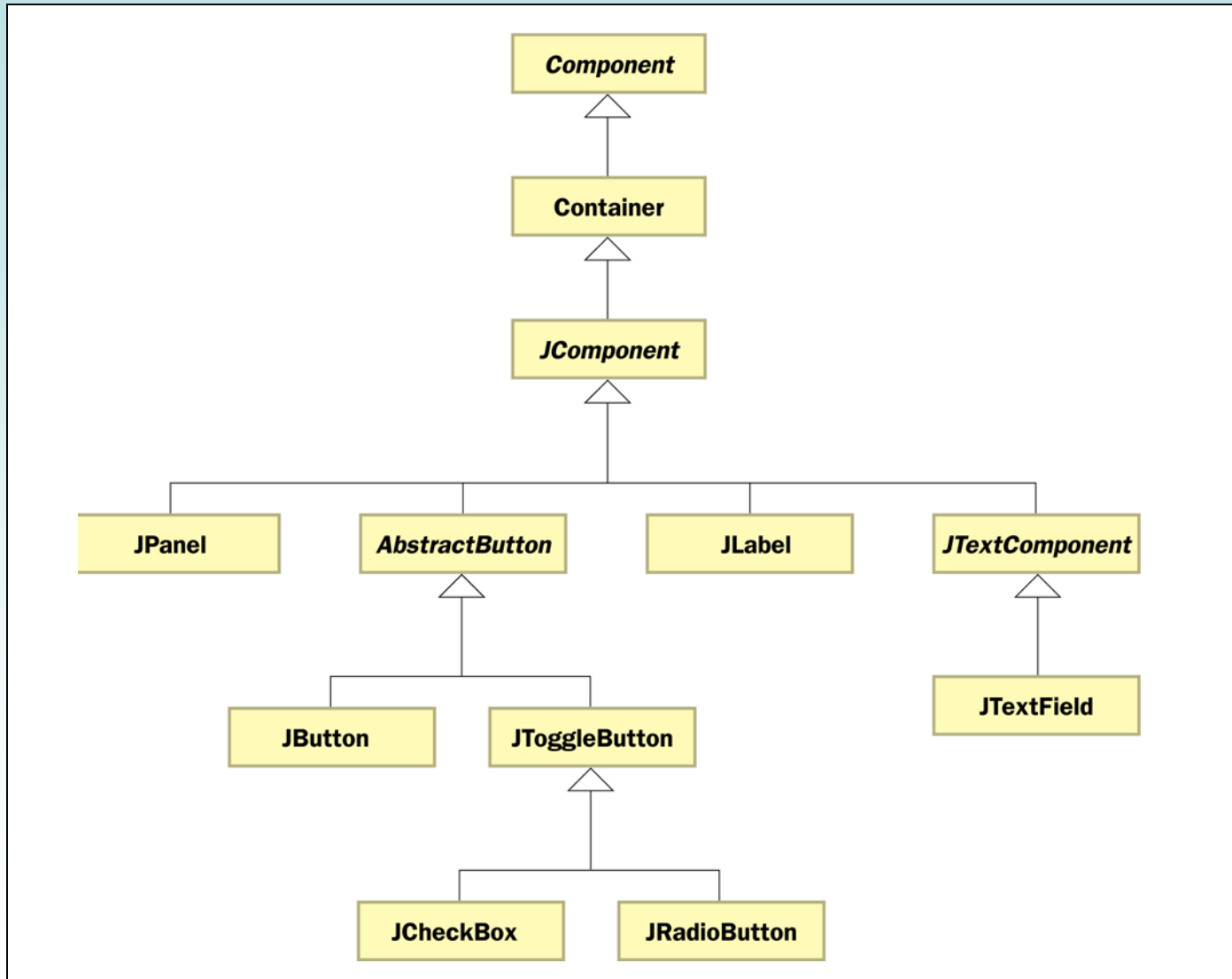
Inheritance and GUIs

The Timer Class

The Component Class Hierarchy

- The Java classes that define GUI components are part of a class hierarchy
- Swing GUI components typically are derived from the `JComponent` class which is derived from the `Container` class which is derived from the `Component` class
- Many Swing components can serve as (limited) containers, because they are derived from the `Container` class
- For example, a `JLabel` object can contain an `ImageIcon`

Partial Component Class Hierarchy



The Component Class Hierarchy

- An applet is another good example of inheritance
- Recall that when we define an applet, we extend the `JApplet` class
- The `JApplet` class already handles all the details about applet creation and execution, including:
 - interaction with a Web browser
 - accepting applet parameters through HTML
 - enforcing security restrictions

The Component Class Hierarchy

- Our applet classes only have to deal with issues that specifically relate to what our particular applet will do
- When we define `paintComponent` method of an applet, we are actually overriding a method defined originally in the `JComponent` class and inherited by the `JApplet` class

Event Adapter Classes

- Inheritance also gives us a alternate technique for creating listener classes
- We've seen that listener classes can be created by implementing a particular interface, such as `MouseListener`
- We can also create a listener class by extending an *event adapter class*
- If a listener interface has more than one method, it has a corresponding adapter class, such as the `MouseAdapter` class

Event Adapter Classes

- Each adapter class implements the corresponding listener, providing empty method definitions
- When you derive a listener class from an adapter class, you only need to override the event methods that pertain to the program
- Empty definitions for unused event methods are automatically provided via inheritance
- **See** `OffCenter.java`
- **See** `OffCenterPanel.java`

```

//*****
//  OffCenter.java          Author: Lewis/Loftus
//
//  Demonstrates the use of an event adapter class.
//*****

import javax.swing.*;

public class OffCenter
{
    //-----
    //  Creates the main frame of the program.
    //-----
    public static void main(String[] args)
    {
        JFrame frame = new JFrame("Off Center");
        frame.setDefaultCloseOperation(JFrame.EXIT_ON_CLOSE);

        frame.getContentPane().add(new OffCenterPanel());
        frame.pack();
        frame.setVisible(true);
    }
}

```

```

//*****
//  OffCenter.java
//
//  Demonstrates
//*****

```

```

import javax.swing.*;

```

```

public class OffCenter
{

```

```

    //-----
    //  Creates
    //-----

```

```

    public static
    {

```

```

        JFrame frame;
        frame.setL

```

```

        frame.get
        frame.pack

```

```

        frame.setVisible(true);

```

```

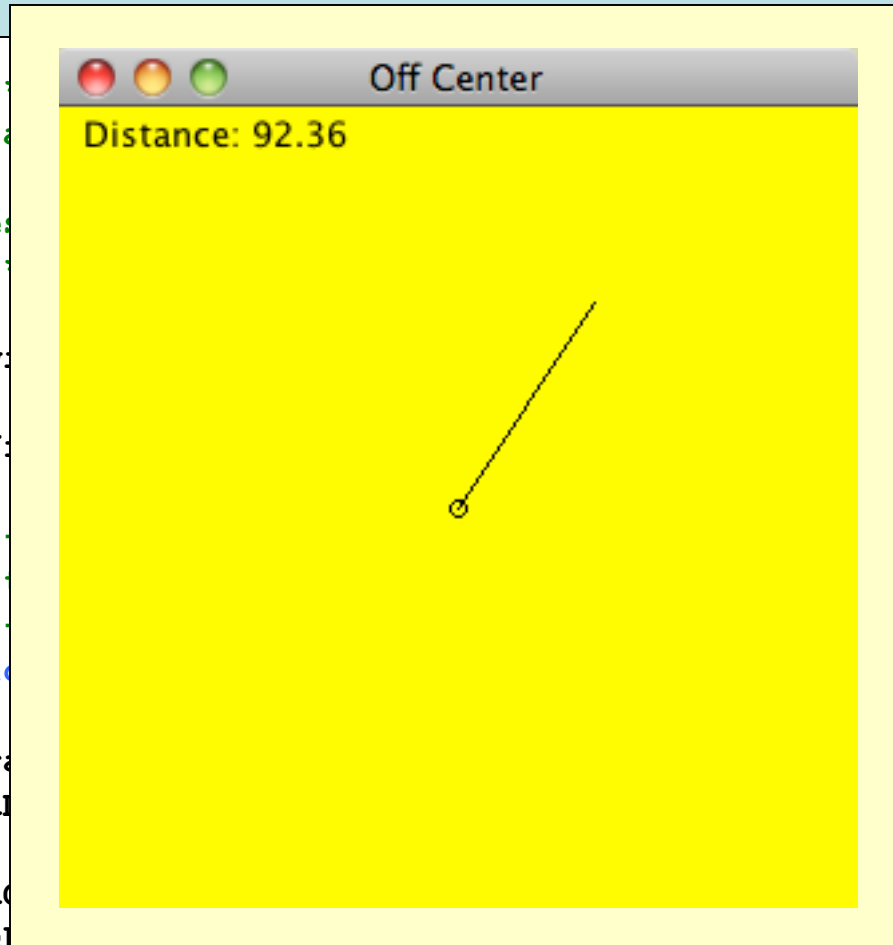
    }

```

```

}

```



```

//*****

```

```

//*****

```

```

//-----

```

```

//-----

```

```

    ...SE);

```

```
//*****  
//  OffCenterPanel.java          Author: Lewis/Loftus  
//  
//  Represents the primary drawing panel for the OffCenter program.  
//*****
```

```
import java.awt.*;  
import java.awt.event.*;  
import java.text.DecimalFormat;  
import javax.swing.*;  
  
public class OffCenterPanel extends JPanel  
{  
    private final int WIDTH=300, HEIGHT=300;  
  
    private DecimalFormat fmt;  
    private Point current;  
    private int centerX, centerY;  
    private double length;
```

continue

continue

```
//-----  
//  Constructor: Sets up the panel and necessary data.  
//-----  
public OffCenterPanel()  
{  
    addMouseListener(new OffCenterListener());  
  
    centerX = WIDTH / 2;  
    centerY = HEIGHT / 2;  
  
    fmt = new DecimalFormat("0.##");  
  
    setPreferredSize(new Dimension(WIDTH, HEIGHT));  
    setBackground(Color.yellow);  
}
```

continue

continue

```
//-----  
//  Draws a line from the mouse pointer to the center point of  
//  the applet and displays the distance.  
//-----  
public void paintComponent(Graphics page)  
{  
    super.paintComponent(page);  
  
    page.setColor(Color.black);  
    page.drawOval(centerX-3, centerY-3, 6, 6);  
  
    if (current != null)  
    {  
        page.drawLine(current.x, current.y, centerX, centerY);  
        page.drawString("Distance: " + fmt.format(length), 10, 15);  
    }  
}
```

continue

continue

```
//*****  
// Represents the listener for mouse events. Demonstrates the  
// ability to extend an adaptor class.  
//*****  
private class OffCenterListener extends MouseAdapter  
{  
    //-----  
    // Computes the distance from the mouse pointer to the center  
    // point of the applet.  
    //-----  
    public void mouseClicked(MouseEvent event)  
    {  
        current = event.getPoint();  
        length = Math.sqrt(Math.pow((current.x-centerX), 2) +  
                            Math.pow((current.y-centerY), 2));  
        repaint();  
    }  
}  
}
```


Outline

Creating Subclasses

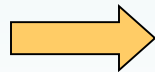
Overriding Methods

Class Hierarchies

Visibility

Designing for Inheritance

Inheritance and GUIs



The Timer Class

The Timer Class

- The `Timer` class of the `javax.swing` package is a GUI component, but it has no visual representation
- A `Timer` object generates an action event at specified intervals
- Timers can be used to manage any events that are based on a timed interval, such as an animation
- To create the illusion of movement, we use a timer to change the scene after an appropriate delay

The Timer Class

- The `start` and `stop` methods of the `Timer` class start and stop the timer
- The delay can be set using the `Timer` constructor or using the `setDelay` method
- See `Rebound.java`
- See `ReboundPanel.java`

```

//*****
//  Rebound.java          Author: Lewis/Loftus
//
//  Demonstrates an animation and the use of the Timer class.
//*****

import java.awt.*;
import java.awt.event.*;
import javax.swing.*;

public class Rebound
{
    //-----
    //  Displays the main frame of the program.
    //-----
    public static void main(String[] args)
    {
        JFrame frame = new JFrame("Rebound");
        frame.setDefaultCloseOperation(JFrame.EXIT_ON_CLOSE);

        frame.getContentPane().add(new ReboundPanel());
        frame.pack();
        frame.setVisible(true);
    }
}

```

```
//*****  
//  Rebound.java  
//  
//  Demonstrates  
//*****
```

```
import java.awt.  
import java.awt.  
import javax.swing.*;
```

```
public class Rebound
```

```
{
```

```
    //-----  
    //  Displays the main frame of the program.  
    //-----
```

```
    public static void main(String[] args)
```

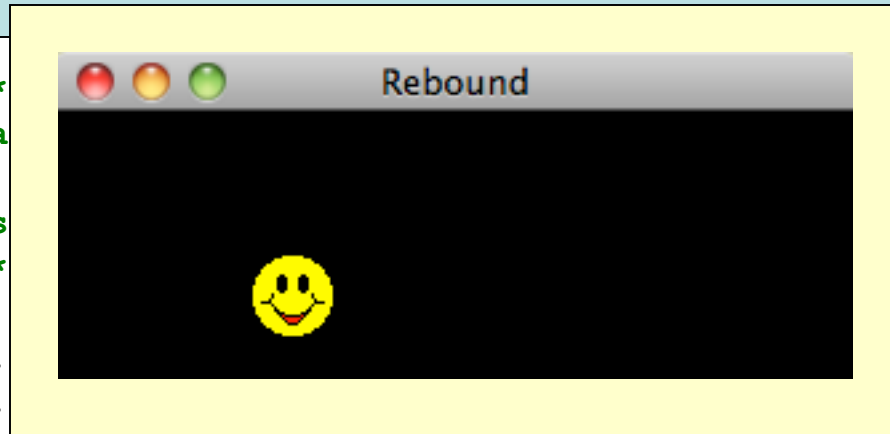
```
    {
```

```
        JFrame frame = new JFrame("Rebound");  
        frame.setDefaultCloseOperation(JFrame.EXIT_ON_CLOSE);
```

```
        frame.getContentPane().add(new ReboundPanel());  
        frame.pack();  
        frame.setVisible(true);
```

```
    }
```

```
}
```



```
*****
```

```
class.
```

```
*****
```

```

//*****
//  ReboundPanel.java          Author: Lewis/Loftus
//
//  Represents the primary panel for the Rebound program.
//*****

import java.awt.*;
import java.awt.event.*;
import javax.swing.*;

public class ReboundPanel extends JPanel
{
    private final int WIDTH = 300, HEIGHT = 100;
    private final int DELAY = 20, IMAGE_SIZE = 35;

    private ImageIcon image;
    private Timer timer;
    private int x, y, moveX, moveY;

```

continue

continue

```
//-----  
//  Sets up the panel, including the timer for the animation.  
//-----  
public ReboundPanel()  
{  
    timer = new Timer(DELAY, new ReboundListener());  
    image = new ImageIcon("happyFace.gif");  
  
    x = 0;  
    y = 40;  
    moveX = moveY = 3;  
  
    setPreferredSize(new Dimension(WIDTH, HEIGHT));  
    setBackground(Color.black);  
    timer.start();  
}  
  
//-----  
//  Draws the image in the current location.  
//-----  
public void paintComponent(Graphics page)  
{  
    super.paintComponent(page);  
    image.paintIcon(this, page, x, y);  
}
```

continue

continue

```
//*****  
// Represents the action listener for the timer.  
//*****  
private class ReboundListener implements ActionListener  
{  
    //-----  
    // Updates the position of the image and possibly the direction  
    // of movement whenever the timer fires an action event.  
    //-----  
    public void actionPerformed(ActionEvent event)  
    {  
        x += moveX;  
        y += moveY;  
  
        if (x <= 0 || x >= WIDTH-IMAGE_SIZE)  
            moveX = moveX * -1;  
  
        if (y <= 0 || y >= HEIGHT-IMAGE_SIZE)  
            moveY = moveY * -1;  
  
        repaint();  
    }  
}
```


Summary

- Chapter 9 focused on:
 - deriving new classes from existing classes
 - the `protected` modifier
 - creating class hierarchies
 - abstract classes
 - indirect visibility of inherited members
 - designing for inheritance
 - the GUI component class hierarchy
 - extending listener adapter classes
 - the `Timer` class