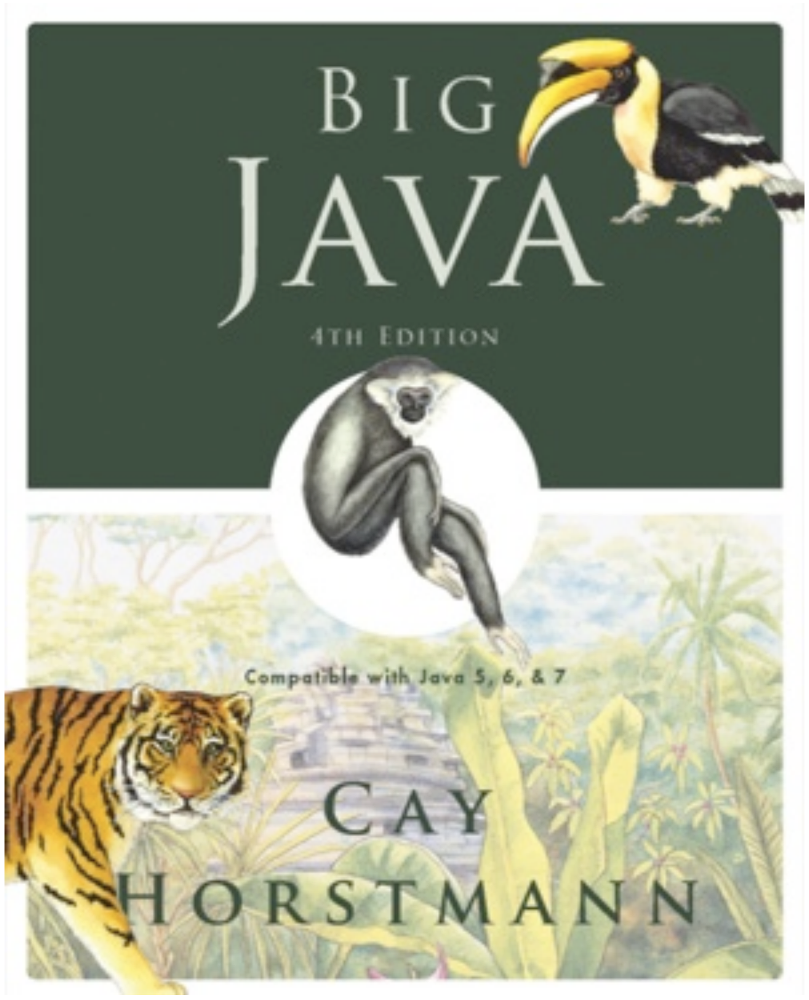
# ICOM 4015: Advanced Programming

Lecture 10

**Reading: Chapter Ten: Inheritance**



# Chapter 10 – Inheritance

## Chapter Goals

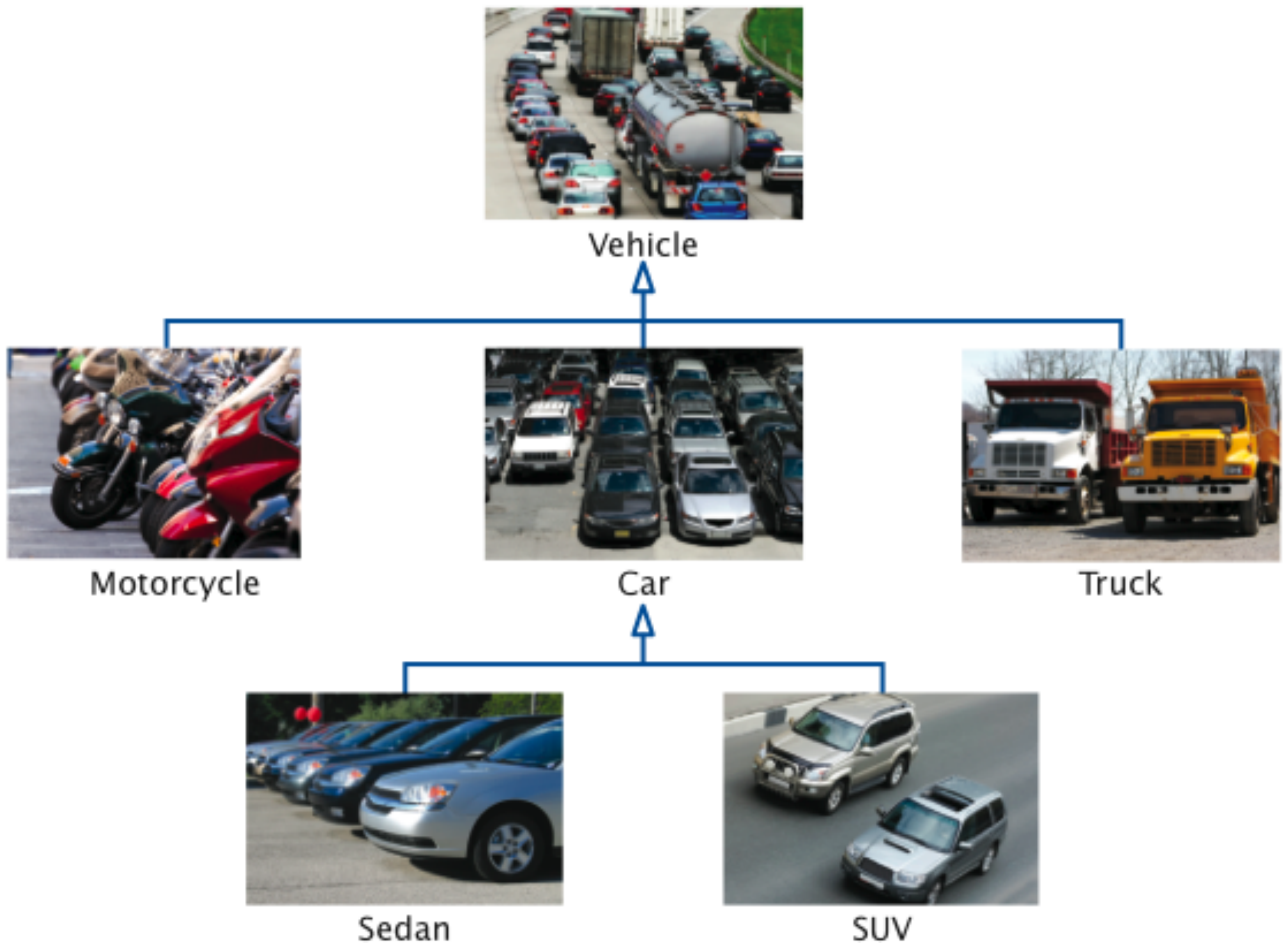
- To learn about inheritance
- To understand how to inherit and override superclass methods
- To be able to invoke superclass constructors
- To learn about `protected` and package access control
- To understand the common superclass `Object` and to override its `toString` and `equals` methods

**G** To use inheritance for customizing user interfaces

## Inheritance Hierarchies

- Often categorize concepts into *hierarchies*:

**Figure 1**
A Hierarchy of Vehicle Types



## Inheritance Hierarchies

- Set of classes can form an *inheritance hierarchy*
  - *Classes representing the most general concepts are near the root, more specialized classes towards the branches:*

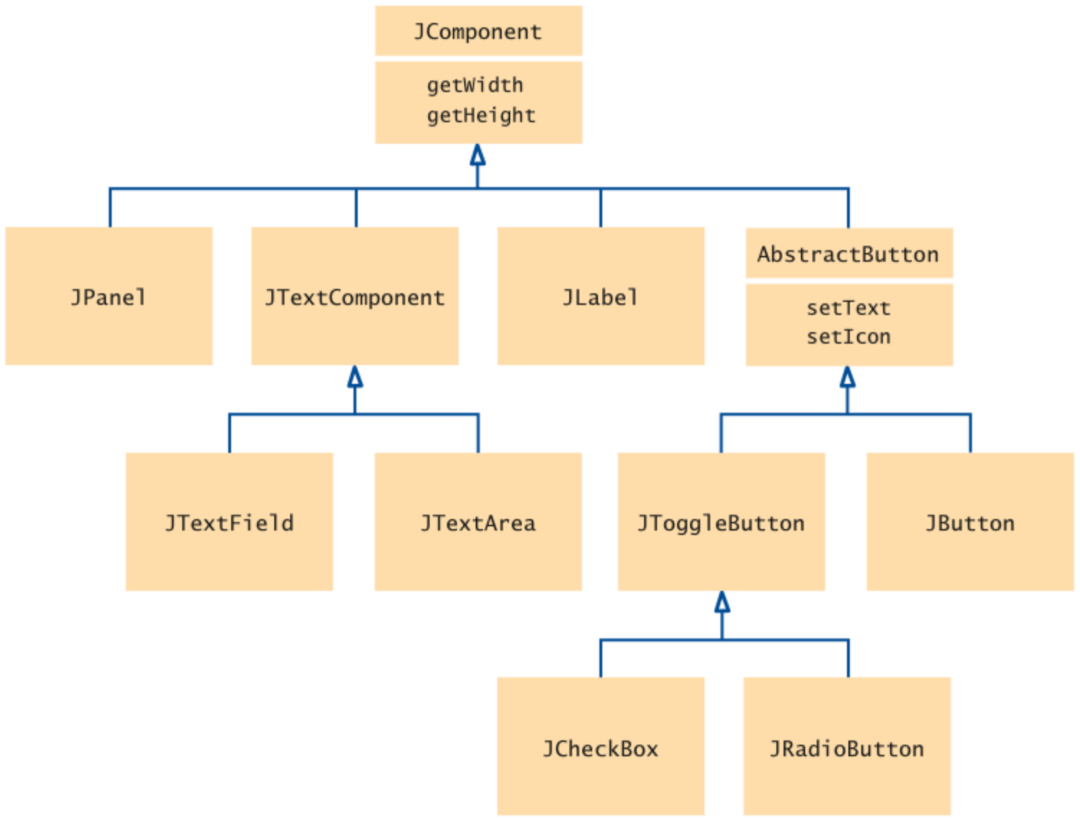


**Figure 2** A Part of the Hierarchy of Swing User Interface Components

## Inheritance Hierarchies

- **Superclass:** more general class
- **Subclass:** more specialized class that inherits from the superclass
    - *Example:* `JPanel` *is a subclass of* `JComponent`

## Inheritance Hierarchies

- **Example:** Different account types:
    1. *Checking account:*
        - *No interest*
        - *Small number of free transactions per month*
        - *Charges transaction fee for additional transactions*
    2. *Savings account:*
        - *Earns interest that compounds monthly*
- Superclass: `BankAccount`
- Subclasses: `CheckingAccount` & `SavingsAccount`

## Inheritance Hierarchies

- Behavior of account classes:
  - *All support* `getBalance` *method*
  - *Also support* `deposit` *and* `withdraw` *methods, but implementation details differ*
  - *Checking account needs a method* `deductFees` *to deduct the monthly fees and to reset the transaction counter*
  - *Checking account must override* `deposit` *and* `withdraw` *methods to count the transactions*

## Inheritance Hierarchies

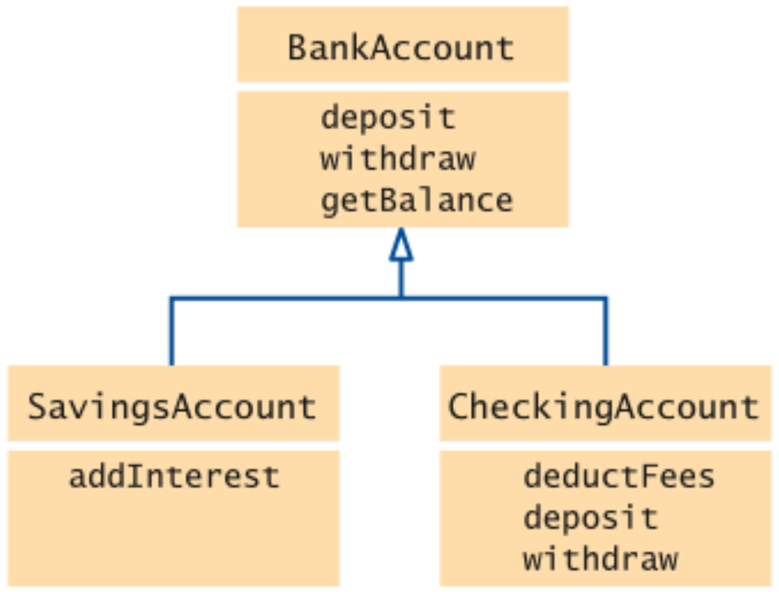


**Figure 3** Inheritance Hierarchy for Bank Account Classes

## Self Check 10.1

What is the purpose of the `JTextComponent` class in Figure 2?

**Answer:** To express the common behavior of text variables and text components.

## Self Check 10.2

Why don't we place the `addInterest` method in the `BankAccount` class?

**Answer:** Not all bank accounts earn interest.

## Inheritance Hierarchies

- Inheritance is a mechanism for extending existing classes by adding instance variables and methods:

```
class SavingsAccount extends BankAccount
{
   added instance variables
   new methods
}
```

- A subclass inherits the methods of its superclass:

```
SavingsAccount collegeFund = new SavingsAccount(10);
// Savings account with 10% interest
collegeFund.deposit(500);
// OK to use BankAccount method with SavingsAccount object
```

## Inheritance Hierarchies

- In subclass, specify added instance variables, added methods, and changed or overridden methods:

```
public class SavingsAccount extends BankAccount
{
   private double interestRate;

   public SavingsAccount(double rate)
   {
      Constructor implementation
   }

   public void addInterest()
   {
      Method implementation
   }
}
```

## Inheritance Hierarchies

- Instance variables declared in the superclass are present in subclass objects
- `SavingsAccount` object inherits the balance instance variable from `BankAccount`, and gains one additional instance variable, `interestRate`:

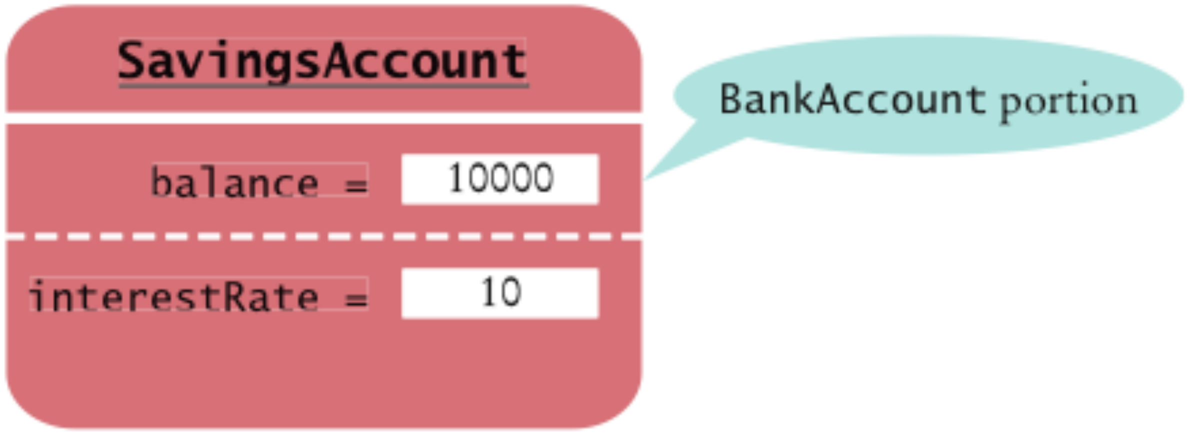


**Figure 4**
Layout of a Subclass Object

## Inheritance Hierarchies

- Implement the new `addInterest` method:

```
public class SavingsAccount extends BankAccount
{
   private double interestRate;
   public SavingsAccount(double rate)
   {
      interestRate = rate;
   }
   public void addInterest()
   {
      double interest = getBalance() * interestRate / 100;
      deposit(interest);
   }
}
```

## Inheritance Hierarchies

- A subclass has no access to private instance variables of its superclass
- **Encapsulation:** `addInterest` calls `getBalance` rather than updating the `balance` variable of the superclass (variable is `private`)
- Note that `addInterest` calls `getBalance` without specifying an implicit parameter (the calls apply to the same object)
- Inheriting from a class differs from implementing an interface: the subclass inherits behavior from the superclass

## ch10/accounts/SavingsAccount.java

```java
/**
   An account that earns interest at a fixed rate.
*/
public class SavingsAccount extends BankAccount
{
   private double interestRate;

   /**
      Constructs a bank account with a given interest rate.
      @param rate the interest rate
   */
   public SavingsAccount(double rate)
   {
      interestRate = rate;
   }
```

**_Continued_**

## ch10/accounts/SavingsAccount.java (cont.)

```
   /**
      Adds the earned interest to the account balance.
   */
   public void addInterest()
   {
      double interest = getBalance() * interestRate / 100;
      deposit(interest);
   }
}
```

## Syntax 10.1 Inheritance

*Syntax*

```
class SubclassName extends SuperclassName
{
    instance variables
    methods
}
```

*Example*

Subclass

Superclass

```
public class SavingsAccount extends BankAccount
{
   private double interestRate;
   . . .

   public void addInterest()
   {
      double interest = getBalance() * interestRate / 100;
      deposit(interest);
   }
}
```

Declare instance variables that are added to the subclass.

The reserved word extends denotes inheritance.

Declare methods that are specific to the subclass.

## Self Check 10.3

Which instance variables does an object of class `SavingsAccount` have?

> **Answer:** Two instance variables: `balance` and `interestRate`.

## Self Check 10.4

Name four methods that you can apply to `SavingsAccount` objects.

> **Answer:** `deposit`, `withdraw`, `getBalance`, and `addInterest`.

## Self Check 10.5

If the class `Manager` extends the class `Employee`, which class is the superclass and which is the subclass?

**Answer:** `Manager` is the subclass; `Employee` is the superclass.

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## Common Error: Shadowing Instance Variables

- A subclass has no access to the private instance variables of the superclass:

```
public class SavingsAccount extends BankAccount
{
   public void addInterest()
   {
      double interest = getBalance() * interestRate / 100;
      balance = balance + interest; // Error
   }
   . . .
}
```

## Common Error: Shadowing Instance Variables

- Beginner's error: "solve" this problem by adding another instance variable with same name:

```
public class SavingsAccount extends BankAccount
{
   private double balance; // Don't
   public void addInterest()
   {
      double interest = getBalance() * interestRate / 100;
      balance = balance + interest; // Compiles but doesn't
         // update the correct balance
   }
   . . .
}
```

## Common Error: Shadowing Instance Variables

- Now the addInterest method compiles, but it doesn't update the correct balance!

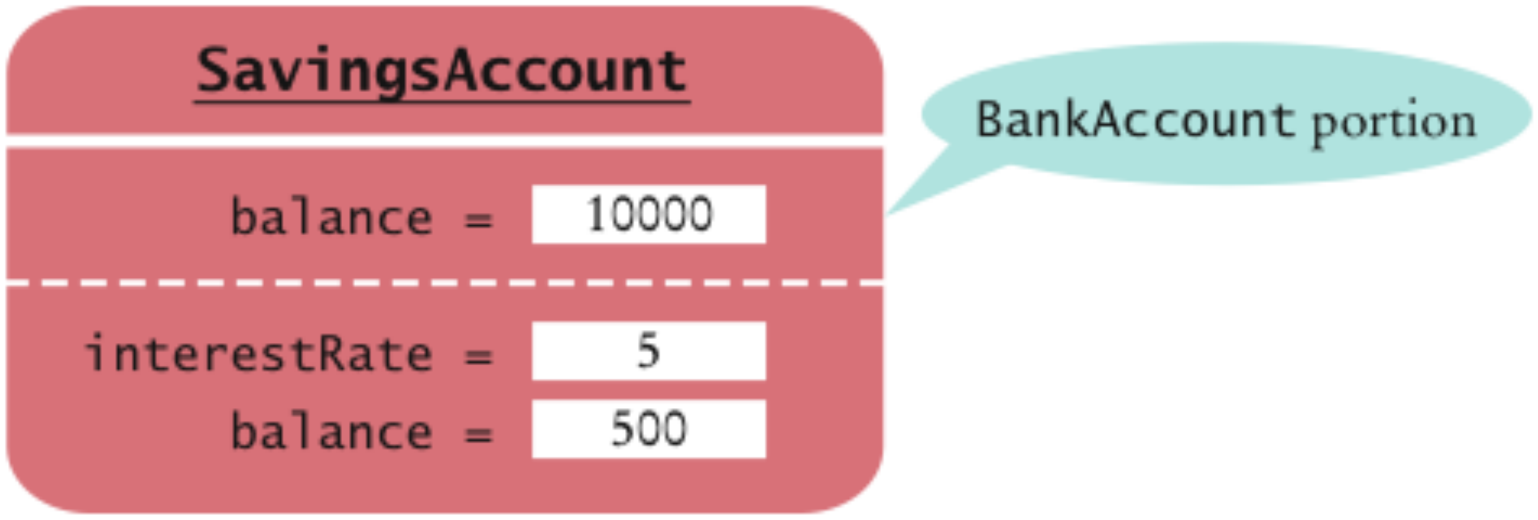

**Figure 5** Shadowing Instance Variables

## Overriding Methods

- A subclass method **overrides** a superclass method if it has the same name and parameter types as a superclass method
  - *When such a method is applied to a subclass object, the overriding method is executed*

## Overriding Methods

- Example: `deposit` and `withdraw` methods of the `CheckingAccount` class override the `deposit` and `withdraw` methods of the `BankAccount` class to handle transaction fees:

```
public class BankAccount
{
   . . .
   public void deposit(double amount) { . . . }
   public void withdraw(double amount) { . . . }
   public double getBalance() { . . . }
}
public class CheckingAccount extends BankAccount
{
   . . .
   public void deposit(double amount) { . . . }
   public void withdraw(double amount) { . . . }
   public void deductFees() { . . . }
}
```

## Overriding Methods

- Problem: Overriding method `deposit` can't simply add `amount` to `balance`:

```
public class CheckingAccount extends BankAccount
{
   . . .
   public void deposit(double amount)
   {
      transactionCount++;
      // Now add amount to balance
      balance = balance + amount; // Error
   }
}
```

- If you want to modify a private superclass instance variable, you must use a public method of the superclass
- `deposit` method of `CheckingAccount` must invoke the `deposit` method of `BankAccount`

## Overriding Methods

- Idea:

```
public class CheckingAccount extends BankAccount
{
   public void deposit(double amount)
   {
      transactionCount++;
      // Now add amount to balance
      deposit; // Not complete
   }
}
```

- Won't work because compiler interprets

  ```
  deposit(amount);
  ```

  as

  ```
  this.deposit(amount);
  ```

  which calls the method we are currently writing ⇒ infinite recursion

## Overriding Methods

- Use the `super` reserved word to call a method of the superclass:

```
public class CheckingAccount extends BankAccount
{
   public void deposit(double amount)
   {
      transactionCount++;
      // Now add amount to balance
      super.deposit(amount);
   }
}
```

## Overriding Methods

- Remaining methods of `CheckingAccount` also invoke a superclass method:

```
public class CheckingAccount extends BankAccount
{
   private static final int FREE_TRANSACTIONS = 3;
   private static final double TRANSACTION_FEE = 2.0;
   private int transactionCount;
   . . .
   public void withdraw(double amount
   {
      transactionCount++;
      // Now subtract amount from balance
      super.withdraw(amount);
   }
```

***Continued***

## Overriding Methods (cont.)

```
   public void deductFees()
   {
      if (transactionCount > FREE_TRANSACTIONS)
      {
         double fees = TRANSACTION_FEE *
            (transactionCount - FREE_TRANSACTIONS);
         super.withdraw(fees);
      }
      transactionCount = 0;
   }
   . . .
}
```

## Syntax 10.2 Calling a Superclass Method

*Syntax* `super.`*methodName*`(`*parameters*`);`

*Example*

```
public void deposit(double amount)
{
   transactionCount++;
   super.deposit(amount);
}
```

Calls the method of the superclass instead of the method of the current class.

If you omit `super`, this method calls itself.

## Animation 10.1: Inheritance

## Self Check 10.6

Categorize the methods of the `SavingsAccount` class as inherited, new, and overridden.

> **Answer:** The `SavingsAccount` class inherits the `deposit`, `withdraw`, and `getBalance` methods. The `addInterest` method is new. No methods override superclass methods.

## Self Check 10.7

Why does the `withdraw` method of the `CheckingAccount` class call `super.withdraw`?

**Answer:** It needs to reduce the balance, and it cannot access the `balance` variable directly.

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## Self Check 10.8

Why does the `deductFees` method set the transaction count to zero?

> **Answer:** So that the count can reflect the number of transactions for the following month.

## Subclass Construction

- To call the superclass constructor, use the `super` reserved word in the first statement of the subclass constructor:

```
public class CheckingAccount extends BankAccount
{
   public CheckingAccount(double initialBalance)
   {
      // Construct superclass
      super(initialBalance);
      // Initialize transaction count
      transactionCount = 0;
   }
   . . .
}
```

## Subclass Construction

- When subclass constructor doesn't call superclass constructor, the superclass must have a constructor with no parameters
  - *If, however, all constructors of the superclass require parameters, then the compiler reports an error*

## ch10/accounts/CheckingAccount.java

```
/**
   A checking account that charges transaction fees.
*/
public class CheckingAccount extends BankAccount
{
   private static final int FREE_TRANSACTIONS = 3;
   private static final double TRANSACTION_FEE = 2.0;

   private int transactionCount;

   /**
      Constructs a checking account with a given balance.
      @param initialBalance the initial balance
   */
   public CheckingAccount(double initialBalance)
   {
      // Construct superclass
      super(initialBalance);

      // Initialize transaction count
      transactionCount = 0;
   }
```

***Continued***

## ch10/accounts/CheckingAccount.java (cont.)

```
   public void deposit(double amount)
   {
      transactionCount++;
      // Now add amount to balance
      super.deposit(amount);
   }

   public void withdraw(double amount)
   {
      transactionCount++;
      // Now subtract amount from balance
      super.withdraw(amount);
   }
```

***Continued***

## ch10/accounts/CheckingAccount.java (cont.)

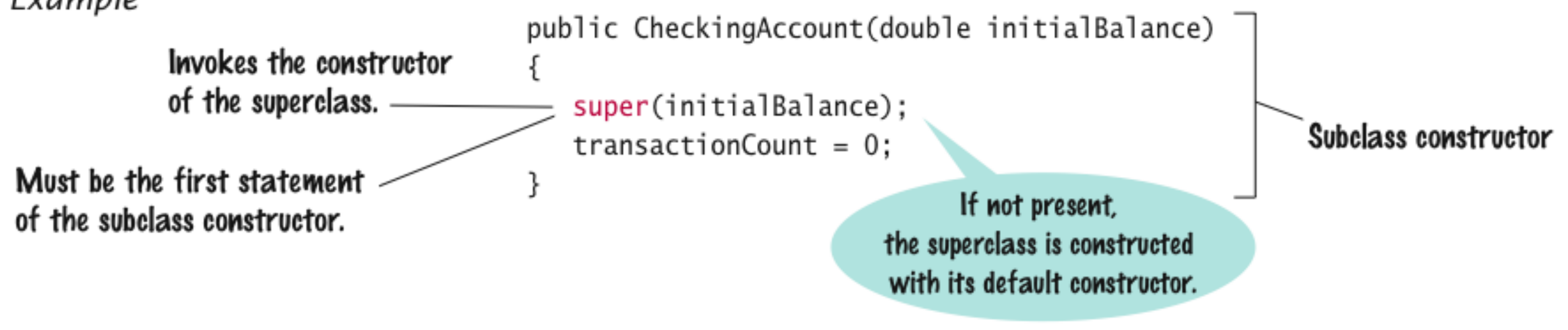
```
    /**
       Deducts the accumulated fees and resets the
       transaction count.
    */
    public void deductFees()
    {
       if (transactionCount > FREE_TRANSACTIONS)
       {
          double fees = TRANSACTION_FEE *
                (transactionCount - FREE_TRANSACTIONS);
          super.withdraw(fees);
       }
       transactionCount = 0;
    }
 }
```

## Syntax 10.3 Calling a Superclass Constructor

*Syntax*

```
accessSpecifier ClassName(parameterType parameterName, . . .)
{
   super(parameters);
   . . .
}
```

*Example*



```
public CheckingAccount(double initialBalance)
{
   super(initialBalance);
   transactionCount = 0;
}
```

Invokes the constructor of the superclass.
Must be the first statement of the subclass constructor.
Subclass constructor
If not present, the superclass is constructed with its default constructor.

## Self Check 10.9

Why didn't the `SavingsAccount` constructor in Section 10.2 call its superclass constructor?

> **Answer:** It was content to use the default constructor of the superclass, which sets the balance to zero.

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## Self Check 10.10

When you invoke a superclass method with the `super` keyword, does the call have to be the first statement of the subclass method?

> **Answer:** No — this is a requirement only for constructors. For example, the `SavingsAccount.deposit` method first increments the transaction count, then calls the superclass method.

## Converting Between Subclass and Superclass Types

- OK to convert subclass reference to superclass reference:

```
SavingsAccount collegeFund = new SavingsAccount(10);
BankAccount anAccount = collegeFund;
Object anObject = collegeFund;
```

- The three object references stored in `collegeFund`, `anAccount`, and `anObject` all refer to the same object of type `SavingsAccount`

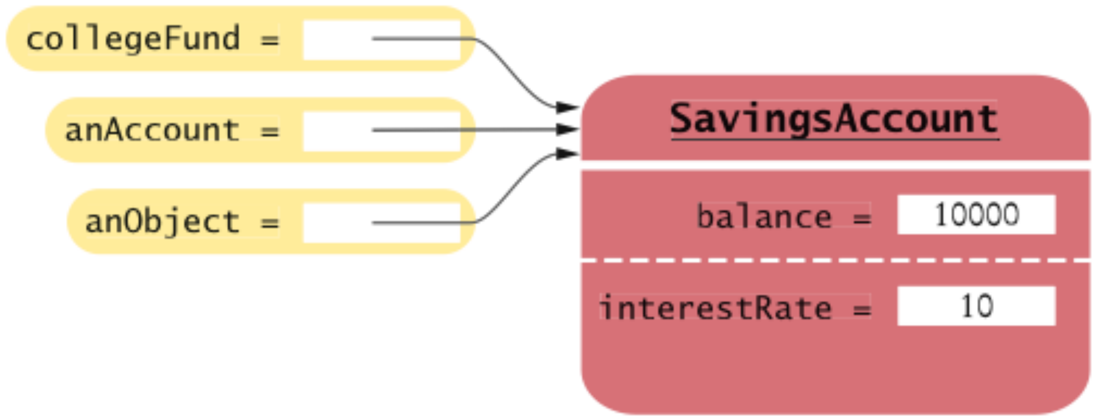


**Figure 6**
Variables of Different Types Can Refer to the Same Object

## Converting Between Subclass and Superclass Types

- Superclass references don't know the full story:

```
anAccount.deposit(1000); // OK
anAccount.addInterest();
// No--not a method of the class to which anAccount
// belongs
```

- Why would anyone want to know *less* about an object?
  - *Reuse code that knows about the superclass but not the subclass:*

```
public void transfer(double amount, BankAccount other)
{
   withdraw(amount);
   other.deposit(amount);
}
```

*Can be used to transfer money from any type of* `BankAccount`

## Converting Between Subclass and Superclass Types

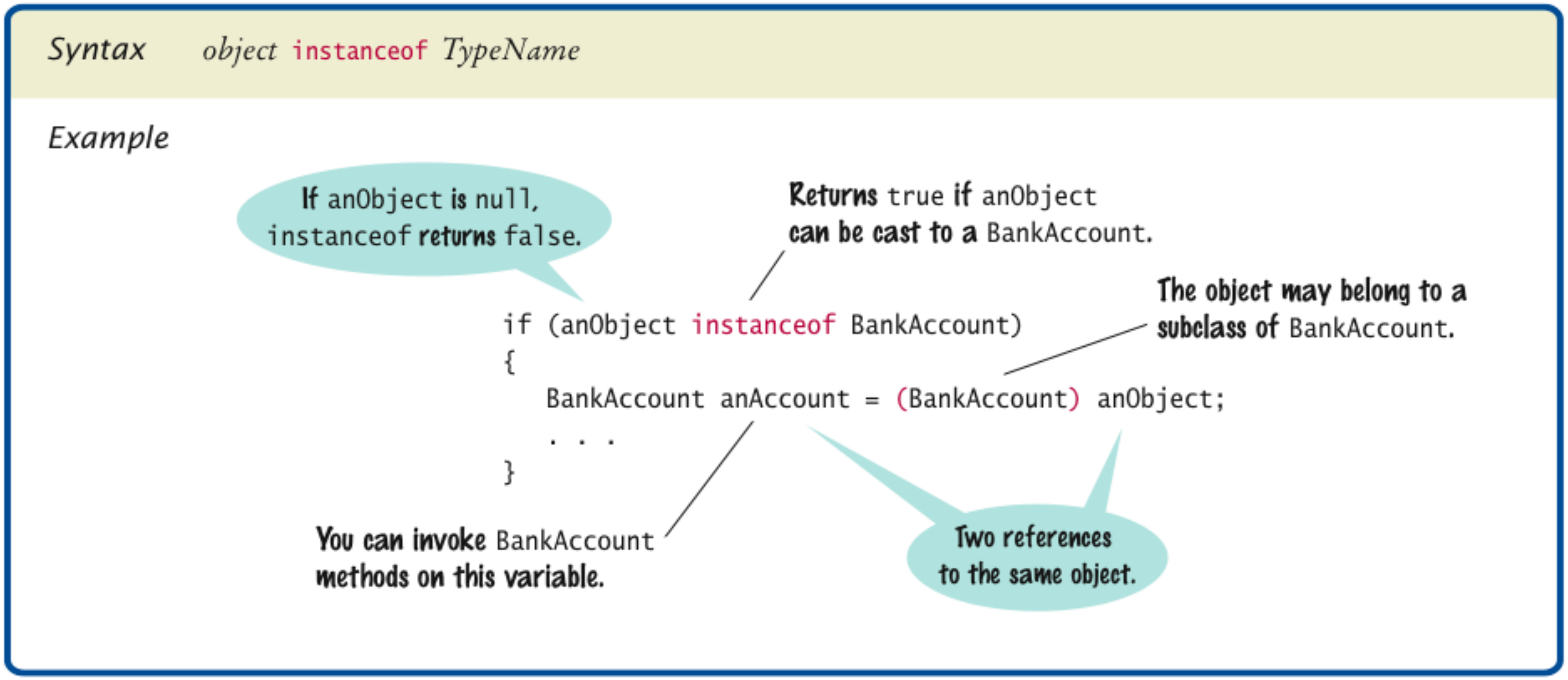
- Occasionally you need to convert from a superclass reference to a subclass reference:

```
BankAccount anAccount = (BankAccount) anObject;
```

- This cast is dangerous: If you are wrong, an exception is thrown
- Solution: Use the `instanceof` operator
- `instanceof`: Tests whether an object belongs to a particular type:

```
if (anObject instanceof BankAccount)
{
   BankAccount anAccount = (BankAccount) anObject;
   ...
}
```

## Syntax 10.4 The `instanceof` Operator


Syntax object instanceof TypeName
Example
If anObject is null, instanceof returns false.
Returns true if anObject can be cast to a BankAccount.
The object may belong to a subclass of BankAccount.
You can invoke BankAccount methods on this variable.
Two references to the same object.

```
if (anObject instanceof BankAccount)
{
   BankAccount anAccount = (BankAccount) anObject;
   . . .
}
```

## Self Check 10.11

Why did the second parameter of the `transfer` method have to be of type `BankAccount` and not, for example, `SavingsAccount`?

> **Answer:** We want to use the method for all kinds of bank accounts. Had we used a parameter of type `SavingsAccount`, we couldn't have called the method with a `CheckingAccount` object.

## Self Check 10.12

Why can't we change the second parameter of the `transfer` method to the type `Object`?

**Answer:** We cannot invoke the `deposit` method on a variable of type `Object`.

## Polymorphism and Inheritance

- Type of a variable doesn't completely determine type of object to which it refers:

  ```
  BankAccount aBankAccount = new SavingsAccount(1000);
  // aBankAccount holds a reference to a SavingsAccount
  ```

-
  ```
  BankAccount anAccount = new CheckingAccount();
  anAccount.deposit(1000);
  ```

  *Which deposit method is called?*

- *Dynamic method lookup:* When the virtual machine calls an instance method, it locates the method of the implicit parameter's class

## Polymorphism and Inheritance

- Example:

```
public void transfer(double amount, BankAccount other)
{
   withdraw(amount);
   other.deposit(amount);
}
```

- When you call

```
anAccount.transfer(1000, anotherAccount);
```

two method calls result:

```
anAccount.withdraw(1000);
anotherAccount.deposit(1000);
```

## Polymorphism and Inheritance

- *Polymorphism:* Ability to treat objects with differences in behavior in a uniform way
- The first method call

  ```
  withdraw(amount);
  ```

  is a shortcut for

  ```
  this.withdraw(amount);
  ```

- `this` can refer to a `BankAccount` or a subclass object

## ch10/accounts/AccountTester.java

```
/**
   This program tests the BankAccount class and
   its subclasses.
*/
public class AccountTester
{
   public static void main(String[] args)
   {
      SavingsAccount momsSavings = new SavingsAccount(0.5);

      CheckingAccount harrysChecking = new CheckingAccount(100);

      momsSavings.deposit(10000);

      momsSavings.transfer(2000, harrysChecking);
      harrysChecking.withdraw(1500);
      harrysChecking.withdraw(80);

      momsSavings.transfer(1000, harrysChecking);
      harrysChecking.withdraw(400);
```

***Continued***

## ch10/accounts/AccountTester.java (cont.)

```
         // Simulate end of month
         momsSavings.addInterest();
         harrysChecking.deductFees();

         System.out.println("Mom's savings balance: "
               + momsSavings.getBalance());
         System.out.println("Expected: 7035");

         System.out.println("Harry's checking balance: "
               + harrysChecking.getBalance());
         System.out.println("Expected: 1116");
      }
   }
```

## Program Run:

```
Mom's savings balance: 7035.0
Expected: 7035
Harry's checking balance: 1116.0
Expected: 1116
```

## Super Classes vs. Interfaces

- Every class can inherit from ONLY ONE class
- Every class can be super class of MANY classes
- Every class can implement MANY interfaces
- Every interface can be implemented by MANY classes
- Interfaces do not inherit components
- Interfaces cannot be instantiated

## Polymorphism

## Super Classes vs. Interfaces

- Use inheritance when:
  - There is some inherent semantic relationship between classes
  - Objects have common properties/methods that you do not want to duplicate
- Use interfaces when:
  - Classes can act in similar fashion yet they do not represent objects of the same nature
- Remember: you only have one shot at selecting the super class. Use it wisely.

## Self Check 10.13

If `a` is a variable of type `BankAccount` that holds a non-`null` reference, what do you know about the object to which `a` refers?

> **Answer:** The object is an instance of `BankAccount` or one of its subclasses.

## Self Check 10.14

If `a` refers to a checking account, what is the effect of calling `a.transfer(1000, a)`?

**Answer:** The balance of `a` is unchanged, and the transaction count is incremented twice.

## Protected Access

- Protected features can be accessed by all subclasses and by all classes in the same package
- Solves the problem that `CheckingAccount` methods need access to the `balance` instance variable of the superclass `BankAccount`:

```
public class BankAccount
{
   . . .
   protected double balance;
}
```

## Protected Access

- The designer of the superclass has no control over the authors of subclasses:
  - *Any of the subclass methods can corrupt the superclass data*
  - *Classes with protected instance variables are hard to modify — the protected variables cannot be changed, because someone somewhere out there might have written a subclass whose code depends on them*
- Protected data can be accessed by all methods of classes in the same package
- It is best to leave all data private and provide accessor methods for the data

## Object: The Cosmic Superclass

- All classes defined without an explicit extends clause automatically extend Object:

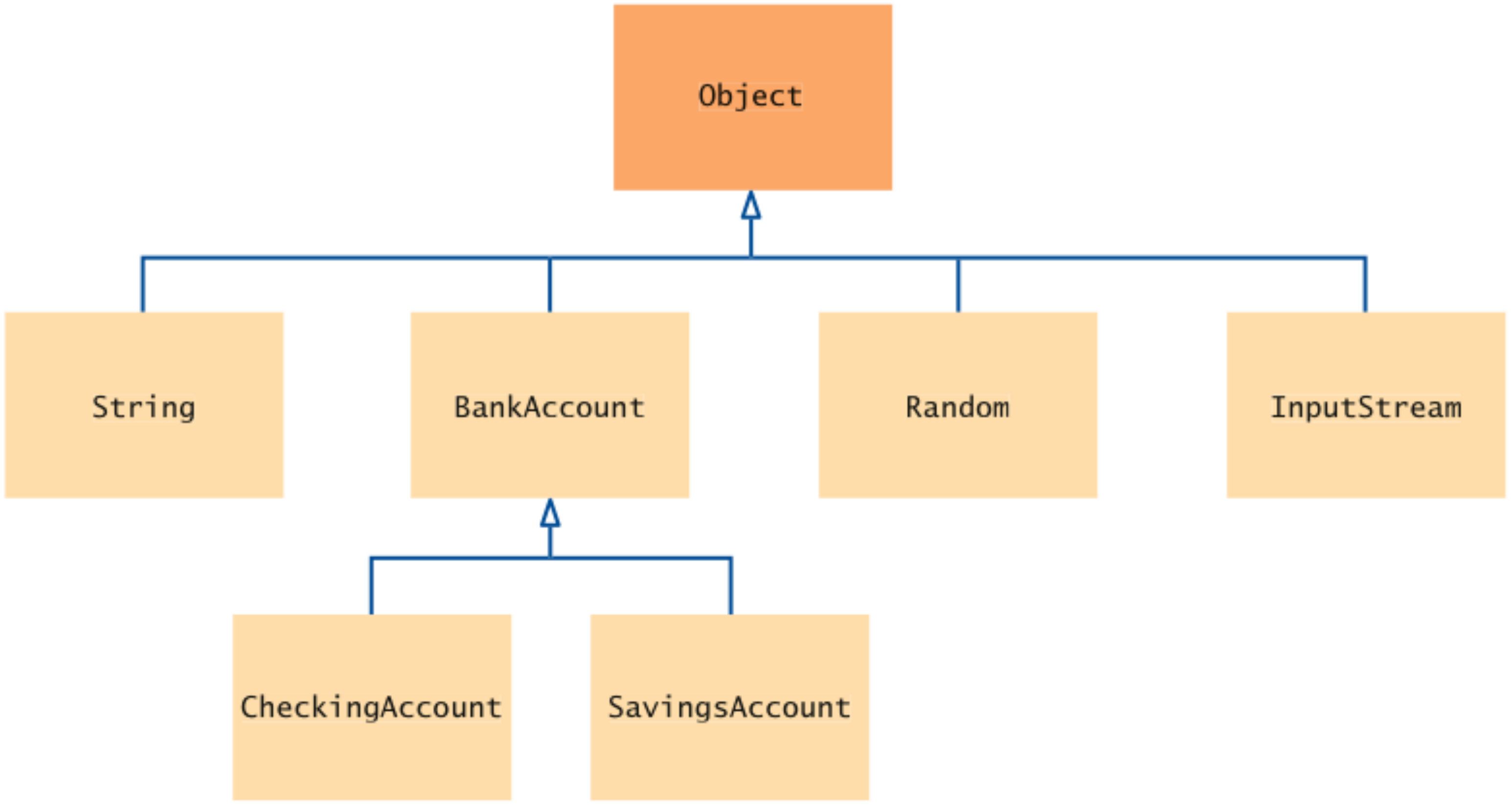


**Figure 7** The Object Class Is the Superclass of Every Java Class

## `Object`: The Cosmic Superclass

- Most useful methods:
  - *`String toString()`*
  - *`boolean equals(Object otherObject)`*
  - *`Object clone()`*
- Good idea to override these methods in your classes

## Overriding the `toString` Method

- Returns a string representation of the object
- Useful for debugging:

```
Rectangle box = new Rectangle(5, 10, 20, 30);
String s = box.toString();
// Sets s to "java.awt.Rectangle[x=5,y=10,width=20,
// height=30]"
```

- `toString` is called whenever you concatenate a string with an object:

```
"box=" + box;
// Result: "box=java.awt.Rectangle[x=5,y=10,width=20,
// height=30]"
```

## Overriding the `toString` Method

- `Object.toString` prints class name and the *hash code* of the object:

```
BankAccount momsSavings = new BankAccount(5000);
String s = momsSavings.toString();
// Sets s to something like "BankAccount@d24606bf"
```

## Overriding the `toString` Method

- To provide a nicer representation of an object, override `toString`:

```
public String toString()
{
   return "BankAccount[balance=" + balance + "]";
}
```

- This works better:

```
BankAccount momsSavings = new BankAccount(5000);
String s = momsSavings.toString();
// Sets s to "BankAccount[balance=5000]"
```

## Overriding the `equals` Method

- `equals` tests for same *contents*:

```
if (coin1.equals(coin2)) . . .
// Contents are the same
```

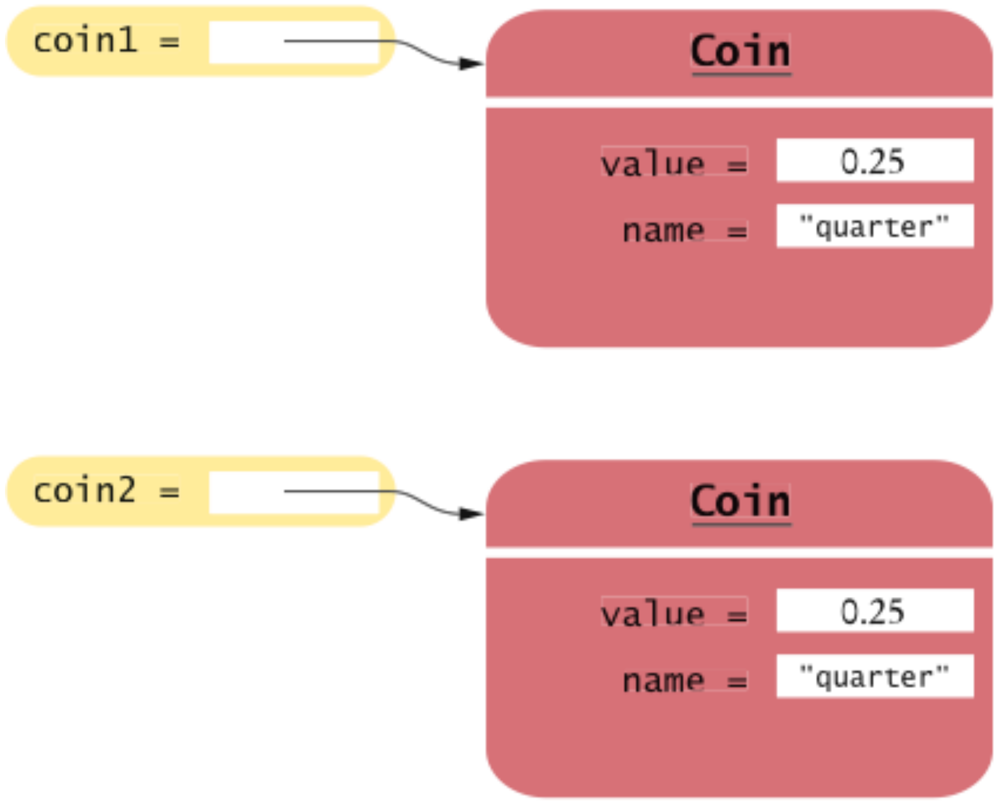


**Figure 8** Two References to Equal Objects

## Overriding the `equals` Method

- `==` tests for references to the same object:

```
if (coin1 == (coin2)) . . .
// Objects are the same
```

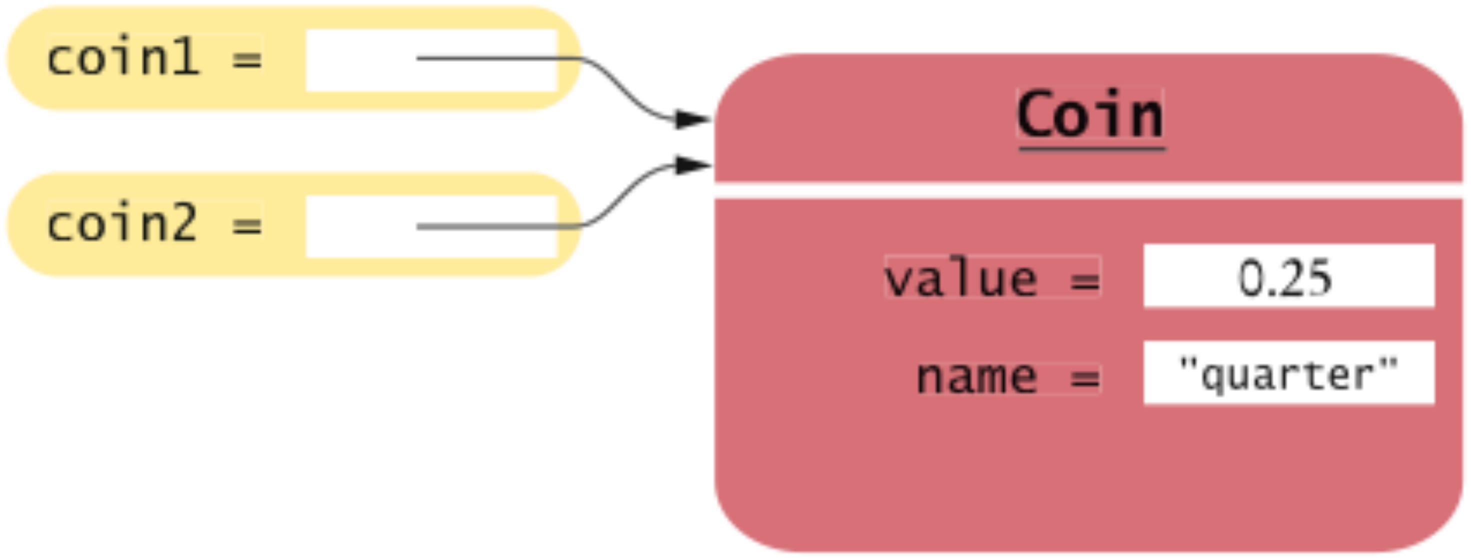


**Figure 9** Two References to the Same Object

## Overriding the `equals` Method

- Need to override the `equals` method of the `Object` class:

```
public class Coin
{
   ...
   public boolean equals(Object otherObject)
   {
      ...
   }
   ...
}
```

## Overriding the `equals` Method

- Cannot change parameter type; use a *cast* instead:

```
public class Coin
{
   . . .
   public boolean equals(Object otherObject)
   {
      Coin other = (Coin) otherObject;
      return name.equals(other.name) && value ==
         other.value;
   }
   . . .
}
```

- You should also override the `hashCode` method so that equal objects have the same hash code

## The `clone` Method

- Copying an object reference gives two references to same object:

```
BankAccount account = newBankAccount(1000);
BankAccount account2 = account;
account2.deposit(500); // Now both account and account2
   // refer to a bank account with a balance of 1500
```

- Sometimes, need to make a copy of the object:

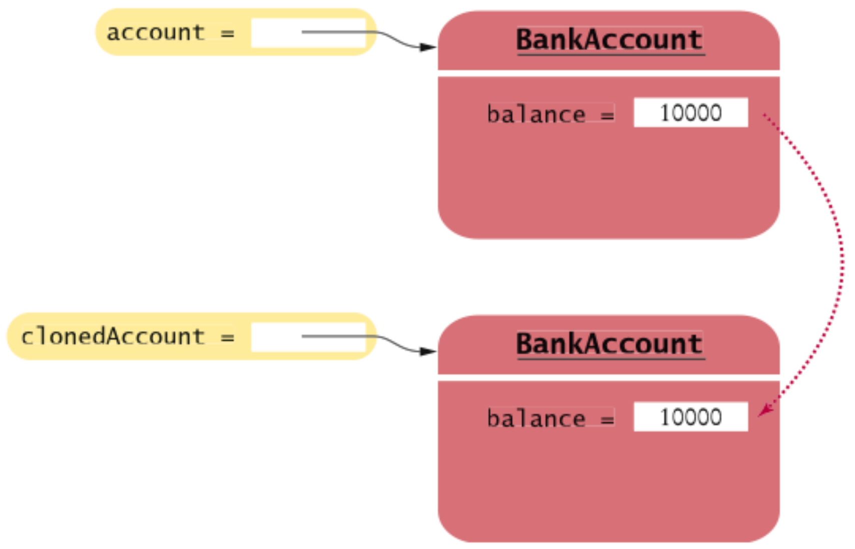


**Figure 10**
Cloning Objects

## The `clone` Method

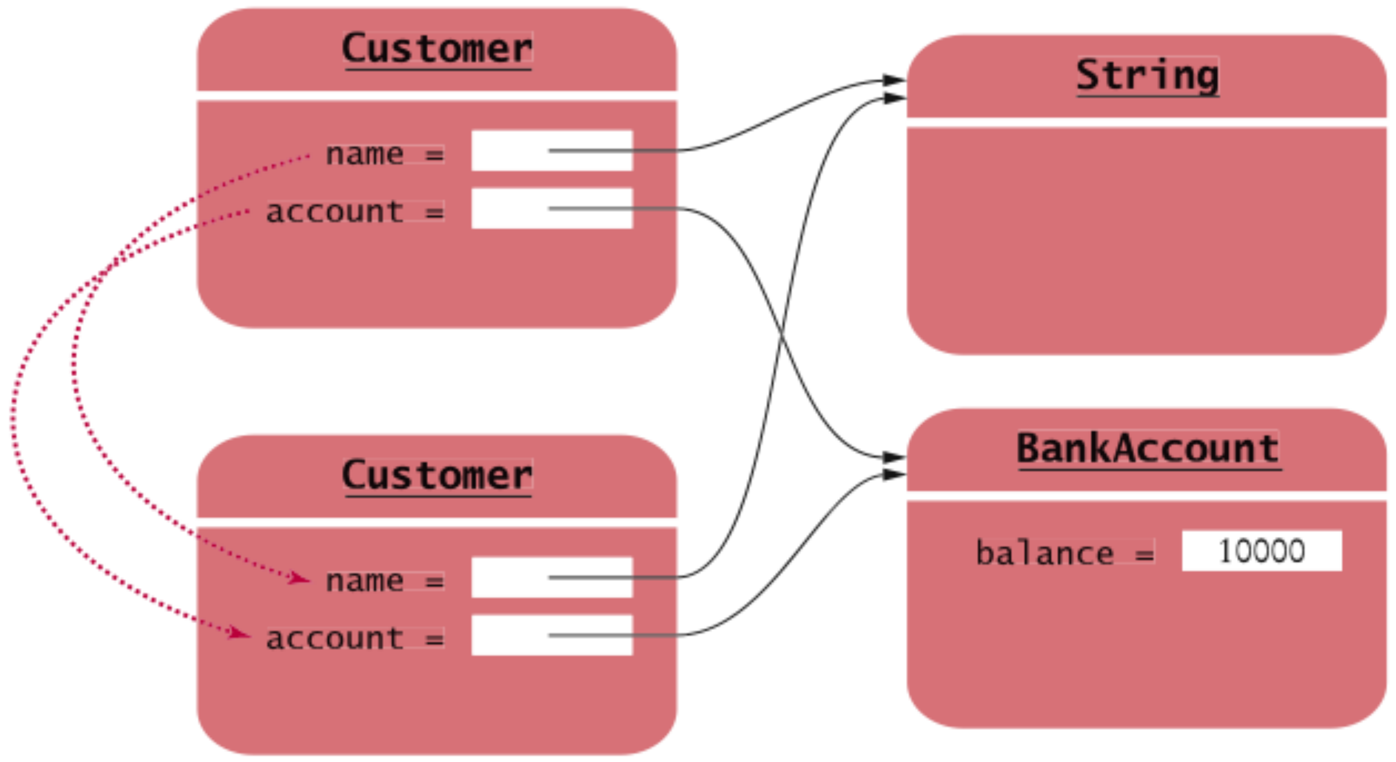
- Implement `clone` method to make a new object with the same state as an existing object
- Use `clone`:

```
BankAccount clonedAccount =
   (BankAccount) account.clone();
```

- Must cast return value because return type is `Object`

## The `Object.clone` Method

- Creates *shallow copies*:



The `Object.clone` Method Makes a Shallow Copy

## The `Object.clone` Method

- Does not systematically clone all subobjects
- Must be used with caution
- It is declared as `protected`; prevents from accidentally calling `x.clone()` if the class to which `x` belongs hasn't redefined `clone` to be `public`
- You should override the `clone` method with care (see Special Topic 10.6)

## Self Check 10.15

Should the call `x.equals(x)` always return `true`?

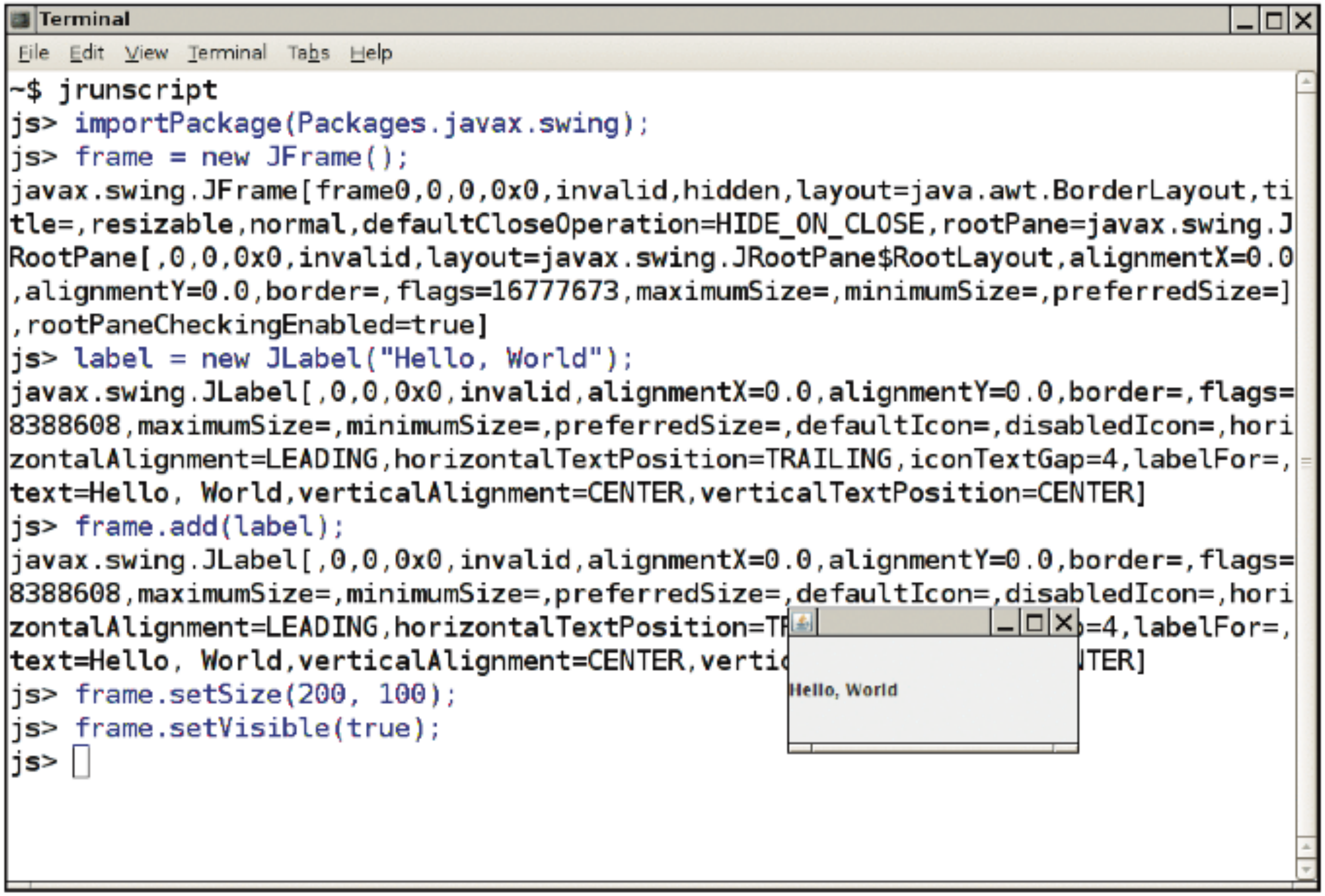
**Answer:** It certainly should — unless, of course, `x` is `null`.

## Self Check 10.16

Can you implement `equals` in terms of `toString`? Should you?

**Answer:** If `toString` returns a string that describes all instance variables, you can simply call `toString` on the implicit and explicit parameters, and compare the results. However, comparing the variables is more efficient than converting them into strings.

## Scripting Languages



```
~$ jrunscript
js> importPackage(Packages.javax.swing);
js> frame = new JFrame();
javax.swing.JFrame[frame0,0,0,0x0,invalid,hidden,layout=java.awt.BorderLayout,ti
tle=,resizable,normal,defaultCloseOperation=HIDE_ON_CLOSE,rootPane=javax.swing.J
RootPane[,0,0,0x0,invalid,layout=javax.swing.JRootPane$RootLayout,alignmentX=0.0
,alignmentY=0.0,border=,flags=16777673,maximumSize=,minimumSize=,preferredSize=]
,rootPaneCheckingEnabled=true]
js> label = new JLabel("Hello, World");
javax.swing.JLabel[,0,0,0x0,invalid,alignmentX=0.0,alignmentY=0.0,border=,flags=
8388608,maximumSize=,minimumSize=,preferredSize=,defaultIcon=,disabledIcon=,hori
zontalAlignment=LEADING,horizontalTextPosition=TRAILING,iconTextGap=4,labelFor=,
text=Hello, World,verticalAlignment=CENTER,verticalTextPosition=CENTER]
js> frame.add(label);
javax.swing.JLabel[,0,0,0x0,invalid,alignmentX=0.0,alignmentY=0.0,border=,flags=
8388608,maximumSize=,minimumSize=,preferredSize=,defaultIcon=,disabledIcon=,hori
zontalAlignment=LEADING,horizontalTextPosition=T        =4,labelFor=,
text=Hello, World,verticalAlignment=CENTER,verti         TER]
js> frame.setSize(200, 100);
js> frame.setVisible(true);
js> 
```

Scripting Java Classes with JavaScript

## Using Inheritance to Customize Frames

- Use inheritance for complex frames to make programs easier to understand
- Design a subclass of `JFrame`
- Store the components as instance variables
- Initialize them in the constructor of your subclass
- If initialization code gets complex, simply add some helper methods

## ch10/frame/InvestmentFrame.java

```
import java.awt.event.ActionEvent;
import java.awt.event.ActionListener;
import javax.swing.JButton;
import javax.swing.JFrame;
import javax.swing.JLabel;
import javax.swing.JPanel;
import javax.swing.JTextField;

public class InvestmentFrame extends JFrame
{
   private JButton button;
   private JLabel label;
   private JPanel panel;
   private BankAccount account;

   private static final int FRAME_WIDTH = 400;
   private static final int FRAME_HEIGHT = 100;

   private static final double INTEREST_RATE = 10;
   private static final double INITIAL_BALANCE = 1000;
```

***Continued***

## ch10/frame/InvestmentFrame.java

```java
public InvestmentFrame()
{
   account = new BankAccount(INITIAL_BALANCE);

   // Use instance variables for components
   label = new JLabel("balance: " + account.getBalance());

   // Use helper methods
   createButton();
   createPanel();

   setSize(FRAME_WIDTH, FRAME_HEIGHT);
}

private void createButton()
{
   button = new JButton("Add Interest");
   ActionListener listener = new AddInterestListener();
   button.addActionListener(listener);
}
```

***Continued***

## Example: Investment Viewer Program (cont.)

```
   private void createPanel()
   {
      panel = new JPanel();
      panel.add(button);
      panel.add(label);
      add(panel);
   }

   class AddInterestListener implements ActionListener
   {
      public void actionPerformed(ActionEvent event)
      {
         double interest = account.getBalance() * INTEREST_RATE / 100;
         account.deposit(interest);
         label.setText("balance: " + account.getBalance());
      }
   }
}
```

## Example: Investment Viewer Program

Of course, we still need a class with a `main` method:

```
import javax.swing.JFrame;

/**
   This program displays the growth of an investment.
*/
public class InvestmentViewer2
{
   public static void main(String[] args)
   {
      JFrame frame = new InvestmentFrame();
      frame.setDefaultCloseOperation(JFrame.EXIT_ON_CLOSE);
      frame.setVisible(true);
   }
}
```

## Self Check 10.17

How many Java source files are required by the investment viewer application when we use inheritance to define the frame class?

**Answer:** Three: `InvestmentFrameViewer`, `InvestmentFrame`, and `BankAccount`.

## Self Check 10.18

Why does the `InvestmentFrame` constructor call `setSize(FRAME_WIDTH, FRAME_HEIGHT)`, whereas the `main` method of the investment viewer class in Chapter 9 called `frame.setSize(FRAME_WIDTH, FRAME_HEIGHT)`?

**Answer:** The `InvestmentFrame` constructor adds the panel to *itself*.