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11/6/2006	Chapter 10, start **Chapter 11**
11/13/2006	Chapter 11, start Chapter 12
11/20/2006	Chapter 12
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12/4/2006	Final Exam
12/11/2006	Project Due

Chapter 10

Object-Oriented Programming
Part 3:
Inheritance, Polymorphism, and Interfaces

Home

Topics

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Inheritance Concepts

- A common form of reuse of classes is inheritance.
- We can organize classes into **hierarchies** of functionality.
- The class at the top of the hierarchy (**superclass**) defines instance variables and methods common to all classes in the hierarchy.
- We derive a **subclass,** which **inherits** behavior and fields from the **superclass**.

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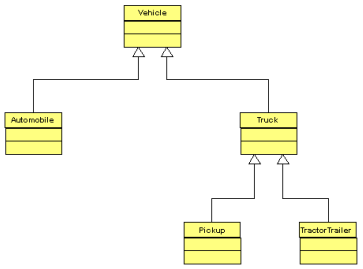
A Sample Vehicle Hierarchy



- This hierarchy is depicted using a Unified Modeling Language (UML) diagram.
- In UML diagrams, arrows point from the subclass to the superclass.

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Superclasses and Subclasses

- A superclass can have multiple subclasses.
- Subclasses can be superclasses of other subclasses.
- A subclass can inherit directly from only one superclass.
- All classes inherit from the *Object* class.

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Superclasses and Subclasses

- A big advantage of inheritance is that we can write common code once and reuse it in subclasses.
  - Generalization
- A subclass can define new methods and instance variables, some of which may **override** (hide) those of a superclass.
  - Specialization

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Specifying Inheritance

- The syntax for defining a subclass is to use the *extends* keyword in the class header, as in

```
accessModifier class SubclassName
                     extends SuperclassName
{
   // class definition
}
```

- The superclass name specified after the *extends* keyword is called the **direct superclass.**
- As mentioned, a subclass can have many superclasses, but only one direct superclass.

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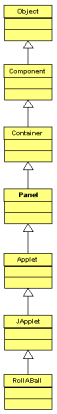
An Applet Hierarchy

- When we wrote an applet, we defined a subclass.
- We say that inheritance implements an "is a" relationship, in that a subclass object "is a" superclass object as well.
- Thus, *RollABall* "is a" *JApplet* (its direct superclass), *Applet*, *Panel, Container, Component*, and *Object*.
- *RollABall* begins with more than 275 methods and 15 fields inherited from its 6 superclasses.



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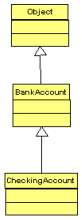
The Bank Account Hierarchy

- The *BankAccount* class is the superclass.
  - Instance variables:
    - *balance* (*double*)
    - *MONEY* (*final DecimalFormat*)
  - Methods:
    - Default and overloaded constructors
    - *deposit* and *withdraw* methods
    - *balance* accessor
    - *toString*
- *See Example 10.1 BankAccount.java (next slide)*



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BankAccount.java 1/3

```
import java.text.DecimalFormat;
public class BankAccount {
  public final DecimalFormat MONEY
              = new DecimalFormat( "$#,##0.00" );
  private double balance;
public BankAccount( )  {
   balance = 0.0;
  }
public BankAccount( double startBalance )  {
   deposit( startBalance );
  }
```

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BankAccount.java 2/3

```
public double getBalance( )  {
   return balance;
  }
public void deposit( double amount )  {
   if ( amount >= 0.0 )
     balance += amount;
   else
     System.err.println( "Deposit amount must be
   positive." );
  }
```

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BankAccount.java 3/3

```
public void withdraw( double amount )  {
   if (  amount >= 0.0 && amount <= balance )
     balance -= amount;
   else
     System.err.println( "Withdrawal amount must be positive "
                 + "and cannot be greater than balance" );
  }
public String toString( )
  {
   return ( "balance is " + MONEY.format( balance ) );
  }
}
```

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The *CheckingAccount* Class

- We derive the *CheckingAccount* subclass from *BankAccount:*

```
public class CheckingAccount extends BankAccount
{ }
```

- A subclass inherits all the ***public*** members of a superclass. Thus, the *CheckingAccount* class inherits
  - the *MONEY* instance variable
  - The *getBalance*, *deposit*, *withdraw*, and *toString* methods
- *See Example 10.3 CheckingAccountClient.java (next slide)*

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CheckingAccountClient.java

```
public class CheckingAccountClient {
  public static void main( String [] args )  {
    CheckingAccount c1 = new CheckingAccount( );
    System.out.println( "New checking account: " + c1 );

    c1.deposit( 350.75 );
    System.out.println( "\nAfter depositing $350.75: " + c1 );

    c1.withdraw( 200.25 );
    System.out.println( "\nAfter withdrawing $200.25: " + c1 );
  }
}
```

Home

private Members

- Superclass members declared as *private* are **NOT** inherited, although they are part of the subclass.
- Thus, the *balance* instance variable is allocated to all *CheckingAccount* objects, but methods of the *CheckingAccount* class cannot directly access *balance*.
- To set or get the value of *balance*, the *CheckingAccount* methods must call the *withdraw*, *deposit,* or *getBalance* methods of the Superclass BankAccount.
- This simplifies maintenance because the *BankAccount* class enforces the data validation rules for *balance*.

Home

protected Members

- *protected* members are inherited by subclasses (like *public* members), while still being hidden from client classes (like *private* members).
- Also, any class in the same package as the superclass can directly access a *protected* field, even if that class is not a subclass.
- Disadvantage:
  - Because more than one class can directly access a *protected* field, *protected* access compromises encapsulation and complicates maintenance of a program.
  - For that reason, we prefer to use *private*, rather than *protected,* for our instance variables.

Home

Inheritance Rules

Superclass Members	Inherited by subclass?	Directly Accessible by Subclass?	Directly Accessible by Client of Subclass?
public fields	yes	yes, by using field name	yes
public methods	yes	yes, by calling method from subclass methods	yes
protected fields	yes	yes, by using field name	no, must call accessors and mutators
protected methods	yes	yes, by calling method from subclass methods	no
private fields	no	no, must call accessors and mutators	no, must call accessors and mutators
private methods	no	no	no

Home

Subclass Constructors

- Constructors are not inherited.
- However, the subclass can call the constructors of the superclass to initialize inherited fields.
- **Implicit** invocation
  - The default constructor of the subclass automatically calls the default constructor of the superclass
- For **explicit** invocation, use this syntax:

```
super( argument list );
```

If used, this statement must be the first statement in the subclass constructor

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CheckingAccount Constructors

```
public CheckingAccount( )
{
  // optional explicit call
  // to BankAccount default constructor
  super( );
}

public CheckingAccount( double startBalance )
{
   // explicit call to BankAccount
   // overloaded constructor
   super( startBalance );
}
```

- *See Examples 10.4 (BankingAccount.java V2 & 10.5 CheckingAccount.java V2)*

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BankAccount.java Version 2

```
import java.text.DecimalFormat;
public class BankAccount {
   public final DecimalFormat MONEY = new DecimalFormat( "$#,##0.00" );
  private double balance;
  public BankAccount( )  {
    balance = 0.0;
    System.out.println( "In BankAccount default constructor" );
  }
  public BankAccount( double startBalance ) {
    if ( balance >= 0.0 )    balance = startBalance;
    else  balance = 0.0;
    System.out.println( "In BankAccount overloaded constructor" );
  }
  public String toString( )
  {
    return ( "balance is " + MONEY.format( balance ) );
  }
}
```

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CheckingAccount.java Version 2

```
public class CheckingAccount extends BankAccount {
  public CheckingAccount( )  {
     super( ); // optional, call BankAccount constructor
     System.out.println( "In CheckingAccount "
                  + "default constructor" );
  }
public CheckingAccount( double startBalance )  {
     super( startBalance ); // call BankAccount constructor
     System.out.println( "In CheckingAccount "
                  + "overloaded constructor" );
  }
}
```

Home

Common Error Trap

- An attempt by a subclass to directly access a *private* field or call a *private* method defined in a superclass will generate a compiler error.
- To set initial values for *private* variables, call the appropriate constructor of the direct superclass.
- For example, this statement in the overloaded *CheckingAccount* class constructor calls the overloaded constructor of the *BankAccount* class:

```
super( startBalance );
```

Home

Software Engineering Tip

Overloaded constructors in a subclass should explicitly call the direct superclass constructor to initialize the fields in its superclasses.

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Inheritance Rules for Constructors

Superclass Members	Inherited by subclass?	Directly Accessible by Subclass?	Directly Accessible by Client of Subclass Using a Subclass Reference?
constructors	no	yes, using `super( arg list )` in a subclass constructor	no

Home

Adding Specialization

- A subclass can define new fields and methods.
- Our *CheckingAccount* class adds
  - these instance variables:
    - *monthlyFee,* a *double*
    - *DEFAULT_FEE*, a *double* constant
  - these methods:
    - *setMonthlyFee,* the accessor
    - *getMonthlyFee*, the mutator
    - *applyMonthlyFee*, which charges the monthly fee to the account.

Home

The *applyMonthlyFee* Method

- Because *balance* is *private* in the *BankAccount* class, the *applyMonthlyFee* method calls the *withdraw* method to subtract the monthly fee from the balance:

```
public void applyMonthlyFee( )
{
   withdraw( monthlyFee );
}
```

- *See Examples 10.7 (CheckoingAccount V3& 10.8 CheckingAccountCLient V3)*

Home

CheckingAccount.java V3 1/2

```
public class CheckingAccount extends BankAccount {
  public final double DEFAULT_FEE = 5.00;
  private double monthlyFee;
  public CheckingAccount( )    {
     super( ); // optional
     monthlyFee = DEFAULT_FEE;
  }
  public CheckingAccount( double startBalance, double
   startMonthlyFee ) {
    super( startBalance ); // call BankAccount constructor
    setMonthlyFee( startMonthlyFee );
  }
```

Home

CheckingAccount.java V3 2/2

```
public void applyMonthlyFee( ) {
    withdraw( monthlyFee );
  }
  public double getMonthlyFee( ) {
   return monthlyFee;
  }
  public void setMonthlyFee( double newMonthlyFee ) {
   if ( monthlyFee >= 0.0 )
     monthlyFee = newMonthlyFee;
   else
     System.err.println( "Monthly fee cannot be negative" );
  }
}
```

Home

CheckingAccountClient.java V3

```
public class CheckingAccountClient {
  public static void main( String [] args )  {
    CheckingAccount c3 = new CheckingAccount( 100.00, 7.50 );
    System.out.println( "New checking account:\n"
                  + c3.toString( ) + "; monthly fee is "
                  + c3.getMonthlyFee( ) );
    c3.applyMonthlyFee( );  // charge the fee to the account
    System.out.println( "\nAfter charging monthly fee:\n"
                  + c3.toString( ) + "; monthly fee is "
                  + c3.getMonthlyFee( ) );
  }
}
```

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Software Engineering Tip

The superclasses in a class hierarchy should contain fields and methods common to all subclasses.

The subclasses should add specialized fields and methods.

Home

Overriding Inherited Methods

- A subclass can **override** (or replace) an inherited method by providing a new version of the method.
- The API of the new version must match the inherited method
- When the client calls the method, it will call the overridden version.
- The overridden method is invisible to the client of the subclass, but the subclass methods can still call the overridden method using this syntax:

```
super.methodName( argument list )
```

Home

The *toString* Method

- The *toString* method in the *CheckingAccount* class overrides the *toString* method in the *BankAccount* class.
- The subclass version call the superclass version to return *balance*.

```
public String toString( )
{
  return super.toString( )
      + "; monthly fee is "
      + MONEY.format( monthlyFee );
}
```

- *See Examples 10.9 & 10.10*

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Inheritance Rules for Overridden Methods

Superclass Members	Inherited by subclass?	Directly Accessible by Subclass?	Directly Accessible by Client of Subclass Using a Subclass Reference?
public or *protected* inherited methods that have been overridden in the subclass	no	yes, using `super.methodName( arg list )`	no

Home

Common Error Trap

- Do not confuse overriding a method with overloading a method.
  - Overriding a method:
    - A subclass provides a new version of that method (same signature), which hides the superclass version from the client.
  - Overloading a method:
    - A class provides a version of the method, which varies in the number and/or type of parameters (different signature). A client of the class can call any of the *public* versions of overloaded methods.

Home

The *protected* Access Modifier

- Declaring fields as *private* preserves encapsulation.
  - Subclass methods call superclass methods to set the values of the fields, and the superclass methods enforce the validation rules for the data.
  - But calling methods incurs processing overhead.
- Declaring fields as *protected* allows them to be accessed directly by subclass methods.
  - Classes outside the hierarchy and package must use accessors and mutators for *protected* fields.

Home

protected fields: Tradeoffs

- Advantage:
  - *protected* fields can be accessed directly by subclasses, so there is no method-invocation overhead.
- Disadvantage:
  - Maintenance is complicated because the subclass also needs to enforce validation rules.
- Recommendation:
  - Define *protected* fields only when high performance is necessary.
  - Avoid directly setting the values of *protected* fields in the subclass.
- *See Examples 10.11, 10.12, & 10.13*

Home

abstract Classes and Methods

- An ***abstract* class** is a class that is not completely implemented.
- Usually, the abstract class contains at least one ***abstract* method.**
  - An *abstract* method specifies an API but does not provide an implementation.
  - The *abstract* method is used as a pattern for a method the subclasses should implement.

Home

More on *abstract* Classes

- An object reference to an *abstract* class can be declared.
  - We use this capability in polymorphism, discussed later.
- An *abstract* class cannot be used to instantiate objects (because the class is not complete).
- An *abstract* class can be extended.
  - subclasses can complete the implementation and objects of those subclasses can be instantiated.

Home

Defining an *abstract* class

- To declare a class as *abstract*, include the *abstract* keyword in the class header:

```
accessModifier abstract class ClassName
{
   // class body
}
```

Home

Defining an *abstract* Method

- To declare a method as abstract, include the *abstract* keyword in the method header:

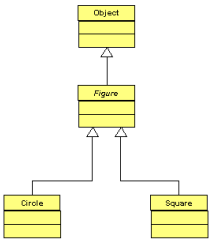
```
accessModifier abstract returnType
          methodName( argument list );
```

- Note:
  - The semicolon at the end of the header indicates that the method has no code.
  - We do not use open and closing curly braces

Home

Example Hierarchy

- We can define a Figure hierarchy.
- The superclass is *Figure*, which is *abstract.* (In the UML diagram, *Figure* is set in ***italics*** to indicate that it is *abstract*.
- We will derive two subclasses: *Circle* and *Square*.



Home

The *Figure* Class

```
public abstract class Figure
{
  private int x;
  private int y;
  private Color color;
  // usual constructors, accessors,
  // and mutators

  // abstract draw method
  public abstract void draw( Graphics g );
}
```

- All classes in the hierarchy will have an (x, y) coordinate and color. Subclasses will implement the *draw* method.

Home

Subclasses of *abstract* Classes

- A subclass of an abstract class can implement all, some, or none of the *abstract* methods.
- If the subclass does not implement all of the *abstract* methods, it must also be declared as *abstract*.
- Our *Circle* subclass adds a *radius* instance variable and implements the *draw* method.
- Our *Square* subclass adds a *length* instance variable and implements the *draw* method.
- *See Examples 10.15, 10.16, 10.17, & 10.18*

Home

Restrictions for Defining *abstract* Classes

- Classes must be declared *abstract* if the class contains any *abstract* methods.
- *abstract* classes can be extended.
- An object reference to an *abstract* class can be declared.
- *abstract* classes cannot be used to instantiate objects.

Home

Restrictions for Defining *abstract* Methods

- *abstract* methods can be declared only within an *abstract* class.
- An *abstract* method must consist of a method header followed by a semicolon.
- *abstract* methods cannot be called.
- *abstract* methods cannot be declared as *private* or *static*.
- A constructor cannot be declared *abstract*.

Home

Polymorphism

- An important concept in inheritance is that an object of a subclass is also an object of any of its superclasses.
- That concept is the basis for an important OOP feature, called **polymorphism**.
- Polymorphism simplifies the processing of various objects in the same class hierarchy because we can use the same method call for any object in the hierarchy using a superclass object reference.

Home

Polymorphism Requirements

- To use polymorphism, these conditions must be true:
  1. the classes are in the same hierarchy.
  2. all subclasses override the same method.
  3. a subclass object reference is assigned to a superclass object reference.
  4. the superclass object reference is used to call the method.

Home

Example

- Example 10.19 shows how we can simplify the drawing of *Circle* and *Square* objects.
- We instantiate a *Figure ArrayList* and add *Circle* and *Square* objects to it.

```
ArrayList<Figure> figuresList
          = new ArrayList<Figure>( );
figuresList.add( new Square( 150, 100,
                  Color.BLACK, 40 ) );
figuresList.add( new Circle( 160, 110,
                   Color.RED, 10 ) );
  …
```

- In the *paint* method, we call *draw* this way:

```
for ( Figure f : figuresList )
       f.draw( g );
```

Home

Polymorphism Conditions

- Example 10.19 shows that we have fulfilled the conditions for polymorphism:
  1. The *Figure*, *Circle,* and *Square* classes are in the same hierarchy.
  2. The non-abstract *Circle* and *Square* classes implement the *draw* method.
  3. We assigned the *Circle* and *Square* objects to *Figure* references.
  4. We called the *draw* method using *Figure* references.

Home

Interfaces

- A class can inherit directly from only one class, that is, a class can *extend* only one class.
- To allow a class to inherit behavior from multiple sources, Java provides the **interface**.
- An interface typically specifies behavior that a class will *implement*. Interface members can be any of the following:
  - classes
  - constants
  - *abstract* methods
  - other interfaces

Home

Interface Syntax

- To define an interface, use the following syntax:

```
accessModifier interface InterfaceName
{
   // body of interface
}
```

- All interfaces are *abstract*; thus, they cannot be instantiated. The *abstract* keyword, however, can be omitted in the interface definition.

Home

Finer Points of Interfaces

- An interface's fields are *public*, *static,* and *final*.
  - These keywords can be specified or omitted.
- When you define a field in an interface, you must assign a value to the field.
- All methods within an interface must be *abstract,* so the method definition must consist of only a method header and a semicolon.
  - The *abstract* keyword also can be omitted from the method definition.

Home

Inheriting from an Interface

- To inherit from an interface, a class declares that it **implements** the interface in the class definition, using the following syntax:

```
accessModifier class ClassName
     extends SuperclassName
     implements Interface1, Interface2, …
```

- The *extends* clause is optional.
- A class can *implement* 0, 1, or more interfaces.
- When a class *implements* an interface, the class **must** provide an implementation **for each** method in the interface.

Home

Example

1. Define an *abstract* class *Animal* with one *abstract* method (See Example 10.22):

```
public abstract void draw( Graphics g );
```

2. Define a *Moveable* interface with one abstract method:

```
public interface Moveable
{
   int FAST = 5; // static constant
   int SLOW = 1; // static constant

   void move( ); // abstract method
}
```

Home

Derived Classes

- *TortoiseRacer* class
  - *extends Animal* class
  - *implements Moveable* interface
  - implements *draw* and *move* methods
- *TortoiseNonRacer* class
  - *extends Animal* class
  - (does not implement *Moveable* interface)
  - implements *draw* method only
- *See Examples 10.21, 10.22, 10.23, & 10.24*

Home

Backup

Home

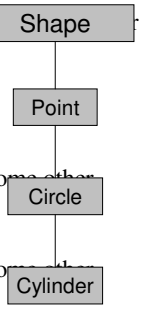
Final Methods and Classes

- A method that is declared final can't be overridden
- A class that is declared final can't be a superclass
  - All methods in a a final class are final

Home

Abstract Classes Example

- Shape
  - Defines all methods that are
    shapes
- Point
  - Inherits these methods
- Circle
  - Inherits some and overrides some other
    methods
- Cylinder
  - Inherits some and overrides some other
    methods



Home

Shape

- Shape is an abstract superclass
- It still contain implementations of methods area and volume which are inheritable
  - Shape provide an inheritable interface (set of services)
  - All subclasses can use or override these interfaces (methods)
- The point here is that subclasses can inherit interface and/or implementation from a supperclass

Home

Shape Example: Shape Class

```
public abstract class Shape extends Object {

  // return shape's area , overridden when it make since
  public double area()    {
    return 0.0;
  }
  // return shape's volume, overridden when it make since
  public double volume()    {
    return 0.0;
  }
  // abstract method must be overridden by all concrete
  // subclasses to return appropriate shape name
  public abstract String getName();
}  // end class Shape
```

Home

Shape Example: Point Class 1/2

```
public class Point extends Shape {
   protected int x, y; // coordinates of the Point
public Point()    {
      setPoint( 0, 0 );
   }
public Point( int xCoordinate, int yCoordinate )    {
      setPoint( xCoordinate, yCoordinate );
   }
public void setPoint( int xCoordinate, int yCoordinate )    {
      x = xCoordinate;
      y = yCoordinate;
   }
public int getX()    {
      return x;
   }
```

Point inherits (NOT overridden) both volume and area methods of shape (zero)

Home

Shape Example: Point Class 2/2

```
public int getY()    {
      return y;
   }
   // convert point into String representation
   public String toString()    {
         return "[" + x + ", " + y + "]";
      }
   // return shape name, an implementation of the abstract method
   public String getName()    {
         return "Point";
      }
   }  // end class Point
```

If getName is not defined here, then point would have been an abstract class and no objects of it can be instantiated

Home

Shape Example: Circle Class 1/2

```
public class Circle extends Point {  // inherits from Point
   protected double radius;
public Circle()    {
      // implicit call to superclass constructor here
      setRadius( 0 );
   }
public Circle( double circleRadius, int xCoordinate,  int yCoordinate )  {
      // call superclass constructor
      super( xCoordinate, yCoordinate );
      setRadius( circleRadius );
   }
public void setRadius( double circleRadius )    {
      radius = ( circleRadius >= 0 ? circleRadius : 0 );
   }
public double getRadius()    {
      return radius;
   }
```

Circle inherits the volume method from point(zero) and overrides the area method

Home

Shape Example: Circle Class 2/2

```
   // calculate area of Circle, overrides area of Shape
   public double area()    {
      return Math.PI * radius * radius;
   }

   // convert Circle to a String represention
   public String toString()    {
      return "Center = " + super.toString() +
         "; Radius = " + radius;
   }
public String getName()    {
      return "Circle";
   }
}  // end class Circl
```

If getName is not defined here, then area() version of Point class would be inherited

Home

Shape Example: Cylinder Class 1/2

```
public class Cylinder extends Circle {
  protected double height;  // height of Cylinder
public Cylinder()   {
 setHeight( 0 );
}
public Cylinder( double cylinderHeight, double cylinderRadius, int
  xCoordinate,   int yCoordinate )   {
    super( cylinderRadius, xCoordinate, yCoordinate );
    setHeight( cylinderHeight );
}
public void setHeight( double cylinderHeight ) {
    height = ( cylinderHeight >= 0 ? cylinderHeight : 0 );
}
public double getHeight()  {
    return height;
  }
```

Cylinder overrides both volume and area methods

Home

Shape Example: Cylinder Class 2/2

```
public double area()   {
    return 2 * super.area() + 2 * Math.PI * radius * height;
  }
public double volume()   {
    return super.area() * height;
  }
public String toString()   {
    return super.toString() + "; Height = " + height;
  }
public String getName()   {
    return "Cylinder";
  }
} // end class Cylinder
```

If getName is not defined here, then area() version of Circle class would be inherited

Home

Shape Example: Test Class 1/3

```
import javax.swing.JOptionPane;
public class Test {              // test Shape hierarchy
  public static void main( String args[] )
  {   // create shapes
    Point point = new Point( 7, 11 );
    Circle circle = new Circle( 3.5, 22, 8 );
    Cylinder cylinder = new Cylinder( 10, 3.3, 10, 10 );
    // create Shape array
    Shape arrayOfShapes[] = new Shape[ 3 ];
    // aim arrayOfShapes[ 0 ] at subclass Point object
    arrayOfShapes[ 0 ] = point;
    // aim arrayOfShapes[ 1 ] at subclass Circle object
    arrayOfShapes[ 1 ] = circle;
    // aim arrayOfShapes[ 2 ] at subclass Cylinder object
    arrayOfShapes[ 2 ] = cylinder;
```

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Shape Example: Test Class 2/3

```
// get name and String representation of each shape
    String output =
      point.getName() + ": " + point.toString() + "\n" +
      circle.getName() + ": " + circle.toString() + "\n" +
      cylinder.getName() + ": " + cylinder.toString();

    // loop through arrayOfShapes and get name,
    // area and volume of each shape in arrayOfShapes
    for ( int i = 0; i < arrayOfShapes.length; i++ ) {
      output += "\n\n" + arrayOfShapes[ i ].getName() +
        ": " + arrayOfShapes[ i ].toString() +
        "\nArea = " +
        precision2.format( arrayOfShapes[ i ].area() ) +
        "\nVolume = " +
        precision2.format( arrayOfShapes[ i ].volume() );
    }
```

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Shape Example: Test Class 3/3

```
// get name and String representation of each shape
   String output =
      point.getName() + ": " + point.toString() + "\n" +
      circle.getName() + ": " + circle.toString() + "\n" +
      cylinder.getName() + ": " + cylinder.toString();
// loop through arrayOfShapes and get name,
// area and volume of each shape in arrayOfShapes
   for ( int i = 0; i < arrayOfShapes.length; i++ ) {
      output += "\n\n" + arrayOfShapes[ i ].getName() +
        ": " + arrayOfShapes[ i ].toString() + "\nArea = " +
        precision2.format( arrayOfShapes[ i ].area() ) + "\nVolume = " +
        precision2.format( arrayOfShapes[ i ].volume() );
   }
   JOptionPane.showMessageDialog(null,output, "Demonstrating
Polymorphism");
   System.exit( 0 );
  }
} // end class Test
```

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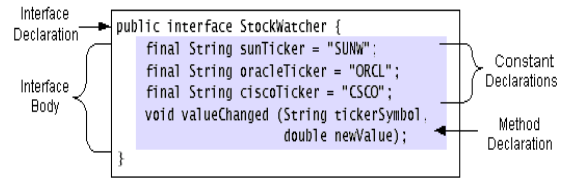
Defining an Interface




```
public interface StockWatcher {
    final String sunTicker = "SUNW";
    final String oracleTicker = "ORCL";
    final String ciscoTicker = "CSCO";
    void valueChanged(String tickerSymbol, double newValue);
}
```

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example

- applet that implements the StockWatcher interface:
- public class StockApplet extends Applet i**mplements StockWatcher** { …
  - public void valueChanged(String tickerSymbol, double newValue)
  - {
    - if (tickerSymbol.equals(sunTicker)) {}
    - else if (tickerSymbol.equals(oracleTicker)) { … }
    - else if (tickerSymbol.equals(ciscoTicker)) { … }
  - }

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}

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Warning! Interfaces Cannot Grow

- Suppose that you want to add some functionality to StockWatcher. For instance, suppose that you want to add a method that reports the current stock price, regardless of whether the value changed:
  - public interface StockWatcher {
    - final String sunTicker = "SUNW";
    - final String oracleTicker = "ORCL";
    - final String ciscoTicker = "CSCO";
    - void valueChanged(String tickerSymbol, double newValue);
    - void currentValue(String tickerSymbol, double newValue);
  - }

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Warning! Interfaces Cannot Grow

- However, if you make this change, all classes that implement the old StockWatcher interface will break because
  - they don't implement the interface anymore!

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