Inheritance

Inheritance

- *Inheritance* allows 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 for the parent class

Inheritance

- To develop a derived class, the programmer can add new variables or methods, or can modify the inherited ones
- *Software reuse* is the main aim of of inheritance

Deriving Subclasses

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

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

The protected Modifier

- Visibility modifiers determine which class members are inherited and which are not
- Variables and methods declared with `public` visibility are inherited; those with `private` visibility are not
- 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 member of a base class to be inherited into a child
- Protected visibility provides more encapsulation than public visibility does
- However, protected visibility is not as tightly encapsulated as private visibility

The super Reference

- Constructors are not inherited, even though they have public visibility
- The `super` reference can be used to refer to the parent class, and often is used to invoke the parent's constructor

The super Reference

- A child's constructor is responsible for calling the parent's constructor
- 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

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
- Java does not support multiple inheritance
- The use of interfaces gives us aspects of multiple inheritance.

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

Overriding

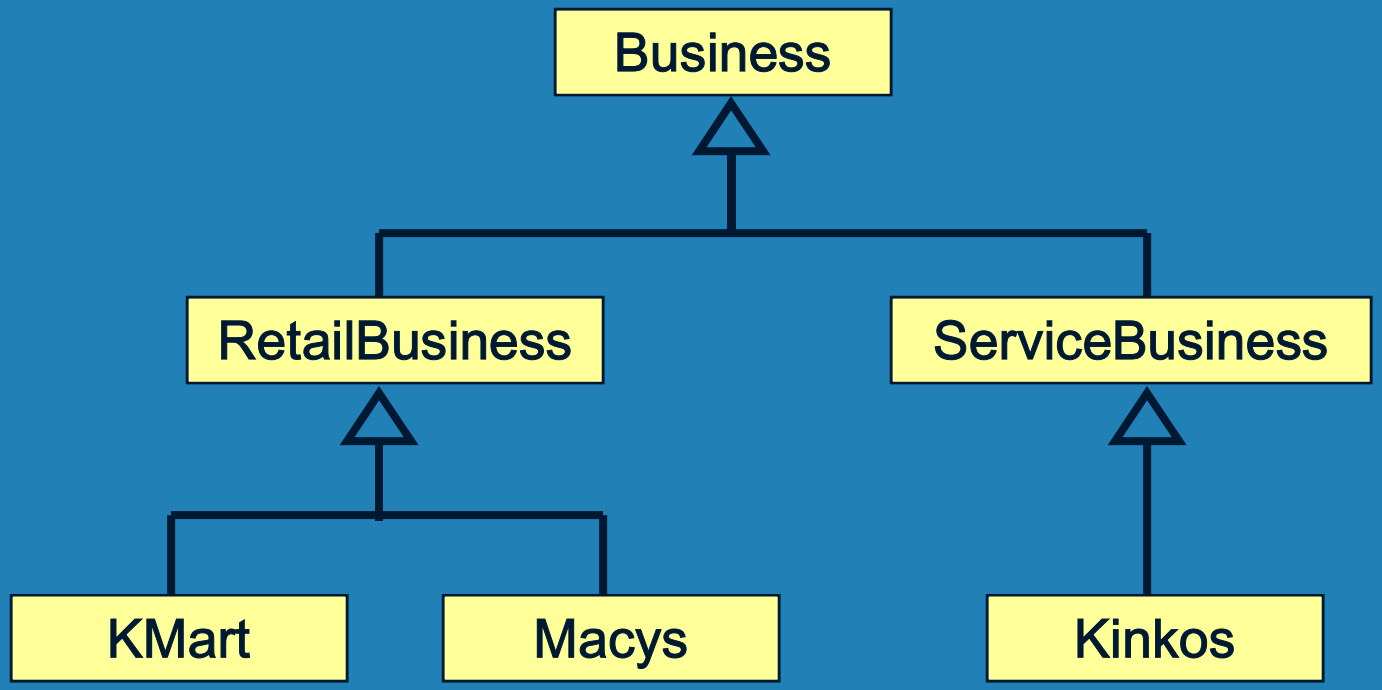
- A parent method can be invoked explicitly using the `super` reference
- If a method is declared with the `final` modifier, it cannot be overridden
- The concept of overriding can be applied to data and is called *shadowing variables*
- Shadowing variables should be avoided because it tends to cause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

Overloading vs. Overriding

- Don't confuse the concepts of overloading and 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 data
- Overriding lets you define a similar operation in different ways for different object types

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 have defined `toString`, we have actually been overriding an existing definition
- The `toString` method in the `Object` class is defined to return a string that contains the name of the object's class together along with some other information

The Object Class

- All objects are guaranteed to have a `toString` method via inheritance
- Thus the `println` method can call `toString` for any object that is passed to it

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
- The `String` class (as we've seen) defines the `equals` method to return true if two `String` objects contain the same characters
- Therefore the `String` class has overridden the `equals` method inherited from `Object` in favor of its own 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 Whatever
{
    // contents
}
```

Abstract Classes

- An abstract class often contains abstract methods with no definitions (like an interface does)
- Unlike an interface, the `abstract` modifier must be applied to each abstract method
- An abstract class typically contains non-abstract methods (with bodies), further distinguishing abstract classes from interfaces
- A class declared as abstract does not need to contain abstract methods

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` (because it must be overridden) or `static` (because it has no definition yet)
- The use of abstract classes is a design decision – it helps us establish common elements in a class that is too general to instantiate

Indirect Use of Members

- An inherited member can be referenced directly by name in the child class, as if it were declared in the child class
- But even if a method or variable is not inherited by a child, it can still be accessed indirectly through parent methods
- See `FoodAnalysis.java` (page 403)
- See `FoodItem.java` (page 404)
- See `Pizza.java` (page 405)

Polymorphism

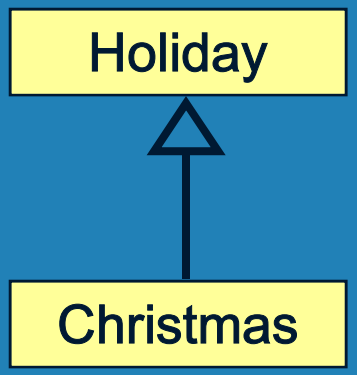
- A reference can be *polymorphic*, which can be defined as "having many forms"

```
obj.doIt();
```

- This line of code might execute different methods at different times if the object that `obj` points to changes
- Polymorphic references are resolved at run time; this is called *dynamic binding*
- Careful use of polymorphic references can lead to elegant, robust software designs
- Polymorphism can be accomplished using inheritance or using interfaces

References and Inheritance

- An object reference can refer to an object of its class, or to an object of any class related to it by inheritance
- For example, if the **`Holiday`** class is used to derive a child class called **`Christmas`**, then a **`Holiday`** reference could be used to point to a **`Christmas`** object




```
Holiday day;
day = new Christmas();
```

References and Inheritance

- Assigning a predecessor object to an ancestor reference is considered to be a widening conversion, and can be performed by simple assignment
- Assigning an ancestor object to a predecessor reference can be done also, but it is considered to be a narrowing conversion and must be done with a cast
- The widening conversion is the most useful
- An `Object` reference can be used to refer to any object
  - An `ArrayList` is designed to hold `Object` references

Polymorphism via Inheritance

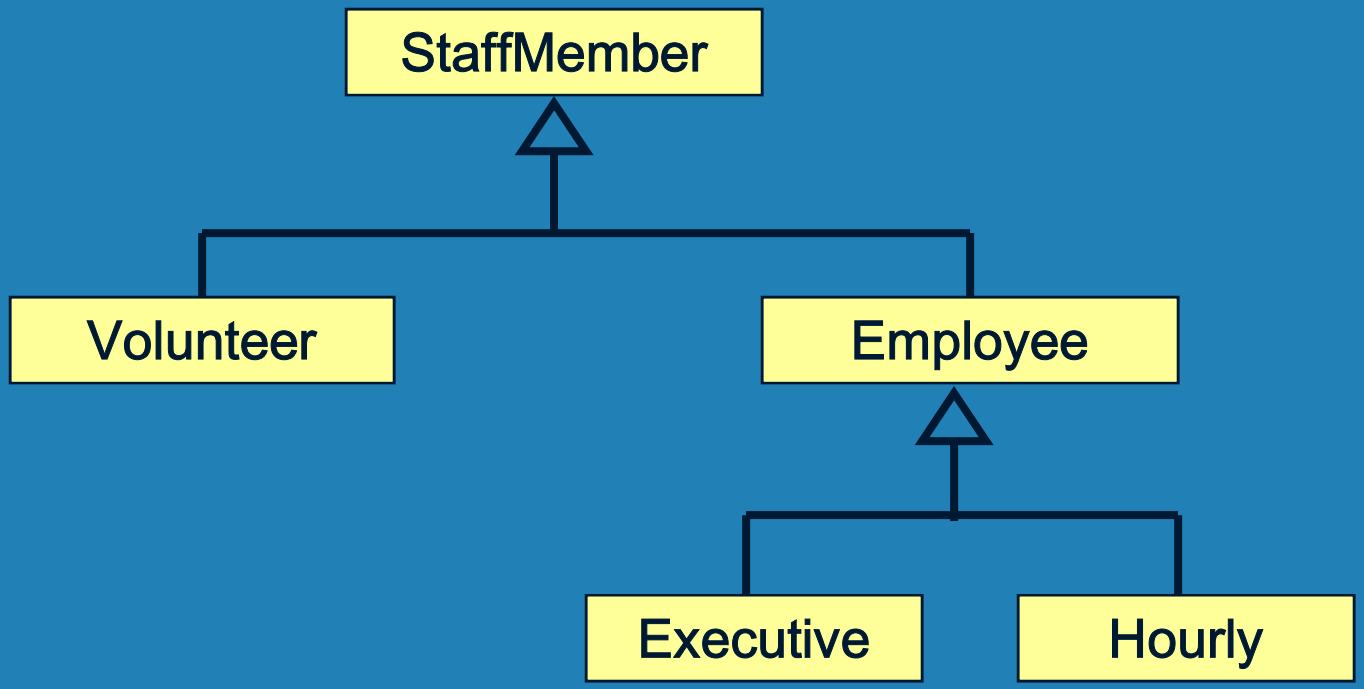
- It is the type of the object being referenced, not the reference type, that determines which method is invoked
- Suppose the `Holiday` class has a method called `celebrate`, and the `Christmas` class overrides it
- Now consider the following invocation:

```
day.celebrate();
```

- If `day` refers to a `Holiday` object, it invokes the `Holiday` version of `celebrate`; if it refers to a `Christmas` object, it invokes the `Christmas` version

Polymorphism via Inheritance

- Consider the following class hierarchy:



Polymorphism via Inheritance

- Now consider the task of paying all employees

- See `Firm.java` (page 410)
- See `Staff.java` (page 412)
- See `StaffMember.java` (page 414)
- See `Volunteer.java` (page 415)
- See `Employee.java` (page 416)
- See `Executive.java` (page 417)
- See `Hourly.java` (page 418)

Interface Hierarchies

- Inheritance can be applied to interfaces as well as classes
- 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 the ancestor and child interfaces
- All members of an interface are public
- Note that class hierarchies and interface hierarchies are distinct (they do not overlap)

Polymorphism via Interfaces

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

```
Doable obj;
```

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

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

Inheritance and GUIs

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

Inheritance and GUIs

- Our applet classes only have to deal with issues that specifically relate to what our particular applet will do
- When we define the `paint` method of an applet, for instance, we are actually overriding a method defined in the `Component` class, which is ultimately inherited into the `Applet` or `JApplet` 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

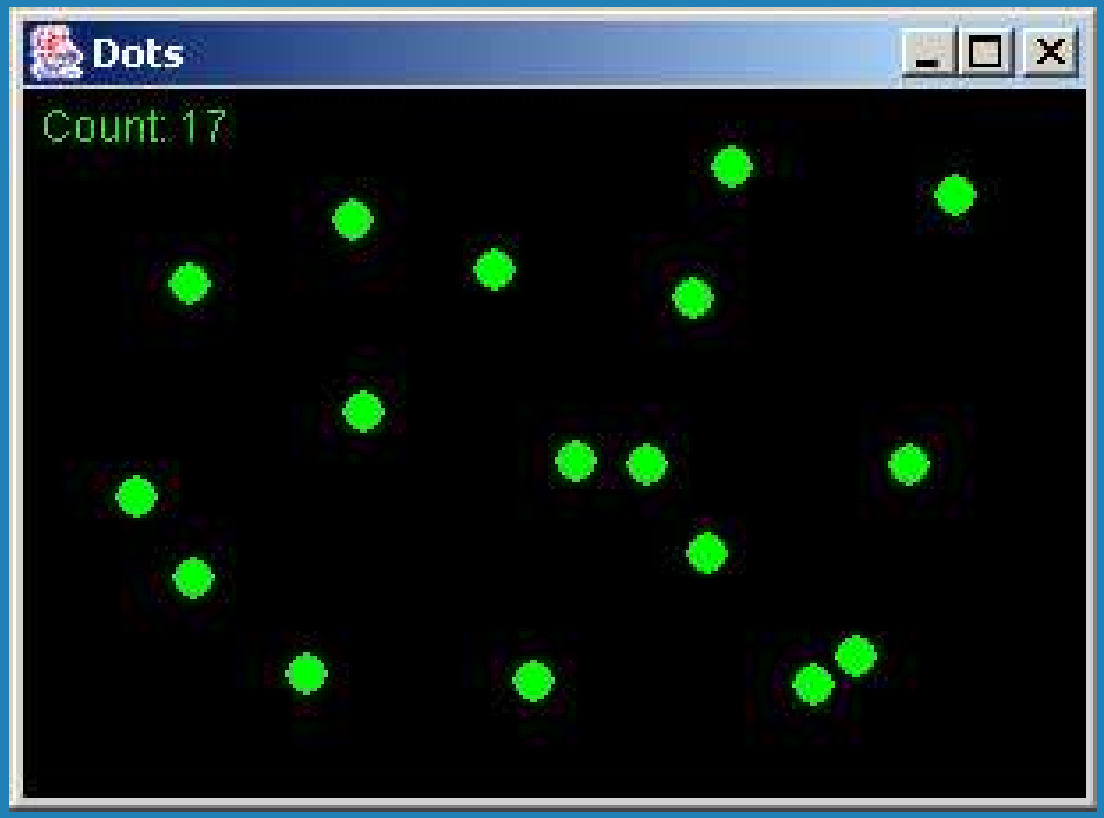
Mouse Events

- Events related to the mouse are separated into *mouse events* and *mouse motion events*
- Mouse Events:
  - *mouse pressed* – the mouse button is pressed down
  - *mouse released* – the mouse button is released
  - *mouse clicked* – the mouse button is pressed down and released without moving the mouse in between
  - *mouse entered* – the mouse pointer is moved onto (over) a component
  - *mouse exited* – the mouse pointer is moved off of a component

Mouse Events

- Mouse Motion Events:
  - *mouse moved* – the mouse is moved
  - *mouse dragged* – the mouse is dragged
- To satisfy the implementation of a listener interface, empty methods must be provided for unused events
- An **`ArrayList`** object is used to store objects so they can be redrawn as necessary
- See `Dots.java` (page 427)
- See `DotsPanel.java` (page 428)

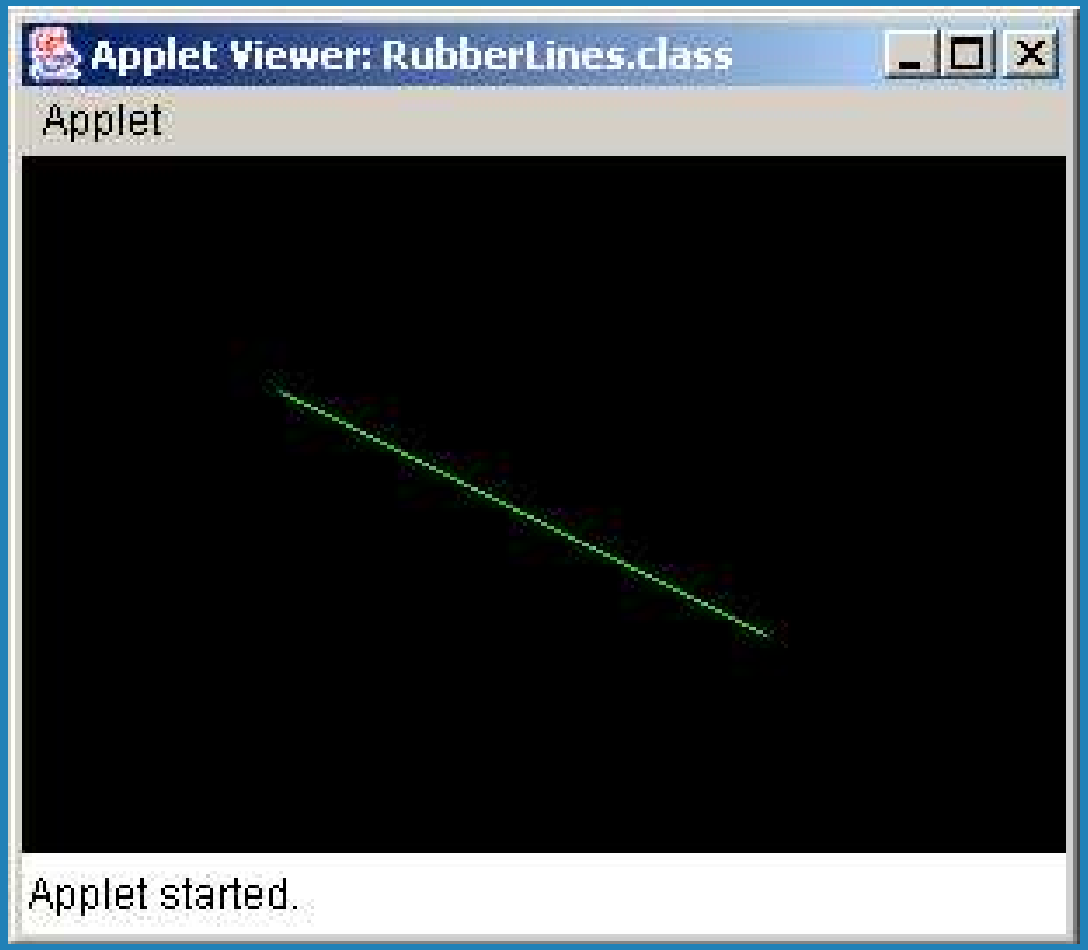
The Dots Program



Mouse Events

- Each time the `repaint` method is called on an applet, the window is cleared prior to calling `paint`
- *Rubberbanding* is the visual effect caused by "stretching" a shape as it is drawn using the mouse
- See `RubberLines.java` (page 431)
- See `RubberLinesPanel.java` (page 432)

The RubberLines Program



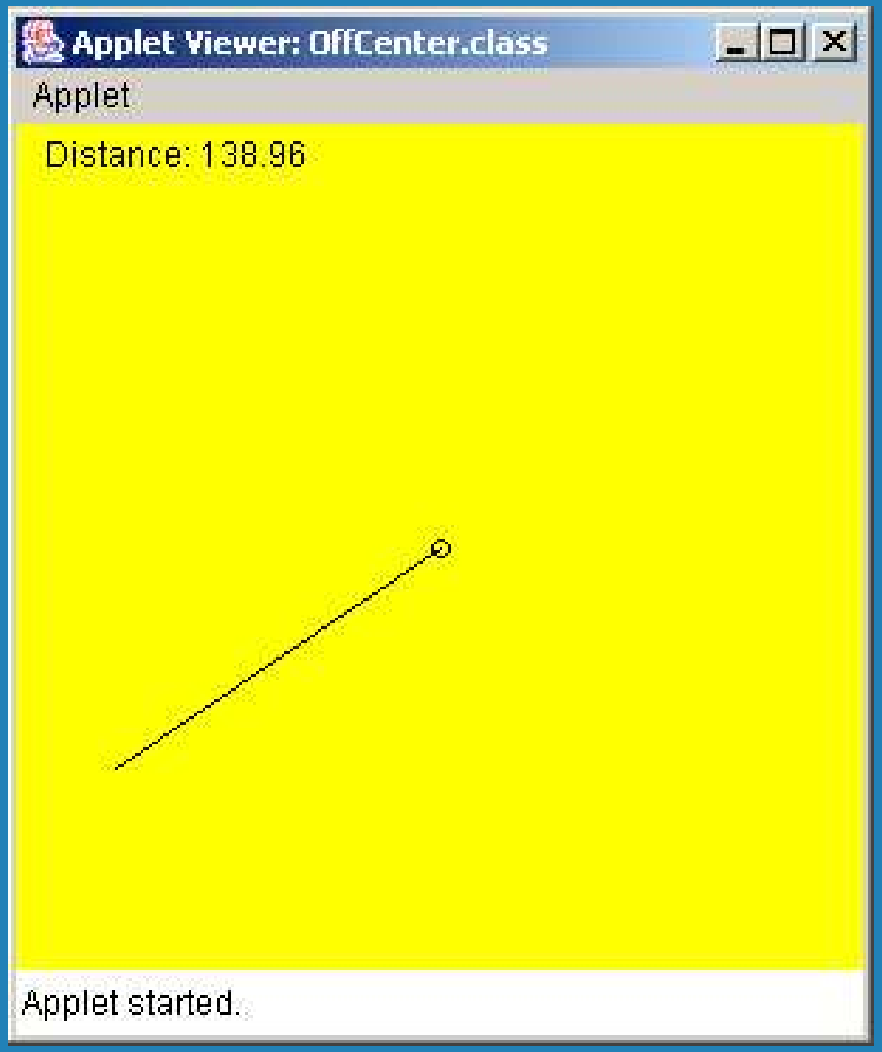
Event Adapter Classes

- Listener classes can be created by implementing a particular interface (such as `MouseListener` interface)
- A listener also can be created by extending an *event adapter class*
- Each listener interface has a corresponding adapter class (such as the `MouseAdapter` class)
- Each adapter class implements the corresponding listener and provides empty method definitions

Event Adapter Classes

- When we derive a listener class from an adapter class, we override any event methods of interest (such as the `mouseClicked` method)
- Empty definitions for unused event methods need not be provided
- See `OffCenter.java` (page 435)
- See `OffCenterPanel.java` (page 437)

The OffCenter Program



Summary

- Chapter 7 has focused on:
  - deriving new classes from existing classes
  - creating class hierarchies
  - the `protected` modifier
  - polymorphism via inheritance
  - inheritance hierarchies for interfaces
  - inheritance used in graphical user interfaces