Beyond Interfaces - Delegation & Multiple Inheritance in Java

- **There are many widgets whose job is to show a value from a range of integer values, like progress bars, sliders, scrollbars, etc.**
- **The common functionality of storing one value from a specified range is described by an interface:**

```
public interface BoundedRangeInterace
{
    int getValue();
    int getMinimum();
    int getMaximum();
    void setValue(int newValue);
    ..................          // lots of more methods
}
```

- **The widgets that need to use this are JSlider and JProgressBar. However, they do not implement the interface, though they provide all the methods.**
- **Instead, there is a DefaultBoundedRangeModel class which implements this interface.**

Class implementing Interface

```
public class DefaultBoundedRangeModel implements
        BoundedRangeInterface, Serializable
{
   private int value = 0;
   private int min = 0;
   private int max = 100;

   public int getValue() {
     return value;
   }

   public int getMinimum() {
     return min;
   }

   public int getMaximum() {
      return max;
   }
    .................
}
```

```
public interface BoundedRangeInterface
{
    int getValue();

    int getMinimum();

    int getMaximum();

    void setValue(int newValue);
    ..................
}
```

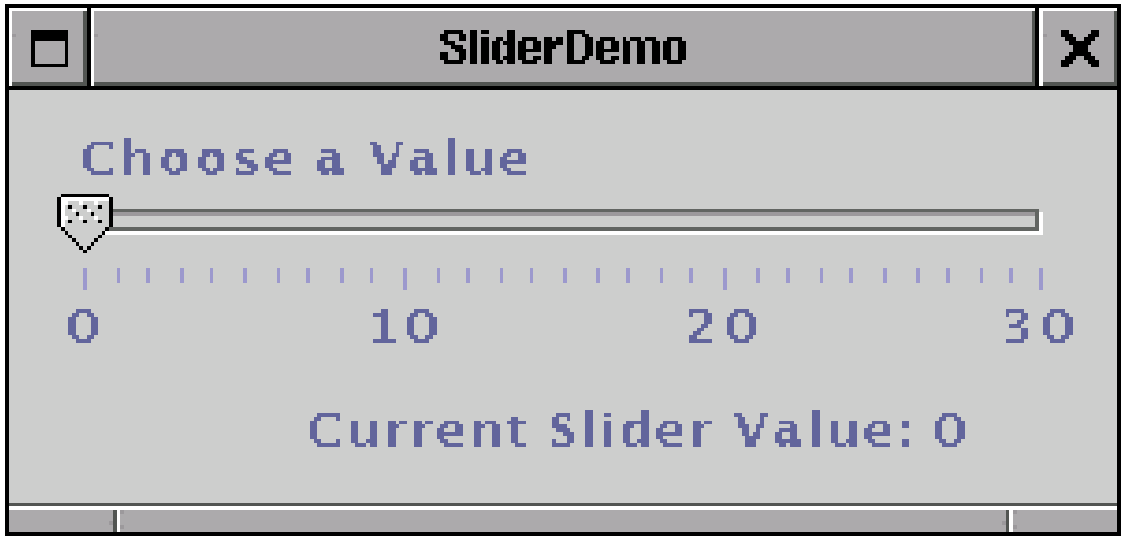
- **Both classes JSlider and JProgressBar have an instance of the BoundedRangeModel class as a member. This lets them use the methods as implemented in the DefaultBoundedModelClass.**

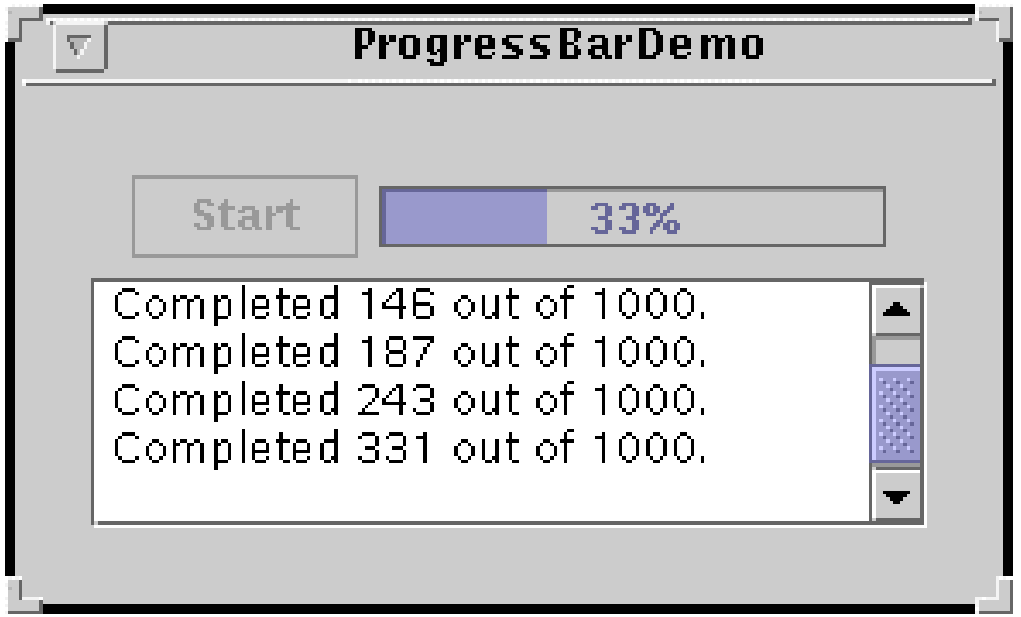
Delegation as Alternative to Inheritance

```
public class JSlider extends JComponent implements
             SwingConstants, Accessible
{
➜ protected BoundedRangeModel sliderModel;

   public JSlider(int orientation, int min, int max, int value)    {
      checkOrientation(orientation);
      this.orientation = orientation;
➜     sliderModel = new DefaultBoundedRangeModel(value, 0, min, max);
      sliderModel.addChangeListener(changeListener);
      updateUI();
   }

➜ public BoundedRangeModel   getModel() { return sliderModel;  }

➜ public int   getValue() { return getModel().getValue();  }

➜ public void setValue(int n) {
      BoundedRangeModel m = getModel();
      int oldValue = m.getValue();
      m.setValue(n);  //..... more stuff, to update slider
   }

➜ public int   getMinimum() { return getModel().getMinimum();  }
    .............
}
```

Similar use of Delegation in JProgressBar

```
public class JProgressBar extends JComponent implements
                                    SwingConstants, Accessible
{
   protected BoundedRangeModel model;
   public JProgressBar(int orient, int min, int max)  {
      setModel(new DefaultBoundedRangeModel(min, 0, min, max));
      updateUI();
   }
   public JProgressBar(BoundedRangeModel newModel)  {
      setModel(newModel);
      updateUI();
   }

   public BoundedRangeModel getModel() { return model; }
            /* ALL OF THE MODEL METHODS ARE IMPLEMENTED BY DELEGATION. */
   public int getValue()  { return getModel().getValue(); }
   public int getMinimum()  { return getModel().getMinimum(); }
   public int getMaximum()  { return getModel().getMaximum(); }

   public void setValue(int n) {
      BoundedRangeModel brm = getModel();
           int oldValue = brm.getValue();
           brm.setValue(n);
   }
}
```


SliderDemo
Choose a Value
0
10
20
30
Current Slider Value: 0


ProgressBarDemo
Start
33%
Completed 146 out of 1000.
Completed 187 out of 1000.
Completed 243 out of 1000.
Completed 331 out of 1000.

Window Events

Window events are associated with:

- Iconifying / Deiconifying a window (Minimizing a window)
- Activating / Deactivating a window (Selecting a window by clicking inside)
- Closing a window (Typically to exit program)

  ... and others.

We'd like to be able write listeners for these events when needed.

The listeners are described by the *interface* WindowListener:

```
public interface WindowListener extends EventListener  {
        // Invoked the first time a window is made visible:
    public void windowOpened(WindowEvent e);
        // Invoked when a window has been closed:
    public void windowClosed(WindowEvent e);
        // Invoked when a window is  minimized:
    public void windowIconified(WindowEvent e);
        // Invoked when a window is expanded to a normal state:
    public void windowDeiconified(WindowEvent e);    //.....  etc.
}
```

Adapters - Another Approach for Inheritance

- Provides ad hoc selective adaptation of each class **instance** created
- We don't want to implement this interface each time we write a class for a window. ◆ The solution: Sun provides an (abstract) class windowAdapter, that *implements* the interface WindowListener.

  public abstract class **WindowAdapter**
  extends Object
  implements WindowListener
- An abstract adapter class for receiving window events..
- Extend this class to create a WindowEvent listener and *override* the methods for the events of interest.
- **If you implement the WindowrListener interface directly, you have to define all of the methods in it. This abstract class defines null methods for them all, so you can only have to define methods for events you care about.**
- Create a listener object using the extended class and then register it with a Window using the window's addWindowListener method.

The Adapter Class

```
public abstract class WindowAdapter implements WindowListener
{
    public void windowOpened(WindowEvent e) {}

    public void windowClosed(WindowEvent e) {}

    public void windowIconified(WindowEvent e) {}

    public void windowDeiconified(WindowEvent e) {}
    ..............
}
```

Using an Adapter Classe

- Add a WindowListener to our Windows and Frames, just by defining an *anonymous* extension of WindowAdapter. The JSlider demo attached works this way:

```
public class SliderDemo extends JFrame implements ChangeListener {
    JSlider mySlider;
    JLabel myValue;

  /* The constructor */
  public SliderDemo(String windowTitle) {
    super(windowTitle);
    ..................
    // Add a listener for window events:
    addWindowListener ( new WindowAdapter() {
        public void windowClosed(WindowEvent e) { System.exit(0); }
    } );
  }
```

Dynamic Instance Inheritance

```
// Much elided and simplified
// visibility modifiers dropped.
/*   instances inherit values from
 *       other instances
 *   dynamic property values
 *   dynamic inheritance hierarchy */

import java.awt.Color;

class Length {
  int  pts;  // assume that pts are universal
  Length(int pts)  { this.pts = pts; }

  public String toString()
    { return String.valueOf(pts) + " pts"; }
}

class Element {
  final static Color  DEFAULT_COLOR   = Color.black;
  final static Length DEFAULT_PADDING = new Length(0);

  Element container;  // ...a root element has container == null

// For the following fields, a a null value at Access Time
// means "no local value,"  i.e., "inherit from container"...
  Color   color;
  Length  paddingLeft;

  Element()
    { container = null;  color = null; }
```

Dynamic Instance Inheritance -- cont'd

```
Element getContainer()
  { return container; }

 void setContainer(Element container)
  { this.container = container; }

 Color getColor() {
  if (color != null)
    // override container...
    return color;

  if (container == null)
    // no value defined...
    return DEFAULT_COLOR;

  // inherit value from container...
  return container.getColor();
 }

  void setColor(Color color)
  { this.color = color; }

 Length  getPaddingLeft() // ...no chaining
  { return (paddingLeft != null) ? paddingLeft : DEFAULT_PADDING; }

 void setPaddingLeft(Length padding)
  { paddingLeft = padding; }
}
```

Document Structure - Instance Inheritance

```
class BlockElement  extends Element { /* ... */ }
class InlineElement extends Element { /* ... */ }

class HTMLElement   extends Element { /* ... */ }
class BodyElement   extends Element { /* ... */ }

class ParagraphElement     extends  BlockElement { /* ... */ }
class UnorderedListElement extends  BlockElement { /* ... */ }
class ListItemElement      extends  BlockElement { /* ... */ }
class BoldElement          extends InlineElement { /* ... */ }

class ElementTest {
  public static void main(String[] as) {
    // <html>                                      <!-- html -->
    //   <body>                                     <!-- body -->
    //     <p style="color: red; padding-left: 10pt">  <!--  p0  -->
    //       <b>bold and red</b>                        <!--  b0  -->
    //       <ul style="color: green">                  <!-- ul0  -->
    //         <li> <b>bold and green</b>                 <!-- li0 & b1 -->
    //       </ul>
    //     </p>
    //   </body>
    // </html>
```

```
HTMLElement          html = new HTMLElement();
BodyElement          body = new BodyElement();
ParagraphElement      p0   = new ParagraphElement();
BoldElement          b0   = new BoldElement();
UnorderedListElement  ul0  = new UnorderedListElement();
ListItemElement       li0  = new ListItemElement();
BoldElement          b1   = new BoldElement();

body.setContainer(html);
p0  .setContainer(body);
b0  .setContainer(p0);
ul0 .setContainer(p0);
li0 .setContainer(ul0);
b1  .setContainer(li0);

p0  .setColor(Color.red);
p0  .setPaddingLeft(new Length(10));

ul0 .setColor(Color.green);

System.out.print ("b0.color has-value ");
System.out.println(b0.getColor());  // red    (inherited from  p0)
System.out.print ("b1.color has-value ");
System.out.println(b1.getColor());  // green  (inherited from ul0)

System.out.print ("p0 .padding-left has-value ");
System.out.println(p0 .getPaddingLeft());  // 10 pts  (local)
System.out.print ("ul0.padding-left has-value ");
System.out.println(ul0.getPaddingLeft());  //  0 pts  (not inherited)
```

```
// PROPERTIES CAN BE DYNAMICALLY MODIFIED...
System.out.println();
System.out.println("p0.color = blue");
p0 .setColor(Color.blue);
System.out.print ("b0.color has-value ");
System.out.println(b0.getColor());  // blue  (inherited from p0)
// ...i.e., "bold and red" is now in blue.
//.AND PROPERTIES CAN LIKEWISE BE DYNAMICALLY OVERRIDDEN
System.out.println("b0.color = red");
b0 .setColor(Color.red);
System.out.print ("b0.color has-value ");
System.out.println(b0.getColor());  // red  (local value overrides p0)
// ...i.e., "bold and red" is back to red.
System.out.println("unset b0.color");
b0 .setColor(null);
System.out.print ("b0.color has-value ");
System.out.println(b0.getColor());  // blue  (inherited from p0)
  // ...i.e., "bold and red" is blue again.
System.out.println("p0.color = red");
p0 .setColor(Color.red);
```

Document Structure - Instance Inheritance - cont'd

```
    System.out.print ("b0.color has-value ");
    System.out.println(b0.getColor());  // red   (inherited from p0)

      // ...i.e., "bold and red" is back to red.

    // THE INHERITANCE HIERARCHY ITSELF IS ALSO DYNAMIC...

    System.out.println();

    System.out.println("b0.container = li0");
    b0 .setContainer(li0);
    System.out.println("b1.container = p0");
    b1 .setContainer(p0);

    System.out.print ("b0.color has-value ");
    System.out.println(b0.getColor());  // green  (inherited from ul0)
    System.out.print ("b1.color has-value ");
    System.out.println(b1.getColor());  // red    (inherited from  p0)

      // ...i.e., "bold and green" is now in red, and "bold and red"
      //  is in green, :).
  }
}
// actually, System.out.println(b0.getColor()) prints...
// java.awt.Color[r=255,g=0,b=0]
```

Extra Slides

Employee - base object

The only difference between the simple Java and JavaScript Employee definitions:

- specify the type for each property in Java but not in JavaScript
- create an explicit constructor method for the Java class

JavaScript	Java

function Employee () {
  this.name = "";
  this.dept = "general";
}
	public class Employee {
	  public String name;
	  public String dept;
	  public Employee () {
	  this.name = "";
	  this.dept = "general";
	  }
	}

The Manager and WorkerBee definitions show the difference in how you specify the

next object higher in the inheritance chain.

- **JavaScript**: add a prototypical instance as the value of the prototype property of the constructor function. You can do so at any time after you define the constructor.
- **Java**: specify the superclass within the class definition. You cannot change the superclass outside the class definition.

JavaScript	Java

`function Manager () {`
`  this.reports = [];`
`}`
`Manager.prototype = new Employee;`
 	
`function WorkerBee () {`
`  this.projects = [];`
`}`
`WorkerBee.prototype = new Employee;`
	`public class Manager extends Employee {`
	`  public Employee[] reports;`
	`  public Manager () {`
	`  this.reports = new Employee[0];`
	`  }`
	`}`
	
	`public class WorkerBee extends Employee {`
	`  public String[] projects;`
	`  public WorkerBee () {`
	`  this.projects = new String[0];`
	`  }`
	`}`

- Engineer & SalesPerson definitions create objects that **descend from** WorkerBee & Employee.
- An object of these types has properties of ancestor objects above it in the linear (single) chain.
- In addition, the constructor definitions **override** the inherited value of the dept property with new values specific to these objects.

JavaScript	Java

`function SalesPerson () {`
`  this.dept = "sales";`
`  this.quota = 100;`
`}`
`SalesPerson.prototype = new WorkerBee;`
	`public class SalesPerson extends WorkerBee {`
	`  public double quota;`
	`  public SalesPerson () {`
	`  this.dept = "sales";`
	`  this.quota = 100.0;`
	`  }`
	`}`

`function Engineer () {`
`  this.dept = "engineering";`
`  this.machine = "";`
`}`
`Engineer.prototype = new WorkerBee;`
	`public class Engineer extends WorkerBee {`
	`  public String machine;`
	`  public Engineer () {`
	`  this.dept = "engineering";`
	`  this.machine = "";`
	`  }`
	`}`

Specifying Properties in Constructors - 1

JavaScript	Java

function Employee (name, dept) {
  this.name = name || "";
  this.dept = dept || "general";
}
	public class Employee {
	  public String name;
	  public String dept;
	  public Employee () {
	  this("", "general");
	  }
	  public Employee (name) {
	  this(name, "general");
	  }
	  public Employee (name, dept) {
	  this.name = name;
	  this.dept = dept;
	  }
	}

Specifying Properties in Constructors - 2

JavaScript	Java

`function WorkerBee (projs) {`
`  this.projects = projs || [];`
`}`
`WorkerBee.prototype = new Employee;`
	`public class WorkerBee extends Employee {`
	`  public String[] projects;`
	`  public WorkerBee () {`
	`  this(new String[0]);`
	`  }`
	`  public WorkerBee (String[] projs) {`
	`  this.projects = projs;`
	`  }`
	`}`

`function Engineer (mach) {`
`  this.dept = "engineering";`
`  this.machine = mach || "";`
`}`
`Engineer.prototype = new WorkerBee;`
	`public class Engineer extends WorkerBee {`
	`  public String machine;`
	`  public WorkerBee () {`
	`  this.dept = "engineering";`
	`  this.machine = "";`
	`  }`
	`  public WorkerBee (mach) {`
	`  this.dept = "engineering";`
	`  this.machine = mach;`
	`  }`
	`}`