Objectives

- GUIs in Java
- Layout Managers
- Event Handling

Assignment 11 Notes

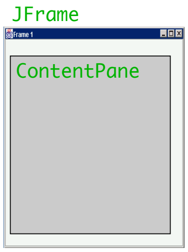
- Focus on Extensibility
- But, handle other code smells as well
- Any questions

GUI Review

- What are the two main packages for GUI development in Java?
- Is GUI development looking a little difficult?
  - Why?

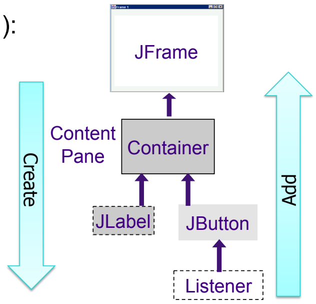
Review: JFrame

- Top-level window
  - Has title, border
- Contains `ContentPane`
  - A `Container` object that holds components you add, placing them in the frame
  - The part of the frame that holds UI components



Review: Building a GUI

1. Create (top down):
   - Frame
   - Container
   - Components
   - Listeners
2. Add (bottom up):
   - Listeners into components
   - Components into panel
   - Panel into frame



More GUI Components

- Choice
  - Drop-down list
- FileDialog
  - Opening and saving files
- List
  - Scrollable
  - Allows multiple selections
- ScrollPane
  - scrollbars
- TextField
  - Single line of text
- TextArea
  - Multiple lines of text

Menus

- `MenuBar`
  - Thing across top of frame
  - `Frame: setMenuBar(MenuBar mb);`
- Menu
  - The dropdown part
  - A sequence of `MenuItems`
  - `Menu` is a subclass of `MenuItems`, so can have submenus

Practice: Combining Components

- Create a panel with three buttons on it

`ButtonPanel.java`

Placement of Components

- How does the panel know where to place a button?
- How does the panel know where to place the next button?
- How does the panel know where to place *any* component that is added to it?

LAYOUT MANAGERS

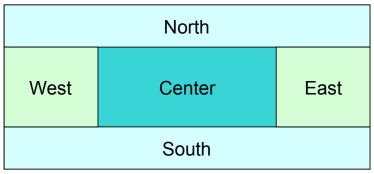
Layout Managers

- Java uses ***layout managers*** to place components inside a container
- `LayoutManager` automatically handles placement of components
  - When a component is added to a container (through `add()`), layout manager decides where to place the component

Border Layout Manager

- Default layout manager of the content pane for `JFrame`
- Lets you choose where you want to place each component
  - Center
  - North
  - South with respect to the container
  - East
  - West

Border Layout Regions



- Edge components are laid out first
- *Center occupies remaining space*

Border Layout Rules

- Grows all components to fill available space
- If container is resized, edge components are redrawn and center region size recomputed
- To add a component to a container using a border layout
  - Ex: `JFrame`'s content pane

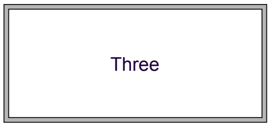
```
Container contentPane = getContentPane();
contentPane.add(button, BorderLayout.SOUTH);
```

Adding Components Using a Border Layout

```
Container contentPane = getContentPane();
contentPane.add(button, BorderLayout.SOUTH);
```

- If no region of the layout is specified
  - Assumes center region
- Since border layout grows the component to fit specified region
  - What happens if we add multiple components, e.g., three buttons, without specifying a region?

A Border Layout Limitation



- Last button added grows to completely fill center region
- First two buttons were discarded/overwritten by each subsequently added component

Changing Layout Managers

- Any container can use any layout manager
- Use `setLayout()` to change layout manager *before adding components*

```
// sets layout to a new flow layout manager that
// aligns row components to the left and uses a 20 pixel
// horizontal separation and 20 pixel vertical separation
setLayout(new FlowLayout(FlowLayout.LEFT, 20, 20));

// sets layout to a new border layout manager that
// uses a 45 pixel horizontal separation between components
// (regions) and a 20 pixel vertical separation
setLayout(new BorderLayout(45, 20));
```

The Flow Layout Manager

- Default layout manager for a *panel*
  - (not `JFrame`)
  - What I changed our `JFrame` to use
- Lines components up horizontally until no more room in container
  - Then starts a new row of components
- If user resizes component, layout manager automatically reflows components

The Flow Layout Manager

- Can choose how to arrange components in a row
  - Default: center each row
  - Other options: left or right align
- Change alignment using `setLayout`

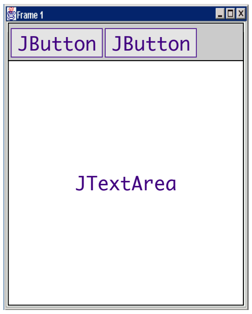
```
setLayout(new FlowLayout( FlowLayout.LEFT ));
```

  - Panel set to use a flow layout manager, with row components aligned to the left
- Another constructor has *hgap* and *vgap* for gaps to put around components

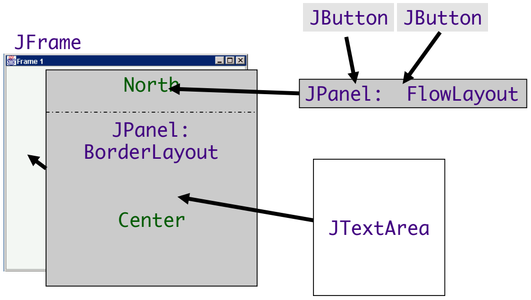
Combining Panels

- **Panels** act as (smaller) containers for UI elements
- Can be arranged inside a larger panel by a layout manager
- Use additional panels to address Border Layout problem
  - Create a panel
  - Add some buttons to it
  - Add that panel to a region in content pane

Combining Panels



Combining Panels


JFrame

JButton JButton

JPanel: FlowLayout

North

JPanel: BorderLayout

Center

JTextArea

Using Additional Panels

- Get fairly accurate and precise placement of components
- Use nested panels with

Layout	Use
BorderLayout	Content panes and enclosing panels
Flow Layouts	Panels containing buttons and other UI components

`FlexibleLayout.java`

Grid Layout Manager

- Divides container into columns and rows of equal size, which collectively occupy the entire container region
- Rows and columns are aligned like a spreadsheet
  - When the container is resized, the “cells” grow and/or shrink
  - Cells always maintain identical sizes

Grid Layout Manager Construction

- Number of rows and columns in layout

```
panel.setLayout(new GridLayout(5, 4)); // 5 rows, 4 cols
```

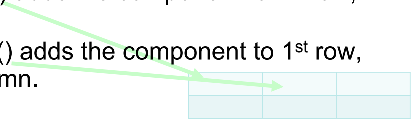
- Can specify a horizontal and vertical separation between rows and columns:

```
panel.setLayout(new GridLayout(5, 4, 20, 20));
// 5 rows, 4 cols, 20 pixels between rows & between cols
```

  - ➢Can also specify with border and flow layout managers

Adding Components to a Grid Layout

- Components added *sequentially*
- 1st add() adds the component to 1st row, 1st column
- 2nd add() adds the component to 1st row, 2nd column.

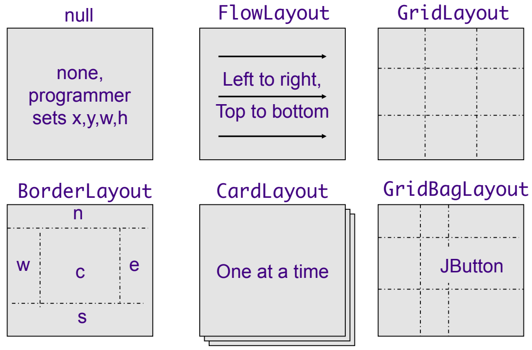


- And so forth until 1st row is filled
- Then 2nd row begins with the 1st column
- Continues until the entire container is filled

Grid Layout Rules

- Components are resized to take up entire cell
- Restrictive but can be useful for some applications
- Example: Create a row of buttons of identical size
  1. Make a panel that has a grid layout with one row
  2. Add a button to each cell
  3. Set horiz/vert separation, so buttons are not touching

Layout Manager Heuristics



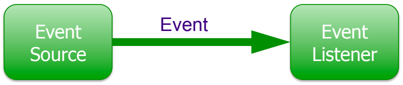
HANDLING USER INTERACTIONS

Event-Driven Programming

- User actions (e.g., mouse clicks, key presses), sensor outputs, or messages from other applications determine flow of program
- Application architecture:

```
while ( true ) {
     event = waitForEvent();
     handleEvent(event);
}
```

Event Basics



- An ***event*** is generated from an ***event source*** and is transmitted to an ***event listener***
- Event sources allow event listeners to ***register*** with them
  - Registered listener requests event source send its event to listener when event occurs

Java Event Handling

- All events are objects of event classes
  - Derive from `java.util.EventObject`
- **Event source**
  - Sends out event objects to *all registered* listeners when that event occurs
- **Listener**
  - Implements a listener interface
  - Uses `EventObject` to determine its reaction to the event

Java Event Handling

- Register a listener with an event source:

```
eventSourceObject.addEventListener(
        eventListenerObject);
```

- Example:

```
ActionListener listener = . . .;
JButton button = new JButton(“Click Me!”);
button.addActionListener(listener);
```

  - Whenever an “action event” occurs on `button`, `listener` is notified
    - For buttons, an action event is a button click

Listener Objects

- A listener object must be an instance of a class that implements the appropriate interface
  - For buttons, that’s **`ActionListener`**
- Listener class must implement `actionPerformed(ActionEvent event)`

Listener Objects and Event Handling

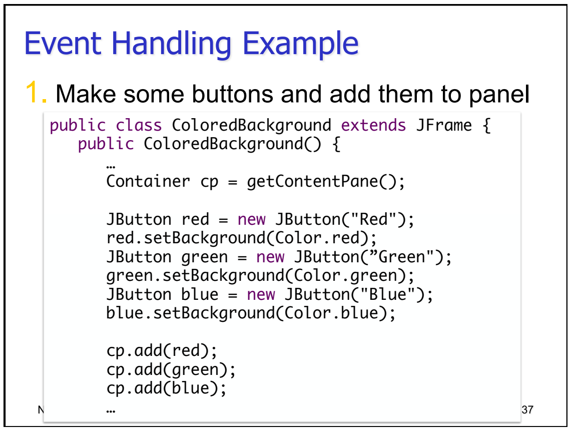
- When a user clicks a button, **`JButton`** object generates an `ActionEvent` object

Which makes `JButton` a *what*?

- `JButton` calls listener object’s `actionPerformed` method, passing generated event object
- A single event source can have *multiple listeners* listening for its events
  - Source calls `actionPerformed` on each of its listeners

An Example of Event Handling

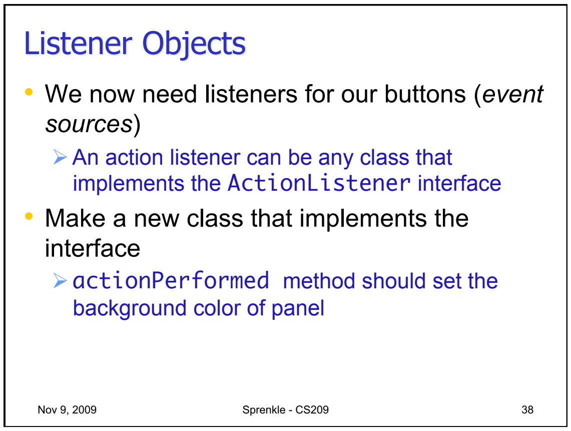
- Suppose we want to make a panel that has three buttons on it
  - Each button has a color associated with it
  - When user clicks a button, background color of panel changes to the corresponding color
- We need
  1. A panel with 3 buttons on it
  2. 3 listener objects, one registered to listen for a button’s events



Event Handling Example

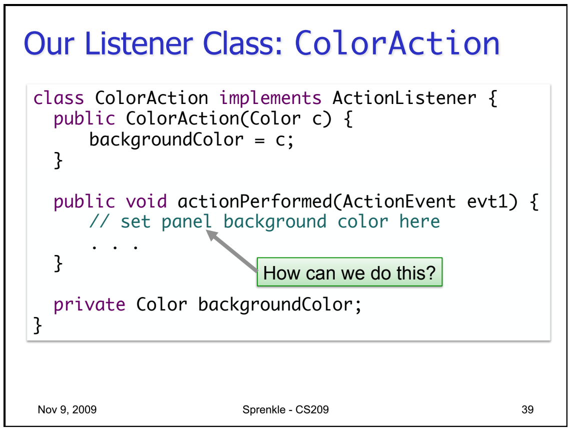
1. Make some buttons and add them to panel

```
public class ColoredBackground extends JFrame {
   public ColoredBackground() {
      …
      Container cp = getContentPane();

      JButton red = new JButton("Red");
      red.setBackground(Color.red);
      JButton green = new JButton(”Green");
      green.setBackground(Color.green);
      JButton blue = new JButton("Blue");
      blue.setBackground(Color.blue);

      cp.add(red);
      cp.add(green);
      cp.add(blue);
      …
```



Listener Objects

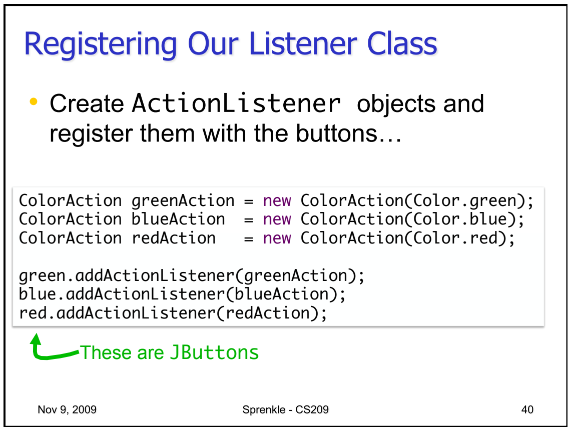
- We now need listeners for our buttons (*event sources*)
  - An action listener can be any class that implements the `ActionListener` interface
- Make a new class that implements the interface
  - `actionPerformed` method should set the background color of panel



Our Listener Class: `ColorAction`

```
class ColorAction implements ActionListener {
  public ColorAction(Color c) {
      backgroundColor = c;
  }

  public void actionPerformed(ActionEvent evt1) {
      // set panel background color here
      . . .
  }

  private Color backgroundColor;
}
```

How can we do this?

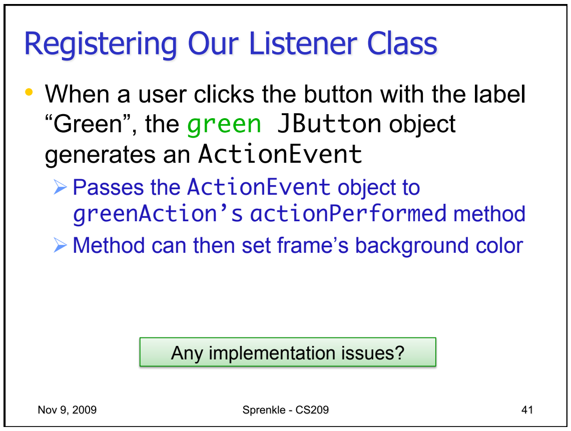


Registering Our Listener Class

- Create `ActionListener` objects and register them with the buttons…

```
ColorAction greenAction = new ColorAction(Color.green);
ColorAction blueAction  = new ColorAction(Color.blue);
ColorAction redAction   = new ColorAction(Color.red);

green.addActionListener(greenAction);
blue.addActionListener(blueAction);
red.addActionListener(redAction);
```

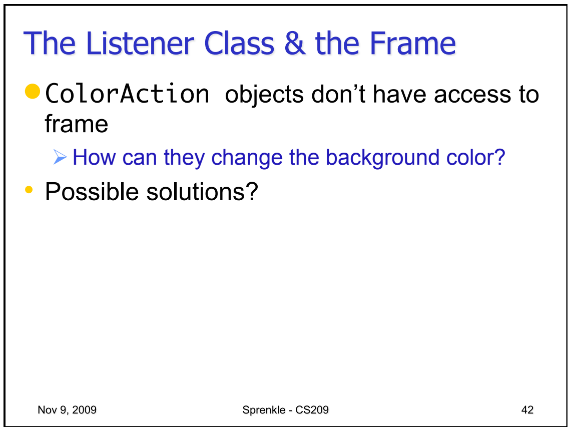
These are `JButtons`



Registering Our Listener Class

- When a user clicks the button with the label “Green”, the `green` `JButton` object generates an `ActionEvent`
  - Passes the `ActionEvent` object to `greenAction’s` `actionPerformed` method
  - Method can then set frame’s background color

Any implementation issues?



The Listener Class & the Frame

- `ColorAction` objects don’t have access to frame
  - How can they change the background color?
- Possible solutions?

The Listener Class & the Frame

- `ColorAction` objects don't have access to frame
  - How can they change the background color?
- Two possible solutions:
  1. Add a frame instance field to `ColorAction` class and set it in constructor
     - `ColorAction` object knows which frame it is associated with and can call appropriate method to change its background color
  2. Make `ColorAction` an ***inner*** class of class

Listener as an Inner Class

```
class ColoredBackground extends JFrame {
   // ColoredBackground code …
   . . .

   private class ColorAction implements ActionListener {
     . . .
     public void actionPerformed(ActionEvent evt) {
            setBackground(backgroundColor);
            repaint();
     }
     private Color backgroundColor;
   }
}
```

Where are these methods coming from?

Close Up: `actionPerformed()`

```
public void actionPerformed(ActionEvent evt) {
      setBackground(backgroundColor);
      repaint();
}
```

- `ColorAction` does not have `setBackground()` or `repaint()` method
- Since `ColorAction` is an *inner class* of `ColoredBackground`, `ColorAction` can *directly access* `ColoredBackground`'s instance fields and methods
  1. Inner class calls outer class's method
     - Parameter: inner's private data (`backgroundColor`)
  2. Inner calls outer class's `repaint()` method
     - Redraw the frame

Event Listeners as Inner Classes

- A common and beneficial practice
- Event listener objects typically need to access/modify other objects when their corresponding event occurs
- It is often possible to place the listener class inside the class whose state the listener should modify
- It's also good OOP design
  - Doesn't violate encapsulation rules
  - Makes code easier

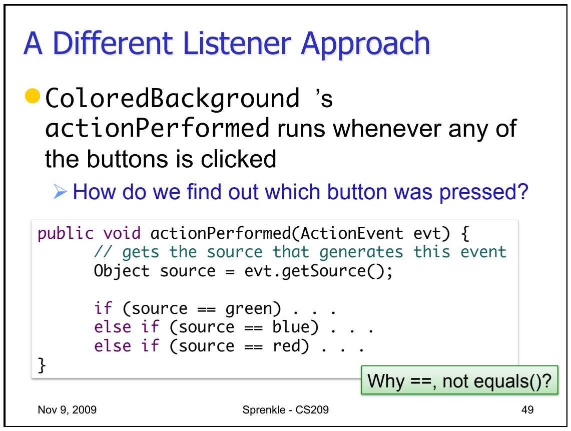
A Different Listener Approach

- Any object of a class that implements `ActionListener` can listen for action events from a source
  - Could make `ColoredBackground` listen for its own buttons' events
  - Implement interface and do correct registering with the buttons

A Different Listener Approach

```
class ColoredBackground2 extends JFrame
      implements ActionListener {

   public ColoredBackground2() {
      . . .
      green.addActionListener(this);
      blue.addActionListener(this);
      red.addActionListener(this);
   }
   . . .

   public void actionPerformed(ActionEvent evt) {
      // set background color
      . . .
   }
}
```

Runs whenever any of the buttons is clicked. What do we need to do in here?

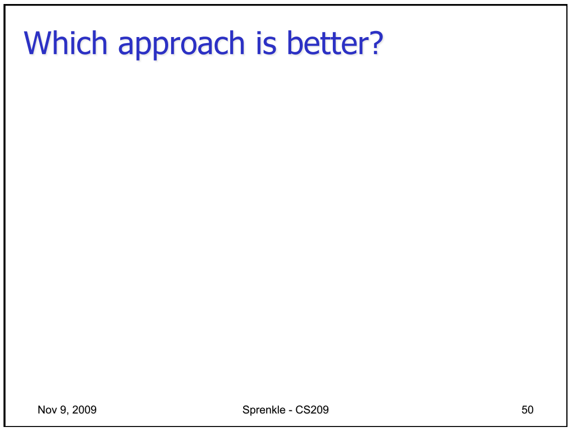


A Different Listener Approach

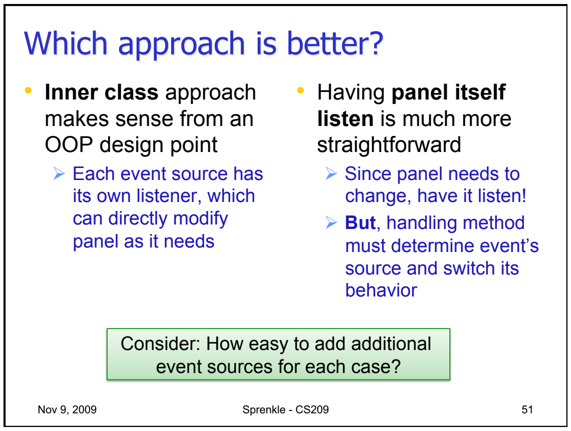
- `ColoredBackground` ’s `actionPerformed` runs whenever any of the buttons is clicked
  - How do we find out which button was pressed?

```
public void actionPerformed(ActionEvent evt) {
      // gets the source that generates this event
      Object source = evt.getSource();

      if (source == green) . . .
      else if (source == blue) . . .
      else if (source == red) . . .
}
```

Why ==, not equals()?



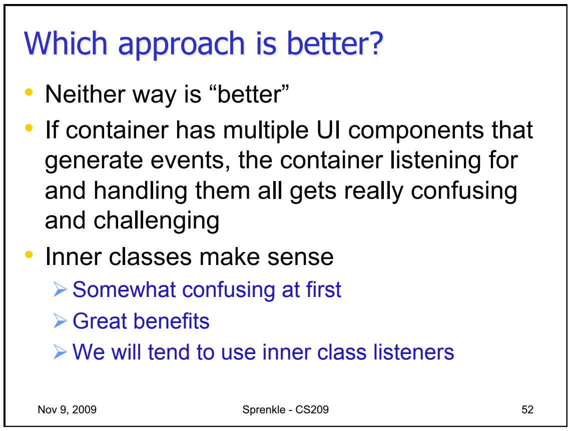
Which approach is better?



Which approach is better?

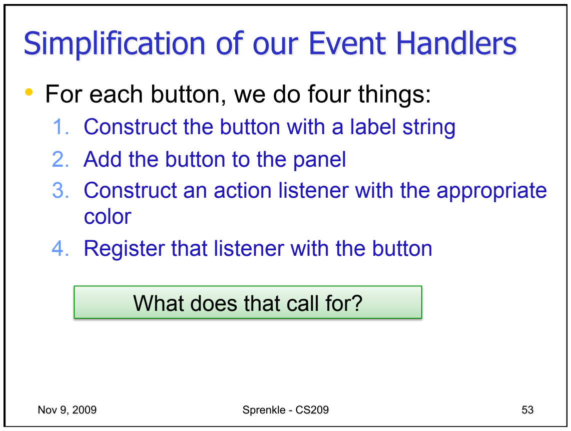
- **Inner class** approach makes sense from an OOP design point
  - Each event source has its own listener, which can directly modify panel as it needs
- Having **panel itself listen** is much more straightforward
  - Since panel needs to change, have it listen!
  - **But**, handling method must determine event’s source and switch its behavior

Consider: How easy to add additional event sources for each case?



Which approach is better?

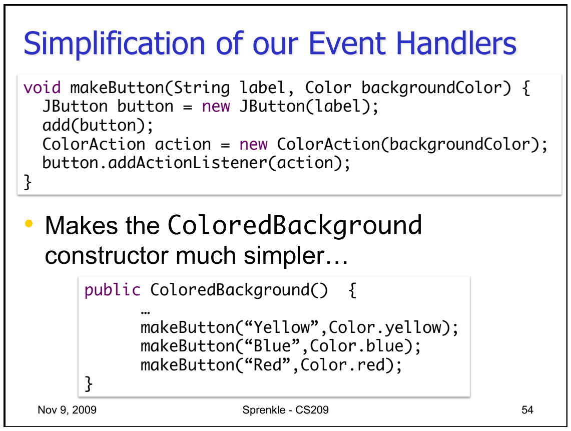
- Neither way is “better”
- If container has multiple UI components that generate events, the container listening for and handling them all gets really confusing and challenging
- Inner classes make sense
  - Somewhat confusing at first
  - Great benefits
  - We will tend to use inner class listeners



Simplification of our Event Handlers

- For each button, we do four things:
  1. Construct the button with a label string
  2. Add the button to the panel
  3. Construct an action listener with the appropriate color
  4. Register that listener with the button

What does that call for?



Simplification of our Event Handlers

```
void makeButton(String label, Color backgroundColor) {
  JButton button = new JButton(label);
  add(button);
  ColorAction action = new ColorAction(backgroundColor);
  button.addActionListener(action);
}
```

- Makes the `ColoredBackground` constructor much simpler…

```
public ColoredBackground()  {
      …
      makeButton(“Yellow”,Color.yellow);
      makeButton(“Blue”,Color.blue);
      makeButton(“Red”,Color.red);
}
```

Simplifying Further

```
void makeButton(String label, Color backgroundColor) {
  JButton button = new JButton(label);
  add(button);
  ColorAction action = new ColorAction(backgroundColor);
  button.addActionListener(action);
}
```

- We *only* use the `ColorAction` class in `makeButton` method
- How can we further simplify the code?

Simplifying Further

- Make the `ColorAction` class an ***anonymous inner class***
- Since only use class at one point, *define class on the fly*

An Anonymous Class Listener

```
void makeButton(String label, final Color bgColor) {
  JButton button = new JButton(label);
  add(button);

  button.addActionListener( new ActionListener() {
         public void actionPerformed(ActionEvent evt) {
            setBackground(bgColor);
            repaint();
         }
      } );
}
```

Anonymous Inner Classes

- Confusing syntax!
- Create a new class that implements `ActionListener` interface
  - Define required method, `actionPerformed`, inside braces
- Any needed parameters are inside the parentheses, following the supertype name:

```
new SuperType(construction parameters) {
      inner class methods and data
};
```

Anonymous Inner Classes

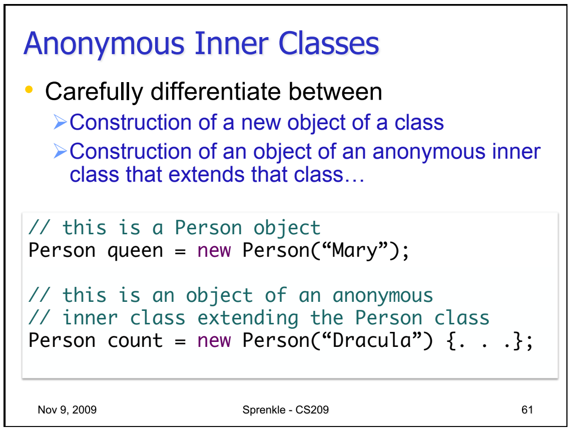
- `Supertype` can be an *interface* or a *class*
  - If an interface, inner class implements the interface and required methods
  - If a class, the inner class extends that class
- Anonymous inner classes do **not** have constructors
  - Parameters are passed to ***superclass's*** constructor
  - If inner class implements an interface, **no** construction parameters

An Anonymous Class Listener

```
void makeButton(String label, final Color bgColor) {
  JButton button = new JButton(label);
  add(button);

  button.addActionListener( new ActionListener() {
         public void actionPerformed(ActionEvent evt) {
            setBackground(bgColor);
            repaint();
         }
      } );
}
```

Interface (no params)

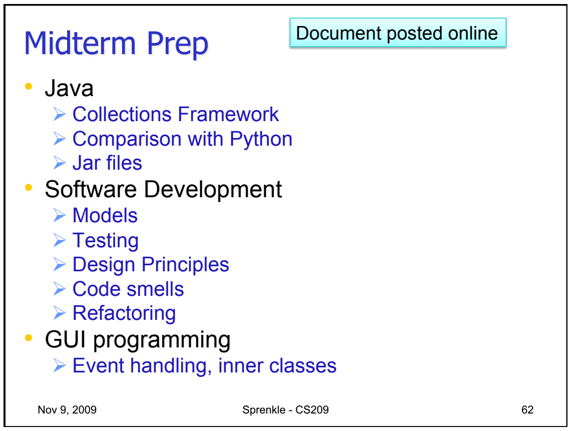
Method required to be implemented for interface



Anonymous Inner Classes

- Carefully differentiate between
  - Construction of a new object of a class
  - Construction of an object of an anonymous inner class that extends that class…

```
// this is a Person object
Person queen = new Person(“Mary”);

// this is an object of an anonymous
// inner class extending the Person class
Person count = new Person(“Dracula”) {. . .};
```



Midterm Prep

Document posted online

- Java
  - Collections Framework
  - Comparison with Python
  - Jar files
- Software Development
  - Models
  - Testing
  - Design Principles
  - Code smells
  - Refactoring
- GUI programming
  - Event handling, inner classes