

GUIs and event driven programming

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- ▶ How do we design graphical user interfaces?
- ▶ Multiple applications simultaneously displayed on screen
- ▶ Keystrokes, mouse clicks have to be sent to appropriate window
- ▶ In parallel to main activity, record and respond to these **events**
 - ▶ Web browser renders current page
 - ▶ Clicking on a link loads a different page

Keeping track of events

Low level solution

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- ▶ Track coordinates of mouse
- ▶ OS reports mouse click at (x, y)
 - ▶ Check which windows are positioned at (x, y)
 - ▶ Check if one of them is “active”
 - ▶ Inform that window about mouse click

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Low level solution

- ▶ Remember coordinates and extent of each window
- ▶ Track coordinates of mouse
- ▶ OS reports mouse click at (x, y)
 - ▶ Check which windows are positioned at (x, y)
 - ▶ Check if one of them is “active”
 - ▶ Inform that window about mouse click
- ▶ Tedious and error-prone

Keeping track of events . . .

Better solution

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 - ▶ Button was clicked, box was ticked . . .

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 - ▶ Button was clicked, box was ticked . . .
- ▶ OS reports low level events
 - ▶ Mouse clicked at (x, y) , key 'a' pressed
- ▶ Run time support for language maps low level events to high level events

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 - ▶ Setting up an association between components and listeners

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- ▶ Different events invoke different functions
 - ▶ Window frame has **Maximize**, **Iconify**, **Close** buttons
- ▶ Language “sorts” out events and automatically calls the correct function in the listener

An example

- ▶ A `Button` with one event, the button being pressed

An example

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- ▶ Pressing the button invokes the function `buttonpush(...)` in a listener

```
interface ButtonListener{  
    public abstract void buttonpush(...);  
}
```

```
class MyClass implements ButtonListener{  
    ...  
    public void buttonpush(...){  
        ...        // what to do when a button is pushed  
    }  
}
```

```
Button b = new Button();  
MyClass m = new MyClass();  
b.add_listener(m);    // Tell b to notify m when pushed
```

An example . . .

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- ▶ We have set up an association between `Button b` and a listener `ButtonListener m`
- ▶ Nothing more needs to be done!
- ▶ Communicating each button push to the listener is done automatically by the run-time system
- ▶ Information about the button push event is passed as an object to the listener
 - ▶ `buttonpush(...)` has arguments
 - ▶ Listener can decipher source of event, for instance

Timer

- ▶ Recall `Timer` example
- ▶ `Myclass m` creates a `Timer t` that runs in parallel
- ▶ `Timer t` notifies a `TimerOwner` when it is done via a function `notify()`
- ▶ In our example, `Myclass m` was itself the `TimerOwner` to be notified
- ▶ In principle, `Timer t` could be passed a reference to **any** object that implements `TimerOwner` interface

Event driven programming in Java

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 - ▶ Three buttons on window frame all report to common listener

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 - ▶ Three buttons on window frame all report to common listener
 - ▶ One component can inform multiple listener
 - ▶ **Exit browser** reported to all windows currently open

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 - ▶ One listener can listen to multiple objects
 - ▶ Three buttons on window frame all report to common listener
 - ▶ One component can inform multiple listener
 - ▶ **Exit browser** reported to all windows currently open
- ▶ Must explicitly set up association between component and listener
- ▶ Events are “lost” if nobody is listening!

A detailed example in Swing

A button that paints its background red

- ▶ `JButton` is Swing class for buttons
- ▶ Corresponding listener class is `ActionListener`
- ▶ Only one type of event, button push — invokes `actionPerformed(...)` in listener
- ▶ Button push is an `ActionEvent`

A detailed example in Swing . . .

```
class MyButtons{
    private JButton b;
    public MyButtons(ActionListener a){
        b = new JButton("MyButton"); // Set the label on the bu
        b.addActionListener(a);      // Associate an listener
    }
}
```

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    }
}
```

```
class MyListener implements ActionListener{
    public void actionPerformed(ActionEvent evt){...}
    // What to do when a button is pressed
}
```

```
class XYZ{
    MyListener l = new MyListener(); // ActionListener l
    MyButtons m = new MyButtons(l);  // Button m, reports to l
}
```

A detailed example in Swing . . .

- ▶ To actually display the button, we have to do more
- ▶ Embed the button in a **panel** — `JPanel`
- ▶ Embed the panel in a **frame** — `JFrame`
- ▶ Display the frame!

A JPanel for our button ...

```
import java.awt.*;
import java.awt.event.*;
import javax.swing.*;

public class ButtonPanel extends JPanel implements ActionListener{
    private JButton redButton;

    public ButtonPanel(){
        redButton = new JButton("Red");        // Create the button
        redButton.addActionListener(this);     // Make panel a listener
        add(redButton);                        // Embed button in panel
    }

    public void actionPerformed(ActionEvent evt){
        Color color = Color.red;              // Set background colour
        setBackground(color);                 // to red when button
        repaint();                             // is clicked
    }
}
```

A `JFrame` for our panel . . .

- ▶ `JFrame` itself generates seven different types of events
- ▶ Corresponding listener class is `WindowListener`
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- ▶ Other six types of events can be ignored

A `JFrame` for our panel . . .

- ▶ `JFrame` itself generates seven different types of events
- ▶ Corresponding listener class is `WindowListener`
 - ▶ Each of the seven events automatically calls a different function in `WindowListener`
- ▶ Need to implement `windowClosing` event to terminate the window
- ▶ Other six types of events can be ignored
- ▶ One more complication
 - ▶ `JFrame` is “complex”, many layers
 - ▶ Items to be displayed have to be added to `ContentPane`

A JFrame for our panel ...

```
public class ButtonFrame extends JFrame implements WindowListener {
    Private Container contentPane;

    public ButtonFrame(){
        setTitle("ButtonTest");  setSize(300, 200);
        addWindowListener(this);  /// ButtonFrame listens to itself
        contentPane = this.getContentPane(); // ButtonPanel is added
        contentPane.add(new ButtonPanel()); // to the contentPane
    }

    // Seven methods required for implementing WindowListener
    // Six out of seven are dummies (stubs)
    public void windowClosing(WindowEvent e){ // Exit when window
        System.exit(0); // is killed
    }

    public void windowActivated(WindowEvent e){}
    ... // 5 more dummy methods
}
```

Finally, a main function

```
import java.awt.*;
import java.awt.event.*;
import javax.swing.*;

public class ButtonTest

{   public static void main(String[] args)
    {   JFrame frame = new ButtonFrame();
        frame.show();
    }
}
```

Three buttons

- ▶ A panel with three buttons, to paint the panel red, yellow or blue
- ▶ Make the panel listen to all three buttons
- ▶ Determine what colour to use by identifying source of the event

```
import java.awt.*;
import java.awt.event.*;
import javax.swing.*;

public class ButtonPanel extends JPanel implements ActionListener{

    private JButton yellowButton;    // Panel has three buttons
    private JButton blueButton;
    private JButton redButton;

    public ButtonPanel(){
        yellowButton = new JButton("Yellow");
        blueButton = new JButton("Blue");
        redButton = new JButton("Red");

        yellowButton.addActionListener(this);    // ButtonPanel is the
        blueButton.addActionListener(this);    // listener for all
        redButton.addActionListener(this);    // three buttons

        add(yellowButton);
        add(blueButton);
        add(redButton);
    }
}
```



```
public class ButtonPanel extends JPanel implements ActionListener{
    ...
    public void actionPerformed(ActionEvent evt){
        Object source = evt.getSource();           // Find the source of the
                                                    // event
        Color color = getBackground();            // Get current background
                                                    // colour

        if (source == yellowButton) color = Color.yellow;
        else if (source == blueButton) color = Color.blue;
        else if (source == redButton) color = Color.red;

        setBackground(color);
        repaint();
    }
}
```