Programmieren II

Graphical Users Interfaces with Swing

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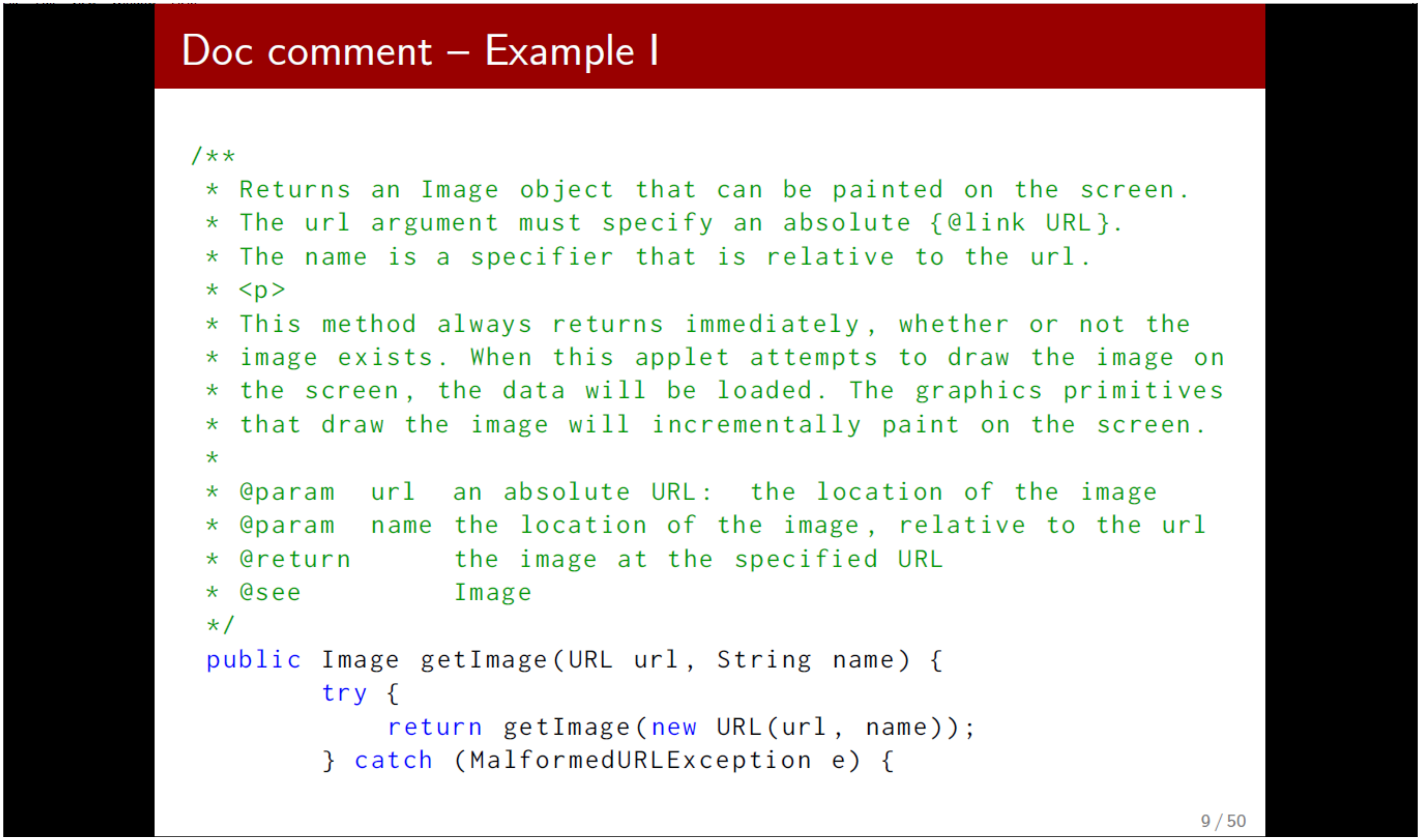
(slides based on material from Richard McKenna, Stonybrook and David Matuszek, U Penn)

July 9th, 2014

Outline

- Recap
  - Javadocs
  - Jar files
  - Ant
- GUI motivation
- GUIs with Swing
- Anonymous classes

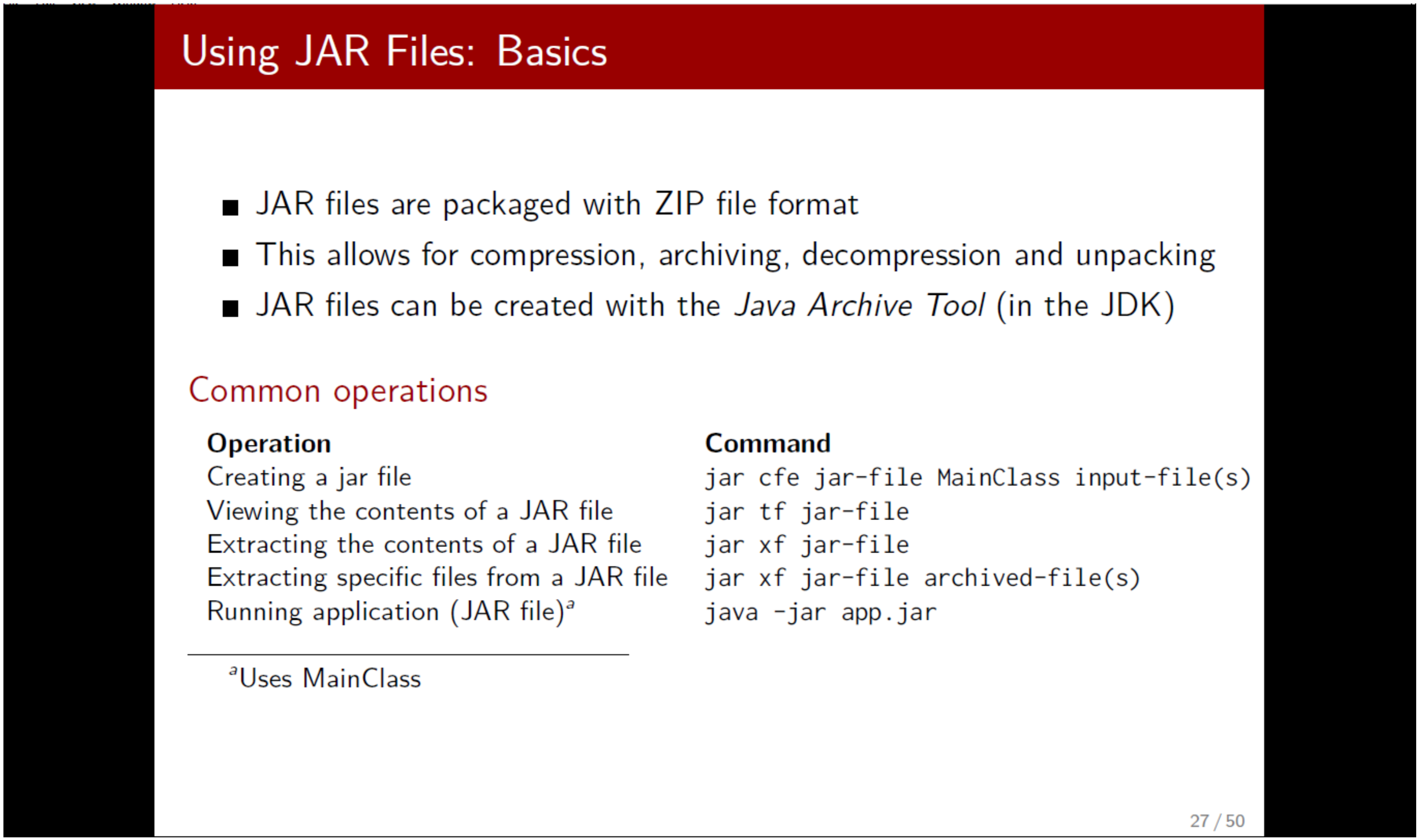
Javadoc



Doc comment – Example I

```
/**
 * Returns an Image object that can be painted on the screen.
 * The url argument must specify an absolute {@link URL}.
 * The name is a specifier that is relative to the url.
 * <p>
 * This method always returns immediately, whether or not the
 * image exists. When this applet attempts to draw the image on
 * the screen, the data will be loaded. The graphics primitives
 * that draw the image will incrementally paint on the screen.
 *
 * @param  url  an absolute URL:  the location of the image
 * @param  name the location of the image, relative to the url
 * @return      the image at the specified URL
 * @see         Image
 */
public Image getImage(URL url, String name) {
       try {
           return getImage(new URL(url, name));
       } catch (MalformedURLException e) {
```

Jar files



Using JAR Files: Basics

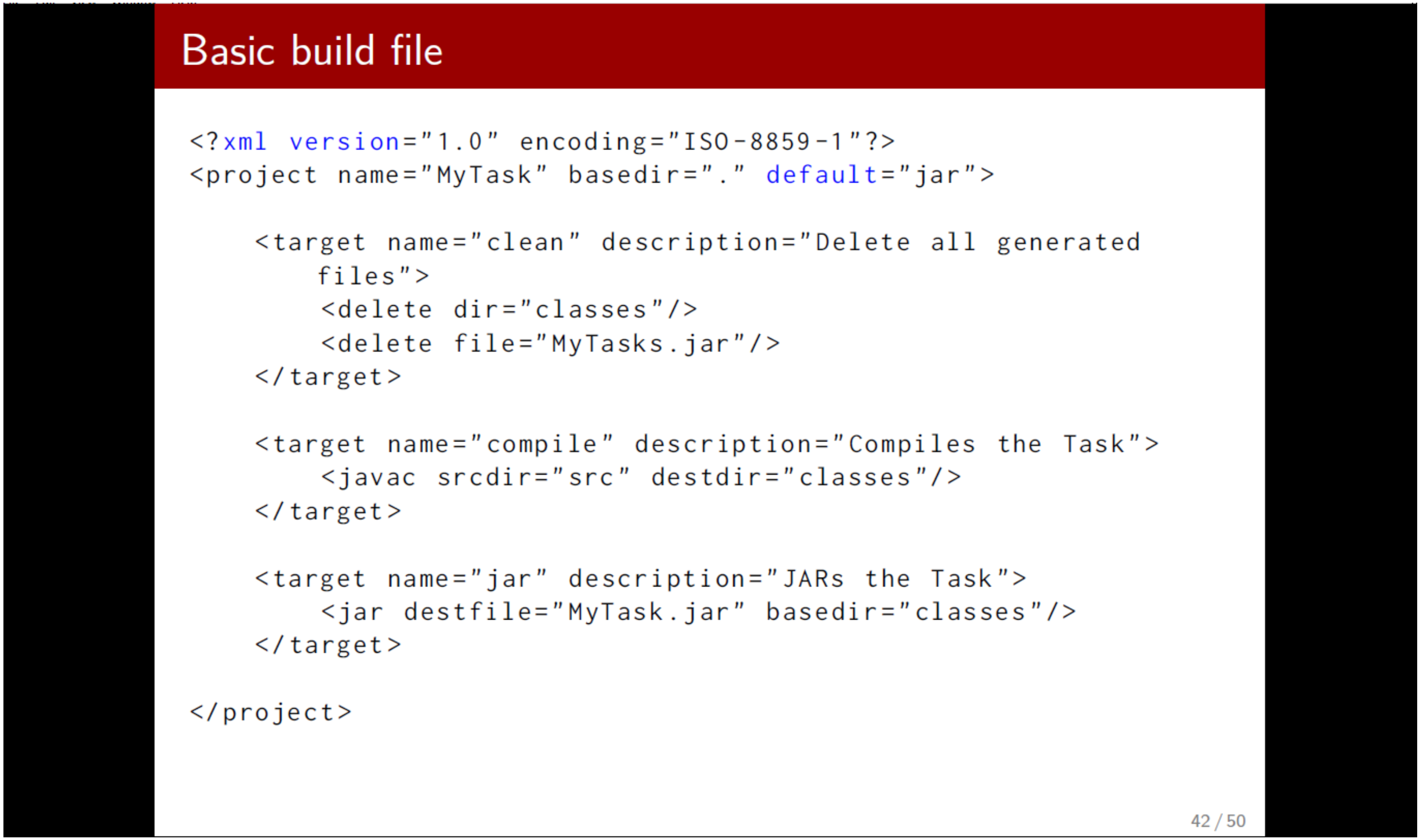
- JAR files are packaged with ZIP file format
- This allows for compression, archiving, decompression and unpacking
- JAR files can be created with the *Java Archive Tool* (in the JDK)

Common operations

Operation	**Command**
Creating a jar file	`jar cfe jar-file MainClass input-file(s)`
Viewing the contents of a JAR file	`jar tf jar-file`
Extracting the contents of a JAR file	`jar xf jar-file`
Extracting specific files from a JAR file	`jar xf jar-file archived-file(s)`
Running application (JAR file)[a]	`java -jar app.jar`

[a] Uses MainClass

Apache Ant

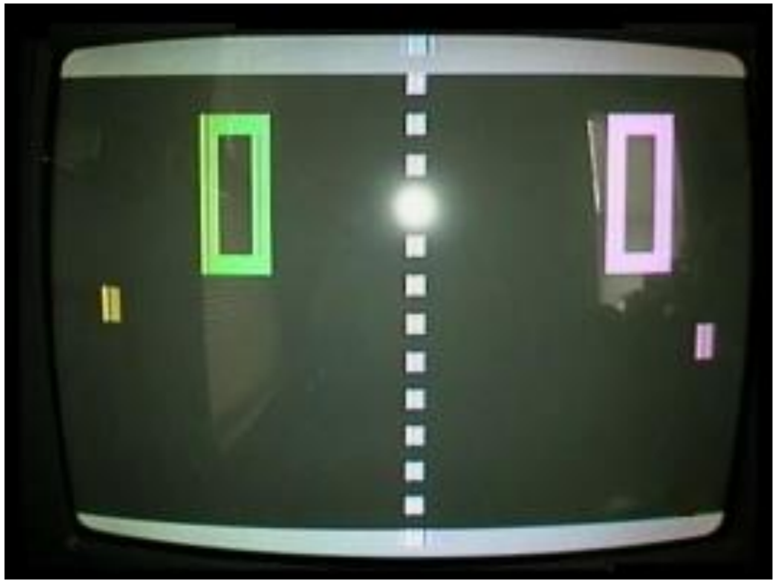


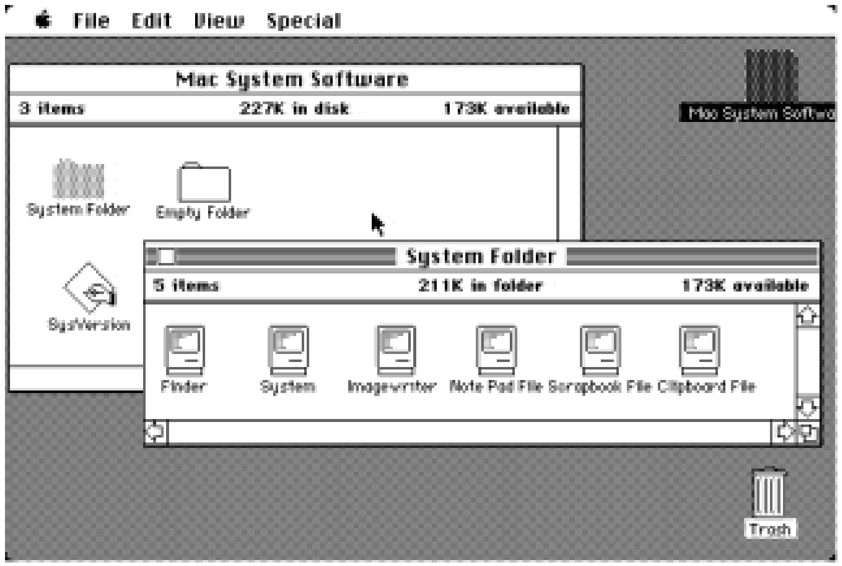
Basic build file

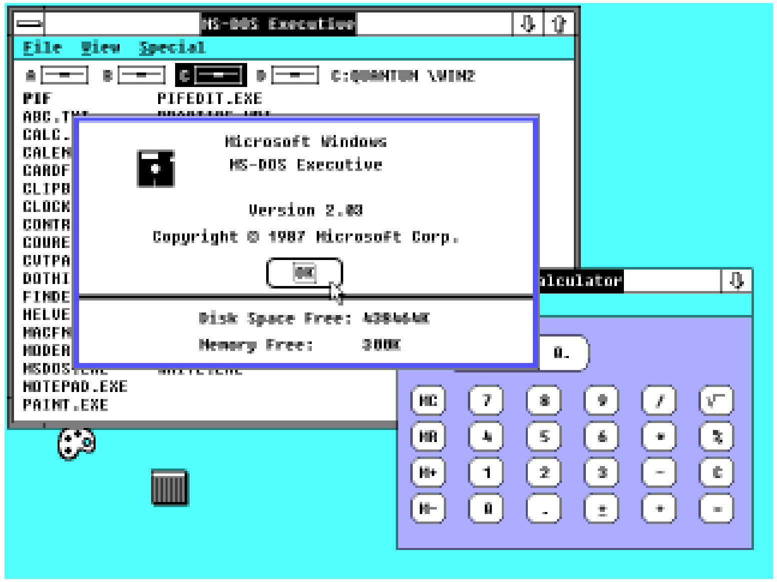
```
<?xml version="1.0" encoding="ISO-8859-1"?>
<project name="MyTask" basedir="." default="jar">

    <target name="clean" description="Delete all generated
        files">
        <delete dir="classes"/>
        <delete file="MyTasks.jar"/>
    </target>

    <target name="compile" description="Compiles the Task">
        <javac srcdir="src" destdir="classes"/>
    </target>

    <target name="jar" description="JARs the Task">
        <jar destfile="MyTask.jar" basedir="classes"/>
    </target>

</project>
```

- Next 9 slides motivating GUIs from Richard McKenna

GUI Examples



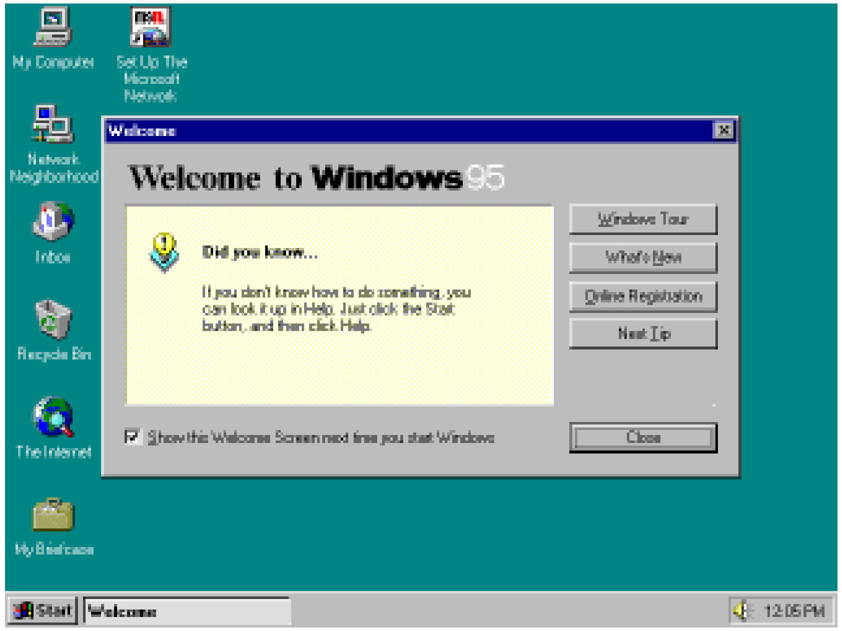




Microsoft Windows
MS-DOS Executive

Version 2.03
Copyright © 1987 Microsoft Corp.

Disk Space Free: 43846K
Memory Free: 308K



Did you know...

If you don't know how to do something, you can look it up in Help. Just click the Start button, and then click Help.

☑ Show this Welcome Screen next time you start Windows

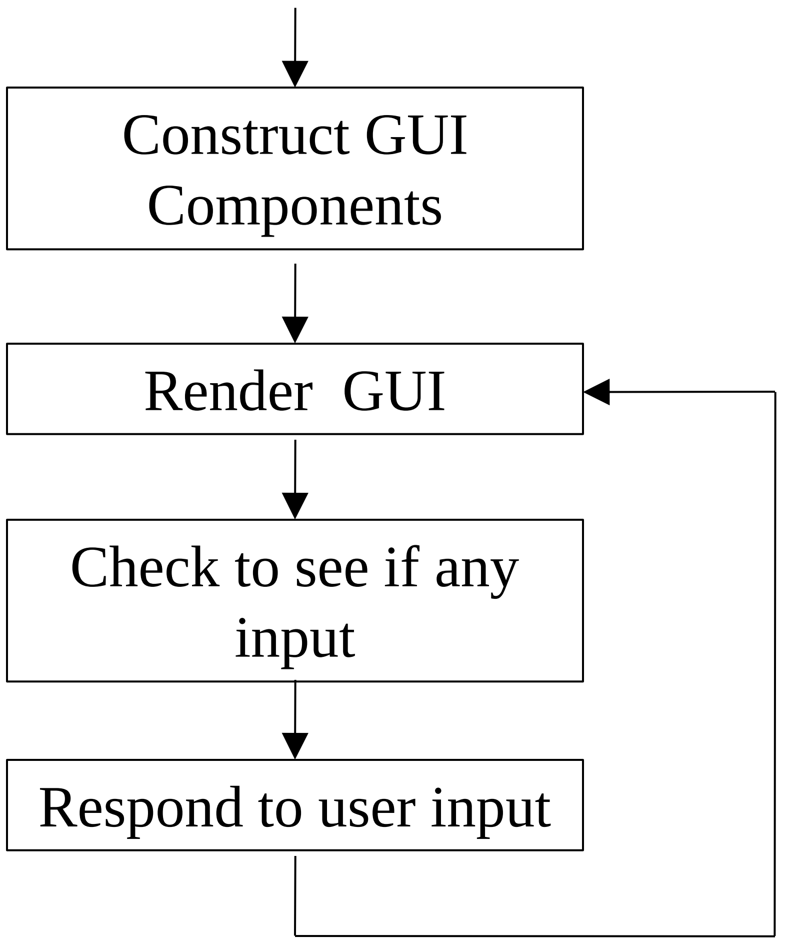
GUI

- Graphical User Interface (GUI)
  - provides user-friendly human interaction

- Building Java GUIs require use of multiple frameworks:
  - Java’s GUI component Libraries
    - `javax.swing.*`
  - Java’s Event Programming Libraries
    - `java.awt.event.*`
    - `Javax.swing.event.*`
  - Java’s Graphics Programming Libraries
    - `java.awt.*`
    - `java.awt.geom.*`

How do GUIs work?

- A giant loop



Example, a mouse click on a button

- Operating System recognizes mouse click
  - determines which window it was inside
  - notifies that program

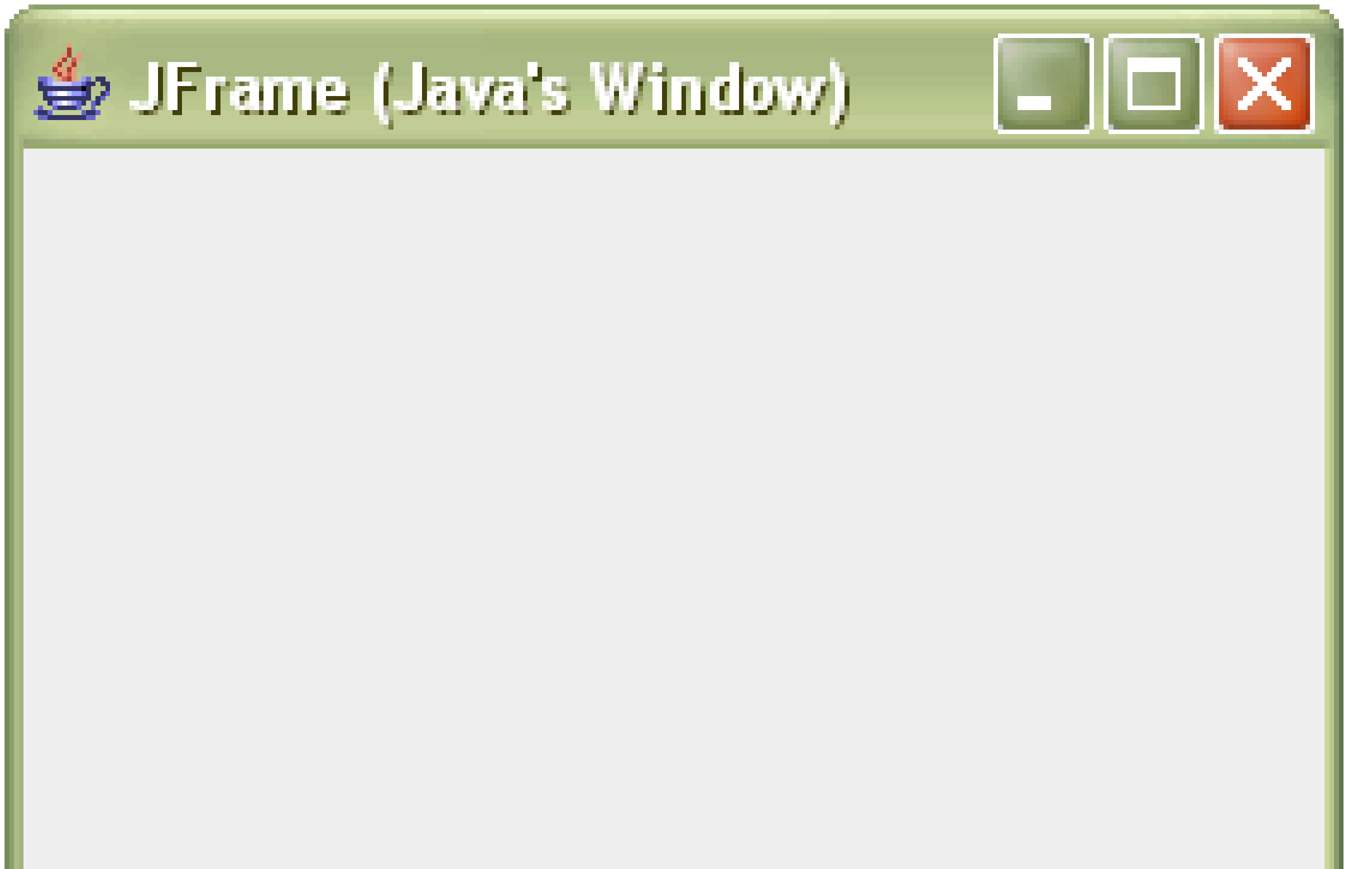
- Program runs in loop
  - checks input buffer filled by OS
  - if it finds a mouse click:
    - determines which component in the program
    - if the click was on a relevant component
      - respond appropriately according to handler

GUI Look vs. Behavior

- Look
  - physical appearance
  - custom component design
  - containment
  - layout management
- Behavior
  - interactivity
  - event programmed response

What does a GUI framework do for you?

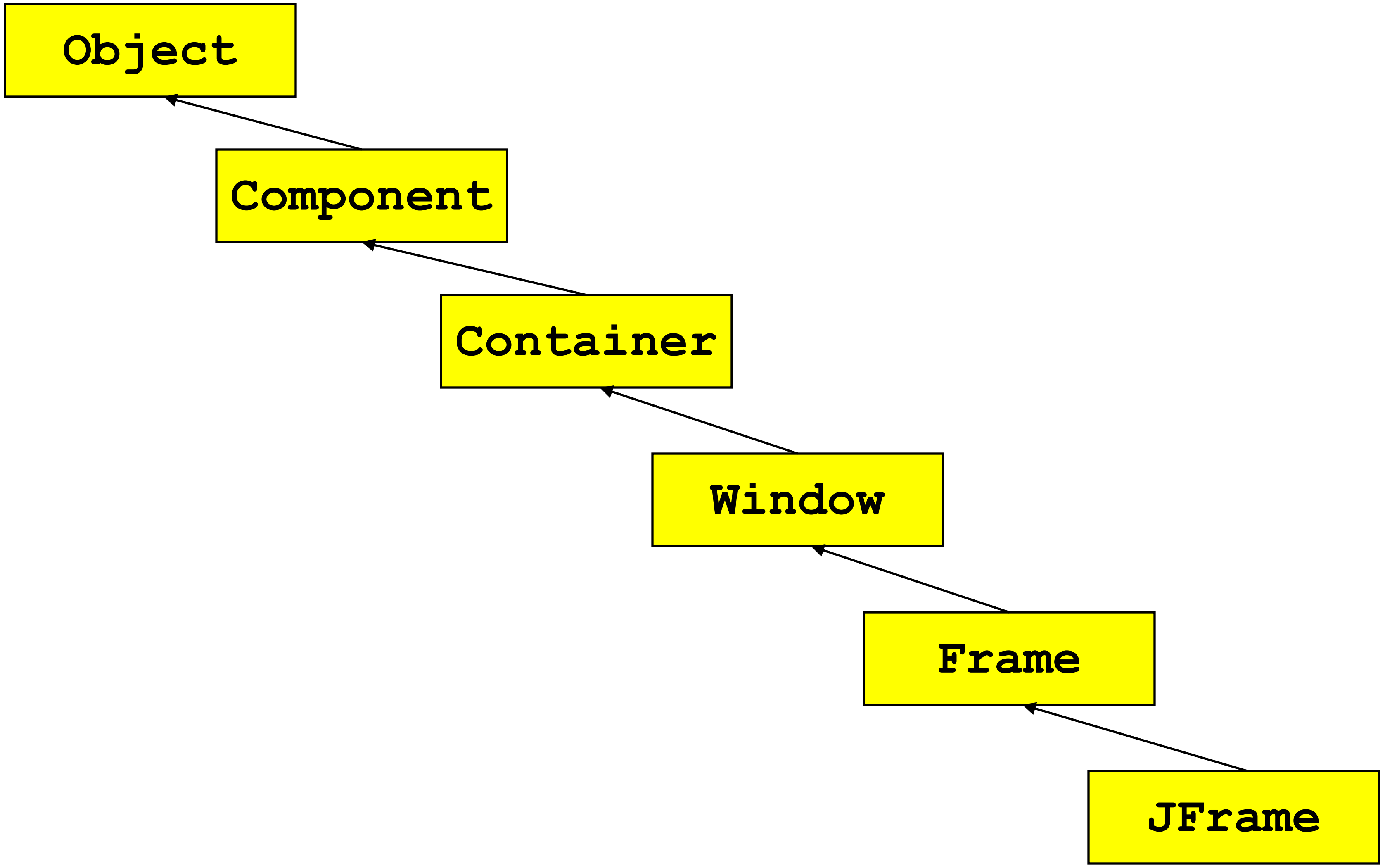
- Provides ready made visible, interactive, customizable components
  - you wouldn’t want to have to code your own window



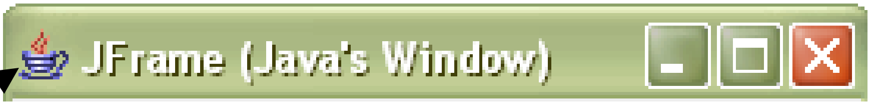
The `JFrame`

- Java’s top-level window
  - a window that is not contained inside another window
- Has methods for:
  - used to specify window to fit screen
    - **`setExtendedState`**
  - specifying a response to clicking window’s ‘X’
    - **`setDefaultCloseOperation`**
  - specifying size and location (top-left corner)
    - **`setSize`**, **`setLocation`** (inherited from **`Component`**)
- Many other useful methods ***inherited*** from ancestors

`javax.swing.JFrame` Class Hierarchy



Useful Inherited Methods for `JFrames`



- **`Frame`**
  - setting window’s icon
    - **`setIconImage(Image image)`**
    - images can be loaded via:
      - **`Toolkit.getDefaultToolkit.getImage(String fileName)`**
- **`Window`**
  - for hiding window
    - **`hide()`**
  - for tightly packing all components inside frame
    - **`pack()`**
- **`Component`**
  - for displaying window
    - **`setVisible(boolean b)`**

GUI Frameworks

- Java supports many GUI frameworks
  - AWT is an older GUI toolkit
  - Swing is a "lightweight" layer on top of AWT
    - Sometimes have to mix Swing and AWT code
  - JavaFX is a new lightweight toolkit from Oracle
    - Not widely adopted yet
  - For web development, see the Google Web Toolkit, this compiles your java code to javascript
    - Example: the Gmail interface
  - For Android, user interface controlled through XML
  - Today we will discuss Swing
    - This is just a light introduction, could spend many weeks on GUI programming!
    - You can learn more about how to work with Swing (or other frameworks) by doing the tutorials

GUI Programming

- GUI programming is fundamentally strange
  - The program is centered around the interaction loop
- Suppose you have a complex syntactic parser with 1000s of lines of code
  - Then you add a simple interactive form
  - Suddenly the program is conceptually based around the form!
- The reason for this is that things are happening asynchronously!

- Next slides: crash course in Swing from David Matuszek

How to build a GUI with Swing

- Create a window in which to display things—usually a `JFrame` (for an application), or a `JApplet`
- Use the `setLayout(LayoutManager` ***manager***`)` method to specify a layout manager
- Create some `Component`s, such as buttons, panels, etc.
- Add your components to your display area, according to your chosen layout manager
- Write some Listeners and attach them to your `Components`
  - Interacting with a Component causes an `Event` to occur
  - A Listener gets a message when an interesting event occurs, and executes some code to deal with it
- Display your window

Import the necessary packages

- The Swing components are in javax.swing.*, so you always need to import that for a Swing application
- Swing is built on top of AWT and uses a number of AWT packages, including most of the layout managers, so you need to import java.awt.*
- Most listeners also come from the AWT, so you also need to import java.awt.event.*
- A few listeners, such as DocumentListener and ListSelectionListener, are specific to Swing, so you may need to import javax.swing event.*
- For more complex GUIs, there are additional java.awt.*something* and javax.swing.*something* packages that you may need to import

Make a Container

- For an application, your container is typically a JFrame
  - `JFrame frame = new JFrame();`
  - `JFrame frame = new JFrame("Text to put in title bar");`
- You can create a JFrame in your "main class"
- It's often more convenient to have your "main class" *extend* JFrame
- For an applet, your "main class" must extend JApplet
- Once your application or applet is up and running, it can create and display various dialogs

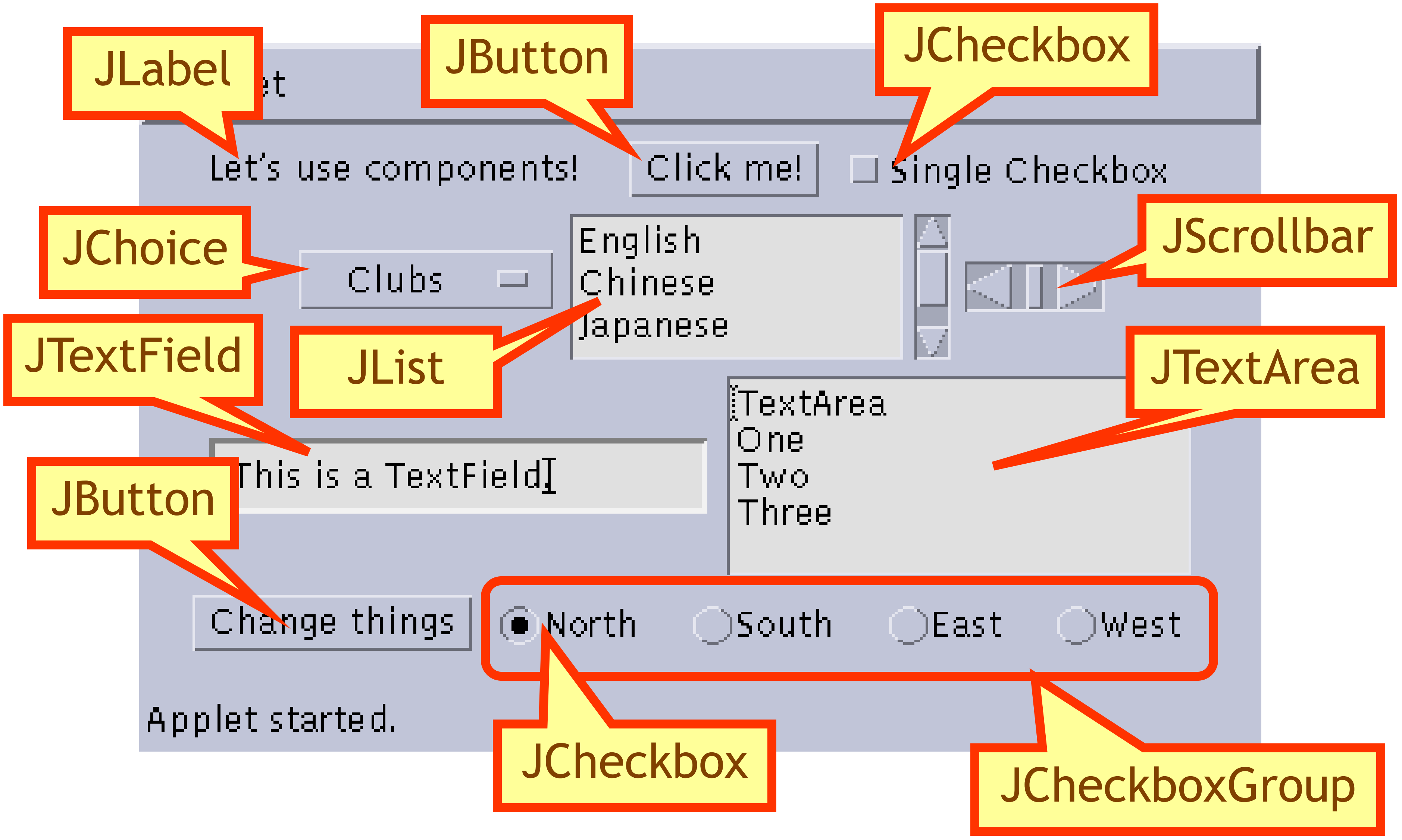
Add a layout manager

- The most important layout managers are:
  - BorderLayout
    - Provides five areas into which you can put components
    - This is the default layout manager for both JFrame and JApplet
  - FlowLayout
    - Components are added left to right, top to bottom
  - GridLayout
    - Components are put in a rectangular grid
    - All areas are the same size and shape
  - BoxLayout
    - Creates a horizontal row or a vertical stack
    - This can be a little weird to use
  - GridBagLayout
    - Too complex and a danger to your sanity—***avoid***
    - See http://www.youtube.com/watch?v=UuLaxbFKAcc (Flash, with audio)

Add components to containers

- The usual command is
  container.add(*component*);
  - For FlowLayout, GridLayout, and BoxLayout, this adds the component to the next available location
  - For BorderLayout, this puts the component in the CENTER by default
- For BorderLayout, it’s usually better to use
  container.add(*component*, BorderLayout.*position*);
  - *position* is one of NORTH, SOUTH, EAST, WEST, or CENTER

Some types of components



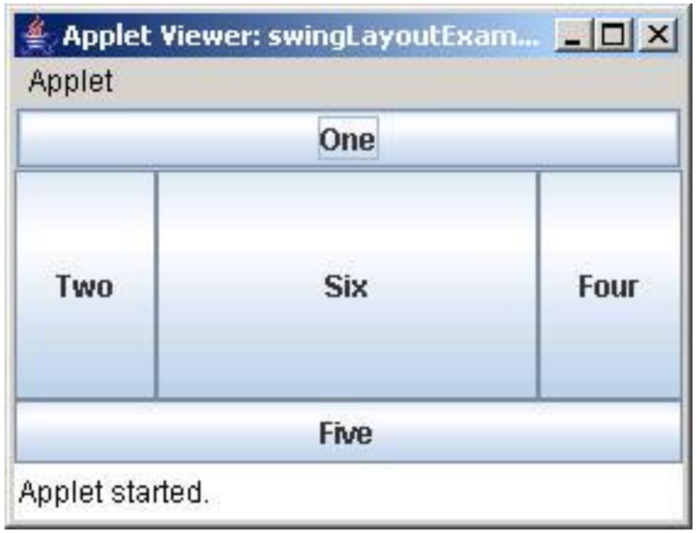
Create components

- JButton button = new JButton("Click me!");
- JLabel label = new JLabel("This is a JLabel");
- JTextField textField1 = new JTextField("This is the initial text");
- JTextField textField2 = new JTextField("Initial text", columns);
- JTextArea textArea1 = new JTextArea("Initial text");
- JTextArea textArea2 = new JTextArea(rows, columns);
- JTextArea textArea3 = new JTextArea("Initial text", rows, columns);
- JCheckBox checkbox = new JCheckBox("Label for checkbox");
- JRadioButton radioButton1 = new JRadioButton("Label for button");
- ButtonGroup group = new ButtonGroup();
  group.add(radioButton1); group.add(radioButton2); *etc.*

- This is just a sampling of the available constructors; see the javax.swing API for all the rest

BorderLayout

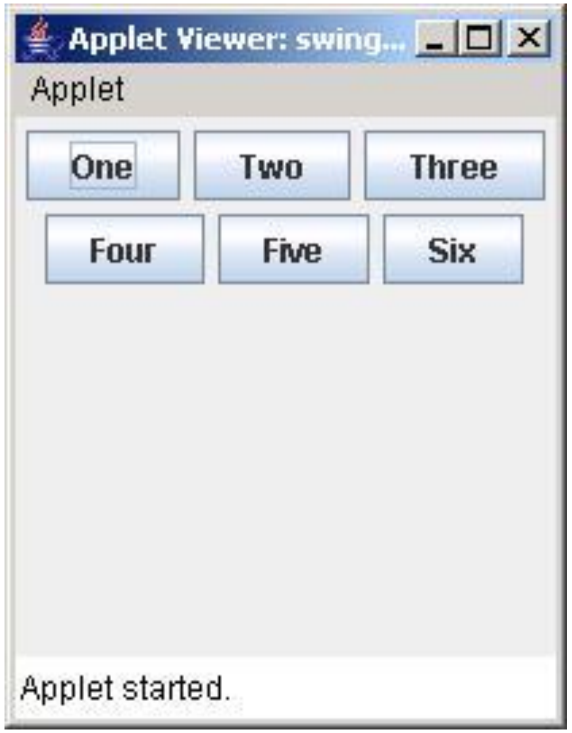
```
public class BorderLayoutExample extends JApplet {
    public void init () {
        setLayout(new BorderLayout ());
        add(new JButton("One"),   BorderLayout.NORTH);
        add(new JButton("Two"),   BorderLayout.WEST);
        add(new JButton("Three"), BorderLayout.CENTER);
        add(new JButton("Four"),  BorderLayout.EAST);
        add(new JButton("Five"),  BorderLayout.SOUTH);
        add(new JButton("Six"));
    }
}
```



Applet started.

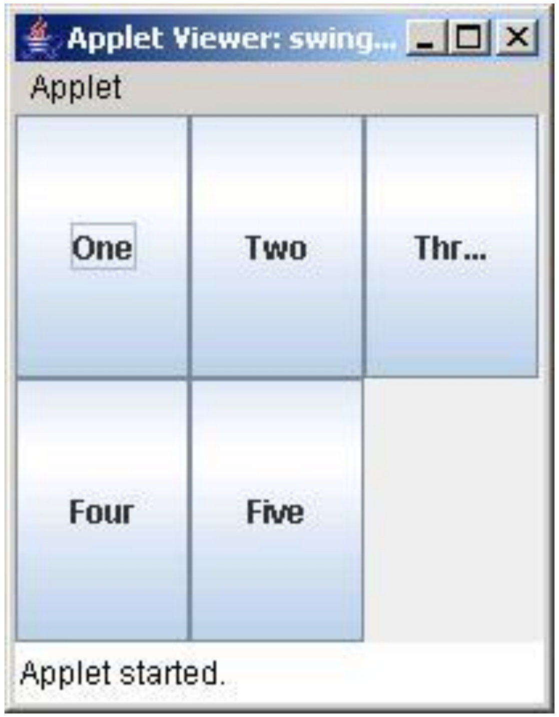
FlowLayout

```
public class FlowLayoutExample extends JApplet {
  public void init () {
    setLayout(new FlowLayout ());
    add(new JButton("One"));
    add(new JButton("Two"));
    add(new JButton("Three"));
    add(new JButton("Four"));
    add(new JButton("Five"));
    add(new JButton("Six"));
  }
}
```



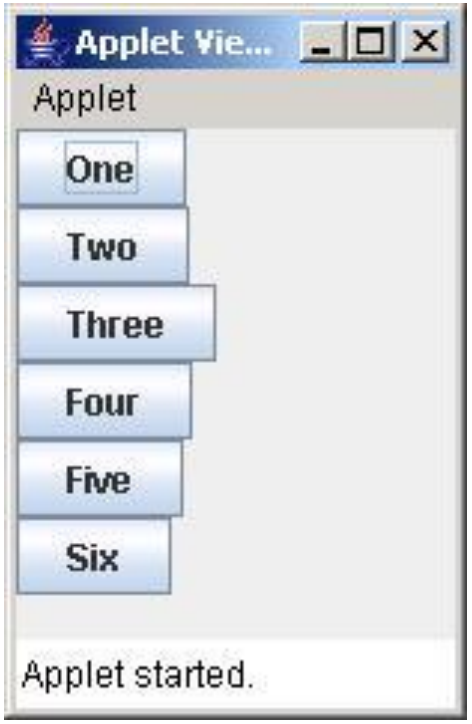
GridLayout

```
public class GridLayoutExample extends JApplet {
    public void init() {
        setLayout(new GridLayout(2, 4));
        add(new JButton("One"));
        add(new JButton("Two"));
        add(new JButton("Three"));
        add(new JButton("Four"));
        add(new JButton("Five"));
    }
}
```



BoxLayout

```
public class BoxLayoutExample extends JApplet {
    public void init () {
        Box box = new Box(BoxLayout.Y_AXIS);
        add(box);
        box.add(new JButton("One"));
        box.add(new JButton("Two"));
        box.add(new JButton("Three"));
        box.add(new JButton("Four"));
        box.add(new JButton("Five"));
        box.add(new JButton("Six"));
      }
}
```



Nested layouts

- A JPanel is both a JContainer and a Component
  - Because it's a container, you can put other components into it
  - Because it's a component, you can put it into other containers
- All but the very simplest GUIs are built by creating several JPanels, arranging them, and putting components (possibly other JPanels) into them
- A good approach is to draw (on paper) the arrangement you want, then finding an arrangement of JPanels and their layout managers that accomplishes this

An example nested layout

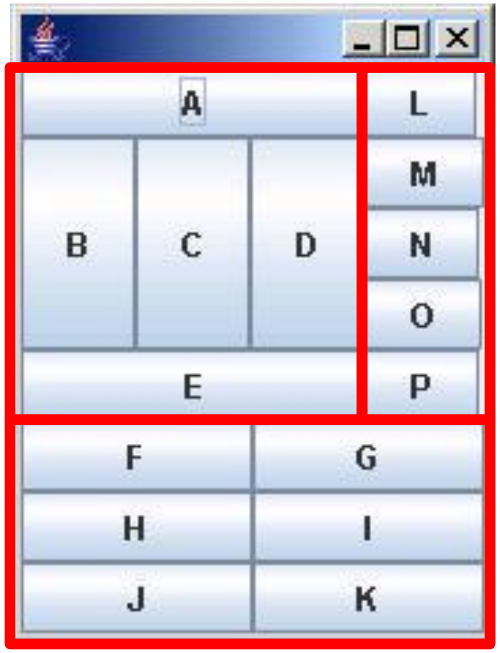
- Container container = new ***JFrame() or JApplet()***;

  JPanel p1 = new JPanel();
  p1.setLayout(new BorderLayout());
  p1.add(new JButton("A"), BorderLayout.NORTH);
      // also add buttons B, C, D, E

  JPanel p2 = new JPanel();
  p2.setLayout(new GridLayout(3, 2));
  p2.add(new JButton("F"));
      // also add buttons G, H, I, J, K

  JPanel p3 = new JPanel();
  p3.setLayout(new BoxLayout(p3, BoxLayout.Y_AXIS));
  p3.add(new JButton("L"));
      // also add buttons M, N, O, P

  container.setLayout(new BorderLayout());
  container.add(p1, BorderLayout.CENTER);
  container.add(p2, BorderLayout.SOUTH);
  container.add(p3, BorderLayout.EAST);



Create and attach listeners

- `JButton okButton = new JButton("OK");`
- `okButton.addActionListener(new MyOkListener());`

-
  ```
  class MyOkListener implements ActionListener {
      public void actionPerformed(ActionEvent event) {
          // code to handle okButton click
      }
  }
  ```
- A small class like this is often best implemented as an anonymous inner class

Anonymous inner classes

- Anonymous inner classes are convenient for short code (typically a single method)
  - b.addActionListener(***anonymous inner class***);
- The *anonymous inner class* can be either:
  - new ***Superclass***(***args***) { ***body*** }
  - or
  - new ***Interface***() { ***body*** }
- Notice that no class name is given--only the name of the superclass or interface
  - If it had a name, it wouldn’t be anonymous, now would it?
- The *args* are arguments to the superclass’s constructor (interfaces don’t have constructors)

Using an anonymous inner class

- Instead of:
  - okButton.addActionListener(new MyOkListener());

```
class MyOkListener implements ActionListener {
    public void actionPerformed(ActionEvent event) {
        // code to handle OK button click
    }
}
```

- You can do this:
  - okButton.addActionListener(new ActionListener() {

```
    public void actionPerformed(ActionEvent event) {
        // code to handle OK button click
    }
);
```

- Keep anonymous inner classes very short (typically just a call to one of your methods), as they can really clutter up the code

Suggested program arrangement 1

```
class SomeClass {
    // Declare components as instance variables
    JFrame frame; // Can also define them here if you prefer
    JButton button;
    public static void main(String[] args) {
        new SomeClass().createGui();
    }
    // Define components and attach listeners in a method
    void createGui() {
        frame = new JFrame();
        button = new JButton("OK");
        frame.add(button); // (uses default BorderLayout)
        button.addActionListener(new MyOkListener());
    }
    // Use an inner class as your listener
    class MyOkButtonListener implements ActionListener {
        public void actionPerformed(ActionEvent event) {
            // Code to handle button click goes here
        }
    }
}
```

Suggested program arrangement 2

```
class SomeClass extends JFrame {
    // Declare components as instance variables
    // JFrame frame; // Don’t need this
    JButton button;
    public static void main(String[] args) {
        new SomeClass().createGui();
    }
    // Define components and attach listeners in a method
    void createGui() {
        // frame = new JFrame();  // Don’t need this
        button = new JButton("OK");
        add(button); // Was: frame.add(button);
        button.addActionListener(new MyOkListener());
    }
    // Use an inner class as your listener
    class MyOkButtonListener implements ActionListener {
        public void actionPerformed(ActionEvent event) {
            // Code to handle button click goes here
        }
    }
}
```

Components use various listeners

- JButton, JMenuItem, JComboBox, JTextField:
  - addActionListener(ActionListener)
    - public void actionPerformed(ActionEvent event)
- JCheckBox, JRadioButton:
  - addItemListener(ItemListener)
    - public void itemStateChanged(ItemEvent event)
- JSlider
  - addChangeListener(ChangeListener)
    - public void stateChanged(ChangeEvent event)
- JTextArea
  - **getDocument().**addDocumentListener(DocumentListener)
    - public void insertUpdate(DocumentEvent event)
    - public void removeUpdate(DocumentEvent event)
    - public void changedUpdate(DocumentEvent event)

Getting values

- Some user actions normally cause the program to *do* something: clicking a button, or selecting from a menu
- Some user actions set values to be used *later:* entering text, setting a checkbox or a radio button
  - You *can* listen for events from these, but it's not usually a good idea
  - Instead, *read* their values when you need them
    - `String myText = myJTextField.getText();`
    - `String myText = myJTextArea.getText();`
    - `boolean checked = myJCheckBox.isSelected();`
    - `boolean selected1 = myJRadioButton1.isSelected();`

Enabling and disabling components

- It is poor style to remove components you don't want the user to be able to use
  - "Where did it go? It was here a minute ago!"
- It's better to *enable* and *disable* controls
  - Disabled controls appear "grayed out"
  - The user may wonder *why?*, but it's still less confusing
- ***anyComponent***`.setEnabled(`***enabled***`);`
  - Parameter should be `true` to enable, `false` to disable

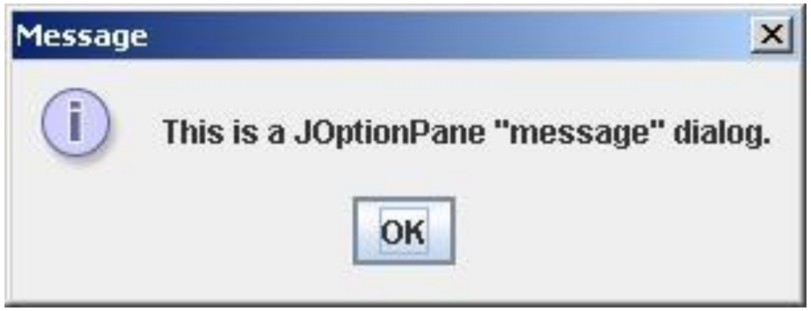
Dialogs

- A dialog (small accessory window) can be modal or nonmodal
  - When your code opens a modal dialog, it waits for a result from the dialog before continuing
  - When your code opens a nonmodal dialog, it does so in a separate thread, and your code just keeps going
- Sun supplies a few simple (but useful) *modal* dialogs for your use
- You can create your own dialogs (with `JDialog`), but they are *nonmodal* by default

Message dialogs

-
  ```
  JOptionPane.showMessageDialog(parentJFrame,
                      "This is a JOptionPane \"message\" dialog.");
  ```

- Notice that `showMessageDialog` is a static method of `JOptionPane`
- The "`parentJFrame`" is typically your main GUI window (but it's OK to use `null` if you don't have a main GUI window)

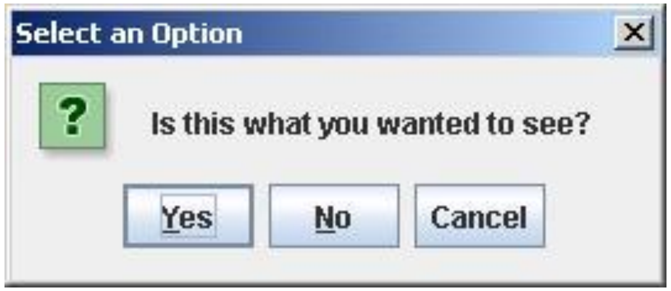


This is a JOptionPane "message" dialog.

Confirm dialogs

-
  ```
  int yesNo =
      JOptionPane.showConfirmDialog(parentJFrame,
                          "Is this what you wanted to see?");
  ```

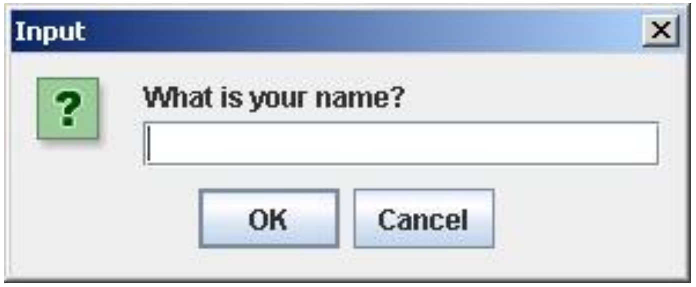
-
  ```
      if (yesNo == JOptionPane.YES_OPTION) { ... }
  ```


Select an Option

Is this what you wanted to see?

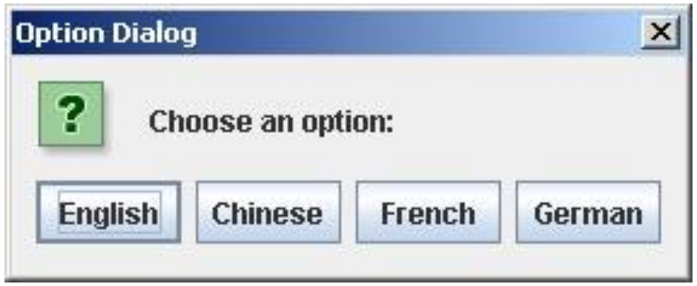
Input dialogs

- String userName =
    JOptionPane.showInputDialog(parentJFrame,
                                                    "What is your name?")



Option dialogs

```
Object[] options =
    new String[] {"English", "Chinese", "French", "German" };
int option =
    JOptionPane.showOptionDialog(parentJFrame,
                                 "Choose an option:",
                                 "Option Dialog",
                                 JOptionPane.YES_NO_OPTION,
                                 JOptionPane.QUESTION_MESSAGE,
                                 null,
                                 options,
                                 options[0]); // use as default
```

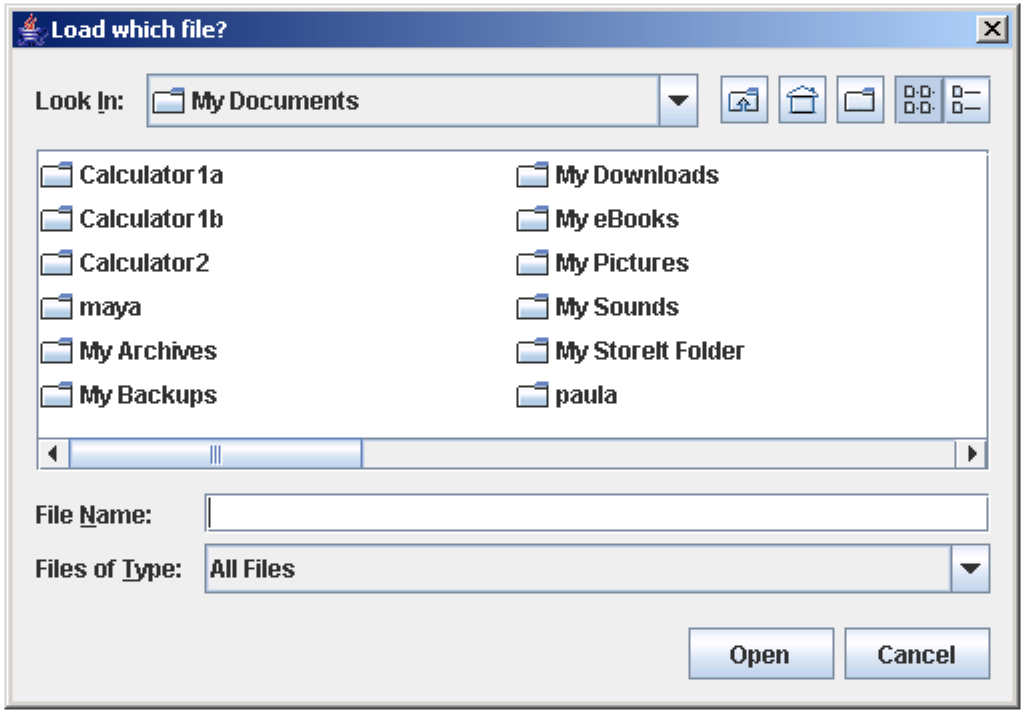


- Fourth argument could be JOptionPane.YES_NO_CANCEL_OPTION
- Fifth argument specifies which icon to use in the dialog; it could be one of ERROR_MESSAGE, INFORMATION_MESSAGE, WARNING_MESSAGE, or PLAIN_MESSAGE
- Sixth argument (null above) can specify a custom icon

Load file dialogs

- JFileChooser chooser = new JFileChooser();
  chooser.setDialogTitle("Load which file?");
- int result = chooser.showOpenDialog(enclosingJFrame);
  if (result == JFileChooser.APPROVE_OPTION) {
      File file = chooser.getSelectedFile();
      // use file
  }

- You could also test for CANCEL_OPTION or ERROR_OPTION
- You will get back a File object; to use it, you must know how to do file I/O


Load which file?

Look In: My Documents

Calculator1a
Calculator1b
Calculator2
maya
My Archives
My Backups
My Downloads
My eBooks
My Pictures
My Sounds
My StoreIt Folder
paula

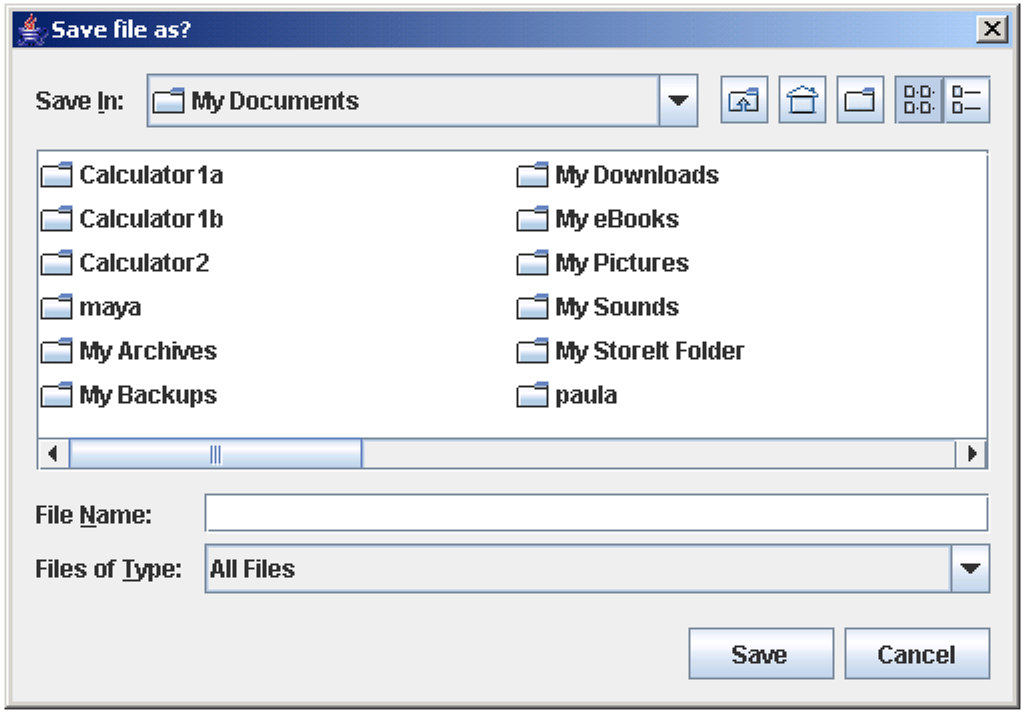
File Name:

Files of Type: All Files

Save file dialogs

- JFileChooser chooser = new JFileChooser();
  chooser.setDialogTitle("Save file as?");

-
  ```
  int result = chooser.showSaveDialog(enclosingJFrame);
  if (result == JFileChooser.APPROVE_OPTION) {
      File file = chooser.getSelectedFile();
      // use file
  }
  ```
- You could also test for CANCEL_OPTION or ERROR_OPTION
- You will get back a File object; to use it, you must know how to do file I/O



Quitting the program

- *gui*.setDefaultCloseOperation(JFrame.EXIT_ON_CLOSE);
- Other options are DO_NOTHING_ON_CLOSE, HIDE_ON_CLOSE, and DISPOSE_ON_CLOSE

Summary I: Building a GUI

- Create a container, such as JFrame or JApplet
- Choose a layout manager
- Create more complex layouts by adding JPanels; each JPanel can have its own layout manager
- Create other components and add them to whichever JPanels you like

Summary II: Building a GUI

- For each active component, look up what kind of Listeners it can have
- Create (implement) the Listeners
  - often there is one Listener for each active component
  - Active components can share the same Listener
- For each Listener you implement, supply the methods that it requires
- For Applets, write the necessary HTML

Literature

- Java Swing Tutorial

  http://docs.oracle.com/javase/tutorial/uiswing/

- Ullenboom, Ch.

  Java ist auch eine Insel (Chapter 19)

  Galileo Computing, 2012