ID2212 Network Programming with Java
Lecture 2

GUI Programming in Java

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User Interface in a Distributed Application

- A (graphical) user interface, (G)UI, needs to be constructed so that the user:
  - knows the current state of the application;
  - knows whether a command given to the application has been received;
  - knows that the application is working on a task and not simply “hung“;
  - can always control the flow of the program, e.g. can cancel the task.
- Specific issue: long communication latency

Responsive (G)UI

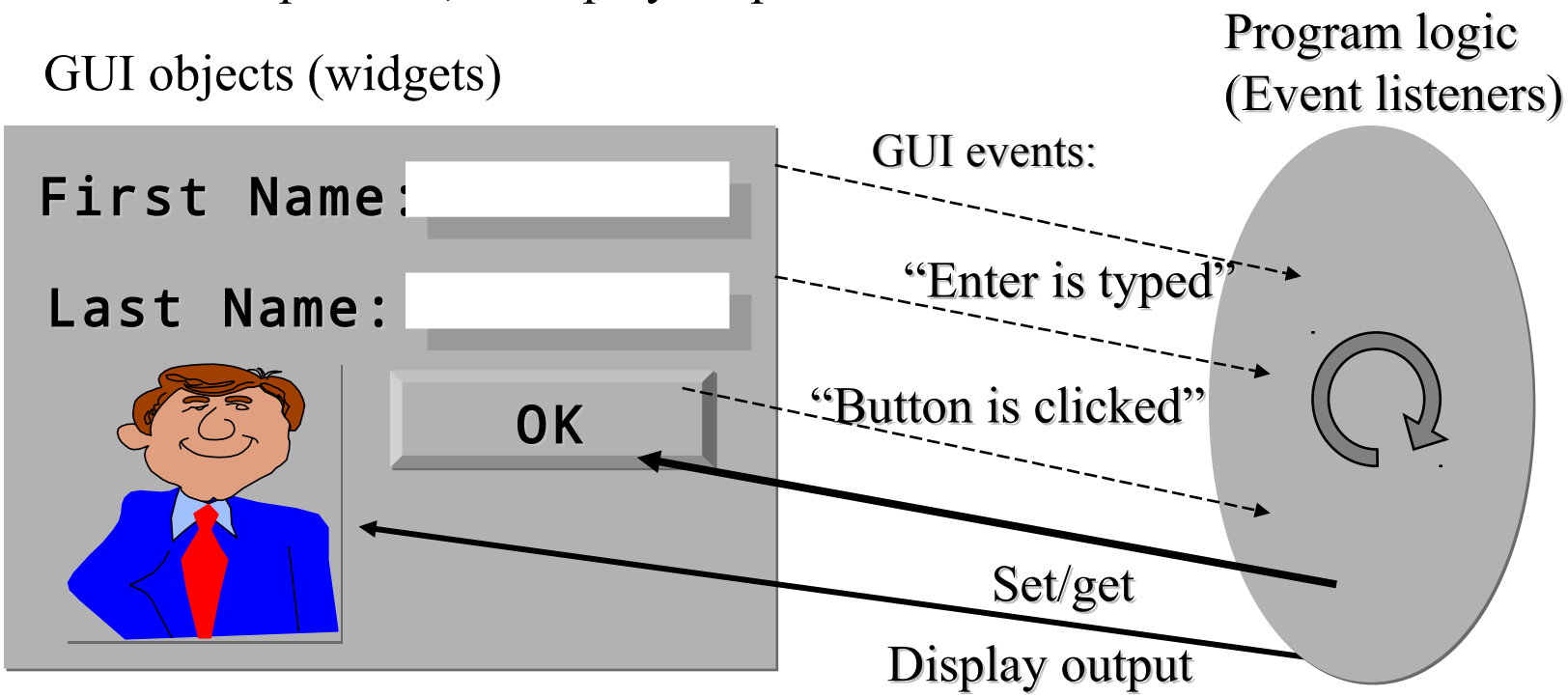
- A responsive UI as an interface that is non-blocking while performing some time-consuming task such as
  - extensive calculations
  - networking with sockets or RMI or CORBA
  - file I/O (loading images, for example), etc.
- Responsive UIs can be implemented by using threads.
  - Move a time-consuming task out of the main thread, so that the GUI comes up faster;
  - Move a time-consuming task out of the event dispatching thread, so that the GUI remains responsive, i.e. not "frozen“;
  - In a listener, create and start a thread to perform the corresponding task; the control flow returns to GUI

Contents

- AWT Packages and classes
- Constructing GUI
- AWT events, listeners and adapters
- Layout Managers and container attributes
- Overview of Swing
- Applets
- JavaBeans

GUI: Graphical User Interface

- GUI allows the user:
  - To control an application in a convenient way,
  - To input data, to display output.



Java GUI APIs and Tools

- APIs for GUI in Java Platform SE:
  - ***Java AWT***: Abstract Window Toolkit (basic GUI classes)
  - ***Java Swing***
    - Lightweight GUI framework.
  - ***JavaBean*** API supports the development of JavaBeans.
    - A JavaBean is a reusable software component that can be manipulated visually in a builder tool, and can provide GUI.
- IDE (Integrated Development Environments), such as Eclipse, NetBeans, JBuilder from Borland, VisualAge from IBM

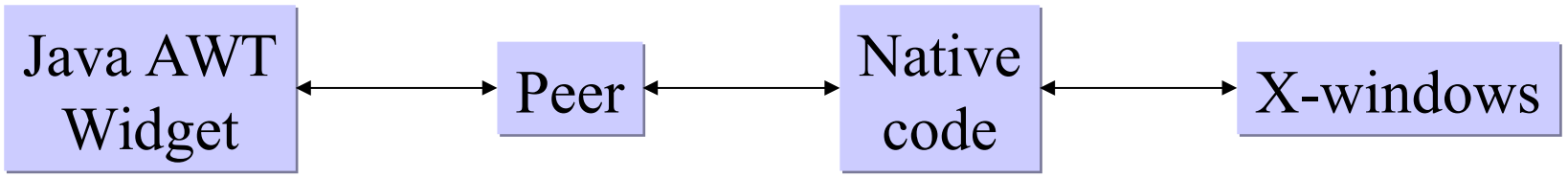
AWT: Abstract Window Toolkit

`java.awt`

Overview

AWT: Abstract Window Toolkit

- ***AWT***: Abstract Window Toolkit is a collection of Java packages that represent
  - GUI containers (frame, panel, etc.)
  - GUI components (button, text-field, etc.)
  - Basic GUI attributes (colors, fonts, cursor, layout, etc.)
  - GUI events and event listener interfaces
  - AWT was developed for building GUI without having to learn many of the details of the underlying windowing system.



AWT Containers

- GUI containers are used to hold GUI components (widgets) :
  - Titled framed windows: **`Frame`**
  - Popup windows:
    - **`Dialog`**
    - **`FileDialog`**
    - **`JFileChooser`**, **`JColorChooser`** in Swing
  - Child sub-windows:
    - **`Panel`**,
    - **`Applet`**,
    - **`ScrollPane`**

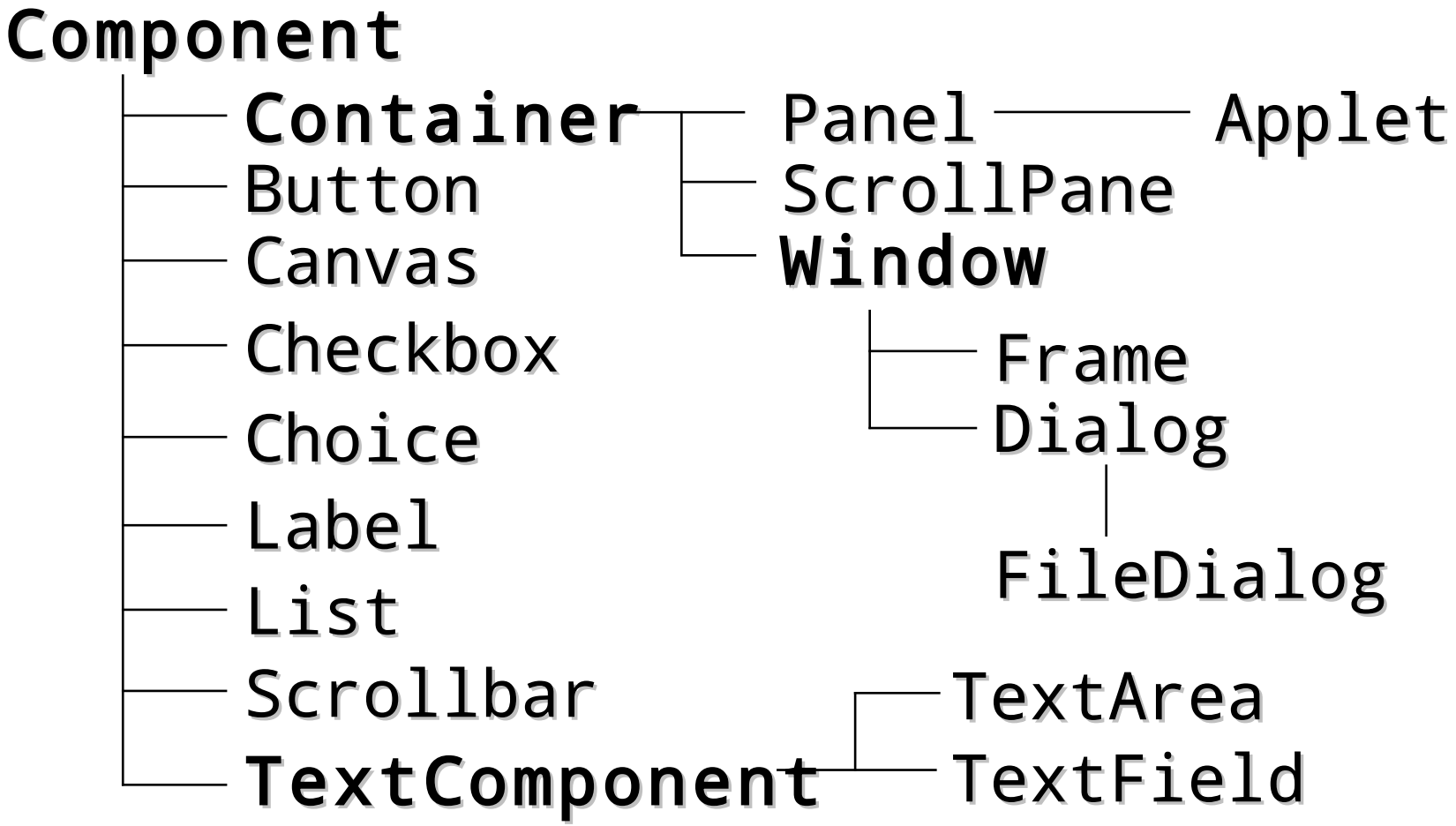
AWT Components

- Buttons
  - used to invoke some actions in an application.
- Selectable components
  - provide several choices to the user in which one or more items (options) can be selected:
    - Pulldown/pop-up menu: **`Choice`**
      - **`JPopupMenu`** in Swing
    - Scrolling list of choices: **`List`**
    - Menus in a menu bar frame : **`Menu`**, **`MenuItem`**, **`MenuBar`**
    - On/off switch element: **`Checkbox`**

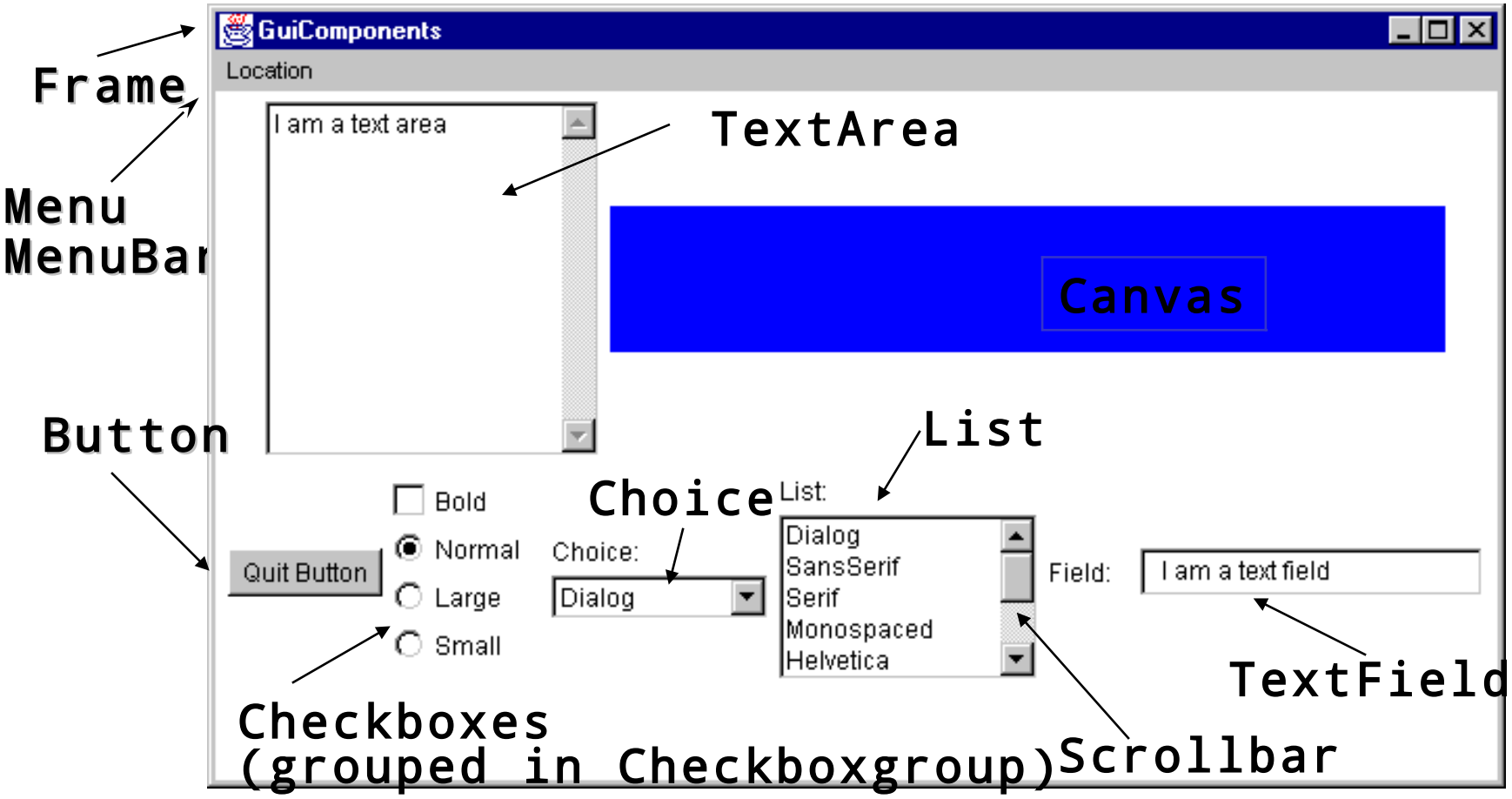
AWT Components (cont'd)

- Text components
  - used to input, edit and output text information:
    - Labels and messages: **`Label`**
    - An editable text string: **`TextField`**
    - A scrolling text area: **`TextArea`**
- Drawing components
  - **`Canvas`** provides a drawing surface for displaying graphical output.
- Scrollbar implements the metaphor of an elevator on a cable.

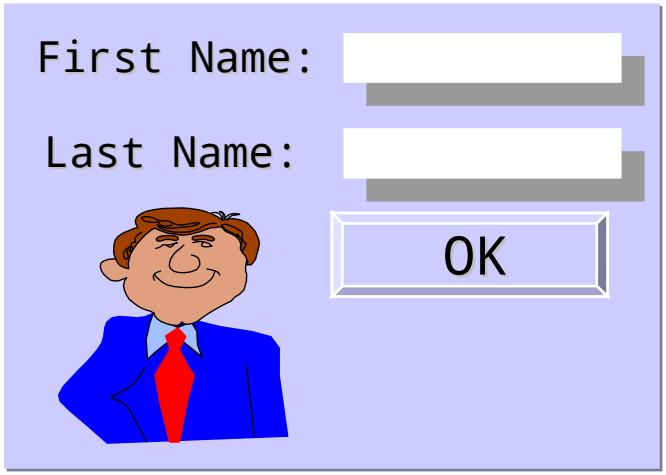
Component classes of AWT



AWT components



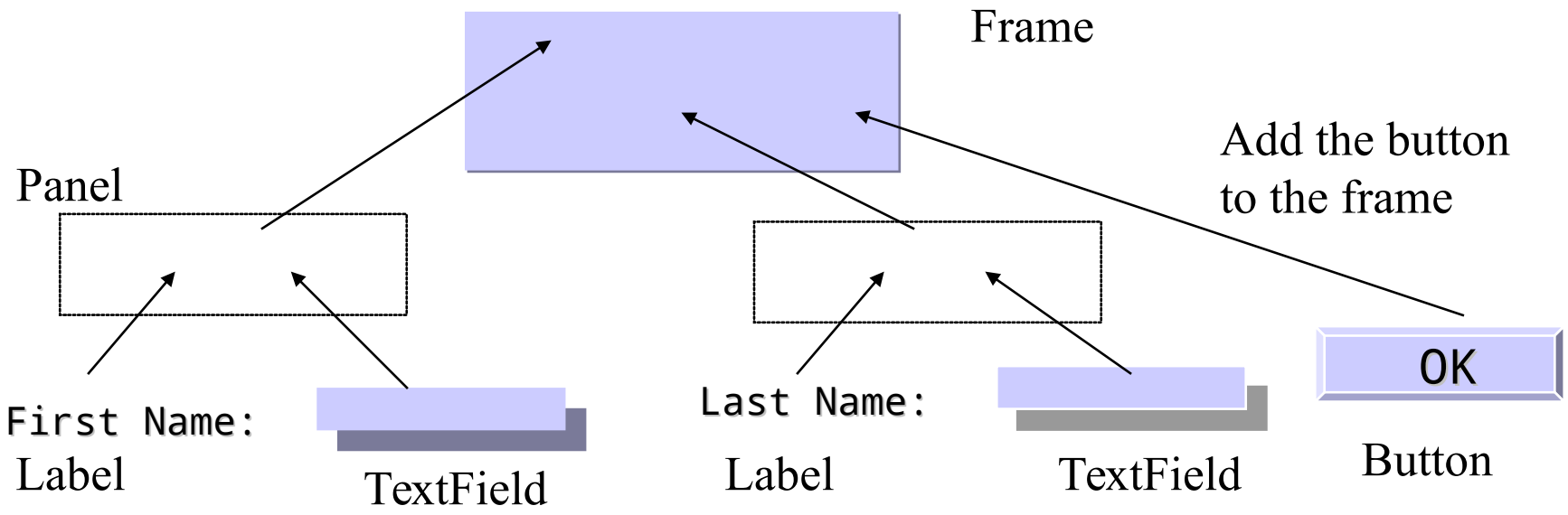
Nesting of GUI Containers and Components



Constructing a GUI

- GUI is constructed by
  - Constructors (create a component object - a widget)
  - Setters (set attributes for the component, e.g. colors, size, labels, etc.)
  - Adders (add child components to the parent container, register event listeners)

Top-Down (Bottom-Up) Construction



Constructing a GUI

- Create a root window (frame)

```
Frame f = new Frame();
```

- Change/set attributes

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

- Construct and add child subcomponents to the frame

```
Panel p = new Panel();
p.add(new Label("First name:"));
TextField tffn = new TextField("", 30);
tffn.addActionListener(this);
p.add(tffn);
f.add(p);
```

- Pack the frame and make it visible

```
f.pack();
f.setVisible(true);
```

Constructing GUI in an Applet

- The **`Applet`** class extends the **`Panel`** class, which is a GUI container, therefore an applet can be directly used as a root container to be filled in with GUI elements.
- The applet's GUI is usually created in the appelt's **`init`** method by instantiating and adding GUI components to the applet.

Events and Listeners

`java.awt.event`

- AWT events
- Event listeners and adapters
- Event delivery

AWT Events

- GUI-controlled Java application (applet) is event-driven.
  - Events propagate notifications of state change or commands from a source object (a GUI component) to one or more target objects (event listeners) via method invocation on listeners' interfaces.
- Examples of AWT Events:
  - Mouse actions, e.g.
    - a right mouse button is down (**`MouseEvent`**)
    - a GUI button is clicked (**`ActionEvent`**)
    - a menu item is chosen (**`ItemEvent`**)
  - Keyboard actions, e.g. a key is pressed (**`KeyEvent`**)
- Classes of AWT events are specified in **`java.awt.event`**

AWT Event Listeners

- A listener must be registered at a source:

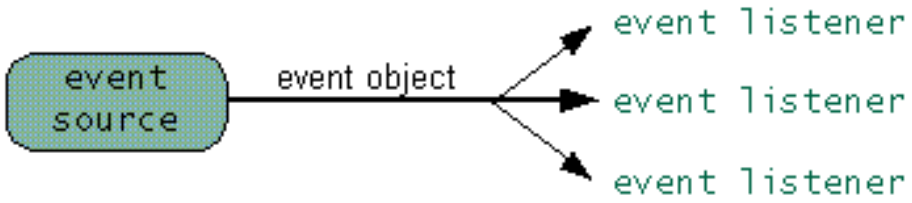
```
Button button = new Button("Start"); // source
  of events
button.addActionListener(new FooListener());
```

- The listener must implement the appropriate event listener interface:

```
class FooListener extends Foo implements
  ActionListener
{
   ...
  public void actionPerformed(ActionEvent e) {
   ... // perform some action on event e
  }
}
```

- Event listener interfaces are specified in **`java.awt.event`**

Event Listeners (cont'd)

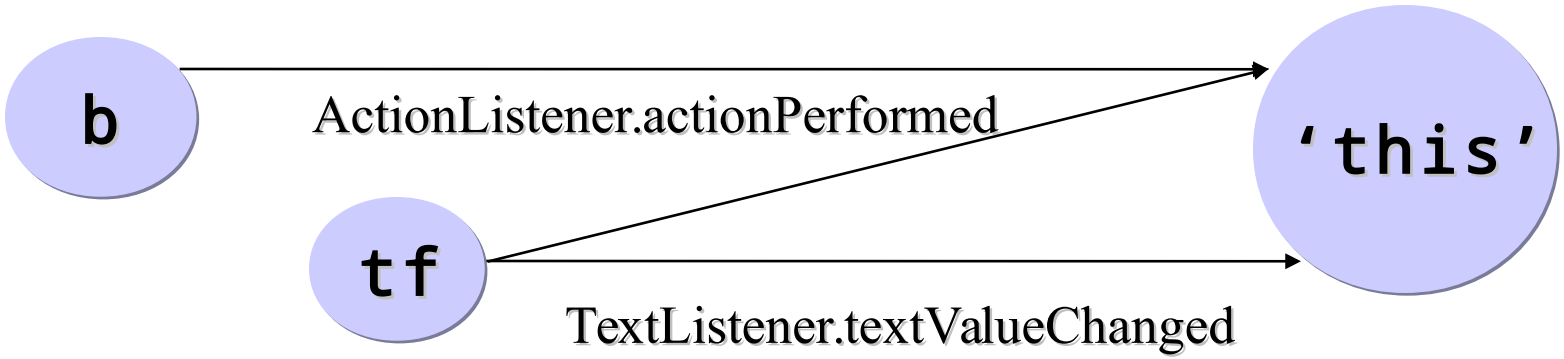


Click a button, press Return while typing in a text field, or choose a menu item	`ActionListener`
Close a frame (main window)	`WindowListener`
Press a mouse button while the cursor is over a component	`MouseListener`
Move the mouse over a component	`MouseMotionListener`
Component becomes visible	`ComponentListener`
Component gets the keyboard focus	`FocusListener`
Table or list selection changes	`ListSelectionListener`

One Listener –Multiple Sources

- One and the same event listener object can be linked to multiple event sources via different interfaces or the same interface.

```
TextField tf = new TextField("", 30);
Button b = new Button("Start");
tf.addActionListener(this); // on Enter
tf.addTextListener(this); // when text
changes
b.addActionListener(this); // on click
```



Using an Adapter Class

- Use of AWT adapter classes simplifies implementation of listener interfaces.
- There is an adapter class for each AWT interface in **`java.awt.event`**
  - An adapter class FooAdapter implements FooListener interface for FooEvent
  - Default implementation: do nothing

Using an Adapter Class (cont'd)

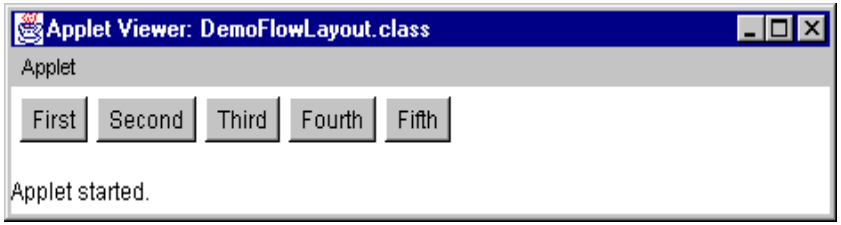
- Example:
  - The **`MouseAdapter`** class implements all five methods of **`MouseListener`** interface that receives **`MouseEvent`**
  - The adapter can be used as follows:

```
addMouseListener(new MouseAdapter
  {
    public void mousePressed () {
      //override the method
      }
});
```

Layout Managers and Container Attributes

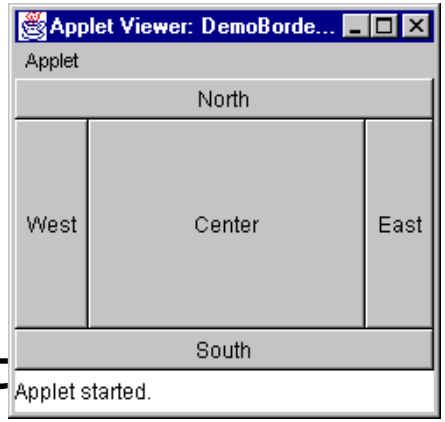
Layout Managers

- Layout manager allows organizing the layout of the GUI elements in a container with this layout.
- **`FlowLayout`**
  - From left to right, top to bottom.
  - The order of adds defines the order of components in the container.



- **`BorderLayout`**
  - "North", "South", "East", "West", "Center"

```
frame.add(b = new Button(), "Sout
```



Layout Managers (cont'd)

- **`GridLayout`**
  - A grid of equal-sized rectangles for components.
  - **`public GridLayout(int rs,int cs)`**
    - where: **`rs`**, **`cs`** - Number of rows and columns.

    0 – "any number".
- **`GridBagLayout`**
  - An irregular grid of components that uses constraints to arrange components.

Layout Managers (cont'd)

- **`CardLayout`**
  - Allows adding "cards" (sub-windows) and flipping through the "cards"
  - A container with CardLayout may contain several "cards" (sub-windows). One is shown at a time.
  - Flip through the cards sequentially, or show a card specified by its name
  - For example:

```
CardLayout cl = (CardLayout)
  mainframe.getLayout();
cl.first(mainframe); // show the first card
cl.next(mainframe); // show the second (next)
  card
cl.show(mainframe, "Card5"); // show the card
  "Card5"
```

Default Layout Managers, Setting a New Layout

Subclasses of `Container`	Default Layout Manager
`Panel, Applet`	`FlowLayout`
`Window`	`BorderLayout`
`Dialog`	`BorderLayout`
`Frame`	`BorderLayout`

- Setting a new layout manager:

```
setLayout(new FlowLayout());
Panel p = new Panel(new
  BorderLayout());
```

Set / Get Container's Attributes

- Size: `setSize(int, int)`
- Location: `setLocation(int, int)`
- Layout manager: `setLayout(LayoutManager)`
- Title (for a Frame): `setTitle(String)`
- Colors:
  - `setBackground(Color);`
  - `setForeground(Color)`
- Visibility: `setVisible(boolean)`
- Cursor: `setCursor(Cursor)`
- Font: `setFont(Font)`
- Event Listeners:
  - `addWindowListener(WindowListener)`
  - `addFocusListener(FocusListener)`, etc.

Applets: Downloadable Web clients

`java.applet.Applet`

Applet

- An applet is a subclass of `java.applet.Applet` that is a subclass of `java.awt.Panel`
  - loaded by a web-browser when an activated html page contains a reference to it – an applet tag.
  - can open a TCP connection (do RMI) to the host from which the applet has been downloaded;
  - expose network methods, e.g. `getImage`

Applet Methods

- Applet includes methods called by the environment where the applet runs:
  - `init()`
    - called once to initialize the applet, e.g. to build its GUI
  - `start()`
    - called each time when the applet's page is (re)open
  - `stop()`
    - called each time when the applet's page is closed
  - `paint(Graphics g)`
    - called when the applet must be repainted (resized, etc)
  - `destroy()` etc.
- The methods can be overridden, if needed.

Applet Tag in HTML Example

```
<HTML>
<HEAD>
<TITLE> This is a html page for running an
  applet </TITLE>
</HEAD>
<BODY>
   <APPLET CODE = "WebApplet.class"
     WIDTH = 500
     HEIGHT = 500>
   <PARAM NAME=”image" VALUE="jim.gif">
   </APPLET>
</BODY>
</HTML>
```

Example of Applet

- Draws a line that follows a mouse pressed and dragged.
- No communication with the server

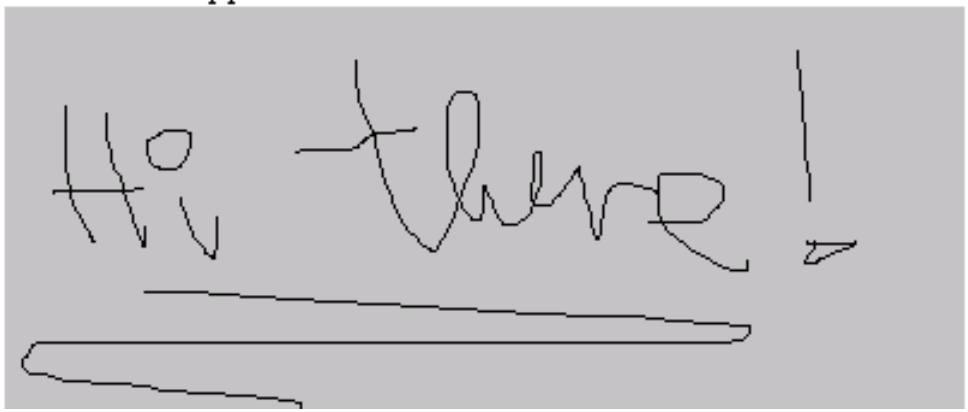
- **See also Applet examples in Lab 0 and Lab 1**

```
import java.awt.*;
import java.awt.event.*;
import java.applet.*;

public class Scribble extends Applet
    implements MouseListener, MouseMotionListener {
  private int last_x, last_y;

  //Initialize the applet
  public void init(){
    this.addMouseListener(this);
    this.addMouseMotionListener(this);
    this.setSize(400, 300);
  }
  public void mousePressed(MouseEvent e) {
    last_x = e.getX();
    last_y = e.getY();
  }
  public void mouseDragged(MouseEvent e) {
    Graphics g = this.getGraphics();
    int x = e.getX();
    int y = e.getY();
    g.drawLine(last_x,last_y,x,y);
    last_x = x;
    last_y = y;
  }
  public void mouseReleased(MouseEvent e) {;}
  public void mouseClicked(MouseEvent e) {;}
  public void mouseEntered(MouseEvent e) {;}
  public void mouseMoved(MouseEvent e) {;}
  public void mouseExited(MouseEvent e) {;}
}
```

Example (cont'd)

- A source and a view of the HTML page with the Scribble applet

Scribble will appear below in a Java enabled browser.




```
<html>
<head>
<title>
HTML Test Page
</title>
</head>
<body>
Scribble will appear below
in a Java enabled browser.<br>
<applet
  codebase = "."
  code     = "Scribble.class"
  name     = "TestScribble "
  width    = "400"
  height   = "300"
  hspace   = "0"
  vspace   = "0"
  align    = "middle"
>
</applet>
</body>
</html>
```

Applet Example 2

- Develop an applet that counts how many times the basic methods of a applet (init, start, paint, stop) are invoked.

```
import java.applet.Applet;
import java.awt.*;
public class StarterApplet extends Applet {

  private int InitCount = 0;
  private int StartCount = 0;
  private int StopCount = 0;
  private int PaintCount = 0;

  public void init() {
    resize( 300, 100 );
    InitCount++;
  }
  public void start() {
    StartCount++;
  }
  public void stop() {
    StopCount++;
  }
  public void paint( Graphics g ) {
    PaintCount++;
    g.drawString( " Inits: " + InitCount +
        " Starts: " + StartCount +
        " Stops: " + StopCount +
        " Paints: " + PaintCount, 30, 50 );
  }
}
```

Example 2 (cont)

- Applet and application combined in one class

```
import java.awt.Frame;
import java.awt.event.*;

public class StarterCombined extends StarterApplet {
  public static void main( String args[] ) {
      Frame f = new Frame( "Starter Application" );
      f.addWindowListener(new WindowAdapter()
      {
          public void windowClosing(WindowEvent e)
          {
              System.exit(0);
          }
      });
      StarterCombined applet = new StarterCombined();
      applet.init();
      f.add( "Center", applet );
      f.setSize( 300, 100 );
      f.setVisible(true);
      applet.start();
  }
}
```

Some Network Methods of the `Applet` Class

- Getting audio and image files:
  - `Image getImage(URL)`
  - `Image getImage(URL, String)`
  - `AudioClip getAudioClip(URL)`
  - `AudioClip getAudioClip(URL, String)`
  - `play(URL)`
  - `play(URL, String)`
- Locate the applet or the document in which the applet is embedded:
  - `URL getCodeBase()`
  - `URL getDocumentBase()`

Applet Context

- The applet context represents an applet's environment, e.g. a browser or an applet viewer:

```
AppletContext ac = getAppletContext();
```

- Useful methods:

  `showDocument(URL)`
  - replace the current Web with the given URL.

  `showDocument(URL url, String target)`
  - Show the Web page indicated by url. The target argument indicates where to display the frame, for instance, in the current frame or in a new navigator.

  `getApplet(String)`
  - returns the applet with the given name

- See Example 3.13 (on the Examples page) `ShowImage1.java`

Named Applets

- An applet can be named in the APPLET (EMBED) tag:

```
<APPLET CODEBASE="../MyClasses" CODE=TalkApplet.class
  WIDTH=793 HEIGHT=130 NAME="Top”>
<PARAM NAME=Partner VALUE="Bottom">
</APPLET>
<HR>
<APPLET CODEBASE="../MyClasses" CODE=TalkApplet.class
  WIDTH=793 HEIGHT=130 NAME="Bottom”>
<PARAM NAME=Partner VALUE="Top">
</APPLET>
```

- Named applets embedded in the same Web page can get references to each other via the shared Applet Context:

```
TalkApplet a = (TalkApplet)(getAppletContext().
    getApplet(getParameter("Partner")));
```

Interaction of Applets via the Applet Context

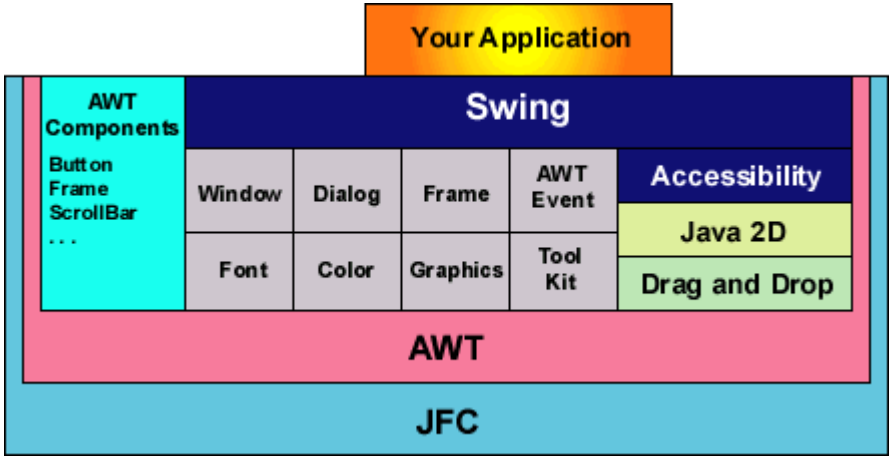
- Applets on the same Web page share the Applet Context (JVM) and can interact with each other via
  - Method invocation. The methods should be declared as synchronized.
  - Static class variables;
  - Piped connection.
- An applet gets reference to another applet by name.
- See Example 4.5 (on the Examples page) TalkApplet.java

Swing: Advanced Window Toolkit

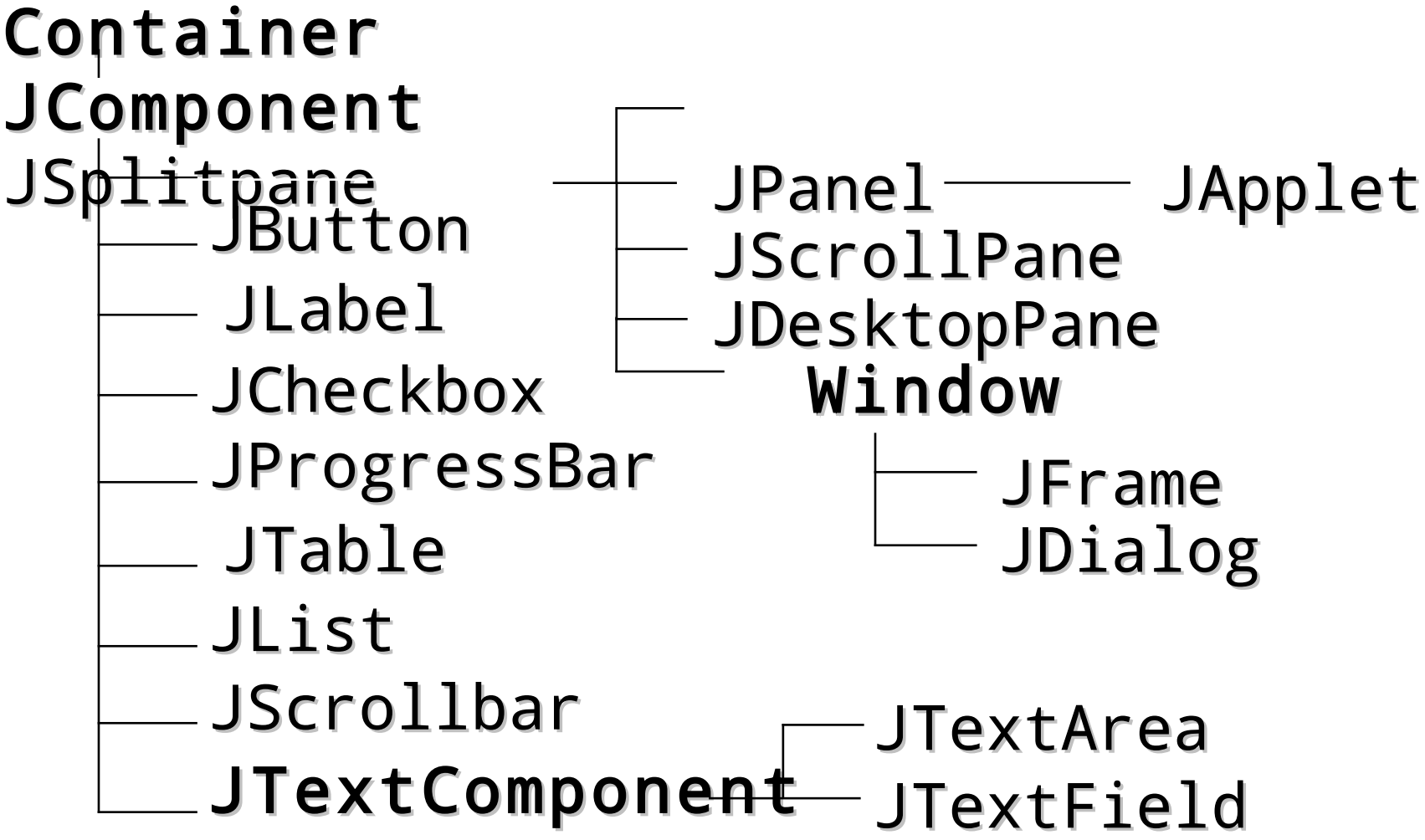
`javax.swing`

What Is Swing?

- ***Java Swing*** – is an API that provides a set of extensible GUI components to develop powerful Java front ends for commercial applications more rapidly.
- 100% pure Java, GUI component kit
- The Swing Stack:



Swing Components



Swing components (1/2)

- See Swing component and container gallery (A Visual Index to the Swing Components) at

`http://download.oracle.com/javase/tutorial/uiswing/components/index.html`

- Basic Controls:
  - `JButton`, `JCheckBox`, `JRadioButton`
  - `JComboBox` –Buttons that bring up menus of choices.
  - `JMenuBar`, `JMenu`, `JRadioButtonMenuItem`, etc.
  - `JList`, `JTextField`
  - `JSlider` lets choose one of a continuous range of values.

Swing Components (2/2)

- Uneditable information displays:
  - `JLabel`
  - `JProgressBar` displays progress toward a goal.
  - `JToolTip` brings up a small window that describes another component.
- Editable displays of formatted information:
  - `JColorChooser`, `JFileChooser`
  - `JPasswordField`, `JTextArea`, `JEditorPane`, `JTextPane`
  - `JTable`
  - `JTree` displays hierarchical data.

Swing containers

- Top-Level Containers: **`JFrame`**, **`JDialog`**, **`JApplet`**
  - **`frame.getContentPane().add(child);`**
  - The content pane should be the parent of any children of a top-level container.
- General-Purpose Containers
  - **`Jpanel`** an empty panel for grouping components.
  - **`JScrollPane`** provides scroll bars around a large or growable component.
  - **`JSplitPane`** displays two components in a specified amount of space.
  - **`JTabbedPane`** contains multiple components but shows one at a time.
  - **`JToolBar`** holds a group of components (usually buttons) in a row or column, allowing the user to drag the tool bar into different locations.

Using a JFrame

Create a frame with a title:

```
JFrame frame = new JFrame("Enter User Data");
```

Place the gui in the frame's content pane (see figure below):

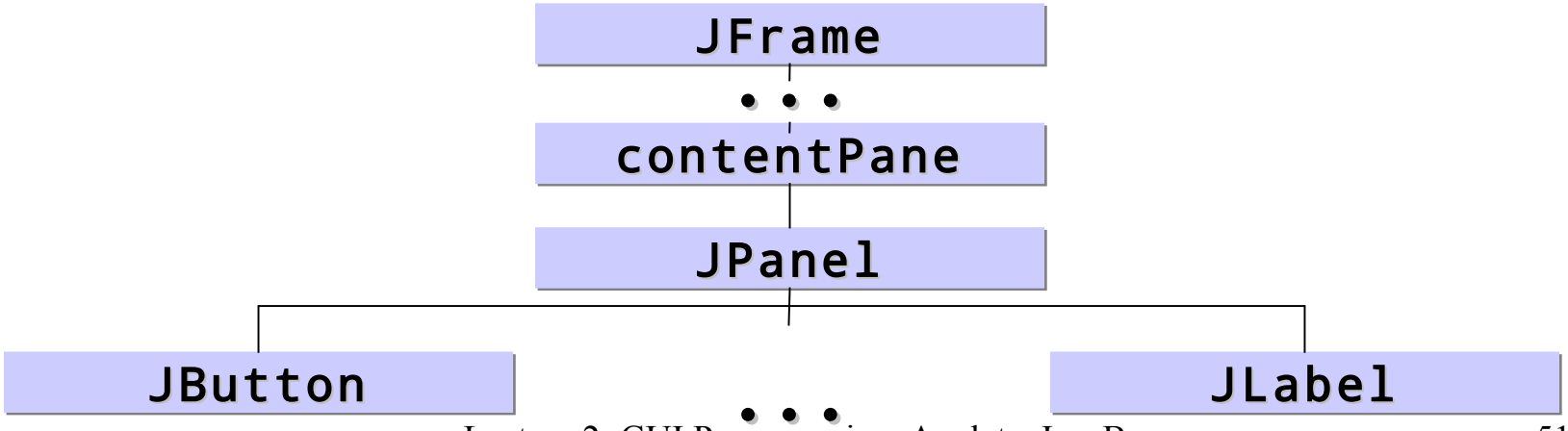
```
frame.setContentPane(new PanelWithComponents());
```

Specify that the JVM shall terminate when the frame is closed:

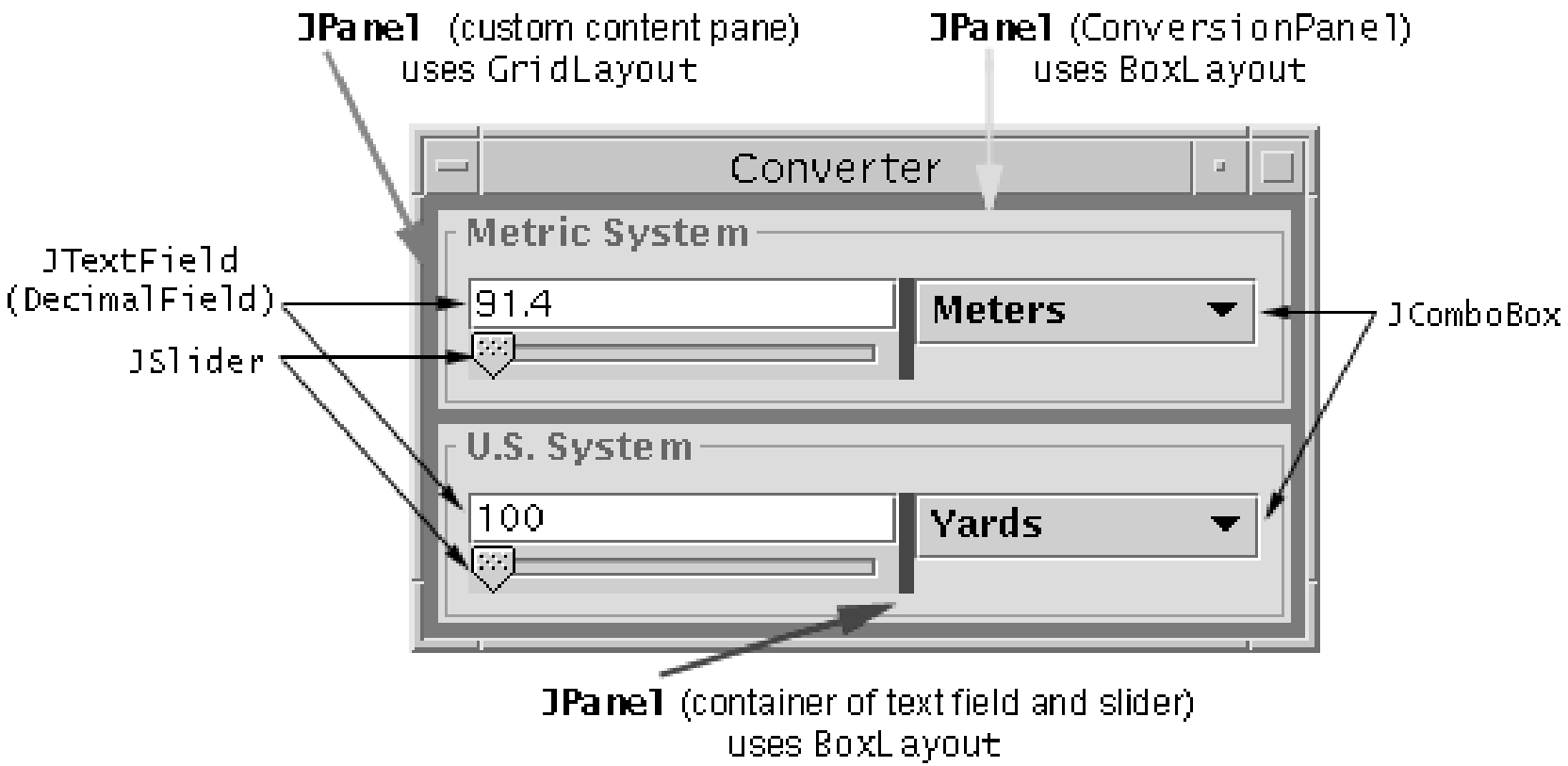
```
frame.setDefaultCloseOperation(Jframe.EXIT_ON_CLOSE);
```

Give the frame the minumum size and show it on the screen:

```
frame.pack();
frame.setVisible(true);
```



View of Some Swing Components



Look-and-Feels

- The Java look-and-feel (Metal): "javax.swing.plaf.metal.MetalLookAndFeel”
- The CDE/Motif look-and-feel: "com.sun.java.swing.plaf.motif.MotifLookAndFeel"
- The Windows look-and-feel: "com.sun.java.swing.plaf.windows.WindowsLookAndFeel“
- Make a program use the Java look & feel:

```
public static void main(String[] args) {
  try {

UIManager.setLookAndFeel( UIManager.getCrossPlatformLookAndFeelClassName());
   } catch (Exception e) { };
   new SwingApplication(); //Create and show the GUI.
}
```

- Setting a specific look & feel, e.g. the Windows Look & Feel:

```
try {

UIManager.setLookAndFeel("com.sun.java.swing.plaf.windows.WindowsLookAndFeel
”);
 } catch (Exception e) { };
```

Overview of JavaBeans

“

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

A Component Model

- A component model
  - includes a component architecture (specification and a set of APIs)
  - allows defining software components to be combined together to create an application.
- Two major groups of elements:
  - Containers
    - Used to hold assembly of related components
    - Provide context for components to interact with one another
  - Components
    - Vary in size and capabilities
    - Can be containers

Java Component Architectures

- ***JavaBeans*** – a first Java component architecture
  - Portable, self-described, reusable software components that can be visually manipulated, customized and combined with other Java components in a builder tool (bean container) such as Eclipse or Sun's NetBeans.
  - Have attributes, expose public methods and may fire events.
  - Example: AWT components, e.g. Button, TextField, etc.
- ***Enterprise Java Beans (EJB)*** – a component architecture for enterprise applications
  - Different from JavaBeans: EJBs are deployable
  - An EJB can be either Session or Message-Driven

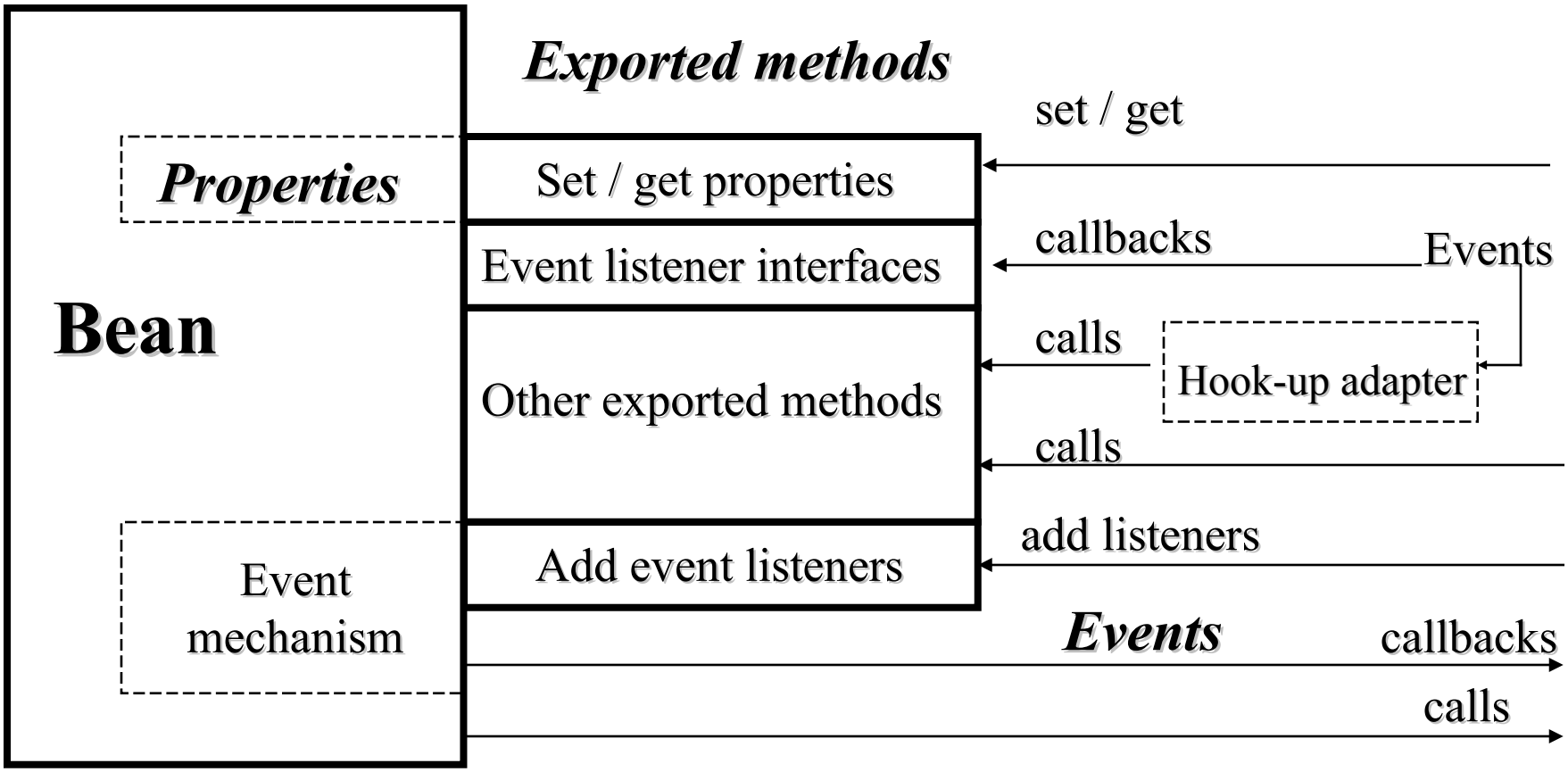
A JavaBean Can

- Export public methods
- Raise and catch events of proper types
- Allow queries about its capabilities - introspection
- Support persistent properties (can be stored and restored)
- Support component editors for builders to allow users to customize component behavior
- Be a container for other beans
  - Hierarchical components
  - Java compound documents

Bean Properties, Methods and Events

- A Bean communicates via:
  - ***Properties*** it exposes.
    - Named attributes that can be read or written by calling the appropriate set and get methods on the bean.
  - ***Methods*** it exports.
    - By default all of the bean's public methods are exported
  - ***Events*** it fires or/and listens.
    - The bean can register listeners for its events via public methods add<EventType>Listener(<EventType>Listener)
    - A bean instance can be registered as a listener of events fired by other components:
      - directly: implementing appropriate event listener interfaces
      - indirectly: via hook-up event adapters.

A Bean Interface



Bean Properties

- Properties are public/private attributes that can be exposed by set / get methods (accessors).
- The name convention: public methods named setFoo and getFoo indicate a property named Foo.
- A ***simple property*** represents a single value.
- An ***indexed property*** represents an array of values.
  - The property can be accessed at once.
  - An element of the property can be accessed by index.
- A ***bound property***
  - Notifies other objects when its value changes via a `PropertyChange` event that contains the property name, old and new value.
- A ***constrained property***
  - Notifies other objects when its value changes via a `VetoableChange` event and allows a listener to veto the change by throwing a `PropertyVetoException`.

Bean Event Mechanism

- Based on Java event delegation model
- Convention: A Bean indicates that it can fire FooEvent if
  - it contains a pair of methods:

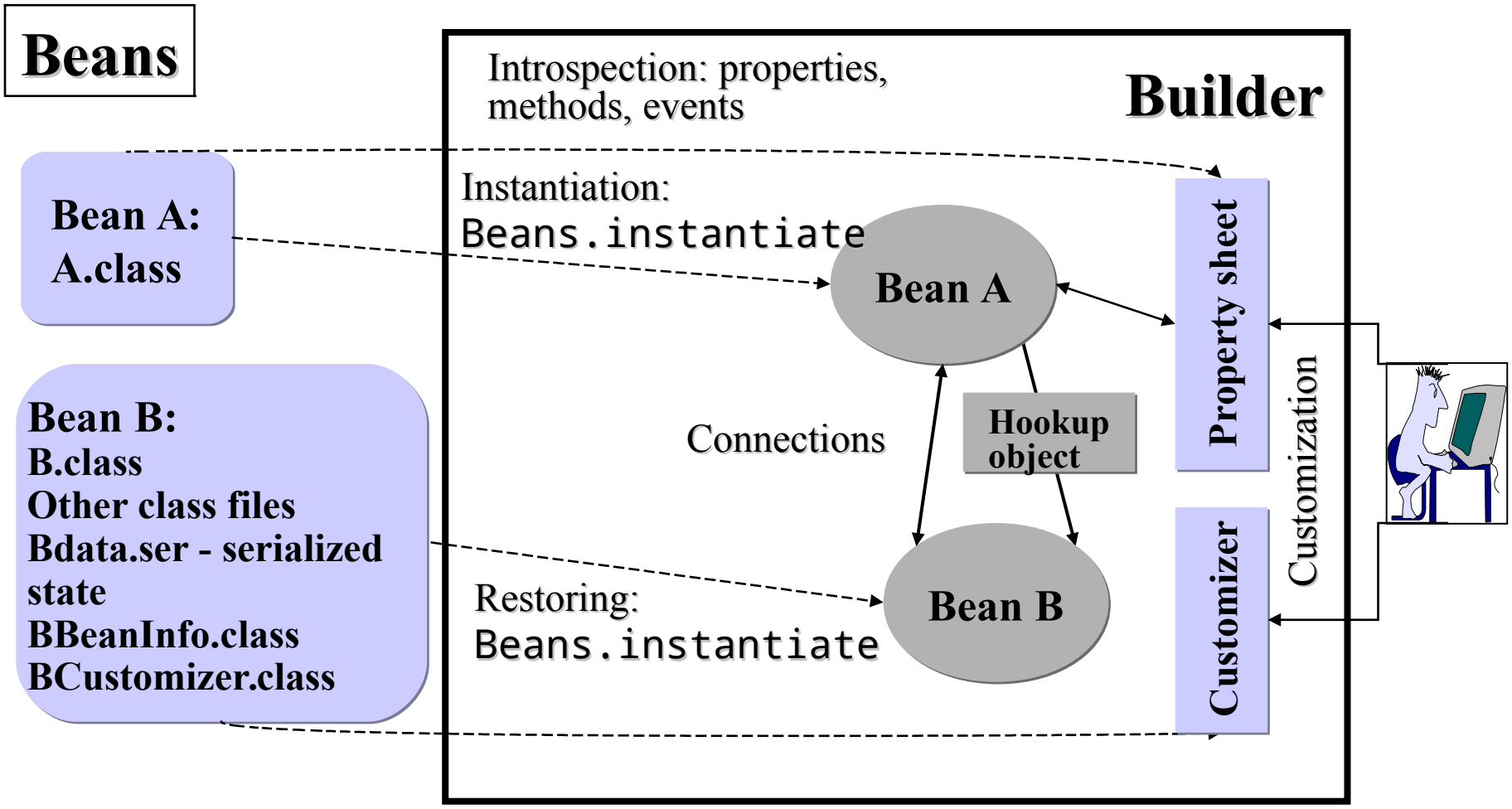
```
public void addFooListener(FooListener a)
public void removeFooListener(FooListener a)
```

  - and it declares or imports the FooListener interface and the FooEvent class.
- Use of a hookup event adapter:
  - If a listener does have the FooListener interface, it can be connected to the bean via a hookup event adapter that implements the interface and invokes appropriate methods on the real listener (i.e. the bean).

Developing Beans with a RAD tool

- Visual development using property sheets, palettes, and design-time drag-and-drop behavior.
  - A Bean class must adhere to a set of name conventions and design patterns for properties it exposes, events it fires
  - A builder tool uses introspection based on reflection to learn about the properties, events, and methods supported by a target Java Bean.
  - The tool relies on design patterns specified in the JavaBeans Specification

Beans in an Application Builder



Saving and Restoring Beans

- ***Java Object Serialization*** provides persistence: saving Beans to streams (files, network streams)
  - The serialized state of the Bean can been restored at design-time (by a builder tool) and at run-time.
  - Loading a serialized state of a Bean to a builder tool, customization of the Bean and saving its state for further use.
- All files related to a Bean can be stored into a JAR file that normally contains:
  - All classes files related to the Bean: <BeanName>.class, others.
  - Supporting classes: <BeanName>BeanInfo.class, <BeanName>Customizer.class
  - Other files: images, audio, etc.
  - A serialized state of the Bean to be restored: <BeanName>Data.ser