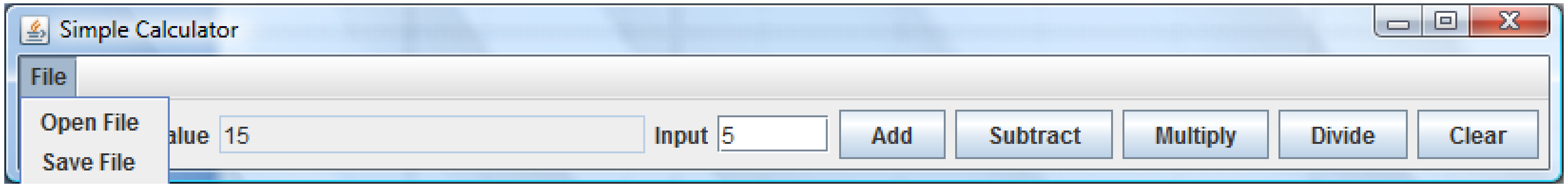
Graphical User Interfaces (pt 2)

Based on slides by Prof. Burton Ma

View

- View
  - Presents the user with a sensory (visual, audio, haptic) representation of the model state
  - A user interface element (the user interface for simple applications)

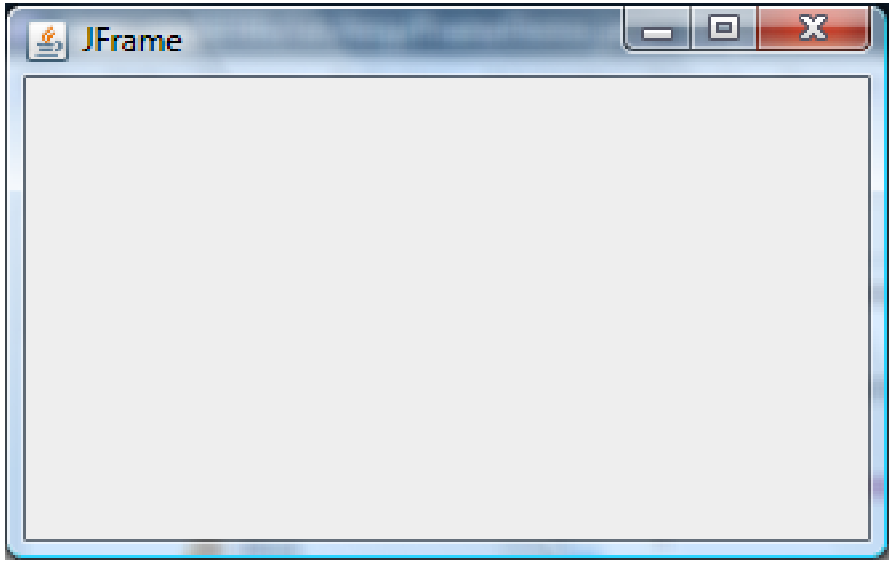


Simple Applications

- Simple applications often consist of just a single window (containing some controls)

JFrame

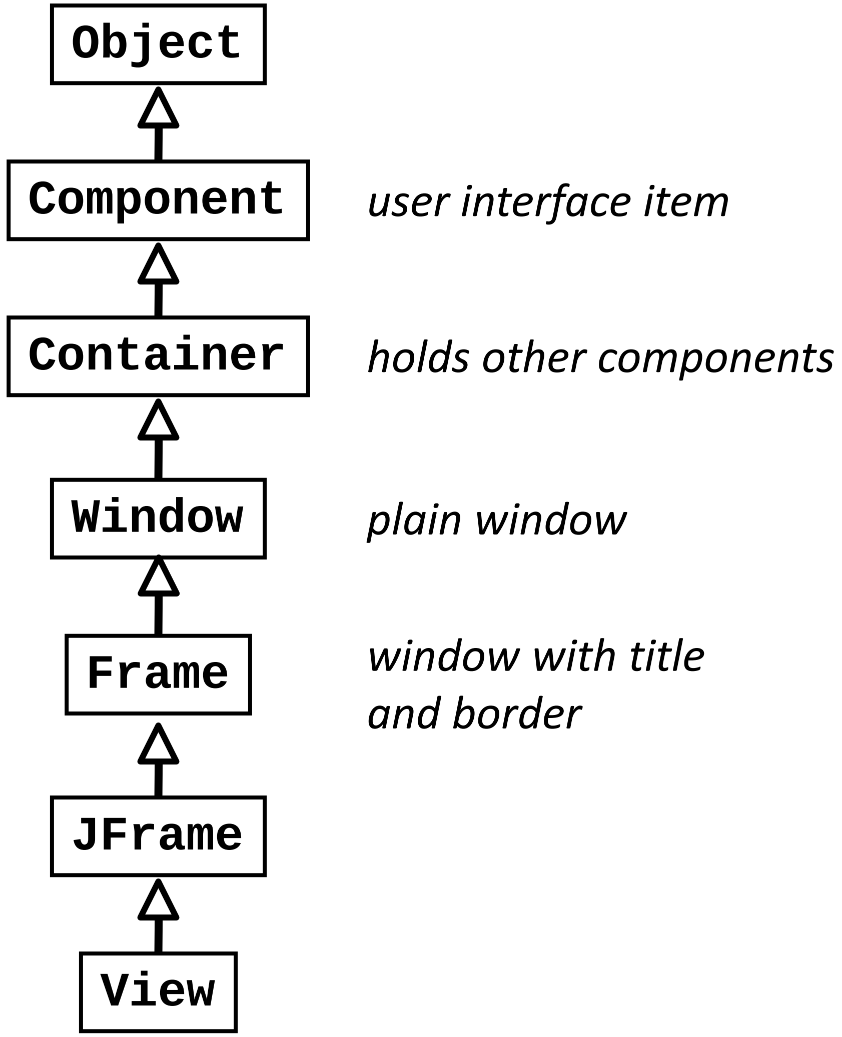
window with border, title, buttons



View as a Subclass of JFrame

- A View can be implemented as a subclass of a JFrame

- Hundreds of inherited methods but only a dozen or so are commonly called by the implementer (see URL below)



http://java.sun.com/docs/books/tutorial/uiswing/components/frame.html

Implementing a View

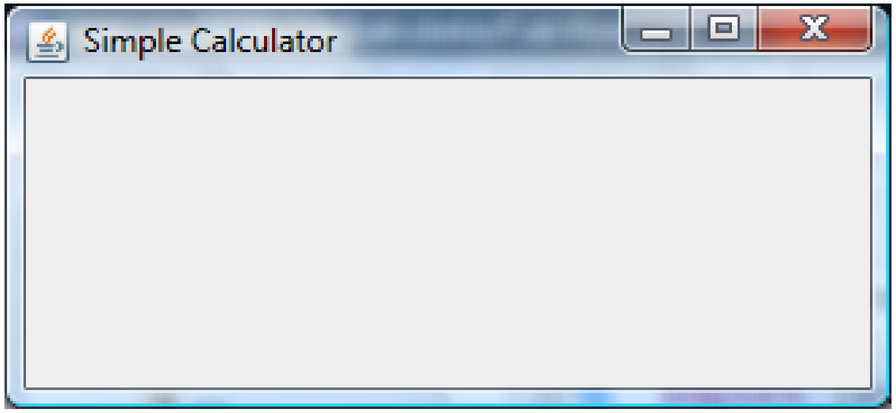
- The View is responsible for creating:
  - The Controller
  - All of the user interface (UI) components

• menus	JMenuBar, JMenu, JMenuItem
• buttons	JButton
• labels	JLabel
• text fields	JTextField
• file dialog	JFileChooser

- The View is also responsible for setting up the communication of UI events to the Controller
  - Each UI component needs to know what object it should send its events to

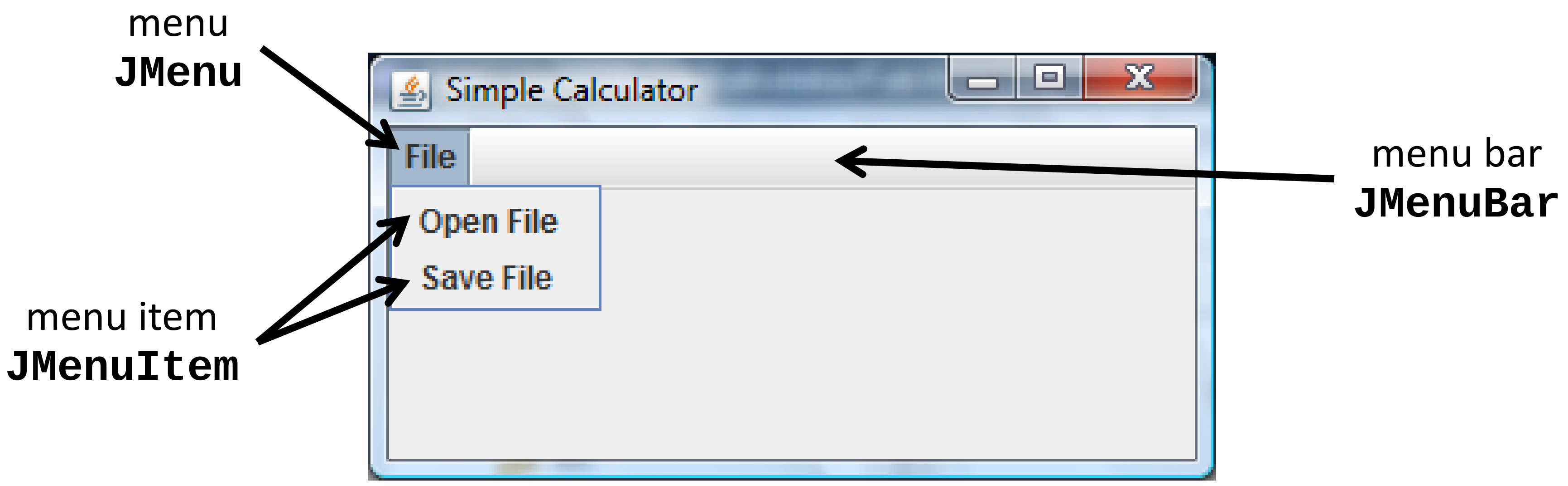
CalcView: Create Controller

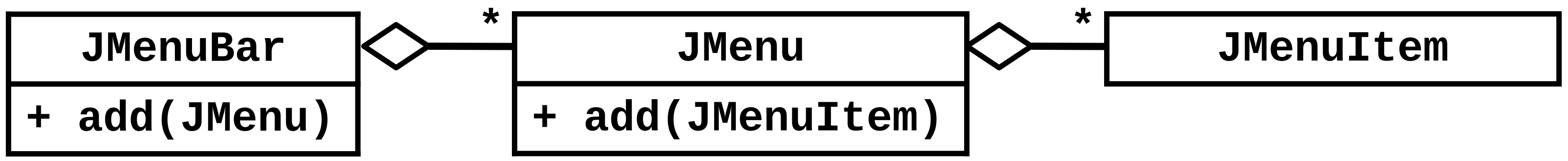
```
public class CalcView extends JFrame
{
  public CalcView(CalcModel model)
  {
    super("Simple Calculator");
    model.clear();
    CalcController controller =
            new CalcController(model, this);
    this.setDefaultCloseOperation(JFrame.EXIT_ON_CLOSE);
  }
}
```



Menus

- a menu appears in a *menu bar* (or a popup menu)
- each item in the menu is a *menu item*





http://docs.oracle.com/javase/tutorial/uiswing/components/menu.html

Menus

- To create a menu
  - Create a JMenuBar
  - Create one or more JMenu objects
    - Add the JMenu objects to the JMenuBar
  - Create one or more JMenuItem objectes
    - Add the JMenuItem objects to the JMenu

Menus

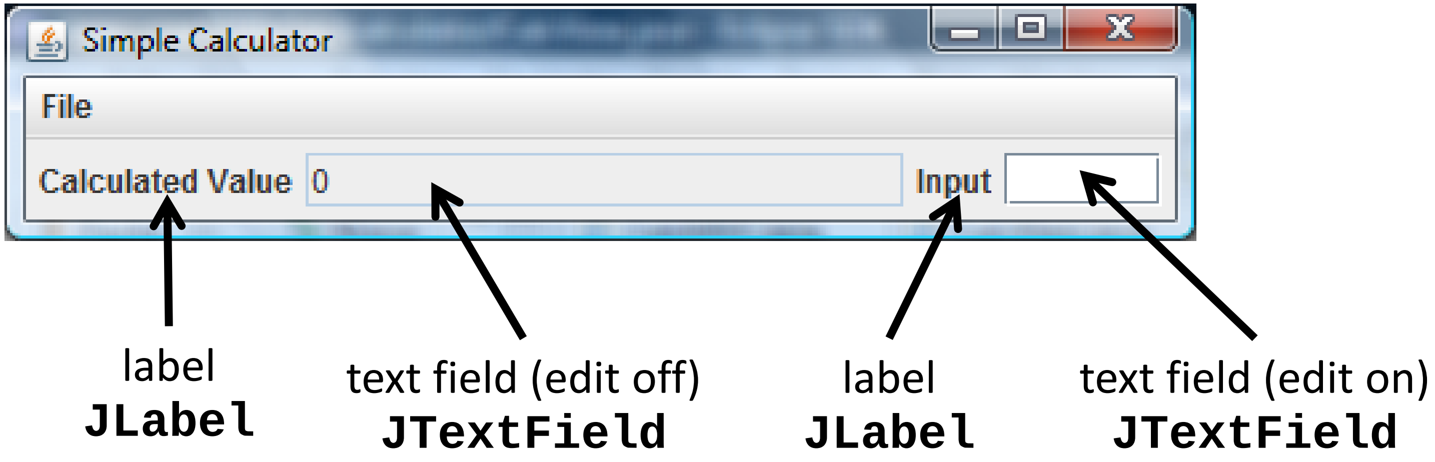
```
JMenuBar menuBar = new JMenuBar();

JMenu fileMenu = new JMenu("File");
menuBar.add(fileMenu);

JMenuItem printMenuItem = new
JMenuItem("Print");
fileMenu.add(printMenuItem);
```

CalcView: Menubar, Menu, Menu Items

```
import javax.swing.JFrame;
import javax.swing.JMenu;
import javax.swing.JMenuBar;
import javax.swing.JMenuItem;

public class CalcView extends JFrame
{
  private JMenuBar menuBar;
  private JMenu fileMenu;

  public CalcView(CalcModel model)
  {
    super("Simple Calculator");
    model.clear();
    CalcController controller =
                new CalcController(model, this);

    this.menuBar = new JMenuBar();
```

Labels and Text Fields

- A label displays unselectable text and images
- A text field is a single line of editable text
  - The ability to edit the text can be turned on and off



http://docs.oracle.com/javase/tutorial/uiswing/components/label.html

http://docs.oracle.com/javase/tutorial/uiswing/components/textfield.html

Labels

- To create a label

```
JLabel label = new JLabel("text for the label");
```

- To create a text field (20 characters wide)

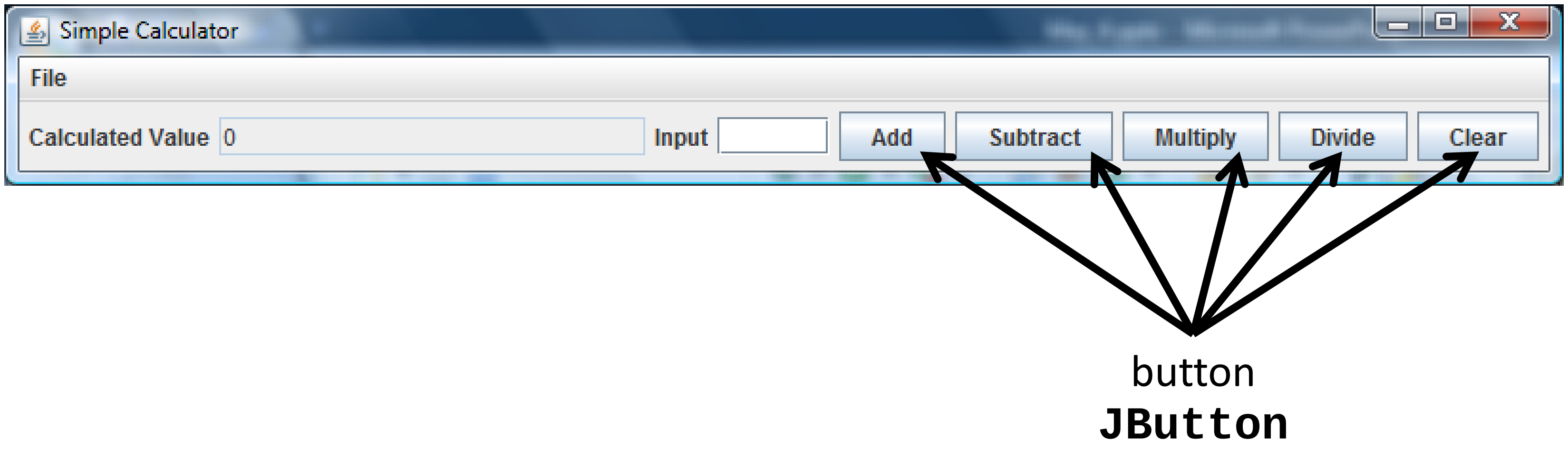
```
JTextField textField = new JTextField(20);
```

CalcView: Labels and Text Fields

```
import java.awt.FlowLayout;

import javax.swing.JFrame;
import javax.swing.JLabel;
import javax.swing.JMenu;
import javax.swing.JMenuBar;
import javax.swing.JMenuItem;
import javax.swing.JTextField;

public class CalcView extends JFrame
{
  private JMenuBar menuBar;
  private JMenu fileMenu;
  private JTextField calcText;
  private JTextField userValueText;

  public CalcView(CalcModel model)
  {
           ("Simple Calculator")
```

Buttons

- A button responds to the user pointing and clicking the mouse on it (or the user pressing the Enter key when the button has the focus)



http://docs.oracle.com/javase/tutorial/uiswing/components/button.html

Buttons

- To create a button

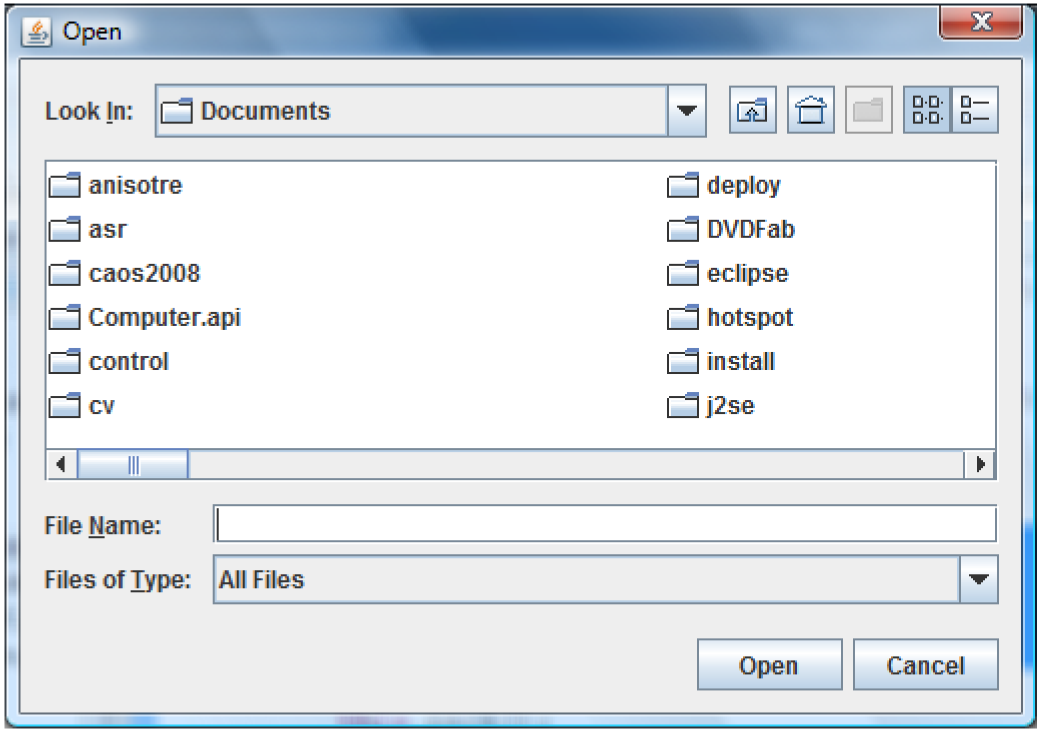
```
JButton button = new JButton("text for the button");
```

CalcView: Buttons

```
import java.awt.FlowLayout;

import javax.swing.JButton;
import javax.swing.JFrame;
import javax.swing.JLabel;
import javax.swing.JMenu;
import javax.swing.JMenuBar;
import javax.swing.JMenuItem;
import javax.swing.JTextField;

public class CalcView extends JFrame
{
  private JMenuBar menuBar;
  private JMenu fileMenu;
  private JTextField calcText;
  private JTextField userValueText;
  private JButton sumButton;
  private JButton subtractButton;
```

File Chooser

- A file chooser provides a GUI for selecting a file to open (read) or save (write)



file chooser (for choosing a file to open)
`JFileChooser`

http://docs.oracle.com/javase/tutorial/uiswing/components/filechooser.html

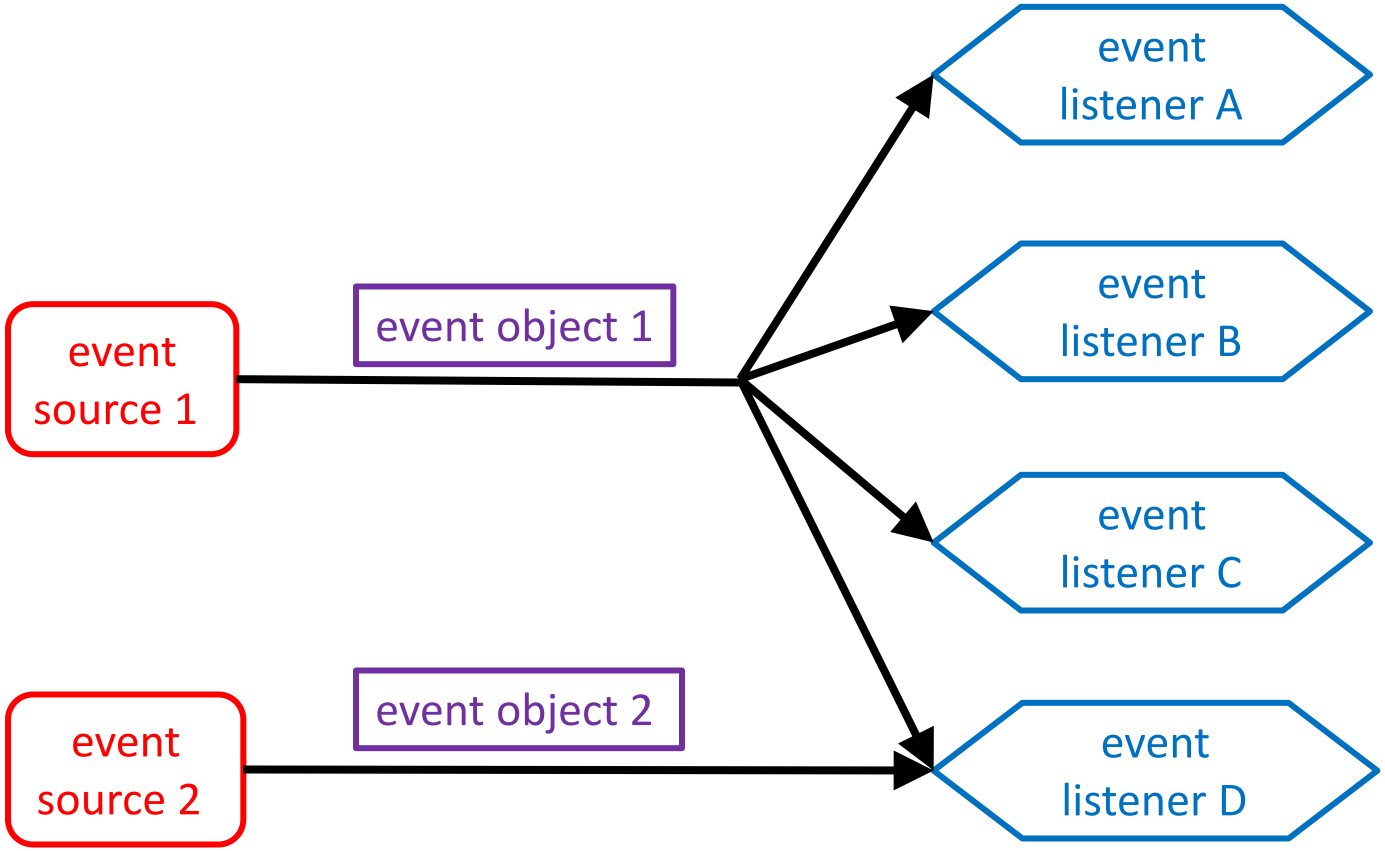
CalcView: File Chooser

```
import java.awt.FlowLayout;
import java.io.File;

import javax.swing.JButton;
import javax.swing.JFileChooser;
import javax.swing.JFrame;
import javax.swing.JLabel;
import javax.swing.JMenu;
import javax.swing.JMenuBar;
import javax.swing.JMenuItem;
import javax.swing.JTextField;

public class CalcView extends JFrame
{
  private JMenuBar menuBar;
  private JMenu fileMenu;
  private JTextField calcText;
  private JTextField userValueText;
```

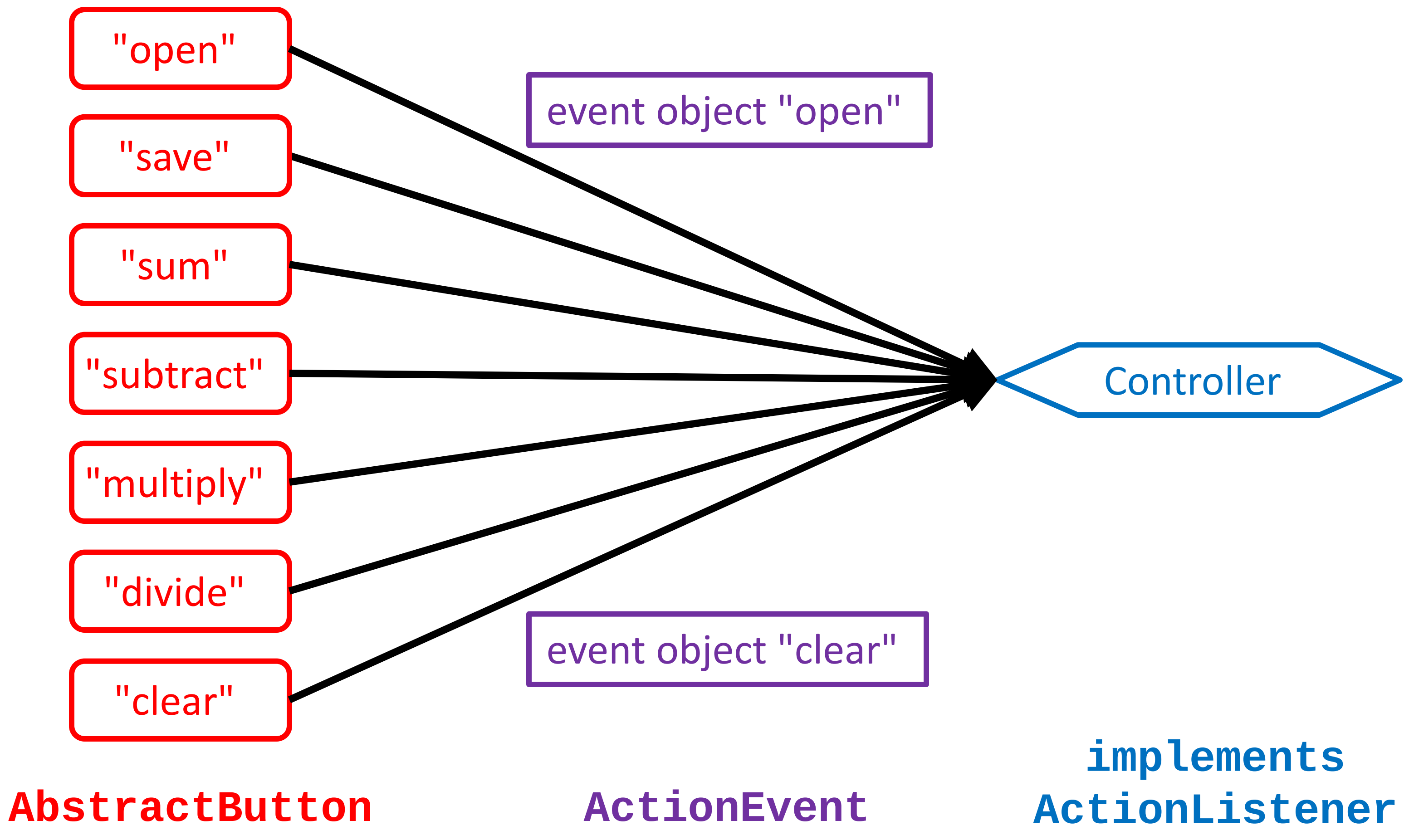
Event Driven Programming

- So far we have a View with some UI elements (buttons, text fields, menu items)
  - Now we need to implement the actions
- Each UI element is a source of events
  - Button pressed, slider moved, text changed (text field), etc.
- When the user interacts with a UI element an event is triggered
  - This causes an event object to be sent to every object listening for that particular event
    - The event object carries information about the event
- The event listeners respond to the event

Not a UML Diagram



Not a UML Diagram



Implementation

- Each **`JButton`** and **`JMenuItem`** has two inherited methods from **`AbstractButton`**

```
public void addActionListener(ActionListener l)

public void setActionCommand(String actionCommand)
```

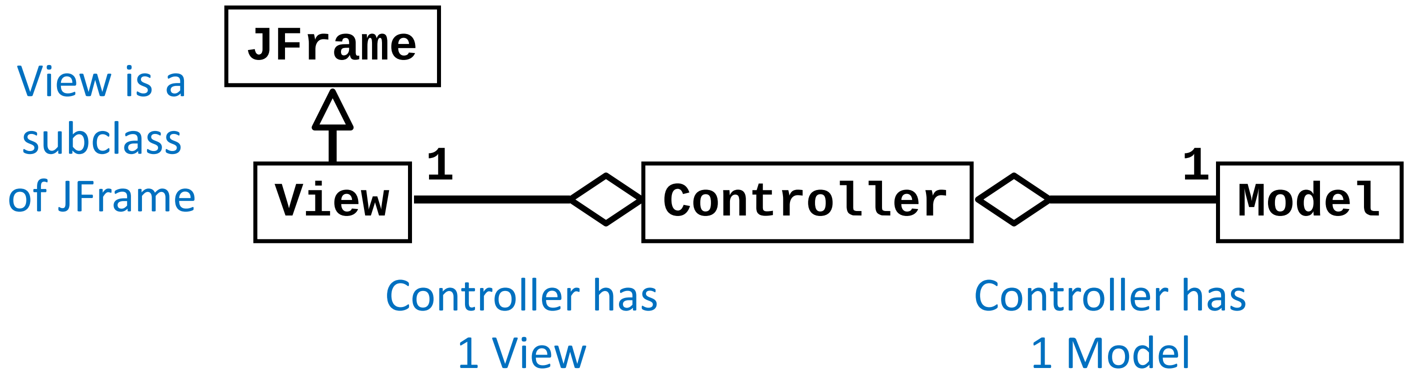
- For each **`JButton`** and **`JMenuItem`**
  1. Call **`addActionListener`** with the controller as the argument
  2. Call **`setActionCommand`** with a string describing what event has occurred

CalcView: Add Actions

```
import java.awt.FlowLayout;
import java.awt.event.ActionListener;
import java.io.File;

import javax.swing.JButton;
import javax.swing.JFileChooser;
import javax.swing.JFrame;
import javax.swing.JLabel;
import javax.swing.JMenu;
import javax.swing.JMenuBar;
import javax.swing.JMenuItem;
import javax.swing.JTextField;

public class CalcView extends JFrame
{
  private JMenuBar menuBar;
  private JMenu fileMenu;
  private JTextField calcText;
```

Controller

- Controller
  - Processes and responds to events (such as user actions) from the view and translates them to model method calls
- Needs to interact with both the view and the model but does not own the view or model
  - Aggregation



CalcController: Attributes & Constructor

```
import java.awt.event.ActionListener;

public class CalcController implements ActionListener
{
  private CalcModel model;
  private CalcView  view;

  public CalcController(CalcModel model, CalcView view)
  {
    this.model = model;
    this.view = view;
  }

}
```

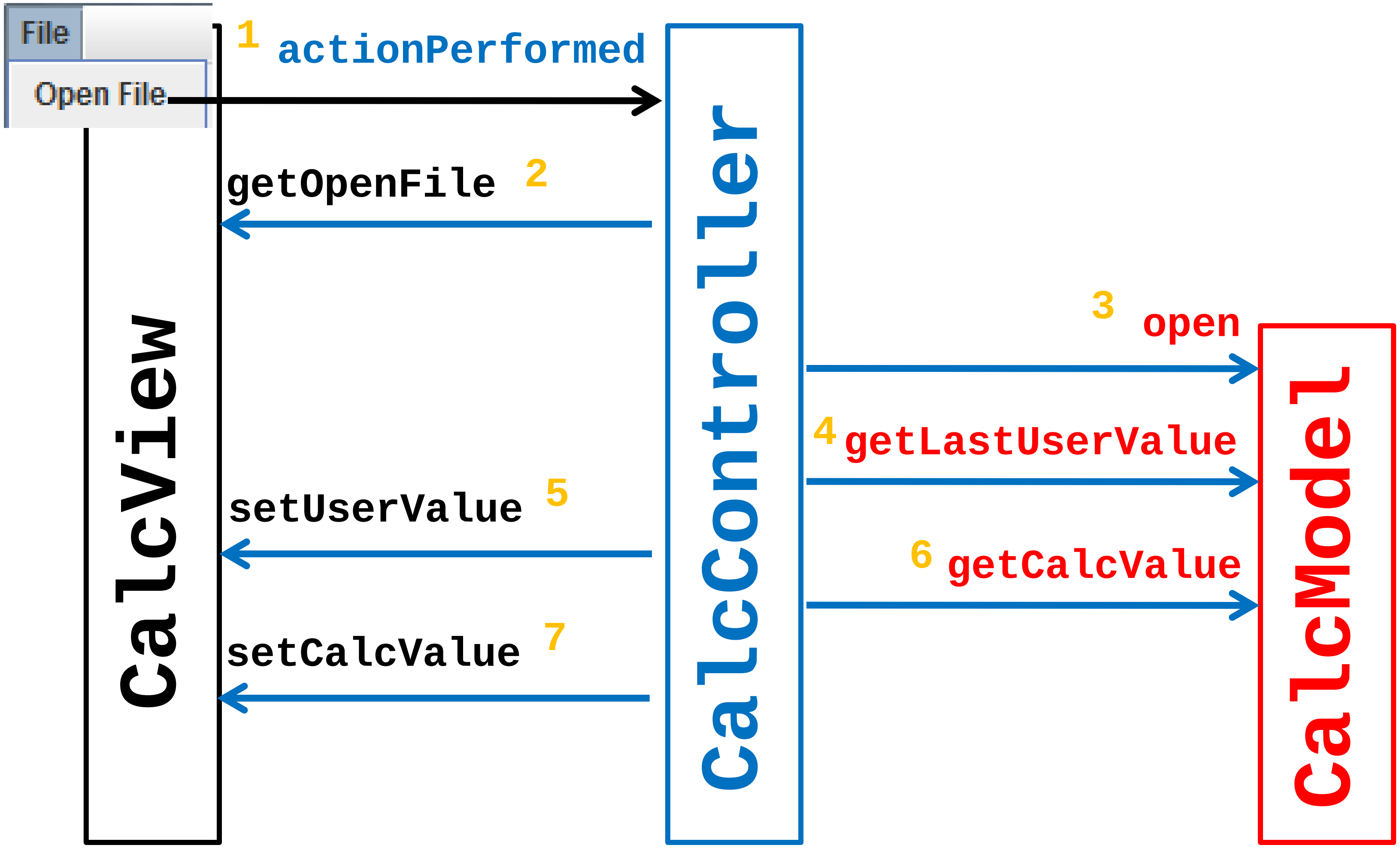
CalcController

- Tecall that our application only uses events that are fired by buttons (**`JButton`**s and **`JMenuItem`**s)
  - A button fires an **`ActionEvent`** event whenever it is clicked
- **`CalcController`** listens for fired **`ActionEvent`**s
  - How? by implementing the **`ActionListener`** interface

```
public interface ActionListener
{
  void actionPerformed(ActionEvent e);
}
```

- **`CalcController`** was registered to listen for **`ActionEvents`** fired by the various buttons in **`CalcView`** (see method **`setCommand`** in **`CalcView`**)
- Whenever a button fires an event, it passes an **`ActionEvent`** object to **`CalcController`** via the **`actionPerformed`** method
  - **`actionPerformed`** is responsible for dealing with the different actions (open, save, sum, etc)

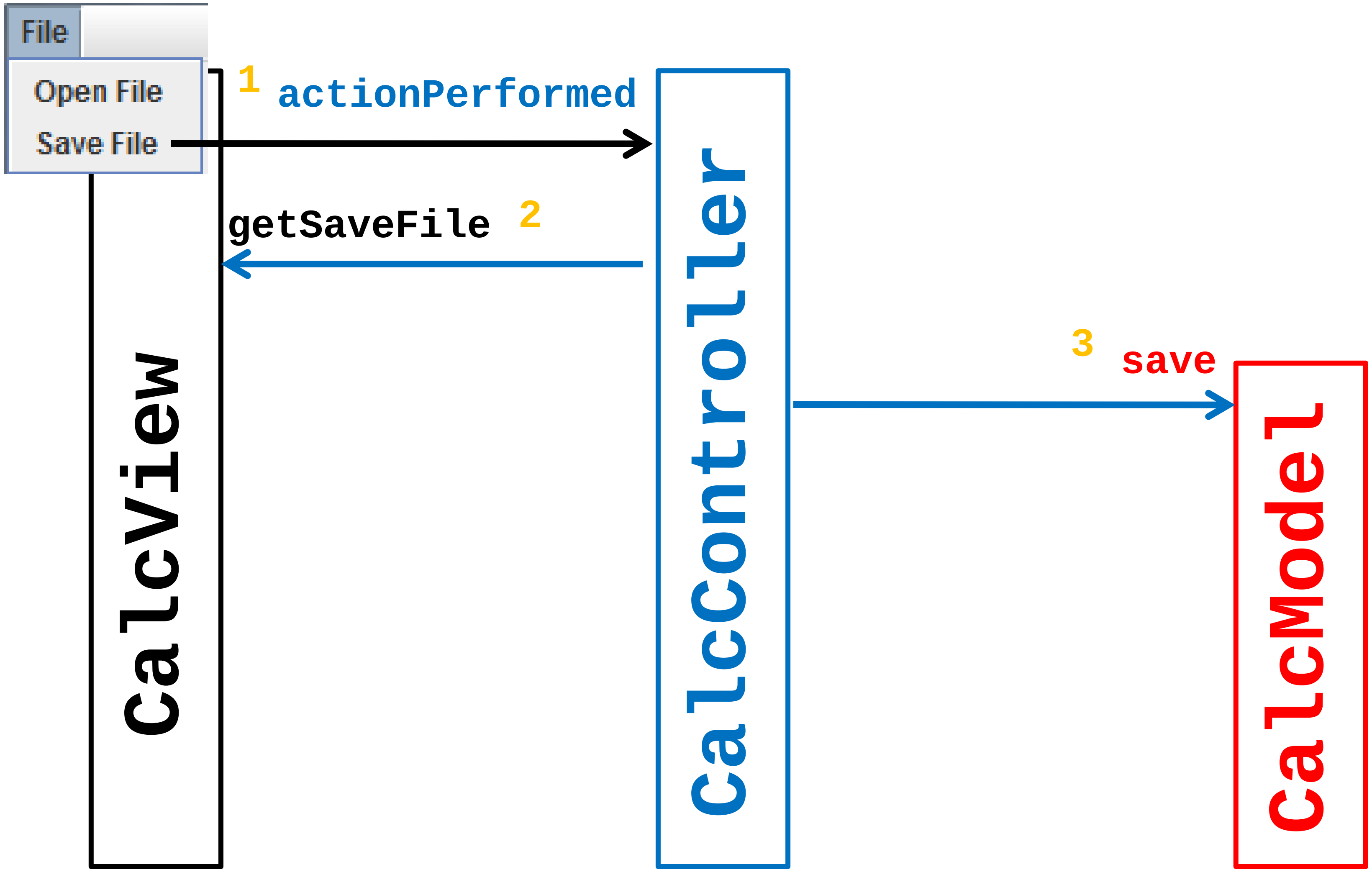
Opening a File



CalcController: Open a File

```
import java.awt.event.ActionListener;

public class CalcController implements ActionListener
{
  private CalcModel model;
  private CalcView  view;

  public CalcController(CalcModel model, CalcView view)
  {
    this.model = model;
    this.view = view;
  }

  /**
   * Invoked when an event occurs.
   *
   * @param event
   *           The event.
   */
```

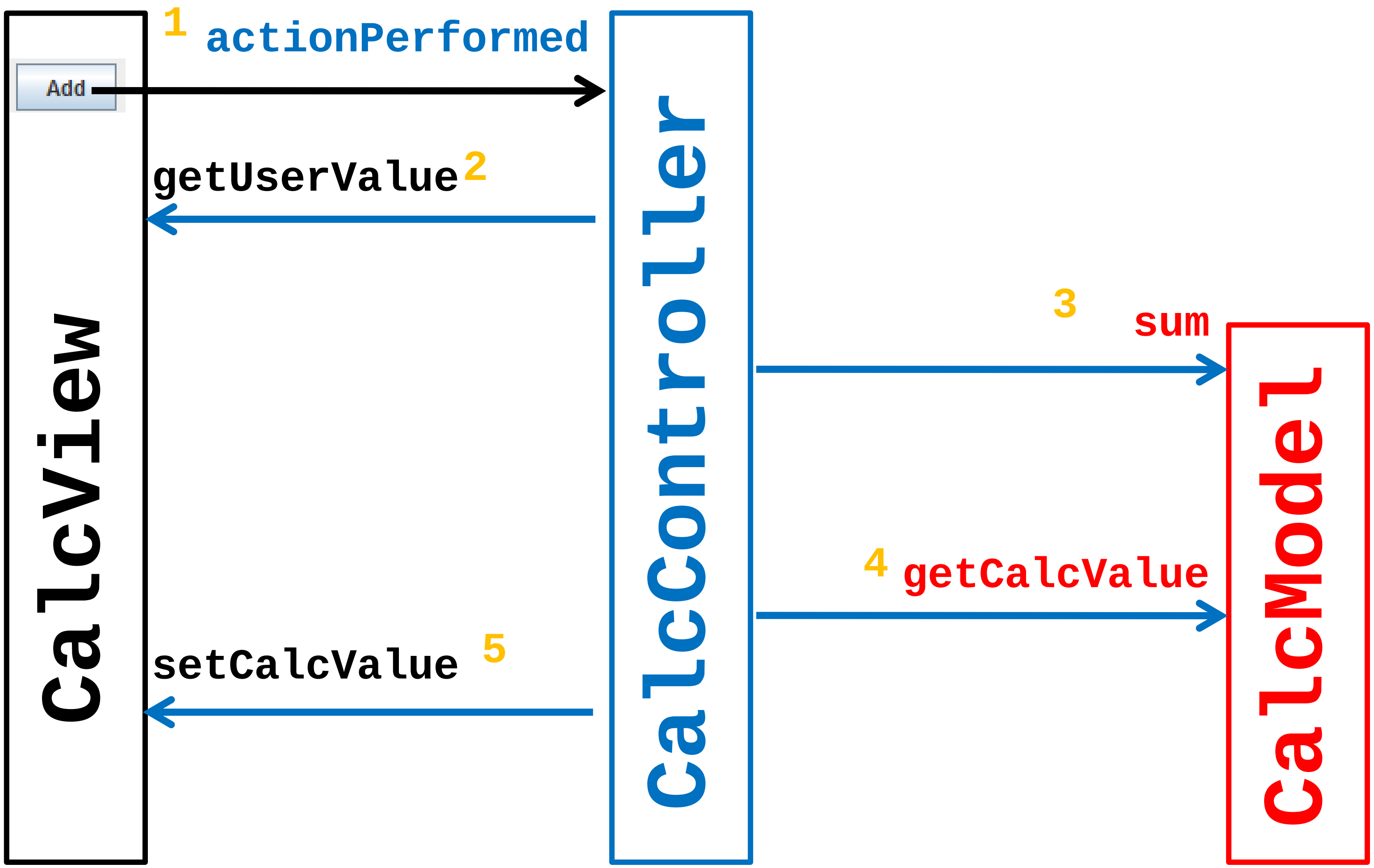
Saving a File



CalcController: Save a File

```
import java.awt.event.ActionListener;

public class CalcController implements ActionListener
{
  private CalcModel model;
  private CalcView  view;

  public CalcController(CalcModel model, CalcView view)
  {
    this.model = model;
    this.view = view;
  }

  /**
   * Invoked when an event occurs.
   *
   * @param event
   *           The event.
   */
```

Sum, Subtract, Multiply, Divide



CalcController: Other Actions

```
import java.awt.event.ActionListener;

public class CalcController implements ActionListener
{
  private CalcModel model;
  private CalcView  view;

  public CalcController(CalcModel model, CalcView view)
  {
    this.model = model;
    this.view = view;
  }

  /**
   * Invoked when an event occurs.
   *
   * @param event
   *           The event.
```

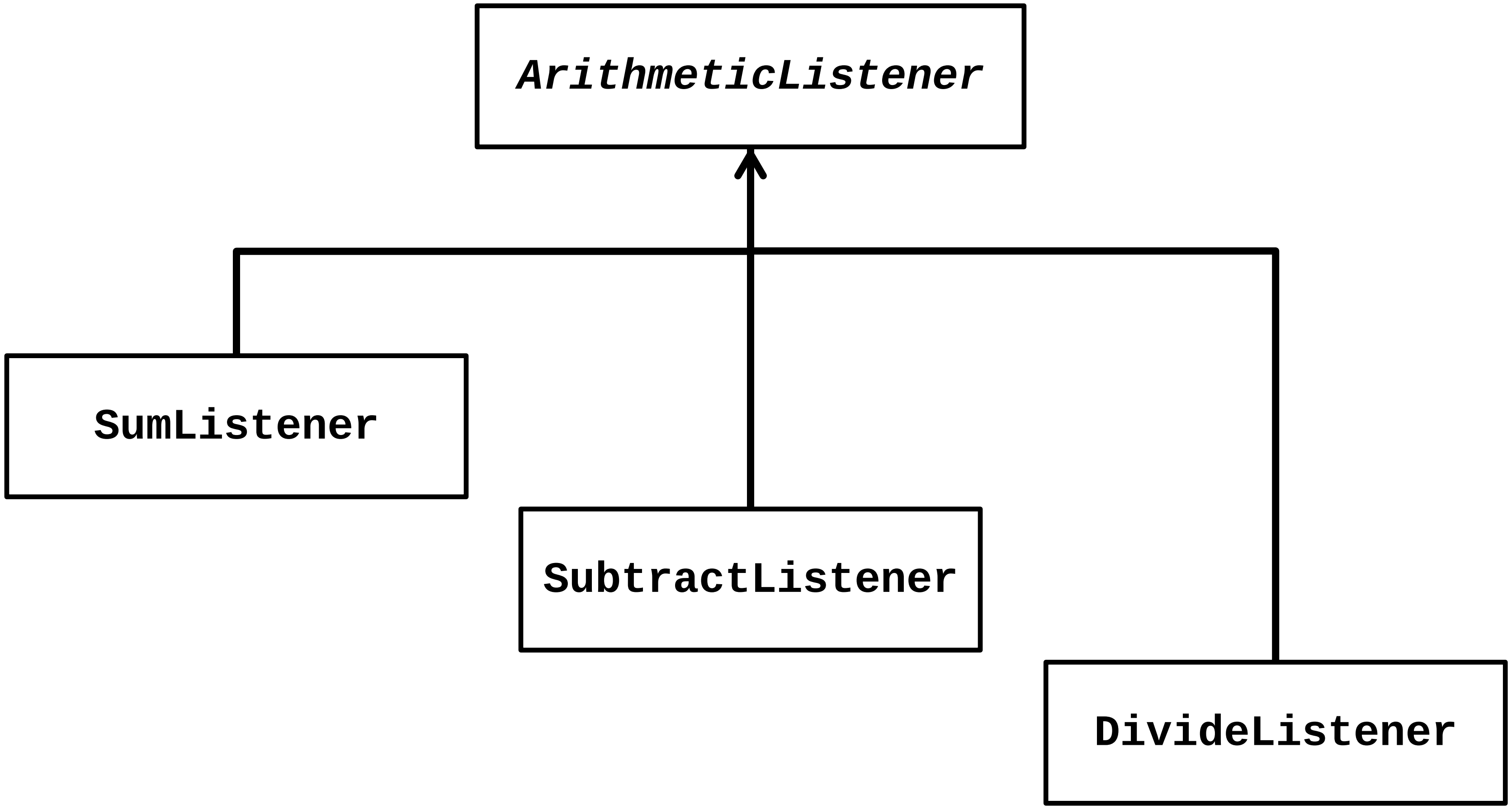
CalcMVC Source Code

- Source code for the model, view, controller, and app can be found on the course web site with the lectures

actionPerformed

- Even with only 5 buttons and 2 menu items our **`actionPerformed`** method is unwieldy
  - Imagine what would happen if you tried to implement a Controller this way for a big application
- Rather than one big actionPerformed method we can register a different **`ActionListener`** for each button
  - Each **`ActionListener`** will be an object that has its own version of the **`actionPerformed`** method

Calculator Listeners



Calculator Listener

- Whenever a listener receives an event corresponding to an arithmetic operation it does:
  1. Asks CalcView for the user value and converts it to a BigInteger
     - **`getUserValue`** method
  2. Asks CalcModel to perform the arithmetic operation
     - **`doOperation`** method
  3. Updates the calculated value in CalcView

ArithmeticListener

```
private abstract class ArithmeticListener implements ActionListener {

 @Override
 public void actionPerformed(ActionEvent action) {
1.  BigInteger userValue = this.getUserValue();
    if (userValue != null) {
2.    this.doOperation(userValue);
3.    this.setCalculatedValue();
    }
 }
```

ArithmeticListener

```
/**
 * Subclasses will override this method to add, subtract,
 * divide, multiply, etc., the userValue with the current
 * calculated value.
 */
protected abstract void doOperation(BigInteger userValue);
```

ArithmeticListener

```
private BigInteger getUserValue() {
  BigInteger userValue = null;
  try {
    userValue = new BigInteger(getView().getUserValue());
  }
  catch(NumberFormatException ex)
  {}
  return userValue;
}

private void setCalculatedValue() {
    getView().setCalcValue(getModel().getCalcValue().
                          toString());
}
```

Note: these methods need access to the view and model which are associated with the controller.

Inner Classes

- How do we give the listeners access to the view and model?
  - Could use aggregation
  - Alternatively, we can make the listeners be inner classes of the controller

Inner Classes

- An inner class is a (non-static) class that is defined inside of another class

```
 public class Outer
{
   // Outer's attributes and methods

   private class Inner
   { // Inner's attributes and methods
   }
}
```

Inner Classes

- An inner class has access to the attributes and methods of its enclosing class, even the private ones

```
public class Outer
{
  private int outerInt;

  private class Inner
  {
    public setOuterInt(int num) { outerInt = num; }
  }
}
```

note not **`this.outerInt`**

use **`Outer.this.outerInt`**

ArithmeticListener

```
public class CalcController2 {
 // ...

 // inner class of CalcController2
 private abstract class ArithmeticListener implements
                                    ActionListener {
  // ...
 }

 // inner class of CalcController2
 private class SumListener extends ArithmeticListener {
  @Override
  protected void doOperation(BigInteger userValue) {
   // ...
  }
 }
}
```

SumListener

```
private class SumListener extends ArithmeticListener {
  @Override
  protected void doOperation(BigInteger userValue) {
    if (userValue != null) {
      getModel().sum(userValue);
    }
  }
}
```

Why Use Inner Classes

- Only the controller needs to create instances of the various listeners
  - I.e., the listeners are not useful outside of the controller
  - Making the listeners private inner classes ensures that only **`CalcController`** can instantiate the listeners
- The listeners need access to private methods inside of **`CalcController`** (namely **`getView`** and **`getModel`**)
  - Inner classes can access private methods