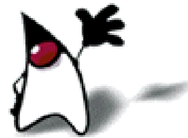
Model-View-Controller



Design Patterns

- The hard problem in O-O programming is deciding what objects to have, and what their responsibilities are
- *Design Patterns* describe the higher-level organization of solutions to common problems
- Design patterns are a major topic in O-O design

The MVC pattern

- MVC stands for Model-View-Controller
- The Model is the actual internal representation
- The View (or a View) is a way of looking at or displaying the model
- The Controller provides for user input and modification
- These three components are usually implemented as separate classes

The Model

- Most programs are supposed to do work, not just be "another pretty face"
  - but there are some exceptions
  - useful programs existed long before GUIs
- The Model is the part that does the work--it *models* the actual problem being solved
- **The Model should be independent of both the Controller and the View**
  - **But it provides services (methods) for them to use**
- Independence gives flexibility, robustness

The Controller

- The Controller decides what the model is to do
- Often, the user is put in control by means of a GUI
  - in this case, the GUI and the Controller are often the same
- The Controller and the Model can almost always be separated (what to do versus how to do it)
- The design of the Controller depends on the Model
- The Model should *not* depend on the Controller

The View

- Typically, the user has to be able to see, or *view*, what the program is doing
- The View shows what the Model is doing
  - The View is a passive observer; it should not affect the model
- The Model should be independent of the View, but (but it can provide access methods)
- The View should ***not*** display what the Controller ***thinks*** is happening

Combining Controller and View

- Sometimes the Controller and View are combined, especially in small programs
- Combining the Controller and View is appropriate if they are very interdependent
- The Model should still be independent
- *Never* mix Model code with GUI code!

Separation of concerns

- As always, you want code independence
- The Model should not be contaminated with control code or display code
- The View should represent the Model as it really is, not some remembered status
- The Controller should *talk to* the Model and View, not *manipulate* them
  - The Controller can set variables that the Model and View can read

The “Reverser” program

- In this program we combine the Controller and the View (indeed, it’s hard to separate them)
- The Model, which does the computation (reversing the string), we put in a separate class

- A bunch of `import` statements, then...

- ```
  public class ReverserGUI extends JFrame {
      ReverserModel model = new ReverserModel();
      JTextField text = new JTextField(30);
      JButton button = new JButton("Reverse");

      public static void main(String[] args) {
          ReverserGUI gui = new ReverserGUI();
          gui.create();
          gui.setDefaultCloseOperation(JFrame.EXIT_ON_CLOSE);
      }
      ... create()...
  }
  ```
  ```

The create method

```
private void create() {
    setLayout(new GridLayout(2, 1));
    add(text);
    add(button);

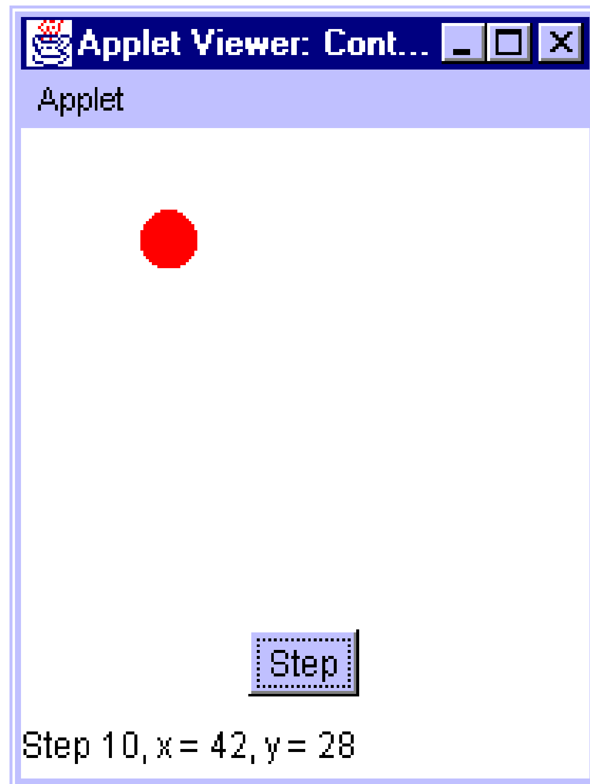
    button.addActionListener(new ActionListener()  {
        public void actionPerformed(ActionEvent arg0) {
            String s = text.getText();
            s = model.reverse(s);
            text.setText(s);
        }
    });
    pack();
    setVisible(true);
}
```

The model

- ```java
  public class ReverserModel {

      public String reverse(String s) {
          StringBuilder builder = new StringBuilder(s);
          builder.reverse();
          return builder.toString();
      }
  }
  ```
  ```

The Bouncing Ball Applet



- Each click of the Step button advances the ball a small amount
- The step number and ball position are displayed in the status line

The Ball Applet: Model

- The Ball Applet shows a ball bouncing in a window
- The Model controls the motion of the ball
- In this example, the Model must know the size of the window
  - so it knows when the ball should be made to bounce
- The Model doesn't need to know anything else about the GUI

Observer and Observable

- java.util provides an Observer *interface* and an Observable *class*
- An Observable is an object that can be "observed"
- An Observer is "notified" when an object that it is observing announces a change
- Here's an analogy:
  - An Observable is like a Button
  - An Observer is like a Listener
  - You have to "attach" a Listener to a Button
- Another analogy:
  - An Observable is like a bulletin board
  - An Observer is like someone who reads the bulletin board

Observable

- An Observable is an object that can be "observed"
- An Observer is "notified" when an object that it is observing announces a change
  - When an Observable wants the "world" to know about what it has done, it executes:
    - `setChanged();`
    - `notifyObservers(); /* or */ notifyObservers(arg);`
      - The *arg* can be any object
  - The Observable doesn't know or care "who is looking"
  - But you have attach an Observer to the Observable with:
    - `myObservable.addObserver(myObserver);`
    - This is best done in the controller class – ***not in the model class!***

Observer

- Observer is an interface
- An Observer implements
  public void update(Observable obs, Object arg)
- This method is invoked whenever an Observable that it is "listening to" does an addNotify() or addNotify(arg)
- The obs argument is a reference to the observable object itself
- If the Observable did addNotify(), the arg is null

Sample CRC index card

Class Name

Responsibilities	Collaborators
. . .	. . .
. . .	. . .
. . .	. . .

Model

Model	
Set initial position Move one step	No collaborators... ....but provide access methods to allow view to see what is going on

Model I

```
import java.util.Observable;

class Model extends Observable {
    final int BALL_SIZE = 20;
    int xPosition = 0;
    int yPosition = 0;
    int xLimit, yLimit;
    int xDelta = 6;
    int yDelta = 4;
        // more...
```

Model II

```
void makeOneStep() {
   xPosition += xDelta;
   if (xPosition < 0) {
      xPosition = 0;
      xDelta = -xDelta;
   }
     // more...
```

Model III

```
if (xPosition >= xLimit) {
    xPosition = xLimit;
    xDelta = -xDelta;
}
  // still more...
```

Model IV

```
    yPosition += yDelta;
      if (yPosition < 0 || yPosition >= yLimit) {
         yDelta = -yDelta;
         yPosition += yDelta;
      }
   setChanged();
   notifyObservers();
   } // end of makeOneStep method
} // end of Model class
```

Model	
Set initial position Move one step	No collaborators... ....but provide access methods to allow view to see what is going on

The Ball Applet: View

- The View needs access to the ball’s state (in this case, its x-y location)
- For a static drawing, the View doesn’t need to know anything else

View

View	
Paint the ball	Get necessary info from Model

View I

```
import java.awt.*;
import java.util.*;

class View extends Canvas
                implements Observer {
   Controller controller;
   Model model;
   int stepNumber = 0;

    View (Model model) {
        this.model = model;
    }
      // more...
```

View II

```
public void paint(Graphics g) {
   g.setColor(Color.red);
   g.fillOval(model.xPosition, model.yPosition,
              model.BALL_SIZE, model.BALL_SIZE);
   controller.showStatus("Step " +
                         (stepNumber++) +
                         ", x = " + model.xPosition +
                         ", y = " + model.yPosition);
} // end paint method
```

View III

```
public void update(Observable obs,
                   Object arg) {
    repaint();
}

} // end class
```

View (repeated)

View	
Paint the ball	Get necessary info from Model

The Ball Applet: Controller

- The Controller tells the Model what to do
- The Controller tells the View when it needs to refresh the display
- The Controller doesn't need to know the inner workings of the Model
- The Controller doesn't need to know the inner workings of the View

Controller

Controller

Create Model Create View GiveView access to Model Tell Model to advance Tell View to repaint	Model View

Controller I

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

public class Controller extends JApplet {
   JPanel buttonPanel = new JPanel();
   JButton stepButton = new JButton("Step");

   Model model = new Model();
   View view = new View();

     // more...
```

Controller II

```
public void init() {

   // Lay out components
   setLayout(new BorderLayout());
   buttonPanel.add(stepButton);
   this.add(BorderLayout.SOUTH, buttonPanel);
   this.add(BorderLayout.CENTER, view);

   // more...
```

Controller III

```
// Attach actions to components
stepButton.addActionListener(new ActionListener() {
        public void actionPerformed(ActionEvent event) {
            model.makeOneStep();
        }
});

    // more...
```

Controller IV

```
  // Tell the View about myself (Controller) and
  //  about the Model
  model.addObserver(view);
  view.controller = this;

} // end init method

  // more...
```

```
public void start() {
    model.xLimit =
            view.getSize().width - model.BALL_SIZE;
    model.yLimit =
            view.getSize().height - model.BALL_SIZE;
    repaint();
} // end of start method

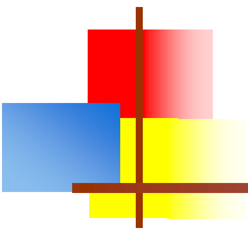
} // end of Controller class
```

Controller (repeated)

Controller	
Create Model Create View GiveView access to Model Tell Model to advance Tell View to repaint (via Observer)	Model View

Key points

- A Model does the “business logic”
  - It should be *I/O free*
  - Communication with the Model is via methods
  - This approach gives maximum flexibility in how the model is used
- The Controller organizes the program and provides input (control) to the Model
- The View displays what is going on in the model
  - It should never display what *should* be going on in the model
  - For example, if you ask to save a file, the View shouldn’t itself tell you that the file has been saved—it should tell you what the model reports
- Especially in small programs, the Controller and View are often combined



The End