Graphical user interfaces

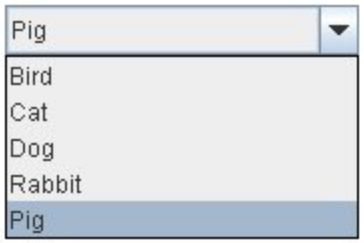
- **interfaces are built from components**
  - buttons, labels, text areas, lists, menus, dialogs, ...
  - canvas: graphics for drawing and image rendering
- **each component has**
  - properties: size, position, visibility, text, font, color, …
  - methods: things it will do, e.g., change properties
  - events: external stimuli it responds to
- **containers hold components and containers**
- **layout managers control size, placement of objects within a container**
  - some programmable, some purely by drawing
  - may adapt to changes like reshaping
- **Swing package (`javax.swing`):**
  - runs standalone everywhere, can be used on web pages in applets
  - Google Web Toolkit is similar
- **other GUI systems are analogous, but with many differences**

Swing examples

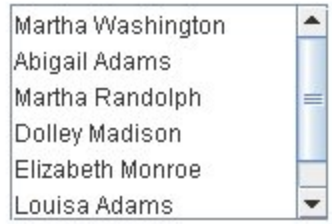
http://docs.oracle.com/javase/tutorial/ui/features/components.html

JButton

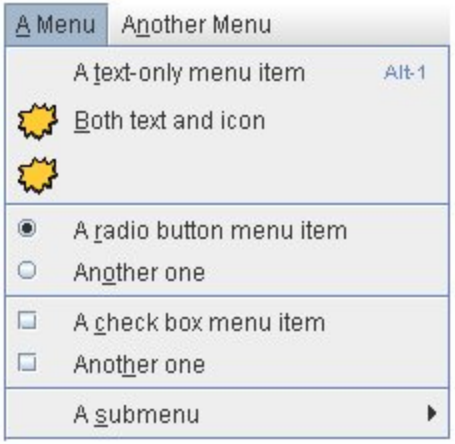
JCheckBox



JComboBox



JList



JMenu

JRadioButton

JSlider

JSpinner

JTextField

JPasswordField

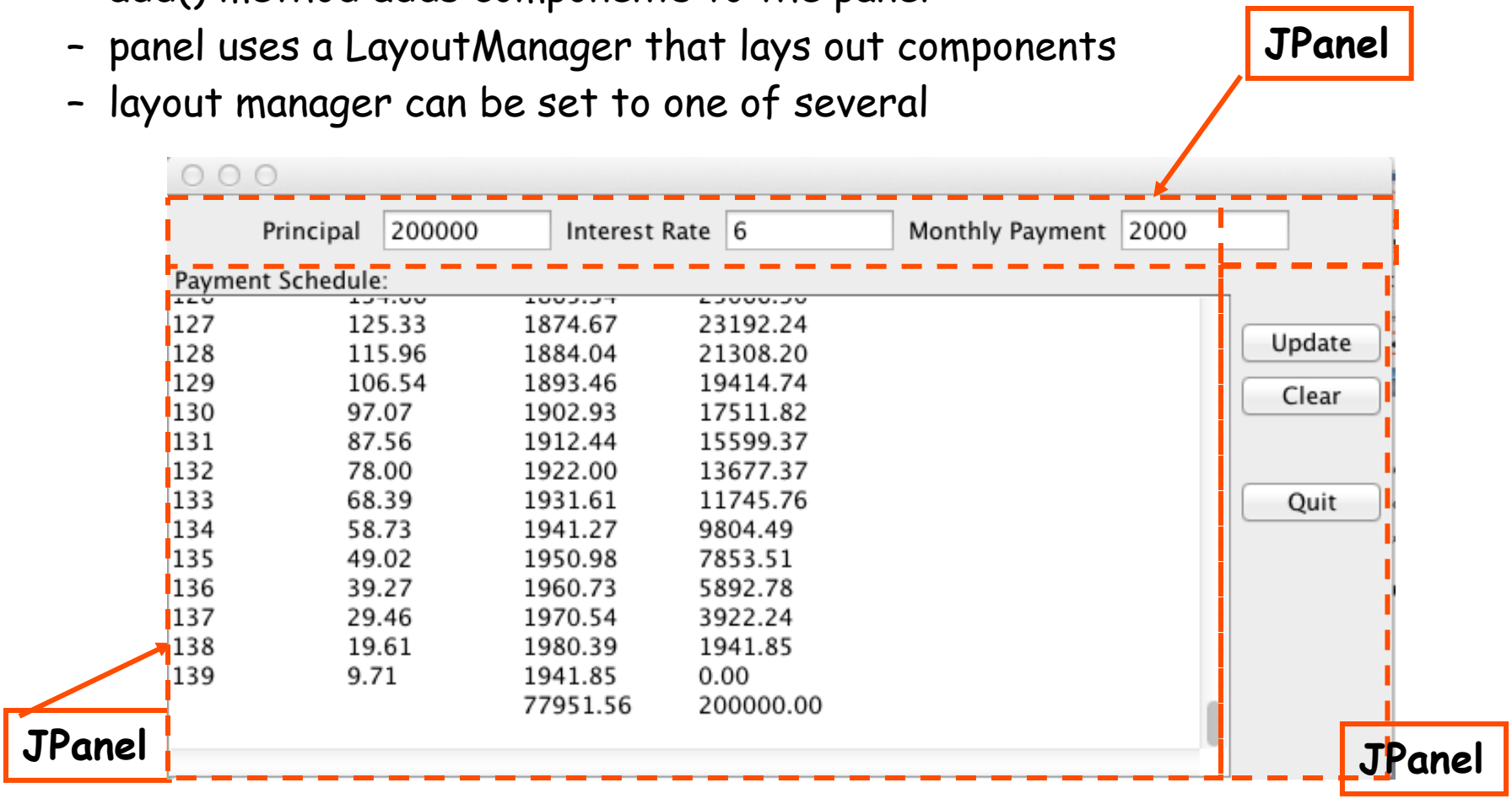
Component object hierarchy

```
Object
    Component
        Container
            JComponent
                JPanel
                JLabel
                JButton
                JTextComponent
                    JTextField
                        JFormattedTextField
                        JPasswordField
                    JTextArea
                    JEditorPane
                        JTextPane
```

- **containers hold components & containers, used to build up nested structures**
  - JFrame: top-level window
  - Jpanel: general container for components & containers
  - JMenuBar for menubar across top of JFrame
  - JToolBar for toolbar, possibly floating
- **individual components like JButton, JText, …**
  - respond to events, have methods for other behaviors
  - have get and set methods for accessing properties like size, color, font

Layout hierarchy

- **JFrame holds one or more JPanels**
- **JPanel holds components and other Jpanels**
- **JPanel used for layout**
  - add() method adds components to the panel
  - panel uses a LayoutManager that lays out components
  - layout manager can be set to one of several



Events

- **stuff happens**
  - mouse motion, button push, button release, …
  - scrollbar fiddled
  - keyboard keypress, release, shift key, etc.
  - component got or lost focus
  - window iconified, uniconified, hidden, exposed, moved, reshaped, killed
  - etc.

- **each such event is passed to event-handling mechanism in the program**

- **program can decide what to do with it**

Events in Swing

- **components register to receive (listen for) events that they are interested in:**

```
JButton jb = new JButton("whatever");
jb.addActionListener(this);
```

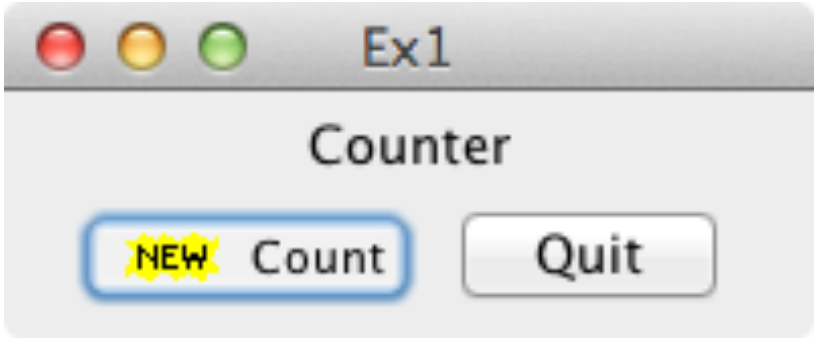
  - tells `jb` to notify `this` container when event happens
    i.e., sets up a callback
  - usually called by container that contains object that will get the event
- **a thread watches for events like button push, mouse motion or click, key down or up, …**
- **when event occurs, listener's `actionPerformed` is called**
  - from component where event occurs (e.g., button instance) when it does
- **handler determines type or instance that caused event, does appropriate action**

```
actionPerformed(ActionEvent e) { … }
```

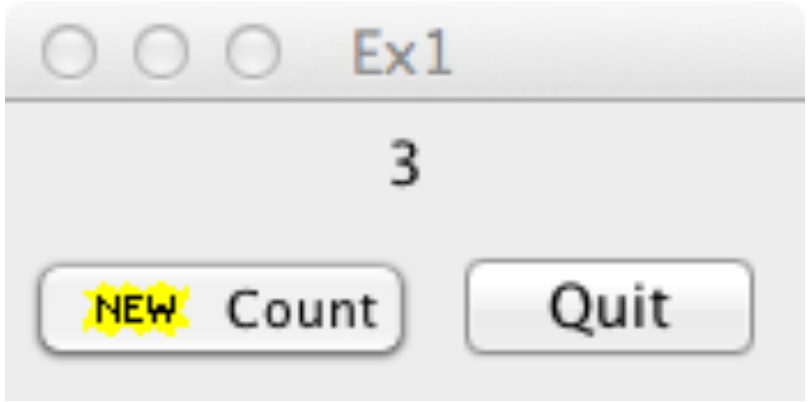
- **different kinds of listeners for different sources**
  - keyboard, mouse, mouse motion, window, …

Example 1: Buttons and labels

- **after it starts:**



- **after Count button is pushed 3 times:**



- **after Quit button is pushed:**

Example 1 events, layout

```
import java.awt.*; import java.awt.event.*; import javax.swing.*;
public class Ex1 extends JFrame implements ActionListener {
   int count;
   JLabel lab;
   JButton bcount, bquit;
public static void main(String[] args) {
   Ex1 a = new Ex1();
}
Ex1() {
   setTitle("Ex1");
   lab = new JLabel("Counter");
   JPanel p1 = new JPanel(); p1.add(lab);
   bcount = new JButton("Count", new ImageIcon("new.gif"));
   bcount.addActionListener(this);
   bquit = new JButton("Quit");
   bquit.addActionListener(this);
   JPanel p2 = new JPanel();
   p2.add(bcount); p2.add(bquit);
   getContentPane().setLayout(new BorderLayout());
   getContentPane().add(p1, BorderLayout.NORTH);
   getContentPane().add(p2, BorderLayout.SOUTH);
   pack();
   setVisible(true);
   setDefaultCloseOperation(EXIT_ON_CLOSE);
}
```

Example 1, continued

```
// the one function of the ActionListener interface:
public void actionPerformed(ActionEvent ae) {
   System.out.println(ae.getActionCommand());
   if (ae.getActionCommand().equals("Count")) { // by content
      count++;
      lab.setText(Integer.toString(count));
   } else if (ae.getSource() == bquit) {    // by object name
      System.exit(0);
   }
}
```

- **five steps to set up a GUI component:**
  - declare an object, like Button
  - create it with **new**
  - add it to a container
  - add an ActionListener to catch events
  - handle events in actionPerformed
- **information is spread all over the place**

Anonymous inner classes

- an unnamed class defined inside another class

```
JLabel label = new JLabel("0");
JButton button = new JButton("Lookup");
button.addActionListener(
    new ActionListener() {
        public void actionPerformed(ActionEvent e) {
            n++;
            label.setText(n);
        }
    }
);
```

- equivalent to this, without separate declaration and name

```
class foo implements ActionListener {
    public void actionPerformed(ActionEvent e) {
        ...
    }
}
button.addActionListener(new foo());
```

Layout manager approaches

- **Java**
  - position by imperative code, with 8 standard layout managers
  - graphical layout by NetBeans IDE
- **Tk**
  - mostly declarative: position relative to other positioned objects
- **VB (pre .NET)**
  - mostly draw on a screen: absolute positioning
  - can modify dynamically by setting properties
- ***C#***
  - drawing objects creates imperative code as side effect
  - can use either method to do layout
- **iPhone**
  - Interface Builder mostly drawing on screen
  - can create objects, position them, etc., by imperative commands
- **Android**
  - declarative positioning specified in XML
  - can create objects, position them, etc., by imperative commands

Layout managers in Swing

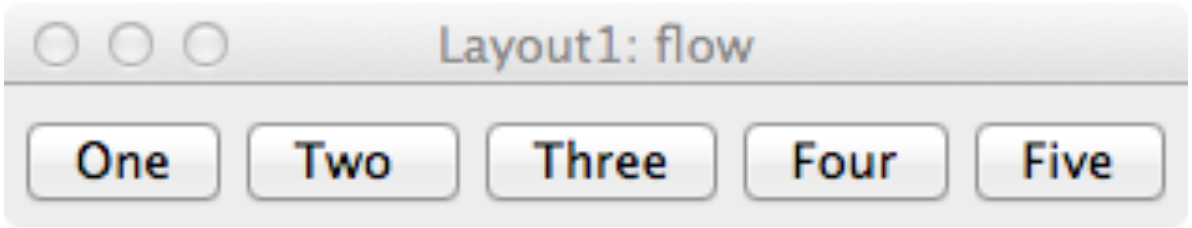
- **control container size, position, padding, stretch & shrink, etc.,**
- **each container has a default layout manager**
  - set it at creation or change it later with setLayout method

```
JPanel jp = new JPanel(new BorderLayout());
jp.setLayout(new BorderLayout())
```

- **FlowLayout**
  - fills area left to right in rows
  - each row can be centered, left or right adjusted
- **BorderLayout**
  - fills North, South, East, West, and Center (`BorderLayout.NORTH`, etc.)
- **GridLayout**
  - regular array of specified number of rows and columns
- **CardLayout**
  - multiple windows that all occupy the same space
  - usually selected with tabs or combo boxes
- **etc., etc.**

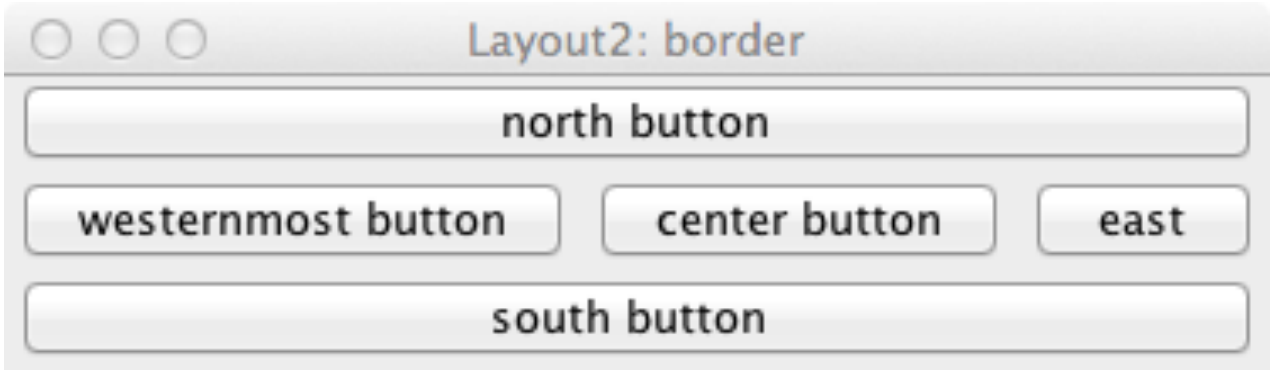
Flow Layout

- default for Panels




```
public class Layout1 extends JFrame {
   public static void main(String[] args) {
      Layout1 a = new Layout1();
      a.setTitle("Layout1: flow");
      JPanel p = new JPanel();
      p.add(new Button("One"));
      p.add(new Button("Two "));
      p.add(new Button("Three"));
      p.add(new Button("Four"));
      p.add(new Button("Five"));
      a.getContentPane().add(p);
      a.pack();
      a.setVisible(true);
   }
}
```

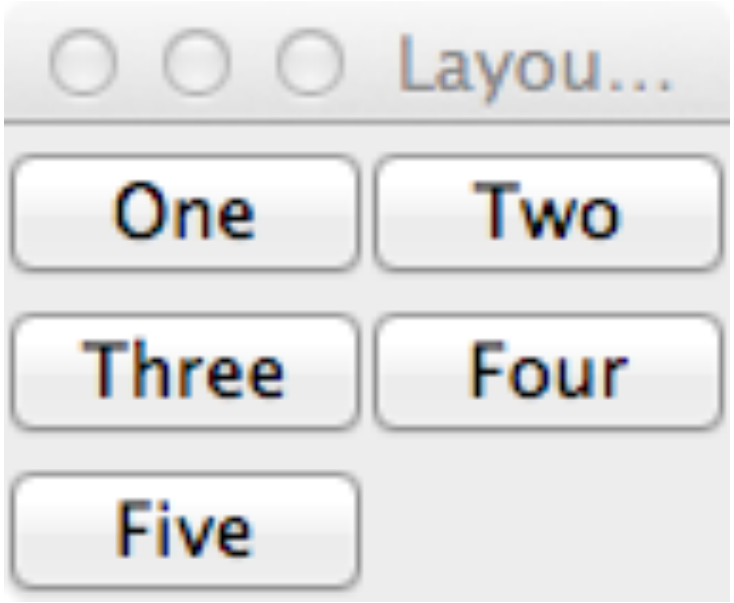
Border Layout




```
public class Layout2 extends JFrame {
  public static void main(String[] args) {
    Layout2 a = new Layout2();
    a.setTitle("Layout2: border");
    JPanel p = new JPanel();
    p.setLayout(new BorderLayout());
    p.add(new JButton("north button"), BorderLayout.NORTH);
    p.add(new JButton("south button "), BorderLayout.SOUTH);
    p.add(new JButton("east"), BorderLayout.EAST);
    p.add(new JButton("westernmost button"), BorderLayout.WEST);
    p.add(new JButton("center button"), BorderLayout.CENTER);
    a.getContentPane().add(p);
    a.pack();
    a.setVisible(true);
  }
```

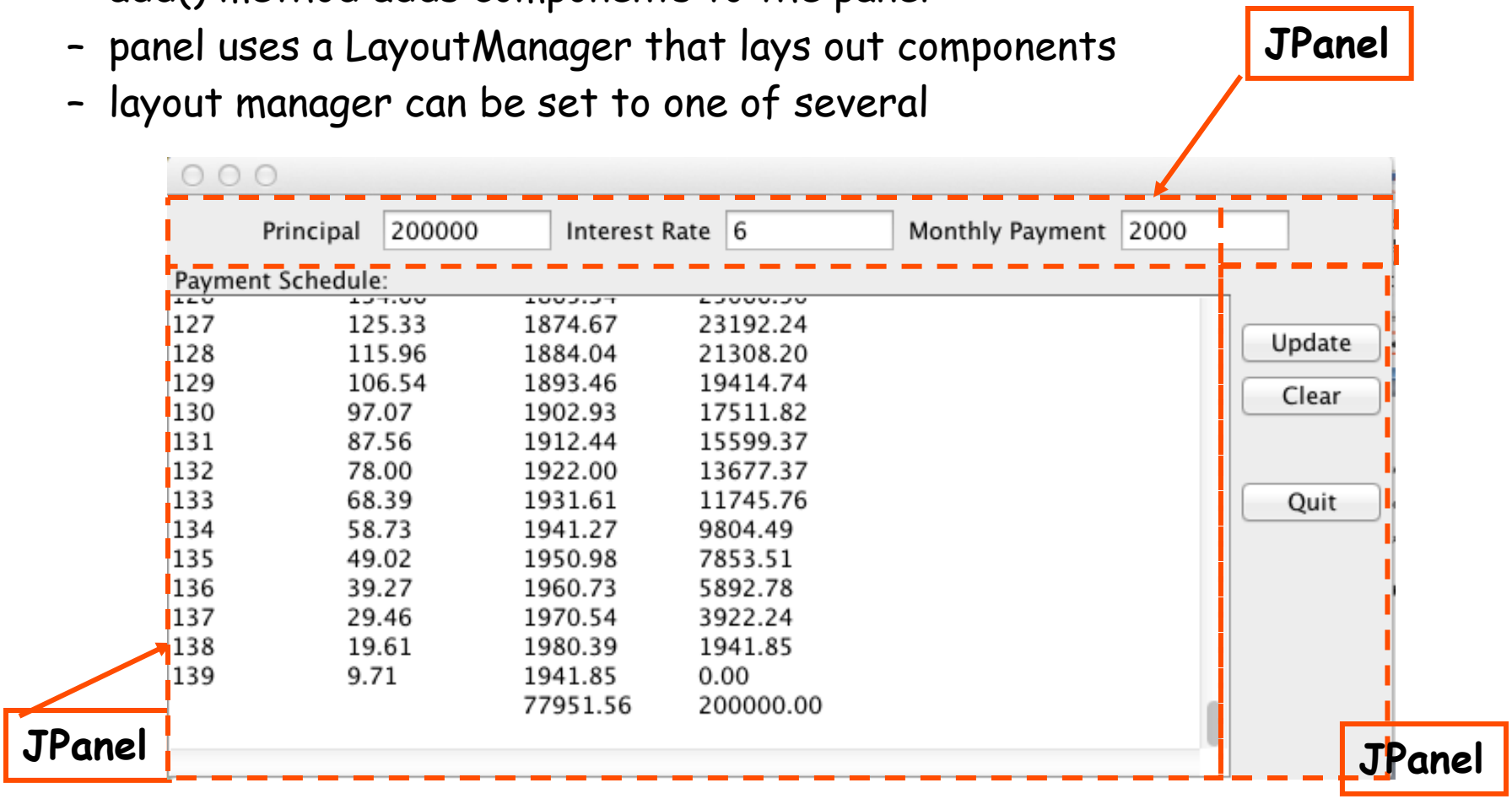
Grid Layout

```
public class Layout3 extends JFrame {
 public static void main(String[] args) {
   Layout3 a = new Layout3();
   a.setTitle("Layout3: grid");
   JPanel p = new JPanel();
   p.setLayout(new GridLayout(3,2));
   p.add(new Button("One"));
   p.add(new Button("Two"));
   p.add(new Button("Three"));
   p.add(new Button("Four"));
   p.add(new Button("Five"));
   a.getContentPane().add(p);
   a.pack();
   a.setVisible(true);
 }
}
```



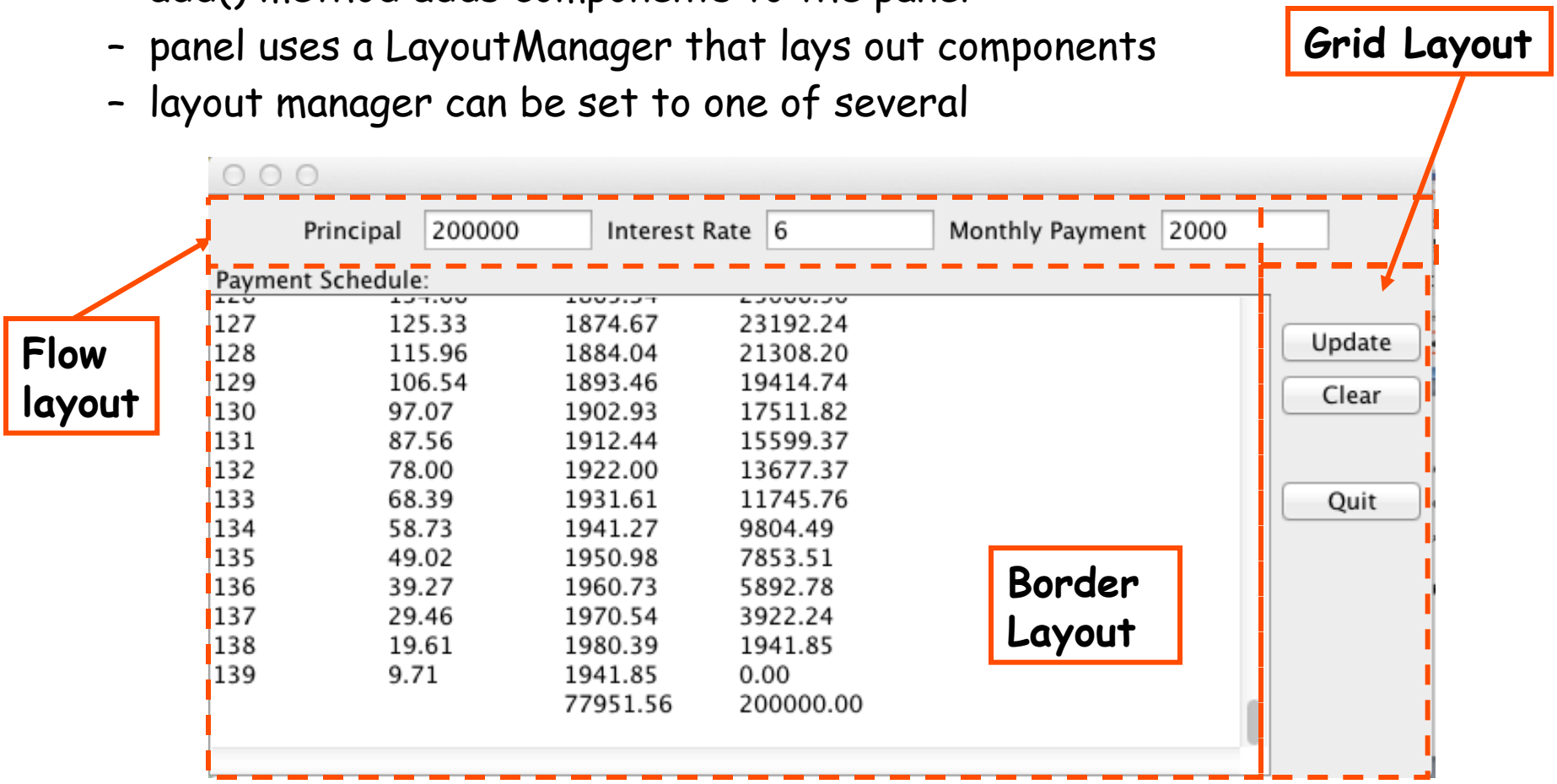
Layout hierarchy

- **JFrame holds one or more JPanels**
- **JPanel holds components and other Jpanels**
- **JPanel used for layout**
  - add() method adds components to the panel
  - panel uses a LayoutManager that lays out components
  - layout manager can be set to one of several



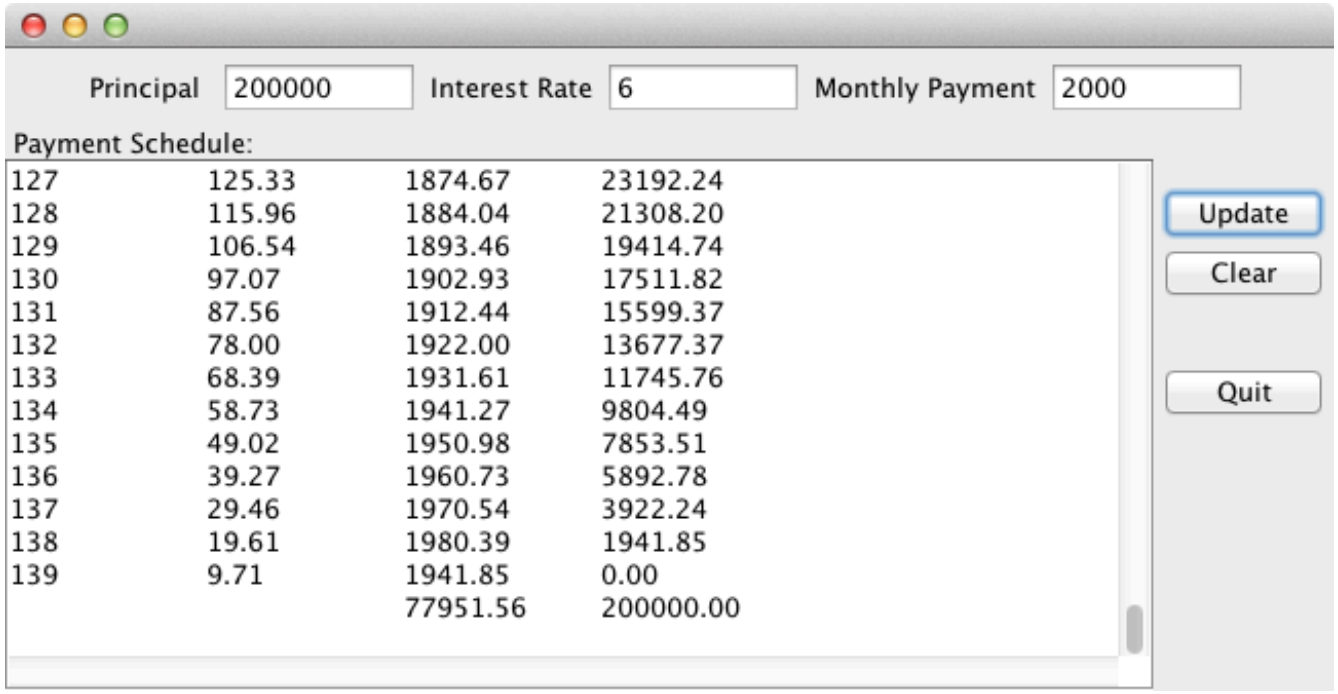
Layout hierarchy

- **JFrame holds one or more JPanels**
- **JPanel holds components and other Jpanels**
- **JPanel used for layout**
  - add() method adds components to the panel
  - panel uses a LayoutManager that lays out components
  - layout manager can be set to one of several



Example 2: Text components

- **JTextField**
  - single line for input
  - main interesting event is pushing Return
- **JTextArea**
  - multiple lines; can add scrolling
  - can edit in place
  - can change size and font for whole area but not parts
  - fancier JTextComponents for editing, display of different sizes and fonts, HTML, etc.



Example 2 code excerpts

```
class Mtg extends JFrame implements ActionListener {
   JLabel lprin = new JLabel("Principal ");
   JTextField tprin = new JTextField(7);
   JLabel lrate = new JLabel("Interest Rate");
   JTextField trate = new JTextField(7);
   JLabel lmpay = new JLabel("Monthly Payment");
   JTextField tmpay = new JTextField(7);

   JLabel lsched = new JLabel("Payment Schedule:");
   JTextArea tpay = new JTextArea(15, 45);

   JButton update = new JButton("Update");
   JButton clear = new JButton("Clear");
   JButton quit = new JButton("Quit");

   public static void main(String[] args) {
      Mtg m = new Mtg();
   }
```

Example 2, page 2

```
Mtg() {
   addWindowListener(new WindowAdapter() {
      public void windowClosing(WindowEvent e) {
         System.exit(0);
      }
   });
   // top row of entry boxes
   JPanel ptop = new JPanel();
   ptop.add(lprin); ptop.add(tprin); ptop.add(lrate);
   ptop.add(trate); ptop.add(lmpay); ptop.add(tmpay);
   tprin.setToolTipText("Enter principal amount");
   trate.setToolTipText("Enter yearly interest rate …");
   tmpay.setToolTipText("Enter monthly payment");
   // text area for payment schedule
   JScrollPane jsp = new JScrollPane(tpay,
      JScrollPane.VERTICAL_SCROLLBAR_ALWAYS,
      JScrollPane.HORIZONTAL_SCROLLBAR_ALWAYS);
   JPanel pctr = new JPanel(new BorderLayout());
   pctr.add(lsched, BorderLayout.NORTH);
   pctr.add(jsp, BorderLayout.CENTER);
```

Example 2, page 3

```
  // buttons on right
   JPanel pr = new JPanel(new GridLayout(0,1));
   pr.add(new JLabel());    // spacer
   pr.add(update); pr.add(clear);
   pr.add(new JLabel());    // spacer
   pr.add(quit);
   JPanel pright = new JPanel(new BorderLayout());
   pright.add(pr, BorderLayout.NORTH);   // pack at top
   update.addActionListener(this);
   clear.addActionListener(this);
   quit.addActionListener(this);
   update.setToolTipText("Update payment schedule");
   clear.setToolTipText("Clear payment schedule");
    // overall layout
   Container cp = getContentPane();
   cp.add(ptop, BorderLayout.NORTH);
   cp.add(pctr, BorderLayout.CENTER);
   cp.add(pright, BorderLayout.EAST);
   pack();
   setVisible(true);
 }
```

Example 2, page 4

```
public void actionPerformed(ActionEvent e) {
  if (e.getSource() == quit) {
        System.exit(0);
  } else if (e.getSource() == update) {
        tpay.setText(pay());
  } else if (e.getSource() == clear) {
        tpay.setText("");
  }
}
```

Example 2, page 5

```
String pay() {
  double mp = Double.parseDouble(tmpay.getText());
  double prin = Double.parseDouble(tprin.getText());
  double mrate = Double.parseDouble(trate.getText())/12/100;
  double totint = 0, totprin = 0;
  String s = "";
  for (int i = 1; i <= 500; i++) {
    double Int = prin * mrate;
    double dp = mp - Int;    // decrease of principal
    if (prin - dp > 0) {
      prin -= dp;
    } else {
      dp = prin;
      prin = 0;
    }
    s += String.format("%d\t%.2f\t%.2f\t%.2f\n",i, Int, dp, prin);
    totint += Int;
    totprin += dp;
    if (prin <= 0)
      break;
  }
  s += String.format("\t\t%.2f\t%.2f\n", totint, totprin);
  return s;
}
```

Google Web Toolkit version (page 1)

```
public void onModuleLoad() {
    final VerticalPanel mainPanel = new VerticalPanel();
    final HorizontalPanel ptop = new HorizontalPanel();

    final Label lprin = new Label("Principal");
    final TextBox tprin = new TextBox();
    final Label lrate = new Label("Interest Rate");
    final TextBox trate = new TextBox();
    final Label lmpay = new Label("Monthly Payment");
    final TextBox tmpay = new TextBox();
    //final Label lsched = new Label("Payment Schedule");
    final TextArea tpay = new TextArea();
    final Button update = new Button("Update");
    final Button clear = new Button("Clear");
    final Button quit = new Button("Quit");
    ptop.add(lprin); ptop.add(tprin); tprin.setVisibleLength(7);
    ptop.add(lrate); ptop.add(trate); trate.setVisibleLength(7);
    ptop.add(lmpay); ptop.add(tmpay); tmpay.setVisibleLength(7);
    tpay.setCharacterWidth(60); tpay.setVisibleLines(15);
```

Google Web Toolkit version (page 2)

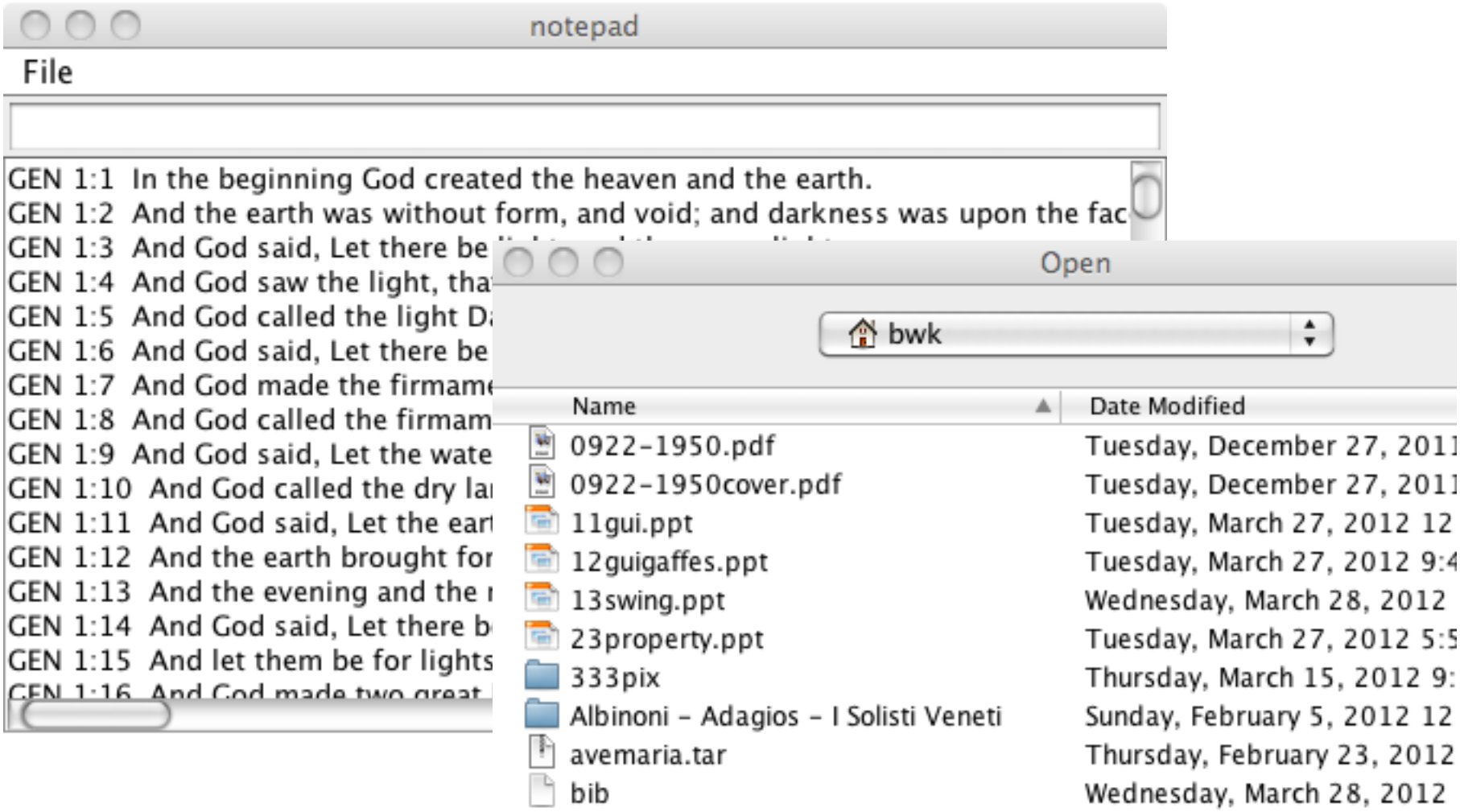
```
HorizontalPanel hp = new HorizontalPanel();
hp.add(tpay);
VerticalPanel buts = new VerticalPanel();
buts.add(update); buts.add(clear); buts.add(quit);
hp.add(buts);
mainPanel.add(ptop);
mainPanel.add(hp);

RootPanel.get("mtgroot").add(mainPanel);

update.addClickHandler(new ClickHandler() {
   public void onClick(ClickEvent event) {
      tpay.setText(computePay(tprin.getText(), trate.getText(),
         tmpay.getText()));
   }
});
clear.addClickHandler(new ClickHandler() {
   public void onClick(ClickEvent event) {
      tpay.setText("");
   }
});
quit.addClickHandler(new ClickHandler() {
   public void onClick(ClickEvent event) {
      //System.exit();
   }
});
```

Google Web Toolkit version (page 3)

```
String s = "";
for (int i = 1; i <= 500; i++) {
   double interest = dprin * drate;
   double dp = mp - interest;
   if (dprin - dp > 0) {
      dprin -= dp;
   } else {
      dp = dprin;
      dprin = 0;
   }
   //s += String.format("%d\t%.2f\t%.2f\t%.2f\n", i, interest, dp, dprin);
   s += i + ”\t" + f2(interest) + ”\t" + f2(dp) + ”\t" + f2(dprin) + "\n";
   totint += interest;
   totprin += dp;
   if (dprin <= 0)
      break;
   }
   return s + "\t\t" + f2(totint) + ”\t" + f2(totprin) + "\n";
}
String f2(double d) {
   NumberFormat fmt = NumberFormat.getFormat("######0.00");
   return fmt.format(d);
}
```

Example 3: Notepad editor

- **menus**
- **file dialog**
- **I/O from file system**



Notepad, page 2

```
public class Notepad extends JFrame implements ActionListener {
   int last;
   JLabel lfind = new JLabel("Find:");
   JTextField tf = new JTextField(60);
   JTextArea ta = new JTextArea(15,60);
   JMenuBar mb = new JMenuBar();
   JMenu mfile;

public static void main(String[] args) {
   Notepad a = new Notepad();
}

Notepad() {
   setTitle("Notepad");
   setJMenuBar(mb);
   mfile = new JMenu("File");
   JMenuItem mi;
   mfile.add(mi = new JMenuItem("Open"));
      mi.addActionListener(this);
   mfile.add(mi = new JMenuItem("Save"));
      mi.addActionListener(this);
   mfile.add(mi = new JMenuItem("Quit"));
      mi.addActionListener(this);
   mb.add(mfile);
   tf.addActionListener(this);
```

Notepad, page 3

```
    getContentPane().setLayout(new BorderLayout());
    JPanel top = new JPanel();
    top.add(lfind); top.add(tf);
    getContentPane().add(top, BorderLayout.NORTH);
    JScrollPane jsp = new JScrollPane(ta,
       JScrollPane.VERTICAL_SCROLLBAR_ALWAYS,
       JScrollPane.HORIZONTAL_SCROLLBAR_ALWAYS);
    getContentPane().add(jsp, BorderLayout.CENTER);
    pack();
    setVisible(true);
    setDefaultCloseOperation(EXIT_ON_CLOSE);
}
public void actionPerformed(ActionEvent e) {
    if (e.getSource() == tf) {
       find(tf.getText());
    } else if (e.getSource() instanceof JMenuItem) {
       String b = e.getActionCommand();
       if (b.equals("Quit")) {
          System.exit(0);
       } else if (b.equals("Open")) {
          openfile();
       } else if (b.equals("Save")) {
          savefile(ta.getText());
       }
    }
}
```

Notepad, page 4

```
public void find(String pat) {   // find next pat in ta
   String s = ta.getText();   // where to search
   if (last + pat.length() >= s.length())
      last = 0;
   int n = s.indexOf(pat, last); // look to end
   if (n == -1) {
      last = 0;
      n = s.indexOf(pat, 0);   // look from beginning
   }
   if (n >= 0) {
      int m = n + pat.length();
      System.err.println("found " + tf.getText() +
                                 " at " + n + "," + m);
      //ta.setHighlighter(new DefaultHighlighter());
      //ta.setSelectedTextColor(Color.green);
      ta.setSelectionColor(Color.red);
      ta.getCaret().setSelectionVisible(true);
      ta.select(n, m);
      last = n + 1;
   }
}
```

Notepad, page 5

```
public void openfile() {
   JFileChooser jfc = new JFileChooser();
   jfc.showOpenDialog(this);
   if (jfc.getSelectedFile() == null)   // cancelled
      return;

   File fil = jfc.getSelectedFile().getAbsoluteFile();
   String f = fil.getAbsolutePath(); // attach directory name
   try {
      FileInputStream in = new FileInputStream(f);
      byte [] data = new byte [in.available()];
      in.read(data);
      ta.setText(new String(data));
   } catch (IOException e) {
      ta.setText("Can't open file " + f);
   }
}
```

Notepad, page 6

```
public void savefile(String s) {
   JFileChooser jfc = new JFileChooser();
   jfc.showSaveDialog(this);
   if (jfc.getSelectedFile() == null)   // cancelled
      return;

   File fil = jfc.getSelectedFile().getAbsoluteFile();
   String f = fil.getAbsolutePath(); // attach directory name
   try {
      FileOutputStream out = new FileOutputStream(f);
      out.write(s.getBytes());
      out.close();
   } catch (FileNotFoundException e) {
      System.err.println(e + " can't open " + f);
   } catch (IOException e) {
      System.err.println(e + " savefile error");
   }
}
```