CS 326
Programming Languages, Concepts and Implementation

Instructor: Mircea Nicolescu

Java

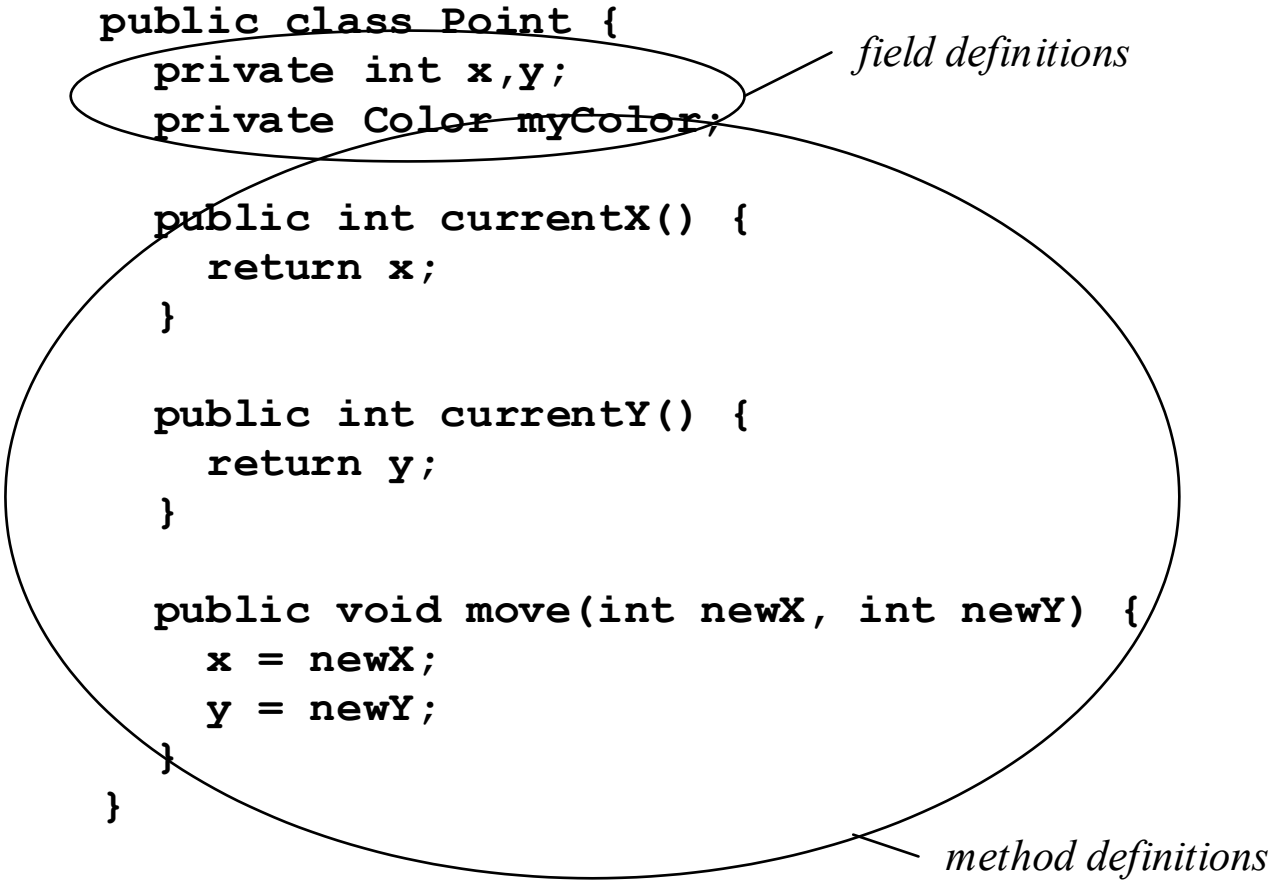
The Java Programming Language

- Developed in the early 1990s by James Gosling and associates at Sun Microsystems
- Initially intended for embedded systems – microwave ovens, TV sets, etc
- Main characteristics:
  - portable, platform independent
  - loaded dynamically from a network
  - robust (strongly typed, no pointers, garbage collection)
  - closer to the OO paradigm
  - support for multi-threading, graphics, remote communication

Portability

- Java compiler (javac):
  - translates source code into byte code (machine-independent)
- Java interpretor (java):
  - interprets and runs byte code
  - implemented for a particular architecture (machine-dependent)
  - machine + interpretor = Java Virtual Machine
- Efficiency?
  - since it uses an interpretor – would be slower than a compiled program
  - improvement – just-in-time compilation
    - first translate byte code into machine target code, then run it

Class Definitions: A Peek



- Everything must be inside some class
- No stand-alone functions
- No global variables

Data Types

- Primitive types
  - **`boolean`**: **`true`** and **`false`**
  - **`char`**: 16 bit Unicode character set
  - **`byte`**: 8 bits
  - **`short`**: 16 bits
  - **`int`**: 32 bits
  - **`long`**: 64 bits
  - **`float`**: 32 bits floating point (IEEE standard)
  - **`double`**: 64 bits floating point (IEEE standard)

Data Types

- Constructed types
  - Any class name, like **`Point`**
  - Any array type, like **`Point[]`** or **`int[]`**
- Variable model
  - Value model for primitive types
  - Reference model for constructed types
- "Java is like C++ without pointers"
  - Not really – in fact, any variable (for a constructed type) is a pointer
  - But you don't see (or have access to) pointers explicitly

Strings

- Predefined but not primitive: a class **`String`**
- “hello” works like a string constant
- It is actually an object (instance of the **`String`** class), containing the given string of characters
- The **+** operator has special overloading and coercion behavior for the class **`String`**:

Java Expression	Value
`"123"+"456"`	`"123456"`
`"The answer is " + 4`	`"The answer is 4"`
`"" + (1.0/3.0)`	`"0.3333333333333333"`

- Other useful methods:
  - length(), charAt(i), toUpperCase(), ...

Enjoy…

```
private static int stringSize(String s){
    int size = 0;
    for (int i = 0; i < s.length(); i++) {
        size++;
    }
    return size;
}
```

Object Creation and Destruction

- To create a new object that is an instance of a given class – use new:

```
Point p;                  // just the declaration
p = new Point; // now it is allocated
```

  - May also have parameters, if an appropriate constructor has been defined:

```
p = new Point(3,8);
```

- To deallocate an object – do nothing
  - Garbage collection

Arrays

- Always allocated dynamically:

```
int a [];                // just the declaration
a = new int[4];          // now it is allocated

double m [][];
m = new double [5][100];
```

Arrays are also objects, not just a contiguous collection of elements:

after allocation, can obtain the number of elements by using the field length:

```
int x = a.length;    // 4 elements
int x = m.length;    // 5 elements
int x = m[0].length;       // 100 elements
```

Classes

- Visibility:
  - a class may be public or not (no label)
  - each field and method may be public, private or protected
  - additional labels:
    - final: a constant field, or a method that cannot be redefined in derived classes
    - static: a field or method shared by all instances (belongs to the class, not to each instance)

- Files:
  - no more header (.h) files
  - each class (MyClass) written in a separate file (MyClass.java)
  - or, several classes in a single file, but only one of them must be public
  - to run a program – the public class must contain a main function

An Example

- **`ConsCell`** - a class for building linked lists of integers

```
/**
    * A ConsCell is an element in a linked list of
    * ints.
    */
   public class ConsCell {
     private int head; // the first item in the list
     private ConsCell tail; // rest of the list, or null

     /**
      * Construct a new ConsCell given its head and tail.
      * @param h the int contents of this cell
      * @param t the next ConsCell in the list, or null
      */
     public ConsCell(int h, ConsCell t) {
       head = h;
       tail = t;
     }
```

An Example

```
  /**
   * Accessor for the head of this ConsCell.
   * @return the int contents of this cell
   */
  public int getHead() {
    return head;
  }

  /**
   * Accessor for the tail of this ConsCell.
   * @return the next ConsCell in the list, or null
   */
  public ConsCell getTail() {
    return tail;
  }
}
```

An Example

`IntList` – the list of integers

```
/**
 * An IntList is a list of ints.
 */
public class IntList {
  private ConsCell start; // list head, or null

  /**
   * Construct a new IntList given its first ConsCell.
   * @param s the first ConsCell in the list, or null
   */
   public IntList(ConsCell s) {
    start = s;
  }
```

An Example

```
/**
 * Cons the given element h onto us and return the
 * resulting IntList.
 * @param h the head int for the new list
 * @return the IntList with head h, and us as tail
 */
public IntList cons (int h) {
  return new IntList(new ConsCell(h,start));
}
```

An **`IntList`** knows how to cons things onto itself. It does not change, but it returns a new **`IntList`** with the new element at the front.

An Example

```
/**
 * Get our length.
 * @return our int length
 */
public int length() {
  int len = 0;
  ConsCell cell = start;
  while (cell != null) { // while not at end of list
    len++;
    cell = cell.getTail();
  }
  return len;
}
```

An **`IntList`** knows how to compute its length

An Example

```
  /**
   * Print ourselves to System.out.
   */
  public void print() {
    System.out.print("[");          // print to standard output
    ConsCell a = start;
    while (a != null) {
      System.out.print(a.getHead());
      a = a.getTail();
      if (a != null) System.out.print(",");
    }
    System.out.println("]");
  }

}
```

An **`IntList`** knows how to print itself

An Example

- The “main” class:

```
public class Driver {
  public static void main(String[] args) {
    IntList a = new IntList(null);
    IntList b = a.cons(2);
    IntList c = b.cons(1);
    int x = a.length() + b.length() + c.length();
    a.print();
    b.print();
    c.print();
    System.out.println(x);
  }
}
```

Compiling the Program

- Three classes to compile, in three files:
  - **`ConsCell.java`**
  - **`IntList.java`**
  - **`Driver.java`**
- Watch capitalization!
- Compile with the command **`javac`**:
  - They can be done one at a time
  - Or, **`javac Driver.java`** gets them all
- The compiler produces **`.class`** files (contain byte code)

Running The Program

- Use the **`java`** command to run the **`main`** method in a **`.class`** file:

```
C:\demo>java Driver
[]
[2]
[1,2]
3
```

Generating Documentation

- Use the **`javadoc`** command to automatically generate documentation (in HTML format) for your classes
- Documentation is based on "special" comments:
  - between /** and */
  - "keywords" that introduce specific descriptions (`@param`, `@return`, etc)

```
/**
 * Cons the given element h onto us and return the
 * resulting IntList.
 * @param h the head int for the new list
 * @return the IntList with head h, and us as tail
 */
public IntList cons (int h) {
  return new IntList(new ConsCell(h,start));
}
```

Generating Documentation

- Example (partial view):

Method Summary

IntList	cons(int h) Cons the given element h onto us and return the resulting IntList.
int	length() Get our length.
void	print() Print ourself to System.out.

Methods inherited from class java.lang.Object

clone, equals, finalize, getClass, hashCode, notify, notifyAll, toString, wait, wait, wait

Constructor Detail

IntList

```
public IntList(ConsCell s)
```

Construct a new IntList given its first ConsCell.

Parameters:
s - the first ConsCell in the list, or null

Method Detail

cons

```
public IntList cons(int h)
```

Cons the given element h onto us and return the resulting IntList.

Parameters:
h - the head int for the new list
Returns:
the IntList with head h, and us as tail

Interfaces

- An interface in Java is a collection of method prototypes (just header, no body)

```
public interface Drawable {
  void show(int xPos, int yPos);
  void hide();
}
```

- A class can declare that it implements a particular interface
- Then it must provide **`public`** method definitions that match those in the interface

Interfaces

```
public class Icon implements Drawable {
  public void show(int x, int y) {
     ... method body ...
  }
  public void hide() {
     ... method body ...
  }
  ...more methods and fields...
}
```

```
public class Square implements Drawable, Scalable {
  ... all required methods of all interfaces implemented ...
}
```

Interfaces

- An interface can be implemented by many classes:

```
public class Window implements Drawable …
public class MousePointer implements Drawable …
public class Oval implements Drawable …
```

- An interface name can be used as a (polymorphic) type:

```
Drawable d;
d = new Icon("i1.gif");
d.show(0,0);
d = new Oval(20,30);
d.show(0,0);
```

Polymorphism with Interfaces

```
static void flashoff(Drawable d, int k) {
  for (int i = 0; i < k; i++) {
    d.show(0,0);
    d.hide();
  }
}
```

- Class of object referred to by **`d`** is not known at compile time
- It is some class that **`implements Drawable`**, so it has **`show`** and **`hide`** methods that can be called

A More Complete Example

- A **`Worklist`** interface for a collection of **`String`** objects
- Can be added to, removed from, and tested for emptiness

```
public interface Worklist {
  /**
    * Add one String to the worklist.
    * @param item the String to add
    */
   void add(String item);

   /**
    * Test whether there are more elements in the
    * worklist:  that is, test whether more elements
    * have been added than have been removed.
    * @return true iff there are more elements
    */
   boolean hasMore();
```

A More Complete Example

```
  /**
   * Remove one String from the worklist and return
   * it.  There must be at least one element in the
   * worklist.
   * @return the String item removed
   */
  String remove();
}
```

- **`Worklist`** interface does not specify ordering: could be a stack, a queue, or something else
- We will do an implementation as a stack, implemented using linked lists

A More Complete Example

- The **`Node`** class:

```
/**
 * A Node is an object that holds a String and a link
 * to the next Node.  It can be used to build linked
 * lists of Strings.
 */
public class Node {
  private String data; // Each node has a String...
  private Node link;   // and a link to the next Node

  /**
   * Node constructor.
   * @param theData the String to store in this Node
   * @param theLink a link to the next Node
   */
  public Node(String theData, Node theLink) {
    data = theData;
    link = theLink;
  }
```

A More Complete Example

```
  /**
   * Accessor for the String data stored in this Node.
   * @return our String item
   */
  public String getData() {
    return data;
  }

  /**
   * Accessor for the link to the next Node.
   * @return the next Node
   */
  public Node getLink() {
    return link;
  }
}
```

A More Complete Example

- The **`Stack`** class:

```
/**
 * A Stack is an object that holds a collection of
 * Strings.
 */
public class Stack implements Worklist {
  protected Node top = null; // top Node in the stack

  /**
   * Push a String on top of this stack.
   * @param data the String to add
   */
  public void add(String data) {
    top = new Node(data,top);
  }
```

A More Complete Example

```
  /**
   * Test whether this stack has more elements.
   * @return true if this stack is not empty
   */
  public boolean hasMore() {
    return (top!=null);
  }

  /**
   * Pop the top String from this stack and return it.
   * This should be called only if the stack is
   * not empty.
   * @return the popped String
   */
  public String remove() {
    Node n = top;
    top = n.getLink();
    return n.getData();
  }
}
```

A Test

```
Worklist w;
w = new Stack();
w.add("- repeat");
w.add("- sleep");
w.add("- goto school ");
w.add("- wake up ");
System.out.print(w.remove());
System.out.print(w.remove());
System.out.print(w.remove());
System.out.println(w.remove());
```

- Output:

```
- wake up - goto school - sleep - repeat
```

- Other implementations of **`Worklist`** are possible: **`Queue`**, **`PriorityQueue`**, etc.

Derived Classes

- One class can be derived from another, using the keyword **`extends`**
- The class **`PeekableStack`** – just like **`Stack`**, but also has a method **`peek`** to examine the top element without removing it

```
public class PeekableStack extends Stack {

  public String peek() {
    return top.getData();
  }
}
```

- What is the difference between extend and implement?
  - Extend a class – inherit all its fields and methods
  - Implement an interface – not inherit anything, just get an obligation to implement its methods

Inheritance Chains

- If you do not give an **`extends`** clause, Java supplies one: **`extends Object`**
- All classes are derived, directly or indirectly, from the predefined class **`Object`** (except **`Object`** itself)

- All classes inherit methods from **`Object`**:
  - **`toString`**, for converting to a **`String`**
  - **`equals`**, for comparing with other objects
  - etc.

- No multiple inheritance
- However, can implement multiple interfaces

Object Oriented Design

- How should we establish inheritance relations?
  - usually, inheritance is one useful class extending another
  - what about this:

```
public class Label {
  private int x,y;
  private int width;
  private int height;
  private String text;
  public void move
      (int newX, int newY)
  {
    x = newX;
    y = newY;
  }
  public String getText()
  {
    return text;
  }
}
```

```
public class Icon {
  private int x,y;
  private int width;
  private int height;
  private Gif image;
  public void move
      (int newX, int newY)
  {
    x = newX;
    y = newY;
  }
  public Gif getImage()
  {
    return image;
  }
}
```

Object Oriented Design

```
public class Graphic {
  protected int x,y;
  protected int width,height;
  public void move(int newX, int newY) {
    x = newX;
    y = newY;
  }
}
```

```
public class Label
    extends Graphic {
  private String text;
  public String getText()
  {
    return text;
  }
}
```

```
public class Icon
    extends Graphic {
  private Gif image;
  public Gif getImage()
  {
    return image;
  }
}
```

- Here - factor out common code from different classes into a shared base class

Object Oriented Design

- In general:

- When you write the same statements repeatedly → that should be a method
- When you write the same methods repeatedly → that should be a common base class

- Difficulty – see the need for a shared base class early in the design, before writing a lot of code that needs to be reorganized

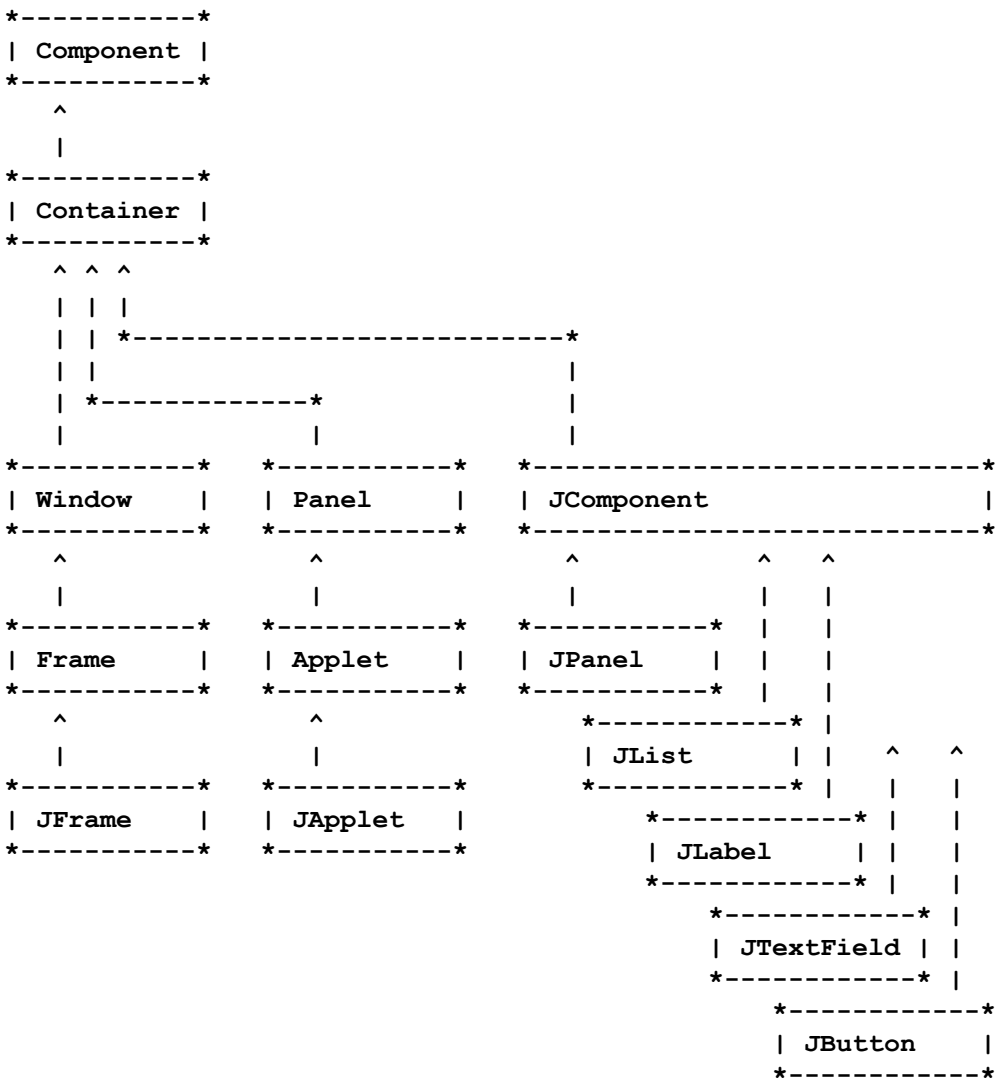
GUIs

- General mechanisms for GUI development:

- Components – classes that have a graphical representation
  - buttons, text fields, labels, choice lists, ...
- Containers – components that allow other components to nest within their boundaries
  - windows, frames, panels, ...

- Two GUI packages:
  - Abstract Window Toolkit (AWT): java.awt
    - Classes: `Frame`, `Button`, `TextField`, `Label`
  - Swing: javax.swing – newer than AWT, improved
    - Classes: `JFrame`, `JButton`, `JTextField`, `JLabel`

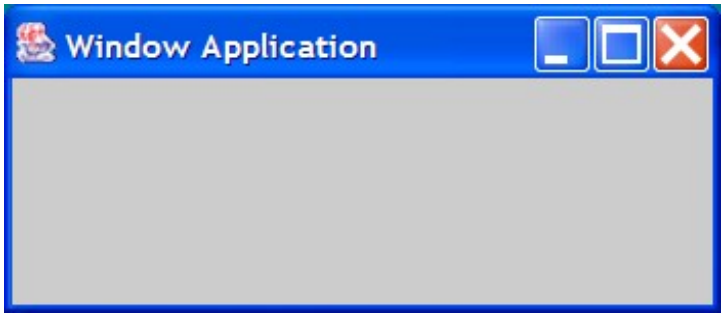
Class Hierarchy



Windows

- Create a window:

```
import javax.swing.*;

public class WindowApplication
{
  public static void main (String argv [])
  {
        JFrame frame = new JFrame("Window Application");
        frame.setSize(350, 150);
        frame.setVisible(true);
  }
}
```



Windows

- Anything wrong?
  - when closing the window, the program will not finish (need to kill it)
- Must explicitly end the program upon closing the window
- Event-driven programming
  - the language implementation generates events – user actions
  - the programmer can define event handlers – methods that specify what to do when a particular event occurs
- In Java – must implement listeners, for various types of events:
  - `WindowListener`
  - `ActionListener`
  - `MouseListener`
  - `ListSelectionListener`

Windows

- The window listener (implement an interface):

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

public class WindowDestroyer implements WindowListener
{
  public void windowClosing(WindowEvent e)
 {  System.exit(0);  }
  public void windowActivated(WindowEvent e) {}
  public void windowClosed(WindowEvent e) {}
  public void windowDeactivated(WindowEvent e) {}
  public void windowDeiconified(WindowEvent e) {}
  public void windowIconified(WindowEvent e) {}
  public void windowOpened(WindowEvent e) {}
}
```

Windows

- The new application:

```
import javax.swing.*;

public class WindowApplication
{
  public static void main (String argv [])
  {
        JFrame frame = new JFrame("Window Application");
        frame.setSize(350, 150);
        frame.addWindowListener(new WindowDestroyer());
        frame.setVisible(true);
  }
}
```

Windows

- Can do better – use a window adapter (extend a class)
- Other changes:
  - have the application itself be the window
  - use an inner class (defined within another class)

```
import javax.swing.*;
import java.awt.event.*;

public class WindowApplication extends JFrame
{
   public static void main (String argv [])
   {
          new WindowApplication("Window Application");
   }
```

Windows

```
    public WindowApplication(String title)
    {
    super(title);  // call constructor of base class
    setSize(350, 150);
    addWindowListener(new WindowDestroyer());
    setVisible(true);
    }

    // Define window adapter
    private class WindowDestroyer extends WindowAdapter
    {
    // implement only the function that you want
    public void windowClosing(WindowEvent e)
    {
    System.exit(0);
    }
    }
}
```

Components

- Components
  - labels, buttons, text fields, selection lists, ...
  - added to the content pane (the client area of a window)
- How will they be arranged?
  - defined by the layout manager – their size/position automatically change with window size
  - defined by explicitly specifying their size/position (with setBounds)
- Types of layout managers:
  - `BorderLayout`
  - `GridLayout`
  - `FlowLayout`
  - `GridBagLayout`
- `GridLayout`
  - usually best tradeoff between simplicity and flexibility
  - specifies the number of rows and columns
  - components are added in order (left-right, top-bottom)
  - all components have the same size

Labels

- Add six labels:

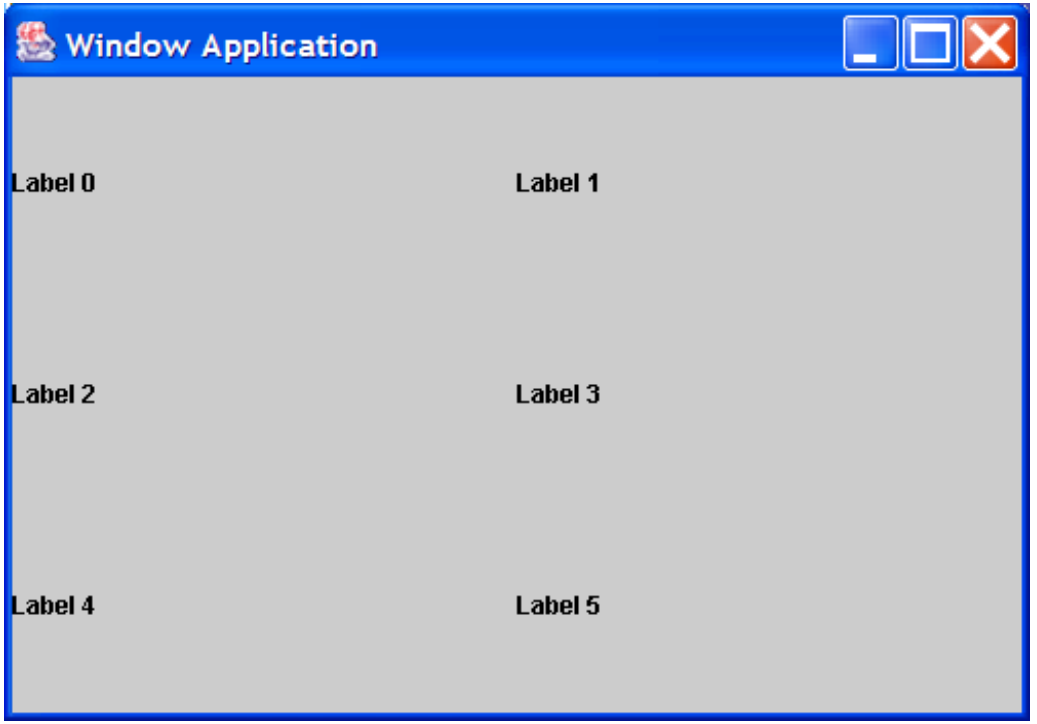
```
import java.awt.*;
import javax.swing.*;
import java.awt.event.*;

public class WindowApplication extends JFrame
{
   public static void main(String argv [])
   {
          new WindowApplication("Window Application");
   }
```

Labels

```
public WindowApplication(String title)
{
        super(title);
        setBounds(100, 100, 500, 350);
        addWindowListener(new WindowDestroyer());

        getContentPane().setLayout(new GridLayout(3, 2));
        int i;
        for (i = 0; i < 6; i++)
        {
                getContentPane().add(new JLabel("Label " + i));
        }

        setVisible(true);
}
```

Labels

```
    // Define window adapter
    private class WindowDestroyer extends WindowAdapter
    {
    public void windowClosing(WindowEvent e)
    {
    System.exit(0);
    }
    }
}
```



Buttons and Text Fields

- Add buttons and text fields:

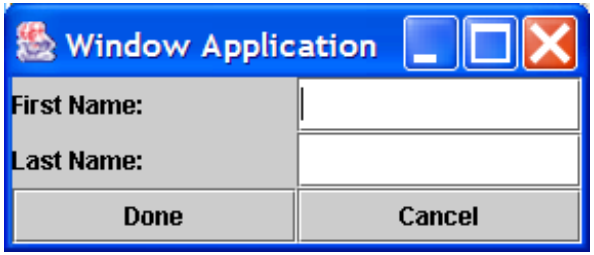
```
import java.awt.*;
import javax.swing.*;
import java.awt.event.*;

public class WindowApplication extends JFrame
{
   public static void main(String argv [])
   {
           new WindowApplication("Window Application");
   }
```

Buttons and Text Fields

```
public WindowApplication(String title)
{
        super(title);
        setBounds(100, 100, 250, 100);
        addWindowListener(new WindowDestroyer());

        getContentPane().setLayout(new GridLayout(3, 2));
        getContentPane().add(new JLabel("First Name:"));
        getContentPane().add(new JTextField(""));
        getContentPane().add(new JLabel("Last Name:"));
        getContentPane().add(new JTextField(""));
        getContentPane().add(new JButton("Done"));
        getContentPane().add(new JButton("Cancel"));

        setVisible(true);
}
```

Buttons and Text Fields

```
    // Define window adapter
    private class WindowDestroyer extends WindowAdapter
    {
    public void windowClosing(WindowEvent e)
    {
    System.exit(0);
    }
    }
}
```



Buttons and Text Fields

- Handle user input
  - implement an action listener
- Also – get and set text in the text fields

```
import java.awt.*;
import javax.swing.*;
import java.awt.event.*;

public class WindowApplication extends JFrame
{
   protected JButton buttonDone;
   protected JButton buttonCancel;
   protected JTextField tfFirstName;
   protected JTextField tfLastName;

   public static void main(String argv [])
   {
   new WindowApplication("Window Application");
   }
```

Buttons and Text Fields

```
public WindowApplication(String title)
{
        super(title);
        setBounds(100, 100, 250, 100);
        addWindowListener(new WindowDestroyer());

        buttonDone = new JButton("Done");
        buttonCancel = new JButton("Cancel");
        buttonDone.addActionListener(new ActionHandler());
        buttonCancel.addActionListener(new ActionHandler());

        tfFirstName = new JTextField("");
        tfLastName = new JTextField("");
```

Buttons and Text Fields

```
        getContentPane().setLayout(new GridLayout(3, 2));

        getContentPane().add(new JLabel("First Name:"));
        getContentPane().add(tfFirstName);
        getContentPane().add(new JLabel("Last Name:"));
        getContentPane().add(tfLastName);
        getContentPane().add(buttonDone);
        getContentPane().add(buttonCancel);

        setVisible(true);

        tfFirstName.setText("John");
        tfLastName.setText("Doe");
}
```

Buttons and Text Fields

```
// Define action listener
private class ActionHandler implements ActionListener
{
        public void actionPerformed(ActionEvent e)
        {
                if ( e.getSource() == buttonDone )
                {
                        String s1 = tfFirstName.getText();
                        String s2 = tfLastName.getText();
                        System.out.println("Full name: " + s1 + " "
                                                        + s2);
                }
                else if ( e.getSource() == buttonCancel )
                        System.out.println("You pressed the Cancel
                                                button.");
        }
}
```

Buttons and Text Fields

```
    // Define window adapter
    private class WindowDestroyer extends WindowAdapter
    {
            public void windowClosing(WindowEvent e)
            {
                    System.exit(0);
            }

    }
}
```

Selection Lists

- Add a selection list (with a scroll-bar)
- Also – implement a list selection listener

```
import java.awt.*;
import javax.swing.*;
import java.awt.event.*;
import javax.swing.event.*;

public class WindowApplication extends JFrame
{
   protected JList listMovies;

   public static void main(String argv [])
   {
           new WindowApplication("Window Application");
   }
```

Selection Lists

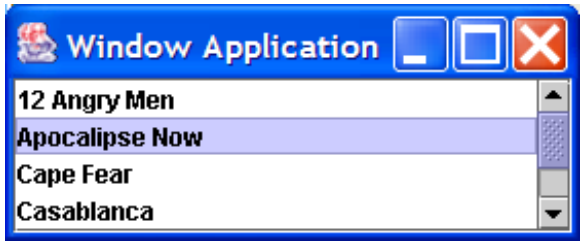
```
public WindowApplication(String title)
{
        super(title);
        setBounds(100, 100, 200, 100);
        addWindowListener(new WindowDestroyer());

        listMovies = new JList();
        listMovies.addListSelectionListener(new ListHandler());

        getContentPane().setLayout(new GridLayout(1, 1));

//      getContentPane().add(listMovies);     // no scroll
        getContentPane().add(new JScrollPane(listMovies));

        setVisible(true);
```

Selection Lists

```
        String movies[] = {"12 Angry Men", "Apocalipse Now",
                           "Cape Fear", "Casablanca", "Fargo",
                           "Solaris"};
        listMovies.setListData(movies);
}

// Define window adapter
private class WindowDestroyer extends WindowAdapter
{
        public void windowClosing(WindowEvent e)
        {
                System.exit(0);
        }
}
```

Selection Lists

```
    // Define list listener
    private class ListHandler implements ListSelectionListener
    {
            public void valueChanged(ListSelectionEvent e)
            {
              if ( e.getSource() == listMovies )
                 if ( !e.getValueIsAdjusting() )
                 {
                    int i = listMovies.getSelectedIndex();
                    String s = (String) listMovies.getSelectedValue();
                    System.out.println("Position " + i + " selected: "
+s);
                 }
            }
    }
}
```



Menus

- Add a menu
- How can we handle user input?
  - menu selection is handled by an action listener

```
import java.awt.*;
import javax.swing.*;
import java.awt.event.*;

public class WindowApplication extends JFrame
{
   protected JButton buttonDone;
   protected JButton buttonCancel;
   protected JTextField tfFirstName;
   protected JTextField tfLastName;
   protected JMenuBar mb;
   protected Jmenu m;
   protected JMenuItem mi[];
```

Menus

```
public static void main(String argv [])
{
new WindowApplication("Window Application");
}

public WindowApplication(String title)
{
super(title);
addWindowListener(new WindowDestroyer());

buttonDone = new JButton("Done");
buttonCancel = new JButton("Cancel");
buttonDone.addActionListener(new ActionHandler());
buttonCancel.addActionListener(new ActionHandler());

tfFirstName = new JTextField("");
tfLastName = new JTextField("");
```

Menus

```
mb = new JMenuBar();
m = new JMenu("Actions");
mi = new JMenuItem[2];
mi[0] = new JMenuItem("Clear");
mi[0].addActionListener(new ActionHandler());
mi[1] = new JMenuItem("Exit");
mi[1].addActionListener(new ActionHandler());
m.add(mi[0]);
m.add(new JSeparator());
m.add(mi[1]);
mb.add(m);
setJMenuBar(mb);

getContentPane().setLayout(new GridLayout(3, 2));
```

Menus

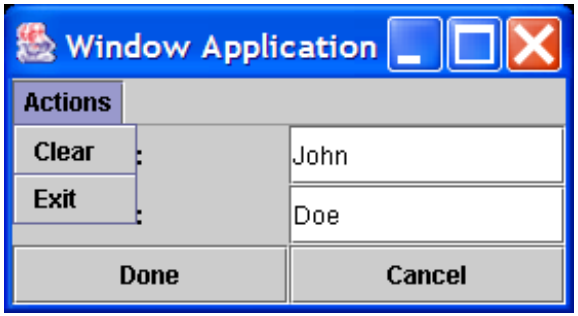
```
getContentPane().add(new JLabel("First Name:"));
getContentPane().add(tfFirstName);
getContentPane().add(new JLabel("Last Name:"));
getContentPane().add(tfLastName);
getContentPane().add(buttonDone);
getContentPane().add(buttonCancel);

setBounds(100, 100, 250, 150);
setVisible(true);

tfFirstName.setText("John");
tfLastName.setText("Doe");
}

// Define window adapter
private class WindowDestroyer extends WindowAdapter
{
public void windowClosing(WindowEvent e)
{    System.exit(0);  }

}
```

Menus

```
// Define action listener
private class ActionHandler implements ActionListener
{
public void actionPerformed(ActionEvent e)
{
   if ( e.getSource() == buttonDone )
   {
      String s1 = tfFirstName.getText();
      String s2 = tfLastName.getText();
      System.out.println("Full name: " + s1 + " " + s2);
   }
   else if ( e.getSource() == buttonCancel )
      System.out.println("You pressed the Cancel button.");
```

Menus

```
            else if ( e.getSource() == mi[0] )          // clear
            {
               tfFirstName.setText("");
               tfLastName.setText("");
            }
            else if ( e.getSource() == mi[1] )          // exit
               System.exit(0);
         }
      }
   }
```



Drawing

- Draw lines, rectangles, arcs, ovals, ...
- Need to redefine the paint method for the component where we draw
  - paint is automatically called every time the component needs to be (re)displayed
  - its only parameter is a Graphics object – contains current information needed for rendering, such as:
    - clip rectangle (the part of the component that needs to be painted)
    - color
    - font
    - logical pixel operation function (XOR or Paint)
  - for drawing - inside paint, call methods of the Graphics object such as:
    - drawRect
    - drawLine
    - drawOval
    - ...

Drawing

```
import java.awt.*;
import javax.swing.*;
import java.awt.event.*;

class DrawingTester extends JComponent
{
   public void paint(Graphics g)
   {
          Dimension d = getSize();

          g.setColor(Color.yellow);
          g.fillRect(1, 1, d.width-2, d.height-2);

          g.setColor(Color.black);
          g.drawRect(1, 1, d.width-2, d.height-2);
          g.drawLine(1, d.height-1, d.width-1, 1);
          g.drawOval(d.width/2 - 30, d.height/2 - 30, 60, 60);
   }
}
```

Drawing

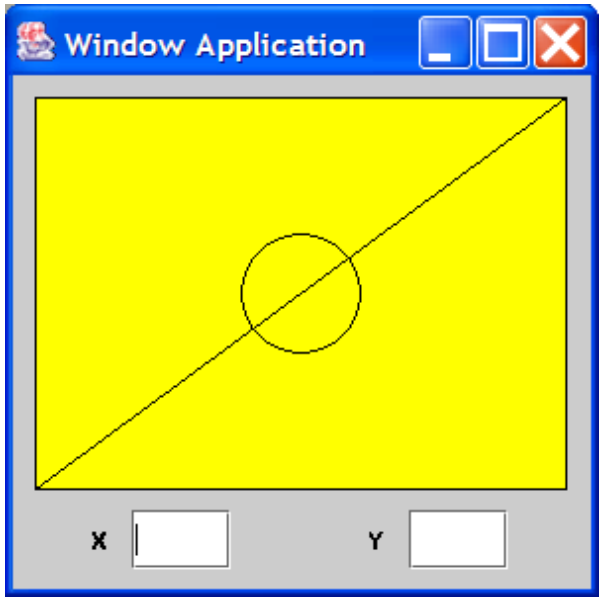
```
public class WindowApplication extends JFrame
{
   protected DrawingTester drawTest;
   protected JLabel labelX;
   protected JLabel labelY;
   protected JTextField tfX;
   protected JTextField tfY;

   public static void main(String argv [])
   {
          new WindowApplication("Window Application");
   }
   public WindowApplication(String title)
   {
          super(title);
          setBounds(100, 100, 300, 300);
          addWindowListener(new WindowDestroyer());
```

Drawing

```
drawTest = new DrawingTester();
labelX = new JLabel("X");
labelY = new JLabel("Y");
tfX = new JTextField("");
tfY = new JTextField("");

// let's also specify the arrangement of components by hand
getContentPane().setLayout(null);

getContentPane().add(drawTest);
getContentPane().add(labelX);
getContentPane().add(labelY);
getContentPane().add(tfX);
getContentPane().add(tfY);
```

Drawing

```
    drawTest.setBounds(10, 10, 270, 200);
    labelX.setBounds(40, 220, 20, 30);
    tfX.setBounds(60, 220, 50, 30);
    labelY.setBounds(180, 220, 20, 30);
    tfY.setBounds(200, 220, 50, 30);

    setVisible(true);
    }



    // Define window adapter
    private class WindowDestroyer extends WindowAdapter
    {
    public void windowClosing(WindowEvent e)
    {
    System.exit(0);
    }
    }
}
```



Mouse Events

- Perform actions upon mouse events
  - implement a mouse listener
- Draw a small circle where the user clicks
  - need to make the component redraw itself – call repaint

```
import java.awt.*;
import javax.swing.*;
import java.awt.event.*;

class DrawingTester extends JComponent implements MouseListener
{
   WindowApplication app;
   int     x = -1;
   int     y = -1;
```

Mouse Events

```
public DrawingTester(WindowApplication a)
{
        app = a;
}

public void paint(Graphics g)
{
        Dimension d = getSize();

        g.setColor(Color.yellow);
        g.fillRect(1, 1, d.width-2, d.height-2);

        g.setColor(Color.black);
        g.drawRect(1, 1, d.width-2, d.height-2);
        g.drawLine(1, d.height-1, d.width-1, 1);
        g.drawOval(d.width/2 - 30, d.height/2 - 30, 60, 60);
        if ( x >= 0 && y >= 0 )
                g.drawOval(x-10, y-10, 20, 20);
}
```

Mouse Events

```
    public void mouseClicked(MouseEvent e)
    {
            x = e.getX();
            y = e.getY();
            repaint();

            // also display click coordinates in the two text fields
            app.tfX.setText(String.valueOf(x));
            app.tfY.setText(String.valueOf(y));
    }
    public void mouseEntered(MouseEvent e)        {}
    public void mouseExited(MouseEvent e) {}
    public void mousePressed(MouseEvent e)        {}
    public void mouseReleased(MouseEvent e)       {}
}
```

Mouse Events

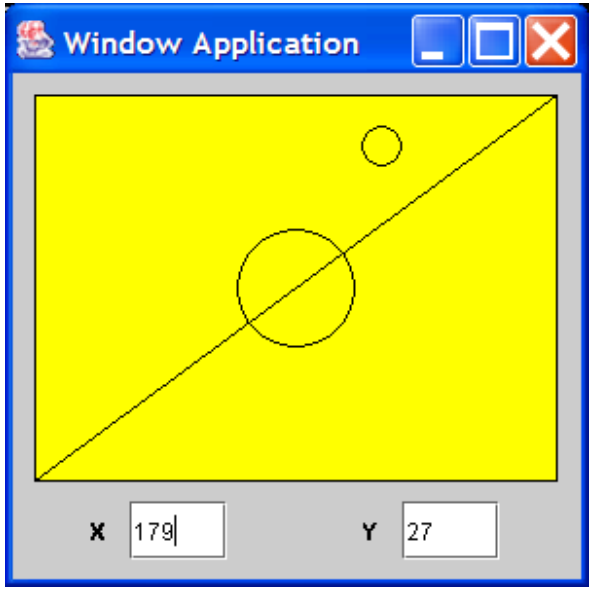
```
public class WindowApplication extends JFrame
{
   protected DrawingTester drawTest;
   protected JLabel labelX;
   protected JLabel labelY;
   protected JTextField tfX;
   protected JTextField tfY;

   public static void main(String argv [])
   {
          new WindowApplication("Window Application");
   }
   public WindowApplication(String title)
   {
          super(title);
          setBounds(100, 100, 300, 300);
          addWindowListener(new WindowDestroyer());
```

Mouse Events

```
drawTest = new DrawingTester(this);
labelX = new JLabel("X");
labelY = new JLabel("Y");
tfX = new JTextField("");
tfY = new JTextField("");

getContentPane().setLayout(null);
getContentPane().add(drawTest);
getContentPane().add(labelX);
getContentPane().add(labelY);
getContentPane().add(tfX);
getContentPane().add(tfY);

drawTest.setBounds(10, 10, 270, 200);
labelX.setBounds(40, 220, 20, 30);
tfX.setBounds(60, 220, 50, 30);
labelY.setBounds(180, 220, 20, 30);
tfY.setBounds(200, 220, 50, 30);
```

Mouse Events

```
    drawTest.addMouseListener(drawTest);

    setVisible(true);
    }
```




```
    // Define window adapter
    private class WindowDestroyer extends WindowAdapter
    {
    public void windowClosing(WindowEvent e)
    {
    System.exit(0);
    }
    }
}
```

File I/O

- Reading from a text file – two main approaches:

File input stream
|
| Bytes
v
Input stream reader
|
| Characters
v
Buffered reader
|
| Lines
v
Your program

OR

\
\ Characters
v
Stream tokenizer
|
| Tokens (numbers, strings)
v
Your program

File I/O

- Read and print (to console) the data in the following file:

Jack	18	3.7
Mary	15	3.8
Jim	12	2.5

```
import java.io.*;

public class FileIODemo
{
   public static void main(String argv[]) throws IOException
   {
          FileInputStream stream = new FileInputStream("input.txt");

          InputStreamReader reader = new InputStreamReader(stream);
          StreamTokenizer tokens = new StreamTokenizer(reader);
```

File I/O

```
        String  s;
        int     n;
        float   f;
        while (tokens.nextToken() != tokens.TT_EOF)
        {
                s = (String) tokens.sval;
                tokens.nextToken();
                n = (int) tokens.nval;
                tokens.nextToken();
                f = (float) tokens.nval;

                System.out.println(s + " " + n + " " + f);
        }

        stream.close();
    }
}
```

File I/O

- Writing to a text file – use a FileOutputStream and a PrintWriter

```
import java.io.*;

public class FileIODemo
{
   public static void main(String argv[]) throws IOException
   {
   FileInputStream istream = new FileInputStream("input.txt");
   InputStreamReader reader = new InputStreamReader(istream);
   StreamTokenizer tokens = new StreamTokenizer(reader);

   FileOutputStream ostream = new FileOutputStream("output.txt");
   PrintWriter writer = new PrintWriter(ostream);
```

File I/O

```
    String  s;
    int     n;
    float   f;
    while (tokens.nextToken() != tokens.TT_EOF)
    {
    s = (String) tokens.sval;
    tokens.nextToken();
    n = (int) tokens.nval;
    tokens.nextToken();
    f = (float) tokens.nval;

    writer.println(s + " " + n + " " + f);
    }
    writer.flush();
    istream.close();
    ostream.close();
    System.out.println("File written.");
    }
}
```

Announcements

- Readings
  - Java resources