Graphical User Interfaces (GUI)

Object Oriented Programming

Version 3.4.1 - May 2016

History

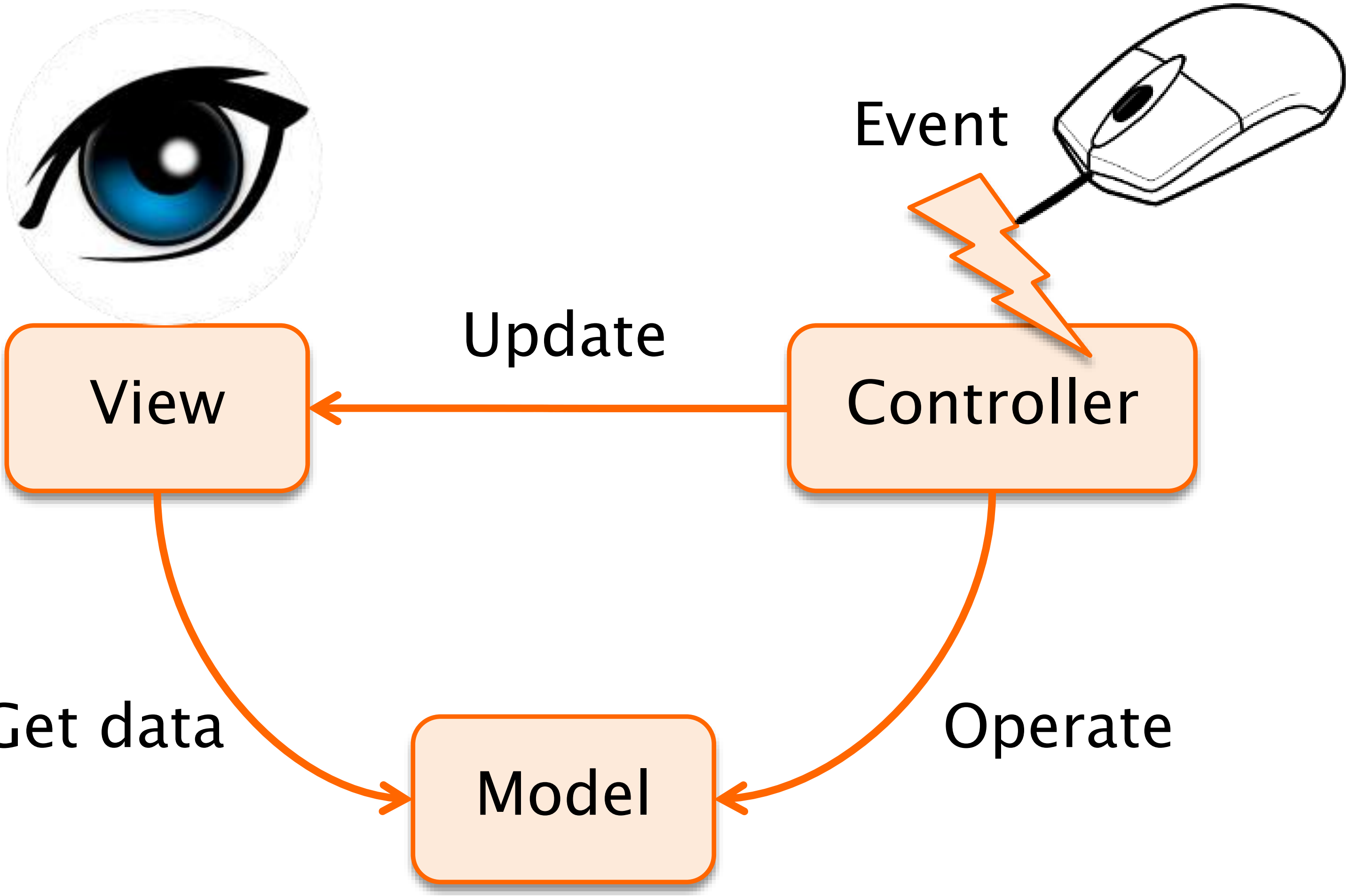
- Abstract Window Toolkit (AWT)
  - Original GUI API
  - Rely on native OS components
- Java Foundation Classes (JFC)
  - Since Java 1.2
  - Includes: AWT, Swing (Widget toolkit), Java 2D
  - Lightweight
  - System independent

Swing

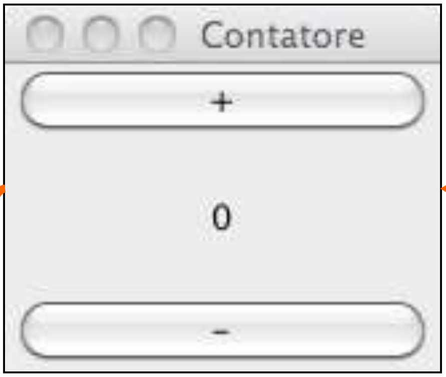
- Widget Toolkit
  - a widget (or control) is an element of a GUI that conveys information and/or represent a point of interaction
- Model–View–Controller pattern
- Pluggable look–and–feel

- Next technology for rich client development
  - Seamlessly integrate several different capabilities
  - FXML: markup language for UI definition
  - New graphics pipeline (Prism)
  - New Toolkit (Glass)
  - Multimedia framework
  - Web component
  - Scene Builder

MVC



MVC example



```
plusBtnClick(){
  theCounter.increment();
  view.update();
}

minusBtnClick(){
  theCounter.decrement();
  view.update();
}
```

```
class Counter{
  private int value;
  public void increment(){ value++;}
  public void decrement(){ value--;}
  public int getValue(){ return value;}
}
```

MVC Principles

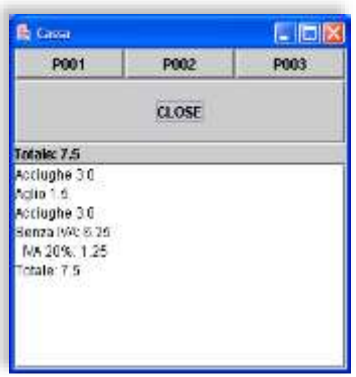
- When building a GUI we must consider two main aspects:
  - Layout (View): how to place the graphical elements to achieve a give visual aspect
  - Events (Controller): which behavior associate to elements' events
- Application logic (Model) must remain, as far as possible, separate from user interface.

Execution flow

- There is no predefined order of execution in GUI applications
  - Operations are performed in response to external events (e.g. mouse click)
  - Event handling is serialized
  - To execute several operations in parallel, threads must be used
- Method main in GUIs has the only goal of instantiating the graphical elements

GUI categories

- It is possible to identify two extreme types of GUIs:
  - Component composition
  - Direct drawing
- In practice a mix of the two is used.

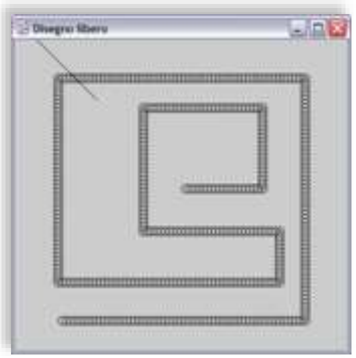


Totale: 7.5

```
Acciughe 3.0
Aglio 1.5
Acciughe 3.0
Senza IVA: 6.25
 IVA 20%: 1.25
Totale: 7.5
```

Components

Direct drawing



GUI with Components

- Use predefined UI components (widgets or controls)
  - E.g. buttons, text fields, labels
- They manage mostly textual information
  - Suitable to build an application that could “theoretically” make it with a textual user interface

GUI with drawing

- They directly access the screen
  - The tool is represented by the Graphics interface
  - They may use sophisticate API such as Java2D
- They manage visual informations (e.g. diagrams, graphs, images)
- Typically are contained in a JPanel component

MAIN CONTAINER

Main GUI container

- Represents the point of interaction between Java and Operating System (OS)
- It may vary:
  - JFrame for desktop applications
  - Applet for web-enabled components
  - Midlet for JavaME (phone) applications
  - …

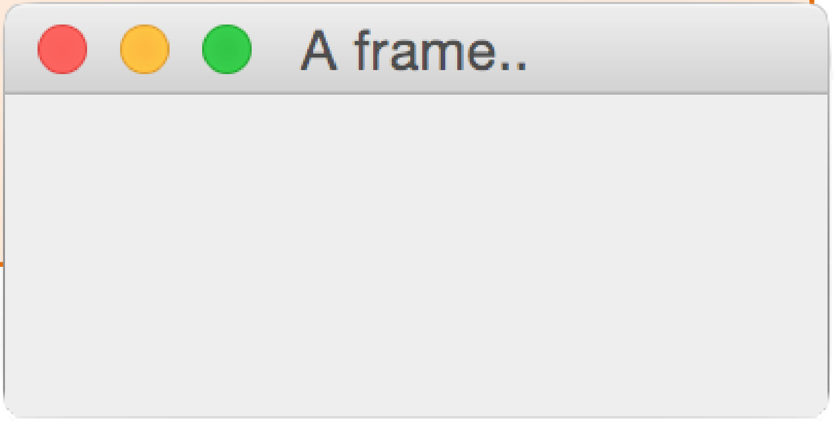
Frame container

- `JFrame` is the base class for desktop graphical applications
- Provides all the features for an empty window
  - Title bar
  - Standard buttons (Max, Min, Close)
  - Resizable border
  - Etc.

JFrame – Example

```
public class BasicFrame extends JFrame {
  public static void main(String[] args) {
   JFrame f = new BasicFrame();
   f.setVisible(true);
  }
  public BasicFrame(){
   super("A frame..");
   setSize(200,100);
  }
}
```

What happens without setSize() ?



Window close

- Clicking the button or
  - Closes the window but
  - DO NOT terminate the application
- It is required to explicitly define the operation to be performed in response to window closure

E.g.

```
setDefaultCloseOperation(
                          JFrame.DISPOSE_ON_CLOSE);
```

Container Basic Features

- `setDefaultCloseOperation(bhvr)`: define the behavior upon window close
  - `EXIT_ON_CLOSE`
  - `DO_NOTHING_ON_CLOSE`
  - `DISPOSE_ON_CLOSE`
  - `HIDE_ON_CLOSE`
- `setSize(int width, int height)`: defines the dimensions of the panel outside

Application

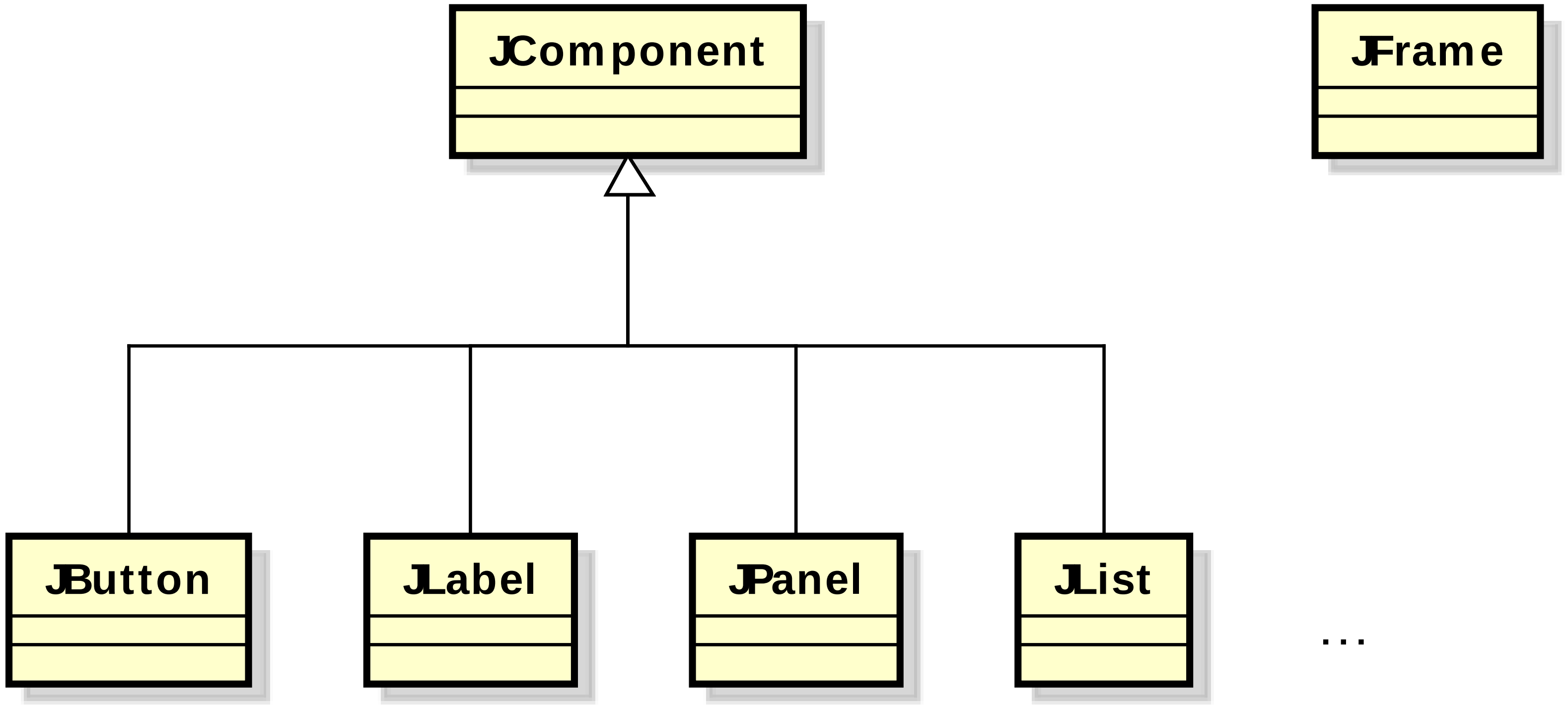
- The main application has to
  - create a container (**`JFrame`**)
  - make it visible (launches a new event thread)

```
public class Minimal extends JFrame {
   public Minimal(){
      setTitle("Minimal UI");
      setSize(200,100);
      setDefaultCloseOperation(EXIT_ON_CLOSE);
   }
   public static void main(String[] args) {
      Minimal gui = new Minimal();
      gui.setVisible(true);
   }}
```

Could be moved into the ctor

COMPONENTS

Main classes



Button: `JButton`

- Constructors:
  - **`JButton();`** creates a button without a text (without label)
  - **`JButton(String);`** creates a button with a label containing the text.
- it is a *component* → inherits all the methods of classes JComponent (javax.swing) and component (java.awt)
- It is a *container* → inherits all methods of java.awt.Container

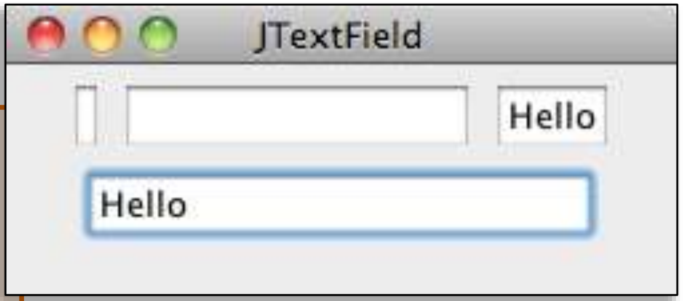
Label: `JLabel`

- Constructors
  - `JLabel(String);` create label with given text, aligned on the left
  - `JLabel(String, int);` create label with given text, aligned:
    - `SwingConstants.LEFT`
    - `SwingConstants.RIGHT`
    - `SwingConstants.CENTER`
- Available methods:
  - `getText(), setText(String)`
  - `getAlignement(), setAlignement(int)`

Text field: `JTextField`

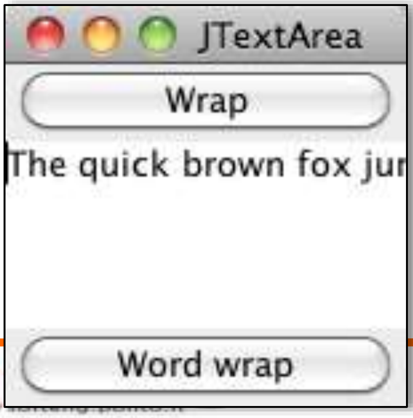
- The text fields allows entering strings of text on a single line
- Constructors:
  - **`JTextField(String)`** initial content
  - **`JTextField(int)`** required size in chars
  - …

```
add(new JTextField());
add(new JTextField("", 20));
add(new JTextField("Hello”));
add(new JTextField("Hello",30));
```

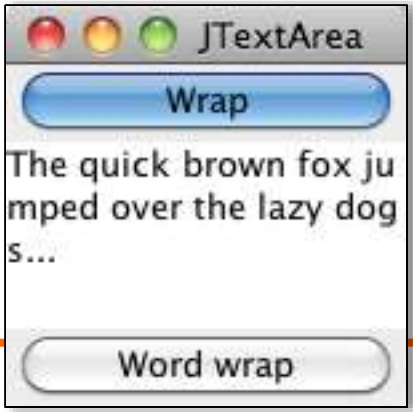


Text area: `JTextArea`

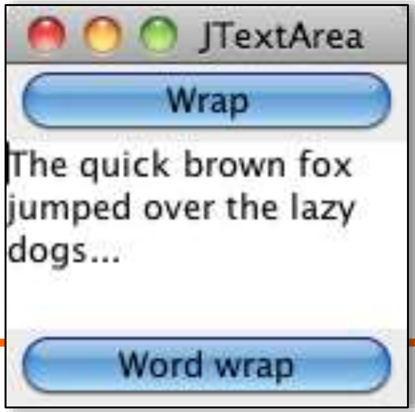
- Manages text on several lines
- Constructors
  - **`JTextArea (int lines, int columns)`**
  - **`JTextArea (String text, int l, int c)`**
- Useful Metods:
  - **`getText(), setText(String);`**
  - **`append(String), insert(String, int);`**
  - **`void setLineWrap(boolean)`**
  - **`void setWrapStyleWord(boolean)`**



The quick brown fox jur



The quick brown fox ju
mped over the lazy dog
s...

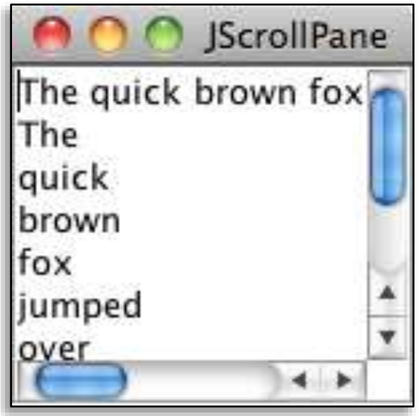


The quick brown fox
jumped over the lazy
dogs...

Scrollpane: `JScrollPane`

- **`JScrollPane`** is able to add scroll bars to a scrollable component (e.g. **`JTextArea`**)
- Constructor:
  - `JScrollPane(Component );`
- Example:

  -
    ```
    JScrollPane sp =
          new JScrollPane(
             new JTextArea(longText));
    ```


JScrollPane

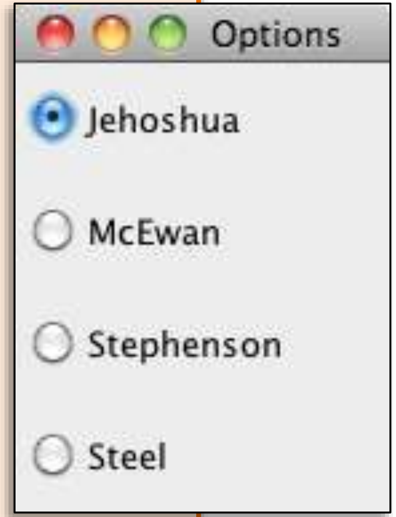
The quick brown fox
The
quick
brown
fox
jumped
over

Checkbox, Options

- Check boxes : `JCheckBox(String, boolean)`
- Option buttons: `JRadioButton(String, boolean)`
- Useful methods:
  - `void setSelected(boolean)`
  - `boolean isSelected()`
- Mutual exclusion:
  - Add RadioButton (or CheckBox) to `ButtonGroup`
  - By default they are non-exclusive

Example

```
public class Authors extends JFrame{
JRadioButton[] list = new JRadioButton[4];
public Authors() {
    super("Select an author");
    setSize(140, 190);
    setDefaultCloseOperation(JFrame.EXIT_ON_CLOSE);
    list[0] = new JRadioButton("Jehoshua", true);
    list[1] = new JRadioButton("McEwan");
    list[2] = new JRadioButton(”Stephenson");
    list[3] = new JRadioButton("Steel");
    JPanel panel = new JPanel();
    ButtonGroup group = new ButtonGroup();
    for (int i = 0; i < list.length; i++) {
        group.add(list[i]);
        panel.add(list[i]);
    }
    setContentPane(panel);
    setVisible(true);
}   public static void main (String args[]) {
    Authors newLista = new Authors(); }
}
```



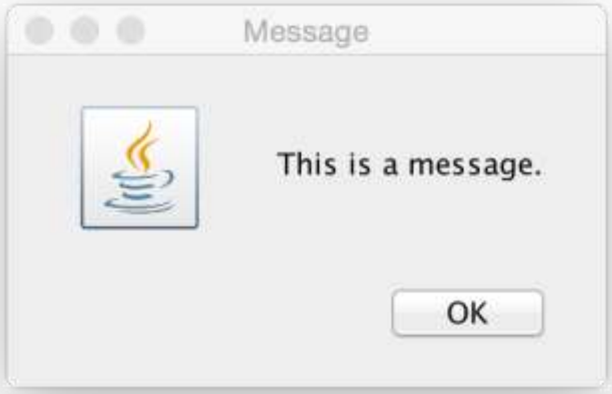
Dialog boxes

- Used for short focused interactions
  - Confirmation
  - Input
  - Message
  - Options
- Methods more efficient than input/output in order to read from keyboard
- Class `JOptionPane`
  - Several static methods for different types

Dialog for confirmation

- Every dialog is dependent on a root Frame component.
  - Example:

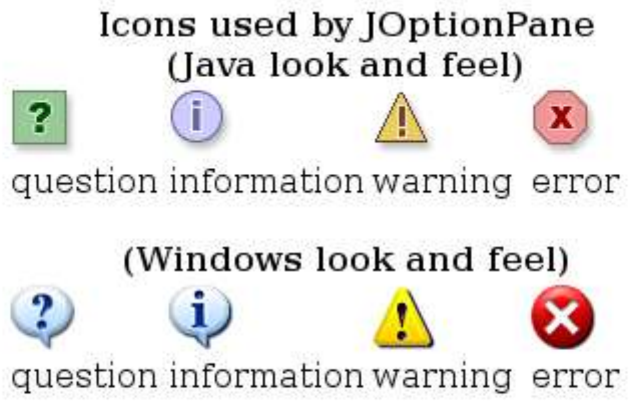
```
JOptionPane.showMessageDialog(frame,
                              "This is a message.");
```


Message

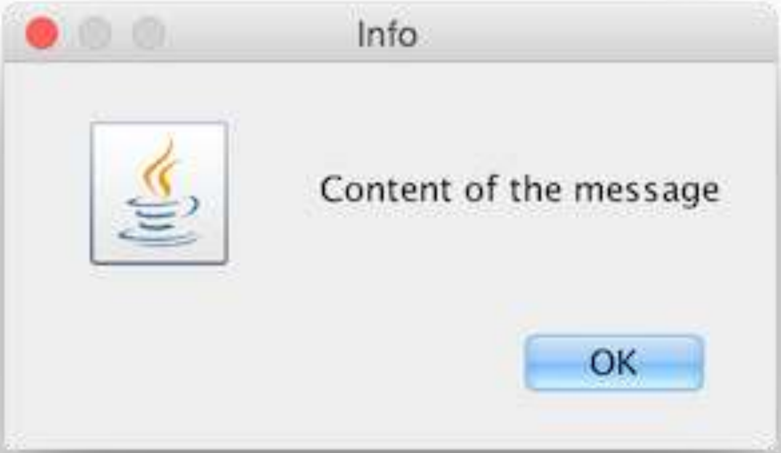
This is a message.

JOptionPane Features

Using **`JOptionPane`**, you can quickly create and customize several different kinds of dialogs. **`JOptionPane`** provides support for laying out standard dialogs, providing icons, specifying the dialog title and text, and customizing the button text.

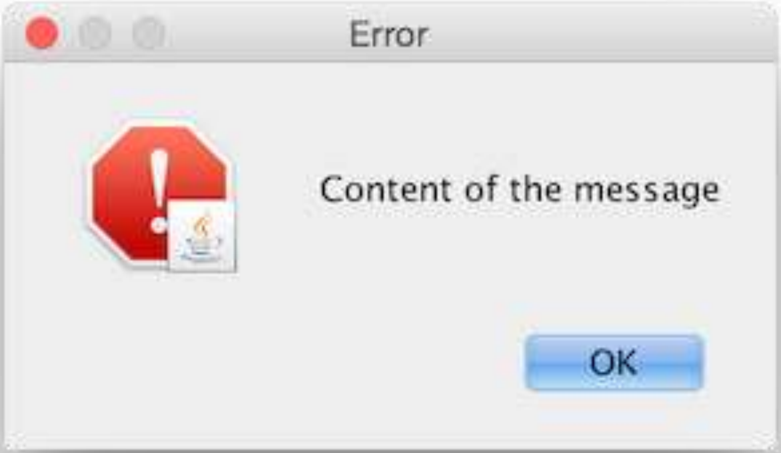


Message dialog types



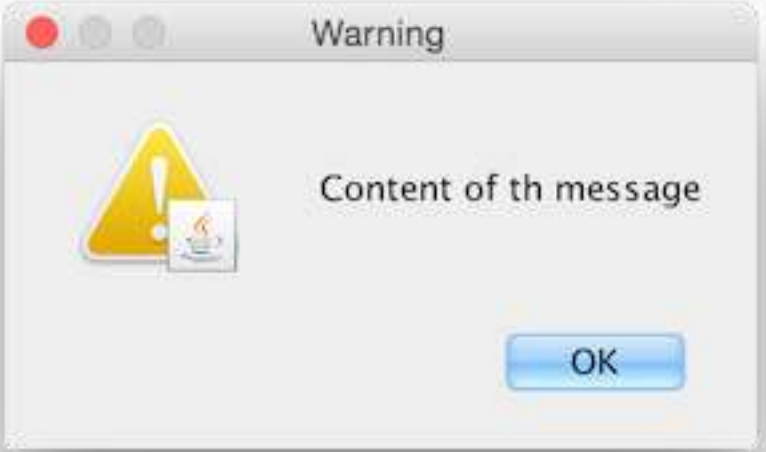
Content of the message

INFORMATION_MESSAGE (default)



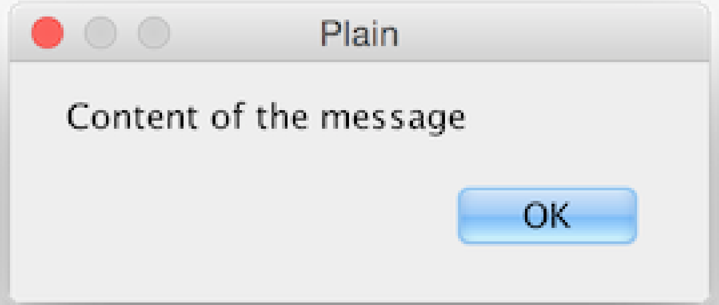
Content of the message

ERROR_MESSAGE



Content of th message

WARNING_MESSAGE



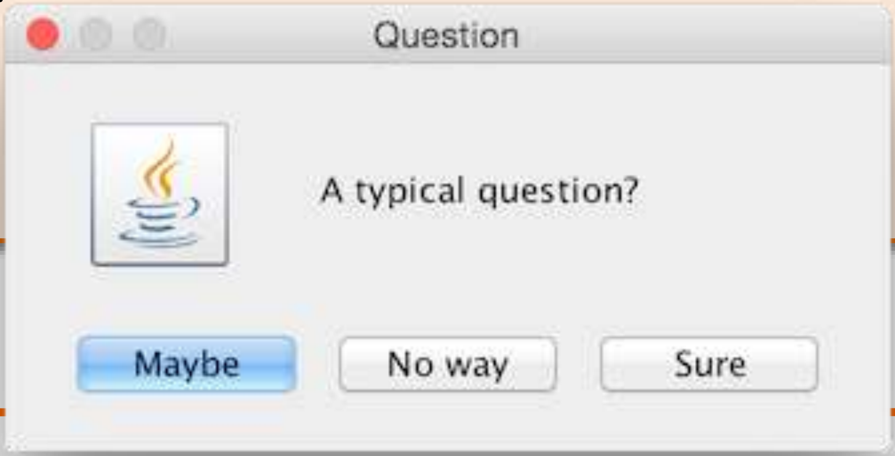
Content of the message

PLAIN_MESSAGE

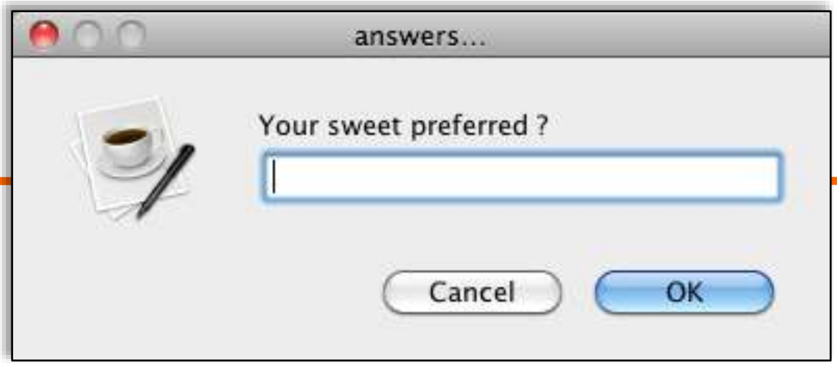
Option dialog

- Presents used with a few choices

```
String[] options={"Sure","No way","Maybe"};
JOptionPane.showOptionDialog(null,
"A typical question?",
"Question",
JOptionPane.YES_NO_CANCEL_OPTION,
JOptionPane.QUESTION_MESSAGE,null,
Options,
options[1]);
```



Input dialog



- Methods
  - `String showInputDialog(Component, Object)`
  - `String showInputDialog(Component, Object, String, int)`
    - Component: in which component appears window
    - Object: Request message input
    - String: title
    - int: type of message (as in confirmation)

```
String answer =
  JOptionPane.showInputDialog(null,
  "Your sweet preferred ?", "answers...",
  JOptionPane.QUESTION_MESSAGE);
```

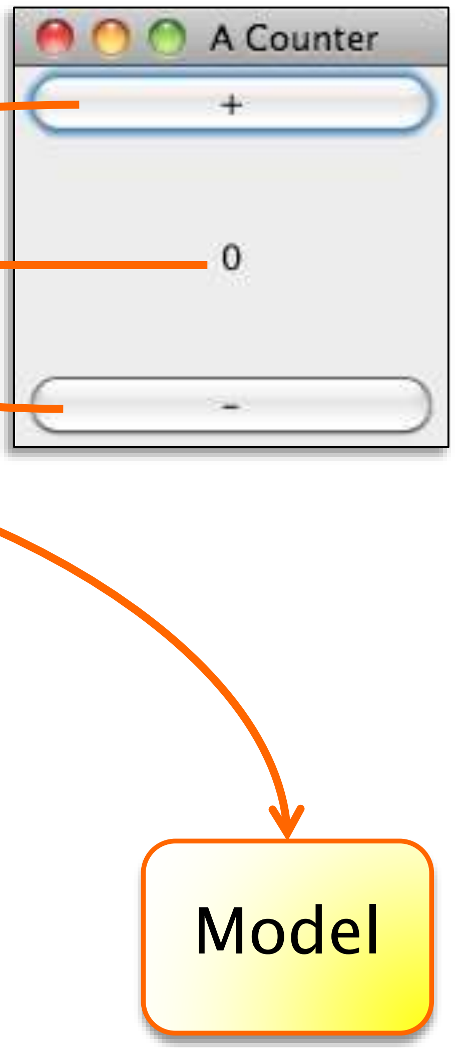
Full example: visual counter

- Model: a simple counter

```
public class Counter {
  private int value;
  public void increment(){
    value++;
  }
  public void decrement(){
     value--;
  }
  public int getValue(){
    return value;
  }
}
```

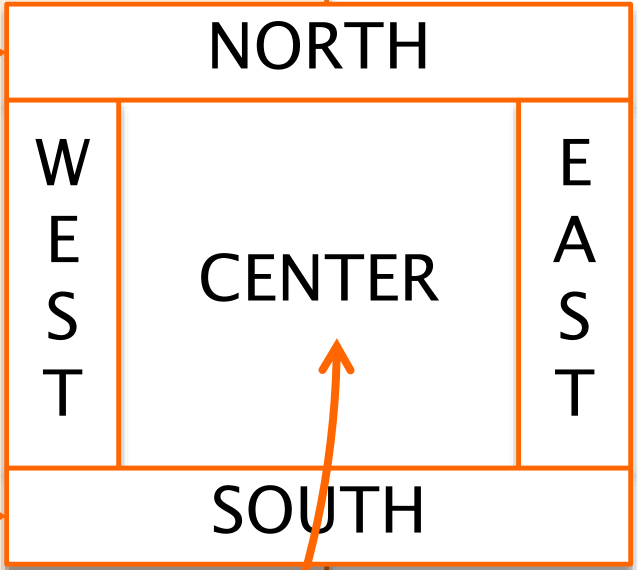
Visual Counter – View

```
public class View extends JFrame {
   private JButton plus;
   private JLabel value;
   private JButton minus;
   private Counter model;
   public View(Counter c,
               Controller controller){
   … }
   public void update(){
   … }
}
```



Visual Counter – View

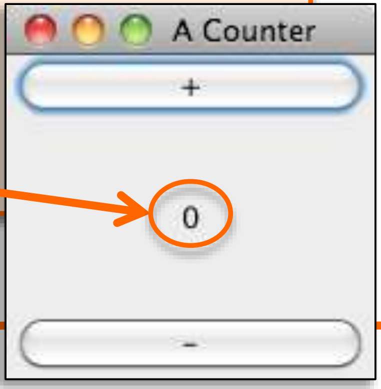
```
public class View extends JFrame {

public View(Counter c, Controller controller){

   setTitle("A Counter");
   setSize(150,150);
   setLayout(new BorderLayout());

   plus = new JButton("+");
   this.add(plus,BorderLayout.NORTH);

   minus = new JButton("-");
   this.add(minus,BorderLayout.SOUTH);

   value = new JLabel("?");
   value.setHorizontalAlignment(JLabel.CENTER);
   this.add(value,BorderLayout.CENTER);

   setVisible(true);
```



Visual Counter – View

```
   setDefaultCloseOperation(JFrame.DISPOSE_ON_CLOSE);
   model = c; // MODEL
   plus.addActionListener(controller);
   minus.addActionListener(controller);
   controller.setView(this); // CONTROLLER --> VIEW
   update();
}
public void update(){
   String v = Integer.toString(model.getValue());
   value.setText(v);
}
```

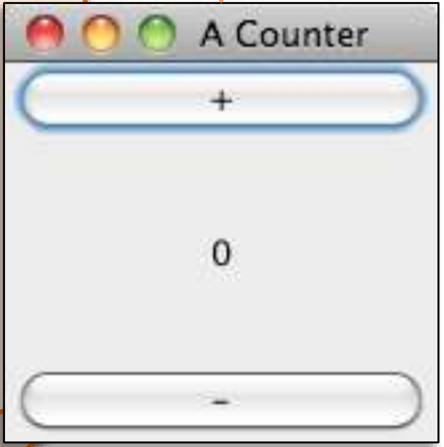
Model



Visual Counter – Controller

```
public class Controller
      implements ActionListener {
  private Counter model;
  private View view;

  public Controller(Counter m){ model = m; }

  public void actionPerformed(ActionEvent e){
    if(e.getActionCommand().equals("+")){
      model.increment();
    else
      model.decrement();
    view.update();
  }

  public void setView(View finestra) {
    view = finestra;
  }
}
```

Model



LAYOUT

Layout managers

- Determine the size and position of the components within a container
  - Manage resize of containers
  - Accounts for differences in OSs and font sizes
- **`setLayout(LayoutManager m);`**
- Absolute positioning is possible
  - **`setLayout(null);`**
  - **`setBounds()`** for each component

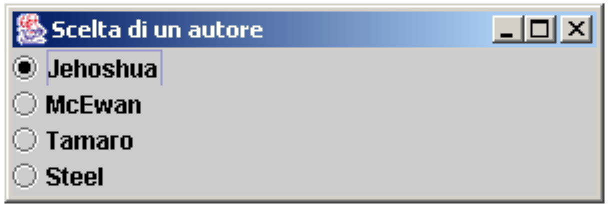
Flow Layout

- From left to right, starting from the left upper corner
- Constructors:
  - **`FlowLayout();`**
  - **`FlowLayout(int align);`**
  - **`FlowLayout(int align, int hgap, int vgap);`**
- Parameters:
  - **`align`**: Alignment of basis (**`FlowLayout.LEFT`**, **`FlowLayout.RIGHT`**, **`FlowLayout.CENTER`**)
  - **`hgap`**: Horizontal space between components (default: 3 px)
  - **`vgap`**: Vertical space between components (default: 3 px)

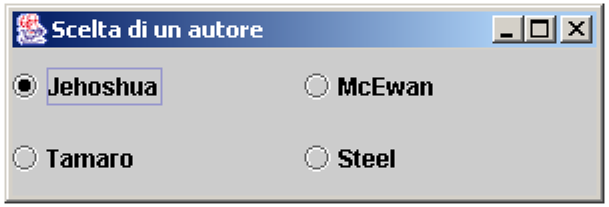
Grid Layout

- Splits the screen in a grid of rows and columns
- Filling: starts from the box in the top left and then by line
- Constructors:
  - **`GridLayout(int rows, int cols)`**
  - **`GridLayout(int rows,int cols,int hgap,int vgap)`**
- Parameters:
  - **`rows`**: number of row;
  - **`cols`**: number of columns;
  - **`hgap`**: Spacing (in pixels) between two horizontal boxes (default: 0 pixel)
  - **`vgap`**: spacing (in pixel) between two vertical boxes (default: 0 pixel)

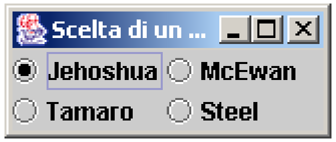
Example of GridLayout



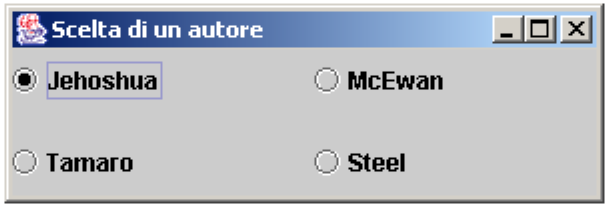
4 row, 1 columns:
distance 0



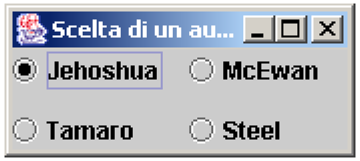
2 row, 2 columns:
distance 0 pixel



(Distanza min = 0)



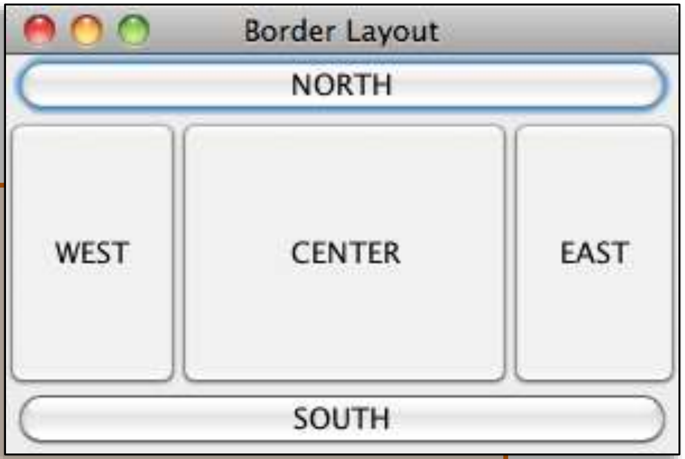
2 row, 2 columns:
distance 10 pixel



(Min distance = 10)

BorderLayout

- Divide the container into five areas
  - 4 in the border 1 in the center



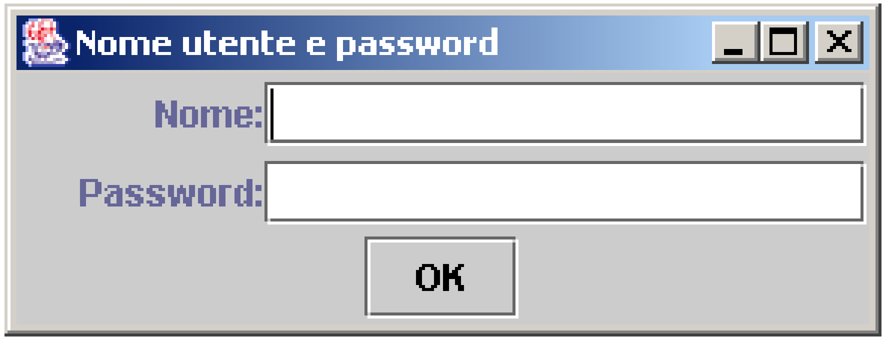
```
setLayout(new BorderLayout());
add("North",new JButton("NORTH"));
add("South",new JButton("SOUTH"));
add("East",new JButton("EAST"));
add(new JButton("WEST"),BorderLayout.WEST);
add(new JButton("CENTER"),BorderLayout.CENTER);
```

Grid bag layout

- Extension of the grid layout (GridLayout)
  - elements of the grid can be adjusted with mechanisms of personalization
- Usage procedure:
  - Create `GridBagLayout` object
  - Create ‘constraint’ object (`GridBagConstraints`)
  - For each component
    - Define the adjustment
    - Register the component-constraint link with the manager
  - Add the component to the container

Example

- What is the structure required to have a simple login window as: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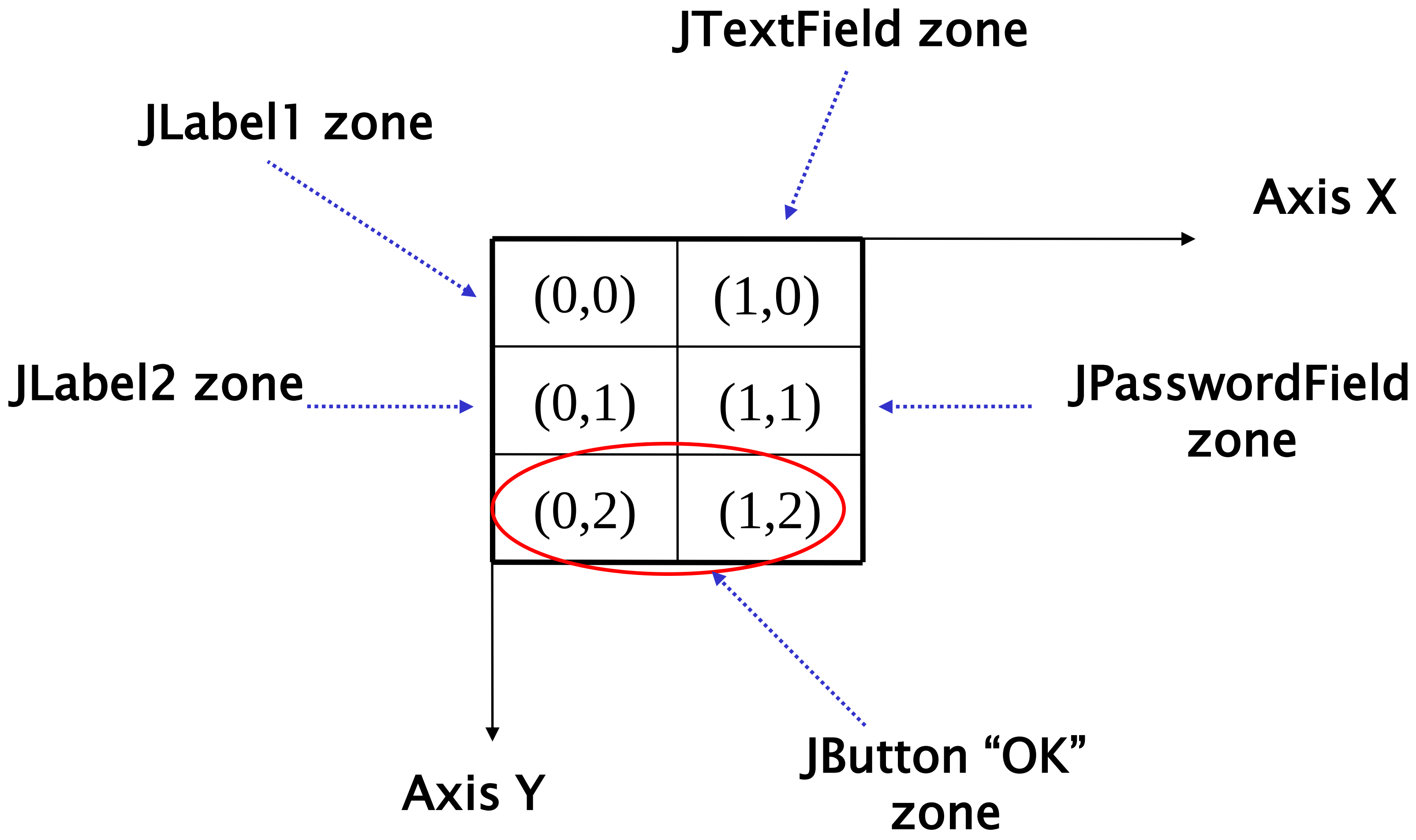
Nome:

Password:

OK

SoftEng http://softeng.polito.it

GridBagConstraints details



Rules expressed as constraints

- Components are placed in the cells at position (x, y)
- "OK" button must occupy two cells: the other components are in a single cell
- breadth of the components is variable (the label "name" occupies about 30% of line…)
- Cells are positioned (the "OK" button is centered, etc.)

Rules on `GridBagConstraints` (2)

- GridBagConstraints has different fields:
  - `gridx` – The initial gridx value.
  - `gridy` – The initial gridy value.
  - `gridwidth` – The initial gridwidth value.
  - `gridheight` – The initial gridheight value.
  - `weightx` – The initial weightx value.
  - `weighty` – The initial weighty value.
  - `anchor` – The initial anchor value.
  - `fill` – The initial fill value.
  - `insets` – The initial insets value.
  - `ipadx` – The initial ipadx value.
  - `ipady` – The initial ipady value.

Regolation on GridBagConstraints (3)

- The values of **`fill`** are : **`BOTH`**, **`NONE`**, **`HORIZONTAL`**, **`VERTICAL`**
- The values of **`anchor`** are: **`CENTER`**, **`NORTH`**, **`NORTHEAST`**, **`EAST`**, **`SOUTHEAST`**, **`SOUTH`**, SOUTHWEST, **`WEST`**, **`NORTHWEST`**
- Therefore…

```
GridBagLayout grid = new GridBagLayout();
pannel.setLayout(grid);
GridBagConstraints Gbc = new GridBagConstraints();
JLabel label1 = new JLabel (“Name:”, JLabel.LEFT);
Gbc.gridx = 0;
Gbc.gridy = 0;
Gbc.gridwidth = 1;
Gbc.gridheigth = 1;
Gbc.weightx = 30;
Gbc.weigthy = 40;
Gbc.fill = GridBagConstraints.NONE;
Gbc.anchor = GridBagConstraints.EAST;
grid.setConstraints(Gbc, label1);
pannello.add(label1);
```

Java Events

http://softeng.polito.it

Event Delegation Model

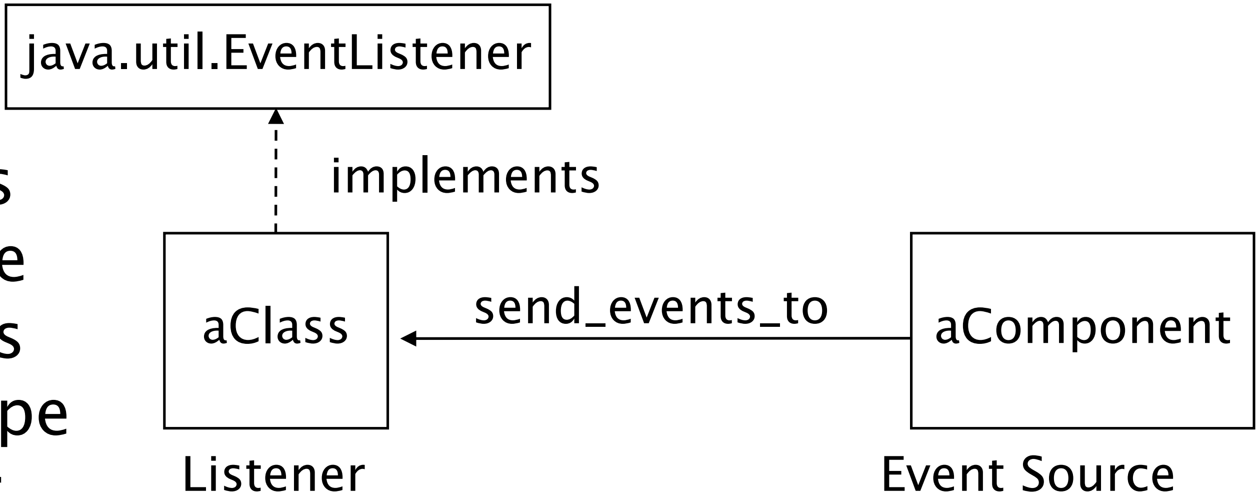
- Since Java1.1
  - Events are classified by type (MouseEvent, KeyEvent, etc.)
  - Events are generated in components sources
  - An object can be registered as handler (listener) of a type of event by sending a message to the component source

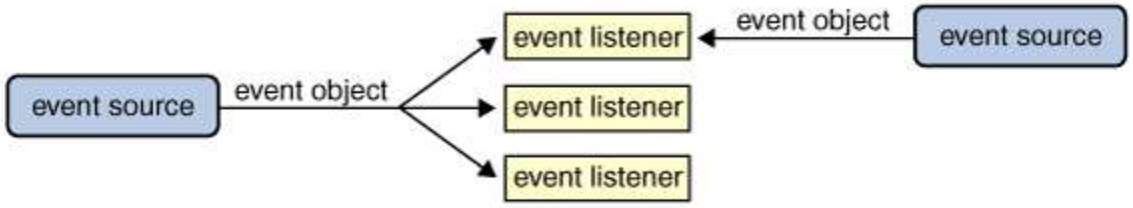
Event Delegation Model

- Whenever an event occurs, the AWT thread sends a message to all the registered listener objects (the event descriptor is passed as a parameter)
- A listener object must implement the appropriate interface (to make possible the call-back)

Event Delegation Model

Multiple listeners can register to be notified of events of a particular type from a particular source. Also, the same listener can listen to notifications from different objects.

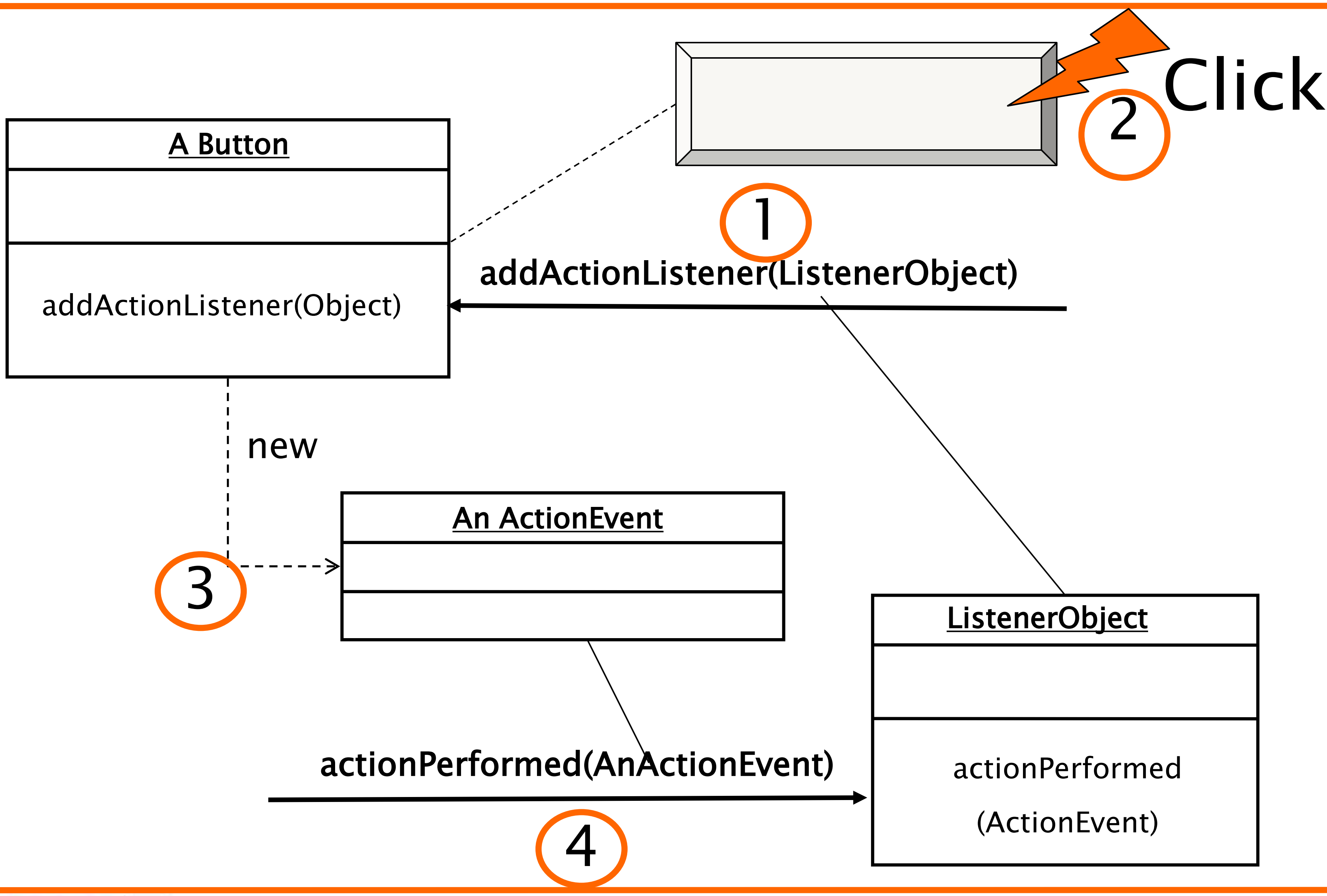




Events

- The events are represented by a hierarchy of classes. Each class is defined by the data representing that type of event.
- Some of the classes that are a set of events (MouseEvent) MAY CONTAIN AN ID that identifies the exact event type.

Example events


Click
2
1
A Button
addActionListener(Object)
addActionListener(ListenerObject)
new
3
An ActionEvent
ListenerObject
actionPerformed
(ActionEvent)
actionPerformed(AnActionEvent)
4

Management of the events

- Events covered in Java :
  - Action event → click a button
  - Adjustment event → actions on scroll bars
  - Focus event → point the mouse on a text field
  - Item event → click on RadioButton, CheckBoxButton
  - Key event → keyboard input
  - Mouse event → click (not covered above)
  - Mouse-motion event → Simple displacement of the mouse
  - Window event → Enlarge, close a window

Managing events

- The principle underlying the events is quite similar to the exceptions :
  - A class declares which event is able to deal with (one or more) → implements one or more interfaces
  - It joins the listener set of the components that are source of events (**`JButton`**, **`JTextField`**, etc..) →
    `aButton.addActionListener(controller)`
    - Pay attention! You're implementing interfaces, so you must overwrite all methods of those interfaces!

How to manage the events in Java

```
class FrameWithEvents extends JFrame implements
InterfaceWithEvents {
     JComponent componentSourceofEvents =
                                   new JComponent();
     componentSourceOfEvents.addListener(this);
     void methodOfTheInterfaceWithEvents() {…}
     void anotehrMethodOfTheInterfaceWithEvents() {…}
}//end class
```

Listener Interfaces (1)

- `ActionListener` → Methods to override :
  - `void actionPerformed (ActionEvent evt)`
- `FocusListener` → Methods to overwrite :
  - `void focusGained (FocusEvent evt)`
  - `void focusLost (FocusEvent evt)`
- `ItemListener` → Methods to rewrite :
  - `void itemStateChanged (ItemEvent e)`

Listener Interfaces (2)

- `MouseListener` Methods to override:
  - `void mouseClicked (MouseEvent evt)`
  - `void mouseEntered (MouseEvent evt)`
  - `void mouseExited (MouseEvent evt)`
  - `void mousePressed (MouseEvent evt)`
  - `void mouseReleased (MouseEvent evt)`
- `MouseMotionListener` Methods to overrid:
  - `void mouseDragged (MouseEvent evt)`
  - `void mouseMoved (MouseEvent evt)`

Listener Interfaces (3)

- **`KeyListener`** Methods to override:
  - `void keyPressed (KeyEvent evt)`
  - `void keyReleased(KeyEvent evt)`
  - `void keyTyped(KeyEvent evt)`
- **`WindowListener`** (Methods to override:
  - `void windowActivated(WindowEvent evt)`
  - `void windowClosed (WindowEvent evt)`
  - `void windowClosing (WindowEvent evt)`
  - `void windowDeactivated (WindowEvent evt)`
  - `void windowDeiconified (WindowEvent evt)`
  - `void windowIconified (WindowEvent evt)`
  - `void windowOpened (WindowEvent evt)`

Add a listener

- Separate controller object

```
button.addActionListener( controller );
```

- Lambda expression relaying call

```
button.addActionListener( e -> doClick());
```

- The container itself (e.g. JFrame)

```
button.addActionListener( this );
```

Handle the event

- Identify the source of events
  - May be implicit in the anonym dispatcher

```
Object ob = evt.getSource();
if (ob == button ){
  // perform event handling
}
```

Note: == reference comparison

- Use event additional information
  - E.g. mouse position

Handle the event

- All methods accept an event as argument
  - The argument (KeyEvent, MouseEvent, etc.) provides methods to get information about the event:
- Examples
  - ActionListener
    - **`String getActionCommand()`**: returns a string identifying the component which generated the command
    - **`String paramString()`**: returns a string describing the event type (common to all event objects)

Event methods

- **`ItemEvent`**:
  - int **`getStateChange`**(): return SELECTED or DESELECTED on whether the RadioButton or the CheckBox is turned or less
- **`KeyEvent`**:
  - char **`getKeyChar`**(): returns the character typed
  - int **`getKeyCode`**(): returns the code of the key pressed o released

GUI TESTING

GUI testing

- To execute a test of a GUI there are two possible approaches:
  - Test from outside
  - Test from within

Test from outside

- Test from outside
  - Through the Operating System events are sent to the application emulating the user behavior
  - Pro: realistic approach
  - Cont: complex, OS dependent
  - There are specific tools that are able to capture operations performed by a user and to replay them later

Test from within

- Test from within
  - Specific methods can be invoked on graphical component to achieve a similar effect to that of a real usage (e.g. doClick() on a button)
  - Pro: simple, OS independent
  - Con: not realistic, not full interaction
  - Con: classes must be designed for testability
    - E.g. let selected attribute visible

GUI Test – Example

```
public void testGUI(){
  SimpleCassa gui = new SimpleCassa();
  gui.setVisible(true);

  gui.input.setText("P001");
  gui.pulsante.doClick();
  gui.input.setText("P002");
  gui.pulsante.doClick();
  gui.input.setText("P001");
  gui.pulsante.doClick();

  gui.input.setText("CLOSE");
  gui.pulsante.doClick();

  String output = gui.output.getText();

  assertTrue("wrong output",
             output.indexOf(”Sum: 7.5")>-1);

}
```

GRAPHICS

Direct drawing

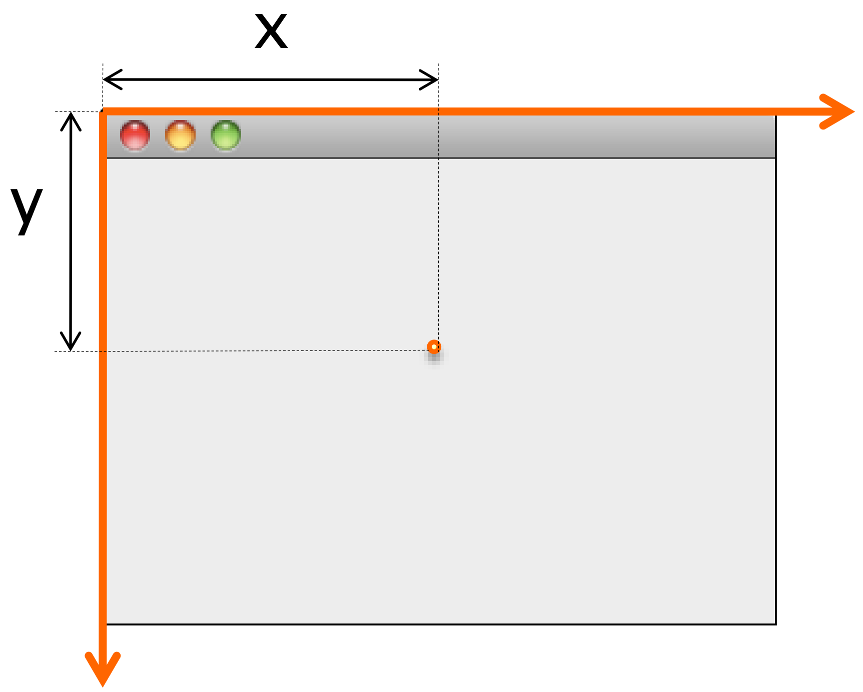
- Two elements are required to draw directly :
  - Method **`void paint(Graphics g)`**
    - Must be redefined in derived classes
    - Invoked by O.S.
  - Class **`Graphics`**
    - Provides methods to draw

Class Graphics

- Is the class that supports the capacity graphics applications, which draw lines, forms, characters and present images on screen, by means of a series of methods .
- The method **`paint()`** provides an object graphics acting on which draws on the screen.
  - It isn’t necessary to create an instance of the class graphics to draw on the screen

Class Graphics

- The coordinate system:
  - Origin in the top left corner
  - X increase moving to the right
  - Y increase moving downwards

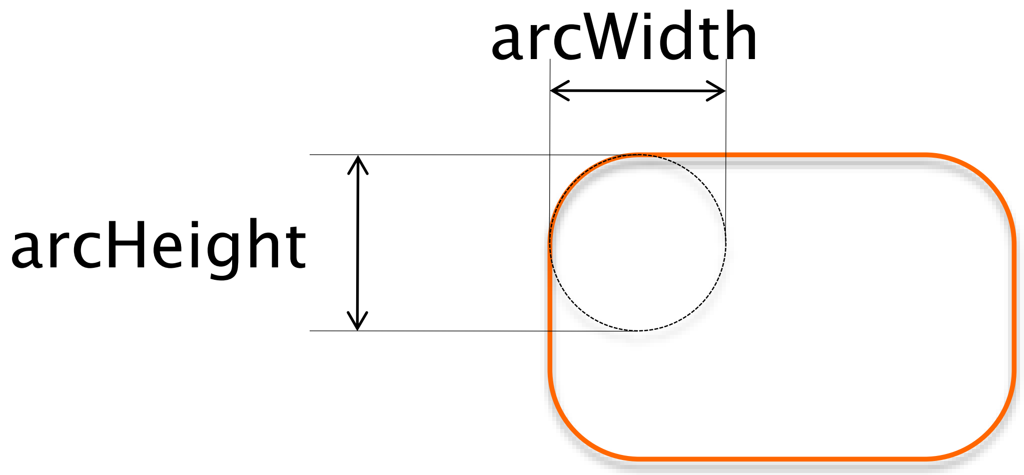


Graphics methods: lines

- **`drawLine(x1,y1,x2,y2)`**
  - Draw a line between two points
- **`drawRect(x,y,width,height)`**
  - Draw a rectangle (x,y) is upper left corner
  - Size is defined by width and height
- **`fillRect()`**
  - Same as above but rectangle is solid filled

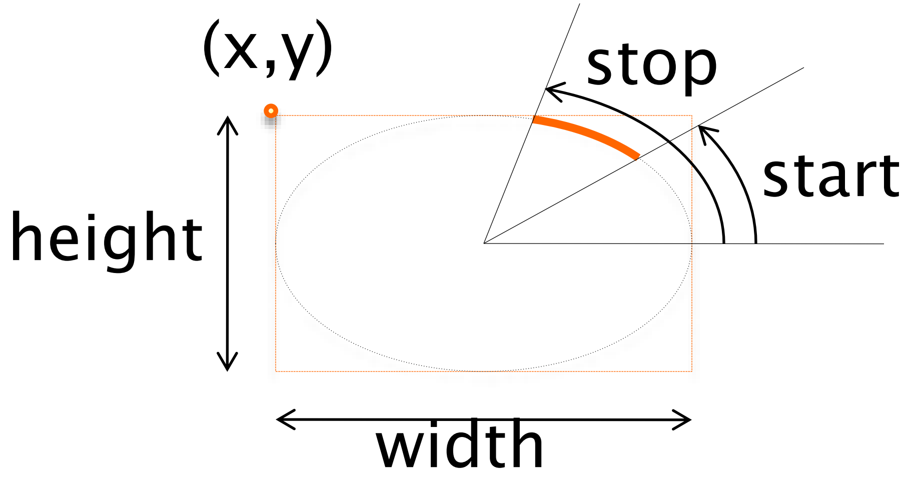
Graphics methods: rectangles

- **`drawRoundRect(x, y, width, height, arcWidth, arcHeight)`**
  - Draw a rectangle with rounded angles
- **`fillRoundRect(x, y, width, height, arcWidth, arcHeight)`**
  - Same as above but with solid filled shape



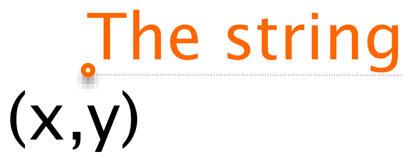
Graphics methods: ellipses

- **`drawOval(x,y,width,height)`**
  - Draw an ellipse inscribed in a rectangle located at (x,y) with the given size
- **`drawArc(x,y,width,height,start,stop)`**
  - Draw an arc of an ellipse starting at *start* degrees and stopping at *stop* degrees
- Also available:
  - **`fillOval()`**
  - **`fillArc()`**



Graphics methods: strings

- **`drawString(str,x,y)`**
  - Draw a string starting at point (x,y)
- **`drawChars(chars, offset, length, x, y)`**
  - Draw a char array starting at point (x,y)
  - Offset is the first char to draw
  - Length is the number of chars to draw



Draw lines and squares

- To draw a line

```
g.drawLine(25, 25, 75, 75);
```

- To Draw a rectangle, specifying the coordinated point in the top left, width and length:

```
g.drawRect(20, 20, 60, 60);
g.fillRect(120, 20, 60, 60);
```

- To Draw a rectangle, specifying the coordinated point in the top left, width and length:

```
g.drawRoundRect(20,20, 60,60, 10,10);
g.fillRoundRect(120,20, 60,60, 20,20);
```

Draw polygons

- A polygon requires a set of points defined as two x and y arrays:

```
int x[ ] = {39,94,97,142,53,58, 26};
int y[ ] = {33,74,36,70,108,80, 106};
int points = x.length;
g.drawPolygon(x,y,points);
```

- ..or as instances of the class polygon:

```
Polygon poly = new Polygon(x,y,points);
g.fillPolygon(poly);
```

- The polygon is closed automatically
  `drawPolyline()` allows to have open polygons.

Draw ellipses and arcs

- To draw circles or ellipses using the oval .

```
g.drawOval(20, 20, 60, 60);
g.fillOval(120, 20, 100, 60);
```

- Arcs are defined as pieces of ellipses with the method drawArc()
    - An ellipsis must be defined plus the starting and ending angles. Which are defined counterclockwise (90 vertical axis).

```
g.drawArc(20, 20, 60, 60, 90, 180);
g.fillArc(120, 20, 60, 60, 90, 180);
```

Draw strings

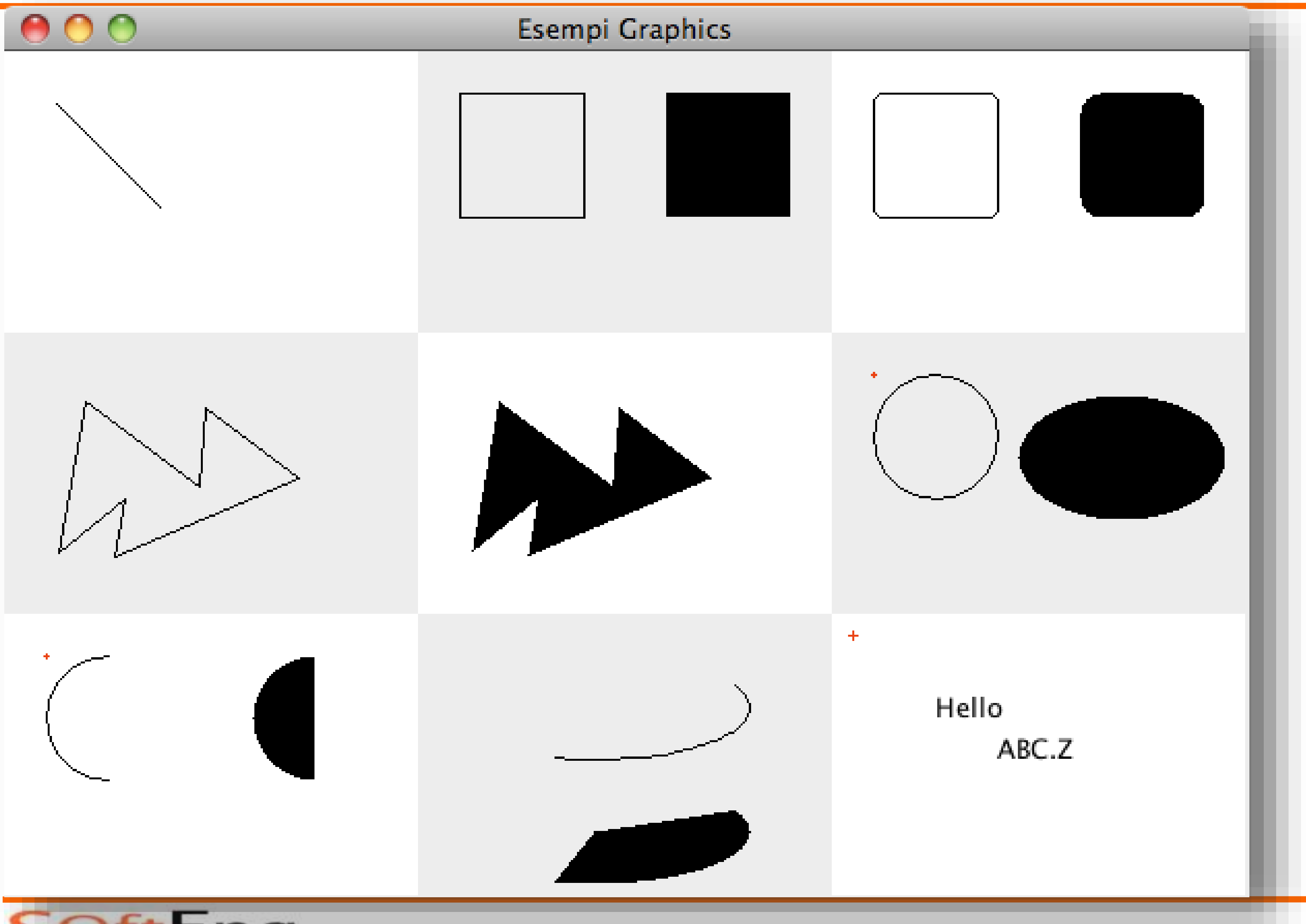
- To draw strings use:

```
g.drawString("Hello", 50, 50);
```

- ..or draw an array of chars:

```
char[] chars = new
char[]{'A','B','C','.','Z'};
g.drawChars(chars,0,chars.length,80,70);
```

Examples



Repaint

- Method **`paint()`** is invoked by OS when needed
  - E.g. window resize, de-iconify
- Method **`repaint()`** signals that window contents must be updated
  - Later OS will invoke paint()
- This method is essential to update the view when something is changed

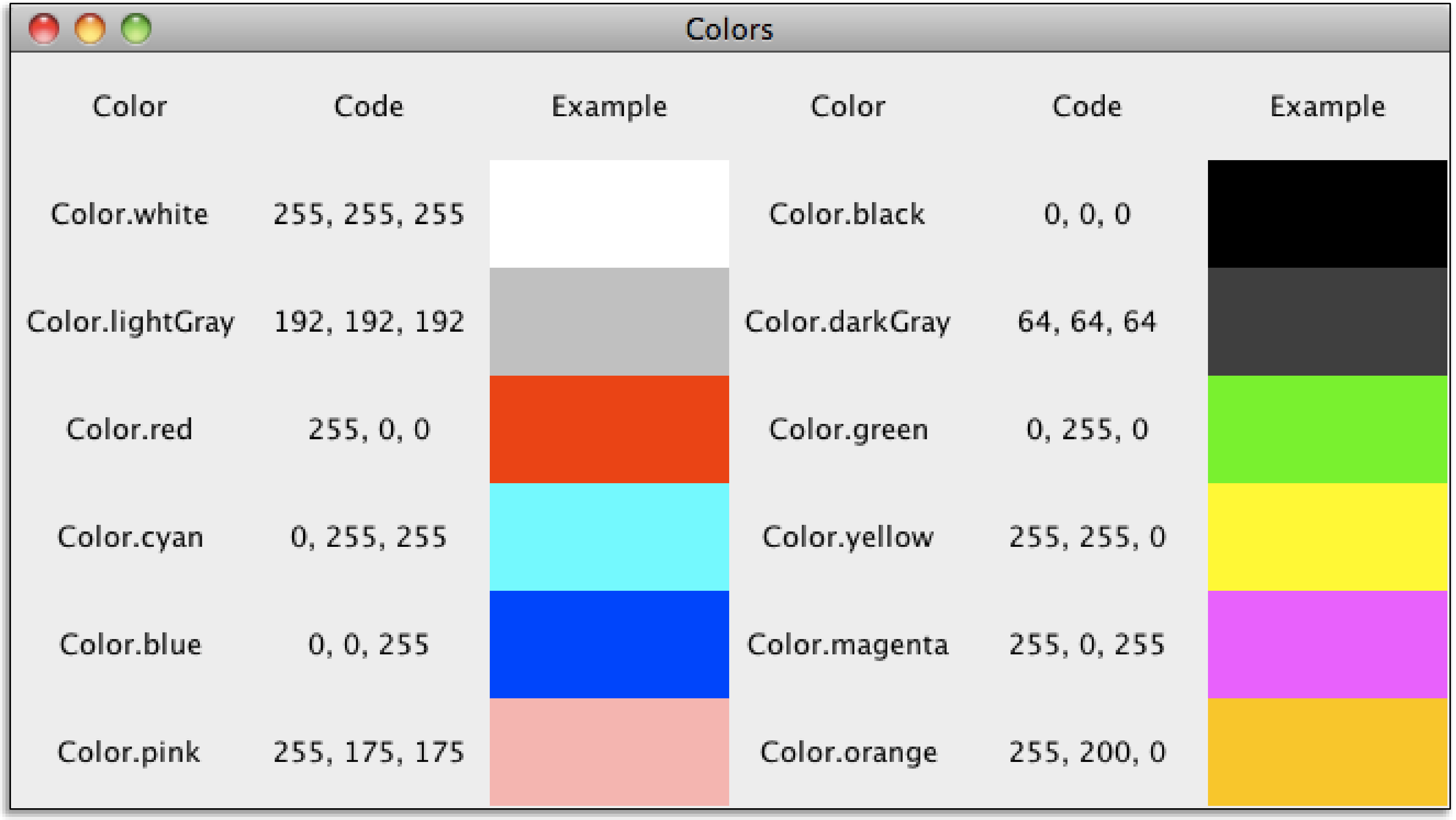
Color management

- The management of colors is performed through class Color.
  - Colors are encoded on 24 bit; each color and consists of a combination of red, green and blue .
  - Each component is represented with a whole number between 0 and 255.
- There are class constants defined for the main colors.

Color management

- For windows (JFrame):
  - **`setBackground(Color c)`**
    - Sets the window internal background
  - **`setForeground(Color c)`**
    - Sets the components foreground color
- For Graphics:
  - **`setColor(Color c)`**
    - Sets the color for all the successive drawing operations

Color management



Color	Code	Example	Color	Code	Example
Color.white	255, 255, 255	⬜	Color.black	0, 0, 0	⬛
Color.lightGray	192, 192, 192	⬜	Color.darkGray	64, 64, 64	⬛
Color.red	255, 0, 0	🟥	Color.green	0, 255, 0	🟩
Color.cyan	0, 255, 255	🟦	Color.yellow	255, 255, 0	🟨
Color.blue	0, 0, 255	🟦	Color.magenta	255, 0, 255	🟪
Color.pink	255, 175, 175	🟥	Color.orange	255, 200, 0	🟧

Font management

- Fonts are represented by class Font
- Constructor

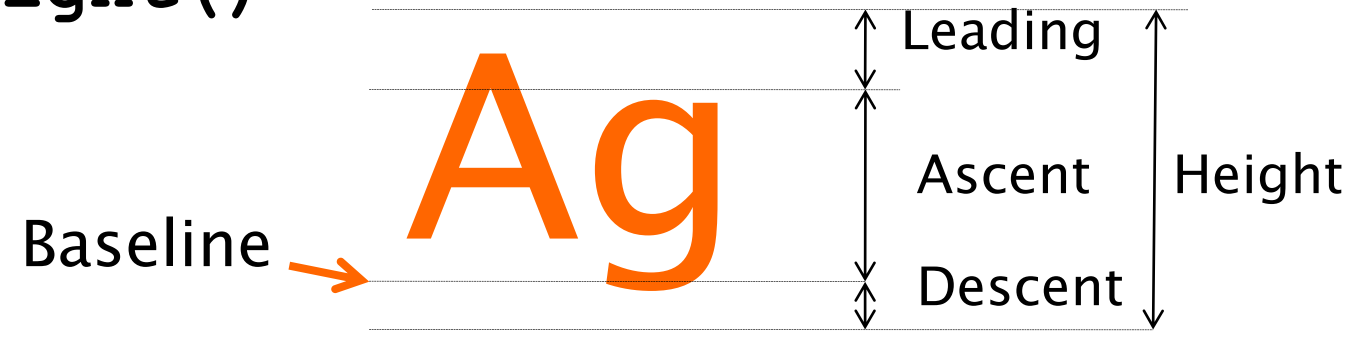
  `Font(String face, int attrs, int size)`
- Parameters
  - Face is the name of the font e.g. “TimesRoman”
  - Attrs represent attributes e.g. Font.BOLD
  - Size is expressed in points

Font management

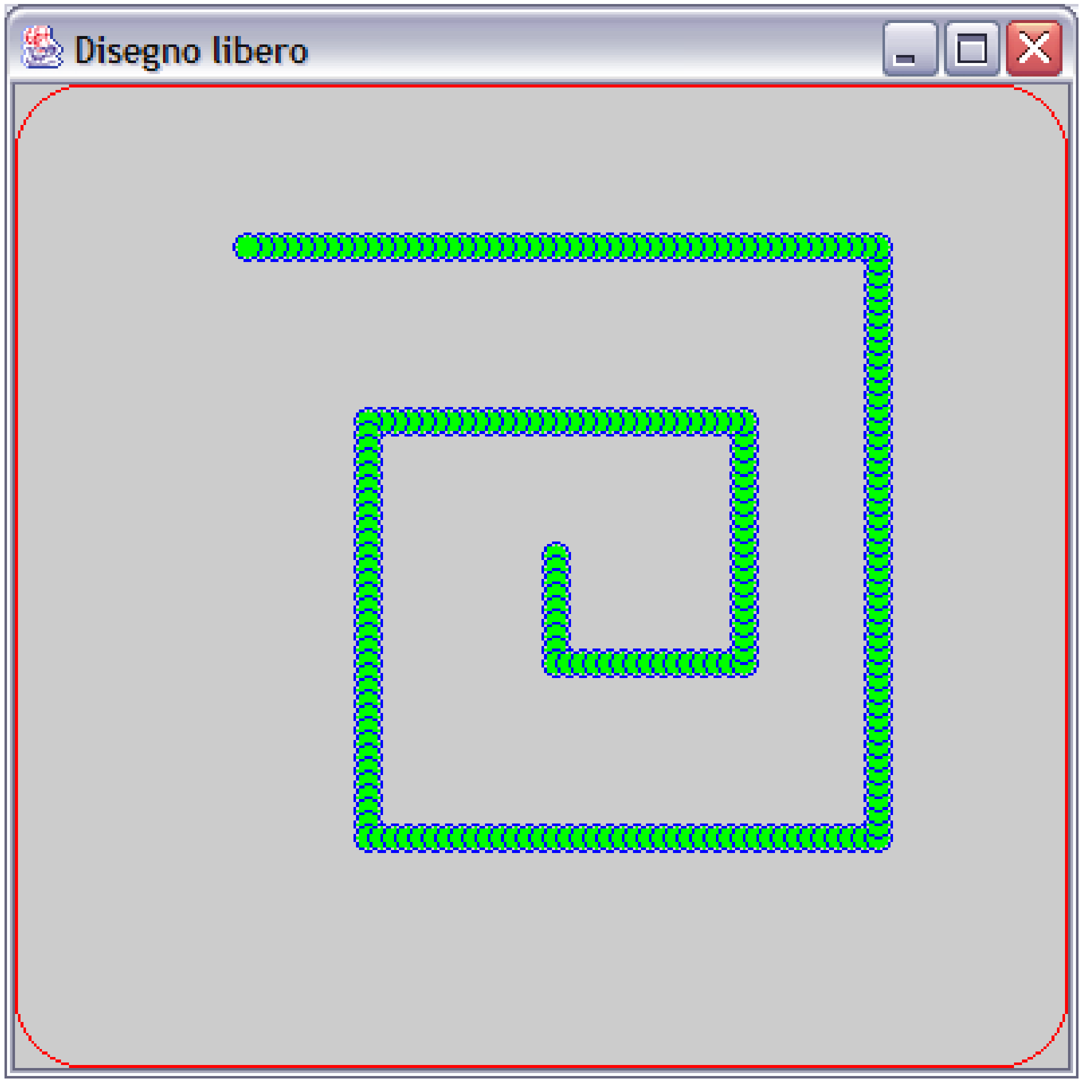
- To get information about a font:
  - **`getFont()`**: returns the current font
  - **`getName()`**: returns font name
  - **`getSize()`**: returns the font size
  - **`getStyle()`**:, Return the style of font
  - **`isPlain()`**, **`isBold()`** , **`isItalic()`**: return the font modifications
- For more information more specific on the individual font use the class **`FontMetrics`**.

FontMetrics

- Main methods are:
  - **`stringWidth()`**: width in pixels of a given string
  - **`charWidth()`**: amplitude of a char
  - **`getAscent()`**
  - **`getDescent()`**
  - **`getLeading()`**
  - **`getHeight()`**



Example



Example

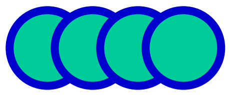
```
public class Drawing extends JFrame{
  int x;
  int y;
  public void paint(Graphics g){
   Rectangle b = getBounds();
   g.setColor(Color.RED);
   g.drawRoundRect(4,30,
      b.width-9,b.height-35,50,50);
   g.setColor(Color.BLUE);
   g.drawOval(x,y,10,10);
   g.setColor(Color.GREEN);
   g.fillOval(x+1,y+1,9,9);
  }
}
```

g covers the full window area, including borders

Events

```
public class Drawing implements KeyListener{
  public void keyPressed(KeyEvent e) {
   if(e.getKeyCode()==KeyEvent.VK_DOWN){
      moveXY(0,5);
   }
   // …
  }
  void moveXY(int deltaX, int deltaY){
   x+=deltaX;
   y+=deltaY;
   this.repaint();
  }
}
```

Considerations

- The repaint operation does not erase the window
  - Therefore we have the trail effect 
- We need to explicitly erase the content of the window:

```
Rectangle bounds = getBounds();
g.clearRect(0,0,bds.width,bounds.height);
```

Advices

- Define a method paint on an empty (e.g. without borders) compoment
- DO NOT override method **`paint()`** on a frame containing components
- Usually a **`JPanel`** is a good candidate to override method **`paint()`**

Summary

- GUI can be build using the MVC pattern:
  - Model: hosts the data
  - View: show the data
  - Controller: manages the interaction
- The view can be build using different libraries:
  - AWT
  - Swing
  - JavaFX

Summary

- In Swing the main elements are
  - JFrame that represent the view container
  - JComponent is the root class of all controls:
    - JButton
    - JLabel
    - JTextField
    - JPanel
    - …

Summary

- The interaction takes place when an event is generated and managed by the appropriate listener
  - A listener must be registered for a component and a specific event category
  - When the event is generated the appropriate method of the listener is called back
  - The method can handle the event as required