OBJECT-ORIENTED LANGUAGE AND THEORY

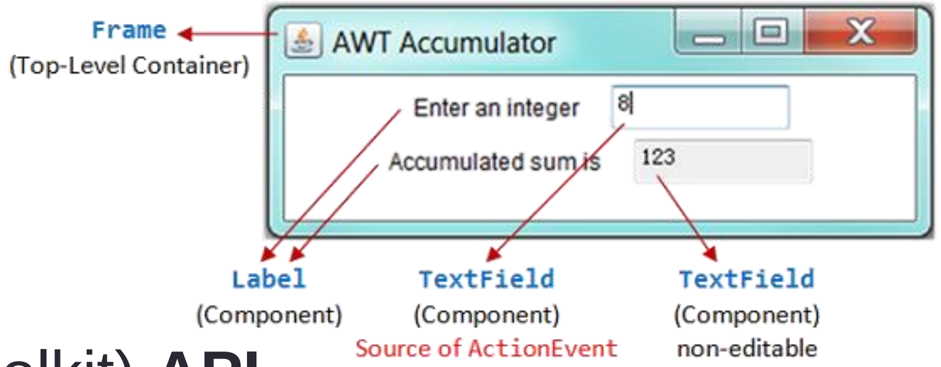
9. GUI PROGRAMMING

Nguyen Thi Thu Trang

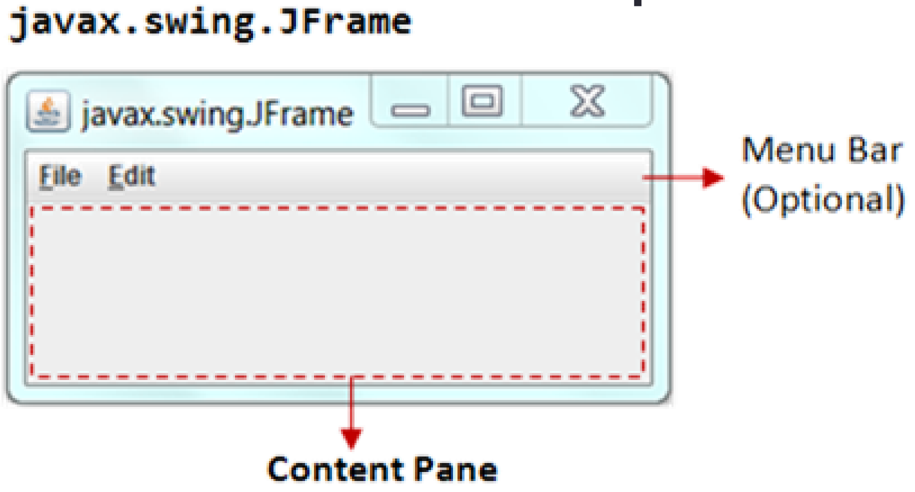
trangntt@soict.hust.edu.vn

Outline

AWT and Swing



- **AWT** (<u>A</u>bstract <u>W</u>indowing <u>T</u>oolkit) **API**
  - From JDK 1.0
  - Most components have **become obsolete** and should be **replaced by Swing** components

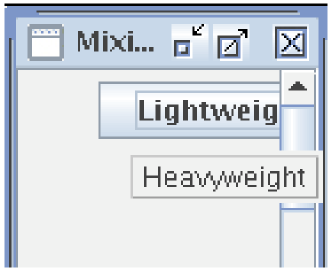


- **Swing** API
  - From JDK 1.1, as a part of **Java Foundation Classes (JFC)**
  - A much more comprehensive set of graphics libraries that enhances the AWT
    - JFC consists of **Swing**, *Java2D, Accessibility*, *Internationalization, and Pluggable Look-and-Feel Support APIs.*

JavaFX

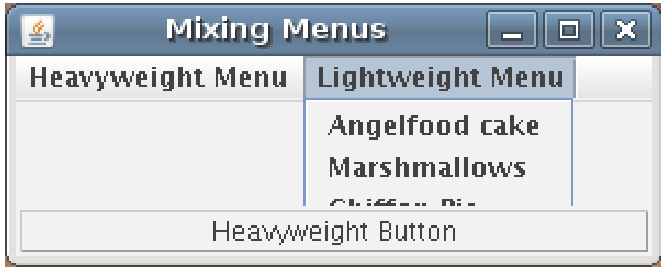
- **JavaFX** is a software platform for creating and delivering desktop applications, as well as **rich internet applications** (RIAs) that can run across a wide variety of devices.
- **JavaFX** is intended to replace **Swing** as the standard ***GUI library*** *for* ***Java SE***, but both will be included for the foreseeable future.

*IFX is just a name, which is normally related with `sound or visual effects` in the **javafx** i was in the belief that the **fx** was function. ...*
*FIPS **stands** for the Federal Information Processing Standardization*



Which should we choose?

- **AWT**: for simple GUI, but not for comprehensive ones
  - Native OS GUI
  - Flatform-independent
    and device-independent interface
  - Heavyweight components



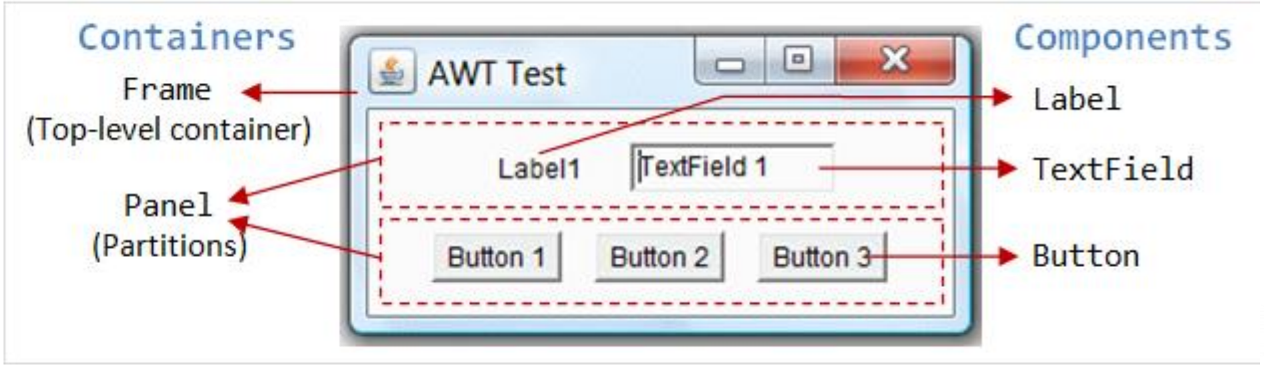
- **Swing**: Pure Java code with a more robust, versatile, and flexible library
  - Use AWT for windows and event handling
  - Pure-Java GUI, 100% portable and same across platform
  - Most components are light-weight, different look-and-feel
- **JavaFX:** for developing rich Internet applications
  - Can run across a wide variety of devices
  - More consistent in style and has additional options, e.g. 3D, chart, audio, video…

Outline

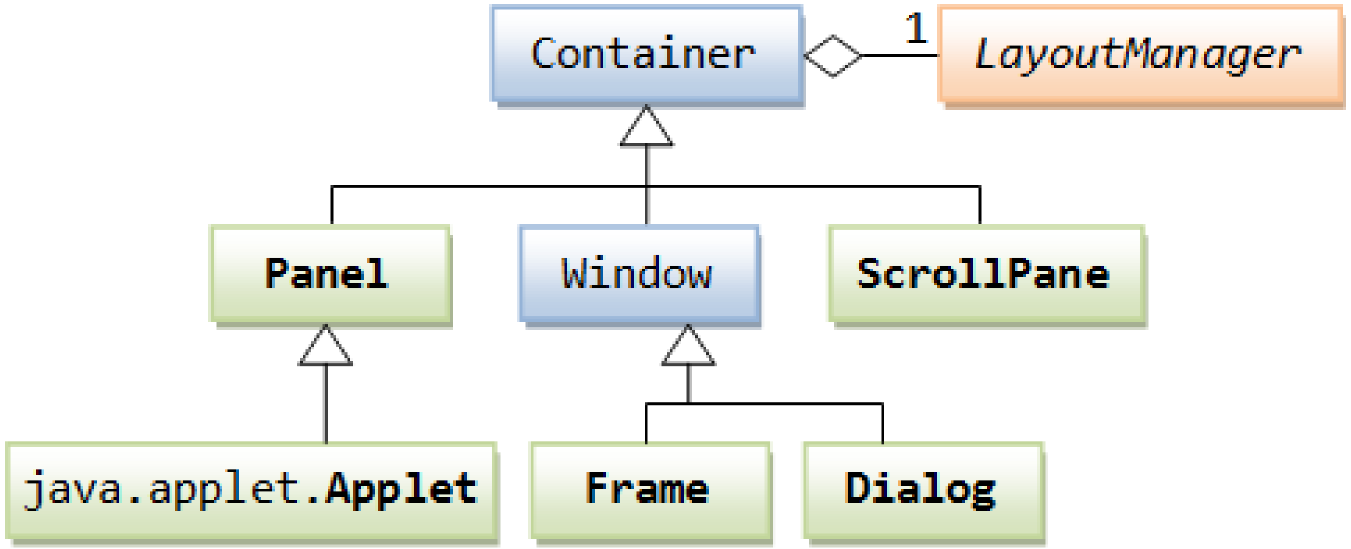
1. GUI Programming in Java
2. AWT
3. Swing
4. JavaFX

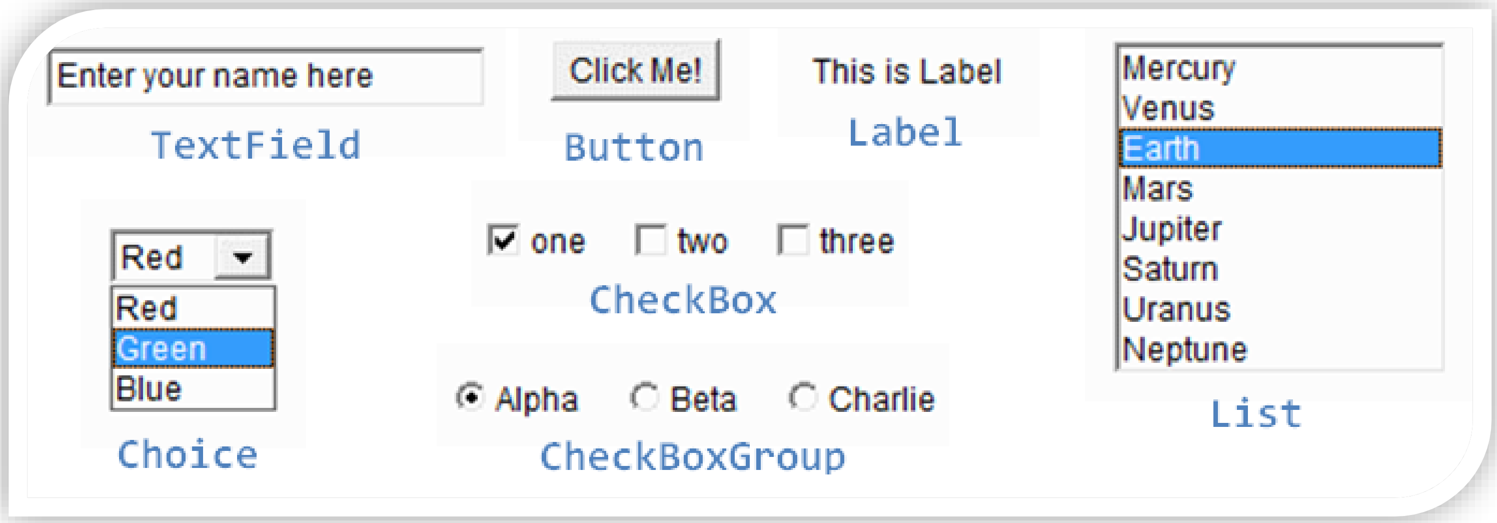
AWT Containers and Components

- There are **two types of GUI elements**:
  - ***Component***: Components are elementary GUI entities (e.g. Button, Label, and TextField.)
  - ***Container***: Containers (e.g. Frame, Panel and Applet) are used to *hold components in a specific layout* (such as flow or grid). A container can also hold sub-containers.
  - **GUI components are also called *controls* (Microsoft ActiveX Control), *widgets* (Eclipse's Standard Widget Toolkit, Google Web Toolkit)**, which allow users to interact with the application through these components (*such as button-click and text-entry).*

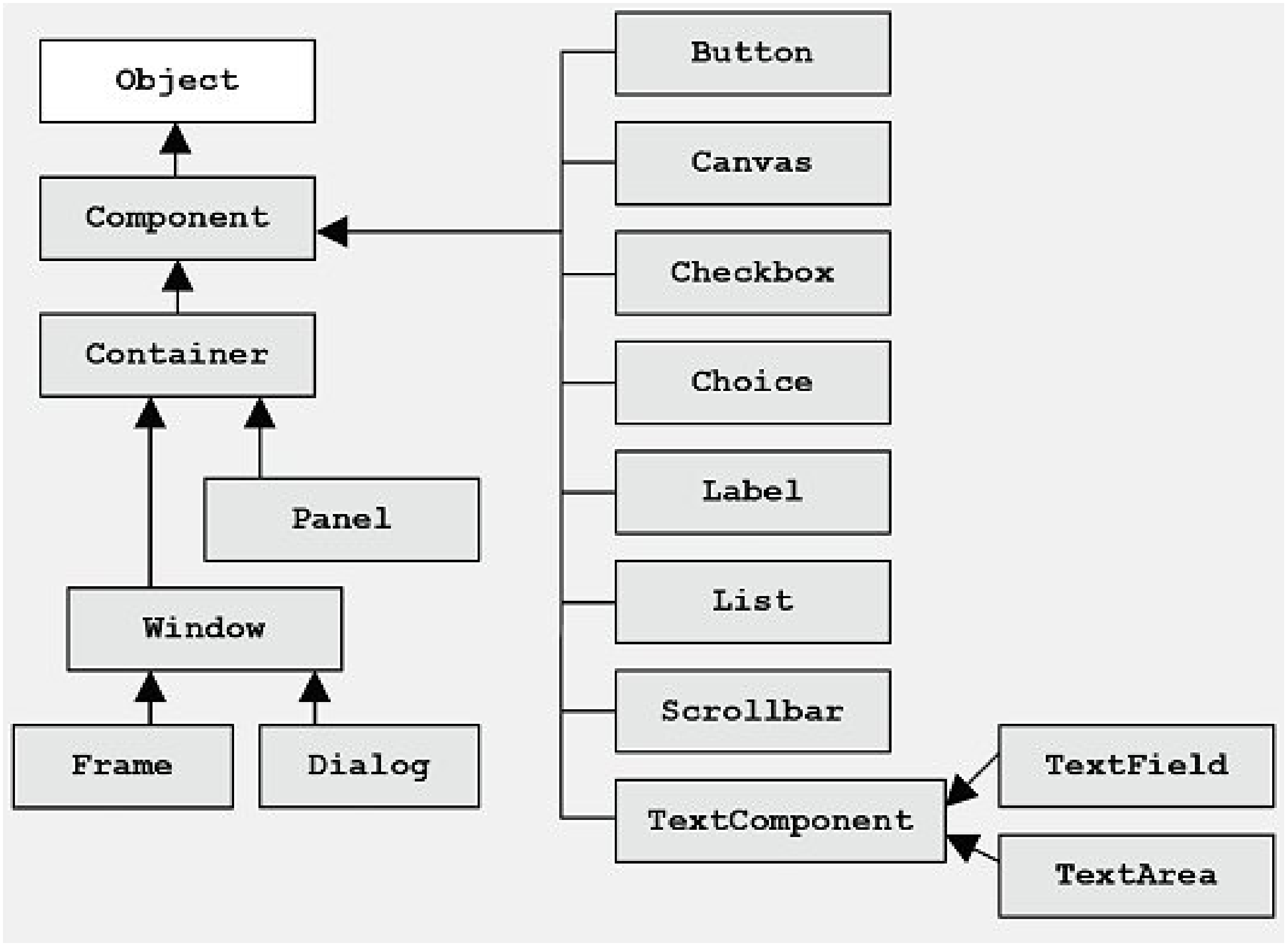


Hierarchy of the AWT Container Classes





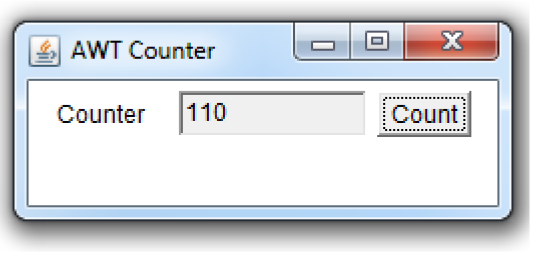
AWT Component Classes

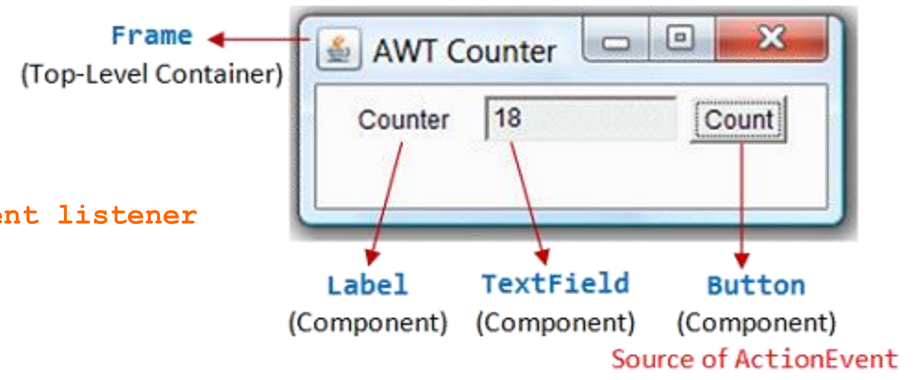


Example: AWT Counter

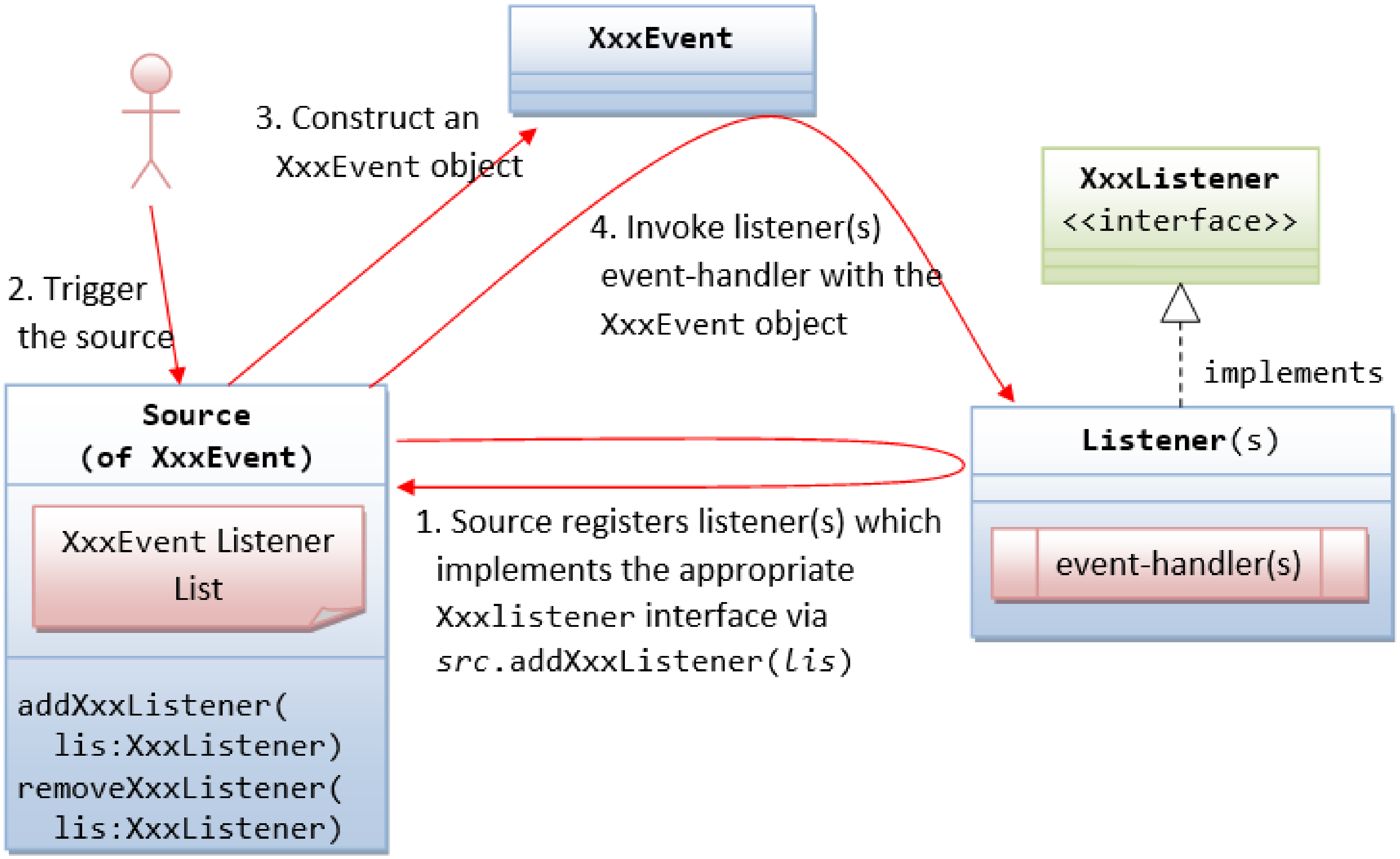
```java
import java.awt.Button;
import java.awt.Frame;
import java.awt.Label;
import java.awt.TextField;
import java.awt.event.ActionListener;

public class AWTCounter
                    extends Frame implements ActionListener {
  private Label lblCount;
  private TextField tfCount;
  private Button btnCount;
  private int count = 0;    // Counter's value

  // Constructor to setup GUI components and event handling

   public AWTCounter () {
        setLayout(new FlowLayout());

        lblCount = new Label("Counter");
        add(lblCount);

        tfCount = new TextField("0", 10);
        tfCount.setEditable(false); // set to read-only
        add(tfCount);

        btnCount = new Button("Count");
        add(btnCount);

        btnCount.addActionListener(this);
        //Clicking Button source fires ActionEvent
       //btnCount registers this instance as ActionEvent listener

        setTitle("AWT Counter");
        setSize(250, 100);

        setVisible(true);
 }
```

```java
/** The entry main() method */
  public static void main(String[] args) {
    // Invoke the constructor to setup the GUI, by allocating an instance
    AWTCounter app = new AWTCounter();
  }
  /** ActionEvent handler - Called back upon button-click. */
  public void actionPerformed(ActionEvent evt) {
    ++count; // increase the counter value
    // Display the counter value on the TextField tfCount
    tfCount.setText(count + ""); // convert int to String
  }
}
```





AWT Event Handling
Event Driven / Event Delegation


XxxEvent
3. Construct an XxxEvent object
2. Trigger the source
4. Invoke listener(s) event-handler with the XxxEvent object
XxxListener
<<interface>>
implements
Source
(of XxxEvent)
XxxEvent Listener List
addXxxListener(
lis:XxxListener)
removeXxxListener(
lis:XxxListener)
Listener(s)
event-handler(s)
1. Source registers listener(s) which implements the appropriate Xxxlistener interface via *src*.addXxxListener(*lis*)

E.g. MouseListener (XxxListener) interface

```
//A MouseListener interface, which declares the signature of the handlers
//for the various operational modes.
public interface MouseListener {
    // Called back upon mouse-button pressed
    public void mousePressed(MouseEvent evt);
    // Called back upon mouse-button released
    public void mouseReleased(MouseEvent evt);
    // Called back upon mouse-button clicked (pressed and released)
    public void mouseClicked(MouseEvent evt);
    // Called back when mouse pointer entered the component
    public void mouseEntered(MouseEvent evt);
    // Called back when mouse pointer exited the component
    public void mouseExited(MouseEvent evt);
}
```

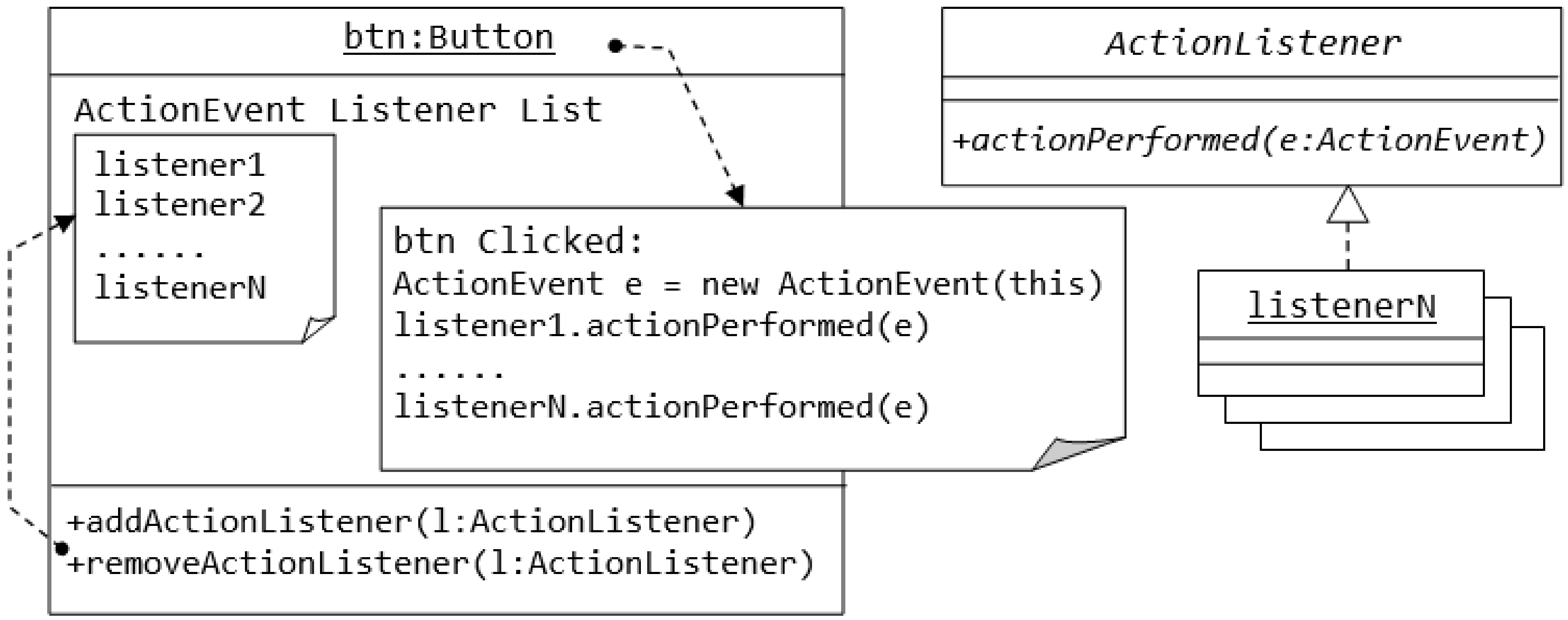
Add or remove XxxListener in the source:

```
public void addXxxListener(XxxListener lis);
public void removeXxxListener(XxxListener lis);
```

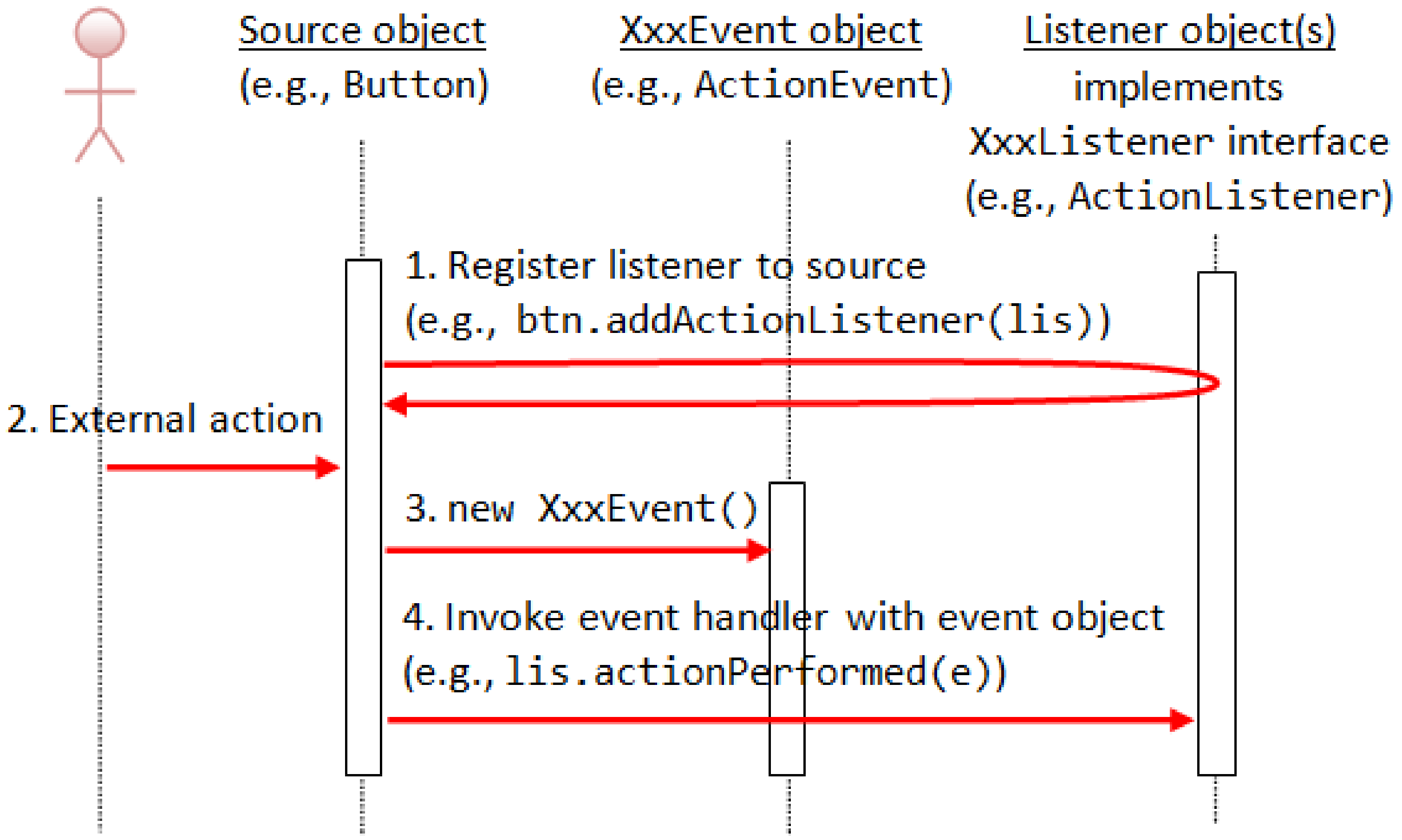
//An example provides implementation to the event handler methods

```
class MouseDemo implements MouseListener {
  private Button btn;
  public MouseDemo(){
              //...
              btn.addMouseListener(this);
  }
_ @Override
_ public void mousePressed(MouseEvent e)  {
___ System.out.println("Mouse-button pressed!");
  }
  @Override
  public void mouseReleased(MouseEvent e) {
___ System.out.println("Mouse-button released!");
  }
  @Override
_ public void mouseClicked(MouseEvent e)  {
___ System.out.println("Mouse-button clicked (pressed and released)!");
  }
  @Override
  public void mouseEntered(MouseEvent e)  {
___ System.out.println("Mouse-pointer entered the source component!");
  }
  @Override
  public void mouseExited(MouseEvent e)   {
___ System.out.println("Mouse exited-pointer the source component!");
  }
}
```

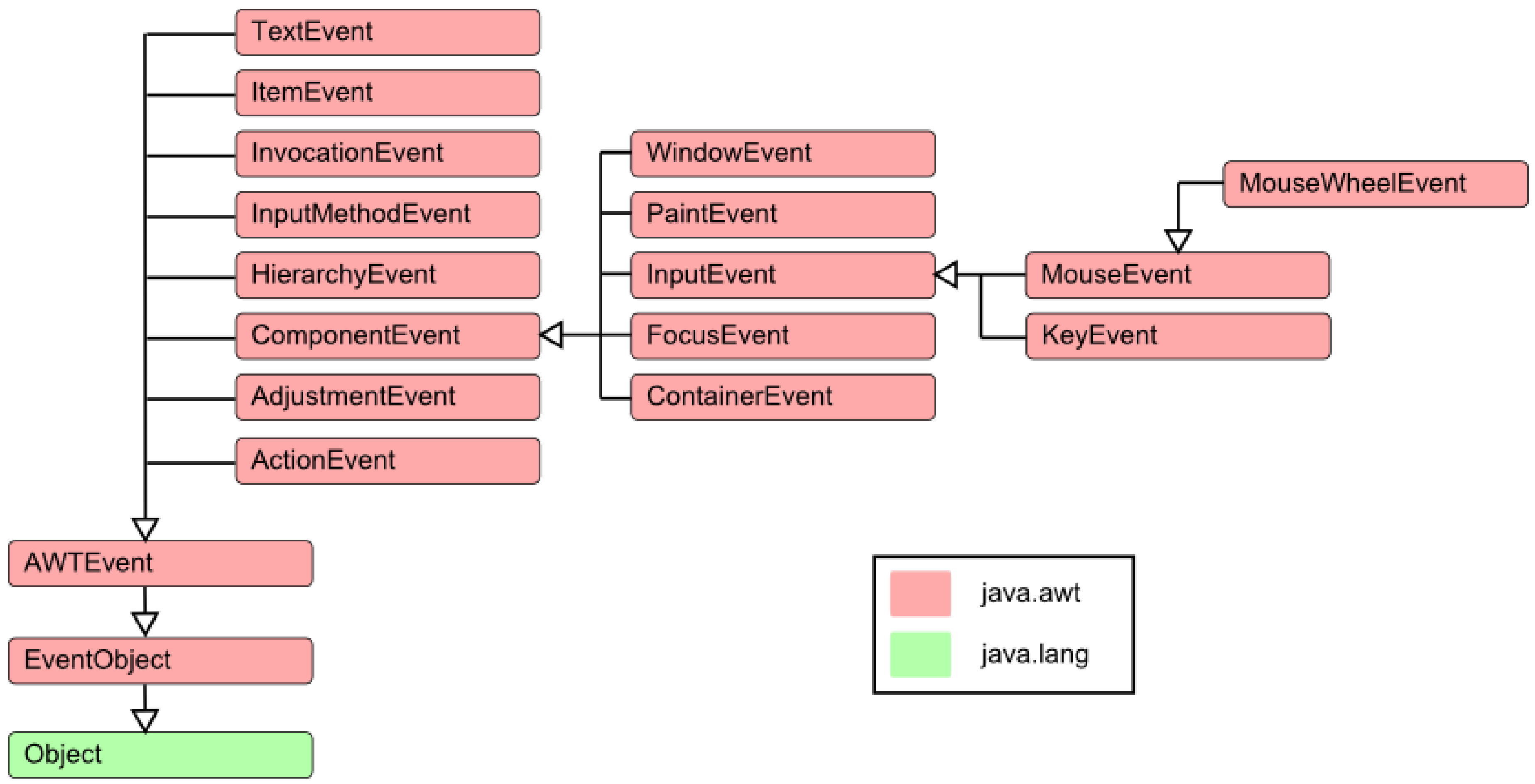
Revisit AWTCounter example


btn:Button
ActionEvent Listener List
listener1
listener2
......
listenerN
btn Clicked:
ActionEvent e = new ActionEvent(this)
listener1.actionPerformed(e)
......
listenerN.actionPerformed(e)
+addActionListener(l:ActionListener)
+removeActionListener(l:ActionListener)
ActionListener
+actionPerformed(e:ActionEvent)
listenerN

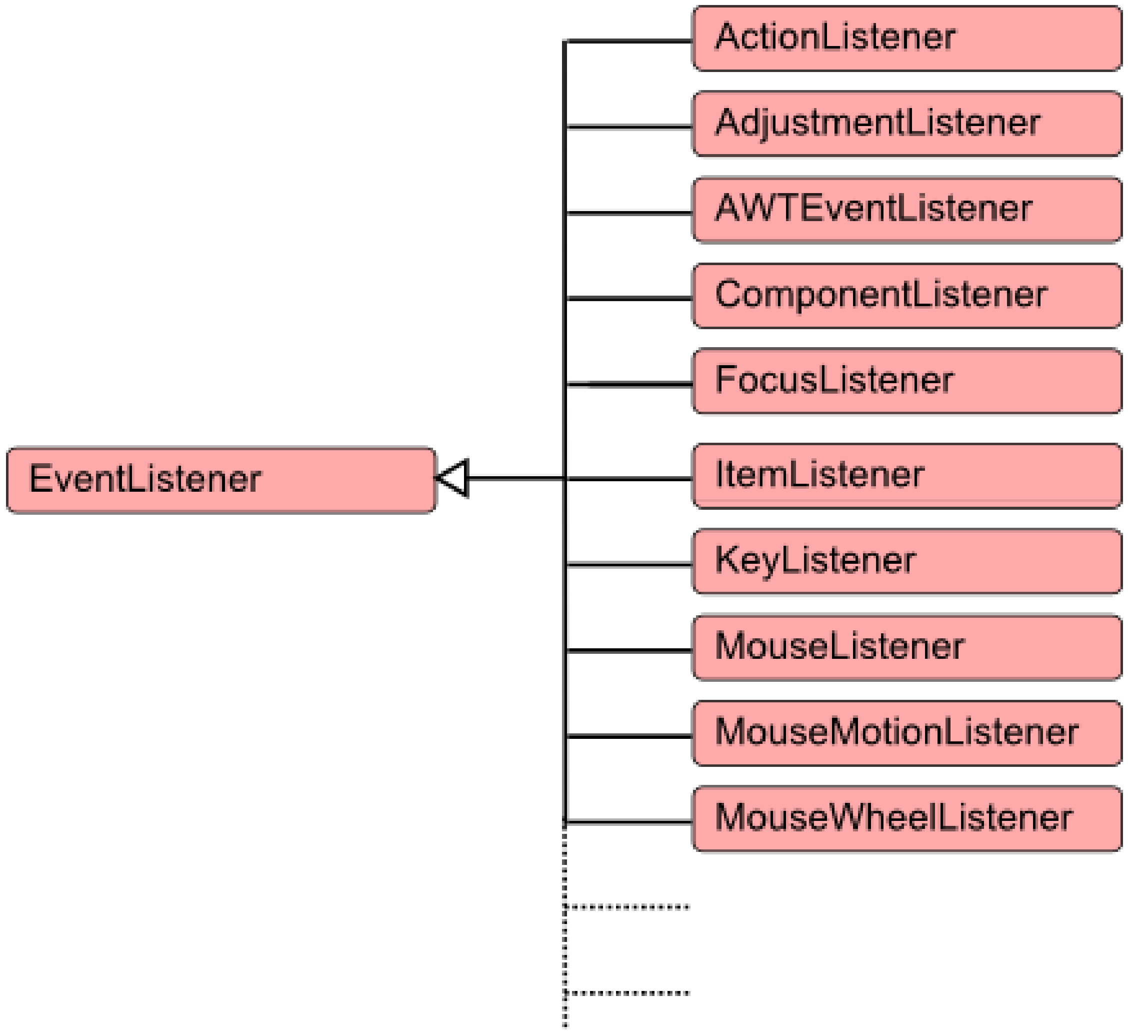
Revisit AWTCounter example



Event Hierarchy



EventListener Hierarchy



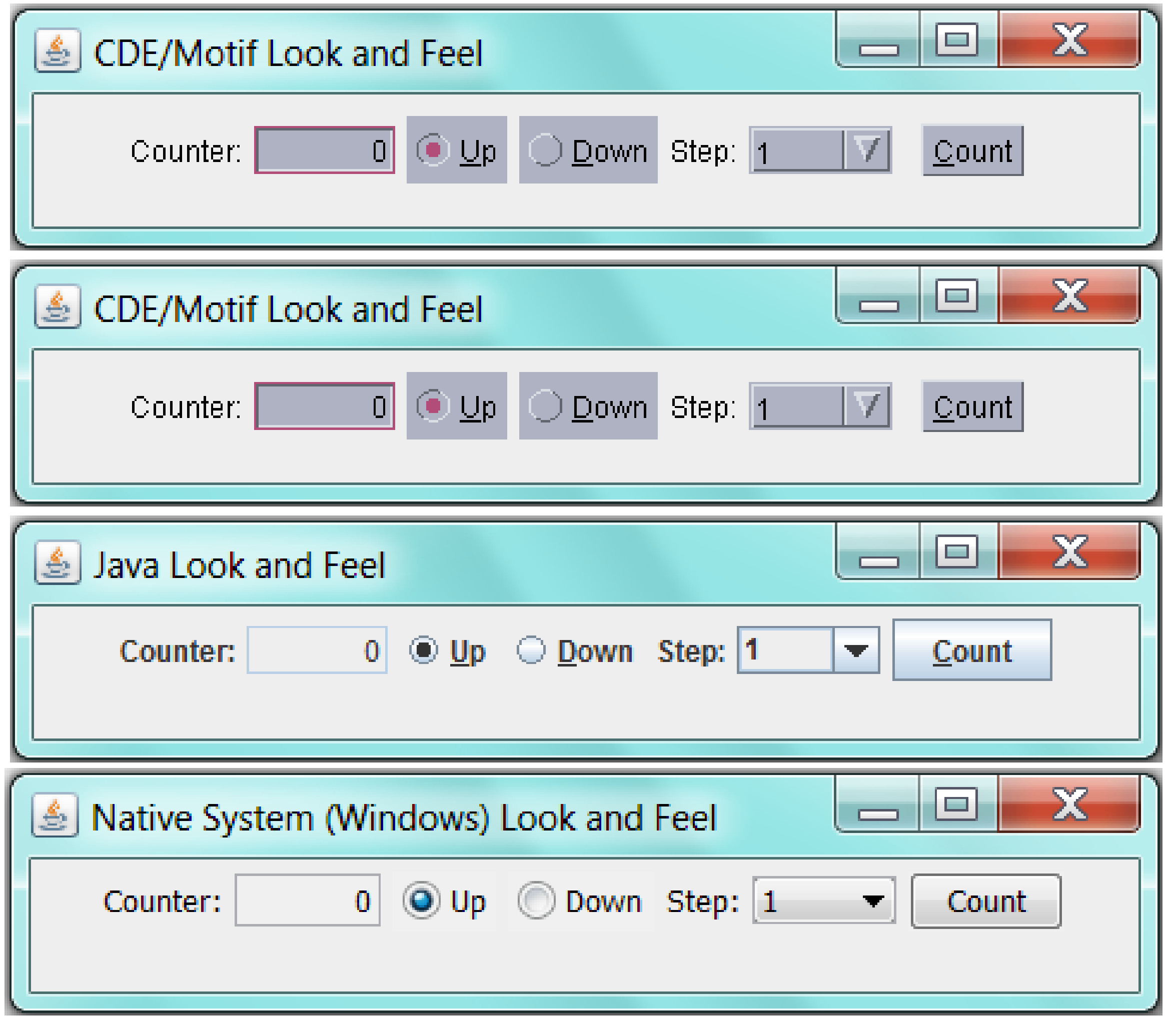
Outline

1. GUI Programming in Java
2. AWT
3. Swing
4. JavaFX

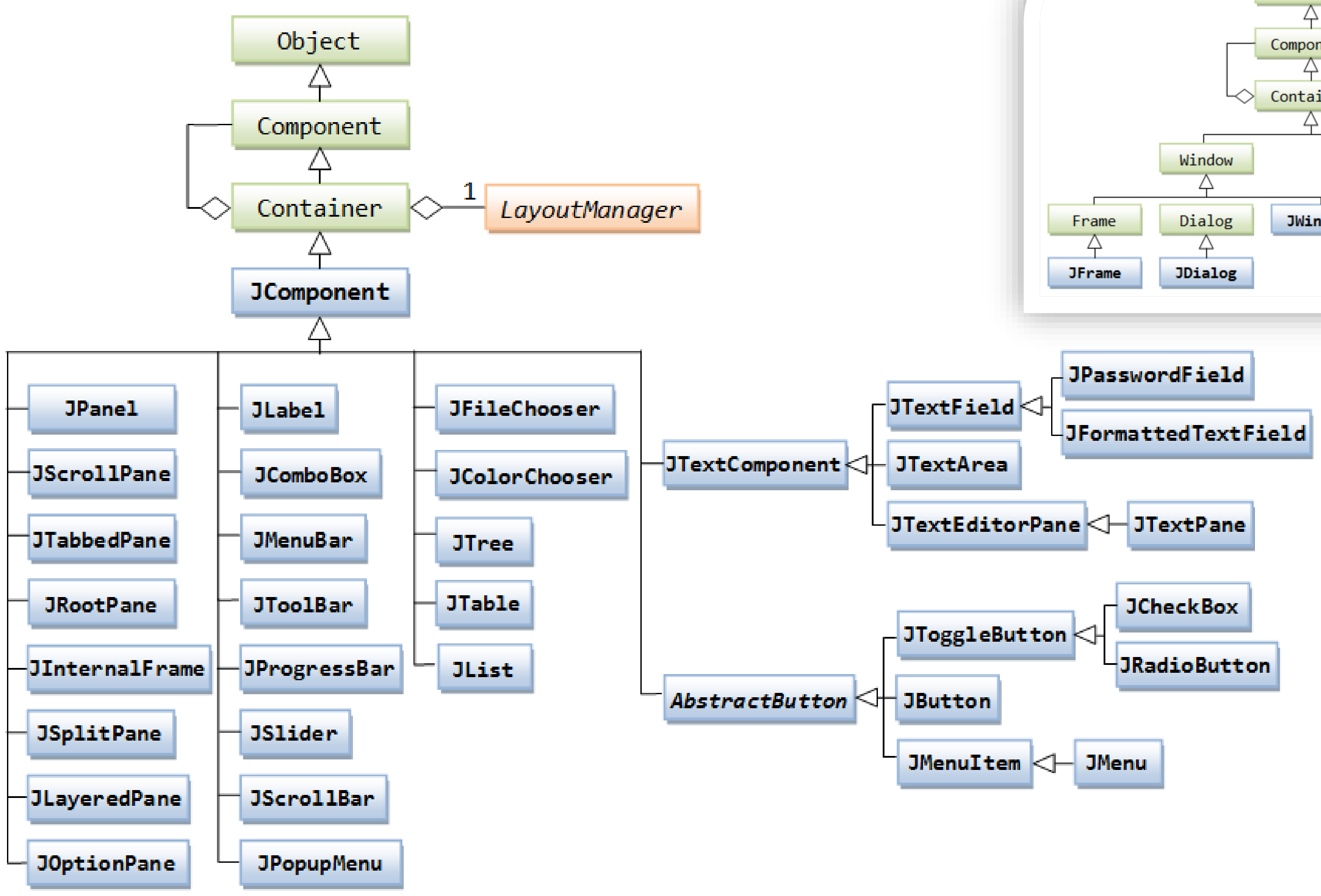
Java Swing

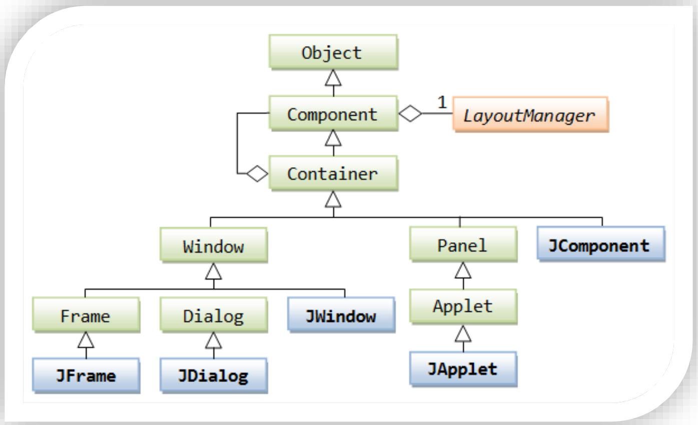
- Light Weight: Pure JAVA code
  - Freelance of native operational System’s API
- Use the Swing components with prefix "J", e.g. JFrame, JButton, JTextField, JLabel, etc.
  - Advanced controls like Tree, color picker, table controls, TabbedPane, slider.
- Uses the AWT event-handling classes
- Highly Customizable
  - Often made-to-order in a very simple method as visual appearance is freelance of content.
- Pluggable look-and-feel
  - Modified at run-time, supported by accessible values.

Swing – Different Look & Feel

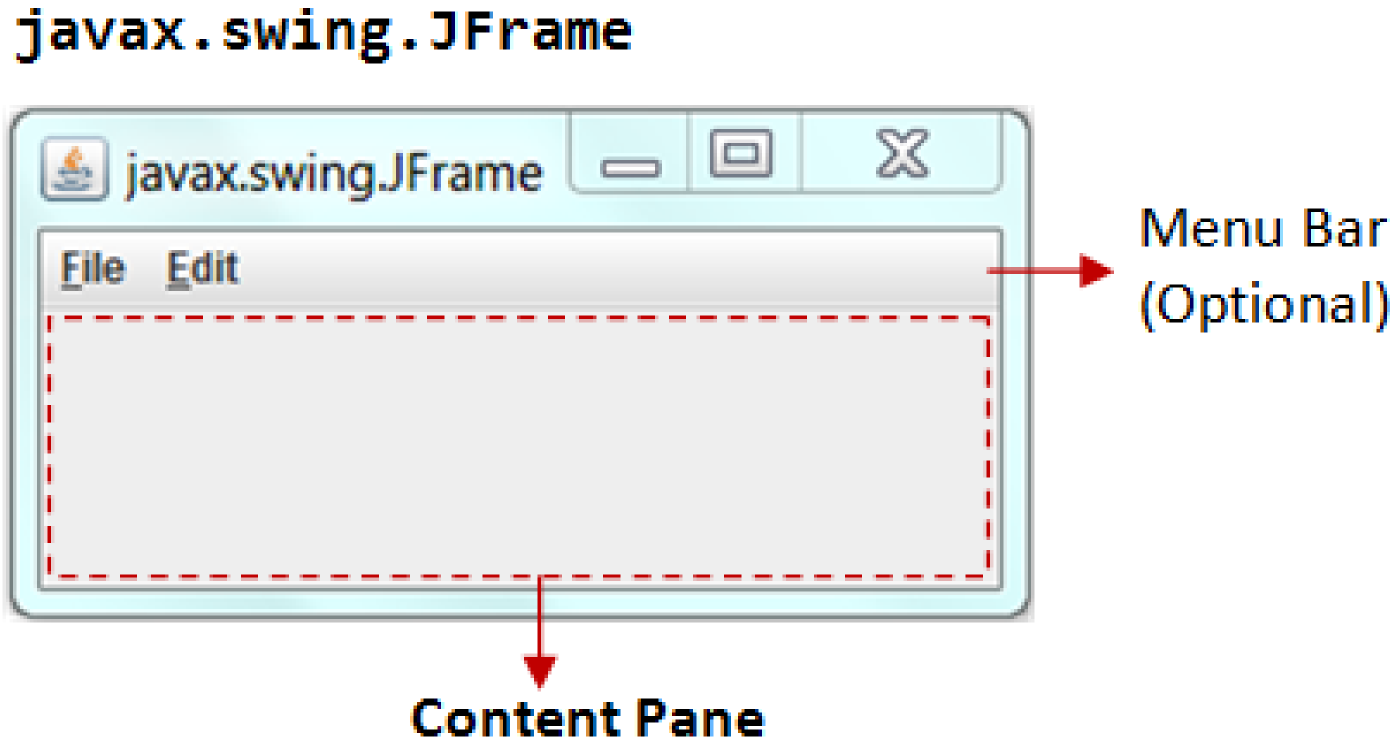


Swing Container and Component





Containers and ContentPane

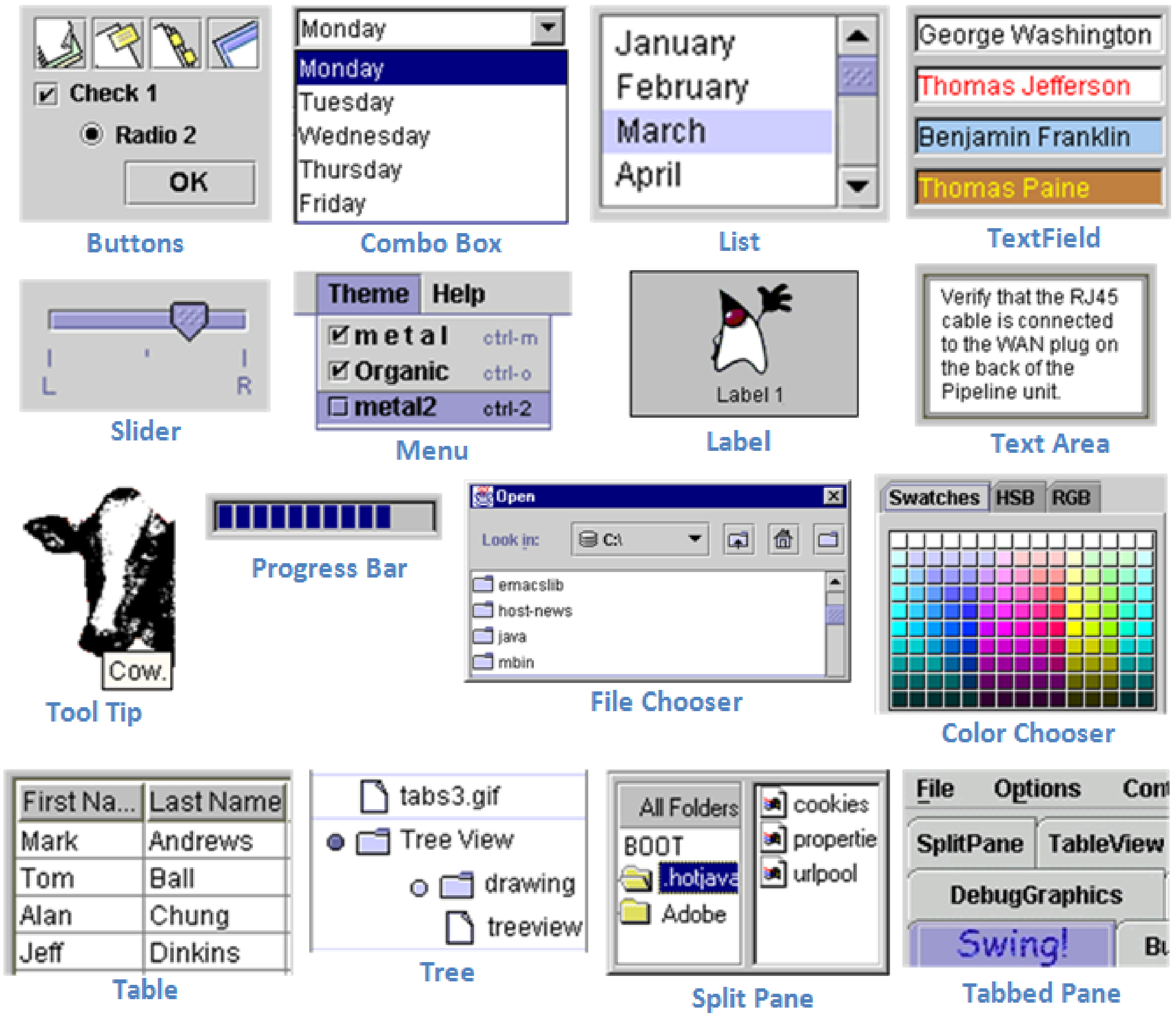


```
Container cp = aJFrame.getContentPane();
aJFrame.setContentPane(aPanel);
```

Swing components

Swing is huge (consists of 18 packages of 737 classes as in JDK 1.8) and has great depth

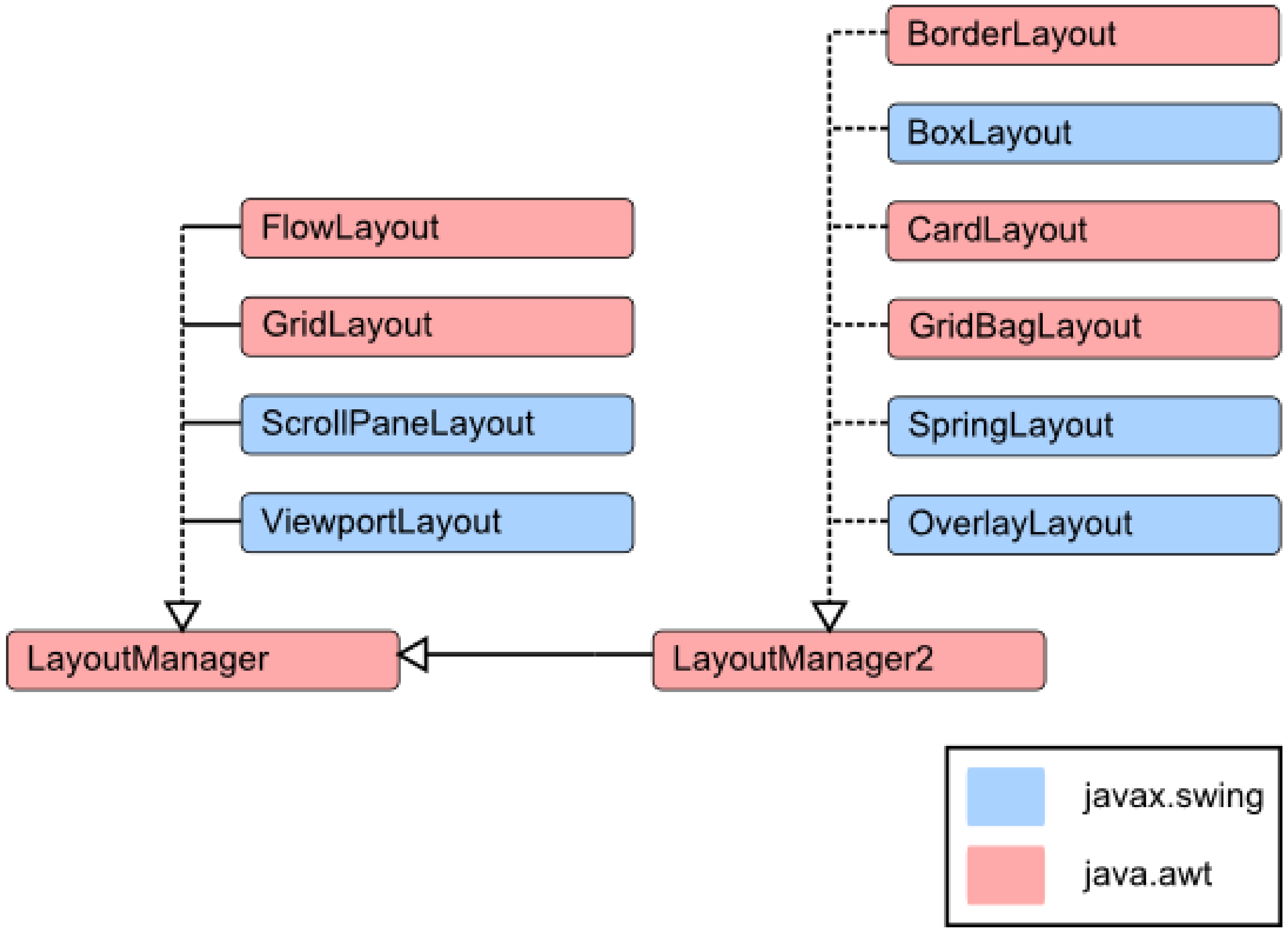
Compare to AWT:
12 packages of 370 classes



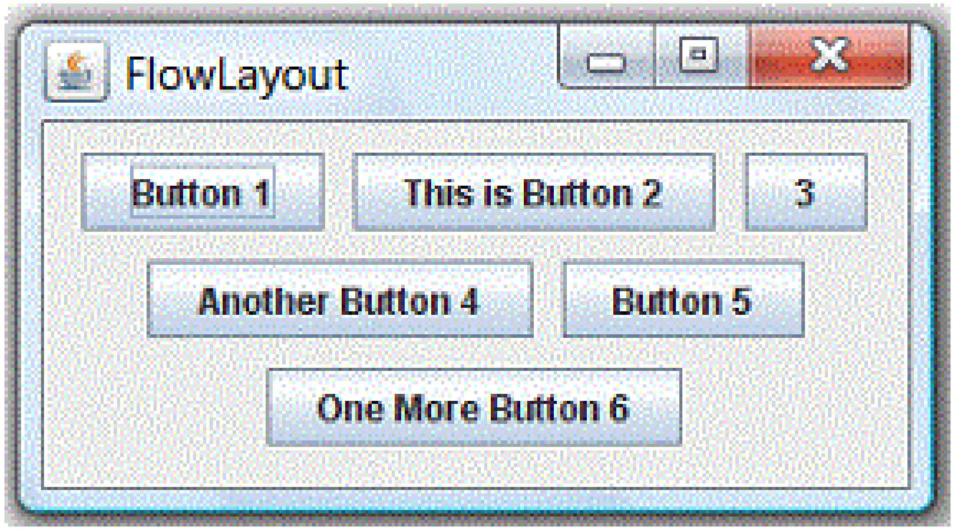
Verify that the RJ45 cable is connected to the WAN plug on the back of the Pipeline unit.

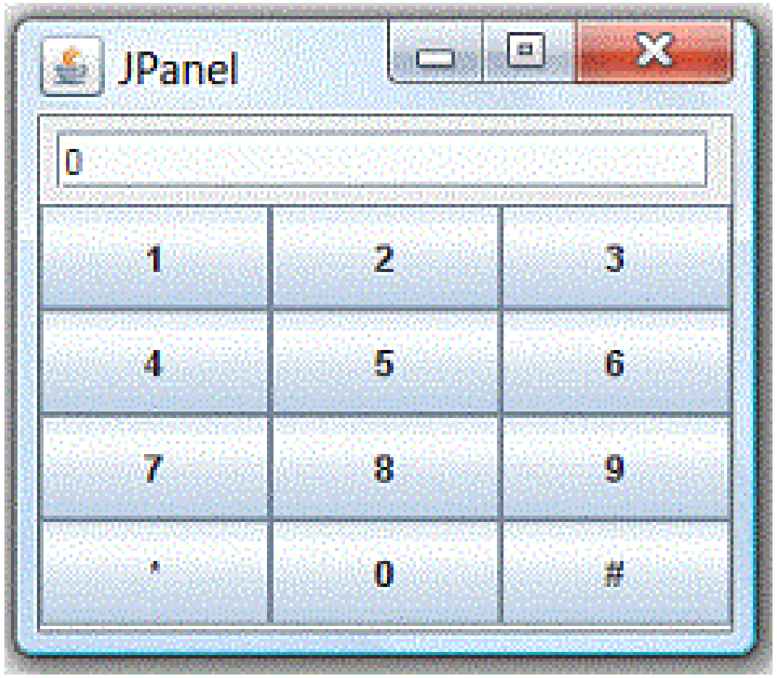
First Na...	Last Name
Mark	Andrews
Tom	Ball
Alan	Chung
Jeff	Dinkins

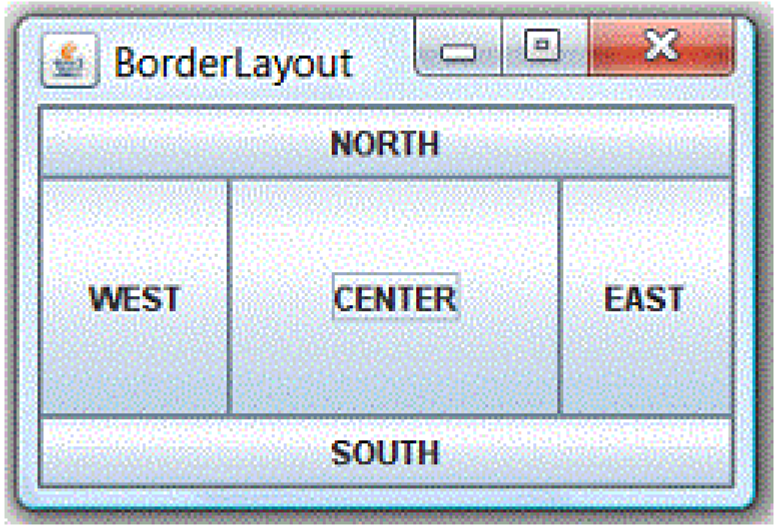
Swing Layout

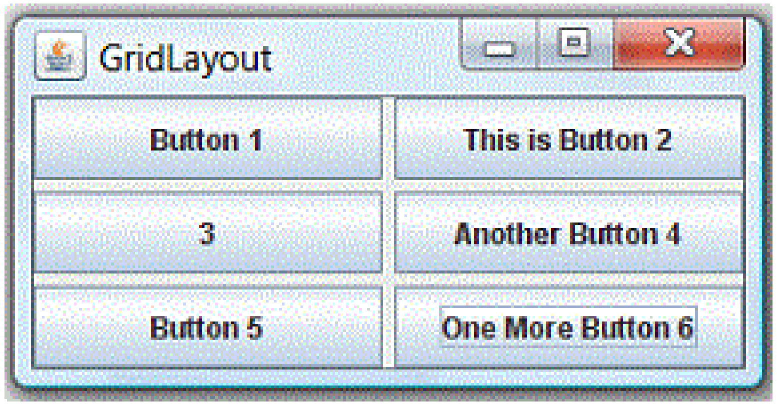


Layout management









//A Swing GUI application inherits from top-level container

```
public class SwingDemo extends JFrame {
  // Private instance variables
  // Constructor to setup the GUI components and event handlers
 public SwingDemo() {
   // top-level content-pane from JFrame
   Container cp = getContentPane();
   cp.setLayout(new ....Layout());

   // Allocate the GUI components
   cp.add(....);

   // Source object adds listener
   setDefaultCloseOperation(JFrame.EXIT_ON_CLOSE);
  // Exit the program when the close-window button clicked
  setTitle("......");  //"super" JFrame sets title
  setSize(300, 150);   //"super" JFrame sets initial size
  setVisible(true);    // "super" JFrame shows
 }
```

(cont.)

```
  // The entry main() method
  public static void main(String[] args) {
    // Run GUI codes in Event-Dispatching thread
    //for thread-safety
    SwingUtilities.invokeLater(new Runnable() {
       @Override
       public void run() {
          new SwingDemo();
       }
     });
  }
}
```

Outline

1. GUI Programming in Java
2. AWT
3. Swing
4. JavaFX

Why JavaFX?

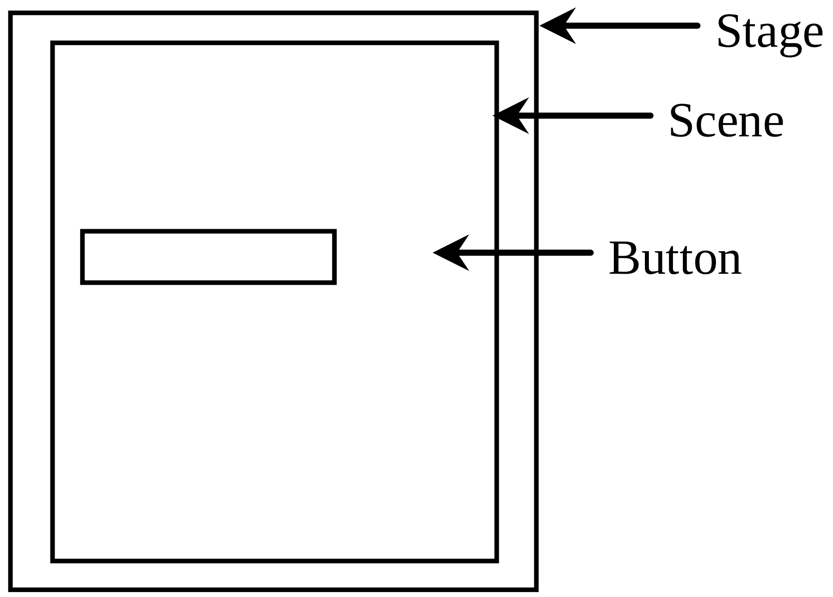
- Additional consistent in its style than Swing
  - Contains WebView supported the popular WebKit browser => Introduce Website within JavaFX
- Design GUI like Web apps with XML and CSS (FXML) than doing in Java code
  - Save building time
- Integrate 3D graphics, charts, and audio, video, and embedded Website inside GUI
  - Easy to develop Game/Media applications
- Light-weight and hardware accelerated

Why JavaFX? (2)

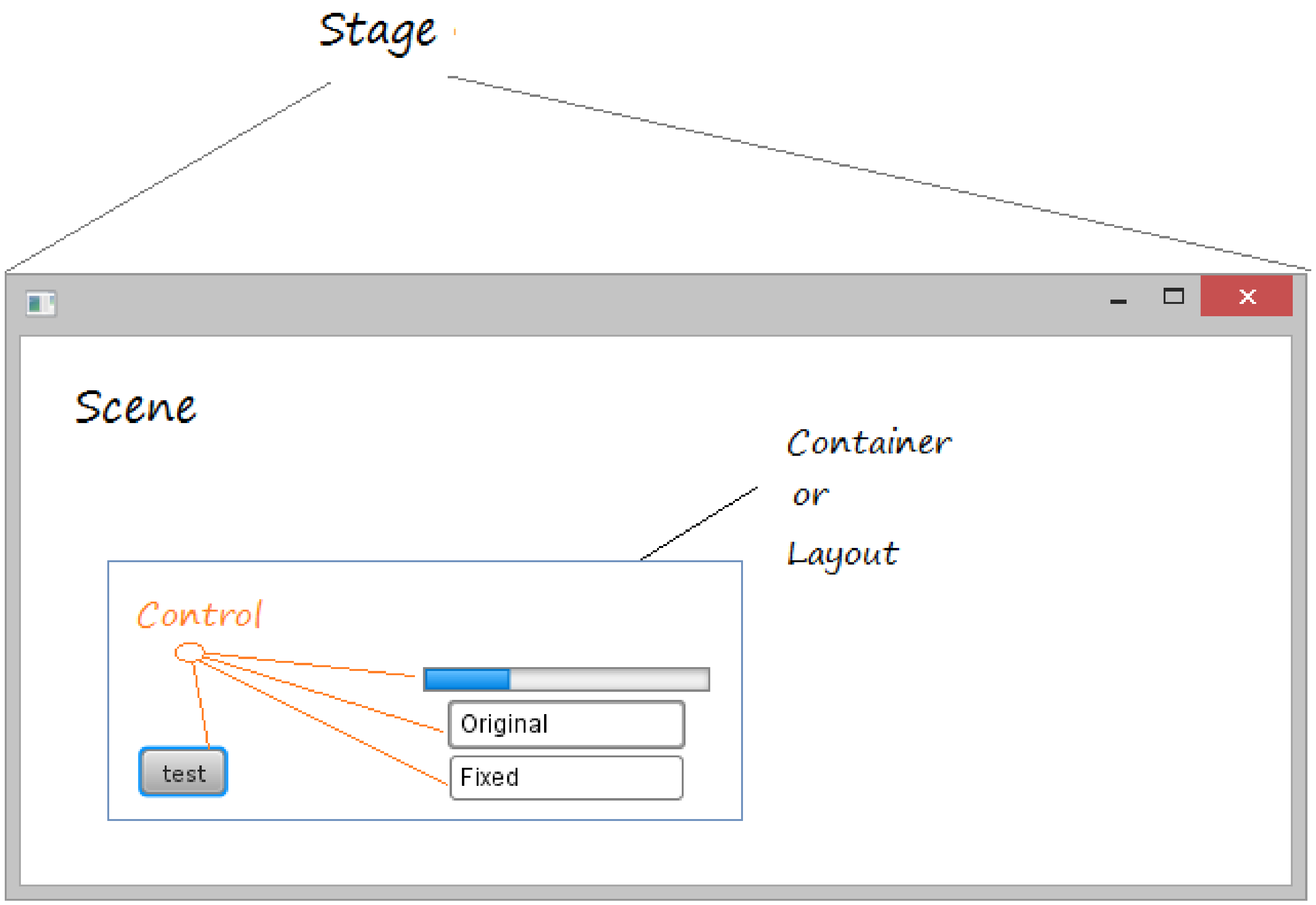
- Support stylish animations
  - Resembling fades, Rotations, Motion ways
  - Custom animations with KeyFrame and Timeline
- Support for modern touch devices
  - Resembling scrolling, swipping, rotating and zooming…
- Many eye-catching controls
  - Collapsible Titled Pane
- Events are higher thought-out and additional consistent

Basic Structure of JavaFX

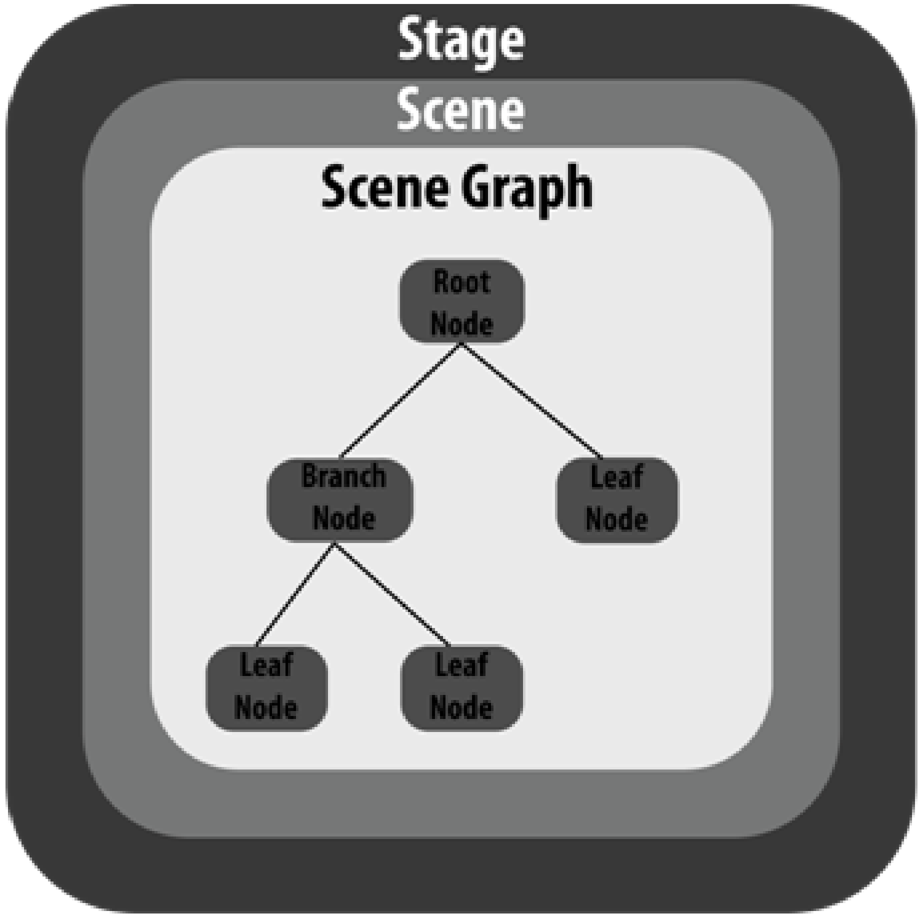
- Application
- Override the start(Stage) method
- Stage, Scene, and Nodes

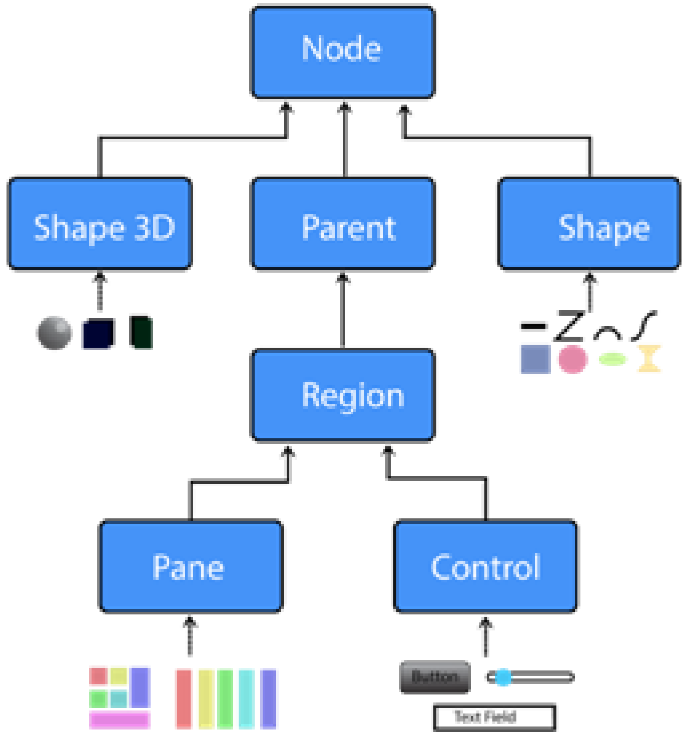


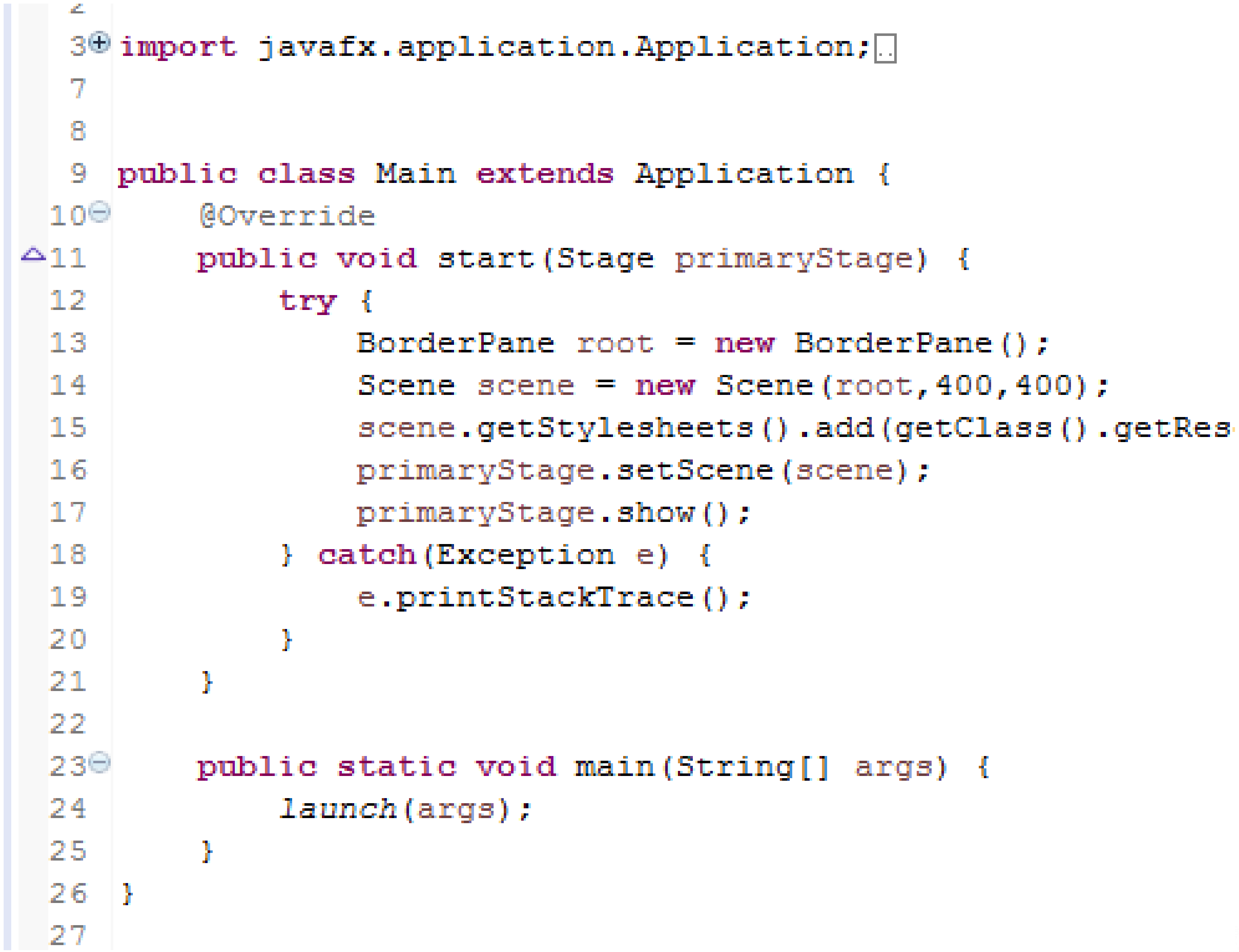
Basic Structure of JavaFX



Basic Structure of JavaFX

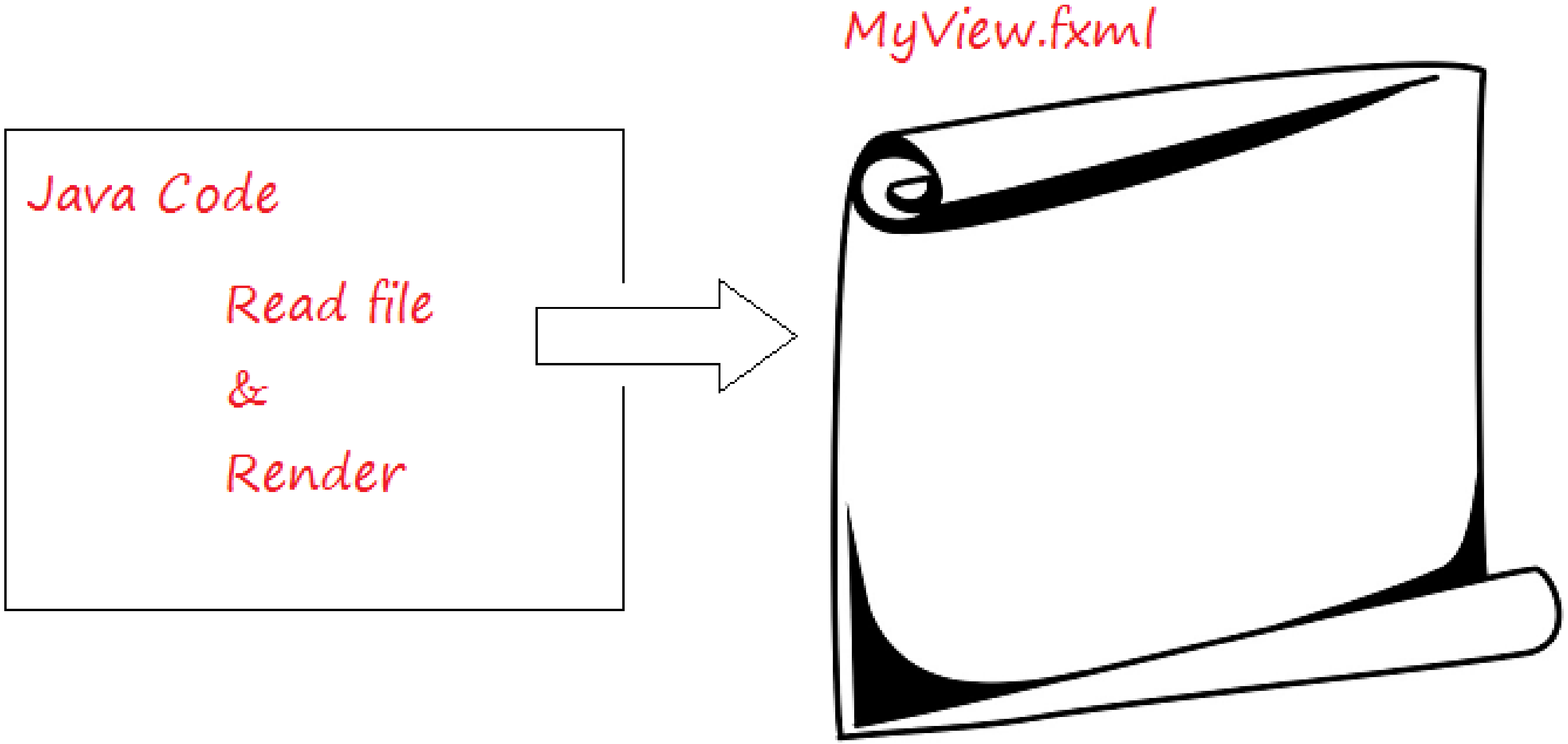






```
import javafx.application.Application;


public class Main extends Application {
	@Override
	public void start(Stage primaryStage) {
		try {
			BorderPane root = new BorderPane();
			Scene scene = new Scene(root,400,400);
			scene.getStylesheets().add(getClass().getRes
			primaryStage.setScene(scene);
			primaryStage.show();
		} catch(Exception e) {
			e.printStackTrace();
		}
	}

	public static void main(String[] args) {
		launch(args);
	}
}

```

JavaFX Scene Builde



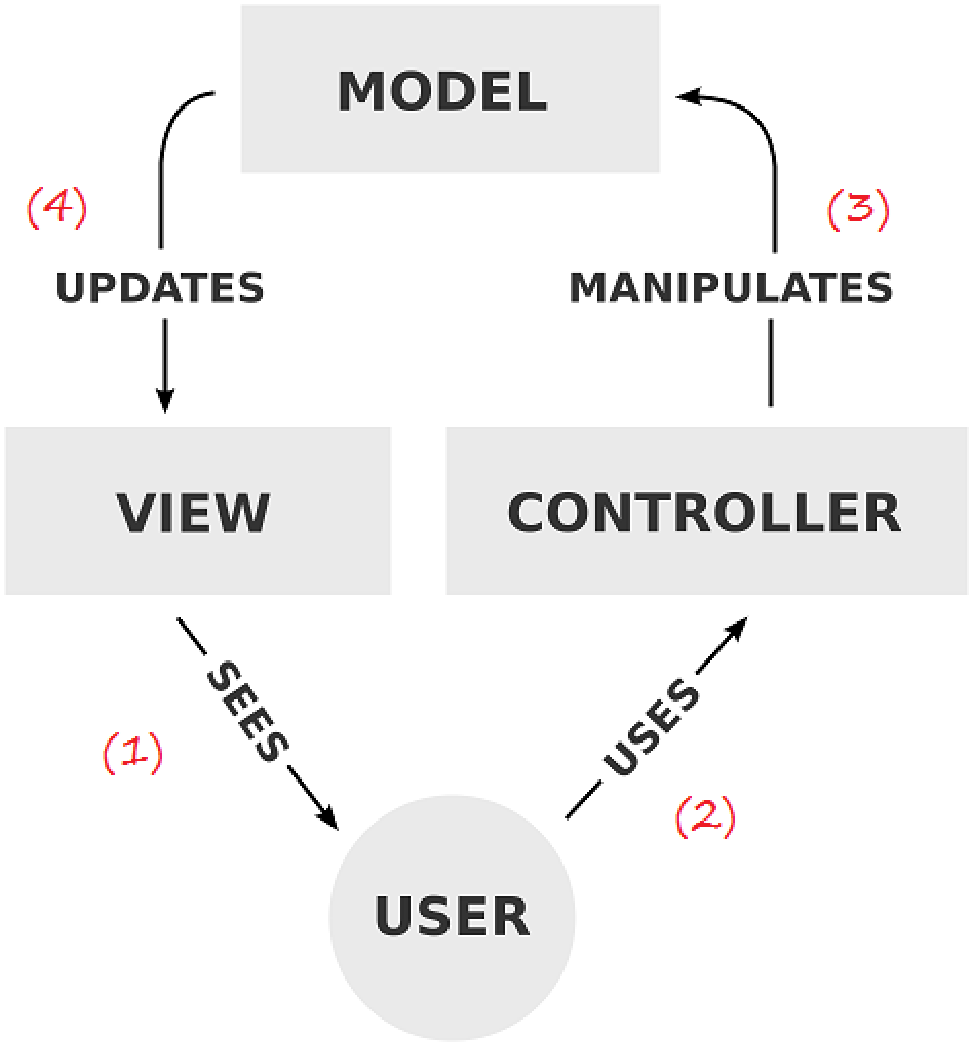
MVC pattern

1. After seeing it on VIEW

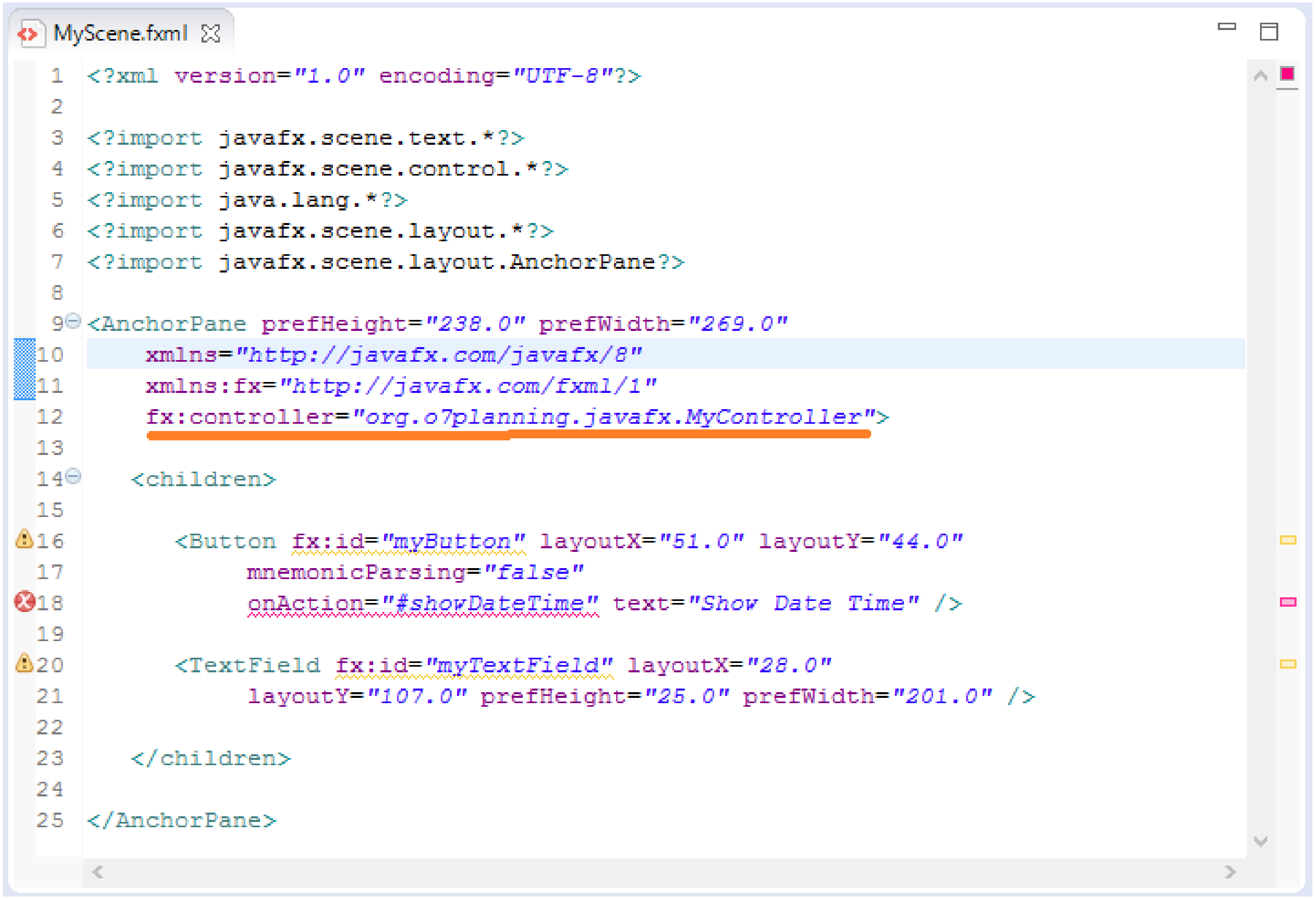
2. Users use CONTROLLER

3. Manipulate data (Update, modify, delete, ..), the data on MODEL has been changed.

4. Displaying the data of MODEL on VIEW.



View: FXML



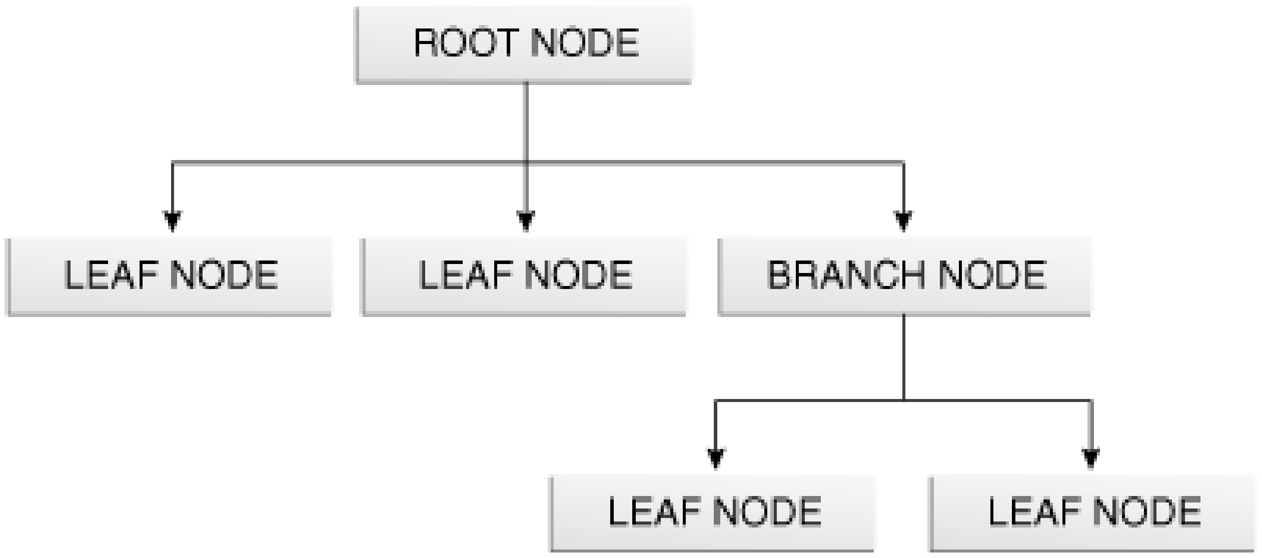
```
<?xml version="1.0" encoding="UTF-8"?>

<?import javafx.scene.text.*?>
<?import javafx.scene.control.*?>
<?import java.lang.*?>
<?import javafx.scene.layout.*?>
<?import javafx.scene.layout.AnchorPane?>

<AnchorPane prefHeight="238.0" prefWidth="269.0"
    xmlns="http://javafx.com/javafx/8"
    xmlns:fx="http://javafx.com/fxml/1"
    fx:controller="org.o7planning.javafx.MyController">

   <children>

      <Button fx:id="myButton" layoutX="51.0" layoutY="44.0"
            mnemonicParsing="false"
            onAction="#showDateTime" text="Show Date Time" />

      <TextField fx:id="myTextField" layoutX="28.0"
            layoutY="107.0" prefHeight="25.0" prefWidth="201.0" />

   </children>

</AnchorPane>
```

Controller: Java code

```
public class MyController implements Initializable {
    @FXML
    private Button myButton;
    @FXML
    private TextField myTextField;

    // When user click on myButton, this method will be called
    public void showDateTime(ActionEvent event) {
      System.out.println("Button Clicked!");
      Date now= new Date();
      DateFormat df = new SimpleDateFormat(
                                              "dd-MM-yyyy HH:mm:ss.SSS");
      // Model Data
      String dateTimeString = df.format(now);
      // Show in VIEW
      myTextField.setText(dateTimeString);
    }
}
```

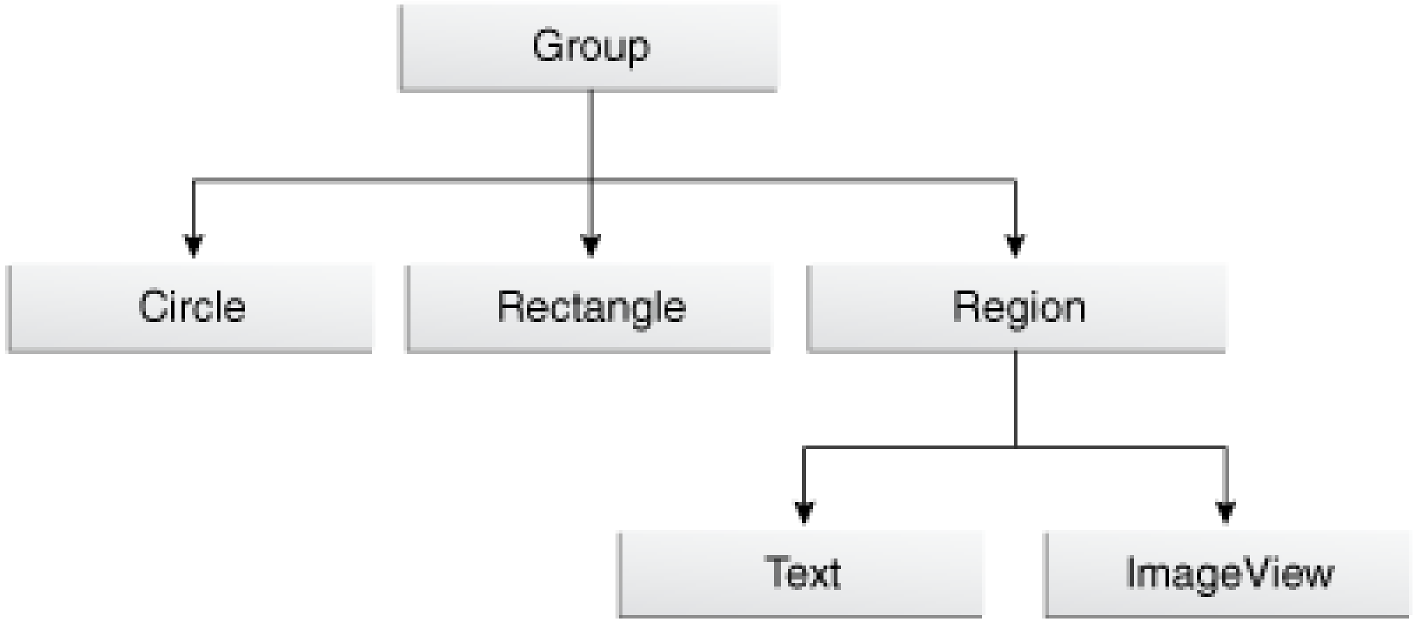
JavaFX Architecture

- A JavaFX user interface is based on a scene graph, which is a tree, much like an html document. To review, the CS conception of a tree looks like this:



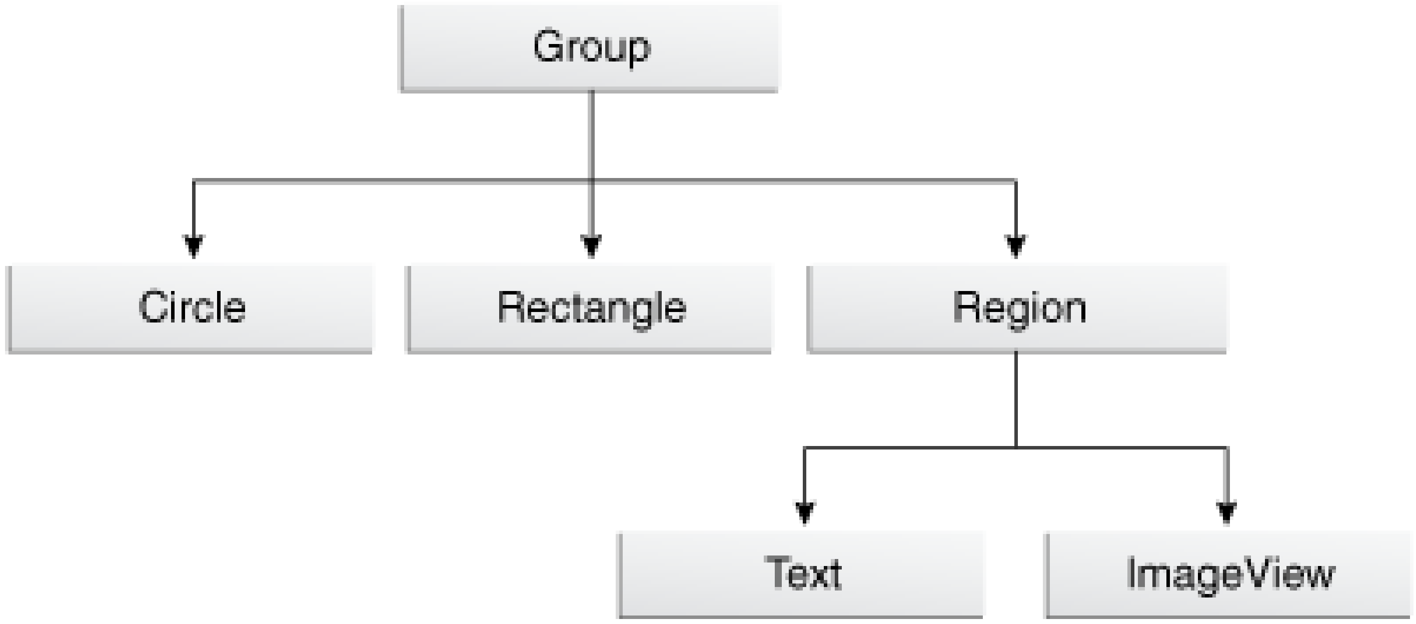
JavaFX Architecture: Example

- In JavaFX, the root of the scene graph tree is the pane.

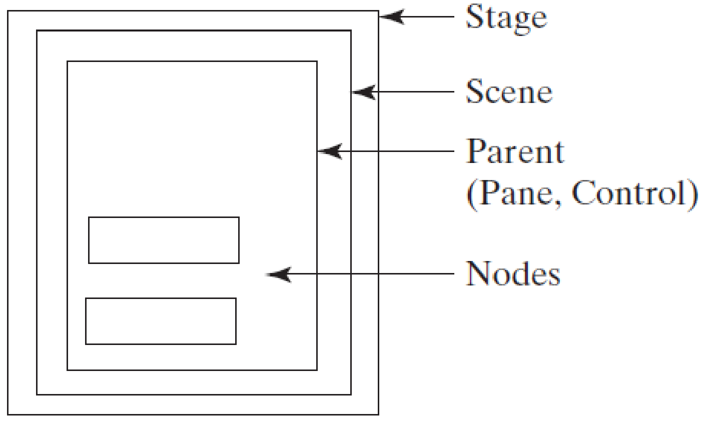


JavaFX Architecture

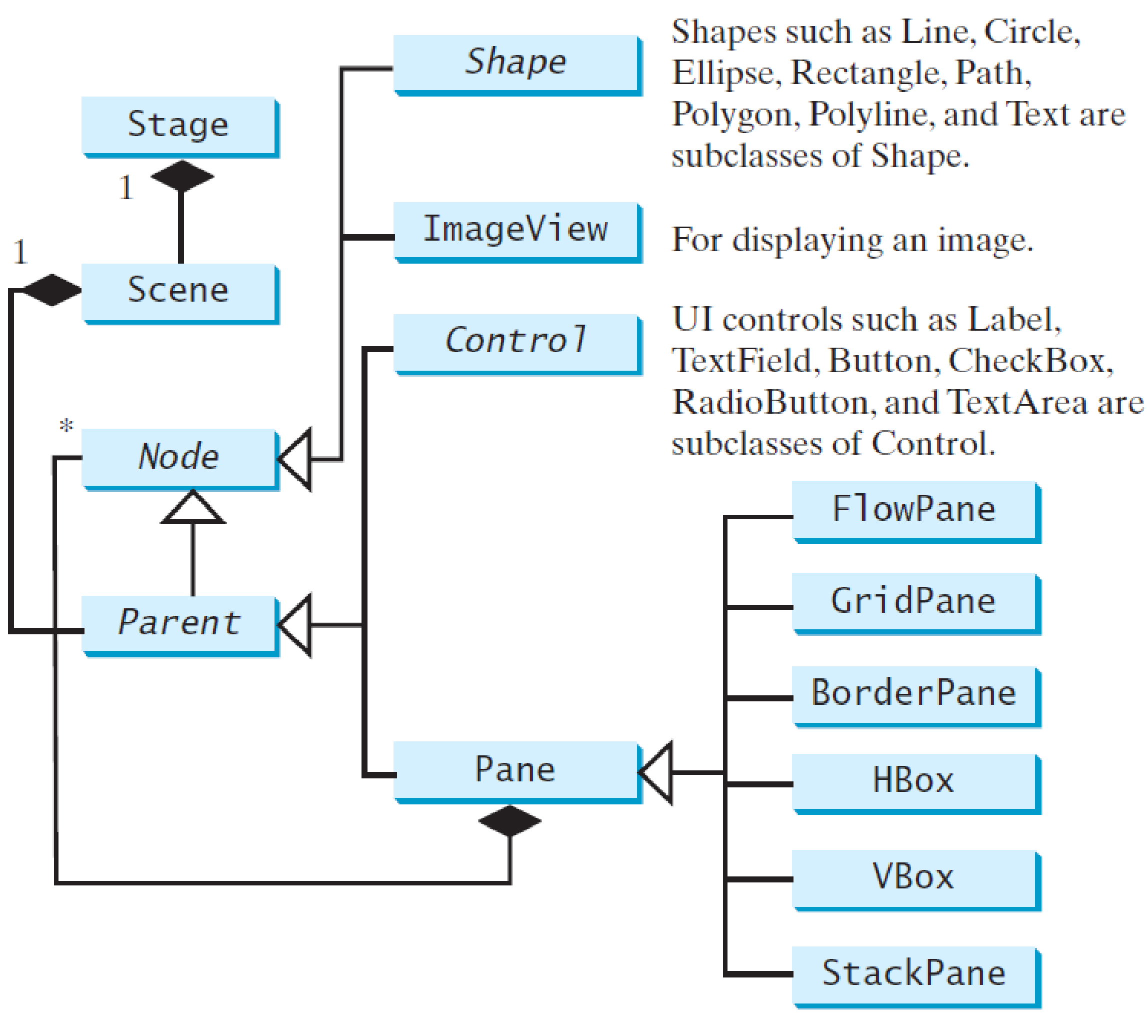
- In JavaFX, the root of the scene graph tree is the pane



Panes, UI Controls, and Shapes



(a)



Shapes such as Line, Circle, Ellipse, Rectangle, Path, Polygon, Polyline, and Text are subclasses of Shape.

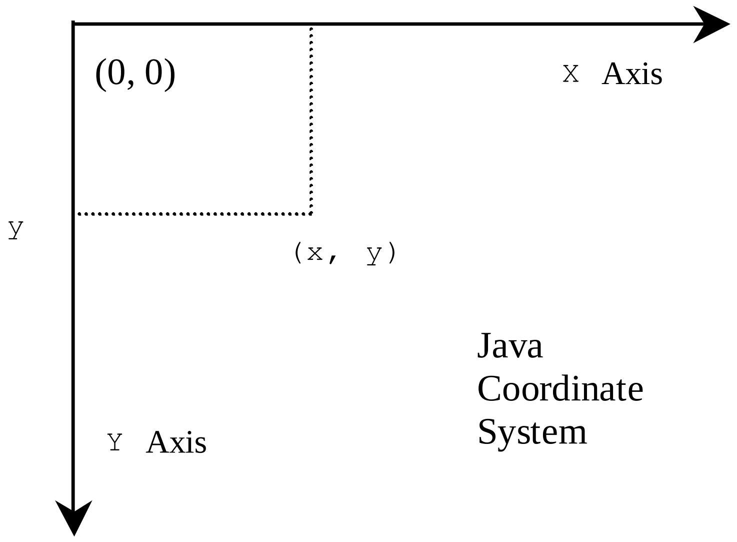
For displaying an image.

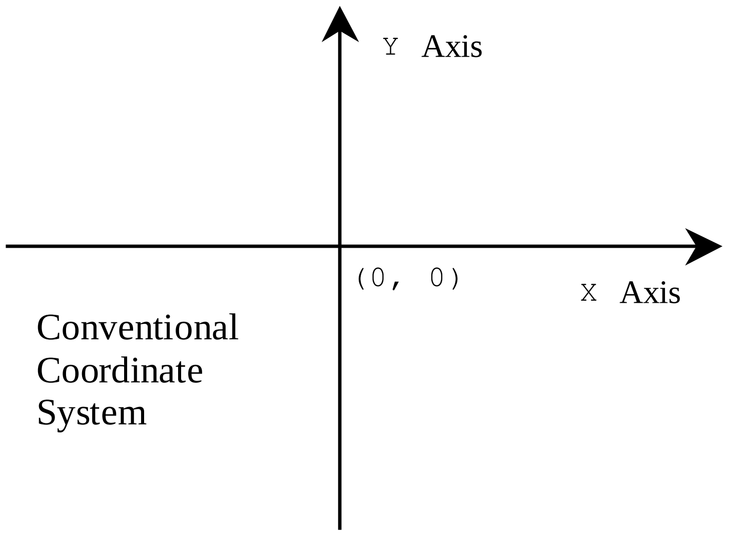
UI controls such as Label, TextField, Button, CheckBox, RadioButton, and TextArea are subclasses of Control.

(b)

Display a Shape

This example displays a circle in the center of the pane.



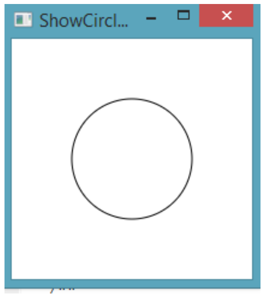


Binding Properties

JavaFX introduces a new concept called *binding property* that enables a *target object* to be bound to a *source object*. If the value in the source object changes, the target property is also changed automatically. The target object is simply called a *binding object* or a *binding property*.

ShowCircleCentered

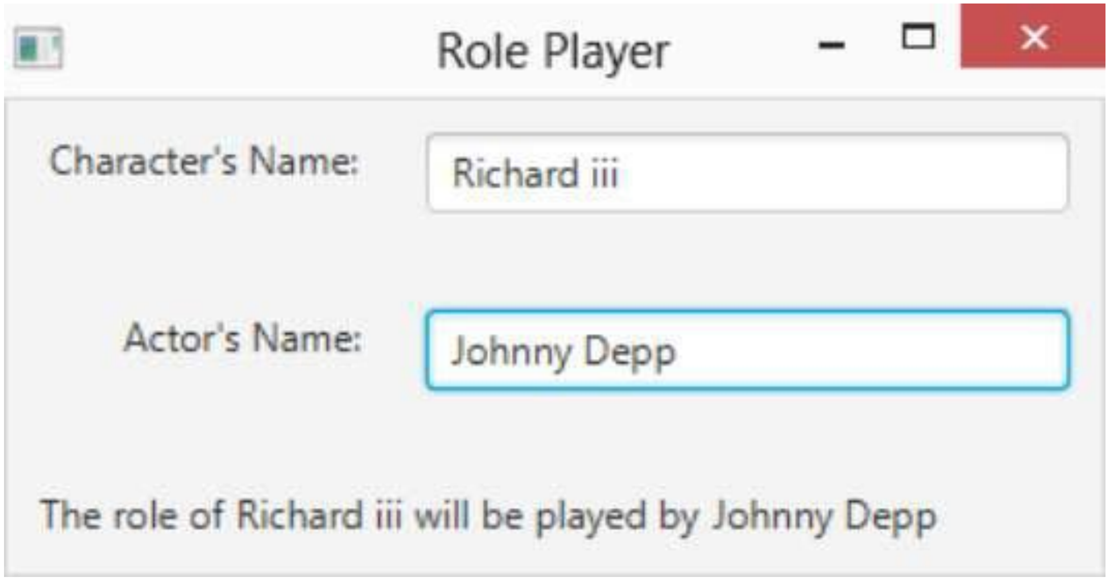
```
import javafx.application.Application;
import javafx.scene.Scene;
import javafx.scene.layout.Pane;
import javafx.scene.paint.Color;
import javafx.scene.shape.Circle;
import javafx.stage.Stage;

public class ShowCircleCentered extends Application {
  public void start(Stage primaryStage) {
   // Create a pane to hold the circle
   Pane pane = new Pane();
   // Create a circle and set its properties
   Circle circle = new Circle();
   circle.centerXProperty().bind(pane.widthProperty().divide(2));
   circle.centerYProperty().bind(pane.heightProperty().divide(2));
   circle.setRadius(50);
   circle.setStroke(Color.BLACK);
   circle.setFill(Color.WHITE);
   pane.getChildren().add(circle); // Add circle to the pane

   // Create a scene and place it in the stage
   Scene scene = new Scene(pane, 200, 200);
   primaryStage.setTitle("ShowCircleCentered"); //Set the stage title
   primaryStage.setScene(scene); // Place the scene in the stage
   primaryStage.show(); // Display the stage
 }

  /**
   * The main method is only needed for the IDE with limited
   * JavaFX support. Not needed for running from the command line.
   */
  public static void main(String[] args) {
    launch(args);
  }
}
```



Example: Binding Properties

Unidirectional Binding

```
lable1.textProperty().bind(text1.textProperty());
lable2.textProperty().bind(text2.textProperty());
```



Character's Name: Richard iii

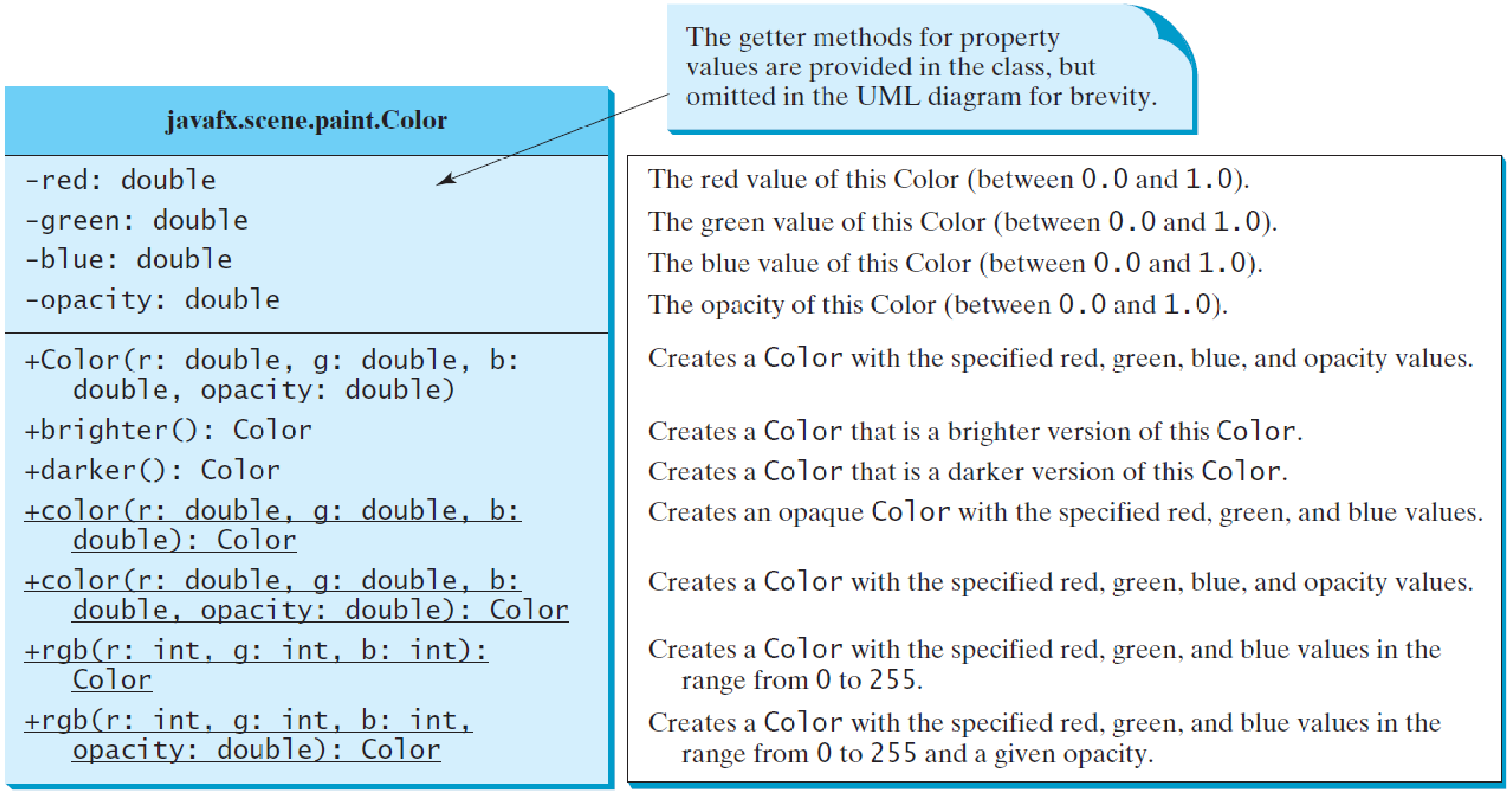
Actor's Name: Johnny Depp

The role of Richard iii will be played by Johnny Depp

Bidirectional Binding

```
text1.textProperty().
            bindBidirectional(text2.textProperty());
```

The Color Class



The getter methods for property values are provided in the class, but omitted in the UML diagram for brevity.

javafx.scene.paint.Color

`-red: double`	The red value of this Color (between `0.0` and `1.0`).
`-green: double`	The green value of this Color (between `0.0` and `1.0`).
`-blue: double`	The blue value of this Color (between `0.0` and `1.0`).
`-opacity: double`	The opacity of this Color (between `0.0` and `1.0`).
`+Color(r: double, g: double, b: double, opacity: double)`	Creates a `Color` with the specified red, green, blue, and opacity values.
`+brighter(): Color`	Creates a `Color` that is a brighter version of this `Color`.
`+darker(): Color`	Creates a `Color` that is a darker version of this `Color`.
`+color(r: double, g: double, b: double): Color`	Creates an opaque `Color` with the specified red, green, and blue values.
`+color(r: double, g: double, b: double, opacity: double): Color`	Creates a `Color` with the specified red, green, blue, and opacity values.
`+rgb(r: int, g: int, b: int): Color`	Creates a `Color` with the specified red, green, and blue values in the range from `0` to `255`.
`+rgb(r: int, g: int, b: int, opacity: double): Color`	Creates a `Color` with the specified red, green, and blue values in the range from `0` to `255` and a given opacity.

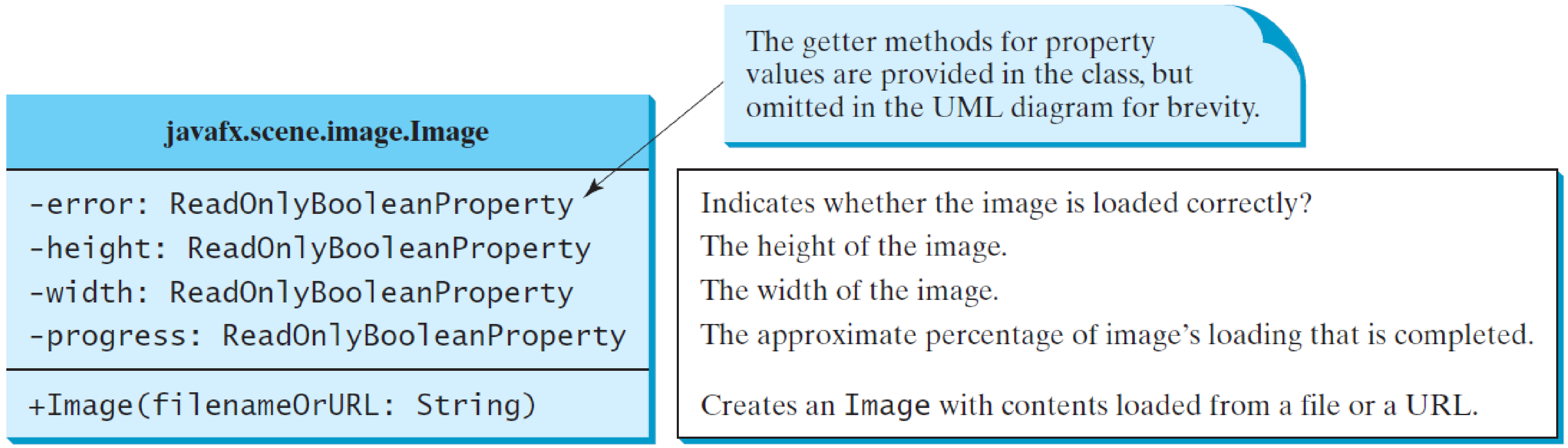
The Font Class

The getter methods for property values are provided in the class, but omitted in the UML diagram for brevity.

javafx.scene.text.Font	
`-size: double`	The size of this font.
`-name: String`	The name of this font.
`-family: String`	The family of this font.
`+Font(size: double)`	Creates a `Font` with the specified size.
`+Font(name: String, size: double)`	Creates a `Font` with the specified full font name and size.
`+font(name: String, size: double)`	Creates a `Font` with the specified name and size.
`+font(name: String, w: FontWeight, size: double)`	Creates a `Font` with the specified name, weight, and size.
`+font(name: String, w: FontWeight, p: FontPosture, size: double)`	Creates a `Font` with the specified name, weight, posture, and size.
`+getFamilies(): List<String>`	Returns a list of font family names.
`+getFontNames(): List<String>`	Returns a list of full font names including family and weight.

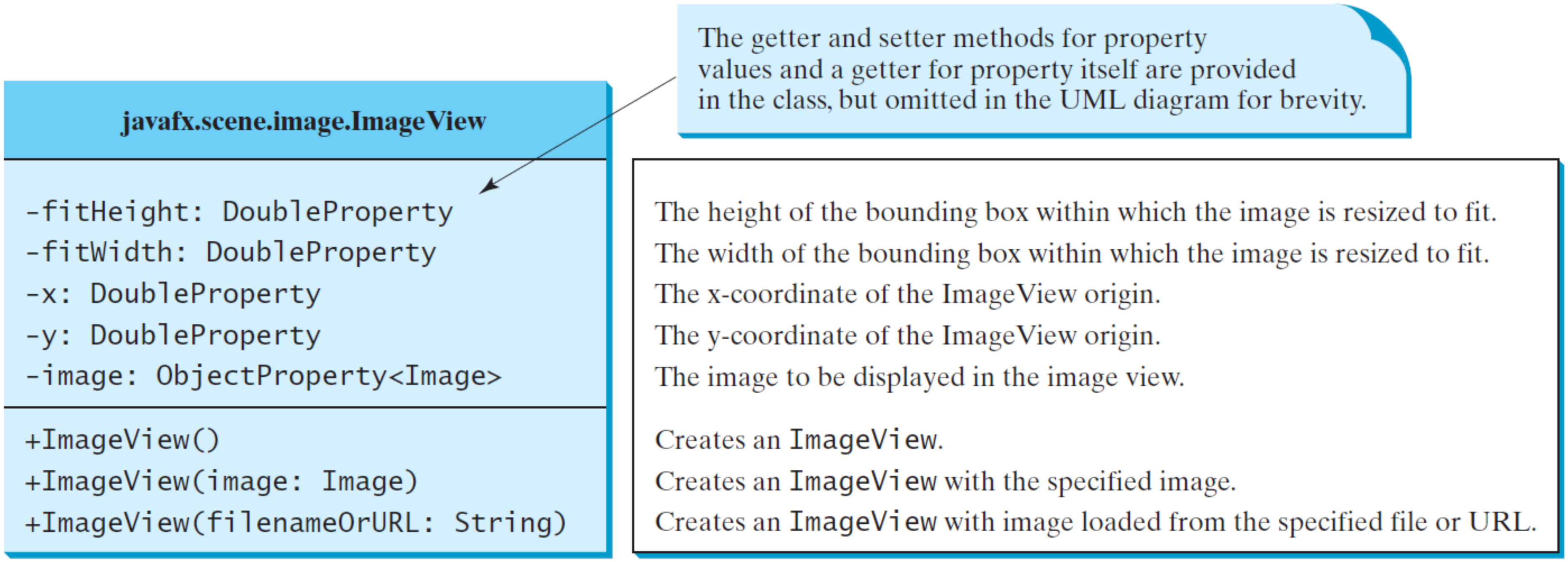
FontDemo Run

The Image Class


The getter methods for property values are provided in the class, but omitted in the UML diagram for brevity.

javafx.scene.image.Image	
-error: ReadOnlyBooleanProperty	Indicates whether the image is loaded correctly?
-height: ReadOnlyBooleanProperty	The height of the image.
-width: ReadOnlyBooleanProperty	The width of the image.
-progress: ReadOnlyBooleanProperty	The approximate percentage of image's loading that is completed.
+Image(filenameOrURL: String)	Creates an Image with contents loaded from a file or a URL.

The ImageView Class



The getter and setter methods for property values and a getter for property itself are provided in the class, but omitted in the UML diagram for brevity.

javafx.scene.image.ImageView

`-fitHeight: DoubleProperty`	The height of the bounding box within which the image is resized to fit.
`-fitWidth: DoubleProperty`	The width of the bounding box within which the image is resized to fit.
`-x: DoubleProperty`	The x-coordinate of the ImageView origin.
`-y: DoubleProperty`	The y-coordinate of the ImageView origin.
`-image: ObjectProperty<Image>`	The image to be displayed in the image view.
`+ImageView()`	Creates an `ImageView`.
`+ImageView(image: Image)`	Creates an `ImageView` with the specified image.
`+ImageView(filenameOrURL: String)`	Creates an `ImageView` with image loaded from the specified file or URL.

ShowImage

Run

Layout Panes

JavaFX provides many types of panes for organizing nodes in a container.

Class	*Description*
`Pane`	Base class for layout panes. It contains the `getChildren()` method for returning a list of nodes in the pane.
`StackPane`	Places the nodes on top of each other in the center of the pane.
`FlowPane`	Places the nodes row-by-row horizontally or column-by-column vertically.
`GridPane`	Places the nodes in the cells in a two-dimensional grid.
`BorderPane`	Places the nodes in the top, right, bottom, left, and center regions.
`HBox`	Places the nodes in a single row.
`VBox`	Places the nodes in a single column.

FlowPane

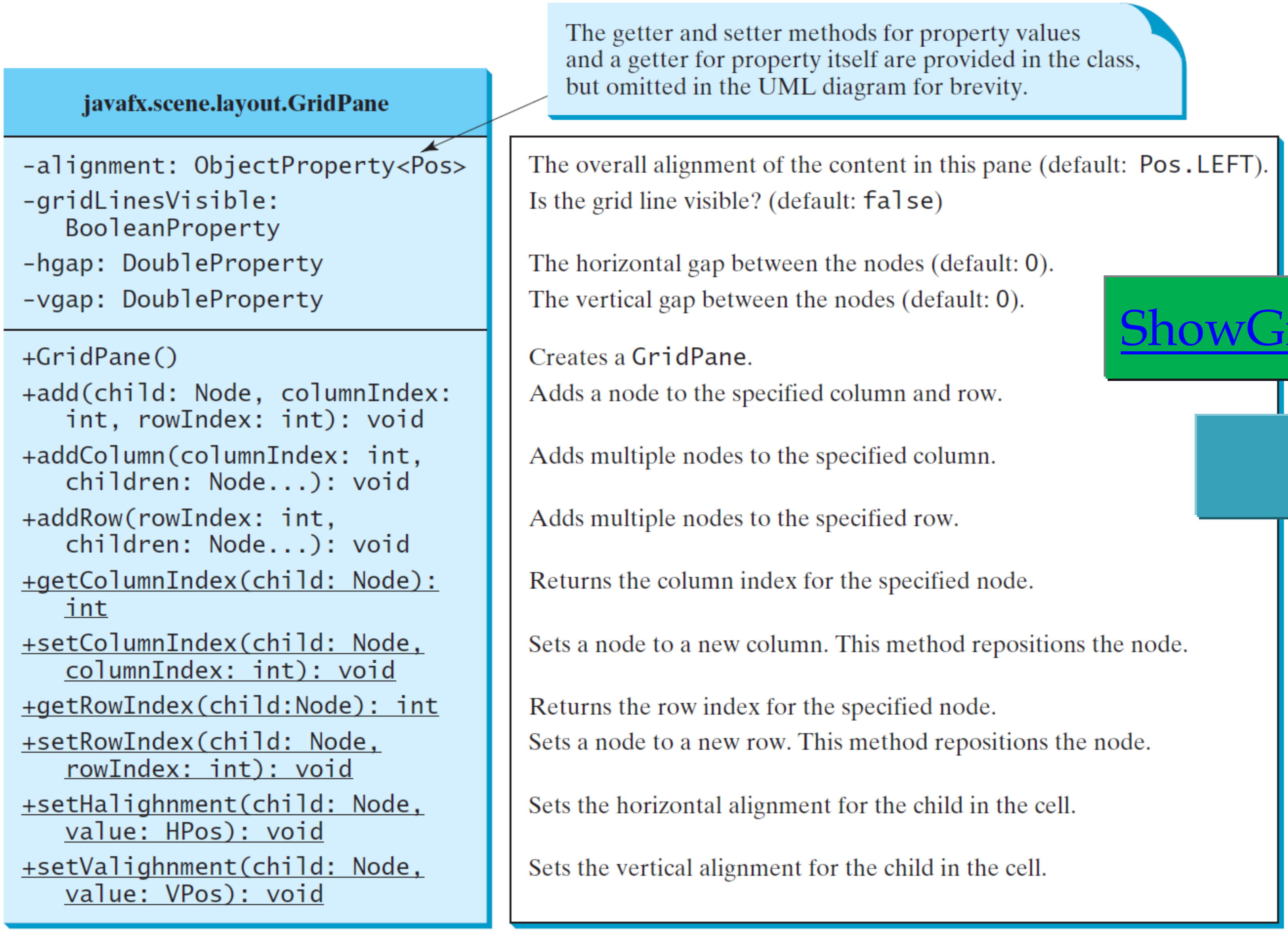
The getter and setter methods for property values and a getter for property itself are provided in the class, but omitted in the UML diagram for brevity.

javafx.scene.layout.FlowPane	
`-alignment: ObjectProperty<Pos>`	The overall alignment of the content in this pane (default: `Pos.LEFT`).
`-orientation: ObjectProperty<Orientation>`	The orientation in this pane (default: `Orientation.HORIZONTAL`).
`-hgap: DoubleProperty`	The horizontal gap between the nodes (default: `0`).
`-vgap: DoubleProperty`	The vertical gap between the nodes (default: `0`).
`+FlowPane()`	Creates a default `FlowPane`.
`+FlowPane(hgap: double, vgap: double)`	Creates a `FlowPane` with a specified horizontal and vertical gap.
`+FlowPane(orientation: ObjectProperty<Orientation>)`	Creates a `FlowPane` with a specified orientation.
`+FlowPane(orientation: ObjectProperty<Orientation>, hgap: double, vgap: double`	Creates a `FlowPane` with a specified orientation, horizontal gap and vertical gap.

ShowFlowPane

Run

GridPane



The getter and setter methods for property values and a getter for property itself are provided in the class, but omitted in the UML diagram for brevity.

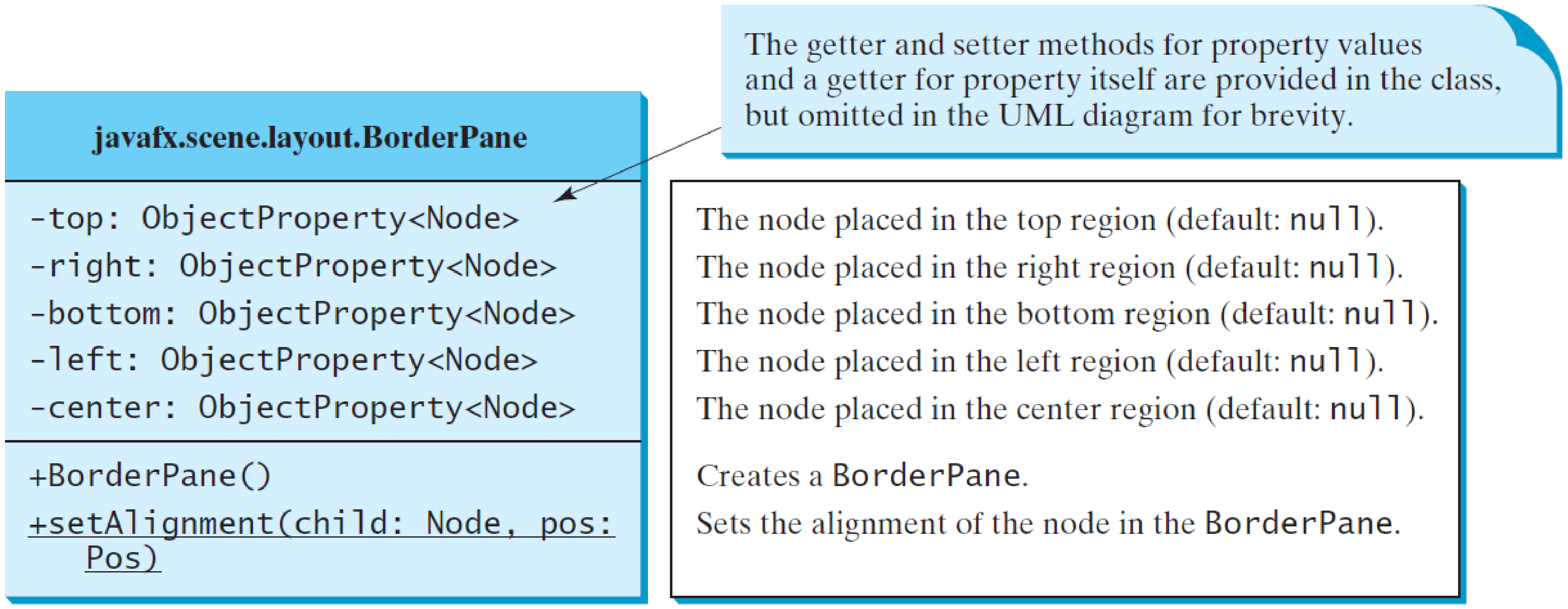
javafx.scene.layout.GridPane

Member	Description
`-alignment: ObjectProperty<Pos>`	The overall alignment of the content in this pane (default: `Pos.LEFT`).
`-gridLinesVisible: BooleanProperty`	Is the grid line visible? (default: `false`)
`-hgap: DoubleProperty`	The horizontal gap between the nodes (default: `0`).
`-vgap: DoubleProperty`	The vertical gap between the nodes (default: `0`).
`+GridPane()`	Creates a `GridPane`.
`+add(child: Node, columnIndex: int, rowIndex: int): void`	Adds a node to the specified column and row.
`+addColumn(columnIndex: int, children: Node...): void`	Adds multiple nodes to the specified column.
`+addRow(rowIndex: int, children: Node...): void`	Adds multiple nodes to the specified row.
`+getColumnIndex(child: Node): int`	Returns the column index for the specified node.
`+setColumnIndex(child: Node, columnIndex: int): void`	Sets a node to a new column. This method repositions the node.
`+getRowIndex(child:Node): int`	Returns the row index for the specified node.
`+setRowIndex(child: Node, rowIndex: int): void`	Sets a node to a new row. This method repositions the node.
`+setHalighnment(child: Node, value: HPos): void`	Sets the horizontal alignment for the child in the cell.
`+setValighnment(child: Node, value: VPos): void`	Sets the vertical alignment for the child in the cell.

ShowGridPane

Run

BorderPane



The getter and setter methods for property values and a getter for property itself are provided in the class, but omitted in the UML diagram for brevity.

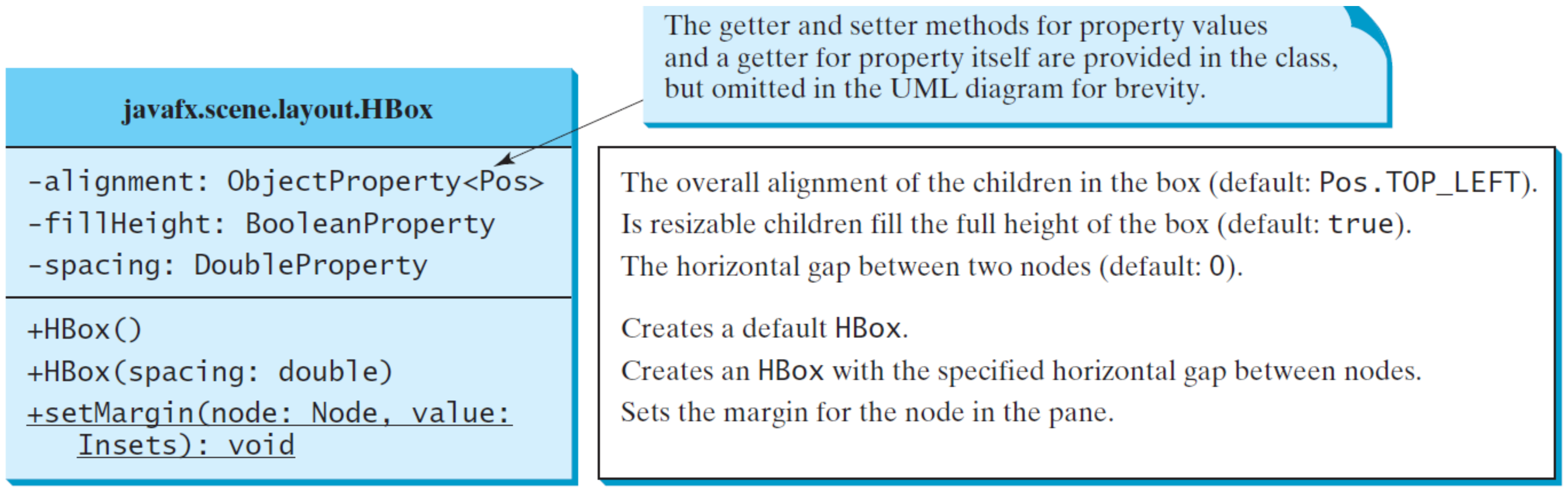
javafx.scene.layout.BorderPane

`-top: ObjectProperty<Node>`	The node placed in the top region (default: `null`).
`-right: ObjectProperty<Node>`	The node placed in the right region (default: `null`).
`-bottom: ObjectProperty<Node>`	The node placed in the bottom region (default: `null`).
`-left: ObjectProperty<Node>`	The node placed in the left region (default: `null`).
`-center: ObjectProperty<Node>`	The node placed in the center region (default: `null`).
`+BorderPane()`	Creates a `BorderPane`.
`+setAlignment(child: Node, pos: Pos)`	Sets the alignment of the node in the `BorderPane`.

ShowBorderPane

Run

HBox



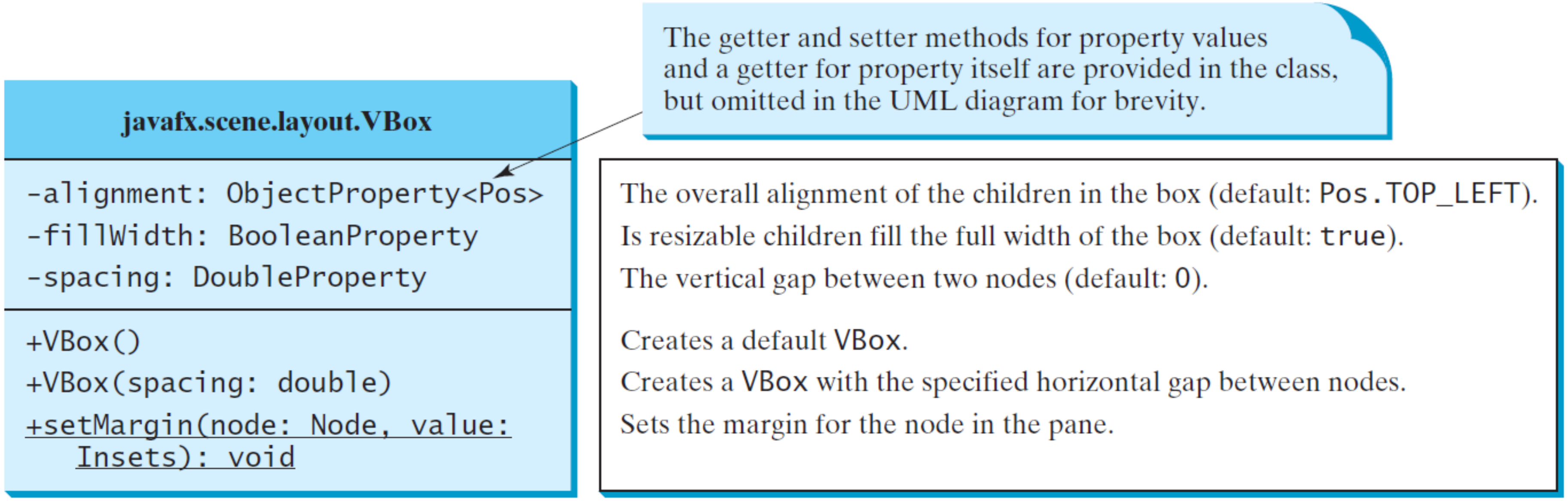
The getter and setter methods for property values and a getter for property itself are provided in the class, but omitted in the UML diagram for brevity.

```
javafx.scene.layout.HBox

-alignment: ObjectProperty<Pos>
-fillHeight: BooleanProperty
-spacing: DoubleProperty

+HBox()
+HBox(spacing: double)
+setMargin(node: Node, value:
   Insets): void
```

The overall alignment of the children in the box (default: `Pos.TOP_LEFT`).
Is resizable children fill the full height of the box (default: `true`).
The horizontal gap between two nodes (default: `0`).

Creates a default `HBox`.
Creates an `HBox` with the specified horizontal gap between nodes.
Sets the margin for the node in the pane.

VBox



The getter and setter methods for property values and a getter for property itself are provided in the class, but omitted in the UML diagram for brevity.

javafx.scene.layout.VBox

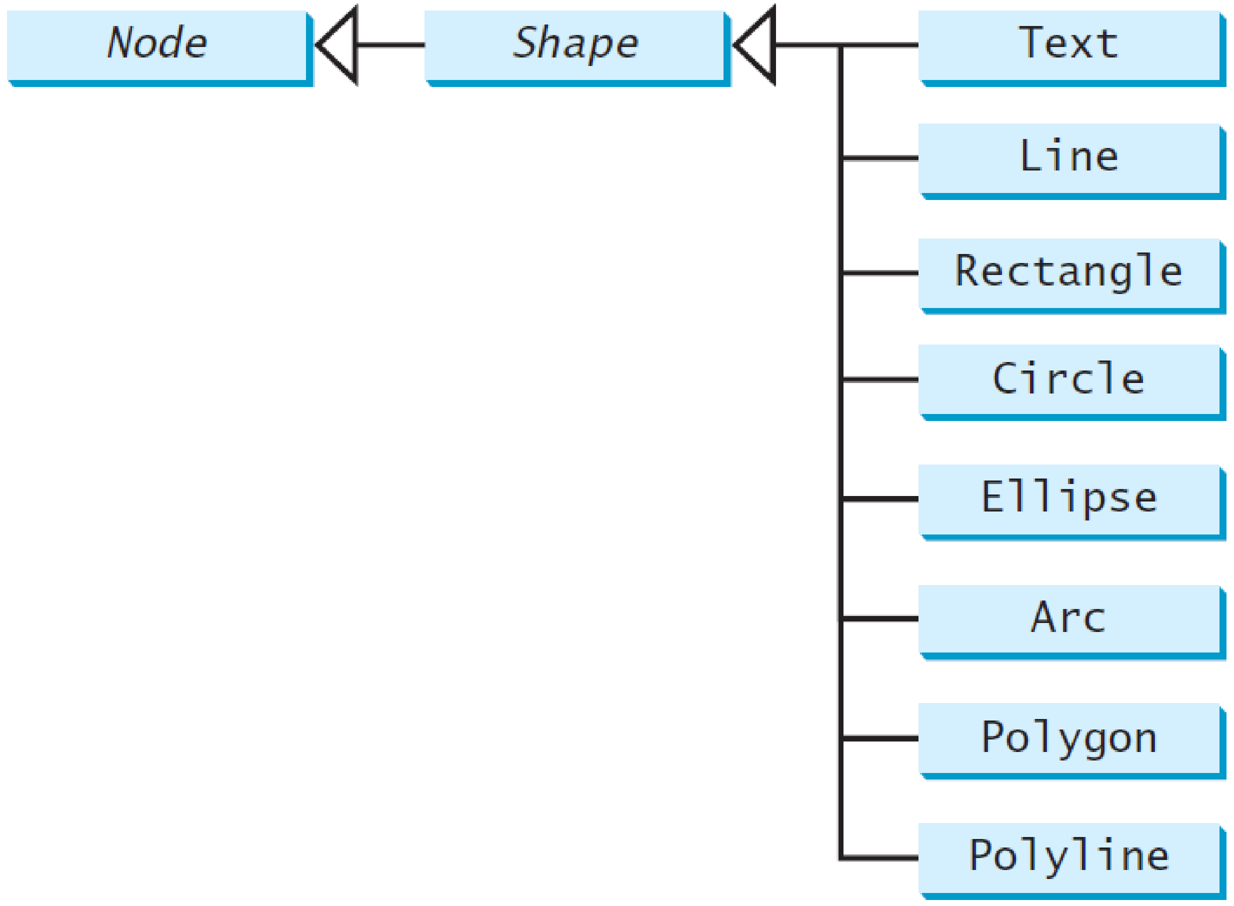
`-alignment: ObjectProperty<Pos>`	The overall alignment of the children in the box (default: `Pos.TOP_LEFT`).
`-fillWidth: BooleanProperty`	Is resizable children fill the full width of the box (default: `true`).
`-spacing: DoubleProperty`	The vertical gap between two nodes (default: `0`).
`+VBox()`	Creates a default `VBox`.
`+VBox(spacing: double)`	Creates a `VBox` with the specified horizontal gap between nodes.
`+setMargin(node: Node, value: Insets): void`	Sets the margin for the node in the pane.

ShowHBoxVBox

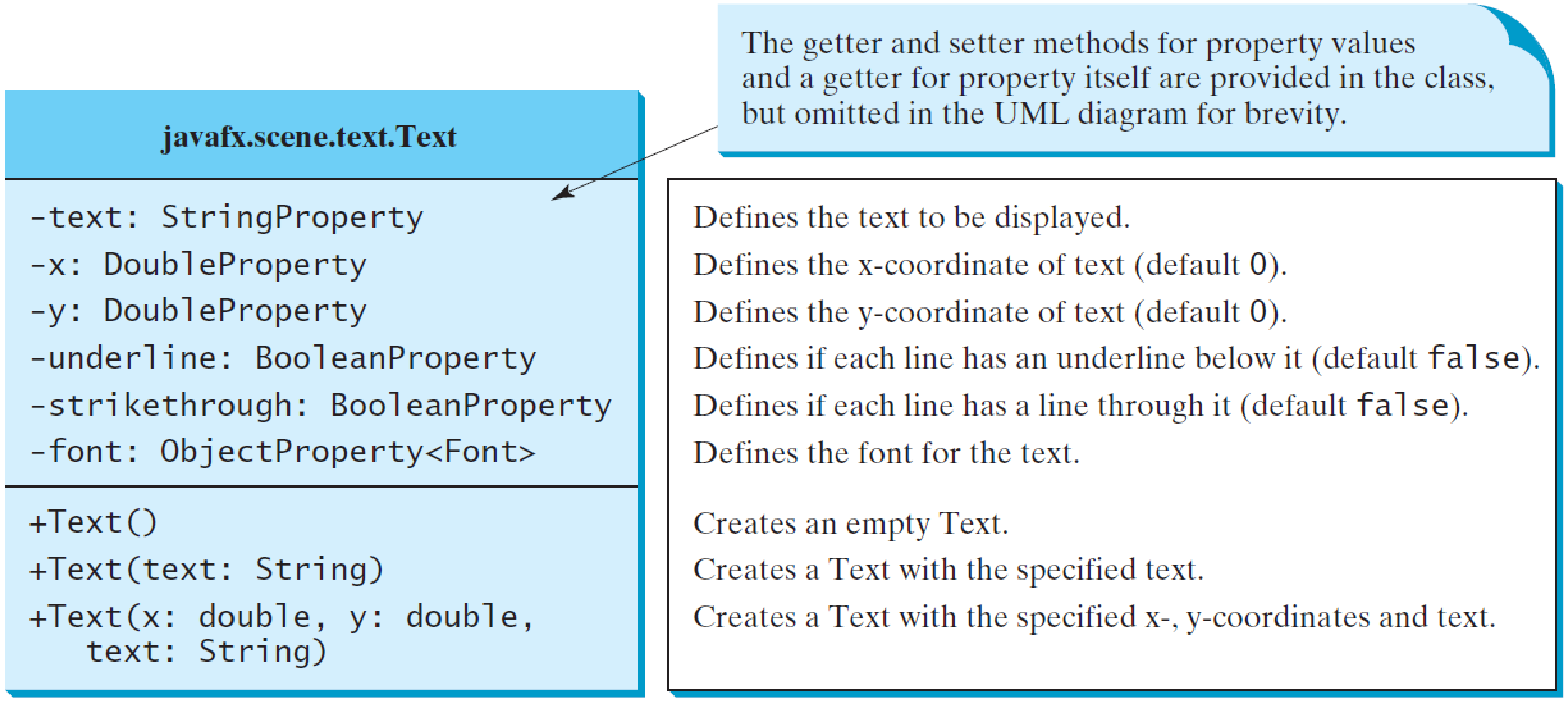
Run

Shapes

JavaFX provides many shape classes for drawing texts, lines, circles, rectangles, ellipses, arcs, polygons, and polylines.



Text

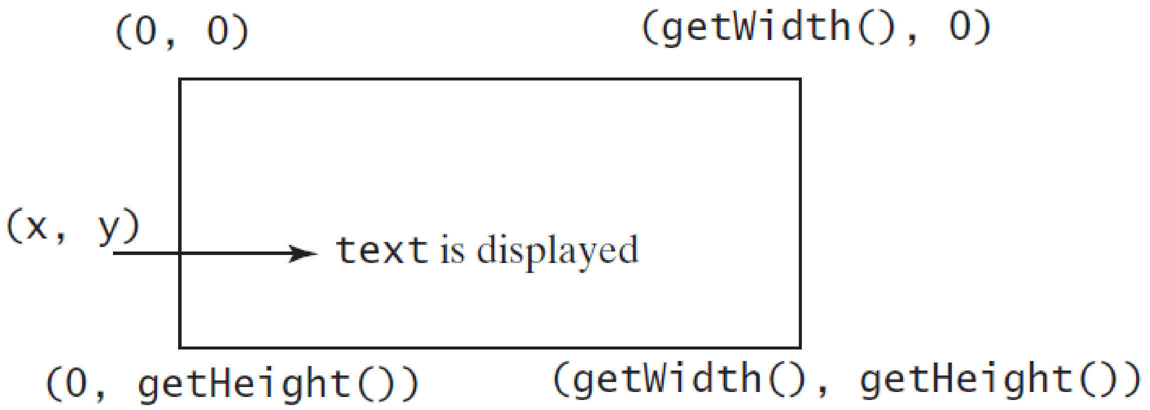


The getter and setter methods for property values and a getter for property itself are provided in the class, but omitted in the UML diagram for brevity.

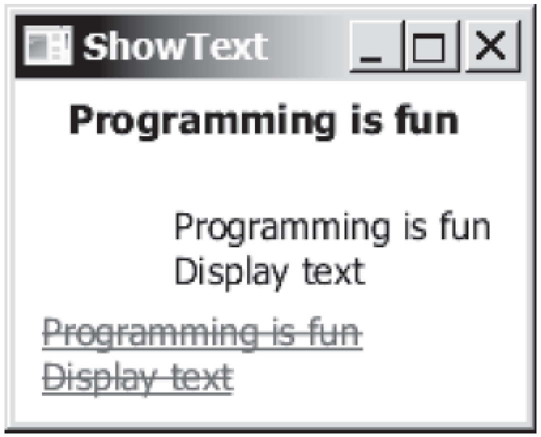
javafx.scene.text.Text

`-text: StringProperty`	Defines the text to be displayed.
`-x: DoubleProperty`	Defines the x-coordinate of text (default `0`).
`-y: DoubleProperty`	Defines the y-coordinate of text (default `0`).
`-underline: BooleanProperty`	Defines if each line has an underline below it (default `false`).
`-strikethrough: BooleanProperty`	Defines if each line has a line through it (default `false`).
`-font: ObjectProperty<Font>`	Defines the font for the text.
`+Text()`	Creates an empty Text.
`+Text(text: String)`	Creates a Text with the specified text.
`+Text(x: double, y: double, text: String)`	Creates a Text with the specified x-, y-coordinates and text.

Text Example



(a) Text(x, y, text)



Programming is fun

Programming is fun
Display text

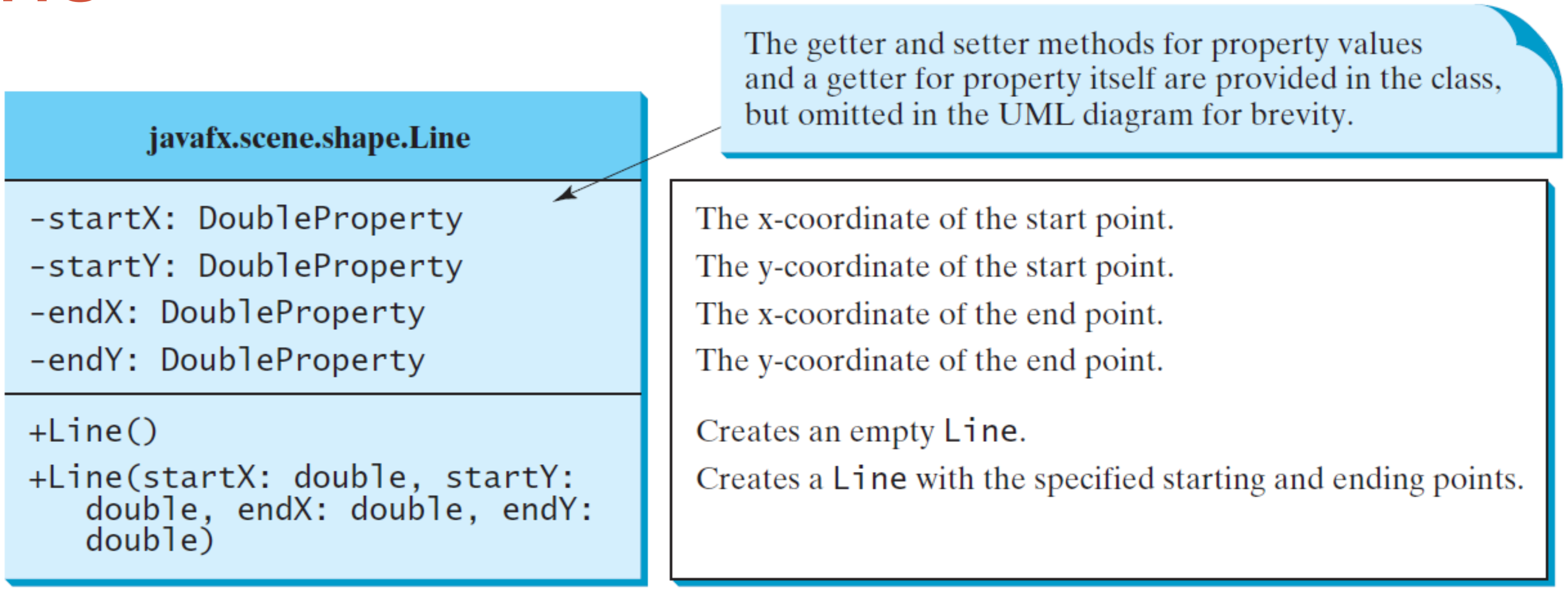
~~Programming is fun~~
~~Display text~~

(b) *Three* Text *objects are displayed*

ShowText

Run

Line



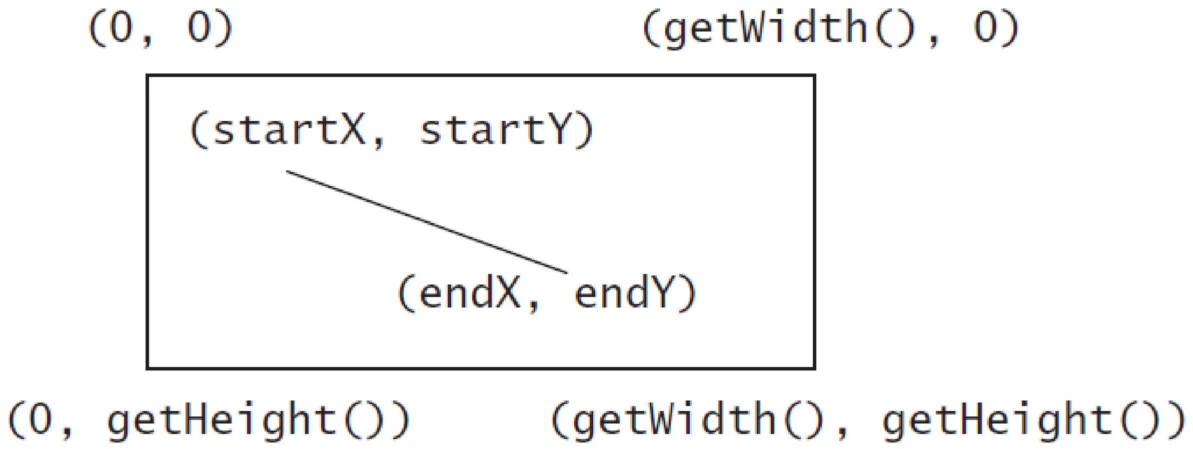
javafx.scene.shape.Line

```
-startX: DoubleProperty
-startY: DoubleProperty
-endX: DoubleProperty
-endY: DoubleProperty

+Line()
+Line(startX: double, startY:
   double, endX: double, endY:
   double)
```

The getter and setter methods for property values and a getter for property itself are provided in the class, but omitted in the UML diagram for brevity.

The x-coordinate of the start point.
The y-coordinate of the start point.
The x-coordinate of the end point.
The y-coordinate of the end point.

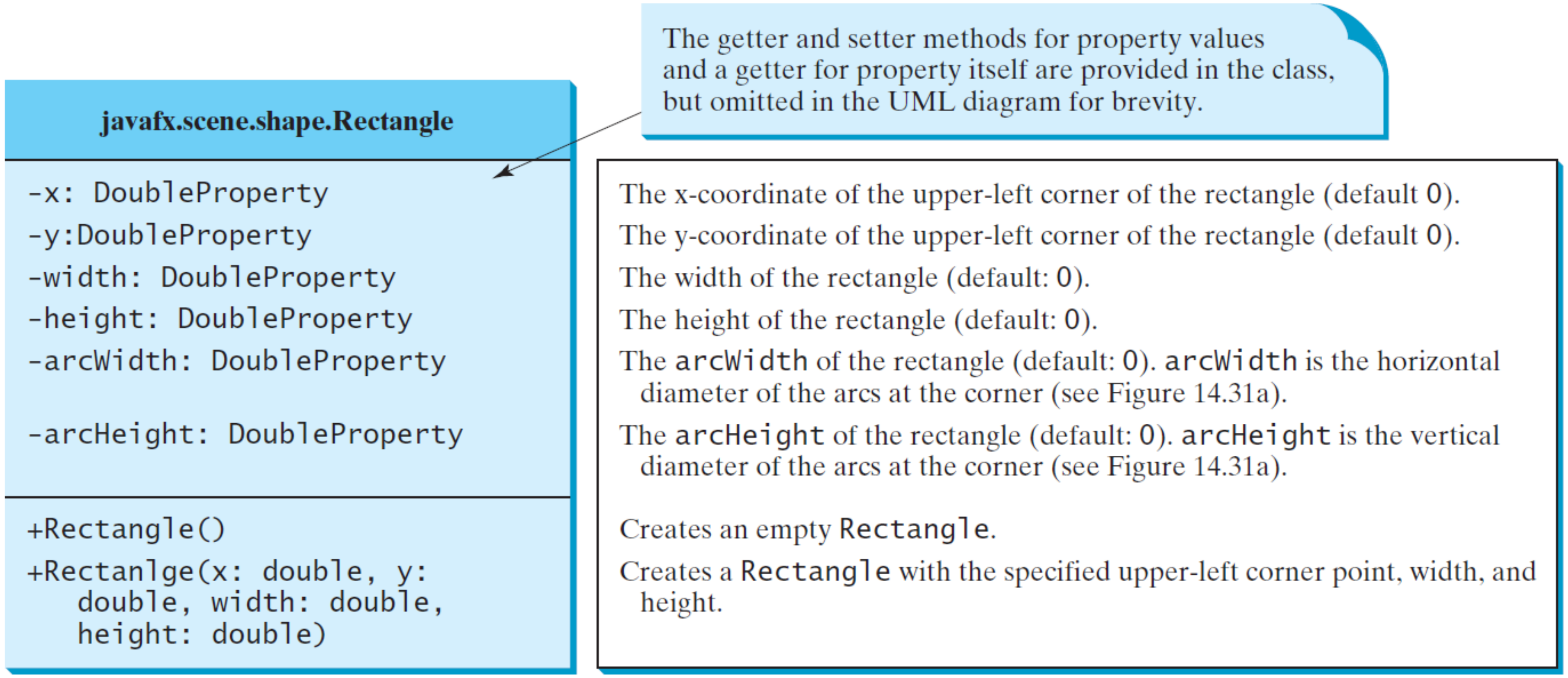
Creates an empty `Line`.
Creates a `Line` with the specified starting and ending points.



ShowLine

Run

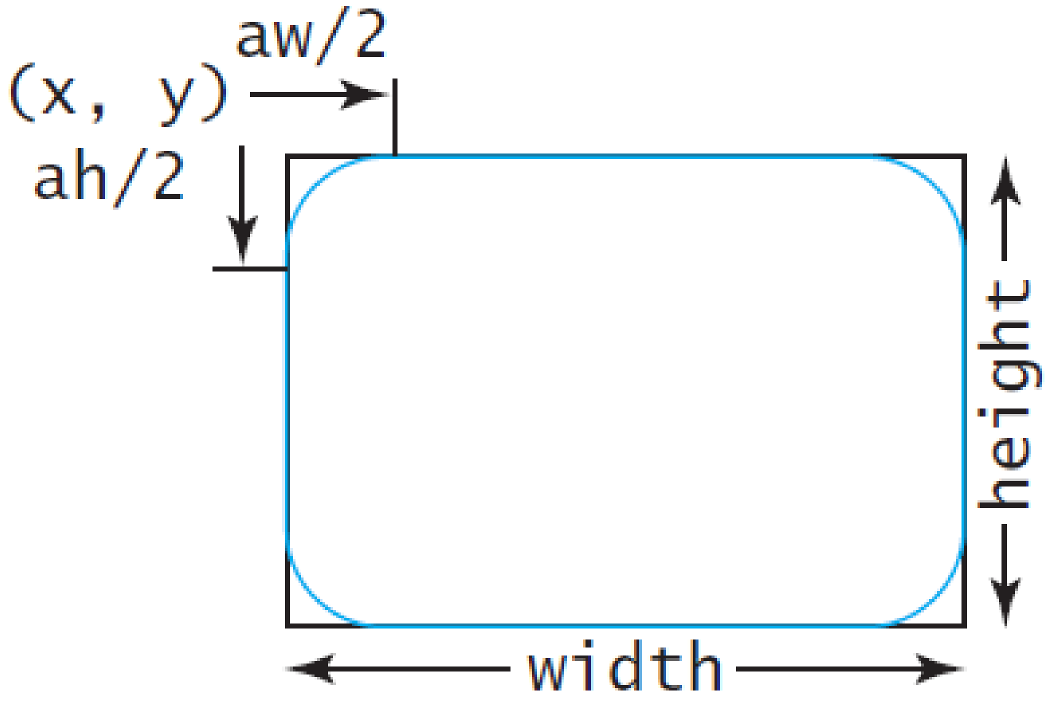
Rectangle



The getter and setter methods for property values and a getter for property itself are provided in the class, but omitted in the UML diagram for brevity.

javafx.scene.shape.Rectangle	
`-x: DoubleProperty`	The x-coordinate of the upper-left corner of the rectangle (default `0`).
`-y:DoubleProperty`	The y-coordinate of the upper-left corner of the rectangle (default `0`).
`-width: DoubleProperty`	The width of the rectangle (default: `0`).
`-height: DoubleProperty`	The height of the rectangle (default: `0`).
`-arcWidth: DoubleProperty`	The `arcWidth` of the rectangle (default: `0`). `arcWidth` is the horizontal diameter of the arcs at the corner (see Figure 14.31a).
`-arcHeight: DoubleProperty`	The `arcHeight` of the rectangle (default: `0`). `arcHeight` is the vertical diameter of the arcs at the corner (see Figure 14.31a).
`+Rectangle()`	Creates an empty `Rectangle`.
`+Rectanlge(x: double, y: double, width: double, height: double)`	Creates a `Rectangle` with the specified upper-left corner point, width, and height.

Rectangle Example

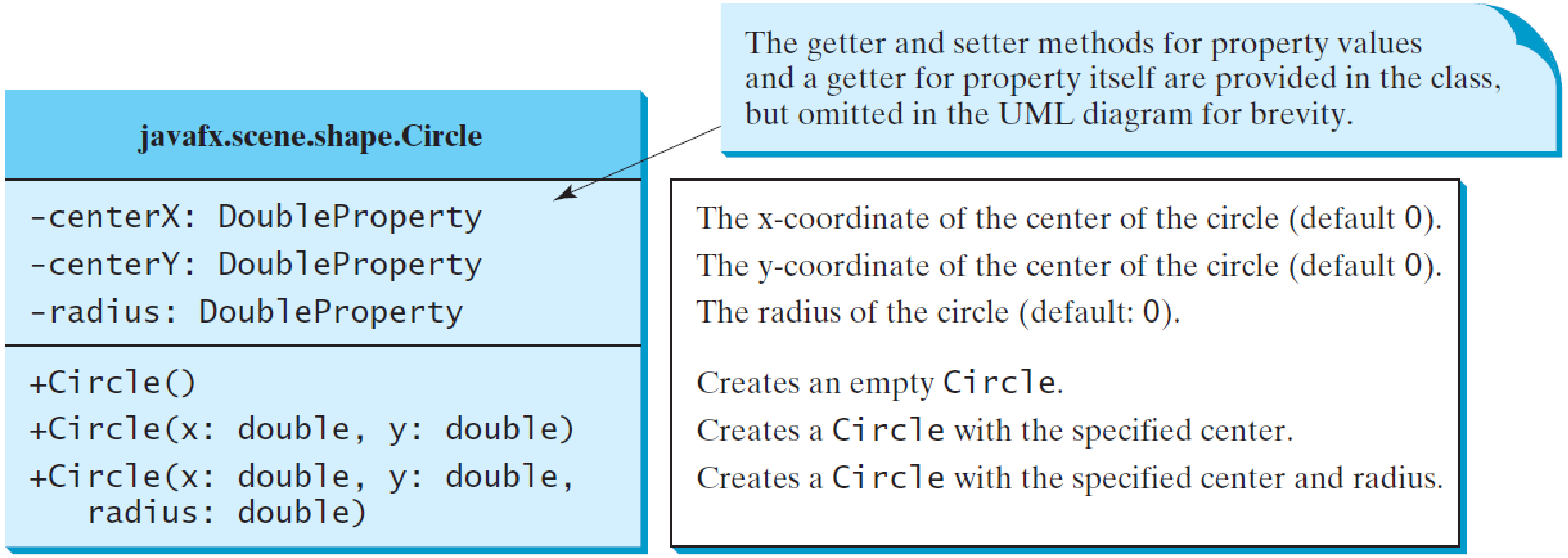


(a) Rectangle(x, y, w, h)

ShowRectangle

Run

Circle



The getter and setter methods for property values and a getter for property itself are provided in the class, but omitted in the UML diagram for brevity.

javafx.scene.shape.Circle

```
-centerX: DoubleProperty
-centerY: DoubleProperty
-radius: DoubleProperty

+Circle()
+Circle(x: double, y: double)
+Circle(x: double, y: double,
   radius: double)
```

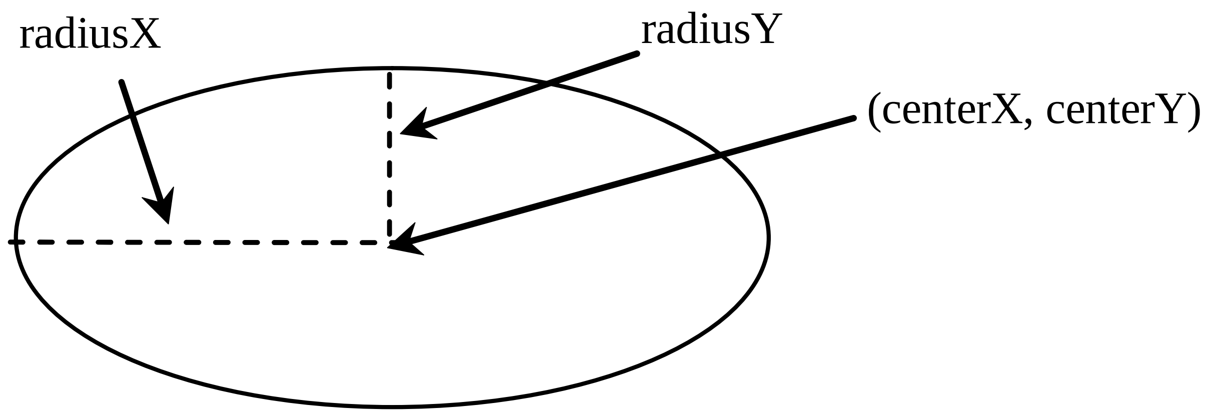
The x-coordinate of the center of the circle (default 0).
The y-coordinate of the center of the circle (default 0).
The radius of the circle (default: 0).

Creates an empty `Circle`.
Creates a `Circle` with the specified center.
Creates a `Circle` with the specified center and radius.

Ellipse

The getter and setter methods for property values and a getter for property itself are provided in the class, but omitted in the UML diagram for brevity.

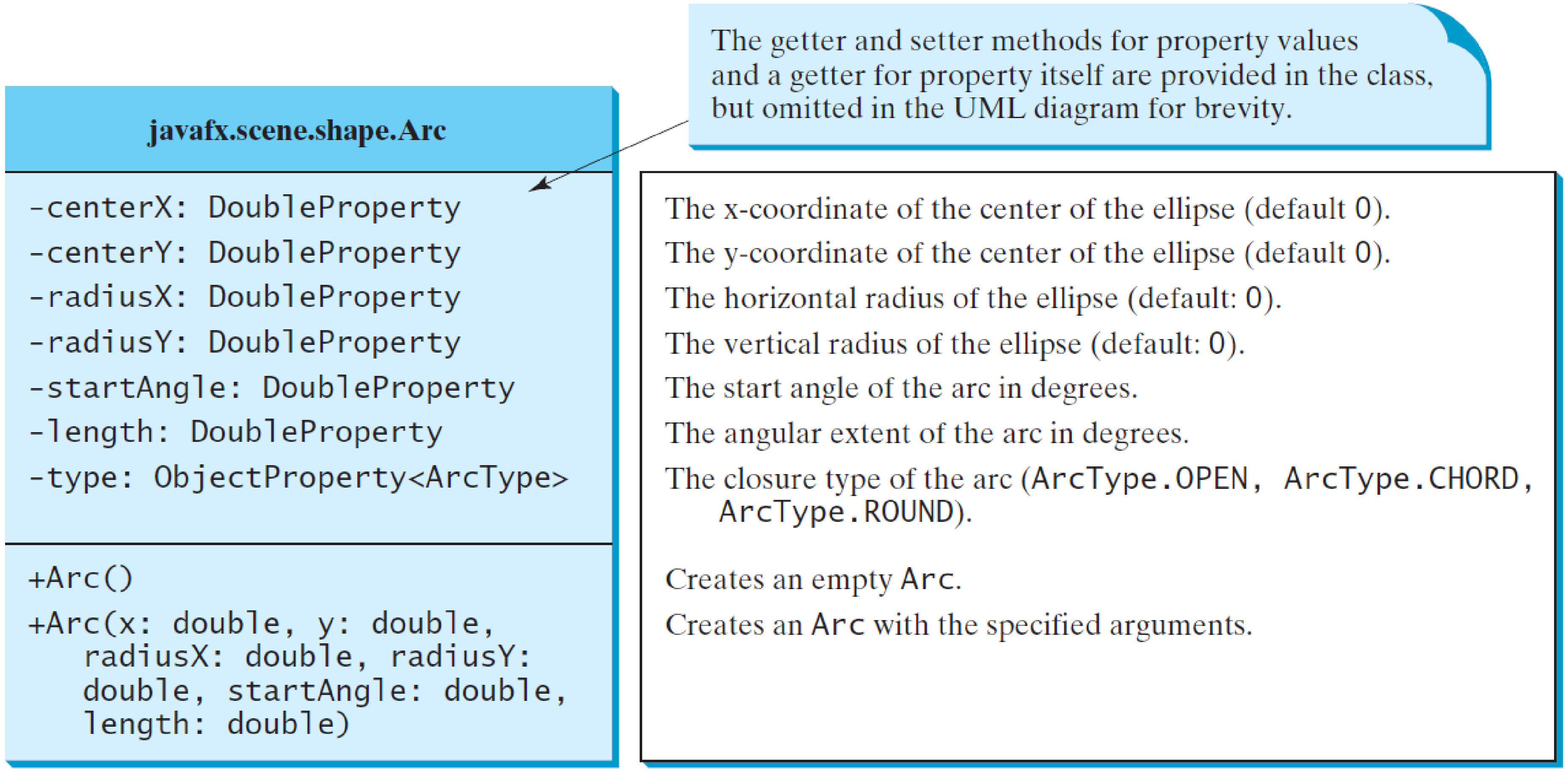
javafx.scene.shape.Ellipse	
`-centerX: DoubleProperty`	The x-coordinate of the center of the ellipse (default 0).
`-centerY: DoubleProperty`	The y-coordinate of the center of the ellipse (default 0).
`-radiusX: DoubleProperty`	The horizontal radius of the ellipse (default: 0).
`-radiusY: DoubleProperty`	The vertical radius of the ellipse (default: 0).
`+Ellipse()`	Creates an empty `Ellipse`.
`+Ellipse(x: double, y: double)`	Creates an `Ellipse` with the specified center.
`+Ellipse(x: double, y: double, radiusX: double, radiusY: double)`	Creates an `Ellipse` with the specified center and radiuses.



ShowEllipse

Run

Arc

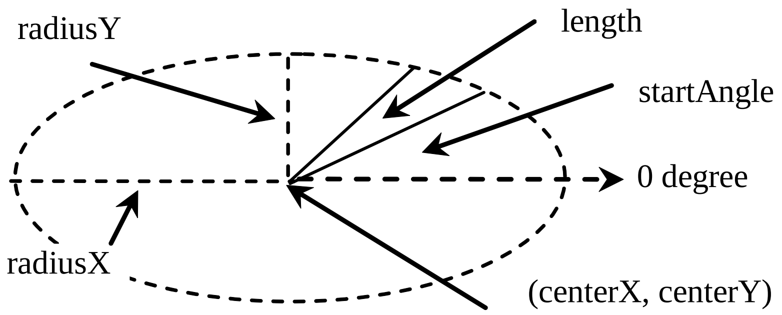


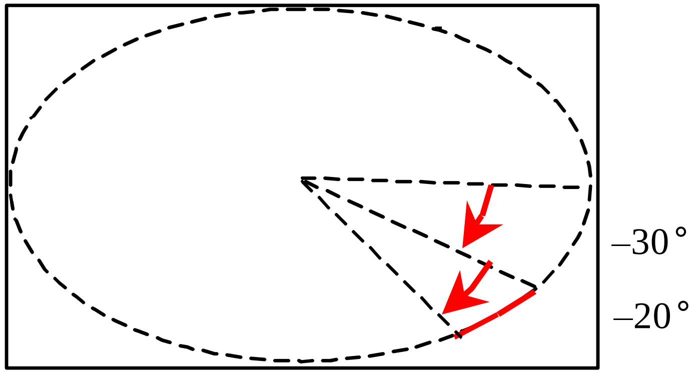
The getter and setter methods for property values and a getter for property itself are provided in the class, but omitted in the UML diagram for brevity.

javafx.scene.shape.Arc

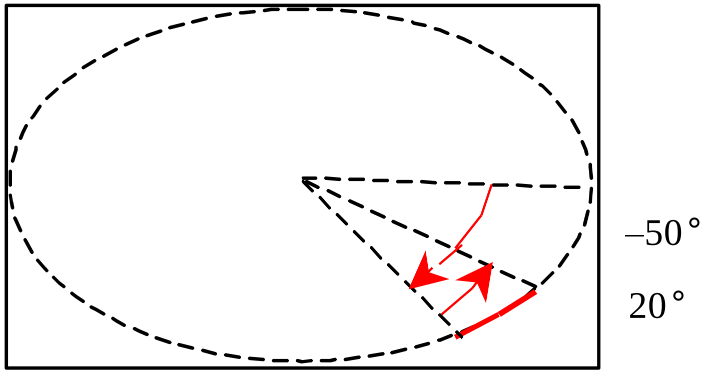
`-centerX: DoubleProperty`	The x-coordinate of the center of the ellipse (default `0`).
`-centerY: DoubleProperty`	The y-coordinate of the center of the ellipse (default `0`).
`-radiusX: DoubleProperty`	The horizontal radius of the ellipse (default: `0`).
`-radiusY: DoubleProperty`	The vertical radius of the ellipse (default: `0`).
`-startAngle: DoubleProperty`	The start angle of the arc in degrees.
`-length: DoubleProperty`	The angular extent of the arc in degrees.
`-type: ObjectProperty<ArcType>`	The closure type of the arc (`ArcType.OPEN`, `ArcType.CHORD`, `ArcType.ROUND`).
`+Arc()`	Creates an empty `Arc`.
`+Arc(x: double, y: double, radiusX: double, radiusY: double, startAngle: double, length: double)`	Creates an `Arc` with the specified arguments.

Arc Examples





(a) Negative starting angle –30° and negative spanning angle –20°

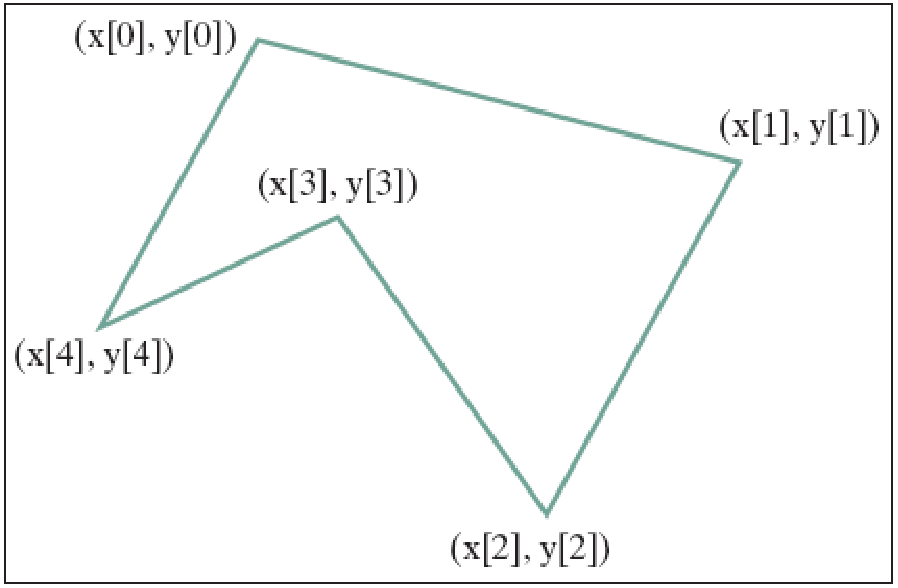


(b) Negative starting angle –50° and positive spanning angle 20°

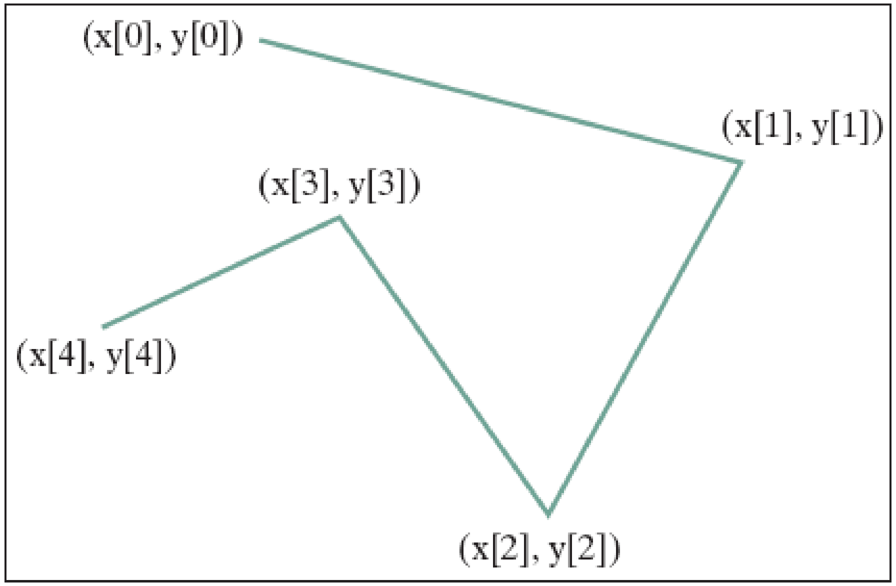
ShowArc

Run

Polygon and Polyline



(a) Polygon

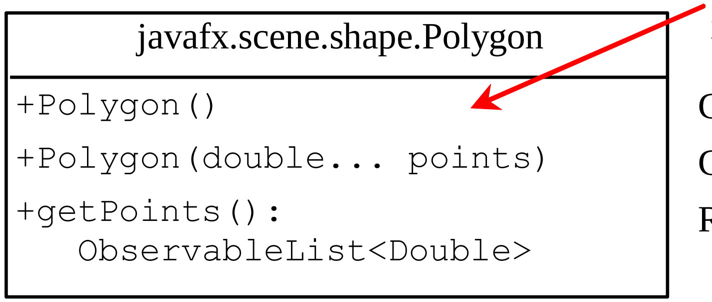


(b) Polyline

ShowArc

Run

Polygon



```
javafx.scene.shape.Polygon
+Polygon()
+Polygon(double... points)
+getPoints():
   ObservableList<Double>
```

The `getter` and `setter` methods for property values and a getter for property itself are provided in the class, but omitted in the UML diagram for brevity.

Creates an empty polygon.

Creates a polygon with the given points.

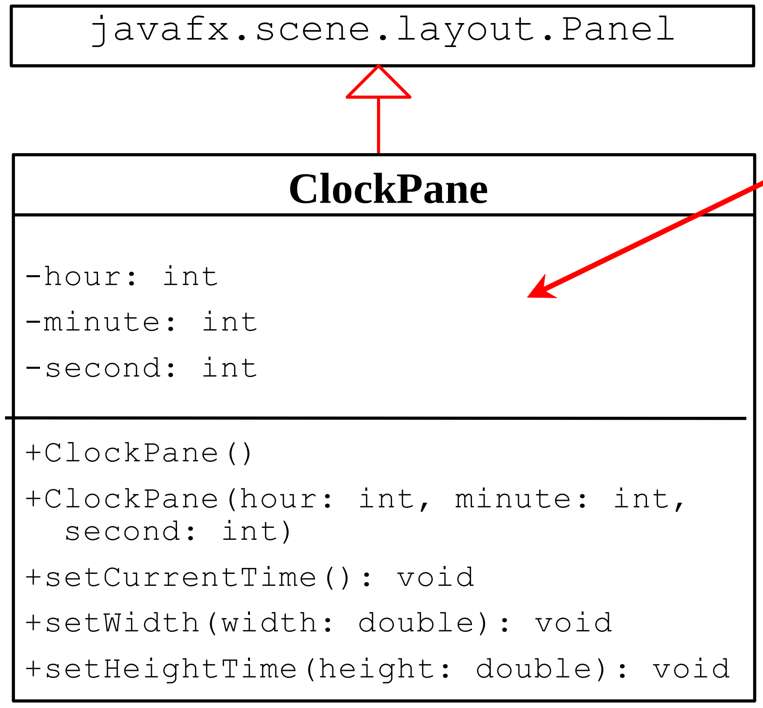
Returns a list of double values as x- and y-coordinates of the points.

ShowPolygon

Run

Case Study: The ClockPane Class

This case study develops a class that displays a clock on a pane.


javafx.scene.layout.Panel
ClockPane
-hour: int
-minute: int
-second: int
+ClockPane()
+ClockPane(hour: int, minute: int, second: int)
+setCurrentTime(): void
+setWidth(width: double): void
+setHeightTime(height: double): void

The getter and setter methods for these data fields are provided in the class, but omitted in the UML diagram for brevity.

The hour in the clock.

The minute in the clock.

The second in the clock.

Constructs a default clock for the current time.

Constructs a clock with the specified time.

Sets hour, minute, and second for current time.
Sets clock pane’s width and repaint the clock,
Sets clock pane’s height and repaint the clock,

ClockPane