JavaFX Graphical User Interfaces: Part 1

Based on Chapter 12 of
Java How to Program, 11/e, Global Edition

Introduction

- A graphical user interface (GUI) presents a user-friendly mechanism for interacting with an app. A GUI (pronounced “GOO-ee”) gives an app a distinctive “look-and-feel.”
- GUIs are built from GUI components—sometimes called controls or widgets.
- “Look-and-feel” is defined as the mechanism needed to interact with an app.

Introduction (Cont.)

- Providing different apps with consistent, intuitive user-interface components gives users a sense of familiarity with a new app, so that they can learn it more quickly and use it more productively.
- Java's GUI, graphics and multimedia API of the future is JavaFX.
- Think about the "look-and-feel" for MS Word or PowerPoint.
  - A Menu Bar across the top has the same set of options such as File, Home, Insert, Design, etc. Wherever the interfaces can be similar, they are similar. This makes it easier to switch between them

JavaFX Parts

- JavaFX has 3 parts
  - A GUI builder called SceneBuilder allows drag-and-drop manipulation of widgets.
  - A configuration language called FXML that records the widgets in the GUI, their visible attributes and their relationship to each other.
  - A Controller class that must be completed by the programmer to bring the GUI to life.
- A JavaFX application has some additional parts
  - A set of classes to describe the model, which is what the GUI allows the user to interact with.
  - A set of cascading style sheets (CSS files) to further specify “look-and-feel”.

JavaFX Scene Builder

- JavaFX Scene Builder is a standalone JavaFX GUI visual layout tool that can also be used with various IDEs including eclipse, NetBeans and IntelliJ.

- JavaFX Scene Builder enables you to create GUIs by dragging and dropping GUI components from Scene Builder's library onto a design area, then modifying and styling the GUI—all without writing any code.

- JavaFX Scene Builder generates FXML (FX Markup Language)—an XML vocabulary for defining and arranging JavaFX GUI controls without writing any Java code.

JavaFX Scene Builder (Cont.)

- The FXML code is separate from the program logic that's defined in Java source code—this separation of the interface (the GUI) from the implementation (the Java code) makes it easier to debug, modify and maintain JavaFX GUI apps.
- Placing GUI components in a window can be tedious. Being able to do it dynamically using a configuration file makes the job much easier.
- No additional compilation is needed unless actions need to be programmed in the Controller.java class.

JavaFX App Window Structure

- A JavaFX app window consists of several parts (Fig. 12.1)
- Figure 12.1 contains a labelled image of a Tip Calculator GUI.

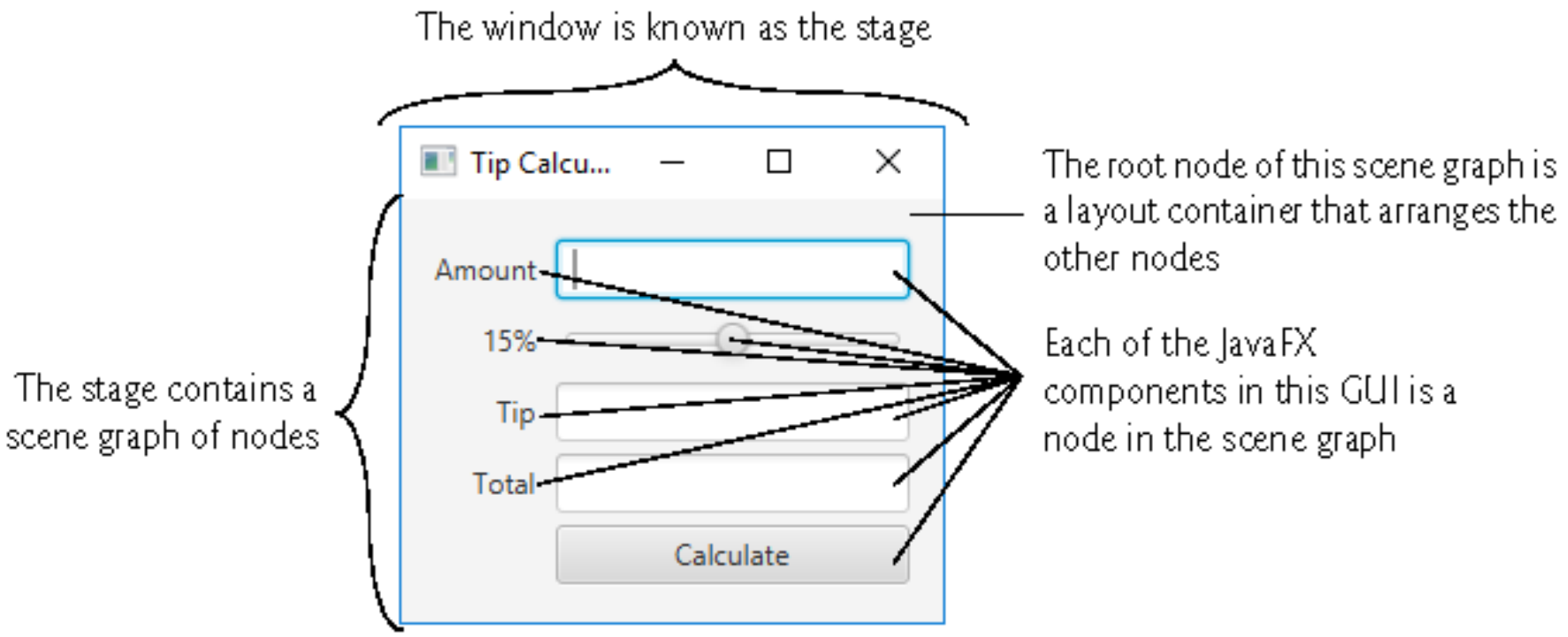


Fig. 12.1 | JavaFX app window parts.

JavaFX App Window Structure (cont.)

- The **Stage** is the window in which a JavaFX app's GUI is displayed
  - It's an instance of class **`Stage`** (package `javafx.stage`).
- The **Stage** contains one active **Scene** that defines the GUI as a **scene graph**—a tree data structure of an app's visual elements, such as GUI controls, shapes, images, video, text and.
- The scene is an instance of class **`Scene`** (package `javafx.scene`).
- **Controls** are GUI components, such as
  - `Labels` that display text,
  - `TextFields` that enable a program to receive user input,
  - `Buttons` that users click to initiate actions, and more.

JavaFX Application Layout

- An application Window in JavaFX is known as a Stage.
  - package `javafx.stage`
- A Stage contains an active Scene which is set to a Layout container.
  - package `javafx.scene`
- The Scene may have other Layout containers for organizing Controllers in a Tree organization.
  - Nodes with children are layout containers.
  - Nodes without children are widgets.

JavaFX App Window Structure (cont.)

- Each visual element in the scene graph is a **node**—an instance of a subclass of **`Node`** (package `javafx.scene`), which defines common attributes and behaviors for all nodes

- With the exception of the first node in the scene graph—the **root node**—each node in the scene graph has one parent.

- Nodes can have transforms (e.g., moving, rotating and scaling), opacity (whether a node is transparent, partially transparent or opaque), effects (e.g., drop shadows, blurs, reflection and lighting) and more.

JavaFX controls

- Nodes with children are typically **layout containers** that arrange their child nodes in the scene.
  - Layout containers contain **controls** that accept inputs or other layout containers.

- When the user interacts with a control, the control generates an event.
- Programs can respond to these events—known as event handling—to specify what should happen when each user interaction occurs.

- An **event handler** is a method that responds to a user interaction. An FXML GUI's event handlers are defined in a so-called **controller class**.

Welcome App—Displaying Text and an Image

- In this section, *without writing any code* you'll build a GUI that displays text in a `Label` and an image in an `ImageView` (Fig. 12.2).
- You'll use only visual programming techniques to *drag-and-drop* JavaFX components onto Scene Builder's content panel—the design area.
- You'll use Scene Builder's **Inspector** to configure options, such as the `Label`'s text and font size, and the `ImageView`'s image.
- You'll view the completed GUI using Scene Builder's **Show Preview in Window** option.

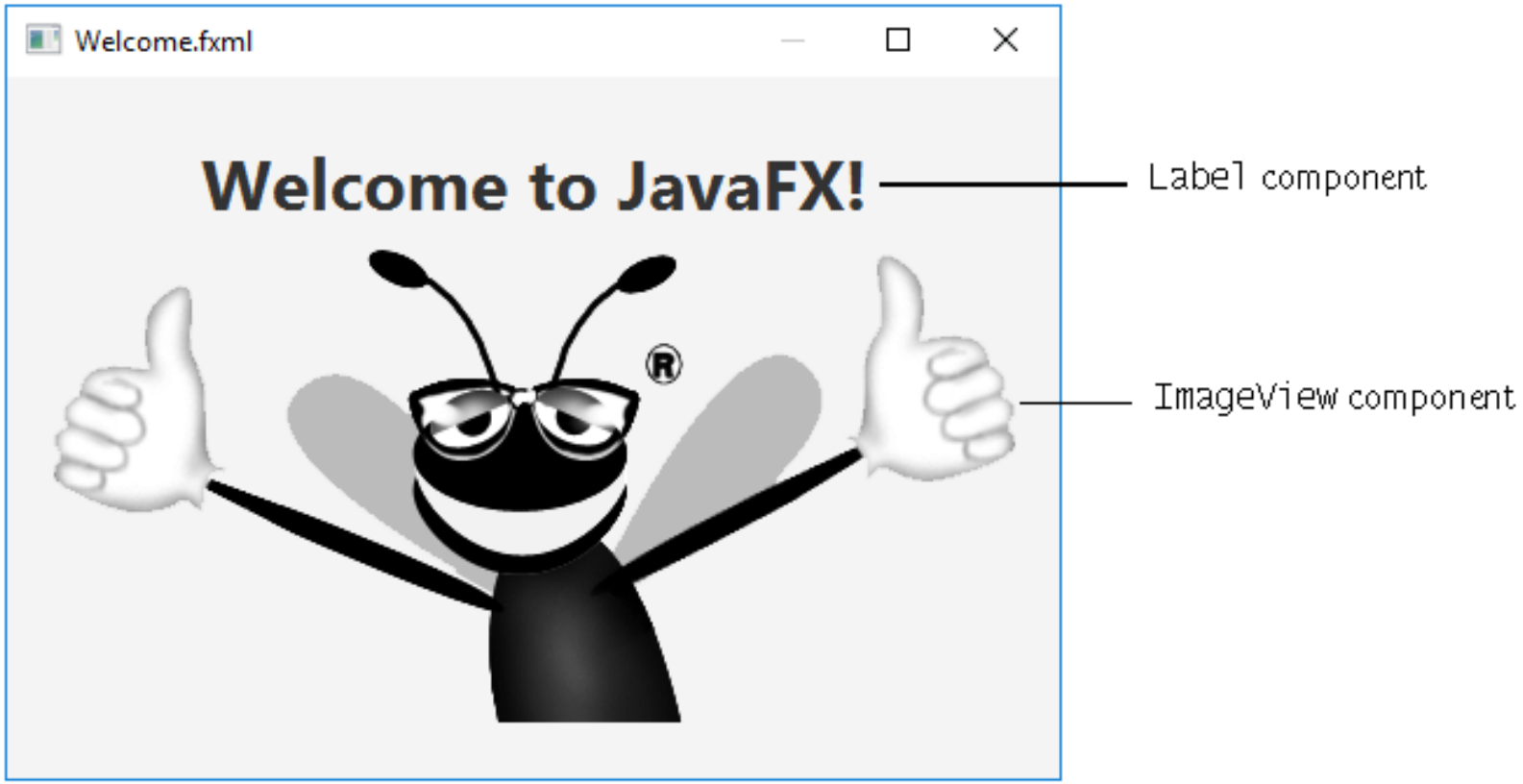


Fig. 12.2 | Final **Welcome** GUI in a preview window on Microsoft Windows 10.

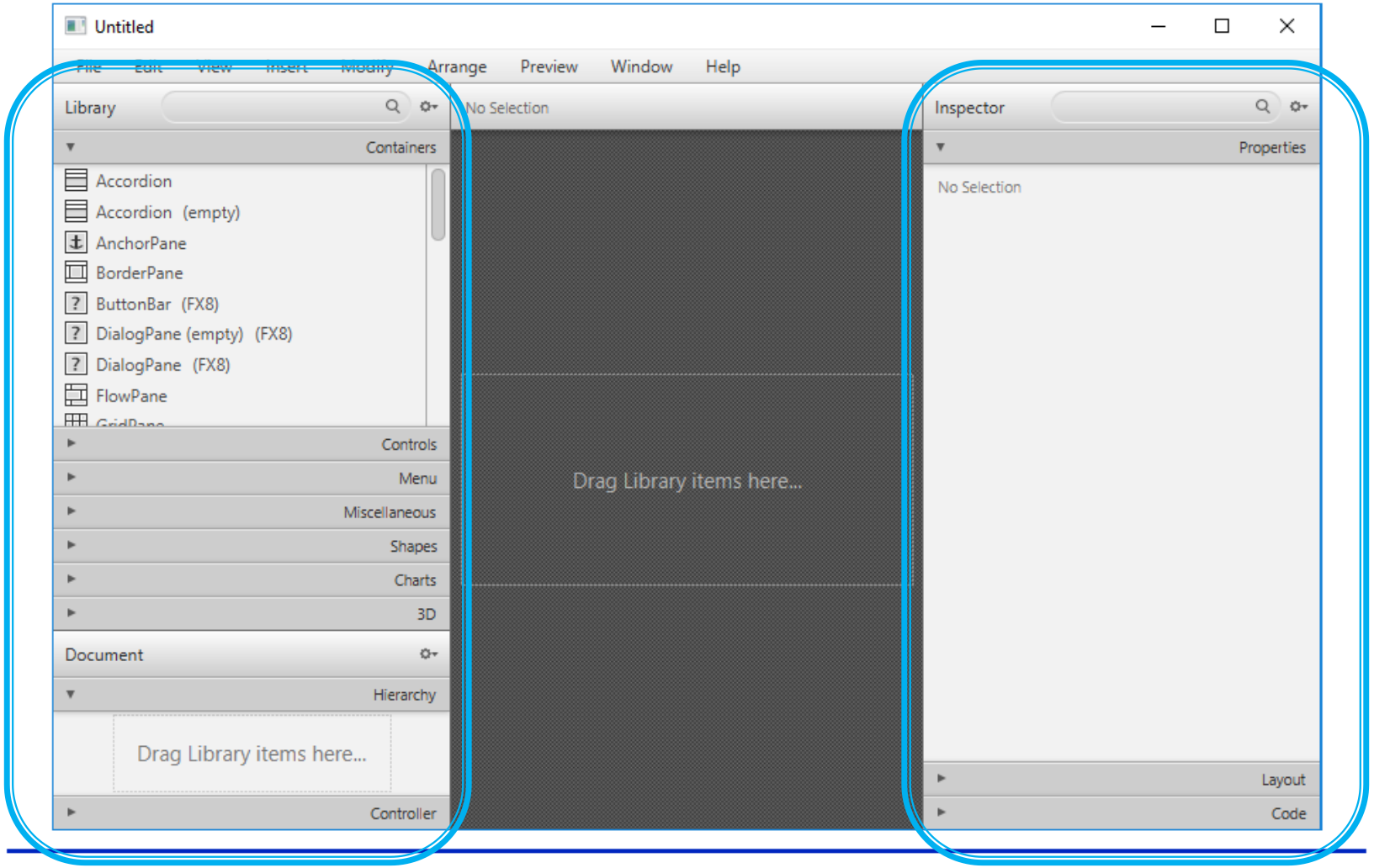
Opening Scene Builder and Creating the File Welcome.fxml

- Open Scene Builder so that you can create the FXML file that defines the GUI. The window initially appears as shown in Fig. 12.3.

- **Untitled** at the top of the window indicates that Scene Builder has created a new FXML file that you have not yet saved.

- Select **File > Save** to display the **Save As** dialog, then select a location in which to store the file, name the file `Welcome.fxml` and click the **Save** button.

Builder Panel on The right



Inspector Panel on The right

Fig. 12.3 | JavaFX Scene Builder when you first open it.

Adding an Image to the Folder Containing Welcome.fxml

- The image you'll use for this app (`bug.png`) is located in the images-subfolder of this chapter's examples folder.

- To make it easy to find the image when you're ready to add it to the app, locate the `images` folder on your file system, then copy `bug.png` into the folder where you saved `Welcome.fxml`.

- https://storm.cis.fordham.edu/harazduk/cs3400/bug.png
  - Right-click and download.

Getting SceneBuilder ready

- SceneBuilder automatically adds an AnchorPane to the canvas.
- Delete the AnchorPane from the SceneBuilder main canvas.
  - On the left-hand side of the tool, find the hierarchy panel 2/3's of the way down and open it.
  - Right-click on the AnchorPane in the hierarchy section of the panel on the left-hand side.
  - Select **x** Delete

Creating a VBox Layout Container

- You'll use a **VBox layout container** (package `javafx.scene.layout`), which will be the scene graph's root node.
- Layout containers help you arrange and size GUI components.
- A VBox arranges its nodes *vertically* from top to bottom.
- To add a VBox to Scene Builder's, double-click VBox in the **Library** window's **Containers** section.
  - You also can drag-and-drop a VBox from the **Containers** section onto Scene Builder's content panel.

Configuring the VBox Layout Container

Specifying the VBox's Alignment

- A VBox's **alignment** determines the layout positioning of the VBox's children.
- Click the **Alignment** property's drop-down list and click **CENTER** to set it.
  - We'd like both children to be centered vertically, so that they are spaced equally above the `Label` and below the `ImageView`.
  - Select the VBox in Scene Builder's content panel by clicking it. Scene Builder displays many VBox properties in the Scene Builder **Inspector**'s **Properties** section.
- Each property value you specify for a JavaFX object is used to set one of that object's instance variables when JavaFX creates the object at runtime.

Configuring the VBox Layout Container (cont.)

Specifying the VBox's Preferred Size

- The **preferred size** (width and height) of the scene graph's root node is used by the scene to determine its window size when the app begins executing
  - Select the VBox.
  - Click the right arrow next to **Inspector**'s **Layout** section to expand it.
    - The section expands and the right arrow changes to a down arrow. Clicking the arrow again would collapse the section.
  - Click the **Pref Width** property's text field, type `450` and press *Enter* to change the preferred width.
  - Click the **Pref Height** property's text field, type `300` and press *Enter* to change the preferred height.

Adding and Configuring a `Label`

Adding a Label to the VBox

- Expand the Scene Builder Library window's **Controls** section by clicking the right arrow next to **Controls**, then drag-and-drop a `Label` from the **Controls** section onto the `VBox`
  - Scene Builder automatically centers the `Label` object horizontally and vertically in the `VBox`, based on the `VBox`'s **Alignment** property.

Adding and Configuring a `Label` (cont.)

Changing the Label's Text

- Two ways to set the Label
  - double click the Label and input the new text directly, or
  - single click to select the `Label`, then in the **Inspector**'s **Properties** section on the right, set the Text property.

- Set the `Label`'s text to "Welcome to JavaFX!".

Adding and Configuring a `Label` (cont.)

Changing the Label's Font

- Set the `Label` to display in a large bold font.
- Select the `Label`, then in the **Inspector**'s **Properties** section, click the value to the right of the **Font** property.
- In the window that appears, set the **Style** property to **Bold** and the **Size** property to **30 (or 36)**.
- The design should now appear as shown in Fig 12.4.

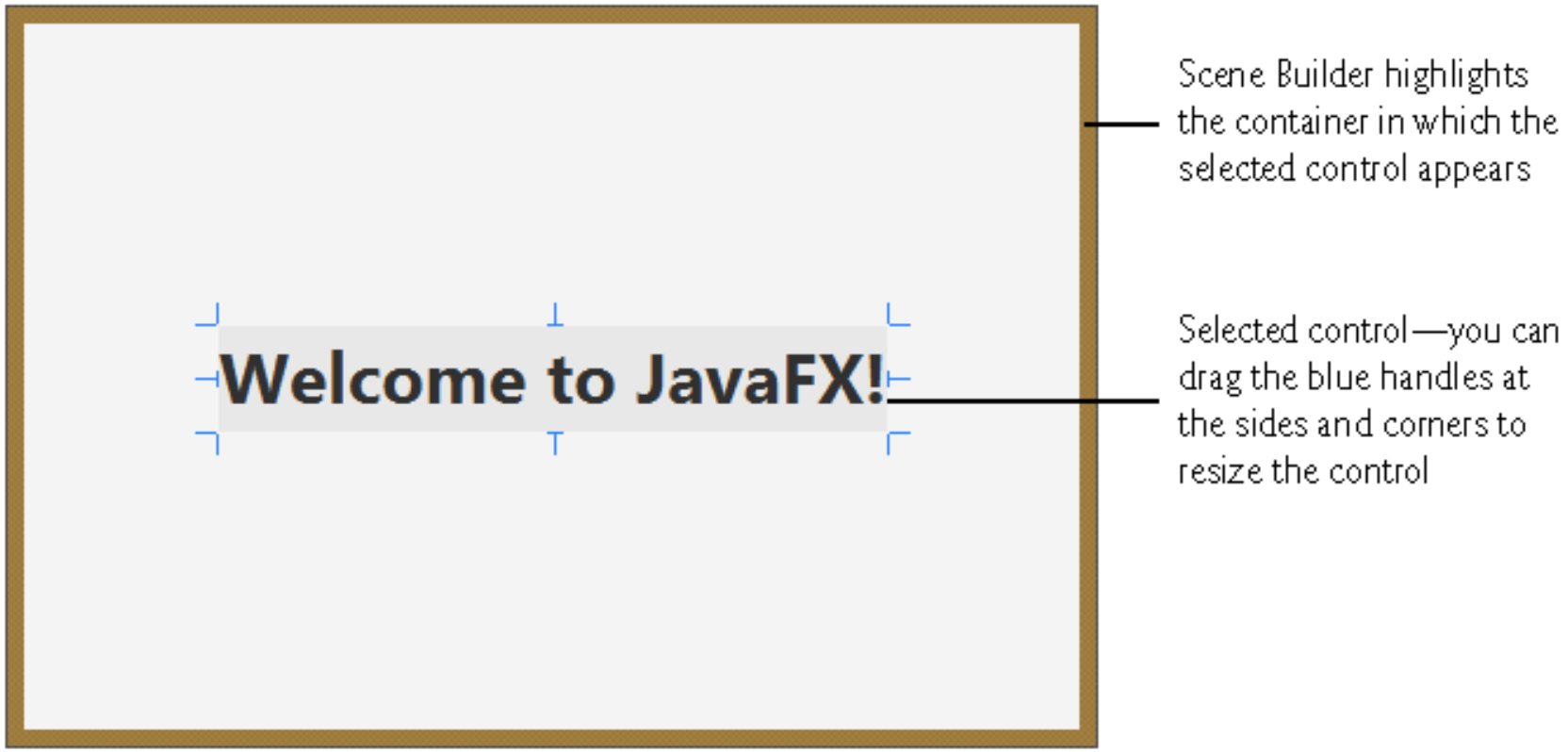


Fig. 12.4 | Welcome GUI's design after adding and configuring a **Label**.

Adding and Configuring an `ImageView`

- Drag and drop an `ImageView` from the Library window's Controls section to just below the `Label`, as shown in Fig. 12.5.
  - You can also double-click `ImageView` in the Library window, in which case Scene Builder automatically places the new `ImageView` object below the `Label`.
- You can reorder a `VBox`'s controls by dragging them in the `VBox` or in the Document window's Hierarchy section (Fig. 12.3).
- Scene Builder automatically centers the `ImageView` horizontally in the `VBox`.
- The `Label` and `ImageView` are centered vertically such that the same amount of space appears above the `Label` and below the `ImageView`.

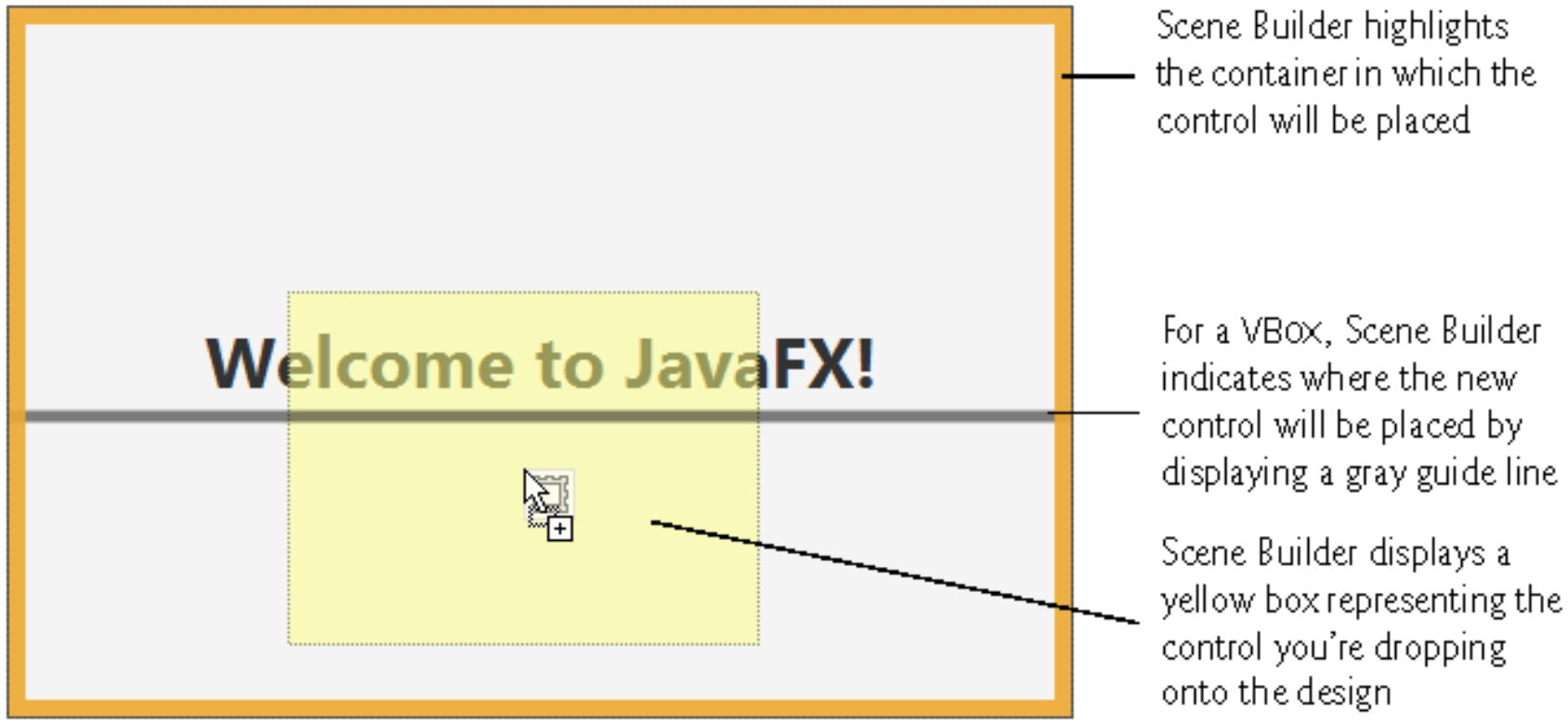


Fig. 12.5 | Dragging and dropping the `ImageView` below the `Label`.

Adding and Configuring an `ImageView` (cont.)

- ***Setting the ImageView's Image***
- Next you'll set the image to display:
  - Select the `ImageView`, then in the **Inspector**'s **Properties** section click the ellipsis (…) button to the right of the **Image** property.
    - By default, Scene Builder opens a dialog showing the folder in which the FXML file is saved.
  - Select the image file, then click **Open**.
    - Scene Builder displays the image and resizes the `ImageView` to match the image's aspect ratio—that is, the ratio of the image's width to its height.

Adding and Configuring an `ImageView` (cont.)

Changing the ImageView's Size

- We'd like to display the image at its original size
- Reset the `ImageView`'s default **Fit Width** and **Fit Height** property values, Scene Builder will resize the `ImageView` to the image's exact dimensions.
  - Expand the **Inspector**'s **Layout** section.
  - Hover the mouse over the **Fit Width** property's value. This displays the button to the right property's value.
  - Click the button and select **Reset to Default** to reset the value.
  - Repeat Step 2 to reset the Fit Height property's value.
- Scene Builder's content panel should now appear as shown in Fig. 12.6.
- Save the FXML file by selecting **File > Save**.

Fig. 12.6 | Completed **Welcome** GUI in Scene Builder's content panel.

Previewing the `Welcome` GUI

- You can preview what the design will look like in a running application's window.
- Select **Preview > Show Preview** in Window, which displays the window in Fig. 12.7.

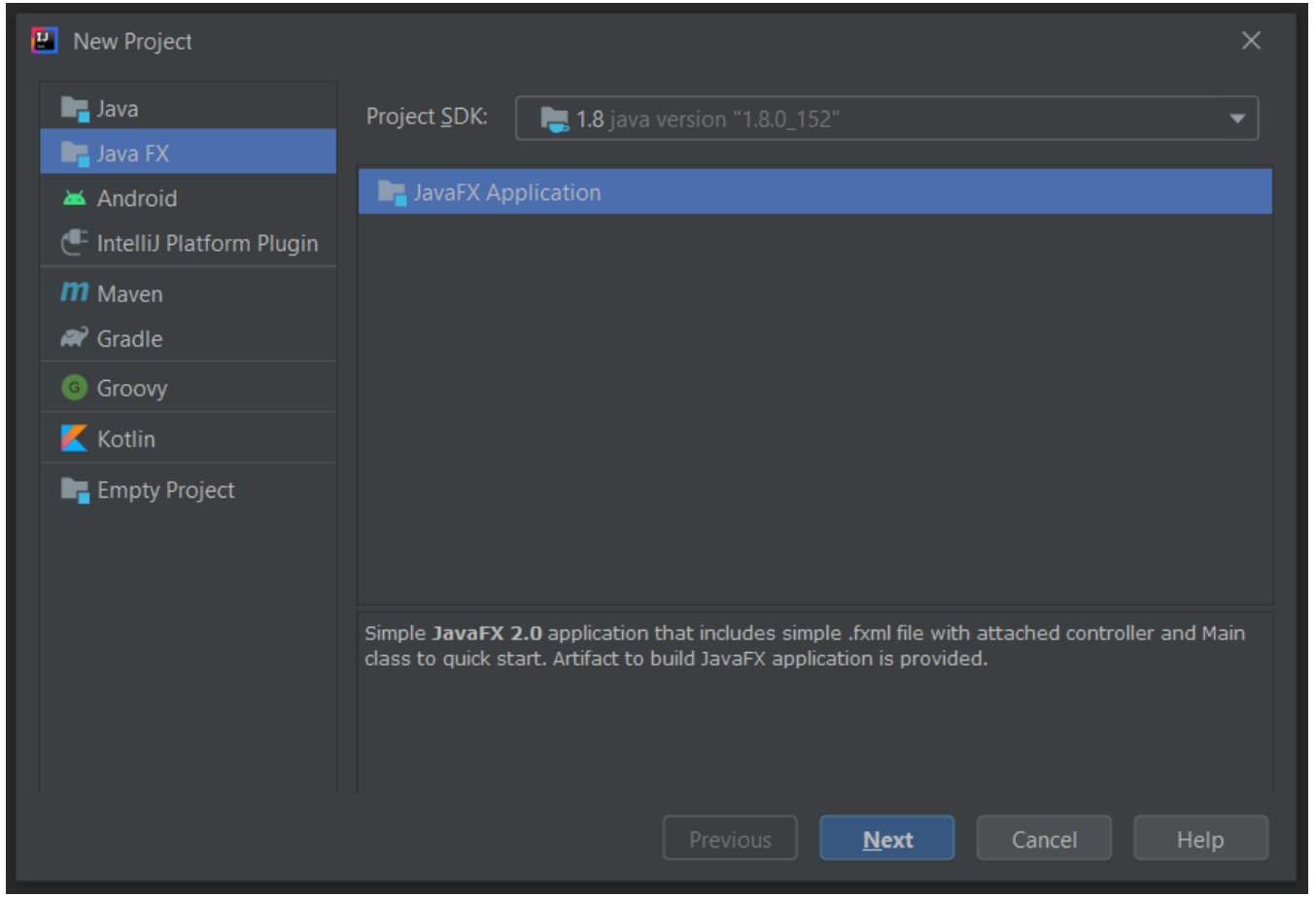
Fig. 12.7 | Previewing the **Welcome** GUI on Microsoft Windows 10—only the window borders will differ on Linux, macOS and earlier Windows versions.

Tip Calculator App—Introduction to Event Handling

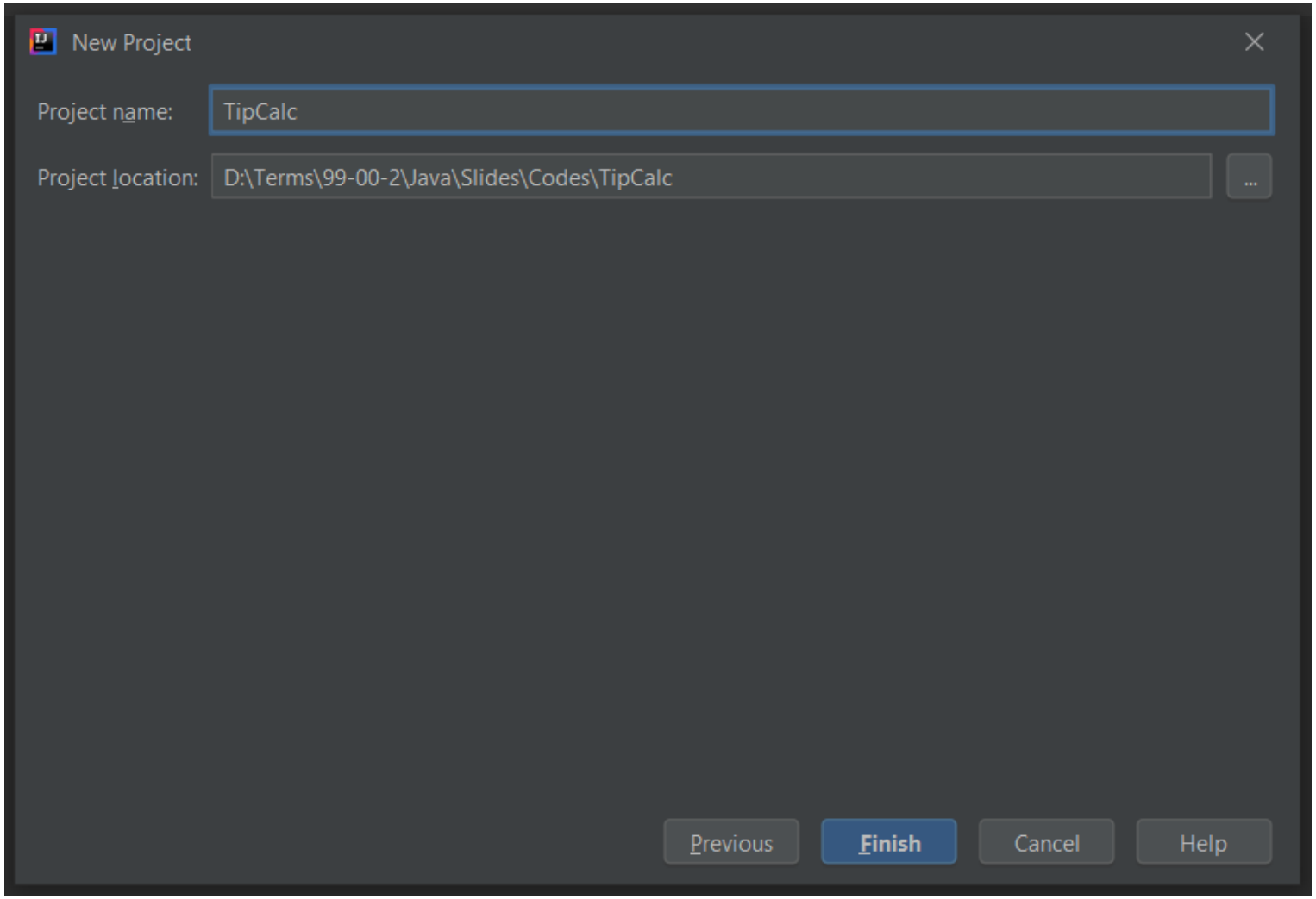
- The Tip Calculator app (Fig. 12.8(a)) calculates and displays a restaurant bill tip and total.
- By default, the app calculates the total with a 15% tip.
- You can specify a tip percentage from 0% to 30% by moving the `Slider` *thumb*—this updates the tip percentage (Fig. 12.8(b) and (c)).
- In this section, you'll build a Tip Calculator app using several JavaFX components and learn how to respond to user interactions with the GUI.

IntelliJ JavaFX project

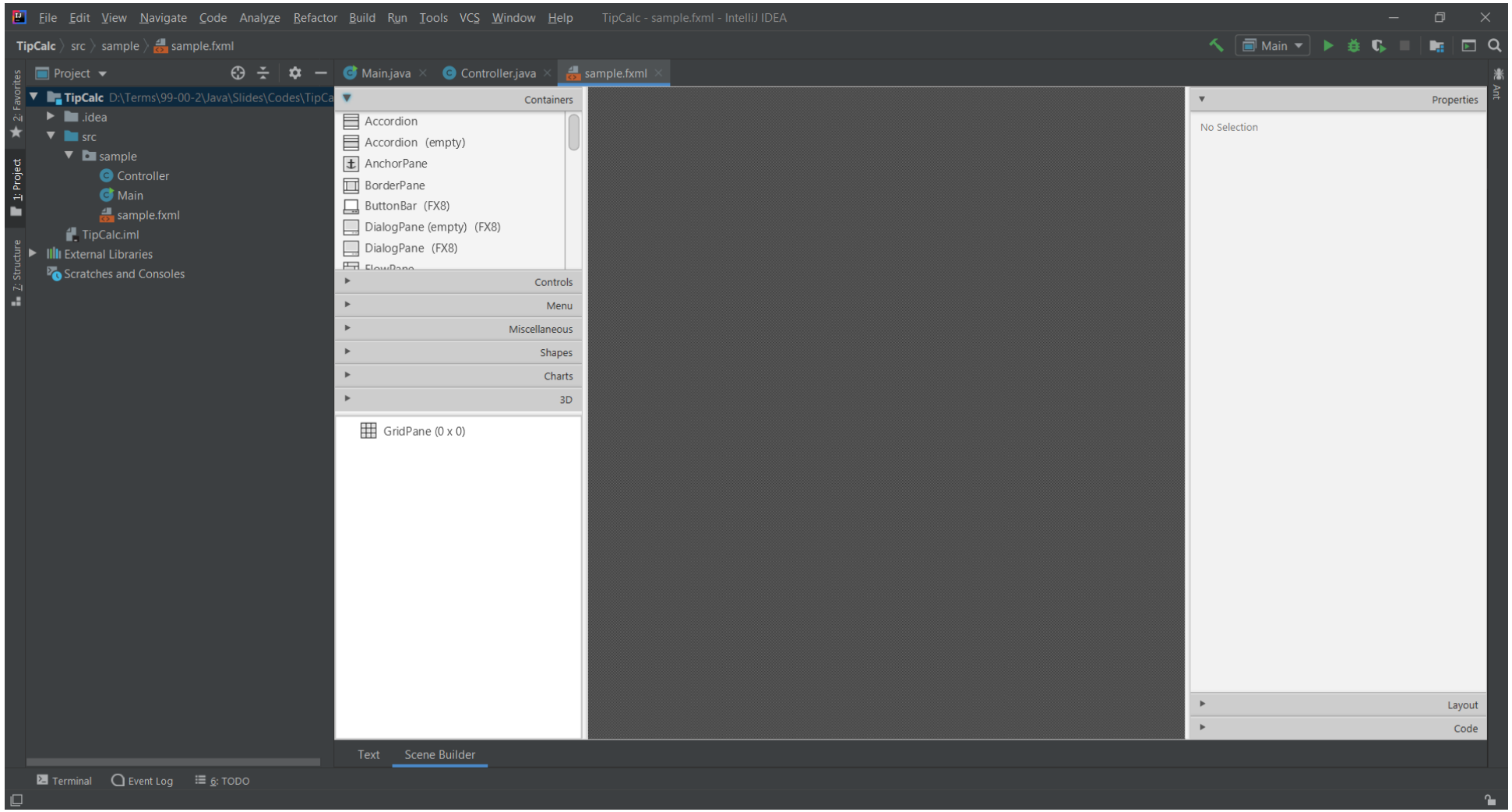
- File menu, select **New -> Project** and then JavaFX



IntelliJ JavaFX project



IntelliJ JavaFX project



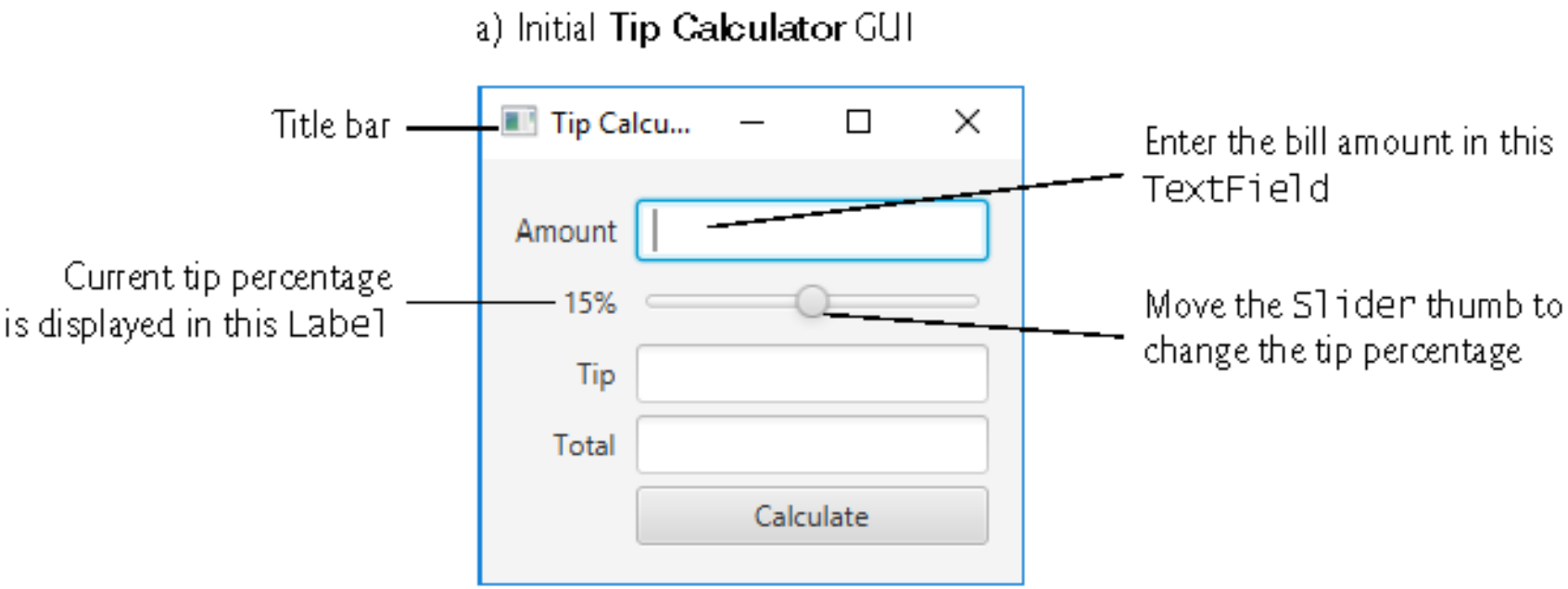


Fig. 12.8 | Entering the bill amount and calculating the tip. (Part 1 of 3.)

b) GUI after you enter the amount 34.56 and click the **Calculate** Button

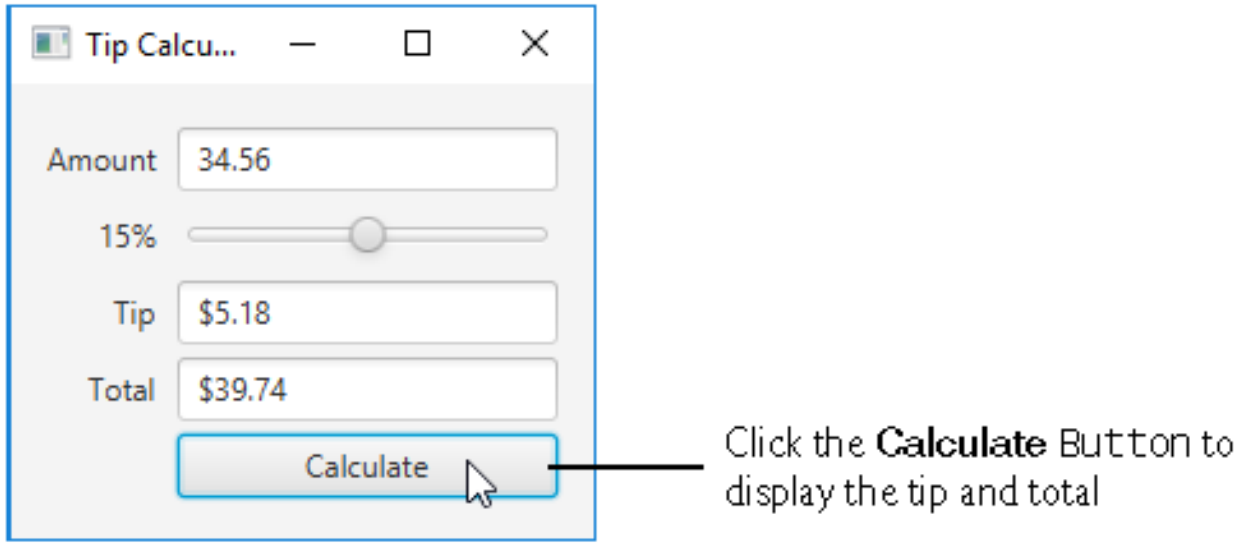


Fig. 12.8 | Entering the bill amount and calculating the tip. (Part 2 of 3.)

c) GUI after user moves the `Slider`'s thumb to change the tip percentage to 20%, then clicks the **Calculate** `Button`

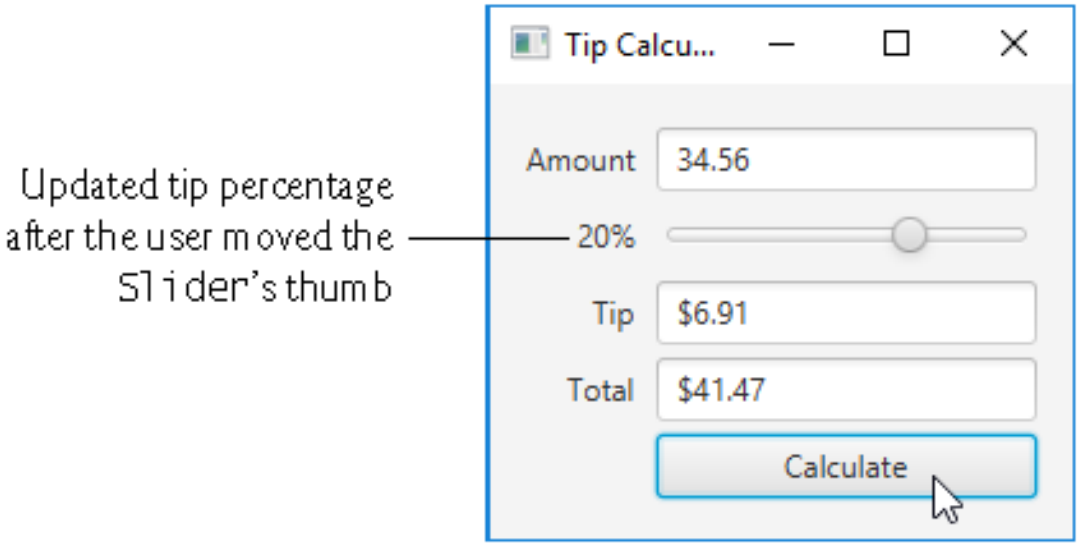


Fig. 12.8 | Entering the bill amount and calculating the tip. (Part 3 of 3.)

Technologies Overview

Class Application

- A subclass of the `Application` class is necessary to launch a JavaFX app
  - (package `javafx.application`).
- When the subclass's `main` method is called:
  - `Application`'s `static` `launch` method is called which transfers control to JavaFX to start the app.
  - The `launch` method, causes the JavaFX runtime to create an object of the `Application` subclass and call its `start` method.
  - The `Application` subclass's `start` method creates the GUI, attaches it to a `Scene` and places it on the `Stage` that `start` receives as an argument.

GridPane is a Layout Container with a Grid

Arranging JavaFX Components with a GridPane

- A `GridPane` (package `javafx.scene.layout`) arranges JavaFX components into columns and rows in a rectangular grid.
- The Tip Calculator app uses a `GridPane` (Fig. 12.9) to arrange views into two columns and five rows.
- Each cell in a `GridPane` can be empty or can hold one or more JavaFX components, including layout containers that arrange other controls.
- Each component in a `GridPane` can span multiple columns or rows, though we did not use that capability in this GUI.
- When you drag a `GridPane` onto Scene Builder's content panel, Scene Builder creates the GridPane with two columns and three rows by default.

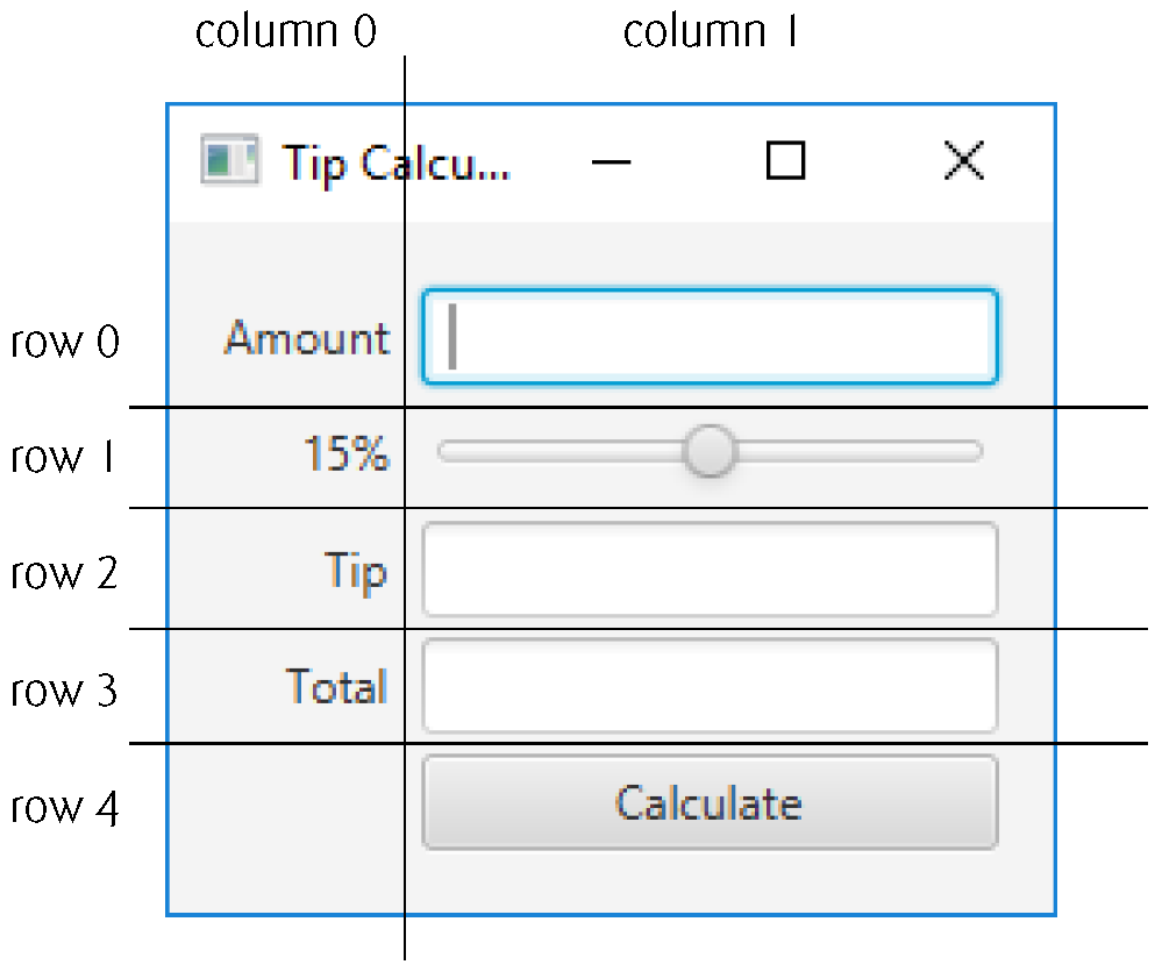


Fig. 12.9 | **Tip Calculator** GUI's `GridPane` labeled by its rows and columns.

A GUI is Made up of Controls

- A `TextField` (package `javafx.scene.control`) can accept text input or display text.
- A `Slider` (package `javafx.scene.control`) represents a value in the range 0.0–100.0 by default and allows the user to select a number in that range by moving the `Slider`'s thumb.
- A `Button` (package `javafx.scene.control`) allows the user to initiate an action.
- Class `NumberFormat` (package `java.text`) can format locale-specific currency and percentage strings.

GUIs are Event Driven

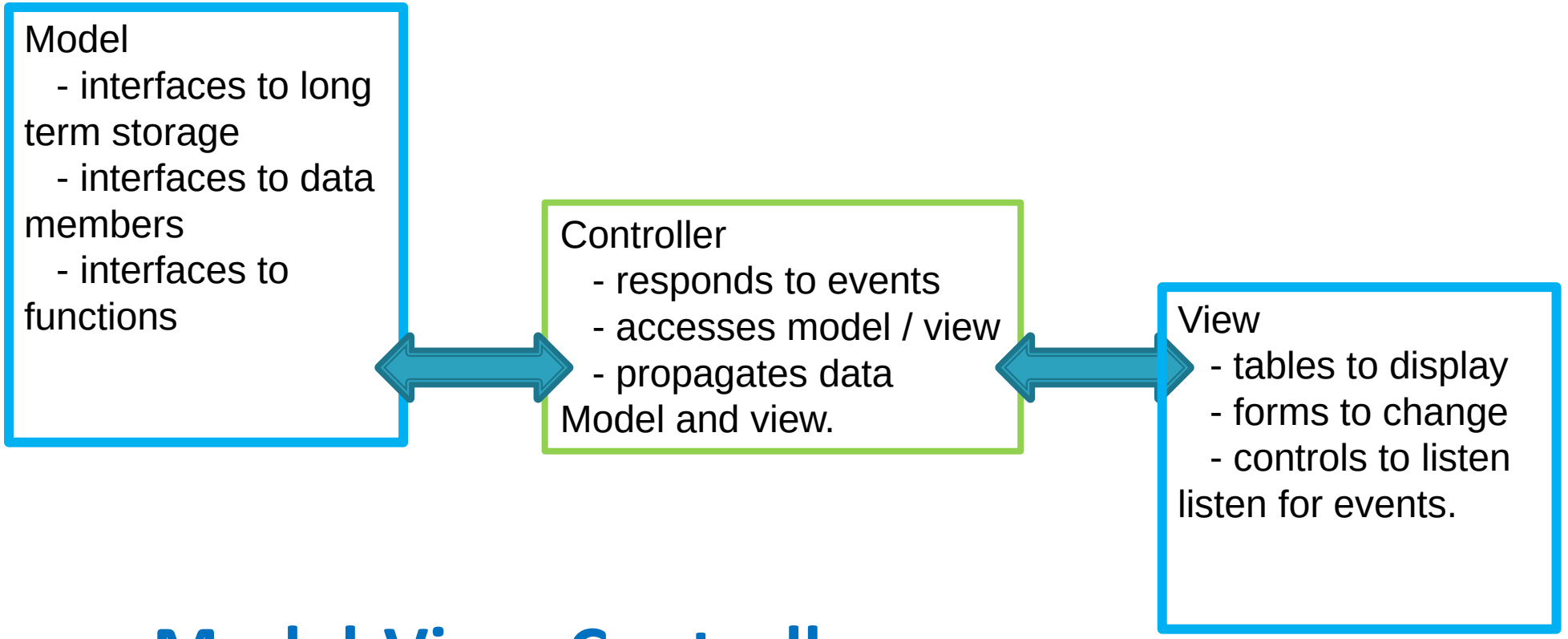
- GUIs are event driven.
  - When the user interacts with a GUI component, the interaction—known as an event—drives the program to perform a task.
- The code that performs a task in response to an event is called an event handler.
- For certain events you can *link* a control to its event-handling method by using the **Code** section of Scene Builder's **Inspector** window.
- You'll create the event handler entirely in code.

Event Handler for a Slider

- You implement the `ChangeListener` interface (package `javafx.beans.value`) to respond when the user moves the `Slider`'s thumb.
- JavaFX applications in which the GUI is implemented as FXML adhere to the Model-View-Controller (MVC) design pattern, which separates an app's data (contained in the model) from the app's GUI (the view) and the app's processing logic (the controller).

MVC means Model-View-Controller

- The model is the domain logic of the application.
- The controller implements logic for processing user inputs.
- The view presents the data stored in the model.
- User input via the controllers modifies the model with the given input.
- Updates to the view from the model come via the controller as well.
- In a simple app, the model and controller are often combined into a single class.
- In a JavaFX FXML app, you define the app's event handlers in a controller class.



Model-View-Controller

Should probably be Model-Controller-View

FXMLLoader and the FXML file

- The controller class defines instance variables for interacting with controls programmatically, as well as event-handling methods.
- Class `FXMLLoader`'s `static` method `load` uses the FXML file that represents the app's GUI to creates the GUI's scene graph and returns a `Parent` (package `javafx.scene`) reference to the scene graph's root node.
- It also initializes the controller's instance variables, and creates and registers the event handlers for any events specified in the FXML.

Building the App's GUI

- The fx:id property must be provided to access the controller in the program. Each object's name is specified via its fx:id property.
- You can set this property's value by selecting a component in your scene, then expanding the Inspector window's Code section—the fx:id property appears at the top.
- Figure 12.10 shows the fx:id properties of the Tip Calculator's programmatically manipulated controls.
- For clarity, our naming convention is to use the control's class name in the fx:id property.

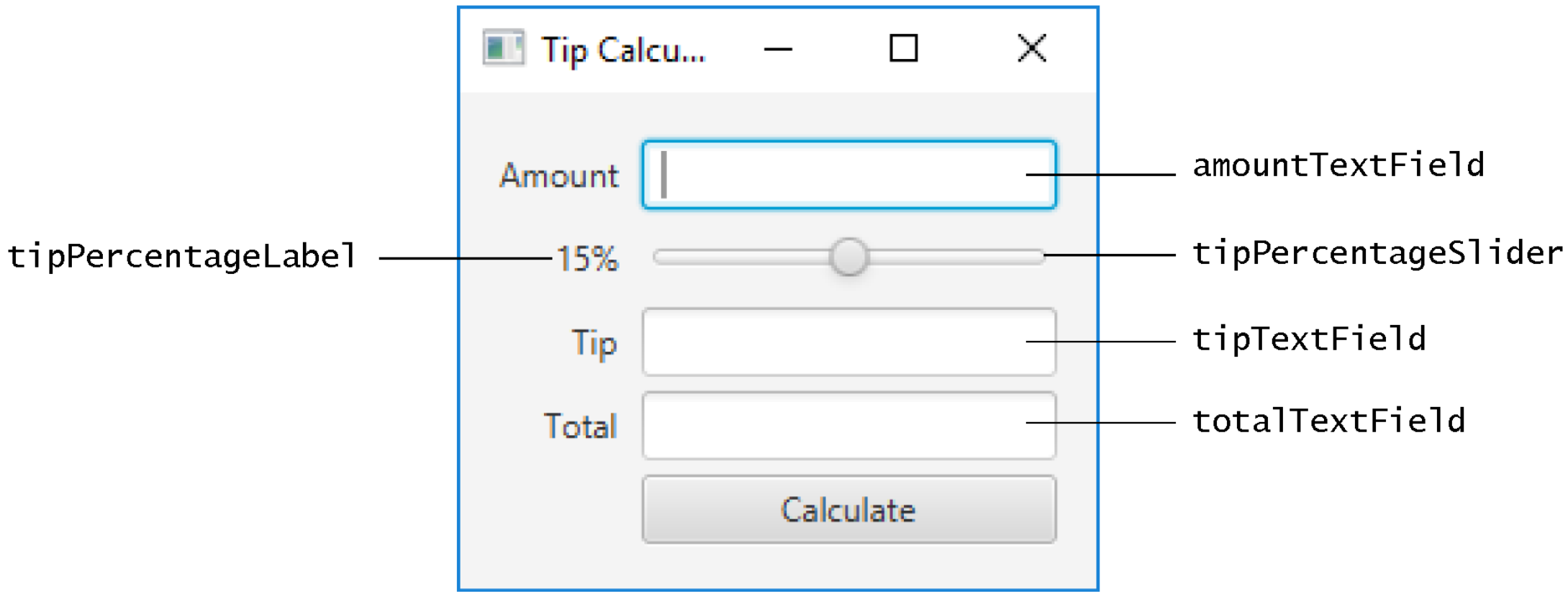


Fig. 12.10 | **Tip Calculator**'s programmatically manipulated controls labeled with their **fx:id**s.

Building the App's GUI (Cont.)

- Open Scene Builder to create a new FXML file. Then, select **File > Save** to display the **Save As** dialog, specify the location in which to store the file, name the file `TipCalculator.fxml` and click the **Save** button.
- Drag a `GridPane` from the **Library** window's **Containers** section onto Scene Builder's content panel.
- By default, the `GridPane` contains two columns and three rows as shown in Fig. 12.11

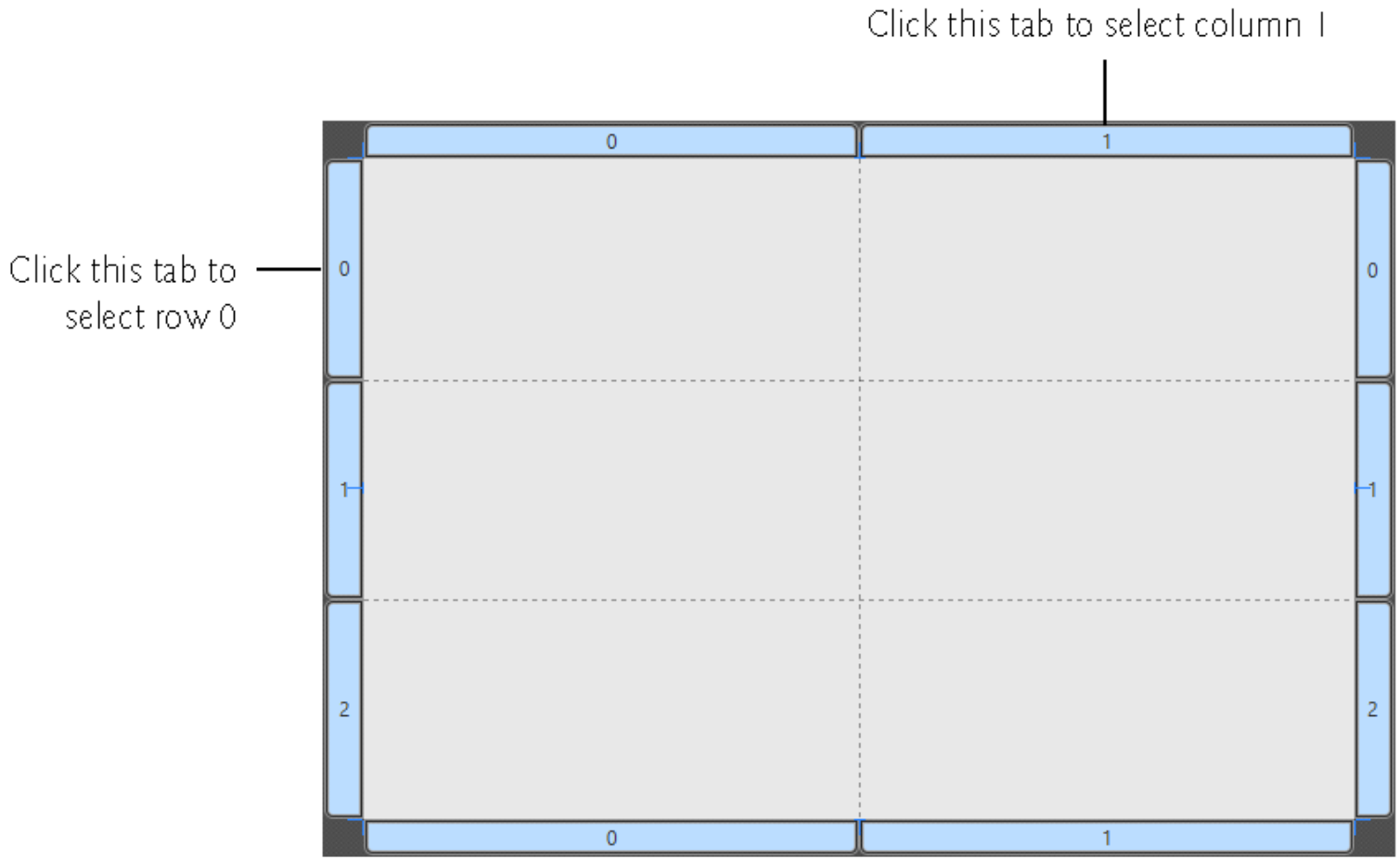


Fig. 12.11 | `GridPane` with two columns (0 and 1) and three rows (0, 1 and 2).

Building the App's GUI (Cont.)

- By default, the `GridPane` contains two columns and three rows.
- You can add a row above or below an existing row by right clicking a row and selecting **Grid Pane > Add Row Above** or **Grid Pane > Add Row Below**.
- You can delete a row or column by right clicking the tab containing its row or column number and selecting **Delete**.
- After adding two rows, the `GridPane` should appear as shown in Fig. 12.12.

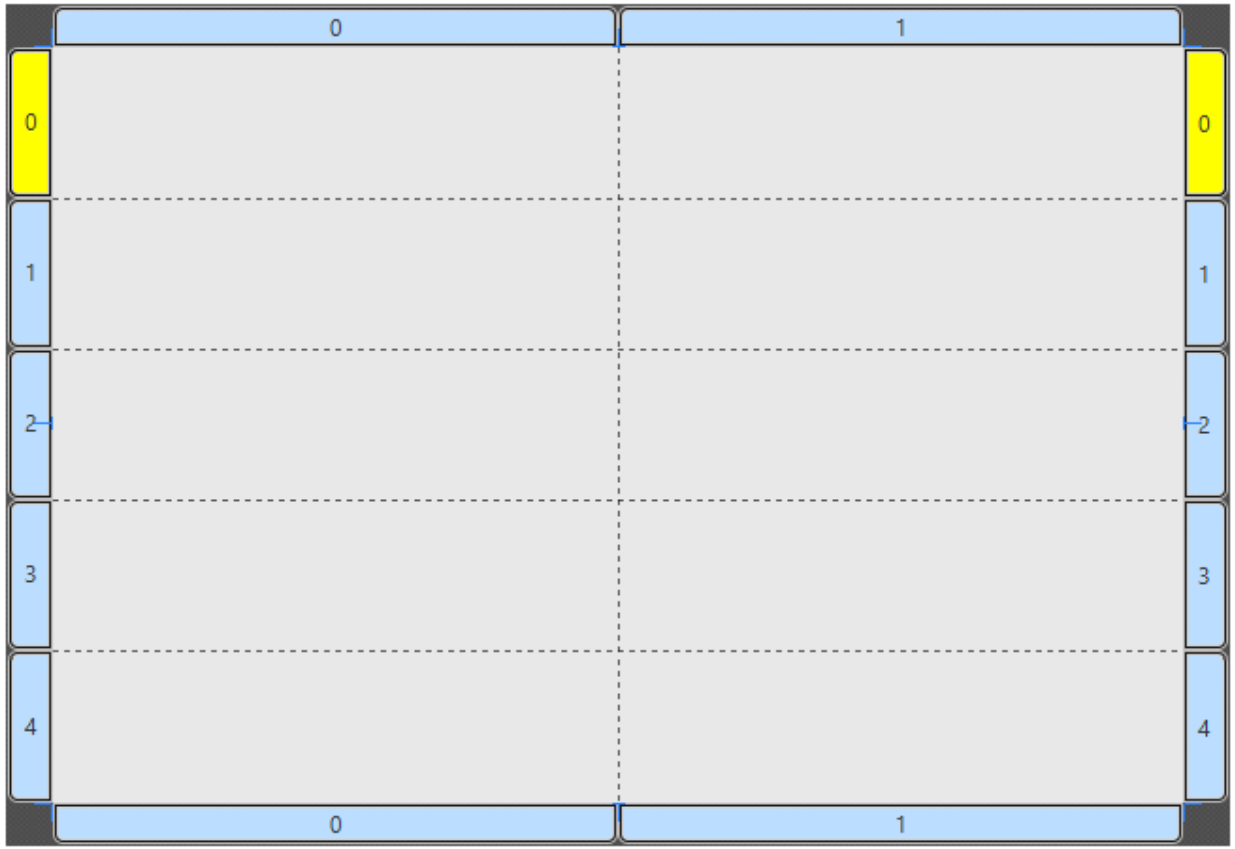


Fig. 12.12 | GridPane after adding two more rows.

Building the App's GUI (Cont.)

- You'll now add the controls to the `GridPane`.
- For those that have **fx:ids**, while the control is selected, set its **fx:id** property in the **Inspector** window's **Code** section.
- Perform the following steps:
  - Drag `Labels` from the Library window's Controls section into the first four rows of the `GridPane`'s column 0.
  - As you add each `Label`, set its text as shown Fig. 12.10.

Building the App's GUI (Cont.)

- Drag `TextFields` from the Library window's Controls section into rows 0, 2 and 3 of the `GridPane`'s column 1
- Drag a horizontal `Slider` from the Library window's Controls section into row 1 of the `GridPane`'s column 1
- Adding a `Button`. Drag a `Button` from the Library window's Controls section into row 4 of the `GridPane`'s right column. You can set the `Button`'s text by double clicking it, or by selecting the `Button`, then setting its Text property in the Inspector window's Properties section.
- The `GridPane` should appear as shown in Fig. 12.13.

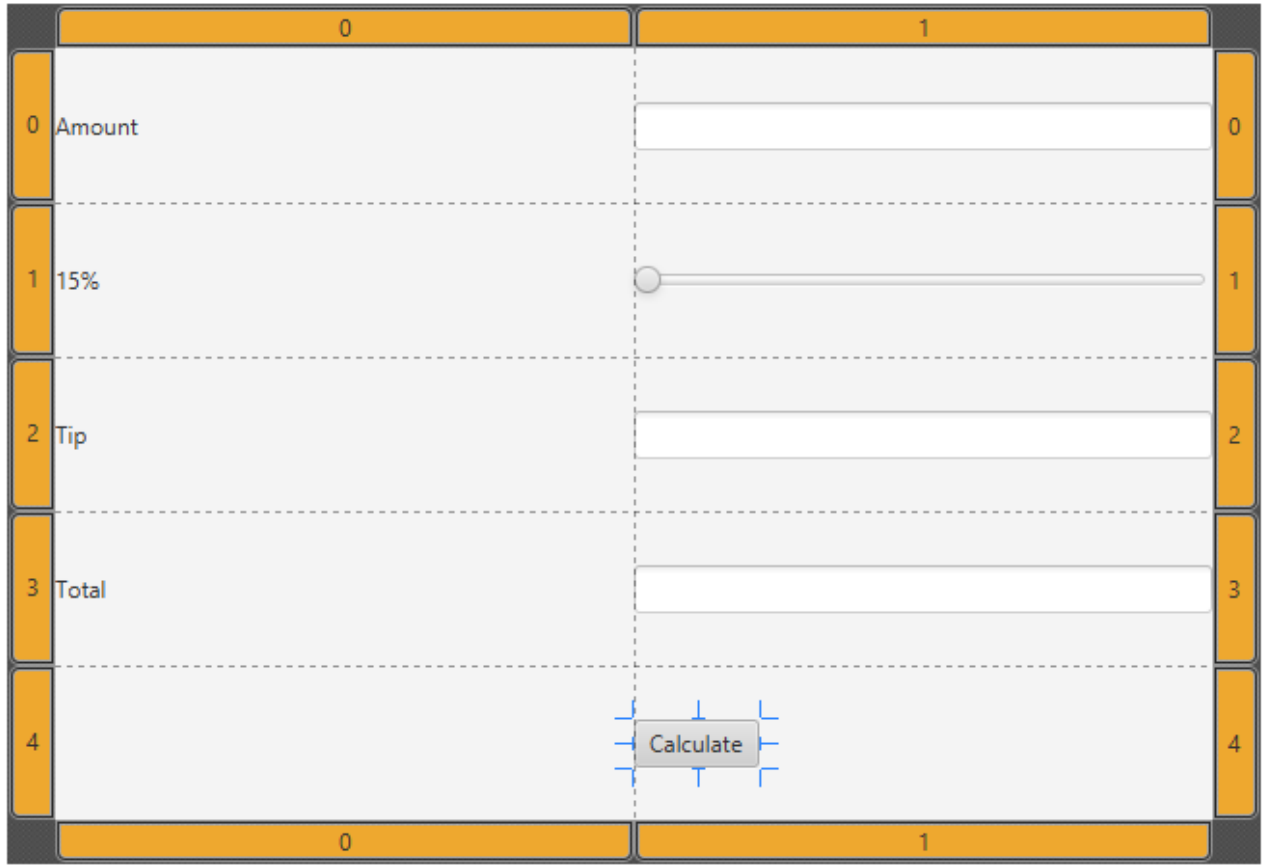


Fig. 12.13 | `GridPane` filled with the **Tip Calculator**'s controls.

Sizing the GridPane

Sizing the GridPane to Fit Its Contents

- When you begin designing a GUI by adding a layout, Scene Builder sets the layout object's **Pref Width** property to **600** and **Pref Height** property to **400**
- We'd like the layout's size to be computed, based on the layout's contents.
  - Select the `GridPane` by clicking inside the `GridPane`, but not on any of the controls you've placed into its columns and rows.
    - Sometimes, easier to select the `GridPane` in the **Document** window's **Hierarchy** section.
  - In the **Inspector**'s Layout section, reset the **Pref Width** and **Pref Height** property values to their defaults (as you did in Section 12.4.4).
    - Sets both properties' values to **USE_COMPUTED_SIZE**, so the layout calculates its own size.
- The layout now appears as shown in Fig. 12.14.

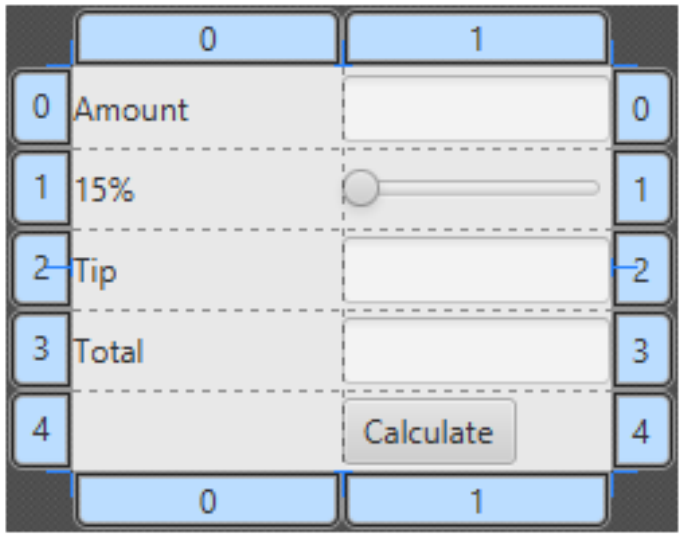


Fig. 12.14 | `GridPane` sized to fit its contents.

Align the GridPane

- A `GridPane` column's contents are left-aligned by default.
- To right-align the contents of column 0, select it by clicking the tab at the top or bottom of the column, then in the Inspector's **Layout** section, set the **Halignment** (horizontal alignment) property to **RIGHT**.

Configure the GridPane

- By default, Scene Builder sets each `GridPane` column's width to 100 pixels and each row's height to 30 pixels to ensure that you can easily drag controls into the `GridPane`'s cells. In this app, we sized each column to fit its contents.
  - Select the column 0 by clicking the tab at the top or bottom of the column, then in the **Inspector**'s **Layout** section, reset the **Pref Width** property to its default size (that is, **USE_COMPUTED_SIZE**) to indicate that the column's width should be based on its widest child—the **Amount** `Label` in this case.
  - Repeat this process for column 1.
- The `GridPane` should appear as shown in Fig 12.15.

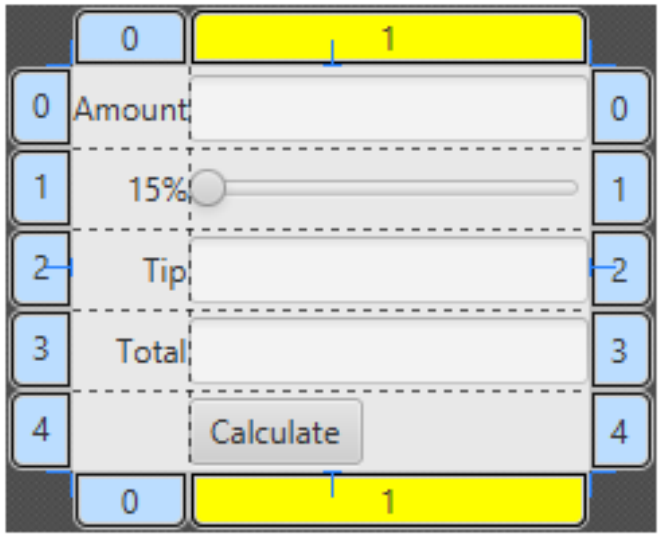


Fig. 12.15 | `GridPane` with columns sized to fit their contents.

Configure the Button

- By default, Scene Builder sets a `Button`'s width based on its text.
- For this app, we chose to make the Button the same width as the other controls in the `GridPane`'s right column.
- To do so, select the `Button`, then in the **Inspector**'s **Layout** section, set the **Max Width** property to **MAX_VALUE**.
  - The `Button`'s width grows to fill the column's width.

See a Preview

- Preview the GUI by selecting **Preview > Show Preview in Window**.
- As you can see in Fig. 12.16,
  - There's no space between the `Labels` in the left column and the controls in the right column.
  - There's no space around the `GridPane`, because by default the `Stage` is sized to fit the Scene's contents. Thus, many of the controls touch the window's borders.
- You'll fix these issues in the next step.

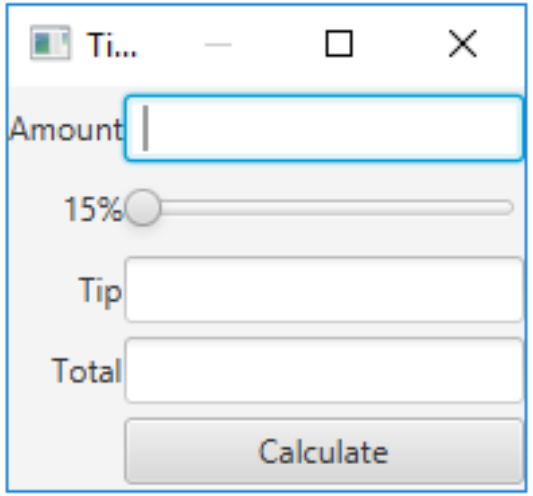


Fig. 12.16 | `GridPane` with the `TextField`s and `Button` resized.

Padding fills the Edges

- The space between a node's contents and its top, right, bottom and left edges is known as the padding, which separates the contents from the node's edges.
- Since the `GridPane`'s size determines the Stage's window size, the `GridPane`'s padding separates its children from the window's edges.

The Gap between Controls

- To set the padding, select the `GridPane`, then in the **Inspector**'s **Layout** section, set the **Padding** property's four values (which represent the **TOP**, **RIGHT**, **BOTTOM** and **LEFT**) to **14**
  - The recommended distance between a control's edge and the `Scene`'s edge.
- You can specify the default amount of space between a `GridPane`'s columns and rows with its **Hgap** (horizontal gap) and **Vgap** (vertical gap) properties, respectively.
  - Because Scene Builder sets each `GridPane` row's height to 30 pixels—which is greater than the heights of this app's controls—there's already some vertical space between the components.

The Gap between Controls

- To specify the horizontal gap between the columns, select the `GridPane` in the **Document** window's **Hierarchy** section
- In the **Inspector**'s **Layout** section, set the **Hgap** property to **8**
  - Recommended distance between controls.
- If you'd like to precisely control the vertical space between components, you can reset each row's **Pref Height** to its default value, then set the `GridPane`'s **Vgap** property.

Keyboard Focus

- You can type in a `TextField` only if it's "in focus"—that is, it's the control that the user is interacting with.
- When you click an interactive control, it receives the focus.
- When you press the *Tab* key, the focus transfers from the current focusable control to the next in the order the controls were added to the GUI.
- In this app, the `tipTextField` and `totalTextField` are neither editable nor focusable.
- Select both `TextFields`, then in the **Inspector**'s **Properties** section uncheck the **Editable** and **Focus Traversable** properties.
- To select multiple controls at once, you can click the first (in the **Document** window's **Hierarchy** section or in the content panel), then hold the *Shift* key and click each of the others.

Configure the Slider

- By default, a `Slider`'s range is 0.0 to 100.0 and its initial value is 0.0.
- This app allows only integer tip percentages in the range 0 to 30 with a default of 15.
- Select the `Slider`, then in the **Inspector**'s **Properties** section, set the **Max** property to **30** and the **Value** property to **15**.
- Set the **Block Increment** property to 5
  - The amount by which the **Value** property increases or decreases when the user clicks between an end of the `Slider` and the `Slider`'s thumb.
- Save the FXML file by selecting **File > Save.**
- We'll restrict the `Slider`'s values to integers when we respond to its events in Java code

Preview the TipCalculator

- Select Preview > Show Preview in Window to view the final GUI (Fig. 12.16).
- When we discuss the `TipCalculatorController` class in Section 12.5.5, we'll show how to specify the Calculate `Button`'s event handler in the FXML file.

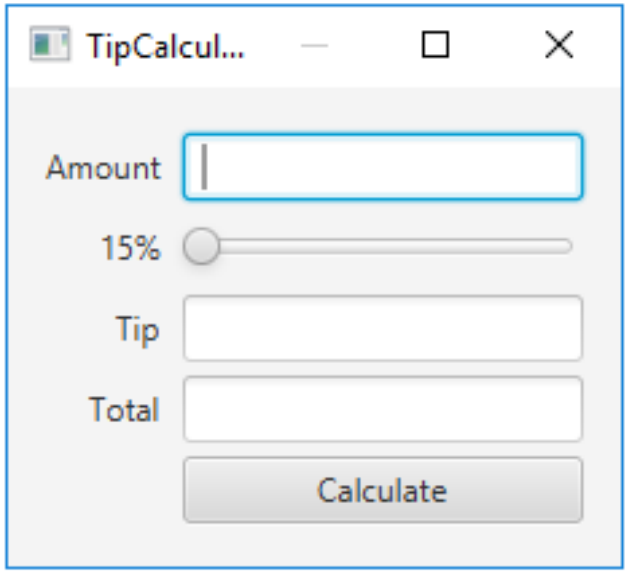


Fig. 12.17 | Final GUI design previewed in Scene Builder.

Associate TipCalculatorController as Controller Class

- To ensure that an object of the controller class is created when the app loads the FXML file at runtime, you must specify the controller class's name in the FXML file:
  - Expand Scene Builder **Document** window's **Controller** section (located below the **Hierarchy** section in).
  - In the **Controller Class** field, type `TipCalculatorController`
    - By convention, the controller class's name starts with the same name as the FXML file (`TipCalculator`) and ends with `Controller`.

Associate calculateButtonPressed with Button OnAction

- You can specify in the FXML file the names of the methods that will be called to handle specific control's events
- When you select a control, the **Inspector** window's **Code** section shows all the events for which you can specify event handlers in the FXML file.
- When the user clicks a `Button`, the method specified in the **On Action** field is called
  - This method is defined in the controller class you specify in Scene Builder's **Controller** window.
- Enter `calculateButtonPressed` in the **On Action** field.

SceneBuilder can Generate Controller class

- You can have Scene Builder generate the initial controller class containing the variables you'll use to interact with controls programmatically and the empty **Calculate Button** event handler.
  - Scene Builder calls this the "controller skeleton."
- Select **View > Show Sample Controller Skeleton** to generate the skeleton in Fig. 12.18.
- The sample class has the class name you specified, a variable for each control that has an **fx:id** and an empty **Calculate Button** event handler.
- You can click the **Copy** button, then paste the contents into a file named `TipCalculatorController.java` in the same folder as the TipCalculator.fxml file you created in this section.

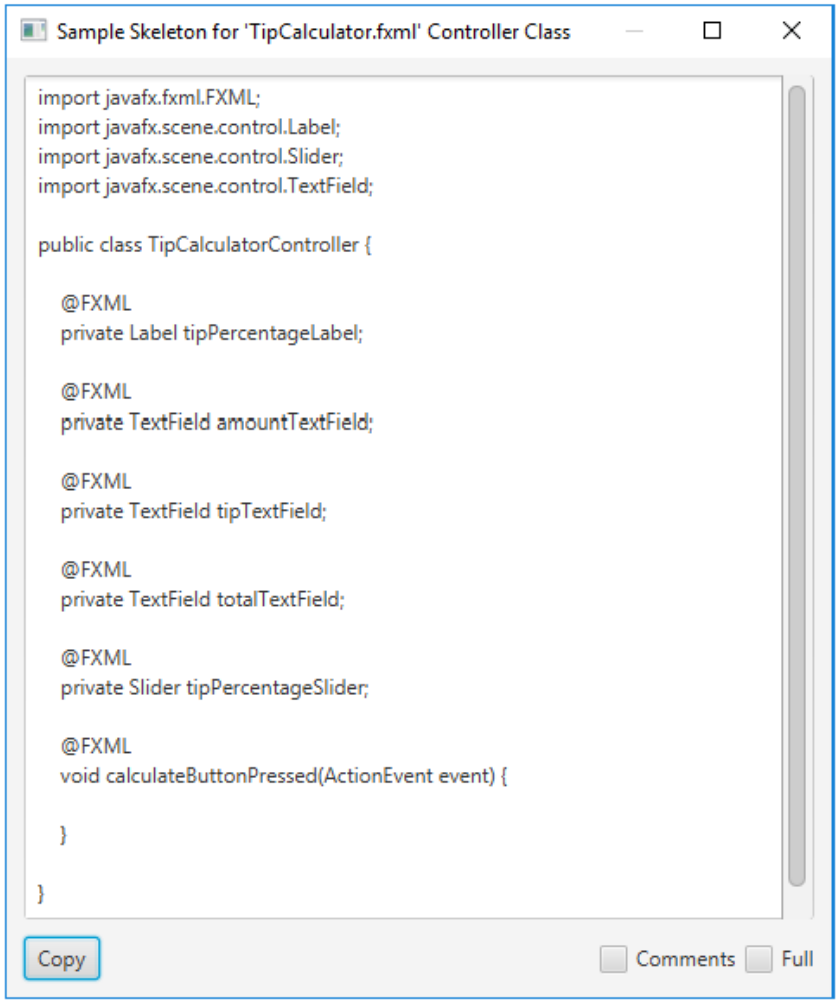


Fig. 12.18 | Skeleton code generated by Scene Builder.

TipCalculator Class

- A simple JavaFX FXML-based app has two Java source-code files
- `TipCalculator.java`—This file contains the `TipCalculator` class, which declares the `main` method that loads the FXML file to create the GUI and attaches the GUI to a `Scene` displayed on the app's `Stage`.
- `TipCalculatorController.java`—This file contains the `TipCalculatorController` class, where you'll specify the `Slider` and `Button` controls' event handlers.

TipCalculator Class

- Fig. 12.19 presents class `TipCalculator`.
- The starting point for a JavaFX app is an `Application` subclass, so class `TipCalculator` extends `Application` (line 9).
- `main` calls class `Application`'s static `launch` method (line 23) to initialize the JavaFX runtime and to begin executing the app.
- This causes the JavaFX runtime to create an object of the `TipCalculator` class and calls its `start` method (lines 10–19), passing the `Stage` object representing the window in which the app will be displayed.
- The JavaFX runtime creates the window.

```
1  // Fig. 12.19: TipCalculator.java
2  // Main app class that loads and displays the Tip Calculator's GUI
3  import javafx.application.Application;
4  import javafx.fxml.FXMLLoader;
5  import javafx.scene.Parent;
6  import javafx.scene.Scene;
7  import javafx.stage.Stage;
8
9  public class TipCalculator extends Application {
10    @Override
11    public void start(Stage stage) throws Exception {
12       Parent root =
13          FXMLLoader.load(getClass().getResource("TipCalculator.fxml"));
14
```

Fig. 12.19 | Main app class that loads and displays the **Tip Calculator**'s GUI. (Part 1 of 2.)

```
15          Scene scene = new Scene(root); // attach scene graph to scene
16          stage.setTitle("Tip Calculator"); // displayed in window's title bar
17          stage.setScene(scene); // attach scene to stage
18          stage.show(); // display the stage
19       }
20
21       public static void main(String[] args) {
22          // create a TipCalculator object and call its start method
23          launch(args);
24       }
25    }
```

Fig. 12.19 | Main app class that loads and displays the **Tip Calculator**'s GUI. (Part 2 of 2.)

TipCalculator Class (Cont.)

- Method `start` (lines 11–19) creates the GUI, attaches it to a `Scene` and places it on the `Stage` that method `start` receives as an argument.
- Lines 12–13 use class `FXMLLoader`'s `static` method `load` to create the GUI's scene graph. This method:
  - Returns a `Parent` (package `javafx.scene`) reference to the scene graph's root node—the GUI's `GridPane` in this app.
  - Creates an object of the `TipCalculatorController` class that we specified in the FXML file.
  - Initializes the controller's instance variables for the components that are manipulated programmatically.
  - Registers the event handlers specified in the FXML to the appropriate controls.
    - Enables the controls to call the corresponding methods when the user interacts with the app.

TipCalculator Class (Cont.)

- To display the GUI, you must attach it to a `Scene`, then attach the `Scene` to the `Stage` that method start receives as an argument.
- To attach the GUI to a `Scene`, line 15 creates a `Scene`, passing `root` (the scene graph's root node) as an argument to the constructor.
  - By default, the `Scene`'s size is determined by the size of the scene graph's root node.
- Line 16 uses `Stage` method `setTitle` to specify the text that appears in the `Stage` window's title bar.
- Line 17 calls `Stage` method `setScene` to place the `Scene` onto the `Stage`.
- Line 18 calls `Stage` method `show` to display the `Stage` window.

TipCalculatorController Class

- Figures 12.20–12.23 present the class `TipCalculatorController`

TipCalculatorController Class (Cont.)

- Figure 12.20 shows class `TipCalculatorController`'s `imports`.
- The `RoundingMode enum` of package `java.math` is used to specify how `BigDecimal` values are rounded during calculations or when formatting floating-point numbers as `Strings`.
- Class `NumberFormat` of package `java.text` provides numeric formatting capabilities, such as locale-specific currency and percentage formats.
- A `Button`'s event handler receives an `ActionEvent`, which indicates that the `Button` was clicked. Many JavaFX controls support `ActionEvents`.

TipCalculatorController Class (Cont.)

- `ChangeListener` and `ObservableValue` are used to respond to `Slider` events.
- The annotation `FXML` (package `javafx.fxml`) is used in a JavaFX controller class's code to mark instance variables that should refer to JavaFX components in the GUI's FXML file and methods that can respond to the events of JavaFX components in the GUI's FXML file.
- Package `javafx.scene.control` contains many JavaFX control classes.

```
1  // TipCalculatorController.java
2  // Controller that handles calculateButton and tipPercentageSlider events
3  import java.math.BigDecimal;
4  import java.math.RoundingMode;
5  import java.text.NumberFormat;
6  import javafx.beans.value.ChangeListener;
7  import javafx.beans.value.ObservableValue;
8  import javafx.event.ActionEvent;
9  import javafx.fxml.FXML;
10 import javafx.scene.control.Label;
11 import javafx.scene.control.Slider;
12 import javafx.scene.control.TextField;
13
```

Fig. 12.20 | `TipCalculatorController`'s `import` declarations.

TipCalculatorController Class (Cont.)

- Fig. 12.21 presents class `TipCalculatorController`'s `static` and instance variables.
- The `@FXML` annotation preceding an instance variable indicates that the variable's name can be used in the FXML file that describes the app's GUI.
- The variable names that you specify in the controller class must precisely match the fx:id values you specified when building the GUI.
- When the `FXMLLoader` loads an FXML file to create a GUI, it also initializes each of the controller's instance variables that are declared with `@FXML` to ensure that they refer to the corresponding GUI components in the FXML file.

```
14  public class TipCalculatorController {
15     // formatters for currency and percentages
16     private static final NumberFormat currency =
17        NumberFormat.getCurrencyInstance();
18     private static final NumberFormat percent =
19        NumberFormat.getPercentInstance();
20
21     private BigDecimal tipPercentage = new BigDecimal(0.15); // 15% default
22
23     // GUI controls defined in FXML and used by the controller's code
24     @FXML
25     private TextField amountTextField;
26
```

Fig. 12.21 | TipCalculatorController's `static` and instance variables. (Part 1 of 2.)

```
27      @FXML
28      private Label tipPercentageLabel;
29
30      @FXML
31      private Slider tipPercentageSlider;
32
33      @FXML
34      private TextField tipTextField;
35
36      @FXML
37      private TextField totalTextField;
38
```

Fig. 12.21 | TipCalculatorController's `static` and instance variables. (Part 2 of 2.)

TipCalculatorController Class (Cont.)

- Figure 12.22 presents class `TipCalculatorController`'s `calculateButtonPressed` method, which is called with the user clicks the Calculate `Button`.
- The `@FXML` annotation preceding a method indicates that the method can be used to specify a control's event handler in the FXML file that describes the app's GUI.

```
39      // calculates and displays the tip and total amounts
40      @FXML
41      private void calculateButtonPressed(ActionEvent event) {
42         try {
43            BigDecimal amount = new BigDecimal(amountTextField.getText());
44            BigDecimal tip = amount.multiply(tipPercentage);
45            BigDecimal total = amount.add(tip);
46
47            tipTextField.setText(currency.format(tip));
48            totalTextField.setText(currency.format(total));
49         }
50         catch (NumberFormatException ex) {
51            amountTextField.setText("Enter amount");
52            amountTextField.selectAll();
53            amountTextField.requestFocus();
54         }
55      }
56
```

Fig. 12.22 | `TipCalculatorController`'s `calculateButtonPressed` event handler.

TipCalculatorController Class (Cont.)

- When the `FXMLLoader` loads `TipCalculator.fxml` to create the GUI, it creates and registers an event handler for the **Calculate** `Button`'s `ActionEvent`.
- The event handler for this event must implement interface **`EventHandler<ActionEvent`**
- This interface contains a `handle` method that returns `void` and receives an `ActionEvent` parameter.
- This method's body, in turn, calls method `calculateButtonPressed` when the user clicks the **Calculate** `Button`.
- `FXMLLoader` performs similar tasks for every event listener you specify via the Scene Builder **Inspector** window's **Code** section.

TipCalculatorController Class (Cont.)

- Figure 12.23 presents class `TipCalculatorController`'s `initialize` method.
- When the `FXMLLoader` creates an object of a controller class, it determines whether the class contains an `initialize` method with no parameters and, if so, calls that method to initialize the controller.
- This method can be used to configure the controller before the GUI is displayed.

```
57      // called by FXMLLoader to initialize the controller
58      public void initialize() {
59         // 0-4 rounds down, 5-9 rounds up
60         currency.setRoundingMode(RoundingMode.HALF_UP);
61
62         // listener for changes to tipPercentageSlider's value
63         tipPercentageSlider.valueProperty().addListener(
64            new ChangeListener<Number>() {
65               @Override
66               public void changed(ObservableValue<? extends Number> ov,
67                  Number oldValue, Number newValue) {
68                  tipPercentage =
69                     BigDecimal.valueOf(newValue.intValue() / 100.0);
70                  tipPercentageLabel.setText(percent.format(tipPercentage));
71               }
72            }
73         );
74      }
75   }
```

Fig. 12.23 | `TipCalculatorController`'s `initalize` method.

TipCalculatorController Class (Cont.)

- Each JavaFX control has properties and some generate events when they change.
- For such events, you must manually register as the event handler an object that implements the `ChangeListener` interface (package `javafx.beans.value`).
  - `ChangeListener` is a generic type that's specialized with the property's type.
- The call to `valueProperty` (line 63) returns a `DoubleProperty` (package `javax.beans.property`) that represents the `Slider`'s value.
  - A `DoubleProperty` is an `ObservableValue<Number>` that can notify listeners when a value changes.
- Each class that implements interface `ObservableValue` provides method `addListener` (called on line 63) to register an event-handler that implements interface `ChangeListener`.
  - For a `Slider`'s value, `addListener`'s argument is an object that implements `ChangeListener<Number>`, because the `Slider`'s value is a numeric value.

TipCalculatorController Class (Cont.)

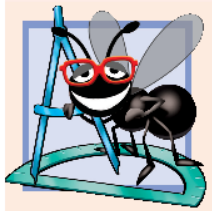
- If an event handler is not reused, you often define it as an instance of an anonymous inner class
- The argument in lines 64–72 is one statement that
  - declares the event listener's class,
  - creates an object of that class and
  - registers it as the listener for changes to the `tipPercentageSlider`'s value.
- Since an anonymous inner class has no name, you must create an object of the class at the point where it's declared (thus the keyword `new` in line 64).
- `ChangeListener<Number>()` in line 64 begins the declaration of an anonymous inner class that implements `ChangeListener<Number>`
  - Similar to beginning a class declaration with
    `public class MyHandler implements ChangeListener<Number>`

TipCalculatorController Class (Cont.)

- The opening left brace at 64 and the closing right brace at line 72 delimit the anonymous inner class's body.
- Lines 65–71 declare the interface's `changed` method, which receives a reference to the `ObservableValue` that changed, a `Number` containing the old value before the event occurred and a `Number` containing the new value.
- When the user moves the `Slider`'s thumb, lines 68–69 store the new tip percentage and line 70 updates the `tipPercentageLabel`.

TipCalculatorController Class (Cont.)

- An anonymous inner class can access its top-level class's instance variables, `static` variables and methods
- However, an anonymous inner class has limited access to the local variables of the method in which it's declared—it can access only the `final` or effectively `final` (Java SE 8) local variables declared in the enclosing method's body.



Software Engineering Observation 12.2

The event listener for an event must implement the appropriate event-listener interface.

Common Programming Error 12.1

If you forget to register an event-handler object for a particular GUI component's event type, events of that type will be ignored.