

JavaFX Documentation Project

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Chapter 1. Introduction

The JavaFX Documentation Project aims to pull together useful information for JavaFX developers from all over the web. The project is [open source](#) and encourages community participation to ensure that the documentation is as highly polished and useful as possible.

1.1. Contributors

This project would not be possible without the contributors who work hard on the content contained within this documentation. Whenever possible contributors are given attribution within the document when they write a section, but it is also important to gather all names here, at the top of the document, to give the recognition that these contributors deserve.

1.2. Contributing

Contributing to this project is easy - fork the [GitHub](#) repo, edit the relevant files, and create a pull request! Once merged, your content will form a part of the documentation and you'll have the unending appreciation of the entire community!

The JavaFX Documentation Project uses AsciiDoc as the syntax of choice for writing the documentation. The [AsciiDoc Syntax Quick Reference](#) guide is a great resource for those learning how to write AsciiDoc.

Authors are welcome to include a byline beneath the sections that they have authored. To ensure consistency, the recommended format for the byline is the following:

Contributed by <name> - <website>

Chapter 2. Scenegraph

Placeholder whilst things get built...

Chapter 3. UI Controls

3.1. ChoiceBox

Author: Carl Walker

This article demonstrates the `ChoiceBox`. The `ChoiceBox` control is a list of values from which the user makes a selection. In this particular implementation, there is an empty value which makes the selection optional.

The following screenshot shows `ChoiceBox` app. A selection "Furniture" is made and the Save `Button` is pressed. The Save `Button` call invokes a `println()` which prints out the object.

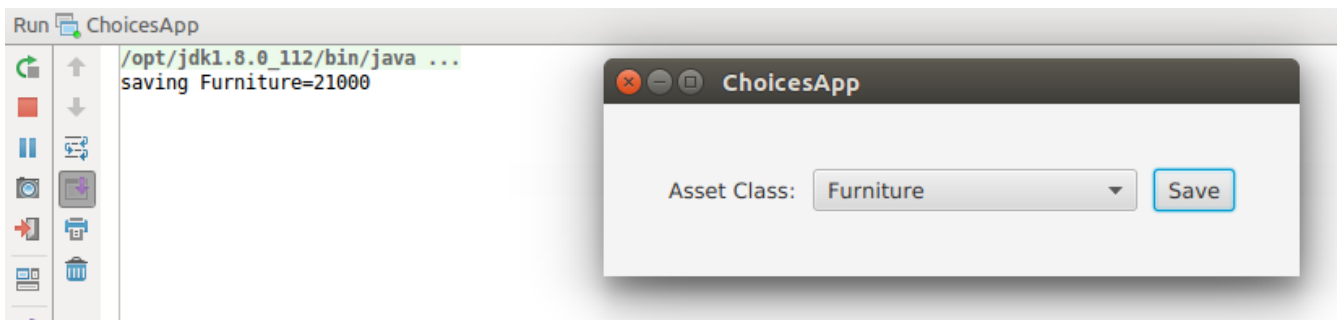


Figure 1. `ChoiceBox` Printing Out Selection

The program puts a `Label`, a `ChoiceBox`, and a `Button` into an `HBox`. An action is set on the Save `Button` which prints out the value.

The simplest usage of the `ChoiceBox` is to fill it with Strings. This `ChoiceBox` in this article is built on a JavaFX class called `Pair`. `Pair` is a general container for any key/value pair and can be used in place of a domain or other special-purpose object. Strings should only be used if they can be used without manipulation or decoded consistently.

```
public class ChoicesApp extends Application {

    private final ChoiceBox<Pair<String,String>> assetClass = new ChoiceBox<>();

    @Override
    public void start(Stage primaryStage) throws Exception {

        Label label = new Label("Asset Class:");
        assetClass.setPrefWidth(200);
        Button saveButton = new Button("Save");

        HBox hbox = new HBox(
            label,
            assetClass,
            saveButton);
        hbox.setSpacing( 10.0d );
        hbox.setAlignment(Pos.CENTER );
        hbox.setPadding( new Insets(40) );

        Scene scene = new Scene(hbox);

        initChoice();

        saveButton.setOnAction(
            (evt) -> System.out.println("saving " + assetClass.getValue())
        );

        primaryStage.setTitle("ChoicesApp");
        primaryStage.setScene( scene );
        primaryStage.show();

    }
}
```

3.1.1. StringConverter

When using a complex object to back a **ChoiceBox**, a **StringConverter** is needed. This object serializes a String to and from the **ChoiceBox**. For this program, only the `toString()` needs to be coded which replaces the default `toString()` of the **Pair** object. (Both `toString` and `fromString` will need an implementation in order to compile.)

An empty object `EMPTY_PAIR` is used to prevent `NullPointerExceptions`. The returned value from `assetClass().getValue()` can be accessed and compared consistently without adding special null handling logic.

```

private final static Pair<String, String> EMPTY_PAIR = new Pair<>("", "");

private void initChoice() {

    List<Pair<String,String>> assetClasses = new ArrayList<>();
    assetClasses.add( new Pair("Equipment", "20000"));
    assetClasses.add( new Pair("Furniture", "21000"));
    assetClasses.add( new Pair("Investment", "22000"));

    assetClass.setConverter( new StringConverter<Pair<String,String>>() {
        @Override
        public String toString(Pair<String, String> pair) {
            return pair.getKey();
        }

        @Override
        public Pair<String, String> fromString(String string) {
            return null;
        }
    });

    assetClass.getItems().add( EMPTY_PAIR );
    assetClass.getItems().addAll( assetClasses );
    assetClass.setValue( EMPTY_PAIR );

}

```

The ChoiceBox is used to select from a list of values. When the list of values is a complex type, provide a StringFormatter to serialize a list object into something presentable. If possible, use an empty object (rather than a null) to support optional values.

Complete Code

The code can be tested in a single .java file.

ChoicesApp.class

```

public class ChoicesApp extends Application {

    private final ChoiceBox<Pair<String,String>> assetClass = new ChoiceBox<>();

    private final static Pair<String, String> EMPTY_PAIR = new Pair<>("", "");

    @Override
    public void start(Stage primaryStage) throws Exception {

        Label label = new Label("Asset Class:");
        assetClass.setPrefWidth(200);
        Button saveButton = new Button("Save");
    }
}

```

```

HBox hbox = new HBox(
    label,
    assetClass,
    saveButton);
hbox.setSpacing( 10.0d );
hbox.setAlignment(Pos.CENTER );
hbox.setPadding( new Insets(40) );

Scene scene = new Scene(hbox);

initChoice();

saveButton.setOnAction(
    (evt) -> System.out.println("saving " + assetClass.getValue())
);

primaryStage.setTitle("ChoicesApp");
primaryStage.setScene( scene );
primaryStage.show();
}

private void initChoice() {

    List<Pair<String,String>> assetClasses = new ArrayList<>();
    assetClasses.add( new Pair("Equipment", "20000"));
    assetClasses.add( new Pair("Furniture", "21000"));
    assetClasses.add( new Pair("Investment", "22000"));

    assetClass.setConverter( new StringConverter<Pair<String,String>>() {
        @Override
        public String toString(Pair<String, String> pair) {
            return pair.getKey();
        }

        @Override
        public Pair<String, String> fromString(String string) {
            return null;
        }
    });

    assetClass.getItems().add( EMPTY_PAIR );
    assetClass.getItems().addAll( assetClasses );
    assetClass.setValue( EMPTY_PAIR );

}

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

```


3.2. ComboBox

Author: Carl Walker

A **ComboBox** is a hybrid control that presents a list of values plus an edit control. This article demonstrates a basic form of the **ComboBox** which is an un-editable list of items built on a complex data structure.

This screenshot shows a **ComboBoxApp** containing a list of expense accounts. The accounts are stored in a key/value JavaFX class **Pair**. The console shows the result of a save operation after the user selects "Auto Expense".

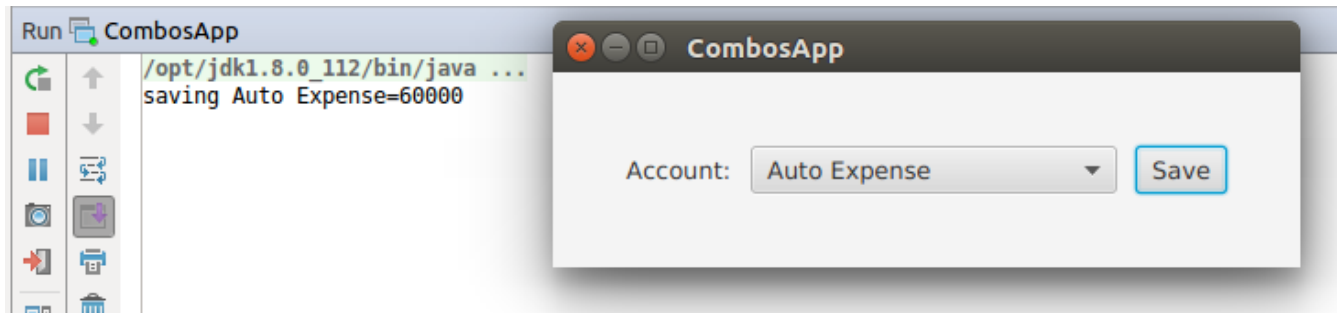


Figure 2. *ComboBox Application*

This code adds a Label, a ComboBox, and a Button to an HBox. The ComboBox is instantiated as a field and initialized in a method presented later `initCombo()`. A handler is put on the Save Button which outputs a value if an item is selected or a special message if no item is selected.

```

public class CombosApp extends Application {

    private final ComboBox<Pair<String, String>> account = new ComboBox<>();

    private final static Pair<String, String> EMPTY_PAIR = new Pair<>("", "");

    @Override
    public void start(Stage primaryStage) throws Exception {

        Label accountsLabel = new Label("Account:");
        account.setPrefWidth(200);
        Button saveButton = new Button("Save");

        HBox hbox = new HBox(
            accountsLabel,
            account,
            saveButton);
        hbox.setSpacing( 10.0d );
        hbox.setAlignment(Pos.CENTER );
        hbox.setPadding( new Insets(40) );

        Scene scene = new Scene(hbox);

        initCombo();

        saveButton.setOnAction( (evt) -> {
            if( account.getValue().equals(EMPTY_PAIR) ) {
                System.out.println("no save needed; no item selected");
            } else {
                System.out.println("saving " + account.getValue());
            }
        });

        primaryStage.setTitle("CombosApp");
        primaryStage.setScene( scene );
        primaryStage.show();
    }
}

```

3.2.1. CellFactory

The `initCombo()` method adds several expense accounts to a `List`. This `List` is added to the `ComboBox` items after an empty `Pair` object is added. The initial value is set to the `EMPTY_PAIR` which is a constant.

If not specified, the `ComboBox` will use the `toString()` method of the object (in this article, a `Pair`) to render a backing object. For Strings, such as a "Yes" or "No" selection, no extra code is needed. However, the `toString()` of a `Pair` will output both the human-readable key and the machine-preferred value. The requirements for this `ComboBox` are to use only the human-readable keys in the

display.

To do this, a cellFactory is provided which will configure a `ListCell` object with the `Pair` key as the contents. The `Callback` type is verbose, but the gist of the factory is set the text of a `ListCell` in the `updateItem()` method of an anonymous inner class. Notice that the super class method must be called.

```
private void initCombo() {

    List<Pair<String,String>> accounts = new ArrayList<>();

    accounts.add( new Pair<>("Auto Expense", "60000") );
    accounts.add( new Pair<>("Interest Expense", "61000") );
    accounts.add( new Pair<>("Office Expense", "62000") );
    accounts.add( new Pair<>("Salaries Expense", "63000") );

    account.getItems().add( EMPTY_PAIR );
    account.getItems().addAll( accounts );
    account.setValue( EMPTY_PAIR );

    Callback<ListView<Pair<String,String>>, ListCell<Pair<String,String>>> factory
=
    (lv) ->
        new ListCell<Pair<String,String>>() {
            @Override
            protected void updateItem(Pair<String, String> item, boolean
empty) {

                super.updateItem(item, empty);
                if( empty ) {
                    setText("");
                } else {
                    setText( item.getKey() );
                }
            }
        };

    account.setCellFactory( factory );
    account.setButtonCell( factory.call( null ) );
}
```

The `Callback` is used in the `setButtonCell()` method to provide a cell for the editing control. Note that this program is not editable which is the default. However, the `factory.call(null)` is needed otherwise only the contents of the popup menu will be properly formatted and the view of the control at rest will fallback on a `toString()`.

This article presented a simple usage of `ComboBox`. Since this control was not editable, `ChoiceBox` can be substituted. For un-editable graphical renderings (ex a color coded shape for a status value), `ComboBox` still would be needed to define the specific `Node` used in the control.

Complete Code

The code can be tested in a single .java file.

CombosApp.class

```
public class CombosApp extends Application {

    private final ComboBox<Pair<String, String>> account = new ComboBox<>();

    private final static Pair<String, String> EMPTY_PAIR = new Pair<>("", "");

    @Override
    public void start(Stage primaryStage) throws Exception {

        Label accountsLabel = new Label("Account:");
        account.setPrefWidth(200);
        Button saveButton = new Button("Save");

        HBox hbox = new HBox(
            accountsLabel,
            account,
            saveButton);
        hbox.setSpacing( 10.0d );
        hbox.setAlignment(Pos.CENTER );
        hbox.setPadding( new Insets(40) );

        Scene scene = new Scene(hbox);

        initCombo();

        saveButton.setOnAction( (evt) -> {
            if( account.getValue().equals(EMPTY_PAIR) ) {
                System.out.println("no save needed; no item selected");
            } else {
                System.out.println("saving " + account.getValue());
            }
        });

        primaryStage.setTitle("CombosApp");
        primaryStage.setScene( scene );
        primaryStage.show();
    }

    private void initCombo() {

        List<Pair<String,String>> accounts = new ArrayList<>();

        accounts.add( new Pair<>("Auto Expense", "60000") );
        accounts.add( new Pair<>("Interest Expense", "61000") );
        accounts.add( new Pair<>("Office Expense", "62000") );
    }
}
```

```

accounts.add( new Pair<>("Salaries Expense", "63000") );

account.getItems().add( EMPTY_PAIR );
account.getItems().addAll( accounts );
account.setValue( EMPTY_PAIR );

Callback<ListView<Pair<String,String>>, ListCell<Pair<String,String>>> factory
=
    (lv) ->
        new ListCell<Pair<String,String>>() {
            @Override
            protected void updateItem(Pair<String, String> item, boolean
empty) {
                super.updateItem(item, empty);
                if( empty ) {
                    setText("");
                } else {
                    setText( item.getKey() );
                }
            }
        };

account.setCellFactory( factory );
account.setButtonCell( factory.call( null ) );
}

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

```

3.3. ListView

3.3.1. ListView Filtering in JavaFX

Author: Carl Walker

This article demonstrates how to filter a ListView in a JavaFX Application. Two lists are managed by the Application. One list contains all of the items in the data model. The second list contains the items currently being viewed. A scrap of comparison logic stored as a filter mediates between the two.

Binding is used heavily to keep the data structures in sync with what the user has selected.

This screenshot shows the Application which contains a top row of ToggleButtons which set the filter and a ListView containing the objects.

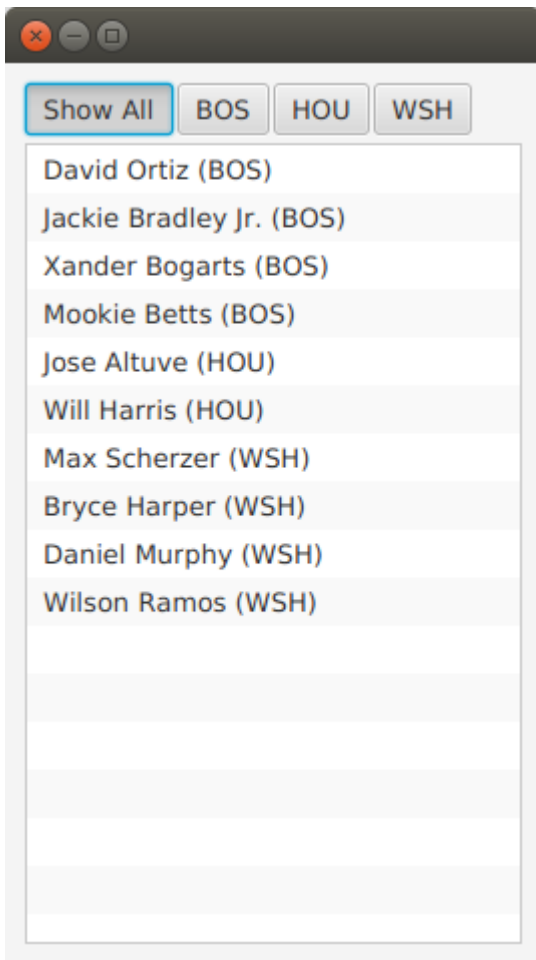


Figure 3. Screenshot of *ListView Filtering App*

The complete code — a single .java file — is listed at the end of the article.

Data Structures

The program begins with a domain model `Player` and an array of `Player` objects.

```
static class Player {  
  
    private final String team;  
    private final String playerName;  
    public Player(String team, String playerName) {  
        this.team = team;  
        this.playerName = playerName;  
    }  
    public String getTeam() {  
        return team;  
    }  
    public String getPlayerName() {  
        return playerName;  
    }  
    @Override  
    public String toString() { return playerName + " (" + team + ")"; }  
}
```

The Player class contains a pair of fields, team and playerName. A toString() is provided so that when the object is added to the ListView (presented later), a custom ListCell class is not needed.

The test data for this example is a list of American baseball players.

```
Player[] players = {new Player("BOS", "David Ortiz"),
                    new Player("BOS", "Jackie Bradley Jr."),
                    new Player("BOS", "Xander Bogaerts"),
                    new Player("BOS", "Mookie Betts"),
                    new Player("HOU", "Jose Altuve"),
                    new Player("HOU", "Will Harris"),
                    new Player("WSH", "Max Scherzer"),
                    new Player("WSH", "Bryce Harper"),
                    new Player("WSH", "Daniel Murphy"),
                    new Player("WSH", "Wilson Ramos") };
```

Model

As mentioned at the start of the article, the ListView filtering is centered around the management of two lists. All the objects are stored in a wrapped ObservableList playersProperty and the objects that are currently viewable are stored in a wrapped FilteredList, viewablePlayersProperty. viewablePlayersProperty is built off of playersProperty so updates made to players that meet the FilteredList criteria will also be made to viewablePlayers.

```
ReadOnlyObjectProperty<ObservableList<Player>> playersProperty =
    new SimpleObjectProperty<>(FXCollections.observableArrayList());

ReadOnlyObjectProperty<FilteredList<Player>> viewablePlayersProperty =
    new SimpleObjectProperty<FilteredList<Player>>(
        new FilteredList<>(playersProperty.get())
    );
```

filterProperty() is a convenience to allow callers to bind to the underlying Predicate.

```
ObjectProperty<Predicate<? super Player>> filterProperty =
    viewablePlayersProperty.get().predicateProperty();
```

The UI root is a VBox which contains an HBox of ToggleButtons and a ListView.

```

VBox vbox = new VBox();
vbox.setPadding( new Insets(10));
vbox.setSpacing(4);

HBox hbox = new HBox();
hbox.setSpacing( 2 );

ToggleGroup filterTG = new ToggleGroup();

```

Filtering Action

A handler is attached the ToggleButtons which will modify filterProperty. Each ToggleButton is supplied a Predicate in the userData field. toggleHandler uses this supplied Predicate when setting the filter property. This code sets the special case "Show All" ToggleButton.

```

@SuppressWarnings("unchecked")
EventHandler<ActionEvent> toggleHandler = (event) -> {
    ToggleButton tb = (ToggleButton)event.getSource();
    Predicate<Player> filter = (Predicate<Player>)tb.getUserData();
    filterProperty.set( filter );
};

ToggleButton tbShowAll = new ToggleButton("Show All");
tbShowAll.setSelected(true);
tbShowAll.setToggleGroup( filterTG );
tbShowAll.setOnAction(toggleHandler);
tbShowAll.setUserData( (Predicate<Player>) (Player p) -> true);

```

The ToggleButtons that filter a specific team are created at runtime based on the Players array. This Stream does the following.

1. Distill the list of Players down to a distinct list of team Strings
2. Create a ToggleButton for each team String
3. Set a Predicate for each ToggleButton to be used as a filter
4. Collect the ToggleButtons for addition into the HBox container


```

List<ToggleButton> tbs = Arrays.asList( players)
    .stream()
    .map( (p) -> p.getTeam() )
    .distinct()
    .map( (team) -> {
        ToggleButton tb = new ToggleButton( team );
        tb.setToggleGroup( filterTG );
        tb.setOnAction( toggleHandler );
        tb.setUserData( (Predicate<Player>) (Player p) -> team.equals(p.getTeam())
    );
        return tb;
    })
    .collect(Collectors.toList());

hbox.getChildren().add( tbShowAll );
hbox.getChildren().addAll( tbs );

```

List View

The next step creates the ListView and binds the ListView to the viewablePlayersProperty. This enables the ListView to receive updates based on the changing filter.

```

ListView<Player> lv = new ListView<>();
lv.itemsProperty().bind( viewablePlayersProperty );

```

The remainder of the program creates a Scene and shows the Stage. onShown loads the data set into the playersProperty and the viewablePlayersProperty lists. Although both lists are in sync in this particular version of the program, if the stock filter is every different than "no filter", this code would not need to be modified.

```

vbox.getChildren().addAll( hbox, lv );

Scene scene = new Scene(vbox);

primaryStage.setScene( scene );
primaryStage.setOnShown((evt) -> {
    playersProperty.get().addAll( players );
});

primaryStage.show();

```

This article used binding to tie a list of viewable Player objects to a ListView. The viewable Players were updated when a ToggleButton is selected. The selection applied a filter to a full set of Players which was maintained separately as a FilteredList (thanks @kleopatra_jx). Binding was used to keep the UI in sync and to allow for a separation of concerns in the design.

Further Reading

To see how such a design would implement basic add and remove functionality, visit the following page https://courses.bekwam.net/public_tutorials/bkcourse_filterlistapp.php.

Complete Code

The code can be tested in a single .java file.

```
public class FilterListApp extends Application {

    @Override
    public void start(Stage primaryStage) throws Exception {

        //
        // Test data
        //
        Player[] players = {new Player("BOS", "David Ortiz"),
                            new Player("BOS", "Jackie Bradley Jr."),
                            new Player("BOS", "Xander Bogarts"),
                            new Player("BOS", "Mookie Betts"),
                            new Player("HOU", "Jose Altuve"),
                            new Player("HOU", "Will Harris"),
                            new Player("WSH", "Max Scherzer"),
                            new Player("WSH", "Bryce Harper"),
                            new Player("WSH", "Daniel Murphy"),
                            new Player("WSH", "Wilson Ramos") };

        //
        // Set up the model which is two lists of Players and a filter criteria
        //
        ReadOnlyObjectProperty<ObservableList<Player>> playersProperty =
            new SimpleObjectProperty<>(FXCollections.observableArrayList());

        ReadOnlyObjectProperty<FilteredList<Player>> viewablePlayersProperty =
            new SimpleObjectProperty<FilteredList<Player>>(
                new FilteredList<>(playersProperty.get()
                    ));

        ObjectProperty<Predicate<? super Player>> filterProperty =
            viewablePlayersProperty.get().predicateProperty();

        //
        // Build the UI
        //
        VBox vbox = new VBox();
        vbox.setPadding( new Insets(10));
        vbox.setSpacing(4);

        HBox hbox = new HBox();
```

```

hbox.setSpacing( 2 );

ToggleGroup filterTG = new ToggleGroup();

//
// The toggleHandler action wills set the filter based on the TB selected
//
@SuppressWarnings("unchecked")
EventHandler<ActionEvent> toggleHandler = (event) -> {
    ToggleButton tb = (ToggleButton)event.getSource();
    Predicate<Player> filter = (Predicate<Player>)tb.getUserData();
    filterProperty.set( filter );
};

ToggleButton tbShowAll = new ToggleButton("Show All");
tbShowAll.setSelected(true);
tbShowAll.setToggleGroup( filterTG );
tbShowAll.setOnAction(toggleHandler);
tbShowAll.setUserData( (Predicate<Player>) (Player p) -> true);

//
// Create a distinct list of teams from the Player objects, then create
// ToggleButtons
//
List<ToggleButton> tbs = Arrays.asList( players)
    .stream()
    .map( (p) -> p.getTeam() )
    .distinct()
    .map( (team) -> {
        ToggleButton tb = new ToggleButton( team );
        tb.setToggleGroup( filterTG );
        tb.setOnAction( toggleHandler );
        tb.setUserData( (Predicate<Player>) (Player p) ->
team.equals(p.getTeam()) );
        return tb;
    })
    .collect(Collectors.toList());

hbox.getChildren().add( tbShowAll );
hbox.getChildren().addAll( tbs );

//
// Create a ListView bound to the viewablePlayers property
//
ListView<Player> lv = new ListView<>();
lv.itemsProperty().bind( viewablePlayersProperty );

vbox.getChildren().addAll( hbox, lv );

Scene scene = new Scene(vbox);

```

```

        primaryStage.setScene( scene );
        primaryStage.setOnShown((evt) -> {
            playersProperty.get().addAll( players );
        });

        primaryStage.show();
    }

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

    static class Player {

        private final String team;
        private final String playerName;
        public Player(String team, String playerName) {
            this.team = team;
            this.playerName = playerName;
        }
        public String getTeam() {
            return team;
        }
        public String getPlayerName() {
            return playerName;
        }
        @Override
        public String toString() { return playerName + " (" + team + ")"; }
    }
}

```

Chapter 4. Layout

4.1. VBox and HBox

Author: Carl Walker

Layout in JavaFX begins with selecting the right container controls. The two layout controls I use most often are **VBox** and **HBox**. **VBox** is a container that arranges its children in a vertical stack. **HBox** arranges its children in a horizontal row. The power of these two controls comes from wrapping them and setting a few key properties: alignment, hgrow, and vgrow.

This article will demonstrate these controls through a sample project. A mockup of the project shows a UI with the following:

- A row of top controls containing a Refresh **Button** and a Sign Out **Hyperlink**,
- A **TableView** that will grow to take up the extra vertical space, and
- A Close **Button**.

The UI also features a **Separator** which divides the top part of the screen with what may become a standard lower panel (Save **Button**, Cancel **Button**, etc) for the application.

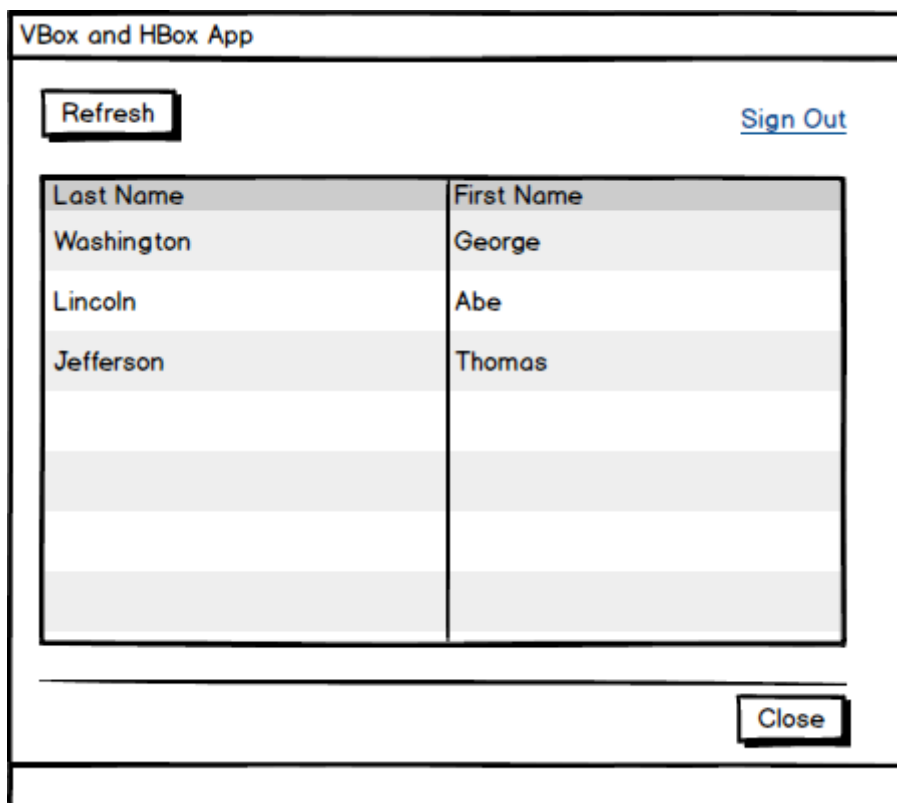


Figure 4. Mockup

4.1.1. Structure

A **VBox** is the outermost container "vbox". This will be the **Parent** provided to the Scene. Simply putting UI controls in this **VBox** will allow the controls—most notably the **TableView**—to stretch to fit the available horizontal space. The top controls, the Refresh **Button** and the Sign Out **Hyperlink**,

are wrapped in an **HBox**. Similarly, I wrap the bottom Close **Button** in an **HBox**, allowing for additional Buttons.

```
VBox vbox = new VBox();

Button btnRefresh = new Button("Refresh");

HBox topRightControls = new HBox();
topRightControls.getChildren().add( signOutLink );

topControls.getChildren().addAll( btnRefresh, topRightControls );

TableView<Customer> tblCustomers = new TableView<>();
Separator sep = new Separator();

HBox bottomControls = new HBox();

Button btnClose = new Button("Close");

bottomControls.getChildren().add( btnClose );

vbox.getChildren().addAll(
    topControls,
    tblCustomers,
    sep,
    bottomControls
);
```

This picture shows the mockup broken down by container. The parent **VBox** is the outermost blue rectangle. The **HBoxes** are the inner rectangles (red and green).

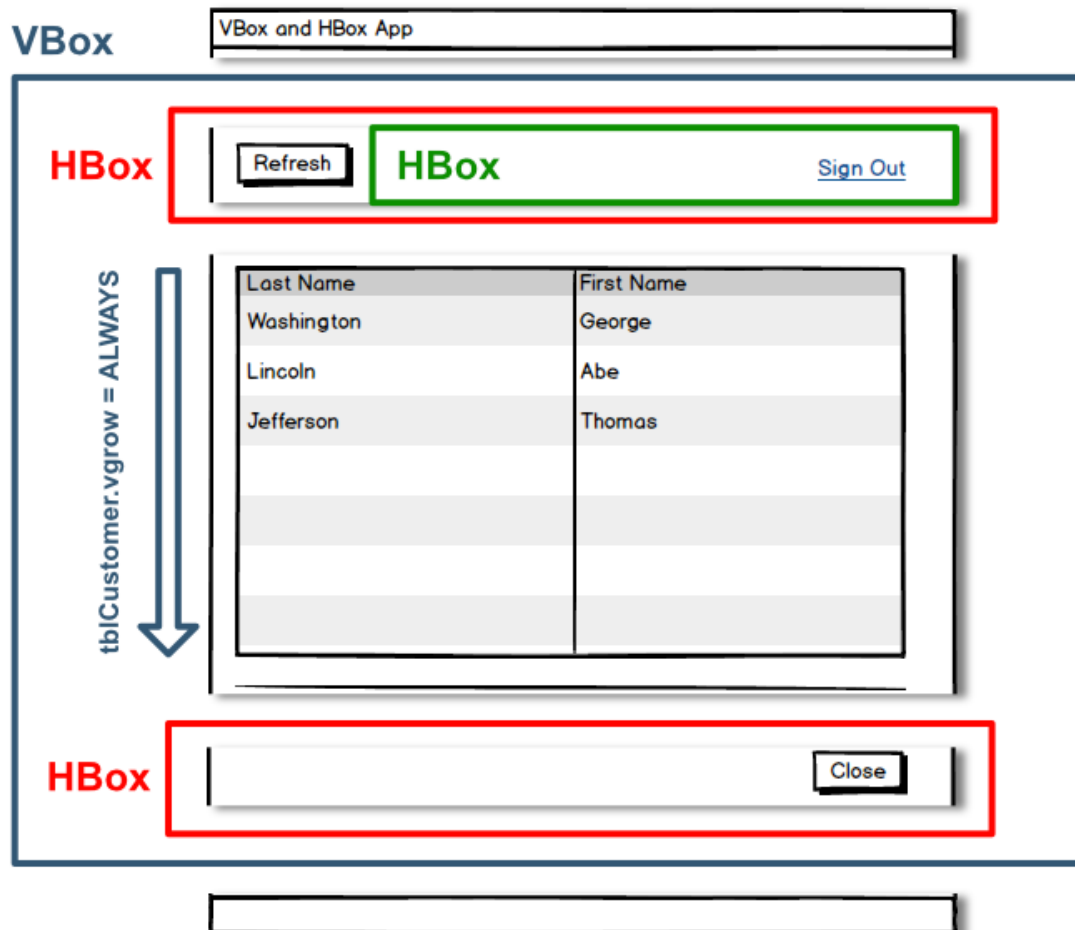


Figure 5. Mockup Broken Down

4.1.2. Alignment and Hgrow

The Refresh **Button** is aligned to the left while the Sign Out **Hyperlink** is aligned to the right. This is accomplished using two **HBoxes**. `topControls` is an **HBox** that contains the Refresh **Button** and also contains an **HBox** with the Sign Out **Hyperlink**. As the screen grows wider, the Sign Out **Hyperlink** will be pulled to the right while the Refresh **Button** will retain its left alignment.

Alignment is the property that tells a container where to position a control. `topControls` sets alignment to the `BOTTOM_LEFT`. `topRightControls` sets alignment to the `BOTTOM_RIGHT`. "BOTTOM" makes sure that the baseline of the text "Refresh" matches the baseline of the text "Sign Out".

In order to make the Sign Out **Hyperlink** move to the right when the screen gets wider, `Priority.ALWAYS` is needed. This is a cue to the JavaFX to widen `topRightControls`. Otherwise, `topControls` will keep the space and `topRightControls` will appear to the left. Sign Out **Hyperlink** still would be right-aligned but in a narrower container.

Notice that `setHgrow()` is a static method and neither invoked on the `topControls` **HBox** nor on itself, `topRightControls`. This is a facet of the JavaFX API that can be confusing because most of the API sets properties via setters on objects.

```
topControls.setAlignment( Pos.BOTTOM_LEFT );

HBox.setHgrow(topRightControls, Priority.ALWAYS );
topRightControls.setAlignment( Pos.BOTTOM_RIGHT );
```

Close **Button** is wrapped in an **HBox** and positioned using the **BOTTOM_RIGHT** priority.

```
bottomControls.setAlignment(Pos.BOTTOM_RIGHT );
```

4.1.3. Vgrow

Since the outermost container is **VBox**, the child **TableView** will expand to take up extra horizontal space when the window is widened. However, vertically resizing the window will produce a gap at the bottom of the screen. The **VBox** does not automatically resize any of its children. As with the **topRightControls HBox**, a grow indicator can be set. In the case of the **HBox**, this was a horizontal resizing instruction **setHgrow()**. For the **TableView** container **VBox**, this will be **setVgrow()**.

```
VBox.setVgrow( tblCustomers, Priority.ALWAYS );
```

4.1.4. Margin

There are a few ways to space out UI controls. This article uses the margin property on several of the containers to add whitespace around the controls. These are set individually rather than using a spacing on the **VBox** so that the **Separator** will span the entire width.

```
VBox.setMargin( topControls, new Insets(10.0d) );
VBox.setMargin( tblCustomers, new Insets(0.0d, 10.0d, 10.0d, 10.0d) );
VBox.setMargin( bottomControls, new Insets(10.0d) );
```

The **Insets** used by **tblCustomers** omits any top spacing to keep the spacing even. JavaFX does not consolidate whitespace as in web design. If the top **Inset** were set to **10.0d** for the **TableView**, the distance between the top controls and the **TableView** would be twice as wide as the distance between any of the other controls.

Notice that these are static methods like the **Priority**.

This picture shows the application when run in its initial 800x600 size.

4.1.5. Select the Right Containers

The philosophy of JavaFX layout is the same as the philosophy of Swing. Select the right container for the task at hand. This article presented the two most versatile containers: **VBox** and **HBox**. By setting properties like alignment, hgrow, and vgrow, you can build incredibly complex layouts through nesting. These are the containers I use the most and often are the only containers that I need.

4.1.6. Complete Code

The code can be tested in a pair of .java files. There is a POJO for the Customer object used by the **TableView**

```
public class Customer {

    private String firstName;
    private String lastName;

    public Customer(String firstName,
                    String lastName) {
        this.firstName = firstName;
        this.lastName = lastName;
    }

    public String getFirstName() {
        return firstName;
    }

    public void setFirstName(String firstName) {
        this.firstName = firstName;
    }

    public String getLastName() {
        return lastName;
    }

    public void setLastName(String lastName) {
        this.lastName = lastName;
    }
}
```

This is the completed JavaFX **Application** subclass and main.

```
public class VBoxAndHBoxApp extends Application {

    @Override
    public void start(Stage primaryStage) throws Exception {

        VBox vbox = new VBox();
```

```

HBox topControls = new HBox();
VBox.setMargin( topControls, new Insets(10.0d) );
topControls.setAlignment( Pos.BOTTOM_LEFT );

Button btnRefresh = new Button("Refresh");

HBox topRightControls = new HBox();
HBox.setHgrow(topRightControls, Priority.ALWAYS );
topRightControls.setAlignment( Pos.BOTTOM_RIGHT );
Hyperlink signOutLink = new Hyperlink("Sign Out");
topRightControls.getChildren().add( signOutLink );

topControls.getChildren().addAll( btnRefresh, topRightControls );

TableView<Customer> tblCustomers = new TableView<>();
tblCustomers.setColumnResizePolicy(TableView.CONSTRAINED_RESIZE_POLICY);
VBox.setMargin( tblCustomers, new Insets(0.0d, 10.0d, 10.0d, 10.0d) );
VBox.setVgrow( tblCustomers, Priority.ALWAYS );

TableColumn<Customer, String> lastNameCol = new TableColumn<>("Last Name");
lastNameCol.setCellValueFactory(new PropertyValueFactory<>("lastName"));

TableColumn<Customer, String> firstNameCol = new TableColumn<>("First Name");
firstNameCol.setCellValueFactory(new PropertyValueFactory<>("firstName"));

tblCustomers.getColumns().addAll( lastNameCol, firstNameCol );

Separator sep = new Separator();

HBox bottomControls = new HBox();
bottomControls.setAlignment(Pos.BOTTOM_RIGHT );
VBox.setMargin( bottomControls, new Insets(10.0d) );

Button btnClose = new Button("Close");

bottomControls.getChildren().add( btnClose );

vbox.getChildren().addAll(
    topControls,
    tblCustomers,
    sep,
    bottomControls
);

Scene scene = new Scene(vbox );

primaryStage.setScene( scene );
primaryStage.setWidth( 800 );
primaryStage.setHeight( 600 );
primaryStage.setTitle("VBox and HBox App");
primaryStage.setOnShown( (evt) -> loadTable(tblCustomers) );

```

```

        primaryStage.show();
    }

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

    private void loadTable(Table<Customer> tblCustomers) {
        tblCustomers.getItems().add(new Customer("George", "Washington"));
        tblCustomers.getItems().add(new Customer("Abe", "Lincoln"));
        tblCustomers.getItems().add(new Customer("Thomas", "Jefferson"));
    }
}

```

4.2. Absolute Positioning with Pane

Author: Carl Walker

Containers like `VBox` or `BorderPane` align and distribute their children. The superclass `Pane` is also a container, but does not impose an order on its children. The children position themselves through properties like `x`, `centerX`, and `layoutX`. This is called absolute positioning and it is a technique to place a `Shape` or a `Node` at a certain location on the screen.

This screenshot shows an About View. The About View contains a `Hyperlink` in the middle of the screen "About this App". The About View uses several JavaFX shapes to form a design which is cropped to appear like a business card.

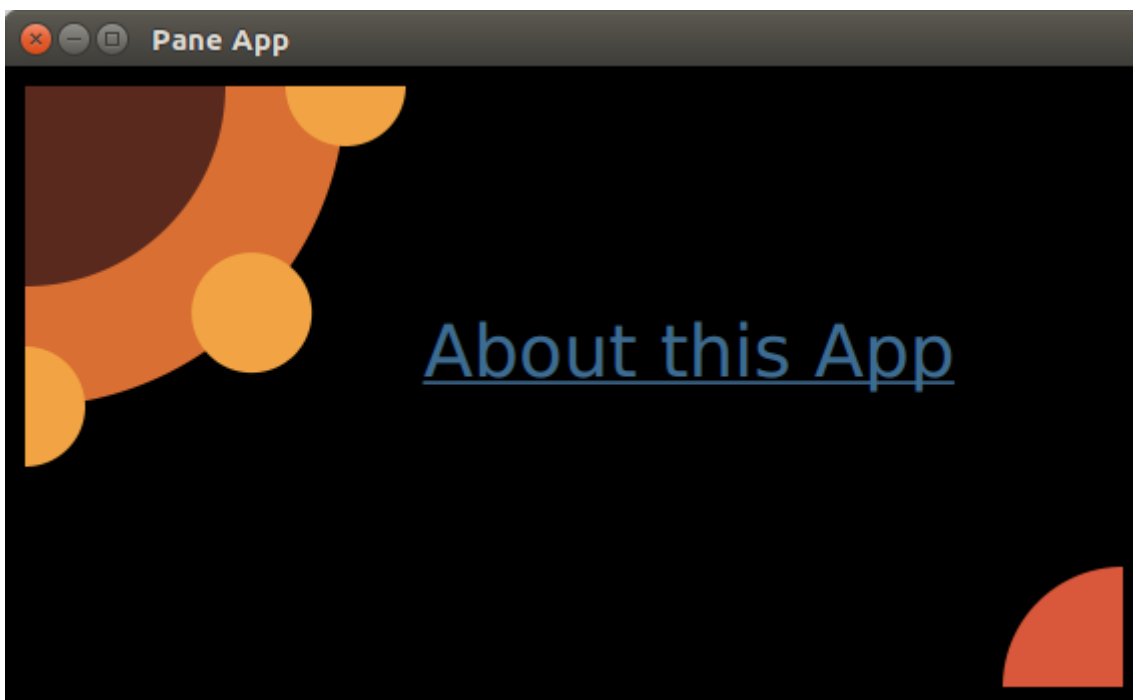


Figure 8. Screenshot of About View in PaneApp

4.2.1. Pane Size

Unlike most containers, **Pane** resizes to fit its contents and not the other way around. This picture is a screenshot from Scenic View taken prior to adding the lower-right **Arc**. The **Pane** is the yellow highlighted area. Notice that it does not take up the full **Stage**.

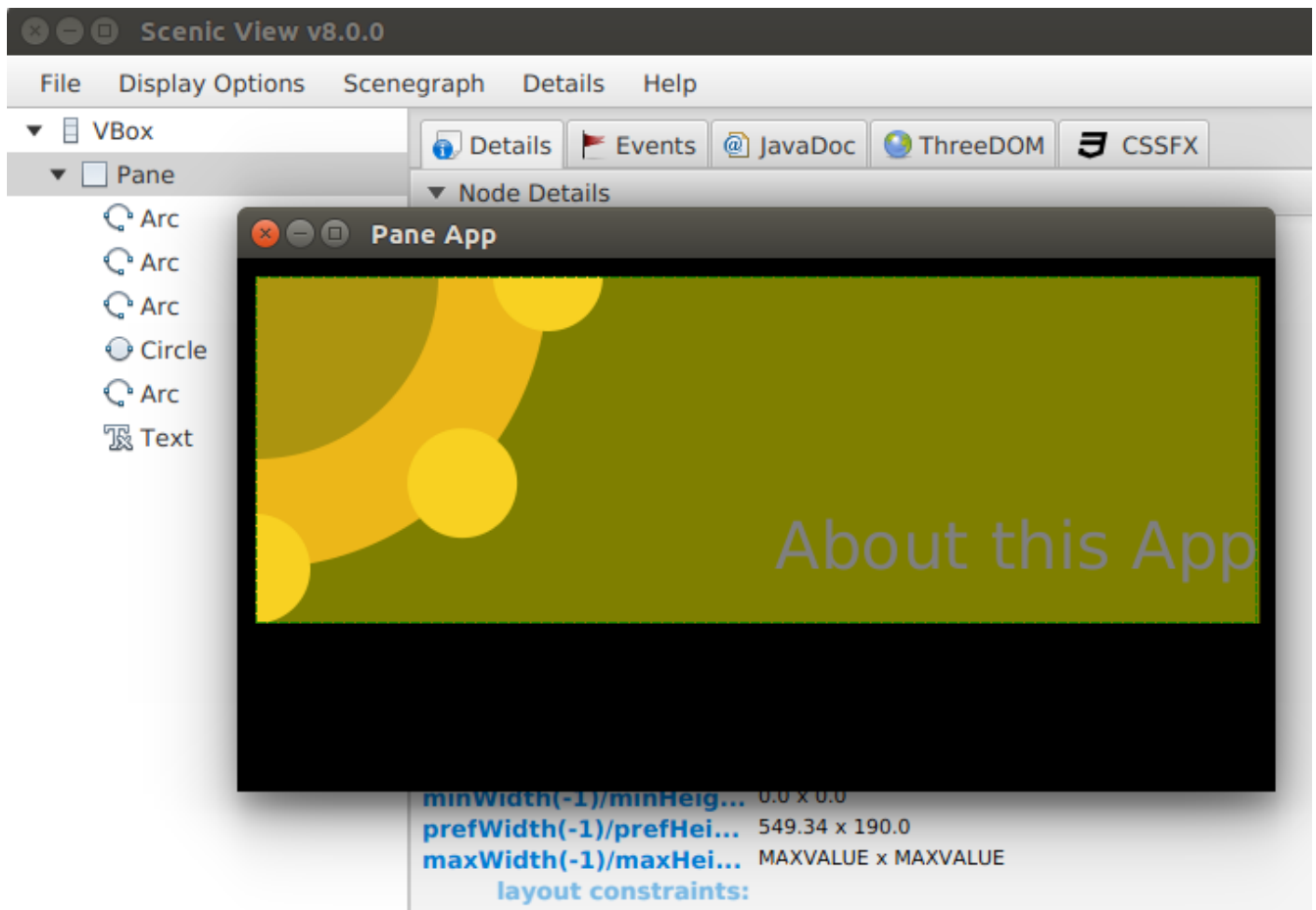


Figure 9. Scenic View Highlighting Partially Built Screen

This is a screenshot taken after the lower-right **Arc** was added. This **Arc** was placed closer to the bottom-right edge of the **Stage**. This forces the **Pane** to stretch to accommodate the expanded contents.

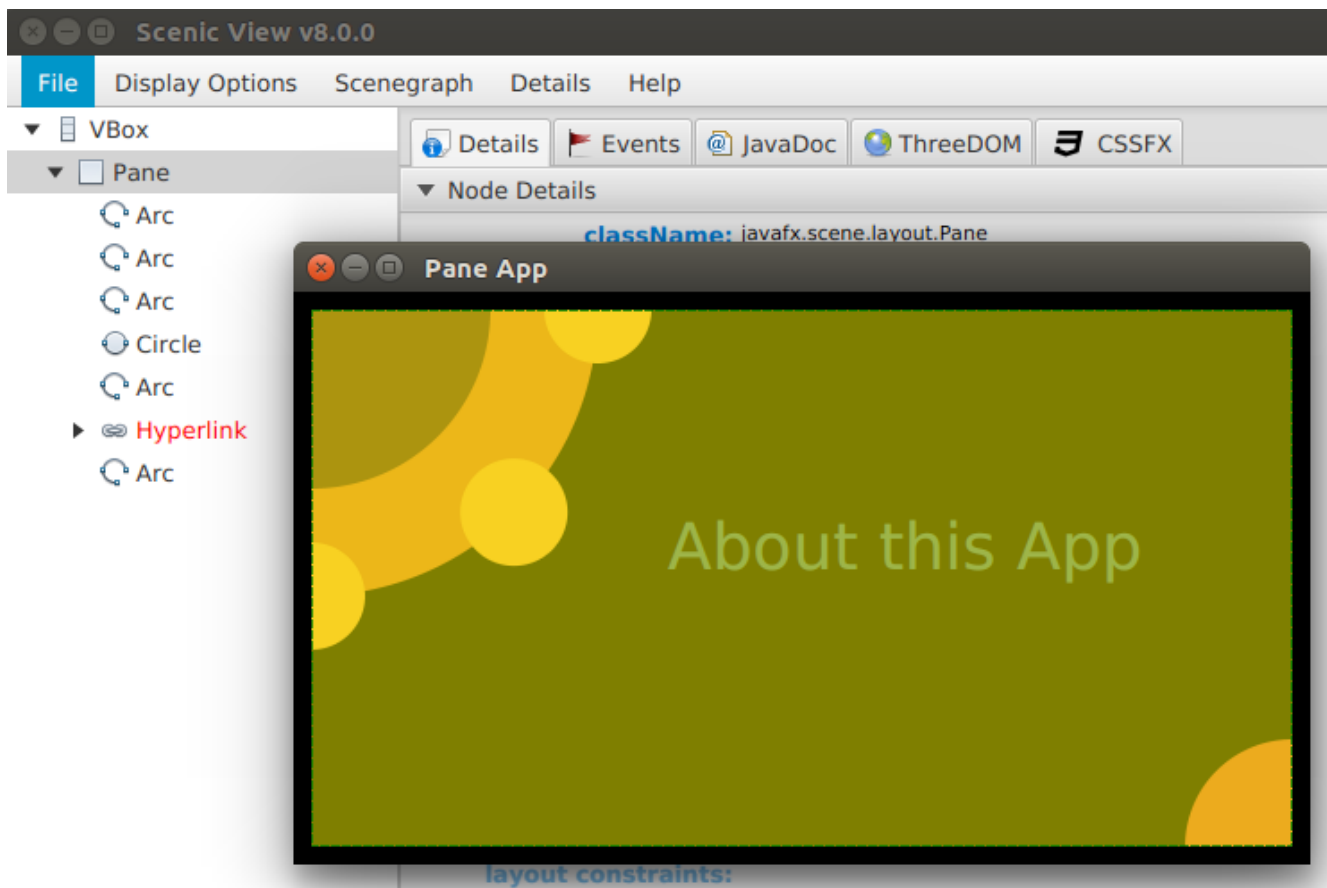


Figure 10. Scenic View Highlighting Expanded Pane

4.2.2. The Pane

The outermost container of the About View is a `VBox` whose sole contents are the `Pane`. The `VBox` is used to fit the entire `Stage` and provides a background.

```
VBox vbox = new VBox();
vbox.setPadding( new Insets( 10 ) );
vbox.setBackground(
    new Background(
        new BackgroundFill(Color.BLACK, new CornerRadii(0), new Insets(0))
    ));

Pane p = new Pane();
```

4.2.3. The Shapes

In the upper left of the screen, there is a group of 4 'Arcs' and 1 'Circle'. This code positions `largeArc` at (0,0) through the `centerX` and `centerY` arguments in the `Arc` constructor. Notice that `backgroundArc` is also positioned at (0,0) and appears underneath `largeArc`. `Pane` does not attempt to deconflict overlapping shapes and in this case, overlapping is what is wanted. `smArc1` is placed at (0,160) which is down on the Y axis. `smArc2` is positioned at (160,0) which is right on the X axis. `smCircle` is positioned at the same distance as `smArc1` and `smArc2`, but at a 45 degree angle.

```
Arc largeArc = new Arc(0, 0, 100, 100, 270, 90);
largeArc.setType(ArcType.ROUND);

Arc backgroundArc = new Arc(0, 0, 160, 160, 270, 90 );
backgroundArc.setType( ArcType.ROUND );

Arc smArc1 = new Arc( 0, 160, 30, 30, 270, 180);
smArc1.setType(ArcType.ROUND);

Circle smCircle = new Circle(160/Math.sqrt(2.0), 160/Math.sqrt(2.0),
30,Color.web("0xF2A444"));

Arc smArc2 = new Arc( 160, 0, 30, 30, 180, 180);
smArc2.setType(ArcType.ROUND);
```

The lower-right **Arc** is positioned based on the overall height of the **Stage**. The 20 subtracted from the height is the 10 pixel **Insets** from the **VBox** (10 for left + 10 for right).

```
Arc medArc = new Arc(568-20, 320-20, 60, 60, 90, 90);
medArc.setType(ArcType.ROUND);

primaryStage.setWidth( 568 );
primaryStage.setHeight( 320 );
```

4.2.4. The Hyperlink

The **Hyperlink** is positioned offset the center (284,160) which is the width and height of the **Stage** both divided by two. This positions the text of the **Hyperlink** in the lower-right quadrant of the screen, so an offset is needed based on the **Hyperlink** width and height. The dimensions are not available for the **Hyperlink** until the screen is shown, so I make a post-shown adjustment to the position.

```
Hyperlink hyperlink = new Hyperlink("About this App");

primaryStage.setOnShown( (evt) -> {
    hyperlink.setLayoutX( 284 - (hyperlink.getWidth()/3) );
    hyperlink.setLayoutY( 160 - hyperlink.getHeight() );
});
```

The **Hyperlink** is not placed in the true center of the screen. The layoutX value is based on a divide-by-three operation that moves it away from the upper-left design.

4.2.5. Z-Order

As mentioned earlier, **Pane** supports overlapping children. This picture shows the About View with depth added to the upper-left design. The smaller **Arcs** and **Circle** hover over backgroundArc as

does largeArc.

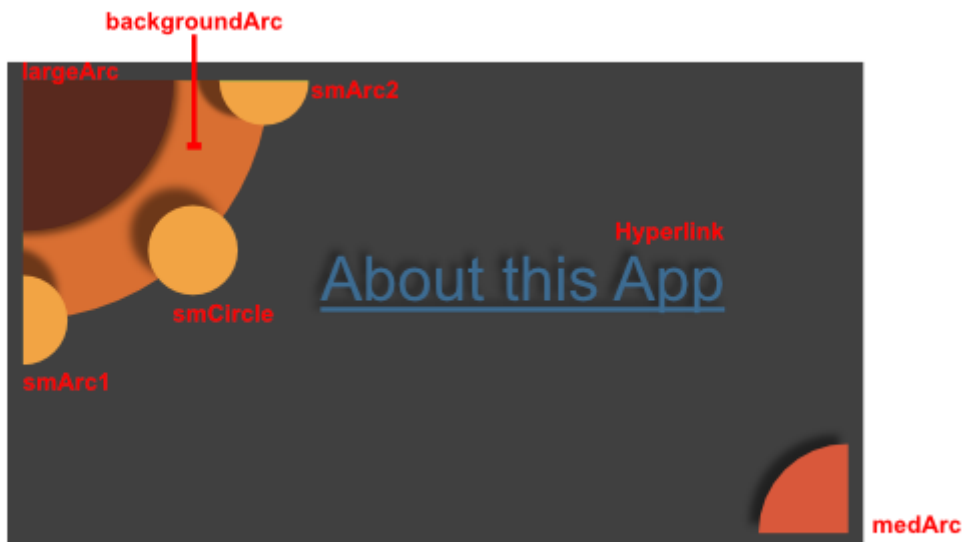


Figure 11. About View Showing Depth

The z-order in this example is determined by the order in which the children are added to the `Pane`. `backgroundArc` is obscured by items added later, most notably `largeArc`. To rearrange the children, use the `toFront()` and `toBack()` methods after the items have been added to the `Pane`.

```
p.getChildren().addAll( backgroundArc, largeArc, smArc1, smCircle, smArc2, hyperlink,
medArc );

vbox.getChildren().add( p );
```

When starting JavaFX, it is tempting to build an absolute layout. Be aware that absolute layouts are brittle, often breaking when the screen is resized or when items are added during the software maintenance phase. Yet, there are good reasons for using absolute positioning. Gaming is one such usage. In a game, you can adjust the (x,y) coordinate of a 'Shape' to move a game piece around the screen. This article demonstrated the JavaFX class `Pane` which provides absolute positioning to any shape-driven UI.

4.2.6. Completed Code

This is the completed JavaFX `Application` subclass and main.

```
public class PaneApp extends Application {

    @Override
    public void start(Stage primaryStage) throws Exception {

        VBox vbox = new VBox();
        vbox.setPadding( new Insets( 10 ) );
        vbox.setBackground(
```



```

        new Background(
            new BackgroundFill(Color.BLACK, new CornerRadii(0), new Insets(0))
        ));

Pane p = new Pane();

Arc largeArc = new Arc(0, 0, 100, 100, 270, 90);
largeArc.setFill(Color.web("0x59291E"));
largeArc.setType(ArcType.ROUND);

Arc backgroundArc = new Arc(0, 0, 160, 160, 270, 90 );
backgroundArc.setFill( Color.web("0xD96F32") );
backgroundArc.setType( ArcType.ROUND );

Arc smArc1 = new Arc( 0, 160, 30, 30, 270, 180);
smArc1.setFill(Color.web("0xF2A444"));
smArc1.setType(ArcType.ROUND);

Circle smCircle = new Circle(
    160/Math.sqrt(2.0), 160/Math.sqrt(2.0), 30,Color.web("0xF2A444")
);

Arc smArc2 = new Arc( 160, 0, 30, 30, 180, 180);
smArc2.setFill(Color.web("0xF2A444"));
smArc2.setType(ArcType.ROUND);

Hyperlink hyperlink = new Hyperlink("About this App");
hyperlink.setFont( Font.font(36) );
hyperlink.setTextFill( Color.web("0x3E6C93") );
hyperlink.setBorder( Border.EMPTY );

Arc medArc = new Arc(568-20, 320-20, 60, 60, 90, 90);
medArc.setFill(Color.web("0xD9583B"));
medArc.setType(ArcType.ROUND);

p.getChildren().addAll( backgroundArc, largeArc, smArc1, smCircle,
    smArc2, hyperlink, medArc );

vbox.getChildren().add( p );

Scene scene = new Scene(vbox);
scene.setFill(Color.BLACK);

primaryStage.setTitle("Pane App");
primaryStage.setScene( scene );
primaryStage.setWidth( 568 );
primaryStage.setHeight( 320 );
primaryStage.setOnShown( (evt) -> {
    hyperlink.setLayoutX( 284 - (hyperlink.getWidth()/3) );
    hyperlink.setLayoutY( 160 - hyperlink.getHeight() );
});

```

```
        primaryStage.show();
    }

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

4.3. Clipping

Author: Christoph Nahr

Most JavaFX layout containers (base class [Region](#)) automatically position and size their children, so clipping any child contents that might protrude beyond the container's layout bounds is never an issue. The big exception is [Pane](#), a direct subclass of [Region](#) and the base class for all layout containers with publicly accessible children. Unlike its subclasses [Pane](#) does not attempt to arrange its children but simply accepts explicit user positioning and sizing.

This makes [Pane](#) suitable as a drawing surface, similar to [Canvas](#) but rendering user-defined [Shape](#) children rather than direct drawing commands. The problem is that drawing surfaces are usually expected to automatically clip their contents at their bounds. [Canvas](#) does this by default but [Pane](#) does not. From the last paragraph of the Javadoc entry for [Pane](#):

[Pane](#) does not clip its content by default, so it is possible that children's bounds may extend outside its own bounds, either if children are positioned at negative coordinates or the pane is resized smaller than its preferred size.

This quote is somewhat misleading. Children are rendered (wholly or partially) outside their parent [Pane](#) 'whenever' their combination of position and size extends beyond the parent's bounds, regardless of whether the position is negative or the [Pane](#) is ever resized. Quite simply, [Pane](#) only provides a coordinate shift to its children, based on its upper-left corner – but its layout bounds are completely ignored while rendering children. Note that the Javadoc for all [Pane](#) subclasses (that I checked) includes a similar warning. They don't clip their contents either, but as mentioned above this is not usually a problem for them because they automatically arrange their children.

So to properly use [Pane](#) as a drawing surface for [Shapes](#), we need to manually clip its contents. This is somewhat complex, especially when a visible border is involved. I wrote a small demo application to illustrate the default behavior and various steps to fix it. You can download it as [PaneDemo.zip](#) which contains a project for NetBeans 8.2 and Java SE 8u112. The following sections explain each step with screenshots and pertinent code snippets.

4.3.1. Default Behavior

Starting up, [PaneDemo](#) shows what happens when you put an [Ellipse](#) shape into a [Pane](#) that's too small to contain it entirely. The [Pane](#) has a nice thick rounded [Border](#) to visualize its area. The application window is resizable, with the [Pane](#) size following the window size. The three buttons on

the left are used to switch to the other steps in the demo; click Default (Alt+D) to revert to the default output from a later step.

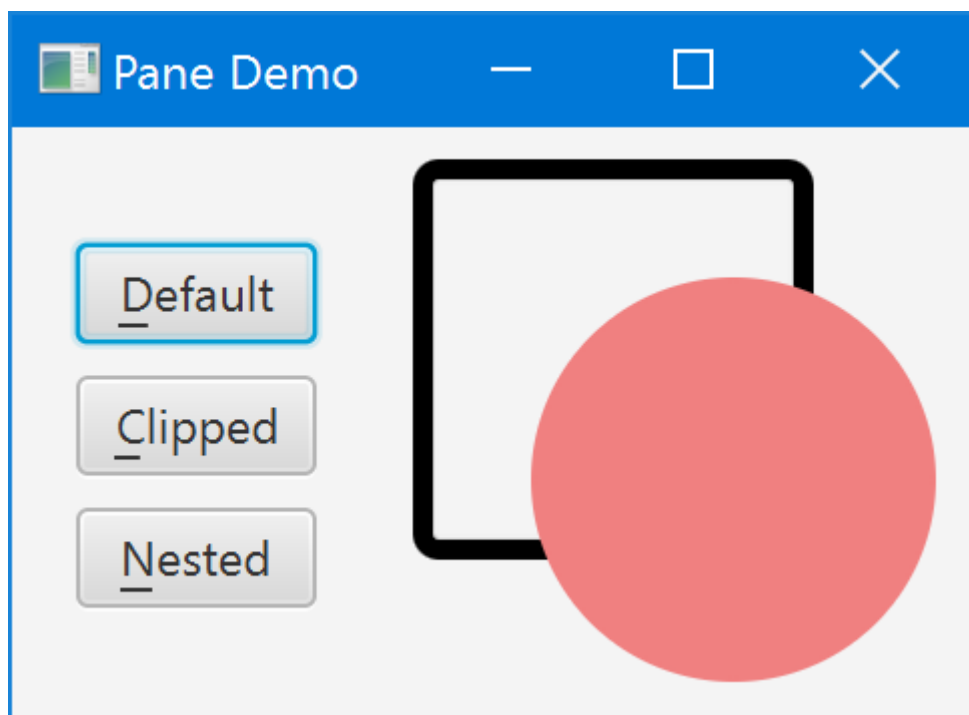


Figure 12. Child Extending Outside Pane Bounds

As you can see, the `Ellipse` overwrites its parent's `Border` and protrudes well beyond it. The following code is used to generate the default view. It's split into several smaller methods, and a constant for the `Border` corner radius, because they will be referenced in the next steps.

```

static final double BORDER_RADIUS = 4;

static Border createBorder() {
    return new Border(
        new BorderStroke(Color.BLACK, BorderStrokeStyle.SOLID,
            new CornerRadii(BORDER_RADIUS), BorderStroke.THICK));
}

static Shape createShape() {
    final Ellipse shape = new Ellipse(50, 50);
    shape.setCenterX(80);
    shape.setCenterY(80);
    shape.setFill(Color.LIGHTCORAL);
    shape.setStroke(Color.LIGHTCORAL);
    return shape;
}

static Region createDefault() {
    final Pane pane = new Pane(createShape());
    pane.setBorder(createBorder());
    pane.setPrefSize(100, 100);
    return pane;
}

```

4.3.2. Simple Clipping

Surprisingly, there is no predefined option to have a resizable `Region` automatically clip its children to its current size. Instead, you need to use the basic `clipProperty` defined on `Node` and keep it updated manually to reflect changing layout bounds. Method `clipChildren` below show how this works (with Javadoc because you may want to reuse it in your own code):

```

/**
 * Clips the children of the specified {@link Region} to its current size.
 * This requires attaching a change listener to the region's layout bounds,
 * as JavaFX does not currently provide any built-in way to clip children.
 *
 * @param region the {@link Region} whose children to clip
 * @param arc the {@link Rectangle#arcWidth} and {@link Rectangle#arcHeight}
 *            of the clipping {@link Rectangle}
 * @throws NullPointerException if {@code region} is {@code null}
 */
static void clipChildren(Region region, double arc) {

    final Rectangle outputClip = new Rectangle();
    outputClip.setArcWidth(arc);
    outputClip.setArcHeight(arc);
    region.setClip(outputClip);

    region.layoutBoundsProperty().addListener((ov, oldValue, newValue) -> {
        outputClip.setWidth(newValue.getWidth());
        outputClip.setHeight(newValue.getHeight());
    });
}

static Region createClipped() {
    final Pane pane = new Pane(createShape());
    pane.setBorder(createBorder());
    pane.setPrefSize(100, 100);

    // clipped children still overwrite Border!
    clipChildren(pane, 3 * BORDER_RADIUS);

    return pane;
}

```

Choose Clipped (Alt+C) in PaneDemo to render the corresponding output. Here's how that looks:

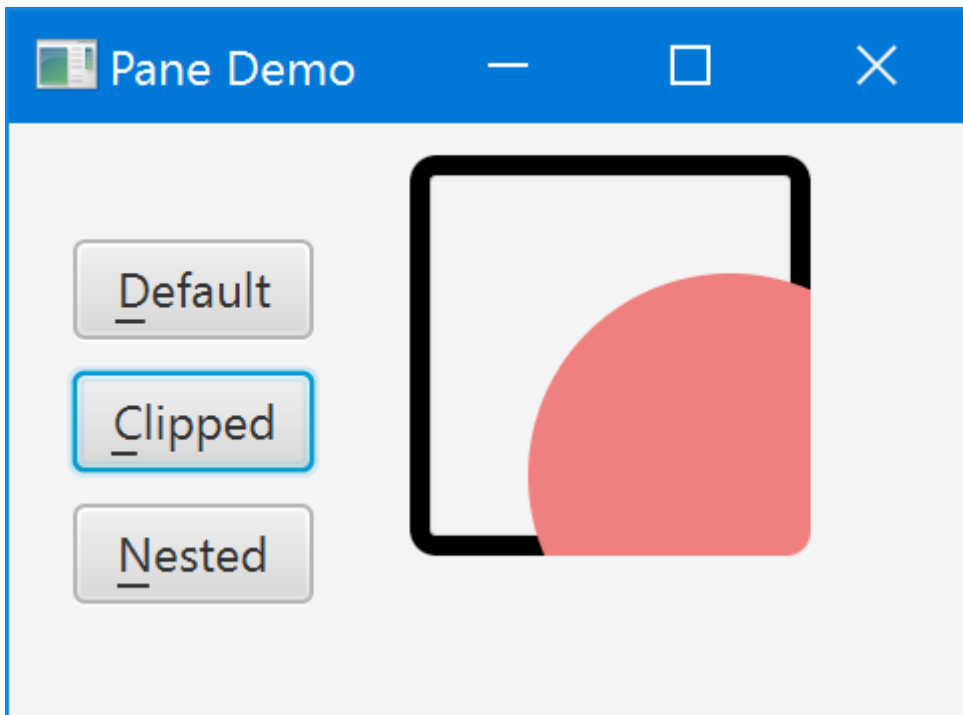


Figure 13. Pane with Clip Applied

That's better. The `Ellipse` no longer protrudes beyond the `Pane` – but still overwrites its `Border`. Also note that we had to manually specify an estimated corner rounding for the clipping `Rectangle` in order to reflect the rounded `Border` corners. This estimate is $3 * \text{BORDER_RADIUS}$ because the corner radius specified on `Border` actually defines its inner radius, and the outer radius (which we need here) will be greater depending on the `Border` thickness. (You could compute the outer radius exactly if you really wanted to, but I skipped that for the demo application.)

4.3.3. Nested Panes

Can we somehow specify a clipping region that excludes a visible `Border`? Not on the drawing `Pane` itself, as far as I can tell. The clipping region affects the `Border` as well as other contents, so if you were to shrink the clipping region to exclude it you would no longer see any `Border` at all. Instead, the solution is to create two nested panes: one inner drawing `Pane` without `Border` that clips exactly to its bounds, and one outer `StackPane` that defines the visible `Border` and also resizes the drawing `Pane`. Here is the final code:

```
static Region createNested() {
    // create drawing Pane without Border or size
    final Pane pane = new Pane(createShape());
    clipChildren(pane, BORDER_RADIUS);

    // create sized enclosing Region with Border
    final Region container = new StackPane(pane);
    container.setBorder(createBorder());
    container.setPrefSize(100, 100);
    return container;
}
```

Choose Nested (Alt+N) in PaneDemo to render the corresponding output. Now everything looks as it

should:

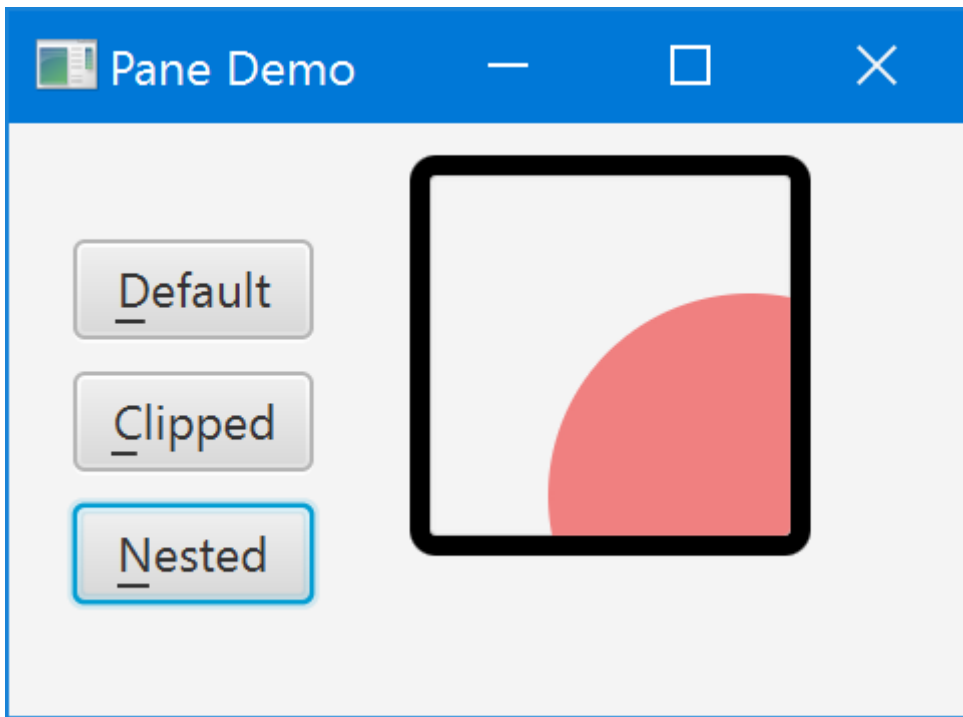


Figure 14. Nesting Pane in StackPane

As an added bonus, we no longer need to guesstimate a correct corner radius for the clipping `Rectangle`. We now clip to the inner rather than outer circumference of our visible `Border`, so we can directly reuse its inner corner radius. Should you specify multiple different corner radii or an otherwise more complex `Border` you'd have to define a correspondingly more complex clipping `Shape`.

There is one small caveat. The top-left corner of the drawing `Pane` to which all child coordinates are relative now starts *within* the visible `Border`. If you retroactively change a single `Pane` with visible `Border` to nested panes as shown here, all children will exhibit a slight positioning shift corresponding to the `Border` thickness.

4.4. GridPane

Author: Carl Walker

Forms in business applications often use a layout that mimics a database record. For each column in a table, a header is added on the left-hand side which is matched with a row value on the right-hand side. JavaFX has a special purpose control called `GridPane` for this type of layout that keeps contents aligned by row and column. `GridPane` also supports spanning for more complex layouts.

This screenshot shows a basic `GridPane` layout. On the left-hand side of the form, there is a column of field names: Email, Priority, Problem, Description. On the right-hand side of the form, there is a column of controls which will display the value of the corresponding field. The field names are of type `Label` and the value controls are a mixture including `TextField`, `TextArea`, and `ComboBox`.

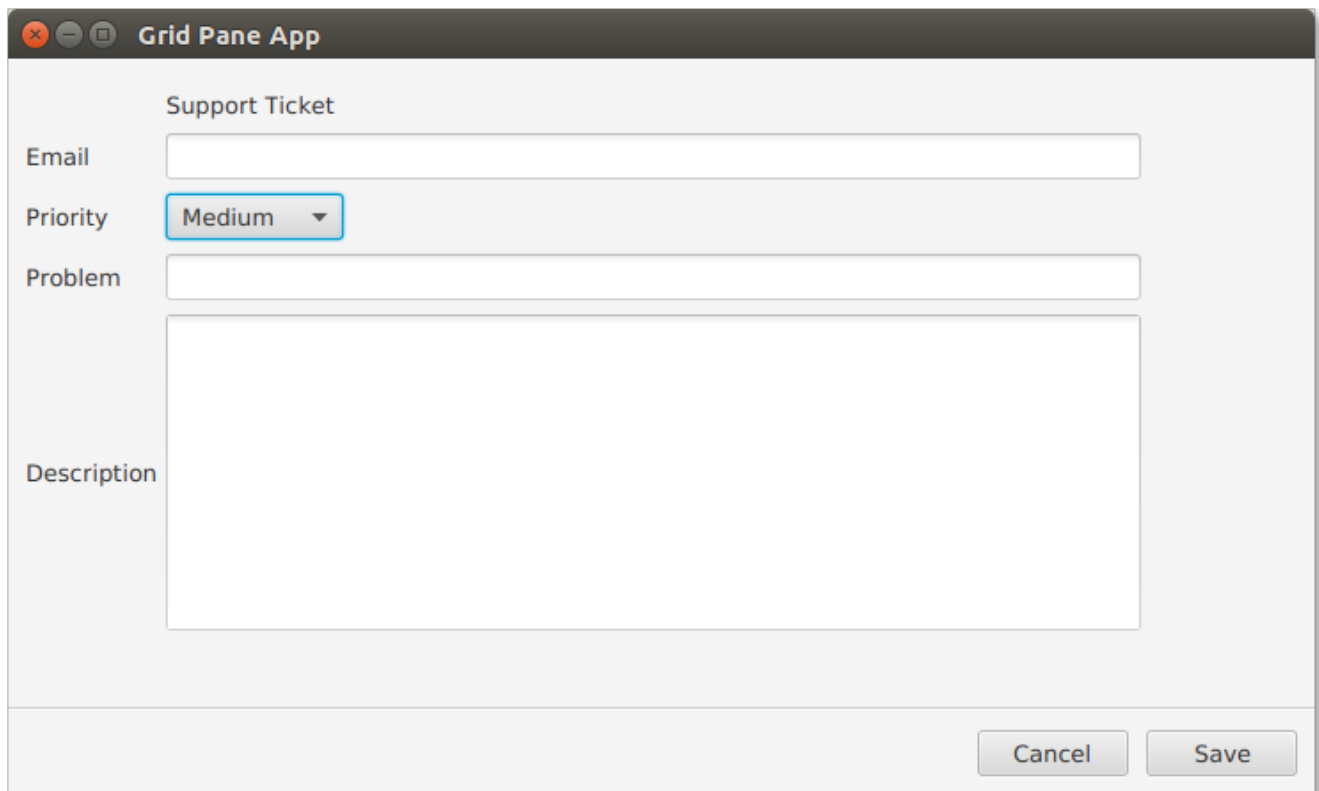


Figure 15. Field Name / Value Pairs in a GridPane

The following code shows the objects created for the form. "vbox" is the root of the **Scene** and will also contain the **ButtonBar** at the base of the form.

```
VBox vbox = new VBox();

GridPane gp = new GridPane();

Label lblTitle = new Label("Support Ticket");

Label lblEmail = new Label("Email");
TextField tfEmail = new TextField();

Label lblPriority = new Label("Priority");
ObservableList<String> priorities = FXCollections.observableArrayList("Medium",
    "High", "Low");
ComboBox<String> cbPriority = new ComboBox<>(priorities);

Label lblProblem = new Label("Problem");
TextField tfProblem = new TextField();

Label lblDescription = new Label("Description");
TextArea taDescription = new TextArea();
```

GridPane has a handy method `setGridLinesVisible()` which shows the grid structure and gutters. It is especially useful in more complex layouts where spanning is involved because gaps in the row/col assignments can cause shifts in the layout.

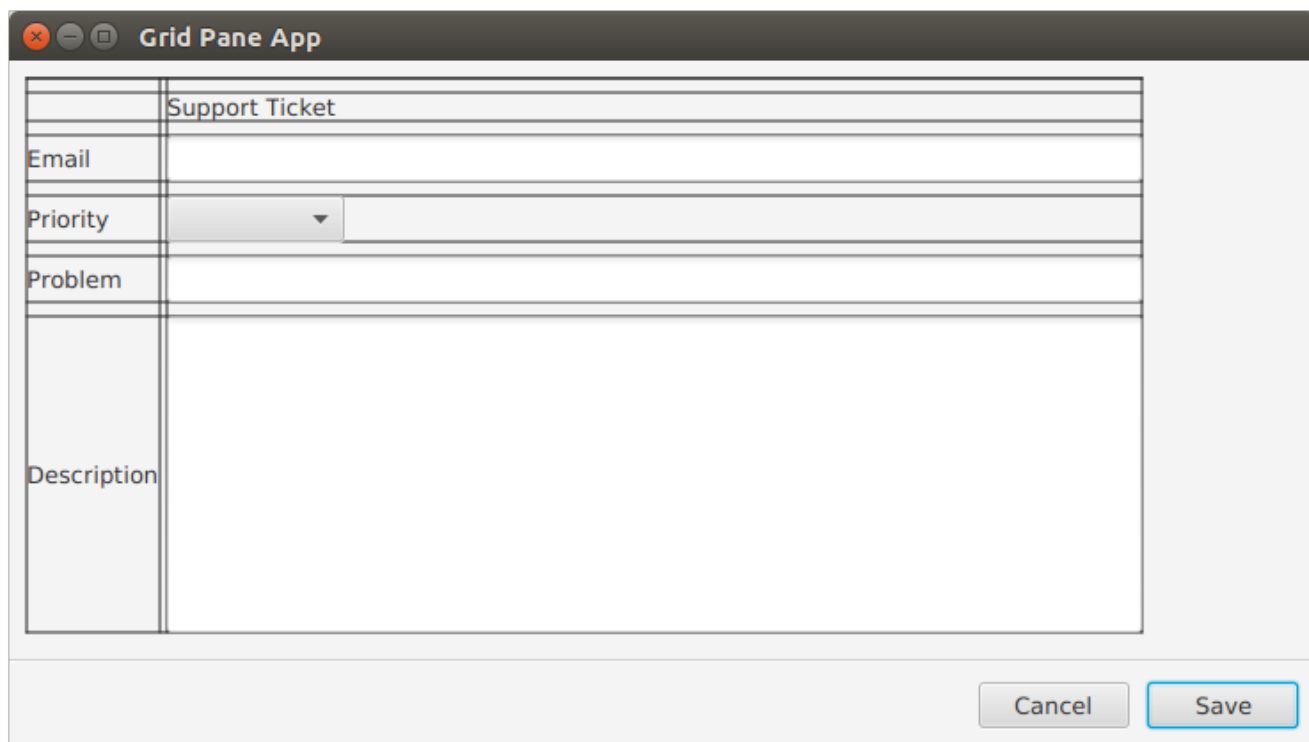


Figure 16. Grid Structure and Gutters

4.4.1. Spacing

As a container, `GridPane` has a `padding` property that can be set to surround the `GridPane` contents with whitespace. "padding" will take an `Inset` object as a parameter. In this example, 10 pixels of whitespace is applied to all sides so a short form constructor is used for `Inset`.

Within the `GridPane`, `vgap` and `hgap` control the gutters. The `hgap` is set to 4 to keep the fields close to their values. `vgap` is slightly larger to help with mouse navigation.

```
gp.setPadding( new Insets(10) );
gp.setHgap( 4 );
gp.setVgap( 8 );
```

In order to keep the lower part of the form consistent, a `Priority` is set on the `VBox`. This will *not* `resize` the individual rows however. For individual `resize` specifications, use `ColumnConstraints` and `RowConstraints`.

```
VBox.setVgrow(gp, Priority.ALWAYS );
```

4.4.2. Adding Items

Unlike containers like `BorderPane` or `HBox`, `Nodes` need to specify their position within the `GridPane`. This is done with the `add()` method on the `GridPane` and not the `add` method on a container children property. This form of the `GridPane` `add()` method takes a zero-based column position and a zero-based row position. This code puts two statements on the same line for readability.

```
gp.add( lblTitle,      1, 1); // empty item at 0,0
gp.add( lblEmail,      0, 2); gp.add(tfEmail,      1, 2);
gp.add( lblPriority,    0, 3); gp.add( cbPriority,    1, 3);
gp.add( lblProblem,    0, 4); gp.add( tfProblem,    1, 4);
gp.add( lblDescription, 0, 5); gp.add( taDescription, 1, 5);
```

lblTitle is put in the second column of the first row. There is no entry in the first column of the first row.

Subsequent additions are presented in pairs. Field name **Label** objects are put in the first column (column index=0) and value controls are put in the second column (column index=1). The rows are added by the incremented second value. For example, lblPriority is put in the fourth row along with its **ComboBox**.

GridPane is an important container in JavaFX business application design. When you have a requirement for name / value pairs, **GridPane** will be an easy way to support the strong column orientation of a traditional form.

4.4.3. Completed Code

The following class is the complete code form the example. This include the definition of the **ButtonBar** which was not presented in the preceding sections focused on **GridPane**.

```
public class GridPaneApp extends Application {

    @Override
    public void start(Stage primaryStage) throws Exception {

        VBox vbox = new VBox();

        GridPane gp = new GridPane();
        gp.setPadding( new Insets(10) );
        gp.setHgap( 4 );
        gp.setVgap( 8 );

        VBox.setVgrow(gp, Priority.ALWAYS );

        Label lblTitle = new Label("Support Ticket");

        Label lblEmail = new Label("Email");
        TextField tfEmail = new TextField();

        Label lblPriority = new Label("Priority");
        ObservableList<String> priorities =
            FXCollections.observableArrayList("Medium", "High", "Low");
        ComboBox<String> cbPriority = new ComboBox<>(priorities);

        Label lblProblem = new Label("Problem");
        TextField tfProblem = new TextField();
```

```

Label lblDescription = new Label("Description");
TextArea taDescription = new TextArea();

gp.add( lblTitle,      1, 1); // empty item at 0,0
gp.add( lblEmail,      0, 2); gp.add(tfEmail,      1, 2);
gp.add( lblPriority,    0, 3); gp.add( cbPriority,    1, 3);
gp.add( lblProblem,    0, 4); gp.add( tfProblem,    1, 4);
gp.add( lblDescription, 0, 5); gp.add( taDescription, 1, 5);

Separator sep = new Separator(); // hr

ButtonBar buttonBar = new ButtonBar();
buttonBar.setPadding( new Insets(10) );

Button saveButton = new Button("Save");
Button cancelButton = new Button("Cancel");

buttonBar.setButtonData(saveButton, ButtonBar.ButtonData.OK_DONE);
buttonBar.setButtonData(cancelButton, ButtonBar.ButtonData.CANCEL_CLOSE);

buttonBar.getButtons().addAll(saveButton, cancelButton);

vbox.getChildren().addAll( gp, sep, buttonBar );

Scene scene = new Scene(vbox);

primaryStage.setTitle("Grid Pane App");
primaryStage.setScene(scene);
primaryStage.setWidth( 736 );
primaryStage.setHeight( 414 );
primaryStage.show();
}

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

```

4.5. GridPane Spanning

Author: Carl Walker

For more complex forms implemented with **GridPane**, spanning is supported. Spanning allows a control to claim the space of neighboring columns (colspan) and neighboring rows (rowspan). This screenshot shows a form that extends the example in the previous section. The two-column layout of the earlier version has been replaced with a multiple-column layout. Fields like Problem and Description retain the original structure. But controls were added to the rows that formerly held only Email and Priority.

Support Ticket

Email Contract

Priority Severity Category

Problem

Description

Cancel Save

Figure 17. Spanning Columns

Turning the grid lines on, notice that the former two column grid is replaced with a six column grid. The third row containing six items — 3 field name / value pairs — dictates the structure. The rest of the form will use spanning in order to fill in the whitespace.

Support Ticket

Email Contract

Priority Severity Category

Problem

Description

Cancel Save

Figure 18. Lines Highlighting Spanning

The `VBox` and `GridPane` container objects used in this update follow. There is a little more `Vgap` to help the user select the `ComboBox` controls.

```
GridPane gp = new GridPane();
gp.setPadding( new Insets(10) );
gp.setHgap( 4 );
gp.setVgap( 10 );

VBox.setVgrow(gp, Priority.ALWAYS );
```

These are control creation statements from the updated example.

```
Label lblTitle = new Label("Support Ticket");

Label lblEmail = new Label("Email");
TextField tfEmail = new TextField();

Label lblContract = new Label("Contract");
TextField tfContract = new TextField();

Label lblPriority = new Label("Priority");
ObservableList<String> priorities =
    FXCollections.observableArrayList("Medium", "High", "Low");
ComboBox<String> cbPriority = new ComboBox<>(priorities);

Label lblSeverity = new Label("Severity");
ObservableList<String> severities =
    FXCollections.observableArrayList("Blocker", "Workaround", "N/A");
ComboBox<String> cbSeverity = new ComboBox<>(severities);

Label lblCategory = new Label("Category");
ObservableList<String> categories =
    FXCollections.observableArrayList("Bug", "Feature");
ComboBox<String> cbCategory = new ComboBox<>(categories);

Label lblProblem = new Label("Problem");
TextField tfProblem = new TextField();

Label lblDescription = new Label("Description");
TextArea taDescription = new TextArea();
```

As in the earlier version, the controls are added to the `GridPane` using the `add()` method. A column and row are specified. In this snippet, the indexing is not straightforward as there are gaps expected to be filled in by spanning content.

```

gp.add( lblTitle,      1, 0); // empty item at 0,0

gp.add( lblEmail,      0, 1);
gp.add(tfEmail,        1, 1);
gp.add( lblContract,   4, 1 );
gp.add( tfContract,    5, 1 );

gp.add( lblPriority,    0, 2);
gp.add( cbPriority,     1, 2);
gp.add( lblSeverity,   2, 2);
gp.add( cbSeverity,    3, 2);
gp.add( lblCategory,   4, 2);
gp.add( cbCategory,    5, 2);

gp.add( lblProblem,     0, 3); gp.add( tfProblem,     1, 3);
gp.add( lblDescription, 0, 4); gp.add( taDescription, 1, 4);

```

Finally, the spanning definitions are set using a static method on `GridPane`. There is a similar method to do row spanning. Title will take up 5 columns as will Problem and Description. Email shares a row with Contract, but will take up more columns. The third row of ComboBoxes is a set of three field/value pairs each taking up one column.

```

GridPane.setColumnSpan( lblTitle, 5 );
GridPane.setColumnSpan( tfEmail, 3 );
GridPane.setColumnSpan( tfProblem, 5 );
GridPane.setColumnSpan( taDescription, 5 );

```

Alternatively, a variation of the `add()` method will `columnSpan` and `rowSpan` arguments to avoid the subsequent static method call.

This expanded `GridPane` example demonstrated column spanning. The same capability is available for row spanning which would allow a control to claim additional vertical space. Spanning keeps controls aligned even in cases where the number of items in a given row (or column) varies. To keep the focus on the spanning topic, this grid allowed the column widths to vary. The article on `ColumnConstraints` and `RowConstraints` will focus on building true modular and column typographical grids by better controlling the columns (and rows).

4.5.1. Completed Code

The following is the completed code for the spanning `GridPane` example.

```

public class ComplexGridPaneApp extends Application {

    @Override
    public void start(Stage primaryStage) throws Exception {

        VBox vbox = new VBox();

```

```

GridPane gp = new GridPane();
gp.setPadding( new Insets(10) );
gp.setHgap( 4 );
gp.setVgap( 10 );

VBox.setVgrow(gp, Priority.ALWAYS );

Label lblTitle = new Label("Support Ticket");

Label lblEmail = new Label("Email");
TextField tfEmail = new TextField();

Label lblContract = new Label("Contract");
TextField tfContract = new TextField();

Label lblPriority = new Label("Priority");
ObservableList<String> priorities =
    FXCollections.observableArrayList("Medium", "High", "Low");
ComboBox<String> cbPriority = new ComboBox<>(priorities);

Label lblSeverity = new Label("Severity");
ObservableList<String> severities =
    FXCollections.observableArrayList("Blocker", "Workaround", "N/A");
ComboBox<String> cbSeverity = new ComboBox<>(severities);

Label lblCategory = new Label("Category");
ObservableList<String> categories = FXCollections.observableArrayList("Bug",
"Feature");
ComboBox<String> cbCategory = new ComboBox<>(categories);

Label lblProblem = new Label("Problem");
TextField tfProblem = new TextField();

Label lblDescription = new Label("Description");
TextArea taDescription = new TextArea();

gp.add( lblTitle,      1, 0); // empty item at 0,0

gp.add( lblEmail,      0, 1);
gp.add( tfEmail,       1, 1);
gp.add( lblContract,   4, 1 );
gp.add( tfContract,    5, 1 );

gp.add( lblPriority,    0, 2);
gp.add( cbPriority,     1, 2);
gp.add( lblSeverity,   2, 2);
gp.add( cbSeverity,    3, 2);
gp.add( lblCategory,   4, 2);
gp.add( cbCategory,    5, 2);

```

```

gp.add( lblProblem,      0, 3); gp.add( tfProblem,      1, 3);
gp.add( lblDescription, 0, 4); gp.add( taDescription, 1, 4);

GridPane.setColumnSpan( lblTitle, 5 );
GridPane.setColumnSpan( tfEmail, 3 );
GridPane.setColumnSpan( tfProblem, 5 );
GridPane.setColumnSpan( taDescription, 5 );

Separator sep = new Separator(); // hr

ButtonBar buttonBar = new ButtonBar();
buttonBar.setPadding( new Insets(10) );

Button saveButton = new Button("Save");
Button cancelButton = new Button("Cancel");

buttonBar.setButtonData(saveButton, ButtonBar.ButtonData.OK_DONE);
buttonBar.setButtonData(cancelButton, ButtonBar.ButtonData.CANCEL_CLOSE);

buttonBar.getButtons().addAll(saveButton, cancelButton);

vbox.getChildren().addAll( gp, sep, buttonBar );

Scene scene = new Scene(vbox);

primaryStage.setTitle("Grid Pane App");
primaryStage.setScene(scene);
primaryStage.setWidth( 736 );
primaryStage.setHeight( 414 );
primaryStage.show();
}

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

```

4.6. GridPane ColumnConstraints and RowConstraints

Author: Carl Walker

Previous articles on [GridPane](#) showed how to create a two-column layout with field names on the left-hand side and field values on the right-hand side. That example was expanded to add more controls to a given row and to use spanning handle gaps in content. This article introduces a pair of JavaFX classes [ColumnConstraints](#) and [RowConstraints](#). These classes give additional specification to a row or column. In this example, a row containing a [TextArea](#) will be given all extra space when the window is resized. The two columns will be set to equals widths.

This screenshot shows an example modified from previous articles. The demo program for this

article has a rotated feel whereby the field names are paired with the field values vertically (on top of the values) rather than horizontally. Row spanning and column spanning is used to align items that are larger than a single cell.

The screenshot shows a window titled "Grid Pane App" containing a form for a "Support Ticket". The form has several sections: "Email" with a text input field; "Contract" with a text input field; "Priority" with three radio buttons labeled "Medium", "High" (selected), and "Low"; "Severity" with a dropdown menu showing "Workaround"; "Category" with a dropdown menu showing "Feature"; "Problem" with a text input field; and "Description" with a large text area. At the bottom are "Cancel" and "Save" buttons. Two red rectangles with the text "Extra Space Available" are overlaid on the form: one to the right of the "Severity" and "Category" dropdowns, and another at the bottom of the "Description" text area.

Figure 19. Example App Using Row and Column Spanning

The red rectangles and text are not part of the UI. They are identifying sections of the screen that will be addressed later with `ColumnConstraints` and `RowConstraints`.

This code is the creation of the `Scene` root and `GridPane` objects.

```

VBox vbox = new VBox();

GridPane gp = new GridPane();
gp.setPadding( new Insets(10) );
gp.setHgap( 4 );
gp.setVgap( 10 );

VBox.setVgrow(gp, Priority.ALWAYS );

```

This code creates the UI controls objects used in the article. Notice that Priority is now implemented as a **VBox** containing RadioButtons.

```

Label lblTitle = new Label("Support Ticket");

Label lblEmail = new Label("Email");
TextField tfEmail = new TextField();

Label lblContract = new Label("Contract");
TextField tfContract = new TextField();

Label lblPriority = new Label("Priority");
RadioButton rbMedium = new RadioButton("Medium");
RadioButton rbHigh = new RadioButton("High");
RadioButton rbLow = new RadioButton("Low");
VBox priorityVBox = new VBox();
priorityVBox.setSpacing( 2 );
GridPane.setVgrow(priorityVBox, Priority.SOMETIMES);
priorityVBox.getChildren().addAll( lblPriority, rbMedium, rbHigh, rbLow );

Label lblSeverity = new Label("Severity");
ObservableList<String> severities =
    FXCollections.observableArrayList("Blocker", "Workaround", "N/A");
ComboBox<String> cbSeverity = new ComboBox<>(severities);

Label lblCategory = new Label("Category");
ObservableList<String> categories =
    FXCollections.observableArrayList("Bug", "Feature");
ComboBox<String> cbCategory = new ComboBox<>(categories);

Label lblProblem = new Label("Problem");
TextField tfProblem = new TextField();

Label lblDescription = new Label("Description");
TextArea taDescription = new TextArea();

```

The Label and value control pairings of Email, Contract, Problem, and Description are put in a single column. They should take the full width of the **GridPane** so each has its columnSpan set to 2.

```
GridPane.setColumnSpan( tfEmail, 2 );
GridPane.setColumnSpan( tfContract, 2 );
GridPane.setColumnSpan( tfProblem, 2 );
GridPane.setColumnSpan( taDescription, 2 );
```

The new Priority RadioButtons are matched horizontally with four controls for Severity and Category. This `rowSpan` setting instructs JavaFX to put the VBox containing the RadioButton in a merged cell that is four rows in height.

```
GridPane.setRowSpan( priorityVBox, 4 );
```

4.6.1. Row Constraints

At this point, the code reflects the UI screenshot presented in [Example App Using Row and Column Spanning](#). To reallocate the extra space at the base of the form, use a `RowConstraints` object to set a `Priority.ALWAYS` on the row of the `TextArea`. This will result in the `TextArea` growing to fill the available space with something usable.

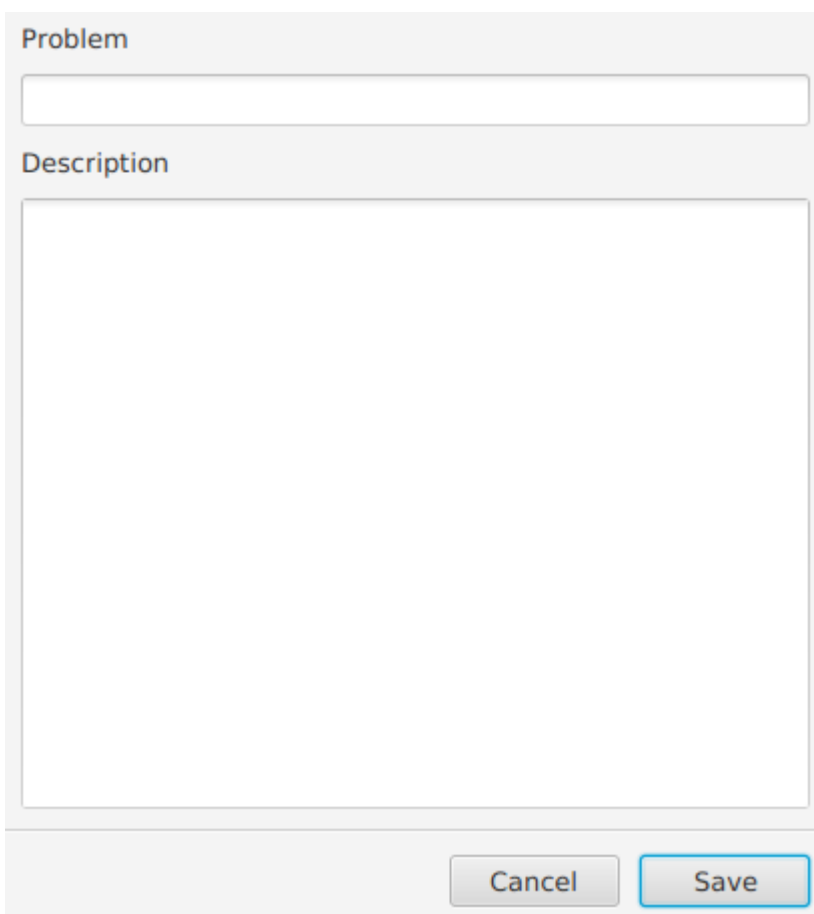
The image shows a JavaFX window titled "Problem". It has a light gray border. Inside, there's a label "Problem" in blue, followed by a text input field. Below that is a label "Description" in blue, followed by a large text area. At the bottom, there are two buttons: "Cancel" and "Save". The text area is expanded to fill the remaining vertical space of the window, demonstrating the effect of the RowConstraints.

Figure 20. *TextArea Grows to Fill Extra Space*

This code is a `RowConstraints` object to the `GridPane` for the `TextArea`. Prior to the setter, `RowConstraints` objects are allocated for all of the other rows. The `set` method of `getRowConstraints()` will throw an index exception when you specify row 12 without first allocating an object.

```

RowConstraints taDescriptionRowConstraints = new RowConstraints();
taDescriptionRowConstraints.setVgrow(Priority.ALWAYS);

for( int i=0; i<13; i++ ) {
    gp.getRowConstraints().add( new RowConstraints() );
}

gp.getRowConstraints().set( 12, taDescriptionRowConstraints );

```

As an alternative syntax, there is a `setConstraints()` method available from the `GridPane`. This will pass in several values and obviates the need for the dedicated `columnSpan` set call for the `TextArea`. The `RowConstraints` code from the previous listing will not appear in the finished program.

```

gp.setConstraints(taDescription,
                 0, 12,
                 2, 1,
                 HPos.LEFT, VPos.TOP,
                 Priority.SOMETIMES, Priority.ALWAYS);

```

This code identifies the `Node` at (0,12) which is the `TextArea`. The `TextArea` will span 2 columns but only 1 row. The `HPos` and `Vpos` are set to the TOP LEFT. Finally, the `Priority` of the `hgrow` is `SOMETIMES` and the `vgrow` is `ALWAYS`. Since the `TextArea` is the only row with "ALWAYS", it will get the additional space. If there were other `ALWAYS` settings, the space would be shared among multiple rows.

4.6.2. Column Constraints

To properly allocate the space surrounding the Severity and Category controls, `ColumnConstraints` will be specified. The default behavior allocates less space to the first column because of the smaller `Priority` `RadioButtons`. The following wireframe shows the desired layout which has equal columns separated by a gutter of 4 pixels (`Hgap`).

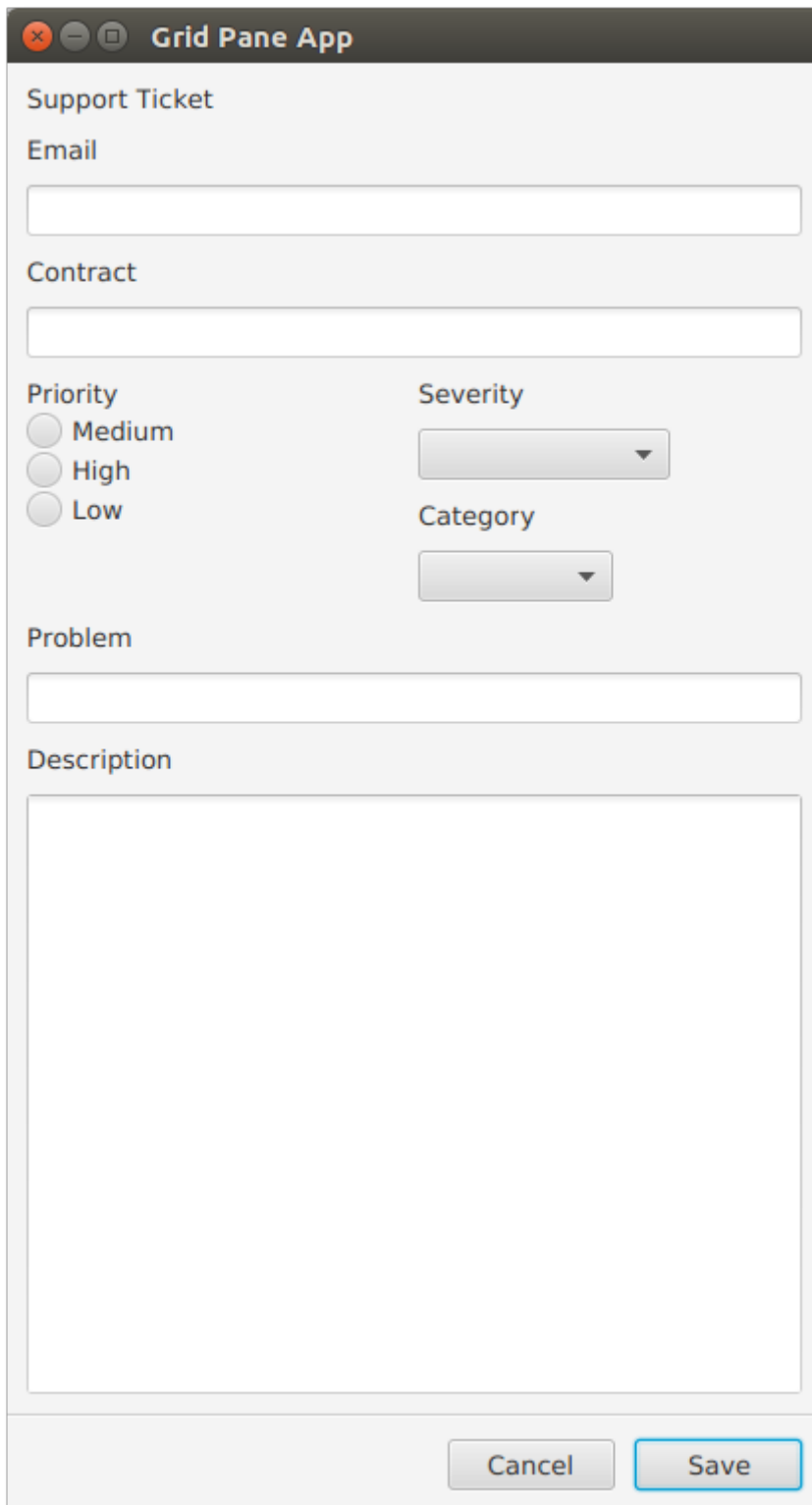
The wireframe shows a window titled "Grid Pane App" with a form layout. The form is organized into two columns. The left column contains the following fields from top to bottom: "Support Ticket", "Email", "Contract", "Priority" (with radio buttons for "Medium", "High", and "Low"), "Problem", and "Description". The right column contains "Severity" and "Category", both of which are dropdown menus. At the bottom of the window are two buttons: "Cancel" and "Save".

Figure 21. Wireframe of the Demo App

To make the column widths equal, define two `ColumnConstraint` objects and use a percentage specifier.

```
ColumnConstraints col1 = new ColumnConstraints();
col1.setPercentWidth( 50 );
ColumnConstraints col2 = new ColumnConstraints();
col2.setPercentWidth( 50 );
gp.getColumnConstraints().addAll( col1, col2 );
```

This is a screenshot of the finished example.



The screenshot shows a JavaFX application window titled "Grid Pane App". The window contains a form for creating a support ticket. The form is organized into sections: "Support Ticket" (header), "Email" (text input), "Contract" (text input), "Priority" (radio buttons for Medium, High, Low), "Severity" (dropdown menu), "Category" (dropdown menu), "Problem" (text input), and "Description" (text area). At the bottom of the window are "Cancel" and "Save" buttons. The "Save" button is highlighted with a blue border.

Figure 22. App With Extra Space Properly Allocated

`GridPane` is an important control in developing JavaFX business applications. When working on a requirement involving name / value pairs and a single record view, use `GridPane`. While `GridPane` is easier to use than the `GridBagLayout` from Swing, I still find that the API is a little inconvenient (assigning own indexes, disassociated constraints). Fortunately, there is Scene Builder which simplifies the construction of this form greatly.

4.6.3. Completed Code

The following is the completed code for the constraints GridPane example.

```
public class ConstraintsGridPaneApp extends Application {

    @Override
    public void start(Stage primaryStage) throws Exception {

        VBox vbox = new VBox();

        GridPane gp = new GridPane();
        gp.setPadding( new Insets(10) );
        gp.setHgap( 4 );
        gp.setVgap( 10 );

        VBox.setVgrow(gp, Priority.ALWAYS );

        Label lblTitle = new Label("Support Ticket");

        Label lblEmail = new Label("Email");
        TextField tfEmail = new TextField();

        Label lblContract = new Label("Contract");
        TextField tfContract = new TextField();

        Label lblPriority = new Label("Priority");
        RadioButton rbMedium = new RadioButton("Medium");
        RadioButton rbHigh = new RadioButton("High");
        RadioButton rbLow = new RadioButton("Low");
        VBox priorityVBox = new VBox();
        priorityVBox.setSpacing( 2 );
        GridPane.setVgrow(priorityVBox, Priority.SOMETIMES);
        priorityVBox.getChildren().addAll( lblPriority, rbMedium, rbHigh, rbLow );

        Label lblSeverity = new Label("Severity");
        ObservableList<String> severities =
FXCollections.observableArrayList("Blocker", "Workaround", "N/A");
        ComboBox<String> cbSeverity = new ComboBox<>(severities);

        Label lblCategory = new Label("Category");
        ObservableList<String> categories = FXCollections.observableArrayList("Bug",
"Feature");
        ComboBox<String> cbCategory = new ComboBox<>(categories);

        Label lblProblem = new Label("Problem");
        TextField tfProblem = new TextField();

        Label lblDescription = new Label("Description");
        TextArea taDescription = new TextArea();
    }
}
```

```

gp.add( lblTitle,      0, 0);

gp.add( lblEmail,      0, 1);
gp.add( tfEmail,       0, 2);

gp.add( lblContract,   0, 3 );
gp.add( tfContract,    0, 4 );

gp.add( priorityVBox,  0, 5);

gp.add( lblSeverity,   1, 5);
gp.add( cbSeverity,    1, 6);
gp.add( lblCategory,   1, 7);
gp.add( cbCategory,    1, 8);

gp.add( lblProblem,    0, 9);
gp.add( tfProblem,     0, 10);

gp.add( lblDescription, 0, 11);
gp.add( taDescription,  0, 12);

GridPane.setColumnSpan( tfEmail, 2 );
GridPane.setColumnSpan( tfContract, 2 );
GridPane.setColumnSpan( tfProblem, 2 );

GridPane.setRowSpan( priorityVBox, 4 );

gp.setConstraints(taDescription,
                  0, 12,
                  2, 1,
                  HPos.LEFT, VPos.TOP,
                  Priority.SOMETIMES, Priority.ALWAYS);

ColumnConstraints col1 = new ColumnConstraints();
col1.setPercentWidth( 50 );
ColumnConstraints col2 = new ColumnConstraints();
col2.setPercentWidth( 50 );
gp.getColumnConstraints().addAll( col1, col2 );

Separator sep = new Separator(); // hr

ButtonBar buttonBar = new ButtonBar();
buttonBar.setPadding( new Insets(10) );

Button saveButton = new Button("Save");
Button cancelButton = new Button("Cancel");

buttonBar.setButtonData(saveButton, ButtonBar.ButtonData.OK_DONE);
buttonBar.setButtonData(cancelButton, ButtonBar.ButtonData.CANCEL_CLOSE);

```



```

        buttonBar.getButtons().addAll(saveButton, cancelButton);

        vbox.getChildren().addAll( gp, sep, buttonBar );

        Scene scene = new Scene(vbox);

        primaryStage.setTitle("Grid Pane App");
        primaryStage.setScene(scene);
        primaryStage.setWidth( 414 );
        primaryStage.setHeight( 736 );
        primaryStage.show();

    }

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

```

4.7. AnchorPane

Author: Carl Walker

AnchorPane is a container control that defines its layout in terms of edges. When placed in a container, the **AnchorPane** stretches to fill the available space. The children of **AnchorPane** express their positions and sizes as distances from the edges: Top, Left, Bottom, Right. If one or two anchor settings are placed on an **AnchorPane** child, the child will be fixed to that corner of the window. If more than two anchor settings are used, the child will be stretched to fill the available horizontal and vertical space.

This mockup shows a **TextArea** surrounded by a set of controls: a **Hyperlink** and two status indicators. Since the **TextArea** will contain all of the content, it should take up most of the space initially and should acquire any additional space from a resize. On the periphery, there is a **Hyperlink** in the upper-right, a connection **Label** and **Circle** in the lower-right, and a status **Label** in the lower-left.

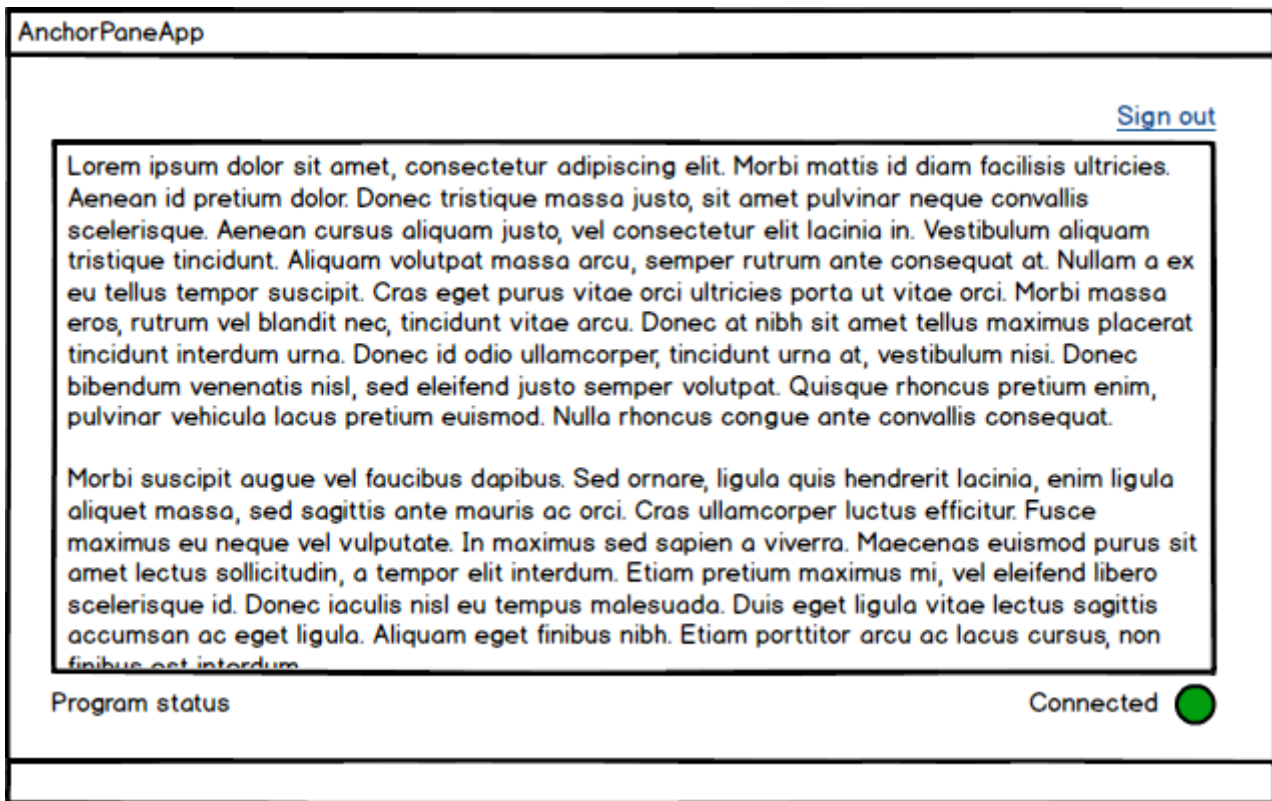


Figure 23. AnchorPane With TextArea

4.7.1. Anchors

To begin the layout, create an `AnchorPane` object and add it to the `Scene`.

```
AnchorPane ap = new AnchorPane();
Scene scene = new Scene(ap);
```

Anchors are set using static methods of the `AnchorPane` class. The methods—one per edge—accept the `Node` and an offset. For the `Hyperlink`, an anchor to the top edge and an anchor to the right edge will be set. An offset of 10.0 is set for each edge so that the link is not compressed against the side.

```
Hyperlink signoutLink = new Hyperlink("Sign Out");

ap.getChildren().add( signoutLink );

AnchorPane.setTopAnchor( signoutLink, 10.0d );
AnchorPane.setRightAnchor( signoutLink, 10.0d );
```

When the screen is resized, the `AnchorPane` will resize and `signoutLink` will maintain its top-right position. Because neither the left nor bottom anchors are specified, `signoutLink` will not be stretched.

Next, the connection `Label` and `Circle` are added. These controls are wrapped in an `HBox`.

```

Circle circle = new Circle();
circle.setFill(Color.GREEN );
circle.setRadius(10);

Label connLabel = new Label("Connection");

HBox connHBox = new HBox();
connHBox.setSpacing( 4.0d );
connHBox.setAlignment(Pos.BOTTOM_RIGHT);
connHBox.getChildren().addAll( connLabel, circle );

AnchorPane.setBottomAnchor( connHBox, 10.0d );
AnchorPane.setRightAnchor( connHBox, 10.0d );

ap.getChildren().add( connHBox );

```

As with `signoutLink`, `connHBox` is fixed to a place on the screen. `connHBox` is set to be 10 pixels from the bottom edge and 10 pixels from the right edge.

The lower-left status `Label` is added. The left and the bottom anchors are set.

```

Label statusLabel = new Label("Program status");
ap.getChildren().add( statusLabel );

AnchorPane.setBottomAnchor( statusLabel, 10.0d );
AnchorPane.setLeftAnchor( statusLabel, 10.0d );

```

This is a screenshot of the finished app. The status and control labels are at the bottom of the screen, pinned to the left and right edges respectively. The `HyperLink` is pinned to the top-right.

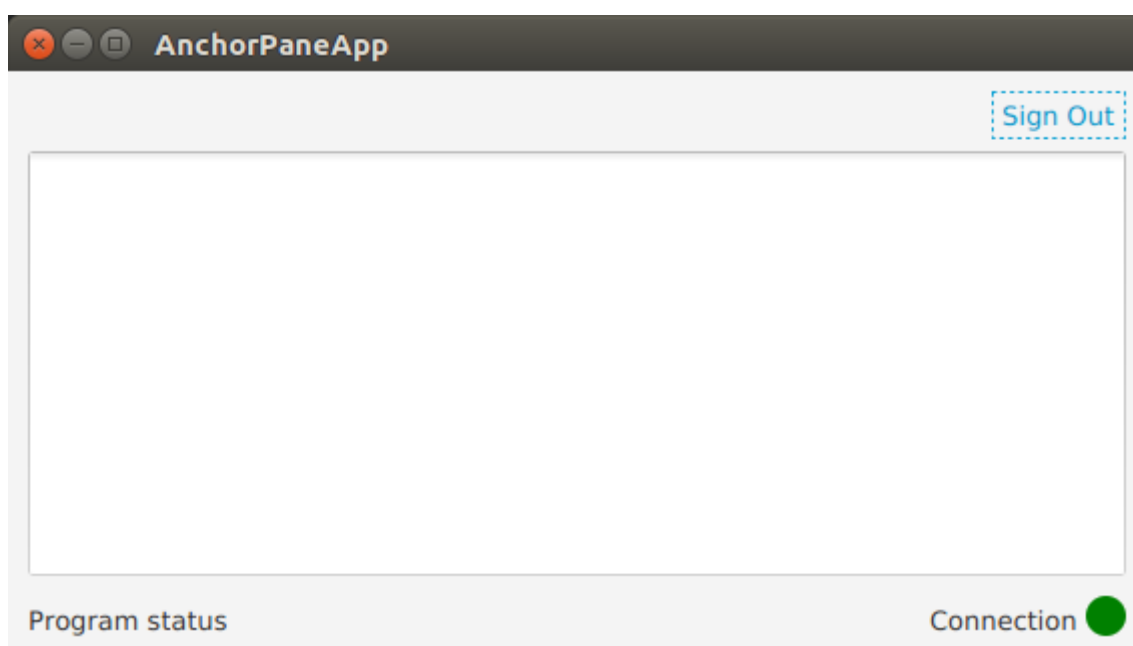


Figure 24. "AnchorPane App"

4.7.2. Resizing

The controls on the periphery may vary in size. For example, a status message or a connection message may be longer. However, the extra length can be accommodated in this layout by extending the bottom-left status `Label` to the right and by extending the bottom-right connection status `Label` to the left. Resizing with this layout will move these controls in absolute terms, but they will adhere to their respective edges plus the offset.

That is not the case with the `TextArea`. Because the `TextArea` may contain a lot of content, it should receive any extra space that the user gives the window. This control will be anchored to all four corners of the `AnchorPane`. This will cause the `TextArea` to resize when the window resizes. The `TextArea` is fixed on the top-left and as the user drags the window handles to the bottom-right, the bottom-right corner of the `TextArea` moves as well.

This picture shows the result of two resize operations. The top screenshot is a vertical resize from dragging the bottom edge of the window down. The bottom screenshot is a horizontal resize from dragging the right edge of the window right.

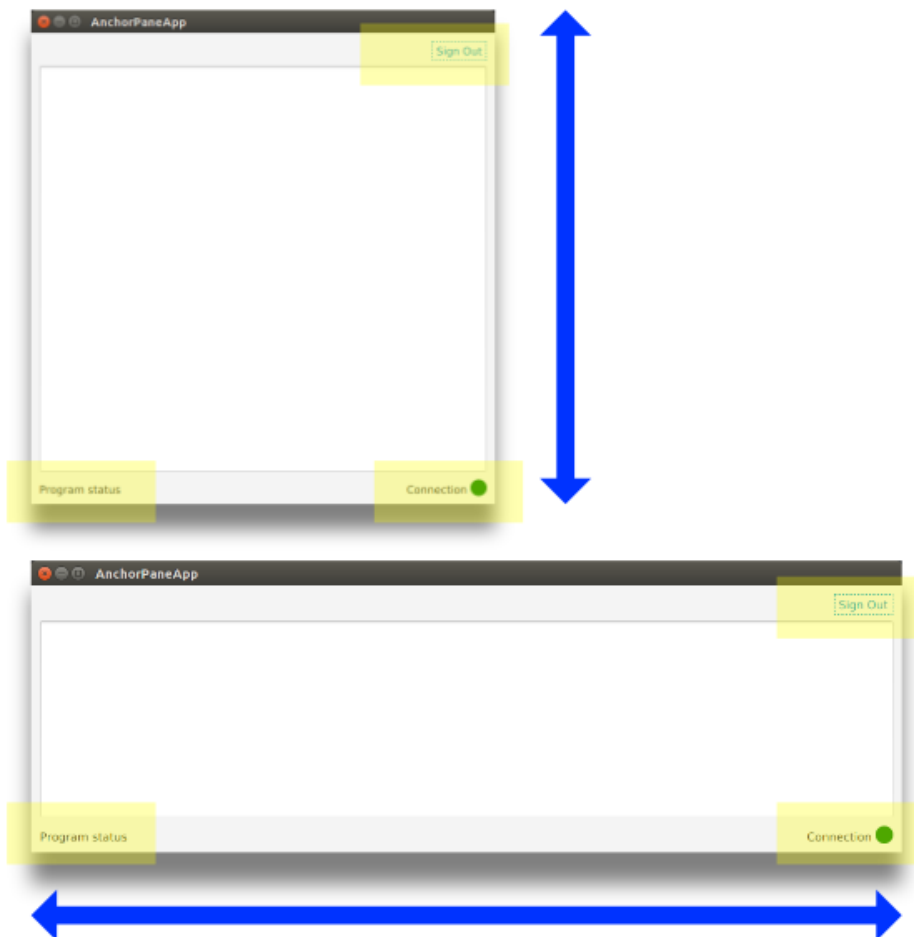


Figure 25. "AnchorPane App Resized"

The highlighted boxes show that the controls bordering the `TextArea` retain their positions relative to the edges. The `TextArea` itself is resized based on the Window resize. The top and bottom offsets of the `TextArea` account for the other controls so that they are not hidden.

```

TextArea ta = new TextArea();

AnchorPane.setTopAnchor( ta, 40.0d );
AnchorPane.setBottomAnchor( ta, 40.0d );
AnchorPane.setRightAnchor( ta, 10.0d );
AnchorPane.setLeftAnchor( ta, 10.0d );

ap.getChildren().add( ta );

```

AnchorPane is a good choice when you have a mixture of resizable and fixed-position children. Other controls like **VBox** and **HBox** with a **Priority** setting are preferred if there is only one child needing resizing. Use these controls instead of **AnchorPane** with a single child that has all four anchors set. Remember that to set an anchor on a child, you use a static method of the container class such as `AnchorPane.setTopAnchor()`.

4.7.3. Completed Code

The following is the completed code for the **AnchorPane** example.

```

public class AnchorPaneApp extends Application {

    @Override
    public void start(Stage primaryStage) throws Exception {

        AnchorPane ap = new AnchorPane();

        // upper-right sign out control
        Hyperlink signoutLink = new Hyperlink("Sign Out");

        ap.getChildren().add( signoutLink );

        AnchorPane.setTopAnchor( signoutLink, 10.0d );
        AnchorPane.setRightAnchor( signoutLink, 10.0d );

        // lower-left status label
        Label statusLabel = new Label("Program status");
        ap.getChildren().add( statusLabel );

        AnchorPane.setBottomAnchor( statusLabel, 10.0d );
        AnchorPane.setLeftAnchor( statusLabel, 10.0d );

        // lower-right connection status control
        Circle circle = new Circle();
        circle.setFill(Color.GREEN );
        circle.setRadius(10);

        Label connLabel = new Label("Connection");

        HBox connHBox = new HBox();
    }
}

```

```

connHBox.setSpacing( 4.0d );
connHBox.setAlignment(Pos.BOTTOM_RIGHT);
connHBox.getChildren().addAll( connLabel, circle );

AnchorPane.setBottomAnchor( connHBox, 10.0d );
AnchorPane.setRightAnchor( connHBox, 10.0d );

ap.getChildren().add( connHBox );

// top-left content; takes up extra space
TextArea ta = new TextArea();
ap.getChildren().add( ta );

AnchorPane.setTopAnchor( ta, 40.0d );
AnchorPane.setBottomAnchor( ta, 40.0d );
AnchorPane.setRightAnchor( ta, 10.0d );
AnchorPane.setLeftAnchor( ta, 10.0d );

Scene scene = new Scene(ap);

primaryStage.setTitle("AnchorPaneApp");
primaryStage.setScene( scene );
primaryStage.setWidth(568);
primaryStage.setHeight(320);
primaryStage.show();
}

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

```

Chapter 5. CSS

Placeholder whilst things get built...

Chapter 6. Performance

Placeholder whilst things get built...

Chapter 7. Application Structure

7.1. The MVVM Pattern

Author: Carl Walker

Model-View-ViewModel (MVVM) is a software architecture that separates UI controls (the View) from data access and business logic (the Model). The separation helps larger applications during the maintenance phase. With MVVM, View changes—especially those that are purely cosmetic—can be made without fear of introducing side effects. Changes to the Model (usually less volatile than the View) can be applied more easily throughout the application because MVVM promotes reuse.

In between the View and the Model is the ViewModel. The ViewModel mediates between the View and the Model, yet contains no references to the View. This enables ViewModel sharing which is useful when two Views show similar data.

This article presents a simplified MVVM example. An Employment Request Form submits several data elements to a back-end service. This screenshot shows the application with the name, position, and annual salary data elements set.

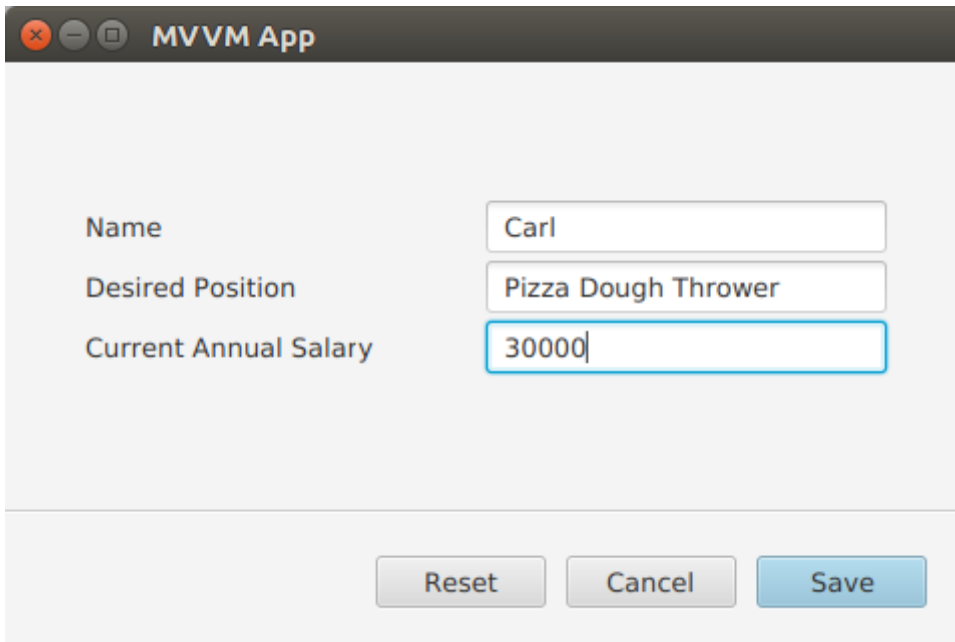
The image shows a screenshot of a web application window titled "MVVM App". Inside the window, there is a form with three labeled text input fields. The first field is labeled "Name" and contains the text "Carl". The second field is labeled "Desired Position" and contains the text "Pizza Dough Thrower". The third field is labeled "Current Annual Salary" and contains the text "30000". Below these fields, there are three buttons: "Reset", "Cancel", and "Save". The "Save" button is highlighted with a blue border.

Figure 26. Employment Request Form

After entering the data and pressing Save, the Model object responds with a `println()`.

Program Output

```
saving EmploymentRequest{name='Carl', position='Pizza Dough Thrower',  
annualSalary=30000.0}
```

If the Reset button is pressed after filling in the TextFields, the form is restored to its original values: empty name and position and an annualSalary of 0.

The Cancel button ends the application.

7.1.1. Structure

A simplified MVVM application is composed of the following types of classes

App

Main entry point

View

UI controls

Model

Function call to business logic and data access

ViewModel

Contains screen state and UI logic

Domain object

UI-neutral transfer object

Converter

Helper class for ViewModel to Model communication

This UML shows the structure of the Employment Request Form. The View class is `EmploymentRequestView` which contains the UI control objects like the Name `TextField`. The ViewModel class is `EmploymentRequestViewModel` and contains JavaFX properties. The Model class is `EmploymentRequestModel` with a single method for persisting the form. `EmploymentRequestConverter` is a helper class. `EmploymentRequest` is a POJO containing data fields. `MVVMApp` is the main entry point, a JavaFX Application subclass.

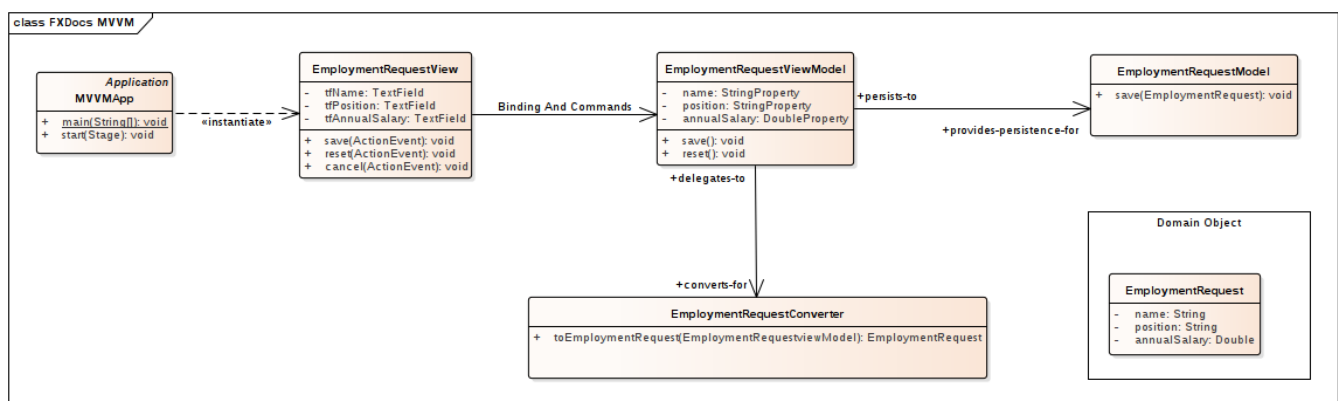


Figure 27. UML Class Model of Application

7.1.2. View

In MVVM, the View class is responsible for the UI controls and nothing else. Event handlers attached to UI controls delegate immediately to the ViewModel. JavaFX data binding updates the UI with Model changes. In the Employment Request Form, three TextFields gather input from the user: `tfName`, `tfPosition`, `tfAnnualSalary`. Three Buttons initiate operations on the application:

btnSave, btnCancel, btnReset. This is the beginning of the `EmploymentRequestView` class.

EmploymentRequestView.class

```
public class EmploymentRequestView extends VBox {

    private GridPane gp = new GridPane();

    private TextField tfName = new TextField();
    private TextField tfPosition = new TextField();
    private TextField tfAnnualSalary = new TextField();

    private Button btnSave = new Button("Save");
    private Button btnCancel = new Button("Cancel");
    private Button btnReset = new Button("Reset");

    public EmploymentRequestView() {
        createView();
        bindViewModel();
    }
}
```

The View knows about the ViewModel and uses JavaFX binding to synchronize the UI with the ViewModel. This demo treats the ViewModel as a prototype object, created when the View object is created. Alternatively, the ViewModel can be a singleton or provided by CDI. Each UI field is bound bi-directionally to the ViewModel. As the UI changes—say through entering a value in `tfName`—the corresponding field in the ViewModel is updated. The more complicated expression for the `tfAnnualSalary` field is needed to convert the String-based `TextField` into a `DoubleProperty`.

EmploymentRequestView.class (cont.)

```
private final EmploymentRequestViewModel viewModel =
    new EmploymentRequestViewModel();

private void bindViewModel() {

    tfName.textProperty().bindBidirectional(viewModel.nameProperty());

    tfPosition.textProperty().bindBidirectional(viewModel.positionProperty());

    Bindings.bindBidirectional(
        tfAnnualSalary.textProperty(),
        viewModel.annualSalaryProperty(),
        new NumberStringConverter()
    );
}
```

The UI in this demo is built in code. The following `createView()` method handles the layout of the form and puts the core controls (such as `tfName` and `btnSave`) in containers.

```
private void createView() {
    VBox gpwrap = new VBox();
    gpwrap.setAlignment( Pos.CENTER );

    gp.setPadding( new Insets(40) );
    gp.setVgap( 4 );
    gp.add(new Label("Name"), 0, 0);          gp.add(tfName, 1, 0);
    gp.add(new Label("Desired Position"), 0, 1);    gp.add(tfPosition, 1, 1);
    gp.add(new Label("Current Annual Salary"), 0, 2); gp.add(tfAnnualSalary, 1,
2);

    final ColumnConstraints col = new ColumnConstraints();
    col.setPercentWidth( 50 );

    gp.getColumnConstraints().addAll( col, col );

    gpwrap.getChildren().add( gp );

    VBox.setVgrow( gpwrap, Priority.ALWAYS );

    btnSave.setOnAction( this::save );
    btnCancel.setOnAction( this::cancel );
    btnReset.setOnAction( this::reset );

    btnSave.setDefaultButton(true);

    ButtonBar buttonBar = new ButtonBar();
    buttonBar.setPadding( new Insets(20.0d) );
    ButtonBar.setButtonData(btnSave, ButtonBar.ButtonData.OK_DONE);
    ButtonBar.setButtonData(btnCancel, ButtonBar.ButtonData.CANCEL_CLOSE);
    ButtonBar.setButtonData(btnReset, ButtonBar.ButtonData.OTHER);

    buttonBar.getButtons().addAll( btnSave, btnCancel, btnReset );

    this.getChildren().addAll(
        gpwrap,
        new Separator(),
        buttonBar);
}
```

The class ends with handlers for the Buttons. These handlers delegate their actions to the ViewModel.

```
private void save(ActionEvent evt) { viewModel.save(); }

private void cancel(ActionEvent evt) {
    Platform.exit();
}

private void reset(ActionEvent evt) { viewModel.reset(); }
}
```

FXML and Scene Builder

In this example, the UI is built in code. Scene Builder is a design-oriented alternative that can be more productive. To convert this example to FXML, the product of Scene Builder, you would build the UI in the tool and annotate the fields and methods of the `EmploymentRequestView` class with `@FXML`. See the following screenshot for how the demo looks in Scene Builder. This is informational only and not part of the working demo.

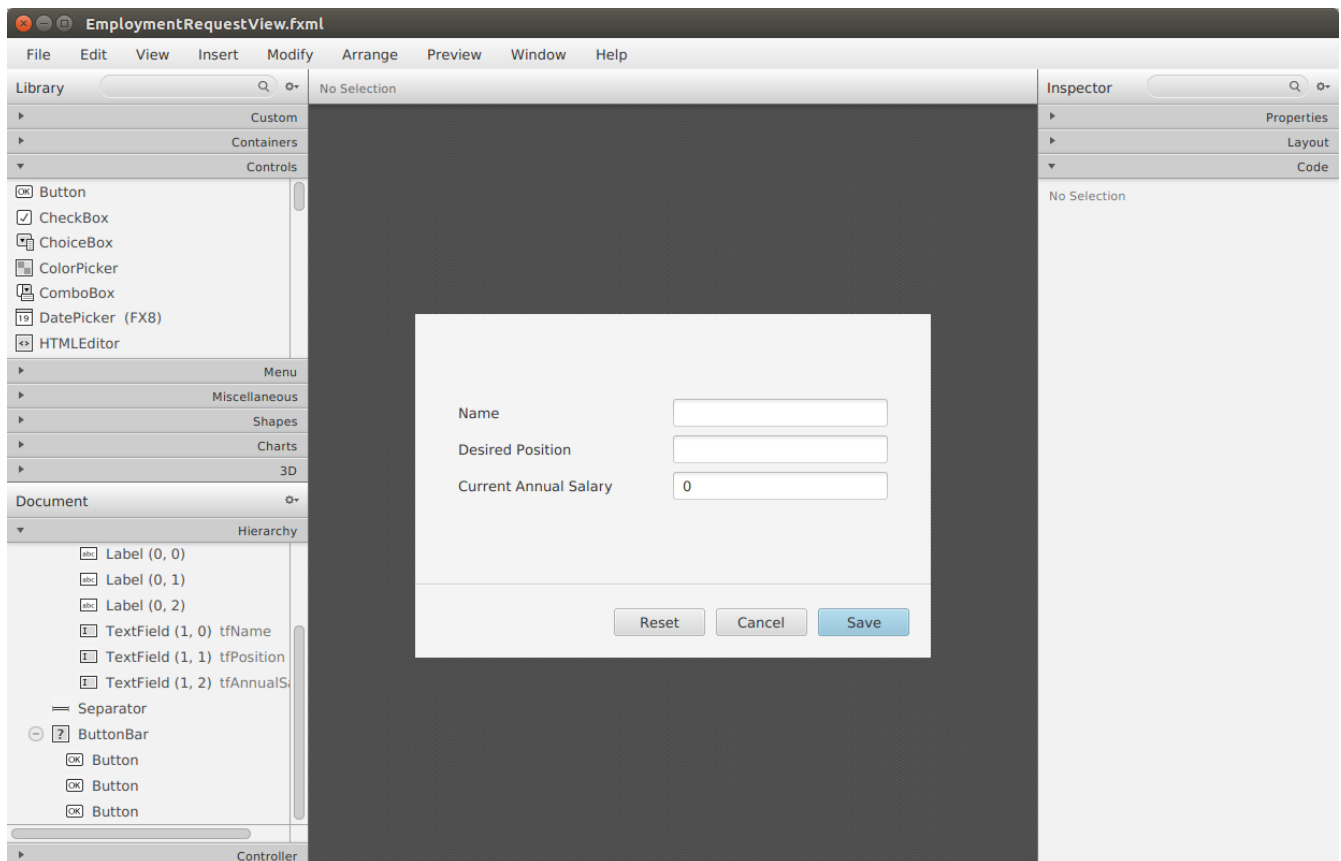


Figure 28. Scene Builder Could Also Implement the View

Notice that the right "half" of the UML diagram would not be changed by switching the View implementation from code to Scene Builder. A sign of a good design is when alternative presentations can be supported easily.

7.1.3. ViewModel

The `ViewModel` is a layer that interacts with both the View and the Model. In this simple

presentation, the value of such a layer is limited; one could just unpack the TextFields into the Model in the `Button` handler. As the UI becomes more complex, it is useful to have a plainer, more business-oriented object to work with. While there is a one-to-one correspondence between View, Model, and ViewModel, that may not always be the case.

Handling a many-to-many relationship is key for the ViewModel. There may be many Views that working with the same Model element. Multiple models may contribute to a single View.

This ViewModel looks like the domain object that will be presented later with one key difference: JavaFX Binding. `EmploymentRequestViewModel` was bound to the `EmploymentRequestView` UI controls and the methods of `EmploymentRequestViewModel` will have access to all of the information within the `save()` method. No extra marshaling of arguments is needed.

EmploymentRequestViewModel.class

```
public class EmploymentRequestViewModel {

    private final StringProperty name = new SimpleStringProperty("");
    private final StringProperty position = new SimpleStringProperty("");
    private final DoubleProperty annualSalary = new SimpleDoubleProperty();

    private final EmploymentRequestConverter converter =
        new EmploymentRequestConverter();

    private final EmploymentRequestModel model = new EmploymentRequestModel();

    public String getName() {
        return name.get();
    }

    public StringProperty nameProperty() {
        return name;
    }

    public void setName(String name) {
        this.name.set(name);
    }

    public String getPosition() {
        return position.get();
    }

    public StringProperty positionProperty() {
        return position;
    }

    public void setPosition(String position) {
        this.position.set(position);
    }

    public double getAnnualSalary() {
```

```

        return annualSalary.get();
    }

    public DoubleProperty annualSalaryProperty() {
        return annualSalary;
    }

    public void setAnnualSalary(double annualSalary) {
        this.annualSalary.set(annualSalary);
    }

    public void save() {
        EmploymentRequest data = converter.toEmploymentRequest( this );
        model.save( data );
    }

    public void reset() {
        this.name.set("");
        this.position.set("");
        this.annualSalary.set(0.0d);
    }
}

```

Both the Converter and the Model have been added to this ViewModel as prototypes, meaning that they were created when the ViewModel was created.

Converter

The Converter is a class the translates between ViewModel and domain object. In this app, there is a single `toEmploymentRequest()` method that creates an object from the ViewModel fields.

EmploymentRequestConverter.class

```

public class EmploymentRequestConverter {

    public EmploymentRequest toEmploymentRequest(EmploymentRequestViewModel viewModel)
    {
        return new EmploymentRequest(
            viewModel.getName(),
            viewModel.getPosition(),
            viewModel.getAnnualSalary()
        );
    }
}

```

7.1.4. Model

Finally, the Model persists the information. This Model example has a single mocked method which will verify that it receives the correct data for the `save()` operation.

EmploymentRequestModel.class

```
public class EmploymentRequestModel {  
  
    public void save(EmploymentRequest req) {  
        System.out.println("saving " + req);  
    }  
}
```

This is the plain Java object used to transport data from the Model to the UI.

EmploymentRequest.class

```
public class EmploymentRequest {  
  
    private final String name;  
    private final String position;  
    private final Double annualSalary;  
  
    public EmploymentRequest(String name,  
                             String position,  
                             Double annualSalary) {  
        this.name = name;  
        this.position = position;  
        this.annualSalary = annualSalary;  
    }  
  
    public String getName() {  
        return name;  
    }  
  
    public String getPosition() {  
        return position;  
    }  
  
    public Double getAnnualSalary() {  
        return annualSalary;  
    }  
  
    @Override  
    public String toString() {  
        return "EmploymentRequest{" +  
            "name='" + name + '\'' +  
            ", position='" + position + '\'' +  
            ", annualSalary=" + annualSalary +  
            "'}";  
    }  
}
```

JavaFX provides developers with a powerful toolkit to build applications. However, a design is still

needed for an effective program. MVVM is an architectural pattern that separates pure UI classes called Views from pure data classes called Models. In the middle sits the ViewModel which relies heavily on the data binding in JavaFX.

7.1.5. Further Work

Sometimes, the View needs to know of a Model change. Because MVVM dictates a one-way control flow — View to ViewModel to Model and not the reverse — a different mechanism than data binding is needed to make the ViewModel aware of Model changes. A publishing / subscribing library can be used for this requirement which would broker the Model/ViewModel interaction. ViewModel would receive a notification from the Model and the Model would not require a reference to the ViewModel object.

To read more about MVVM and JavaFX, check out the mvvmFX project. The examples in that project provided the basis for this demonstration.

[mvvmFX](#)

7.1.6. Completed Code

The completed code in this example is available as a Gradle project [here](#). There are two examples in the JAR. Run the class `net.bekwam.bkcourse.mvvmapp.MVVMApp`.

[bkcourse_mvvmapp_sources.zip](#)

7.2. Model Change with MVVM

The previous article showed how to add a JavaFX binding-based ViewModel to an application architecture. However, the Model presented was a simple service call. This expands on the prior concepts and adds

1. Asynchrony,
2. A `ProgressBar` and status `Label`, and
3. Event broadcasting.

All operations taking more than a few milliseconds should be run on a separate `Thread`. Something that runs quickly but involves IO or the network often turns into a performance problem as code moves to new computers and new network configurations. A JavaFX `Task` is used to invoke the Model operation. While this potentially long process is running, feedback is given to the user via a `ProgressBar` and `Label`. The status `Label` conveys messages to the user from the JavaFX `Task`.

It is important that the Model not hold a reference to the ViewModel, so an event notification scheme is introduced. The ViewModel listens for an `EVENT_MODEL_UPDATE` message from the Model. Although this example uses only one ViewModel, this scheme makes it possible for more than one ViewModel to be aware of data changes from a single Model component.

7.2.1. Demo Program

The demo program in this section is a URL tester. The user enters a URL in the `TextField` and presses the Submit `Button`. If the HTTP request to the specified URL returns successfully, the HTTP response status code is displayed alongside the number of milliseconds the request took. This screenshot shows a successful usage.

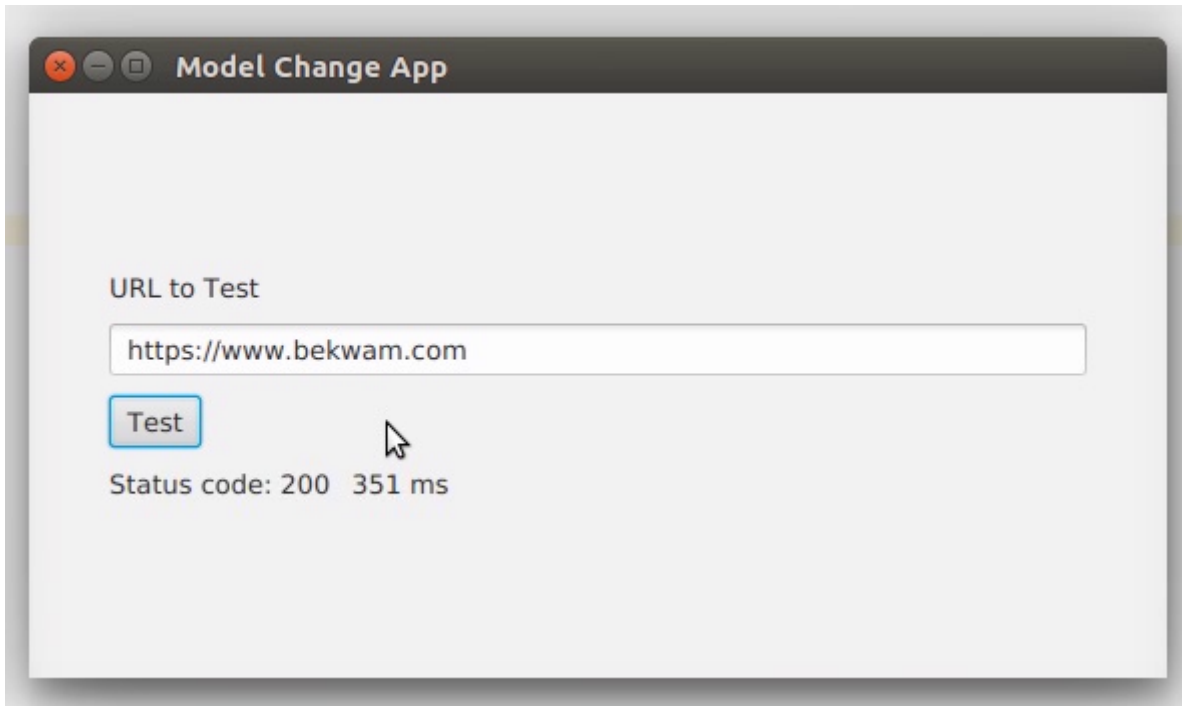


Figure 29. A Successful Run

The UI remains responsive throughout the request. The responsiveness comes from the use of a JavaFX `Task` to run the URL retrieval on a background thread. To make the user aware that processing is occurring, UI controls are tied to the properties of the `Task` through JavaFX binding. This screenshot shows the feedback the user receives while the `Task` runs.

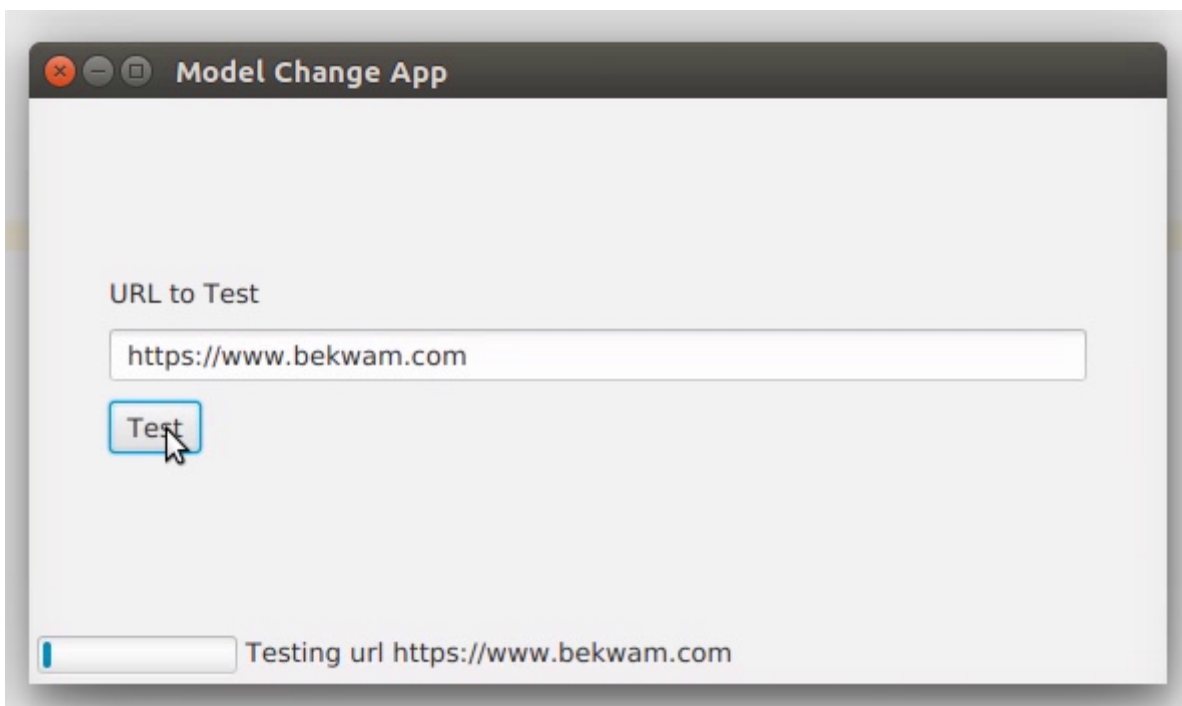


Figure 30. In-Progress View of a Retrieval

When the Submit **Button** is pressed, a pair of controls are displayed: a **ProgressBar** and a **Label**. Both controls are updated with information about the running background **Thread**.

Errors in the URL retrieval are handled by passing an alternate response object out of the Model. In the successful case, the Model returned the HTTP status code and elapsed time. In the error case, the Model sets a flag and returns an error message. This screenshot shows an error dialog produced by the View in response to an error in the Model. The errorMessage is from the message property of the thrown Exception. If needed, additional fields like the Exception class name can be added.

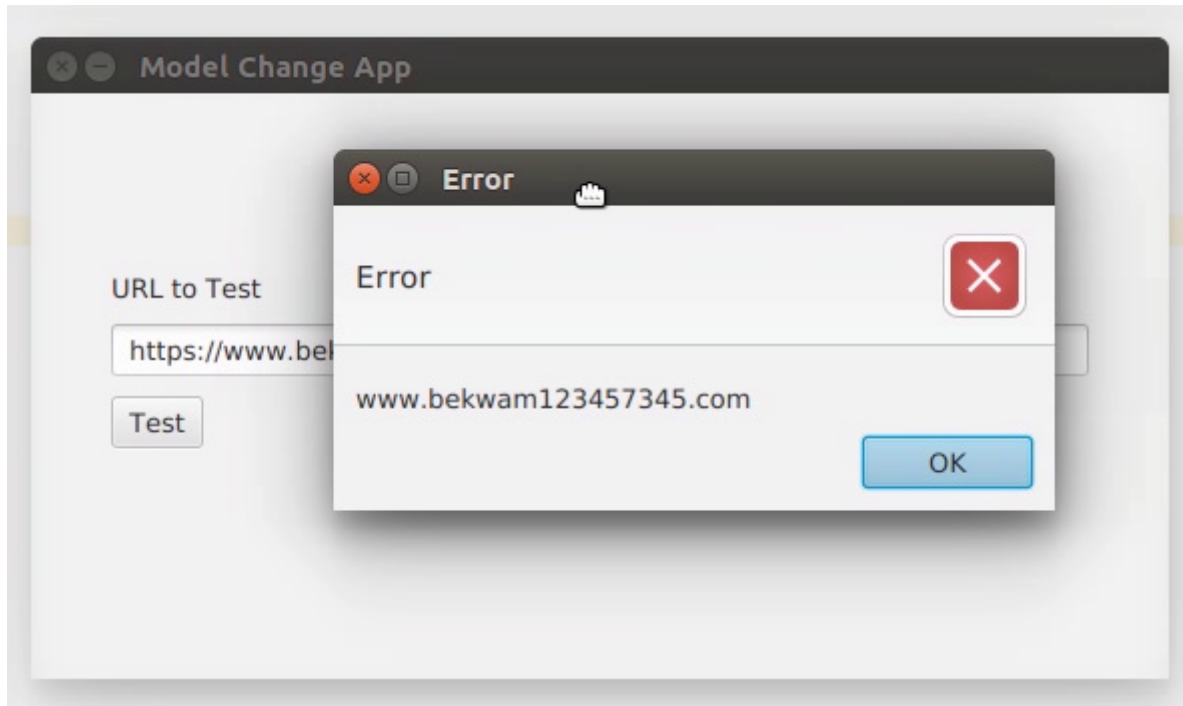


Figure 31. Error Produced by Model

7.2.2. Design

The demo program consists of a single View / ViewModel / Model triple. The View communicates with the ViewModel through JavaFX binding. UI controls in the View are bound to JavaFX properties in the ViewModel. Event handlers in the View delegate to methods in the ViewModel. The ViewModel forms an asynchronous command which interacts with the Model. The Model communicates indirectly with the ViewModel through a notification subsystem rather than an object reference.

This is a UML class model of the program.

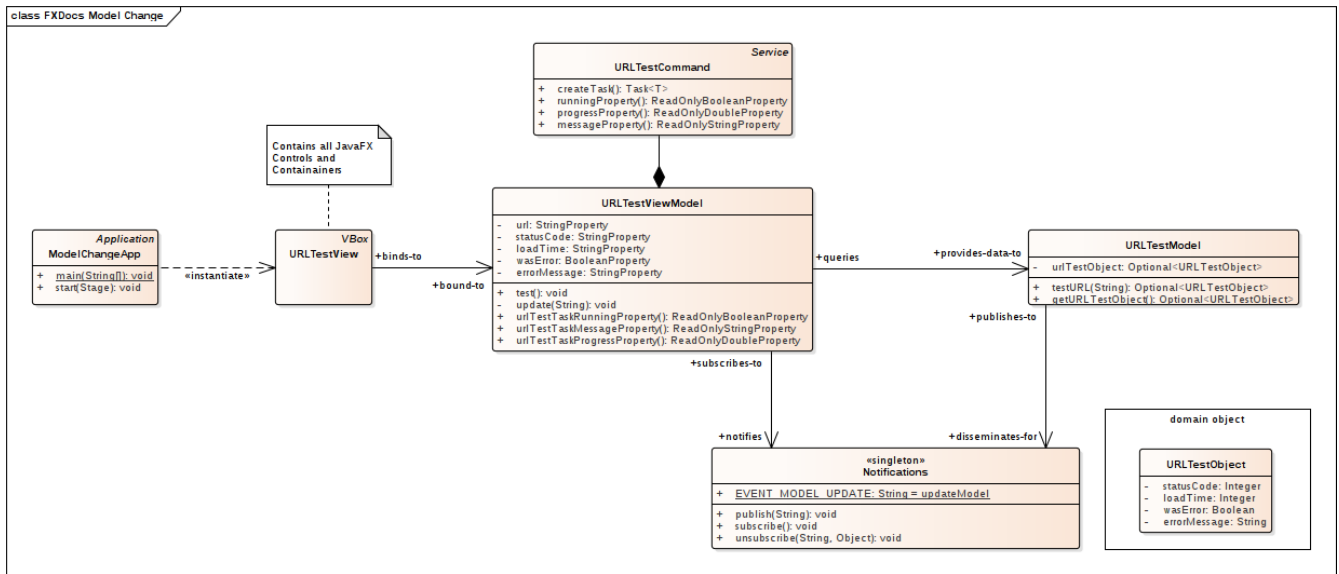


Figure 32. Class Model of MVVM App

URLTestView is the View component and contains the UI controls. The ViewModel contains properties for the domain — url, last status code, last elapsed time — and for the screen state such as urlTestTaskRunning. Model contains a service call and works with a UI-neutral POJO URLTestObject. Communication between the Model and the ViewModel is brokered through a Notifications singleton which has methods for publishing (for the Model) and subscribing (for the ViewModel).

This sequence diagram shows how the app wires itself up and the interactions that follow from a test operation.

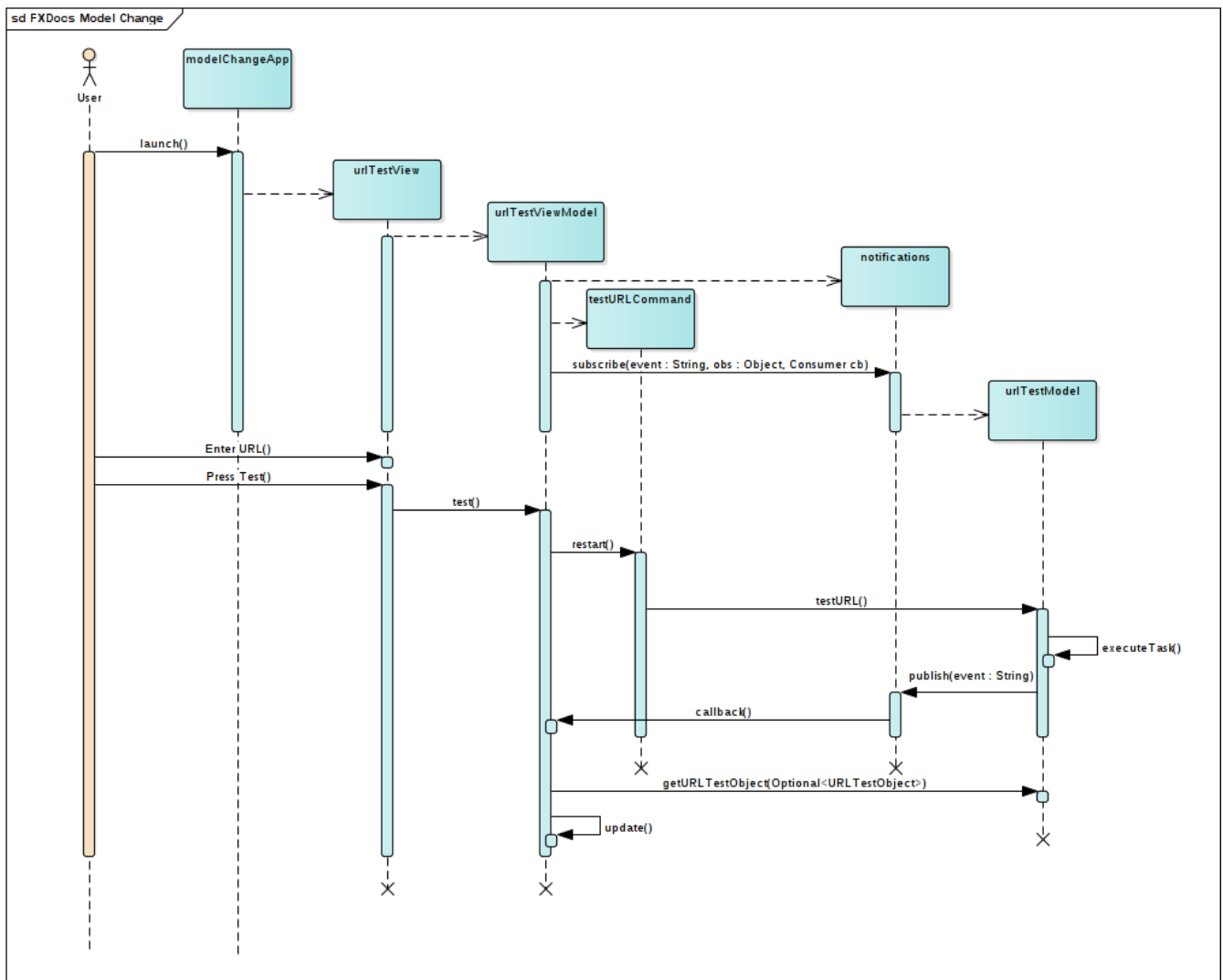


Figure 33. Sequence Diagram of Successful Retrieval

After all the objects are created, the user initiates a test operation. This results in a TestURLCommand object being created which is a JavaFX **Service**. The service invokes a Model method testURL(). When testURL() finishes, it publishes a notification. This notification triggers a call to the ViewModel to refresh itself which uses a second call to the Model. The ViewModel refresh sets ViewModel JavaFX properties which automatically update the View.

7.2.3. View

The View is a StackPane containing the **TextField** that will gather the URL input and a Submit **Button**. A **StackPane** was used so that the temporary status display could be added without breaking the centering of the main UI controls. The **HBox** containing the status **Label** and **ProgressBar** is always present in the lower-left, but hidden unless a **Task** is running.

```

public class URLTestView extends StackPane {

    private final URLTestViewModel testViewModel =
        new URLTestViewModel();

    public URLTestView() {

        Label lblURL = new Label("URL to Test");
        TextField tfURL = new TextField();
        Button btnTest = new Button("Test");
        Label lblStatus = new Label("");
        Label lblLoadTime = new Label("");
        HBox resultHBox = new HBox(lblStatus, lblLoadTime);
        resultHBox.setSpacing(10);

        VBox vbox = new VBox( lblURL, tfURL, btnTest, resultHBox );
        vbox.setPadding( new Insets(40) );
        vbox.setSpacing( 10 );
        vbox.setAlignment(Pos.CENTER_LEFT);

        Label lblTaskStatus = new Label("");
        ProgressBar pb = new ProgressBar();
        HBox statusHBox = new HBox(pb, lblTaskStatus);
        statusHBox.setSpacing(4);
        statusHBox.setPadding(new Insets(4));
        statusHBox.setMaxHeight( 20 );

        StackPane.setAlignment(statusHBox, Pos.BOTTOM_LEFT );

        this.getChildren().addAll( vbox, statusHBox );
    }
}

```

The URLTestViewModel object is created in this class. Alternatively, dependency injection can be used to distribute the same ViewModel object among other Views.

The URLTestView constructor continues with several binding expressions. These link the UI controls to the ViewModel properties.

URLTestView.class (cont.)

```

        lblStatus.textProperty().bind( testViewModel.statusCodeProperty() );
        lblLoadTime.textProperty().bind( testViewModel.loadTimeProperty() );
        testViewModel.urlProperty().bind( tfURL.textProperty() );

        statusHBox.visibleProperty().bind(testViewModel.urlTestTaskRunningProperty()
);
        pb.progressProperty().bind( testViewModel.urlTestTaskProgressProperty() );
        lblTaskStatus.textProperty().bind(
testViewModel.urlTestTaskMessageProperty());

```

The above statements register the UI controls for changes to the corresponding property in the ViewModel, except for `tfURL`. `tfURL` uses a different binding direction since it is producing the value for the ViewModel. In some cases, the binding may need to be bi-directional if a control can both be manipulated by the user and set from the ViewModel.

The action which initiates the `testURL()` operation is mapped to the Submit **Button**.

URLTestView.class (cont.)

```
btnTest.setOnAction( (evt) -> testViewModel.test() );
```

The `URLTestView` constructor finishes with a special `ChangeListener` binding to a `ViewModel` property. This is a notification that an error has occurred. When the `errorMessage` property of the `ViewModel` is notified, the View displays a popup dialog.

URLTestView.class (cont.)

```
testViewModel.errorMessageProperty().addListener(
    (obs,ov,nv) -> {
        if( nv != null && !nv.isEmpty() ) {
            Alert alert = new Alert(
                Alert.AlertType.ERROR, nv
            );
            alert.showAndWait();
        }
    }
);
```

7.2.4. ViewModel

`URLTestView` binds its UI controls to properties in `URLTestViewModel`. This section of the class `URLTestViewModel` shows the properties used by the View and their corresponding access methods. The `test()` method — which was mapped to the Submit **Button** press event — is also listed. The object `urlTestCommand` will be presented later.

```
public class URLTestViewModel {

    // Data elements
    private final StringProperty url = new SimpleStringProperty("");
    private final StringProperty statusCode = new SimpleStringProperty("");
    private final StringProperty loadTime = new SimpleStringProperty("");

    // Status elements
    private final BooleanProperty wasError = new SimpleBooleanProperty(false);
    private final StringProperty errorMessage = new SimpleStringProperty("");

    public StringProperty urlProperty() { return url; }

    public StringProperty statusCodeProperty() { return statusCode; }

    public StringProperty loadTimeProperty() { return loadTime; }

    public StringProperty errorMessageProperty() { return errorMessage; }

    public ReadOnlyBooleanProperty urlTestTaskRunningProperty() {
        return urlTestCommand.runningProperty(); // presented later
    }

    public ReadOnlyStringProperty urlTestTaskMessageProperty() {
        return urlTestCommand.messageProperty(); // presented later
    }

    public ReadOnlyDoubleProperty urlTestTaskProgressProperty() {
        return urlTestCommand.progressProperty(); // presented later
    }

    public void test() {
        urlTestCommand.restart(); // presented later
    }
}
```

URLTestViewModel collaborates with two objects: URLTestModel and Notifications. URLTestViewModel subscribes to a Notification in its constructor. A URLTestViewModel method "update" will be called when the Notifications object posts an EVENT_MODEL_UPDATE.

URLTestViewModel.class (cont.)

```
private final URLTestModel urlTestModel = new URLTestModel();

private final Notifications notifications = new Notifications();

public URLTestViewModel() {
    notifications.subscribe(Notifications.EVENT_MODEL_UPDATE,
                           this,
                           this::update); // presented later
}
```

Command

urlTestCommand is a JavaFX **Service** object. As a part of the URLTestViewModel class, urlTestCommand has access to the url property which provides a parameter for the call to the Model object. urlTestCommand also uses the URLTestModel member to initiate the call to test the URL.

URLTestViewModel.class (cont.)

```
private final Service<Void> urlTestCommand = new Service<Void>() {
    @Override
    protected Task<Void> createTask() {
        return new Task<Void>() {
            @Override
            protected Void call() throws Exception {
                updateProgress(0.1d, 1.0d);
                updateMessage("Testing url " + url.get());
                urlTestModel.testURL( url.get() );
                return null;
            }
            protected void failed() {
                getException().printStackTrace(); // just in case
            }
        };
    }
};
```

A JavaFX **Service** was used since the **Service** objects needs to always exist for binding purposes. URLTestView binds its **ProgressBar**, status **Label**, and container controls to the URLTestViewModel object which will be available for the life of the app. Shown earlier, the URLTestViewModel properties delegate to the **Service** object. A **Task** is a one-shot invocation and using that would not work for multiple test() invocations.

Asynchrony

The design in this article puts the burden of asynchronous processing on the ViewModel. This provides direct feedback to View controls using JavaFX binding. An alternative approach is to use a general event emitting scheme to listen for task starting, task ending, progress, and message events. This would support breaking out the `urlTestCommand` [Service](#) subclass into a separate code module.

The presentation of the `URLTestViewModel` class concludes with the `update()` method. This method issues a call to the Model, unpacks the results, and updates the ViewModel properties. Recall that the View has bound to these properties and will automatically be updated (there is no similar `update()` method in the View).

URLTestViewModel.class (cont.)

```
private void update(String event) {

    urlTestModel.getUrlTestObject().ifPresent(

        (testObject) -> {

            wasError.set( testObject.getWasError() );

            if( !testObject.getWasError() ) {

                statusCode.set(
                    "Status code: " +
                    String.valueOf(testObject.getStatusCode())
                );

                loadTime.set(
                    String.valueOf(testObject.getLoadTime()) +
                    " ms"
                );

                errorMessage.set(testObject.getErrorMessage());
            } else {
                statusCode.set(""); // use empty TextField, not 0
                loadTime.set(""); // use empty TextField, not 0
                errorMessage.set( testObject.getErrorMessage() );
            }
        });
}
```

7.2.5. Model

`URLTestModel` is presented in its entirety below. `URLTestModel` maintains a copy of a domain object. Upon initialization, this object is empty so an [Optional](#) is used. A getter is provided for

ViewModels. The `testURL()` method issues an HTTP GET call and records the results in the `URLTestObject` member. If the HTTP GET call is successful, the `URLTestObject` will contain the status code (probably 200) and an elapsed time. If unsuccessful, the `URLTestObject` will set a convenient `wasError` flag and an `errorMessage`.

When the Model has retrieved the contents at the URL or generated an error, the `publish()` method of the Notifications object is invoked. This prompts `URLTestViewModel` to update itself, but in a decoupled fashion. It is important to note that `URLTestModel` does not hold a reference to a `URLTestViewModel` object.

```
public class URLTestModel {

    private final Notifications notifications =
        new Notifications();

    private Optional<URLTestObject> urlTestObject =
        Optional.empty();

    public Optional<URLTestObject> getUrlTestObject() {
        return urlTestObject;
    }

    public Optional<URLTestObject> testURL(String url) {

        try {
            long startTimeMillis = System.currentTimeMillis();
            HttpURLConnection urlConnection =
                (HttpURLConnection) new URL(url).openConnection();
            try (
                InputStream is = urlConnection.getInputStream();
            ) {
                while (is.read() != -1) {
                }
            }
            long endTimeMillis = System.currentTimeMillis();

            URLTestObject uto = new URLTestObject(
                urlConnection.getResponseCode(),
                (int) (endTimeMillis - startTimeMillis)
            );

            urlTestObject = Optional.of(uto);

        } catch (Exception exc) {
            URLTestObject uto = new URLTestObject(exc.getMessage());
            urlTestObject = Optional.of(uto);
        }

        notifications.publish(Notifications.EVENT_MODEL_UPDATE);

        return urlTestObject;
    }
}
```

URLTestModel also does not attempt to bind to URLTestViewModel using JavaFX. Since the asynchrony is handled at the ViewModel layer, the Model is free to operate off of the JavaFX Thread. Attempting to double-bind (View→ViewModel→Model) would result in an application threading error if binding were used. Wrapped in a Platform.runLater(), a double-bind does not

violate the prescribed dependency order — ViewModel already holds a reference to Model — but might result in an inconsistent update.

This POJO is the domain object used by the Model. As a POJO, this can be maintained in a commons library and shared among non-UI components like a RESTful web services project.

URLTestObject.class

```
public class URLTestObject {

    private final Integer statusCode;
    private final Integer loadTime;
    private final Boolean wasError;
    private final String errorMessage;

    public URLTestObject(Integer statusCode,
                          Integer loadTime) {
        this.statusCode = statusCode;
        this.loadTime = loadTime;
        wasError = false;
        errorMessage = "";
    }

    public URLTestObject(String errorMessage) {
        this.statusCode = null;
        this.loadTime = null;
        wasError = true;
        this.errorMessage = errorMessage;
    }

    public Integer getLoadTime() {
        return loadTime;
    }

    public Integer getStatusCode() {
        return statusCode;
    }

    public Boolean getWasError() {
        return wasError;
    }

    public String getErrorMessage() {
        return errorMessage;
    }
}
```

7.2.6. Notifications

This class is a lightweight pub/sub implementation. Event types are registered as String constants

at the top of the file. Subscribers are identified by their class hashCode. All the published events will run on the JavaFX Thread.

Notifications.class

```
public class Notifications {

    public final static String EVENT_MODEL_UPDATE = "modelUpdate";

    private final Map<String, List<SubscriberObject>> subscribers = new
    LinkedHashMap<>();

    private static Notifications instance = new Notifications();

    public void publish(String event) {

        Platform.runLater( () -> {
            List<SubscriberObject> subscriberList = instance.subscribers.get(event);

            if (subscriberList != null) {

                subscriberList.forEach(
                    subscriberObject -> subscriberObject.getCb().accept(event)
                );

                // event ends after last subscriber gets callback
            }
        } );
    }

    public void subscribe(String event, Object subscriber, Consumer<String> cb) {

        if( !instance.subscribers.containsKey(event) ) {
            List<SubscriberObject> slist = new ArrayList<>();
            instance.subscribers.put( event, slist );
        }

        List<SubscriberObject> subscriberList = instance.subscribers.get( event );

        subscriberList.add( new SubscriberObject(subscriber, cb) );
    }

    public void unsubscribe(String event, Object subscriber) {

        List<SubscriberObject> subscriberList = instance.subscribers.get( event );

        if (subscriberList == null) {
            subscriberList.remove( subscriber );
        }
    }
}
```

```

static class SubscriberObject {

    private final Object subscriber;
    private final Consumer<String> cb;

    public SubscriberObject(Object subscriber,
                           Consumer<String> cb) {
        this.subscriber = subscriber;
        this.cb = cb;
    }

    public Object getSubscriber() {
        return subscriber;
    }

    public Consumer<String> getCb() {
        return cb;
    }

    @Override
    public int hashCode() {
        return subscriber.hashCode();
    }

    @Override
    public boolean equals(Object obj) {
        return subscriber.equals(obj);
    }
}

```

Notifications is a singleton so that any class — both `URLTestViewModel` and `URLTestModel` in this case — will subscribe to and publish to the right instance.

7.2.7. App

For completeness, the `Application` subclass is listed below.

```
public class ModelChangeApp extends Application {

    @Override
    public void start(Stage primaryStage) throws Exception {

        Scene scene = new Scene(new URLTestView());

        primaryStage.setTitle("Model Change App");
        primaryStage.setScene( scene );
        primaryStage.setWidth(568);
        primaryStage.setHeight(320);
        primaryStage.show();
    }

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

MVVM is an architecture that separates the View from the Model. Unlike other architectures, this separation includes a specific dependency graph: View depends on ViewModel depends on Model. All three component types collaborate, but in cases where data moves in the opposite direction of the dependency graph, the communication is indirect. In this example, the indirect communication was provided by JavaFX binding and a special Notifications class. By keeping the Model and ViewModel free of View dependencies, the MVVM architecture fosters reuse. URLTestModel can be used by other ViewModels and URLTestViewModel can be used by other Views.

7.2.8. Completed Code

The completed code in this example is available as a Gradle project [here](#). There are two examples in the JAR. Run the class `net.bekwam.bkcourse.modelchangeapp.ModelChangeApp`.

[bkcourse_mvvmapp_sources.zip](#)

Chapter 8. Best Practices

Placeholder whilst things get built...

1. Styleable Properties

8.1. Styleable Properties

Author: Gerrit Grunwald

```
/* Member variables for StyleablePropertyFactory
 * and StyleableProperty
 */
private static final StyleablePropertyFactory<MY_CTRL> FACTORY =
    new StyleablePropertyFactory<>(Control.getClassCssMetaData());

private static final CssMetaData<MY_CTRL, Color> COLOR =
    FACTORY.createColorCssMetaData("-color", s -> s.color, Color.RED, false);
private final StyleableProperty<Color> color = new
SimpleStyleableObjectProperty<>(COLOR, this, "color");

// Getter, Setter and Property method
public Color getColor() {
    return this.color.getValue();
}

public void setColor(final Color color) {
    this.color.setValue(COLOR);
}

public ObjectProperty<Color> colorProperty() {
    return (ObjectProperty<Color>) this.color;
}

// Return CSS Metadata
public static List<CssMetaData<? extends Styleable, ?>> getClassCssMetaData() {
    return FACTORY.getCssMetaData();
}

@Override public List<CssMetaData<? extends Styleable, ?>> getControlCssMetaData() {
    return getClassCssMetaData();
}
```

8.2. Tasks

Author: Carl Walker

This article demonstrates how to use a JavaFX Task to keep the UI responsive. It is imperative that any operation taking more than a few hundred milliseconds be executed on a separate Thread to avoid locking up the UI. A Task wraps up the sequence of steps in a long-running operation and provides callbacks for the possible outcomes.

The **Task** class also keeps the user aware of the operation through properties which can be bound to UI controls like ProgressBars and Labels. The binding dynamically updates the UI. These properties include

1. **runningProperty** - Whether or not the Task is running
2. **progressProperty** - The percent complete of an operation
3. **messageProperty** - Text describing a step in the operation

8.2.1. Demonstration

The following screenshots show the operation of an HTML retrieval application.

Entering a URL and pressing "Go" will start a JavaFX Task. When running, the Task will make an HBox visible that contains a ProgressBar and a Label. The ProgressBar and Label are updated throughout the operation.

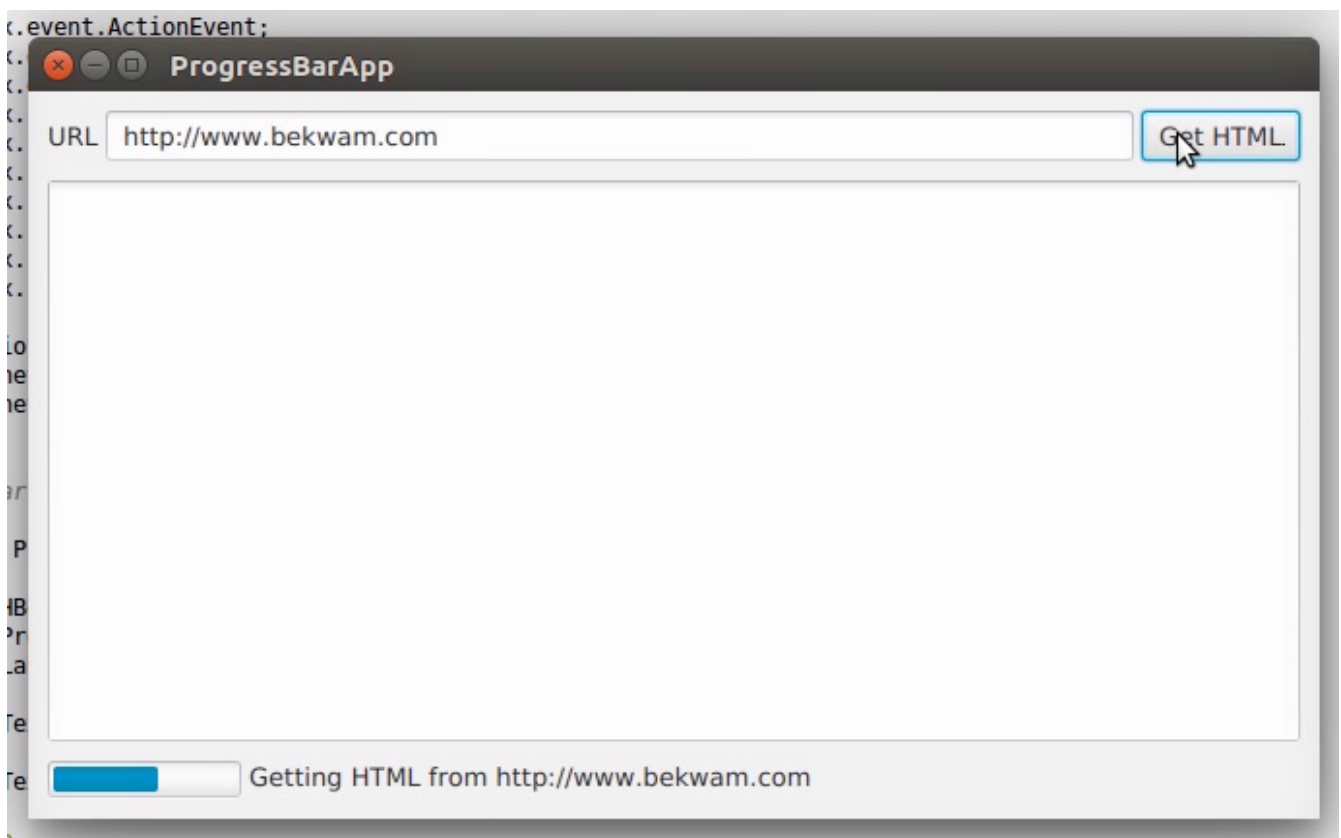


Figure 34. Screenshot of App Showing ProgressBar and Label

When the retrieval is finished, a `succeeded()` callback is invoked and the UI is updated. Note that the `succeeded()` callback takes place on the FX Thread, so it is safe to manipulate controls.

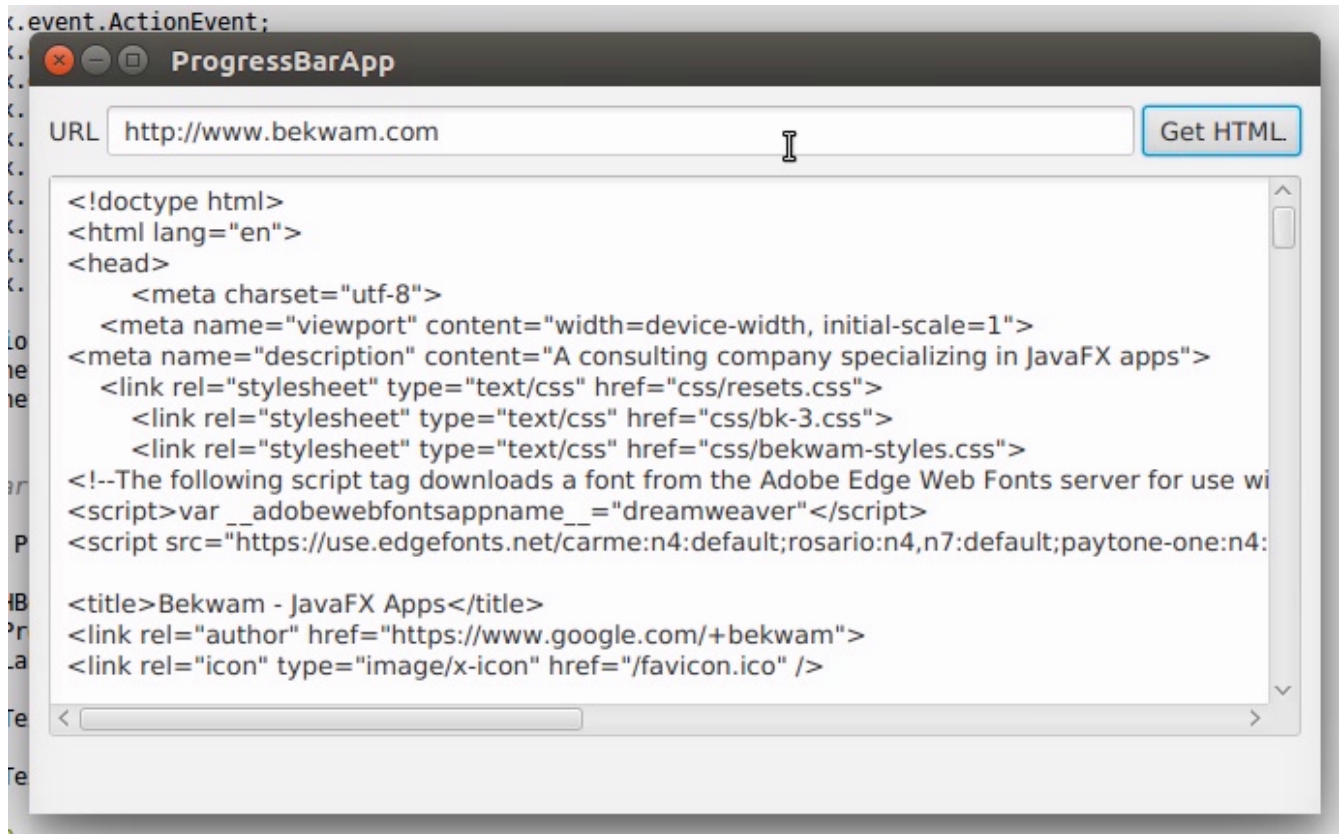


Figure 35. Screenshot of App Showing Successful Retrieval

If there was an error retrieving the HTML, a `failed()` callback is invoked and an error Alert is shown. `failed()` also takes place on the FX Thread. This screenshot shows invalid input. An "h" is used in the URL instead of the correct "http".

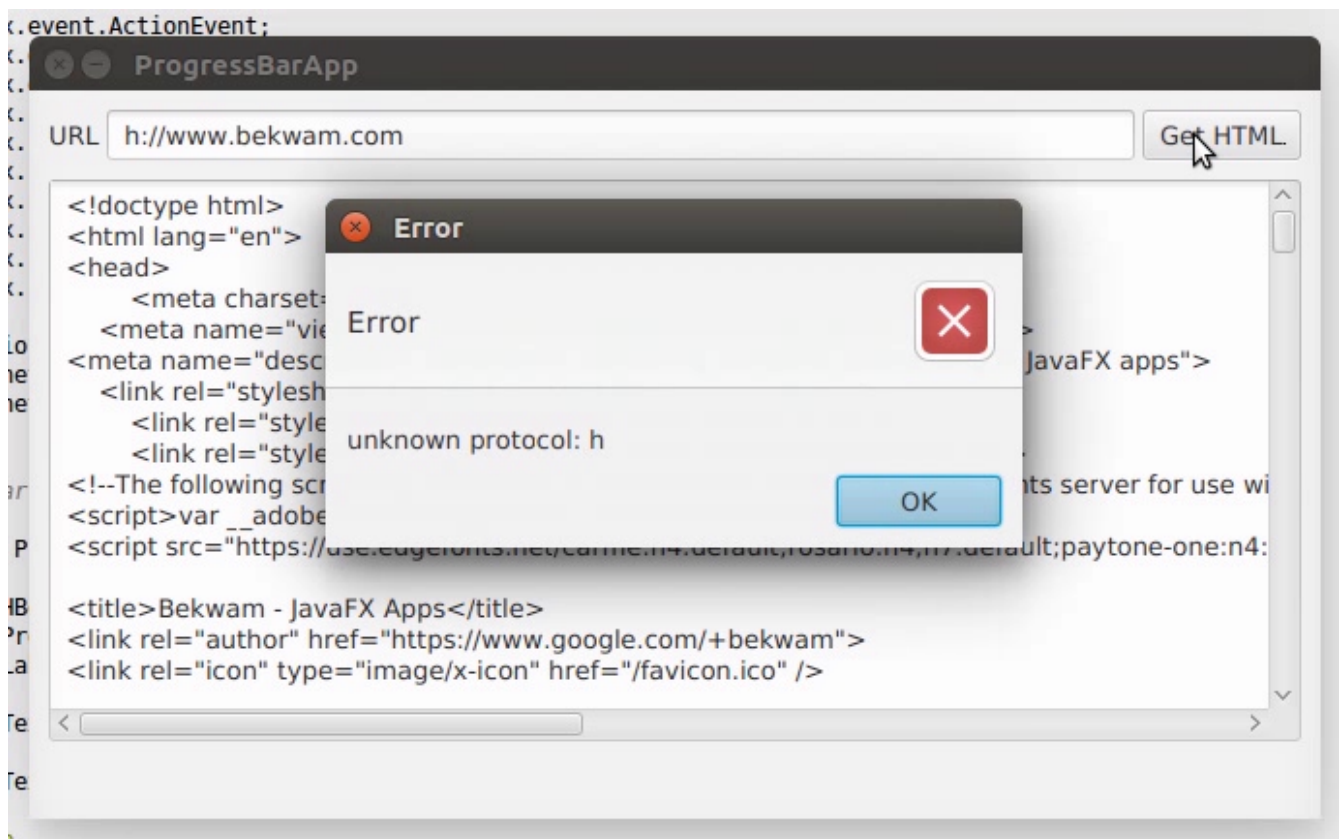


Figure 36. Screenshot of App Showing Failure

8.2.2. Code

An event handler is placed on the Get HTML Button which creates the Task. The entry point of the Task is the call() method which starts by calling updateMessage() and updateProgress(). These methods are executed on the FX Thread and will result in updates to any bound properties.

The program proceeds by issuing an HTTP GET using standard java.net classes. A String "retval" is built up from the retrieved characters. The message and progress properties are updated with more calls to updateMessage() and updateProgress(). The call() method ends with a return of the String containing the HTML text.

On a successful operation, the succeeded() callback is invoked. getValue() is a Task method that will return the value accrued in the Task (recall "retval"). The type of the value is what is provided in the generic argument, in this case "String". This could be a complex type like a domain object or a Collection. The succeeded() operation runs on the FX Thread, so the getValue() String is directly set on the TextArea.

If the operation failed, an Exception is thrown. The Exception is caught by the Task and converted to a failed() call. failed() is also FX Thread-safe and it displays an Alert.

```
String url = tfURL.getText();

Task<String> task = new Task<String>() {

    @Override
    protected String call() throws Exception {

        updateMessage("Getting HTML from " + url );
        updateProgress( 0.5d, 1.0d );

        HttpURLConnection c = null;
        InputStream is = null;
        String retval = "";

        try {

            c = (HttpURLConnection) new URL(url).openConnection();

            updateProgress( 0.6d, 1.0d );
            is = c.getInputStream();
            int ch;
            while( (ch=is.read()) != -1 ) {
                retval += (char)ch;
            }

        } finally {
            if( is != null ) {
                is.close();
            }
            if( c != null ) {
```

```

        c.disconnect();
    }
}

updateMessage("HTML retrieved");
updateProgress( 1.0d, 1.0d );

return retval;
}

@Override
protected void succeeded() {
    contents.setText( getValue() );
}

@Override
protected void failed() {
    Alert alert = new Alert(Alert.AlertType.ERROR, getException().getMessage() );
    alert.showAndWait();
}
};

```

Notice that the Task does not update the ProgressBar and status Label directly. Instead, the Task makes safe calls to `updateMessage()` and `updateProgress()`. To update the UI, JavaFX binding is used in the following statements.

```

bottomControls.visibleProperty().bind( task.runningProperty() );
pb.progressProperty().bind( task.progressProperty() );
messageLabel.textProperty().bind( task.messageProperty() );

```

`Task.runningProperty` is a boolean that can be bound to the `bottomControls HBox visibleProperty`. `Task.progressProperty` is a double that can be bound to the `ProgressBar progressProperty`. `Task.messageProperty` is a String that can be bound to the `status Label textProperty`.

To run the Task, create a Thread providing the Task as a constructor argument and invoke `start()`.

```

new Thread(task).start();

```

For any long-running operation—File IO, the Network—use a JavaFX Task to keep your application responsive. The JavaFX Task gives your application a consistent way of handling asynchronous operations and exposes several properties that can be used to eliminate boilerplate and programming logic.

8.2.3. Complete Code

The code can be tested in a single .java file.

```

public class ProgressBarApp extends Application {

    private HBox bottomControls;
    private ProgressBar pb;
    private Label messageLabel;

    private TextField tfURL;

    private TextArea contents;

    @Override
    public void start(Stage primaryStage) throws Exception {

        Parent p = createMainView();

        Scene scene = new Scene(p);

        primaryStage.setTitle("ProgressBarApp");
        primaryStage.setWidth( 667 );
        primaryStage.setHeight( 376 );
        primaryStage.setScene( scene );
        primaryStage.show();
    }

    private Parent createMainView() {

        VBox vbox = new VBox();
        vbox.setPadding( new Insets(10) );
        vbox.setSpacing( 10 );

        HBox topControls = new HBox();
        topControls.setAlignment(Pos.CENTER_LEFT);
        topControls.setSpacing( 4 );

        Label label = new Label("URL");
        tfURL = new TextField();
        HBox.setHgrow( tfURL, Priority.ALWAYS );
        Button btnGetHTML = new Button("Get HTML");
        btnGetHTML.setOnAction( this::getHTML );
        topControls.getChildren().addAll(label, tfURL, btnGetHTML);

        contents = new TextArea();
        VBox.setVgrow( contents, Priority.ALWAYS );

        bottomControls = new HBox();
        bottomControls.setVisible(false);
        bottomControls.setSpacing( 4 );
        HBox.setMargin( bottomControls, new Insets(4));

        pb = new ProgressBar();
        messageLabel = new Label("");
    }
}

```

```

        bottomControls.getChildren().addAll(pb, messageLabel);

        vbox.getChildren().addAll(topControls, contents, bottomControls);

        return vbox;
    }

    public void getHTML(ActionEvent evt) {

        String url = tfURL.getText();

        Task<String> task = new Task<String>() {

            @Override
            protected String call() throws Exception {

                updateMessage("Getting HTML from " + url );
                updateProgress( 0.5d, 1.0d );

                HttpURLConnection c = null;
                InputStream is = null;
                String retval = "";

                try {

                    c = (HttpURLConnection) new URL(url).openConnection();

                    updateProgress( 0.6d, 1.0d );
                    is = c.getInputStream();
                    int ch;
                    while( (ch=is.read()) != -1 ) {
                        retval += (char)ch;
                    }

                } finally {
                    if( is != null ) {
                        is.close();
                    }
                    if( c != null ) {
                        c.disconnect();
                    }
                }

                updateMessage("HTML retrieved");
                updateProgress( 1.0d, 1.0d );

                return retval;
            }

            @Override
            protected void succeeded() {

```

```

        contents.setText( getValue() );
    }

    @Override
    protected void failed() {
        Alert alert = new Alert(Alert.AlertType.ERROR,
getException().getMessage() );
        alert.showAndWait();
    }
};

bottomControls.visibleProperty().bind( task.runningProperty() );
pb.progressProperty().bind( task.progressProperty() );
messageLabel.textProperty().bind( task.messageProperty() );

new Thread(task).start();
}

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

```

8.3. Avoid Nulls in ComboBoxes

Author: Carl Walker

To use a **ComboBox** in JavaFX, declare a List of items and set an initial value using `setValue()`. The **ComboBox** method `getValue()` retrieves the currently selected value. If an initial value is not provided, the control defaults to a null value.

The null value is a problem when the **ComboBox** drives other logic like an upper-case transformation or the lookup of a database record. While a null check is usually used to prevent this type of error, an empty object is preferred in order to simplify the code. ComboBoxes often appear in clusters and the empty object technique reduces null checks in the interaction of related ComboBoxes and on save and load operations.

This article presents a pair of related ComboBoxes. A country selection in one **ComboBox** modifies the list of available city items in a second **ComboBox**. Neither selection is required. The user can press the Save **Button** at any time and if no selection is made for either **ComboBox**, an empty object — in this case an empty String — will be returned.

This is a screenshot of the app. Selecting "Switzerland" from an empty initial value will fill the city **ComboBox** with Swiss cities. Selecting the city "Zurich" and pressing Save will retrieve those values.

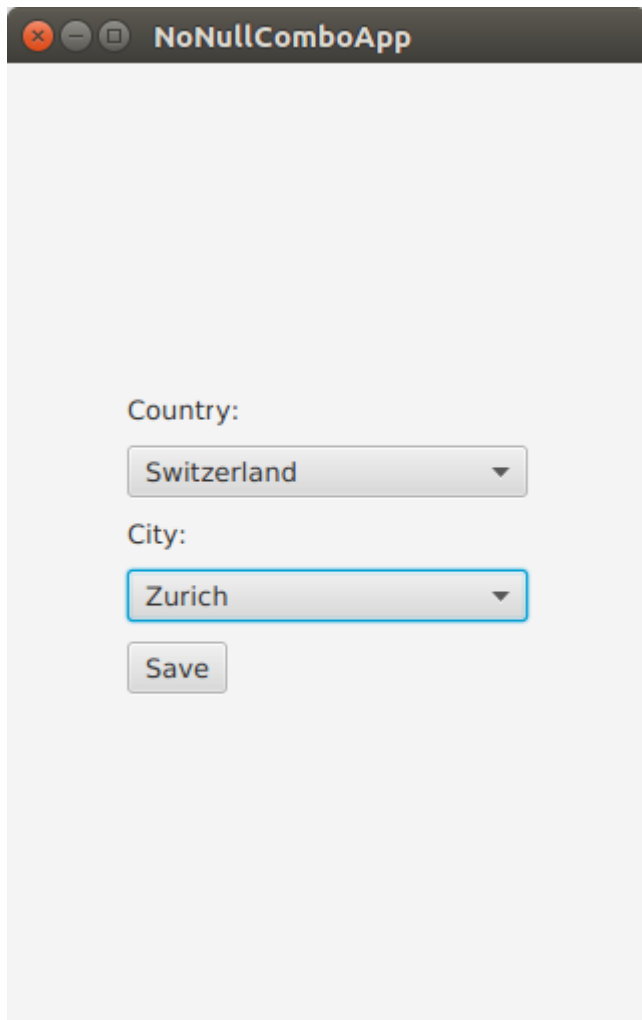


Figure 37. Related ComboBoxes

8.3.1. Data Structure

The data structures supporting the app are a List of countries and a Map of cities. The Map of cities uses country as a key.

```
public class NoNullComboApp extends Application {

    private List<String> countries = new ArrayList<>();

    private Map<String, List<String>> citiesMap = new LinkedHashMap<>();

    private void initData() {

        String COUNTRY_FR = "France";
        String COUNTRY_DE = "Germany";
        String COUNTRY_CH = "Switzerland";

        countries.add(COUNTRY_FR); countries.add(COUNTRY_DE);
countries.add(COUNTRY_CH);

        List<String> frenchCities = new ArrayList<>();
        frenchCities.add("Paris");
        frenchCities.add("Strasbourg");

        List<String> germanCities = new ArrayList<>();
        germanCities.add("Berlin");
        germanCities.add("Cologne");
        germanCities.add("Munich");

        List<String> swissCities = new ArrayList<>();
        swissCities.add("Zurich");

        citiesMap.put(COUNTRY_FR, frenchCities );
        citiesMap.put(COUNTRY_DE, germanCities );
        citiesMap.put(COUNTRY_CH, swissCities );
    }
}
```

To retrieve the set of cities for a given country, use the `get()` method of the `Map`. The `containsKey()` method can be used to determine whether or not the `Map` contains a value for the specified country. In this example, `containsKey()` will be used to handle the empty object case.

8.3.2. UI

The UI is a pair of `ComboBoxes` with `Labels` and a `Save Button`. The controls are put in a `VBox` and left-justified. The `VBox` is wrapped in a `TilePane` and centered. The `TilePane` was used since it does not stretch the `VBox` horizontally.

```

@Override
public void start(Stage primaryStage) throws Exception {

    Label countryLabel = new Label("Country:");
    country.setPrefWidth(200.0d);
    Label cityLabel = new Label("City:");
    city.setPrefWidth(200.0d);
    Button saveButton = new Button("Save");

    VBox vbox = new VBox(
        countryLabel,
        country,
        cityLabel,
        city,
        saveButton
    );
    vbox.setAlignment(Pos.CENTER_LEFT );
    vbox.setSpacing( 10.0d );

    TilePane outerBox = new TilePane(vbox);
    outerBox.setAlignment(Pos.CENTER);

    Scene scene = new Scene(outerBox);

    initData();
}

```

8.3.3. Initial Values

As mentioned earlier, if a value is not specified for a **ComboBox**, then null will be returned in a `getValue()` call. Although there are several defensive techniques—if checks, Commons StringUtils methods—for fending off `NullPointerExceptions`, it is better to avoid them completely. This is especially true as the interactions become complex or there are several **ComboBoxes** that allow empty selections.

```

country.getItems().add("");
country.getItems().addAll( countries );
country.setValue( "" ); // empty selection is object and not null

city.getItems().add("");
city.setValue( "" );

```

In this app, the Country **ComboBox** will not be changed, so its items are added in the `start()` method. Country starts with an initial empty selection as does city. City—at this point—contains a single empty item.

8.3.4. Interaction

When the country value is changed, the contents of the city **ComboBox** should be replaced. It is common to use `clear()` on the backing list; however, this will produce a null value in the **ComboBox** (no items, no value). Instead, use `removeIf()` with a clause to keep a single empty item. With the list cleared of all data (except the empty item), the newly-selected contents can be added with `addAll()`.

NoNullComboApp.class

```
country.setOnAction( (evt) -> {

    String cty = country.getValue();

    city.getItems().removeIf( (c) -> !c.isEmpty() );

    if( citiesMap.containsKey(cty) ) { // not an empty key
        city.getItems().addAll( citiesMap.get(cty) );
    }
});

saveButton.setOnAction( (evt) -> {
    System.out.println("saving country='" + country.getValue() +
        "', city='" + city.getValue() + "'");
});
```

The Save Button action will print out the values. In no case will a null value be returned from `getValue()`.

If you're a Java developer, you've written "if not null" thousands of times. Yet, project after project, I see `NullPointerExceptions` highlighting cases that were missed or new conditions that have arisen. This article presented a technique for keeping empty objects in **ComboBoxes** by setting an initial value and using `removeIf()` rather than `clear()` when changing lists. Although, this example used `String` objects, this can be expanded to work with domain objects that have an `hashCode/equals` implementation, an empty object representation, and a `cellFactory` or `toString()` to produce an empty view.

8.3.5. Complete Code

The code can be tested in a single `.java` file.

NoNullComboApp.class

```
public class NoNullComboApp extends Application {

    private final ComboBox<String> country = new ComboBox<>();
    private final ComboBox<String> city = new ComboBox<>();

    private List<String> countries = new ArrayList<>();

    private Map<String, List<String>> citiesMap = new LinkedHashMap<>();
```

```

@Override
public void start(Stage primaryStage) throws Exception {

    Label countryLabel = new Label("Country:");
    country.setPrefWidth(200.0d);
    Label cityLabel = new Label("City:");
    city.setPrefWidth(200.0d);
    Button saveButton = new Button("Save");

    VBox vbox = new VBox(
        countryLabel,
        country,
        cityLabel,
        city,
        saveButton
    );
    vbox.setAlignment(Pos.CENTER_LEFT );
    vbox.setSpacing( 10.0d );

    TilePane outerBox = new TilePane(vbox);
    outerBox.setAlignment(Pos.CENTER);

    Scene scene = new Scene(outerBox);

    initData();

    country.getItems().add("");
    country.getItems().addAll( countries );
    country.setValue( "" ); // empty selection is object and not null

    city.getItems().add("");
    city.setValue( "" );

    country.setOnAction( (evt) -> {

        String cty = country.getValue();

        city.getItems().removeIf( (c) -> !c.isEmpty() );

        if( citiesMap.containsKey(cty) ) { // not an empty key
            city.getItems().addAll( citiesMap.get(cty) );
        }
    });

    saveButton.setOnAction( (evt) -> {
        System.out.println("saving country='" + country.getValue() +
            "', city='" + city.getValue() + "'");
    });

    primaryStage.setTitle("NotNullComboApp");
}

```

```

        primaryStage.setScene( scene );
        primaryStage.setWidth( 320 );
        primaryStage.setHeight( 480 );
        primaryStage.show();
    }

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

    private void initData() {

        String COUNTRY_FR = "France";
        String COUNTRY_DE = "Germany";
        String COUNTRY_CH = "Switzerland";

        countries.add(COUNTRY_FR); countries.add(COUNTRY_DE);
countries.add(COUNTRY_CH);

        List<String> frenchCities = new ArrayList<>();
        frenchCities.add("Paris");
        frenchCities.add("Strasbourg");

        List<String> germanCities = new ArrayList<>();
        germanCities.add("Berlin");
        germanCities.add("Cologne");
        germanCities.add("Munich");

        List<String> swissCities = new ArrayList<>();
        swissCities.add("Zurich");

        citiesMap.put(COUNTRY_FR, frenchCities );
        citiesMap.put(COUNTRY_DE, germanCities );
        citiesMap.put(COUNTRY_CH, swissCities );
    }
}

```

Chapter 9. Contributing

Placeholder whilst things get built...

Chapter 10. License



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