Lecture 8

Graphics Part I

Intro to JavaFX

(photo courtesy of Snapchat filters)

This Lecture

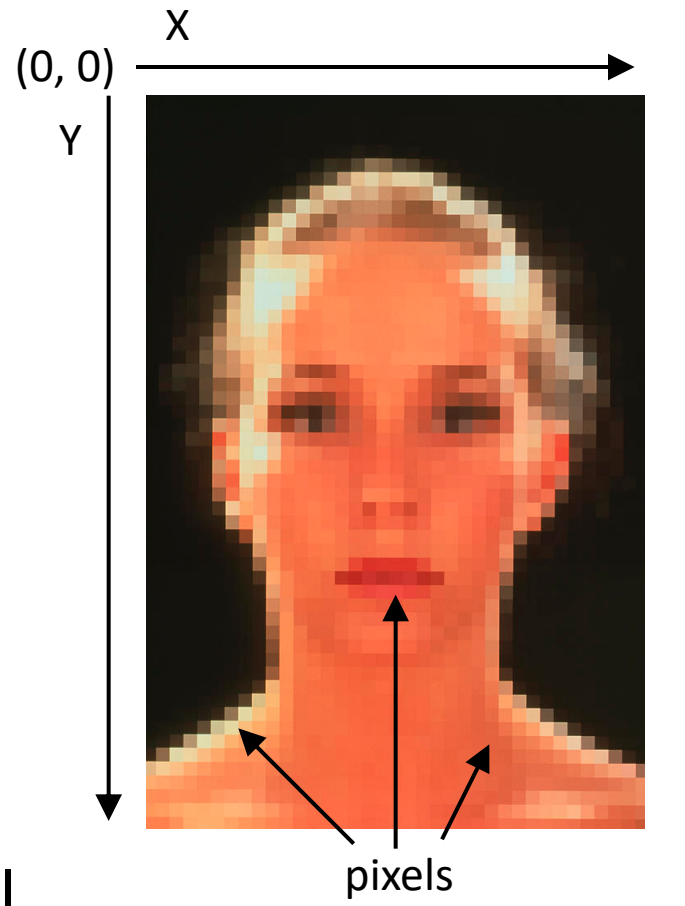
- GUIs and JavaFX
- JavaFX Scene Graph Hierarchy
  - Aside: `VBox`
- Example: `ColorChanger`
  - Event Handling
  - Private inner classes
  - Random number generation
  - `javafx.scene.paint.Colors`
- Logical vs. Graphical Containment with JavaFX

Pixels and Coordinate System

- Screen is a grid of **pixels (**tiny squares, each with RGB components)

- Cartesian plane with:
  - origin in upper-left corner
  - x-axis increasing left to right
  - y-axis increasing top to bottom
  - corresponds to English writing order

- Each graphical element is positioned at specific pixel



Former HTA Sam Squires!

What is JavaFX?

- Usually don't want to program at the pixel level – far too tedious!

- JavaFX is a set of graphics and media packages enabling developers to design, create, and test powerful graphical applications for desktop, web, and mobile devices

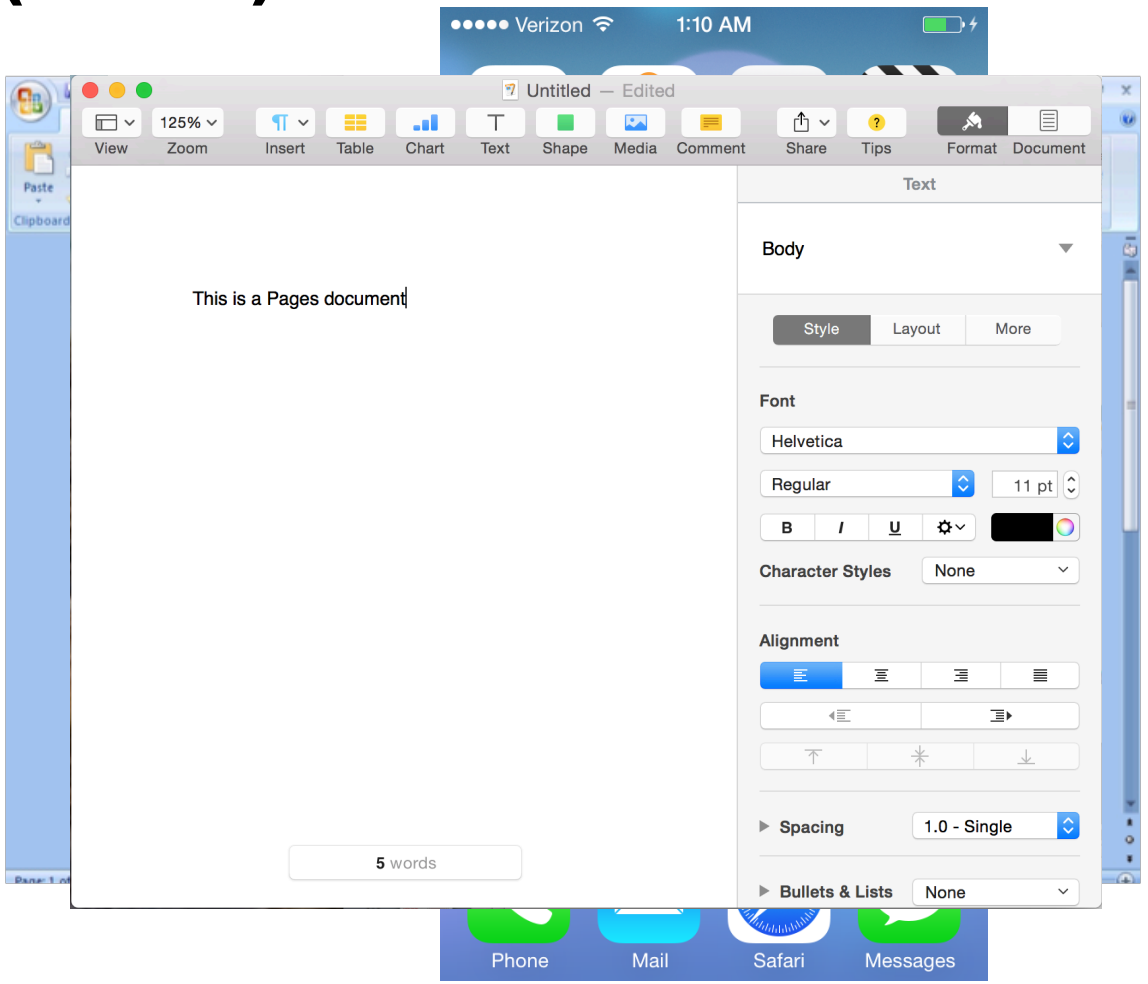
- JavaFX is an API (Application Programming Interface) to a graphics and media library: a collection of useful classes and interfaces and their methods (with suitable documentation) – no internals accessible!

Creating Applications from Scratch

- Until now, TAs took care of graphical components for you
  - our support code defined the relevant classes
- *From now on, **you** are in charge of this!*
- JavaFX is quite powerful but can be a bit tricky to wrap your head around because of the size of the JavaFX library
  - not to fear, all JavaFX packages, classes, and method descriptions can be found in the JavaFX guide on our website!

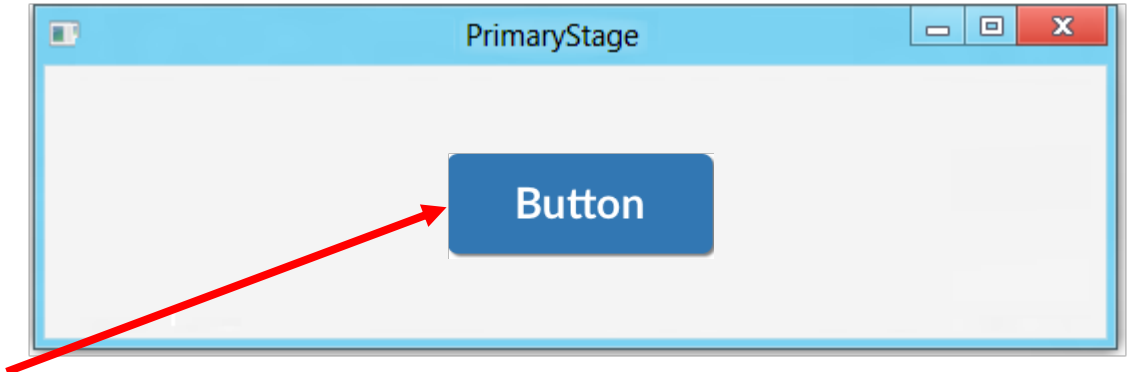
Graphical User Interface (GUIs)

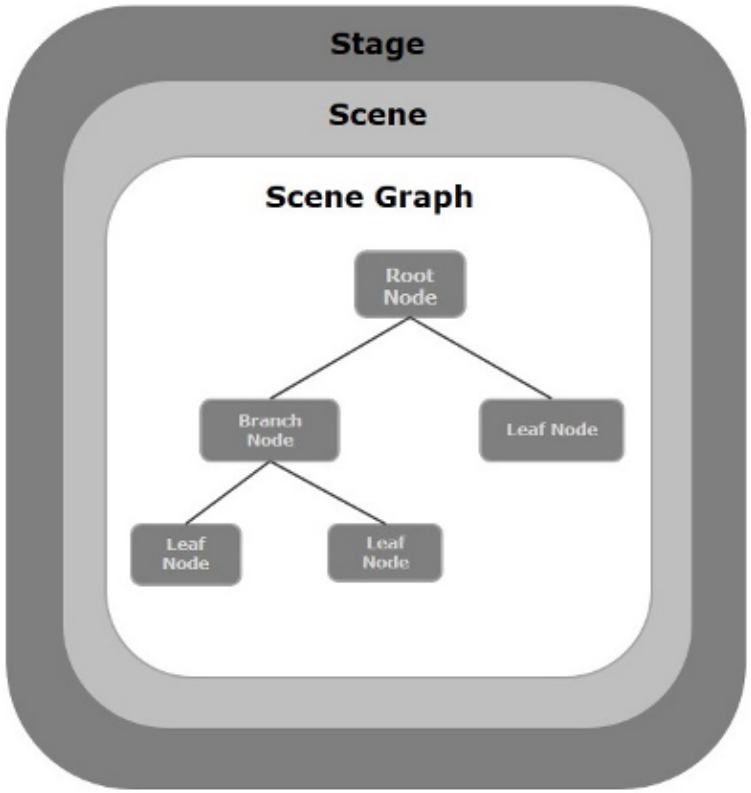
- GUIs provide user- controlled (i.e., graphical) way to send messages to a system of objects, typically your app
- Use JavaFX to create your own GUIs throughout the semester



Components of JavaFX application

- Stage
  - **location** (or “window”) where all graphic elements will be displayed
- Scene
  - **container** for all UI elements to be displayed on a stage
  - scene must be on a stage to be visible
- Scene Graph
  - family tree of graphical elements
- Nodes
  - all elements of the Scene Graph
  - graphical representation called a UI element, widget or control (synonyms)

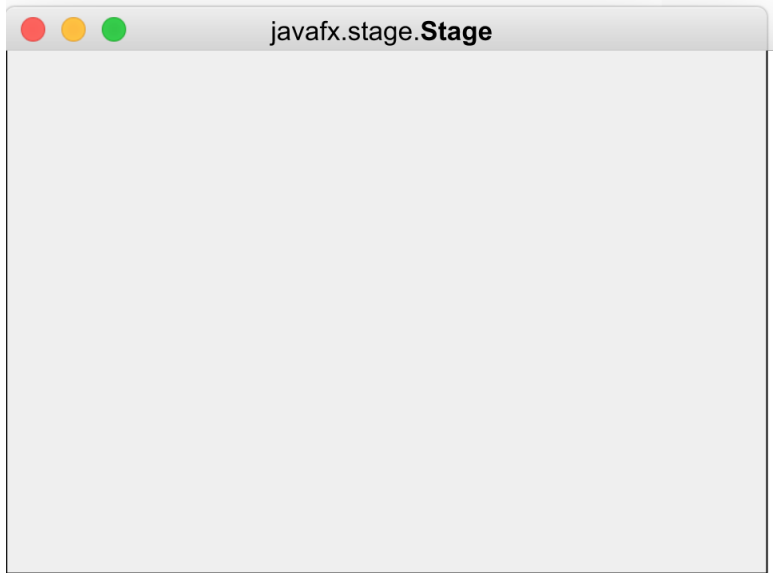




Creating GUIs With JavaFX (1/2)

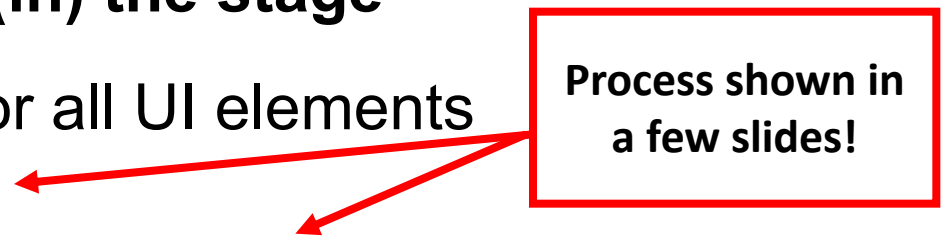
- `App` class for our main JavaFX application extends the imported `abstract` class `javafx.application.Application`
- From now on in CS15, we'll begin every project by implementing the `Application` class' `start` method
  - `start` is called automatically by JavaFX to launch program
- Java automatically creates a `Stage` using the imported `javafx.stage.Stage` class, which is passed into `start` method
  - the `stage` becomes a window for the application when `stage`'s `show` method is called in the `Application` class' `start` method.

```
public class App extends Application {
    //mainline provided by TAs elided
    @Override
    public void start( Stage stage ) {
        stage.show();
    }

}
```



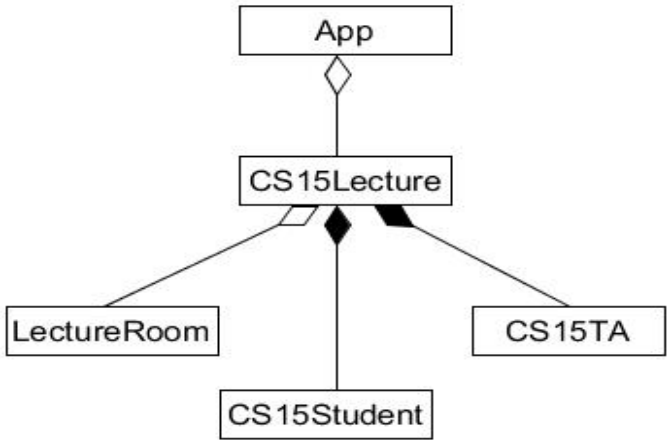
Creating GUIs With JavaFX (2/2)

- In order for our application to provide **content** for what to show on the stage, must first **set** **(specify) a scene** before **showing it on (in) the stage**
- `javafx.scene.Scene` is the top-level container for all UI elements
  - first instantiate `Scene` within `App` class' `start` method
  - then pass that `Scene` into `Stage`'s `setScene(Scene scene)` method to *set the scene!*
- In CS15, only specify 1 `Scene` – though JavaFX does permit creation of applications with multiple `Scene`s
  - ex: A gaming application where you could select to play either DoodleJump, Tetris or Pacman from the main screen might utilize multiple `Scene`s - one for each subgame
- So what exactly is a `javafx.scene.Scene` ?

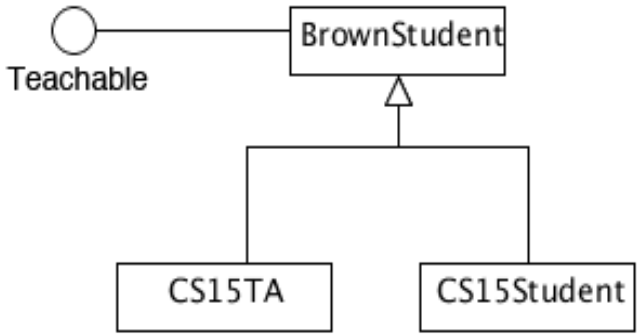


JavaFX Scene Graph Hierarchy (1/3)

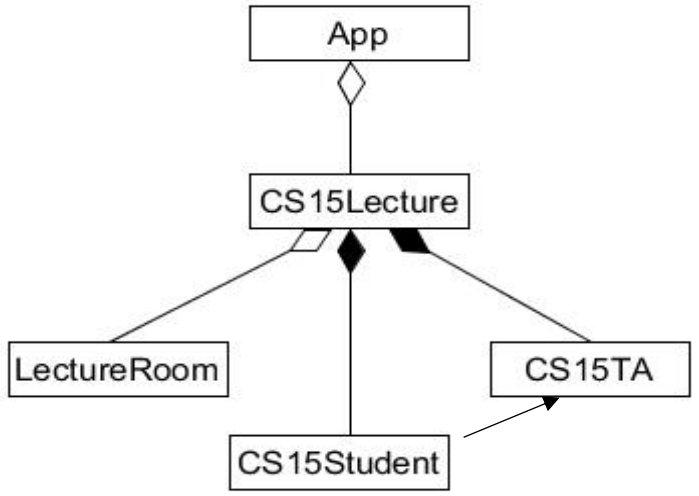
- In JavaFX, contents of the `Scene` (UI elements) are represented as a hierarchical **tree**, known as the Scene Graph
  - you are familiar with some other hierarchies already - containment and inheritance



containment hierarchy



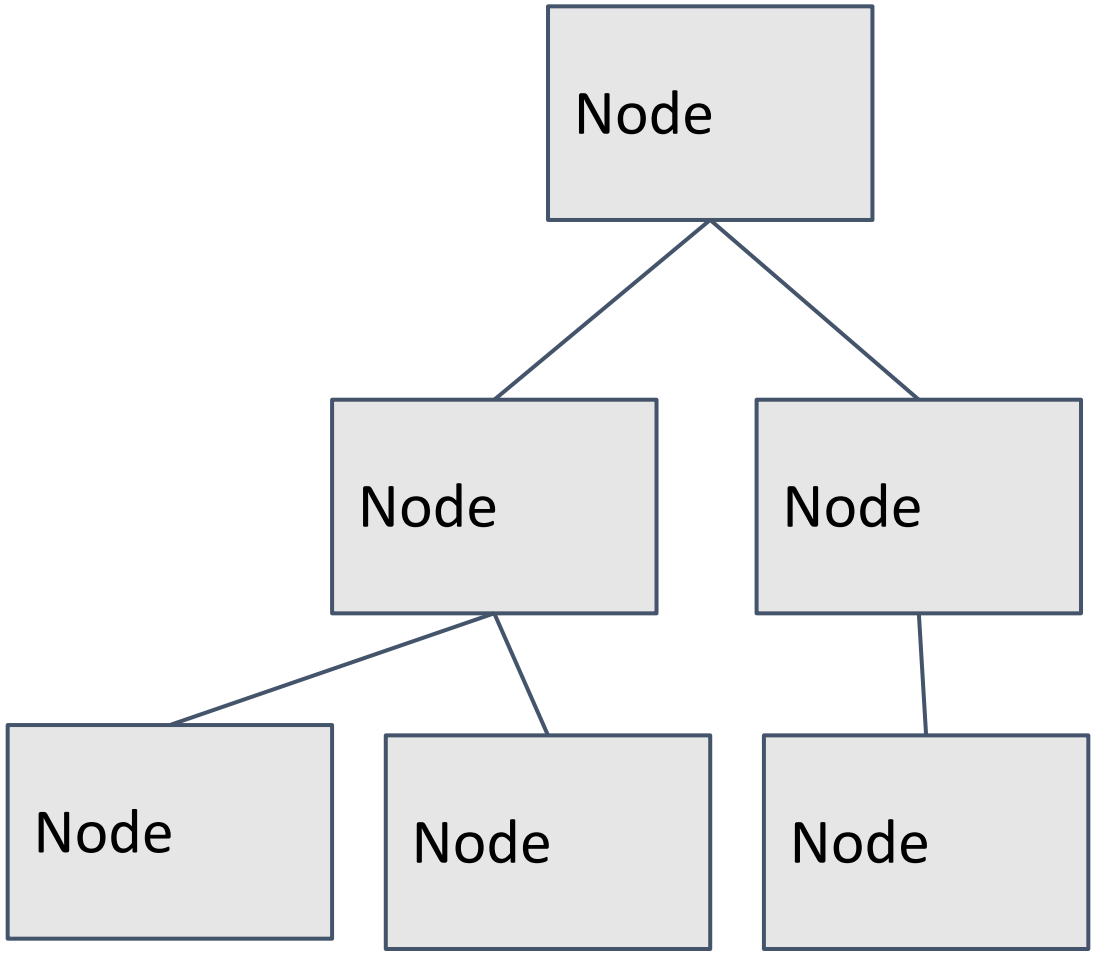
inheritance hierarchy



directed graph

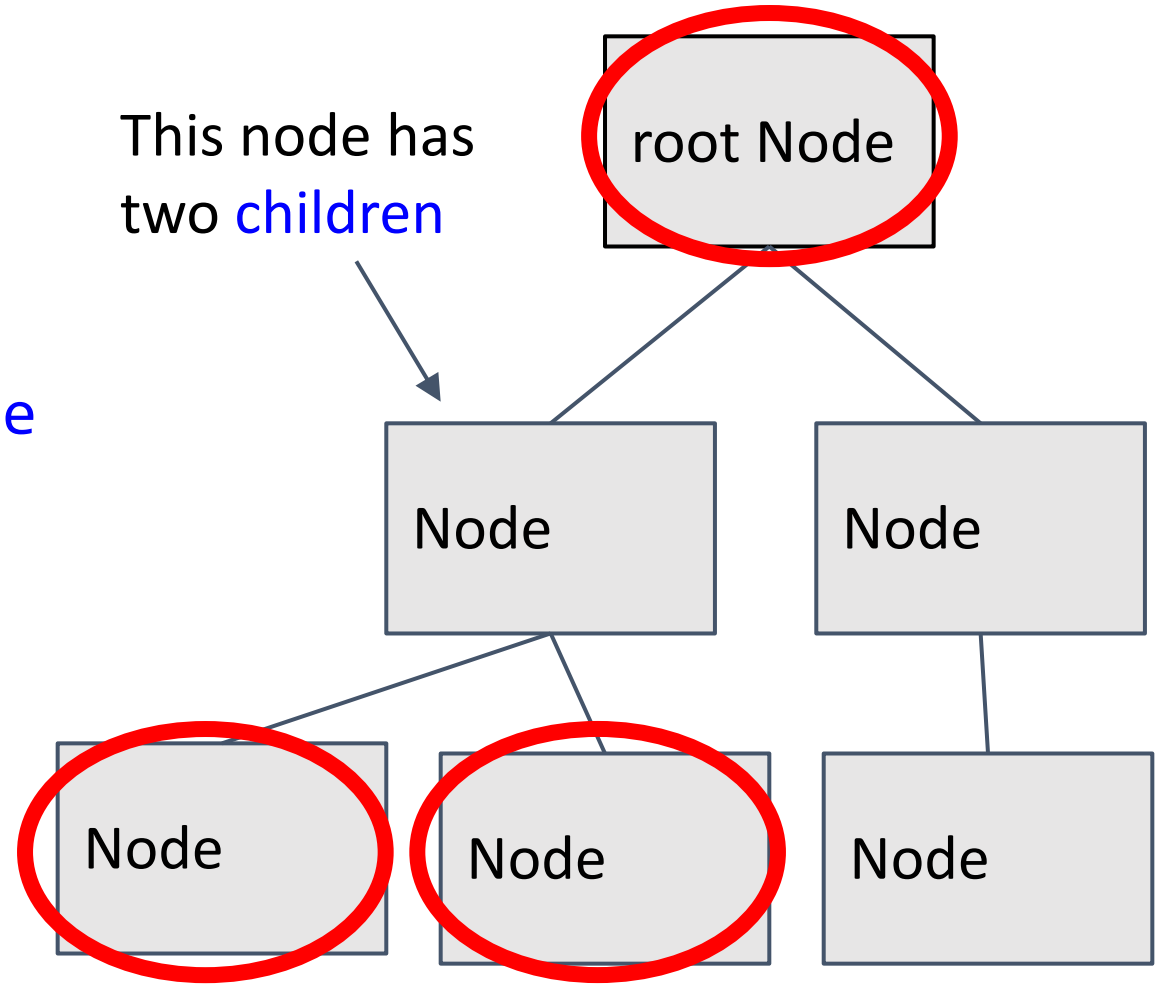
JavaFX Scene Graph Hierarchy (2/3)

- Think of the Scene Graph as a *family tree of visual elements*
- `javafx.scene.Node` is the abstract superclass for all UI elements that can be added to the `Scene`, such as a `Button` or a `Label`
  - all UI elements are concrete subclasses of `Node` (`Button`, `Label`, `Pane`, etc.)
- Each UI component that is added to the Scene Graph as a `Node` gets displayed *graphically*



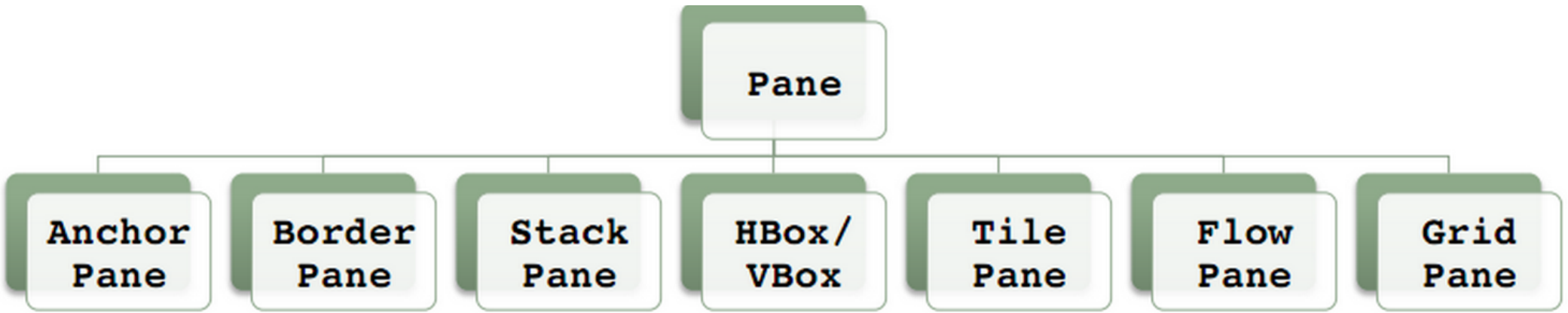
JavaFX Scene Graph Hierarchy (3/3)

- Each Node can have multiple *children* but at most one *parent*
  - child Nodes are almost always *graphically contained* in their parent Node
  - more on graphical containment later!
- The Node at the top of the Scene Graph is called the root Node
  - the root Node has no parent



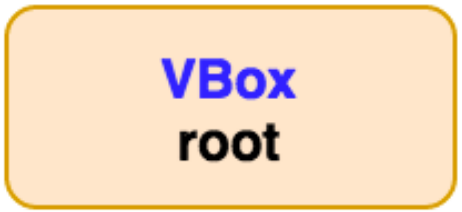
The root of the `Scene`

- In CS15, root `Node` will **always** be a `javafx.scene.layout.Pane` or one of `Pane`'s subclasses.
- Different `Pane`s have different built-in layout capabilities to allow easy positioning of UI elements - see inheritance tree below for flavors
- For now, use a `VBox` as the root of the `Scene`– more on `VBox` later



Constructing the Scene Graph (1/3)

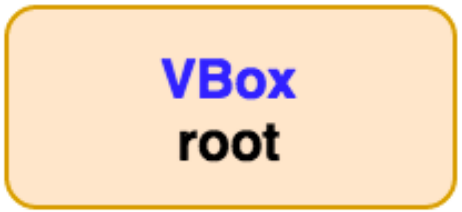
- Instantiate root Node




```
public class App extends Application {

	@Override
	public void start(Stage stage) {
		//code to populate Scene Graph
		VBox root = new VBox();



	}
}
```

Constructing the Scene Graph (2/3)

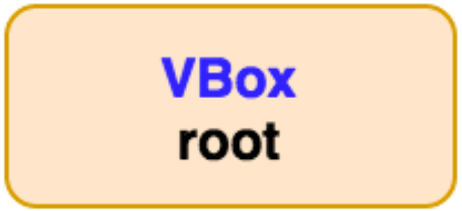
- Instantiate root `Node`
- Then pass it into `Scene` constructor to construct Scene Graph
  - Scene Graph starts off as a single root `Node` with no children
  - the root is simply a container, without graphical shape




```
public class App extends Application {

        @Override
        public void start(Stage stage) {
                //code to populate Scene Graph
                VBox root = new VBox();
                Scene scene = new Scene(root);


        }
}
```

Constructing the Scene Graph (3/3)

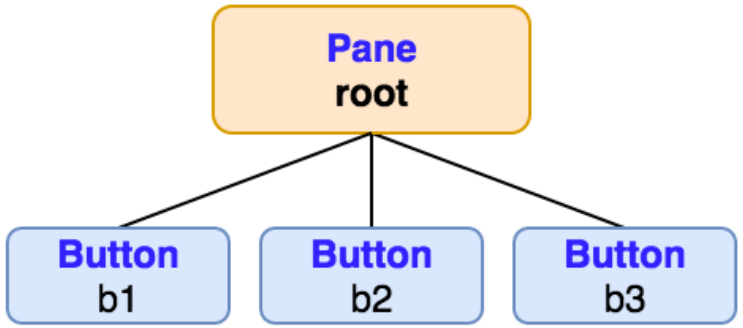
- Once we `setScene()` and `show()` on `Stage`, we begin populating the Scene Graph




```
public class App extends Application {

        @Override
        public void start(Stage stage) {
                //code to populate Scene Graph
                VBox root = new VBox();
                Scene scene = new Scene(root);
                stage.setScene(scene);
                stage.show();
        }
}
```

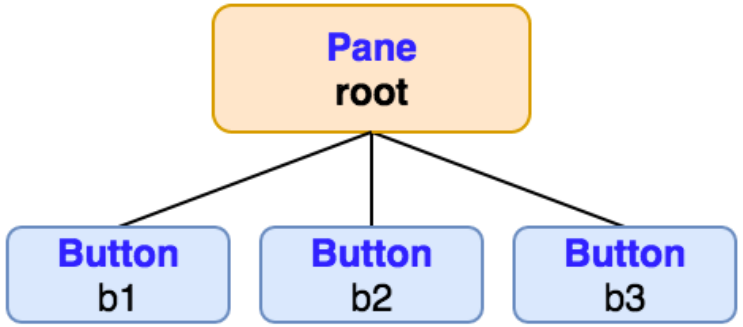
Adding UI Elements to the Scene (1/2)

- How do we add more `Node`s to the Scene Graph?
- Adding UI elements as children of root `Node` will add them to `Scene` and make them appear on the `Stage`!
- Calling `getChildren()` method on a `Node` returns a list of that `Node`'s children
  - by adding/removing `Node`s from a `Node`'s list of children, we can add/remove `Node`s from the Scene Graph!



Adding UI Elements to the Scene (2/2)

- `getChildren()` returns a `List` of child `Node`s
  - in example on right, `root.getChildren()` returns a `List` holding three `Button`s (assuming we created them previously - next slide)
- To add a `Node` to this list of children, call `add(Node node)` on that returned `List`!
  - can also use `addAll(Nodes… node1, node2, …)` which takes in *any number of* `Node`*s*
  - allowing *any* number of arguments is a new capability of parameter lists
- To remove a `Node` from this list of children, call `remove(Node node)` on that returned `List`

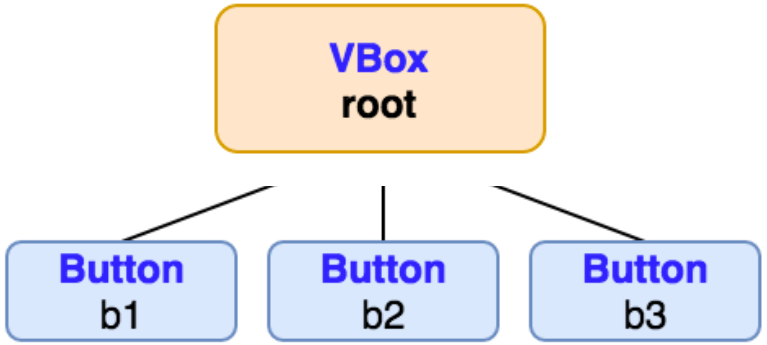


root.getChildren().add(…) in action

- Add 3 Buttons to the Scene by adding them as children of the root Node (no children before this)
- First create buttons
- Then add buttons to Scene Graph

```
/* Within App class */
    @Override
    public void start(Stage stage) {
    //code for setting root, stage, scene elided

        Button b1 = new Button("Button 1");
        Button b2 = new Button("Button 2");
        Button b3 = new Button("Button 3");
        root.getChildren().addAll(b1,b2,b3);
    }
```

Order matters - order buttons added effects order displayed
(b1, b2, b3) vs. (b2, b1, b3)

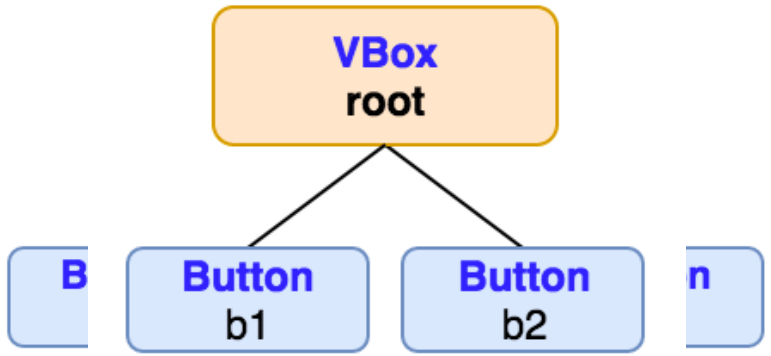


Note the default button selection in blue

Remember double dot method call shorthand?
root.getChildren() returns a List of root's children. Rather than storing that returned List in a variable and calling add(…) on that variable, we can simplify our code by calling add(…) directly on the returned List of children!

Removing UI Elements from the Scene (2/2)

- Similarly, remove a UI element by removing it from **root**'s children
  - note: order of children doesn't matter when removing elements since you specify their variable names



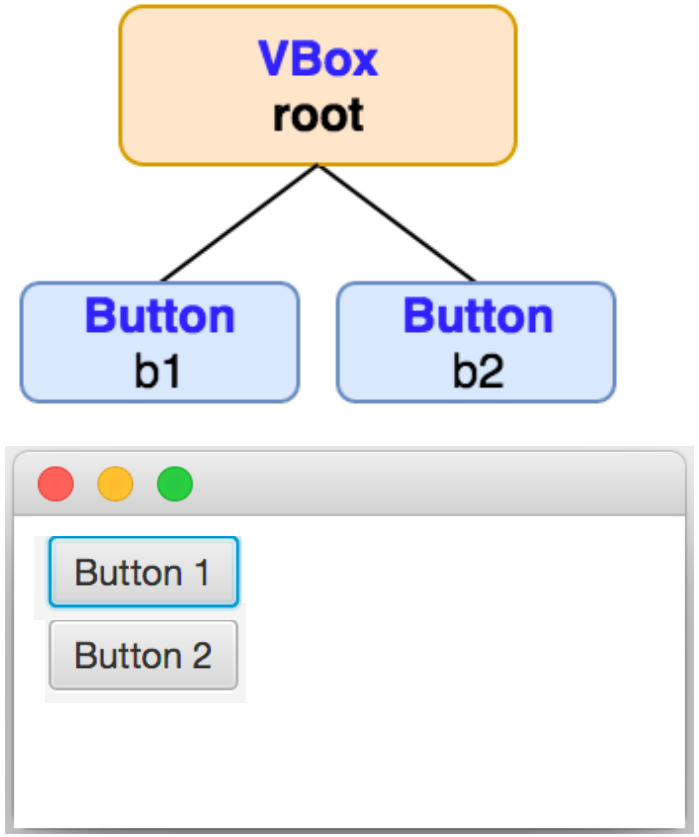
- Let's remove third `Button`*

```
/* Within App class */
        @Override
        public void start(Stage stage) {
        //code for setting root, stage, scene elided

                Button b1 = new Button("Button 1");
                Button b2 = new Button("Button 2");
                Button b3 = new Button("Button 3");
                root.getChildren().addAll(b1,b2,b3);
                root.getChildren().remove(b3);
        }
```

*Note: not a typical design choice to add and then remove a Node in the same code block!

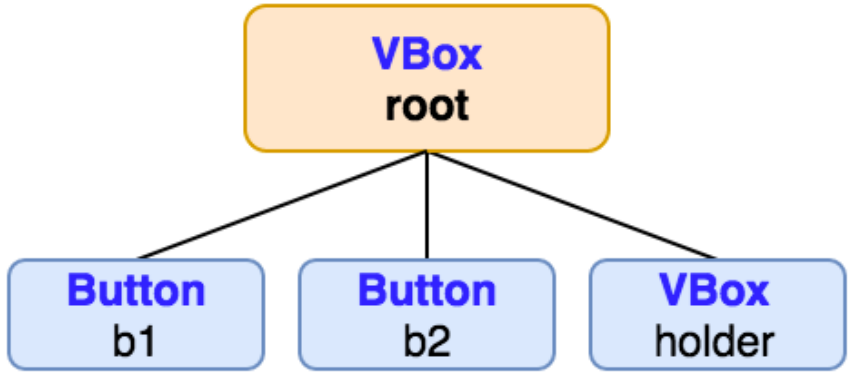
Populating the Scene Graph (1/3)

- What if we want to make more complex applications?
- Add specialized layout containers, called `Panes`
- Add another `Pane` as child of root `Node`, then add more UI elements as child `Nodes` of this `Pane` – next slide
- This will continue to populate the scene graph!



Populating the Scene Graph (2/3)

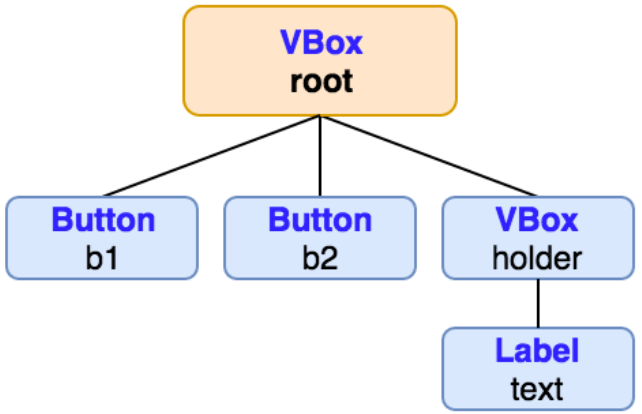
- First, instantiate another VBox and add it as child of root Node
  - **Note**: VBox is a pure container without graphical shape



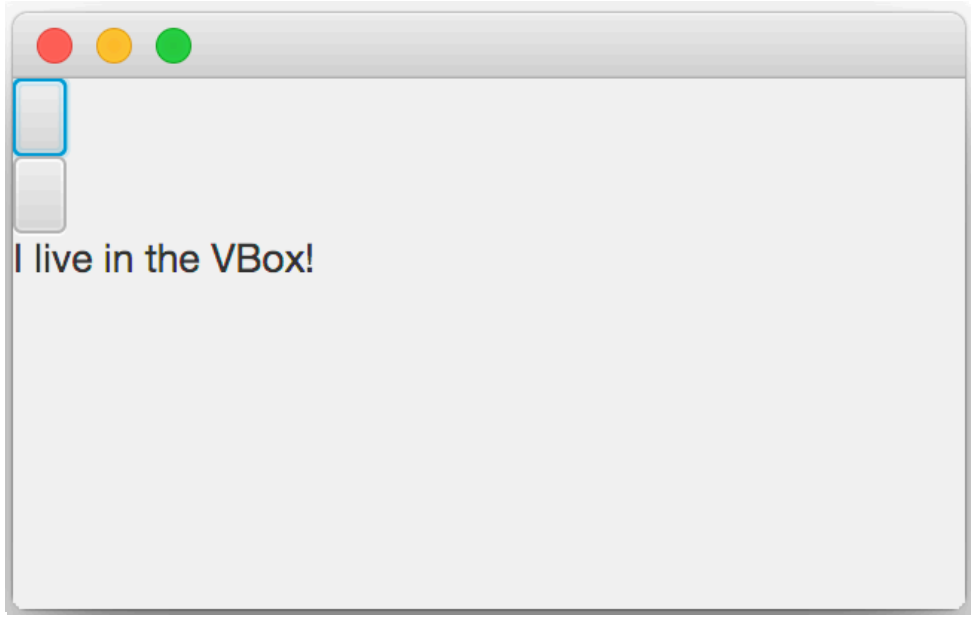

```
/* Within App class */
        @Override
        public void start(Stage stage) {
                //code for setting scene elided

                Button b1 = new Button(); //no label
                Button b2 = new Button(); //no label
                root.getChildren().addAll(b1,b2);

                VBox holder = new VBox();
                root.getChildren().add(holder);
        }
```

Populating the Scene Graph (3/3)

- Next, add `Label` to `Scene` as child of new `VBox`

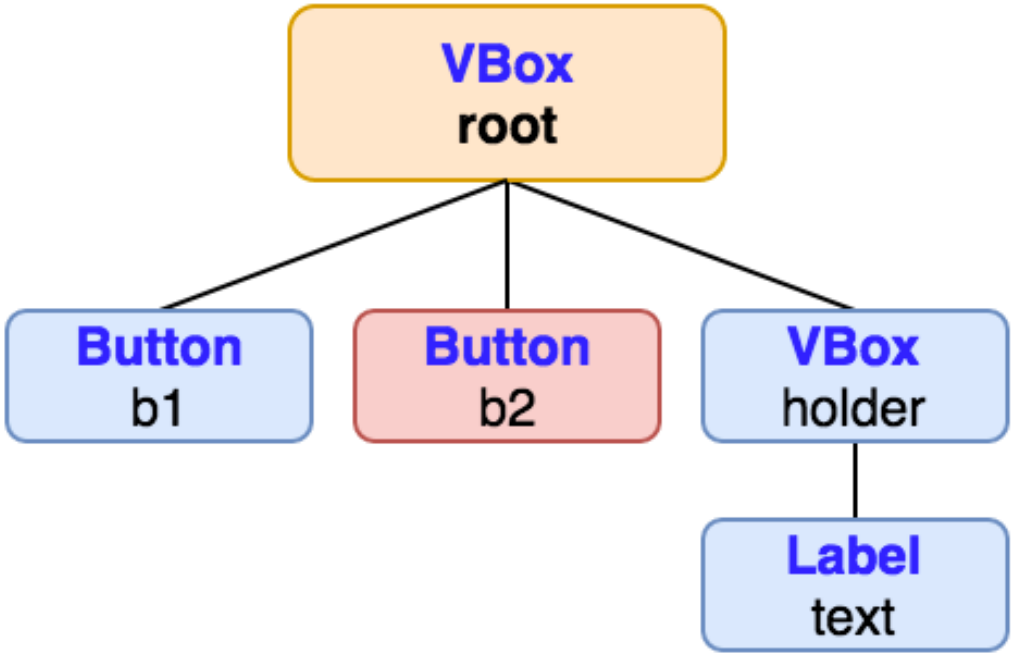



```
/* Within App class */
        @Override
        public void start(Stage stage) {
                //code for setting scene elided

                Button b1 = new Button();
                Button b2 = new Button();
                root.getChildren().addAll(b1,b2);
                VBox holder = new VBox();
                root.getChildren().add(holder);
                Label text = new Label(
                        "I live in the VBox!");
                holder.getChildren().add(text);
        }
```



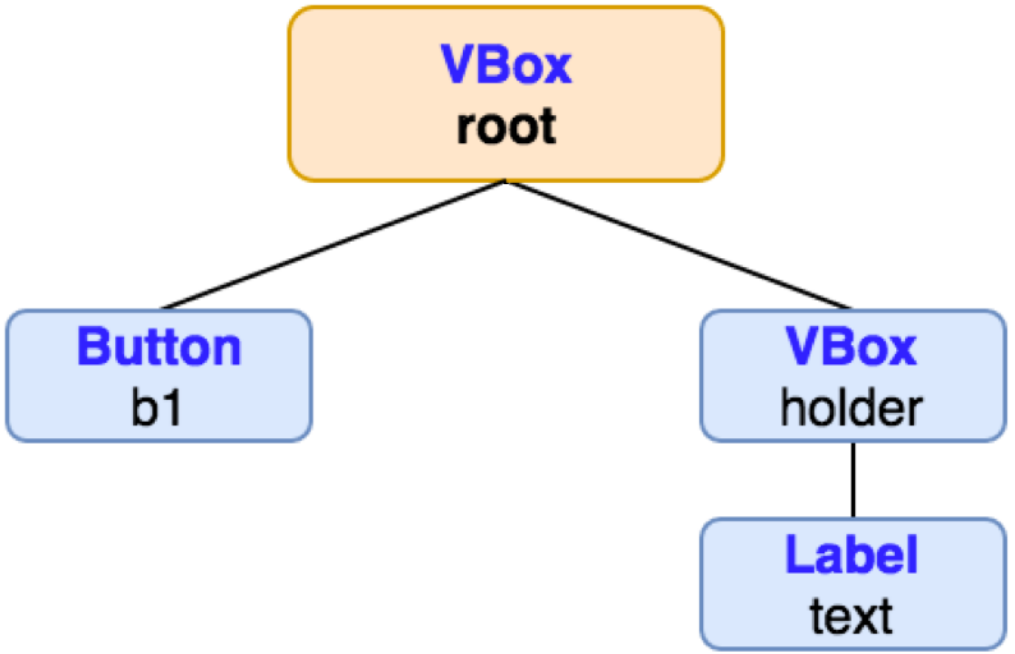
Removing a `Node` with children (1/3)

- Removing a `Node` with no children simply removes that `Node`…
  - `root.getChildren().remove(b2);` to remove second `Button`



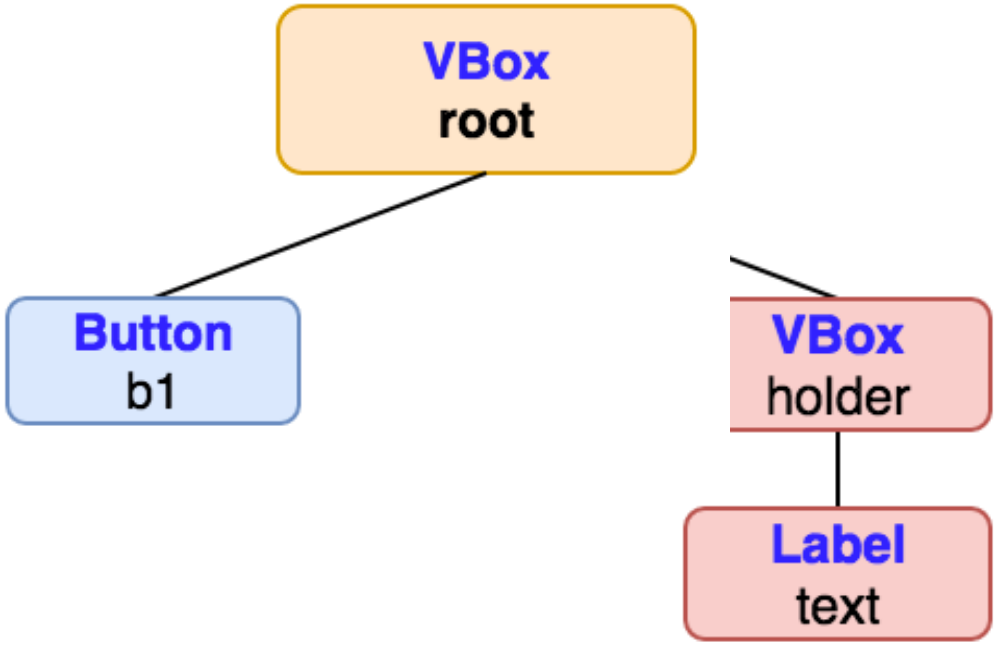
Removing a `Node` with children (2/3)

- Note that removing a `Node` with no children simply removes that `Node`…
  - `root.getChildren().remove(b2);` to remove second `Button`
- Removing a `Node` with children removes all of its children as well!



Removing a `Node` with children (3/3)

- Note that removing a `Node` with no children simply removes that `Node`…
  - `root.getChildren().remove(b2);` to remove second `Button`
- Removing a `Node` with children removes all of its children as well!
  - `root.getChildren().remove(holder);` makes both `VBox` and `Label` disappear



TopHat Question

Given this code:

```
public void start(Stage stage) {
    //code for setting scene elided

    Button b1 = new Button();
    Button b2 = new Button();
    root.getChildren().addAll(b1,b2);

    VBox holder = new VBox();
    root.getChildren().add(holder);
    Label removeLabel = new Label("remove me!");
    holder.getChildren().add(removeLabel);
}
```

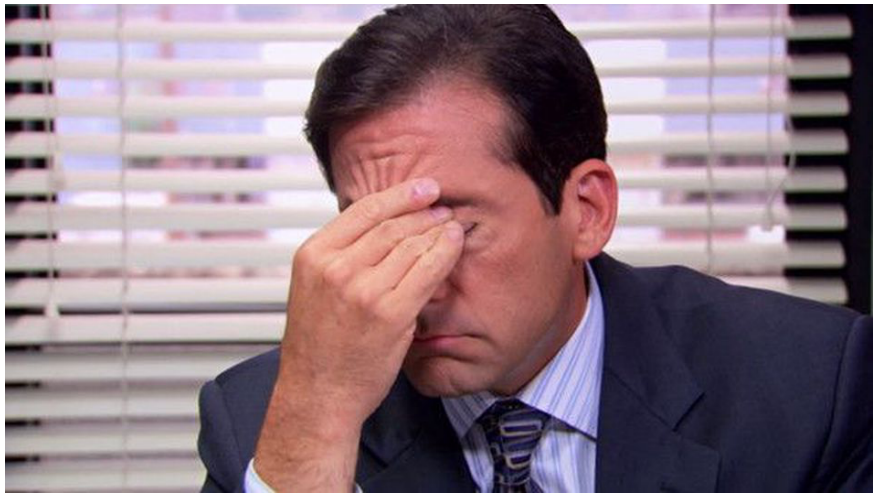
Which of the following correctly would next remove `removeLabel` from the VBox `holder`?

A. `root.remove(removeLabel);`

B. `holder.remove(removeLabel);`

C. `root.getChildren.remove(removeLabel);`

D. `holder.getChildren().remove(removeLabel);`



VBox layout pane (1/5)

- So what exactly is a VBox?
- VBox layout Pane creates an easy way for arranging a series of children in a *single vertical column*
- We can customize vertical spacing *between* children using VBox's setSpacing(double) method
  - the larger the double passed in, the more space between the child UI elements

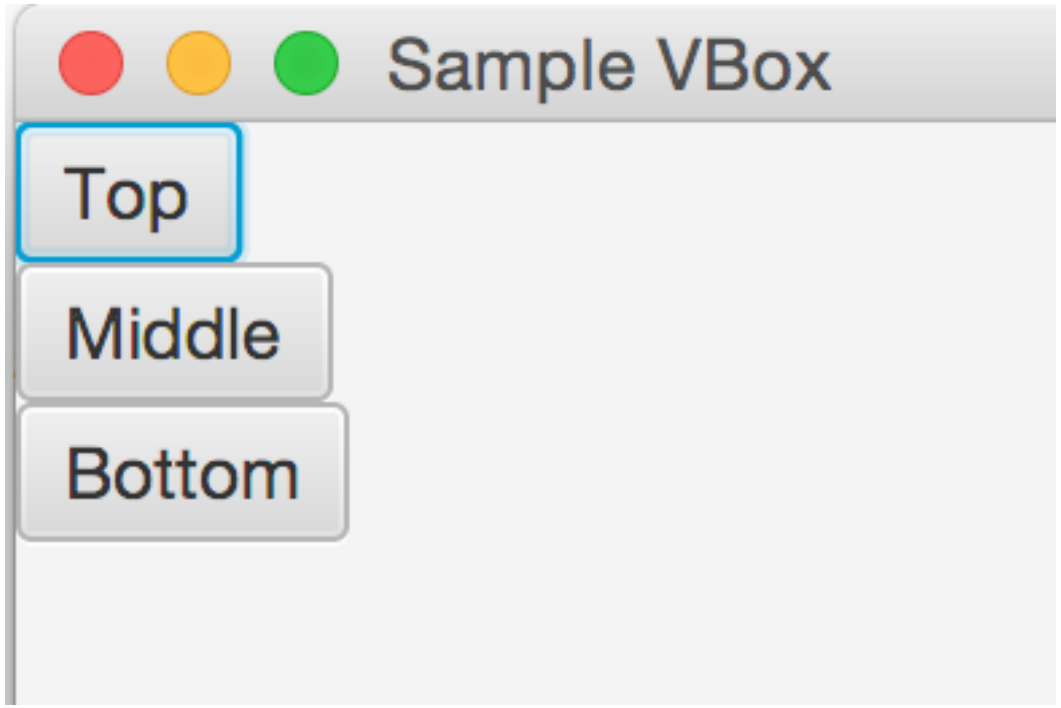
VBox layout pane (2/5)

- Can also set positioning of entire vertical column of children
- Default positioning for the vertical column is in `TOP_LEFT` of `VBox` (Top Vertically, Left Horizontally)
  - can change Vertical/Horizontal positioning of column using `VBox`'s `setAlignment(Pos position)` method, passing in a `javafx.geometry.Pos` constant — `javafx.geometry.Pos` is a class of enums, or fixed set of values, to describe vertical and horizontal positioning. Use these values just like a constants class that you would write yourself!
- `Pos` options are in the form `Pos.`<vertical position>_<horizontal position>
  - e.g. `Pos.BOTTOM_RIGHT` represents positioning on the bottom vertically, right horizontally
  - full list of `Pos` constants can be found here

Why `ALL_CAPS` *notation* ?
It is a "symbolic constant" with pre-defined meaning.

VBox layout pane (3/5)

- The following code produces the example on the right:




```
VBox root = new VBox();

Button b1 = new Button(“Top”);
Button b2 = new Button(“Middle”);
Button b3 = new Button(“Bottom”);
root.getChildren().addAll(b1,b2,b3);
```

width, height

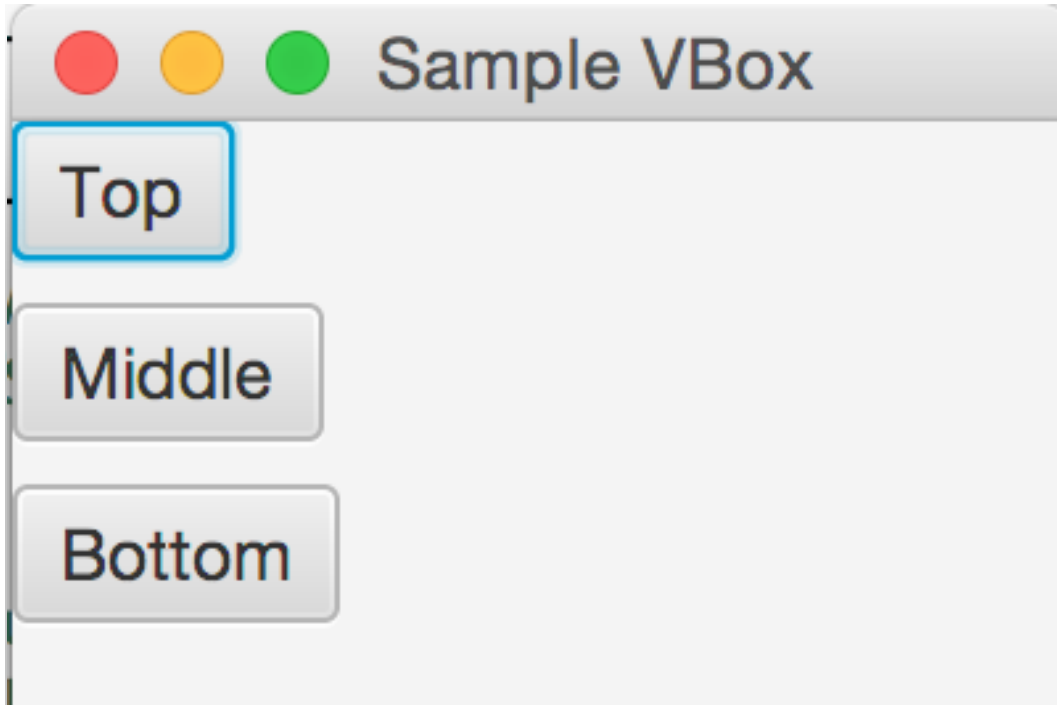
```
Scene scene = new Scene(root, 200, 200);
stage.setTitle("Sample VBox");
stage.setScene(scene);
stage.show();
```

Overloaded Scene constructor with three parameters

VBox layout pane (4/5)

- Adding spacing between children

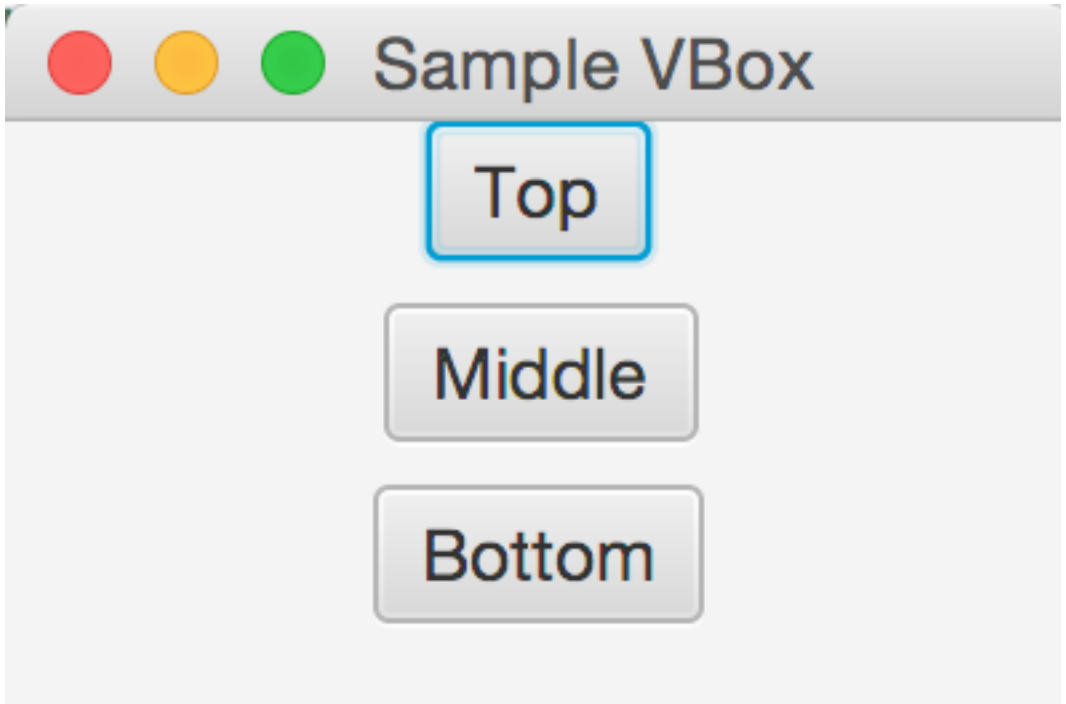
```
VBox root = new VBox();

Button b1 = new Button(“Top”);
Button b2 = new Button(“Middle”);
Button b3 = new Button(“Bottom”);
root.getChildren().addAll(b1,b2,b3);

root.setSpacing(8);

//code for setting the Scene elided
```



VBox layout pane (5/5)

- Setting alignment property to configure children in TOP (vertically) CENTER (horizontally) of the VBox

```
VBox root = new VBox();

Button b1 = new Button("Top");
Button b2 = new Button("Middle");
Button b3 = new Button("Bottom");
root.getChildren().addAll(b1,b2,b3);

root.setSpacing(8);
root.setAlignment(Pos.TOP_CENTER);

//code for setting the Scene elided
```



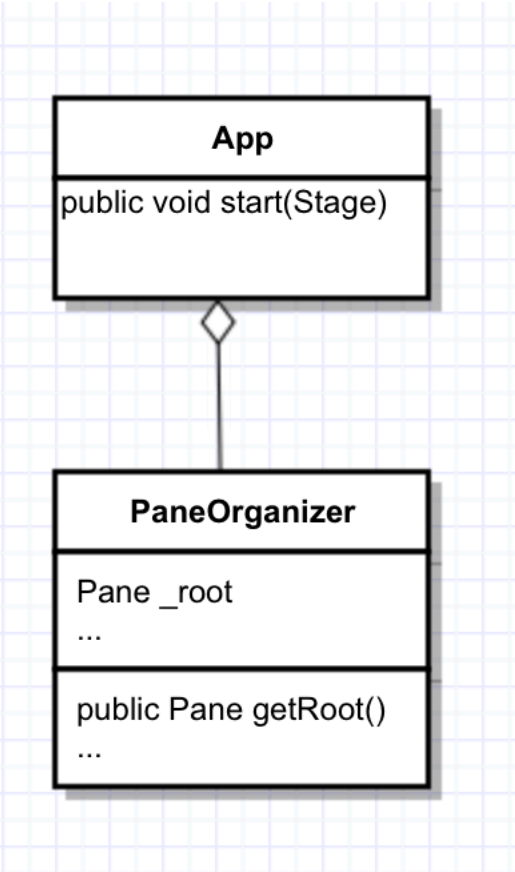
CS15 `PaneOrganizer` Class (1/2)

- Until now, all code dealing with the `Scene` has been inside `Application`'s `start` method; adding more nodes will clutter it up…
- In CS15, write a `PaneOrganizer` class where all graphical application logic will live – an example of "delegation" pattern
- Delegation removes application-dependent code from `App` class, which only creates scene and instantiates a `PaneOrganizer` – another example of "divide et impera"
- `PaneOrganizer` will instantiate root `Pane`, and provide a public `getRoot()` method that returns this root
  - `App` class can now access root `Pane` through `PaneOrganizer`'s public `getRoot()` method and pass root into `Scene` constructor
- We'll do this together soon!

CS15 `PaneOrganizer` Class (2/2)

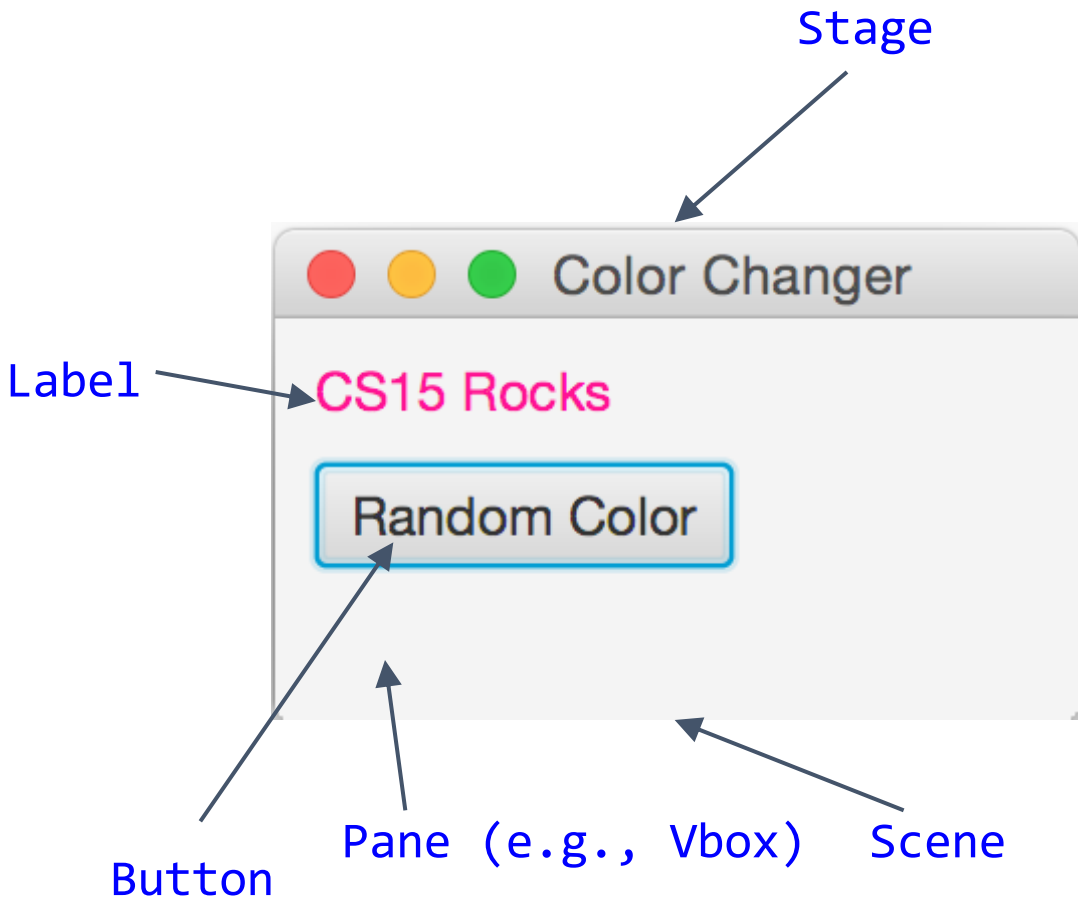
Pattern

1. `App` class instantiates a `PaneOrganizer`, which creates root
2. Then `App` class passes return value from `getRoot()` to `Scene` constructor, so `Scene` has a root
3. Top-level `PaneOrganizer` class instantiates JavaFX UI components (`Button`,`Label`,`Pane`…)
4. These UI components are then added to `root` `Pane` (and the `Scene`, indirectly) using `root.getChildren().add(...);` or `root.getChildren().addAll(...);`



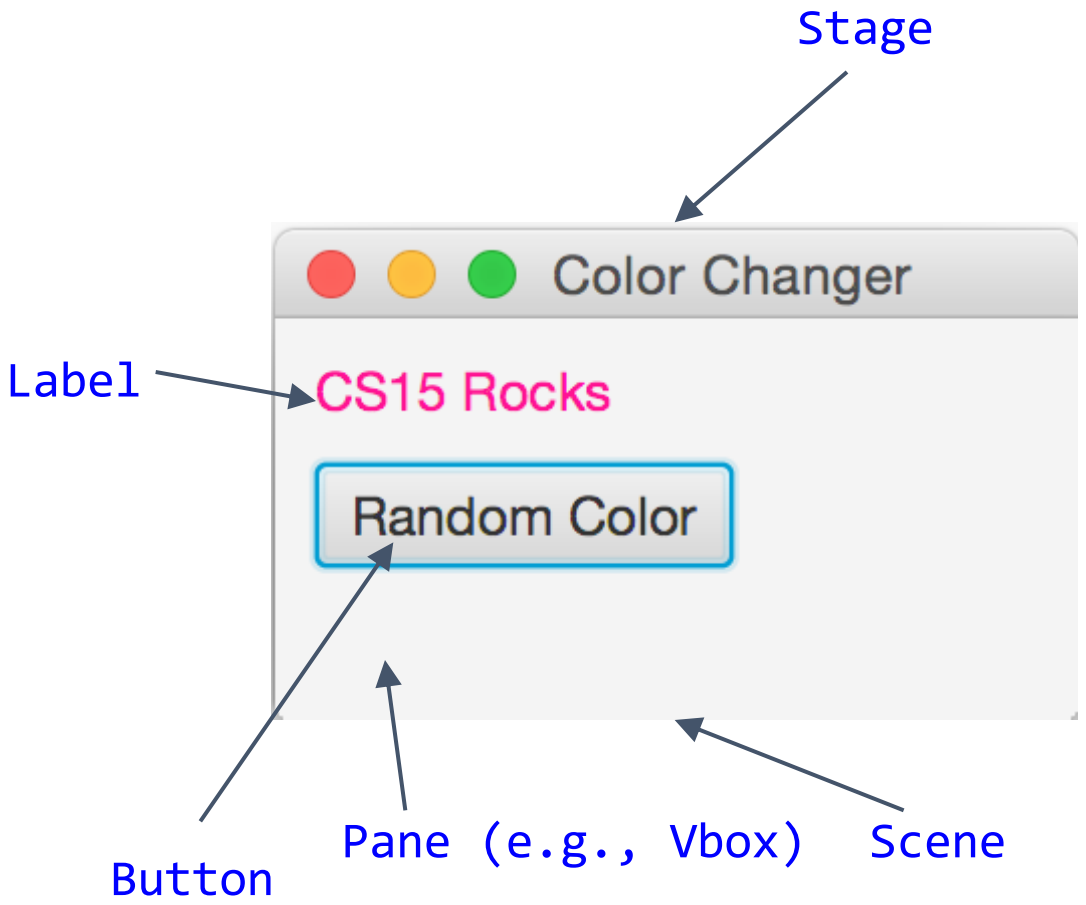
Our First JavaFX Application: `ColorChanger`

- Spec: App that contains text reading “CS15 Rocks!” and a `Button` that randomly changes text’s color with every click
- Useful classes: `Stage`, `Scene`, `VBox`, `Label`, `Button`, `EventHandler`



Process: ColorChanger

1. Create App class that extends javafx.application.Application and implements start (where you set Scene) – the standard pattern
2. Create PaneOrganizer class that instantiates root Pane and provides public getRoot() method to return the Pane. In PaneOrganizer, instantiate a Label and Button and add them as children of root Pane
3. Set up a custom EventHandler that changes Label's color each time Button is clicked, and register Button with this new ClickHandler



ColorChanger: App class (1/3)

1. **To implement `start`:**

A. Instantiate a `PaneOrganizer` and store it in the local variable `organizer`

```
public class App extends Application {

        @Override
        public void start(Stage stage) {
                PaneOrganizer organizer = new PaneOrganizer();
                /*write our PaneOrganizer class later,
                where we will instantiate the root Pane */




        }

}
```

ColorChanger: App class (2/3)

1. **To implement `start`:**

A. Instantiate a `PaneOrganizer` and store it in the local variable `organizer`

B. Instantiate a new `Scene`, passing in:

- root `Pane`, accessed through `organizer`'s public `getRoot()`
- along with desired width and height of `Scene`

```
public class App extends Application {

        @Override
        public void start(Stage stage) {
                PaneOrganizer organizer = new PaneOrganizer();
                /*write our PaneOrganizer class later,
                where we will instantiate the root Pane */
                Scene scene =
                    new Scene(organizer.getRoot(),80,80);
                                                    root   width height
        }

}
```

ColorChanger: App class (3/3)

1. **To implement `start`:**

A. Instantiate a `PaneOrganizer` and store it in the local variable `organizer`

B. Instantiate a new `Scene`, passing in:

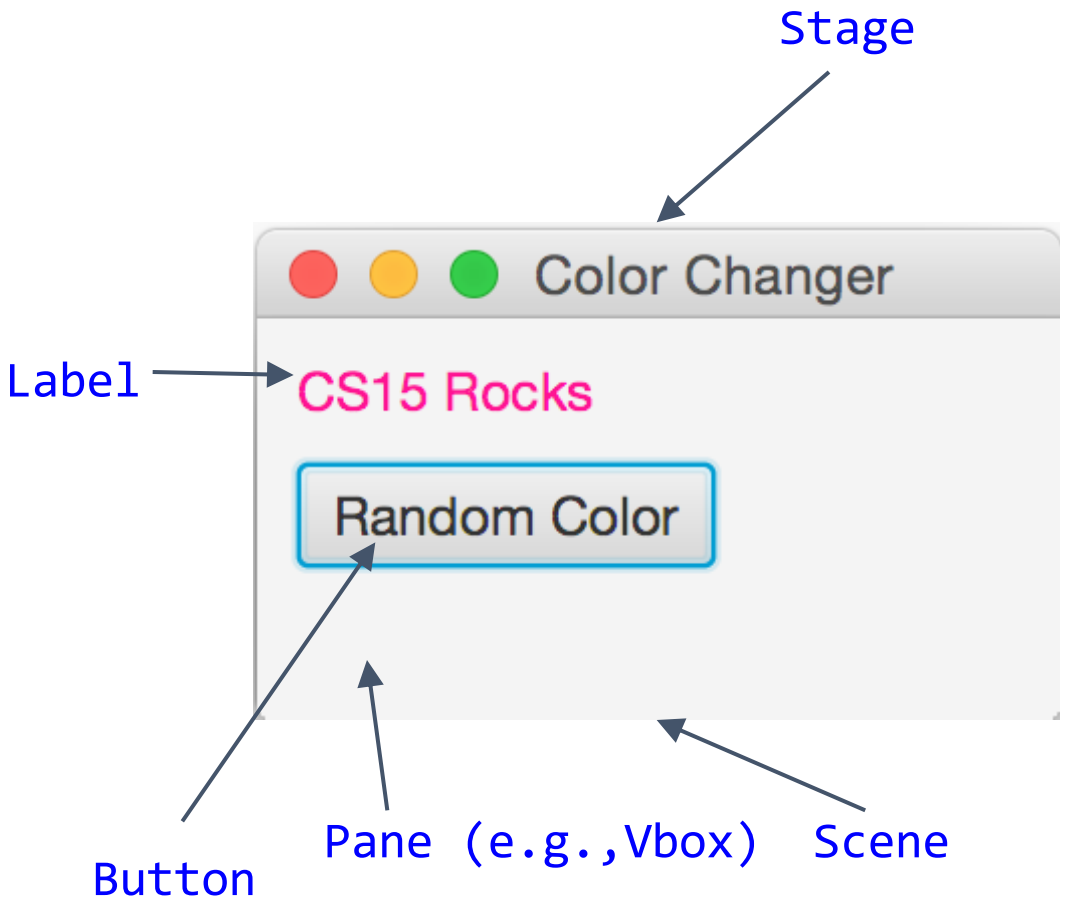
- the root `Pane`, which is accessed through `organizer` public `getRoot()` method
- along with desired width and height of `Scene`

C. Set the `Scene`, title the `Stage`, and show the `Stage`

```
public class App extends Application {

        @Override
        public void start(Stage stage) {
                PaneOrganizer organizer = new PaneOrganizer();
                /*write our PaneOrganizer class later,
                where we will instantiate the root Pane*/
                Scene scene =
                    new Scene(organizer.getRoot(),80,80);
                stage.setScene(scene);
                stage.setTitle("Color Changer!");
                stage.show();

        }

}
```

Process: ColorChanger

1. Create App class that extends javafx.application.Application and implements start (where you set Scene!)
2. Create PaneOrganizer class that instantiates root Pane and provides public getRoot() method to return the Pane. In PaneOrganizer, instantiate a Label and Button and add them as children of root Pane
3. Set up a custom EventHandler that changes Label's color each time Button is clicked, and register Button with this new ClickHandler



ColorChanger: Our PaneOrganizer Class (1/4)

2. To write PaneOrganizer class:

A. Instantiate root VBox and store it in instance variable _root

```
public class PaneOrganizer {
        private VBox _root;


        public PaneOrganizer() {
                _root = new VBox();




        }


}
```

ColorChanger: Our PaneOrganizer Class (2/4)

2. To write `PaneOrganizer` class:

A. Instantiate root `VBox` and store it in instance variable `_root`

B. Create a public `getRoot()` method that returns `_root`

- reminder: this makes root `Pane` accessible from within `App`'s `start` for `new Scene(root)`

```
public class PaneOrganizer {
        private VBox _root;


        public PaneOrganizer() {
                _root = new VBox();









        }

        public VBox getRoot() {
                return _root;
        }

}
```

ColorChanger: Our PaneOrganizer Class (3/4)

2. To write PaneOrganizer class:

C. Instantiate Label and Button, passing in String representations of text we want displayed

- _label is an instance variable because need to access it elsewhere in P.O. to change its color
- btn is a local variable because only need to access it from within constructor

```
public class PaneOrganizer {
        private VBox _root;
        private Label _label;

        public PaneOrganizer() {
                _root = new VBox();
                _label = new Label("CS15 Rocks!");
                Button btn = new Button("Random
                    Color");


        }

        public VBox getRoot() {
                return _root;
        }

}
```

ColorChanger: Our PaneOrganizer Class (4/4)

2. To write PaneOrganizer class:

C. Instantiate Label and Button, passing in String representations of text we want displayed

- _label is an instance variable because need to access it elsewhere in P.O. to change its color
- btn is a local variable because only need to access it from within constructor

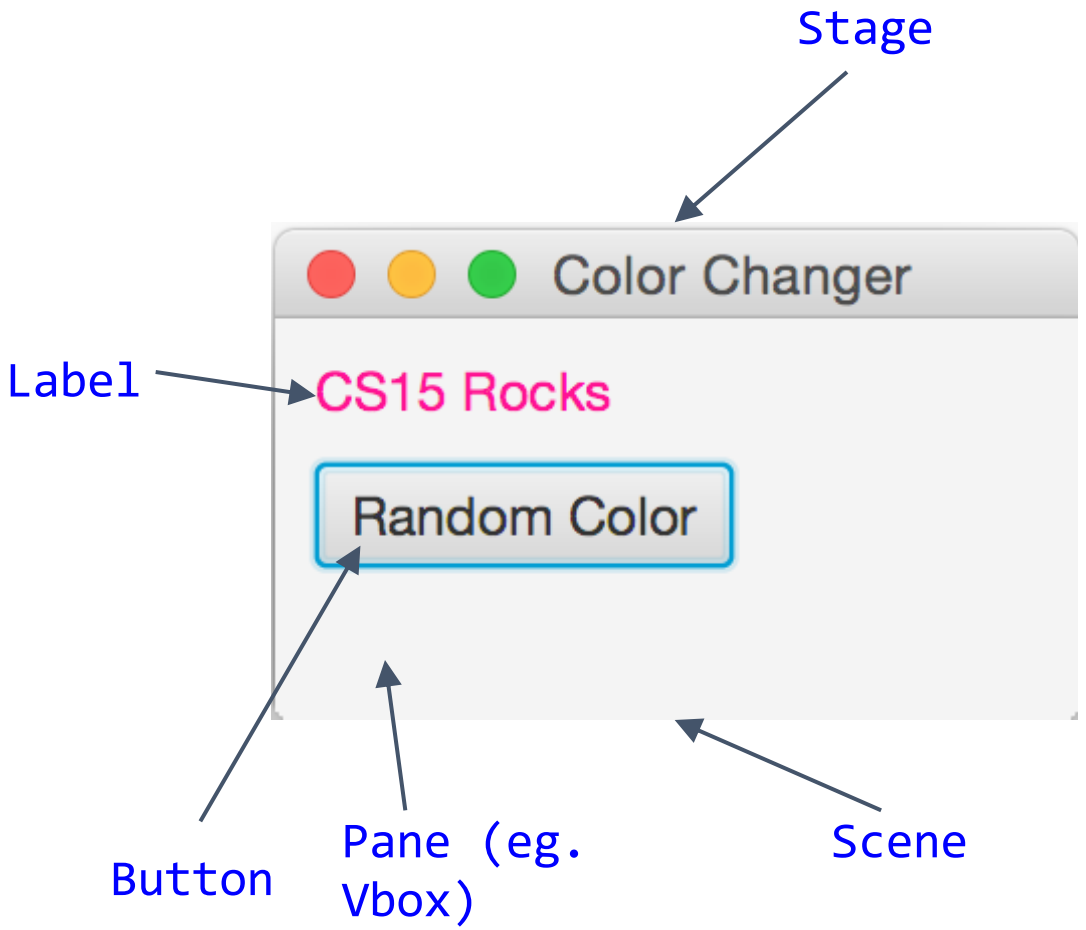
D. Add Label and Button as children of root

- root.setSpacing(8) is optional but creates a nice vertical distance between Label and Button

```
public class PaneOrganizer {
        private VBox _root;
        private Label _label;

        public PaneOrganizer() {
                _root = new VBox();
                _label = new Label("CS15 Rocks!");
                Button btn = new Button("Random
                    Color");
                _root.getChildren().addAll(
                    _label,btn);
                _root.setSpacing(8);
        }

        public VBox getRoot() {
                return _root;
        }

}
```

Process: ColorChanger

1. Create App class that extends javafx.application.Application and implements start (where you set Scene!)
2. Create PaneOrganizer class that instantiates root Pane and provides public getRoot() method to return the Pane. In PaneOrganizer, instantiate a Label and Button and add them as children of root Pane
3. Set up a custom EventHandler that changes Label's color each time Button is clicked, and register Button with this new ClickHandler



Responding to User Input

- Need a way to respond to stimulus of `Button` being clicked
- We refer to this as **Event Handling**
  - a source (`Node`), such as a `Button`, generates an `Event` (such as a mouse click) and notifies all registered `EventHandler` objects
  - `EventHandler` is an interface, so all classes that implement `EventHandler` must implement `handle(Event event)` method, which defines response to event
  - note that `handle(Event event)` is called by JavaFX, not the programmer

EventHandlers (1/3)

- Button click causes JavaFX to generate a javafx.event.ActionEvent
  - ActionEvent is only one of many JavaFX EventTypes that are subclasses of Event class
- Classes that implement EventHandler interface can polymorphically handle any subclass of Event
  - when a class implements EventHandler interface, it must specify what type of Event it should know how to handle
  - how do we do this?
- EventHandler interface declared as: public interface EventHandler<T extends Event>…
  - the code inside literal < > is known as a "generic parameter" – this is magic for now
  - lets you specialize the interface to deal in all its methods only with a specialized subclass of Event
  - forces *you* to replace what is inside the literal < > with some subclass of Event, such as ActionEvent, whenever *you* write a class that implements EventHandler interface (next slide)

EventHandlers (2/3)

- We can create an `EventHandler` and call it `ClickHandler`
- This `EventHandler` will handle an `ActionEvent`, meaning that `ClickHandler` will implement the "`EventHandler<ActionEvent>`" interface
  - literally, "< >" included!!

```
public class ClickHandler implements EventHandler<ActionEvent> {

}
```

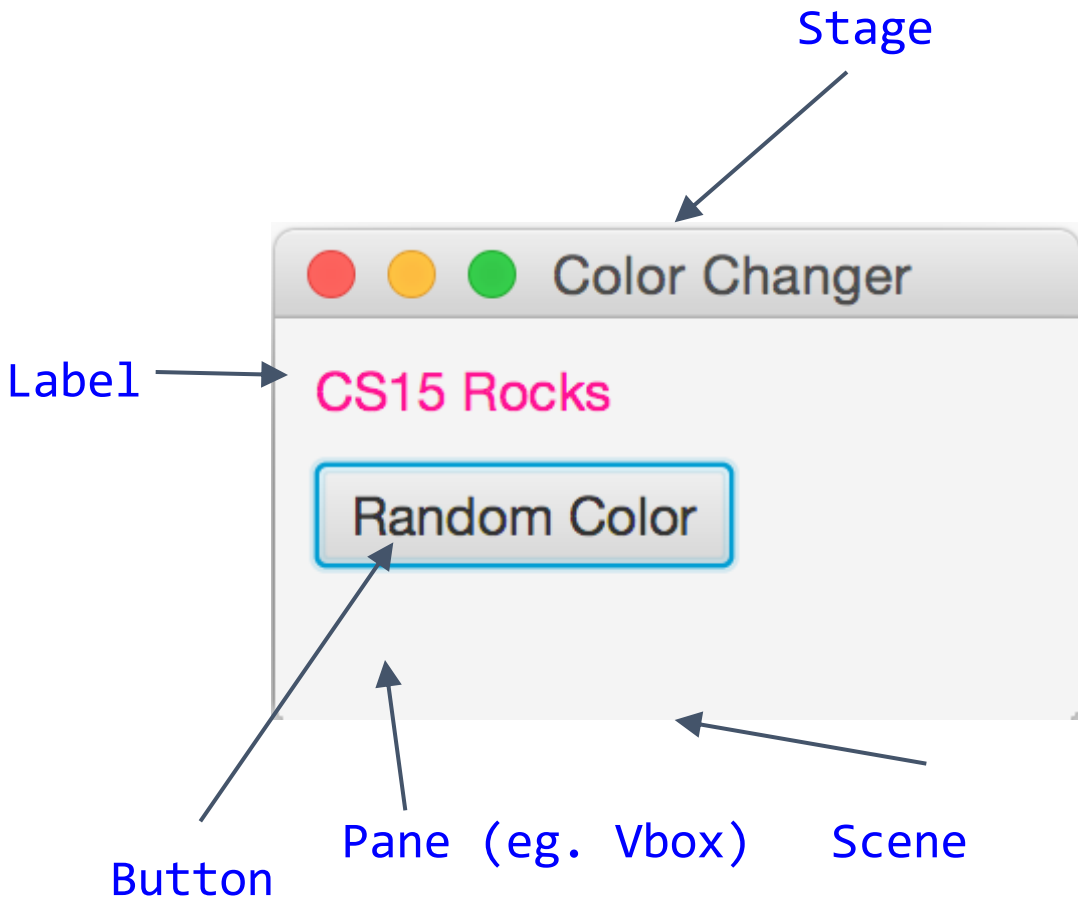
EventHandlers (3/3)

- Our `ClickHandler` must implement the `handle(ActionEvent e)` method of the `EventHandler` interface, which will specify the response to the `ActionEvent` (in this case, a click)
  - for now, you most likely won't need to use the parameter `e`
- To tell this new `ClickHandler` to *listen* for the `Button`'s `ActionEvent`, ***register*** `Button` with the `ClickHandler` by calling `btn.setOnAction`, passing in an instance of our `ClickHandler` class
  - the mechanics of handing off the event to the handler happen under hood of JavaFX

```
public class ClickHandler implements EventHandler<ActionEvent> {
        public ClickHandler() { //code elided }

        @Override
        public void handle(ActionEvent e) {
                //code to change _myLabel Label
        }
}
-------------------------------------------------------------------------
//elsewhere in program
public class PaneOrganizer {
        //instance variable declarations elided
        public PaneOrganizer() {
                _root = new VBox();
                _label = new Label("CS15 Rocks!");
                Button btn = new Button("Random Color");
                _root.getChildren().addAll(_label,btn);
                _root.setSpacing(8);
                btn.setOnAction(new ClickHandler());
        }
        //code to return root elided
}
```

Back to Process: `ColorChanger`

1. Create `App` class that extends `javafx.application.Application` and implements `start` (where you set `Scene`!)
2. Create `PaneOrganizer` class that instantiates root `Pane` and provides public `getRoot()` method to return the `Pane`. In `PaneOrganizer`, instantiate a `Label` and `Button` and add them as children of root `Pane`
3. Define a custom `EventHandler` that changes `Label`'s color each time `Button` is clicked, and register `Button` with this new `ClickHandler`



ColorChanger: ClickHandler class

3. Defining our custom EventHandler, ClickHandler:

- ClickHandler must listen for click event and respond to it by changing the color of "CS15 Rocks!" Label
- How will ClickHandler access Label?
  - multiple ways to do this: could have ClickHandler constructor take in a Label as a parameter
  - **this works, but is there a better way?**

```
public class ClickHandler implements EventHandler<ActionEvent> {
        private Label _myLabel;
        public ClickHandler(Label label) {
                _myLabel = label;
        }
        @Override
        public void handle(ActionEvent e) {
                //code to change _myLabel Label
        }
}
```

Aside: Private Inner Classes (1/2)

- Until now, all classes we have created have been public
  - live in their own file
  - can be accessed from within any class
- Introducing private inner classes!
  - useful when there is a class, such as an `EventHandler`, for which you only need to create a single instance, from within a single class
  - **private inner classes have access to instance variables/methods of the class that contains them (that declared them)**
  - **inner classes are a convenient and safe shortcut -- don't require a file**

Aside: Private Inner Classes (2/2)

- Rather than making the `ClickHandler` class a public class in its own file, we can make it a private inner class of the `PaneOrganizer` class
- Our `ClickHandler` will then have access to `PaneOrganizer`'s **`_label`** instance variable
- Can then set **`_label`**'s text color from within `ClickHandler`'s `handle(ActionEvent)` method, without needing to deal with any unnecessary passing around of references to `Label`

ColorChanger: ClickHandler Private Inner Class (1/2)

3. Defining our custom EventHandler, ClickHandler:

- In order to make ClickHandler a private inner class of PaneOrganizer class, we simply declare ClickHandler as a private class and place it within braces of public PaneOrganizer class

```
public class PaneOrganizer {
        private VBox _root;
        private Label _label;

        public PaneOrganizer() {
                _root = new VBox();
                _label = new Label("CS15 Rocks!");
                Button btn = new Button("Random Color");
                _root.getChildren().addAll(_label,btn);
                _root.setSpacing(8);
        }

        public VBox getRoot() {
                return _root;
        }

        private class ClickHandler implements EventHandler<ActionEvent> {




        }
}
```

ColorChanger: ClickHandler Private Inner Class (2/2)

3. Defining our custom EventHandler, ClickHandler:

- Now must implement handle method
- How will ClickHandler generate a random color whenever btn's ActionEvent is detected?

```
public class PaneOrganizer {
        private VBox _root;
        private Label _label;

        public PaneOrganizer() {
                _root = new VBox();
                _label = new Label("CS15 Rocks!");
                Button btn = new Button("Random Color");
                _root.getChildren().addAll(_label,btn);
                _root.setSpacing(8);
        }

        public VBox getRoot() {
                return _root;
        }

        private class ClickHandler implements EventHandler<ActionEvent> {
                public ClickHandler() { //code and annotations elided}
                        public void handle(ActionEvent event) {
                                //implementation elided for now
                        }
                }
}
```

Generating `javafx.scene.paint.Colors`

- We can generate most colors of visible color spectrum by additive mixtures of Red, Green and Blue "primaries" generated by display hardware
  - each display pixel has a R,G, and B sub-pixels to do this color mixing

- `javafx.scene.paint.Color` has static method `rgb(int red, int green, int blue)` that returns a custom color according to specific passed-in Red, Green, and Blue integer values in [0-255]
  - ex: `Color.WHITE` can be expressed as `Color.rgb(255,255,255)`

ColorChanger: Our EventHandler, ClickHandler

3. Defining our custom `EventHandler`, `ClickHandler`:

- `Math.random()` returns a random `double` between 0 inclusive and 1 exclusive
- Multiplying this value by 256 turns [0, 1) `double` into a [0, 255) `double`, which we cast to a [0,255] `int` by using `(int)` cast operator
- Use these `int`s as Red, Green, and Blue RGB values for a custom `javafx.scene.paint.Color`
- Call `setTextFill` on `_label`, passing in new random `Color` we've created

```
private class ClickHandler implements EventHandler<ActionEvent> {
        public ClickHandler() {
                //code elided
        }
        @Override
        public void handle(ActionEvent event) {
                int red = (int) (Math.random()*256);
                int green = (int) (Math.random()*256);
                int blue = (int) (Math.random()*256);
                Color customColor = Color.rgb(red,green,blue);
                _label.setTextFill(customColor);
        }
}
```

ColorChanger: Back to our PaneOrganizer Class

3. Defining our custom EventHandler, ClickHandler:

- Last step is to *register* the Button with the click Event
- To do so, call setOnAction on btn, passing in an instance of our ClickHandler (Did this on S49)

```
public class PaneOrganizer {
    private VBox _root;
    private Label _label;

    public PaneOrganizer() {
            _root = new VBox();
            _label = new Label("CS15 Rocks!");
            Button btn = new Button("Random Color");
            _root.getChildren().addAll(_label,btn);
            _root.setSpacing(8);
            btn.setOnAction(new ClickHandler());
    }

    public VBox getRoot() {
            return _root;
    }

    private class ClickHandler implements EventHandler<ActionEvent> {
            // code on previous slide
    }

}
```

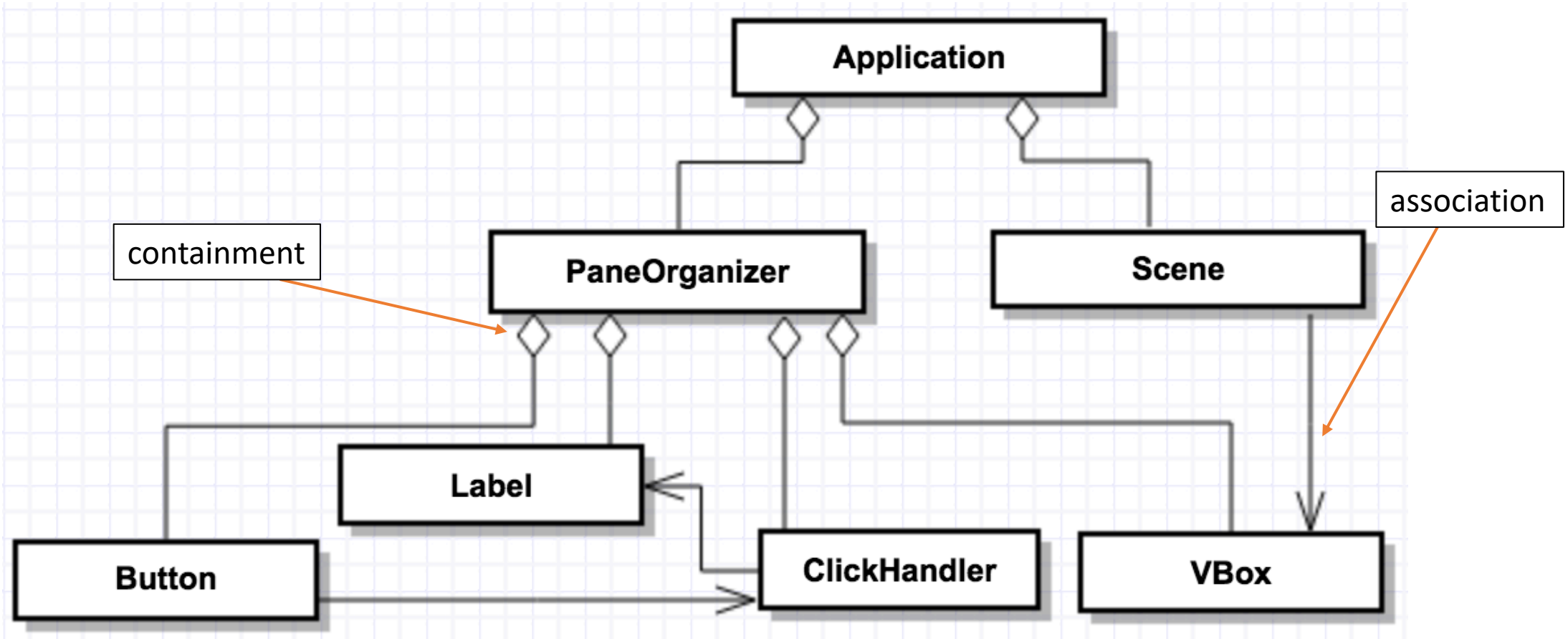
The Whole App: ColorChanger

```
//App class imports
import javafx.stage.Stage;
import javafx.scene.Scene;
import javafx.application.*;
// package includes Pane class and its subclasses
import javafx.scene.layout.*;
//package includes Label, Button classes
import javafx.scene.control.*;
//package includes ActionEvent, EventHandler classes
import javafx.event.*;
import javafx.scene.paint.Color;
```

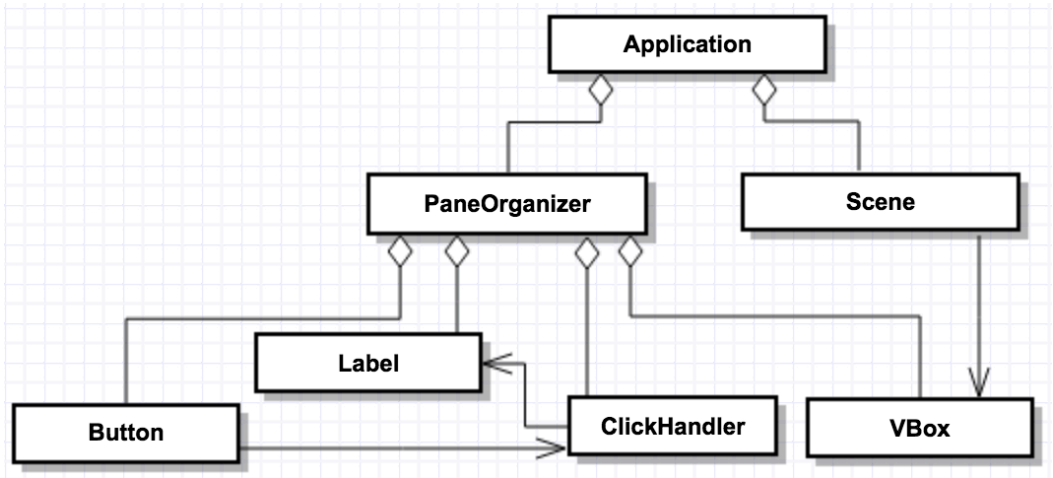
```
public class App extends Application {

    @Override
    public void start(Stage stage) {
        PaneOrganizer organizer = new PaneOrganizer();
        Scene scene = new Scene(organizer.getRoot(),80,80);
        stage.setScene(scene);
        stage.setTitle("Color Changer");
        stage.show();
    }

}
```

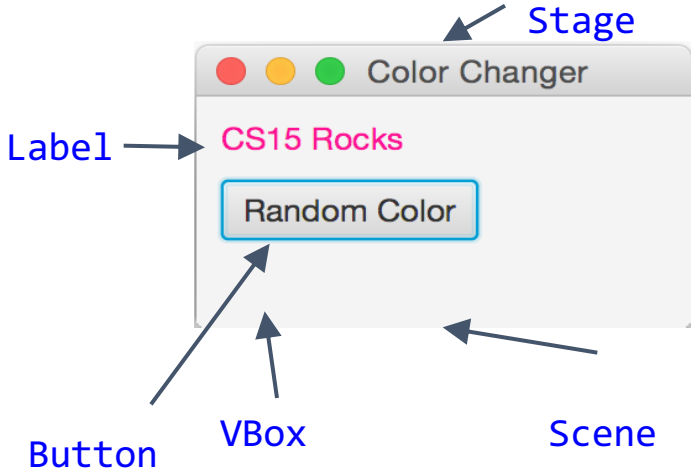
```
public class PaneOrganizer {
        private VBox _root;
        private Label _label;

        public PaneOrganizer() {
                _root = new VBox();
                _label = new Label("CS15 Rocks!");
                Button btn = new Button("Random Color");
                _root.getChildren().addAll(_label,btn);
                _root.setSpacing(8);
                btn.setOnAction(new ClickHandler());
        }

        public VBox getRoot() {
                return _root;
        }

        private class ClickHandler
        implements EventHandler<ActionEvent> {
                //constructor elided
                @Override
                public void handle(ActionEvent event) {
                        int red = (int) (Math.random()*256);
                        int green = (int) (Math.random()*256);
                        int blue = (int) (Math.random()*256);
                        Color customColor =
                        Color.rgb(red,green,blue);
                        _label.setTextFill(customColor);
                                                }
        }
}
```

Putting It All Together



Logical vs. Graphical Containment/Scene Graph





- *Graphically*, `VBox` is a `pane` contained within `Scene`, but *logically*, `VBox` is contained within `PaneOrganizer`
- *Graphically*, `Button` and `Label` are contained within `VBox`, but *logically*, `Button` and `Label` are contained within `PaneOrganizer`, which has no graphical appearance
- *Logical* containment is based on where objects are instantiated, while *graphical* containment is based on JavaFX elements being added to other JavaFX elements via `getChildren.add(…)` method, and the resulting scene graph

Announcements

- FruitNinja deadlines:
  - Early: Friday, 10/4 at 11:59pm
  - On-time: Sunday, 10/6 at 11:59pm
  - Late: Tuesday, 10/8 at 11:59pm
- Sections will be a Design Discussion this week!
- Please spend some time reviewing these slides on your own to make sure you fully understand them
  - JavaFX is a dense topic that will be essential to all future assignments
  - There is a JavaFX guide on the website!
    - All material will be covered by Graphics III