CS209

Computer system design and application

Stéphane Faroult
faroult@sustc.edu.cn

Zhao Yao zhaoy6@sustc.edu.cn

```
class OuterClass {

    ...
    class NestedClass {
        ...
    }
}

class OuterClass {

    ...
    public void doSomething() {
        class LocalClass {
            ...
        }
    }
}
```

I introduced the topic of lambda expressions last time by remarking that you can have nested classes (inside another class) and local classes inside a method) in Java.

Grouping

Encapsulation

Not really needed elsewhere

You do this for code clarity, but it also means that the objects are kind of "technical objects" that aren't expected to be used anywhere else. You won't have any reference to them elsewhere.

Anonymous Classes

```
class NamedClass implements Interface {
    ...
}

Interface anObject = new NamedClass(...);
```

You often have the same idea of "not needed elsewhere" with function, that require an interface (for instance to compare objects) the caller doesn't really need. Of course, the caller can define everything and create an object ...

别处不需要使用的方法

Anonymous Classes

```
Interface anObject = new Interface() {
                    // attribute and method definitions
                   };
```

Very convenient for parameters

... but the Java syntax allow creating an interface on the fly, and you can directly instantiate an object in the list of parameters passed to a function.

Anonymous Classes

```
class NamedClass extends ParentClass {
   ...
}

NamedClass anObject = new NamedClass(...);


ParentClass anObject = new ParentClass() {
                    // attribute and method definitions
                   };
```

The same can be done with inheritance.

Many examples of this in graphical interfaces (coming soon ...)

```
Button btn = new Button();
btn.setText("Say 'Hi'");
btn.setOnAction(new
            EventHandler<ActionEvent>() {

         @Override
         public void handle(ActionEvent e) {
            System.out.println("Hi!");
         }
   });
```

Single Method

Can be simpler

Now, very often interfaces require a single method!

From Java 8: Lambda expressions

Functional Programming

Programming only with functions, no state stored

In the very common case where your interface requires a single method, you can use lambda expressions. Lambda expressions come from functional programming, where you try not to store any state (which is completely opposed to attributes that store the state of an object ...)

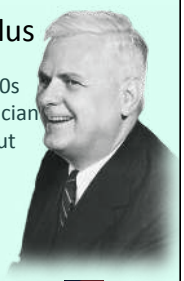
Comes from lambda calculus

Lambda λ (Λ) Greek L – lowercase (uppercase)

"Lambda Calculus" comes from the name of the Greek letter lambda, which is the same as L in the Latin alphabet. Greek letters are much used in mathematics (and from there in physics), and you won't be surprised to learn that lambda calculus comes straight from mathematics.

Comes from lambda calculus

Lambda calculus was developed in the 1930s by Alonzo Church, an American mathematician not as well known (so far) as Alan Turing but with similar concerns.



Alonzo Church
(1903 –1995)

Invented in the 1930s by Alonzo Church a pioneer with Alan Turing of theoretical computing.

What Church was after was a simple notation for mathematical functions, mostly to ease proofs of results (don't underestimate notation, a lot of mathematical progresses came from better notation).

Comes from lambda calculus

Simple notation for functions and applications.

$$\lambda x.(4x^3 + 2x + 1)$$

function expression (often called M)

Church came out with this, and here is lambda.

"binding" of x (means that x is the variable)

Comes from lambda calculus

Simple notation for functions and applications.

$$\lambda x.(4x^3 + 2x + 1)$$

$$((\lambda x.\mathrm{M})\ \mathrm{E}) \ \text{->}\ (\mathrm{M}[x{:=}\mathrm{E}])$$

This is how giving value E to x is written. Notice the arrow.

β reduction

Simpler way of writing expressions

You are probably unimpressed by lambda expressions. Once again, it's just notation. However, notation often opens whole new vistas. Think of the "0" notation. Envisioning nothing as a computable quantity (first done by Indian mathematicians about 1,500 years ago) opened the door first to equations and then to a lot of mathematical feats. "Cartesian coordinates" linked algebra to geometry. In the case of lambda notation applied to Java programming, it seriously makes programs easier to read – which means fewer bugs.

Lambda expression in Java

Lambda expressions only work with functional interfaces.

Functional interface: only one abstract method

@FunctionalInterface

Method written without its name as

(parameter list) -> {method body}

Data types optional

If there is only one method to redefine, its name no longer needs to be given.

BENEFIT?

Easily passing a function as parameter

Much less code

Easier to read

As said earlier, using lambda expressions make the code far more readable.

```
Button btn = new Button();
btn.setText("Say 'Hi'");
btn.setOnAction(new
          EventHandler<ActionEvent>() {

        @Override
        public void handle(ActionEvent e) {
           System.out.println("Hi!");
        }
   });
```

Anonymous class

We have seen this expression with an anonymous class.

```
Button btn = new Button();
btn.setText("Say 'Hi'");
btn.setOnAction((e)->{
            System.out.println("Hi!");
        });
```

Much shorter!

As "handle()" is the only method of an event handler, it can also be written like this.

Other common usages

Collections

Lambda expressions are also commonly used for searching data in Collections, as seen in the following example.

```
class Film {
     private String    title;
     private String    countries;
     private int       year;
     private float     billionRMB;

     // Constructor
     public Film(String title, String countries,
                 int year, float billionRMB) {...}
     // Getters
     ...
     // toString()
     ...
}
```

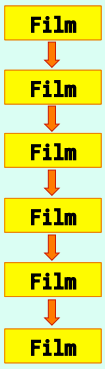
Suppose that a Film class stores box-office information.

```
ArrayList<Film> films = new ArrayList<Film>();
```

Populate the list from a file

Retrieve information using different conditions

We can build a collection read from a file, and then the problem is how to search this collection. We can search on many different criteria – film title, year of release, country, how much it made so far.



Walk the list

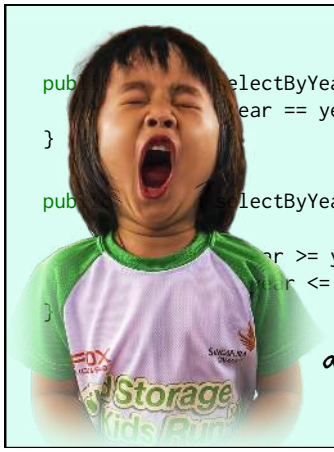
Test each element against a condition

In all cases the process will be the same one – only the condition will change.

Add methods to Film

```
public boolean selectByTitle(String str) {
    return this.title.contains(str);
}

public boolean selectByCountry(String cntry) {
    return this.countries.contains(cntry);
}
```

One option is to add a boolean method that tests every possible condition.



```
pub  electByYear(int year) {
     ear == year;
}

pub  electByYear(int year1,
                 int year2) {
     r >= year1)
     r <= year2);
}
```

and so forth

Very boring code.

Use Anonymous Objects

```
interface SelectFilm { boolean test(Film film);}

static void showFilms(SelectFilm tester) {
   for (Film f: films) {
     if (tester.test(f)) {
       System.out.println(f);
     }
   }
}
```

A second solution is to define an interface that implements a "test" boolean method.

2 Use Anonymous Objects

```
showFilms(new SelectFilm() {
            public boolean test(Film f) {
                return f.getYear() == 2014;
            }
        });
```

Anonymous objects allow to define on the fly a suitable test() method that tests for the condition we want.

3 Use Lambda Expressions

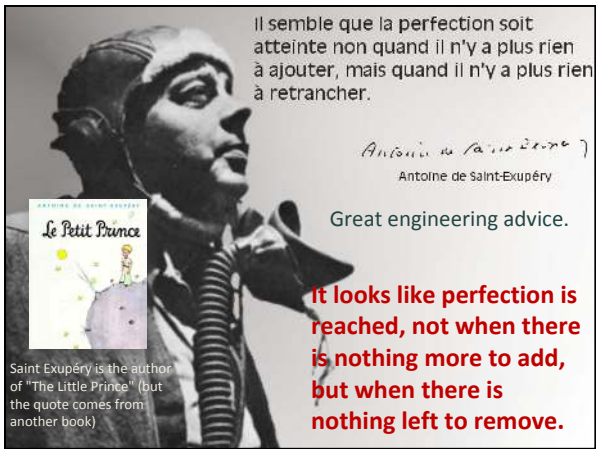
```
showFilms((f)-> {return f.getYear() == 2014;});
```

As the preceding interface only defines a single method, it can be called as a lambda expression. As showFilms takes a SelectFilm parameter that only implements a test() method which takes a Film parameter, there is no ambiguity.

3 Use Lambda Expressions

```
showFilms((f)-> f.getYear() == 2014);
```

In fact, the expression can be further simplified when the returned value can be directly computed, as is the case here.



Great engineering advice.

It looks like perfection is reached, not when there is nothing more to add, but when there is nothing left to remove.

Lambda Expressions - Variant

Built-in Functional Interfaces

Testing elements in collections is so frequent in practice that there is a built-in functional interface for that.

```
import java.util.function.Predicate;

Predicate<Film> pred
```

method is called "test"

Here is an example of how you can use a Predicate.

Lambda Expressions - Variant

Built-in Functional Interfaces

```
static void filter(Predicate<Film> pred) {
      Film f;
      ListIterator<Film> iter = films.listIterator();
      while (iter.hasNext()) {
         f = iter.next();
         if (pred.test(f)) {
           System.out.println(f);
         }
      }
filter((film)->film.getYear() == 2014);
```

There are a few functional interfaces available. Supplier/Consumer are related to multithreading, which we'll see later.

Lambda Expressions - Variant

Built-in Functional Interfaces

Predicate<T>	T	⟹	boolean
Supplier<R>	void	⟹	R
Consumer<T>	T	⟹	void
Function<T,R>	T	⟹	R
UnaryOperator<T>	T	⟹	T

Streams

And after annotations, reflection and lambda expressions, the fourth interesting new Java feature is called "Streams".

NOT to be confused with files

Beware that in spite of the name, it's unrelated to files. It's about chaining processing.

~~InputStream~~

~~OutputStream~~

The Idea

When you apply to a string a method that returns a string, you can apply a new method to the result.

```
String str = "now let's have some fun";

"now let's have some fun"  str
"NOW LET'S HAVE SOME FUN"  .toUpperCase()
"NOW LET'D HAVE DOME FUN"  .replace('S','D')
                "DOME"     .substring(15,19)
                "DONE"     .replace('M','N')
```

And so forth until you get the result you want.

There is in functional programming a specific term to describe this kind of process.

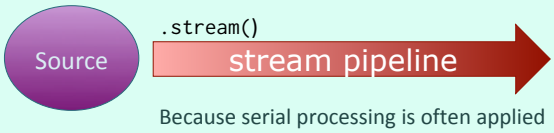
Because we use functions that return strings, we can chain them.

MONAD

structure that represents computations defined as sequences of steps.

Stream

Same idea applied to collections



array
collection
generator function
I/O channel

Because serial processing is often applied to collections of data, the idea is to do something similar in Java – which will look as nothing new to someone who knows SQL, based on similar ideas.

Intermediate operations return a stream

filter
distinct
sorted
map

Terminal operations

foreach
toArray
reduce
count
min, max

With stream operations you have methods that return a stream (which can be fed into something else), and those that don't and terminate the streaming process.

Lambda Expressions - Variant

Built-in Functional Interfaces

```
static void filter(Predicate<Film> pred) {
        Film f;
        ListIterator<Film> iter = films.listIterator();
        while (iter.hasNext()) {
            f = iter.next();
            if (pred.test(f)) {
              System.out.println(f);
            }
        }
```

If you remember the preceding filtering of films ...

ArrayList<Film>

`films.stream()`

... we can take the collection and turn it into a stream

```
films.stream()
     .filter((film)->film.getYear() == 2014)
```

In that case the filter will be applied to one element at a time.

```
films.stream()
     .filter((film)->film.getYear() == 2014)
     .forEach(System.out::println);
```

We can display any film that "gets through" with a forEach() call (a terminal operation) that applies println() to it. Note the special, unusual notation that specifies the method applied to each element.

You can insert other intermediate operations before the terminal one, for instance sort the output, if of course Java knows how to sort Film objects. Note that it's FAR more efficient to sort AFTER filtering rather than BEFORE filtering, even if both are possible ...

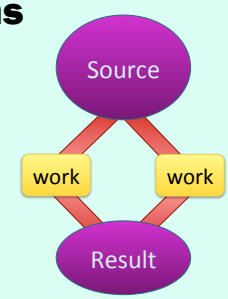
```
films.stream()
     .filter((film)->film.getYear() == 2014)
     .sorted()
     .forEach(System.out::println);
```

must have a compareTo() method (implements Comparable<T>)

You can also provide a Comparator

Parallel streams

```
.parallelStream()
```



Like big rivers that reach the sea with a delta, streams can be split into multiple parallel streams but we'll talk about parallelism later. "Data Science" and "Big Data" are full of this.

Graphical User Interfaces

An interesting topic is the one of graphical user interfaces (GUI, pronounced Gooey). The programs that you usually write in labs are far uglier than the programs that you use every day: they run in consoles, read from the keyboard, just display text ... So 1970s. Having a nice interface requires quite a lot of coding, but what is interesting is that the logic is very different from the procedural logic you have seen so far (and this logic is the same one with all programming languages and graphical interfaces)

Tons of graphical packages

First of all you don't code everything by yourself, but use functions from packages that you must import when writing your program.

Low level graphics

High level graphics

You have low-level packages with functions (called "primitives") for performing tasks such as drawing a rectangle, a line or a curve.

You also have high-level packages that use the previous ones to draw for instance buttons, and automatically change them when they are clicked — this is what we'll talk about.

Historically several packages in Java

1995 **AWT** (Abstract Window Toolkit)

Looks like other applications on the system

Dec 1996 **Java Foundation Classes** Swing

Looks the same on all systems

In Java, several packages allow you to code a GUI. The first one was AWT, followed by "Java Foundation Classes" quicky renamed "Swing".

Historically several packages in Java

```
import java.awt.*;
import javax.swing.*;
import javax.imageio.*;
```

Swing relies on AWT, and whenever you code a Swing application you also need to import classes from AWT, as well as from other packages for images.

Historically several packages in Java

A new package, JavaFX, was introduced in 2008.

2008 **JavaFX** `import javafx.*;`

2007

1990s, early 2000s

Officially adopted by many Smartphones

JavaFX, with which you import classes from a single package (but many subpackages) supports other devices than computer screens for which AWT and Swing were written — mobile phones in particular. It also allows to define the looks of applications in external files called "style sheets" or "CSS" files (CSS means "Cascading Style Sheet" — 'cascade' is French for 'Waterfall'), a technique borrowed from web programming. However, because software has a long life, there is a lot of Swing around, Swing is still much in use and will probably stay around for quite a while. It's good to know both Swing and JavaFX (they aren't VERY different, class names change, basic ideas are the same).

Historically several packages in Java

2008 **JavaFX** `import javafx.*;`

	Model	Data Management	
Application	**View**	User Interface	Visual Elements Looks
	Controller	Logic	

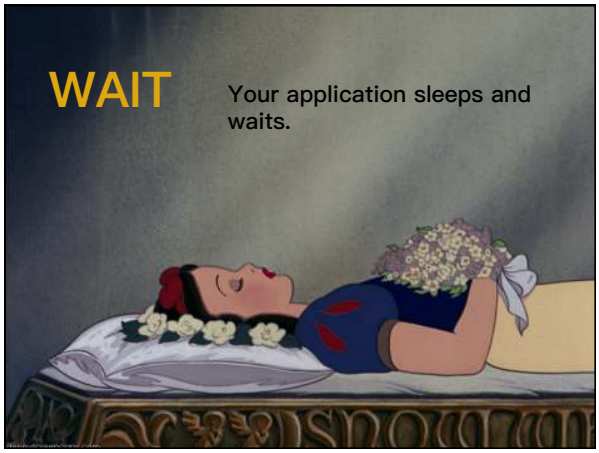
JavaFx applications often follow a popular structure known as "Model/View/Controller" (or MVC) in which data management, user interface and logic are clearly separated.

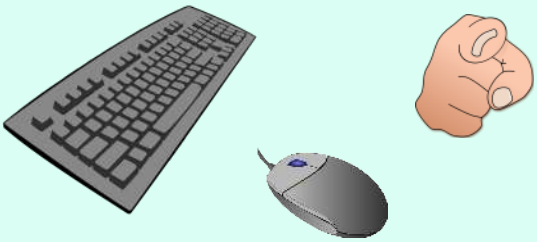
Event-driven programming

Whichever package you are using, and even whichever programming language you are using (what I'm saying about Java is also true in C/C++ or Python for example), programming graphical interfaces is a very different kind of programming that what you have done so far, and is called event-driven programming.

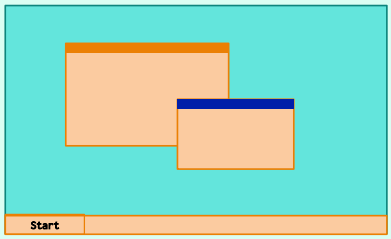
a Graphical Application is a big loop ...

You don't have to code the loop, it's performed for you by the graphical package functions. Basically, you draw things on the screen, display them, and run a loop that does nothing but wait. What is it waiting for? Simply for the user who (presumably) is sitting in front of the screen to do something (other than head-scratching).



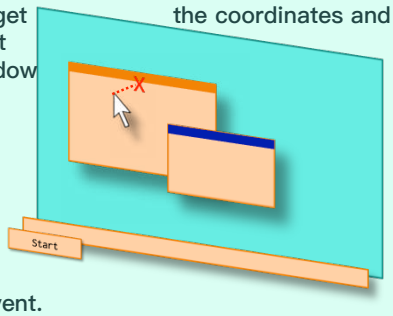


An event can be anything. A key pressed, a move of the mouse, a finger swiping a touch screen, somebody jumping in front of a webcam ... Anything that can be translated into an electrical signal reaching the computer.



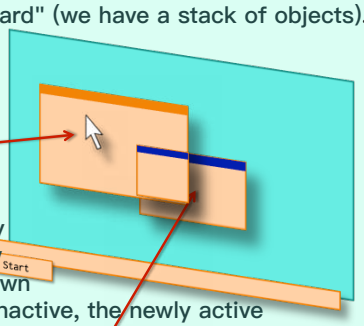
Your graphical application will run in a Window Manager that also reacts to events. For instance you may have an active window and an inactive window on the screen.

The user may move the mouse and click it outside the active window. The Windows management system will get the coordinates and discover that another window is at this location.



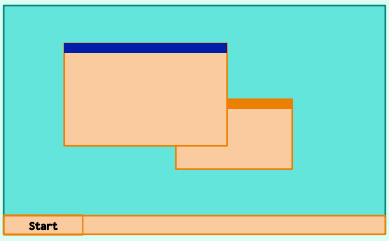
This is an event.

That means that the inactive window has to been "brought forward" (we have a stack of objects).

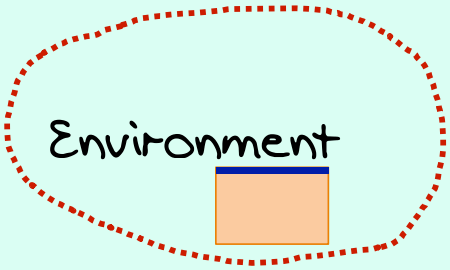


The previously active window must be redrawn to show it is inactive, the newly active window must be redrawn too, including what was previously hidden **deactivate** by the other window.

And finally your screen will look like this.



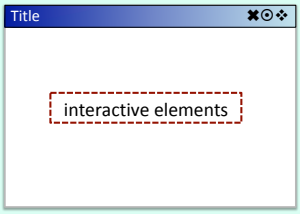
All this work is performed by the Windows Manager and doesn't require your writing a single line of code.

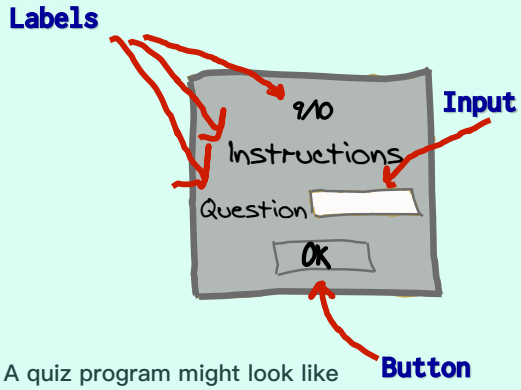


You must always keep in mind that when you are writing a graphical user interface it is running within an environment that manages windows (including resizing, destruction and so forth).

When you design your application you must decide on what the user will see: will your window have a title, will it be resizable, which elements will the user interact with in the window?

What does the user see?





A quiz program might look like this. Clicking the button evaluates the answer.

Your program must prepare everything in advance and, like a conjuror, only reveal elements at the right time when they should be visible.

Window gadget Widget

Entree

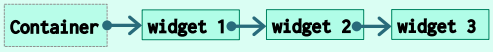
Nachos

Guacamole

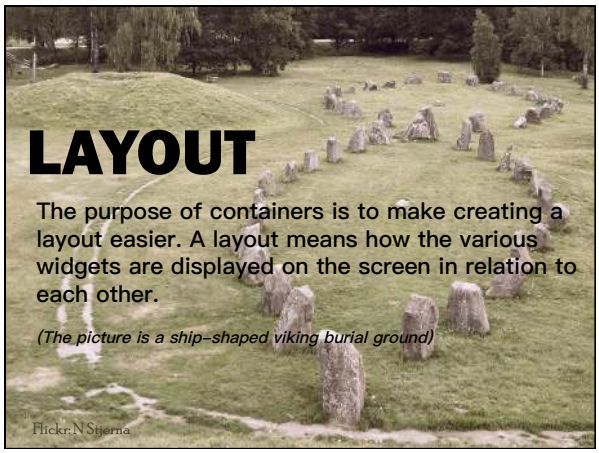
Order!

Visual elements are called "widgets" (short for window gadgets) and you are familiar with labels, entry-fields, drop-down and check boxes, as well as buttons ...

Containers



Something that you are probably not familiar with is the notion of "container". If you see widgets, you don't see containers that are nothing more than linked lists of widgets and (more about this soon) other containers.



LAYOUT

The purpose of containers is to make creating a layout easier. A layout means how the various widgets are displayed on the screen in relation to each other.

(The picture is a ship-shaped viking burial ground)

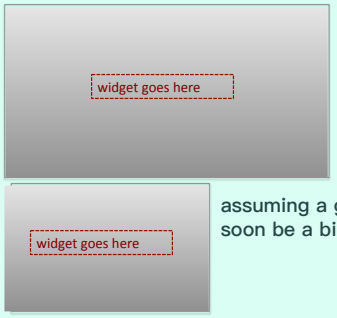
Flickr:N Stjerna

If you have a fixed-size window, things are easy. You can say "I want this widget to appear at these coordinates relative to the upper-left corner of the window".

Unfortunately, the easy case isn't the most common one.

Some containers are fixed

Most aren't



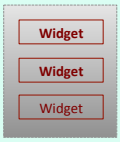
Usually people can (and do) resize windows and you want a "fluid" layout. If you give absolute coordinates assuming a given window size, it will soon be a big mess.

Boxes

Containers are here for solving these issues. Boxes come in two flavors, and display widgets next to each other (with some padding in-between) in only one direction.

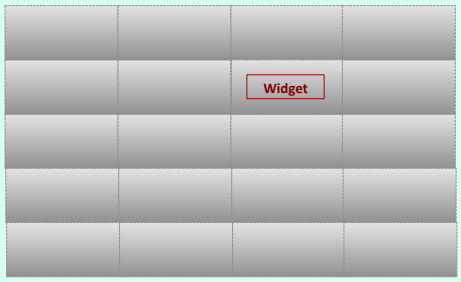
Horizontal boxes

Vertical boxes



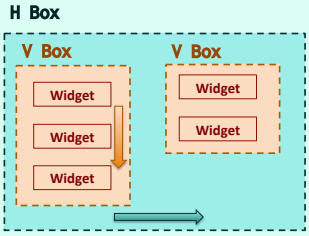
Grids

Other frequently used containers are grids, which allow you to place widgets at relative (row, column) coordinates rather than distance coordinates.



The great thing with containers is that they can be nested: you can have vertical boxes in horizontal ones or in grids, or the reverse.

Flickr: Jeff Hitchcock



For instance you can have two vertical boxes (each one showing widgets vertically) and add them to a horizontal box (side by side). When the window is resized, the global layout is respected and it still looks (more or less) as intended.

CALLBACK

function associated with an event

The last important idea to understand with graphical user interfaces is the one of "callbacks", often called "handlers" in Java, which is the name given to a function associated with an event. For instance, clicking a button might trigger a search inside a database. This is a function that you write, and associate with the button.

Predefined events

- destroy window
- button press/release
- key press/release
- focus in/out
- move in/out

and so forth

Predefined events are very, very numerous. You only handle those that matter to you. You often must perform a number of checks when the window is destroyed (for instance a text editor will ask you whether you want to save your changes)

OK, so how does it work with Java?

DEMO

The demo is simply a window that moves away every time you try to click the button (merely to irritate people)

What is shown here is the JavaFx version but a Swing version is also available.

Life of a javafx application

Create an instance of the **Application** class

The program class must extend Application

A JavaFX application derives from the Application class in the JavaFx package. It means that it automatically inherits standard attributes and methods.

Life of a javafx application

Create an instance of the **Application** class

Call the **init()** method

Does nothing by default

JavaFx will also automatically call a function called init(). By default, this function does nothing. You can write your own version, and connect to a network or a database, or read a parameter file.

Life of a javafx application

Create an instance of the **Application** class

Call the **init()** method

Call the **start(javafx.stage.Stage)** method

Window

MUST be rewritten

What you must write is a function called "start()" that takes a "Stage" (the name given to windows in JavaFx) as parameter. The function adds the widgets to the window and defines how it looks, and how widgets will react.

Life of a javafx application

Create an instance of the **Application** class

Call the **init()** method

Call the **start(javafx.stage.Stage)** method

Wait for the application to finish:

the application calls **Platform.exit()**

or window closed

You must write the event handlers you need, and nothing else — JavaFx will run the application until it calls an exit routine (perhaps associated with a "Quit" button) or it receives the event "Window destroyed".

Life of a javafx application

Create an instance of the **Application** class

Call the **init()** method

Call the **start(javafx.stage.Stage)** method

Wait for the application to finish:

the application calls **Platform.exit()**

or window closed

Call the **stop()** method It will then call a stop() method where you can undo what you have done in init() — disconnect for instance from a database or network. Like with init(), rewriting stop() is optional.

soothsayerfx.java

```
import java.util.Random;
import javafx.application.Application;
import javafx.event.ActionEvent;
import javafx.event.EventHandler;
import javafx.scene.Group;
import javafx.scene.Scene;
import javafx.scene.layout.VBox;
import javafx.scene.control.Button;
import javafx.scene.control.Label;
import javafx.scene.image.Image;
import javafx.scene.image.ImageView;
import javafx.scene.input.MouseEvent;
import javafx.stage.Stage;
import javafx.stage.Screen;
import javafx.geometry.Rectangle2D;
import javafx.geometry.Insets;
import javafx.geometry.Pos;
```

Tons of things to import (to be honest, you can also say `import javafx.scene.*;` for instance but I'm showing everything I'm using)

soothsayerfx.java

```
public class Soothsayerfx extends Application {
    private Rectangle2D screenBounds
                    = Screen.getPrimary().getVisualBounds();
    private Random    rand_generator;
    private double    x;
    private double    y;

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

    public void start(Stage stage) {
        this.rand_generator = new Random();
        stage.setTitle("Meaning of Life");
        stage.setResizable(false);
        Group root = new Group();
        Scene scene = new Scene(root);
        scene.getStylesheets().add("soothsayer.css");
```

Javafx bridges those two and provides a Window (stage)

The Scene class has a `getStylesheets()` method to retrieve a list of stylesheets, to which you may add a new one.

Cascading Style Sheet

You can load in javafx a CSS file, which is a technique borrowed from the web. If the file is missing, a simple warning will appear on the console. "Cascade" means waterfall in French and means that you can have several style sheets taken into account one after each other and overriding parts of the previous one (yours overrides parts of the default one)

```
.root {
    -fx-font-size: 28pt;
}
```

Entries look like this. The –fx- prefix is specific to javafx.

You may use reflection for finding the location (unless it's in a package)

name of my class "Reflection"

Problem: location?

```
private String directory = Soothsayerfx.class
                           .getProtectionDomain()
                           .getCodeSource()
                           .getLocation()
                           .toString();
scene.getStylesheets().add(directory + "soothsayer.css");
```

soothsayerfx.java

```
Group root = new Group();
Scene scene = new Scene(root);
scene.getStylesheets().add("soothsayer.css");
VBox vBox = new VBox();
vBox.setPadding(new Insets(10));
vBox.setSpacing(8);
vBox.setAlignment(Pos.CENTER);
root.getChildren().add(vBox);

Label label =
    new Label("Click the button to have"
              + " the Meaning of Life revealed");
vBox.getChildren().add(label);
Image myPicture = new Image("psychic.png");
ImageView img = new ImageView();
img.setImage(myPicture);
vBox.getChildren().add(img);
```

soothsayerfx.java

```
    Button button = new Button("Click to Learn");
    vBox.getChildren().add(button);
    button.addEventHandler(MouseEvent.MOUSE_ENTERED,
          new EventHandler<MouseEvent>() {
              @Override
              public void handle(MouseEvent e) {
                 moveWindow(stage);
              }
           });
    stage.setScene(scene);
    stage.show();
    stage.setX((screenBounds.getWidth()
                 - stage.getWidth()) / 2);
    stage.setY((screenBounds.getHeight()
                 - stage.getHeight()) / 2);
    this.x = stage.getX();
    this.y = stage.getY();
}
```

soothsayerfx.java

```
    private void moveWindow(Stage stage) {
        double height = screenBounds.getHeight();
        double width = screenBounds.getWidth();

        double x_move = width / 10
                + rand_generator.nextDouble() * width/2;
        double y_move = height / 10
                + rand_generator.nextDouble() * height/2;
        this.x = (double)((long)(this.x + x_move)
                    % (long)(width - stage.getWidth()));
        this.y = (double)((long)(this.y + y_move)
                    % (long)(height - stage.getHeight()));
        stage.setX(this.x );
        stage.setY(this.y);
    }

}
```

No explicit test

No explicit loop

Just events

What is important in a graphical application is that you just declare everything, and there is no procedural logic (if ... and loops) outside event handlers.

Coding forms isn't exactly thrilling.

You can create your widgets by hand, instantiating widgets objects one by one.

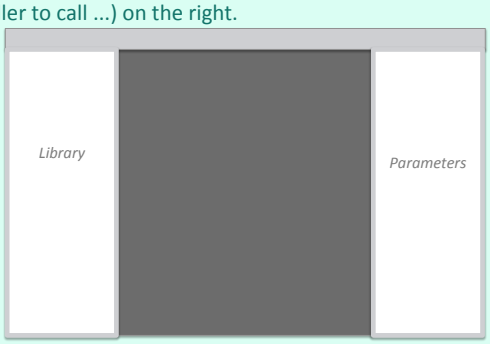
You can also use tools to create an XML (called FXML here) file describing widgets and containers. It will be loaded by JavaFx and graphical objects will be created from this static description.

Interface Design Tools

Scene Builder

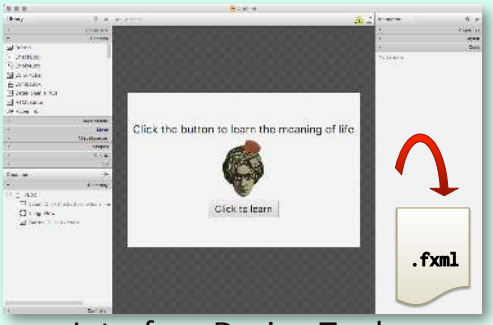
There are several such tools available, here is one in particular.

With Scene Builder, you drag widgets from the Libray into the middle part and set parameters (spacing, centering, handler to call ...) on the right.



Interface Design Tools

When your interface is designed, you save it to a .fxml file.



Interface Design Tools

Interface Design Tools

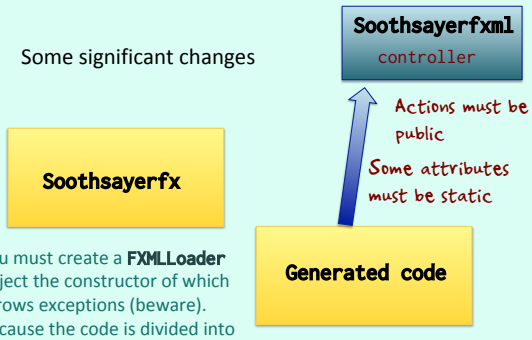
It looks like this (it's text)

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

<?import javafx.geometry.Insets?>
<?import javafx.scene.control.Button?>
<?import javafx.scene.control.Label?>
<?import javafx.scene.image.Image?>
<?import javafx.scene.image.ImageView?>
<?import javafx.scene.layout.VBox?>
<?import javafx.scene.text.Font?>

<VBox alignment="CENTER" maxHeight="-Infinity" maxWidth="-
Infinity" minHeight="-Infinity" minWidth="-Infinity"
prefHeight="400.0" prefWidth="600.0" spacing="8.0"
xmlns="http://javafx.com/javafx/8.0.111" xmlns:fx="http://
javafx.com/fxml/1" fx:controller="Soothsayerfxml">
```

these "imports" will no longer appear in the .java file

Interface Design Tools

Some significant changes



You must create a **FXMLLoader** object the constructor of which throws exceptions (beware). Because the code is divided into new modules, actions must be **public**.

Events and Change Listeners

Parent class Event

Most used children classes:

What `javafx.event.ActionEvent;` Button click

How `javafx.scene.input.InputEvent`
`javafx.scene.input.KeyEvent`
`javafx.scene.input.MouseEvent`
`javafx.scene.input.TouchEvent` Enums

External `javafx.stage.WindowEvent`

There are different rules for the system to find the target – widget that has the focus for key events, cursor position for mouse events, etc, and of course if an element is hidden by another it's the one on top that is considered to be the target.

Events and Change Listeners

Determine the Event Target

EventTarget interface
- Window
- Scene
- Node

"Bubbles up" like exceptions

Event handler ≅ **catch**

Events and Change Listeners

Tons of

`.setOn`*`SomeAction`*`()` methods for Nodes

```
KeyPressed
KeyReleased
KeyTyped
MouseClicked
MouseExited
...
```

Events and Change Listeners

`.setOnAction()` method for Buttons
Radio Buttons
Check Boxes

Events and Change Listeners

Lambda expressions!

```
Button btn = new Button();
btn.setText("Say 'Hi'");
btn.setOnAction((e)->{
            System.out.println("Hi!");
        });
```

You can also define Event Filters to intercept (block) some events or override them

Events and Change Listeners

Instead of `.setOnxxxx()` methods, you can use `addEventHandler()` for unusual actions

```
button.addEventHandler(MouseEvent.MOUSE_ENTERED,
                       (e)->{moveWindow(stage);});
```

Moving the window away when you try to click on the button isn't usual.